

Chapter 2 Part B

General engine overhaul procedures

Contents

Camshaft, lifters and bearing surfaces — inspection	15	Engine rebuilding alternatives	3
Crankshaft — removal	12	General information	1
Crankshaft — inspection	17	Initial start-up and break in after overhaul	23
Crankshaft and rear main seal — installation	21	Main and connecting rod bearings — inspection	18
Crankshaft oil clearance — check	20	Oil pan — removal and installation	9
Cylinder head — disassembly	5	Oil pump — removal, inspection and installation	10
Cylinder head — cleaning and inspection	6	Piston/connecting rod assembly — removal	11
Cylinder head — assembly	8	Piston/connecting rod assembly — inspection	16
Engine block — cleaning	13	Piston rings — installation	19
Engine block — inspection	14	Piston/connecting rod assembly — installation and oil clearance check	22
Engine overhaul — disassembly sequence	4	Valves — servicing	7
Engine overhaul — general information	2		

Specifications

Head, camshaft and valve train

Head surface warpage limit	
standard	0.05 mm (0.002 in)
maximum	0.1 mm (0.004 in)
Valve stem diameter	
intake	6.965 to 6.980 mm (0.2742 to 0.2748 in)
exhaust	7.965 to 7.970 mm (0.3136 to 0.3138 in)
Valve margin	
intake	1.3 mm (0.051 in)
exhaust	1.5 mm (0.059 in)
Valve margin limit	More than 0.5 mm (0.020 in)
Valve spring free height	
outer	51.2 mm (2.016 in)
inner	44.1 mm (1.736 in)
Valve spring pressure/height	
outer	30.0 mm @ 53.4 kg (1.81 in @ 117.7 lb)
inner	25.0 mm @ 26.0 kg (0.984 in @ 57.3 lb)
Valve spring assembled height	
outer	40.0 mm @ 25.5 kg (1.575 in @ 56.2 lb)
inner	35.0 mm @ 11.0 kg (1.378 in @ 24.3 lb)
Valve spring out of square	
outer	2.2 mm (0.087 in)
inner	1.9 mm (0.075 in)
Hydraulic valve lifter	
lifter outside diameter	15.947 to 15.957 mm (0.6278 to 0.6282 in)
lifter guide inside diameter	16.000 to 16.013 mm (0.6299 to 0.6304 in)
lifter movement limit	0.1 mm (0.04 in)
Valve stem to guide clearance	
intake	
standard	0.020 to 0.053 mm (0.0008 to 0.0021 in)
maximum	0.10 mm (0.004 in)
exhaust	
standard	0.040 to 0.073 mm (0.0016 to 0.0029 in)
maximum	0.20 mm (0.008 in)
Rocker shaft and rocker arm	
shaft outer diameter	17.979 to 18.000 mm (0.7078 to 0.7087 in)
rocker arm inner diameter	18.007 to 18.028 mm (0.7089 to 0.7098 in)
Clearance between rocker arm and shaft	0.007 to 0.049 mm (0.0003 to 0.0019 in)
Intake valve seat	
seat angle	45-degrees
seat width	1.75 mm (0.0689 in)
seat diameter (upper edge)	41.6 to 41.8 mm (1.638 to 1.646 in)
Exhaust valve seat	
seat angle	45-degrees
seat width	1.7 mm (0.067 in)
seat diameter	34.4 to 34.6 mm (1.354 to 1.362 in)

Camshaft

journal to bearing clearance	
standard	0.045 to 0.090 mm (0.0018 to 0.0035 in)
maximum	0.15 mm (0.0059 in)
inner diameter of camshaft bearing	47.00 to 47.025 mm (1.8504 to 1.8514 in)
outer diameter of camshaft journal	46.935 to 46.955 mm (1.8478 to 1.8486 in)
camshaft runout – total indicator reading	Less than 0.04 mm (0.0016 in)
camshaft end play	0.03 to 0.06 mm (0.0012 to 0.0024 in)
cam lobe height	39.537 to 39.725 mm (1.5566 to 1.5640 in)
cam wear limit	0.15 mm (0.0059 in)

Cylinder block

Surface flatness	
standard	less than 0.03 mm (0.0012 in)
limit	0.10 mm (0.0039 in)

Cylinder bore

inner diameter – standard	
grade no. 1	87.000 to 87.010 mm (3.4252 to 3.4256 in)
grade no. 2	87.010 to 87.020 mm (3.4256 to 3.4260 in)
grade no. 3	87.020 to 87.030 mm (3.4260 to 3.4264 in)
grade no. 4	87.030 to 87.040 mm (3.4264 to 3.4268 in)
grade no. 5	87.040 to 87.050 mm (3.4268 to 3.4272 in)
wear limit	0.20 mm (0.0079 in)
out-of-round	less than 0.015 mm (0.0006 in)
taper	less than 0.015 mm (0.0006 in)

Main journal inner diameter

grade no. 0	66.645 to 66.654 mm (2.6238 to 2.6242 in)
grade no. 1	66.654 to 66.663 mm (2.6242 to 2.6245 in)
grade no. 2	66.663 to 66.672 mm (2.6245 to 2.6249 in)

Piston and rings**Piston skirt diameter**

grade no. 1	86.965 to 86.975 mm (3.4238 to 3.4242 in)
grade no. 2	86.975 to 86.985 mm (3.4242 to 3.4246 in)
grade no. 3	86.985 to 86.995 mm (3.4246 to 3.4250 in)
grade no. 4	86.995 to 87.005 mm (3.4250 to 3.4254 in)
grade no. 5	87.005 to 87.015 mm (3.4254 to 3.4258 in)
Piston clearance to cylinder block	0.025 to 0.045 mm (0.0010 to 0.0018 in)

Piston rings

side clearance	
top	
standard	0.040 to 0.073 mm (0.0016 to 0.0029 in)
maximum	0.10 mm (0.004 in)
2nd	
standard	0.030 to 0.063 mm (0.0012 to 0.0025 in)
maximum	1.0 mm (0.04 in)
oil rail	
standard	0.015 to 0.190 mm (0.0006 to 0.0075 in)
maximum	1.0 mm (0.04 in)
end gap	
top	
standard	0.21 to 0.44 mm (0.008 to 0.017 in) (1988 and later turbo = 0.008 to 0.012 in)
maximum	1.0 mm (0.040 in)
2nd	
standard	0.18 to 0.44 mm (0.007 to 0.017 in)
maximum	1.0 mm (0.040 in)
oil rail	
standard	0.20 to 0.76 mm (0.008 to 0.030 in)
maximum	1.0 mm (0.040 in)

Crankshaft**Main journal diameter**

grade no. 0	62.967 to 62.975 mm (2.4790 to 2.4793 in)
grade no. 1	62.959 to 62.967 mm (2.4787 to 2.4790 in)
grade no. 2	62.951 to 62.959 mm (2.4784 to 2.4787 in)
Rod journal diameter	49.961 to 49.974 mm (1.9670 to 1.9675 in)

Out-of-round

less than 0.005 mm (0.0002 in)

End play

standard	0.05 to 0.17 mm (0.0020 to 0.0067 in)
maximum	0.30 mm (0.0118 in)

Main bearing clearance

standard	0.028 to 0.055 mm (0.0011 to 0.0022 in)
maximum	0.090 mm (0.0035 in)

Crankshaft (continued)

Rod bearing clearance		
standard	0.010 to 0.052 mm (0.0004 to 0.0020 in)	
maximum	0.090 mm (0.0035 in)	
Torque specifications	Kg-m	Ft-lbs
Oil pan		
1984 thru 1987	0.5 to 0.7	3.6 to 5.1
1988 on	0.7 to 0.8	5.1 to 5.8
Oil pump regulator valve	4.0 to 5.0	29 to 36
Oil pump mounting bolts		
6 mm	0.6 to 0.7	4.3 to 5.1
8 mm	1.2 to 1.6	9 to 12
Oil strainer	1.6 to 2.1	12 to 15
Rear oil seal retainer	0.6 to 0.7	4.3 to 5.1
Connecting rod	4.5 to 5.5	33 to 40
Main bearing cap	9.2 to 10.2	67 to 74
Rocker cover	0.1 to 0.3	0.7 to 2.2
Rocker shaft	1.8 to 2.2	13 to 16
Camshaft plate	8.0 to 9.0	58 to 65
Flywheel	10 to 11	72 to 80
Cylinder head – tighten in five stages		
1st stage	3.0	22
2nd stage	6.0	43
3rd stage	Loosen all bolts	
4th stage	3.0	22
5th stage	5.5 to 6.5	40 to 47
Intake manifold bolt – tighten in two stages		
1st stage	0.3 to 0.5	2.2 to 3.6
2nd stage	1.6 to 2.0	12 to 14
Intake manifold nut – tighten in two stages		
1st stage	0.3 to 0.5	2.2 to 3.6
2nd stage	24 to 27	17 to 20

1 General information

Included in this portion of Chapter 2 are the general overhaul procedures for the cylinder head and internal engine components. The information ranges from advice concerning preparation for an overhaul and the purchase of replacement parts to detailed, step-by-step procedures covering removal and installation of internal engine components and the inspection of parts.

The following Sections have been written based on the assumption that the engine has been removed from the vehicle. For information concerning in-vehicle engine repair, as well as removal and installation of the external components necessary for the overhaul, see Part A of Chapter 2 and Section 2 of this Part.

The specifications included here in Part B are only those necessary for the inspection and overhaul procedures which follow. Refer to Part A for additional specifications related to this engine.

2 Engine overhaul – general information

Because a number of factors must be taken into consideration, it is not always easy to determine when, or if, an engine should be completely overhauled.

High mileage is not necessarily an indication that an overhaul is needed, while low mileage does not preclude the need for an overhaul. Frequency of servicing is probably the most important consideration. An engine that has had regular and frequent oil and filter changes, as well as other required maintenance, will most likely give many thousands of miles of reliable service. Conversely, a neglected engine may require an overhaul very early in its life.

Excessive oil consumption is an indication that piston rings and/or valve guides are in need of attention. Make sure that oil leaks are not responsible before deciding that the rings and guides are bad. Perform a cylinder compression test (Chapter 1) or have a leak-down test performed by an experienced mechanic to determine for certain the extent of the work required.

If the engine is making obvious knocking or rumbling noises, the connecting rod and/or main bearings are probably at fault. Check the oil

pressure with a gauge installed in place of the oil pressure sending unit and compare it to the Specifications. If it is extremely low, the bearings and/or oil pump are probably worn out.

Loss of power, rough running, excessive valve train noise and high fuel consumption rates may also point to the need for an overhaul, especially if they are all present at the same time. If a complete tune-up does not remedy the situation, major mechanical work is the only solution.

An engine overhaul involves restoring the internal components to the same specifications as those of a new engine. During an overhaul, the piston rings are replaced and the cylinder walls are reconditioned (rebored and/or honed). If a rebore is done, new pistons are required. The main and connecting rod bearings are replaced with new ones and, if necessary, the crankshaft may be reground to restore the journals. Generally, the valves are serviced as well, since they are usually in less-than-perfect condition at this point. While the engine is being overhauled other components, such as the carburetor/fuel injection system, distributor, starter and alternator can be rebuilt as well. The end result should be a like-new engine that will give many trouble-free miles.

Before beginning the engine overhaul, read through the entire procedure to familiarize yourself with the scope and requirements of the job. Overhauling an engine is not difficult, but it is time consuming. Plan on the vehicle being tied up for a minimum of two weeks, especially if parts must be taken to an automotive machine shop for repair or reconditioning. Check on availability of parts and make sure that any necessary special tools and equipment are obtained in advance. Most work can be done with typical shop tools, although a number of precision measuring tools are required for inspecting parts to determine if they must be replaced. Often an automotive machine shop will handle the inspection of parts and offer advice concerning reconditioning and replacement. **Note:** *Always wait until the engine has been completely disassembled and all components, especially the engine block, have been inspected before deciding what service and repair operations must be performed by an automotive machine shop.* Since the condition of the block will be the major factor to consider when determining whether to overhaul the original engine or buy a rebuilt one, never purchase parts or have machine work done on other components until the block has been thoroughly inspected. As a general rule, time is the primary cost of an overhaul, so it does not pay to install worn

or sub-standard parts.

As a final note, to ensure maximum life and minimum trouble from a rebuilt engine, assemble everything with care in a spotlessly clean environment.

3 Engine rebuilding alternatives

The do-it-yourselfer is faced with a number of options when performing an engine overhaul. The decision to replace the engine block, piston/connecting rod assemblies and crankshaft depends on a number of factors, with the number one consideration being the condition of the block. Other considerations are cost, access to machine shop facilities, parts availability, time required to complete the project and experience.

Some of the rebuilding alternatives include:

Individual parts — If the inspection procedures reveal that the engine block and most engine components are in reusable condition, purchasing individual parts may be the most economical alternative. The block, crankshaft and piston/connecting rod assemblies should all be inspected carefully. Even if the block shows little wear, the cylinder bores should receive a finish hone.

Crankshaft kit — This rebuild package usually consists of a reground crankshaft and a matched set of pistons and connecting rods. The pistons will already be installed on the connecting rods. Piston rings and the necessary bearings are included in the kit. These kits are commonly available for standard cylinder bores, as well as for engine blocks which have been bored to a regular oversize.

Short block — A short block consists of an engine block with a crankshaft and piston/connecting rod assemblies already installed. All new bearings are incorporated and all clearances will be correct. Depending on where the short block is purchased, a guarantee may be included. The existing camshaft, valve train components, cylinder head and external parts can be bolted to the short block with little or no machine shop work necessary.

Long block — A long block consists of a short block plus an oil pump, oil pan, cylinder heads, rocker arm covers, camshafts and valve train components, timing sprockets and belt and timing belt cover. All components are installed with new bearings, seals and gaskets incorporated throughout. The installation of manifolds and external parts is all that is necessary. Some form of guarantee is usually included with the purchase.

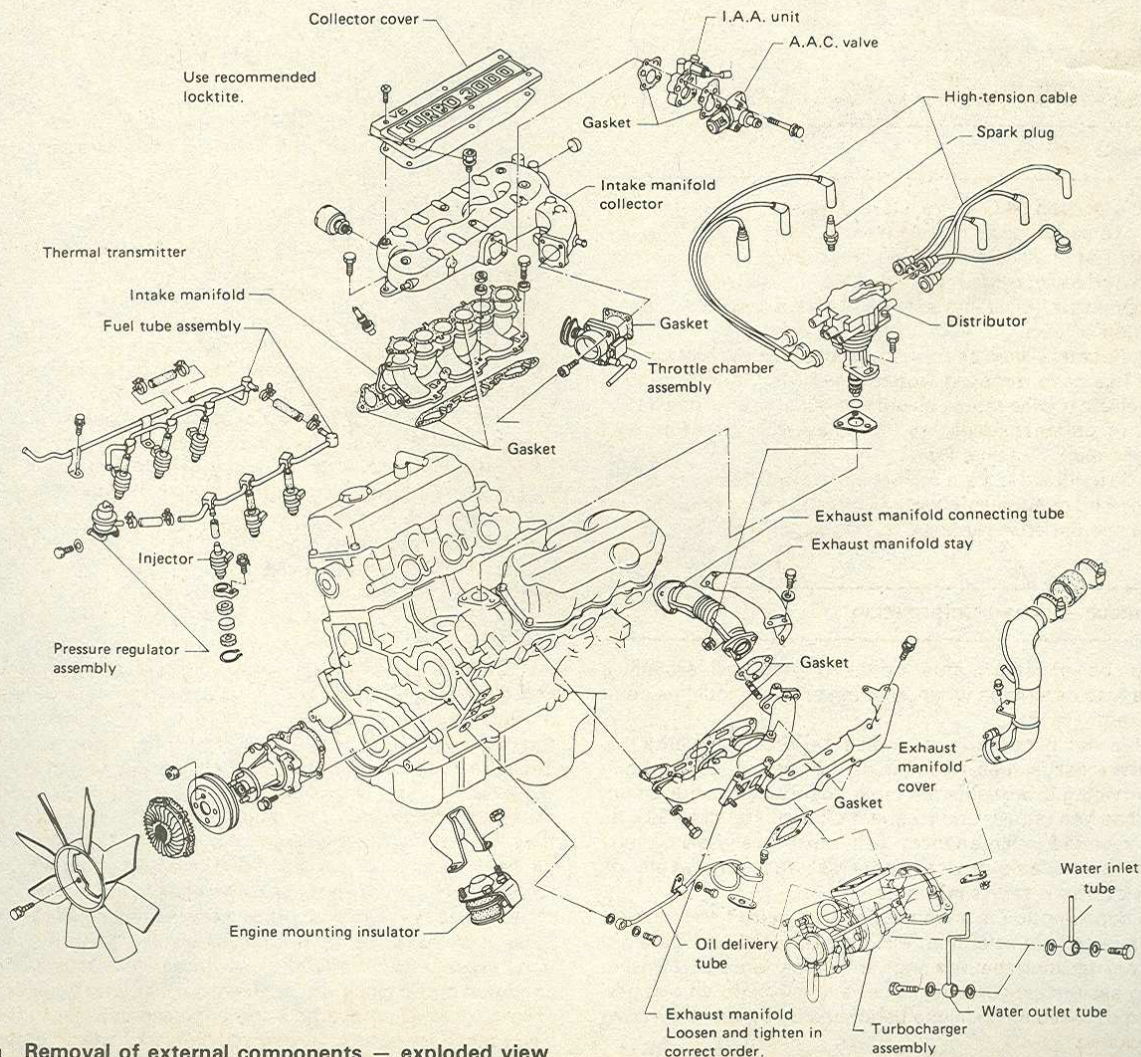
Give careful thought to which alternative is best for you and discuss the situation with local automotive machine shops, auto parts dealers or your local dealership before ordering or purchasing replacement parts.

4 Engine overhaul — disassembly sequence

Refer to illustrations 4.5a, 4.5b and 4.5c

1 It is much easier to disassemble and work on the engine if it is mounted on an engine stand. These stands can often be rented for a reasonable fee from an equipment rental yard. Before the engine is mounted on a stand, the flywheel/driveplate should be removed from the engine (Chapter 8).

2 If a stand is not available, it is possible to disassemble the engine



4.5a Removal of external components — exploded view

with it blocked up on a sturdy workbench or on the floor. Be extra careful not to tip or drop the engine when working without a stand.

3 If you are going to obtain a rebuilt engine, all external components must come off your old engine first in order to be transferred to the replacement engine, just as they will if you are doing a complete engine overhaul yourself. These include:

- Alternator and bracket
- Air conditioning compressor and bracket
- Power steering pump and bracket
- Emission control components
- Distributor, spark plug wires and spark plugs
- Thermostat and housing cover
- Water pump
- Fuel injection components
- Intake/exhaust manifolds
- Oil filter
- Engine mounts
- Flywheel/driveplate

Note: When removing the external components from the engine, pay close attention to details that may be helpful or important during installation. Note the installed position of gaskets, seals, spacers, pins, washers, bolts and other small items.

4 If you are obtaining a short block, which consists of the engine block, crankshaft, pistons and connecting rods all assembled, then the

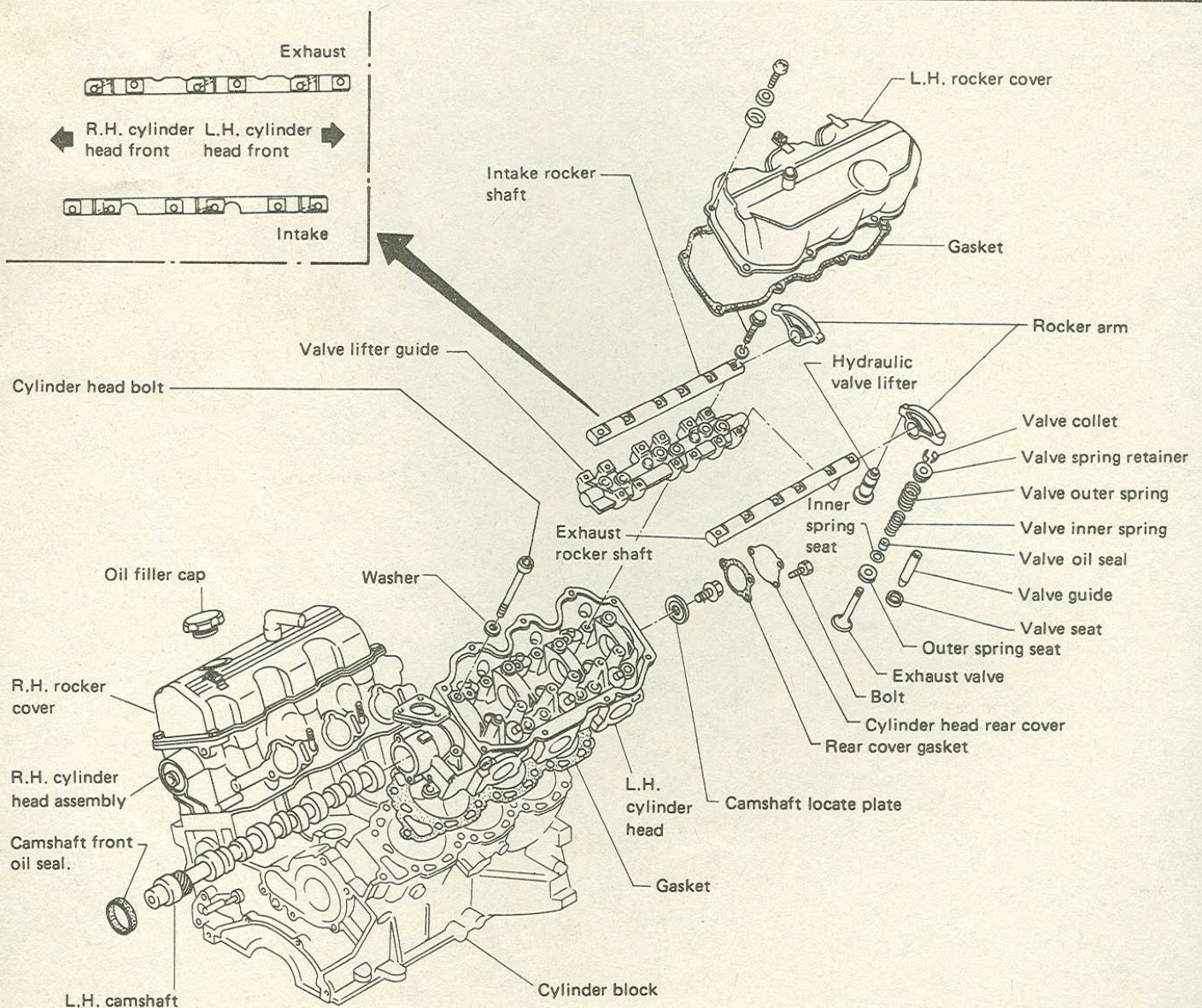
cylinder heads, oil pan and oil pump will have to be removed as well. See *Engine rebuilding alternatives* for additional information regarding the various approaches you should consider.

5 If you are planning a complete overhaul, the engine must be disassembled and the components removed in the following order (see illustrations):

- Rocker arm covers
- Timing belt cover
- Timing belt and gears
- Cylinder heads
- Oil pan
- Oil pump
- Piston/connecting rod assemblies
- Crankshaft

6 Before beginning the disassembly and overhaul procedures, make sure the following items are available:

- Common hand tools
- Small cardboard boxes or plastic bags for storing parts
- Gasket scraper
- Ridge reamer
- Vibration damper puller
- Micrometers
- Telescoping gauges
- Dial indicator set



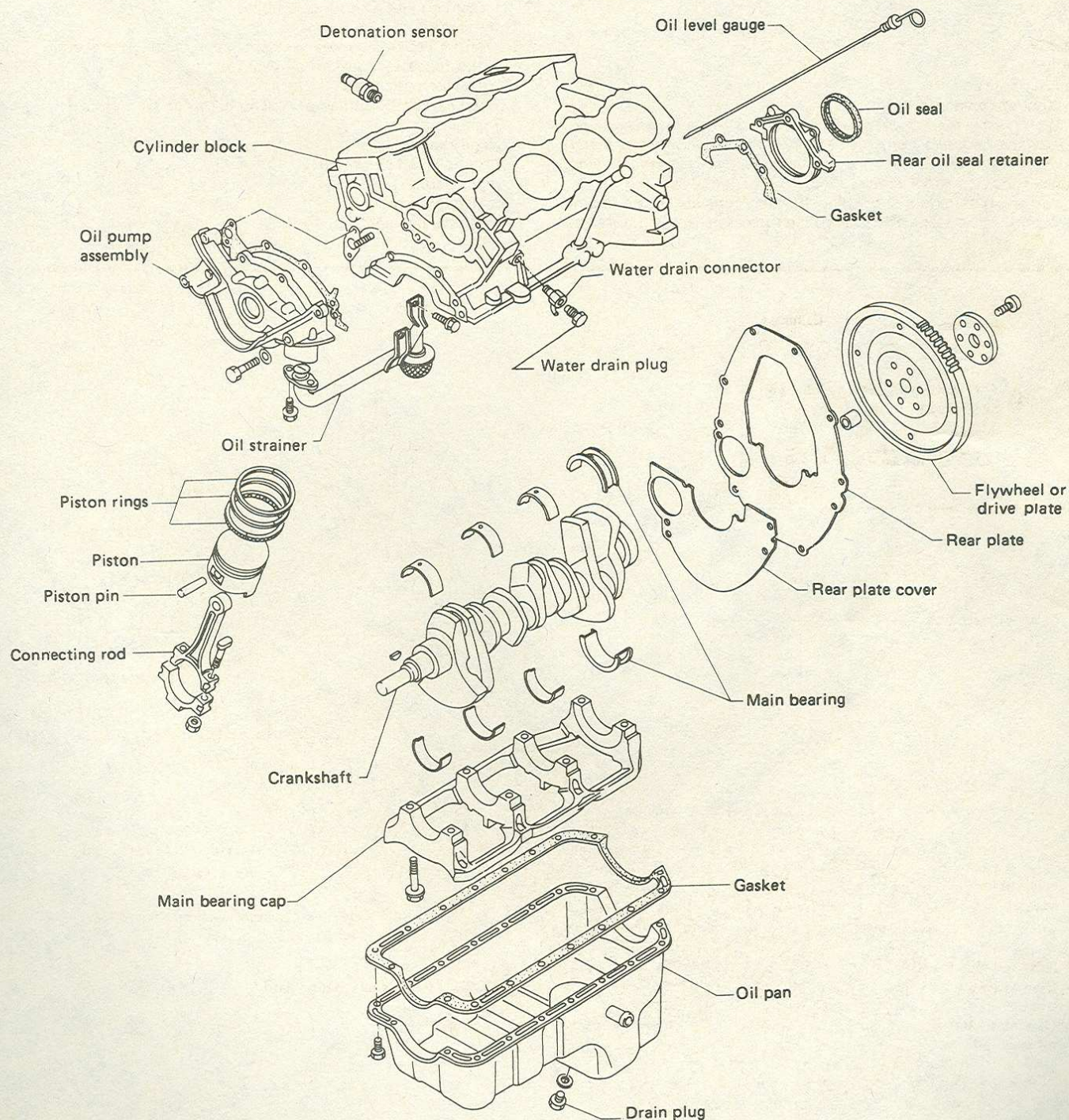
4.5b Removal and disassembly of the cylinder head — exploded view

Valve spring compressor
Cylinder surfacing hone
Piston ring groove cleaning tool
Electric drill motor
Tap and die set
Wire brushes
Cleaning solvent

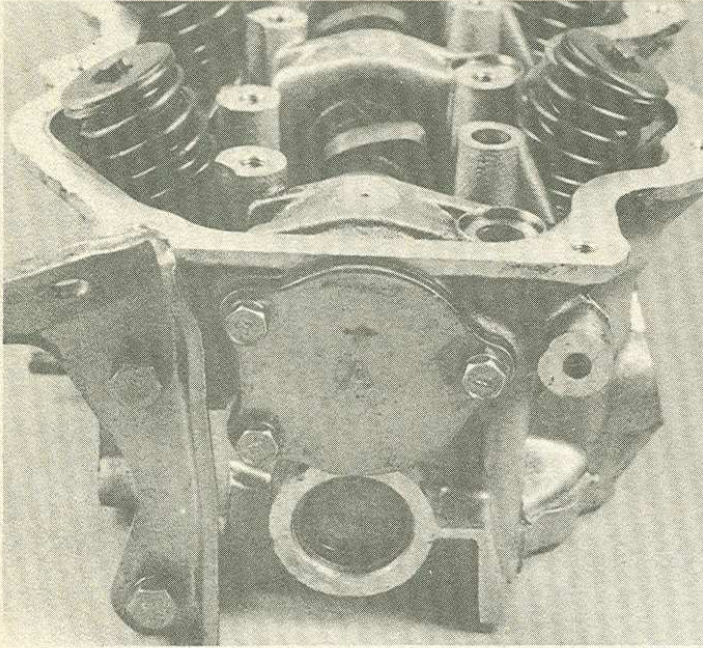
5 Cylinder head — disassembly

Refer to illustrations 5.4, 5.5a, 5.5b, 5.6, 5.7, 5.8 and 5.9

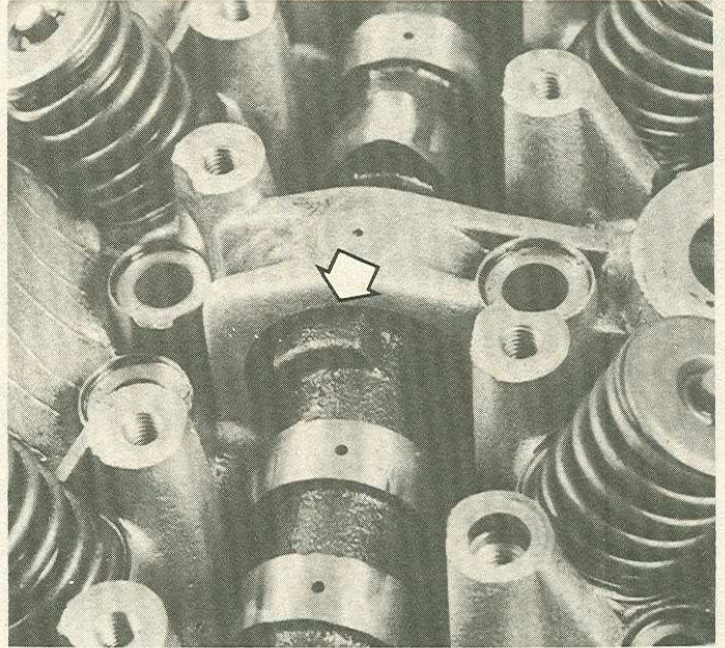
- 1 Remove the cylinder head from the engine (Chapter 2A).
- 2 Remove the rocker arm shafts (Chapter 2A).
- 3 Remove the hydraulic valve lifters and lifter guide (Chapter 2A).



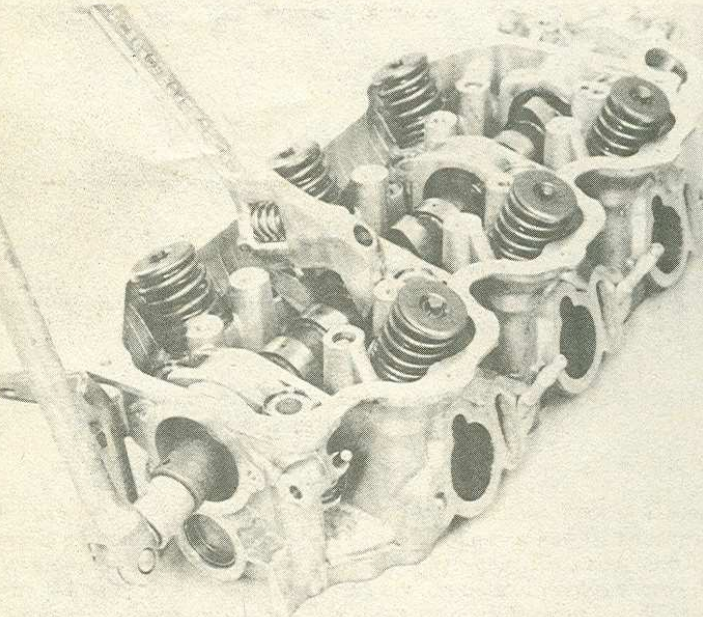
4.5c Disassembly of internal engine components — exploded view



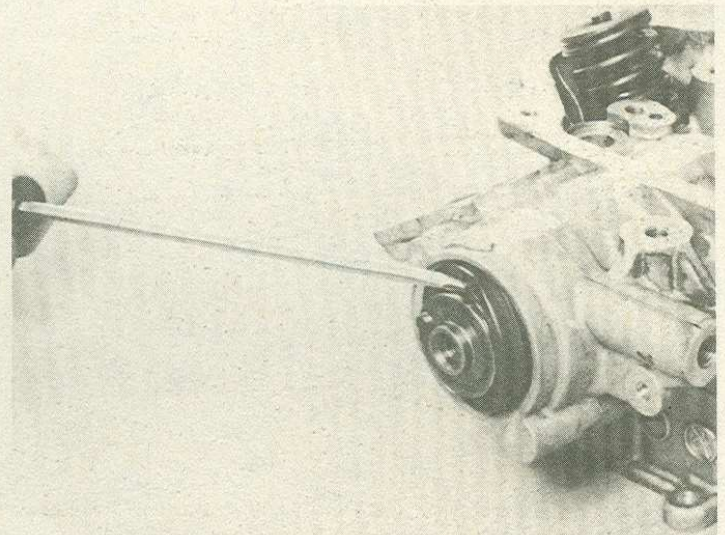
5.4 Remove the three camshaft plate retaining bolts



5.5a Use the holding lug located behind the number three bearing to hold the camshaft



5.5b While holding the camshaft, break loose the camshaft retaining bolt



5.6 Carefully pry out the camshaft oil seal with a small screwdriver

4 Remove the camshaft plate cover retaining bolts and gently pry it off (see illustration).

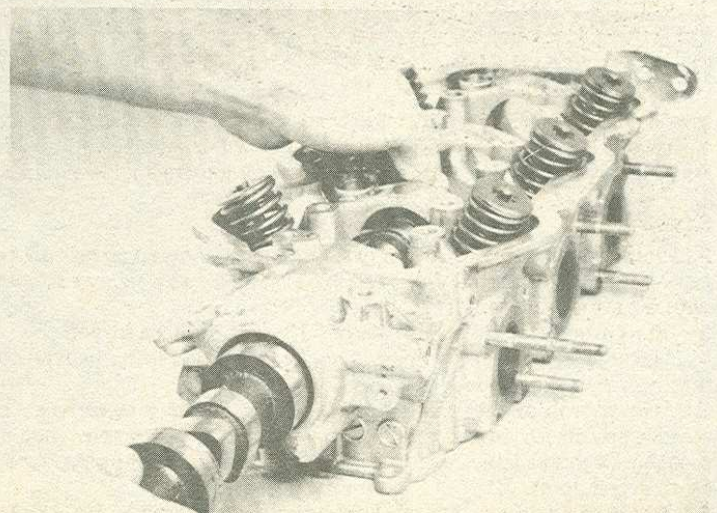
5 Use the holding lug on the camshaft (see illustration) to secure the camshaft with a wrench while loosening the camshaft plate retaining bolt (see illustration).

6 Carefully remove the camshaft oil seal at the front of the cylinder head by prying out the seal with a small screwdriver (see illustration).

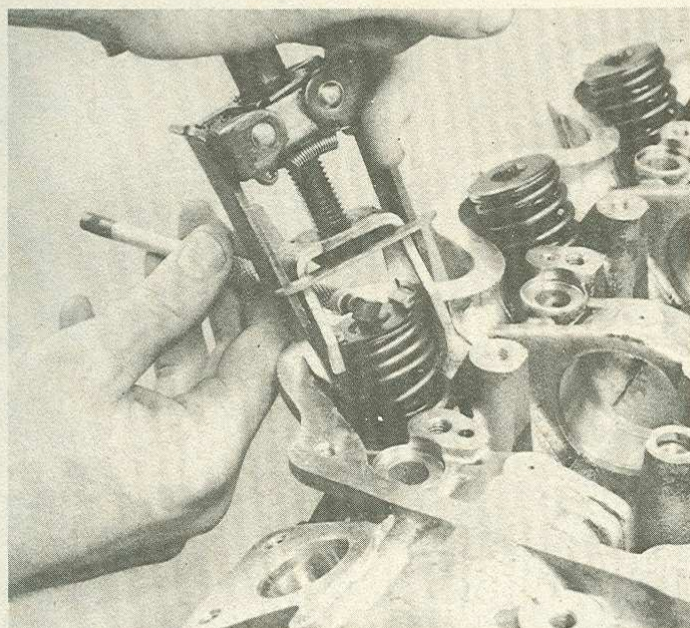
7 Carefully pull the camshaft out the front of the head (see illustration). **Caution:** Be careful. Do not scratch the cam lobes or bearing journals.

8 Install a valve spring compressor, compress the spring, remove the keepers from the valve stem with a small magnet, then remove the retainer and valve springs (see illustration). **Caution:** Before extracting the valve itself from the valve guide, check for mushrooming on the tip of the stem. Do not attempt to extract a valve with a mushroomed tip through its guide before deburring the tip with a small file. Repeat this step for each valve.

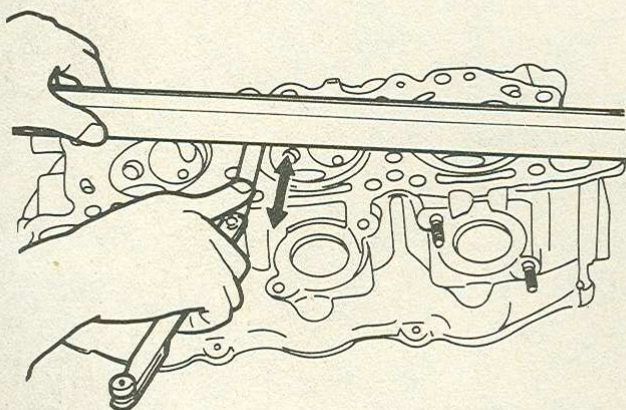
9 Place the valve stem components for each valve in separate bags and mark each bag so the components can be installed in their original positions (see illustration).



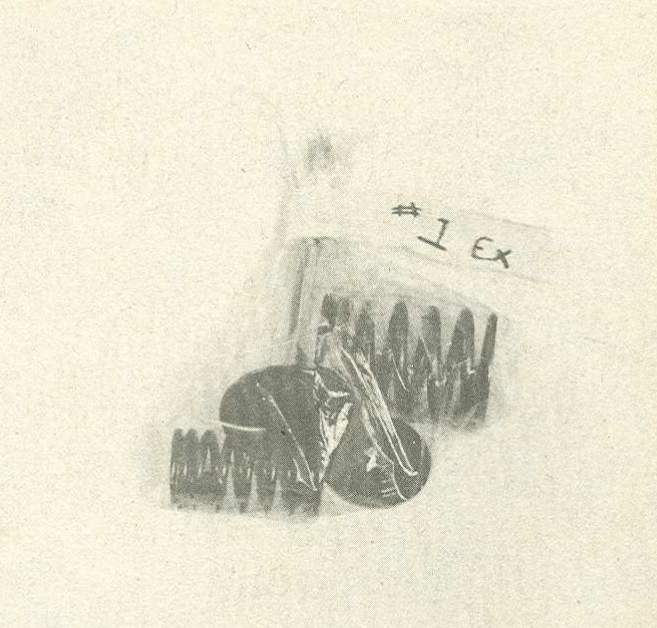
5.7 Pull the camshaft out the front of the head, using both hands to support the camshaft



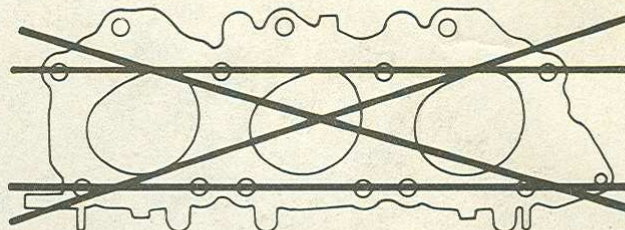
5.8 Use a valve spring compressor to compress the spring, then remove the keepers from the valve stem with a small magnet



6.12a Lay a straightedge along the head and use a feeler gauge to check for warpage



5.9 Keep the valve spring components for each valve separate so each valve assembly can be installed in its original location



6.12b Make three more checks for head straightness by laying the straightedge at these angles

6 Cylinder head — cleaning and inspection

Refer to illustrations 6.12a, 6.12b, 6.14, 6.15, 6.16, 6.17, 6.18, 6.19, 6.23, 6.24 and 6.25

1 Thorough cleaning of the cylinder head and related valve train components, followed by a detailed inspection, will enable you to decide how much valve service work must be done during the engine overhaul.

Cleaning

2 Scrape away all traces of old gasket material and sealing compound from the head, intake manifold and exhaust manifold sealing surfaces with a gasket scraper.

3 Remove any scale build-up around the coolant passages.

4 Run a stiff wire brush through the oil holes to remove any deposits that may have formed in them.

5 Run an appropriate size tap into each of the threaded holes to remove any corrosion and thread sealant that may be present. If compressed air is available, use it to clear the holes of debris produced by this operation.

6 Clean the exhaust and intake manifold stud threads in a similar manner with an appropriate size die.

7 Clean the cylinder head with solvent and dry it thoroughly. Com-

pressed air will speed the drying process and ensure that all holes and recessed areas are clean. **Note:** Decarbonizing chemicals may prove helpful when cleaning cylinder heads and valve train components. Follow the instructions on the container. Such chemicals are very caustic and should be used with caution. Make sure they're not harmful to aluminium heads.

8 Clean the rocker arms with solvent and dry them thoroughly. Compressed air will speed the drying process and can be used to clean out the oil passages.

9 Clean all the valve springs, retainers, collets and spring seats with solvent and dry them thoroughly. Clean each valve assembly one at a time to avoid mixing up the parts.

10 Scrape off any heavy deposits that may have formed on the valves, then use a motorized wire brush to remove deposits from the valve heads and stems. Again, make sure the valves do not get mixed up.

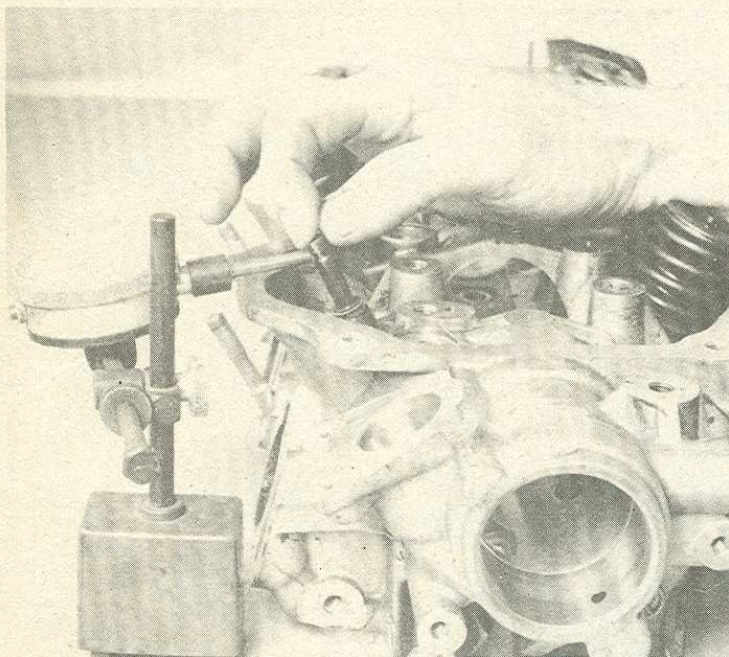
Inspection

Cylinder head

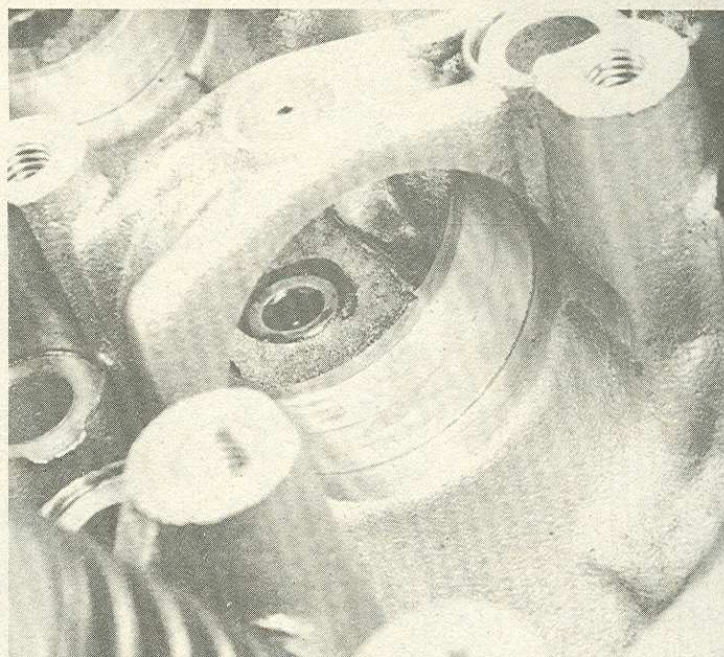
11 Inspect the head very carefully for cracks, evidence of coolant leakage or other damage. If cracks are found, a new cylinder head should be obtained.

12 Using a straightedge and feeler gauge, check the head gasket mating surface for warpage at four angles (see illustrations). If any measurement exceeds the specified warpage, have the head resurfaced at an automotive machine shop.

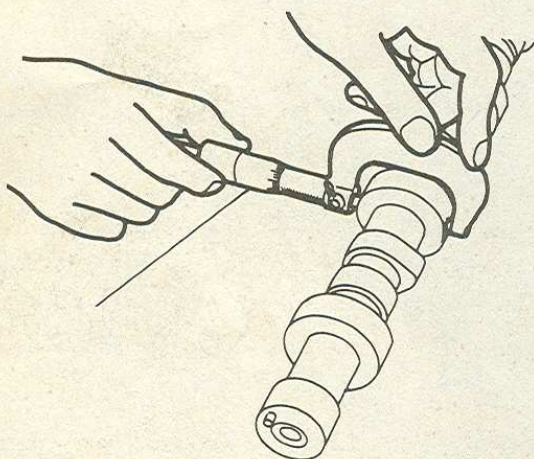
13 Examine the valve seats in each of the combustion chambers. If any of them are pitted, cracked or burned, the head will require valve service that is beyond the scope of the home mechanic.



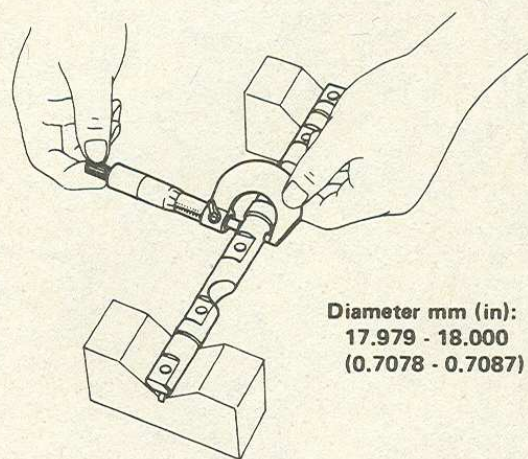
6.14 A dial indicator can be used to determine valve stem-to-guide clearance



6.15 Inspect the cam bearing journal surfaces for pitting, scoring or abnormal wear. If defective, the head must be replaced

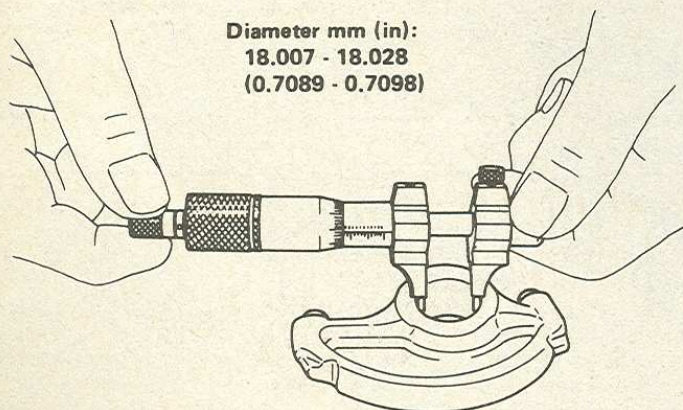


6.16 Measure the camshaft bearing journal diameter and subtract that figure from the bearing inside diameter to obtain the camshaft oil clearance



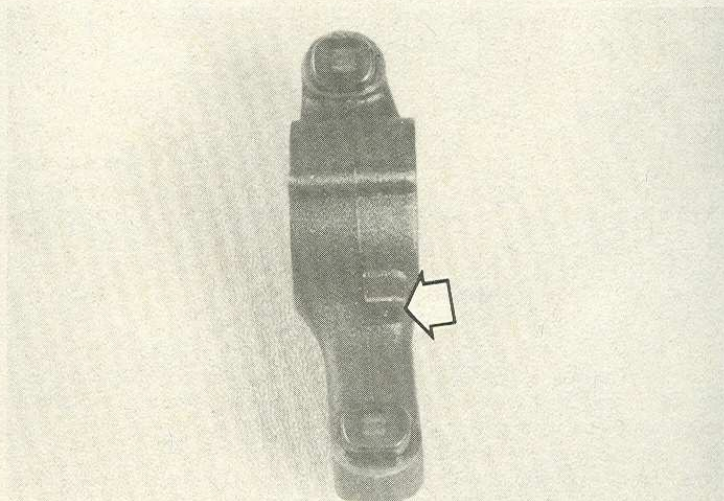
Diameter mm (in):
17.979 - 18.000
(0.7078 - 0.7087)

6.17 Measure the rocker arm shafts for wear

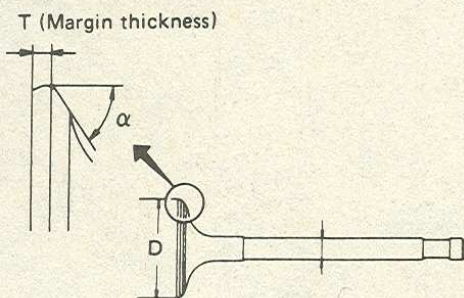


Diameter mm (in):
18.007 - 18.028
(0.7089 - 0.7098)

6.18 An inside micrometer or vernier caliper can be used to check the rocker arms



6.19 Inspect the rocker arm pad for scuffing or wear and check that the oil passage is free of any obstructions



6.23 Measure the valve margin

14 Use a dial indicator to measure the lateral movement of each valve stem with the valve in the guide and approximately 1/16-inch off the seat. Mount the indicator onto the head, push the valve stem to one side and zero the dial indicator. Push the valve stem to the other side and read the indicator. Because the dial indicator reads the total side play of the valve stem, you must divide your measurement by 2 to get the actual valve stem to guide clearance (see illustration).

15 Check the camshaft bearing surfaces for pitting, scoring or any other abnormal wear (see illustration). If the bearing surfaces are damaged the head will have to be replaced.

16 Measure the inside diameter of the camshaft bearing surfaces and the outside diameter of the camshaft bearing journals. Then subtract each journal diameter from its corresponding bearing surface inside diameter to compute the journal-to-bearing oil clearances (see illustration). Compare your results to the specified clearance.

Rocker arm components

17 Check the valve rocker arms and rocker arm shafts for pits, wear and rough spots. Measure the outside diameter of each rocker shaft, at the journals on which the rocker arms pivot, with a micrometer (see illustration) and compare your measurements to the specified outside diameter for rocker arm shafts.

18 Measure the inside diameter of each rocker arm with an inside micrometer (see illustration) or a dial caliper and compare your measurements to the specified inside diameter for rocker arms.

19 Inspect the lifter pads and the pads at the valve end of the rocker arms for indications of scuffing or abnormal wear and check to make sure the oil passage is clear (see illustration). Any rocker arm with grooved pads must be replaced. Do not attempt to true the pad surface by grinding.

20 All damaged or excessively worn parts must be replaced with new components.

21 Clean all the parts thoroughly. Make sure that all oil passages are open.

Valves

22 Carefully inspect each valve face for cracks, pits and burn spots. Check the valve stem and neck for cracks. Roll the valve stem between the palms of your hands and watch the valve head. If it wobbles, the valve may be bent. Check the end of the stem for pits and excessive wear. The presence of any of these conditions indicates the need for valve service by a shop.

23 Measure the width of the valve margin (see illustration) on each valve and compare it to Specifications. Any valve with a margin narrower than specified must be replaced with a new one.

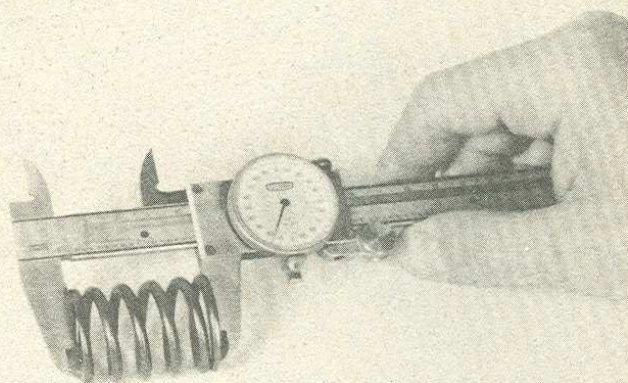
Valve train components

24 Check each valve spring for pitting and wear on the ends. Measure the length of each spring and compare it to the specified free height (see illustration). A spring that is shorter than specified has sagged and must not be used.

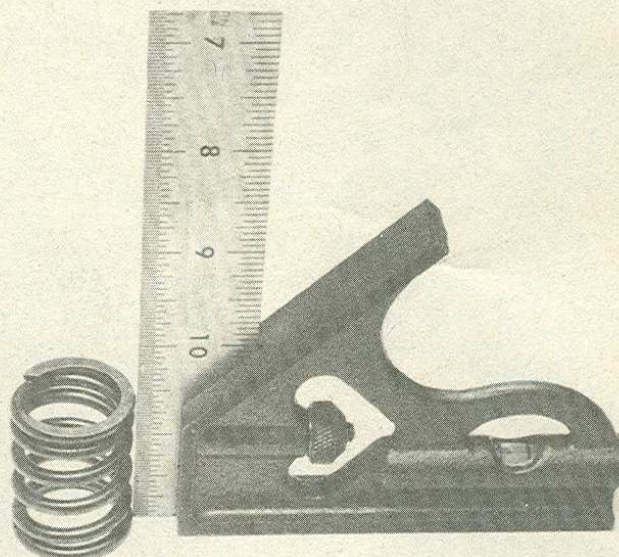
25 Stand each spring upright on a flat surface and check it for squareness (see illustration).

26 Check the spring retainers and keepers for obvious wear and cracks. Extensive damage can occur in the event of failure during engine operation, so any parts in marginal condition must be replaced.

27 If the inspection process indicates that the valve components are



6.24 Measure the free length of each valve spring



6.25 Check each valve spring for squareness and replace any which have sagged off center

in generally poor condition and worn beyond the limits specified, often the case in an older engine being overhauled, refer to the next Section, *Valves — servicing*, before installing the valve train in the cylinder head.

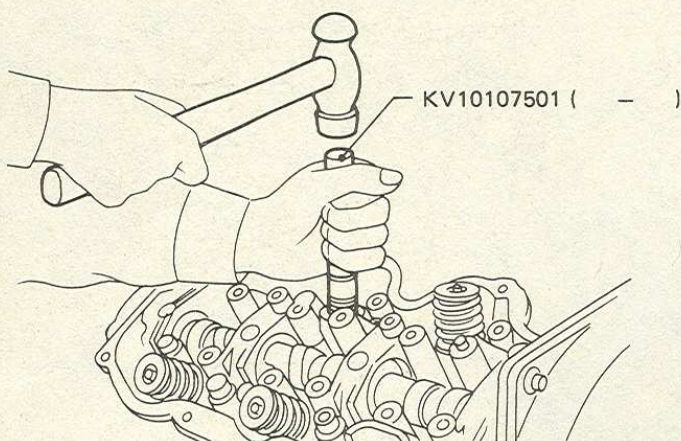
28 If the inspection turns up no excessively worn parts, and if the valve faces and seats are in good condition, the valve train components can be reinstalled in the cylinder head without major servicing. Refer to Section 8 for cylinder head reassembly procedures.

7 Valves — servicing

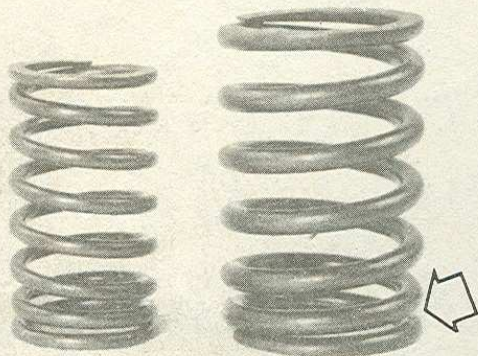
1 Because of the complex nature of the job and the special tools and equipment needed, servicing of the valves, the valve seats and the valve guides — commonly known as a valve job — is best left to an automotive machine shop.

2 The home mechanic can remove and disassemble the head, do the initial cleaning and inspection, then reassemble and deliver the head to a dealer service department or an automotive machine shop for the actual valve servicing.

3 The dealer service department or automotive machine shop, will remove the valves and springs, recondition or replace the valves and valve seats, recondition the valve guides, check and replace the valve springs, spring retainers and keepers (as necessary), replace the valve guide seals, reassemble the valve components and make sure the in-



8.3 Installing intake oil seals with a seal installation tool



8.5 Make sure the outer valve spring has its narrow pitch side (arrow) toward the cylinder head

stalled spring height is correct. The cylinder head gasket surface will also be resurfaced if it is warped.

4 After the valve job has been performed by a shop the head will be in like-new condition. When the head is returned, be sure to clean it again before installation to remove any metal particles and abrasive grit that may still be present from the valve service or head resurfacing operations. Use compressed air, if available, to blow out all the oil holes and passages.

8 Cylinder head — assembly

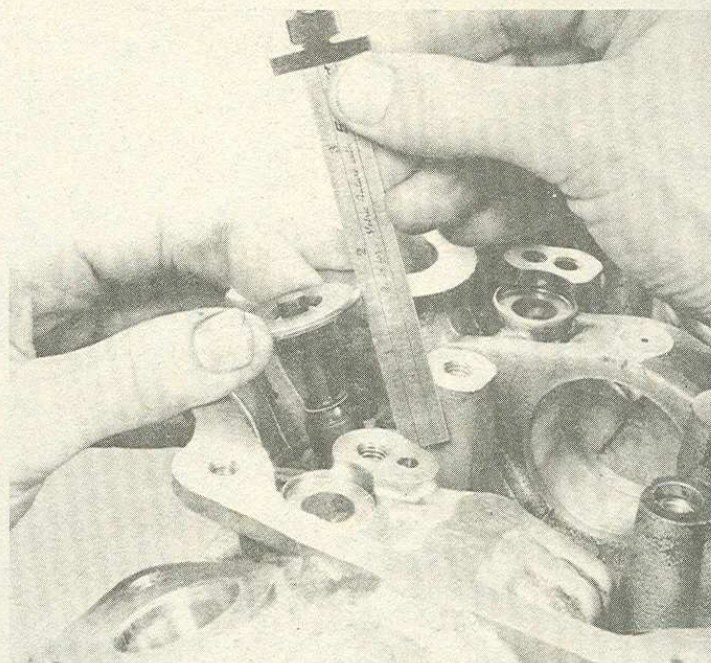
Refer to illustrations 8.3, 8.4, 8.5, 8.7, 8.10a, 8.10b and 8.10c

1 Regardless of whether or not the head was sent to an automotive repair shop for valve servicing, make sure it is clean before beginning reassembly.

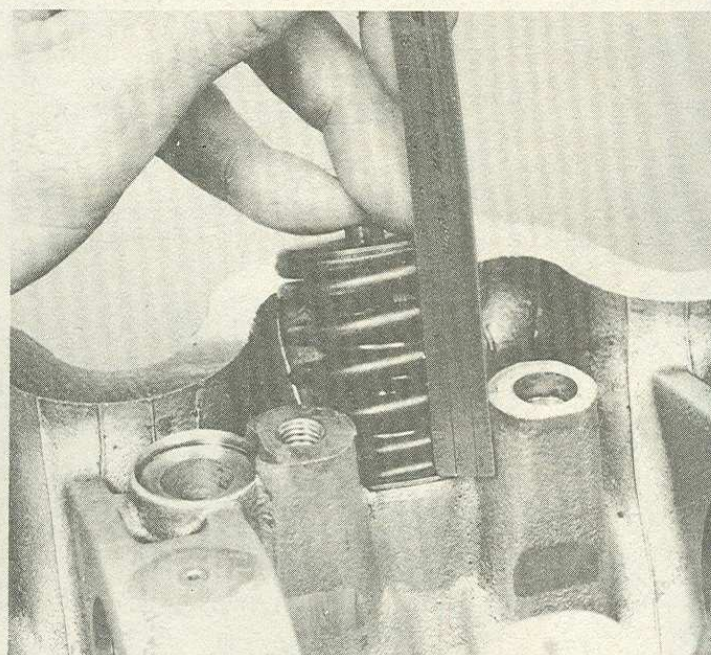
2 If the head was sent out for valve servicing, the valves and related components will already be in place. Begin the reassembly procedure with Step 7.

3 Install new seals on each of the valve guides. To install the intake oil seals, you will need a seal installation tool (Nissan part number KV10107501) or an appropriate size deep socket. Gently tap each seal into place until it is properly seated onto the guide (see illustration). **Caution:** Do not hammer on the guide seal once it is seated or you may damage the seal. Do not twist or cock the seals during installation or they will not seal properly on the valve stems.

4 Install the valves, taking care not to damage the new valve guide oil seals. Slip the valve spring shim(s) around the valve guide boss and set the keepers and retainer in place. Measure the installed spring height by lifting up on the retainer until the valve is seated. Measure the distance between the upperside of the shim(s) and the underside of the retainer (see illustration). Compare your measurement to the



8.4 Measuring the valve spring installed height without the spring installed



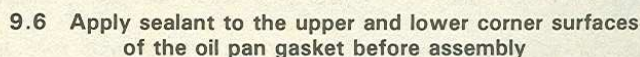
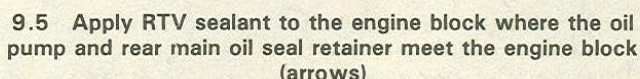
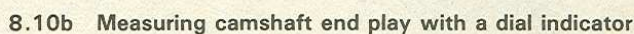
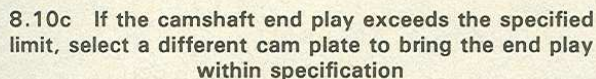
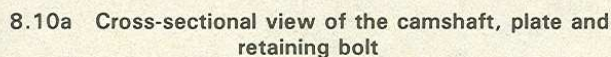
8.7 Measuring the valve spring installed height with the spring installed

specified installed height. Add shims to bring the height within specifications.

5 Once the correct height is established, remove the keepers and retainer and install the valve springs. **Note:** The outer spring has a graduated pitch. Install it with the narrow pitch end toward the cylinder head (see illustration).

6 Compress the springs and retainer with a valve compressor and slip the keepers into place. Release the compressor, making sure the keepers are seated properly in the valve stem upper groove. If necessary, grease can be used to hold the keepers in place as the compressor is released.

7 Double-check the installed valve spring height of each valve. Measure the installed spring height with a small ruler and compare it to the specified installed height (see illustration). If it was correct prior to reassembly, it should still be within the specified limits. If it is not, you must install an additional valve spring seat shim(s) to bring the height within the specified limits.

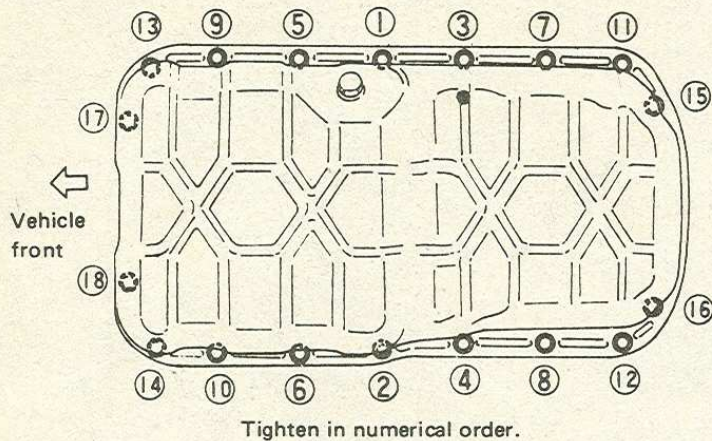


6 Apply sealant to the upper and lower surfaces of the oil pan gasket itself at the same four corners (see illustration). **Note:** On 1988 and later models, no oil pan gasket is used. A continuous bead of sealant 5/32-inch wide should be applied to the oil pan flange to form a seal (apply it to the inside of the bolt holes).

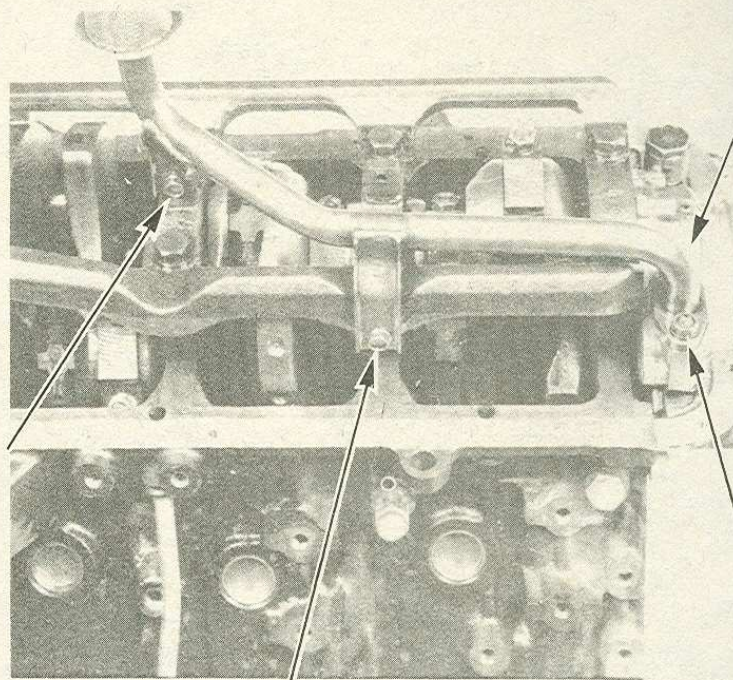
9 Oil pan – removal and installation

Refer to illustrations 9.5, 9.6 and 9.7

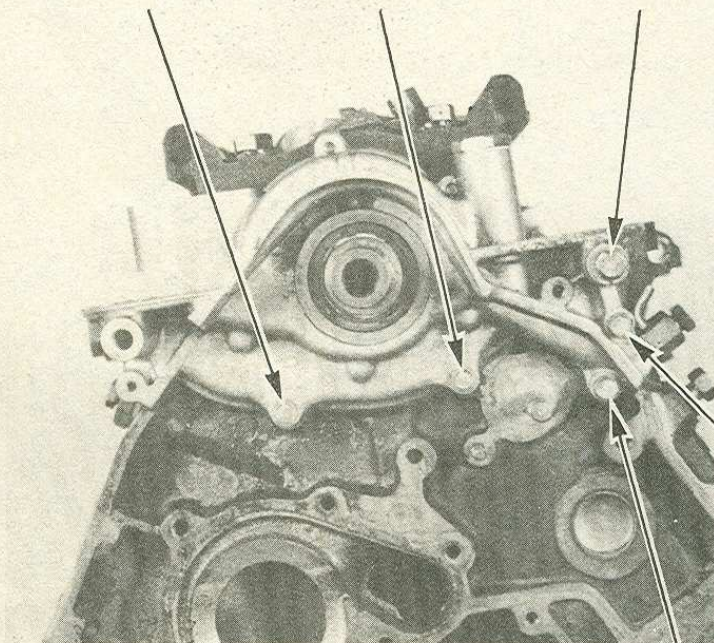
- 1 With the engine mounted on an engine stand, drain the oil.
- 2 Rotate the engine on the stand until the oil pan is facing upward. Remove all the oil pan retaining bolts.
- 3 It may be necessary to pry the pan from the block with a screwdriver. **Caution:** Do not damage the gasket mounting surface or bend the oil pan.



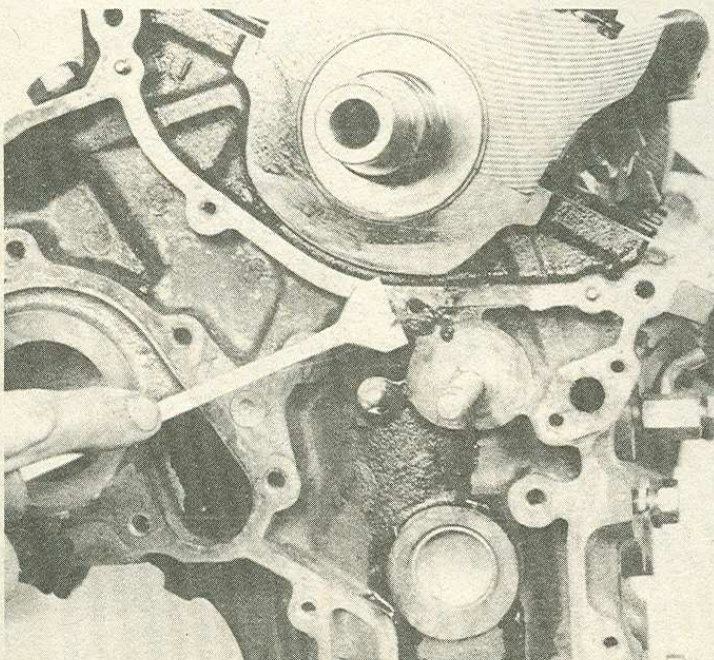
9.7 Tightening sequence for the oil pan bolts



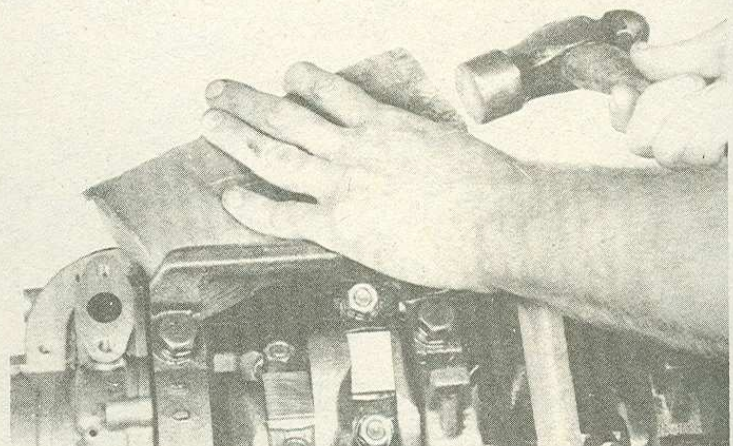
10.2 Remove the four pickup tube retaining bolts (arrows) to remove the oil pump pickup tube



10.3 Remove the oil pump to engine retaining bolts (arrows) to remove the pump from the engine



10.6 Clean all the old gasket material from the mating surfaces



10.4 Use a block of wood and a hammer to gently break the oil pump gasket seal

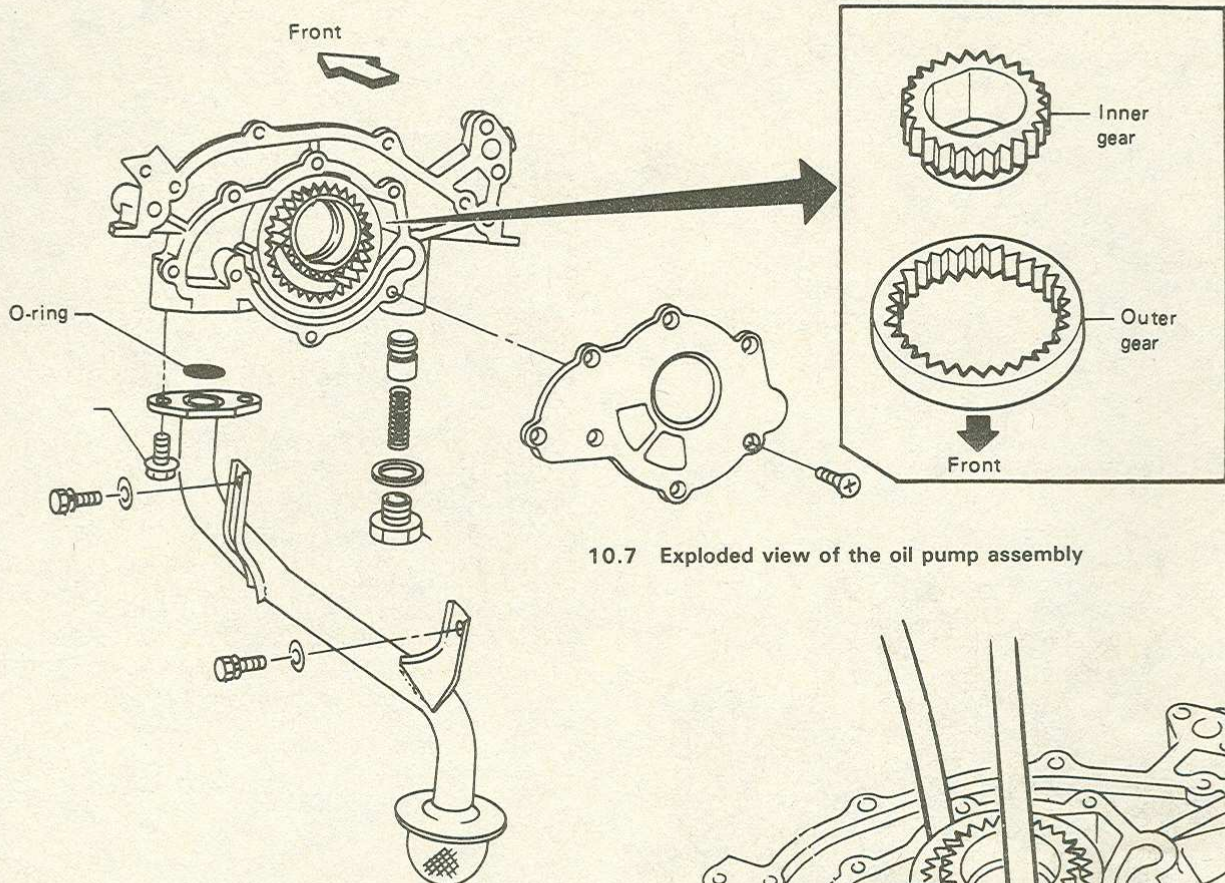
7 Installation of the oil pan is the reverse of the removal procedure. Tighten oil pan flange bolts to the specified torque in numerical order (see illustration).

10 Oil pump — removal, inspection and installation

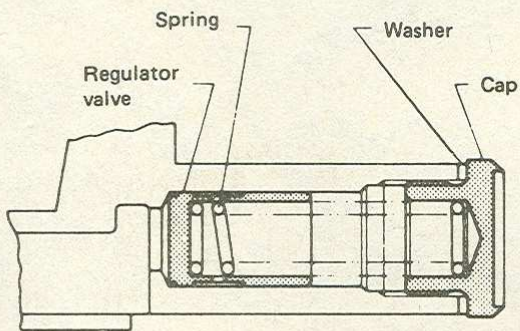
Refer to illustrations 10.2, 10.3, 10.4, 10.6, 10.7, 10.9, 10.10a, 10.10b and 10.13

Removal

- 1 Remove the oil pan (Section 9).
- 2 Remove the four oil pump pickup tube retaining bolts (see illustration) and remove the oil pump pick up tube.
- 3 From the front of the engine remove the oil pump-to-engine block retaining bolts (see illustration).
- 4 Use a block of wood and small hammer to break the oil pump gasket seal (see illustration).
- 5 Pull forward on the oil pump and remove it from the engine block.
- 6 Use a small scraper to clean old gasket material and sealant from the oil pump and engine block mating surfaces (see illustration).



10.7 Exploded view of the oil pump assembly



10.9 Check the oil pressure regulator valve sliding surface and the valve spring for damage and replace if necessary

Inspection

7 Use a large Phillips screwdriver to remove the seven retaining screws holding the front and rear halves of the oil pump together (see illustration).

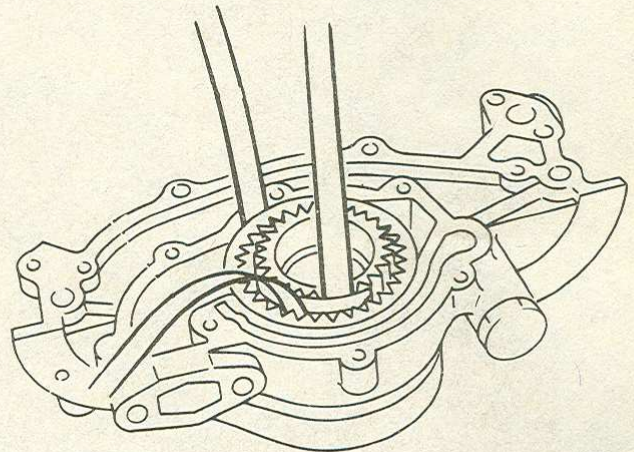
8 Thoroughly clean all components in solvent, then inspect them for wear and damage.

9 Remove the oil pressure regulator cap bolt, washer, spring and valve. Check the oil pressure regulator valve sliding surface and valve spring (see illustration). If either the spring or the valve is damaged, they must be replaced as a set.

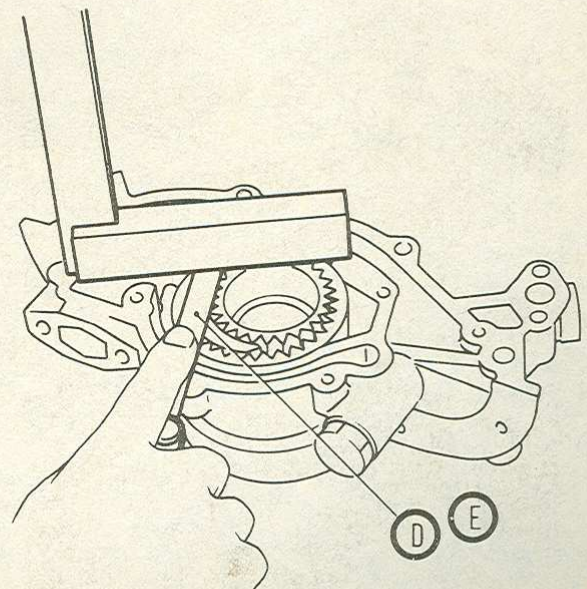
10 Check the following clearances with a feeler gauge (see illustrations) and compare your measurements to the specified clearances:

- Body to outer gear
- Inner gear to crescent
- Outer gear to crescent
- Housing to inner gear
- Housing to outer gear

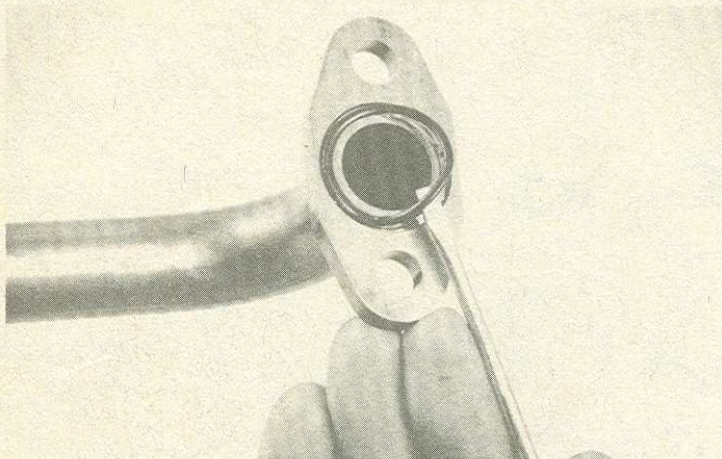
If any of these clearances are excessive, replace the entire gear set or the entire oil pump assembly.



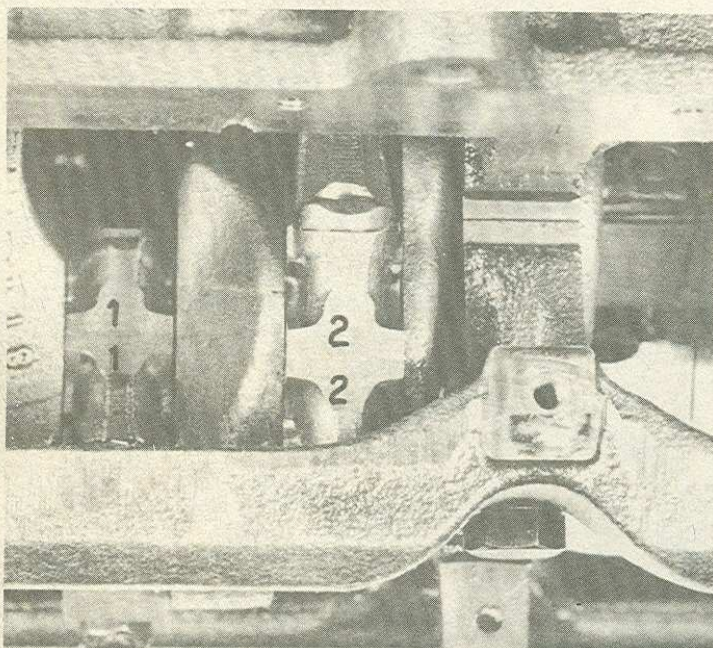
10.10a Use a feeler gauge to check the body-to-outer gear clearance, the clearance between the inner gear and crescent and the clearance between the outer gear and crescent



10.10b Check the housing-to-inner gear clearance and the housing-to-outer gear clearance



10.13 Before installing the oil pickup tube, replace the rubber O-ring



11.3 Check to make sure the rods and caps are identified before removal

11 Assemble the oil pump and tighten the retaining screws to the specified torque. Install the oil pressure regulator valve, spring and washer, then tighten the oil pressure regulator valve cap to the specified torque. **Note:** Pack the pump with petroleum jelly to prime it for startup.

Installation

12 Apply gasket sealant to the oil pump gasket mounting surface.
13 Use new gaskets on all disassembled parts and reverse the removal procedures for installation. Tighten all fasteners to the specified torque. **Note:** Before installing the oil pump pick up tube replace the rubber O-ring (see illustration).

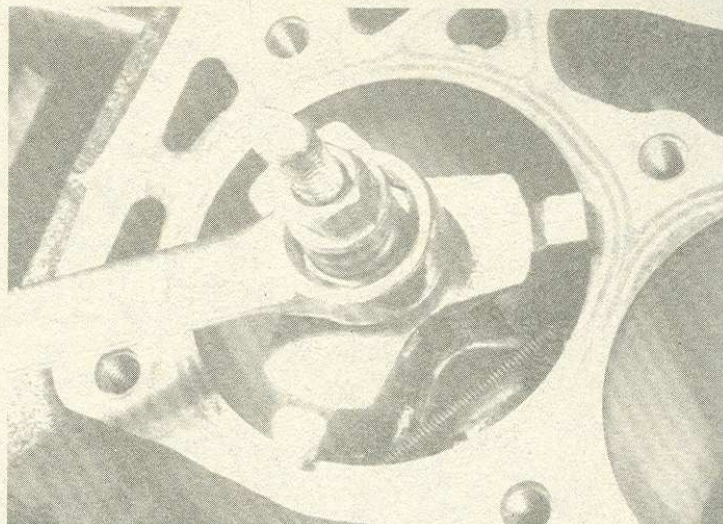
11 Piston/connecting rod assembly — removal

Refer to illustrations 11.1, 11.3, 11.6 and 11.7

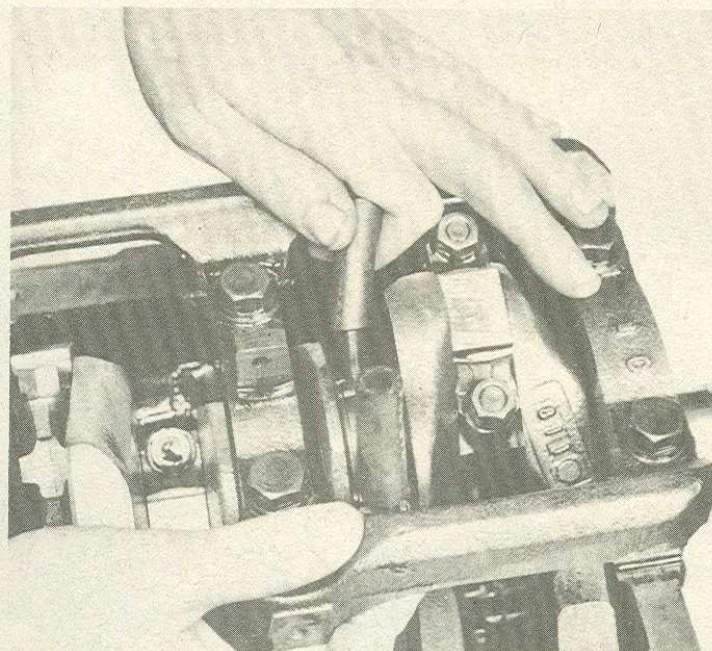
1 Using a ridge reamer, completely remove the ridge at the top of each cylinder (see illustration). Follow the manufacturer's instructions provided with the ridge reaming tool. **Caution:** Failure to remove the ridge before attempting to remove the piston/connecting rod assemblies can result in broken piston rings.

2 After all of the cylinder wear ridges have been removed, rotate the engine until the crankshaft is facing upward.

3 Check the connecting rods and connecting rod caps for identifica-



11.1 A ridge reamer must be used to remove the wear ridge at the top of each cylinder before the pistons can be removed



11.6 To prevent damage to the crankshaft journals and the cylinder walls, slip sections of hose over the rod bolts before removing the pistons

tion marks (see illustration).

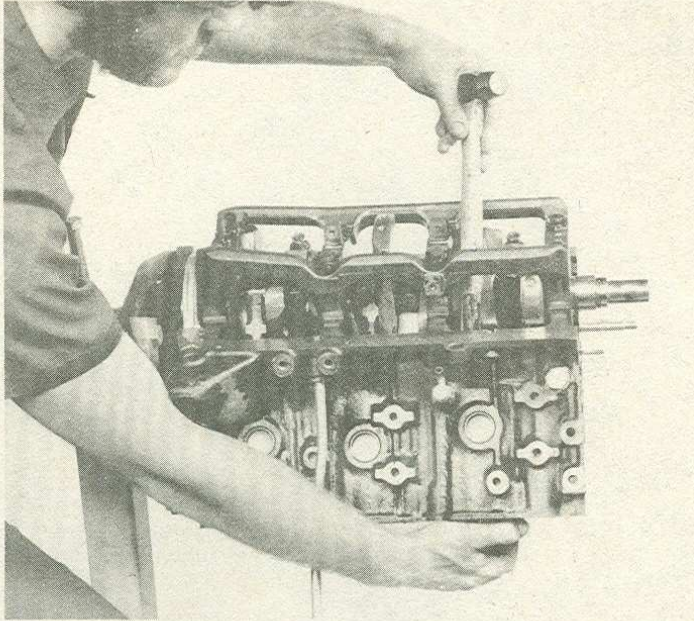
4 If they are not plainly marked, identify each rod and cap, using a small punch to make the appropriate number of indentations to indicate the cylinders with which they are associated.

5 Loosen each of the connecting rod cap nuts approximately 1/2 turn, then remove all of them. Lift off the rod caps and bearing inserts. **Note:** Do not drop the bearing inserts out of the caps. The bearing inserts must remain paired with their respective rod caps for diagnostic purposes.

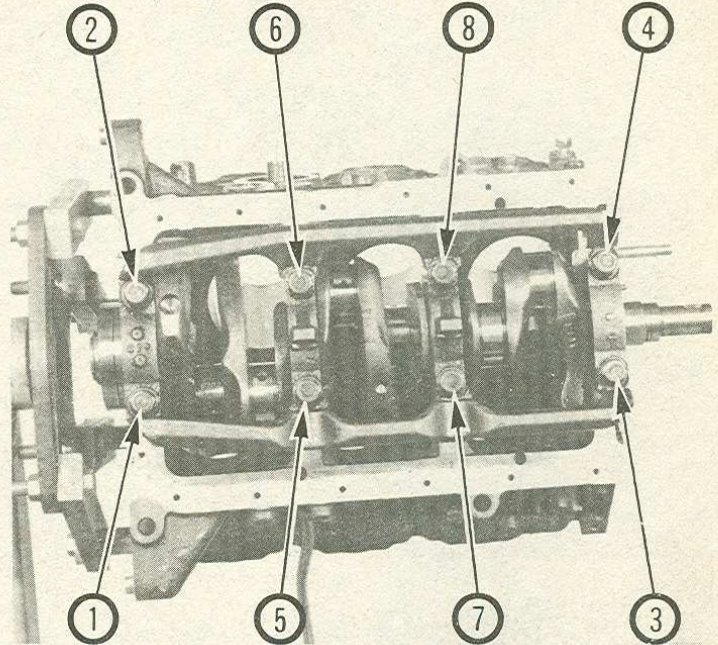
6 Slip a short length of plastic or rubber hose over each connecting rod cap bolt to protect the crankshaft journal and cylinder wall during piston/rod removal (see illustration).

7 Push the connecting rod/piston assembly out through the top of the engine. Use a wooden tool to push on the upper bearing insert in the connecting rod (see illustration). If you feel resistance, double-check to make sure that all of the ridge has been removed from the cylinder.

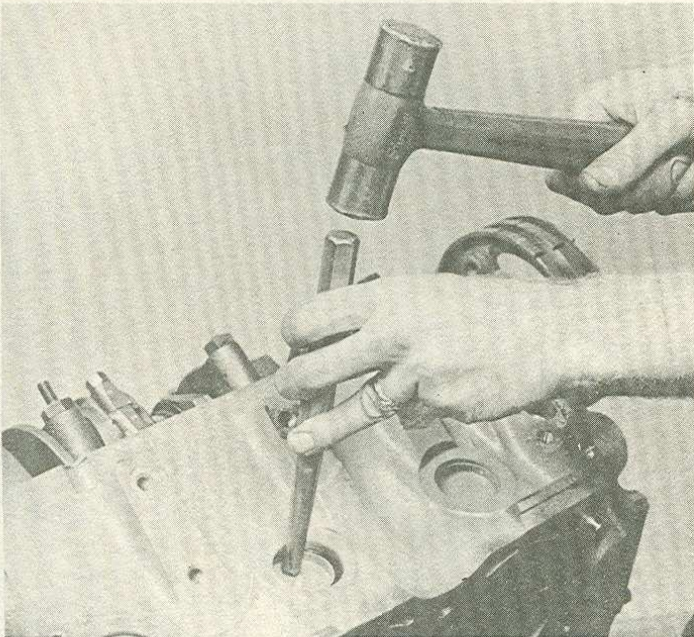
8 Repeat this procedure for the remaining cylinders. After removal, reassemble the connecting rod caps and bearing inserts to their respective connecting rods and install the cap nuts finger tight. Leave the old bearing inserts in place until reassembly to prevent the connecting rod bearing surfaces from accidental nicks or gouges.



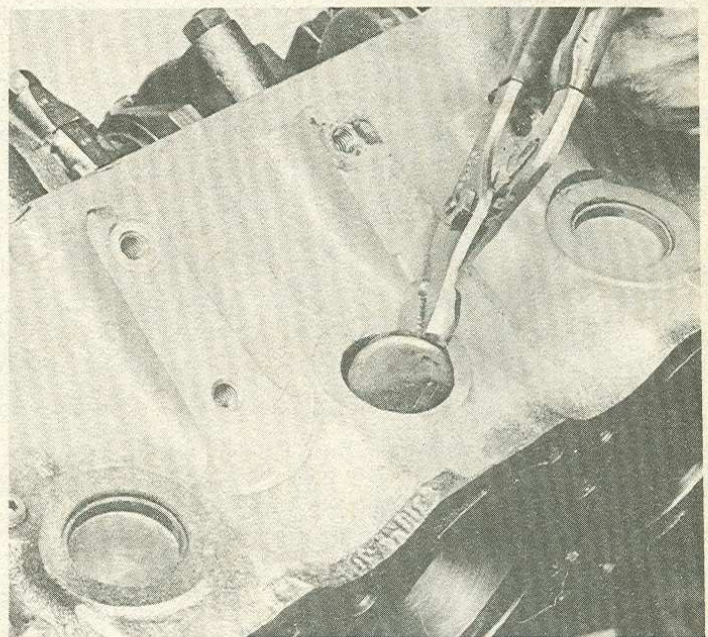
11.7 The wooden handle of a hammer can be used to tap the piston from the cylinder block — be ready to catch the piston as it falls from the block



12.6 Loosen the main bearing cap assembly retaining bolts in the sequence shown



13.1a Use a large punch to drive the freeze plugs into the block



13.1b Grab the plugs with pliers and pull them out of the block at an angle

12 Crankshaft — removal

Refer to illustration 12.6

- 1 Remove the oil pan (Section 9).
- 2 Remove the pick up tube and oil pump (Section 10).
- 3 Remove the connecting rods and pistons (Section 11).
- 4 Remove the four oil seal retainer bolts.
- 5 Remove the oil seal retainer by pulling the retainer from the retaining pins.
- 6 Loosen each of the main bearing cap assembly retaining bolts 1/4-turn at a time, in the correct numerical order (see illustration) until the bolts can be removed by hand. Check the main bearing cap assembly to see that it is marked with an arrow pointing to the front of the engine. If it is not, mark the main bearing cap assembly with stamping dies or a center punch to insure that it is bolted back on facing the proper direction.

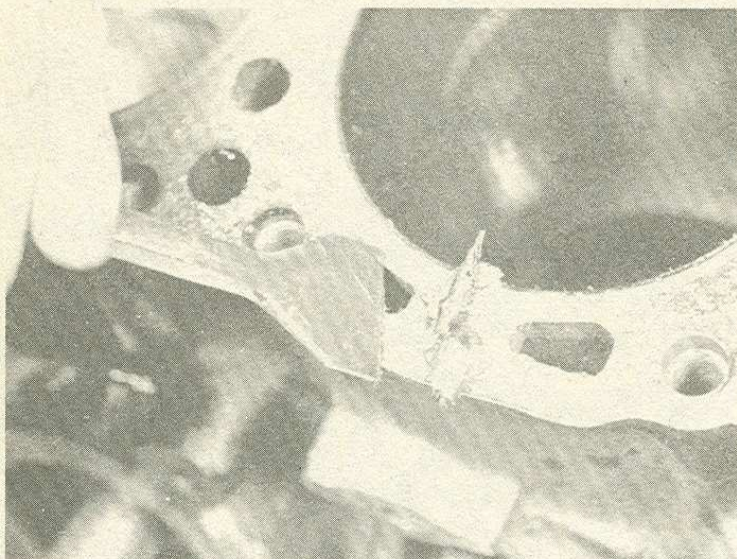
- 7 Gently tap the cap assembly with a soft face hammer, then separate it from the engine block. If necessary, use the main bearing cap bolts as levers to remove the caps. Do not drop the bearing inserts when lifting off the caps.

- 8 Carefully lift the crankshaft out of the engine. It is a good idea to have an assistant available, since the crankshaft is quite heavy. With the bearing inserts in place in the engine block and in the main bearing cap assembly, return the cap assembly to the engine block and tighten the bolts finger tight.

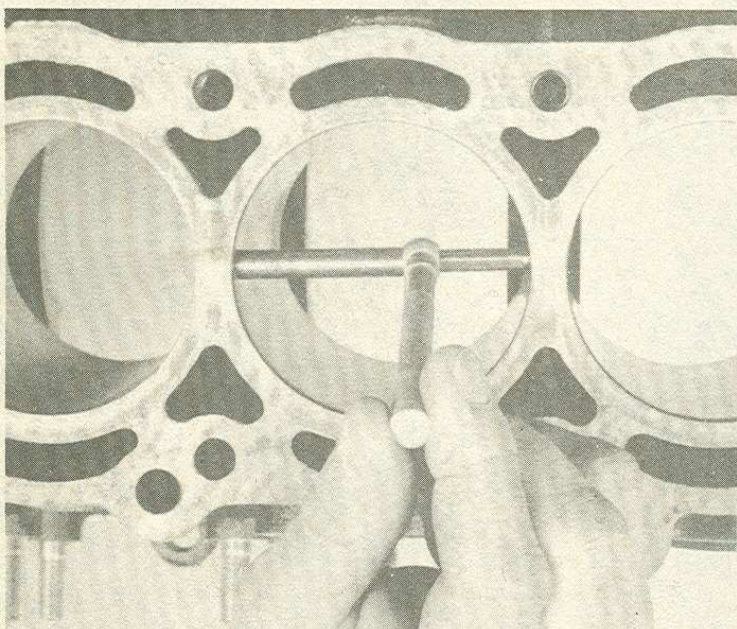
13 Engine block — cleaning

Refer to illustrations 13.1a, 13.1b, 13.2 and 13.9

- 1 Knock the freeze plugs into the block with a hammer and punch (see illustration), then grasp them with large pliers and pull them back through the holes (see illustration).



13.2 Use a gasket scraper to remove all traces of gasket material from the engine block



14.4a A telescoping bore gauge is used to measure cylinder bore diameter

2 Using a gasket scraper, remove all traces of gasket material from the engine block (see illustration). Be very careful not to nick or gouge the gasket sealing surfaces.

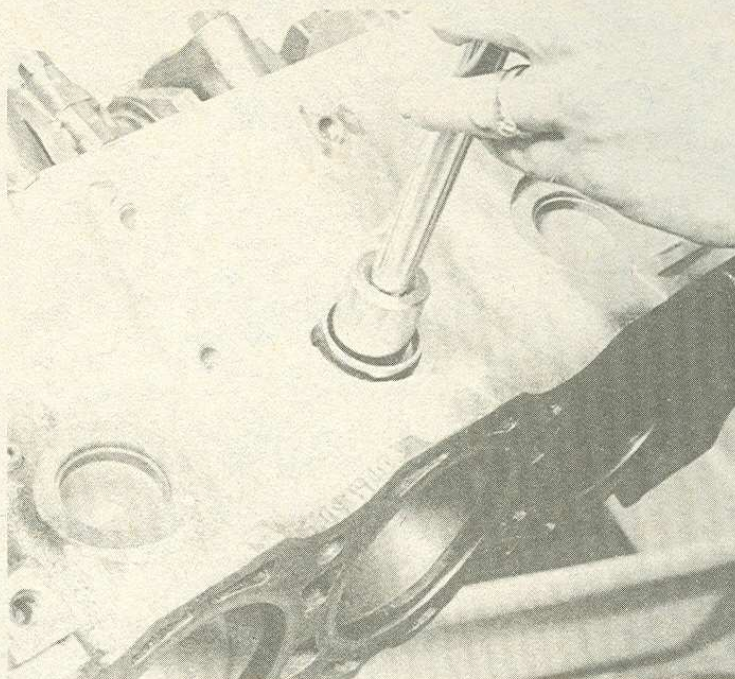
3 Remove the main bearing cap assembly and separate the bearing inserts from the caps and the engine block. Tag the bearings to indicate the main bearing cap from which they were removed and to show whether they were in the cap or the block. Set them aside.

4 If the engine is extremely dirty, take it to an automotive machine shop to be steam cleaned or hot tanked.

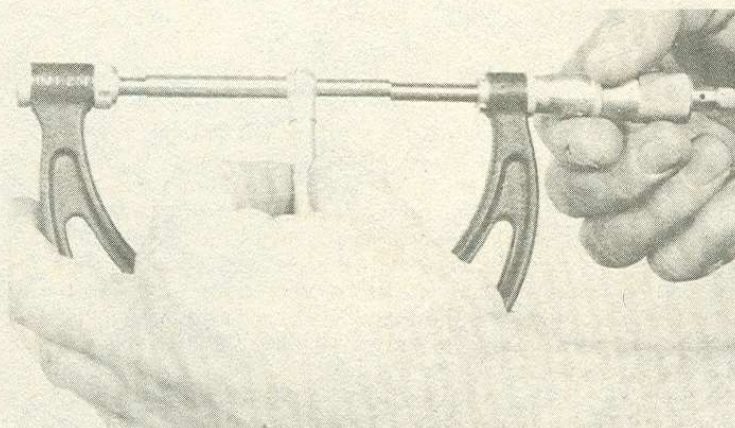
5 After the block is returned, clean all oil holes and oil galleries. Brushes for cleaning oil holes and galleries are available at most auto parts stores. Flush the passages with warm water until the water runs clear, dry the block thoroughly and wipe all machined surfaces with a light, rust-preventative oil. If you have access to compressed air, use it to speed the drying process and to blow out all the oil holes and galleries.

6 If the block is not extremely dirty or sludged up, you can do an adequate cleaning job with warm soapy water and a stiff brush. Take plenty of time and do a thorough job. Regardless of the cleaning method used, be very sure to thoroughly clean all oil holes and galleries, dry the block completely and coat all machined surfaces with light oil.

7 The threaded holes in the block must be clean to ensure accurate torque readings during reassembly. Run the proper size tap into each of the holes to remove any rust, corrosion, thread sealant or sludge



13.9 Coat the new soft plug with silicone sealant, then use a large socket to drive it into the block, being careful to keep it straight



14.4b After extending the telescoping gauge until it touches the cylinder bore, remove and measure it with a micrometer

and to restore any damaged threads. If possible, use compressed air to clear the holes of debris produced by this operation. Thoroughly clean the threads on the head bolts and the main bearing cap assembly bolts as well.

8 Reinstall the main bearing cap assembly and snug the bolts finger tight.

9 After coating the sealing surfaces of the new freeze plugs with a good quality gasket sealer, install them in the engine block. Make sure they are driven in straight and seated properly or leakage could result. Special tools are available for this purpose, but equally good results can be obtained with a large socket of an outside diameter slightly smaller than that of the freeze plug (see illustration). Gently tap the plugs into place with a hammer.

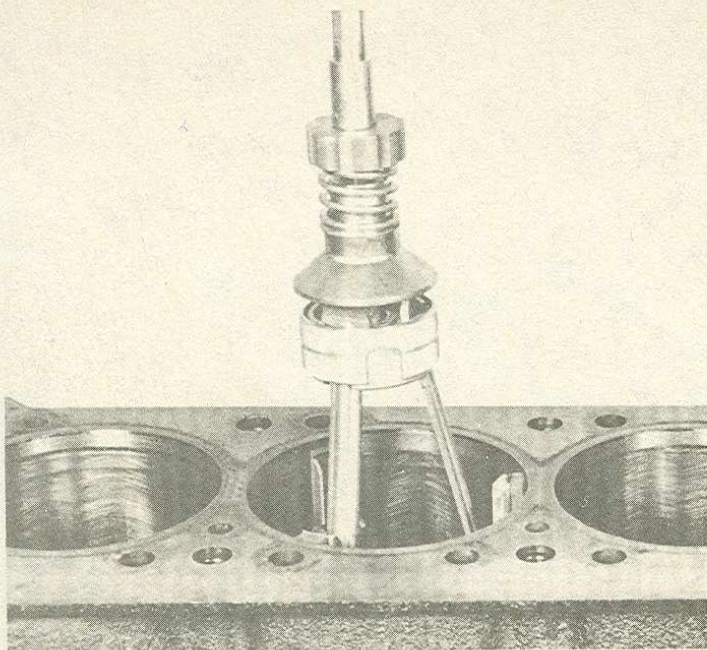
10 If the engine is not going to be reassembled right away, cover it with a large plastic trash bag to keep it clean.

14 Engine block — inspection

Refer to illustrations 14.4a, 14.4b and 14.7

1 Thoroughly clean the engine block as described in the previous Section.

2 Check the block for cracks, rust and corrosion. Look for stripped threads in bolt holes. It is also a good idea to have the block checked for hidden cracks by an automotive machine shop with the special



14.7 Cylinders should always be honed before installing new rings to give the bore surface the proper finish for proper ring seating

equipment for this type of work. If cracks are found, the block must be repaired or replaced.

3 Check the cylinder bores for scuffing and scoring.

4 Using a cylinder bore gauge, measure the diameter at the top (just under the ridge), center and bottom of each cylinder bore, parallel to the crankshaft axis (see illustrations). Next, measure each cylinder's diameter at the same three locations at a 90 degree angle to the crank axis. Compare your results to the specified cylinder bore diameter. If the cylinder walls are badly scuffed or scored, or if they are out-of-round or tapered beyond the specified limits, have the engine block rebored and honed at an automotive machine shop. If a rebore is done, oversize pistons and rings will be required.

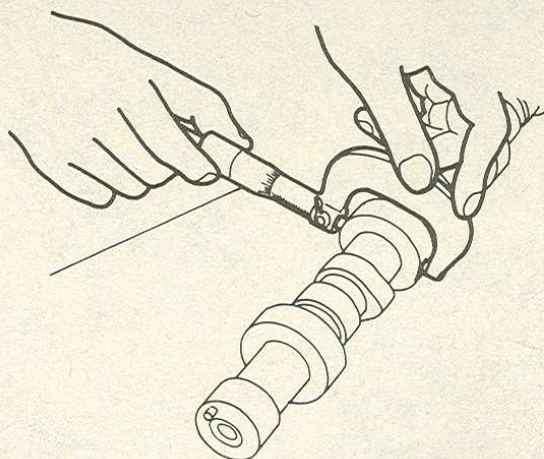
5 If the cylinders are not worn to the limit and if the piston-to-cylinder clearances fall within specification (Section 16), then the cylinders need not be rebored. But they must still be honed.

6 Before honing the cylinders, install the main bearing cap assembly (without the bearings) and tighten the main bearing cap retaining bolts to the specified torque.

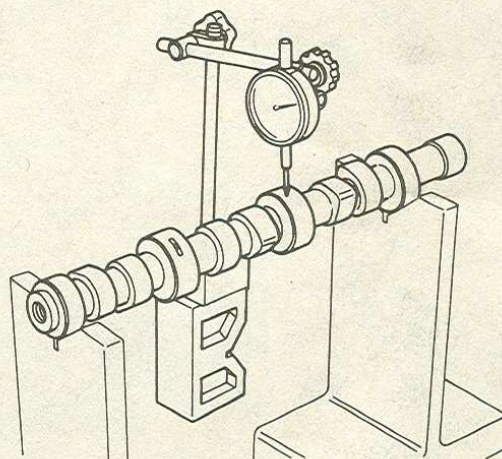
7 To perform the honing operation you will need the proper size flexible hone with fine stones, plenty of light oil or honing oil, some clean shop rags and an electric drill motor. Mount the hone in the drill chuck, compress the stones and slip the hone into the cylinder (see illustration). Lubricate the cylinder thoroughly, turn on the drill and move the hone up and down in the cylinder at a pace which will produce a fine cross-hatch pattern on the cylinder walls (with the cross-hatch lines intersecting at approximately a 60° angle). Be sure to use plenty of lubricant. Do not withdraw the hone from the cylinder while it is running. Instead, shut off the drill and continue moving the hone up and down in the cylinder until it comes to a complete stop, then compress the stones and withdraw the hone. Wipe the oil out of the cylinder and repeat the procedure on the remaining cylinders. If you do not have the tools or do not desire to perform the honing operation, most automotive machine shops will do it for a reasonable fee.

8 After the honing job is complete, chamfer the top edges of the cylinder bores with a small file so the rings won't catch when the pistons are installed.

9 The entire engine block must be thoroughly washed again with warm, soapy water to remove all traces of the abrasive grit produced during the honing operation. Be sure to run a brush through all oil holes and galleries and flush them with running water. After rinsing, dry the block and apply a coat of light rust preventative oil to all machined surfaces. Wrap the block in a plastic trash bag to keep it clean and set it aside until reassembly.



15.2 Measure the outside diameter of each camshaft journal



15.3 Measuring cam journal runout

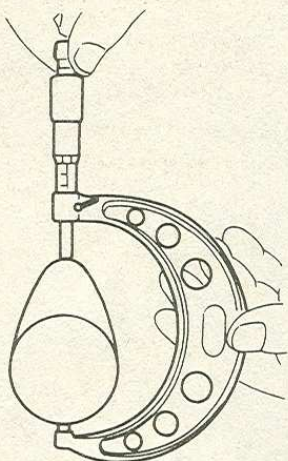
15 Camshaft, lifters and bearing surfaces — inspection

Refer to illustrations 15.2, 15.3, 15.4, 15.5, 15.6, 15.7, 15.10 and 15.11

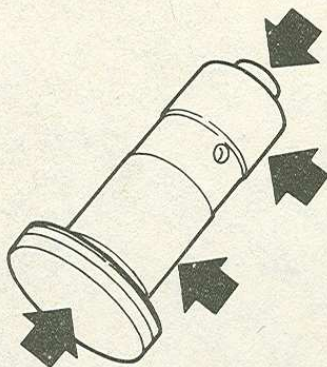
1 Visually check the camshaft bearing surfaces for pitting, scoring or any abnormal wear. If the bearing surfaces are damaged the head will have to be replaced (Section 6).

2 Measure the outside diameter of each camshaft bearing journal and record your measurements (see illustration). Compare your readings to the specified journal outside diameter, then measure the inside diameter of each corresponding camshaft bearing tunnel with a vernier caliper and record those measurements. Compare your readings to the specified camshaft bearing inside diameter. Subtract each cam journal outside diameter from its respective cam bearing tunnel inside diameter to compute the oil clearance for each bearing. Compare your results to the specified journal to bearing clearance. If any of these measurements fail to fall within the standard specified wear limits, either the camshaft or the head, or both, must be replaced.

3 Check camshaft runout by placing the camshaft between two V-blocks and set up a dial indicator on the center journal (see illustration). Zero the dial indicator. Turn the camshaft slowly and note the dial indicator readings. Record your readings and compare them with the specified runout. If the measured runout exceeds the specified runout, replace the camshaft.

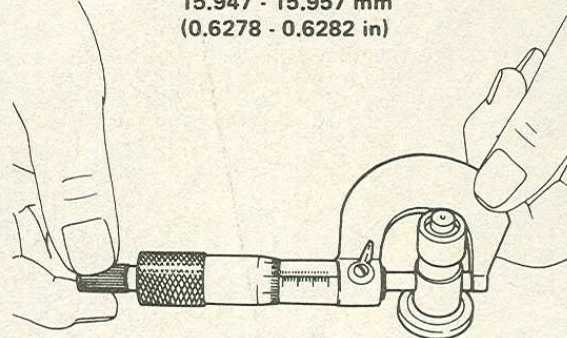


15.4 Measuring cam lobe height

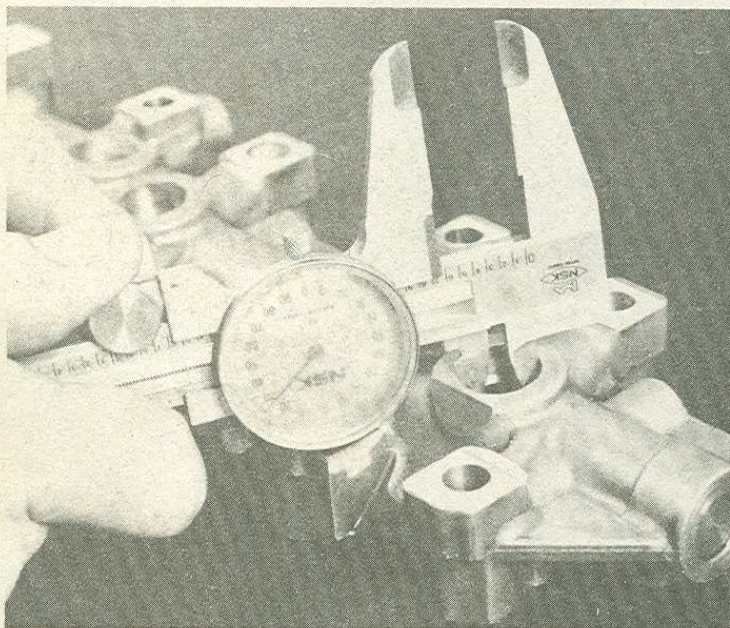


15.5 Check the contact and sliding surfaces of each lifter (arrows) for wear or scratches

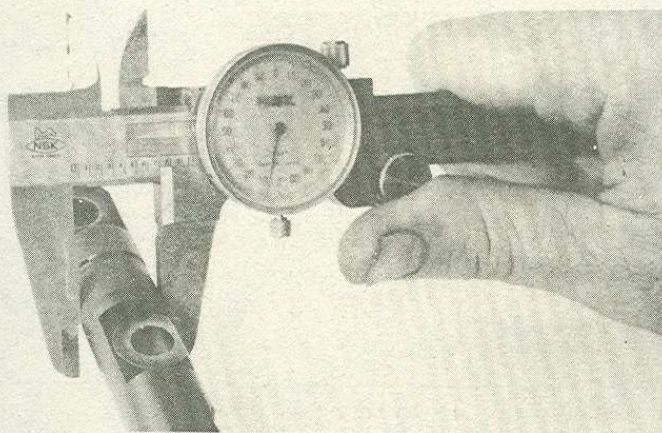
Outside diameter:
15.947 - 15.957 mm
(0.6278 - 0.6282 in)



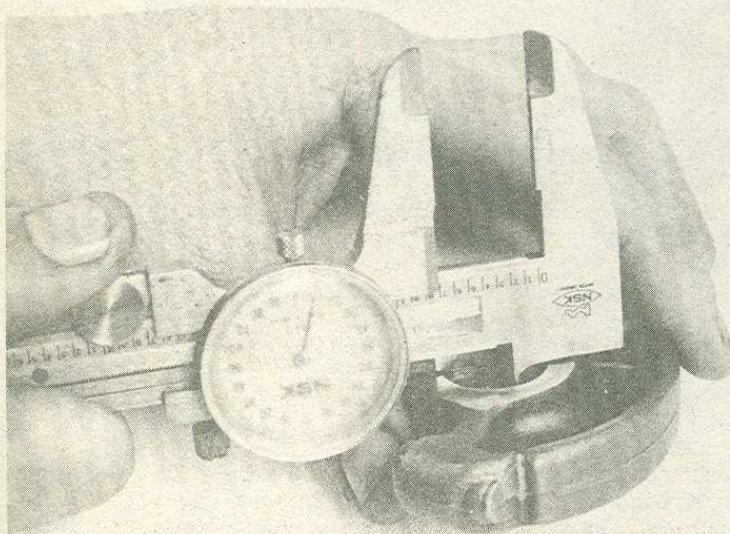
15.6 Measure the outside diameter of each lifter with a micrometer



15.7 Measure the inside diameter of each lifter bore, subtract the valve lifter diameter to find the lifter-to-bore clearance and compare your measurements with the specified clearance



15.10 Measure the rocker arm shaft diameter at each journal where a rocker arm rides on the shaft



15.11 Measure the inside diameter of each rocker arm, subtract the corresponding rocker arm shaft diameter to get the oil clearance and compare your results to the specified clearance

4 Check the camshaft cam lobe height for wear by measuring it with a micrometer (see illustration). Compare your measurement to the specified cam lobe height. Then subtract your measured cam lobe height from the specified height to compute wear on the cam nose. Compare this figure to the specified wear limit. If it's greater than the specified wear limit, replace the camshaft. Repeat this procedure for each cam lobe.

5 Inspect the contact and sliding surfaces of each lifter for wear or scratches (see illustration). **Note:** If the lifter pad is worn, it's a good idea to check the corresponding camshaft lobe, because it will probably be worn too. **Caution:** Do not turn the lifters upside down — air can enter and become trapped inside (see Chapter 2A, Section 7).

6 Measure the outside diameter of each lifter with a micrometer (see illustration) and compare your readings to the specified outside diameter. If any lifter is worn beyond the specified outside diameter, replace it. **Note:** Lifters can be purchased individually. It's not absolutely necessary to replace one or two damaged lifters with an entire set.

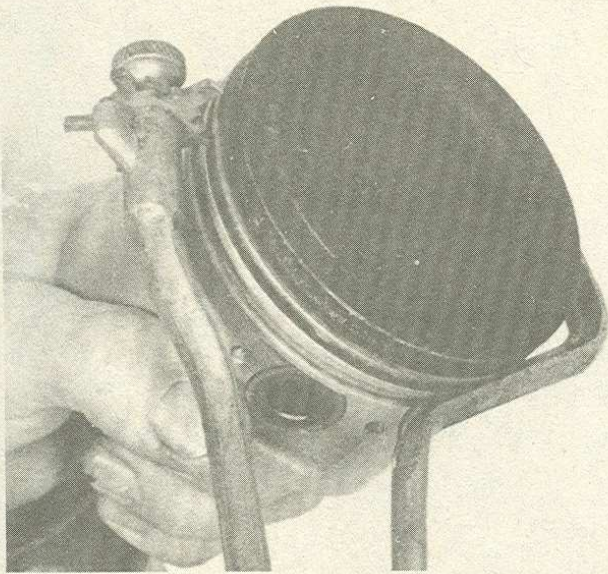
7 Check each lifter bore diameter in the lifter guide assembly (see illustration) and compare your reading to the specified tolerance. If any lifter bore is worn beyond the specified tolerance, the lifter guide assembly must be replaced.

8 Subtract the outside diameter of each lifter from the inside diameter of its lifter bore and compare the difference to the specified clearance. If both the lifter and the bore are within acceptable limits, this measurement should fall within tolerance as well. However, should you buy a new set of lifters alone, or a lifter guide assembly by itself, you may find that this clearance no longer falls within the specified tolerance.

9 Inspect the rocker arms and rocker shafts for abnormal wear and scratches.

10 Measure the outside diameter of the rocker arm shaft at each rocker arm journal with a micrometer (see illustration). Compare your measurements to the specified rocker arm shaft outside diameter.

11 Measure the inside diameter of each rocker arm with either an inside micrometer or a dial caliper (see illustration). Compare your measurements to the specified rocker arm inside diameter.



16.4a If available, a ring groove cleaning tool can be used to remove carbon from the ring grooves

12 Subtract the outside diameter of each rocker arm shaft journal outside diameter from its corresponding rocker arm inside diameter to compute the clearance between the rocker arm shaft and the rocker arm. Compare these measurements to the specified clearance. If any of them fall outside the specified clearance, replace either the rockers or the rocker shaft, or both.

16 Piston/connecting rod assembly — inspection

Refer to illustrations 16.4a, 16.4b, 16.10 and 16.11

1 Using a piston ring installation tool, carefully remove the rings from the pistons. Do not nick or gouge the pistons in the process.

2 Scrape all traces of carbon from the crown (top) of the piston. A hand-held wire brush or a piece of fine emery cloth can be used once the majority of the deposits have been scraped away.

3 **Caution:** Do not, under any circumstances, use a wire brush mounted in a drill motor to remove deposits from the pistons. The piston material is soft and will be eroded away by the wire brush.

4 Use a piston ring groove cleaning tool to remove any carbon deposits from the ring grooves (see illustration). If a tool is not available, a piece broken off the old ring will do the job (see illustration). **Caution:** Do not remove any metal and do not nick or scratch the sides of the ring grooves.

5 Once all carbon deposits have been removed from the ring grooves, clean the piston/rod assemblies with solvent and dry them thoroughly.

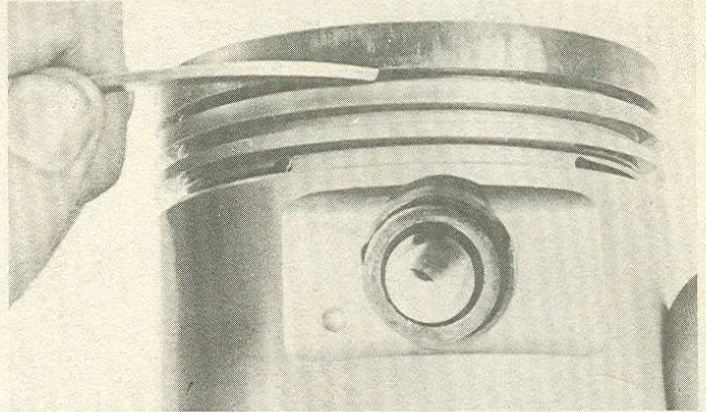
6 If the pistons are not damaged or worn excessively, and if the engine block isn't rebored, new pistons won't be necessary. Normal piston wear appears as even vertical wear lines on the piston thrust surfaces and slight looseness of the top ring in its groove.

7 Carefully inspect each piston for cracks around the skirt, at the pin bosses and at the ring lands.

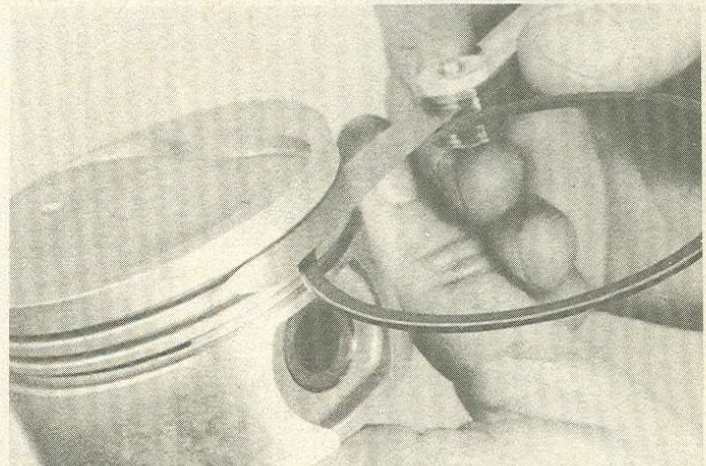
8 Look for scoring and scuffing on the thrust faces of the skirt, holes in the piston crown and burned areas at the edge of the crown. If the skirt is scored or scuffed, the engine may have been suffering from overheating and/or abnormal combustion, either of which may have caused inordinately high operating temperatures. The cooling and lubrication systems should be thoroughly inspected. A hole in the piston crown is an indication that preignition was occurring. Burned areas at the edge of the piston crown are usually evidence of detonation (spark knock). If any of the above problems exist, the causes must be corrected or the damage will occur again.

9 Corrosion of the piston (evidenced by pitting) indicates that coolant is leaking into the combustion chamber and/or the crankcase. Again, the cause must be corrected or the problem may persist in the rebuilt engine.

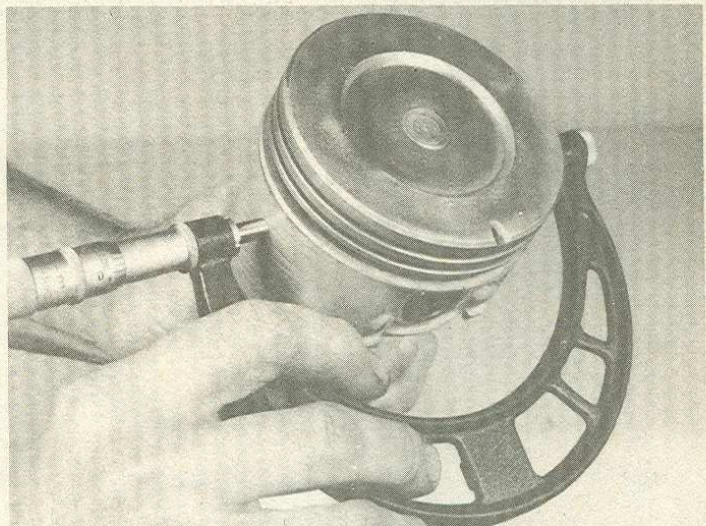
10 Measure the piston ring side clearance by laying a new piston ring in each ring groove and slipping a feeler gauge in between the ring



16.4b Use a piece of broken ring to remove carbon deposits from the ring grooves, but don't chip any piston material with it



16.10 To check ring side clearance, insert the ring in the groove then use a feeler gauge to measure the remaining gap



16.11 Measure the diameter of each piston at 90° to the wrist pin

and the edge of the ring groove (see illustration). Check the clearance at 90 degree increments around each groove. The rings differ in thickness, so be sure to use the correct ring for each groove. Compare your readings to the specified ring side clearance for each ring. If the side clearance is greater than specified, new pistons will have to be used.

11 Check the piston-to-bore clearance by measuring the cylinder bore diameter (Section 6) and the piston diameter. Make sure that the pistons

and bores are correctly matched. Measure the piston across the skirt (see illustration). Subtract the piston diameter from the bore diameter for each cylinder to compute the clearance. Compare your results with the specified piston-to-bore clearance. If it is greater than specified, the block will have to be rebored and new oversize pistons and rings installed.

12 Check the piston-to-rod clearance by twisting the piston and rod in opposite directions. Any noticeable play indicates that there is excessive wear and the piston/connecting rod assemblies may have to be replaced.

13 Check the connecting rods for cracks and other damage. Temporarily remove the rod caps, lift out the old bearing inserts, wipe the rod and cap bearing surfaces clean and inspect them for nicks, gouges or scratches. After checking the rods, replace the old bearings, slip the caps into place and tighten the nuts finger tight.

17 Crankshaft — inspection

Refer to illustration 17.2

1 Clean the crankshaft with solvent and dry it thoroughly. Be sure to clean the oil holes with a stiff brush and flush them with solvent. Check the main and connecting rod bearing journals for uneven wear, scoring, pitting or cracks. Check the remainder of the crankshaft for cracks and damage.

2 Using a micrometer, measure the diameter of the main and connecting rod journals (see illustration). Compare your measurements to the specified main and connecting rod journal outside diameters. By measuring the diameter at a number of points around each journal's circumference, you will be able to determine whether the journal is out of round. Take the measurement at each end of the journal, near the crank counterweights, to determine whether the journal is tapered.

3 If the crankshaft journals are damaged, tapered, out of round or worn beyond the specified limits, the crankshaft must be reground by an automotive machine shop. Be sure to use the correct oversize bearing inserts if the crankshaft is reconditioned.

18 Main and connecting rod bearings — inspection

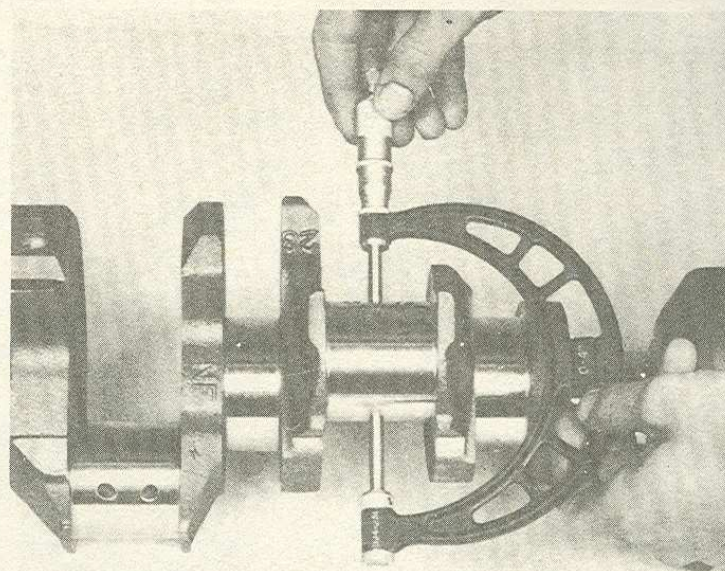
1 Even though the main and connecting rod bearings should be replaced with new ones during the engine overhaul, the old bearings can reveal valuable information about the condition of the engine.

2 Bearing failure usually occurs because of lack of lubrication, the presence of dirt or other foreign particles, engine overloading and/or corrosion. Therefore, the causes of bearing failure must be diagnosed and corrected before the engine is reassembled to prevent it from happening again.

3 When examining the bearings, remove the main bearing caps, the connecting rods and the rod caps. Lay them out on a clean surface in the same position as their location in the engine so that you can trace any problems to the corresponding crankshaft journal.

4 Dirt and contamination gets into the engine in a variety of ways. Sometimes it's left in the engine during assembly. It can also pass through filters or breathers. Or it can get into the oil, and from there into the bearings. Metal chips from machining operations and normal engine wear are also carried throughout the engine by oil. Abrasives are sometimes left in engine components after reconditioning, especially when parts are not thoroughly cleaned. Regardless of the means by which they enter the engine, these foreign particles often end up embedded in the soft material of the bearings. Larger particles will not embed in the bearings — instead they will score or gouge both bearings and shafts. The best prevention is thorough cleaning of parts and spotlessly clean engine assembly procedures. Frequent and regular engine oil and filter changes are also recommended.

5 Poor lubrication has a number of interrelated causes. Excessive heat thins the oil. Overloading squeezes the oil from bearing faces. Excessive bearing clearances cause a phenomenon known as "throw-off." A worn oil pump lowers oil pressure. High engine speeds can cause lubrication breakdown. Blocked oil passages, usually the result of misaligned oil holes in a bearing shell, can oil-starve and destroy a bearing. When lack of lubrication is the cause of bearing failure, the bearing material is wiped, or extruded, from the steel backing of the bearing. Extreme temperatures can turn the steel backing a bluish color.



17.2 Measure the diameter of each crankshaft journal at several places to detect taper and out-of-round conditions

6 Driving habits can have an effect on bearing life. Lugging the engine puts very high loads on bearings, squeezing out the thin oil film. Such loads also cause the bearings to flex, producing fatigue failure (fine cracks in the bearing face). Eventually the bearing material will loosen and tear away in pieces from the steel backing. Short trips lead to bearing corrosion because insufficient engine heat is produced to dissipate condensed water and corrosive gases. These products collect in the engine oil, forming acid and sludge. This contaminated oil carries these acids to the bearing material, which they attack and corrode.

7 Incorrect bearing installation during engine assembly will lead to bearing failure as well. Tight-fitting bearings leave insufficient bearing oil clearance and result in oil starvation. Dirt or foreign particles trapped behind a bearing insert can result in high spots on the bearing which lead to failure.

19 Piston rings — installation

Refer to illustrations 19.3a, 19.3b, 19.9 and 19.12

1 Before installing new piston rings, the ring end gaps must be checked. It is assumed that the piston ring side clearance has been checked and verified correct (Section 16).

2 Lay a new ring set next to each piston/connecting rod assembly prior to measuring the end gap for each set of rings. Once end gap has been measured, these rings must remain matched with the same piston and cylinder throughout reassembly.

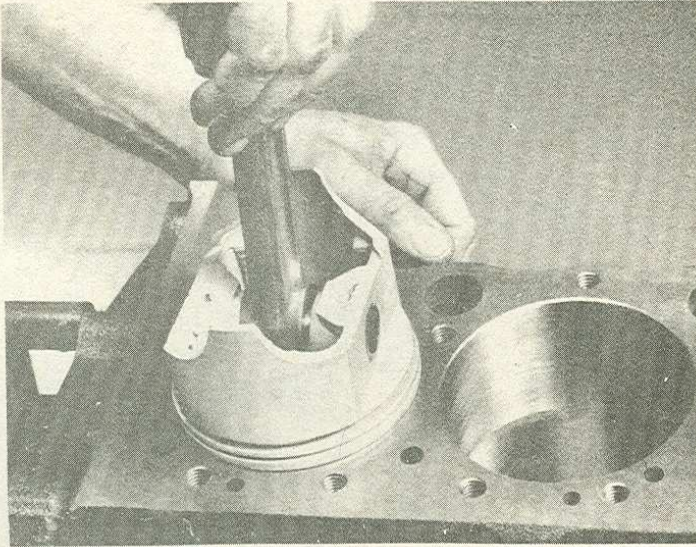
3 Insert the top (number one) ring into the first cylinder and square it up with the cylinder walls by pushing it in with the top of the piston (see illustration). To measure the end gap, slip a feeler gauge between the ends of the ring (see illustration). Record your measurements for each ring and compare them to the specified end gap.

4 If any gap is larger or smaller than specified, double-check to make sure that you have the correct rings before proceeding.

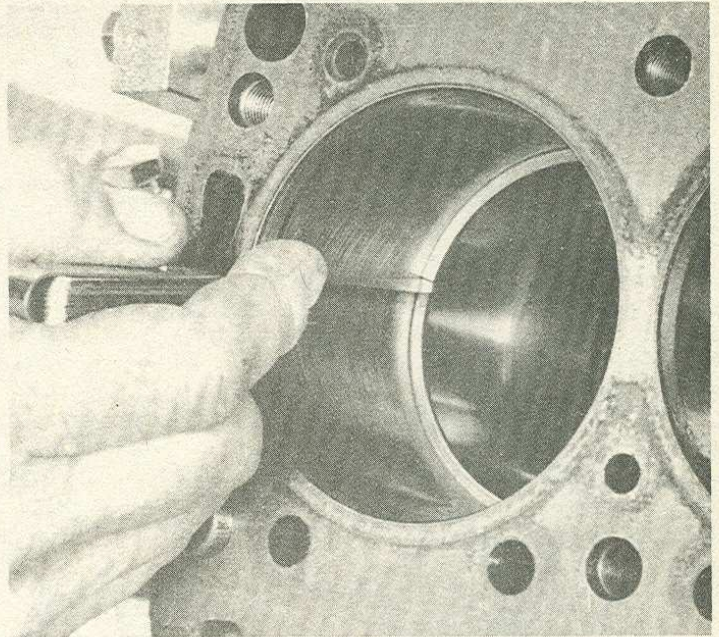
5 If a gap is too small, it must be enlarged. If it's too small, the ring ends can come in contact with each other during engine operation, causing serious damage to the engine. The end gap is increased by filing the ring ends very carefully with a fine-toothed file. Mount the file in a vise equipped with soft jaws, slip the ring over the file with the ends contacting the file face and slowly move the ring against the file to remove material from the ends. When performing this operation, file only from the outside in.

6 End gap can also be too big. If your measurements indicate an excessive end gap when compared to the specified maximum end gap, you probably purchased the wrong size rings. Double check them to make sure they are correctly matched to the piston and cylinder.

7 Repeat the procedure above for each ring to be installed in the first cylinder, then go on to the next cylinder. Remember to keep rings, pistons and cylinders matched up.



19.3a Before checking piston ring end gap, the ring must be squared in the cylinder bore by pushing it down into the cylinder with the top of a piston



19.3b With the ring square in the cylinder measure the end gap with a feeler gauge



19.9 Roll the oil control ring side rails into place above and below the oil control ring expander — don't use a ring expander

8 Once the ring end gaps have been checked and corrected, the rings can be installed on the pistons.

9 The three-part oil control ring (lowest one on the piston) is installed first. Slip the spacer/expander into the groove, then install the lower side rail (see illustration). Do not use a piston ring installation tool on the oil ring side rails — it could damage them. Instead, place one end of the side rail into the groove between the spacer/expander and the ring land, hold it firmly in place and slide a finger around the piston while pushing the rail into the groove. Next, install the upper side rail in the same manner.

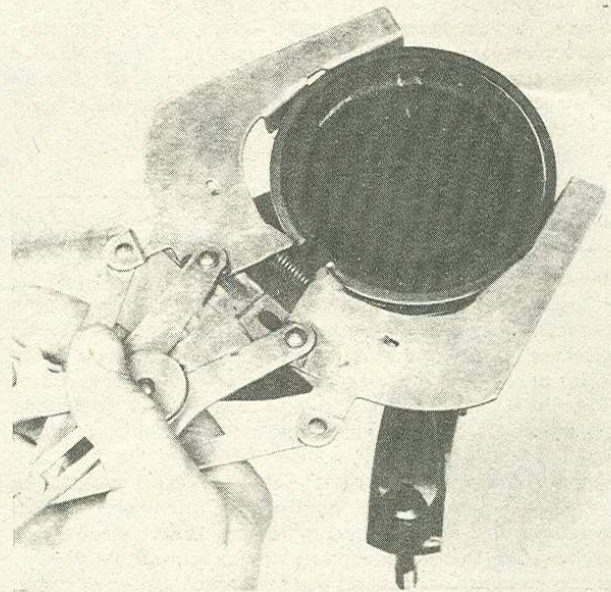
10 After the three oil ring components have been installed, check to make sure that both the upper and lower side rails can be turned smoothly in the ring groove.

11 The middle ring is installed next. It should be stamped with a mark so it can be readily distinguished from the top ring. Always follow the instructions printed on the ring package or box — different manufacturers may require different approaches. **Note:** Do not mix up the top and middle rings — they have different cross sections.

12 Make sure that the identification mark is facing upward, then slip the ring into the middle groove on the piston with a piston ring installation tool (see illustration). Do not expand the ring any more than necessary to slide it over the piston.

13 Install the top ring in the same manner. Make sure the identification mark faces up.

14 Repeat this procedure for the remaining pistons and rings. Remember that the middle and top rings are different and must not be switched.



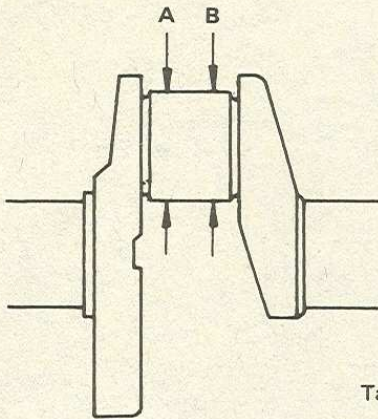
19.12 Use a ring expander to install the compression rings. Be sure that the top and middle rings aren't mixed up and that the identification mark (usually one or two dots) is facing up

20 Crankshaft oil clearance — check

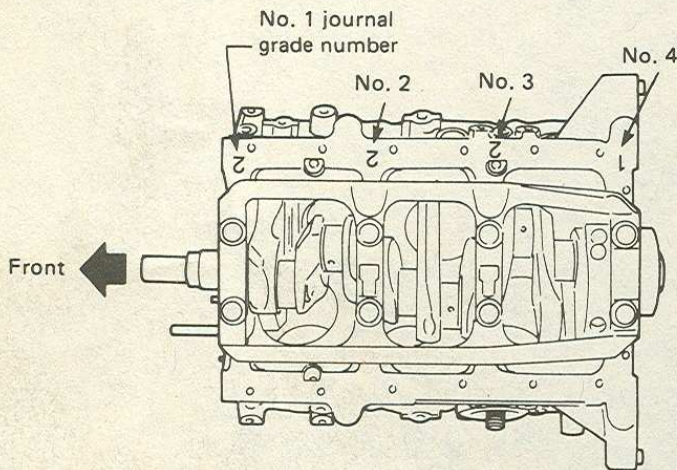
Refer to illustrations 20.7, 20.8, 20.9a, 20.9b and 20.9c

1 The running oil clearance of the main bearings should be checked anytime the crankshaft is removed. A clearance check will determine whether old bearings are excessively worn and will tell you if new bearings are the correct size. Using Plastigage, readily available at any automotive parts store, is the easiest way to measure oil clearance. However, three precautions must be taken when working with Plastigage:

- All traces of oil and grease must be completely removed from the crankshaft and bearing surfaces before taking any measurements.



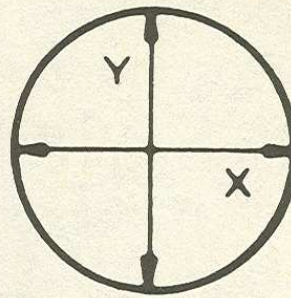
20.7 To calculate crankshaft journal taper, find the difference between the width of Plastigage (the oil clearance) at points A and B and compare the results to the specified allowable taper



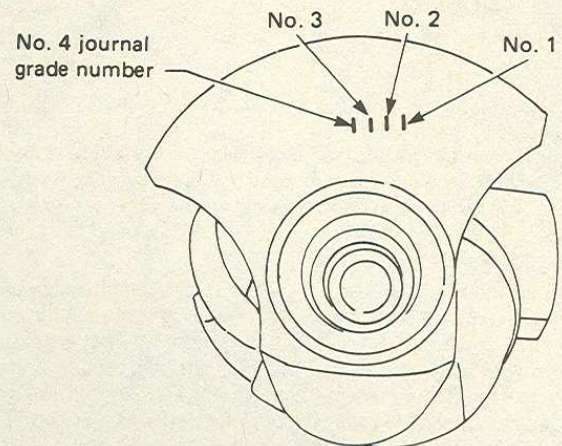
20.9a The cylinder block main journal grade numbers are stamped into the oil pan mating surface of the block

- b) The crankshaft must not be rotated while Plastigage is being used.
- c) All traces of Plastigage must be removed when testing is complete. Avoid scratching or nicking the crank journal or bearing surfaces when removing Plastigage. Do not use sharp tools or abrasive cleaners. Instead, remove the Plastigage with your fingernail or a small blunt piece of wood.

- 2 Following removal of the crankshaft and bearings, clean them thoroughly with fresh solvent, then allow them to dry.
- 3 After they are thoroughly dry, reinstall the main bearings into their respective positions in the engine block and main bearing caps. Then carefully lay the crankshaft into position in the engine block.
- 4 Cut a piece of Plastigage approximately the width of the bearing, or a little shorter, and lay it on the crank journal parallel with the crankshaft axis. Do this for each crank journal.
- 5 Carefully install the main bearing cap assembly and tighten the bolts in the proper sequence (Section 21) to the specified torque.
- 6 Remove the bearing cap assembly and measure the width of the flattened Plastigage strips. A scale is provided on the Plastigage envelope for measuring the width of the flattened strip, which is analogous to bearing clearance.
- 7 If the Plastigage is wider (flatter) at one end of a journal than it is at the other, the journal is tapered. To calculate taper, find the difference between the width of the Plastigage (the oil clearance) at points A and B (see illustration). Compare your measurement to the specified taper limit. Be sure to note the amount of taper, if any, for each journal.
- 8 To determine whether the journals are out-of-round, remove all traces of Plastigage and rotate the crankshaft 90 degrees. Lay down



20.8 To compute out-of-round, find the difference between diameter X and diameter Y and compare the result with the specified allowable out-of-round



20.9b The crankshaft main journal grade numbers are stamped on the crank counterweight

	Main journal grade number			
	0	1	2	
	Main bearing grade number			
	0	0	1	2
Crankshaft journal grade number	1	1	2	3
	2	2	3	4

For example:

Main journal grade number: 1

Crankshaft journal grade number: 2

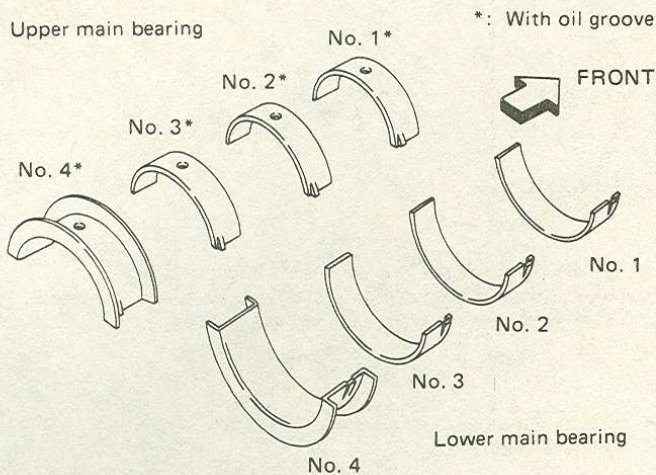
Main bearing grade number = 1 + 2
= 3

20.9c Once you know the correct main journal and crankshaft journal grade numbers, use this table to determine the correct size main bearing inserts

new strips of Plastigage, torque the main bearing cap retaining bolts (Section 21) and check each journal-to-bearing clearance again. Compare these measurements with your initial readings. Compute the difference between the two (see illustration) and compare it to the specified out-of-round.

9 To select new main bearings, select the proper thickness as follows:

- a) The "grade number" of each cylinder block main journal is punched on the respective cylinder block (see illustration).



21.5 The main bearing insert must be installed in this order, with the thrust bearing at the fourth main journal and oil grooves in the upper main bearing halves

- b) The grade number of each crankshaft main journal is punched onto the respective crank counterweight (see illustration).
- c) Select the appropriate thickness of main bearing in accordance with the following table (see illustration).

10 Once you have obtained new bearings of the proper thickness, install them and calculate oil clearance, taper and out-of-round in accordance with the procedures outlined above.

Connecting rod bearing oil clearance

11 The oil clearance of the connecting rod bearings is measured using the same method as the procedure outlined above for the main bearings. Before you can check the rod bearing clearances, however, you must tighten the main bearing caps to the specified torque and temporarily install the connecting rods on their respective journals.

21 Crankshaft and rear main seal — installation

Refer to illustrations 21.5, 21.10, 21.13, 21.14, 21.16, 21.17, 21.18, 21.19, 21.20 and 21.21

1 Crankshaft installation is generally the first step in engine reassembly. It is assumed at this point that the engine block and crankshaft have been cleaned, inspected and reconditioned. It is also assumed that you have assembled all the correct size main bearings and have checked the main journal-to-bearing oil clearance outlined in the previous Section.

2 Rotate the engine on its stand until the bottom of the block is facing upward.

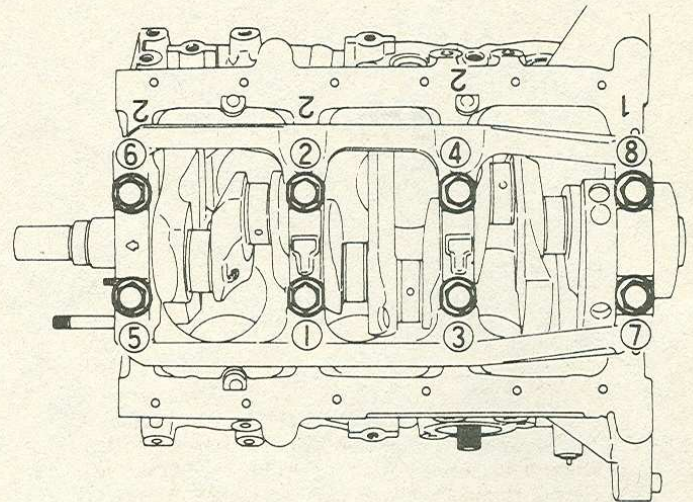
3 Remove the main bearing cap assembly retaining bolts and lift out the cap assembly.

4 Remove the bearing inserts from the block and the main bearing cap assembly. Wipe the main bearing surfaces of the block and caps with a clean, lint-free cloth. Everything must be kept spotlessly clean from this point.

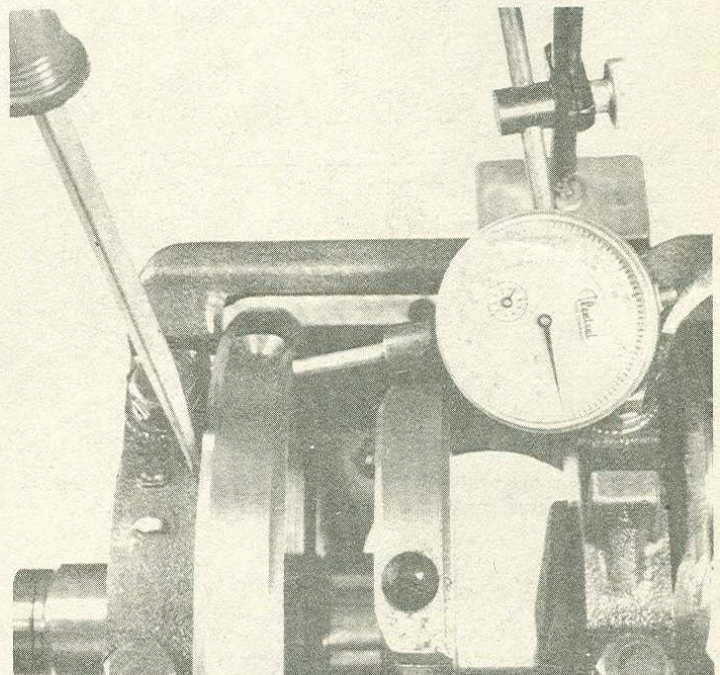
5 Clean the back sides of the new main bearing inserts and lay one bearing half in each main bearing saddle in the block. Lay the other bearing half from each bearing set in the corresponding main bearing cap (see illustration). Make sure the tab on the bearing insert fits into the recess in the block or cap. The oil hole in the block must line up with the oil hole in the bearing insert. Do not hammer the bearing into place and do not nick or gouge the bearing faces. No lubrication should be used at this time.

6 Clean the faces of the bearings in the block and the crankshaft main bearing journals with a clean, lint-free cloth. Check or clean the oil holes in the crankshaft. Any dirt here can only go one way — straight through the new bearings.

7 Apply a uniform layer of moly-based grease or engine assembly



21.10 Tighten the main bearing cap retaining bolts in this sequence



21.13 Crankshaft end play can be checked with a dial indicator on the front counterweight

lube to each of the bearing surfaces. Be sure to coat the thrust flange faces as well as the journal face of the number 4 bearing.

8 Make sure the crankshaft journals are clean, then gently lay the crankshaft into place in the block.

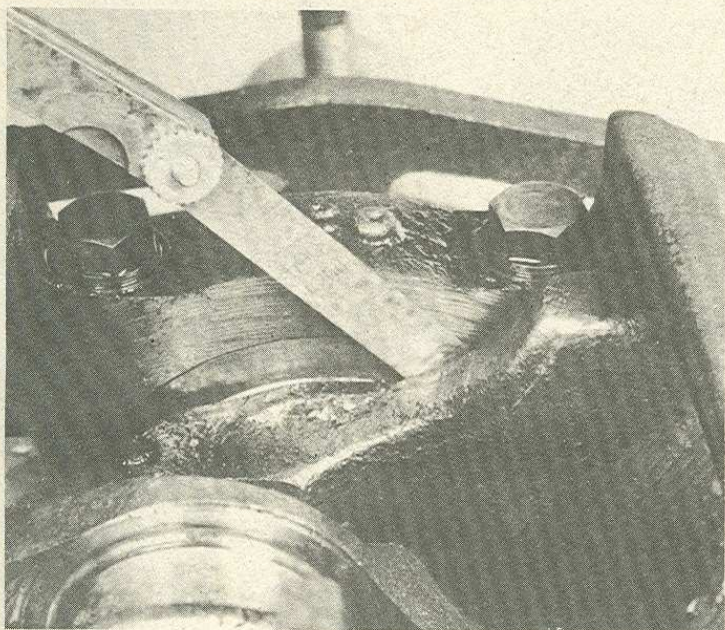
9 Clean the bearing faces in the main journal caps, then apply a uniform layer of moly-based grease to each of them. Install the main cap assembly with the arrow pointing toward the front of the engine.

10 Install and tighten all main bearing bolts finger tight. Then tighten all bolts by starting at the middle main journal and working outward (see illustration). Work up to the final specified torque in three steps.

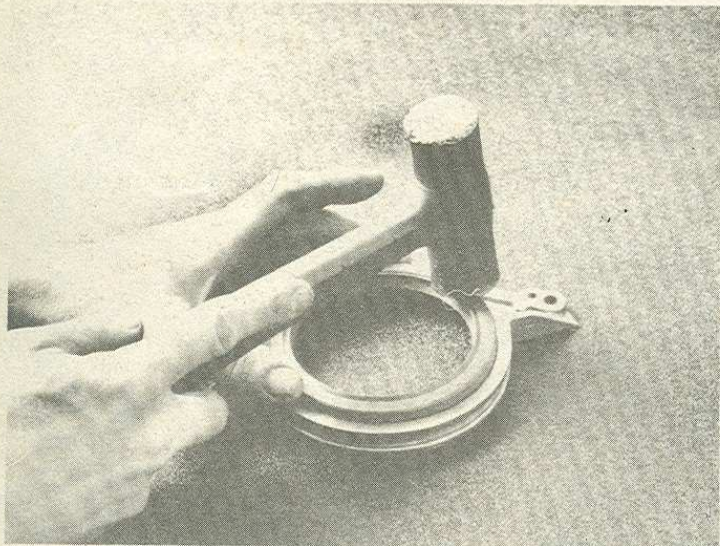
11 Rotate the crankshaft a number of times by hand and check for any obvious binding.

12 Check crankshaft free end play with a feeler gauge or a dial indicator.

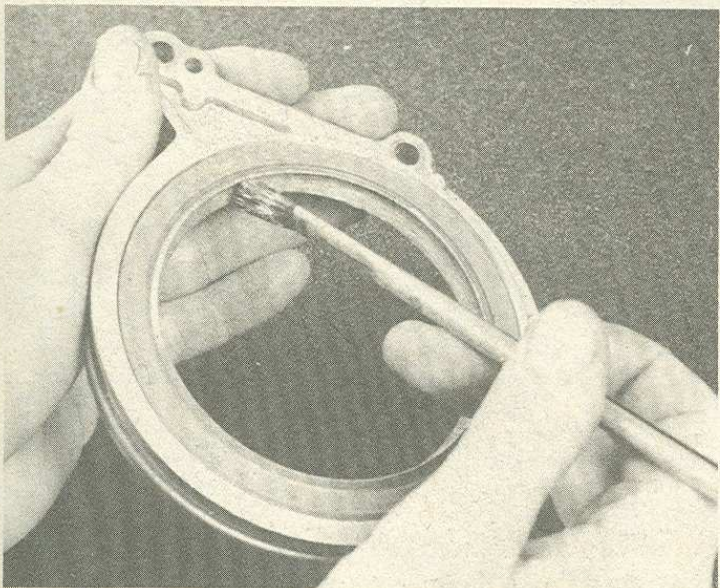
13 Set a dial indicator on the engine block with the probe touching the number 4 journal. Use a screwdriver to push the crankshaft forward. Zero in the dial indicator and use a screwdriver to push the crankshaft back (see illustration). Record your reading and compare it to the specified end play.



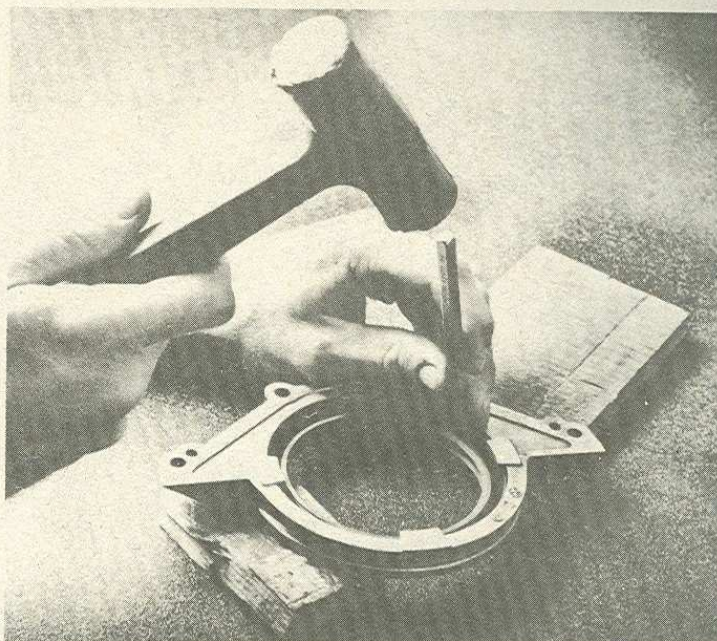
21.14 Crank end play can also be measured with a feeler gauge on the number 4 crank throw



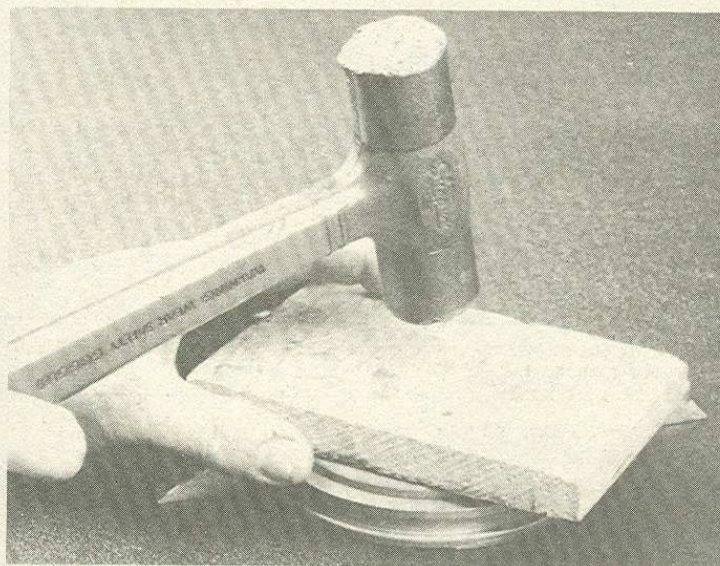
21.17 Install the oil seal and gently tap it into place



21.19 Lubricate the inside of the oil seal so it will slide smoothly onto the crankshaft



21.16 Place the retainer between two blocks of wood and drive the seal out of the retainer from the rear



21.18 Place a block of wood over the seal and drive it down evenly by working the hammer around the edges of the seal

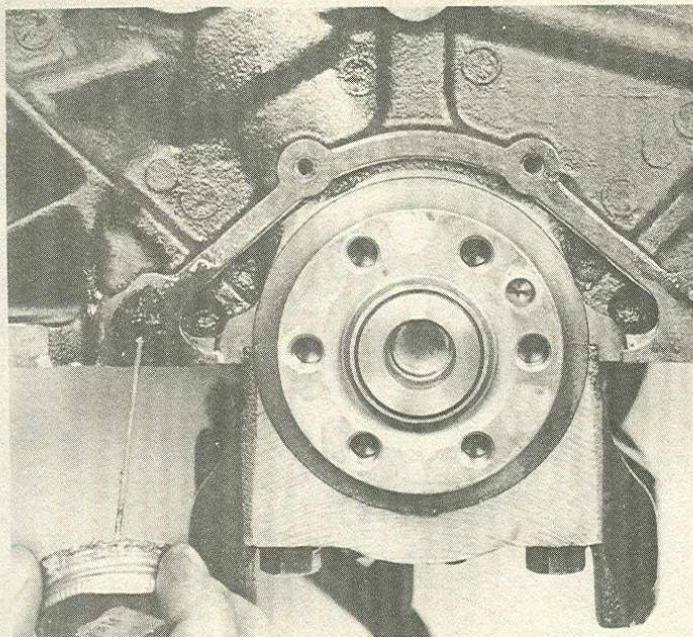
14 If a dial indicator isn't available, use a feeler gauge. Gently pry or push the crankshaft all the way to the front of the engine. Slip a feeler gauge between the crankshaft and the front face of the number 4 bearing, the rear main bearing (see illustration). The measured clearance is the end play. Compare your measurement to the specified free end play.

15 Should your measurement fail to fall within the specified crankshaft free end play, double check your reading, the bearings for correct size and the crankshaft bearing retaining bolts for proper torque. **Note:** The thrust flange on the number 4 main bearing is the primary determinant of free end play, so if your measurement falls outside the specified end play, the number 4 bearing is probably the wrong size. If you determine that it is the right size, you may need a new crankshaft.

16 Place the oil seal retainer, face down, atop two wooden blocks on a flat surface to raise it enough to allow removal of the seal. Use a hammer and punch to drive the seal out of the retainer (see illustration).

17 Remove the wood blocks, flip the retainer over and lay the new seal in place. Gently tap it into place with a small hammer (see illustration).

18 Place one of the wood blocks on top of the new seal and drive the new seal into place by working the hammer around the edges of



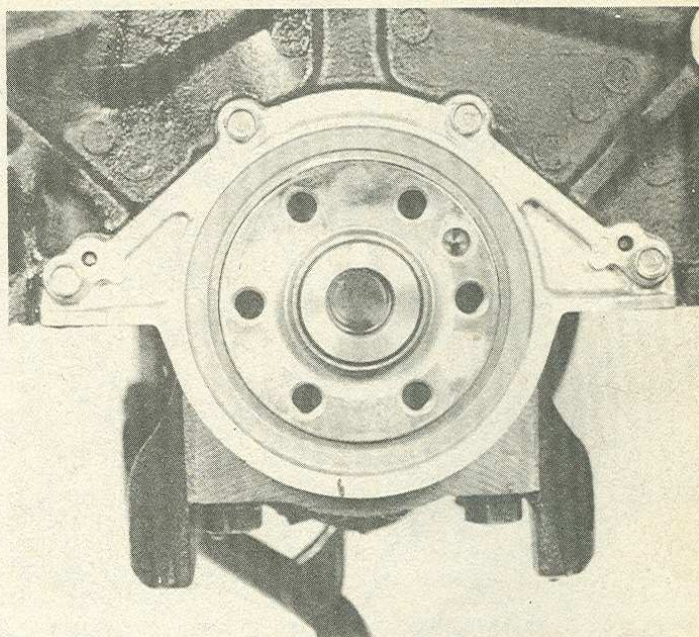
21.20 Apply sealant to the engine block mating surface

the wood block (see illustration).

19 Lubricate the inside of the seal to allow it to slide freely onto the crankshaft (see illustration).

20 Apply gasket sealer to the engine block mating surface (see illustration).

21 Slide the rear main seal onto the rear of the crankshaft and tighten the seal retainer bolts to the specified torque in a criss cross pattern (see illustration).



21.21 Tighten the oil seal retainer assembly bolts evenly, drawing the retainer to the block

22 Piston/connecting rod assembly — installation and bearing oil clearance check

Refer to illustrations 22.5, 22.6, 22.10, 22.12, 22.13, 22.14, 22.17, 22.19a and 22.19

1 Before installing the piston/connecting rod assemblies the cylinder walls must be perfectly clean, the top edge of each cylinder must be chamfered, and the crankshaft must be in place.

2 Remove the connecting rod cap from the end of the number one connecting rod. Remove the old bearing inserts and wipe the bearing surfaces of the connecting rod and cap with a clean, lint-free cloth. Everything must be kept spotlessly clean.

3 Clean the back side of the new upper bearing half, then lay it in place in the connecting rod. Make sure that the tab on the bearing fits into the recess in the rod. Do not hammer the bearing insert into place and be very careful not to nick or gouge the bearing face. Do not lubricate the bearing at this time.

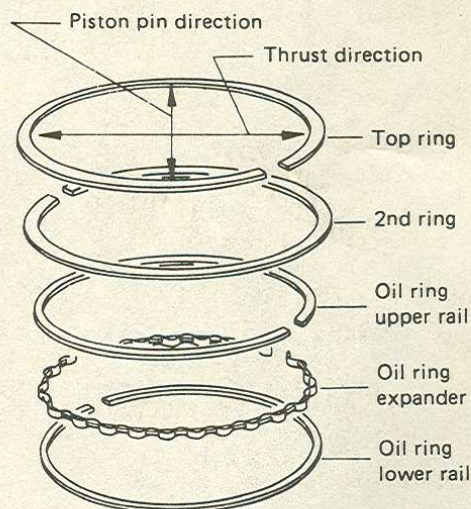
4 Clean the back side of the other bearing insert and install it in the rod cap. Again, make sure the tab on the bearing fits into the recess in the cap, and do not apply any lubricant. It is imperative that the mating surfaces of the bearing and connecting rod be perfectly clean and oil-free when they are assembled.

5 Position the piston ring gaps correctly (see illustration), then slip a section of plastic or rubber hose over the connecting rod cap bolts.

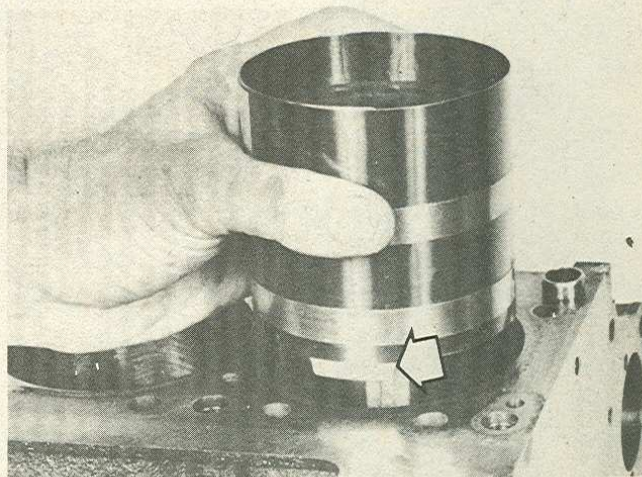
6 Lubricate the piston and rings with clean engine oil and attach a piston ring compressor to the piston. The piston skirt should protrude about one-quarter inch to guide the piston into the cylinder (see illustration). The rings must be compressed as far as possible.

7 Rotate the crankshaft until the number one connecting rod journal is as far from the number one cylinder as possible (bottom dead center), and apply a uniform coat of engine oil to the cylinder walls.

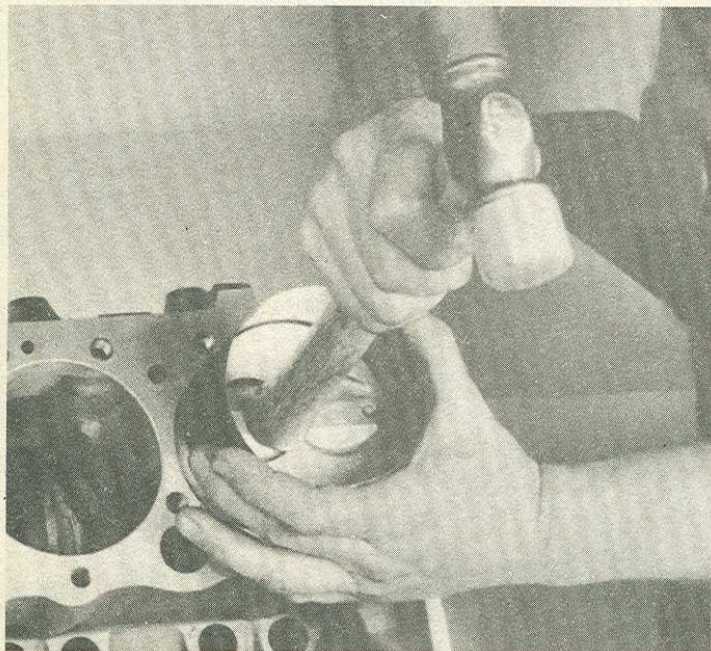
8 With the dot on top of the piston facing to the front of the engine, gently place the piston/connecting rod assembly into the number one cylinder bore and rest the bottom edge of the ring compressor on the engine block. Tap the top edge of the ring compressor to make sure



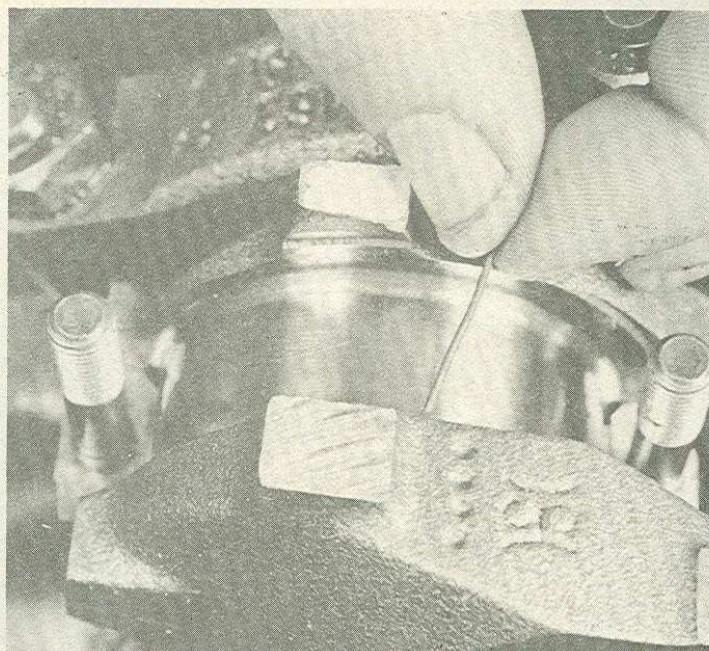
22.5 Position piston ring gaps as shown



22.6 When installing the pistons and rings, allow a portion of the piston skirt to extend below the ring compressor (arrow) to center the piston in the cylinder



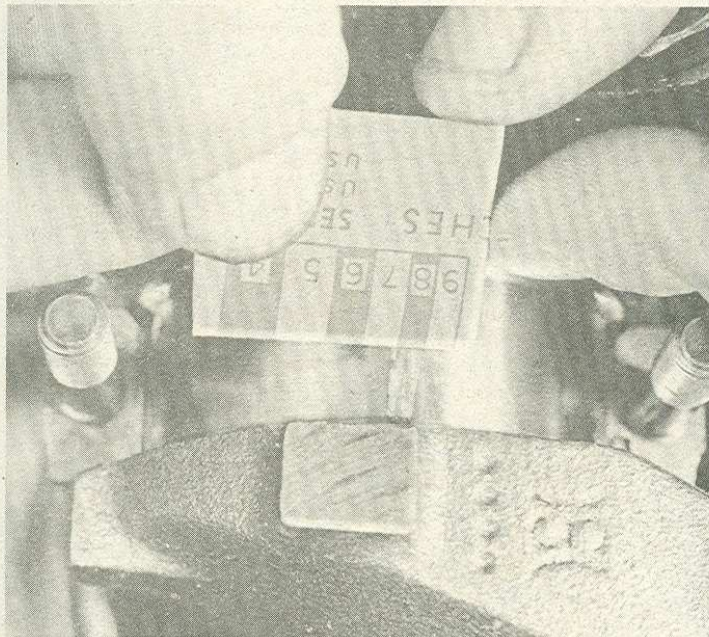
22.10 Gently drive the piston into the cylinder bore with the end of a wooden hammer handle



22.12 Lay a piece of the proper size Plastigage across the rod journal before installing the rod cap



22.13 Match the connecting rod and caps to the cylinder by matching the numbers stamped on the rod and cap



22.14 After removing the rod cap, compare the width of the crushed Plastigage to the scale on the package to determine oil clearance

it is contacting the block around its entire circumference.

9 Clean the number one connecting rod journal on the crankshaft and the bearing faces in the rod.

10 Carefully tap on the top of the piston with the end of a wooden hammer handle (see illustration) while guiding the end of the connecting rod into place on the crankshaft journal. The piston rings may try to pop out of the ring compressor just before entering the cylinder bore, so keep some downward pressure on the ring compressor. Work slowly, and if any resistance is felt as the piston enters the cylinder, stop immediately. Find out what is hanging up and fix it before proceeding. Do not, for any reason, force the piston into the cylinder or you might break a ring and/or the piston.

11 Once the piston/connecting rod assembly is installed, the connecting rod bearing oil clearance must be checked before the rod cap is permanently bolted in place.

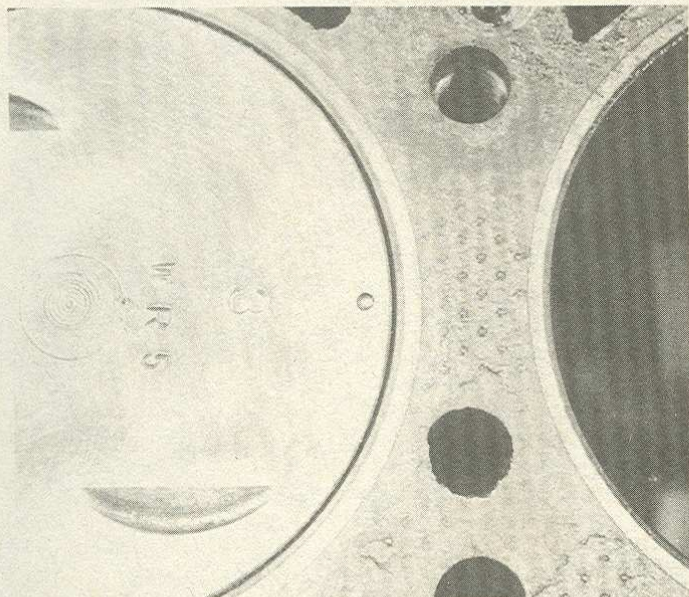
12 Cut a piece of the the appropriate size Plastigage slightly shorter than the width of the connecting rod bearing and lay it in place on the number one connecting rod journal, parallel with the journal axis (it

must not cross the oil hole in the journal) (see illustration).

13 Clean the connecting rod cap bearing face, remove the protective hoses from the connecting rod bolts and gently install the rod cap in place. Make sure the mating mark on the cap is on the same side as the mark on the connecting rod (see illustration). Install the nuts and tighten them to the specified torque, working up to it in three steps. Do not rotate the crankshaft at any time during this operation.

14 Remove the rod cap, being very careful not to disturb the Plastigage. Compare the width of the crushed Plastigage to the scale printed on the Plastigage container to obtain the oil clearance (see illustration). Compare it to the specified clearance. If the clearance is not correct, double-check to make sure that you have the correct size bearing inserts. Also, recheck the crankshaft connecting rod journal diameter and make sure that no dirt or oil was between the bearing inserts and the connecting rod or cap when the clearance was measured.

15 Carefully scrape all traces of the Plastigage material off the rod journal and/or bearing face. Be very careful not to scratch the bearing



22.17 The dot stamped on the piston should point to the front of the engine after installation

— use your fingernail or a piece of hardwood. Make sure the bearing faces are perfectly clean, then apply a layer of moly-based grease or engine assembly lube to both of them. You will have to push the piston into the cylinder to expose the face of the bearing insert in the connecting rod. Be sure to slip the protective hoses over the rod bolts first.

16 Slide the connecting rod back into place on the journal, remove the protective hoses from the rod cap bolts, install the rod cap and tighten the nuts to the specified torque. Again, work up to the torque in three steps.

17 Repeat the entire procedure for the remaining piston/connecting rod assemblies. Keep the back sides of the bearing inserts and the inside of the connecting rod and cap perfectly clean during reassembly. Make sure you have the correct piston for the cylinder and that the dot on the piston faces to the front of the engine when the piston is installed (see illustration). Remember, use plenty of oil to lubricate the piston before installing the ring compressor. Also, when installing the rod cap assembly for the final time, be sure to lubricate the bearing faces adequately.

18 After all the piston/connecting rod assemblies have been properly installed, rotate the crankshaft a number of times by hand and check for any obvious binding.

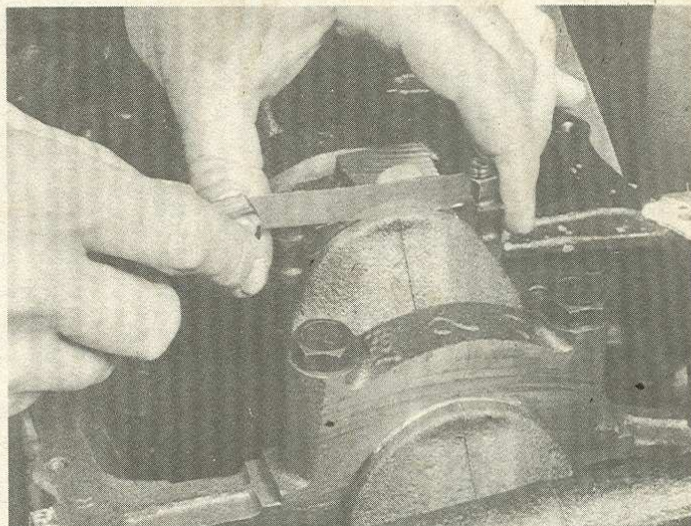
19 The connecting rod end play must be checked. There are two ways to do it:

- Slip a feeler gauge(s) between the connecting rod and the crankshaft throw (see illustration). End play is equal to the thickness of the feeler gauge(s). Compare your measurement to the specified end play.
- Set up a dial indicator with its probe touching the rod cap (see illustration). Force the rod to the rear by prying on it with a screwdriver between the rod cap and the main bearing cap. Zero the dial indicator. Then pry the rod forward until it stops. The indicated reading is end play. Compare this measurement to the specified end play.

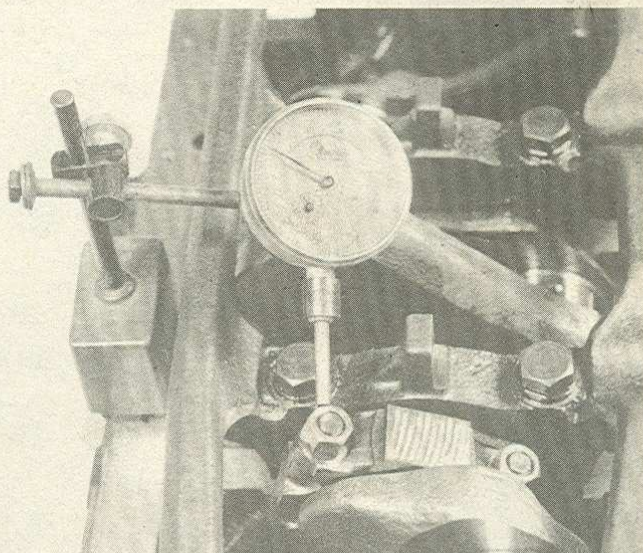
20 If, using either of the above methods, you find that your measurement does not agree with specified end play, double check your reading. Then check the bearing inserts to make sure that they are the right ones. If they are, you will have to buy either a new set of rods, or a new crankshaft, or both.

23 Initial start-up and break-in after overhaul

- Once the engine has been properly installed in the vehicle (Chapter 2A), double check the engine oil and coolant levels.
- With the spark plugs out of the engine and the coil high-tension lead grounded to the engine block, crank the engine over until oil pressure registers on the gauge (if so equipped) or until the oil light goes off.



22.19a A feeler gauge slipped between the side of the rod and the machined face of the crank throw measures the rod side clearance



22.19b A dial indicator can be used to measure rod side clearance

3 Install the spark plugs, hook up the plug wires and the coil high tension lead.

4 It may take a few moments for the gasoline to reach the engine, but the engine should start without a great deal of effort.

5 As soon as the engine starts it should be set at a fast idle (to ensure proper oil circulation) and allowed to warm up to normal operating temperature. While the engine is warming up, make a thorough check for oil and coolant leaks.

6 Shut the engine off and recheck the engine oil and coolant levels. Restart the engine and check the ignition timing and the engine idle speed (Chapter 1). Make any necessary adjustments.

7 Drive the vehicle to an area with minimum traffic, accelerate at full throttle from 30 to 50 mph, then allow the vehicle to slow to 30 mph with the throttle closed. Repeat the procedure 10 or 12 times. This will load the piston rings and cause them to seat properly against the cylinder walls. Check again for oil and coolant leaks.

8 Drive the vehicle gently for the first 500 miles (no sustained high speeds) and monitor the oil level. It is not unusual for an engine to use oil during the break-in period.

9 At approximately 500 to 600 miles, change the oil and filter and retorque the cylinder head bolts.

10 For the next few hundred miles, drive the vehicle normally. Do not pamper or abuse it.

11 After 2000 miles, change the oil and filter again and consider the engine fully broken in.