In servicing the engine proper, use the following tools and measuring instruments.

Special Tool Name	Part No.	Use
Valve Lifter	MH061668 MH061679	Removal and installation of inlet and exhaust valve cotters
Nozzle Tube Remover	MH061232	Removal of nozzle tube
Nozzle Tube Stamp	MH061229	Installation of nozzle tube
Nozzle Tube Installer Flange	MH061416	
Nozzle Tube Installer Bolt	MH061231	
Rocker Bushing Puller	MH061236	Removal and installation of rocker bushing
Valve Guide Puller	30091-08100	Removal and installation of valve guide
Caulking Tool, Exhaust	MH061651	Caulking of valve seat insert
Caulking Tool, Inlet	MH061650	
Valve Stem Seal Installer	ME067431	Installation of valve stem seal
Gear Puller	MH061061	Removal of gear and pulley
Piston Ring Tool	31191-02900	Removal and installation of piston ring
Piston Guide	31191-03200	Insertion of piston
Connecting Rod Bushing Puller	MH061238	Removal and installation of connecting rod bushing
Idler Gear Bushing Puller	MH061228	Removal and installation of idler gear bushing
Cylinder Liner Extractor	MH061490	Removal of cylinder liner
Cylinder Liner Installer	31191-03101	Installation of cylinder liner
Front Slinger Installer	MH061247	Installation of front slinger
Oil Seal Slinger Installer	MH061652	Installation of rear oil seal slinger

General tools and measuring instruments

Snap ring pliers	Spring tester	Straight edge
Varnier calipers	Caliper gauge	Valve seat cutter
Portable jack	Thickness gauge	Dial gauge
Torque wrench	Connecting rod aligner	Square
Micrometer	Cylinder gauge	Valve lapper

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7-1 DISASSEMBLY

This paragraph contains the procedures for disassembly of the engine proper with the engine auxiliaries removed. For removal and installation of the auxiliaries, refer to "Group 6 Removal and Installation of Auxiliaries."

For disassembly of the individual parts, the operational procedures aimed at their overhaul are shown, but the procedures are simply fundamental examples.
They may be changed as the occasion may demand.

As for the cylinder head and valve mechanism, the procedures for only one cylinder are shown. For the other cylinders, follow the same procedures.

When proceeding with disassembly operations, observe the following precautions.

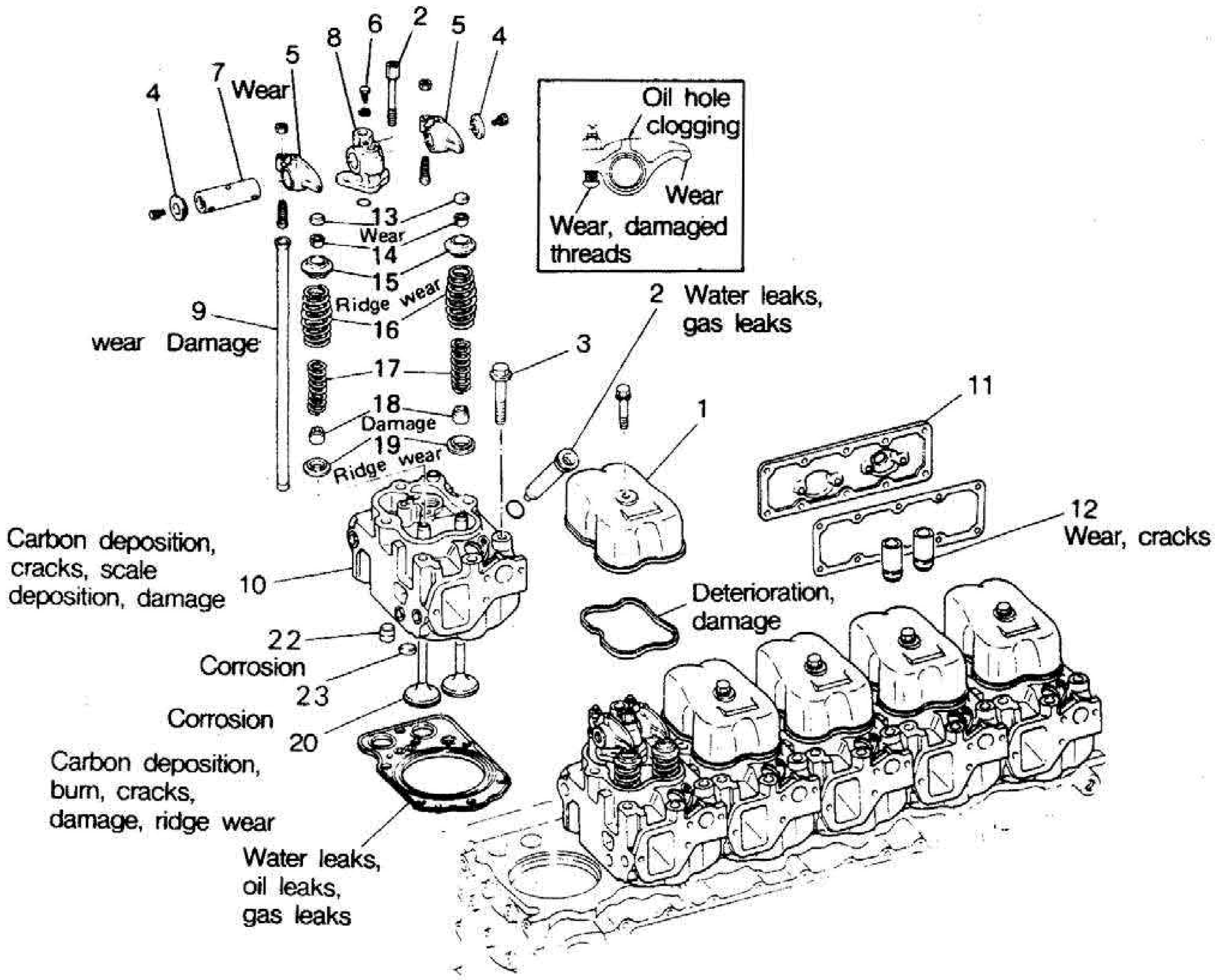
(1) Use proper tools suitable for disassembly operations to prevent damage.

(2) For parts which might cause confusion at reassembly, make alignment marks on functionally safe points before disassembly.

(3) The disassembled parts should be kept in order to prevent confusion. The parts independently assembled for each cylinder should be kept in a separate place to eliminate the possibility of their reinstallation in different positions.

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7-1-1 Cylinder Head and Valve Mechanism



1 Rocker cover
2 Rocker bracket mounting bolt
3 Cylinder head bolt
4 Thrust plate
5 Rocker
6 Set screw
7 Rocker shaft
8 Rocker shaft bracket
9 Push rod
10 Cylinder head
11 Crankcase side cover
12 Tappet
13 Valve cap
14 Valve cotter
15 Upper retainer
16 Outer valve spring
17 Inner valve spring
18 Valve stem seal
19 Lower retainer
20 Valve
21 Nozzle tube
22 Water director
23 Sealing cap

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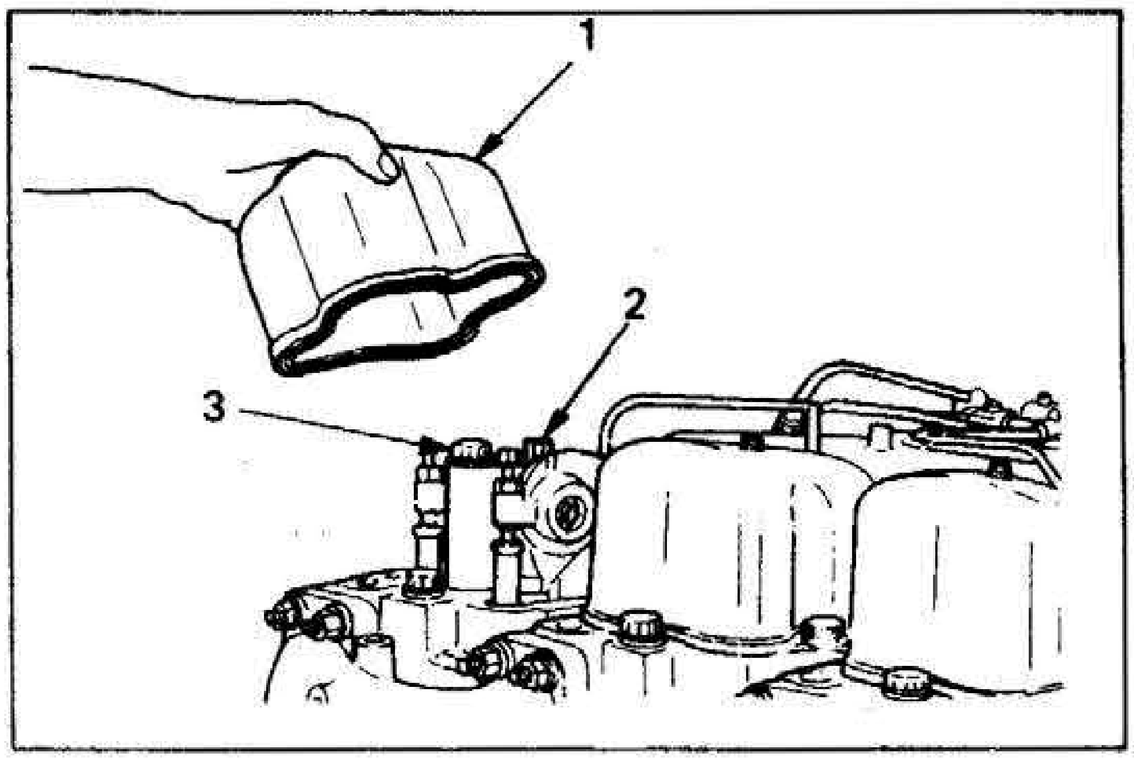
(1) Remove the following parts.

1 Rocker cover

2 Rocker bracket mounting bolt

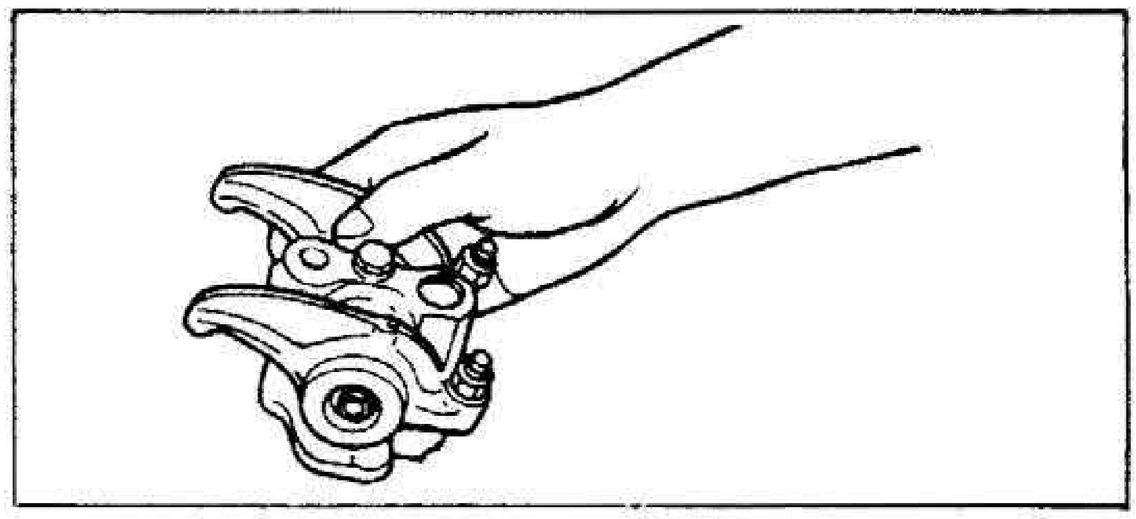
3 Cylinder head bolt

NOTE : Where the push rod is forcing the rocker up, the rocker adjusting screws should be loosened before all bolt are removed.



(2) Remove the rocker shaft bracket assembly from the cylinder head.

NOTE : The rocker shaft bracket assembly is set in position on the cylinder head by spring pins.



(3) Remove the following parts.

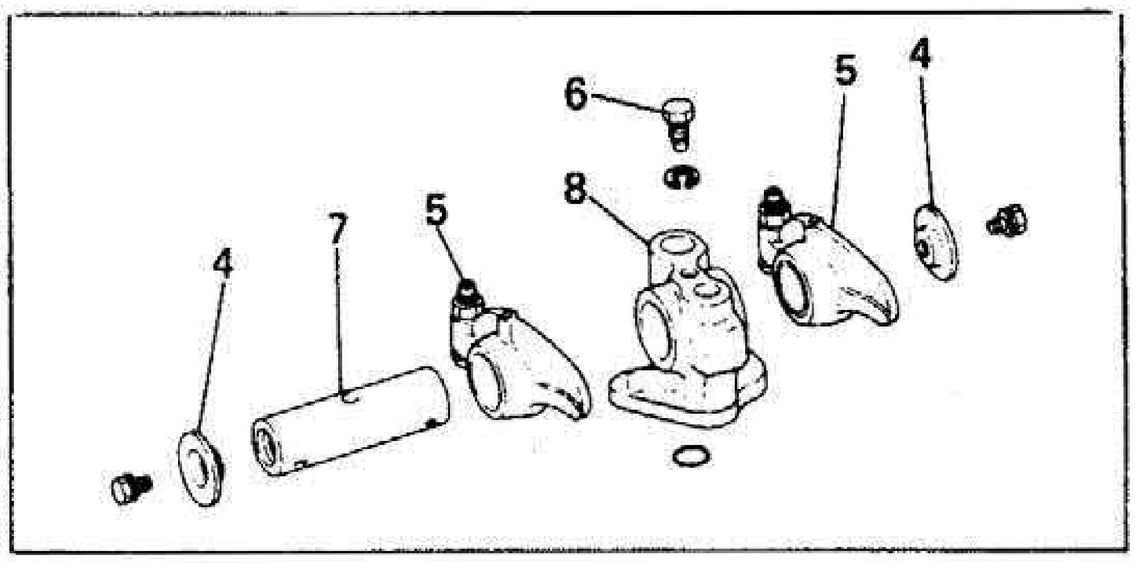
4 Thrust plate

5 Rocker

6 Set screw

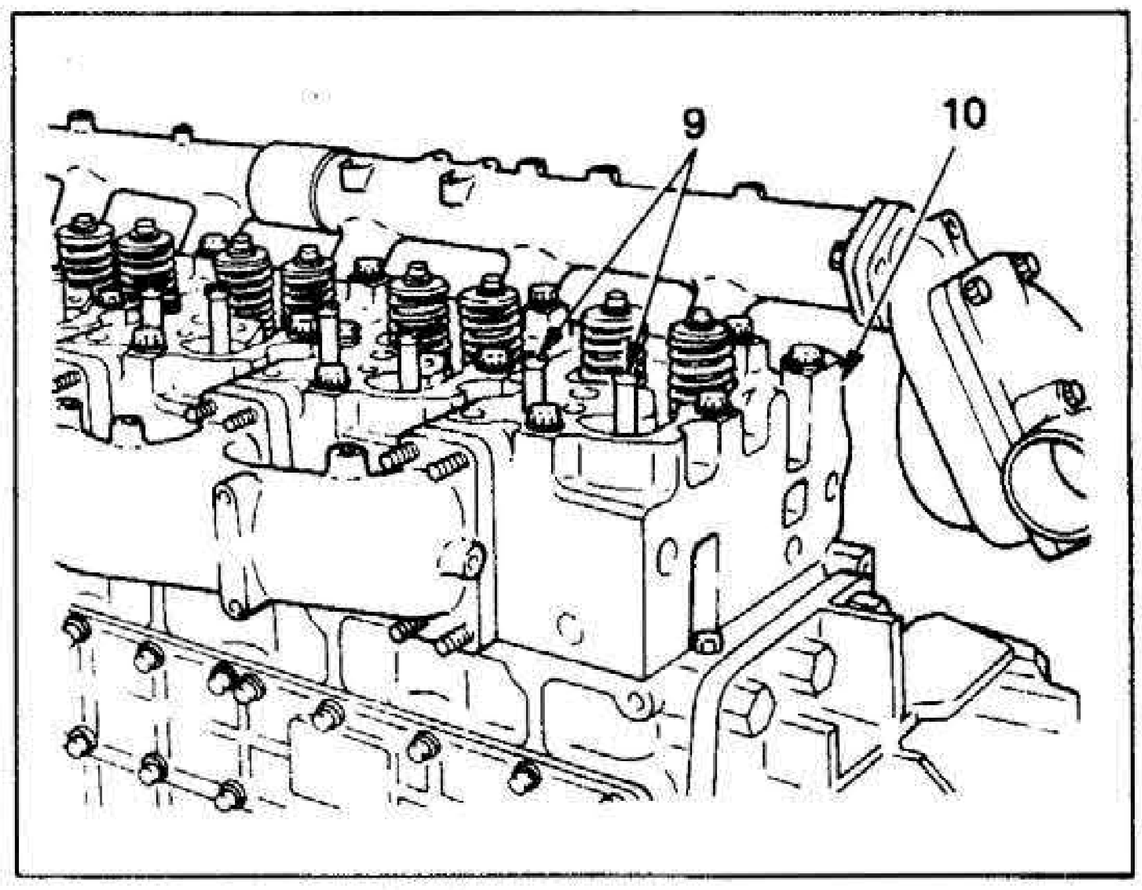
7 Rocker shaft

8 Rocker shaft bracket



(4) Withdraw the push rod 9 and remove the cylinder head 10 from the crankcase.

NOTE : 1. To remove the cylinder head, make sure that the injection nozzle is removed beforehand. If the cylinder head with nozzle mounted is placed on the work table, damage to the nozzle end projecting from the bottom surface of the cylinder head will result.

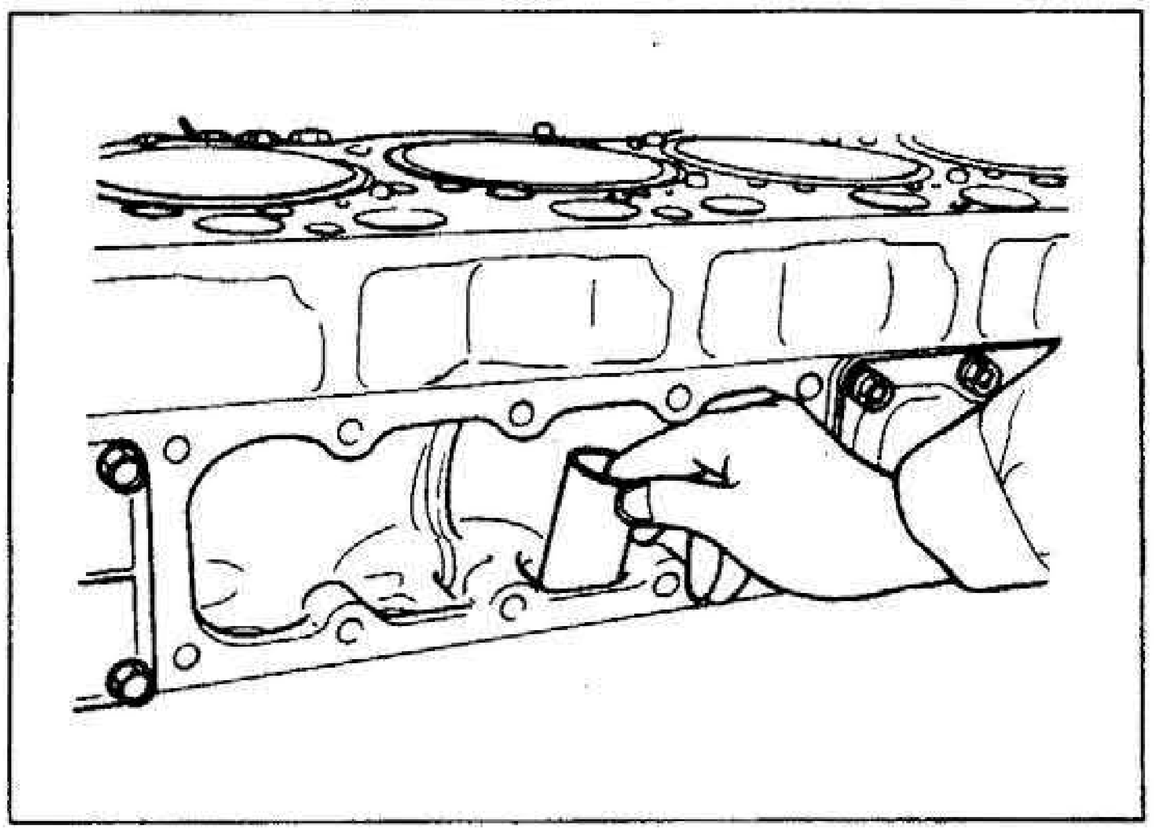


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2. When the cylinder head gasket is removed, make sure that the cylinder head and crankcase are not scratched.

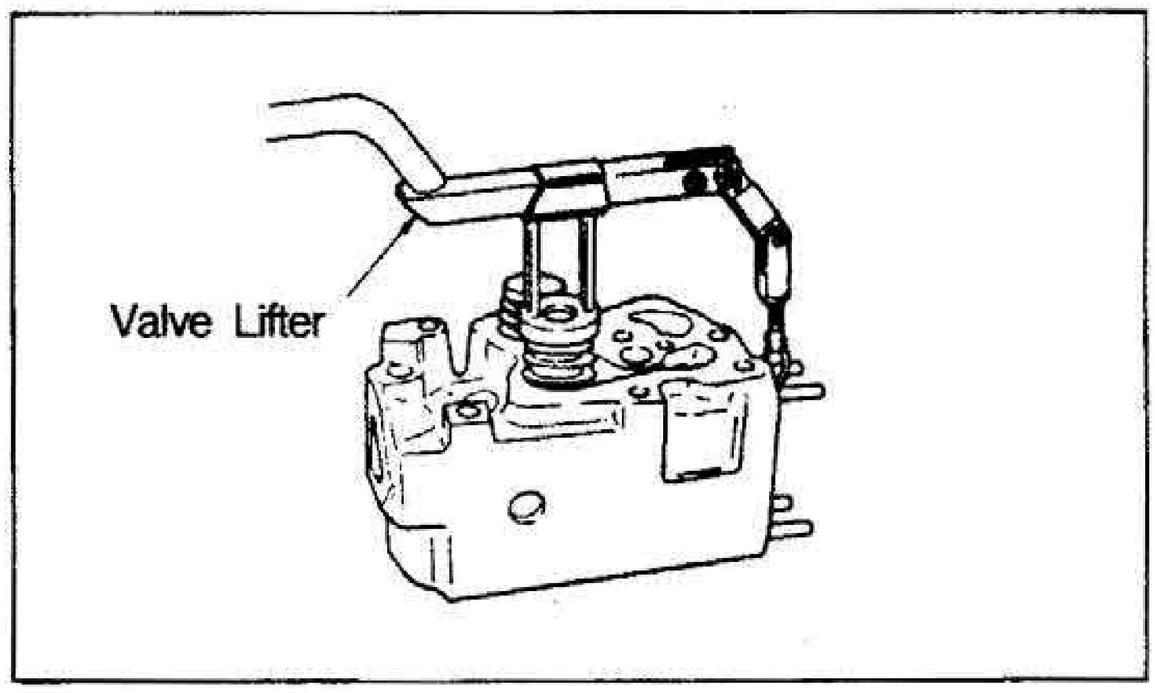
3. Since the cylinder head is located by dowel pins on the top surface of the crankcase, make sure that the cylinder head is lifted straight upward when removed.

(5) Remove the crankcase side cover 11 and remove the tappet 12 from the crankcase.



(6) Remove the valve cap 13. Using Valve Lifter(special tool) as shown, remove the valve cotter 14.

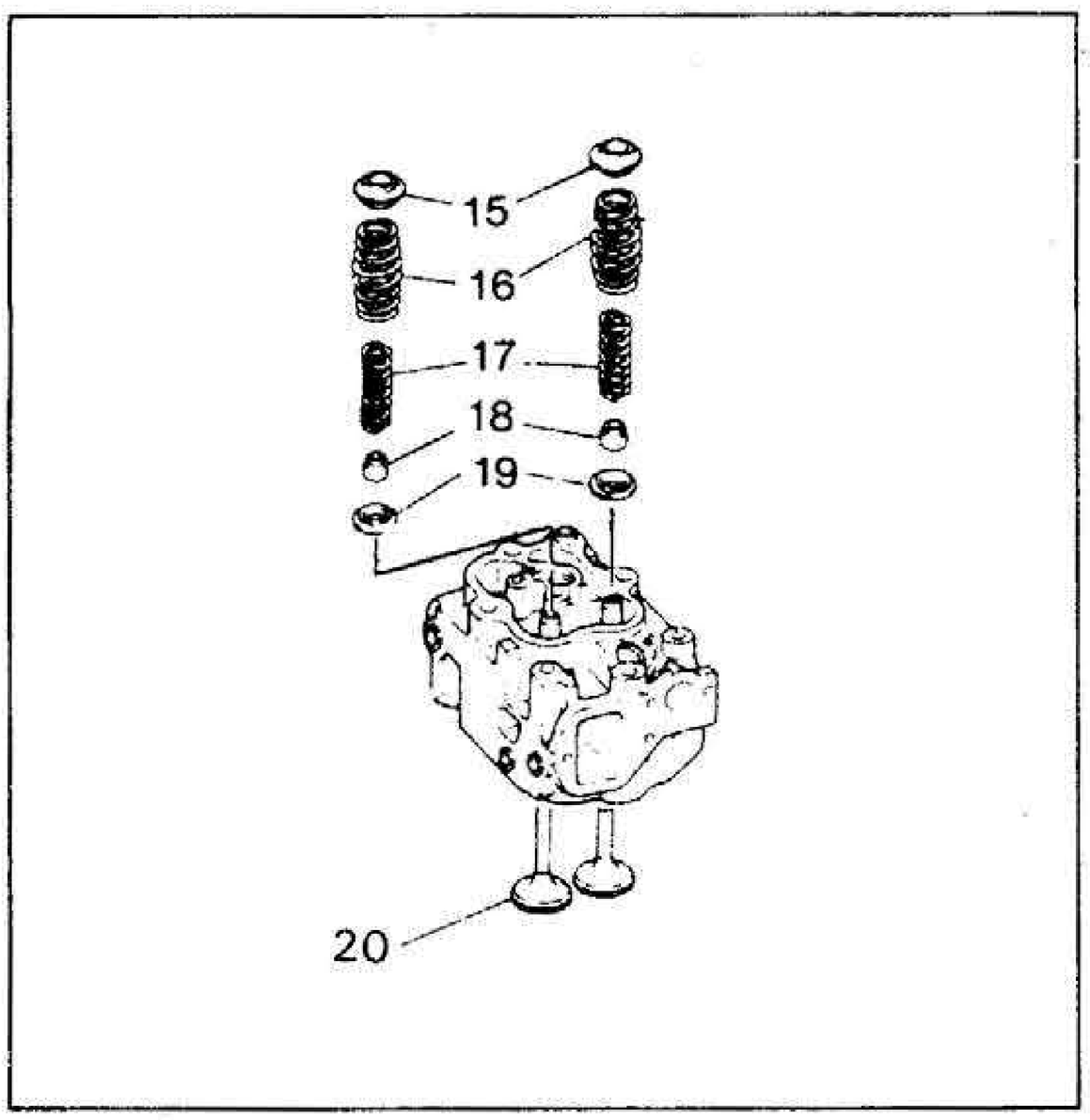
NOTE : Make sure that the valve spring is evenly compressed.



(7) Remove the following parts.

15 Upper retainer
16 Outer valve spring
17 Inner valve spring
18 Valve stem seal
19 Lower retainer
20 Valve

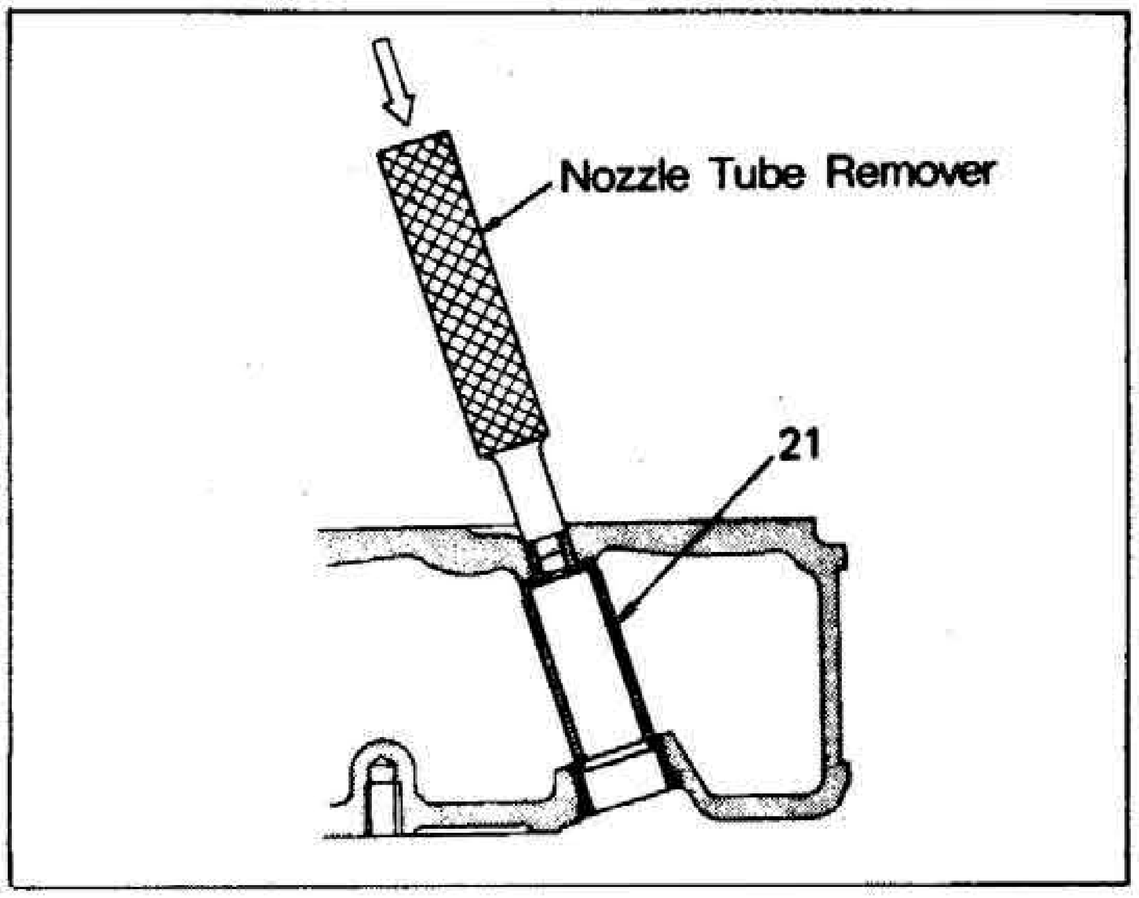
NOTE : When the valve stem seal was removed, make sure that a new one is installed.



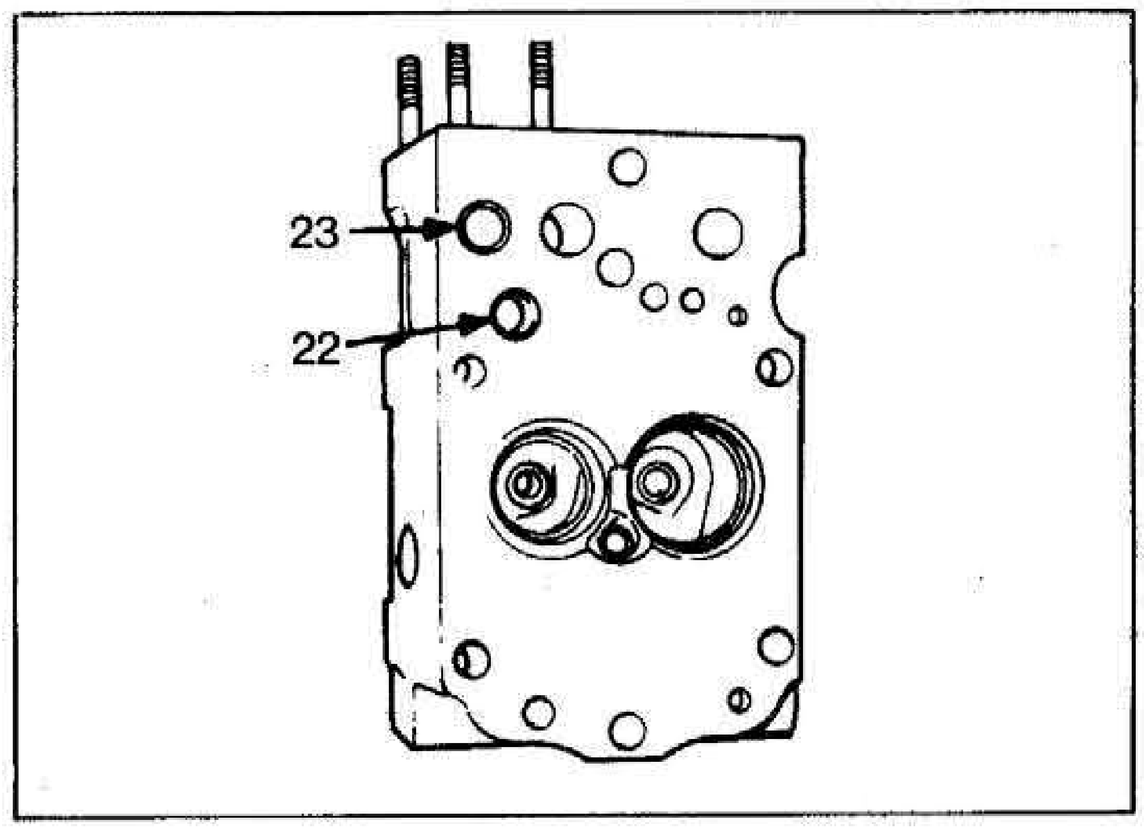
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(8) Withdraw the nozzle tube 21 with Nozzle Tube Remover(special tool).

NOTE : The nozzle tube need not be removed unless water leaks, gas leaks, etc. are evident.

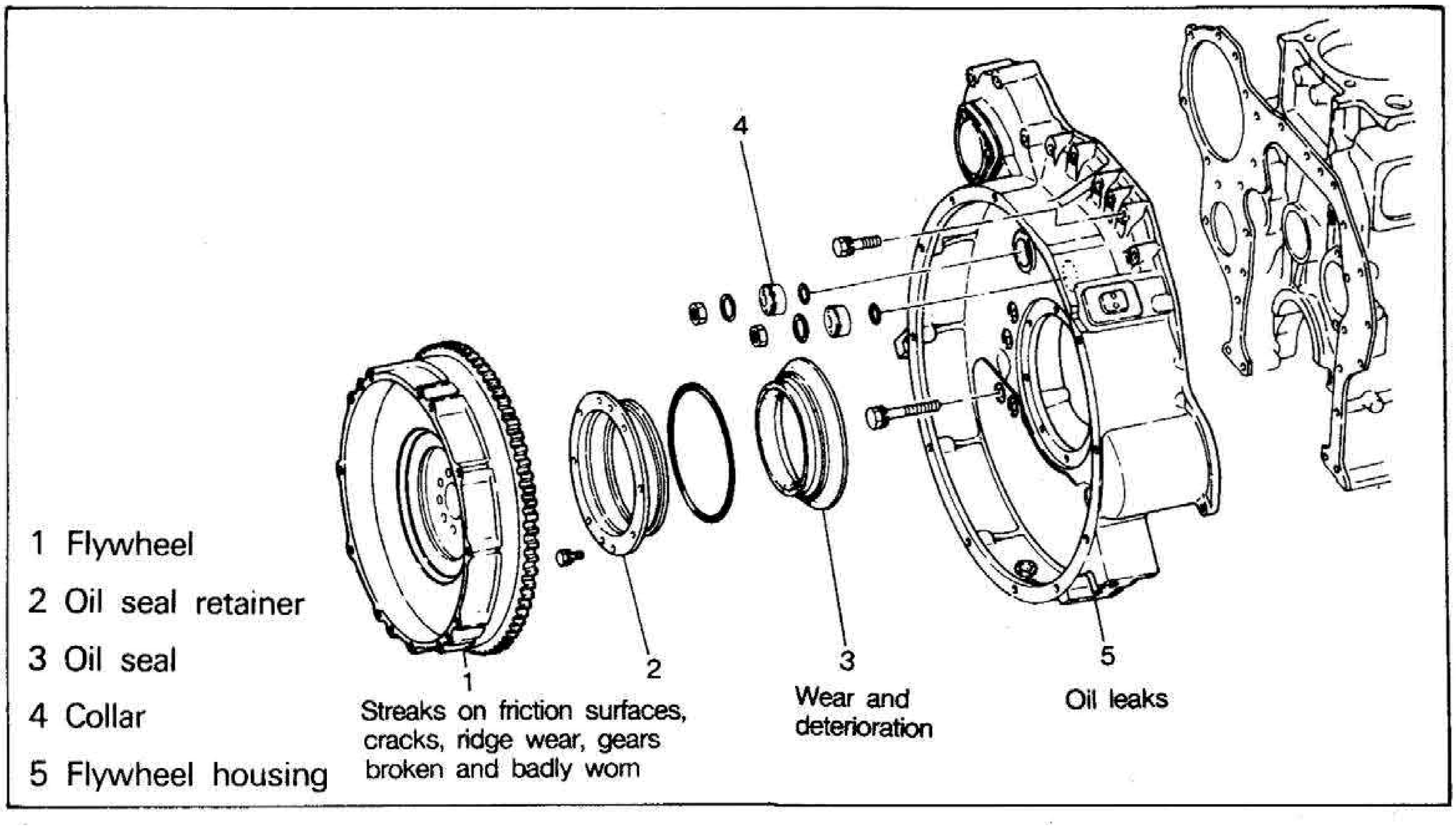


(9) If the water director 22 and sealing cap 23 are corroded, withdraw.



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7-1-2 Flywheel, Timing Gear and Camshaft



1 Flywheel
2 Oil seal retainer
3 Oil seal
4 Collar
5 Flywheel housing

1 Streaks on friction surfaces, cracks, ridge wear, gears broken and badly worn

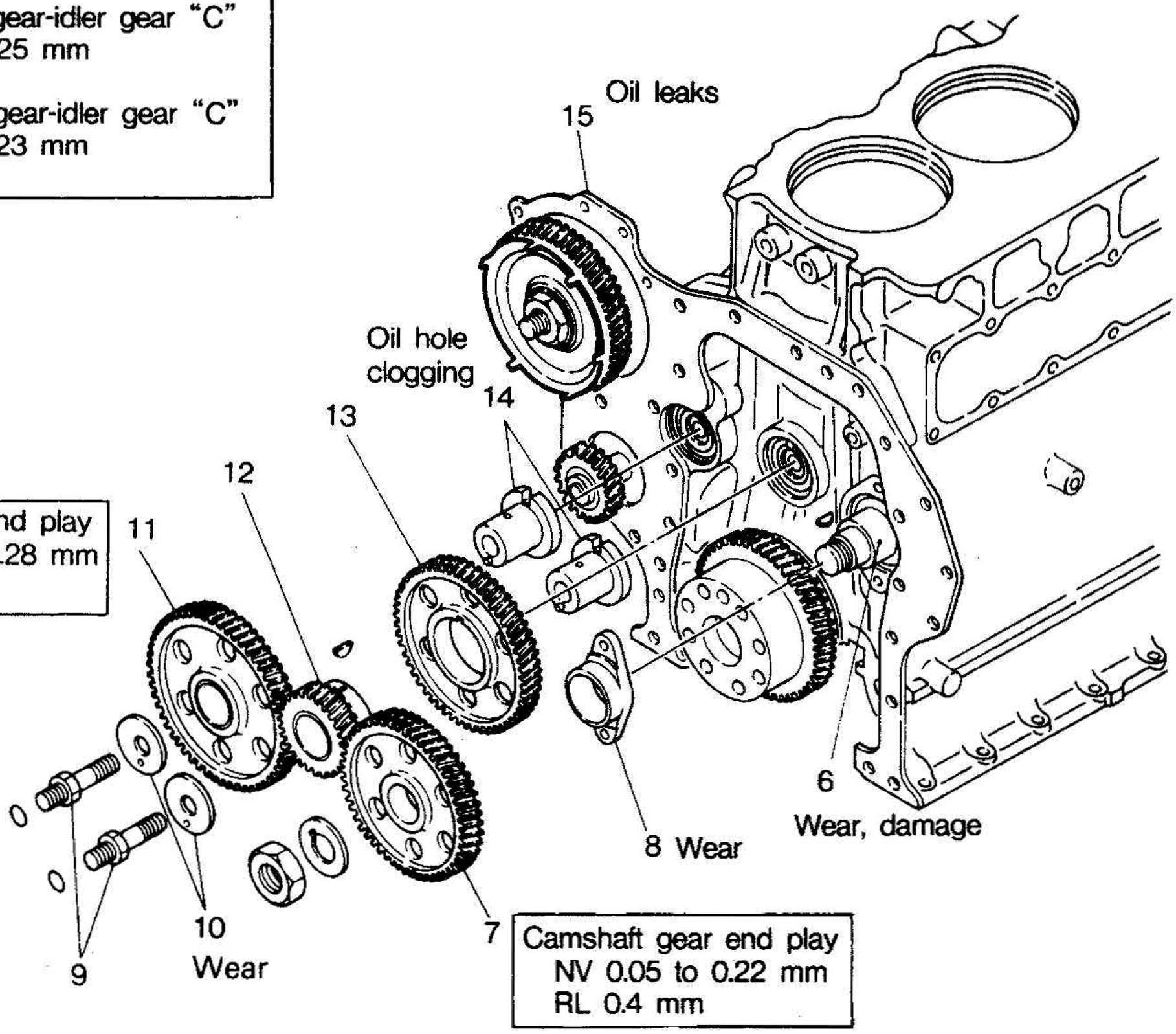
2

3 Wear and deterioration

5 Oil leaks

NV···Nominal Value
RL···Repair Limit
SL···Service Limit

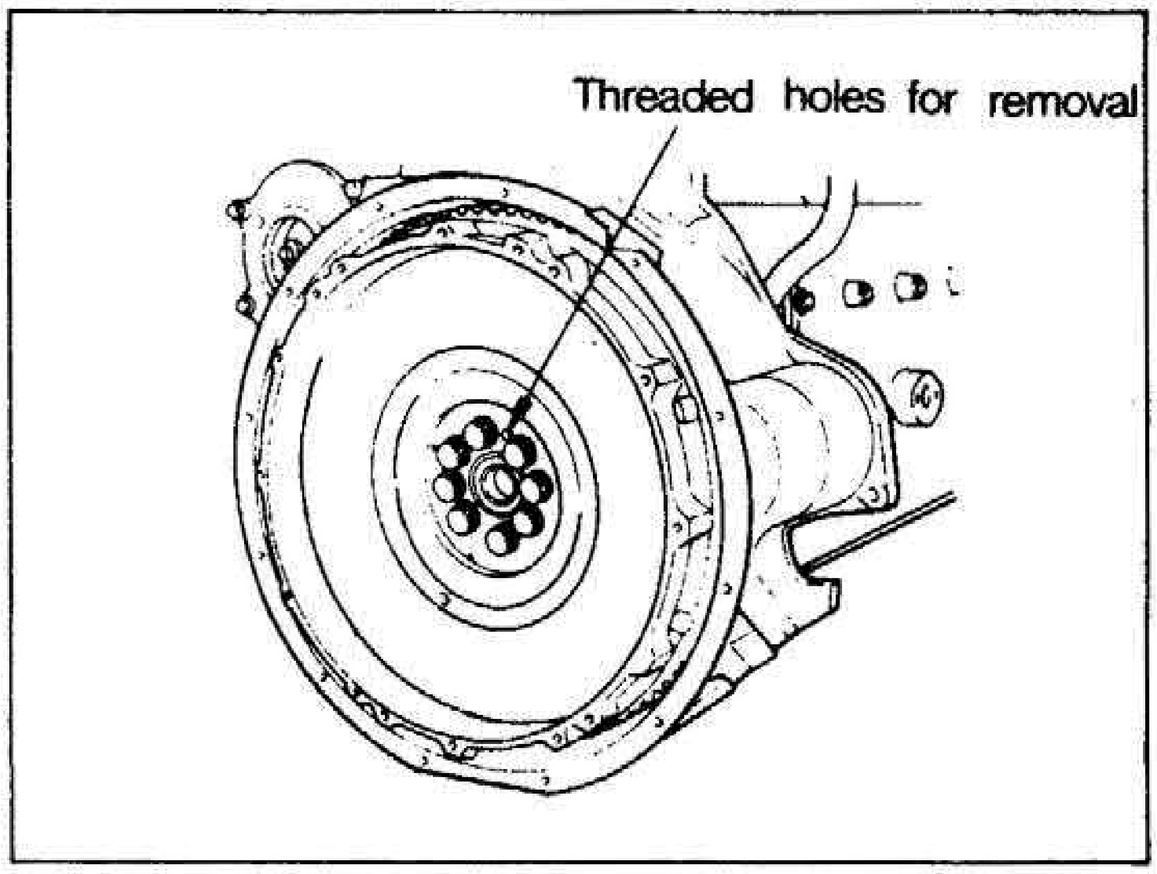
Timing gear backlash
Crankshaft gear-idler gear "B"
NV 0.12 to 0.26 mm
SL 0.4 mm
Idler gear "A"-camshaft gear
NV 0.11 to 0.23 mm
SL 0.4 mm
Idler gear "A"-idler gear "C"
NV 0.11 to 0.24 mm
SL 0.4 mm
Injection pump gear-idler gear "C"
NV 0.12 to 0.25 mm
SL 0.4 mm
Power steering gear-idler gear "C"
NV 0.10 to 0.23 mm
SL 0.4 mm



6 Camshaft
7 Camshaft gear
8 Thrust plate
9 Idler shaft bolt
10 Thrust plate
11 Idler gear "C"
12 Idler gear "A"
13 Idler gear "B"
14 Idler shaft
15 Rear plate

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(1) Thread the mounting bolt into the removing threaded hole to remove the flywheel 1.



(2) Remove the following parts.

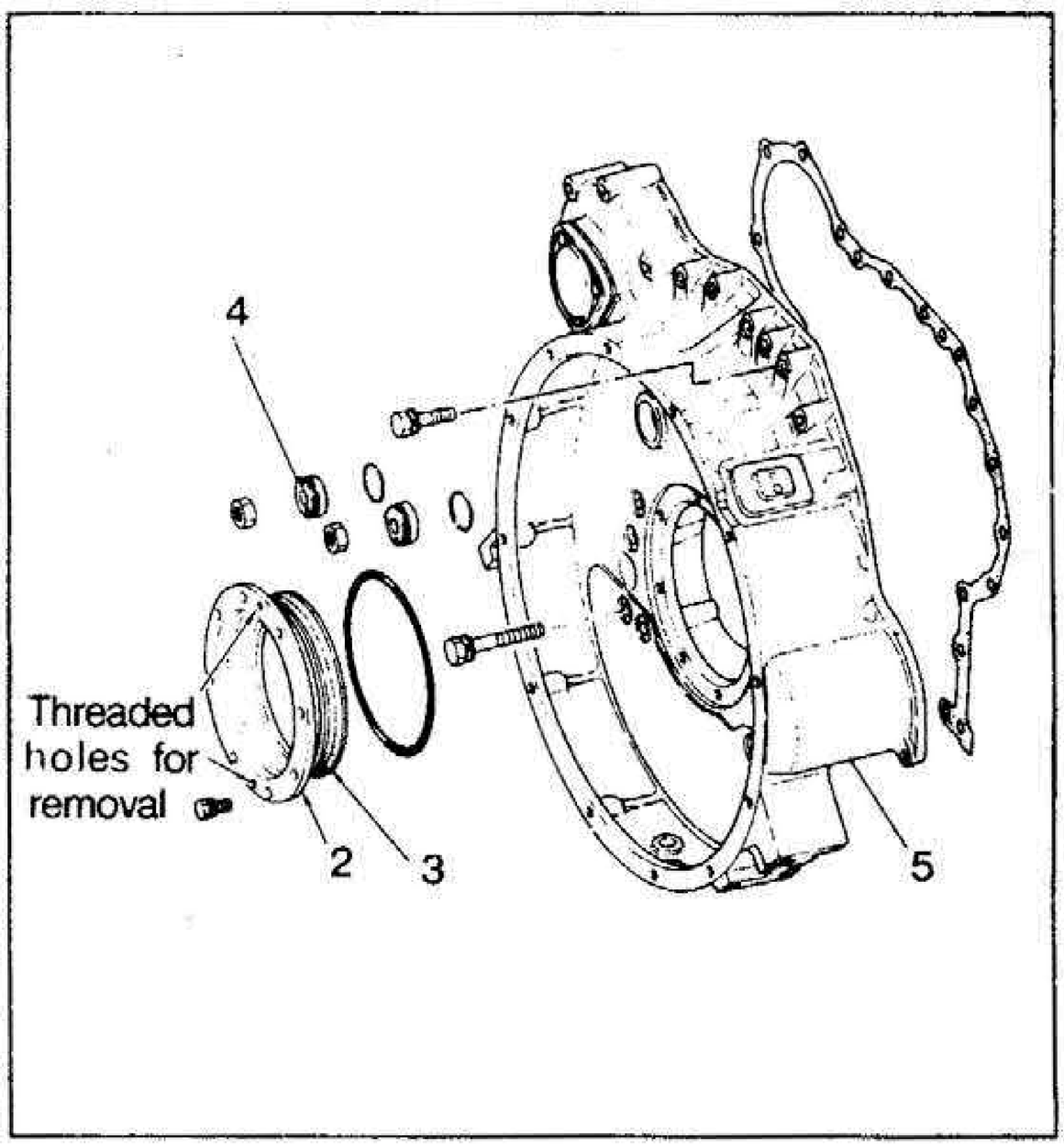
2 Oil seal retainer

3 Oil seal

4 Collar

5 Flywheel housing

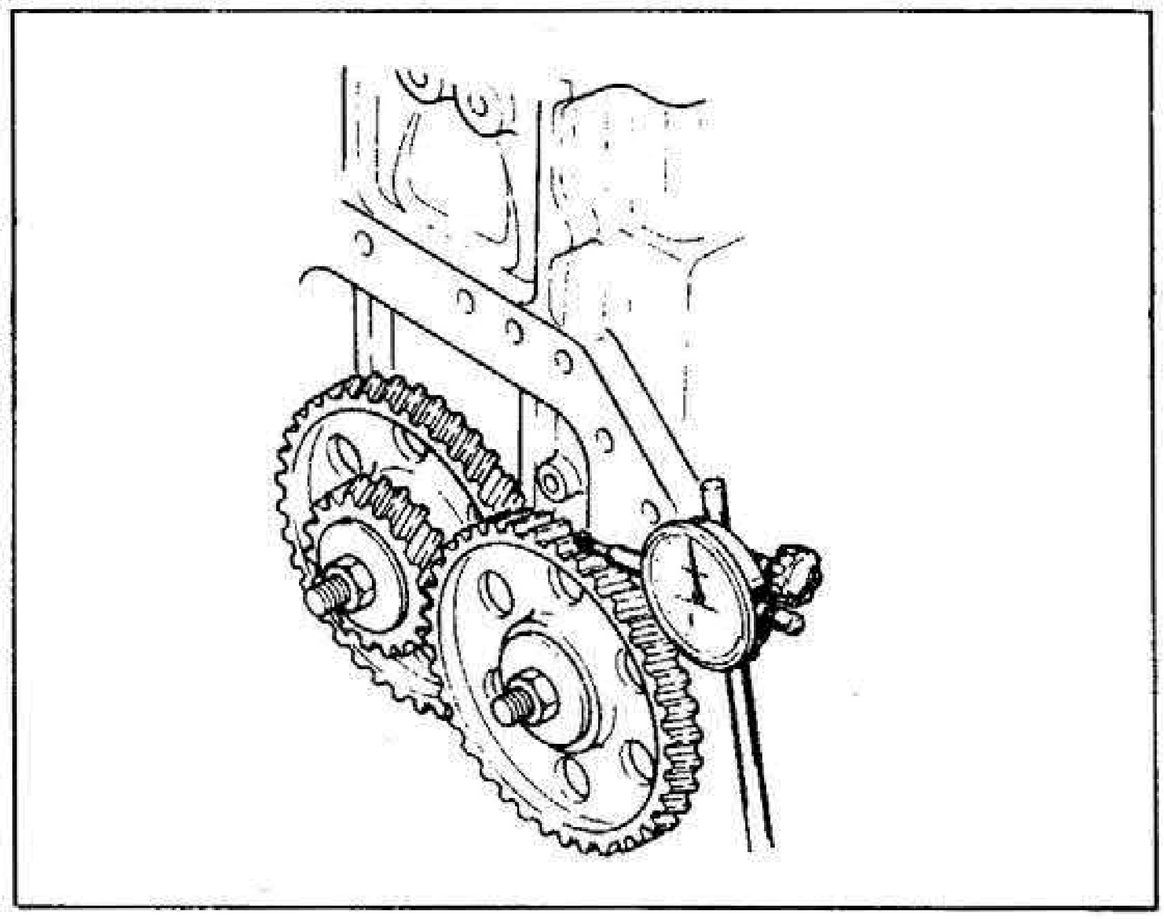
Remove the oil seal retainer with oil seal attached by threading the mounting bolts evenly into the removing threaded holes.



NOTE : Do not remove the pointer mounted to the inspection window of the flywheel housing.

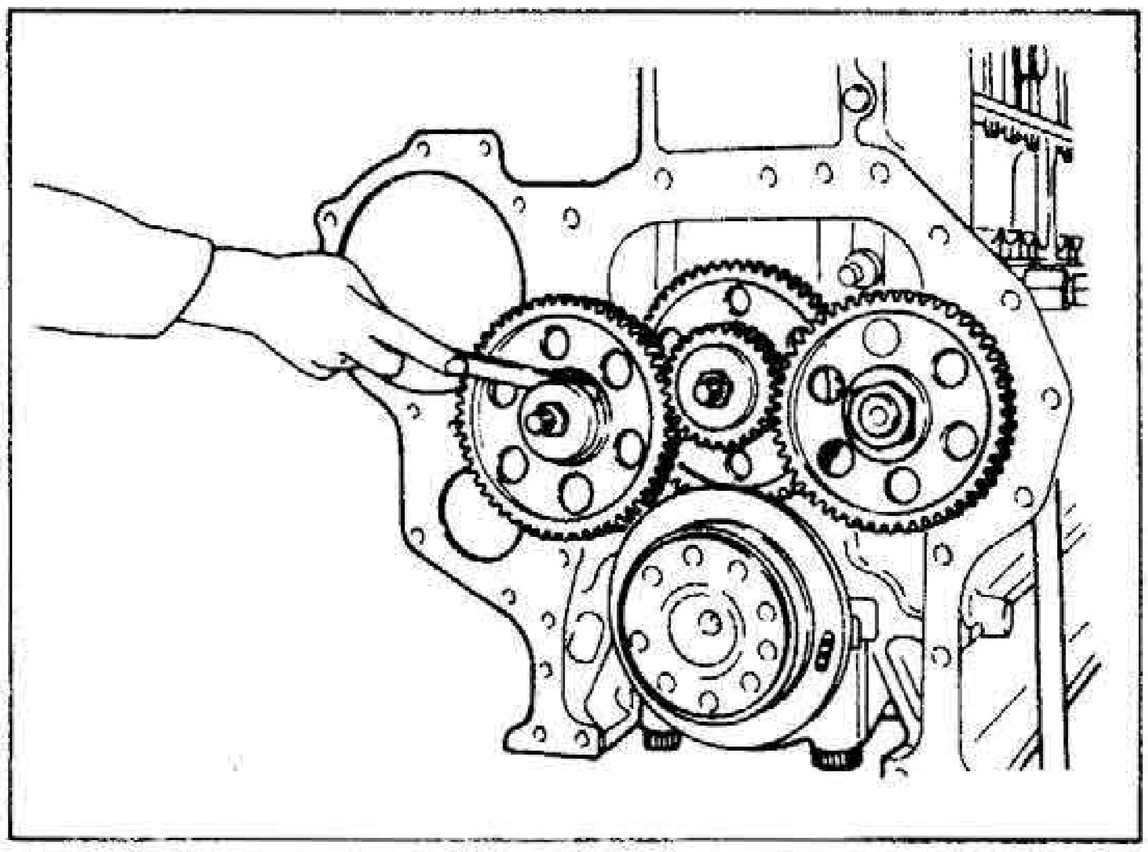
(3) Measure the backlash between the individual gears. Parts that have exceeded the service limit should be replaced.

NOTE : For a pair of gears, the backlash should be measured at more than three points to determine whether it is acceptable.

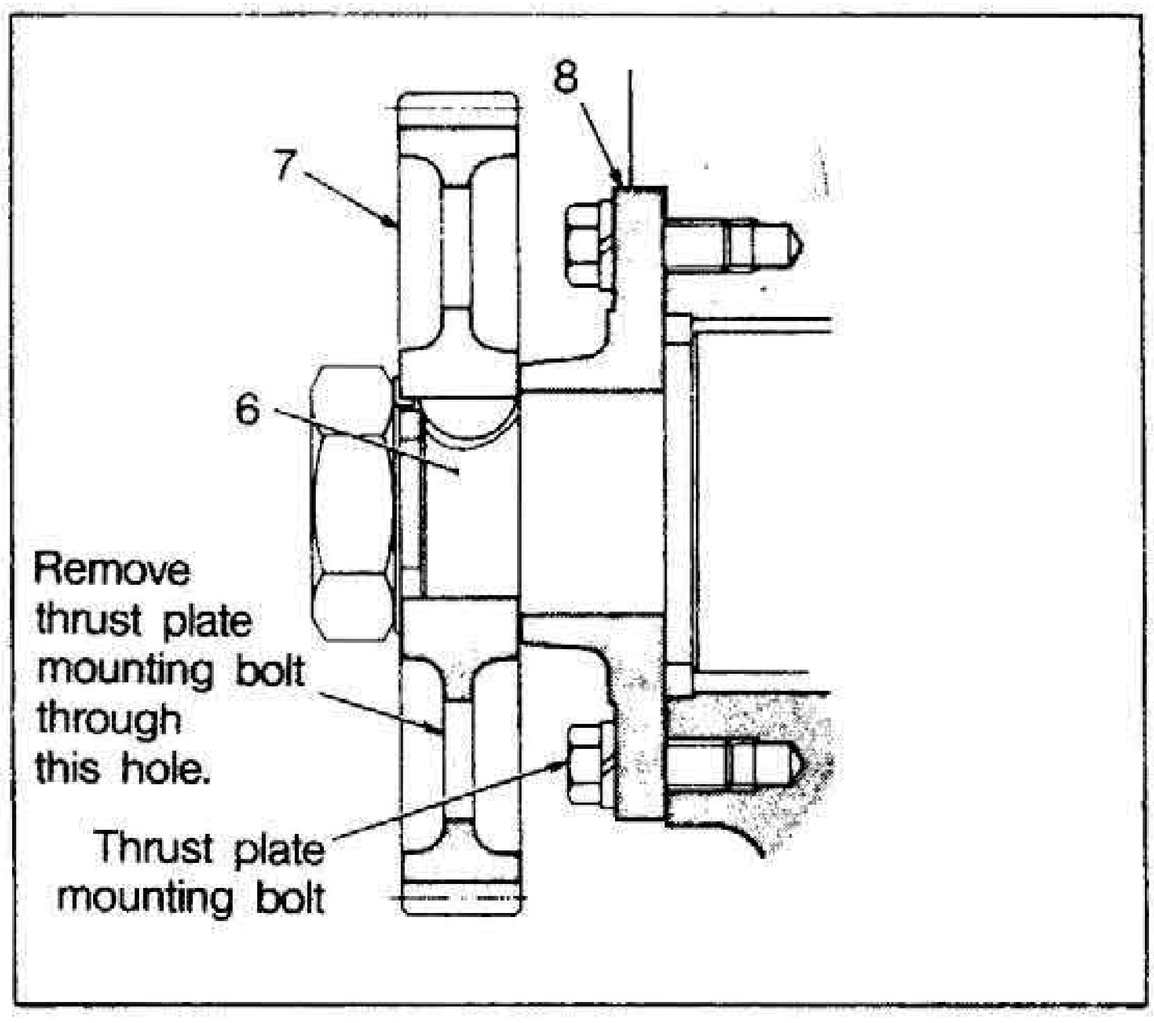


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(4) Measure the idler gear and camshaft gear end plays with a thickness gauge and dial indicator. If the readings are over the repair limit, replace the thrust plate.

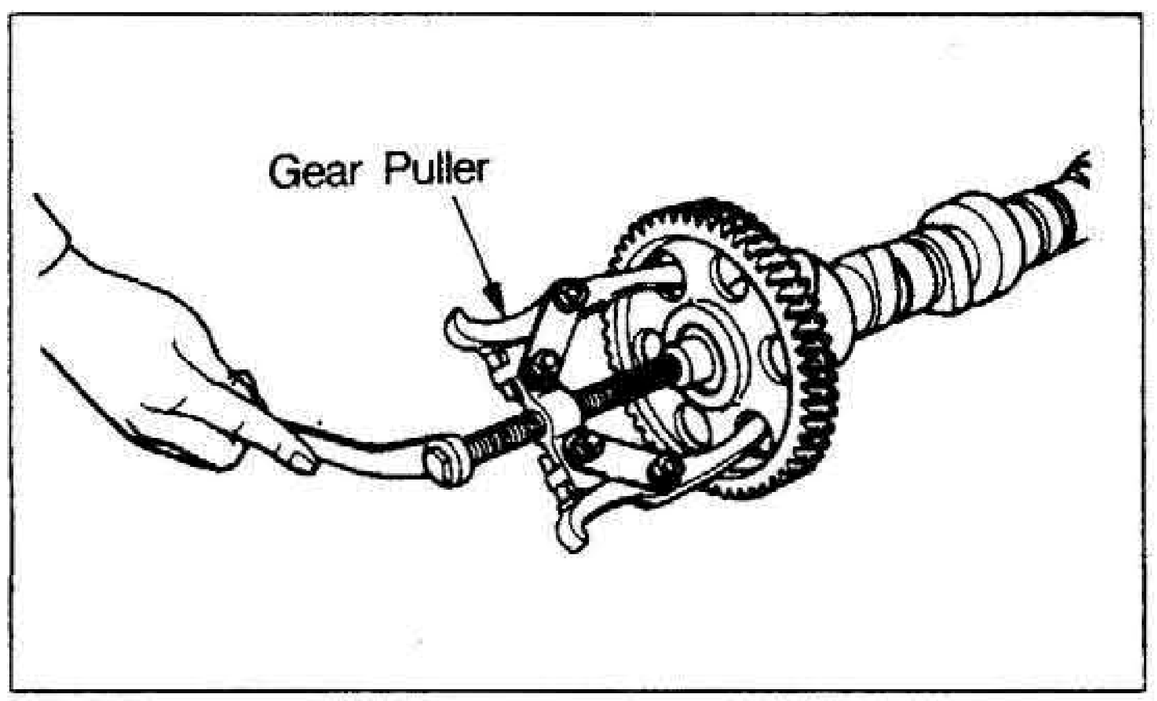


(5) Loosen the thrust plate mounting bolt through the camshaft gear hole and remove the camshaft 6.



(6) Remove the lock nut and lock washer of the camshaft gear and withdraw the camshaft gear 7 with Gear Puller(special tool).

Remove the thrust plate 8.



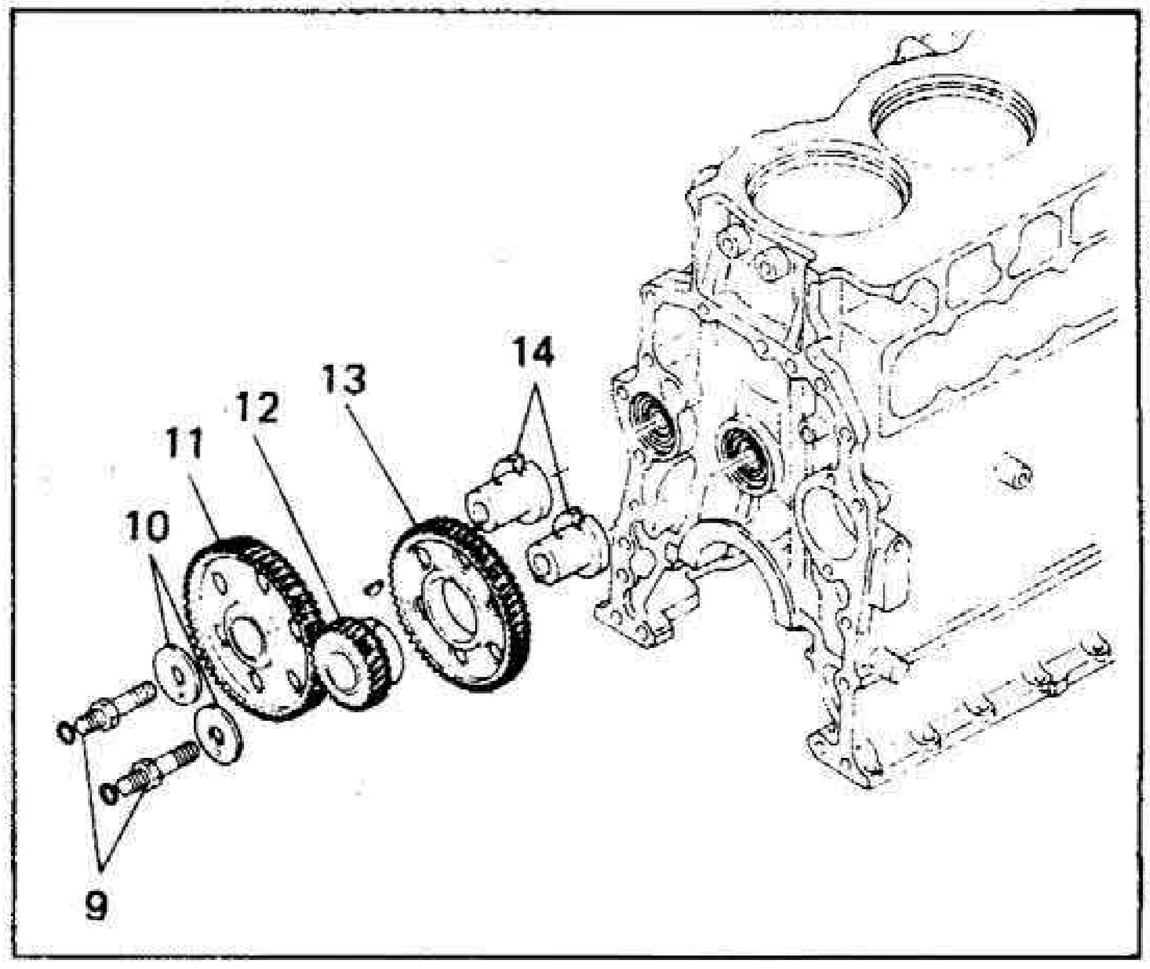
NOTE : 1. Do not remove the gears unless trouble is evident.

2. Do not strike the gears with a hammer. Make sure that the gears are removed by use of a gear puller.

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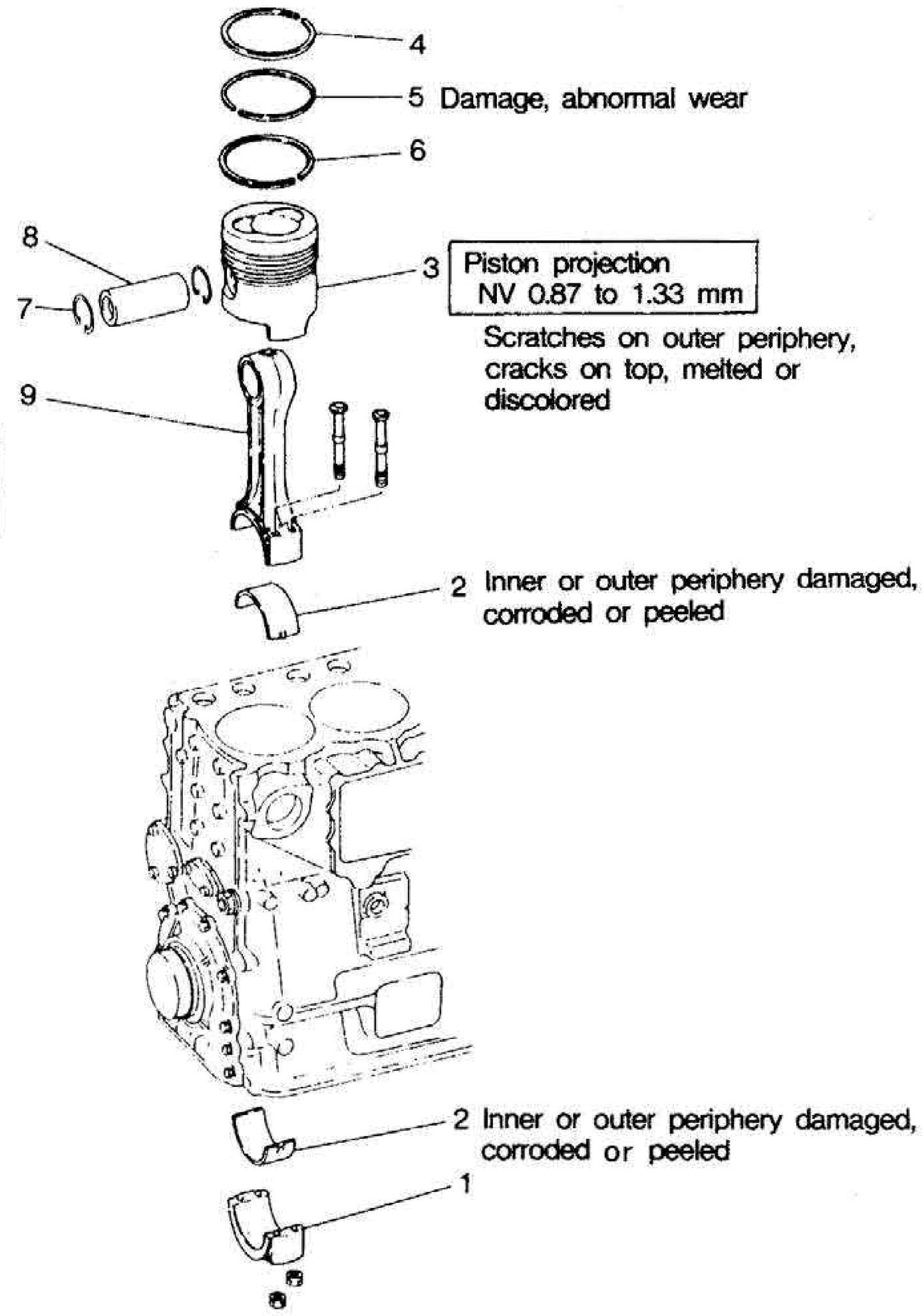
(7) Remove the following parts.

9 Idler shaft bolt
10 Thrust plate
11 Idler gear "C"
12 Idler gear "A"
13 Idler gear "B"
14 Idler shaft



7-1-3 Crankcase and Main Moving Parts

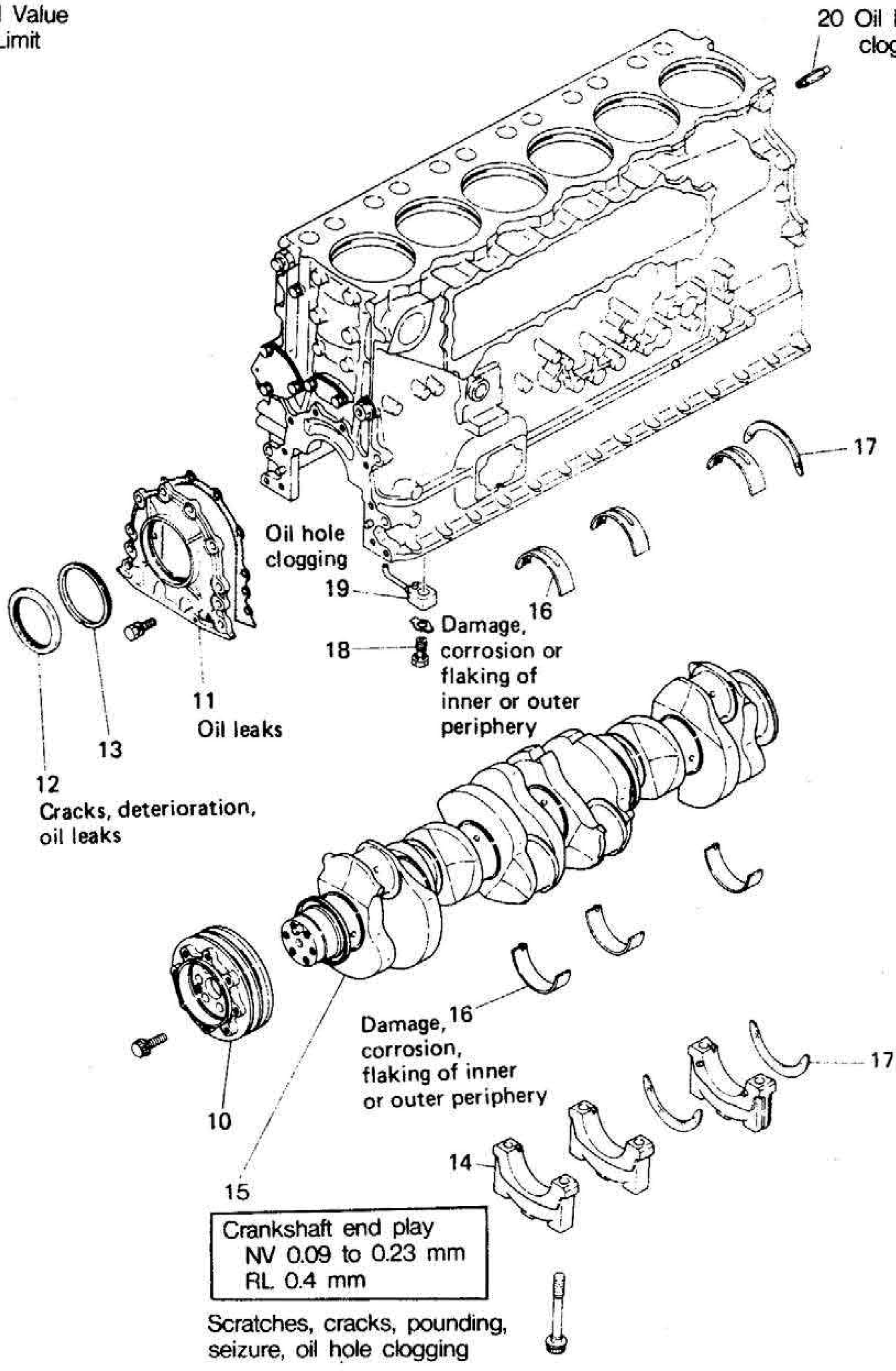
NV···Nominal Value
SL···Service Limit



1 Connecting rod cap
2 Connecting rod bearing
3 Piston
4 1st compression ring
5 2nd compression ring
6 Oil ring
7 Snap ring
8 Piston Pin
9 Connecting rod

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NV···Nominal Value
RL···Repair Limit



10 Crankshaft pulley
11 Front cover
12 Oil seal
13 Seal plate
14 Main bearing cap
15 Crankshaft
16 Main bearing
17 Thrust plate
18 Check valve
19 Oil jet
20 Oil spray plug

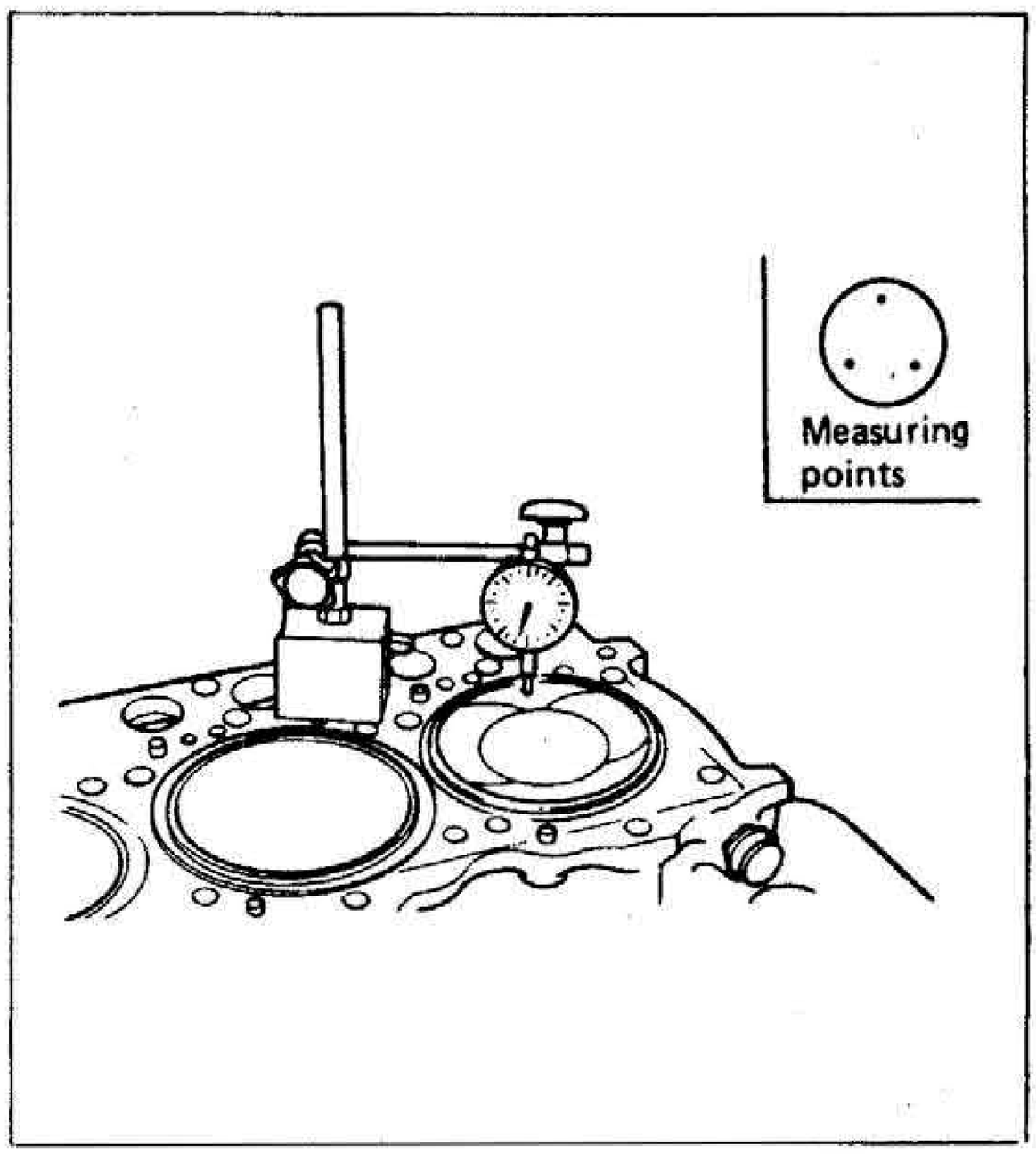
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(1) Measure the projection of each piston by the following procedures. If the readings are out of specification, check all clearances.

(a) Hold the dial indicator to the top surface of the crankcase and make zero adjustment.

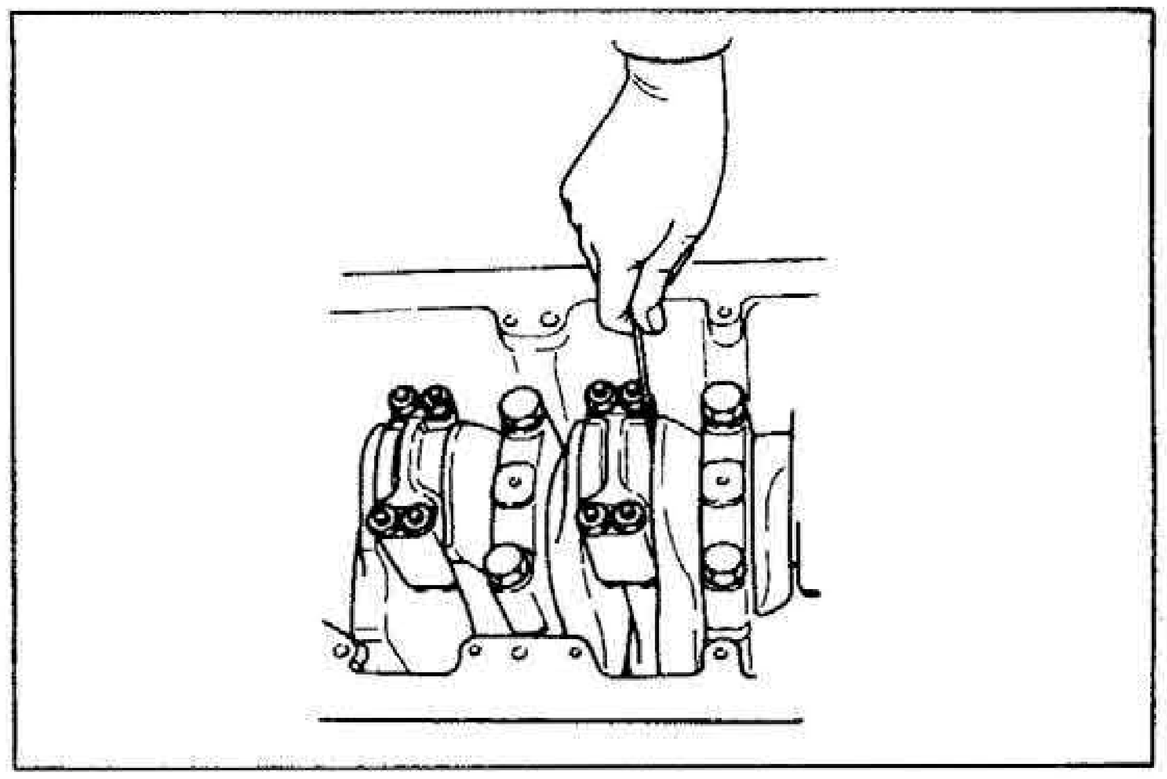
(b) Find the top dead center of piston with a dial indicator.

(c) Measure three points on the top surface of piston to find the average value.



NOTE : Make sure that the piston projection is up to specification, because an incorrect projection could cause adverse effects on engine performance.

(2) Measure the end play of each connecting rod. If the service limit is exceeded, replace the connecting rod.



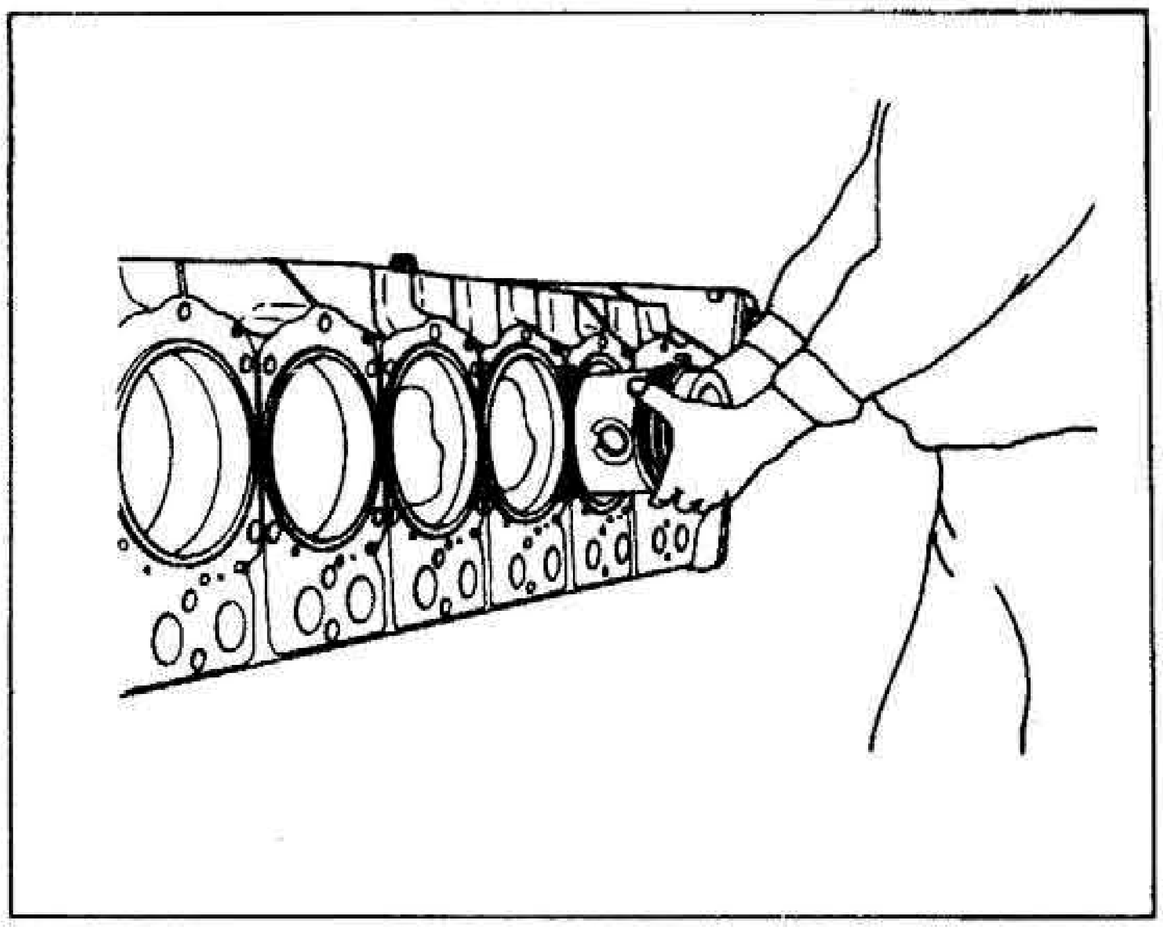
(3) Remove the following parts.

1 Connecting rod cap

2 Connecting rod bearing

3 Piston

NOTE : When withdrawing the piston from the crankcase by pushing up together with the connecting rod use care to prevent damage to the cylinder liner.



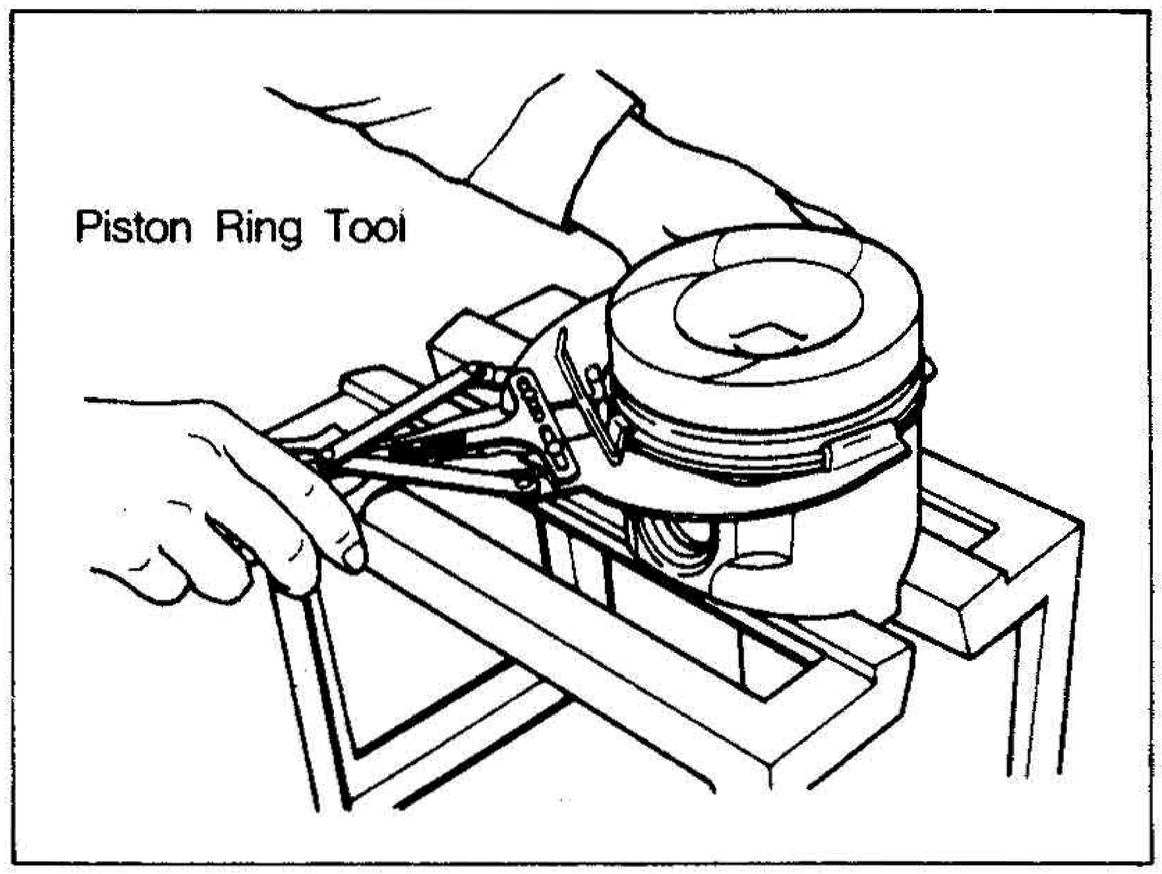
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(4) Remove the piston rings, using piston Ring Tool(special tool).

4 1st compression ring

5 2nd compression ring

6 Oil ring



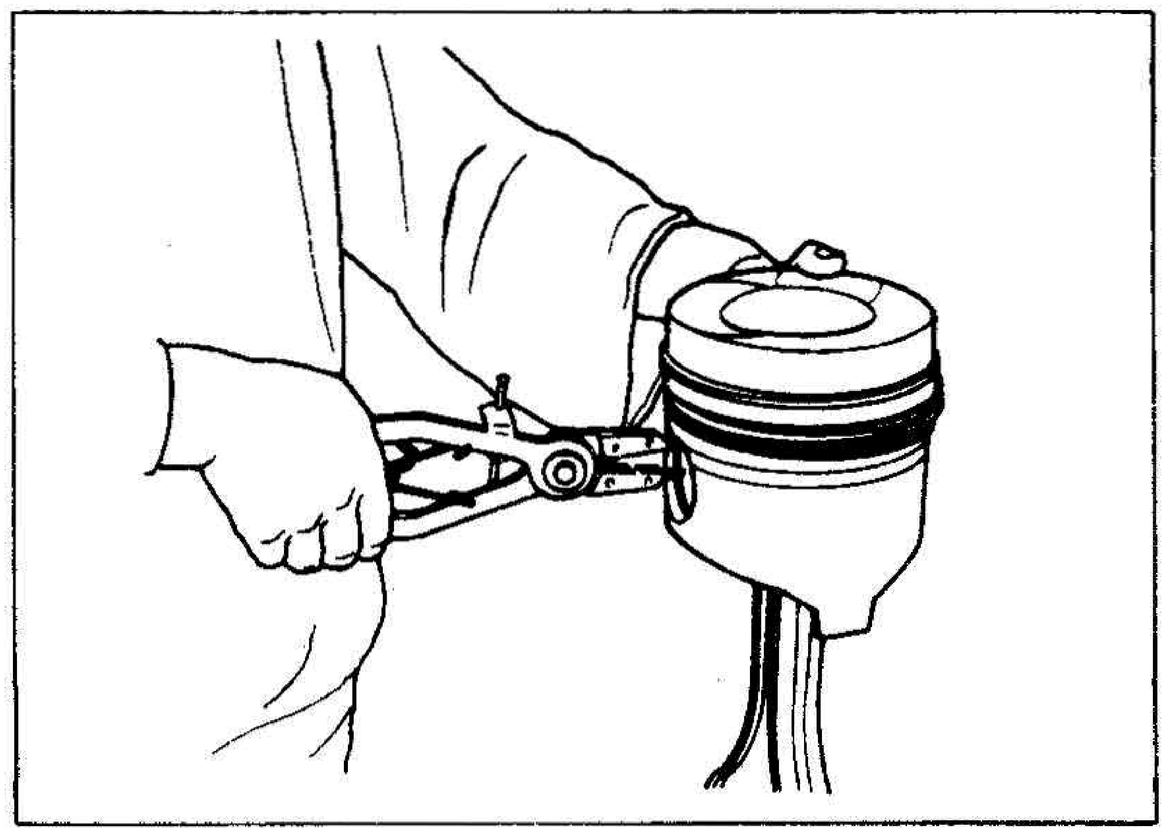
(5) Remove the following parts.

7 Snap ring

8 Piston pin

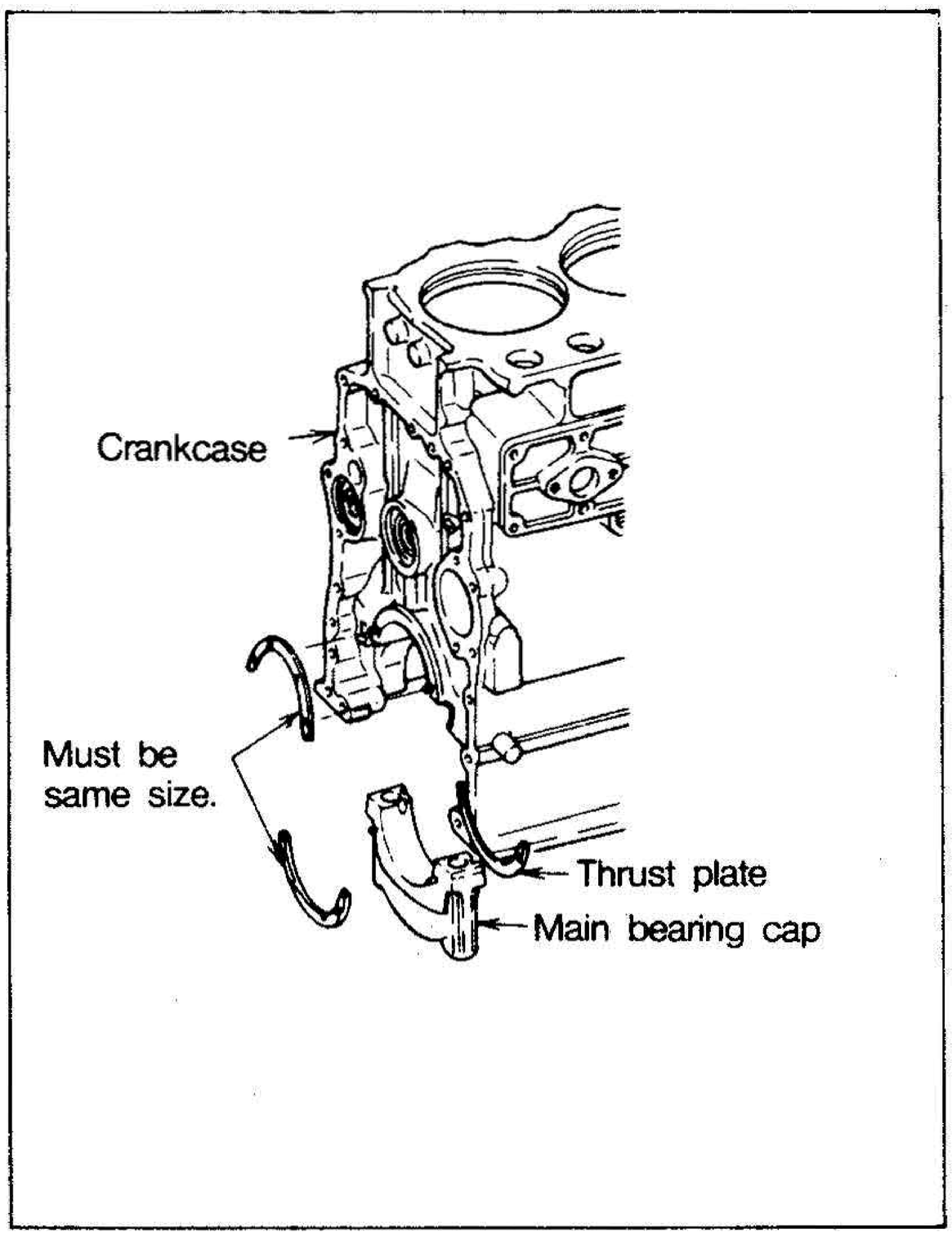
9 Connecting rod

If the piston pin is hard to remove, heat it with a piston heater or in hot water.



(6) Measure the end play of crankshaft. If the reading is in excess of the repair limit, replace the thrust plate with an oversize one.

There are three kinds of oversize thrust plates ; +0.15, +0.30 and +0.45mm.



The thrust plates on both sides of the bearing cap need not be the same size. However, the thrust plate on the rear end of the crankcase and the one on the rear side of the bearing cap must be the same size.

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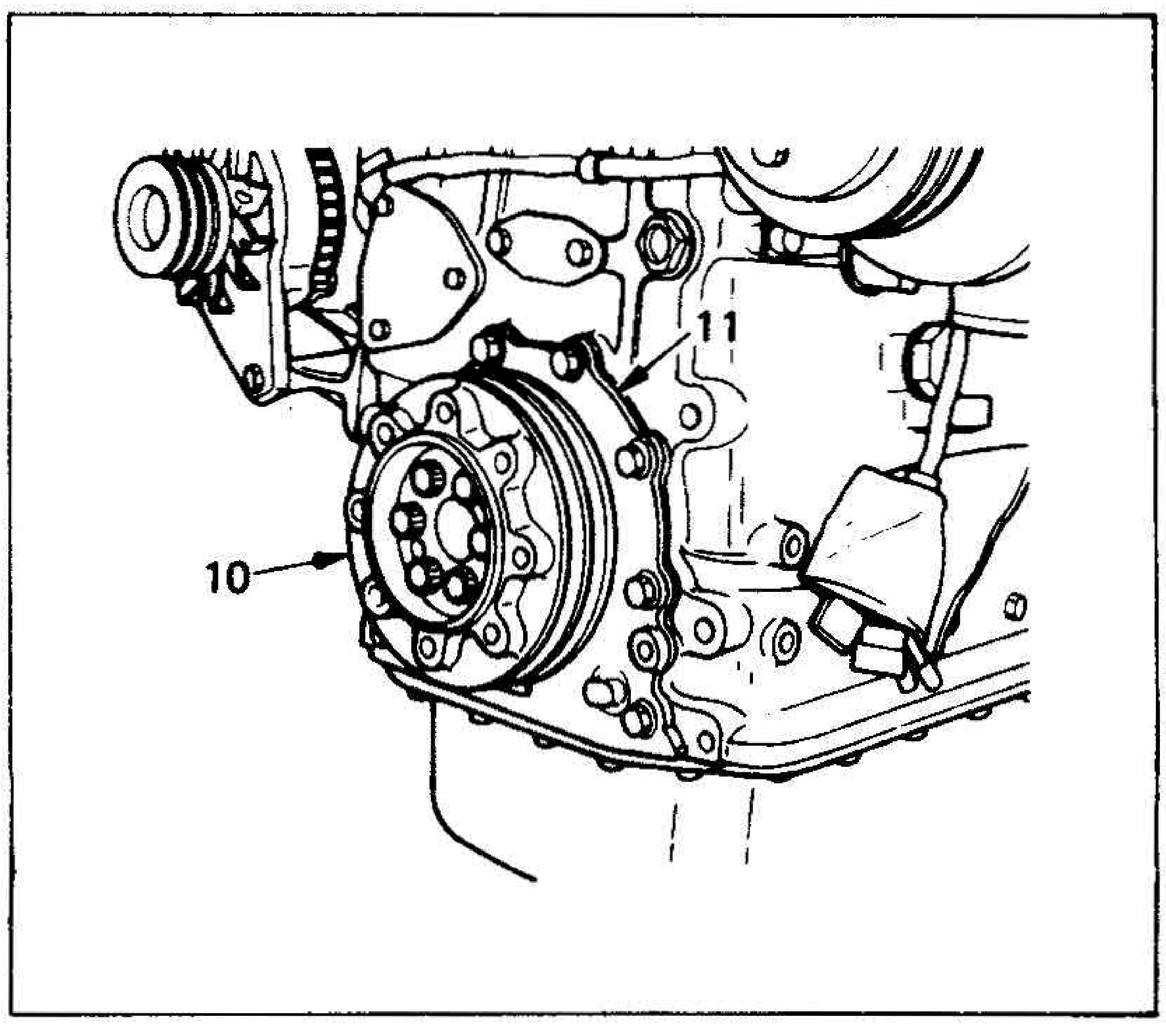
(7) Remove the following parts.

10 Crankshaft pulley

11 Front cover

The crankshaft pulley should be removed by threading the removed bolt into the removing threaded hole.

NOTE : The oil seal 12 and seal plate 13 need not be removed unless trouble is evident.



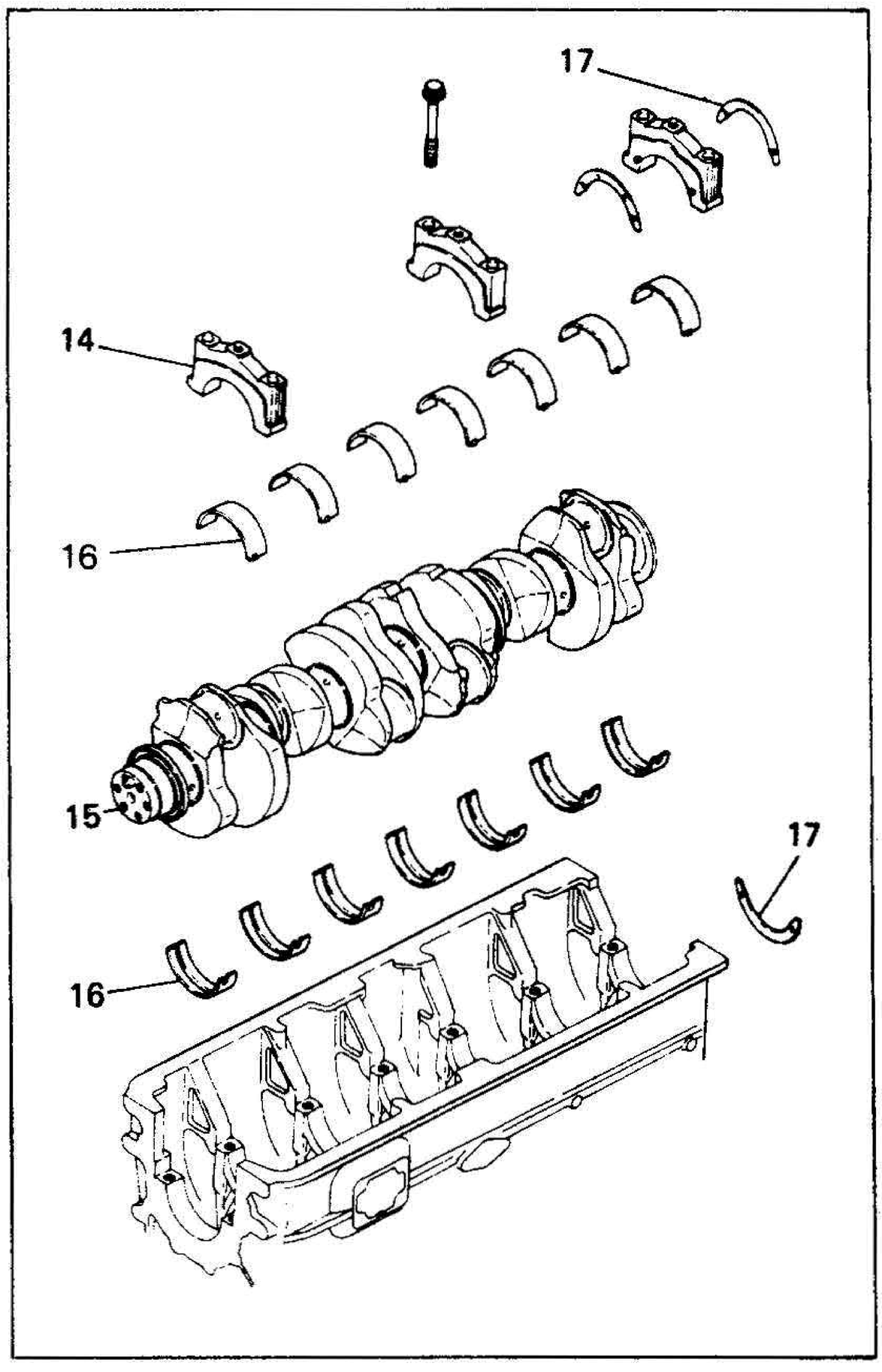
(8) Remove the following parts.

14 Main bearing cap

15 Crankshaft

16 Main bearing

17 Thrust plate

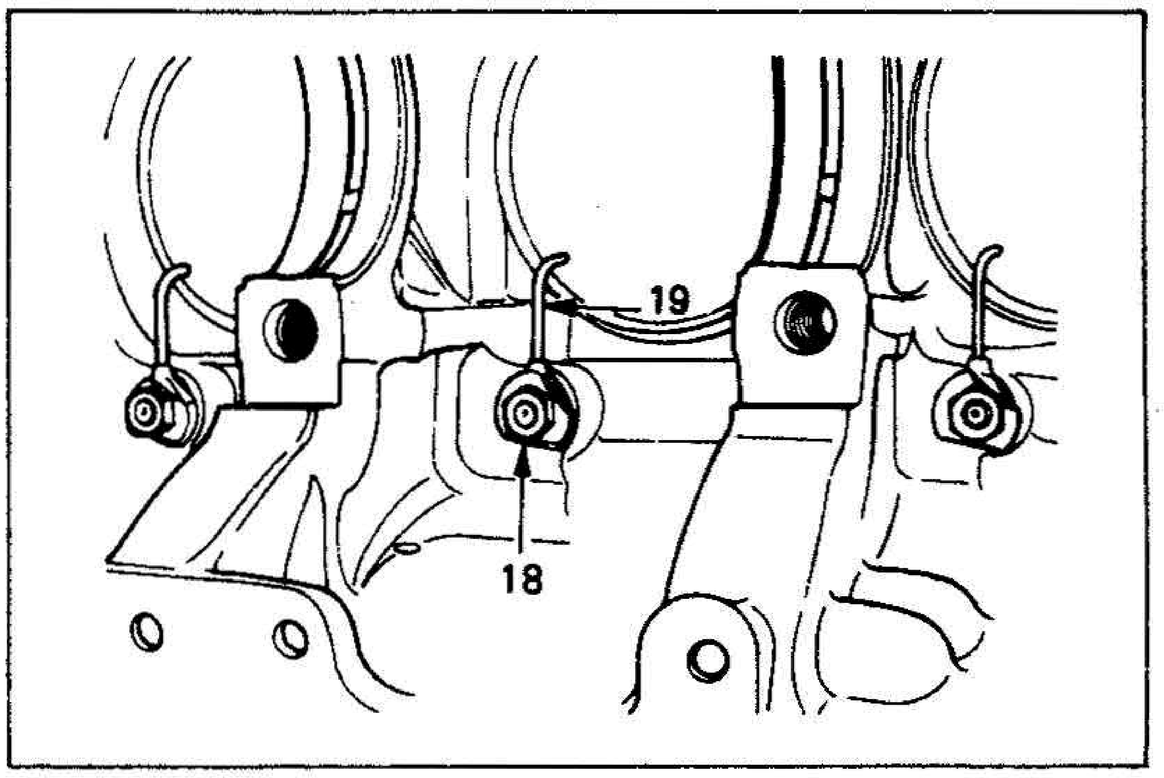


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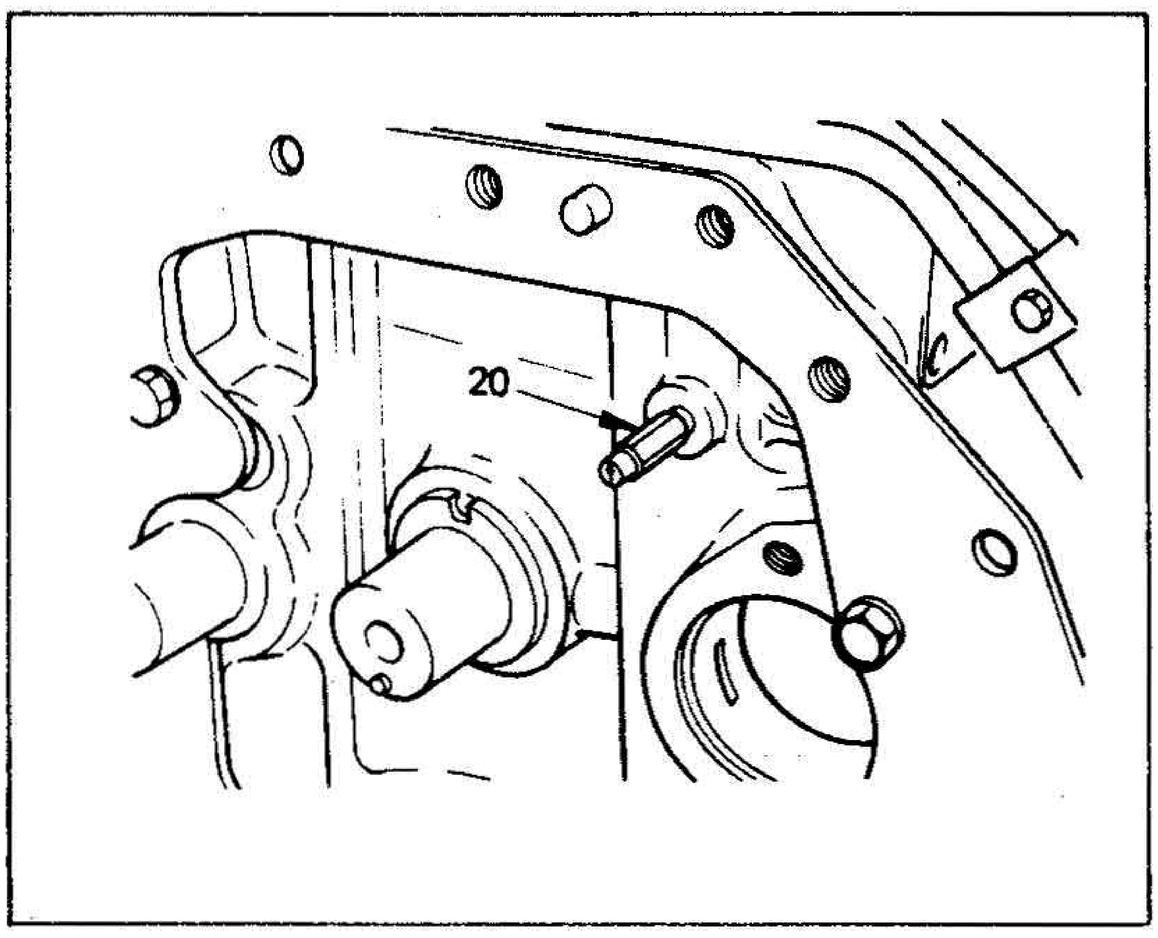
(9) Remove the following parts.

18 Check valve

19 Oil jet



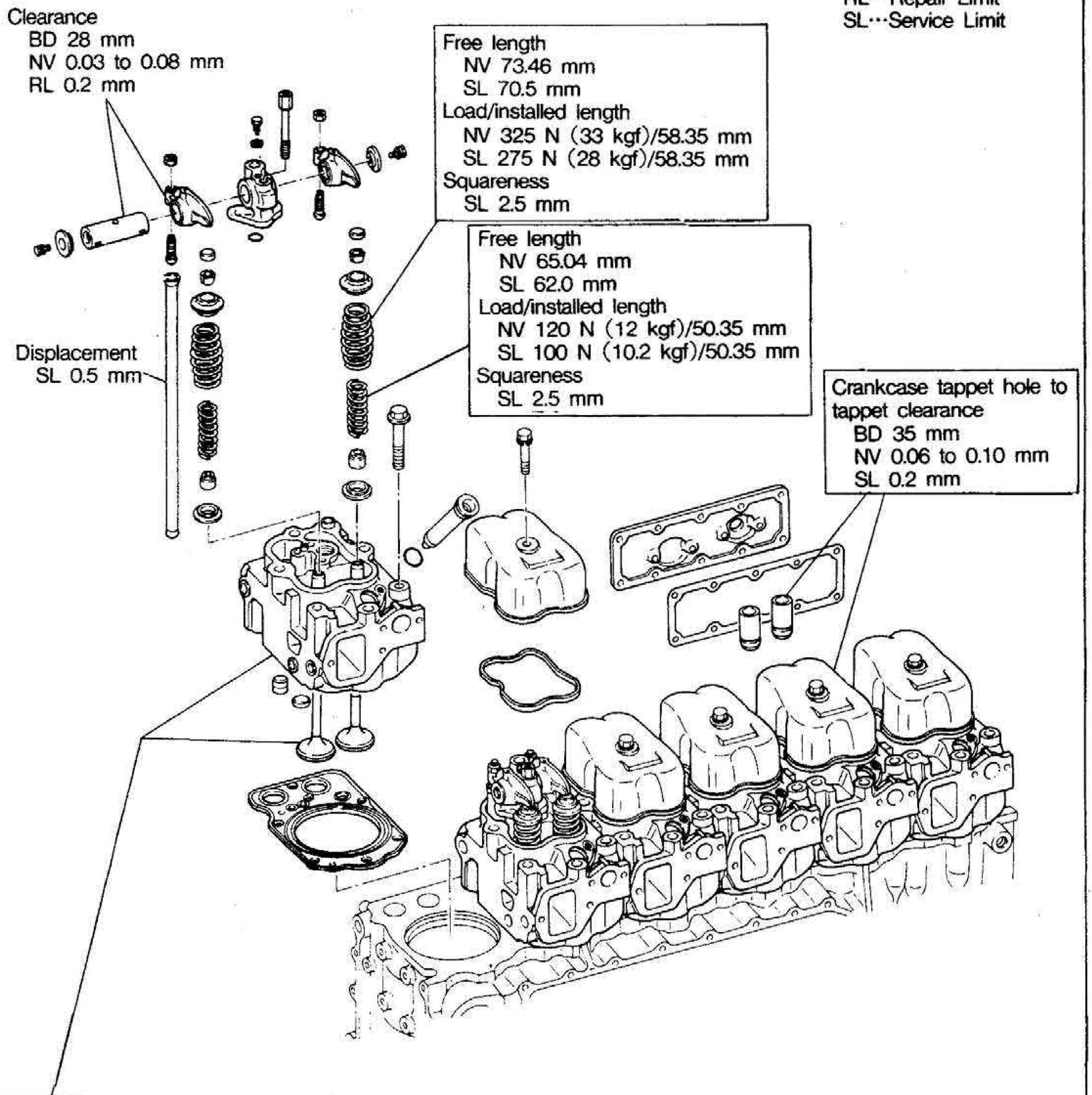
(10) Remove the oil spray plug 20 and check to ensure that the oil hole is not clogged.



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7-2 INSPECTION AND CORRECTION

BD···Basic Diameter
NV···Nominal Value
RL···Repair Limit
SL···Service Limit

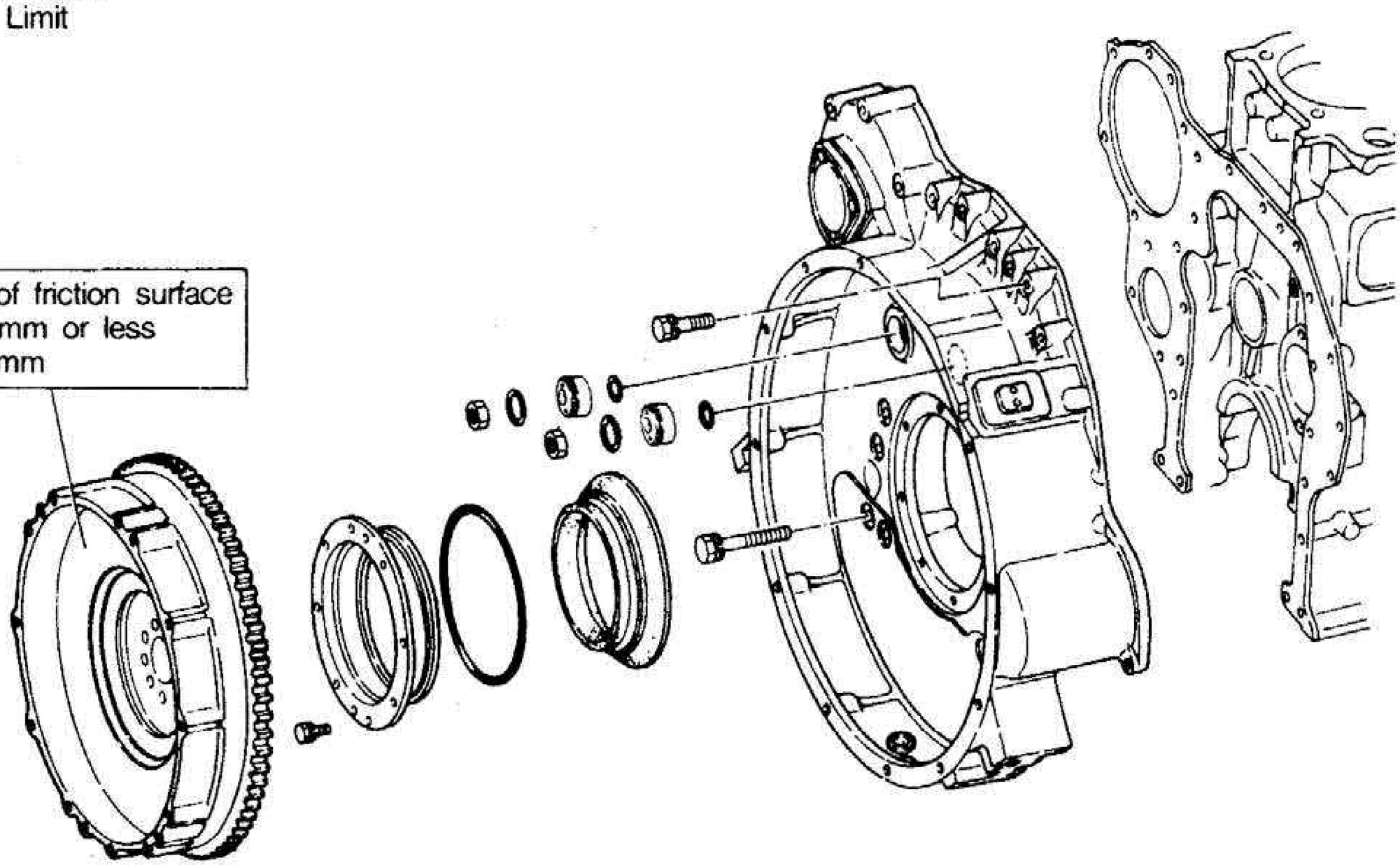


Valve stem O.D Inlet valve NV 11.95 to 11.96 mm SL 11.85 mm Exhaust valve NV 11.91 to 11.93 mm SL 11.85 mm	Valve margin Inlet NV 2.2 mm SL 1.7 mm Exhaust NV 2.5 mm SL 2.0 mm
Valve guide to valve stem clearance Inlet valve BD 12 mm NV 0.05 to 0.09 mm SL 0.2 mm Exhuast valve BD 12 mm NV 0.09 to 0.12 mm SL 0.2 mm	Sinkage of valve from bottom surface of cylinder head Inlet valve NV 0.25 to 0.75 mm SL 1.0 mm Exhaust valve NV −0.05 to 0.45 mm SL 0.7 mm
Valve seat insert seat width NV 2.69 to 2.96 mm RL 3.5 mm	Distortion of cylinder head bottom surface NV 0.07 mm RL 0.08 mm

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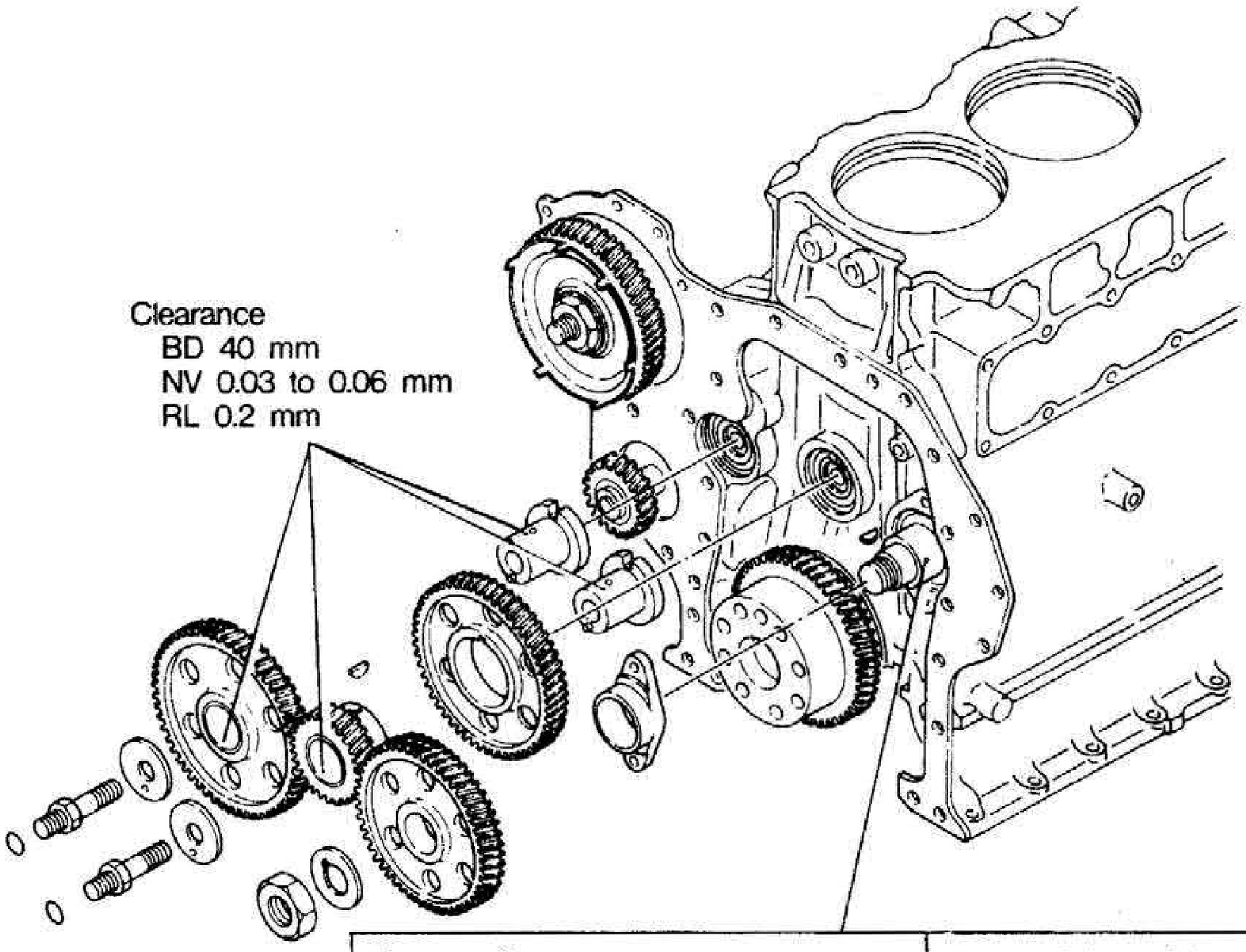
NV···Nominal Value
RL···Repair Limit

Distortion of friction surface
NV 0.1 mm or less
RL 0.2 mm



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BD···Basic Diameter
NV···Nominal Value
RL···Repair Limit
SL···Service Limit



Cam profile (difference between lobe height and base circle diameter)	
BD	
(intake valve cam)	
Lobe height	56.167 mm
Base circle diameter	47.334 mm
(exhaust valve cam)	
Lobe height	56.036 mm
Base circle diameter	47.216 mm

Camshaft journal to bushing clearance	
BD No. 1	65.00 mm
No. 2	65.25 mm
No. 3, 4	65.50 mm
No. 5, 6	65.75 mm
No. 7	66 mm
NV 0.03 to 0.08 mm	
RL 0.25 mm	

Bend
NV 0.05mm or less
RL 0.08mm

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BD···Basic Diameter
NV···Nominal Value
RL···Repair Limit
SL···Service Limit

Open end clearance
NV 0.4 to 0.6 mm
SL 1.5 mm

Clearance
BD 50 mm
NV 0.01 to 0.02 mm
SL 0.1 mm

Piston ring groove to piston ring clearance
1st ring
NV 0.02 to 0.08 mm
SL 0.25 mm
2nd ring
NV 0.05 to 0.08 mm
SL 0.15 mm
Oil ring
NV 0.03 to 0.06 mm
SL 0.15 mm

Clearance
BD 50 mm
NV 0.02 to 0.05 mm
RL 0.1 mm

Clearance
BD 130 mm
NV 0.176 to 0.202 mm

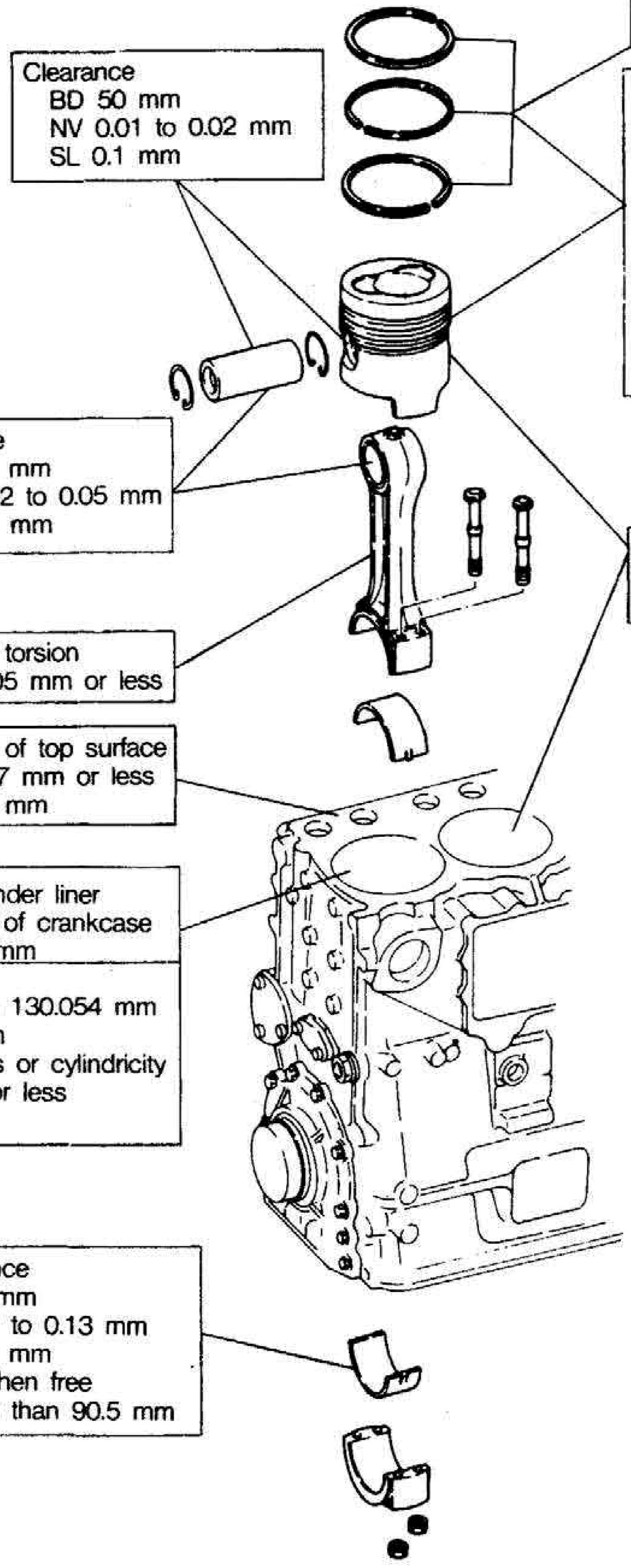
Bend or torsion
RL 0.05 mm or less

Distortion of top surface
NV 0.07 mm or less
RL 0.2 mm

Projection of cylinder liner from top surface of crankcase
NV 0 to 0.08 mm

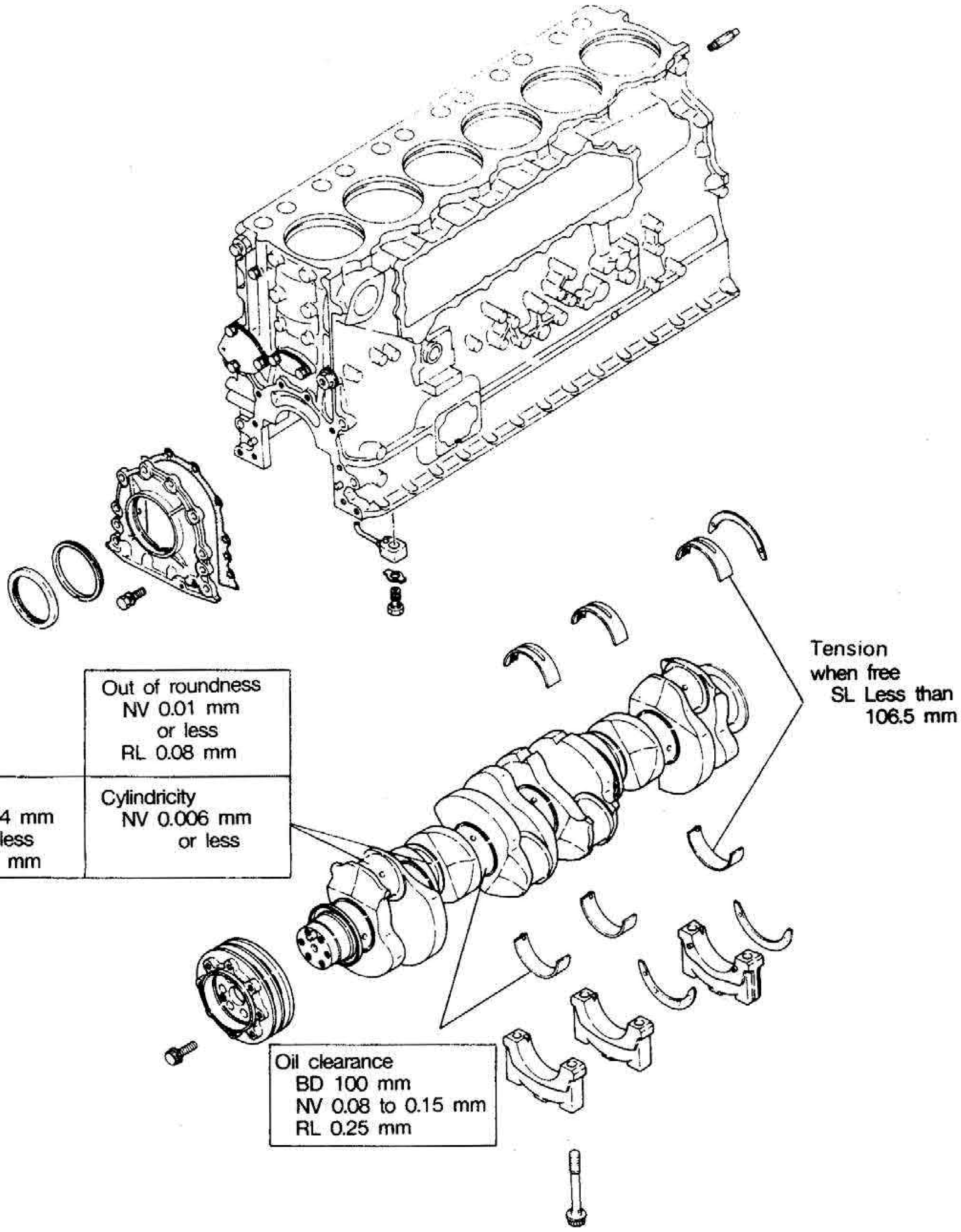
Inside diameter
NV 130.014 to 130.054 mm
RL 130.25 mm
Out of roundness or cylindricity
NV 0.02 mm or less
RL 0.03 mm

Oil clearance
BD 84 mm
NV 0.07 to 0.13 mm
RL 0.25 mm
Tension when free
SL Less than 90.5 mm



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BD···Basic Diameter
NV···Nominal Value
RL···Repair Limit
SL···Service Limit



Out of roundness
NV 0.01 mm
or less
RL 0.08 mm

Bend
NV 0.04 mm
or less
RL 0.1 mm

Cylindricity
NV 0.006 mm
or less

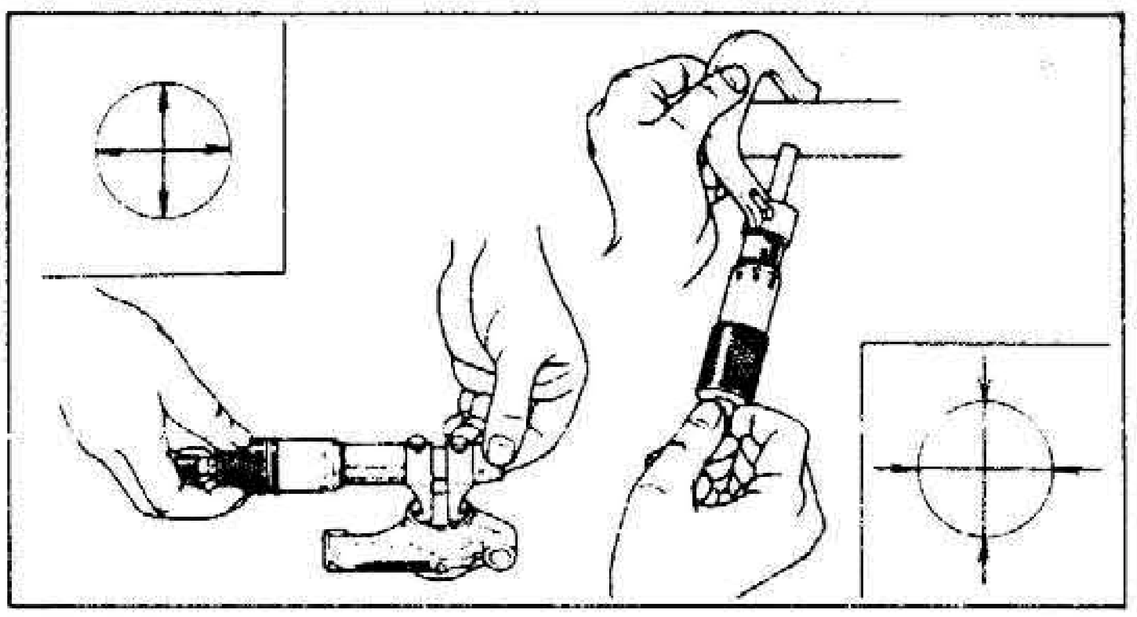
Tension
when free
SL Less than
106.5 mm

Oil clearance
BD 100 mm
NV 0.08 to 0.15 mm
RL 0.25 mm

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7-2-1 Valve Mechanism

(1) Calculate the clearance from the rocker I.D. and rocker shaft O.D. If the repair limit is exceeded, replace the bushing in the rocker.

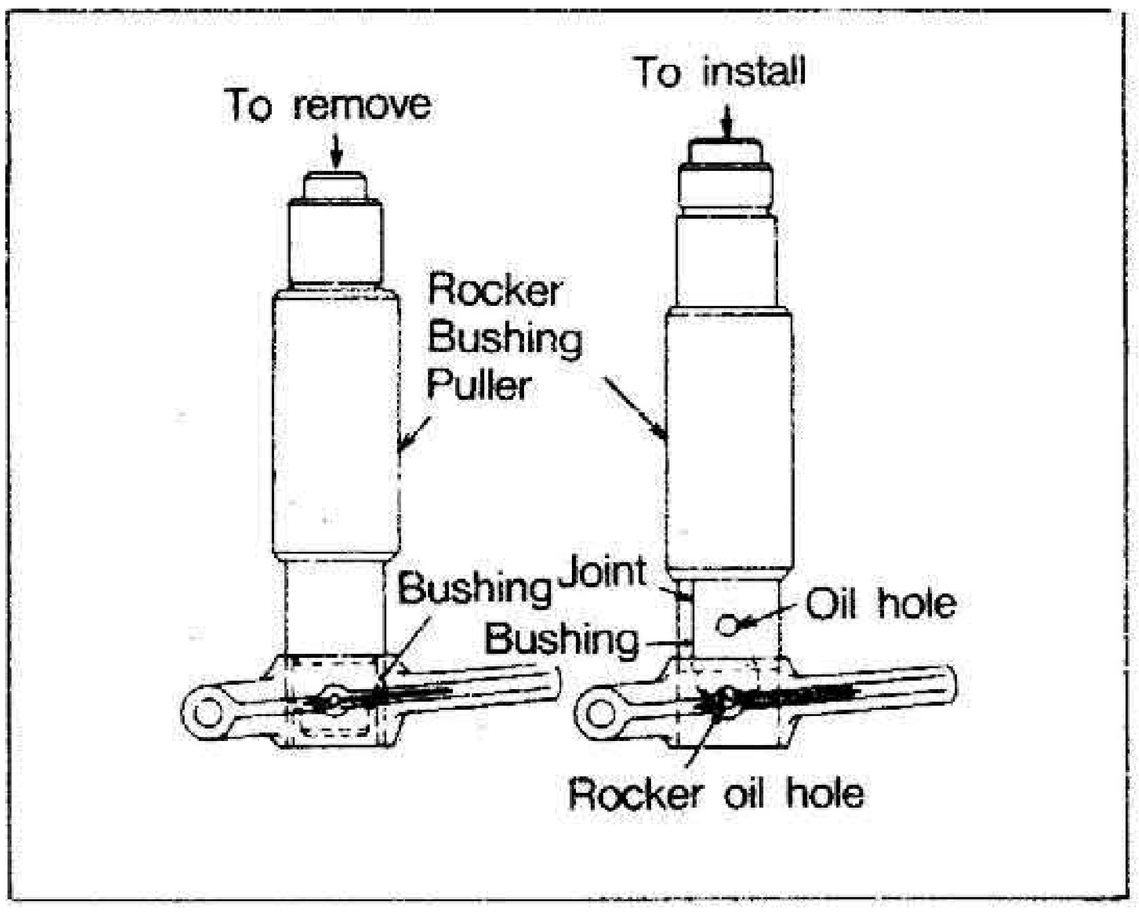


(2) Replacement of Rocker Bushing

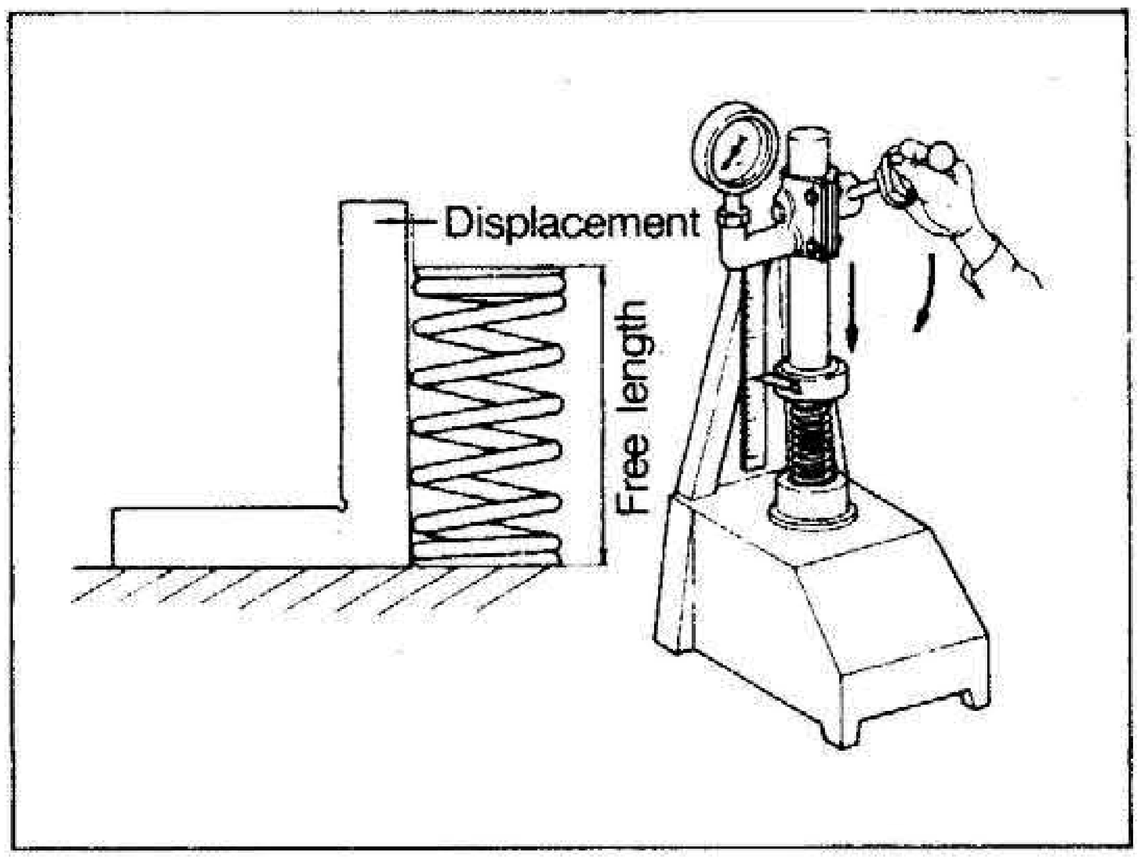
Replace the bushing by the procedures shown in illustration, using Rocker Bushing Puller(special tool).

NOTE : 1. Align the bushing and rocker oil holes.

2. Face the bushing joint toward the adjusting screw.

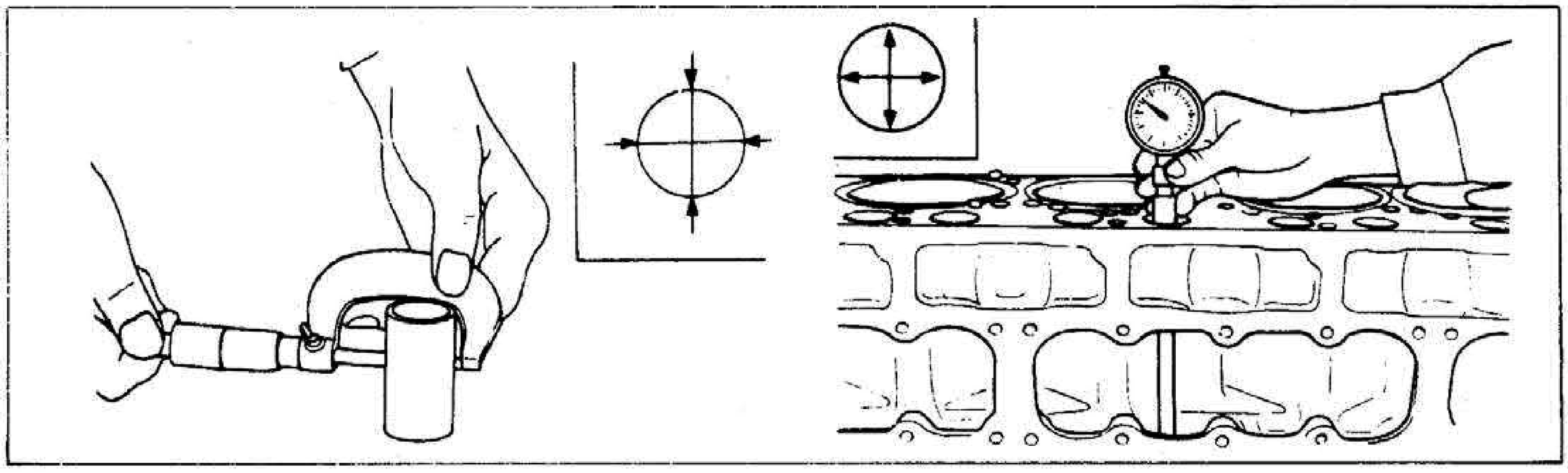


(3) Measure the displacement, free length, and installed length/load of the valve spring. If the service limit is exceeded, replace.

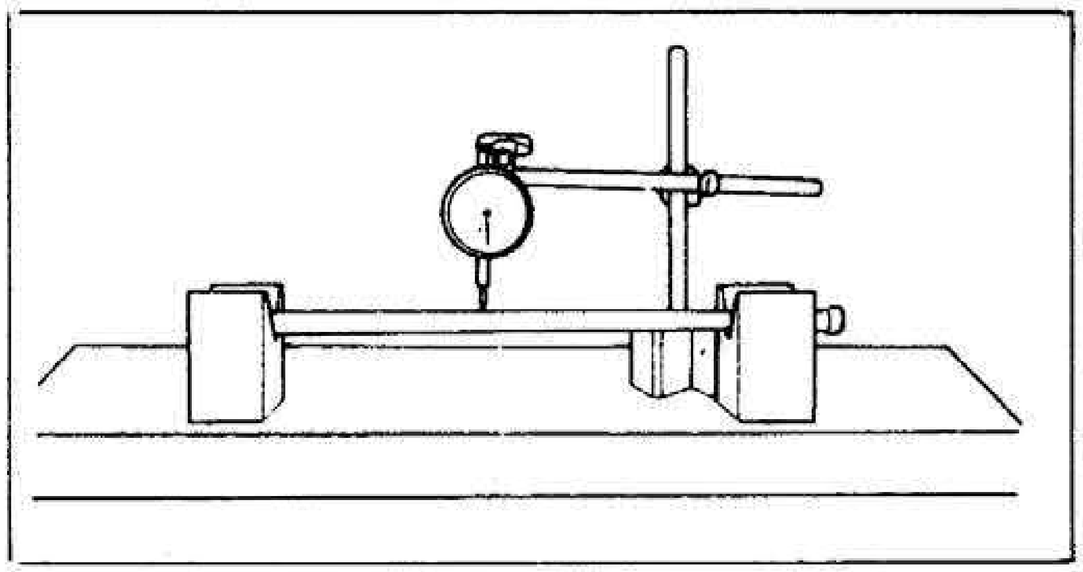


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(4) Measure the clearance from the tappet O.D. and crankcase I.D. If the service limit is exceeded, replace the tappet.



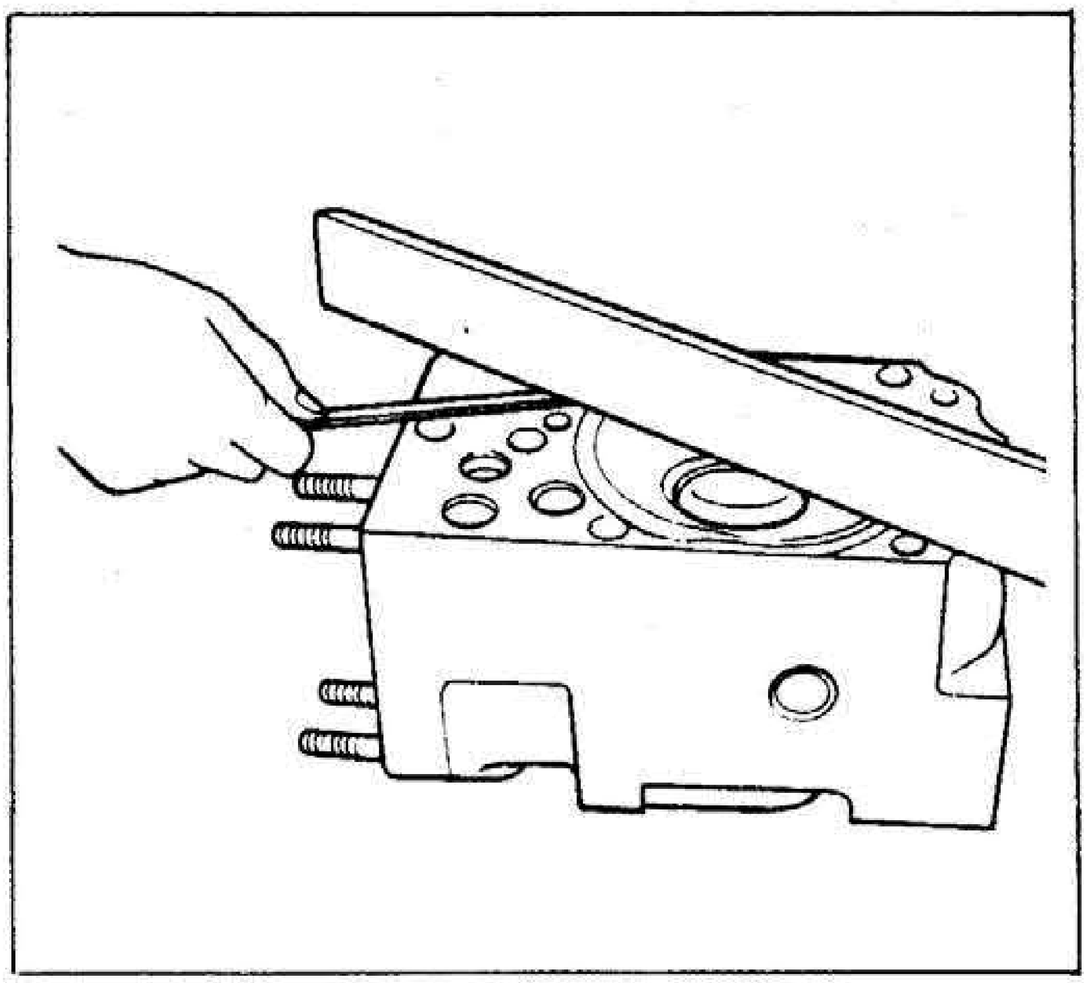
(5) Measure the push rod runout. If the service limit is exceeded, replace.



7-2-2 Cylinder Head, Valve and Valve Seat Insert

(1) Measure the cylinder head bottom surface distortion. If the repair limit is exceeded, correct the distortion with a surface grinder.

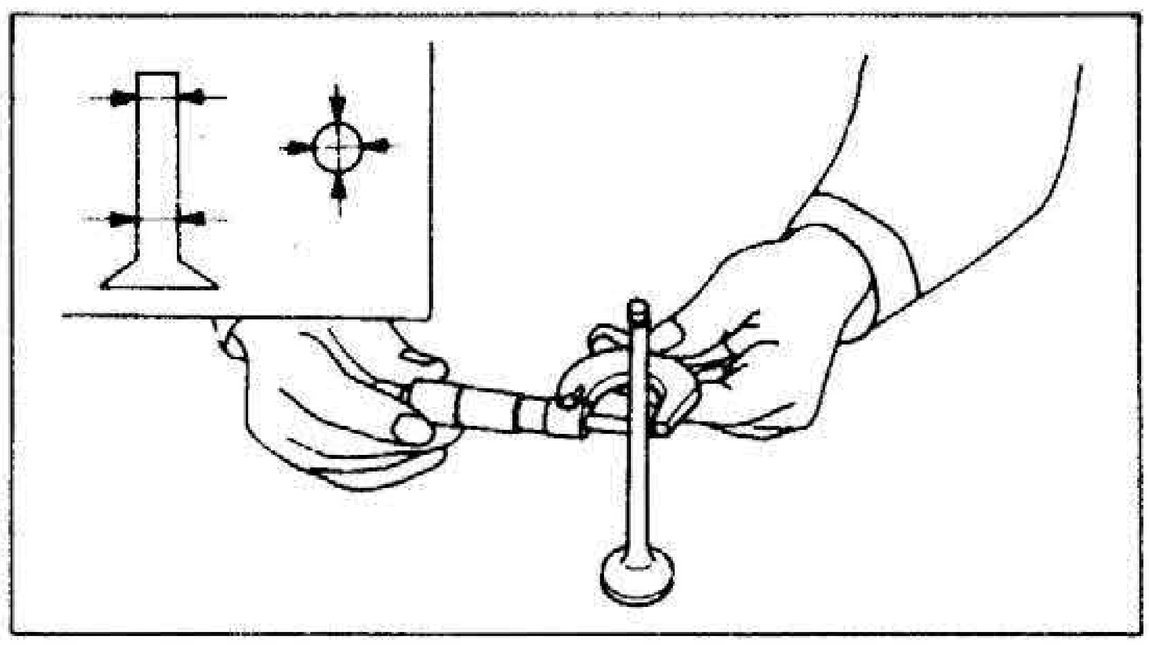
NOTE : The height from the top to bottom surface of the cylinder head after grinding must be more than 129.8mm.



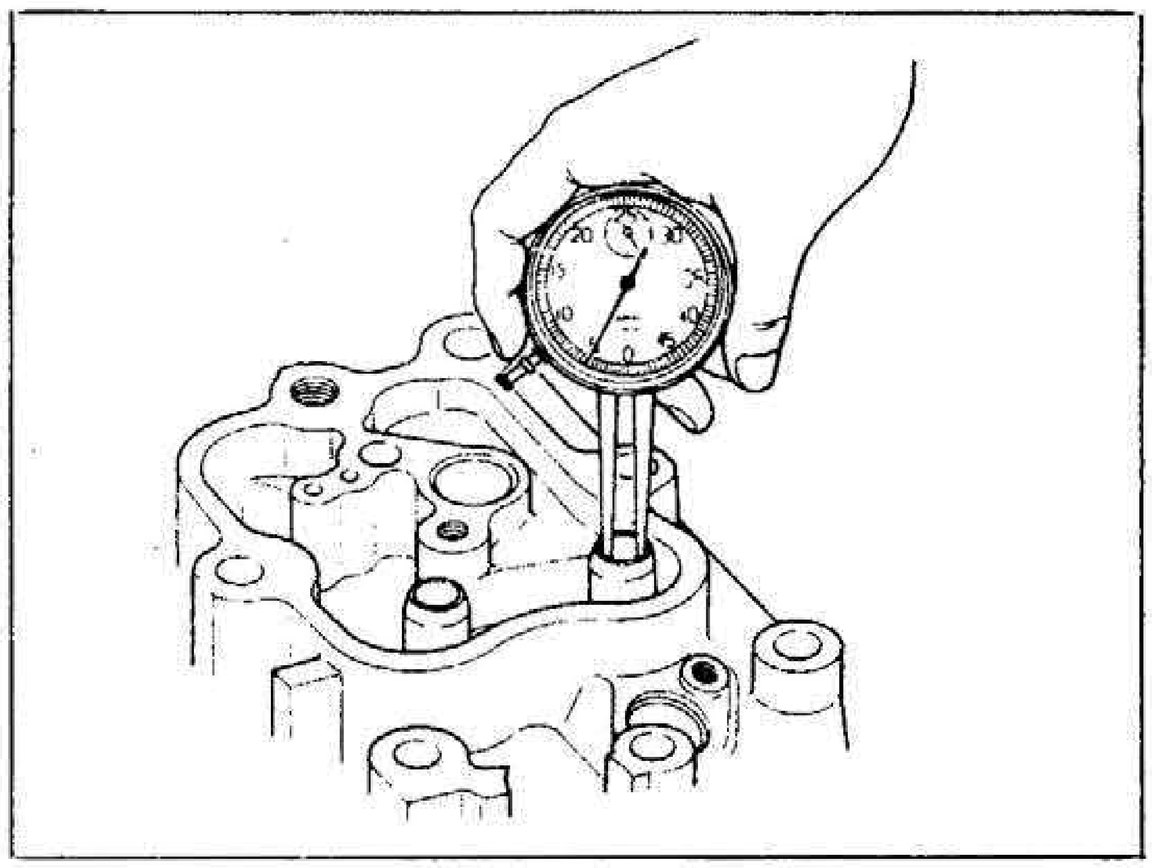
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(2) Measure the valve stem O.D. If it is smaller than the service limit, replace.

An excessively unevenly worn stem should also be replaced.



(3) Calculate the clearance from the valve guide I.D. and valve stem O.D. If the service limit is exceeded, replace the valve guide.

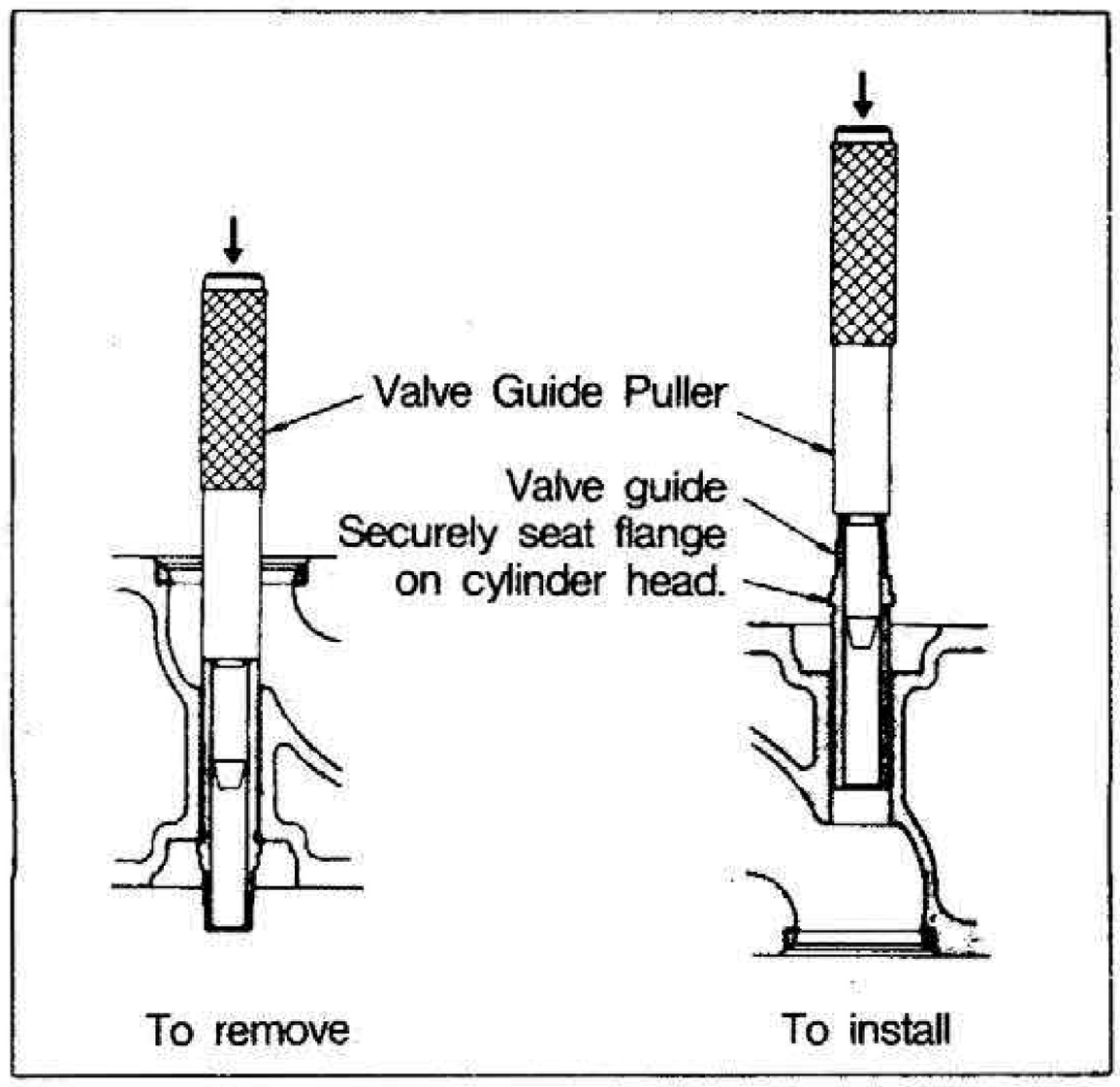


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(4) Replacement of Valve Guide

Using Valve Guide Puller(special tool), replace the valve guide.

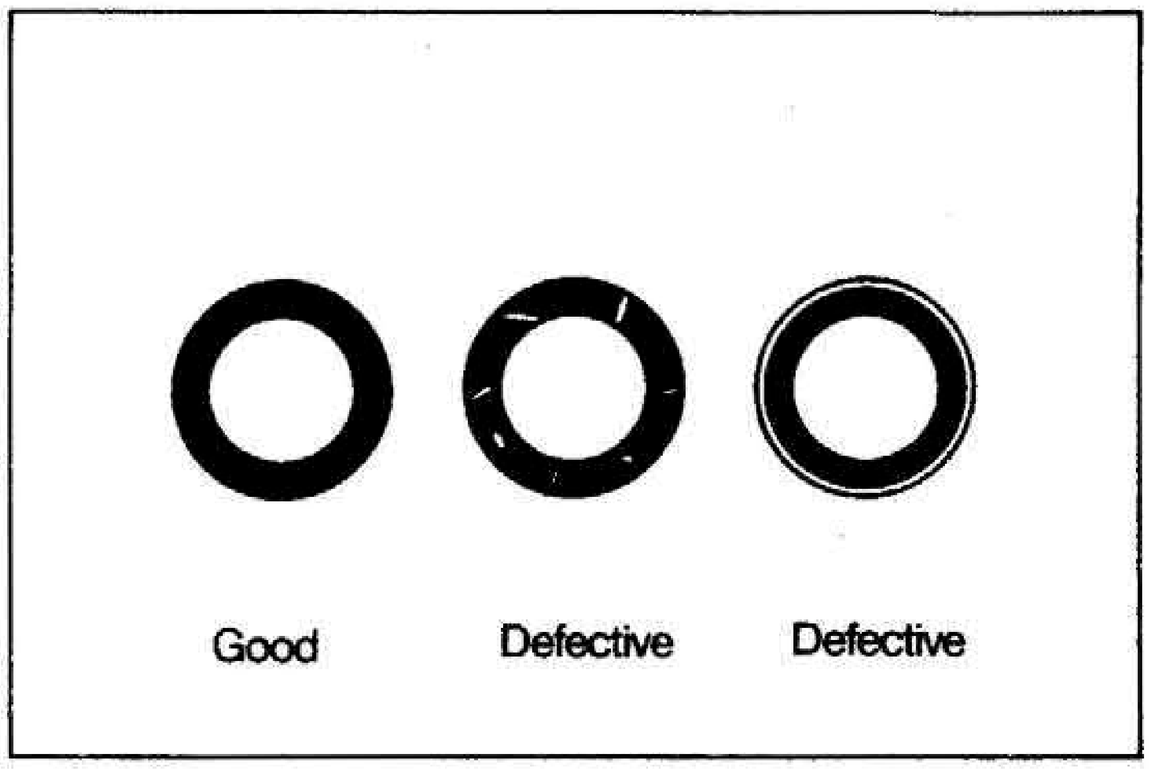
NOTE : When the valve guide is installed, make sure that the valve guide flange is securely seated on the cylinder head.



(5) Check the contacting condition of the valve seat insert and valve. If anything wrong is noted, correct or replace the valve seat insert and valve.

NOTE : 1. The contacting condition should be checked after inspection/replacement of the valve guide.

2. When the valve is pressed against a red lead coated valve seat insert, make sure that the valve is not turned.

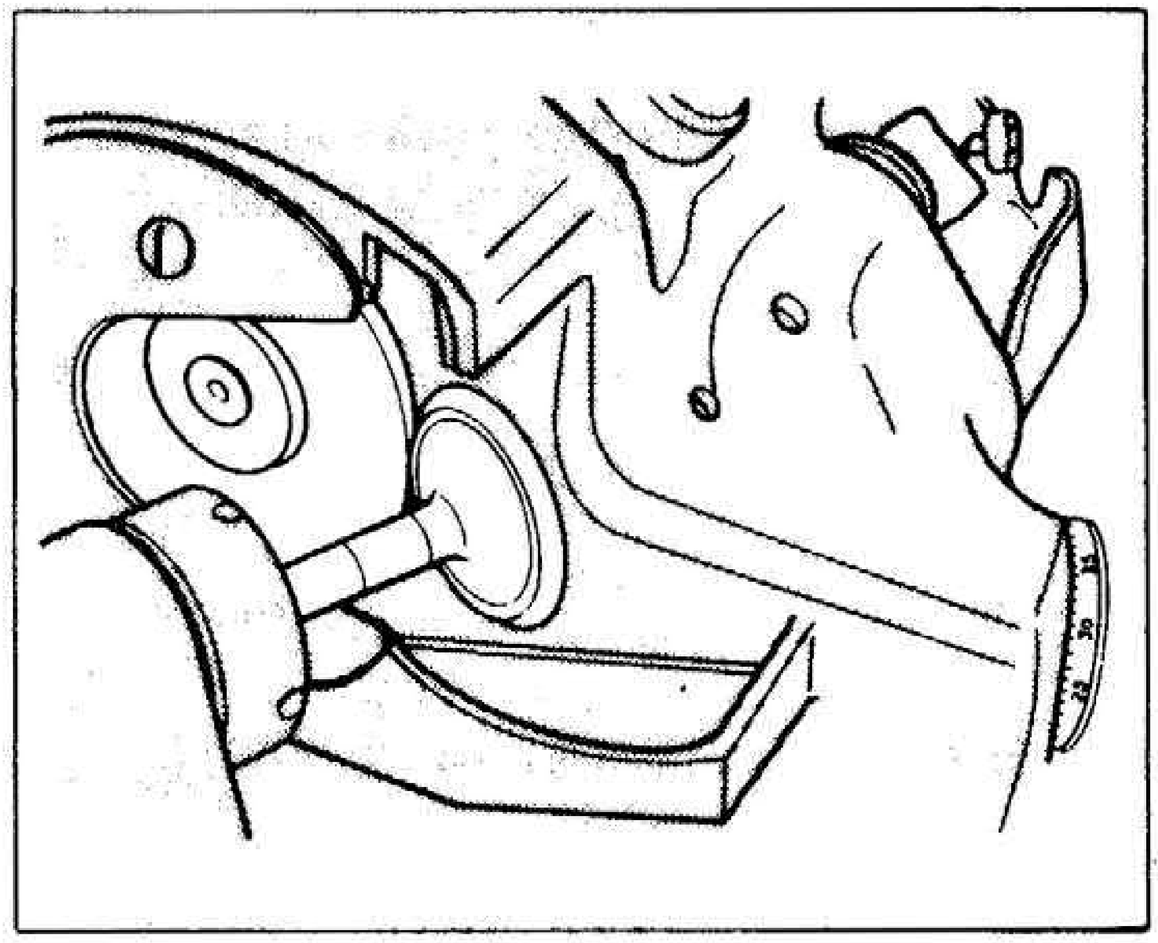


(6) Correction of Valve Face

Grind the valve face with a valve refacer. The grinding should be limited to a minimum.

NOTE : 1. The valve seat angle is 45°.

2. Secure a valve margin of more than 1.7mm for inlet valves and more than 2.0mm for exhaust valves. If these margins cannot be secured after grinding and correction, replace.



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(7) Correction of Valve Seat Insert

(a) Grind with a valve seat cutter or a valve seat grinder.

(b) After machining, lightly grind by holding about #400 sandpaper between the cutter and valve seat.

NOTE : 1. The valve seat angle is 45°.

2. If the valve sinkage is beyond the service limit, replace the valve seat insert.

(c) Correct the seat width to the nominal dimension, using a 15° cutter.

(d) Seat the valve and valve seat insert. Refer to Para.(9).

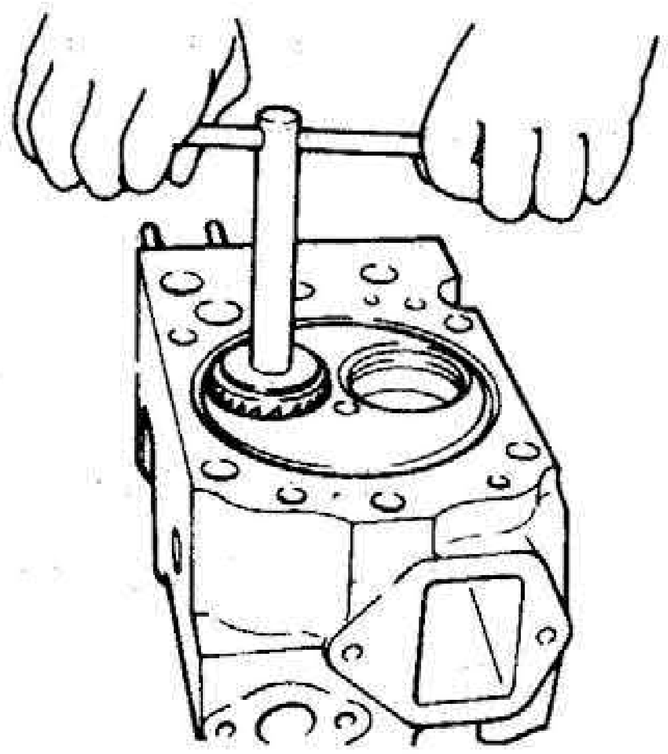
(8) Replacement of Valve Seat Insert

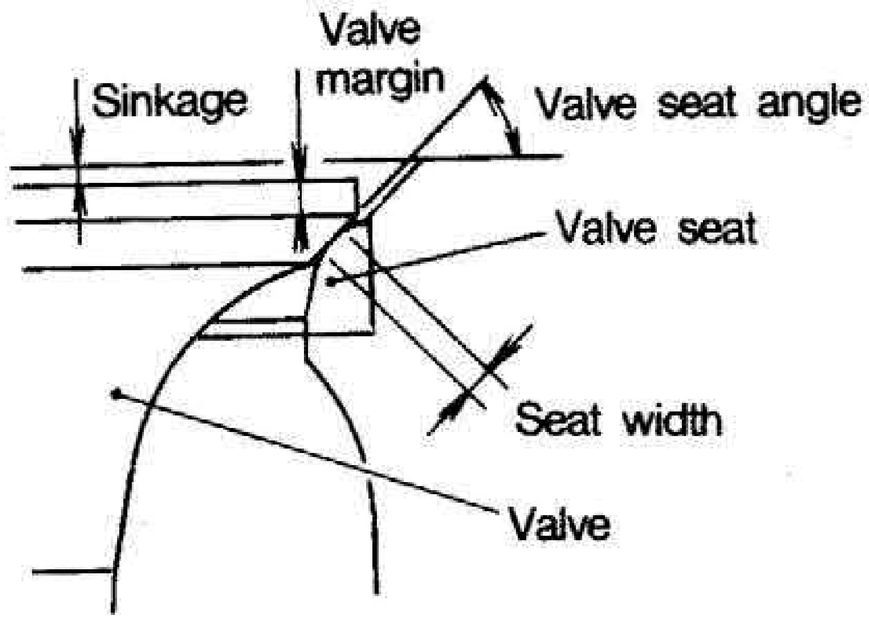
Since the valve seat insert is cold fitted, replace it by the following procedures.

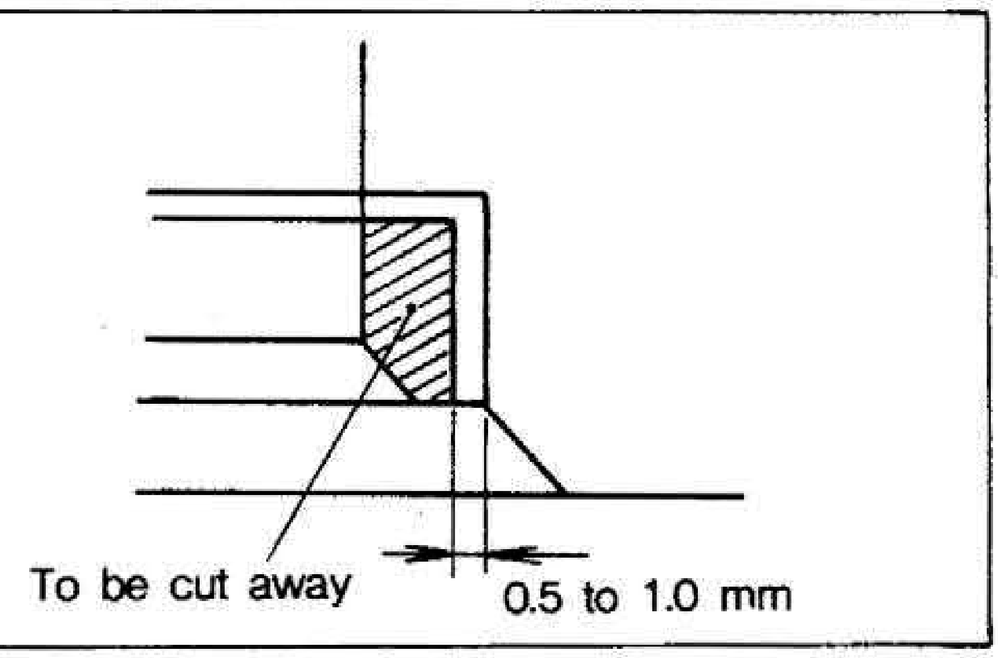
(a) Grind the valve seat insert from inside to reduce the thickness, and remove it at normal temperature.

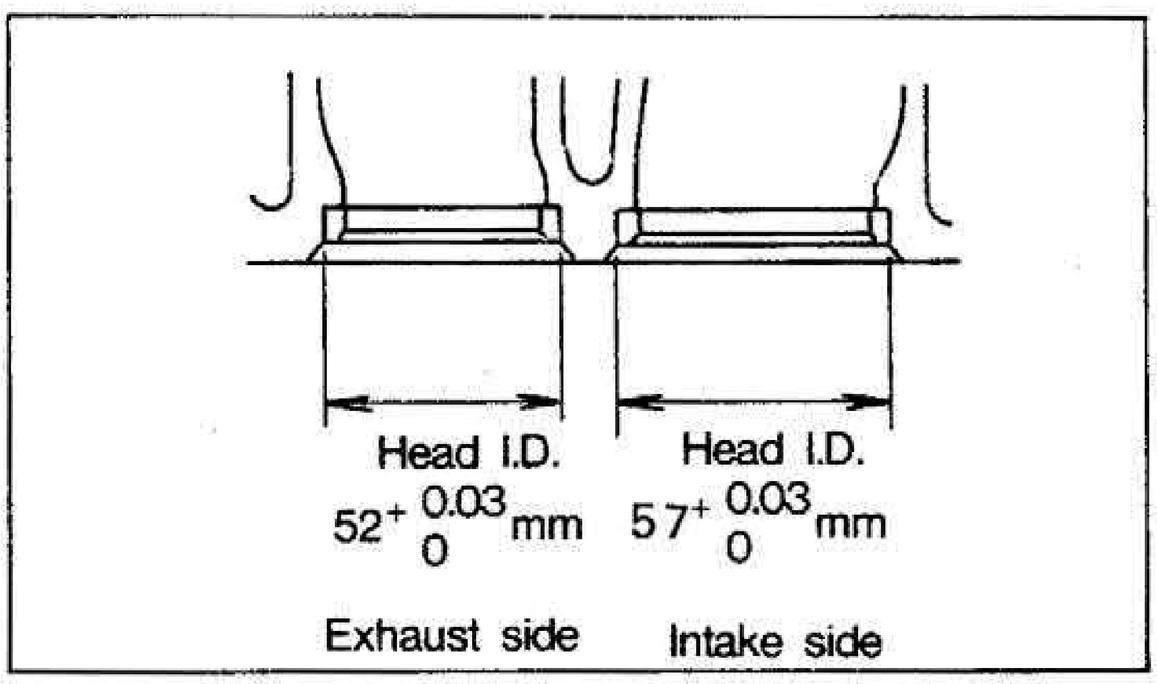
(b) Check to ensure that there is enough interference between the cylinder head and valve seat insert.

(c) Cool the valve seat insert by immersing in liquid nitrogen. The cylinder head should be fully heated.



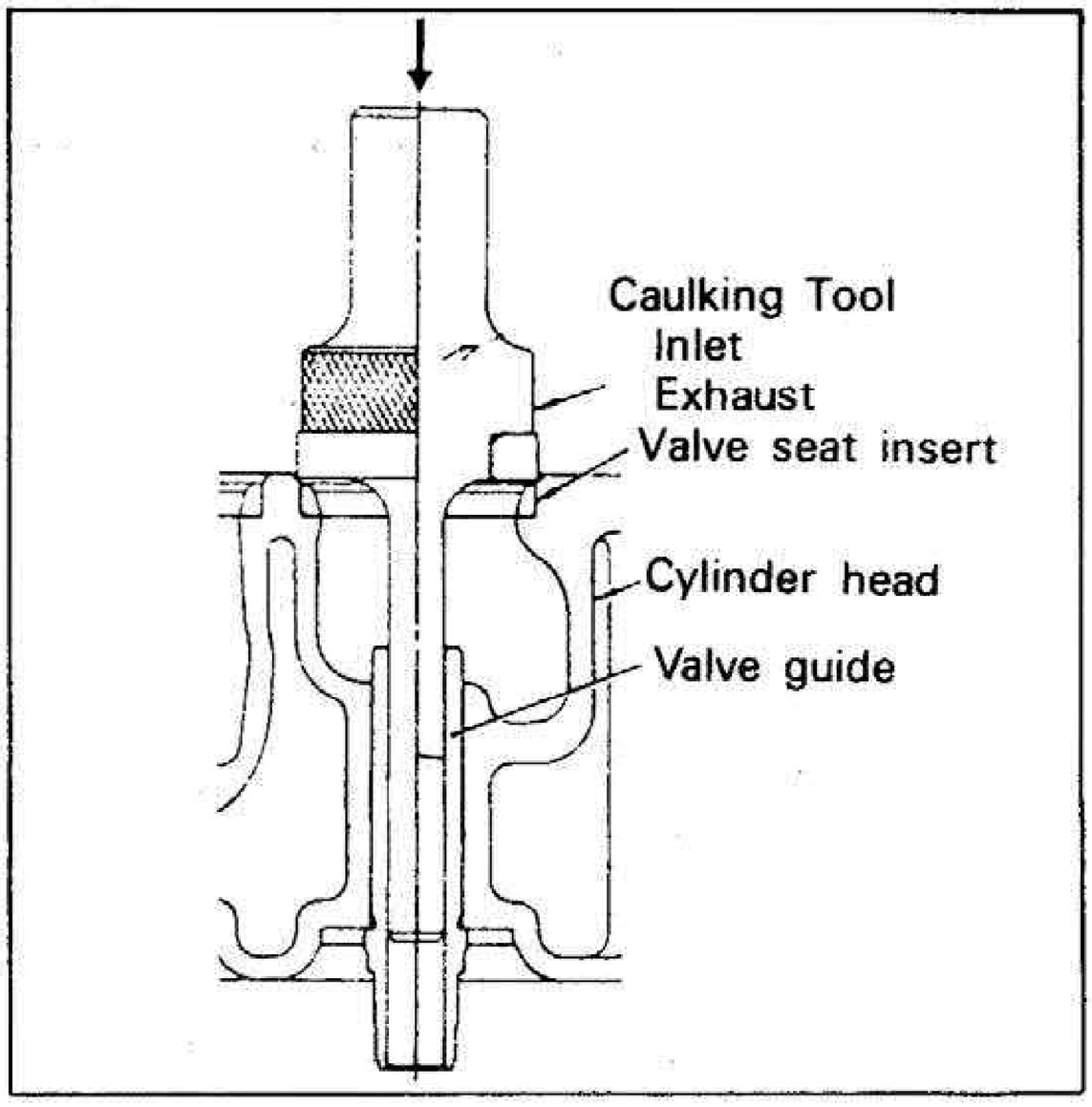




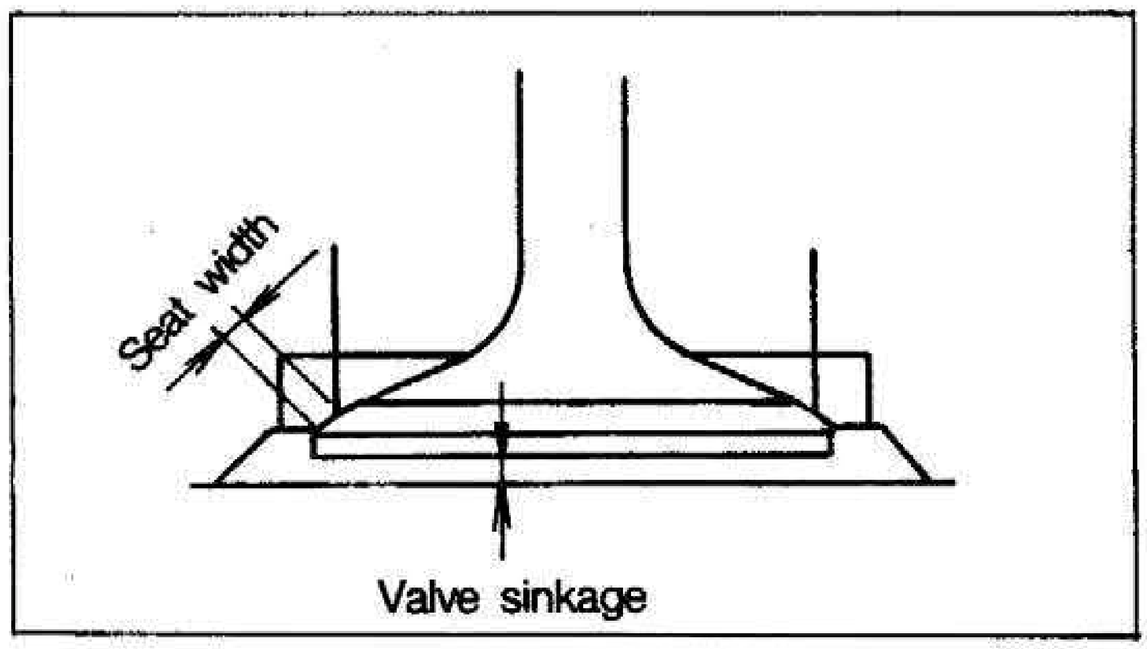


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(d) Using Caulking Tool(special tool), install the valve seat insert and caulk the periphery of the valve seat.



(e) Reface the valve seat insert so that the seat width and valve sinkage will have the nominal dimensions.



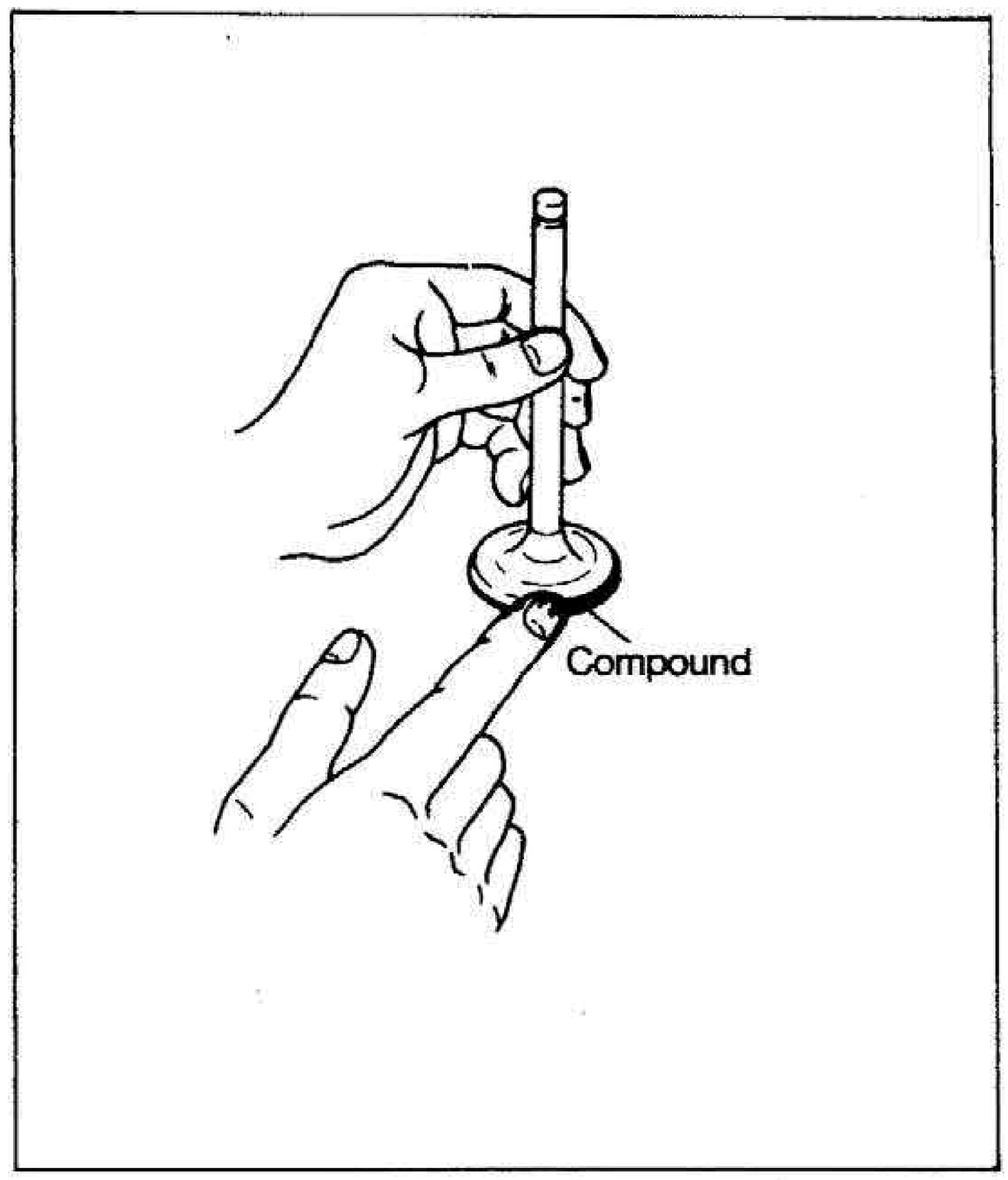
(9) Seating of Vale and Valve Seat Insert

The valve and valve seat insert must be in even contact throughout.

When the valve or valve seat insert is corrected or replaced, make sure that they are seated.

(a) Apply a thin coat of compound evenly to the seating surface of the valve.

NOTE : 1. Make sure that there is no compound on the stem of the valve.



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2. Use intermediate mesh compound(120 to 150 meshes) first and then use fine mesh compound (200 meshes or more) for finishing.

3. If the compound is mixed with a small amount of engine oil, it can be evenly applied.

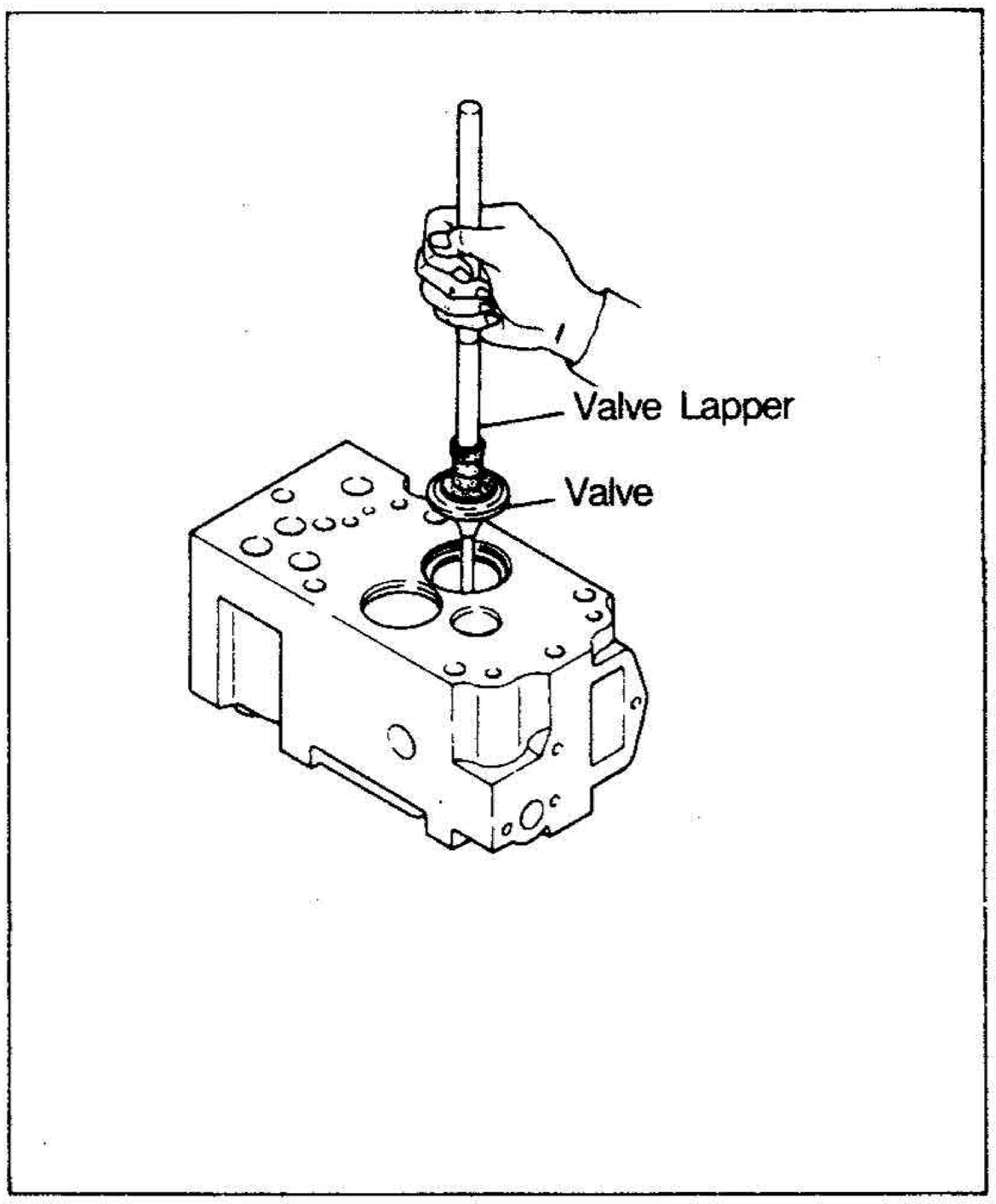
(b) Using Valve Lapper(special tool), seat the valve and valve seat insert.

While turning the valve slightly at a time, strike it against the valve seat insert.

(c) Wash away the compound in gas oil, etc.

(d) Apply engine oil to the contacting surface to seat them with oil.

(e) Check to ensure that they are properly seated.



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7-2-3 Flywheel

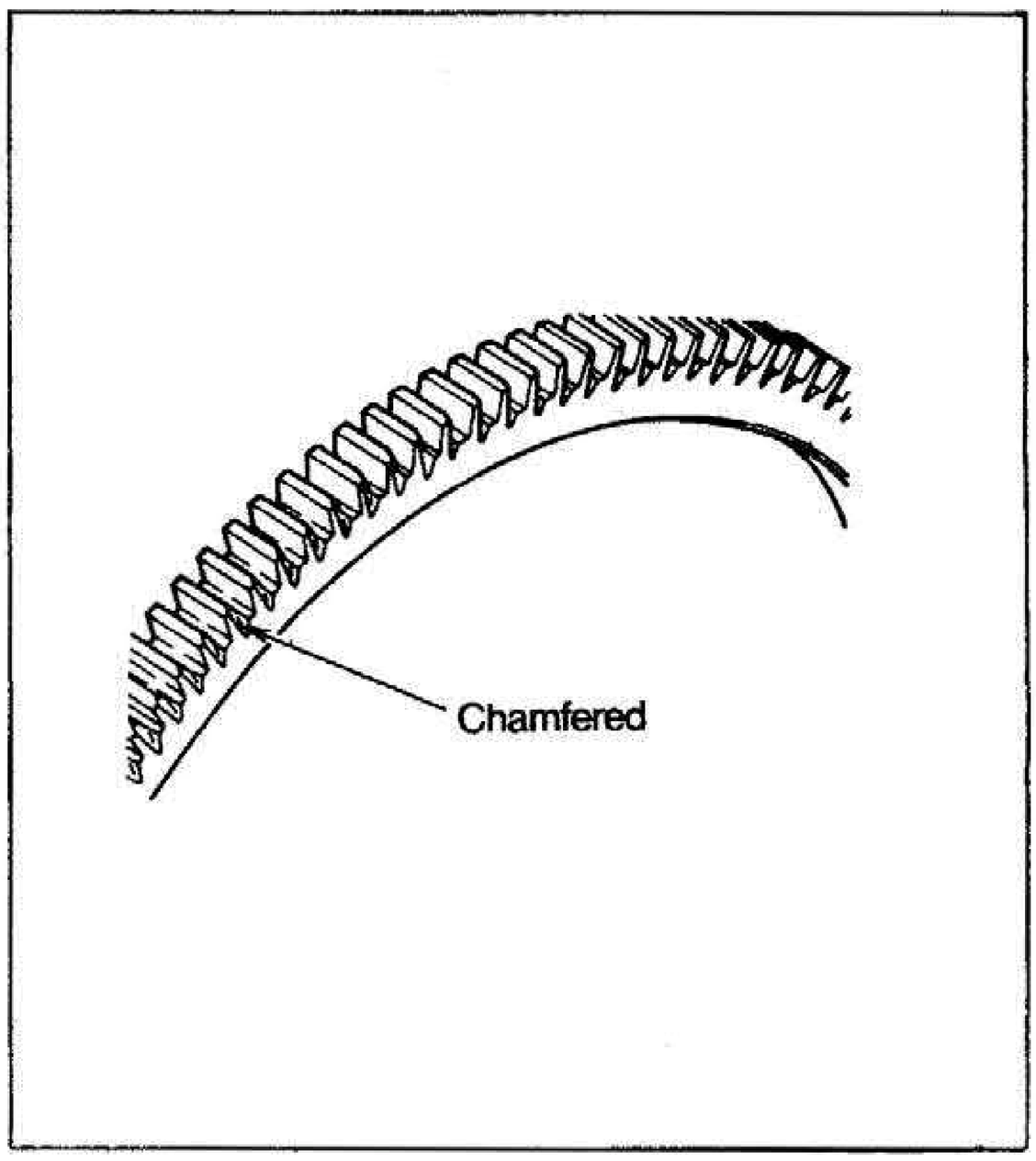
Check the ring gear. If broken teeth or abnormally worn tooth surface are evident, replace by the following procedures.

(1) Replacement of Ring Gear

(a) Removal

1) Evenly heat the ring gear with an acetylene torch, etc.

2) While holding a protective rod, strike the ring gear all around with a hammer to force it out of position.



(b) Installation

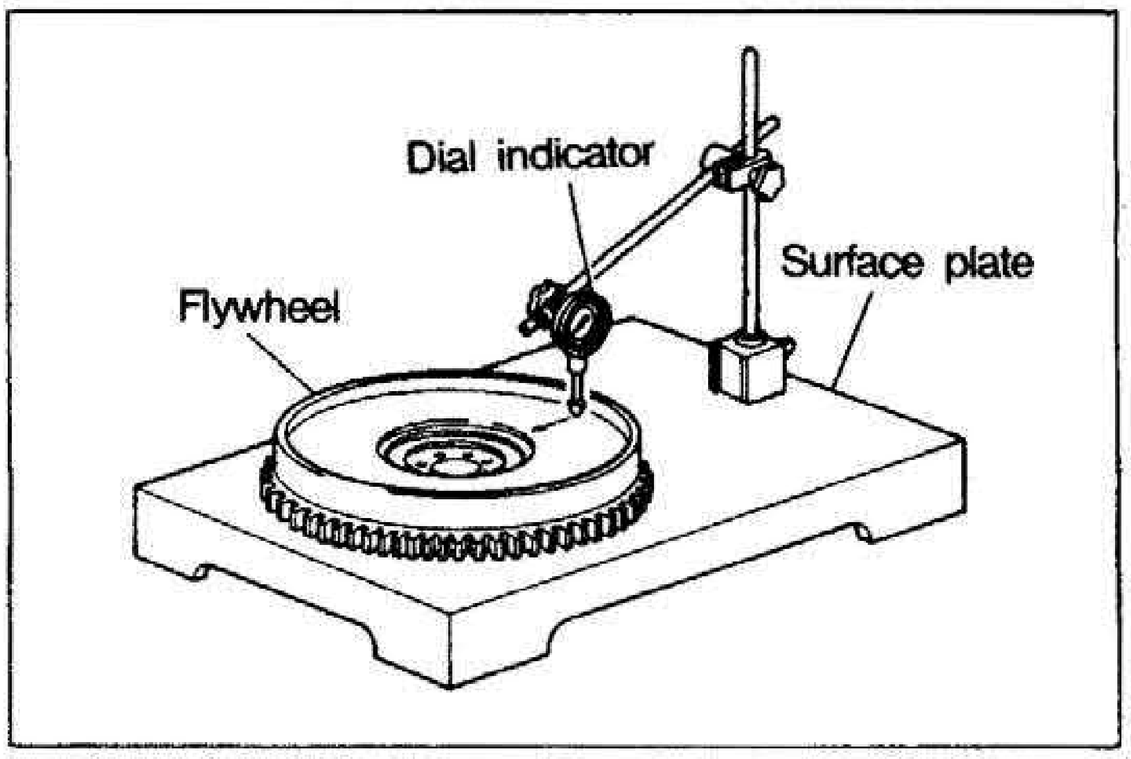
1) Heat the ring gear with piston heater(approx. 100℃) for three minutes.

2) Fit the ring gear onto the flywheel with the nonchamfered side of tooth end to ward the flywheel.

(2) Friction Surface distortion

Place the flywheel on a surface plate and move a dial indicator in the diametral direction of the flywheel to measure distortion.

Use of a portable jack will make it possible to take a more accurate reading.



If the distortion is in excess of the repair limit, grind the friction surface.

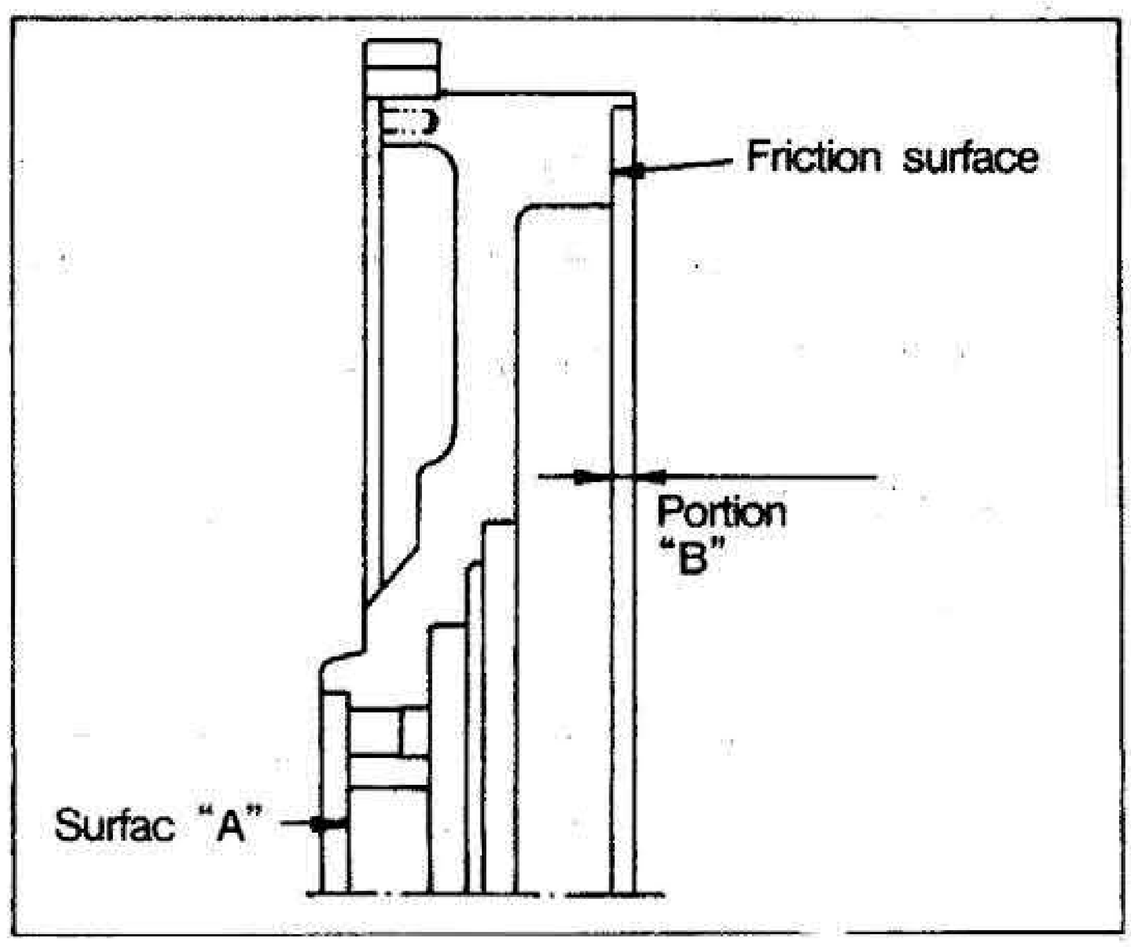
NOTE : If the ring gear shows an abnormal condition, replace the ring gear before measurement.

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(3) If the distortion of the surface making friction with the clutch is in excess of the repair limit, grind.

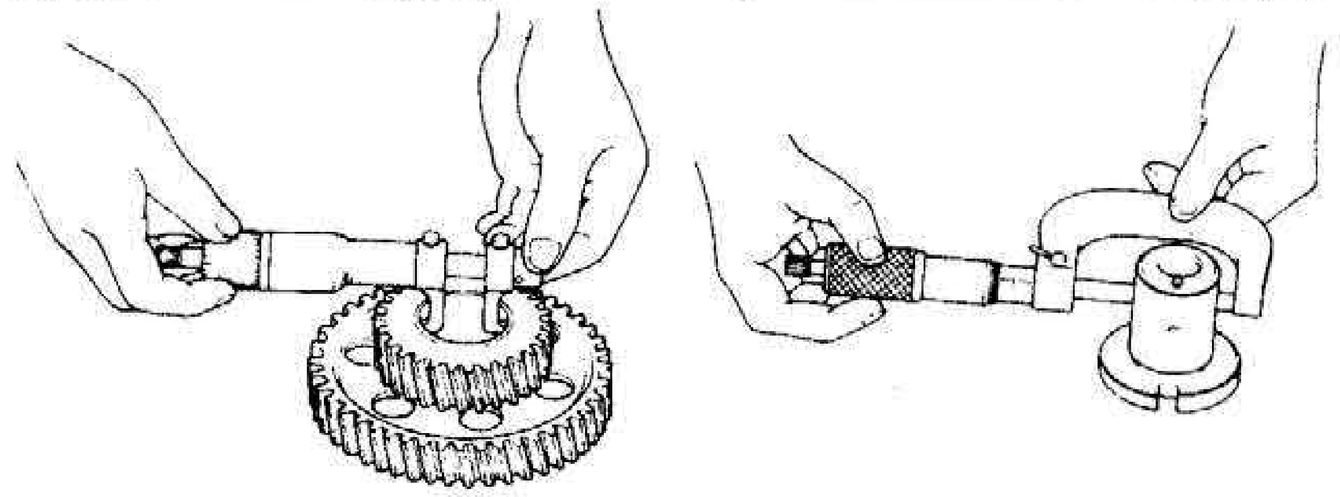
Make sure that the friction surface is parallel to surface A with in 0.1mm.

If the dimension of portion B exceeds the service limit, replace.



7-2-4 Timing Gear

(1) Calculate the clearance from the idler gear I.D. and idler shaft O.D. If the repair limit is exceeded, the bushing in the gear should be replaced.



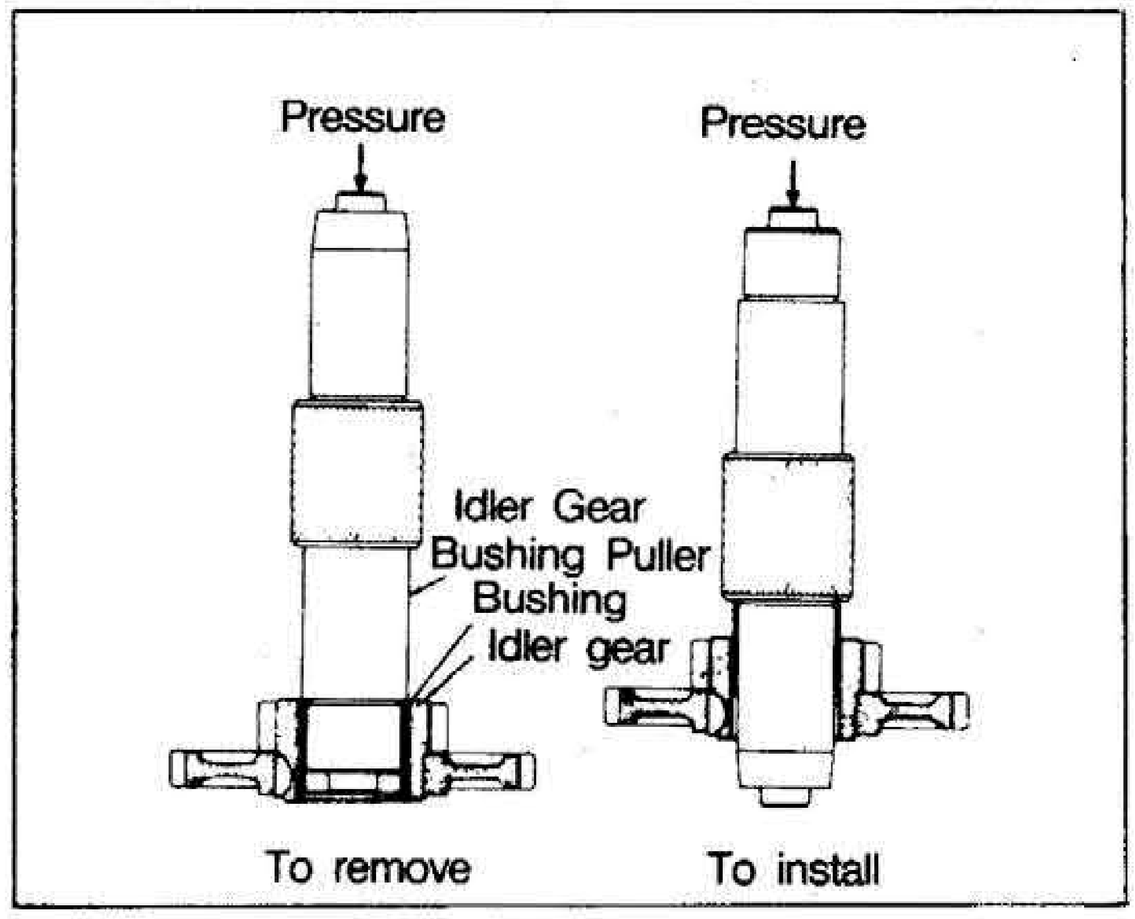
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(2) Replacement of Idler Gear Bushing

Replace the bushing by the procedures shown in illustration, using Idler Gear Bushing Puller(special tool).

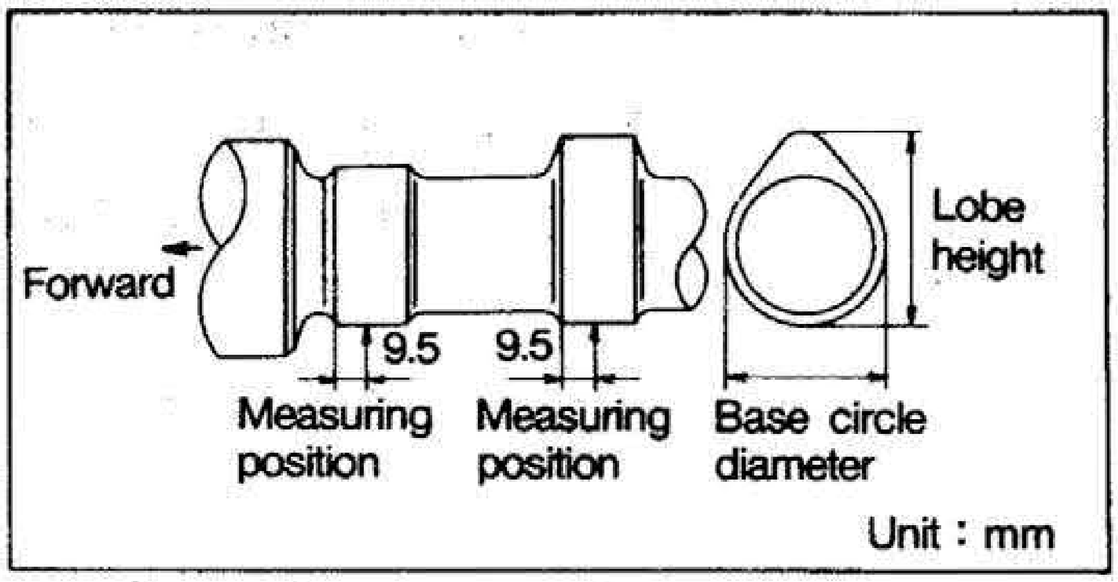
NOTE : 1. Install the bushing with chamfered side of gear I.D. inward.

2. After installation, check to ensure that the bushing to idler shaft clearance is within the nominal dimension. If it is below the nominal dimension, ream the bushing.

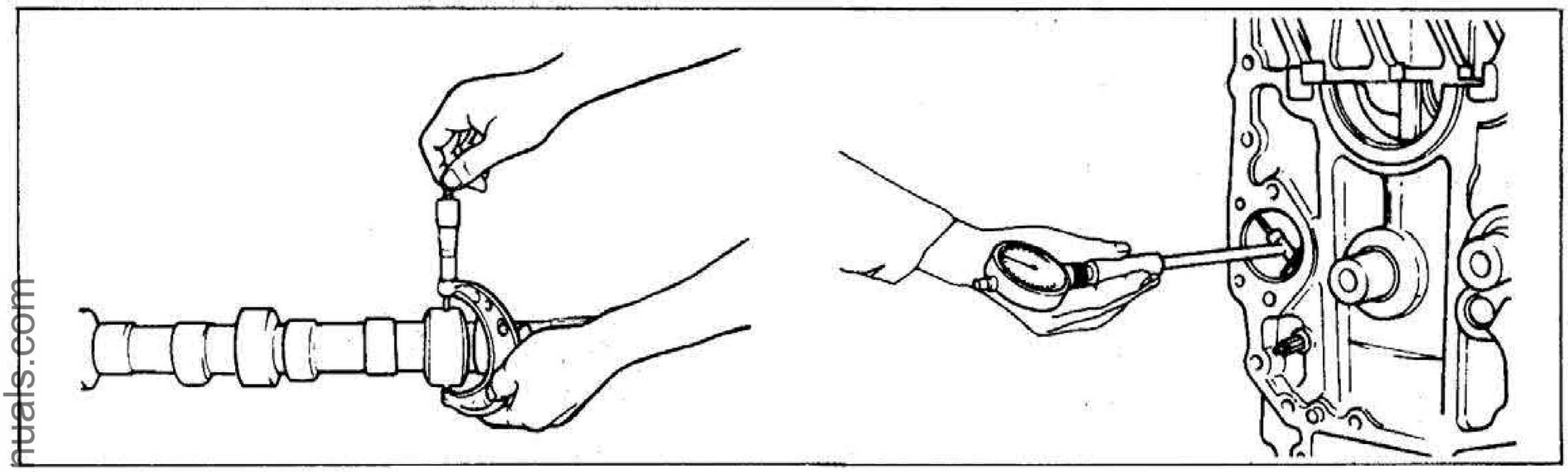


7-2-5 Camshaft

(1) Measure the lobe height and base circle diameter of each cam. If the difference between them is below the service limit, replace.



(2) Measure the camshaft journal O.D. and crankcase I.D. If the repair limits are exceeded, the bushing in the crankcase should be replaced.



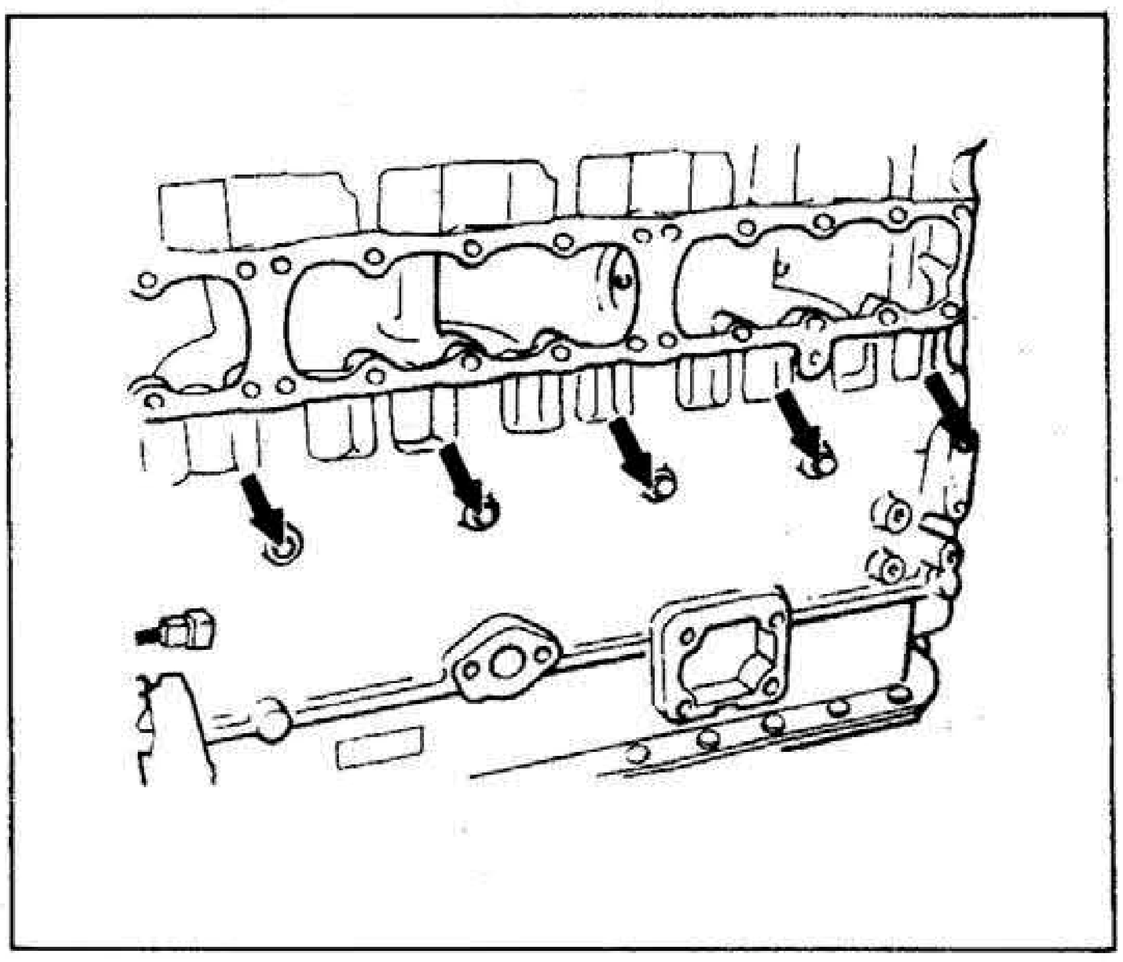
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(3) Replacement of Camshaft Bushing

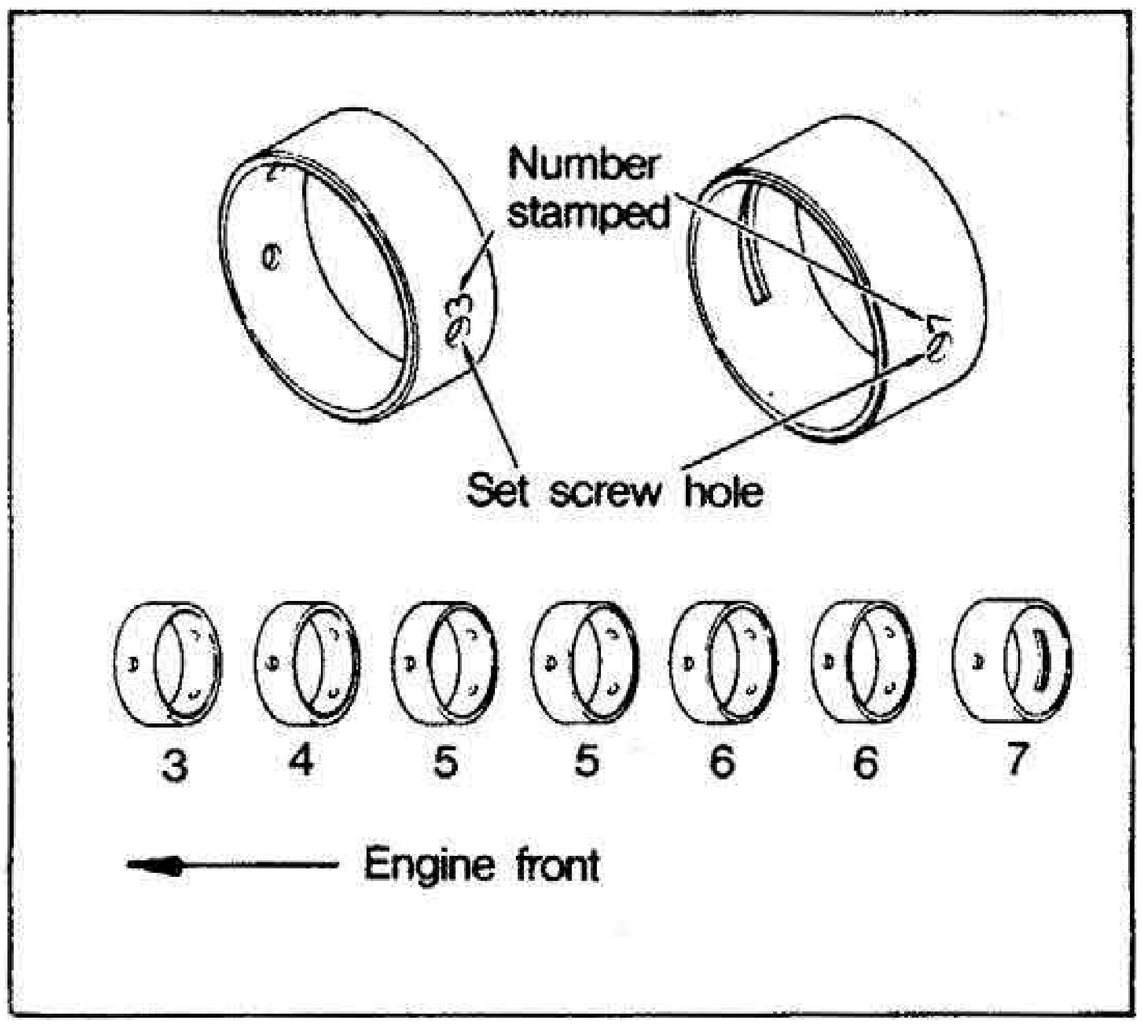
Remove the camshaft bushing screws to remove the bushing. Since the bushing and crankcase are clearance fitted, they are easily replaceable.

NOTE : For installation, pay attention to the following points.

1. Thread the set screw positively into the set hole of the bushing.

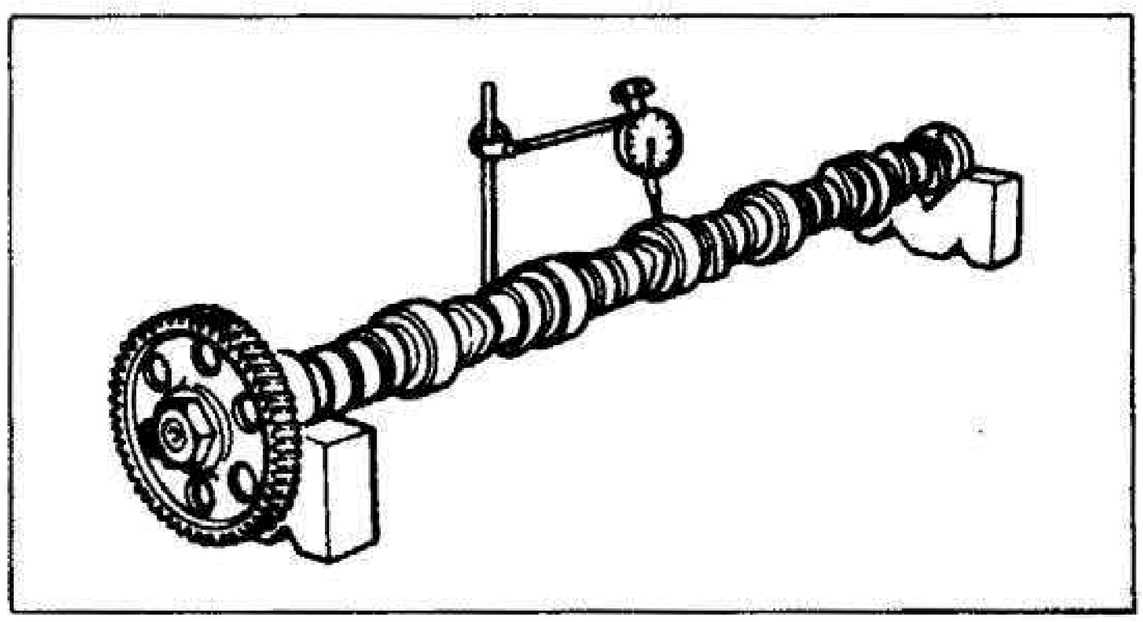


2. The number stamped on the external periphery of bushing near the set screw hole shows the position where the bushing is to be installed. Insert the bushings in the order of 3-4-5-5-6-6-7 from the front. At that time, the set screw hole(Ø8mm) and threaded hole of the crankcase should be aligned.



(4) Measure the bend of the camshaft. If the repair limit is exceeded, correct with a press or replace.

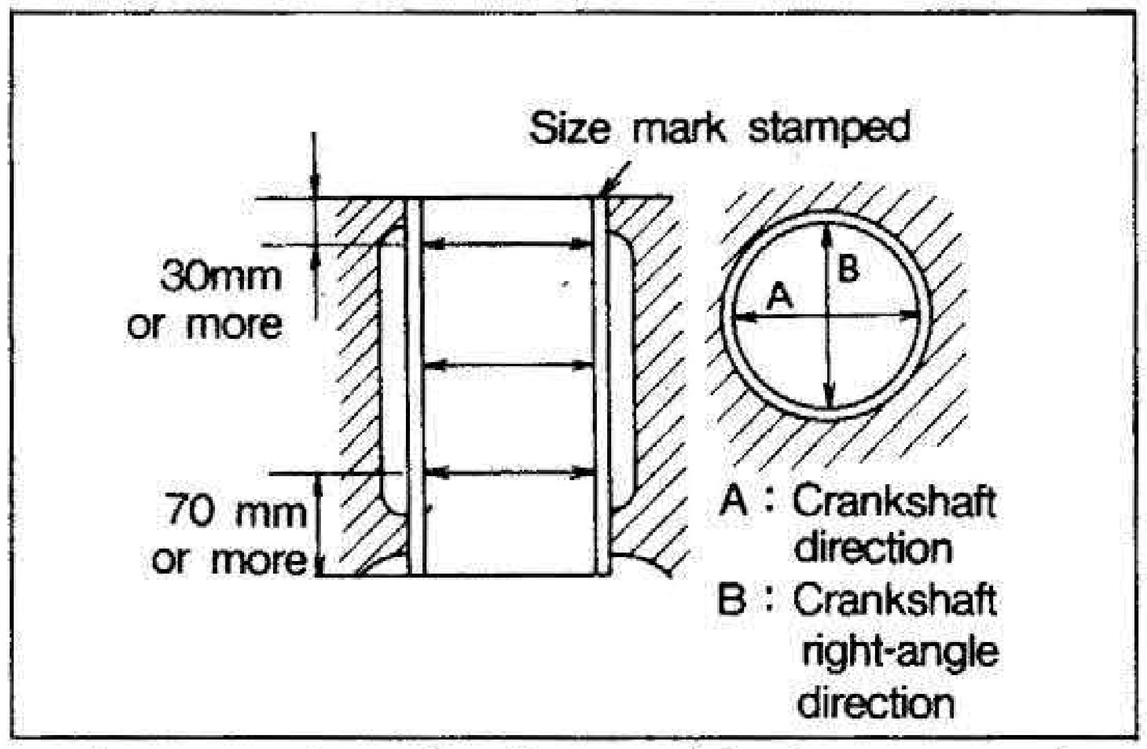
NOTE : Turn the camshaft a turn and read the deflection of the pointer, using a dial indicator. One half of the reading is the bend.



7-2-6 Crankcase and Cylinder Liner

(1) Measure the cylinder liner I.D. at six positions shown in illustration. If the I.D. is in excess of the repair limit, replace or bore to oversize.

If the out-of-roundness and cylindricity are in excess of the repair limit, take the same corrective action.

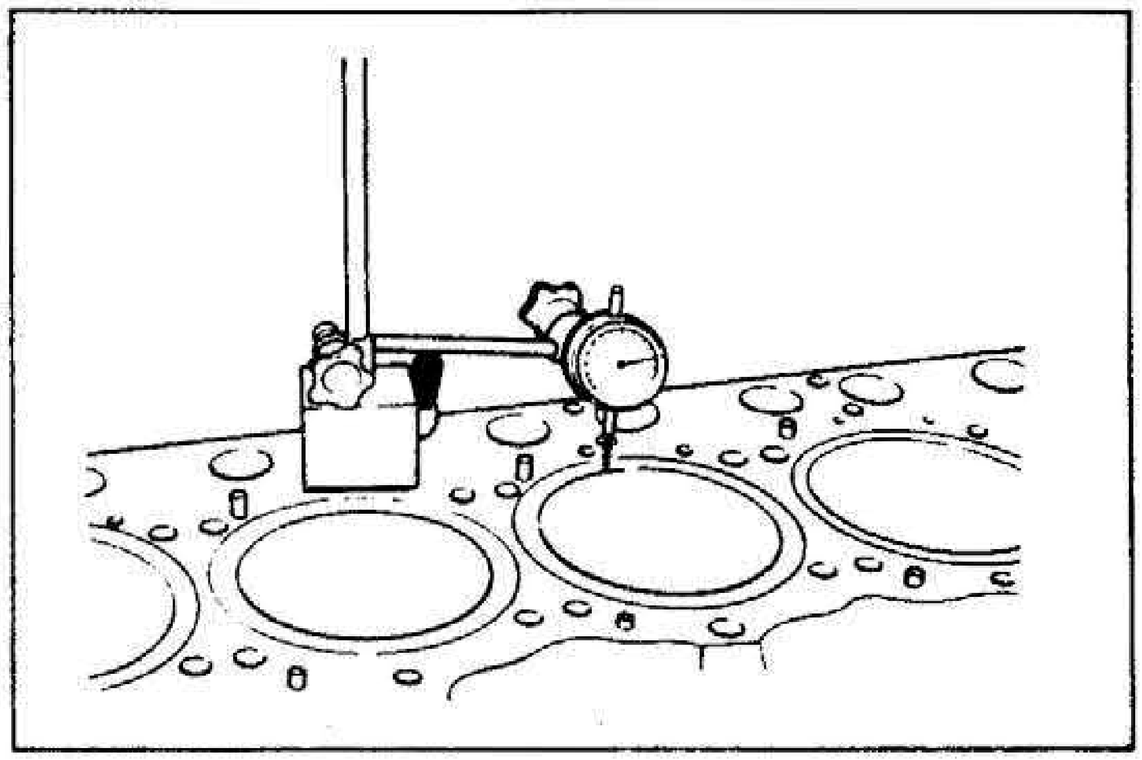


NOTE : When a cylinder liner needs replacing, make sure that the liner with the same size mark as that of the piston is selected.

Piston size mark	A	B	C
Cylinder liner size mark	A	B	C

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(2) Measure the cylinder liner flange to determine whether it is projecting from the top surface of the crankcase as specified.

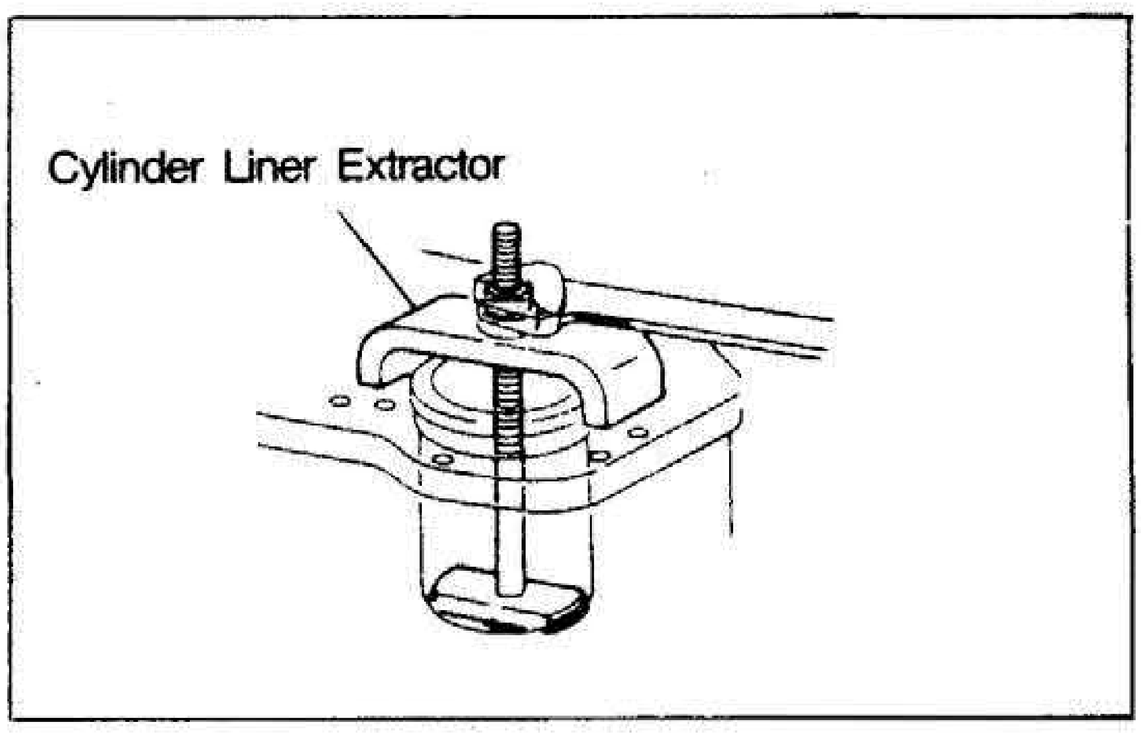


If the projection is out of specification, replace the cylinder liner or crankcase.

NOTE : If the projection is in sufficient, the surface pressure around the bore of the cylinder head gasket will fall and cause gas leakage.

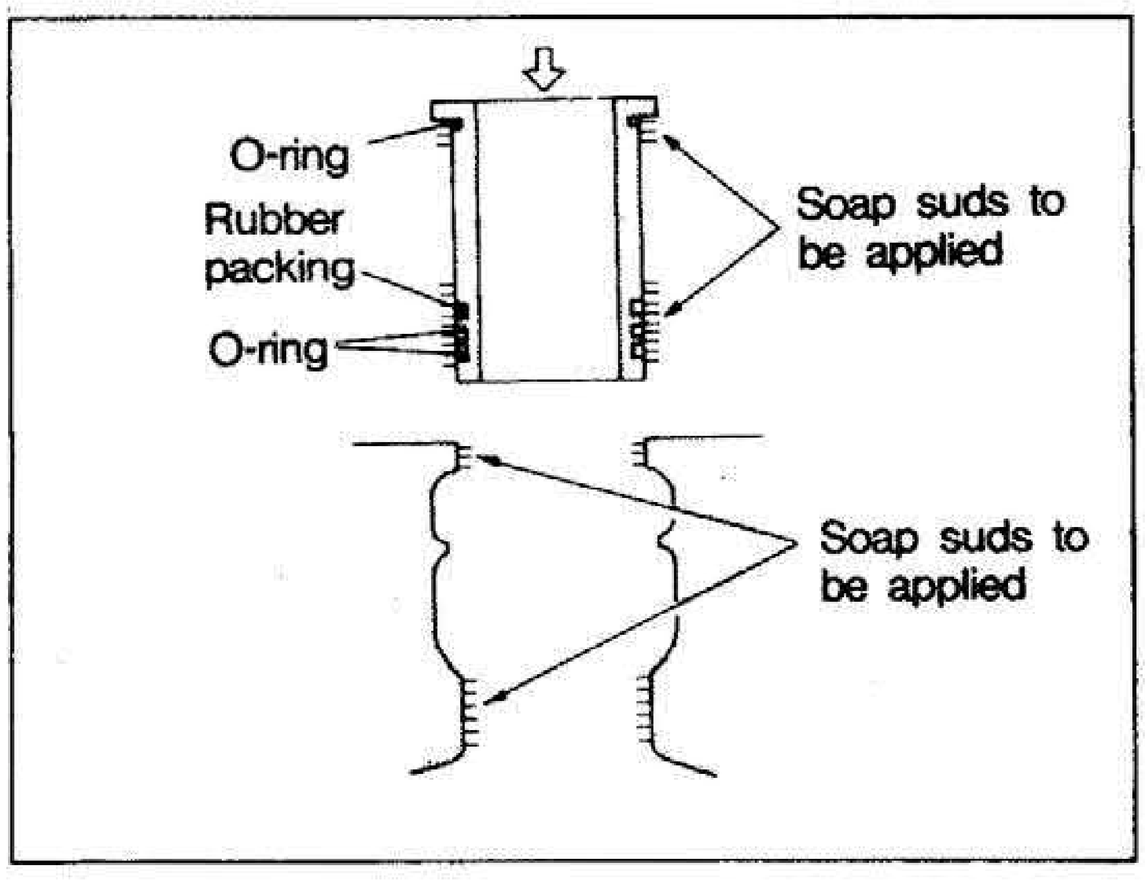
(3) Replacement of Cylinder Liner

(a) Remove the cylinder liner through use of cylinder Liner Extractor(special tool).



(b) After the rubber packing and O-ring have been installed to the cylinder liner, slowly insert the cylinder liner into the crankcase.

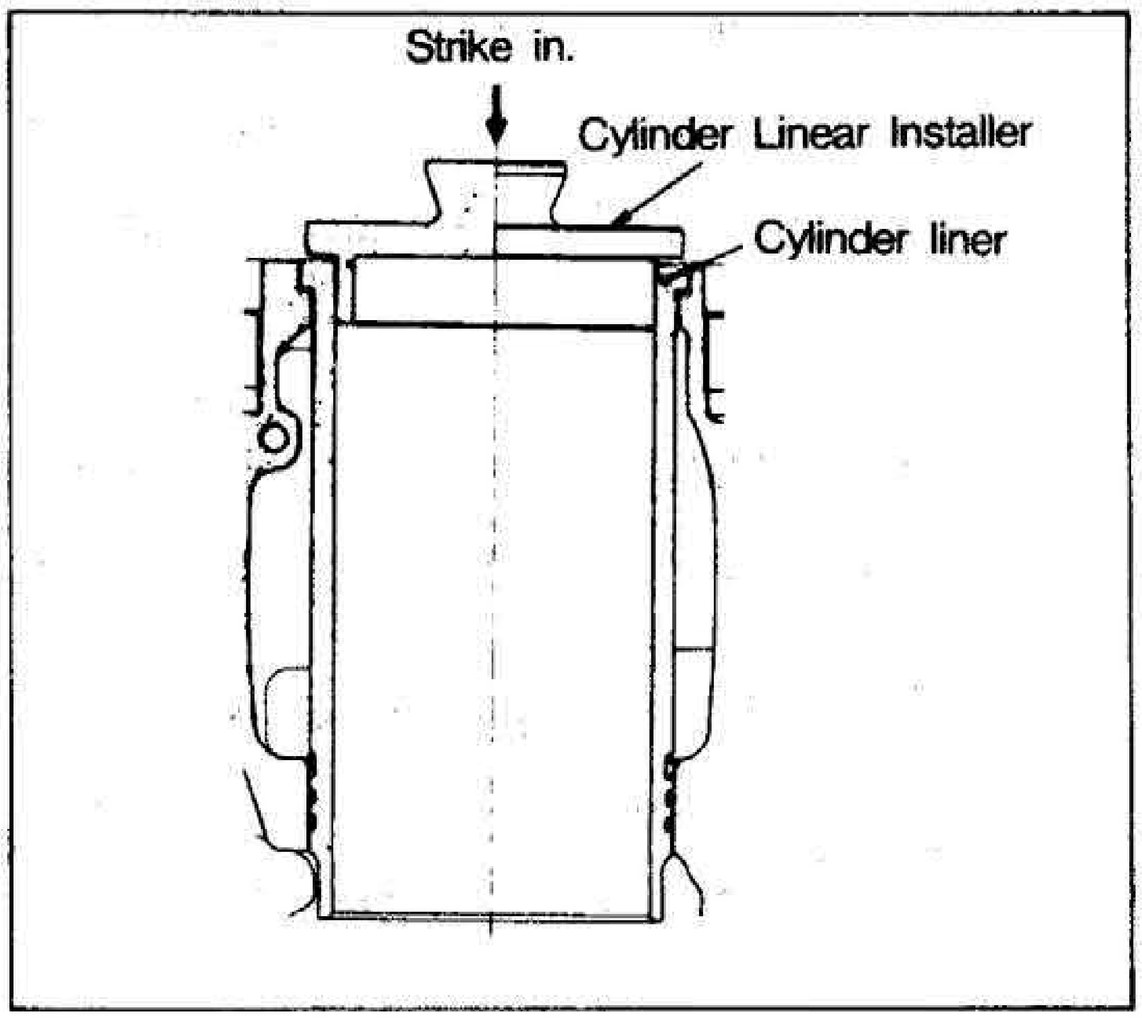
NOTE : Apply soap suds to the crankcase and cylinder liner fitting portions and make sure that the rubber packing and O-ring are not twisted when inserted.



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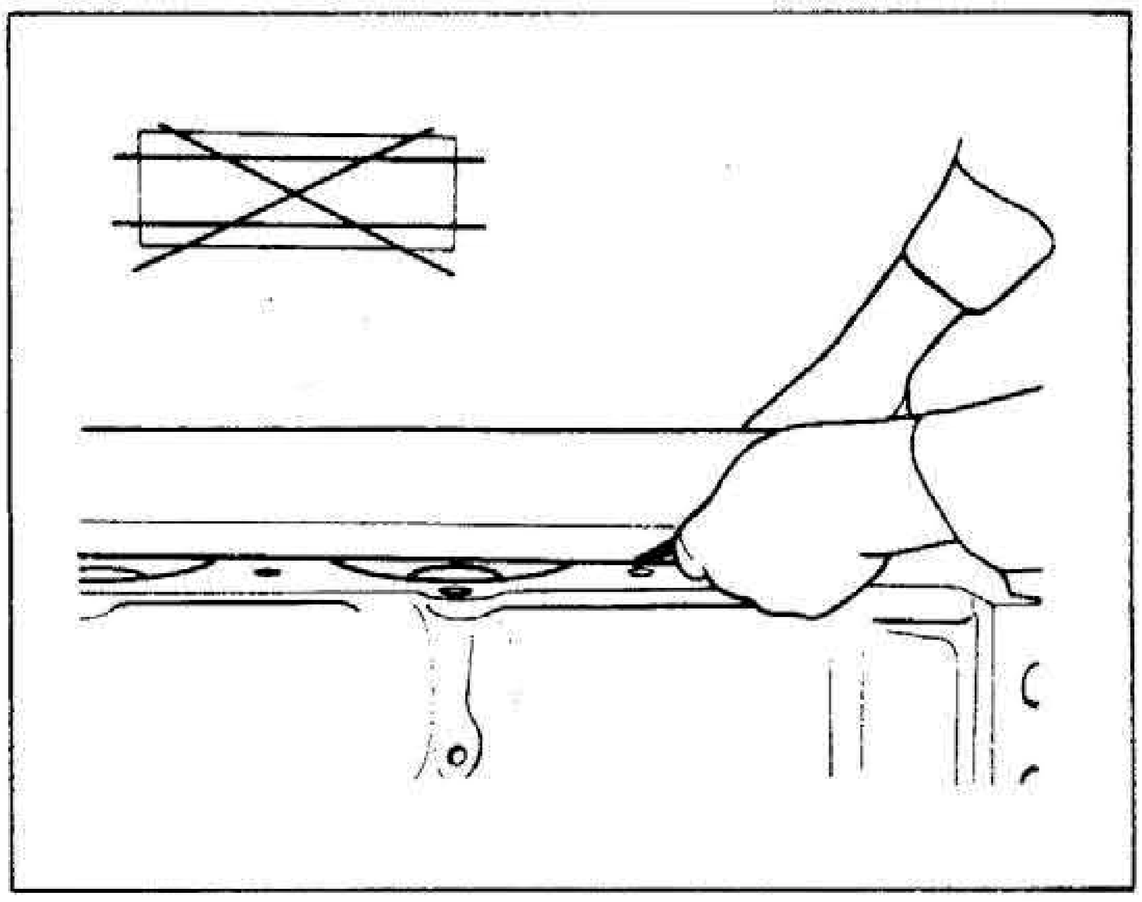
(c) Securely seat the cylinder liner on the crankcase by lightly striking the flange portion, using Cylinder Liner Installer(special tool).

NOTE : After installation, make leak test to confirm air-tightness. Keep hold-down pressure on the cylinder liner flange portion.



(4) Measure the crankcase top surface distortion. If the repair limit is exceeded, correct the distortion with a surface grinder. If the service limit is exceeded, replace the crankcase.

NOTE : When the crankcase is ground, make sure that the piston projection does not exceed the nominal dimension.

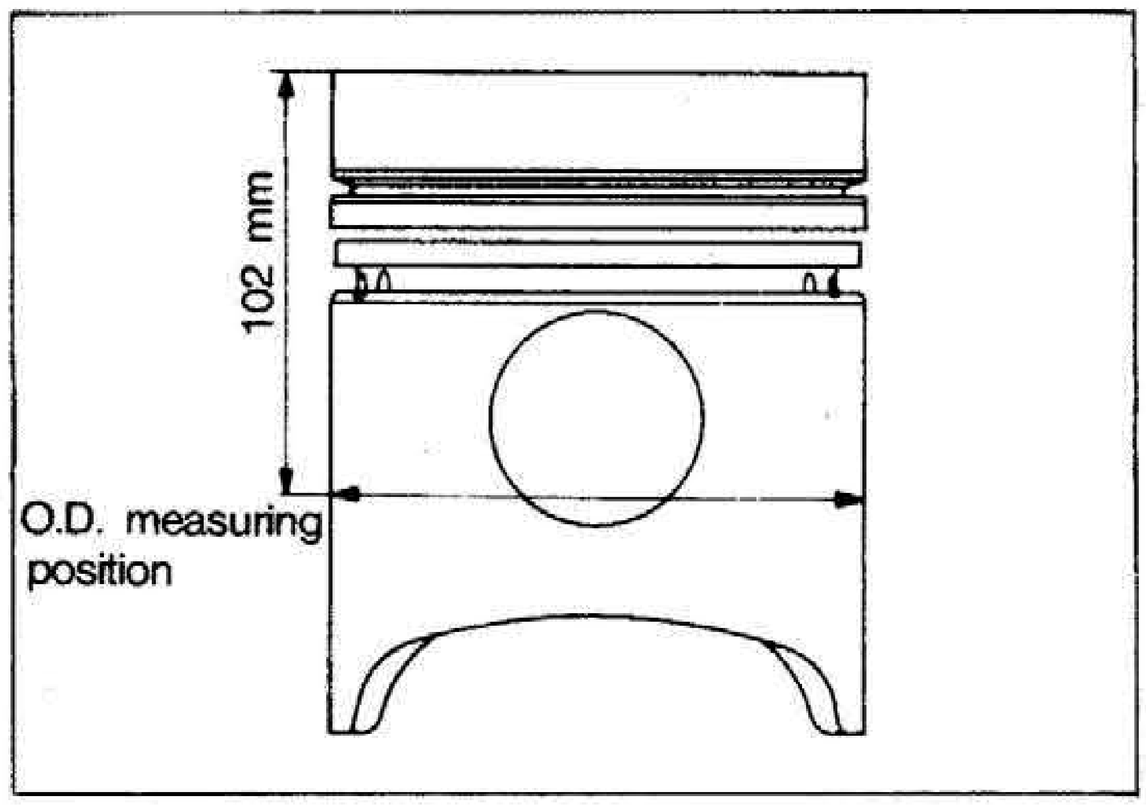


(5) Oversize of Cylinder Liner

Oversize(three kinds)

+0.5mm, +0.75mm and +1.00mm

(a) Selection of an oversize should be accomplished in consideration of the maximum worn portion from all cylinder I.D. measurements.



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(b) Measure the O.D. of each oversize piston to be used, using a micrometer.

(c) Bore and hone-finish the cylinder liner so that the cylinder liner to piston clearance will have the nominal dimension.

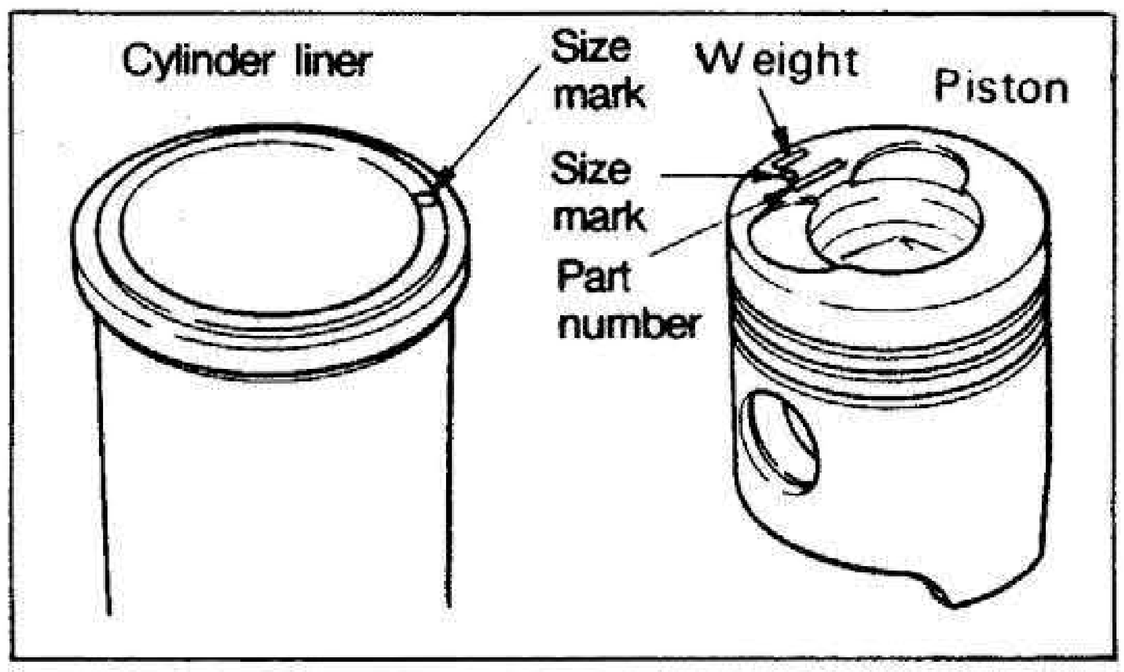
NOTE : 1. Even if it is only one cylinder that needs boring, make sure that all cylinders are bored to the same oversize.

2. The piston rings should be replaced with corresponding oversize rings.

7-2-7 Piston and Piston Ring

(1) Replacement of Piston

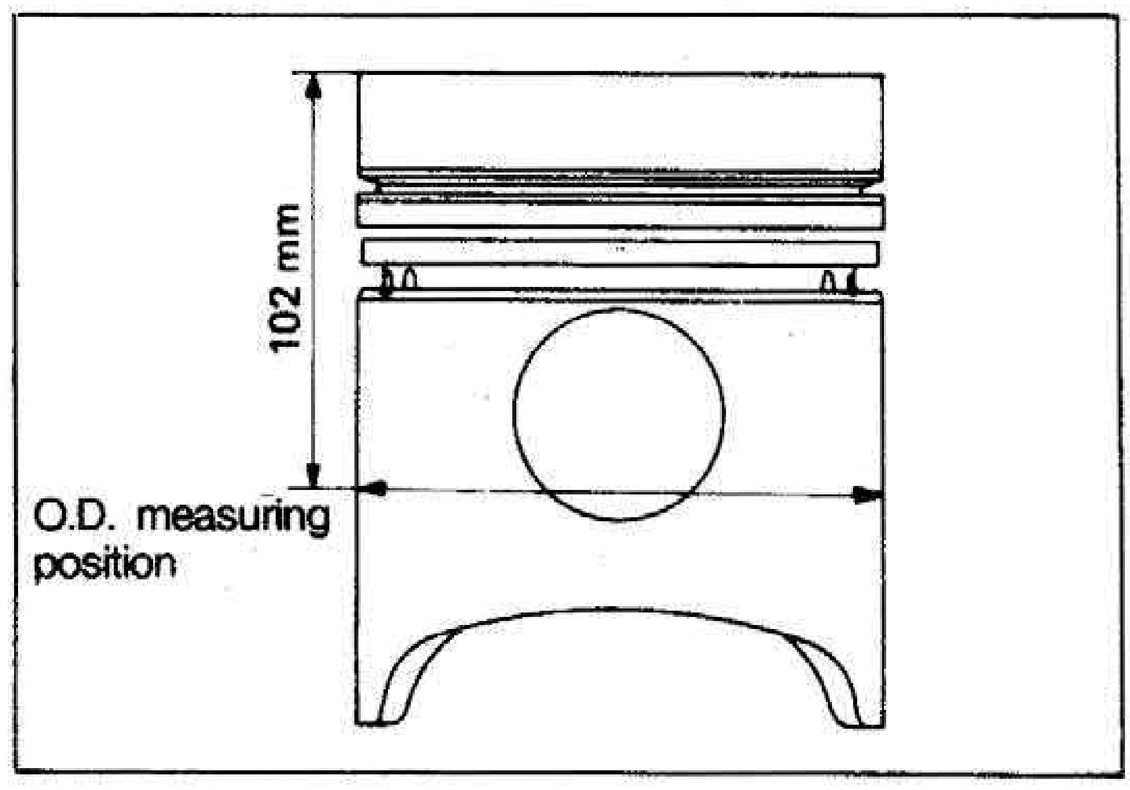
(a) If the piston to be replaced is a standard(STD) one, select one of the same size mark as stamped on the cylinder liner.



(b) The weight of six pistons for a vehicle must fall within the range of 10 g difference in stamped value of weight.

(c) Make sure that the piston rings are also replaced.

(2) Measure the piston skirt O.D. and calculate the clearance from the measured value of cylinder liner I.D., refer to Para. 7-2-6(1). If the nominal dimension is exceeded by a large margin, replace the cylinder liner or piston.

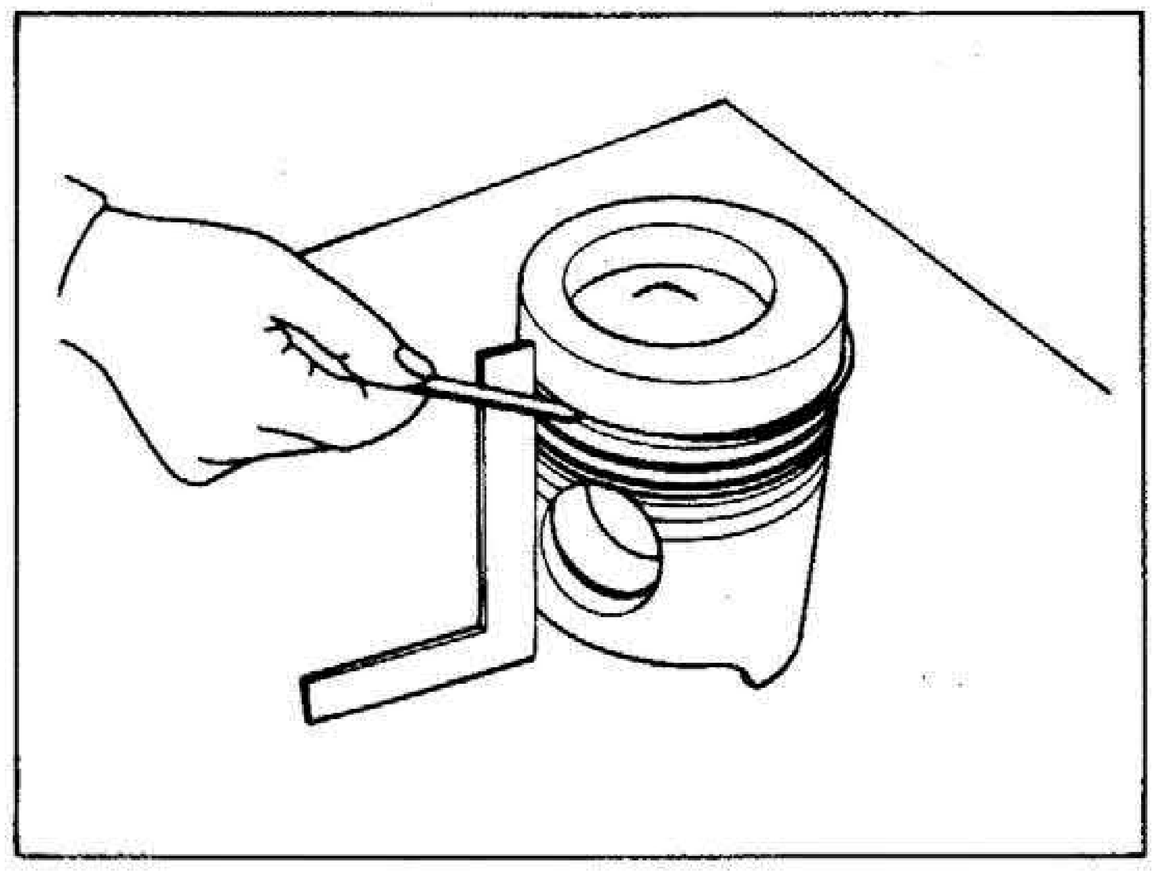


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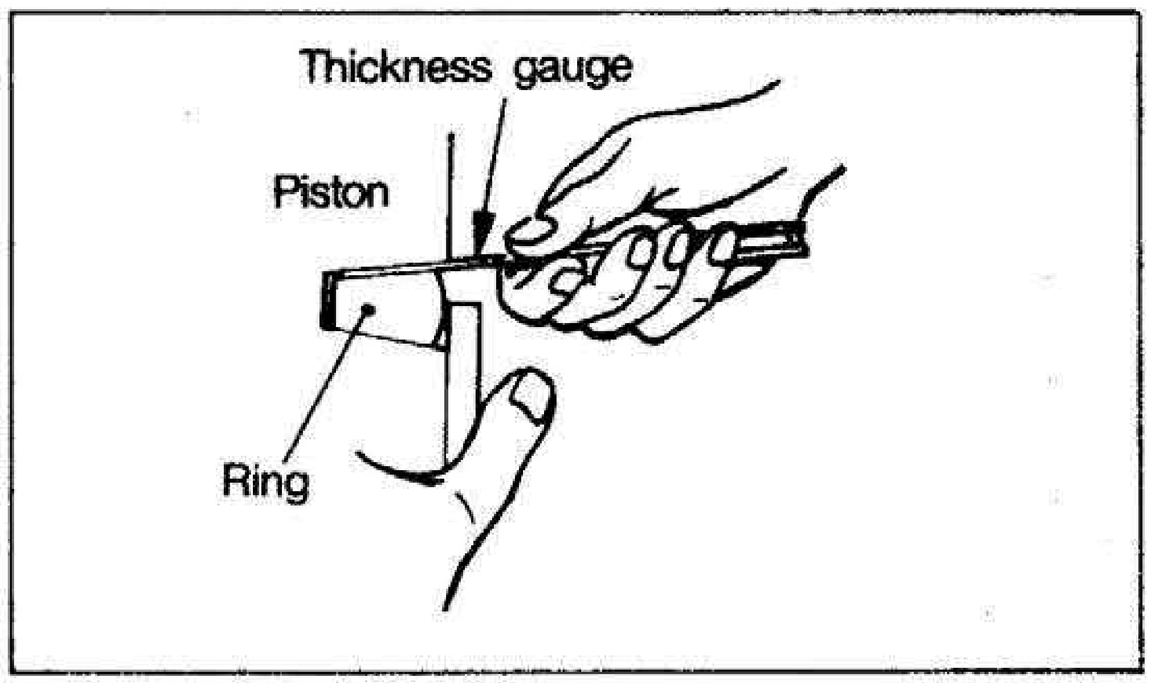
(3) Measure the piston to piston ring clearance. If the service limit is exceeded, replace the piston rings or piston.

NOTE : 1. After carbon has been removed, measure the clearance all around the piston.

2. Replace the piston rings as a set.



The 1st compression ring should be measured by pressing the ring against the piston with a straight edge.

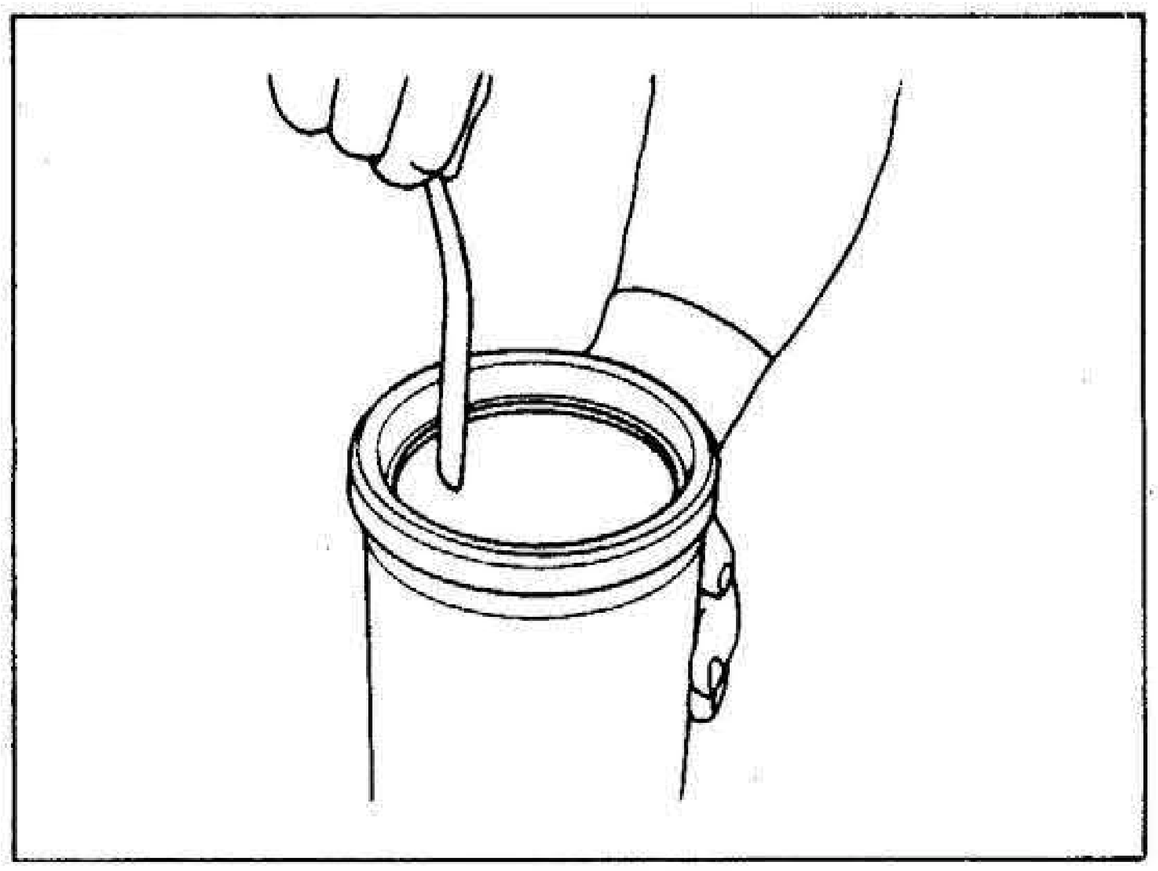


(4) Place the piston ring in a standard gauge or new cylinder to measure the open end clearance.

If the clearance is over the service limit, replace.

Standard gauge I.D. 130± 0mm

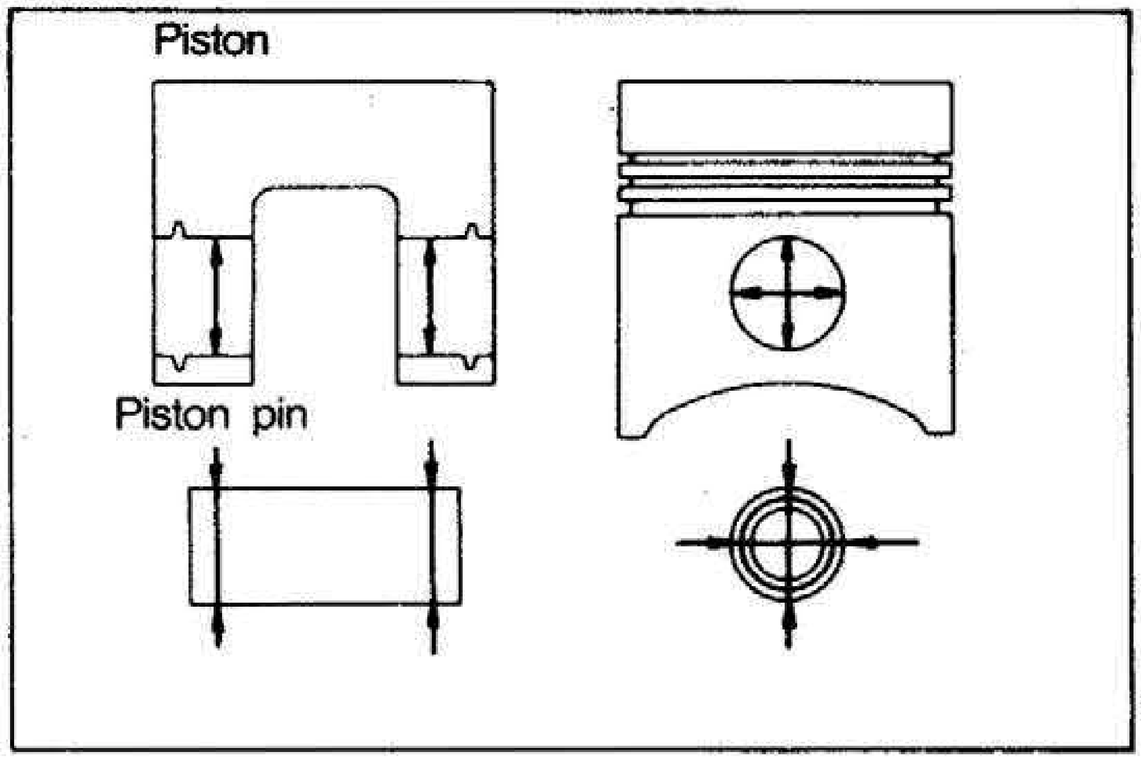
NOTE : Using a piston, push the piston ring in horizontally into a standard gauge cylinder.



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(5) Calculate the clearance from the piston pin O.D. and piston I.D.

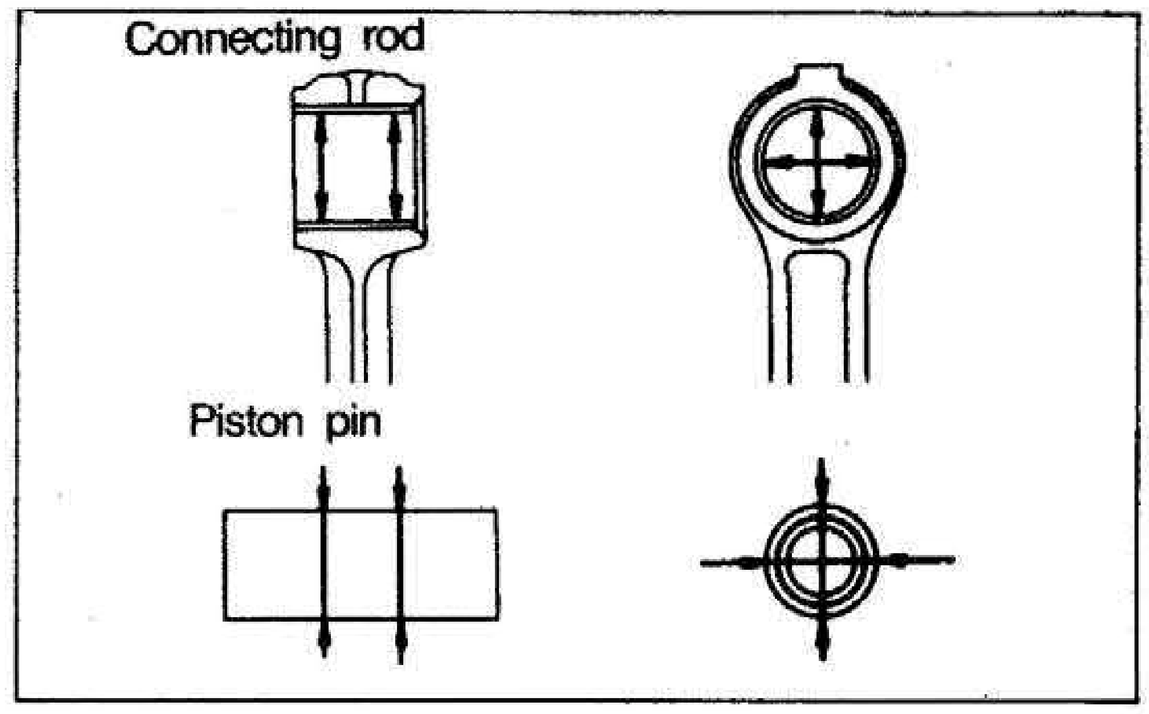
If the clearance is over the service limit, replace the piston pin or piston.



7-2-8 Connecting Rod

(1) Calculate the clearance from the piston pin O.D. and connecting rod I.D.

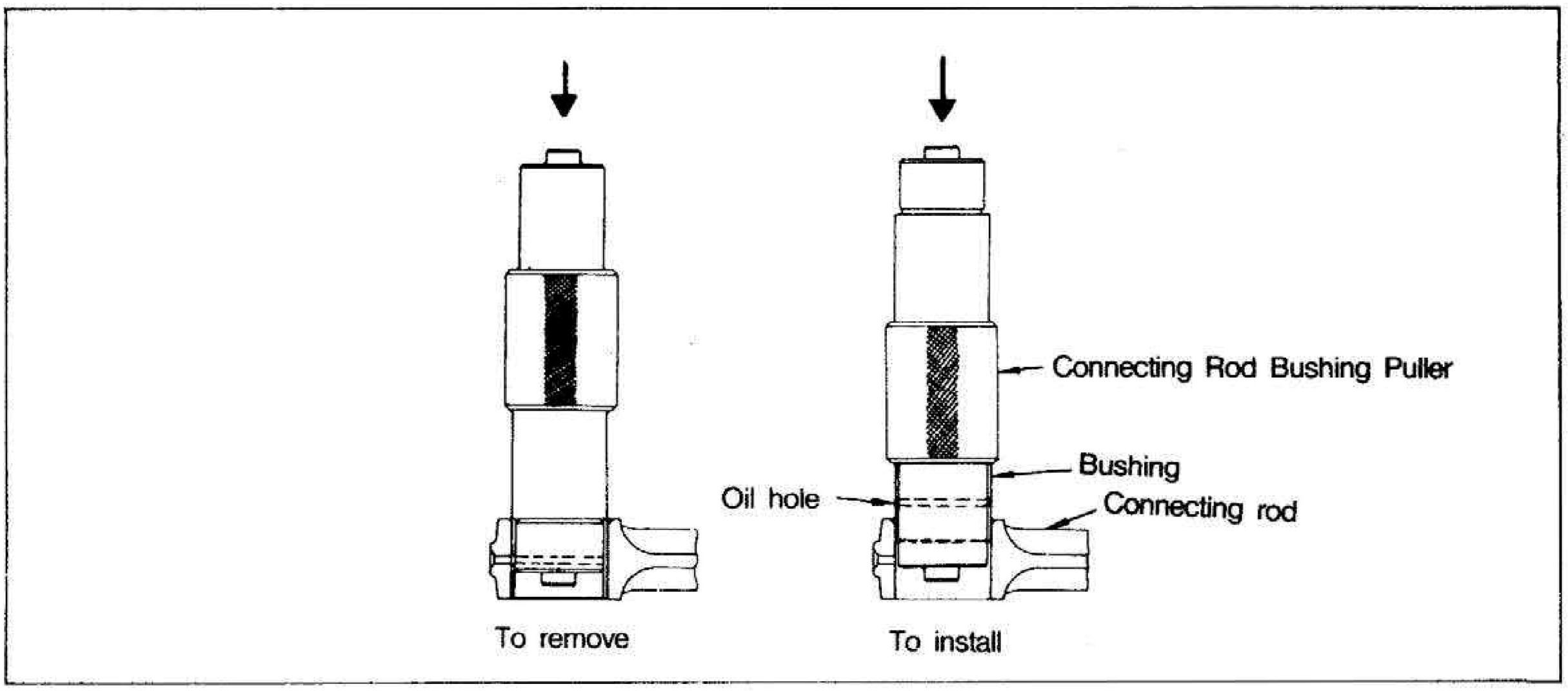
If the clearance is over the repair limit, replace the bushing in the connecting rod.



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(2) Replacement of Connecting Rod Bushing

Replace the bushing by procedures shown in illustration, using Connecting Rod Bushing Puller(special tool).



(a) Align the oil hole of the bushing with the oil hole of the connecting rod.

(b) Press the bushing in from the chamfered side of connecting rod end.

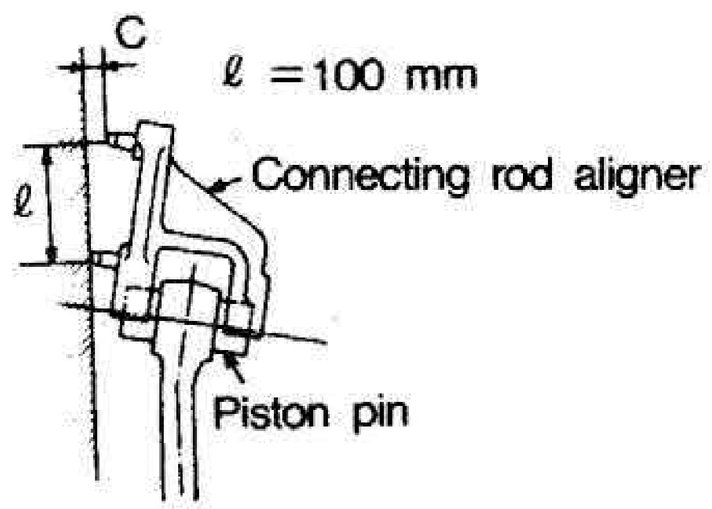
(c) After the bushing has been pressed in, insert the piston pin and check to ensure that it turns lightly without play.

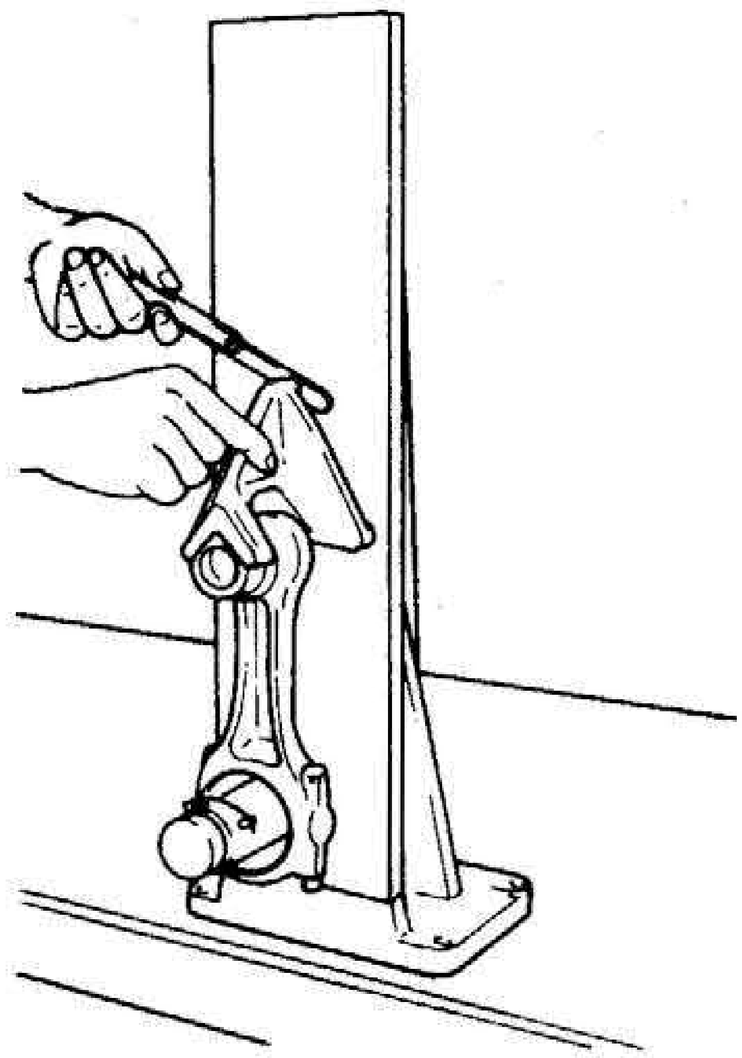
(3) Measure the bend and torsion of the connecting rod with Connecting Rod Aligner(measuring instrument).

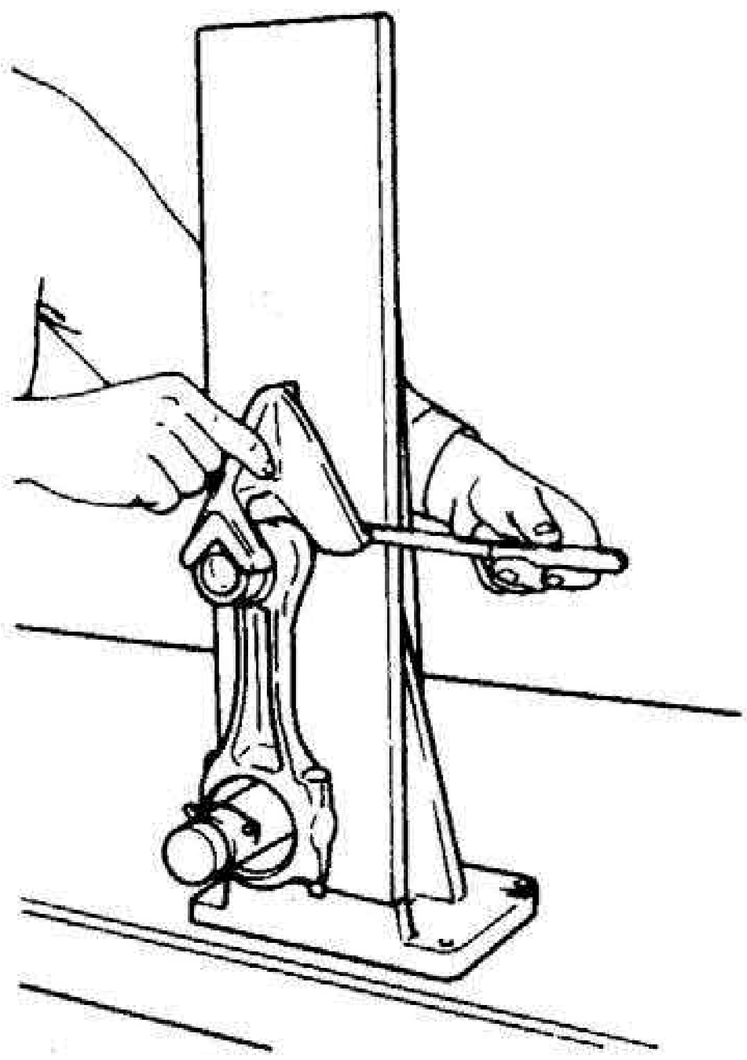
If the reading is in excess of the repair limit, replace or correct with a press.

NOTE : 1. Install the bushing and connecting rod bearing to the connecting rod before measurement.

2. Tighten the connecting rod and connecting rod cap to the specified torque before measurement.



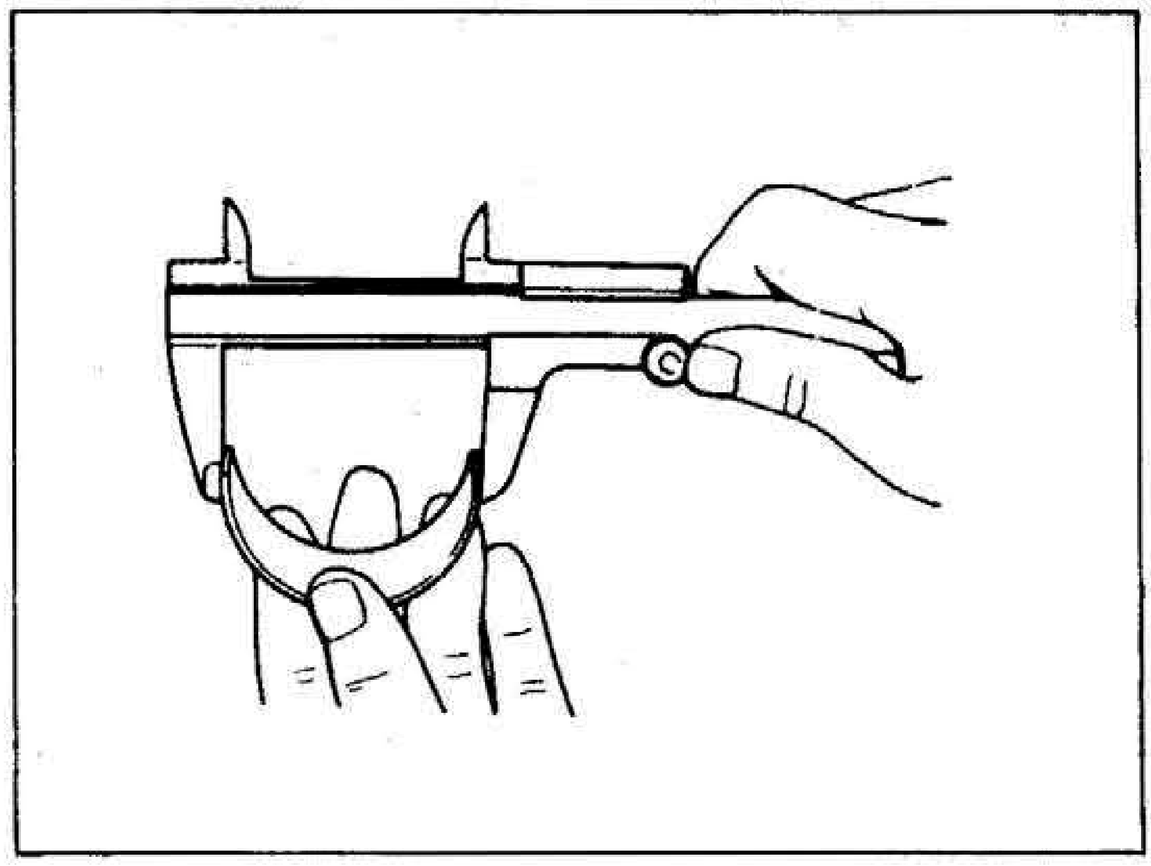




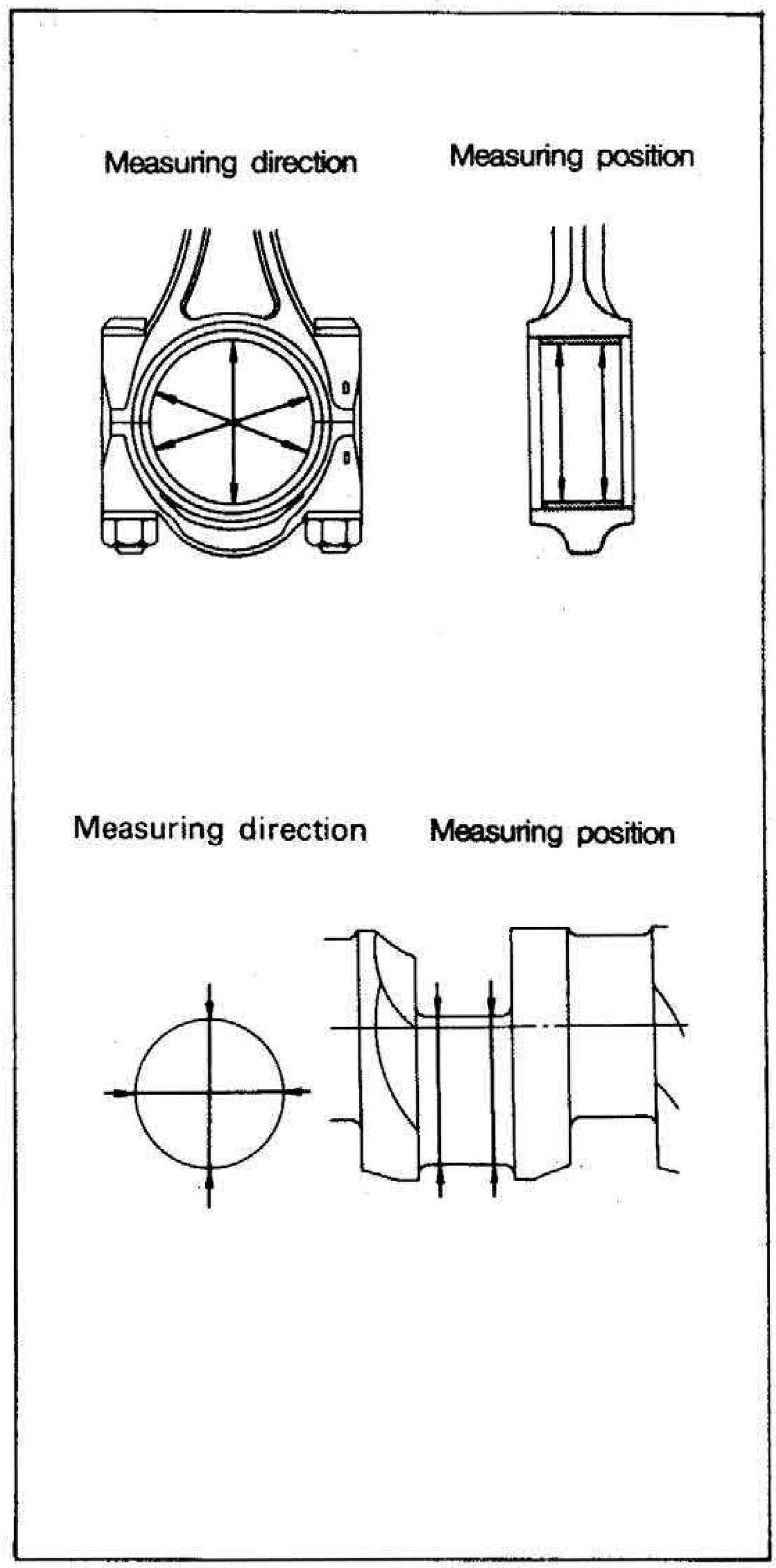
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(4) Measure the free time tension of the connecting rod bearing. If the tension is lower than the service limit, replace the upper and lower bearings as a set.

NOTE : Do not use the bearing by artificially expanding it.



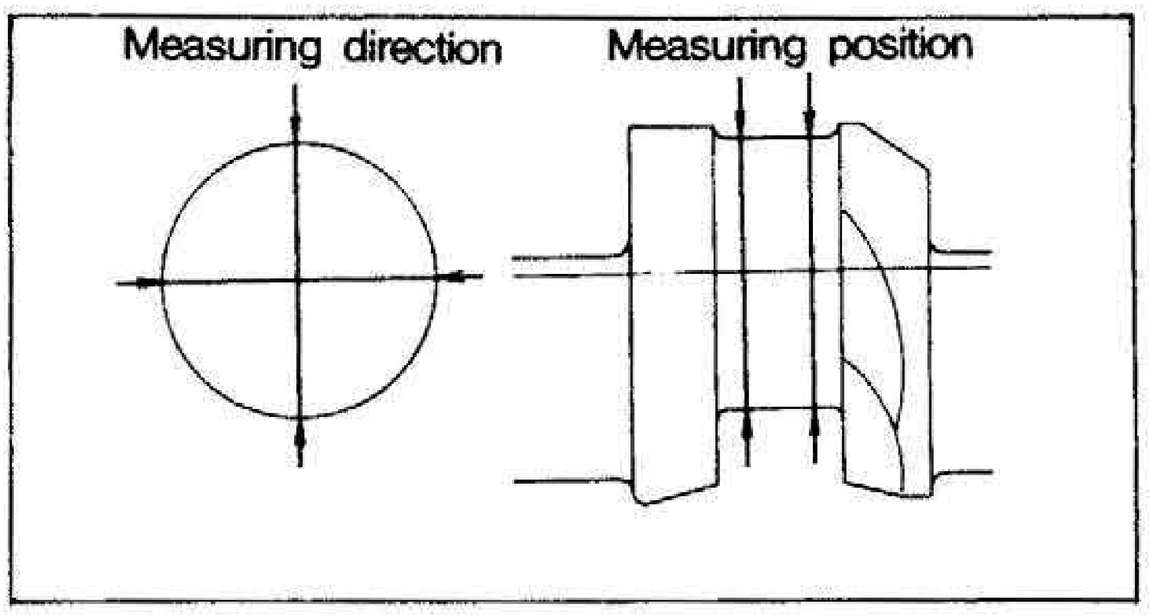
(5) Calculate the clearance from the bearing I.D. and crankshaft O.D. If the repair limit is exceeded, replace the upper and lower bearings as a set.

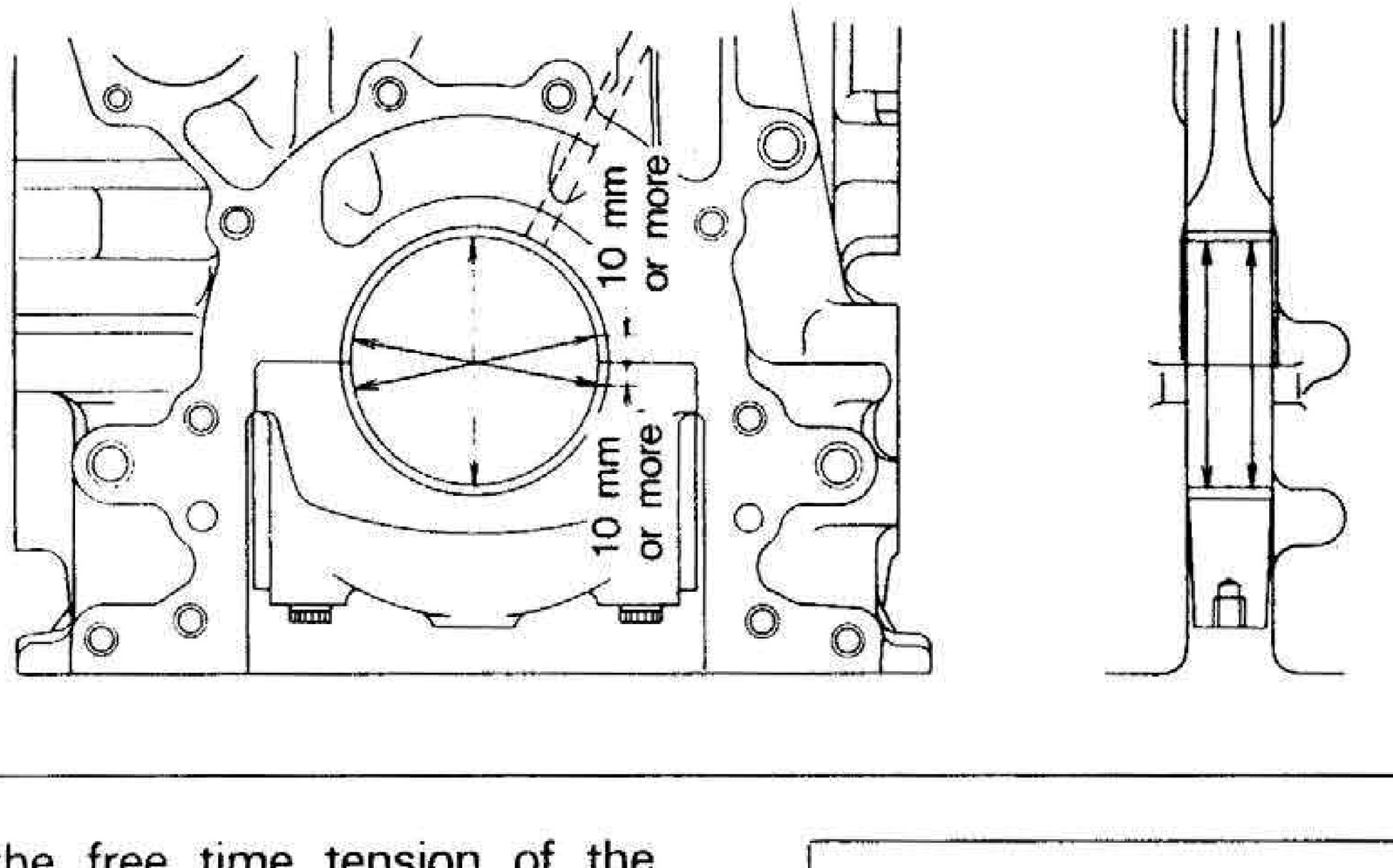


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7-2-9 Crankshaft and Main Bearing

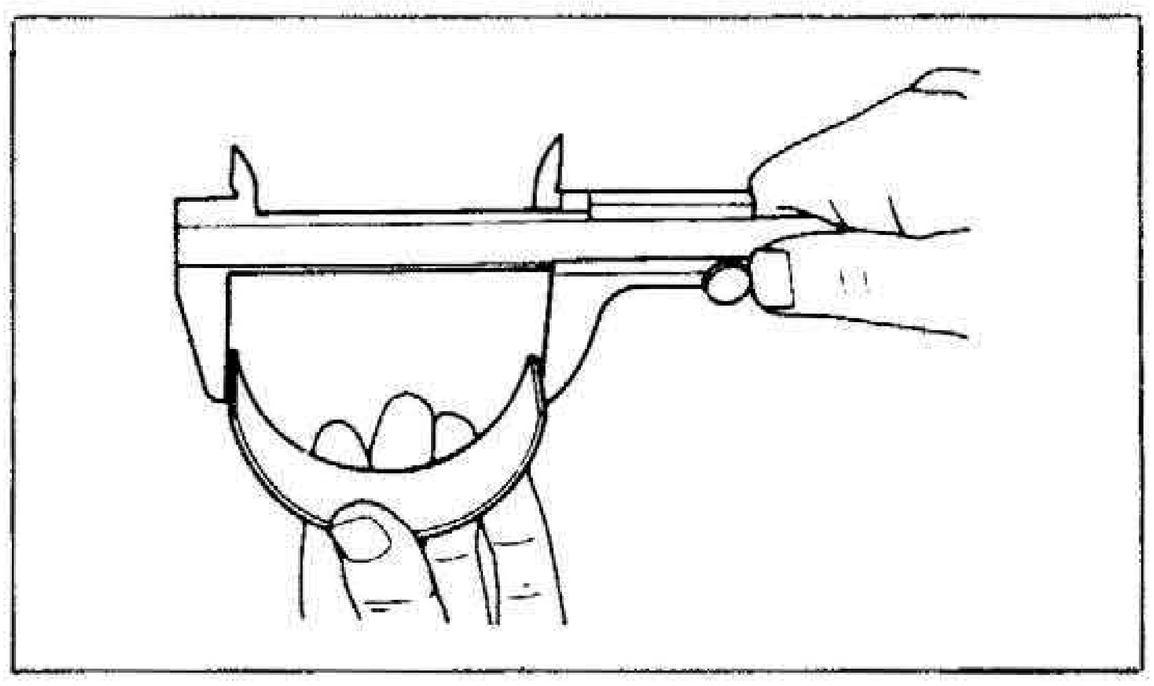
(1) Calculate the clearance from the main bearing I.D. and crankshaft O.D. If the repair limit is exceeded, replace the upper and lower bearings as a set.





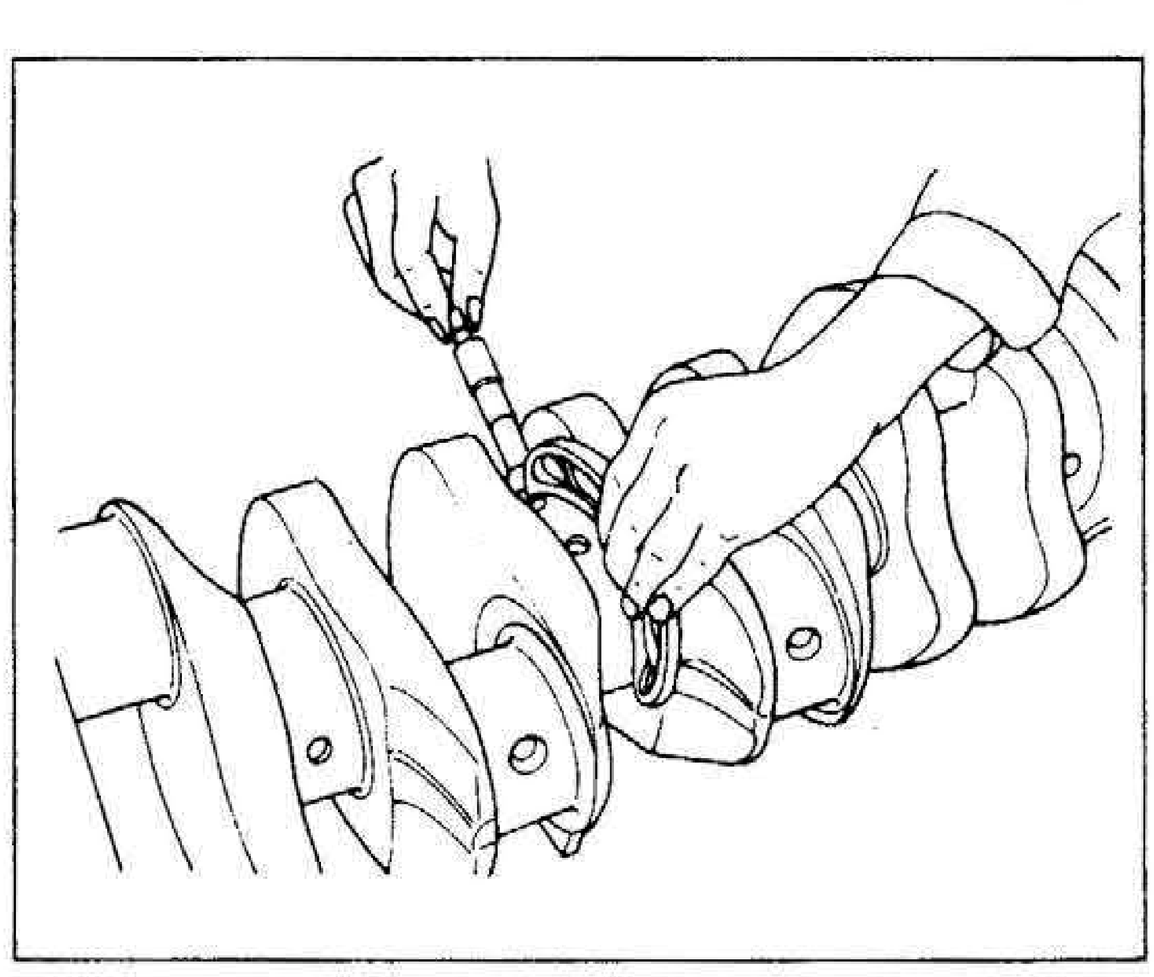
(2) Measure the free time tension of the main bearing. If the tension is below the service limit, replace the upper and lower bearings as a set.

NOTE : Do not use the bearing by artificially widening it.



(3) Determine the out-of-roundness on the basis of the crankshaft journal and pin O.D. measurements.

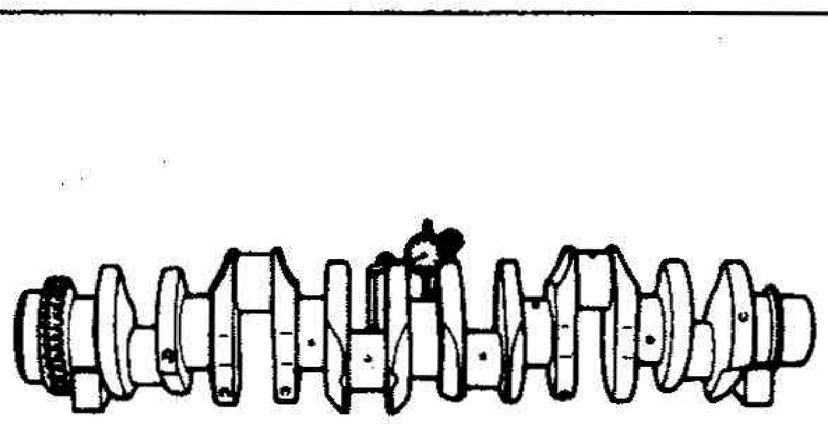
If the repair limit is exceeded, grind to undersize.



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(4) Measure the bend of the crankshaft. If the repair limit is exceeded, correct with a press or grind to undersize.

NOTE : Read the crankshaft center journal runout with a dial indicator. One half of the reading is the bend.



(5) Correction of Crankshaft to Undersize

If the journal or pin is damaged or seized, grind the crankshaft by the following procedures. Replace the bearing with an undersized one.

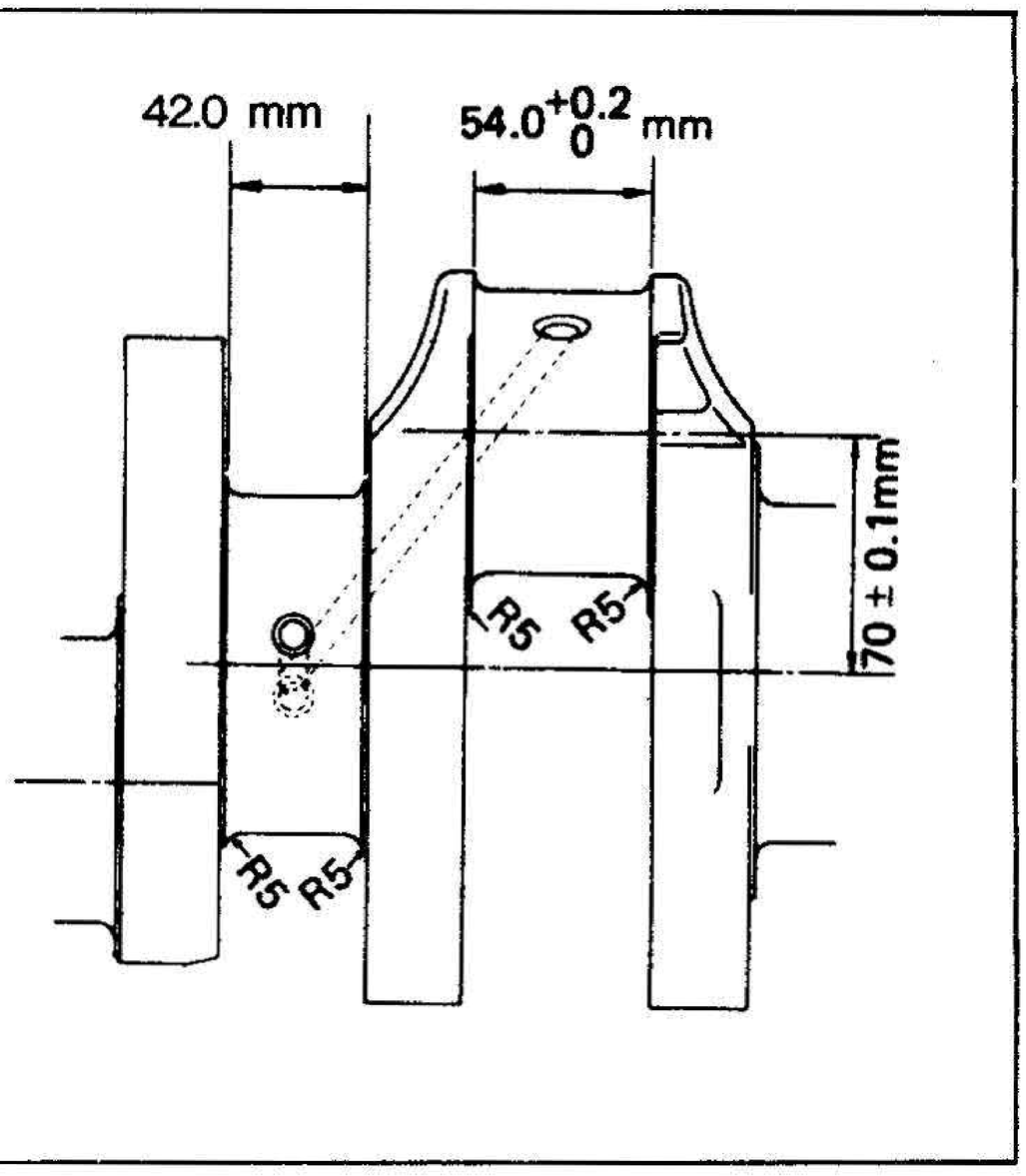
(a) When the crankshaft is ground, take care not to change the center distance of journal and pin.

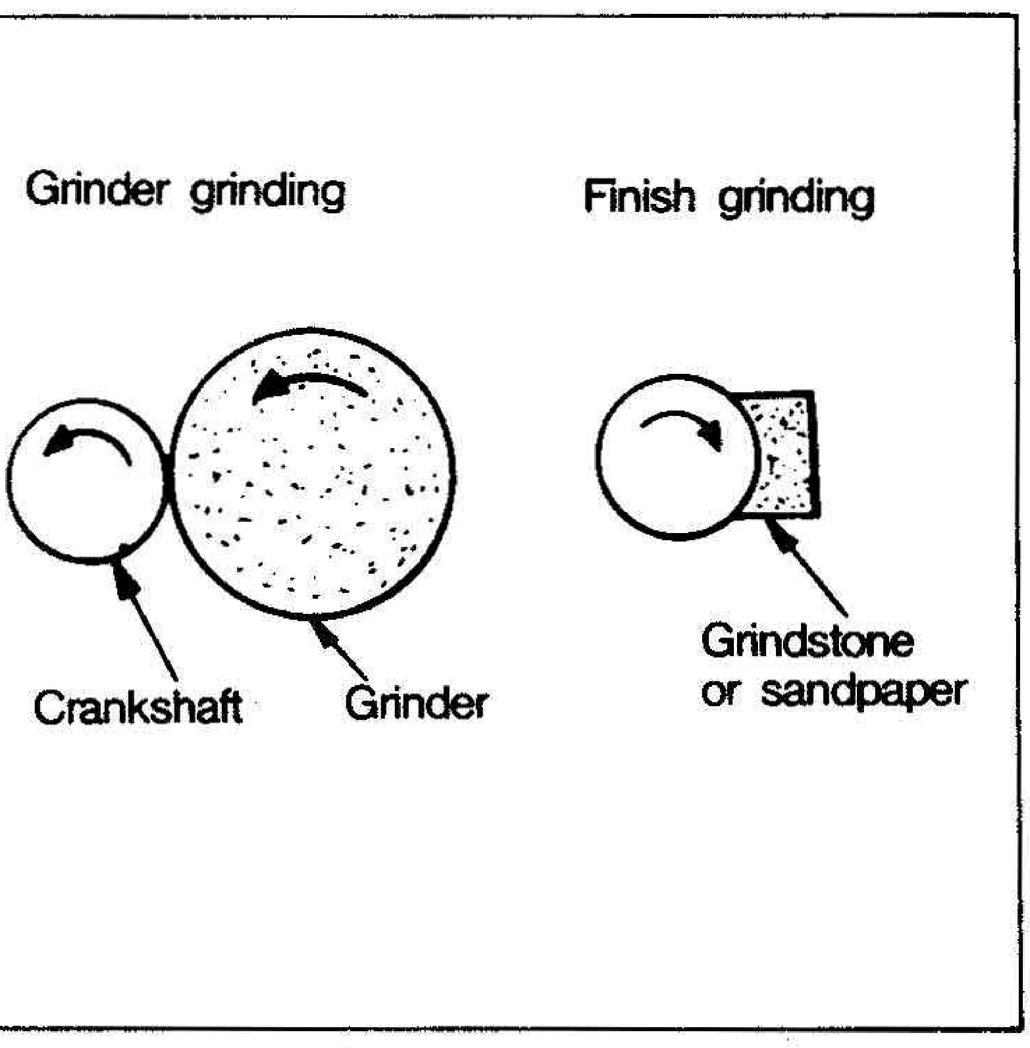
(b) Grind the crankshaft in such a way as not to change the width of journal and pin.

(c) Finish the fillet smooth to the specified R.

(d) Check for ground cracks by the magnetic particle inspection method. The surface hardness(Hs 75 or more) should also be checked to confirm that it has not decreased.

(e) To grind the crankshaft with grinder, the grinder and crankshaft should be turned clockwise as viewed from the crankshaft front end.





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(f) To finish the crankshaft with a grindstone or sandpaper, turn the crankshaft counterclockwise.

Undersize	Journal O.D. finish dimension		Pin O.D. finish dimension		Out-of-roundness	Cylindricity
-0.25	99.75	-0.08 -0.10	83.75	-0.06 -0.09	0.01 or less	0.006 or less
-0.50	99.50	-0.08 -0.10	83.50	-0.06 -0.09		
-0.75	99.25	-0.08 -0.10	83.25	-0.06 -0.09		
-1.00	99.00	-0.08 -0.10	83.00	-0.06 -0.09		
-1.25	98.75	-0.08 -0.10	82.75	-0.06 -0.09		
-1.50	98.50	-0.08 -0.10	82.50	-0.06 -0.09		

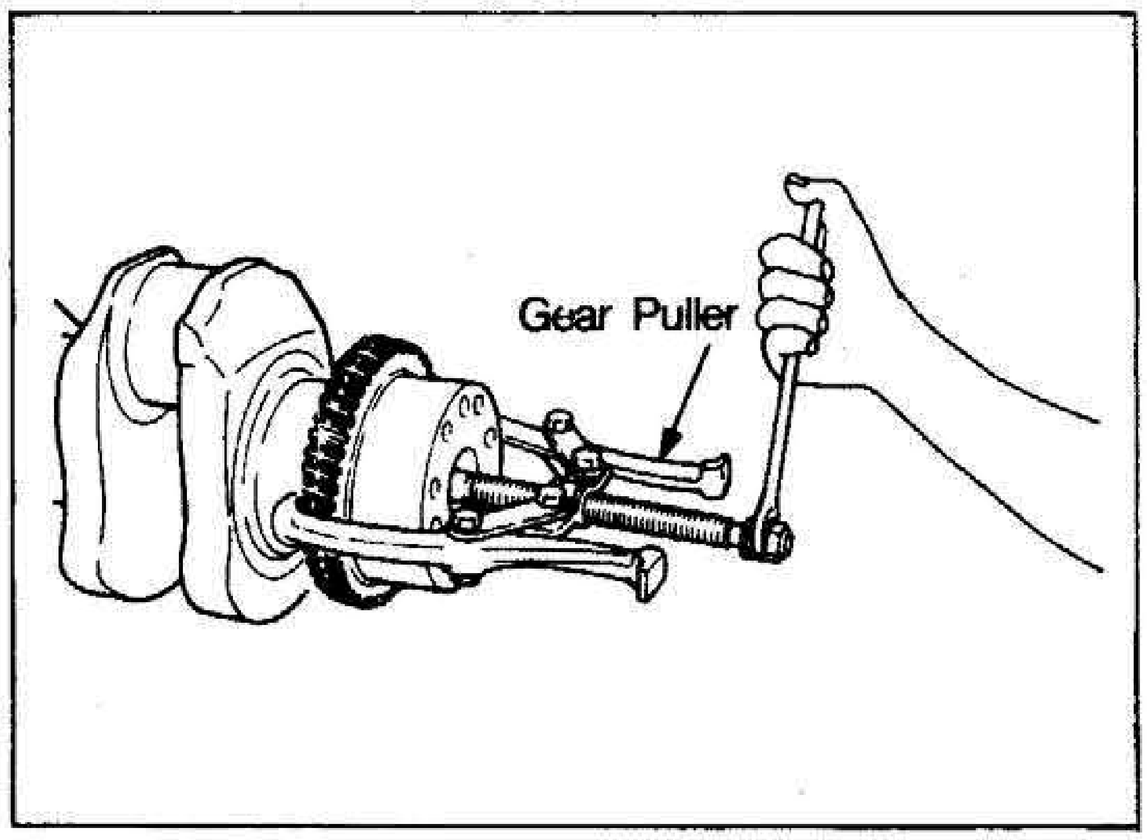
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(6) Replacement of Crankshaft Gear

(a) Remove the oil seal slinger from the crankshaft.

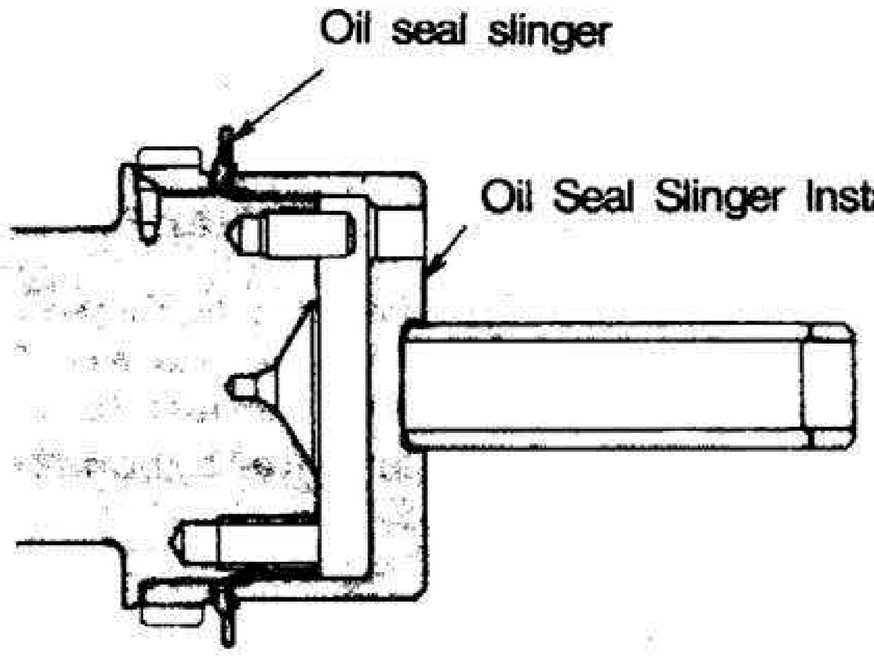
(b) Remove the gear from the crankshaft, using Gear Puller (special tool).

NOTE : Do not attempt removing the gear by striking.



(c) Heat the gear to about 100℃, using a piston heater, etc.
Locate the gear so that the dowel pin of the crankshaft will fit in the notch of the gear and fit the gear by lightly striking the gear end with a soft hammer.

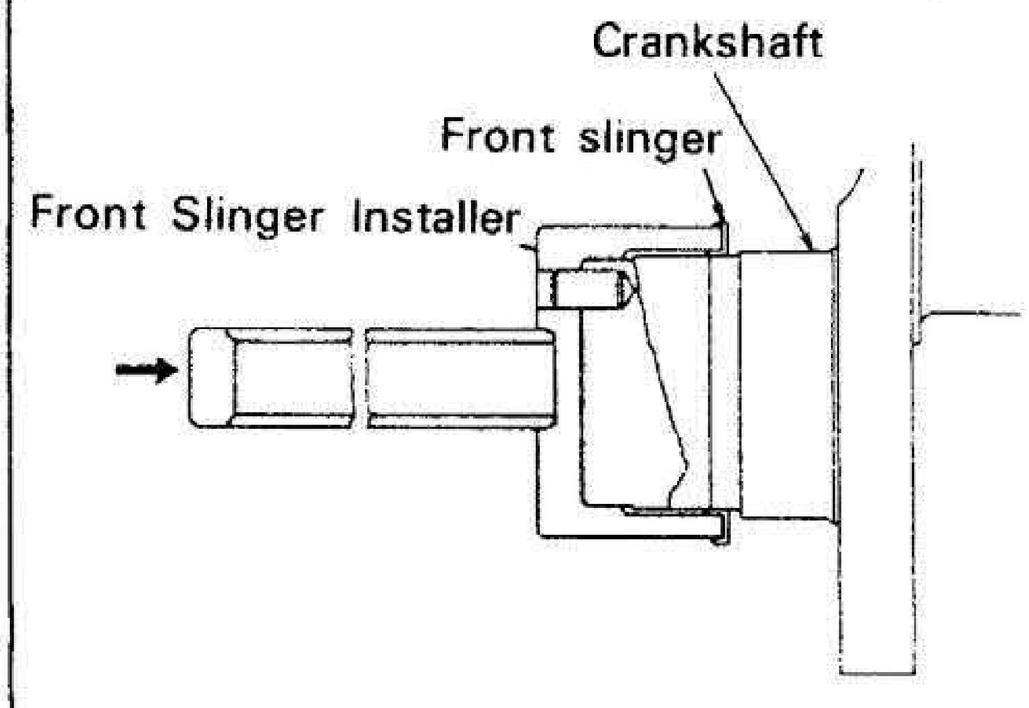
(b) Install the oil seal slinger, using Oil Seal Slinger Installer(special tool).
NOTE : Install the oil seal slinger with the threaded surface toward the flywheel.



(7) Relacement of Front Slinger

(a) Remove the front slinger from the crankshaft.

(b) Install the front slinger, using Front Slinger Installer(special tool).



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7-3 REASSEMBLY

Observe the following items when proceeding with reassembly.

(1) Thoroughly clean all parts to be assembled. Check to ensure that there are no dust, oil and water on the joining surfaces of the parts before reassembly.

(2) The gaskets, O-rings, packings, lock washers, split pins, etc. should be replaced with new ones. Since gasket kits are available, use them at the time of an overhaul.

(3) Use of sealants is not required as a rule. Where use of a sealant is specified, however, use the specified sealant.

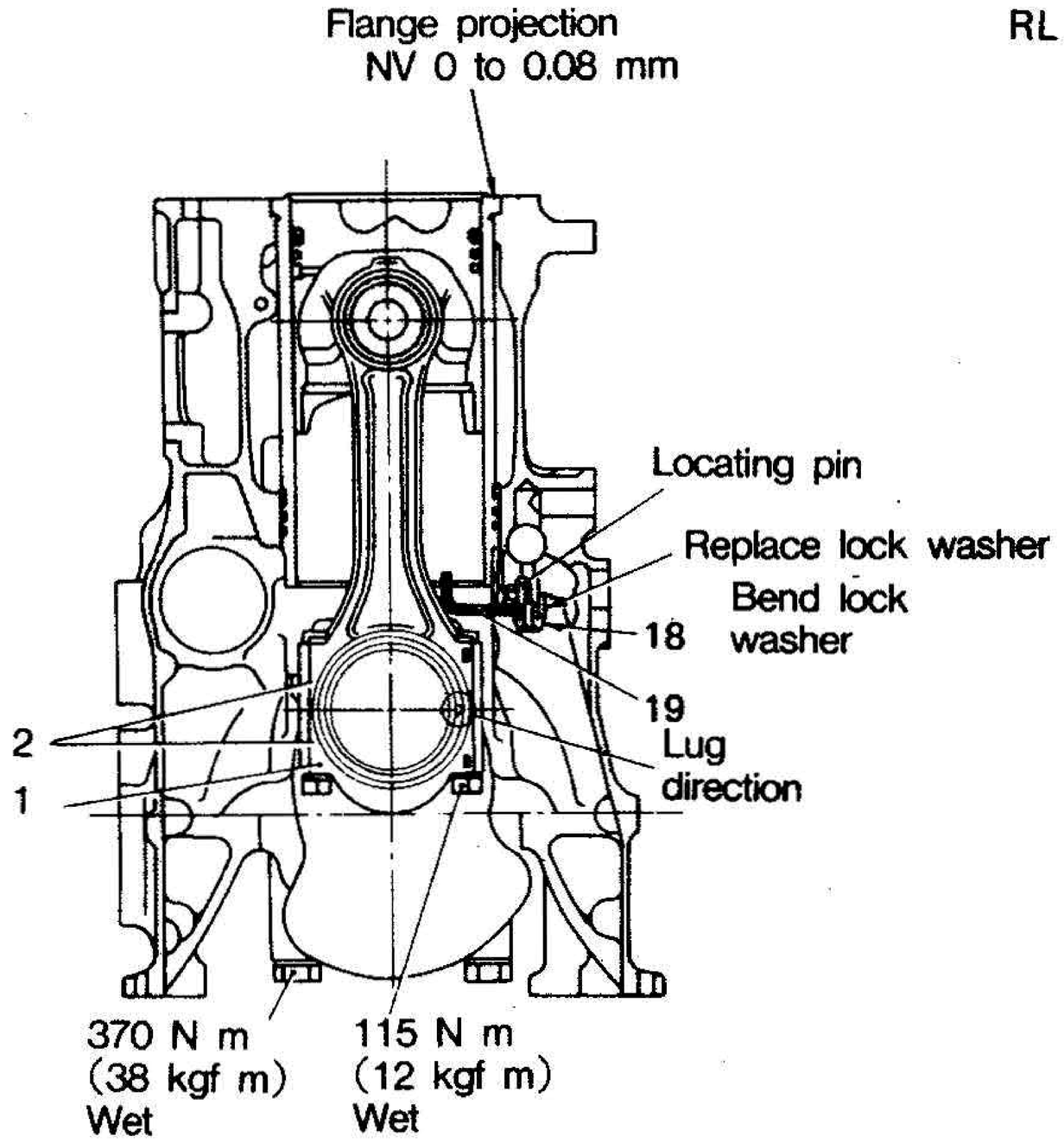
(4) Parts for which a tightening torque is specified should be tightened to the specified torque. Parts for which no tightening torque is specified should be tightened to the general bolt and nut tightening torque.

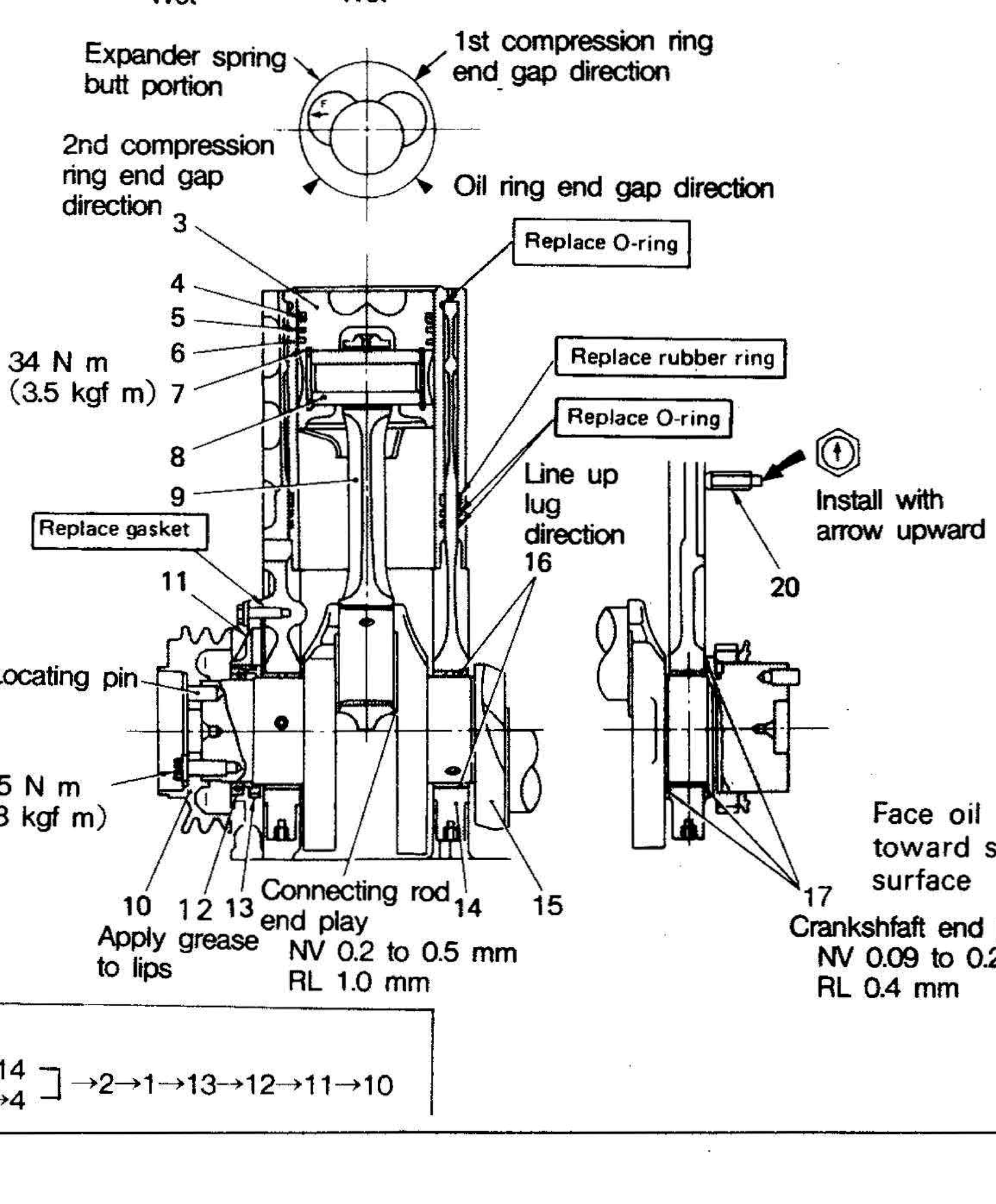
(5) Apply engine oil to all moving parts before reassembly unless otherwise specified.

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7-3-1 Crank case and Main Moving parts

NV··· Nominal Valve
RL··· Repair Limit





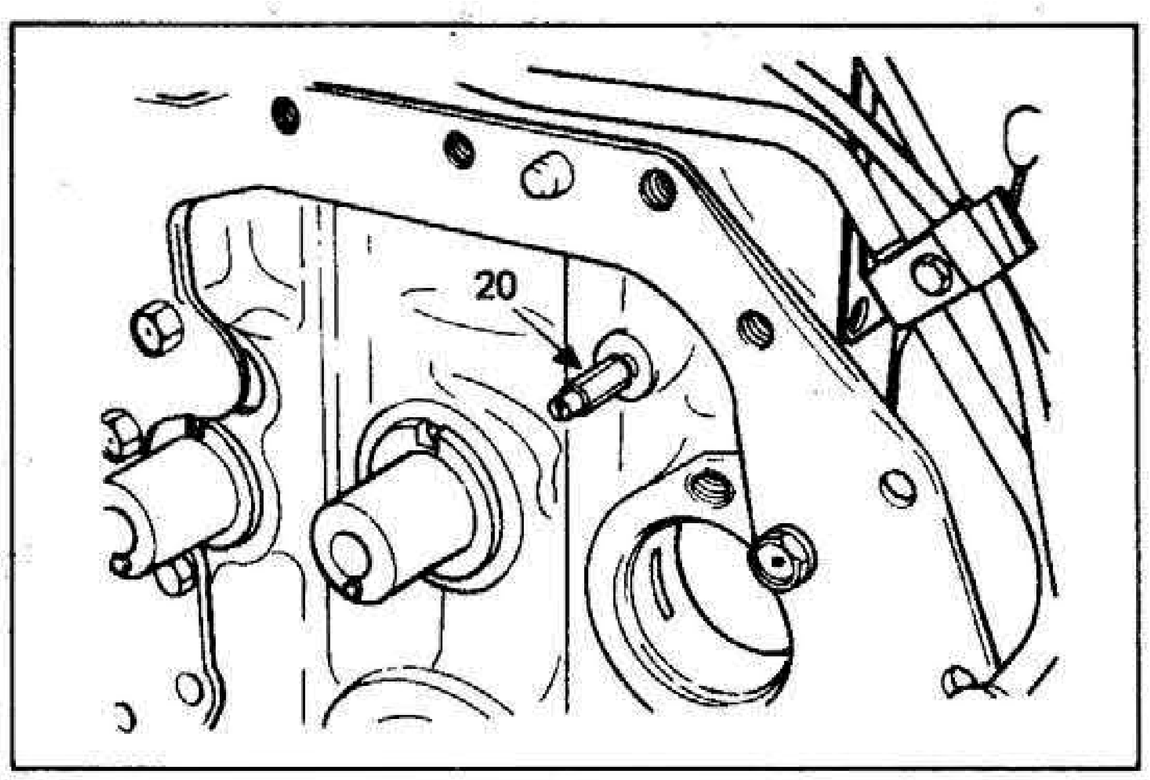
Assembling sequence

20→19→18→17→16→15→14
3→9→8→7→6→5→4
→2→1→13→12→11→10

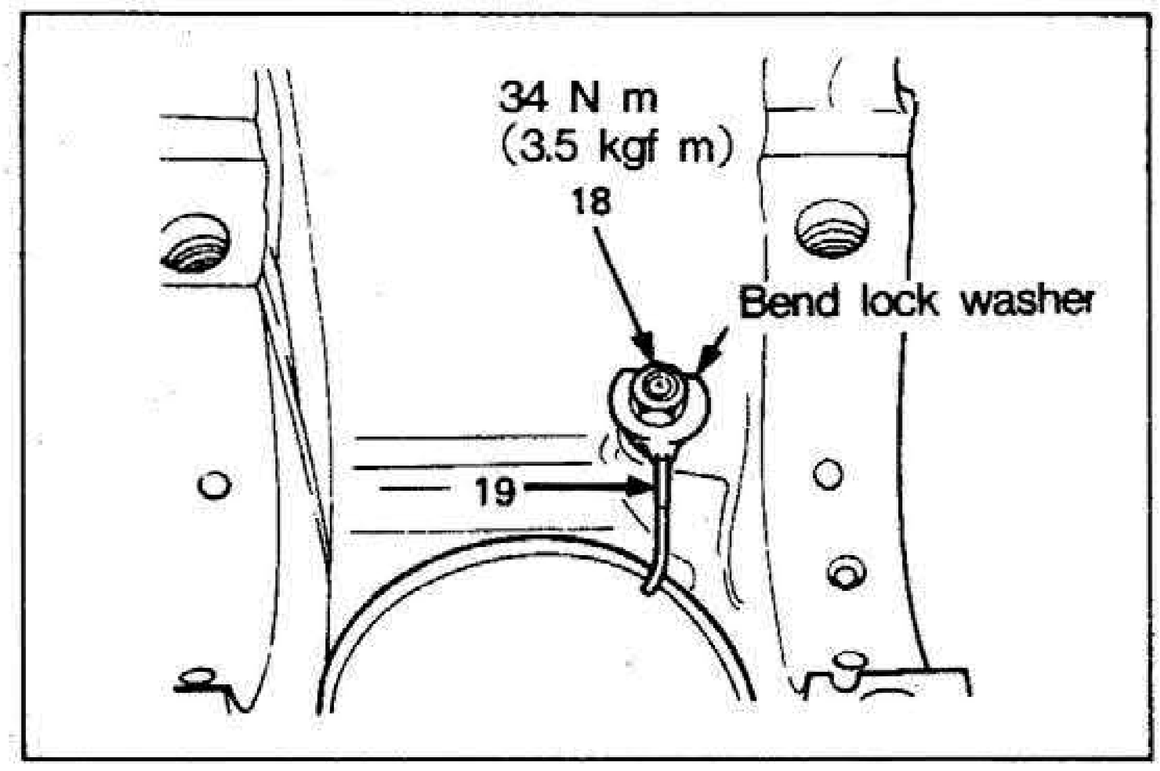
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(1) Install the oil spray plug 20 to the crankcase.

NOTE : Install the oil spray plug with the arrow stamped on the plug toward the top of the engine.



(2) Tighten the oil jet 19 and check valve 18 to the specified torque. After they have been tightened, bend the lock washer to prevent turning.

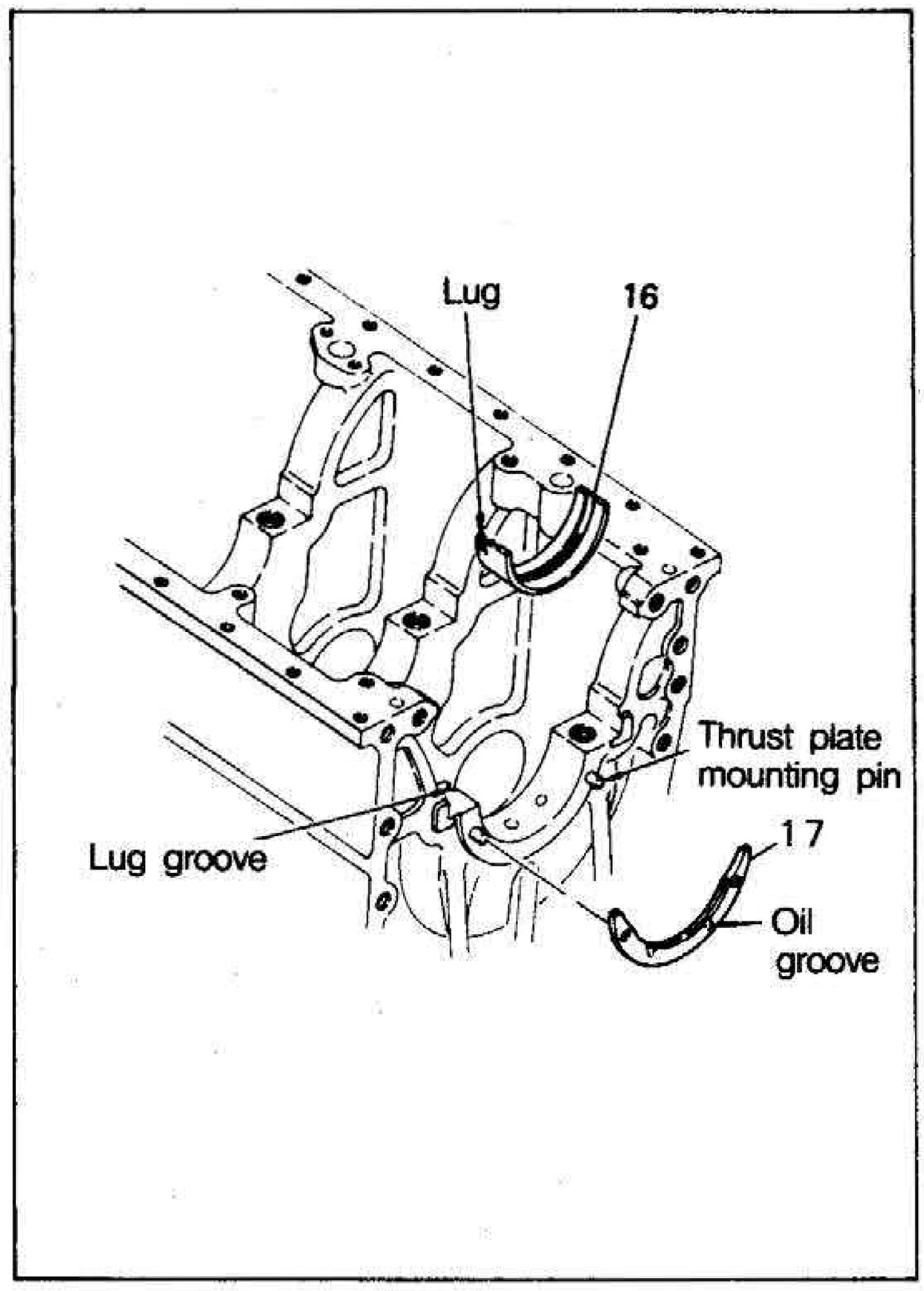


(3) Install the thrust plate 17 and upper main bearing 16 to the crankcase.

NOTE : 1. Install the thrust plate with the oil grooveless side toward the crankcase.

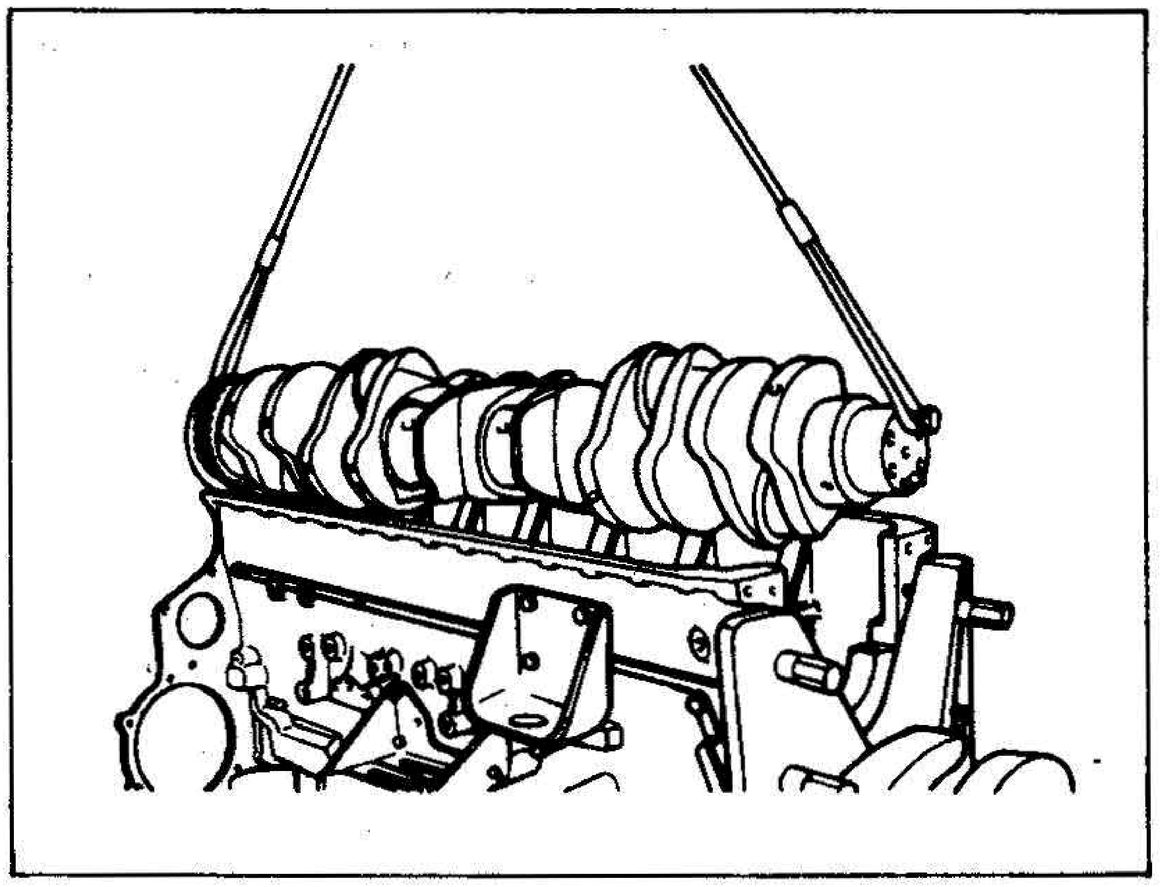
2. Line up the lug of the main bearing and the groove of the crankcase. The upper main bearing is one with oil holes. Take care not to confuse it with the lower one.

3. The crankcase and rear main bearing cap rear end thrust plates should be the same size.

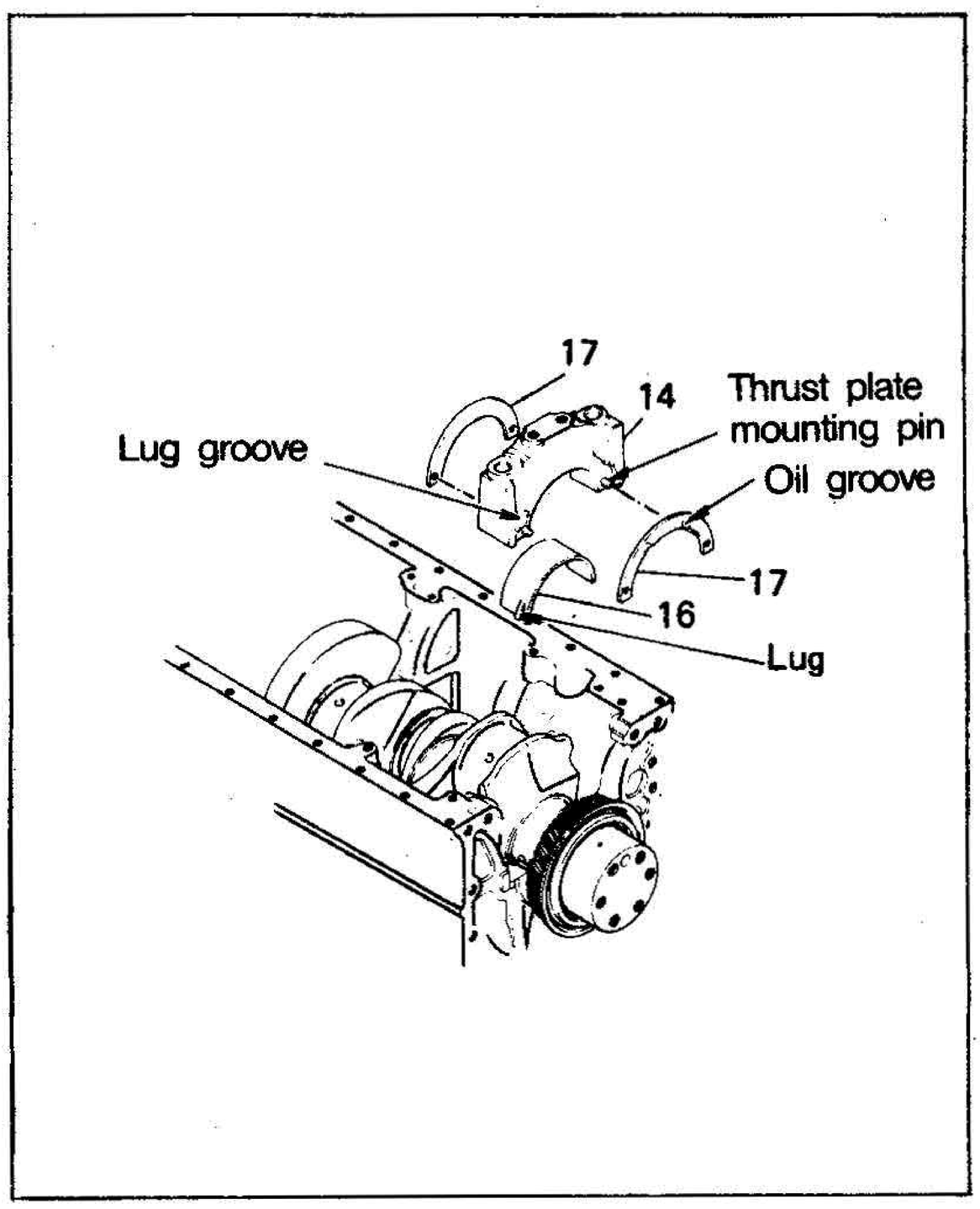


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(4) Lift the crankshaft 15 with chain blocks, etc. While keeping it in horizontal position, slowly lower it into the crankcase.



(5) Fit the lower main bearing 16 onto the main bearing cap 14. Install the main bearing cap to the crankcase while tapping it with a soft hammer. The thrust plates 17 should also be installed to the front and rear of the rear main bearing cap.

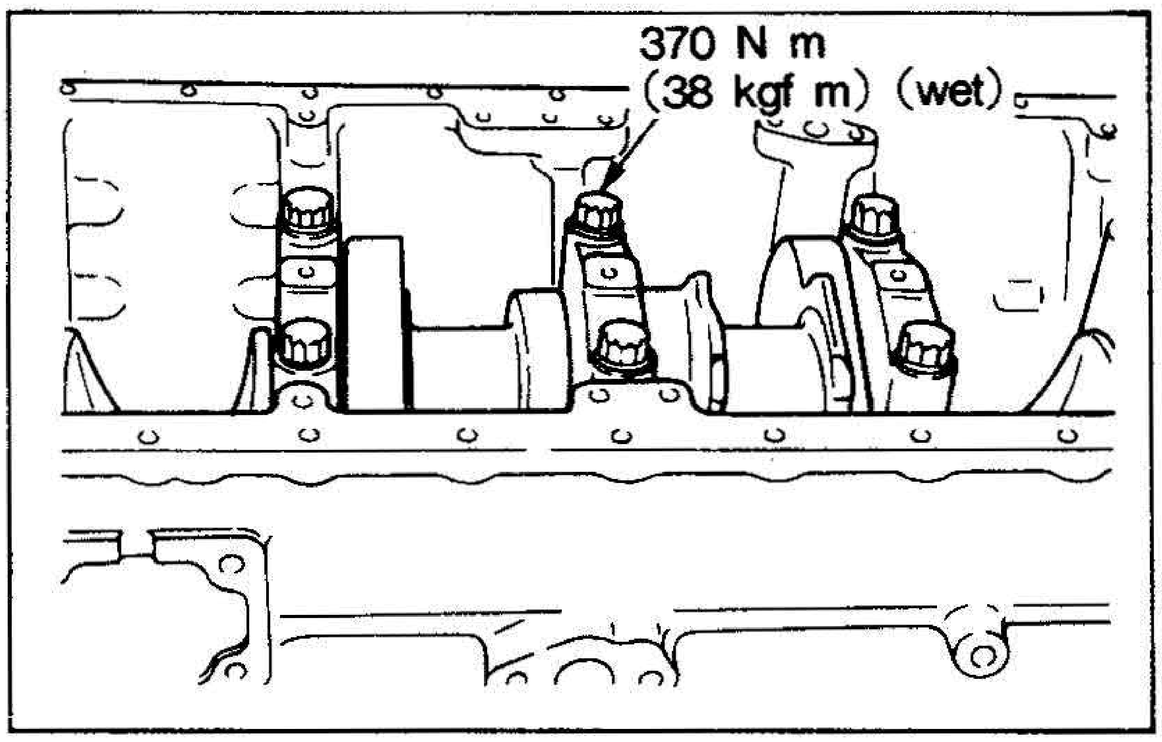


NOTE : 1. The lug of the lower main bearing should be on the same side as the lug of the upper main bearing.

2. Install both thrust plates with the oil grooveless surface toward the rear main bearing cap.

(6) Tighten the main bearing cap to the specified torque.

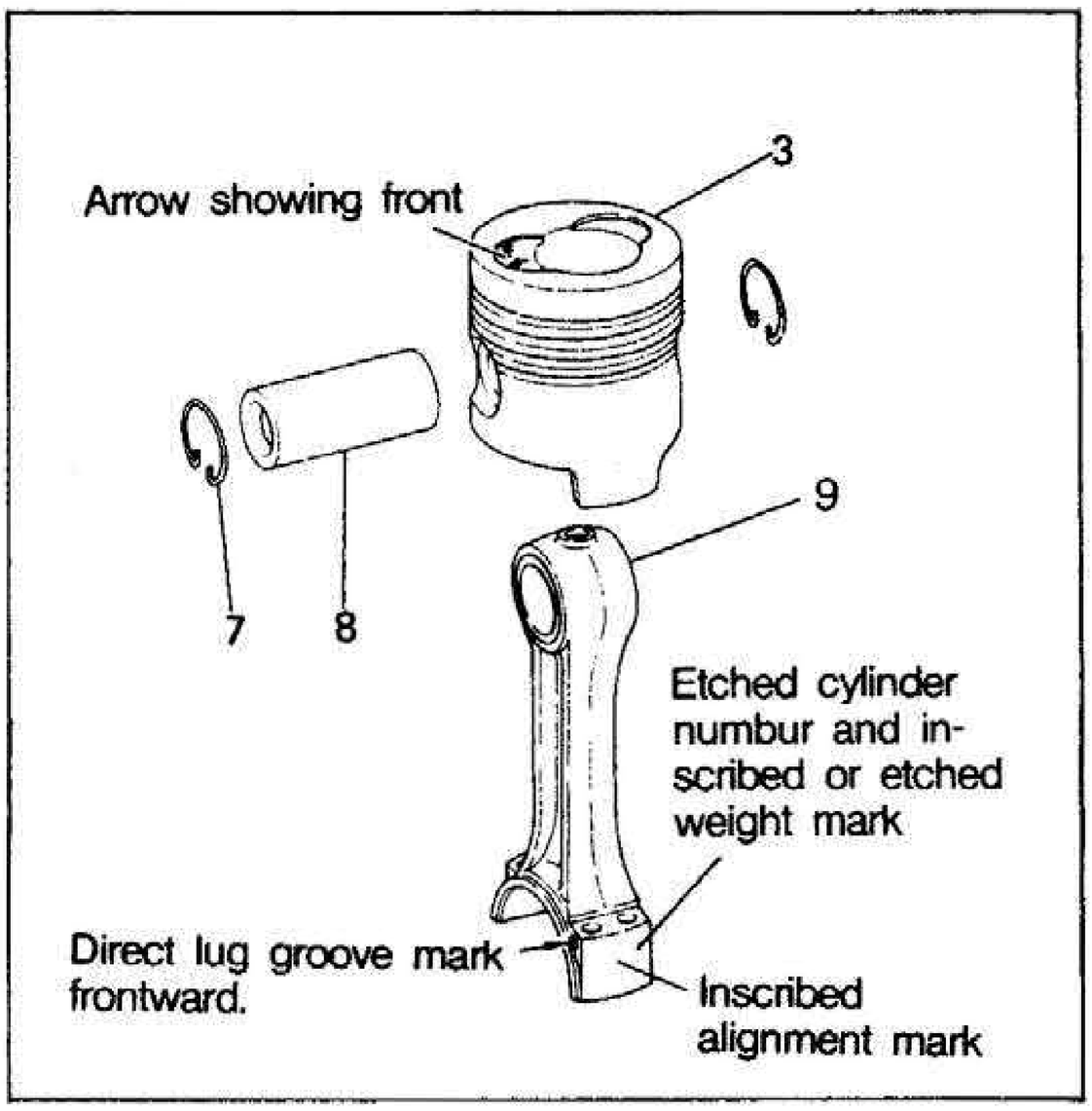
After reassembly, check to ensure that the crankshaft can be turned lightly by hand. Check to ensure that the crankshaft end play has the nominal dimension. Refer to Para. 7-1-3(6).



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(7) Reassembly of Piston and Connecting Rod

(a) When the piston 3 and connecting rod 9 are installed, direct them as shown.



(b) Insert the piston pin 8 to couple the piston and connecting rod.

Fit the snap ring 7 to prevent the piston pin from slipping out of position.

If the piston and piston pin are hard to insert, heat the piston with a piston heater or in hot water.

NOTE : The parts for an engine must be of the same weight mark.

Weight marks

Heavy ◄——————————► Light

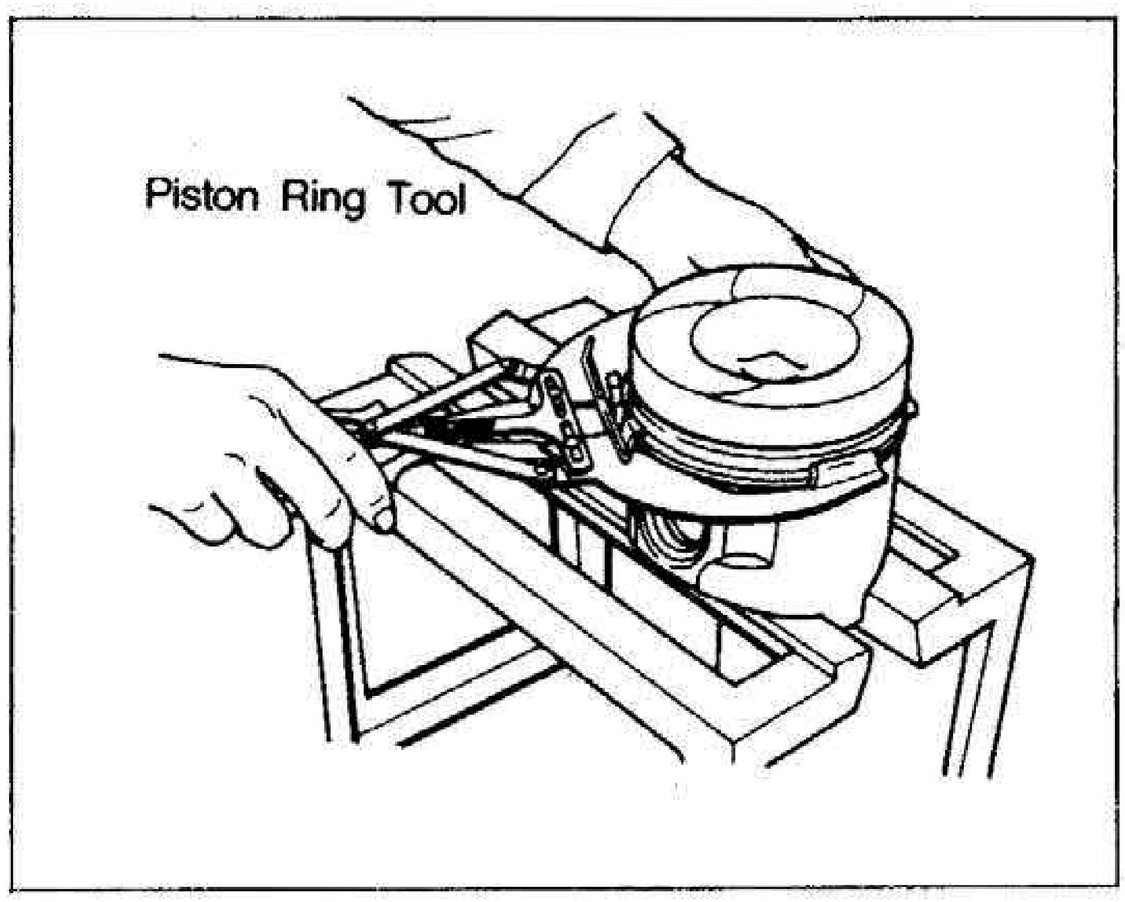
A B C D E F G H J K

(c) Using Piston Ring Tool(special tool), install the piston rings in the following sequence.

6 Oil ring

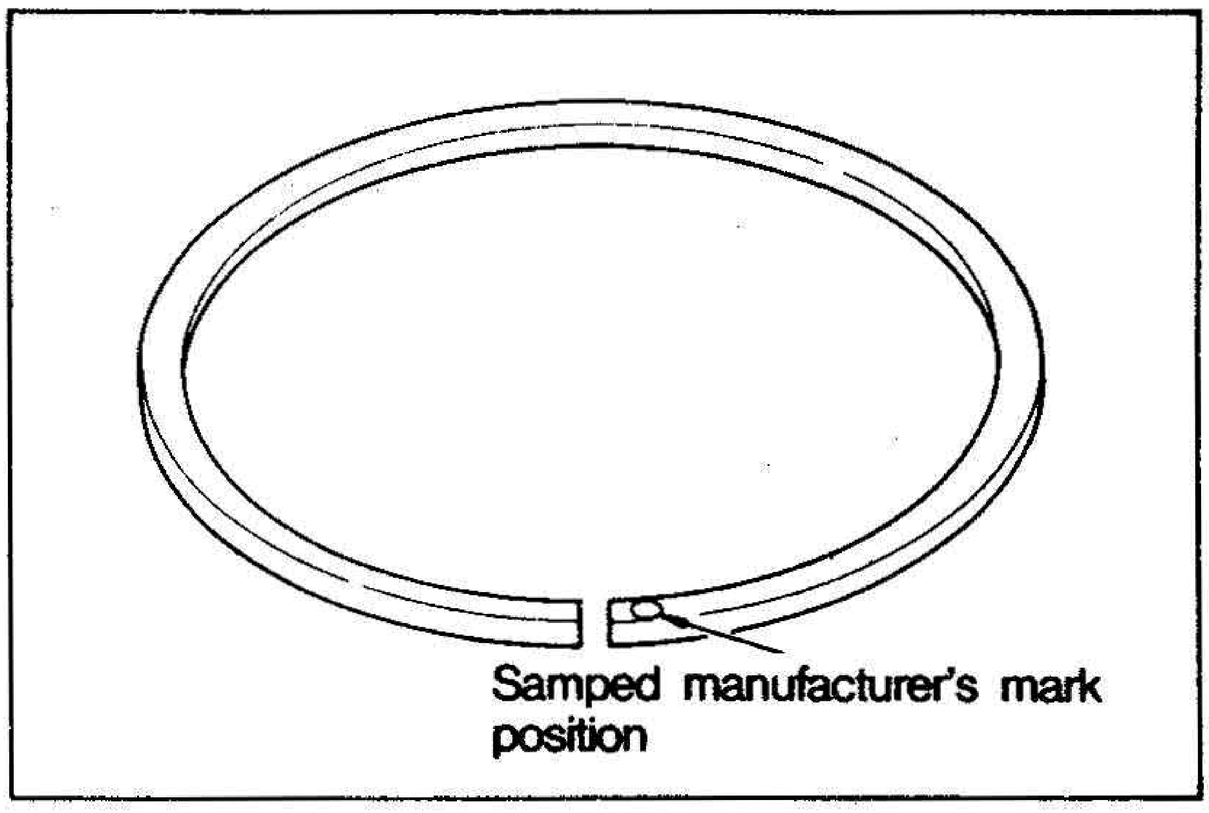
5 2n compression ring

4 1st compression ring

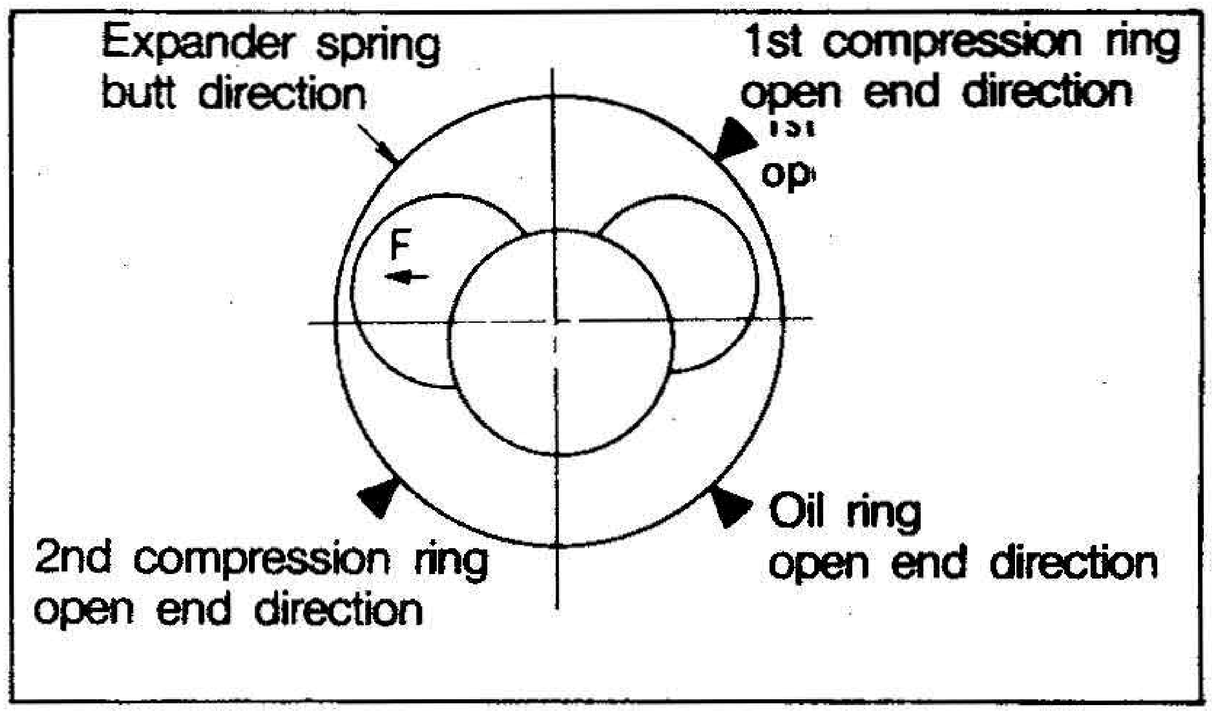


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Install the piston ring with the manufacturer's mark at the open end of the ring upward.

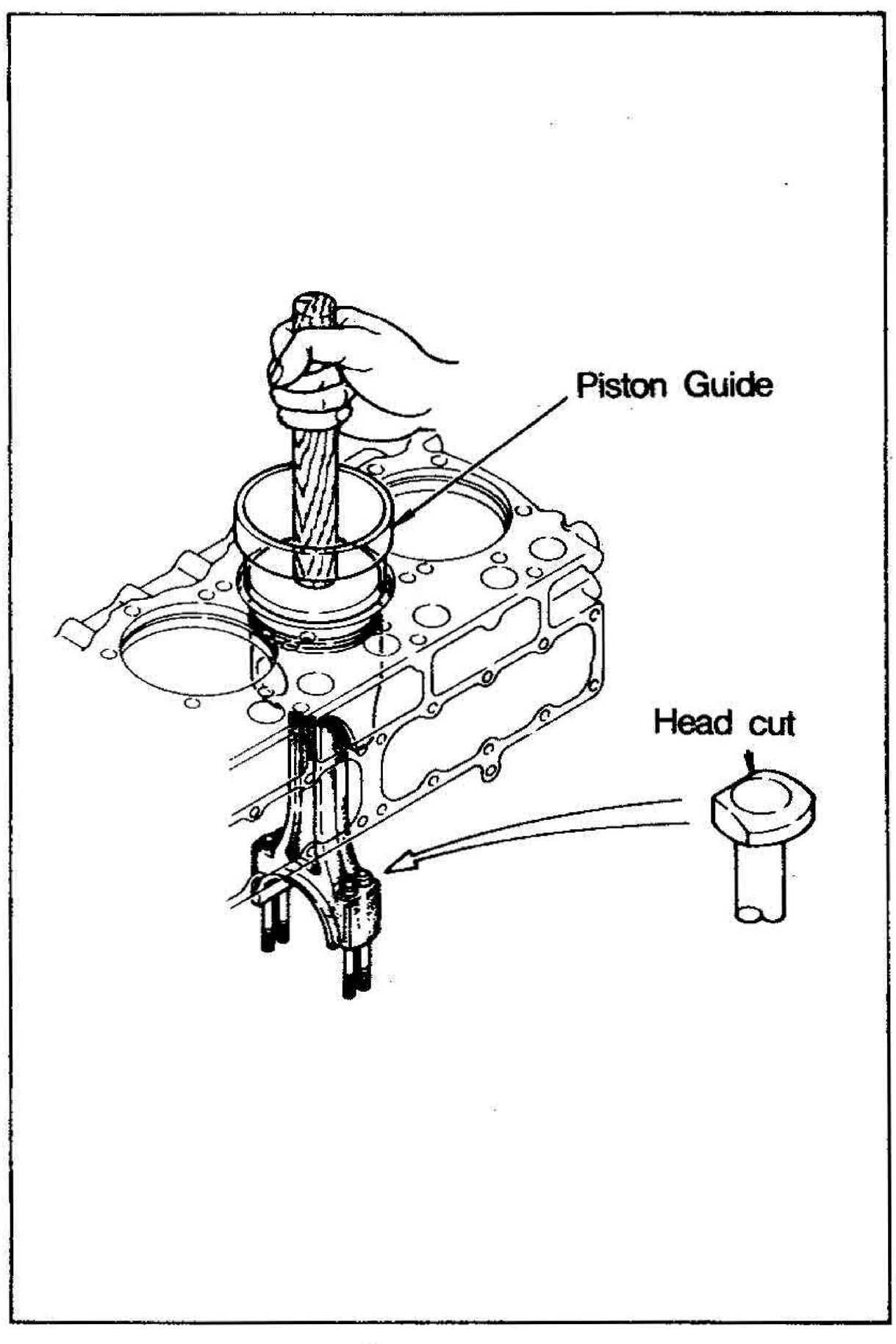


Direct the open ends of the piston rings as shown.



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(d) Fit the oil-holed upper connecting rod bearing 2 on the connecting rod in such a way that the oil hole will match the oil hole in the connecting rod, and insert the piston into the cylinder liner, using a special tool (Piston Guide).



NOTE : 1. Assemble the piston and connecting rod so that the arrow mark on the top of the piston will be directed toward the front.

2. Make sure that the open ends of the piston rings do nt change their directions.

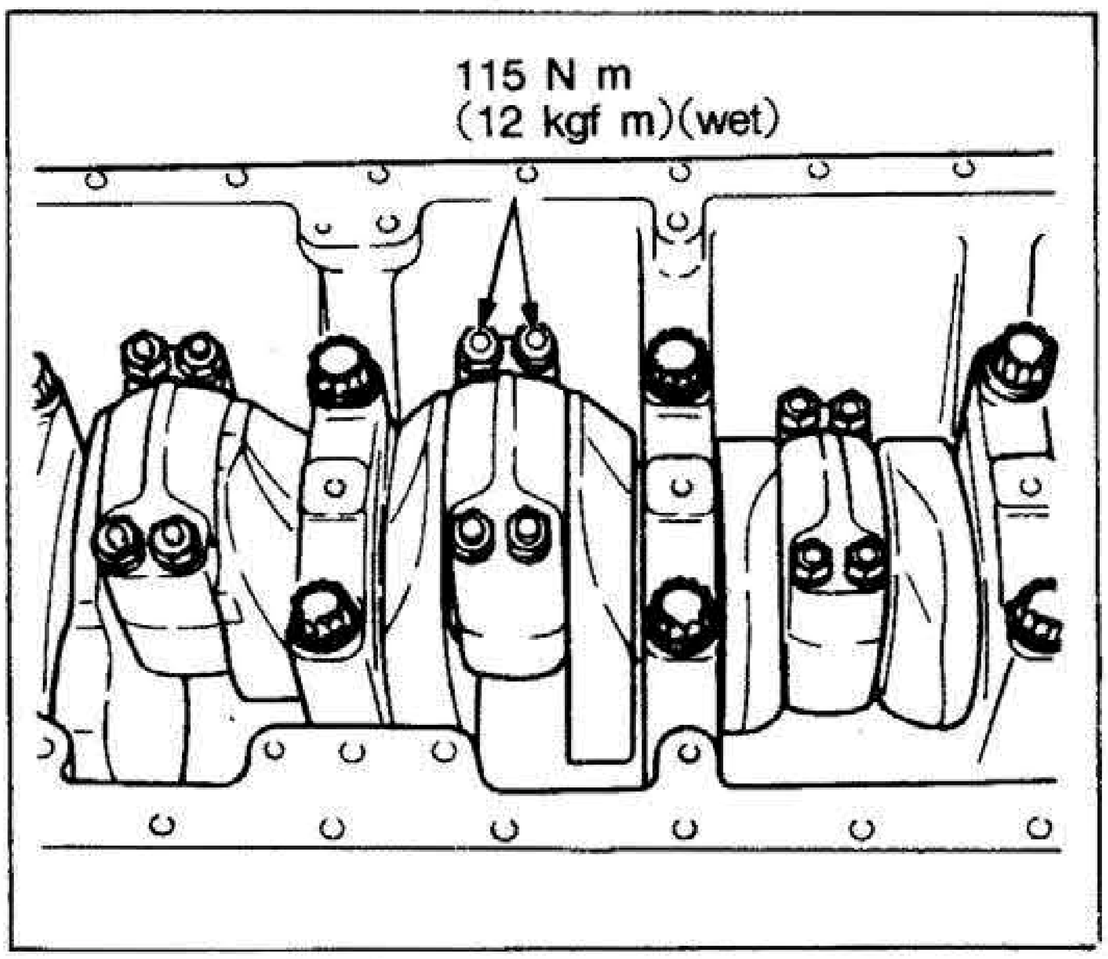
3. When the connecting rod is inserted, be sure not to damage the cylinder liner and crankshaft pin.

4. The notched portion of bolt head should be directed toward the connecting rod.

5. The connecting rod bearings are of two kinds, the upper and lower bearings. Assemble by fitting the oil-holed upper bearing on the connecting rod with the oil holes in alignment and by fitting the lower bearing without an oil hole in the connecting rod cap.

(e) Fit the lower connecting rod bearing 2 without an oil hole in the connecting rod cap 1 and tighten the cap to the connecting rod to the specified torque.

NOTE : The lug side of connecting rod and the lug side of connecting rod cap should be in the same direction.



(f) Check the connecting rod end play. Refer to Para. 7-1-3(2).

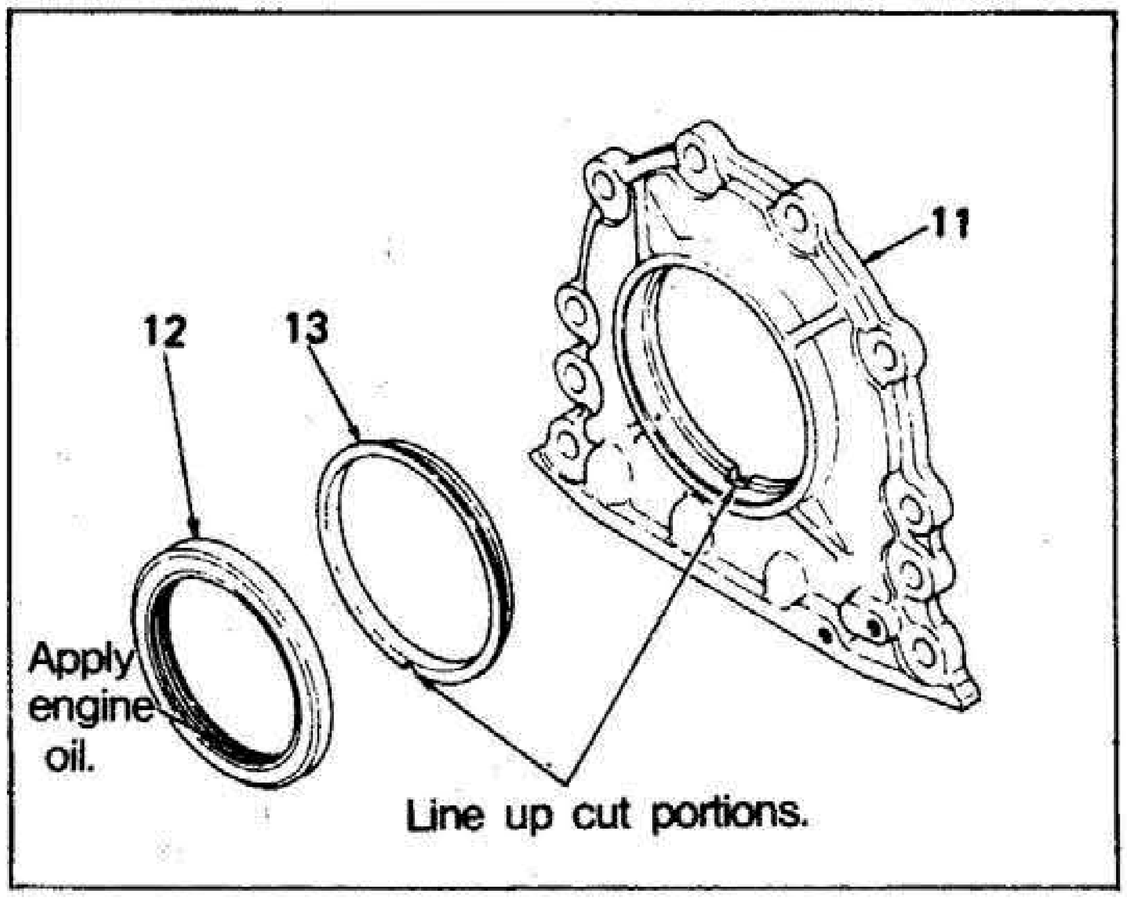
(g) Check the projection of the piston. Refer to Para. 7-1-3(1).

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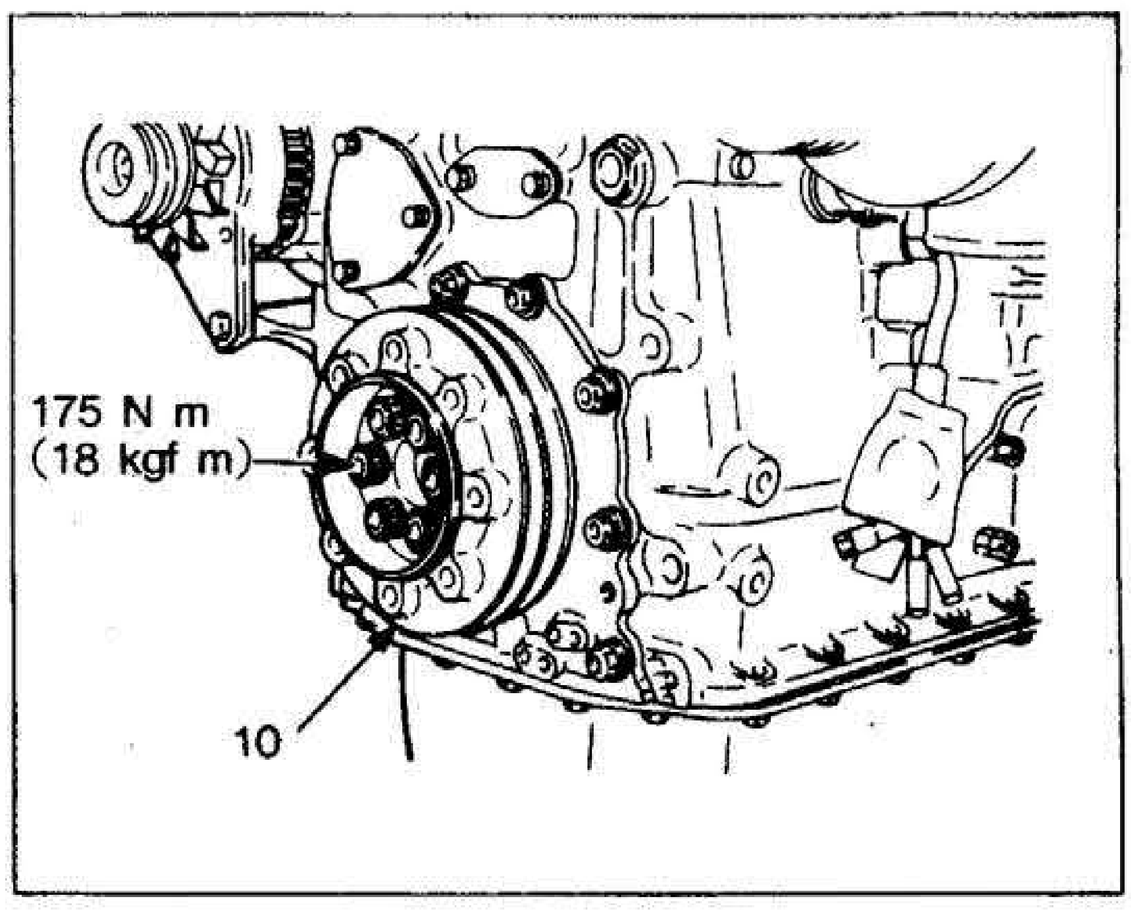
(8) Fit the seal plate 13 and oil seal 12 into the front cover 11 and install the front cover 11 to the crankcase.

NOTE : 1. Apply engine oil to the oil seal lips.

2. Check to ensure that the front slinger pressed into the crankshaft is free from deformation.



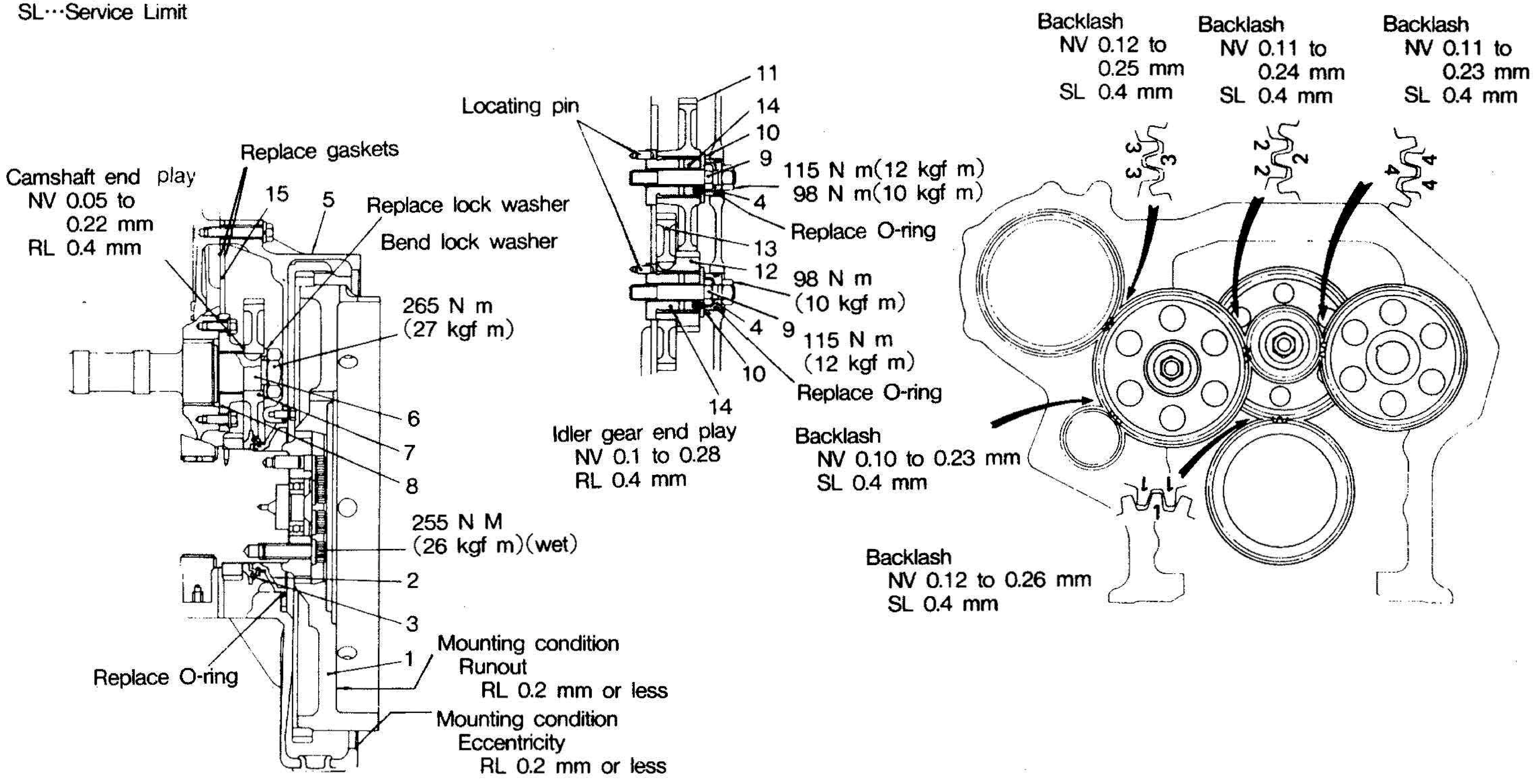
(9) Tighten the crankshaft pulley 10 to the specified torque.



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NV···Nominal Value
RL···Repair Limit
SL···Service Limit



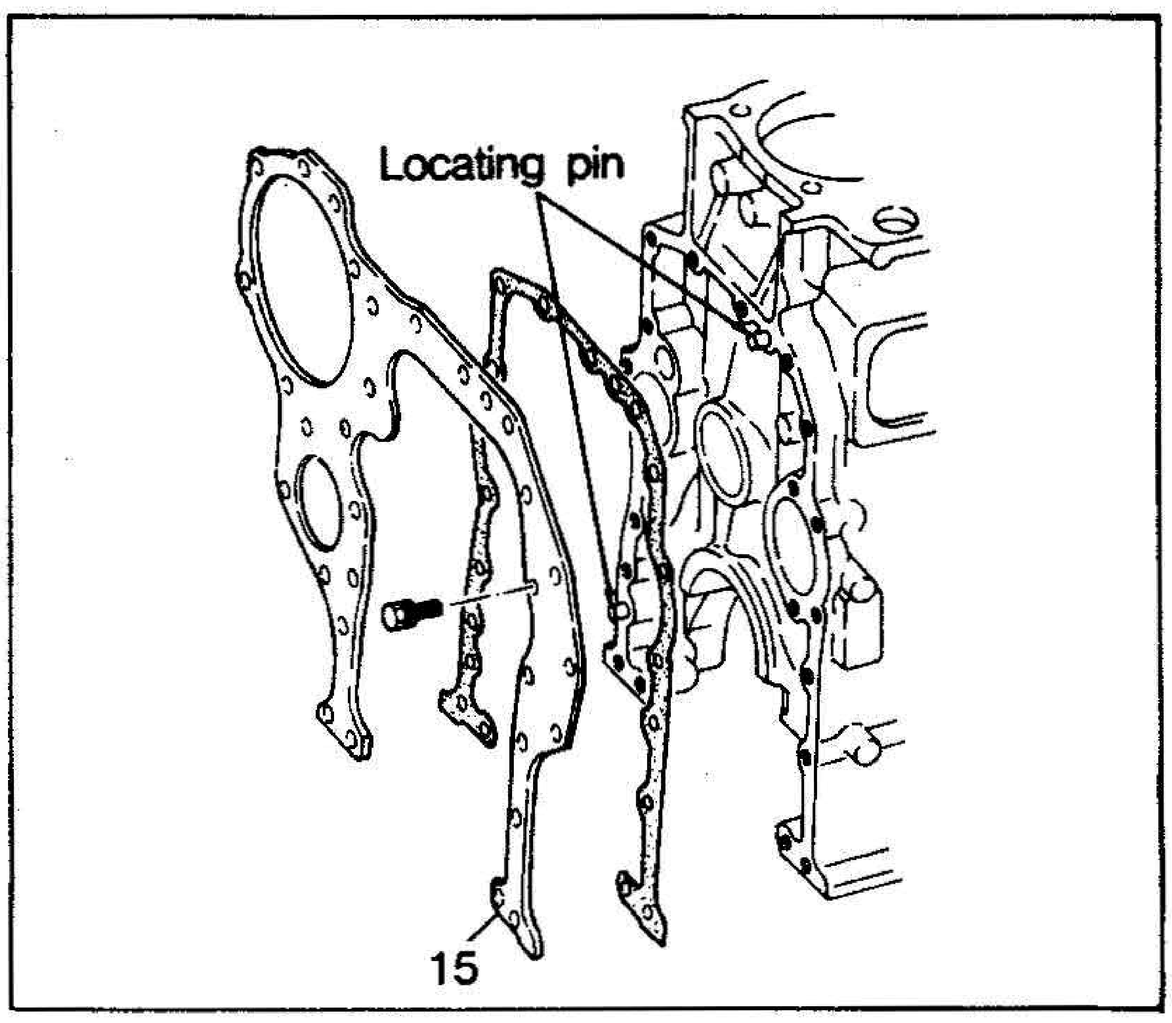
Assembling sequence

15→14→13→12→11→10→9 ┐
8→7→6 ┘ →5→4→3→2→1

(1) Install the rear plate 15 to the crankcase rear end.

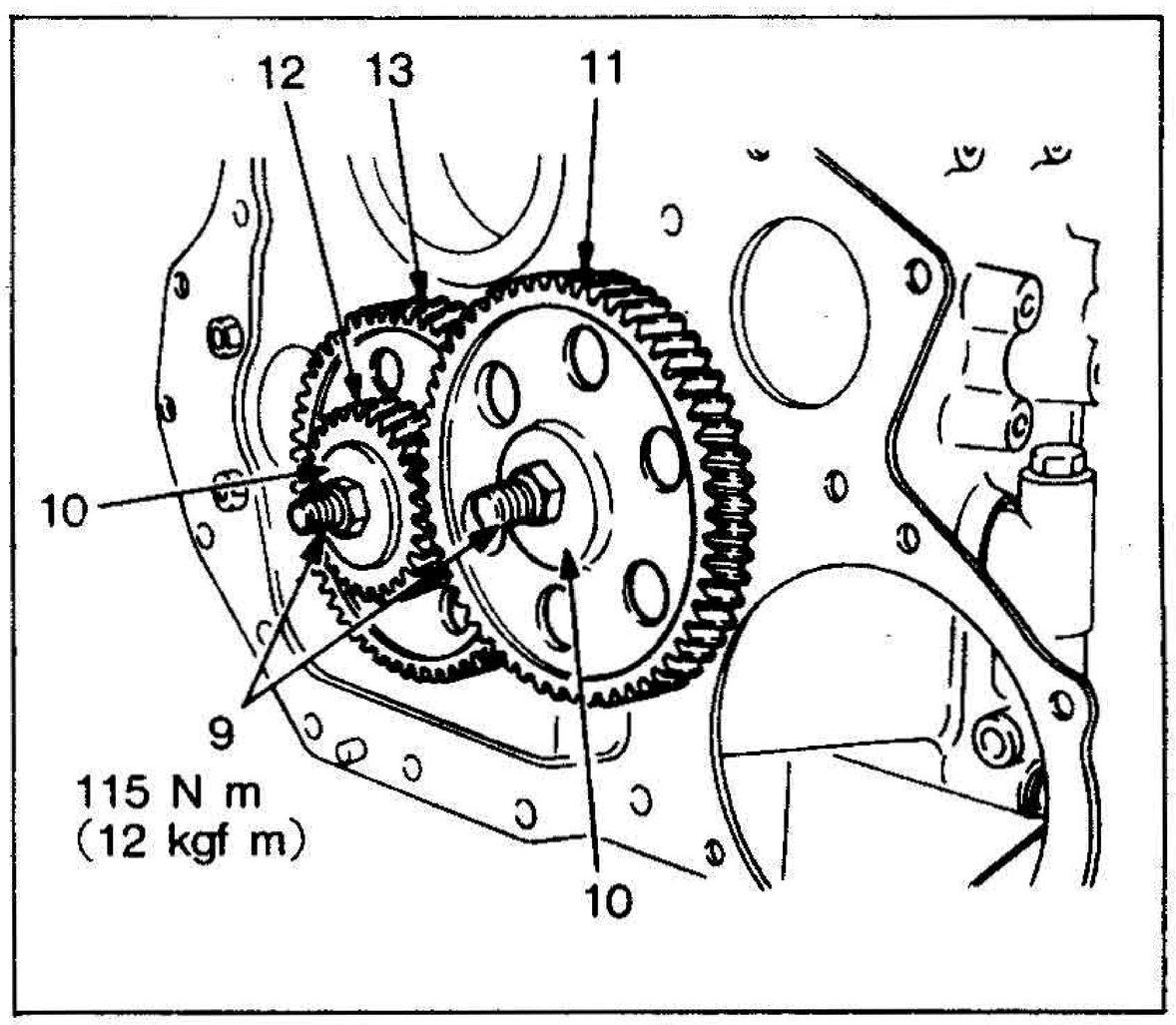
The bottom of gasket installed between the rear plate and crankcase will protrude. After the flywheel housing has been installed, cut away the protruding portion.

NOTE : Do not apply sealant to the joining surfaces of the rear plate and crankcase.



(2) Install the idler gears in the following sequence.

14 Idler shaft
13 Idler gear "B"
12 Idler gear "A"
11 Idler gear "C"
10 Thrust plate
9 Idler shaft bolt



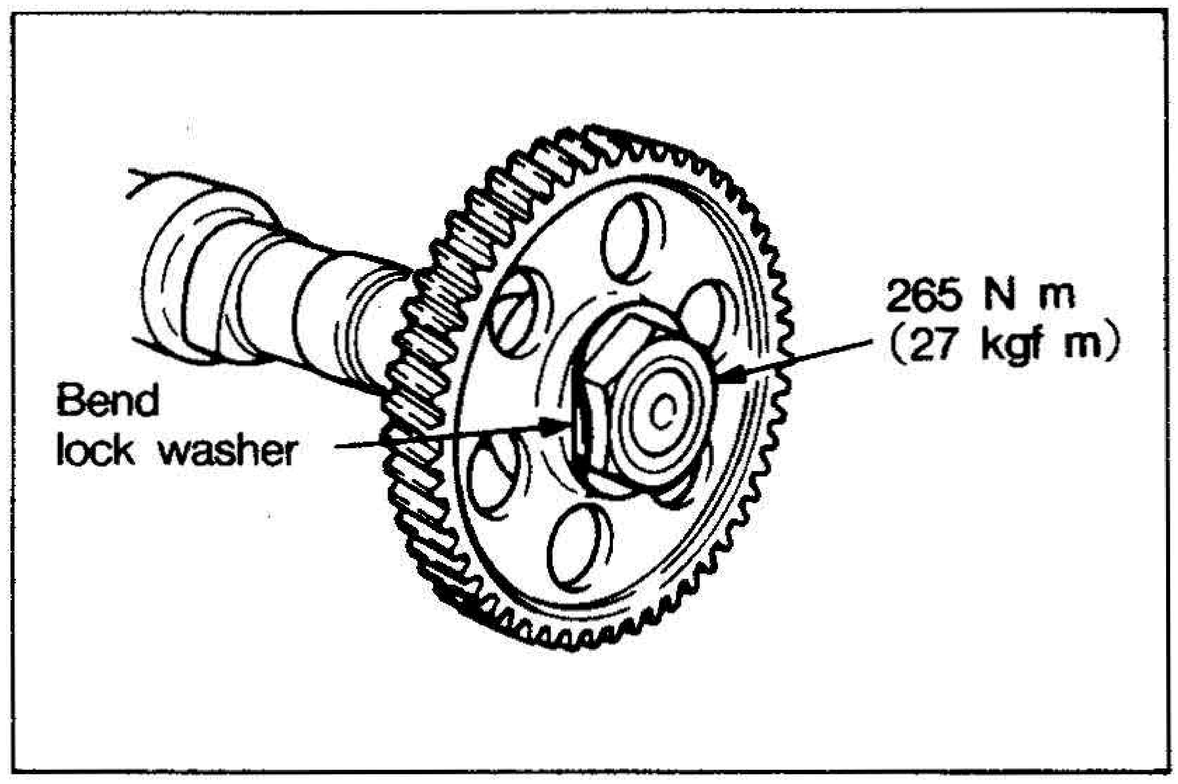
When the idler gears are installed, make sure that the alignment marks are in alignment.

Tighten the idler shaft bolt to the specified torque.

(3) Install the thrust plate 8 and camshaft gear 7 to the camshaft 6.

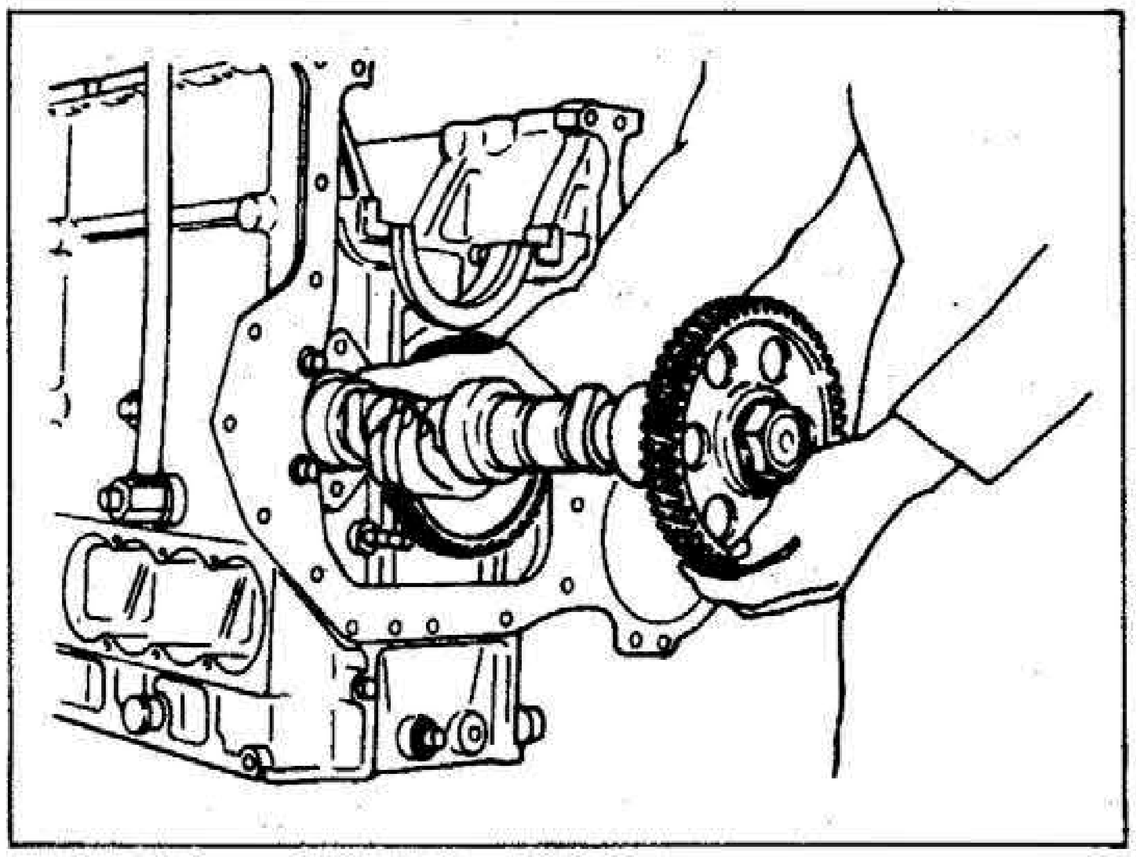
The gear mounting nut should be tightened to the specified torque.

As for the lock washer, make sure that its claws are fitted and positively bent toward the nut.



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(4) Install the camshaft.



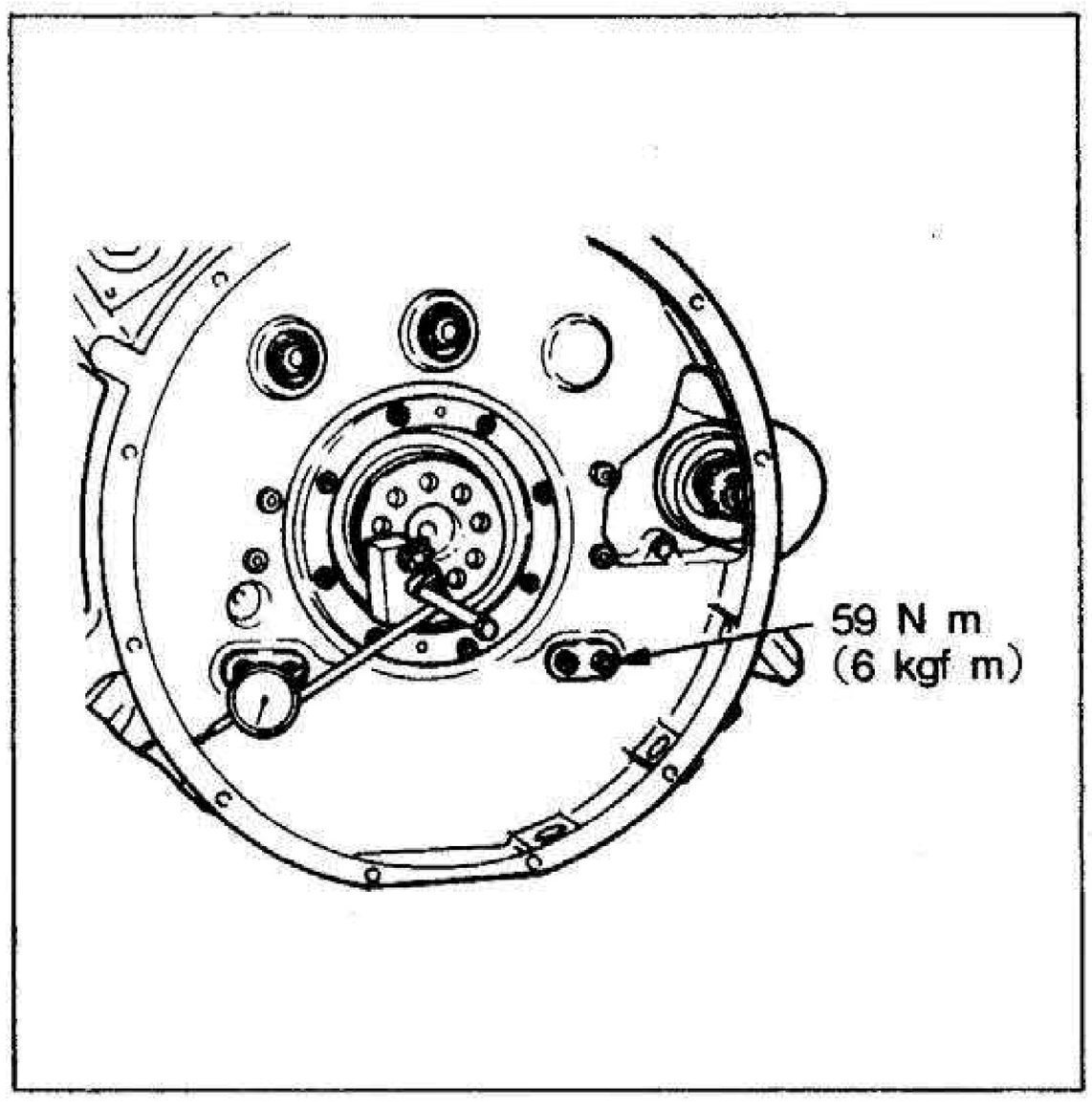
NOTE : 1. When the camshaft is inserted, take care not to damage the camshaft bushing.

2. When the idler gears and camshaft gear are installed, make sure that their alignment marks are in alignment.

(5) Check the camshaft gear and idler gear end play. Refer to Para. 7-1-2(4).

(6) Check the backlash of each gear. Refer to Para 7-1-2(3).

(7) Install the flywheel housing 5 to the crankcase by tightening to the specified torque.



Measure the mounting condition(eccentricity) at the flywheel housing joint. If the pointer of a dial indicator deflects beyond the repair limit, loosen the bolts and lightly strike the housing to correct the mounting condition.

NOTE : 1. The protruding bottom ends of the gaskets between the rear plate and crankcase and between the rear plate and flywheel housing should be cut away.

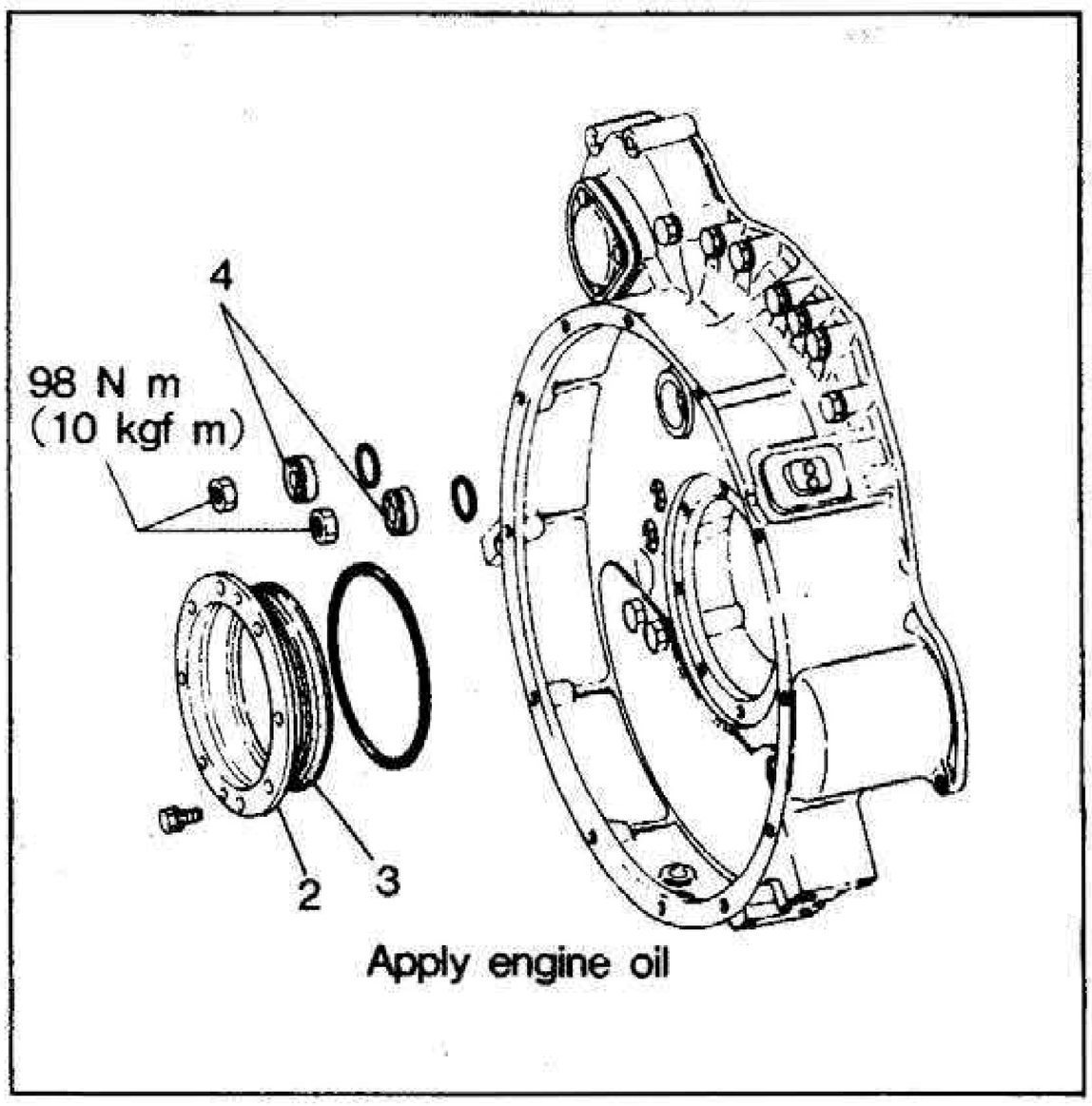
2. Do not apply sealant to the mounting surfaces of the rear plate and flywheel housing.

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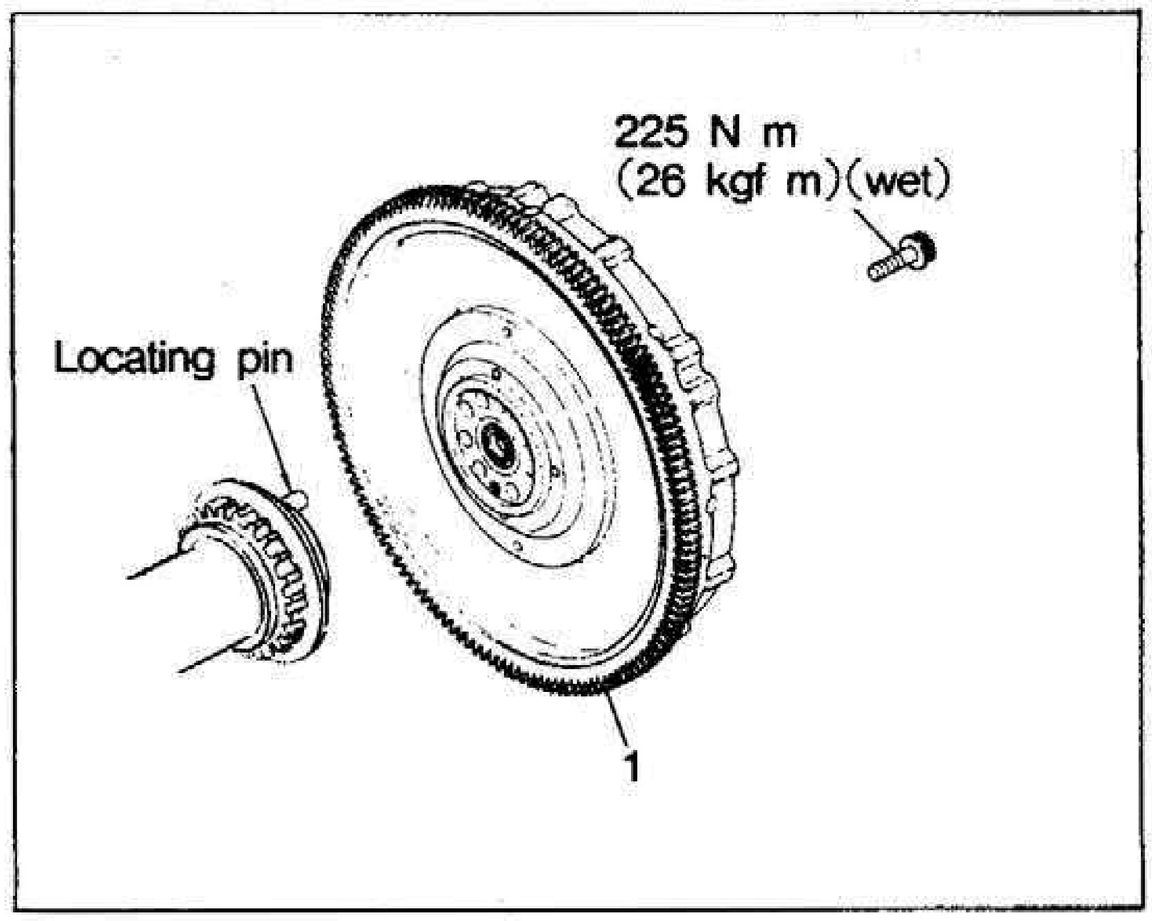
(8) Install the collar 4 to the idler shaft bolt and tighten the nut to the specified torque.

(9) Install the oil seal retainer 2 in which the oil seal 3 was pressed to the flywheel housing.

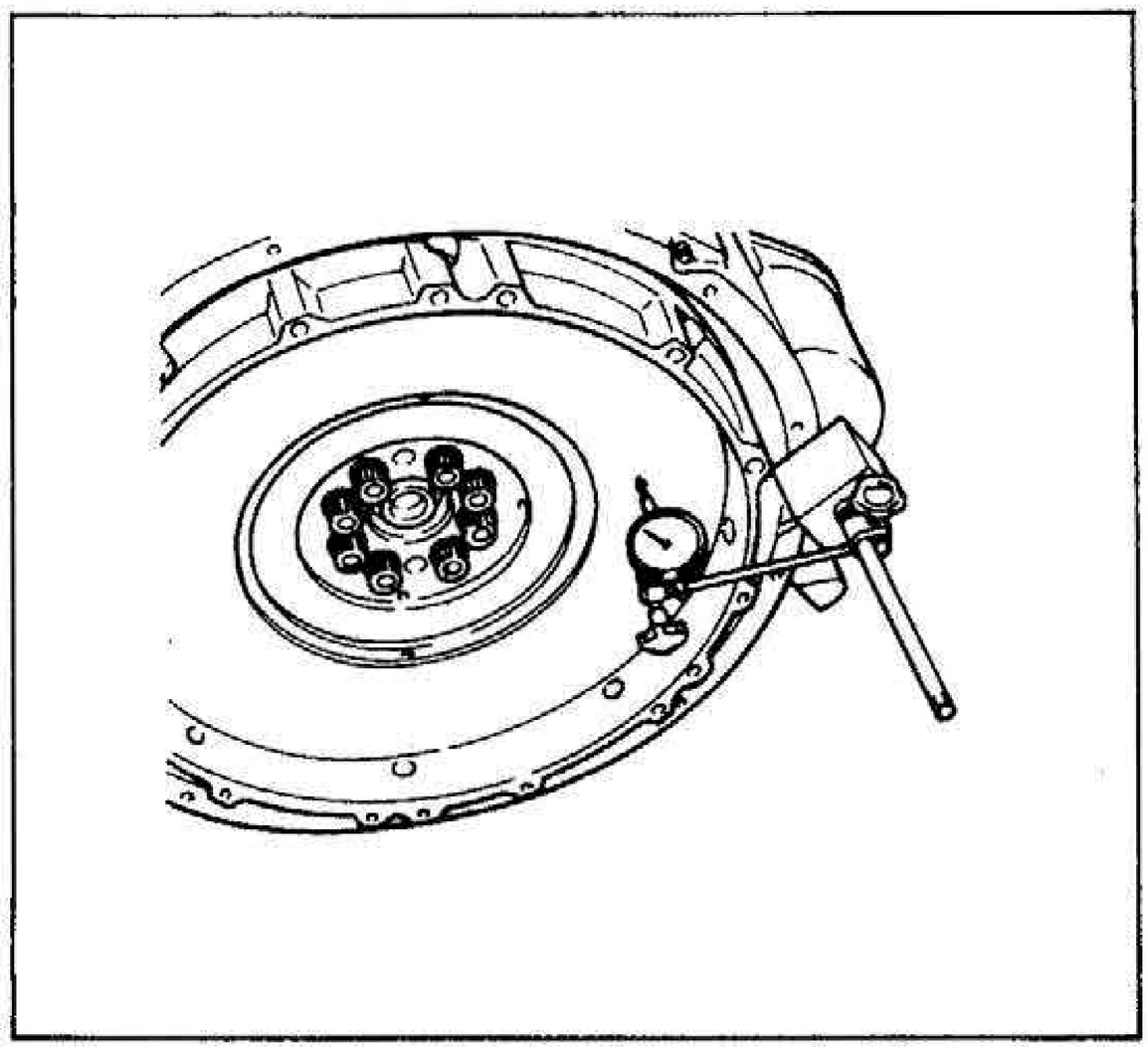
NOTE : Apply engine oil to the sliding surface of the oil seal.



(10) Install the flywheel 1 to the crankshaft and tighten the bolt to the specified torque.

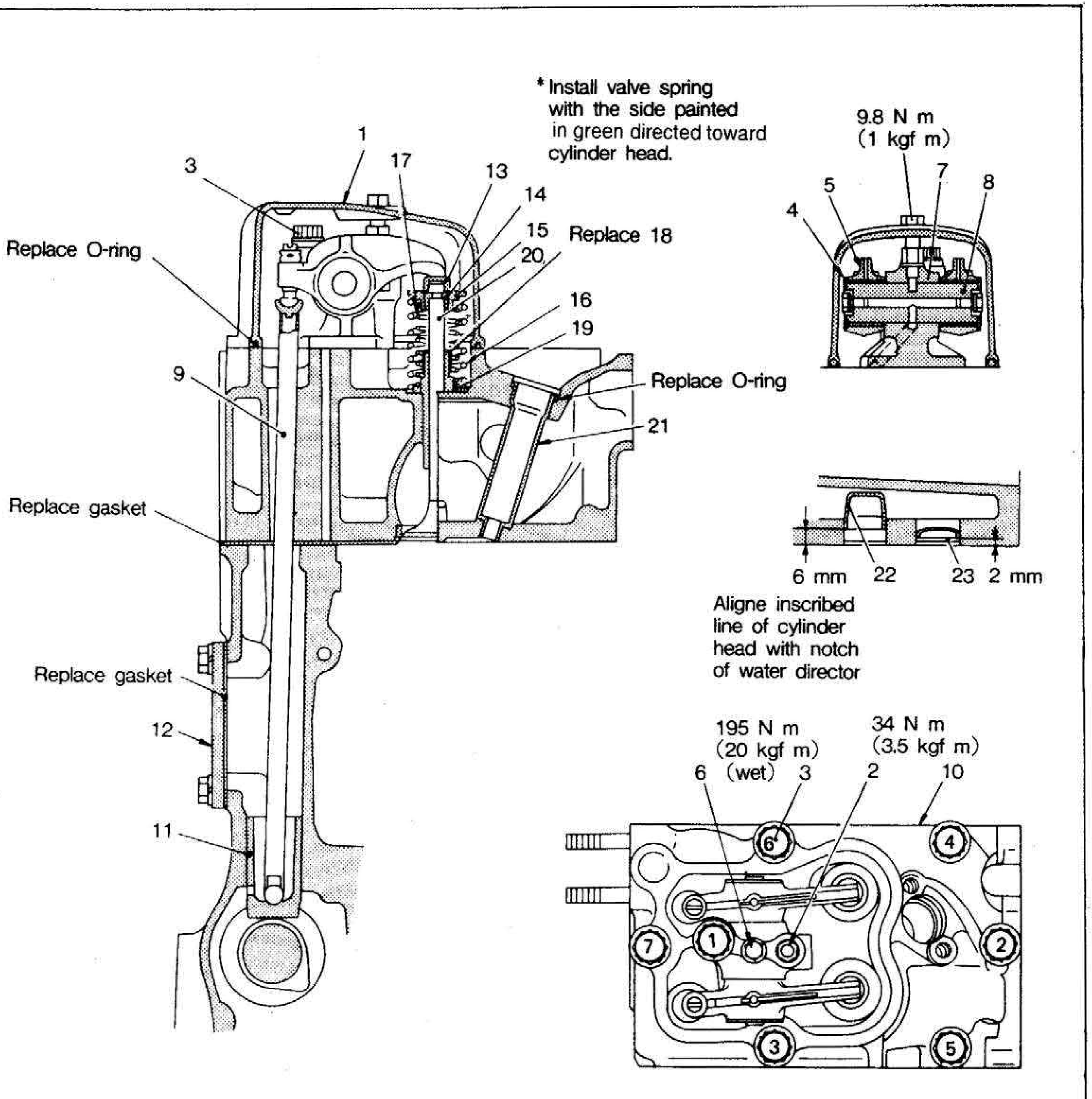


(11) Measure the flywheel mounting condition(runout). If the pointer of the dial indicator deflectis beyond the repair limit, check the bolt tightness or mounting surface.



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7-3-3 Cylinder Head and Valve Mechanism



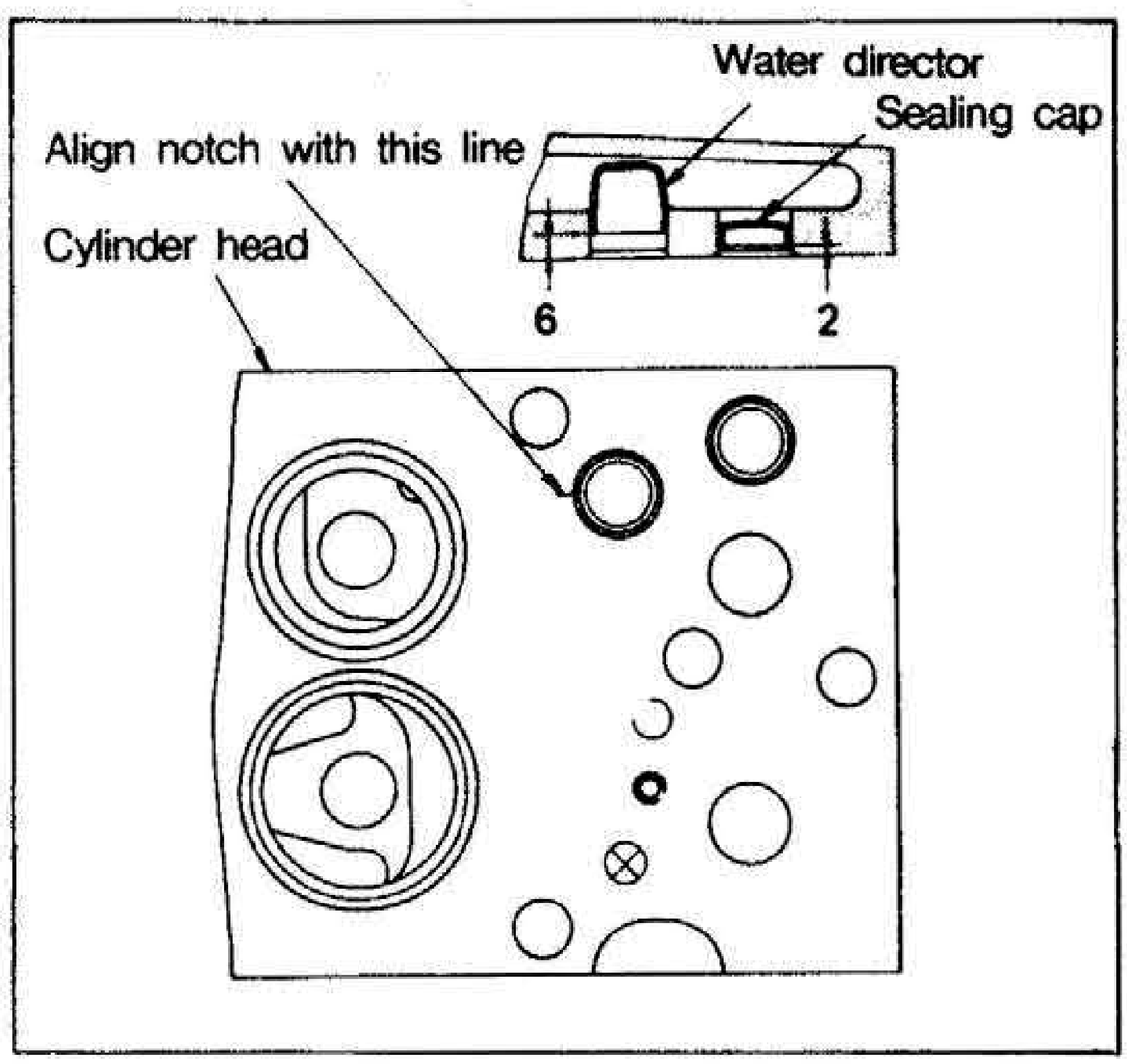
Assembling sequence

23→22→21→20→18→19→17→16→16→14→13→
12→11→10→9→8→7→6→5→4→3→2→1

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(1) Install the sealing cap 23 and water director 22 in the cylinder head.

NOTE : Install the water director with its notch directed as shown.



(2) Installation of Nozzle Tube

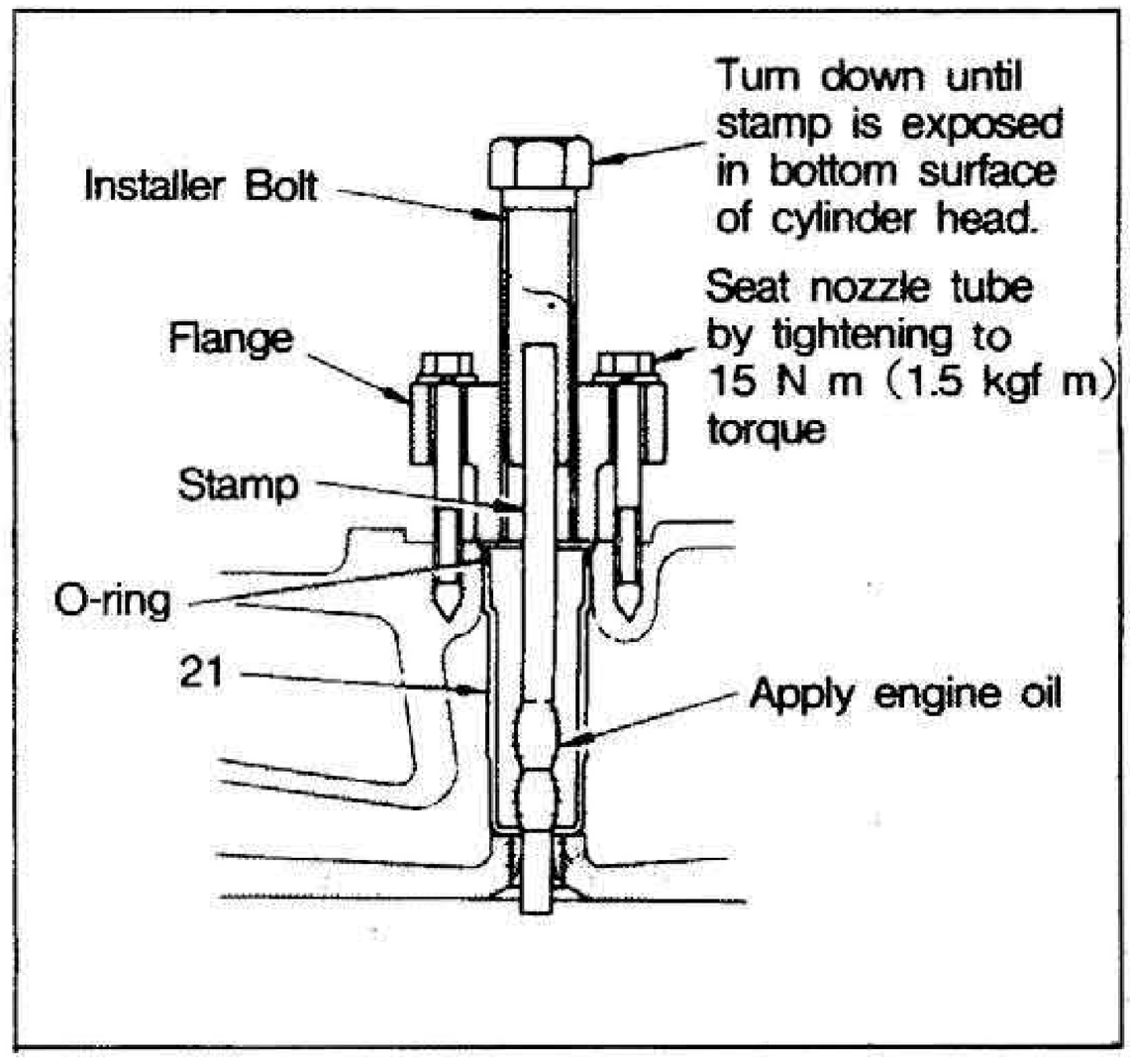
(a) Apply sealant to the end of the nozzle tube 21 and insert into the cylinder head together with the O-ring.

(b) Using Flange(special tool), press the nozzle tube against the cylinder.

(c) Apply engine oil to Stamp(special tool) and insert into the nozzle tube.

(d) Thread Installer Bolt(special tool) to push the stamp until it can be removed from the bottom of the cylinder head.

(e) After the nozzle tube has been installed, perfrom hydraulic test to check for water leaks.(Test pressure 195 kPa or 2 kgf/m^2)



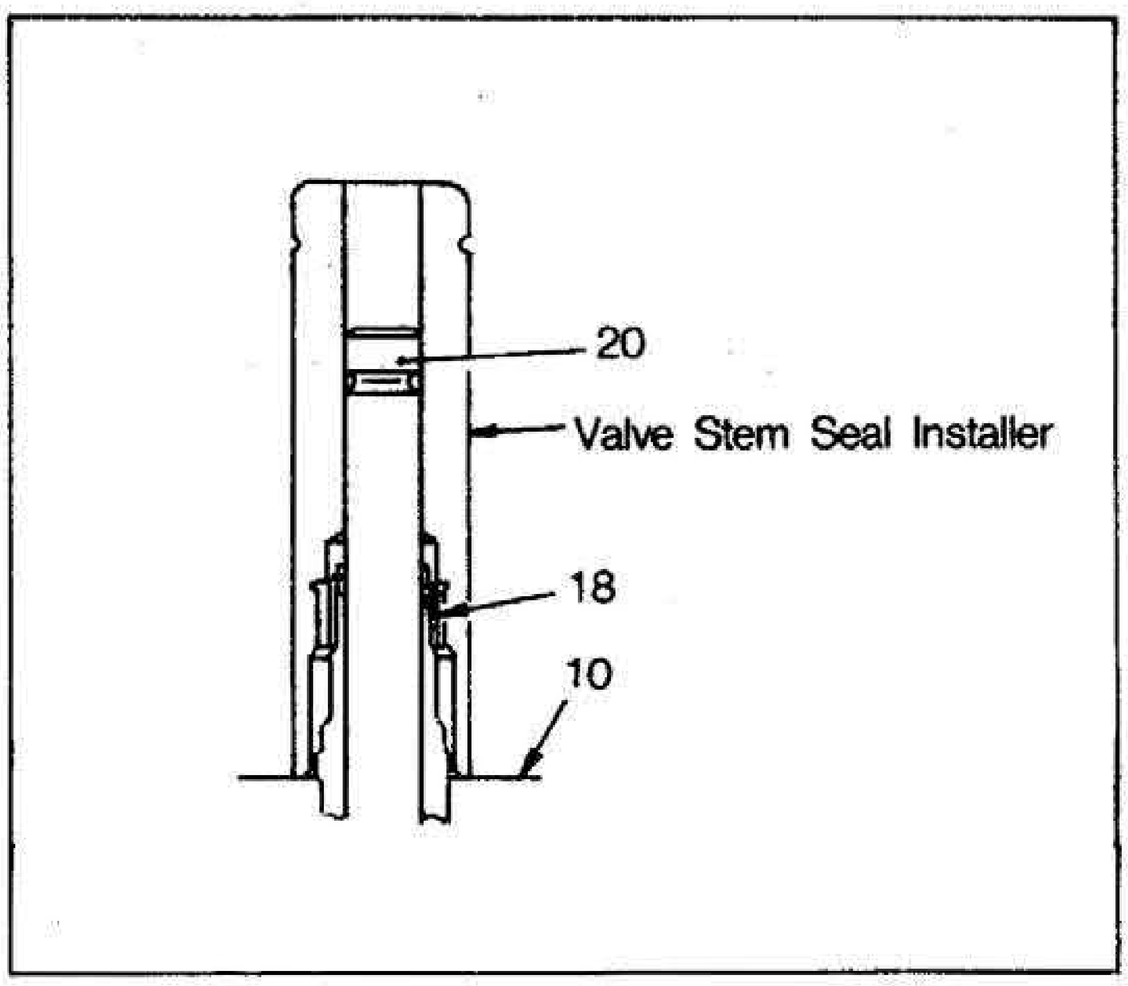
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(3) Install the following parts.

20 Valve

18 Valve stem seal

The valve stem seal should be installed by applying engine oil to the lip and striking down Valve Stem Seal Installer (special tool) until it touches the cylinder head.



NOTE : 1. Before the valve is installed, apply a small amount of engine oil to the stem.

2. Ater installation, check to ensure that the valve stem seal spring has not been deformed or damaged.

(4) Install the forllowing parts.

19 Lower retainer

17 Inner valve spring

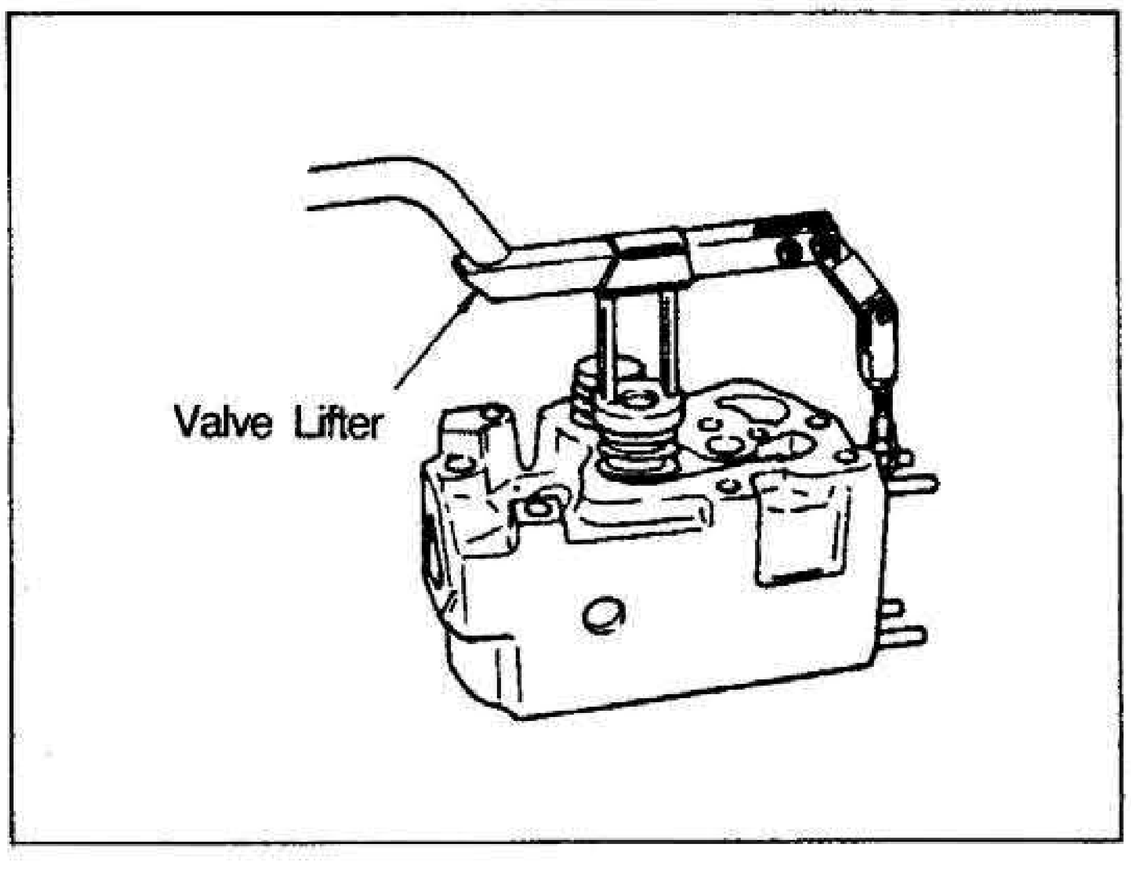
16 Outer valve spring

15 Upper retainer

14 Valve cotter

13 Valve cap

Install the valve cotter, while compressing the valve spring, using Valvė Lifter (special tool).

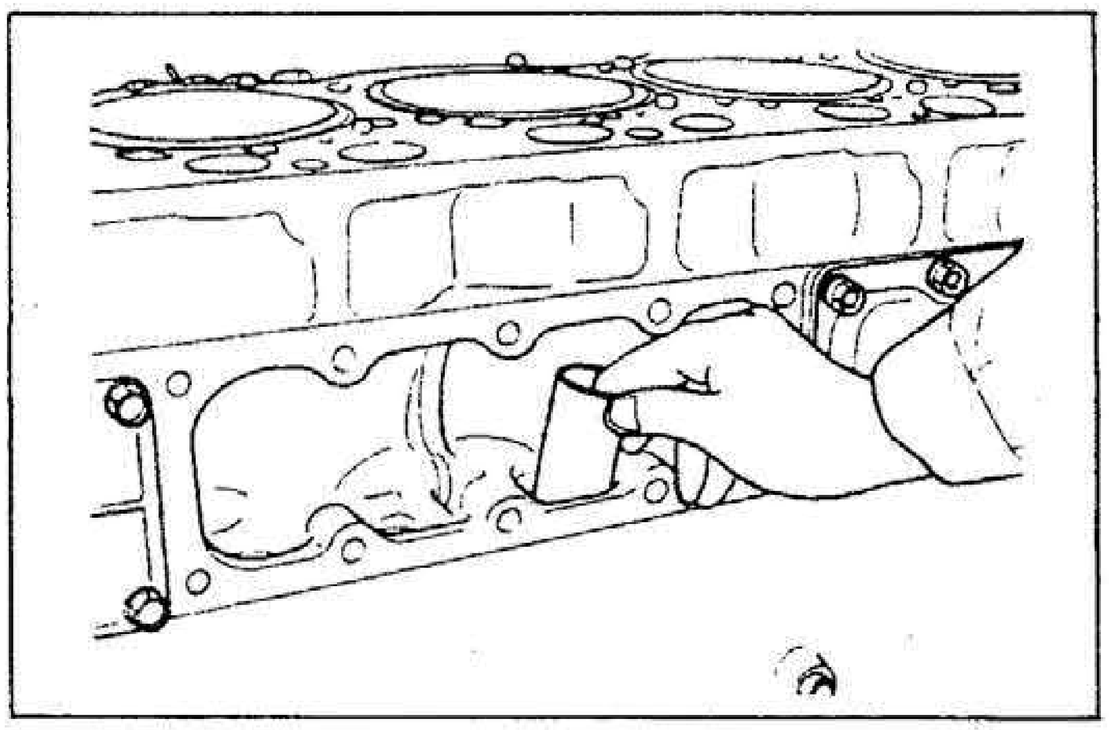


NOTE : 1. Install the valve spring with the closely coiled portion (blue painted) toward the cylinder.

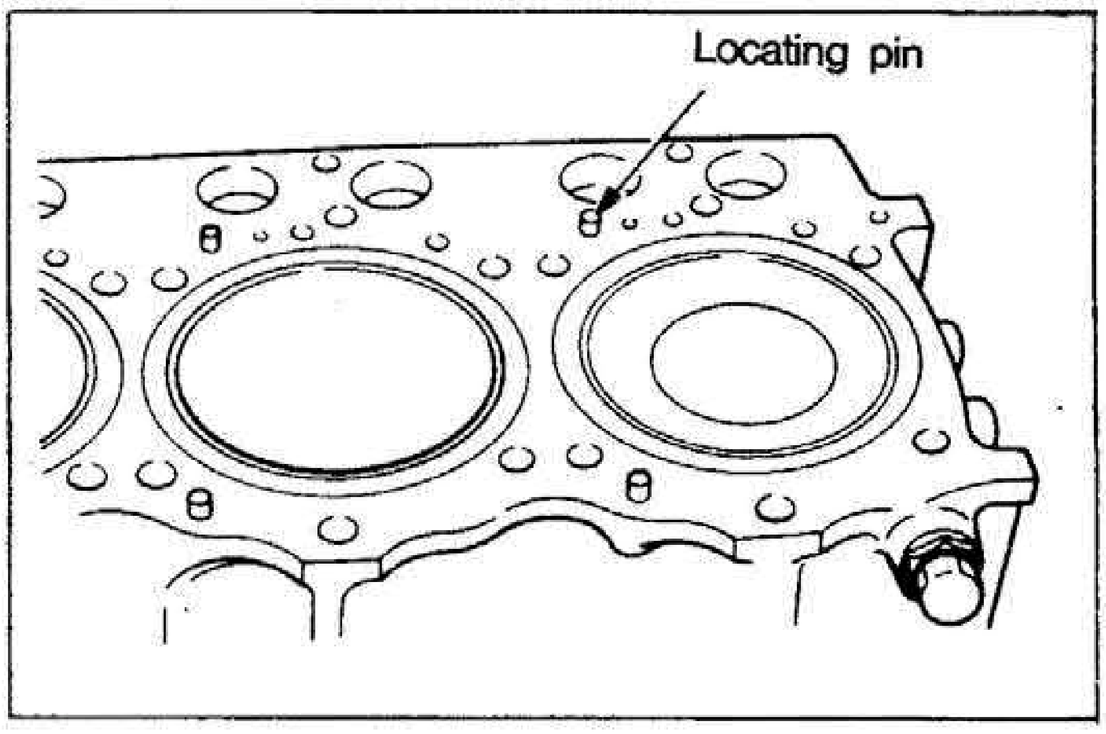
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2. When the valve spring is compressed with the valve lifter, make sure that it is evenly compressed.

(5) Insert the tappet 12 and install the crankcase side cover 11.

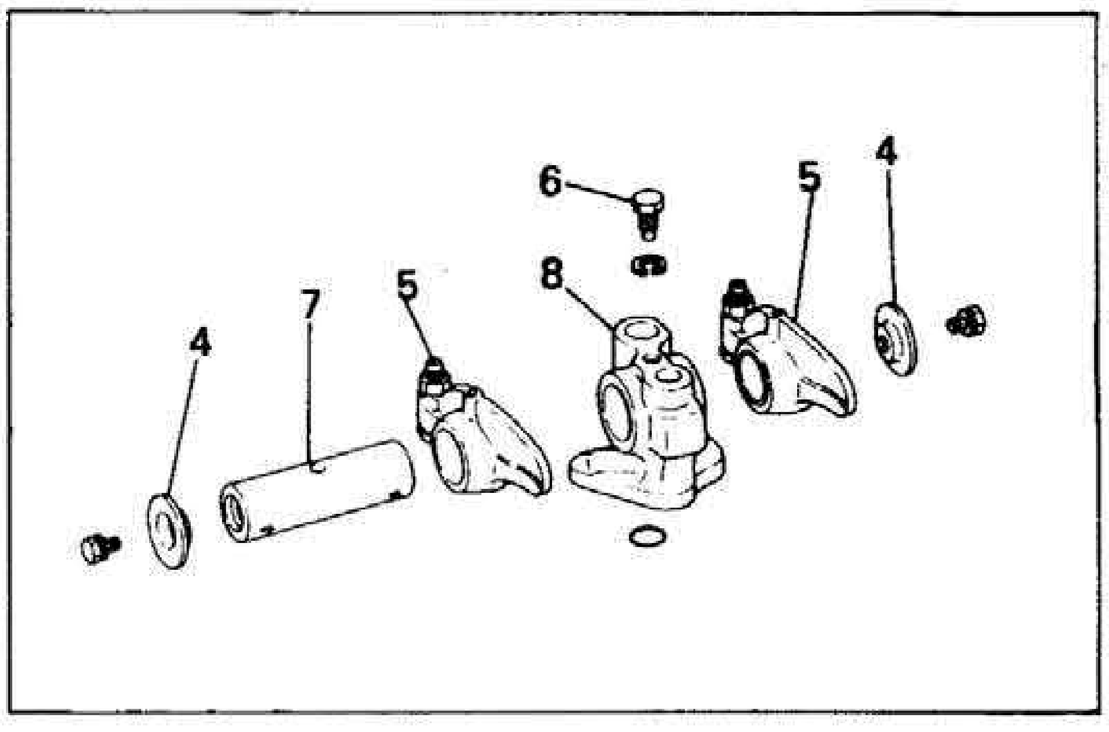


(6) Seat the cylinder head 10 on the crankcase, while lining it up with the locating pin.



(7) Assemble the rocker shaft bracket assembly.

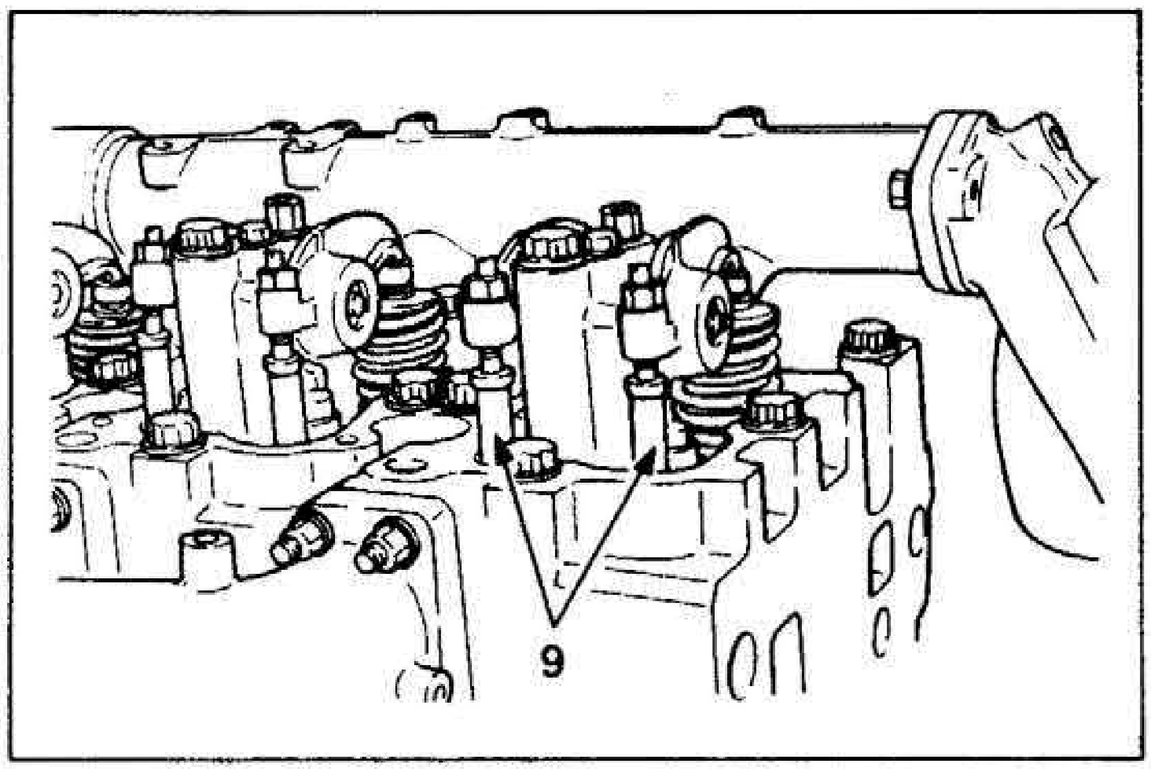
8 Rocker shaft bracket
7 Rocker shaft
6 Set screw
5 Rocker
4 Thrust plate



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(8) Install the push rod 9 and rocker shaft bracket assembly.

NOTE : Install a new O-ring to the bottom of the rocker shaft bracket.

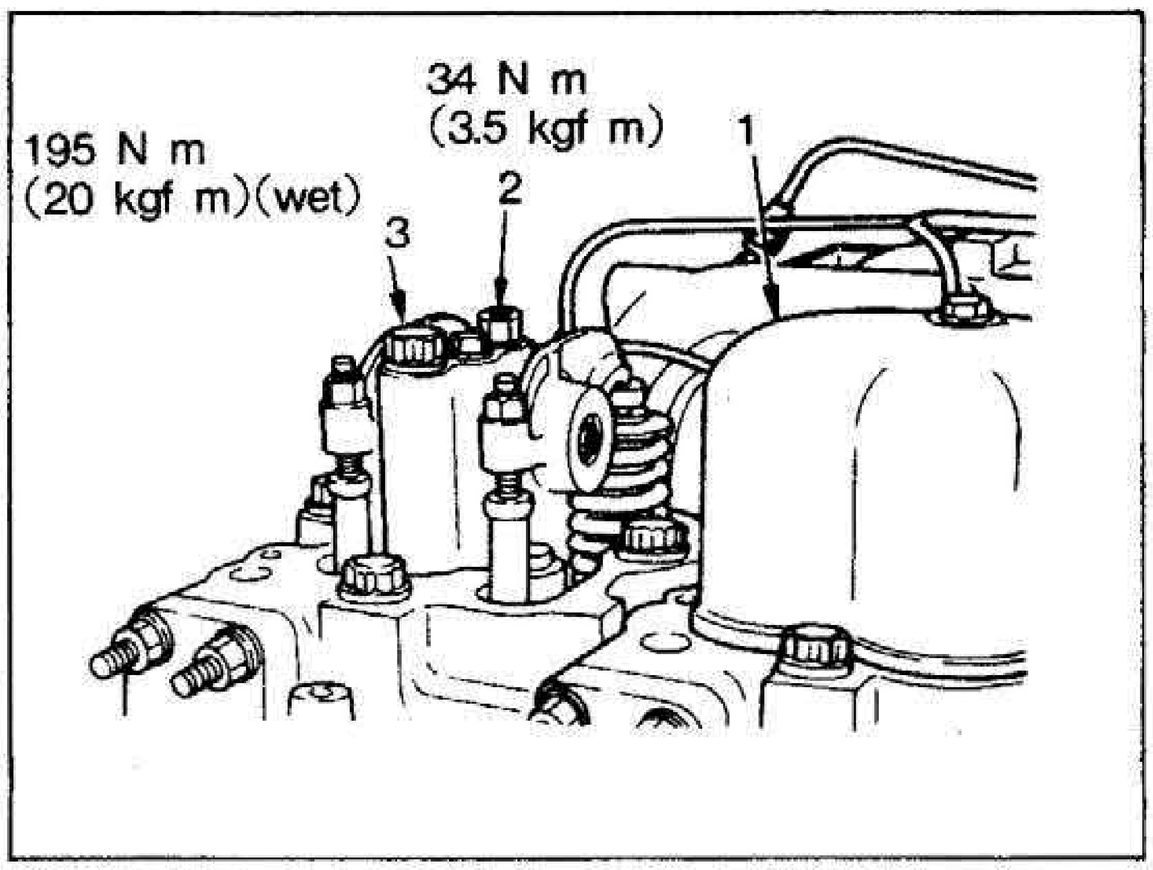


(9) Install the following parts.

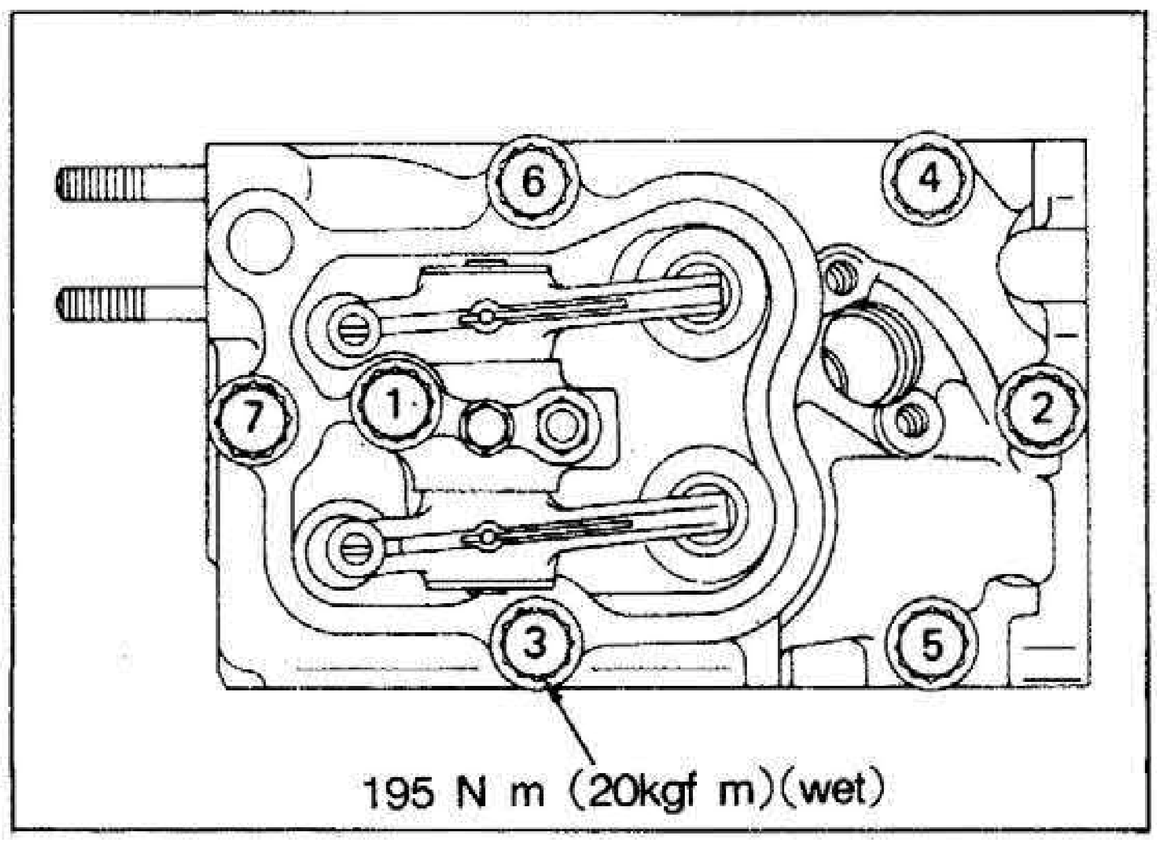
3 Cylinder head bolt

2 Rocker bracket mounting bolt

1 Rocker cover



Temporarily turn down the cylinder head bolts in the sequence shown. As a final step, torque them to specifications.



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