FOREWORD

This shop manual contains the specifications, construction, operation, adjustment and service procedures of the Model D6B diesel engine for service mechanics engaged in servicing of the Hyundai diesel engines.

Please make the most of this shop manual to perform correct servicing and wasteless operations.

Note that some of the contents of this shop manual are subject to change owing to improvements, etc. that may be introduced after publication of the shop manual.

Printed in Korea

HYUNDAI MOTOR COMPANY
INDUSTRIAL ENGINE ENGINEERING DEP'T

COMPILATION OF THIS MANUAL

1. The contents of this shop manual are divided as shown below when edited.

Group No.	Group Name	Contents
1	General	General description, outside view photograph and cross section view of engine, specifications, construction and operation
2	Service standards	Engine service standards, service standards talble, tightening torque table, sealant and grease table
3	Special tools	Shapes and usages of special tools
4	Inspection and adjustment of engine	Decision on time to overhaul, measurement of compression pressure, troubleshooting Inspection and adjustment of valve clearance, inspection and adjustment of fuel injection start timing, engine speed adjustment
5	Removal and installation of auxiliaries	Removal and installation of auxiliaries such as injection pump, starter, alternator and compressor
6	Engine proper	Disassembly, inspection and reassembly of engine proper, including cylinder head, valve mechanism, camshaft, piston, crankshaft, timing gear, flywheel, etc.
7	Inlet and exhaust	Disassembly, inspection and reassembly of air cleaner, etc.
8	Lubrication	Disassembly inspection and reassembly of lubrication system, including oil pump, oil filter, oil cooler, etc.
9	Cooling	Disassembly, inspection and reassembly of cooling system, including water pump, thermostat, radiator, etc.

Group No.	Group Name	Contents
10	Fuel	Disassembly, inspection and reassembly of fuel system, including injection pump, injection nozzle, fuel filter, water separator, etc.
11	Electrical	Inspection of starter, starter relay, alternator, etc.
12	Other equipment	Disassembly, insection and reassembly of air compressor automatic stop device

2. How to read disassembly and reassembly drawings

(a) The part names and numbers in the drawings correspond to those in the text. The parts are numbered in the order of disassembly.

(b) The inspection items to be performed during disassembly operations are shown in the disassembly drawings.

(c) All tightening torque specifications in the reassembly drawings may be considered "dry" unless "wet" is specified.

3. Definition of terms

(a) Nominal Value (Abbr.: NV)

Shows dimension of an individual part, mutual clearance between parts or standard performance. Values, however, do not necessarily coincide with design values as they are rounded off to fall within limits necessary for inspection.

(b) Repair Limit (Abbr.: RL)

Shows that when specified value is reached, repair is necessary. Repair means adjustment, grinding, replacement of bushings, metals and the like, selection of oversize, selection of shim thickness, etc.

(c) Service Limit (Abbr.: SL)

Shows that when specified value is reached, replacement of the parts with new one is necessary.

(d) Basic Diameter (Abbr.: BD)

Shows nominal diameter of part to be measured.

4. Unit

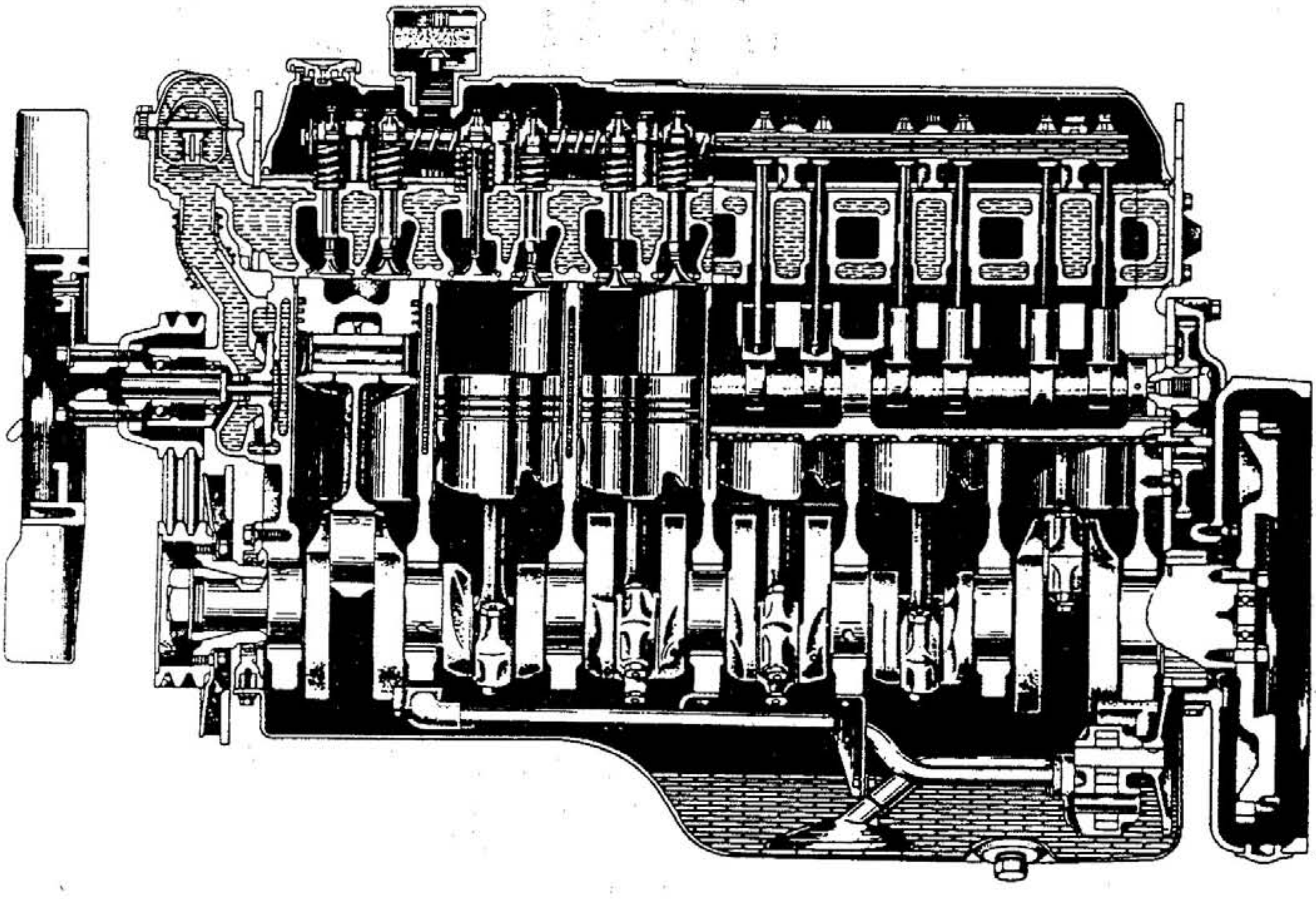
The SI unit (International System of Units) is used. Metric notation is jointly shown in parentheses.

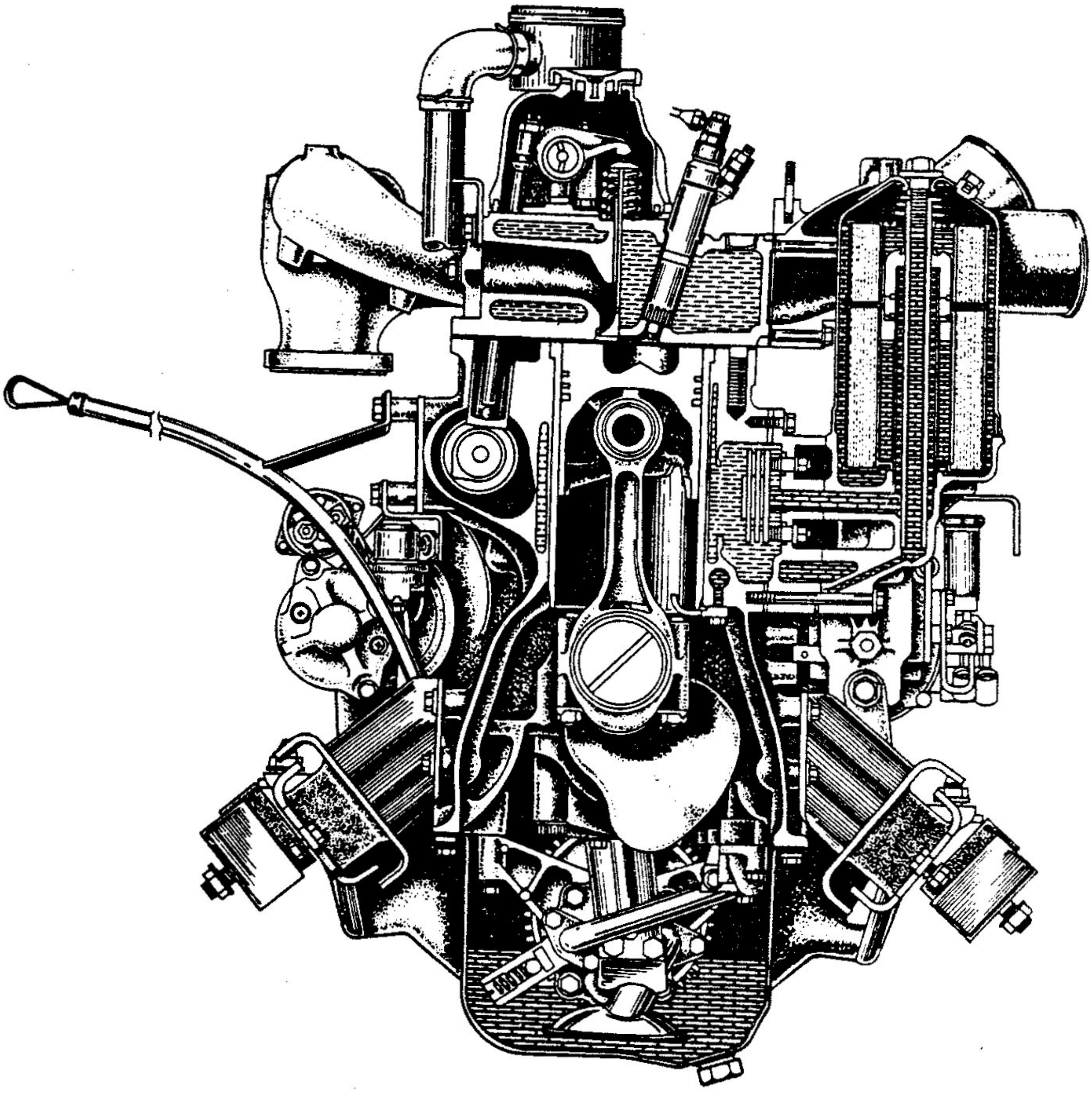
5. Table of Conversion Rate for Foot-pound Units into SI Units

Unit	Sign of SI unit	Sign of foot-pound unit	Conversion rate
Mass quantity of matter	kg g	lb oz	1kg=2.2046 lb 1g=0.035274 oz
Dimension	m mm	ft. in.	1m=3.2808 ft. 1mm=0.03937 in.
Capacity	lit. cc	gal. oz	1 lit.=0.2642 gal. (U.S.) 0.220 gal. (Imp.) 1cc=0.033814 oz(U.S.) 0.035195 oz(Imp.)
Force	N(Newton)	lbf	1 N=0.2248 lbf
Pressure	kPa(Kilopascal)	lbf/ in.²	1 kPa=0.145 lbf/ in.² 1 kPa=0.2953 in. Hg
Stress	N/ cm²	lbf/ in.²	1 N/ cm²=1.45 lbf/ in.²
Moment of force	N m	ft. lbf	1 N m=0.7375 ft. lbf
Output	kW(kilowatt)	HP	1kW=1.34 HP
Temperature	℃	°F	t℃=(1.8t℃+32)°F

1-1 GENERAL DESCRIPTION

1-1-1 Engin Sectional Views

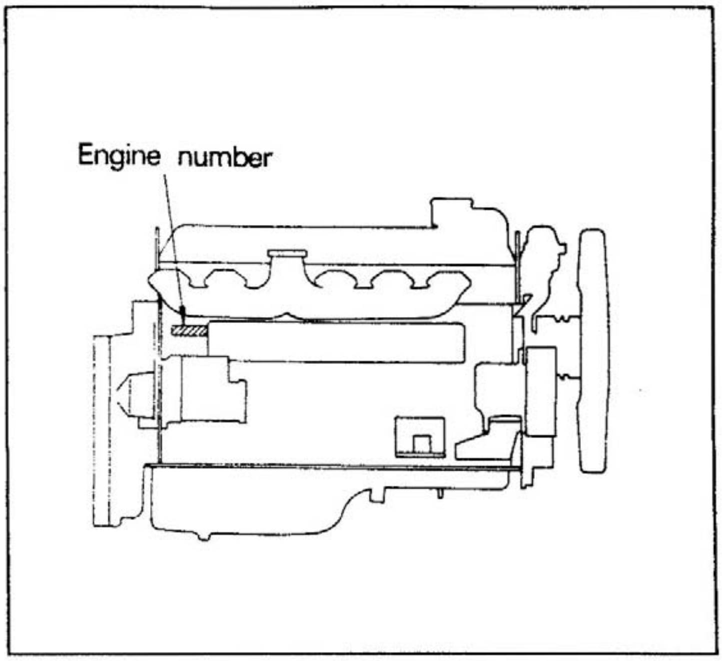




1-1-2 Engine Number and Nameplate

(1) Engine Number

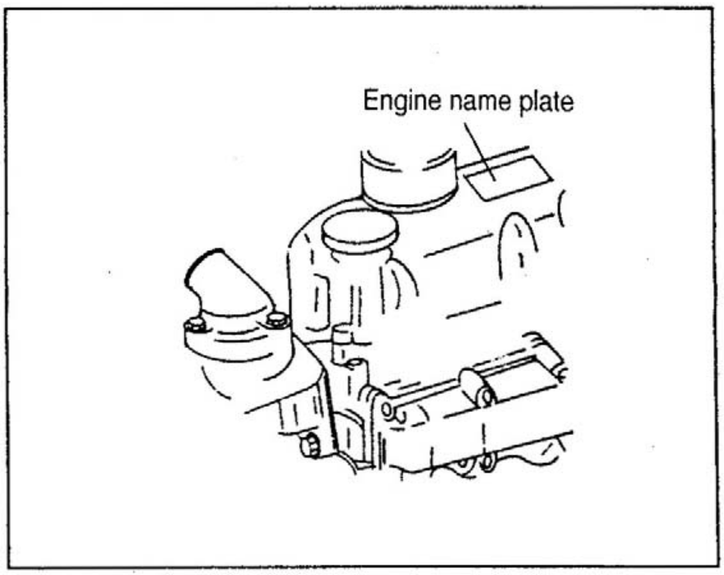
The engine number is stamped on the right side of the crankcase(as shown below).



Example D6BR T 012345
- 012345 — Engine No
- T — Production year
- D6BR — Model

The engine number is an important number in learning the history of the engine.

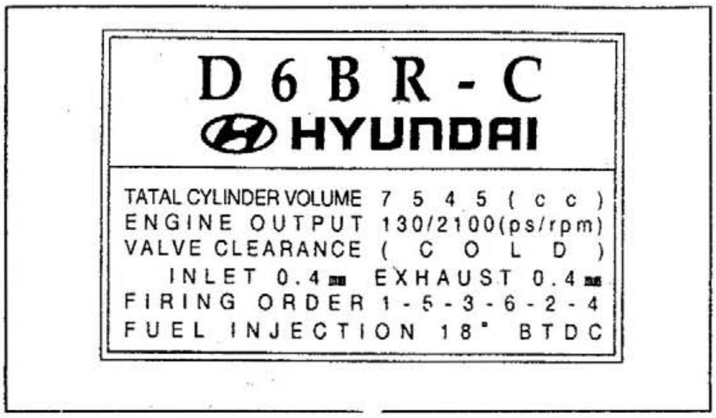
(2) Nameplate



The nameplate is located at the position shown in illustration at right. the nameplate shows the engine model, total displacement, rated output/ engine speed, valve clearance, firing order, and fuel injection timing.

Indication on Nameplate

1. Engine model
2. Total displacement
3. Rated output
4. Engine speed



1-2 SPECIFICATIONS

1-2-1 Principal Specifications

Item	Specification
Engine model	D6BR
Type	Water cooled, 4-cycle diesel
Number of cylinders-arrangement	6-in-line
Valve mechanism	Overhead valve
Combustion chamber	Direct injection type
Cylinder bore×stroke	118×115mm
Total displacement	7,545 cc
Compression ratio	17.5
Firing order	1-5-3-6-2-4
Engine dimensions(Generator)	
Overall length	1,492mm
Overall width	706mm
Overall height	1,088mm
Weight	580kg

1-2-2 Specifications of Each Device

Engine proper

Item		Specification
Cylinder liner		
	Type	Dry type
Piston	Tyep	Trunk, slipper skirt type
Piston ring	Quantity	Compression ring : 2 Oil ring : 1

Inlet and Exhaust

Item		Specification
Air cleaner		
Element	Type	Cyclone type filter paper element

Lubrication

Item		Specification
Engine oil		
	Quality	API Classification Grade CC or better
	Quantity	[For general purposes] Approx. 12 ℓ (oil pan only) Approx. 2.3 ℓ (oil filter only)
Lubrication system		Forced lubrication by oil pump
Oil pump	Type	Gear pump
Relief valve		
	Type	Ball valve type
Oil filter	Type	Filter paper type with bypass flow element
Full-flow filter element		
	Type	Filter paper type
Bypass Filter element		
	Type	Filter paper type
Oil bypass alarm		
	Type	Piston valve containing electric contact
Oil cooler	Type	Shell and plate type(multi-plate type)
Bypass valve		
	Type	Piston valve type
Regulating valve		
	Type	Piston valve type
Oil jet check valve		
	Type	Piston valve type

Cooling

Item		Specification	
Cooling system		Water-cooled, forced circulation type	
Cooling water quantity (engine proper)		Approx. 13 lit.	
Water pump	Type	Centrifugal type	
	Drive system	V-belt drive	
V-belt	Type	Low edge cog B type	
	Quantity	2	
Thermostat	Type	Wax pellet bottom bypass type	
	Valve opening temperature	76.5℃	
Fan	Type	Polypropylene pusher type	[Option] Polypropylene suction type

Fuel

Item		Specification
Injection pump proper	Type	Bosch PE6A NP-PES6A95
Turning direction (as viewed from drive side)		Counterclockwise
Plunger	Diameter	9.5mm
	Lead	LH single-or two-step lead
Governor	Type	RSV type mechanical all speed governor or RFD type mechanical minimum-maximum governor
Feed pump	Model	NP-FP/ KE22AC
Automatic timer	Type	SA type mechanical automatic timer

Item		Specification
Injectin nozzle		
	Type	Hole type
	Model	NP-DLLA
	No. of injection holes	5
	Injection orifice diameter	0.31mm
	Spray angle	160°
	Injection pressure	21.6 MPa (220 kgf/ cm^2)

Item		Specification
Fuel filter	Type	Cartridge type
Water separator [Option]	Type	Sediment type
Secondary fuel filter [Option]	Type	filter paper type

Electrical

Item		Specification
Voltage-Polarity		24V-(−) earth
Starter		
	Type	Overhang electromagnetic push-in type reduction starter

Item		Specification
Starter		
	Model	M3T56072
	Output	24V-5kW
	Reduction mechanism	Single, external, spur gear
Starter relay		
	Model	UIT06781
Alternator		
	Type	Alternator with built-in IC regulator
	Output	24V-40A
Intake air heater		
	Type	electric heating type
	Capacity	2.86kW
Heater relay		
Fuse	Capacity	127A [for 24V]

Air compresor [Option]

Item	Specification
Type	Air cooled, single cylinder
cylinder bore × stroke	80×60mm
Total displacement	341cc
Turning direction (as viewed from drive side)	counter-clockwise

Automatic stop system [Option]

Item	Specification
Stop solenoid	
Type	Electromagnetic type
Solenoid relay	Energize to run type

Etc

Oil pressure switch	
Type	diaphragm, built-in electric contact
Thermo switch	
Type	Wax type, built-in electric contact

1-2-3 Engine outputs classified by Application

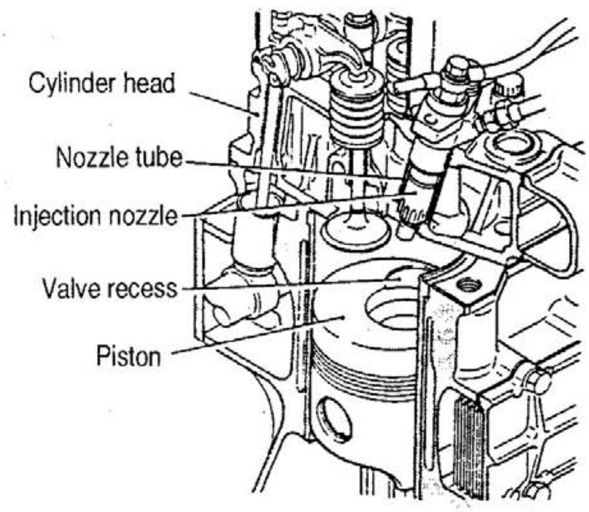
Application \ Engine model	D6BR
Continuous rated output kW/ rpm(PS/ rpm)	67/ 1,500 (91/ 1,500) 78/ 1,800 (106/ 1,800) 85/ 2,000 (116/ 2,000) 92/ 2,200 (125/ 2,200) 100/ 2,500 (136/ 2,500) 107/ 2,800 (145/ 2,800)
Rated output kW/ rpm(PS/ rpm)	73/ 1,500 (100/ 1,500) 86/ 1,800 (117/ 1,800) 94/ 2,000 (128/ 2,000) 101/ 2,200 (138/ 2,200) 110/ 2,500 (150/ 2,500) 118/ 2,800 (160/ 2,800)

1-3 CONSTRUCTION AND OPERATION

1-3-1 Engine Proper

(1) Combustion Chamber

The combustion chamber is made up of the cylinder head and toroidal piston. The hole type injection nozzle is mounted to the cylinder head together with the nozzle tube.



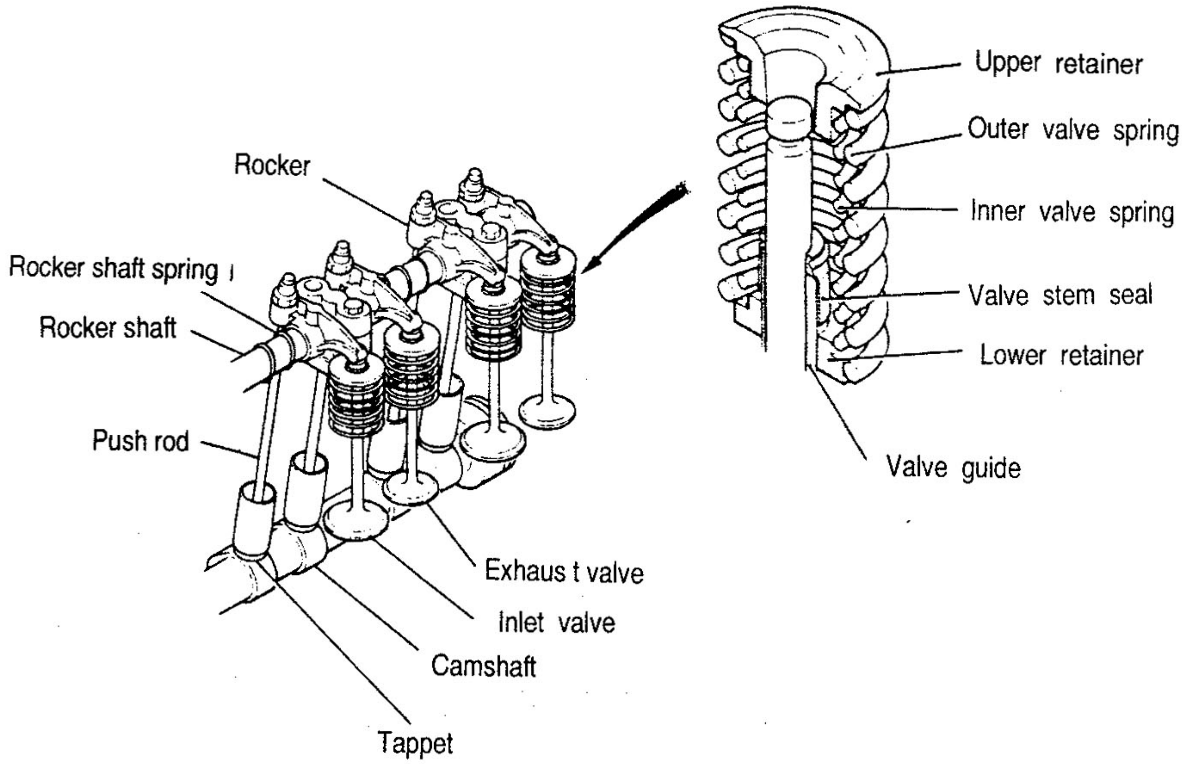
The nozzle tube accomplishes the function of holding the nozzle in position and cooling it. Since the outside of the nozzle tube is exposed to the water jacket, the top end of the tube is sealed off with an O-ring and the bottom end staked to prevent water leakage.

Combustion is accomplished by directly injecting fuel into the combustion chamber.

A valve recess is machined on the top of the piston for providing a clearance between the piston and exhaust valve.

(2) Valve Mechanism

The valve mechanism is an overhead valve type and is constructed as shown.



(a) Both inlet and exhaust valves are made of surface-treated heat-resistant steel to increase durability.

The valve seat angle of both valves is 45°

A valve stem seal is provided on the stem of valve to control the quantity of lubricant of the valve and valve guide sliding portions. The valve guide of the exhaust valve is equipped with a carbon cutter.

(b) To prevent abnormal vibration during high speed operation, two unevenly pitched springs are provided as valve springs. The inner and outer springs are different in coiled direction.

(c) The rocker is a precision forged carbon steel product. The rocker end sliding portion is quenched.

The rocker shaft is a hollow round rod with expansion plugs at both ends to seal off the rod. The inside of the shaft constitutes an engine oil passage.

(d) A steel ball is welded to the bottom end tappet side of the push rod, whereas a spherical concave type end cap is welded to the top end rocker side. both ends are carburized and hardened.

(e) The tappet is a cylindrical type and has a spherical suface which makes contact with the camshaft. The tappet can be removed without removing the camshaft, provided that the cylinder head is removed.

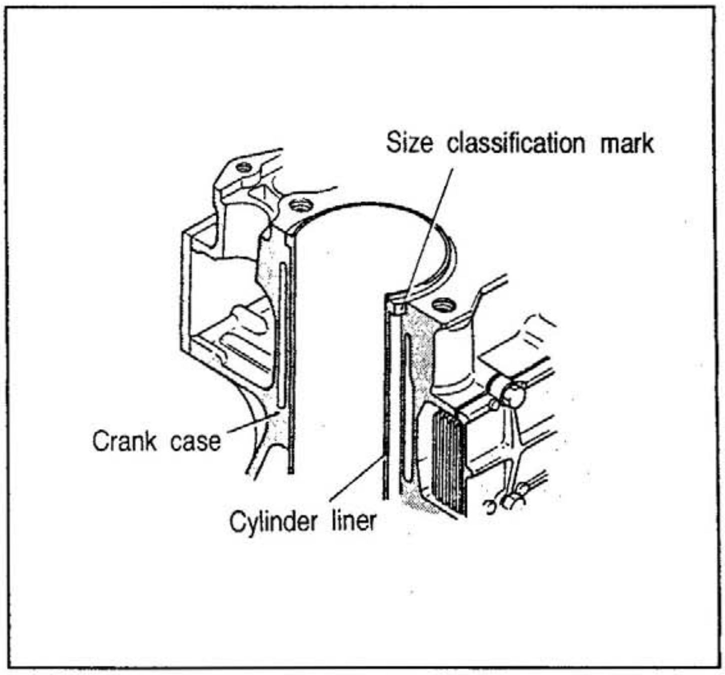
(f) Because of the high cam design, the push rod is shorter, assuring higher rigidity and higher dependability against high speed rotation.

(3) Crankcase and Cylinder Liner

(a) The crankcase is made of cast iron and highly rigid. It is so constructed as to minimize stress concentration and deformation.

(b) For camshaft bushings are placed in the crankcase camshaft bearing. The bushing bore tapers toward the front end to make it easier to install and remove the camshaft from the rear end of the crankcase.

(c) For D6BR engine, dry type cylinder liner is adopted and the liner is press-fitted to the crankcase in such a way as to facilitate removal. A size mark is stamped on the side of the cylinder liner flange for selective fit to the crankcase.



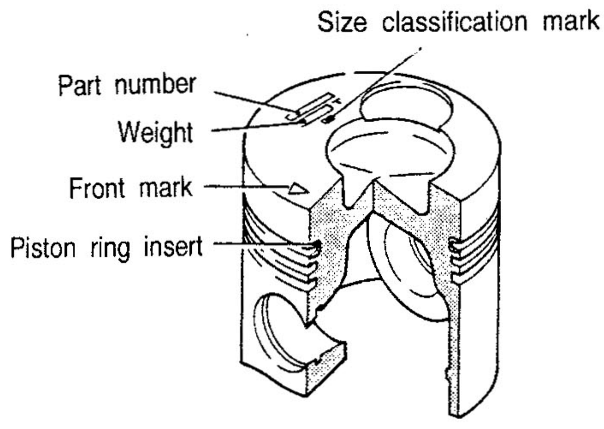
(4) Piston and Piston Ring

(a) Piston

The piston is made of aluminum alloy casting and is provided with a toroidal combustion chamber on top.

A niresist piston ring insert is cast into the 1st piston ring groove to enhance durability.

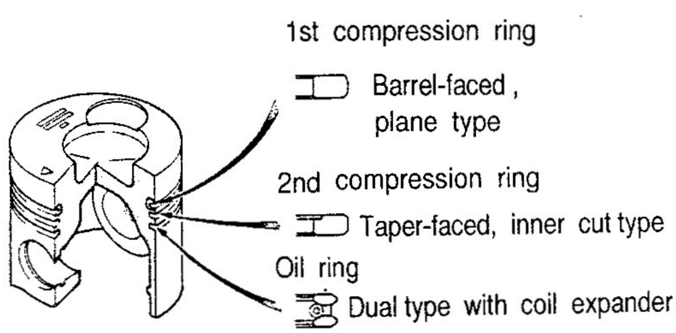
Stamped on the top surface of the piston are the part number, weight, size mark, identification mark, and the front mark that shows the piston installation direction. The piston pin is installed in the free floating arrangement, locked by a snap ring on both ends.



(b) Piston ring

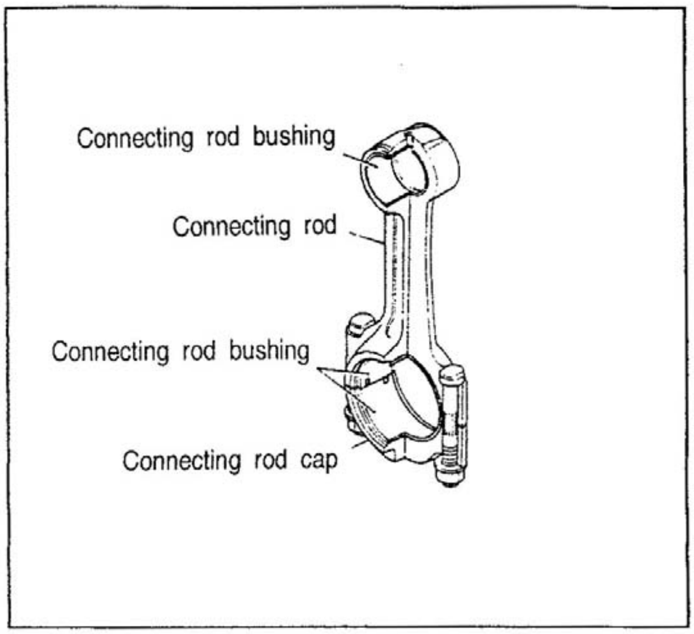
The piston rings are three in total: two compression rings and one oil ring. The sliding surface of each piston ring is hard chrome plated to improve wear resistance.

The piston rings are shaped as shown in the figure.



(5) Connecting Rod, Connecting Rod Bearing

The connecting rod is an I-section stamp forging ensuring high rigidity. A lead bronze bushing is press-fitted into the small end. the connecting rod bearing for the big end is a split-style plain bearing. This bearing is soft steel backed kelmet metal, the inside surface of which is plated with an alloy of lead, tin and copper. The whole bearing is then plated with tin.

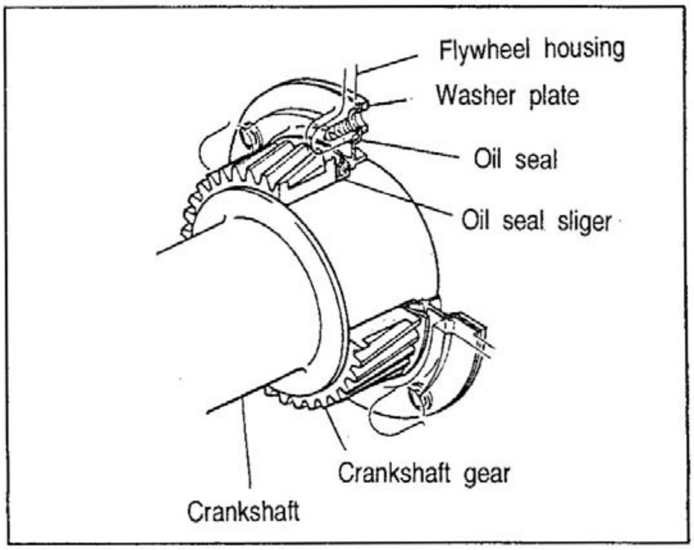


(6) Crankshaft and Main Bearing

(a) Crankshaft

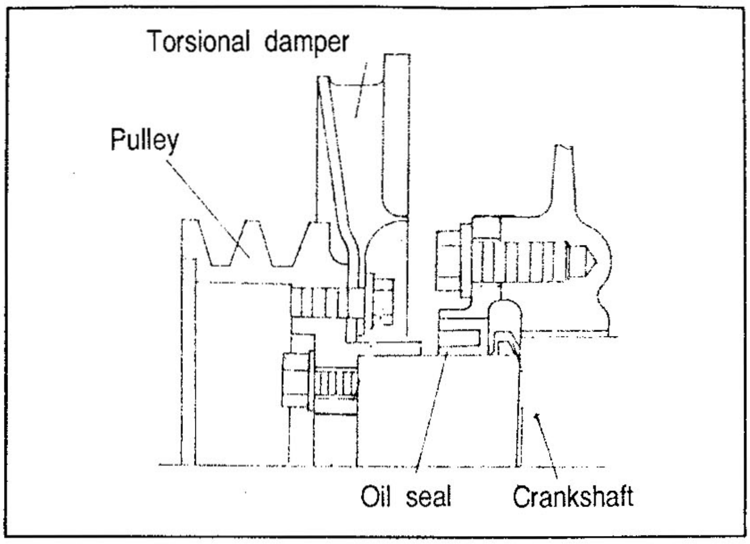
The crankshaft is a rigid die forging integral with the balance weight.

The pin and journal are induction hardened for higher resistance to wear. An oil hole in each journal is aligned with that in pin, feeding some of the main bearing lubricating oil to the pin for lubricatin of the connecting rod bearing



An oil seal is provided at the front and rear of the crankshaft. The one in the rear is the axial lip type.

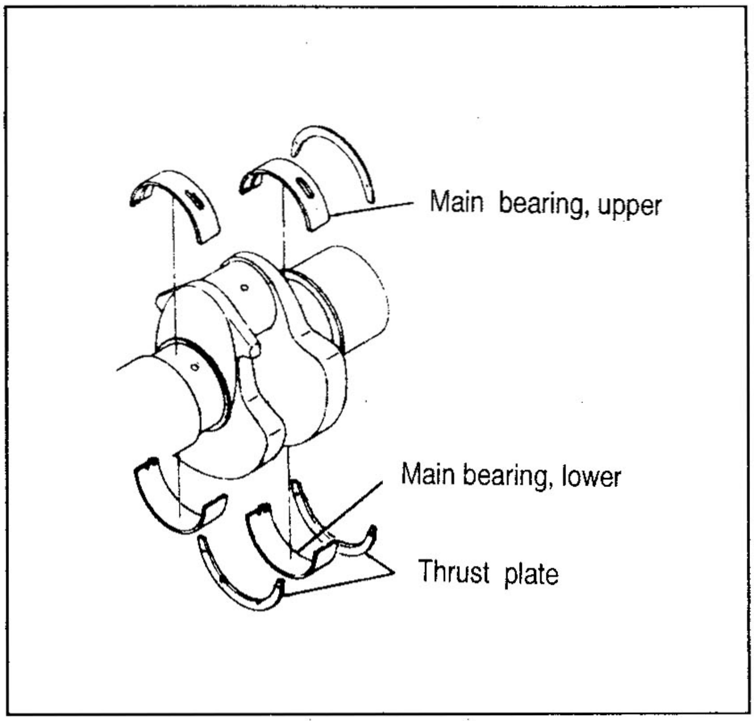
A torsional damper is mounted to the front of the crankshaft along with a pulley to prevent torsional vibration of the crankshaft.



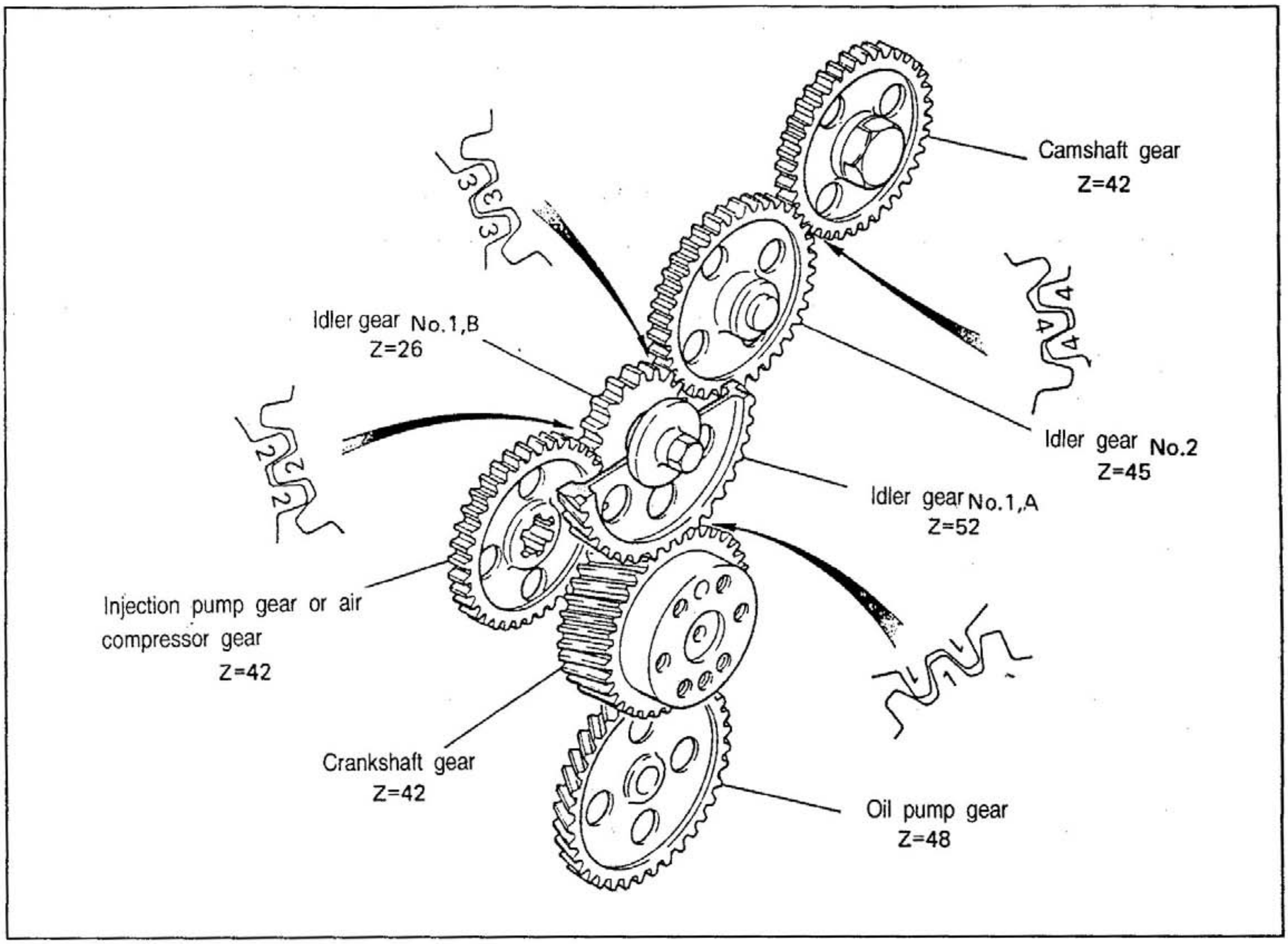
(b) Main bearing

The main bearing is a split type plain bearing and is made of the same material as the connecting rod bearing.

The main bearing upper has an oil groove and hole lined up with that in the crankshaft. Split type thrust plates are mounted to the rear-most bearing to support the thrust of the crankshaft.



(7) Timing Gear



The timing gears are accommodated in the rear of the engine. The gear train is as shown in the figure.

The timing gears are accommodated in the rear of the engine. The figure above shows the gear train. Gears are made of either alloy steel or high-carbon steel. Tooth surfaces are shaved to form high-precision teeth and surface-treated to improve durability. Helical gears are used for the crankshaft, idler A, and oil pump gears, reducing mechanical noise to a minimum.

The crankshaft gear turns the idler gears to drive the camshaft, air compressor, and injection pump. It also drives the oil pump on the opposite end.

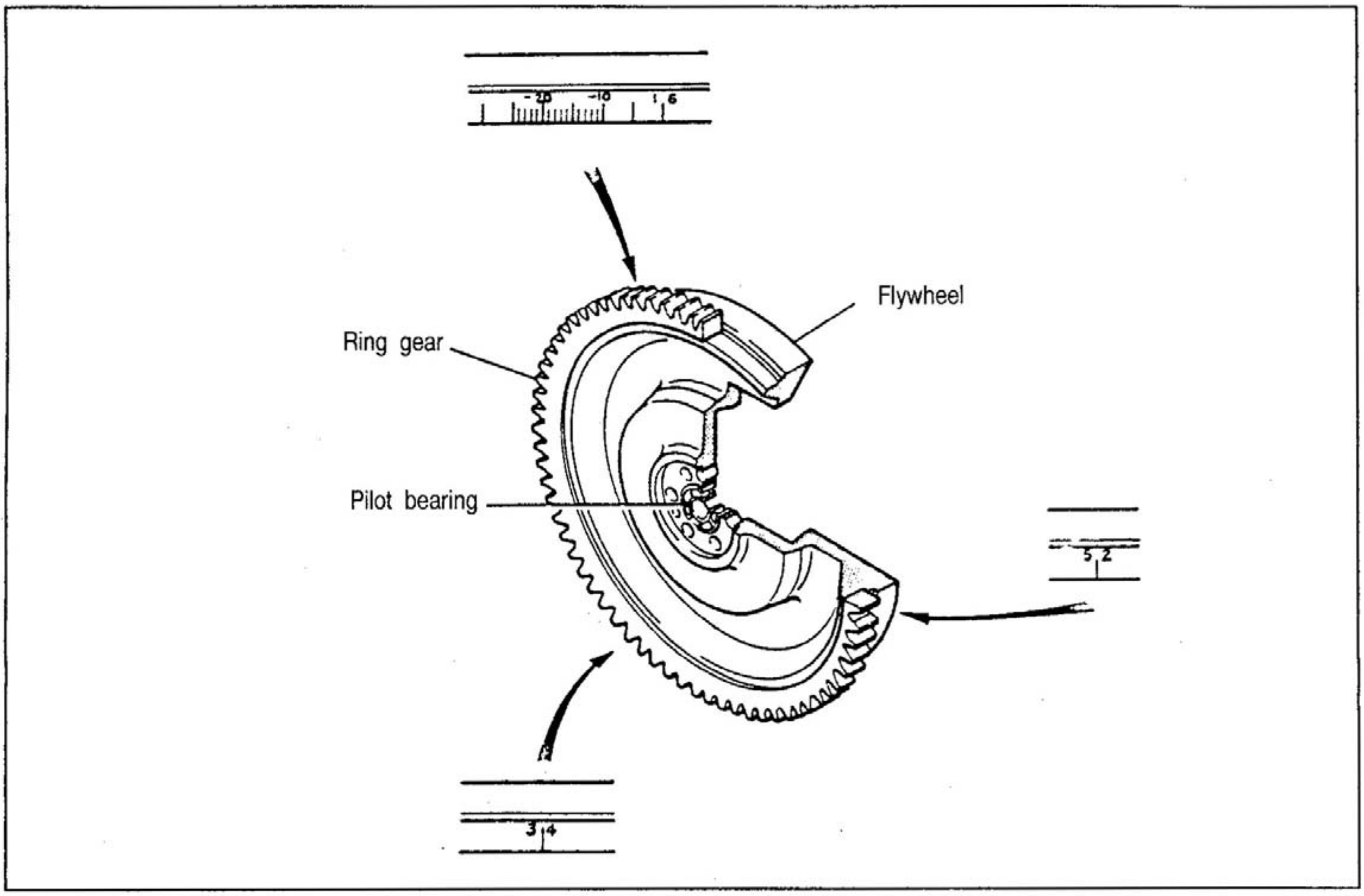
A timing mark is stamped on each gear. Correct meshing can be achieved by aligning the timing marks at reassembly.

(8) Flywheel

The flywheel is made of cast iron. The pilot bearing of the transmission drive pinion is installed in the center of the flywheel. The ring gear which meshes with the starter pinion is shrinkage fitted around the flywheel.

The ring gear teeth are induction hardened to assure high durability. One side of the teeth is chamfered to make sure that the starter pinion fits easily.

The cylinder Nos. and angle scale are stamped on the outside periphery of the flywheel as shown.

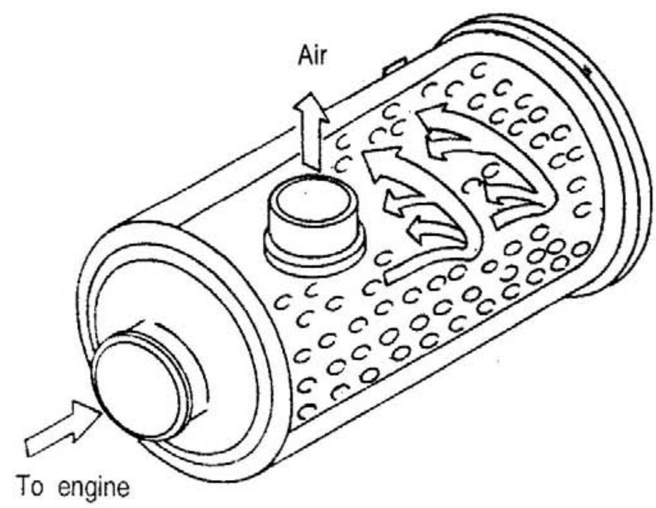


1-3-2 Inlet and Exhaust

(1) Air Cleaner

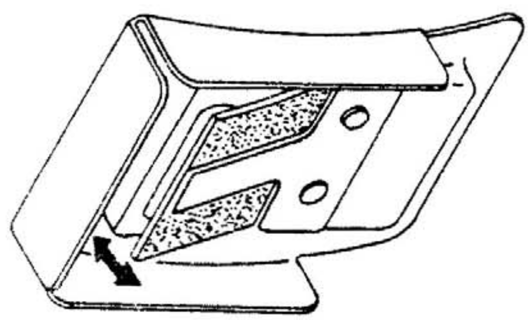
(a) Cyclone type air cleaner

The element is a plastic-coated and heat-treated filter paper type and is resistant to water and oil. Even if it is contaminated with oil or water, it can be restored to normal by washing.



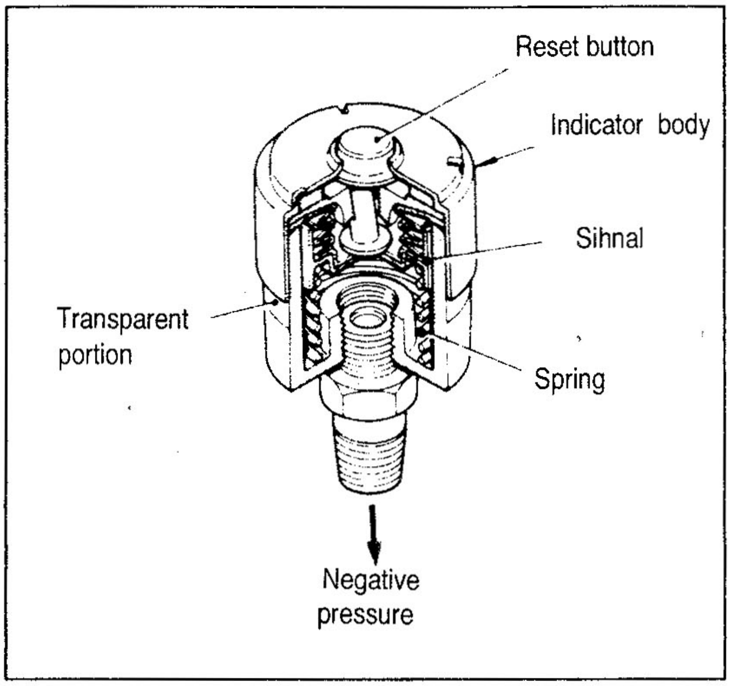
The air drawn into the element is made to spin at high speed by the vanes on the element, so large particles of dust are centrifugally separated(cyclone function). Small particles of dust are removed by the filter paper element, so clean air is drawn into the engine.

(b) Read Valve



The centrifugally separated particles of dust and dirt are collected at the bottm of the air cleaner. The collected particles of dust and dirt are discharged outside by pulsations of the rebber read valve mounted in the air cleaner. If the engine speed increases(to 800 rpm or more), the read valve will be closed by a high negative pressure in the air cleaner, so no outside air will be drawn in.

(2) Dust Indicator

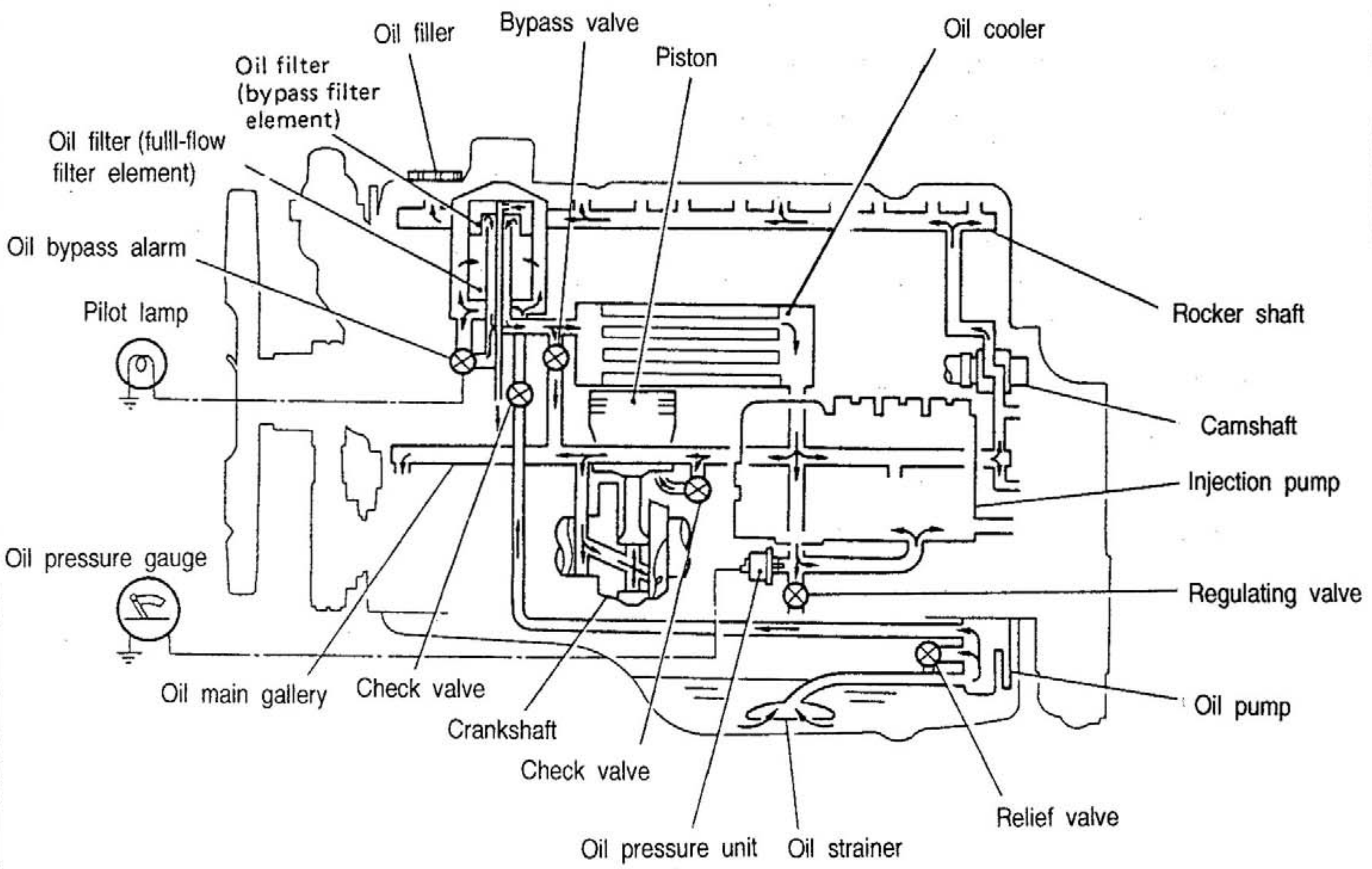


The dust indicator, mounted near the outlet of a paper element type air cleaner, operates on the negative pressure of the air drawn into the engine, performing the function of indicating, the time to clean or replace the element.

If dust is collected in the element, the suction resistance increases. When the negative pressure reaches 700mmAq, the signal is pulled down against the pressure of the spring. and the transparent portion of the body chang -es to red, indication the time to clean or replace the element.

1-3-3 Lubrication

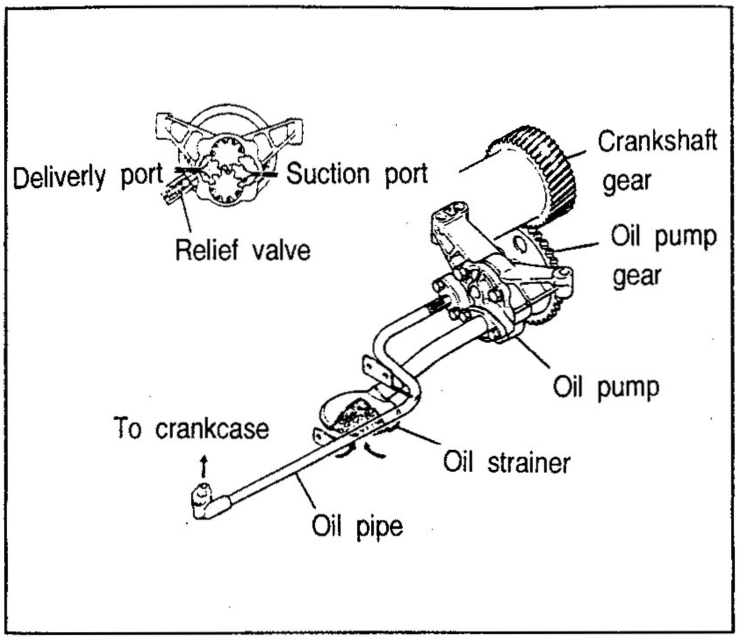
The engine lubrication system is a gear pump forced feed system. The engine oil in the oil pan will be pumped up through the oil strainer by the oil pump and will be forced to the oil filter and oil cooler for lubrication of all the parts before the oil returns to the oil pan.



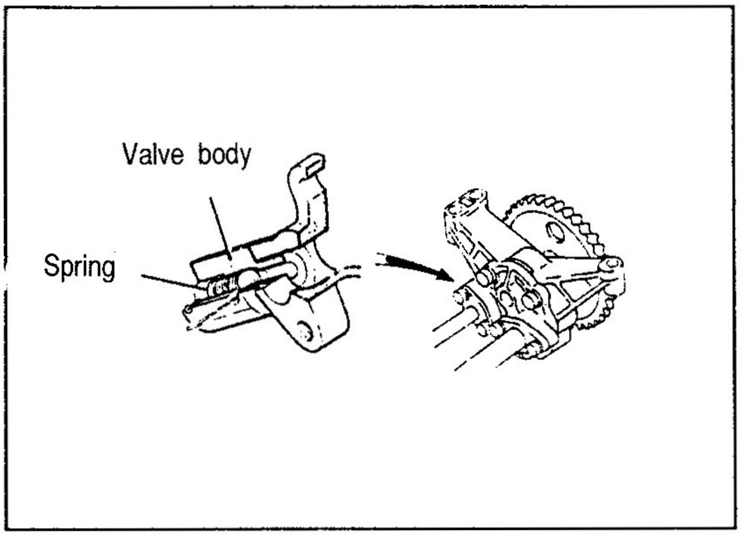
(1) Oil Pump

The oil pump is a gear pump. Mounted to the bottom of the crank case, the oil pump is directly driven by the crankshaft gear.

An oil strainer is mounted to the suction port of the oil pump, and an oil pipe mounted to the delivery port.



The oil pump is driven at a speed proportional to the engine speed. During a cold starting. therefore, the lubrication system could be overloaded as the delivery pressure of the oil pump rises. To prevent overloading the lubrication system, a relief valve is provided in the oil pump.



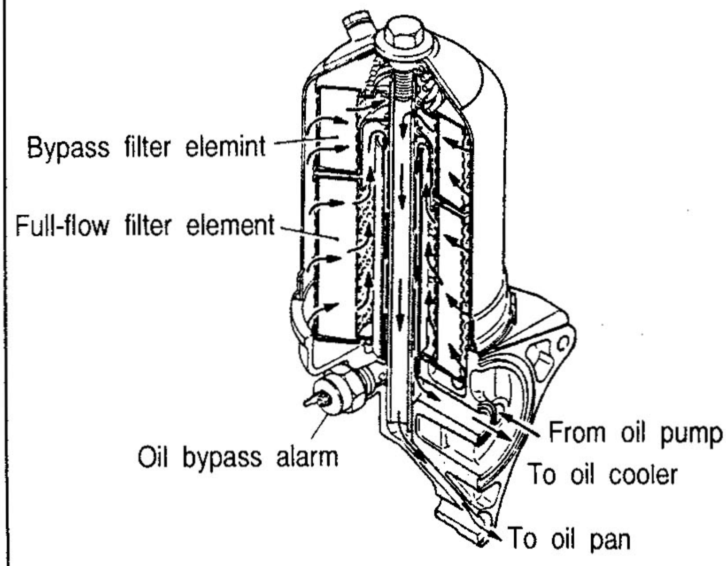
(2) Oil Filter

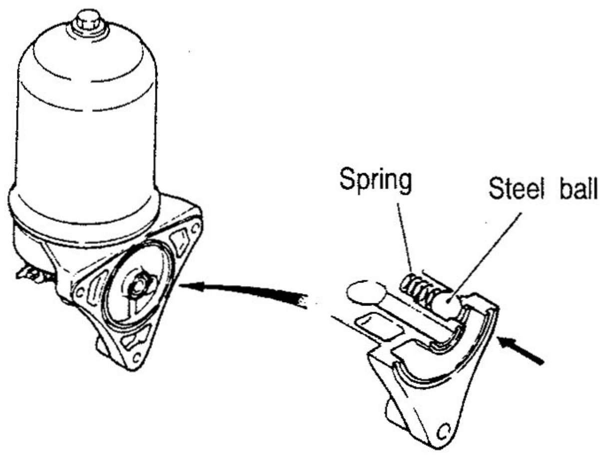
The oil filter is a combined full-flow filter and bypass filter using a one-piece filter paper element.

The engine oil passed through the full-flow filter is forced to the oil cooler, whereas the engine oil passed through the upper bypass filter is routed through the oil filter bracker mounting bolt hole and back to the oil pan.

An oil bypass alarm is mounted to the oil filter bracket. If the oil pressure difference between before and after the oil filter exceeds specification, the valve will automatically open to bypass the unfiltered oil to the oil cooler.

The oil bypass alarm has electric contact points which, when the valve is opened, close to light the pilot lamp and warn the driver that the element has been clogged.



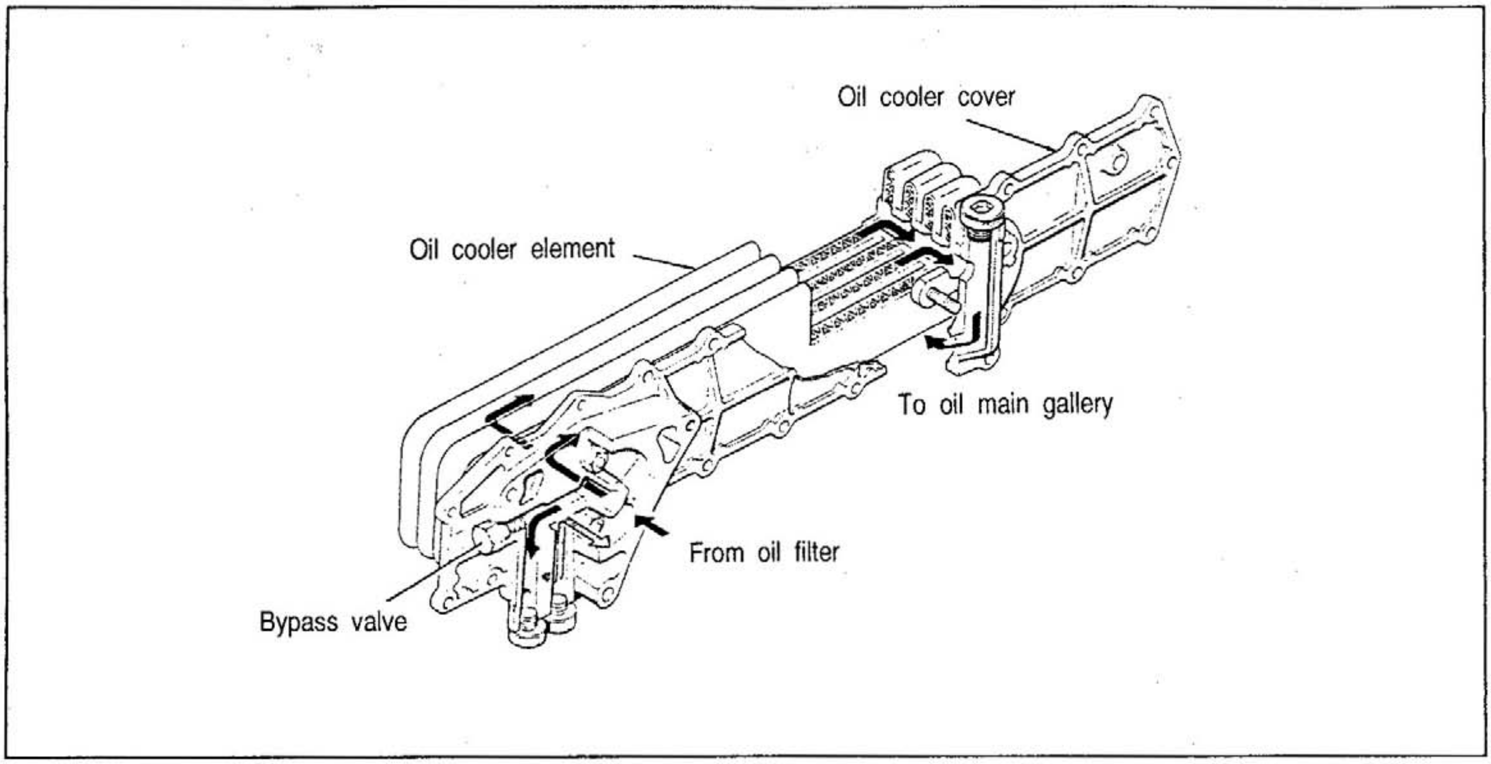


Since the oil filter is located at a relatively high position, the oil in the oil filter could fall down to the extent that there is no more oil left in the oil filter when the engine is stationary. To prevent this, therefore, a check valve operating at a very low pressure and a center pipe are provided at the inlet so that the oil level in the filter is maintained constant at all times and the oil is quickly supplied to the lubricated parts when the engine is started.

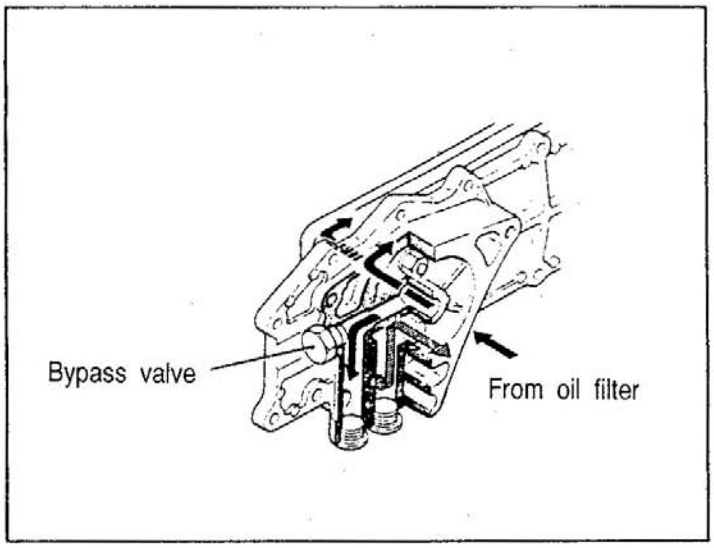
(3) Oil Cooler

The oil cooler is a shell and plate type(water-cooled multi-plate type). It is mounted on the coolant path on the left side of the crankcase.

The engine oil forced through the oil filter is cooled or heated by the oil cooler element and forced to the oil main gallery.



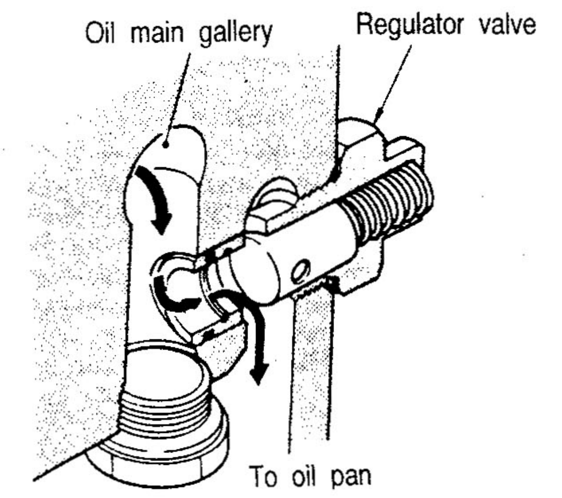
When the viscosity is high as at low temperatures or when the flow resistance of the element is high due to clogging, the oil bypass valve mounted to the oil cooler will open to let the engine oil flow to the main gallery without passing through the oil cooler.



(4) Regulator Valve

Located at the bottom of the injection pump on the left side of the crankcase, the regulator valve regulates the pressure of the engine oil which flows through the oil filter and oil cooler into the oil main gallery.

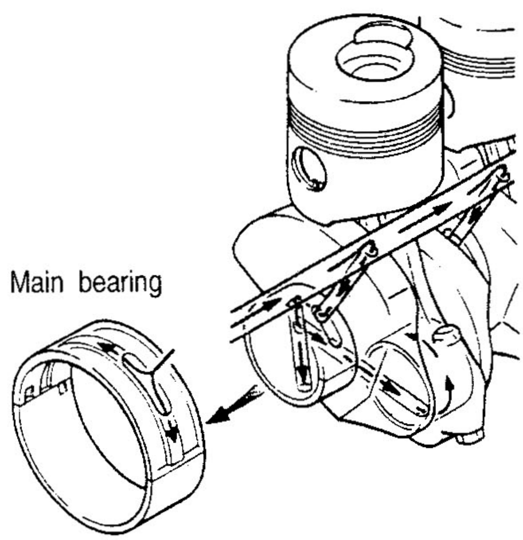
If the oil pressure of the oil main gallery exceeds specification, the valve of the regulator valve will open to return some of the engine oil to the oil pan.



(5) Lubrication of Individual Parts

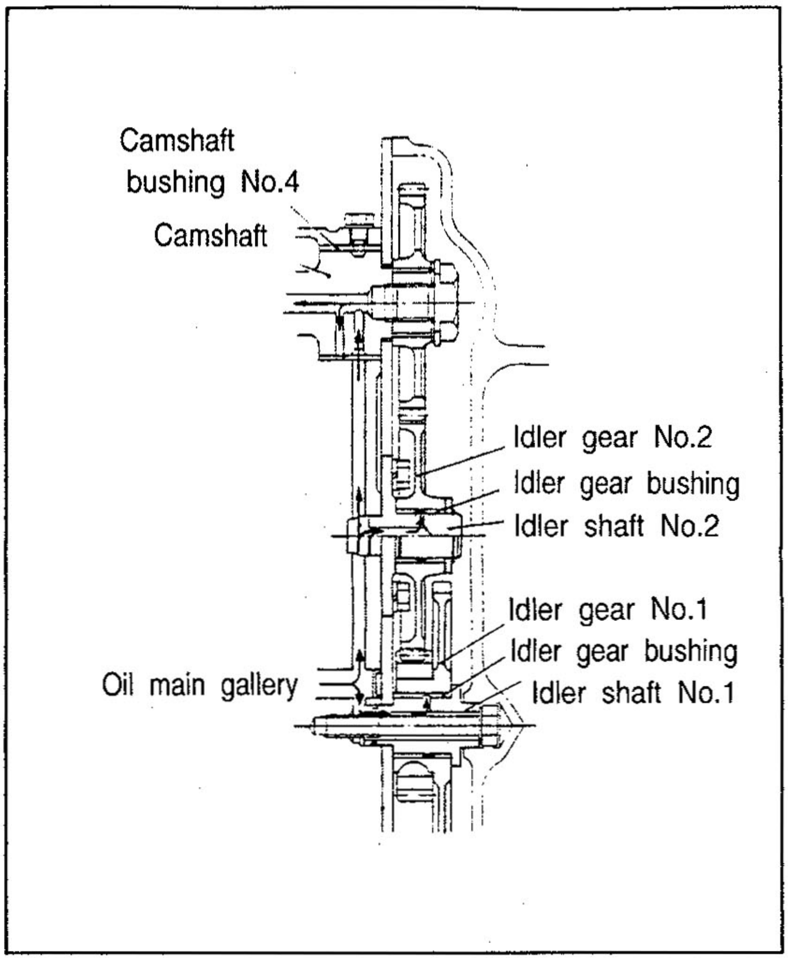
The engine oil forced to the oil main gallery lubricates the individual parts as described below.

(a) Main bearing and connecting rod bearing
The oil flows form the oil main gallery through the respective oil holes to lubricate the crankshaft main bearings. Part of this engine oil passes through the oil hole in the crankshaft to lubricate the connecting rod bearings.



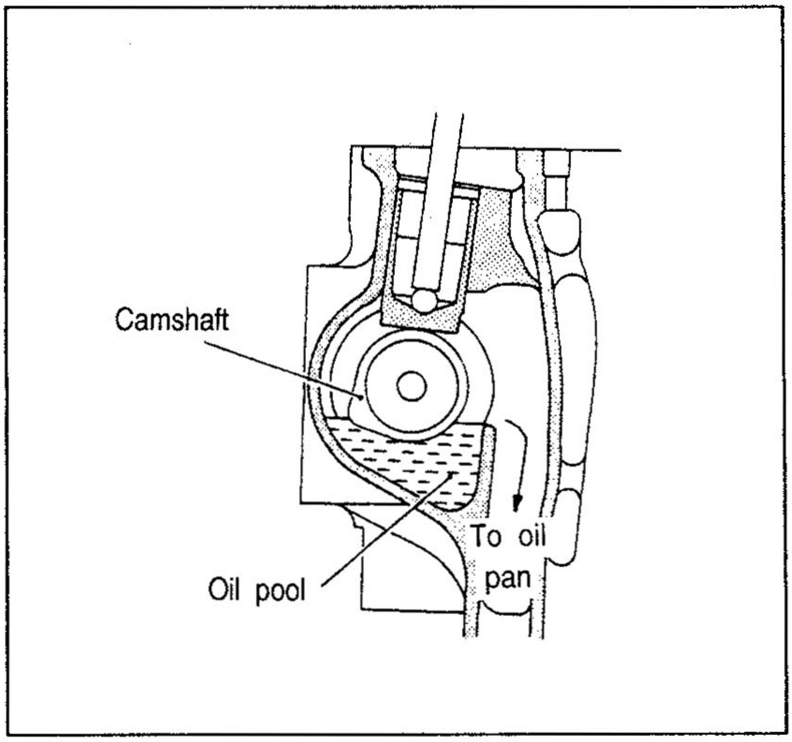
(b) Timing gear and camshaft

For lubrication of the timing gears, oil is fed from the oil main gallery through an oil hole to each bushing as illustrated at the right.

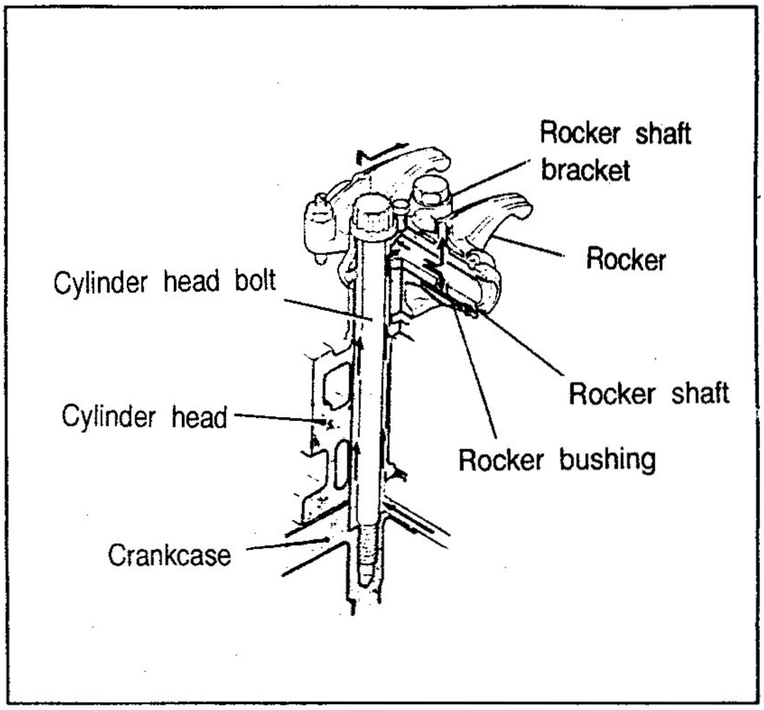


For lubrication of the camshaft bushings, the engine oil from the oil main gallery lubricates the camshaft bushing No. 4, flows through the oil hole in the axial direction of the camshaft, and lubricates other camshaft bushings.

The engine oil that has lubricated the rockers, camshaft bushings, etc. enters the oil pool and lubricates the peak portion of the cam of the camshaft.



(c) Valve mechanism

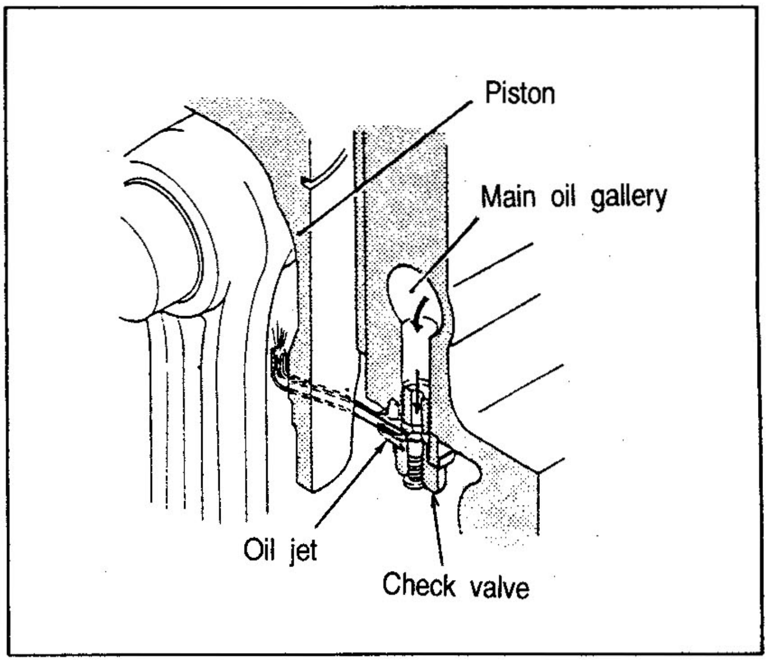


Lubrication of the rocker bushing is accomplished by the engine oil from the camshaft bushing No. 4. The engine oil flows as described below.

Camshaft bushing No. 4→Oil hole to cylinder head bolt→ Clearance around cylinder head bolt→Rocker shaft bracket→ Rocker shaft center oil hole→ Rocker bushing.

After lubrication of the rocker bushing, the engine oil works its way up through the oil hole of rocker and lubricates the valve cap sliding portion, valve stem, etc., passes through the push rod hole of the cylinder head, falls in the oil pool of the camshaft, and the oil which has overflowed the pool returns to the oil pan.

(d) Cooling the piston

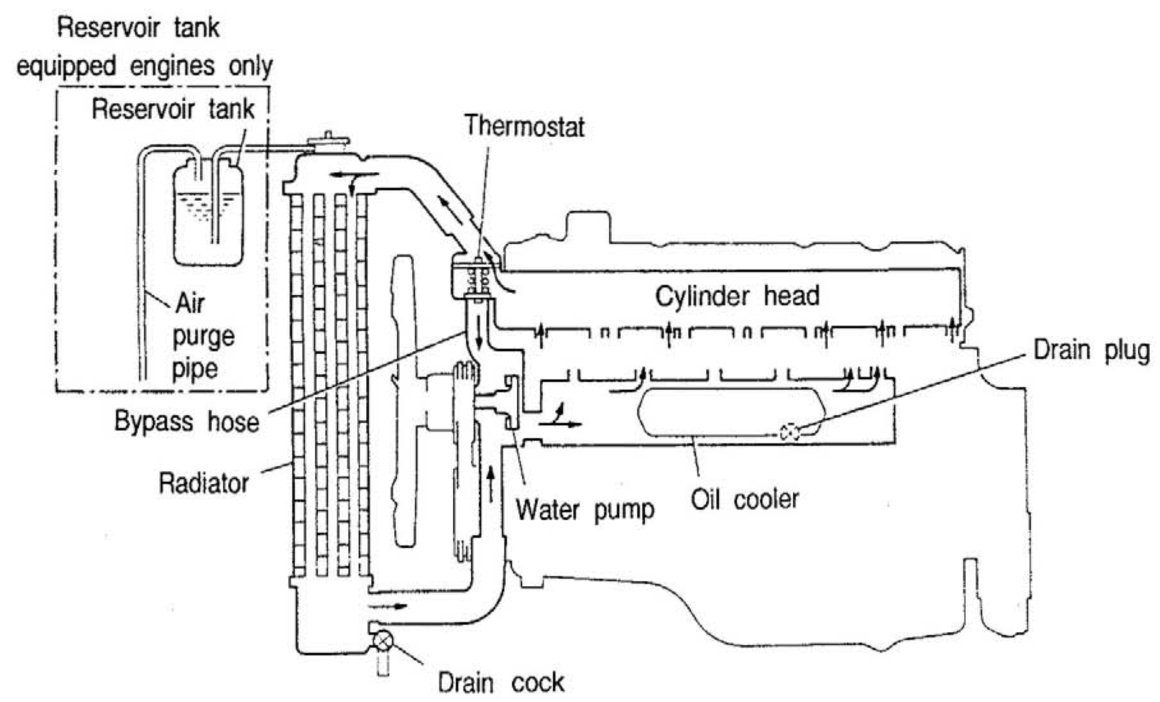


The oil jet provided under the main oil gallery for each cylinder sprays engine oil against the reverse surface of the piston to cool the piston.

The oil jet is equipped with a check valve which opens and closes at specified oil pressure, preventing the decreased amount of oil at low oil pressure and loss in oil pressure.

1-3-4 Cooling

The cooling system is a water cooled forced circulation system using a water pump. The schematic diagram is shown below.

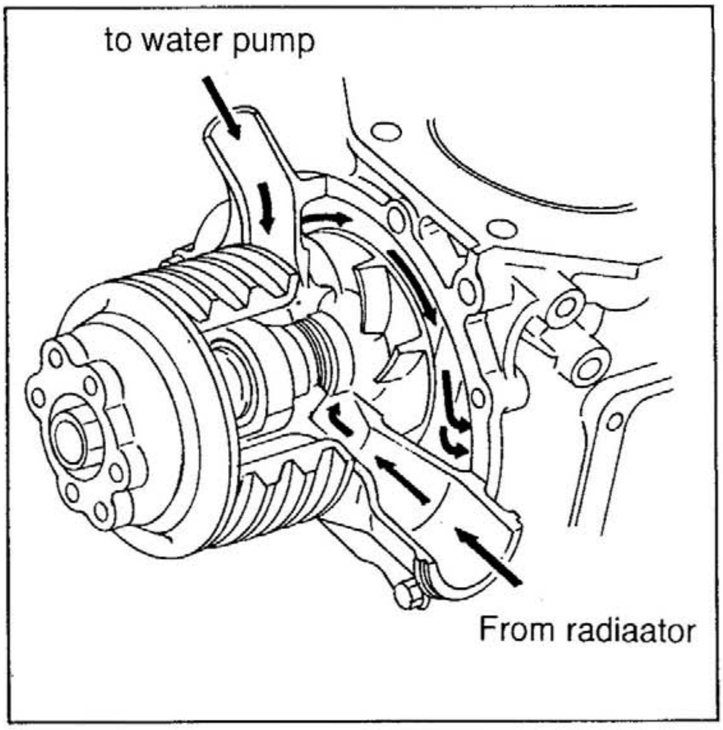


(1) Water Pump

The water pump is a centrifugal pump mounted on the front of the crankcase. The water pump is driven by a V-belt.

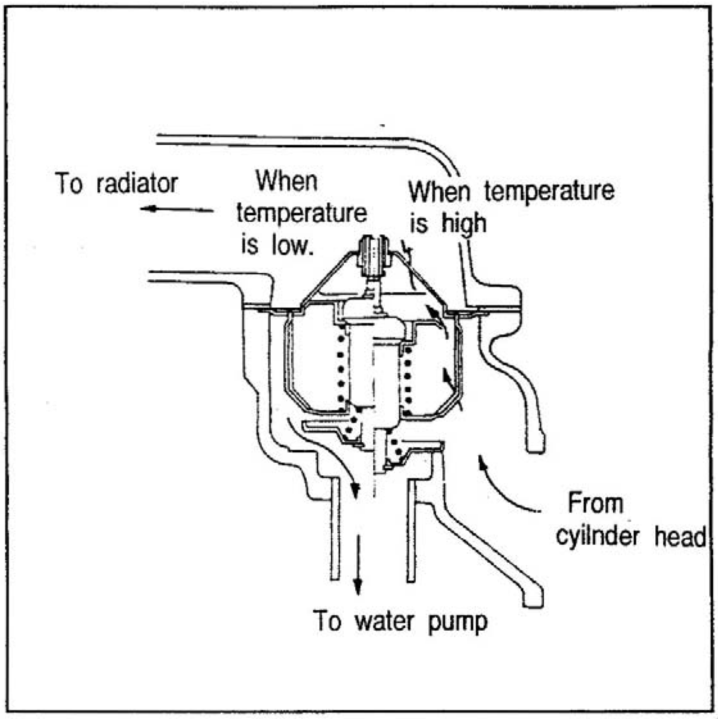
A backward type impeller is press-fitted into the rear end of the water pump shaft.

Leakage of coolant is prevented by a unit seal mounted to the front surface of the impeller.



The ball bearing is sealed on one side and lubricated by grease packed in the water pump case. Grease can be supplied through a grease nipple.

(2) Thermostat

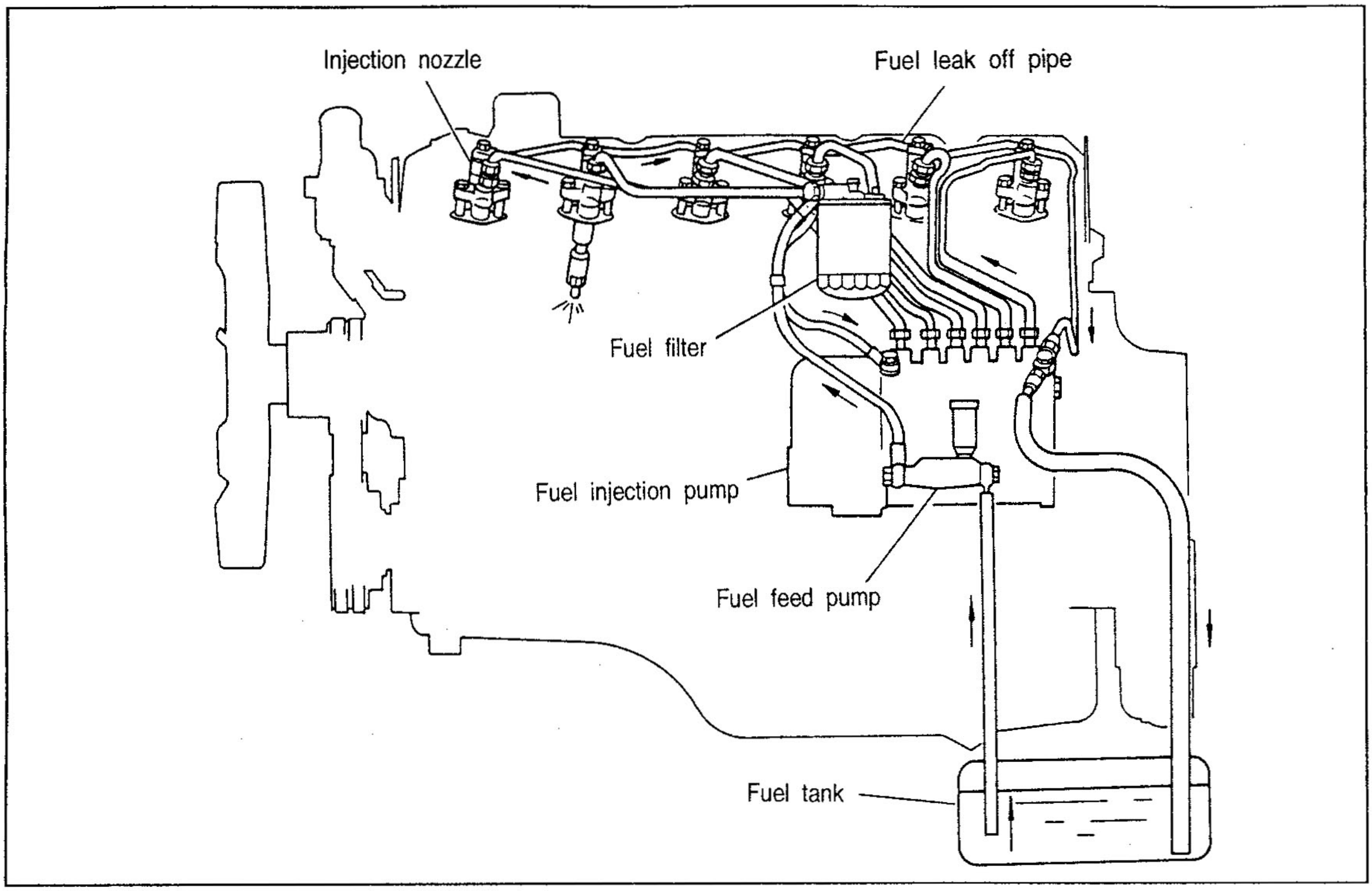


The thermostat is a wax pellet type and is mounted to the front end of the cylinder head.

The pellet contains a special wax which changes from a solid to liquid state and vice versa, depending on heat, and consequent change in its volume causes the valve to open or close, thereby changing the quantity of coolant which flows into the radiator and water pump (bypass side) to control the coolant temperature.

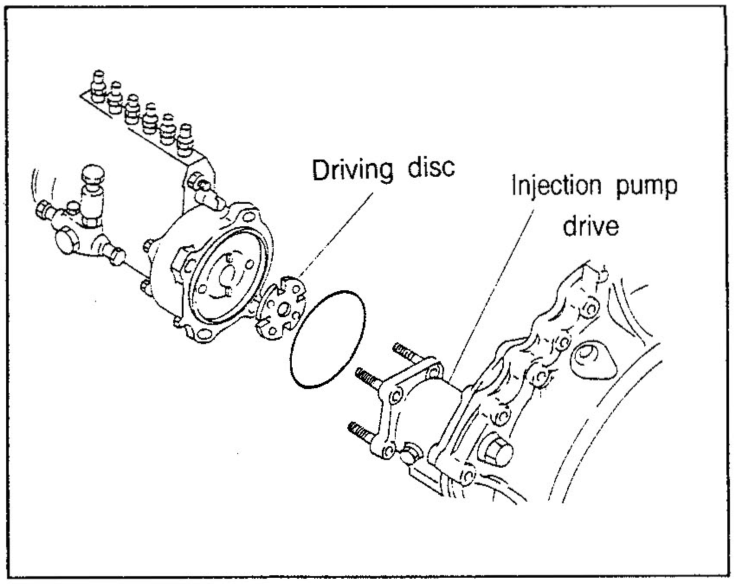
1-3-5 Fuel

The fuel system consists of a fuel filter, injection pump, general assembly, injection nozzle, fuel pipes, etc.

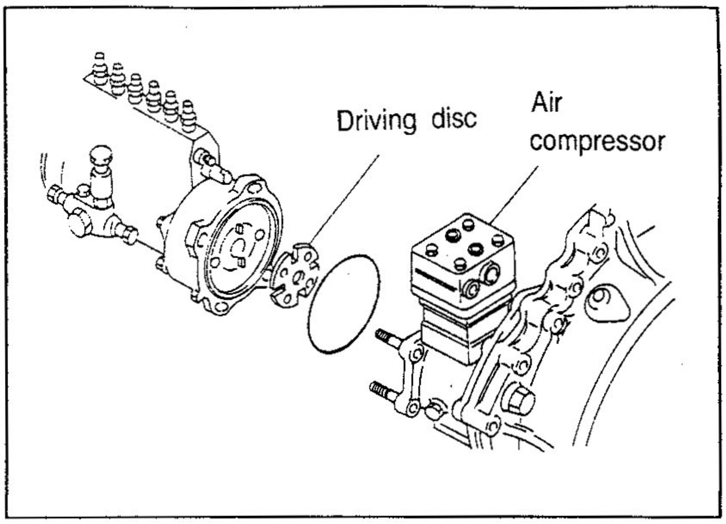


The injection pump drive method differs, depending on whether an air compressor is provided or not.

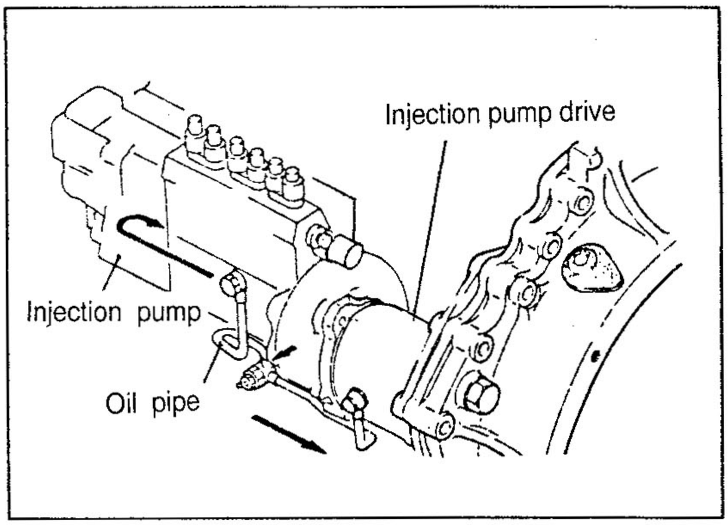
If air compressor is not provided, the injection pump drive gear is directly driven by the timing gear.



If an air compressor is provided, the drive gear of the air compressor is driven by the timing gear, whereas the portion between the crankshaft of the air compressor and auto timer is driven through the driving disc.



The injection pump and injection pump drive are forced-lubricated. The engine oil is introduced from crankcase through oil pipe to the pump housing and injection pump drive



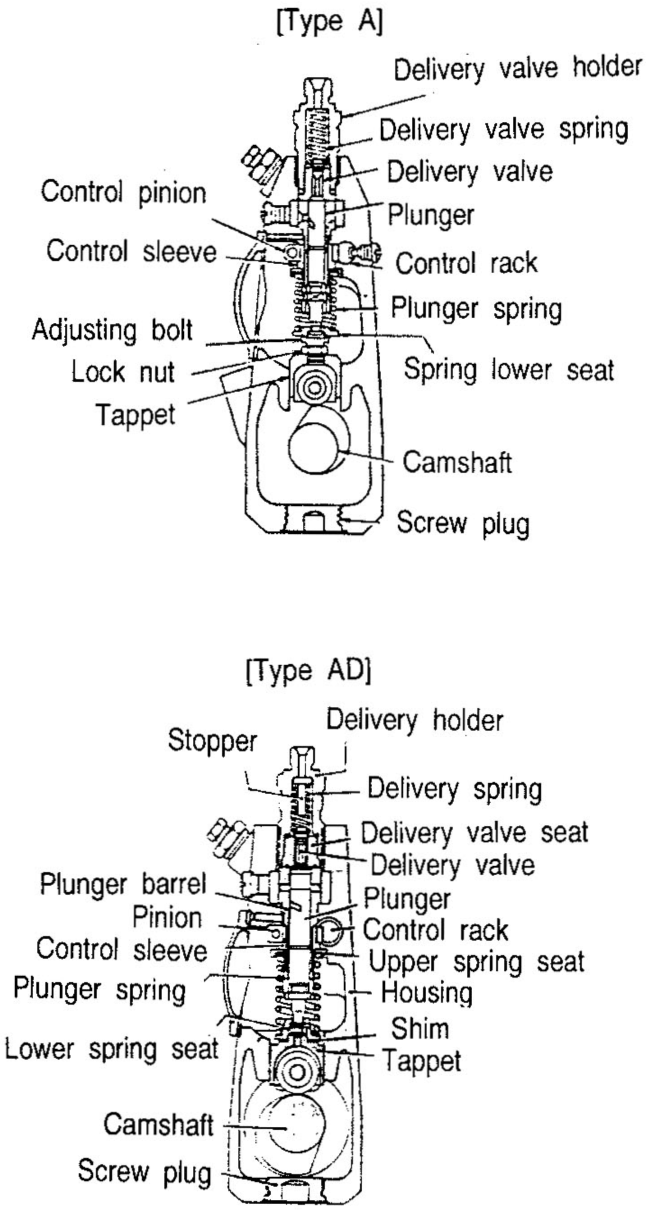
(1) A- and AD-type Injection Pump

The injection pump is a device which forces fuel to the injection nozzle and has a mechanism for increasing or decreasing the pressure feed quantity according to the engine load and speed.

The injection pump is constructed as shown in illustration at right. It has one plunger and delivery valve for each cylinder.

The plunger, pushed up by the camshaft and pushed back by the plunger spring, moves up and down through the plunger barrel on a predetermined stroke to feed fuel under pressure.

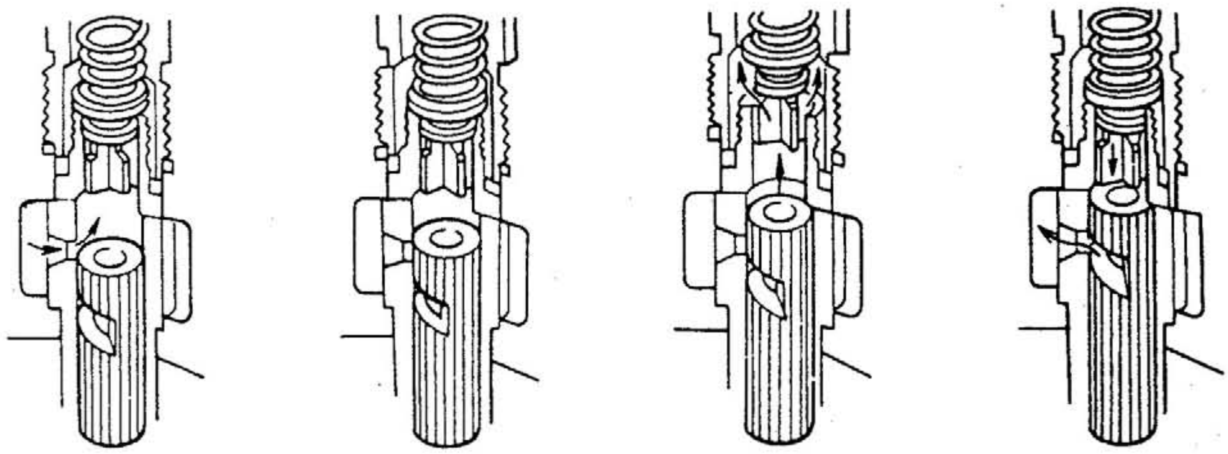
The camshaft is supported by two taper roller bearings and center bearing and is driven by the timing gear(If air compressor is not provided) or air compressor at 1/ 2 engine speed.



(a) Pressure feed of fuel

The plunger has an obliquely cut groove (lead) on its side as shown. At the top of the plunger there is a hole which leads to the groove. The plunger barrel has suction and discharge ports.

The fuel delivered to the injection pump is forced by the rotation of the camshaft or reciprocating motion of the plunger as shown below.



(a) Bottom dead center (b) Application of pressure begun (c) Pressure feed stroke (d) Pressure feed completed

When the plunger is at the lowest position or bottom dead center (a), fuel flows through the suction and discharge ports into the plunger.

Rotation of the camshaft moves the plunger up. When the top surface of the plunger is lined up with the suction and discharge ports, application of pressure to fuel begins (b).

When the plunger moves up further, the fuel pressure is increased until the delivery valve is pushed up against the delivery valve spring. While the delivery valve is pushed up, the fuel flows through the injection pipe to be pressure-fed to the nozzle (c).

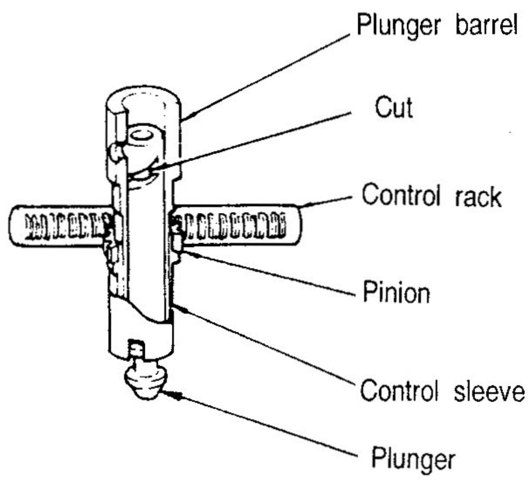
As the plunger moves up further (c), and the lead of the plunger meets with the suction and discharge ports, the high pressure fuel flows through the hole in the plunger and runs back from the lead to the suction and discharge ports, and the pressure feed of fuel is completed (d).

The plunger stroke during which the fuel is fed under pressure is called the effective stroke.

(b) Injection amount control system

According to the engine load, the amount of injection is increased or reduced by turning the plunger a certain angle to change the position where the lead meets with the suction and discharge ports on the up stroke and increasing or reducing the effective stroke.

The control rack is coupled to the floating lever in the governor. If the control rack is moved to right or left by operation of the accelerator pedal or governor, the control sleeve in mesh with the rack is turnes. Since the bottom of the control sleeve is in mesh with the bar of the plunger, the plunger turns with the control sleeve, so the effective stroke changes and the injection amount increases or decreases. The more the control rack is pulled toward the governor, the less the effective stroke and the less the injection amount.

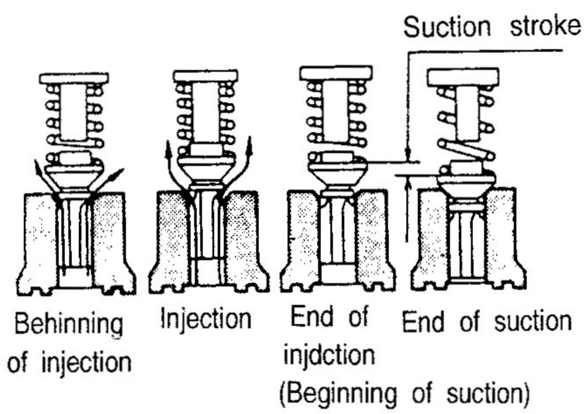


Each plunger is in mesh with this single control rack and simultaneously turns the same amount.

(c) Delivery valve

The delivery valve, provided on the top of the pump housing, performs the function of discharging the pressure in the injection pump.

The fuel compressed to a high pressure by the plunger pushes the delivery valve up and spouts out. If the pressure feed stroke of the plunger ends, the delivery valve is



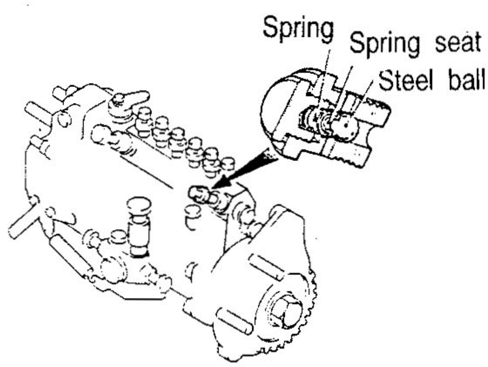
brought back to its original position by the pressure of the delivery valve spring to block the fuel path, thereby prebenting counter flow of the fuel.

The delivery valve is brought down further until the seat surface is held tight. During that stroke the fuel is drawn back from above to instantly lower the residual pressure between the delivery valve and nozzle. The draw-back effect improves the end break of an injection from the nozzle and prevents after-injection dripping.

A delivery valve stopper is provided on the top of the delivery valve spring. The stopper limits the lift of the delivery valve and prevents valve surging during high speed rotation. In addition, it reduces the dead volume between the delivery valve and nozzle, thereby stabilizing the injection amount.

(d) Overflow valve

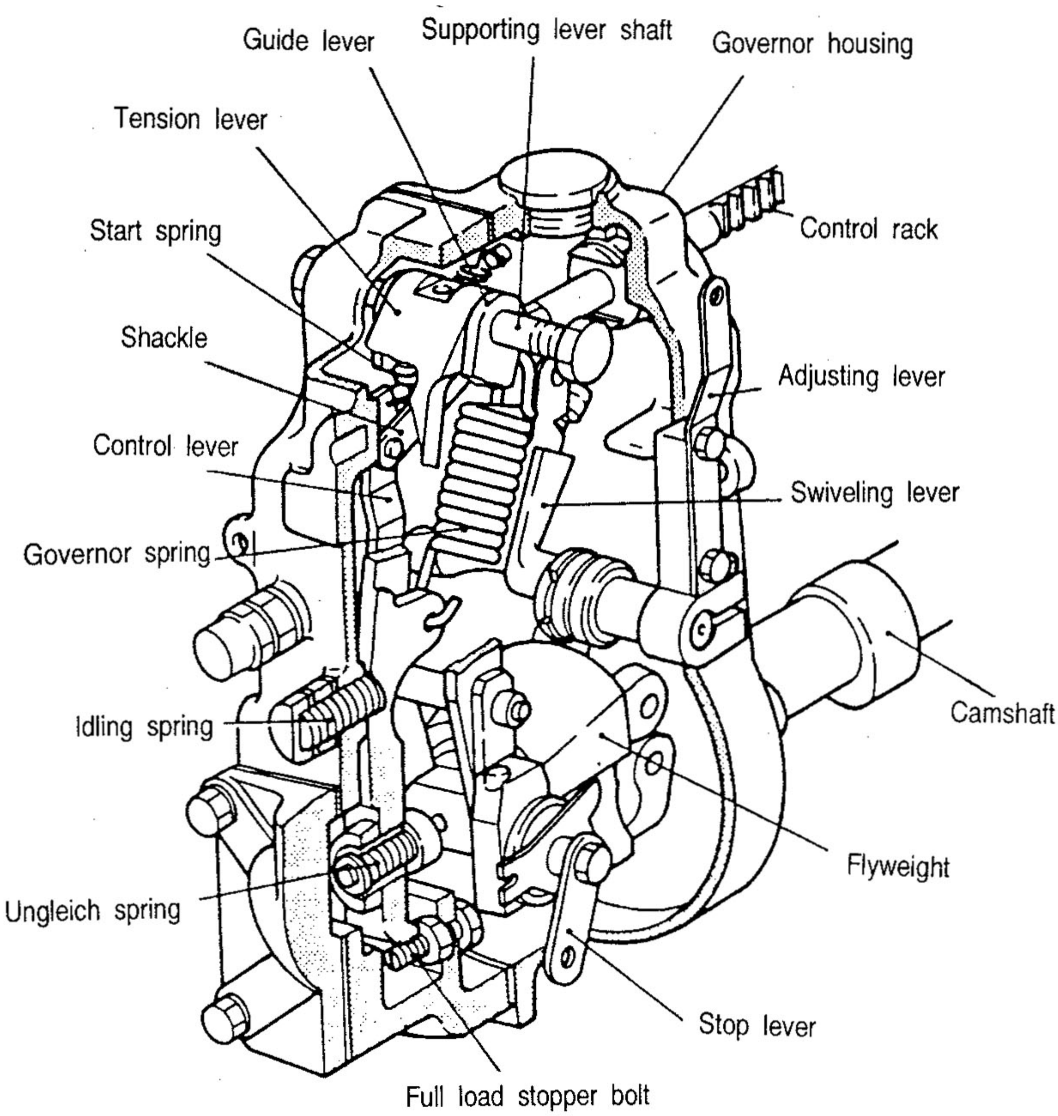
When the fuel pressure in the injection pump exceeds a set level, the steel ball in the overflow valve goes up to let the fuel flow out of the injection pump and return to the fuel tank, thereby stabilizing the fuel temperature and temperature distribution in the injection pump and maintaining the injection rate into each cylinder constant.



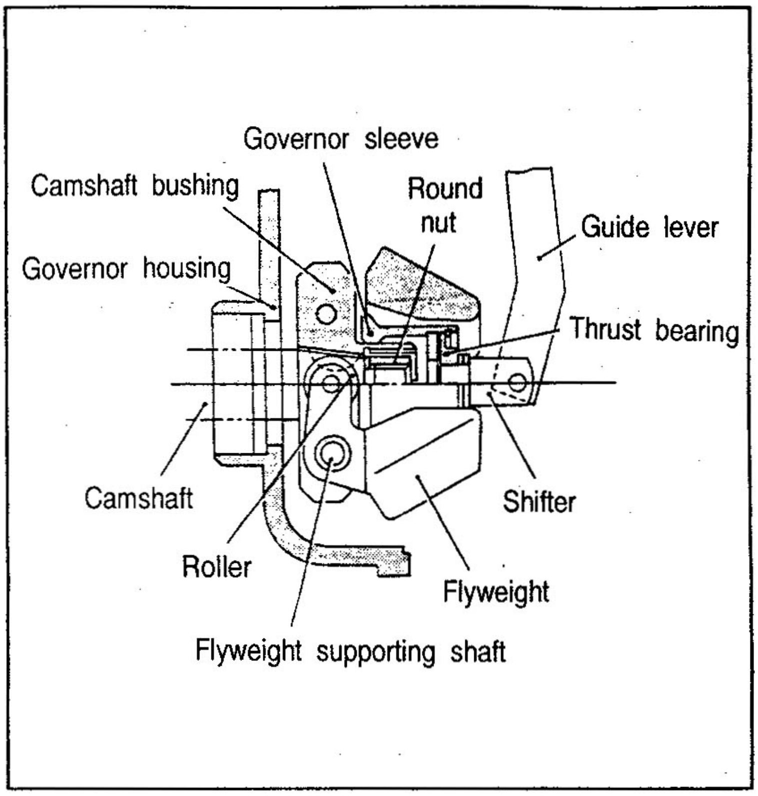
(2) Governor

(a) RSV type governor

The RSV type governor is a centrifugal type all-speed governor coupled to the camshaft of the injection pump. The governor not only controls the maximum and minimum speeds but also automatically controls the engine speed at any intermediate speed position.



The governor, as shown, consists of flyweights mounted to the injection pump camshaft. When the flyweights turning on the flyweight supporting shaft open outward, the roller mounted to the end of flyweight arm pushes the end of the sleeve in the axial direction. The governor sleeve, being made integral with the shifter through a bearing, moves only in the axial direction.



The shifter, mounted to the guide lever hung on the supporting lever shaft of the governor cover, prevents rotation.

The control lever is mounted to the middle of the guide lever by the shaft with the bottom end as the fulcrum, whereas the top of the lever is coupled through the shackle to the control rack.

The start spring, attached to the top end of the control lever, always pulls the control rack in the direction that fuel is increased.

The turning shaft of the swiveling lever is fitted into the bushing of the governor cover and its center is eccentric with respect to the mounting position of the governor spring installed to the tension lever. The governor spring is installed to the end of the swiveling lever. When the governor spring receives tension, the bottom end of the tension lever touches the adjustable full-load stopper bolt.

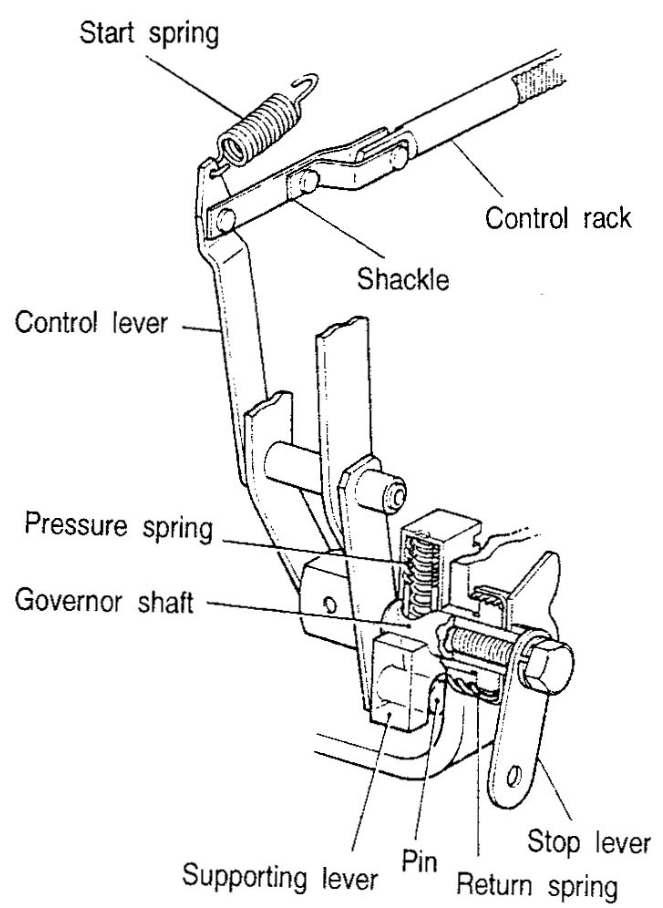
When the angle of the adjusting lever is changed, the angle of the swiveling lever is also changed and the tension of the governor spring changed. This is because the turning center of the swiveling lever and the mounting position of the governor spring installed to the tension lever are eccentric to each other as mentioned above.

An adjustiing screw is also mounted to the swiveling lever. Adjustment of the screw changes the tension of the governor spring, thereby making it possible to adjust the speed regulation.

An Ungleich spring is provided in the bottom portion of the tension lever. Adjust the tension of the spring by adding or removing shims.

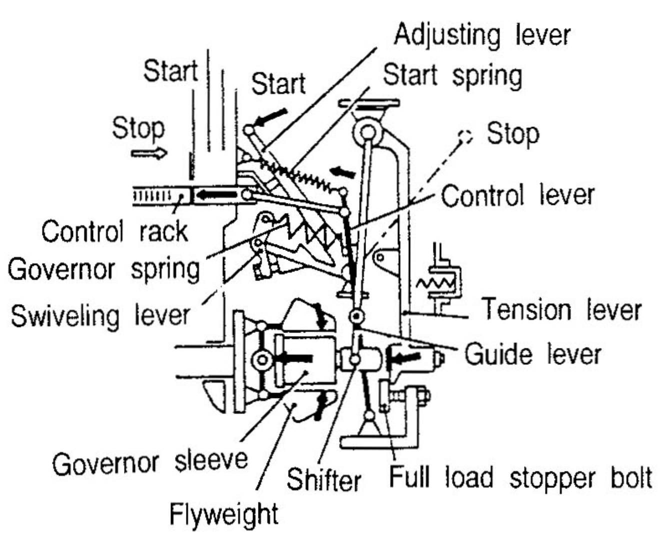
An idling sub spring adjustable from outside is provided in the middle of the governor cover. During idling, the spring always keeps in contact with the tension lever to maintain a constant idling speed.

The stop lever, mounted through the supporting lever to the bottom end of the control lever, returns the control rack to the stop position with a slight pressure irrespective of the adjusting lever position.



1) Start of engine

When the adjusting lever is moved to the start position (until it touches the maximum speed stopper), the swiveling lever which moves with the adjusting lever pulls the governor spring and moves the tension lever until it touches the full-load stopper bolt.

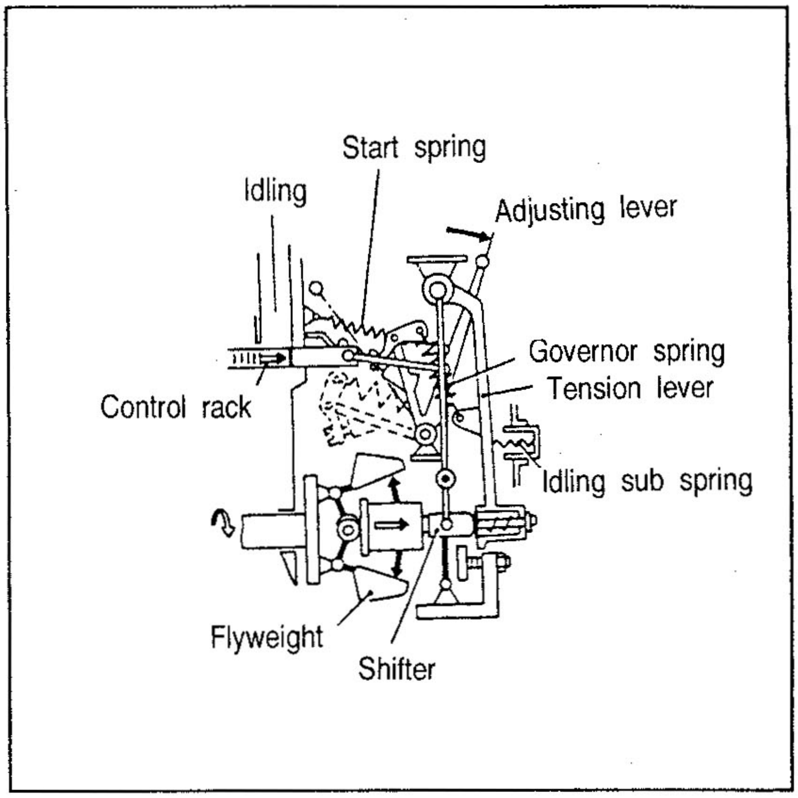


At that time, the flyweights are stationary, and the start spring with weak tension pulls the control lever in the direction that fuel is increased.

At the same time, the shifter and governor sleeve push the flyweight roller to the left.

As the result, the tension lever and shifter are spaced that much apart, and the corresponding amount of fuel is supercharged to facilitate starting.

2) Idling control



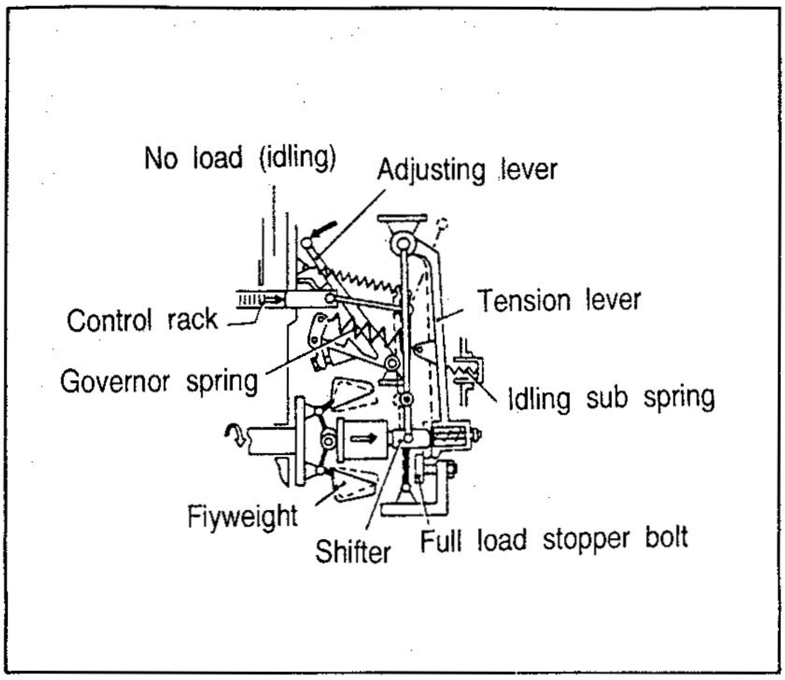
Once the engine is started and the adjusting lever returned to the idling position, the tension of the governor spring is drastically reduced.

Now the flyweights can move outward even at a low speed, so the tension lever is pushed back until it touches the idling sub spring and places the control rack at the idling position. In this state, the centrifugal force of the flyweight and the weak-state governor spring and idling sub spring achieve balance and maintain smooth idling.

When the speed falls, the centrifugal force decreases, the flyweights move inward, and the idling sub spring pushes the tension lever to the left and moves the control rack in the direction that fuel is increased.

If the speed falls radically, the start spring with weak tension acts and moves the control rack in the direction that fuel is increased to maintain the idling speed.

3) Maximum speed control



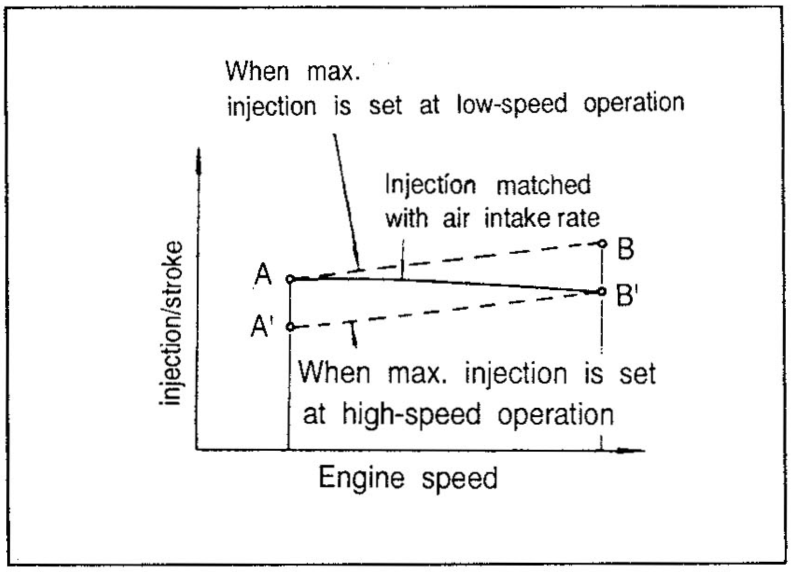
When the adjusting lever is moved to the full-load position, the tension of the governor spring is increased and pulls the tension lever until it touches the full-load stopper bolt.

When the engine exceeds the specified speed, the centrifugal force of flyweights becomes larger than the force of the governor spring pulling the tension lever. So the tension lever is moved to the right and moves the control rack in the direction that fuel is reduced, thereby preventing the engine from exceeding the specified speed.

If the speed further increases, the centrifugal force of flyweight increases and pushes the tension lever to the right and also compresses the idling sub spring to pull the control rack back to the no-load maximum speed position, thereby preventing over-speed operation of the engine.

The RSV type governor controls the entire speed range from idling to maximum speed. If load increases or decreases at a certain speed determined by the position of the adjusting lever, the governor automatically funtions and maintains the engine speed constant at all times.

4) Ungleich operation



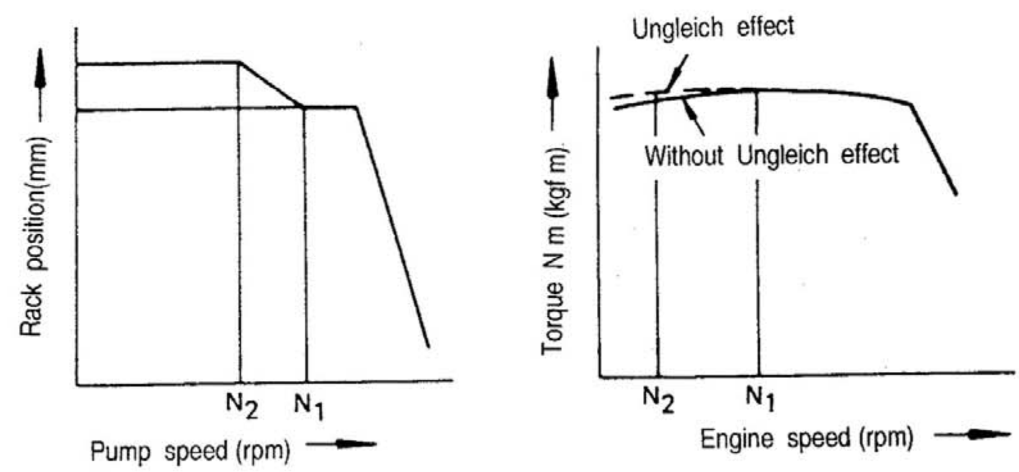
The Ungleich device controls fuel injection in such a way as to match the engine performance(the required injection varies with engine speed).

The air intake rate of the engine falls as the engine speed increases. The injection pump, on the other hand, increases the per-stroke injection as the speed increases, even with the control rack at the same position.

Therefore, if full load is set at point A to derive enough output at low speeds, the injection will reach B as the speed increases, and the engine will produce black smoke.

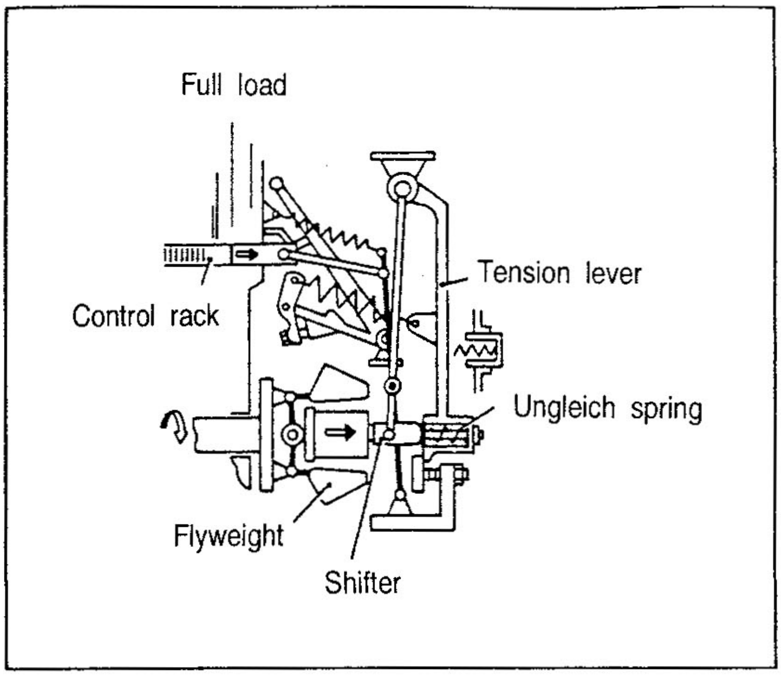
If full load is set at point B´ to prevent black smoke, the low speed injection will come down to A´, allowing combustion of more fuel.

So the Ungleich device accomplishes the function of setting full load at point A to derive the largest possible torque in the low speed range, and chaning it to adjust the injection to point B´ in the high speed range.



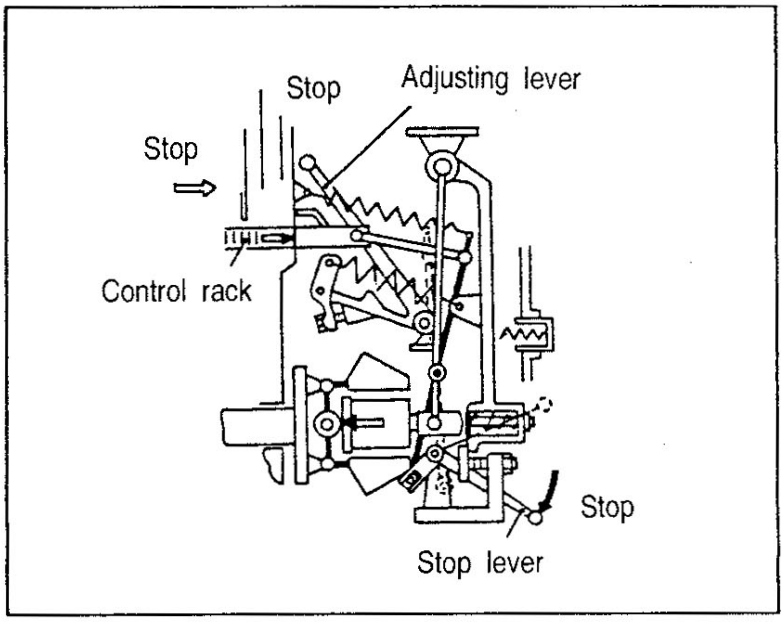
When the engine speed is low and the centrifugal force of flyweight smaller than the pressure of the Ungleich spring, the shifter is moved as much as the Ungleich stroke to the left, so the control rack moves in the direction that fuel is increased to increase the torque of the engine at low speeds.

As the engine speed increases, the centrifugal force of flyweight increases. If it becomes larger than the pressure of the Ungleich spring, the Ungleich spring is slowly compressed before the start of high speed control, and the control rack moves in the direction that fuel is reduced. The Ungleich stroke is completed at the position where the shifter directly touches the tension lever.



5) Stopping of engine

When the stop lever is moved to the stop position, the control rack is moved to the stop position to stop the engine regardless of the position of the adjusting lever.

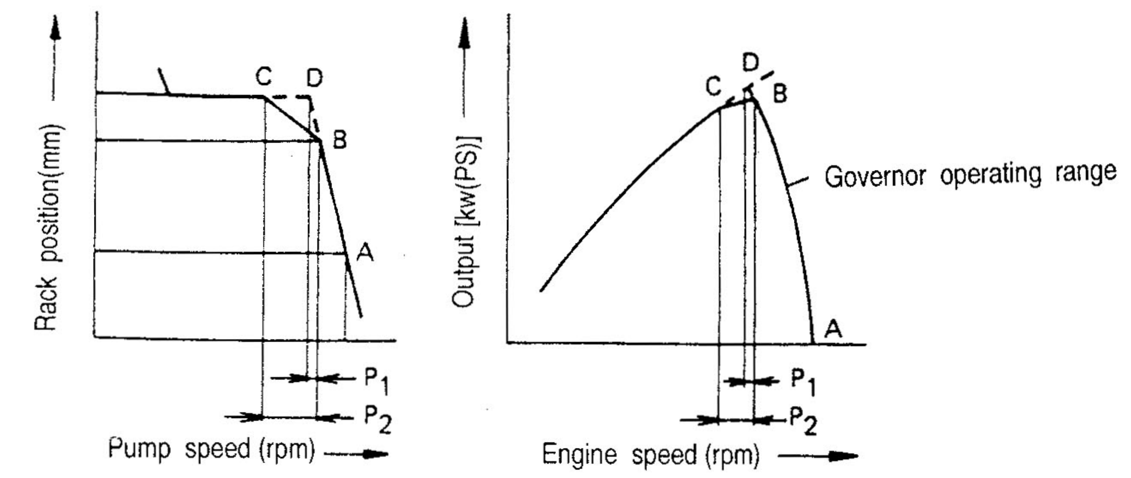


6) Operation of torque spring

Construction machinery engines are often subjected to a large load during operation, and reduced speeds often lead to stalls. To prevent this, a torque spring is provided.

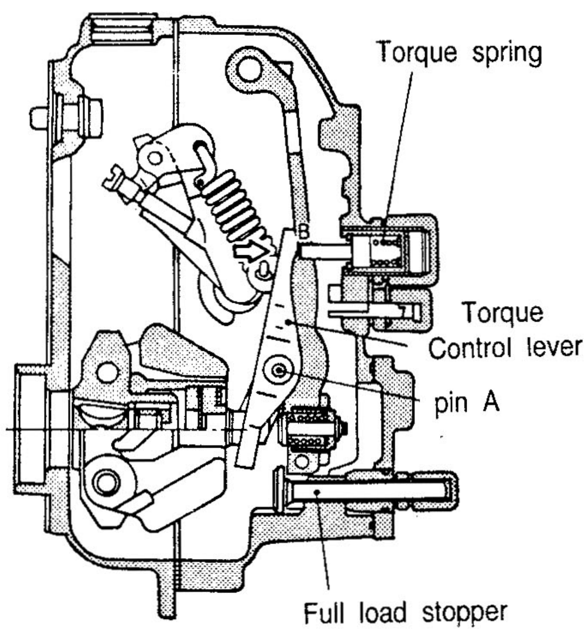
When the adjusting lever is fixed in the lever set position, a sudden increase of load, if no torque spring is provided, will move the control rack along the B-D curve as the speed falls. The rotational displacement at the time may be expressed as P_1.

If a torque spring is provided, the control rack moves along B-C, and the rotational displacement at the time may be expressed as P_2. Therefore, large changes occur in P_2 and engine speed, and because of increased fuel injection, the engine torque increases, and large combustion noise warns the operator of the increased load, enabling him to take proper action to prevent stopping the engine.



In an abrupt increase of load occurs when the engine is running at continuous rating, the engine speed falls. So the flyweights are moved inward and the tension lever pulled to left by the governor spring, causing the control rack to move in the direction that fuel is increased.

At the time, the tension Lever pin pushes the bottom of the torque control lever, and the lever moves with the pin "A" as the fulcrum, whereas the portion "B" is pushed to right. As the result, the torque



spring performs the function of reducing movement of the tension lever.

(g) RFD type governor

The RFD governor is a mechanical governor that controls only the minimum and maximum speeds.

This governor has a flyweight installed to the injection pump camshaft. This flyweight rotates about the pin that is press fitted to the flyweight holder. When the flyweight is opened outward, the roller installed to the end of the flyweight arm pushes the sleeve end in the axial direction.

The sleeve sliding on the flyweight roller is coupled to the shifter by a snap ring and the shifter is in engagement with the guide lever suspended from the tension lever shaft so theat it is locked against rotation.

A shaft is mounted to the middle of the guide lever and this shaft carries floating levers at both its ends.

To the bottom end of a floating lever is press fitted a block which engages with the lower section of the sliding lever. A load control lever is mounted through an eccentric shaft to this sliding lever so that the floating lever can be operated by operating the load control lever. To the top end of the other floating lever, the injection pump control rack is coupled through the floating lever link and the start spring is attached to the bottom end of the control rack.

The other end of this spring is attached to the spring eye on the governor housing side.

To the tension lever shaft carrying the guide lever, the tension lever is hung and between this tension lever and the speed setting lever, the governor spring is hung of which tension is determined by the speed control lever that is mounted to the speed setting lever shaft. Accordingly, in the normal speed range, the bottom end of the tension leber is in contact with the stroke adjusting bolt at all times.

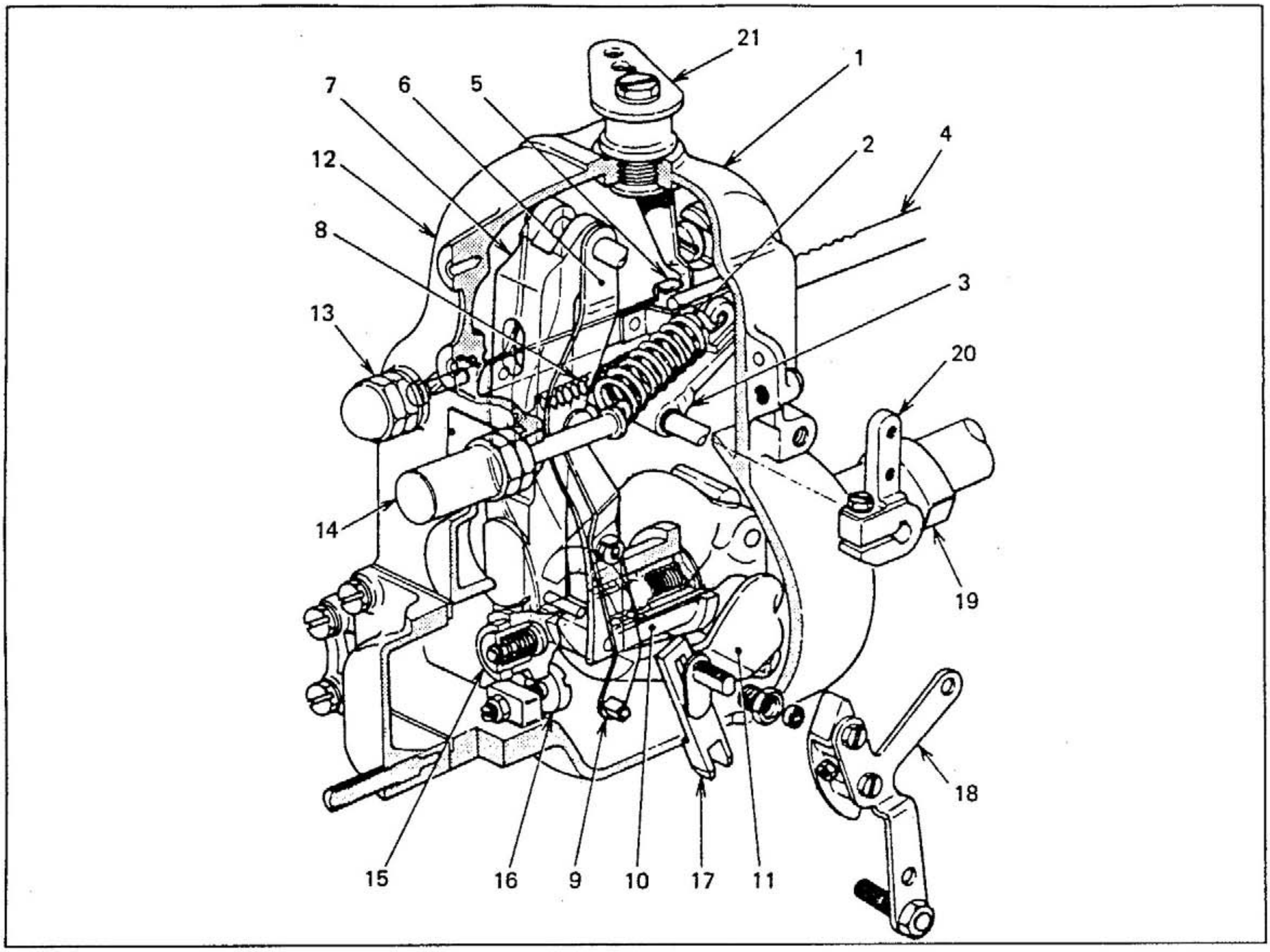
To the bottom side of the tension lever, a pin is press fitted which is in the top groove of the sliding lever. Accordingly, during high speed control, the leverage ratio can be increased by this pin, the sliding lever and floating lever linkage.

The idling spring is mounted to the lower end of the tension lever to provide low speed control during driving. To the top of the governor, the engine stop lever is mounted which moves the control rack to non-injection position to stop the engine. A cancel spring is provided to protect the control rack from undue force when it is operated.

To the top of the governor cover, the start booster (spring capsule assembly) is mounted to incresase the amount of fuel injection and facilitate starting. This device also serves to reduce smoke emission during operation in practical full load low speed range.

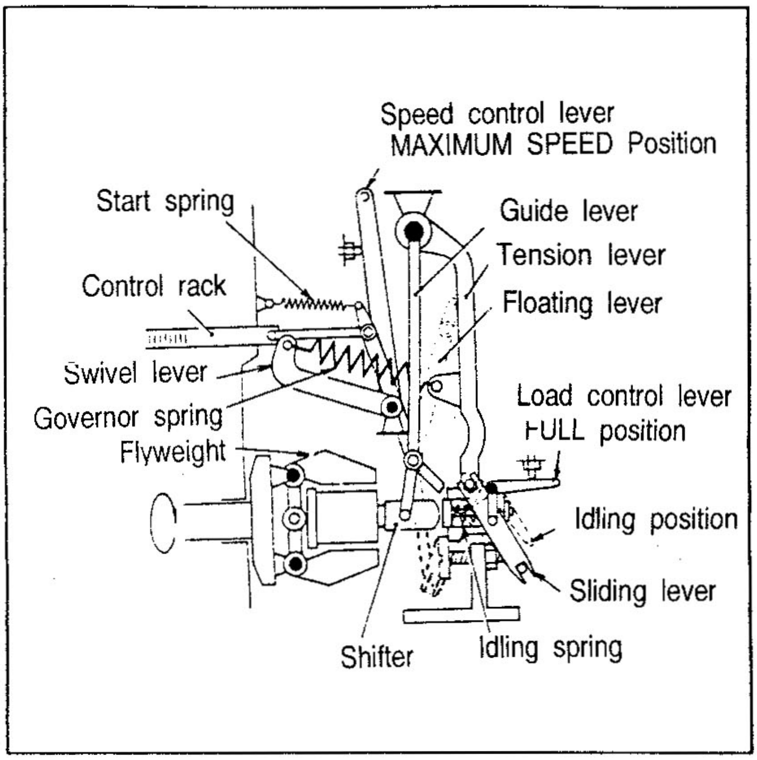
The RFD type governor spring tension changes with the degree of inclination of the speed control lever so that this governor can be set to any speed.

Because of this construction, any speed can be achieved by operating the speed control lever with the load control lever fixed at the full load position.



1	Governor housing	12	Governor cover
2	Governor spring	13	Damper spring
3	Swivel lever	14	Start booster
4	Control rack	15	Idling spring assembly
5	Floating lever link	16	Stroke adjusting bolt
6	Guide lever	17	Sliding lever
7	Tension lever	18	Load control lever
8	Start spring	19	Camshaft
9	Floating lever	20	Speed control lever
10	Sleeve assembly	21	Engine stop lever
11	Flyweight		

1) Control during engine starting and idling



When the engine is stationary, the flyweights are held closed by the governor spring, idling spring and start spring.

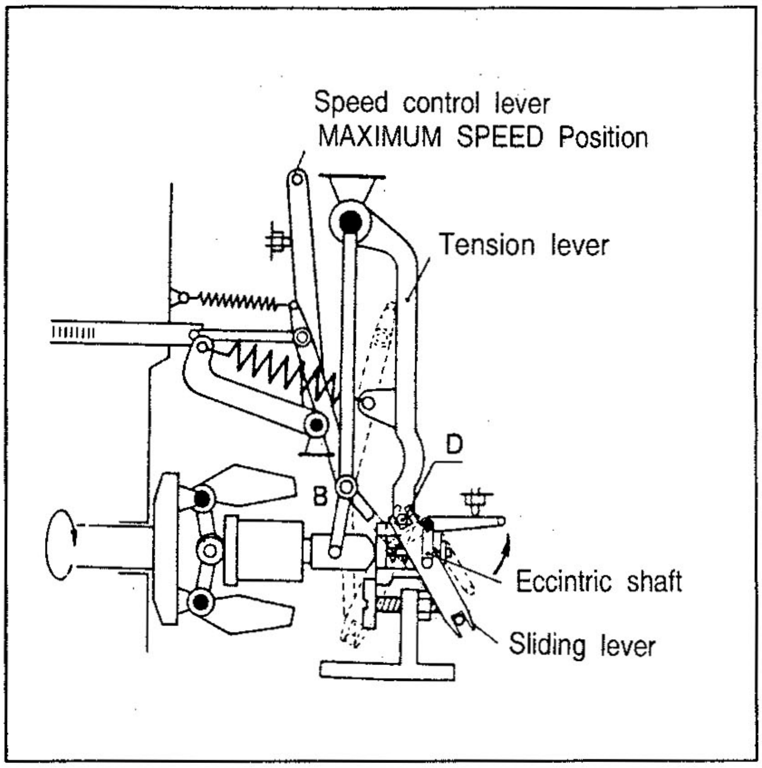
If, in this condition, the load control lever is pushed all the way to the full load position(in the direction that fuel is increased), the control rack, because of the functions of the start spring and idling spring, moves to the position of maximum fuel injection for the engine start beyond the full load position. This governor is provided with the start booster of which position is described in (d).

When the load control lever is brought back to the idling position after the engine has started, the centrifugal force of the flyweights changes with their rotational speed. The centrifugal force in the idling speed range is of such an extent as to compress the idling spring. Therefore, the flyweight centrifugal force balances with the idling spring and start spring force. As a result, the control rack is held at a fixed position, ensuring smooth engine idling.

If the engine speed increases, the increasing centrifugal force of the flyweights causes them to open and the shifter is pushed to the right, which in turn causes the guide lever and the floating lever to move. As a result, the control rack moves in the direction that fuel is decreased (to the right).

On the other hand, if the engine speed decreases, the control rack moves in the direction that fuel is increased. In this manner, the amount of injection is adjusted to achieve stable engine idling.

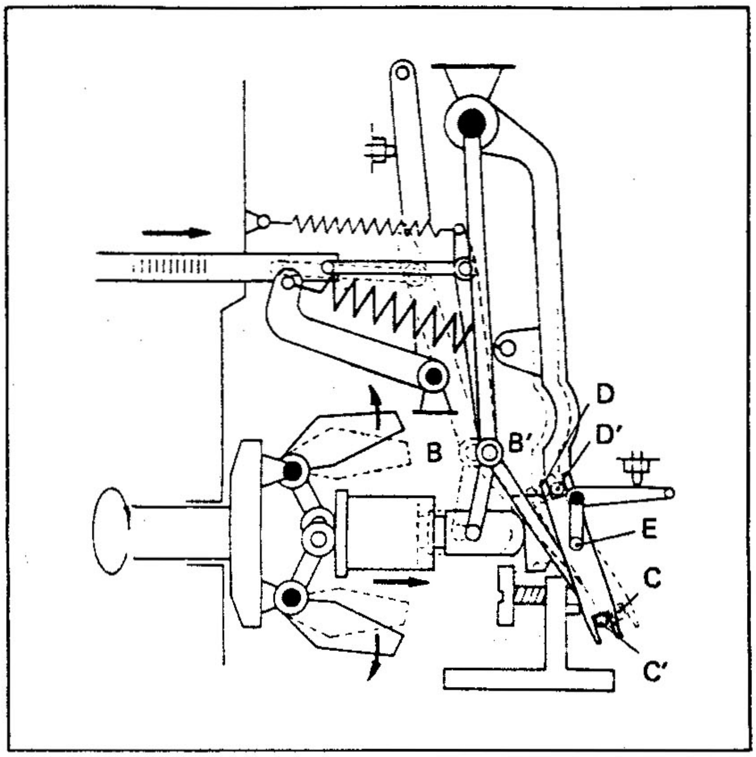
2) During normal operation



When the load control lever is moved toward the full load position (in the direction that fuel is increased), the eccentric shaft coupled to the load control lever causes the sliding lever to turn with the pin D in the lower part of the tension lever as the fulcrum. Furthermore, the floating lever also turns about the common fulcrum B to push the control rack in the direction that fuel is increased and consequently the engine speed increases.

When the speed increases beyond the idling control range, the idling spring is fully compressed into the tension lever and the shifter is brought into direct contact with the tension lever. However, the tension lever is held against the stroke adjusting bolt by the tension of the governor spring that is key taut by the speed control lever and in the normal engine speed range, the flyweight centrifugal force remains small. To tension lever, therefore, cannot move. Accordingly, the common fulcrum B can move neither. As a result, the movement of the load control lever is transmitted as it is via the eccentric shaft, sliding lever and floating lever to the control rack to increase or decrease the amount of fuel injection.

3) Control of maximum speed



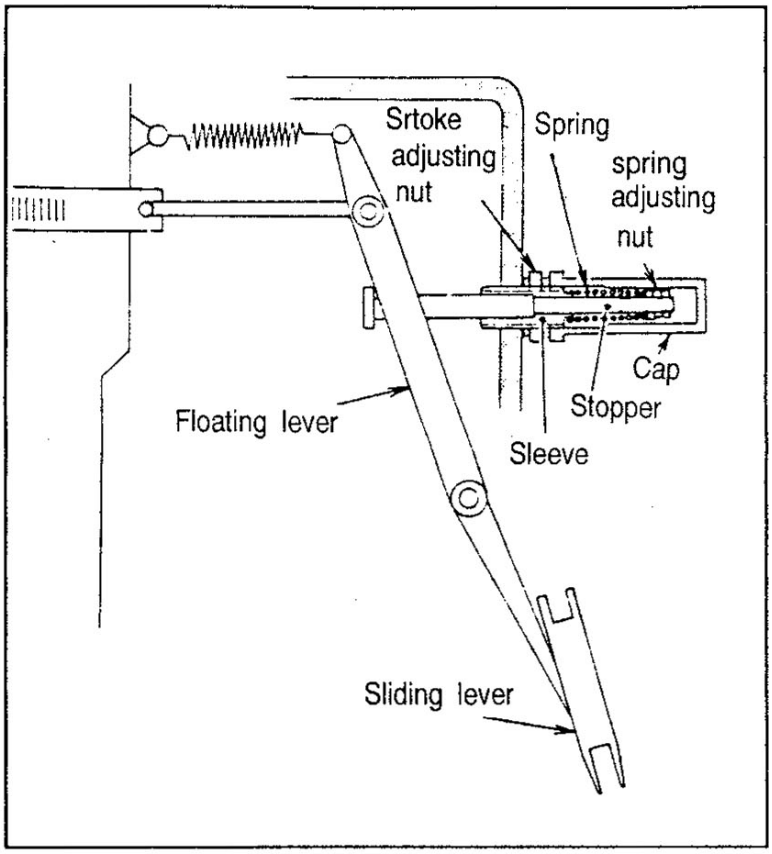
If the engine speed reaches the specified maximum speed due to changes in the engine load, the centrifugal force of the flyweights overcomes the tension of the governor spring to open them, and pushes the shifter and the tension lever to the right. As a result, the common point B moves to the point B′ and the point D on the tension lever moves to the point D′ so that the engine speed is controlled not to exceed the specified maximum speed.

In case this governor is used as an all-speed governor, the engine speed is changed by the operation of the speed control lever with the load control lever fixed at the full load position. Namely, the engine speed remains constant at the level determined by the angle of the speed control lever and when the load changes, the governor adjusts itself to keep that speed. Suppose the speed control lever is set to the position that gives maximum output(position where it is in cotact with the maximum speed stopper bolt). When the engine speed increases with the speed control lever in this position. the centrifugal force of the flyweights increases and when it overcomes the tension of the governor spring pulling the tension lever, the flyweights start to open and this movement causes the shifter and the tension lever to move to the right. As a result, the common fulcrum B moves to B′, the point D on the tension lever moves to D′ and the lower fulcrum C of the floating lever moves to C′. Thus, the control rack is pulled to the direction that fuel is decreased and the engine speed decreases. On the other hand, if the load increases and the engine speed decreases, the centrifugal force of the flyweights is overcome by the tension of the governor spring and the common fulcrum B′ moves to B, the point D′ on the tension lever moves to D and the lower fulcrum C′ of the floating lever to C, pushing control rack to the direction that fuel is increased.

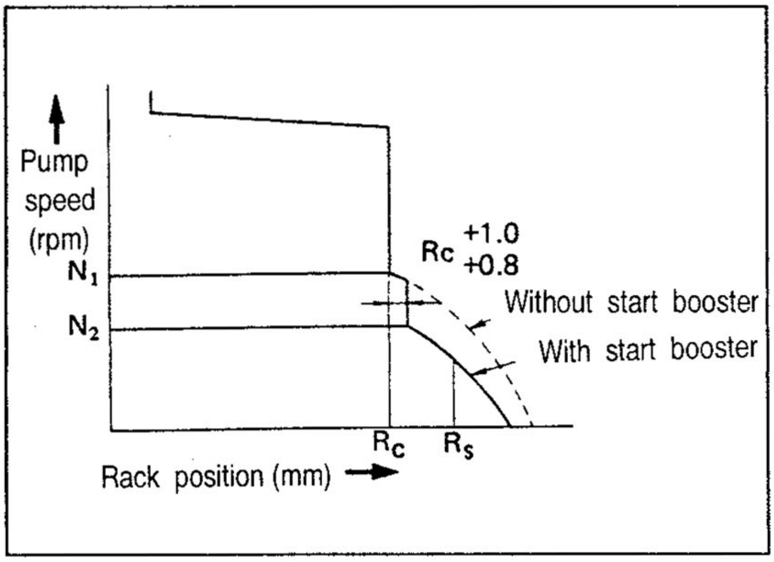
In this manner, the governor operates automatically with changes in the load, keeping a constant engine speed.

4) Start booster(smoke set assembly)

The start booster mounted to the rear of the governor consists of the functional parts (spring with setting force and stopper), a sleeve, stroke adjusting nut, spring adjusting nut and cap.



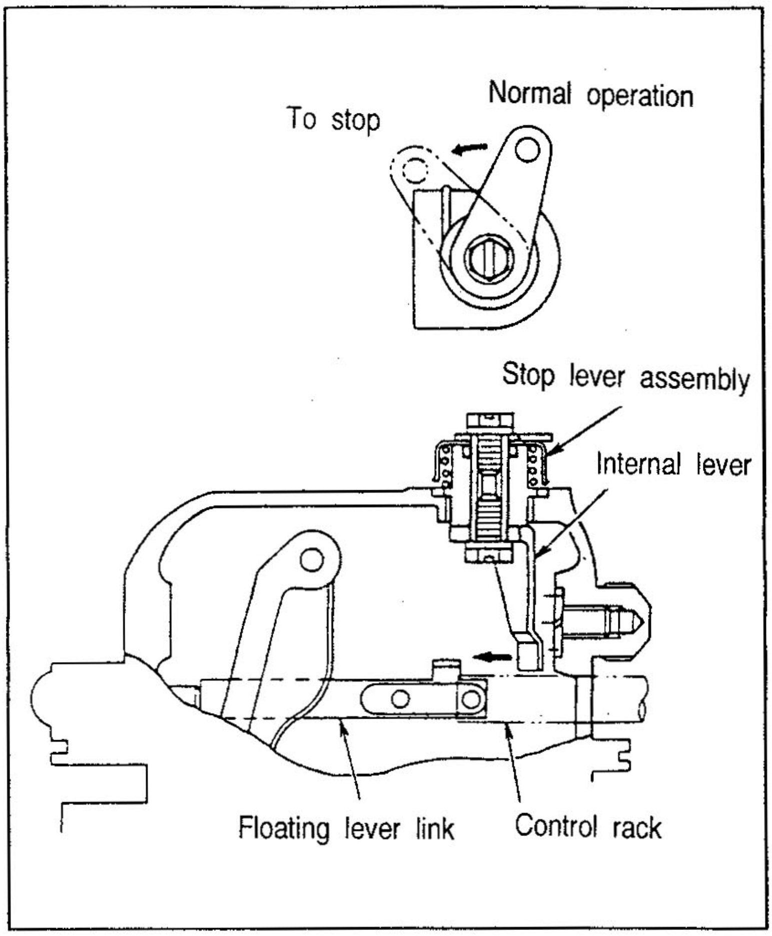
As shown in the governor characteristic curve, if the start booster is not provided, the idling spring force pushes back the shifter and floating lever when the pump speed is N_1 to move the control rack in the direction that fuel is increased. In this case, therefore, N_1 is the smoke limit.



If the start booster is provided, the spring force of the booster overcomes the idling spring force and stops movement of the floating lever unit the speed N_2 is reached.

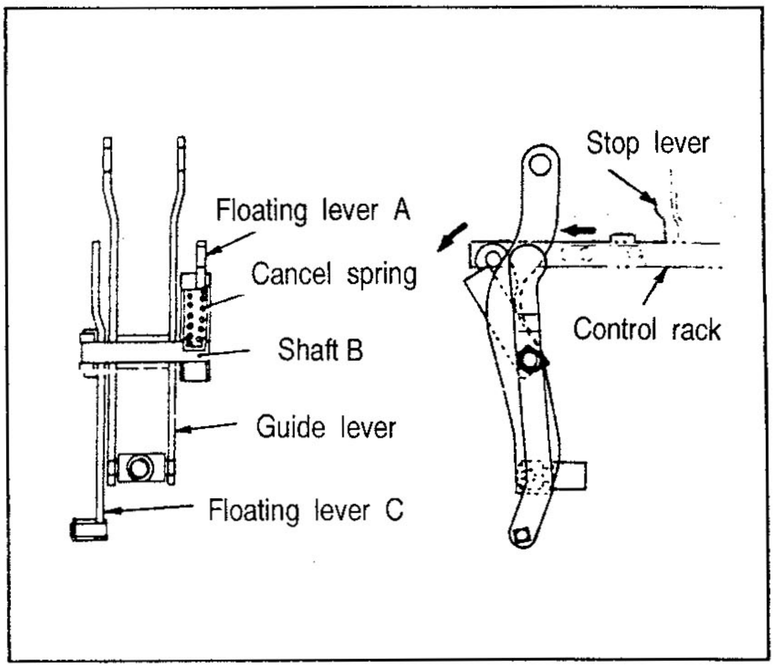
As a result, the smoke limit goes down to N_2 from N_1. In addition, the rack position Rs required for starting can be secured.

5) Engine stop



The engine is shut down by cutting off fuel supply through operation of the stop lever on the top of the governor. The stop lever is wired to the engine stop button in the cab and it is operated when the stop button is pulled. When the stop lever is turned, the internal lever pushes the bar of the floating lever link to force the control rack out to the non-injecting position, stopping the engine. When the stop button is released the stop lever is brought back to its original position by the reaction force of the spring built in the stop lever.

6) Cancel mechanism



The cancel machanism consists of a lever with a built-in spring and the shaft B carrying the lever.

The amount of the movement of the control rack caused by the stop lever operation exceeds the operation range of the floating lever.

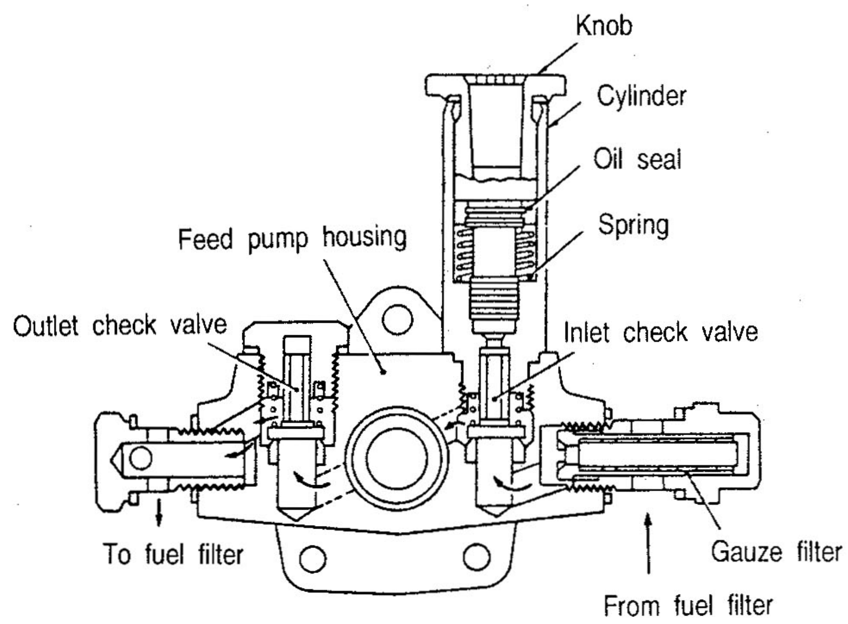
Therefore, the cancel mechanism is provided to protect the link and allied parts against damage.

The floating lever A pushed by the control rack turns in such a way as to deflect the cancel spring against the shaft B. Therefore, no load is imposed on the floating lever C held stationary.

(3) Feed Pump

Supply of fuel to the injection pump proper is accomplished by the feed pump mounted to the side of the injection pump proper and driven by the cam of the injection pump camshft provided for the purpose.

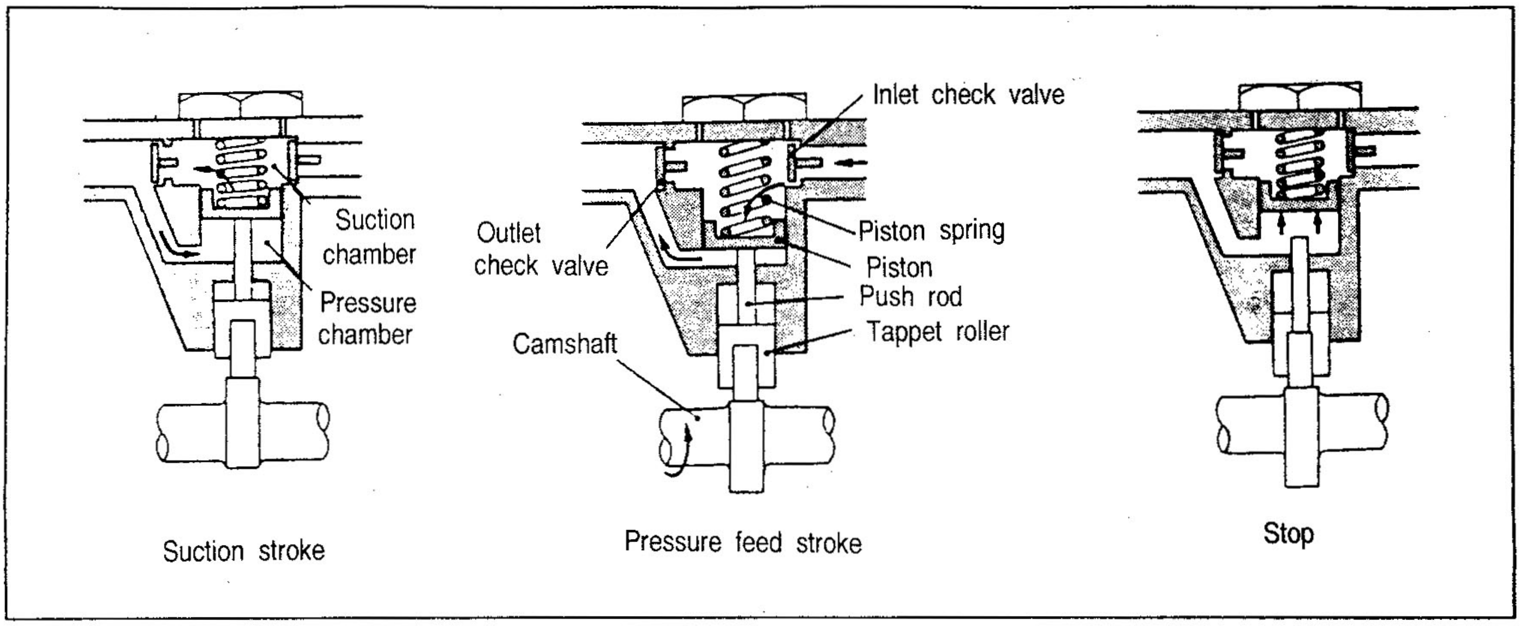
The priming pump mounted to the feed pump makes it possible to lift fuel manually when the engine is stationary.



The fuel is fed under pressure as described below. When the camshaft of the injection pump forces the push rod up, the fuel in the suction chamber is compressed and opens the outlet check valve. Most of the fuel forced out is drawn into the pressure chamber above the piston. when the cam, moved away by rotation of the camshaft, ceases to push up, the piston is pushed back by the pressure of the piston spring and forces out the fuel from the pressure chamber and forces it into the fuel filter.

At the time, the outlet valve simultaneously closes, and the inlet valve opens, so the fuel is drawn into the suction chamber.

If the pressure in the pressure chamber exceeds specification, the piston cannot be brought back by the pressure of the piston spring and stops the pump function. So the pressure in the fuel filter is adjusted not to rise more than necessary.



(4) Automatic Timer

The time interval between fuel injection into the cylinders and ignition of the fuel is called the ignition lag. The ignition lag is a certain time interval and has nothing to do with the engine speed. Variations in engine speeds, therefore, change the relationship between the piston position and ignition timing with a constant injection timing, resulting in reduced engine performance. To keep the relation between piston position and ignition timing constant, it is necessary to vary the injection timing according to the engine speed. The automatic timer changes the injection timing automatically according to engine speed.

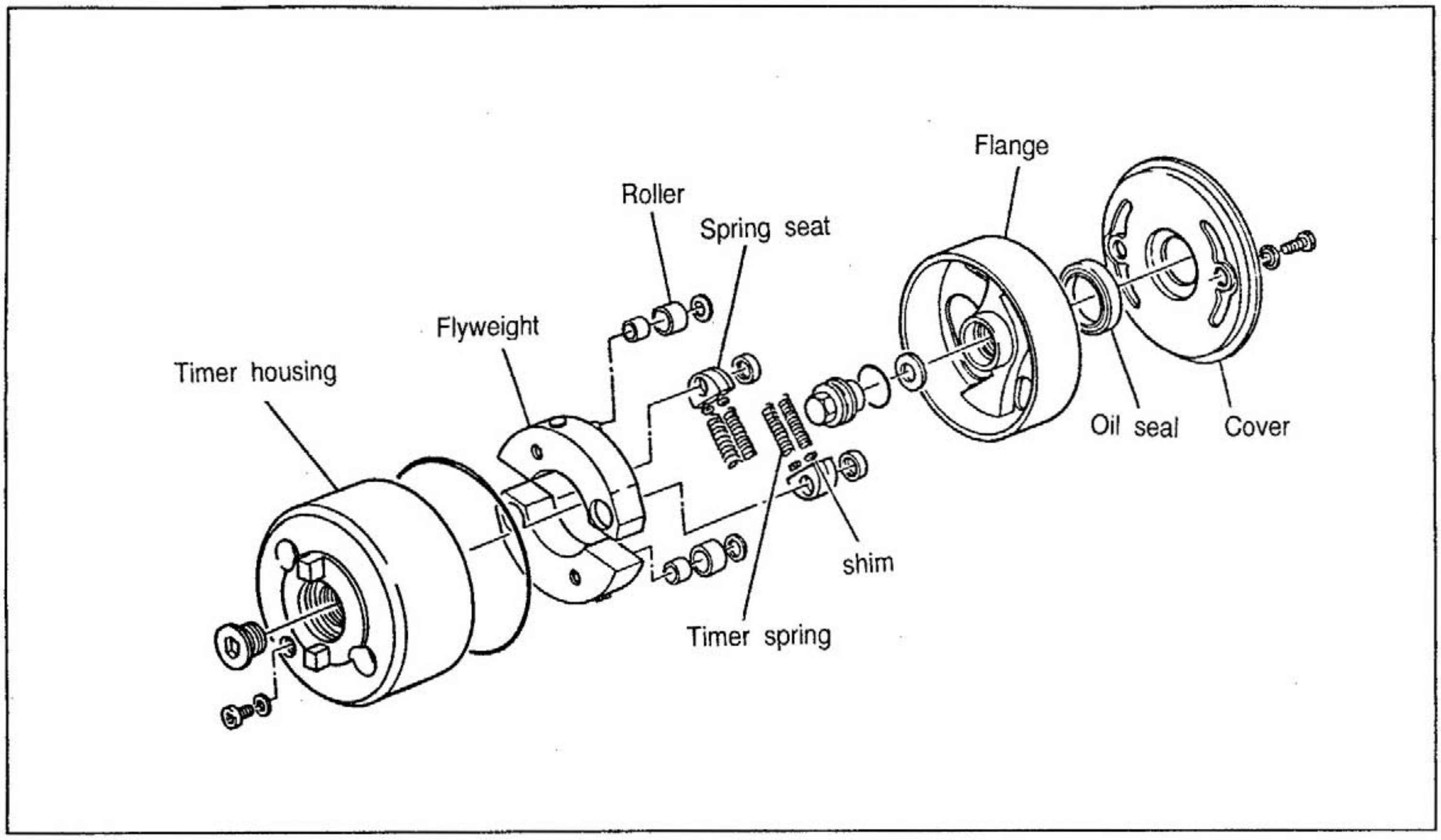
A machanical auto timer is used that is attached to the injection pump camshaft with round nuts. It operates on the centrifugal force of the flyweights, advancing the injection timing as engine speed increases and retarding it as speed decreases.

On the injection pump with air compressor, a driving flange is installed on the automatic timer that is driven by the driving disc from air compressor crankshaft. On the injection pump without air compressor, the auto timer is driven by the timing gear installed.

(a) SA-D automatic timer

The constructions of these automatic timers are shown below. Theyconsitst of timer housing, flyweights, roller, and spring seat that interlock the driving end, and the flange that is coupled to the injection pump camshaft.

Power is transmitted fromthe driving end of flange by the timer spring that is installed between the timer housing and flange.



With engine at low speed, the timer spring tension is greater than the centrifugal force of flyweights and the flyweight roller is held by the flange, providing no advance.

As the engine speed goes high, flyweight centrifugal force becomes greater. The flyweight roller pivots about the timer housing pin, pressing the flange curved surface and compressing the timer spring to move outward.

There is an advance equivalent to the movement of flange by the roller, advancing the injection timing.

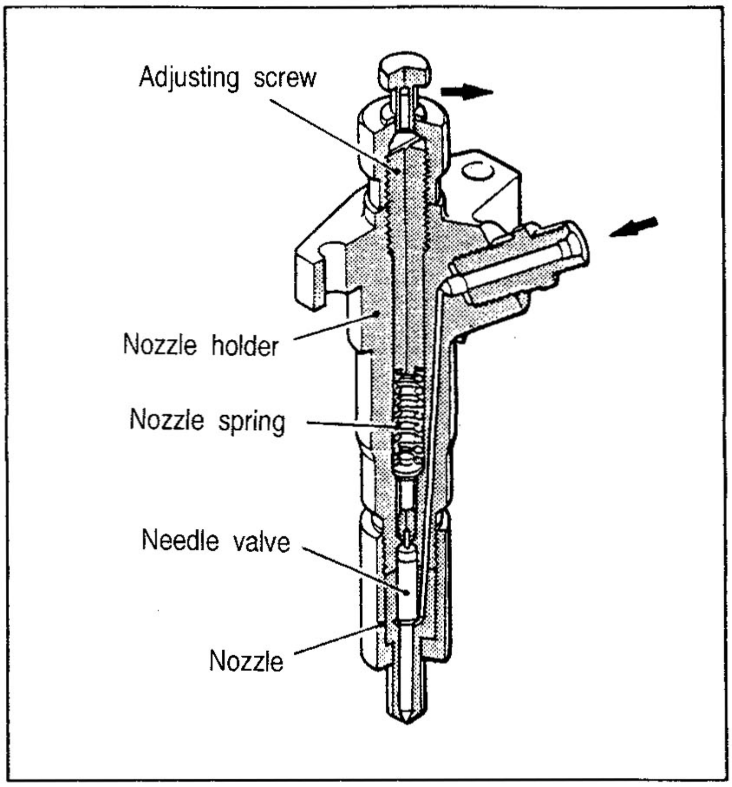
(5) Injection Nozzle

The injection nozzle is a hole type.

The fuel delivered from the injection pump enters the nozzle holder. When fuel reaches the specified pressure, it pushes the needle valve of the nozzle tip against the nozzle spring, so fuel is sprayed from the injection orifice at the end of the nozzle into the cylinder.

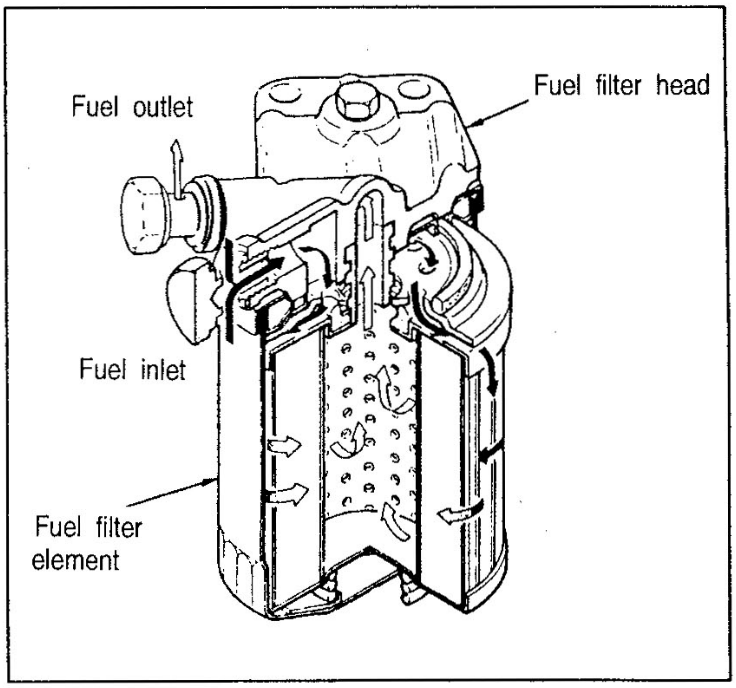
Some of the high pressure fuel lubricates the needle valve and returns through the fuel leak-off pipe to the fuel tank.

The injection pressure is adjustable with the adjusting screw.



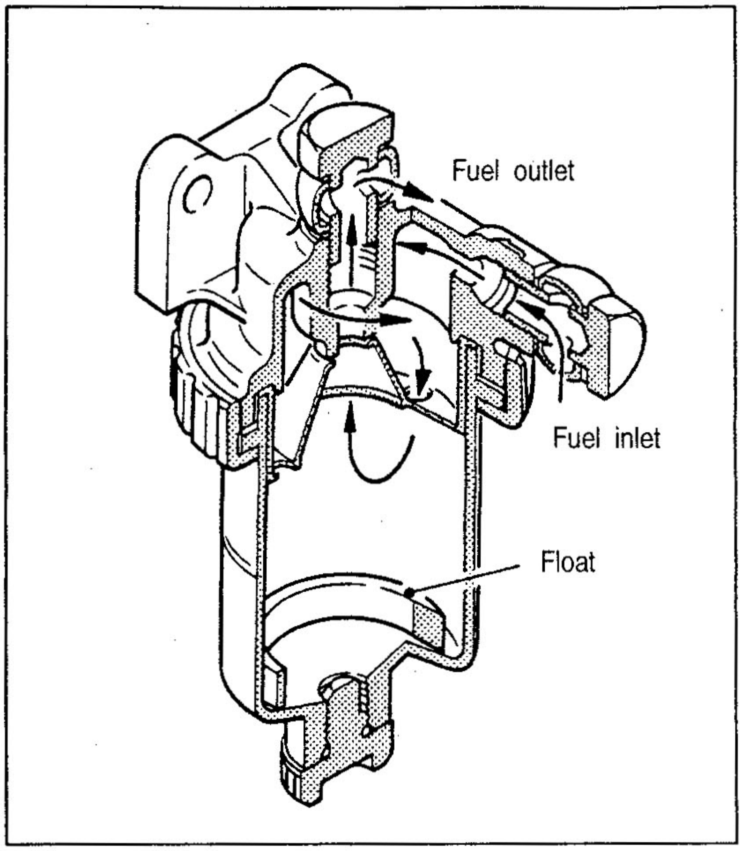
(6) Fuel Filter

The fuel filter is a cartridge type designed for ease of element replacement.



(7) Water Separator [Option]

The sedimenter type water separator separates gas oil and water centrifugally by taking advantage of their difference in specific gravity.

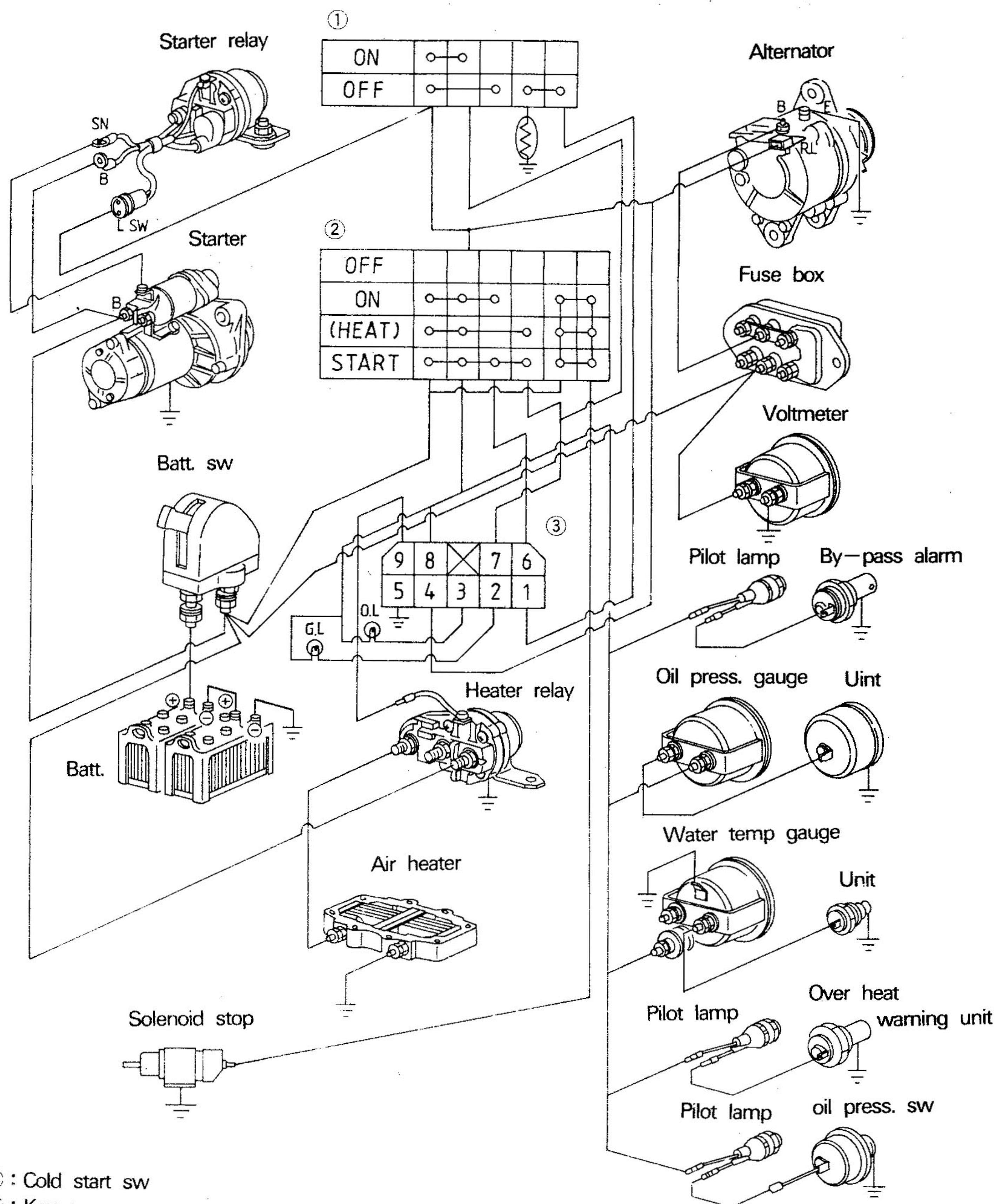


The fuel that has flowed in from the inlet connector is squeezed by the fuel path of the head to increase the flow velocity and spins. The separated water is sedimented in the case, whereas the water-separated fuel is drawn through the fuel path in the center of the head into the feed pump.

The water separator sediments not only water but also mud components.

A red float goes up and down with the water level in the semitransparent case, making it possible to visually check the water quantity.

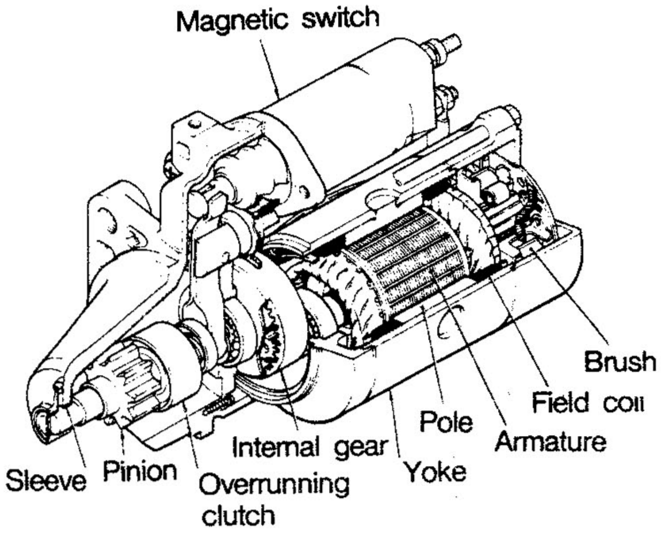
1-3-6 Electrical



① : Cold start sw
② : Key sw
③ : Preheat controller
G.L : Green lamp
O.L : Orenge lamp

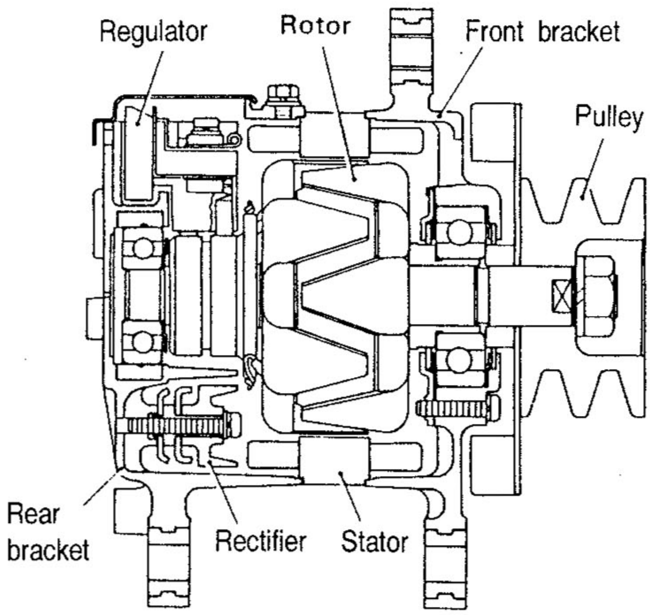
(1) Starter

The starter is an overhang type electromagnetic push-in reduction starter.



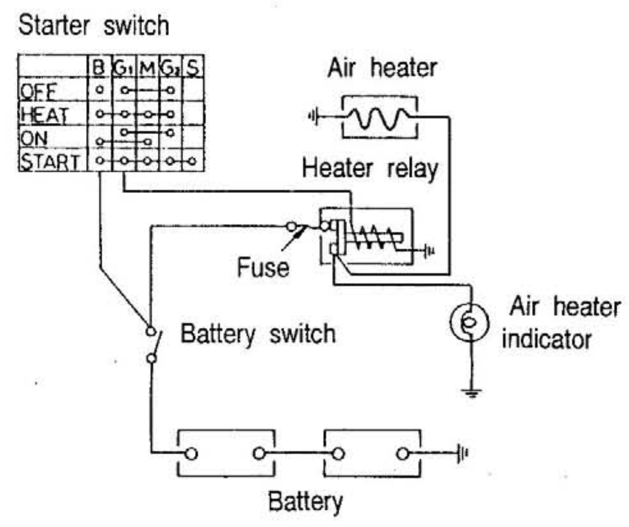
(2) Alternator

(a) Alternator with built-in IC regulator
The alternator used is one with built-in IC regulator.



(3) Intake Air Heater

The intake air heater heats the intake air to ensure better startup of the engine.

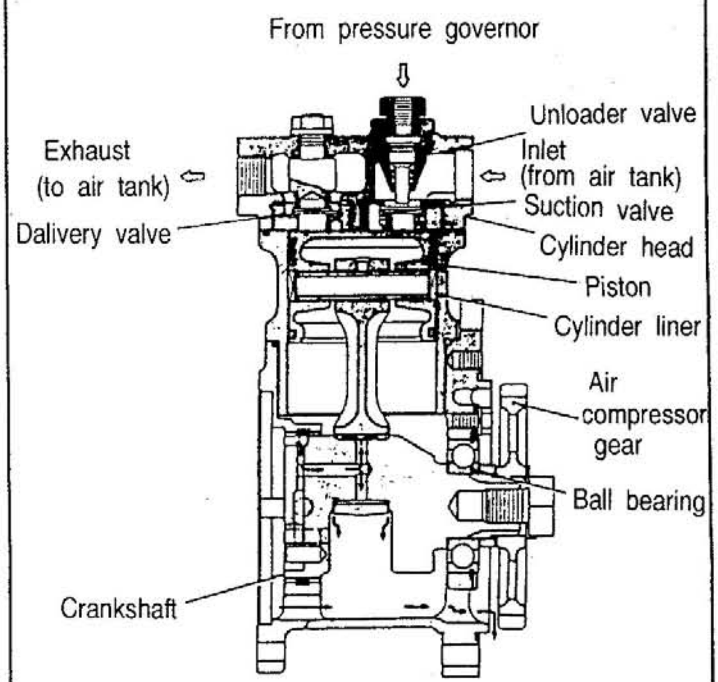


1-3-7 Air Compressor [Option]

The air compressor is mounted to the flywheel housing on the left side of the engine and is driven at half the engine speed by the air compressor gear which is in mesh with the timing gear of the engine.

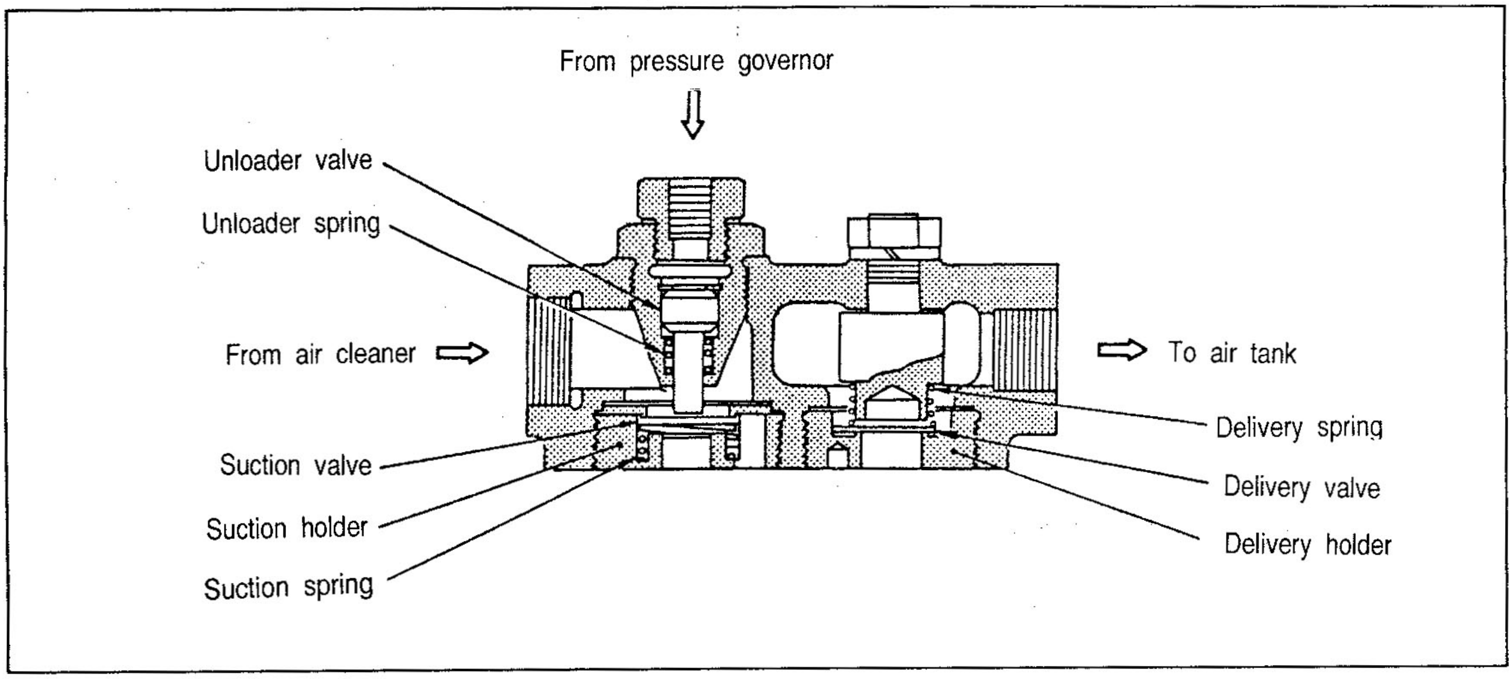
A coupling is mounted at the rear end of the air compressor crankshaft to drive the injection pump. The piston is made of aluminum alloy and has three compression rings and one oil ring.

The connecting rod is made of aluminum alloy. It consists of a connecting rod proper and cap and is secured on the crankshaft pin with reamer bolts.



Each of the parts is lubricated by the engine oil introduced through the oil pipe from the oil main gallery and passed through the oil holes of the crankshaft. The cylinder liner and connecting rod small end are splash-lubricated by the crankshaft. The excess oil returns from the bottom of the drive side ball bearing through the timing gear train to the oil pan.

A suction valve, delivery valve and unloader valve are provided in the cylinder head of the air compressor.



When the piston falls, a negative pressure is produced which causes the suction valve to open, so the air is drawn into the cylinder. When the piston goes up, the suction valve is closed by the suction valve spring, so the air is compressed.

The air compressed as the piston goes up overcomes the delivery valve spring and forces the delivery valve to open, so the air is forced into the air tank.

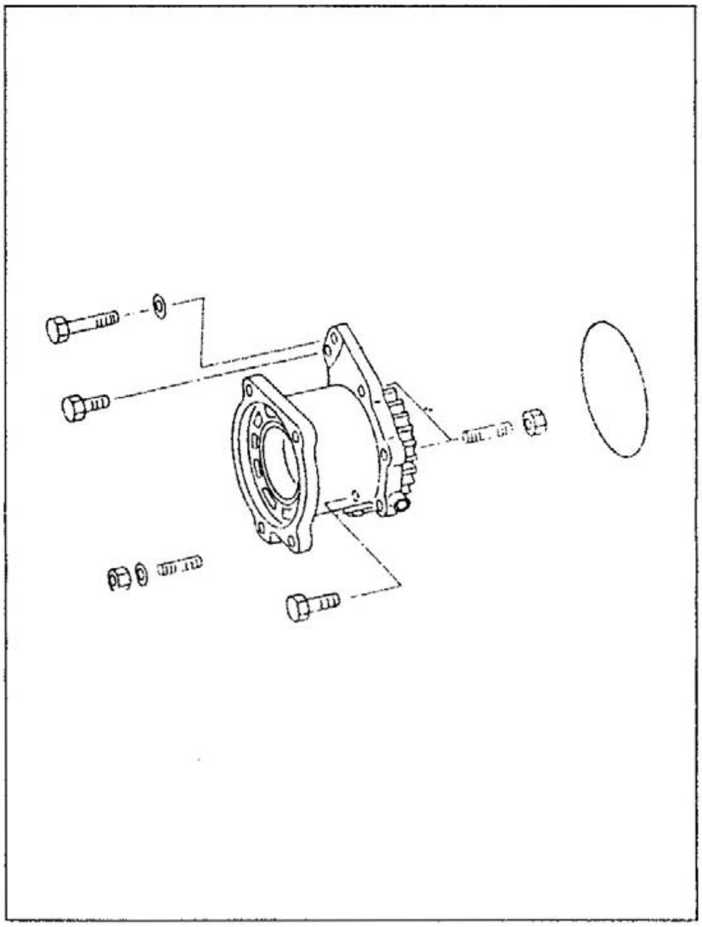
The unloader valve, operating with the pressure governor, regulates the pressure in the air tank. When the air pressure of the air tank exceeds the specified pressure(pressure governor operating pressure), the pressure governor opens to send compressed air to the unloader valve. The compressed air presses down the unloader valve and also keeps the suction valve in opened position, so the air compressor operates at no load.

When the air pressure of the air tank falls below the specified pressure, the pressure governor operates again and exhausts the compressed air on the top of the unloader. As a result, the unloader valve is moved back to its original position by the unloader valve spring and the suction valve begins to operate.

1-3-8 Injection pump drive

The injection pump drive is mounted to the flywheel housing on the left side of the engine and is driven at half the engine speed by the injection pump drive gear which is in mesh with the timing gear of the engine.

Each of the parts is lubricated by the engine oil introduced through the oil pipe from the oil main gallery and passed through the oil holes. The excess oil returns from the bottom of the drive side ball bearing through the timing gear train to the oil pan.



2-1 ENGINE ADJUSTMENT STANDARDS

Description			Standard values
Engine Model			D6BR
Valve timing	Intake valve opnes		21° BTDC
	Intake valve closes		51° ABDC
	Exhaust valve opens		62° BBDC
	Exhaust valve closes		18° ATDC
Valve clearance (when engine is cold)			0.4 mm
Fuel injection timing			Differs with specifications
No-load minimum speed (idling)			
NO-load maximum speed			
compression pressure (with engine at 200 rpm)	Nominal value		2,550 kPa (26 kgf/ cm²)
	Repair limit		1,960 kPa (20 kgf/ cm²) or less
	Difference between cylinders		390 kPa max. (4 kgf/ cm² max.)
V-belt tension (deflection when fan belt B pressed down at center under approx. 98 N or 10 kgf pressure)			10 to 15mm
Oil pressure (oil temperature 70 to 90℃)	At idling speed	Nominal value	145~295kPa (1.5~3.0 kgf/cm²)
		Repair Limit	49 kPa (0.5 kgf/ cm²)
	At maximum speed	Nominal value	295 to 490 kPa (3.0 to 5.0 kgf/ cm²)
		Repair Limit	195 kPa (2 kgf/ cm²)

2-2 SERVICE STANDARDS

2-2-1 Engine Proper

Unit : mm

Description		Nominal value (Basic diameter in [mm])	Re-pair limit	Service limit	Remedy and remarks
Clearance between rocker and rocker shaft		[24] 0.01 to 0.08	0.12		Replace rocker bushing.
Cylinder head bottom surface distortion		0.08 or less	0.2		Correct by grinding small amount.
Outer valve spring	Load at in-stalled length (47.5)	240 N (24.7 kgf)		205 N (20.9 kgf)	Replace.
	Free length	58.1		55.1	
	Squareness			2.5	
Inner valve spring	Load at in-stalled length (40.3)	93 N (9.5 kgf)		79 N (8.1 kgf)	Replace.
	Free length	55.1		52.1	
	Squareness			2.0	
Valve stem O.D.	Inlet	8.96 to 8.97		8.85	Replace.
	Exhaust	8.93 to 8.94		8.85	
Clearence betwe-en valve guide and valve	Inlet	[9.0] 0.04 to 0.06		0.15	Replace.
	Exhaust	[9.0] 0.07 to 0.10		0.15	
Sinkage of valve	Inlet	0.8 to 1.2		1.5	Repalce valve seat insert.
	Exhaust	1.0 to 1.4		1.7	
Seat width		1.8 to 2.2	2.8		Correct or replace.
Valve margin		1.5		1.2	Replace.
Runout of push rod				0.4	Replace.
Clearance between tappet and crankcase hole		[31] 0.06 to 0.10		0.2	Replace tappet.

Unit : mm

Description		Nominal value (Basic diameter in [ ])	Re-pair limit	Service limit	Remedy and remarks
Backlash	Between crankshaft gear and idler gear No. 1	0.10 to 0.19		0.35	Replace.
	Between idler gear No. 1 and injection pump gear or air compressor gear	0.11 to 0.24		0.35	Replace.
	Between idler gear No. 1 and idler gear No. 2	0.11 to 0.24		0.35	Replace.
	Between idler gear No. 2 and camshaft gear	0.12 to 0.26		0.35	Replace.
End play of idler gear No. 1		0.1 to 0.4		1.0	Replace idler shaft.
End play of idler gear No. 2		0.1 to 0.68	1.0		Replace thrust washer.
End play of camshaft gear		0.05 to 0.22	0.4		Replace thrust plate.
Clearance between idler gear No. 1 and idler shaft No.1		[32] 0.03 to 0.07	02.		Replace bush-ing.
Clearance between idler gear No. 2 and idler shaft No. 2		[25] 0.02 to 0.06	0.2		Replace bush-ing.

Unit : mm

Description		Nominal value (Basic diameter in [ ])	Re-pair limit	Ser-vice limit	Remedy and remarks
Clerance between camshaft journal and bushing	No. 1	[57.75] 0.03 to 0.08	0.15		Replace bushing.
	No. 2	[58.00] 0.03 to 0.08			
	No. 3	[58.25] 0.03 to 0.08			
	No. 4	[58.50] 0.03 to 0.08			
Cam profile (Cam lobe height:)	Inlet	49.547		49.047	Replace.
	Exhaust	49.307		48.807	
Camshaft bend			0.04		Press correct or replace.
Fly-wheel	Friction surface distortion	0.05 or less	0.2		Correct or replace.
	Height up to friction surface	20		19	Replace.
	Runout of friction surface		0.2		Correct installation.
Eccentricity of flywheel			0.2		Correct installation.
Cylinder liner	Flange pr-ojction	0.03 to 0.10			replace crankcase and cylinder liner.
	I.D.	118.00 to 118. 035		118.25	Replace

Unit : mm

Description		Nominal value (Basic diameter in [ ])	Re-pair limit	Ser-vice limit	Remedy and remarks
Piston projection		0.85 to 1.35			Check all parts.
Connecting rod end play		0.15 to 0.45		0.6	Replace.
Clearance between piston ring grooves and rings	1st ring	0.09 to 0.13		0.2	Replace piston rings.
	2nd ring	0.05 to 0.08		0.15	
	Oil ring	0.03 to 0.06		0.15	
Piston ring open end clearance		0.35 to 0.55		1.5	Replace.
Clearance between piston pin and piston pin hole		[38] 0.01 to 0.02		0.05	Replace piston pin.
Clearance between piston pin and connecting rod small end		[38] 0.02 to 0.05	0.1		Replace bushing.
Clearance between piston and cylinder liner(selection fit)		[118] 0.12 to 0.15		0.25	Replace.
Connecting rod bend and distortion			0.05		Correct or replace.
Crankcase top surface distortion		0.07 or less	0.2		correct by grinding small amount.
Crankshaft pin and journal	Roundness	0.01 or less	0.03		Correct or replace
	Cylindricity	0.006 or less			
Crankshaft	Bend	0.05 or less	0.1		Correct by press or replace.
	End play	0.10 to 0.25	0.4		Replace thrust plate.
Main bearing	Oil clearance	[80] 0.05 to 0.10		0.15	Replace.
	Span when free			85.5 or less	
Connecting rod bearing	Oil clearance	[65] 0.06 to 0.11		0.2	Replace.
	Span when free			69.5 or less	

2-2-2 Inlet and Exhaust

Unit : mm

Description	Nominal value (Basic diameter in [mm])	Repair limit	Service limit	Remedy and remarks
Suction resistance when dust indicator operates	700±50 mm H2O 7.47±0.57kpa			Replace

2-2-3 Lubrication

Unit : mm

Description		Nominal value (Basic diameter in [mm])	Repair limit	Service limit	Remedy and remarks
Oil pump	Backlash between oil pump gear and crankshaft gear	0.10 to 0.19		0.35	Adjust by shims.
	Difference between oil pump case depth and gear height	0.04 to 0.09		0.15	Replace.
	Clearance between oil pump case and gear tooth end	0.10 to 0.19		0.2	Replace.
	Clearance between drive gear shaft and cover inside diameter	[20] 0.04 to 0.07		0.15	Replace.
	Clearance between driven gear shaft and case or cover inside diameter	[20] 0.04 to 0.07		0.15	Replace.
Relief valve	Valve opening pressure	980 to 1,180 kPa (10 to 12 kgf/ cm²)			Replace.
	Spring installed load (installed length 30)	84 N (8.6 kgf)			
Oil bypass alarm valve opening pressure (pressure at which lamp begins to light)		145 to 170 kPa (1.5 to 1.8 kgf/ cm²)			Replace.

unit : mm

<table>
<tr><th colspan="2">Description</th><th>Nominal value (Basic diameter in [mm])</th><th>Re-pair limit</th><th>Ser-vice limit</th><th>Remedy and remarks</th></tr>
<tr><td colspan="2">Oil cooler bypass valve opening pressure</td><td>275 to 315 kPa (2.8 to 3.2 kgf/ cm²)</td><td></td><td></td><td>Replace.</td></tr>
<tr><td rowspan="2">Regulator valve</td><td>Valve opening pressure</td><td>360 to 420 kPa (3.7 to 4.3 kgf/ cm²)</td><td></td><td></td><td rowspan="2">Replace</td></tr>
<tr><td>Spring installed load (installed length 48.3)</td><td>76 to 80 N (7.8 to 8.2 kgf)</td><td></td><td></td></tr>
<tr><td colspan="2">check valve opening pressure</td><td>265 to 325 kPa (2.7 to 3.3 kgf/ cm²)</td><td></td><td></td><td>Replace.</td></tr>
</table>

2-2-4 Cooling

Unit : mm

Description		Nominal value (Basic diameter in [mm])	Re-pair limit	Service limit	Remedy and remarks
Water pump	Interference between pump shaft and flange	[25] 0.05 to 0.08		Up to two reassemblings	replace.
	Interference between pump shaft and impeller	[13] 0.04 to 0.06		Up to two reassemblings	replace.
	Clearance between impeller and case	0.55 to 1.20			Correct.
Thermostat	Valve opening temperature	80 to 84℃			Replace.
	Valve lift/ temperature	10 or more/ 90℃			
Radiator pressure (Valve opening pressure)		39 to 59 kpa (0.4 to 0.6 kgf/cm²)			Replace.
Radiator Inspection pressure (air pressure)		98 kpa R (1.0 kgf/cm²)			eplace

2-2-5 Fuel

(1) Injection Pump(Manufactured by Zexel Co., Ltd.)

Unit : mm

	Description		Nominal value (Basic diameter in [mm])	Re-pair limit	Service limit	Remedy and remarks
Injection pump proper	Injection interval		60° ± 30°			Adjust.
	Pre-stroke		3.3 ± 0.05			Adjust.
	Tappet clearance		0.3 or more			Adjust.
	Overflow valve opening pressure		225 kPa ($2.6\ kgf/cm^2$)			Replace.
	Backlash between control rack and pinion		0.15		0.3	Replace.
	Control rack sliding resistance(when not rotating)		1.5 N (150 gf) or less			Check parts.
	Tapper roller overall clearance			0.2	Replace.	
	Tappet to pump housing clearance		[24] 0.03 to 0.07		0.2	Replace.
	Plunger driving face to control sleeve clearance		0.02 to 0.08		0.12	Replace.
	Camshaft end play		0.02 to 0.06	0.1		Adjust.
Governor	Distance between governor housing and shifter	RSV	19 to 19.2			Adjust with shim.
		RFD	33 to 33.4			

unit : mm

Description			Nominal value (Basic diameter in [mm])	Re-pair limit	Service limit	Remedy and remarks
Feed pump	Tappet overall clearance				0.2 or more	Replace.
	Lift cap-acity	No. of strokes required before lifting when operated at a rate of 60 to 100 strokes per minute	25 strokes or less			
	Airtinghtness (When 195 kPa or 2 kgf/ cm² air pressure is applied)		0 cc/ min			
	Delivery (for 15 seconds at 1,000 rpm)		405 cc			

(3) Injection Nozzle

Description	Nominal value (Basic diameter in [ ])	Repair limit	Service limit	Remedy and remarks
Injection prssure	21.6 to 22.6 MPa (220 to 230 kgf/ cm²)	19.6 MPa (200 kgf / cm²)		Adjust.

2-2-6 Electrical

(1) Starter

Unit : mm

Description		Nominal value (Basic diameter in [mm])	Repair limit	Service limit	Remedy and remarks
Commutator O.D.		38.7		37.7	Replace
Commutator O.D. runout			0.05 or more		Correct or replace
Mica depth between segments			0.2 or less		Correct
Brush length		17		11	Replace
Brush spring pressure		25 to 34 N (2.55 to 3.45 kgf)		18 N (1.8 kgf)	Replace
Pinion shaft thrust gap		0.1 to 0.5			Adjust with washer.
No-load character-istics	Voltage	23V			check
	Current	95 A or less			
	Speed	3,300 rpm or more			
Characteristics in locked state	Voltage	9V			Check
	Current	1,400 A or less			
	Rotating torque	88 N m(9 kgf m) or more			
Magnet switch operating voltage		16V or less			Check
Starter relay coil resistance	24 V type	10.4 Ω			Replace

(2) Alternator

Unit : mm

Description			Nominal value (Basic diameter in [mm])	Repair limit	Service limit	Remedy and remarks
Slip ring section O.D.			41		40.4	Replace
Brush spring pressure			3.7 N(380 gf)		2N (200 gf)	Replace
Brush length			23		8	Replace
Field coil resistance (at 20 ℃)			Approx. 10Ω			Replace
Load characteristics	Terminal voltage		27V			Check
	Current	When cold	26 A or more			
		When hot	22 A or more			
	Speed		1,500 rpm			
	Terminal voltage		27V			Check
	Current	When cold	37 A or more			
		When hot	33 A or more			
	Speed		2,500 rpm			
Regulator regulated voltage (between terminals K and E)			28 to 29 V			Replace

(3) Preheater

Description		Nominal value (Basic diameter in [ ])	Repair limit	Service limit	Remedy and remarks
Intake air heater	Time required for indicator to become red hot	40 to 60 sec.			

2-2-7 Other Equipment

(1) Air compressor

Unit : mm

Description		Nominal value (Basic diameter in [mm])	Re-pair limit	Service limit	Remedy and remarks
Clearance between cylinder liner and piston	Crown	[80]		0.35	Replace piston or cylinder liner.
	Skirt			0.19	
Clearance between piston ring groove and ring	Compression ring	[3]		0.08	Replace piston or ring.
	Oil ring	[4]		0.08	
Piston ring end gap				1.0	Repalce piston ring.
Clearance between piston and piston pin		[16]		0.06	Repalce.
Clearance between piston pin and connecting rod small end		[16]		0.07	Replace piston pin or connecting rod.
Grankshaft end play				1.0	Replace.
Suction valve spring	Load N(kgf)/ installed length			3.9 (0.396)/ 6.5	Replace.
Delivery valve spring	Load N(kgf)/ installed length			2.6 (0.264)/ 9.5	Replace.
connecting rod bearing				when copper is exposed due to wear of inner plated surface.	Repalce.
Cranksahft(pin section) O.D.		[34]		33.94	Replace.
Connecting rod end play				0.5	Repalce connecting rod or crankshaft.
Clearance between crankshaft journal and bearing		[76.5]		0.12	Replace crankshaft or crankcase assembly.

2-3 TIGHTENING TORQUE TABLE

2-3-1 Tightening Torque for Major Bolts and Nuts

Tightening torque unit : N m(kgf m)

Description		Thread size	torque	Remarks
Engine proper	Rocker cover bolt	M8×1.25	9.8(1.0)	
	Cylinder head bolt	M14×2.0	195 to 215 (20 to 22)	Wet
		M10×1.5	34(3.5)	
	Flywheel housing bolt	M10×1.5	44(4.5)	
	Rocker bracket bolt	M10×1.5	34(3.5)	
	Flywheel bolt	M14×1.5	175(18)	Wet
	Camshaft gear bolt	M20×1.5	175(18)	
	Idler gear No. 1 shaft bolt	M12×1.75	88(9)	
	Main bearing cap bolt	M14×2.0	175(18)	Wet
	Connecting rod nut	M13×1.25	115(12)	Wet
	Crankshaft pulley Bolt	M14×1.5		
	Torsional damper bolt	M10×1.5	44(4.5)	
Inlet and exhaust	Inlet manifold bolt	M8×1.25	19 to 27 (1.9 to 2.8)	
	Exhaust manifold nut	M10×1.25	41 to 45 (4.2 to 4.6)	

Tightening torque unit : Nm(kgfm)

Description		Thread size	torque	Remarks
Lubrication	Oil pump cover bolt	M10×1.5	20 to 29 (2 to 3)	
	Relief valve	M18×2.0	52 to 72 (5.3 to 7.3)	
	Oil filter case bolt	M14×1.5	49 to 59 (5.0 to 6.0)	
	Oil bypass alarm	M20×1.5	44 to 54 (4.5 to 5.5)	
	Oil cooler nut	M10×1.25	15 to 25 (1.5 to 2.5)	
	Oil cooler plug	M20×1.5	20 to 29 (2 to 3)	
	Oil cooler bypass valve	M16×1.5	15 to 25 (1.5 to 2.5)	
	Regulator valve	M27×1.5	98 to 115 (10 to 12)	
	Oil jet check valve	M12×1.75	34(3.5)	

Tightening torque unit : N m(kgf m)

Description			Thread size	torque	Remarks
Cooling	Cooling fan bolt		M10×1.5	34(3.5)	
Fuel	Delivery valve holder	A type	M20×1.5	39 to 44 (4 to 4.5)	
		AD type	M24×1.5	64 to 68 (6.5 to 7)	
	Delivery valve holder lock plate		M6×1.0	4.4 TO 5.9 (0.45 TO 0.6)	
	Injection nozzle	Retaining nut	M19×1.0	59 to 78 (6 to 8)	
		Screw cap	M14×1.0	39 to 49 (4 to 5)	
		Inlet connector	M14×1.5	69 to 78 (7 to 8)	
	Injection nozzle attaching bolt (to engine)		M8×1.25	15(1.5)	
	Fuel filter connector		M14×1.5	34(3.5)	
	Water separator	Center bolt	M14×1.5	29 to 39 (3 to 4)	
		Drain plug, air bleeding plug	M8×1.25	7.8 to 12 (0.8 to 1.2)	
	Timer	Cover bolt	–	22 to 24 (2.2 to 2.4)	
		Oil sealing cap	–	64 to 83 (6.5 to 8.5)	
		Plug tightening	–	13 to 15 (1.3 to 1.5)	
		Round nut	–	83 to 98 (8.5 to 10)	

Tightening torque unit: N m(kgf m)

Description		Thread size	torque	Remarks
Air compressor and injection pump drive	Suction valve holder	M45×1.5	98 to 115 (10 to 12)	Punch three places on circumfer-ence.
	Delivery valve holder	M42×1.5	98 to 115 (10 to 12)	
	Delivery valve spring holder nut	M12×1.25	44 to 59 (4.5 to 6.0)	
	Unloader valve guide	M28×1.5	98 to 115 (10 to 12)	
	Coupling bolt	M8×1.25	30 to 36 (3.1 to 3.7)	
	Cylinder head bolt	M10×1.5	25 to 29 (2.5 to 3.0)	
	Plate bolt	M8×1.25	14 to 18 (1.4 to 1.8)	
	Connecting rod cap bolt	M8×1.25	23 to 25 (2.3 to 2.6)	
	Connector(unloader section)	M18×1.5	29 to 34 (3.0 to 3.5)	
	Compressor gear attaching bolt	M18×1.5	165 to 210 (17 to 21.5)	

2-3-2 Tightening Torque for General Bolts and Nuts

Unless otherwise specified, the parts and accessories of engine should be tightened by the bolts and nuts conforming to the standards. The tightening torques of these bolts and nuts are shown below.

Unit : Nm (kgf m)

Thread diameter mm	Pitch mm	4T (Head mark: 4 or ○)	7T (Head mark: 7 or ⊘)	8T (Head mark: 8 or ⊕)
5	0.8	2.0 to 2.9 (02. to 0.3)	3.9 to 5.9 (0.4 to 0.6)	4.9 to 6.9 (0.5 to 0.7)
6	1.0	3.9 to 5.9 (0.4 to 0.6)	6.9 to 10.8 (0.7 to 1.1)	7.8 to 11.8 (0.8 to 1.2)
		[3.9 to 5.9 (0.4 to 0.6)]	[7.8 to 11.8 (0.8 to 1.2)]	[8.8 to 13.7 (0.9 to 1.4)]
8	1.25	[8.8 to 13.7 (0.9 to 1.4)]	[16.7 to 25.5 (1.7 to 2.6)]	[19.6 to 29.4 (2.0 to 3.0)]
		[9.8 to 14.7 (1.0 to 1.5)]	[18.6 to 27.5 (1.9 to 2.8)]	[21.6 to 32.4 (2.2 to 3.3)]
10	1.25	18.6 to 27.5 (1.9 to 2.8)	34.3 to 53.9 (3.5 to 5.5)	44.1 to 58.8 (4.5 to 6.0)
		[20.6 to 30.4 (2.1 to 3.1)]	[38.2 to 58.8 (3.9 to 6.0)]	[49.0 to 63.7 (5.0 to 6.5)]
	1.5	17.7 to 26.5 (1.8 to 2.7)	32.4 to 49.8 (3.3 to 5.0)	42.1 to 58.8 (4.3 to 6.0)
12	1.25	33.3 to 49.0 (3.4 to 5.0)	68.6 to 9329 (7.0 to 9.5)	83.4 to 108 (8.5 to 11)
		[37.3 to 53.9 (3.8 to 5.5)]	[78.5 to 108 (8.0 to 11)]	[88.3 to 118 (9.0 to 12)]
	1.75	30.4 to 46.1 (3.1 to 4.7)	63.7 to 83.4 (6.5 to 8.5)	73.5 to 98.1 (7.3 to 10)
14	1.5	58.8 to 83.4 (6.3 to 8.5)	118 to 157 (12 to 16)	127 to 177 (13 to 18)
	2.0	53.9 to 73.5 (5.5 to 7.5)	108 to 137 (11 to 14)	118 to 167 (12 to 17)

Unit : N m (kgf m)

Thread diameter mm	Pitch mm	4T (Head mark: 4 or ○)	7T (Head mark: 7 or ⊖)	8T (Head mark: 8 or ⊕)
16	1.5	93.2 to 127 (9.5 to 13)	117 to 235 (18 to 24)	196 to 265 (20 to 27)
	2.0	88.3 to 118 (9.0 to 12)	157 to 216 (16 to 22)	186 to 255 (19 to 26)

NOTE : 1. The above values are valid when the threads and bearing surface are dry.

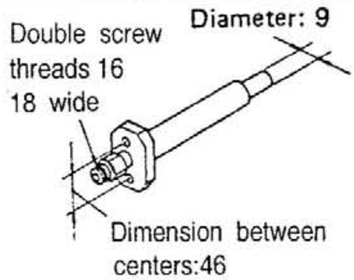
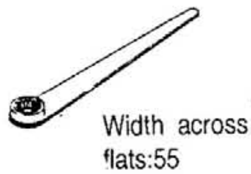
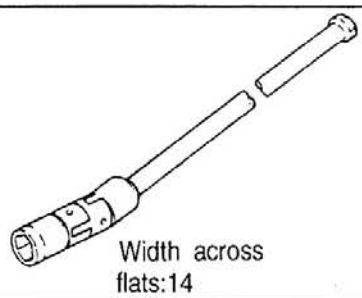
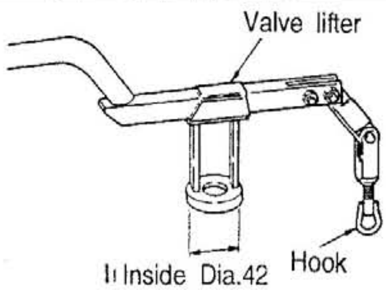
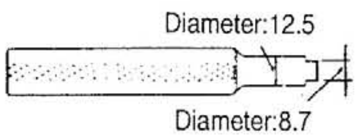
2. Values in [ ] denote flange bolts and nuts.

2-4 SEALANT, OIL AND GREASE

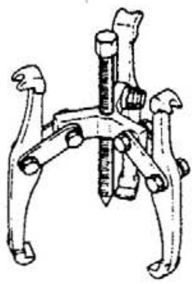
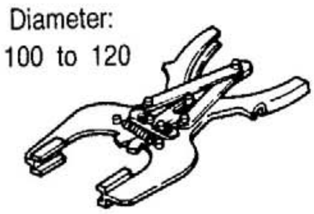
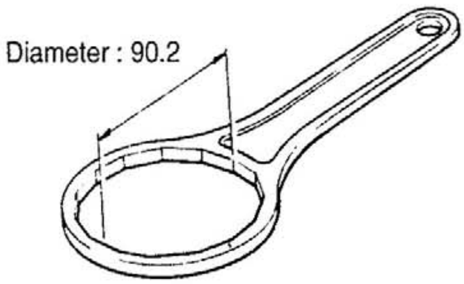
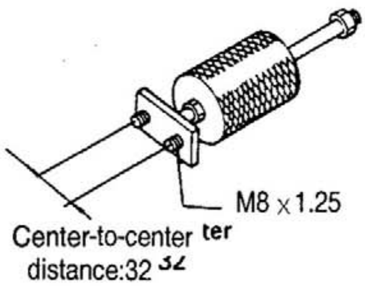
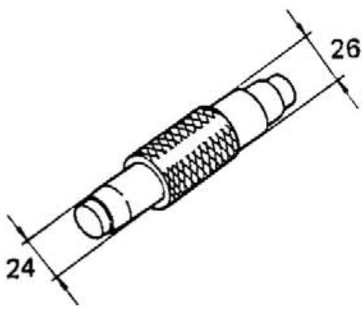
Description		Sealant, oil or grease	Application method
Engine proper	Nozzle tube	THREEBOND 1211 or equivalent	Apply to nozzle tube end which fits in cylinder head.
	Crankcase	THREEBOND 1104 or equivalent	Apply to joining surfaces of rear plate and crank-case
	Flywheel housing	THREEBOND 1105 or equivalent	Apply to joining surfaces of rear plate and flywheel housing.
	Front oil seal	Lithium type grease	Apply to lips.
Cooling	Water pump case	JT-6 grease or equivalent	Pack 60 g in case.
	Water pump unit seal external cyl-indrical portion	THREEBOND 1102 or equivalent	Apply to portion which fits in case.
Starter	Reduction gear	MULTEMP PS No. 2 or equivalent	Apply to gear.
	Rear bracket		Pack rear portion.
	Pinion shaft stop-per		Apply to contacting surfaces.
	Plunger		Apply to contacting surfaces.
	Lever		Apply to contacting surfaces.
	Sleeve bearing		Apply to inside.
	Pinion		Apply to splines.

(1) Engine

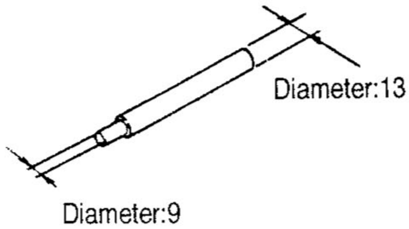
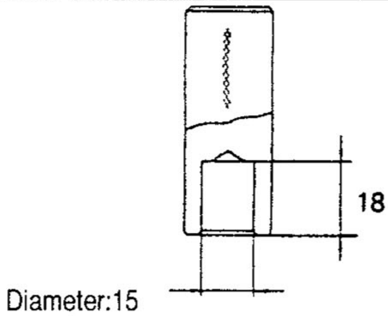
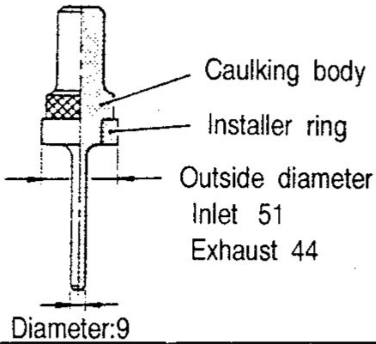
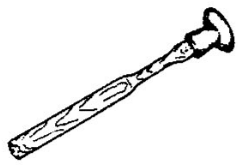
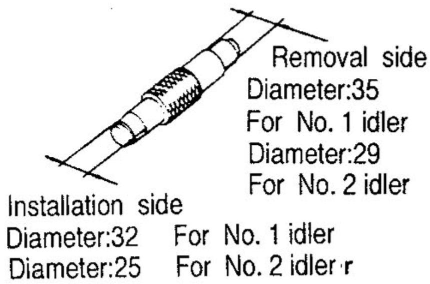
unit : mm

Tool name	Part No.	Shape	Use
Pressure Gauge Adapter	MH061461		Measurement of compression pressure
Cranking Handle	MH061273		Engine cranking
Universal Extension	MH061099		Adjustment of injection pump timing and removal of injection pump (with air compressor)
Valve Lifter	MH061668		Removal and installation of valve cotter
Valve Lifter Hook	MH061679		
Nozzle Tube remover	MH061232		Removal of nozzle tube
Plug	MF665007		Blind plug to be used when camshaft gear is removed.

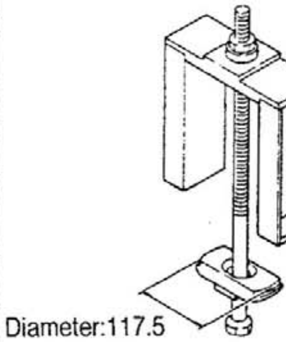
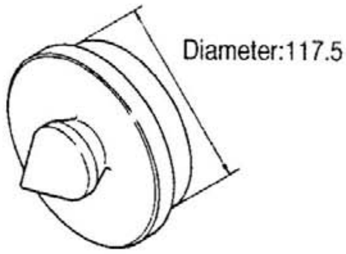
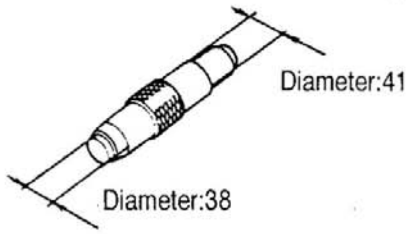
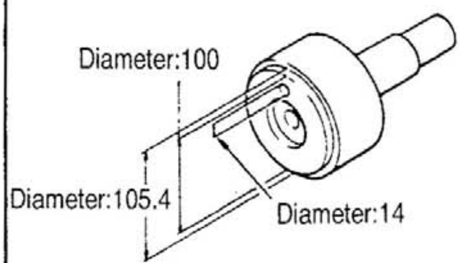
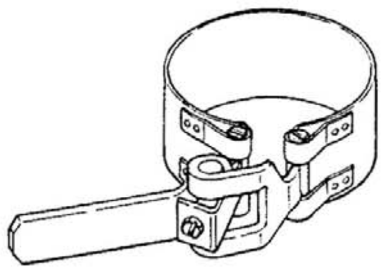
Unit : mm

Tool name	Part No.	Shape	Use
Gear Puller	MH061326		Removal of gears
Piston ring Tool	30091-07100		Removal and installation of piston ring
Filter Wrench	MH061509		Removal of fuel filter element
Bearing Cap Extractor	MH061189		Removal and main bearing cap
Rocker Bushing Puller	MH061777		Replacement of rocker bushing

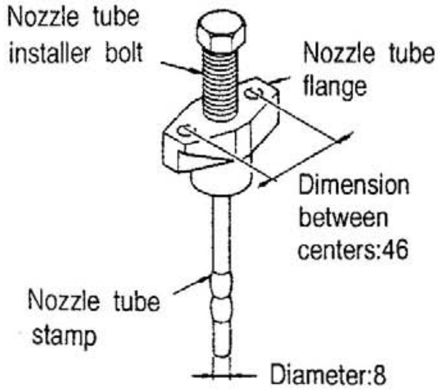
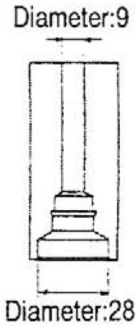
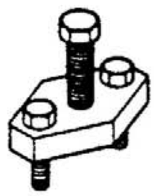
Unit : mm

Tool name	Part No.	Shape	Use
Valve Guide Remover	MH061066		Removal of valve guide
Valve Guide Installer	MH061223		Installation of valve guide
Caulking Tool Body	MH061067		Installation of balve seat
Installer Ring	MH061693 for inlet MH061694 for exhaust		
Valve Lapper	30091-07500		Lapping of valve seat
Idler Gear Bushing Puller	MH061779		Replacement of No. 1 idler gear bushing
	MH061780		Replacement of No. 2 idler gear bushing

Unit : mm

Tool name	Part No.	Shape	Use
Cylinder Liner Extractor	MH061761		Removal of cylinder liner
Cylinder Liner Installer	MH061771		Installation of cylinder liner
Connecting Rod Bushing Puller	MH061193		Replacement of conn-ecting rod bushing
Oil Seal slinger Installer	MH061470		Installation of oil seal slinger
Piston Guide	MH061760		Insertion of piston
Piston Guide Lever	MH061658		

Unit : mm

<table>
<tr><th>Tool name</th><th>Part No.</th><th>Shape</th><th>Use</th></tr>
<tr><td>Nozzle Tube Flange</td><td>MH061416</td><td rowspan="3">
</td><td rowspan="3">Installation of nozzle tube</td></tr>
<tr><td>Nozzle Tube Stamp</td><td>MH061229</td></tr>
<tr><td>Nozzle Tube Installer Bolt</td><td>MH061231</td></tr>
<tr><td>Valve Stem Seal Installer</td><td>MH061293</td><td>
</td><td>Installation of valve stem seal</td></tr>
<tr><td>Water Pump Impeller Puller</td><td>MH061417</td><td></td><td>Removal of water pump impeller</td></tr>
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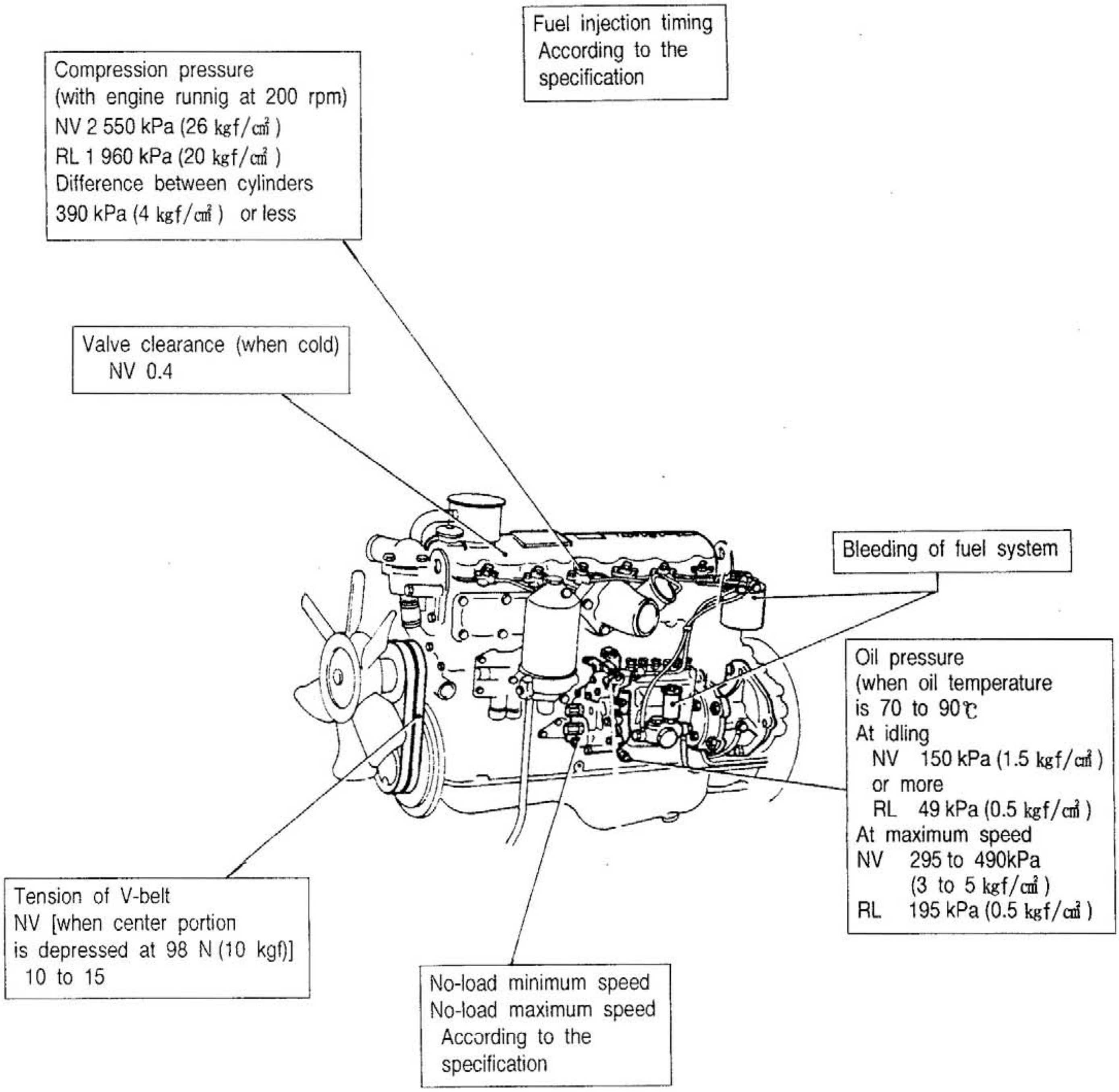
Inspection and Adjustment of Engine

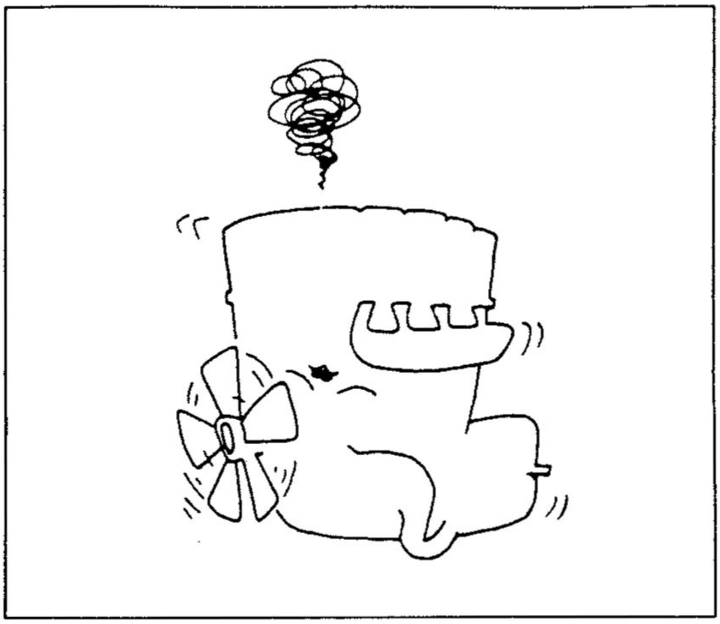


NV···Nominal Valve

RL···Repair Limit

4-1 MEASUREMENT OF COMPRESSION PRESSURE

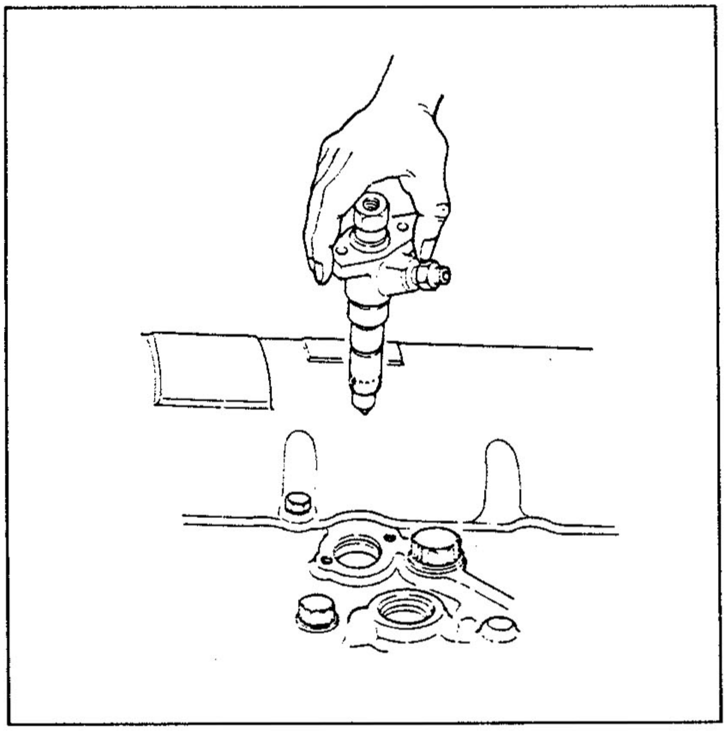
(1) Retighten the cylinder head bolts to the specified torque and let the engine warm up until the coolant temperature of the engine reaches 75° to 85℃.



NOTE: 1. It is important to measure the compression pressure at regular intervals and to be aware of its changes.

2. When the engine is new or when parts are replaced, the compression pressure slightly rises due to inadequate seating of the piston rings, valve seats, etc. but will soon fall as the parts are worn down.

(2) Remove all of the injection nozzles from the cylinder head.

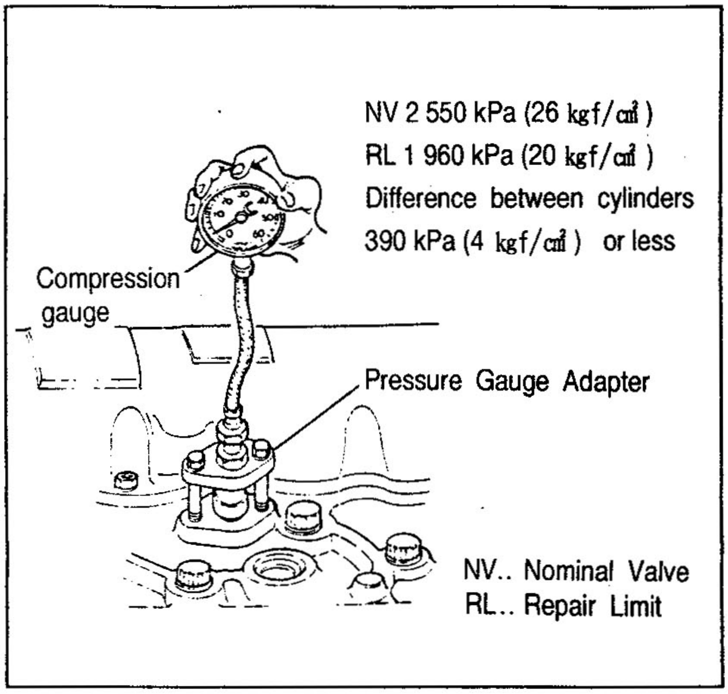


NOTE: Put a cover over the injection nozzle mounting holes and injection pipes to prevent entry of dust and dirt.

(3) Install Pressure Gauge Adapter (special tool) to the injection nozzle mounting hole together with a gasket and connect a measuring instrument (compression gauge).

(4) Turn the engine with the starter and read the pointer of the compression gauge when the engine speed is 200 rpm.

(5) If the reading is below the repair limit, disassemble and check.



NOTE : 1. Since the compression pressure varies with the engine speed, make sure that the engine speed is also measured at the same time.

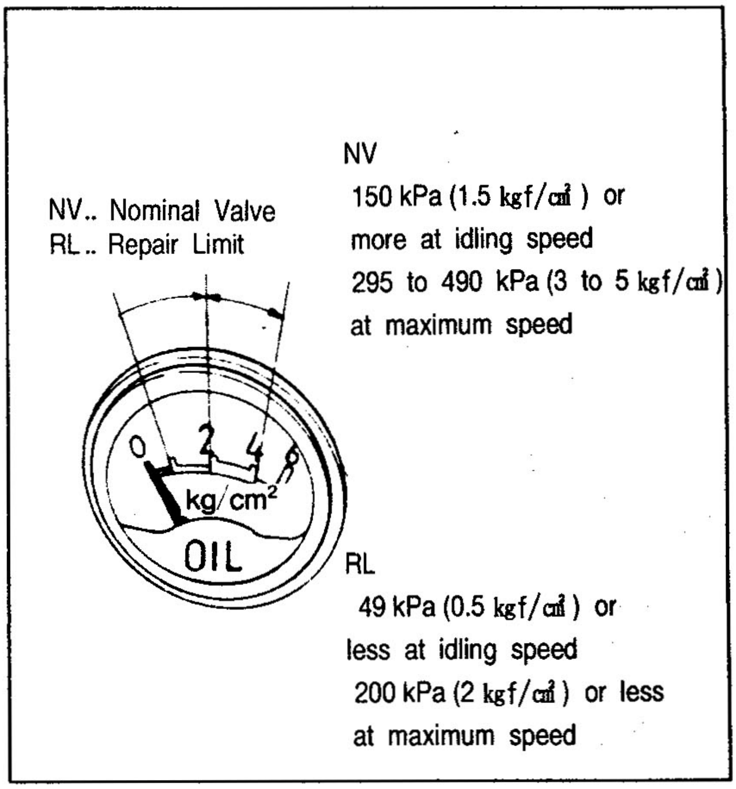
2. Since wear and other conditions differ from cylinder to cylinder, make sure that all cylinders are measured. If the condition of a cylinder is estimated on the basis of one measured, incorrect diagnosis will result.

4-2 OIL PRESSURE

(1) Let the engine warm up until the oil temperature reaches 70 to 90℃

(2) Measure oil pressures during idling and maximum speed.

If the readings are below the repair limit, overhaul the lubrication system.

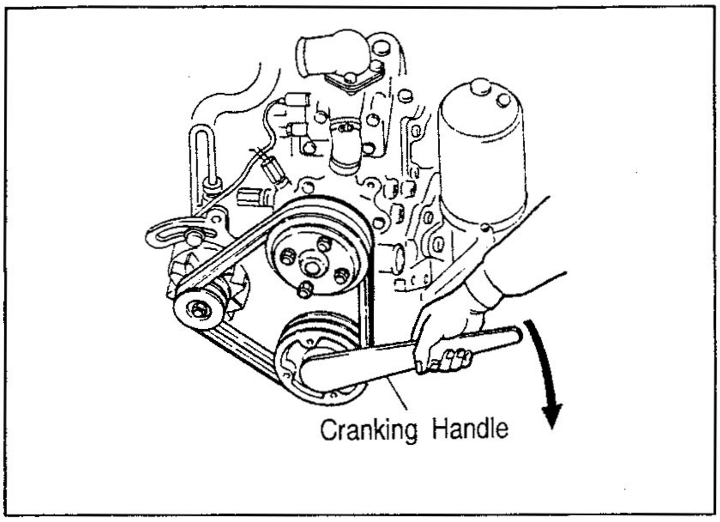


4-3 INSPECTION AND ADJUSTMENT OF VALVE CLEARANCE

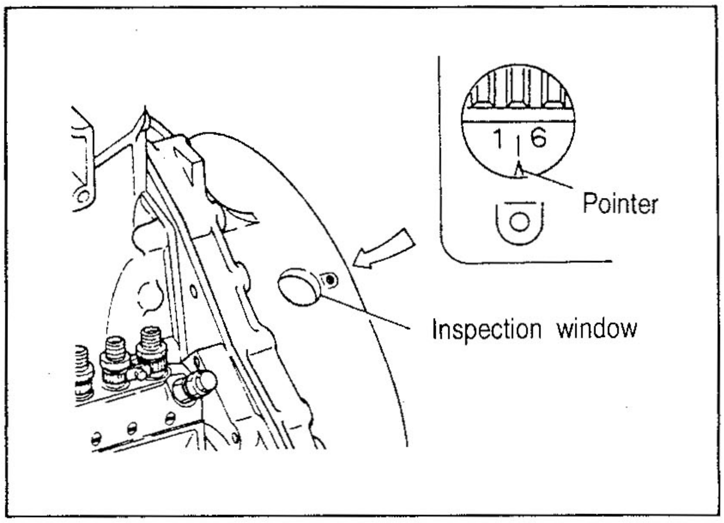
The valve clearance should be checked and adjusted by the following procedures when the engine is cold.

(1) Slowly crank the engine to align the inscribed line 1-6 of the flywheel with the pointer of the flywheel housing inspection window.

At the time, the piston in the cylinder where the push rod is not pushing the rocker up is at the top dead center on the compression stroke.



(2) When the piston in the No. 1 cylinder is at the top dead center on the compression stroke, check and adjust the valves marked ○ in the following table. When the piston in the No. 6 cylinder is at the top dead center on the compression stroke, check and adjust the valves marked × in the following table.

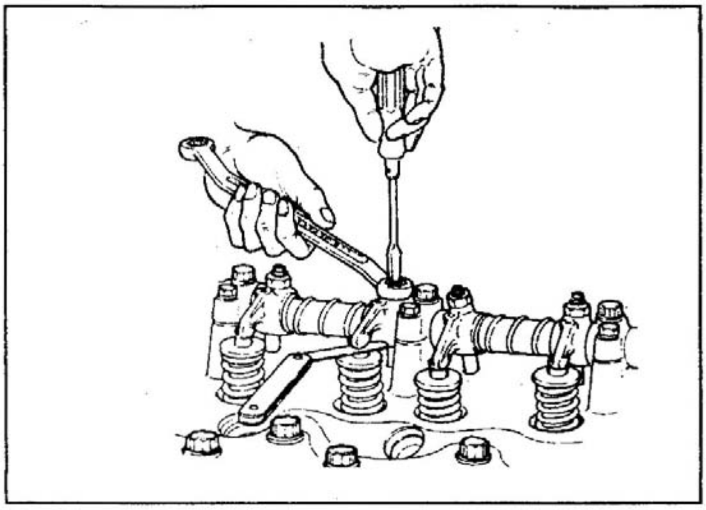


Crank the engine another rotation and check and adjust the valve clearance of all valves.

Cylinder No.	1		2		3		4		5		6	
Valve layout	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.
No. 1 at TDC on compression stroke	○	○	○			○	○			○		
No. 6 at TDC on compression stroke				×	×			×	×		×	×

(3) Measure the clearance between the rocker arm and valve cap with a thickness gauge to see if it has the nominal value.

If the thickness gauge having a thickness of the nominal value is slightly hard to move, the clearance is good.



If the clearance is out of the nominal value, loosen the lock nut and adjust by the adjusting screw.

After the clearance has been adjusted, hold a screwdriver to the adjusting screw to prevent turning, and tighten the lock nut to secure the adjusting screw.

NOTE : After the lock nut has been tightened, recheck the clearance.

4-4 BLEEDING OF FUEL SYSTEM

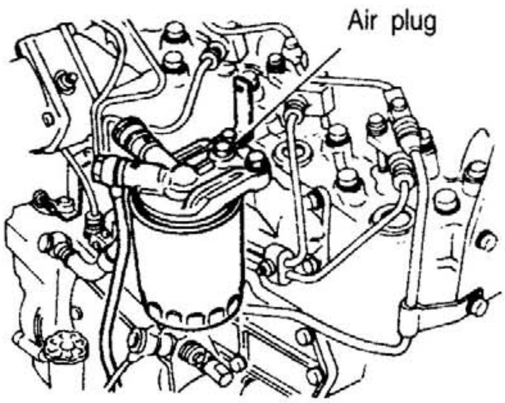
Bleed the fuel system by the following procedures.

(1) Loosen the air plug of the fuel filter.

(2) Turn the priming pump knob of the injection pump counterclockwise to let the knob move up.

(3) Move the knob of the priming pump up and down to feed fuel.

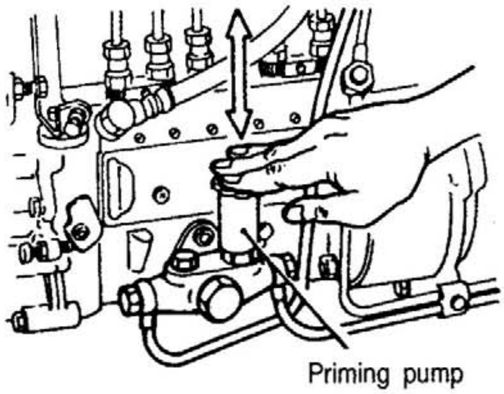
(4) If there are no more air bubbles in the fuel that runs out from the air plug of the fuel filter, firmly tighten the air plug.



(5) Loosen the air bleeder of the injection pump, and operate the priming pump to feed fuel until there are no more air bubbles in the fuel that flows out.

Before tightening the air bleeder, secure the priming pump knob by turning clockwise while depressing it.

NOTE : Wipe away all fuel spilt around.



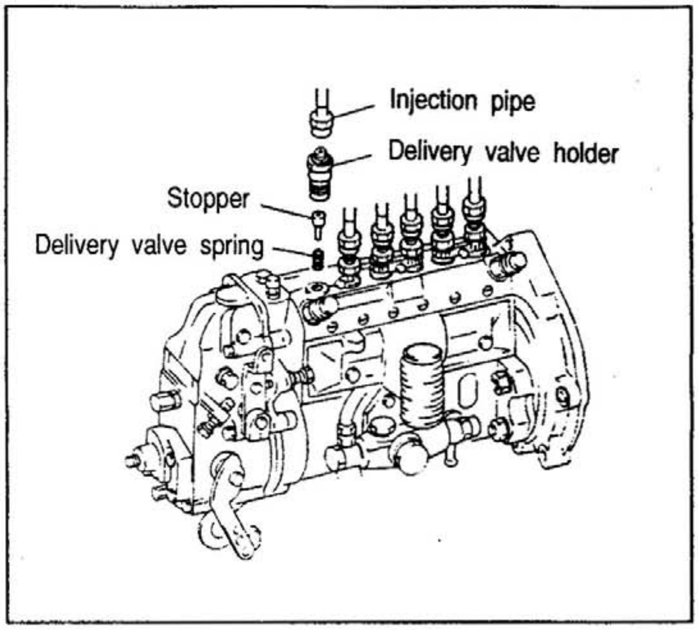
(6) Operate the starter to force the remaining air in the fuel system into the fuel tank.

NOTE : Do not operate the starter continuously for more than 15 seconds.

4-5 INSPECTION AND ADJUSTMENT OF FUEL INJECTION START TIMING

(1) Remove the injection pipe, delivery valve spring and stopper from the No. 1 cylinder of the injection pump. Leave the delivery valve holder attached.

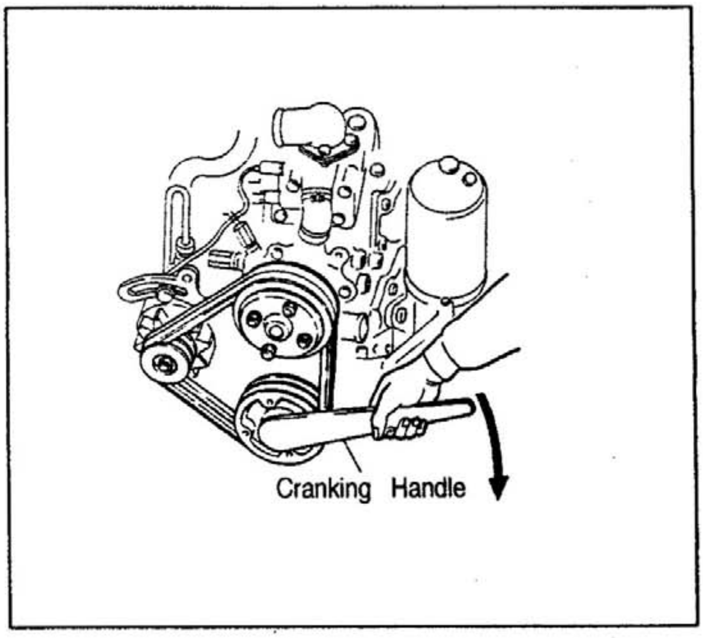
NOTE : Put the removed delivery valve spring in a cleaning oil to keep out dust and dirt.



(2) Install a sprae injection pipe to the No. 1 cylinder. Face the other end of the pipe down and make sure that the fuel running out can be clearly seen.

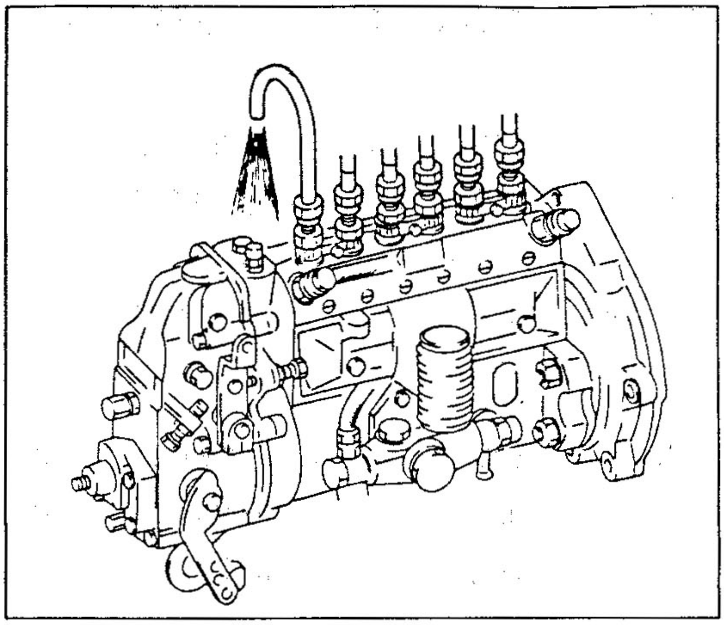
(3) Crank the crankshaft more than 180° in normal direction to place the piston in the No. 1 cylinder at a position about 30° before the top dead center on the compression stroke.

NOTE : If the engine is turned in reverse direction (either when the engine is stopped or by cranking), the auto timer will stay advanced and may not return to normal even if the engine is slightly cranked in normal direction. Make sure that the engine is manually cranked more than 180° in normal direction.

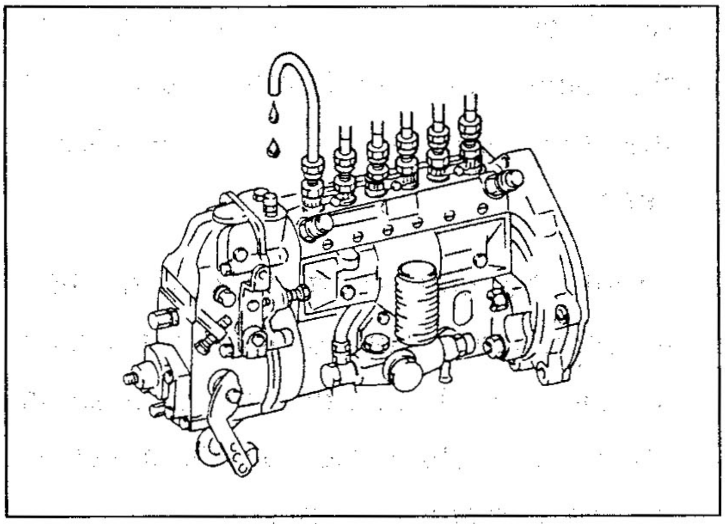


(4) While operating the priming pump to let fuel run out from the injection pipe, slowly crank the engine in normal turning direction.

NOTE : Check to ensure that the stop lever on the top of the governor is not pulled in the "STOP" direction.

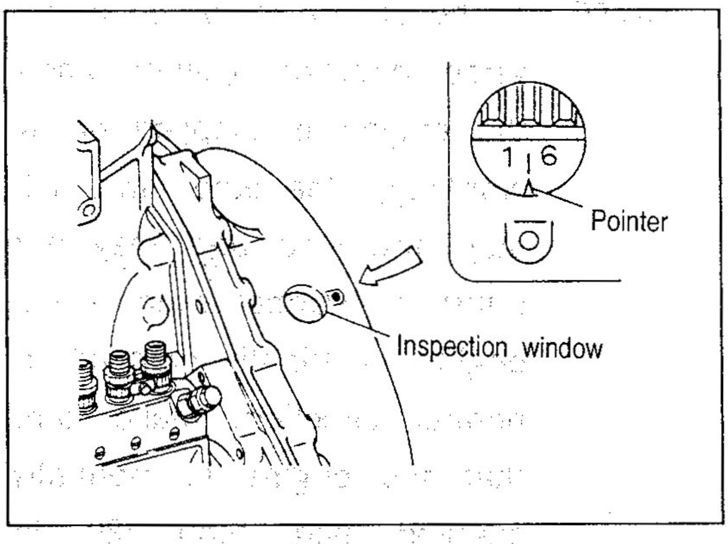


(5) If the fuel has almost creased to run out from the injection pipe, crank the engine at lower speed. After the fuel has completely cesed to runout, stop cranking the engine.



(6) Check if the flywheel timing mark and the pointer indicate a position about 1° before the fuel injection start timing.

NOTE : An advance of approximately 1° before the specified injection start timing is involved because the valve opening pressure of the delivery valve spring is not applied.

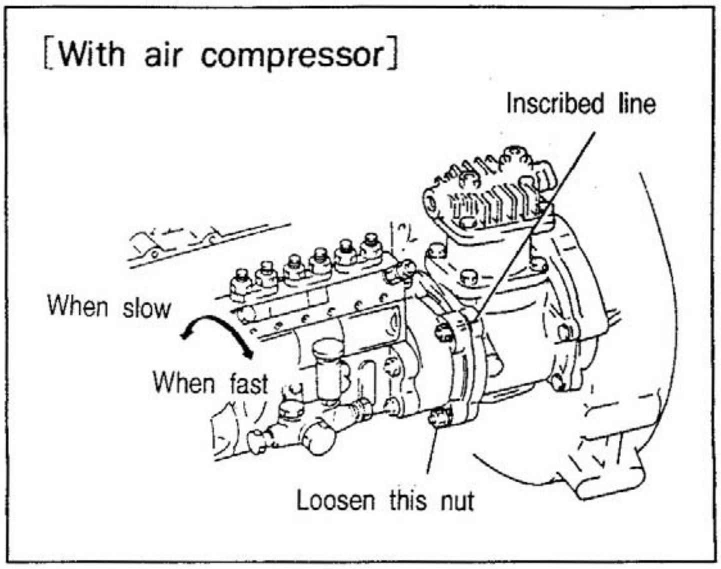


If the fuel injection timing is out of specification, adjust as follows.

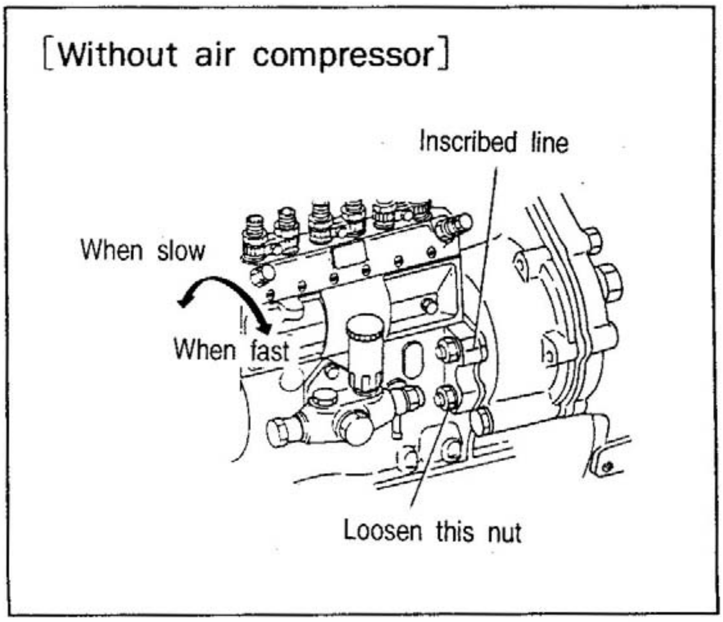
(7) Use Universal Extension (special tool, MH061099) to loosen the nuts.

(8) If the fuel injection timing is slow, push the injection pump toward the crankcase.

If the fuel injection timing is fast, push the injection pump in an opposite direction to the crankcase.

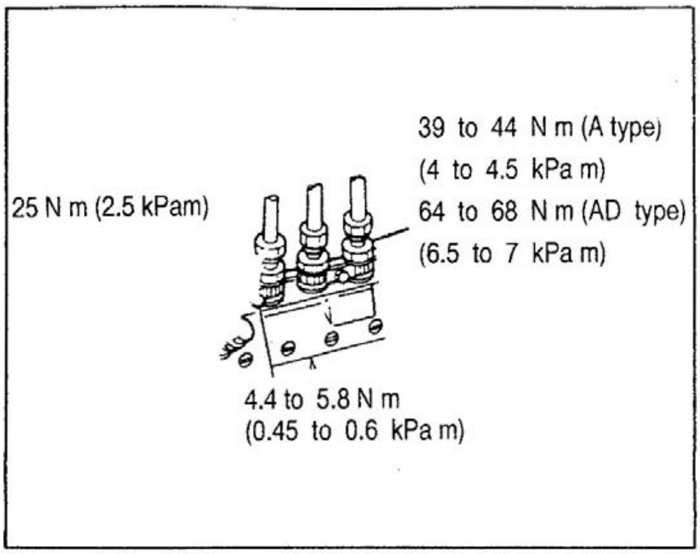


(9) Move the injection pump as required.
A shift of one part in the scale will vary the injecton timing by 6°.
Moving the injection pump 1° will advance or retard the injection timing about 2°.



(10) Tighten the injection pump attaching nuts and remeasure the fuel injection timing.

(11) After adjustment, install the delivery valve spring and stopper and tighten the lock plate and delivery valve holder to the specified torque. Then install the injection pipe.



(12) For in inspection in a dusty place, use the following procedures.

(a) Crank the crankshaft more than 180° in normal direction beforehand.

(b) Remove only the injecton pipe and leave some fuel behind on top of the delivery valve holder.

(c) Crank the engine to place the piston in the No. 1 cylinder at a position about 30° before the top dead center on the compression stroke. Then slowly recrank the engine, and fuel on top of the delivery valve will begin to move.

(d) This position is the fuel injection start timing.

NOTE : If the fuel injection timing is radically different from the specification, beyond the adjustable range by the injection pump, it is probably because of the engine timing gear not in the proper mesh with the injection pump gear, In this case, remove the injection pump and reinstall it according to 5-2-3(3).

4-6 INSPECTION AND ADJUSTMENT OF NO-LOAD MINIMUM AND MAXIMUM SPEEDS

Prior to inspection and adjustment, start the engine and let it warm up until the coolant temperature exceeds 60℃.

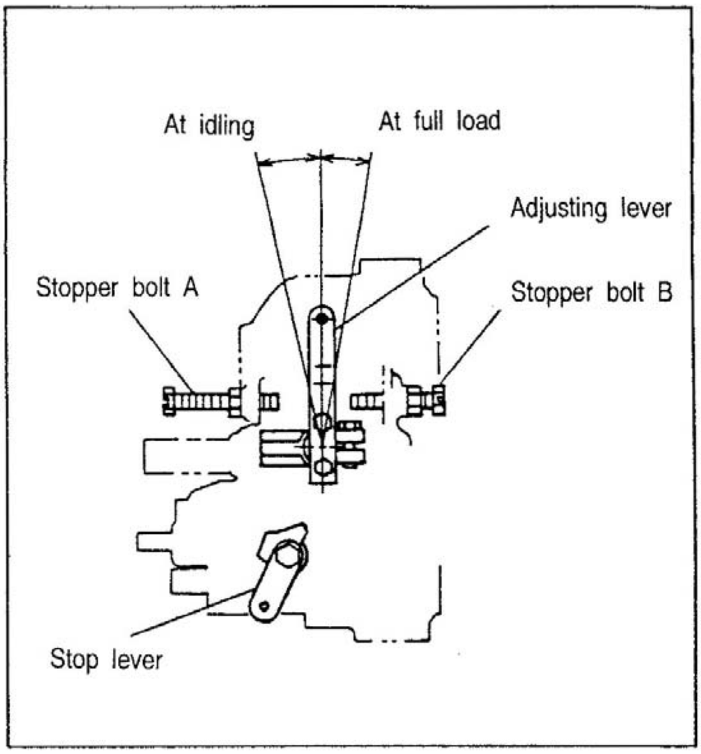
(1) Make sure that the adjusting lever is in contact with the stopper bolt.

(2) Then measure the minimum(idle) speed to ensure the measured value is within the specification.

(3) If it is out of the specification, adjust with the stopper bolt A.

(4) Operate the adjusting lever until it comes in contact with the stopper bolt B.

(5) Then measure the maximum speed to check if it is within the specification.



(6) If it is out of specification, adjust with the stopper bolt B.

NOTE : Make sure that the engine does not stall or no hunting occurs even if the adjusting lever is abruptly returned from the full load position to the idling position. Adjust to specification if any unusual condition is present.

4-7 INSPECTION AND ADJUSTMENT OF V-BELT TENSION

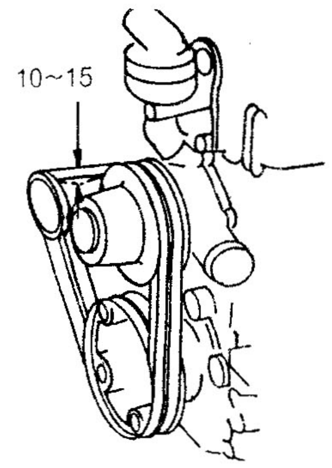
(1) Inspection

Press down on the middle of the belt by finger to check whether the belt deflection is within the specified limits.

If the deflection is out of the specified limits, adjust by the following procedures.

check the V-belt for damage. Make sure that a damaged or badly worn belt should be replaced.

Pressure : approx. 98 N(10kgf)

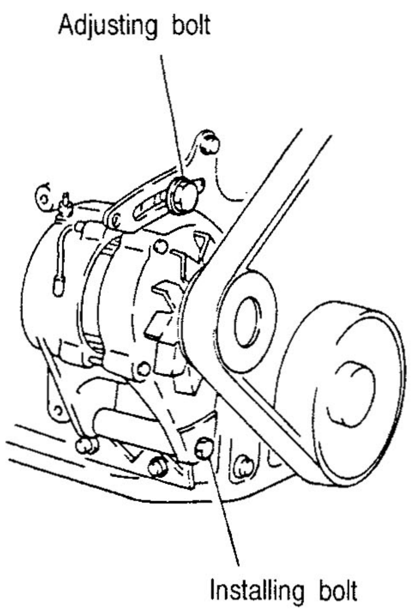


NOTE : A loose belt will cause engine overheating, poor alternator charging, etc. A tight belt, on the other hand, will cause damage to the shafts or bearings of various parts or will damage the belt.

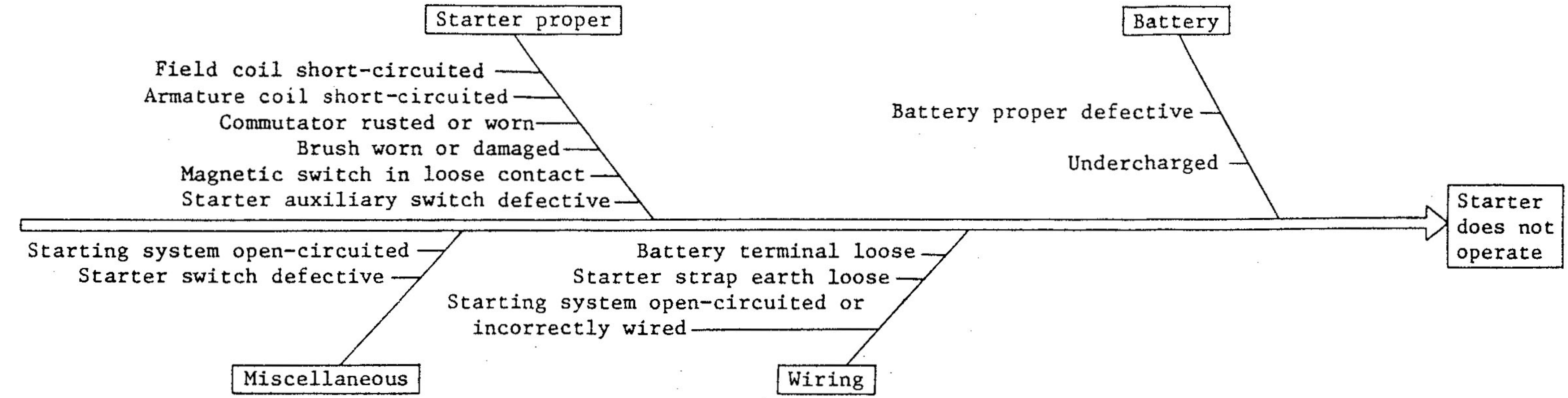
(2) Adjustment

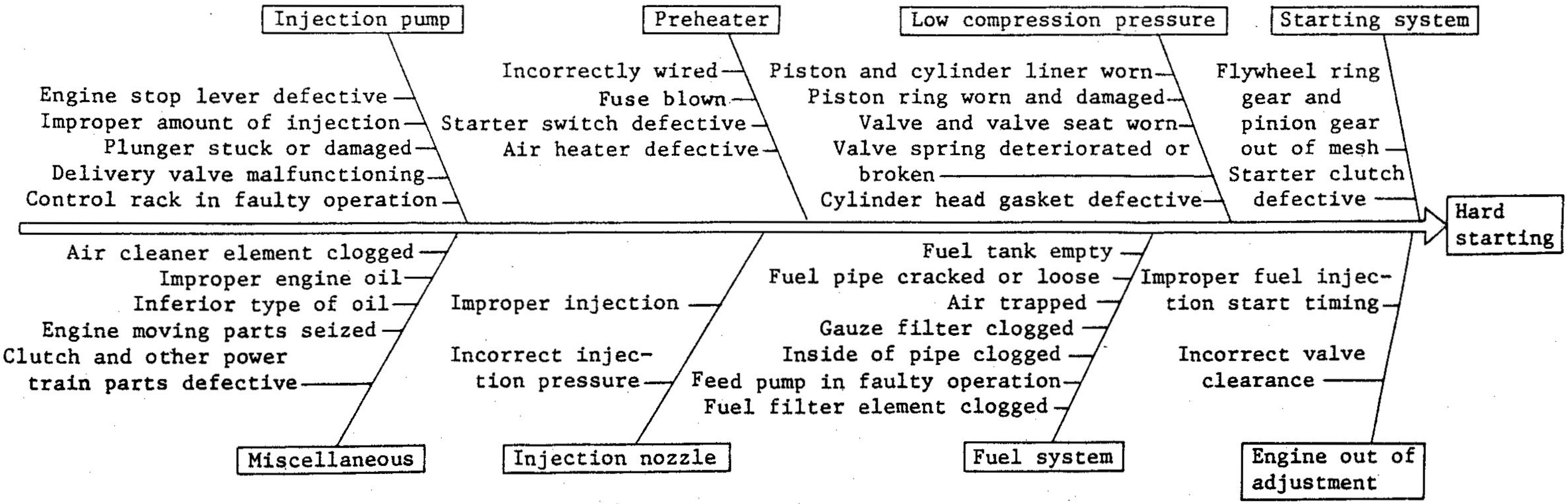
(a) Slightly loosen the alternator attaching bolt and the adjusting bolt and adjust by moving the alternator to right or left.

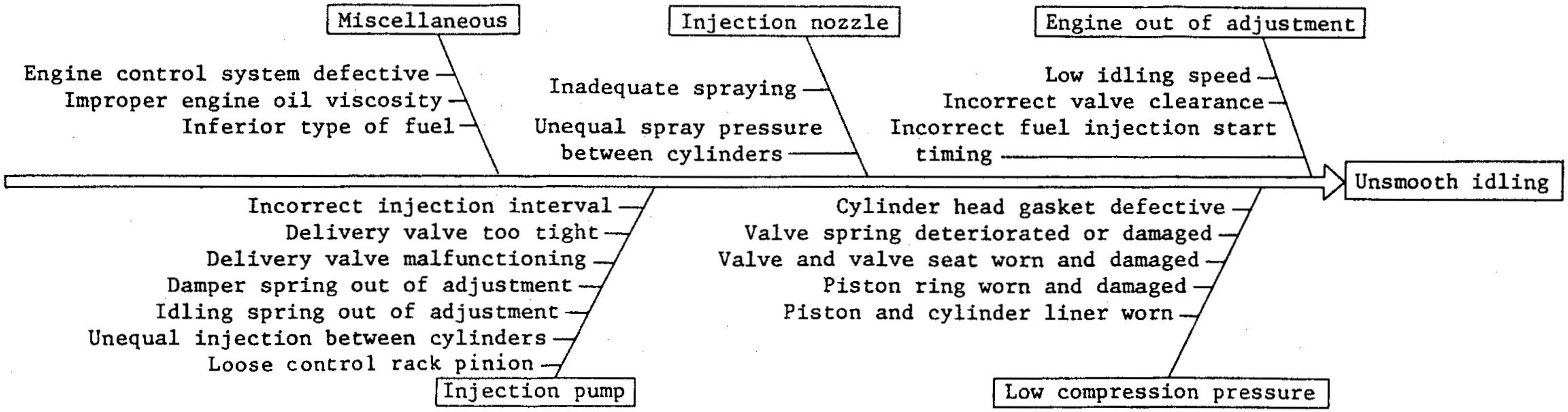
After adjustment, firmly tighten all the bolts.

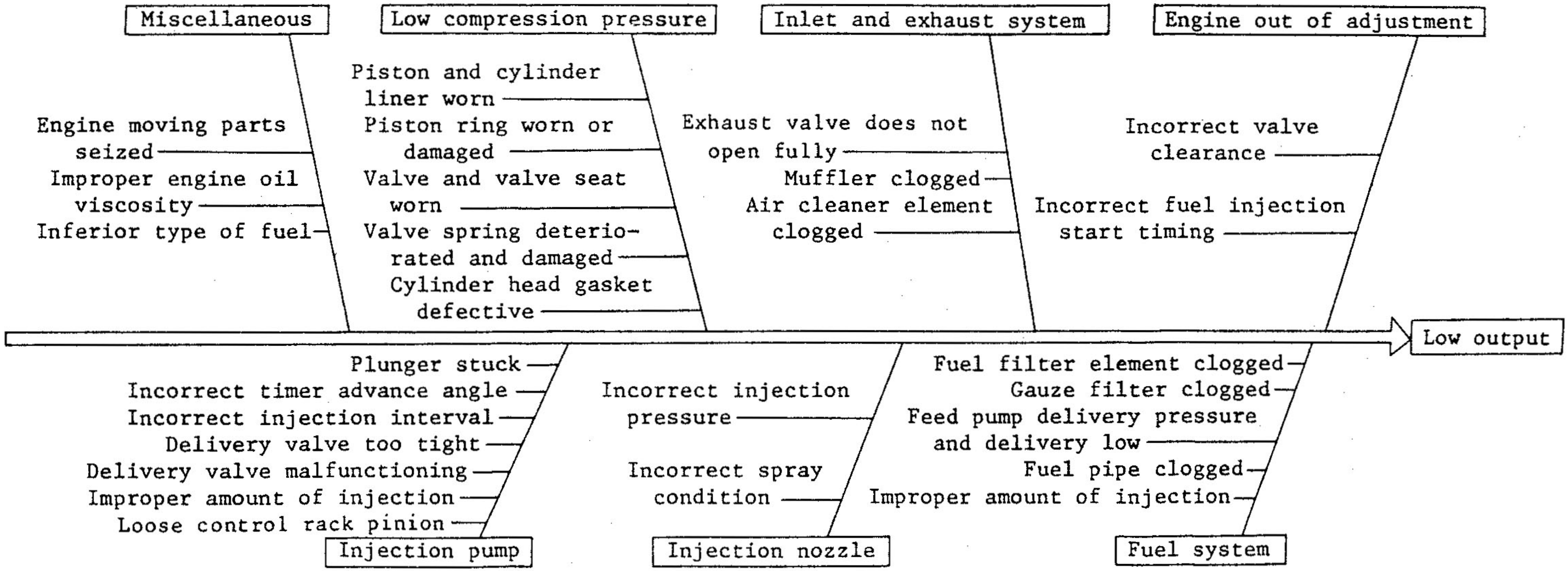


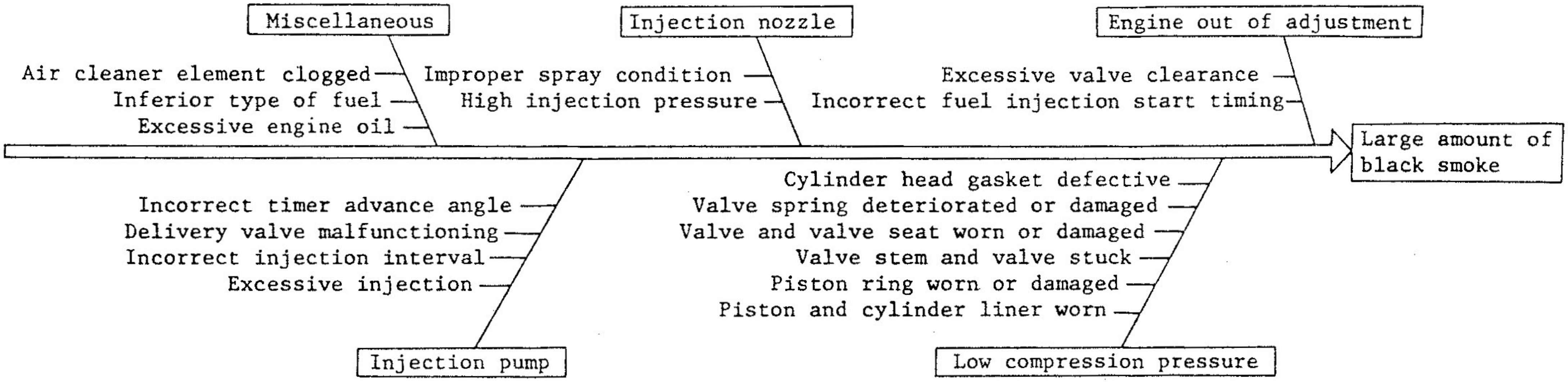
4-8 TROUBLESHOOTING

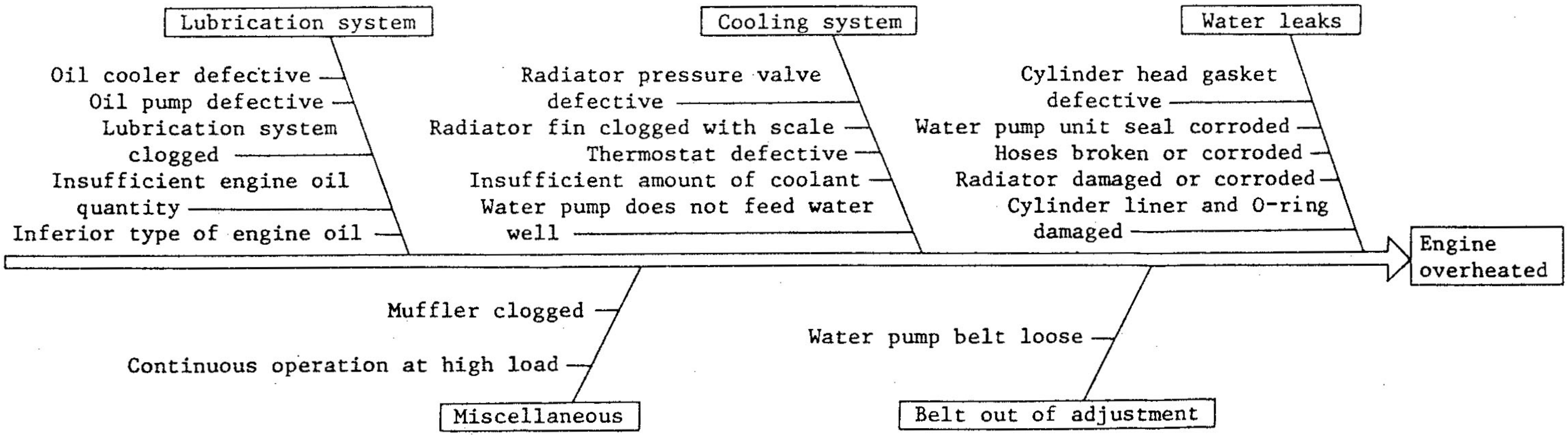


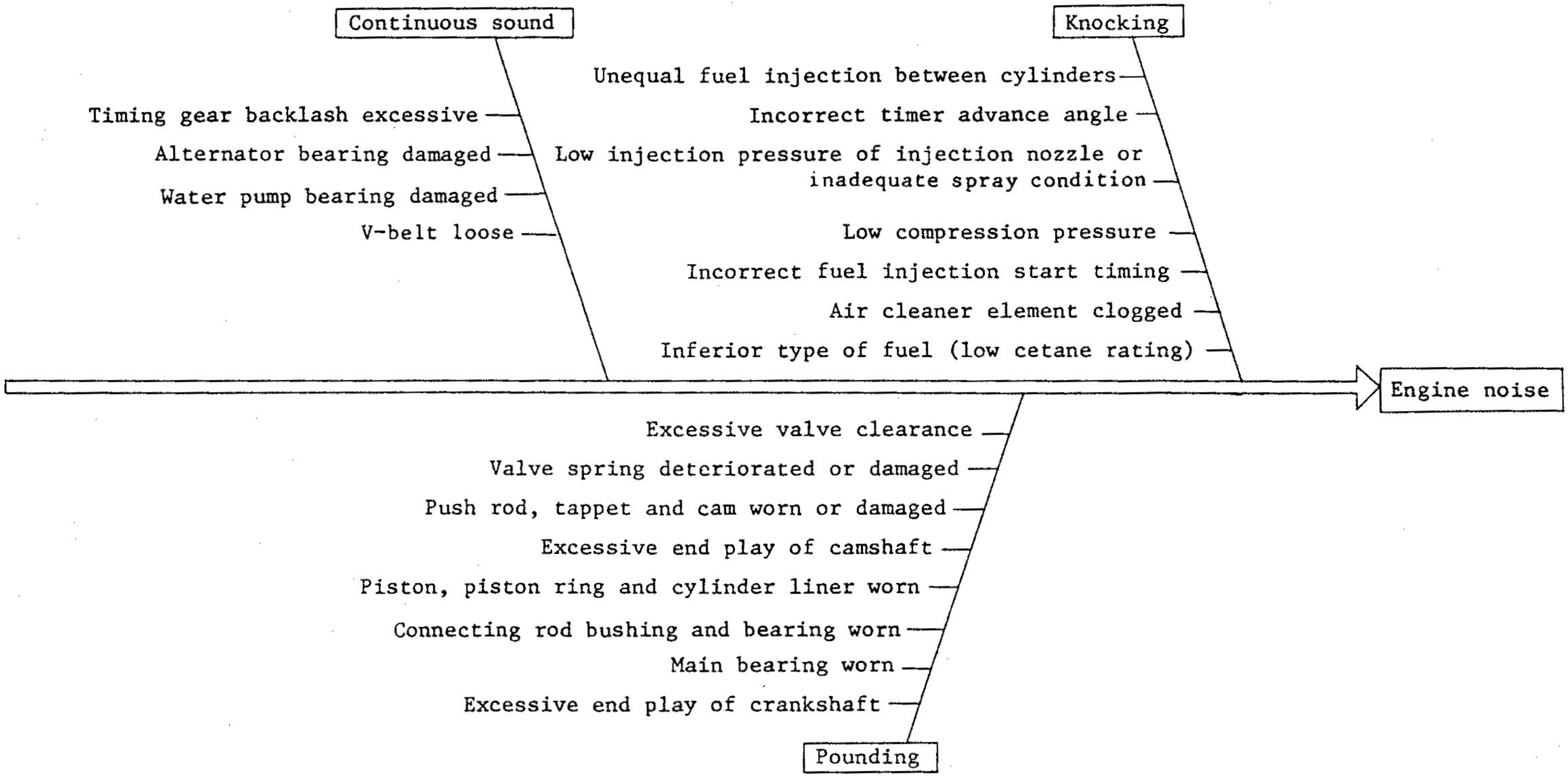


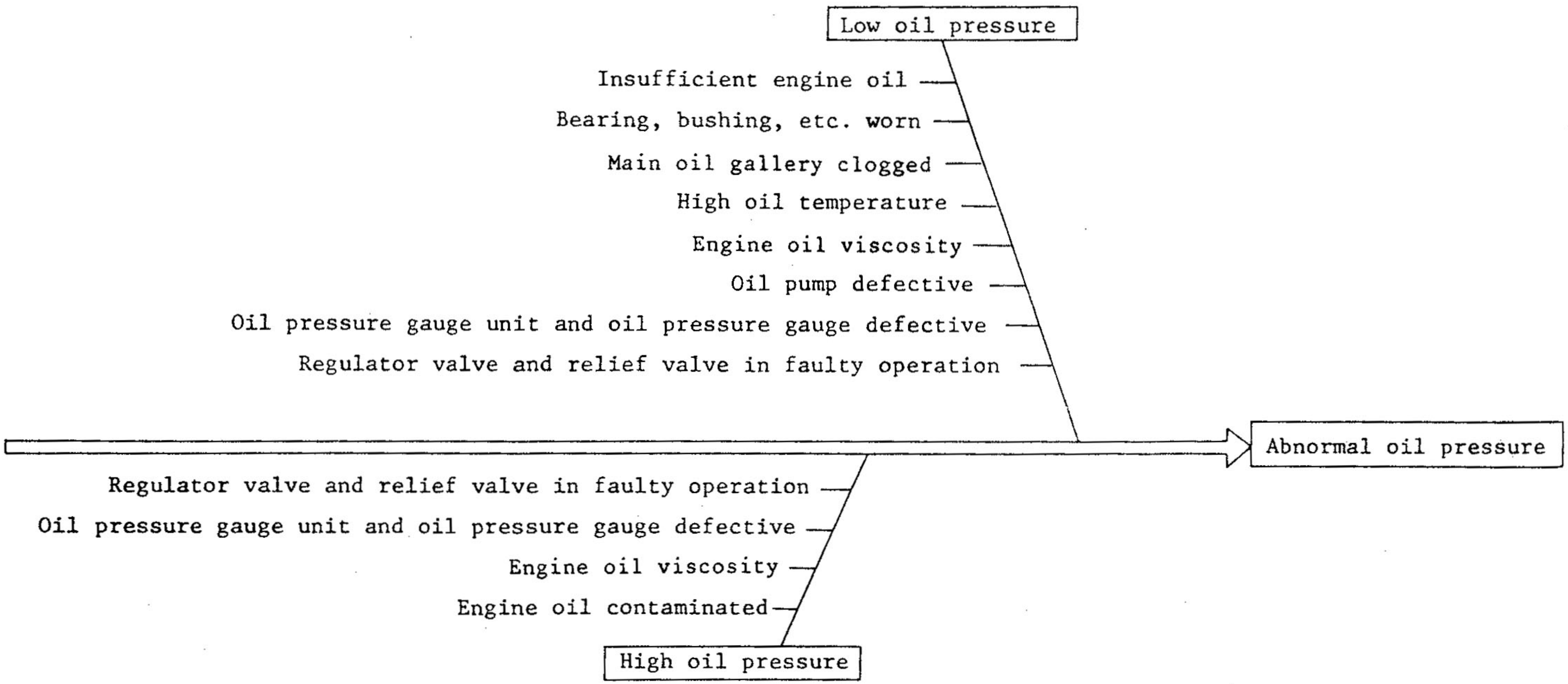

Miscellaneous
Engine control system defective
Improper engine oil viscosity
Inferior type of fuel
Injection nozzle
Inadequate spraying
Unequal spray pressure between cylinders
Engine out of adjustment
Low idling speed
Incorrect valve clearance
Incorrect fuel injection start timing
Unsmooth idling
Incorrect injection interval
Delivery valve too tight
Delivery valve malfunctioning
Damper spring out of adjustment
Idling spring out of adjustment
Unequal injection between cylinders
Loose control rack pinion
Injection pump
Cylinder head gasket defective
Valve spring deteriorated or damaged
Valve and valve seat worn and damaged
Piston ring worn and damaged
Piston and cylinder liner worn
Low compression pressure


Miscellaneous
Engine moving parts seized
Improper engine oil viscosity
Inferior type of fuel
Low compression pressure
Piston and cylinder liner worn
Piston ring worn or damaged
Valve and valve seat worn
Valve spring deteriorated and damaged
Cylinder head gasket defective
Inlet and exhaust system
Exhaust valve does not open fully
Muffler clogged
Air cleaner element clogged
Engine out of adjustment
Incorrect valve clearance
Incorrect fuel injection start timing
Low output
Plunger stuck
Incorrect timer advance angle
Incorrect injection interval
Delivery valve too tight
Delivery valve malfunctioning
Improper amount of injection
Loose control rack pinion
Injection pump
Incorrect injection pressure
Incorrect spray condition
Injection nozzle
Fuel filter element clogged
Gauze filter clogged
Feed pump delivery pressure and delivery low
Fuel pipe clogged
Improper amount of injection
Fuel system


Miscellaneous
Air cleaner element clogged
Inferior type of fuel
Excessive engine oil
Injection nozzle
Improper spray condition
High injection pressure
Engine out of adjustment
Excessive valve clearance
Incorrect fuel injection start timing
Large amount of black smoke
Injection pump
Incorrect timer advance angle
Delivery valve malfunctioning
Incorrect injection interval
Excessive injection
Low compression pressure
Cylinder head gasket defective
Valve spring deteriorated or damaged
Valve and valve seat worn or damaged
Valve stem and valve stuck
Piston ring worn or damaged
Piston and cylinder liner worn


Lubrication system
Oil cooler defective
Oil pump defective
Lubrication system clogged
Insufficient engine oil quantity
Inferior type of engine oil
Cooling system
Radiator pressure valve defective
Radiator fin clogged with scale
Thermostat defective
Insufficient amount of coolant
Water pump does not feed water well
Water leaks
Cylinder head gasket defective
Water pump unit seal corroded
Hoses broken or corroded
Radiator damaged or corroded
Cylinder liner and O-ring damaged
Engine overheated
Miscellaneous
Muffler clogged
Continuous operation at high load
Belt out of adjustment
Water pump belt loose


Continuous sound
Timing gear backlash excessive
Alternator bearing damaged
Water pump bearing damaged
V-belt loose
Knocking
Unequal fuel injection between cylinders
Incorrect timer advance angle
Low injection pressure of injection nozzle or inadequate spray condition
Low compression pressure
Incorrect fuel injection start timing
Air cleaner element clogged
Inferior type of fuel (low cetane rating)
Engine noise
Excessive valve clearance
Valve spring deteriorated or damaged
Push rod, tappet and cam worn or damaged
Excessive end play of camshaft
Piston, piston ring and cylinder liner worn
Connecting rod bushing and bearing worn
Main bearing worn
Excessive end play of crankshaft
Pounding


Low oil pressure
Insufficient engine oil
Bearing, bushing, etc. worn
Main oil gallery clogged
High oil temperature
Engine oil viscosity
Oil pump defective
Oil pressure gauge unit and oil pressure gauge defective
Regulator valve and relief valve in faulty operation
Abnormal oil pressure
Regulator valve and relief valve in faulty operation
Oil pressure gauge unit and oil pressure gauge defective
Engine oil viscosity
Engine oil contaminated
High oil pressure

This section describes the procedures for removal and installation of auxiliaries on the assumption that the engine is overhauled. Being based on the systematic classification, the removal and installation procedures given here may be found to be inconsistent somewhere. To serve actual needs, flexibility is allowed as required.

Observe the following items.

(1) During operations, use special care not to overlook the symptoms or phenomena that could lead to abnormal conditions, because they are often hard to find after remoal or cleaning of the parts.

(2) Do not touch the electrical prats, rubber parts and the like with oil-contaminated hands.

(3) Have a table and cleaner ready and put the removed parts classified by system in order on the table.

(4) On the parts that could be misassembled, make alignment marks on functionally safe portions.

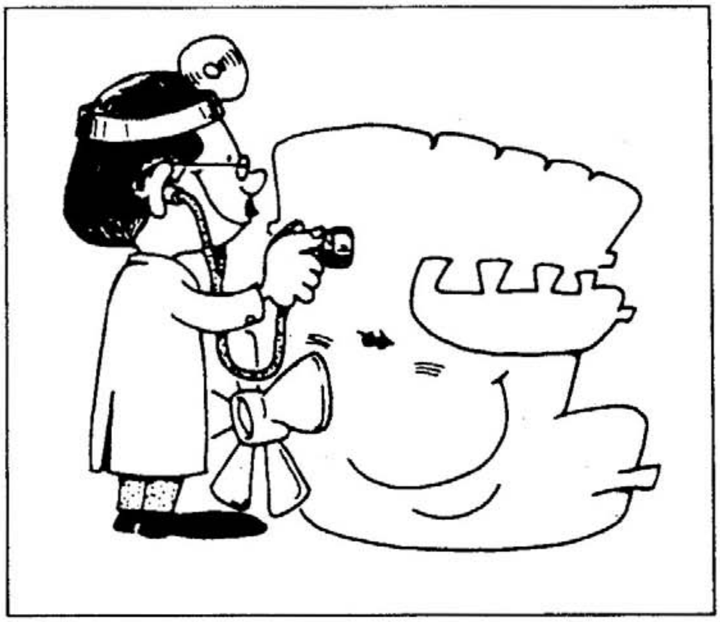
(5) Use the right tool for each part to prevent unnecessary damage.

5-1 PREPARATIONS

5-1-1 Preliminary Inspection of Engine

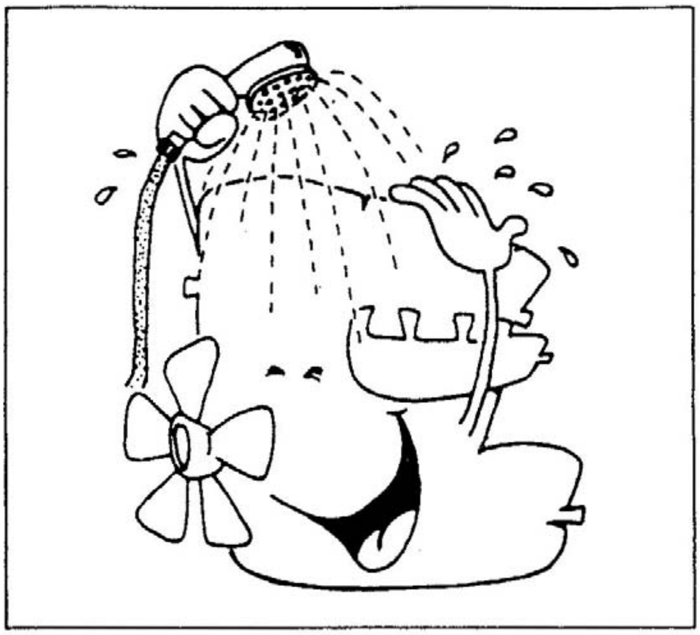
Before the engine is overhauled, check and record the cylinder compression pressure, engine oil consumption, fuel consumption, startability, exhaust gas condition, diesel knocking and other noises and refer to the data as nescessary after disassembly, correction and reassembly.

For determination of the time to overhaul the engine, refer to "Group 4 INSPECTION AND ADJUSTMENT OF ENGINE".



5-1-2 Cleaning of Engine

Oil, grease, dust, etc. are deposited on the engine. Therefore, use steam cleaner, engine cleaner, etc. to clean the engine.



Remove the electrical devices(alternator, starter, etc.), V-belt, rubber hose, wiring, etc. before cleaning the engine.

NOTE : Before disassembly and cleaning, isolate symptoms and possible causes of problem which are not easily detected after disassembly and cleaning.

5-2 REMOVAL AND INSTALLATION

5-2-1 Electrical

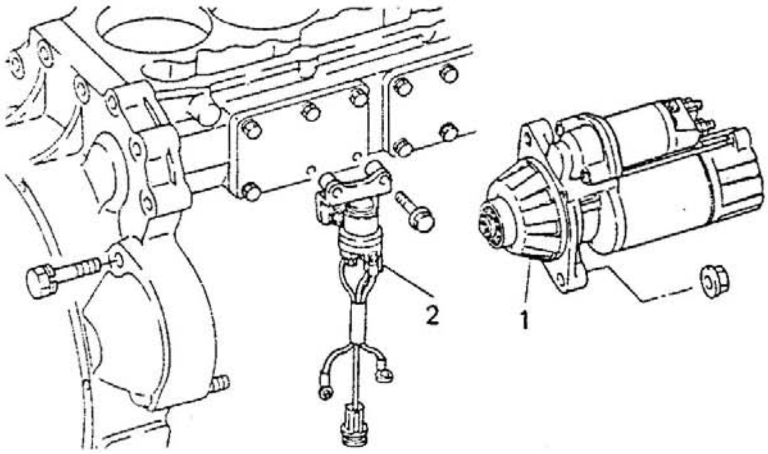
When electrical devices are to be removed, set the starter switch(battery switch) to OFF, then remove ⊖ (mimus) battery cable.

(1) Harness

In disconnecting engine harness terminals, mark each clamp as it is removed to prevent wrong wiring in reinstallation.

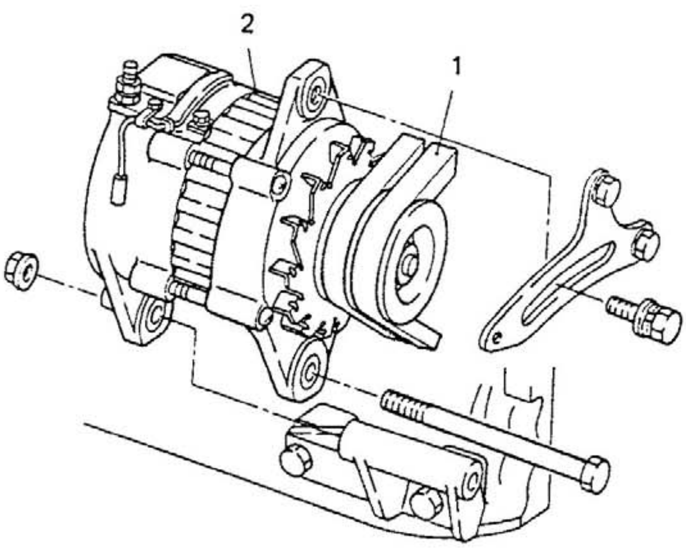
(2) Starter

1. Starter
2. Starter relay



(3) Alternator

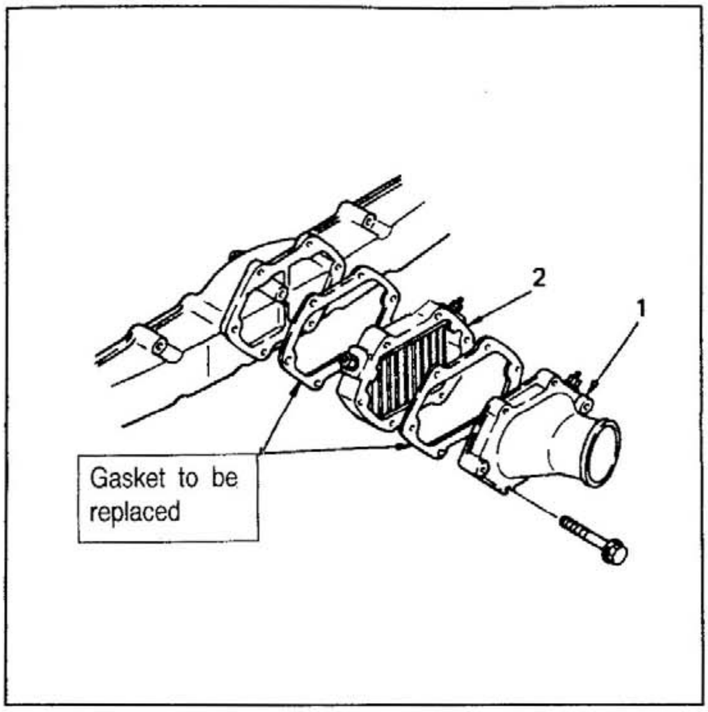
1. V-belt
2. Alternator



(4) Intake Air Heater

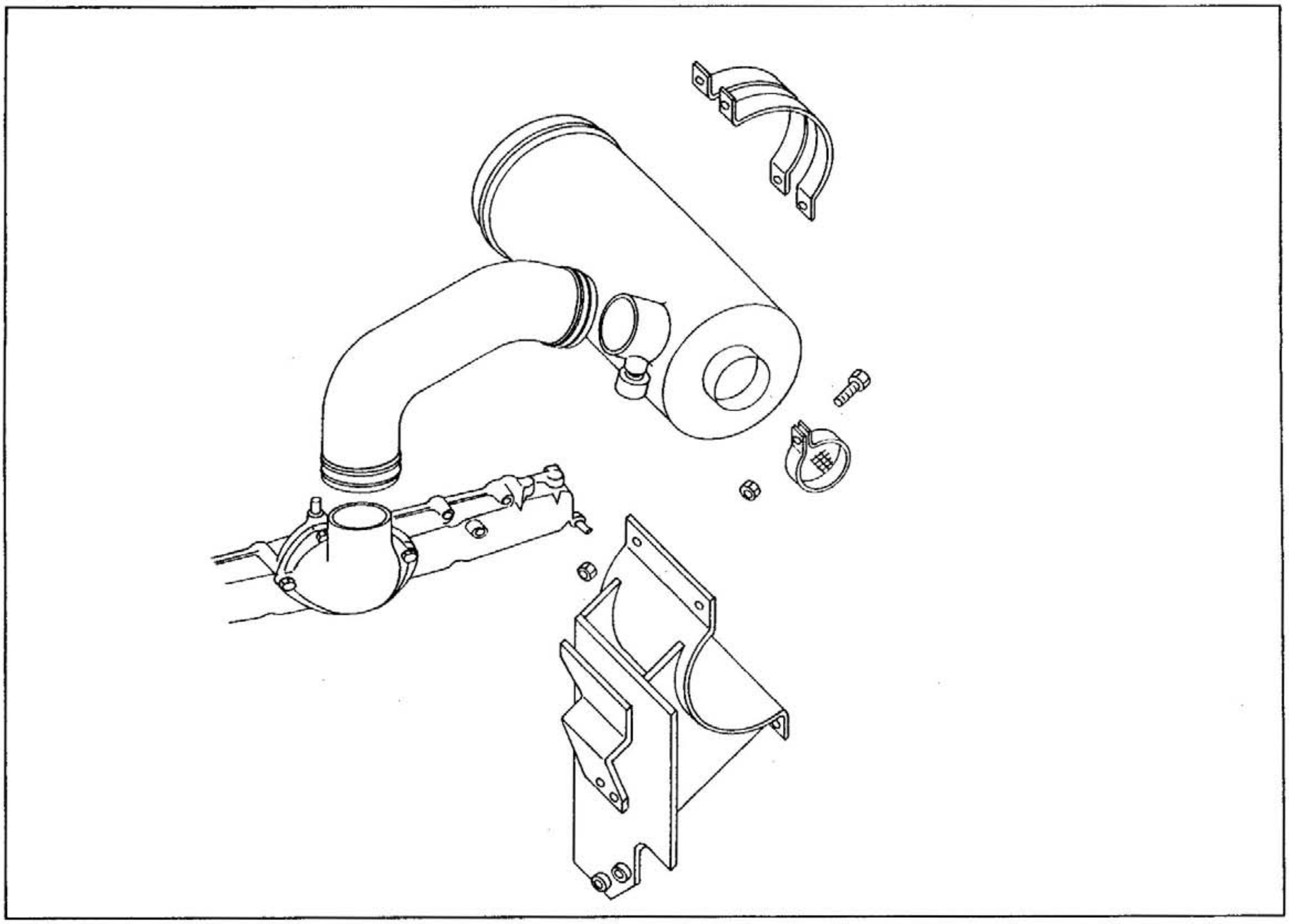
1. Coupler
2. Air heater

NOTE : Install the air heater with the embossed arrow directed to the inlet manifold side.



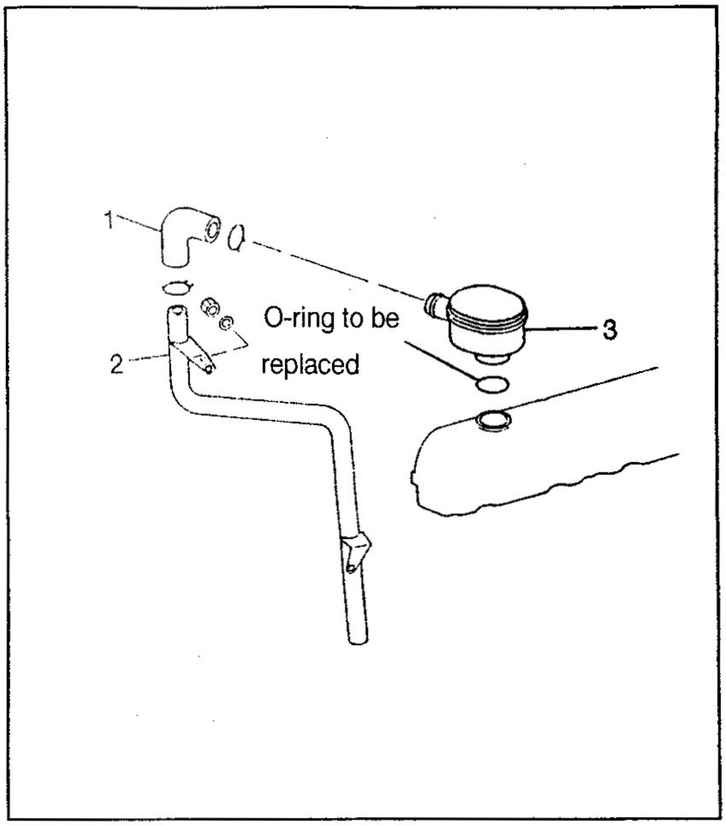
5-2-2 Inlet and Exhaust

(1) Air cleaner



(2) Breather

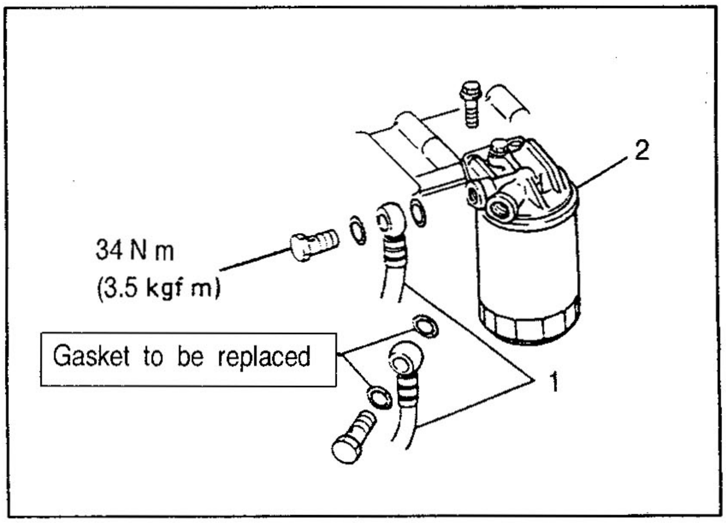
1. Rubber hose
2. Breather pipe
3. Breather



5-2-3 Fuel

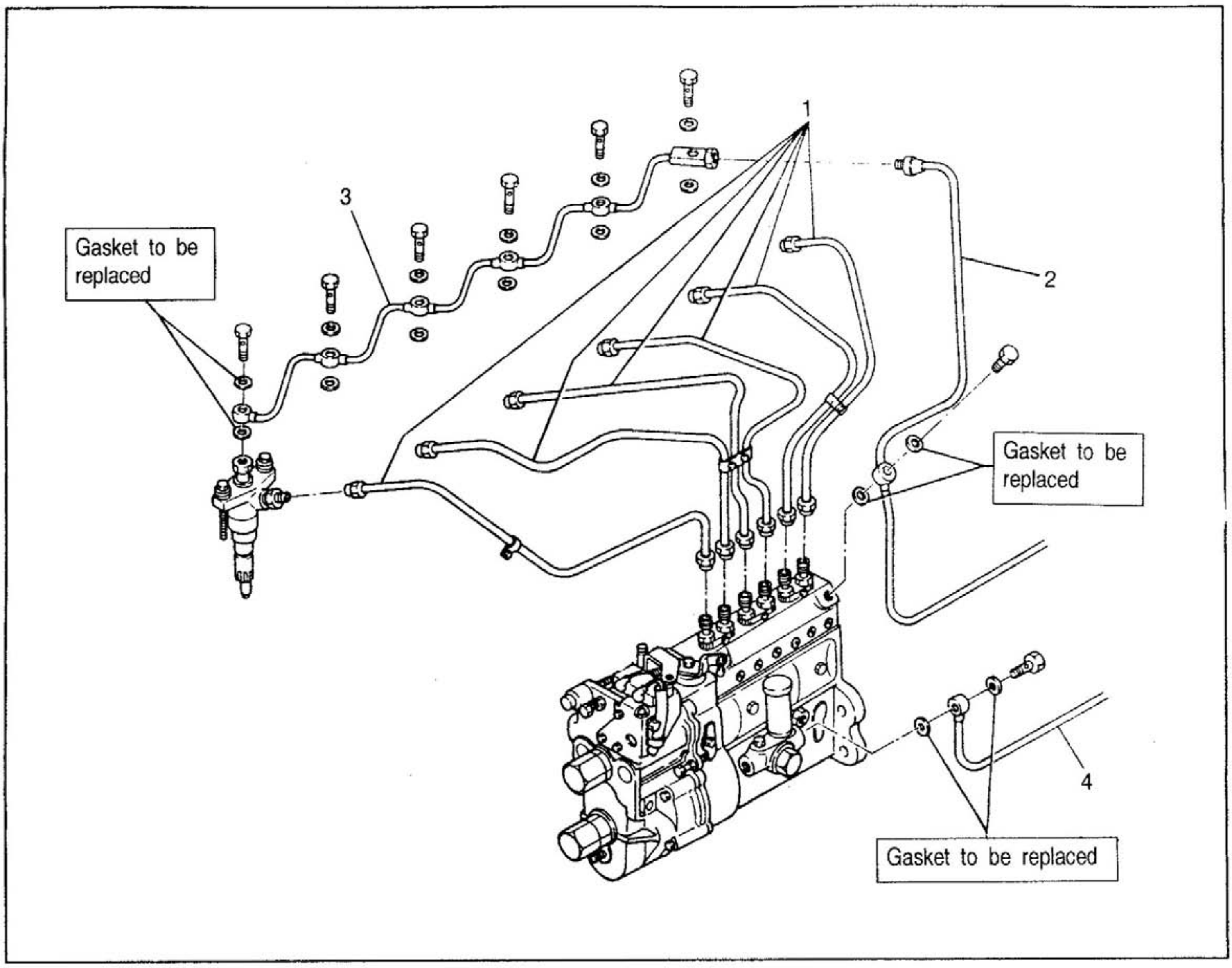
(1) Fuel Filter

1. Fuel feed hose
2. Fuel filter



(2) Injection Pipe

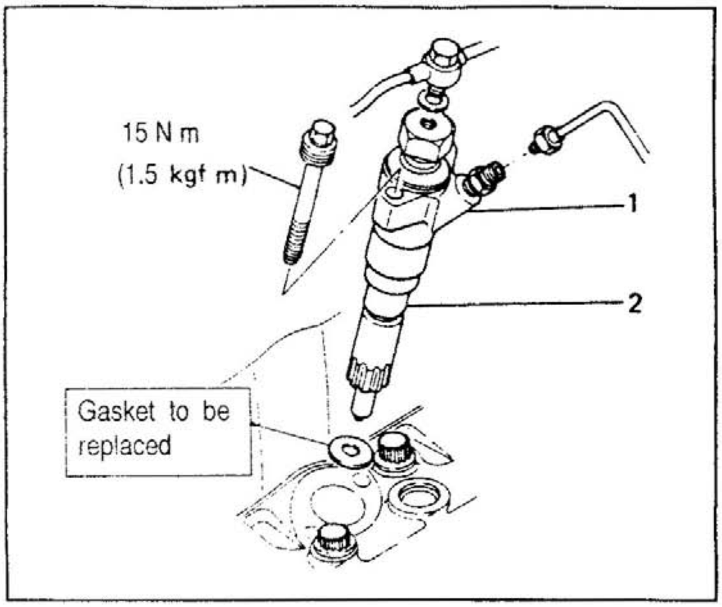
1. Injection pipe
2. fuel leak off pipe
3. fuel overflow pipe
4. fuel inlet pipe



(3) Injection Nozzle

1. Injection nozzle
2. Dust seal

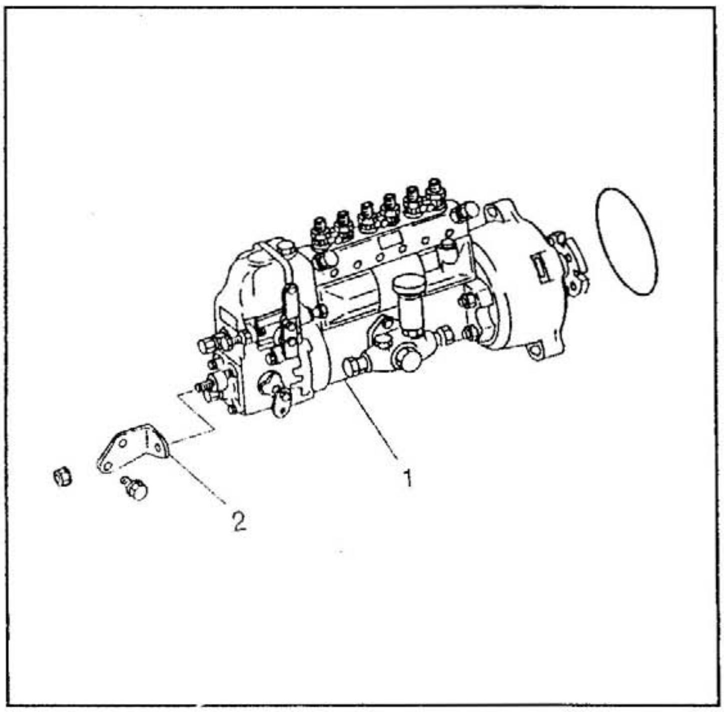
NOTE : Tighten the two nozzle attaching bolts alternately, a small amount at a time.



(4) Injection Pump

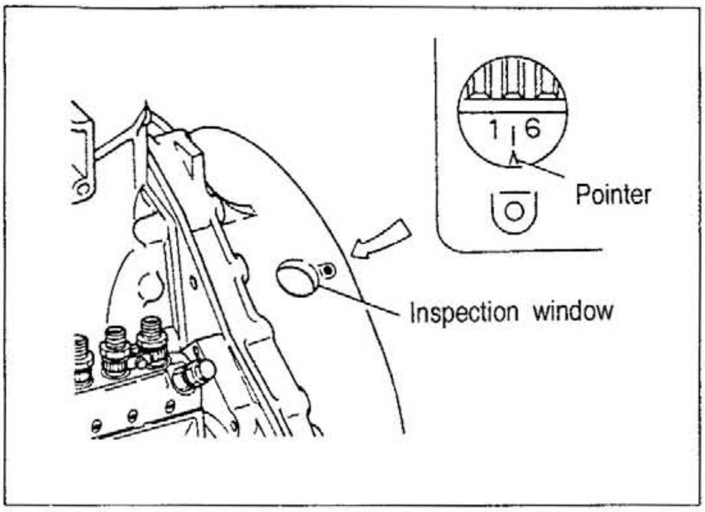
(a) Removal

1. Injection pump
2. Stey

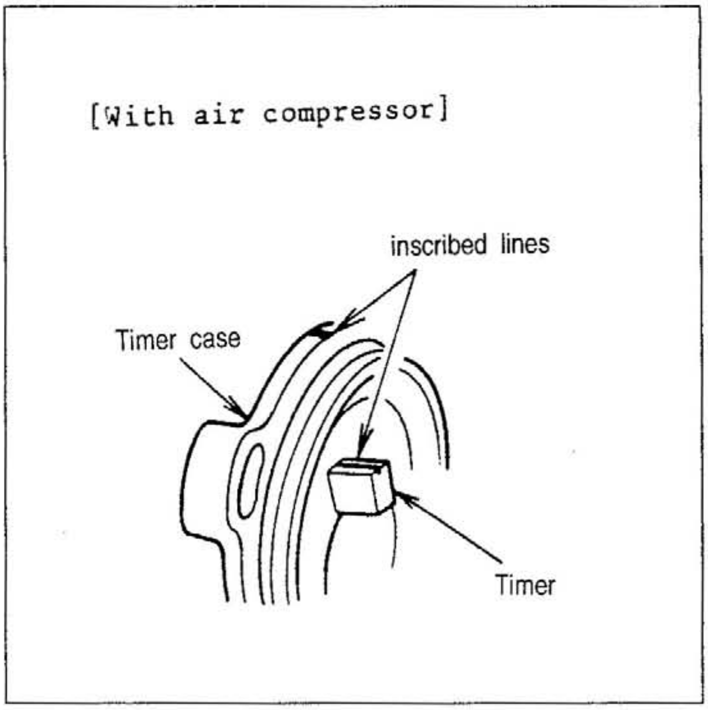


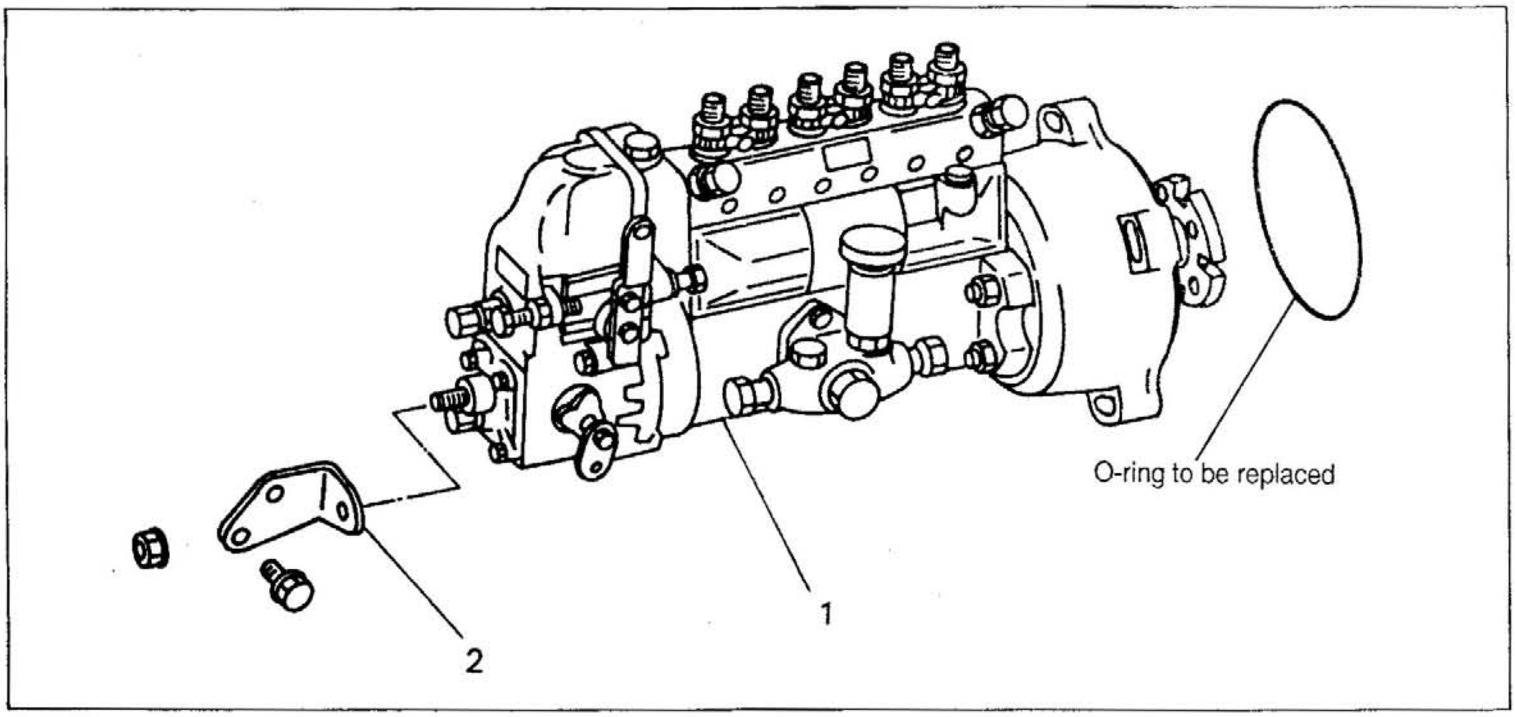
(b) Installation

1) Place the No. 1 piston at top dead center on the compression stroke.



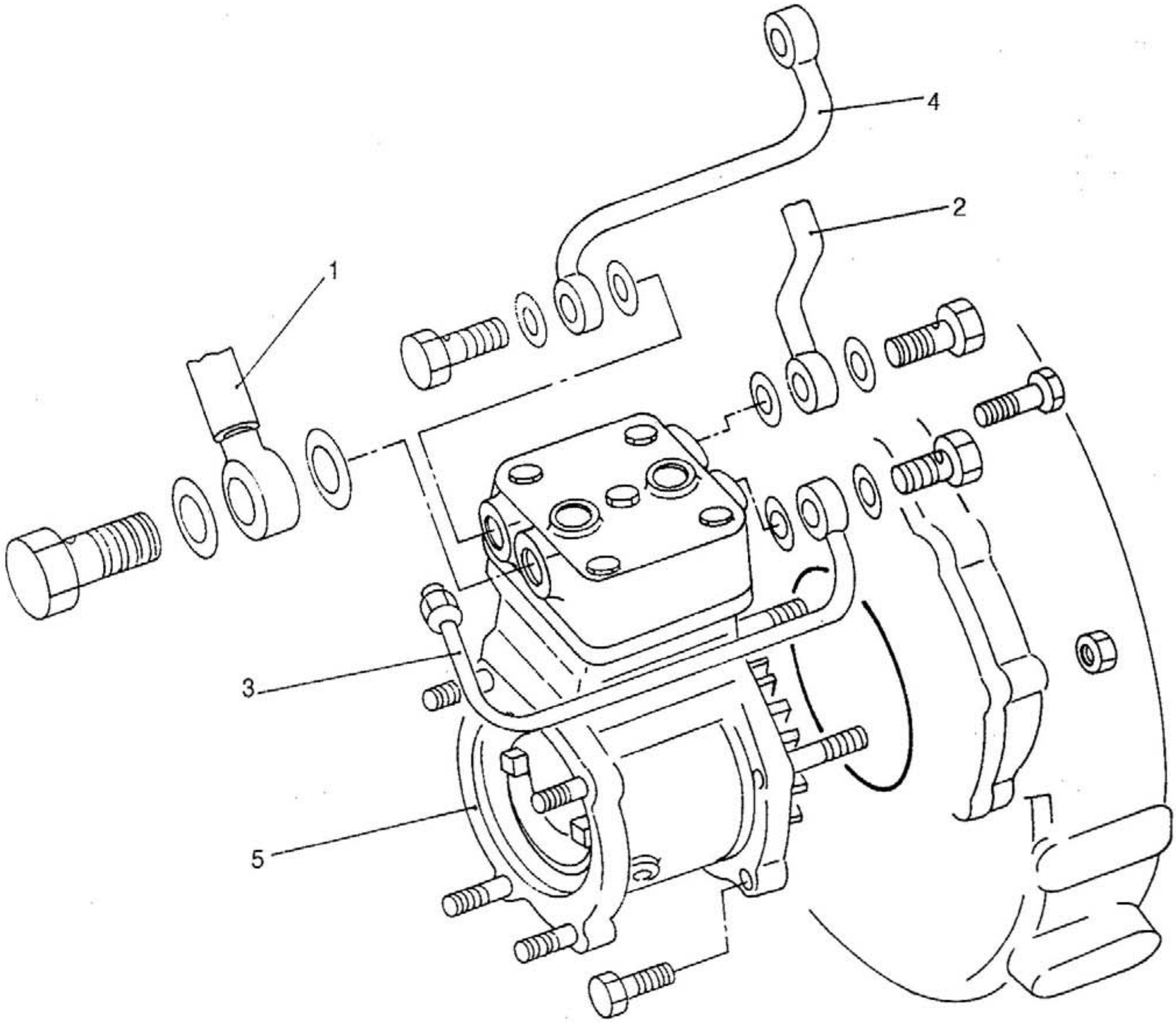
2) Line up the inscribed lines of the timer and timer case or the injectin pump gear and injection pump flange.





5-2-4 Air Compressor [Option]

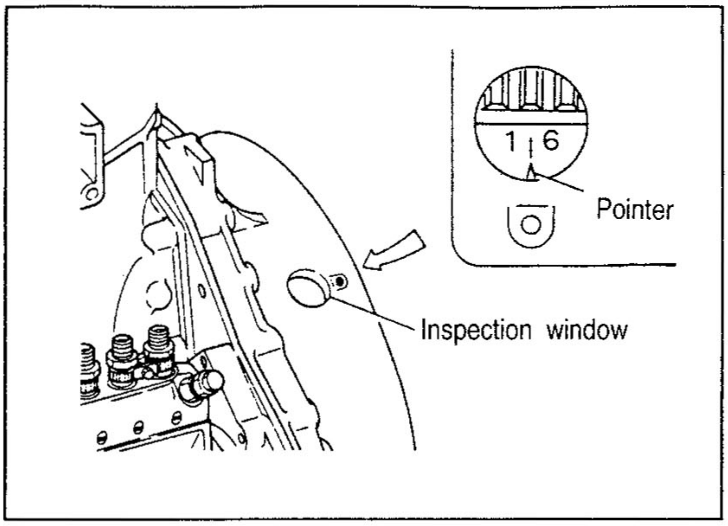
(1) Removal



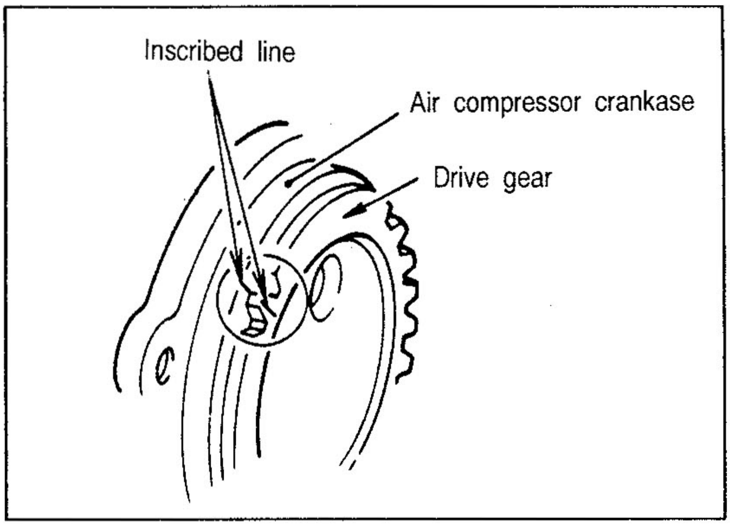
1 Air surtion hose
2 Air outlet pipe
3 Water inlet pipe
4 Water outlet pipe
5 Air compressor

(2) Installation

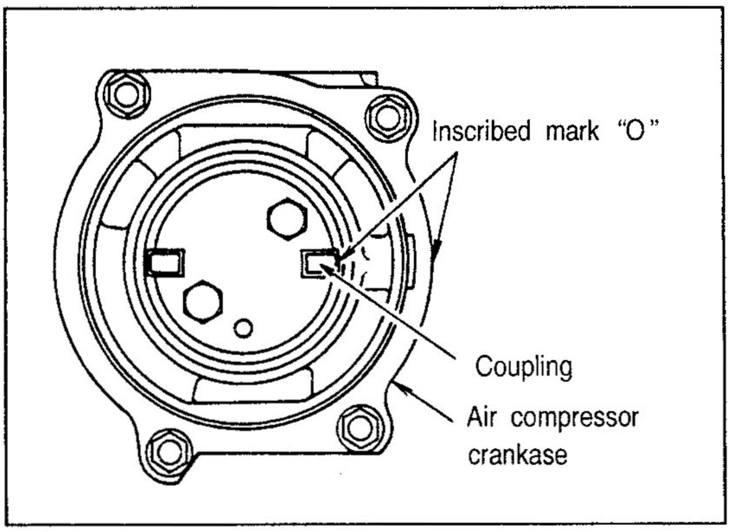
(a) Place the piston in the No. 1 cylinder of the engine at the top dead center on the compression stroke.



(b) Line up the inscreibed lines of the drive gear and air compressor crankcase.

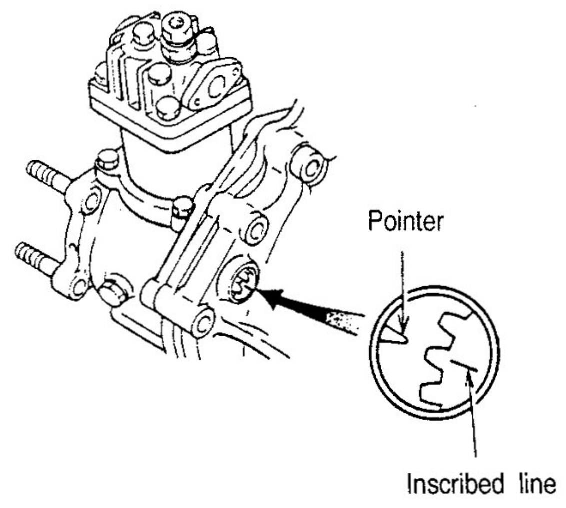


(c) Check to ensure that the inscribed marks "O" on the coupling and air compressor crankcase are in alignment.



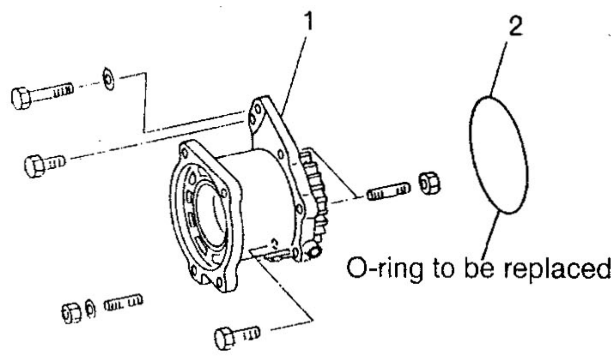
(d) After the air compressor has been mounted to the flywheel housing, remove the inspection plug of the flywheel housing and check to see that the inscribed line of the drive gear is in alignment with the pointer.

If they are out of alignment, re-install.



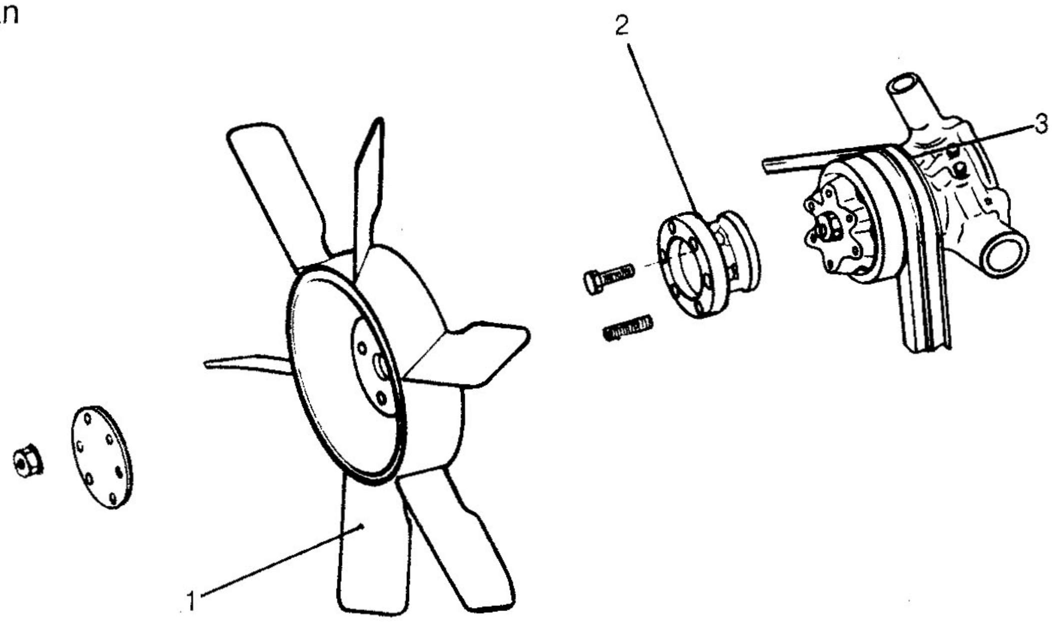
5-2-5 Injection pump drive

1. Injection pump drive
2. O-Ring



5-2-6 Cooling

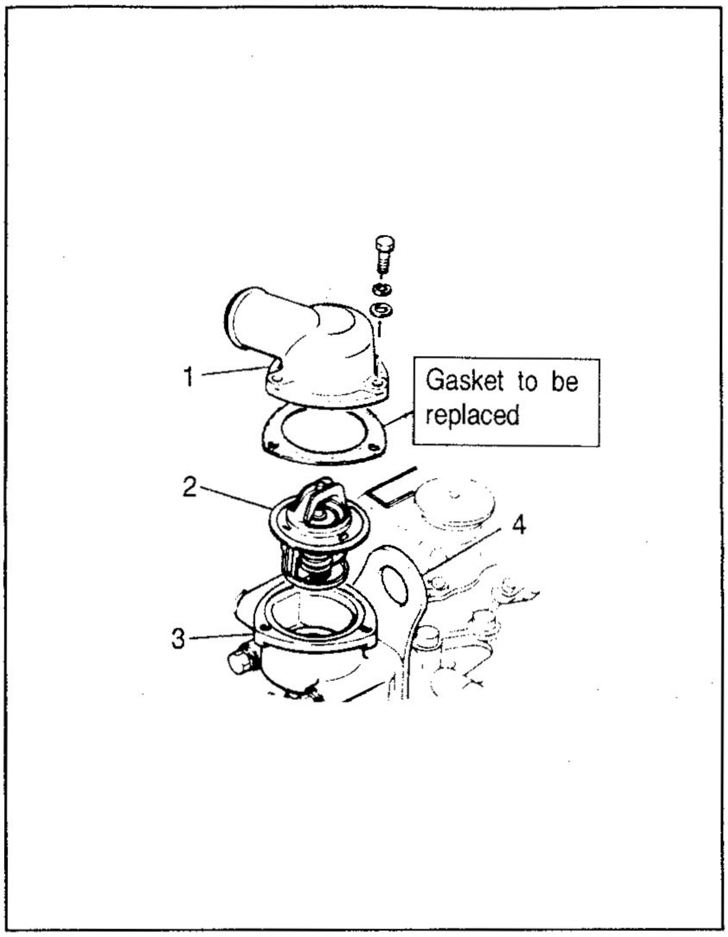
1. Fan
2. Coupling-Fan
3. V-Belt



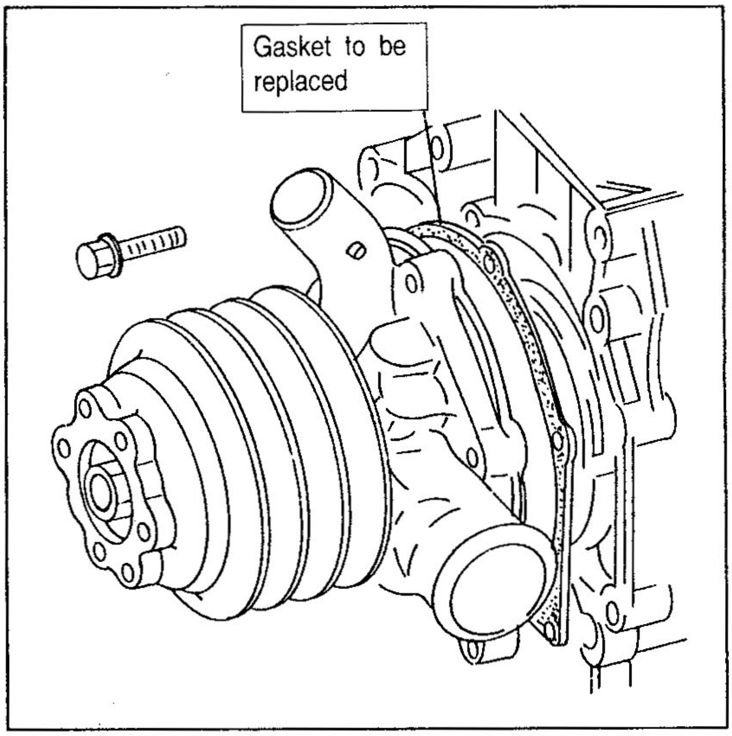
(2) Thermostat

1. Thermostat cover
2. Thermostat
3. Thermostat case
4. Front hanger

NOTE : Thermostat case and front hunger must not be replaced unless when checking for water leaks.



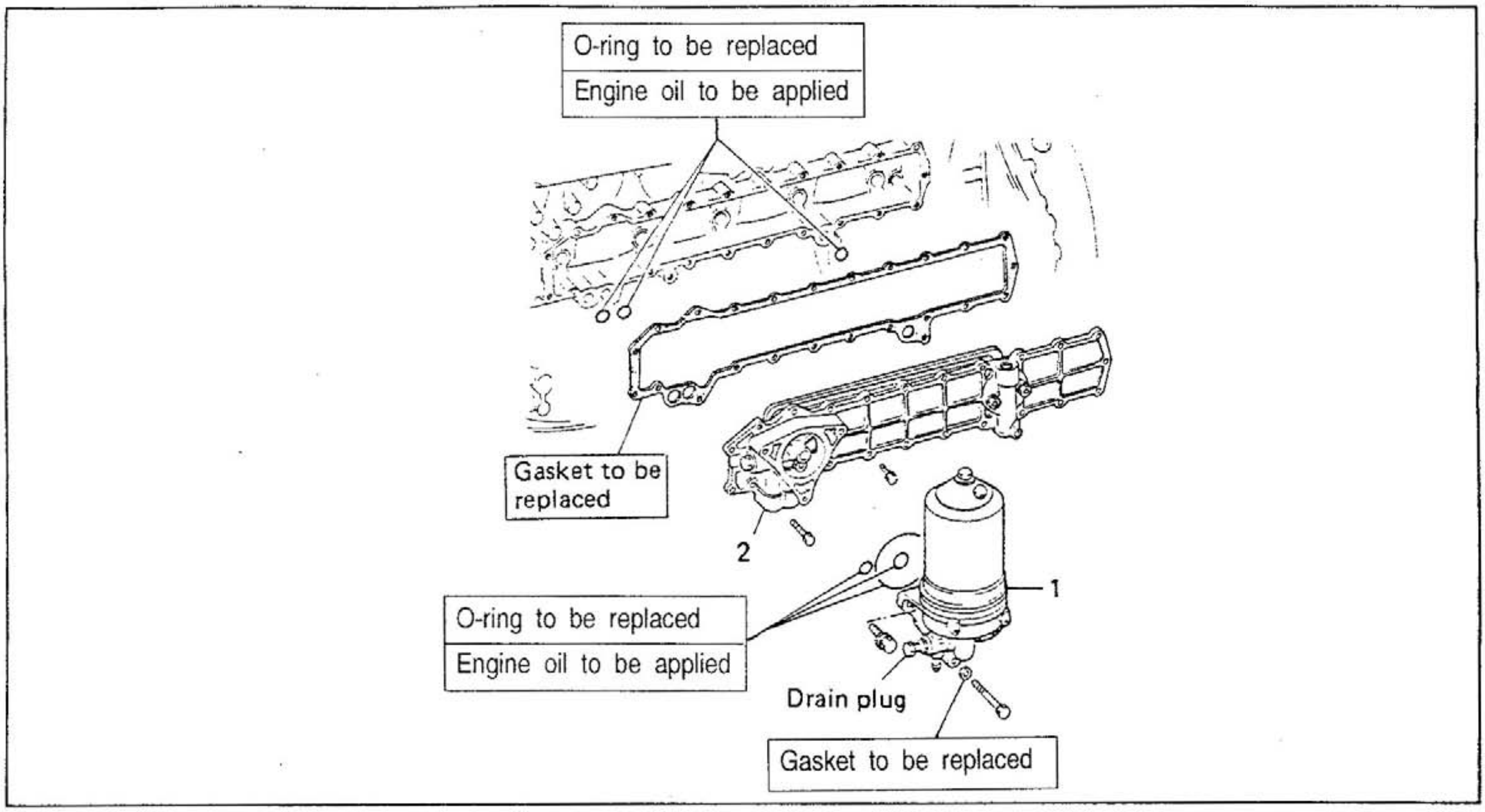
(3) Water Pump



5-2-7 Lubrication

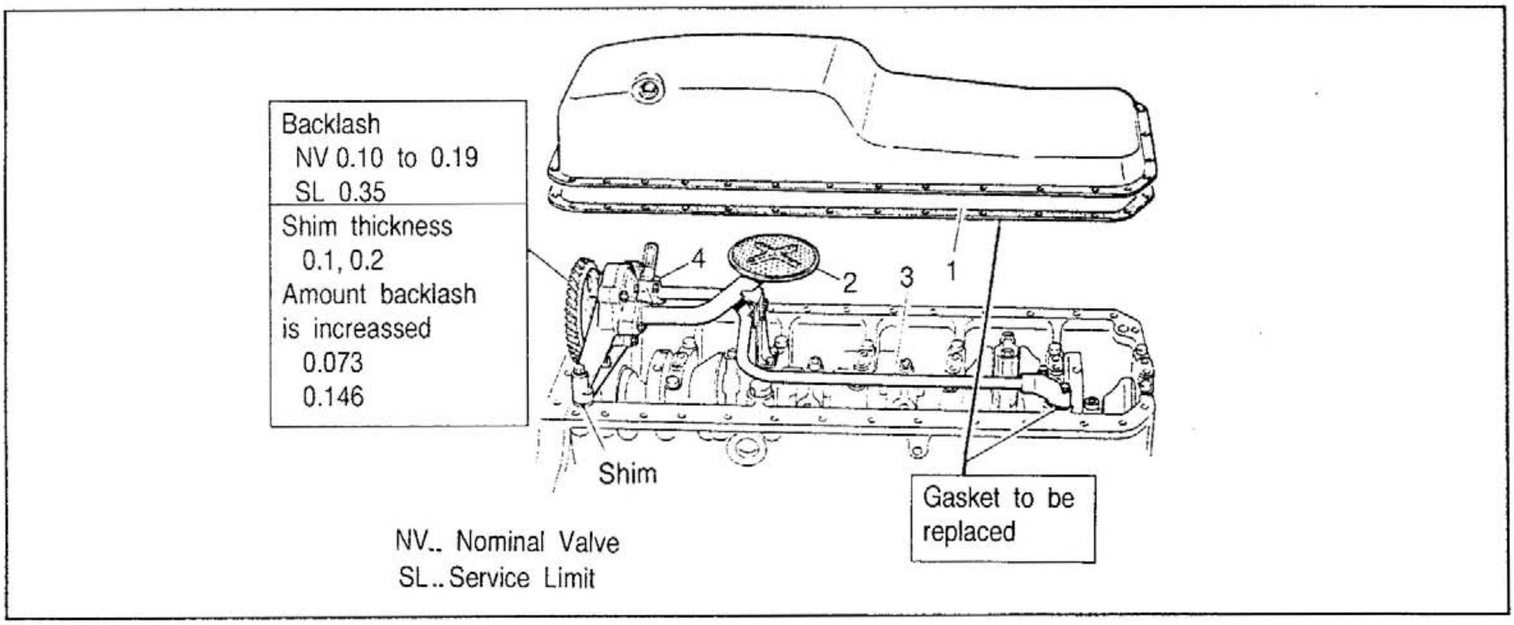
(1) Oil Filter and Oil Cooler

1. Oil filter
2. Oil cooler



(2) Oil Pump and Oil Strainer

1. Oil pan
2. Oil strainer
3. Oil pipe
4. Oil pump



If an adjusting shim is installed, use one of the same thickness for installation.

When the oil pump assembly is replaced, measure and adjust the gear backlash.

NOTE : 1. The oil strainer 2 and oil pipe 3 should be removed together with the oil pump unless anything wrong is evident.

2. Use adjusting shims of the same thickness at right and left.

6-1 DISASSEMBLY

This paragraph contains the procedures for disassembly of the engine proper with the auxiliaries removed. The procedures, shown for the purpose of overhaul, are merely fundamental examples and may be changed as the occasion may demand.

In disassembly of some of the parts, unnecessary procedures may be omitted.

When parts are disassembled, ovserve the following occasion may demand.

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

(4) Before the parts are disassembled and cleaned, use special care not to overlook the symptoms or phenomena that may be hard to find after disassembly and cleaning.

(5) Clean the engine proper after removal of the electrical parts(alternator, starter and wiring), V-belt, rubber hose, etc.
In servicing the engine proper, use the following tools and measuring instruments.

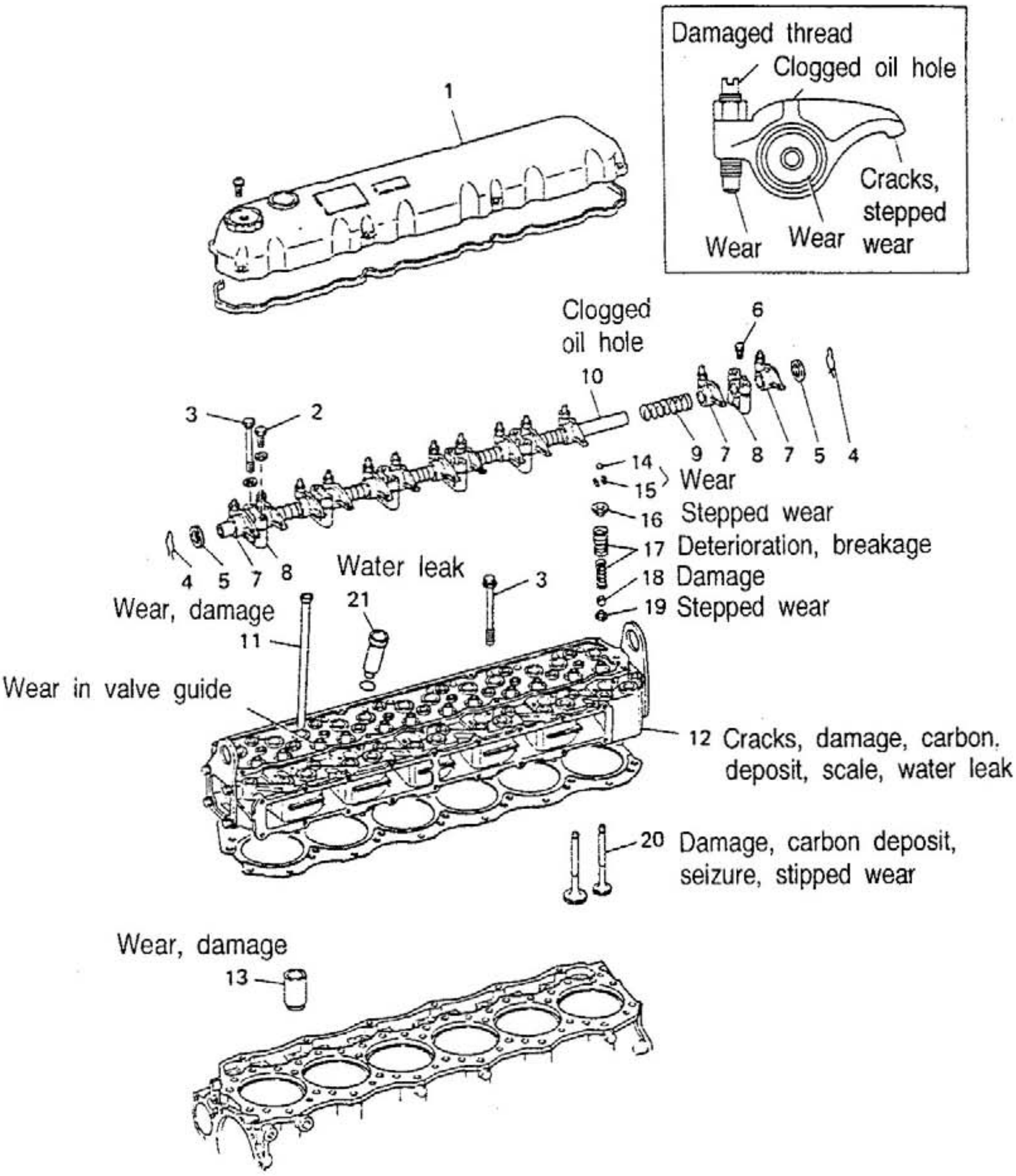
Special Tool Name	Part No.	Use
Valve Lifter	MH061668	Removal and installation of valve cotter
Valve Lifter Hook	MH061679	
Valve Stem Seal Installer	MH061293	Installation of valve stem seal
Nozzle Tube Remover	MH061232	Removal of nozzle tube
Nozzle Tube Flange	MH061416	Installation of nozzle tube
Nozzle Tube Stamp	MH061229	
Nozzle Tube Installer Bolt	MH061231	
Gear Puller	MH061326	Removal of gears
Plug	MF665007	Blind plug to be used when camshaft gear is removed

Special Tool Name		Part No.	Use	
Piston Ring Tool		30091-07100	Removal and installation of piston ring	
Piston Guide		MH061760	Insertion of piston	
Piston Guide Lever		MH061658	Insertion of piston	
Cone Puller		MH061697	Removal of crankshaft taper cone	
Bearing Cap Extractor		MH061189	Removal of main bearing cap	
Cylinder Liner Exteractor		MH061761	Removal of cylinder liner	
Cylinder Liner Installer		MH061771	Installation of cylinder liner	
Rocker Bushing Puller		MH061777	Replacement of rocker bushing	
Valve Guide Remover		MH061066	Removal of valve guide	
Valve Guide Installer		MH061470	Installation of oil seal slinger	
Valve Lapper		30091-07500	Lapping of valve seat	
Caulking Tool Body		MH061067		
Installer Ring	For inlet	MH061693	Installation of valve seat	
	For exhaust	MH061694		
Idler Gear Bushing Puller		MH061076	For No. 1 idler gear	Replacement of bushing
		MH061196	For No. 2 idler gear	
Connecting Rod Bushing Puller		MH061193	Replacement of connecting rod bushing	

General Tools and Measuring Devices

Snap ring pliers	Valve seat cutter	Portable jack
Square	Connecting rod aligner	Thickness gauge
Micrometer	Spring tester	Dial gauge
Cylinder gauge	Straight edge	Magnet stand
Surface plate	Calipers	Torque wrench
V-block	Caliper gauge	

6-1-1 Cylinder Head and Valve Mechanism

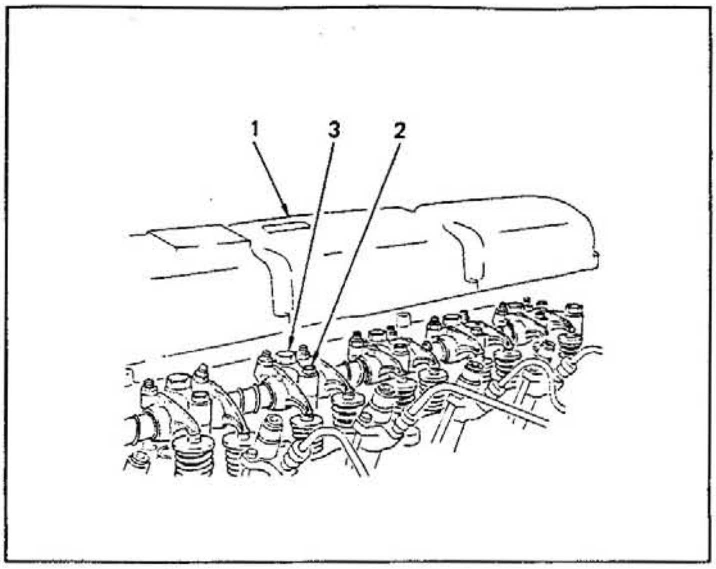


1	Rocker cover	8	Rocker shaft bracker	15	Valve cotter
2	Rocker bracker bolt	9	Rocker shaft spring	16	Upper retainer
3	Cylinder head bolt	10	Rocker shaft	17	Valve spring
4	Snap ring	11	Push rod	18	Valve stem seal
5	Washer	12	Cylinder head	19	Lower retainer
6	Set screw	13	Tappet	20	Valve
7	Rocker	14	Valve cap	21	Nozzle tube

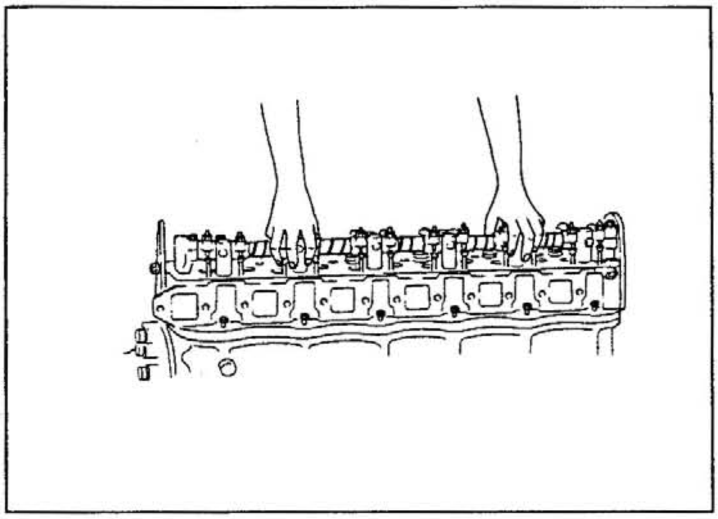
(1) Remove the following parts.

1 Rocker cover
2 Rocker bracket bolt
3 Cylinder head bolt

NOTE : Where the push rods are pushing the rockers up, loosen the adjusting screws before the bolt are removed.

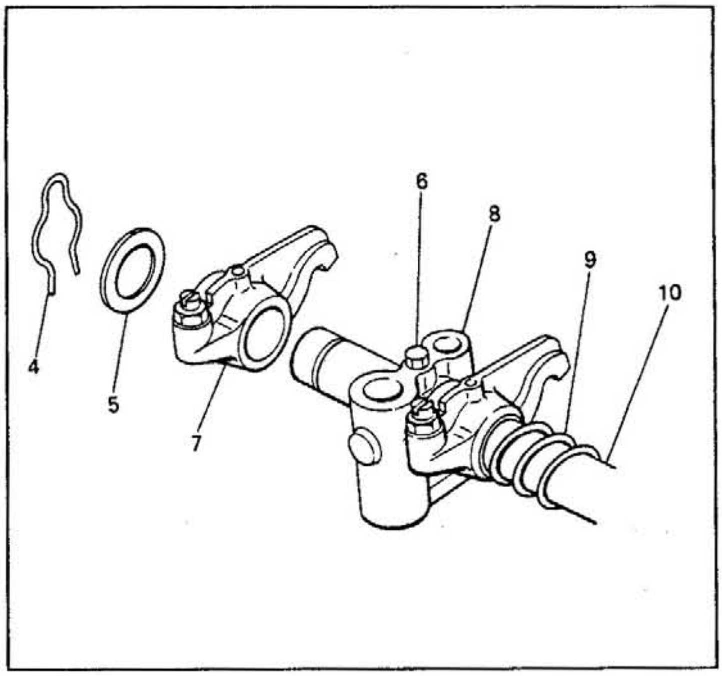


(2) Remove the rocker and bracket assembly from the cylinder head.

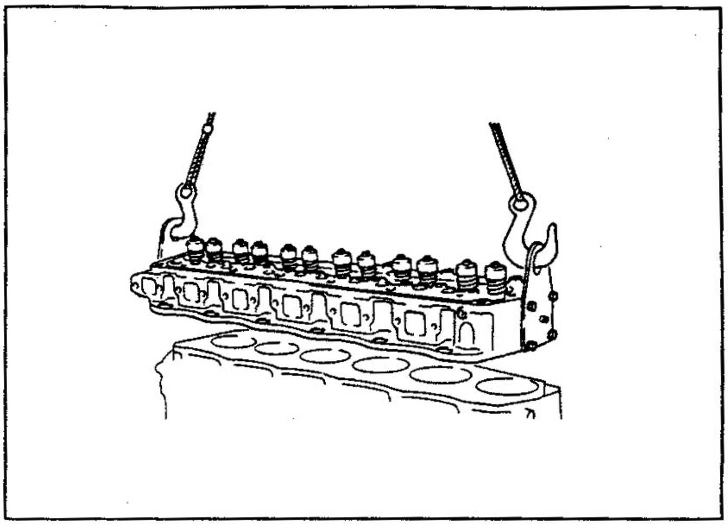


(3) Remove the following parts.

4 Snap ring
5 Washer
6 Set screw
7 Rocker
8 Rocker shaft bracket
9 Rocker shaft spring
10 Rocker shaft



(4) Withdraw the push rod 11 and remove the cylinder head 12 from the crankcase.

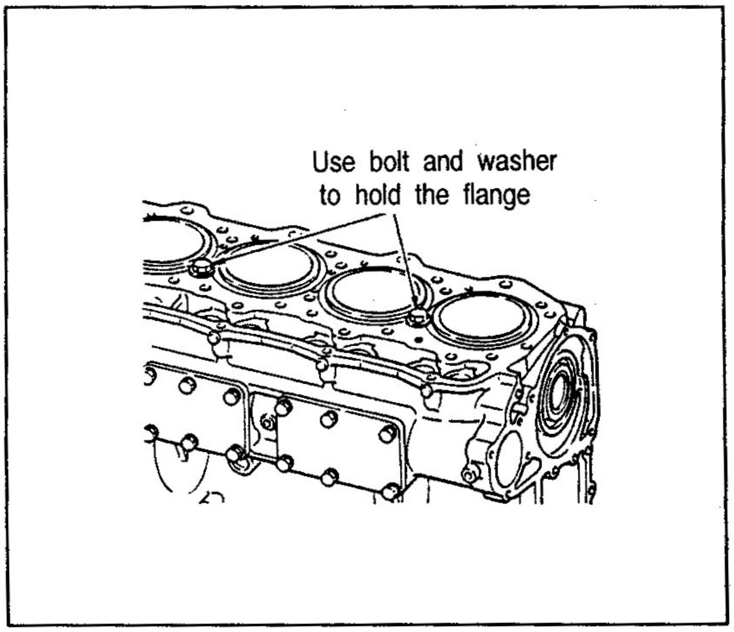


NOTE : 1. Make sure that the injection nozzle is removed before operations.

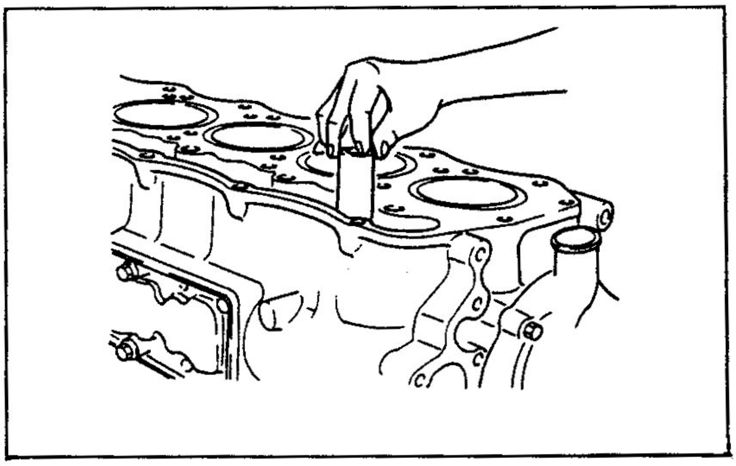
If the cylinder head is placed on a work bench with the nozzle attached, the nozzle tip projecting from the bottom surface of the cylinder head might be damage or deformed.

2. When the cylinder head gasket sticking to the crankcase is removed, take care not to scratch or pound the crankcase.

3. Cylinder liner may rise if the crankshaft is turned after removal of cylinder head. To prevent the liner from moving up, use bolt and washer to hold the flange of cylinder liner.

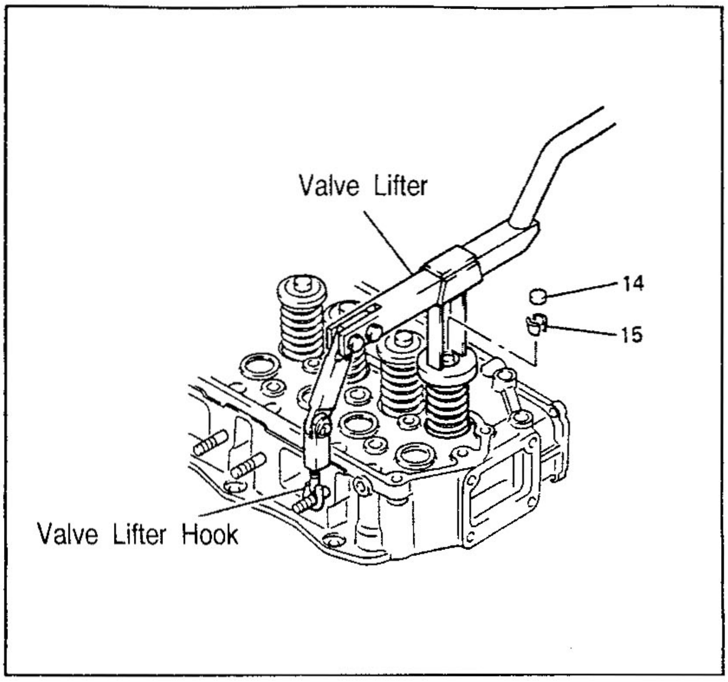


(5) Remove the tappet 13 from the crankcase.



(6) Remove the valve cap 14 and remove the valve cotter 15, using a Valve Lifter, (special tool).

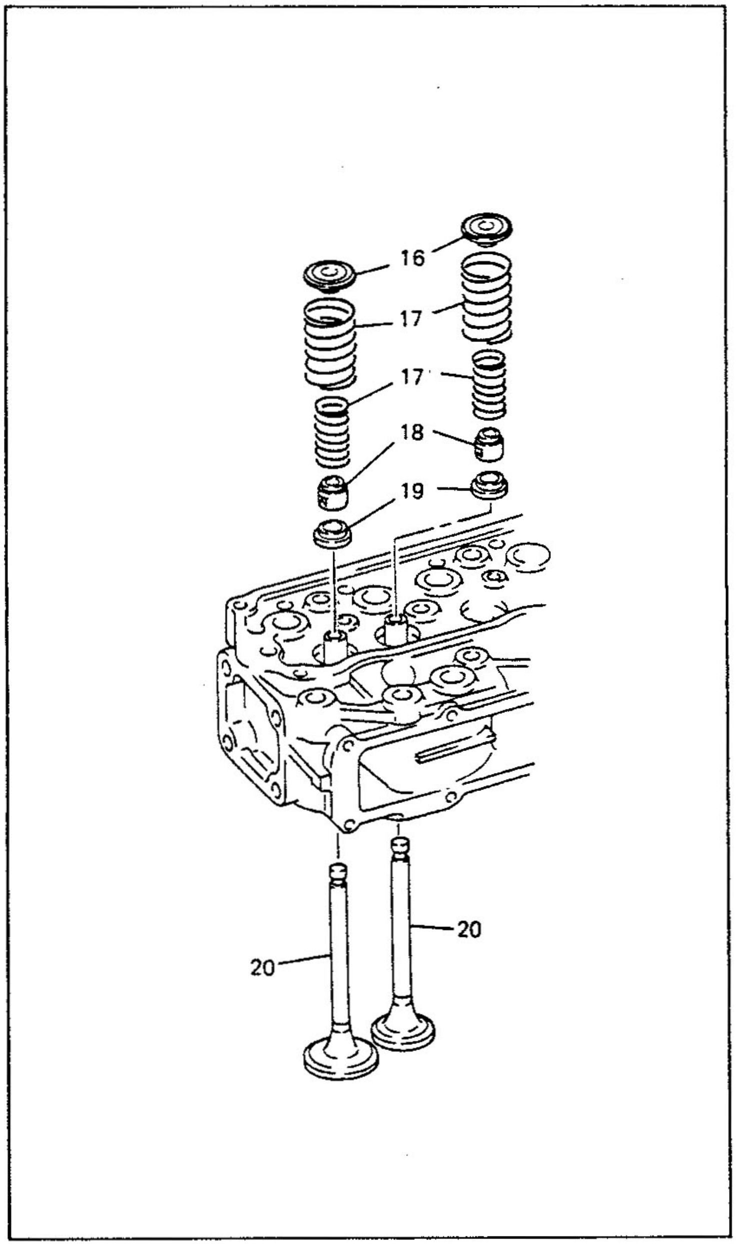
NOTE : Make sure that the valve spring is compressed evenly.



(7) While slowly relaxing the compressed valve spring, remove the following parts.

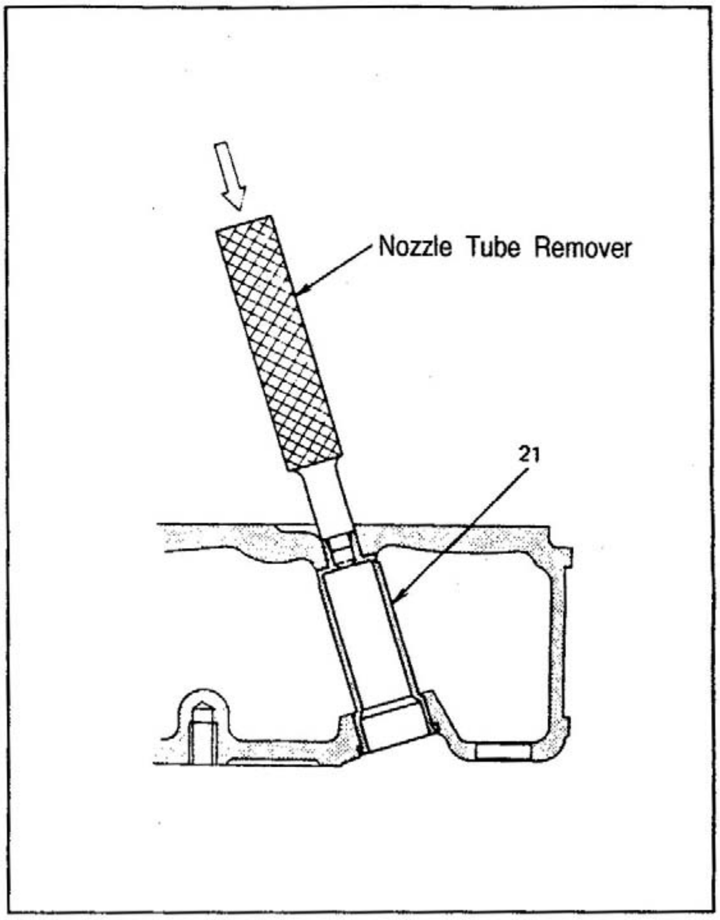
16 Upper retainer
17 Valve spring
18 Valve stem seal
19 Lower retainer
20 Valve

NOTE : When the valve stem seal or valve was removed, make sure the valve stem seal is replaced.



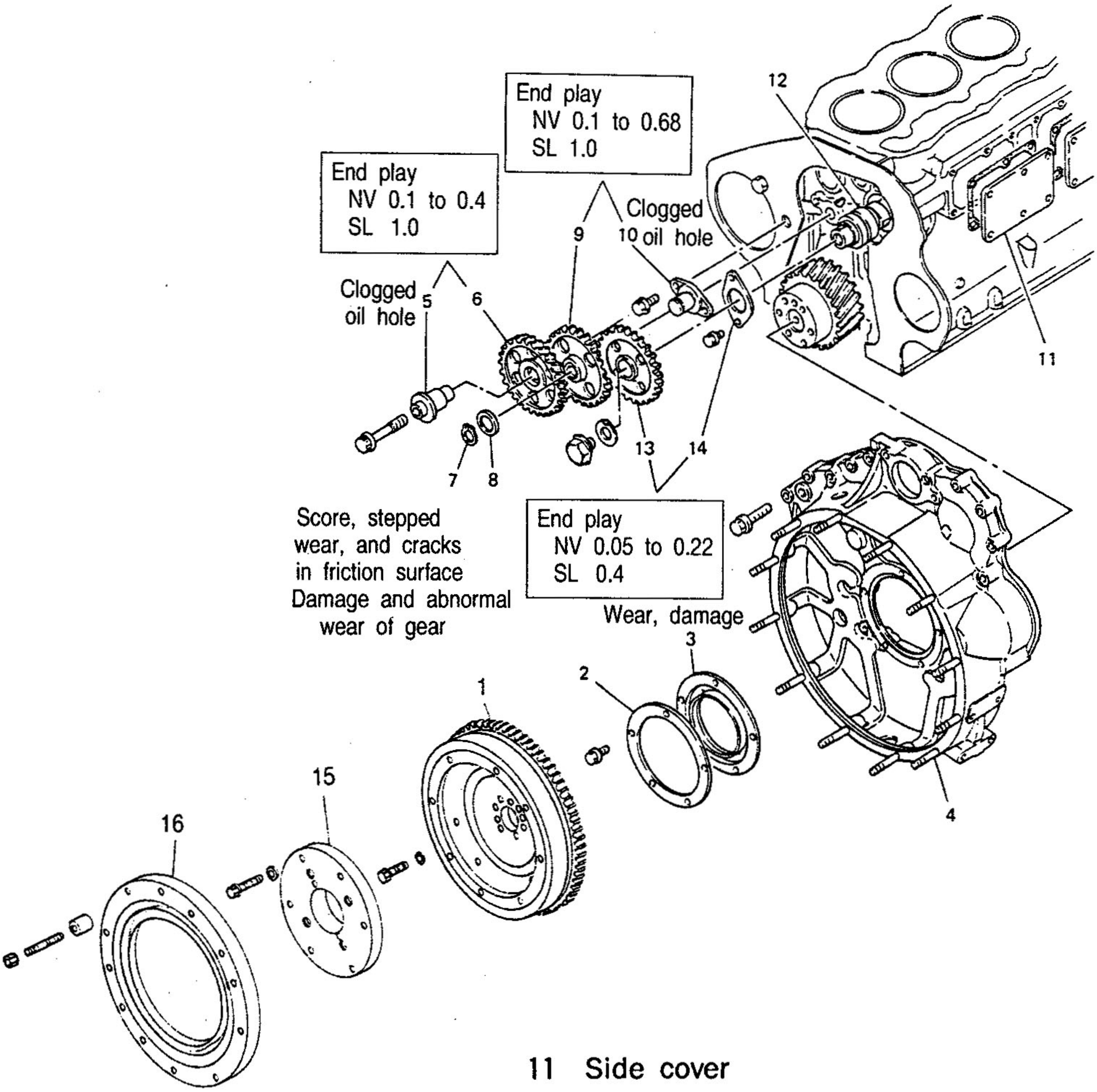
(8) Remove the nozzle tube 21 with Nozzle Tube Remover(special tool).

NOTE : Do not remove the nozzle tube unless trobles such as water leaks and gas leaks are evident.



6-1-2 Flywheel, Timing Gear and Camshaft

Crankshaft gear and idler gear No. 1 backlash NV 0.10 to 0.19 SL 0.35	Idler gear No, 1 and idler gear No. 2 backlash NV 0.11 to 0.24 SL 0.35
Idler gear No. 1 and injection pump gear (or air compressor gear) backlash NV 0.11 to 0.24 RL 0.35	Idler gear No. 2 and camshaft gear backlash NV 0.12 to 0.26 RL 0.35



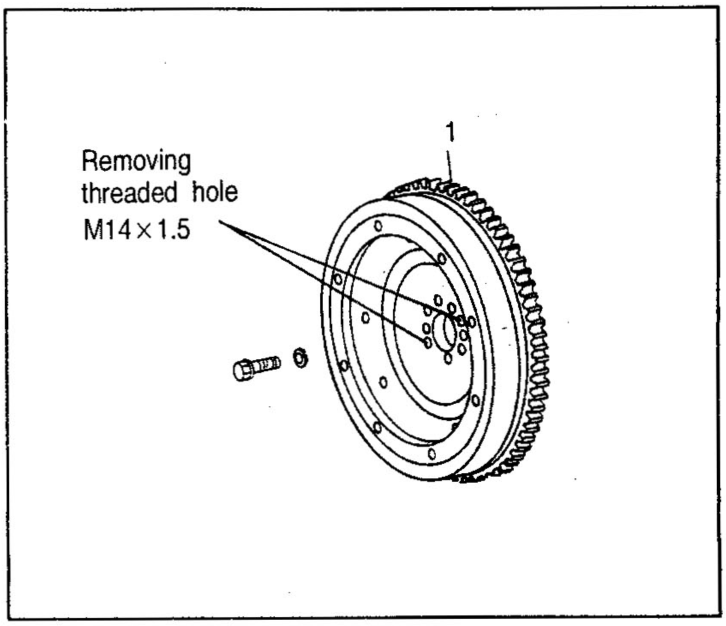
1	Flywheel	6	Idler gear No. 1	11	Side cover	
2	Washer plate	7	Snap ring	12	Camshaft	
3	Oil seal	8	Thrust washer	13	Camshaft gear	
4	Flywheel housing	9	Idler gear No. 2	14	Thrust plate	
5	Idler shaft No. 1	10	Idler shaft No. 2	15.	Adaptor	
				16.	Spacer	

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

(1) Remove the flywheel 1.

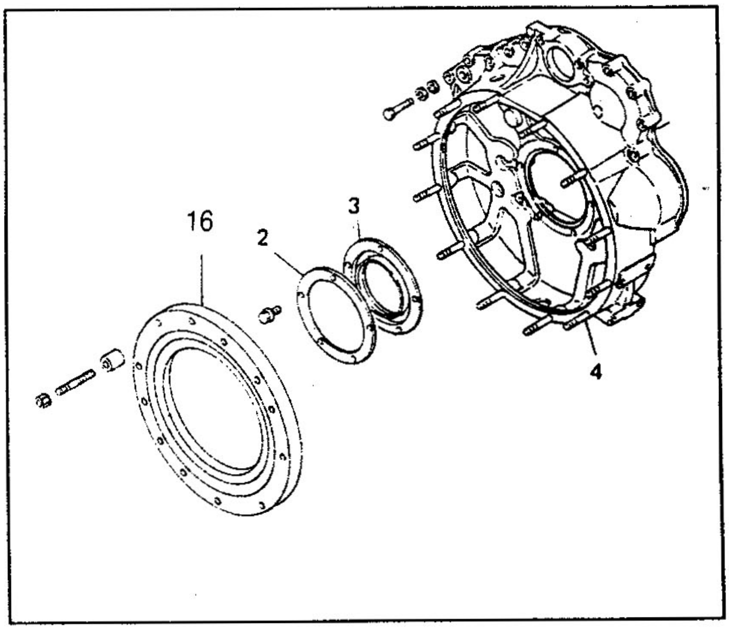
Remove the flywheel by evenly turning down bolts into the removing threaded holes.

Remove the ring gear with the flywheel attached.



(2) Remove the following parts.

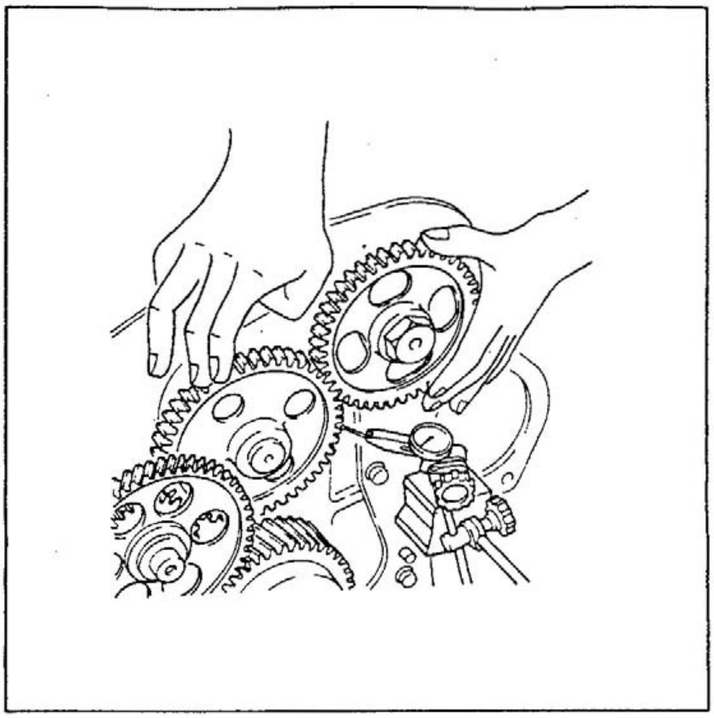
2 Washer plate
3 Oil seal
4 Flywheel housing
16. Spacer



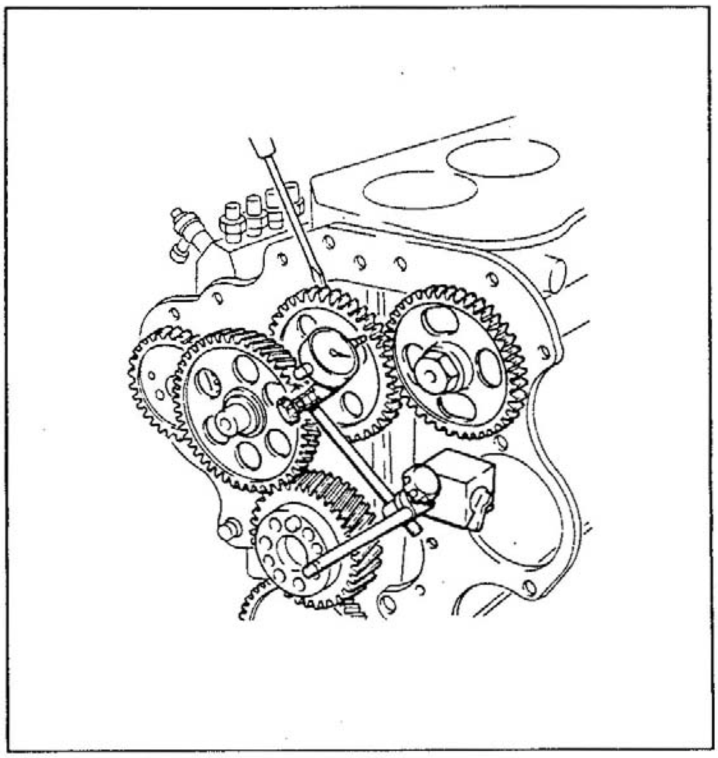
(3) Measure the backlash between gears, and a gear whose backlash is over the service limit should be replaced.

NOTE : 1. Measure the injectin pump gear backlash with the injectin pump or air compressor secured to the rear plate.

2. To determine whether the backlash for a pair of gears is up to specification, measure more than three points.



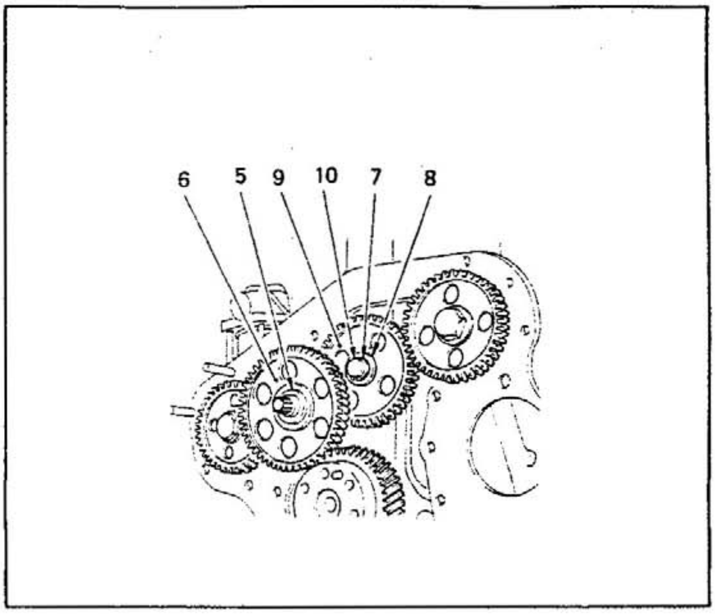
(4) Measure the end play of the idler gear No. 1 and idler gear No. 2 with a thickness gauge or dial gauge. If the repair limit is exceeded, replace the thrust washer or idler shaft.



(5) Remove the following parts.

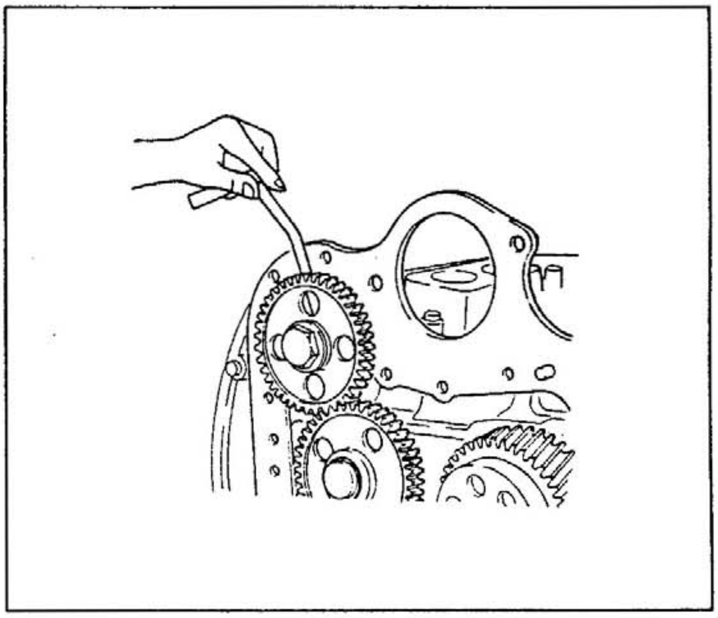
5 Idler shaft No. 1
6 Idler gear No. 1
7 Snap ring
8 Thrust washer
9 Idler gear No. 2
10 Idler shaft No. 2

NOTE : Remove the idler shat No. 1 and idler gear No. 1 as an assembly.



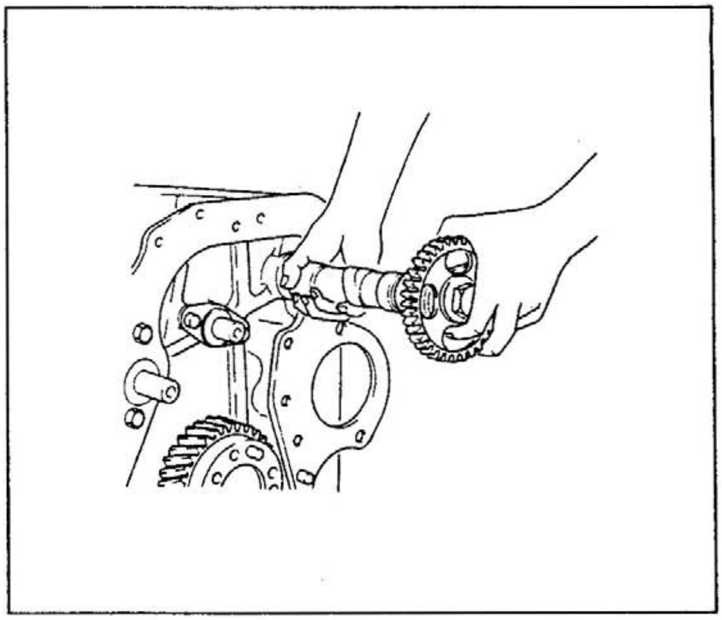
(6) Measure the end play of the camshaft gear with a thickness gauge or dial gauge.

If the service limit is exceeded, replace the thrust plate.



(7) After removing the side cover 11, remove the thrust plate attaching bolt to withdraw camshaft 12.

NOTE : When removing camshaft from the side cover. Support it by hand with care to prevent damage to the cam on the camshaft.



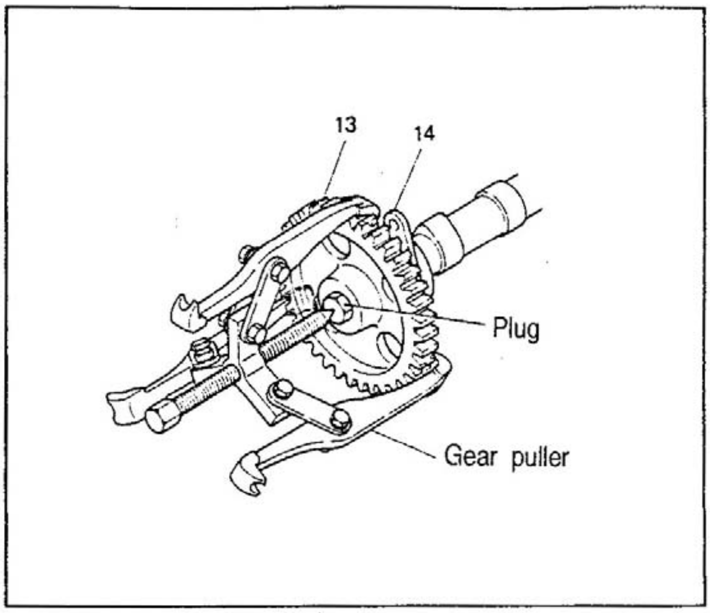
(8) Withdraw the camshaft gear 13 with Gear Puller (special tool).

When the camshaft gear is removed, install the plug in place of the gear attaching bolt.

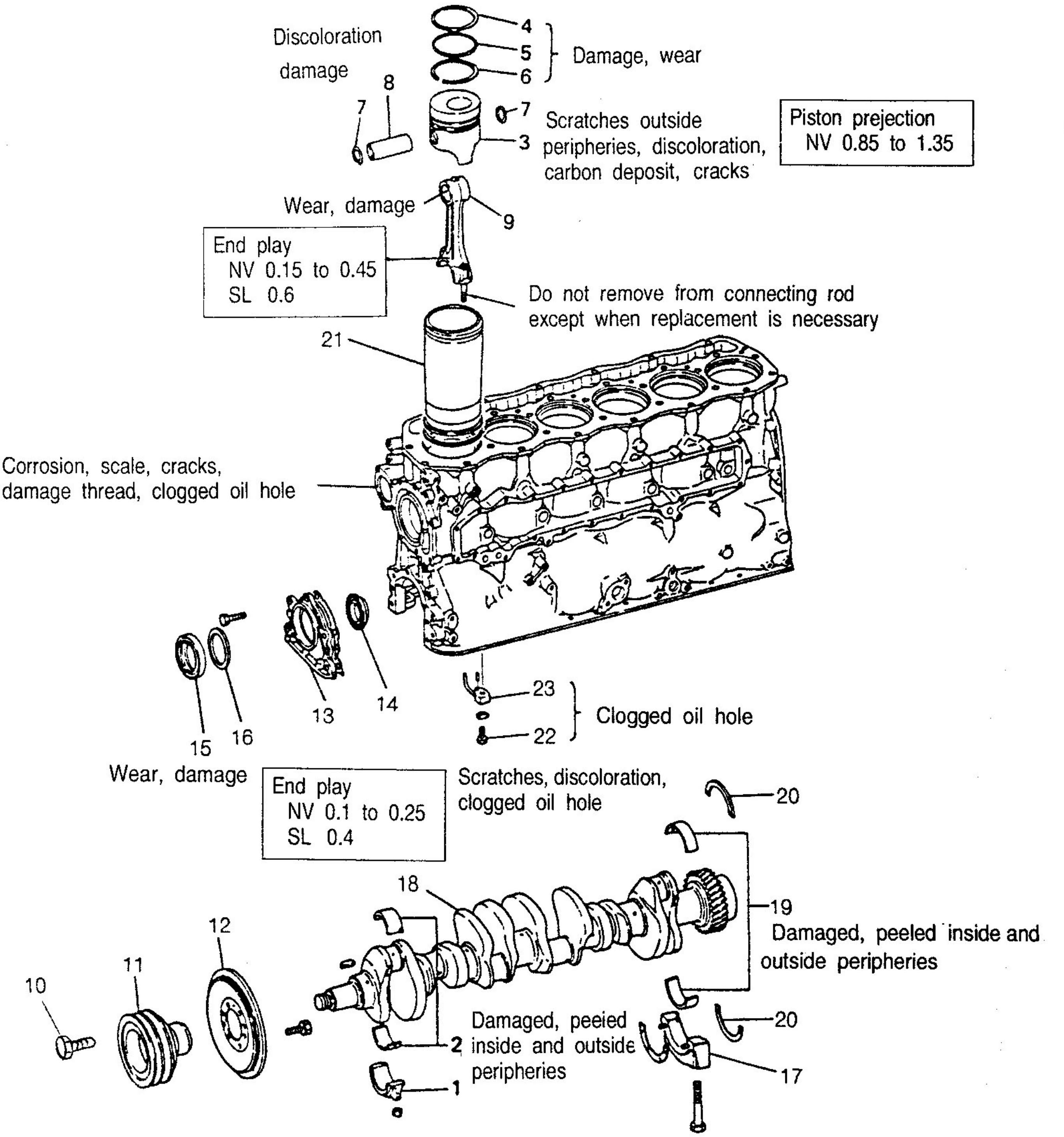
Remove the thrust plate 14.

NOTE : 1. Do not attempt disassembly unless trouble is evident.

2. Make sure that the plug is installed to the threaded portion, as the gear puller damages the threaded portion at the end of the camshaft.



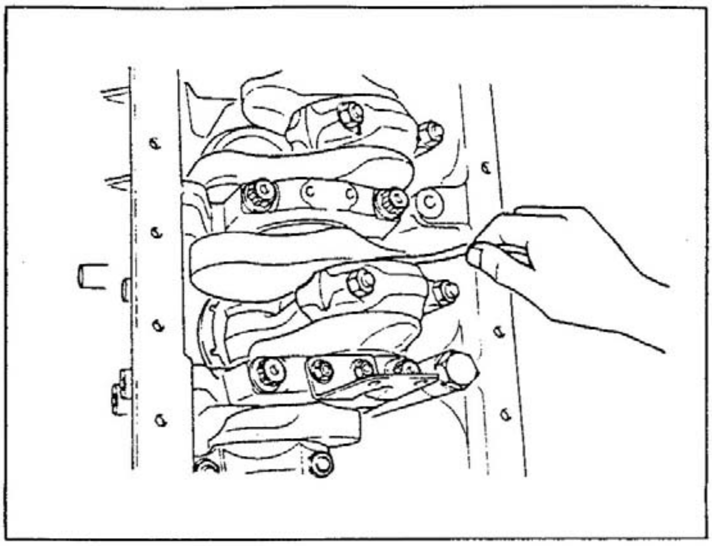
6-1-3 Crankcase and Main Moving Parts



1. Connecting rod cap
2. Connecting rod bearing
3. Piston
4. 1st compression ring
5. 2nd compressinon ring
6. Oil ring
7. Snap ring
8. Piston pin
9. Connecting rod
10. Crankshaft Bolt
11. Crankshaft pulley
12. Torsional damper
13. Front cover
14. Slinger
15. Oil seal
16. seal plate
17. Main bearing cap
18. Crankshaft
19. Main bearing
20. Thrust plate
21. Cylinder Liner
22. Check valve
23. Oil jet

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

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



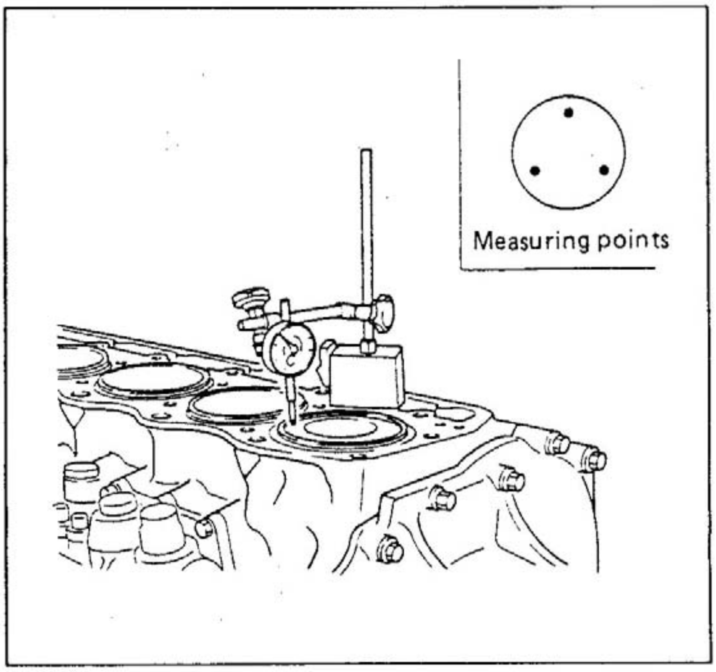
(2) Measure the projection of each piston by the following procedures. If the measurements are out of specification, check the connecting rod bushing, piston pin, connecting rod bearing, etc. parts found defective should be replaced.

(a) Hold the dial indicator to the top surface of the crankcase and set at zero.

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

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

NOTE : Make sure that the piston projection conforms to specification.



(3) Remove the following parts.

1 Connecting rod cap

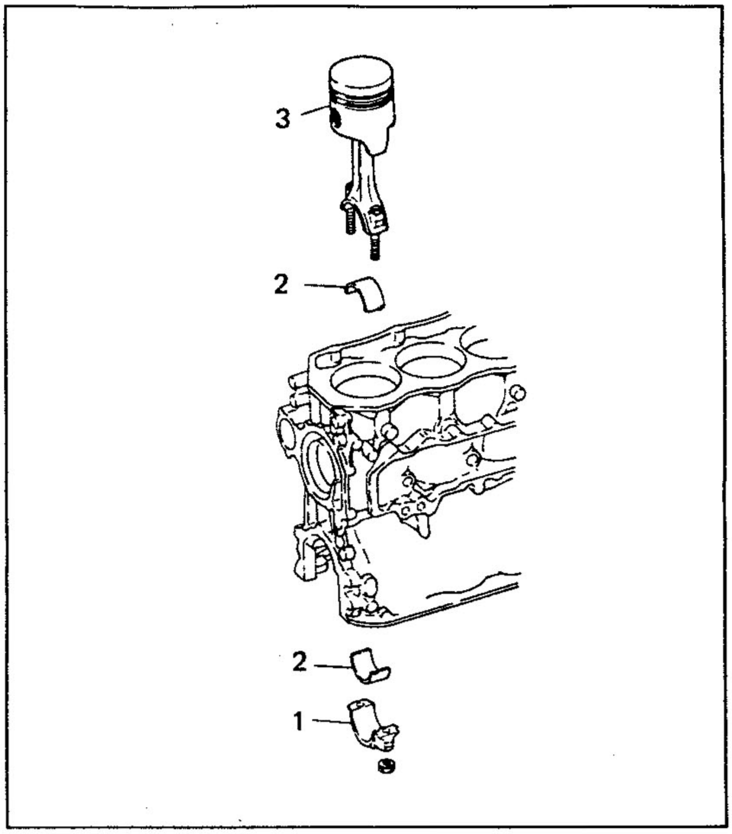
2 Connecting rod bearing

3 Piston

Remove the piston complete with the connecting rod from the crankcase by pushing up.

NOTE : 1. Shave off the stepped wear portion of the cylinder liner with a ridge reamer, etc.

2. Do not remove the bolt from the connecting rod. When a broken bolt is to be replaced, refer to "6-3-1 Crankcase and Main Moving Parts" and install a new bolt.

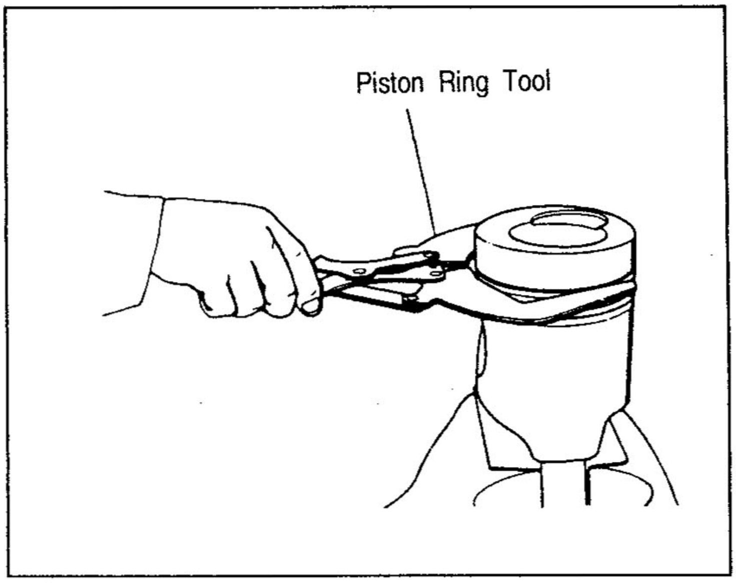


(4) Remove the piston rings, using Piston Ring Tool(special tool).

4 1st compression ring

5 2nd compression ring

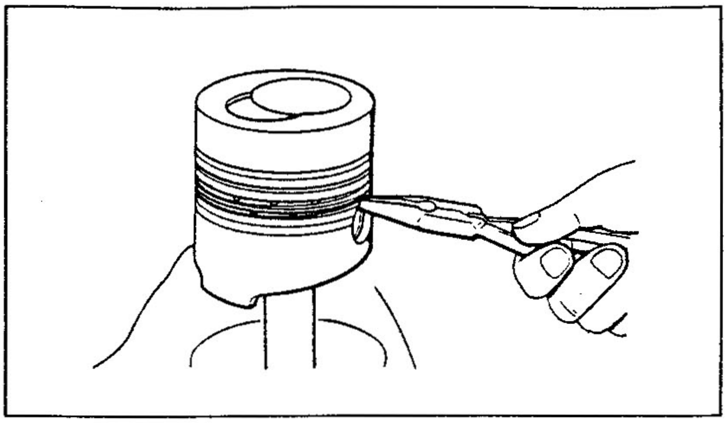
6 Oil ring



(5) Remove the following parts.

7 Snap ring
8 Piston pin
9 Connecting rod

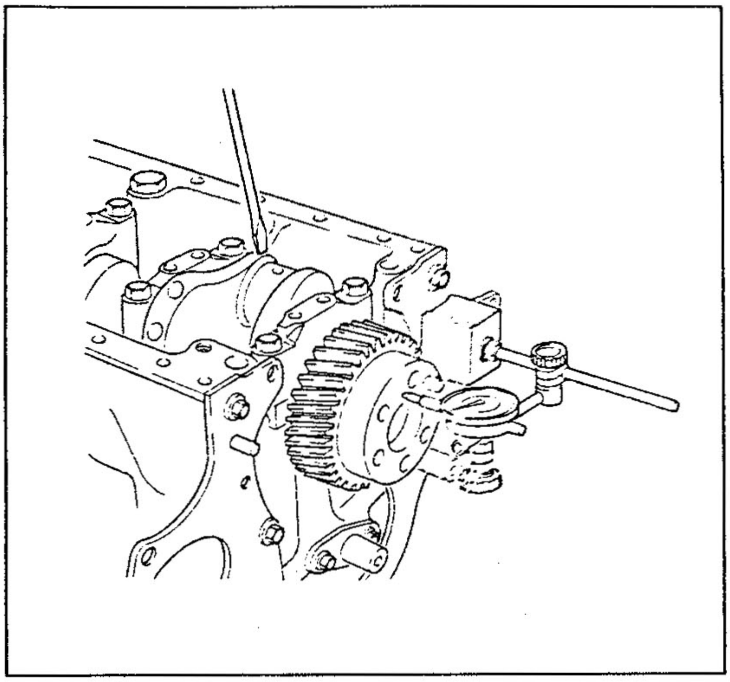
The piston and piston pin are clearance fitted. If the piston pin is hard to remove, heat it with a piston hearter or in hot water.



(6) Measure the end play of the crankshaft. If the repair limit is exceeded, replace the thrust plates with ones of properly selectd thicknesses.

Four kinds of thrust plates, 2.45mm, 2.60mm, 2.75mm and 2.90mm thick, are available.

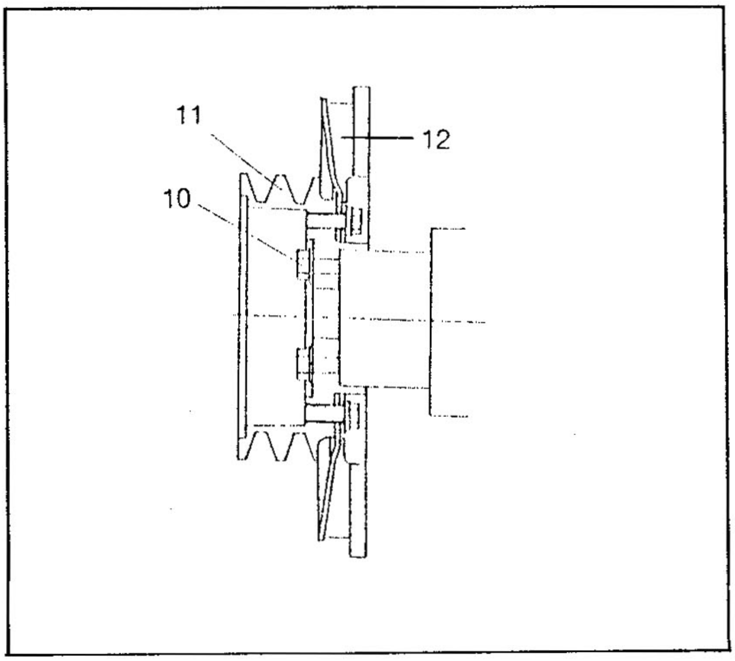
NOTE : 1. One thrust plate is mounted inside the rearmost end journal of the crankshaft and two outside.



2. The inside and outside thrust plates may be different in thickness, but the two outside ones must be equal in thickness.

(7) Remove the following parts.

10 Crankshaft Bolt
11 Crankshaft pulley
12 Torsional damper

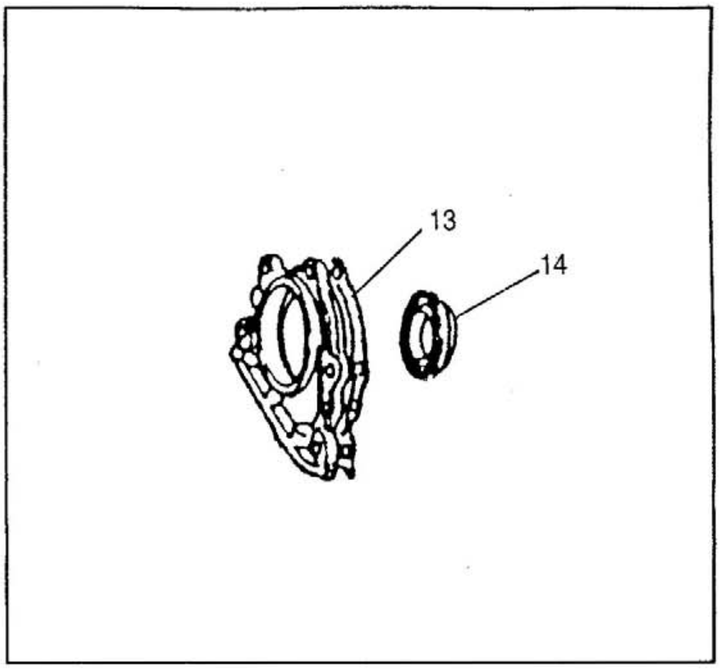


(8) Remove the following parts.

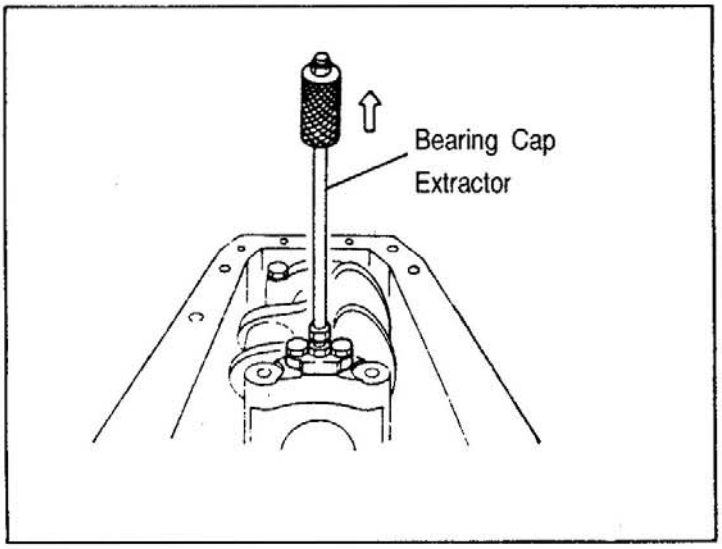
13 Front cover

14 Slinger

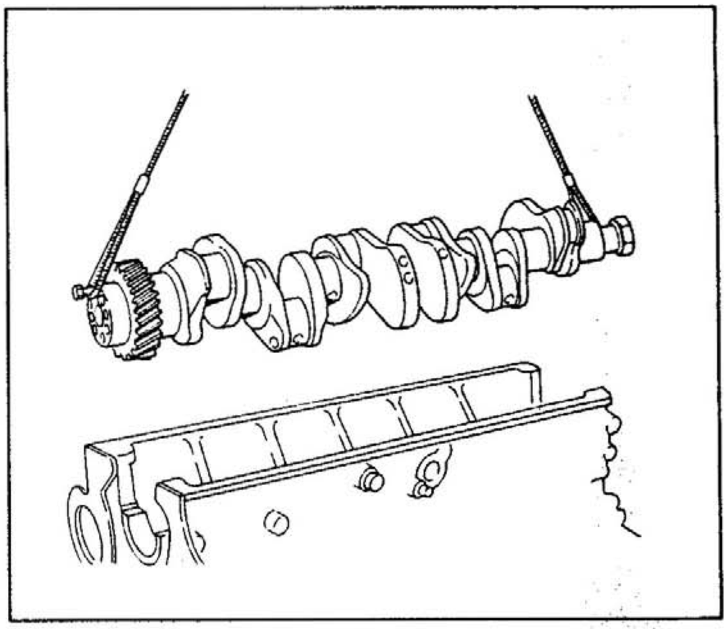
NOTE : Do not remove the oil seal 15 and seal plate 16 from the front cover unless defect is evident.



(9) Remove the main bearing cap 17 by using Bearing Cap Extractor(special tool).



(10) Slowly remove the crankshaft 18, using chain blocks, etc.

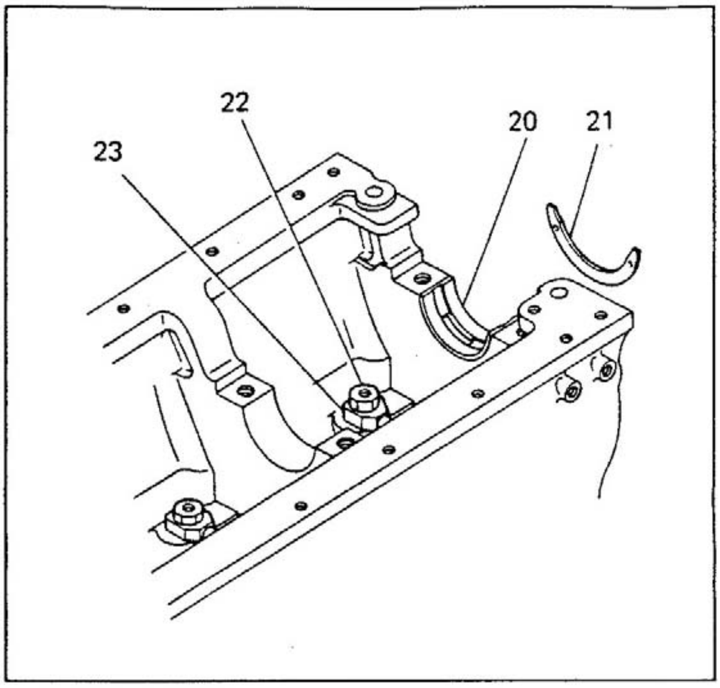


(11) Remove the following parts.

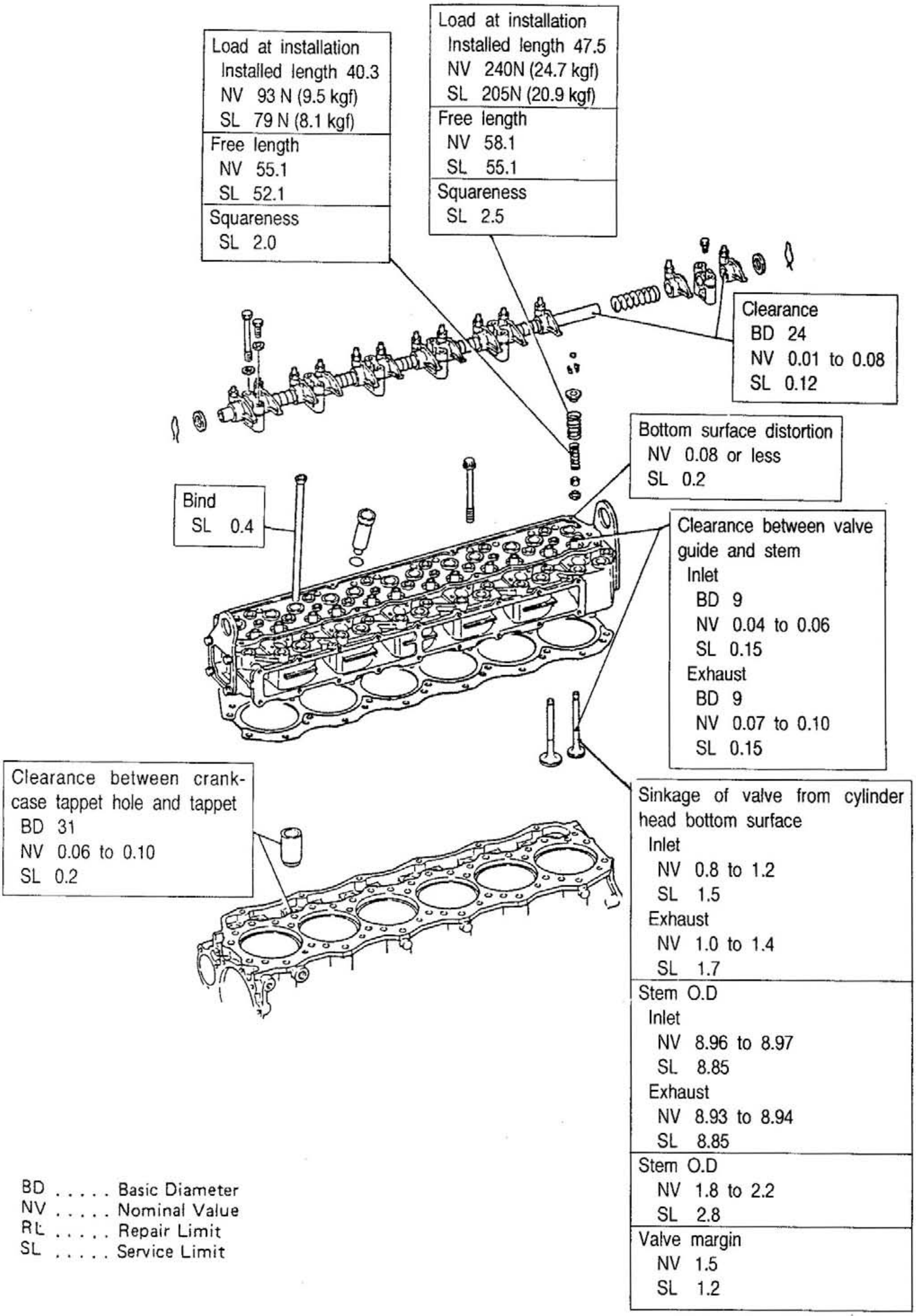
19 Main bearing

20 Thrust plate

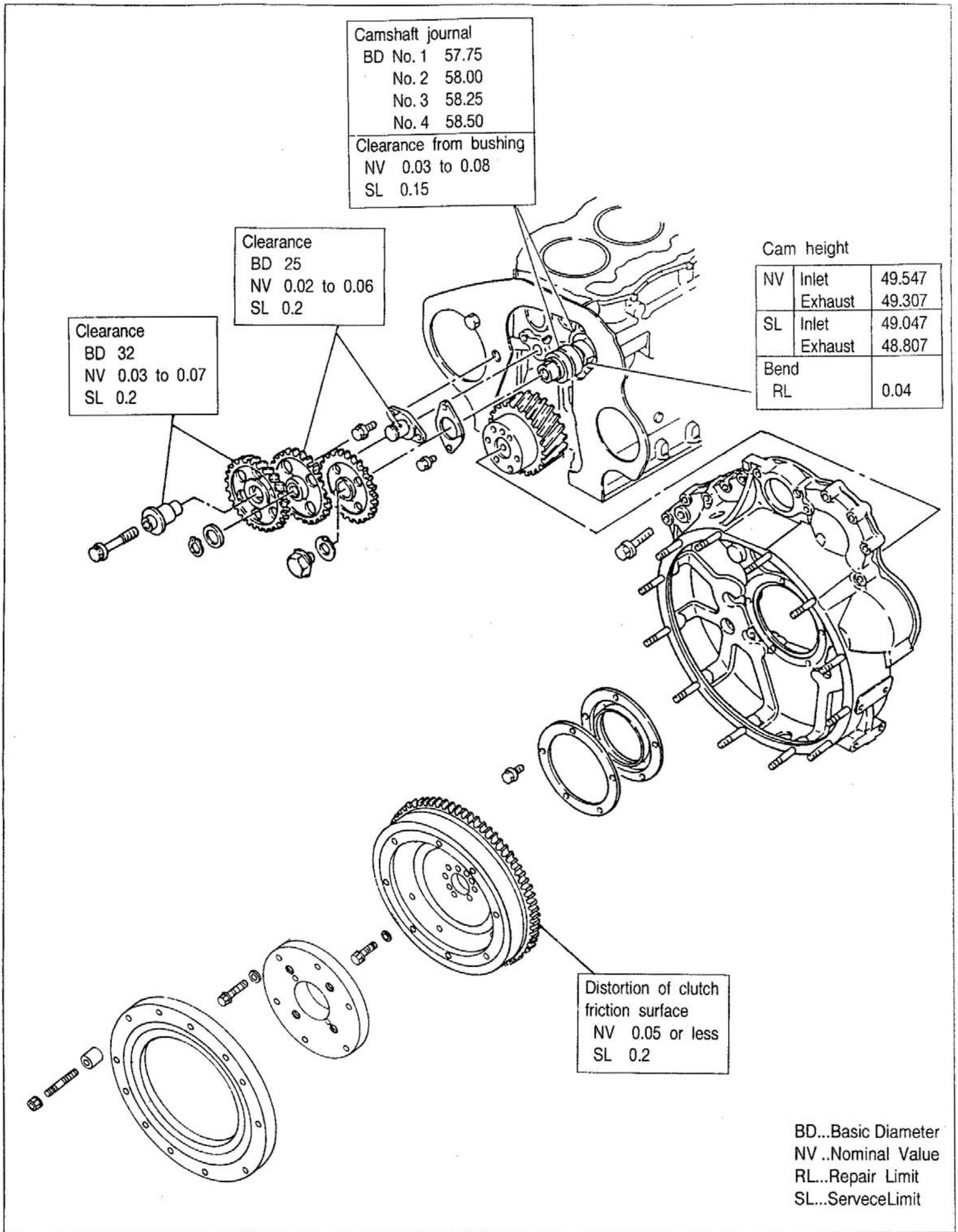
NOTE : Do not remove check valve 22 and oil jet 23 unless oil holes are clogged or other unusual conditions are evident.

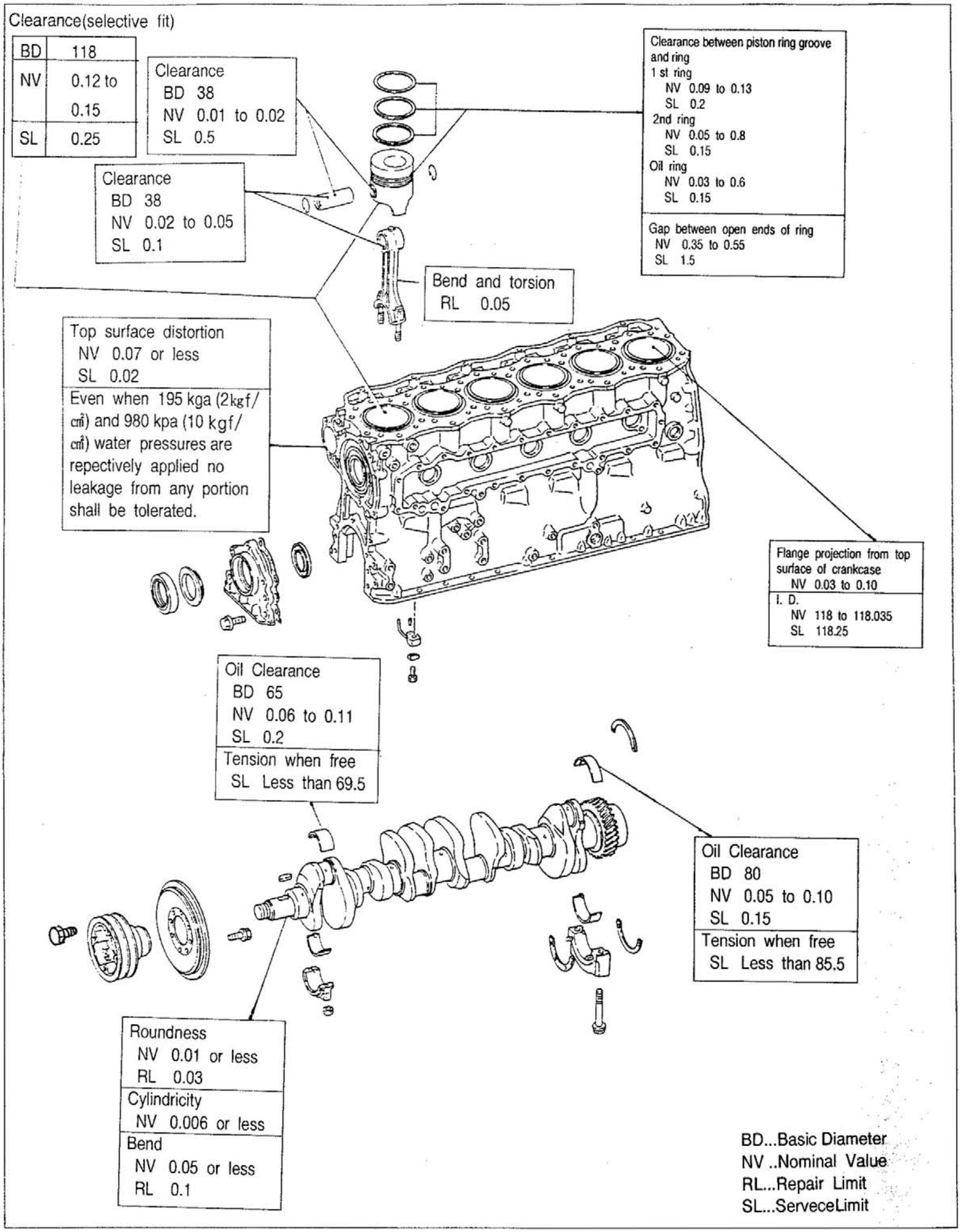


6-2 INSPECTION AND CORRECTION



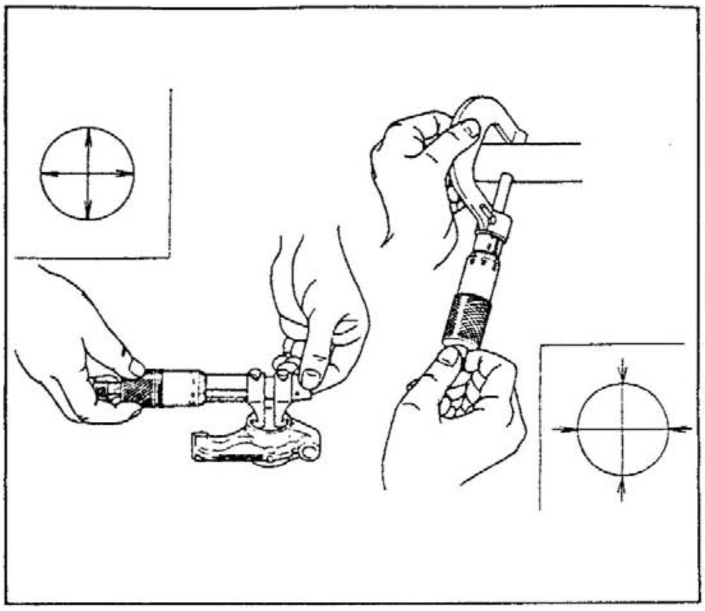
BD ..... Basic Diameter
NV ..... Nominal Value
RL ..... Repair Limit
SL ..... Service Limit


Camshaft journal
BD No. 1 57.75
No. 2 58.00
No. 3 58.25
No. 4 58.50
Clearance from bushing
NV 0.03 to 0.08
SL 0.15
Clearance
BD 25
NV 0.02 to 0.06
SL 0.2
Clearance
BD 32
NV 0.03 to 0.07
SL 0.2
Cam height
NV Inlet 49.547
Exhaust 49.307
SL Inlet 49.047
Exhaust 48.807
Bend
RL 0.04
Distortion of clutch friction surface
NV 0.05 or less
SL 0.2
BD...Basic Diameter
NV ..Nominal Value
RL...Repair Limit
SL...ServeceLimit


Clearance(selective fit)
BD 118
NV 0.12 to 0.15
SL 0.25
Clearance
BD 38
NV 0.01 to 0.02
SL 0.5
Clearance
BD 38
NV 0.02 to 0.05
SL 0.1
Clearance between piston ring groove and ring
1 st ring
NV 0.09 to 0.13
SL 0.2
2nd ring
NV 0.05 to 0.8
SL 0.15
Oil ring
NV 0.03 to 0.6
SL 0.15
Gap between open ends of ring
NV 0.35 to 0.55
SL 1.5
Bend and torsion
RL 0.05
Top surface distortion
NV 0.07 or less
SL 0.02
Even when 195 kga (2kgf/cm²) and 980 kpa (10 kgf/cm²) water pressures are repectively applied no leakage from any portion shall be tolerated.
Flange projection from top surface of crankcase
NV 0.03 to 0.10
I. D.
NV 118 to 118.035
SL 118.25
Oil Clearance
BD 65
NV 0.06 to 0.11
SL 0.2
Tension when free
SL Less than 69.5
Oil Clearance
BD 80
NV 0.05 to 0.10
SL 0.15
Tension when free
SL Less than 85.5
Roundness
NV 0.01 or less
RL 0.03
Cylindricity
NV 0.006 or less
Bend
NV 0.05 or less
RL 0.1
BD...Basic Diameter
NV ..Nominal Value
RL...Repair Limit
SL...ServeceLimit

6-2-1 Valve Mechanism

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

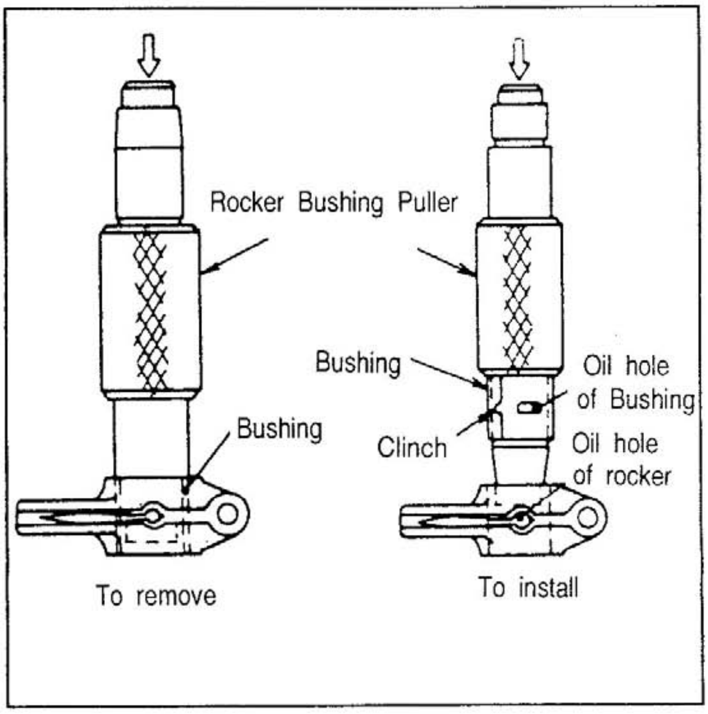


(2) Replacement of Rocker Bushing

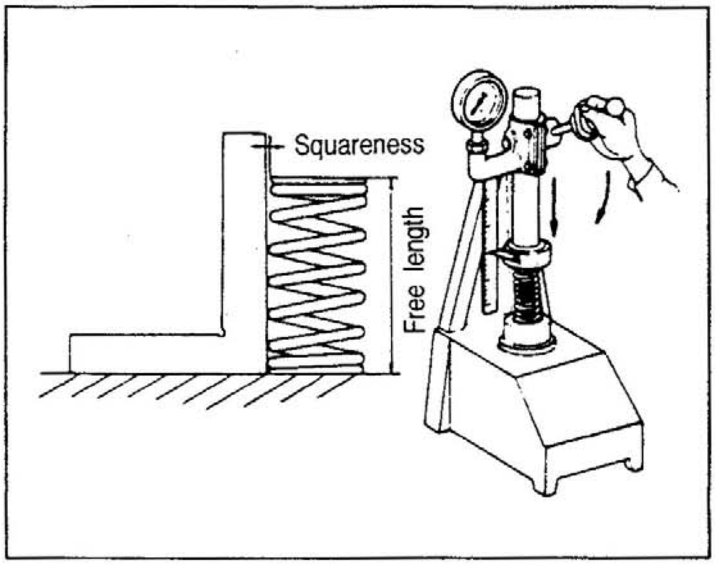
Replace the bushing as shwon in illustration, using Rocker Bushing Puller(special tool).

NOTE : When the bushing is installed, make sure that the following points are strictly observed.

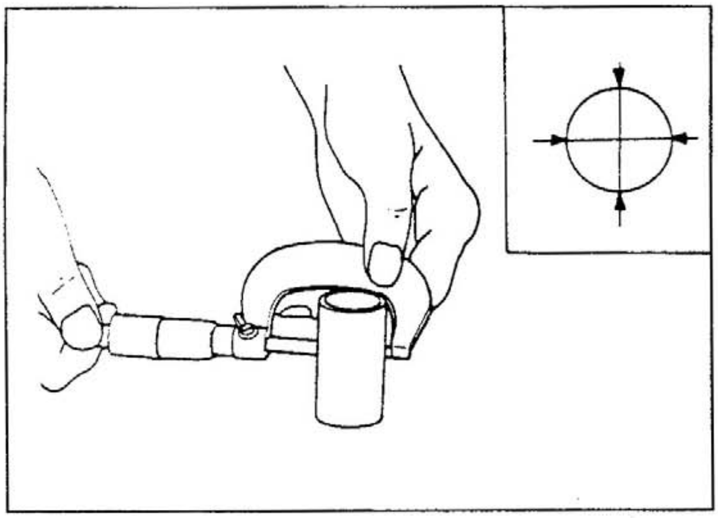
1. Align the oil holes of the bushing and rocker.
2. Face the clinch on bushing toward the valve.

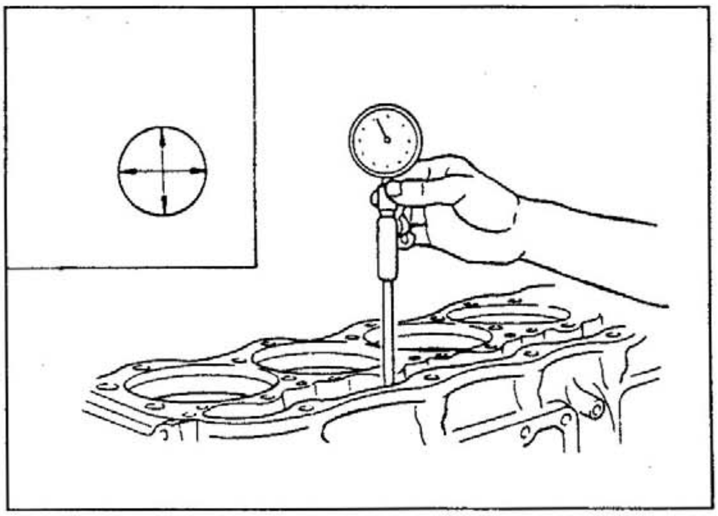


(3) Measure the squareness, free length and load when compressed to the installed length of the valve spring. If the service limit is exceeded, replace.



(4) Calculate the clearance between the tappet and crankcase tappet hole by measuring their O.D. and I.D. If the service limit is exceeded, replace the tappet.

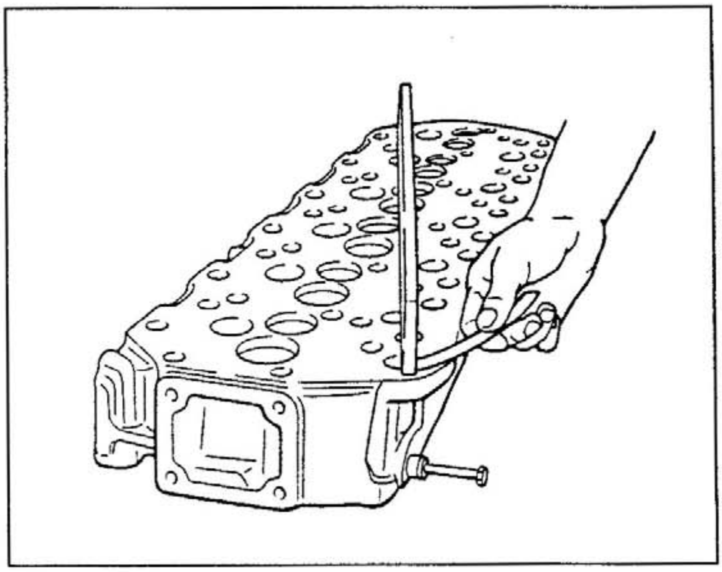




6-2-2 Cylinder Head, Valve and Valve Seat Insert

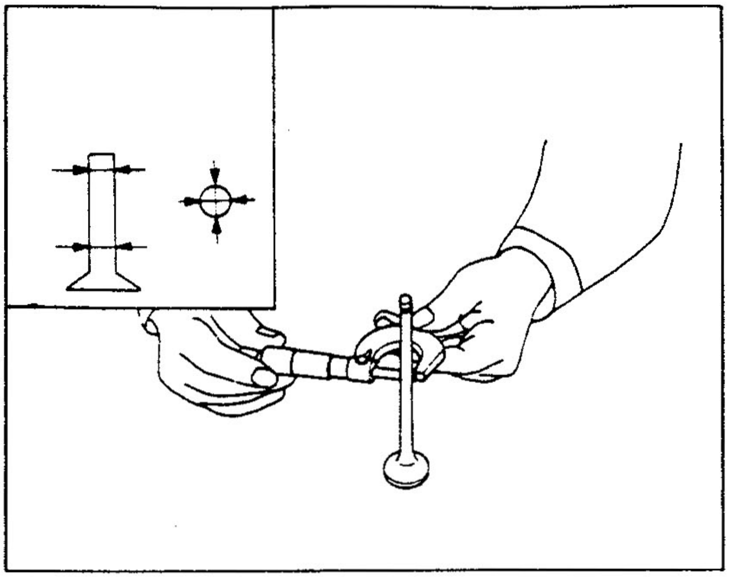
(1) measure the distortion of the cylinder head bottom surface. If th repair limit is exceeded, correct with a surface grinder.

NOTE : The height of the cylinder head from the top to bottom surface after grinding must be more than 94.5mm.

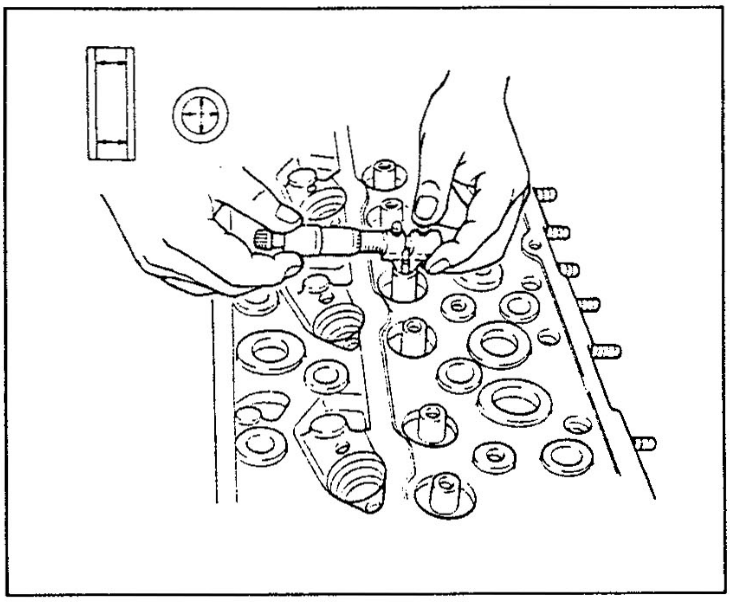


(2) Measure the valve stem O.D. If the service limit is exceeded, replace.

An excessively unevenly worn stem should also be replaced.

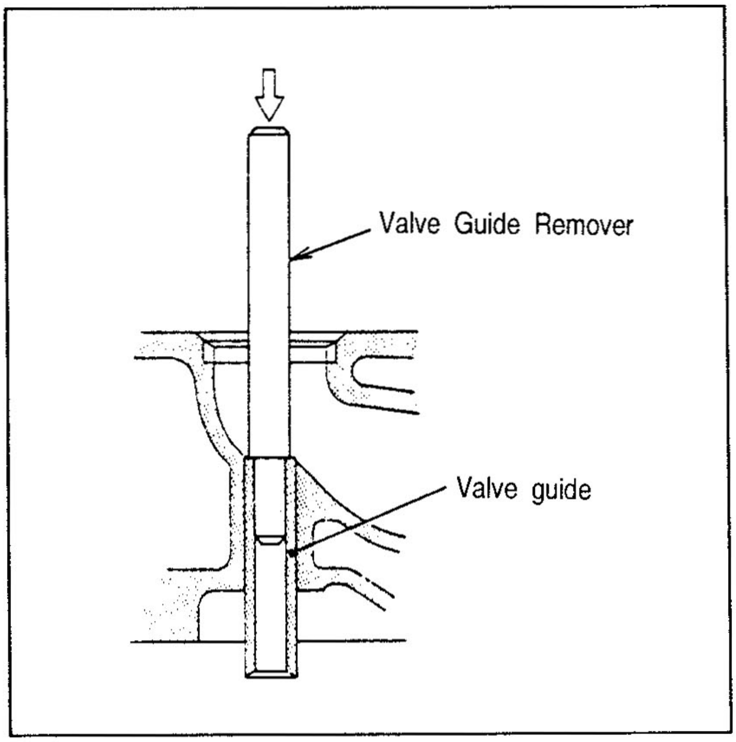


(3) Calculate the clearance from the valve guide I.D. and valve stem O.D. If the service limit is exceeded, replace the valve guide.



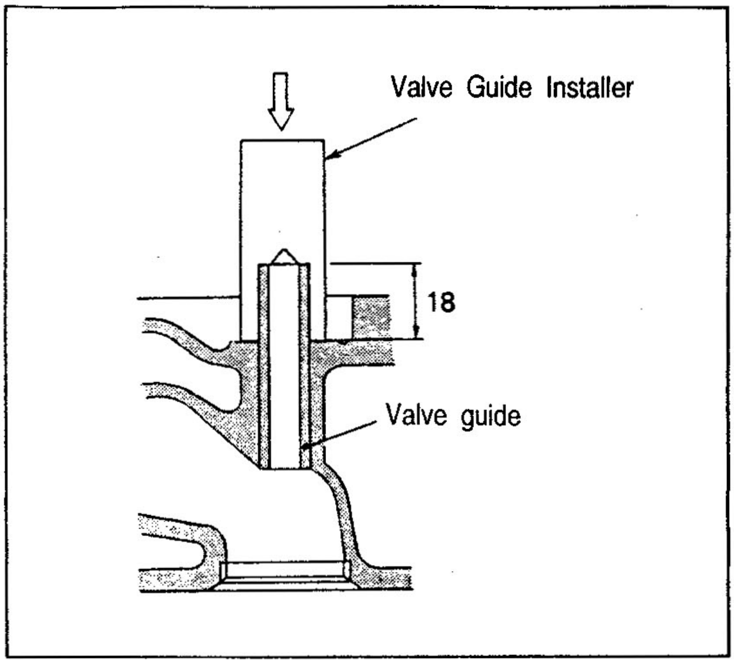
(4) Replacement of Valve Guide

(a) To remove the valve guide, use Valve Guide Remover(special tool).



(b) To install the valve guide, use Valve Guide Installer (special tool). Strike the installer until it touches the cylinder head.

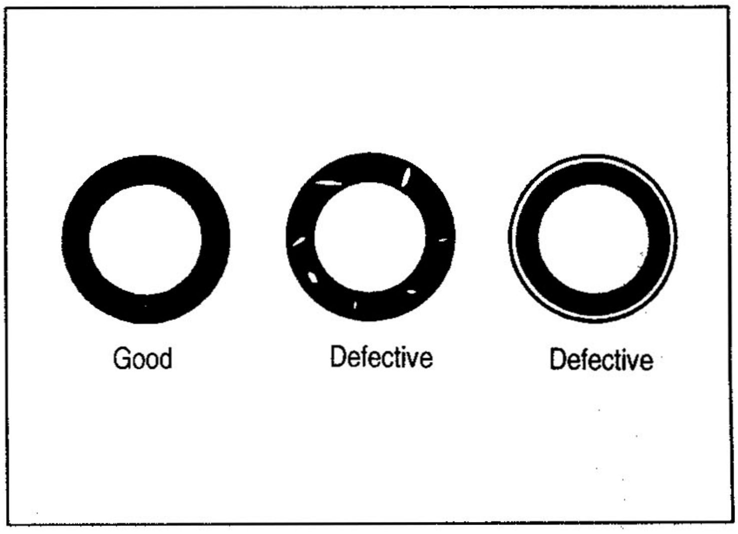
NOTE : Since the amount the valve guide is to be driven in is specified, be sure to use the special tool.



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

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, mark sure that the valve is not turned.

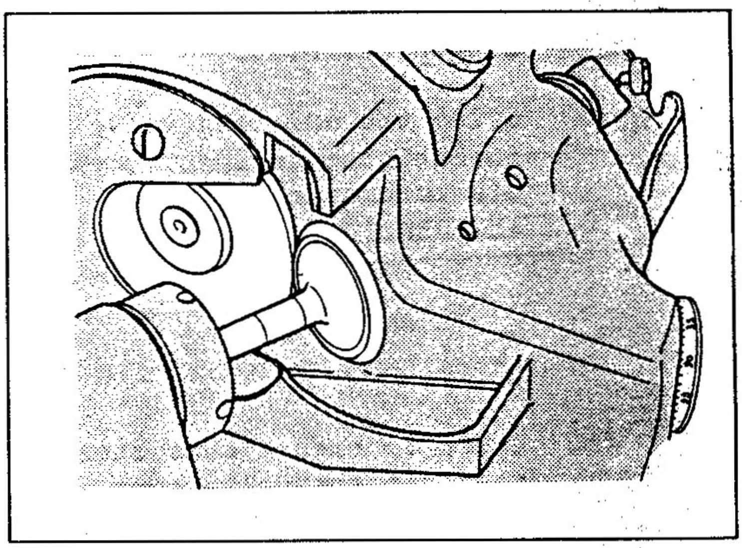


(6) Correction of Valve Face

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

NOTE : 1. The valve seat angle is 45°

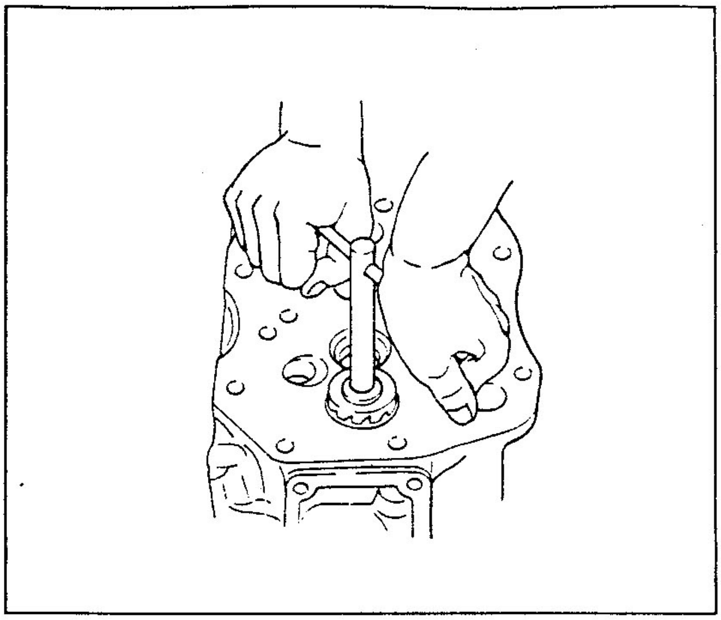
2. When correcting, ensure that the valve margin does not exceed the service limit.



(7) Correction of Valve Seat

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

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

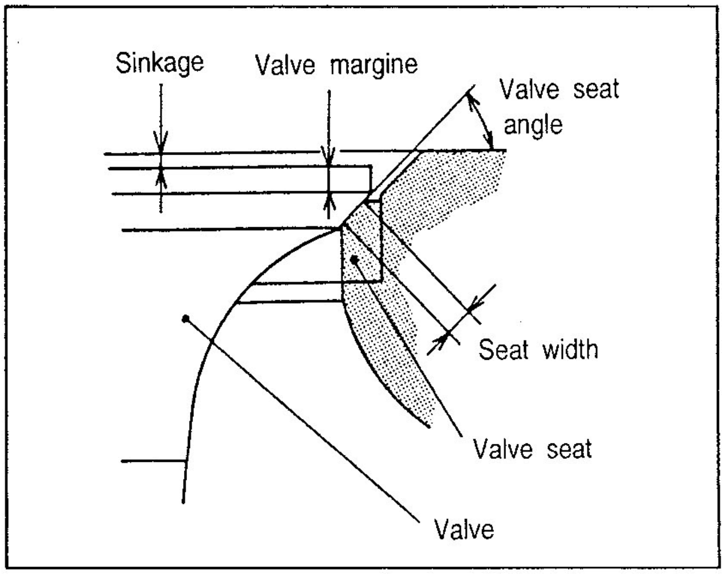


NOTE : 1. The valve seat angle is 45°

2. Correct to make sure that valve seat width and valve sinkage do not exceed respective limits.

(c) Correct the seat width to the nominal dimension, using 15° or 75° cutter.

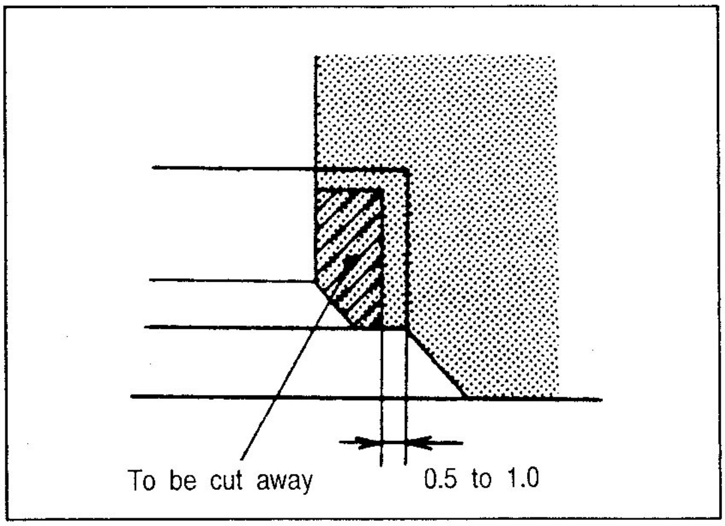
(d) Lap the valve and valve seat for good seating. See Para.(9).



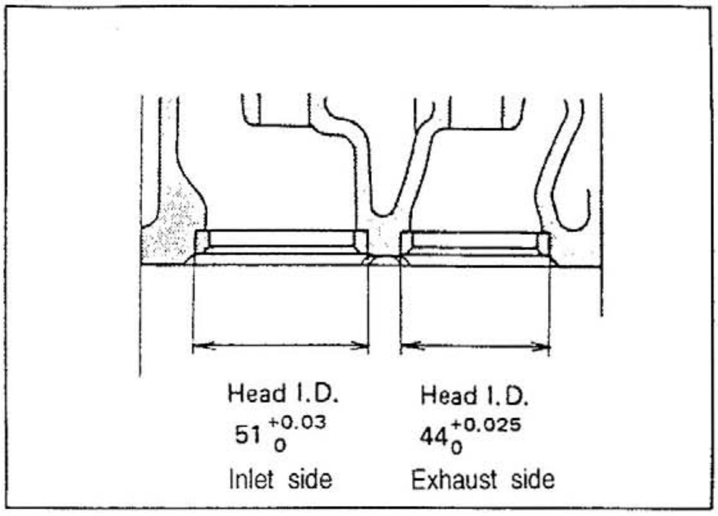
(8) Replacement of Valve Seat Insert

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

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

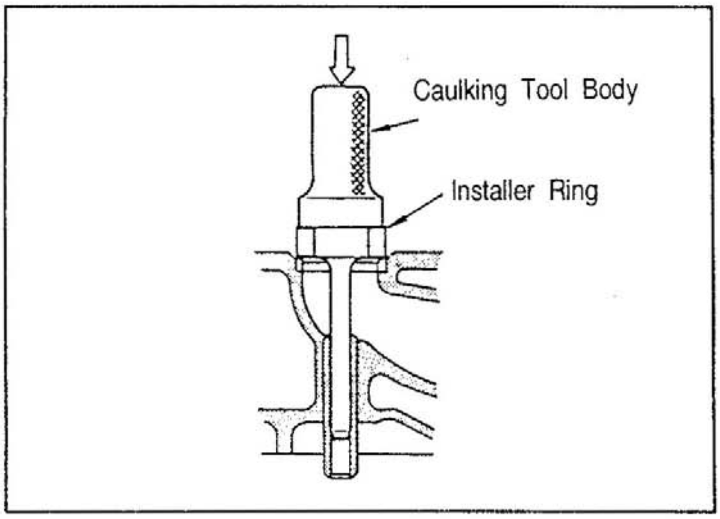


(b) Check to ensure that there is enough interference between the cylinder head and the valve seat insert.

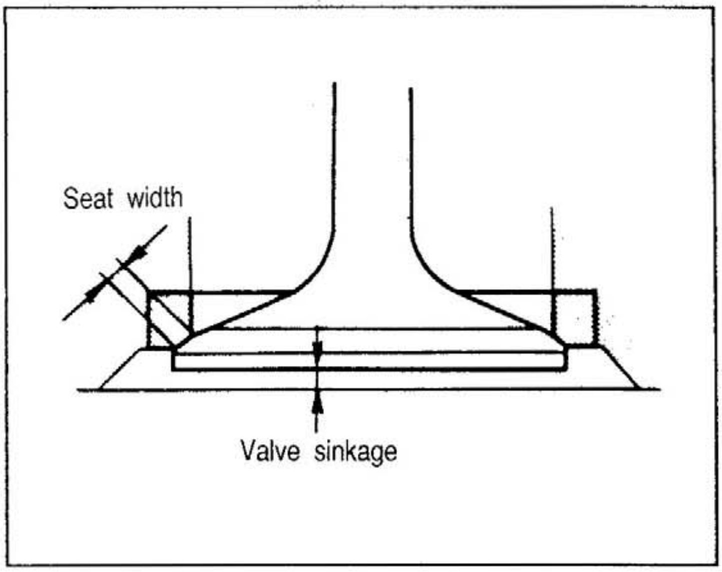


(c) Cool the valve seat insert by immersing in liquid nitrogen, and fully heat the cylinder head.

(d) Using Caulking Tool Body and Installer Ring(special tools), install the valve seat.



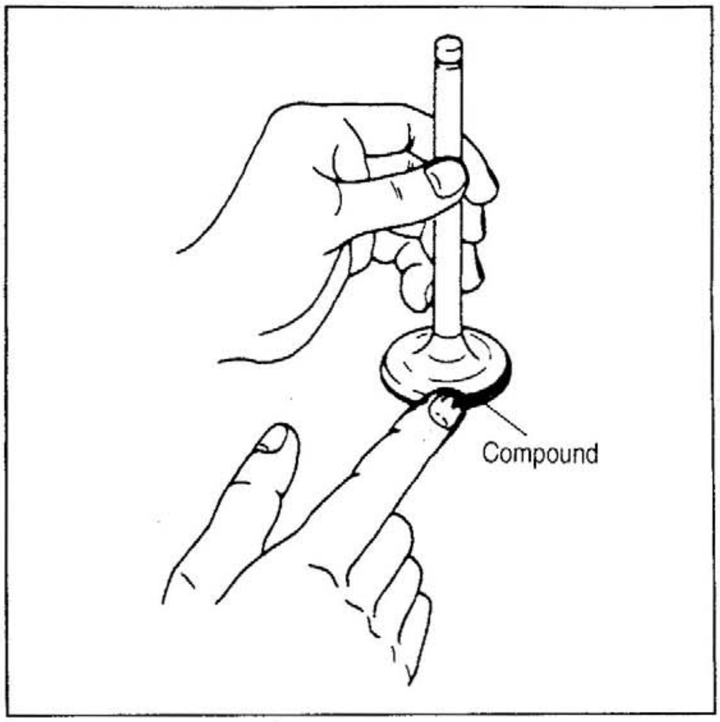
(e) Reface the valve seat so that the seat width and the valve sinkage will conform to the nominal dimensions.



(9) Lapping of Valve and Valve Seat

The valve and valve seat must be in even contact throughout. When the valve or valve seat was corrected or replaced, make sure that they are lapped.

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



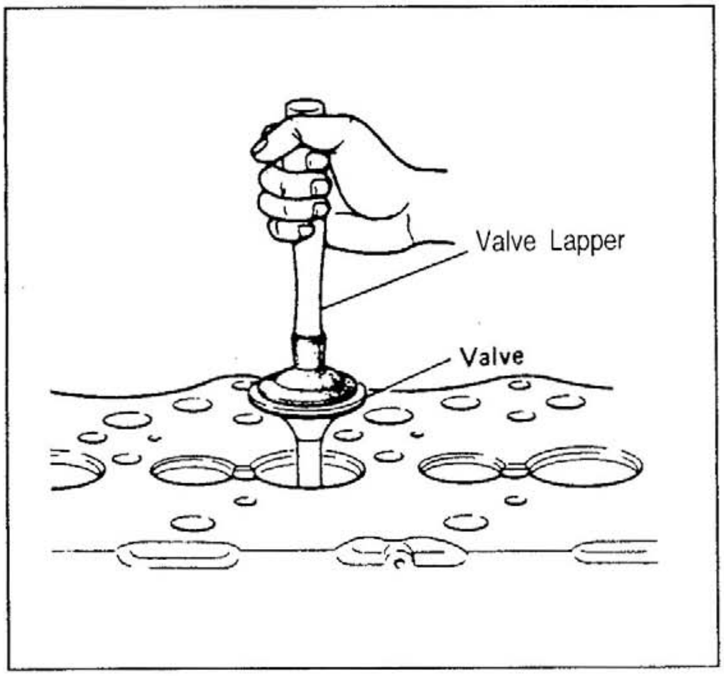
NOTE : 1. Make sure that no compound sticks to the stem of the valve.

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) Lap the valve and valve seat by using a Valve Lapper(special tool).

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



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

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

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

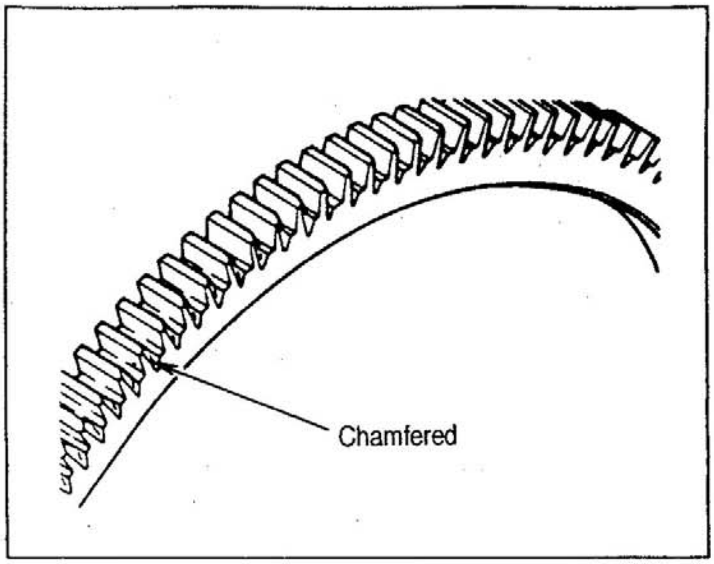
6-2-3 Flywheel

(1) Replacement of Ring Gear

(a) Removal

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

2) Strike the ring gear all around with a rod and a hammer to force it out of positon.



(b) Installation

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

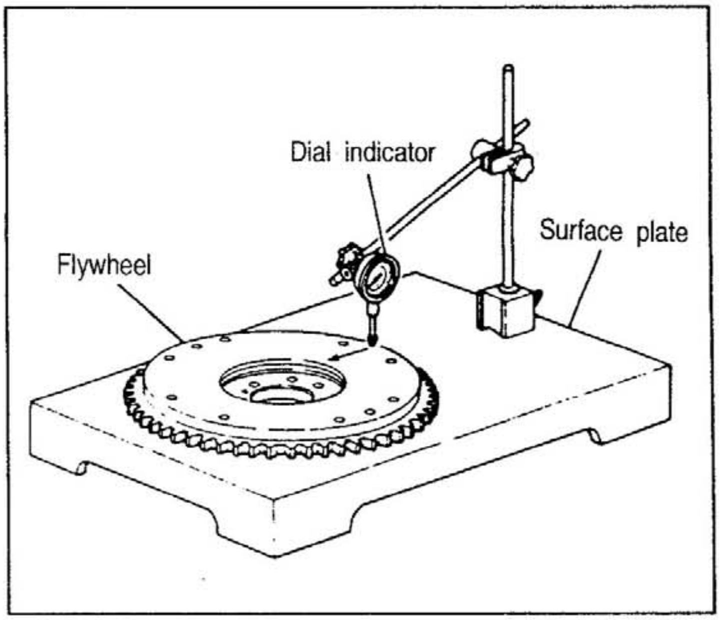
2) Fit the ring gear onto the flywheel with the nonchamfered side of tooth end toward the flywheel.

(2) Distortion of Friction Surface

Place the flywheel on a surface plate and move a dial gauge in the diametric 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.

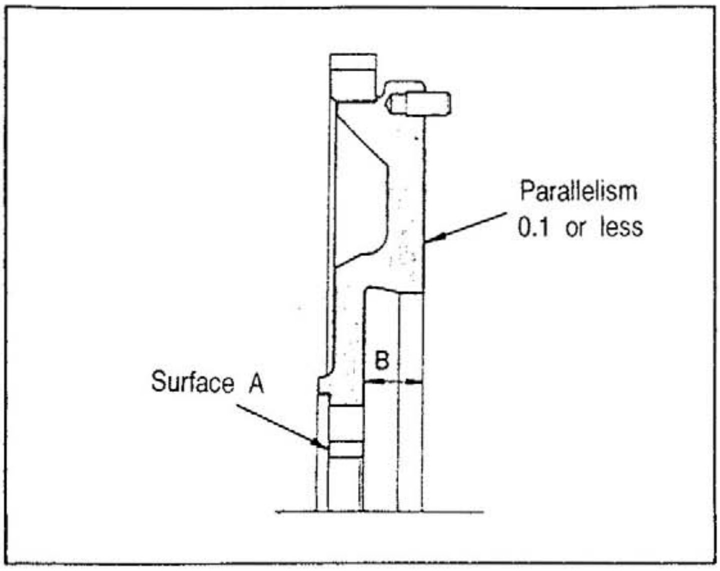


NOTE : If the ring gear shows an abnormal condition, replace the ring gear before measurement.

(3) Correction of Friction Surface

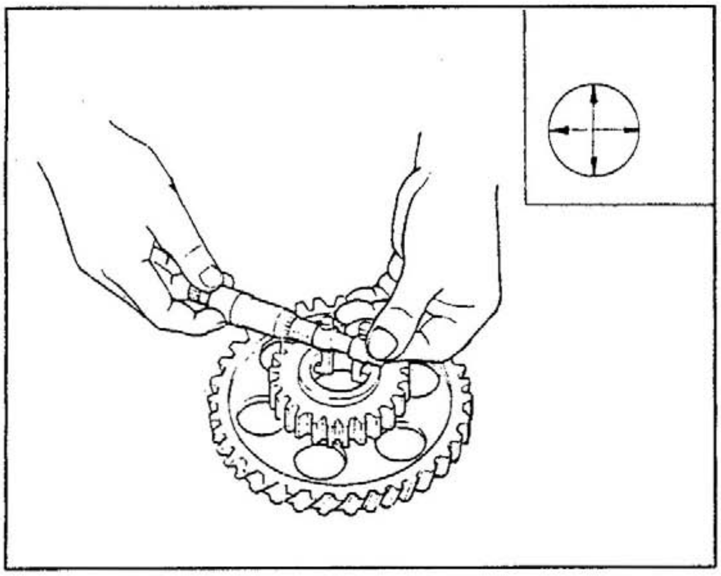
Correct the friction surface with a surface grinder. Make sure that the friction surface is parallel to the surface A within 0.1mm.

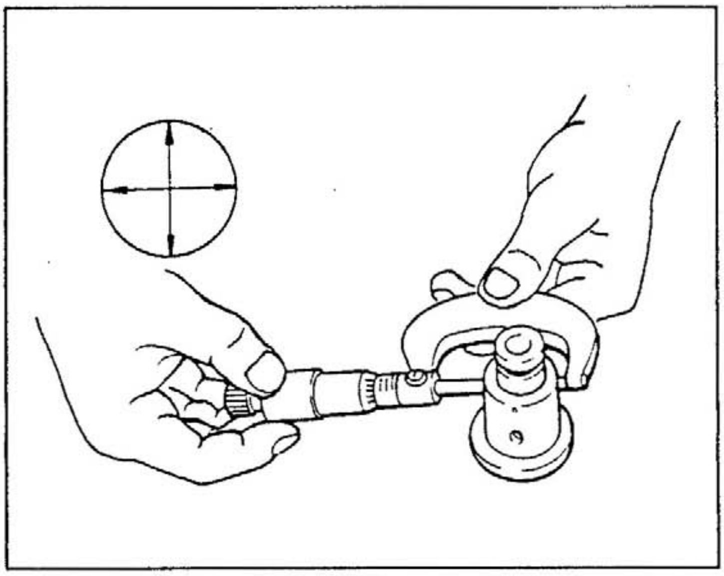
NOTE : After correctin, check to ensure that the height of the friction surface(the dimension B) has not reached the service limit.



6-2-4 Timing Gear

(1) Calculate the clearance between the idler gear and idler shaft from their I.D. and D. If the repair limit is exceeded, replace the bushing in the gear.



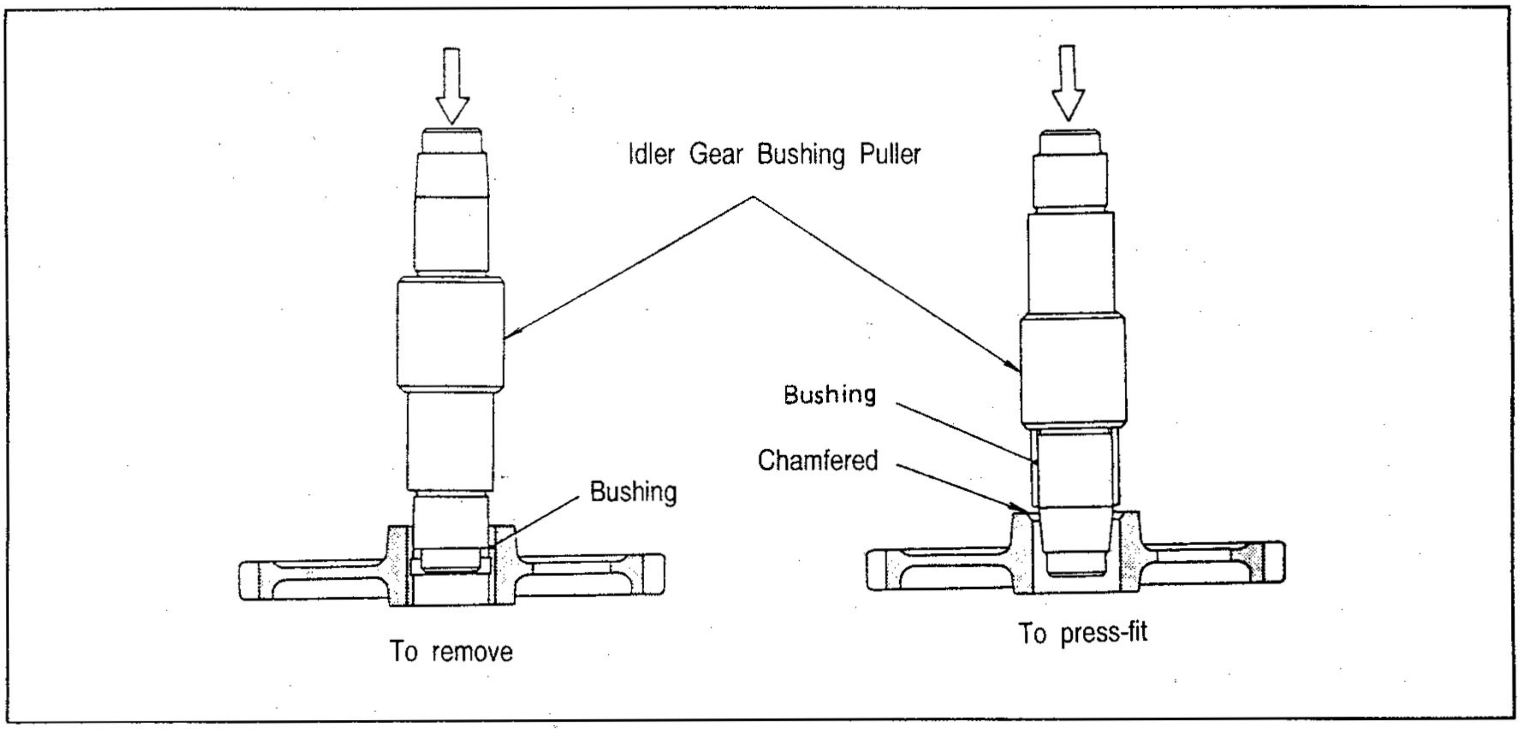


(2) Replacement of Idler Gear Bushing

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

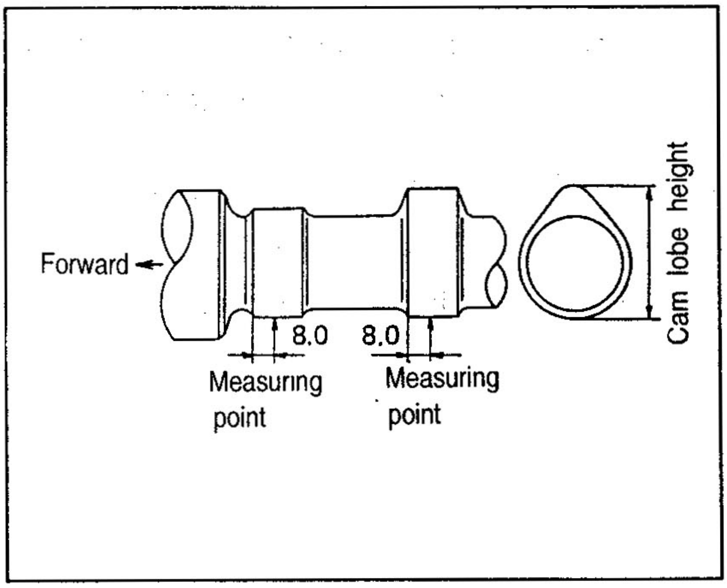
NOTE : 1. Install the bushing to the gear I.D. from the chamfered side.

2. After installation, check to ensure that the clearance between shaft and gear is more than the nominal dimension at least. If it is less than the nominal dimension, ream the bushing.

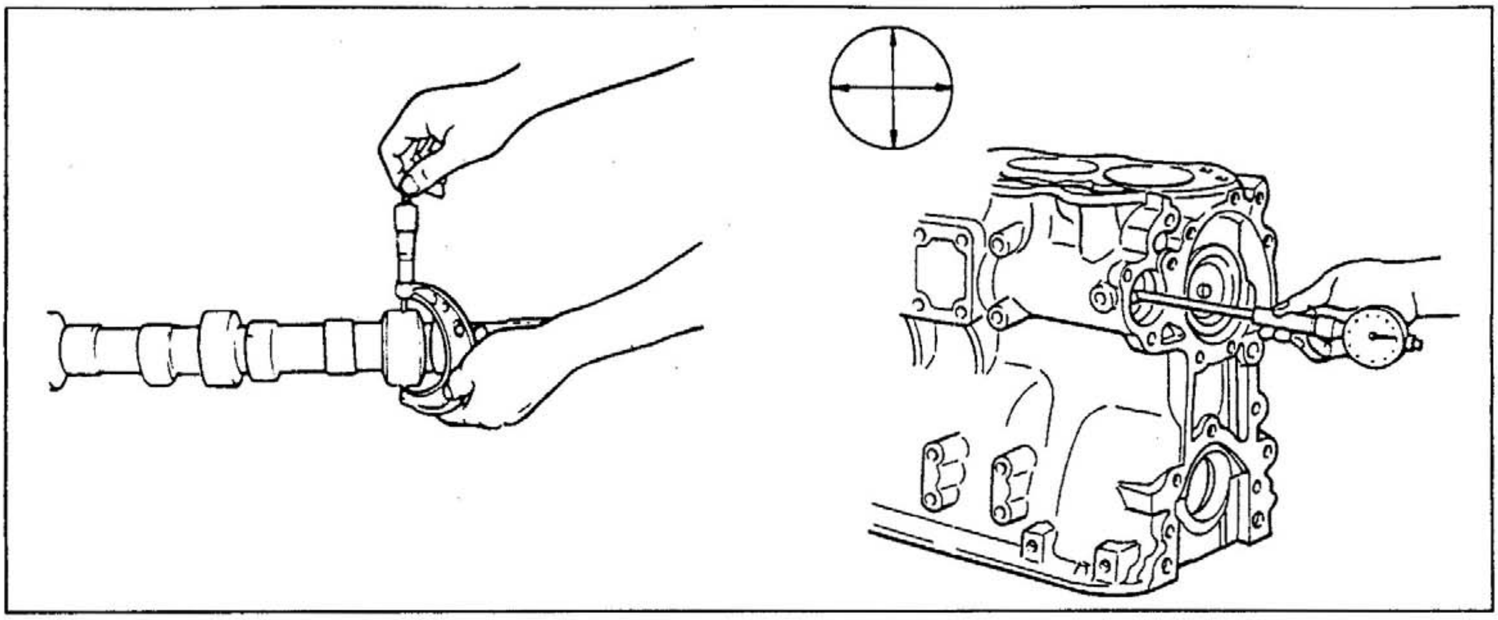


6-2-5 Camshaft

(1) Measure each cam lobe height and if it is below the service limit, replace.



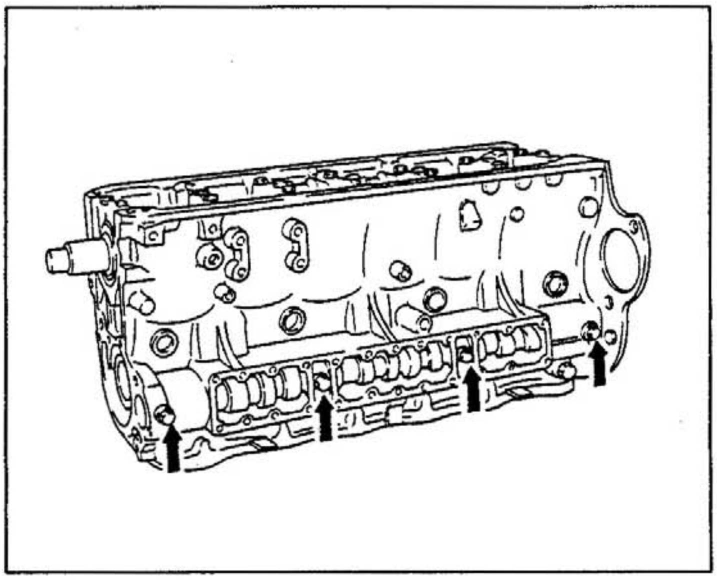
(2) Measure the camshaft journal O.D. and bush hole I.D. If the repair limits are exceeded, the bushing in the crankcase should be replaced.



(3) Replacement of Camshaft bushing

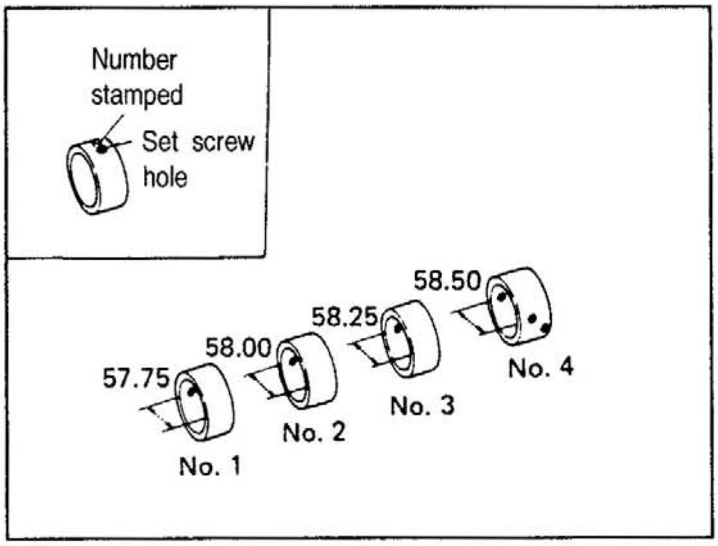
Remove the set screw of each bushing and remove the bushing.

The bushing is clearance fitted so that it can be easily removed and installed by hand.



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

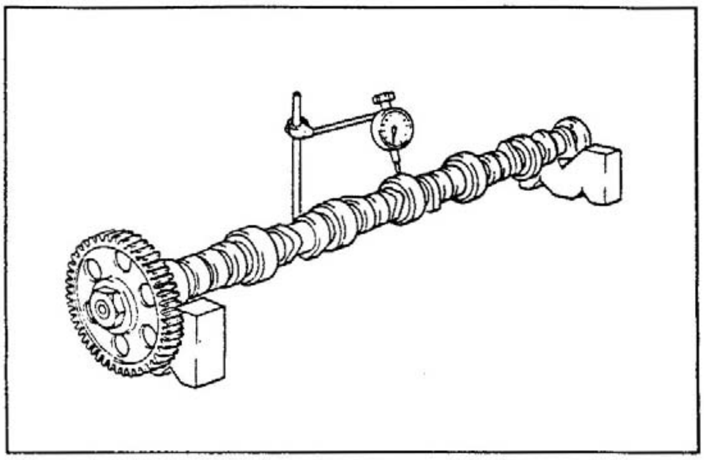
1. Thread the set screw positively into the set screw holes of the bushing.



2. All bushings have the same outside diameter, but the inside diameter differs from bushing to bushing. Each bushing has a stamped number near the set screw hole. If it is unclear, measure the inside diameter.

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

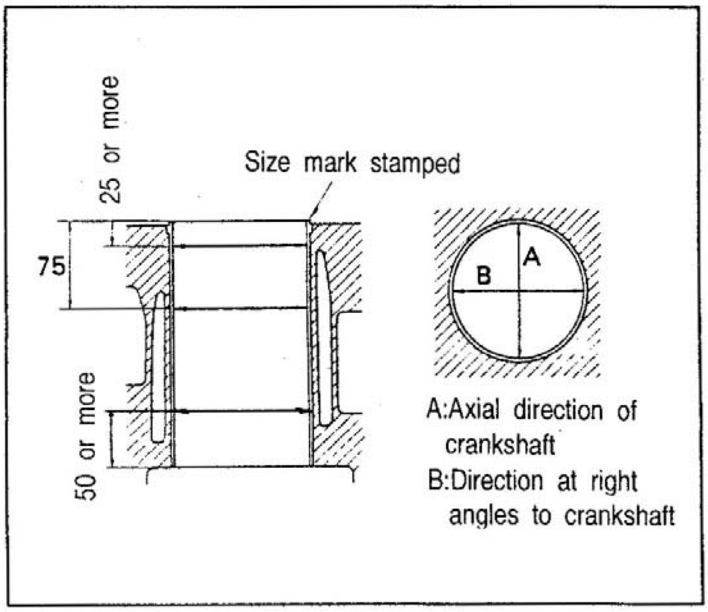
NOTE : Turn the camshaft a turn and read the deflection of the pointer, using a dial indicator. One half of the reading is the bend.



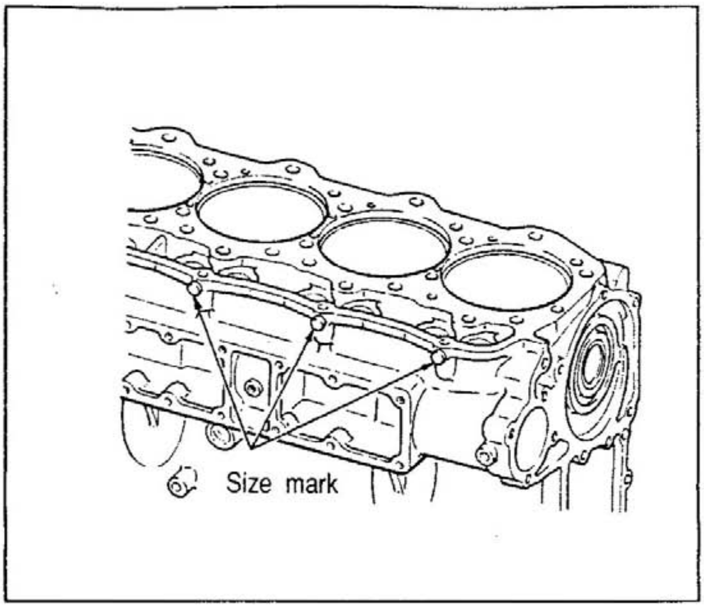
6-2-6 Crankcase and Cylinder Liner

(1) Measure the cylinder liner I.D. at six positions as shown in the illustration.

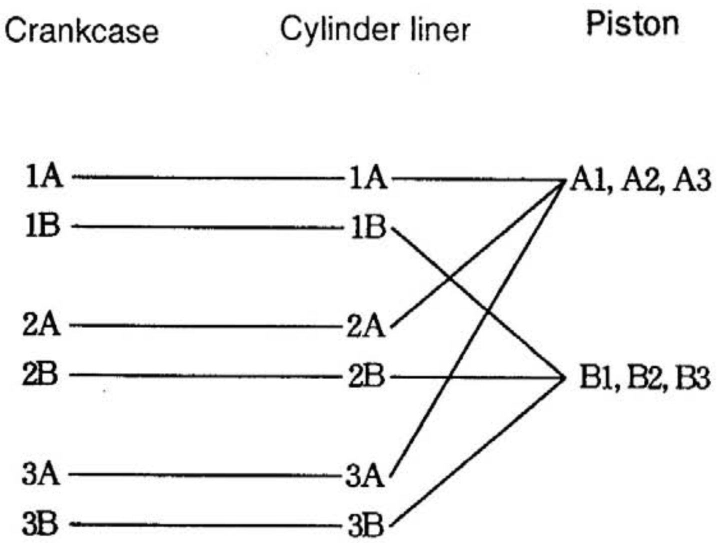
If the I.D. is in excess of the service limit, replace.

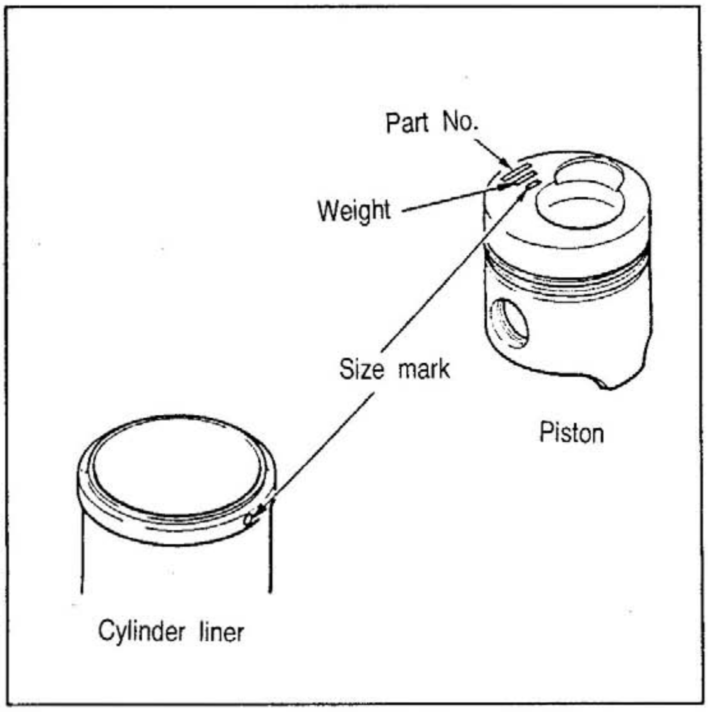


NOTE : When replacing the cylinder liner, make sure that the cylinder liner with the same size mark as that of the piston is selected.



a) Size mark

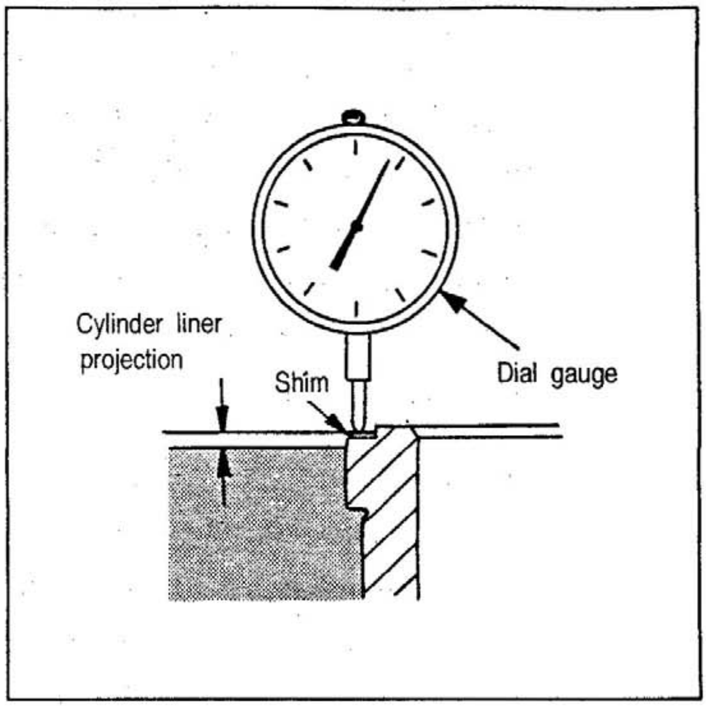




(2) Measure the cylinder liner flange to determine whether it is projecting from the top surface of the crankcase as specified.

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

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

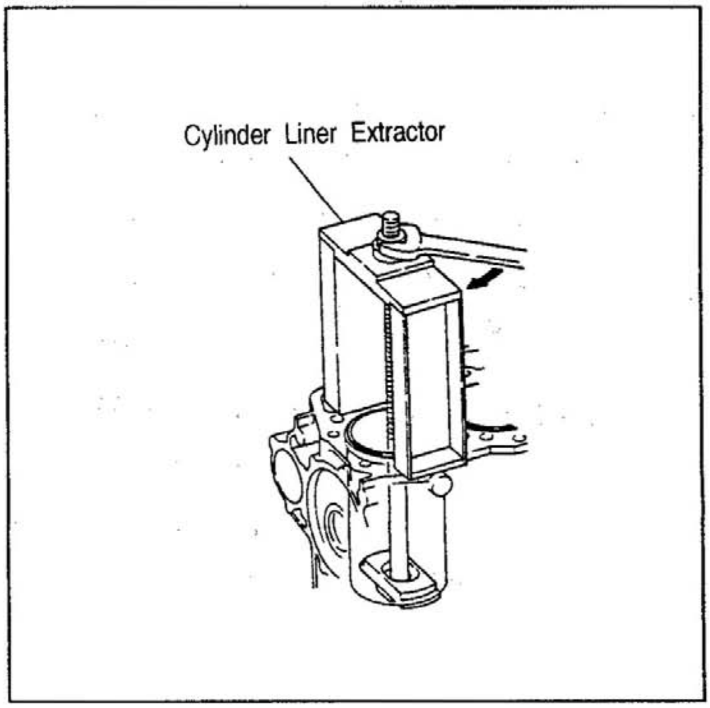


(3) Replacement of Cylinder Liner

(a) Removel of cylinder liner

1) Use Cylinder Liner Extractor (special tool) to remove the cylinder liner.

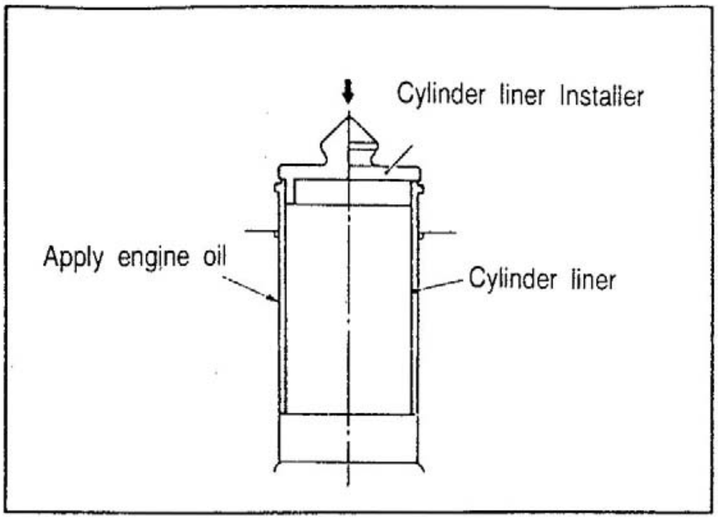
NOTE : 1. The cylinder liner on D6BR has a thin wall and must not be removed except when replacing for deformation.



2. Where the cylinder liner must be reused, put alignment mark with paint to make sure that the liner is reinstalled in its original position.

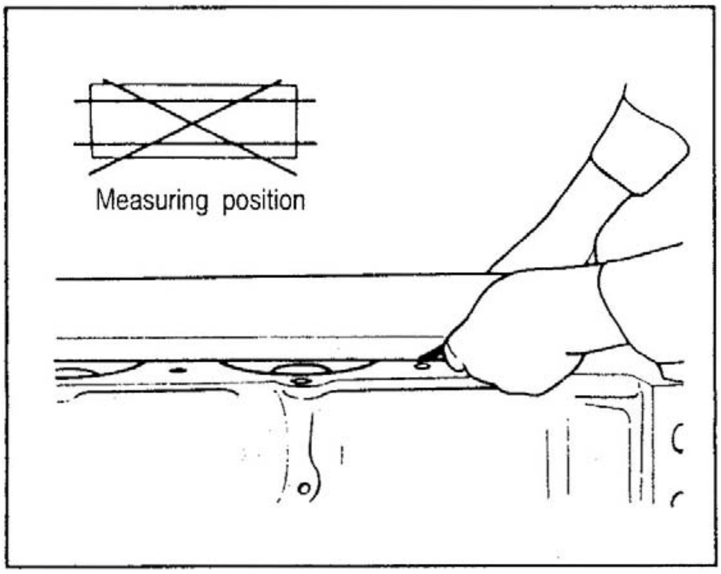
(b) Installation of cylinder liner

Apply engine oil to the outside surface of the cylinder liner. Then, using cylinder Liner Installer (special tool), carefully insert the liner into crankcase while pushing the entire top surface evenly by hand.



NOTE : Special care must be exercised when handling the liner as it is of thin wall. Do not apply strong shock, such as by hammer.

(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.

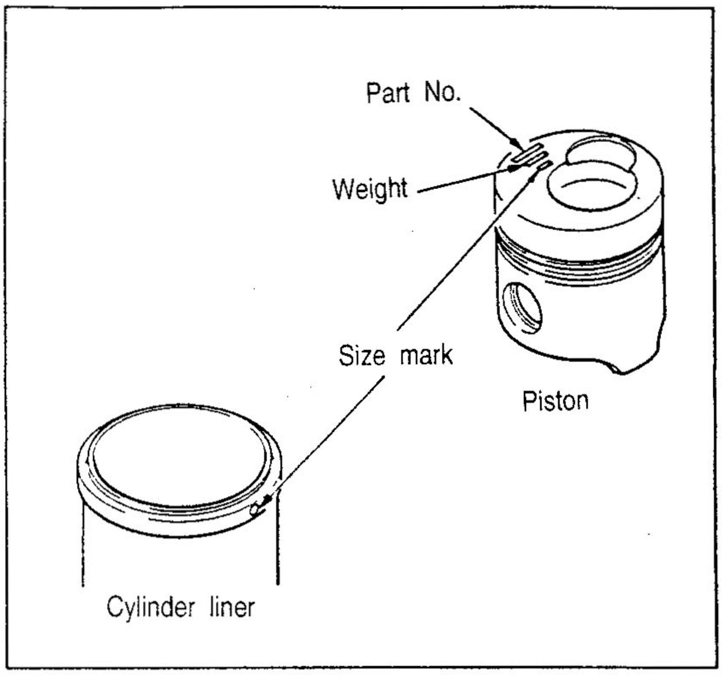
6-2-7 Piston and Piston Ring

(1) Replacement of Piston

In case of standard (STD) piston, select the piston having the same size mark as the cylinder liner.

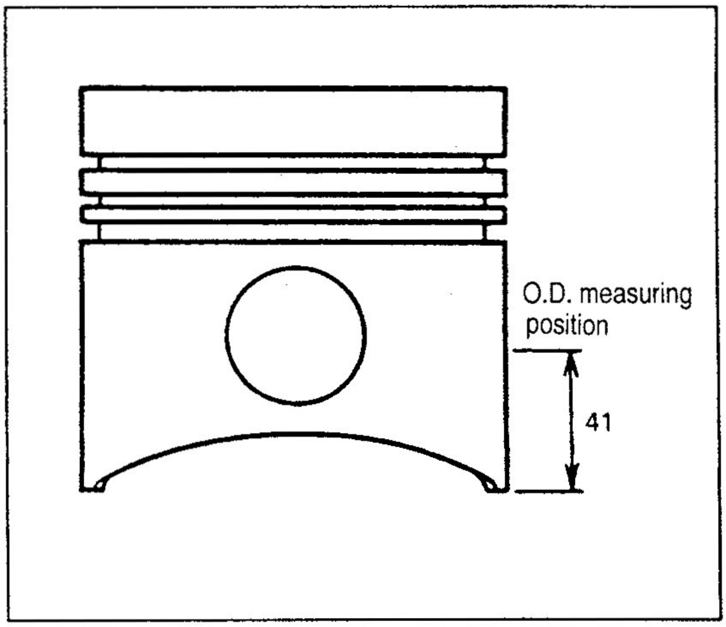
For size mark, see 6-2-6(1).

NOTE : Make sure that the piston rings are also replaced.



(2) Measure the piston skirt O.D. and calculate the clearance from the minimum measured value of cylinder liner I.D. [Refer to Para. 6-2-6 (1).]

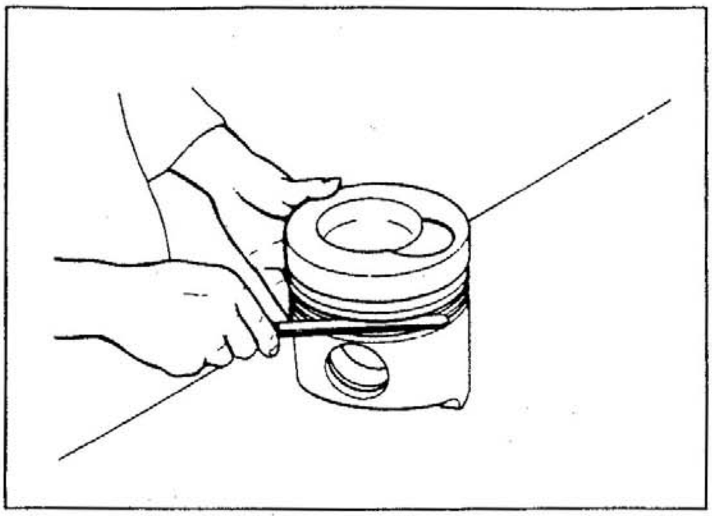
If the clearance is over the service limit, replace cylinder liner and piston.



(3) Measure the clearance between the grooves in piston and piston rings. 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 ring as a set.



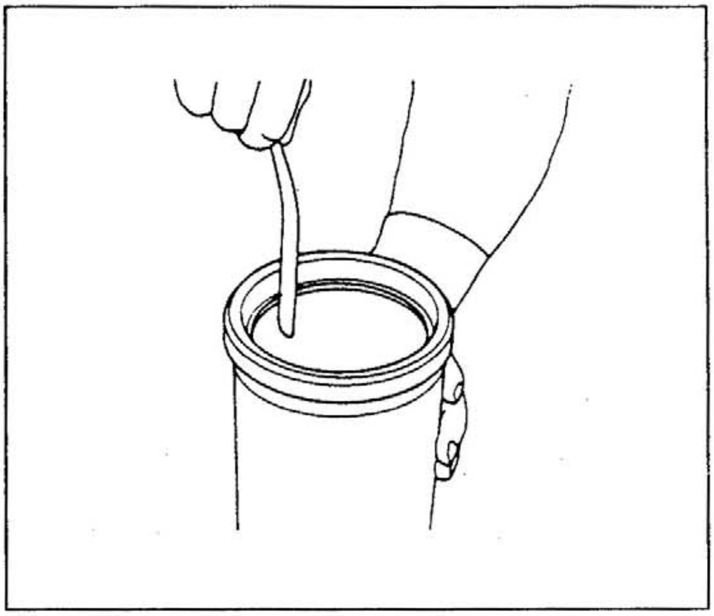
(4) Place the piston ring in a standard gauge or new cylinder liner to measure the open end gap.

If the service limit is exceeded, replace.

Standard gauge I.D.

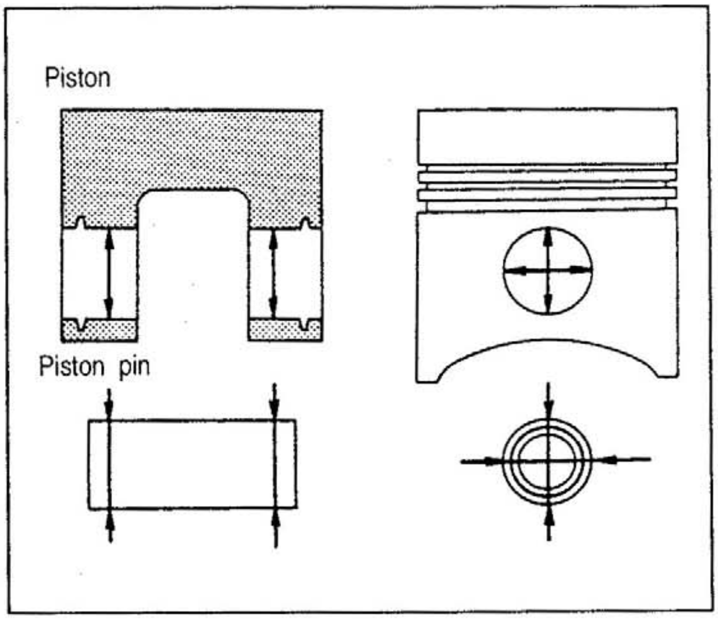
D6BR : 118 ± 0

NOTE : For measurement, push the piston ring into the standard gauge with a piston to level its position.



(5) Calculate the clearance between the piston pin and its hole in piston by measuring their O.D. and I.D.

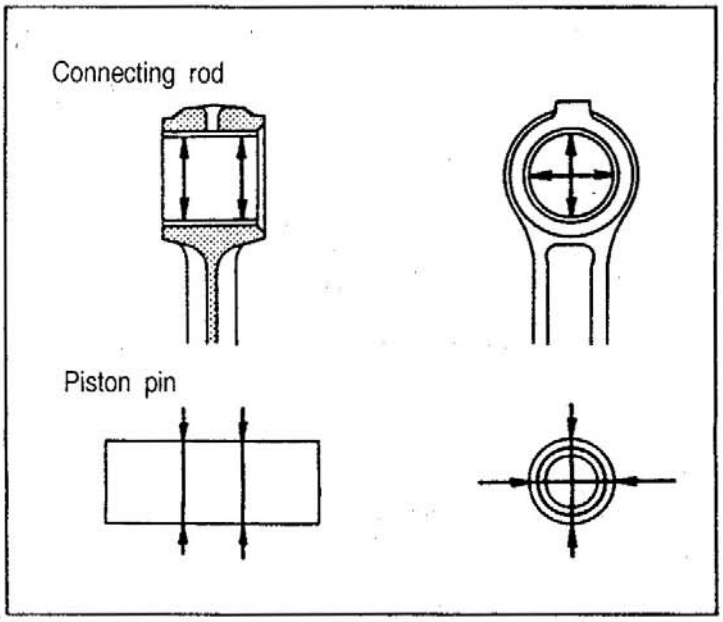
If the clearance is over the service limit, replace the piston pin or piston.



6-2-8 Connecting Rod

(1) Calculate the clearance between the piston pin and connecting rod end by measuring their O.D. and I.D.

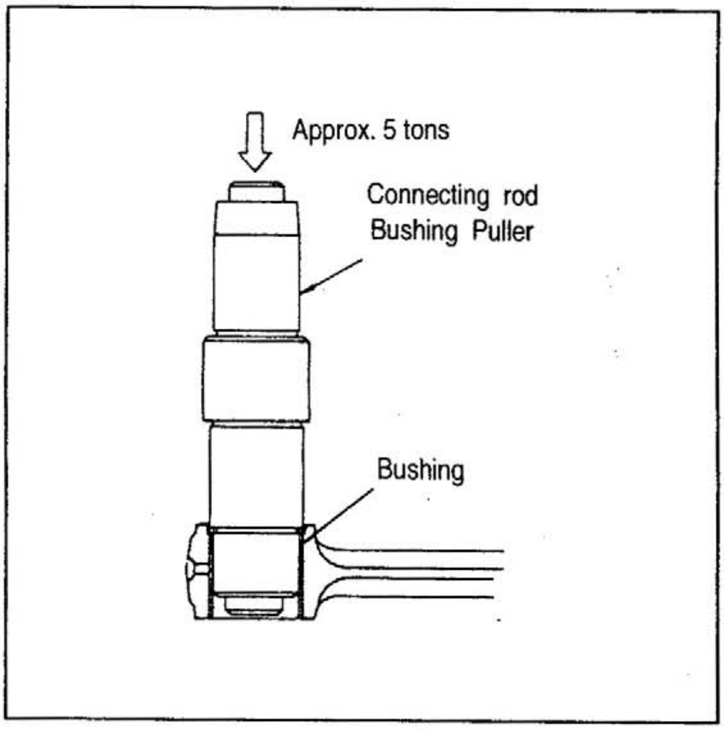
If the repair limit is exceeded, replace the bushing in the connecting rod.



(2) Replacement of Connecting Rod bushing

(a) Removal

Replace the bushing by using Connecting Rod Bushing Puller or Connecting Rod Bushing Puller Kit(special tools).



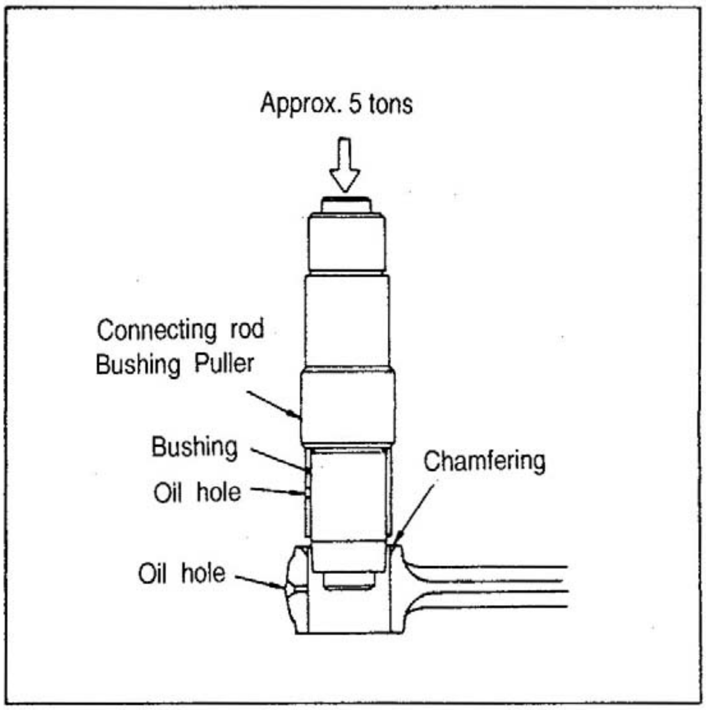
(b) Press fit

1) Insert the bushing into the Connecting Rod Bushing Puller (special tool).

Install the bushing into the connecting rod.

NOTE : 1. Press the bushing in from the chamfered side of connecting rod end.

2. Align the oil hole of the bushing with the oil hole of the connecting rod.

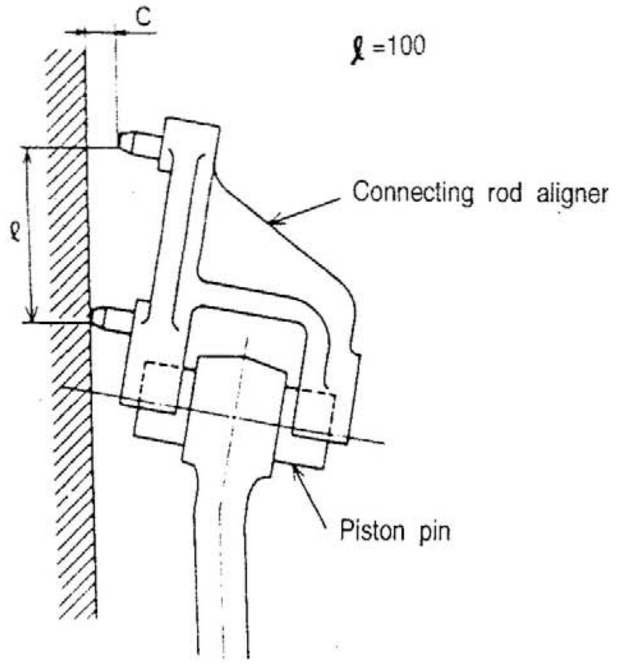


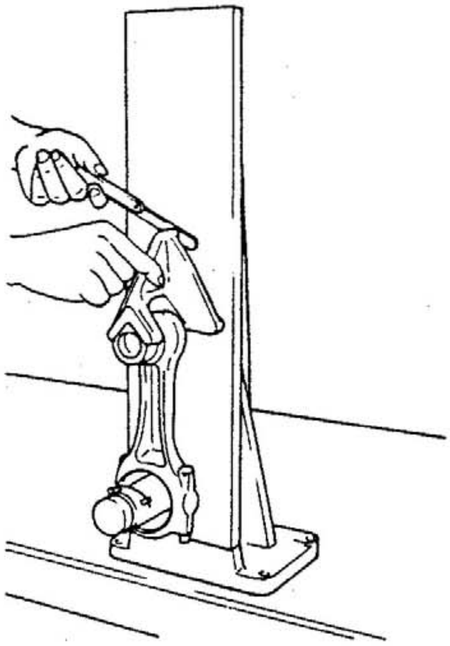
3. After the bushing has been pressed in, insert the piston pin and check to ensure that it turns lightly without play.

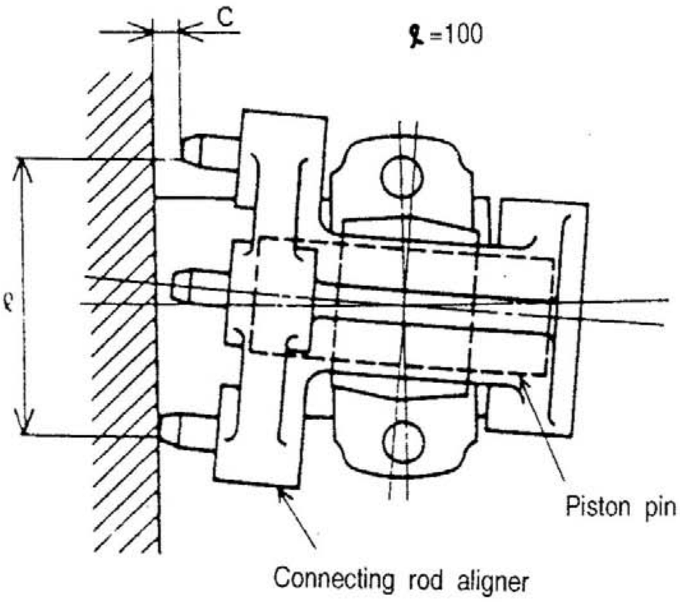
(3) Measure the bend and torsion of the connecting rod with Connecting Rod Aligner (measuring instrument). If the repair limit is exceeded correct with a press or replace.

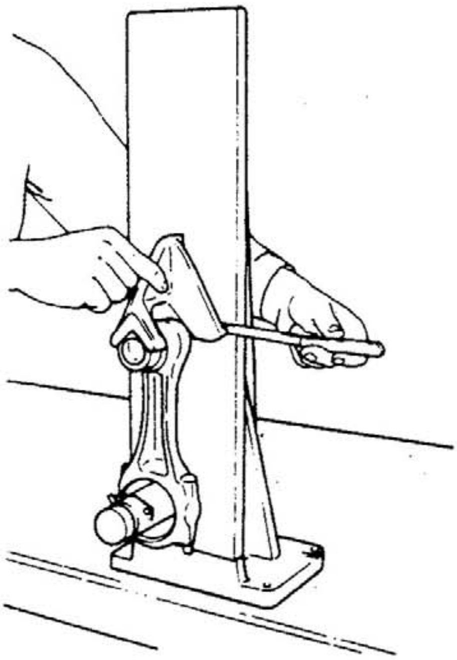
NOTE : 1. These measurements must be taken with bushing and connecting rod bearing mounted on the connecting rod.

2. Tighten connecting rod and connecting rod cap to specification before measurement.


C
ℓ =100
ℓ
Connecting rod aligner
Piston pin

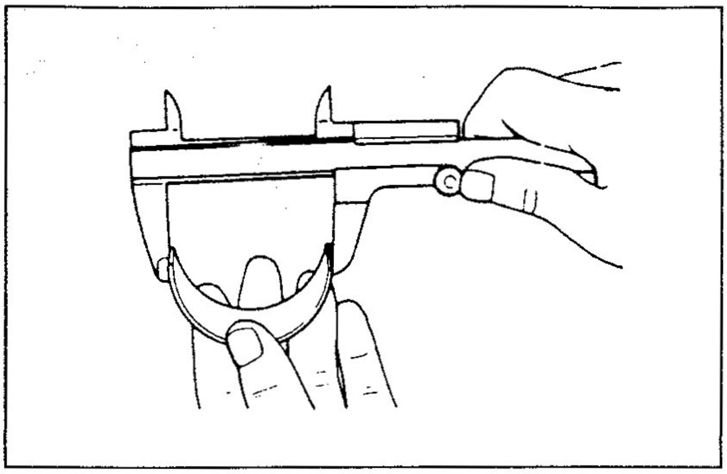



C
ℓ =100
ℓ
Piston pin
Connecting rod aligner

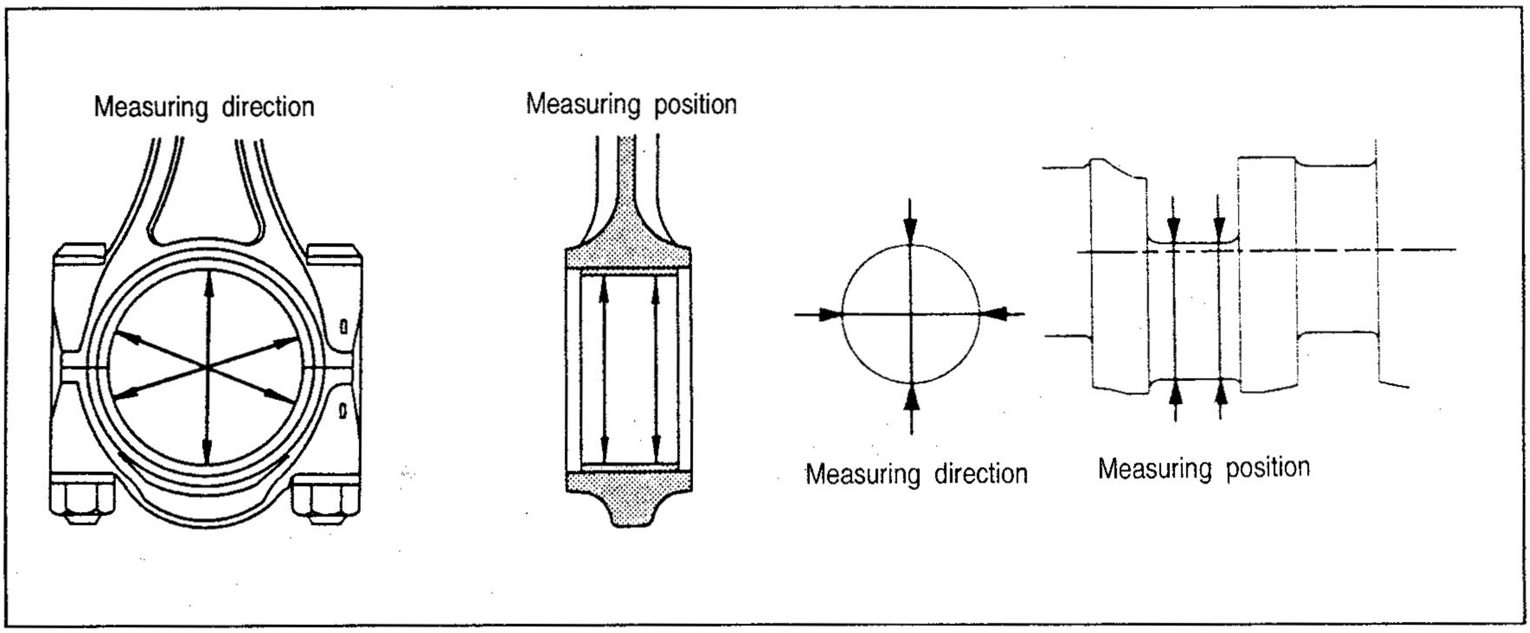


(4) Measure the tension of the connecting rod bearing when it is in free state. If the service limit is exceeded. replace the upper and lower bearings as a set.

NOTE : Do not try to artificially expand the bearing to increase the tension.

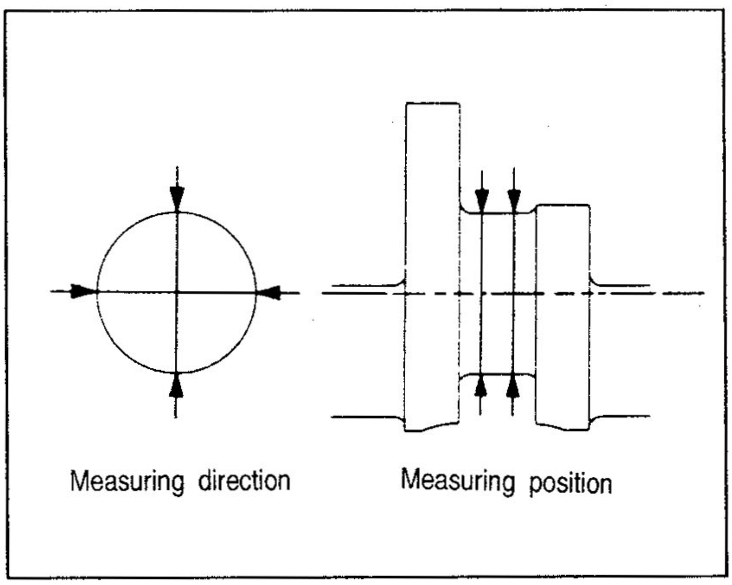


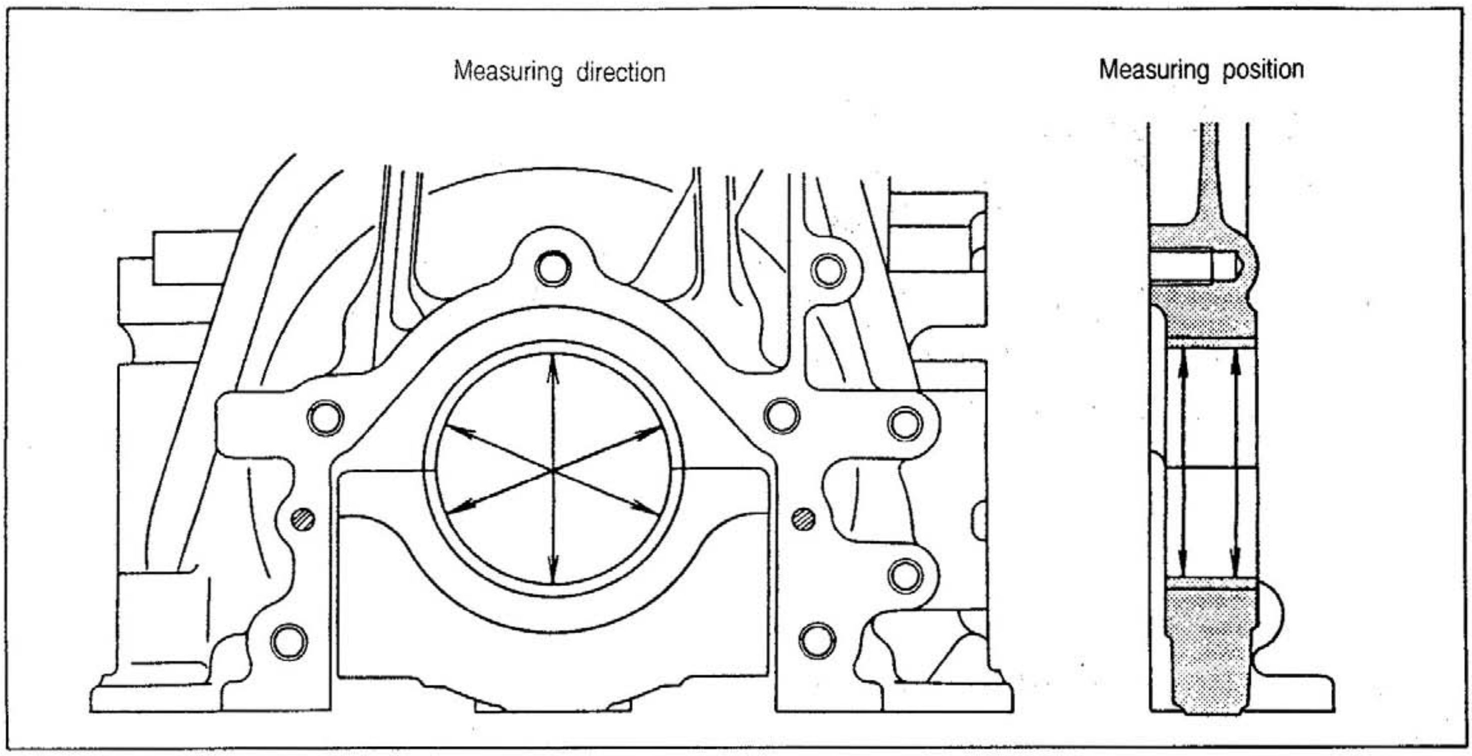
(5) Calculate the clearance from the bearing I.D. and crankshaft O.D. If the service limit is exceeded, replace the upper and lower bearings as a set.



6-2-9 Crankshaft and Main Bearing

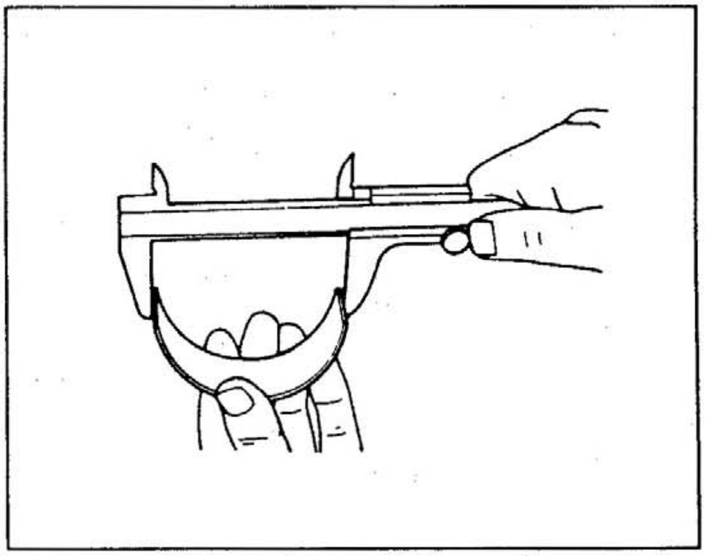
(1) Calculate the clearance from the main bearing I.D. and crankshaft O.D. If the service limit is exceeded, replace the upper and lower bearings as a set.



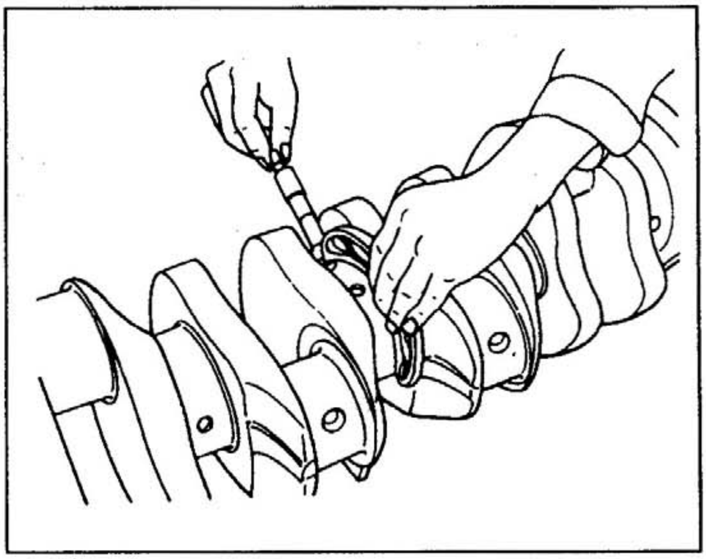


(2) Measure the tension of main bearing when it is in free state. If the tension is below the service limit, replace the upper and lower bearings as a set.

NOTE : Do not try to artificially expand the bearing to increase the tension.



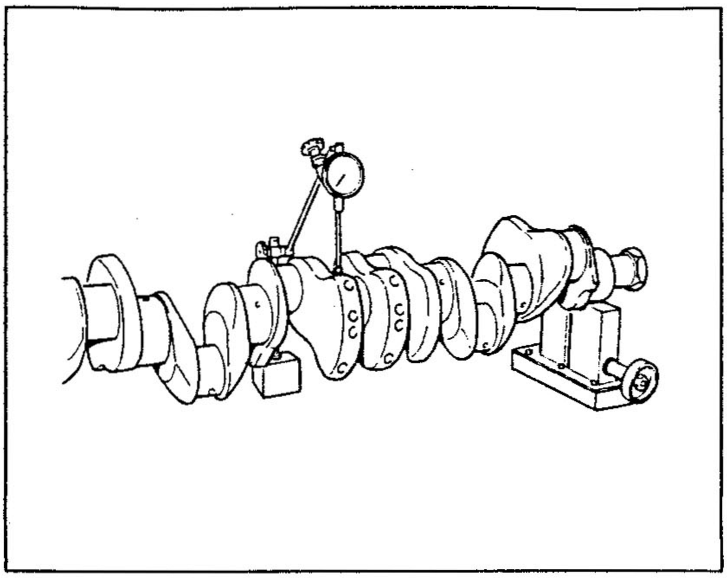
(3) Determine the roundness and cylindricity of the crankshaft journal and pin by measuring their O.D. If the service limit is exceeded, grind to undersize.



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

If an excessive bend is evident, replace.

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



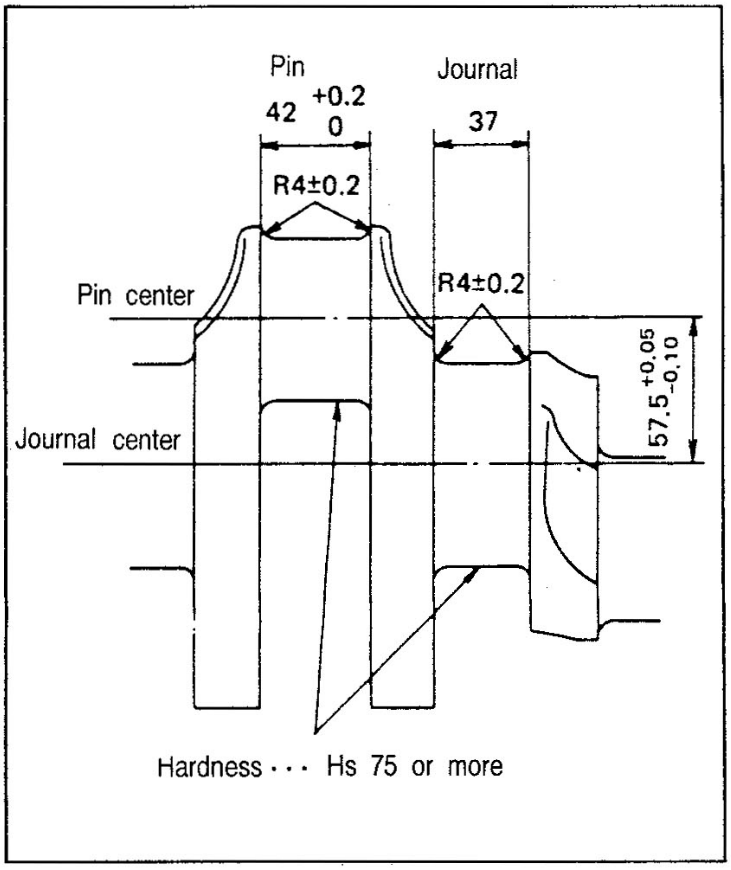
(5) Correction of Crankshaft to Undersize

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

(a) Do not change the center to center distance of the journal and pin.

(b) Do not change the widths of the journal and pin.

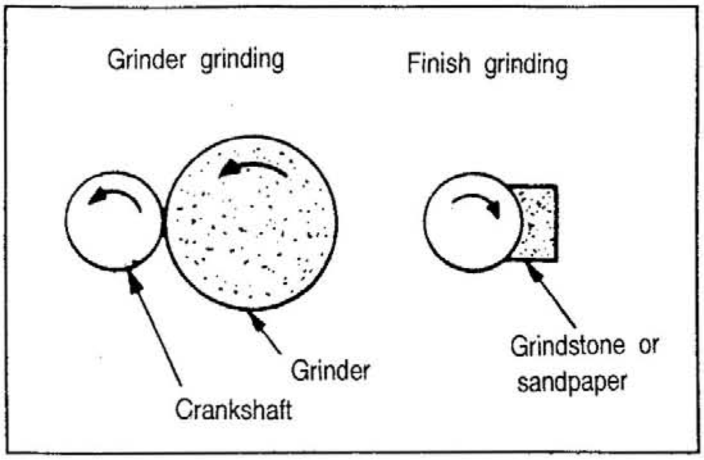
(c) Finish the fillet smooth to the specified radius.



(d) Check for ground cracks by the magnetic particle inspection method. The surface hardness(shore 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 counterclockwise as viewed from the crankshaft front end.

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



unit : mm

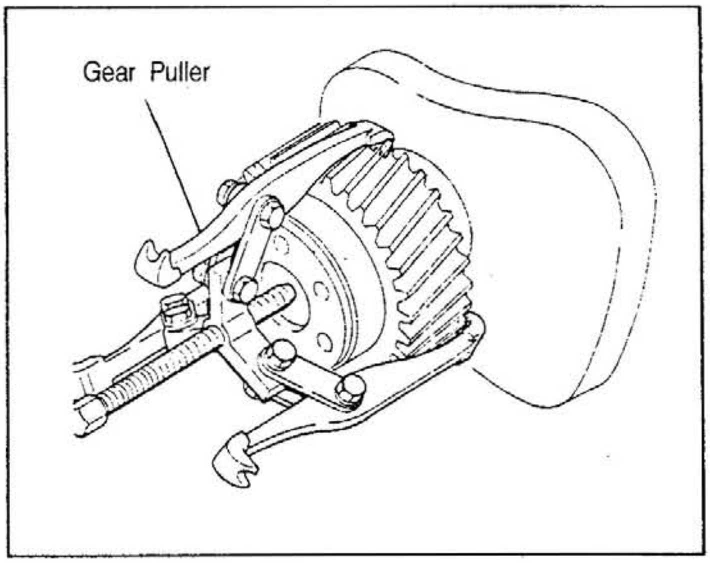
Undersize	Journal O.D. finish dimension	Pin O.D. finish dimension	Roundness	cylindricity
−0.25	76.685 to 79.705	64.67 to 64.69	0.01 for less	0.006 or less
−0.50	79.453 to 79.455	64.42 to 64.44		
−0.75	79.185 to 79.205	64.17 to 64.19		
−1.00	78.935 to 78.955	63.92 to 63.94		

(6) Replacement of Crankshaft Gerar

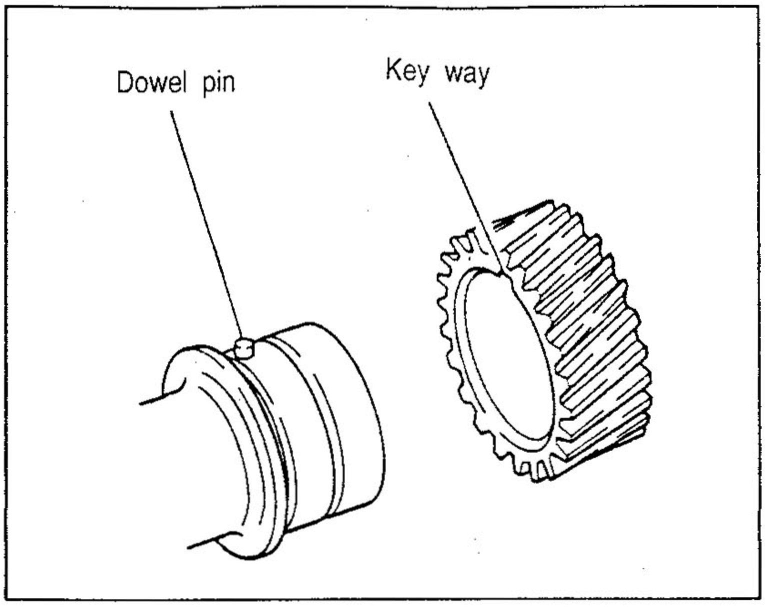
1) Crack a oil seal slinger, using a chisel etc., and remove it from the crankshaft.

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

NOTE : do not attempt removing the gear by striking.

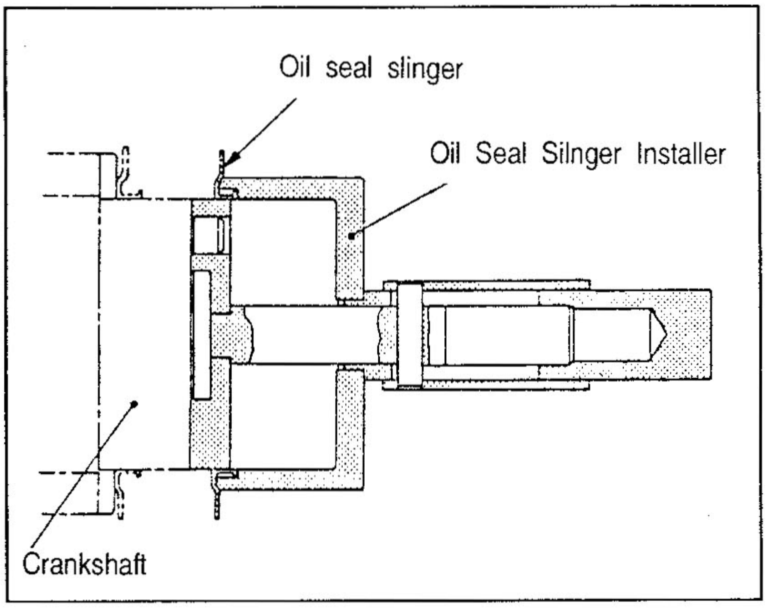


3) Heat the gear to about 100℃ with a heater, etc. Locate the gear so that the dowel pin of the crankshaft will fit in the notch of the gear and fit the gear by lightly striking the gear end with a soft hammer.



4) Install the oil seal slinger, using Oil Seal Slinger Installer(special tool).

NOTE : The Oil seal slinger should be installed with the thread grooved side toward the flywheel.



6-3 REASSEMBLY

For reassembly, make sure that the following items are strictly observed.

(1) Throughly clean all parts to be reassembled. check to ensure that there are no dust, oil or water on the joining surfaces of the parts before reassembly.

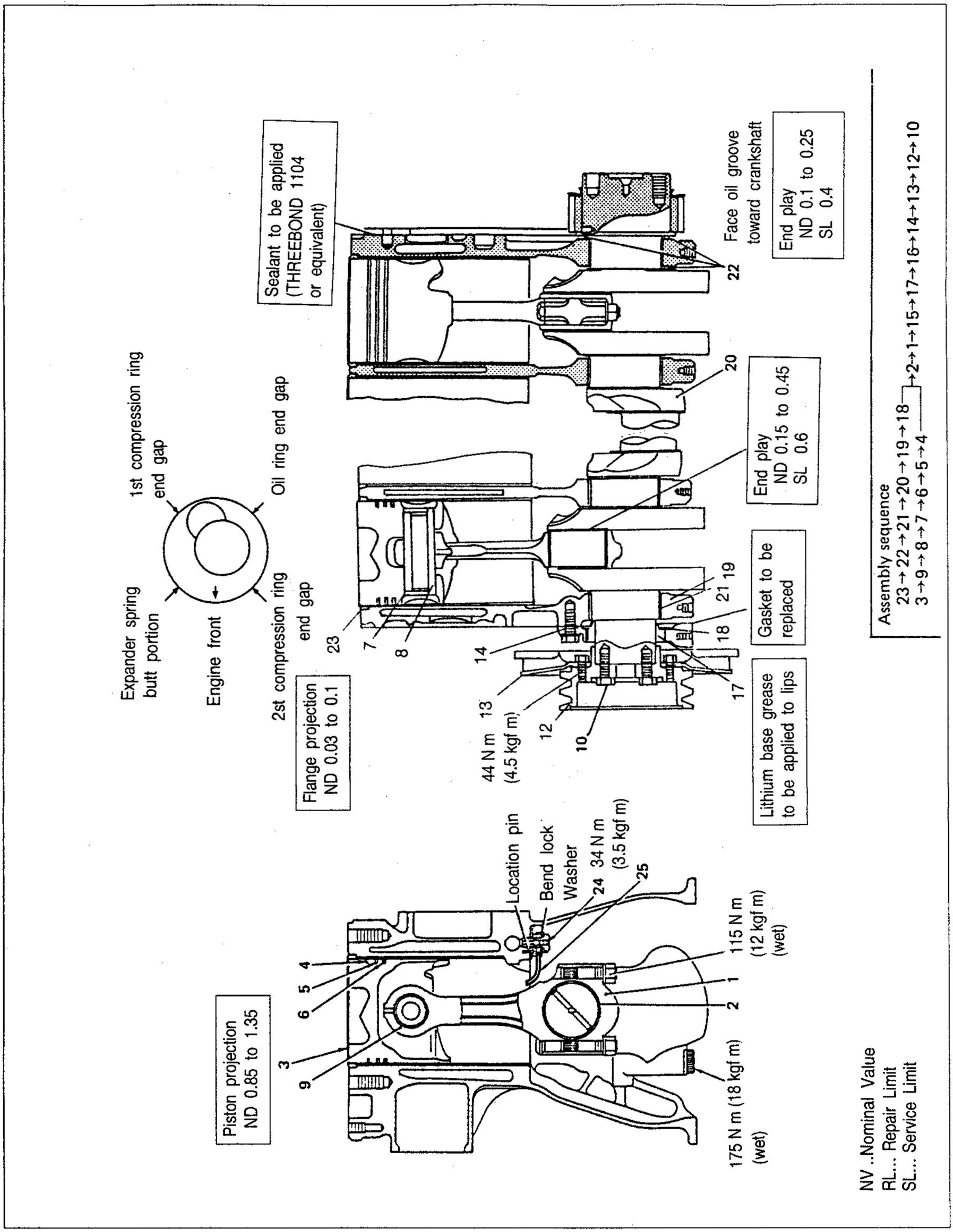
(2) The gaskets, O-rings, packings, lock washers, split pins, etc. should be replaced with new ones. Since gasket kits are available, use them at the time of an overhaul.

(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 tigtening torque is specified should be tightened to the general bolt and nut tightening torque.

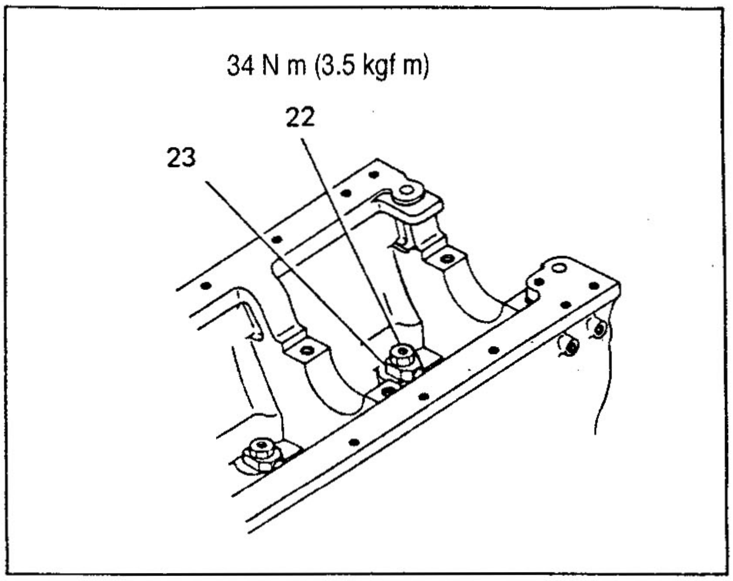
(5) Apply engine oil to all moving parts before reassembly unless otherwise specified.

6-3-1 Crankcase and Main Moving Parts



(1) Fix the oil jet 23 in alignment with the locating pin and tighten check valve 22 to specification.

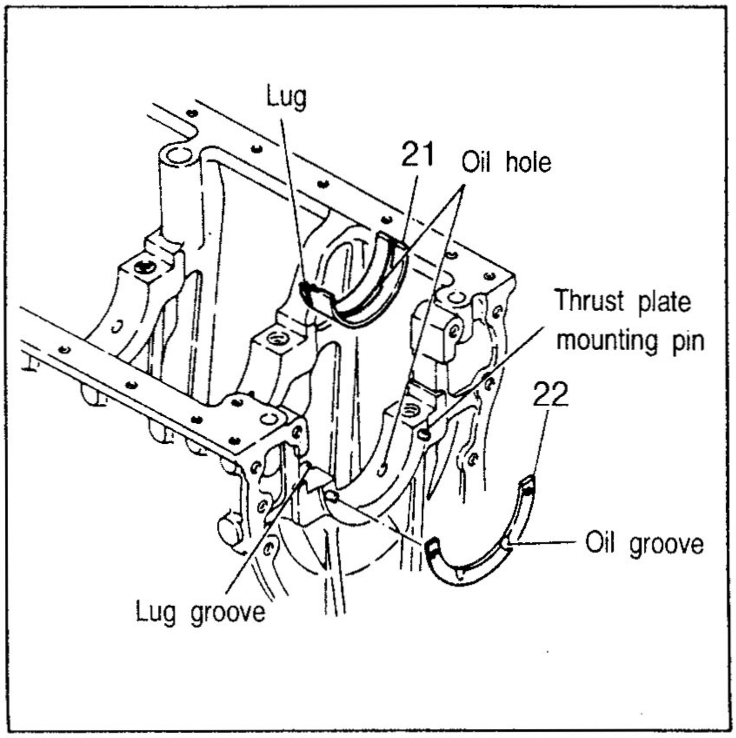
NOTE : Secure check valve by bending lock washer.



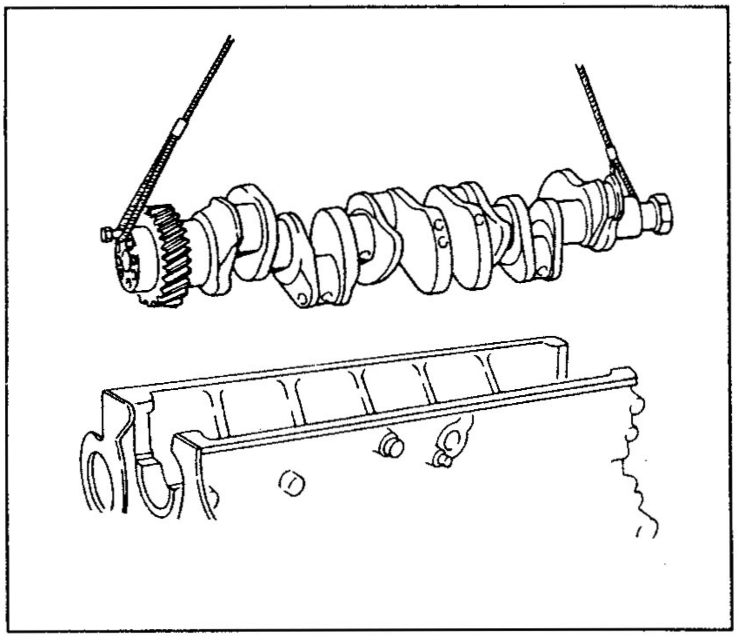
(2) Install the thrust plate 22 and upper main bearing 21 to the crankcase.

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

2. Line up the oil hole of the upper main bearing with the oil hole of the crankcase. (The lower bearing has no oil hole.) Now the lug of the main bearing is aligned with the groove of the crankcase.

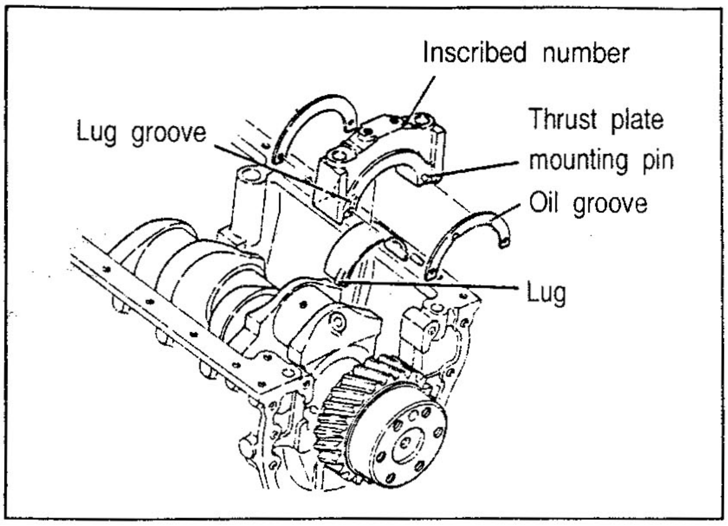


(3) Lift the crankshaft 20 with chain blocks, etc. While keeping it in horizontal position, slowly lower it into the crankcase.



(4) After fitting the lower main bearing 21 onto the main bearing cap 19, install the bearing cap to the crankcase, while tapping it with a soft hammer.

The thrust plates 22 should also be installed to the front and rear of the rear main bearing cap.



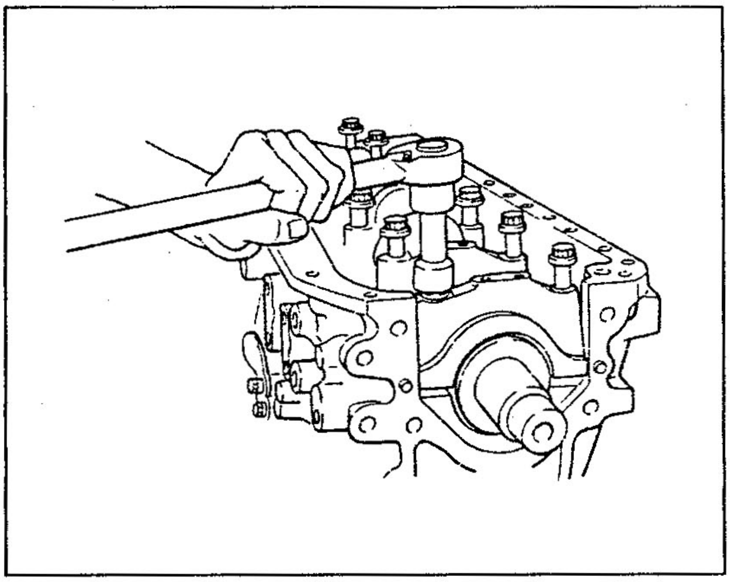
NOTE : 1. The lug of the lower main bearing should be on the same side as the lug of the upper main bearing.

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

(5) Tighten the bearing cap bolts to the specified torque.

NOTE : 1. Tighten two bolts alternaterly.

2. Check to ensure that the crankshaft turns lightly when turned by hand.



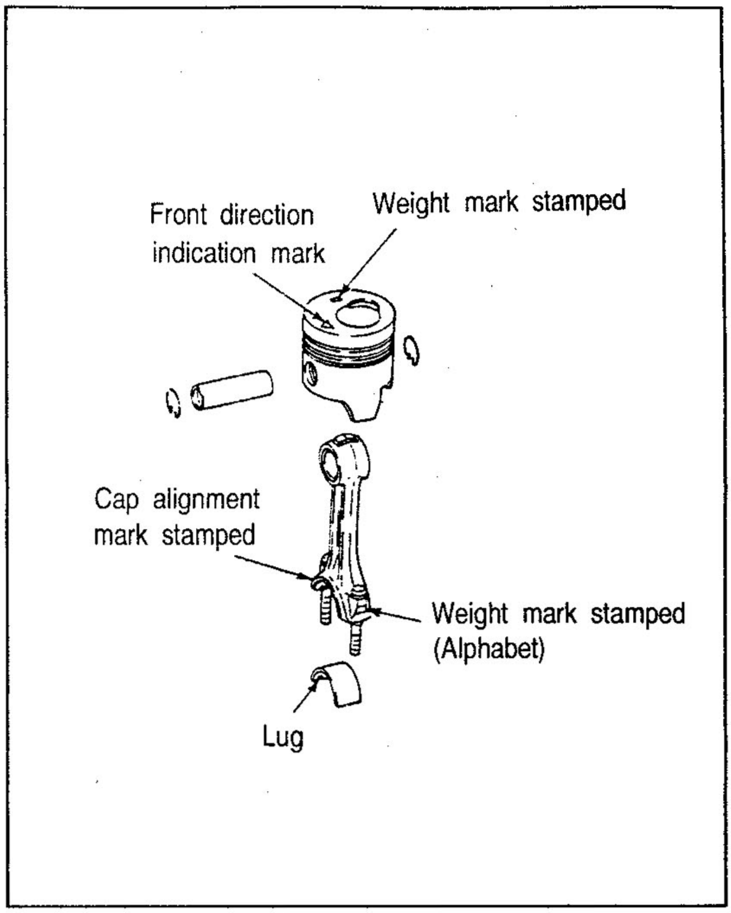
(6) Check the end play of the crankshaft. See Para. 6-1-3 (6).

(7) Reassembly of Piston and Connecting Rod

(a) Face the weight mark stamped side of the piston and the lug groove side of the connecting rod in the same direction.

(b) Insert the piston pin to couple the piston and connecting rod. Fit the snap rings onto the piston pin to prevent the piston pin from slipping out of position.

The piston and piston pin are to be clearance fitted. If the piston pin is hard to insert, however, heat the piston with a piston heater or in hot water.



NOTE : 1. The weight of piston is indicated in gram on the piston head. Piston weight difference for an engine must be within 10g.

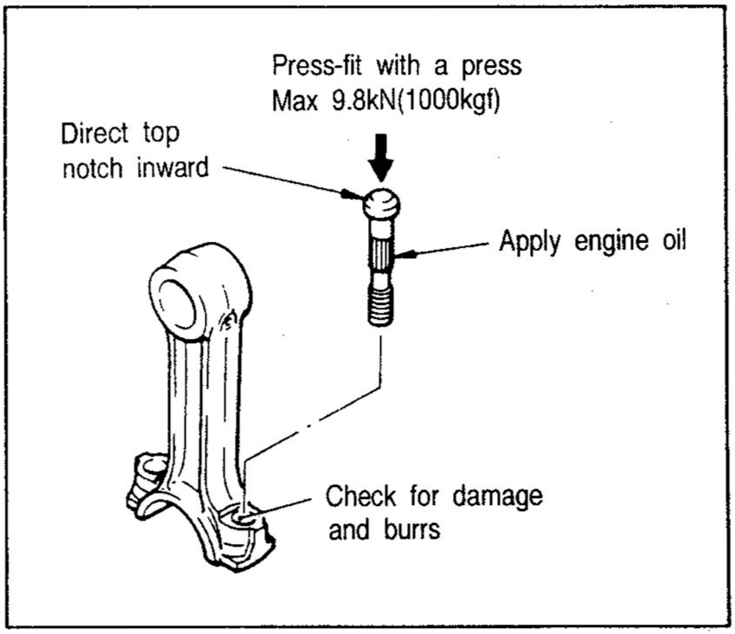
2. Install connecting rods having the same weight symbol for an engine.

3. Ensure that the size marks on piston and cylinder liner match.

The connecting rod bolt usually need not to be removed. When a defective one is to be replaced, install a new bolt by the following procedures.

Check to ensure that the connecting rod bolt hole has no damage, burrs, etc., apply engine oil to the connecting rod bolt, and install the bolt with a press.

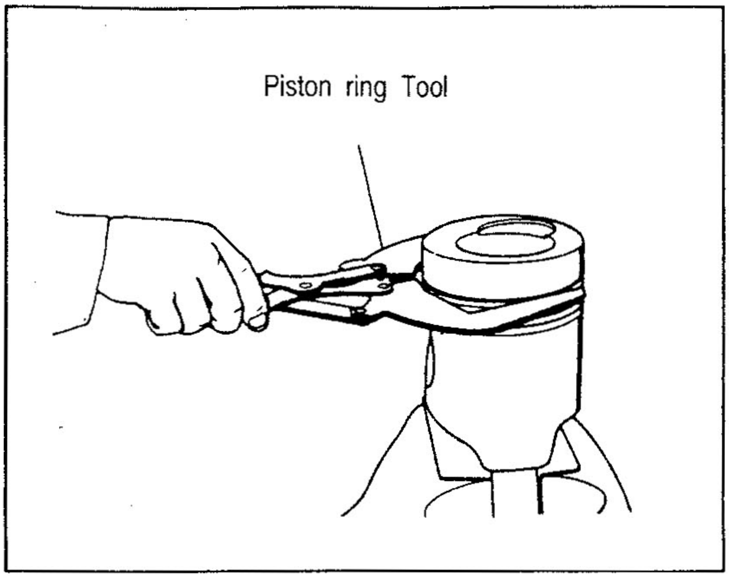
(Installation load 9.8kN(1,000kgf) maximum)



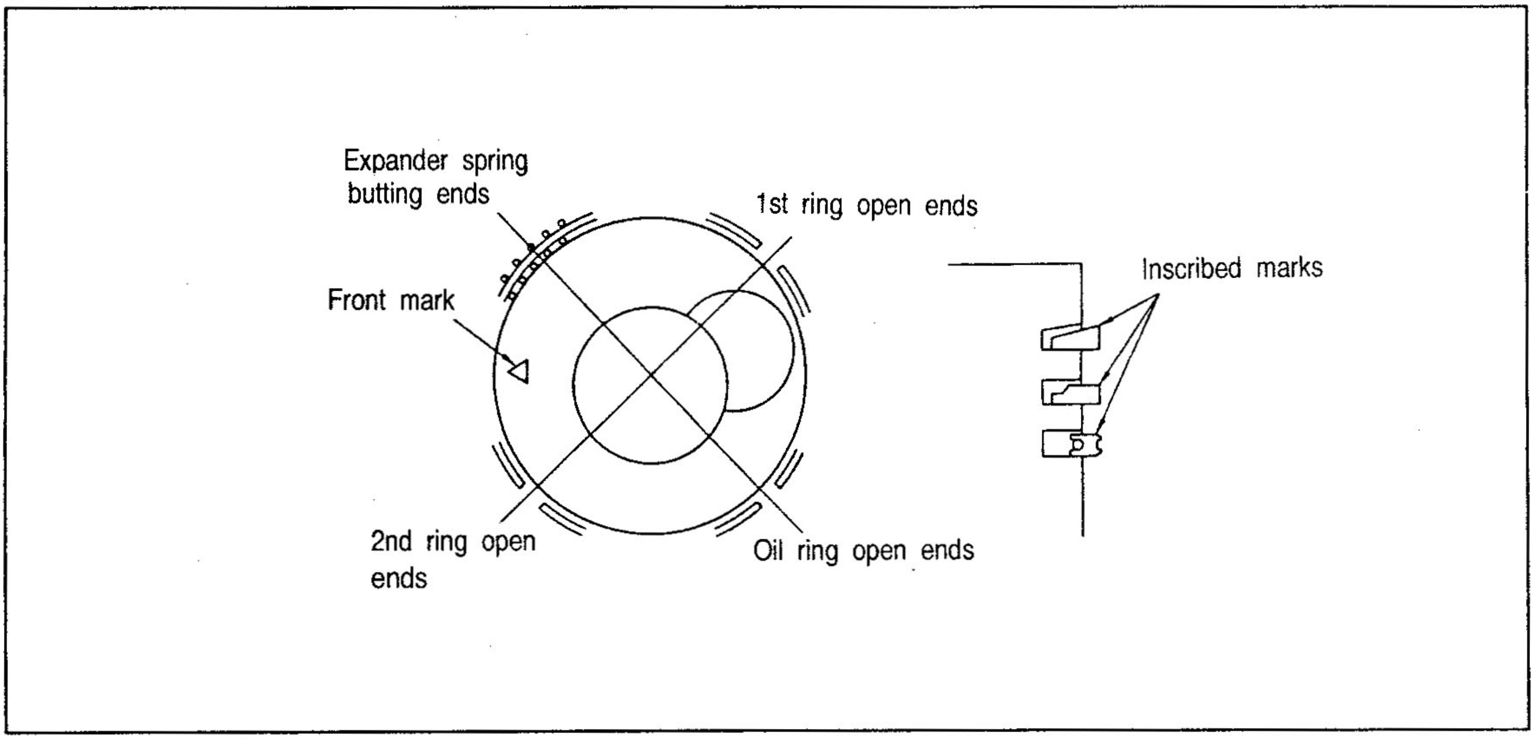
(c) Using Piston Ring Tool(special tool), install the piston rings in the following sequence.

6 Oil ring
5 2nd compression ring
4 1st compression ring

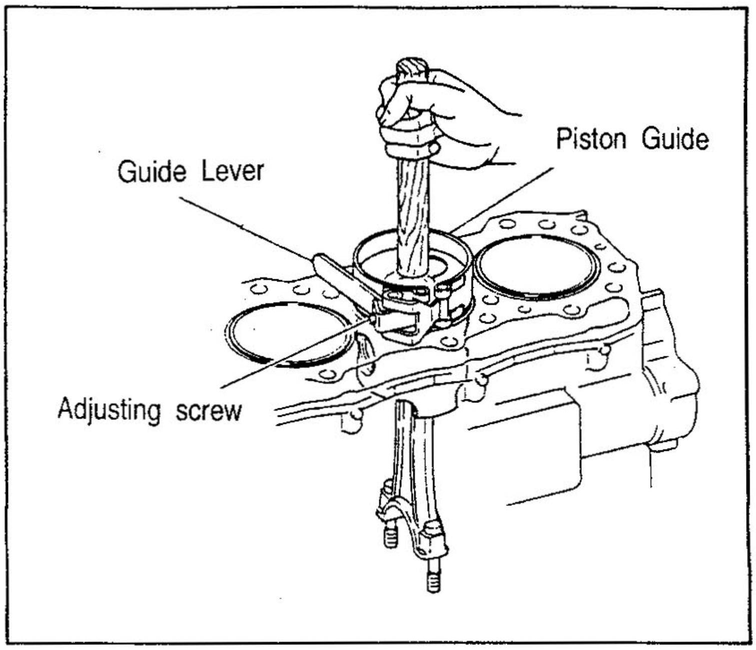
NOTE : The manufacturer's mark is stamped near the open ends of piston ring. Install the piston ring with the manufacturer's mark upward.



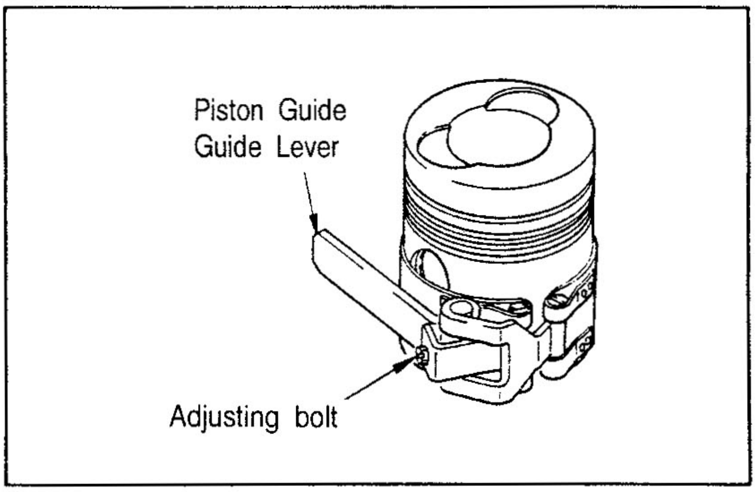
Locate the open ends of each piston ring with respect to the piston as shown in the figure at right.



(d) Fit the connecting rod bearing 2 upper into the connecting rod and insert the piston into the cylinder liner, using Piston Guide(special tool).

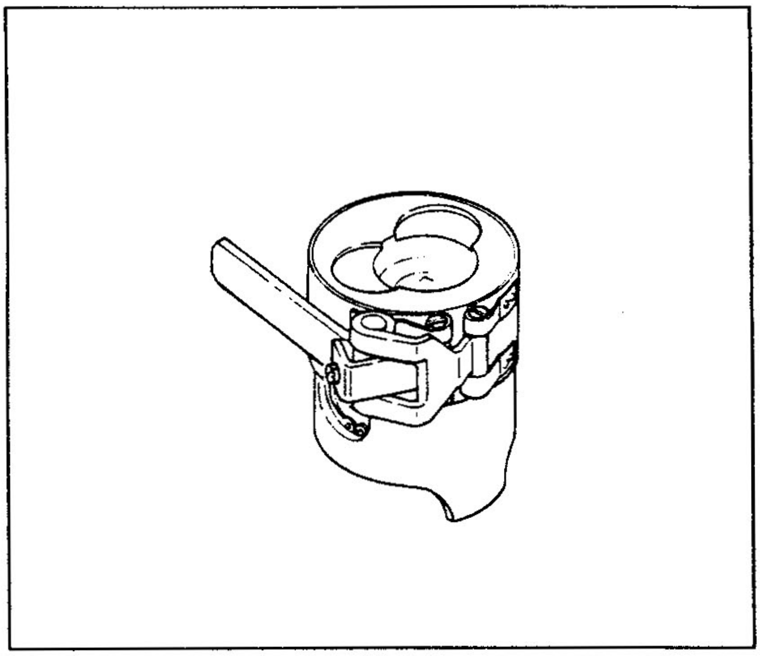


NOTE : For engine, keep the piston guide flush with the piston skirt and set the piston guide lever. Adjust with the adjusting bolt until the clamp I.D. fits to the piston O.D.



After adjustment, remove the piston guide from the piston and apply engine oil to the Piston O.D., piston guide I.D., and cylinder liner I.D.

With above procedure compleetd, install the piston guide so that it may be flush with the piston top surface.



NOTE : 1. Direct the lug side of the connecting rod bearing toward the right side(exhaust manifold side) of the engine.

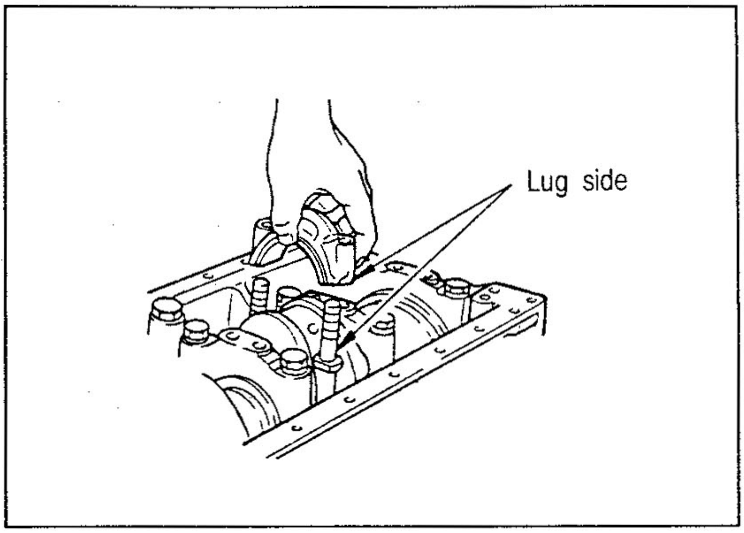
2. Make sure that the open ends of the piston rings do not change their positions.

3. Place a vinyl hose, tec. on the connecting rod bolts to prevent damage to the crankshaft pins.

4. At installation, make sure that the connecting rod does not interfere with the oil jet.

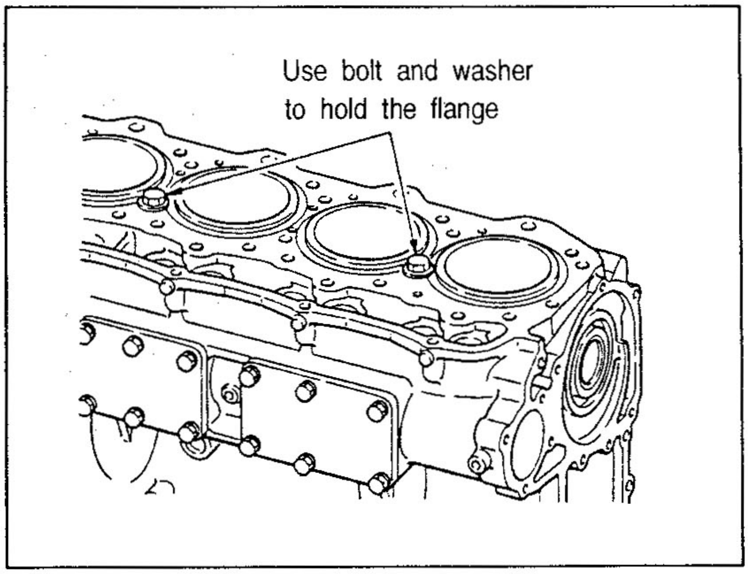
(e) Install the connecting rod cap 1 with the connecting rod bearing 2 lower in position.

Tighten the nut to the specified torque.



NOTE : 1. direct the lug side of connecting rod and the lug side of the connecting rod cap in the same direction.

2. Install the connecting rod and turn the crankshaft. If the cylinder liner rises, use bolt and washer to hold the flange of cylinder liner.



(8) Check the following points.

(a) Piston projection, see Para. 6-1-3 (2).

(b) Cylinder liner flange projection, see Para. 6-2-6 (2).

(c) Crankshaft end play, see Para. 6-1-3 (6).

(d) connecting rod end play, see Para. 6-1-3 (1).

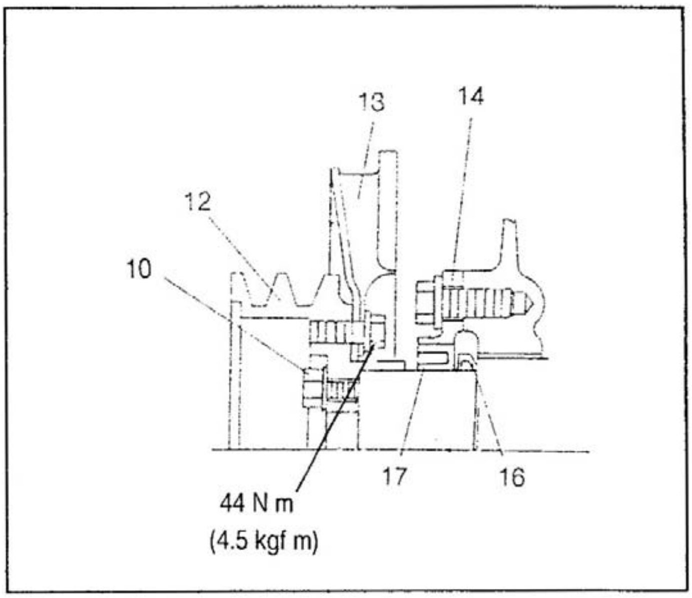
(e) Hydraulic test (Any water leaks from cylinder liner fitting portion are not permitted.)

(9) Fit the slinger 16 into the crankshaft.

(10) Install the seal plate 18 and oil seal 17 fitted front cover 14 to the crankcase.

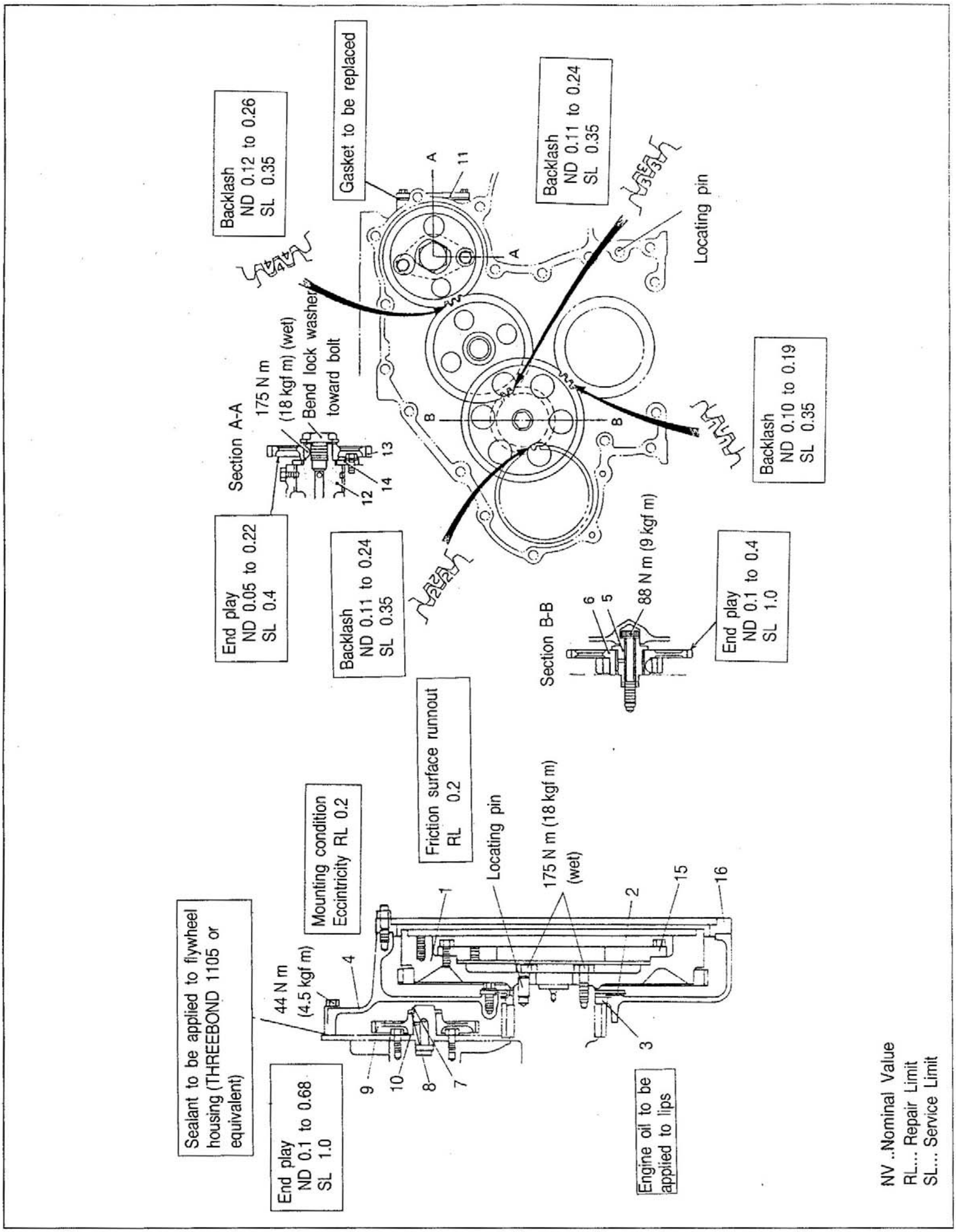
(11) Bolt-tighten the torsional damper 13 to the crankshaft pulley 12.

(12) Fit the sunk key into the crankshaft pulley 12 and install to the crankshaft.



(13) Insert the crankshaft pulley 12 into the crankshaft and tightem the crankshaft pulley bolt 10 to the specified torque.

6-3-2 Flywheel, Timing Gear and Camshaft



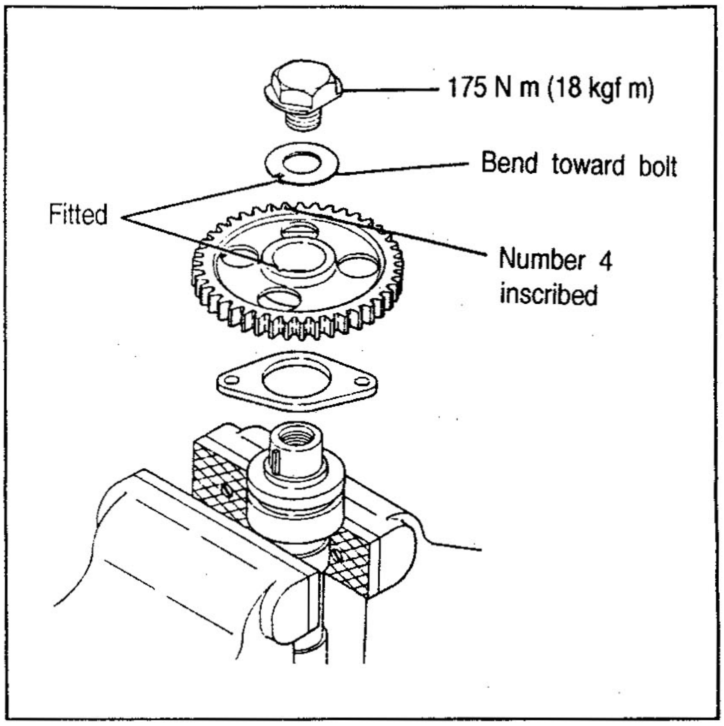
(1) Camshaft

(a) Hold the camshaft in a vice.

(b) Install the following parts in the order of mention.

14 Thrust plate

13 Camshaft gear

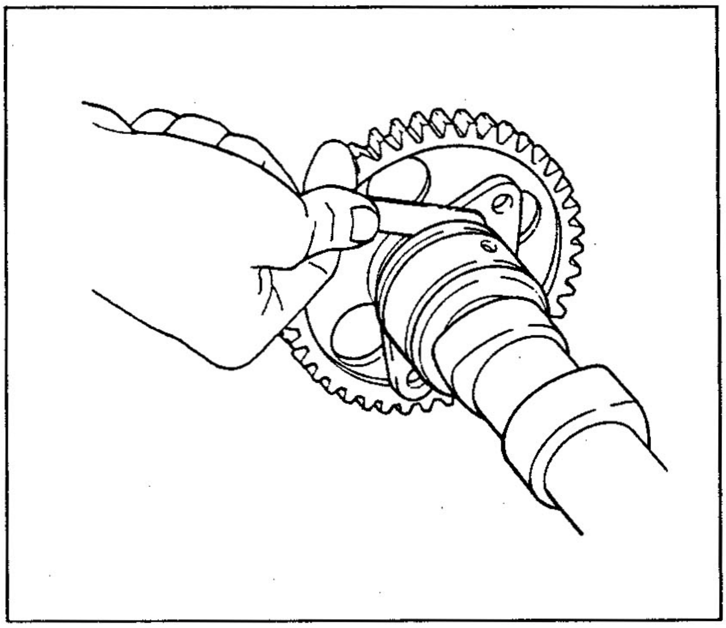


NOTE : 1. Protect the camshaft with an aluminum or copper plate when it is held in a vice.

2. Install the camshaft gear with the number inscribed side of teeth outward.

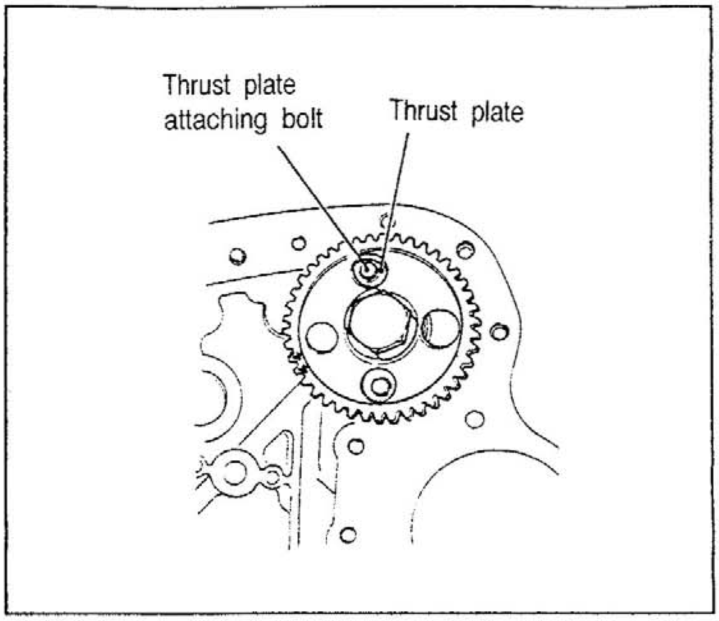
3. To prevent the gear attaching bolt from turning, make sure that the lug of lock washer is positively fitted in the groove and the washer is bent.

(c) Check the end play of the camshaft gear.



(d) Insert the camshaft 12 into the crankcase and mount the thrust plate to the crankcase with bolt.

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

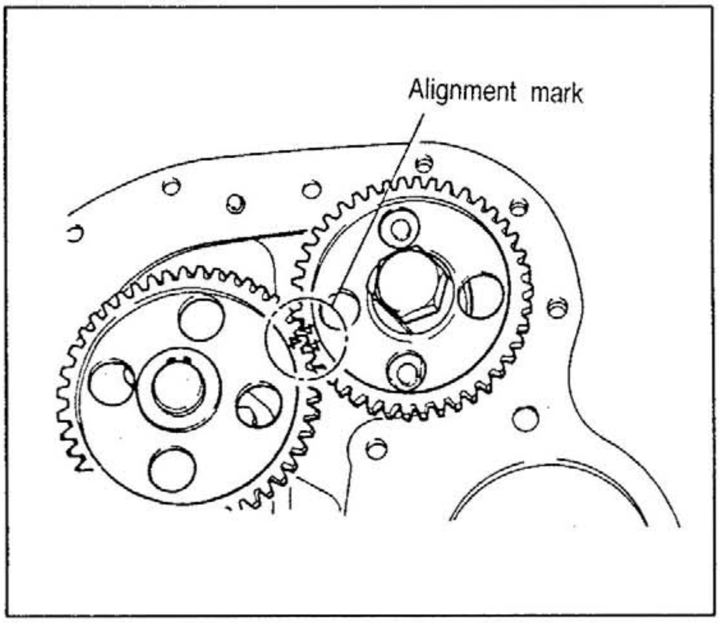


(2) Idler Gear No. 2

Install inthe following sequence.

10 Idler shaft No. 2
9 Idler gear No. 2
8 thrust washer
7 Snap ring

NOTE : Put the idler gear No. 2 and camshaft gear in mesh so that the same marks inscribed on the side of teeth will meet with each other.

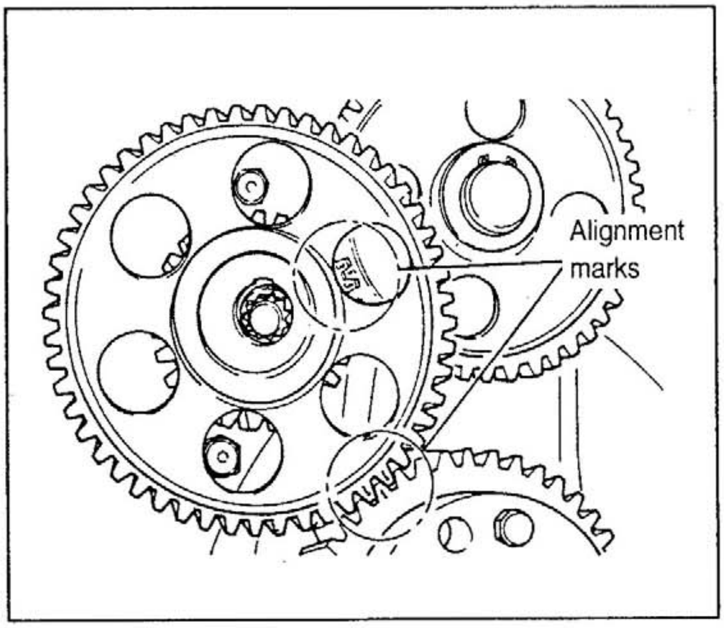


(3) Idler Gear No. 1

(a) Insert the idler shaft No. 1 8 into the idler gear No. 19.

(b) Mount the idler shaft No. 1 to the crankcase together with the gear.

(c) Tighten the bolt to the specified torque.

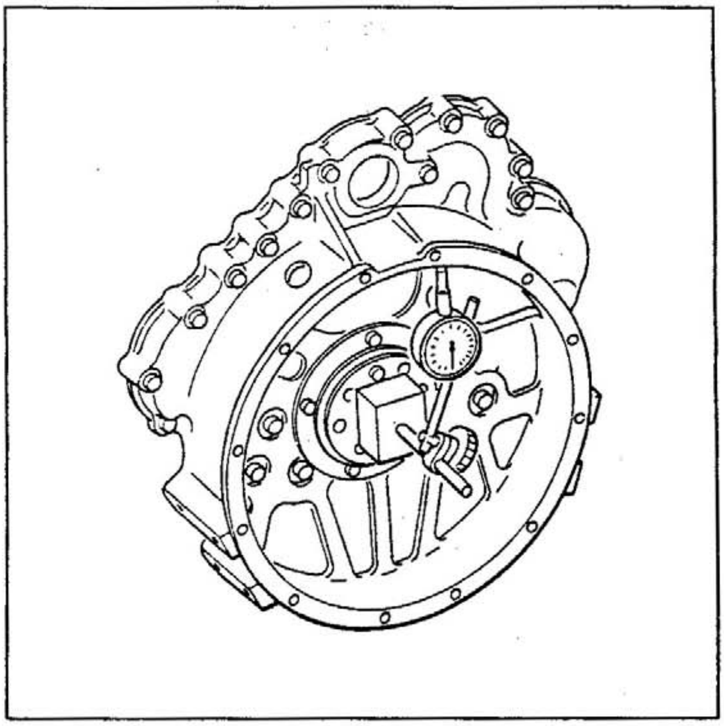


NOTE : The alignment mark is stamped on the side of teeth of the idler gear No. 1. Put the idler gear No. 2 and crankshaft gear in mesh so that the teeth of the same marks will meet with each other.

(4) Flywheel Housing and Flywheel

(a) Apply sealant to the flywheel housing.

(b) Install the flywheel housing 4 to the crankcase and tighten the bolts to the specified torque.



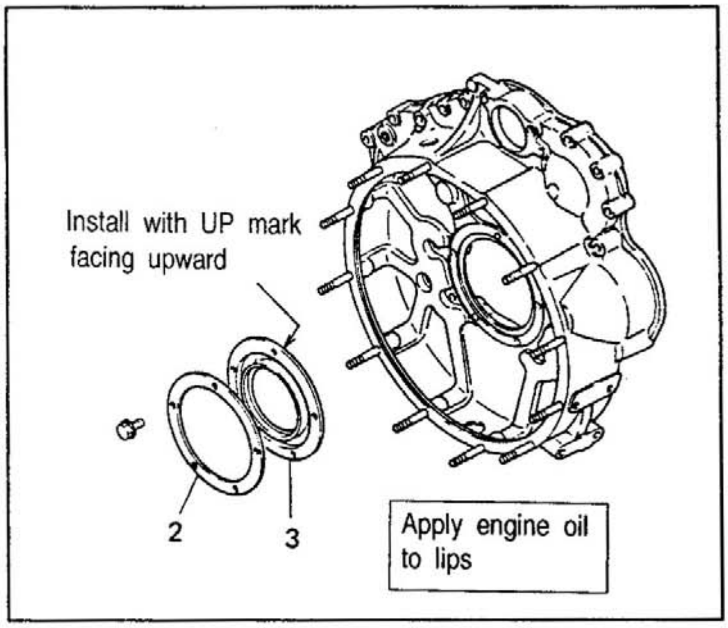
(c) Measure the mounting condition (eccetricity) at the flywheel housing sockeet.

If the pointer of the dial indicator deflects beyond the repair limit, loosen the bolts and lightly strike the housing to correct the mounting condition.

(d) Install the following parts

3 Oil seal
2 Washer plate

NOTE : Apply engine oil to the oil seal lips and turn down the bolts evenly to make sure that the eccentricity of the oil seal does not occur.

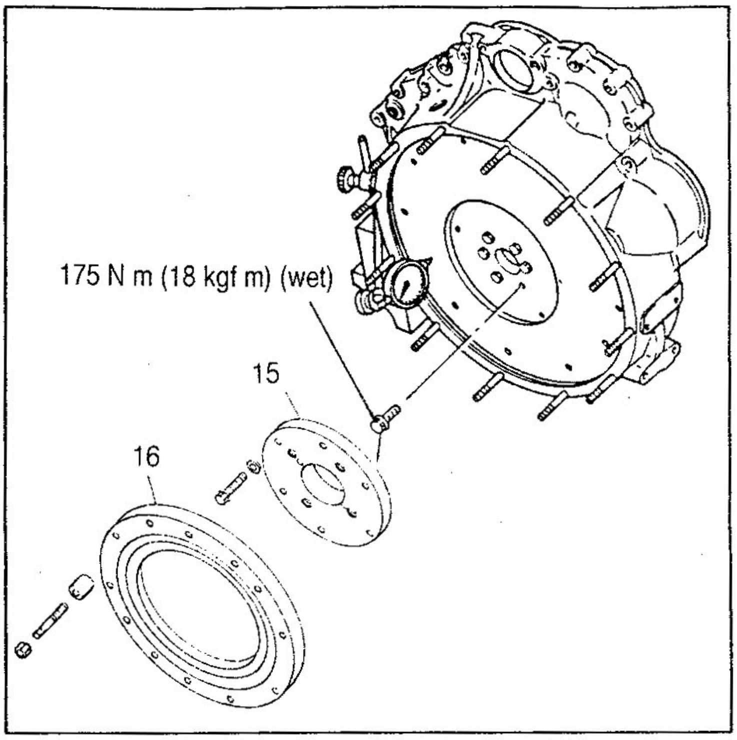


(e) Installation of flywheel

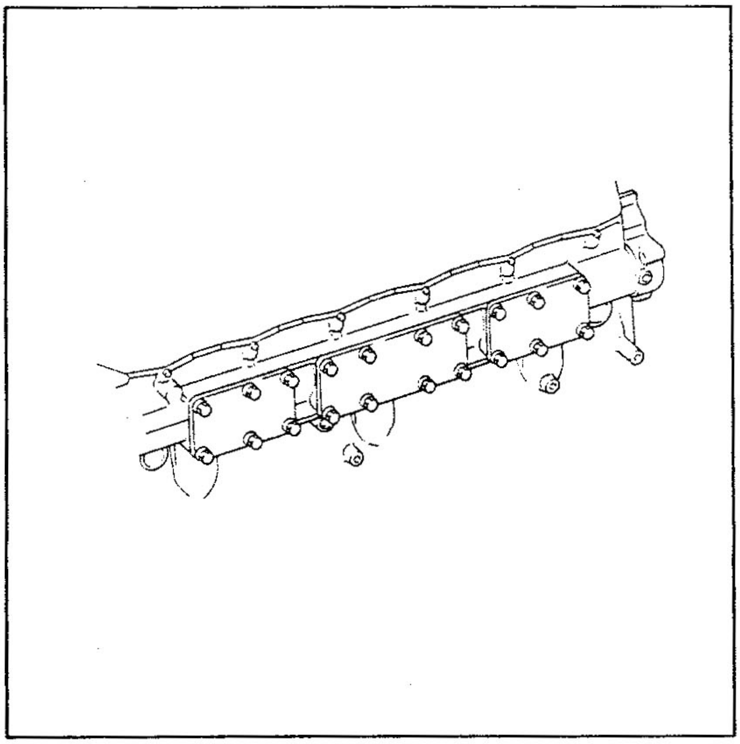
1) Install the flywheel 1 to the crankshaft. Tighten the bolts to the specified torque.

2) Measure the mounting conditin (runout). If the repair limit is exceeded, check for improper bolt tightness and presence of foreign matter on the mounting surfaces.

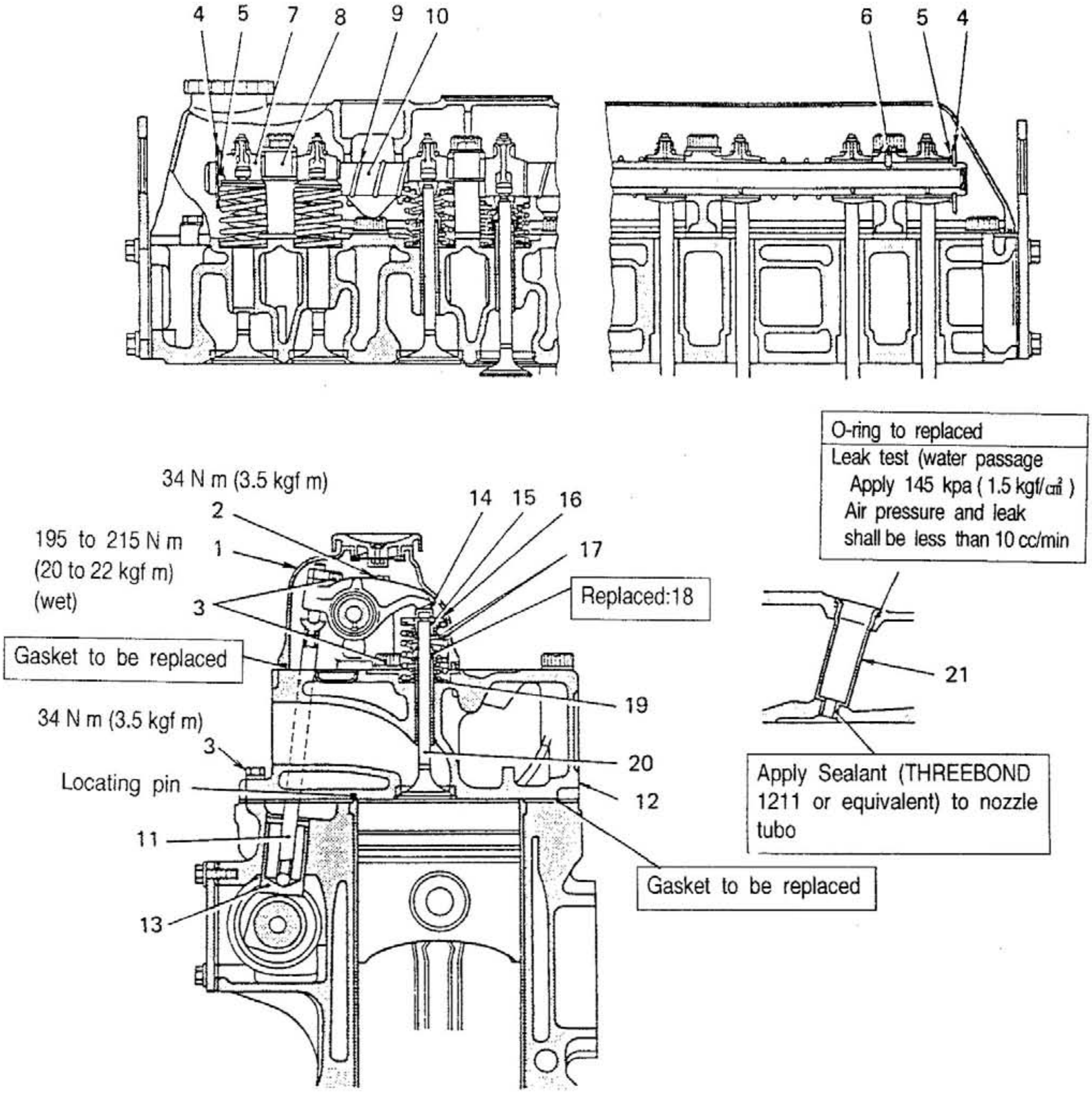
3) Install the adaptor 15 to the flywheel and the spacer 16 to the flywheel housing.



(f) Install the side cover 11 to the crankcase.



6-3-3 Cylinder Head and Valve Mechanism



Assembly sequence

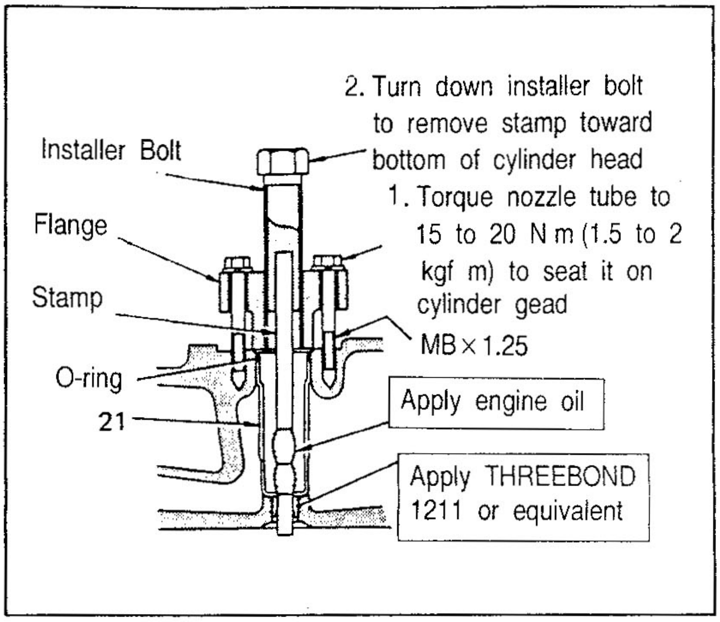
21 → 20 → 19 → 18 → 17 → 16 → 15 → 14 → 13 → 12 → 11 ┐
10 → 8 → 6 → 7 → 9 → 5 → 4 ┘→ 3 → 2 → 1

(1) Nozzle Tube

(a) Apply sealant to the end of the nozzle tube 21 and insert into the cylinder head.

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

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



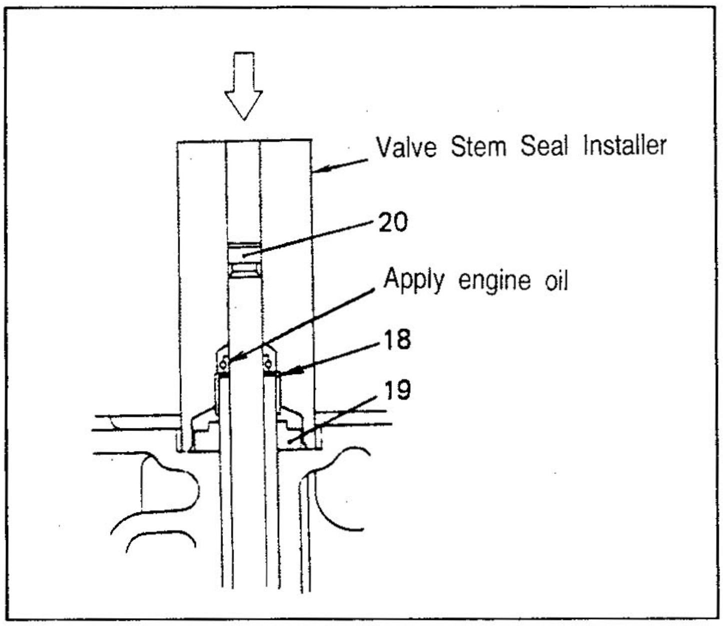
(d) Turn down Installer Bolt (special tool) to remove the Stamp toward the bottom of the cylinder head.

NOTE : After installation, conduct leak test to ensure air-tightness.

(2) Install the following parts.

20 Valve
19 Lower retainer
18 Valve stem seal

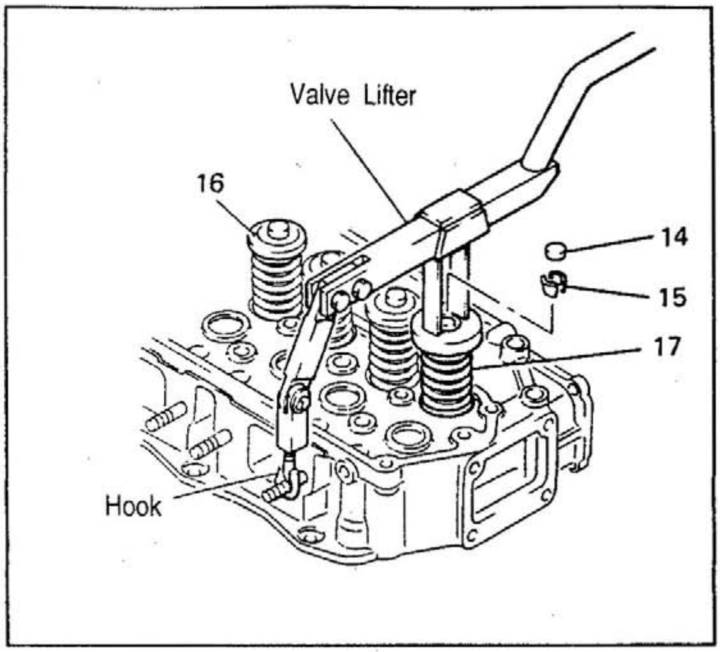
Apply engine oil to the lips of the valve stem seal and strike Valve Stem Seal Installer (special tool) until it touches the cylinder head.



(3) Install the following parts.

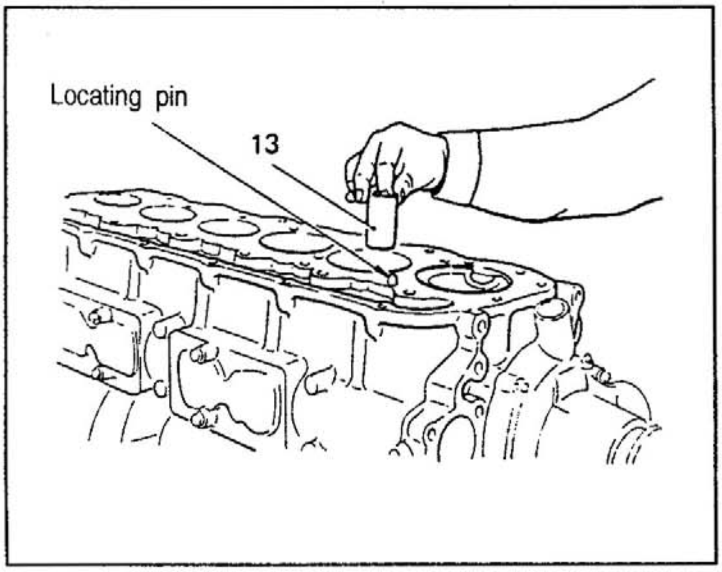
17 Valve spring
16 Upper retainer
15 Valve cotter
14 Valve cap

Install the valve cotter and valve cap, while compressing the valve spring with a Valve Lifter (special tool).

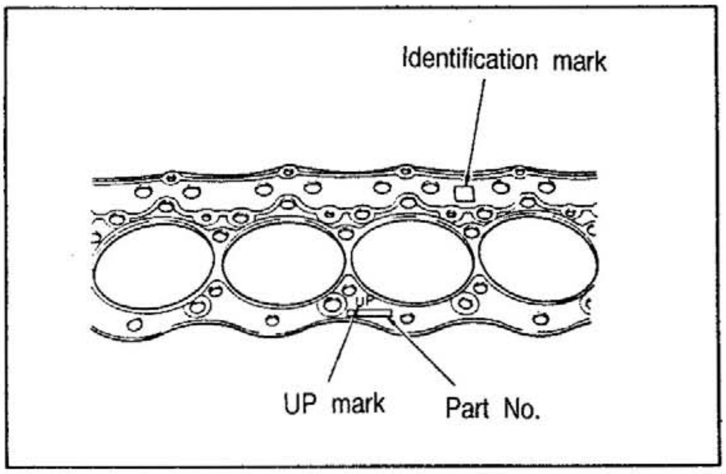


(4) Slowly seat the tapper 13 on the camshaft.

(5) Seat the cylinder head 12 on the crankcase, while making sure that it fits on the locating pins.



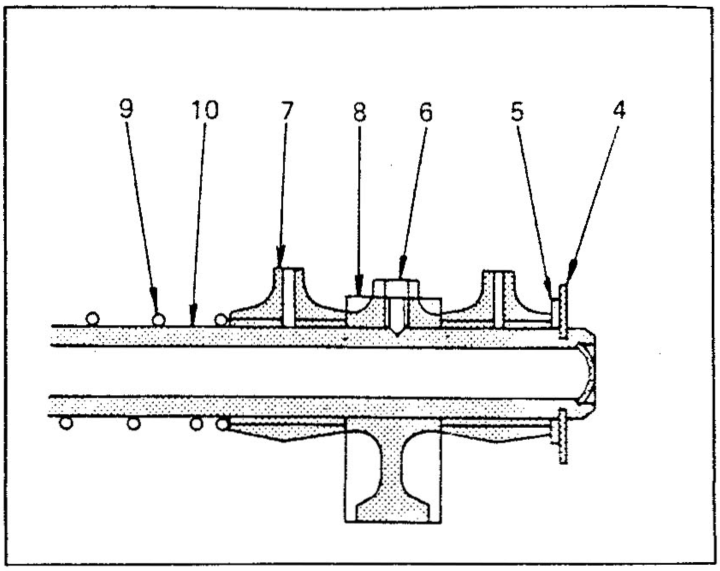
NOTE : Install the cylinder head gasket with the UP mark side toward the cylinder head.

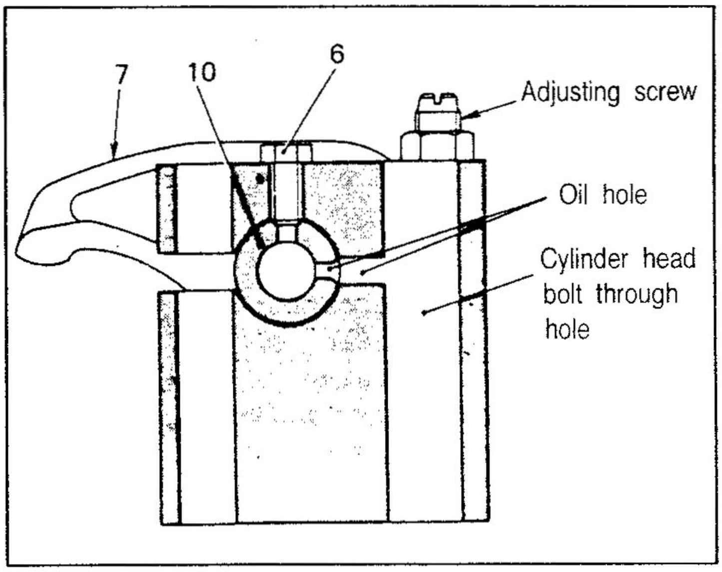


(6) Install the following parts to the rocker shaft 10.

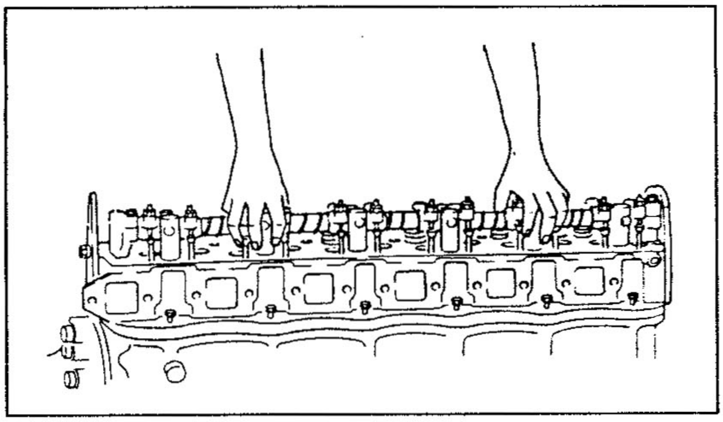
8 Rocker shaft bracket
6 Set screw
7 Rocker
9 Rocker shaft spring
5 Washer
4 Snap ring

NOTE : The rocker shaft bracket in the rear has an oil hole. Line up the oil hole of the rocker shaft and the oil hole of the rocker shaft bracket and secure with the set screw.

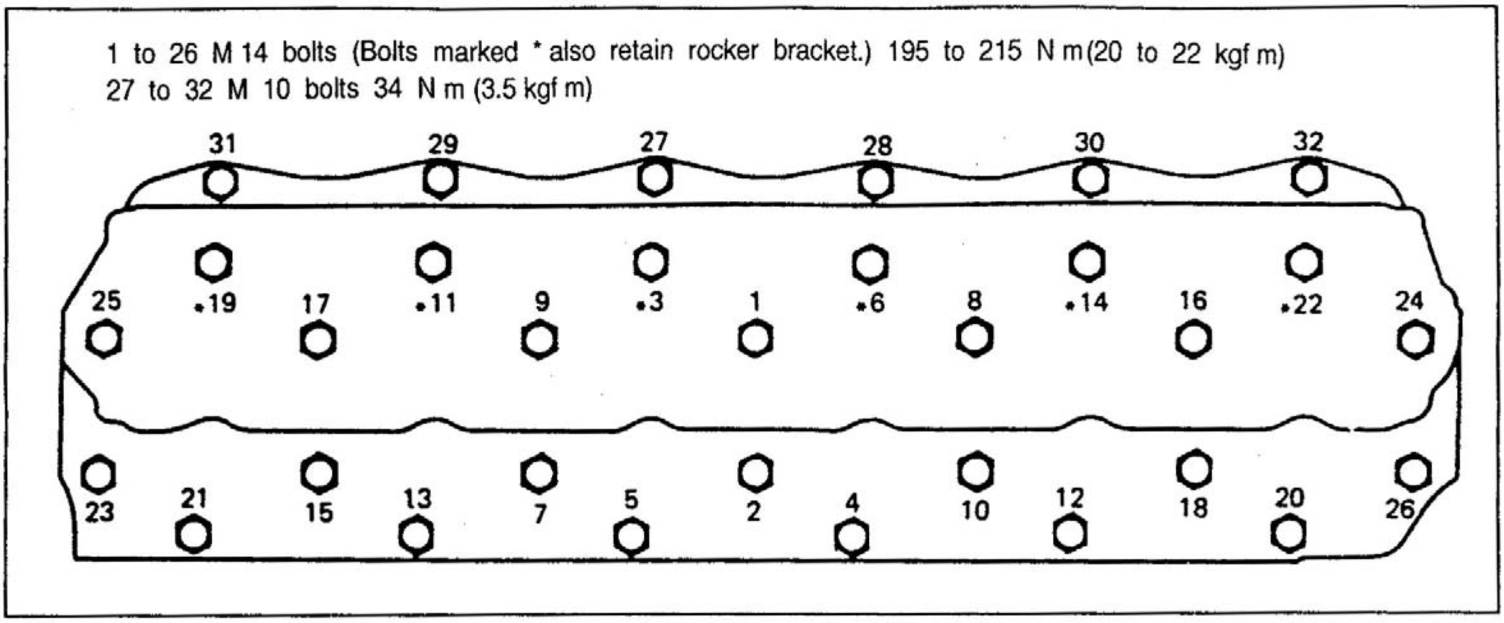




(7) Install the push rod 11 and rocker and bracket assembly.



(8) Tighten the cylinder head bolts 3 evenly to the specified torque in the sepuence shown below.



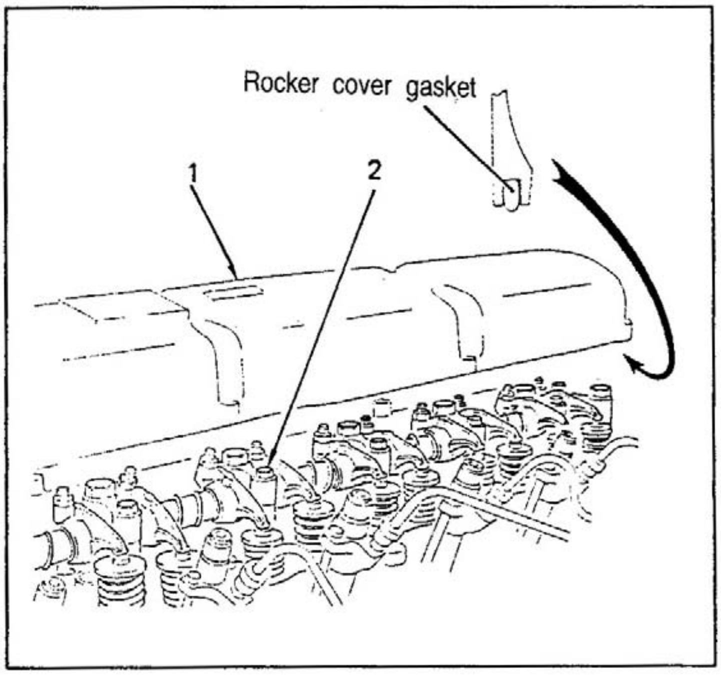
(9) Install the following parts.

2 Rocker backet bolt
1 Rocker cover

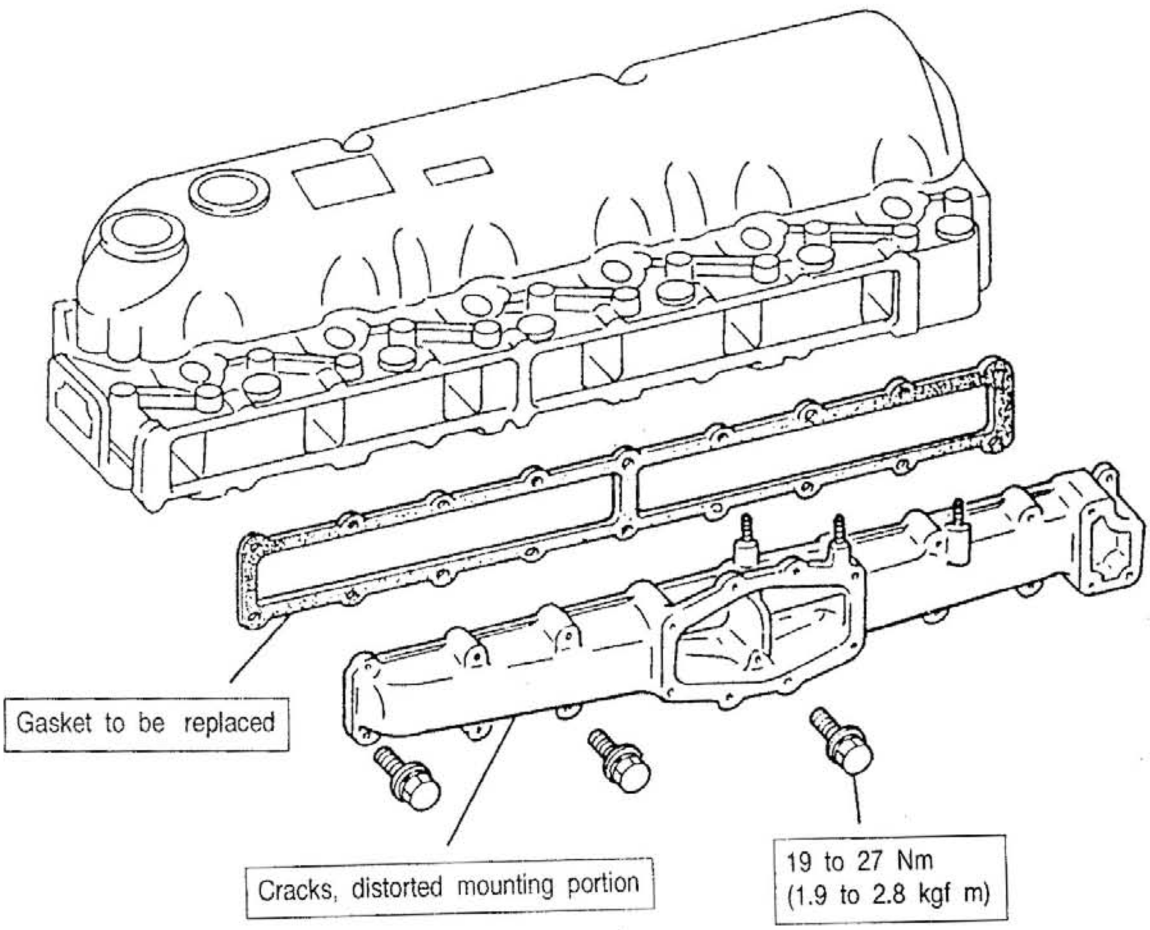
Tighten the bolts to the specified torque.

Complete engine adjustment before installation of the rocker cover.

NOTE : The rocker cover gasket should be installed with the round side toward the cylinder head.



7-1 INLET MANIFOLD

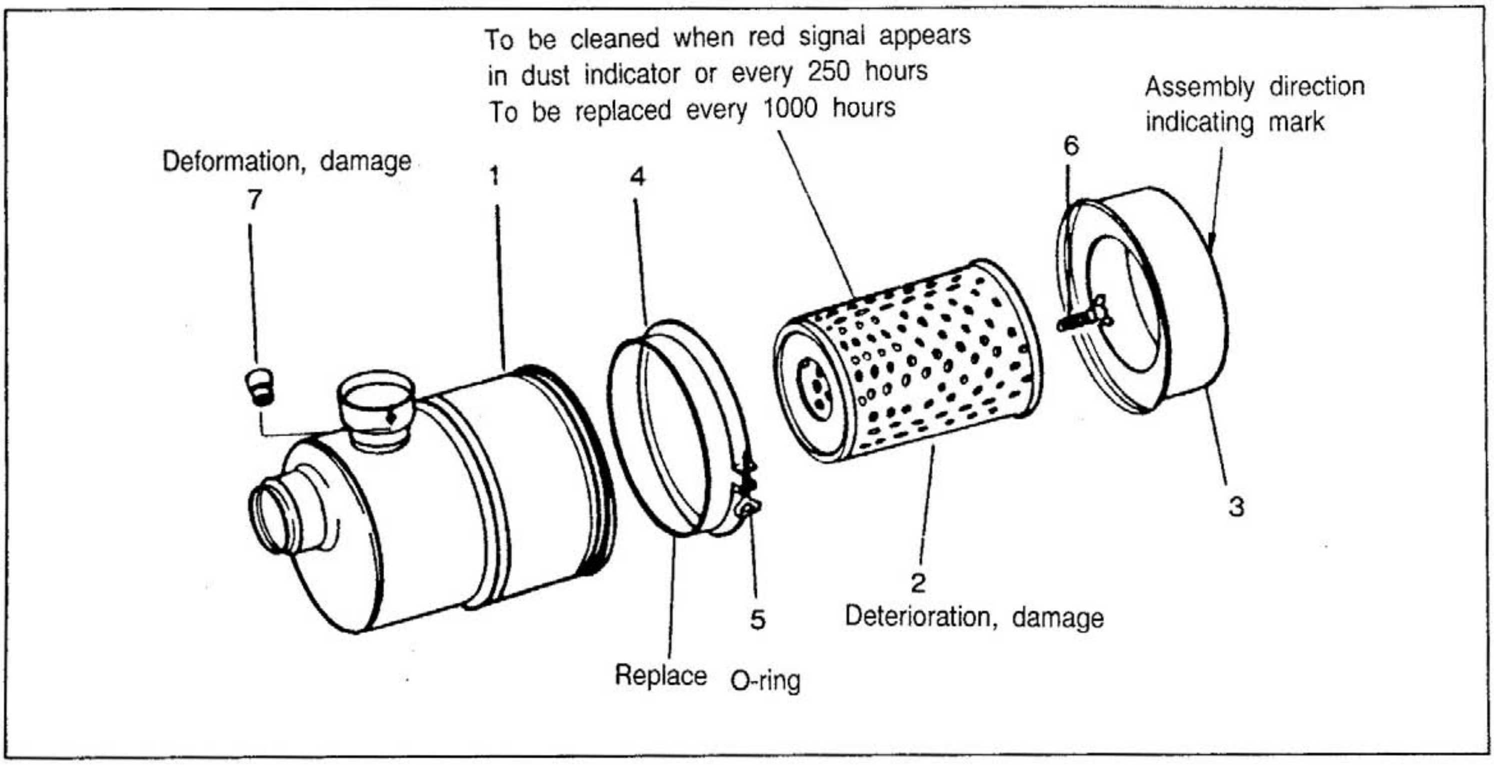


7-2 AIR CLEANER

7-2-1 Disassembly and Reassembly

(2) Cyclone Type Air Cleaner

[Single element type]

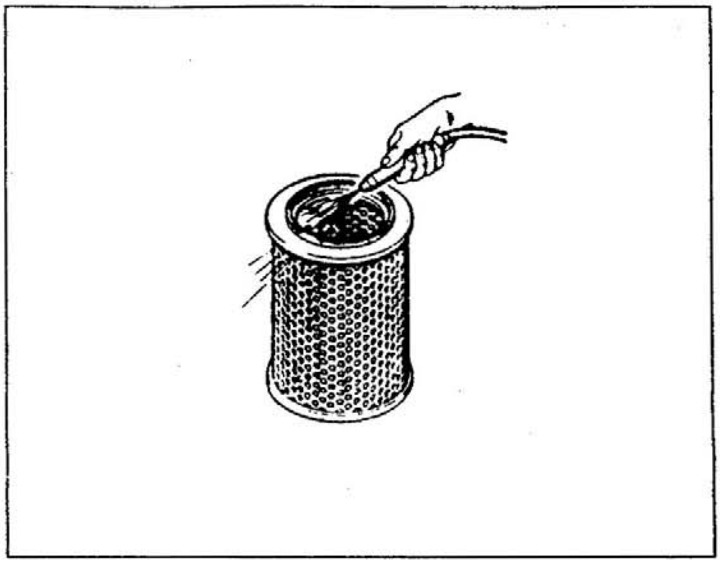


1 Air cleaner body	4 O-ring	7 Dust indicator
2 Element	5 Clamp	
3 Dust cup	6 Wing screw	

7-2-2 Inspection and Cleaning

(1) Inspection and Cleaning of Filter Paper Type Element

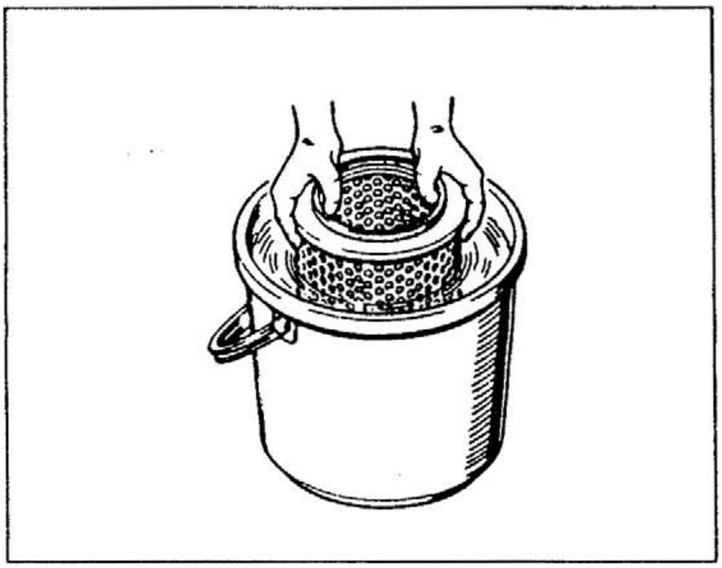
(a) Whent there is dry dust on the element



Clean by blowing compressed air [less than 685 kPa (7kgf/ cm^2)] against the element.
Blow compressed air from inside the element, moving the nozzle up and down along the filter paper frills, and clean the entire element.

NOTE : Avoid cleaning dust by striking the element or striking it against anything.

(b) When there is moist dust on the element.



When there is oil smoke or soot moistened dust on the element, clean the element using an element cleaner ND-1500.

Put 15g of the cleaner per liter of about 40℃ hot water, stir, and soak the element in the solution for about 30minutes, and clean.

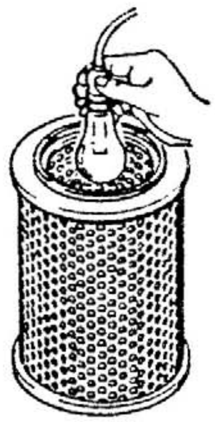
After cleaning, rinse the element in water [water pressure less than 275 kPa(2.8kgf/ cm^2)], and let dry in a well-ventilated place.

An element cleaned four times should be replaced irrespective of the distance covered

NOTE : When the element has to be dried in a short time, an electric fan may be used, but compressed air or fire must not be used.

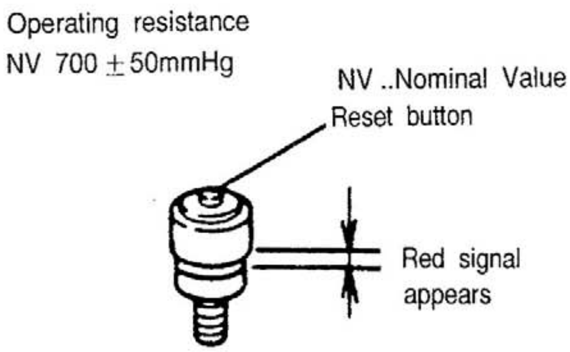
(c) Inspection of element

After the element has been cleaned, put an electric lamp inside the element, and check for damage and pinholes. If the filter paper has a thin portion, replace. If the packing on the top of the element is broken, replace.

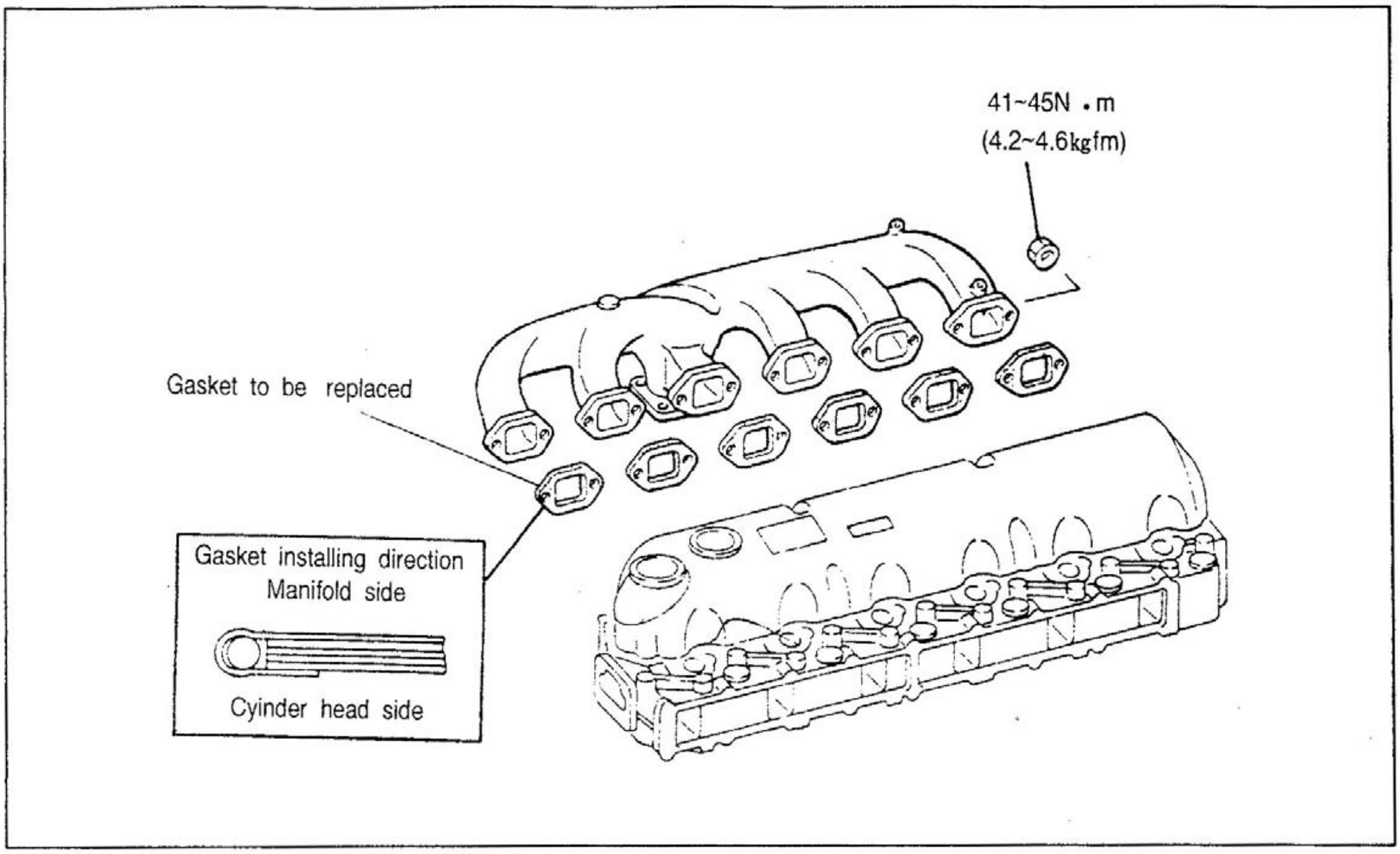


7-2-3 Inspection of Dust Indicator

Start the engine and close the inlet port of air cleaner gradually to increase negative pressure. If the red signal is displayed at the dust indicator, the dust indicator is normal.



7-3 EXHAUST MANIFOLD

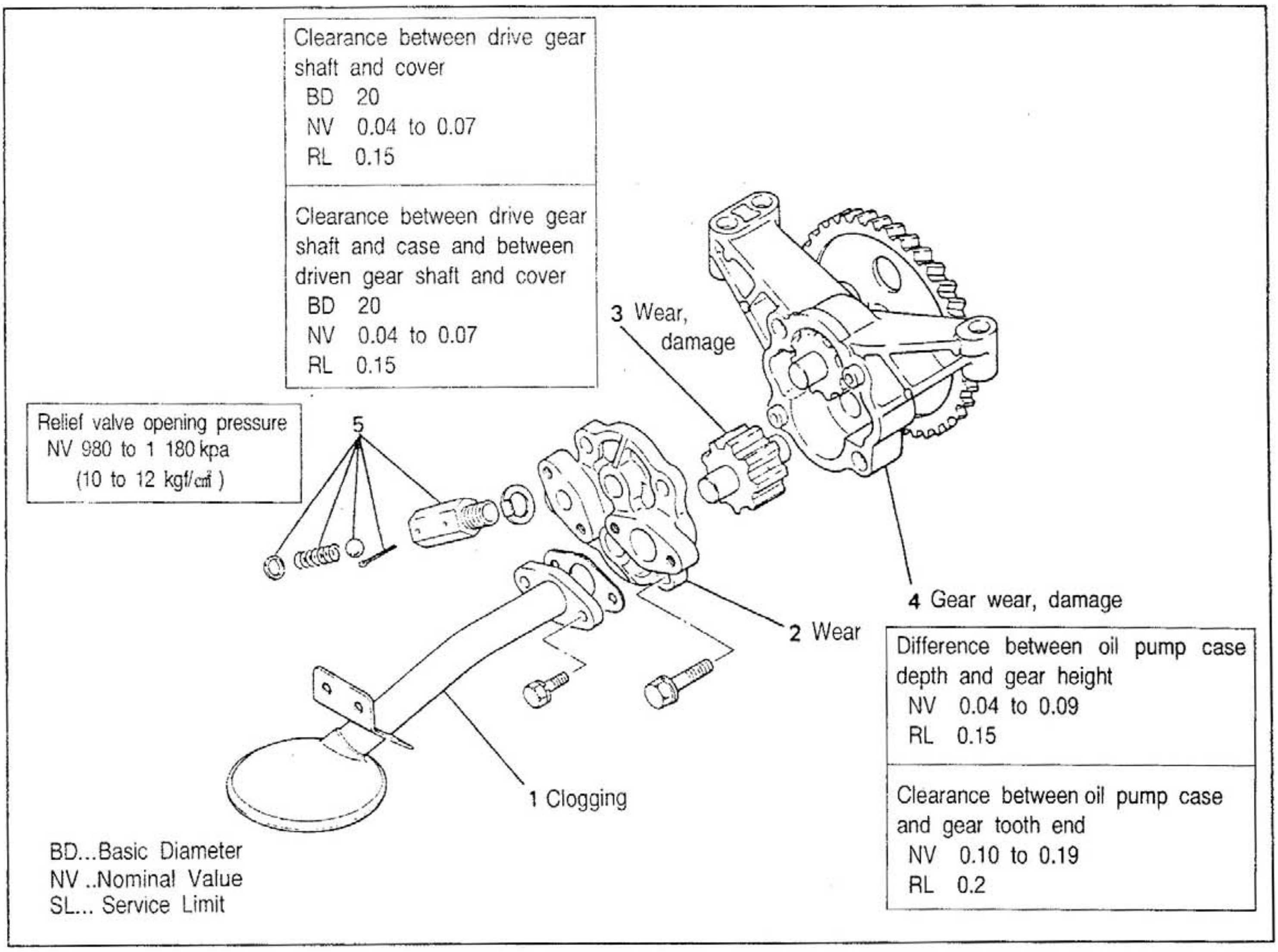


In Servicing the lubrication System, use the following tools.

Measuring Tools Thickness gauge, straight edge, micrometer, caliper gauge

8-1 OIL PUMP

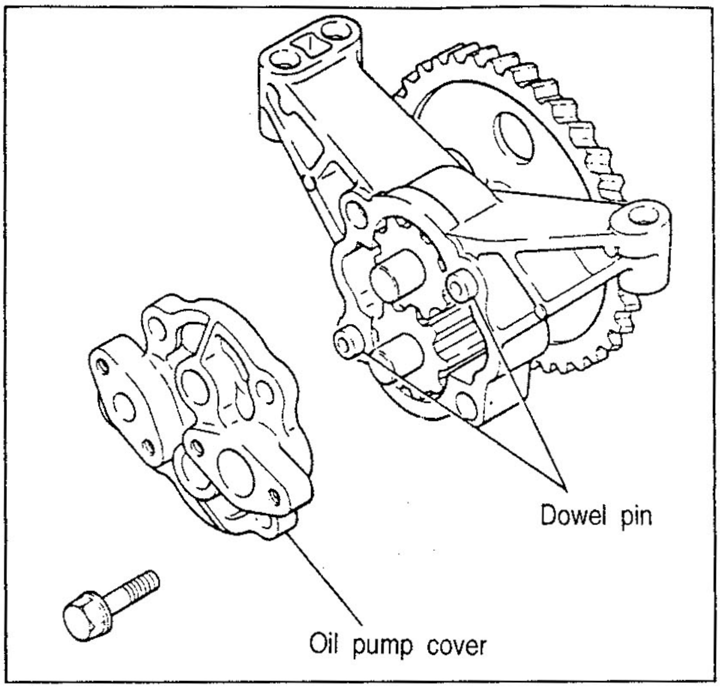
8-1-1 Disassembly and Inspection



1 Oil strainer
2 Oil pump cover
3 Driven gear assembly
4 Gear and case assembly
5 Relief valve

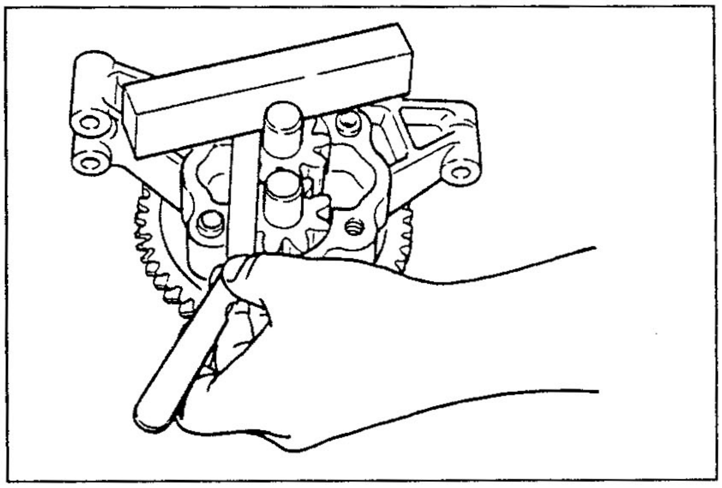
(1) Remove the oil strainer 1 and remove the oil pump cover 2 by lightly striking with a plastic hammer.

NOTE : The oil pump cover is positioned by the dowel pin of the oil pump case.

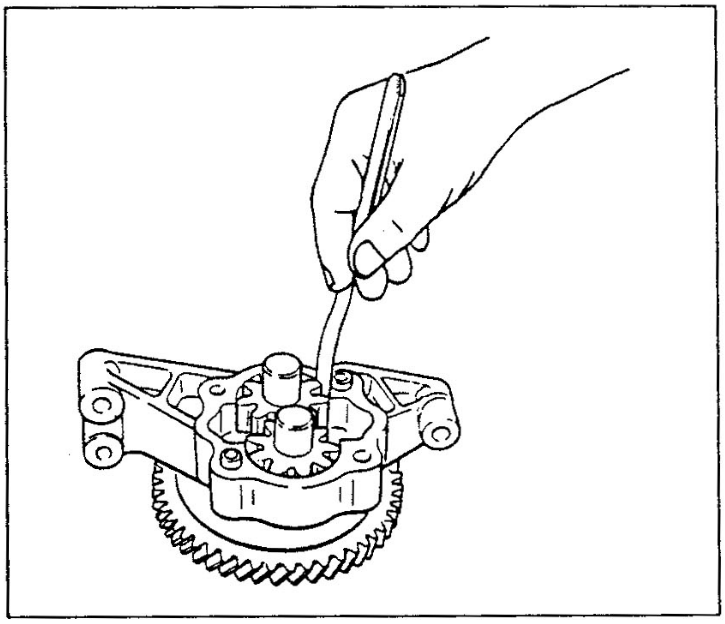


(2) Before the driven gear is removed, measure and record the following items.

(a) Measure the difference between the drive and driven gear height and oil pump case with a thickness gauge.

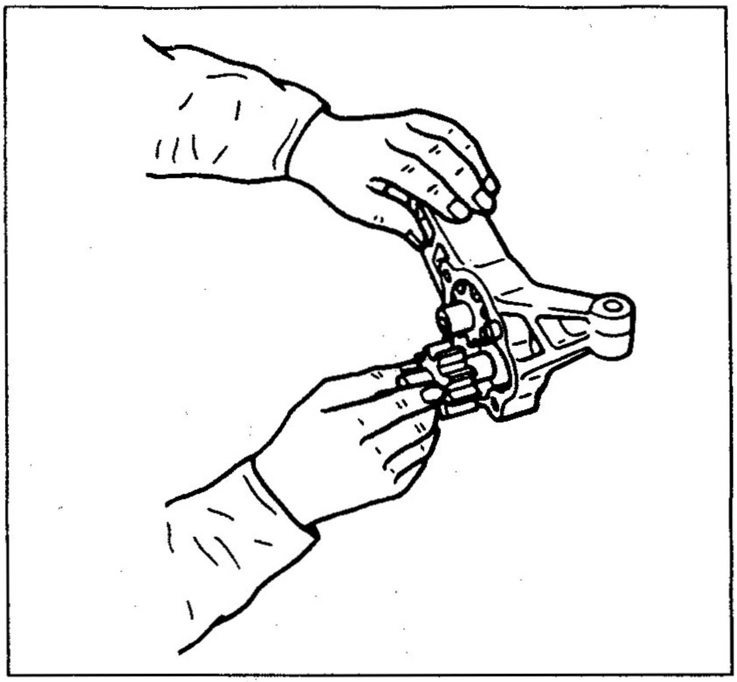


(b) Measure the clearance between the drive and driven gear tooth end and oil pump case with a thickness gauge.

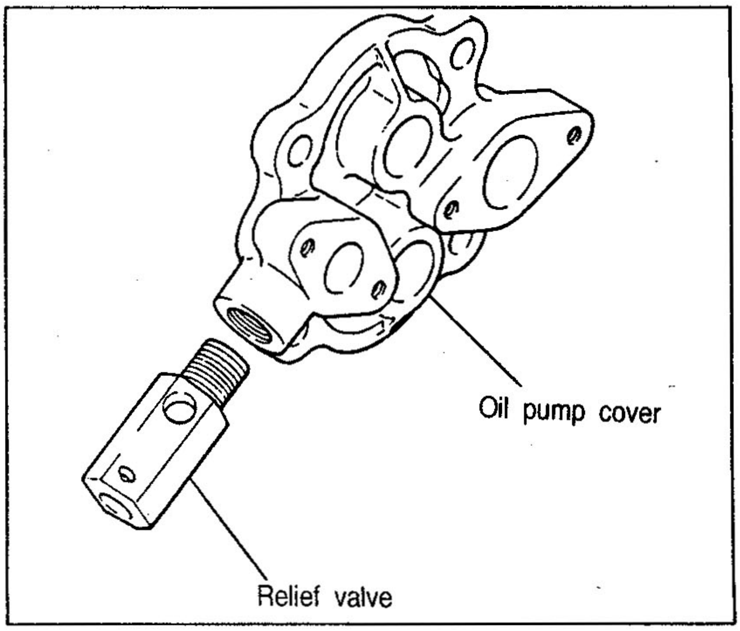


(3) Remove the driven gear 3.

NOTE : The gear and case assembly 4 is a non-disassembly type. If defective, replace as an assembly.



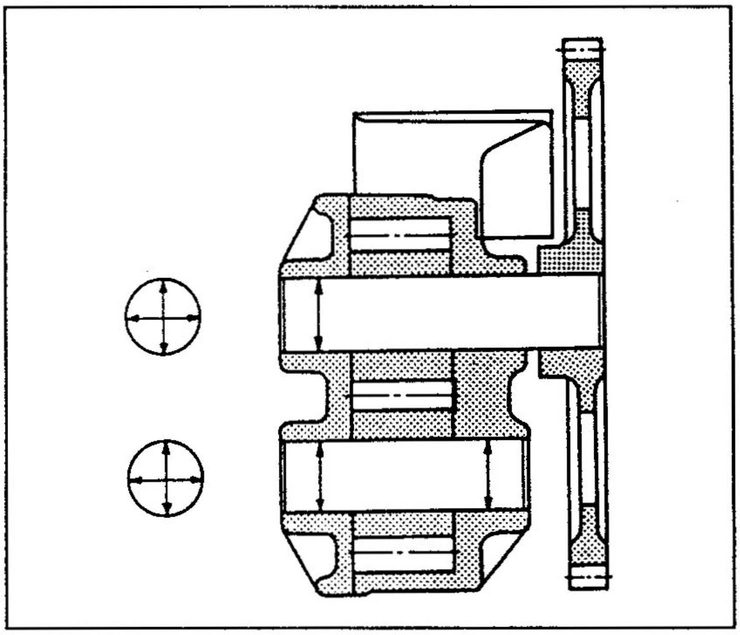
(4) Remove the relief valve 5.



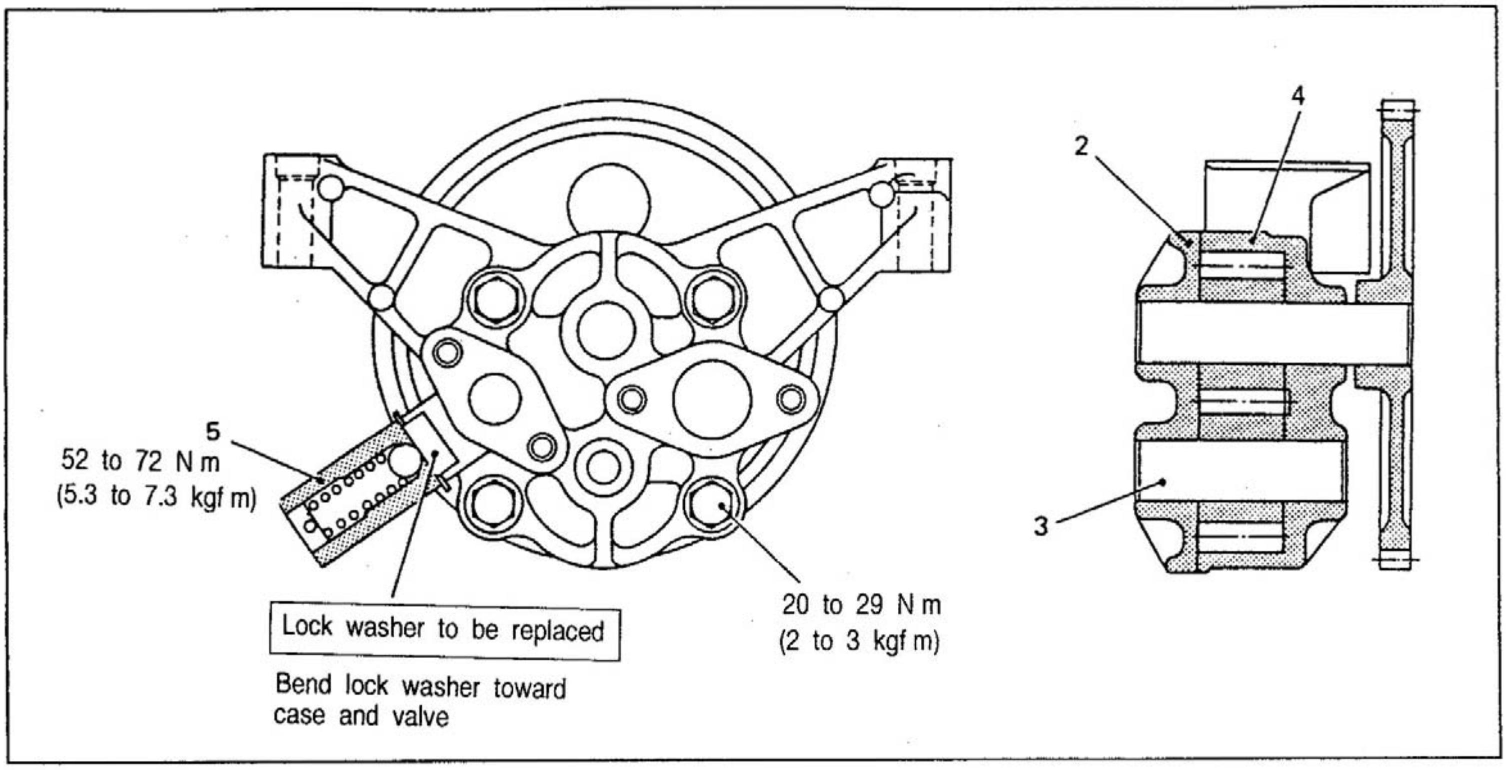
(5) Measure and record the outside diameters of the drive gear shaft and driven gear shaft.

Then measure and record the inside diameters of the oil pump case and conver.

Calculate the clearances from these readings, and if out of the service limite, replace.



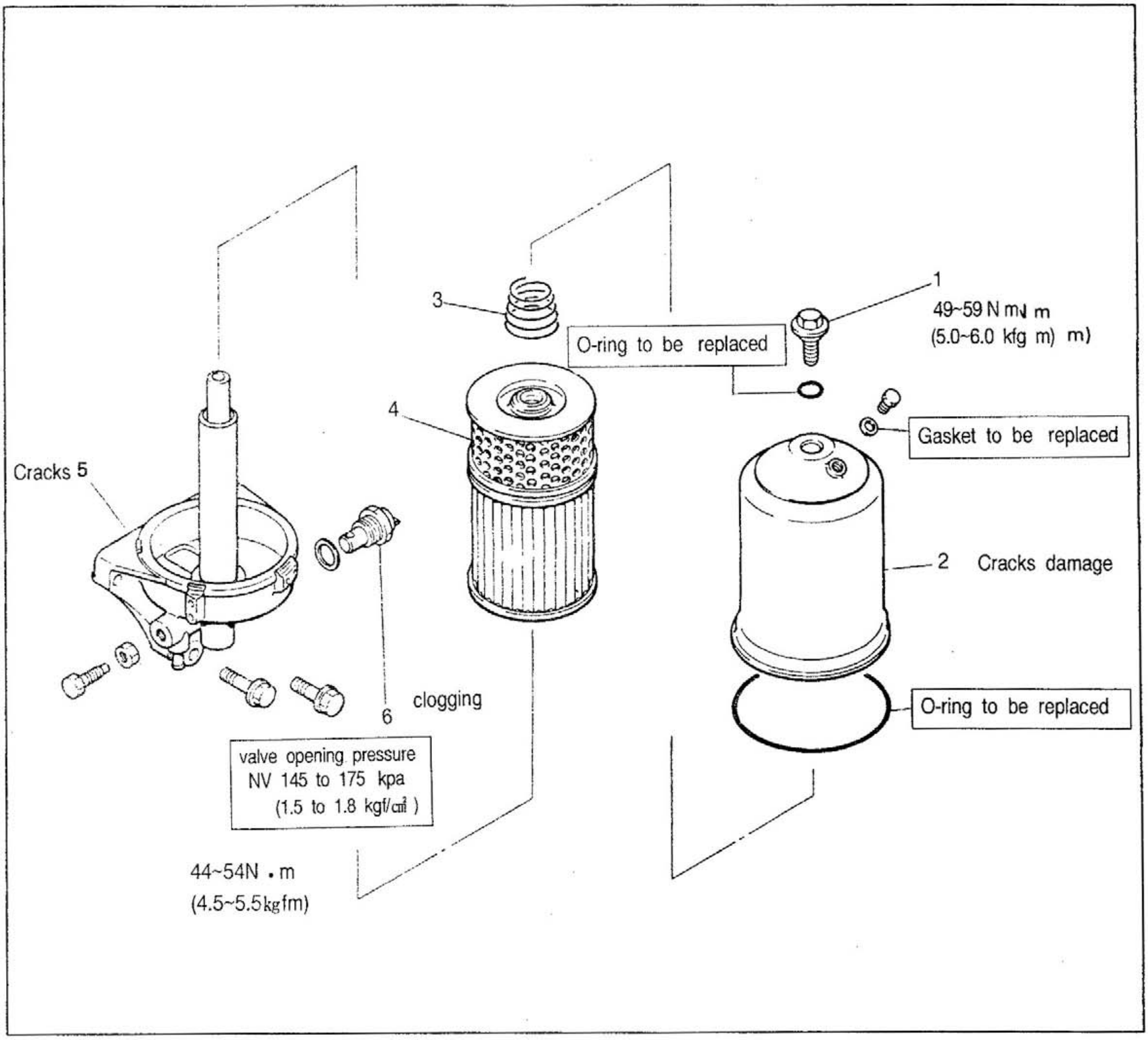
8-1-2 Reassembly



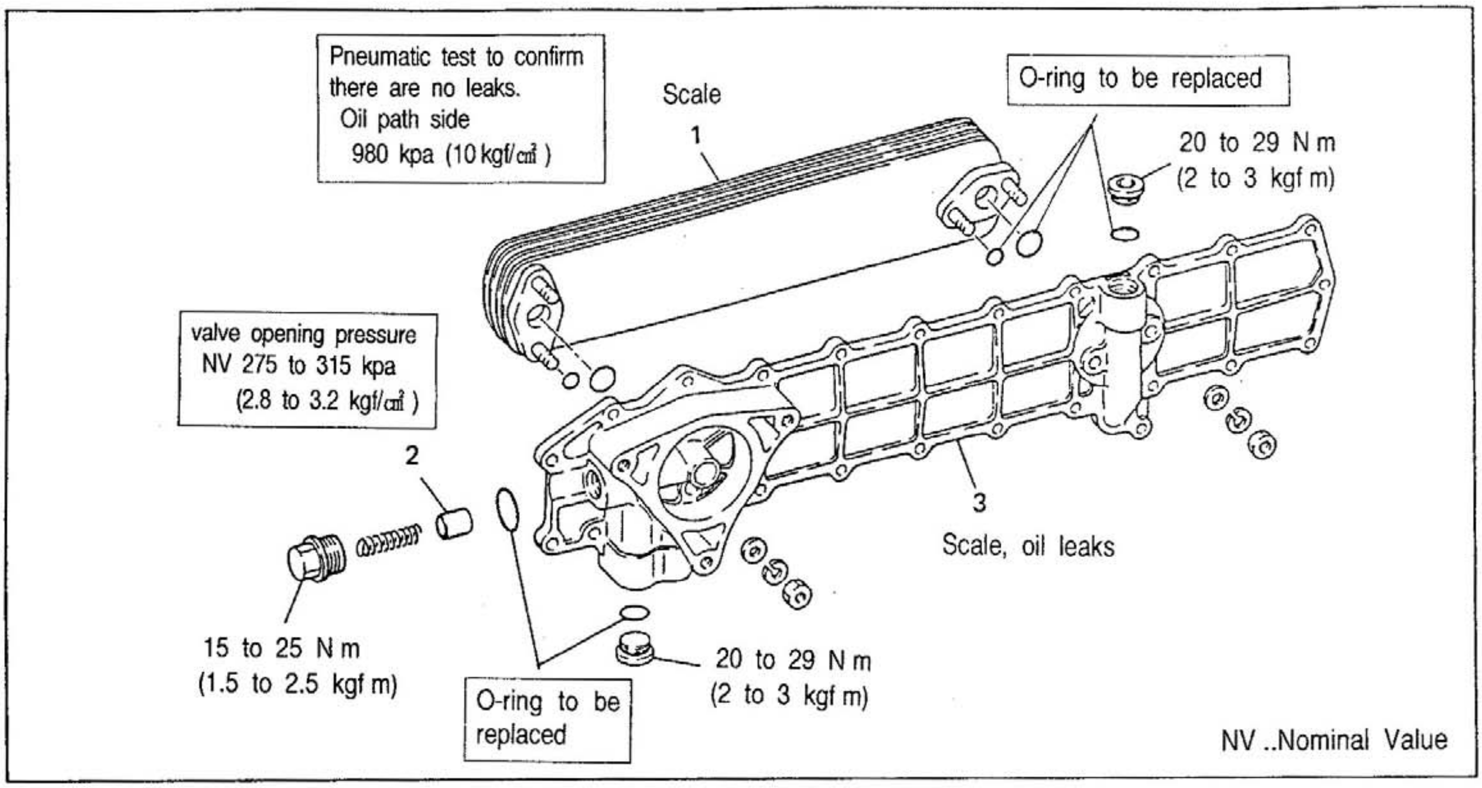
NOTE : For mounting to the crankcase, partially tighten the oil strainer 1.

8-2 OIL FILTER

1 Center bolt
2 Case
3 Set spring
4 Element
5 Bracket
6 Oil bypass alarm



8-3 OIL COOLER



1 Oil cooler element
2 Bypass valve
3 Oil cooler cover

8-3-1 Cleaning

(1) Check the oil cooler element oil path and bypass valve portion for carbon and sludge. If contaminated, clean in a cleaning oil.

(2) Clean the element and cover with city water(perferably a hot water).

8-3-2 Air Pressure Test

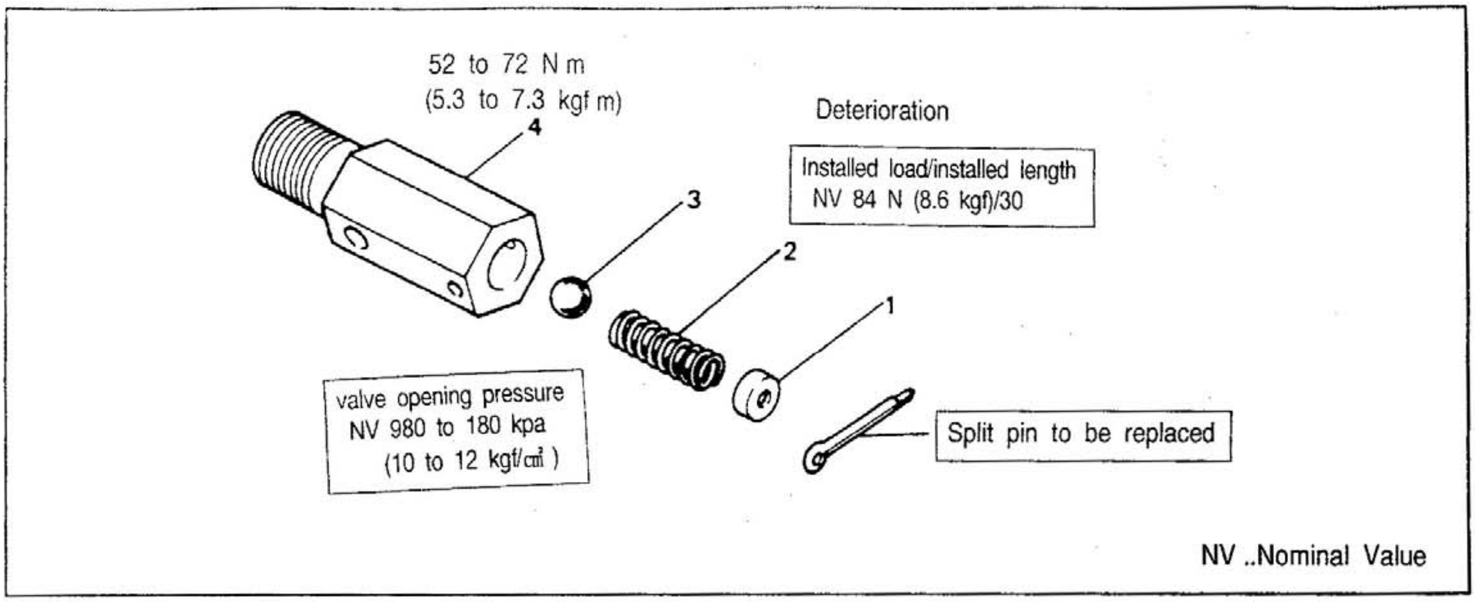
Perform air pressure test to check for oil leakage due to a broken or cracked element.

Apply an air pressure of 980kpa(10 kgf/ cm²) to the element to check for leakage.

If air leakage or other defects are evident, replace the element.

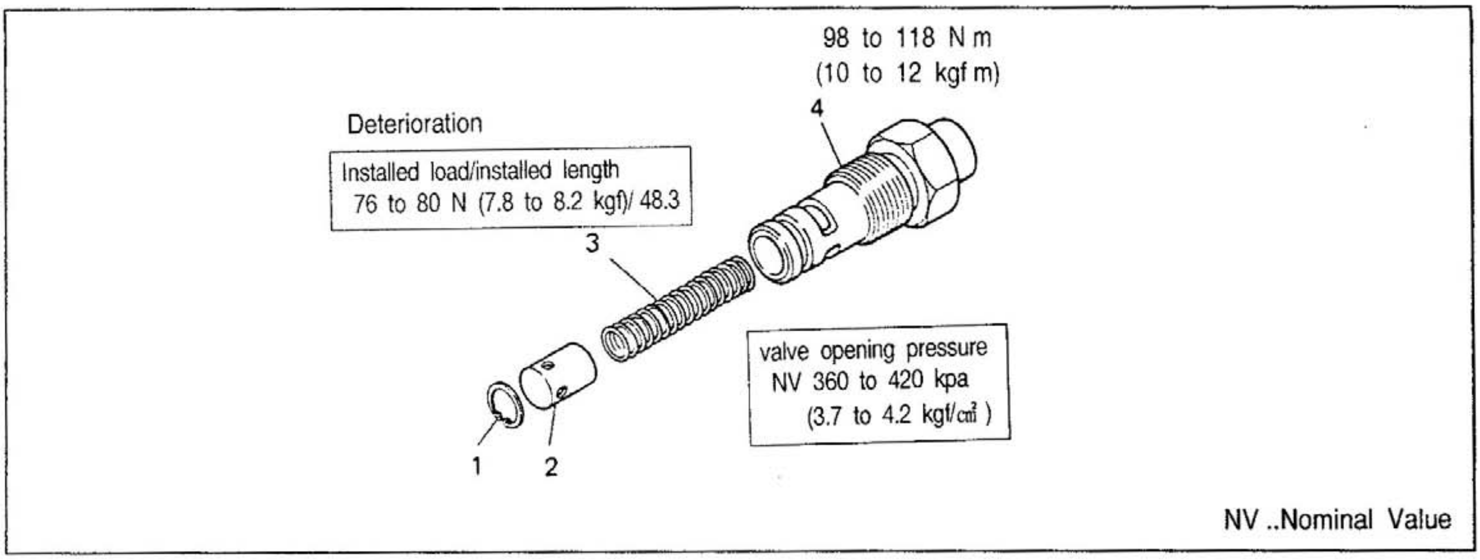
NOTE : Make sure that an air pressure higher than specified is never applied.

8-4 RELIEF VALVE



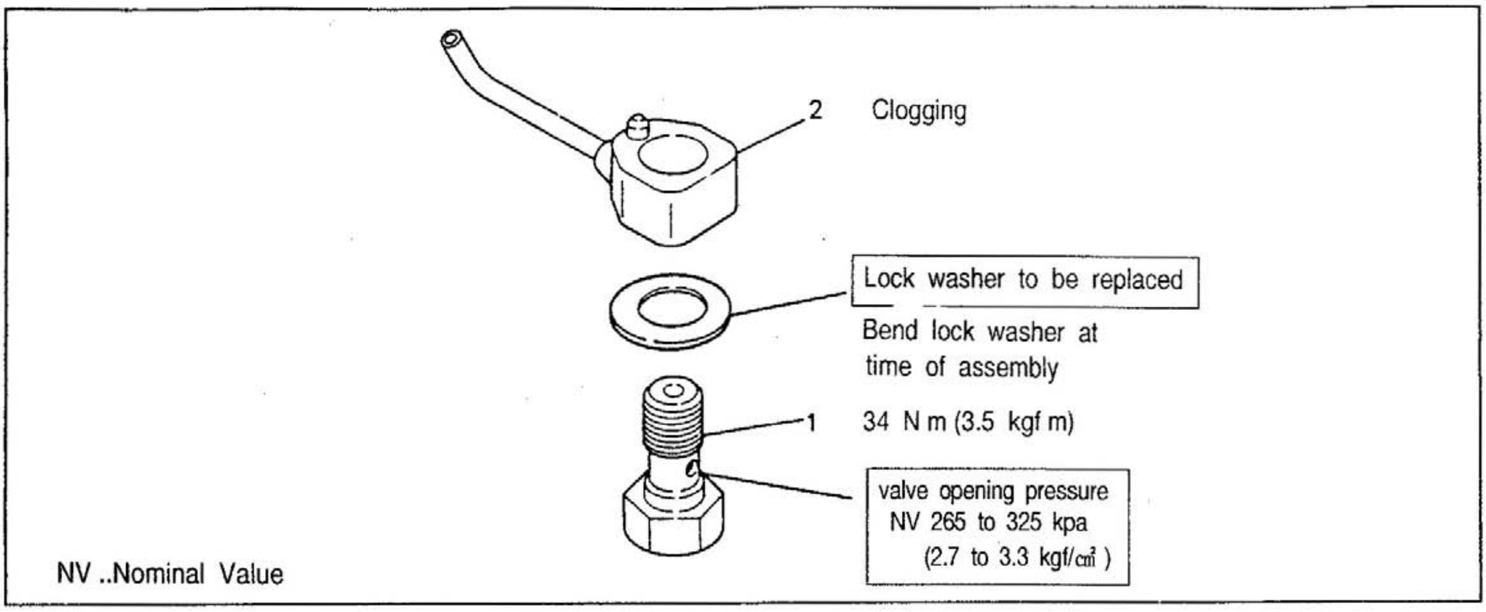
1 Spring seat
2 Valve spring
3 Ball valve
4 Valve case

8-5 REGULATOR VALVE



1 Snap ring
2 Valve
3 Spring
4 Body

8-6 CHECK VALVE



1 Check valve

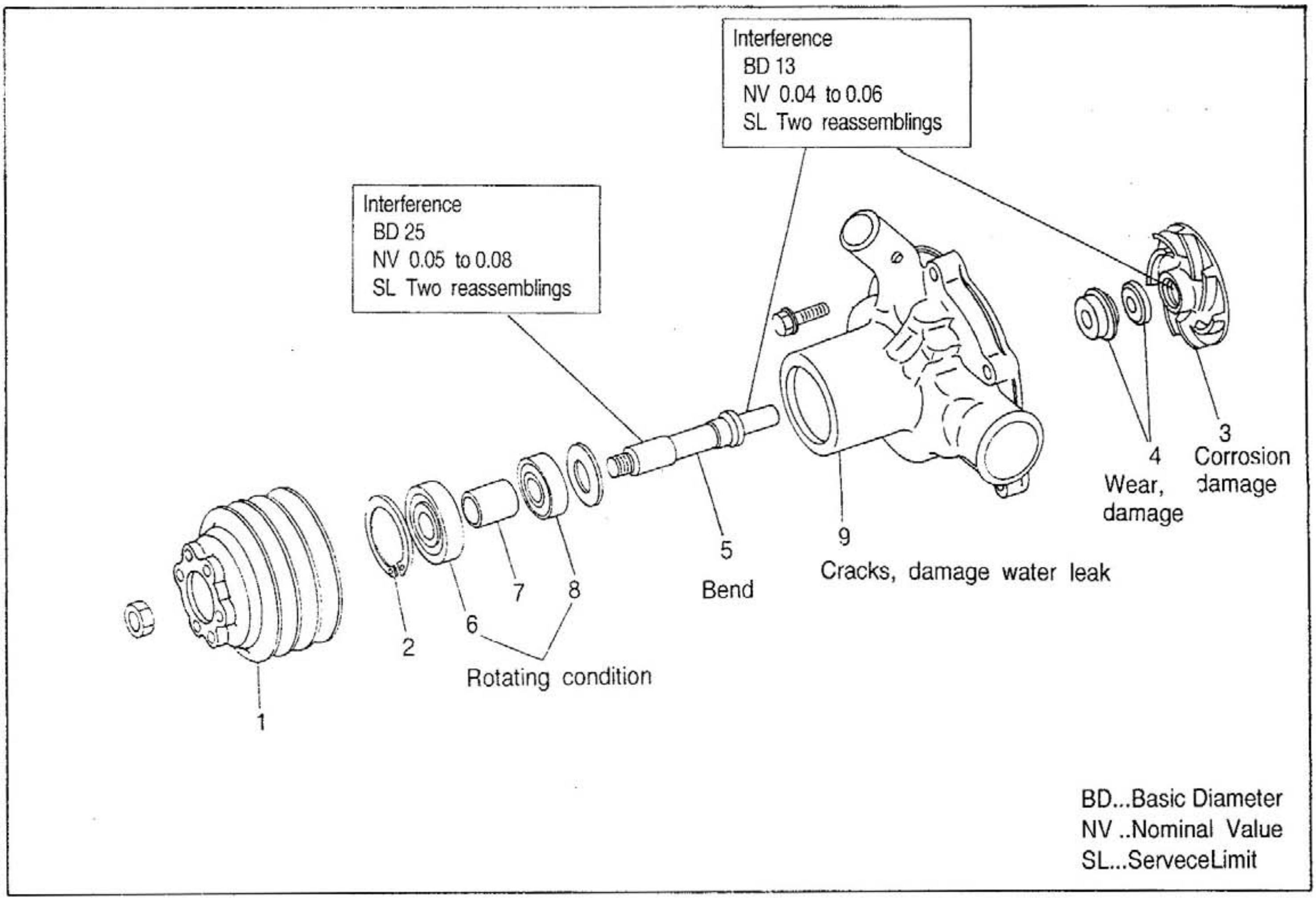
2 Oil jet body

In servicing the cooling system, use the following tools.

Special Tool Name	Part No.	Use
Water Pump Impeller Puller	MH061417	Removal of water pump impeller
General Tools and Measuring Devices		
Gear puller, snap ring expander, thickness gauge		

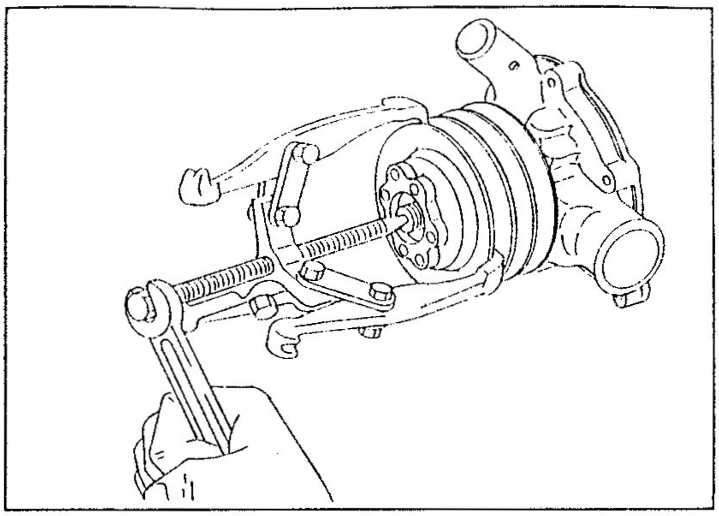
9-1 WATER PUMP

9-1-1 Disassembly and Inspection



1 pulley	4 **Unit seal**	7 **Spacer**
2 **snap ring**	5 **Water pump shaft**	8 **Ball bearing**
3 **Impeller**	6 **Ball bearing**	9 **Water pump case**

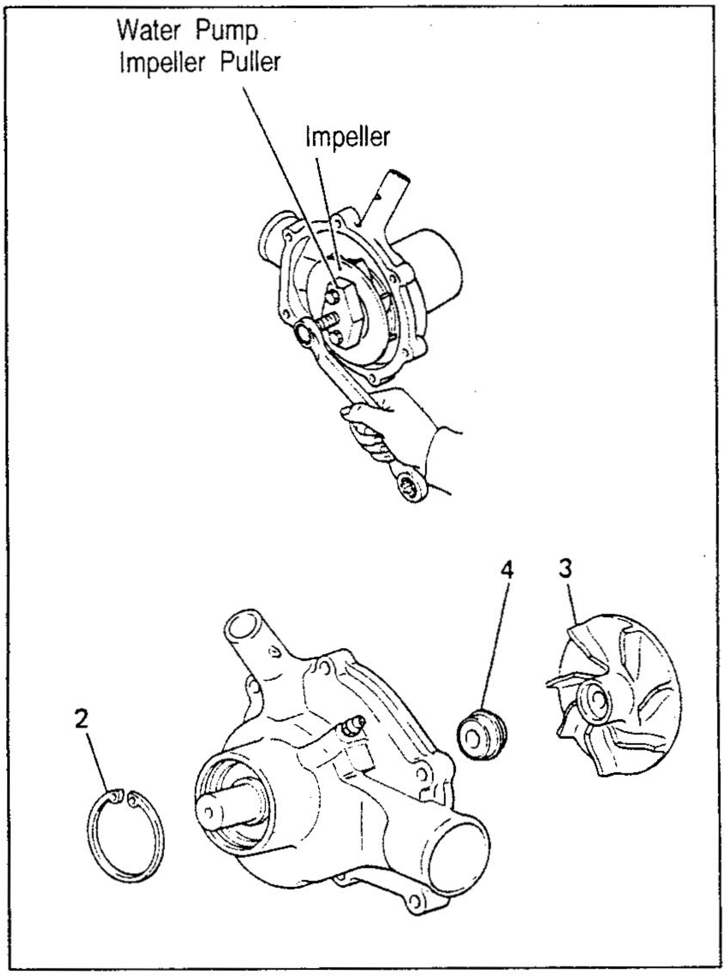
(1) Remove the pulley 1, using a gear puller, etc.



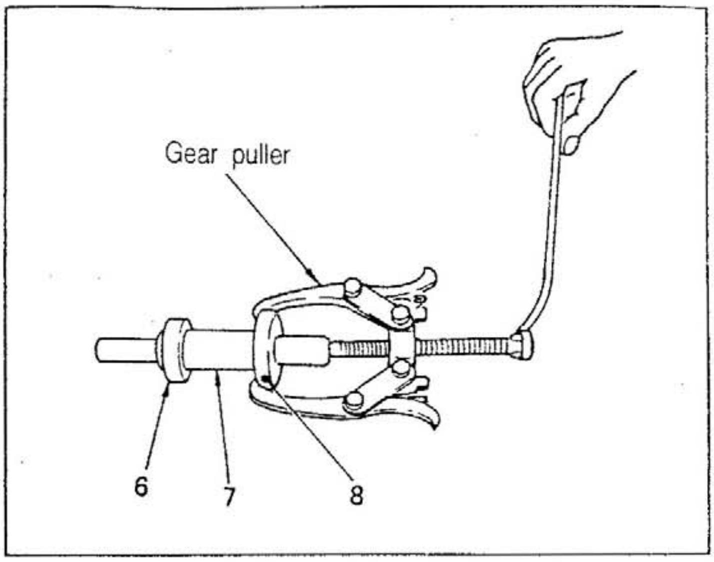
(2) Remove the snap ring 2 and then re move the impeller 3, using a Water Pump Impeller Puller (special tool).

Check the impeller and water pump case unit seal for damage and wear. If abnormal condition or water leakage during operation is evident, remove the unit seal 4.

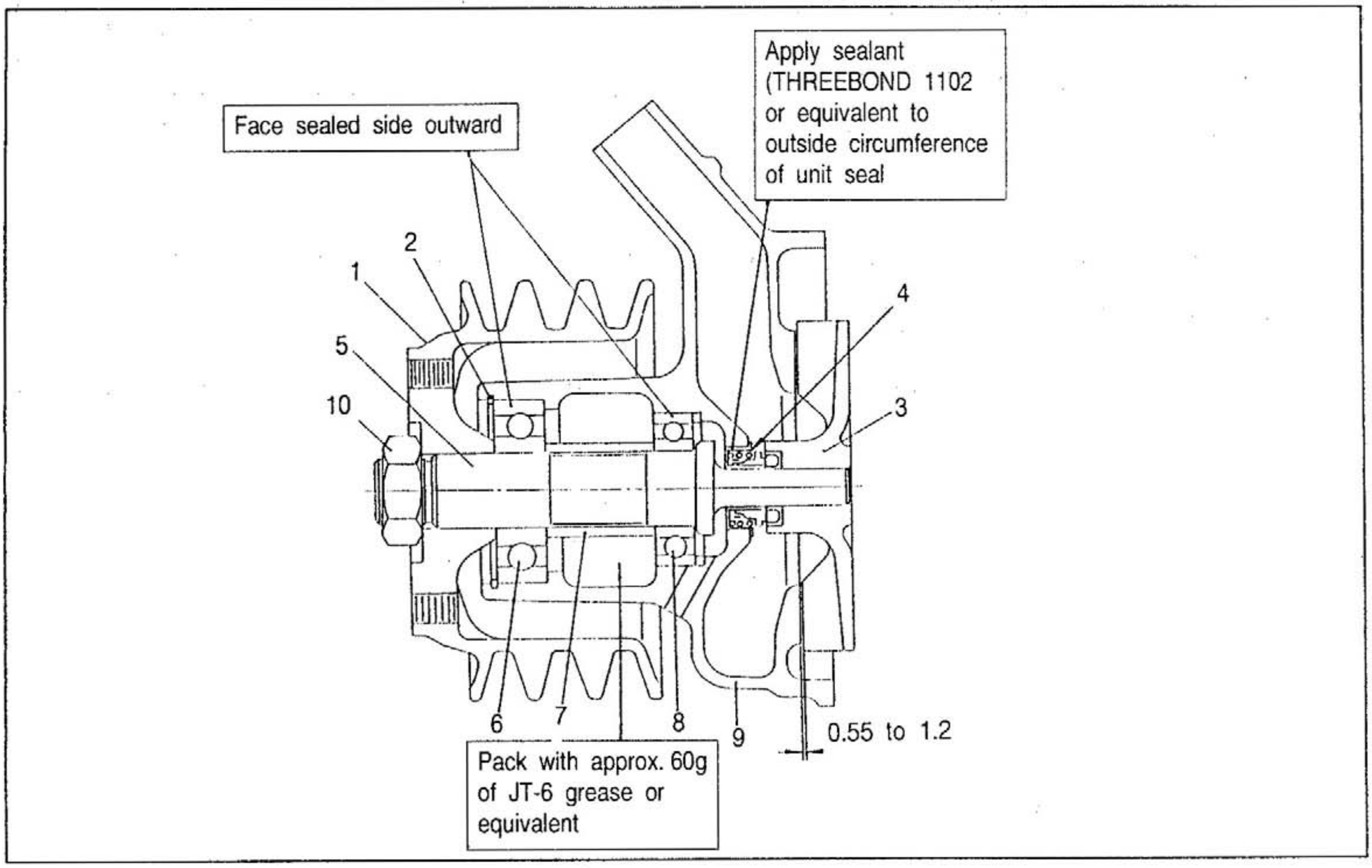
NOTE : When the unit seal was removed, make sure that it is replaced with a new one.



(3) Remove the ball bearing 6 and 8 from the water pump shaft, using a gear puller, etc. Remove the spacer 7.



9-1-2 Reassembly

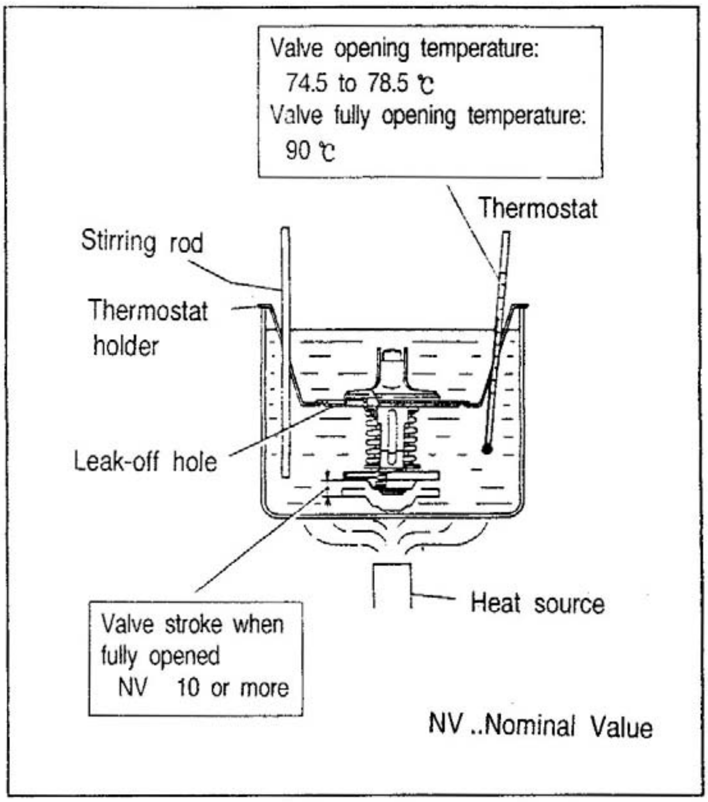


NOTE : 1. Install the impeller until the shaft and impeller ends are flush.

2. After reassembly, turn the shaft to confirm that the impeller does not touch the case.

9-2 THERMOSTAT

Inspection of Thermostat



Check the thermostat by the following procedures. Stir the water in the container well with a stirring rob to equalize the temperature distribution in the container.

(1) Slowly heat the thermostat until the valve opening temperature is reached.

Keep this condition for about five minutes and check to see that the valve is open.

(2) Raise the water temperature to 95℃.

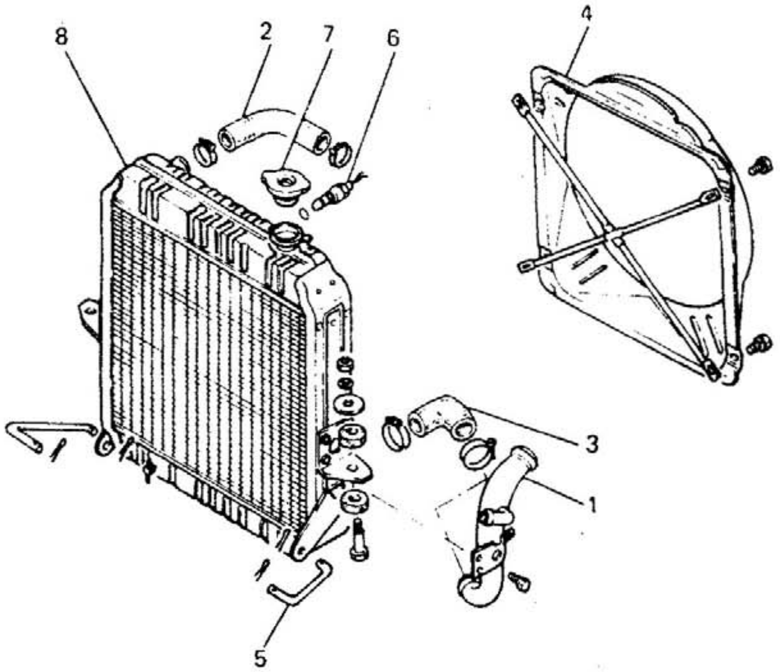
Keep this condition for about five minutes and measure the pellet lift amount.

(3) Lower the temperature to less than 65℃ and check to see that the valve is held tightly against the valve seat.

Perform the above mentioned checks. If any of the items is defective, replace the thermostat.

9-3 RADIATOR

9-3-1 Disassembly of Radiator



1. Water inlet pipe
2. Outlet hose
3. Inlet hose
4. Radiator Shroud
5. Support Rod
6. Water level Sensor
7. Pressure Cap
8. Radiator

9-3-2 Inspection of radiator.

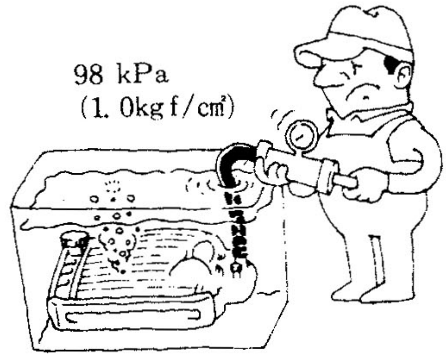
1) If there are muds, insects, etc. on the front of the radiator core, remove using a copper wire, etc., while using care to prevent damaging the tubes.

2) Check for water scale and rust in the core. If abnormal condition is evident, clean, using a cleaning agent and water.

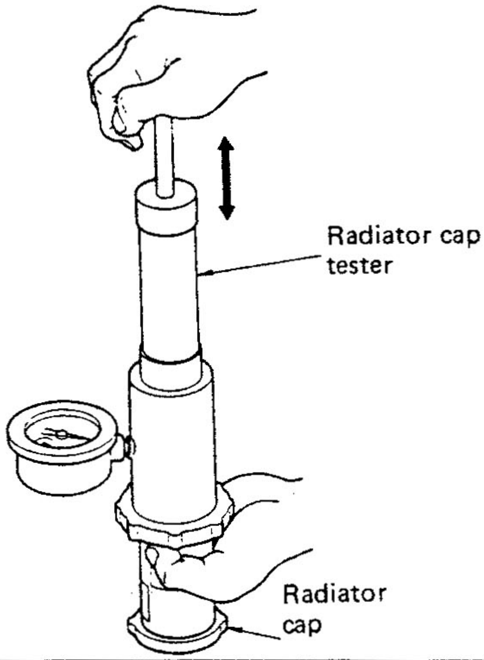
NOTE : To clean the radiator, refer to 9-4 CLEANING COOLING SYSTEM.

3) Mount a house to the inlet of the radiator, cap the outlet, and immerse the radiator in a water tank. Using a radiator cap tester, etc., send compressed air at the specified inspection pressure through the hose and check for leaks.

If leaks are evident, correct by soldering, or replace the radiator.

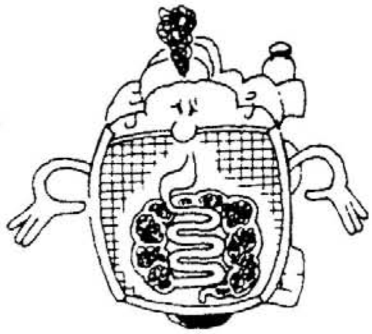


4) Inspection of Radiator Cap
Check the spring tension and sealing condition of the pressure valve and vent valve. If defective, replace.



9-4 CLEANING COOLING SYSTEM

If the radiator is used for a long time, rust, scale, mud, etc. are deposited inside, resulting in overheat. Clean the cooling system with city water by using the follwing procedures.



The city water to be used should have the following properties.

Required properties of city water

Tatal hardness	300 rpm or less
Sulfate so- 4	100 rpm or less
Chloride c1-	100 rpm or less
Total dissolved solids	500 rpm or less
PH	6 to 8

NOTE: 1. Use a cleaning solution if the radiator is seriously obstructed or coolant is seriously contaminated.

2. When the cooling system is cleaned or washed with water, make sure that the coolant temperature is maintained at 90℃; the coolant temperature below the valve opening temperature closes the thermostat resulting in poor coolant circulation.

3. The radiator cover can help quickly increase the coolant temperature.

1) Washing with Water (Every 6 months or before and after the use of antifreeze)

(a) Discharge the coolant from the radiator, crankcase, and reservoir tank.

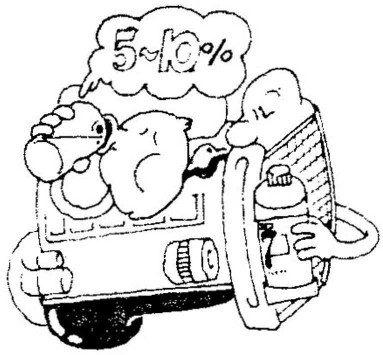
(b) After draining the coolant, pour in tap water (preferably hot water), let the engine run at idle for about 10 minutes while keeping the coolant temperature at about 90℃, and drain the water.

2) Washing with Cleaning Solution

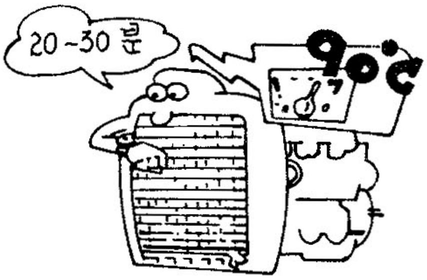
(When radiator is seriously obstructed or coolant is seriously) contaminated)

(a) Discharge the coolant from the radiator, crankcase, and reservoir tank.

(b) Ready a mixture of Radiator Cleaner 5-10% and tap water(90-95%). Pour the specified amount of mixture into the radiator.

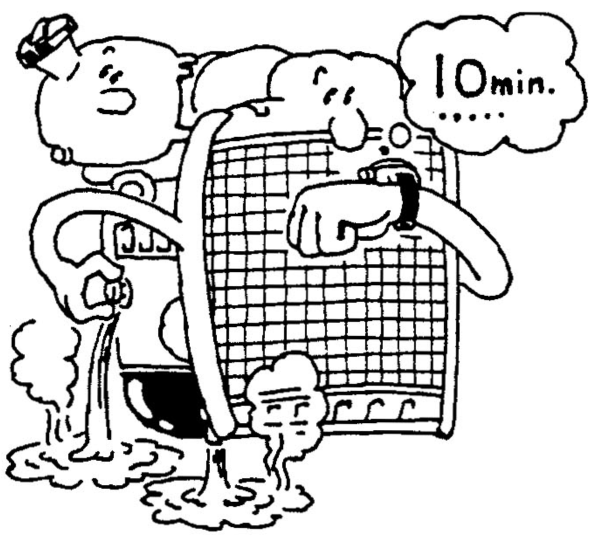


(c) Run the engine to raise the solution temperature to about 90℃. Let the engine run at idle for about 30 minmutes, and then remove the cleaning solution



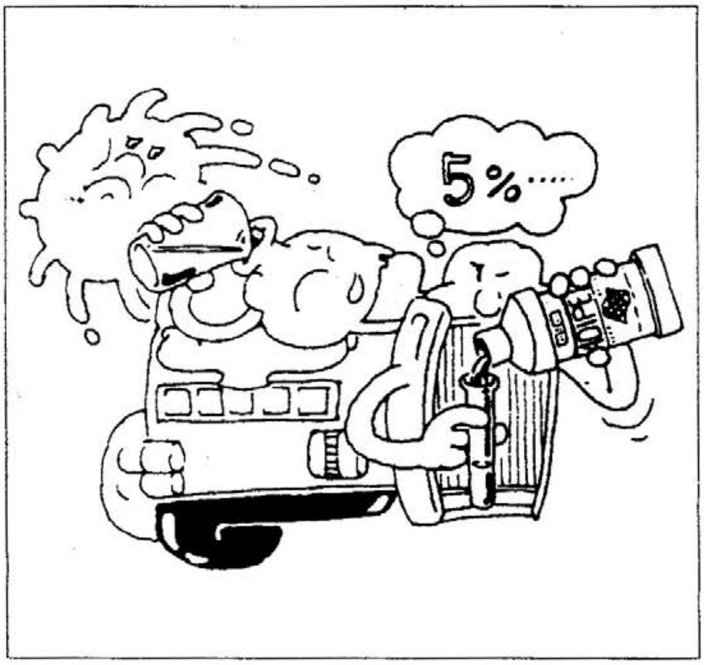
(d) After removing the cleaning solution, pour in tap water (preferably hot water), let the engine run at idle for about 10 minutes while keeping the coolant temperature at about 90℃, and drain the water.

Repeat washing until drained water gets clean.



3) Antirust and Antifreeze

(a) After cleaning, add the radiator antirust at a ratio of 5% to the coolant quantity to prevent corrosion in summer.

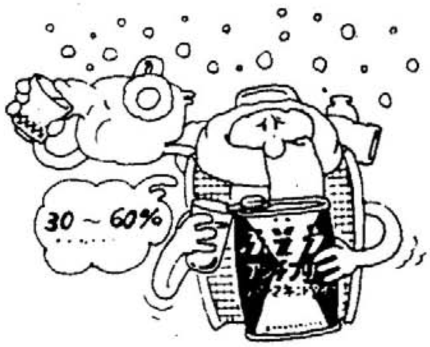


(b) In winter, add antifreeze at a ratio of 30 to 60% to prevent.
freezing.

NOTE : 1. Make sure that the antirust is added in summer and the antifreeze in winter at the apecified ratios.

2. The antifreeze or antirust added coolant used for a season(about six months) must not be reused.

3. Use the antifreeze at a proper mixing ratio of 30 to 60% suitable for the atmospheric temperature. if the mixing ratio is less than 30%, the ratio exceeds 60% the antifreeze effect will fall, and engine overheating will result.



9-5 GAS LEAKAGE TEST

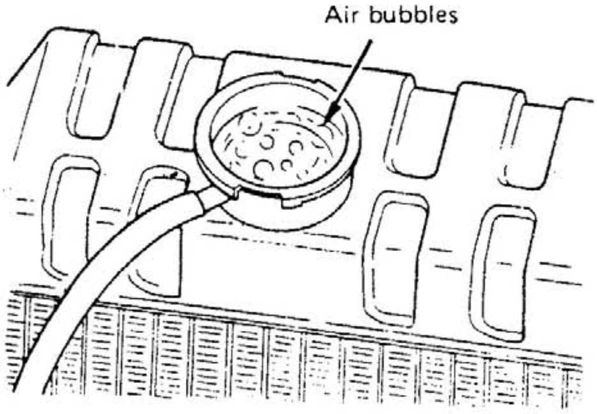
Presence of air or exhaust gas in the coolant will promote corrosion, rust formation and cavitation.

1) Inspection

(a) Remove the radiator cap.

(b) Operate the engine to raise the fluid temperature to about 90℃

(c) If air bubbles are continously produced in the coolant in this condition, it is evident that there is air or exhaust gas in the coolant.



2) Cause

(a) If there is air in the coolant, check for loose cylinder head bolts, water pump attaching bolts and hose connection in addition to damaged hose.

(b) If there is exhaust gas in the coolant, check for damaged cylinder head gasket on nozzle tube end staked portion or cracked sylinder head.

The fuel system parts should be tested whenever possible before disassembly to thoroughly check their condition.

Perform disassembly and reassembly in a clean place as deposit of small dust particles on parts could cause significant reduction of the engine performance.

In the disassembly of the injection pump, put the disassembled parts orderly on a clean work bench, grouped by each cylinder. Never change the combination of plunger and plunger barrel, and delivery valve and delivery valve seat.

Pay utmost care when disassembling and reassembling critical parts.

Use special tools and protect the parts from undue force and rough handling.

Before proceeding with disassembly, make tests to locate troubles correctly.

The servicing of the fuel system requires the use of the following tools.

Part numbers in ( ) refer to Zexel part numbers.

Name of Special Tool	Par No.	Application	
Filter Wrench	MH061509	For removal of fuel filter element	
Injection Pump Special Tool Set	(105790-1010)	Set of Tools for disassembly and assembly of injection pump proper (including tools marked* below)	
Universal Vice	(105794-0020)	Vice for holding injection pump	
Tappet Insert	*(157931-2100)	[A type]	For holding tappet
Tappet Pin	(157931-3120)	[AD type]	
Wrench	(157910-1120)	For mounting and dismounting of screw plug, timer cap	
Guide	(157920-8700)	[A type]	For oil seal protection
	(157920-5400)	[AD type]	
Roller Pincers	*(157921-0120)	[A type]	For mounting and dismounting of tappet
	(157921-6420)	[AD type]	
Tappet Pincers	*(157931-6120)	For mounting and dismounting of tappet	

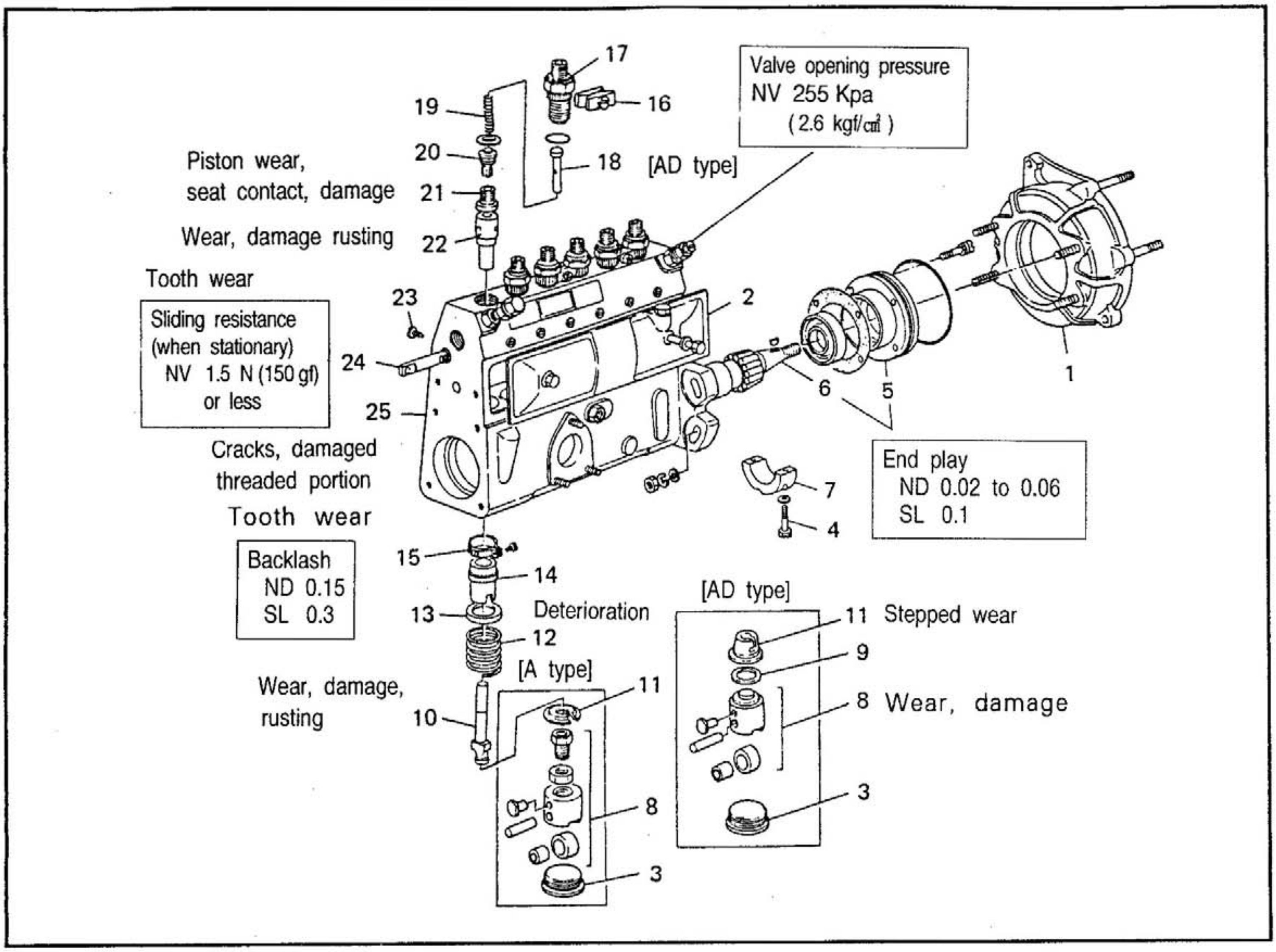
Name of Special Tool	Par No.		Application
Plunger Pincers	*(157921-4120)	[A type]	For mounting and dis-mounting of plunger
	(157921-5620)	[AD type]	
Wrench	*(157914-0500)	For mounting and dismounting of delivery valve holder.	
Hand Fraise	(157930-4120)	[A type]	Correction of pump housing
	(157930-4620)	[AD type]	
Extractor	(157925-4120)	[A type]	For removal of taper roller bearing
	(157925-6520)	[AD type]	
	(157925-0120)	[A Type]	For extraction of outer bearing
	(157925-0320)	[AD type]	
	*(157926-5110)	For removal of flyweight	
Socket Wrench	*(157915-0100)	For mounting and dismounting of flyweight round nut	
Special Wrench	(157916-5720)	[SBZ type]	For locking timer
	(157916-5420)	[SA type]	
	(157916-5320)	[SAZ type]	
Timer Extractor	(157926-6920)	[SBZ type]	For removal of timer
	(157916-4120)	[SA type]	
	(157924-3720)	[SAZ type]	
Base	(157924-3520)	[SBZ type]	Base for disassembly and
	(157926-6410)	[SA type]	
	(157926-6420)	[SAZ type]	
support	(157932-0100)	[SBZ type]	For mounting timer spring
Special Wrench	(157916-9420)	For disassembly and assembly of timer	

<table>
<tr><th>Name of Special Tool</th><th>Par No.</th><th colspan="2">Application</th></tr>
<tr><td rowspan="4">Measuring Device</td><td>(105782-4200)</td><td colspan="2">For measurement of camshaft end play</td></tr>
<tr><td>(105782-6010)</td><td colspan="2">For measurement of control rack position</td></tr>
<tr><td>(105782-6130)</td><td>[A type]</td><td rowspan="2">For measurement of pre-stroke</td></tr>
<tr><td>(105782-4020)</td><td>[AD type]</td></tr>
<tr><td>Holder</td><td>(157931-4400)</td><td colspan="2">For measurement of tappet clearance</td></tr>
<tr><td>Nozzle Cleaning Tool</td><td>(105789-0010)</td><td colspan="2">Set of tools for cleaning injection nozzle</td></tr>
</table>

10-1 INJECTION PUMP GENERAL

10-1-1 A, AD Type Injection Pump

(1) Disassembly

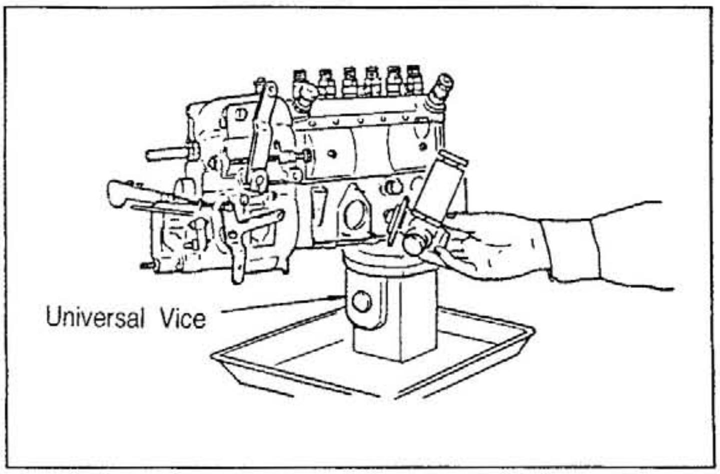


1 Bracket
2 Cover
3 Screw plug
4 Screw
5 Bearing cover
6 Camshaft
7 Center bearing
8 Tappet
9 Shim
10 Plunger
11 Lower spring seat
12 Plunger spring
13 Upper spring seat
14 Control sleeve
15 Pinion
16 Lock plate
17 Delivery valve holder
18 Stopper [AD type]
19 Delivery valve spring
20 Delivery valve
21 Delivery valve seat.
22 Plunger barrel
23 Screw
24 Control rack
25 Pump housing

NOTE : 1. Keep the disassembled parts neatly arranged for each cylinder.

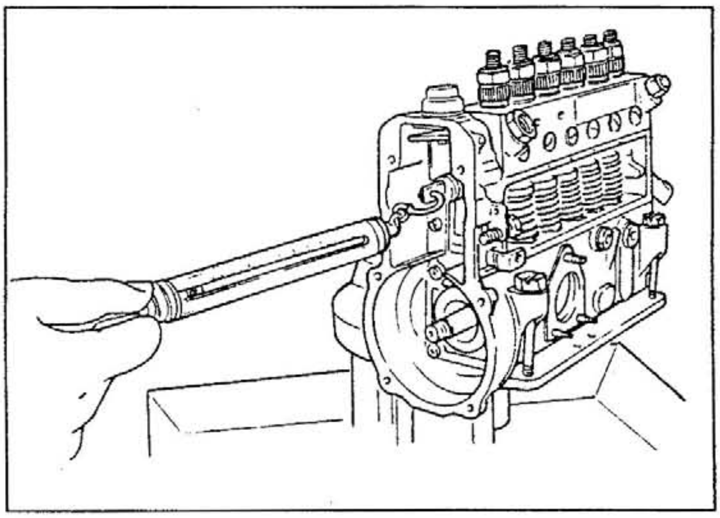
2. Keep the plunger, plunger barrel and delivery valve immersed in gas oil.

(a) Remove the automatic timer and the bracket. Then, mount the injection pump to Universal Vice (special tool) and remove the feed pump.
For removal of the automatic timer, see 10-1-5.



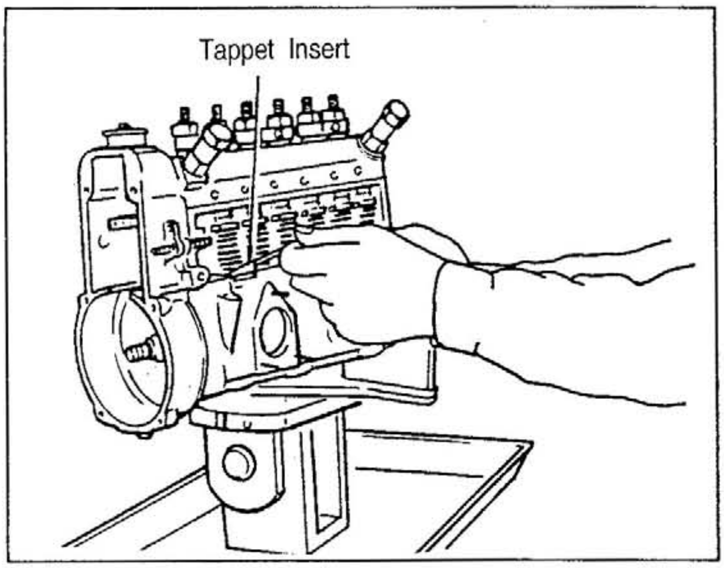
(b) Remove the governor.(See 10-1-2.)

(c) Measure the control rack sliding resistance.
Turn the camshaft and make sure that the value is as specified when measured at any position.
If the value is larger that the NV value, the probable causes include the following

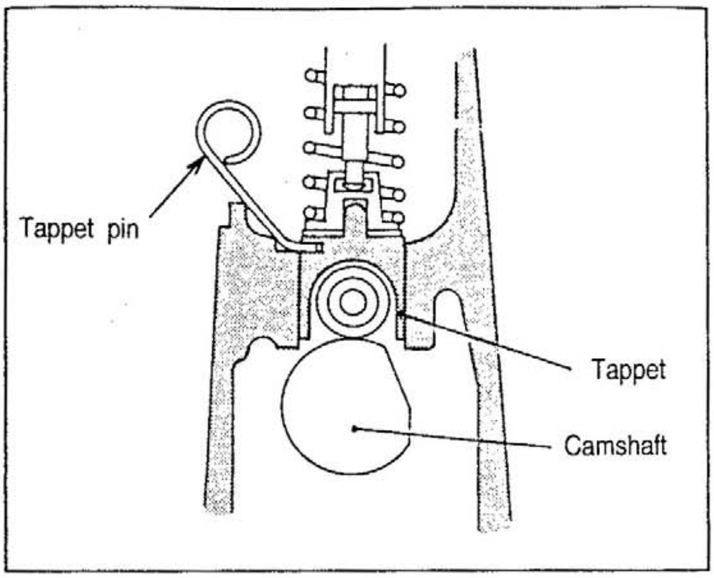


1) Damage or defective teeth of the control rack
2) Defective pinion rack teeth or contact with housing
3) Overtightening of the delivery valve holder

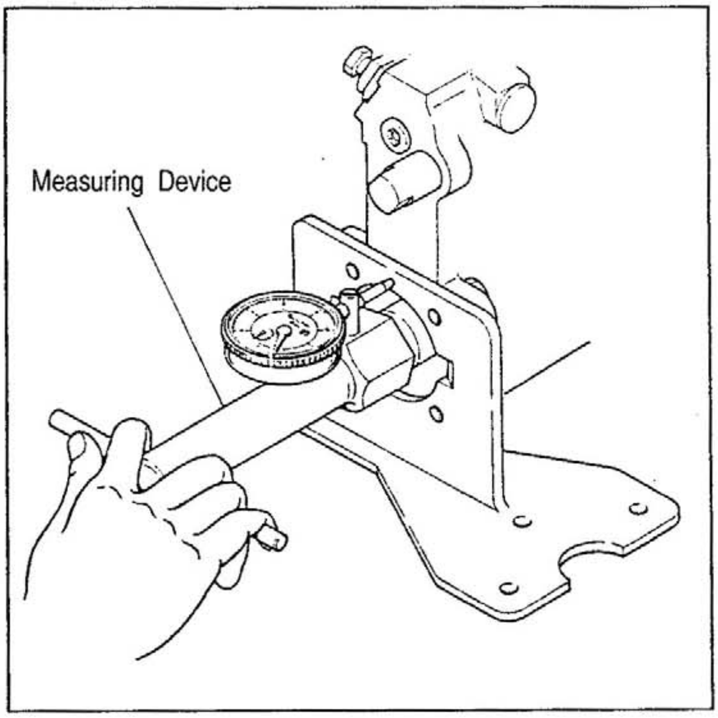
(d) Turn the camshaft to bring the tappet to the top dead center. In the case of A type, insert Tappet Insert(special tool) between the adjusting bolt and nut successively to separate the camshaft from the tappet.



In the case of AD type, insert Tappet pin (special tool) into the tappet hole to separate the tappet from the camshaft.



(e) Measure the end play of the camshaft with Measuring Device (special tool). If the end play is in excess of the repair limit, adjust by using shims or replace the bearing.

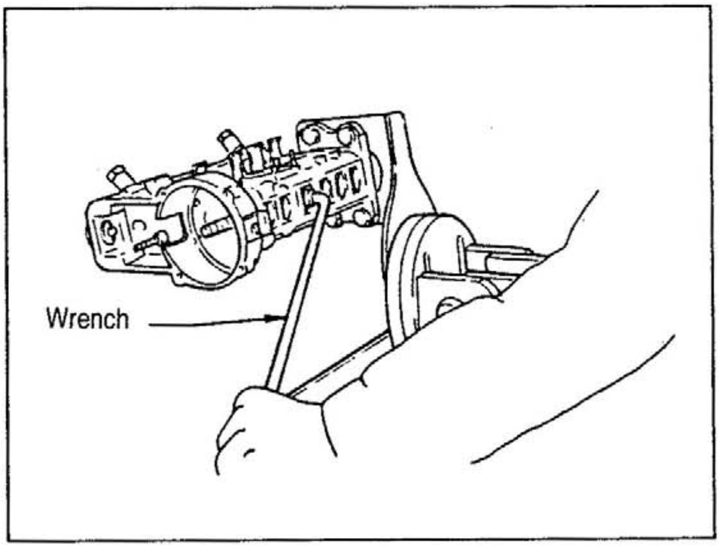


Shim thickness

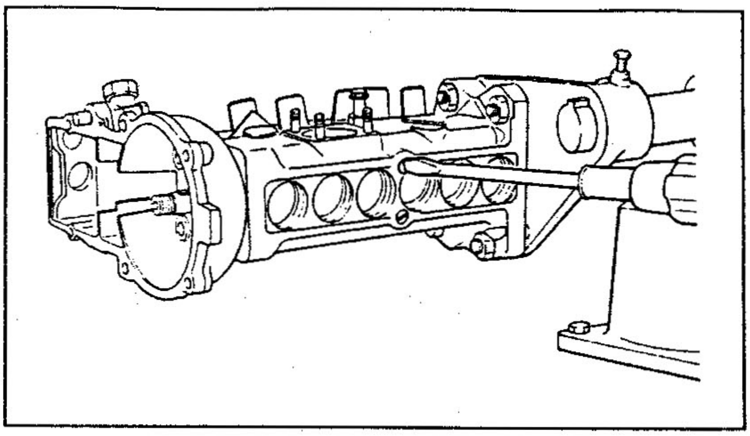
Timer side	0.10, 0.12, 0.14, 0.16, 0.18, 0.30, 0.50, 1.00mm
governor side	0.10, 0.12, 0.14, 0.16, 0.18, 0.30, 0.50, 0.70, 1.00, 1.40mm

NOTE : Select timer and governor side shims so that their thicknesses will be about equal.

(f) Remove the screws 3 at the bottom of the injection pump with Wrench(special tool).

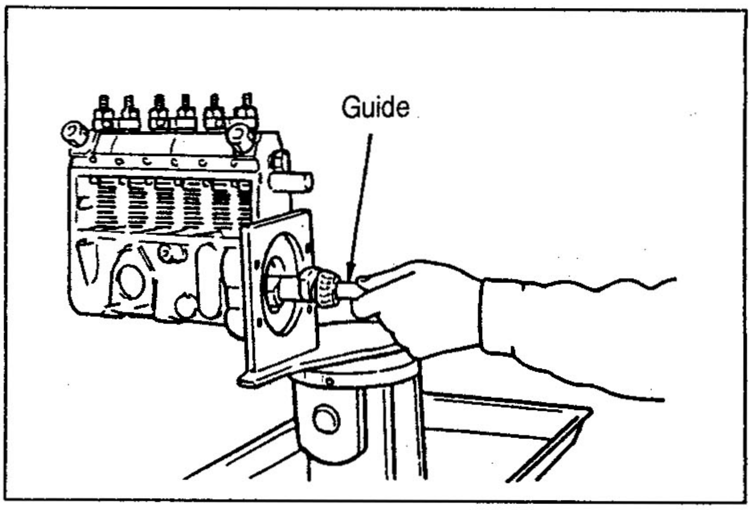


(g) Remove center bearing mounting screws 4.



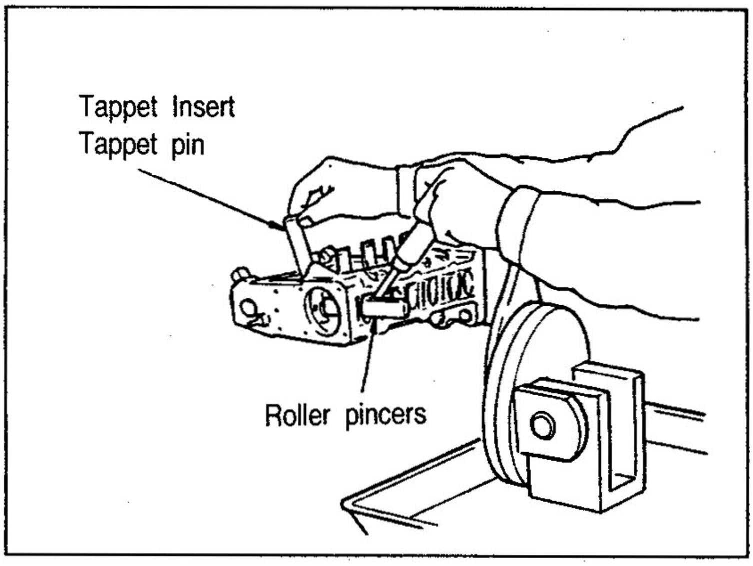
(h) Install Guide(special tool) to the threaded portion of camshaft end, and remove the following parts.

5 Bearing cover
6 Camshaft
7 Center bearing

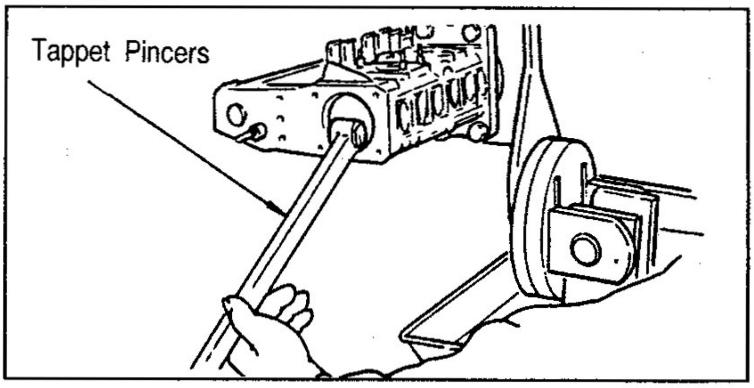


NOTE : The oil seal in the bearing cover should be replaced to a new one at the time of disassembly.

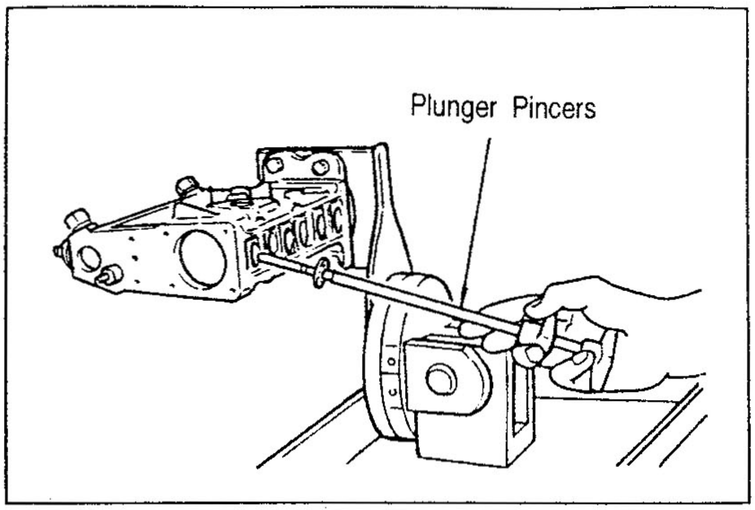
(i) Insert Roller Pincers(special tool) from the pump bottom to lift up the tappet. In this condition, remove Tappet Insert or Tappet Pin (special tool). Insert Tappet Pincers(special tool) through the camshaft hole and hold the tappet 8.



(j) Then, after removing Roller Pincers (special tool), take out the tappet 8 and shim 9.



(k) Insert plunger Pincers (special tool) from the pump bottom and remove the plunger 10 and the lower spring seat 11.

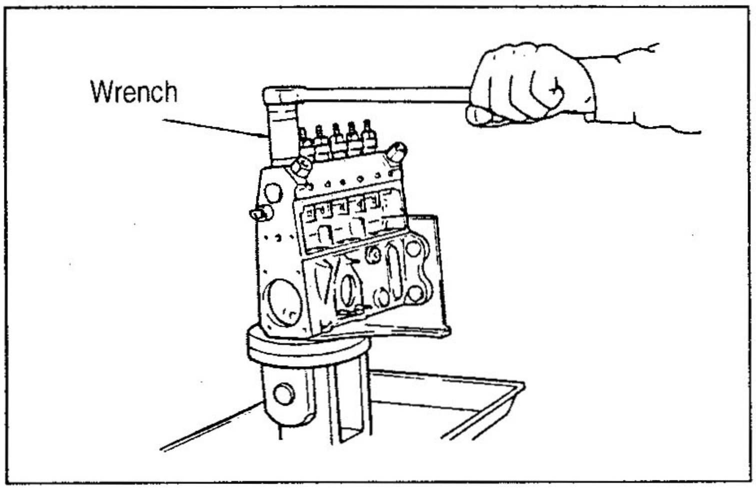


(l) Measure the backlash between control rack and pinion. If the value exceeds the service limit, replace.

(m) Remove the following parts.

16 Lock plate
17 Delivery valve holder
18 Stopper [AD type]
19 Delivery valve spring

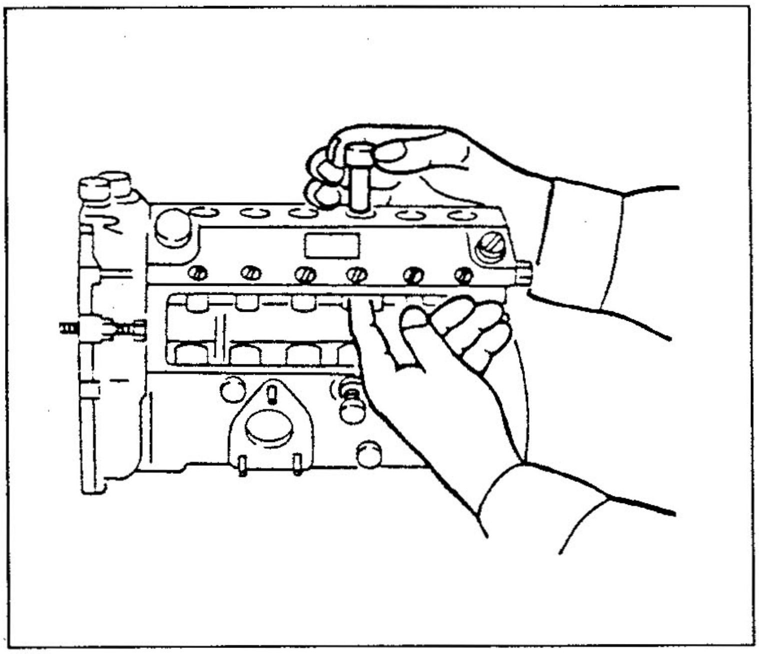
Use Wrench (special tool) to remove the delivery valve holder.



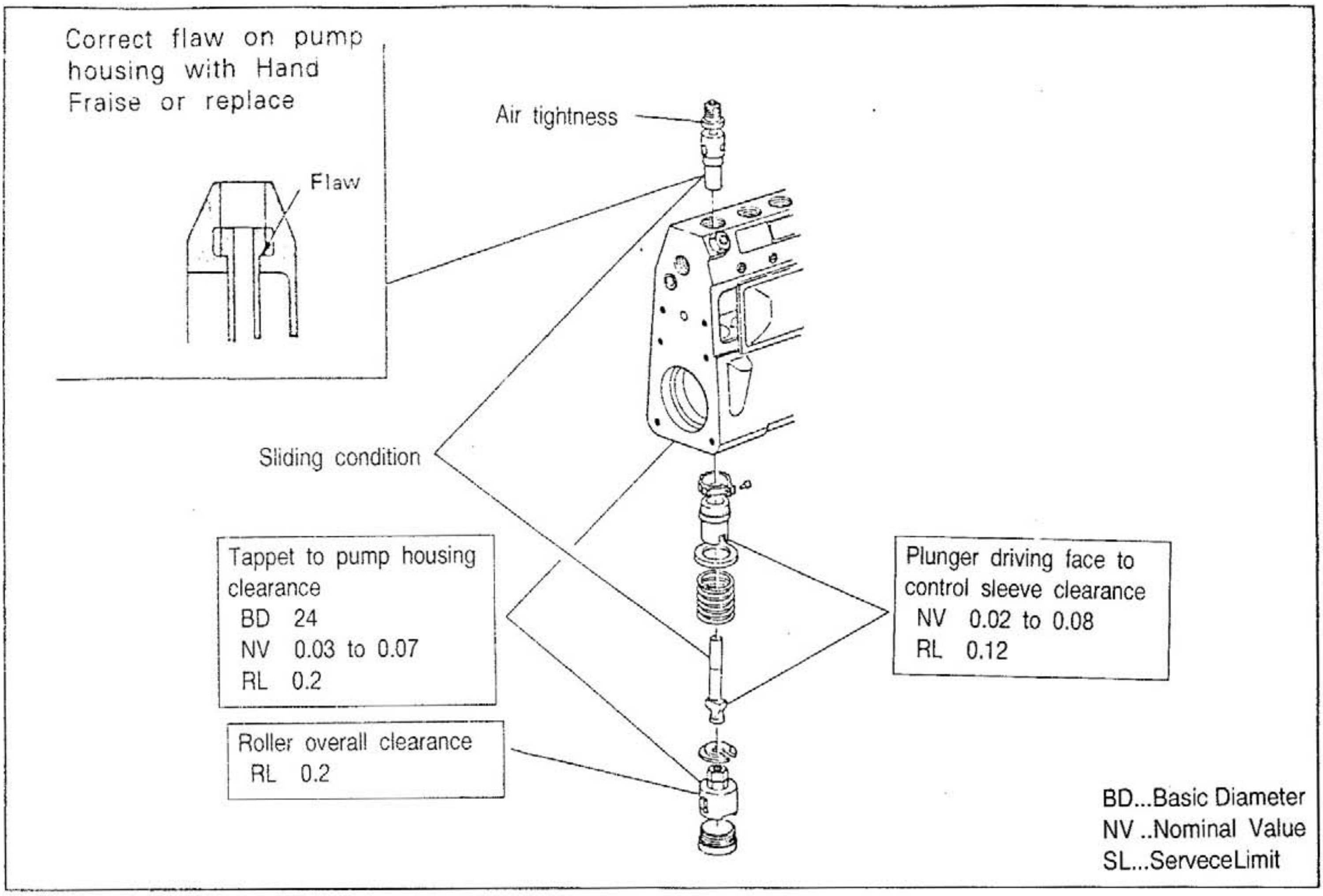
(n) Remove the following parts.

20 Delivery valve
21 Delivery valve seat
22 Plunger barrel

NOTE : Keep the plunger and plunger barrel and the delivery valve and valve seat in original combination and leave them immersed in gas oil.



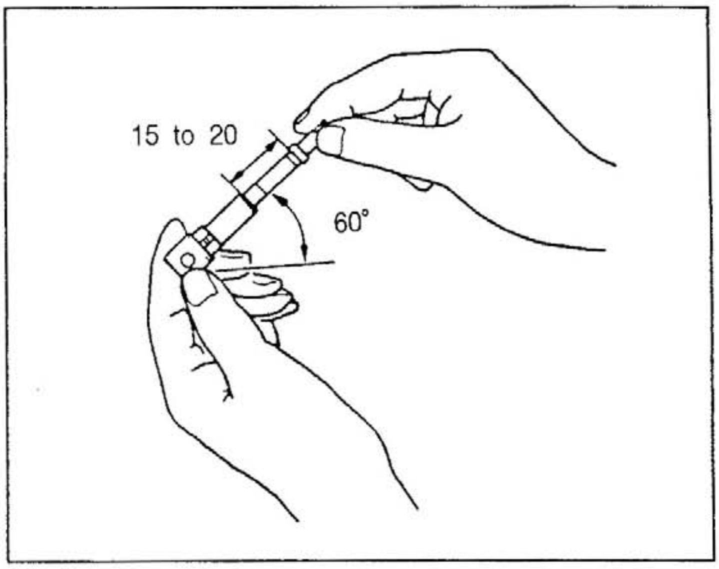
(2) Inspection and Correction



(a) Plunger and plunger barrel

After cleaning in gas oil, check if the plunger in the plunger barrel falls smoothly under its own weight.

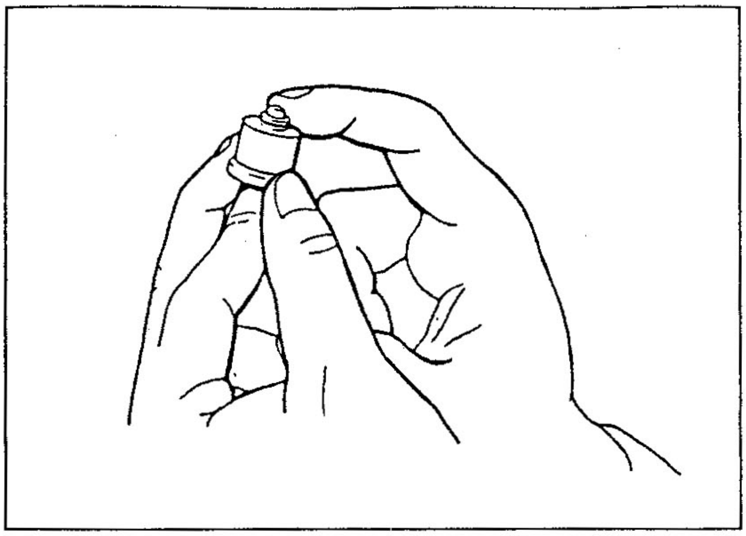
For this check, proceed as follows:



1) Hold the plunger barrel at an angle of about 60 degrees.
2) Draw out the plunger by about 15 to 20mm.
3) Turn the plunger to check at several points.

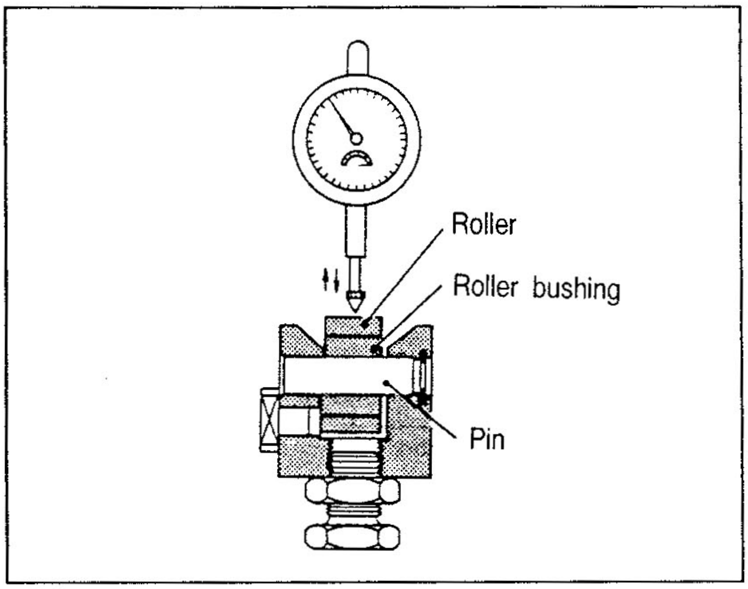
Replace if the plunger does not fall under its own weight.

(b) Delivery valve



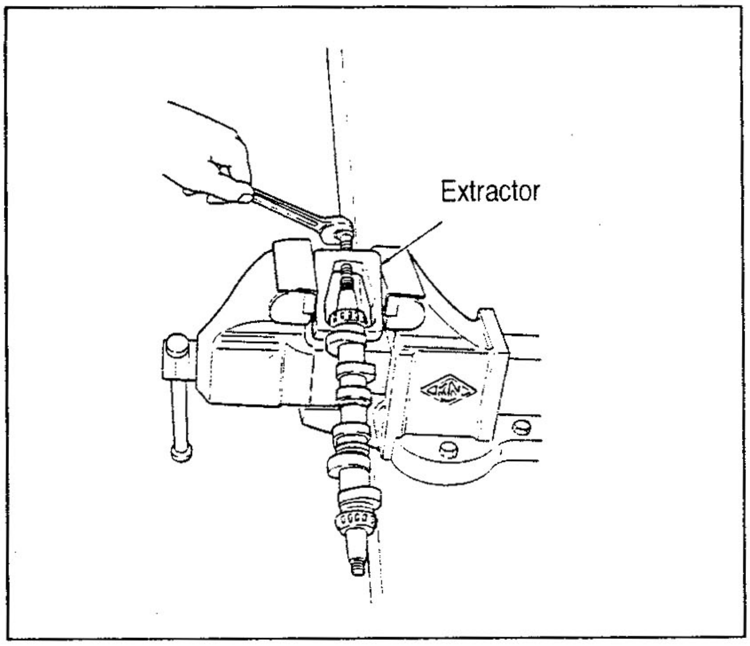
After washing the delivery valve section and valve seat in gas oil, check for wear. With the bottom of the valve seat closed with a finger, push the piston with another finger and then release. The valve is in good condition if the piston spring back.
Otherwise, replace the delivery valve as it is heavily worn.

(c) Tappet



Mount the dial gauge to the roller section of the tappet and move the roller up and down to check the total clearance.
It the total clearance exceeds the service limit, replace the tappet assembly.

(d) Replacement of taper roller bearing



1) Inner race

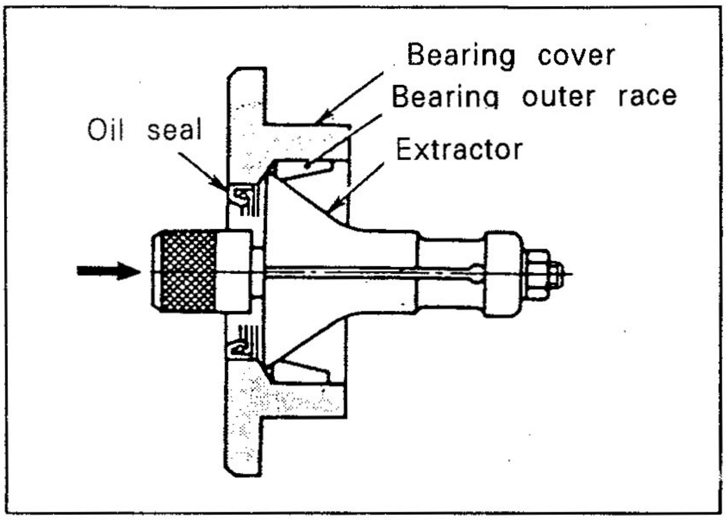
Remove the taper roller bearing using Extractor (special tool). For installation, put ring and shim and then press-fit the taper roller bearing.

NOTE : Use shims of nearly the same thickness on both ends of the camshaft.

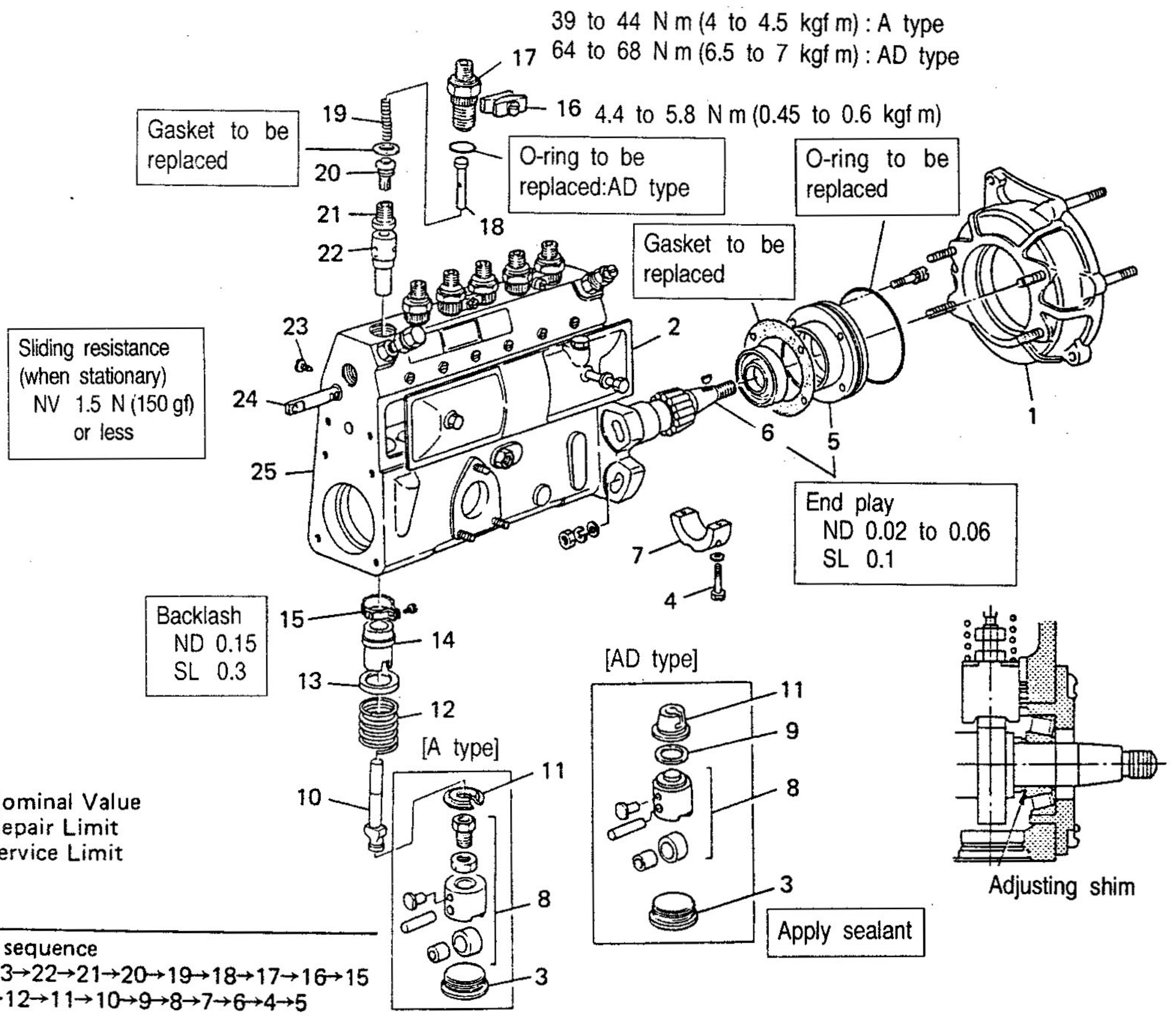
2) Outer race

To remove the outer race from the bearing cover side, use Outer Race Extractor(special tool).

For mounting, use a new oil seal and drive in the outer race.



(3) Assembly



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

Assembly sequence
25→24→23→22→21→20→19→18→17→16→15
→14→13→12→11→10→9→8→7→6→4→5
→$\underbrace{3→2→1}$
After pump adjustment

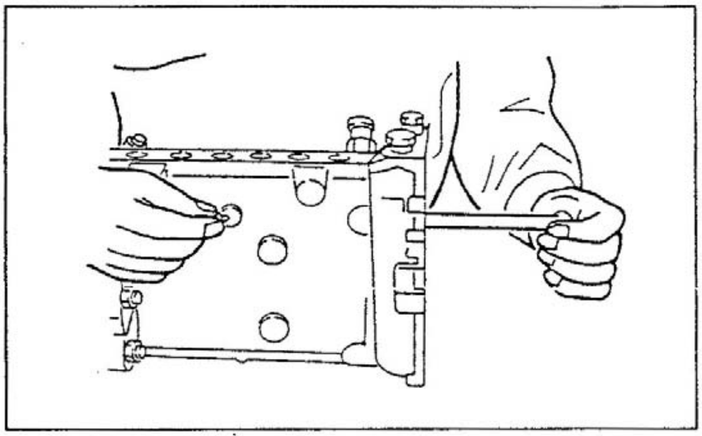
NOTE : 1. If the camshaft end play measured after disassembly is beyond the assembly standard, adjust with shims. Use shims of the same thickness on the governor and timer sides.

2. Mount the camshaft with the end having a scribed line on the threaded end face directed toward the drive side.

(a) Mount the following parts.

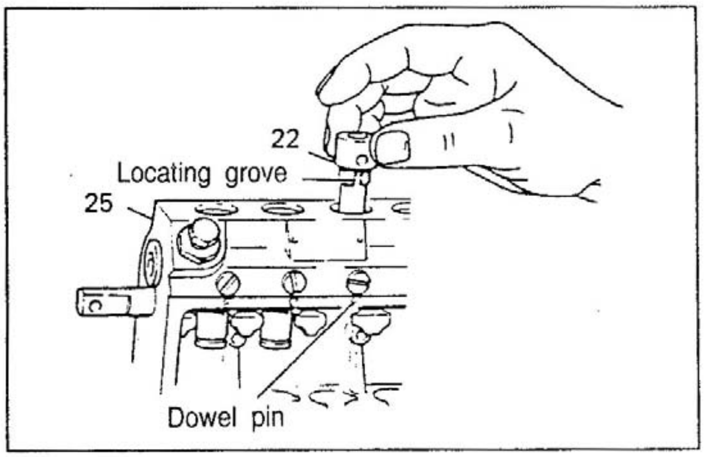
24 Control rack
23 Screw

NOTE : Check that the rack moves smoothly. Also check that the rack does not turn when so attempted.



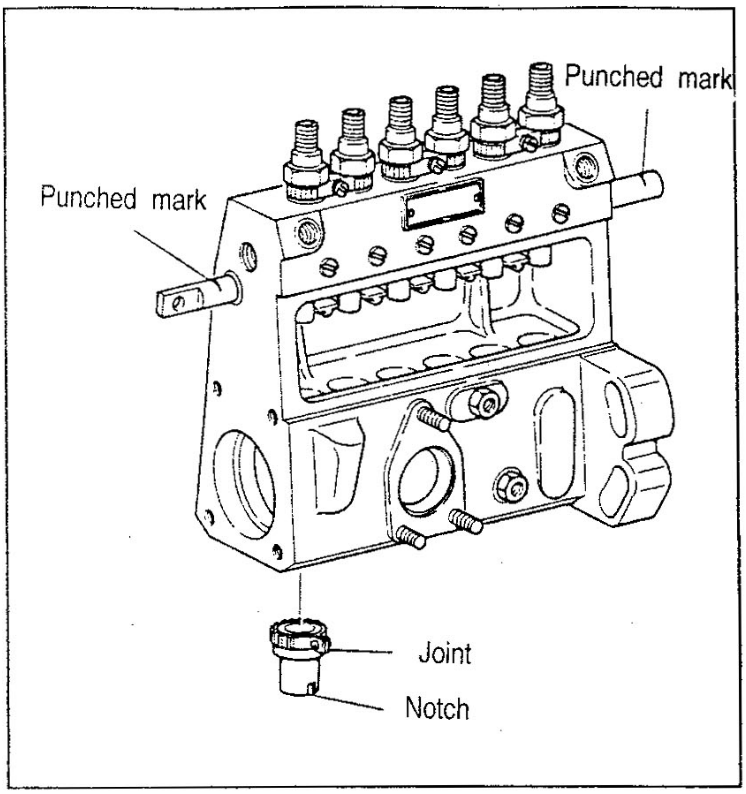
(b) Aligning the dowel pin of the pump housing 25 with the locating groove of the plunger barrel 22, mount the plunger barrel.

NOTE : Clean the pump housing hole into which the plunger barrel is inserted.



(c) With the injection pump lying on its side, set the control rack so that the punched marks on the rack are positioned at the same distance from the housing end faces.

Assemble the pinion 15 with the control sleeve 14, and mesh the pinion with the control rack teeth.



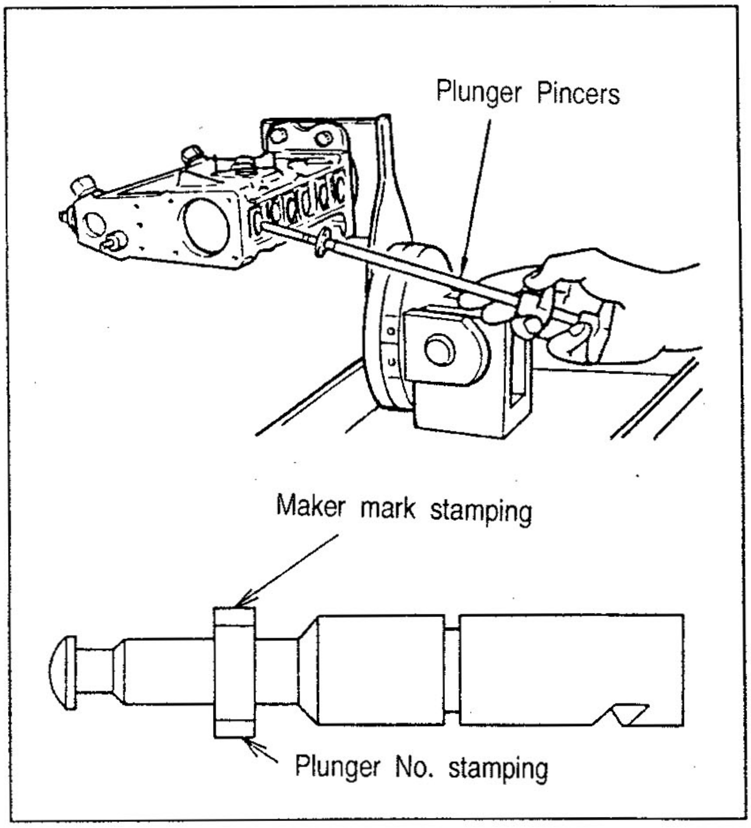
NOTE : 1. Install the control rack with the pinion joint and the control sleeve notch facing to your side.

2. Every time a pinion is installed, move the control rack to make sure that the amount of movement is the same on both sides.

(d) Install the following parts.

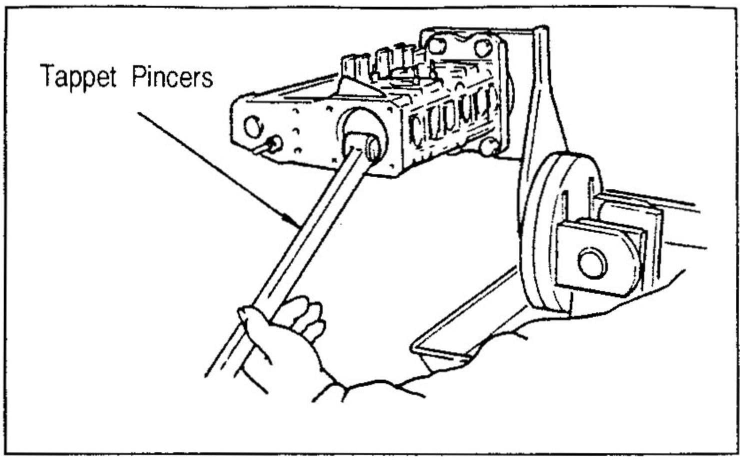
13 Upper spring seat
12 Plunger spring
11 Lower spring seat
10 Plunger

Install the lower spring seat and plunger together, using Plunger Pincers (special tool).



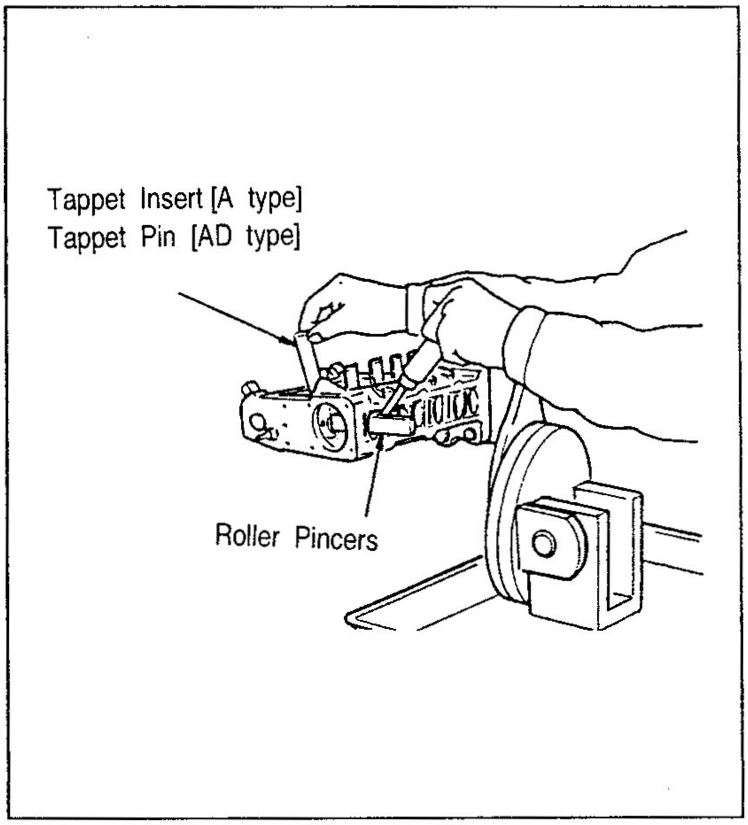
NOTE : Install the plunger with the stamped model number toward you (the housing cover).

(e) Holding the tappet 8 and the shim 9(AD type) with Tappet Pincers (special tool), insert into the pump housing.



(f) Lift up the tappet using Roller Pincers (special tool) and insert Tappet Insert (special tool) between the tappet adjusting bolt and nut in the case of the A type or insert Tappet Pin (special tool) into the tappet hole in the case of the AD type.

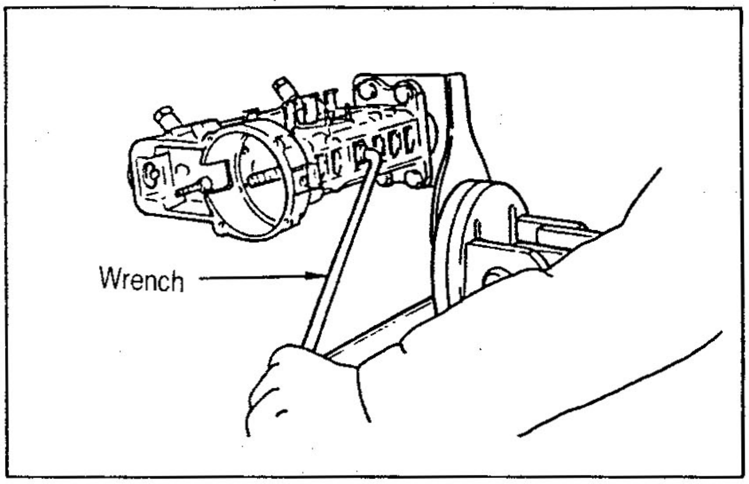
Make sure that the plunger flange is so positioned that the plunger No. on the flange faces the cover plate side.



(g) Check the following

1) Camshaft end play [see 10-1-1 (1) (e)]
2) control rack sliding resistance [see 10-1-1 (1) (c)]
   Perform checking after removing Tappet Insert (special tool).

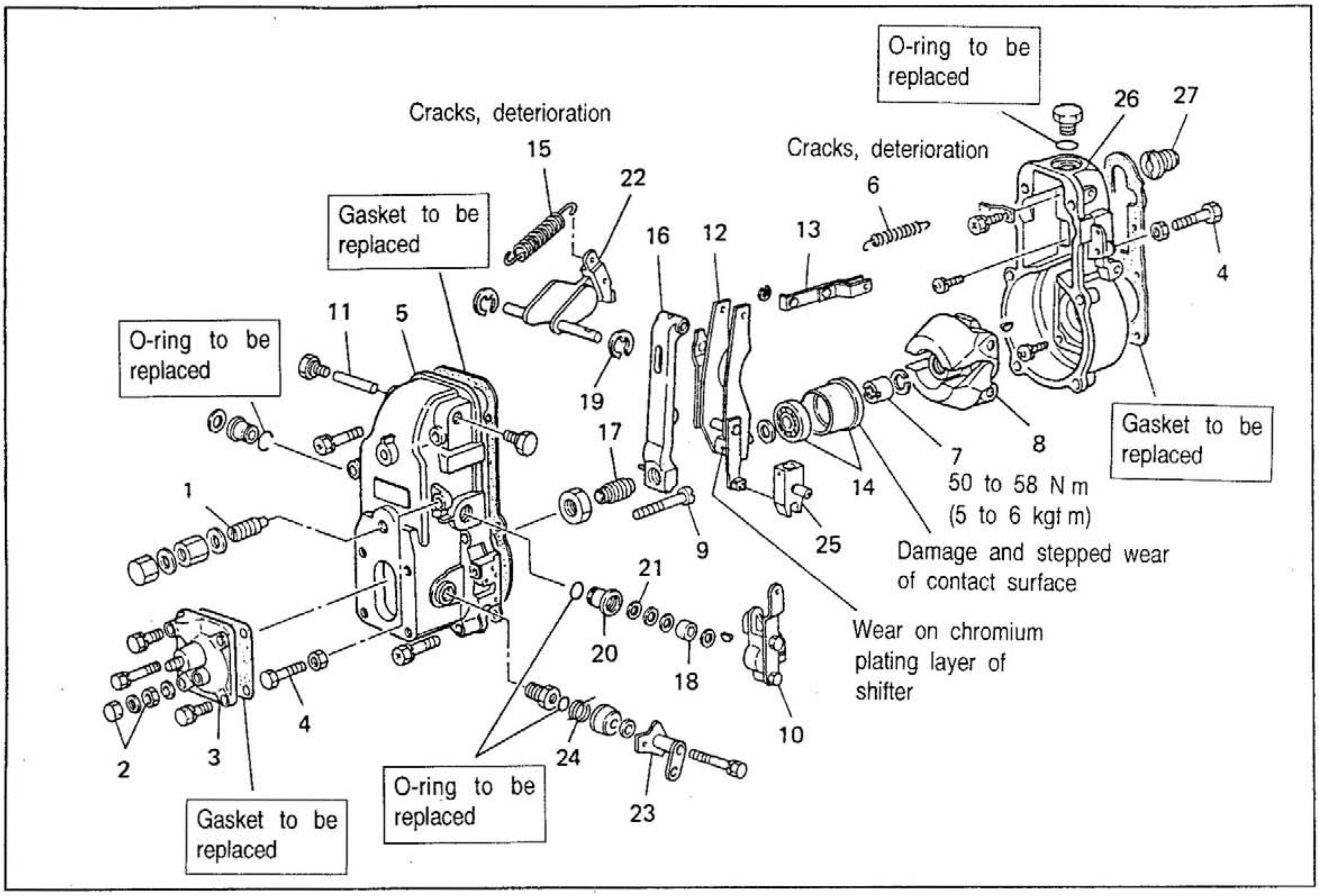
(f) Coat the screw plug 3 with sealant and mount using Wrench (special tool).



(i) Adjust the injection pump using the tester.

10-1-2 RSV Type Governor

(1) Disassembly, Inspection and Assembly



1	Idling subspring	10	Adjusting lever	19	Snap ring
2	Cap nut, lock nut	11	Tension lever pin	20	Bushing
3	Cover	12	Guide lever assembly	21	Oil seal
4	Stopper	13	Floating lever link	22	Swivel lever
5	Governor cover	14	Sleeve	23	Stop lever
6	Start spring	15	Governor spring	24	Return spring
7	Round nut	16	Tension lever	25	Sliding lever
8	Flyweight	17	Ungleich spring adapter	26	Governor housing
9	Full load stopper	18	Collar	27	Adapter

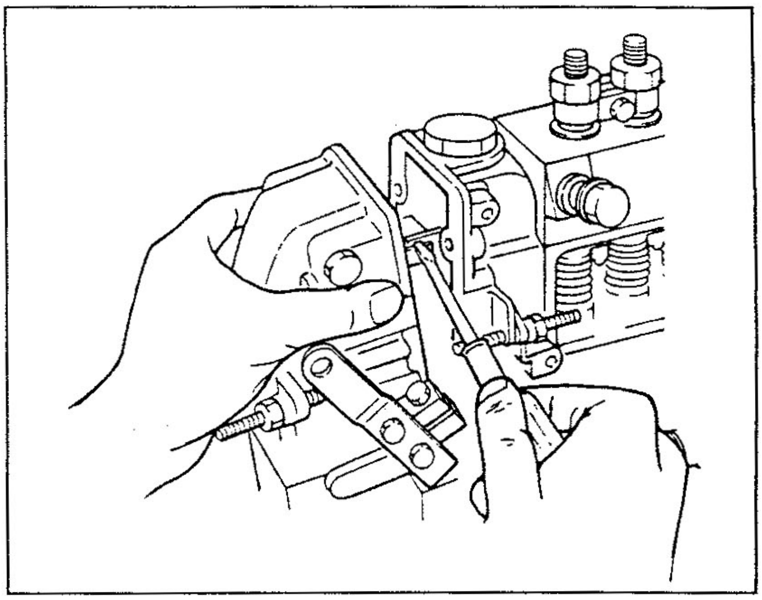
NOTE : 1. Before disassembling the governor, throghly clean the outside of the injection pump and mount correctly to the pump support.

Before disassembly, record the governor performance and the tightening amount of each adjusting point. Comparison of these values with the adjusted values after the disassembly will help determine misadjustment and the causes or troubles of parts if any.

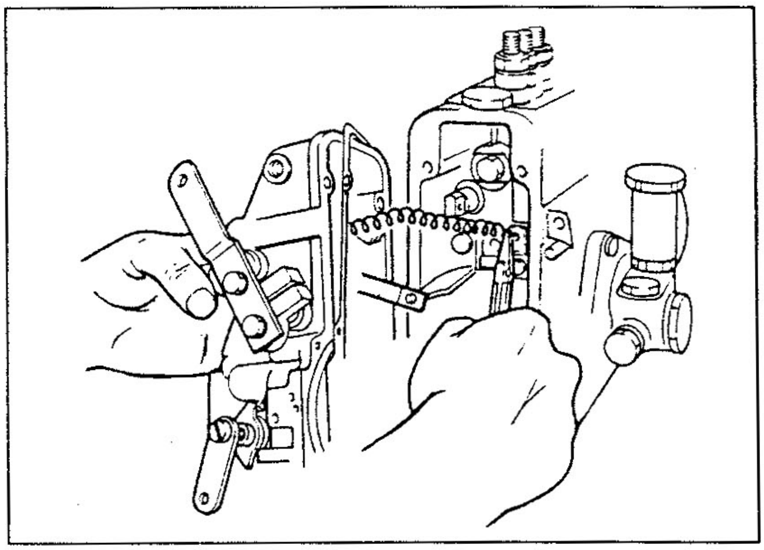
2. Do not disassemble the guide lever 12, floating lever link 13 and sleeve 14 unless replacement is necessary.

(a) Remove the governor cover 5 from the governor housing.

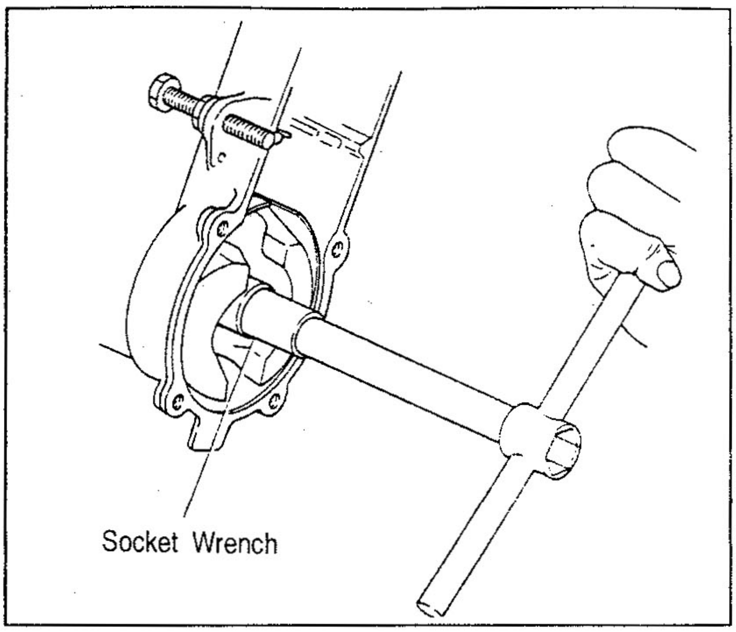
Open the governor cover slightly to the front and slide downward the shackle latch connected to the control rack to disconnect it from the control rack.



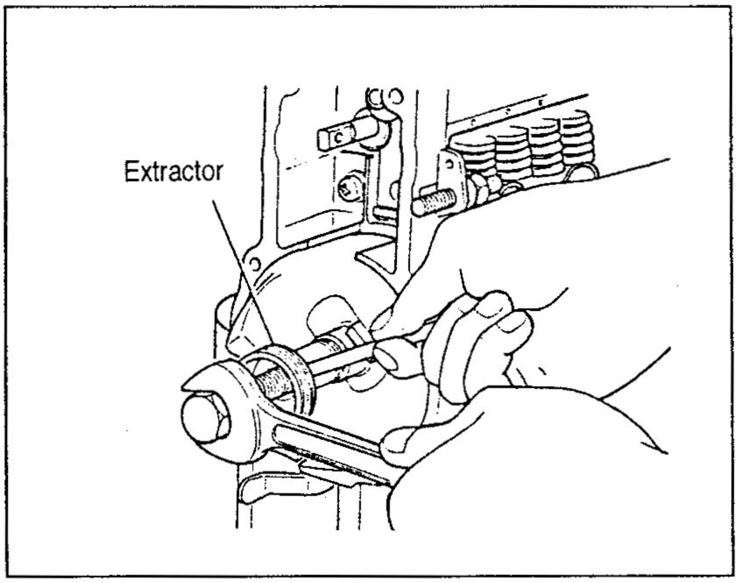
(b) Remove the start spring 6 using long-nose pliers.



(c) Remove the round nut 7 using Socket Wrench (special tool).



(d) Screw in Extractor (special tool) to the flyweight 8 and extract it.



(e) Remove the swivel lever 22.

Remove the snap ring 19 from the bushing and hit lightly the swivel lever shaft from the control lever mounting side to remove the bushing 20 from both ends. Then, remove the swivel lever.

(f) Replacement of sleeve or guide lever assembly

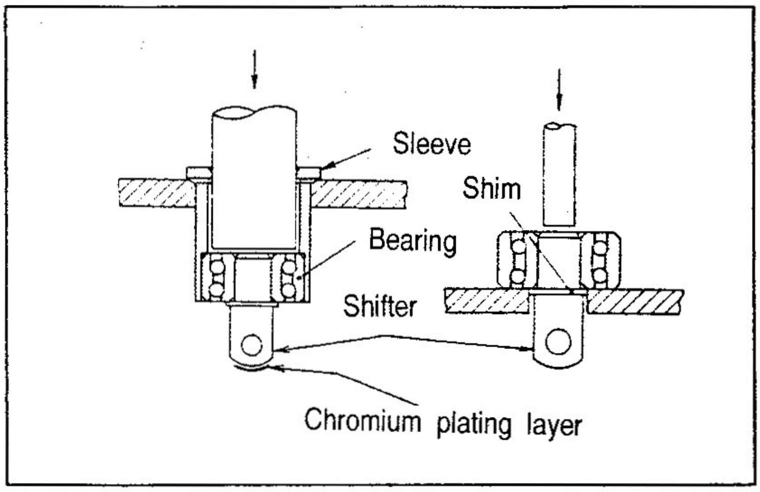
1) Using a press, remove the bearing from the shifter.

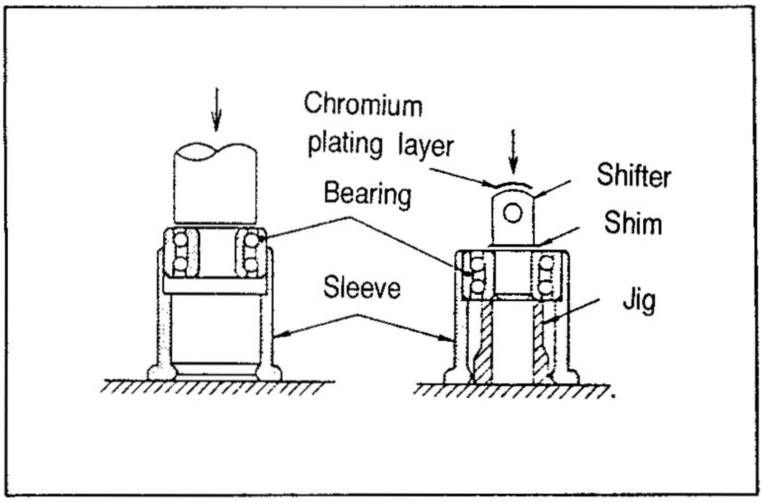
2) Using a press, remove the guide lever assembly shifter from the bearing

3) Press fit the bearing to the sleeve.

4) Press fit the guide lever assembly shifter to the bearing.

5) Make sure that the sleeve turns smoothly.





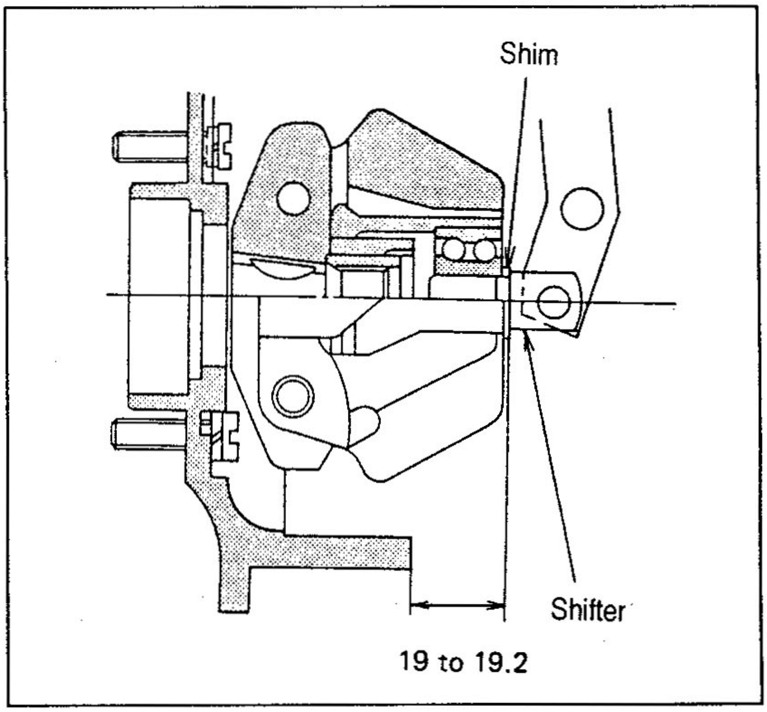
NOTE : 1. Do not replace the shim as it thickness has been established by the adjustment of (g).

2. During removal and installation take care not to damage the chromium plated surface of the shifter.

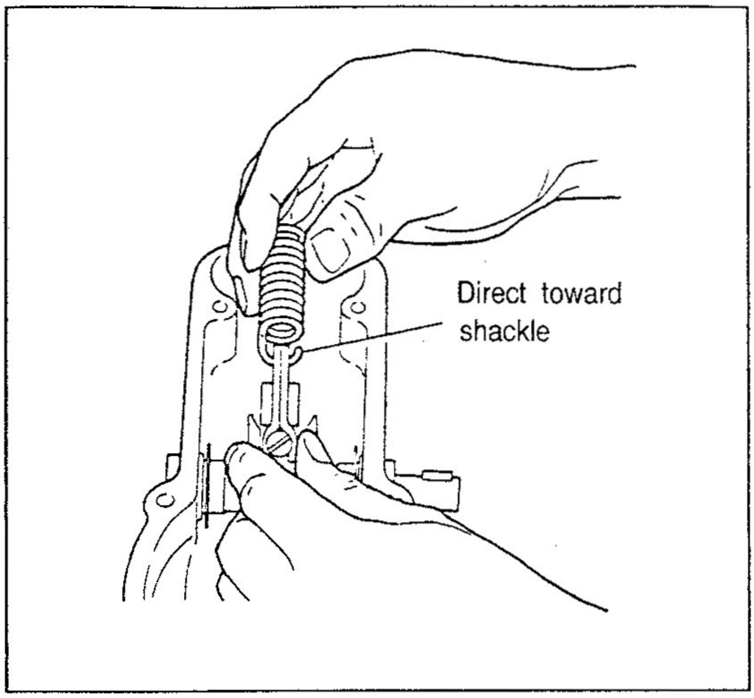
(g) If shims have to be replaced, assemble the associated parts correctly and select the thickness of shims that gives correct housing end to shifter dimension.

Shim thickness (4 types)
0.2, 0.3, 04. and 1.0mm

NOTE : Measure the assembled dimension without lifting the flyweight.



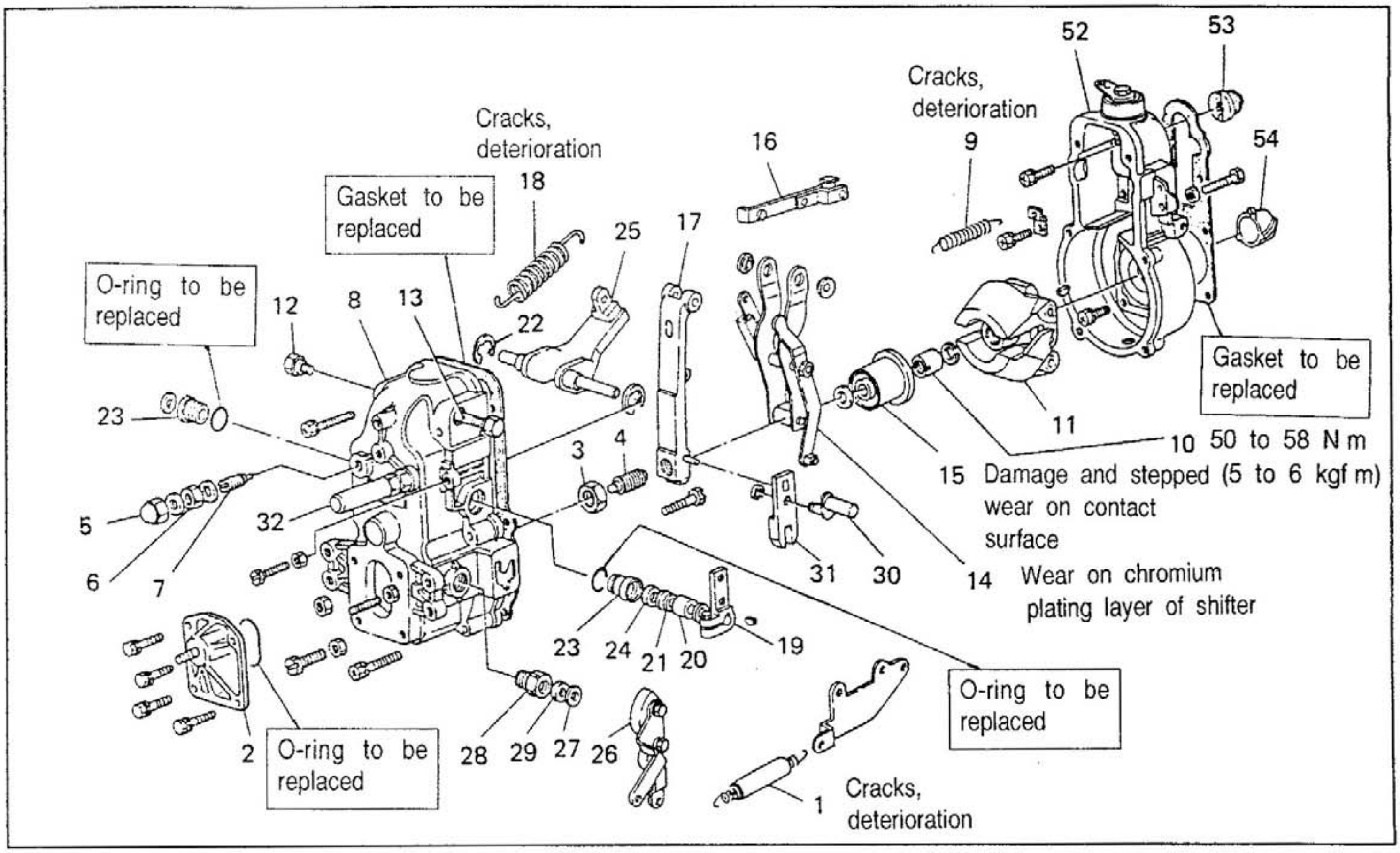
(h) When mounting the governor spring to the swivel lever, position the spring so that its end faces the shackle.



10-1-3 RFD Type Governor

(1) Disassembly and Inspection

The RFD type governor differs in the construction from the RSV type governor but the disassembling procedures are the same. Referring to 10-1-2, disassemble in the order of the numbers shown below.



1	Return spring	13	Pin	25	Swivel lever
2	Cover	14	Guide lever assembly	26	Load control lever
3	Lock nut	15	Sleeve	27	Shim
4	Idling spring capsule	16	Floating lever link	28	Sleeve
5	Cap nut	17	Tension lever	29	Oil seal
6	Lock nut	18	Governor spring	30	Shaft
7	Damper spring capsule	19	Speed control lever	31	Sliding lever
8	Governor cover	20	Collar	32	Smoke set assembly
9	Start spring	21	Shim	52	Governor housing
10	Round nut	22	Snap ring	53	Adapter
11	Flyweight	23	bushing	54	Impeller
12	Plug	24	Oil seal		

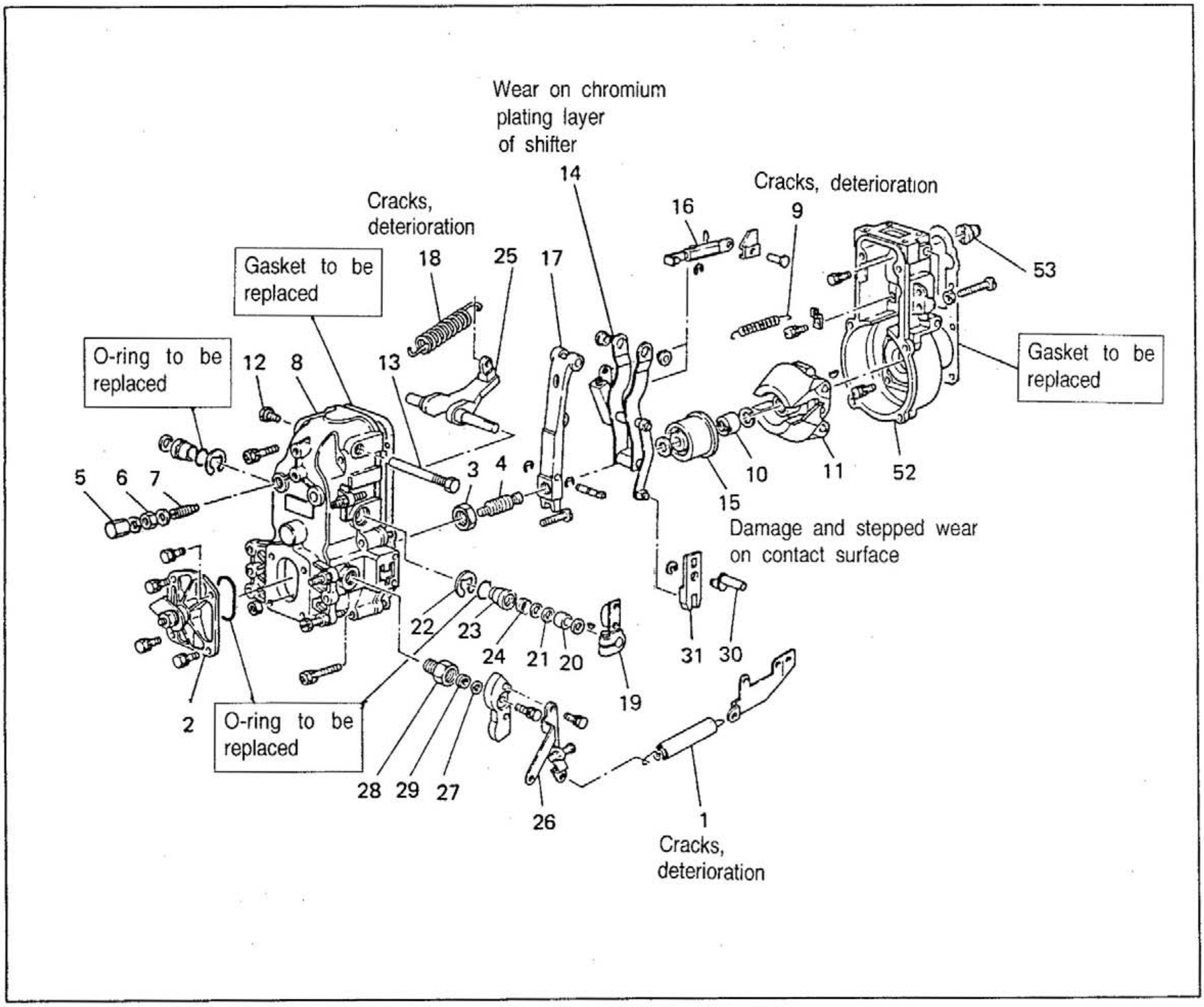
NOTE : 1. Before disassembly, loosen the stopper bolt of the speed control lever until the governor spring tension is not applied.

2. Do not disassemble the guide lever assembly 14, sleeve 15 and floating lever link 16 unless replacement is necessary.

3. Do not remove the smoke set assembly 32 unless necessary.

4. Do not remove the governor housing 52 from the pump proper unless removal is necessary due to oil leaks, etc. Do not remove, in particular, the stop lever on the top of the housing.

[With boost compensator]



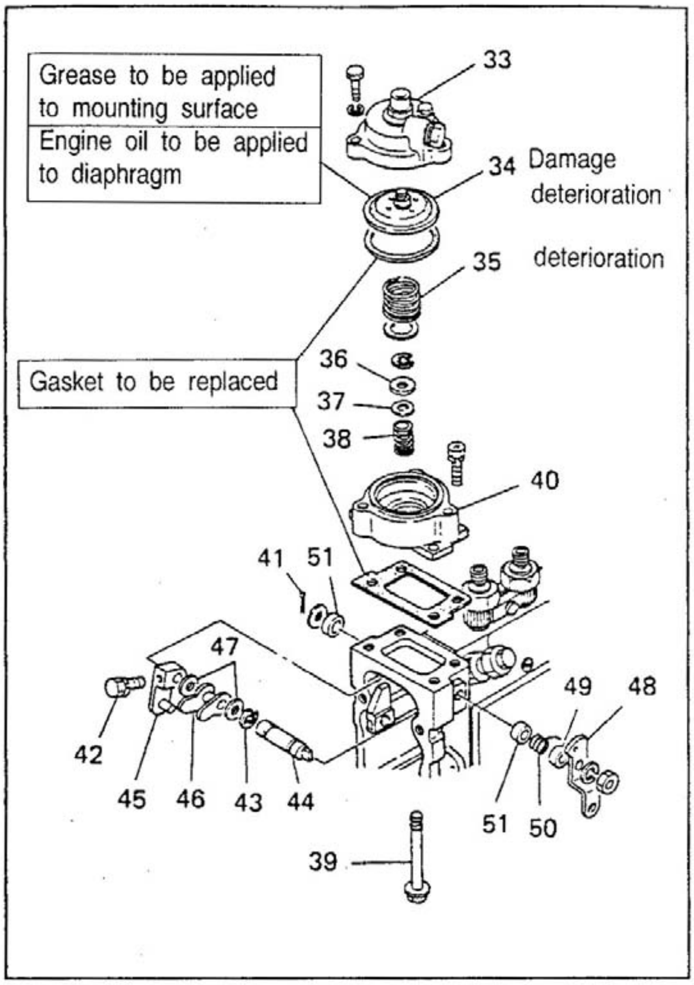
1	Return spring	12	Plug	23	bushing
2	Cover	13	Pin	24	Oil seal
3	Lock nut	14	Guide lever assembly	25	Swivel lever
4	Idling spring capsule	15	Sleeve	26	Load control lever
5	Cap nut	16	Floating lever link	27	Shim
6	Lock nut	17	Tension lever	28	Sleeve
7	Damper spring capsule	18	Governor spring	29	Oil seal
8	Governor cover	19	Speed control lever	30	Shaft
9	Start spring	20	Collar	31	Sliding lever
10	Round nut	21	Shim	52	Governor housing
11	Flyweight	22	Snap ring	53	Adapter

NOTE : 1. Before disassembly, loosen the stopper bolt of the speed control lever until the governor spring tension is not applied.

2. Do not disassemble the guide lever assembly 14, sleeve 15 and floating lever link 16 unless replacement is necessary.

3. Do not remove the governor housing 52 from the pump proper unless removal is necessary due to oil leaks, etc.

33 Boost compensator cover
34 Diaphragm
35 Boost compensator spring
36 Spring seat
37 Washer
38 Start spring
39 Push rod
40 Boost compensator housing
41 Split pin
42 Set bolt
43 Snap ring
44 Shaft
45 Lever
46 Lever
47 Shim
48 Lever
49 Collar
50 Return spring
51 Oil seal

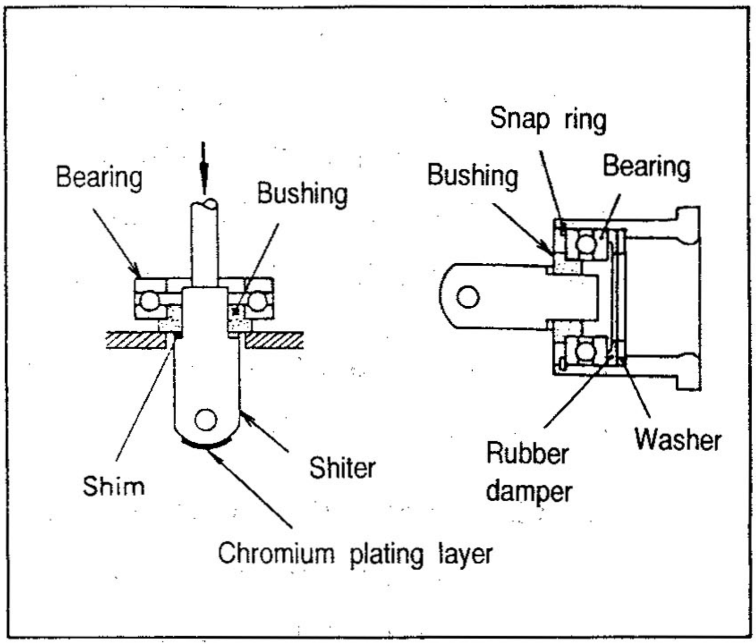


Replacement of sleeve or guide lever assembly

(a) Remove the snap ring from the inside of the sleeve and separate the sleeve and the guide lever assembly shifter section.

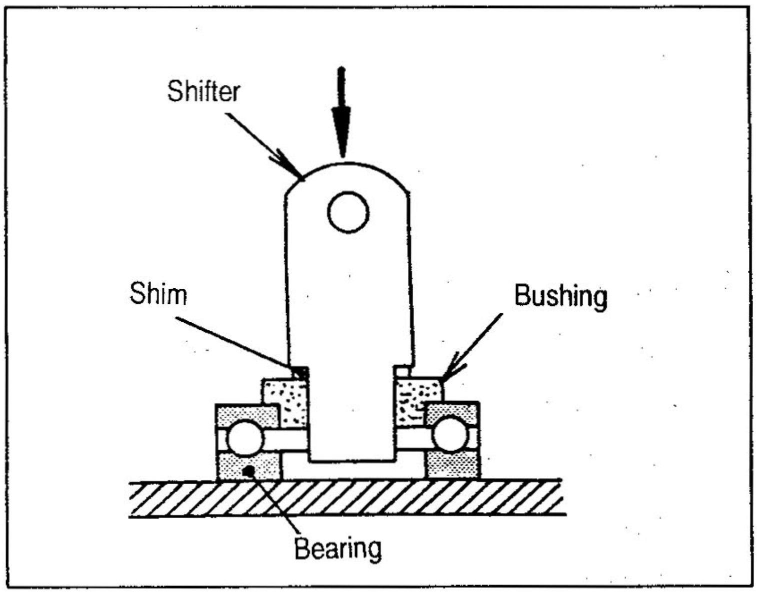
Using a press, remove the bushing and bearing.

NOTE : Do not perform disassembly unless necessary.



(b) Press fit the bushing and shim to the guide lever shifter section.

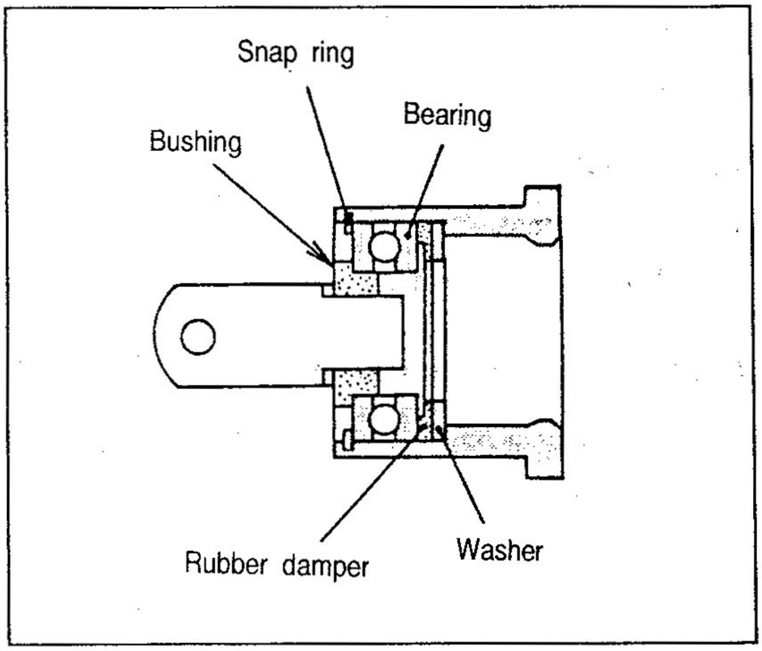
NOTE : Do not replace the shim as its thickness is determined by the adjustment below.



(c) Insert the bushing until it is seated in the plate bearing and fit the snap ring.

Make sure that the sleeve turns smoothly.

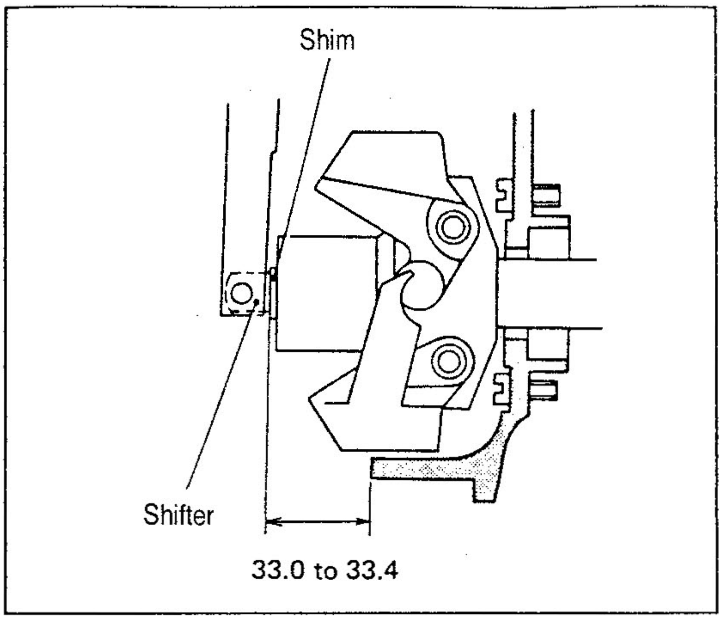
NOTE : During removal and installation take care not to damage the chromium plated surace of the shifter.



(d) If the shim requires replacement, mount the associated parts correctly and select the thickness of shim that gives the specified housing end to shifter dimension.

Shim thickness (4 types)
0.2, 0.3, 0.4 and 1.0mm

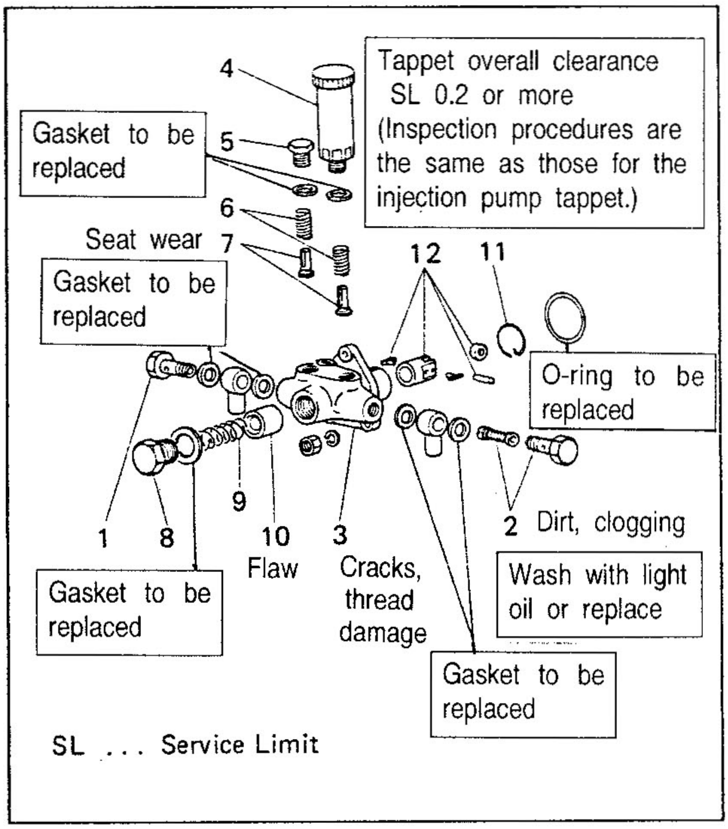
NOTE : With the flyweight fully lifted, measure the assembling dimension.



10-1-4 Feed pump

1 Eye bolt(delivery side)
2 Eye bolt(suction side with gauze filter)
3 Feed pump housing
4 Priming pump
5 Plug
6 Spring
7 Check valve
8 Plug
9 Spring
10 Pistion
11 Snap ring
12 Tappet assembly

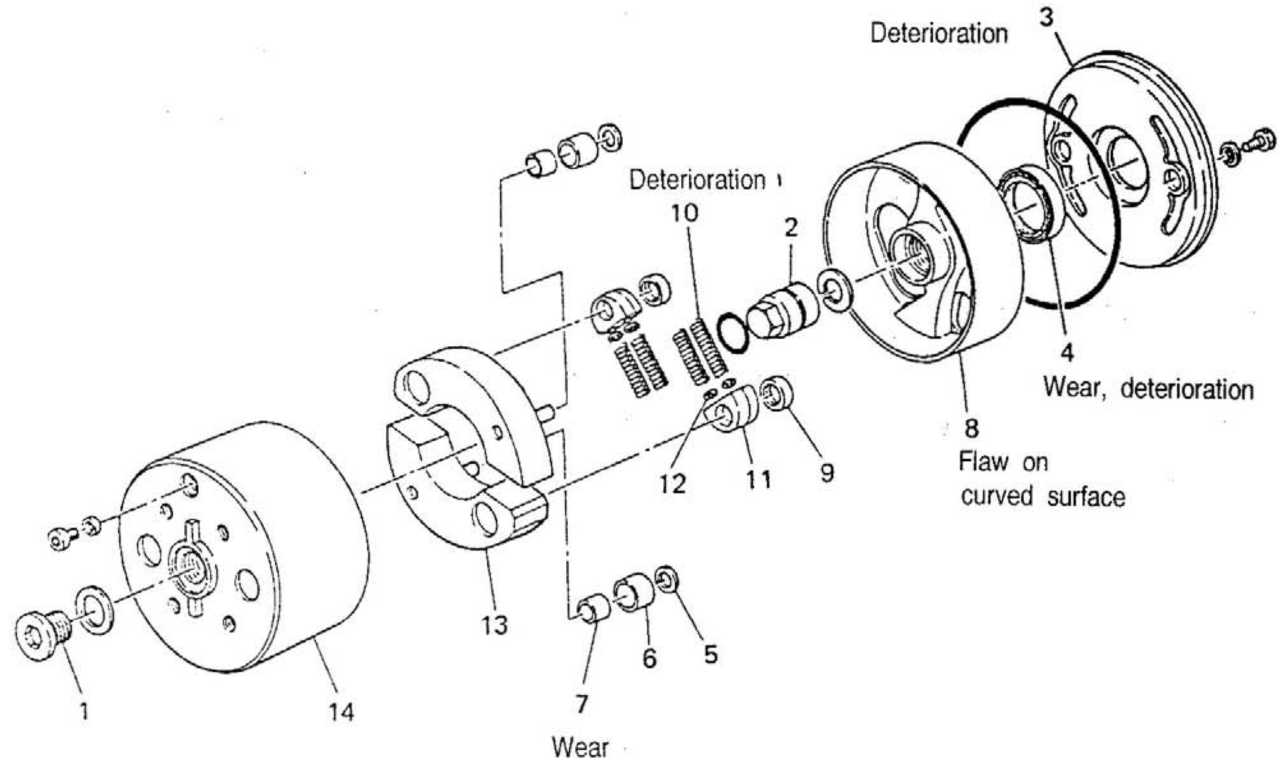
NOTE : Before disassembly, test the pump thoroughly to identify defective parts.



10-1-5 SA, SA-D Type Automatic Timer

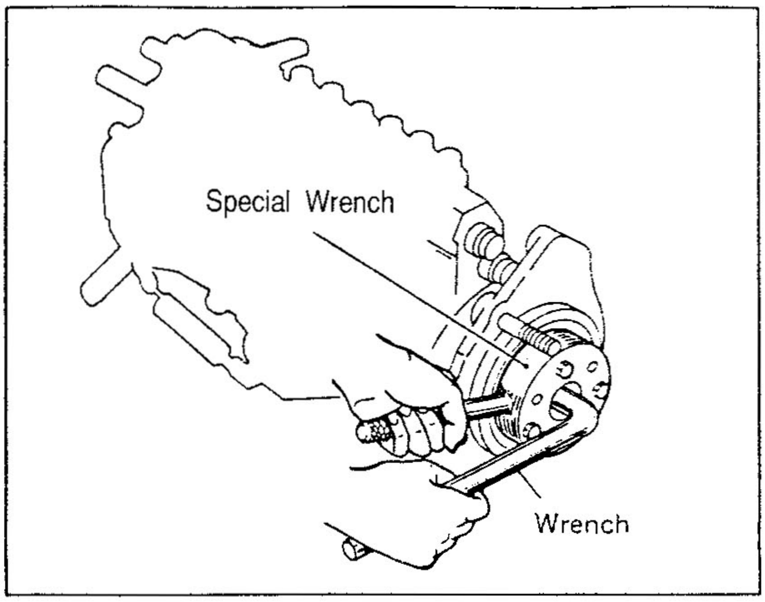
(1) Disassembly and Inspection

[SA type]

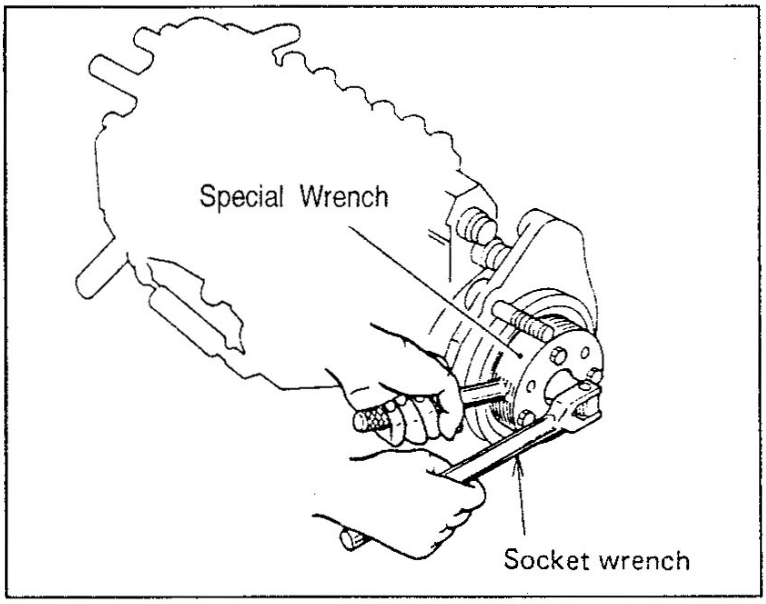


1	Cap	6	Roller	11	Spring seat
2	Round nut	7	Bushing	12	Shim
3	Cover	8	Flange	13	Flyweight
4	Oil seal	9	Retainer	14	Timer housing
5	Washer	10	Timer spring		

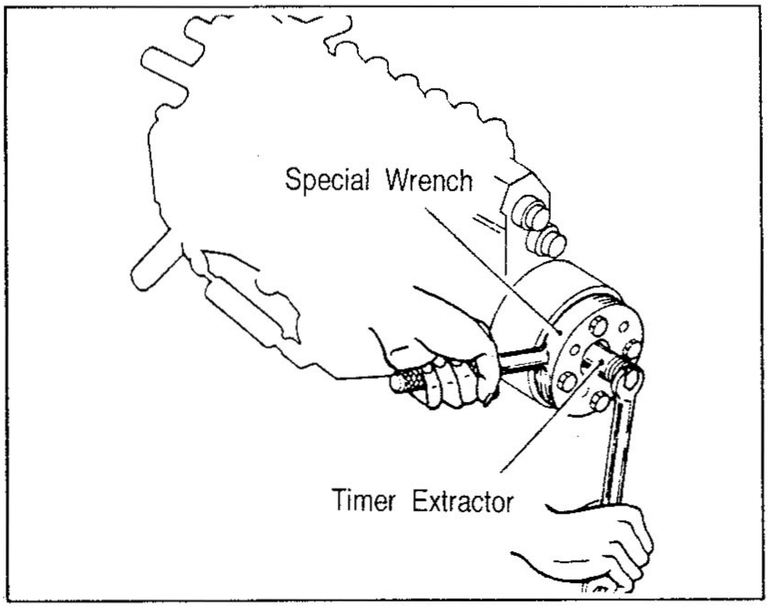
(a) Locking the cap 1 against rotation using Special Wrench (special tool), remove the cap using Wrench (special tool).



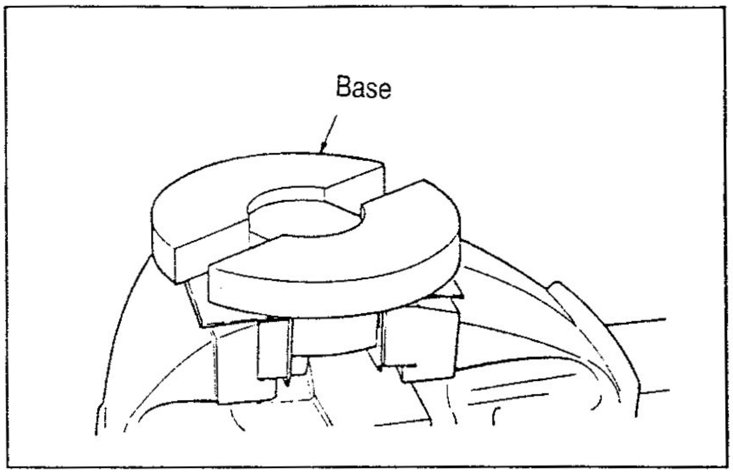
(b) While locking with Special Wrench (special tool) against rotation, remove the round nut 2 using the socket wrench (17mm.)



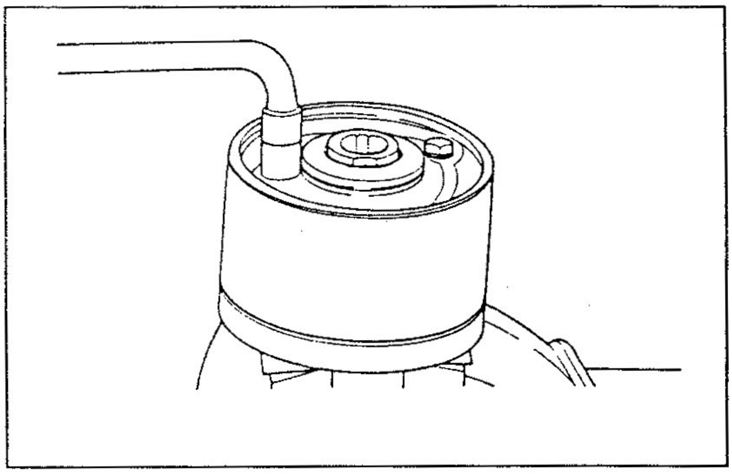
(c) While locking with Special Wrench (special tool), remove the automatic timer from the injection pump using the Timer Extractor (special tool).



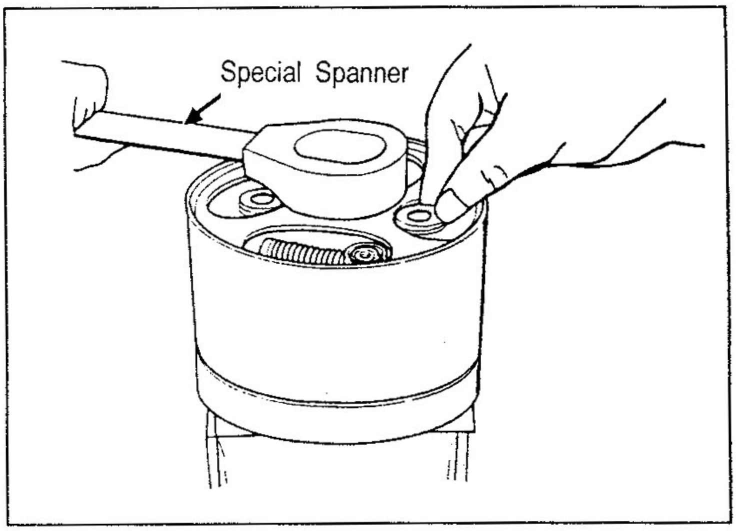
(d) Install Base (special tool) to the vice and mount the automatic timer to it.



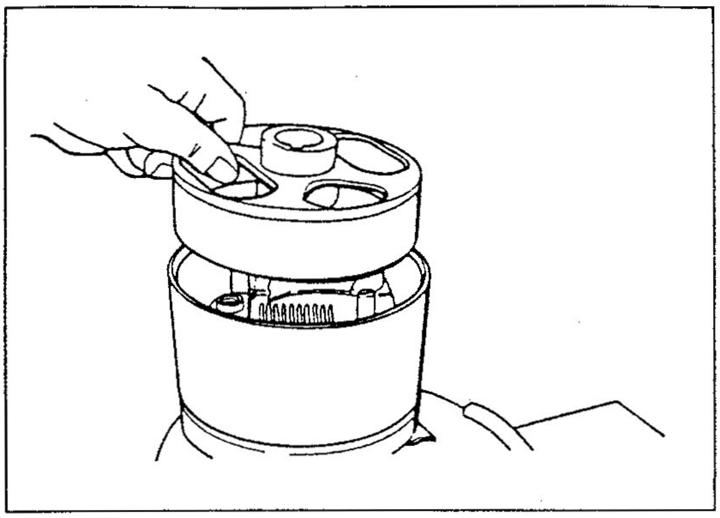
(e) Remove the cover 3 along with the oil seal 4. Check the oil seal and replace if defective.



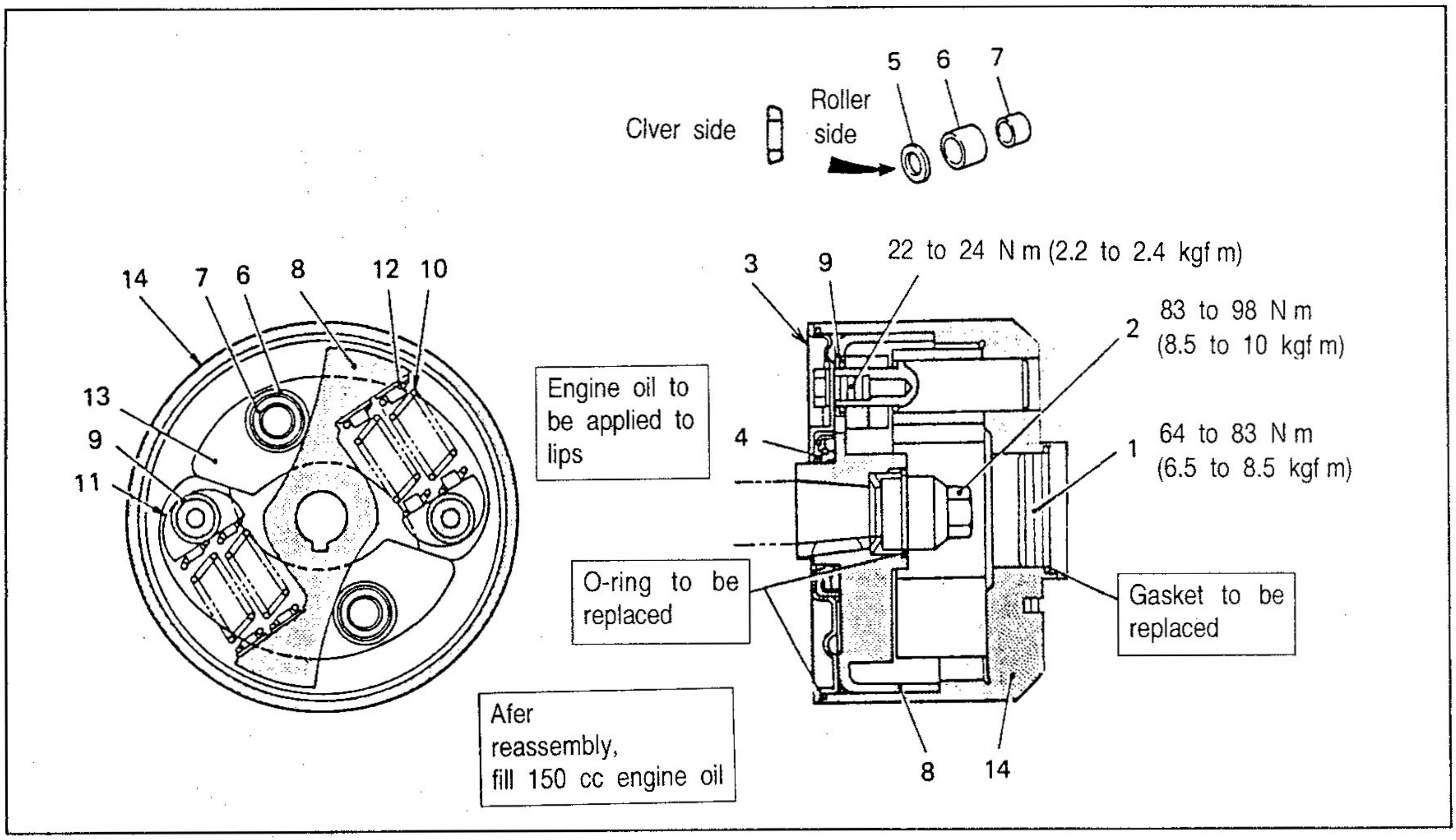
(f) Mount Special Spanner (special tool) to the flange and with the timer spring compressed, remove the washer 5, roller 6 and bushing 7.



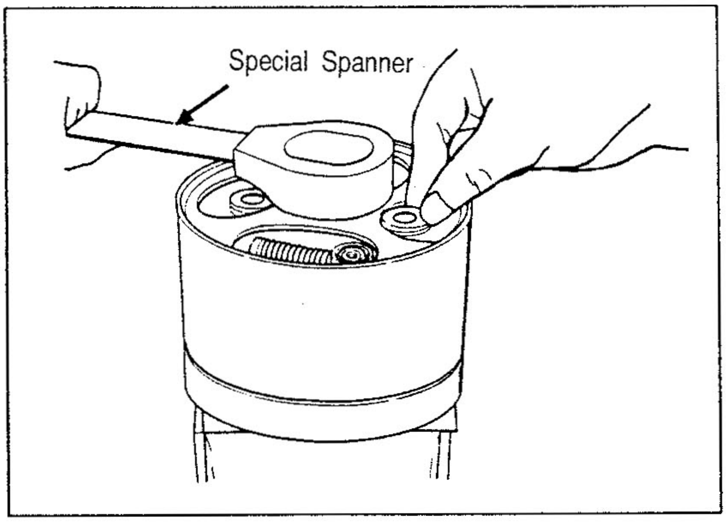
(g) Lift up and remove the flange 8. Then, remove the retainer 9, timer spring 10, spring seat 11 and shim 12. Finally remove the fly-weight 13.



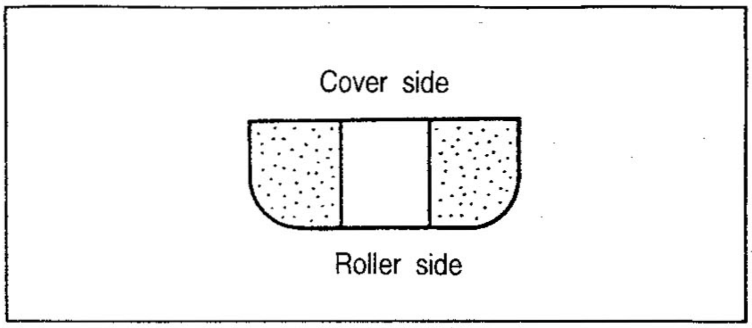
(2) Assembly



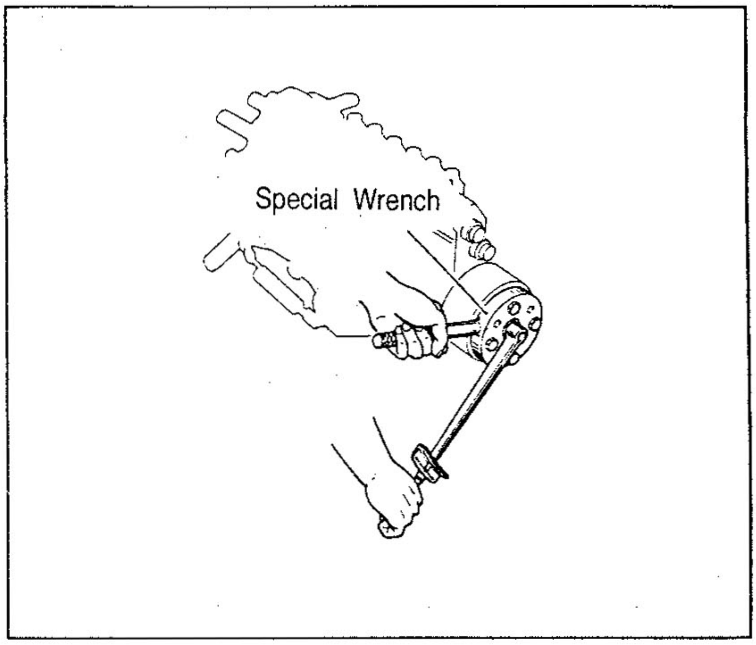
(a) Mount Special Spanner (special tool) to the flange and mount the bushing 7, roller 6 and washer 5 while compressing the timer spring.



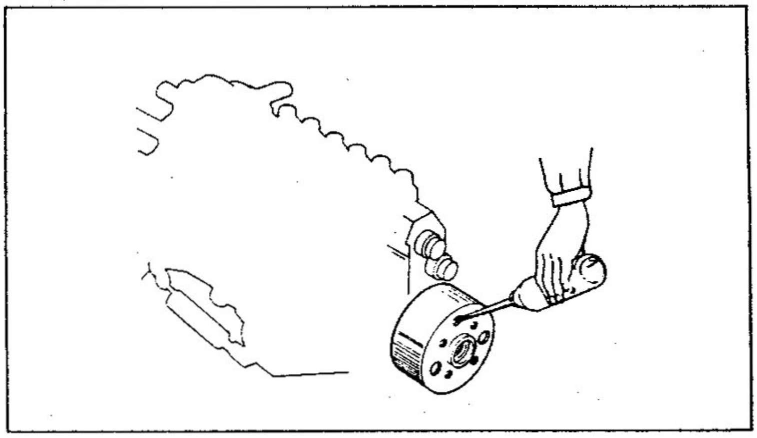
NOTE : Mount the washer in the direction shown.



(b) Put the key to the injection pump camshaft and insert the automatic timer. Locking with Special Wrench (special tool) against rotation, tighten the round nut 2 to the specified torque.

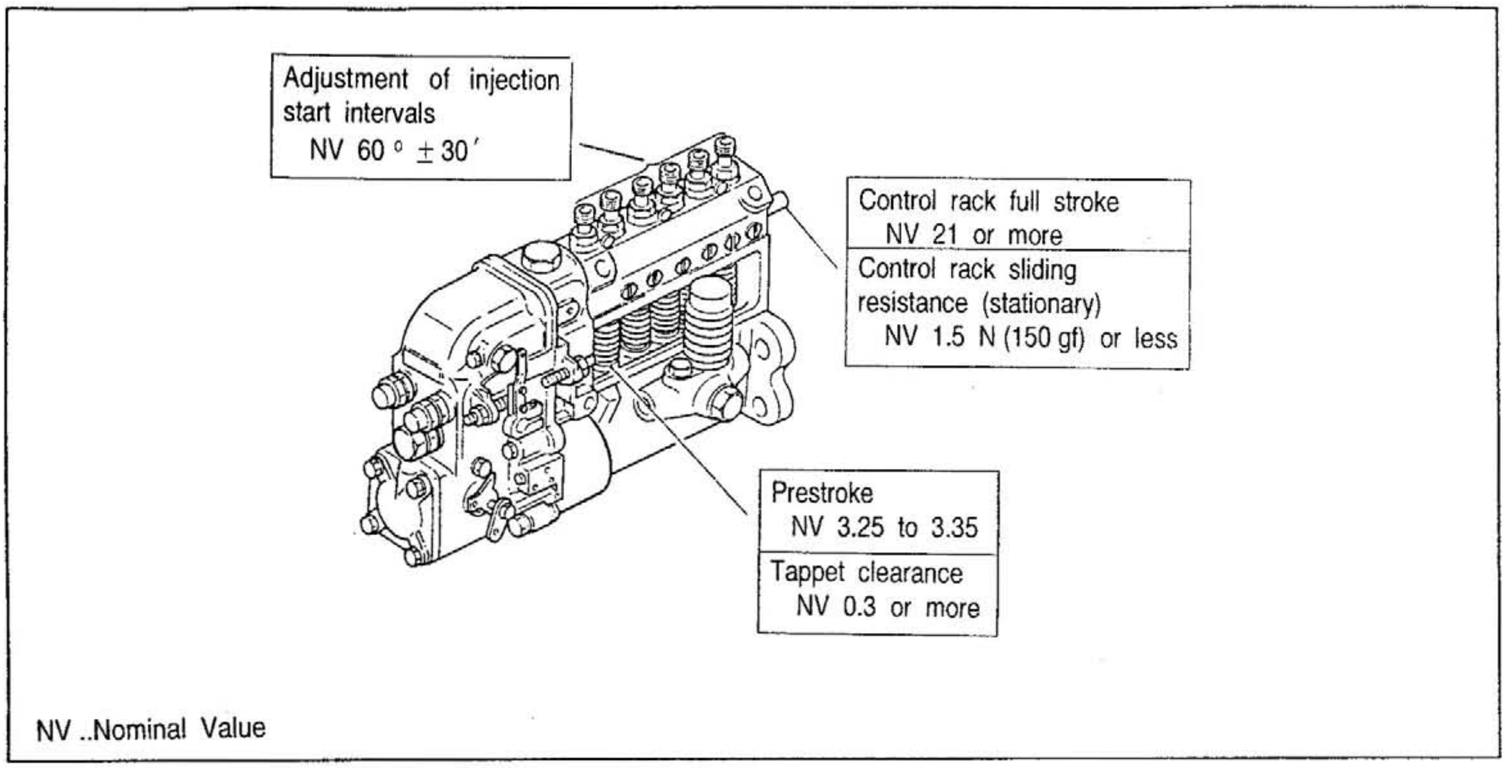


(c) Supply 150cc of engine oil before fitting the plug to the timer housing front.



10-1-6 Test and Adjustment

(1) Injection Pump



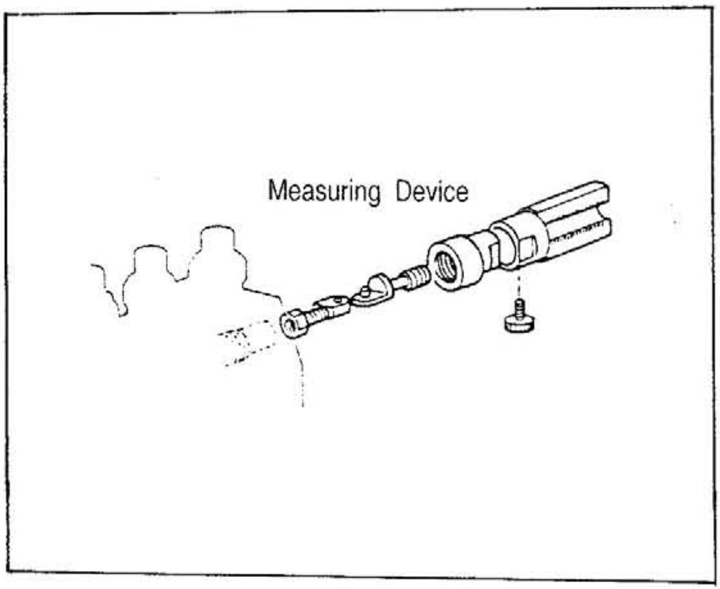
NOTE : 1. Supply oil to the injection pump cam chamber.

2. Adjust the amount of injection after governor adjustment.

(a) Control rack "0" position setting

Install Measuring Device (special tool) on the injection pump.

temporarily set the speed control lever to maintain the injection pump speed at 500 to 600rpm. Further increase the speed to pull the control rack; at the same time, push the control rack fully.



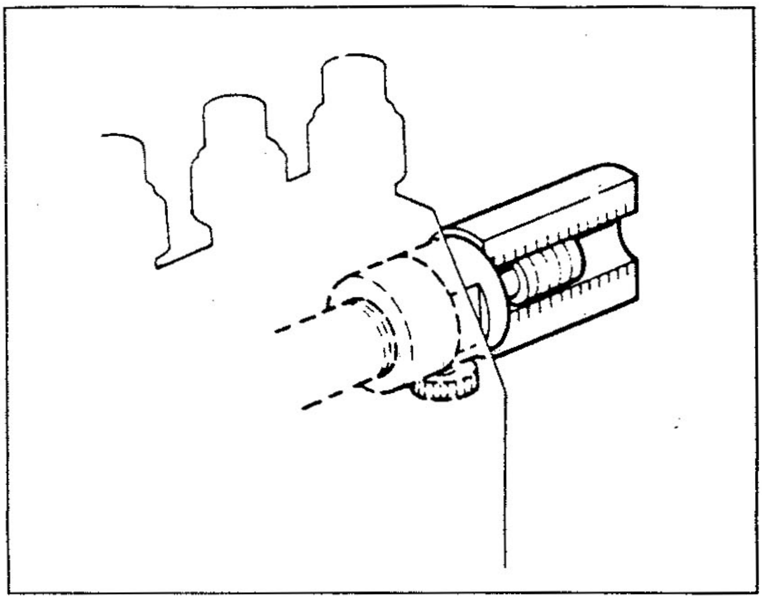
With this position of control rack regarded as "0", set "0" on the Measuring Device scale to the position.

NOTE : Pushing the control rack without turning the injection pump can damage the governor linkage.

(b) Control rack stroke check

Move the control rack to check its stroke is more tha the specified value.

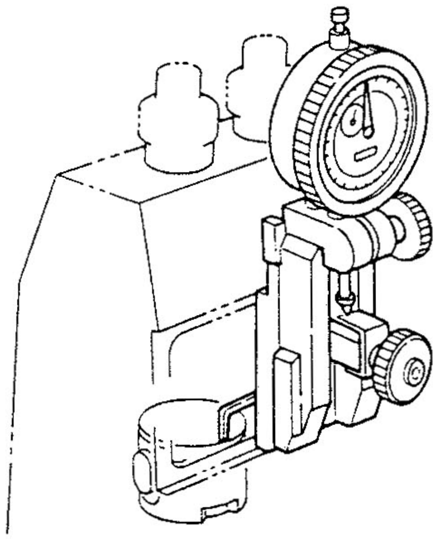
Ensure also that the start spring and idling spring move the control rack smoothly in the direction to increase the amount of fuel injected.



(c) Prestrok check

1) Withdraw and fix the control rack in the full injection position.

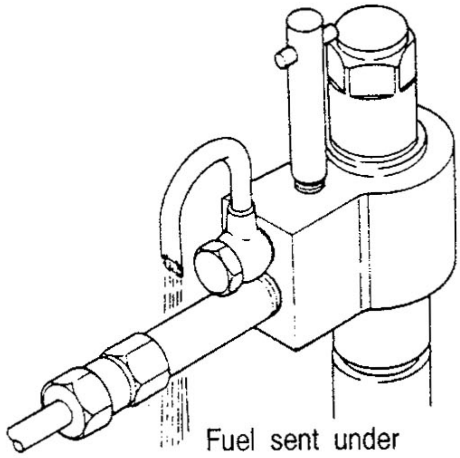
2) With No. 1 cylinder plunger at BDC, install the Measuring Device (special tool). Set the stylus at tappet head.



3) Connect injection pump to test nozzle.

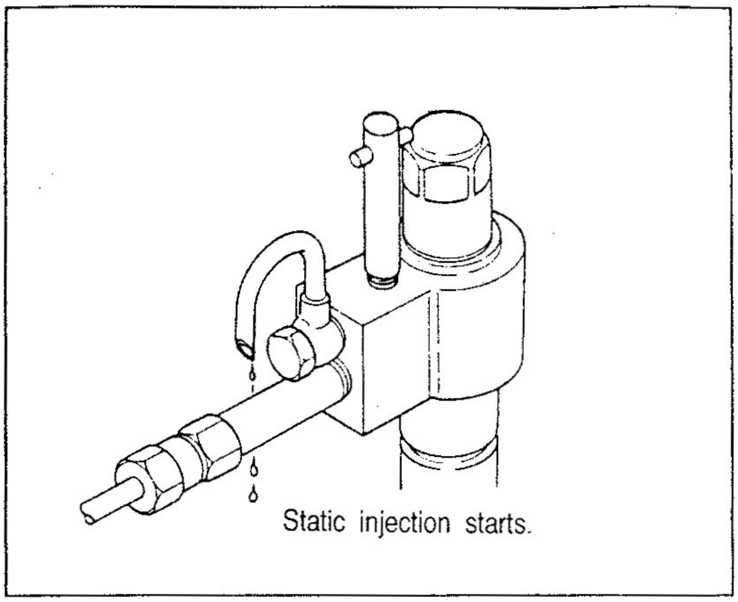
4) Send fuel to injection pump under high pressure to let the fuel flow out from the overflow pipe of nozzle holder.

NOTE : The fuel pressure must be over the delivery valve opening pressure.



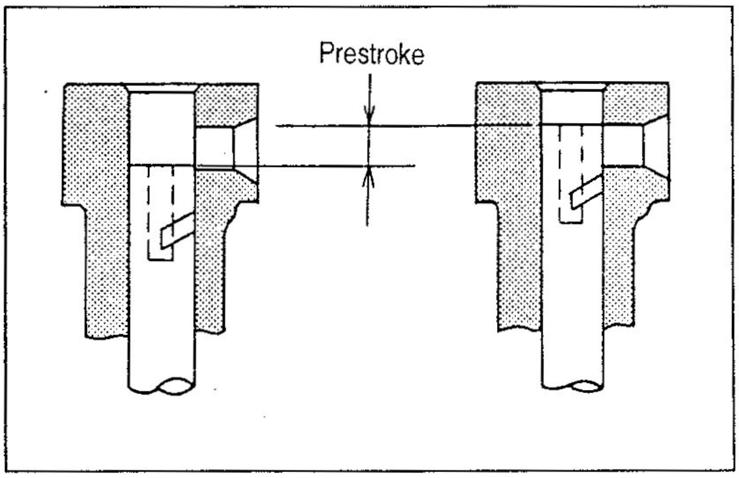
5) Slowly turn the camshaft until the fuel stops flowing out of the nozzle holder overflow pipe (static injection starts).

NOTE : Measurement must be made with the camshaft turned in the normal rotating direction (counterclockwise as viewed from the drive end).



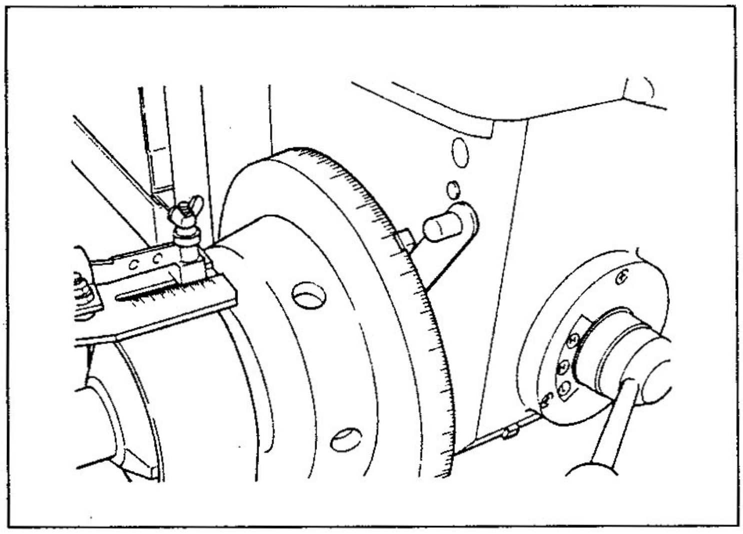
6) Read the prestroke of plunger on the gauge, from BDC until fuel stops flowing

If the prestroke is out of the nominal value, adjust with adjusting bolt for A type pump, and with shims for AD type pump. [See (e).]



(d) Injection start interval adjustment.

1) With the static injection start of No. 1 cylinder used as a basis, measure injection start interval of each cylinder accdording to the injection sequence using an angle scale.



2) If the angle is out of the specified value, adjust as in prestroke adjustment.

NOTE : Injection sequence

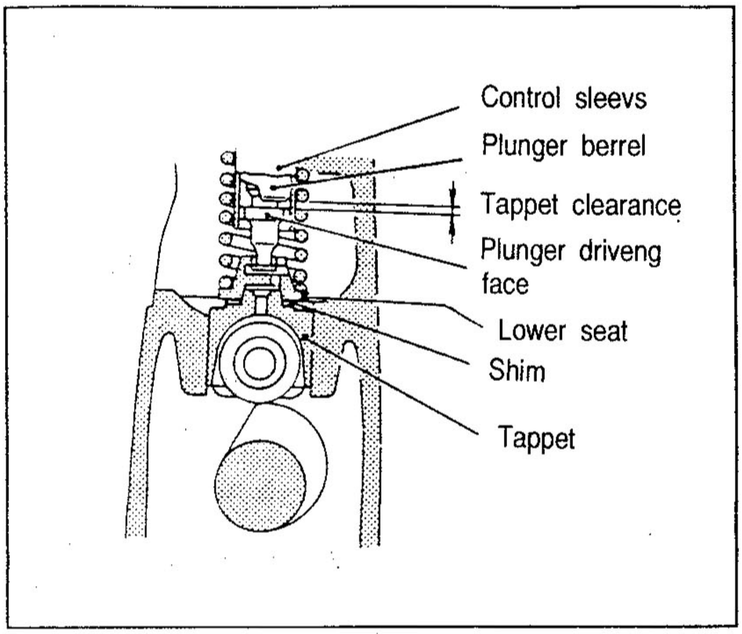
1→5→3→6→2→4

(e) Tappet clearance measurement

1) Place the tappet at TDC.

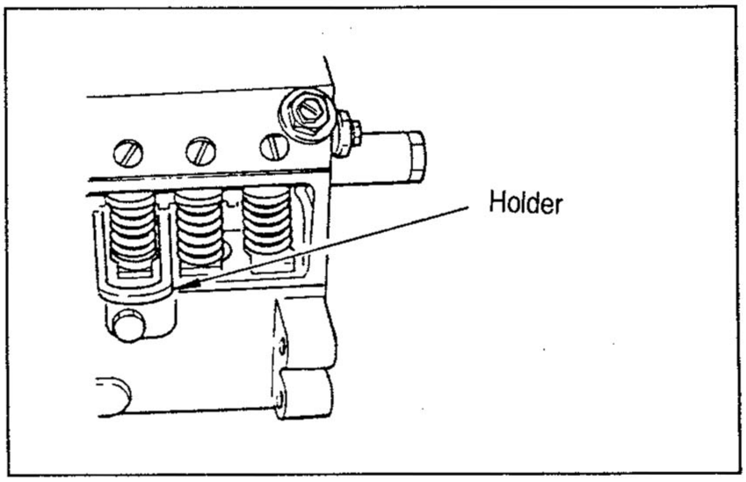
2) Using a screwdriver, raise the tappet until the plunger driving face comes in contact with the Plunger barrel bottom end.

3) Measure the tappet stroke from TDC to contact with the plunger barrel.



4) If the tappet clearance is less than the nominal value, adjust within the allowable range of injection start interval. If the range does not permit correction, readjust with No. 1 cylinder prestroke at the maximum nominal value.

5) For A type pump, adjust with adjusting bolt. For AD type pump, adjust by varying shim thickness with Holder (special tool) inserted between the tappet and lower seat.



(f) Adjustment of amount of fuel injected

Adjust as follows to obtain the specified amount of fuel injected with the specified rack position and speed.

NOTE : 1. Use special care to make the adjustment. Improper or failure of adjustment greatly influences engine performance.

2. The amount of fuel injected varies with nozzle and pipe used. Observe measuring requirement strictly.

3. Deviations

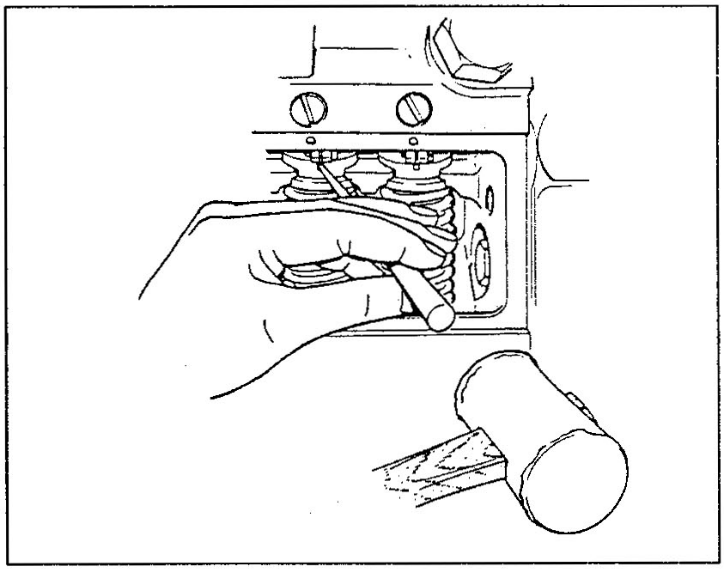
$$\text{Deviation}(+) = \frac{\begin{array}{ll}\text{Max. amount of fuel injected} - & \text{Average amout of fuel} \\ \text{in each cylinder} & \text{injected in each cylinder}\end{array}}{\text{Averge amount of fuel injected in each cylineder}} \times 100$$

$$\text{Deviation}(-) = \frac{\begin{array}{ll}\text{Min. amount of fuel injected} - & \text{Average amout of fuel} \\ \text{in each cylinder} & \text{injected in each cylinder}\end{array}}{\text{Averge amount of fuel injected in each cylineder}} \times 100$$

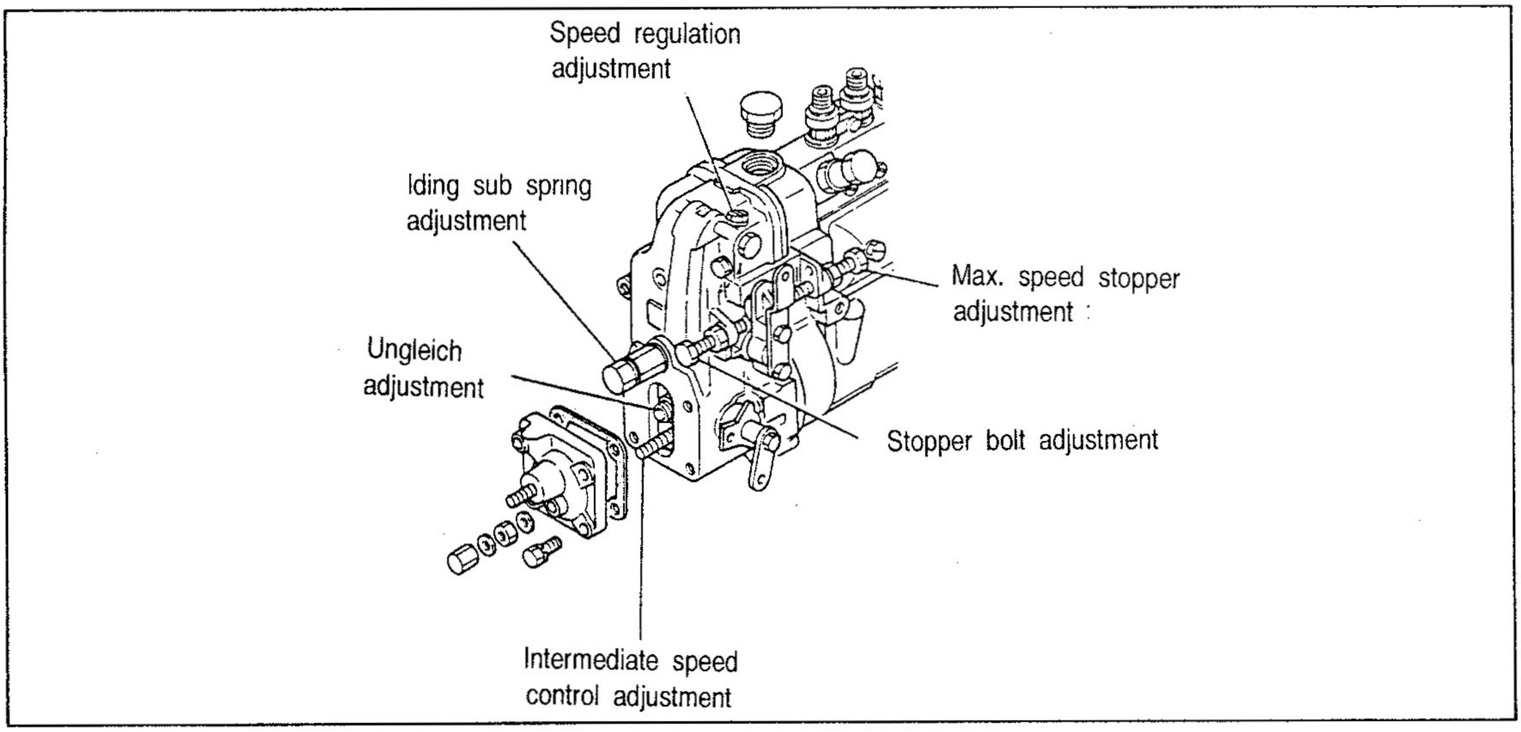
1) Loosen pinion screw.

2) With the control rack held in position, turn the control sleeve with the adjusting rod.

3) Tighten pinion screw.



(2) RSV Type Governor



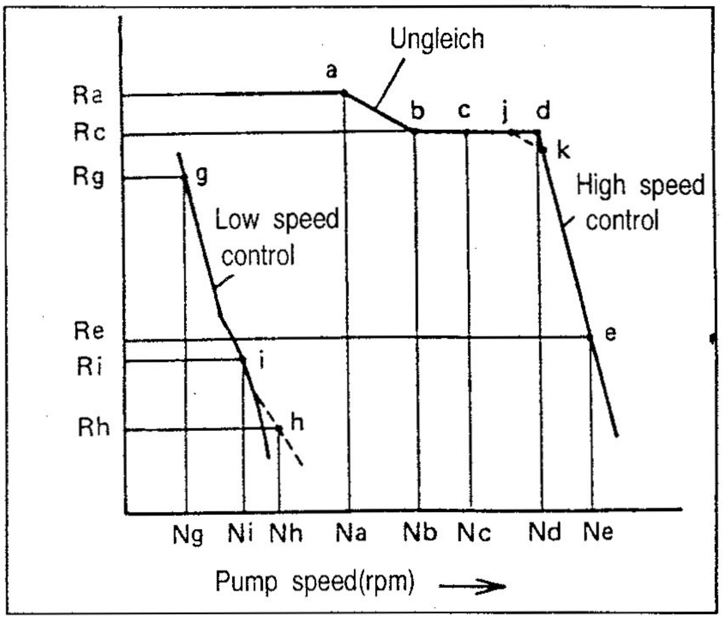
NOTE : 1. Supply oil to the injection pump cam chamber.

2. Loosen the control lever stopper bolt.

3. Remove the idling subspring.

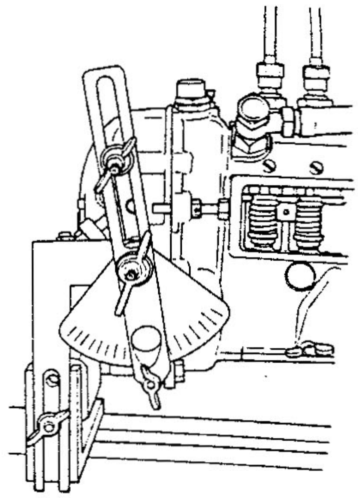
4. Do not allow the Ungleich spring to work.

Adjust the relationship between the pump speed and the rack position to the specified governor performance curve as follows.

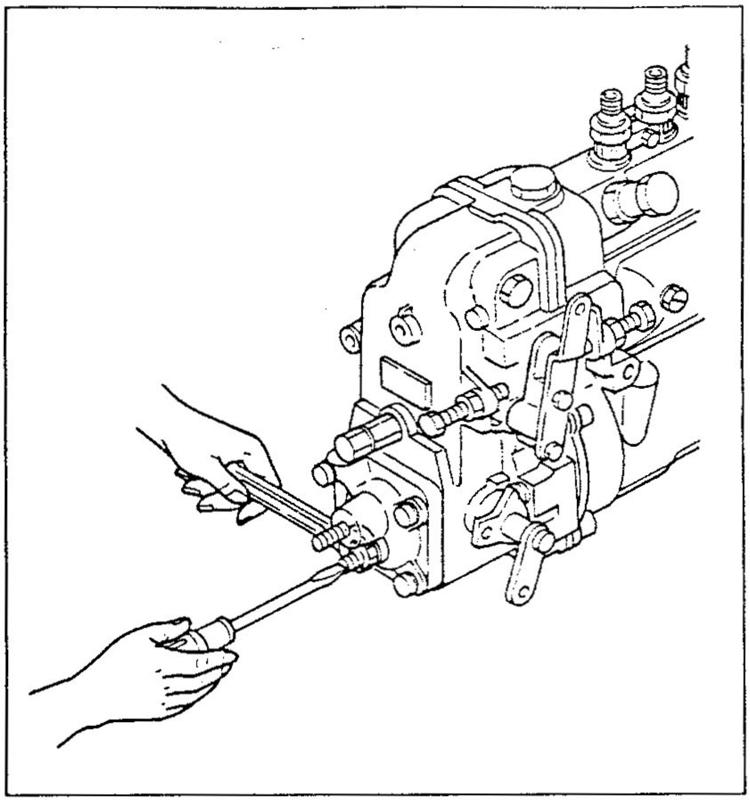


(a) "0" position setting of control rack
[See 10-1-7 (1) (a)]

(b) Mount the angle scale plate for the adjusting lever fixing device.

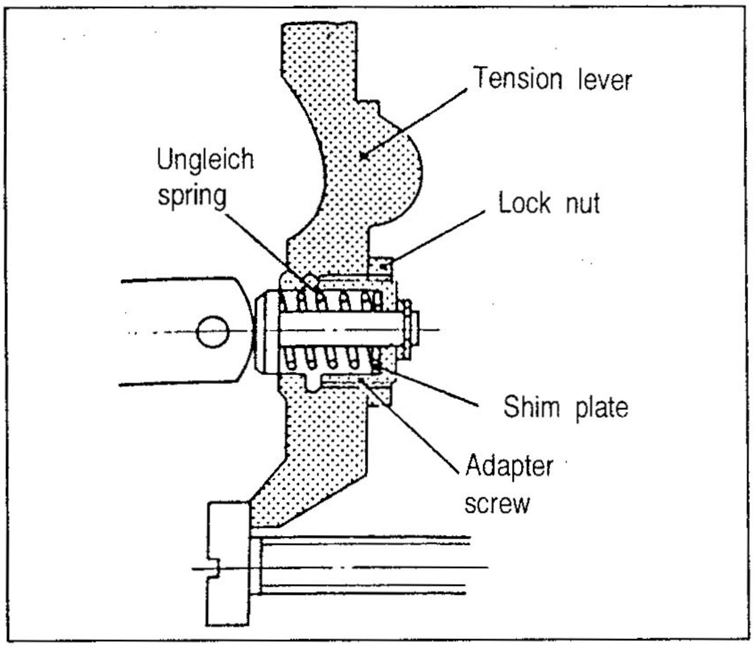


(c) Adjustment of intermediate speed control



This adjustment sets the control rack position point C(maximum injection) when the injuection pump is at full load. With the injection pump at Nc rpm, set the adjusting the governor spring in the governor is tensioned fairly strongly and hold the lever at that position temporarily. Then, adjust the full load stopper to bring the control rack to the Rc position. Turning the full load stopper to bring the control rack to the Rc position Turning the full load stopper clockwise as viewed from the rear of the governor moves the rack in the direction that fuel is increased and turning in counter-clockwise moves the rack in the direction that fuel is decreased.

(d) Adjustment of Ungleich

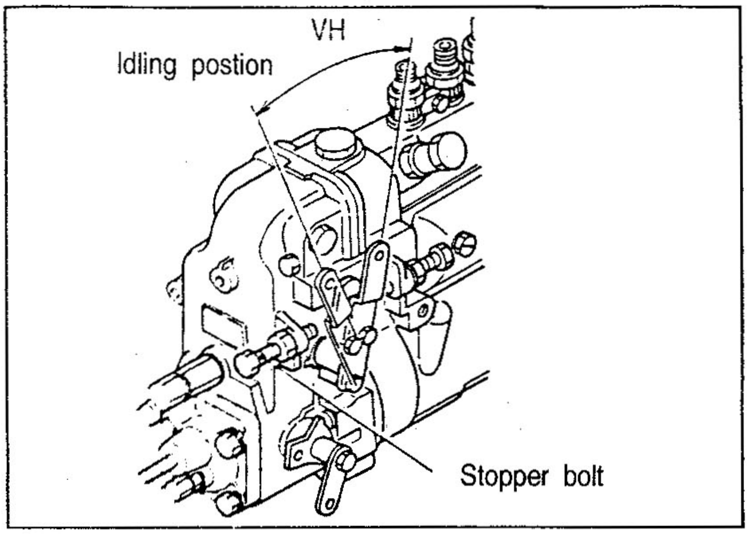


Set the adjusting lever at the maximum speed stopper position. Adjust the adapter screw so that the rack position changes from Ra to Rc when the speed is changed from Na to Nb. The change in the rack position from Ra to Rc is called the Ungleich stroke.
Tightening the adapter screw increases the Ungleich stroke and loosening the screw decreases the Ungleich stroke. Change the Ungleich spring assembly so that the rack is positioned at Ra when the speed is Na.

(e) Adjustment of low speed control

1) Adjustment of stopper bolt

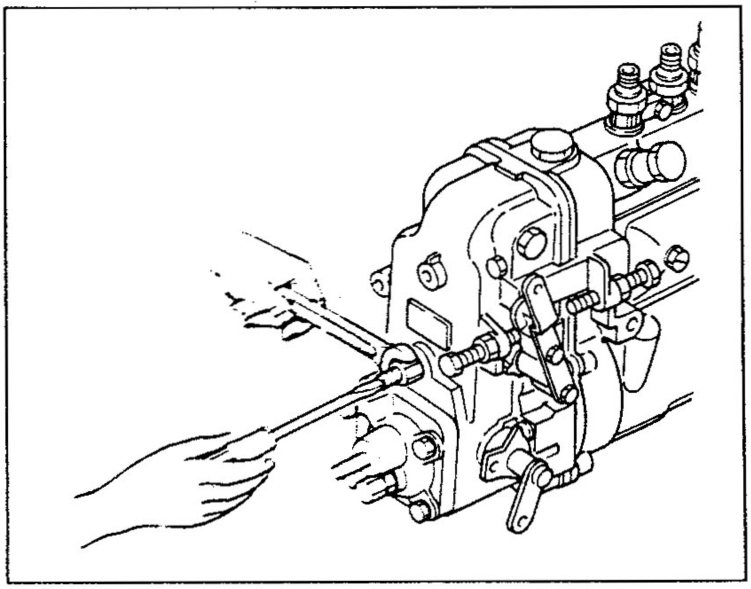
While rotation the pump at Ni, tilt the adjusting lever and adjust the stopper bolt to bring the control rack to the Ri position.



2) Adjustment of idling sub spring

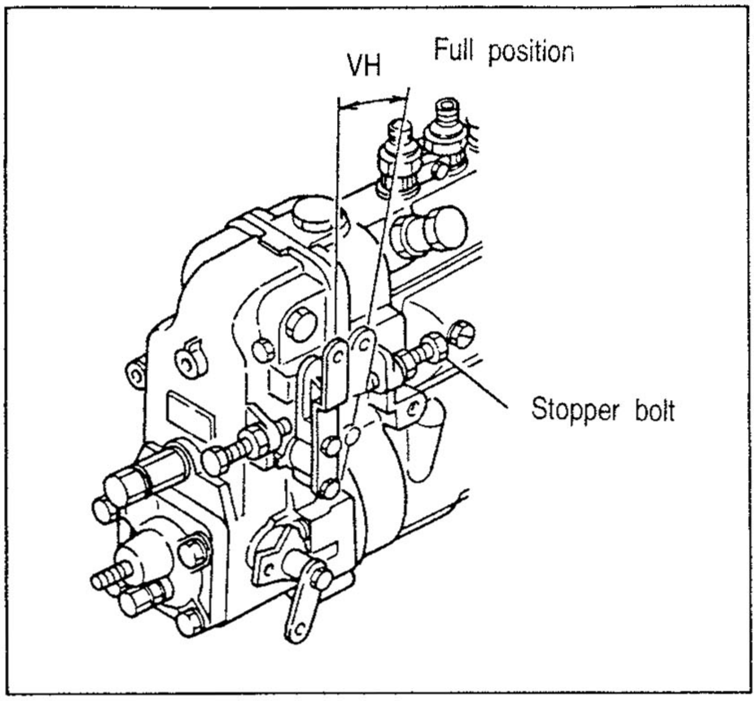
Adjust the idling sub spring so that the rack is positioned at Rh when the pump is running at a speed of Nh.

Then, decrease the pump speed and check that the rack is positioned at Rg at the pump speed of Ng.



(f) Adjustment of high speed control

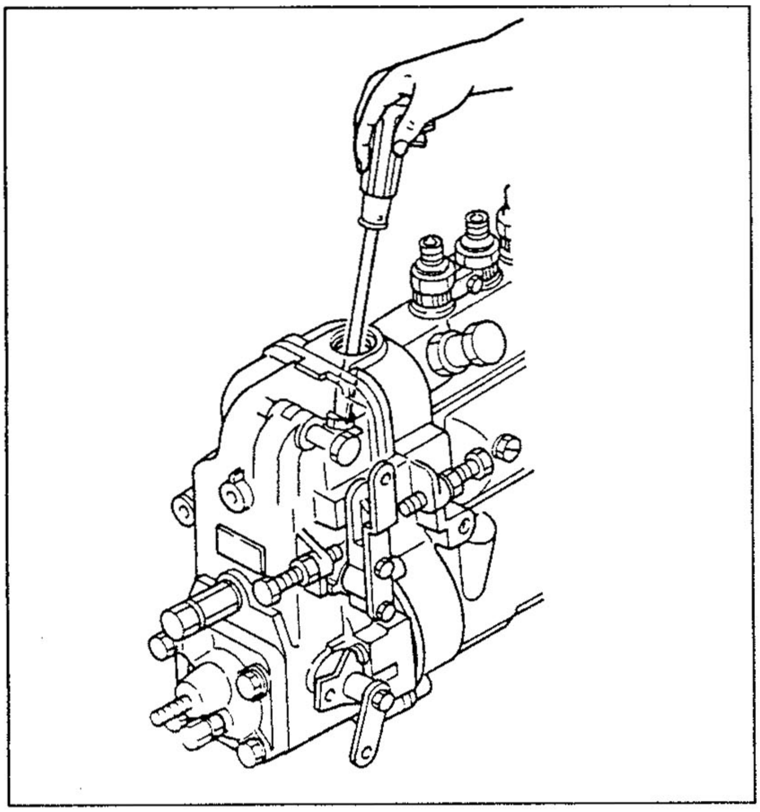
1) Adjustment of maximum speed stopper



Tilt the adjusting lever and set the maximum control speed of the governor.

Tilt the adjusting lever and adjust the maximum speed stopper so that the control rack is moved from the Rc position when the pump speed increased slowly from Nc reaches Nd.

2) Adjustment of speed variation rate



Increase the pump speed from Nd and check to see that when the speed reaches Ne, the rack position is pulled back to Re.

If it is out of specification, adjust the amount the adjusting screw of the swivel lever is turned down.

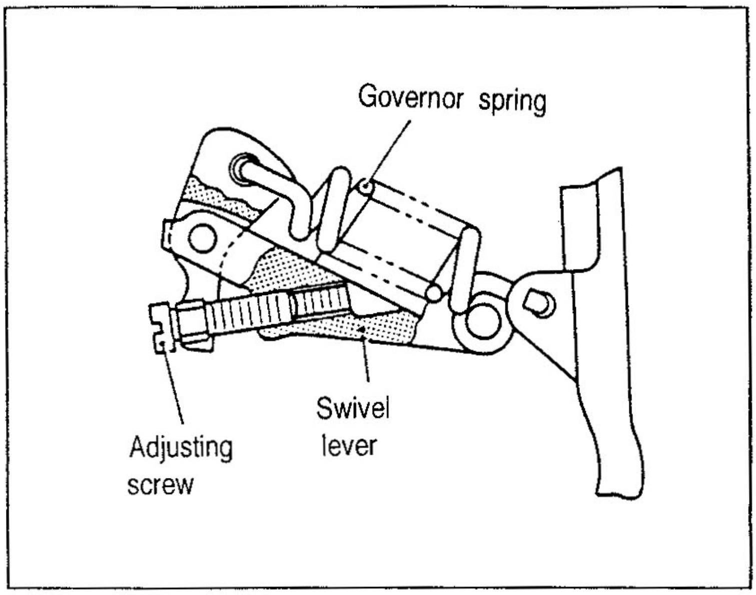
Tightening the screw will improve the speed variation rate.

Loosening it will worsen the speed variation rate.

$$\text{Speed varitation rate} = \frac{Ne - Nd}{Nd} \times 100(\%)$$

NOTE : 1. If the variation rate is poor, the engine will exceed the specified maximum speed at no load and will enter a hazardous condition.

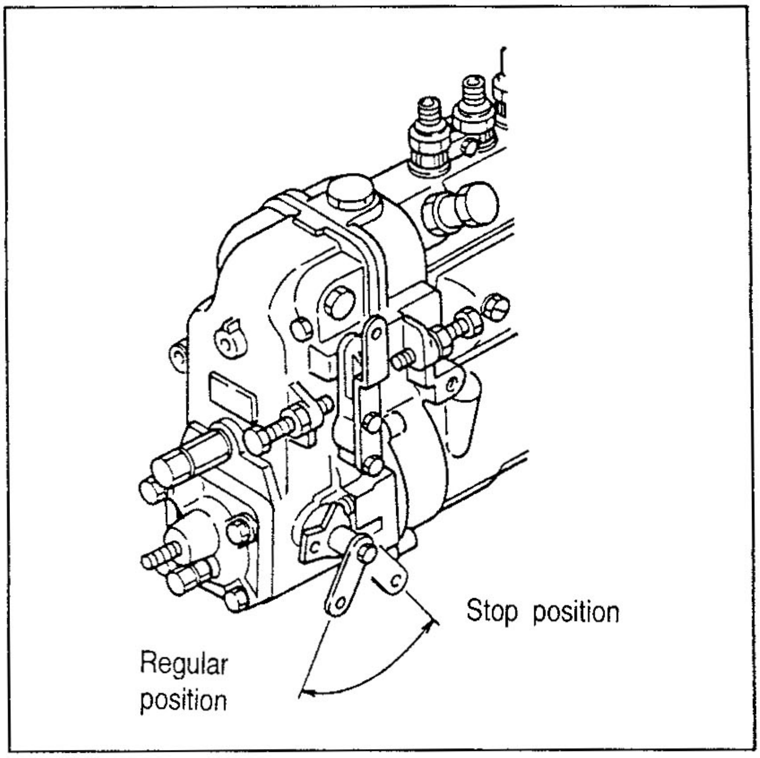
2. The maximum extent to which the adjusting screw can be loosend is 20 notches (5 rotations) from the fully tightened position. Loosening it any further can be dangerous.



3. If the adjusting screw is adjusted, the tension of the governor spring will change and the high speed control start point will change. Make sure that the high speed control start point of Item 1) is readjusted.

(g) Stop lever operation check

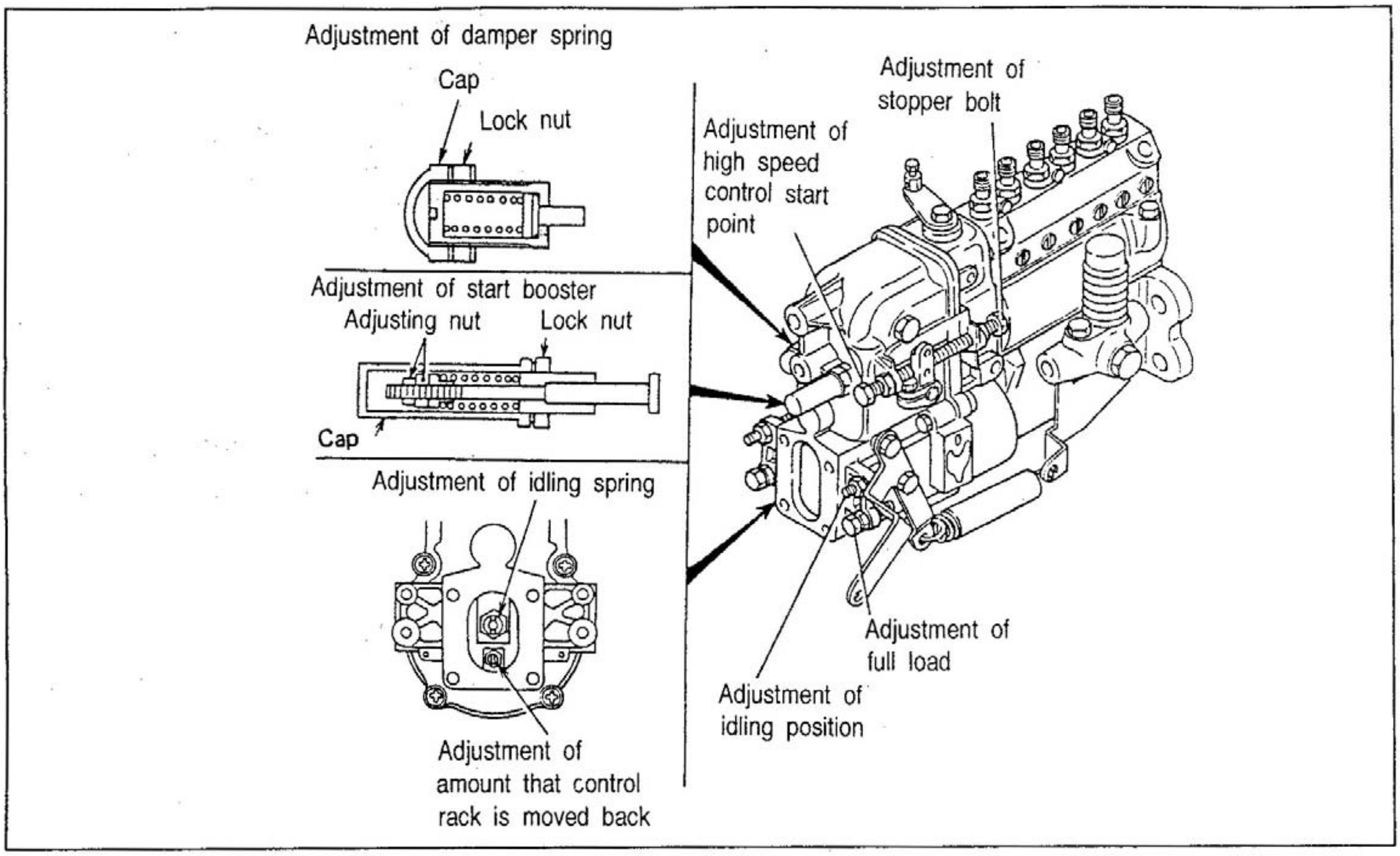
With the injection pump at full load, move the stop lever fully to the stop side and check that this moves the rack to the 0 mm position.



(h) Adjustment for adaptation to engine

Upon completion of the governor adjustment, measure the total injection amout with the lever set at the same angle as in the high speed control in accordance with the adjustment standard and adjust as necessary.

(3) RFD Type governor



NOTE : 1. Remove the damper spring.

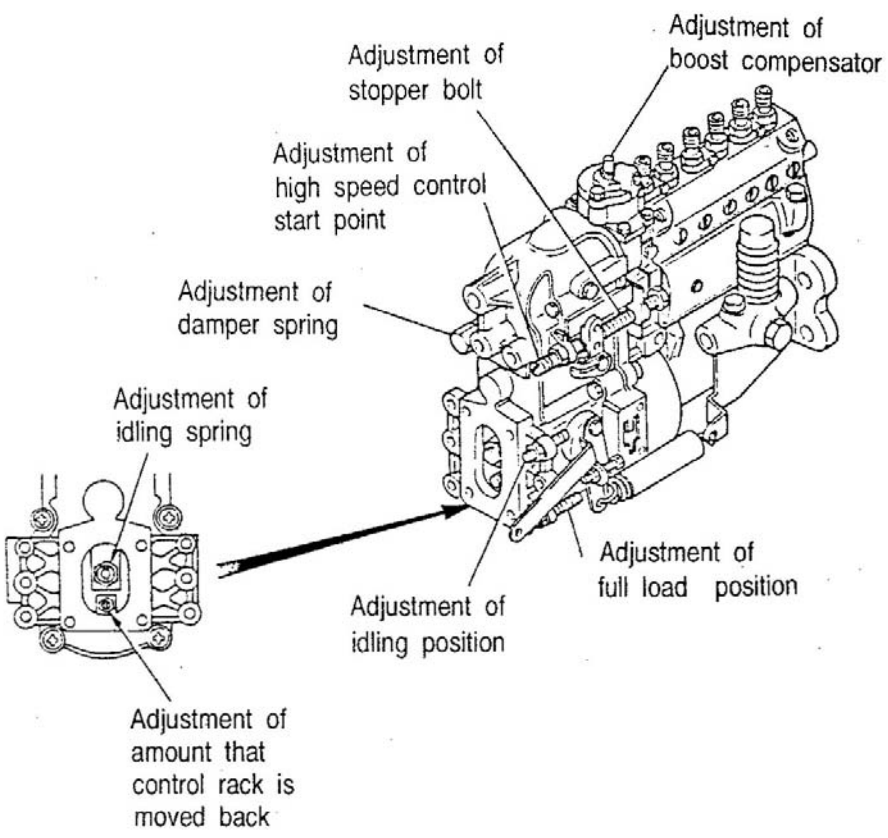
2. Remove the idling spring

3. Remove the start booster (smoke set assembly).

4. Loosen the speed control lever stopper bolt.

5. Loosen the load control lever stopper bolt.

[With boost compensator]



NOTE : 1. Remove the damper spring.

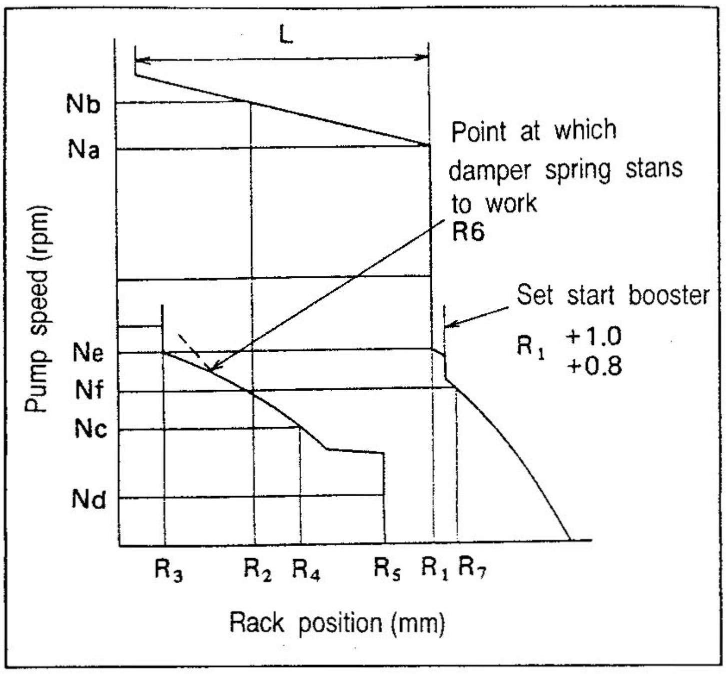
2. Remove the idling spring

3. Loosen the speed control lever stopper bolt.

4. Loosen the load control lever stopper bolt.

5. Allow the boost compensator to be set free.

Adjust the relationship between the pump speed and the rack position to the specified governor performance curve as follow:

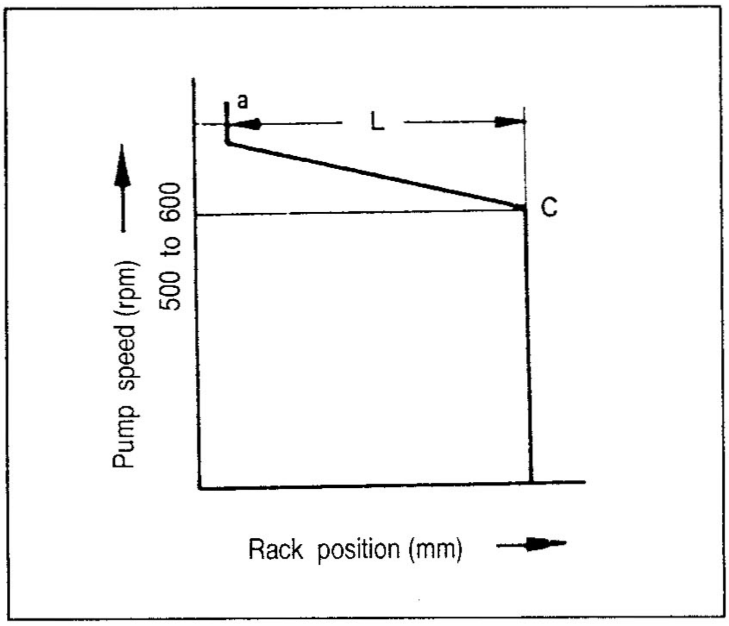


(a) "0" position setting of the control rack
[See 10-1-7 (1) (a)]

(b) Control rack stroke check
[See 10-1-7 (1) (b)]

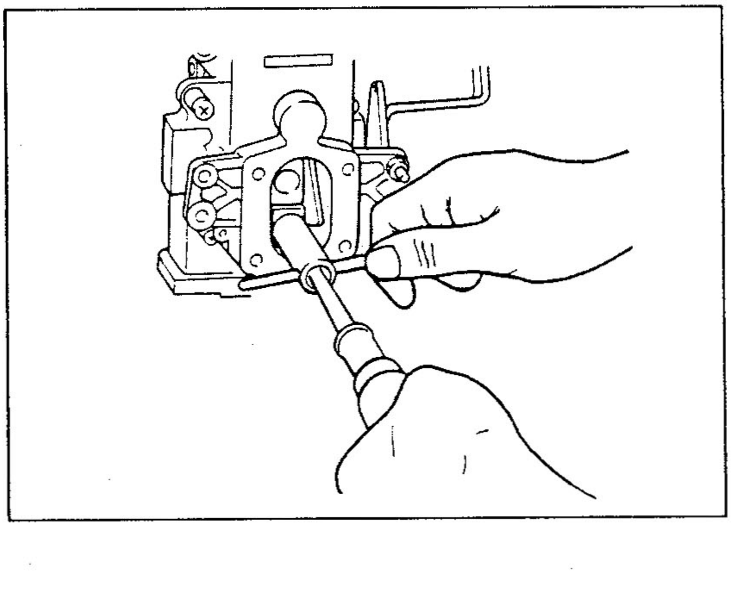
(c) Adjustment of flyweight life

Divide the fulll lift of the flyweight into the lift necessary for the high speed conrol and the lift necessary for the idling control as follows.



1) Temporarily set the speed control lever so that the high speed control is made at the injection pump speed of approximately 500 to 600 rpm.

2) Set the load control lever at the full load position.



3) Increase the injection pump speed gradually to cause the control rack to be drawn back from the control start point C to control end point a.

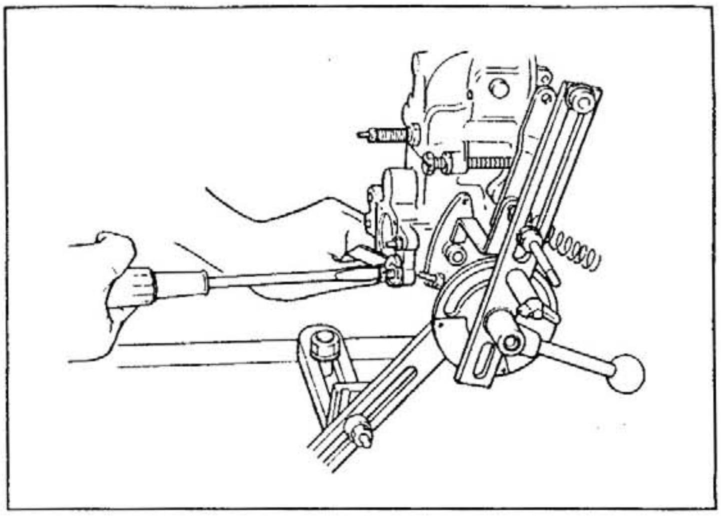
4) Adjust the stroke adjusting bolt so that the back stroke of the control rack (L) from the point "C" to the point "a" becomes a specified.

(d) Adjustment of high speed control

1) Adjustment of full load position

Set the injection pump at the speed of 500 to 600 rpm.

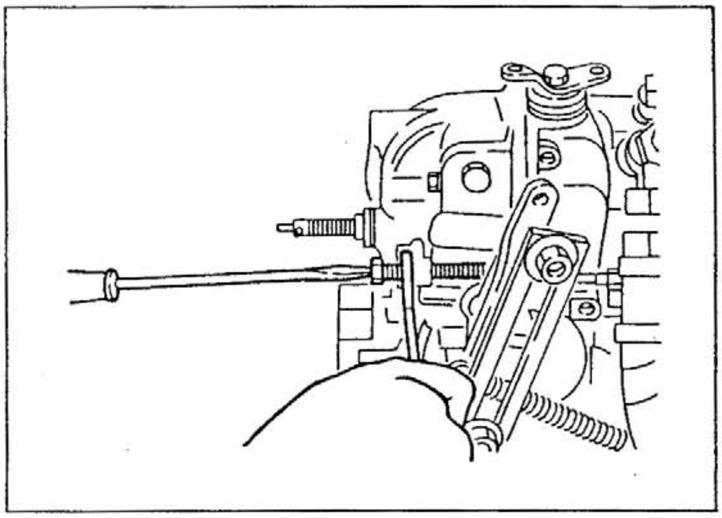
Adjust the position of the load control lever with the full load stopper bolt so that the control rack is positioned at R1.



2) Adjustment of high speed control start point

Set the load control lever at the full load position.

Adjust the speed control lever stopper bolt so that the control rack moves from the R1 position when the injection pump speed is increased gradually to Na.

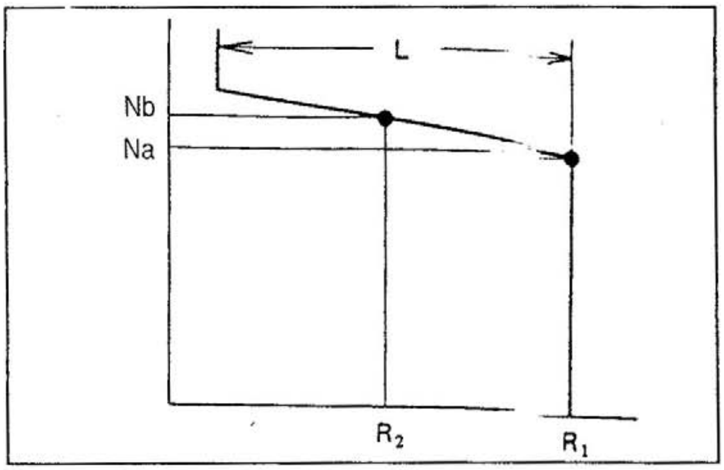


3) Speed regulation check

Gradually increase the injection pump speed until the control rack is drawn back to the R2 position.

Check that the injection pump speed is Nb as the control rack reaches this position.

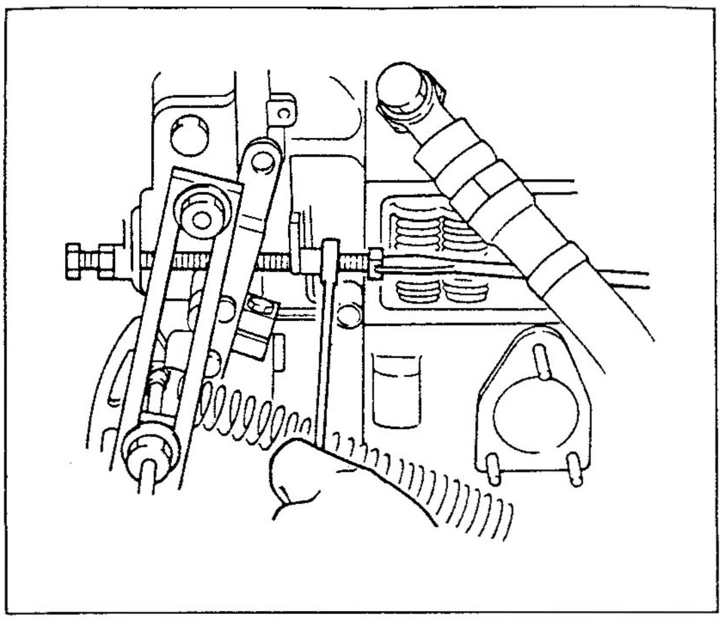
Further increase the pump speed to check that the back stroke of the control rack L is as specified.



NOTE : Poor speed regulation is dangerous as the engine could exceed the specified maximum speed under no load condition.

4) Adjustment of speed control lever stopper bolt

Tighten the bolt until it is seated on the speed control lever.

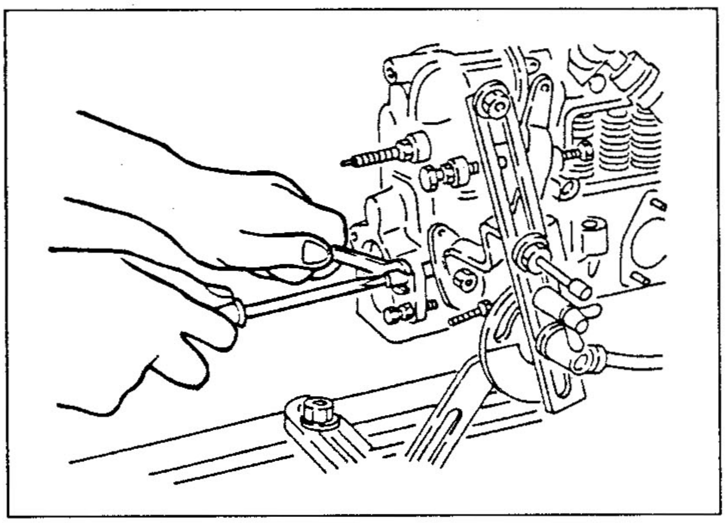


NOTE : Perform this adjustment after the adjustment of the high speed control start point and the confirmation of the speed regulation.

(e) Idling adjustment

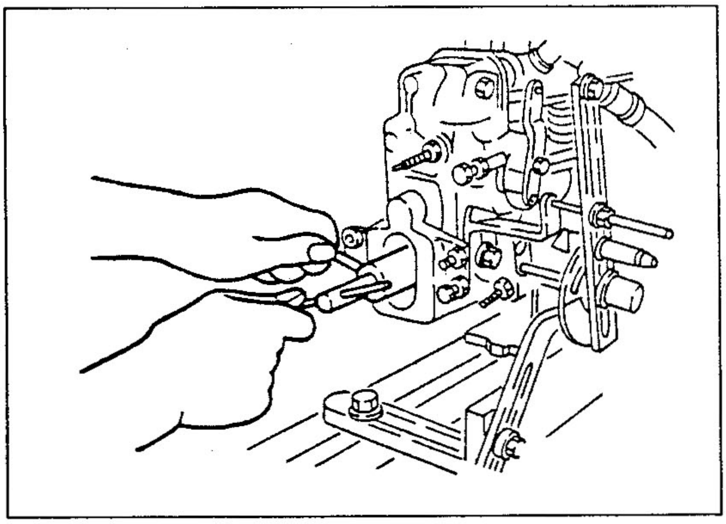
1) Idling spring adjustment

Run the injection pump at a speed of 800 to 1000rpm and adjust the control lever stopper bolt so that the control rack is positioned at R3.



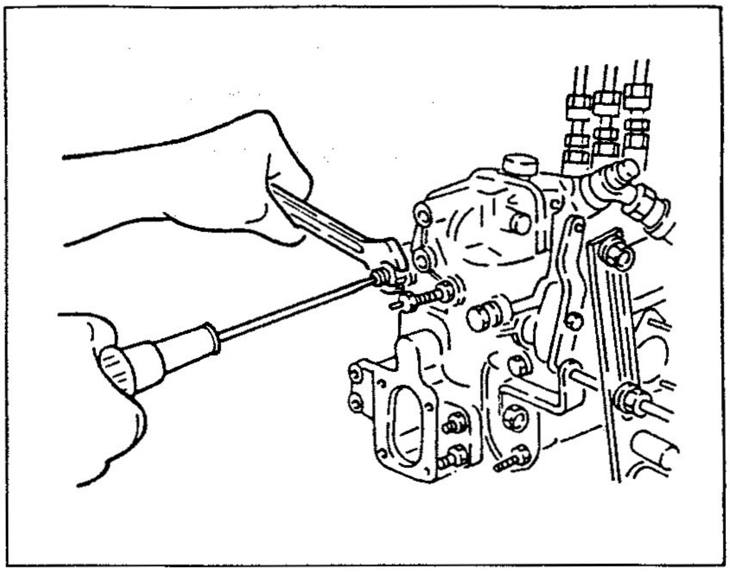
Under this condition, reduce the injection pump speed to Nc and adjust the idling spring so that the control rack is positioned at R4.

Also check that the control rack is positioned at R5 and R3 when the pump speed is Nd and Ne, respectively.



2) Damper spring adjustment

With the control rack positioned at R6, screw in the damper spring capsule until it seats on the back of the floating lever link.



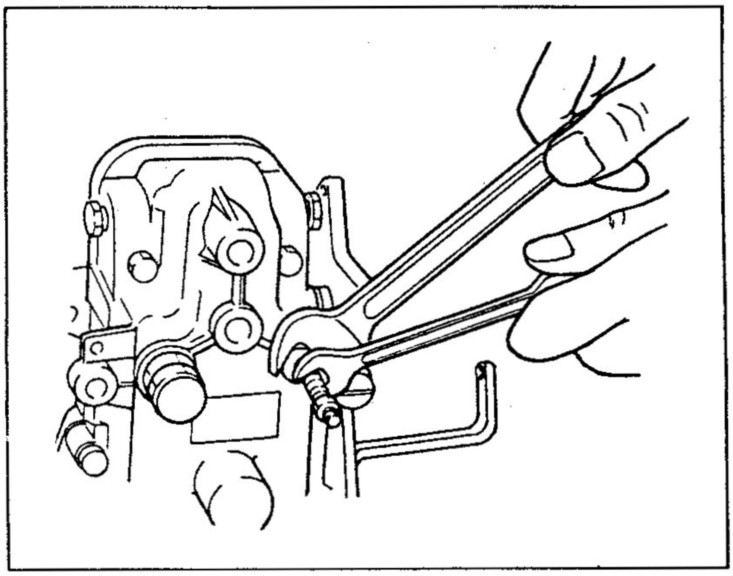
NOTE : If the capsule is not screwed in sufficiently, the damper effect is reduced and the engine could stop at abrupt deceleration.

If the capsule is overtightened, the idling speed increases, causing poor deceleration performance.

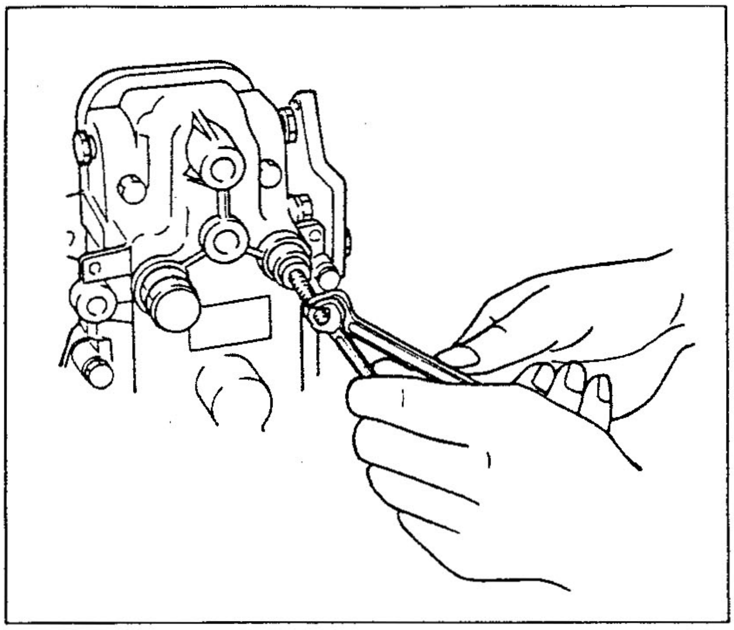
(f) Adjustment of start booster (smoke set assembly)

Set the load control lever at the full load position and set the smoke set assembly adjusting nut at 0 to 4mm from the stopper end.

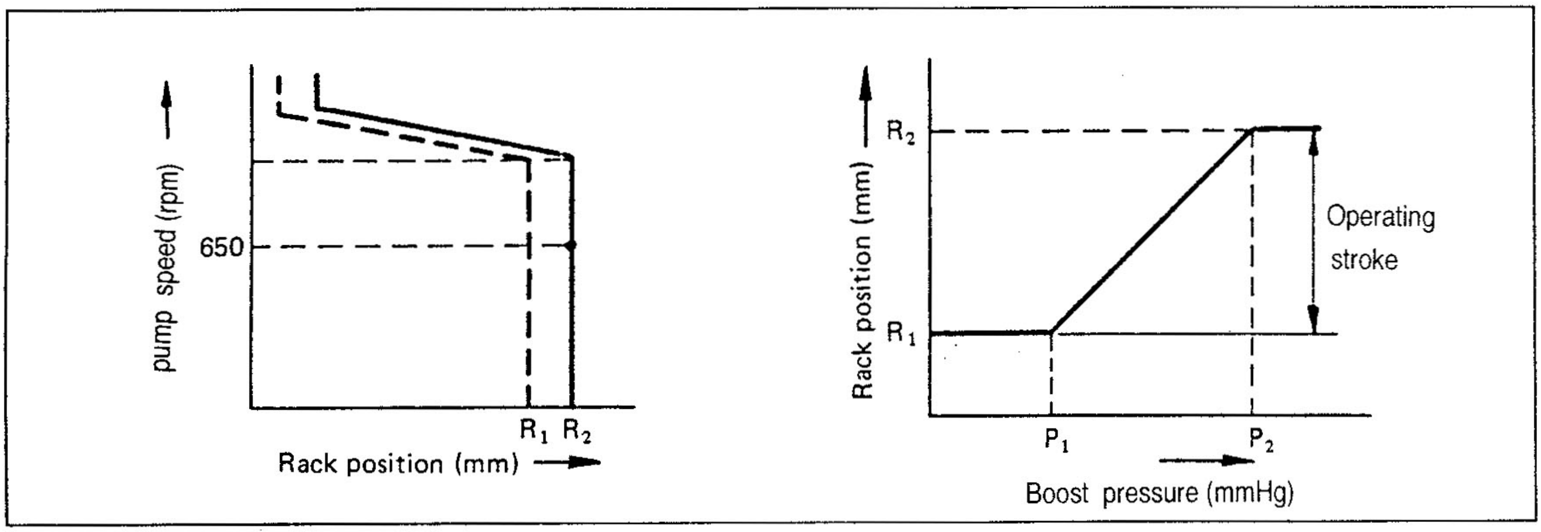
Adjust the stopper position so that the control rack can move 0.8 to 1.0mm from the R1 position when the injection pump runs at a speed of Ne.



Then, adjust the nut so that the control rack is positioned at R7 when the injection pump speed is Nf.



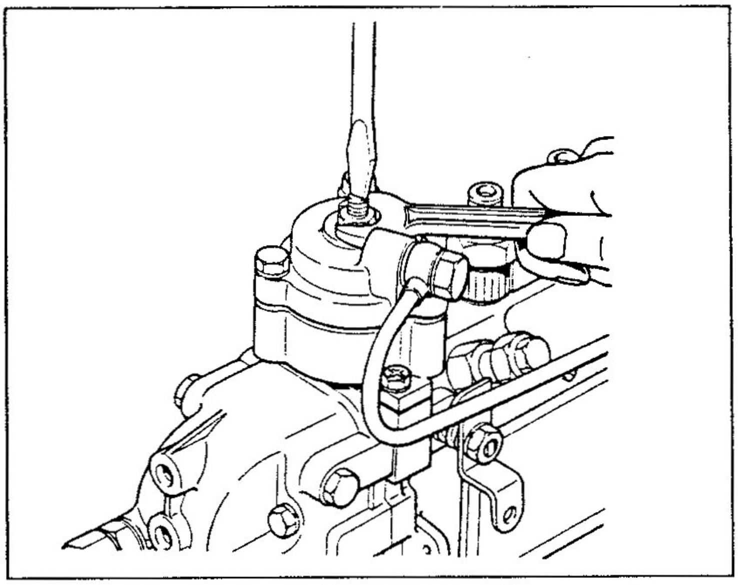
(g) Boost compensator adjustment



1) Adjustment of boost compensator operation strok

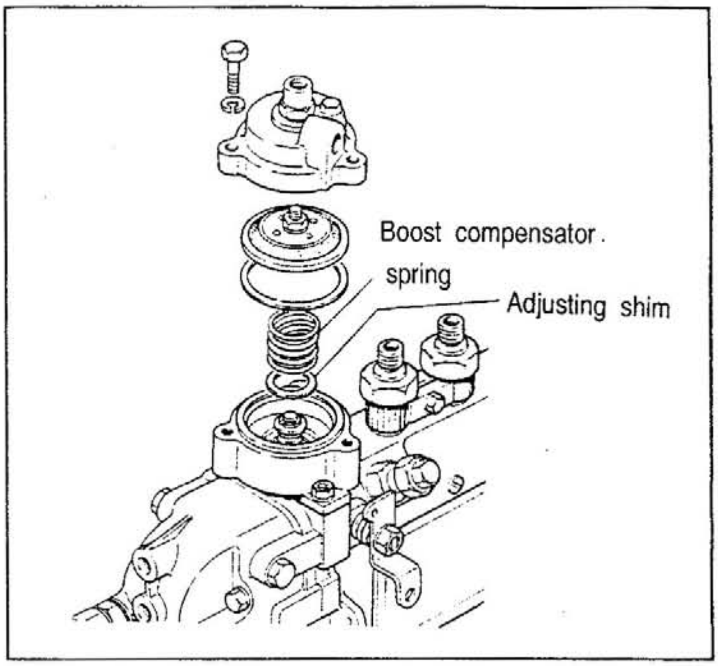
Check that the control rack is positioned at R1 when the load control lever is set at the full load position with the pump runing at 650 rpm.

Under this condition, adjust the boost compensator stopper bolt so that the control rack is positioned at R8.



2) Adjustment of boost compenstor spring

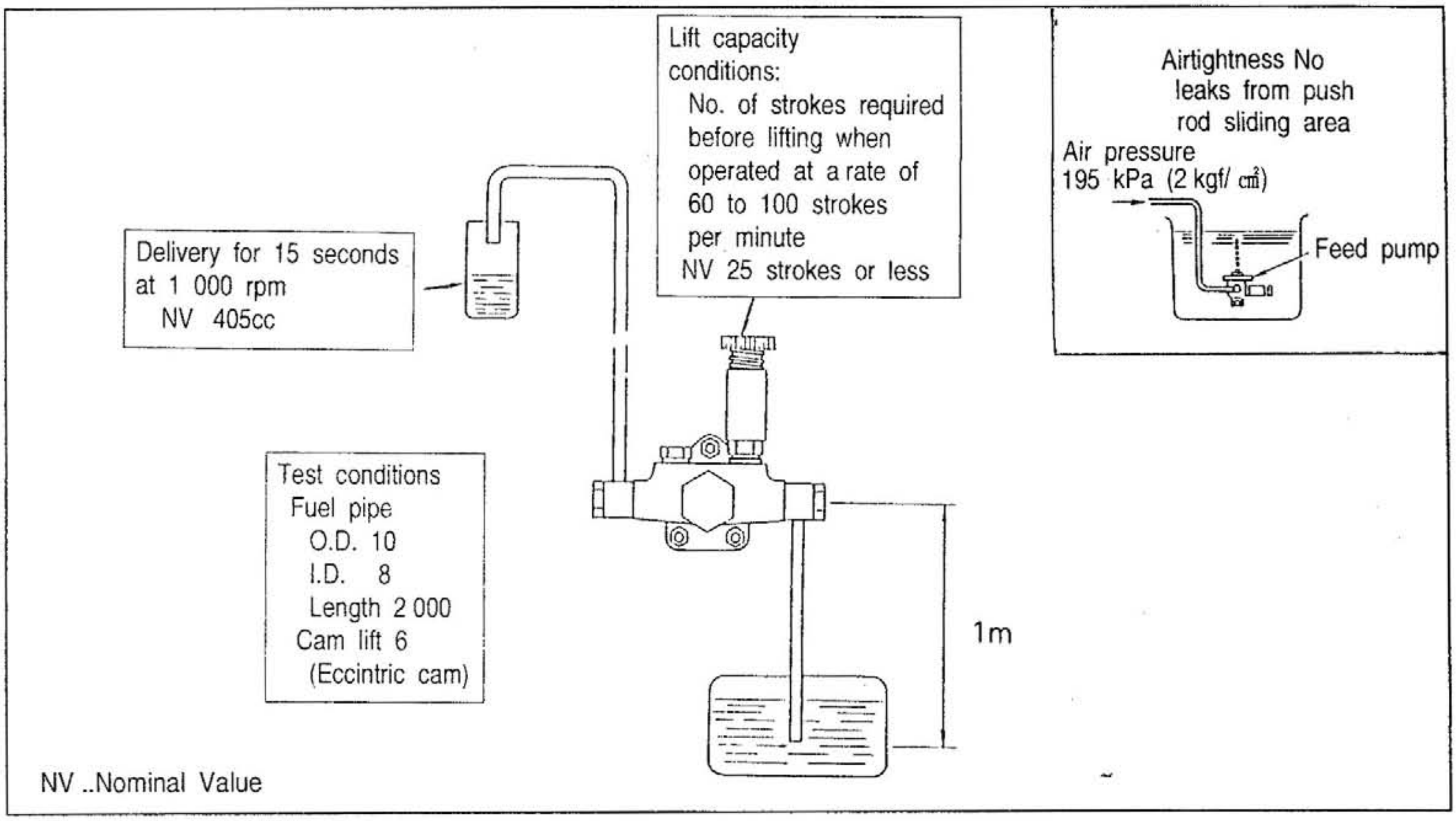
Gradually apply the boost pressure with the pump running at the same speed as above and adjust the boost compensator spring tension with the adjustion shim so that the control rack is positioned at R8 and R1 when the boost pressure is P1 and P2, respectively. If the control rack is positioned at smaller value than specified, decrease the number of adjusting shims.



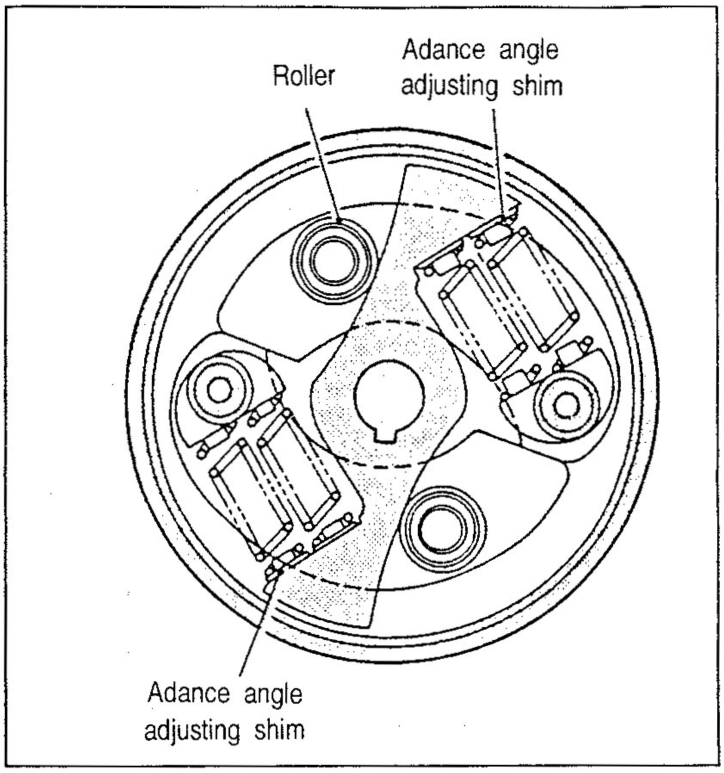
NOTE : 1. When adjusting with shims, removal of the boost compensator cover could change the boost compensator operation stroke. After adjustment, therefore, check the stroke.

2. Be sure to increase the boost pressure before measurement.

(4) Feed pump



(5) SA, SA-D Type Automatic Timer



Advance angle characteristics

To adjust the advance angle characteristics, adjust the number of adjusting shims or replace the roller. Larger shim thickness reduces the advance angle.

Shim thickness (11type)

0.1, 0.2, 0.25, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0

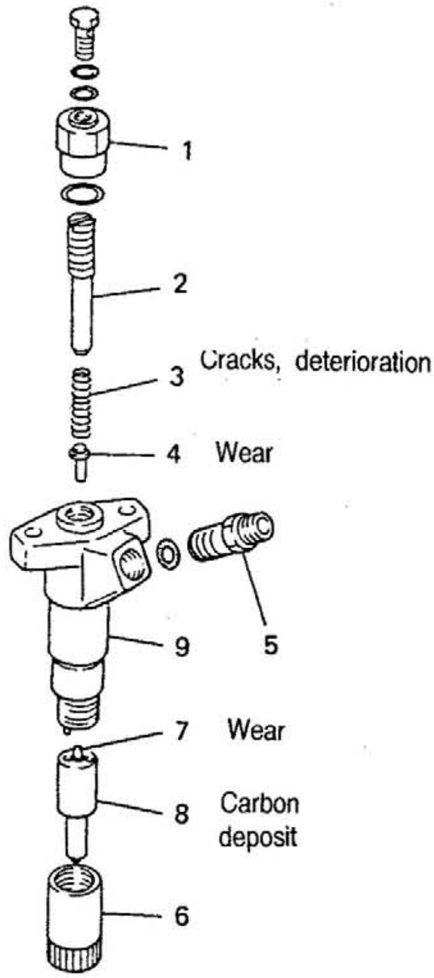
Roller O.D. (4 types)

17.9, 18.0, 18.1, 18.2mm

10-2 INJECTION NOZZLE

10-2-1 Disassembly

1 Cap nut
2 Adjusting screw
3 Spring
4 Push rod
5 Connector
6 Retaining nut
7 Needle valve
8 Nozzle
9 Nozzle holder

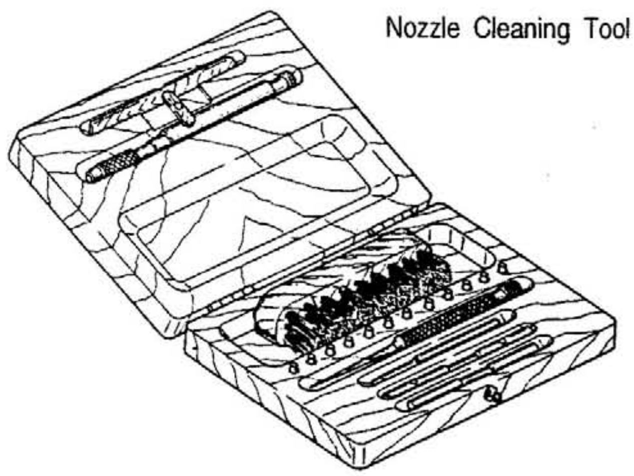


10-2-2 Cleaning and Inspection

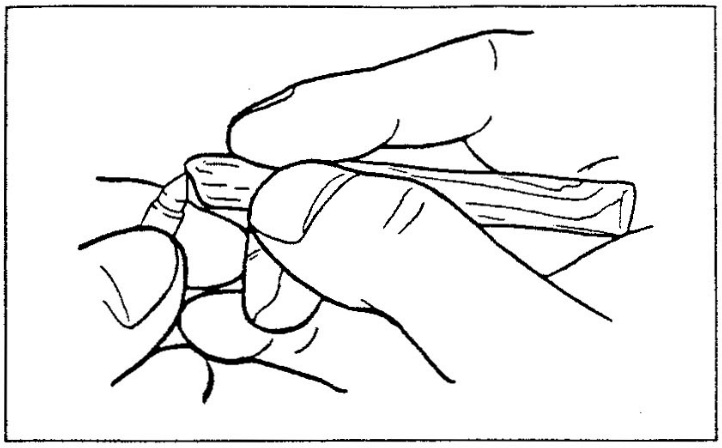
(1) Cleaning

After the nozzle has been cleaned is gas oil, remove the deposited carbon by the following procedure, using Nozzle Cleaning Tool (special tool).

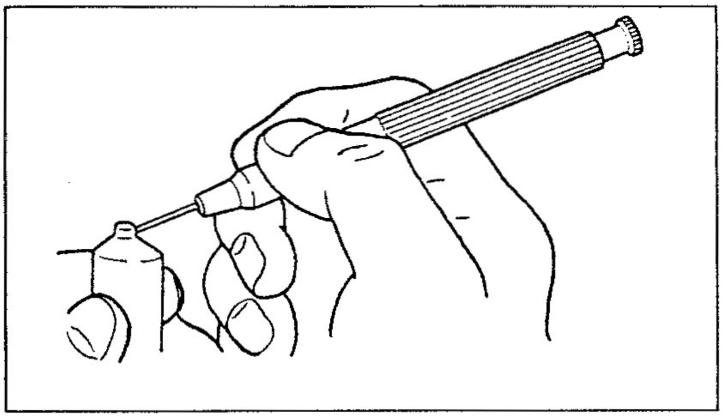
NOTE : Be careful not to change the combination of the nozzle and needle valve.



(a) Remove the needle valve from the nozzle and clean the needle valve with the needle valve cleaning wood piece.



(b) Insert a cleaning needle into the injection hole of the nozzle, while turning it, to remove the carbon. First pass a cleaning needle 0.25mm in diameter through the orifice and then pass a finishing needle 0.29mm in diameter

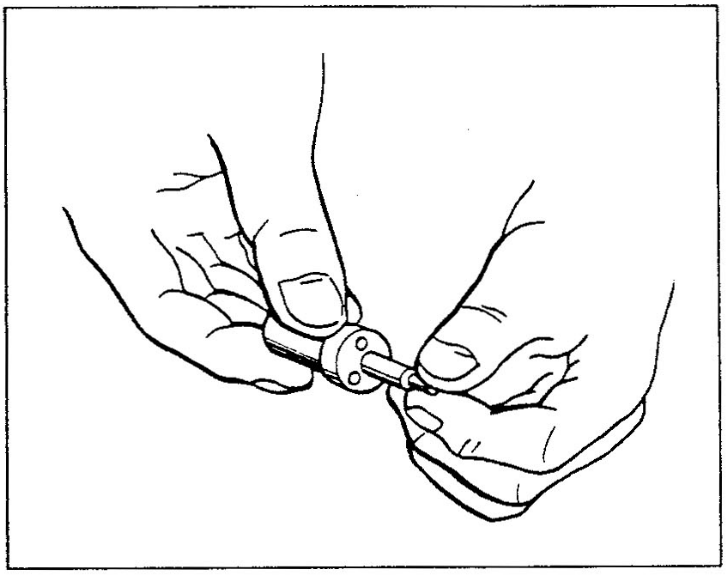


(c) To remove a burnt and hardened carbon, use the FUSO carbon remover.

(2) Inspection

After the nozzle has been cleaned in gas oil, immerse it in gas oil and slide the needle valve to confirm somooth motion.

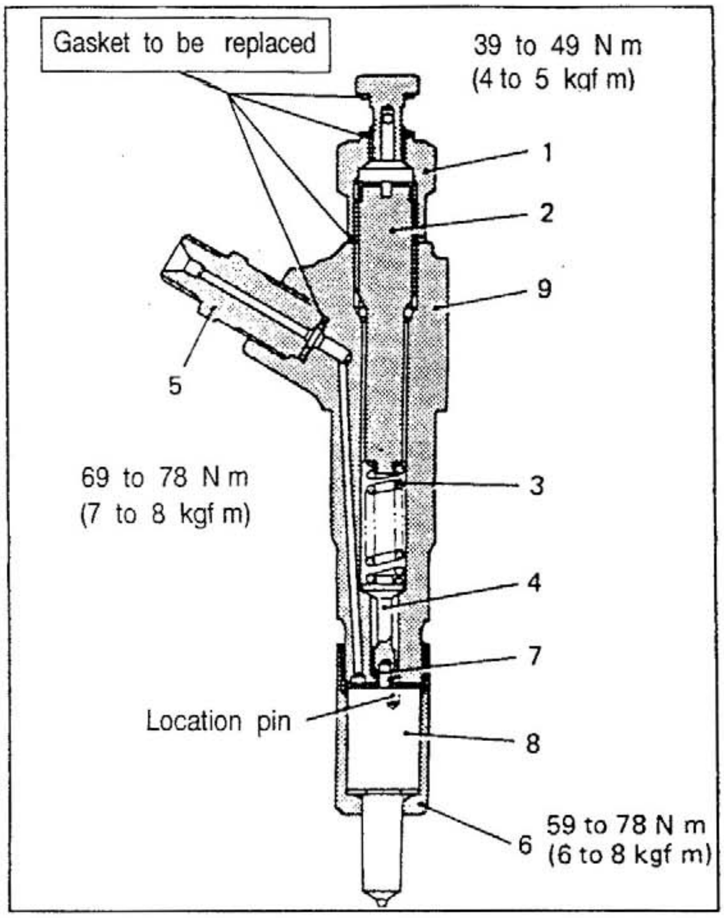
Draw out the needle valve vertically about 1/ 3 it way and check to see that the needly valve falls under its own weight. If it doesn't fall, replace the nozzle.



10-2-3 Reassembly

NOTE : 1. Be careful not to touch the sliding surfaces of the needle valve by hand.

2. Tighten the nozzle nut to the specified torque, while centering it.



10-2-4 Test and Adjustment

(1) Injection Pressure

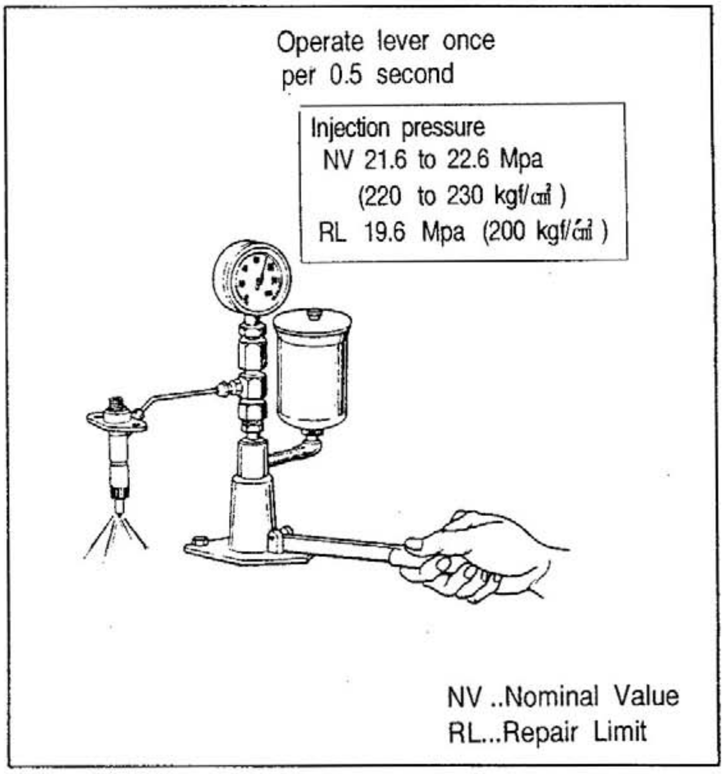
(a) Remove the cap nut and mount the nozzle to a nozzle tester.

(b) Loosen the adjusting screw. In that condition, let the nozzle spray two or three times for bleeding.

(c) Operate the lever of the nozzle tester at the specified speed.

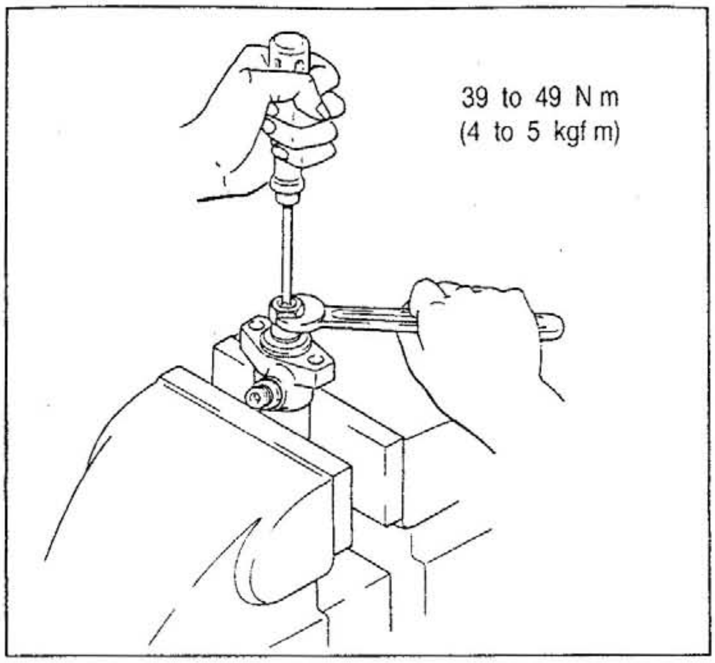
Adjust the injection pressure to the standard value with the adjusting screw.

NOTE : Be careful not to touch the spray injected from the nozzle.



(d) After the injection pressure has been adjusted, tighten the cap nut to the specified torque. In this case, hold the adjusting screw in position by inserting a screwdriver through the hole of the cap nut.

(e) After the cap nut has been tightened, recheck the injection pressure to determine whether it is correct.



(2) Spray condition

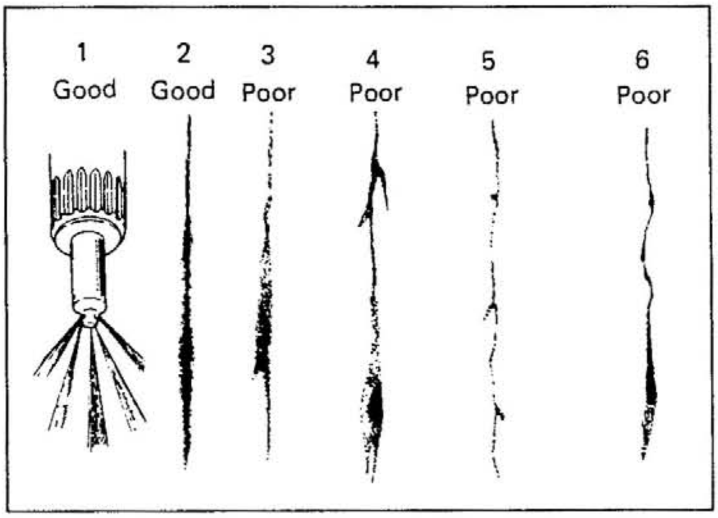
When the pressure is adjusted with the nozzle tester, check for clogged injection orifices, spray condition, fuel leaks from the injection orifices, etc. and replace the nozzle if defective.

Good spray

1. Evenly sprayed from every injection orifices
2. Even and symmetrical

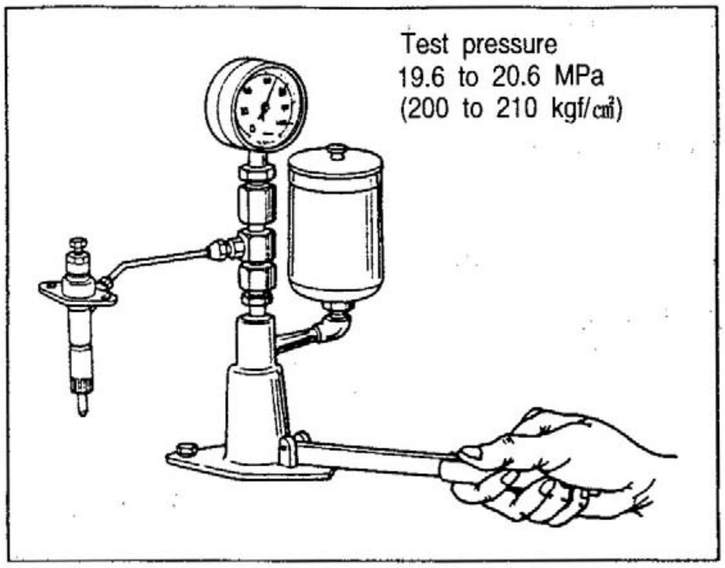
Poor spray

3. Asymmetrical
4. Intermediate branches
5. Thin spray
6. Stepped spray



(3) Fuel-tighteness Test

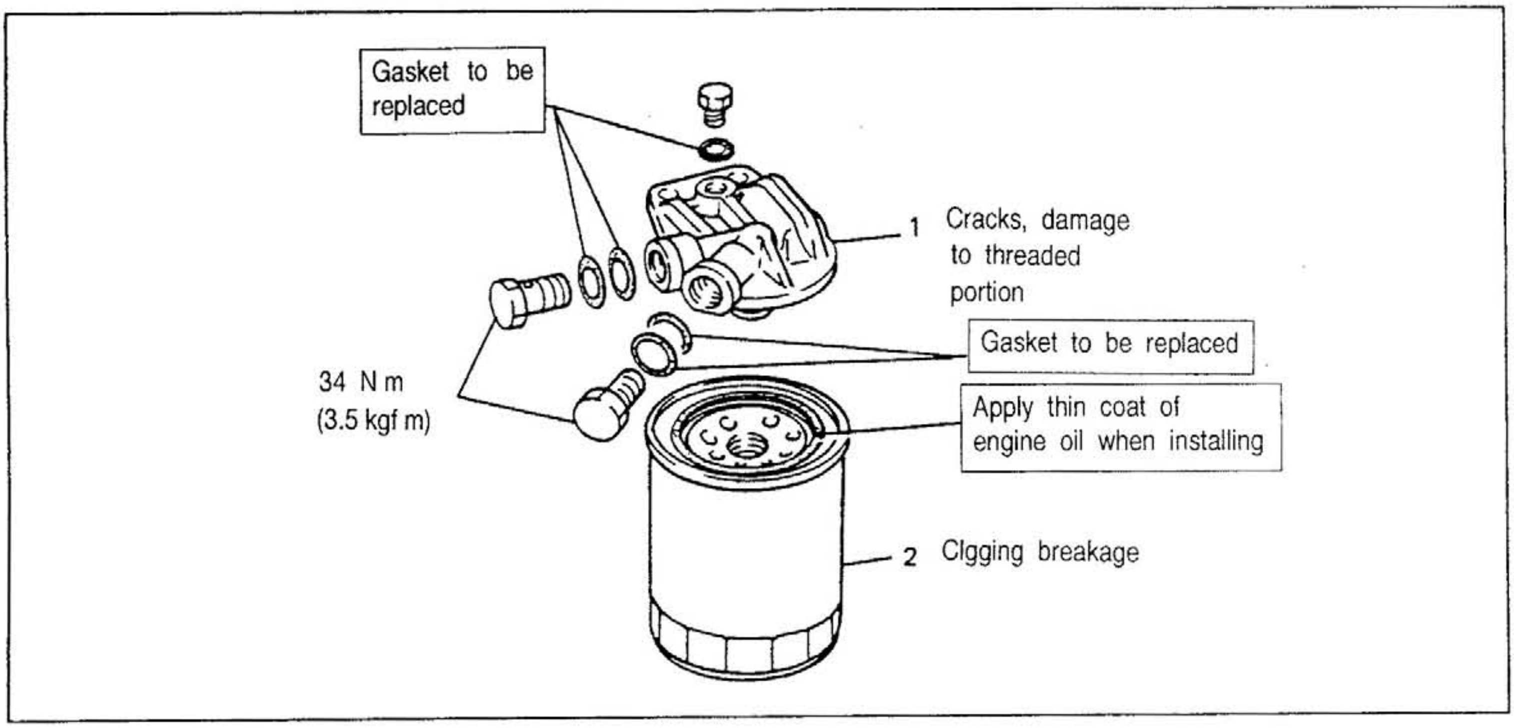
After the injection pressure has been adjusted to 21.6 to 22.6MPa(220 to 230 kgf/ cm²), mount the nozzle to the nozzle tester and slowly raise the pressure to the test pressure. While maintaining the condition, check for fuel leaks from the bottom of the nozzle. If there are no leaks, the nozzle is good.



10-3 FUEL FILTER

10-3-1 Fuel Filter

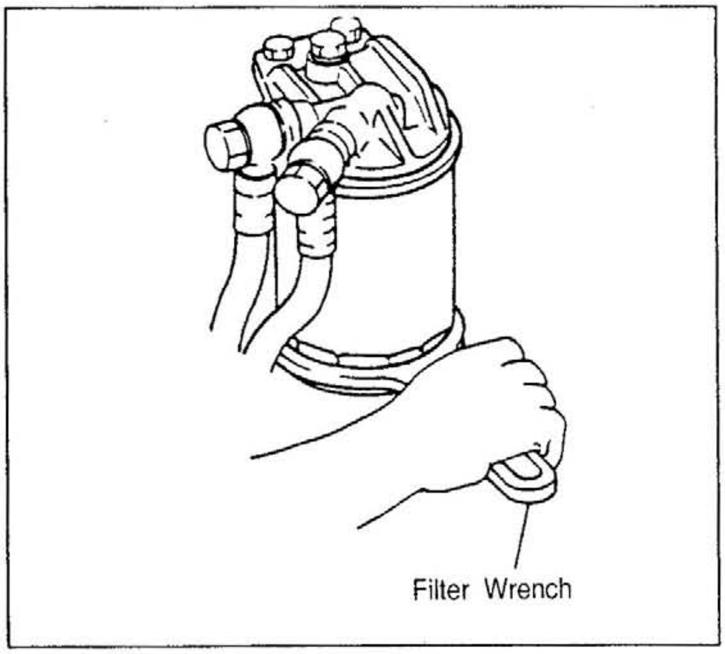
1 Fuel filter head
2 Element



NOTE : 1. To install, tighten fully by hand.

2. After installation, start the engine and check for fuel leaks.

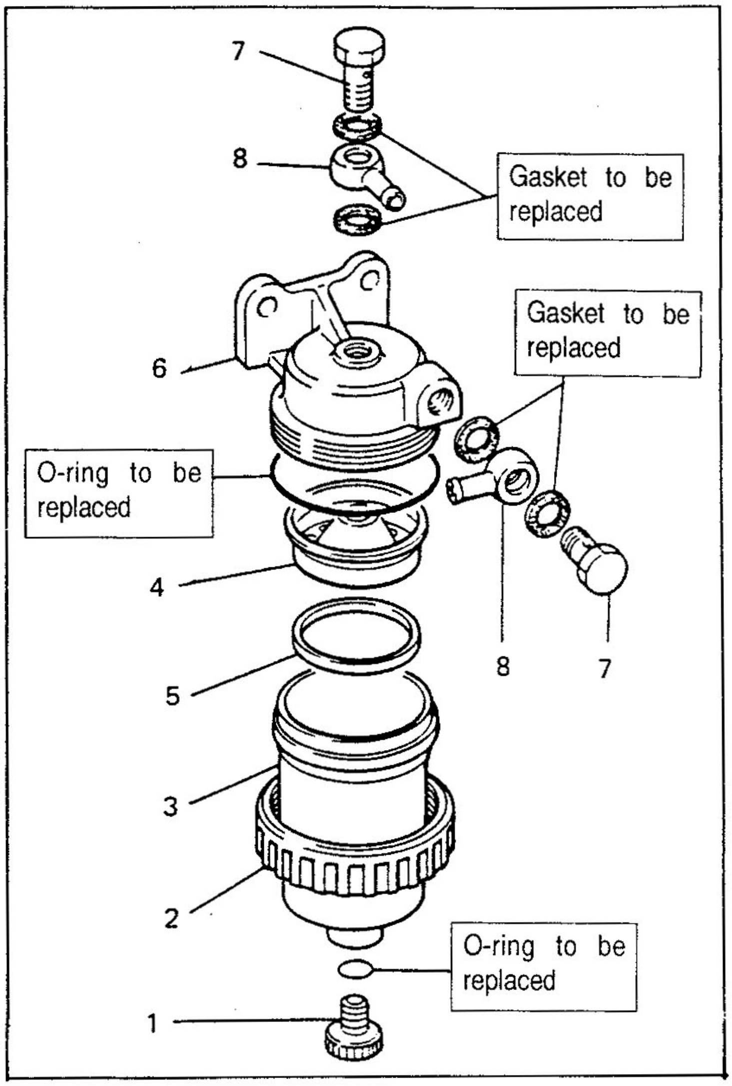
Use Filte Wrench(special tool) to remove the element.



10-4 WATER SEPARATOR [OPTION]

(1) Sedimentor type Water Separator

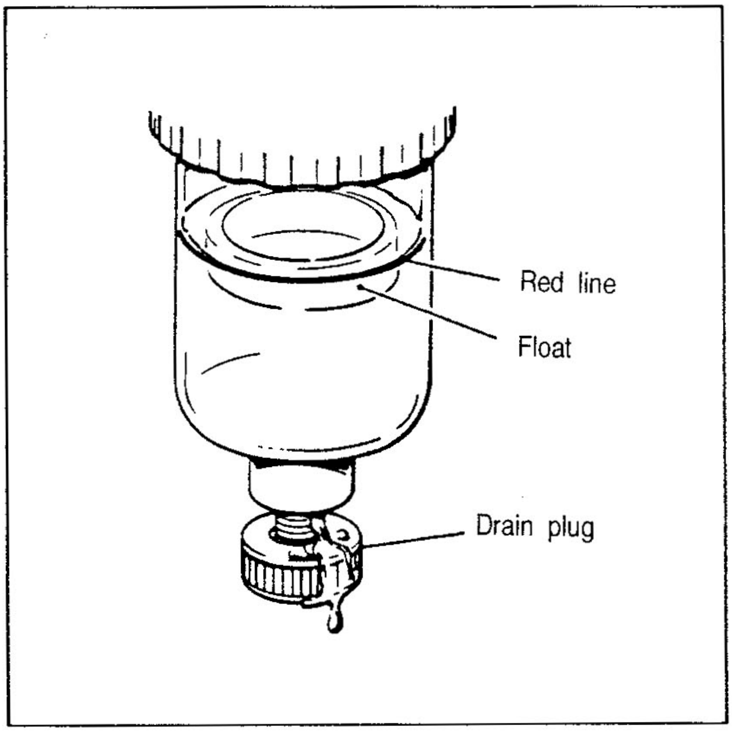
1 Drain plug
2 Ring nut
3 Case
4 Baffle plate
5 Float
6 Head
7 connector bolt
8 Joint



If the red float in the translucent case rises to the level of the red line marked on the outer circumference of the case, immediately loosen the drain plug to discharge water.

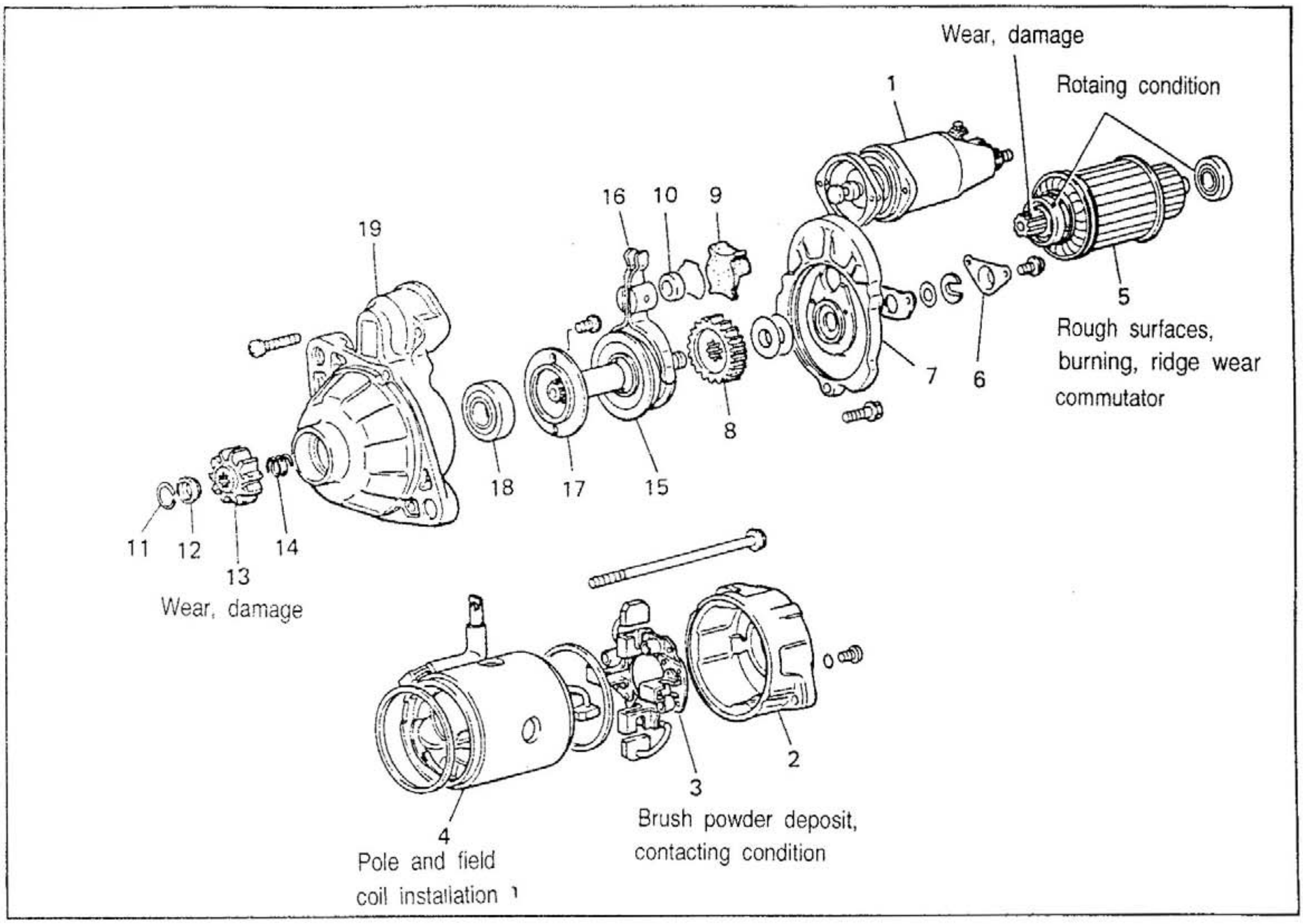
It is necessary to completely remove the drain plug as water is discharged gradually through the groove of the loosened plug.

NOTE : After draining, tighten firmly the drain plug before bleeding the fuel system.



11-1 STARTER

11-1-1 Disassembly



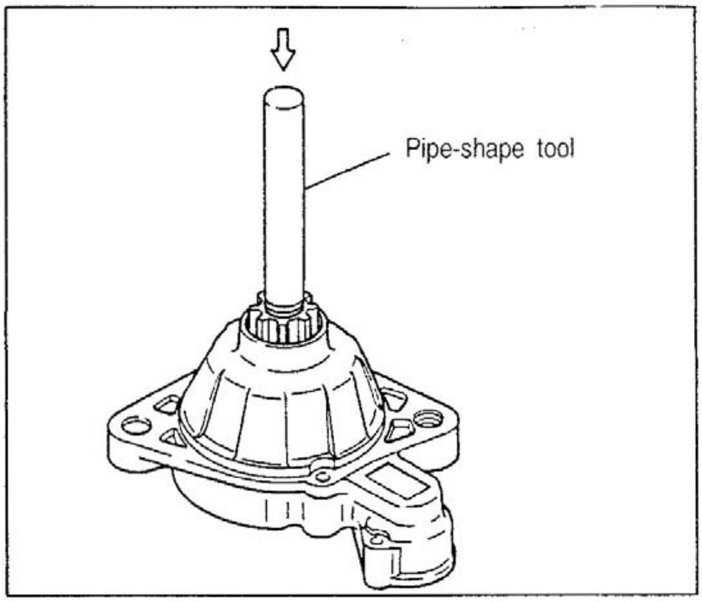
1	Magnet swithch	11	Stop ring
2	Rear bracket	12	Pinion stopper
3	Brush holder	13	Pinion
4	Yoke	14	Spring
5	Armature	15	Pinion shaft
6	Cover	16	Lever
7	Center bracket	17	Plate
8	Gear	18	Bearing
9	Packing	19	Front brackt
10	Spacer		

NOTE : 1. Do not remove the bearings on armature ends unless they are defective.

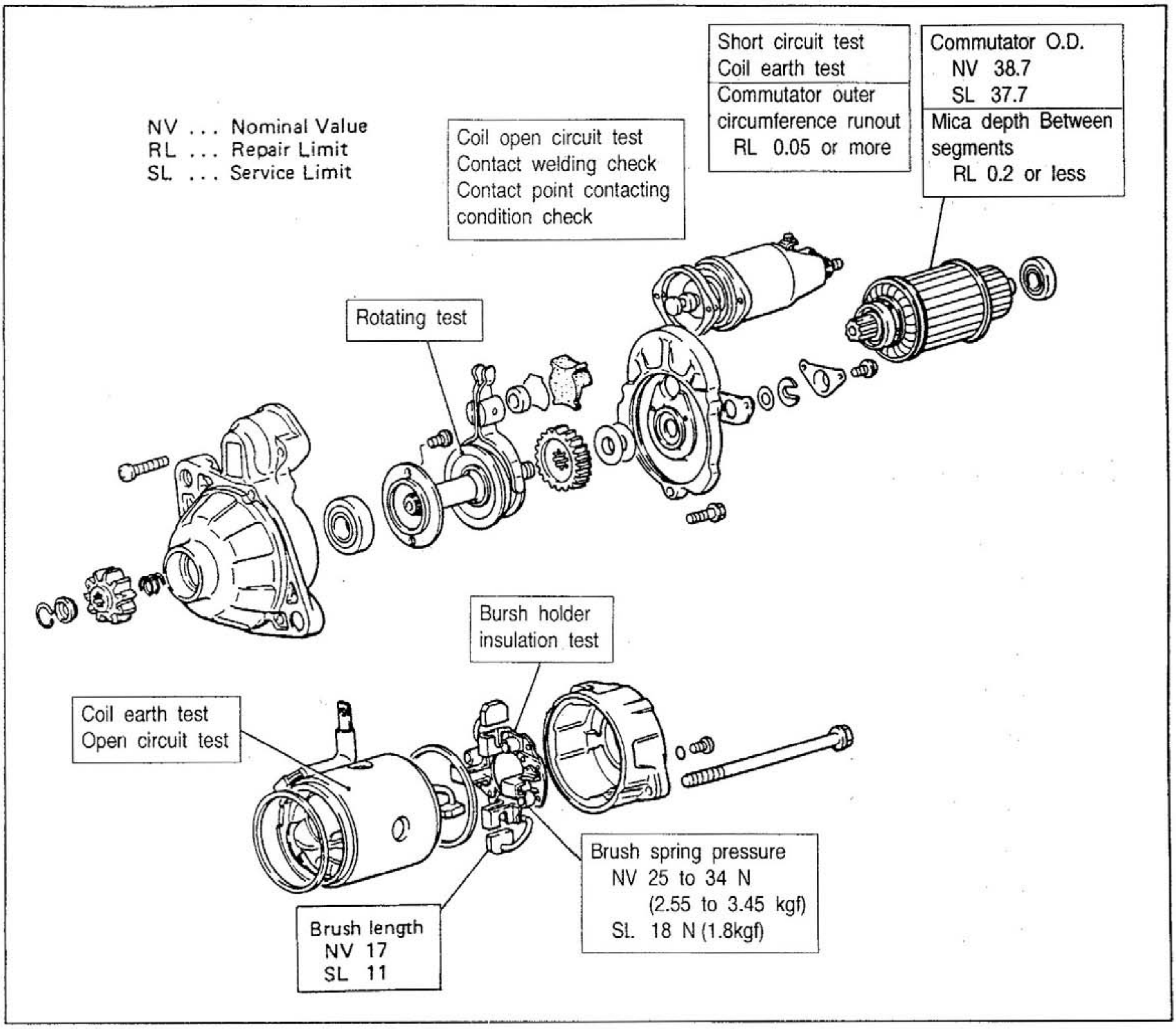
2. Note the mounting direction of the lever.

(1) With a pipe applied to the pinion stopper, hammer it to drive the pinion stopper out to the clutch side and remove the ring. Then, remove the pinion stopper.

NOTE : If the pinion stopper will not come out of position, grind away the burrs from the pinion shaft groove.

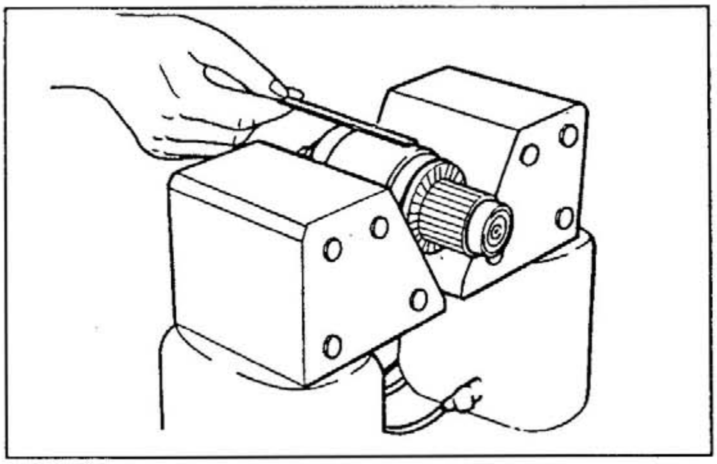


11-1-2 Inspection



(1) Armature

(a) Coil short circuit test

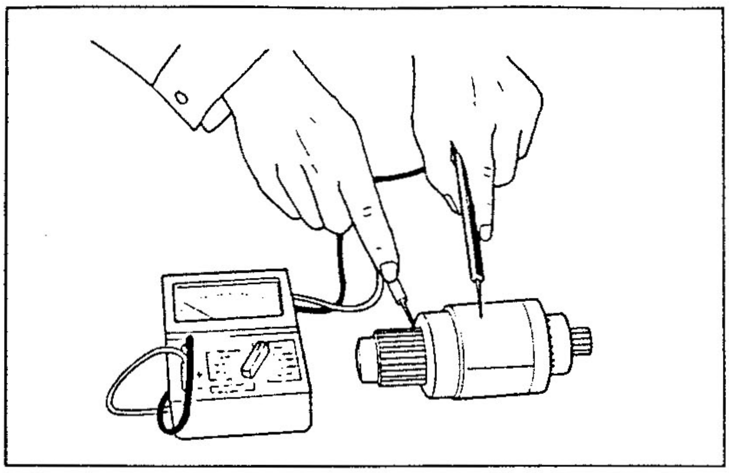


Place the armature on the growler tester. Slowly turn the armature manually with armature core parallel to the armature. If the core is attracted or vibrates, it indicated coil short circuit.

Then replace the armature.

(b) Coil earth test

Check continuity between the commutator and the shaft (or core). If there is continuity, it indicates earthing. Then replace the armature.

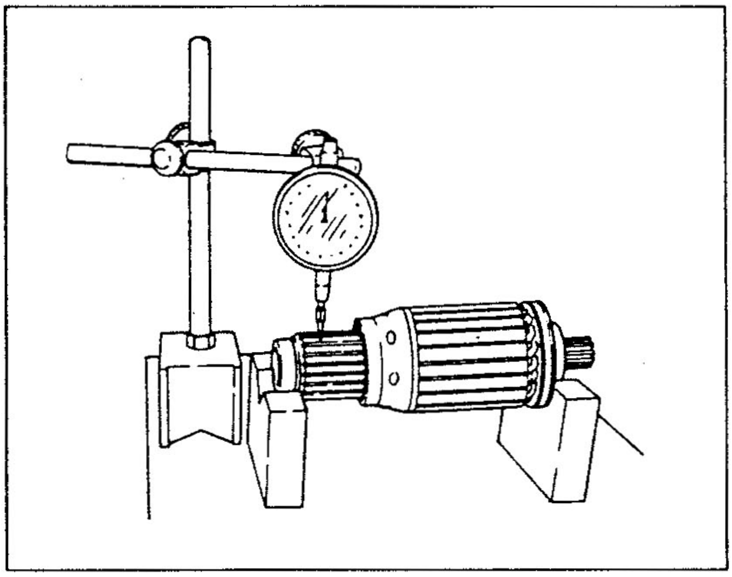


(c) Commutator check

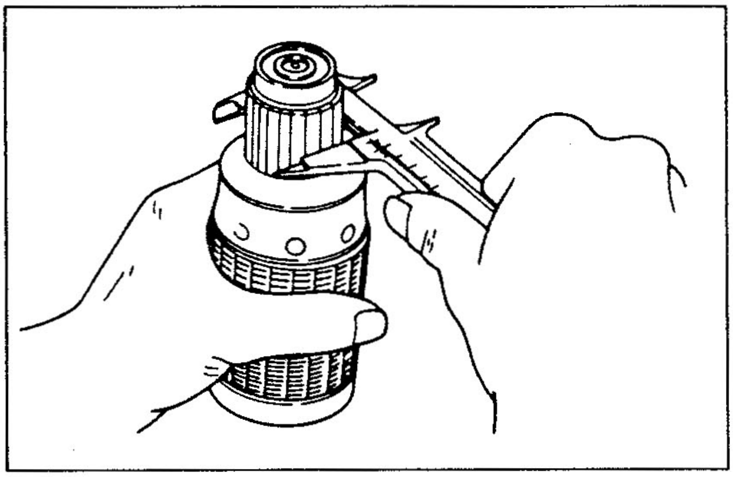
Measure the commutator runout using a dial gauge.

If the runout exceeds the repair limit, correct within the service limit of commutatroO.D.

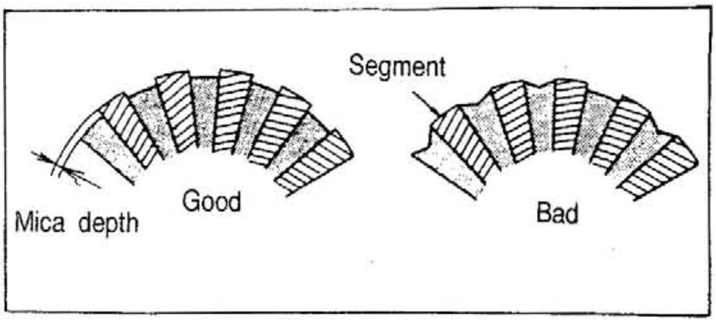
If the commutator surface is rough or has stepped wear, correct with sandpaper(No. 330 to 500).



d) Measure the commutator o.d. and replace the armature if it is less than the service limit.

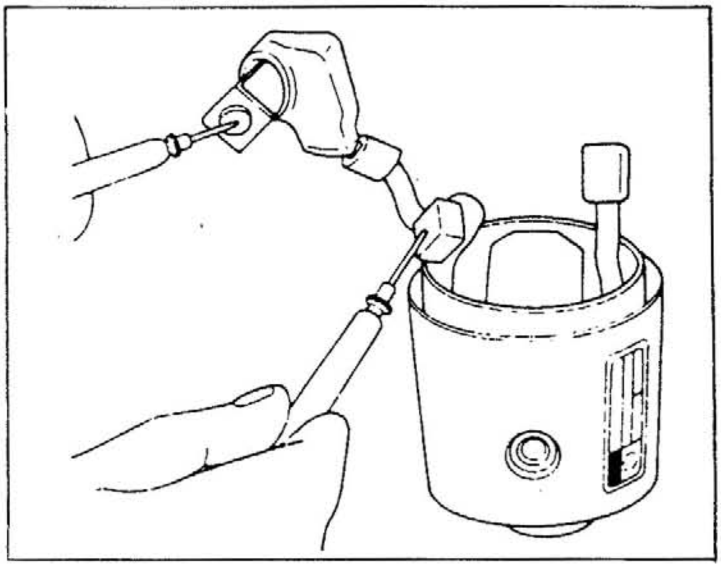


e) Measure the mica depth between segments and correct if it is less than repair limit.



(2) field Coil

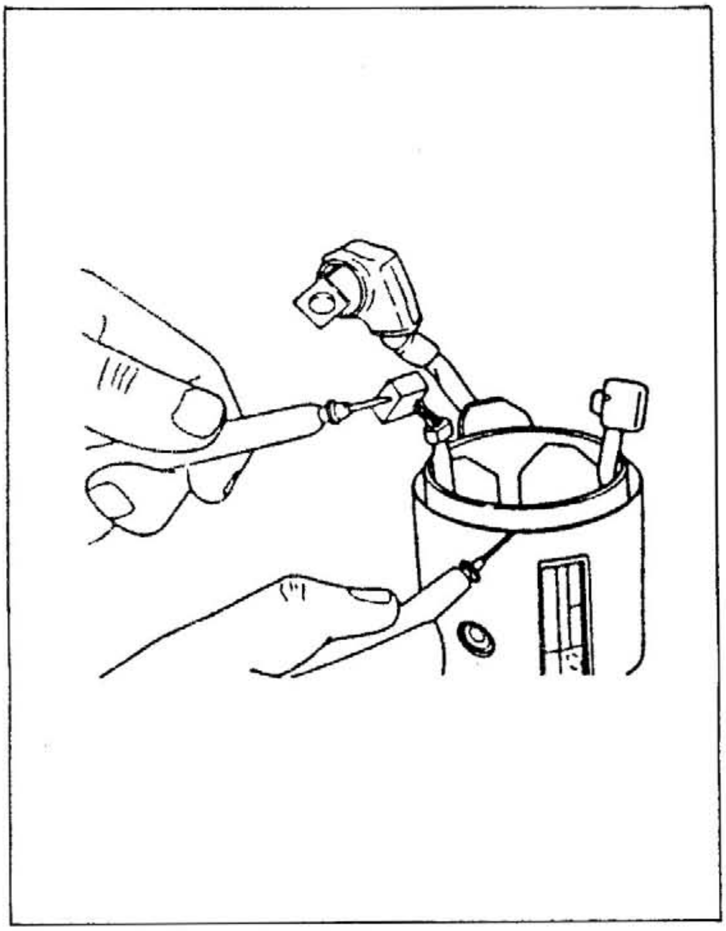
(a) Coil open circuit test



Check continuity between the terminal lead and the brush(+).

No continuity indicates a short circuit. Then, replace the yoke assembly.

(b) Coil earth test

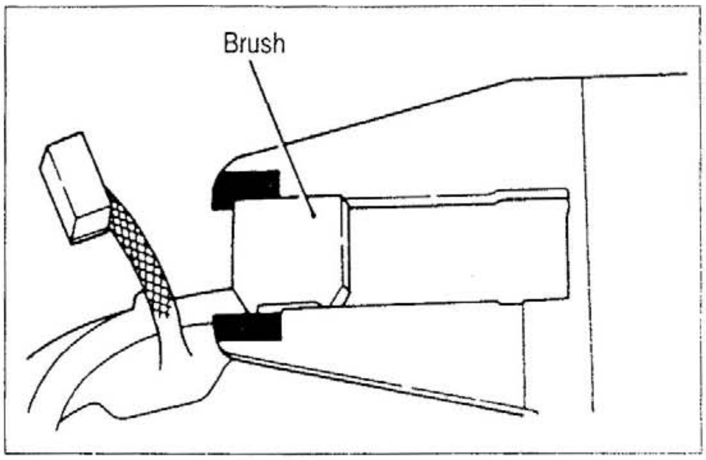


Check continuity between the yoke and the brush(+). If there is continuity, it indicates earthing.

Then, check insulation and if repair is impossible, replace the yoke assembly.

(3) Brush and Brush Holder

(a) Brush wear

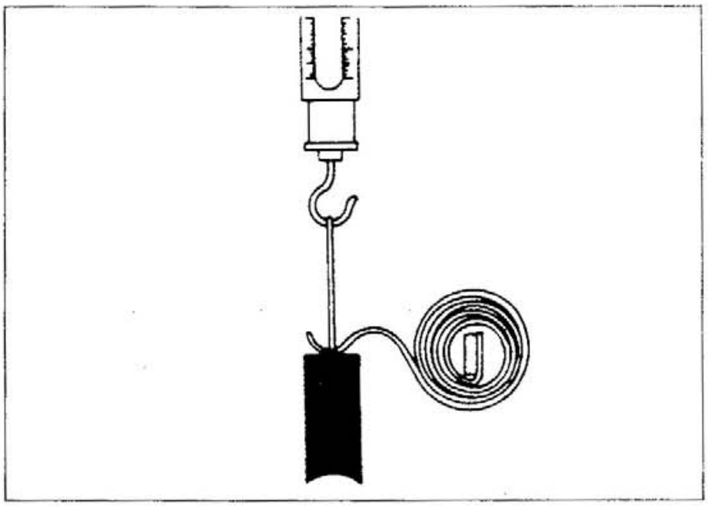


Measure the brush length and replace the brush if the length is shorter than the service limit.

If the brush is unevenly worn or the contacting surfaces are rough, correct with sandpaper(No. 300 to 500).

NOTE : Correct the brush contacting surfaces to the same curvature as the commutator.

(b) Brush spring pressure

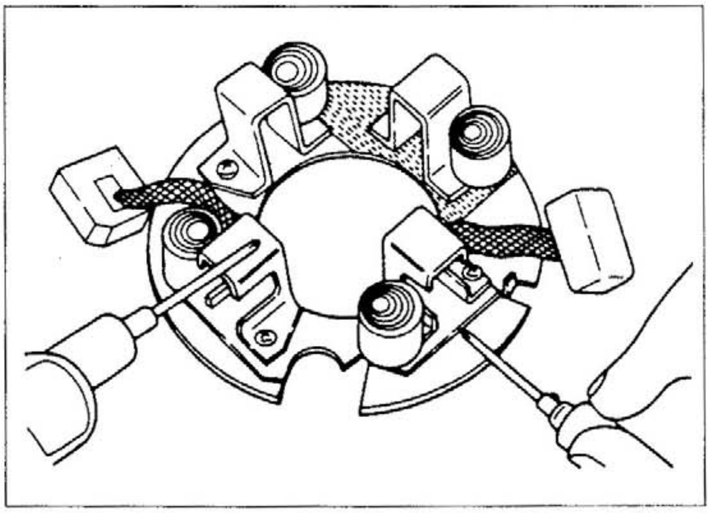


Measure the installed load of the brush spring.

Use a new brush and read the load at the moment the spring leaves the brush surface.

Replace the spring if the spring pressure is lower than the service limit.

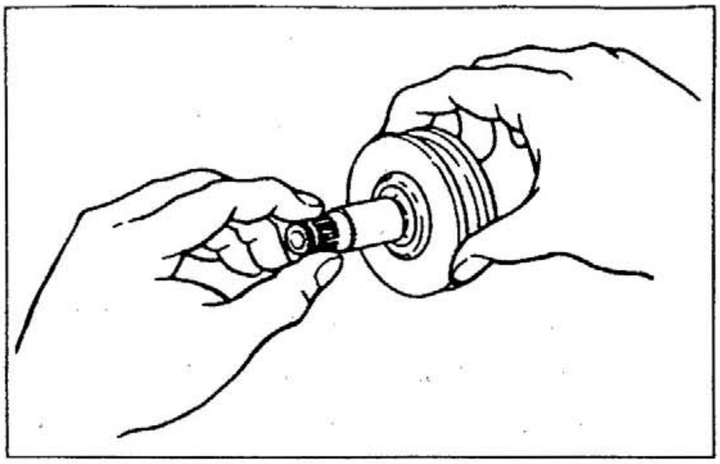
(4) Brush holder insulation test



Check to see that there is no continuity between the positive (+) brush holder and the negative (−) holder plate.

If there is continuity, replace the brush holder.

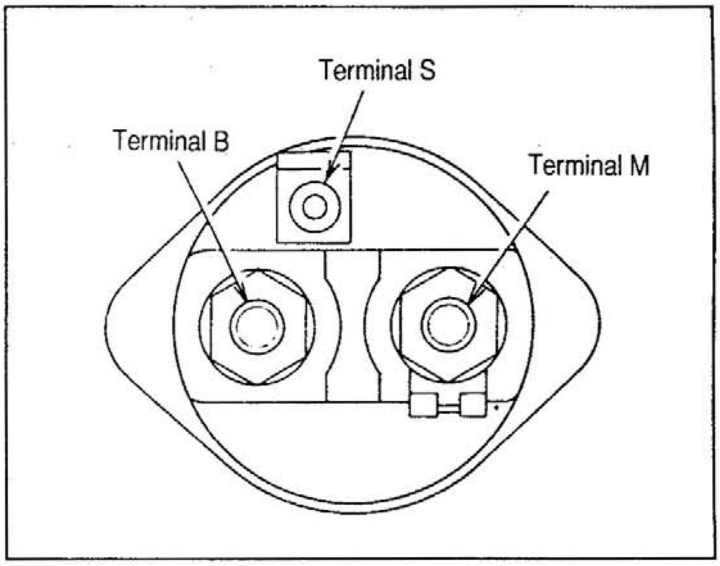
(5) Overrunning Clutch



Check to ensure that the pinion gear rotates smoothly when turned in the drive direction (clockwise) and is locked when turned in the reverse direction (counterclockwise)

If the Pinion gear does not rotates smoothly, replace overrunning clutch.

(6) Magnet Switch



Perform the following continuity tests and replace the magnet switch if any abnormality is found.

(a) Coil open circuit test

Check that there is continuity between terminals S and M and between terminal S and ground.

(b) Contact point welding check

Check that there is no contինity between terminals B and M

(c) Contact point contact check

Check that there is only a small voltage drop across contact. Contact is defective if there is a large voltage drop.

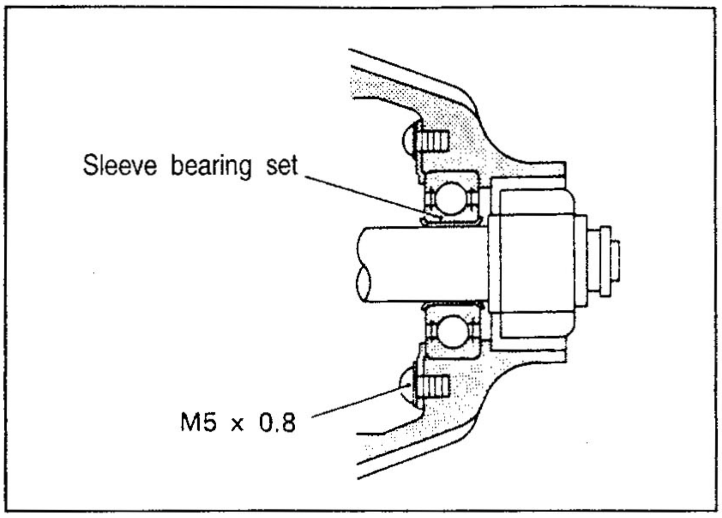
(7) Replacement of Bearing

(a) Bearing Puller can be used to remove ball bearing on both ends of the armature.

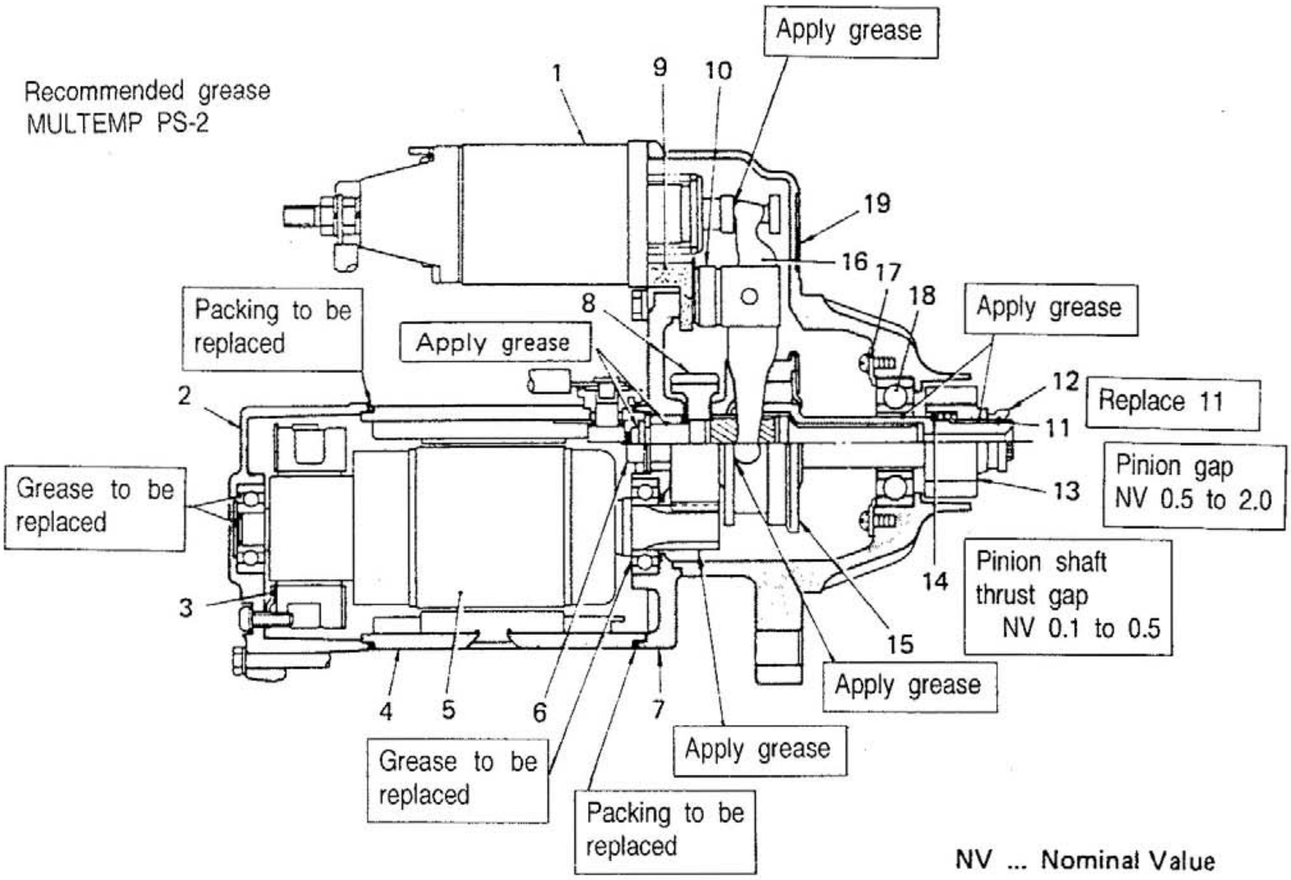
(b) The center bracket needle bearing cannot be removed. To replace it, replace the entire center bracket.

(c) To replace the front bearing remove screws(M5 x 0.8, at two locations) shown in Fig.

The front bearing cannot be removed. Replace the entire front bracket.



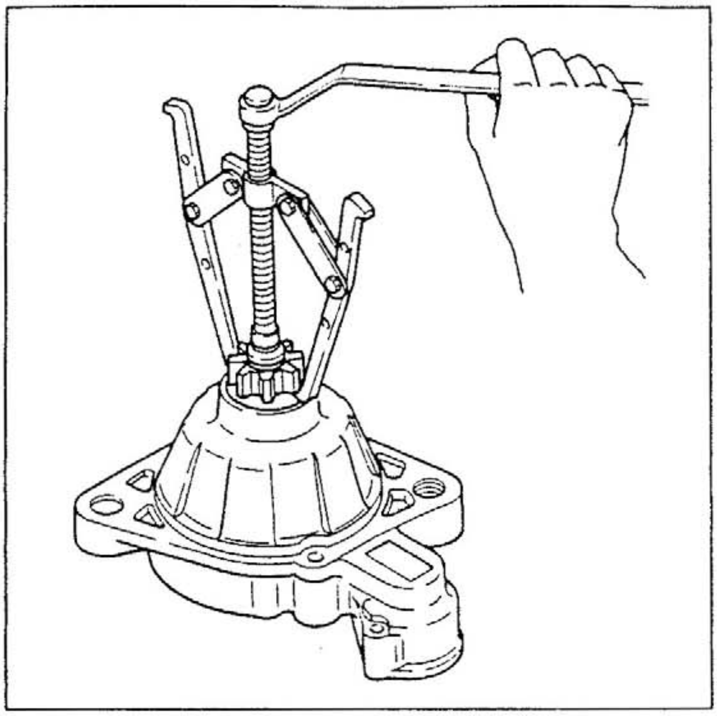
11-1-3 Reassembly



NOTE : 1. Pay attention to the direction when mounting the lever assembly.

2. When assembling the yoke and the center bracket, engage locating notch and projection.

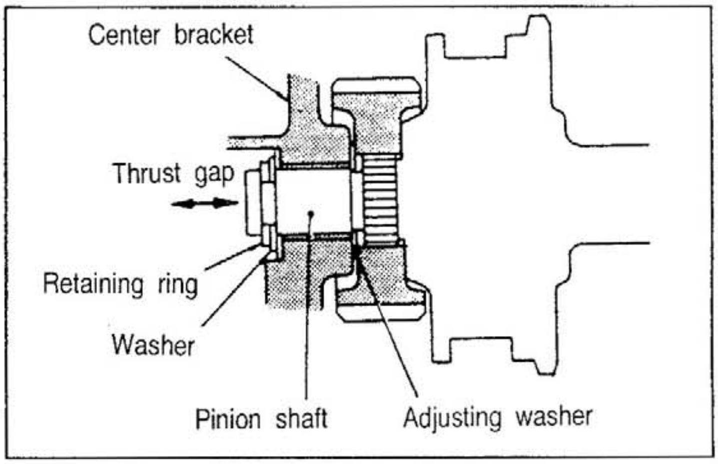
(1) To install the pinion, first insert the pinion shaft through the front bracket. Then, install the spring, pinion and pinion stopper and seat the ring in the groove of the pinion shaft. Then, pull firmly the pinion or the pinion stopper to the ring side to secure in position.



(2) Pinion Shaft thrust Gap Adjustment

The pinion shaft thrust gap is the play when the pinion shaft is moved axially.

Measure the thrust gap as described below and if the gap is not as specified, select adequate adjusting washer and adjust the gap.



(a) When pinion shaft is not is place:

Mount the gear over the pinion shaft, insert the pinion shaft through the center bracket and secure the pinion shaft with the washer and retaining ring. Then, move the pinion shaft axially to measure the thrust gap.

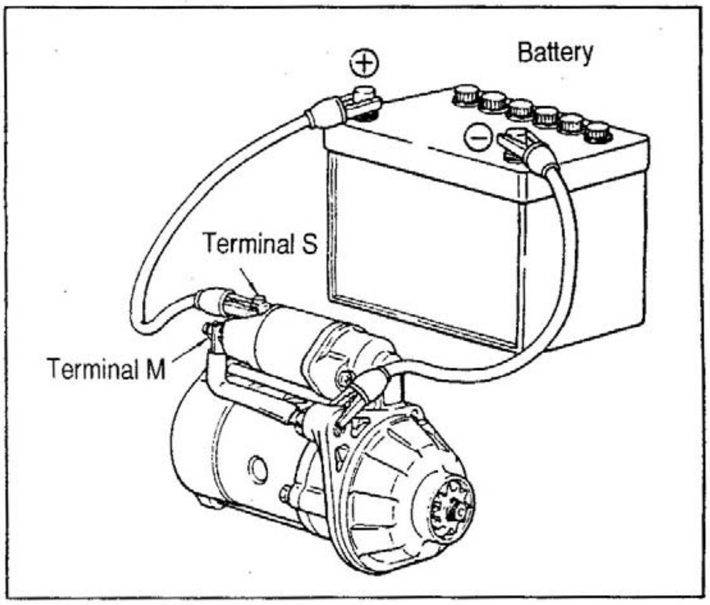
(b) when pinion shaft is in place:

Temporarily fix the pinion shaft and the gear between the front bracket and the center bracket. Then, move the pinion shaft axially to adjust the thrust gap.

11-1-4 Adjustment and Test After assembly

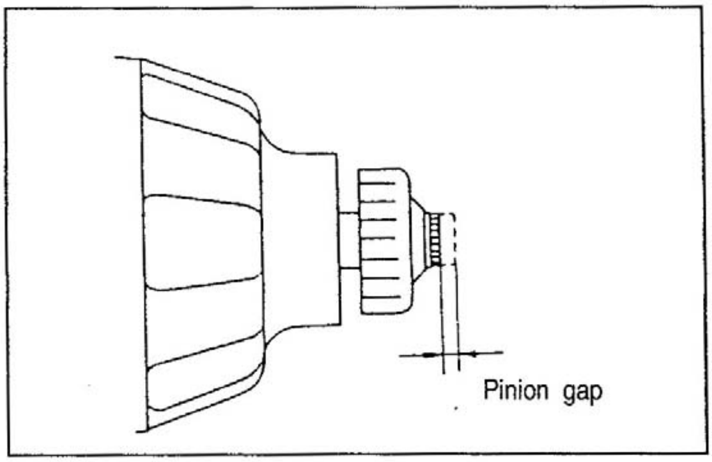
(1) Pinion Gap Adjustment

When connections are made as shown below to the assembled starter, the pinion pops out and rotates. Then, disconnect the connector from the terminal M and the rotation will stop, the pinion being left popped out.



In this state, lightly push down the pinion with finger and measure the retraction (displacement).

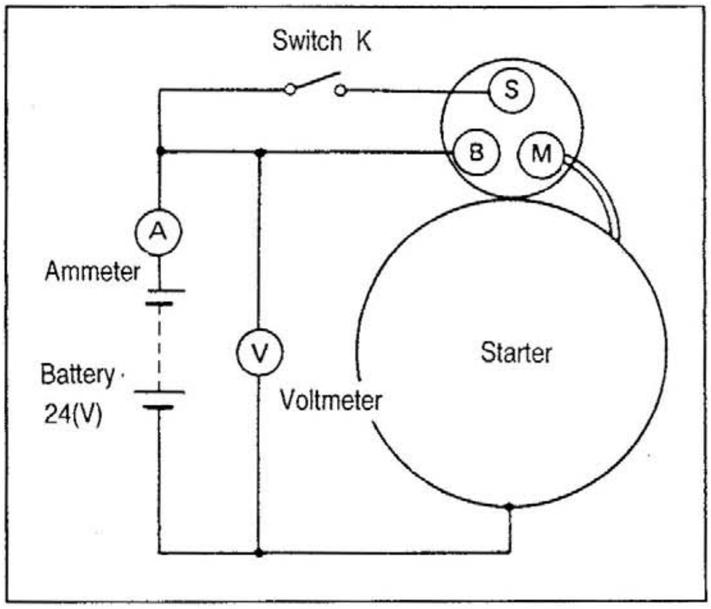
This is the pinion gap. Adjust the number of packing of the magnet switch for the specified pinion gap. Increasing the number of packings decreases the pinion gap.



(2) Test

Make connections as illustrated and check the no-load characteristics.

No load Characteristics	Voltage	23V
	Current	85A or less
	Rotating speed	3300rpm or more
Locked characteristics	Voltage	9V
	Current	1 400A or les
	Rotating force	88Nm (9kgf m) or more
Magnet switch operating voltage		16V or less



NOTE : 1. Use wires of diameter as large as possible and tighten each terminal securely.

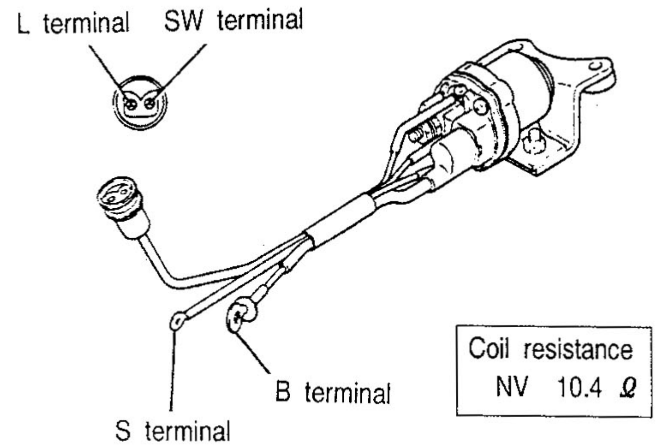
2. The starter produces louder noise under no-load condition due to built-in reduction gears.

3. Prolonged operation of the starter heavily consumes the battery and the rotation speed decreases. Run for 10 to 15 seconds and then stop for 10 to 15 seconds before resuming operation.

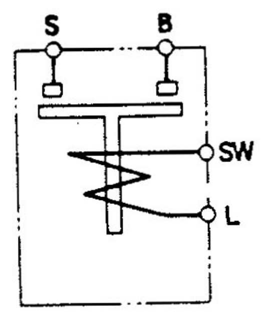
11-2 STARTER RELAY

(1) Check for continuity between the "SW" and "L" terminals and check to ensure that the coil resistance is up to specification

(2) Check to ensure that when the beattery voltage (24V or 12V) is applied across the "SW" and "L" terminals, there is continuity between the "B" and "S" terminals



NV ... Nominal Value

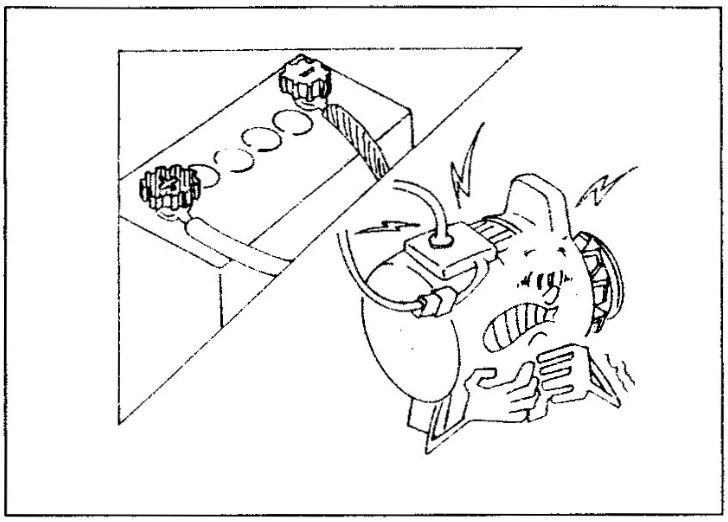


11-3 ALTERNATOR

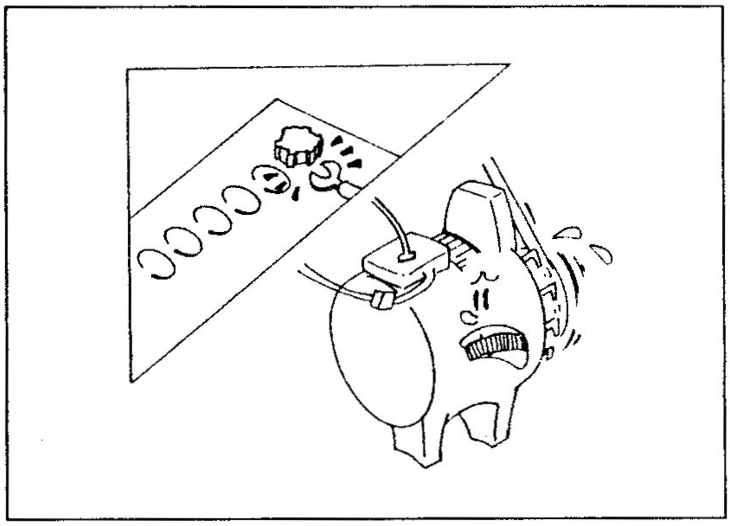
11-3-1 Alternator Handling Precautions

When servicing the alternator, pay attention to the following.

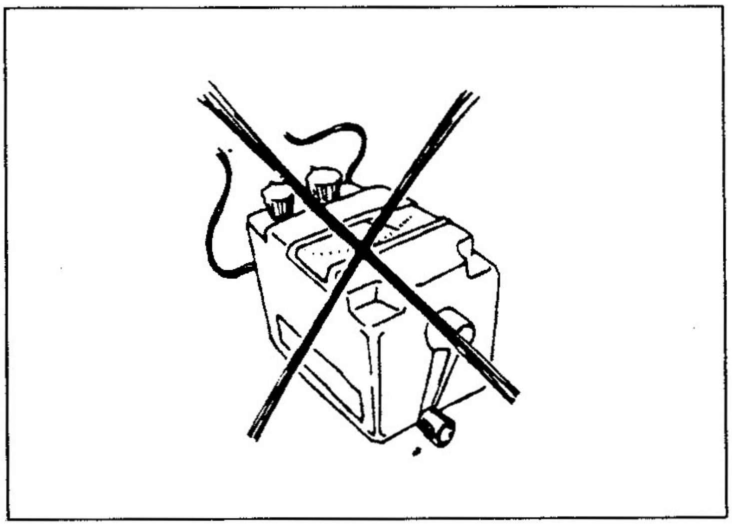
(1) If the polarity of the battery is reversed when connections are made, large current will flow from the battery to the alternator, causing damage to the diode and the IC regulator.



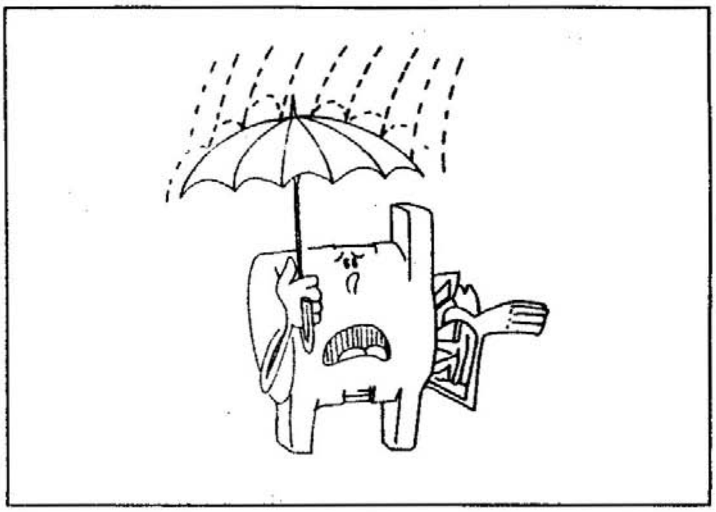
(2) Do not disconnect the battery terminal connections while the engine is running. Otherwise, a surge voltage will be generated, causing deterioration of the diode and the regulator.



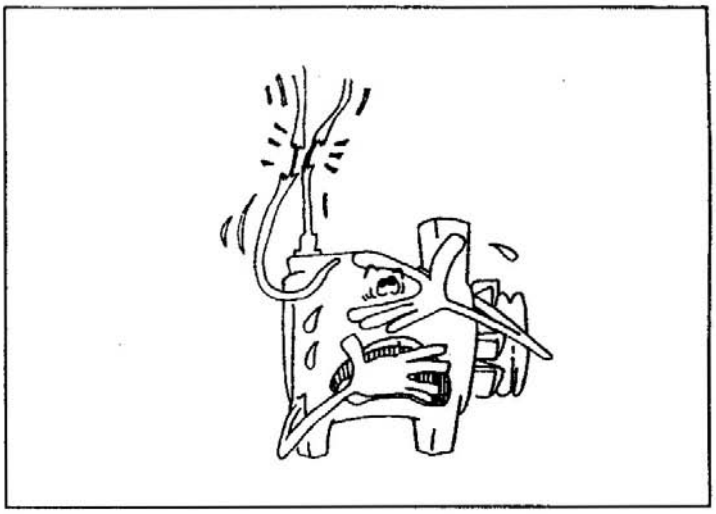
(3) Do not use a high voltage tester such as megger to test the alternator as it could cause damage to the diode and the regulator.



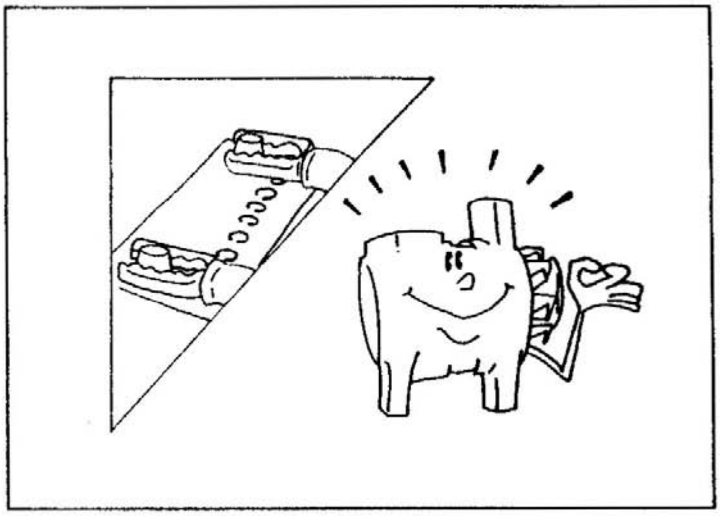
(4) When a steam cleaner is used, take care to prevent direct exposure of the alternator to the steam.



(5) Operation of the alternator with "B" terminal short-circuited with "K" or "L" terminal could result in damaged diode trio.

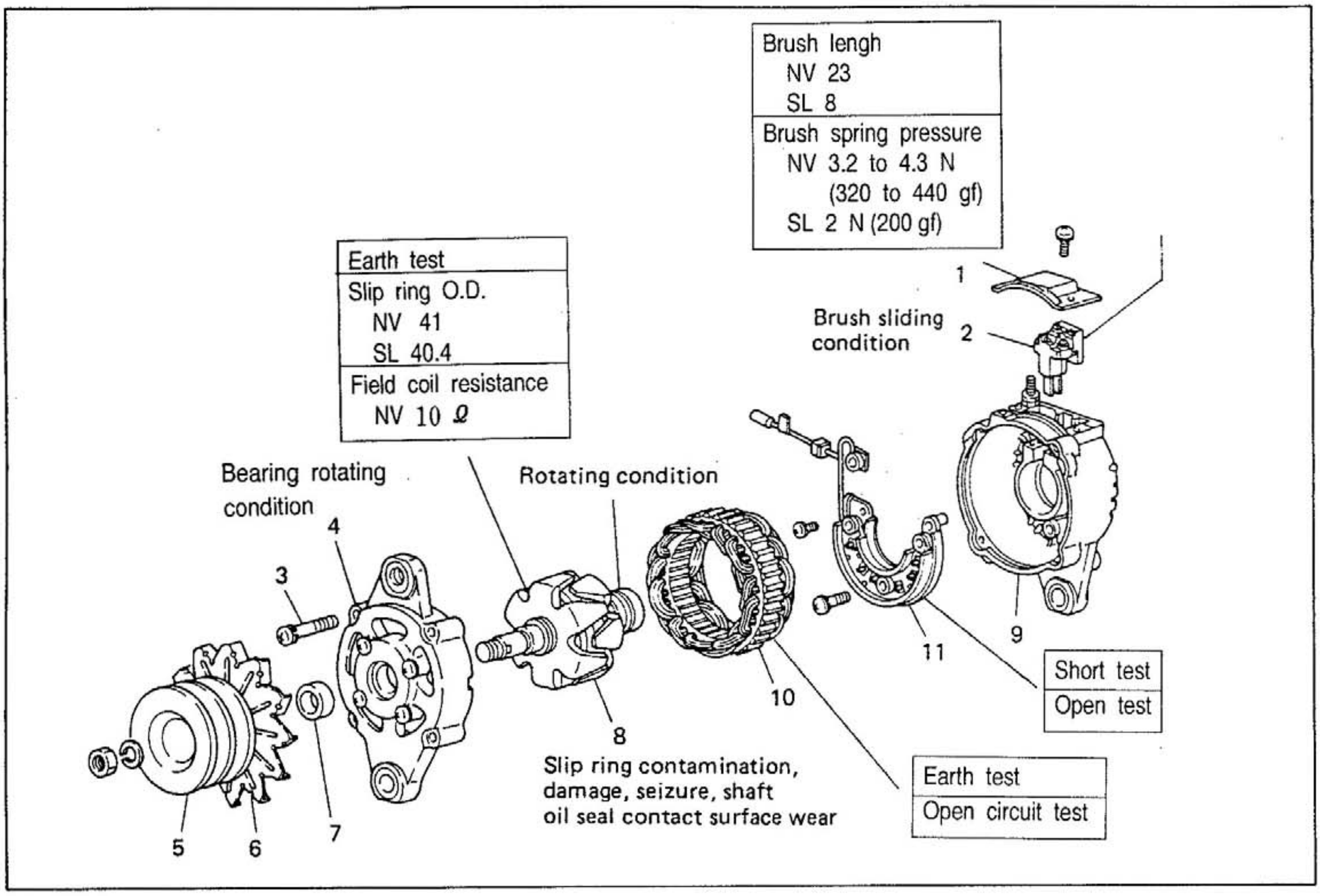


(6) When the battery is to be quickcharged with a quick charger, be sure to disconnect the battery terminal connections beforehand. Otherwise, the diode and the regulator would be damaged.



11-3-2. 40A Alternator

(1) Disassembly and Inspection

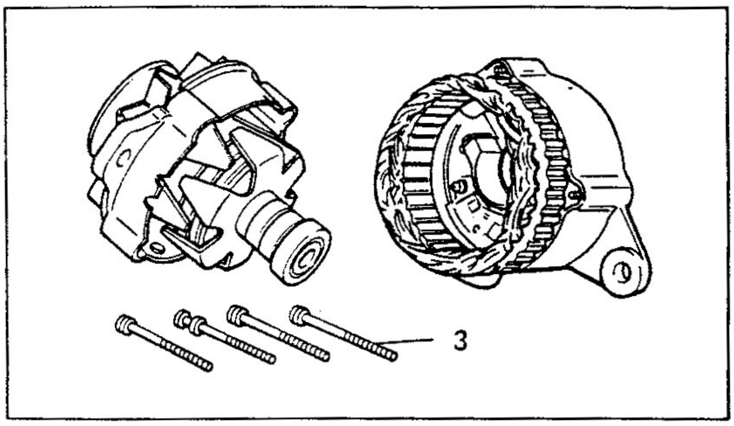


1	Cover	5	Pulley	9	Rear bracket
2	Regulator assembly	6	Fan	10	Stator
3	Through bolt	7	Spacer	11	Rectifier
4	Front bracket	8	Rotor		

NOTE : 1. If disassembly is continued without removing the regulator assembly, the brush will be damaged when removing the rotor.

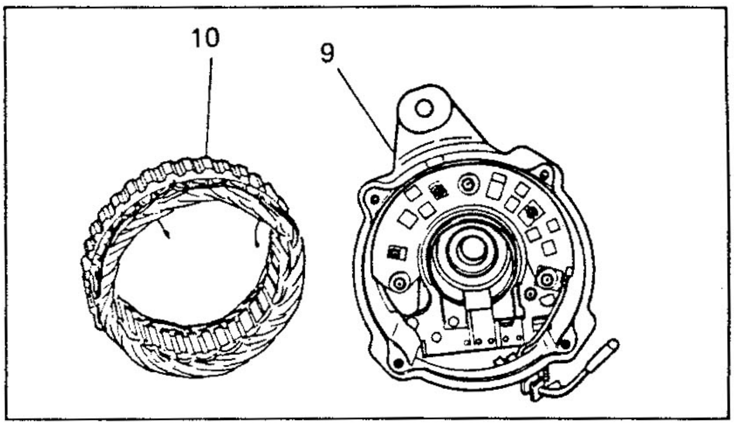
2. Do not remove the oil seal unless it is defective.

(a) Remove the throught bolt 3 and separate the assembly into the front bracket and the rear bracket as illustrated.



(b) Unsolder the stator coil leads and remove the stator 10 from the rear bracket 9.

NOTE : When unsoldering, operate the soldering iron quickly (within 5 seconds or so).



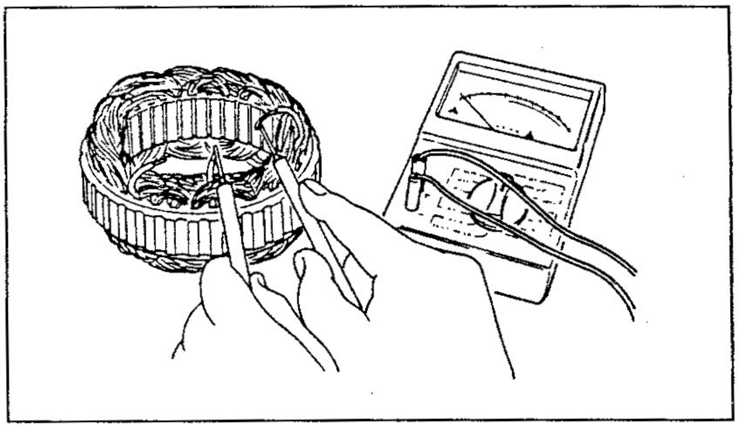
(c) Inspection of stator

1) Check that there is continuity between stator leads.

If not, replace the stator as leads are broken.

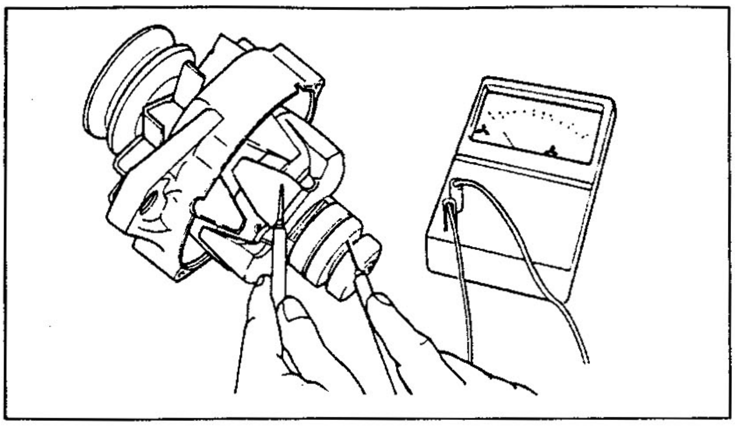
2) Check that there is no continuity between the stator leads and core.

If ther is continuity, replace the stator as it is earthed.

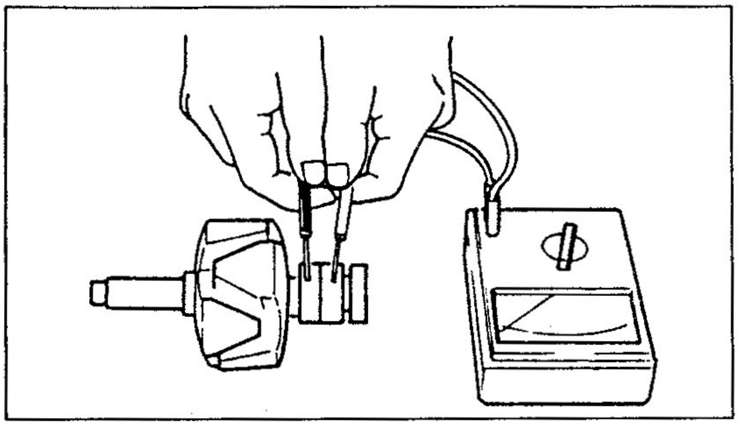


(d) Inspection of rotor

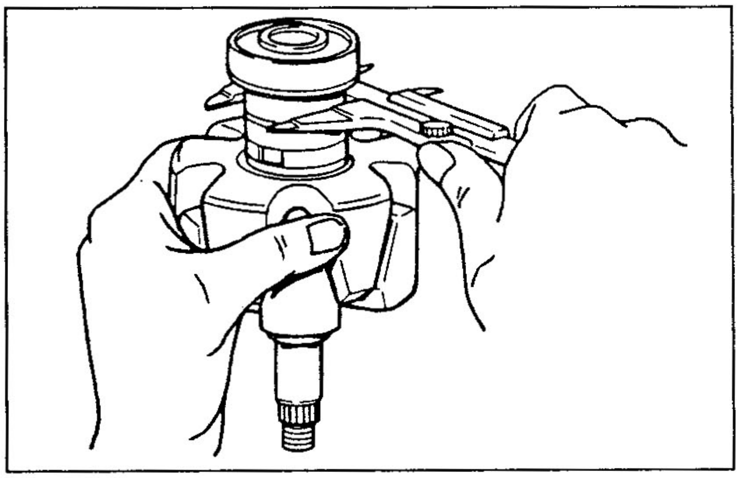
1) Check that there is no continuity between the slip ring and the core. If there is continuity, replace the rotor.



2) measure the resistance between the slip rings. Replace the rotor if the resistance is not as specified.

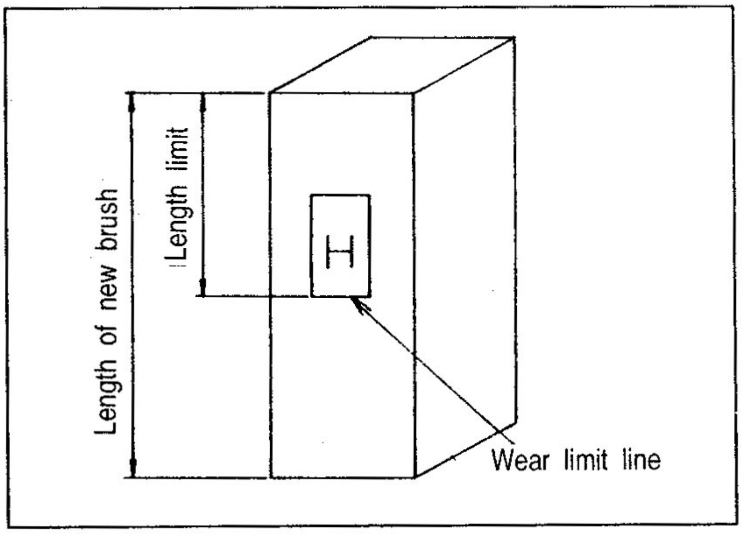


3) If the slip ring has rough surface or unevenly worn surface, correct with sandpaper or lathe.



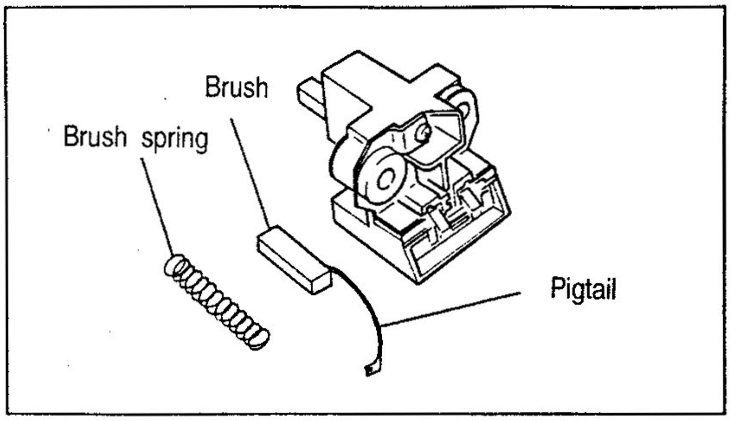
(e) Inspection of brush

1) Replace the brush if it is worn beyond the wear limit.



2) When a brush has been replaced, push in the new brush and measure the brush spring pressure.

If the spring pressure is lower than the service limit replace the brush spring

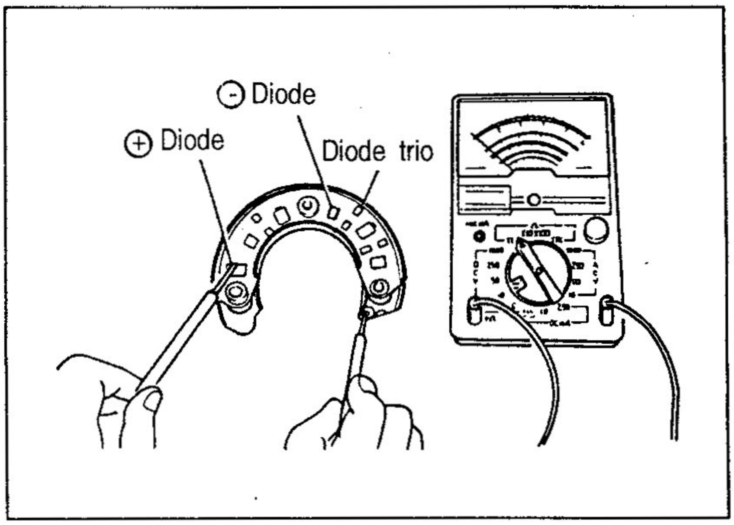


3) Replacement of brush and brush spring

The brush and brush spring can be removed by unsoldering the pigtail.

(f) Inspection of diode

For each diode check the resistance between the diode leads and the heat sink.



Check the resistance in two manners, namely connecting the positive (+) tester lead to the diode or connecting the negative (−) lead to the diode.

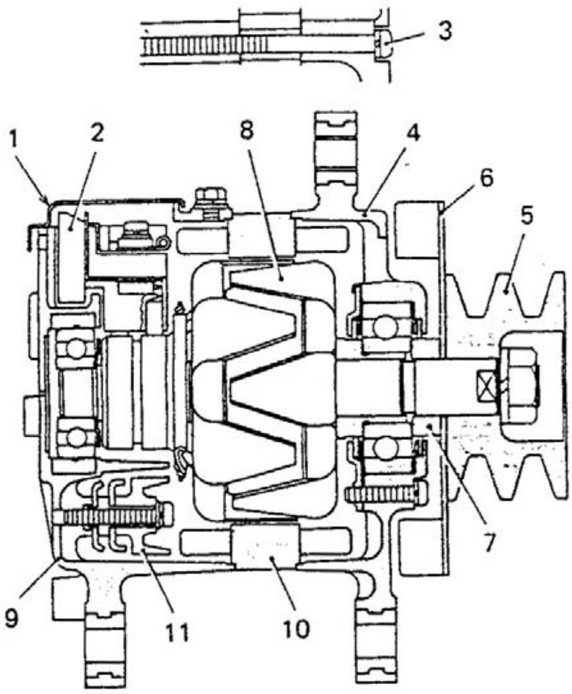
The diode is open if the resistance is infinite in both cases.

The diode is shorted if the resistance is nearly 0 in both cases.

Replace the rectifier if the diode is open or shorted.

As for the diode trio, check resistance between diode trio leads.

(2) Reassembly



NOTE : 1. When inserting the shaft through the oil seal, apply vinyl tape around the splined section of the shaft to prevent the oil seal lip from being damaged by the splined section.

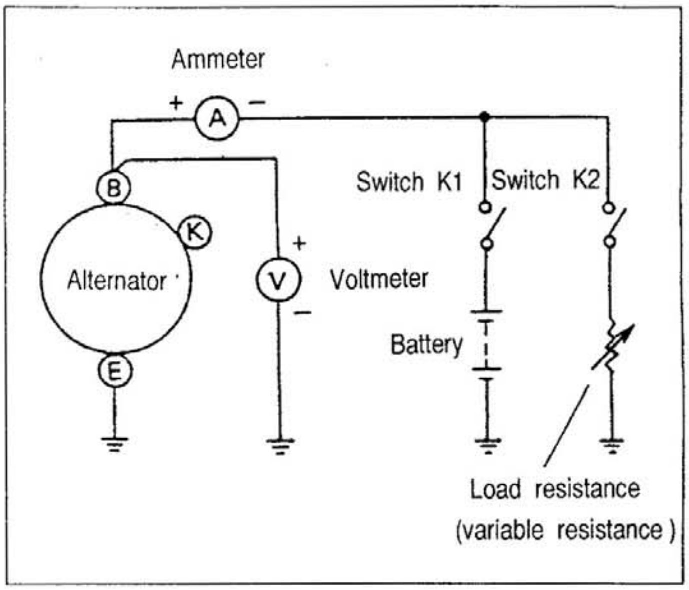
2. When inserting the oil seal into the rear bracket, work uniformly on the outer circumference of the oil seal to prevent local shock or heavy shock.

(3) Test

(a) Performance test(on test bench)

Characteristics under load

Model			40A
Charac-ter-istics when loaded	Terminal voltage		27V
	Cur-rent	When cold	26A or more
		When hot	22A or more
	Rotating speed		1500rpm
	Terminal voltage		27V
	Cur-rent	When cold	37A or more
		When hot	33A or more
	Rotating speed		2500rpm

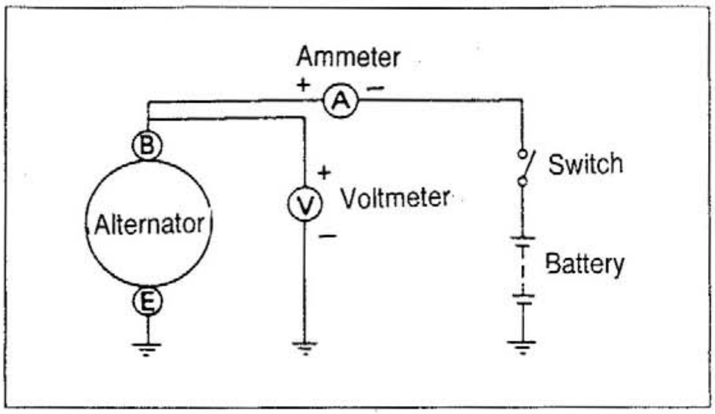


With the load resistance set at maximum(almost no load current flowing), close switches K1 and K2. While increasing the alternator speed gradually, decrease the load resistance and measure the specified terminal voltage and the current value at specified speed.

If the measurement reading is less than the specified level, check each section of the alternator.

(b) Performance test (as mounted to engine)

1) Provide a switch between the battery and the alternator "B" terminal.
With the switch turned off, connect an ammeter (50A class) and a voltmeter.



2) Turn on the switch to check that the voltmeter indicates the battery voltage.

3) Start up the engine and immediately turn on all lamp switches. Then, increases the maximum current value as soon as the alternator speed reaches 5000rpm.

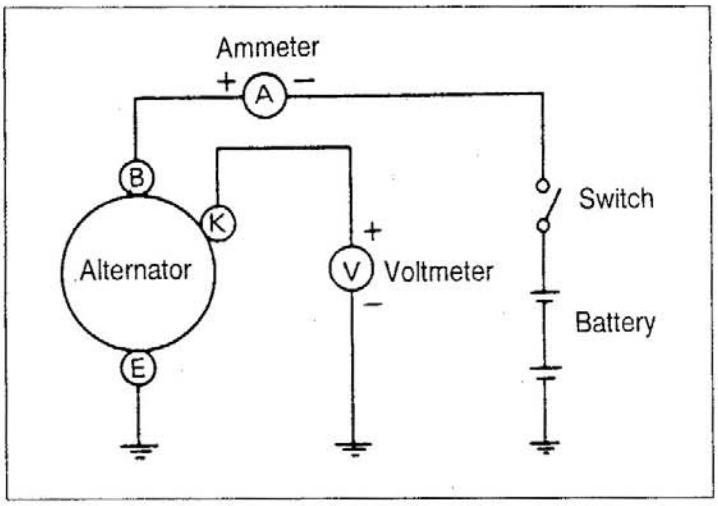
4) If the current reading is 70% or more of the nominal output, the alternator may be safely regarded as good.

NOTE : The on-vehicle inspection is a simple way of inspection and the test bench inspetion is necessary for more accurate results.

(c) IC regulator regulated voltage inspection (on thest bench)

IC regulator regulated voltage

28 to 29V	(Measured between terminals K and E at 5000rpm, load 5A or less)



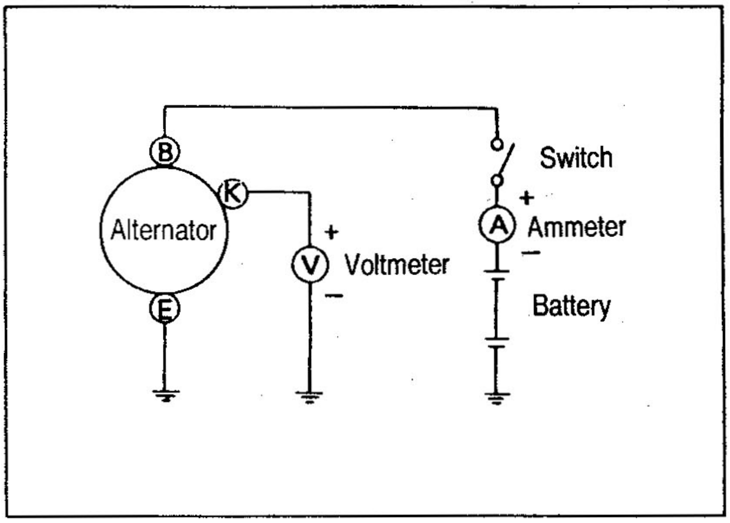
Use a fully charged battery. Close the swith and gradually increases the alternator speed to 5000rpm. Check that the current value at this speed is 5A or less. The regulator is good if the regulated voltage under this condition is as specified.
If not, replace the regulator assembly as the regulated voltage is not readjustable.

(d) IC regulator regulated voltage inspection (as mounted to engine)

1) Connect a voltmeter and an ammeter and provide a switch.

2) The regulator is normal if the voltmeter reads 0 when the swith is closed. If the voltmeter pointer deflects, the alternator or wiring is defective.

3) With the ammeter teminal shorted to prevent flow of the starter current throught it, start up the engine.



4) Increase the engine speed to approximately 2000rpm and read the regulator voltage value if the charge current is 5A or less.

If the charge current is 5A or more, continue charging for some time or replace with a fully charged battery. It is also acceptable to connect a 1/ 4 resistor (25W) in series to the battery to limit the charge current.

5) It is good if the regulator voltage is specified.

If not, replace the regulator assembly as the regulator voltage is not readjustable.

11-4 PREHEATER

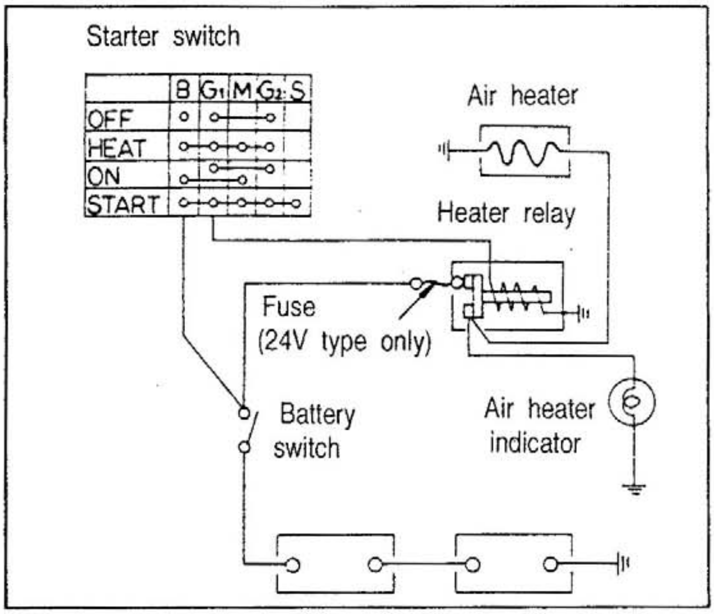
11-4-1 Intake Air Heater

Inspection

(1) Perform the following inspection and check the function of each part or the wiring if necessary.

Time required before indicator becomes red-hot : 40 to 60 seconds

(2)Check each terminal of the air heater for looseness and the heater element for damage and contract with other aparts.



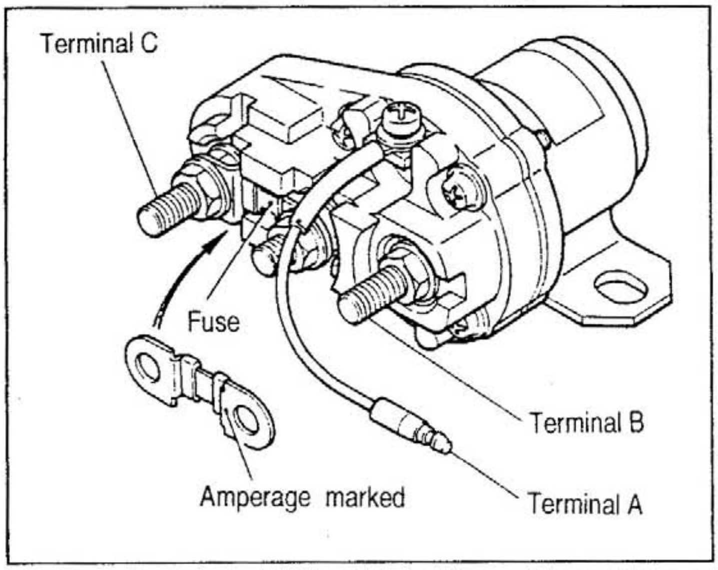
11-4-2 Heater Relay

Inspection

Check to ensure that there is continuity between the terminals "B" and "C" when 2. 3A exciting current (24V) is applied between terminal A in the figure and body earth.

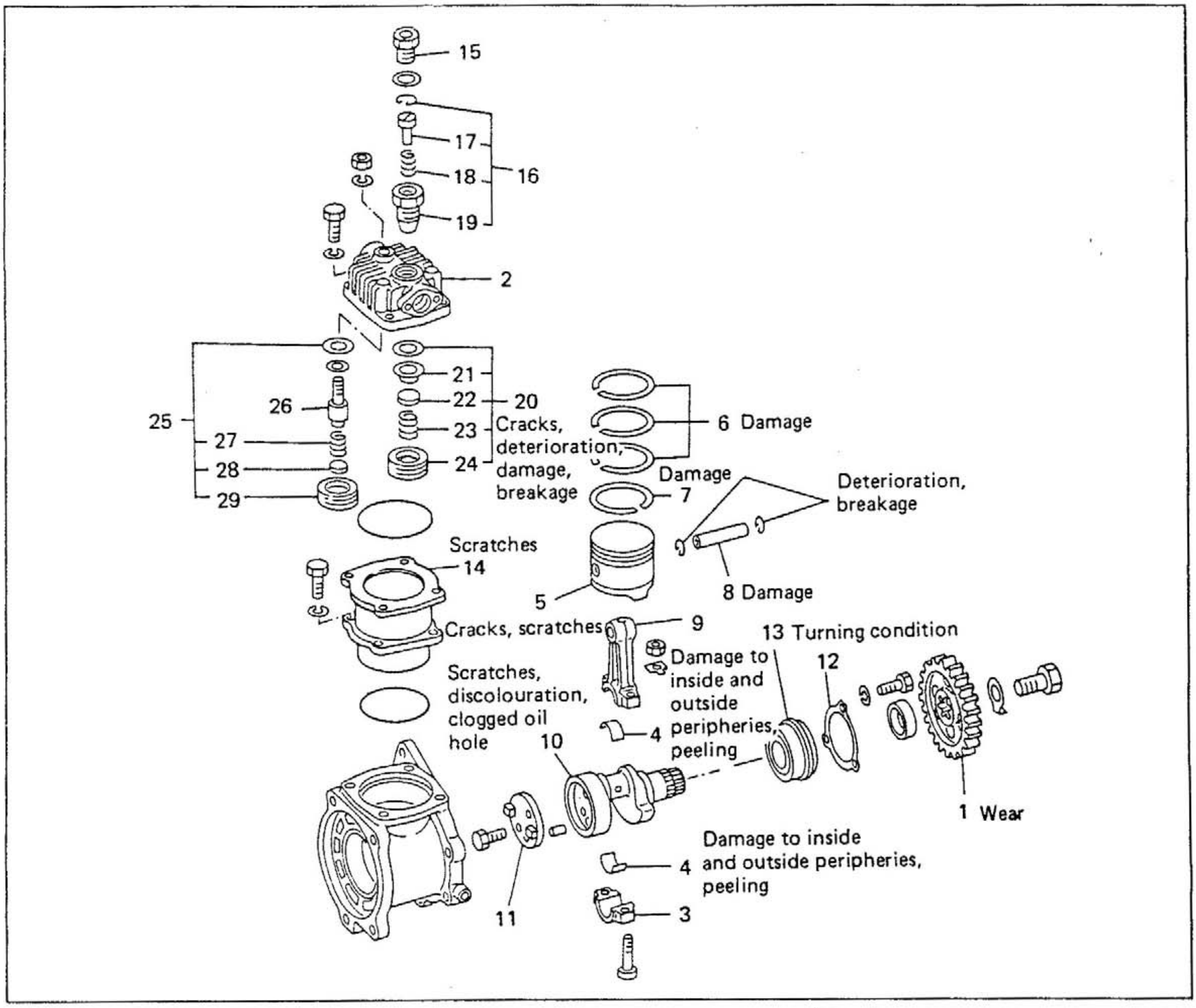
Check also the hearter relay fuse and replace with new one if it has been burnt out.

When replacing fuses, be sure to use a fuse of specified capacity.



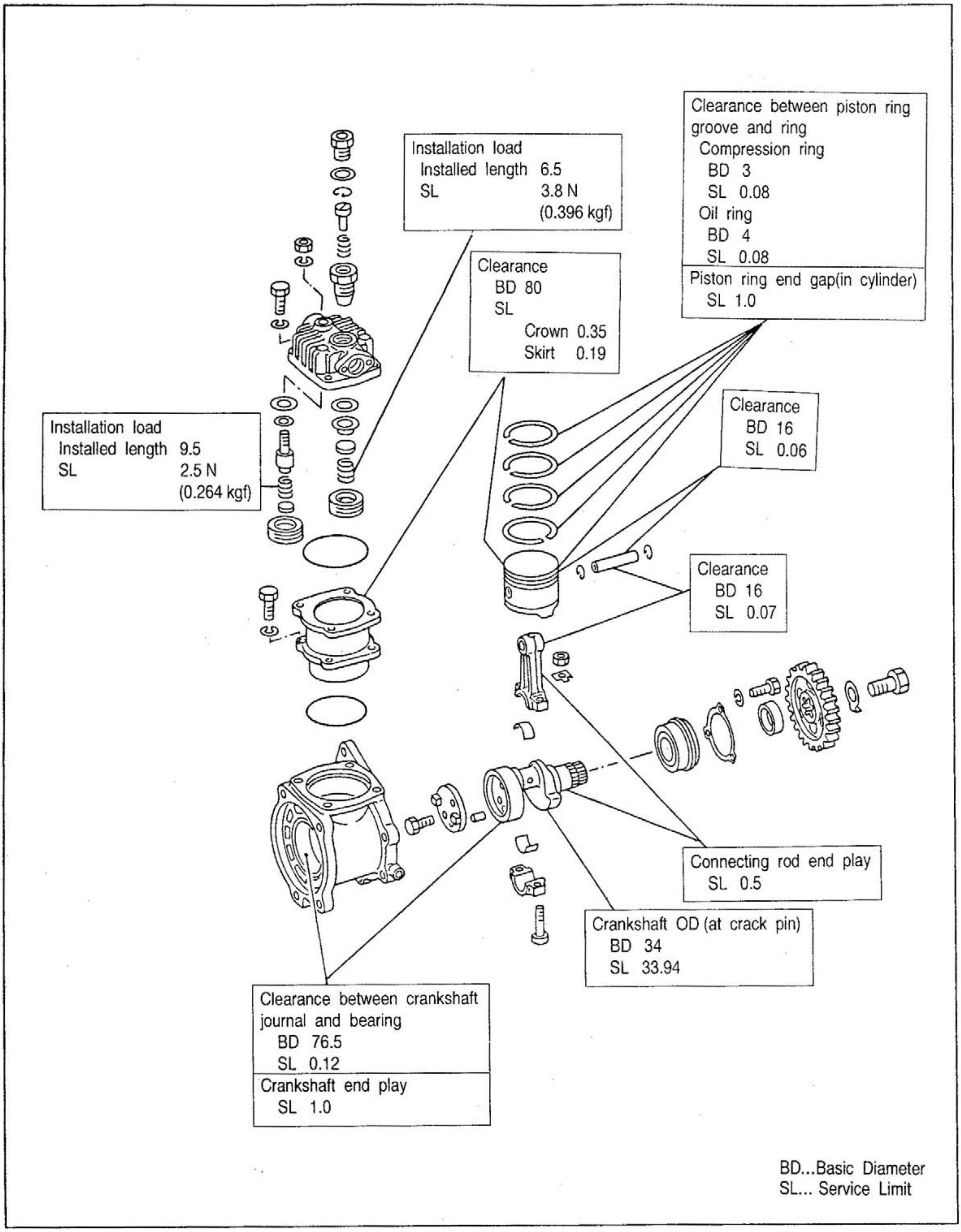
12-1 AIR COMPRESSOR

12-1-1 Disassembly

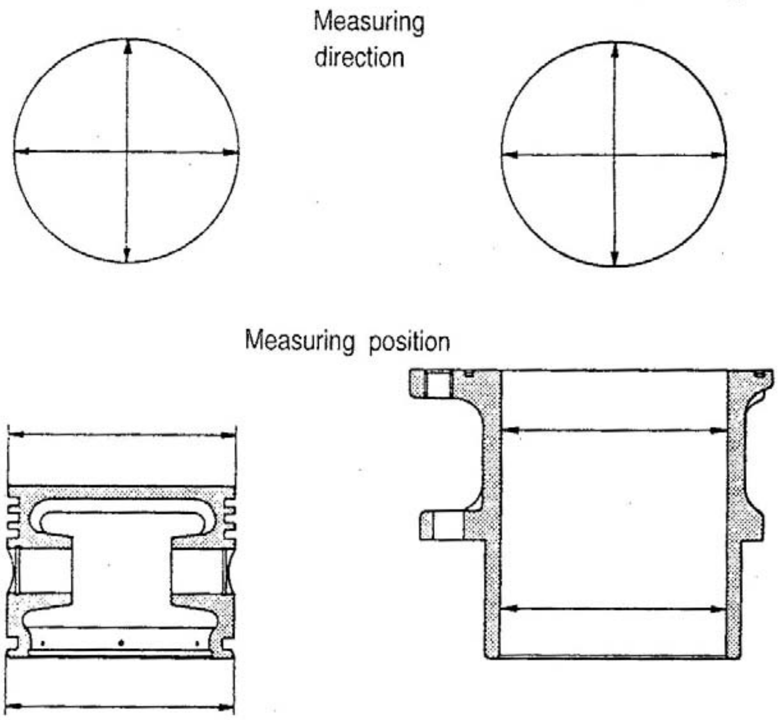


1	Compressor gear	11	Coupling	21	Suction valve seat
2	Cylinder head	12	Plate	22	Suction valve
3	Connecting rod cap	13	Bearing	23	Suction valve spring
4	Connecting rod bearing	14	Cylinder liner	24	Suction valve holder
5	Piston	15	Connector	25	Delivery valve assembly
6	Compression ring	16	Unloader valve assembly	26	Spring holder
7	Oil ring	17	Unloader valve	27	Delivery valve spring
8	Piston Pin	18	Unloader valve spring	28	Delivery valve
9	Connecting rod	19	Unloader valve guide	29	Delivery valve holder
10	Crankshaft	20	Suction valve aassembly		

12-1-2 Inspection and Correction



(1) Measure the clearance between the cylinder liner I.D. and the piston. If the clearance exceeds the service limit, replace the piston or cylinder liner.

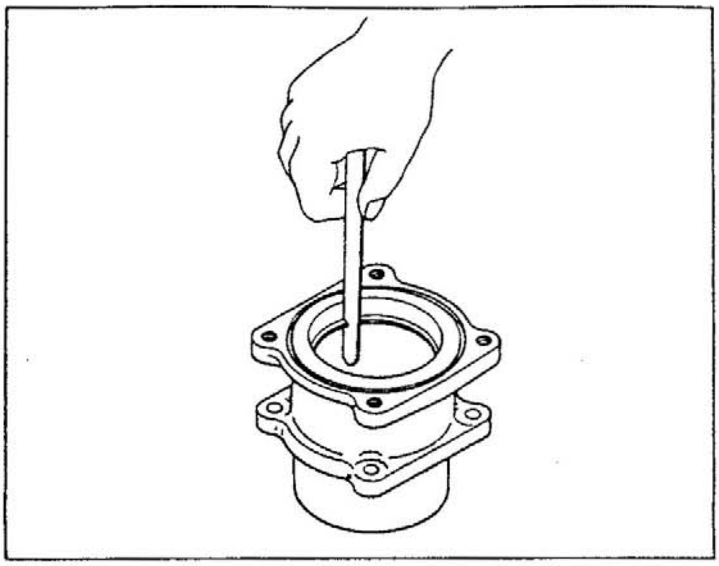


(2) Measure the clearance between the piston ring groove and piston ring. If the clearance is over the service limit, replace the piston ring.

NOTE : Measure the clearance around the full circumberence of the piston.

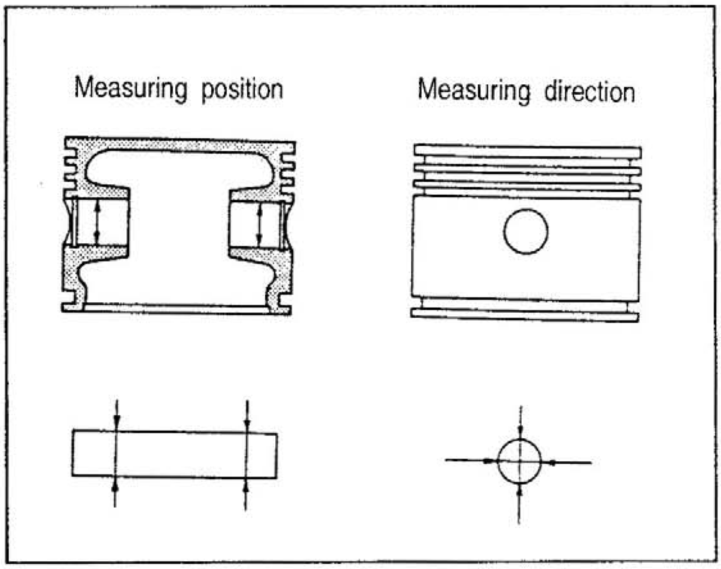
(3) Fit the piston ring in a standard cylinder liner or the gauge and measure the open end clearance. If the clearance is over the service limit, replace the piston ring.

NOTE : Push the piston ring in with a piston and measure the clearance with the piston ring in horizontal position.



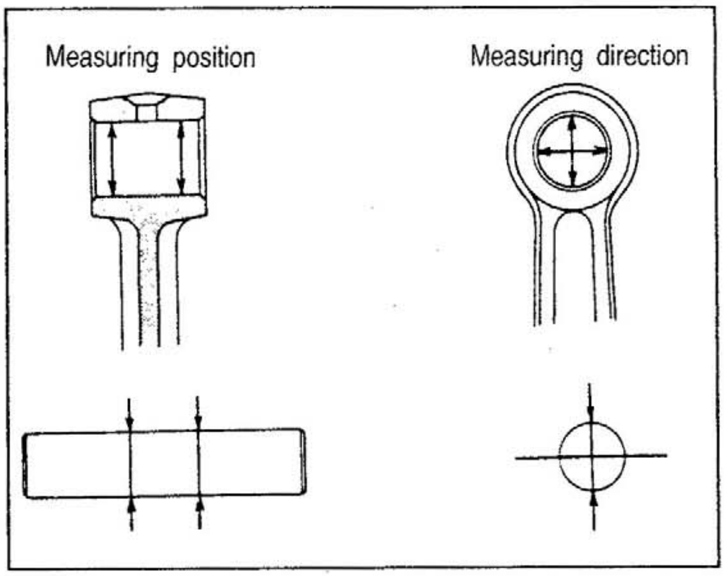
(4) Caculate the Clearance from the piston pin O.D. and piston I.D.

If the service limit is exceeded, replace the piston pin or piston.



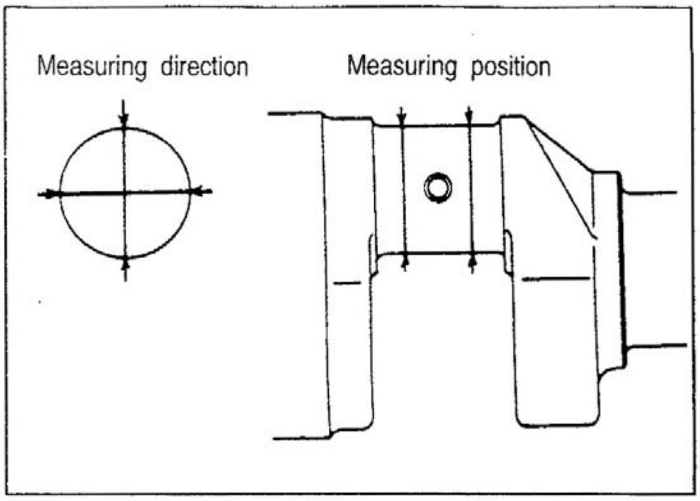
(5) Calculate the clearance from the piston pin O.D. and connecting rod I.D.

If the service limit is exceeded, replace the piston pin or connecting rod.



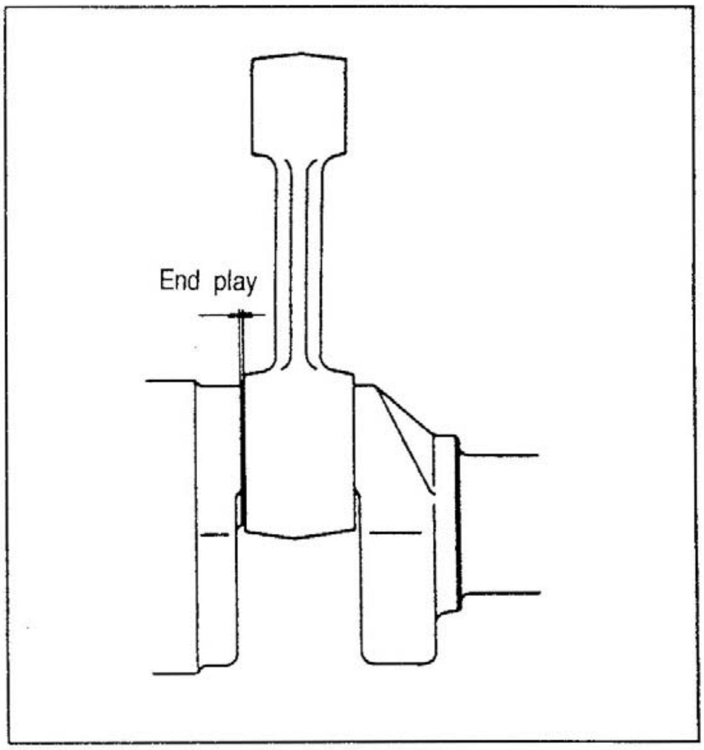
(6) Measure the O.D. of the crankshaft pin section.

If the service limit is exceeded, replace the crankshaft.



(7) Connecting Rod End Play

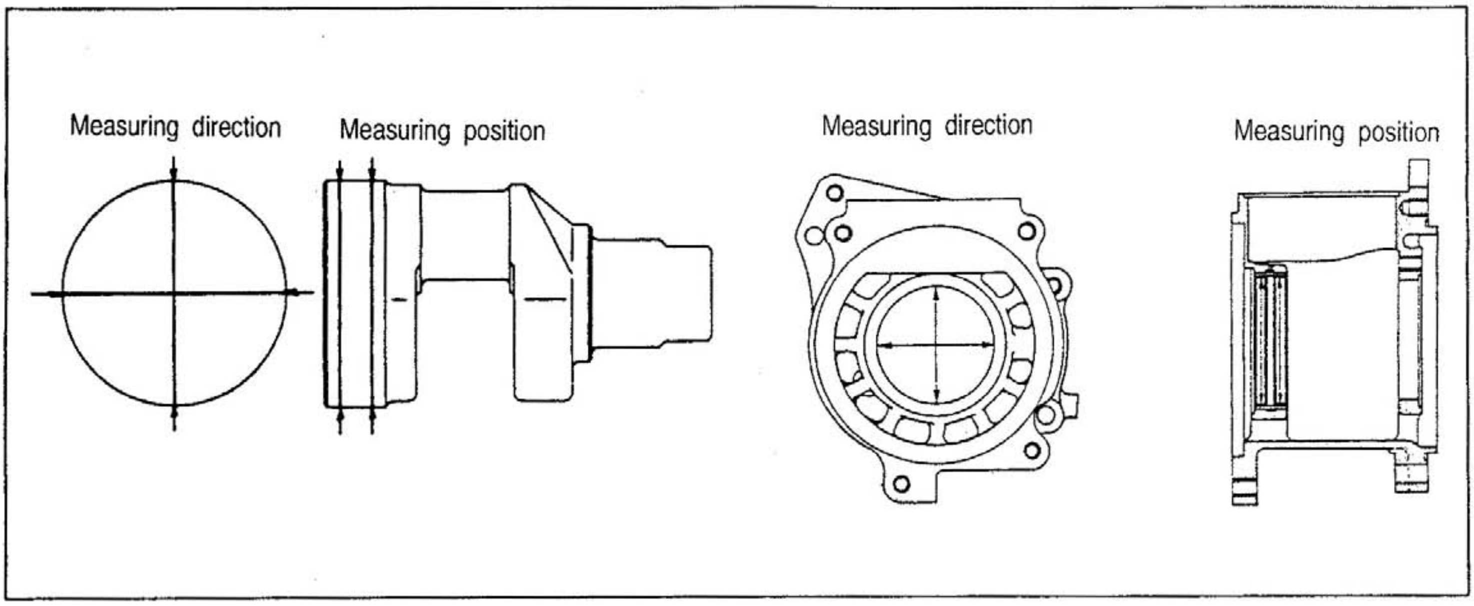
Measure the end play of the connecting rod on crankshaft. If the service limit is exceeded, Replace the connecting rod.



(8) Measurement of Clearance between Crankshaft Journal and Bearing

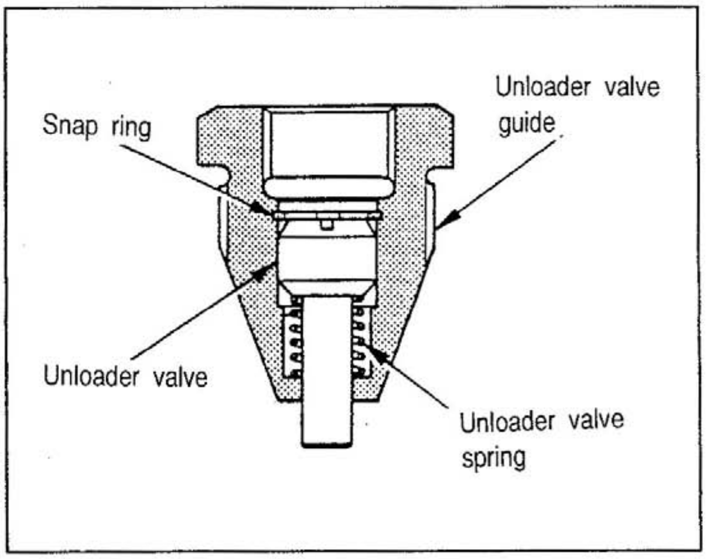
Calculate the clearance from the measurements of crankshaft journal O.D. and bearing I.D.

If the service limit is exceeded, replace the bearing

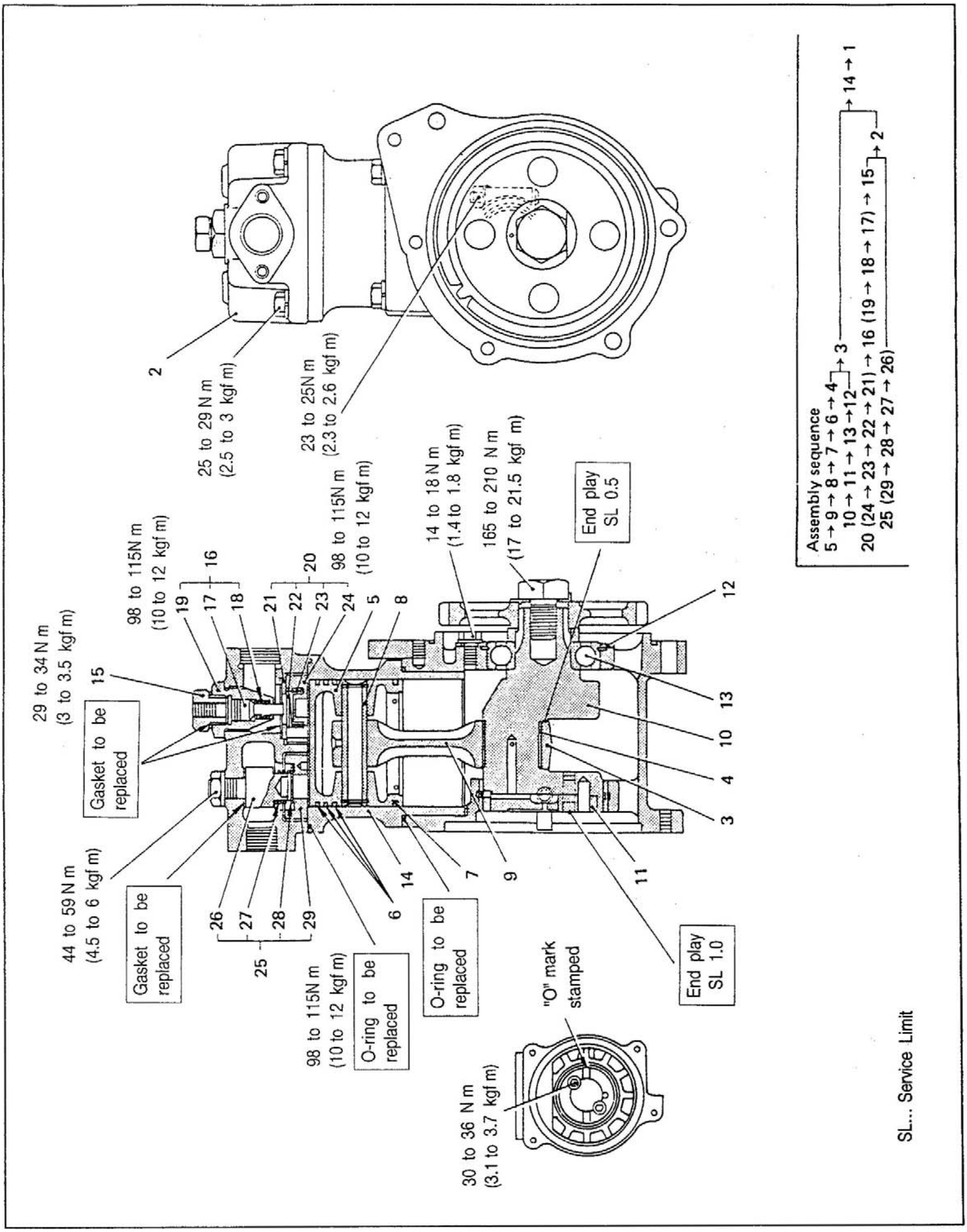


(9) Replacement of Unloader Valve

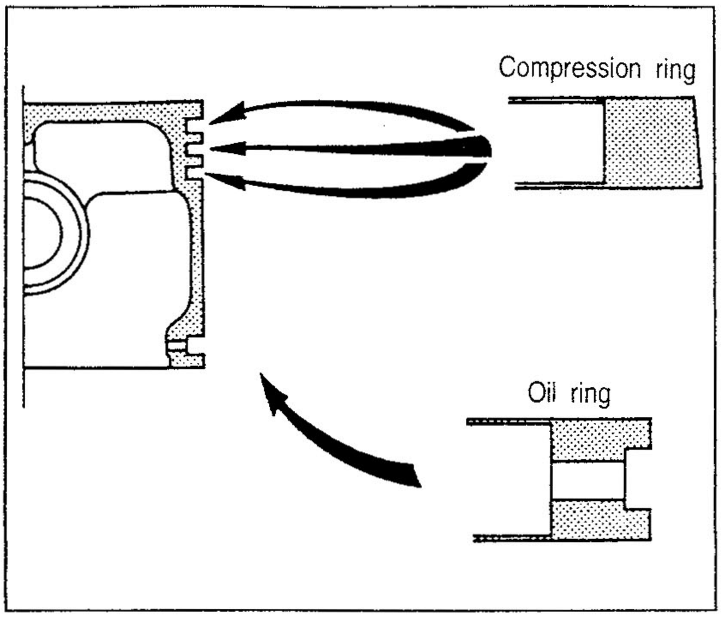
If the unloader valve is badly worn, replace it as an assembly.



12-1-3 Reassembly

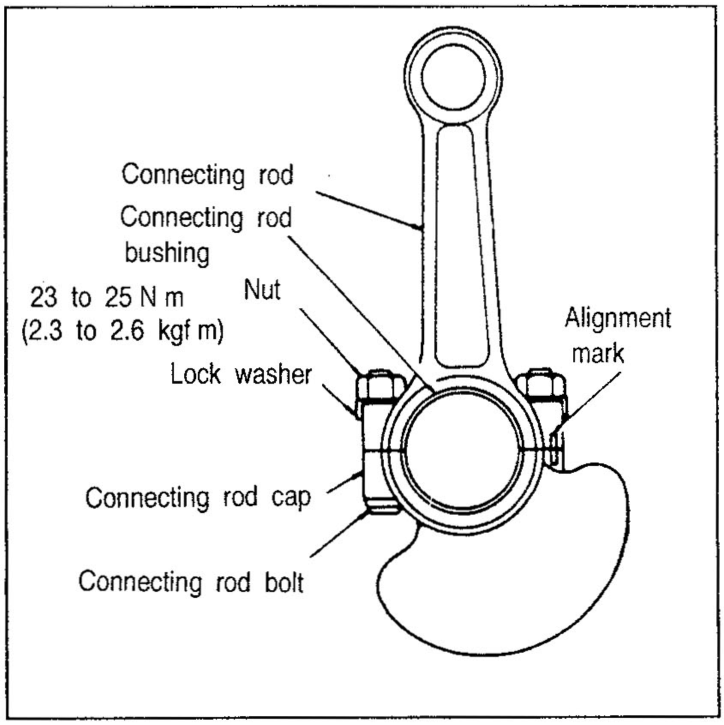


(1) Installation of Piston Rings.

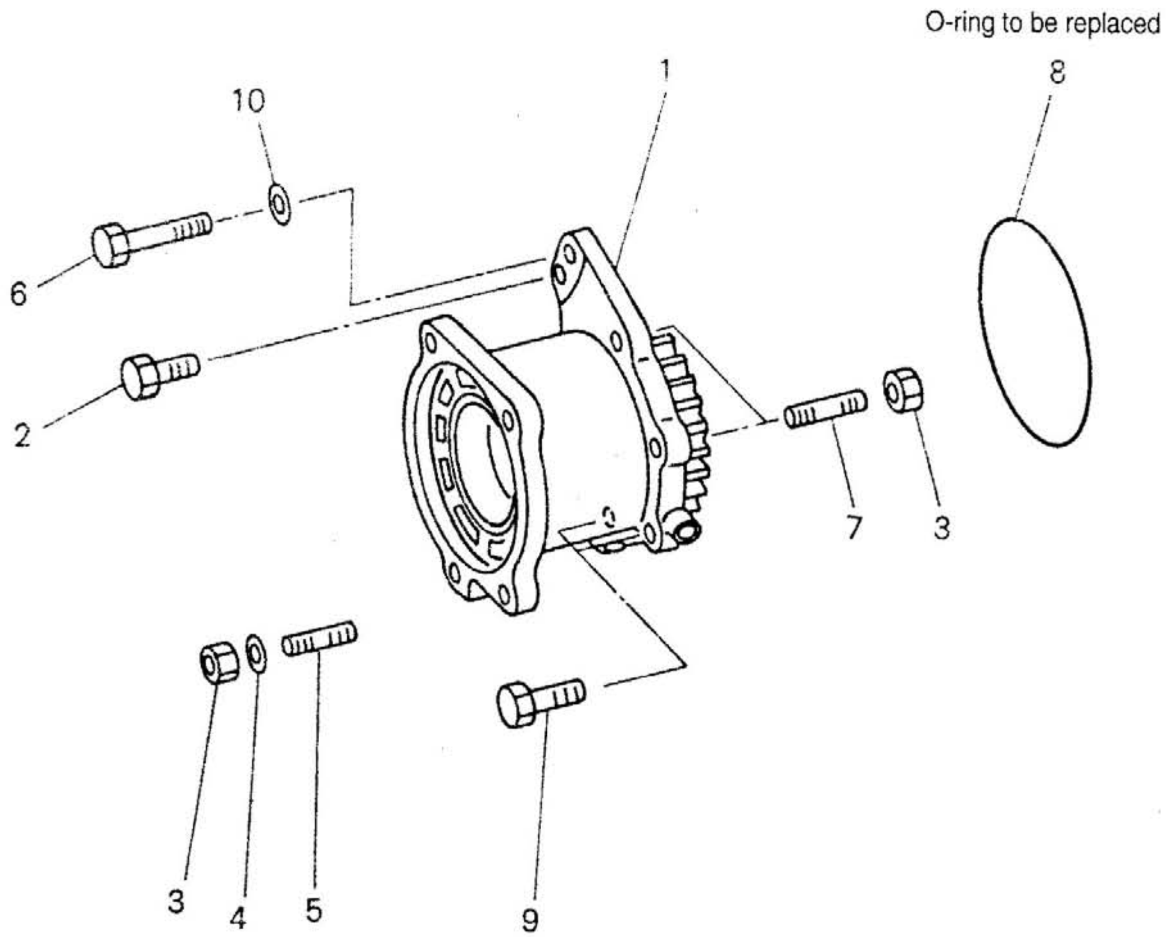


(2) Installation of Connecting Rod

Reassemble aligning the alignment mark of the connecting rod with that of the connecting rod cap.



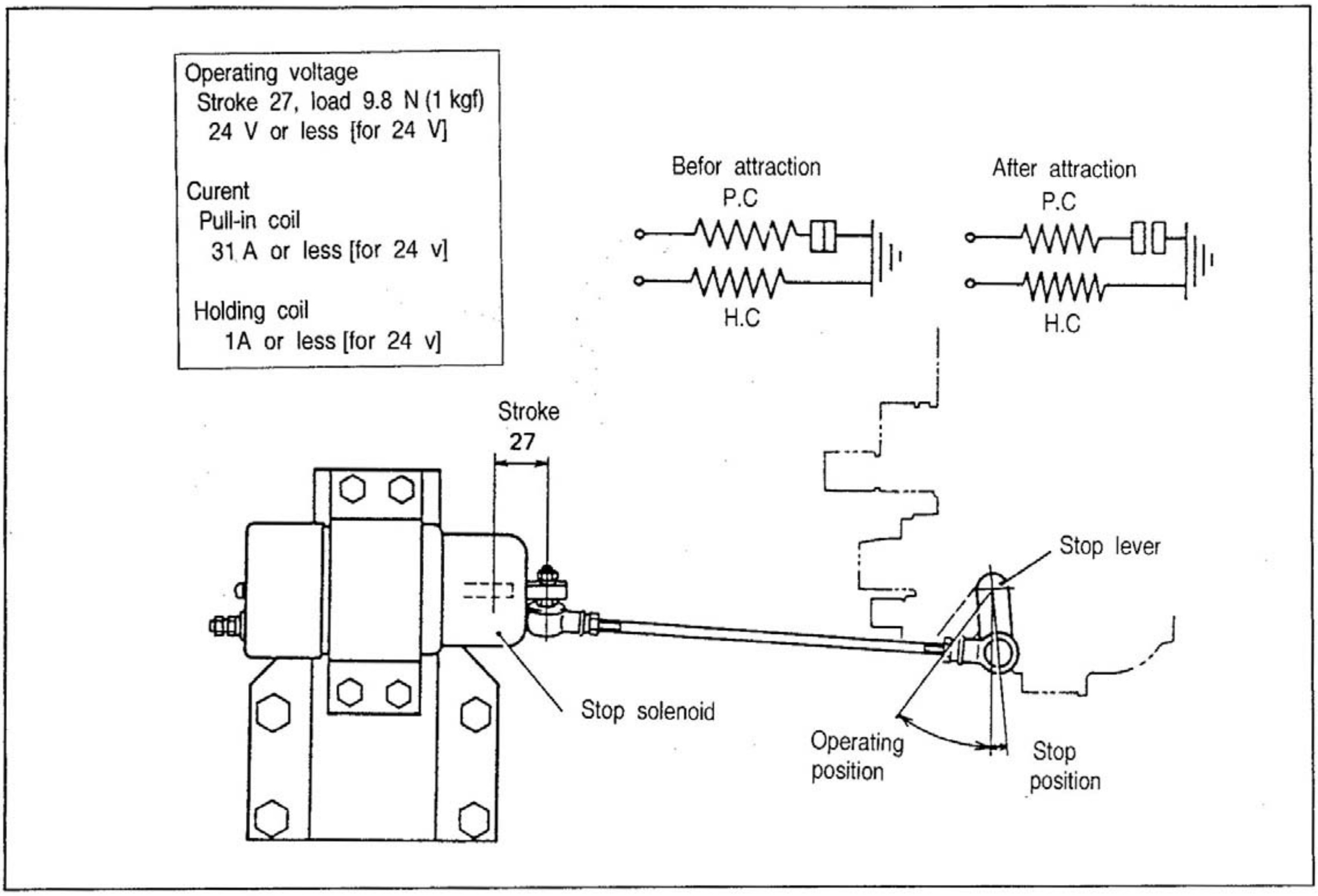
12-2 INJECTION PUMP DRIVE



1. Crank case
2. Bolt
3. Nut
4. Washer
5. Stud
6. Bolt
7. Stud
8. O-ring
9. Bolt
10. Washer

12-3 AUTOMATIC STOP SYSTEM

12-3-1 Stop Sloenoid (Energize TO RUN Type)



Energize the stop solenoid and check to see that the run lever comes to the run position. Using an ammeter, check to see that when the solenoid is held, only the holding coil is energized.

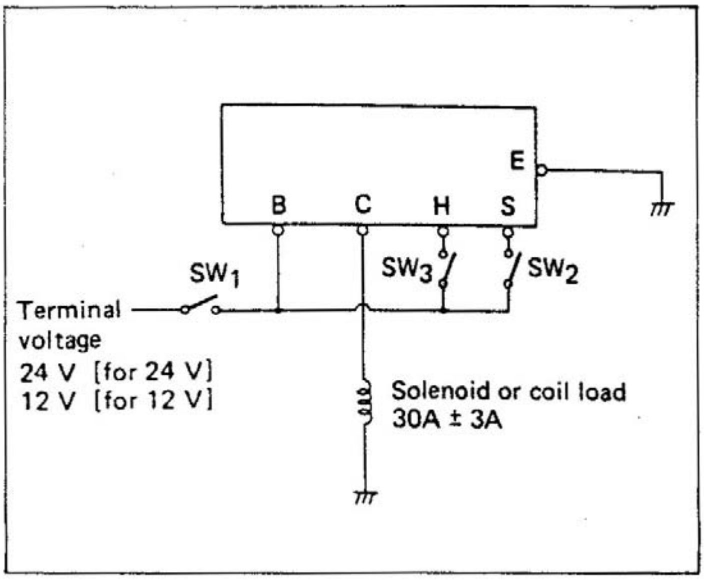
12-3-2 Solenoid Relay

Wire as shown at right and check the following

(a) Relay operation and delay time

1) Check if the solenoid is energized when switches SW1 and SW2 are tured ON.
2) Using a stopwatch, measure the time required for the solenoid to return after switch SW2 is turned OFF.

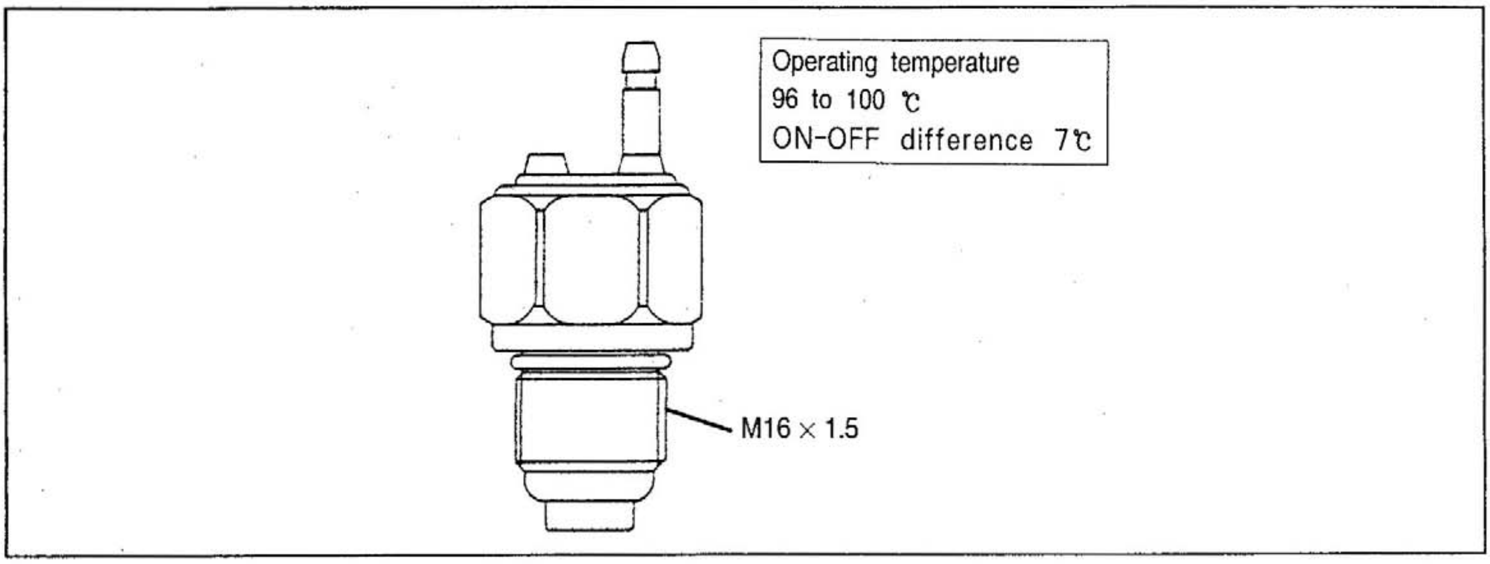
Dalay time:30 ± 4 seconds



(b) Relay holding

1) Turn ON switches SW1 and SW2 and, after the solenoid is activated, turen ON the switch SW3.
2) Turn OFF the switch SW2 and make sure that the solenoid remains activated for more than 34 seconds.
3) After verifying 2) above, turn OFF the switch SW3 to ensure that the solenoid returns.

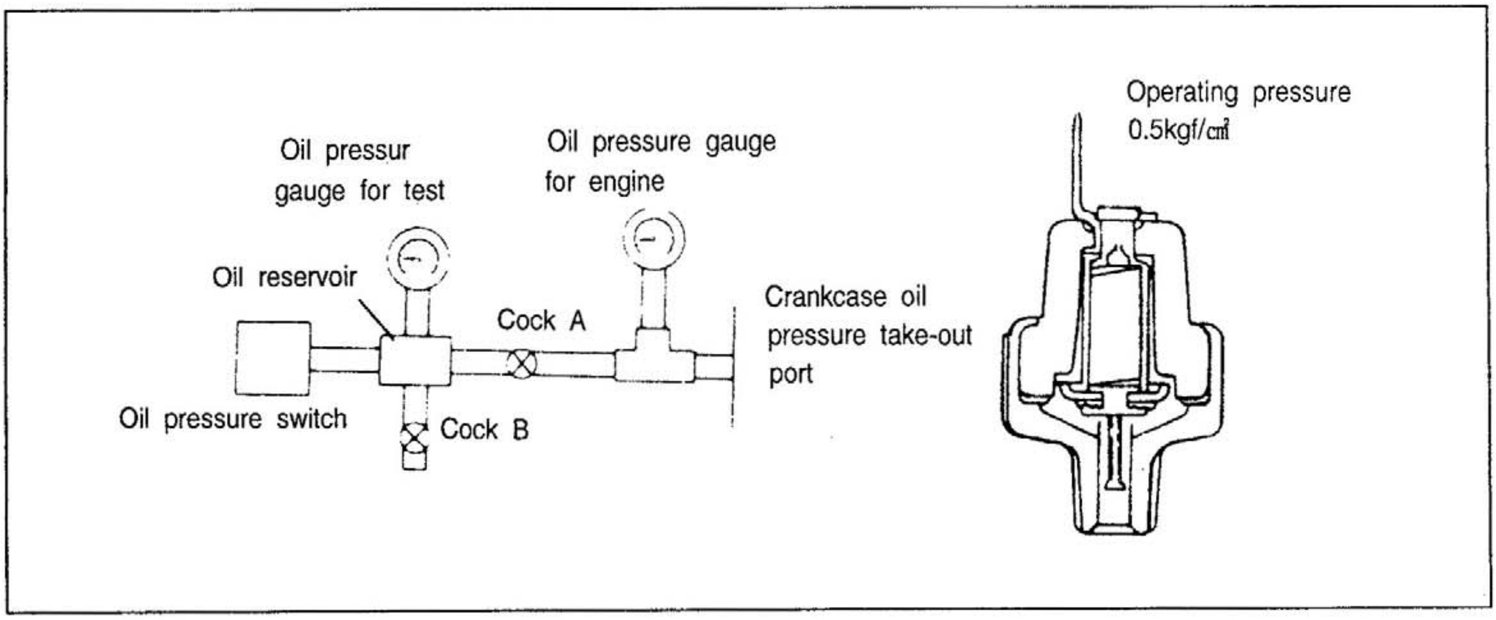
12-4 OVER HEAT WARNING UNIT



The over heat waring unit won't operate if the temperature-sensing portion is not in contact with coolant. If the coolant level is low or if there is only steam, the thermo switch won't operate completely.

Immerse the temperature-sensing portion in water, heat the water, and check the thermo switch operating temperature with a mercury thermometer.

12-5 OIL PRESSURE SWITCH



Connect the pipes as shown above, close the cocks A and B, and start the engine. After the oil pressure has risen, fully open the cock A to lead the oil pressure to the oil pressure switch. Then close the cock A to shut off the oil pass age to the engine and hold the oil pressure directly in the oil reservoir.