



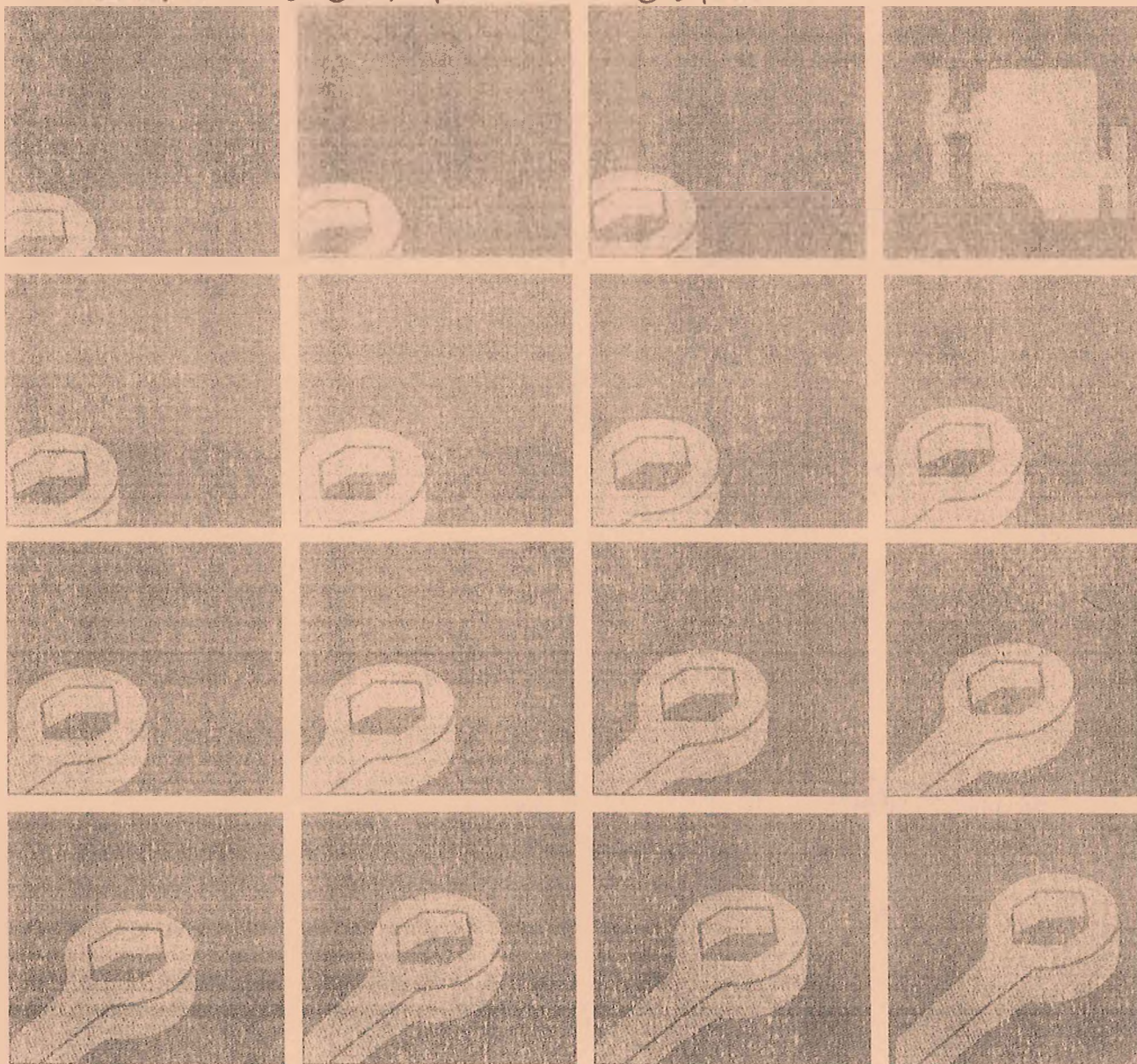
Shop Manual

diesel engine

for parts
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6D2 (for industrial use)

6D22 6D22T 6D22TC



6D2

ENGINE

Shop Manual

FOREWORD

This shop manual contains the specification, construction, operation, adjustment and service procedures of the Model 6D22, diesel engine for service mechanics engaged in servicing of the Mitsubishi 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 this shop manual.

MAR. 1989

Applicable Engine Models

6D22	}	For industrial use
6D22-T		
6D22-TC		

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ORGANIZATION – GROUP CLASSIFICATION

1. GROUP CLASSIFICATION

This manual is organized into several groups classified according to the engine basic elements.

No.	Group name	Description
00	General	External view, major specifications, engine outputs classified by application, engine numbers, caution plate, general precautions for servicing, general bolts and nuts tightening torque table
11	Engine	Engine proper (cylinder head, valve mechanism, camshaft, piston, crankshaft, timing gear, flywheel), specifications, service standards, special tool, troubleshooting
12	Lubrication	Lubrication system (oil pump, oil filter, oil cooler), specifications, service standards, special tool, troubleshooting
13	Fuel and engine control	Fuel system (injection pump, injection nozzle, fuel filter, pump drive case, water separator), specifications, service standards, special tool, troubleshooting
14	Cooling	Cooling system (water pump, thermostat, radiator, cooling system cleaning procedures, fan), specifications, service standards, special tool, troubleshooting
15	Intake and exhaust	Air cleaner, turbocharger, after cooler, specifications, service standards, special tool, troubleshooting
16	Engine electrical	Starter, alternator, preheating system, relays, automatic stop device, specifications, service standards, special tool, troubleshooting
21	Clutch	Clutch proper, bearing case, specifications, service standards, special tool, troubleshooting
61	Special equipment	Air compressor, air pressure governor, specification, service standards, special tool

NOTE:

Each group starts with page 1.

ORGANIZATION – TERMS AND UNITS, TABLE OF CONVERSION RATE FOR FOOT-POUND UNITS INTO SI UNITS

2. TERMS AND UNITS

The following terms and units are used throughout the entire texts of this manual.

(1) Front and Rear

The terms “front” is the fan side and “rear” the flywheel side of the engine.

(2) Right and Left

The terms “right” and “left” shall be used to indicate the side as viewed from the flywheel side of the engine.

(3) Service Standard Terms

- Nominal value

Shows the nominal dimensions, dimension of an individual part, standard clearance between parts in an assembly, or the standard performance of an assembly.

- Limit

Shows the value of a part at which the part is no longer serviceable from the performance as well as strength viewpoints, requiring replacement or repair.

(4) Tightening Torque

Over- or undertightening of bolts and nuts has critical effects on performance and functions.

Tightening torque is therefore specified for some tightening points.

All tightening torque specifications may be considered as “dry” unless “wet” is specified.

Where no tightening torque is specified, use a torque value specified in the General Bolts and Nuts Tightening Torque Table.

(5) Units

For length, weight, area, and volume, the SI unit (International System of Units) is used with the metric notation jointly shown in parentheses.

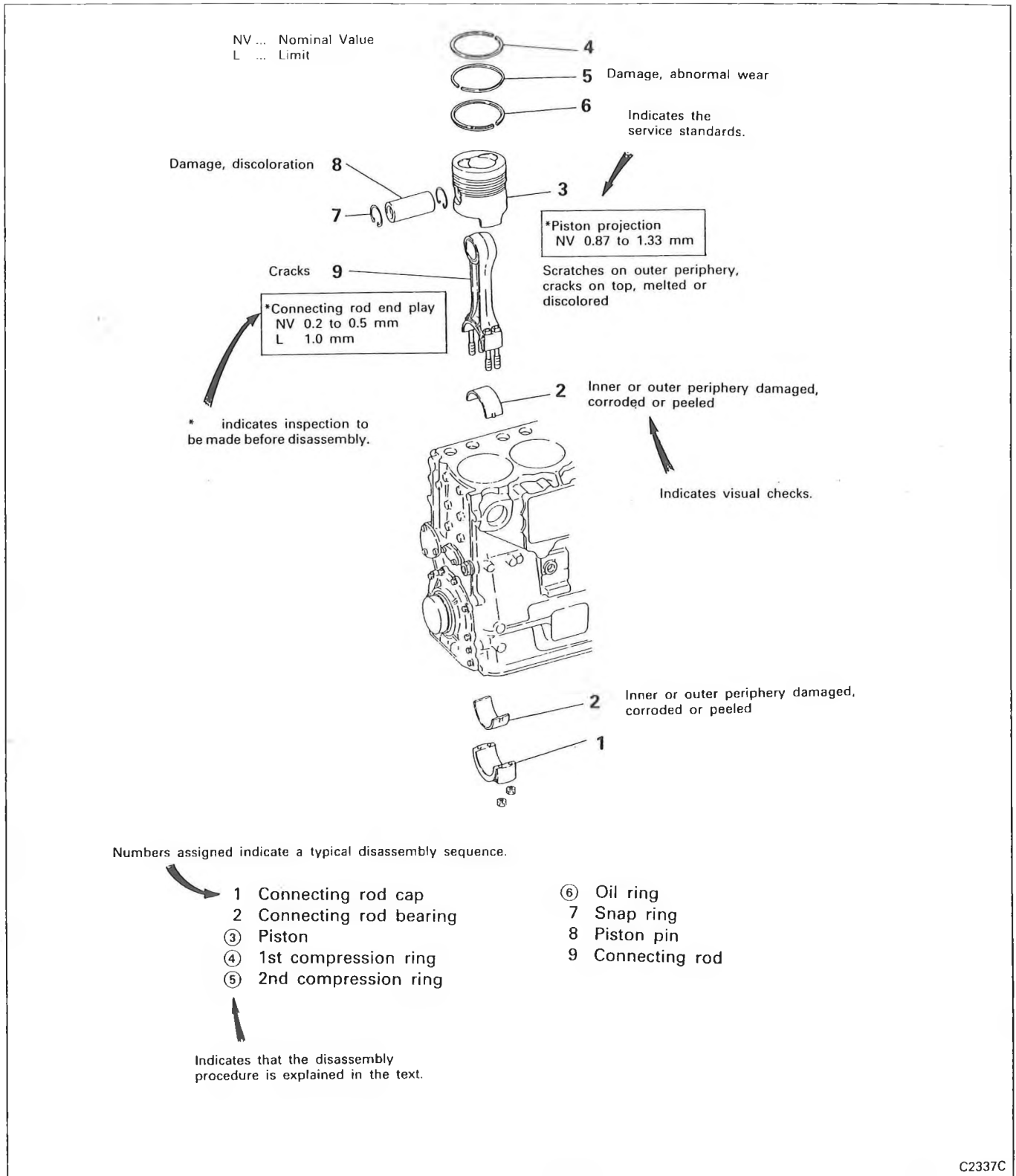
Temperature is shown in centigrade (°C).

3. 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	1 kg = 2.2046 lb 1 g = 0.035274 oz
Dimension	m mm	ft. in.	1 m = 3.2808 ft. 1 mm = 0.03937 in.
Capacity	lit. cc	gal. oz	1 lit. = 0.2642 gal. (U.S.) 1 lit. = 0.220 gal. (Imp.) 1 cc = 0.033814 oz (U.S.) 1 cc = 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/cm ²	lbf/in. ²	1 N/cm ² = 1.45 lbf/in. ²
Moment of force	N m	lbf. ft	1 N m = 0.7375 lbf. ft
Output	kW (kilowatt)	HP	1 kW = 1.34 HP
Temperature	°C	°F	t°C = (1.8t°C + 32)°F

4. READING THE ILLUSTRATION

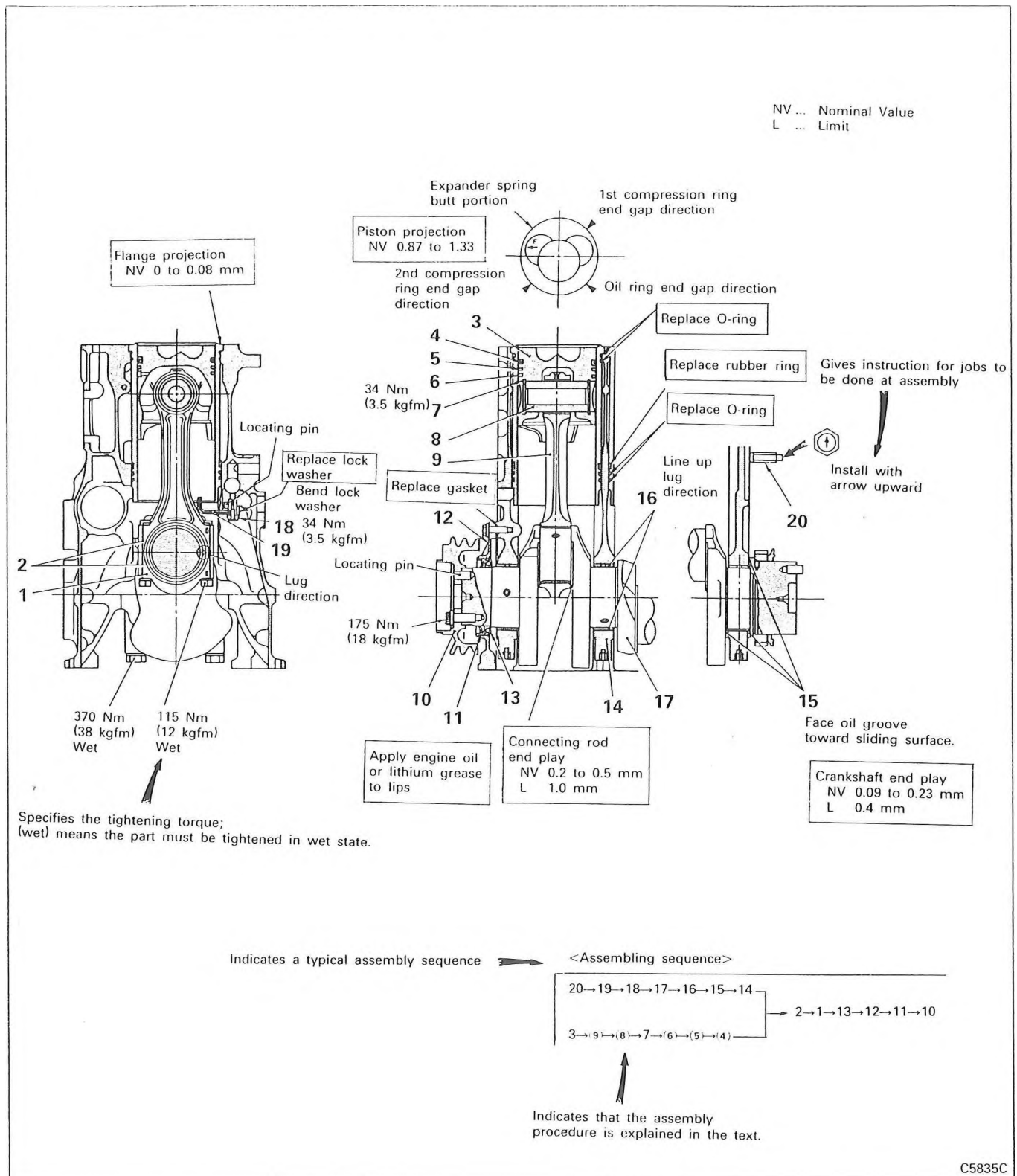
(Ex. 1: Disassembly and Inspection)



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ORGANIZATION – READING THE ILLUSTRATION

(Ex. 2: Reassembly)



(1) Illustrations (exploded views and assembly drawings) show a typical service procedures if it is

identical among various types of available systems and units.

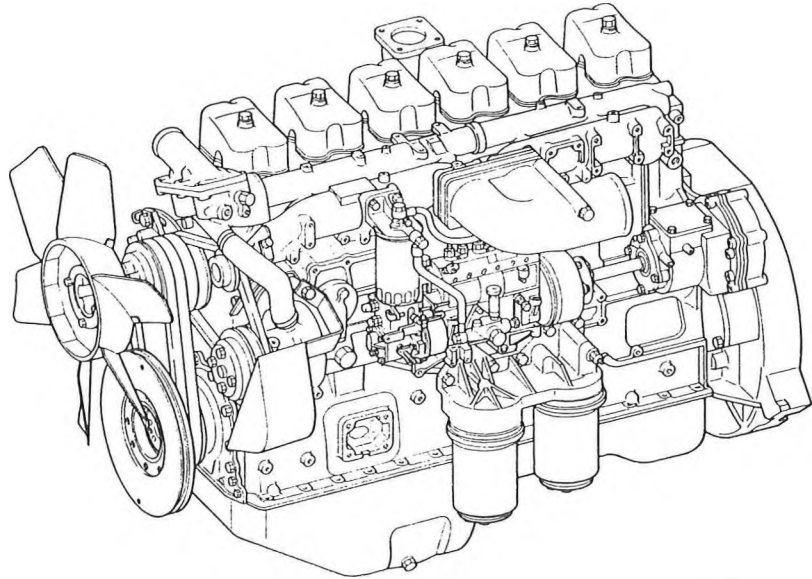
GENERAL

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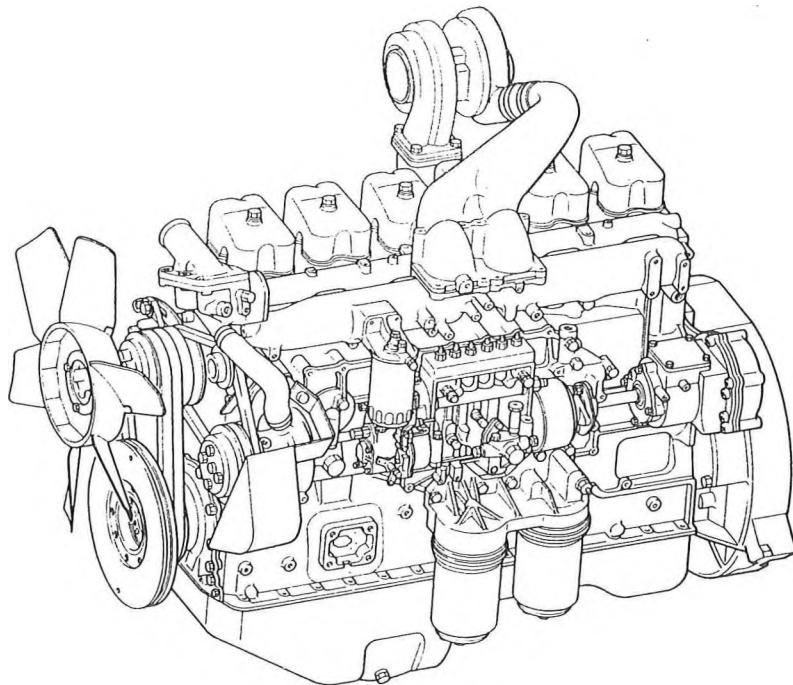
1. EXTERNAL VIEW

<Natural-aspirated engine>



A0243A

<Turbocharged engine>



A0244A

2. MAJOR SPECIFICATIONS

2.1 MAJOR SPECIFICATIONS

Item \ Engine model	6D22	6D22-T (Turbocharged)	6D22-TC (Turbocharged, with after cooler)
Type	Diesel, 4-cycle, water-cooled	Diesel, 4-cycle, water-cooled	Diesel, 4-cycle, water-cooled
Combustion method	Direct injection	Direct injection	Direct injection
No. and arrangement of cylinder	6 in-line	6 in-line	6 in-line
Cylinder bore x stroke mm	130 x 140	130 x 140	130 x 140
Total displacement cc	11 149	11 149	11 149
Engine dimension (without fan)			
Overall length mm	1 390	1 390	1 401
Overall width mm	898	872	882
Overall height mm	1 023	1 162	1 209
Empty weight kg*	980	1 010	1 015

* Empty weight as measured according to Mitsubishi Motors Corporation standard.

2.2 ENGINE OUTPUTS CLASSIFIED BY APPLICATION

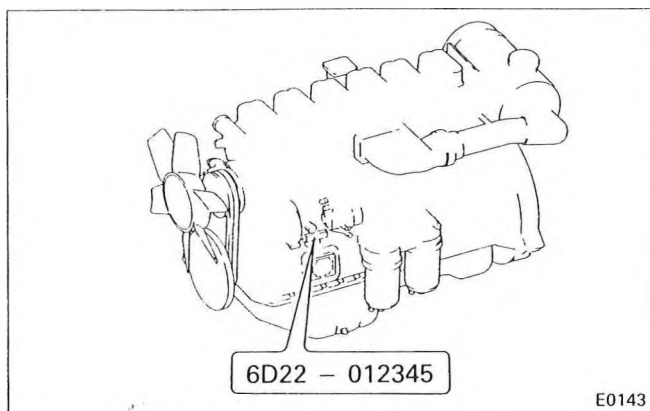
Application \ Engine model	6D22	6D22-T (Turbocharged)	6D22-TC (Turbocharged, with after cooler)
Intermittent rated output kW (HP)/rpm	109 (146)/1 500 129 (173)/1 800 141 (189)/2 000 149 (200)/2 200	161 (216)/1 500 186 (249)/1 800 195 (261)/2 000 201 (269)/2 200	179 (240)/1 500 207 (277)/1 800 219 (294)/2 000 227 (304)/2 200
Continuous rated output kW (HP)/rpm	99 (132)/1 500 117 (157)/1 800 128 (171)/2 000 135 (181)/2 200	146 (196)/1 500 169 (226)/1 800 178 (238)/2 000 183 (245)/2 200	163 (218)/1 500 188 (252)/1 800 199 (267)/2 000 206 (276)/2 200

NOTE:

1. The output (SAE, gross) is corrected to standard ambient conditions based on SAE J1349.
2. The continuous rated output allows 10% (one hour) overload operation.

3. ENGINE NUMBERS AND CAUTION PLATE

(1) Engine Number



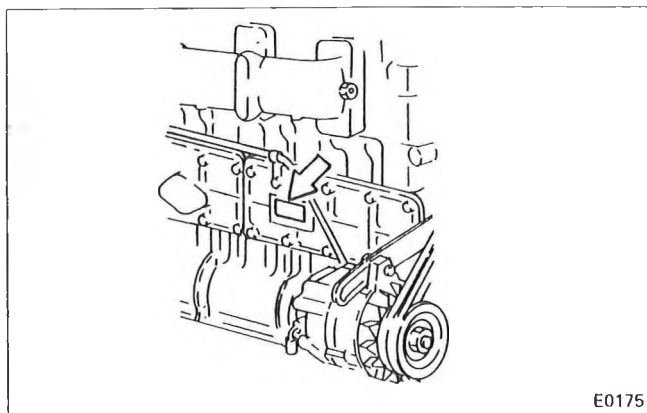
The engine number is stamped on the position as illustrated.

Ex: 6 D 2 2 - 0 1 2 3 4 5

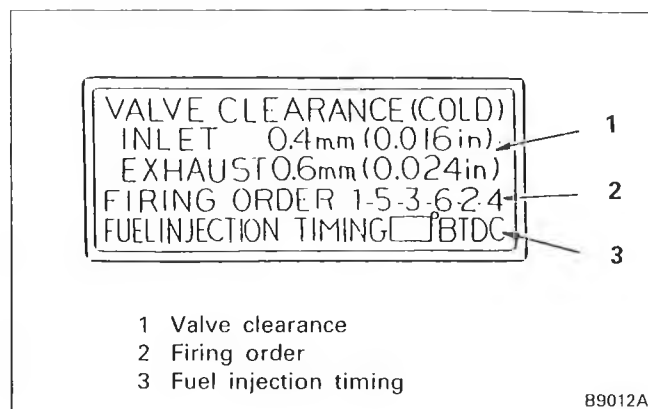
Engine number
Engine model

The engine number is important in knowing the history of the engine.

(2) Caution Plate



The caution plate is located as illustrated. The caution plate bears the valve clearance, fuel injection sequence and timing.



4. GENERAL PRECAUTIONS FOR SERVICING

Before starting the service procedures, check the vehicle for total time driven, use conditions, and user's complaints and requests to know exactly the engine conditions. Record information where necessary.

To ensure you are doing correct and efficient service jobs, observe the following precautions:



(1) Before performing the service procedures given in this manual, know the trouble spots and isolate the possible cause to determine whether the removal or disassembly procedure is required.

(2) Select a flat surface for the service job.

(3) When servicing the electrical system, be sure to disconnect the negative cable from the battery.

(4) Carefully check parts for oil leaks before cleaning. After cleaning, it may become difficult to spot defective areas.

(5) Ready and make the most of the special tools required for servicing. Use the right tools (specified special tools) in the right place to prevent damages to parts and personal injury.

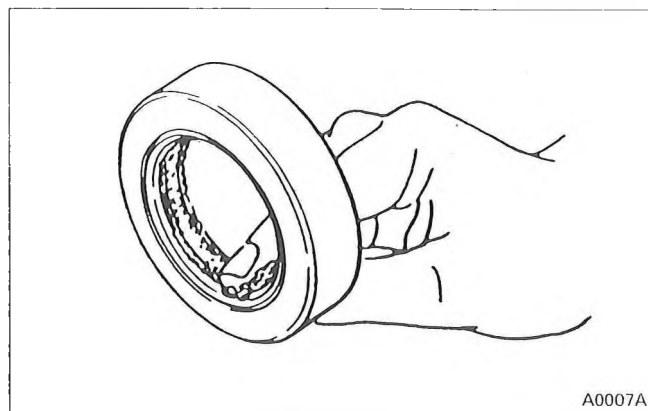
(6) Make alignment marks and keep disassembled parts neatly arranged to ensure that they are reassembled into the right positions.

- Special care must be taken for assemblies involving a number of parts, similar parts, or parts identical at right- and left-hand sides to ensure correct reassembly.
- For alignment and punching markings, select a position that would not mar the appearance and function.
- Clearly distinguish parts to be replaced from those reused.

**MITSUBISHI MOTORS
GENUINE PARTS**

A0006A

(7) The oil seals, packings, O-rings, and other rubber parts, gaskets, and split pins must be replaced with a new one whenever they are removed. For replacement, use Mitsubishi Genuine parts.



(8) Apply the specified grease to U-packings, oil seals, dust seals, and bearings before installation.

(9) When work requires an assistant or two, always make sure of the safety each other. Never play with switches and levers.

(10) Make sure that your shoes are free from grease and oil especially when working on a heavy item.

(11) When checking or changing lubricants, wipe off grease and oil from parts immediately with a waste.

(12) Special care must be taken in handling sensors and relays which are susceptible to shocks and heat.

(13) Use care so that hands and fingers are not injured by sharp edges or corners of the parts.

(14) Wear safety goggles whenever handling a grinder or welding machine. Wear gloves as required to ensure utmost safety.

5. GENERAL BOLTS AND NUTS TIGHTENING TORQUE TABLE

Unless otherwise specified, the parts and equipment of vehicle must be tightened by the following standard bolts and nuts. Tightening torques for these bolts and nuts are shown below.

Standard bolts and nuts

Unit: Nm (kgfm)

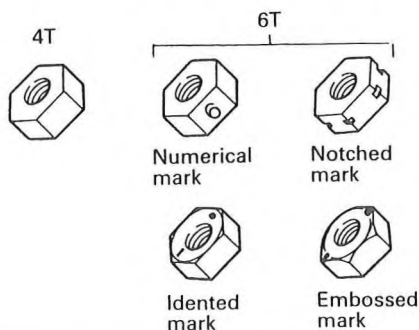
Dia. mm	Pitch mm	4T (Head mark 4 or ○)	7T (Head mark 7 or ⊖)	8T (Head mark 8 or ⊕)
5	0.8	2.0 to 2.9 (0.2 to 0.3)	3.9 to 5.9 (0.4 to 0.6)	4.9 to 6.9 (0.5 to 0.7)
6	1.0	3.9 to 5.9 (0.4 to 0.6)	6.9 to 10.8 (0.7 to 1.1)	7.8 to 11.8 (0.8 to 1.2)
8	1.25	8.8 to 13.7 (0.9 to 1.4)	16.7 to 25.5 (1.7 to 2.6)	19.6 to 29.4 (2.0 to 3.0)
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)
	1.5	17.7 to 26.5 (1.8 to 2.7)	32.4 to 49.0 (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 93.2 (7.0 to 9.5)	83.4 to 108 (8.5 to 11)
	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 (7.5 to 10)
14	1.5	58.8 to 83.4 (6.0 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)
16	1.5	93.2 to 127 (9.5 to 13)	177 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)

Flange bolts and nuts

Unit: Nm (kgfm)

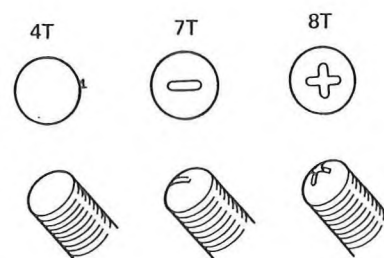
Dia. mm	Pitch mm	4T (Head mark 4 or ○)	7T (Head mark 7 or ⊖)	8T (Head mark 8 or ⊕)
6	1.0	3.9 to 5.9 (0.4 to 0.6)	7.8 to 11.8 (0.8 to 1.2)	8.8 to 13.7 (0.9 to 1.4)
8	1.25	9.8 to 14.7 (1.0 to 1.5)	18.6 to 27.5 (1.9 to 2.8)	21.6 to 32.4 (2.2 to 3.3)
10	1.25	20.6 to 30.4 (2.1 to 3.1)	38.2 to 58.8 (3.9 to 6.0)	49.0 to 63.7 (5.0 to 6.5)
	1.5	18.6 to 28.4 (1.9 to 2.9)	35.3 to 53.0 (3.6 to 5.4)	44.1 to 63.7 (4.5 to 6.5)
12	1.25	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	33.3 to 51.0 (3.4 to 5.2)	68.6 to 93.2 (7.0 to 9.5)	83.4 to 108 (8.5 to 11)

Identification mark of nut



A0066A

Identification mark of stud



A0067A

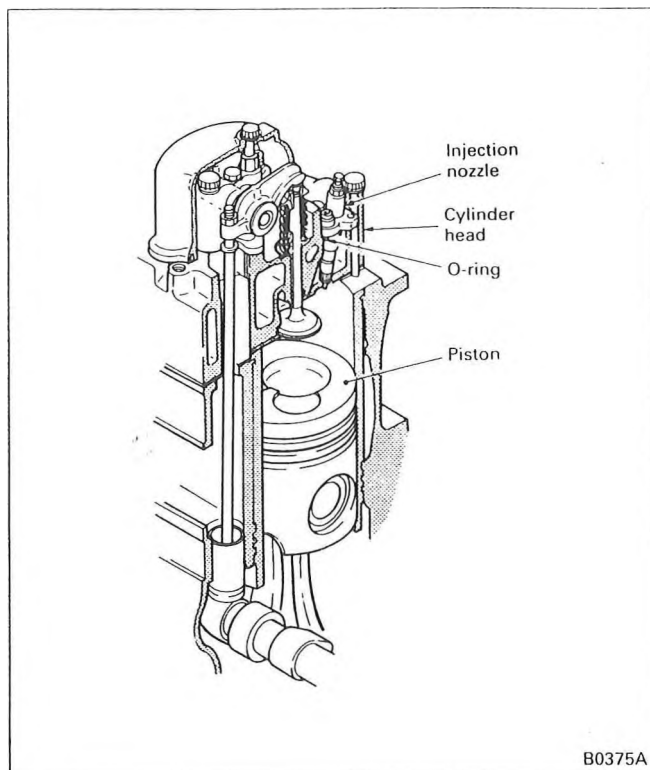
ENGINE

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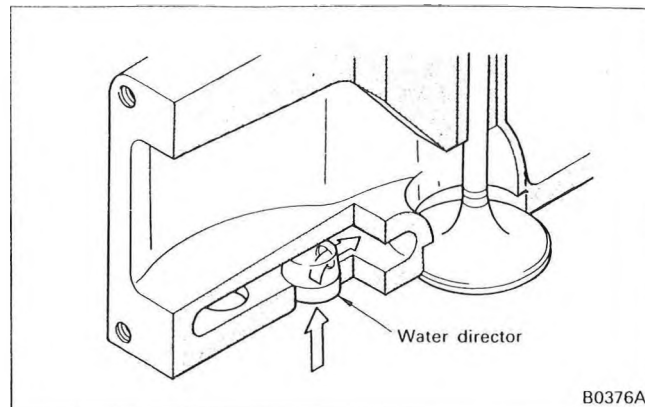
1. GENERAL

(1) Combustion Chamber



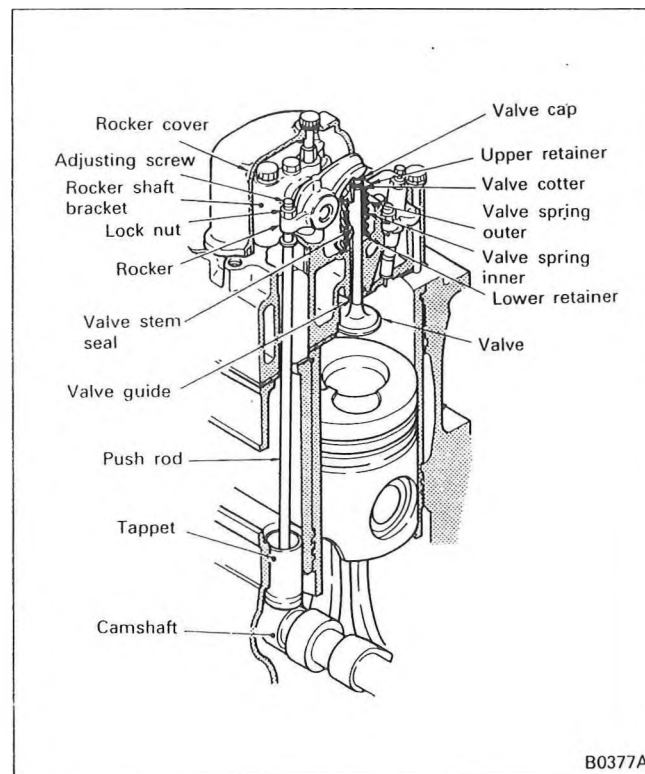
The combustion chamber is made up of the cylinder head and piston top. The injection nozzle as well as the nozzle tube is mounted to the cylinder head. The nozzle tube holds the nozzle in position and protects the nozzle sheathed by it from coolant. Since the outside of the nozzle tube is exposed to the water jacket, the top end of the tube is sealed off with an O-ring and the bottom end staked to prevent entrance of water.

Combustion is accomplished by compressing the fuel directly injected into the combustion chamber.



For more effective cooling of the combustion chamber, water directors which direct coolant flow are pressed into the bottom of the cylinder head.

(2) Valve Mechanism



The valve mechanism is of overhead valve type and is constructed as shown above.

(a) Both inlet and exhaust valves are made of surface-treated heat-resistant steel. The valve seat angle 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.

(b) The valve springs are unevenly-pitched springs. Two inner and outer springs different in coiled direction are installed.

(c) The rocker and rocker shaft are supported on the rocker shaft bracket and are independently installed for each cylinder. Some rockers are used for both inlet and exhaust valves, and the end sliding portion is quenched.

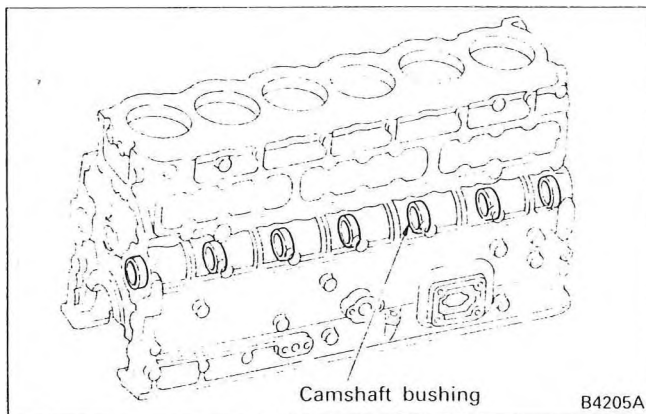
The rocker shaft is a hollow round rod sealed off by thrust plates at both ends. The inside of the shaft constitutes an engine oil passage.

(d) A steel ball and concave piece are respectively welded to the bottom and top ends of the push rod and both ends are case-hardened.

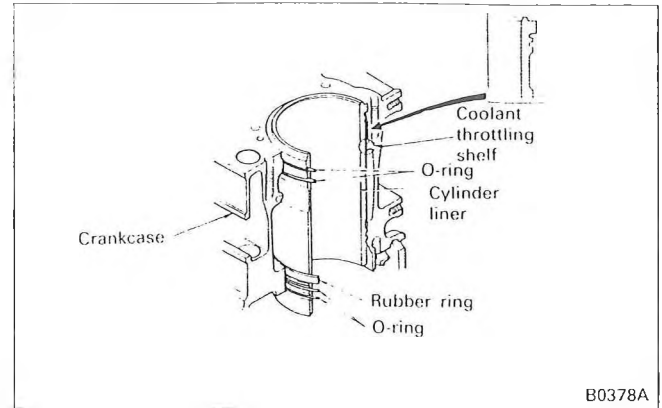
(e) The tappet is of cylindrical shape and its mating surfaces with the camshaft are spherical. The tappet is removable through the side of the crankcase.

(f) The cam profile of the camshaft has a special curve. The surface is induction-hardened to improve the performance of the valve mechanism at high speed operation and improve wear resistance.

(3) Crankcase and Cylinder Liner



(a) Seven camshaft bushings are installed to the camshaft bearing portion of the crankcase. To facilitate insertion and removal of the camshaft from the rear end of the case, the bearing I.D. is narrower toward the front.



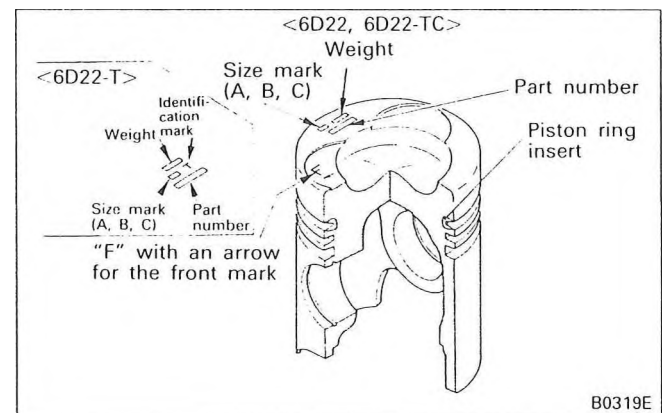
(b) The coolant fed in from the water pump at the left front end of the crankcase cools the oil cooler, then flows through the water jacket holes and around all the cylinders to cool them before reaching the cylinder head.

(c) The cylinder liner is of removable wet type and its top and bottom are press-fitted at the top of the crankcase and the water jacket in crankcase, respectively.

Rubber rings and O-rings are installed at the top and bottom of cylinder liner to prevent entry of coolant. The water jacket has a coolant throttling shelf for higher cooling performance.

(4) Piston and Piston Ring

(a) Piston



The piston, made of aluminum alloy casting, has a toroidal type combustion chamber at its top.

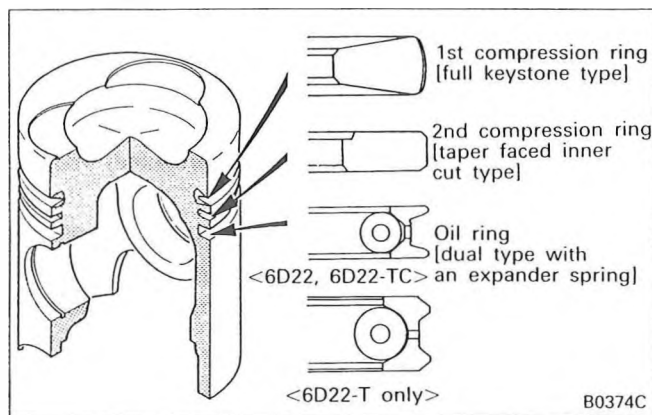
A Niresist piston ring insert is cast into the 1st piston ring groove to increase durability.

Stamped on the top surface of the piston are a size mark (or oversize dimension on oversize pistons) for selection fit with the cylinder liner, a piston weight mark, part number, identification mark, and the "F" with an arrow for the front mark showing the piston installing direction.

Piston pin for connecting piston to connecting rod is of full-floating type and is prevented from moving out by means of a snap ring installed on each end of the pin ends.

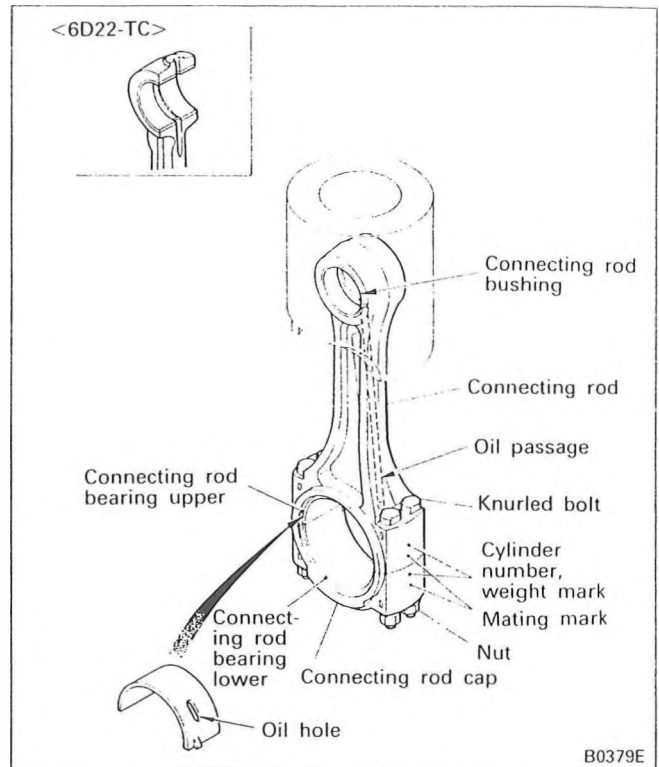
On the piston for the 6D22-TC, a cooling cavity is provided.

(b) Piston ring



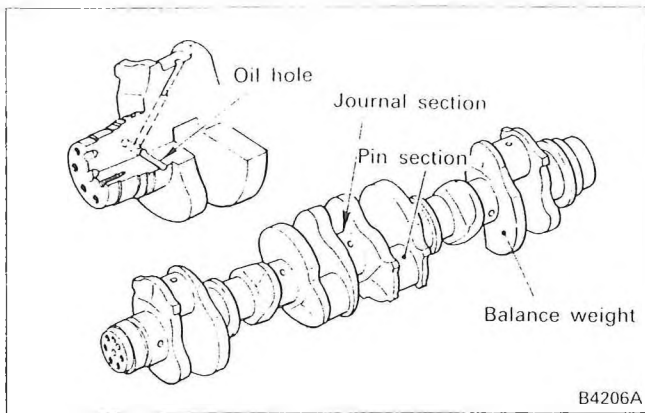
There are three piston rings installed: two compression rings and one oil ring. The sliding surface of each ring is hard chrome plated to improve durability. The piston rings are shaped as shown in the figure.

(5) Connecting Rod and Connecting Rod Bearing



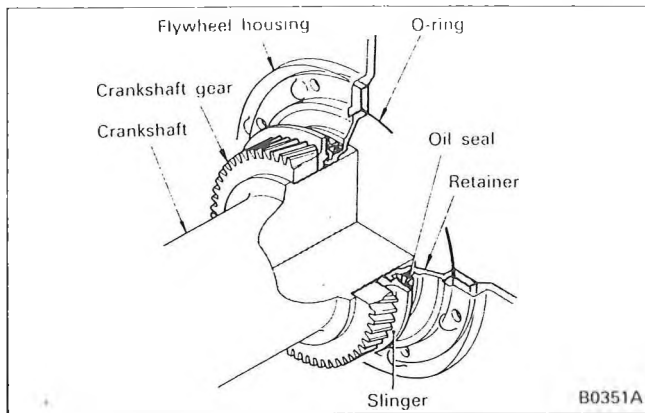
The connecting rod is a die forging of I cross section providing high rigidity. A lead bronze bushing is press-fitted onto the small end. The connecting rod bearing of the big end is a split type plain bearing. Through the stem of connecting rod, an oil passage is provided obliquely to lubricate the small end bushing. On the top of connecting rod for the 6D22-TC, an oil hole is provided for cooling the piston.

The connecting rod and connecting rod cap are coupled with four bolts.

(6) Crankshaft and Main Bearing

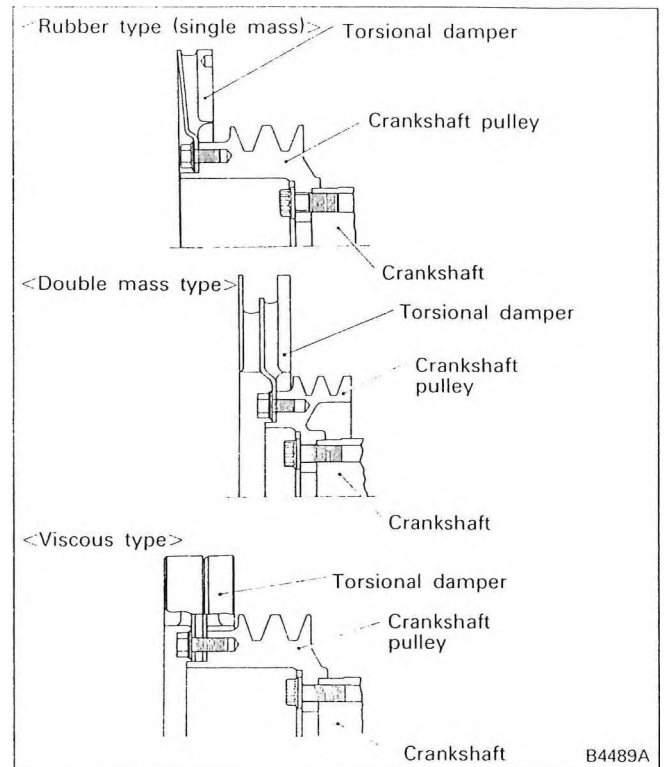
(a) The crankshaft is a high-rigidity die forging integral with the balance weight.

An oil hole in each journal is through to that in pin, feeding some of the main bearing lubricating oil to the pin for lubrication of the connecting rod bearing.

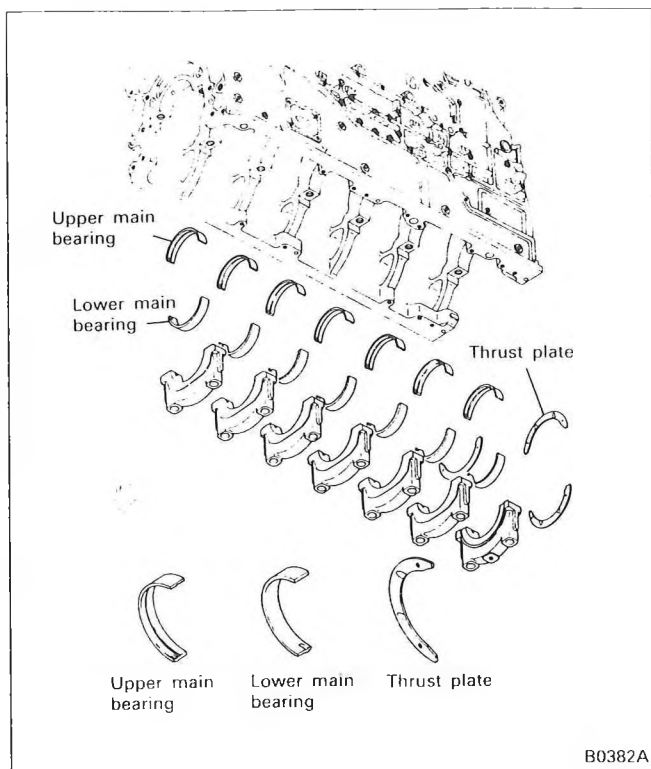


(b) The crankshaft gear driving timing gear is fitted onto the rear end of the crankshaft.

Note that the crankshaft has an axial lip type oil seal fitted to each of its front and rear ends.

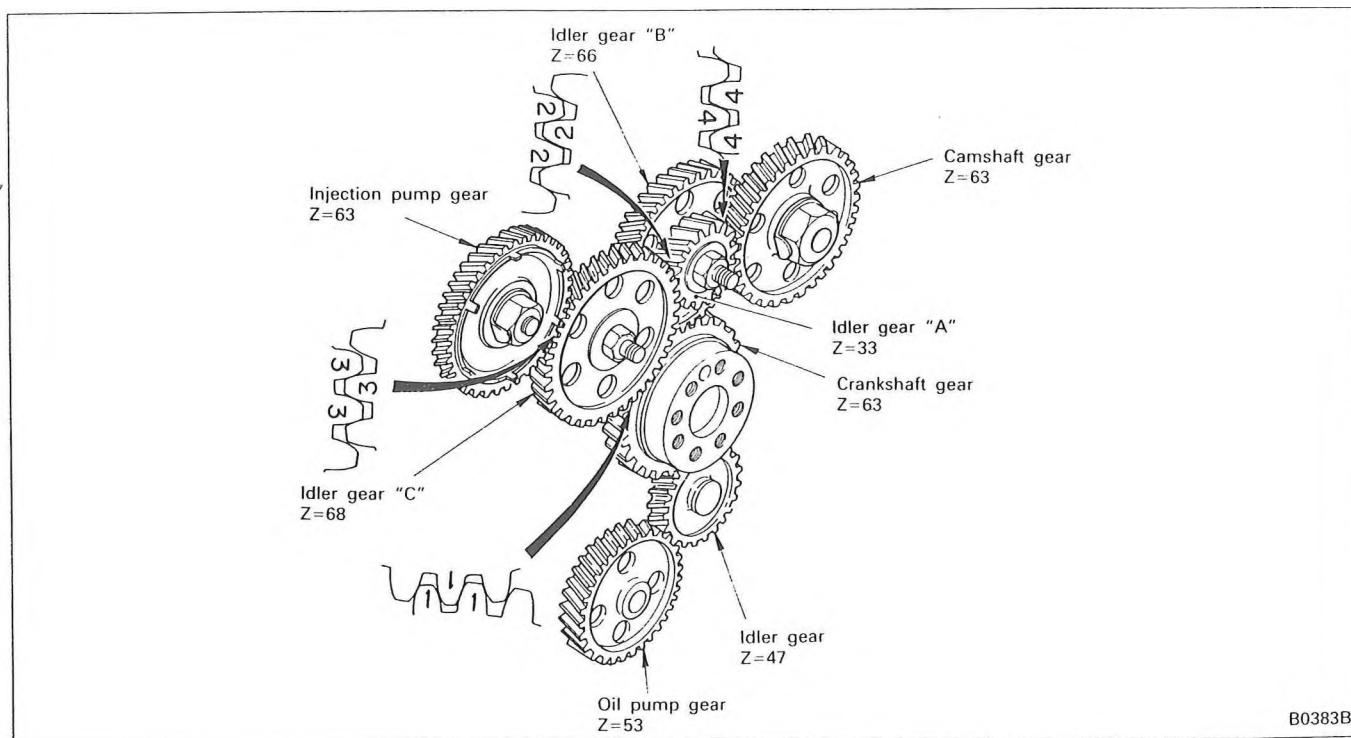


The front portion of the crankshaft is a flange type to which the crankshaft pulley is mounted with bolts. A torsional damper mounted to the pulley absorbs the torsional vibration of the crankshaft.

(a) Main bearing

The main bearing is a split type plain bearing made of special alloy plated kelmet metal with backing metal. The upper main bearing has an internal oil groove and oil hole which coincides with the oil hole in the crankshaft.

Seven pairs of main bearings are provided. Split type thrust plates are mounted to the rear-most bearing to bear the thrust of the crankshaft.

(7) Timing Gears

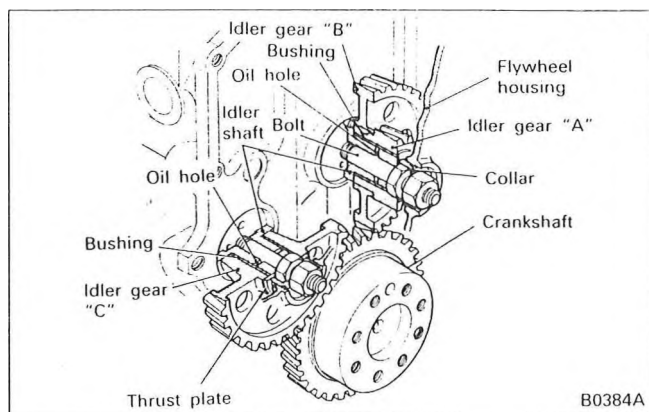
The timing gears are accommodated in the flywheel housing at the rear of the engine. The gear train is as

shown above.

Each gear is a carbon steel helical gear having a high-precision tooth surface machined by the shaving machine and given surface treatment to improve durability.

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

The crankshaft gear, press-fitted onto the crankshaft and held in position by a dowel pin, drives all gears.

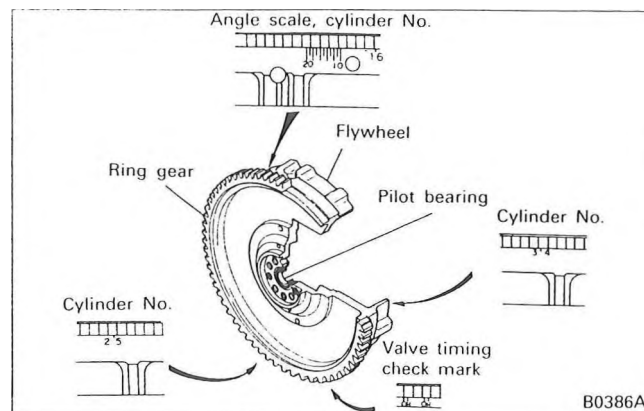


The idler gear is, at one end, mounted to the crankcase with the idler shaft bolt, and supported, at the other end, on the flywheel housing.

A bushing is pressed into the idler gear which turns on the idler shaft.

The bushing is lubricated by the engine oil flowing through the inside of the idler shaft from the crankcase oil hole.

(8) Flywheel



The flywheel is made of cast iron. The pilot bearing of the clutch shaft is installed at the center of the flywheel. The ring gear which meshes with the starter pinion is shrinkage-fitted on the outside periphery of the flywheel.

The ring gear teeth crests 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 numbers and angle scale are stamped on the outside periphery of the flywheel as shown in the figure.

2. SPECIFICATIONS

Item		Specifications		
Engine model		6D22	6D22-T	6D22-TC
Type		Water cooled, 4-cycle diesel	Water cooled, 4-cycle diesel	Water cooled, 4-cycle diesel
Number of cylinders-arrangement		6-in-line	6-in-line	6-in-line
Valve mechanism		Overhead valve	Overhead valve	Overhead valve
Combustion chamber		Direct injection type	Direct injection type	Direct injection type
Cylinder bore x stroke	mm	130 x 140	130 x 140	130 x 140
Total displacement	cc	11 149	11 149	11 149
Compression ratio		17	16	15.5
Firing order		1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4
Cylinder liner	Type	Wet type	Wet type	Wet type
Piston	Type	Trunk, slipper skirt type	Trunk, slipper skirt type	Trunk, slipper skirt type (Cooling cavity provided)
Piston ring	Q'ty	Compression ring: 2 Oil ring: 1	Compression ring: 2 Oil ring: 1	Compression ring: 2 Oil ring: 1

3. SERVICE STANDARDS**3.1 SERVICE STANDARD TABLE**

Unit: mm

Description		Nominal value [Basic diameter]	Limit	Correction and remarks
Compression pressure (at 200 rpm)		2.75 MPa (28 kgf/cm ²)	1.96 MPa 20 kgf/cm ²	Difference between cylinder within 0.39 MPa (4 kgf/cm ²)
Rocker to rocker shaft clearance		[28] 0.03 to 0.08	0.2	Replace bushing.
Outer valve spring	Free length	89.38	85	Replace.
	Load (Installed length: 58.35)	450 N (46.1 kgf)	380 N (39 kgf)	
Inner valve spring	Free length	65.04	62.0	Replace.
	Load (Installed length: 50.35)	115 N (12 kgf)	100 N (10.2 kgf)	
	Squareness	—	2.5	
Crankcase tappet hole to tappet clearance		[35] 0.06 to 0.10	0.2	Replace tappet.
Push rod runout		—	0.5	Replace.
Cylinder head bottom surface distortion		0.07 or less	0.08	Correct or replace.
Height from top to bottom surface of cylinder head		130	129.8	Replace.
Valve stem O.D.	Inlet	11.95 to 11.96	11.85	Replace.
	Exhaust	11.91 to 11.93		
Valve stem to valve guide clearance	Inlet	[12] 0.05 to 0.09	0.2	Replace valve guide.
	Exhaust	[12] 0.09 to 0.12		
Depth of valve from cylinder head bottom surface	Inlet	0.25 to 0.75	1.0	Replace valve seat insert. Service limit: value when a new valve is installed. (— indicates projection amount.)
	Exhaust	−0.05 to 0.45	0.7	
Valve seat angle		45°	—	
Valve margin	Inlet	2.2	1.7	Replace.
	Exhaust	2.5	2.0	
Seat width of valve seat insert		2.69 to 2.96	3.5	Correct or replace.
Eccentricity of flywheel housing		—	0.2	Correct installed condition.

Unit: mm

Description			Nominal value [Basic diameter]	Limit	Correction and remarks
Flywheel	Eccentricity (Flywheel housing)		—	0.2	Correct installed condition.
	Friction surface distortion		0.1 or less	0.2	Correct.
	Depth from clutch cover mounting surface to friction surface		48	49.5	Replace.
Backlash of timing gears	Between crankshaft gear and idler gear "B"		0.12 to 0.26	0.4	Replace.
	Between idler gear "A" and camshaft gear		0.13 to 0.26	0.4	
	Between idler gear "A" and idler gear "C"		0.13 to 0.26	0.4	
	Between injection pump gear and idler gear "C"		0.12 to 0.26	0.4	
End play of idler gear			0.1 to 0.28	0.4	Replace thrust plate.
Idler shaft "A" to idler gear "A" bushing clearance			[40] 0.03 to 0.06	0.2	Replace bushing.
Idler shaft "C" to idler gear "C" bushing clearance			[46] 0.03 to 0.06	0.2	Replace bushing.
End play of camshaft gear			0.05 to 0.22	0.4	Replace thrust plate.
Camshaft journal to camshaft bushing clearance	No. 1 journal		[65] 0.03 to 0.08	0.25	Replace bushing.
	No. 2 journal		[65.25] 0.03 to 0.08		
	No. 3 journal		[65.50] 0.03 to 0.08		
	No. 4 journal		[65.50] 0.03 to 0.08		
	No. 5 journal		[65.75] 0.03 to 0.08		
	No. 6 journal		[65.75] 0.03 to 0.08		
	No. 7 journal		[66] 0.03 to 0.08		
Cam profile (Difference between lobe height and base circle diameter)		Inlet	[8.83]	8.3	Inlet: lobe height, 56.167; base circle diameter, 47.334
		Exhaust	[8.82]	8.3	Exhaust: lobe height, 56.036; base circle diameter, 47.216
Camshaft bend			0.05 or less	0.08	Replace.
Crankcase top surface distortion			0.07 or less	0.2	Correct.

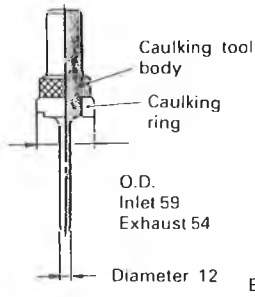
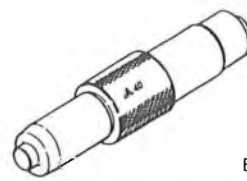
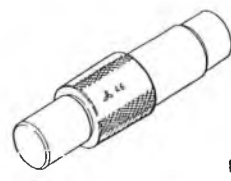
Unit: mm

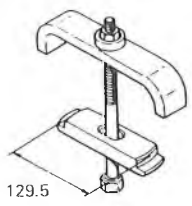
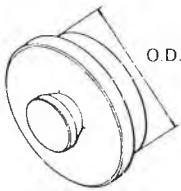
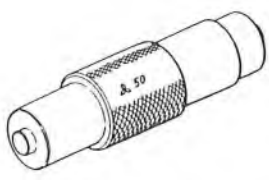
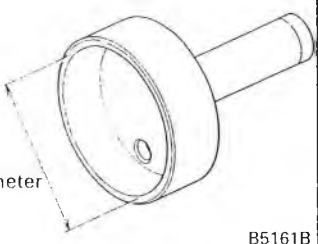
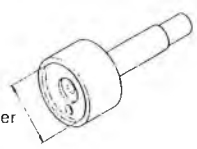
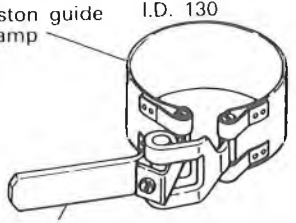
Description			Nominal value [Basic diameter]	Limit	Correction and remarks
Cylinder liner	I.D.		130.014 to 130.054	130.25	Replace or correct to oversize.
	Cylindricity (diameter base)		0.02 or less	—	
	Projection from crankcase top surface		0 to 0.08	—	
Piston to cylinder liner clearance (selection fit)	6D22		[130] 0.178 to 0.204	—	Repair or replace cylinder liner, or replace piston.
	6D22-T		[130] 0.173 to 0.199	—	
	6D22-TC		[130] 0.188 to 0.214	—	
Piston ring groove to ring clearance	1st ring		0.06 to 0.11	0.25	Replace piston ring or piston.
	2nd ring	6D22	0.05 to 0.08	0.15	
		6D22-T, 6D22-TC	0.07 to 0.10		
	Oil ring		0.03 to 0.06	0.15	
Piston ring open end clearance			0.4 to 0.6	1.5	Replace.
Projection of piston from top surface of crankcase			0.87 to 1.33	—	Check each part.
Piston pin hole to piston pin clearance			[50] 0.01 to 0.02	0.1	Replace piston or piston pin.
Flatness of cylinder liner flange supporting surface on crankcase			—	More than 0.1	Replace crankcase.
Connecting rod	Bushing to piston pin clearance		[50] 0.02 to 0.05	0.1	Replace bushing.
	Bend and torsion		—	0.05 or less	Correct or replace.
	End play		0.2 to 0.5	1.0	Replace.
Connecting rod bearing	Oil clearance		[84] 0.07 to 0.13	0.25	Replace bearing.
	Tension when free		—	Less than 90.5	Replace.
Crankshaft	End play		0.09 to 0.23	0.4	Adjust with oversize thrust plate.
	Bend		0.04 or less	0.1	Correct or replace.
	Out-of-roundness of journal and pin		0.01 or less	0.08	Grind and correct to undersize.
	Cylindricity of journal and pin		0.006 or less	—	
Main bearing	Oil clearance		[100] 0.08 to 0.15	0.25	Replace bearing.
	Tension when free		—	Less than 106.5	Replace.
Valve clearance		Inlet	0.4	—	Adjust.
		Exhaust	0.6	—	Adjust.

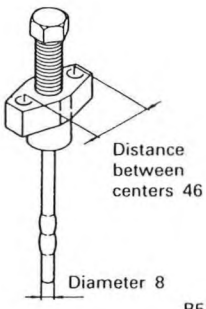
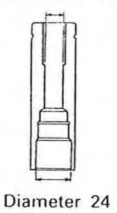
3.2 TIGHTENING TORQUE TABLE

Description		Thread size O.D. x Pitch mm	Tightening torque Nm (kgfm)	Remarks
Engine proper	Cylinder head bolt	M14 x 2	—	Wet For tightening procedure refer to 5.2.3 (6).
	Rocker shaft bracket bolt	M10 x 1.5	34 (3.5)	
	Rocker cover bolt	M10 x 1.25	9.8 (1)	
	Rocker adjusting screw lock nut	M10 x 1.25	59 (6)	
	Oil jet check valve	M12 x 1.75	34 (3.5)	
	Connecting rod nut	M13 x 1.25	115 (12)	Wet
	Main bearing cap bolt	M18 x 2.5	370 (38)	Wet
	Crankshaft pulley bolt	M14 x 1.5	175 (18)	
	Camshaft gear nut	M27 x 1.5	265 (27)	Wet
	Idler shaft bolt "A"	M16 x 2	155 (16)	
	Idler shaft bolt "C"	M16 x 2	155 (16)	
	Idler shaft nut (for mounting collar)	M16 x 1.5	98 (10)	
	Flywheel bolt	M16 x 1.5	315 (32)	Wet
	Flywheel housing bolt	M12 x 1.75	69 (7)	

Tool name		Part No.	Shape	Use
Compression gauge adapter		MH061461	16W x 18 threads Diameter 9 Distance between centers 46 B5001A	Measurement of compression pressure
Thickness gauge		MH061359	B5011A	Adjustment of valve clearance
Valve lifter	Valve lifter	MH061668	Valve lifter Valve lifter seat I.D. 42 Hook B5042A	Removal and installation of valve cotter
	Hook	MH061679		
Nozzle tube remover		MH061232	Diameter 12.5 Diameter 8.7 B5051A	Removal of nozzle tube
Gear puller		MH061061	Maximum pulling O.D. 200 B5071A	Removal of gear and pulley
Piston ring tool		31191-02900	For 102 to 178 diameter B5091A	Removal and installation of piston ring

Tool name	Part No.	Shape	Use
Rocker bushing puller	MH061236	 B5311A	Removal and installation of rocker bushing
Valve guide puller	30091-08100	 B5111A	Removal and installation of valve guide
Valve seat insert caulking tool	Caulking tool body MH061360	 B5202A	Installation and caulking of valve seat insert
	Caulking ring inlet MH061650		
	Caulking ring exhaust MH061651		
Valve lapper	30091-07500	 B5261A	Lapping of valve
Idler gear bushing puller	MH061228	 B5121A	Removal and installation of idler gear bushing (Idler gear "A")
	MH062046	 B4384A	Removal and installation of idler gear bushing (Idler gear "C")
Crankcase table	MH061889	 B1480A	Measurement of flatness of cylinder liner flange supporting surface on crankcase

Tool name		Part No.	Shape	Use
Cylinder liner extractor		MH061490	 129.5 B5131A	Removal of cylinder liner
Cylinder liner installer		MH061759	 O.D. 129.5 B5141A	Press-fitting of cylinder liner
Connecting rod bushing puller		MH061238	 $\phi 50$ B5321A	Removal and installation of connecting rod bushing
Rear oil seal slinger installer		MH061652	 Diameter 123 B5161B	Press-fitting of rear oil seal slinger
Front oil seal slinger installer		MH061817	 Diameter 95 B0585A	Press-fitting of front oil seal slinger
Piston guide	Piston guide clamp	MH061666	 I.D. 130 B5171B	Insertion of piston
	Piston guide lever	MH061658		

Tool name	Part No.	Shape	Use
Nozzle tube stamp	MH061229	 Distance between centers 46 Diameter 8 B5181A	Installation of nozzle tube
Nozzle tube installer flange	MH061416		
Nozzle tube installer bolt	MH061231		
Valve stem seal installer	ME067431	 Diameter 12 Diameter 24 B5191A	Press-fitting of valve stem seal

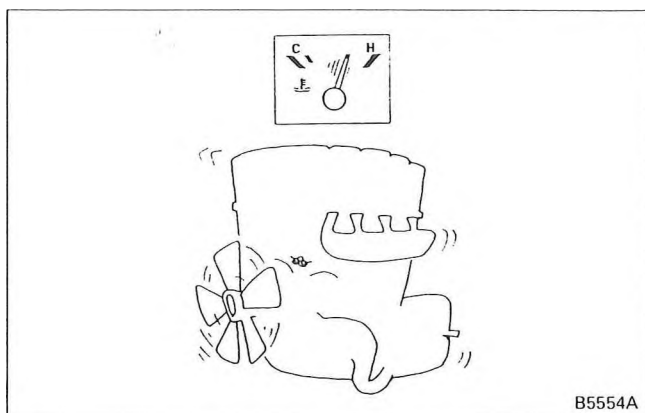
5. SERVICE PROCEDURES

5.1 MEASUREMENT OF COMPRESSION PRESSURE

Compression pressure must be measured prior to disassembly of the engine.

Measure the compression pressure at regular intervals and keep track of its changes. During the break-in period or after parts have been replaced with new ones, there is a slight increase in the pressure as the piston rings and valve seats fit snugly in position. As rough edges and friction between parts are gradually reduced, the pressure comes down.

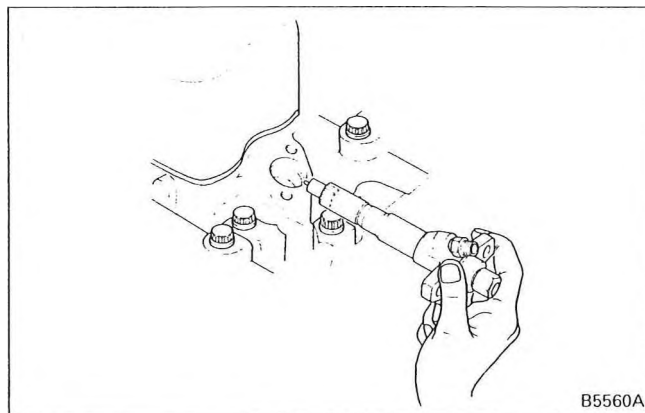
Measurement Procedure



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

NOTE:

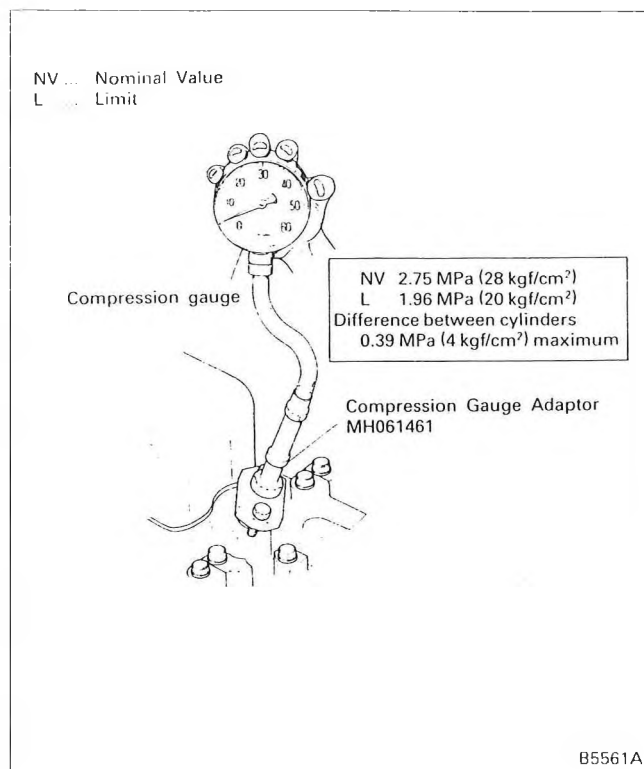
In retightening the cylinder head bolts, observe the tightening sequence in (6) in 5.2.3.



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

NOTE:

Cover the mounting holes and injection pipes to prevent entry of dust and dirt.



(3) Install Compression Gauge Adaptor (special tool) on the injection nozzle mounting hole together with a gasket and connect the compression gauge (measuring instrument).

(4) To make sure that the fuel is not fed under pressure from the injection pump, pull the stop lever of the injection pump all the way in the stop direction beforehand.

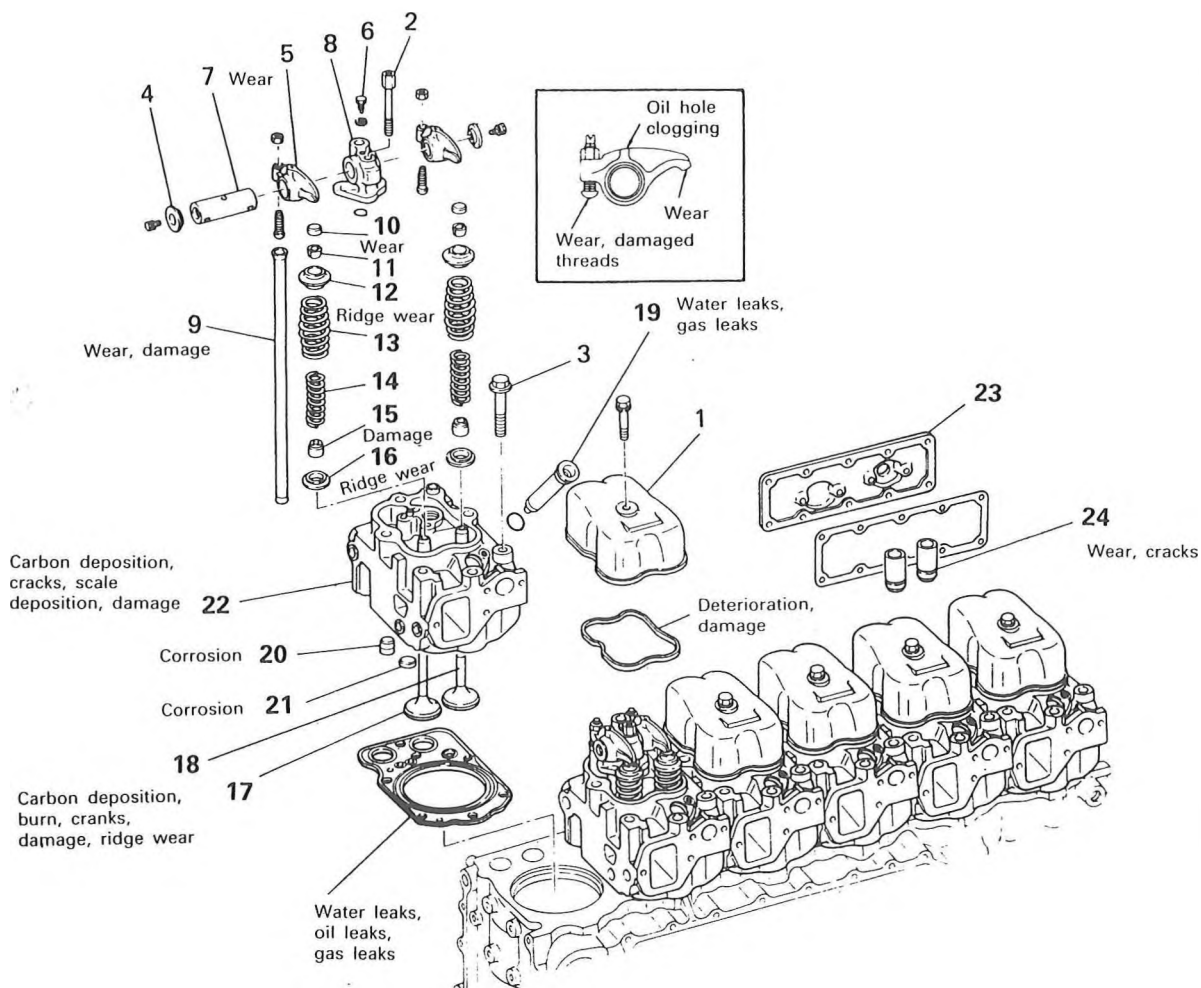
(5) In this condition, let the starter run the engine and measure the compression pressure at a rotating speed of 200 rpm.

NOTE:

1. Make sure that the engine speed is also measured as compression pressure varies with the engine speed.
2. Make measurement for all cylinders, as wear and other conditions vary from one cylinder to another.

5.2 CYLINDER HEAD AND VALVE MECHANISM

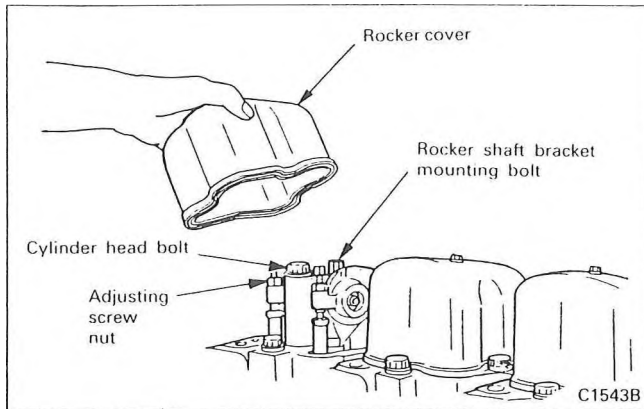
5.2.1 Disassembly



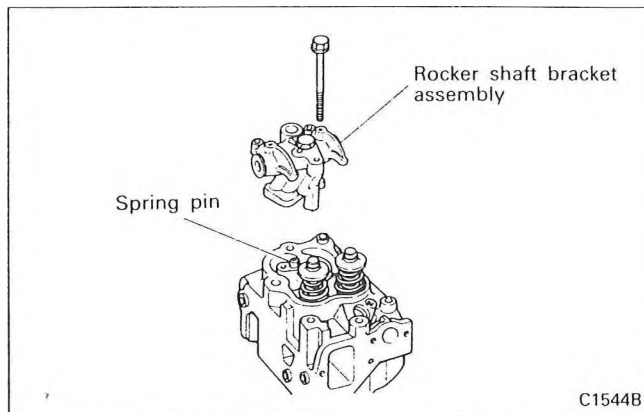
<Disassembly sequence>

- | | |
|--------------------------------|-------------------------|
| 1 Rocker cover | 13 Outer valve spring |
| 2 Rocker bracket mounting bolt | 14 Inner valve spring |
| 3 Cylinder head bolt | ⑮ Valve stem seal |
| 4 Thrust plate | 16 Lower retainer |
| 5 Rocker | 17 Inlet valve |
| 6 Set screw | 18 Exhaust valve |
| 7 Rocker shaft | ⑲ Nozzle tube |
| ⑧ Rocker shaft bracket | 20 Water director |
| 9 Push rod | 21 Sealing cap |
| 10 Valve cap | ⑳ Cylinder head |
| ⑪ Valve cotter | 23 Crankcase side cover |
| 12 Upper retainer | 24 Tappet |

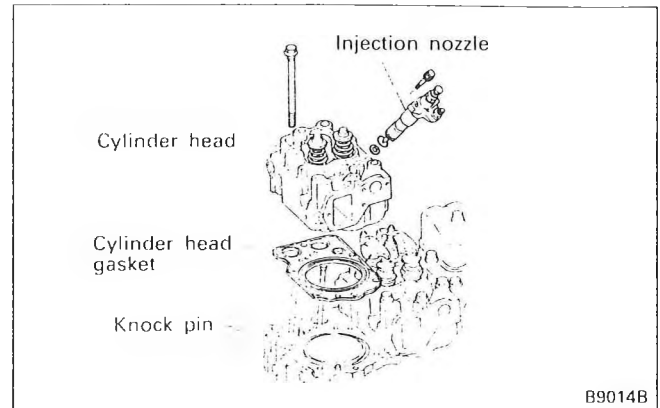
For disassembly of parts with an encircled number, see following items.

Disassembly Procedure**(1) Removal of the Rocker Shaft Bracket Assembly**

(a) Where the push rod is forcing the rocker up, the rocker adjusting screws should be loosened before all bolts are removed.



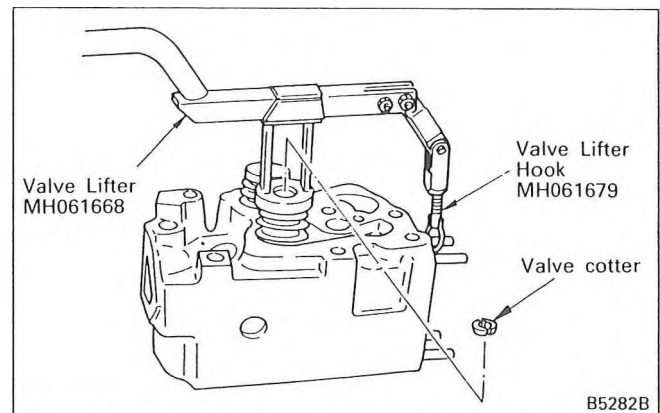
(b) The rocker shaft bracket assembly is held in position on the cylinder head by spring pins. Lift it directly upward to remove it.

(2) Removal of Cylinder Head Assembly

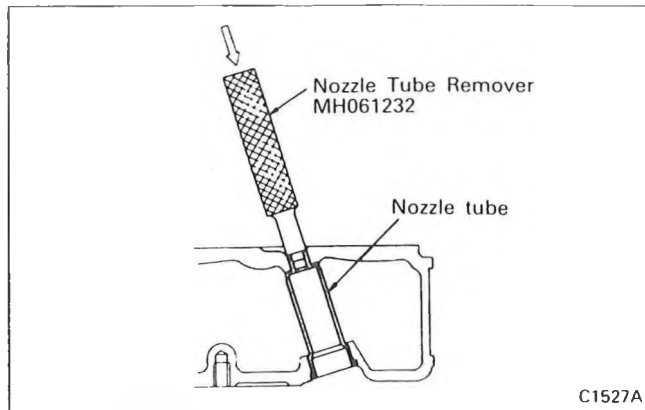
The cylinder head is held in position by the dowel pins on the top surface of the crankcase. To remove the cylinder head, lift it directly upward.

NOTE:

1. To remove the cylinder head, make sure that the injection nozzle is removed beforehand. (Refer to Group 13 Fuel and Engine Control.) If the cylinder head is placed on a workbench with the nozzle still installed, the end of the nozzle extending from the bottom surface of the cylinder head will be damaged.
2. When the cylinder head gasket is removed, use care to prevent damage to the cylinder head and crankcase.

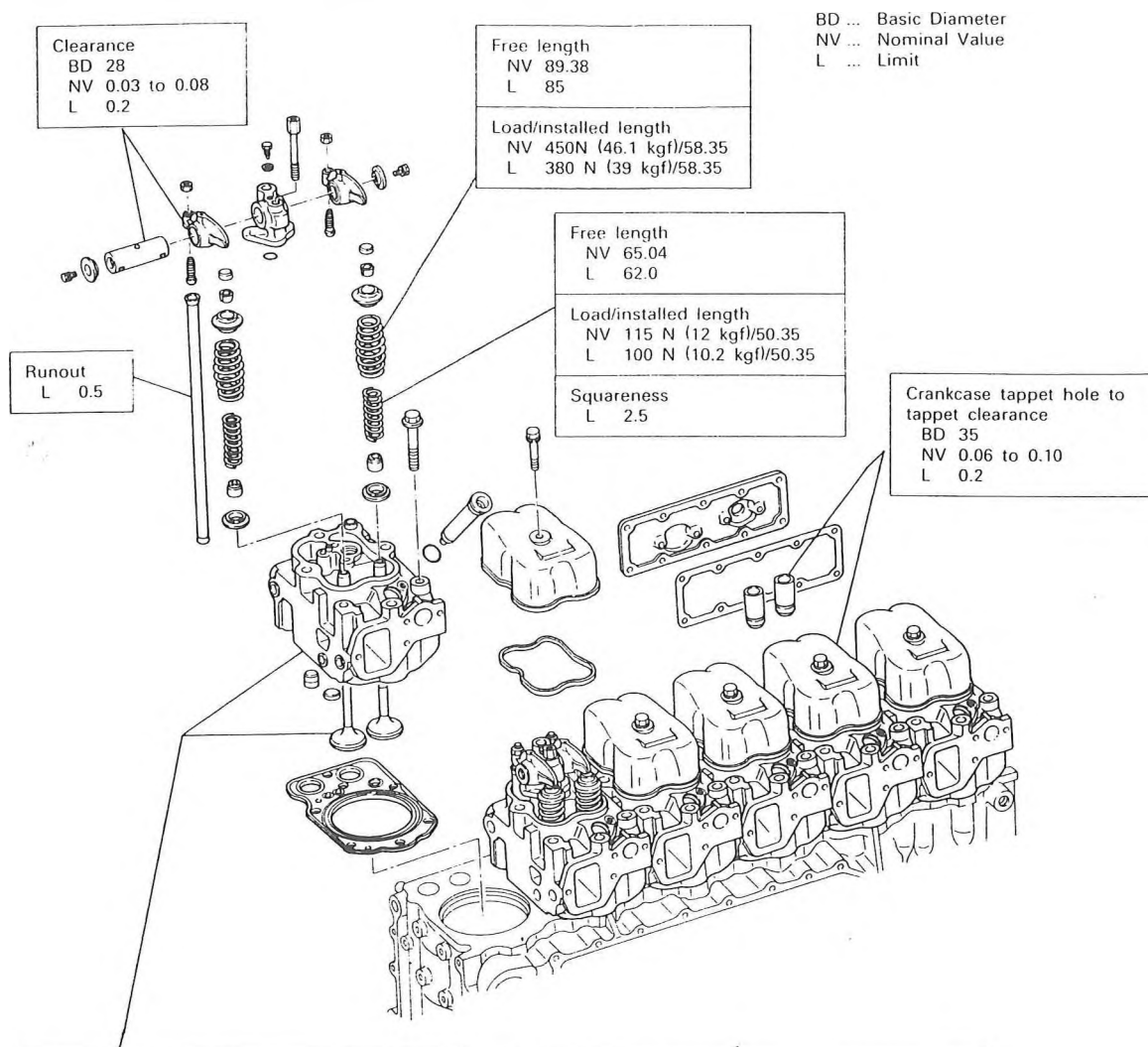
(3) Removal of Valve Cotter

To remove the valve cotter, use special tools (Valve Lifter and Hook) and compress evenly the valve spring.

(4) Removal of Nozzle Tube**NOTE:**

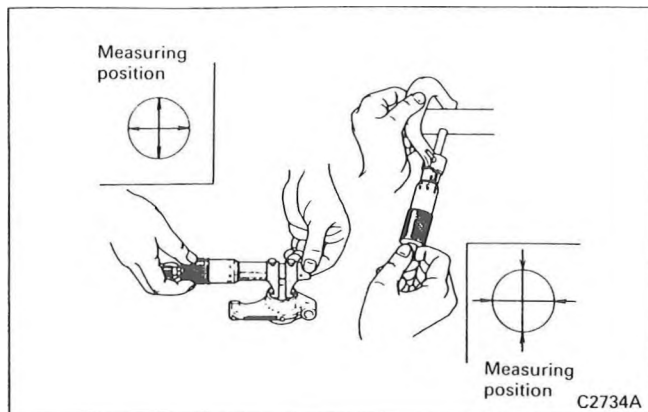
The nozzle tube need not be removed unless water leaks, gas leaks, etc. are evident.

5.2.2 Inspection

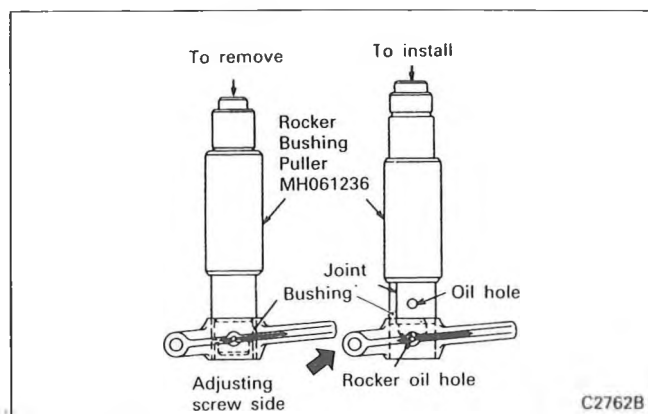


Valve stem O.D.		Valve margin	
Inlet valve	Exhaust valve	Inlet	Exhaust
NV 11.95 to 11.96	NV 11.91 to 11.93	NV 2.2	NV 2.5
L 11.85	L 11.85	L 1.7	L 2.0
Valve guide to valve stem clearance		Valve seat insert seat width	
Inlet valve	Exhaust valve	NV 2.69 to 2.96	
BD 12	BD 12	L 3.5	
NV 0.05 to 0.09	NV 0.09 to 0.12	Distortion of cylinder head bottom surface	
L 0.2	L 0.2		
Depth of valve from bottom surface of cylinder head		NV 0.07 or less	
Inlet valve	Exhaust valve	L 0.08	
NV 0.25 to 0.75	NV -0.05 to 0.45	Height from top to bottom surface of cylinder head	
L 1.0	L 0.7		
		NV 130	
		L 129.8	
		Valve seal angle	
		NV 45°	

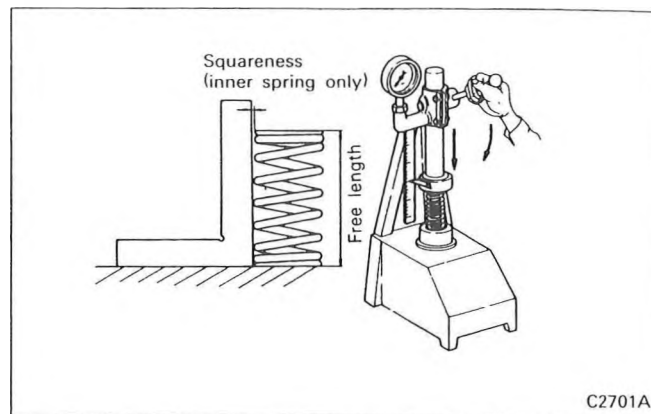
C2757A

Inspection Procedure**(1) Rocker to Rocker Shaft Clearance**

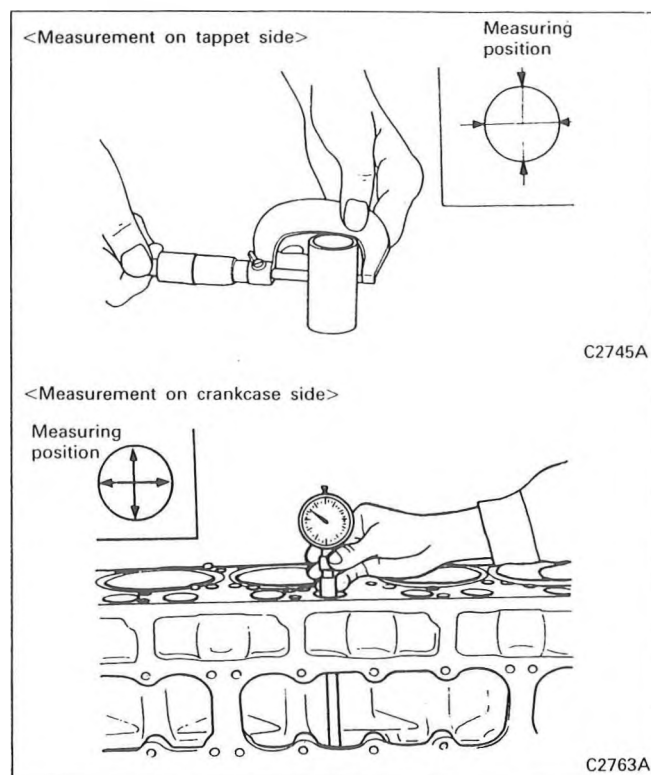
If the limit is exceeded, replace the bushing in the rocker.

(2) Replacement of Rocker Bushing**NOTE:**

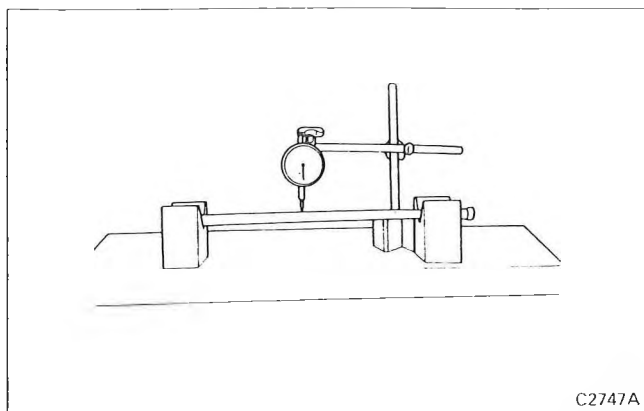
1. Align the bushing and rocker oil holes.
2. Face the bushing joint toward the adjusting screw.

(3) Inspection of Valve Spring

Measure the free length and installed load of the spring and replace if the measurement exceeds the limit. For the inner spring, check also for squareness.

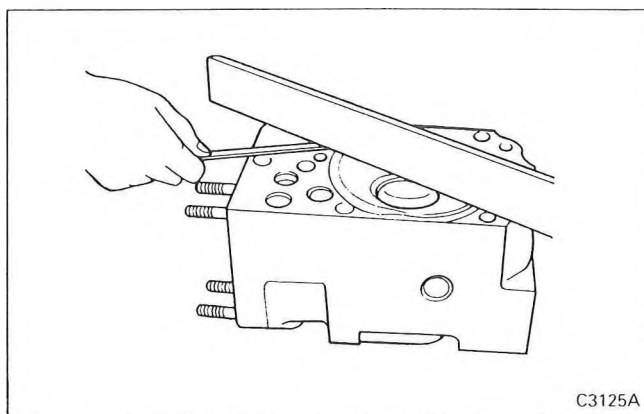
(4) Tappet to Crankcase Clearance

If the limit is exceeded, replace the tappet.

(5) Runout of Push Rod

C2747A

Check for runout and replace if the reading on the dial indicator exceeds the limit.

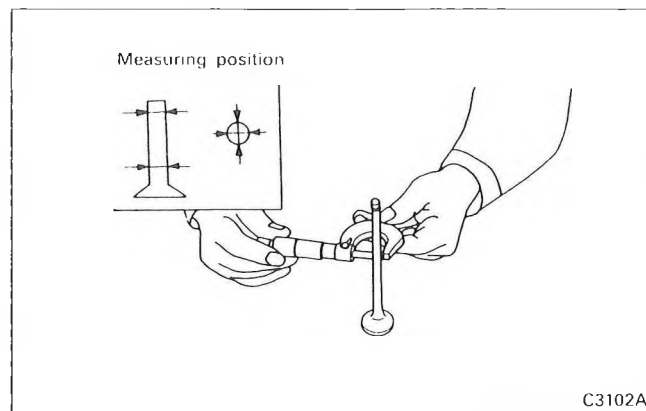
(6) Cylinder Head Bottom Surface Distortion

C3125A

If the limit is exceeded, correct the distortion with a surface grinder.

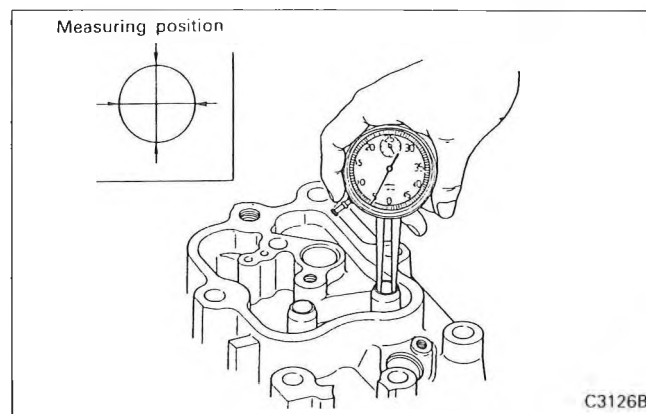
NOTE:

Grind the cylinder head only to the extent that the height from the top to bottom surfaces is within the limit.

(7) Valve Stem O.D.

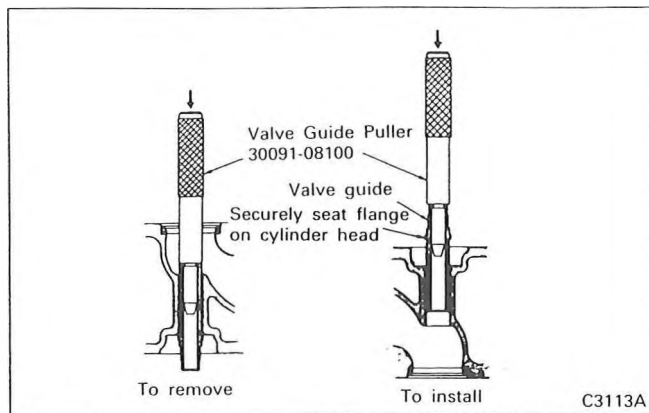
C3102A

Replace the valve if the measurement is below the limit.

(8) Valve Guide to Valve Stem Clearance

C3126B

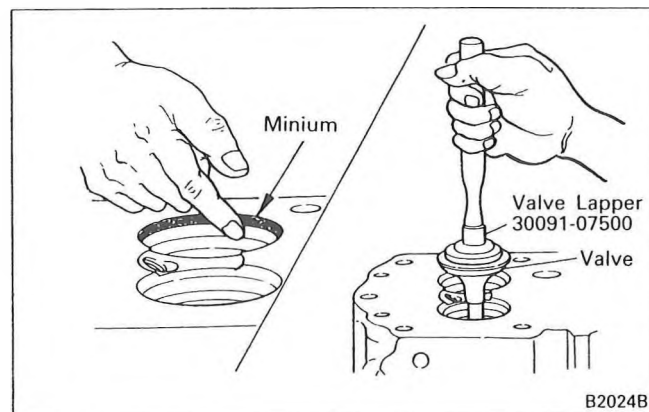
Calculate the clearance from the valve guide I.D. and valve stem O.D. If the limit is exceeded, replace the valve guide.

(9) Replacement of Valve Guide

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

NOTE:

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

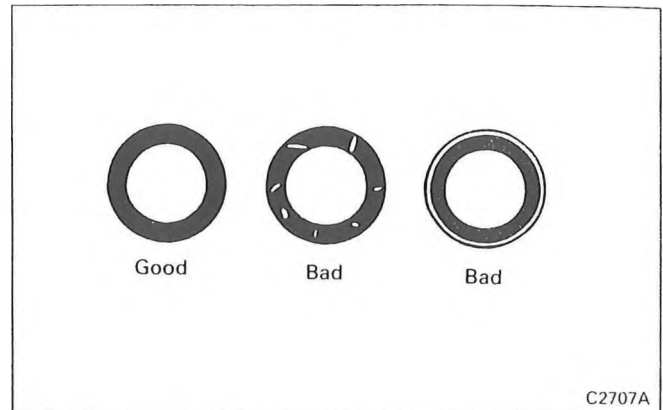
(10) Valve Contact with Valve Seat Insert

(a) Apply an even coat of minium to the valve seat insert surface in contact with the valve.

(b) Using Valve Lapper (special tool), let the valve hit against the valve seat insert once.

NOTE:

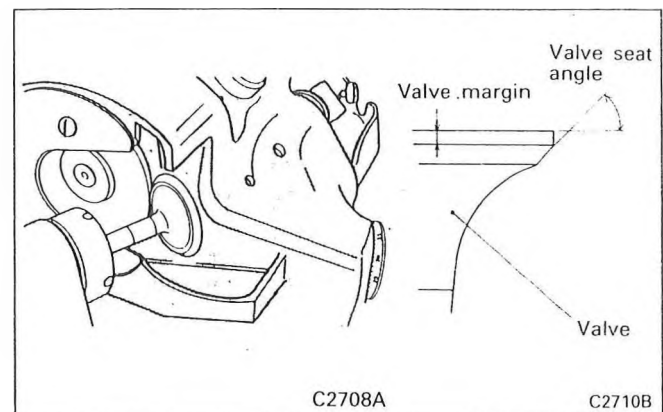
1. When letting the valve hit against the valve seat insert, do not turn the valve.
2. Contact pattern should be checked when the valve guide is inspected or replaced.



If any unusual contact pattern is noted, correct as follows.

Minor fault: Lapping

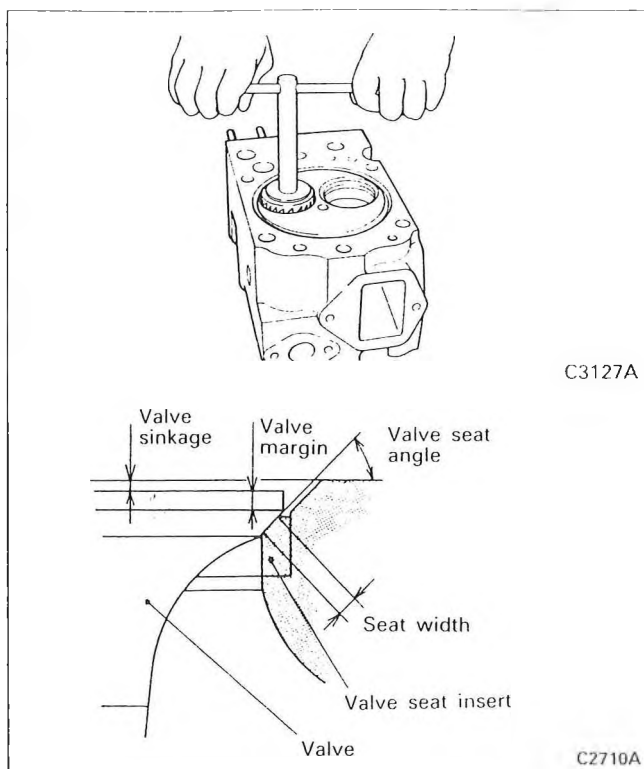
Serious fault: Correct valve and valve seat.

(11) Correction of Valve Face

Grind the valve face with a valve refacer to obtain the specified valve seat angle.

NOTE:

1. Keep grinding margin to a minimum.
2. If the valve margin is below the limit after the grinding correction, replace the valve.
3. After the grinding correction, be sure to lap the valve and valve seat insert. [Refer to Item (14) that follows.]

(12) Correction of Valve Seat Insert

(a) Using a valve seat cutter, cut the insert to obtain the specified valve seat angle and seat width. Use 15° or 75° cutter first, then 45° one.

NOTE:

1. Keep the amount of cut to a minimum.
2. If the valve sinkage after cutting exceeds the limit, replace the valve seat insert.

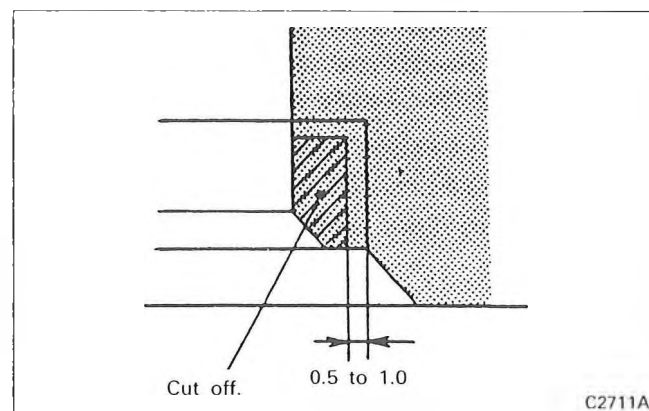
(b) After correction, lightly grind by holding about #400 sandpaper between the cutter and valve seat insert.

NOTE:

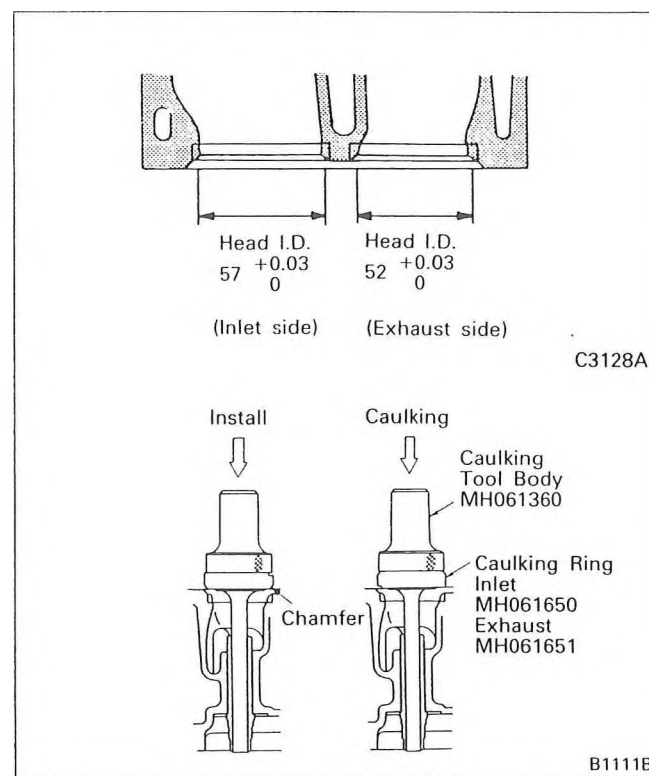
After the correction procedure, be sure to lap the valve and valve seat insert. [Refer to Item (14) that follows.]

(13) Replacement of Valve Seat Insert

Since the valve seat insert is installed by expansion fit, replace it by the following procedures.



(a) Grind inside surface of the valve seat insert to reduce the thickness and then remove it at room temperature.



(b) Make sure that the cylinder head and valve seat insert are provided with sufficient interference.

(c) Immerse the valve seat insert in liquid nitrogen for cooling it, and fully heat the cylinder head.

(d) Install the valve seat insert using the Caulking Tool Body, Caulking Ring and Caulking Tool (special tools) and caulk the periphery of the valve seat insert.

NOTE:

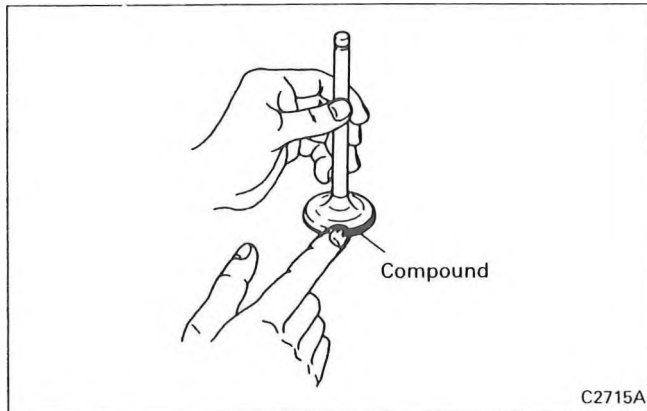
When the valve seat insert is installed, direct the chamfered side of the caulking ring toward the valve seat insert.

(e) Reface the valve seat insert so that the seat width and valve sinkage are up to specifications.

(14) Lapping the Valve and Valve Seat Insert

The valve and valve seat insert contact must be even throughout their contacting surfaces.

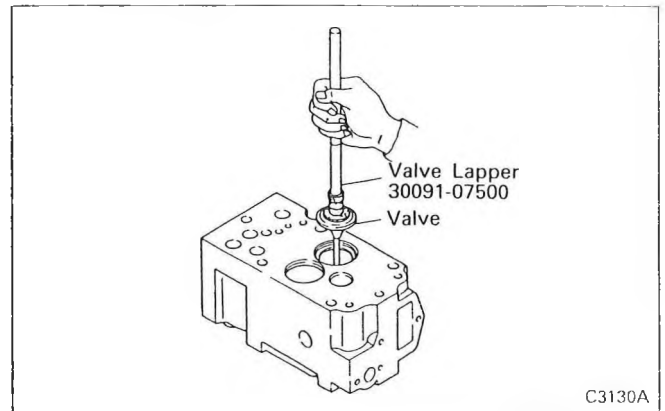
They must be lapped whenever either the valve or valve seat insert has been corrected or replaced.



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

NOTE:

1. **Make sure that no compound sticks to the valve stem.**
2. **Use intermediate-mesh compound (120 to 150 meshes) first, then fine-mesh compound (200 meshes or more) for finishing.**
3. **Addition of a small amount of engine oil to the compound helps make it easier to apply it evenly.**



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

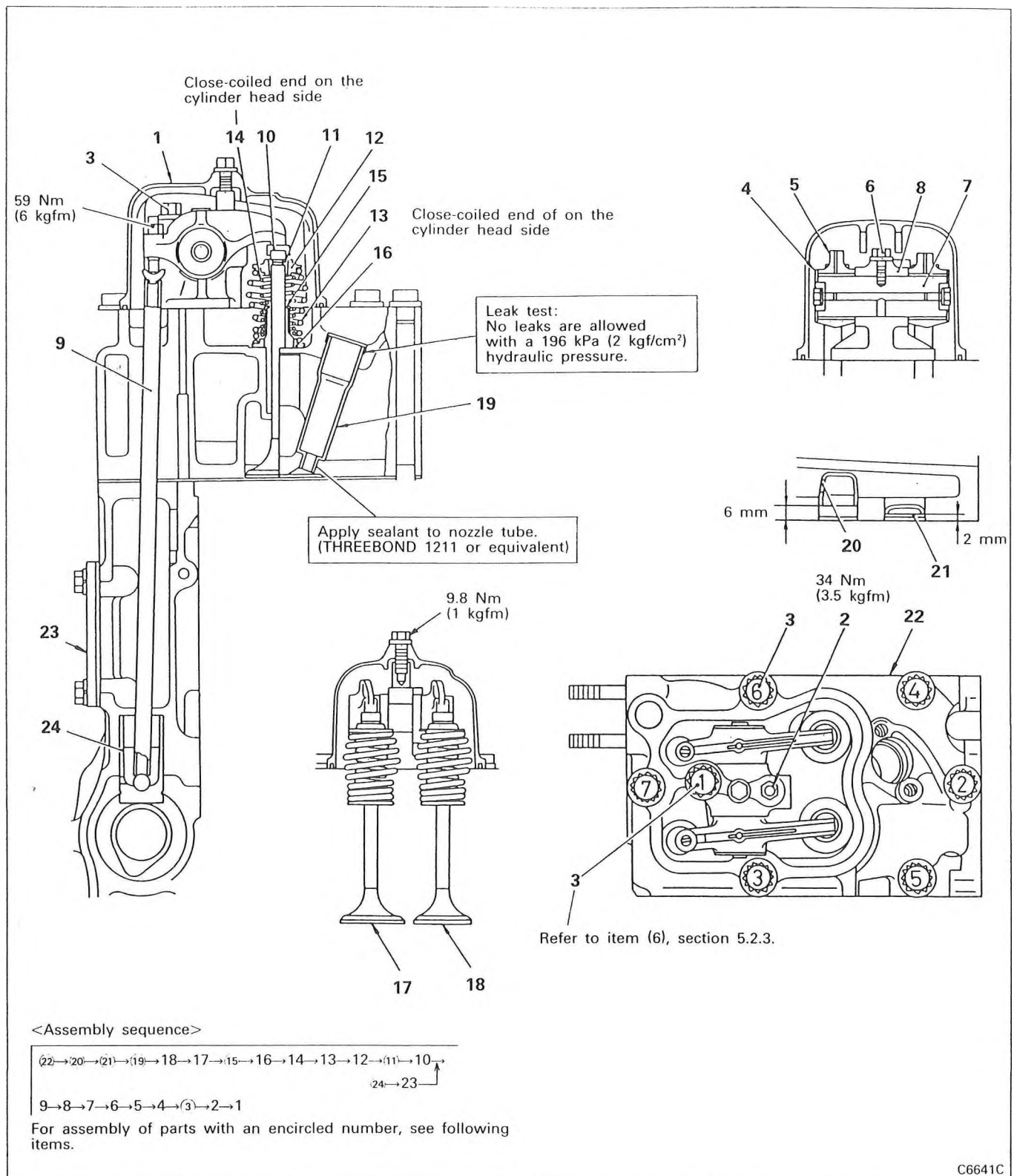
While turning the valve slightly at a time, strike it against the valve seat insert.

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

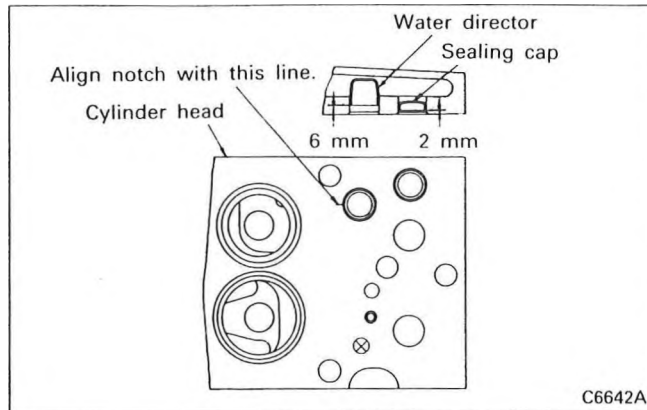
(d) Apply engine oil to the contacting surface to seat them with oil.

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

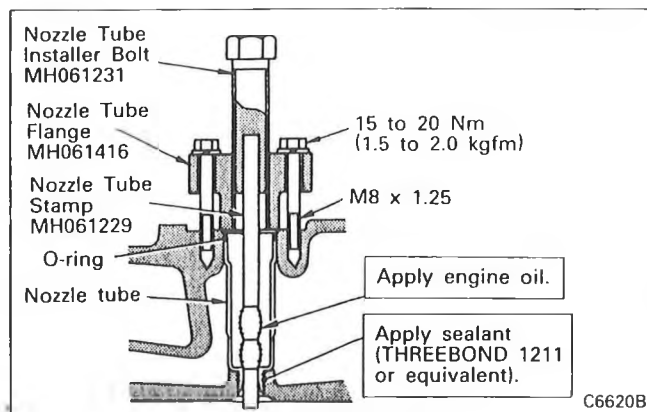
5.2.3 Reassembly



C6641C

Reassembly Procedure**(1) Installation of Water Director**

Install the water director with its notch directed as shown.

(2) Installation of Nozzle Tube

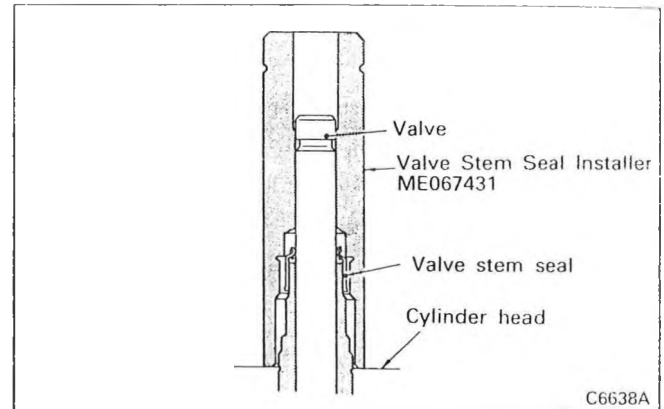
(a) Apply sealant to the end of the nozzle tube and insert into the cylinder head.

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

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

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

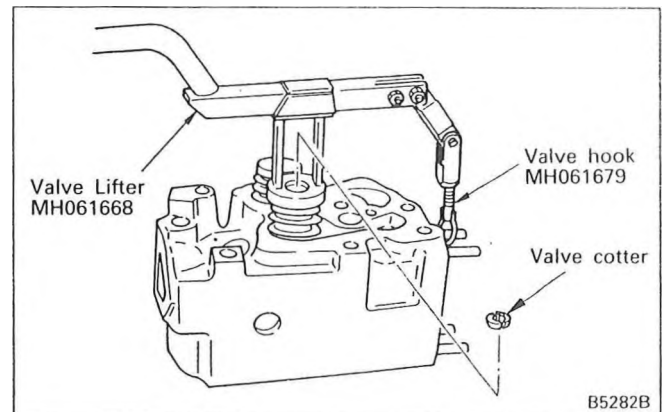
(e) After installation, perform leak test to verify water-tightness.

(3) Installation of Valve Stem Seal

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

NOTE:

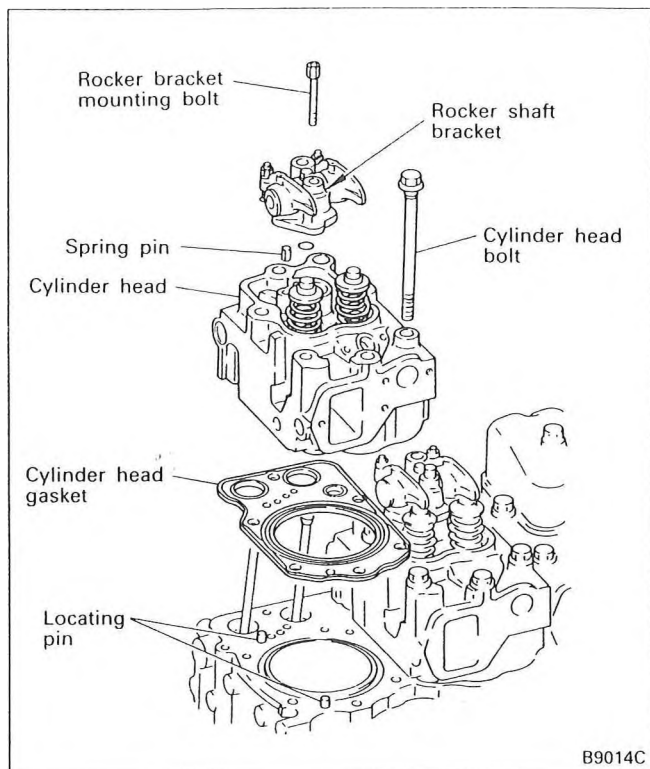
1. Before the valve is installed, apply a small amount of engine oil to the stem.
2. After installation, check to ensure that the valve stem seal spring has not been deformed or damaged.

(4) Installation of Valve Cotter

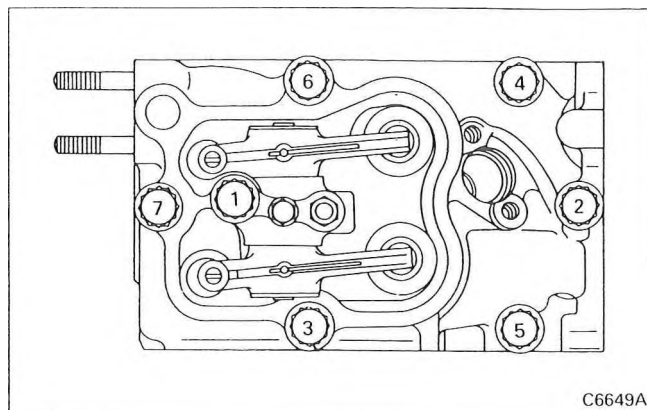
Install the valve cotter, while compressing the valve spring, using Valve Lifter (special tool).

NOTE:

Install the valve spring with the closely coiled portion toward the cylinder head.

(5) Installation of Rocker Shaft Bracket and Cylinder Head

Seat the cylinder head on the crankcase, while lining it up with the locating pin.

(6) Tightening of the Cylinder Head Bolts

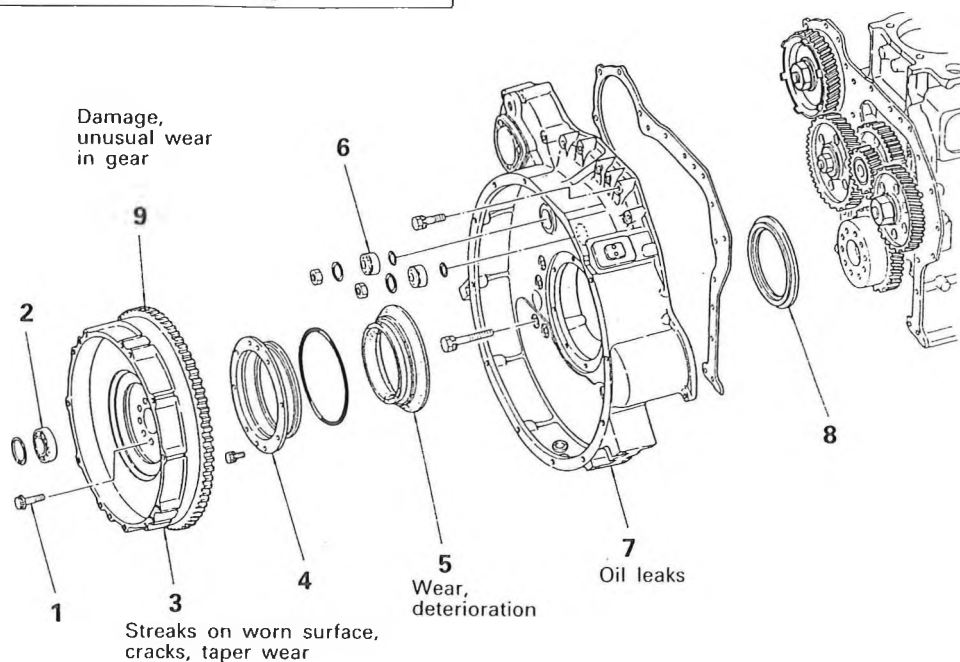
Tighten the cylinder head bolts in the sequence shown above to 175 Nm (18 kgfm).

After tightening, verify the correct torque, then re-tighten $90^{\circ} \begin{smallmatrix} +20^{\circ} \\ -0^{\circ} \end{smallmatrix}$.

5.3 FLYWHEEL, TIMING GEAR AND CAMSHAFT**5.3.1 Disassembly**

<With mechanical tachometer drive>

<With electrical speed sensor>



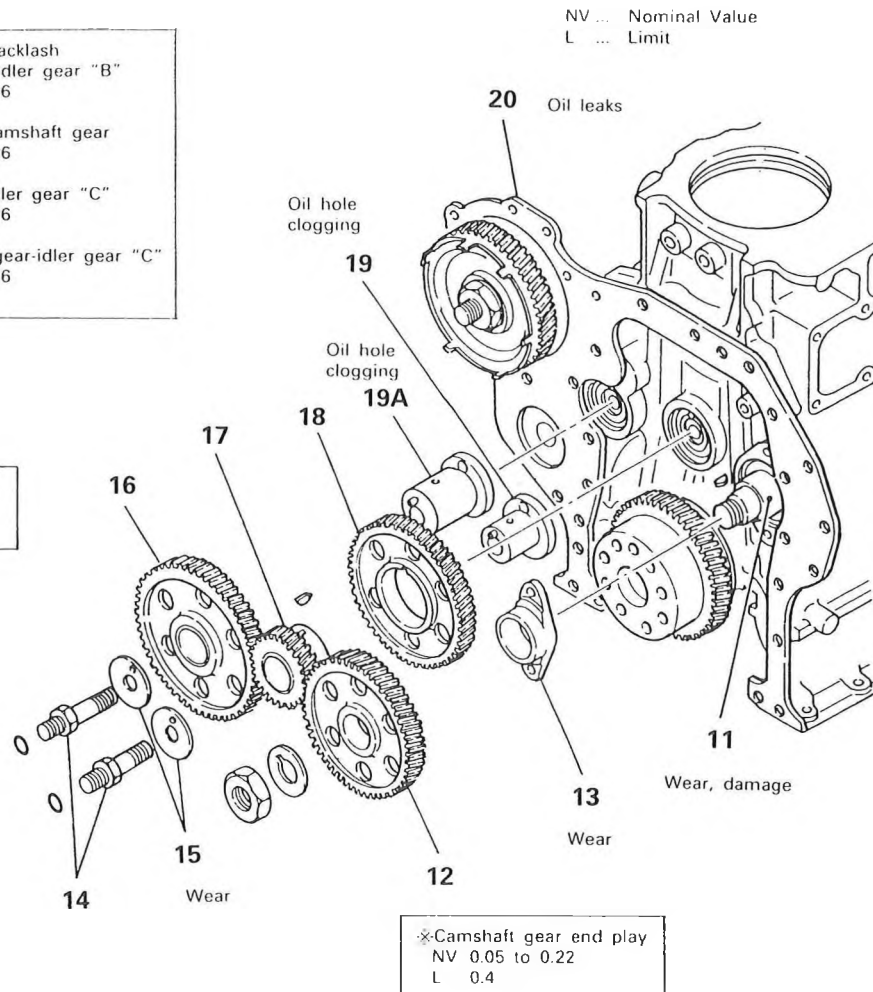
<Disassembly sequence>

- | | |
|--------------------------|-------------------------|
| 1 Flywheel mounting bolt | ⑥ Collar |
| 2 Pilot bearing | 7 Flywheel housing |
| ③ Flywheel | 8 Rear oil seal slinger |
| ④ Oil seal retainer | ⑨ Ring gear |
| 5 Oil seal | 10 Tachometer drive |
| | 10A Speed sensor |

For disassembly of parts with an encircled number, see following items.

※Timing gear backlash
 Crankshaft gear-idler gear "B"
 NV 0.12 to 0.26
 L 0.4
 Idler gear "A"-camshaft gear
 NV 0.13 to 0.26
 L 0.4
 Idler gear "A"-idler gear "C"
 NV 0.13 to 0.26
 L 0.4
 Injection pump gear-idler gear "C"
 NV 0.12 to 0.26
 L 0.4

※Idler gear end play
 NV 0.1 to 0.28
 L 0.4

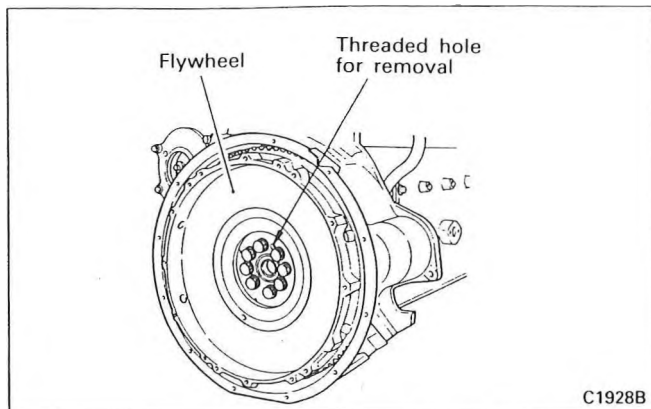


<Disassembly sequence>

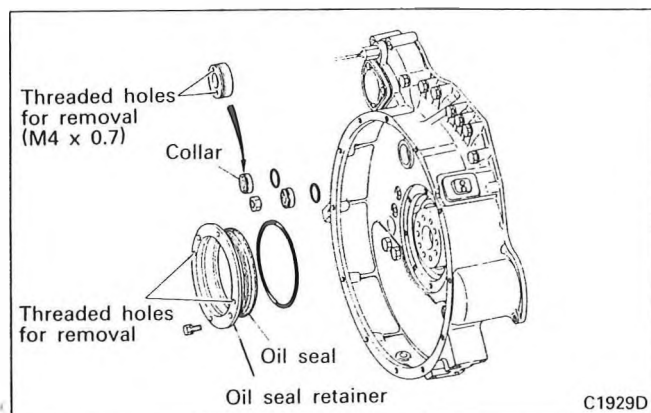
- (11) Camshaft
- * (12) Camshaft gear
- 13 Thrust plate
- 14 Idler shaft bolt
- 15 Thrust plate
- 16 Idler gear "C"
- 17 Idler gear "A"
- 18 Idler gear "B"
- 19 Idler shaft "A"
- 19A Idler shaft "C"
- 20 Rear plate

For disassembly of parts with an encircled number, see following items.
 The part marked ※ must be inspected before disassembly.
 Part marked with * should not be removed unless defects are evident.

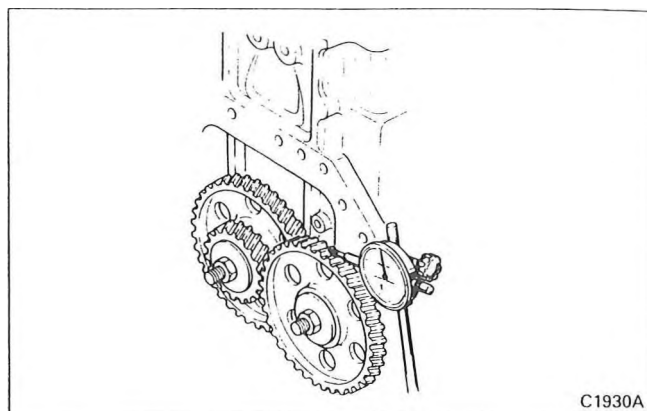
C1927C

Disassembly Procedure**(1) Removal of Flywheel**

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

(2) Removal of Oil Seal Retainer and Collar

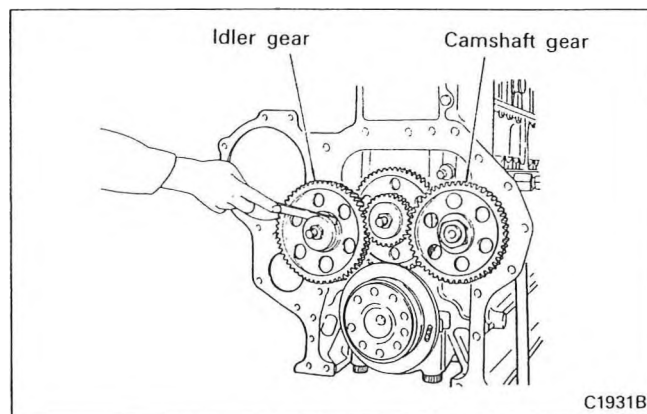
- To remove the oil seal retainer, turn down the attaching bolts into the removing threaded holes evenly, while making sure that the oil seal retainer does not have eccentricity, remove the retainer with the oil seal attached.
- Remove the collar by screwing M4 x 0.7 bolts into the removing threaded holes.

(3) Measurement of Gear Backlash

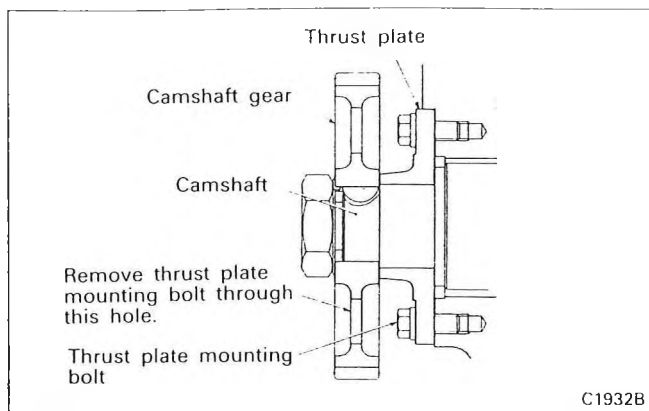
If the backlash exceeds the limit, check idler gear bushing and gears and replace parts as necessary.

NOTE:

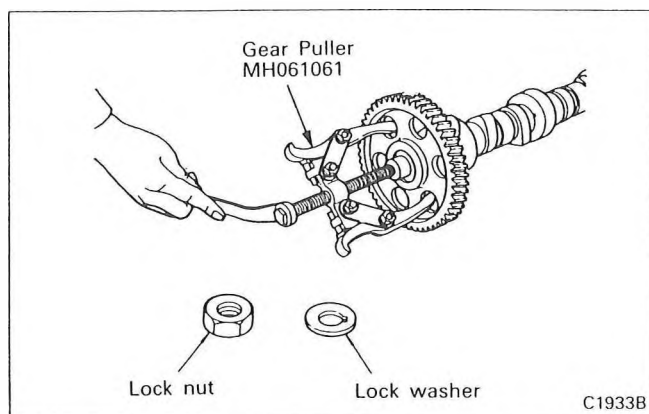
For a pair of gears, the backlash should be measured at more than three points to determine whether it is acceptable.

(4) Measurement of End Play in Idler Gear and Camshaft Gear

If the end play exceeds the limit, replace the thrust plate.

(5) Removal of Camshaft Gear

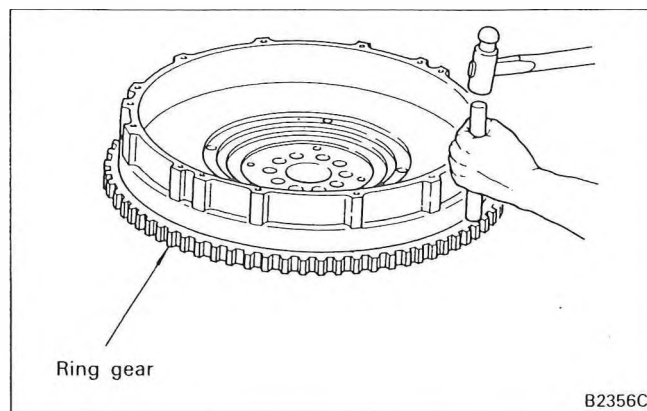
Accessing through the holes in camshaft gear, loosen the thrust plate attaching bolts. Then, remove the gear together with the camshaft.

(6) Removal of Camshaft Gear

Remove the lock nut and lock washer from the camshaft gear and, using Gear Puller (special tool), remove the camshaft gear.

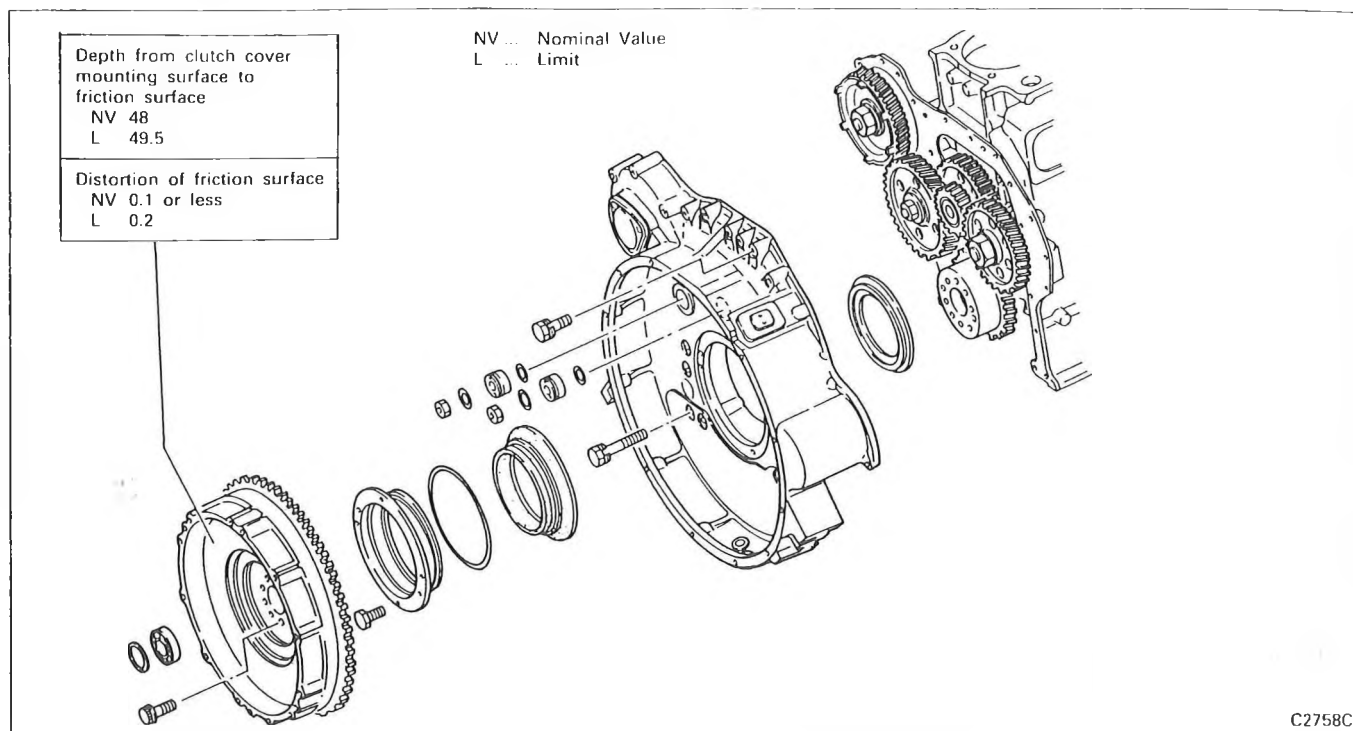
NOTE:

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

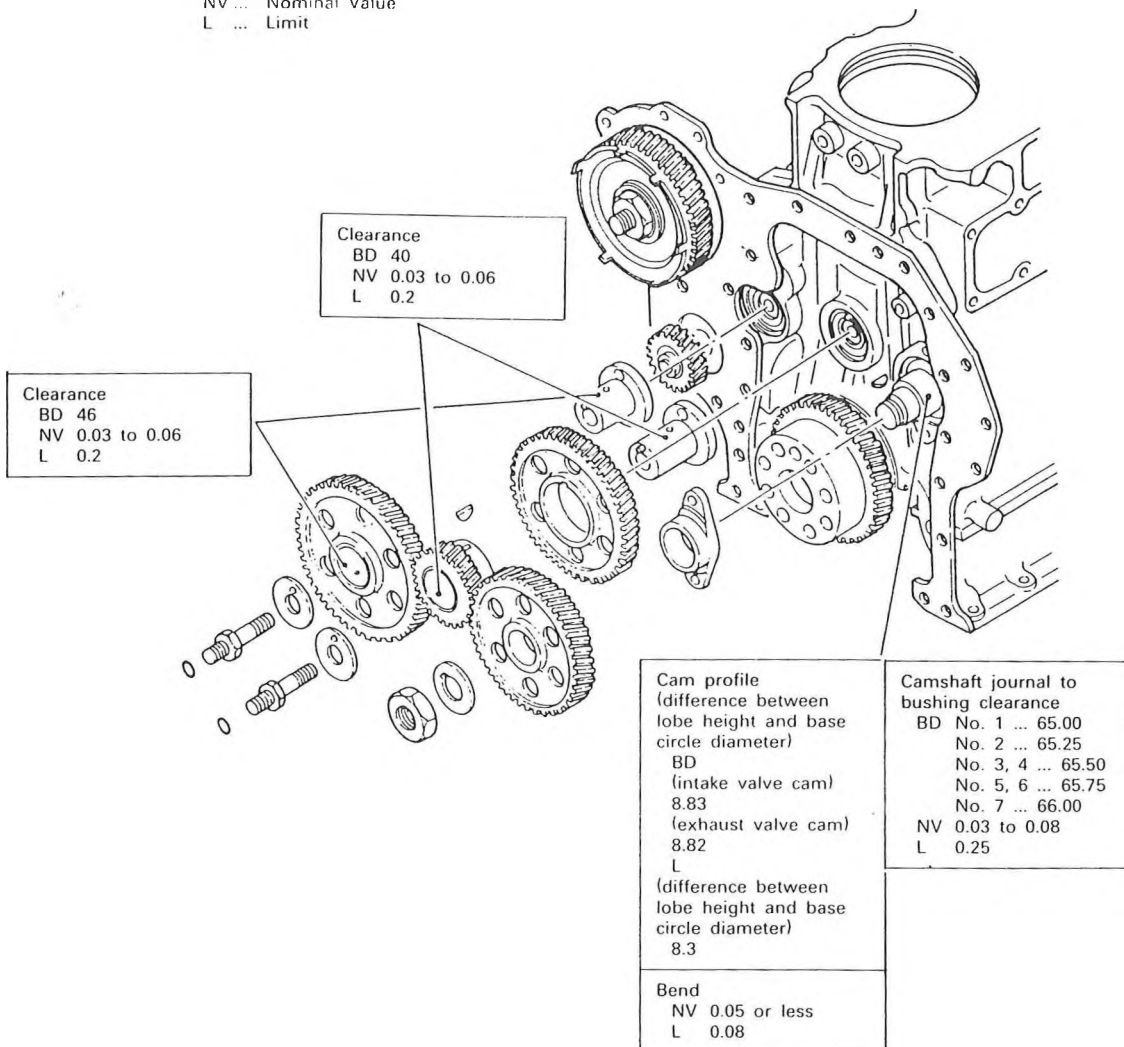
(7) Removal of Ring Gear

Using an acetylene torch, heat evenly the ring gear and apply a rod to the ring gear to tap it throughout its periphery.

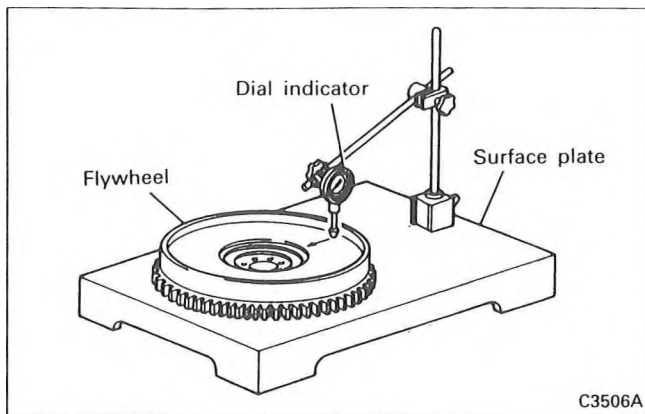
5.3.2 Inspection



BD — Basic Diameter
 NV ... Nominal Value
 L ... Limit



C2759C

Inspection Procedure**(1) Distortion of Friction Surface**

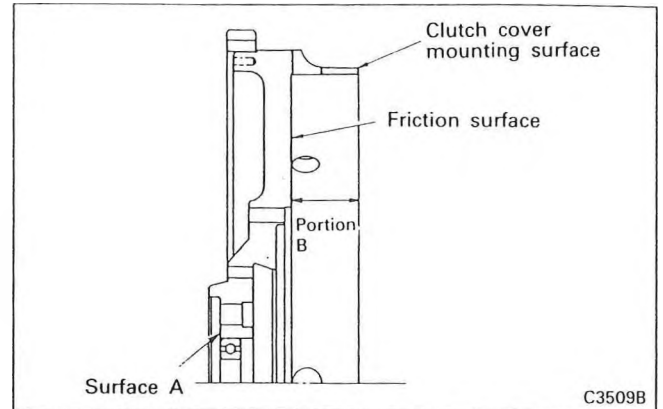
Place the flywheel on a surface plate and move a dial indicator in the diametral direction of the flywheel to measure distortion.

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

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

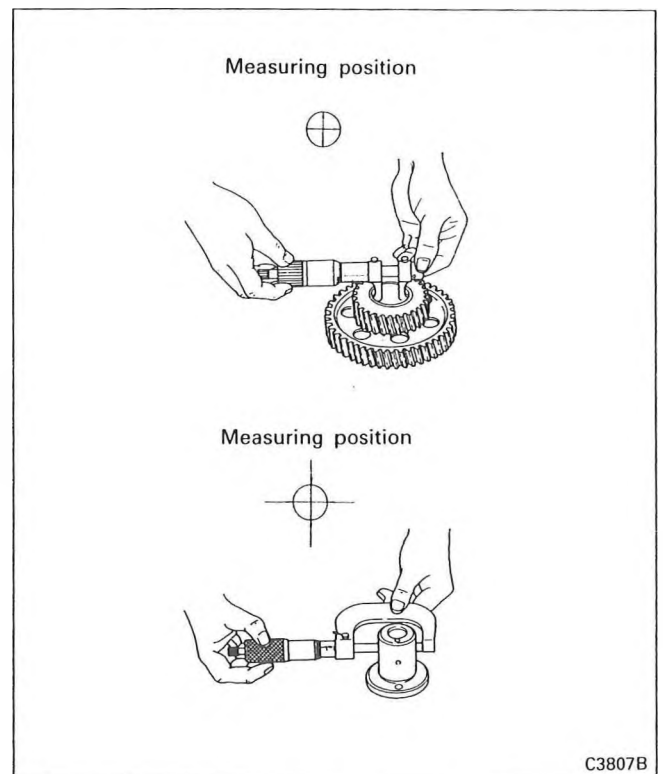
NOTE:

If the ring gear shows an abnormal condition, replace the ring gear before measurement. [Refer to 5.3.1 (7)]

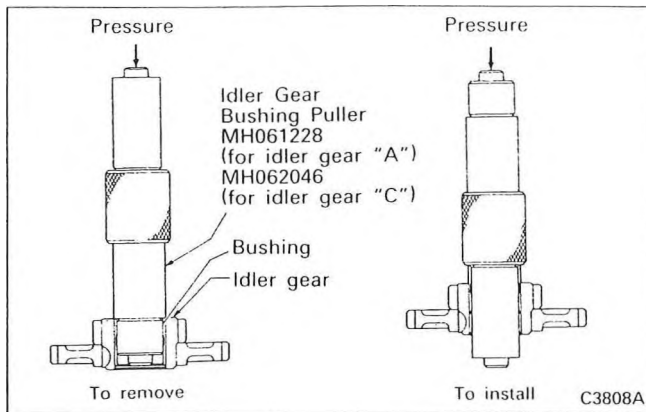
(2) Correction of Flywheel Friction Surface

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

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

(3) Idler Gear to Idler Shaft Clearance

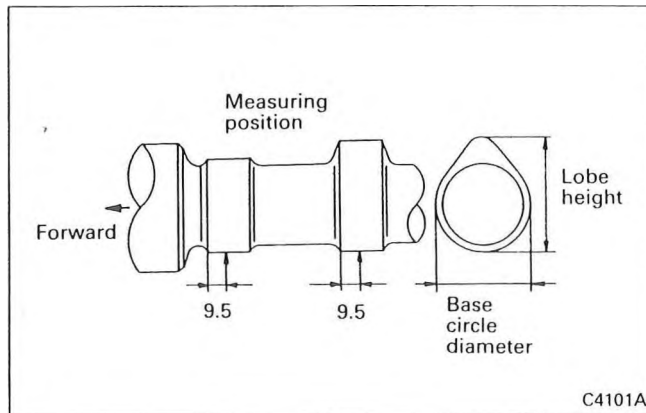
If the limit is exceeded, the bushing in the gear should be replaced.

(4) Replacement of Idler Gear Bushing

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

NOTE:

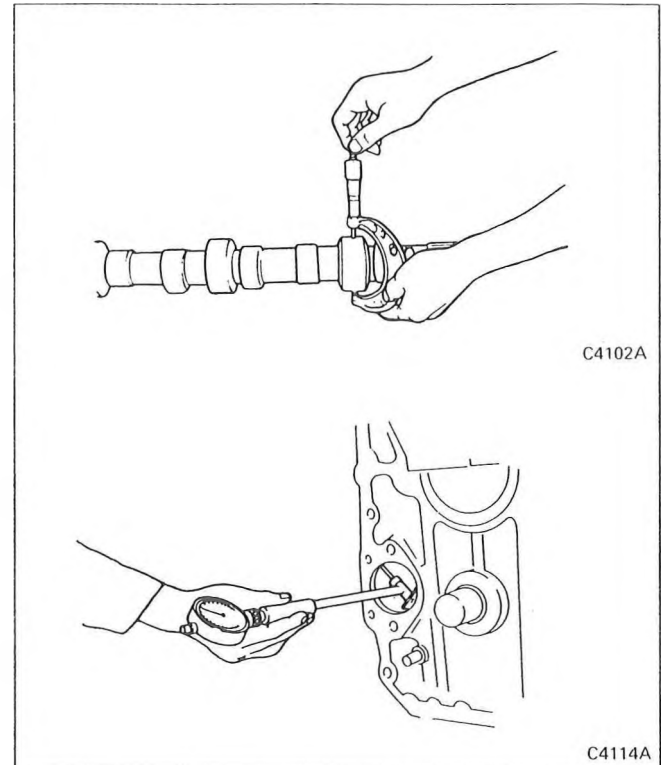
1. Install the bushing with chamfered side of gear I.D. inward.
2. After installation, check to ensure that the bushing to idler shaft clearance is within the nominal dimension. If it is below the nominal dimension, ream the bushing.

(5) Cam Profile

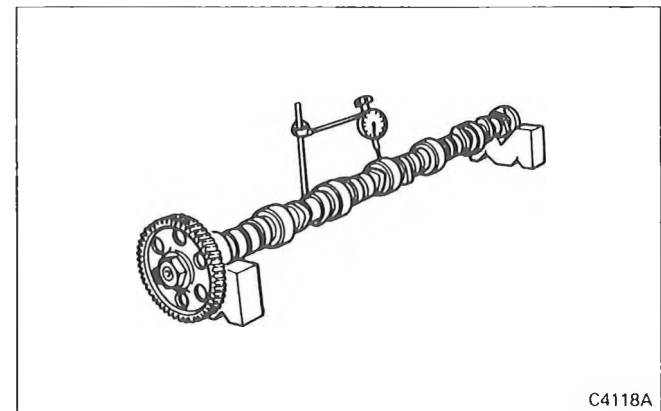
Measure the lobe height and base circle diameter and replace the camshaft if the difference between the two is below the limit.

NOTE:

The cam must be measured at locations shown as it is tapered.

(6) Camshaft Journal to Crankcase Camshaft Bushing Clearance

If the limits are exceeded, the bushing in the crankcase should be replaced.

(7) Bend of Camshaft

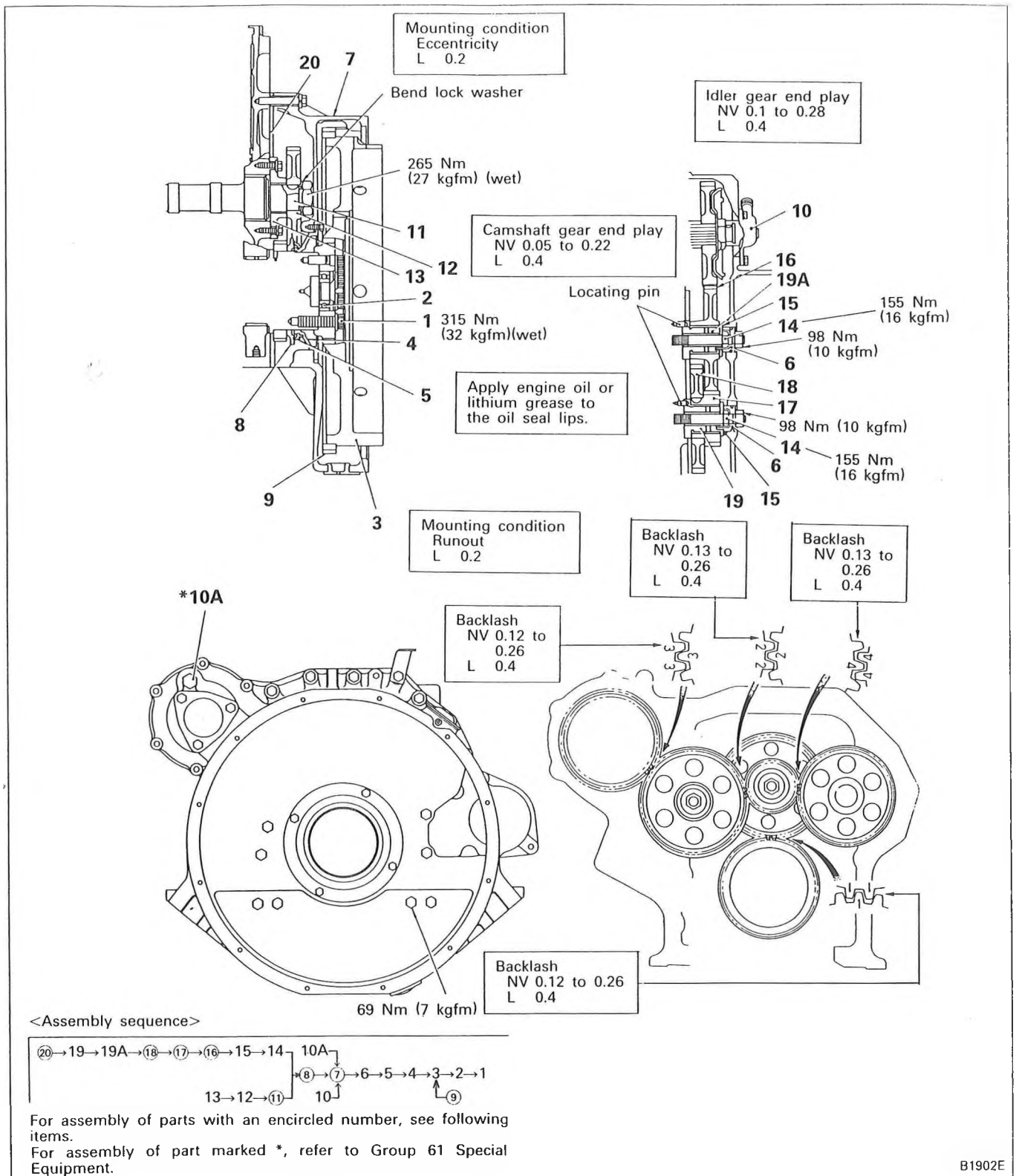
Measure the bend of the camshaft. If the limit is exceeded, replace.

NOTE:

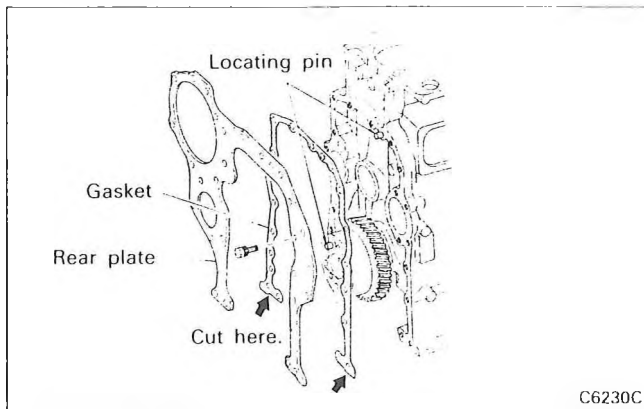
Turn the camshaft a turn and read the deflection of the pointer, using a dial indicator.

One half of the reading is the bend.

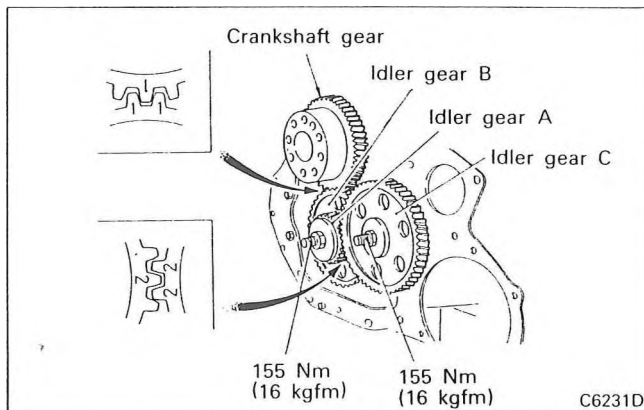
5.3.3 Disassembly



B1902E

Reassembly Procedure**(1) Installation of Rear Plate**

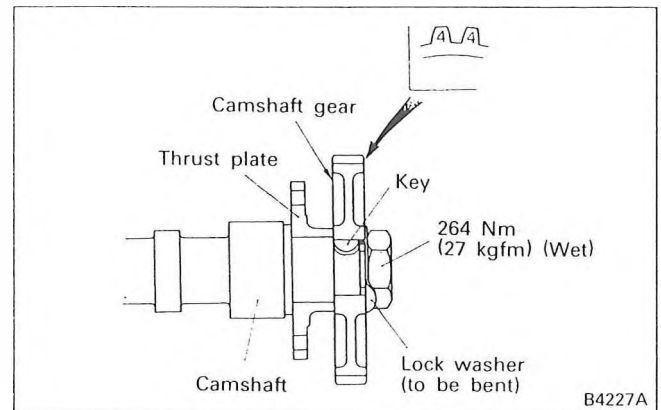
The bottom of gasket installed between the rear plate and crankcase will protrude. After the flywheel housing has been installed, cut away the protruding portion.

(2) Installation of Idler Gears

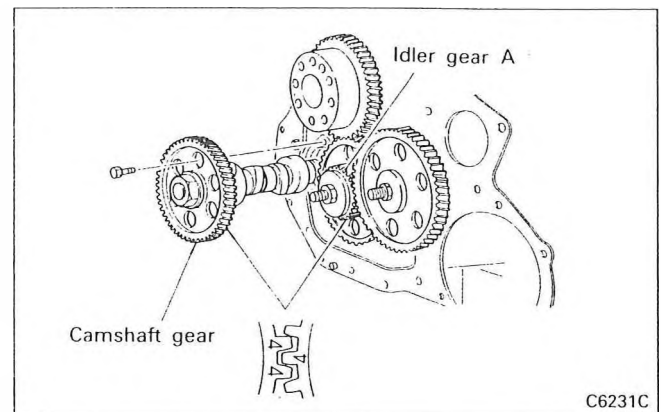
Then, install the idler gear B so that its alignment mark "1" is aligned with the alignment mark "1" on the crankshaft gear.

Next, install idler gears A and C so that their alignment marks "2" are aligned.

Tighten the idler shaft bolt to specification.

(3) Installation of Camshaft Gear

Install the camshaft gear so that the side having stamped numbers "4" faces front.

(4) Installation of Camshaft

Install the camshaft so that the alignment mark "4" on the camshaft gear is aligned with the alignment mark "4" on idler gear A.

NOTE:

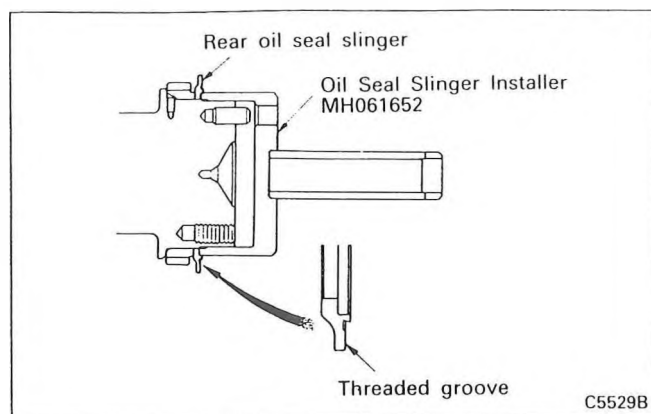
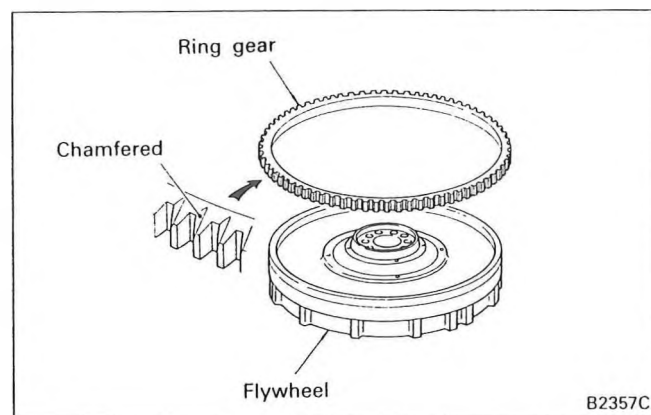
When the camshaft is inserted, take care not to damage the camshaft bushing.

(5) Check camshaft gear and idler gear for correct end play.

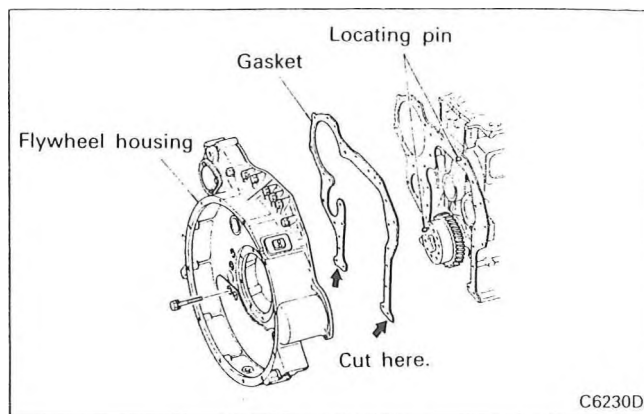
[Refer to Section 5.3.1 (4)]

(6) Check backlash in gears.

[Refer to Section 5.3.1 (3)]

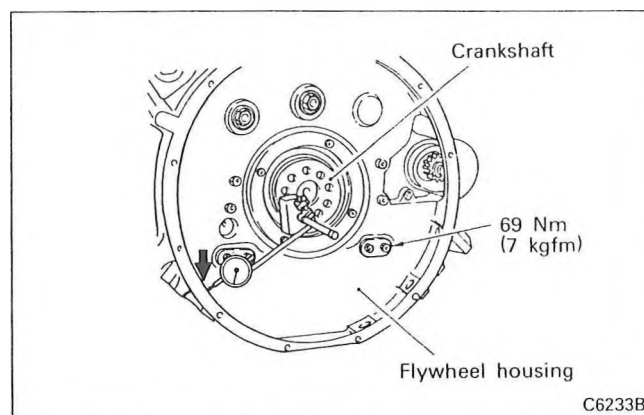
(7) Installation of Rear Oil Seal Slinger**(8) Installation of Ring Gear**

- (a) Heat the ring gear for 3 minutes with piston heater (approx. 100°C).
- (b) Fit the ring gear onto the flywheel with the nonchamfered side of the teeth end toward the flywheel.

(9) Installation of Flywheel Housing

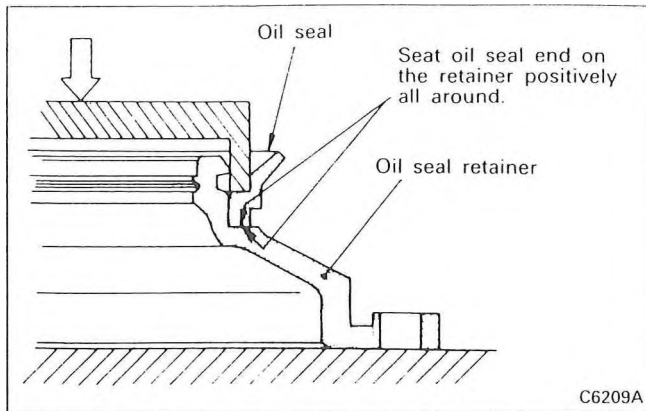
Install the flywheel housing and gasket so that they are aligned with the locating pins in the crankcase. Cut the bottom portions of the gasket after installation as they are excess.

Cut at the same time the excess portions of the gasket between the rear plate and crankcase.

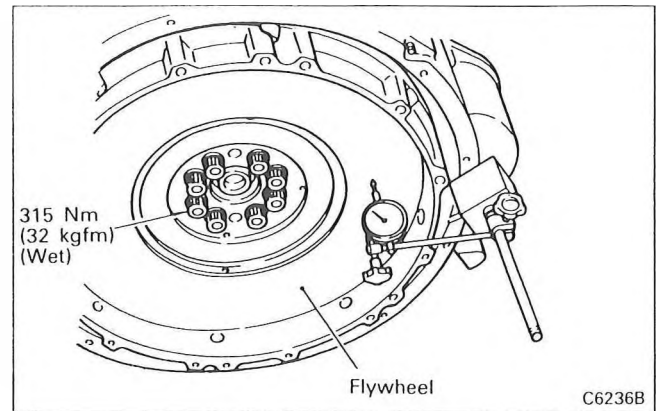
(10) Flywheel Housing Eccentricity Check

Install the flywheel housing to the crankcase by tightening to the specified torque.

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

(11) Installation of Oil Seal

When press-fitting an oil seal to the retainer, apply force uniformly to the entire periphery.

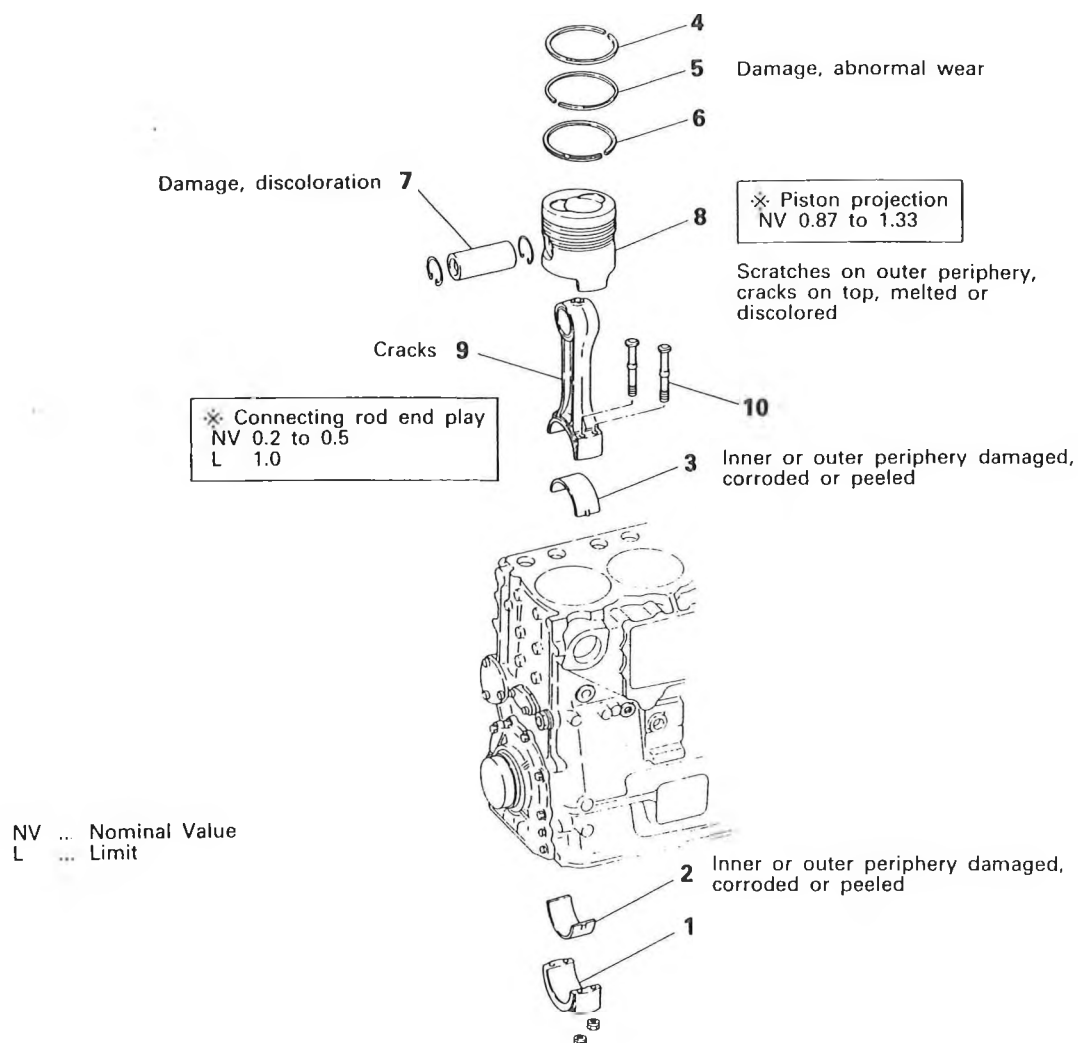
(12) Flywheel Runout Check

Install the flywheel to the crankshaft by tightening to the specified torque.

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

5.4 CRANKCASE AND MAIN MOVING PARTS

5.4.1 Disassembly



Disassembly sequence

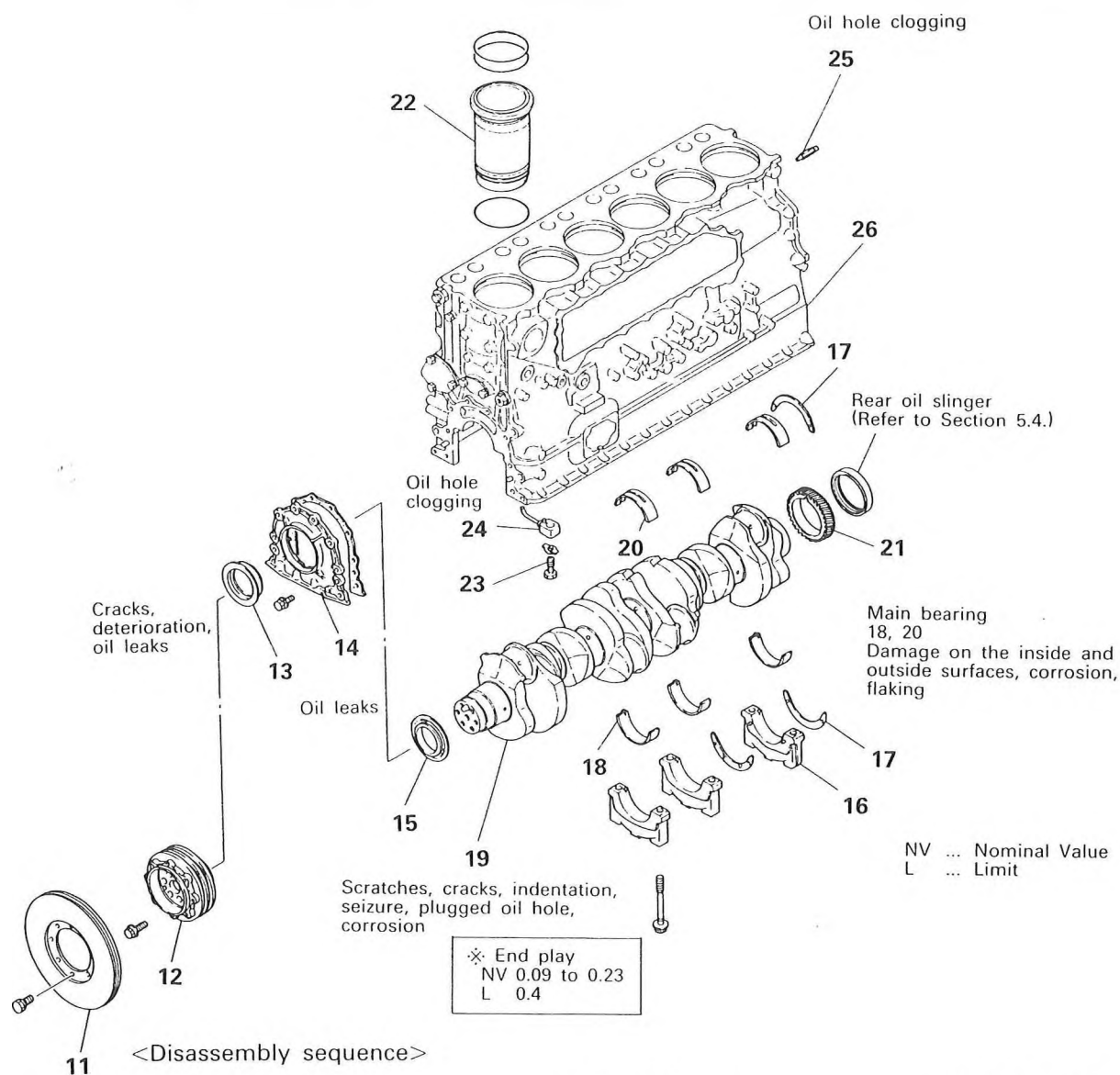
- | | |
|--------------------------------|-------------------------|
| 1 Connecting rod cap | ⑥ Oil ring |
| 2 Lower connecting rod bearing | 7 Piston pin |
| 3 Upper connecting rod bearing | ⑧ Piston |
| ④ 1st compression ring | ⑨ Connecting rod |
| ⑤ 2nd compression ring | *10 Connecting rod bolt |

For disassembly of parts with an encircled number, see following items.

Part marked with * should not be removed unless defects are evident.

Service items marked with ✱ should be inspected before disassembly.

C2337D



<Disassembly sequence>

- 11 Torsional damper
- (12) Crankshaft pulley
- *1 13 Front oil seal
- 14 Front cover
- *1 15 Front oil seal slinger
- 16 Main bearing cap

- 17 Thrust plate
- 18 Lower main bearing
- 19 Crankshaft
- 20 Upper main bearing
- *1 (21) Crankshaft gear

- *1 22 Cylinder liner
- *2 23 Check valve
- 24 Oil jet
- 25 Oil spray plug
- 26 Crankcase

For disassembly of parts with an encircled number, see following items.

The part marked ※ must be inspected before disassembly.
Parts marked with *1 should not be removed unless defects are evident.

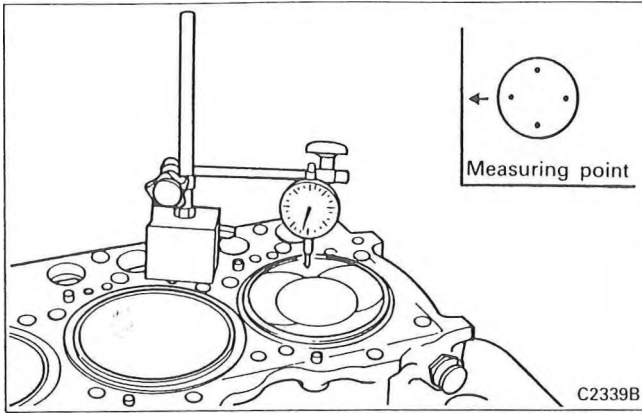
For inspection of the part marked with *2, refer to Group 12 Lubrication.

B0599G

Disassembly Procedure

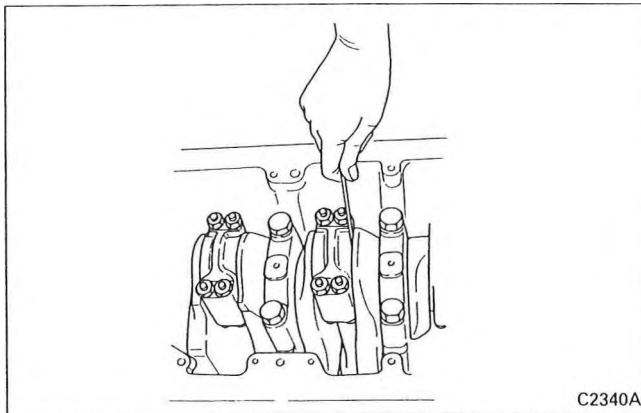
(1) Piston Projection

The piston projection must be up to specification, as it affects engine performance and is also necessary for preventing interference with the valve.



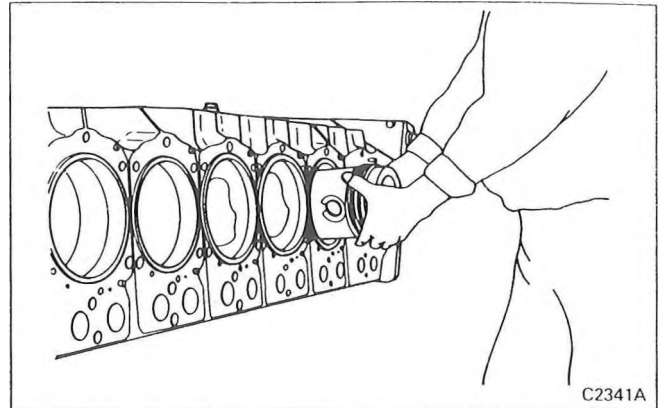
- Hold the dial indicator to the top surface of the crankcase and make zero adjustment.
- Find the top dead center of piston with a dial indicator.
- Measure three points on the top surface of piston to find the average value.
- If the projection is out of specification, check the connecting rod, bushing, piston pin, connecting rod bearing, etc. and replace defective parts.

(2) Connecting Rod End Play



Measure the end play of each connecting rod. If the limit is exceeded, replace the connecting rod or crankshaft.

(3) Removal of Piston

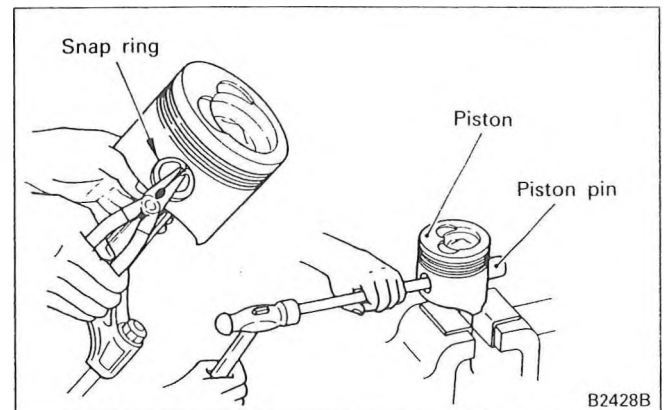


When withdrawing the piston from the crankcase by pushing up together with the connecting rod.

NOTE:

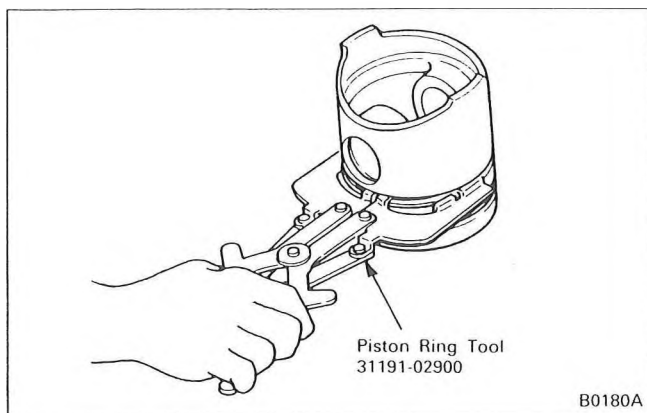
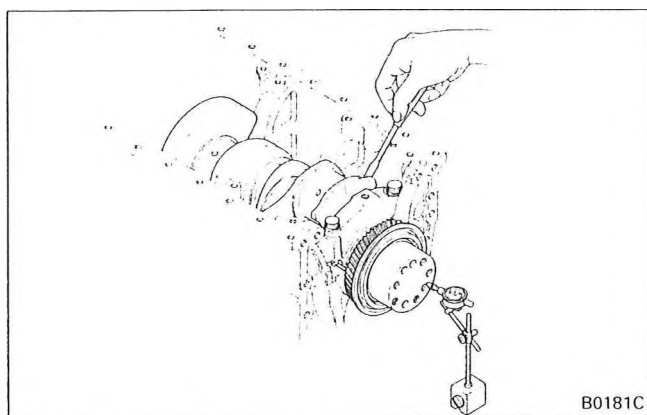
When removing the pistons, use care to prevent damage to the cylinder liner

(4) Separating Piston from Connecting Rod



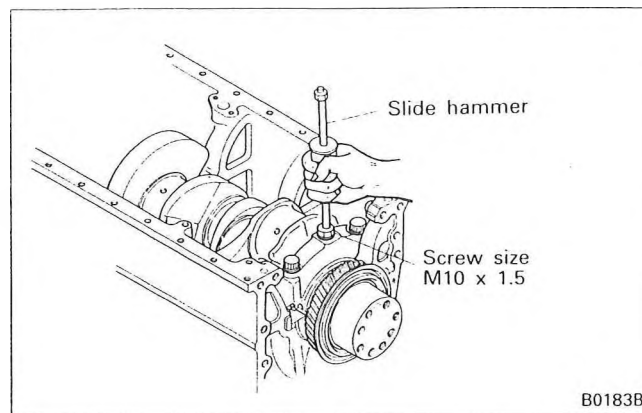
Remove the snap ring and, using a rod, tap piston pin off.

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

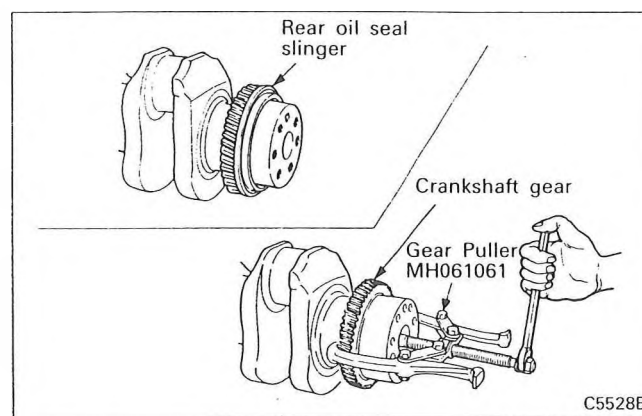
(5) Removal of Piston Ring**(6) Crankshaft End Play**

Before removing the main bearing caps, measure the end play in the crankshaft.

If the end play exceeds the limit, replace the thrust plate with an oversize one. [Refer to Section 5.4.3 (3)]

(7) Removal of Main Bearing Cap

The rearmost main bearing cap is held in position by dowel pins. Remove it by use of a slide hammer.

(8) Removal of Crankshaft Gear

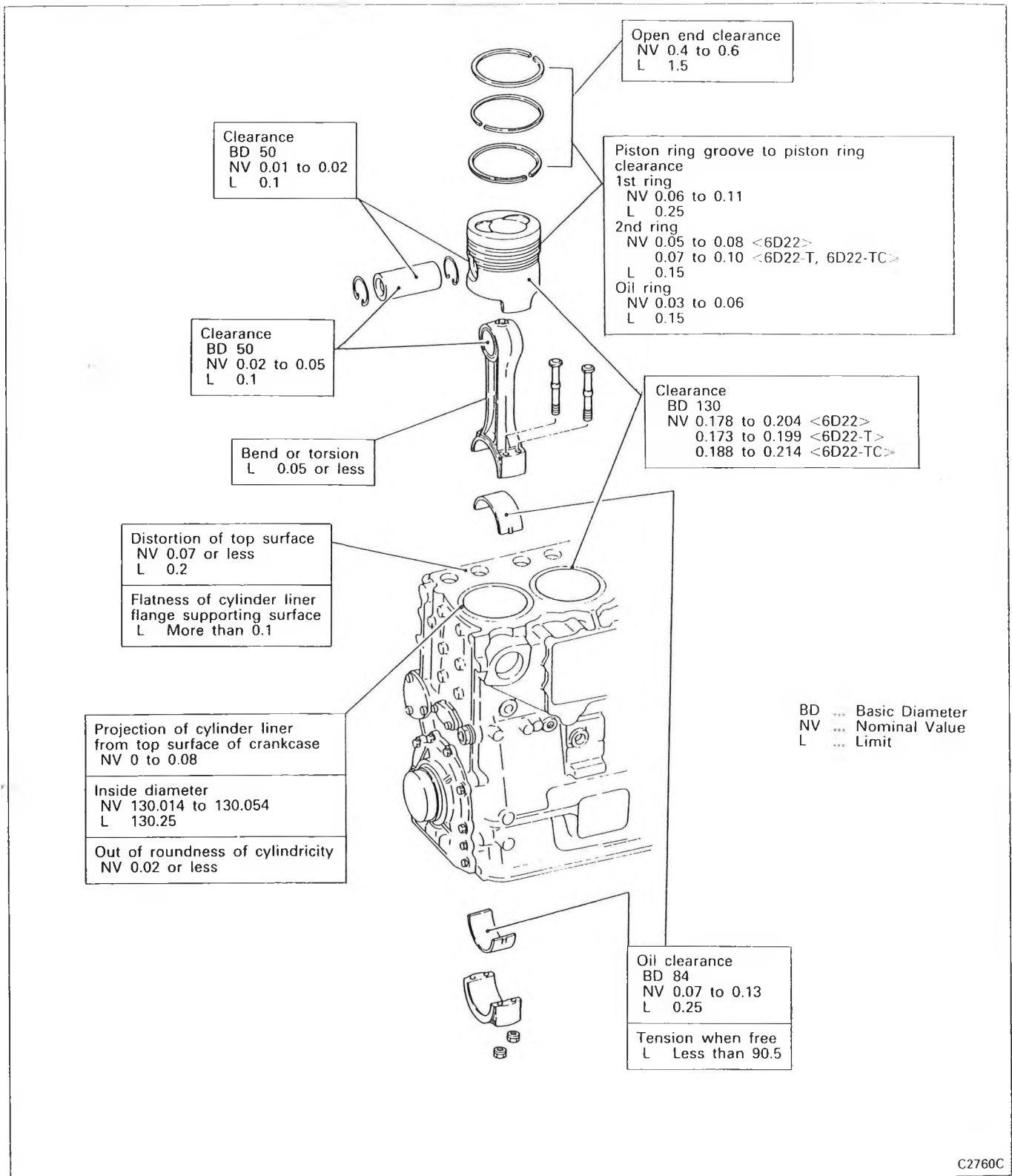
(a) Remove the rear oil seal slinger from the crankshaft by cutting it with a punch.

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

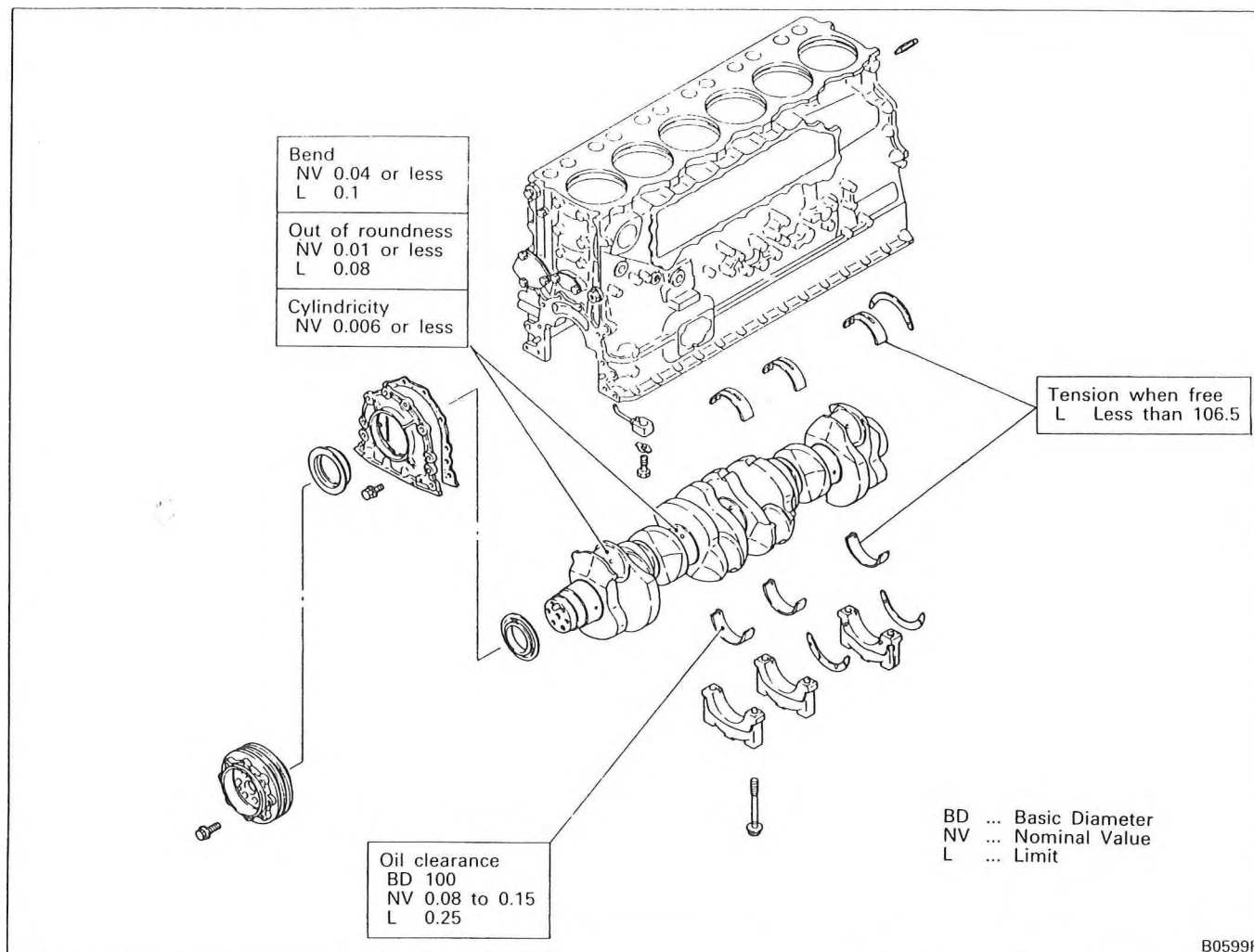
NOTE:

Do not attempt removing the crankshaft gear by striking with a hammer or prying with a lever.

5.4.2 Inspection

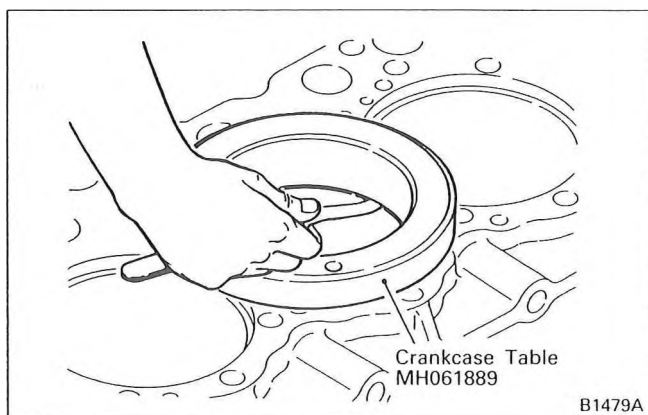


C2760C



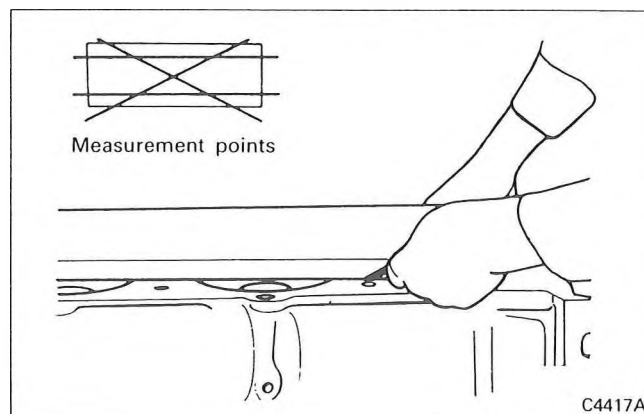
Inspection Procedure

(1) Flatness of Cylinder Liner Flange Supporting Surface on Crankcase



Replace the crankcase with new one if the limit is exceeded.

(2) Crankcase Top Surface Distortion

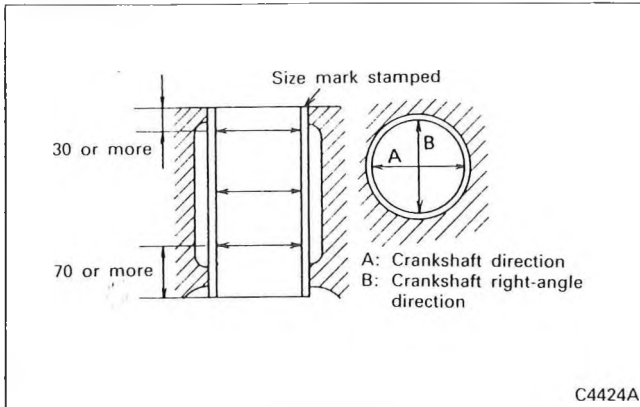


Measure the crankcase top surface distortion. If it exceeds the limits, correct the distortion with a surface grinder.

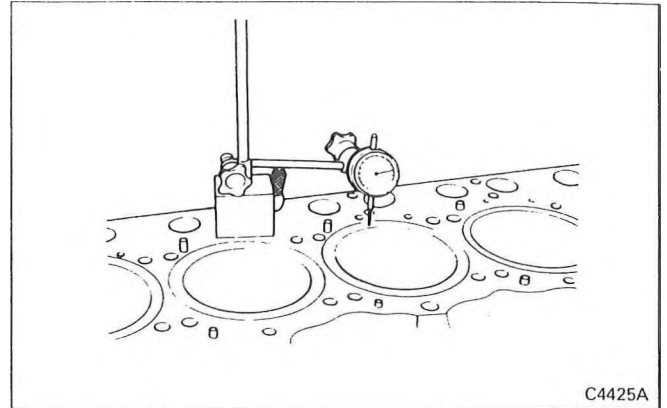
NOTE:

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

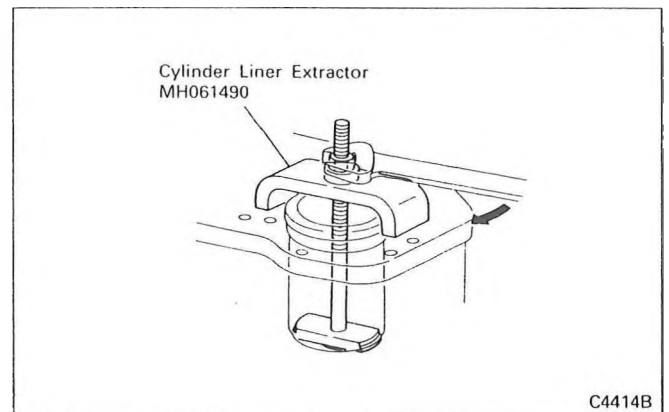
[Refer to Item (1), Section 5.4.1.]

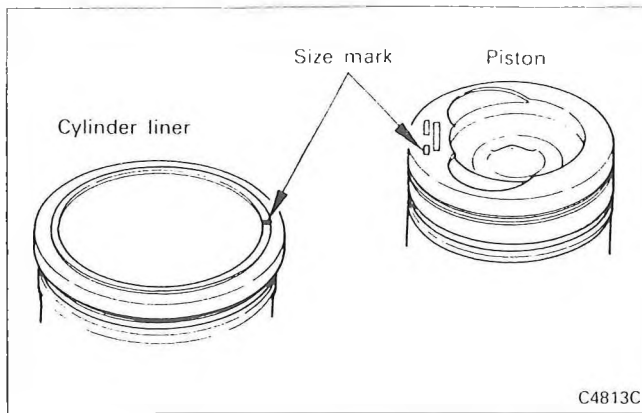
(3) Cylinder Liner I.D.

Measure the cylinder liner I.D. at six positions as shown in the right figure. If the I.D. is more than the limits, replace the cylinder liner or bore it to oversize. [For replacement of the cylinder liner, refer to Item (5).]

(4) Cylinder Liner Flange Projection

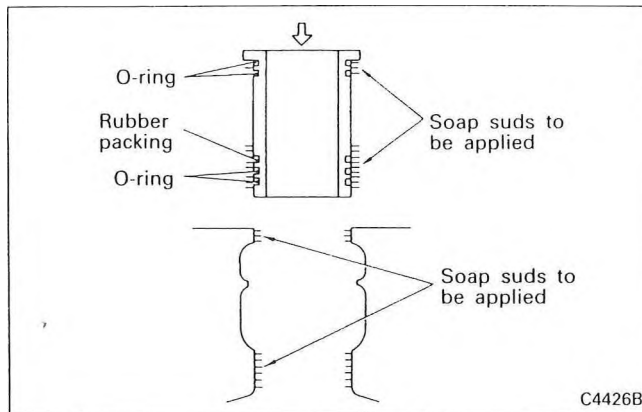
If the projection is out of specification, replace the cylinder liner or crankcase. [For replacement of the cylinder liner, refer to Item (5).]

(5) Replacement of Cylinder Liner**(a) Removal**

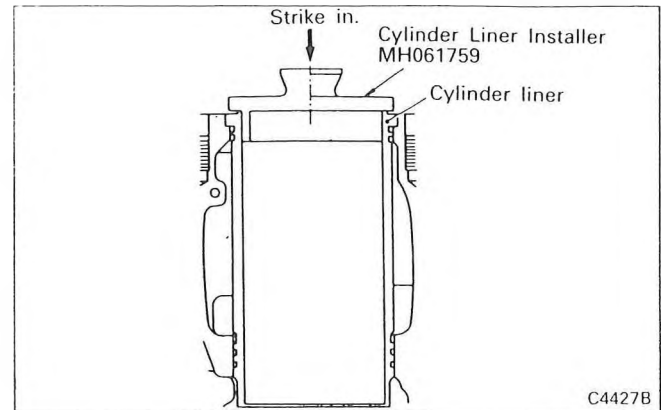
(b) Installation

- 1) When replacing the cylinder liner, use a cylinder liner with the same size mark as that of the piston to be selected.

Size mark of piston	A	B	C
Size mark of cylinder liner	A	B	C



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



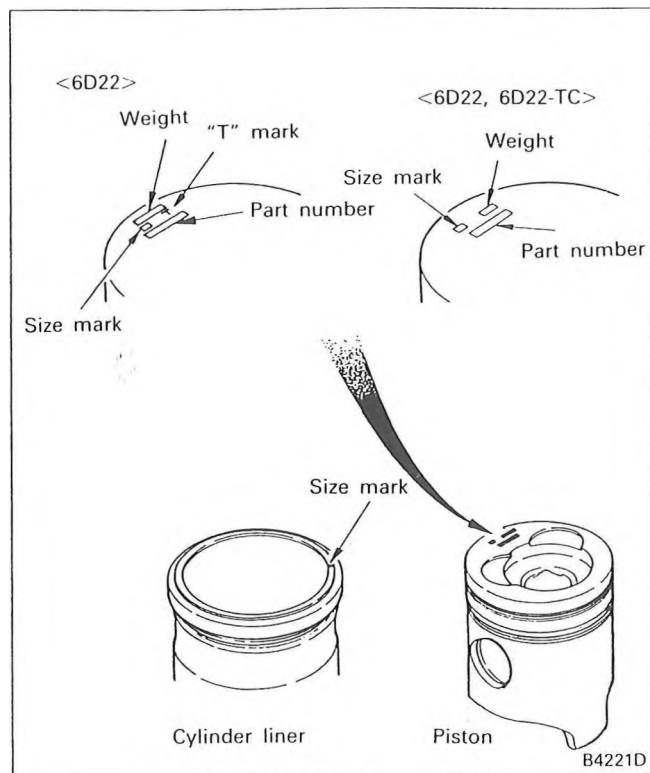
- 3) Securely seat the cylinder liner on the crankcase by lightly striking the flange portion, using Cylinder Liner Installer (special tool).

NOTE:

1. Apply soap suds to the crankcase and cylinder liner fitting portions and make sure that the rubber packing and O-ring are not twisted when inserted.
2. After installation, conduct the leak test to verify air-tightness. Apply thrust force to cylinder liner flange.

(6) Selection of Piston and Cylinder Liner

A piston may be standard or oversize, depending on which the cylinder liner is to be selected as follows.

(a) Standard piston

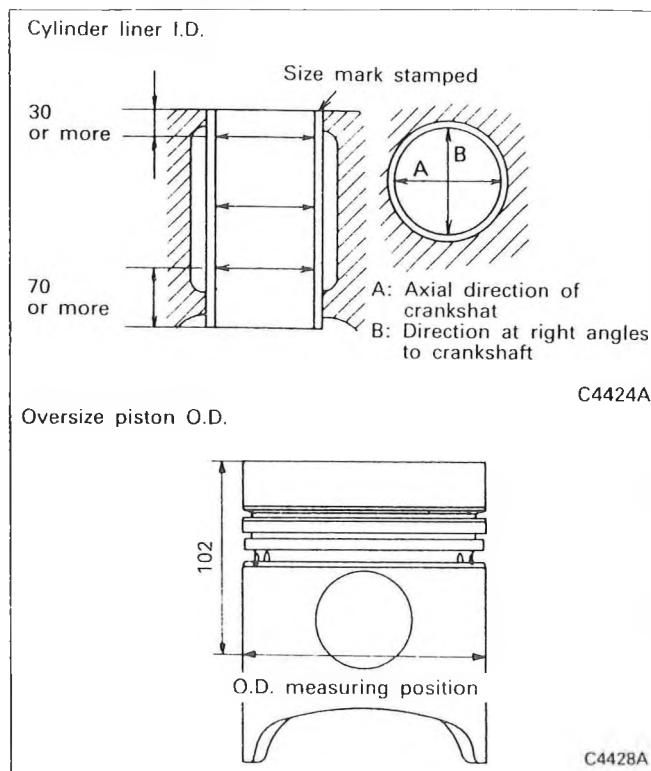
- 1) Select the piston with the same size mark as that stamped on the cylinder liner.
- 2) Make sure that the weight of pistons for one engine (six pistons) is in the range of ± 10 g of the weight stamped.

NOTE:

Whenever the piston is replaced, replace the piston rings.

(b) Oversize piston

Bore the cylinder liner as follows according to the type of piston (+0.5, +0.75, +1.00 mm).



- 1) Determine the amount of metal to be bored from the cylinder liner by taking into account the portion which wears most with reference to the measurements of I.D.s of all cylinders.
- 2) Bore and hone-finish the cylinder liner to obtain the specified clearance between the oversize piston and cylinder liner.

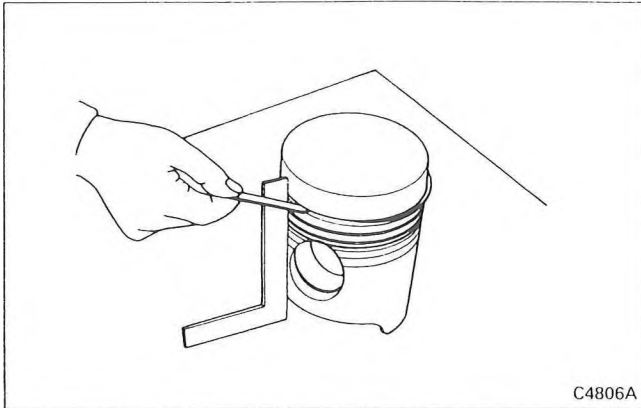
NOTE:

1. **Even when only one cylinder requires boring, bore all cylinders to the same oversize.**
2. **Replace the piston rings to those corresponding to the oversize.**

(7) Piston to Cylinder Liner Clearance

If the clearance is out of specification, replace the piston or cylinder liner.

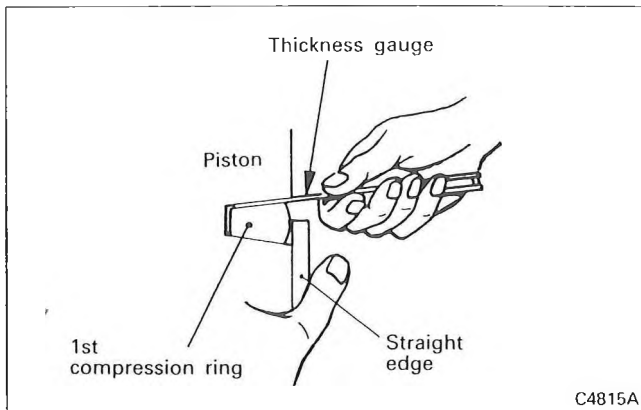
[Refer to Item (6)]

(8) Piston to Piston Ring Clearance

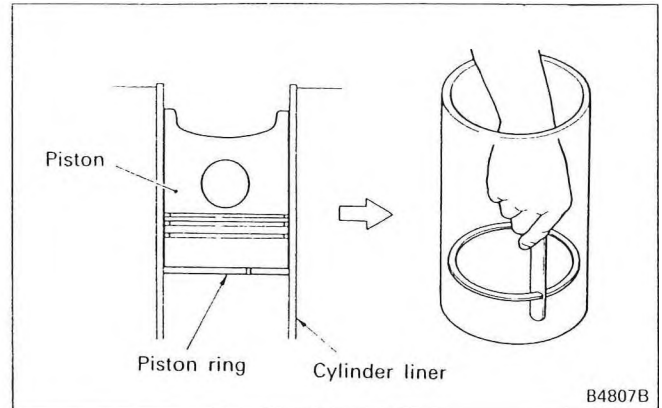
Measure the piston to piston ring clearance. If the limit is exceeded, replace the piston rings or piston.

NOTE:

1. After carbon has been removed, measure the clearance all around the piston.
2. Replace the piston rings as a set.



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

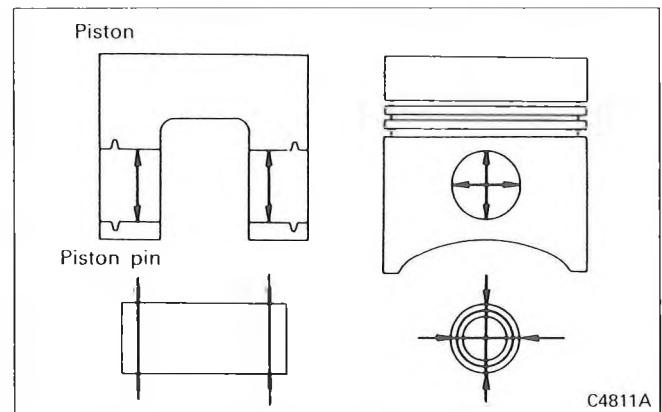
(9) Piston Ring Gap

Measure the piston ring gap with the piston ring horizontally pushed into a standard cylinder liner or actual one in the crankcase with a piston. Replace the piston ring if the gap exceeds the limit.

Standard cylinder liner I.D.: 130 ± 0

NOTE:

Use the piston to push the piston rings horizontally into a standard gauge.

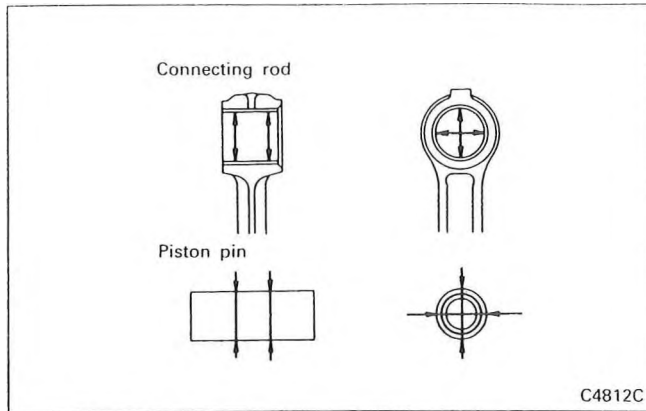
(10) Piston to Piston Pin Clearance

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

NOTE:

Whenever the piston is replaced, be sure to replace the piston rings.

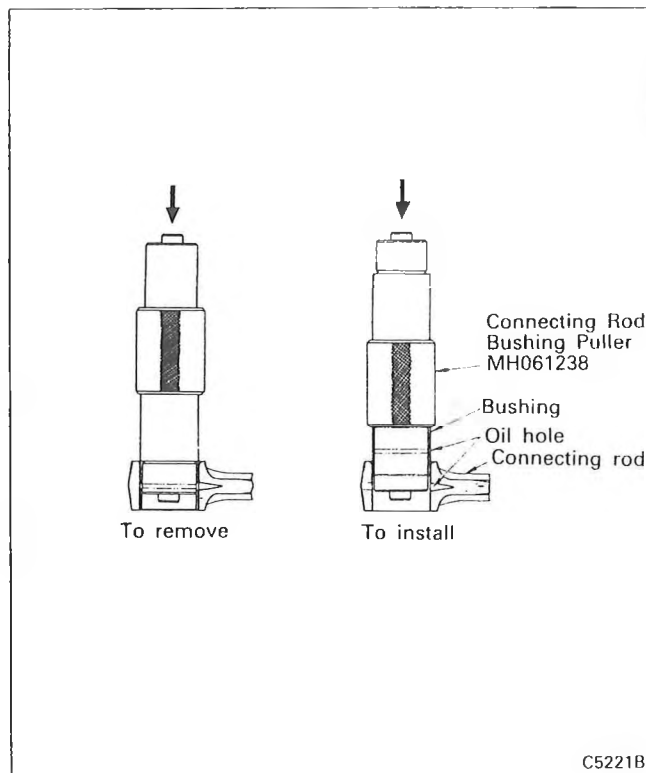
(11) Piston Pin to Connecting Rod Small End Clearance



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

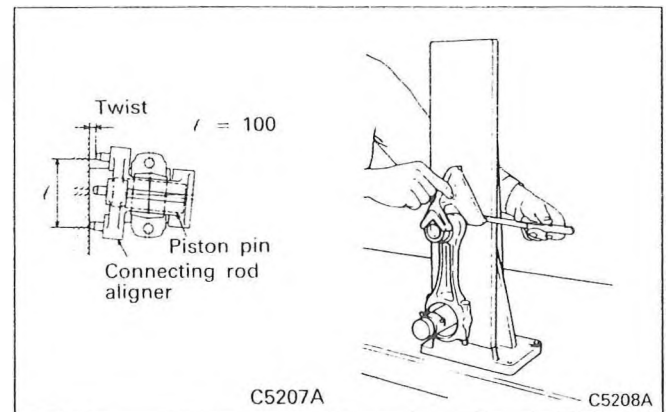
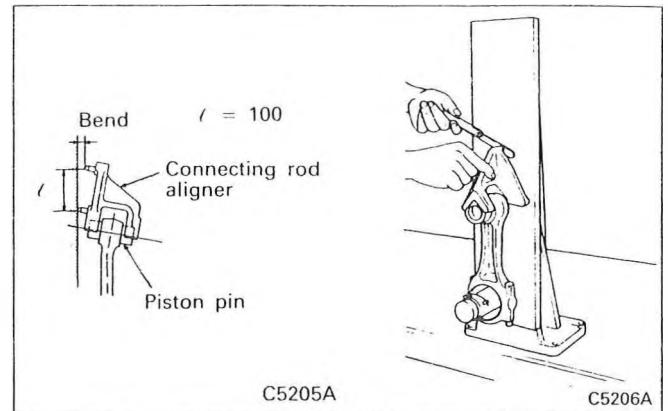
(12) Replacement of Connecting Rod Bushing

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



- Align the oil hole of the bushing with the oil hole of the connecting rod.
- Press the bushing in from the chamfered side of connecting rod end.
- After the bushing has been pressed in, insert the piston pin and check to ensure that it turns lightly without play.

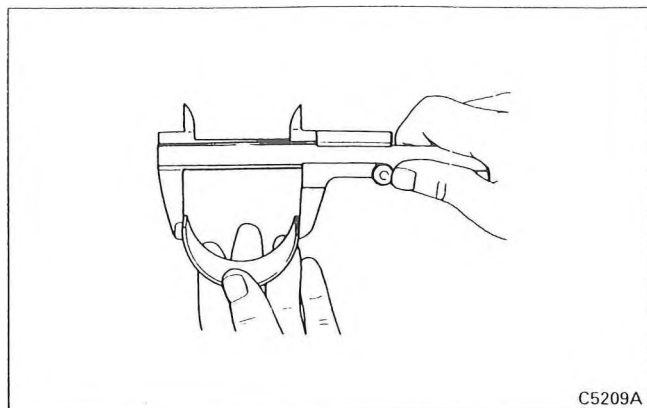
(13) Connecting Rod Bend and Twist



Measure the bend and torsion of the connecting rod with Connecting Rod Aligner (measuring instrument). If the reading is in excess of the limit, replace or correct with a press.

NOTE:

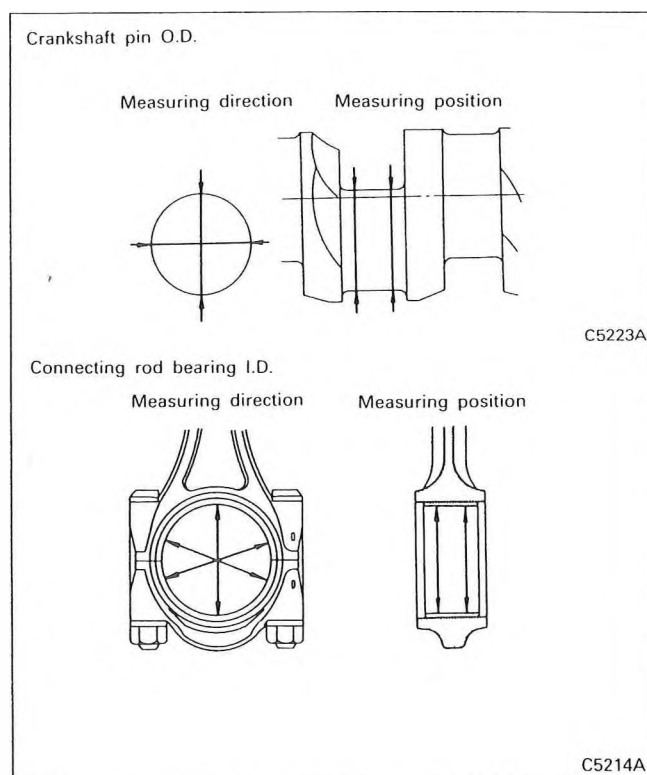
- Install the bushing and connecting rod bearing to the connecting rod before measurement.
- Tighten the connecting rod and connecting rod cap to the specified torque before measurement.

(14) Tension of Connecting Rod Bearing and Main Bearing when Free

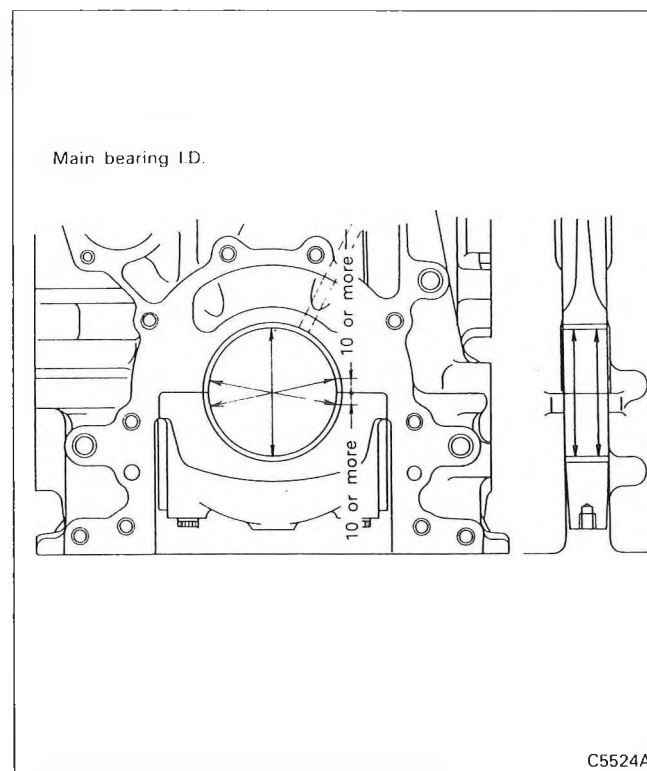
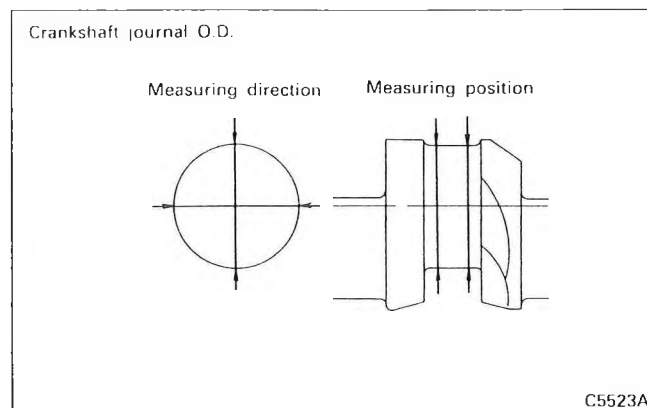
If the tension is lower than the limit, replace the upper and lower bearings as a set.

NOTE:

Do not use the bearing by artificially expanding it.

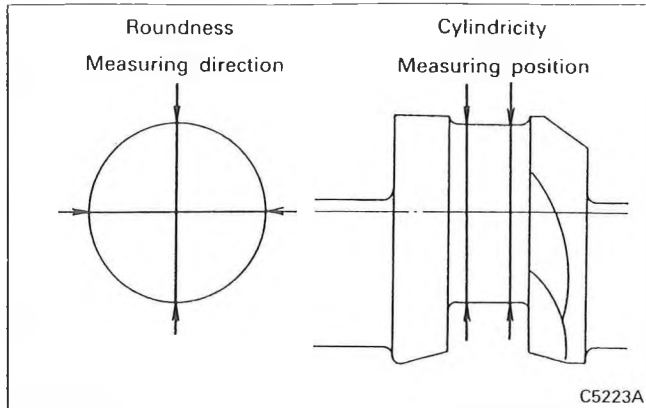
(15) Connecting Rod Bearing to Crankshaft Pin Clearance

If the limit is exceeded, replace the upper and lower bearings as a set.

(16) Main Bearing to Crankshaft Journal Clearance

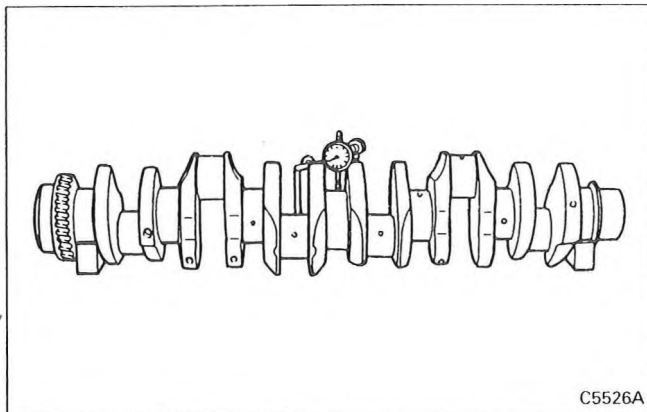
If the limit is exceeded, replace the upper and lower bearings as a set.

(17) Crankshaft Roundness and Cylindricity



Determine the out-of-roundness on the basis of the crankshaft journal and pin O.D. measurements. If the limit is exceeded, grind to undersize. [Refer to (19)]

(18) Crankshaft Bend



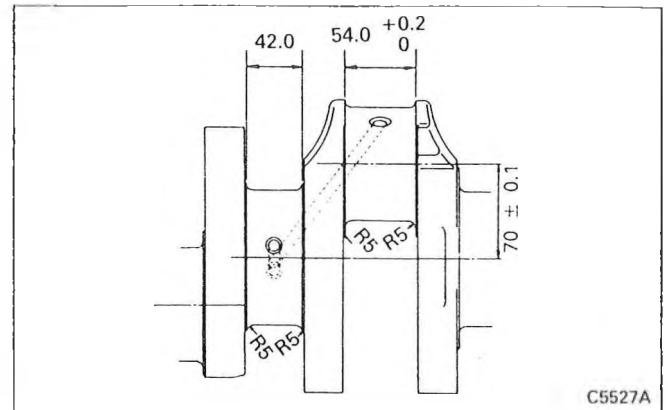
Measure the bend of the crankshaft. If the limit is exceeded, correct with a press or grind to undersize.

NOTE:

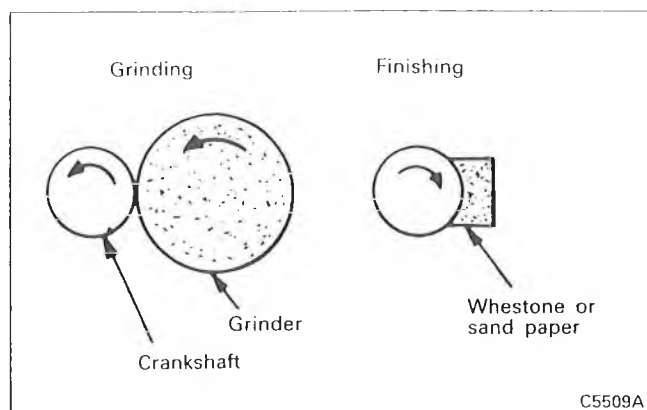
Read the crankshaft center journal runout with a dial indicator. One half of the reading is the bend.

(19) 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.



- When the crankshaft is ground, take care not to change the center distance of journal and pin.
- Grind the crankshaft in such a way as not to change the width of journal and pin.
- Finish the fillet smooth to the specified R.
- Check for ground cracks by the magnetic particle inspection method. The surface hardness (Hs 75 or more) should also be checked to confirm that it has not decreased.



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

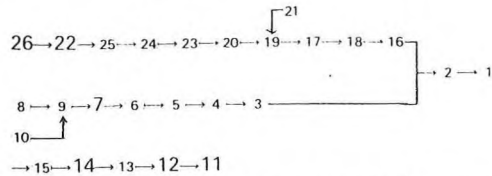
(f) To finish the crankshaft with a grindstone or sandpaper, turn the crankshaft counterclockwise.

Unit: mm

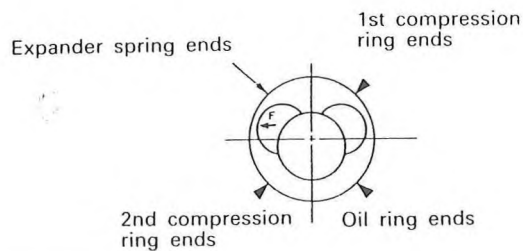
Undersize	Journal O.D. finish dimension	Pin O.D. finish dimension	Out-of- roundness	Cylind- ricity
-0.25	99.75 - 0.08 - 0.10	83.75 - 0.06 - 0.09	0.01 or less	0.006 or less
-0.50	99.50 - 0.08 - 0.10	83.50 - 0.06 - 0.09		
-0.75	99.25 - 0.08 - 0.10	83.25 - 0.06 - 0.09		
-1.00	99.00 - 0.08 - 0.10	83.00 - 0.06 - 0.09		

5.4.3 Reassembly

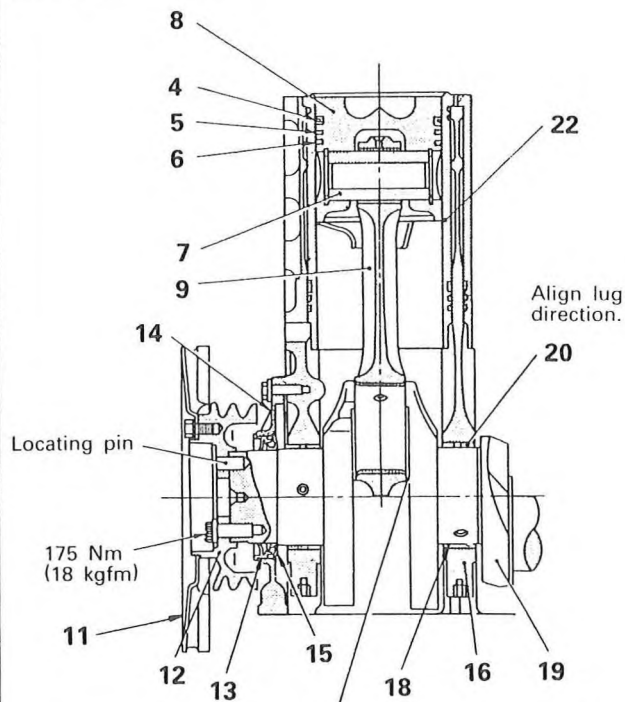
<Assembly sequence>



For assembly of parts with an encircled number, see following items.

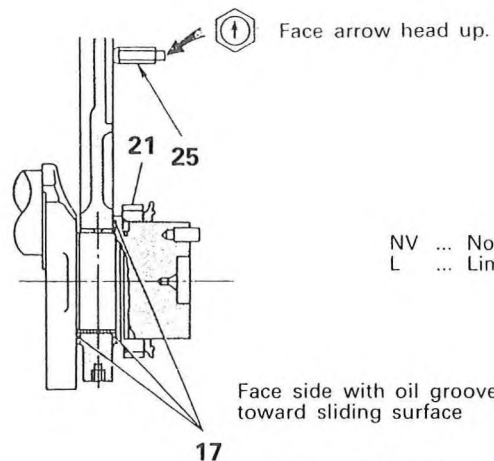
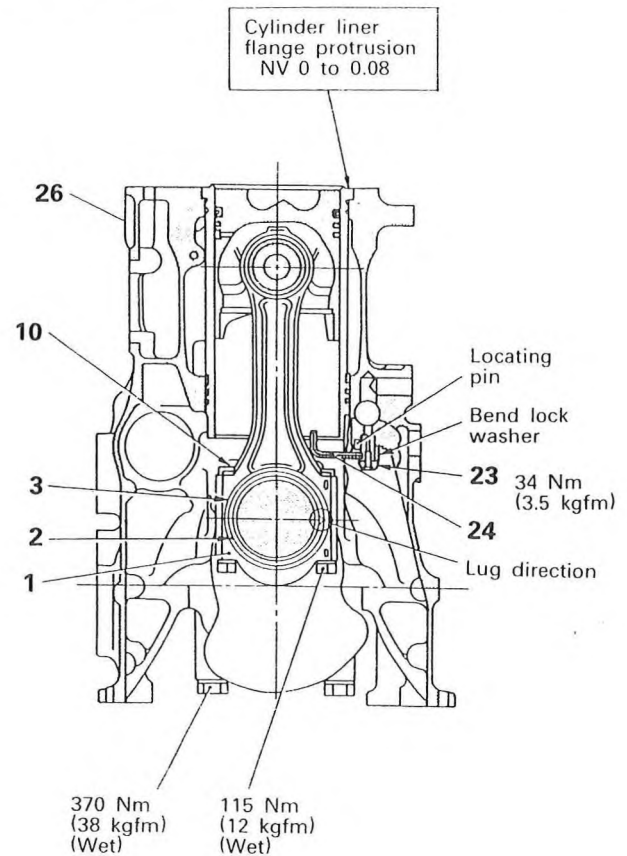


Piston projection
NV 0.87 to 1.33



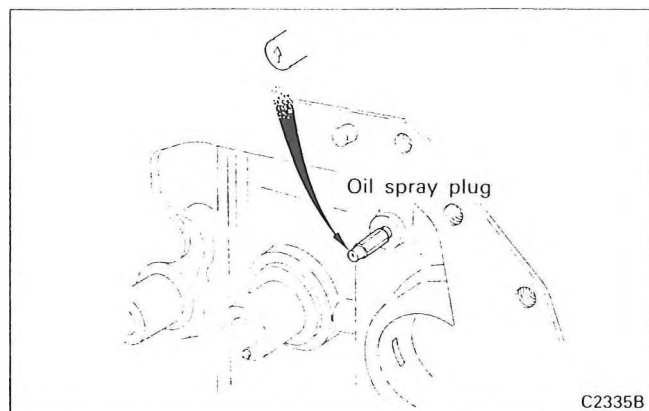
Apply lithium base grease to lips

Connecting rod end play
NV 0.2 to 0.5
L 1.0

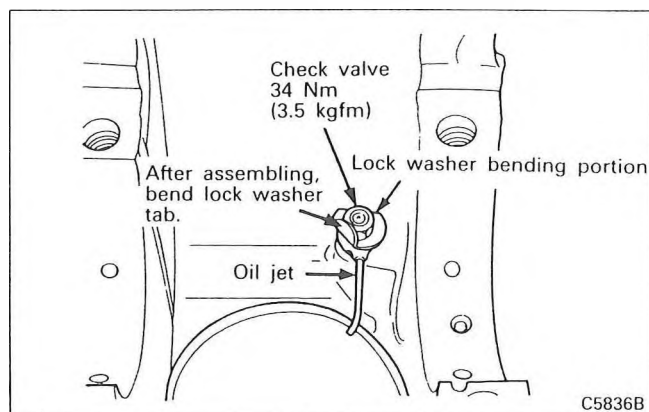


NV ... Nominal Value
L ... Limit

Crankshaft end play
NV 0.09 to 0.23
L 0.4

Reassembly Procedure**(1) Installation of Oil Spray Plug**

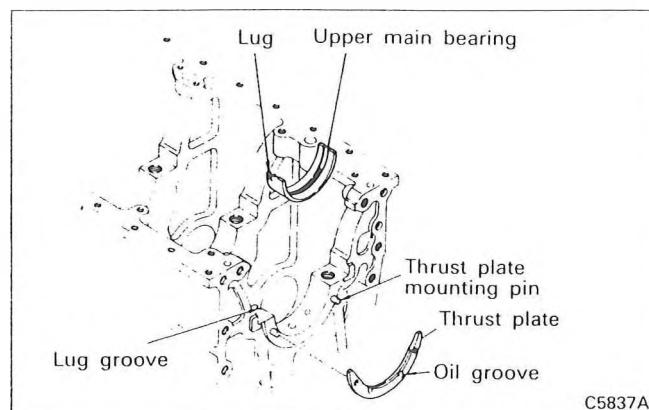
Install the oil spray plug with the arrow stamped on the plug toward the top of the engine.

(2) Installation of Oil Jet and Check Valve

(a) Install the oil jet, while making sure that its locating pin fits in the crankcase.

(b) Mount the lock washer in such a way that its bending portion will fit the end of the oil jet.

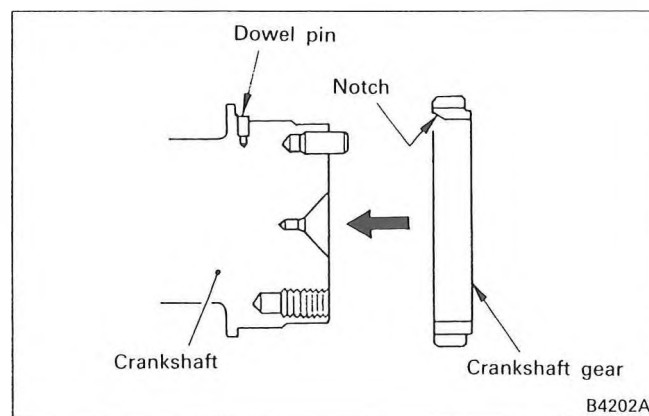
(c) After the check valve has been tightened to the specified torque, bend the lock washer to fit the hexagonal portion of the check valve.

(3) Installation of Upper Main Bearing and Thrust Plate**NOTE:**

1. Install the thrust plate with the oil grooveless side toward the crankcase.
2. Line up the lug of the main bearing and the groove of the crankcase.

The upper main bearing is one with oil holes. Take care not to confuse it with the lower one.

3. Oversize (0.15, 0.30, 0.45 mm) thrust plates are available for adjusting the end play in crankshaft [refer to Item (6), Section 5.4.1]. If any one of these is used, ensure the correct of the thrust plate to be installed to the main bearing cap [refer to Item (7)].

(4) Installation of Crankshaft Gear

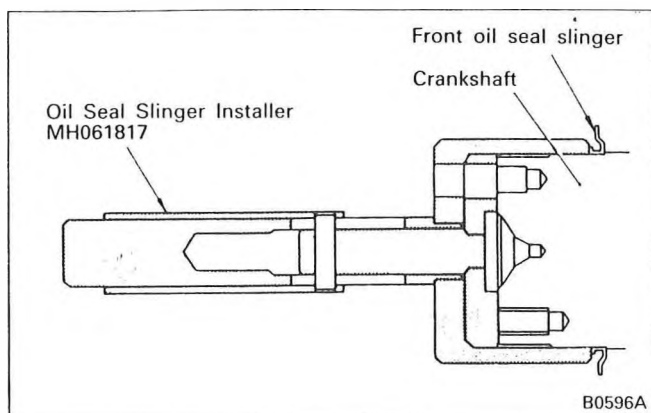
(a) Heat the gear to about 100°C, using a piston heater, etc.

(b) 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.

(c) Install the rear oil seal slinger.

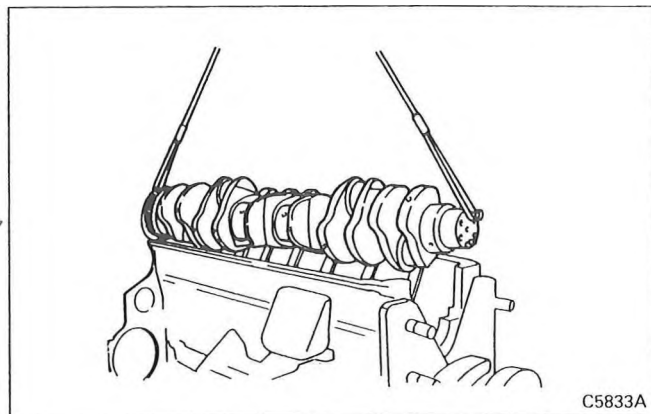
[Refer to Item (7), Section 5.3.3.]

(5) Installation of Front Oil Seal Slinger



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

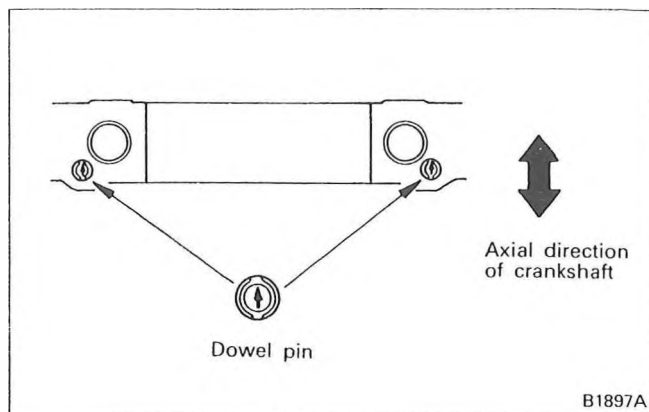
(6) Installation of Crankshaft



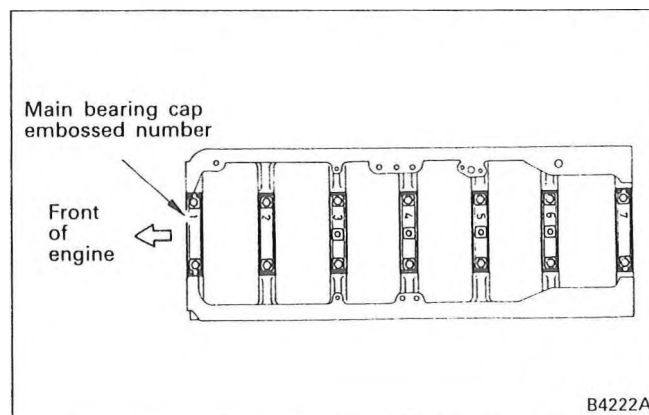
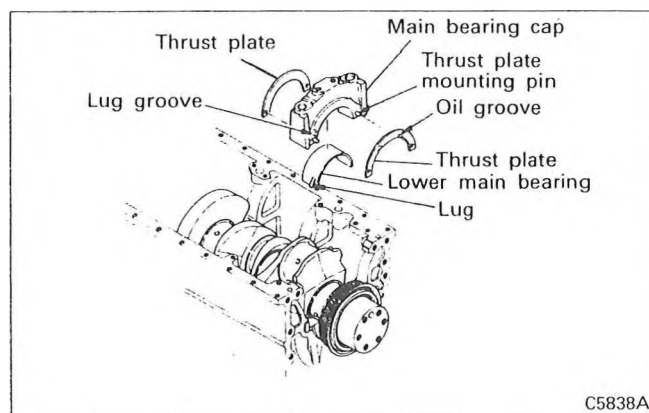
Lift the crankshaft with chain blocks, etc. While keeping it in horizontal position, slowly lower it into the crankcase.

(7) Installation of Lower Main Bearings and Main Bearing Caps

Follow the procedure given below.



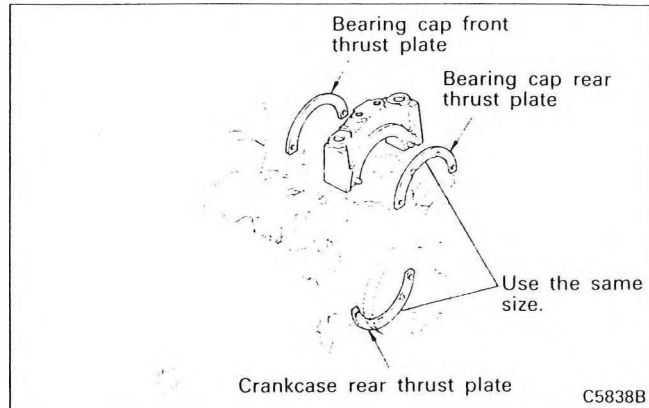
(a) Drive the locating dowel pins into the rearmost main bearing cap in the direction shown.



(b) Mate the lower main bearing with each main bearing cap, making sure that the lug in bearing is fitted into the lug groove in cap.

(c) Only to both sides of the rearmost main bearing cap, install the thrust plates facing their oil grooveless side toward the cap.

NOTE:



If an oversize thrust plate is used, use the bearing cap rear thrust plate of the same size as that of the thrust plate in the crankcase rear end [Refer to Item (3)]. Note, however, that the bearing cap front and rear thrust plates may be of different sizes.

(d) Install the main bearing caps, making sure that the side with the lug groove placed on the right-hand side of the engine and they are installed in the order of embossed numbers from the front of engine.

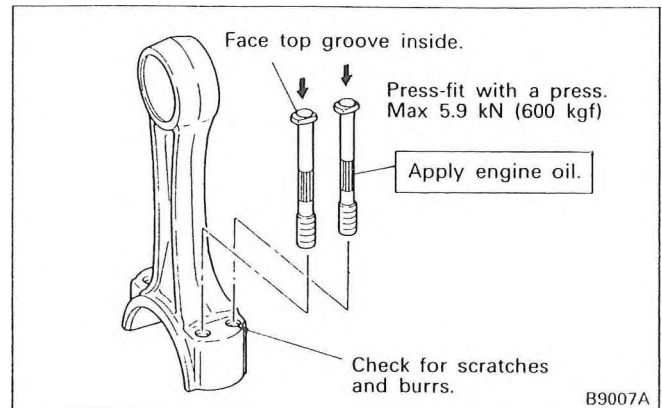
(e) Tighten main bearing cap bolts to specified torque. Then, tighten main bearing cap side bolts to specified torque.

After the bolts are tightened, make sure that the crankshaft is free to rotate by hand.

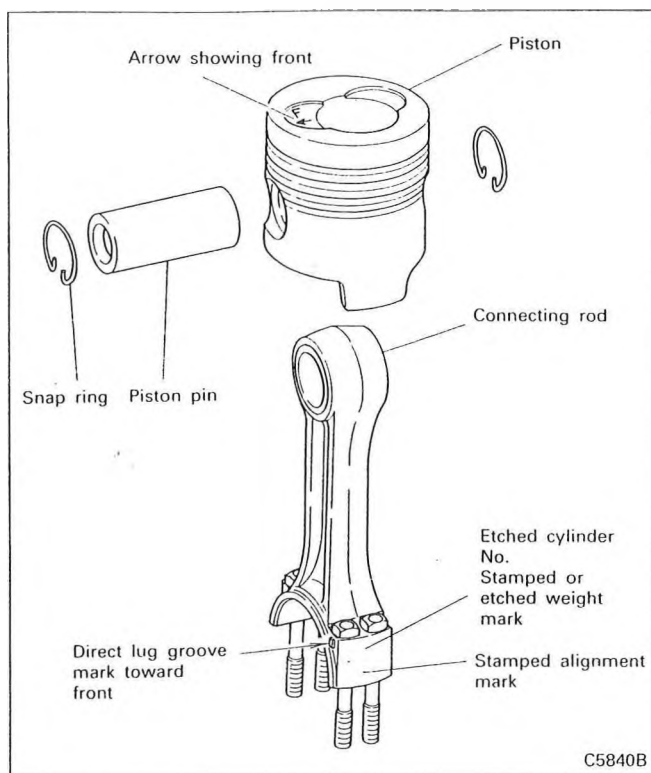
(f) Check to see if the end play of the crankshaft is within nominal value.

[Refer to Item (6), Section 5.4.1.]

(8) Installation of Connecting Rod Bolt



After checking the connecting rod for damage and burr in the bolt hole, apply engine oil to the connecting rod bolt and press-fit it into the connecting rod.

(9) Reassembly of Piston and Connecting Rod

Connect the piston to the connecting rod with the piston pin so that the Front mark on piston and lug groove mark in connecting rod are placed on the same side.

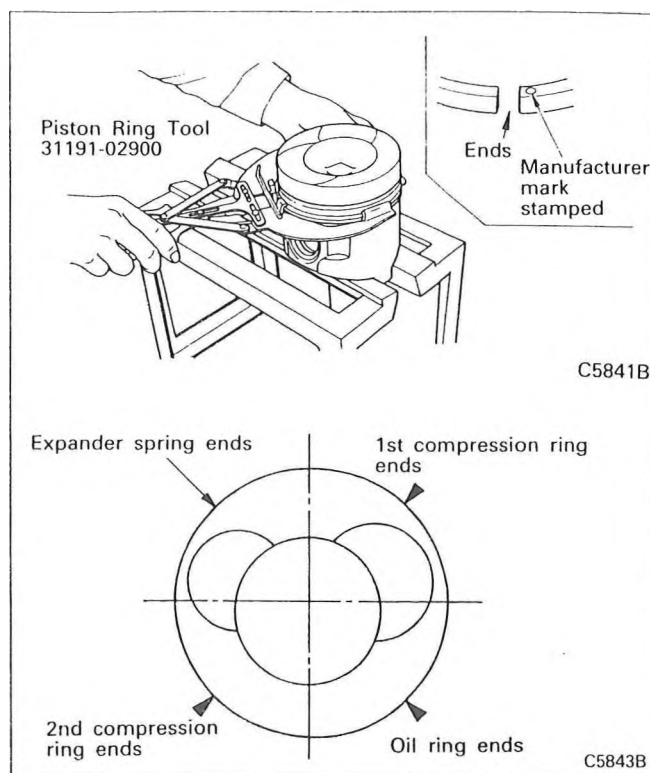
If the piston and piston pin are hard to insert, heat the piston with a piston heater or in hot water.

NOTE:

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

Weight marks

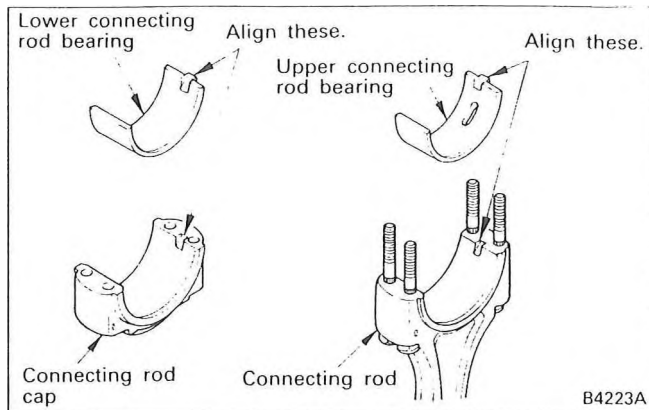
Heavy ← ————— → Light
A B C D E F G H J K

(10) Installation of Piston Ring

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

1. Oil ring
2. 2nd compression ring
3. 1st compression ring

(11) Installation of Upper and Lower Connecting Rod Bearings



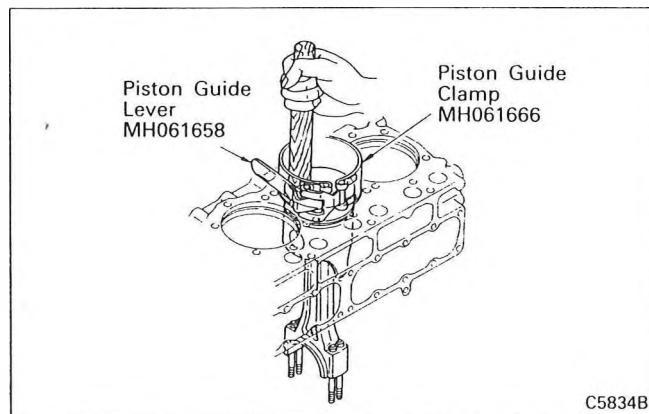
Install the upper connecting rod bearing, making sure that the bearing lug is aligned with the lug groove in the connecting rod.

Install the lower connecting rod bearing, making sure that the bearing lug is aligned with the lug groove in the connecting rod cap.

NOTE:

Note that the only the upper connecting rod bearing has an oil hole.

(12) Installation of Piston and Connecting Rod

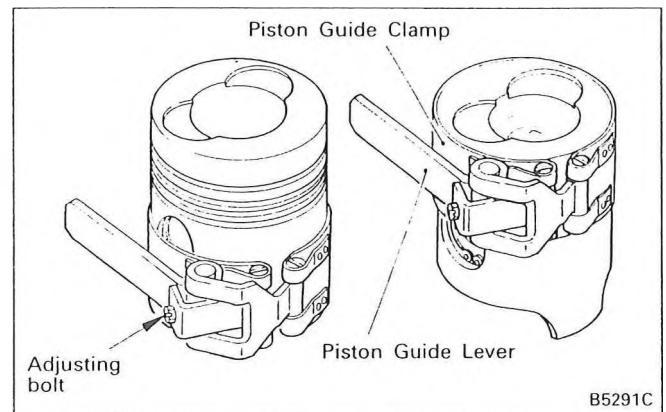


Using Piston Guide Clamp and Piston Guide Lever (special tools), install the piston and connecting rod so that the front mark on piston head faces the front of engine.

NOTE:

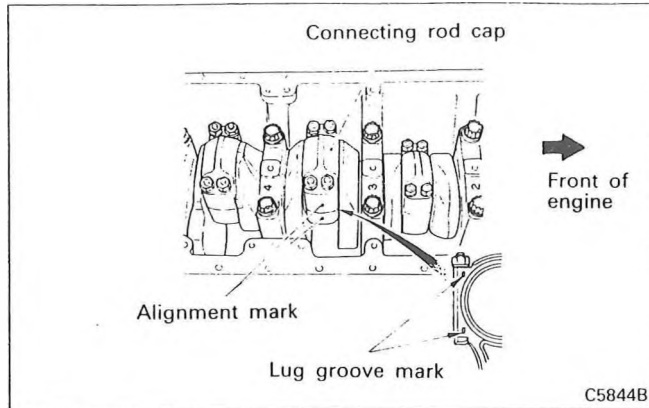
1. Make sure that the size symbol of the piston is the same as that of the cylinder liner.
2. Make sure that the piston ring open end directions do not change.
3. Put a vinyl hose or something else on the bolt of connecting rod for protection of the crankshaft pin against damage by the bolt.

Using the Piston Guide Clamp and Piston Guide Lever (special tools).



Line up the Piston Guide with the piston skirt and set the lever into position. Then, turn the adjusting bolt so that the clamp I.D. equals piston O.D. After the adjustment, apply engine oil to piston outer surfaces, Piston Guide inner surfaces, and cylinder liner inner surfaces.

After these procedures have been completed, fit Piston Guide onto the piston so that it is flush with the pistonhead. Using a mallet or wood block, tap piston into position with care not to damage it.

(13) Installation of Connecting Rod Caps

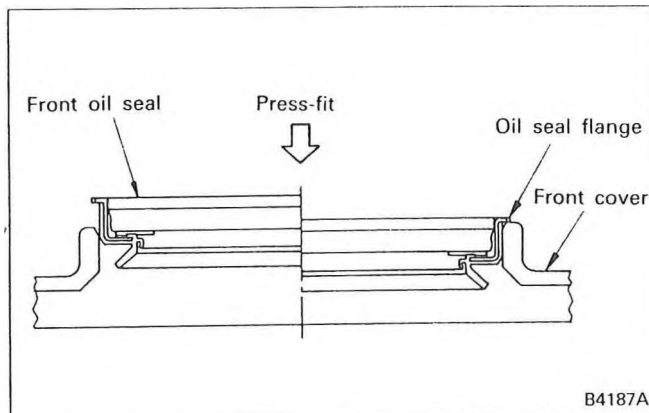
Make sure that the alignment marks and lug groove marks on the connecting rod cap and connecting rod are aligned.

(14) Check the connecting rod end play.

[Refer to Item (2), Section 5.4.1.]

(15) Check the projection of the piston.

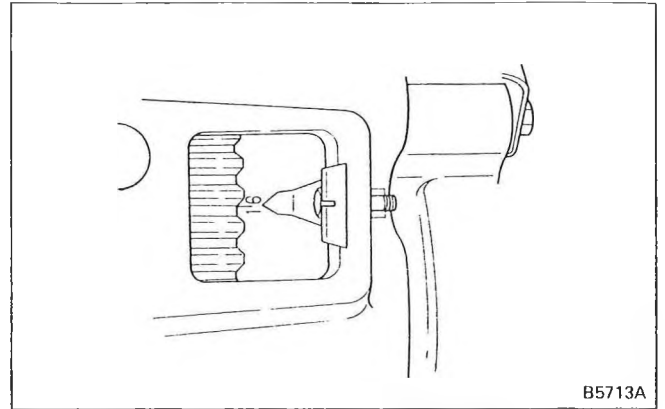
[Refer to Item (1), Section 5.4.1.]

(16) Installation of Front Oil Seal

Evenly press the oil seal throughout its entire periphery to prevent it from tilting. Press-fit the oil seal into the front cover until the oil seal flange is held tight up against the front cover.

5.5 INSPECTION AND ADJUSTMENT OF VALVE CLEARANCE

The valve clearance should be checked and adjusted as described below while the engine is cold.

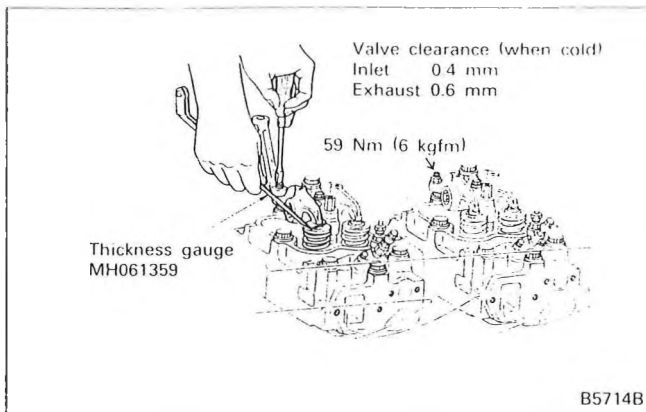


(1) Crank the engine to align the pointer of the inspection window of the flywheel housing with the inscribed mark 1.6 of the flywheel. Check the push rods, and the piston whose push rod is not pushing up the rocker is at the top dead center of the compression stroke.

(2) When the No. 1 cylinder piston is at the top dead center on the compression stroke, check and adjust the clearance of valves marked "o" in the following table.

When the No. 6 cylinder piston is at the top dead center on the compression stroke, check and adjust the clearances of valve marked "x". Turn the crankshaft through a rotation, and make sure that valve clearance inspection and adjustment are performed for all of the six cylinders.

Cylinder No.	1		2		3		4		5		6	
Valve arrangement	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.
No. 1 at TDC on the compression stroke	o	o	o			o	o			o		
No. 6 at TDC on the compression stroke				x	x			x	x		x	x



(3) Measure the rocker arm to valve cap clearance with a thickness gauge to determine whether the clearance is up to specification.

If the thickness gauge of the specified thickness is somewhat hard to move, the clearance is good.

If the clearance is out of specification, loosen the lock nut and adjust with the adjusting screw. After adjustment, turn down the lock nut to lock the adjusting screws.

NOTE:

After the lock nut has been turned down, recheck the clearance.

6. TROUBLESHOOTING

Symptom	Probable cause	Remedy	Ref. group
Engine will not start	Inadequate oil viscosity	Replace	Group 12
	Incorrect fuel in use		Group 13
	Low compression pressure Incorrect valve clearance	Adjust	
	Defective head gasket	Replace	
	Worn valve and valve seat, carbon deposit		
	Deteriorated valve spring		
	Worn or damaged piston ring		
	Worn or damaged piston ring groove	Change to oversize	
	Worn piston and cylinder liner		
	Defective preheater Defective starter switch	Correct or replace	Group 16
	Defective heater relay		
	Incorrect injection timing	Adjust	Group 13
	Insufficient injection amount Defective injection pump	Correct or replace	Group 13
Incorrect injection amount			
Cooling system not functioning properly	Correct or replace	Group 14	
Rough idle	Inadequate oil viscosity	Replace	Group 12
	Incorrect fuel in use		Group 13
	Defective cooling system	Correct or replace	Group 14
	Low compression pressure (See "Engine will not start".)		
	Incorrect injection timing	Adjust	Group 13
	Defective fuel system Defective injection pump	Correct or replace	Group 13
	Defective injection nozzle		
	Air trapped in fuel system		
Abnormal exhaust gas color	Incorrect fuel in use	Replace	Group 13
	Cooling system not functioning properly	Correct or replace	Group 14
	Intake/exhaust system not functioning properly Clogged air cleaner	Correct or replace	Group 15
	Clogged muffler		
	Oil leaks to intake/exhaust pipes		
	Low compression pressure (See "Engine will not start".)		
	Defective fuel system Defective injection pump	Correct or replace	Group 13
	Defective injection nozzle		
	Incorrect injection timing	Adjust	
	Excessive engine oil	Adjust	Group 12
Binding of major moving parts	Correct or replace		

Symptom	Probable cause	Remedy	Ref. group
Low output	Inadequate oil viscosity	Replace	Group 12
	Incorrect fuel in use		Group 13
	Defective cooling system	Correct or replace	Group 14
	Intake/exhaust system not functioning properly • Clogged air cleaner • Clogged muffler	Correct or replace	Group 15
	Low compression pressure (See "Engine will not start".)		
	Defective fuel system • Defective injection pump • Defective injection nozzle • Air trapped in fuel system	Correct or replace	Group 13
	Incorrect injection timing	Adjust	
Large oil consumption	Oil leaks from lubrication system	Check and correct	Group 12
	Oil leaks from engine and related parts • Defective gasket and oil seal	Replace	
	Oil entered to combustion chamber from piston side • Worn cylinder liner and piston	Correct or replace	
	• Worn, damaged or seized piston ring • Clogged piston and oil ring oil holes	Replace as a set Clean	
	Oil entered to combustion chamber from valve side • Worn valve stem and valve guide • Worn valve stem seal	Replace	
Abnormal engine noise	Noise produced from around the engine • Loose piping or hosing connection	Check and correct	
	• Injection pump, alternator or other auxiliary units defective or incorrectly mounted	Check and adjust	Group 13 and 16
	• Loose or damaged V-belt	Replace	Group 14
	• Crankshaft pulley incorrectly mounted	Check and adjust	
	• Air cleaner, muffler not functioning properly	Correct or replace	Group 15
	Noise produced from around rocker cover • Incorrect valve clearance • Defective valve spring • Defective rocker shaft and bracket • Poor lubrication in rocker shaft	Adjust Replace Check and correct Check	
	Noise produced from around flywheel housing • Incorrect timing gear backlash • Poor lubrication around timing gear and idler shaft	Replace Check	

Symptom	Probable cause	Remedy	Ref. group
Abnormal engine noise	Noise produced from cylinder head or crankcase		
	• Low compression pressure (See "Engine will not start")		
	• Incorrect injection timing	Adjust	Group 13
	• Incorrect spray condition	Correct or replace	
	• Worn connecting rod small end bushing and piston pin	Replace	
	• Worn or damaged crankshaft pin and connecting rod big end bearing		
	• Worn or damaged crankshaft journal and main bearing		
	• Excessive crankshaft, to camshaft end play	Replace thrust plate	
	• Worn tappet and camshaft	Replace worn part	

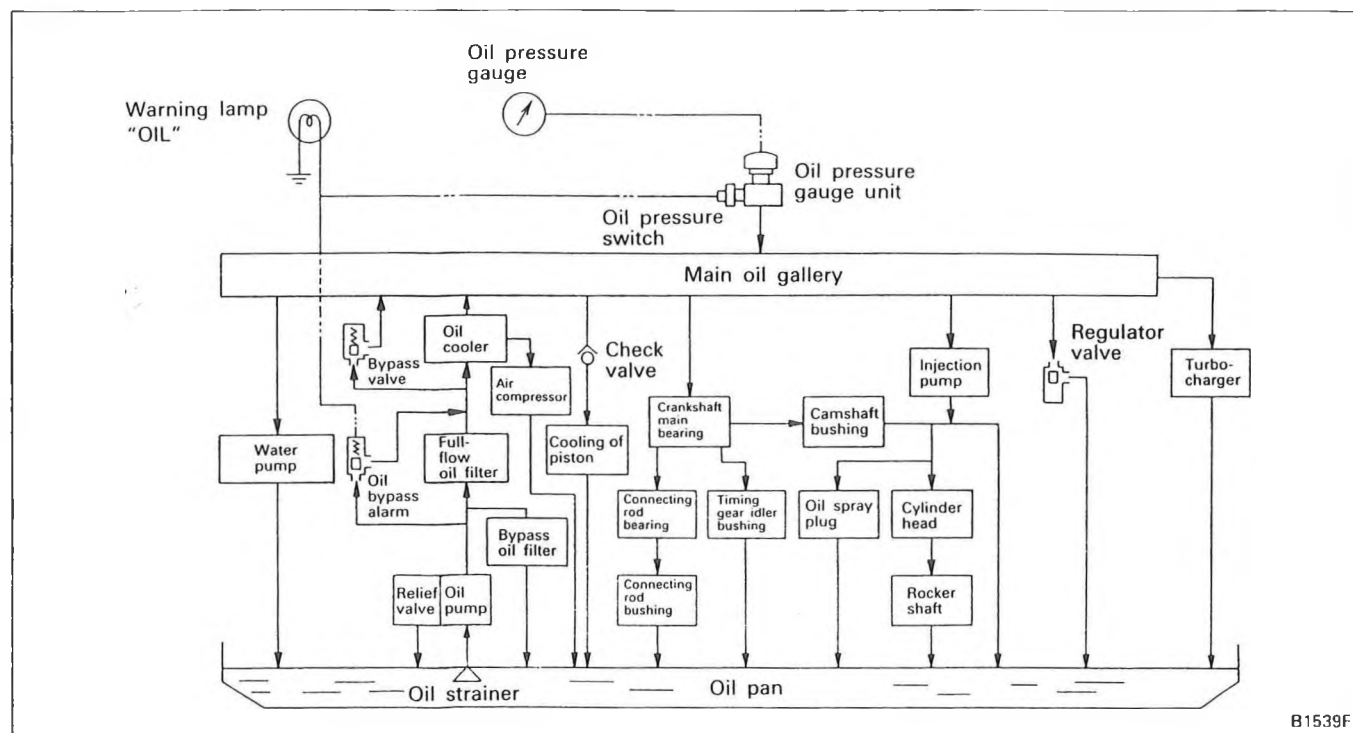
LUBRICATION

CONTENTS

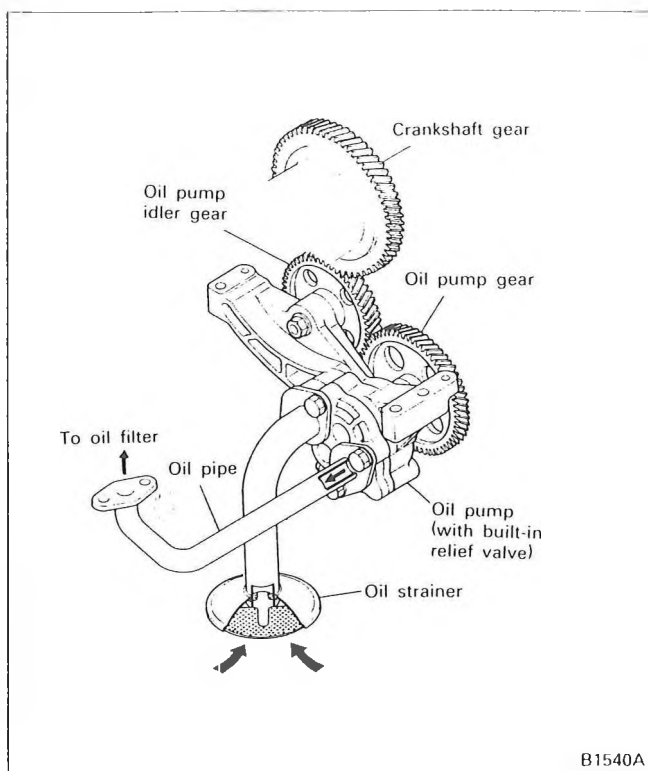
1. GENERAL	2	4.2 DISASSEMBLY, INSPECTION AND REASSEMBLY	13
2. SPECIFICATIONS	10	4.2.1 Oil Pump	13
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1. GENERAL

Engine lubrication is accomplished by forced lubrication system using gear pump. The engine oil in the oil pan is drawn up through the oil strainer by the oil pump and force-fed to the oil filter and oil cooler to lubricate all parts.



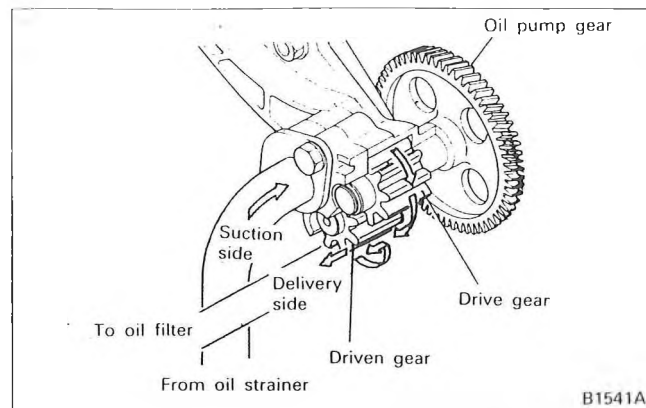
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(1) Oil Pump

The oil pump, of a gear pump type, is mounted in the rear bottom portion of the crankcase, driven by the crankshaft gear.

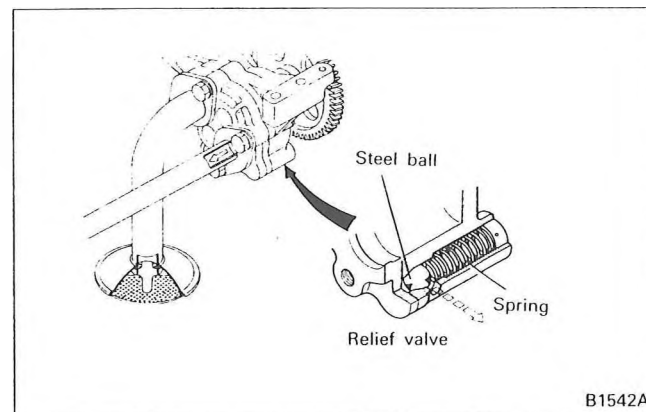
An oil strainer is mounted at the suction port of the oil pump; an oil pipe at the delivery port.

The crankshaft gear drives the oil pump idler gear and oil pump gear to transmit rotation to the oil pump drive gear. In the oil pump, the oil pump drive gear is in mesh with the oil pump driven gear. When the oil pump drive gear is driven, the oil pump driven gear is turned in the opposite direction.

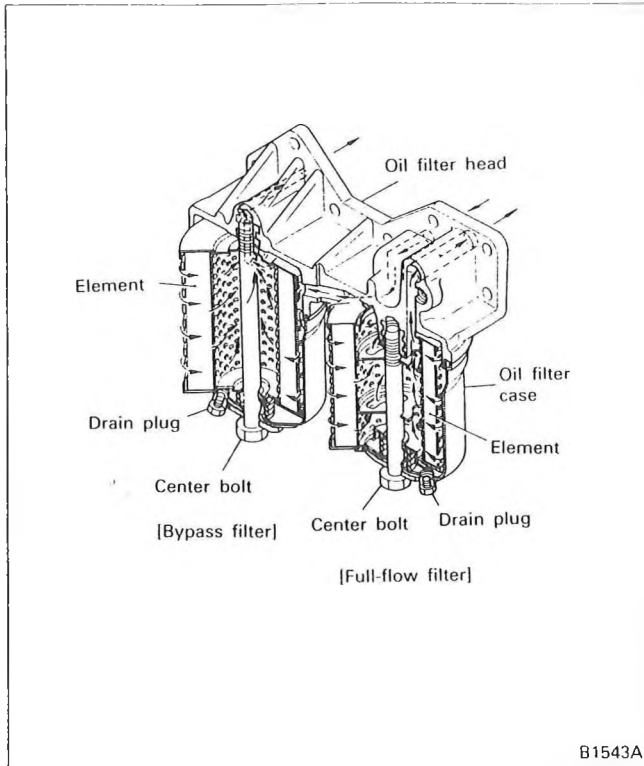


At the time, the engine oil is drawn in from the suction side by the negative pressure produced as the gear turns along the inside of the pump case, and is carried along the gear and case inside wall to the delivery side.

The oil strainer at the suction port prevents entry of foreign matter in the oil pan and air. The engine oil is routed to the crankcase by the oil pipe connected to the delivery port.

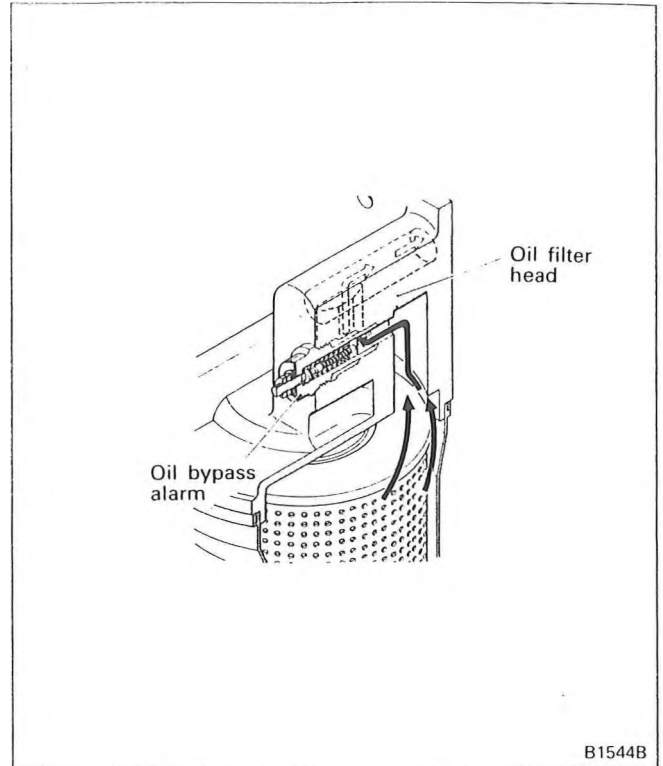


Since the oil pump is driven at speeds proportional to the engine's, the delivery pressure of the oil pump increases during starting in cold weather. A relief valve is provided in the oil pump to make sure that no excessive pressure acts on the lubrication system.

(2) Oil Filter

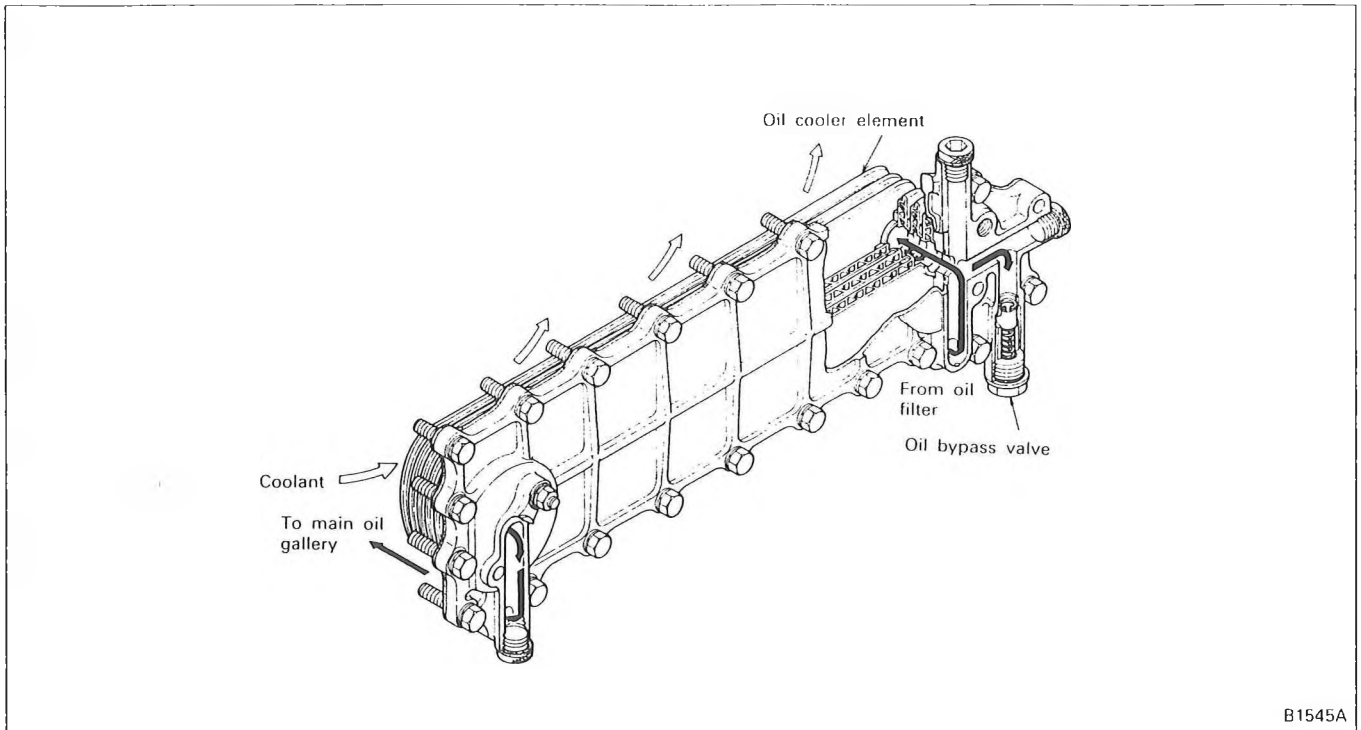
The oil filter is a double oil filter consisting of a full-flow filter made integral with bypass filter. Element is a filter paper element.

Engine oil fed under pressure from the oil pump passes through the oil hole in the crankcase and flows from the oil filter head into the full-flow filter and bypass filter. The engine oil filtered through the full-flow filter is routed from the oil filter head through the crankcase oil hole to the oil cooler. The engine oil filtered through the bypass filter returns to the oil pan.



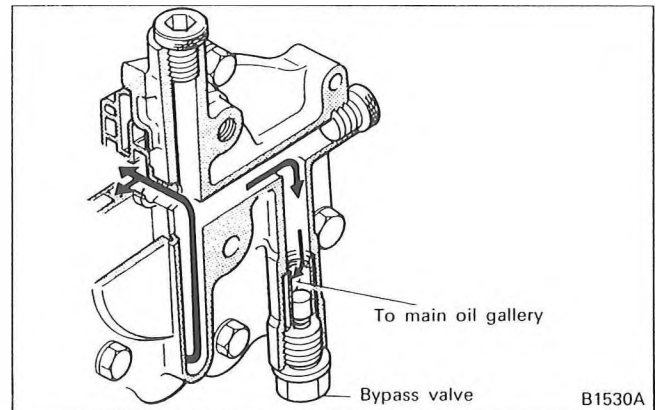
When the oil filter element is clogged and the difference in pressure between the filtered and unfiltered oil exceeds the limit specified, the valve in the oil bypass alarm moves against the spring force, allowing the unfiltered oil to flow to the filtered oil path.

The oil bypass alarm has electric contacts that are closed to turn on the pilot lamp, warning the driver of clogged element when the valve is opened.

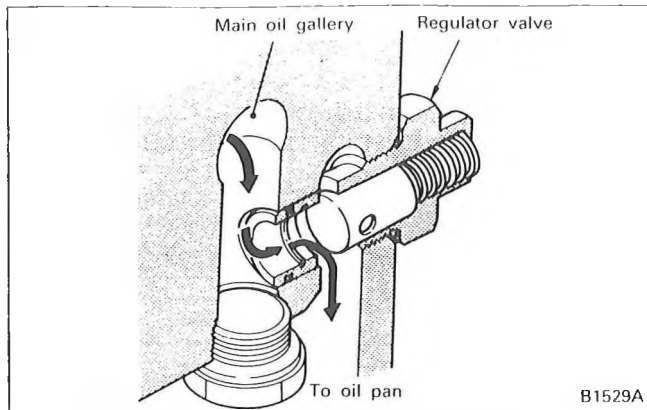
(3) Oil Cooler

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

Engine oil forced through the oil filter flows inside the oil cooler element; whereas the coolant forced from the water pump flows around the element. The engine oil in the element is then cooled or heated before it flows to the main oil gallery.

(4) Bypass Valve

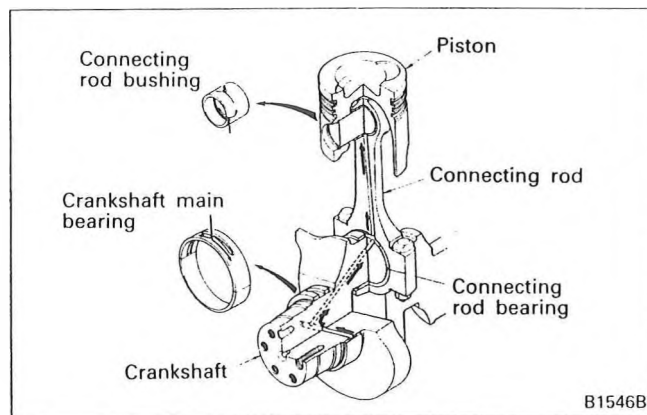
When the oil viscosity is high at low temperatures or when the element has high resistance to flow because of clogging, the bypass valve installed at the oil cooler opens to allow engine oil to flow to the main gallery bypassing the oil cooler.

(5) Regulator Valve

The regulator valve is mounted in the main oil gallery in the crankcase to make sure that no excessive pressure acts on the lubrication system.

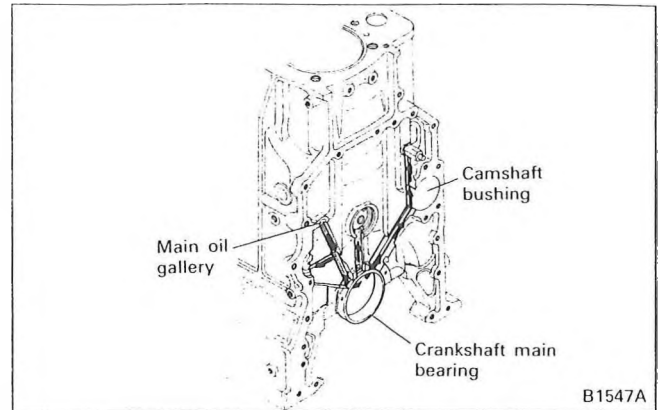
(6) Lubrication of All Parts

The engine oil routed to the main oil gallery lubricates all parts as described in the following.

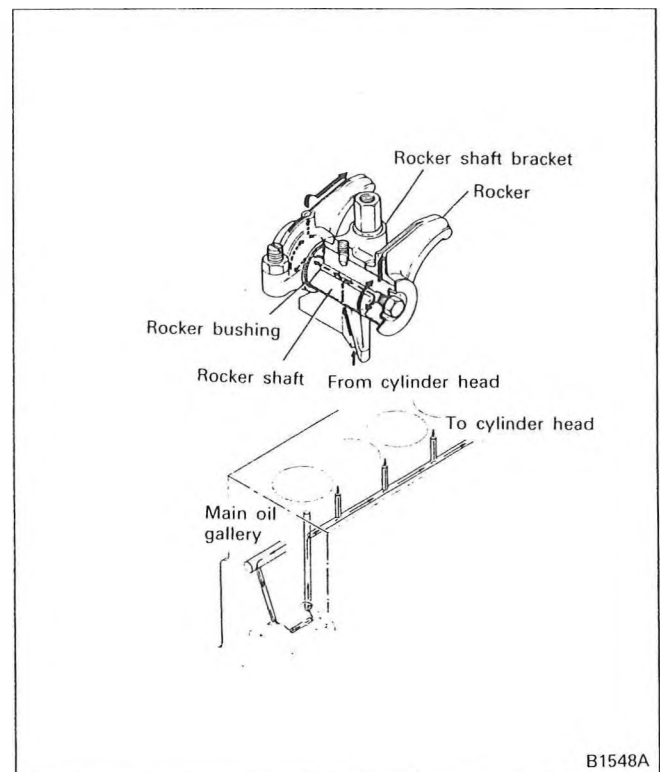
(a) Main bearing, connecting rod bearing, and connecting rod bushing

The oil hole extends from the main oil gallery to the crankshaft main bearing to lubricate the main bearing. Part of the engine oil that has lubricated the main bearing passes through the oil hole in the crankshaft to lubricate the connecting rod bearing, and then through the oil hole in the connecting rod to lubricate connecting rod bushing.

On 6D22-TC, there is a hole provided in top of connecting rod, from which oil spurts out to the piston.

(b) Camshaft

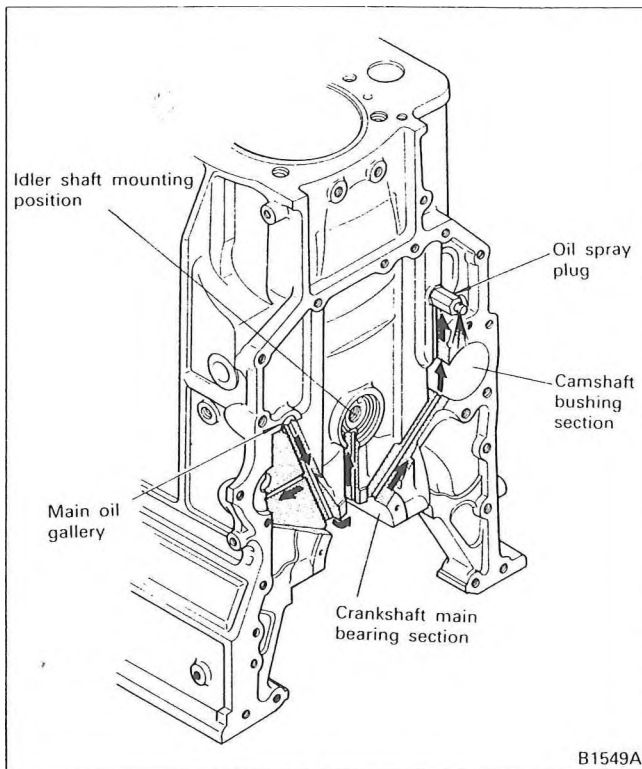
Lubrication of the camshaft bushings is accomplished by the oil flowing through the oil holes from the outside periphery of the crankshaft main bearing to the individual camshaft bushing.

(c) Valve mechanism

The engine oil that has lubricated the No. 7 camshaft bushing flows through the oil hole provided at the top of the crankcase to each cylinder head.

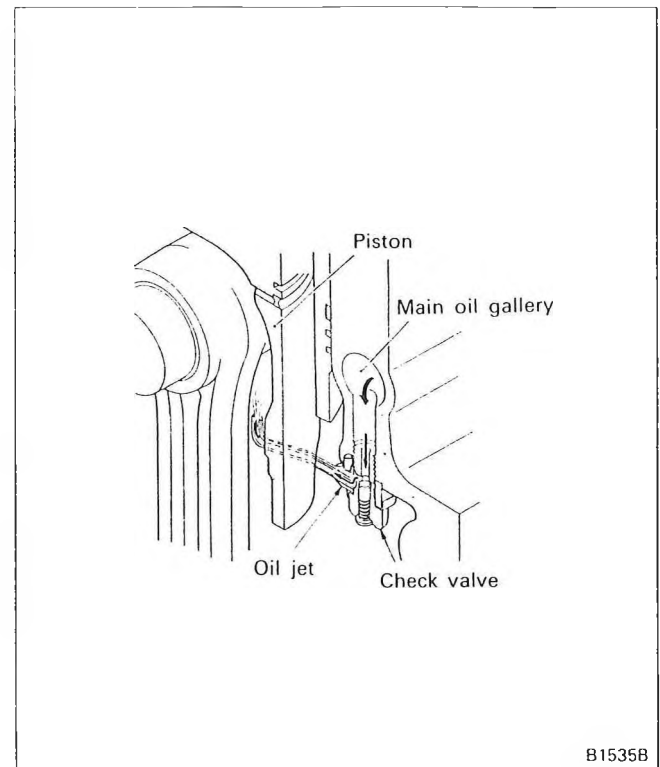
Engine oil fed to the cylinder head flows through the oil holes in the rocker shaft bracket and rocker shaft to lubricate each rocker bushing. The engine oil is also sprayed out of the rocker arm oil holes for lubrication of the sliding surfaces of valve cap and valve stem as well as the sliding surfaces of push rod and adjusting screw. The oil then flows through the push rod holes in the cylinder head and crankcase to lubricate the tappet and cam of the camshaft and returns to the oil pan.

(d) Timing gears



The timing gear idler shaft are lubricated, as shown in the figure, by engine oil flowing through the oil holes routed from the main oil gallery and the crankshaft main bearing in the rear end. Each gear is lubricated by the engine oil sprayed from the oil spray plug.

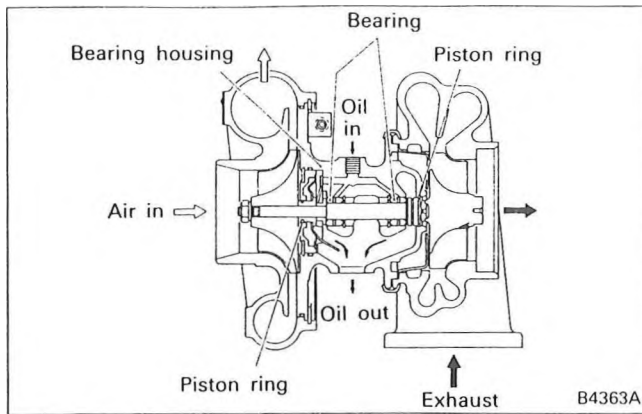
(e) Cooling the piston (oil jet)



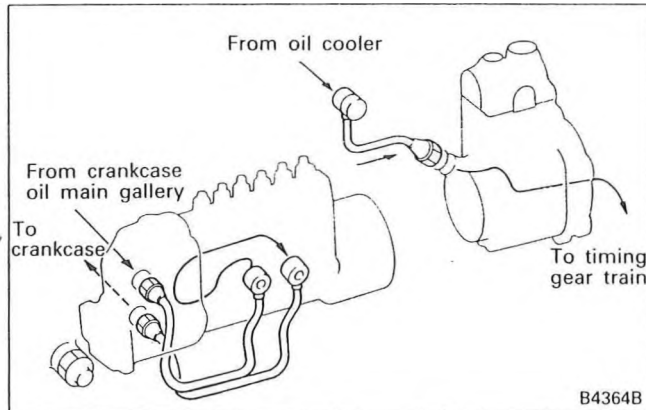
The oil jet provided under the main oil gallery for each cylinder sprays engine oil against the reverse surface of the piston to cool the piston.

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.

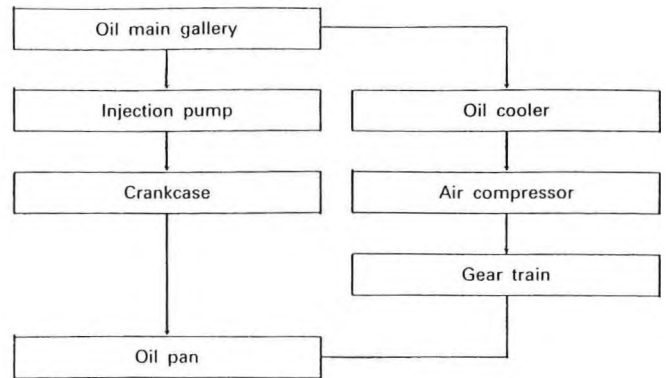
On the piston for the 6D22-TC, a cooling cavity is provided. The oil injected from the oil jet enters the cooling cavity to cool the piston.

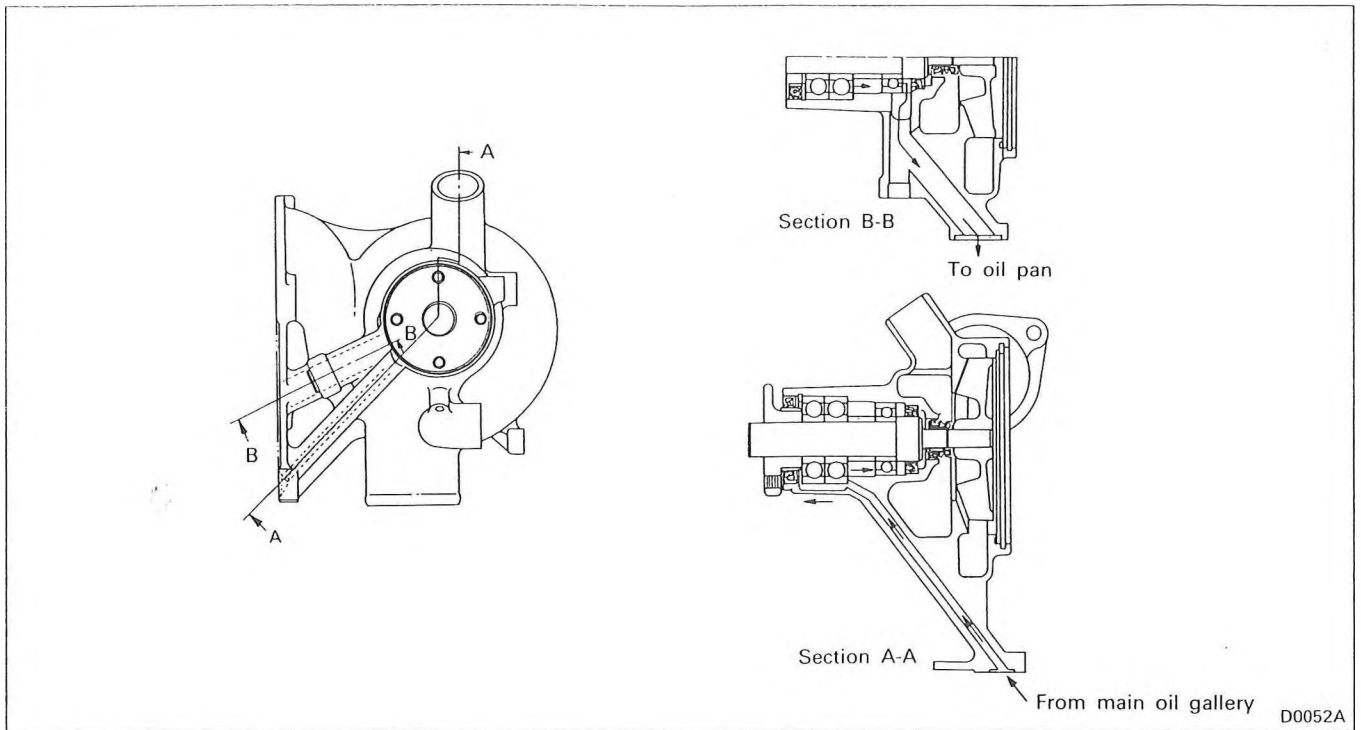
(7) Lubrication of Turbocharger

Part of the engine oil is directed through the oil pipe from the crankcase into the turbocharger. The engine oil passes through the oil hole in the turbocharger bearing housing to lubricate the bearings. It is then returned through the oil outlet at the bottom of the bearing housing back to the crankcase and to the oil pan. A piston ring is installed on the outside of each bearing, serving as an oil seal.

(8) Injection Pump and Air Compressor

The injection pump and air compressor are lubricated as follows:



(9) Lubrication of Water Pump

The engine oil drawn by the oil pump is routed through the crankcase oil passage to the water pump. The engine oil delivered to the water pump flows through the oil hole of the water pump and lubricates the bearings.

The engine oil is then forced back from the drain port to the crankcase and returns to the oil pan.

2. SPECIFICATIONS

Item		Specifications
Engine oil	Quality	[Without turbocharger] API classification Class CC or better [With turbocharger] API classification Class CD or better [For general power] [For construction machinery] Approx. 27 lit. Approx. 25 lit. 4 to 4.5 lit. 4 to 4.5 lit.
Oil pan capacity		
Oil filter capacity		
Lubrication method		Forced lubrication by oil pump
Oil pump	Type	Forced lubrication by gear pump (with built-in relief valve)
Relief valve	Type	Ball valve
Oil filter		
Full-flow filter element	Type	Filter paper type
Bypass filter element	Type	Filter paper type
Oil bypass alarm	Type	Piston valve type with built-in electric contacts
Oil cooler	Type	Shell and plate type (multi-plate type)
Oil bypass valve	Type	Piston valve type
Regulator valve	Type	Piston valve type
Oil jet		
Check valve	Type	Piston valve type

3. SERVICE STANDARDS

3.1 SERVICE STANDARD TABLE

Unit: mm

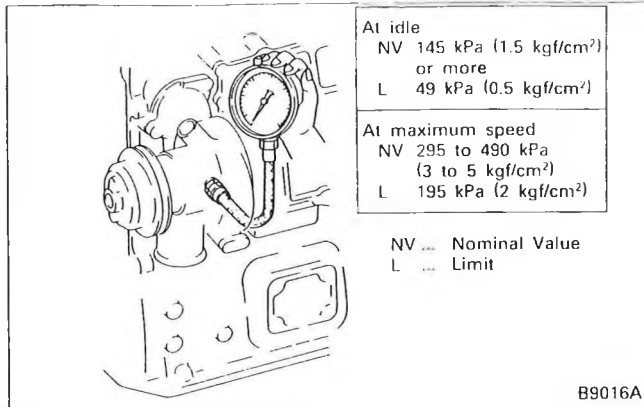
Description		Nominal value [Basic diameter]	Limit	Correction and remarks
Oil pressure (Oil temperature at 70 to 90°C)	At idle	145 kPa (1.5 kgf/cm ²) or more	49 kPa (0.5 kgf/cm ²)	Inspection.
	At maximum speed	295 to 490 kPa (3 to 5 kgf/cm ²)	195 kPa (2 kgf/cm ²)	Adjust.
Oil pump	Backlash between crankshaft gear and oil pump idler gear	0.13 to 0.25	0.4	Replace.
	Backlash between idler gear and oil pump gear	0.11 to 0.24	0.4	Replace.
	Difference between pump case depth and gear height	0.05 to 0.11	0.15	Replace.
	Gear tooth tip to pump case clearance	0.11 to 0.18	0.2	Replace.
	Drive gear shaft to cover clearance	[20] 0.04 to 0.07	0.15	Replace.
	Driven gear shaft to driven gear clearance	[20] 0.04 to 0.07	0.15	Replace.
	Idler gear shaft to idler gear clearance	[22] 0.03 to 0.05	0.15	Replace bushing.

Description		Nominal value (Basic diameter)	Limit	Correction and remarks
Oil pump	Relief valve valve opening pressure	1180 kPa (12 kgf/cm ²)		Replace spring.
	Relief valve spring load (Installed length: 46.3)	150 to 165 N (15.3 to 16.9 kgf)		
Oil bypass alarm valve opening pressure (ON start pressure)		345 to 390 kPa (3.5 to 4 kgf/cm ²)		Replace.
Oil cooler bypass valve opening pressure		175 to 215 kPa (1.8 to 2.2 kgf/cm ²)		Replace.
Regulator valve	Valve opening pressure	360 to 420 kPa (3.7 to 4.3 kgf/cm ²)		Replace.
	Spring load (Installed length: 48.3)	76 to 80 N (7.8 to 8.2 kgf)		
Check valve opening pressure		265 to 325 kPa (2.7 to 3.3 kgf/cm ²)		Replace.

3.2 TIGHTENING TORQUE TABLE

Description	Thread size O.D. x Pitch mm	Tightening torque Nm (kgfm)	Remarks
Oil pump idler gear shaft nut	M12 x 1.25	59 to 78 (6 to 8)	Apply LOCTITE No. 262.
Oil bypass alarm	M20 x 1.5	44 to 54 (4.5 to 5.5)	
Oil filter center bolt	M16 x 1.5	59 to 69 (6 to 7)	
Oil cooler bypass valve	M27 x 1.5	15 to 20 (1.5 to 2.0)	
Regulator valve	M27 x 1.5	98 to 115 (10 to 12)	
Oil pan drain plug	M18 x 1.5	69 (7)	
Oil jet check valve	M12 x 1.75	34 (3.5)	

4. SERVICE PROCEDURES

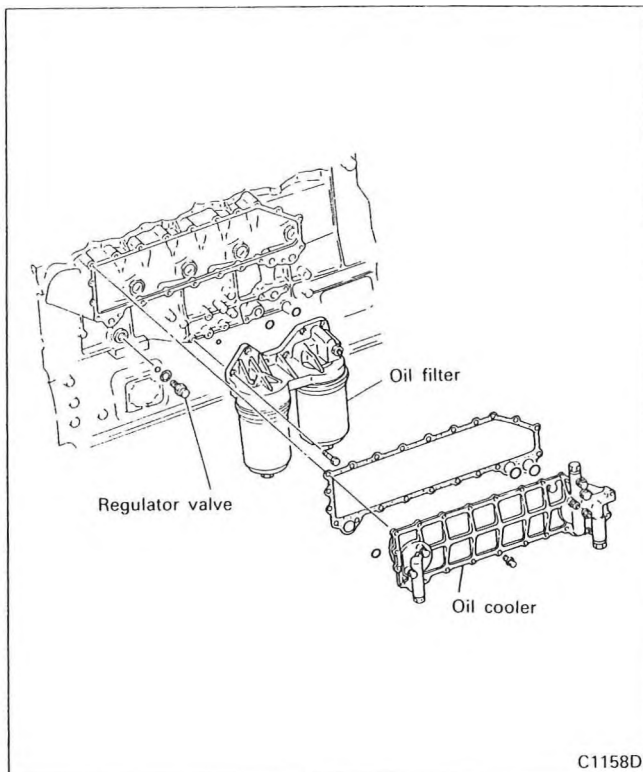


With the oil pressure switch removed and pressure gauge installed, warm up the engine until the oil temperature reaches 70°C to 90°C.

Measure the oil pressure at idle and maximum speeds. If the measurement is below the limit, overhaul the lubricating system.

4.1 REMOVAL AND INSTALLATION

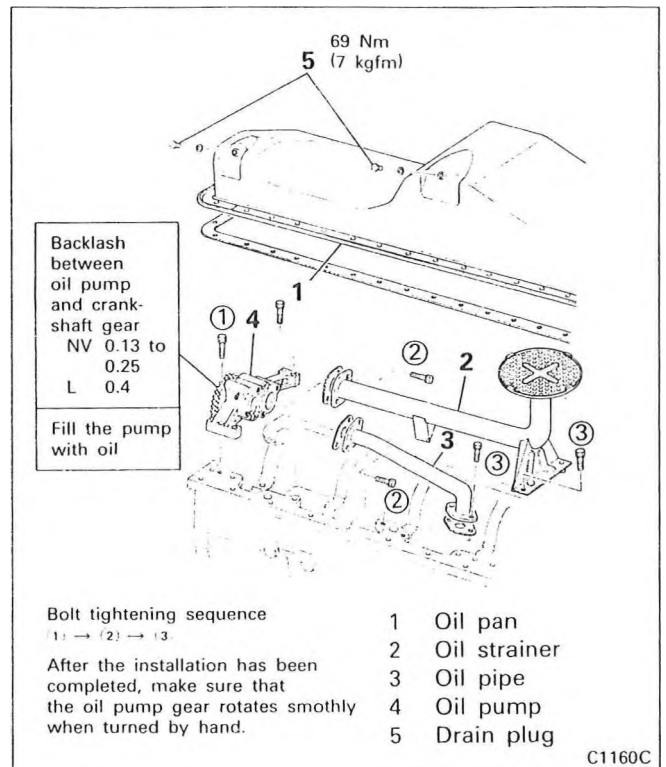
(1) Oil Filter, Oil Cooler



NOTE:

1. To remove the oil cooler, remove the injection pump beforehand.
2. After the element has been installed, start the engine and check connections for oil leaks.

(2) Oil Pump, Oil Strainer



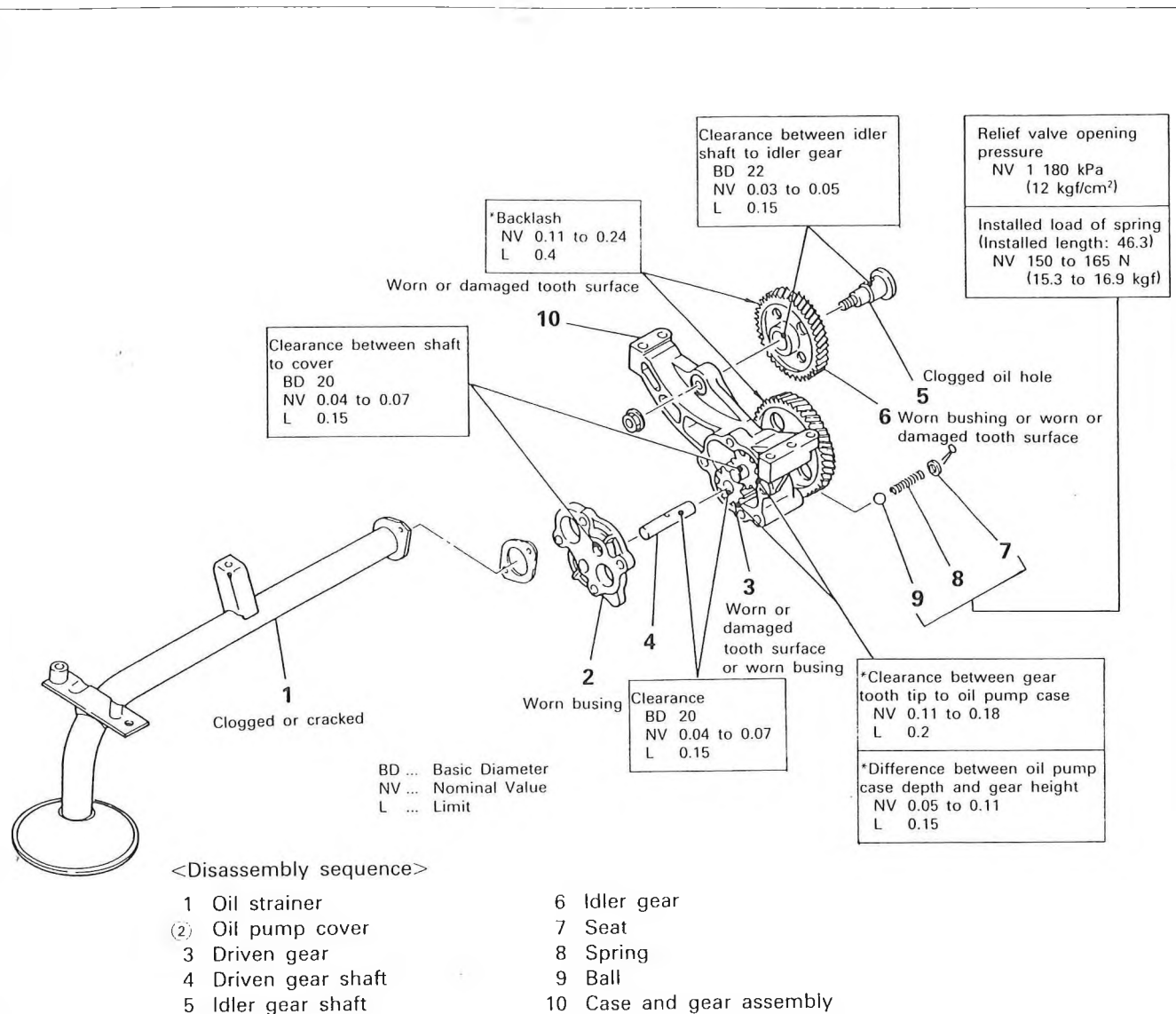
NOTE:

1. Measure the backlash in advance of removal of oil pump.
2. The oil strainer and oil pipe should be removed together with the oil pump unless anything wrong is evident.
3. After the oil pump has been installed, verify that the backlash is within the specified range.

4.2 DISASSEMBLY, INSPECTION AND REASSEMBLY

4.2.1 Oil Pump

(1) Disassembly and Inspection



For disassembly of parts with an encircled number, see following items.
 The part marked * must be inspected before disassembly.

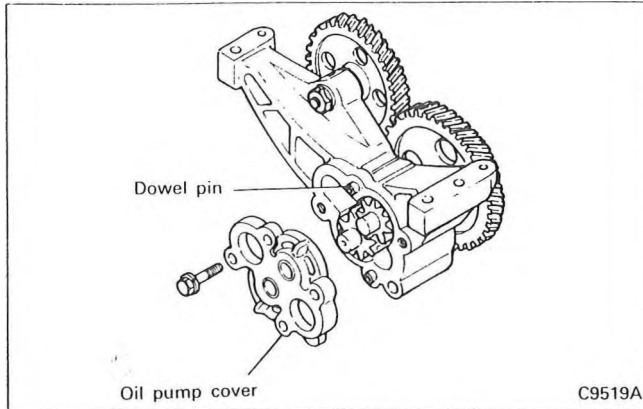
NOTE:

- Do not remove the driven gear shaft unless it is faulty. Removal of the shaft may result in loss of allowance for tightening the oil pump case.
- The case and gear assembly is a non-disassembled type. Replace the assembly if it is defective.

C9518D

Disassembly and Inspection Procedure

(a) Before disassembly, measure and record the backlash between the oil pump gear and the idler gear.

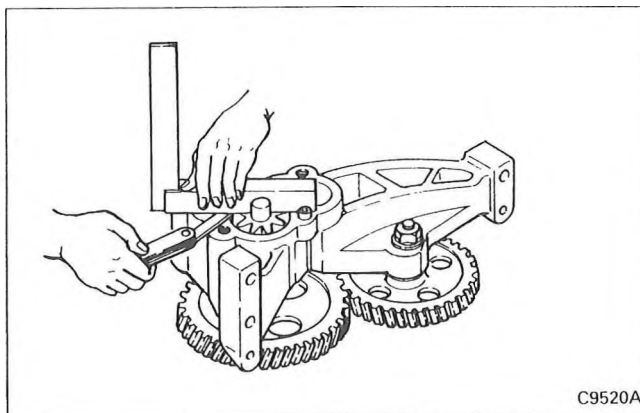


(b) Remove the oil strainer and drive out the oil pump cover with a plastic hammer etc.

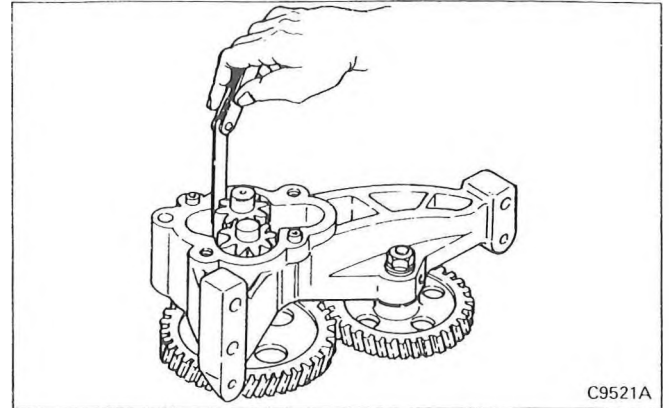
NOTE:

The oil pump cover is located by the dowel pins installed to the oil pump case.

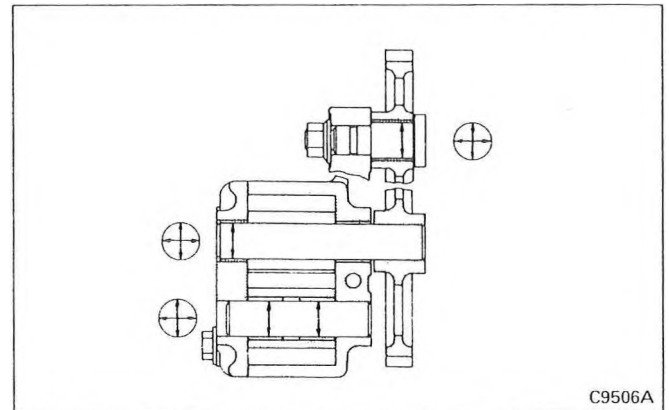
(c) Before the driven gears are removed, measure and record the following items.



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



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



(d) Measure and record the outside diameter of each of the drive gear shaft, driven gear shaft and idler gear shaft. Then, measure and record the inside diameter of each of the oil pump case, cover and driven gear bushings. Calculate the clearance between each shaft and bushing. If the service limit is exceeded, replace the assembly.

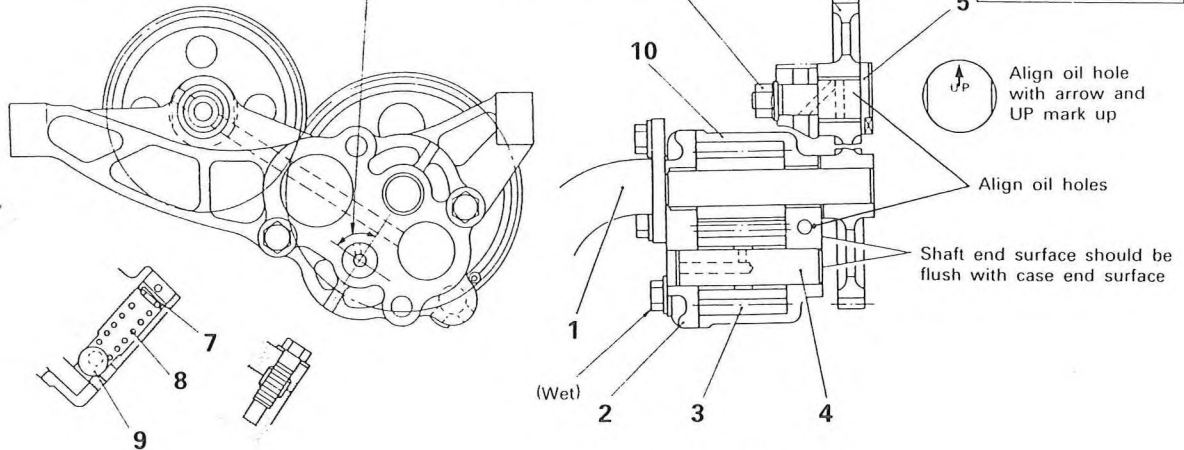
(2) Reassembly

Backlash between driven gear
and idler gear
NV 0.11 to 0.24
L 0.4

Shaft oil hole should
be in this range

Remove oils or greases
from threaded area and
then apply Loctite 262.
59 to 78 Nm
(6 to 8 kgfm)

Apply sealant to the
portion to be fitted
in bushing (Moly-
bdenum base grease)



<Assembly sequence>

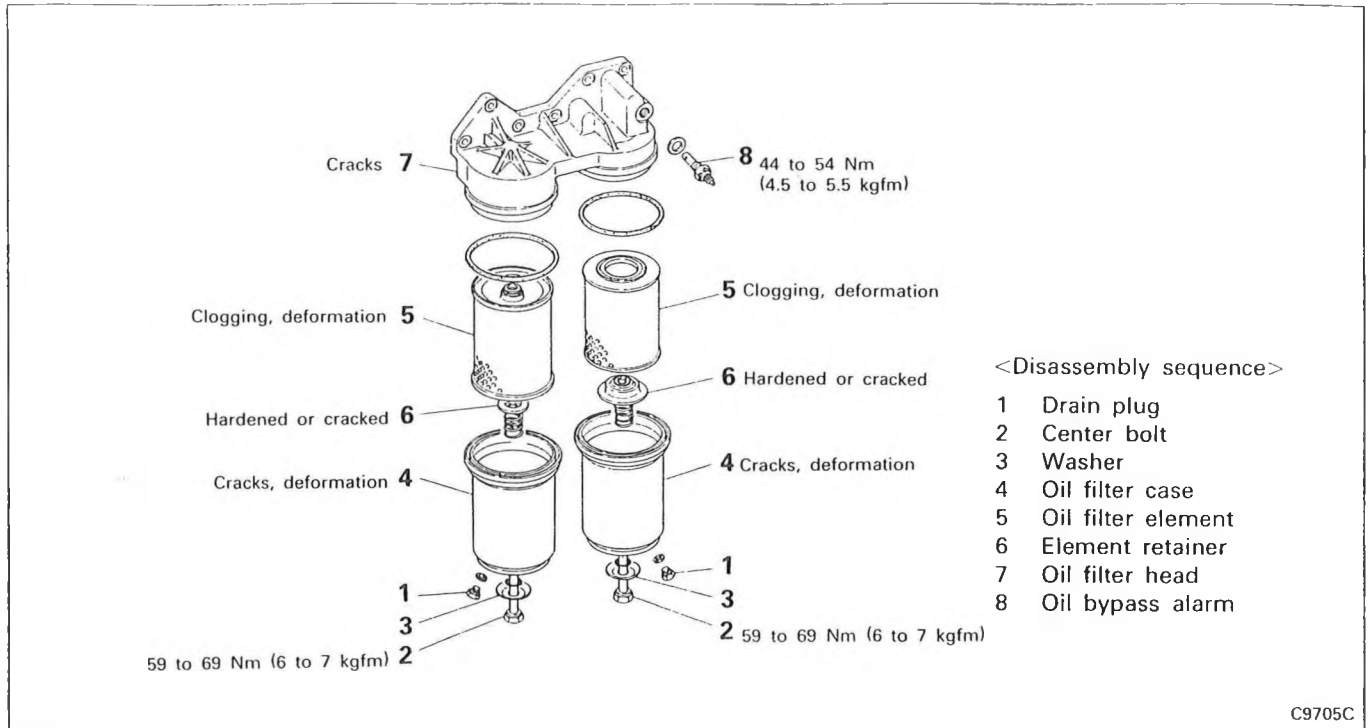
10 → 9 → 8 → 7 → 6 → 5 → 4 → 3 → 2 → 1

NOTE:

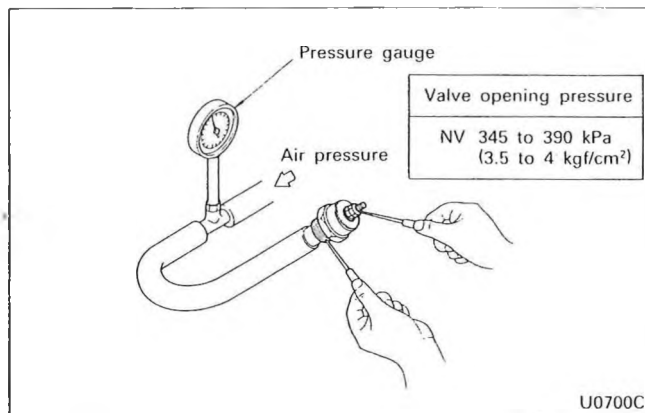
1. Before reassembly, apply engine oil to all parts unless otherwise specified.
2. Temporarily tighten the oil strainer, taking into consideration its installation to the crankcase.

C9525C

4.2.2 Oil Filter



Inspection of Oil Bypass Alarm

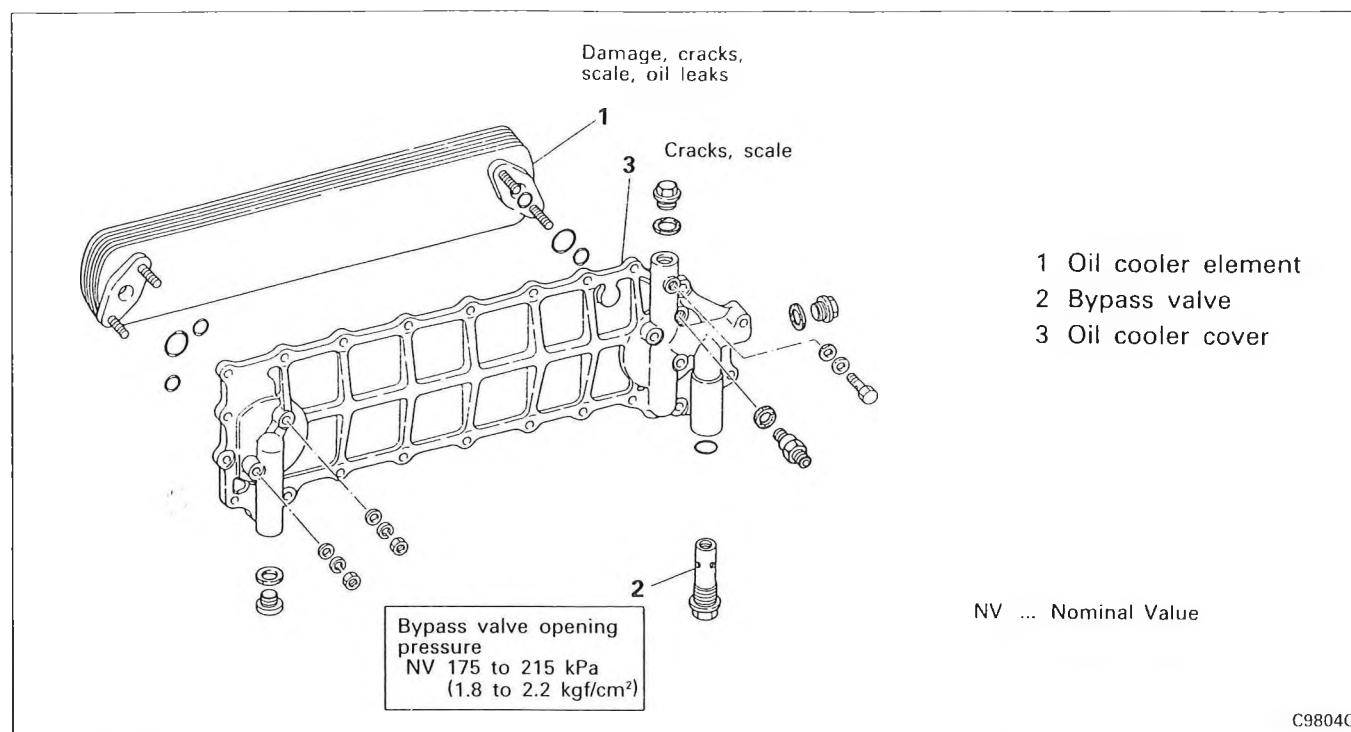


With no air pressure applied, check for continuity across the terminals as shown and replace the oil bypass alarm if there is continuity.

Next, with the air pressure applied and gradually increasing, measure the air pressure when there is continuity.

If the measurement is out of specification, replace the oil bypass alarm.

4.2.3 Oil Cooler

**(1) Cleaning**

- (a) Check for carbon or sludge deposited in the oil passage of the oil cooler element and bypass valve. If contamination is evident, wash in a cleaning oil.
- (b) If there is much scale on the element and cover, wash with tap water (preferably hot water).

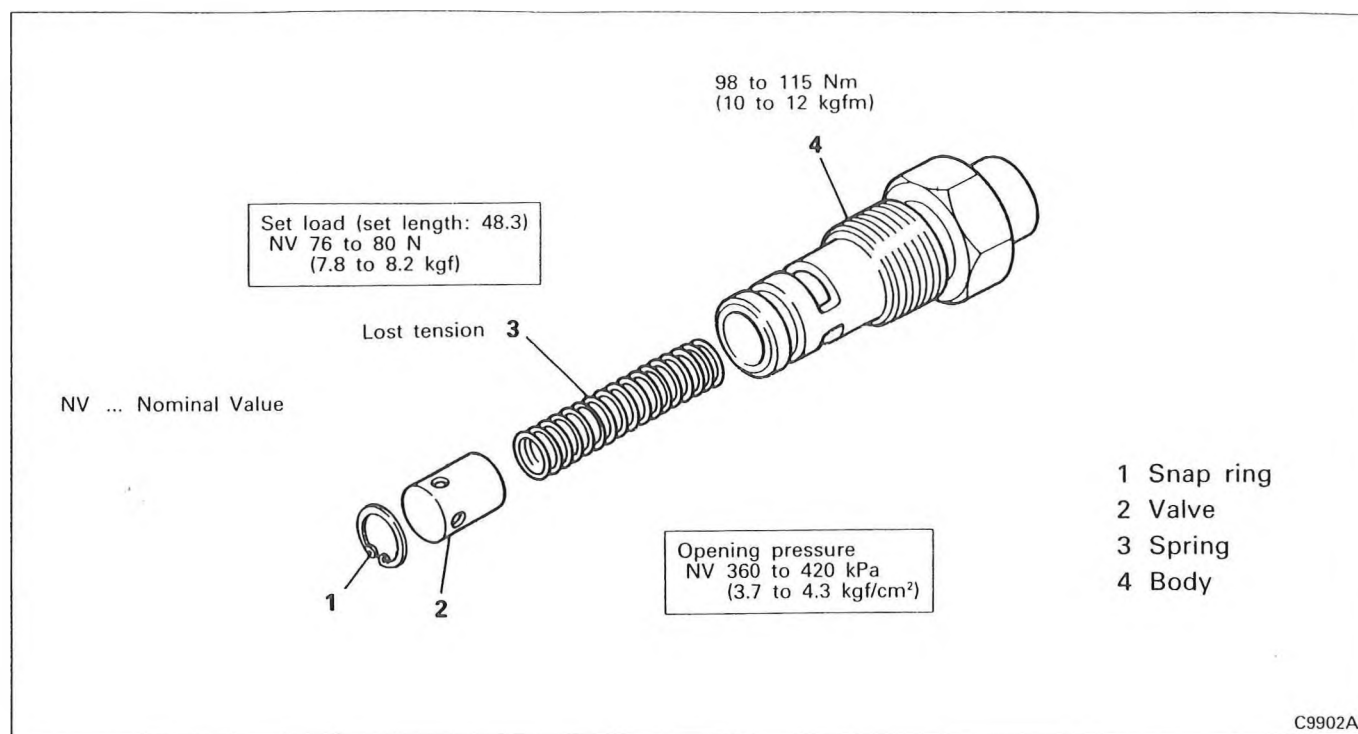
(2) Air Pressure Test

To check for oil leaks due to a broken or cracked element, air pressure test should be performed. Apply 1470 kPa (15 kgf/cm²) air pressure to the element to check for leaks. If air leaks or other defects are evident, replace the element.

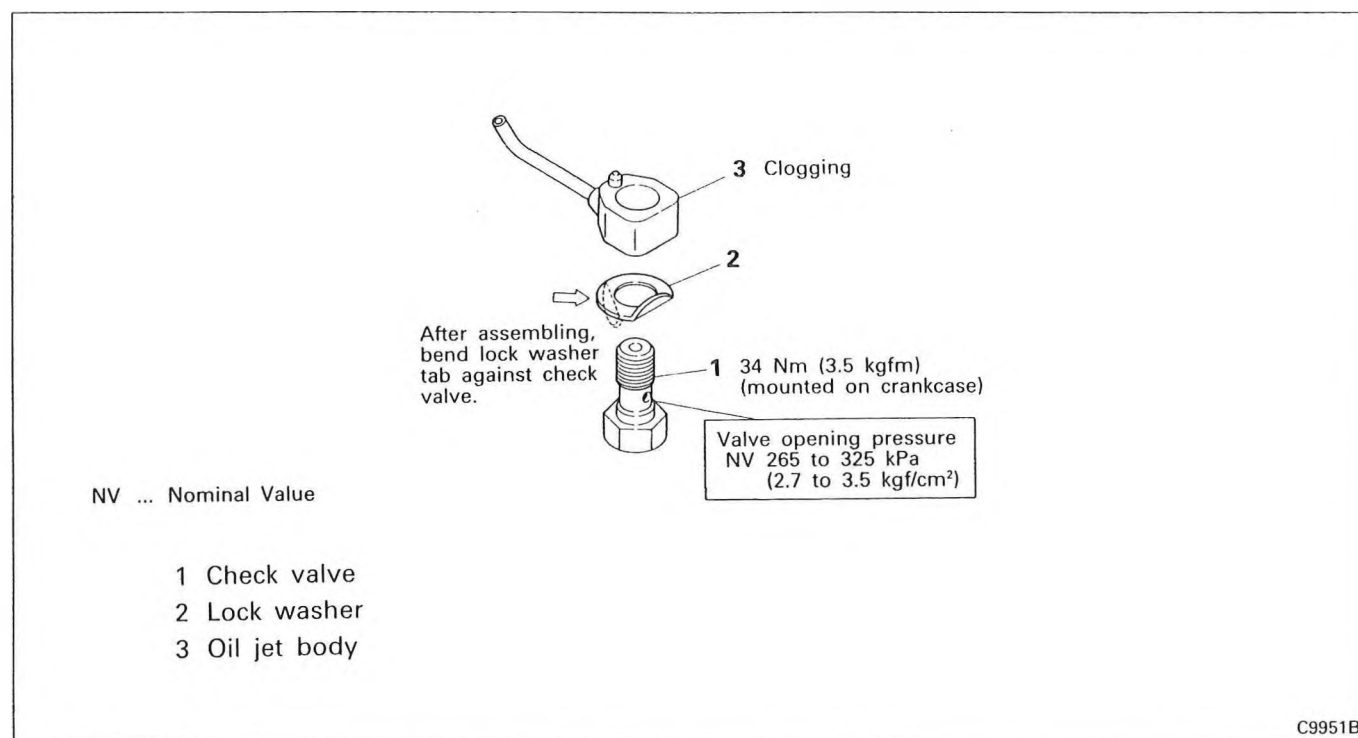
NOTE:

Make sure that the specified air pressure is not exceeded.

4.2.4 Regulator Valve



4.2.5 Check Valve



For the check valve mounting position, refer to (e) in (6) in 1 General and (2) in 5.4.3 in Group 11 Engine.

5. TROUBLESHOOTING

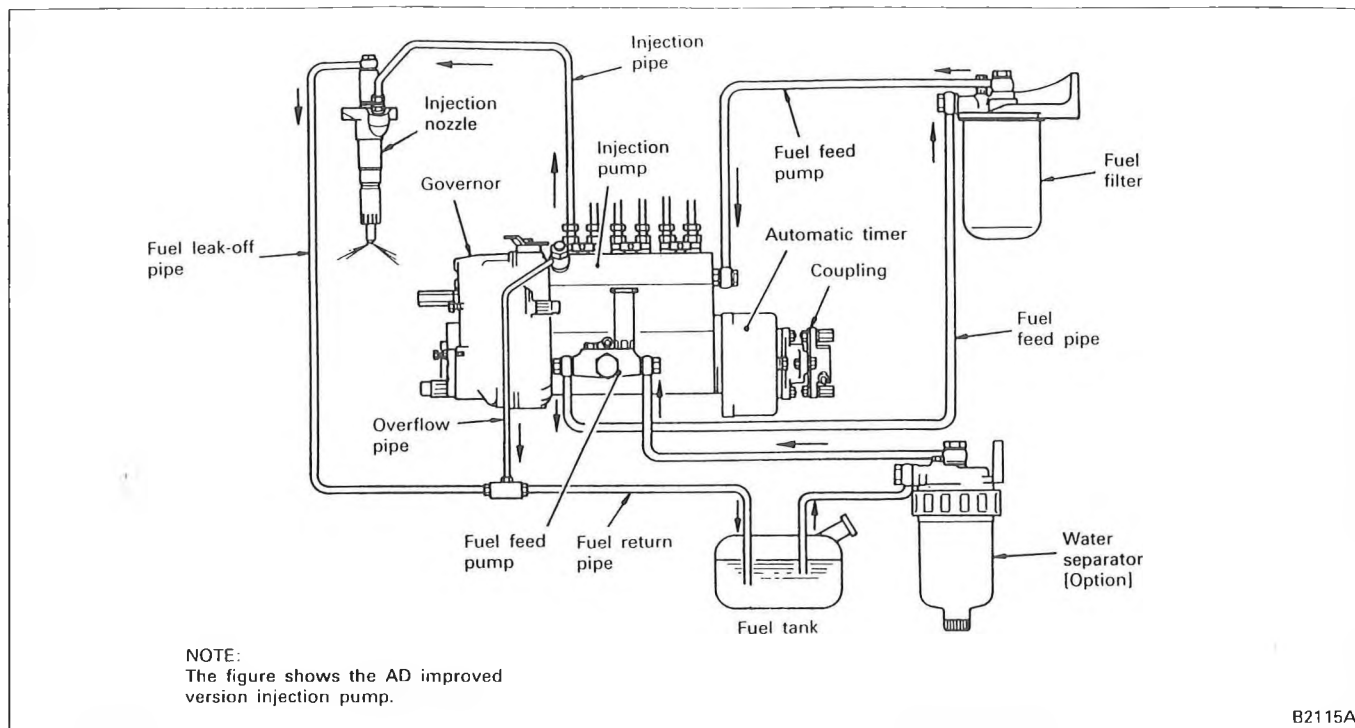
Symptom	Probable cause	Remedy	Ref. group
Oil pressure does not increase	Abnormal oil level Oil leaks into coolant	Correct and fill to specified level	
	Oil leaks		
	Incorrect oil viscosity Oil out of life	Replace	
	Fuel in oil	Replace (cause)	
	Oil pressure switch not functioning properly	Replace	
	Loaded oil filter element	Replace element	
	Loaded oil strainer, loose oil pump joint, cracked pipe	Correct or replace	
	Relief valve, bypass valve not functioning properly		
	Worn or damaged oil pump proper	Replace	
Excessive oil consumption	Oil leaks from engine	Correct or replace	Group 11
	Oil leaks from crankshaft front or rear oil seal	Correct or replace	
	Leaks to cooling system Defective oil cooler water jacket	Correct or replace	
	Abnormal compression pressure	Check	Group 11

FUEL AND ENGINE CONTROL

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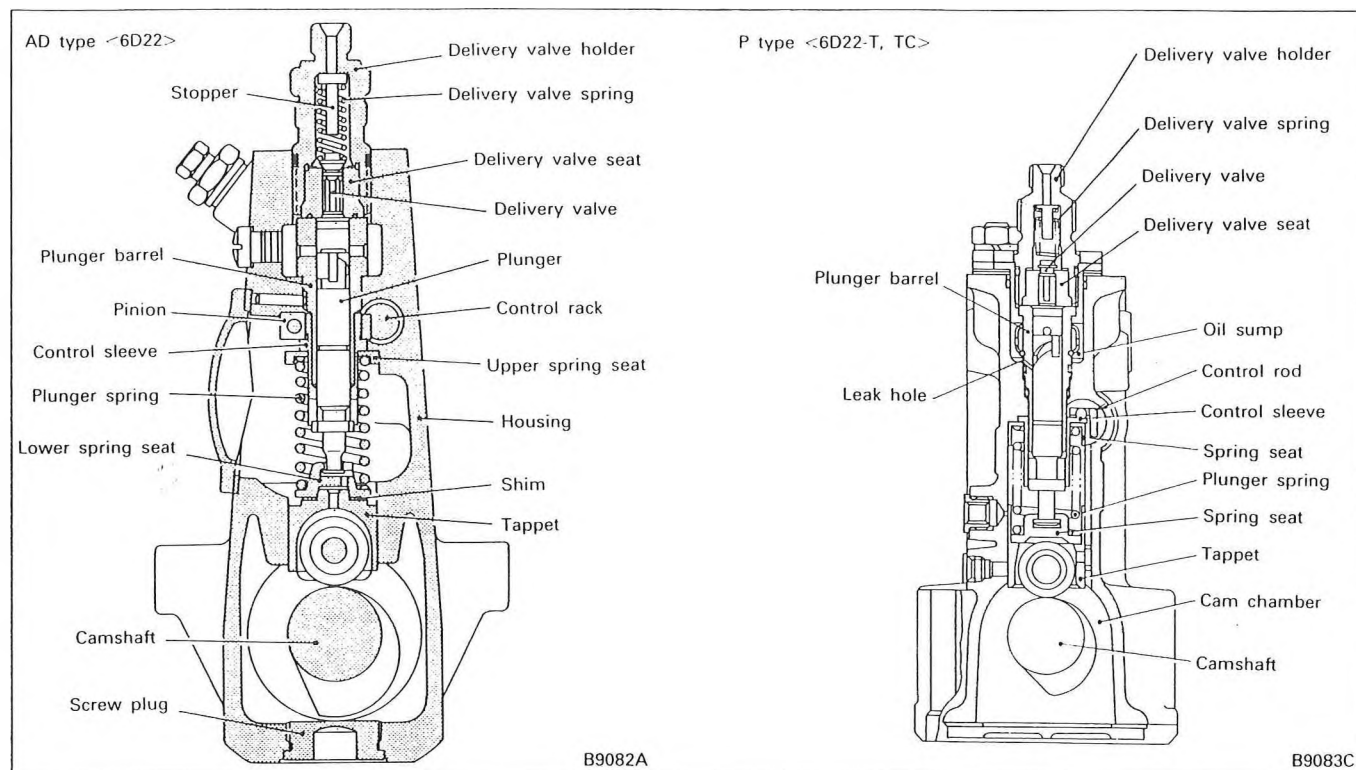
1. GENERAL



B2115A

The fuel system consists of the injection pump general assembly (injection pump proper, governor, timer, feed pump and coupling), fuel filter, water separator, injection pipe, injection nozzle, fuel leak-off pipe, etc.

The injection pump is driven at one-half the engine speed.

(1) Injection Pump Proper**(a) Injection pump**

The camshaft driven at half the engine speed is supported by taper roller bearings at both ends. The camshaft has a cam for operating the plunger and a cam for operating the feed pump.

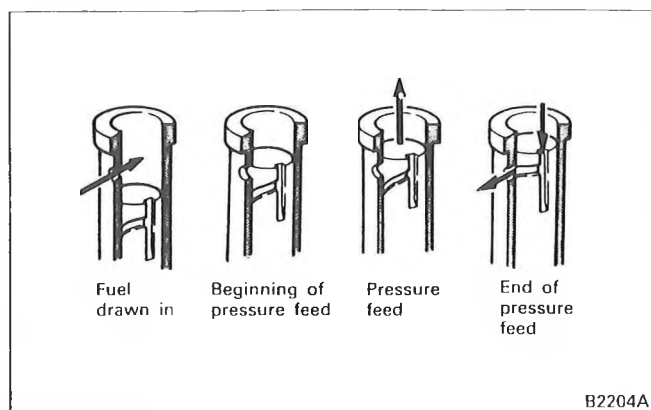
A tappet operating with the pump housing as the guide is in contact with the camshaft. The tappet changes the rotary motion of the cam to up-and-down motion which is transmitted to the plunger.

The P type injection pump offers the following features.

- 1) The pump housing is a totally enclosed type.
- 2) The plunger barrel has an oblique hole made to return the fuel that has leaked to the oil sump to minimize the leakage of the fuel into the cam chamber.

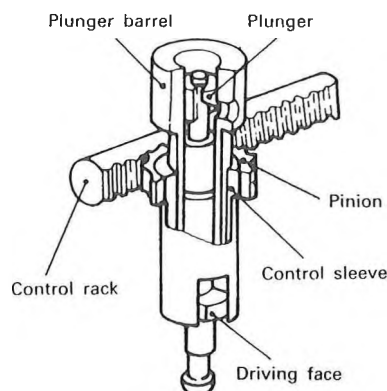
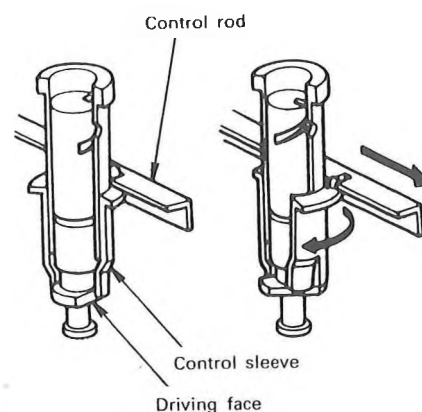
- 3) To prevent the fuel in the oil sump from leaking into the cam chamber, an O-ring is provided on the outer circumference of the plunger barrel, thereby maintaining its tightness.

- 4) A deflector is provided on the outer circumference of the plunger barrel to prevent erosion of the pump housing that may be caused by counter flow of fuel at the end of an injection.

(b) Plunger

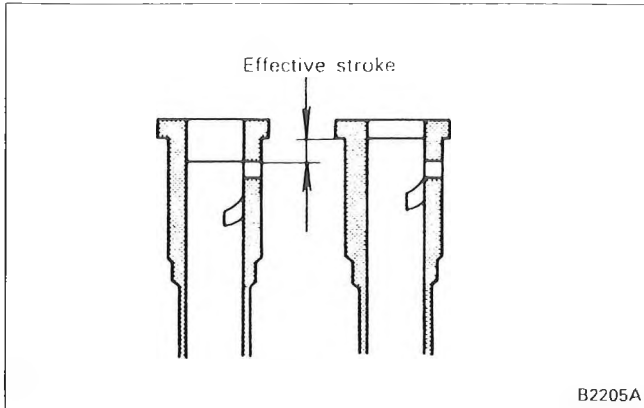
The plunger has an oblique groove and a vertical groove, while the plunger barrel has 2 inlet-outlet holes.

Pressurized feeding of fuel oil begins when the plunger, pushed up by the cam of camshaft, closes the inlet-outlet holes of plunger barrel. When the plunger is further pushed up, fuel oil is discharged through the vertical groove of plunger from the inlet-outlet holes.

AD type injection pump**P type injection pump**

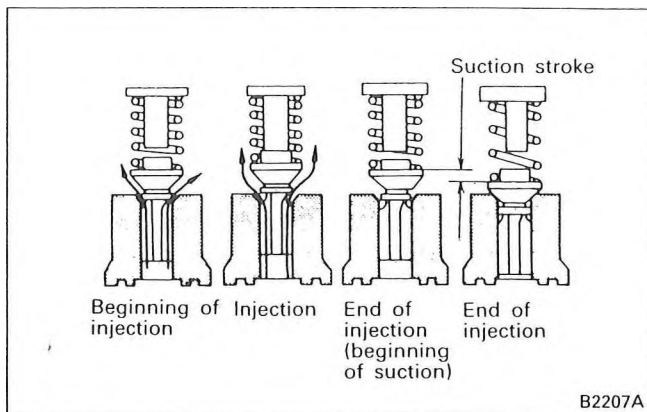
A deflector is installed on the periphery of the plunger barrel so that high pressure fuel oil discharged from inlet and outlet ports will not erode the pump housing. Fuel injection volume is controlled by the governor which moves the control rod (or the control rack) left and right and rotates the control sleeve

which engages with the control rod (or the control rack and pinion). Since the driving face of plunger meshes with the control sleeve at the lower part thereof, the plunger turns with the rotation of control sleeve and injection volume is controlled through the changing of the effective stroke.



The effective stroke means the length of the plunger stroke from the time when the upper end of plunger closes the inlet-outlet holes of plunger barrel until the oblique groove of plunger opens to the inlet-outlet holes. When the effective stroke stands at zero, it indicates that no fuel injection takes place.

(c) Delivery valve

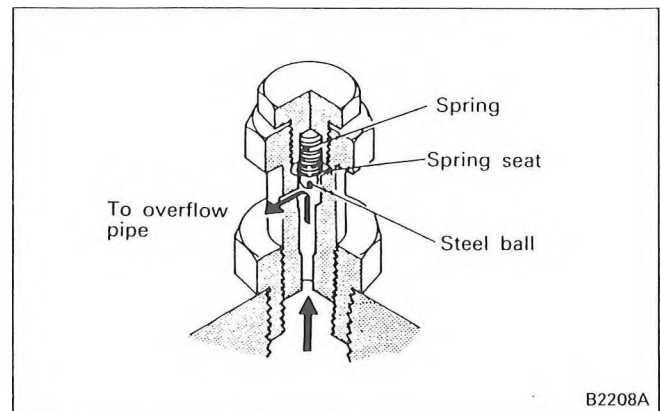


The fuel highly pressurized by the plunger pushes the delivery valve up and gushes out. When delivery of the fuel under pressure by the plunger is completed, the delivery valve is pushed back by the delivery valve spring and closes the fuel passage to prevent counter flow of the fuel.

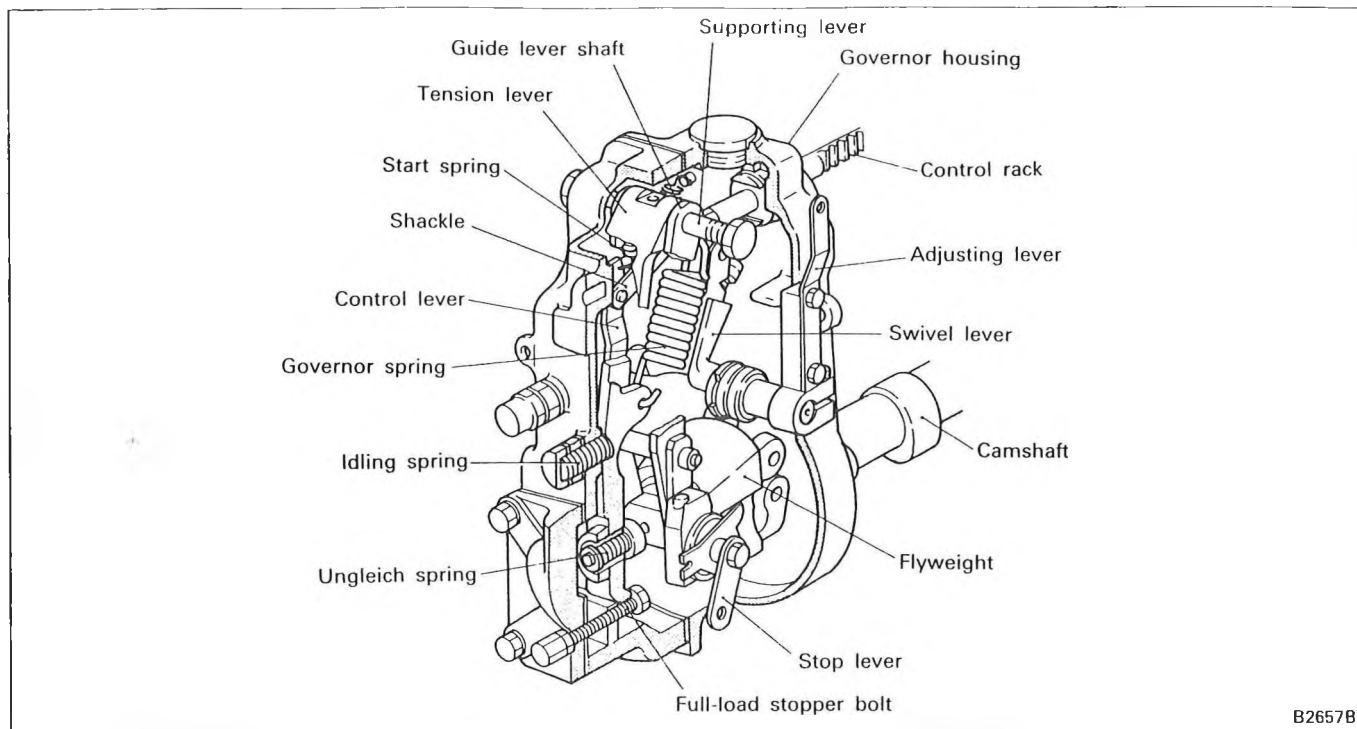
The delivery valve is further brought down until it is held against the seat surface tightly. The amount of fuel corresponding to the stroke during the period is drawn back from above to instantly lower the residual pressure in the line between the delivery valve and nozzle. The draw-back effect improves the cutting of fuel from the nozzle and prevents after-injection dripping.

A delivery valve stopper, provided on the top of the delivery valve spring, limits the lift of the delivery valve to prevent the surging of the valve during high speed operation. It also reduces the dead volume between the delivery valve and nozzle and stabilizes the injection rate.

(d) Overflow valve



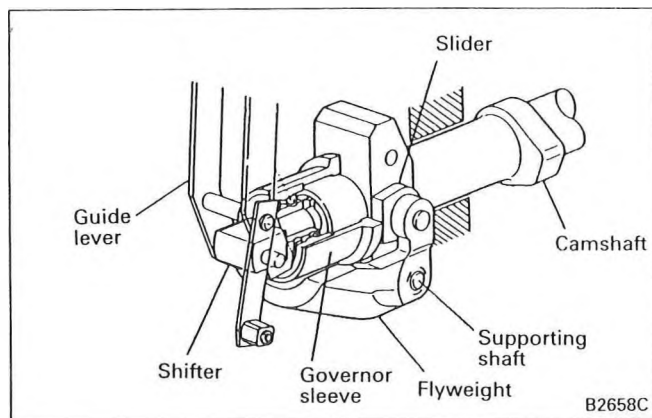
When the fuel pressure in the injection pump exceeds a predetermined pressure, the steel ball in the overflow valve is pushed up to let the fuel flow out from the injection pump and return to the fuel tank, thereby stabilizing the fuel temperature and temperature distribution in the injection pump and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

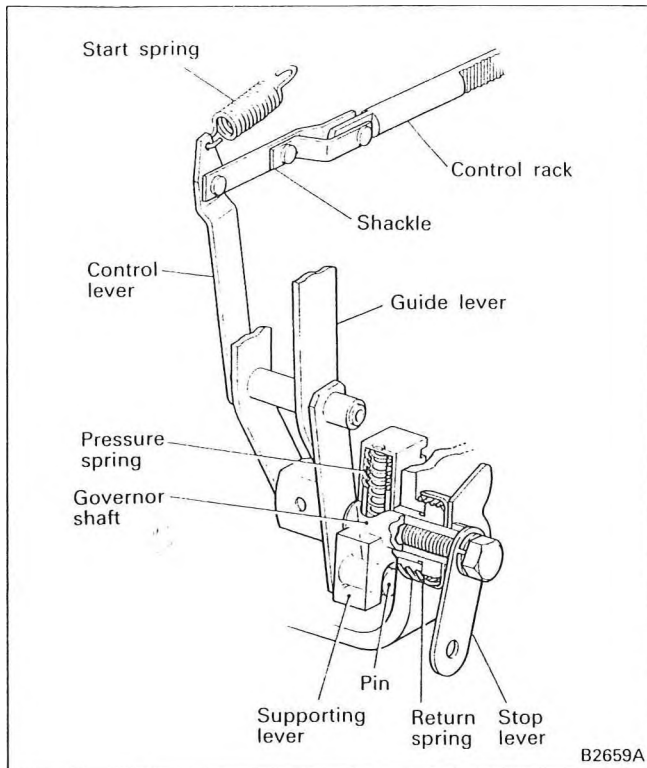
(2) Governor**(a) RSV type governor**

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.

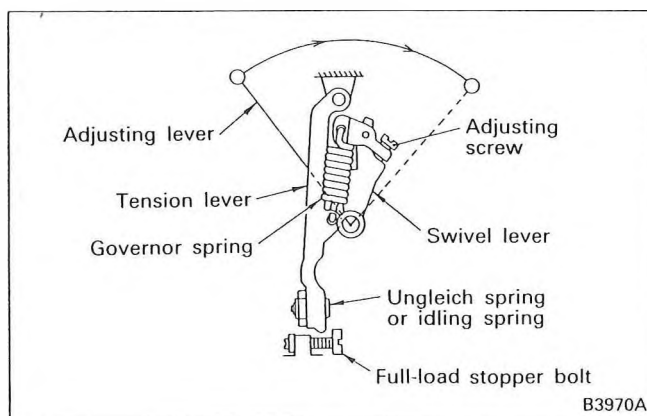
The governor, as shown, consists of flyweights mounted to the injection pump camshaft. When the flyweights turning on the flyweight supporting shaft open outward, the roller mounted to the end of flyweight arm pushes the end of the sleeve in the axial direction. The governor sleeve, being made integral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

The control block, 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 swivel 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 swivel lever.

When the governor spring receives tension, the bottom end of the tension lever touches the adjustable full-load stopper bolt.

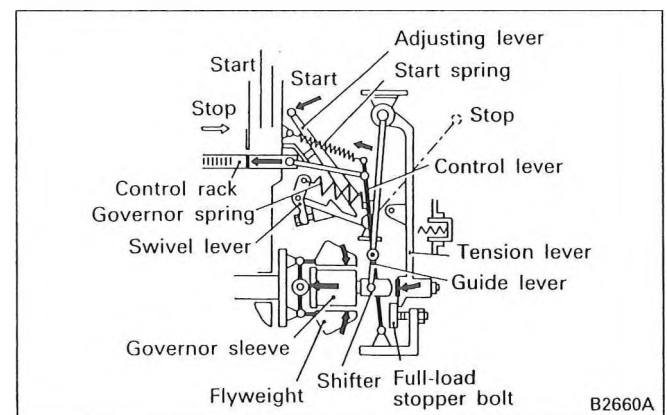
When the angle of the adjusting lever is changed, the angle of the swivel lever is also changed and the tension of the governor spring changed. This is because the turning center of the swivel lever and the mounting position of the governor spring installed to the tension lever are eccentric to each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

An adjusting screw is also mounted to the swivel 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



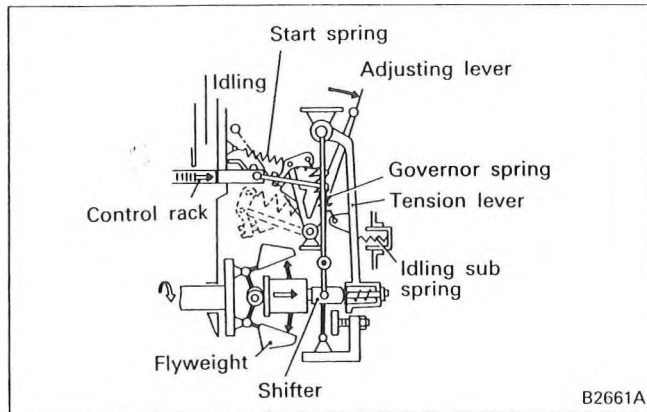
When the adjusting lever is moved to the start position (until it touches the maximum speed stopper), the swivel lever which moves with the adjusting lever pulls the governor spring and moves the tension lever until it touches the full-load stopper bolt.

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 control block and governor sleeve push the flyweight roller to the left.

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

2) Idling control

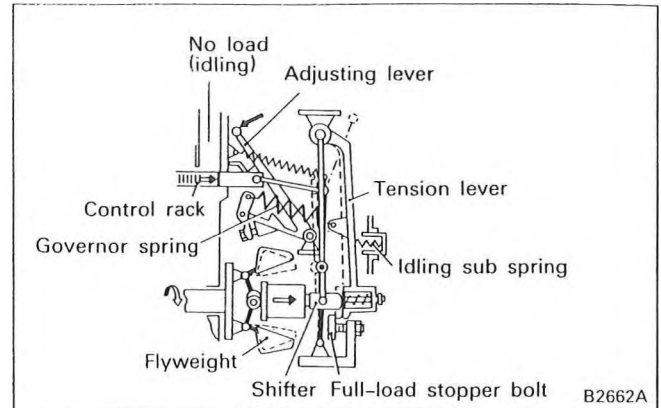


Once the engine is started and the adjusting lever returned to the idling position, the tension of the governor spring is drastically reduced.

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 flyweights 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



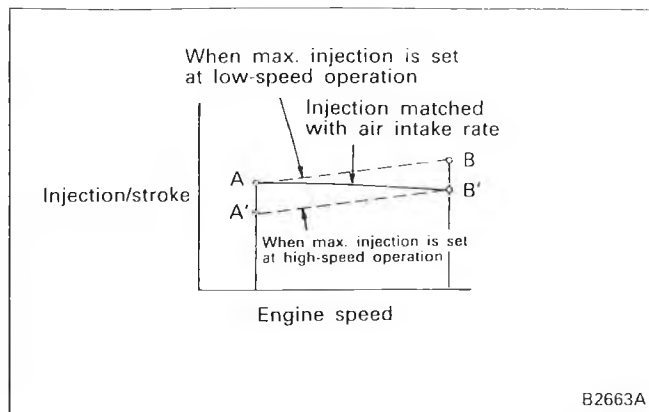
When the adjusting lever is moved to the full-load position, the tension of the governor spring is increased and pulls the tension lever until it touches the full-load stopper bolt.

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 functions and maintains the engine speed constant at all times.

4) Ungleich operation



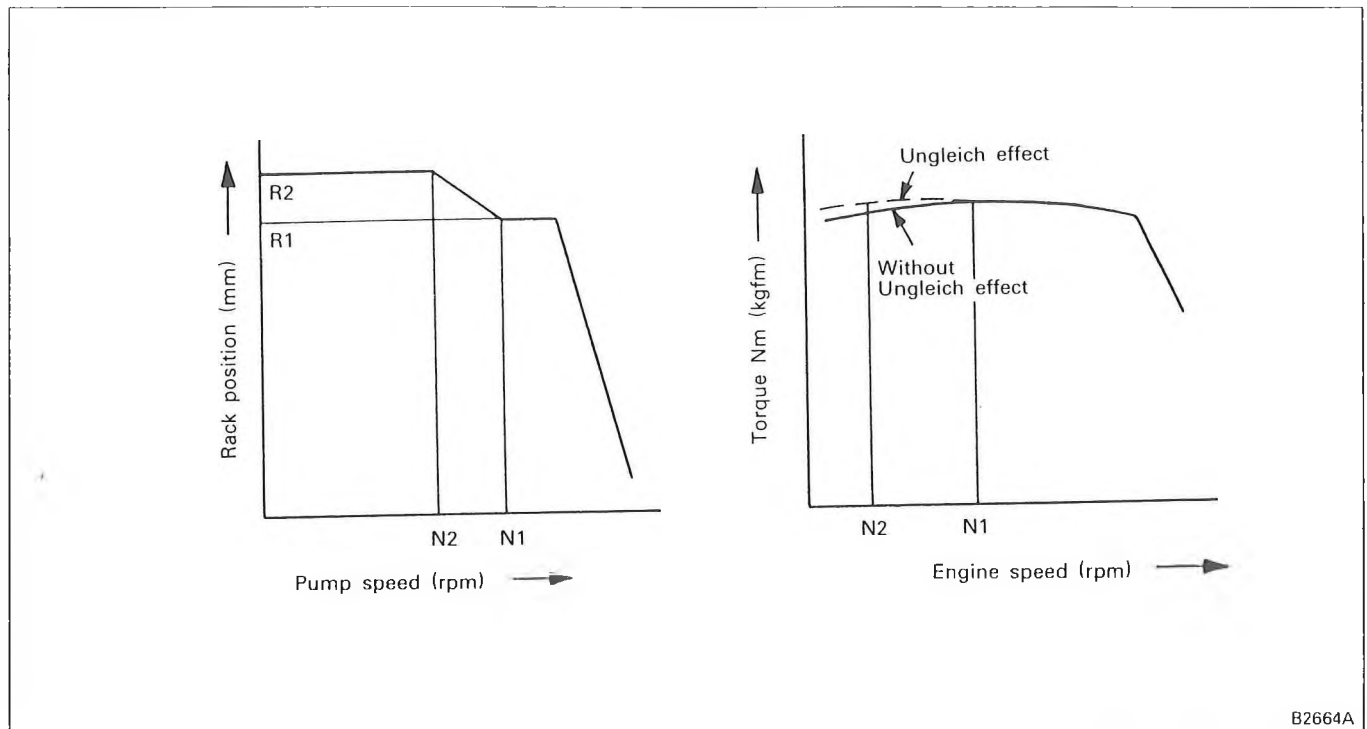
The Ungleich device controls fuel injection in such a way as to match the engine performance (the required injection varies with engine speed).

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.

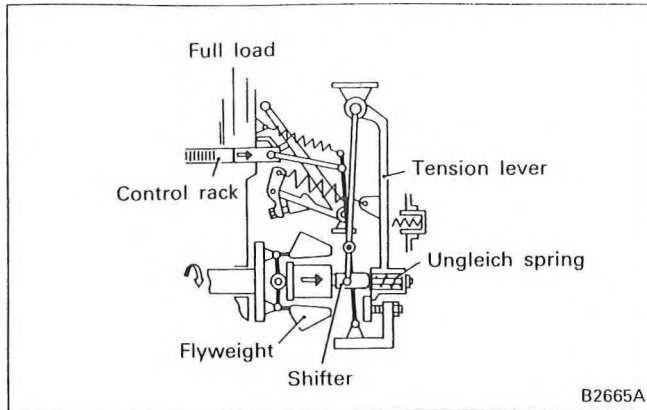
Therefore, if full load is set at point A to derive enough output at low speeds, the injection will reach B as the speed increases, and the engine will produce black smoke.

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 changing it to adjust the injection to point B' in the high speed range.

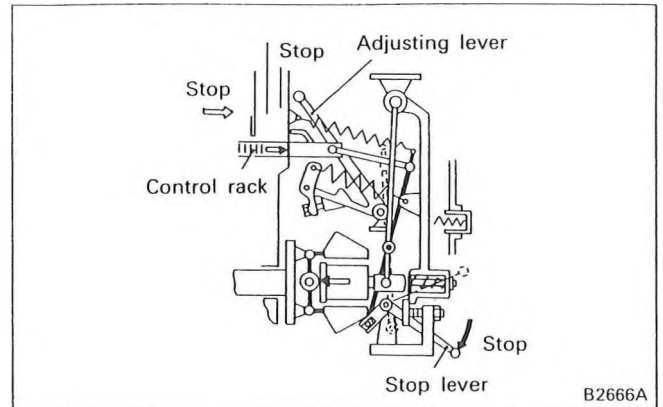


When the engine speed is low and the centrifugal force of flyweight smaller than the pressure of the Ungleich spring, the control block is moved as much as the Ungleich stroke to the left, so the control rack moves in the direction that fuel is increased to increase the torque of the engine at low speeds.



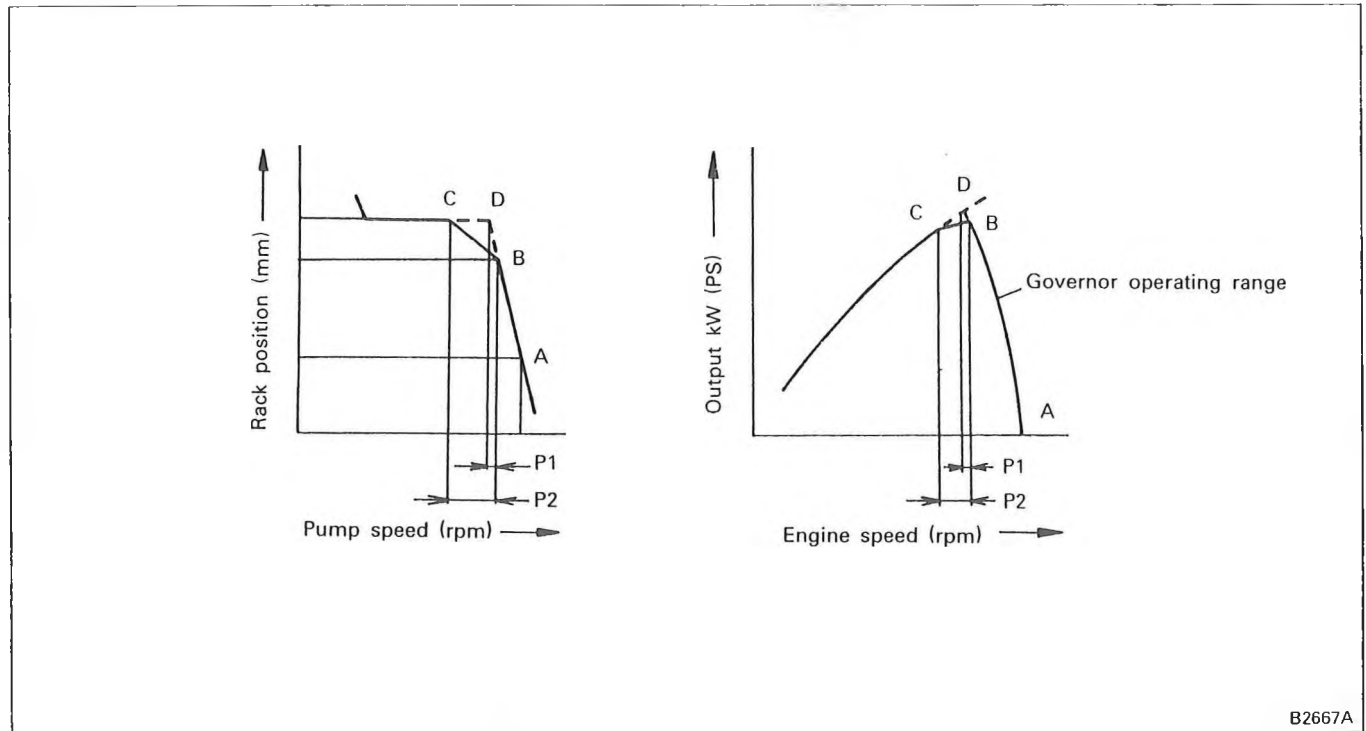
As the engine speed increases, the centrifugal force of flyweight increases. If it becomes larger than the pressure of the Ungleich spring, the Ungleich spring is slowly compressed before the start of high speed control, and the control rack moves in the direction that fuel is reduced. The Ungleich stroke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

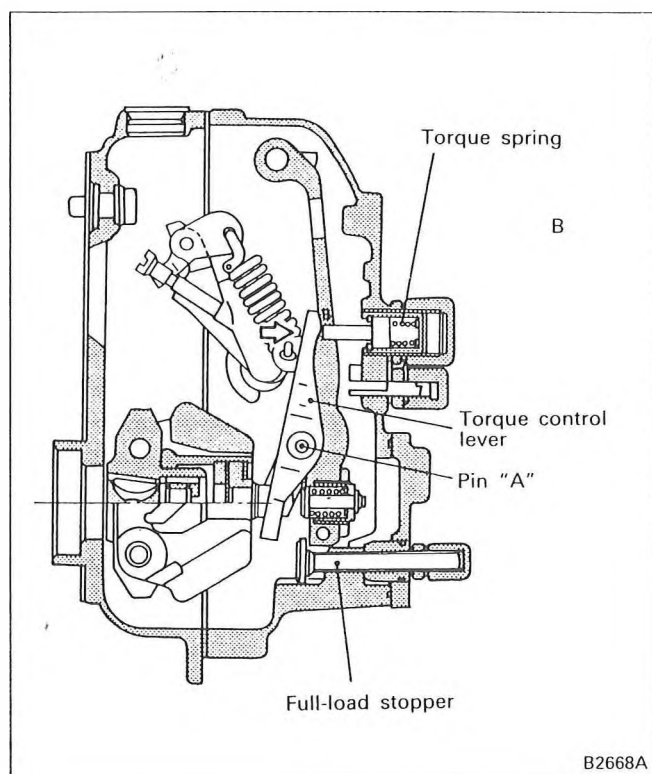
6) Operation of torque spring [Option]



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.

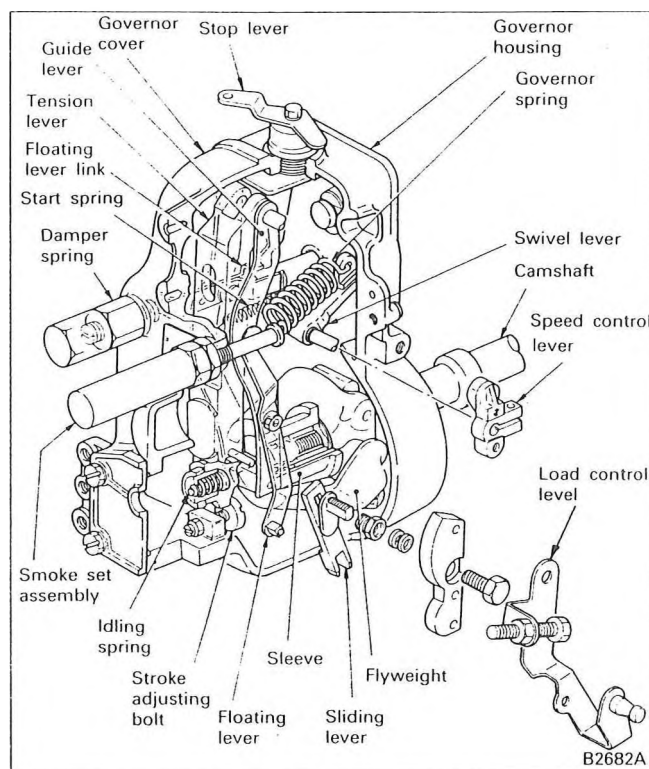
When the adjusting lever is fixed in the lever set position, a sudden increase of load, if no torque spring is provided, will move the control rack along the B-D curve as the speed falls. The rotational displacement at the time may be expressed as P_1 . If a torque spring is provided, the control rack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

(b) RFD type governor [Option]



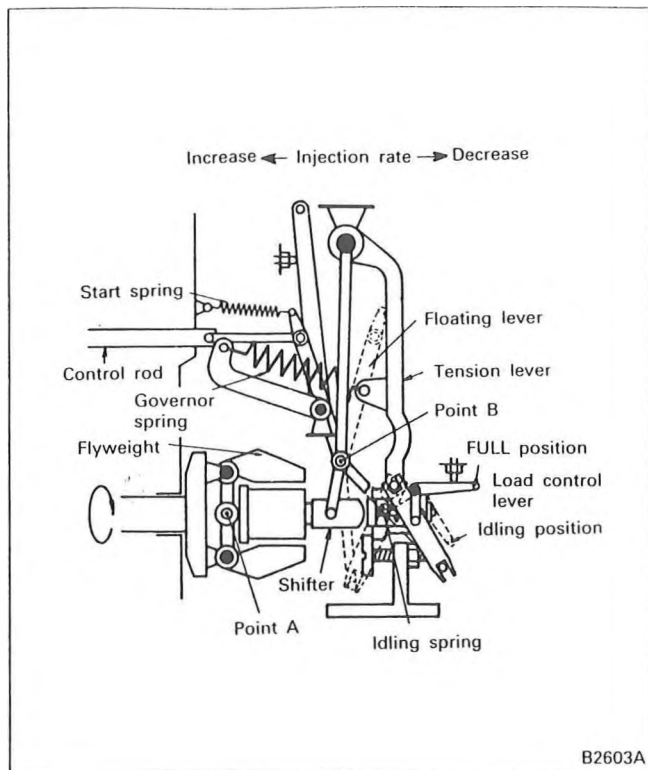
The RFD type governor is a minimum-maximum governor which controls only the minimum and maximum speeds.

The RFD type governor make it possible to increase or reduce fuel by the load control lever which operates the control rod. Any desired speed can be set as a displacement of the speed control lever changes the tension of the governor spring.

Because of the construction described above, the RFD governor can be operated as an all-speed governor by holding the load control lever in the FULL position and operating the speed control lever.

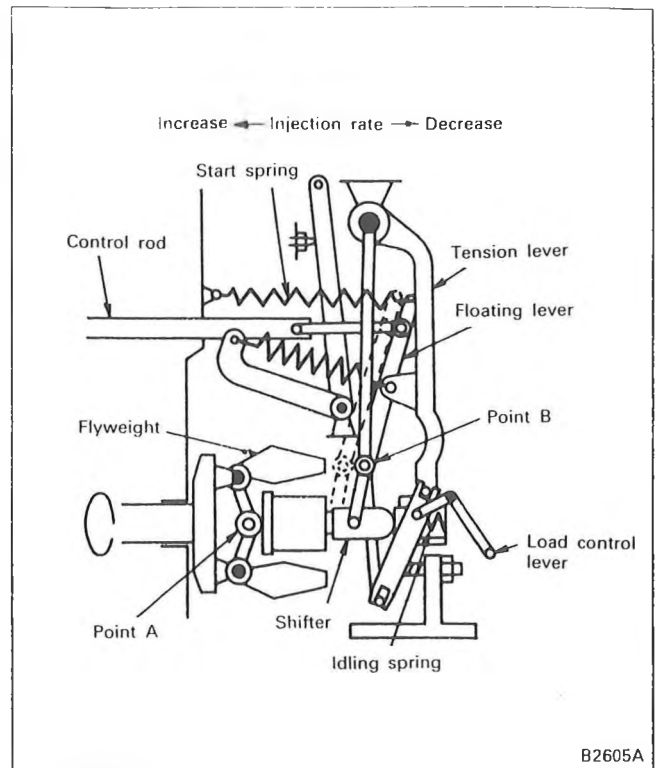
On the top of the governor, an engine stop lever is provided which creates a no-fuel injection state for stopping the engine. A cancel spring is provided to make sure that when the lever is operated, no undue force is applied to the link.

1) Start of engine and control of idling



When the engine is stationary, the flyweight is in closed position, pushed by the governor spring, idling spring and start spring.

If, in this condition, the load control lever is moved all the way to the FULL position (in the direction of greater fuel delivery), the start spring and idling spring will cause the control rod to move to the fuel increasing position.



If the load control lever is placed to the idling position after the engine has started, the floating lever will move the control rod back to a position where a fuel injection rate suitable for the idling speed is available, with the point B as the fulcrum.

As the engine speed increases, the flyweights will move outward by the centrifugal force and will shift the shifter by the point A until the shifter compresses the idling spring.

At this time, the fulcrum B will also slightly move toward the tension lever and will move the control rod back in the direction for reducing the fuel injection rate.

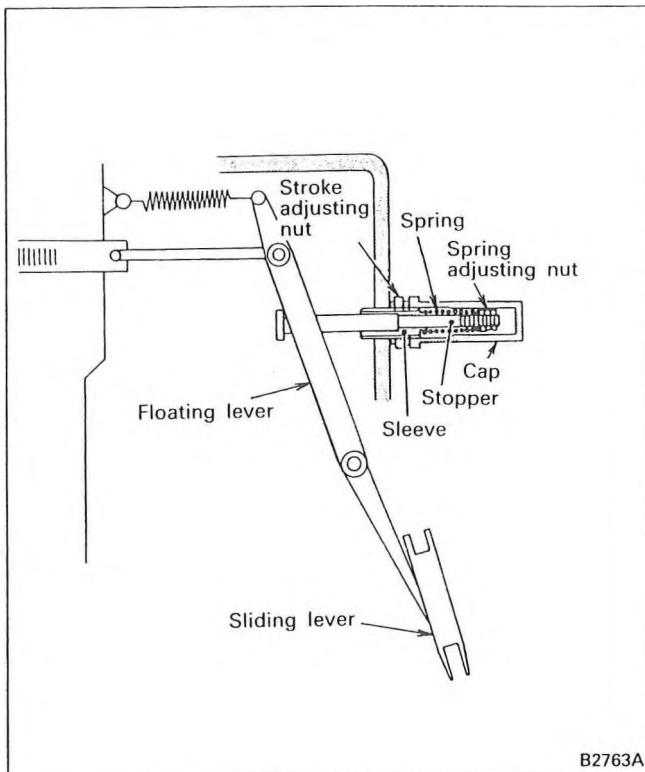
As the engine speed decreases, the centrifugal force of the flyweights will decrease and the flyweights will move inward, so the point A will return toward the pump housing. This will set the shifter in the free state, pushing it back toward the pump housing by idling spring force.

Movement of the shifter will move the point B, and movement of the tension lever will move the point D, and will also move the point C with the point E as the fulcrum.

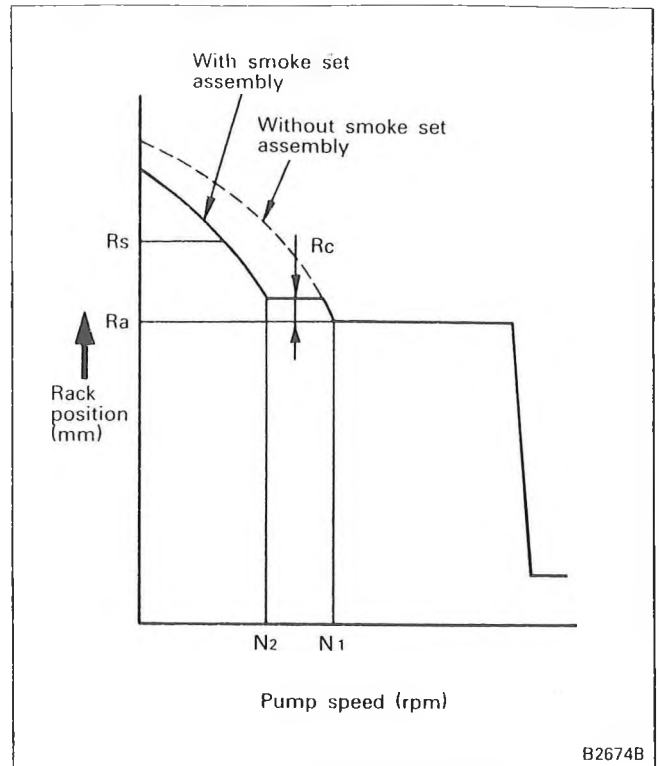
Movement of the point B and movement of the point C will combine to pull the control rod back in the direction of less fuel injection rate, thereby preventing the engine speed from increasing.

If an engine control mechanism which operates the speed control lever adjusting the tension of the governor spring is employed, the governor can be operated as an all-speed governor which maintains a desired engine speed constant.

4) Start booster (smoke set assembly)



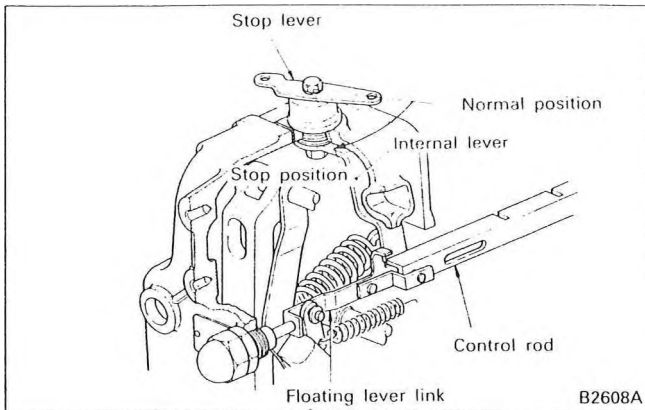
The smoke set assembly installed to the rear of the governor has a spring with setting force and a stopper as functional parts. It also has sleeve, stroke adjusting nut, spring adjusting nut and cap.



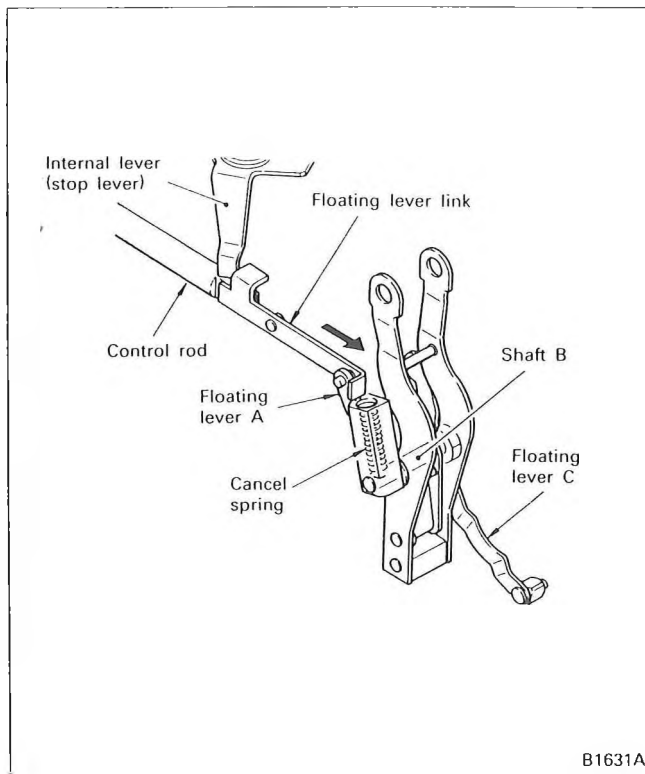
As indicated by the governor characteristics shown above, when without the smoke set assembly, the shifter and floating lever are pushed back by the idling spring force, moving the control rack toward fuel increasing direction when pump speed reaches N_1 . Namely, N_1 is the smoke limit in this case. When with the smoke set assembly, the spring force of the smoke set assembly overcomes that of the idling spring so that the floating lever motion is inhibited until the speed reaches N_2 . Thus, the smoke limit decreases from N_1 to N_2 .

It is also possible to secure rack position R_s needed at time of start.

5) Engine stop



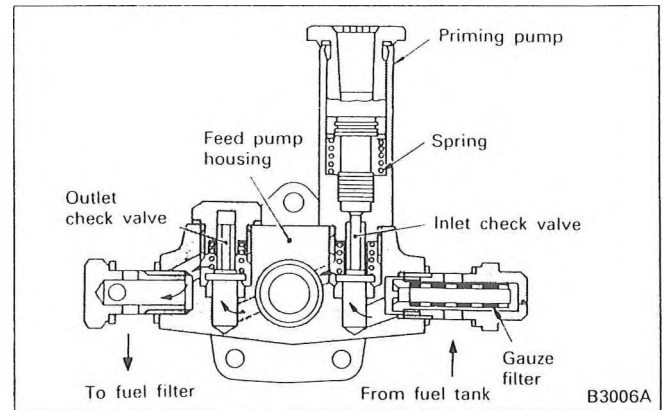
To stop the engine, fuel is cut off by operating the stop lever on the top of the governor. If the stop lever is operated, the internal lever pushes the pawl of the floating lever link to force the control rod out to the no-injection position. Since the amount the control rod is moved by operation of the stop lever exceeds the operating range of the floating lever mechanism, damage to the link and allied parts is prevented by the cancel mechanism shown.



The floating lever A pushed by the floating lever link turns in such a way as to make the cancel spring bend over the shaft B. So no load is placed on the floating lever C blocked by the idle stopper bolt outside the governor.

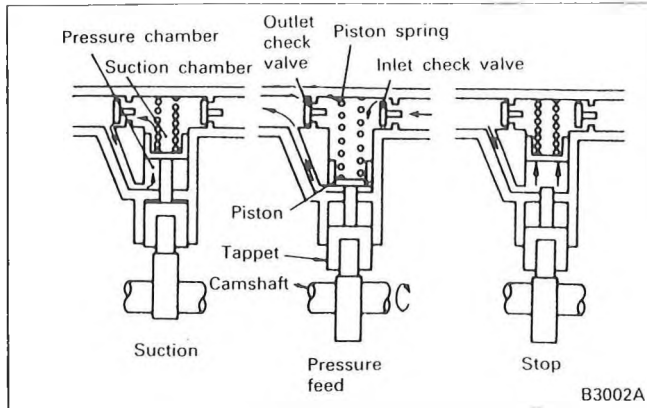
Operation of the ungleich device is the same as the RSV type governor.

(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 camshaft 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 feed pump feeds fuel under pressure as follows. When the piston is pushed up by the cam of the camshaft, the fuel in the suction chamber opens the outlet check valve, so most of the fuel is forced out and drawn into the pressure chamber. When the cam is moved away by rotation of the camshaft, the piston is pushed back by the pressure of the piston spring. At the time, the outlet check valve closes and the inlet check valve opens. So fuel is drawn into the suction chamber, whereas the fuel in the pressure chamber is forced out.

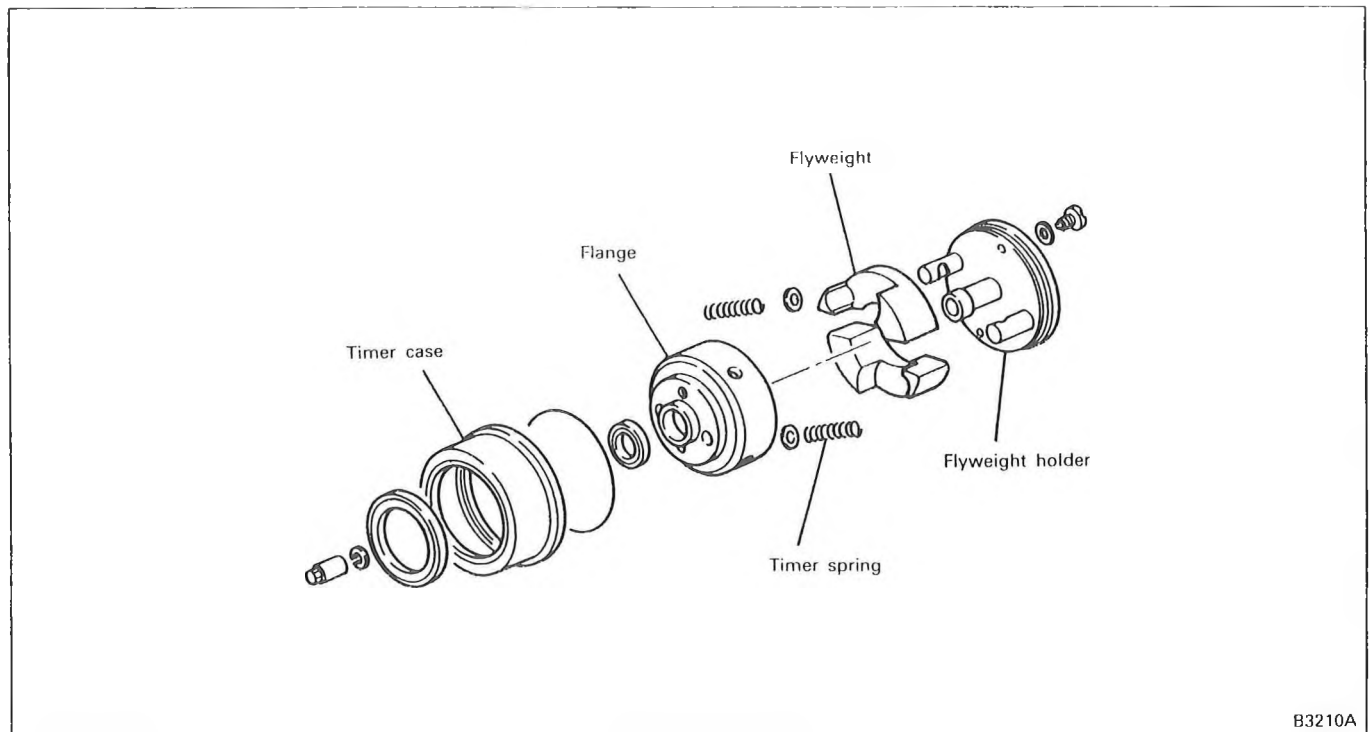
When the pressure of the pressure chamber or the delivery pressure exceeds specification, the piston cannot be brought back by the pressure of the piston spring, so the pump action stops and the fuel pressure in the fuel filter does not rise more than necessary.

(4) Automatic Timer

The interval between fuel injection into the cylinder and its ignition is called the ignition delay interval. The ignition delay interval is constant regardless of the engine speed. If the ignition timing is always constant, changes in the engine speed will vary the relation between the piston position and ignition timing, making it impossible to obtain the best engine performance. To maintain the relation between the piston position and ignition timing constant at all times, the injection timing must be changed to match the engine speed.

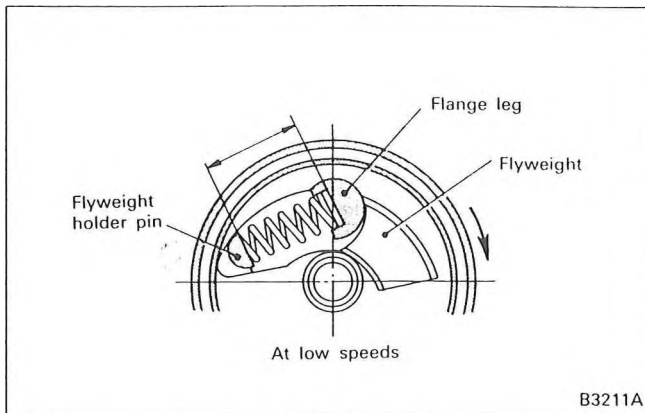
The automatic timer is a device which automatically changes the injection timing according to the engine speed.

(a) SA type automatic timer [6D22]

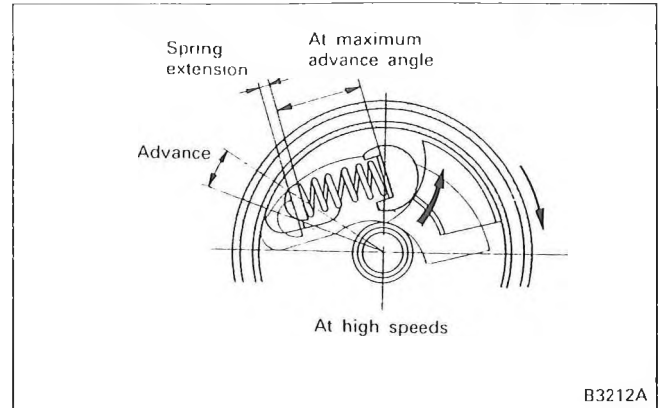


The two flyweights have a hole at one end. The pins of the flyweight holder fit in the holes. The flange legs touch the curved surfaces of the flyweights. Timer springs are mounted to the flyweight pins and flange legs.

Rotation of the engine is transmitted to the flange and from there to the flange legs, flyweights and flyweight holder and to the injection pump camshaft.

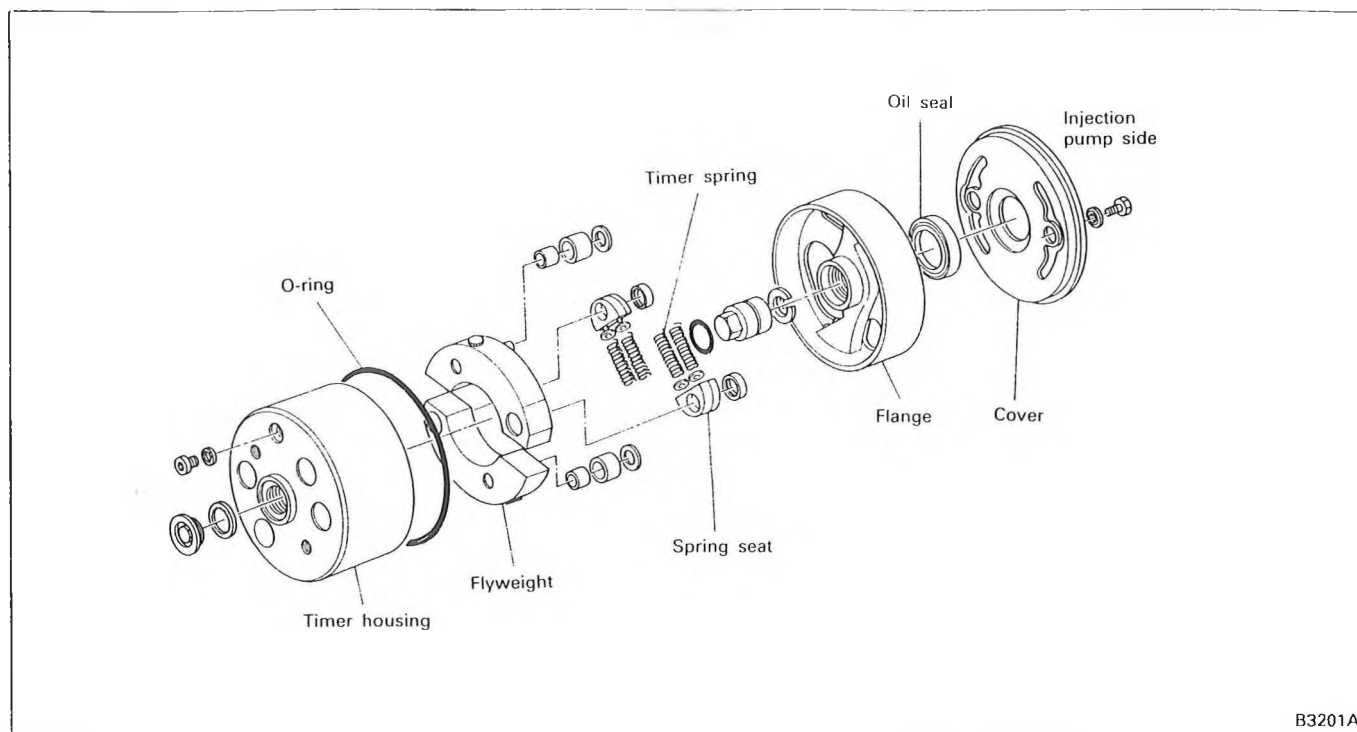


During low speed operation of the engine, no centrifugal force acts on the flyweights, so the timer springs have the longest installed length.



When the engine runs at a high speed, a centrifugal force acts on the flyweights and causes them to open outward with the pins of the flyweight holder as the fulcrums. The flange legs are pushed by the curved surfaces of the flyweights in the direction of the timer spring compression, but they cannot be moved because they are coupled to the drive side.

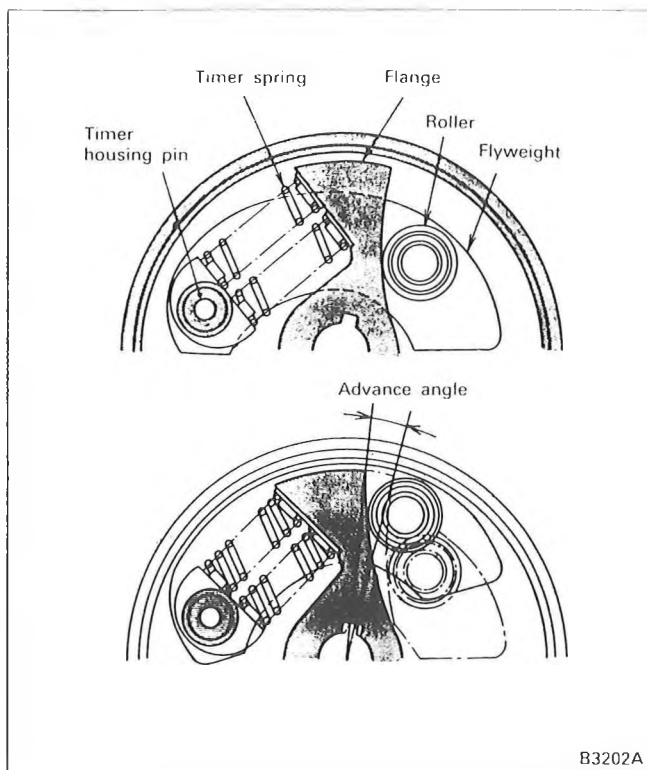
As a result, the pins of the flyweight holder are drawn in the turning direction, while compressing the timer springs, and move the camshaft of the pump in the turning direction to advance the injection timing. If the engine speed changes from a high to low speed, the centrifugal force of the flyweights will decrease and the flyweights will return to their original positions. At the same time, the pins of the flyweight holder will be pushed back by the timer springs.

(b) SP type automatic timer [6D22-T, TC]

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Two flyweights are fitted on the pins of the timer housing and are held in the timer housing. On the other hand, the injection pump connection side flange has a curved surface, and the roller fitted on the pin installed in the flyweight touches the curved surface.

Timer springs are held between the spring seats fitted on the timer housing pins which extend through the flange and flyweight. These parts are housed in the timer housing and are totally enclosed with a cover, O-ring and oil seal.

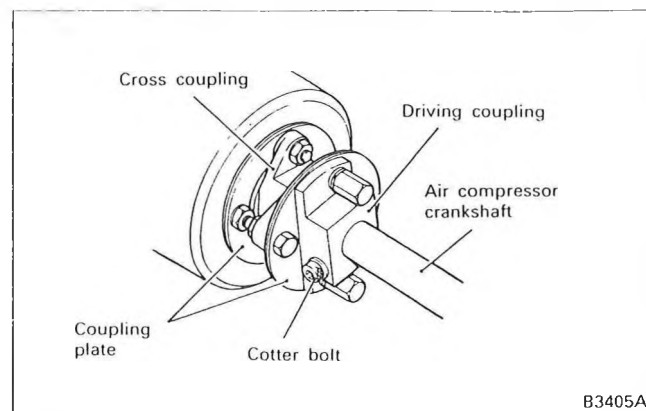


When the engine is running at a low speed, the timer spring pressure is stronger than the centrifugal force of flyweight, so the roller of flyweight is held down by the flange, creating no advance state.

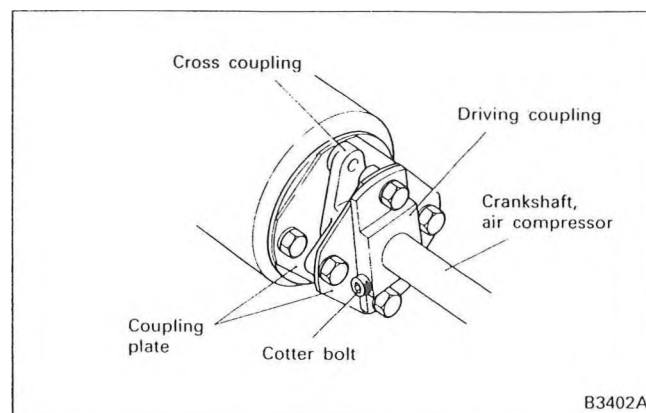
When the engine reaches a high speed, the centrifugal force of flyweight becomes stronger, the roller of flyweight pushes the curved surface of flange with the timer housing pin as the fulcrum, and the flyweight opens outward, while compressing the timer springs. In this manner, the roller installed on the flyweight moves the flange in the turning direction and advances the injection timing.

(5) Coupling

[For AD type]



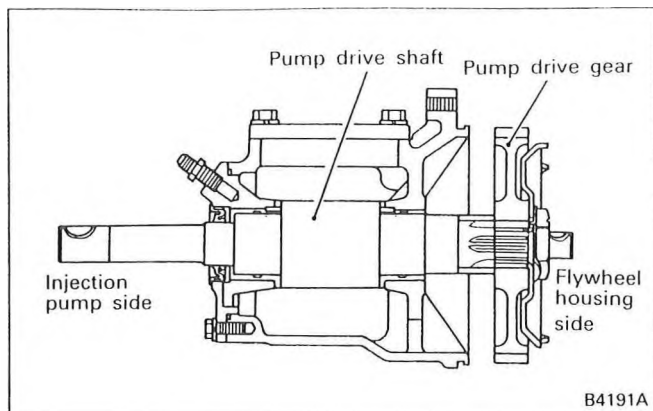
[For P type]



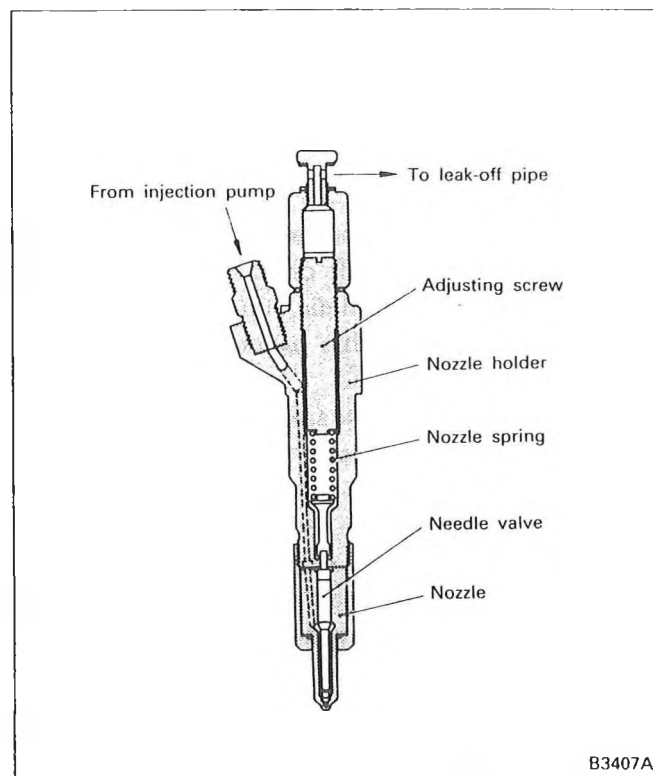
The coupling which transmits drive power from the air compressor crankshaft or injection pump drive crankshaft to the automatic timer is a laminated coupling consisting of thin plates placed one upon another.

The laminated coupling, thanks to the reversibility of the plates, absorbs excess forces other than the torque, thereby providing protection against application of forces other than necessary to the injection pump.

Adjustment of the fuel injection start timing is made by changing the installed condition of the driving coupling.

(6) Pump Drive Case

The pump drive case is mounted on the flywheel housing on the left side of the engine and is driven by the timing gear of the engine at half the engine speed. The pump drive shaft, with its end connected to the coupling of the injection pump, drives the injection pump.

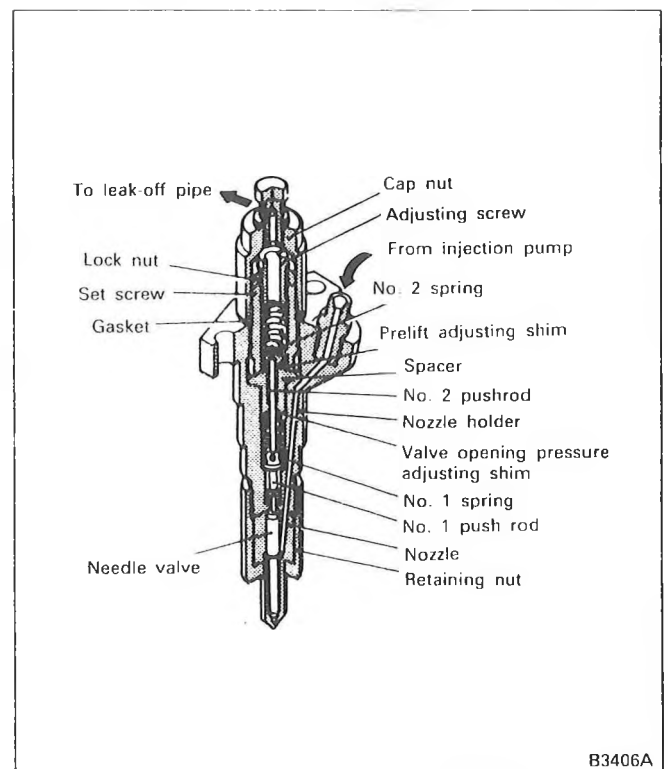
(7) Injection Nozzle**(a) Hole type (1-spring nozzle)**

The fuel delivered from the injection pump enters the nozzle holder and has a pressure higher than the specified pressure. So the fuel overcomes the nozzle spring and pushes the needle valve up.

The high pressure fuel which has forced the needle valve up is injected from the orifice at the end of the nozzle into the engine combustion chamber.

Some of the high pressure fuel lubricates the needle valve, etc. and is returned through the fuel leak-off pipe to the fuel tank.

The injection pressure of the injection nozzle is adjusted by changing the tension of the nozzle spring with the adjusting screw.

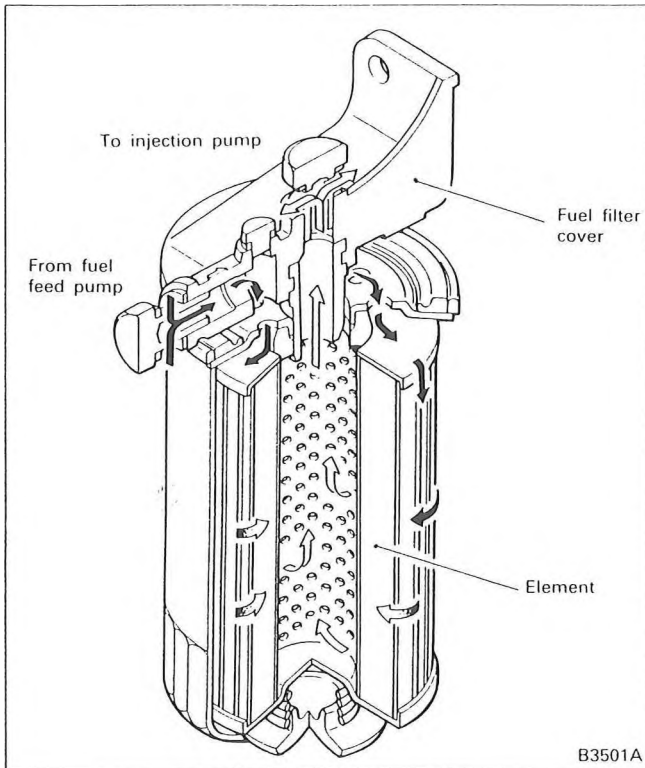
(b) Hole type (2-spring nozzle) [Option]

The fuel delivered from the injection pump enters the nozzle holder and overcomes the No. 1 and No. 2 springs, depending on its pressure, and pushes the needle valve up.

The high pressure fuel which has forced the needle valve up is properly injected from the orifice at the end of the nozzle into the engine combustion chamber.

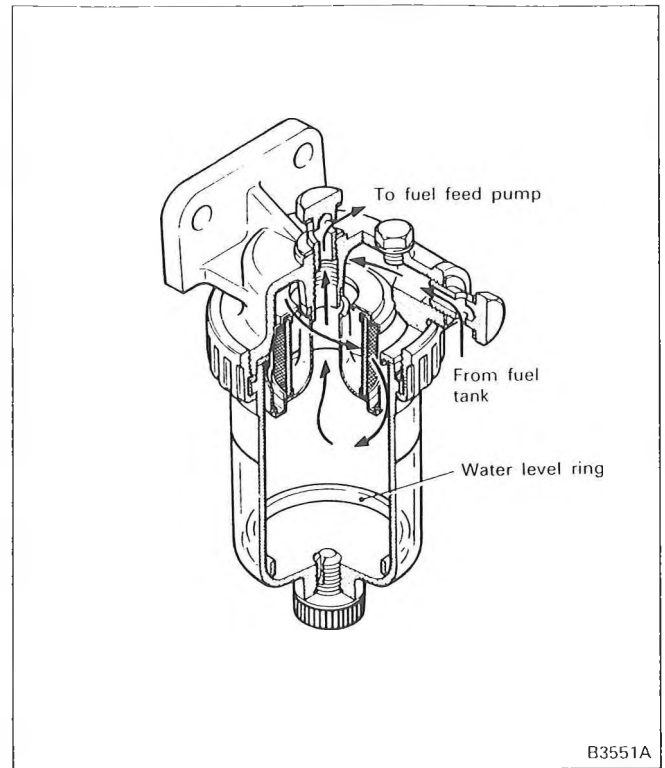
Some of the high pressure fuel lubricates the needle valve, etc. and is returned through the fuel leak-off pipe to the fuel tank.

The injection pressure of the injection nozzle is adjusted by changing the tension of the nozzle spring with the shim and adjusting screw.

(8) Fuel Filter

The fuel filter is a spin-on type. So the element is easily replaceable.

The fuel filter separates the water contained in the fuel fed under pressure from the feed pump of the injection pump and removes dust and dirt by the element.

(9) 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 semi-transparent case, making it possible to visually check the water quantity.

2. SPECIFICATIONS

Item		Specification					
		(Diesel Kiki Co., Ltd. product)					
		[6D22]		[6D22-T]		[6D22-TC]	
		(Standard)	(Option)	(Standard)	(Option)		
Injection pump proper	Type	Bosch in-line type	Bosch in-line type	Bosch in-line type	Bosch in-line type	Bosch in-line type	
	Model	AD	AD	P	P	P	
Turning direction (as viewed from drive side)		Clockwise	Clockwise	Clockwise	Clockwise	Clockwise	
Plunger	Diameter mm	10.5	10.5	12	12	12	
Governor	Type	All speed governor	Minimum maximum mechanical governor	All speed governor	Minimum maximum mechanical governor	All speed governor	
	Model	RSV	RFD	RSV	RFD	RSV	
Feed pump	Model	KE	KE	K	K	K	
Automatic timer	Type	Mechanical automatic timer	Mechanical automatic timer	Mechanical automatic timer	Mechanical automatic timer	Mechanical automatic timer	
	Model	SA	SA	SP	SP	SP	
Injection nozzle	Type	Hole type (1-spring nozzle)	Hole type (1-spring nozzle)	Hole type (1-spring nozzle)	Hole type (1-spring nozzle)	Hole type (1-spring nozzle)	Hole type (2-spring nozzle)
	Model	DLLA	DLLA	DLLA	DLLA	DLLA	DLLA
	No. of orifices	4	4	4	4	5	5
	Orifice diameter mm	0.37	0.37	0.37	0.37	0.36	0.36
	Orifice angle °	154	154	154	154	150	150
	Injection pressure MPa (kgf/cm ²)	21.6 (220)	21.6 (220)	17.7 (180)	21.6 (220)	21.6 (220)	17.7 (180)
Fuel filter	Type	Spin-on type					
Water separator		Sediment trap type					

3. SERVICE STANDARDS

3.1 SERVICE STANDARD TABLE

(1) Injection Pump

Unit: mm

Description			Nominal value (Basic diameter)	Limit	Correction and remarks
Fuel injection start timing (BTDC)			Dependent on specification	—	Adjust.
Eccentricity with respect to air compressor crankshaft (or pump drive shaft)			0.2 or less	—	Adjust.
Injection pump proper	Injection spacing		60 ± 30	—	Adjust.
	Prestroke	AD type	4.5 ± 0.05	—	Adjust.
		P type	4.8 ± 0.05	—	
	Overall tappet clearance		—	0.2	Replace.
	Overflow valve opening pressure	6D22 (for general power application)	155 kPa (1.6 kgf/cm ²)	—	Replace.
		6D22 (for construction machinery) 6D22-T, 6D22-TC	255 kPa (2.6 kgf/cm ²)	—	
	End play of camshaft		0.02 to 0.06	0.1	Adjust shims.
	Sliding resistance of control rack (when stationary)	AD type	1.5 N or less (150 gf or less)	—	Check.
	Sliding resistance of control rod (when stationary)	P type	1.3 N or less (130 gf or less)	—	Check.
	Tappet clearance	AD type	0.3 or more	—	Adjust.
Governor	Full stroke of control rack (or control rod)		21 or more	—	Check.
	Backlash between control rack and pinion	AD type	0.15	0.3	Replace.
	Dimension from governor housing to shifter	RSV type	19 to 19.2	—	Adjust shims.
		RFD type	33 to 33.4	—	

Unit: mm

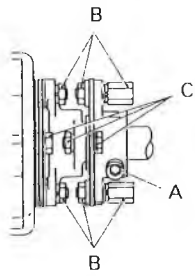
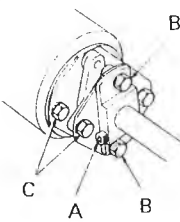
Description				Nominal value [Basic diameter]	Limit	Correction and remarks
Feed pump	Tightness [when 195 kPa (2 kgf/cm ²) of air pressure is applied]			0 cc/min.	–	Replace.
	Lifting capacity	No. of strokes required before lifting when operated at 60 to 100 strokes per minute		25 strokes or less		
	Delivery (min.) for 15 seconds cc	100 rpm	KE type	60		Replace.
			K type	60		
		500 rpm	KE type	340		
			K type	260		
		1000 rpm	KE type	405		
			K type	530		
		1500 rpm	KE type	430		
			K type	520		

(2) Injection nozzle

Unit: mm

Description		Nominal value [Basic diameter]	Limit	Correction and remarks
Injection nozzle injection pressure	One-spring nozzle	21.6 MPa (220 kgf/cm ²)		Adjust or replace nozzle.
	Two-spring nozzle	17.7 MPa (180 kgf/cm ²)		
Prelift		0.10 ± 0.02		Adjust.
2-spring regulated pressure (open pressure)		24.8 to 25.4 MPa (253 to 259 kgf/cm ²)		Adjust.
2-spring regulated pressure (cover pressure) with a 0.05 needle valve lift		23 to 23.5 MPa (235 to 240 kgf/cm ²)		Adjust.

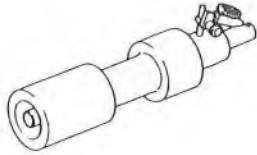
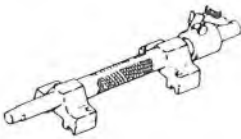
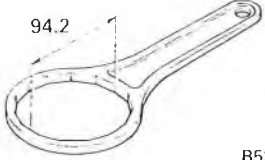
3.2 TIGHTENING TORQUE TABLE

Description			Thread size O.D. x pitch (mm)	Tightening torque Nm (kgfm)	Remarks
Injection pump bracket			M10 x 1.5	35 to 53 (3.6 to 5.4)	
Injection pump	AD type injection pump	Delivery valve holder		64 to 69 (6.5 to 7)	
		Lock plate		4.4 to 5.9 (0.45 to 0.6)	
	P type injection pump	Flange sleeve nut		39 to 44 (4 to 4.5)	
		Delivery valve holder		110 to 115 (11 to 12)	Tighten three times to the specified torque.
	Governor flyweight nut			49 to 59 (5 to 6)	
	SA type automatic timer	Round nut		83 to 98 (8.5 to 10)	
	SP type automatic timer	Round nut		125 to 145 (13 to 15)	
		Cap screw		29 to 39 (3 to 4)	
		Cover mounting bolt		22 to 24 (2.2 to 2.4)	
	(For AD type injection pump)		A bolt	49 to 54 (5 to 5.5)	
 B3408A		B bolt	29 to 34 (3 to 3.5)		
		C bolt	29 to 34 (3 to 3.5)		
		(For P type injection pump)		A bolt	74 to 83 (7.5 to 8.5)
 B3401A		B bolt	59 to 64 (6 to 6.5)		
		C bolt	59 to 64 (6 to 6.5)		
		Injection nozzle	One-spring nozzle	Retaining nut	M22 x 1.5
Inlet connector	M14 x 1.5			69 to 78 (7 to 8)	
Cap nut	M14 x 1			39 to 49 (4 to 5)	
Two-spring nozzle	Retaining nut		M19 x 1	59 to 78 (6 to 8)	
	Set screw			49 to 59 (5 to 6)	
	Lock nut			20 to 25 (2 to 2.5)	
	Cap nut		M22 x 1.5	39 to 49 (4 to 5)	
	Inlet connector		M14 x 1.5	69 to 78 (7 to 8)	

Description			Thread size O.D. x pitch (mm)	Tightening torque Nm (kgfm)	Remarks
Injection nozzle bolt (for attaching to cylinder head)			M8 x 1.25	15 (1.5)	
Injection pipe union nut	On pump side	P type	M14 x 1.5	29 (3)	
		AD type	M12 x 1.5	29 (3)	
	On nozzle side		M12 x 1.5	29 (3)	
Leak off pipe eye bolt			M8 x 1	9.8 to 15 (1 to 1.5)	
Fuel filter	Connector bolt		M14 x 1.5	25 (2.5)	
Water separator	Ring nut		—	5.9 to 7.8 (0.6 to 0.8)	
	Drain plug		—	2.9 to 3.9 (0.3 to 0.4)	
	Air plug		M8 x 1.25	7.8 to 9.8 (0.8 to 1.0)	
	Connector bolt		M14 x 1.5	25 (2.5)	
Injection pump piping tightening eyebolt	Fuel inlet		—	20 to 25 (2 to 2.5)	
	Fuel feed (feed pump)		—	20 to 25 (2 to 2.5)	
	Fuel feed (pump proper)		—	20 to 29 (2 to 3)	
	Fuel overflow		—	20 to 29 (2 to 3)	
	Lubricant (inlet)	AD type	—	9.8 to 13 (1 to 1.3)	
		P type	—	12 to 15 (1.2 to 1.5)	
	Lubricant (outlet)	AD type	—	15 to 18 (1.5 to 1.8)	
		P type	—	20 to 29 (2 to 3)	
Injection pump gear mounting nut of pump drive case			M24 x 1.5	22 (2.2)	

4. SPECIAL TOOL

Unit: mm

Tool name	Part No.	Shape	Use
Injection pump centering tool	MH061270	 B5032A	Centering of bracket of AD type injection pump
	MH061340	 B5031A	Centering of bracket of P type injection pump
Filter wrench	MH061572	 B5222A	Removal of fuel filter element

Diesel Kiki Products**(1) AD Type Injection Pump Proper**

The part numbers are the DIESEL KIKI part numbers.

Special Tool Name	Part No.	Use
AD type injection pump special tool set	105790-1060	Disassembly and reassembly
Universal vice	105794-0090	Mounting base
Tappet pin	157931-7320	Supporting of tappet
Measuring device	105782-4130	Measurement of camshaft end play
Wrench	157910-1120	Removal and installation of screw
Guide	157920-5400	Protection of oil seal
Roller pincers	157921-3020	Removal and installation of tappet
Tappet pincers	157931-6120	
Plunger pincers	157921-6120	Removal and installation of plunger
Wrench	157914-0500	Removal and installation of delivery valve holder
Extractor	157925-6520	Removal of inner race
	157925-0520	Removal of outer race (timer side)
	157925-0120	Removal of outer race (governor side)
Reamer	157930-4620	Correction of pump housing

The part numbers are the DIESEL KIKI part numbers.

Special Tool Name	Part No.	Use
Stand	105781-0430	Test and adjustment of injection pump
Measuring device	105782-6010	
	105782-4020	
Holder	157931-4400	
Nozzle holder wrench	157916-8220	

(2) P Type Injection Pump Proper

The part numbers are the DIESEL KIKI part numbers.

Special Tool Name	Part No.	Use
P type injection pump special tool	105790-7050	Disassembly and reassembly
Universal vice	105794-0010	Mounting base
Fitting plate	157944-3620	Installation
Plate	157944-3820	
Tappet holder	157931-4700	Supporting of tappet
Bracket	157920-9900	Removal of bearing cover
Extractor bearing cover	157920-7720	
Tappet mounting device	157921-8020	Removal and installation of tappet
Plunger insert	157921-4820	Removal and installation of plunger
Plunger clamp device	157921-5620	Removal and installation of control sleeve
Extractor	105792-0030	Removal of plunger block assembly
Fitting plate	157944-3520	Disassembly and reassembly of plunger block assembly
Socket wrench	157914-0500	Removal and installation of delivery holder
Special wrench	157915-6500	Removal and installation of screw bushing
Inner race extractor	157925-7120	Removal of inner race
Outer race extractor	157925-2020	Removal of outer race
O-ring insert	105792-0000	Installation of O-ring
Plate measuring	157828-7200	Positioning of governor side taper roller bearing
Camshaft measuring device	105782-4140	Measurement of camshaft end play
Fixing stand	105781-0170	Test and adjustment of injection pump
Measuring device	105782-4210	
	105782-4270	

(3) RSV Type Governor

The part numbers are the DIESEL KIKI part numbers.

Special Tool Name	Part No.	Use
Handle	157910-1120	Removal and installation of lock nut
Socket wrench	157914-0500	
Wrench	157915-0100	Removal and installation of round nut
Extractor	157926-5320	Removal and installation of flyweight
Special wrench	157916-2620	Adjustment of Angleich

(4) RFD Type Governor

The part numbers are the DIESEL KIKI part numbers.

Special Tool Name	Part No.	Use
Handle	157910-1120	Removal and installation of lock nut
Socket wrench	157914-0500	
Special wrench	157915-0100	Removal and installation of round nut
Extractor	157926-5320	Removal of flyweight
Special wrench	157916-2620	Adjustment of idle speed
Guide screw	157976-3100	Adjustment of rack limit

(5) SA Type Automatic Timer

The part numbers are the DIESEL KIKI part numbers.

Special Tool Name	Part No.	Use
SA type automatic timer special tool set	105790-5010	Disassembly and reassembly
Special spanner	157916-5320	Removal and installation of round nut
Extractor	157926-6210	Removal
Guide bolt	157924-0200	Disassembly and reassembly
Base	157924-0110	
Hand spanner	157916-6120	Removal and installation of timer case
Thrust bushing	157924-1500	Installation of oil seal
Guide bushing	157924-1200	
Block	157924-0800	
Guide bushing	157924-1300	
Guide	157924-0900	
Support	157932-0100	Installation of flyweight
Guide	157924-0400	
Thrust bushing	157924-0500	Installation of flange
Oil seal guide	157914-0600	Insertion of timer case

(6) SP Type Automatic Timer

The part numbers are the DIESEL KIKI part numbers.

Special Tool Name	Part No.	Use
SP type automatic timer special tool set	105790-5050	Disassembly and reassembly
Box spanner	157915-2320	Removal and installation of round nut
Box wrench	157916-2800	
Special spanner	157916-5320	Removal and installation
Extractor	157926-7220	
Base	157924-2520	Disassembly and reassembly
Special spanner	157916-8320	

(7) Injection Nozzle

The part numbers are the DIESEL KIKI part numbers.

Special Tool Name	Part No.	Use
Nozzle cleaning tool	105789-0010	Cleaning of nozzle
Nozzle tester	105785-1010	Adjustment and testing
Adjusting device set	105789-0500 (*: Components)	Adjustment and testing of 2-spring nozzle
Adjusting device	*157892-0220	
Dial gauge	*157954-3800	
Pin $\ell = 50$	*157892-1200	
Pin $\ell = 60.5$	*157892-1100	
Connector	*157892-1320	
Base	*157892-1800	
Gasket	*157892-1500	
Retaining nut	*157892-1420	
Gasket	*026508-1140	

5. SERVICE PROCEDURES

Wherever possible, test the fuel system parts before disassembly to precisely know their conditions. Select a clean site for disassembly and reassembly work, as even small dust particles on the fuel system parts can adversely affect engine performance. When disassembling the injection pump, keep work bench clean and disassembled parts neatly arranged for each cylinder. Use special care to ensure correct combination of plunger and plunger barrel and of delivery valve and delivery valve seat.

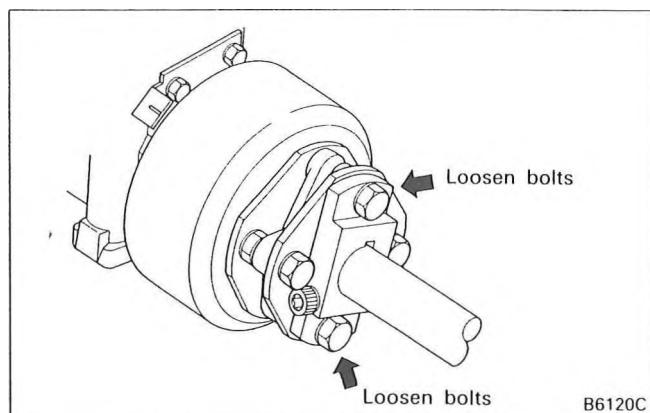
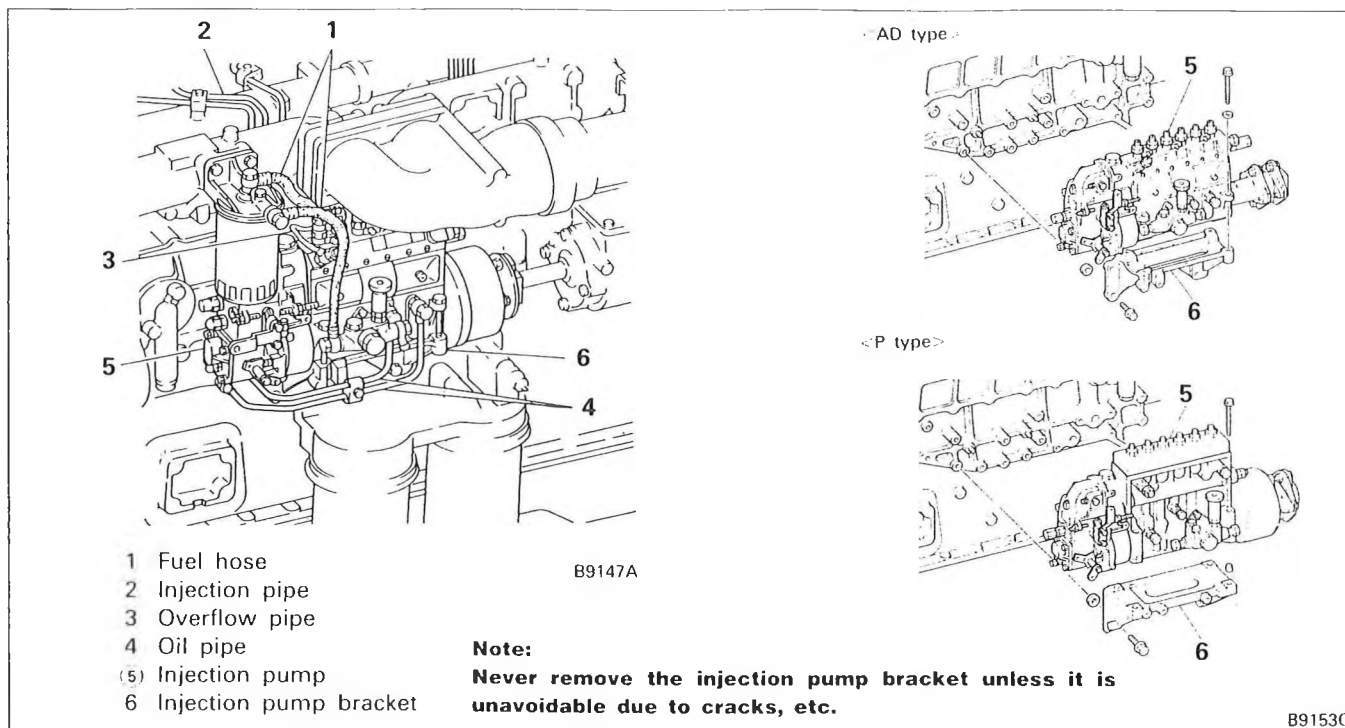
Scrupulous care must be exercised when disassembling and reassembling critical parts.

Use the specified special tools for disassembly and reassembly; never apply excessive force or handle parts carelessly.

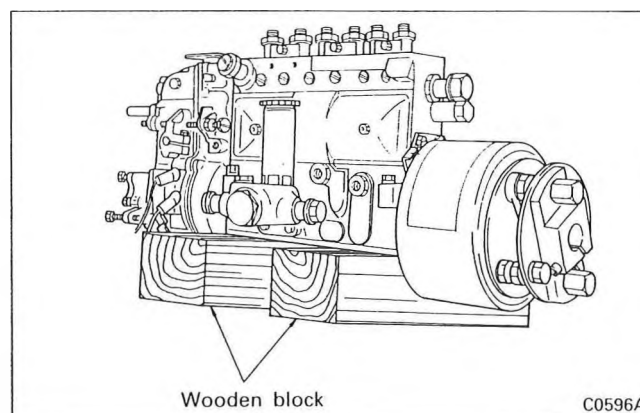
Before disassembly, test the system to know exactly the trouble spots.

5.1 INJECTION PUMP

5.1.1 Removal



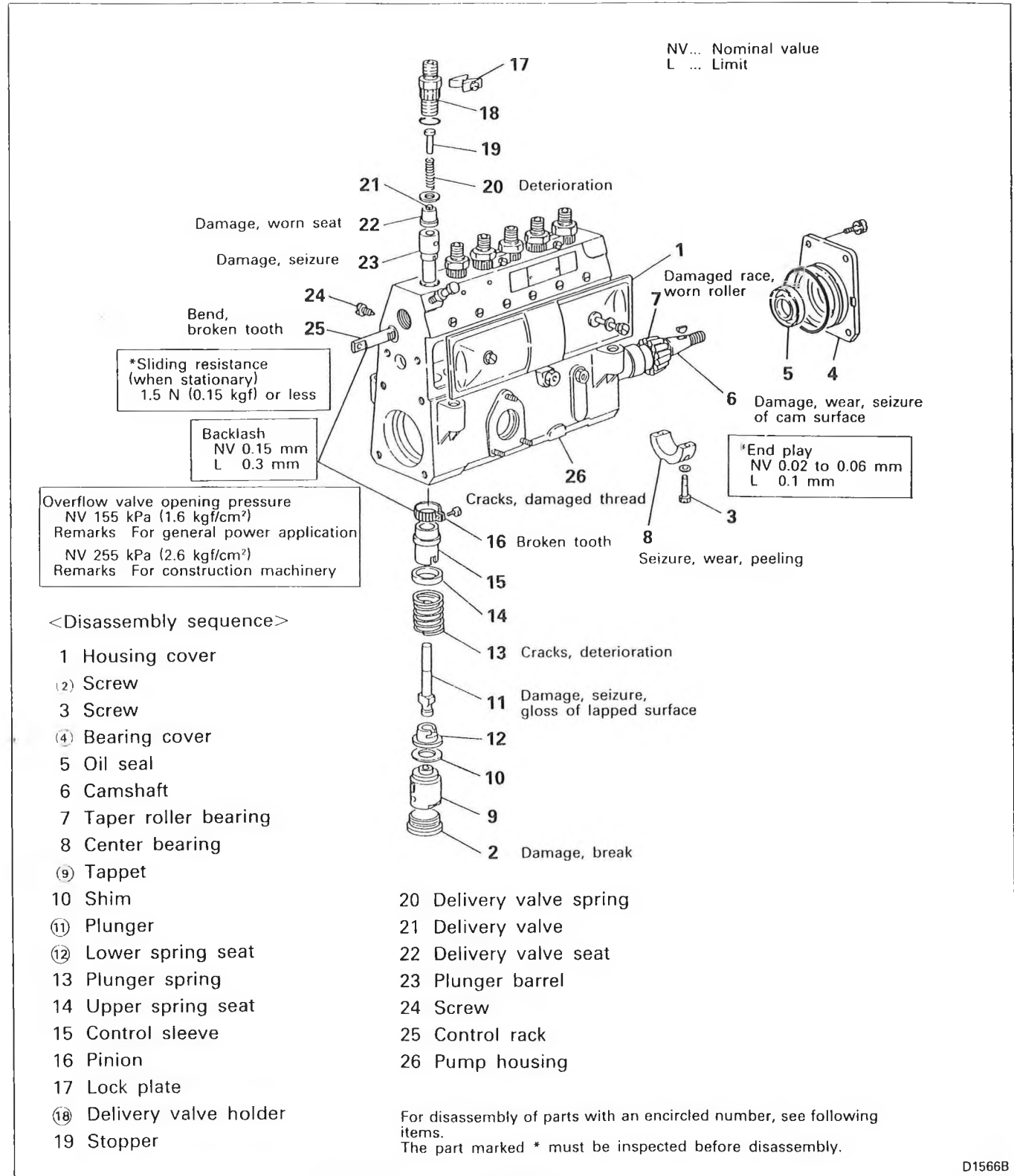
(1) At removal, first loosen bolts indicated by arrows in figure from coupling.



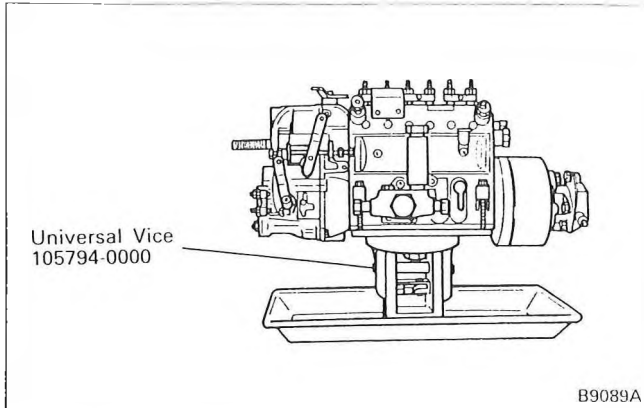
(2) Use a wood block to store injection pump lest excess force might be applied to timer.

5.1.2 AD Type Injection Pump

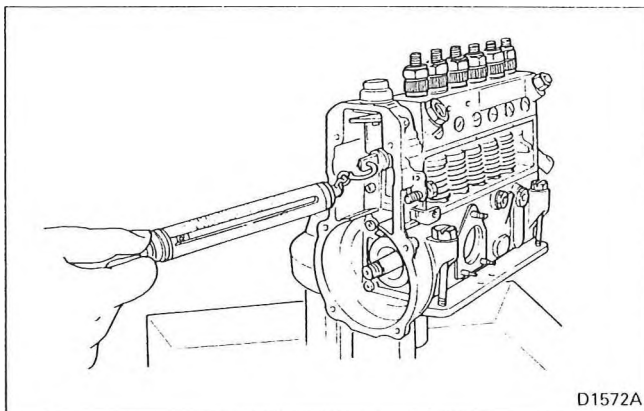
(1) Disassembly



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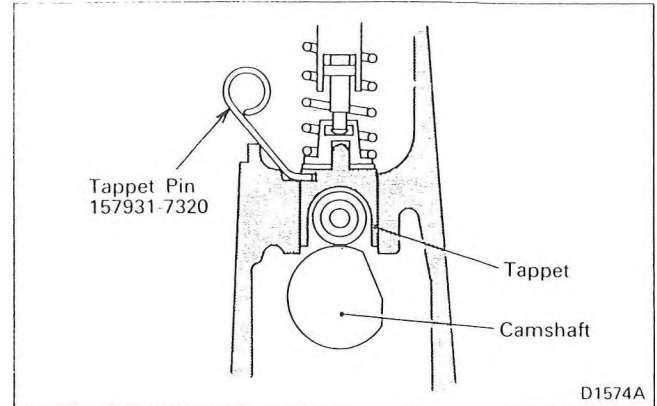


- (a) Install the injection pump in Universal Vice (special tool).
- (b) Remove the feed pump.
- (c) Remove the coupling and automatic timer. [Refer to 5.4.1.]
- (d) Remove the governor. (Refer to 5.2.1 or 5.2.2.)

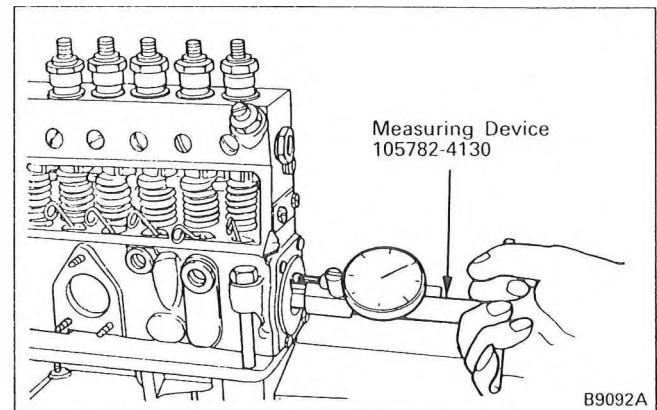


- (e) Measure the sliding resistance of the control rack with a spring balancer.
- Turn the camshaft and measure the sliding resistance in all of the rising and falling positions of the cam. If the readings are in excess of the nominal value, the following causes are probable.

- 1) Damaged control rack, abnormal teeth
- 2) Abnormal teeth of pinion, contact with housing
- 3) Overtightened delivery valve holder



- (f) Remove the housing cover.
- Insert Tappet Pins (special tools) into the tappet holes of all the cylinders to space the tappets away from the camshaft.

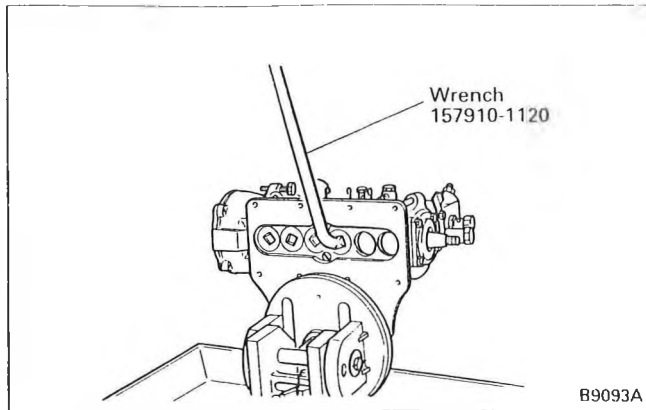


- (g) Measure the end play of the camshaft with Measuring Device (special tool). If the end play is in excess of the limit, adjust by using shims or replace the bearing.

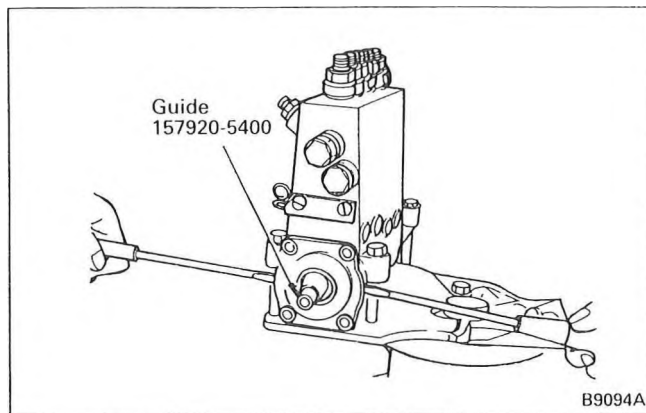
Shim thickness: 0.10, 0.12, 0.14, 0.16, 0.18, 0.30, 0.50, 1.00 mm

NOTE:

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



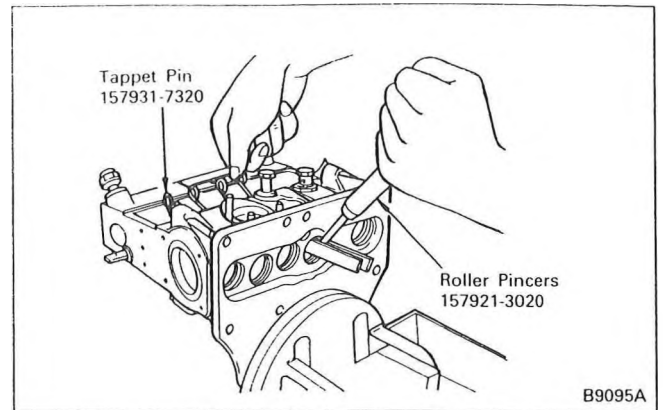
(h) Remove the screws at the bottom of the injection pump with Wrench (special tool).



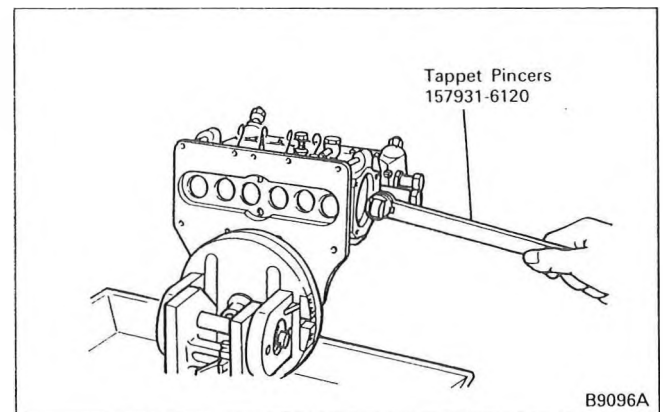
(i) Insert a screwdriver into the groove in the bearing cover to remove the bearing cover and oil seal.

NOTE:

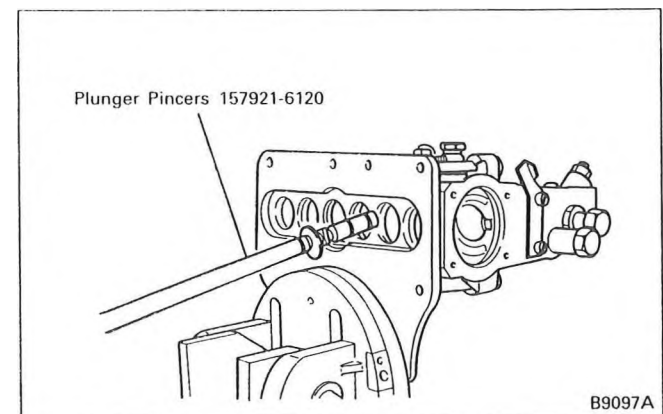
1. To prevent damaging the oil seal, remove the woodruff key from the camshaft and put Guide (special tool) on the threaded portion.
2. To remove the camshaft, direct the first cam lobe on the removal side of camshaft toward the top of the pump to prevent the camshaft lobe from touching the tappets, and then lightly strike.



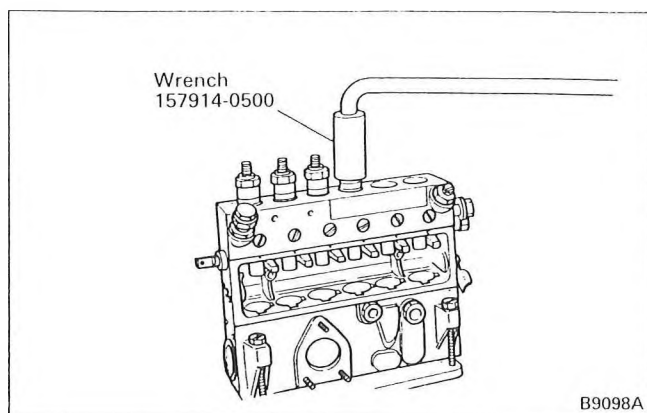
(j) Push the tappets up from the bottom of the injection pump with Roller Pincers (special tool) and remove the Tappet Pins (special tools).



(k) Hold a tappet in Tappet Pincers (special tool), remove the Roller Pincers (special tool), and then take out the tappet and shim.



(l) Remove the plunger together with the lower spring seat, using Plunger Pincers (special tool).
 (m) Measure the backlash between the control rack and pinion. If the backlash is in excess of the limit, replace.

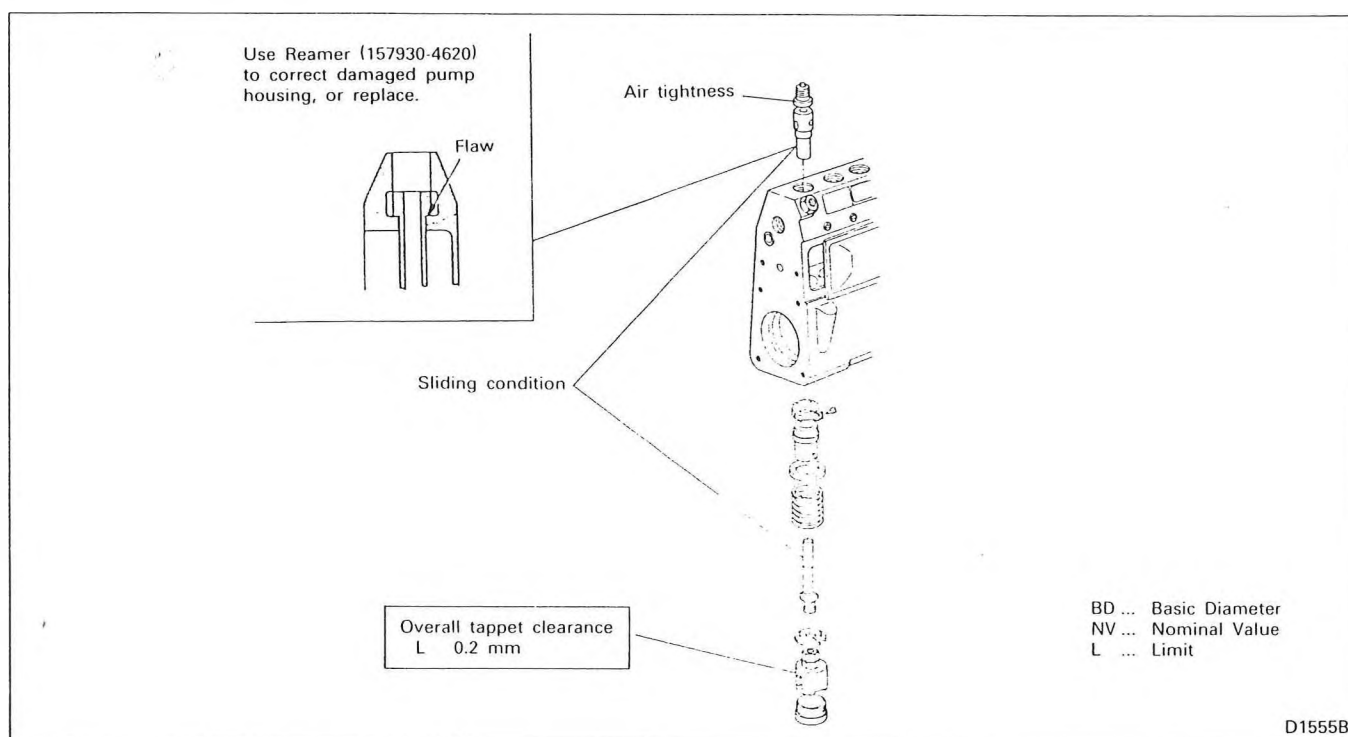


(n) Use Wrench (special tool) to remove the delivery valve holder.

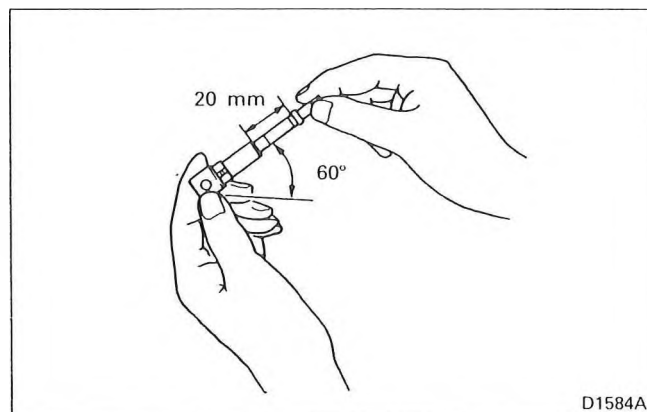
NOTE:

Immerse the delivery valve combined with delivery valve seat and the plunger combined with plunger barrel in gas oil without changing their combinations.

(2) Inspection and Correction



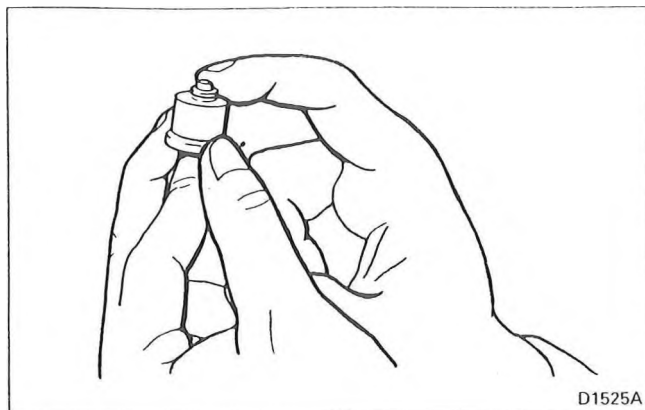
(a) Plunger and plunger barrel



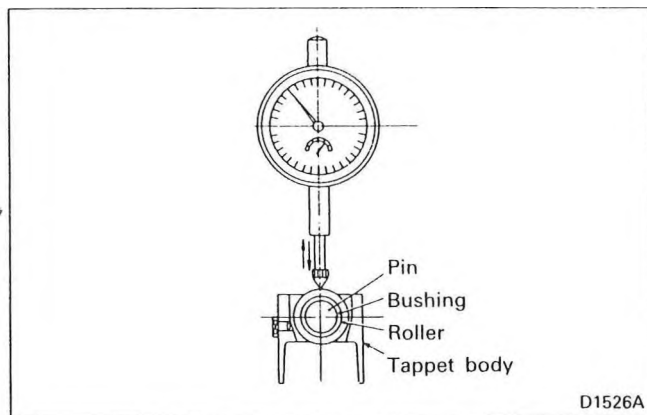
After cleaning in gas oil, check to see that the plunger falls smoothly in the plunger barrel under its own weight.

Check by the following procedure.

- 1) Tilt the plunger barrel approx. 60°.
- 2) Pull the plunger about 20 mm out.
- 3) Turn the plunger and check several points.

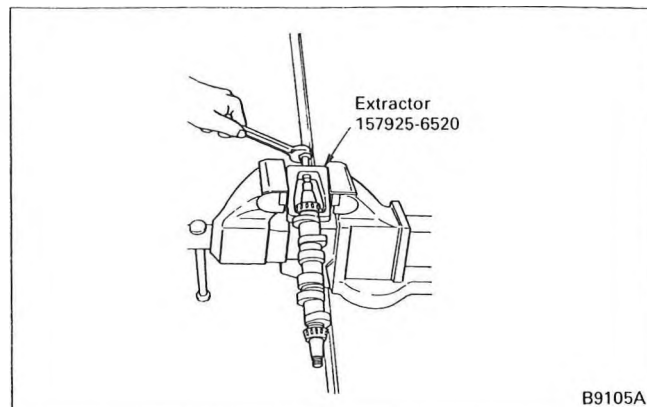
(b) Delivery valve

Clean the valve and valve seat portions of the delivery valve in gas oil and check worn condition. Seal off the bottom of the valve seat portion with a finger tip and press down the valve portion with a finger. If the valve portion bounces back when released, the valve portion is good. If it does not bounce back, the valve portion is badly worn. Replace the delivery valve.

(c) Tappet

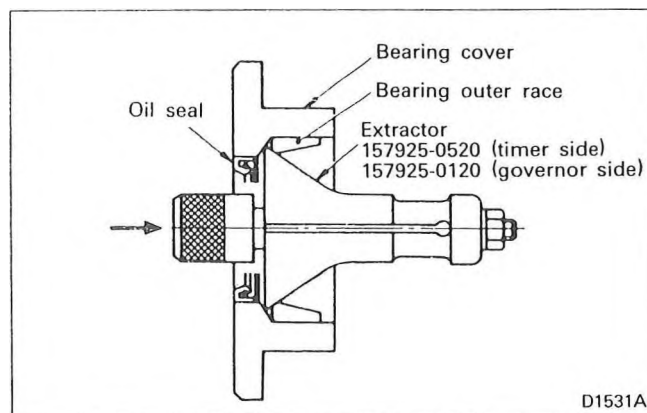
Hold a dial gauge to the roller portion of tappet and check the overall clearance by moving the roller up and down.

If the overall clearance is in excess of the limit, replace the tappet assembly.

**(d) Replacement of taper roller bearing
Inner race**

To remove, use Extractor (special tool).

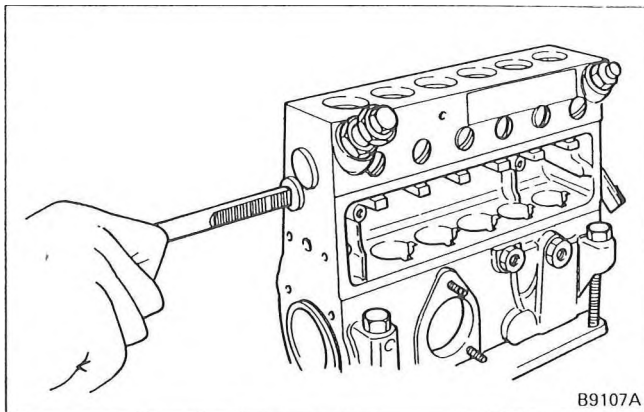
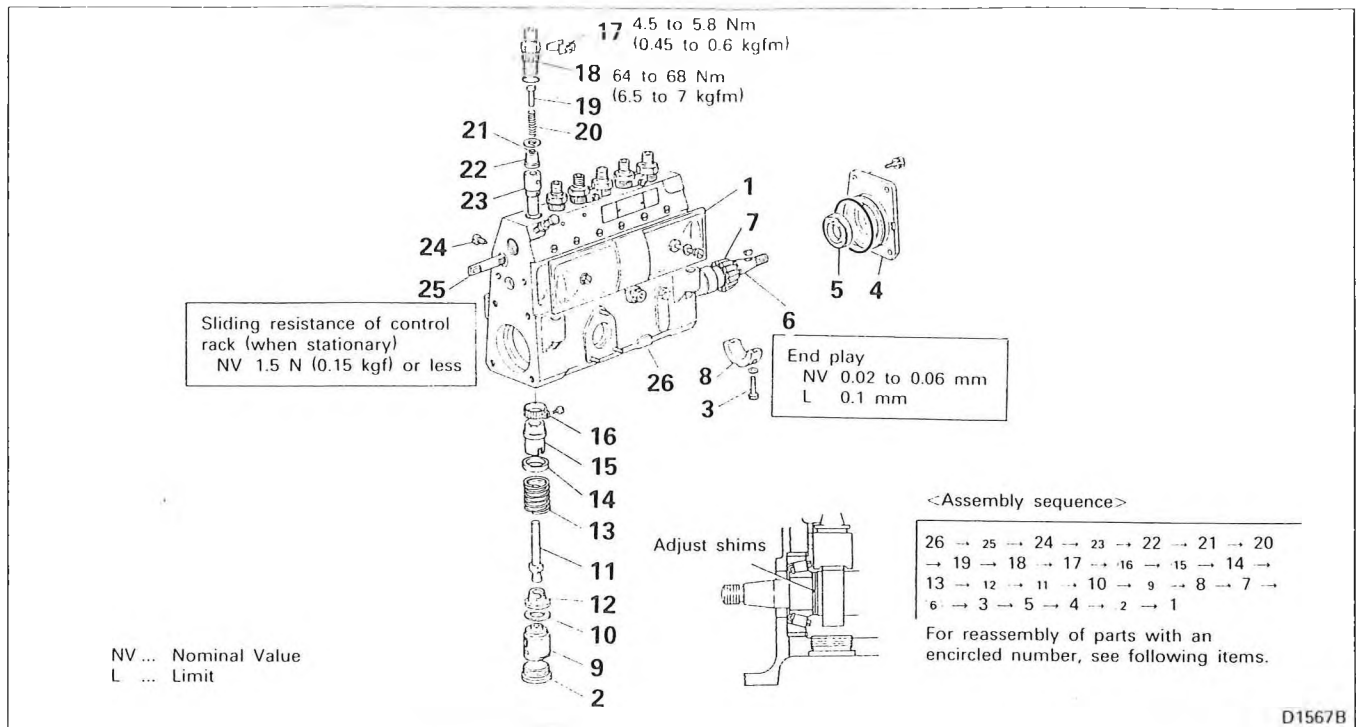
To install, put the ring and shims and then install the taper roller bearing.

Outer race

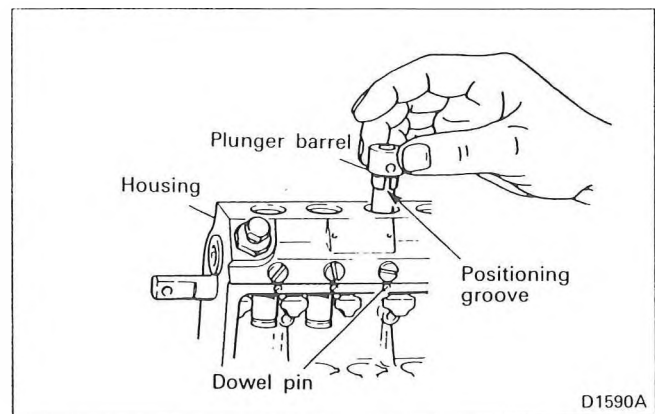
The bearing cover side outer race should be removed by use of Outer Race Extractor (special tool).

To install, put a new oil seal in position, and then install the outer race.

(3) Reassembly



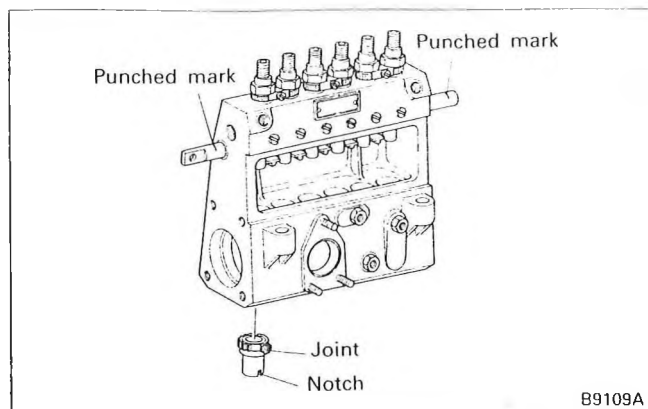
(a) Mount the pump housing in Universal Vice (special tool). After the control rack has been inserted, thread the screw into the back of the pump housing. Check to see if the control rack lightly operates.



(b) Insert the plunger barrel into the housing.

NOTE:

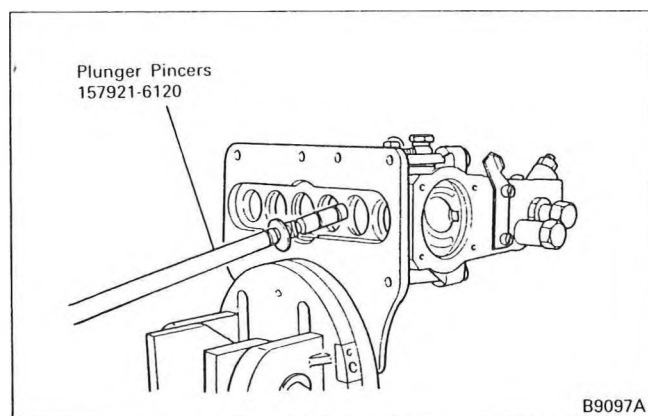
1. Align the notch of the plunger barrel with the dowel pin of the housing.
2. Do not lightly strike the plunger barrel but securely push in by finger.



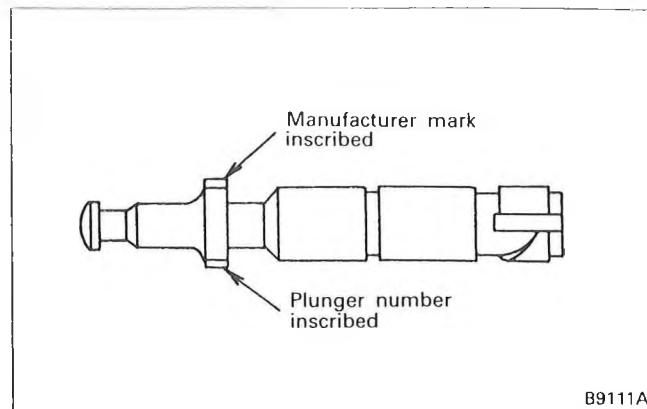
(c) Place the pump housing on its side and set the control rack so that the punched marks of the control rack will be positioned the same dimension away from the ends of the housing. After the pinion and control sleeve have been combined, put the pinion in mesh with the teeth of the control rod.

NOTE:

1. Install the pinion and control sleeve so that the joint of the pinion and notch of the control sleeve will be faced toward you.
2. After each pinion has been installed, move the control rack to confirm that it can be moved the same amount to right and left.

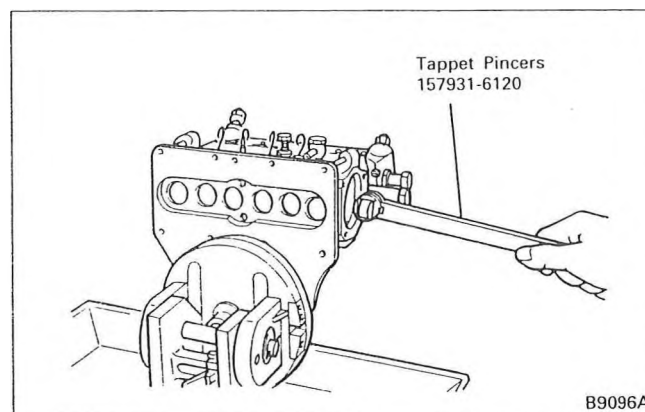


(d) Install the lower spring seat and plunger together, using Plunger Pincers (special tool).

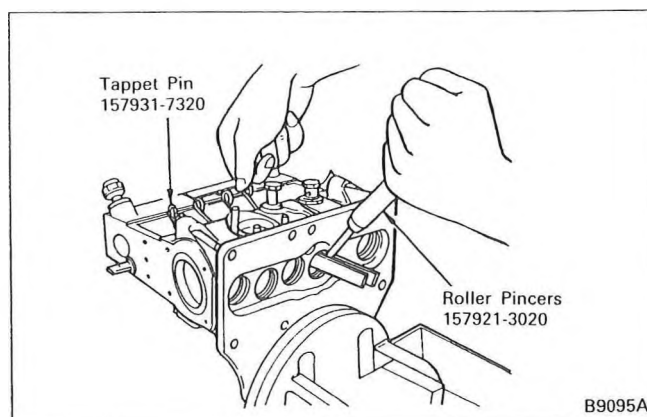


NOTE:

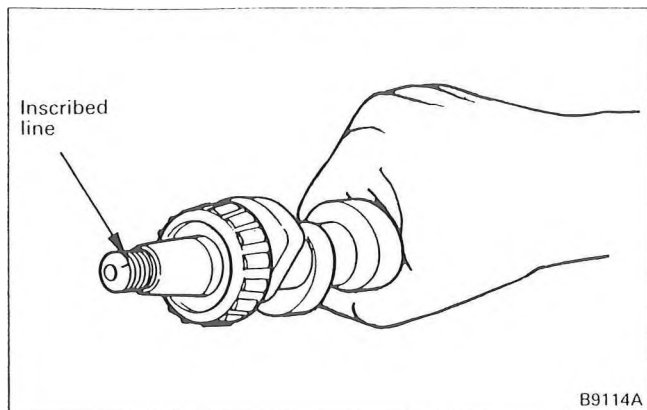
Install the plunger with the stamped model number toward you (the housing cover).



(e) Hold the tappet and shim in Tappet Pincers (special tool) and insert into the housing.



(f) Push the tappet inserted into the housing up with Roller Pincers (special tool) and insert Tappet Pin (special tool) into the hole in the tappet.



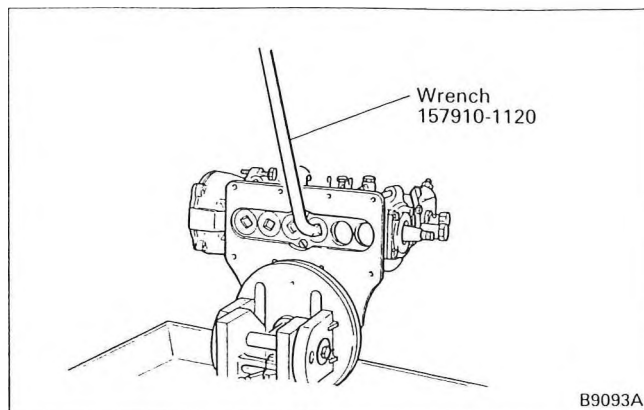
NOTE:

when the camshaft is inserted, face the inscribed line on the end of the camshaft toward the timer.

(g) Confirm the following items.

- 1) End play of camshaft [Refer to 5.1.2 (1)(g).]
- 2) Sliding resistance of control rack [Refer to 5.1.2 (1)(e).]

Check after removal of Tappet Pin (special tool).



(h) Install the screws, using Wrench (special tool).

(i) Install the following parts.

Governor (Refer to 5.2.1. or 5.2.2.)

Feed pump

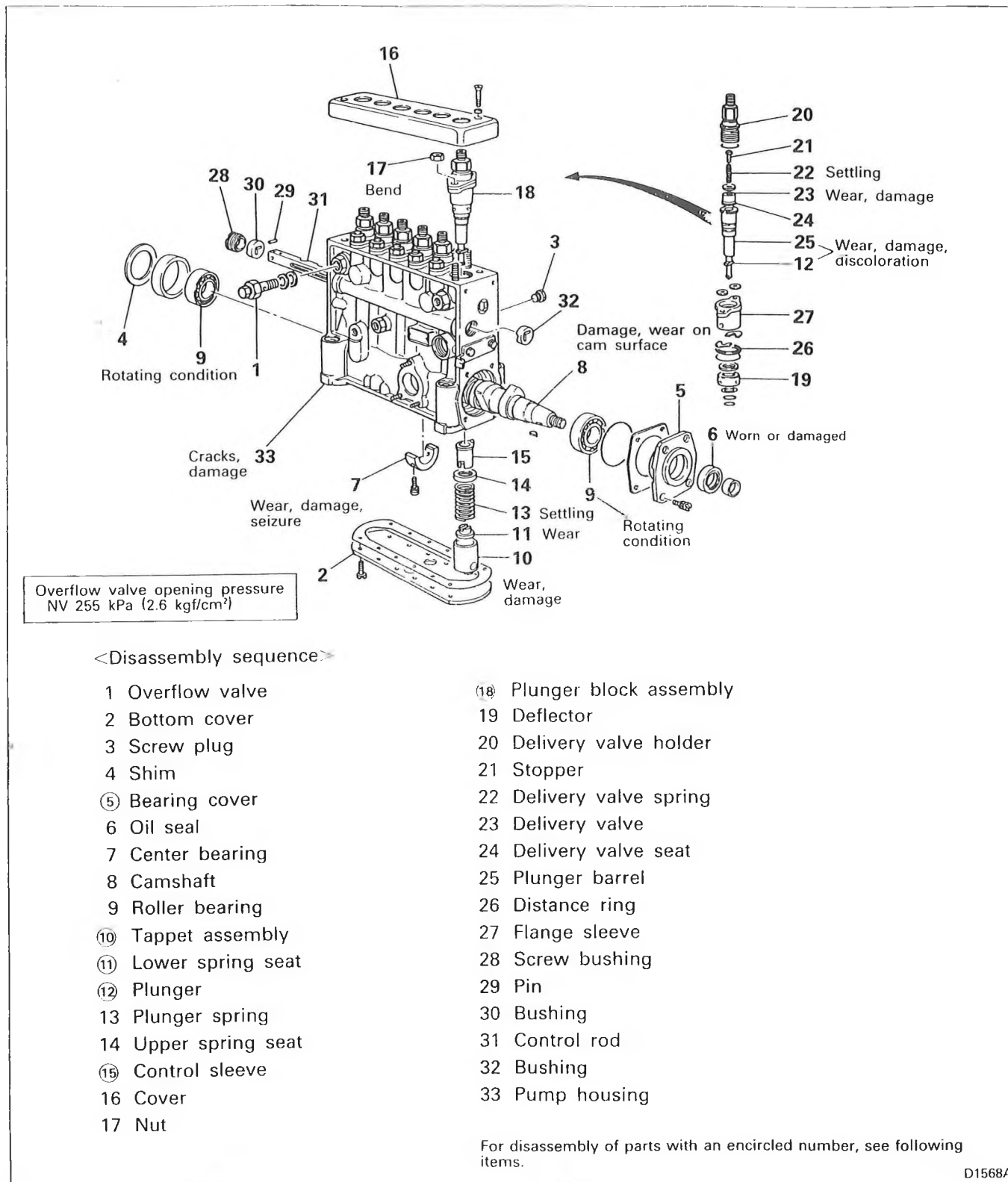
Automatic timer (Refer to 5.4.1.)

Coupling

(j) After the reassembly has been completed, adjust the injection pump.

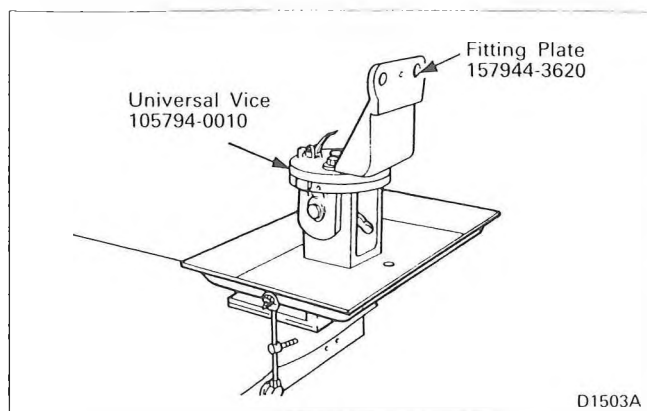
5.1.3 P Type Injection Pump

(1) Disassembly

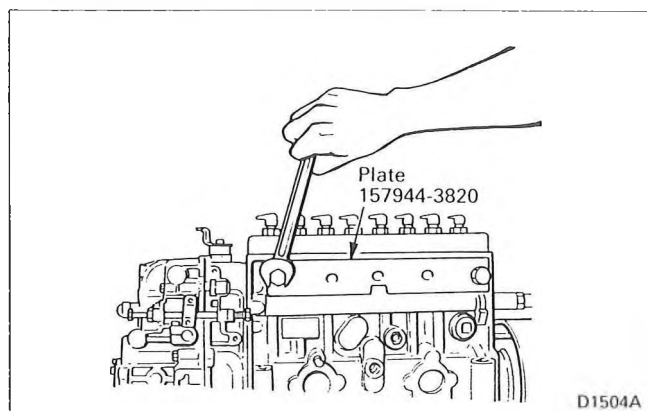


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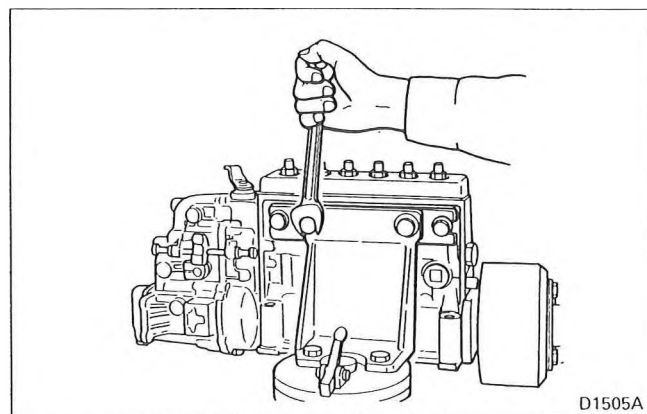
(a) Remove the feed pump.



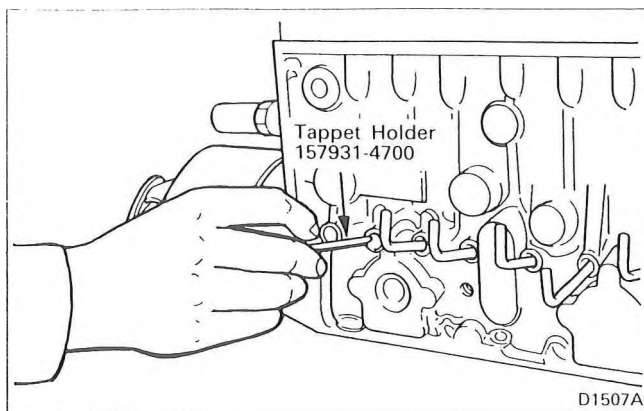
(b) Install Fitting Plate (special tool) in Universal Vice (special tool).



(c) Utilizing the threaded hole, install Plate (special tool).



(d) Install the injection pump in Universal Vice (special tool).



(e) Remove the screw plug, turn the camshaft to place the tappet at the top dead center position, and insert Tappet Holder (special tool) into the screw plug hole to space the tappet away from the camshaft.

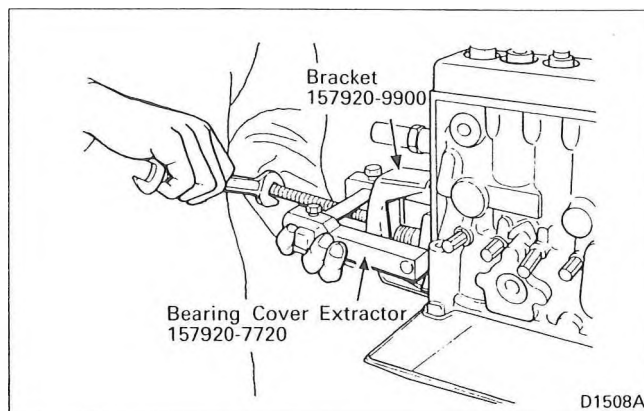
(f) Remove the coupling.

(g) Remove the automatic timer.

(Refer to 5.4.2)

(h) Remove the governor.

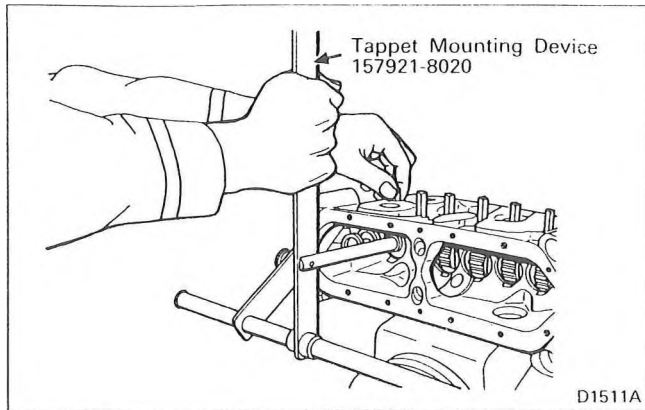
(Refer to 5.2.1 or 5.2.2)



(i) Remove the bearing cover, using Bracket and Bearing Cover Extractor (special tools).

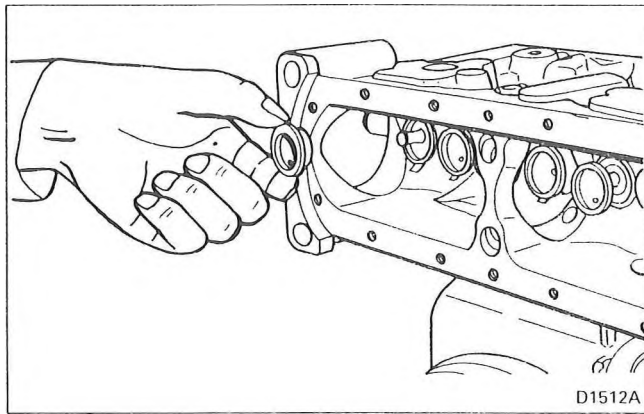
NOTE:

1. When the bearing cover is removed, use care not to lose the end play adjusting shims.
2. Check the oil seal and do not remove it unless defective.

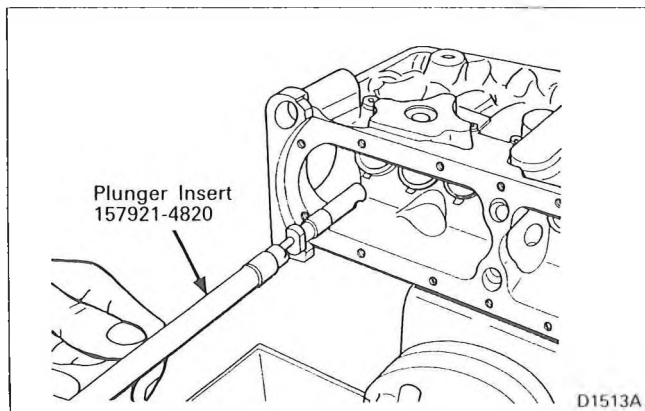


(j) Install Tappet Mounting Device (special tool) to the pump housing.

Then operate the lever to push the tappet up, remove Tappet Holder (special tool), and take out the tappet assembly.



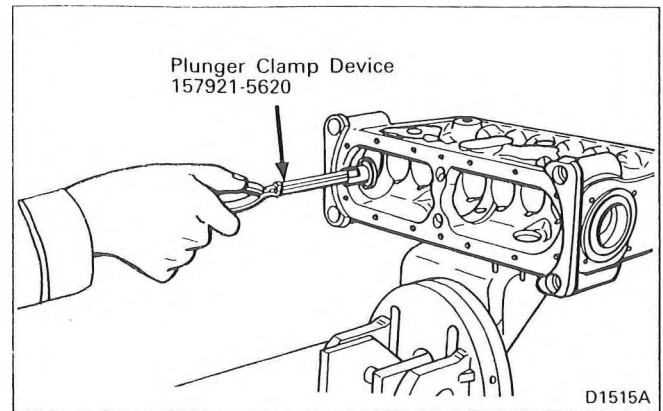
(k) Remove Tappet Mounting Device (special tool), install a wire in the hole of the lower spring seat, pull it together with the plunger until the lower spring seat can be removed, and remove only the lower spring seat.



(l) Remove the plunger, using Plunger Insert (special tool).

NOTE:

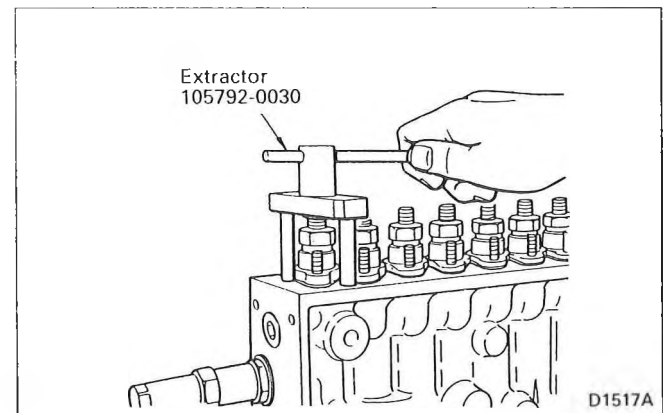
Put the removed plungers orderly in a tray containing clean gas oil.



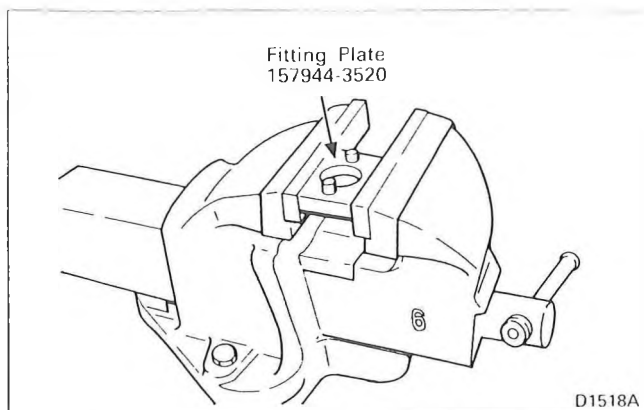
(m) Remove the upper spring seat and control sleeve. The control sleeve can be easily removed by use of Plunger Clamp Device (special tool).

NOTE:

The control sleeve cannot be removed unless the ball mounted on the flange of the control sleeve and the tappet guide groove in the pump housing are in alignment.

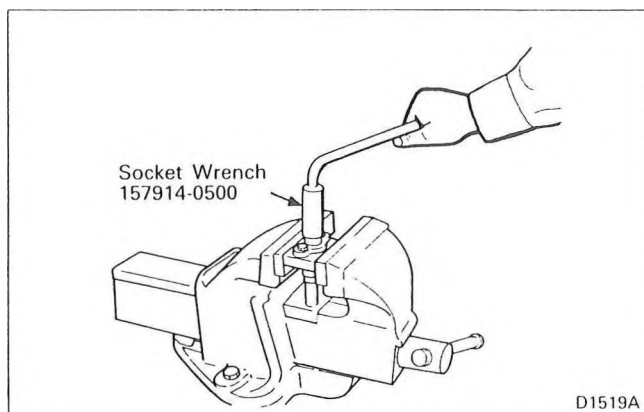


(n) Mount Extractor (special tool) to the delivery holder and remove the plunger block assembly.

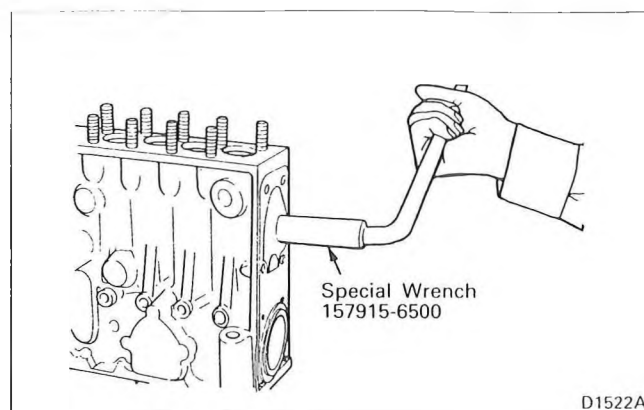


(o) Disassemble the plunger block assembly by the following procedure.

a) Mount Fitting Plate (special tool) in the vice.



(p) Secure the plunger block assembly to the Fitting Plate (special tool) and loosen the delivery valve holder with Socket Wrench (special tool).



(q) Remove the governor side screw bushing with special Wrench (special tool) and remove the pin and bushing.

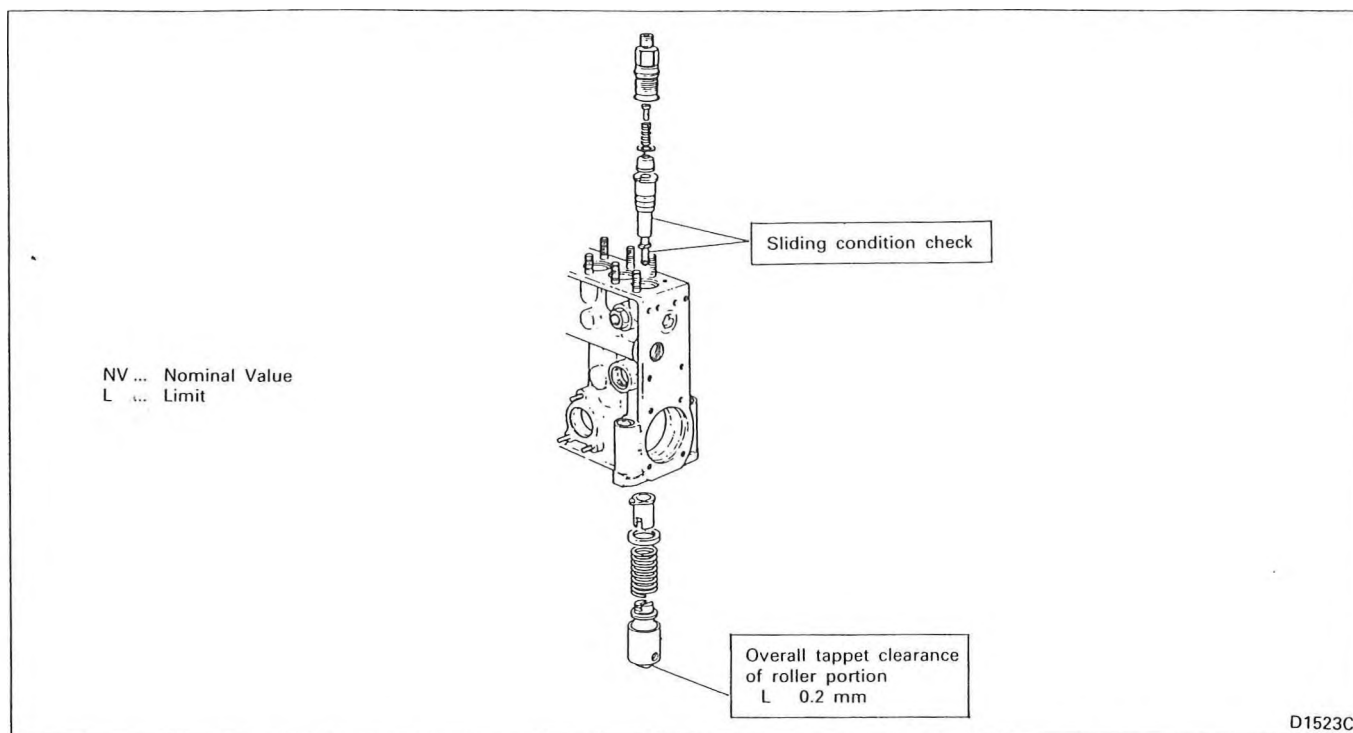
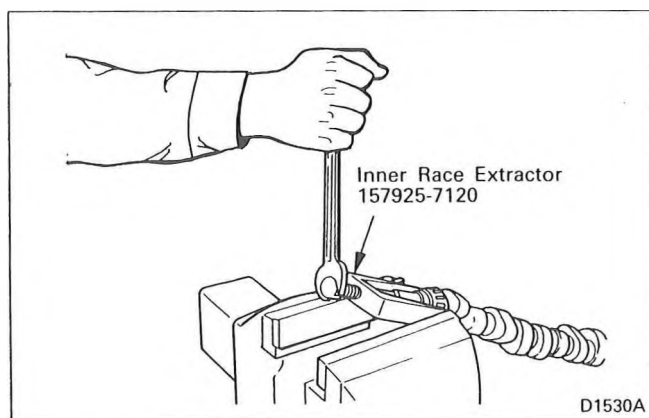
Then remove the control rod and bushing from the timer side.

NOTE:

1. Arrange all removed parts orderly by cylinders.
2. Be sure not to change the combination of the paired plunger barrel and plunger and that of delivery valve and delivery valve seat.

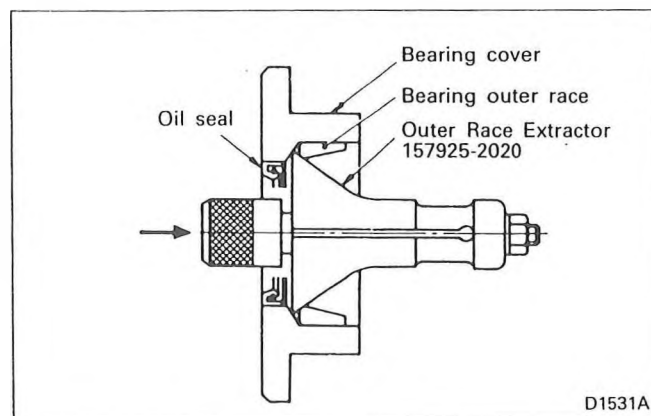
(2) Inspection and Correction

The inspection procedure is the same as that for the AD type except the following.

**Replacement of taper roller bearing****Inner race**

Remove inner race by use of Inner Race Extractor (special tool).

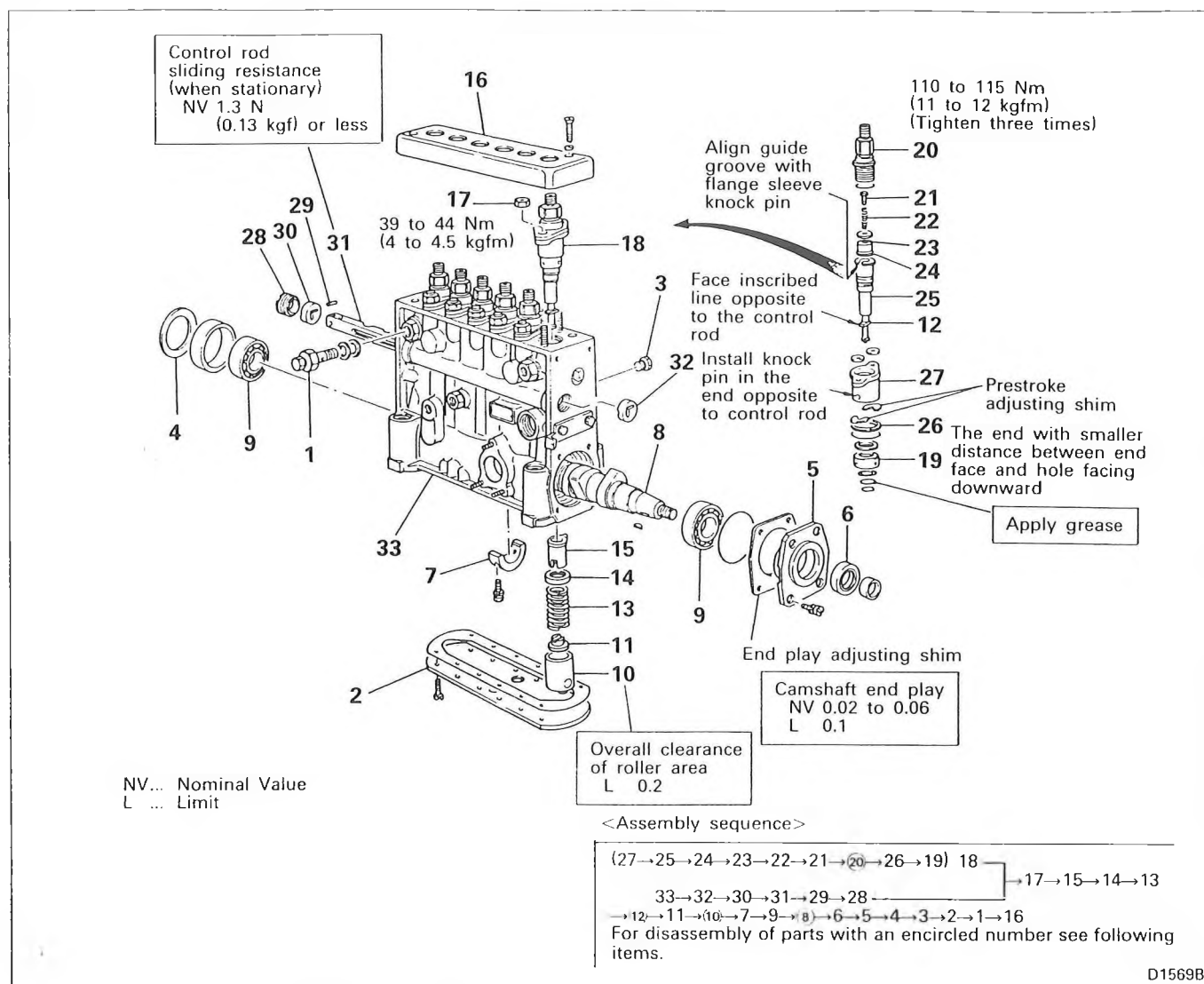
To install, use press.

Outer race

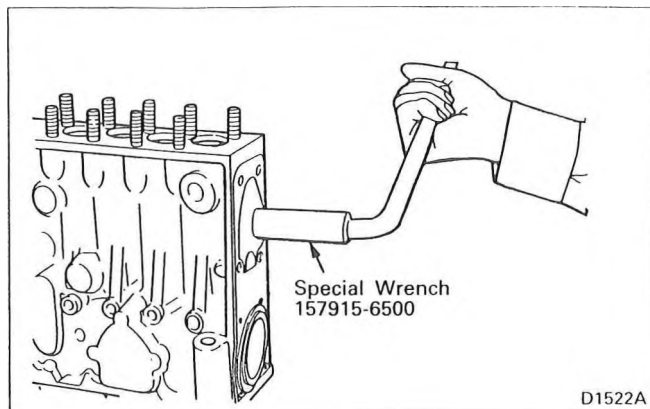
Remove the bearing cover side outer race by use of Outer Race Extractor (special tool).

To install, install a new oil seal and then install the outer race.

(3) Reassembly

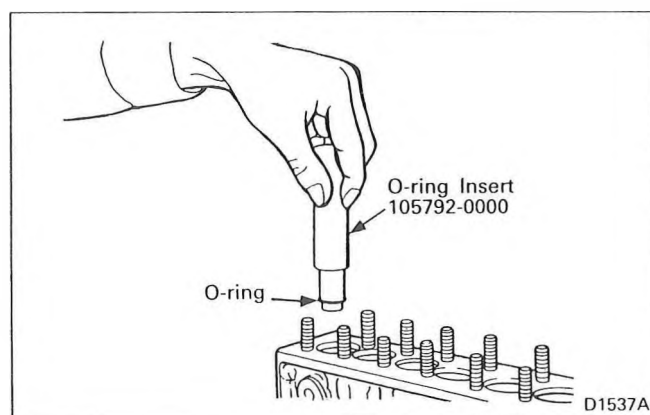


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(a) Mount the pump housing in Universal Vice (special tool).

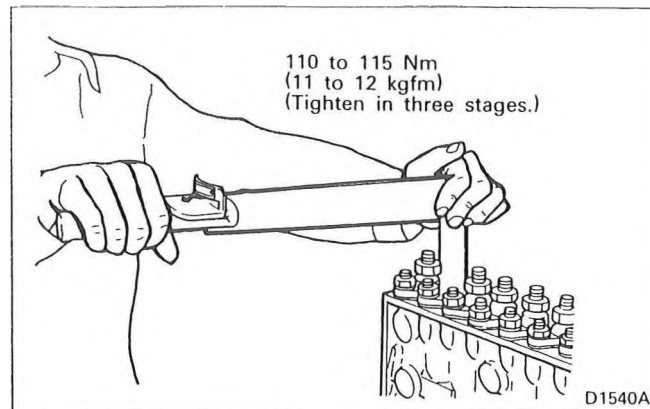
Then install bushings and control rod, pin and screw bushing with Special Wrench (special tool). Check to see that the control rod lightly operates.



(b) Install the O-ring on the upper side of the plunger barrel, and insert the lower side O-ring into the pump housing with O-ring Insert (special tool).

NOTE:

Make sure that the lower side O-ring is not set on the plunger barrel and slid along the wall surface of pump housing.

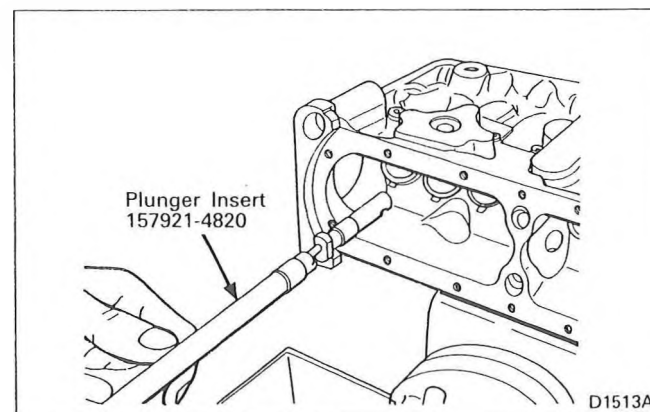


(c) Using Socket Wrench (special tool), tighten the delivery valve holder to the specified torque (tighten in three stages).

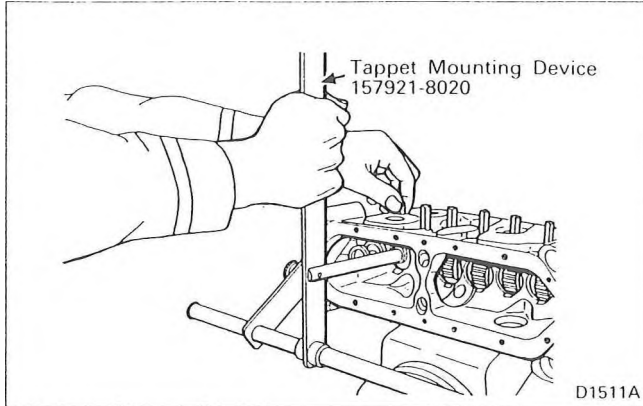
NOTE:

If the tightening torque is smaller than the specified torque, oil leakage or damage to the related parts could result.

If the tightening torque is excessive, unsmooth plunger movement or damage to the related parts could result.



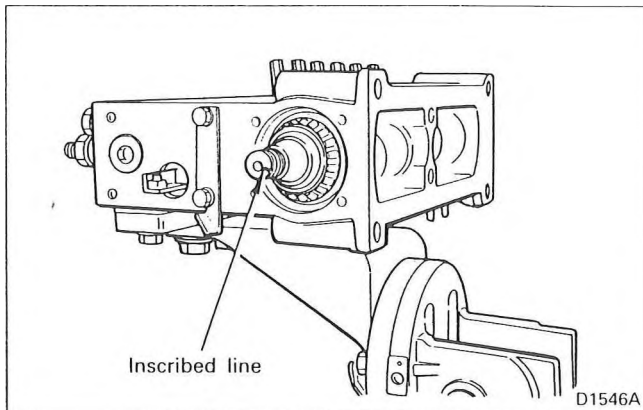
(d) Mount the plunger to Plunger Insert (special tool) and insert it into the plunger barrel.



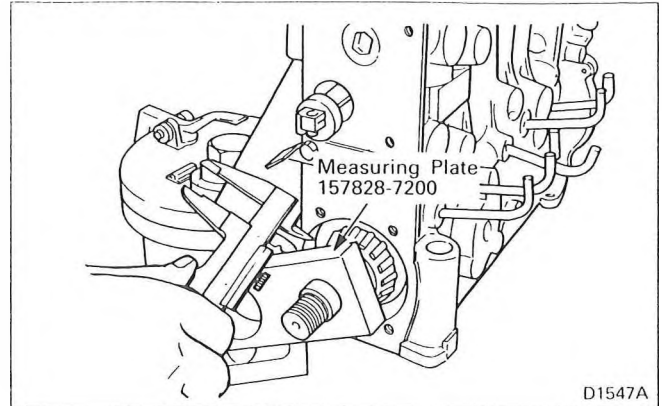
(e) Mount Tappet Mounting Device (special tool) to the pump housing.

Then install the tappet by operating the Tappet Mounting Device.

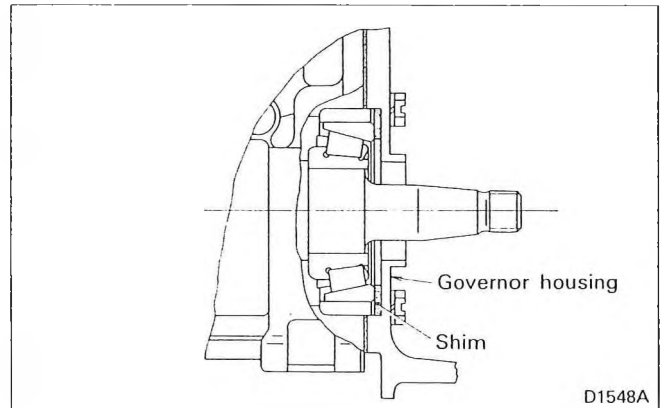
At this time, compress the plunger spring and insert the mitt portion of the plunger into the guide groove in the control sleeve, and insert Tappet Holder (special tool) into the screw plug hole. The operation of inserting the mitt portion of the plunger into the guide groove of the control sleeve can be easily performed by inserting the mitt portion, while moving the control rod to right and left.



(f) Insert the camshaft from the timer side. When the camshaft is installed, face the inscribed line of the end of the camshaft toward the timer side.

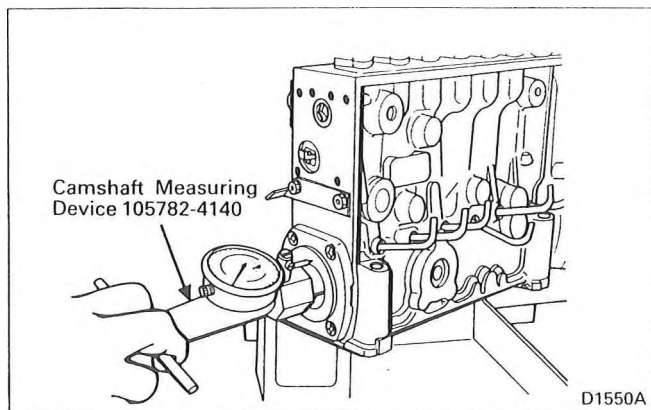


(g) Install the governor housing. At this time, perform the following operation. Mount Measuring Plate (special tool) to the timer side taper portion of the camshaft, and install and position the governor side taper roller bearing outer race in the ring so that the dimension from the end of the pump housing to the end of the Measuring Plate will be 13.85 ± 0.5 mm.

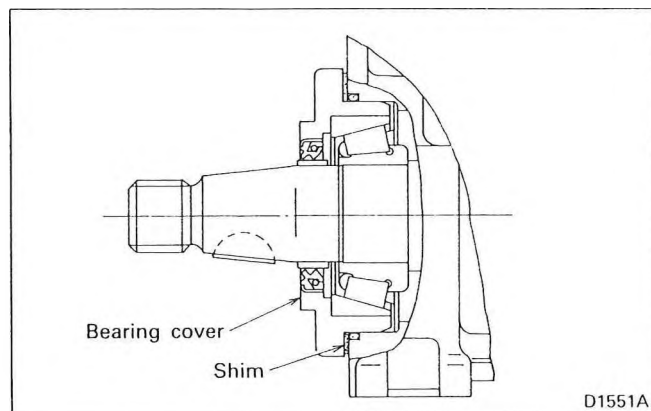


Installation of the taper roller bearing outer race will produce a clearance between the governor housing and taper roller bearing outer race. Change shims to eliminate the clearance.

Shim thickness: 0.6, 1.2, 1.5, 1.8, 2.0 mm

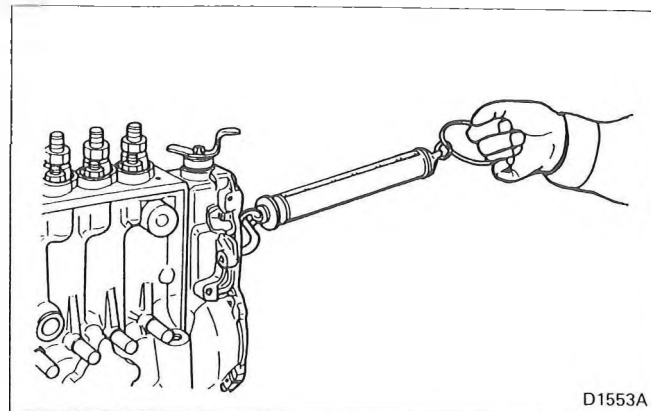


(h) Measure the camshaft end play.
Install Camshaft Measuring Device (special tool) to the timer side of the camshaft to measure the end play.



If the camshaft end play is out of the nominal value, adjust by changing shims between the bearing cover and pump housing.

Shim thickness: 0.10, 0.12, 0.14, 0.16, 0.18, 0.30, 0.50 mm



(i) Install a spring balance to the control rod and check to see that the control rod slides smoothly over the entire stroke without exceeding the standard sliding resistance value.

Remove the Tappet Pin (special tool) before checking.

(j) Install the following parts.

Governor (Refer to 5.2.1 or 5.2.2.)

Feed pump

Automatic timer (Refer to 5.4.2.)

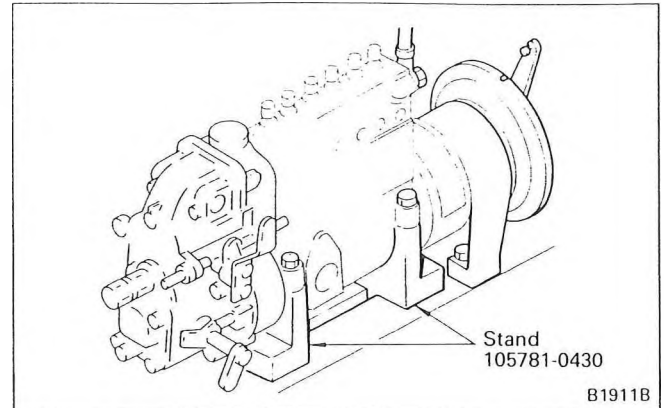
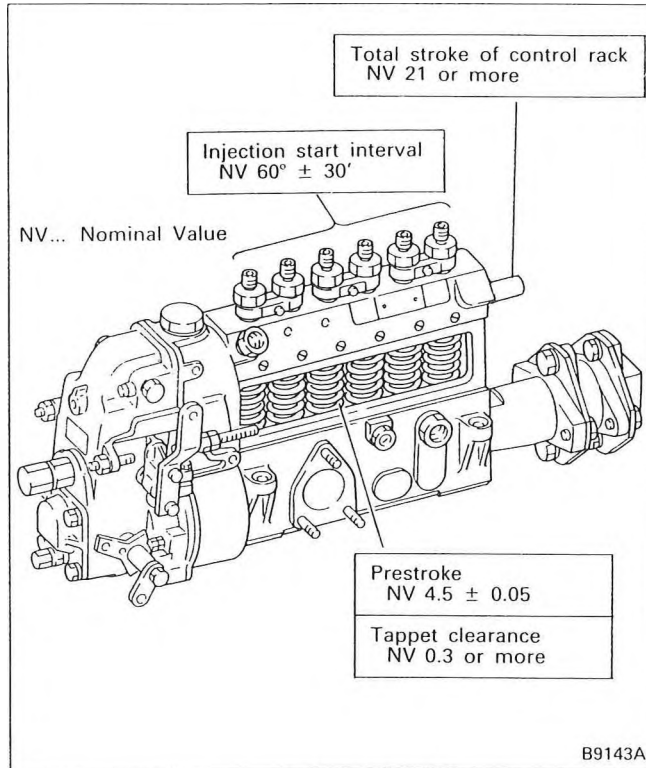
Coupling

(k) After reassembly has been completed, adjust the injection pump.

5.1.4 Adjustment after Reassembly

For fuel injection rate adjusting standard, see Service Information published separately.

(1) AD Type Injection Pump



(a) Install the pump on the injection pump tester Fixing Stand (special tool) and secure it.

NOTE:

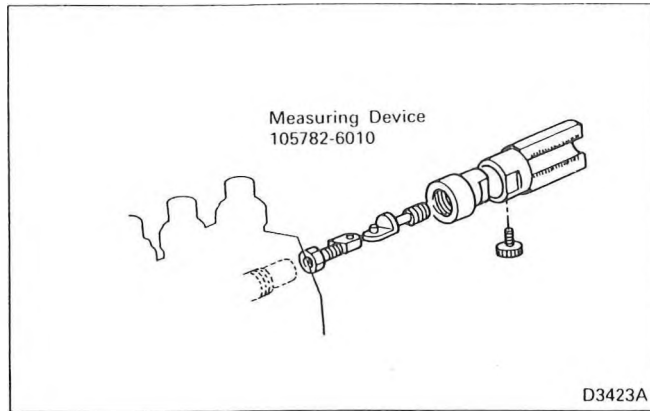
Make sure that the center of coupling is aligned with that of injection pump so that the coupling and injection pump turn smoothly.

NOTE:

1. Supply oil to the injection pump cam chamber.
2. Adjust the injection amount after adjusting the governor.

Injection sequence

1 – 5 – 3 – 6 – 2 – 4



(b) Setting position 0 of control rack

Mount Measuring Device (special tool) to the injection pump.

<With RSV governor>

- 1) Keep the pump running at 750 rpm.
- 2) Loosen the stopper bolt and pull the adjusting lever toward the non-injecting direction.
- 3) Press the end of the measuring device all the way toward the governor and adjust the position of point "0" on the scale of the measuring device.

<With RFD governor>

- 1) Fix the load control lever at the idling position.
- 2) Let the pump run at 500 to 600 rpm and temporarily fix the speed control lever so that the governor will begin to provide control at the speed.
- 3) Press the end of the measuring device all the way toward the governor and adjust the position of point "0" on the scale of the measuring device.

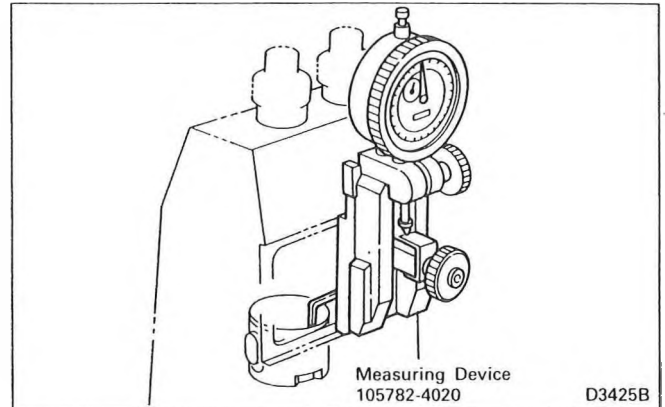
NOTE:

If the injection pump is not running at the speed mentioned above, position 0 won't be obtained even if the control rack is pressed with a strong pressure, and there will be danger of damage to the link mechanism of the pump.

(c) Checking stroke of control rack

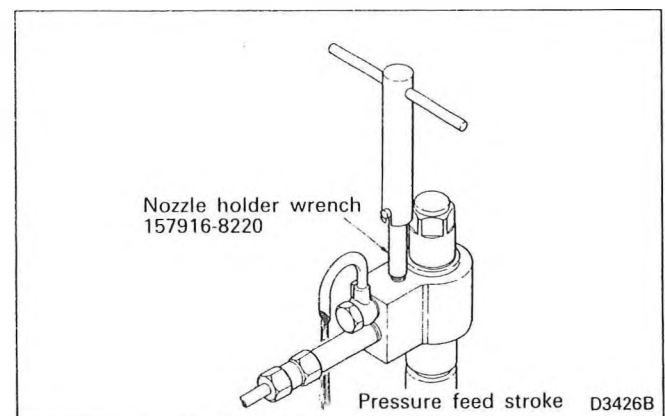
Move the control rack to confirm that the total stroke is over the specified value.

In addition, check to see that the start spring and idling spring smoothly move the control rack in the maximum injection direction.



(d) Adjusting prestroke

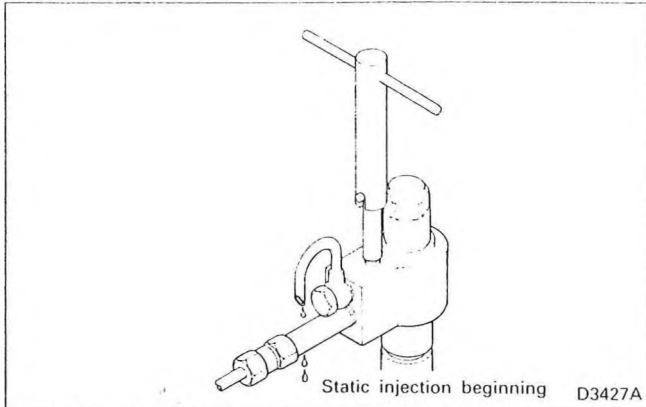
- 1) Pull the control rack out to the total injection position and secure it there.
- 2) Place the plunger of the No. 1 cylinder in the bottom dead center position and mount Measuring Device (special tool). Set the contactor on the tappet.
- 3) Couple the injection pump and tester nozzle.



- 4) Send a high pressure fuel into the injection pump to let the fuel flow out from the overflow pipe of the nozzle holder.

NOTE:

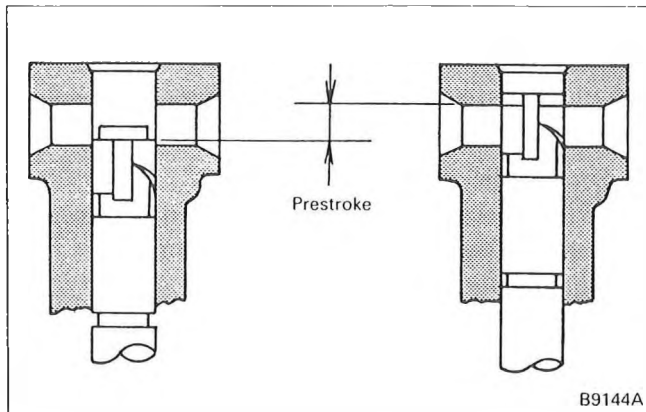
The pressure of the fuel forced into the injection pump must be higher than the delivery valve opening pressure.



5) Slowly turn the camshaft until the fuel ceases to flow from the overflow pipe of the nozzle holder (until static injection begins).

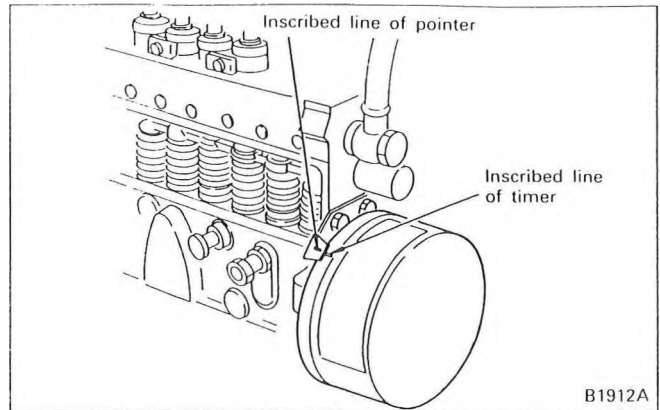
NOTE:

Make measurement by turning the camshaft clockwise.



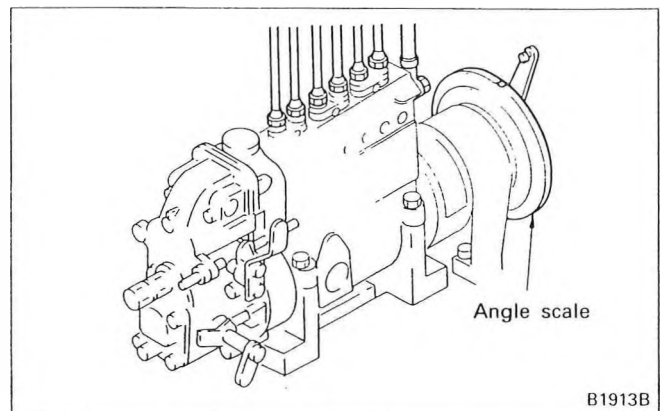
6) Read the prestroke from the bottom dead center to the point where the fuel ceases to flow (static injection begins), using a dial gauge.

If the prestroke is out of specification, adjust by shims. [Refer to (e).]



7) After adjustment of the prestroke, check to see that, at the static injection beginning, the inscribed lines of the pointer and timer are in alignment.

If they are out of alignment, restamp a line on the automatic timer.



(e) Adjustment of injection start interval

1) Couple tester nozzles to all the cylinders of the injection pump as in the case of adjustment of the prestroke.

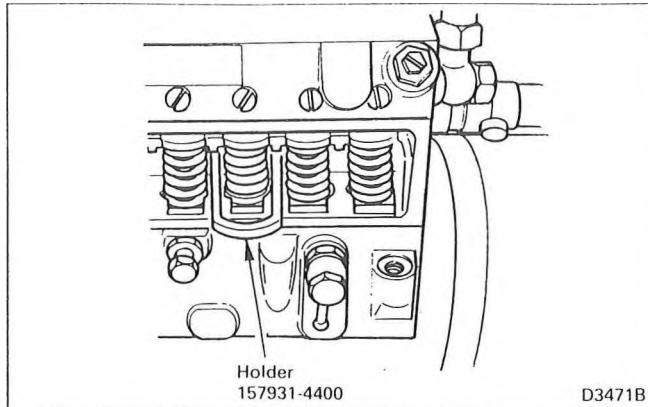
2) Force fuel into the injection pump to let the fuel flow out from the tester nozzle.

3) On the basis of the static injection beginning of the No. 1 cylinder, measure the interval when the fuel ceases to flow out according to the injection sequence, using an angle scale.

NOTE:

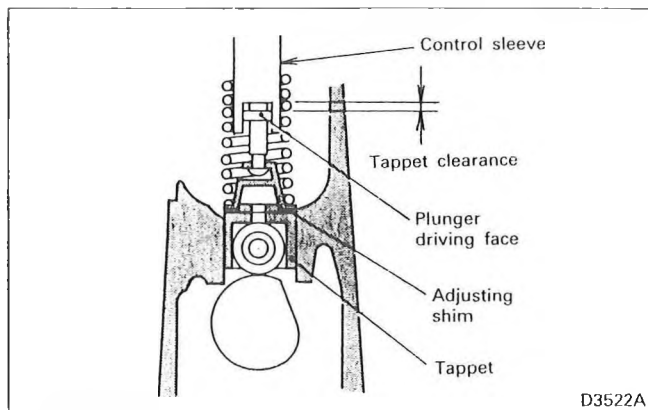
Injection sequence

1 – 5 – 3 – 6 – 2 – 4



4) If the prestroke and injection start interval are out of specification, insert a Holder (special tool) between the tappet and lower seat and then adjust by changing the shim thickness.

Shim thickness: 0.2 to 1.60 mm, 29 types in 0.05 mm increment



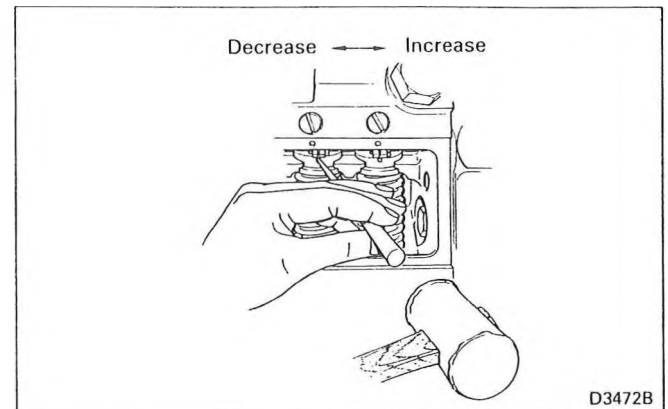
(f) Adjustment of tappet clearance

- 1) Place the tappet in the top dead center position.
- 2) Raise the tappet with a screwdriver, etc. until the driving face of the plunger touches the bottom end of the plunger barrel.

3) Measure the stroke of the tappet from the top dead center to the point where the plunger barrel is touched.

4) If the tappet clearance is less than the nominal value, adjust within the extent permitted by the injection start interval.

If correction within the permitted extent is impossible, set the prestroke of the No. 1 cylinder to the maximum of the set value and readjust.



(g) Adjustment of fuel injection amount

To check whether the injection amount is up to specification at the specified rack position and speed, measure with a measuring cylinder.

If the injection amount is out of specification, adjust by the following procedures.

- 1) Loosen the screw of the pinion.
- 2) While blocking movement of the control rack, turn the control sleeve with an adjusting rod.
- 3) Tighten the screw of the pinion.

NOTE:

1. A maladjusted injection amount will produce marked effects on engine performance. Make sure the injection amount is carefully adjusted.

2. The injection amount varies on different nozzles and pipes. Make sure that the measuring conditions are observed.

3. Injection amount uneven ratio

$$\text{Uneven ratio (+)} = \frac{\text{Maximum injection amount in each cylinder} - \text{Average injection amount of each cylinder}}{\text{Average injection amount of each cylinder}} \times 100 (\%)$$

$$\text{Uneven ratio (-)} = \frac{\text{Minimum injection amount in each cylinder} - \text{Average injection amount of each cylinder}}{\text{Average injection amount of each cylinder}} \times 100 (\%)$$

(h) Adaptation to engine

After the governor has been adjusted, measure the fuel injection rate adaptable to the engine.

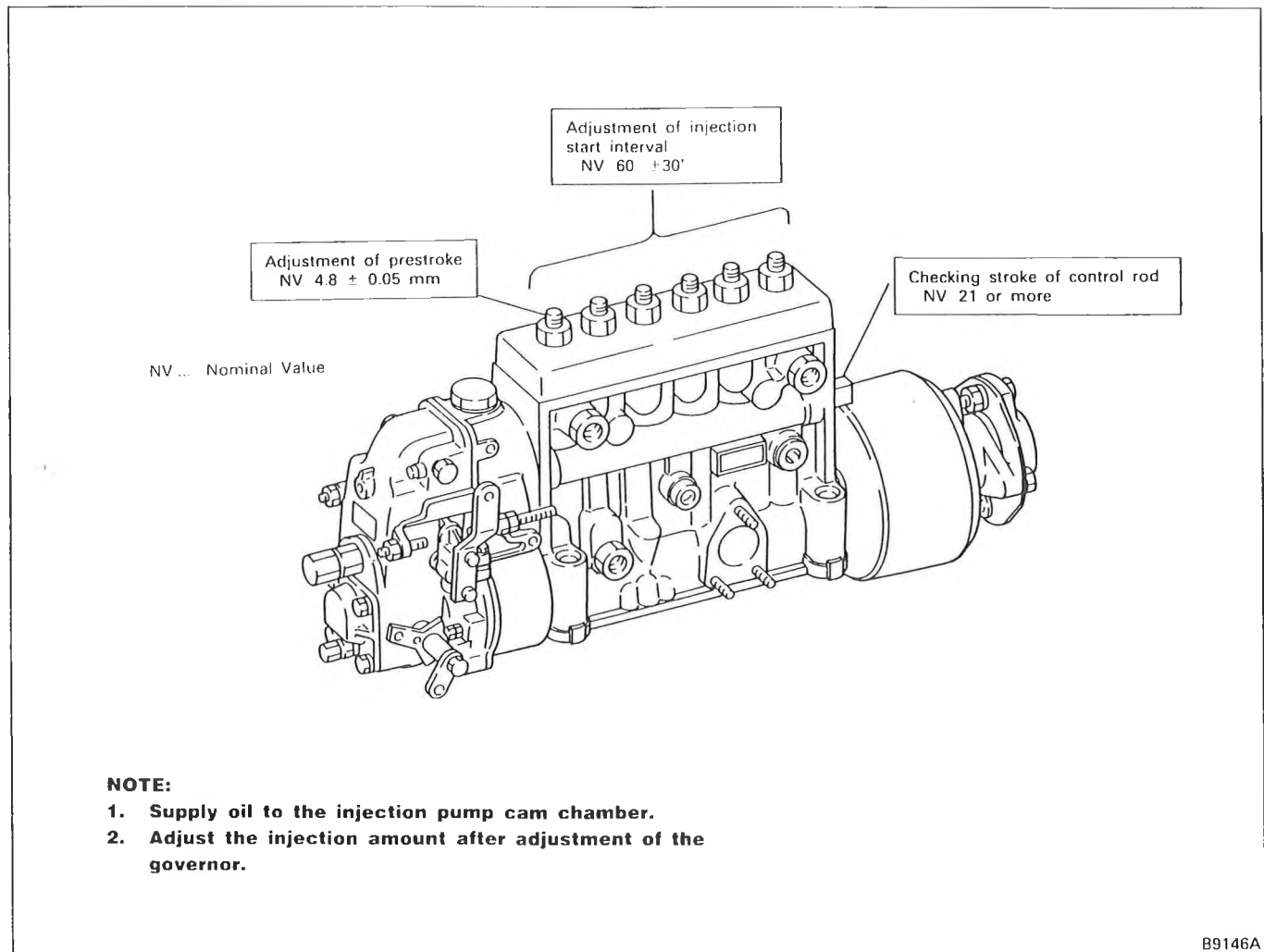
(i) Inspection of fuel and oil leaks

- Fuel leaks from delivery valve attaching position and other parts
- Oil leaks from oil seals and other parts

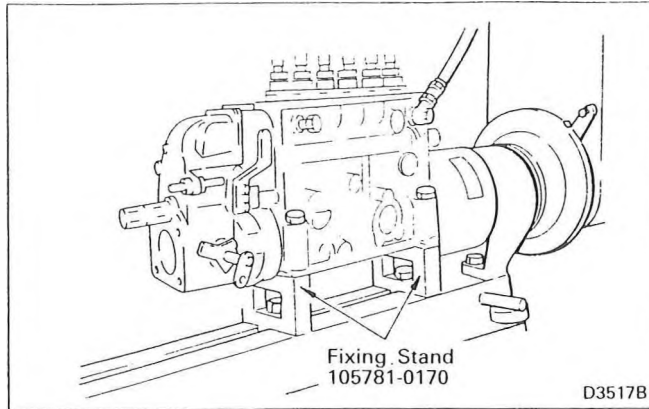
(j) Inspection of parts

Check parts for unusual noise and bearings for excessive heat.

(2) P Type Injection Pump



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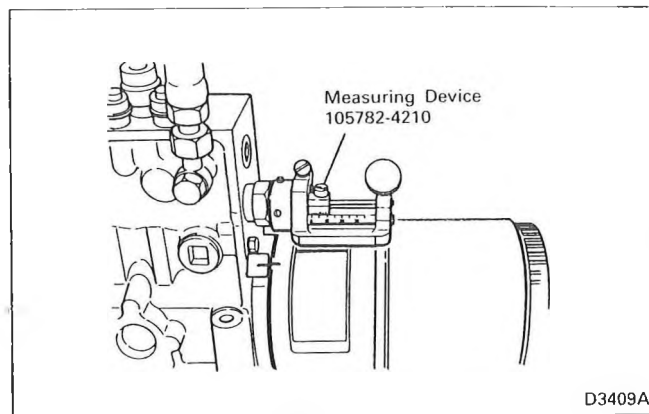


(a) Mount two Fixing Stands (special tools) to an injection pump tester.

Secure the injection pump firmly to the special tools.

NOTE:

To make sure that the coupling and injection pump rotate smoothly, align the centers of the coupling and injection pump accurately.



(b) Setting position "0" of control rod

Mount Measuring Device (special tool) to the injection pump.

<With RSV governor>

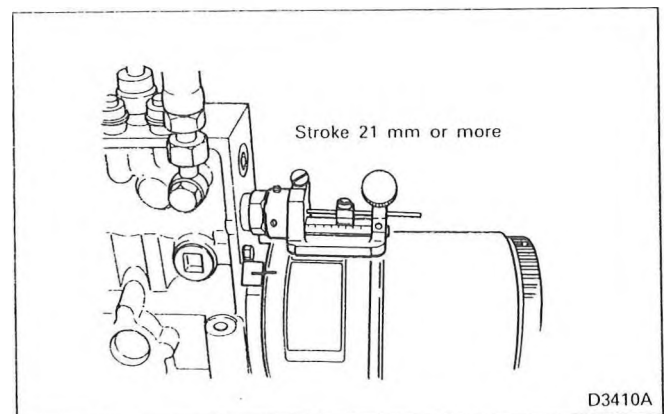
- 1) Keep the pump running at 750 rpm.
- 2) Loosen the stopper bolt and pull the adjusting lever toward the non-injecting direction.
- 3) Press the end of the measuring device all the way toward the governor and adjust the position of point "0" on the scale of the measuring device.

<With RFD governor>

- 1) Fix the load control lever at the idling position.
- 2) Let the pump run at 500 to 600 rpm and temporarily fix the speed control lever so that the governor will begin to provide control at the speed.
- 3) Press the end of the measuring device all the way toward the governor and adjust the position of point "0" on the scale of the measuring device.

NOTE:

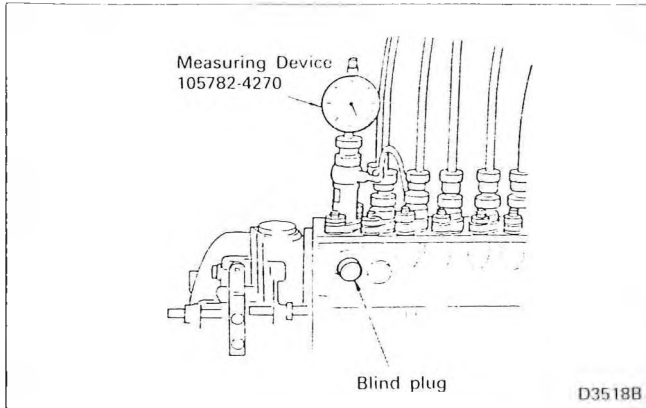
1. If the position "0" of the control rod is set by operating the load control lever, there is danger of damage to the link mechanism and other parts of the governor. Do not set the position "0" by operating the load control lever.
2. When the position "0" is set, remove the damper spring beforehand.



(c) Checking stroke of control rod

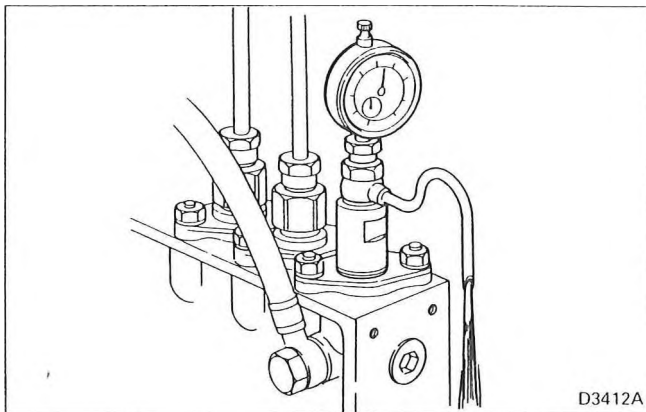
Move the control rod to confirm that the total stroke is more than the specified value.

Check to see that the control rod is moved smoothly in the maximum injection amount direction by the start spring and idling spring.

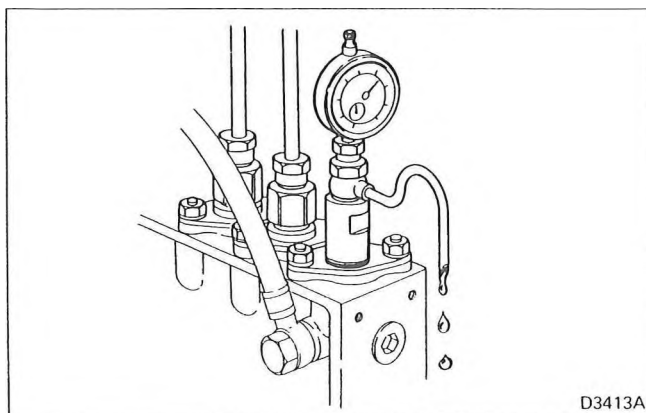


(d) Adjustment of prestroke

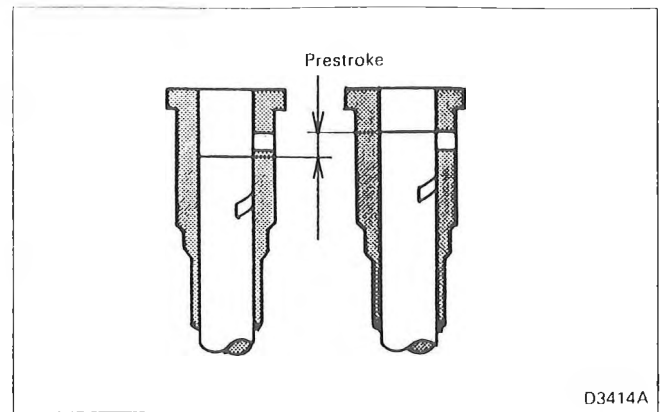
- 1) Remove the governor side No. 1 cylinder delivery valve holder; spring, delivery valve and gasket.
- 2) Mount Measuring Device (special tool) to the flange sleeve.
- 3) Turn the flywheel of the pump tester to detect the bottom dead center of the plunger with a dial gauge.



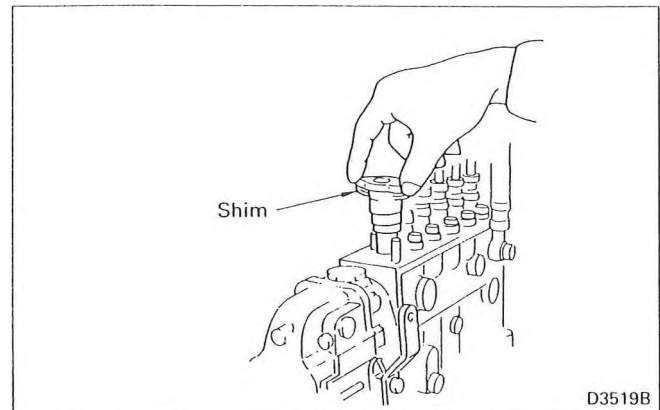
- 4) With the control rod set in the full position, force a high pressure fuel into the injection pump to let the fuel flow out from the overflow pipe.



- 5) Slowly turn the flywheel of the pump tester clockwise until the fuel ceases to flow out from the overflow pipe (until static injection begins).



- 6) Measure the prestroke of the plunger from the bottom dead center to the point where the fuel ceases to flow out (static injection beginning).



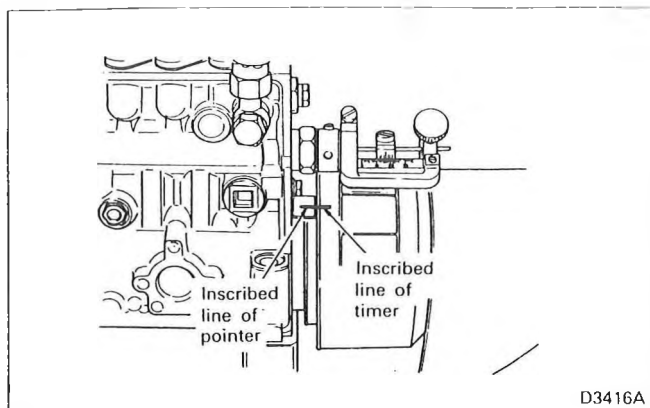
- 7) If the prestroke is out of specification, adjust by changing the shim thickness between the flange sleeve and pump housing.

Shim thickness: 0.50 to 1.975 mm, 59 types in 0.025 increment

If the prestroke is smaller, increase the thickness. If the prestroke is larger, reduce the thickness.

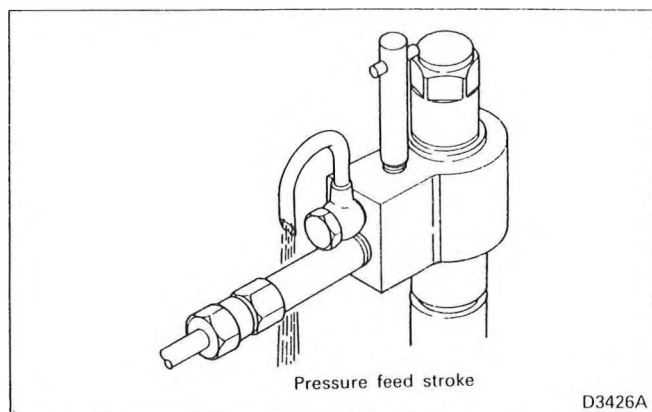
NOTE:

To install the plunger block, apply grease to each O-ring. After inserting the O-ring in the lower part of the plunger barrel into the pump housing in advance, apply grease to the skirt portion of the plunger barrel and then install the plunger barrel.



8) After adjustment of the prestroke, check to see that the inscribed line of the timer and that of the pointer are in alignment.

If they are out of alignment, inscribe another line on the timer. When the automatic timer was replaced with a new one, proceed in the same way.

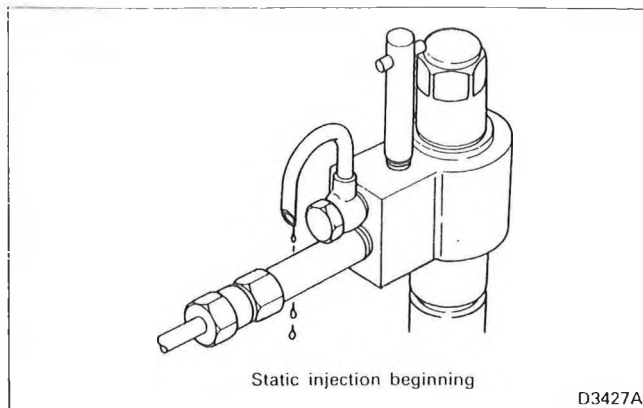


(e) Adjustment of injection start interval

- 1) Set the static injection beginning position of the No. 1 cylinder on the pump tester scale plate.
- 2) Force a high pressure fuel into the injection pump to let the fuel flow out from the overflow pipe of the tester nozzle.

NOTE:

The pressure of the fuel forced into the injection pump must be higher than the delivery valve opening pressure.



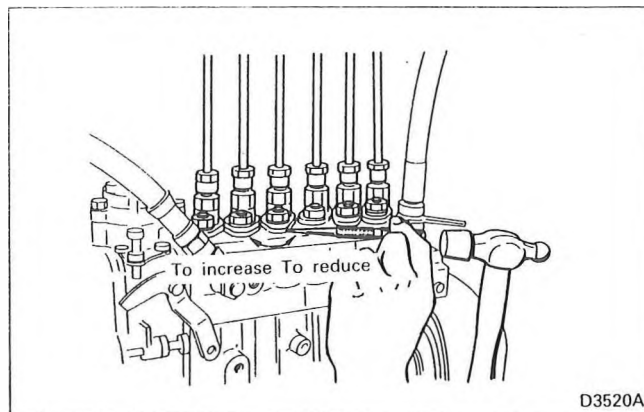
3) Slowly turn the flywheel of the pump tester clockwise until the fuel ceases to flow out from the tester nozzle.

Read the rotation angles (injection start intervals) where the fuel ceases to flow, according to the injection sequence.

4) If the injection start interval is out of the standard angle, adjust by the same procedures as for prestroke adjustment.

NOTE:

Injection sequence: 1 – 5 – 3 – 6 – 2 – 4



(f) Adjustment of fuel injection amount

At the specified rack position and speed, measure the injection amount and uneven ratio with a measuring cylinder to check whether they are up to specification. If the injection amount is out of specification, adjust by the following procedures.

- 1) Loosen the two nuts tightening the flange sleeve.
 - 2) Turn the flange sleeve by lightly striking.
 - 3) Tighten the nuts to the specified torque to secure the flange sleeve. [39 to 44 Nm (4 to 4.5 kgfm)]
- Perform the operations repeatedly.

NOTE:

1. A maladjusted injection amount will produce considerable effects on engine performance. Make sure that the injection amount is carefully adjusted.
2. Since the injection amount varies on different nozzles and pipes, make sure that the measuring conditions are observed.
3. Injection amount uneven ratio

Maximum injection amount in – Average injection amount of
each cylinder each cylinder

Uneven ratio (:) = $\frac{\text{Maximum injection amount in each cylinder}}{\text{Average injection amount of each cylinder}} \times 100 (\%)$

Average injection amount of
each cylinder

Minimum injection amount in – Average injection amount of
each cylinder each cylinder

Uneven ratio (-) = $\frac{\text{Minimum injection amount in each cylinder}}{\text{Average injection amount of each cylinder}} \times 100 (\%)$

(g) Adaptation to engine

After the governor has been adjusted, measure the fuel injection rate adaptable to the engine.

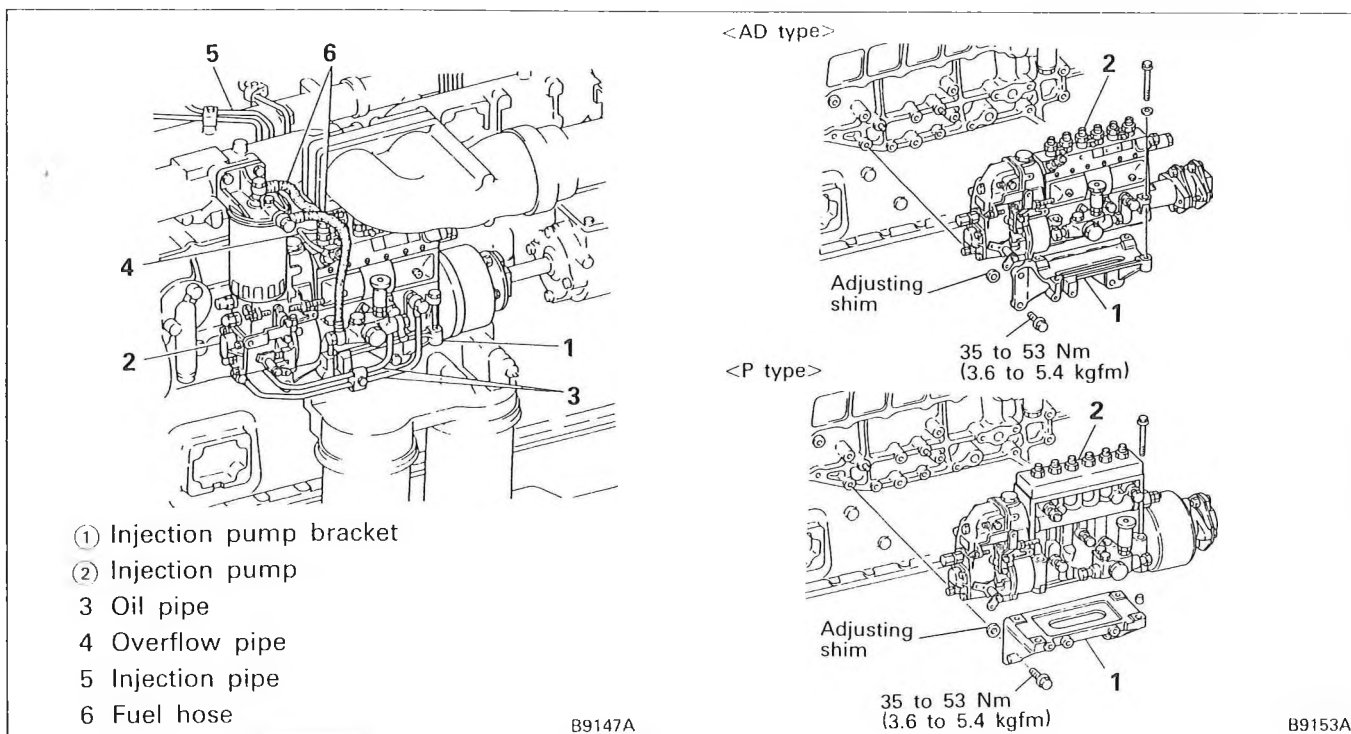
(h) Inspection of fuel and oil leaks

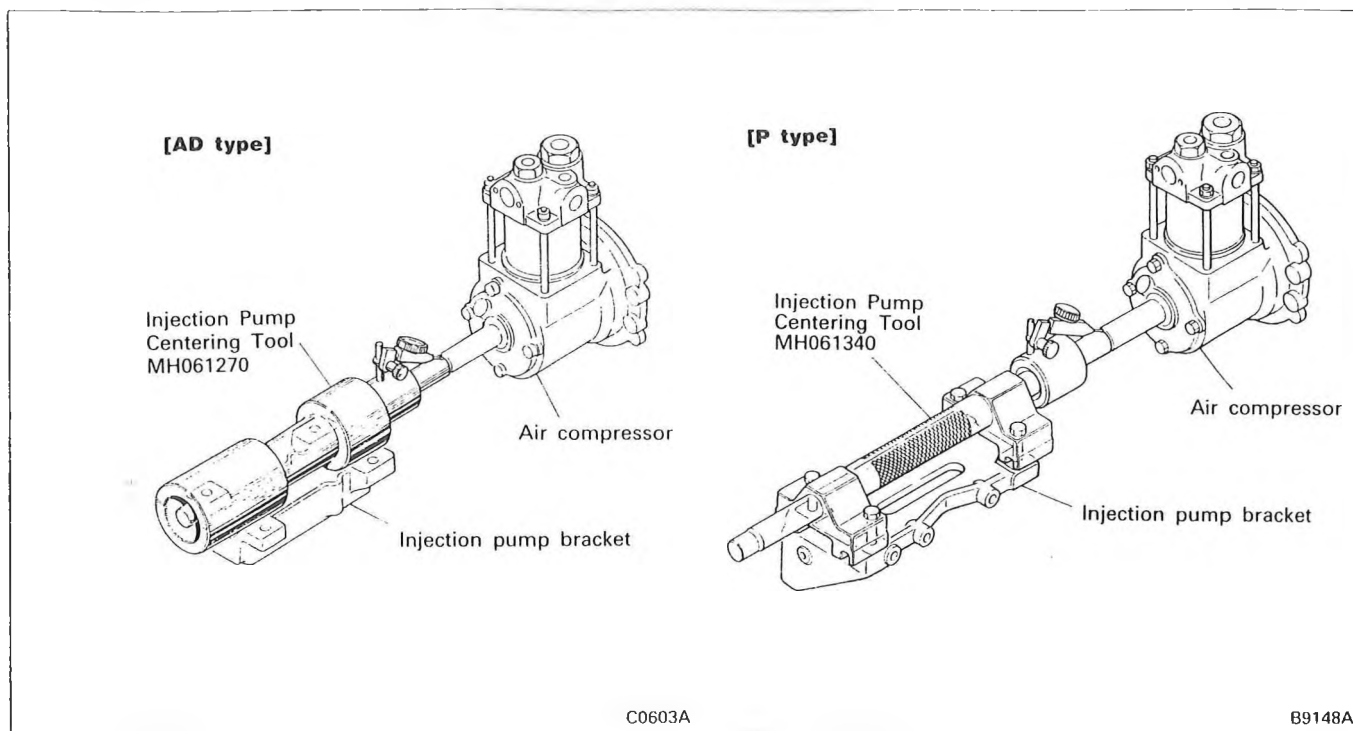
- Fuel leaks from delivery valve attaching position and other parts.
- Oil leaks from oil seals and other parts

(i) Inspection of parts

Check parts for unusual noise and bearings for excessive heat.

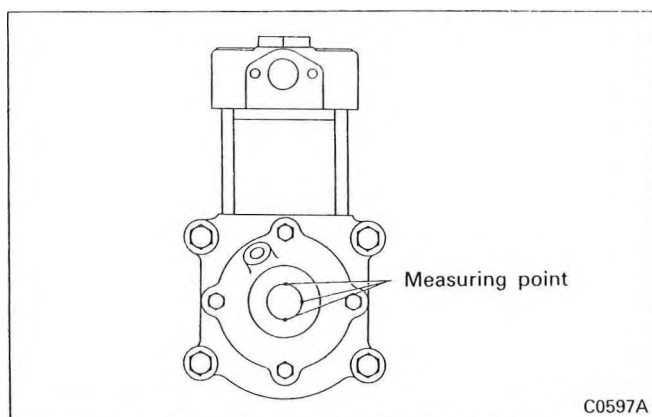
5.1.5 Installation

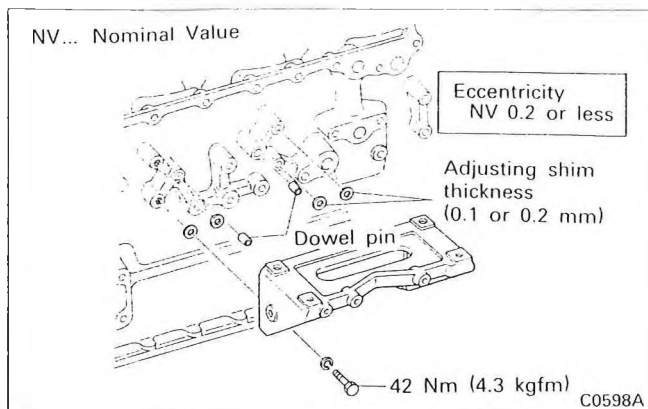


(1) Adjustment of Injection Pump Bracket

(a) Place Injection Pump Centering Tool (special tool) on the injection pump bracket, hold a dial indicator to the mandrel of the centering tool, and perform O-point adjustment.

(b) Slide the dial indicator of the centering tool toward the air compressor (or injection pump drive) and measure the positions of the compressor crankshaft (or injection pump drive shaft) shown in the illustration with the dial indicator.





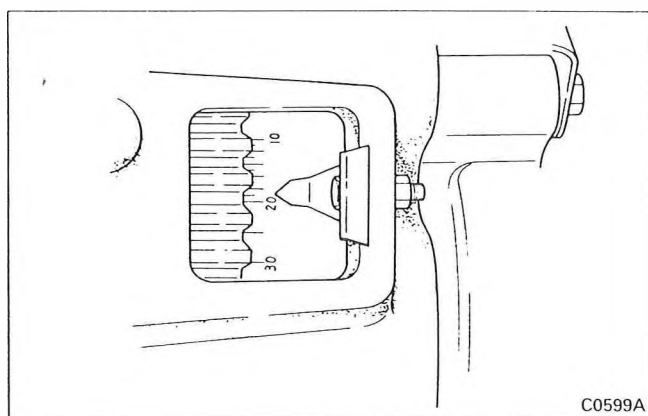
(c) If the eccentricity between the mandrel and air compressor crankshaft is in excess of the nominal dimension, adjust by adding or removing injection pump bracket shims.

Shim Inserting Condition

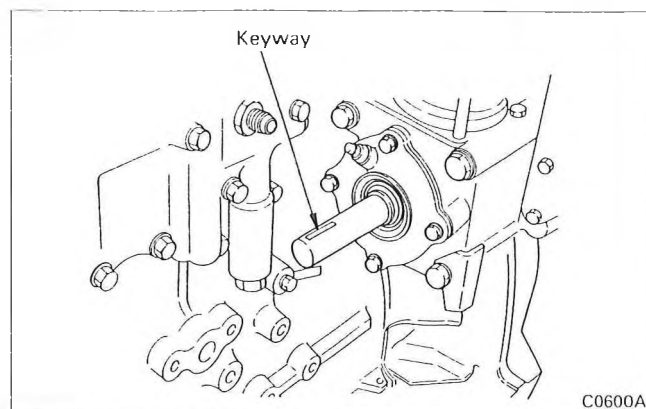
- The number of shims inserted into a single point must not exceed three.
- The front and rear shims must be equal in number.
- The difference in number between the top and bottom shims must not exceed one.

(d) After adjustment, tighten the tightening bolts to the specified torque before confirmation.

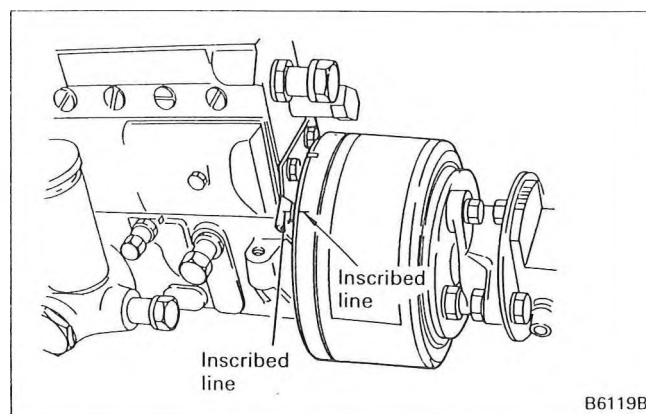
(2) Installation of Injection Pump



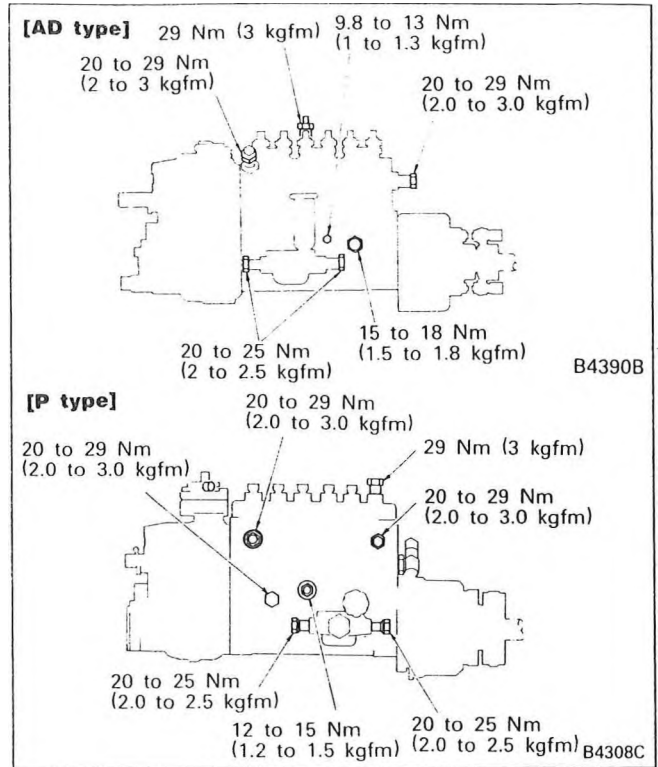
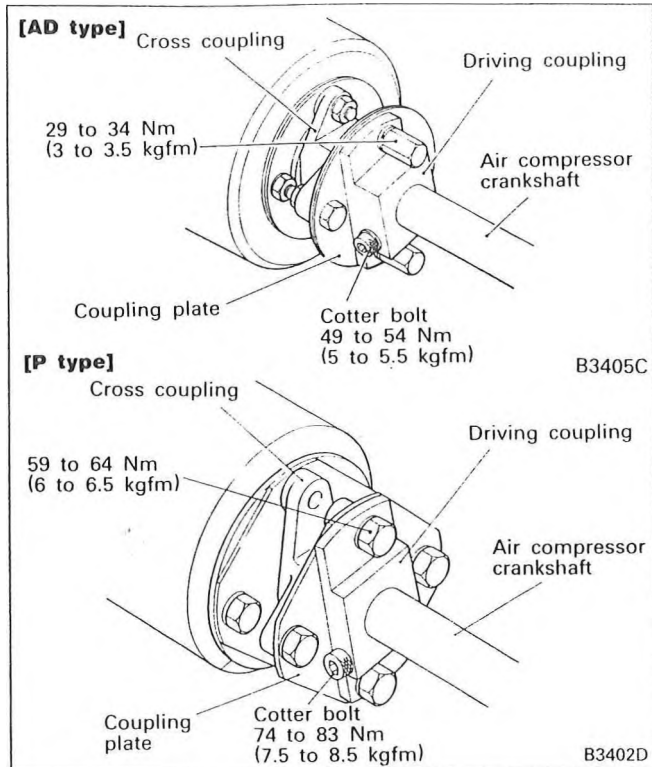
(a) Crank the engine to adjust the No. 1 cylinder to the fuel injection timing. For this purpose, align the angle scale inscribed on the outer periphery of the flywheel with the pointer of the inspection window of the flywheel housing.



(b) At this point, check to ensure that the keyway of the crankshaft of the air compressor (or injection pump drive) is in the uppermost position. If the keyway is not in the uppermost position, turn the engine crankshaft.



(c) Align the pointer of the injection pump and the inscribed mark of the auto timer. (On engines with no auto timer, align the inscribed mark on the pump bearing cover with that on the pump side coupling.)



(d) Install the driving coupling on the crankshaft of the air compressor, and put it a little toward the air compressor.

Install the injection pump on the injection pump bracket. Move the driving coupling toward the coupling plate and tighten it with the timing adjusting bolt.

Then tighten the cotter bolt to the specified torque to reduce the clearance between the driving coupling and coupling plate to less than 0.5 mm.

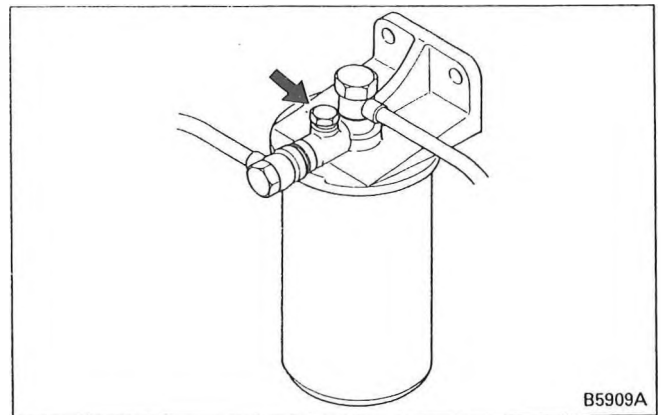
NOTE:

After the injection pump has been installed, be sure to check and adjust the fuel injection start timing. (Refer to 5.1.7.)

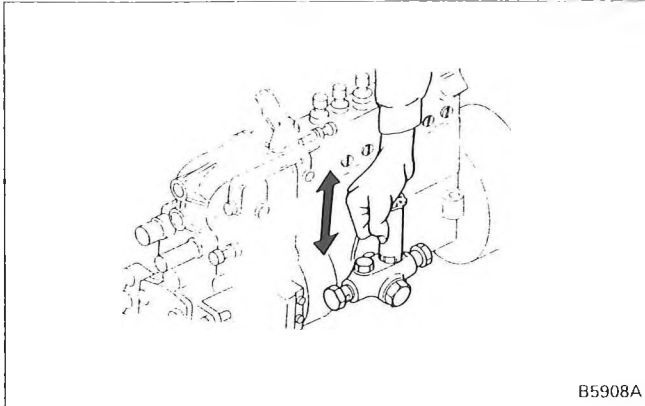
(e) Tighten each pipe to the specified torque.

5.1.6 Bleeding the Fuel System

Bleed the fuel system as described below.



- (1) Loosen the air plug of the fuel filter.
- (2) Turn the priming pump knob of the injection pump counterclockwise to let the knob float up.



- (3) Move the priming pump knob up and down by hand to force the fuel out until no air bubbles come out from the air plug.
- (4) After air bubbles have ceased to come out in the fuel, firmly tighten the air plug.
- (5) Move the priming pump knob several times up and down and turn down the knob, while pressing it down.

NOTE:

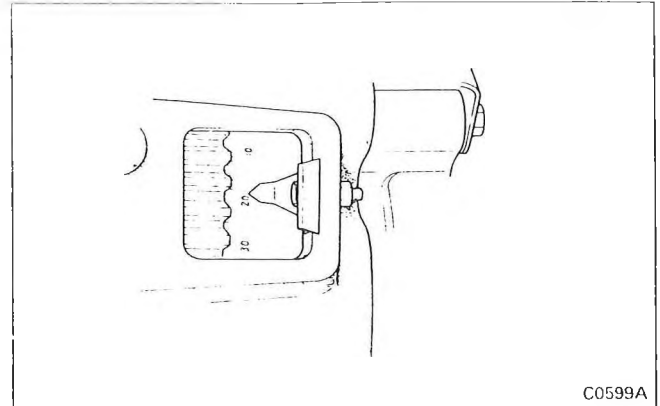
Make sure that fuel split around is thoroughly wiped away.

- (6) Operate the starter to exhaust the air from inside the injection pump and injection pipe.

NOTE:

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

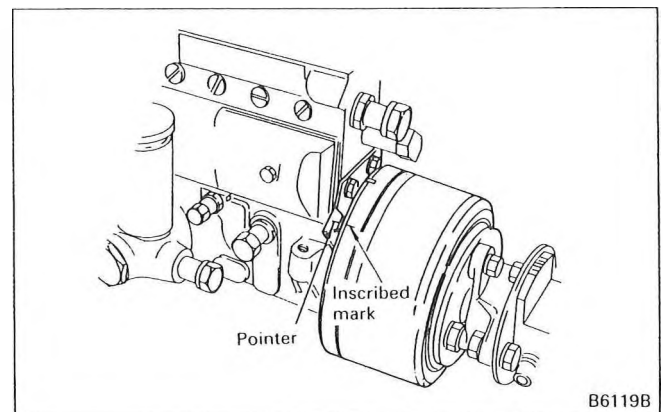
5.1.7 Inspection and Adjustment of Fuel Injection Start Timing



- (1) Crank the crankshaft more than 180° in normal direction to align the fuel injection start timing angle scale inscribed on the periphery of the flywheel with the pointer.

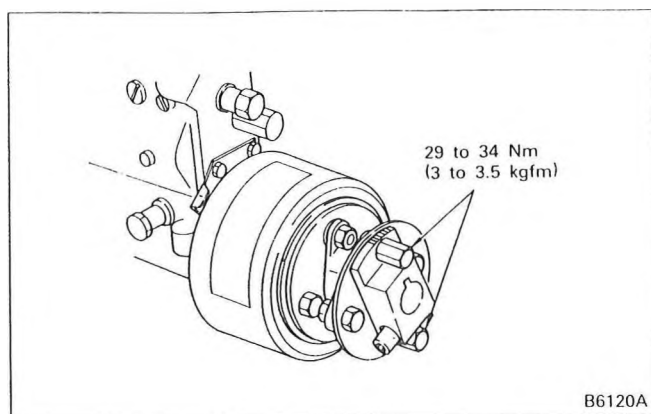
NOTE:

If the engine is reversed (by cranking or when it is stopped), the automatic timer will stay operated in advancing direction and will not readily return to normal even if it is made to resume normal operation by turning the engine in normal direction for a while. Make sure that the crankshaft is cranked more than 180° in normal direction by hand.

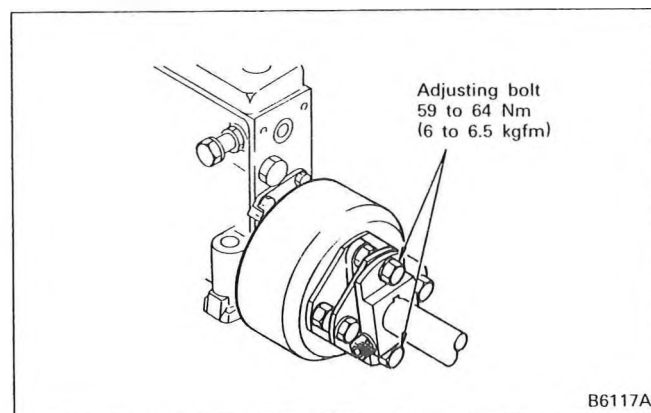


- (2) If, under the condition of Item (1), the pointer of the injection pump and the inscribed line of the automatic timer are in alignment, the injection start timing is correct.

[AD type injection pump]



[P type injection pump]



(3) If the fuel injection start timing is not correct, loosen the two timing adjusting bolts and adjust the timing by turning the automatic timer.

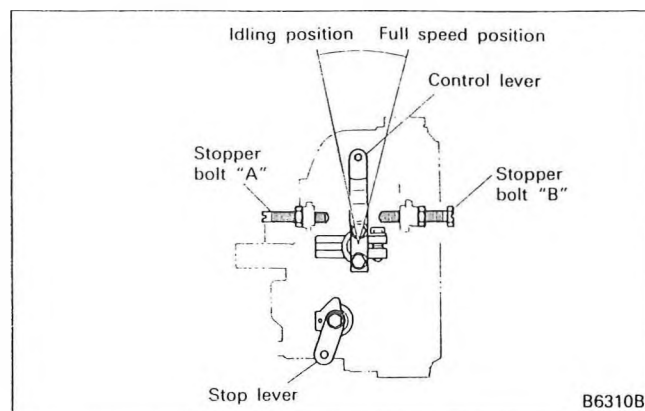
Tighten the adjusting bolts to the specified torque. Recheck the fuel injection start timing by the procedure described in Items (1) and (2).

NOTE:

Do not loosen any other parts than the adjusting bolts.

5.1.8 Inspection and Adjustment of No-load Minimum and Maximum Speeds

(1) RSV Type Governor



(a) Inspection and adjustment of idling

Run the engine at idle and check to ensure that the control lever touches the stopper bolt "A", and measure the engine speed at the time.

If the idling speed is not within the specified limits, adjust with the stopper bolt "A".

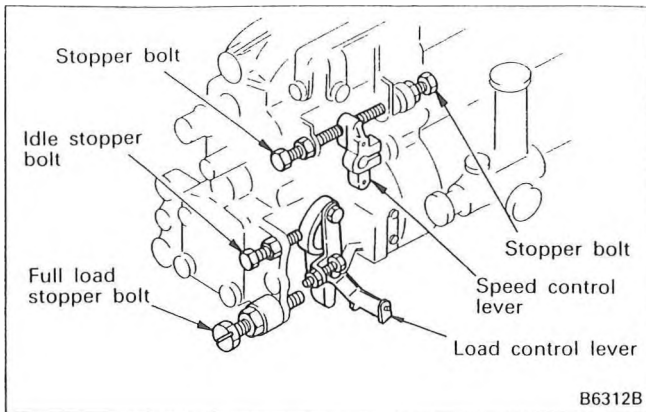
(b) Inspection and adjustment of no-load maximum speed

Push the control lever until it touches the stopper bolt "B". If the engine speed is out of the maximum speed limits, adjust with the stopper bolt "B".

NOTE:

After idling adjustment, quickly move the control lever from the full load position to the idling position to verify that the engine does not stall and no hunting occurs. If abnormal condition occurs, make adjustment as far as the specified idling limits allow. If adjustment is impossible, disassemble and inspect the injection pump.

(2) RFD Type Governor



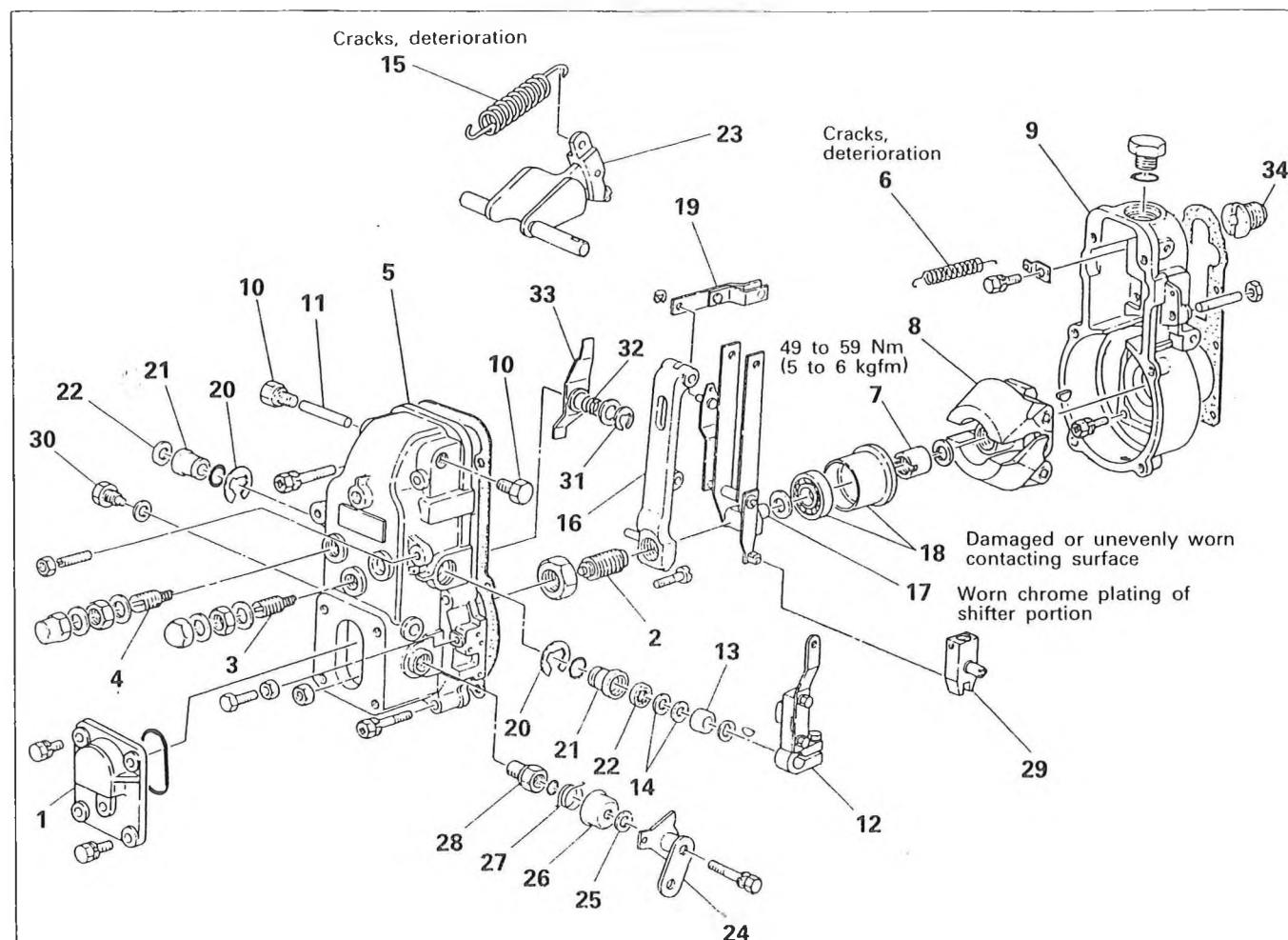
- Check to ensure that the load control lever is touching the idle stopper bolt.
- In the above condition (a), measure the idling speed to determine whether it is within the specified limits.
- If it is not within the specified limits, adjust with the idle stopper bolt.
- Operate the load control lever to the full load position (until it touches the full load stopper bolt).

(e) In the above condition (d), measure the maximum speed to determine whether it is within the specified limits.

(f) If it is not within the specified limits, adjust the fixed position of the speed control lever with the stopper bolt.

NOTE:

- If the fixed position of the full load stopper bolt is changed, the amount of fuel injection will change. Be careful not to change the fixed position.
- Check to ensure that even if the load control lever is quickly returned from the full load position to the idling position, the engine does not stop and is free from hunting.

5.2 GOVERNOR**5.2.1 RSV Type Governor****(1) Disassembly, Inspection and Reassembly**

<Disassembly sequence>

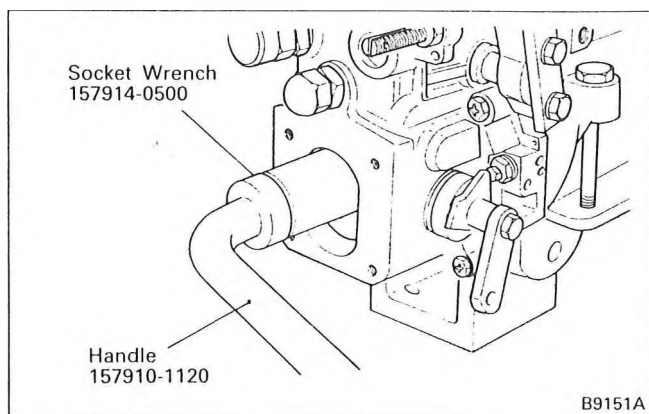
- | | | |
|----------------------------|-------------------------|-------------------------|
| 1 Closing cover | 11 Tension lever shaft | 21 Bushing |
| ② Ungleich spring capsule | 12 Control lever | 22 Oil seal |
| 3 Idling subspring capsule | 13 Collar | 23 Swivel lever |
| 4 Torque spring capsule | 14 Shim | 24 Stop lever |
| 5 Governor cover | 15 Governor spring | 25 Shim |
| 6 Start spring | 16 Tension lever | 26 Spring cap |
| 7 Round nut | 17 Guide lever assembly | 27 Return spring |
| ⑧ Flyweight | ⑮ Sleeve | 28 Bushing |
| 9 Governor housing | 19 Floating lever link | 29 Sliding lever |
| 10 Plug | 20 Snap ring | 30 Bolt |
| | | 31 Snap ring |
| | | 32 Spring |
| | | 33 Torque control lever |
| | | 34 Adapter |

For disassembly and reassembly of parts with an encircled number, see following items.
For reassembly, reverse the order of disassembly.

B9150A

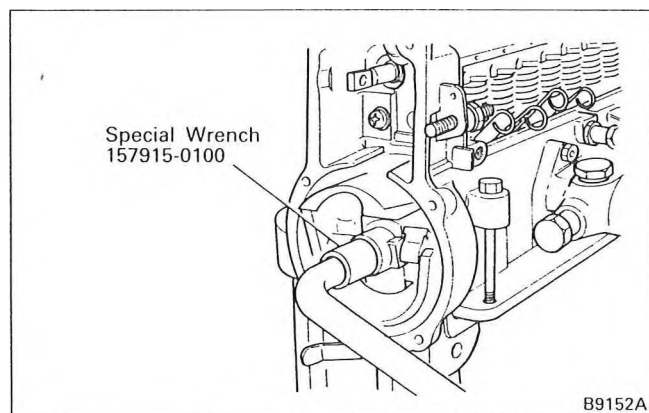
NOTE:

1. Do not disassemble the shackle and governor sleeve from the guide lever, unless replacement is necessary.
 2. Do not remove the governor housing unless removal is necessitated for correction of oil leaks, parts replacement, etc.
- Before removing the housing, use Tap-pet Insert (special tool) to separate the camshaft from the tappet.



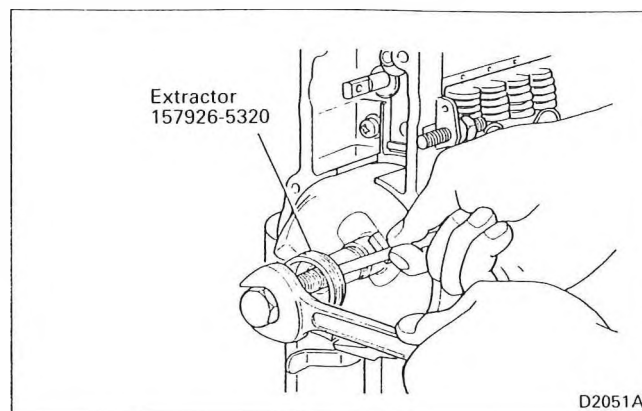
(a) Removal of ungleich spring assembly

Using Socket Wrench (special tool), loosen the nut tightening the ungleich spring assembly to the tension lever, and remove the ungleich spring capsule.



(b) Removal of flyweight

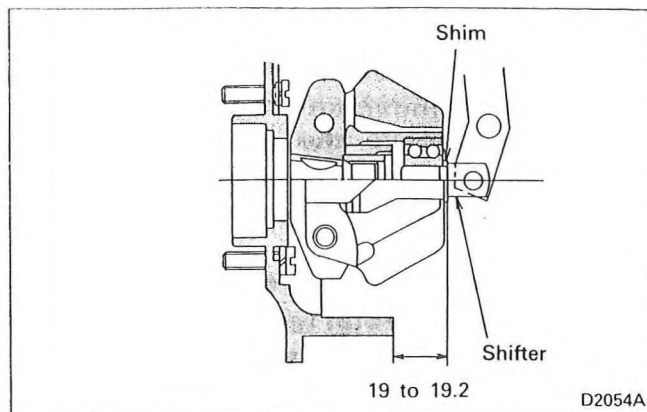
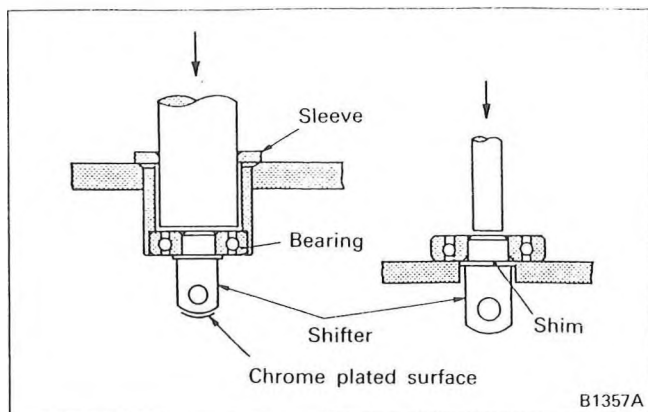
Using Special Wrench (special tool), remove the round nut tightening the flyweight. At this time, hold the drive side to prevent it from turning.



Thread Extractor (special tool) into the flyweight. After the bolt end has touched the camshaft, lightly strike the bolt head and turn down the bolt to remove the flyweight.

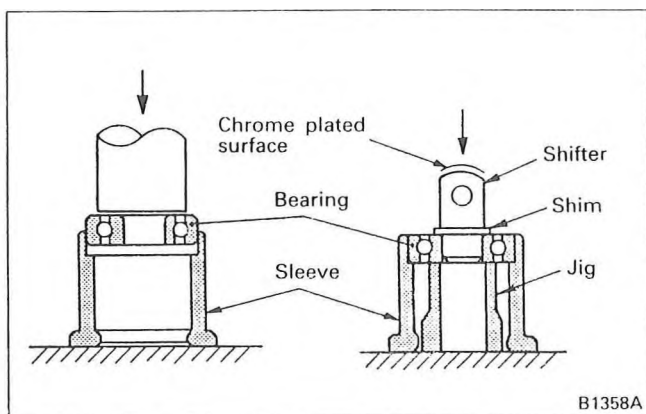
NOTE:

Do not attempt disassembly to remove the swivel lever except when replacement of parts is necessary or when unsmooth operation is evident. In addition, disassembly of parts for the stop device and torque spring mechanism of the governor is not generally required.



(c) Replacement of sleeve or guide lever assembly

- 1) Remove the bearing from inside the shifter, using a press.
- 2) Using a press, remove the shifter of the guide lever assembly from the bearing.



- 3) Install the bearing in the sleeve.
- 4) Then install the shifter of the guide lever assembly in the bearing.
- 5) Check to ensure that the sleeve rotates smoothly.

NOTE:

1. Do not replace the shim, as it has a thickness determined by adjustment of Item 6).
2. During the removal and installation operations, use care not to damage the chrome plated surface of the shifter.

6) When the shim has to be replaced, assemble all related parts correctly and select the right shim thickness to make sure that the dimension from the end of the housing to the shifter complies with the specified value.

Shim thickness (6 types):

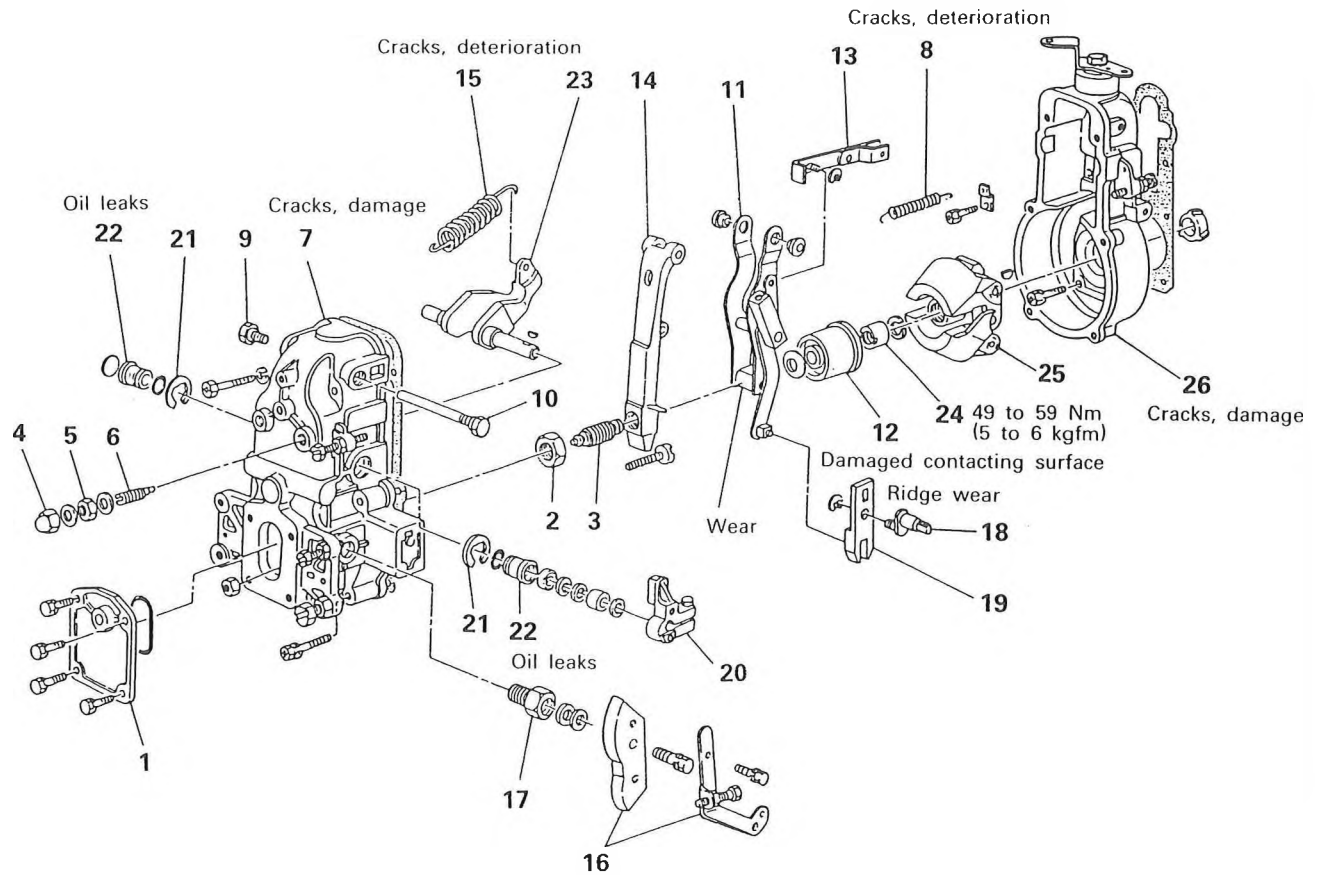
0.2, 0.3, 0.4, 0.5, 1.0, 1.5 mm

NOTE:

Measure the assembly dimension without lifting the flyweights.

5.2.2 RFD Type Governor

(1) Disassembly, Inspection and Reassembly



<Disassembly sequence>

- 1 Governor cover
- ② Lock nut
- ③ Idling spring assembly
- 4 Cap nut
- 5 Lock nut
- 6 Damper spring
- 7 Governor cover
- 8 Start spring
- 9 Tension lever plug
- 10 Tension lever shaft
- ⑪ Guide lever assembly
- ⑫ Sleeve
- 13 Floating lever link
- 14 Tension lever

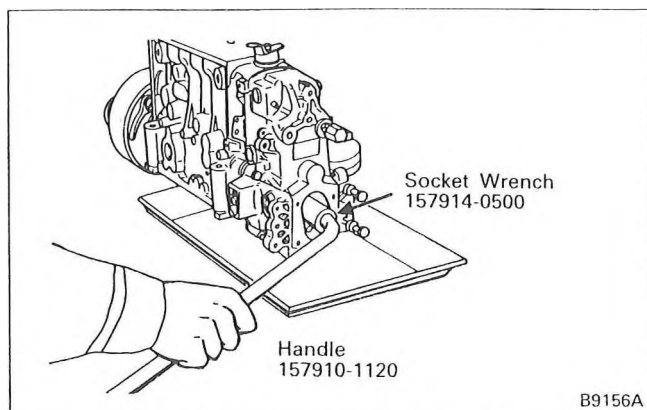
- 15 Governor spring
- 16 Load control lever
- 17 Bushing
- 18 Lever shaft
- 19 Sliding lever
- 20 Speed control lever
- 21 Snap ring
- 22 Bushing
- 23 Swivel lever
- ②④ Round nut
- ②⑤ Flyweight
- ②⑥ Governor housing

For disassembly and reassembly of parts with an encircled number, see following items.
For reassembly, reverse the order of disassembly.

B9155A

NOTE:

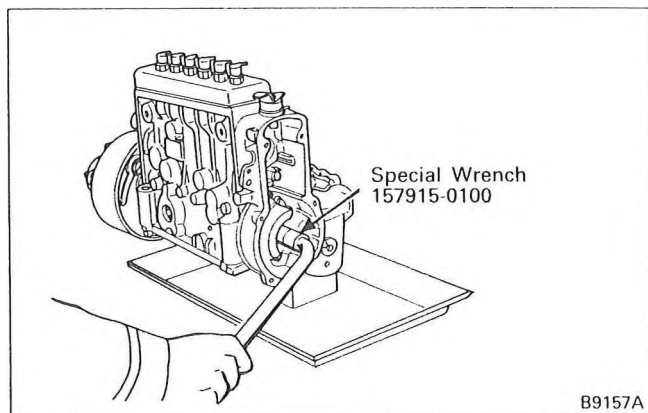
1. Do not disassemble the shackle and sleeve from the guide lever, unless replacement is necessary.
 2. Do not remove the governor housing unless removal is necessitated for correction of oil leaks, parts replacement, etc.
- Before removing the housing, use Tappet Insert (special tool) to separate the camshaft from the tappet.



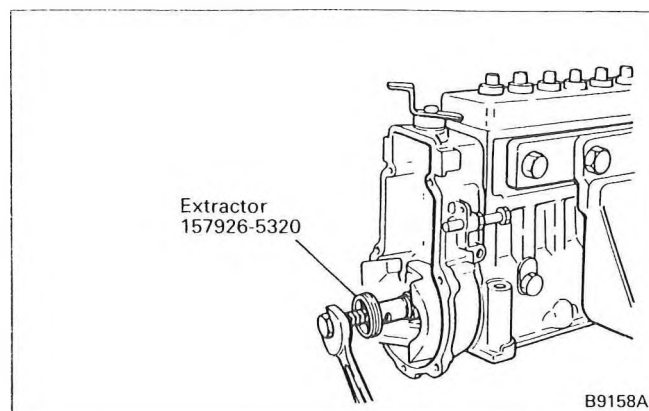
- (a) Remove the lock nut with Socket Wrench and Handle (special tools). Furthermore, remove the idle spring capsule.

NOTE:

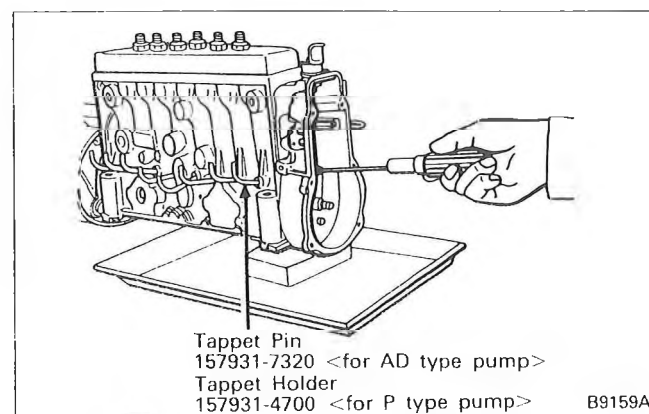
Check the speed setting lever. If there is nothing wrong, do not disassemble it.



- (b) Remove the flyweight by the following procedure. Using Special Wrench (special tool), remove the round nut of the flyweight.



- Using Extractor (special tool), remove the flyweight.

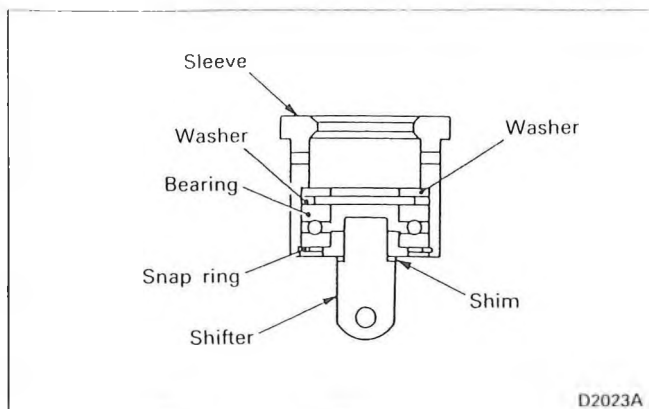


- (c) Remove the governor housing by the following procedure.

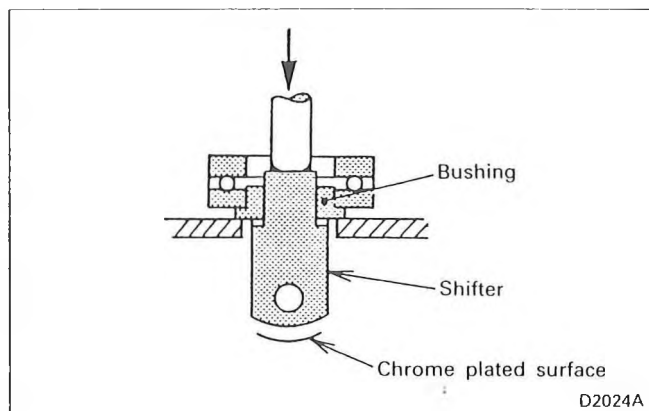
Using Tappet Holder or Tappet Pin (special tool), disconnect the tappet from the camshaft. Then remove the governor housing tightening bolts, and remove the governor housing, while striking with a plastic hammer, etc.

NOTE:

Do not remove the stop lever assembly on the top of the governor housing from the governor housing.



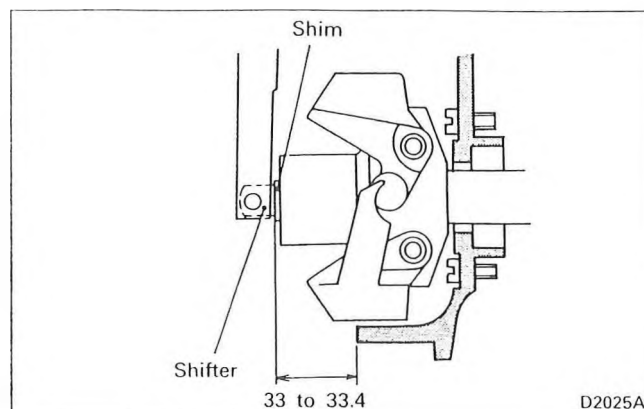
(d) Replacement of sleeve or guide lever assembly
To disassemble the shifter and sleeve, remove the snap ring in the sleeve, and the shifter and sleeve can be separated.



Use a press to remove the shifter and bushing.

NOTE:

When the shifter and bushing are installed, use care not to damage the chrome plated surface of the shifter.



(e) Assembly dimension of shifter

When the shifter and sleeve are assembled, be sure not to change the adjusting shim, as the assembly dimension of the shifter has been adjusted by the shim.

If readjustment is necessary, assemble all related parts correctly and select the right shim thickness to make sure that the dimension from the housing end to the shifter complies with the specified value.

Shim thickness (6 types):

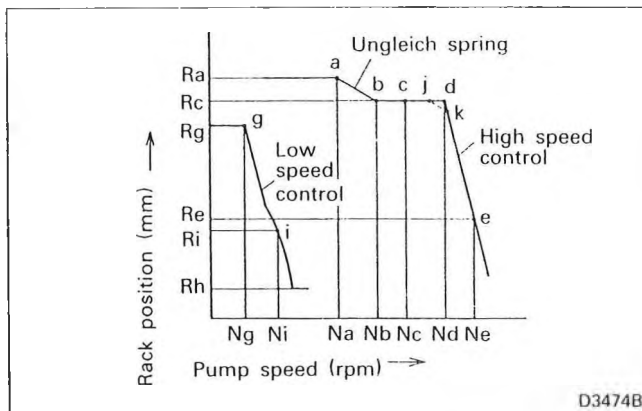
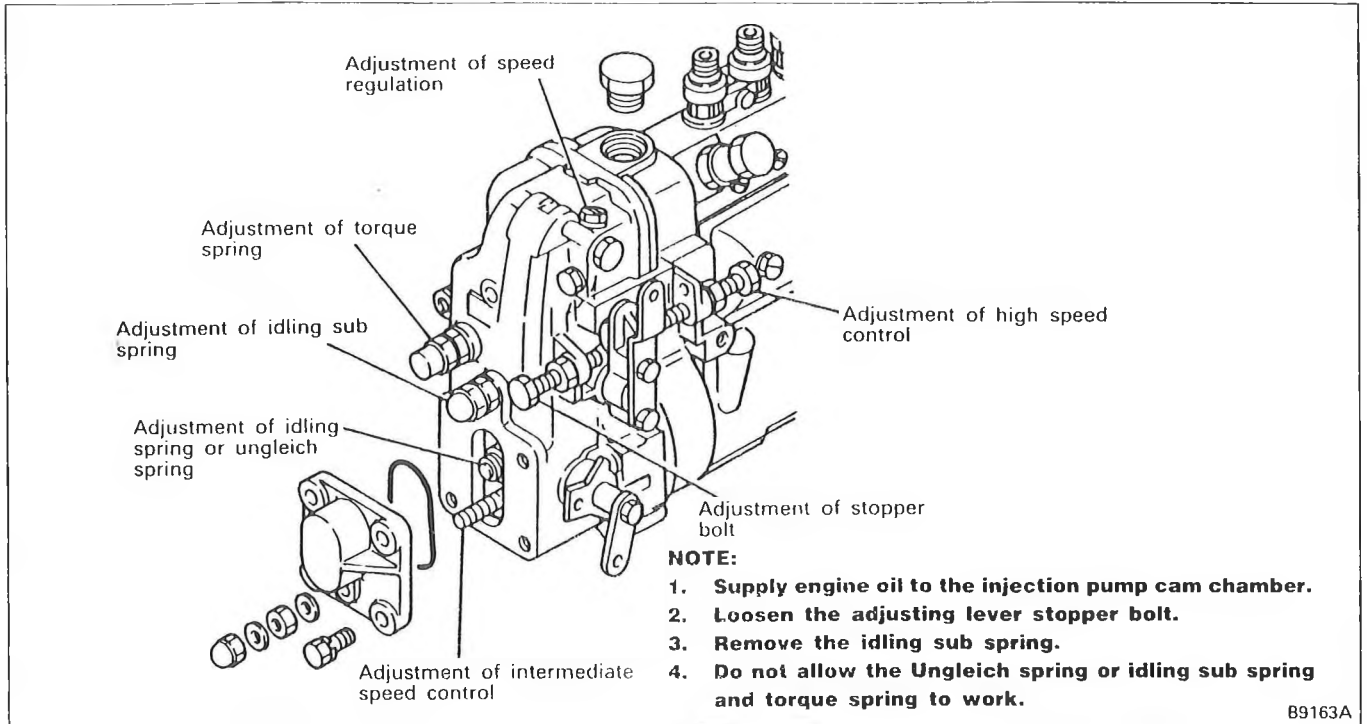
0.2, 0.3, 0.4, 0.5, 1.0, 1.5 mm

NOTE:

Measure the assembly dimension with all flyweight lifted.

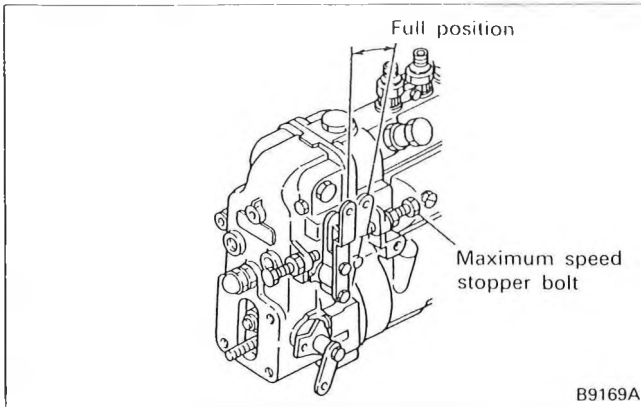
5.2.3 Adjustment after Reassembly**(1) RSV Type Governor**

For governor performance curve, see Service Information published separately.

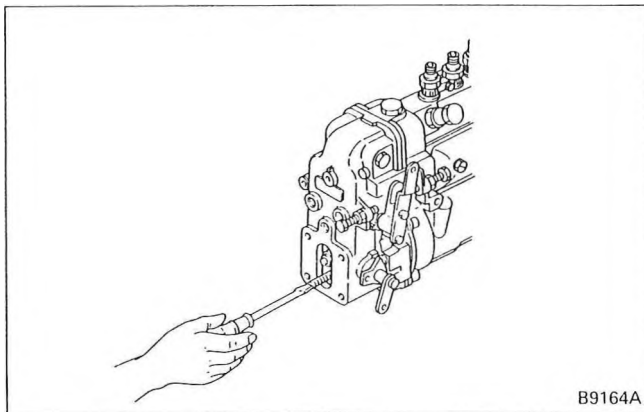


- (a) "0" position setting of control rack
[Refer to Item (1) (b) or (2) (b), Section 5.1.4.]
- (b) Install the angle scale plate for fixing the adjusting lever.

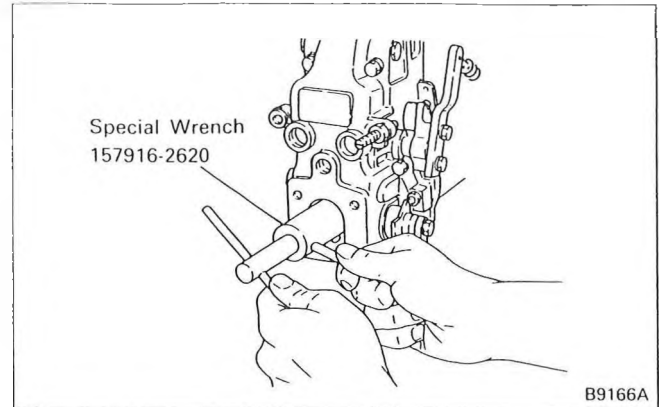
Adjust the relationship between pump speed and the rack position to specified governor performance curve by the following procedure.



(c) Temporary adjustment of high speed control
With the adjusting lever in full position, adjust the maximum speed stopper bolt so that high speed control starts to work when the pump speed is "Nd".

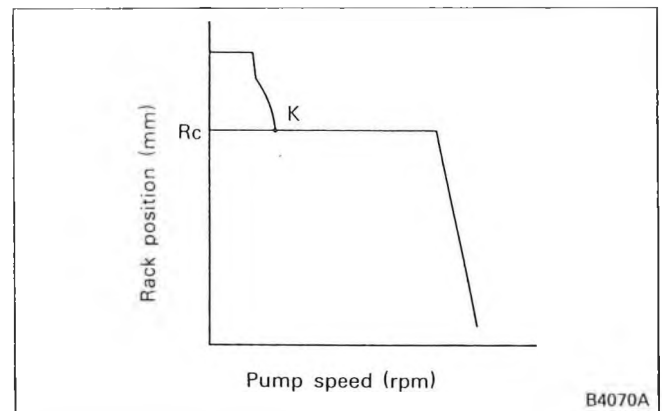


(d) Adjustment of intermediate speed control
With the pump speed at "Nc" (c point) which is a little lower than "Nd", adjust the full load stopper bolt so that the rack is positioned at "Rc".



(e) Adjustment of Ungleich spring (governor with Ungleich spring only)

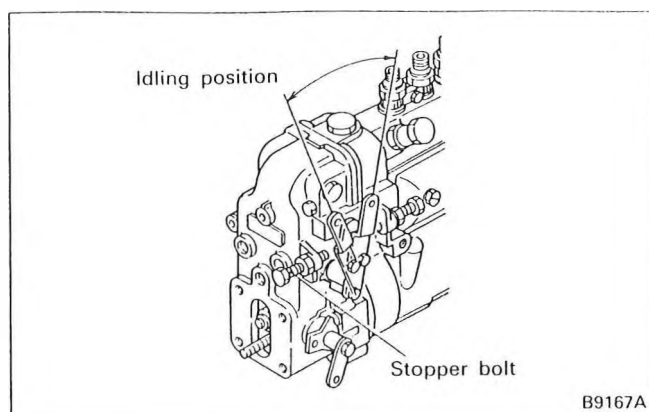
- 1) Keep the pump running at a speed which is a littler lower than "Na" (speed at which Ungleich spring starts to work).
- 2) Fix the adjusting lever at the full position.
- 3) Using the special tool, Special Wrench, tighten the Ungleich spring so that the rack will move from "Rc" to "Ra". Fix the spring with lock nut.
- 4) Check that the pump speed is "Na" and "Nb" when the rack position is "Ra" and "Rb", respectively.



(f) Adjustment of idling spring (governor with idling spring only)

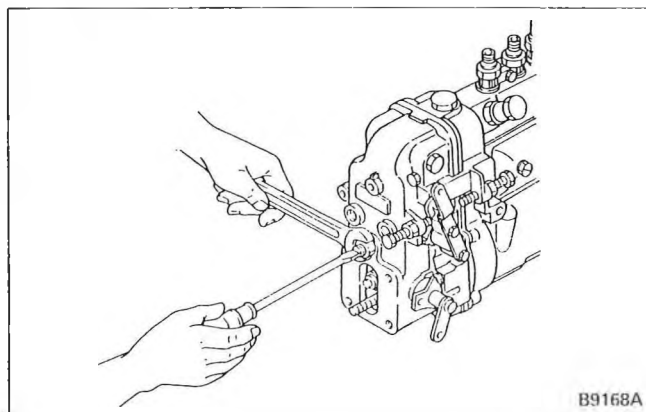
Adjust the idling spring so that the rack starts to move from "Rc" to direction to increase fuel rate at point k.

(g) Adjustment of low speed control



1) Adjustment of stopper bolt

Adjust the stopper bolt so that the rack is positioned at "Rg" when the adjusting lever is set at idling position with the pump stationary.

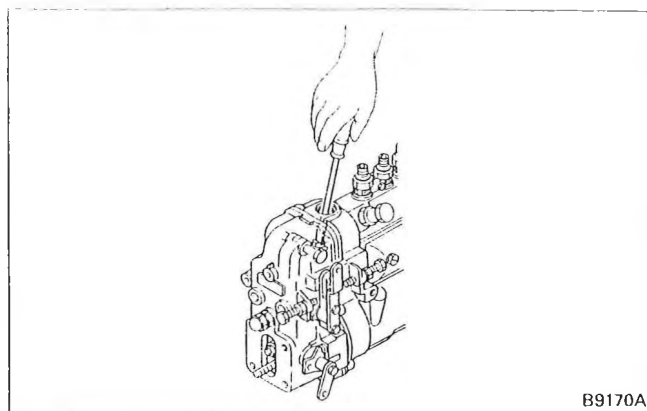


2) Adjustment of idling sub spring

Adjust the idling sub spring so that the rack is positioned at "Ri" when the pump speed is "Ni". Check that the rack is positioned at "Rh" when the pump speed is further increased.

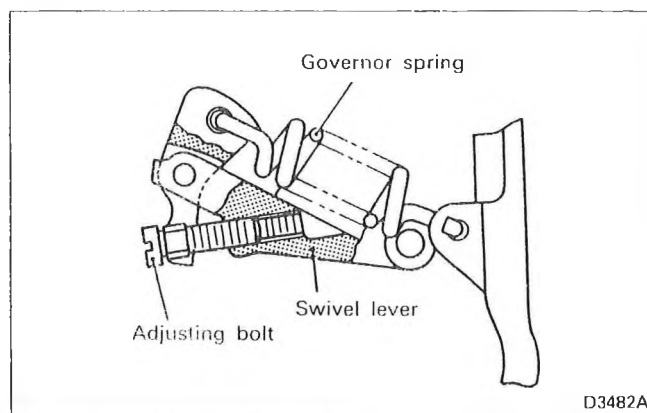
(h) Adjustment of high speed control

Adjust as in (c) and fix the maximum speed stopper bolt in position.



(i) Adjustment of speed regulation

Check that the rack is pulled back to position "Re" when the pump speed is increased from "Nd" to "Ne".



If the pump fails to do so, adjust tightening amount of the swivel lever adjusting screw.

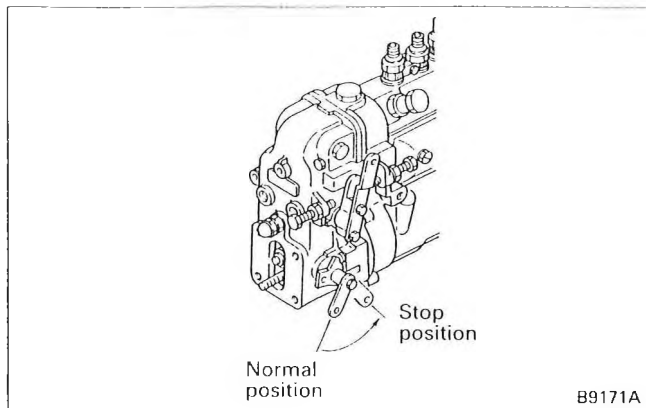
Tightening gives better speed regulation.

Loosening gives poorer speed regulation.

$$\text{Speed regulation} = \frac{Ne - Nd}{Nd} \times 100 (\%)$$

NOTE:

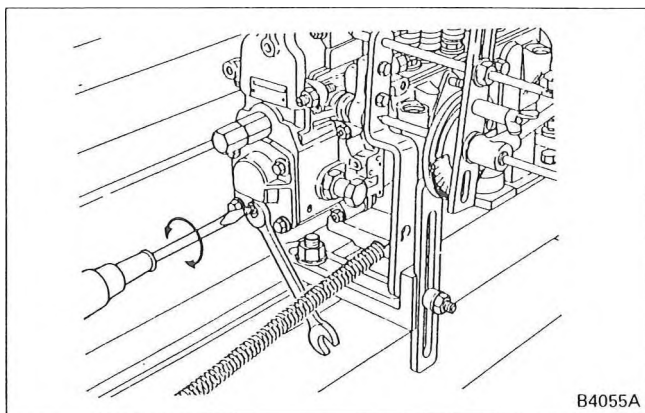
1. If the speed regulation is poor, the engine will exceed the specified maximum speed at no load and will enter a hazardous condition.
2. The maximum extent to which the adjusting screw can be loosened is 20 notches (5 turns) from the fully tightened position. Loosening it any further can be dangerous.
3. If the adjusting screw is adjusted, the tension of the governor spring will change and the high speed control start point will change. Be sure to readjust the high speed control in accordance with (h).



(j) Stop lever operation check

With the adjusting lever fixed at the full position, pull the stop lever all the way to the stop side and check that the rack is positioned at 0 mm.

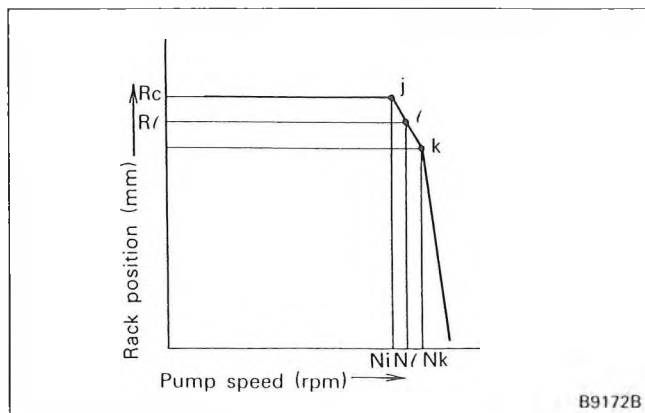
(k) Adjustment of full load



1) Install the lever to the governor cover.

2) With the adjusting lever at the full position, adjust the full load stopper bolt so that the rack is positioned at "Rc".

(l) Adjustment of torque spring



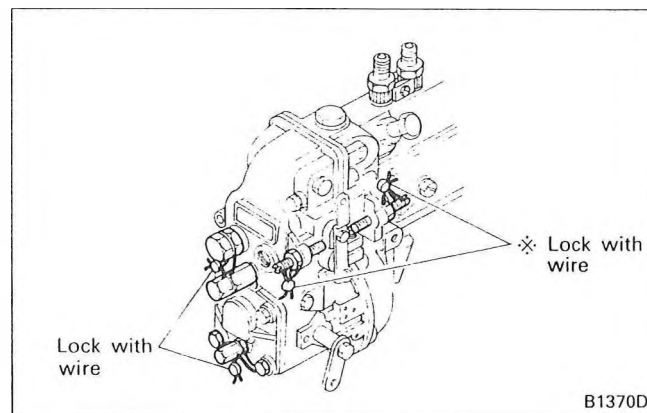
- 1) Fix the adjusting lever at the full position and set the pump speed at "Nk".
- 2) Screw in until the torque spring contacts the lever and fix temporarily.
- 3) Adjust the torque spring so that the rack is positioned at "Rr" when the pump speed is lowered to "Ni".
- 4) Check that the pump speed is "Nj" when the pump speed is lowered to position the rack at "Rc".
- 5) After the adjustment, check that the rack position is as specified at each pump speed.

If the rack position is out of specification, readjust the torque spring and full load stopper bolt.

(m) Adjustment of adaptation to engine

After the governor has been adjusted, measure overall injection amount at the same lever angle as in the high speed control and in accordance with the adjustment standard and readjust as necessary.

(n) Locking with wire



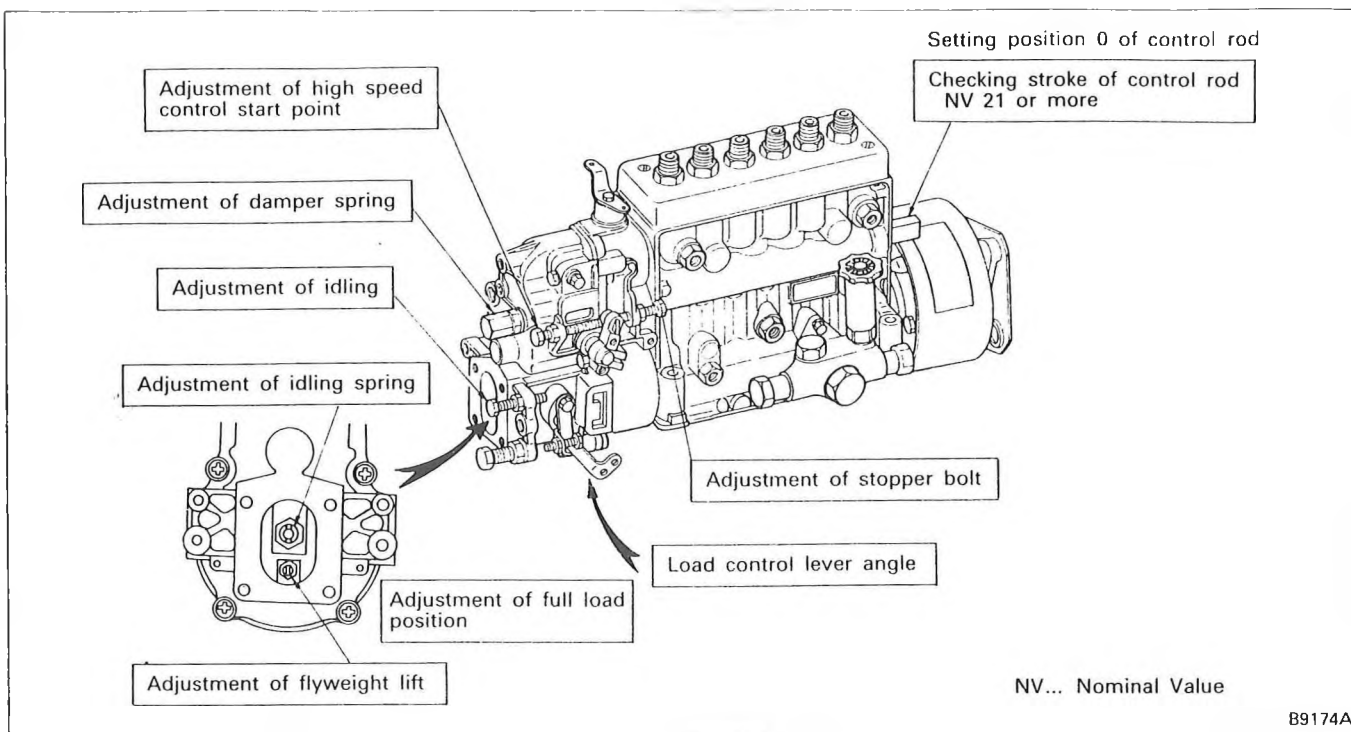
After adjustments, lock the governor with wires.

NOTE:

Locking of the sections marked with * must be done after adjustment of no-load minimum and maximum speeds.

(2) RFD Type Governor

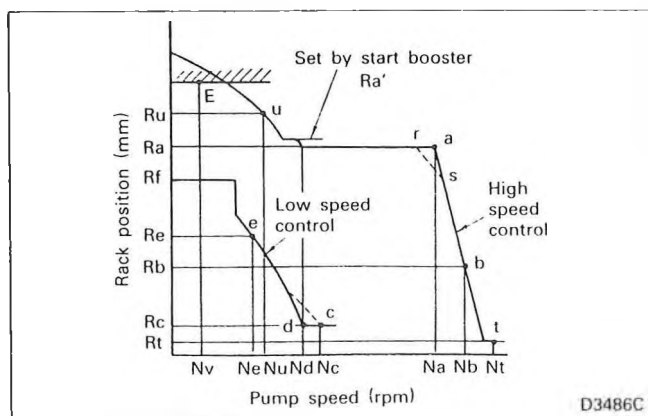
For governor performance, curve, see Service Information published separately.

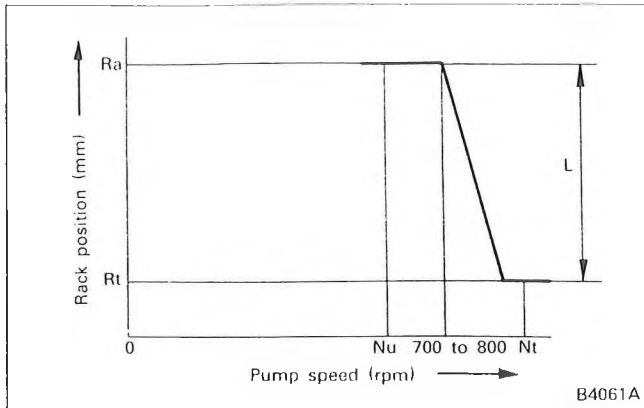
**NOTE:**

1. Remove the damper spring.
2. Remove the idling spring.
3. Keep the stopper bolt of the speed control lever loosened.
4. Keep the stopper bolt of the load control lever loosened.
5. Supply engine oil to the injection pump cam chamber.

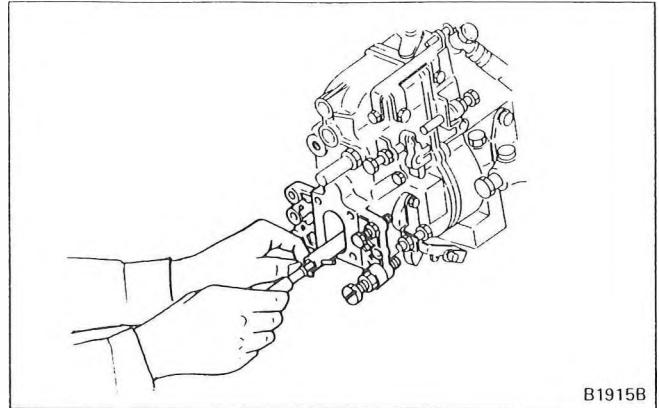
Adjust the relation between pump speed and the rack position to specified governor performance curve by the following procedure.

- (a) "0" position setting of control rack
[Refer to Item (1) (b) or (2) (b), Section 5.1.4.]
- (b) Install the angle scale plate for fixing the control lever.





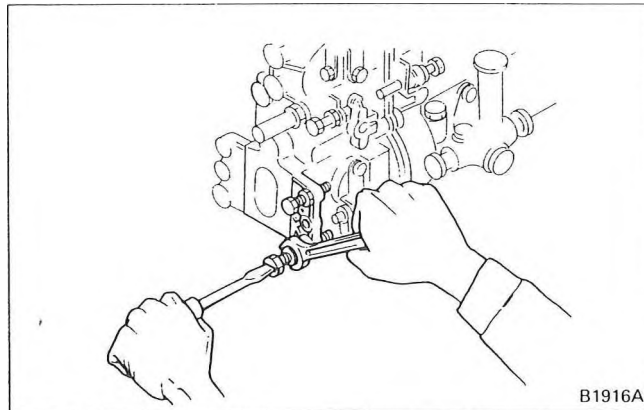
B4061A



B1915B

(c) Adjustment of flyweight lift and full load position
Divide the flyweight full lift into the lift necessary for high speed control and the lift necessary for idling control.

1) With the load control lever fixed at the full load position, temporarily set the speed control lever so that high speed control works when the pump speed is 700 to 800 rpm.

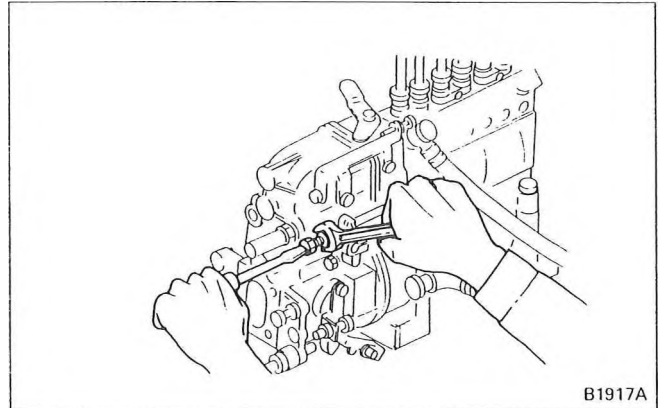


B1916A

2) Increase the pump speed slowly and adjust the full load stopper bolt so that the rack is positioned at "Rt" when the pump speed reaches "Nt".

3) Lower the pump speed to "Nu" and adjust the high speed lift "L" with the stroke adjusting screw.

(d) Adjustment of high speed control

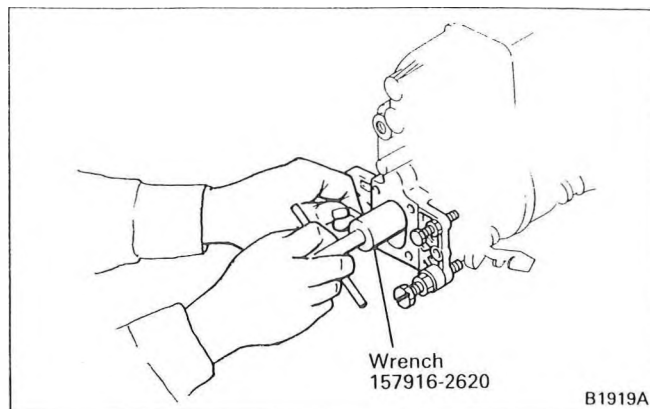
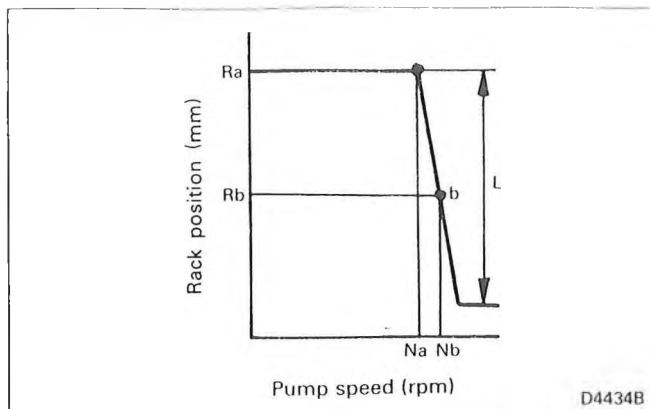


B1917A

1) Adjustment of high speed control start point

Set the control lever at the full load position and set the speed control lever at the maximum speed position.

Increase the pump speed slowly and adjust the speed control lever stopper bolt so that the rack starts to move from "Ra" toward fuel decreasing direction when the pump speed reaches "Na".



2) Check of speed regulation

Increase the pump speed slowly until the control rack is pulled back to "Rb" position.

Upon reaching "Rb" position, check that the pump speed is "Nb".

Further increase the pump speed and check that the rack pull back amount "L" is as specified.

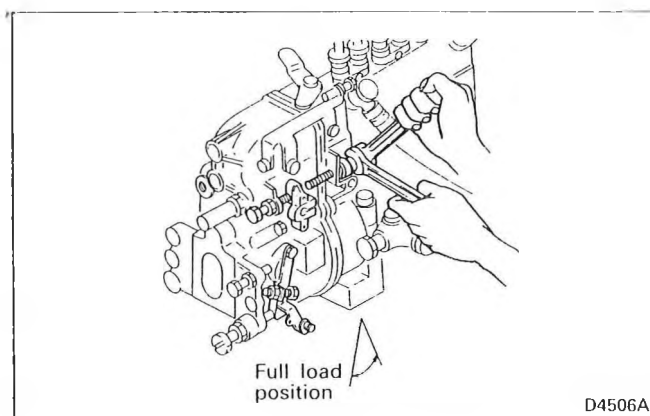
NOTE:

1. If the speed regulation check point (point b) is where the damper spring acts, check the speed regulation after idling and damper spring adjustment.
2. If the value is out of specification, replace the governor spring.

(e) Adjustment of idling spring (governor with idling spring only)

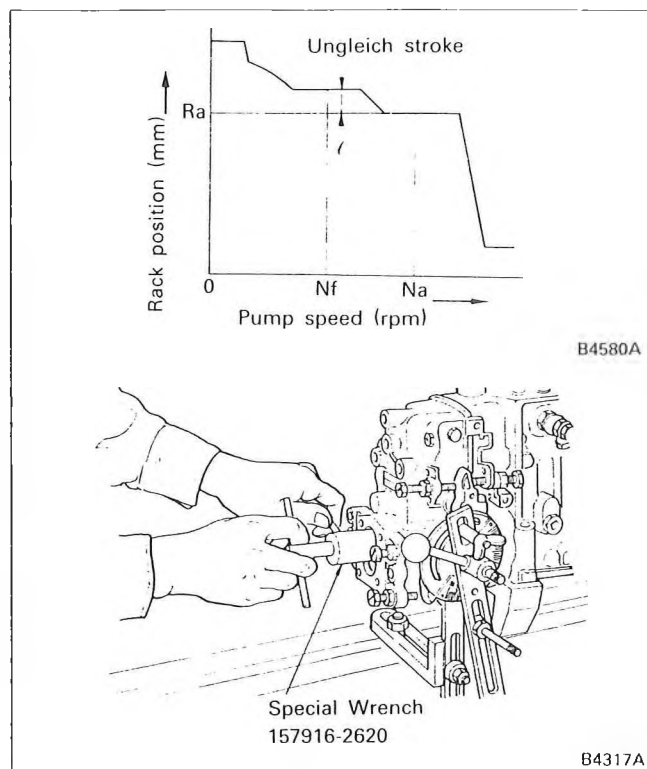
2) Lower the pump speed to "Ne" and adjust the idling spring using the special tool, Wrench so that the rack is positioned at "Re".

3) When the pump is stopped the rack should be at "Rf" or higher position. Also check that the rack is positioned at "Rc" when the pump speed is increased to "Nd".

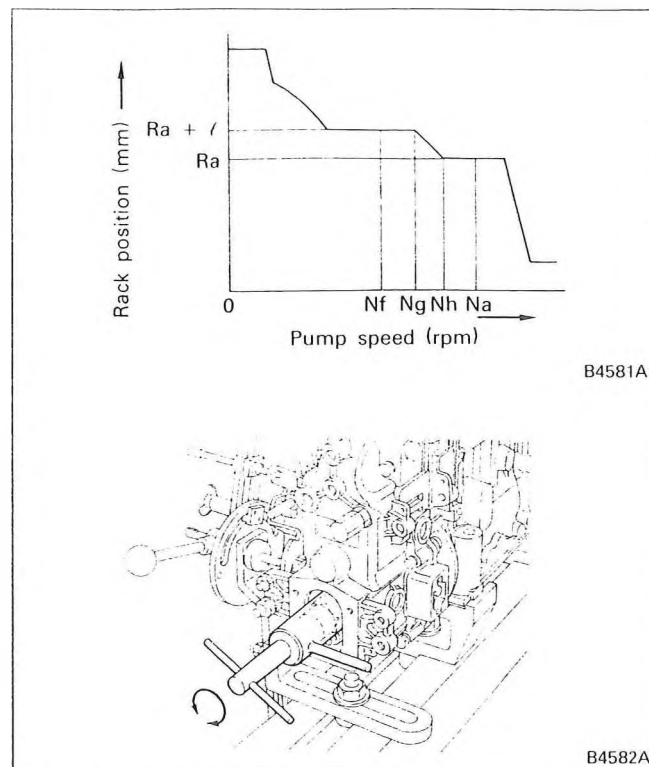


1) Set the pump speed at "Nc" (Nd + 100 rpm) and adjust the stopper bolt so that the rack is positioned at "Rc".

(f) Adjustment of Ungleich spring
(Vehicles with Ungleich spring only)



- 1) Set the pump speed at "Nf" and place the load control lever in the full load position.
- 2) Using the special tool, Special Wrench, adjust the Ungleich spring capsule position so that the Ungleich stroke l in the state of Step 1 will have the specified value. After the adjustment, firmly tighten it with the lock nut.



- 3) Slowly increase the pump speed from "Nf" to "Ng" and adjust the screw position so that the Ungleich spring will start working.
- 4) Increase the pump speed to check that the Ungleich spring stops working at "Nh".
- 5) Change the pump speed between "Nf" and "Na" to check that the Ungleich stroke has the specified values.

NOTE:

1. If the Ungleich stroke is out of specification, readjust the Ungleich spring capsule position.
2. If the speed at which the Ungleich spring stops working is out of specification, replace the Ungleich spring capsule.

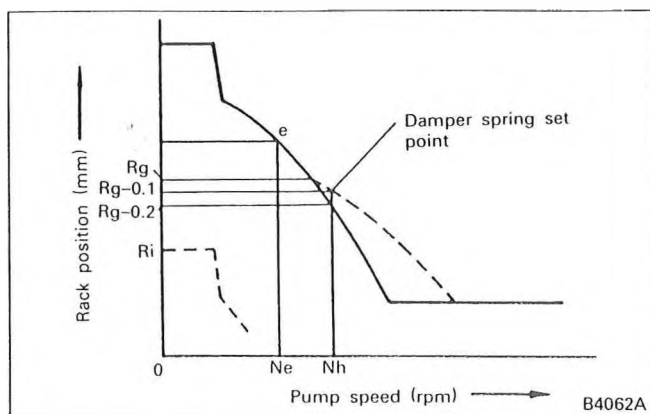
(g) Measurement of load control lever angle

Check that when the load control lever is held at the idling position and the full load position, the lever angle at the respective positions is up to specification. If the lever angle is out of specification, replace the shim installed between the shifter and sleeve.

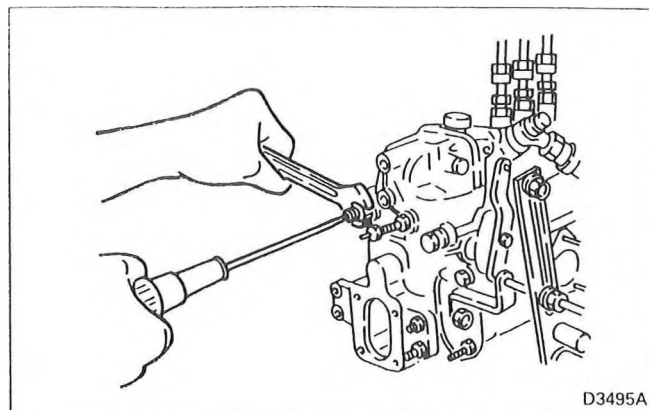
NOTE:

If the shim was replaced, repeat adjustment of the governor from the beginning.

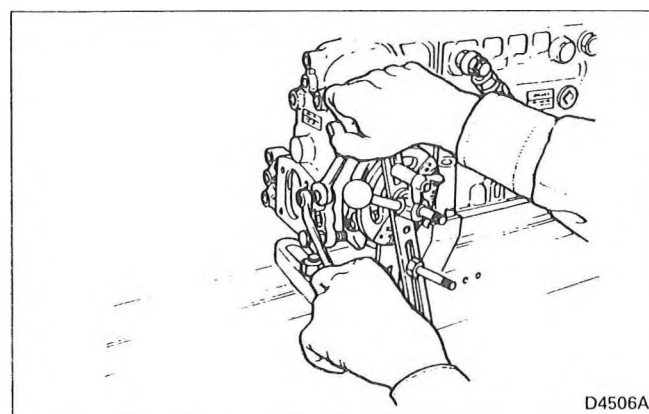
(h) Adjustment of damper spring



1) Holding the load control lever at the idle position (point e) and slowly increase the pump speed from " N_e " until the rack is positioned at " $R_g - 0.2$ mm". Hold the pump speed " N_h " when the rack is so positioned.



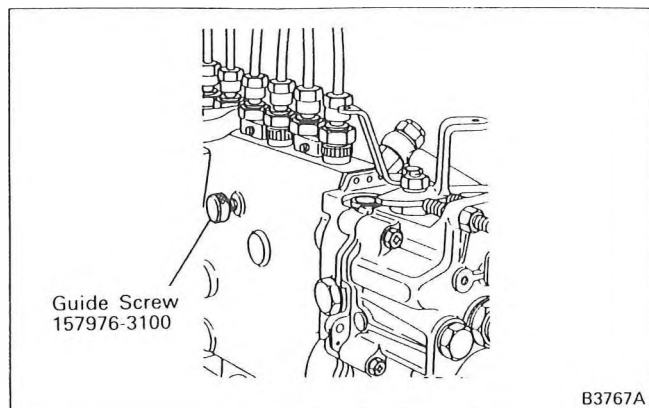
2) Adjust the damper spring tightening amount so that the rack is positioned at " $R_g - 0.1$ mm".



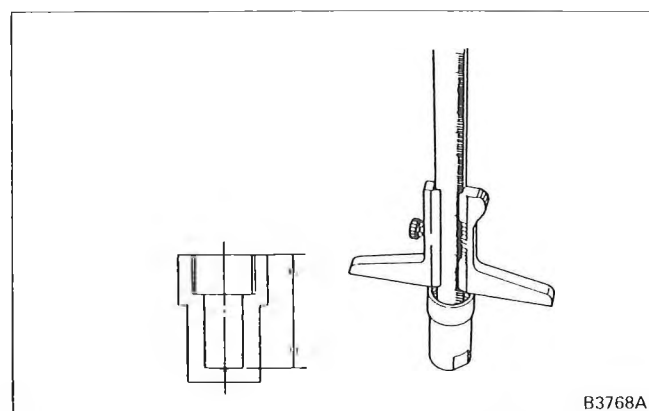
3) After adjustment, stop the pump and loosen and adjust the stopper bolt so that the rack is positioned at " R_i ".

(i) Adjustment of rack limit

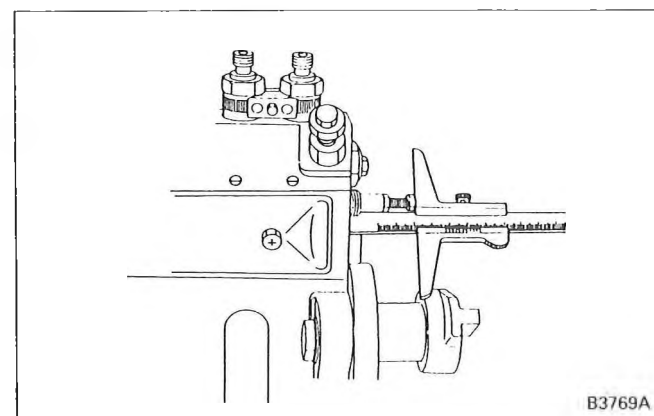
1) Cap type



a) Remove the guide screw from the back of the pump housing and install the special tool, Guide Screw.



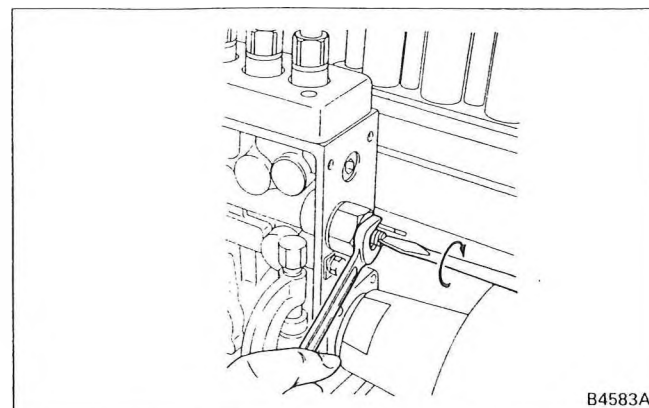
b) Using a depth gauge, measure the rack cap depth.



c) Adjust the adjusting nut mounted to the tip of the rack for the same depth as the rack cap depth measured above. Fix the nut in position with the lock nut.

After adjustment, install the cap nut securely.

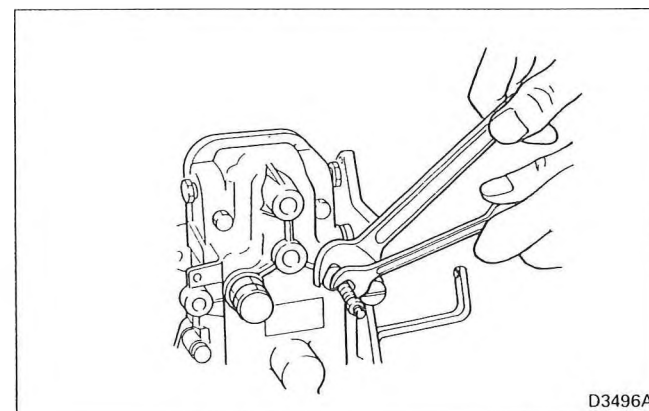
2) Screw type



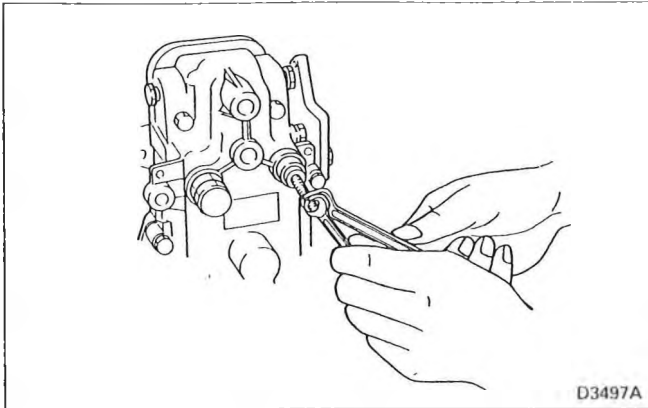
a) Place the load control lever in the full load position and keep the pump speed at "Nv".

b) Adjust the screw of the rack limiter so that the rod position and fuel injection (point E) will be up to specification, and secure it with the lock nut.

(j) Adjustment of start booster (smoke set assembly)



- 1) With the load control lever set at the full load position, set the smoke set assembly adjusting nut at 0 to 4 mm from the stopper tip.
- 2) Adjust to make sure that when the pump speed is changed to "Nd", the rack position will change from "Ra" to "Ra''".

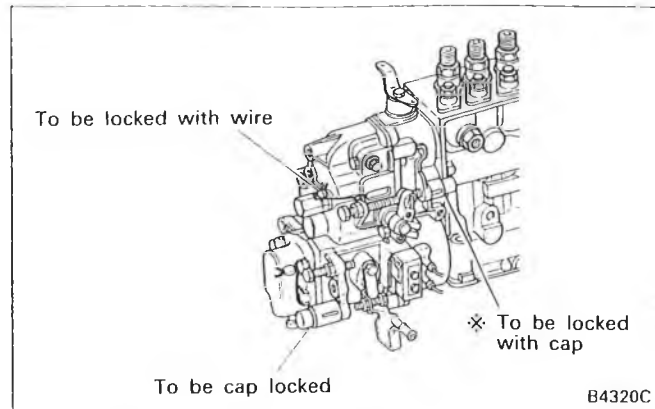


- 3) Set and fix the nut so that the rack is positioned at "Ru" when the pump speed is "Nu".

(k) Adjustment of adaptation to engine

After the governor has been adjusted, measure overall injection amount at the same lever angle as in the high speed control and in accordance with the adjustment standard and readjust as necessary.

(l) Locking with wire



After adjustments, lock the governor.

NOTE:

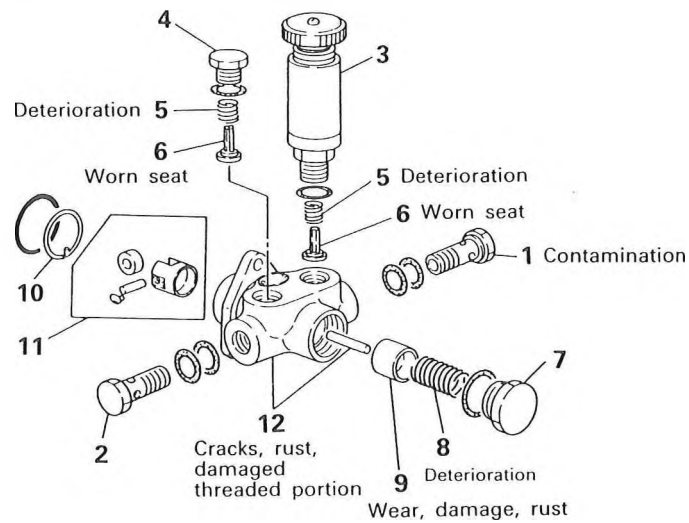
Lock parts marked with * after adjustment of no load maximum speed.

5.2.4 Inspection and Adjustment of No-load Minimum and Maximum Speeds

[Refer to 5.1.8.]

5.3 FEED PUMP

5.3.1 Disassembly, Inspection and Reassembly



<Disassembly sequence>

- | | |
|--|----------------------|
| 1 Eye bolt (suction side: with gauze filter) | 7 Plug |
| 2 Eye bolt (delivery side) | 8 Piston spring |
| 3 Priming pump | 9 Piston |
| 4 Check valve plug | 10 Snap ring |
| 5 Check valve spring | 11 Tappet |
| 6 Check valve | 12 Feed pump housing |

For reassembly, reverse the order of disassembly.

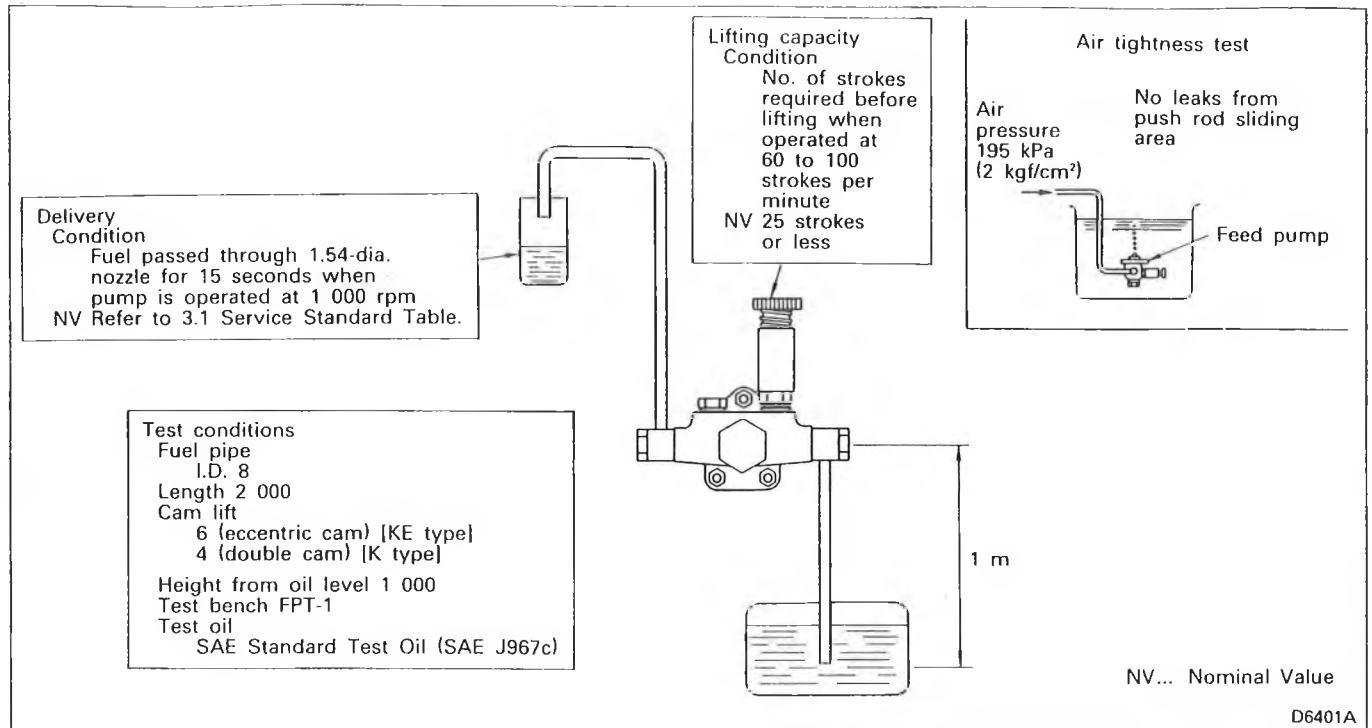
NOTE:

Before disassembly, know the trouble spots thoroughly by making tests.

B9175A

5.3.2 Test and Adjustment

The feed pump tests are as follows.

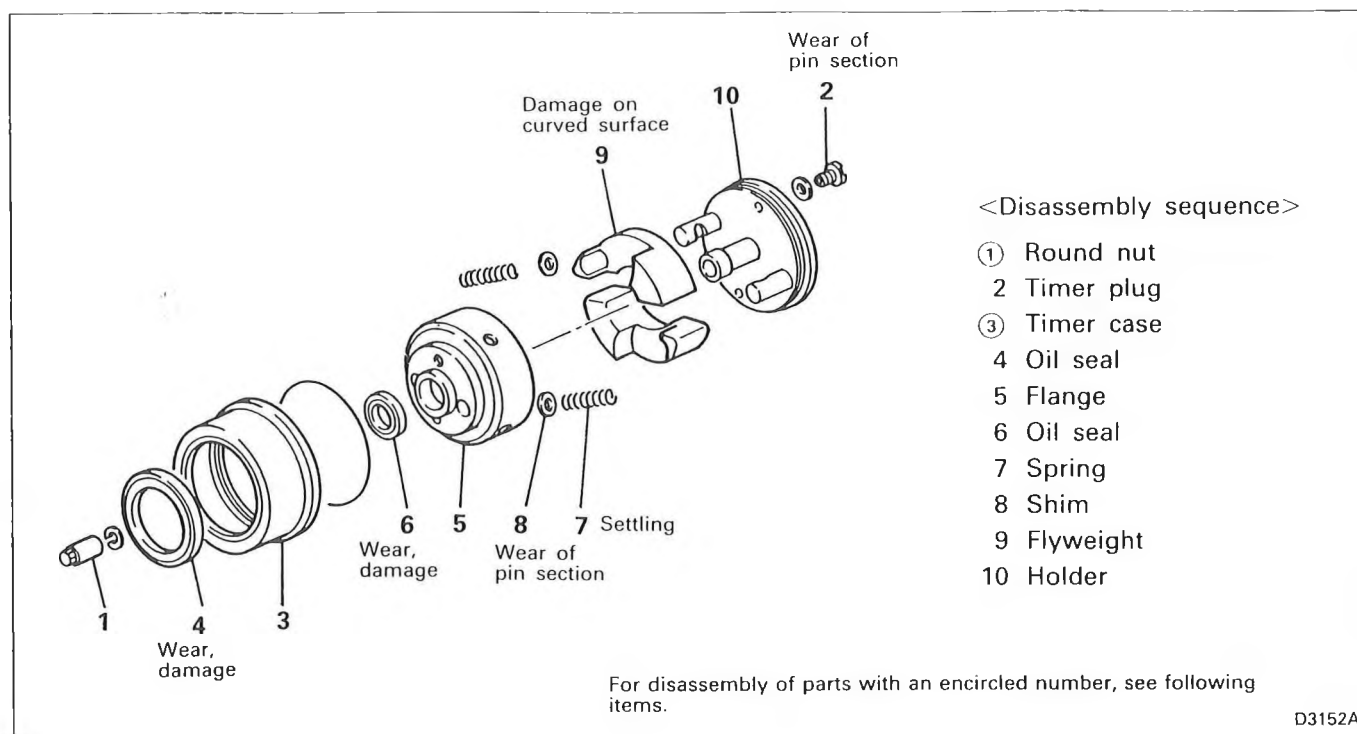


5.4 AUTOMATIC TIMER

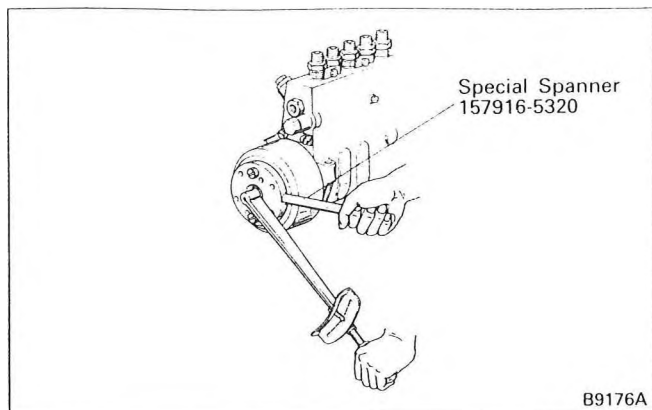
5.4.1 SA Type Automatic Timer

(1) Disassembly and Inspection

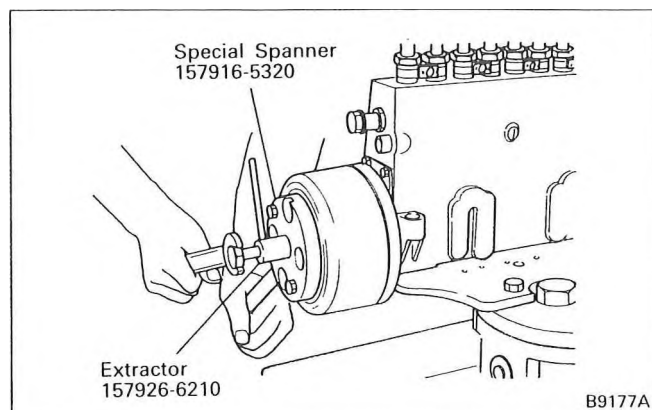
For disassembly and reassembly of the automatic timer, use SA Type Automatic Timer Special Tool (105790-5010).



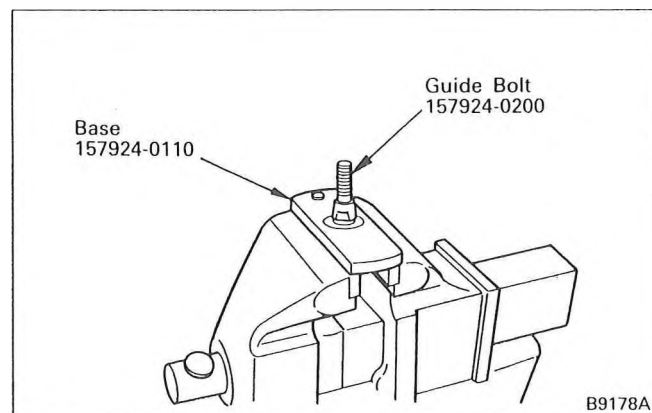
(a) Remove the coupling from the automatic timer.



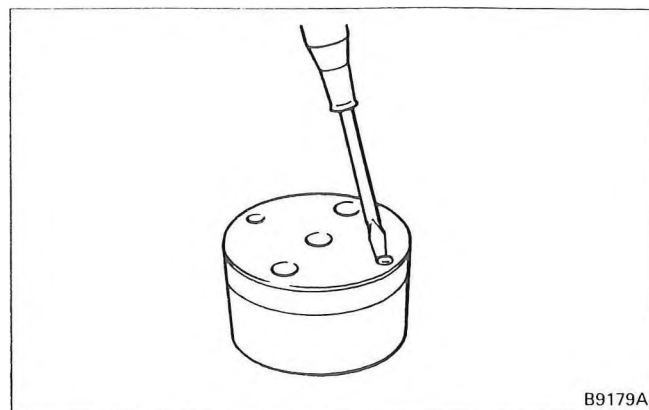
(b) Mount Special Spanner (special tool) in the coupling mounting threaded hole to prevent turning, and remove the round nut.



(c) While holding the automatic timer with Special Spanner (special tool) to prevent it from turning, remove the automatic timer with Extractor (special tool).



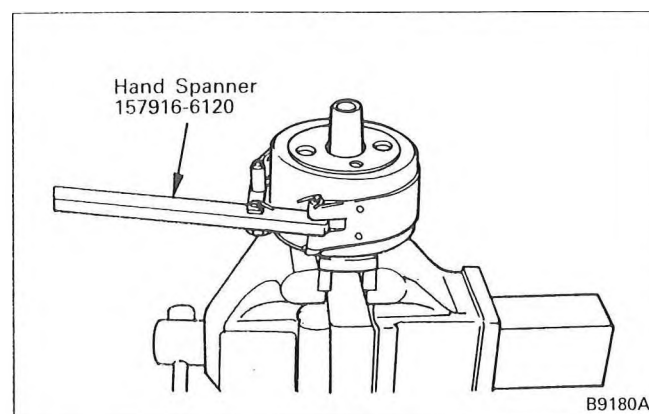
(d) Mount Base and Guide Bolt (special tools) in the vice.



(e) Remove the timer plug and place the automatic timer on Base (special tool).

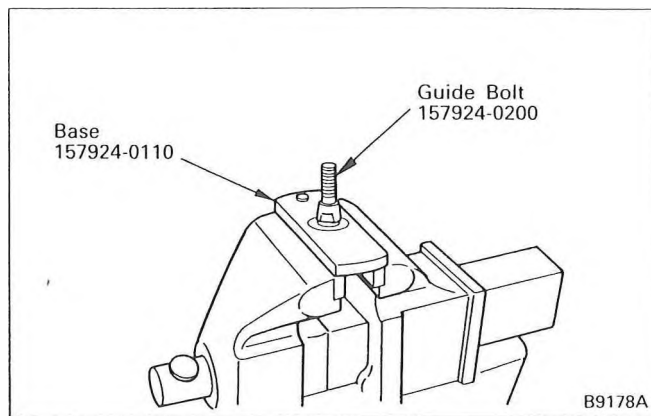
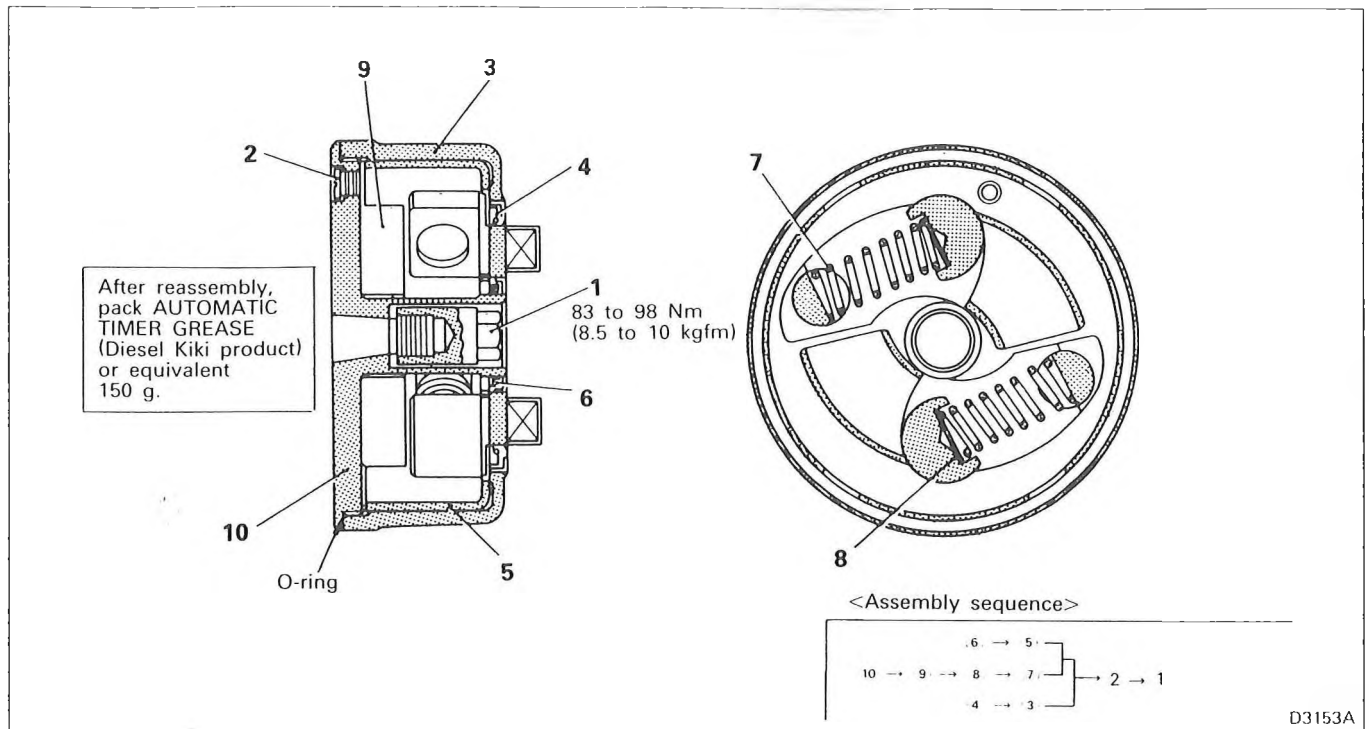
NOTE:

Line up the hole in the timer plug with the pin of the base.

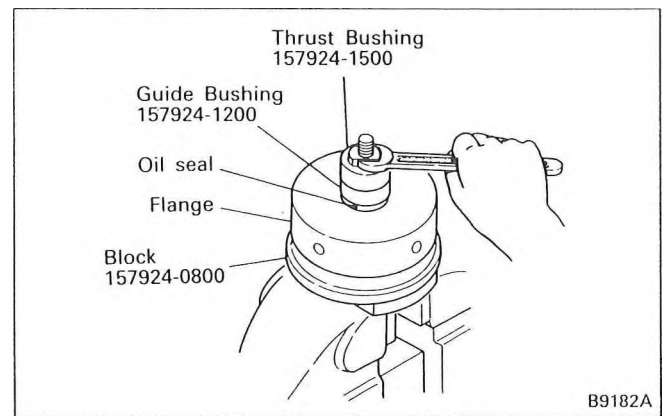


(f) Using Hand Spanner (special tool), remove the timer case by turning clockwise.

(2) Reassembly

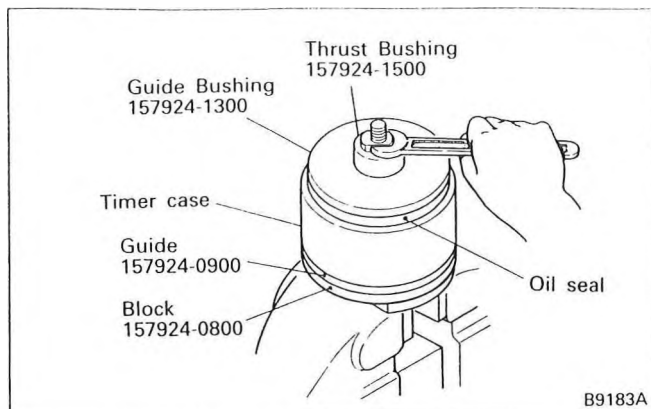


(a) Mount Base and Guide Bolt (special tools) in a vice.



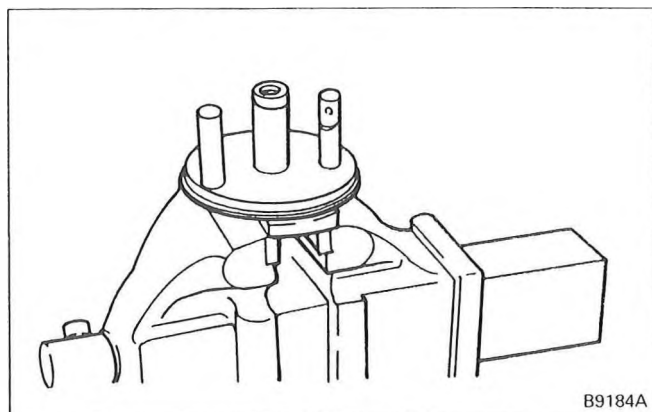
(b) Install the oil seal in the flange.

- 1) Mount Block (special tool) to the base.
- 2) Put the flange so that its pins will fit in the holes in the block.
- 3) Apply NEJI LOCK to the oil seal installing hole in the flange.
- 4) Put the oil seal in the hole in the flange. Install the oil seal by turning down Thrust Bushing (special tool) with Guide Bushing (special tool) in between.

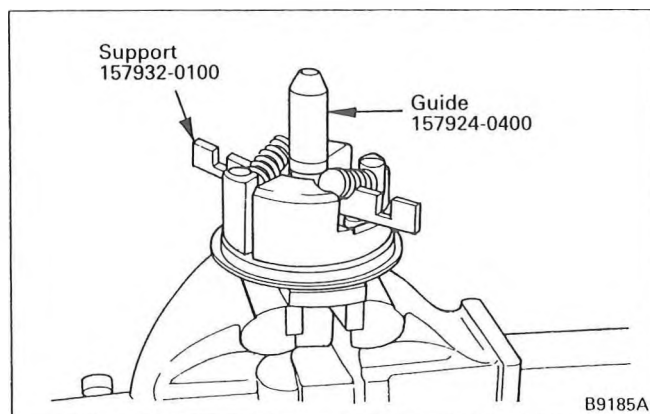


(c) Install the oil seal in the timer case.

- 1) Mount Block and Guide (special tools) to the base.
- 2) Put the timer case on the guide.
- 3) Apply NEJI LOCK to the oil seal installing hole in the timer case.
- 4) Put the oil seal in the hole in the timer case. Install the oil seal by turning down Thrust Bushing (special tool) with Guide Bushing (special tool) in between.



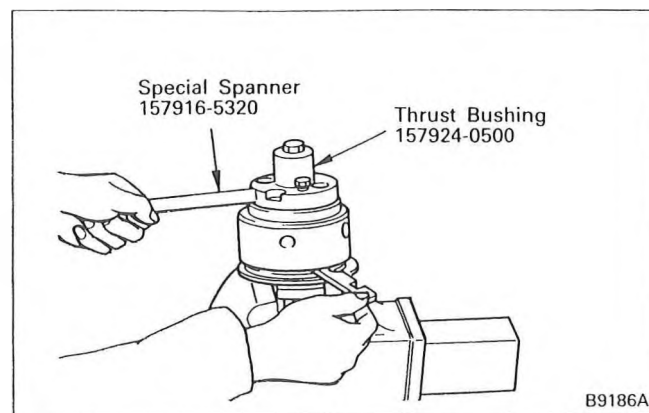
(d) Place the holder on Base (special tool).



(e) After placing Support (special tool) on the flyweight, install the shim and spring. Thread Guide (special tool) onto the guide bolt.

NOTE:

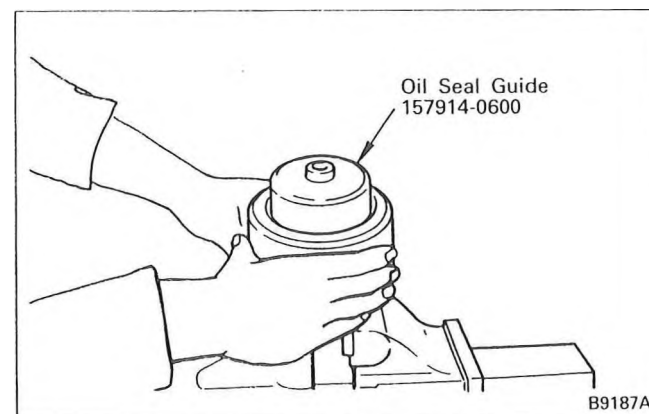
Select the proper shim thickness suitable for the advance angle of the automatic timer.



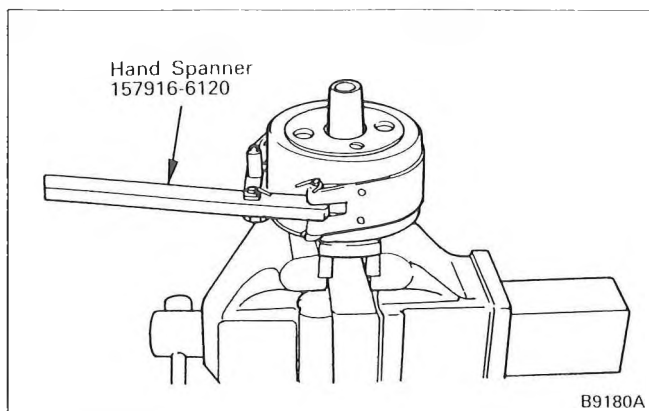
(f) Put the flange so that the pin of the flange will touch one end of the spring.

Mount Special Spanner (Special tool) to the coupling mounting hole of the flange.

Furthermore, mount Thrust Bushing (special tool) with a bolt.



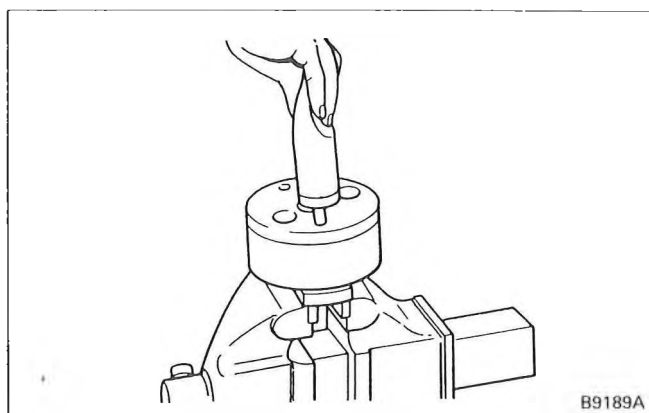
(g) After placing Oil Seal Guide (special tool) on the flange, insert the timer case



(h) After the oil seal guide has been removed, turn down the timer case onto the holder with Hand Spanner (special tool), and punch it.

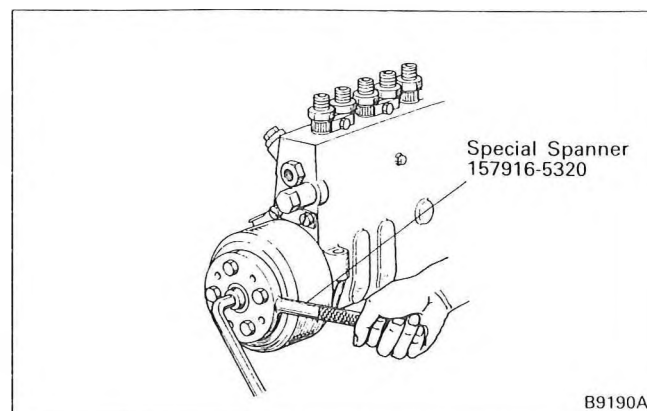
NOTE:

Turn down the timer case until the injection start timing lines inscribed on the timer case and flange are in alignment.



(i) Inject approx. 150 g of automatic timer grease from the timer plug hole.

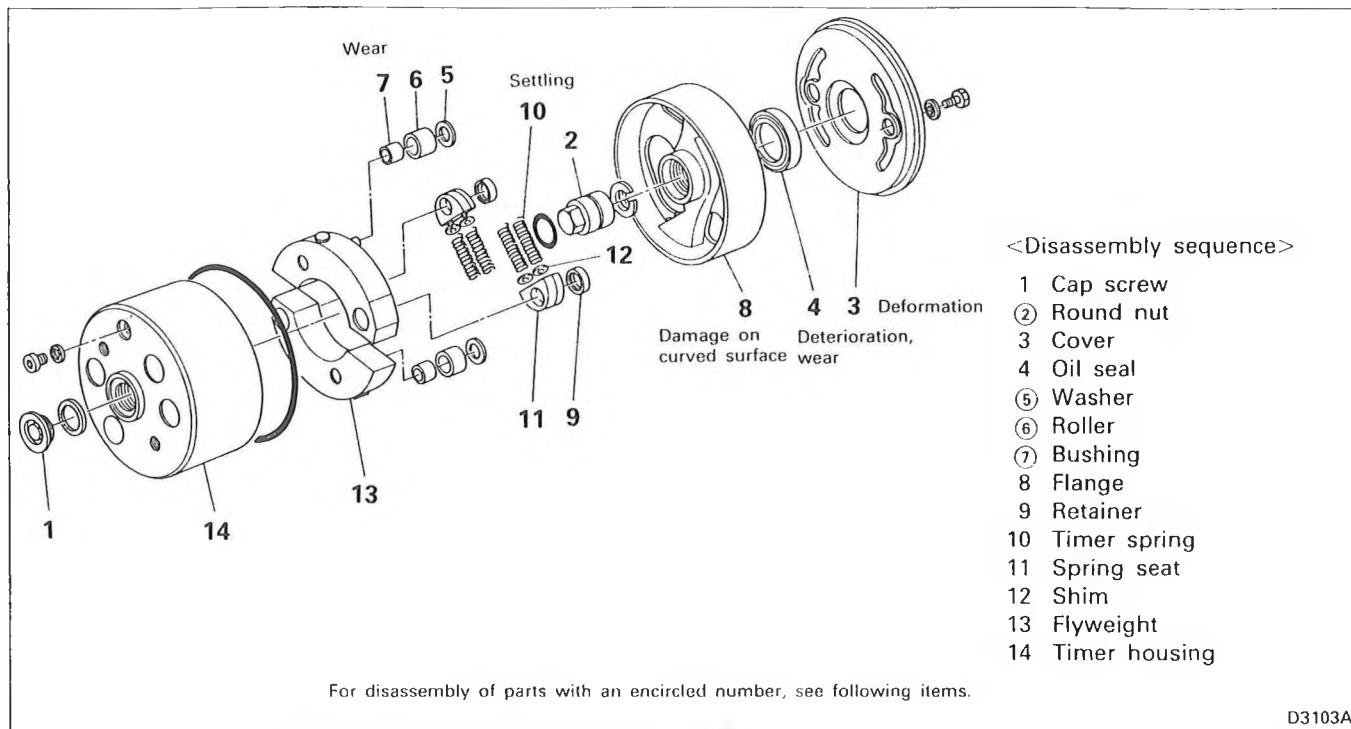
After grease has been injected, tighten the timer plug.



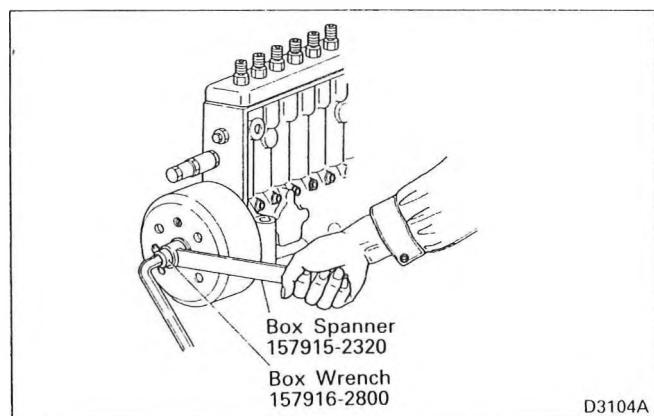
(j) After the automatic timer has been installed on the camshaft, fit Special Spanner (special tool) into the coupling mounting hole. While holding it to prevent turning, tighten the round nut to the specified torque.

5.4.2 SP Type Automatic Timer**(1) Disassembly and Inspection**

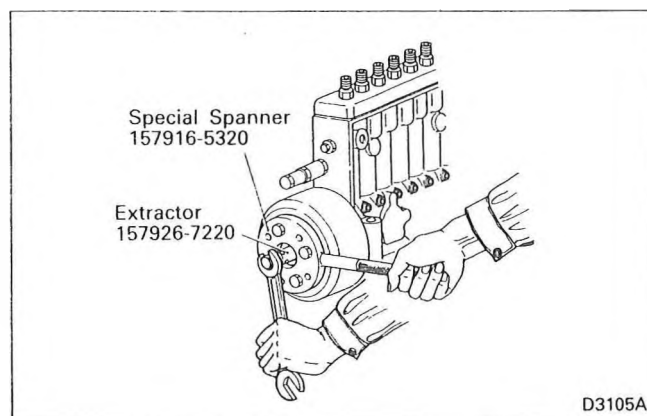
For disassembly and reassembly of the automatic timer, use the special tool, SP Type Automatic Timer Special Tool (105790-5050).



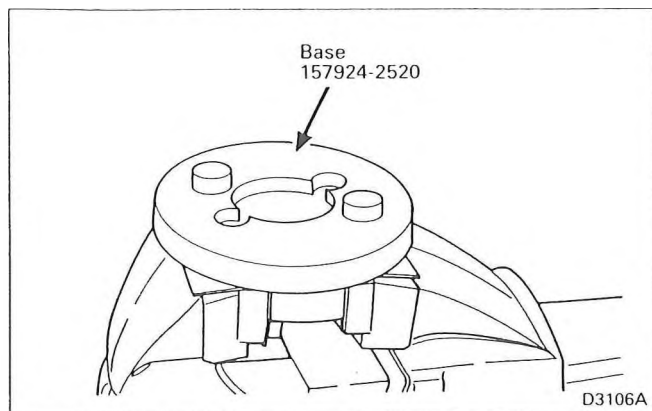
(a) Remove the coupling from the timer.



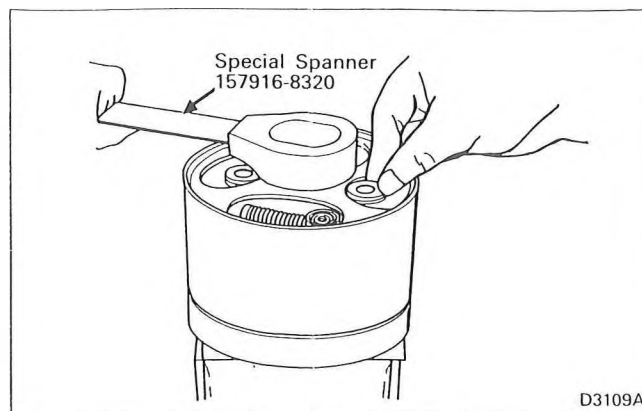
(b) Remove the cap screw of the timer. While using Box Spanner (special tool), remove the round nut with Box Wrench (special tool).



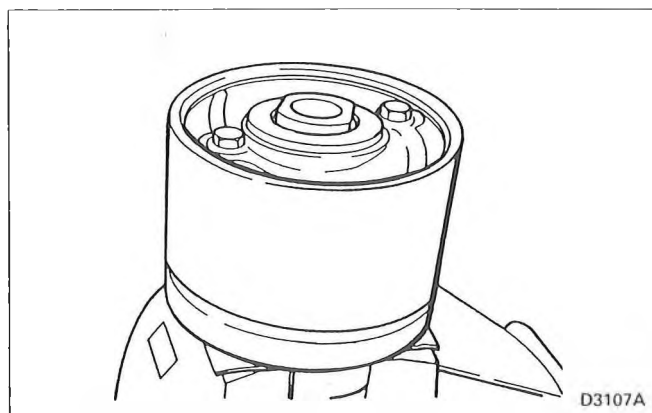
(c) Mount Special Spanner (special tool) by taking advantage of the coupling mounting thread. While holding it to prevent turning, remove the timer from the injection pump, using Extractor (special tool).



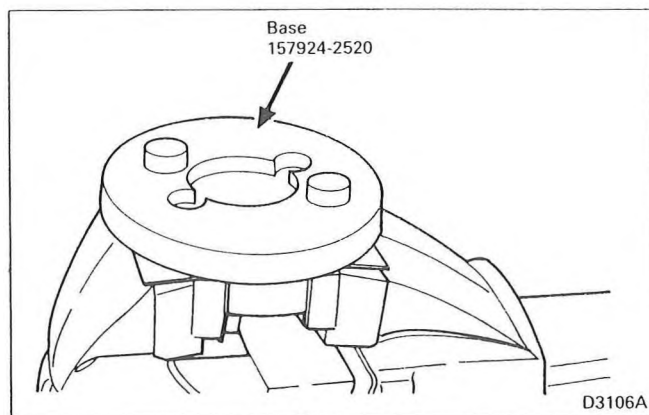
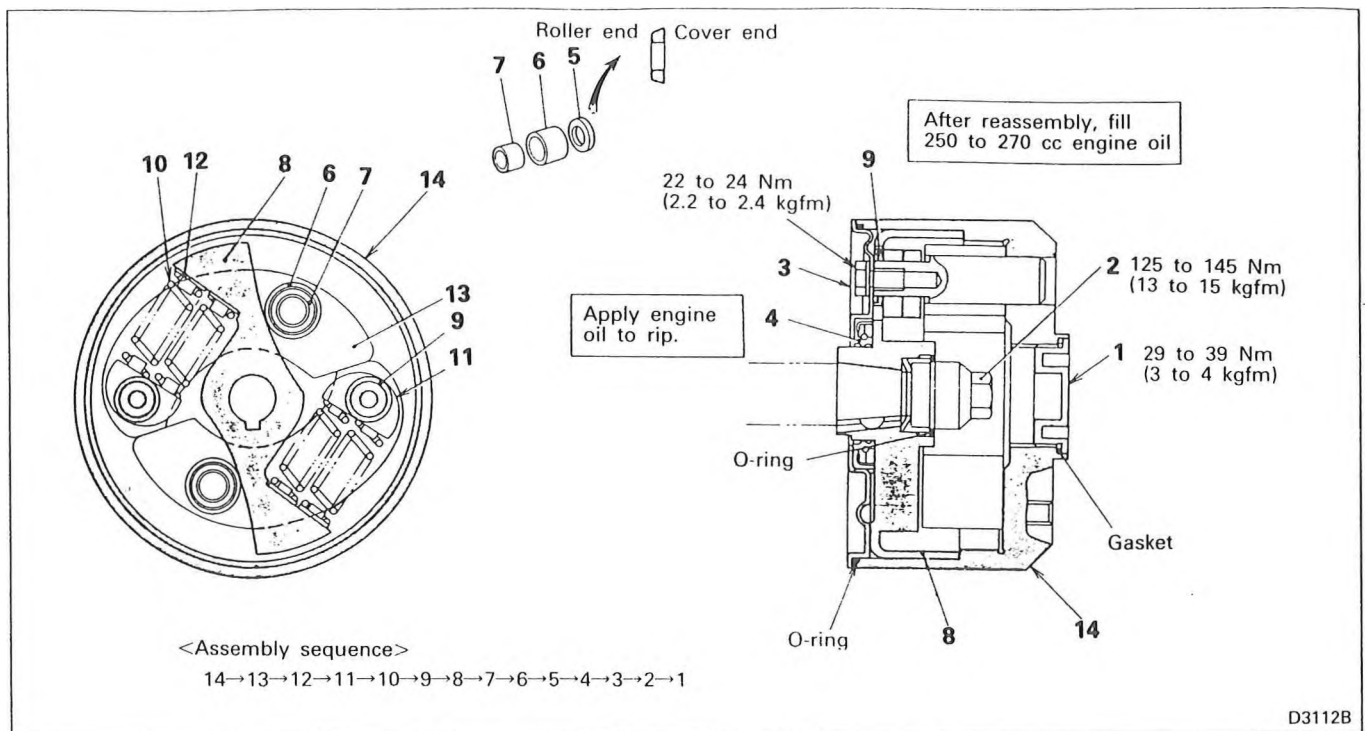
(d) Mount Base (special tool) in a vice.



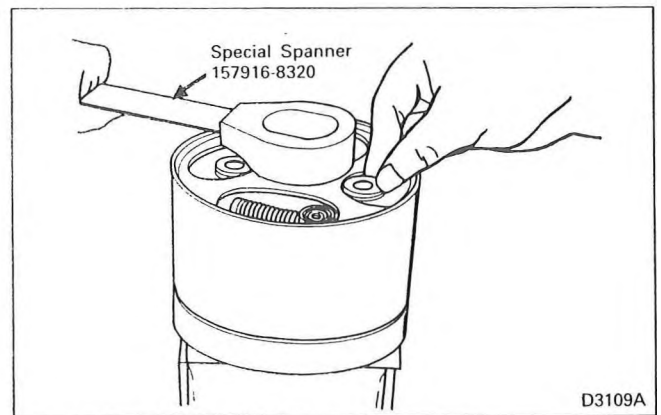
(f) Mount Special Spanner (special tool) to the flange. With the timer spring compressed, remove the washer, roller and bushing.



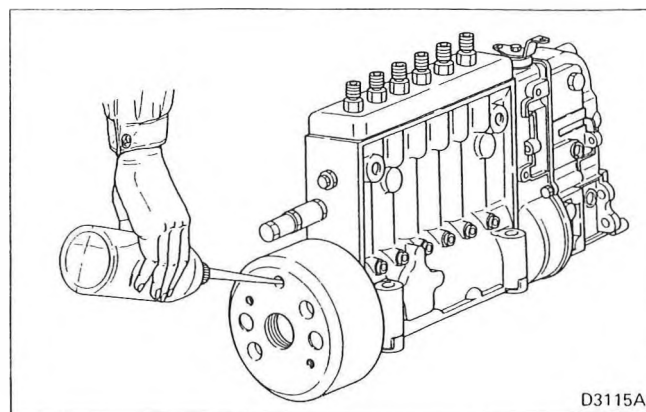
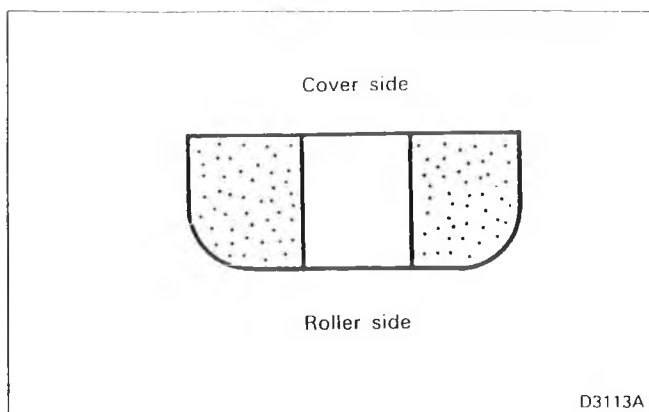
(e) Fix the timer to Base (special tool)

(2) Reassembly

(a) Mount Base (special tool) in a vice and secure the timer housing to the base.

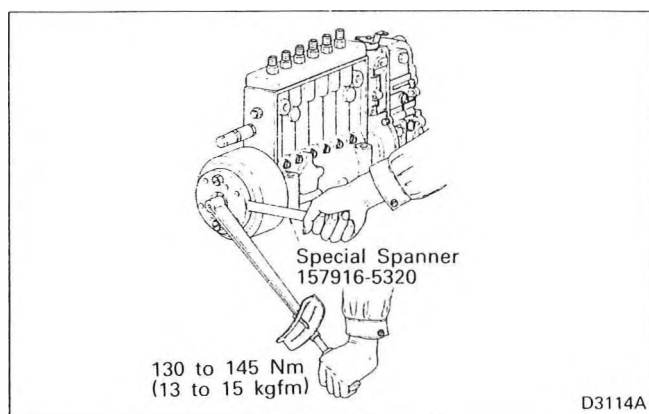


(b) Mount Special Spanner (special tool) to the flange. With the timer spring compressed, install the bushing, roller and washer.



NOTE:
When the washer is installed, direct it as shown.

(d) Remove the plug at the rear end of the timer and supply 250 to 270 cc of engine oil.

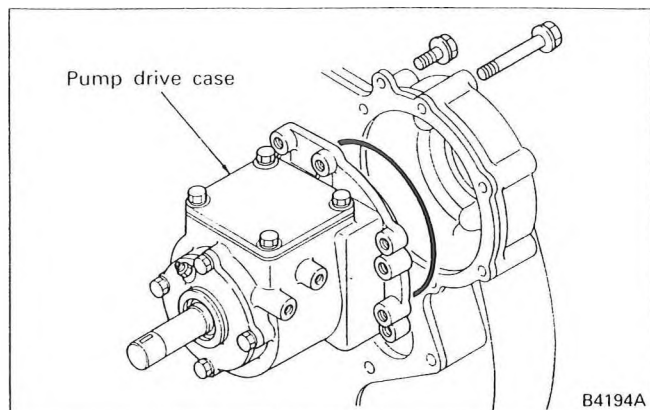


(c) Install the key to the injection pump camshaft and install the automatic timer. While using Special Spanner (special tool) to prevent turning, tighten the round nut to the specified torque.

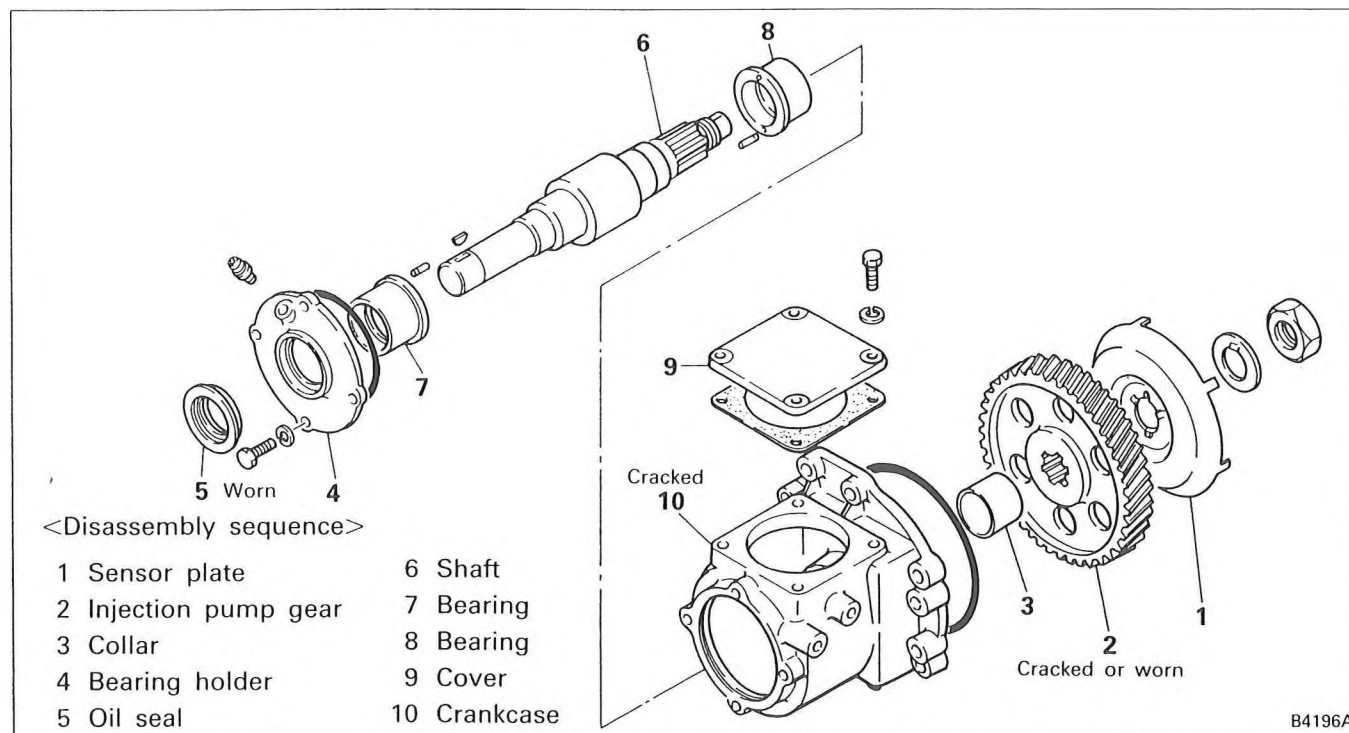
5.5 PUMP DRIVE CASE

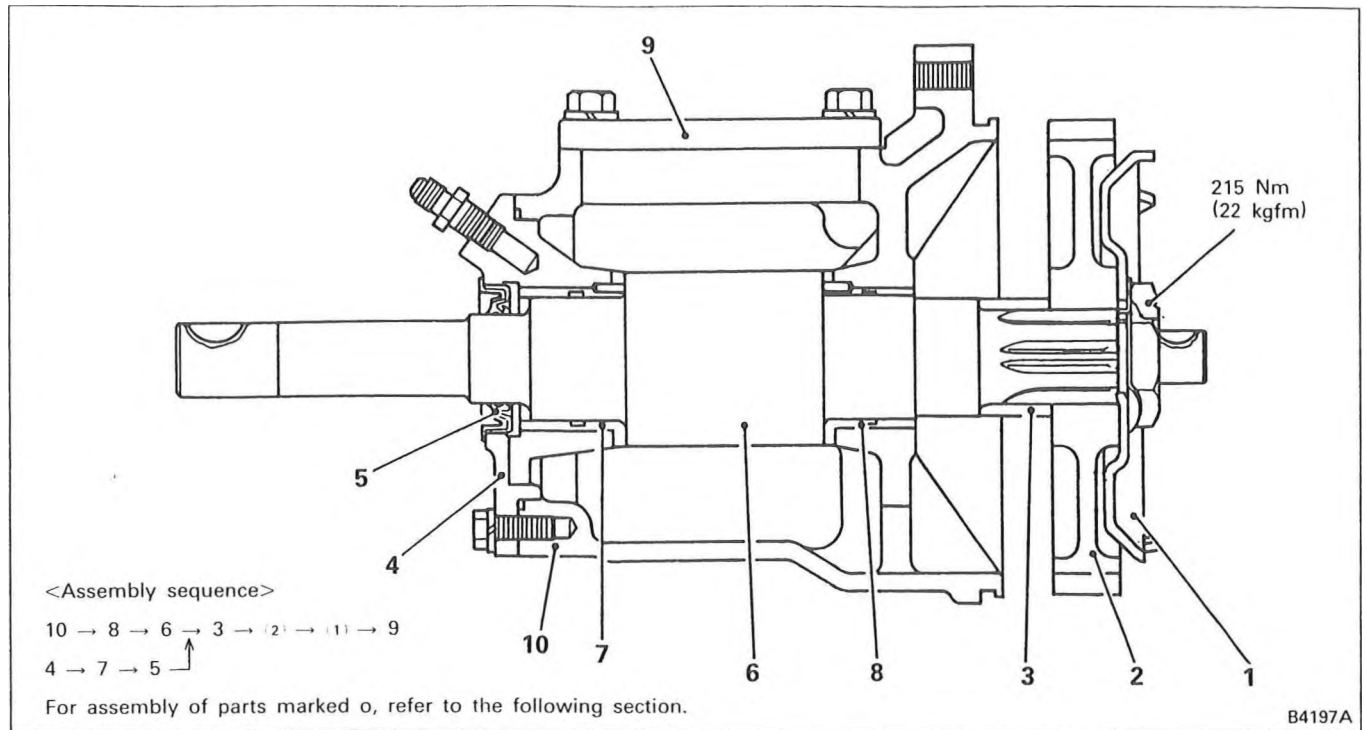
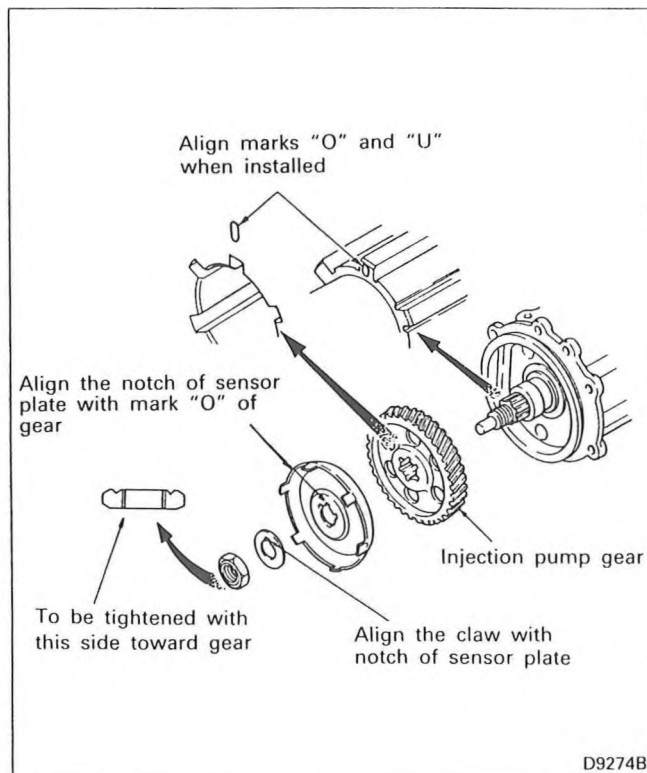
5.5.1 Removal and Installation

For removal and installation of the pump drive case, refer to 5.1.1 in Group 61 Special Equipment.



5.5.2 Disassembly and Inspection

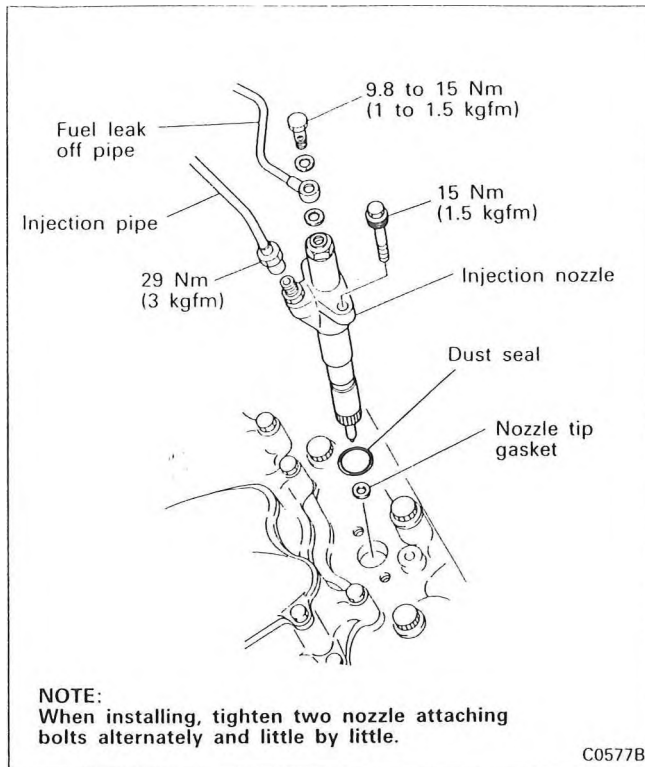


5.5.3 Reassembly**Installation of Injection Pump Gear**

Install the injection pump gear, sensor plate and nut as shown.

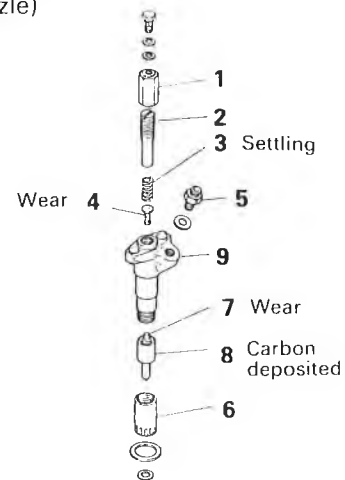
5.6 INJECTION NOZZLE

5.6.1 Removal and Installation



5.6.2 Disassembly

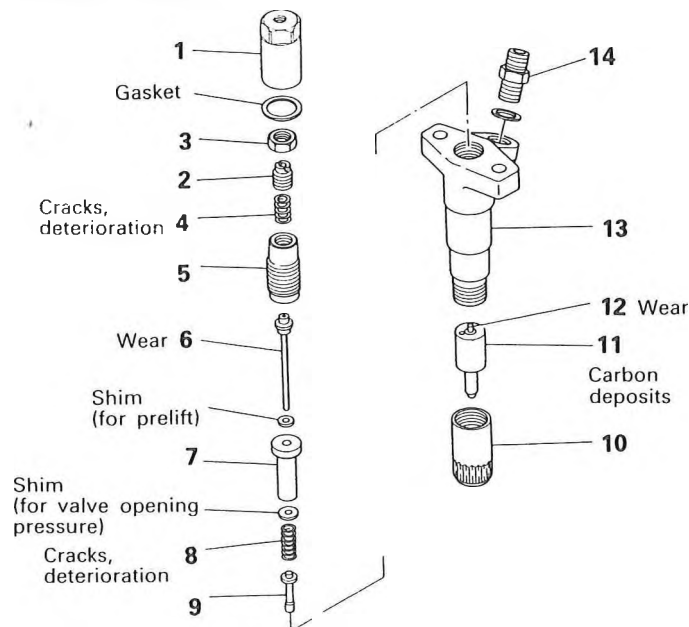
(1-spring nozzle)



Disassembly sequence

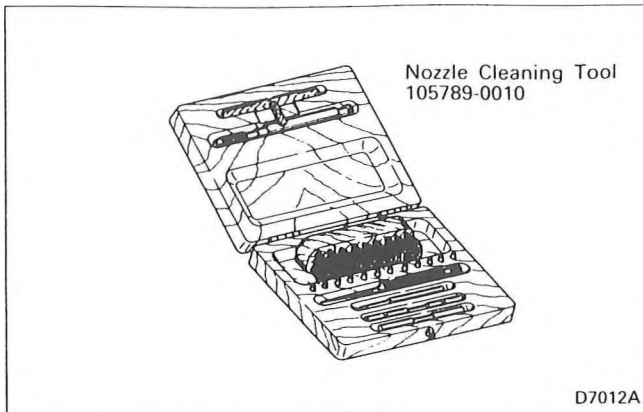
- | | |
|-------------------|-----------------|
| 1 Cap nut | 5 Connector |
| 2 Adjusting screw | 6 Retaining nut |
| 3 Spring | 7 Needle valve |
| 4 Push rod | 8 Nozzle |
| | 9 Nozzle holder |

(2-spring nozzle)



Disassembly sequence

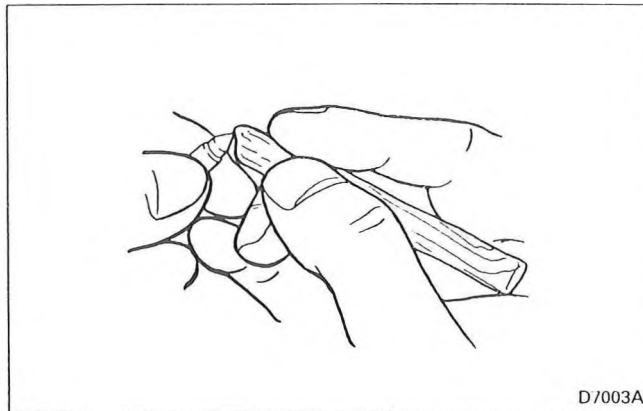
- | |
|-------------------|
| 1 Cap nut |
| 2 Adjusting screw |
| 3 Lock nut |
| 4 No. 2 spring |
| 5 Set screw |
| 6 No. 2 push rod |
| 7 Spacer |
| 8 No. 1 spring |
| 9 No. 1 push rod |
| 10 Retaining nut |
| 11 Nozzle |
| 12 Needle valve |
| 13 Nozzle holder |
| 14 Connector |

5.6.3 Cleaning and Inspection**(1) Cleaning**

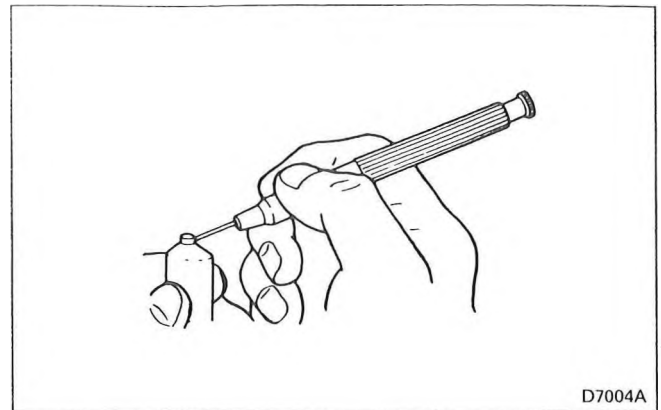
After washing the nozzle in gas oil, remove deposited carbon using the Nozzle Cleaning Tool (special tool) by the following procedures.

NOTE:

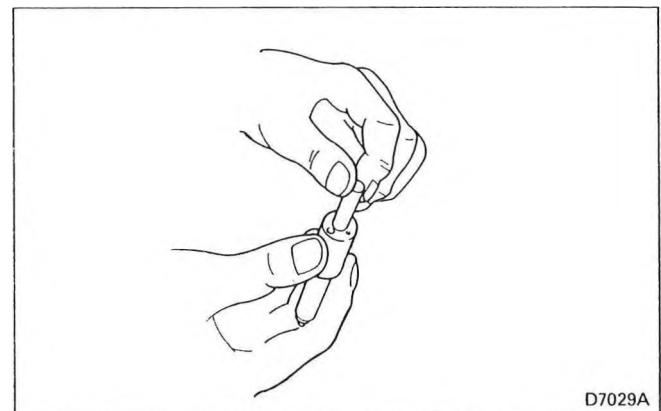
Never change the combination of the nozzle and needle valve.



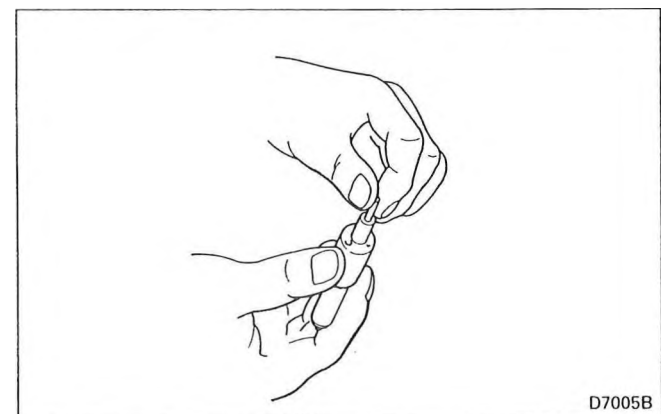
(a) Remove the needle valve from the nozzle and clean the needle valve with the needle valve cleaning wood piece.



(b) Insert, while turning, a cleaning needle into the injection orifice of the nozzle to remove carbon. Use the needle of proper size for injection orifice.



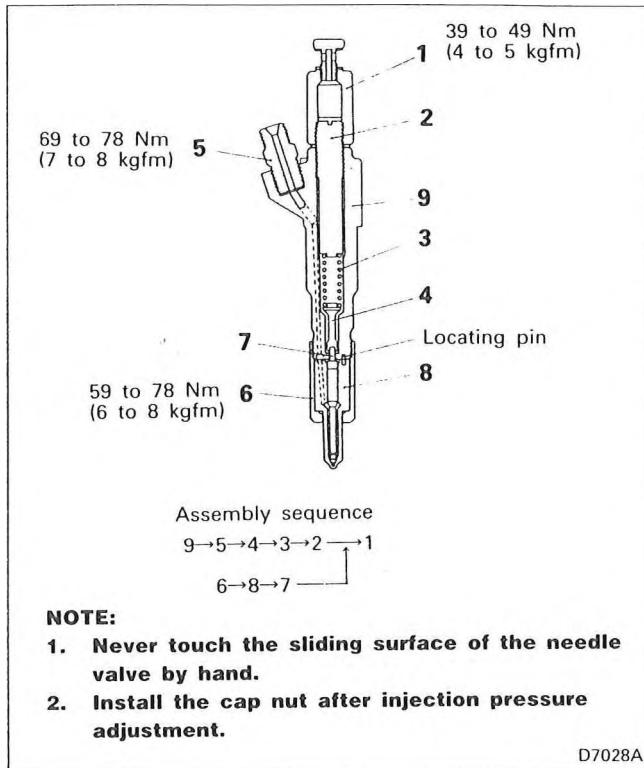
(c) Clean the nozzle seat using the cleaning needle.
(d) To remove burnt and hardened carbon, use FUSO Carbon Remover or equivalent.

(2) Inspection

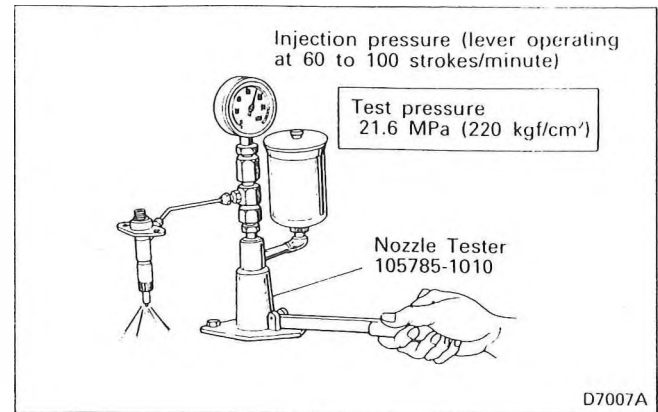
Clean and immerse the nozzle in gas oil, slide the needle valve and check that it moves smoothly.

Next, pull up the needle valve vertically about 1/3 of its entire stroke and check that it falls under its own weight. If it does not fall, replace the nozzle.

5.6.4 Reassembly and Adjustment (1-spring nozzle)



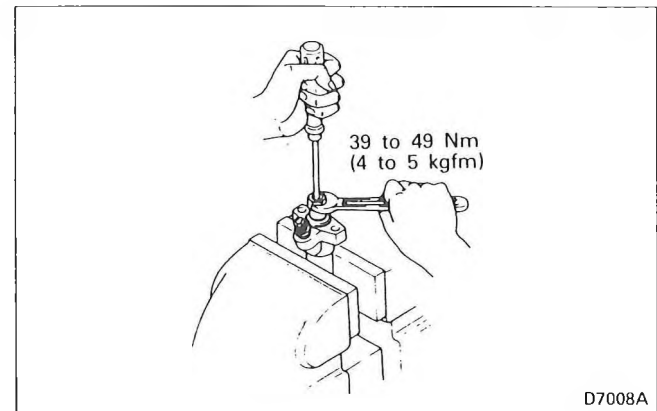
(1) Injection Pressure



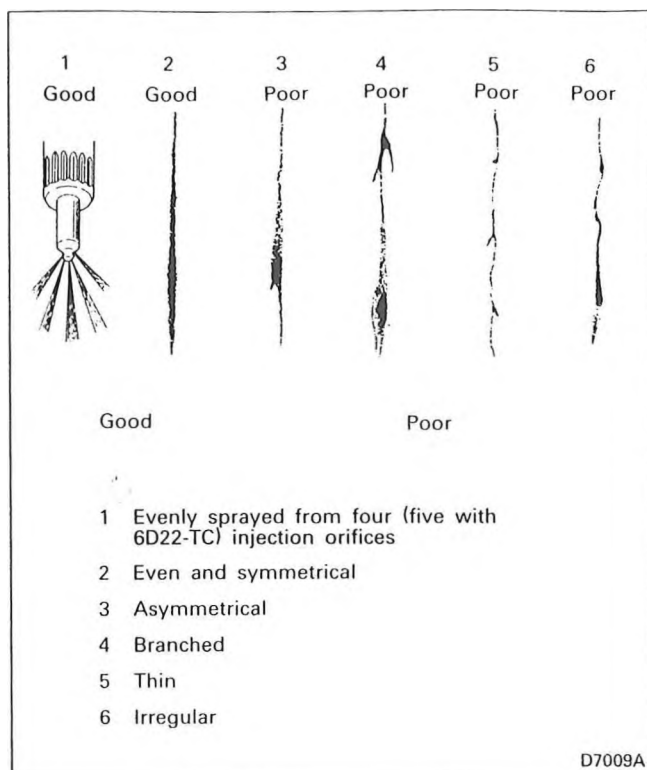
- (a) Remove the cap nut and install to the nozzle tester.
- (b) Loosen the adjusting screw and operate the nozzle tester two or three times for bleeding.
- (c) Operate the nozzle tester at specified speed, adjusting the adjusting screw for specified injection pressure.

NOTE:

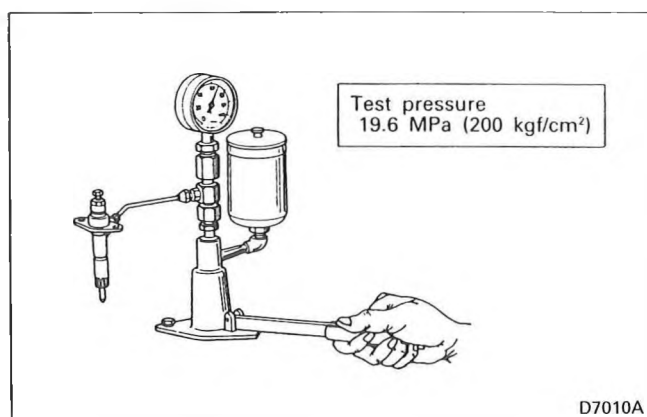
Never let yourself exposed directly to the atomized fuel injected from the nozzle.



- (d) After adjustment, tighten the cap nut to specified torque. Fix the adjusting screw with a screwdriver inserted through the cap nut hole to prevent turning of the adjusting screw.
- (e) After tightening the cap nut, check again the injection pressure.

(2) Spray Condition

When adjusting the pressure with a nozzle tester, check also for clogged injection orifices, spray condition, and fuel leaks from the orifices. Replace the nozzle if defective.

(3) Fuel Tightness Test

Install a nozzle that has been adjusted to specified injection start pressure to the nozzle tester. Slowly increase the pressure to the test pressure and keeping this condition, check for fuel leaks from the bottom of the nozzle. The nozzle is functioning normally if there is no leak.

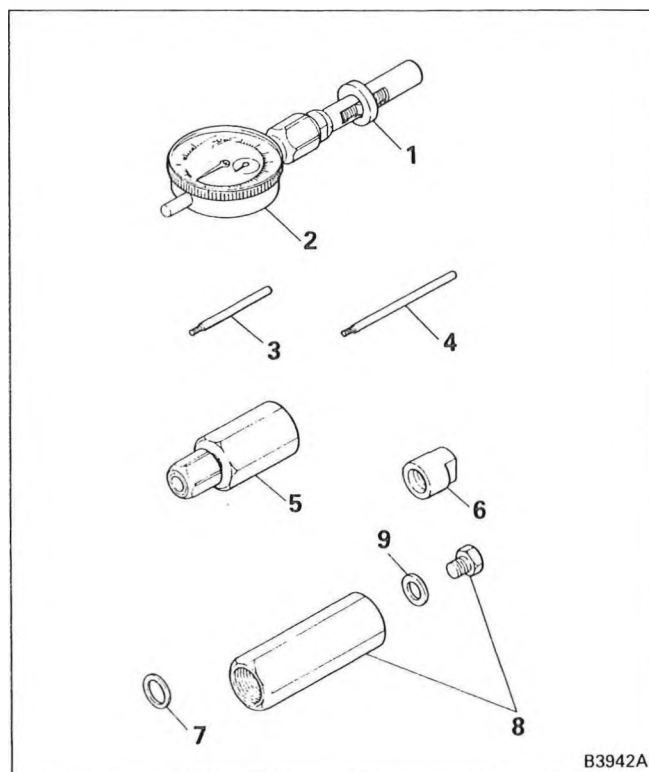
5.6.5 Reassembly and Adjustment (2-spring nozzle)

Adjust while assembling the parts by the following procedures.

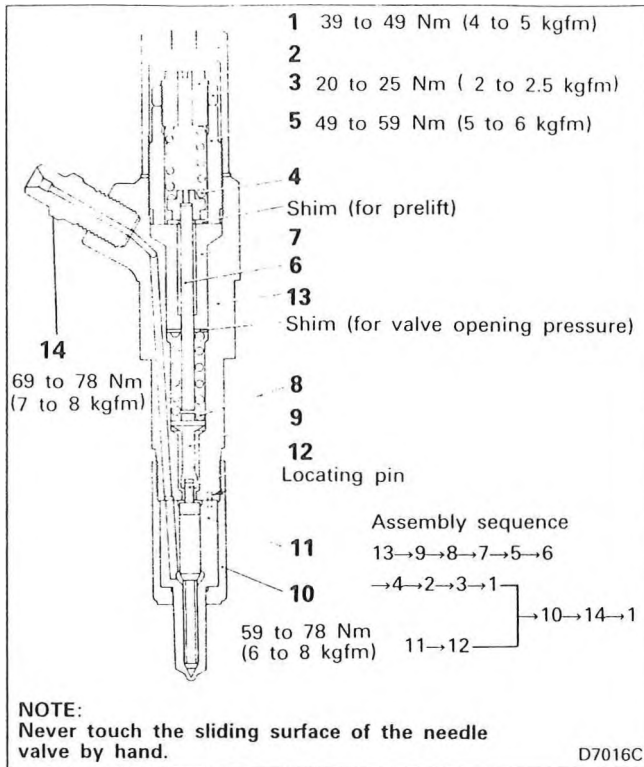
As the prelift is adjusted in 1/100 mm increments, use clean detergent to thoroughly remove dust and dirt before adjustment.

For adjustment, the following special tools are required.

Special tool	Diesel Kiki part No.
Nozzle tester (500 kg/cm²)	105785-1010
Adjusting device	105789-0500



1	Adjusting device assembly	157892-0220
2	Dial gauge	157954-3800
3	Pin, $l = 50$ mm	157892-1200
4	Pin, $l = 60.5$ mm	157892-1100
5	Connector assembly	157892-1320
6	Base	157892-1800
7	Gasket (for retaining nut)	157892-1500
8	Retaining nut for adjustment	157892-1420
9	Gasket (for bolt of retaining nut)	026508-1140

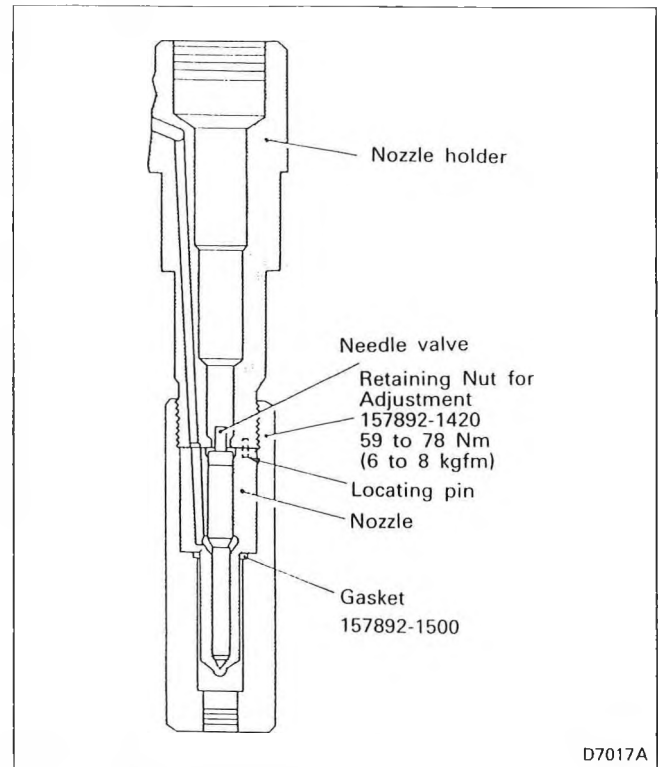


Adjusting steps

- ① Adjustment of nozzle opening pressure
- ② Selection of prelift adjusting shims
- ③ Adjustment of 2-spring adjusting pressure
- *④ Check of needle valve full lift
- ⑤ Installation of prelift shims
- *⑥ Checking of prelift
- *⑦ Checking of 2-spring adjusting pressure
- ⑧ Inspection

Inspection make operations marked with * as necessary for inspection or confirmation.

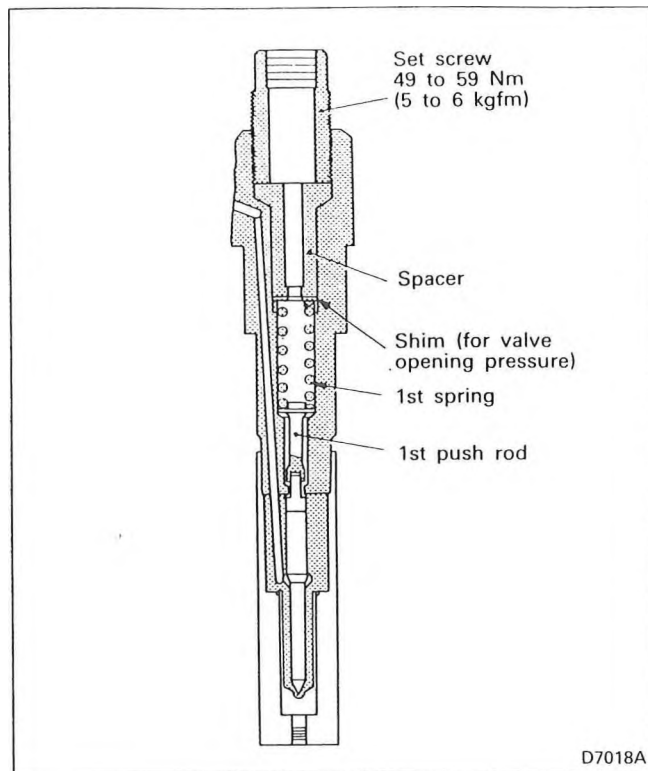
(1) Adjustment of Nozzle Valve Opening Pressure



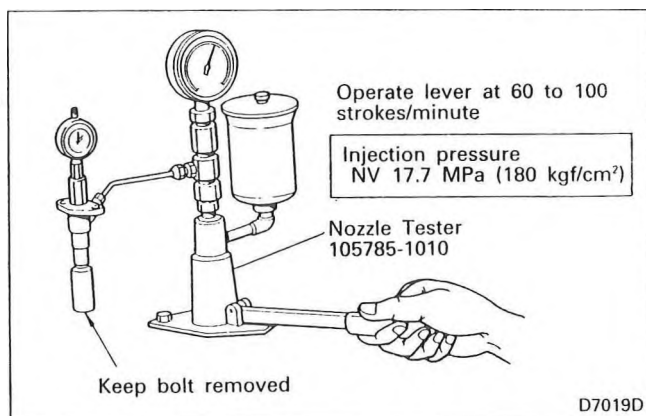
(a) Using the Retaining Nut for Adjustment (special tool) install the nozzle and needle valve to the nozzle holder.

NOTE:

1. Make sure that the knock pin has seated completely in the nozzle before tightening the retaining nut for adjustment. Tighten the retaining nut finger tight and then tighten to specified torque using a torque wrench.
2. Remove the bolt from the tip of the retaining nut.



(b) Insert 1st push rod 1st spring, valve opening pressure adjusting shim (first use about 1 mm thick one) and spacer to the nozzle holder. Then tighten the setscrew to specified torque.



(c) Install the nozzle holder to the Nozzle Tester (special tool) and adjust the shim thickness for nominal injection pressure.

Shim types:

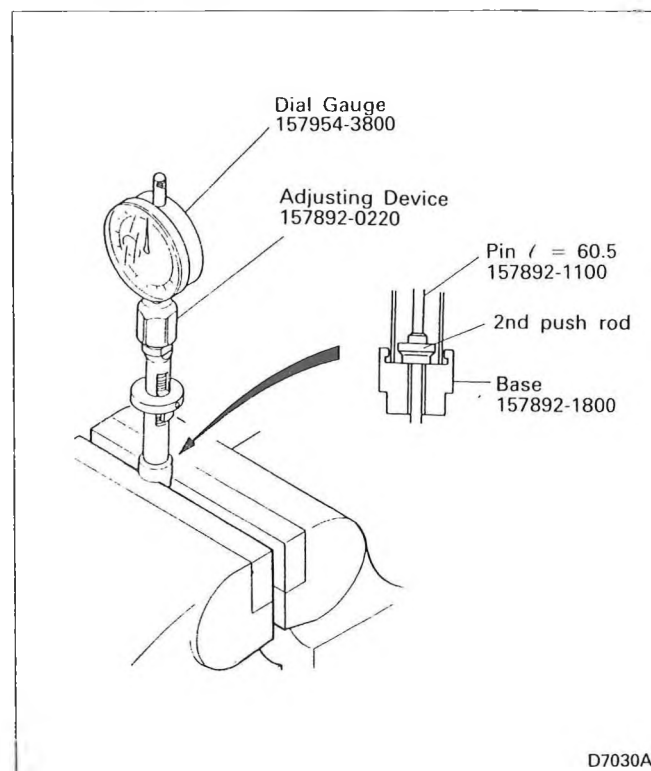
0.50 to 1.54 mm (by 0.02 mm)

NOTE:

1. When using a shim, be sure to check its thickness by a micrometer.
2. Use same shim for prelift adjustment.
3. Use of a 0.02 mm thick shim changes the valve opening pressure by about 235 kPa (2.4 kgf/cm²)

(2) Selection of Prelift Adjusting Shim

(a) 0 point adjustment of adjusting device



Install the Dial Gauge (special tool) to the Adjusting Device (special tool).

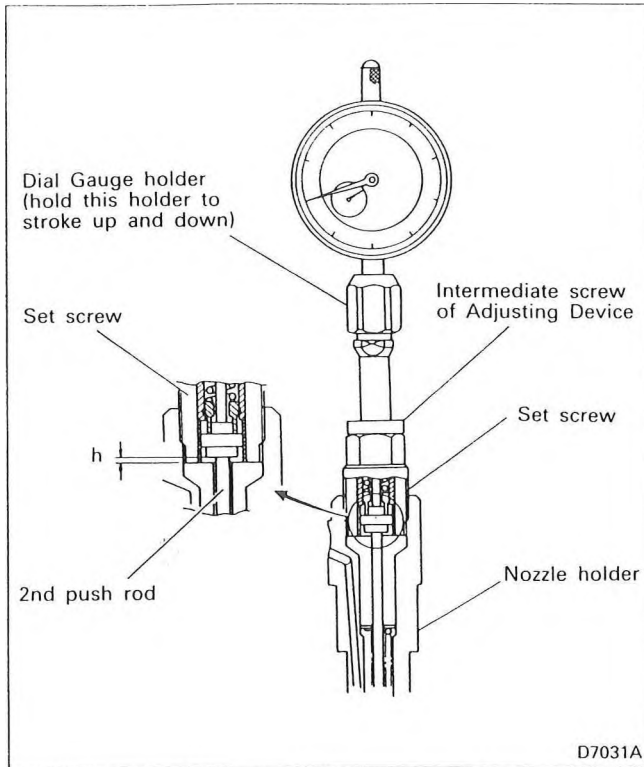
Install the 2nd push rod to the Base (special tool) and install the assembly to a vice.

Set the pin and adjusting device as indicated in the above illustration and adjust 0 point of the dial gauge. Use a 60.5 mm long pin.

(b) Install the 2nd push rod to the nozzle holder.

NOTE:

Do not install the 2nd spring and prelift adjusting shim.



(c) Install the adjusting device to the set screw using its intermediate screw.
After installation, holding the dial gauge at its holder, move it up and down to check that the gauge operates smoothly.
Push down the gauge, holding its holder and read its lift h .

NOTE:
Read to 1/100 mm.

(d) Selection of prelift adjusting shim

$$t = \ell + h$$

Where t : Shim thickness (measured)

ℓ : Prelift (0.10 + 0.02 mm)

h : Dimension selected in (c)

$$T = t \pm 0.015 \text{ mm}$$

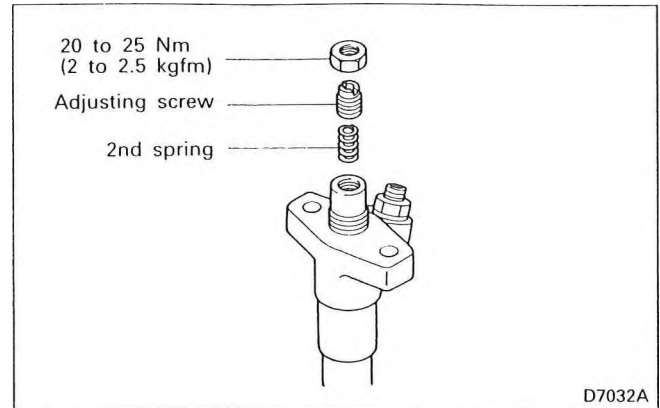
T : Thickness of shim to be used

Type of shims

0.75 to 1.50 mm (by 0.01 mm)

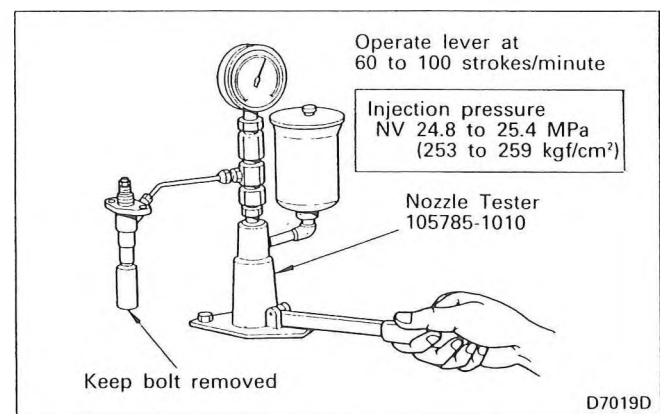
(e) Remove the adjusting device from the nozzle holder.

(3) Adjustment of 2-spring Adjusting Pressure



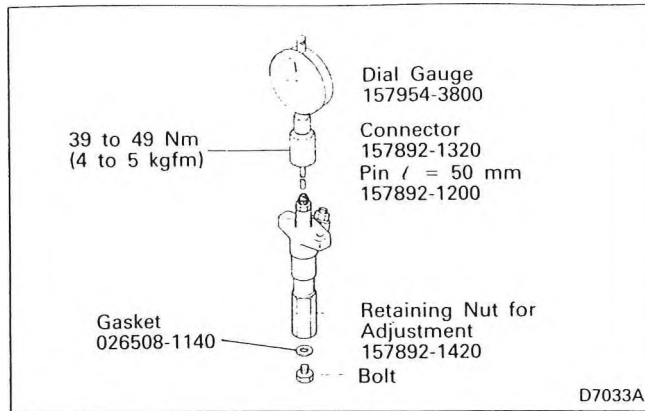
Install the 2nd spring, adjusting screw and lock nut to the nozzle holder.

NOTE:
Do not install the prelift adjusting shim.

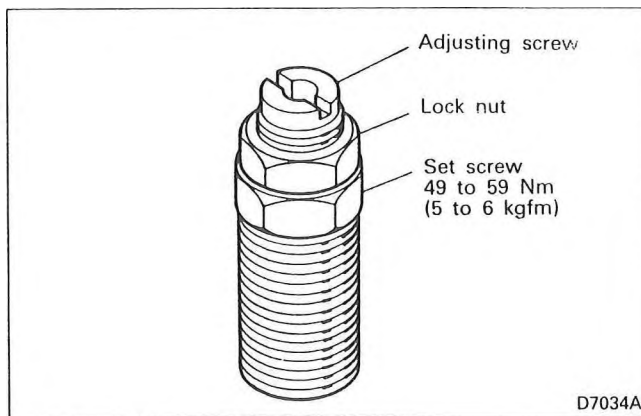


Adjust the 2-spring adjusting pressure (open pressure) to the nominal value, using the adjusting screw and nozzle tester.

After adjustment, tighten the lock nut to specified torque.

(4) Checking Full Lift of Needle Valve

- Install the special tools indicated in above illustration and set 0 point of the Dial Gauge.
- Install the nozzle to the nozzle tester and operate the tester lever to bleed the inside of the retaining nut. Also check for fuel leaks.
- Operate the tester lever to increase the pressure to about 34.5 to 44 MPa (350 to 450 kgf/cm²) so that the needle valve of the nozzle is fully lifted. Read this lift dimension "L" off the dial gauge.
- Remove the Dial Gauge, Connector and Pin (special tool).

(5) Installation of Prelift Shim

- Remove the setscrew, lock nut and adjusting screw as an assembly from the nozzle holder.

NOTE:

Never loosen the lock nut as loosening it changes the 2-spring adjusting pressure.

- Install the prelift shim selected in (2) between the spacer and 2nd push rod.
- Install the 2nd push rod and 2nd spring and tighten the setscrew, lock nut and adjusting screw as an assembly to specified torque.
- Check again that the needle valve full lift dimension "S" with the dial gauge by the procedures described in (4).

(6) Checking Prelift

Check the prelift based on dimension "L" measured in (4) and dimension "S" measured in (5).

$$L - S = \Delta \ell$$

$$\text{where } \ell - 0.02 < \Delta \ell < \ell + 0.02 \text{ mm}$$

$\Delta \ell$: Prelift (measured)

ℓ : Prelift (0.1 mm)

L: Needle valve full lift dimension (measured)

S: Needle valve lift dimension (measured) with prelift subtracted

If $\Delta \ell$ is outside of specified dimension $\ell \pm 0.02$ mm, replace the prelift adjusting shim as described in (5) and repeat steps (4) and (5) so that $\Delta \ell$ will fall within $\ell \pm 0.02$ mm.

Select thickness t' of shim to be used as follows.

$$t' = t + (\ell - \Delta \ell)$$

$$T = t' \pm 0.015 \text{ mm}$$

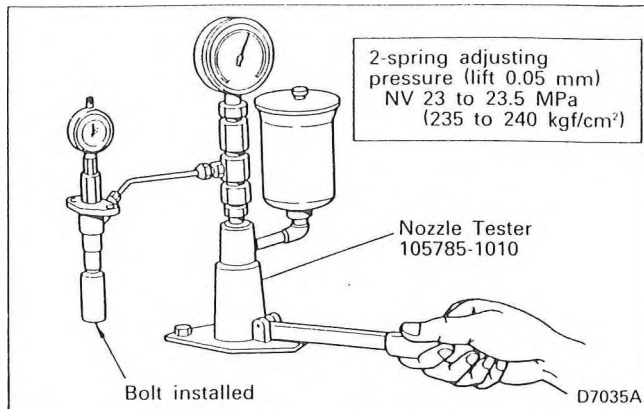
where t: Thickness of existing shim

t' : Shim thickness

T: Thickness of shim to actually replace existing shim

ℓ : Prelift (0.1 mm)

(7) Checking Adjusting Allowance of 2-spring



(a) After checking the prelift in Item (6), increase the pressure again to about 34.5 to 44 MPa (350 to 450 kgf/cm²) so that the needle valve of the nozzle is fully lifted.

NOTE:

The Retaining Nut for Adjustment (special tool) must have a bolt fitted at its tip.

(b) When the nozzle tester lever operation is stopped with the nozzle needle valve fully lifted, the pressure will start to drop and the needle valve will go down.

(c) At the moment the nozzle lift has dropped to 0.05 mm, read the pressure gauge indication.

(d) If the 2-spring adjusting pressure (cover pressure) is out of specification, adjust the 2-spring adjusting pressure as described in (3).

NOTE:

Adjust without installing prelift shim.

(e) Remove special tools.

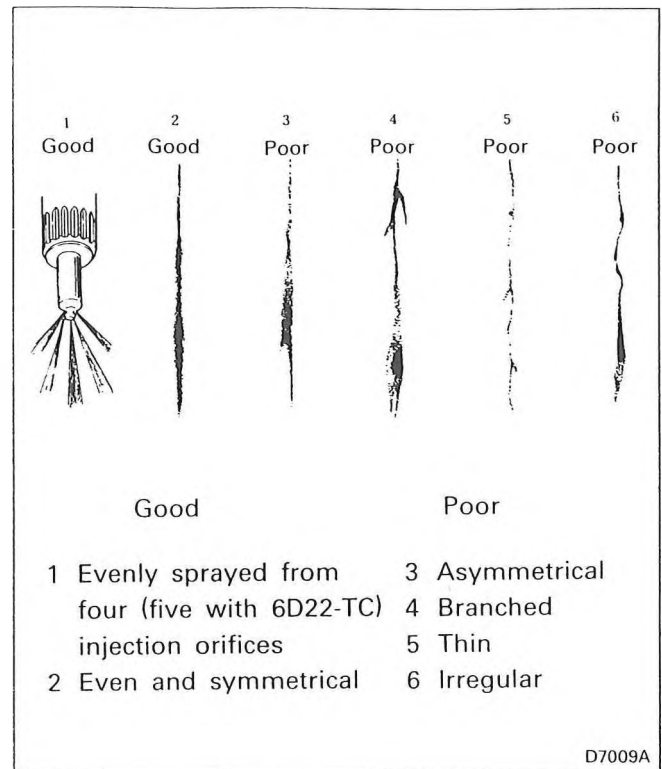
(8) Inspection

(a) Tighten the retaining nut and cap nut to specified torque.

NOTE:

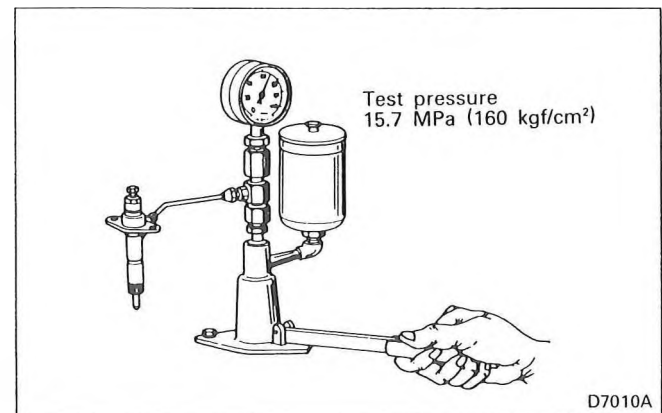
1. **Make sure that the knock pin has seated completely before tightening the retaining nut.**
2. **Tighten the retaining nut finger tight and then tighten to specified torque using a torque wrench.**

(b) Spray condition



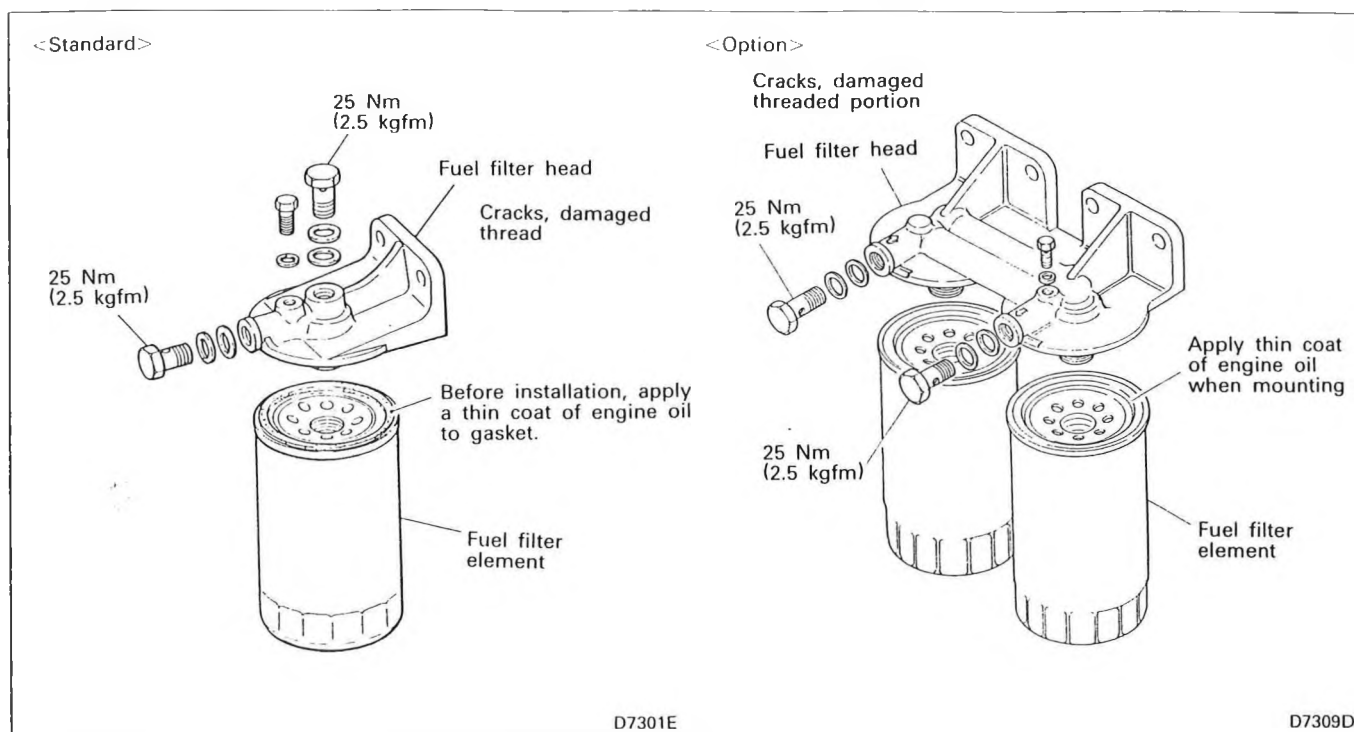
When adjusting the pressure with a nozzle tester, check also for clogged injection orifices, spray condition, and fuel leaks from the orifices. Replace the nozzle if defective.

(c) Fuel tightness test

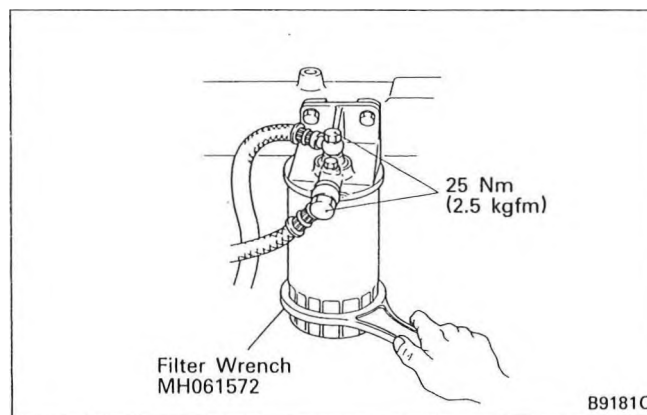


Install a nozzle that has been adjusted to specified injection start pressure to the nozzle tester. Slowly increase the pressure to the test pressure and keeping this condition, check for fuel leaks from the bottom of the nozzle. The nozzle is functioning normally if there is no leak.

5.7 FUEL FILTER

**NOTE:**

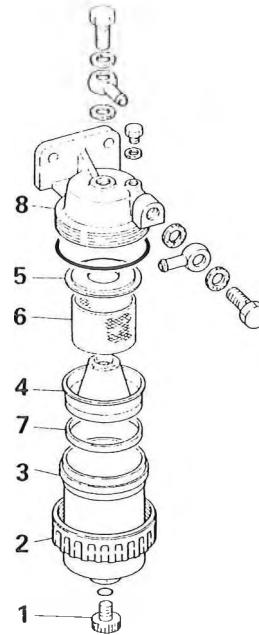
1. When removing the element, check for the gasket left behind on the head side.
2. To mount, apply a thin coat of engine oil to the gasket, and then secure the element by tightening $\frac{3}{4}$ to 1 turn after the gasket comes in contact with the fuel filter head.
3. After installation, bleed the fuel system.
4. After bleeding the air, start the engine and check for fuel leaks.



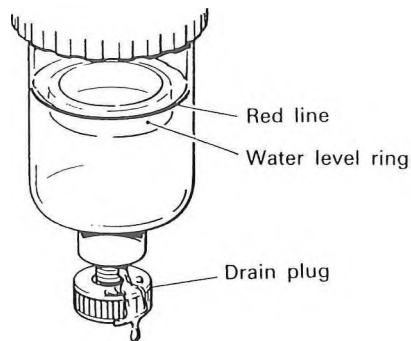
To remove the element, use Filter Wrench (special tool).

5.8 WATER SEPARATOR

- 1 Drain plug
- 2 Ring nut
- 3 Case
- 4 Baffle plate
- 5 Isolation plate
- 6 Screen assembly
- 7 Water level ring
- 8 Cover



D7405C



D7404A

If the red water level ring 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 not 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.

6. TROUBLESHOOTING

Symptom	Probable cause	Remedy	Ref. group
Engine is hard to start	Defective feed pump		
	• Clogged gauze filter	Clean	
	• Check valve inoperative	Replace	
	• Binding or worn piston	Replace	
	• Binding push rod	Replace	
	• Worn tappet	Replace	
	Defective injection pump		
	• Binding or worn plunger	Replace	
	• Binding control rack or control rod	Replace	
	• Binding delivery valve	Replace	
	• Worn tappet	Replace	
	• Worn camshaft	Replace	
	Defective injection nozzle		
Engine stops immediately after starting	• Binding needle valve	Replace	
	• Valve opening pressure too low	Adjust	
	• Clogged injection orifice	Clean	
	• Nozzle not air-tight	Correct or replace	
	Fuel tank empty	Supply fuel	
	Clogged fuel pipe or fuel leak from connections	Correct or replace	
	Air or water trapped in fuel system	Bleed or replace	Group 11
	Clogged fuel filter or secondary filter	Replace	
	Clogged fuel filter or secondary filter	Replace	
	Air or water trapped in fuel system	Bleed or replace	Group 11
	Defective feed pump	Check	
	Defective injection pump		
	• Incorrect injection timing	Adjust	
Engine knocks	• Worn plunger	Replace	
	• Defective valve seat of delivery valve	Replace	
	Defective injection nozzle		
	• Valve opening pressure too high	Adjust	
Smoky exhaust gas and engine knocking	• Clogged injection orifice	Clean	
	• Nozzle not air-tight	Correct or replace	
	Poor quality fuel in use	Replace	
	Defective injection pump		

Symptom	Probable cause	Remedy	Ref. group
Smoky exhaust gas and engine knocking	Poor quality fuel in use	Replace	
	Defective injection nozzle		
	• Valve opening pressure too low	Adjust	
	• Broken spring	Replace	
Unstable engine output	• Clogged injection orifice	Clean	
	Defective injection pump		
	• Insufficient plunger sliding stroke	Replace	
	• Broken plunger spring	Replace	
	• Control rack or control rod not sliding smoothly	Correct	
	• Worn or sticky tappet	Replace	
	• Broken delivery valve spring	Replace	
	• Loss of air-tightness due to loose delivery valve holder	Correct	
	• Delivery valve not functioning normally	Replace	
	Defective injection nozzle		
	• Needle valve not sliding smoothly	Replace	
	• Broken spring	Replace	
	• Valve opening pressure too low	Adjust	
	Defective feed pump		
	• Check valve not functioning normally	Replace	
	• Worn piston	Replace	
	Air or water trapped in fuel system	Bleed or replace	Group 11
	Clogged fuel filter or secondary filter	Replace	
	Incorrect injection timing	Adjust	
	Control lever not in contact with full speed set bolt	Adjust	
Loss of engine output	Defective injection nozzle		
	• Nozzle not air-tight	Correct or replace	
	• Broken spring	Replace	
	• Clogged injection orifice	Clean	
	Defective injection pump		
	• Worn plunger	Replace	
Loss of engine output	• (Broken) Damaged delivery valve spring	Replace	
	• Defective delivery valve seat	Replace	
	• Loss of air-tightness due to loose delivery valve holder	Correct	
	Defective governor		
	• Too early rotation control due to weak governor spring	Adjust	
	• Faulty full load stopper position	Adjust	
	• Adjusting lever (or load control lever) poorly adjusted	Adjust	
	Poorly adjusted injection timing	Adjust	
	Incorrect timing advance of automatic timer	Adjust	
	Poor quality fuel in use	Replace	

Symptom	Probable cause	Remedy	Ref. group
Engine cannot develop maximum speed	Defective governor		
	• Governor spring too weak	Adjust	
	• Adjusting lever (or load control lever) poorly adjusted	Adjust	
	Defective injection nozzle		
	• Clogged injection orifice	Clean	
Engine maximum speed to high	• Nozzle not air-tight	Correct or replace	
	• Valve opening pressure too low	Adjust	
	Injection pump control rack or control rod not sliding smoothly	Correct	
	Defective governor		
	• Governor spring too weak	Adjust	
Idling is not smooth	• Flyweight not functioning effectively	Correct	
	Defective injection pump		
	• Binding, sticky or worn plunger	Replace	
	• Loose control pinion	Correct	
	• Plunger spring not seating correctly	Replace	
	• Delivery valve holder too tight	Correct	
	• Uneven fuel injection rate among cylinders	Adjust	
	• Broken plunger spring	Replace	
	• Air or water trapped in fuel system	Bleed or replace	Group 11
	Defective governor		
	• Idling spring too weak	Adjust	
	• Bent linkage	Correct	
	• Large friction or play in linkage	Replace	
	• Loose round nut	Correct	
	• Poorly adjusted idling set bolt	Adjust	
Idling is not smooth	Defective feed pump		
	• Defective check valve	Replace	
	• Worn piston	Replace	
	• Clogged gauze filter	Clean	
	Clogged fuel filter or secondary filter	Replace	
	Poorly adjusted injection timing	Adjust	
	Defective automatic timer	Correct	
	Defective injection nozzle		
	• Clogged injection orifice	Clean	
	• Weak spring	Replace	
Engine will not stop	• Nozzle not air-tight	Correct or replace	
	Broken or elongated engine stop cable	Replace	
	Engine stop cable poorly adjusted	Adjust	
Poor supply of fuel	Damaged governor stop mechanism	Replace	
	Cracked fuel hose or pipe	Replace	
	Fuel tank not air-tight	Replace	

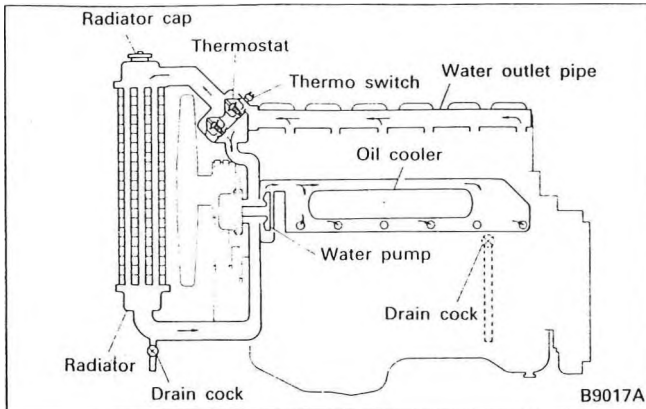
COOLING

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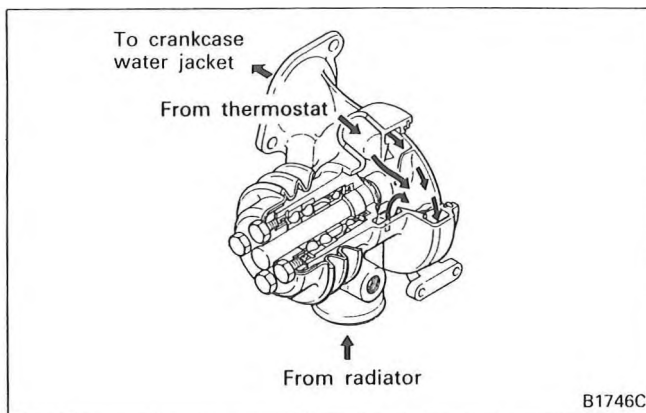
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1. GENERAL

The engine is cooled by forced circulation of coolant by the water pump. The illustration below shows the coolant flow.



(1) Water Pump

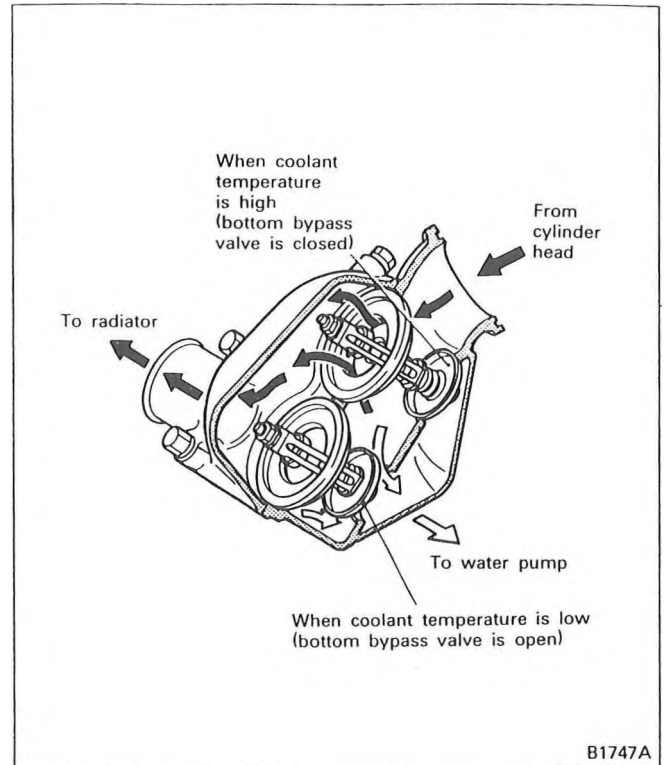


The water pump is a centrifugal pump. Mounted on the left side of the crankcase, the pump is driven by the crankshaft pulley via a V-belt.

An impeller having a blade is mounted at one end of the water pump shaft and coolant is sealed off by a unit seal.

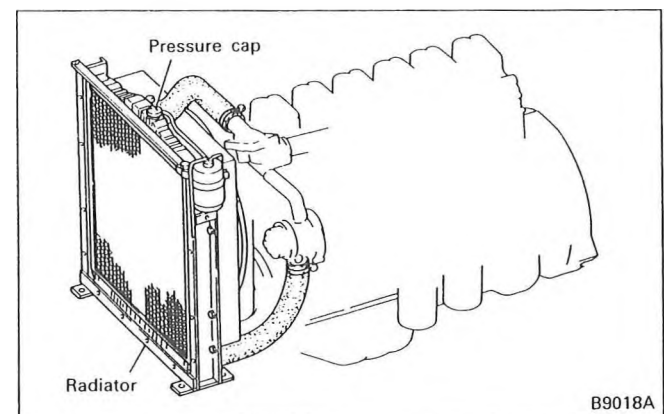
For lubrication of the water pump, refer to "Group 12 Lubrication".

(2) Thermostat



The thermostat is a bottom bypass type with a special wax enclosed in a pellet. When the wax is heated, it changes from solid to liquid and its volume also changes. This change in volume changes the opening of the valve and changes the quantity of coolant flowing into the radiator and water pump (bypass side), thereby controlling the coolant temperature.

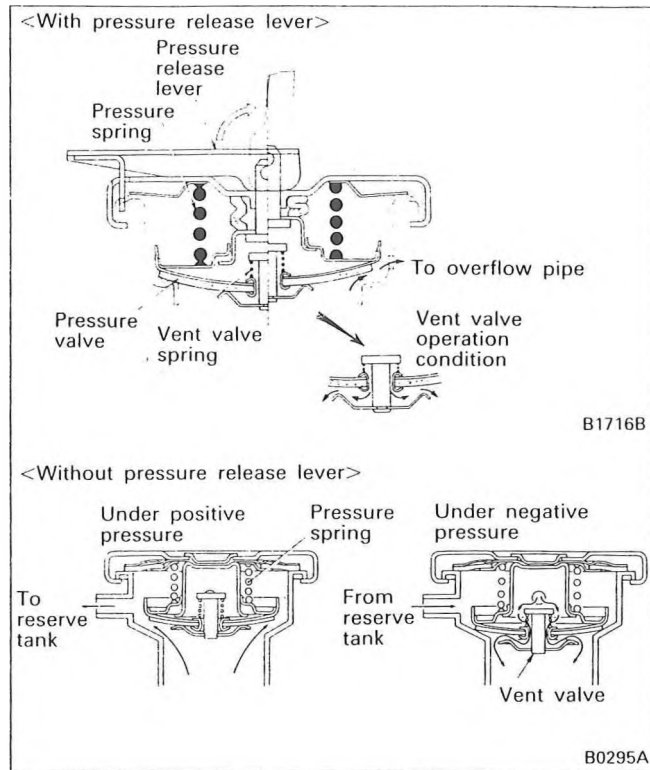
(3) Radiator



The radiator cooling capacity varies depending on applications (installation in an enclosed generator room of a building, operation in stationary state, etc.).

Considerations are, therefore, paid to the fan diameter, radiator capacity and other factors. Some units for construction plants are equipped with an oil cooler to cool hydraulic oil.

(4) Pressure Cap



The pressure cap regulates the pressure in the cooling system. When the pressure builds up in the system that exceeds a predetermined level, the pressure valve compresses the pressure spring, releasing the excessive pressure through the overflow pipe into the atmosphere.

If equipped with a reserve tank, the coolant that has overflowed is channeled into it.

When the coolant temperature drops and negative pressure builds up in the system, the vent valve opens to take in air to prevent the radiator from becoming deformed.

If equipped with a reserve tank, coolant is taken from the reserve tank to prevent the radiator from becoming deformed and to keep the quantity of coolant in the system constant.

If equipped with a pressure release lever on the cap, raising the lever upright opens the pressure valve and releases the pressure in the cooling system.

2. SPECIFICATIONS

Item		Specification
Cooling method		Water-cooled, forced circulation
Cooling water quantity (Engine proper)		6D22, 6D22-T: 22 lit. 6D22-TC: 24 lit.
Water pump	Type	Centrifugal type
	Drive	V-belt drive
V-belt	Type x quantity	[With fan] Low edge cogged B type x 1 (for water pump) Low edge cogged C type x 2 (for fan drive)
		[Without fan] Low edge cogged C type x 1 (for water pump)
		Wax pellet, bottom bypass
		76.5°C x 2
Thermostat	Type	Pusher type or suction type
Fan	Type	Tube and corrugated fin type or tube and plate fin type
Radiator	Type	

3. SERVICE STANDARDS**3.1 SERVICE STANDARD TABLE**

Unit: mm

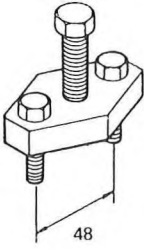
Description		Nominal value [Basic diameter]	Limit	Correction and remarks
Thermostat	Valve opening start temperature	74.5 to 78.5°C	—	Replace.
	Valve lift/temperature	10 or more/90°C		
Water pump	Interference between pump shaft and flange	[25] 0.05 to 0.08	—	Reassembling up to two times
	Interference between pump shaft and impeller	[11.8] 0.03 to 0.06		
Radiator pressure valve opening pressure		39 to 59 kPa (0.4 to 0.6 kgf/cm ²)	—	Replace pressure cap.
Radiator check pressure		98 kPa (1.0 kgf/cm ²)	—	Correct or replace.
Tension of V-belt (deflection of V-belt when pressed down at middle under approx. 98 N (10 kgf) pressure)	w/fan drive	10 to 15	—	Adjust.
	w/o fan drive	17 to 22	—	

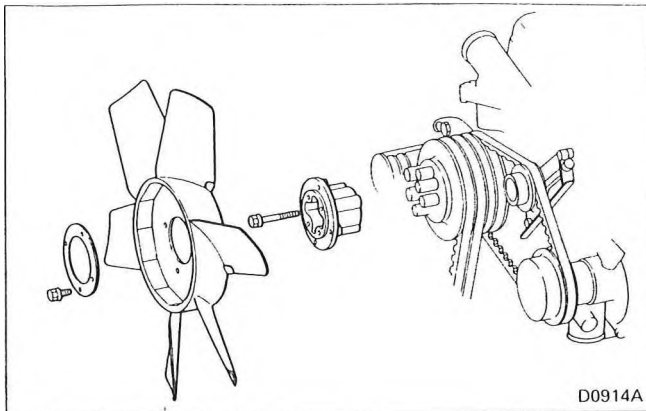
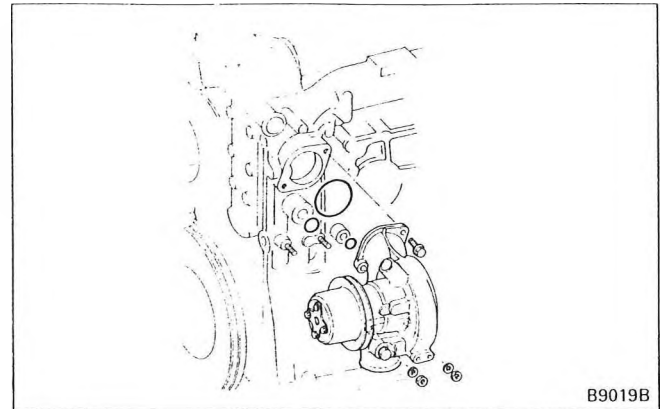
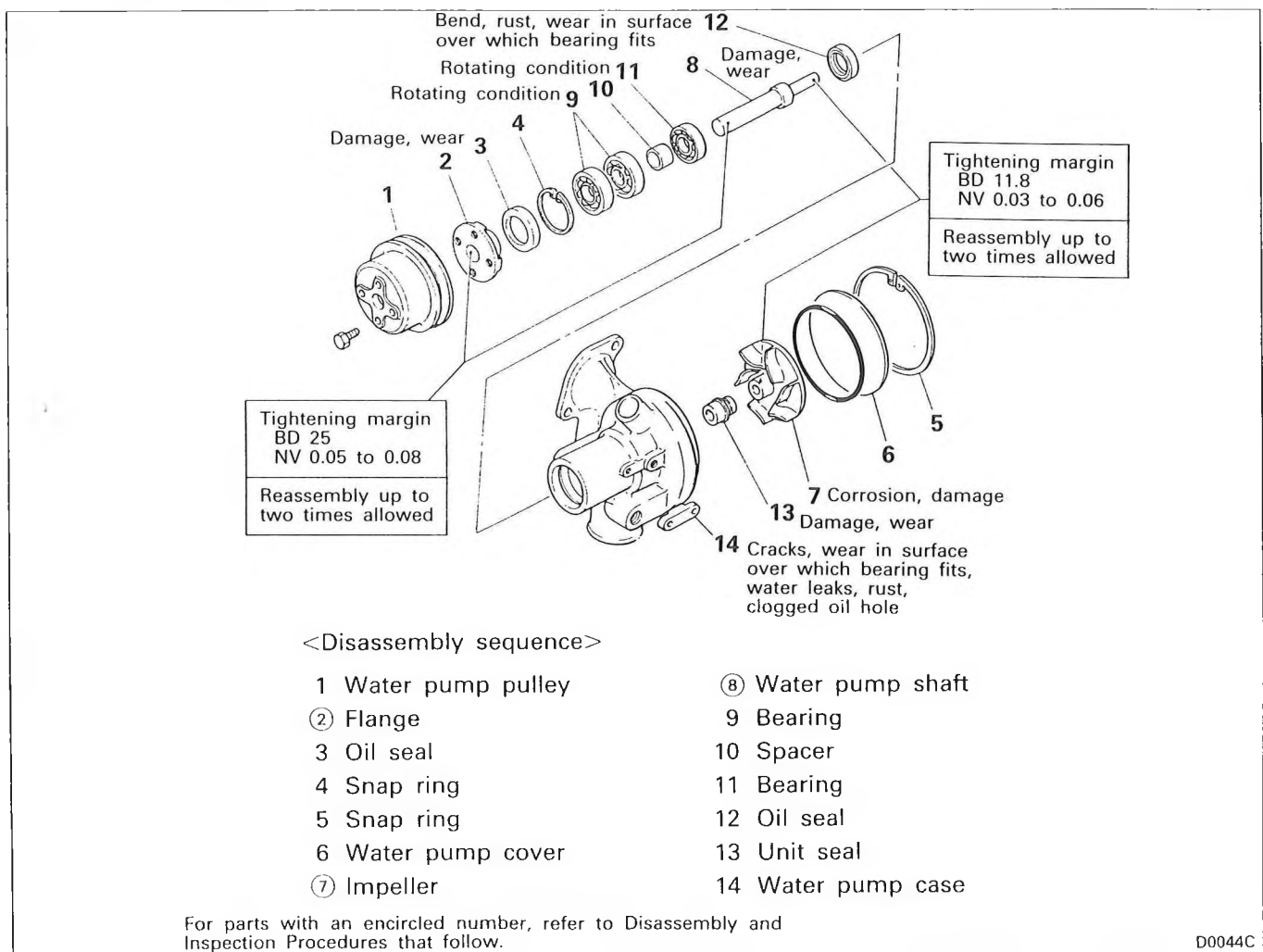
3.2 TIGHTENING TORQUE TABLE

Description	Thread size O.D. x pitch mm	Tightening torque Nm (kgfm)	Remarks
Fan drive flange nut	M20 x 1.5	145 (15)	
Tension pulley shaft nut	M16 x 1.5	98 (10)	

4. SPECIAL TOOL

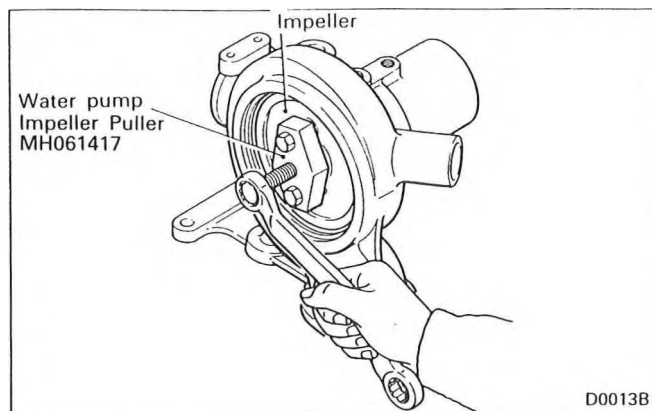
Unit: mm

Tool name	Part No.	Shape	Use
Water Pump Impeller Puller	MH061417	 B5251A	Removal of pump impeller

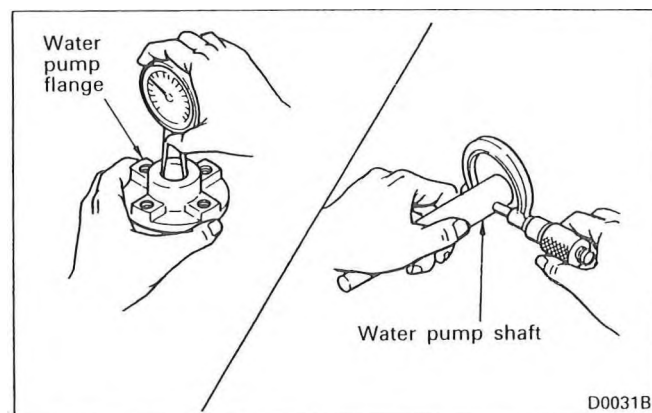
5. SERVICE PROCEDURES**5.1 REMOVAL AND INSTALLATION OF COOLING FAN****5.2 WATER PUMP****5.2.1 Removal and Installation****5.2.2 Disassembly and Inspection**

D0044C

Disassembly and Inspection Procedures

**(1) Removal of Impeller**

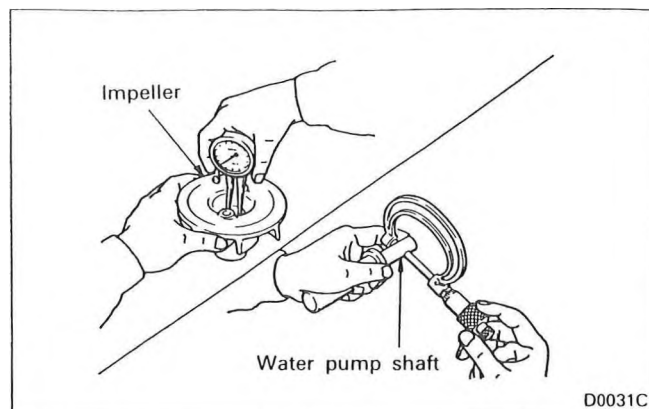
Using two threaded holes (M8 x 1.25) in the impeller and the Water Pump Impeller Puller (special tool), pull off the impeller.

**(2) Flange to Water Pump Shaft Tightening Margin**

If the tightening margin exceeds specification, replace the flange or water pump shaft.

NOTE:

Do not reassemble more than three times even when the specification is met.

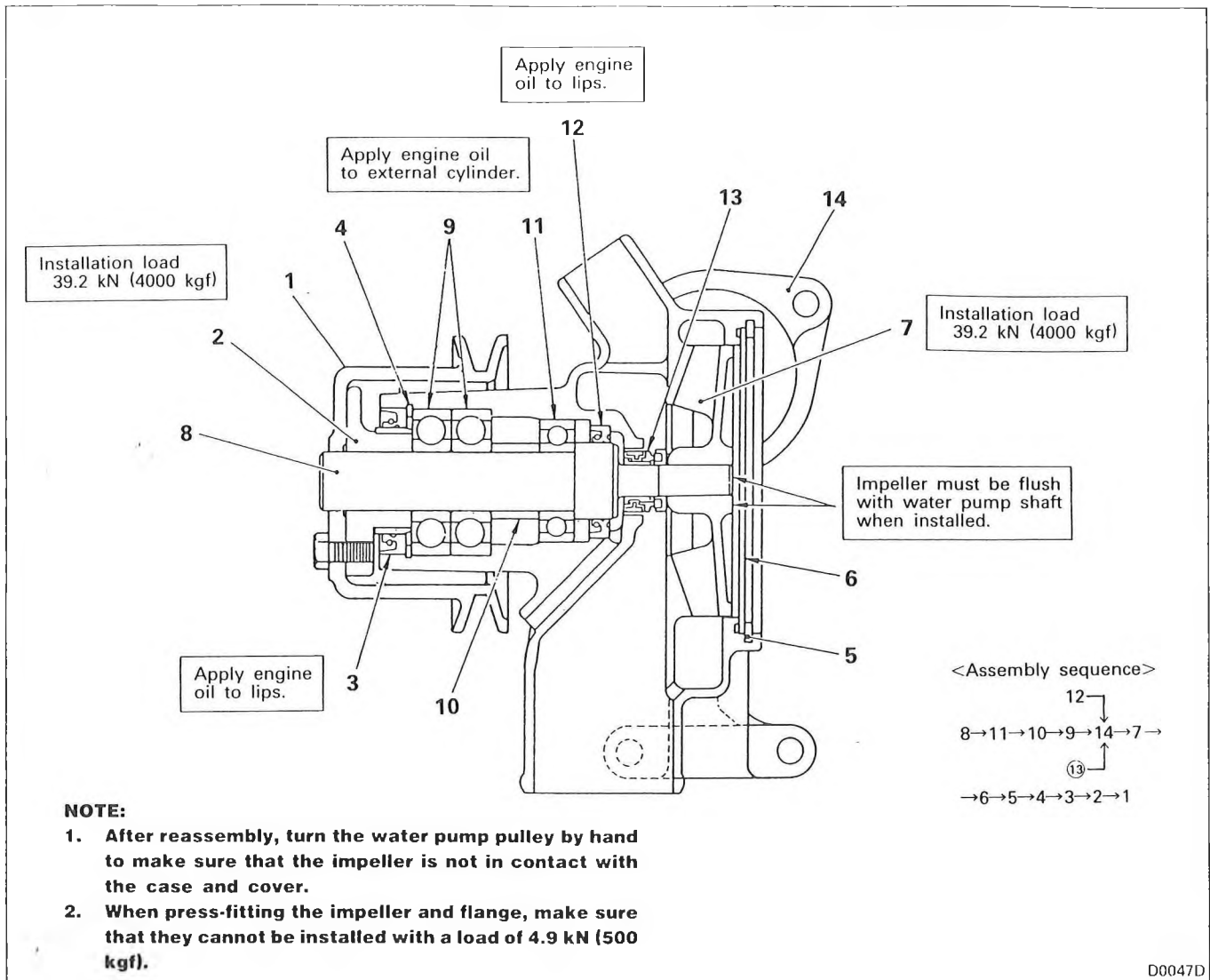
**(3) Impeller to Water Pump Shaft Tightening Margin**

If the tightening margin exceeds specification, replace the impeller or water pump shaft.

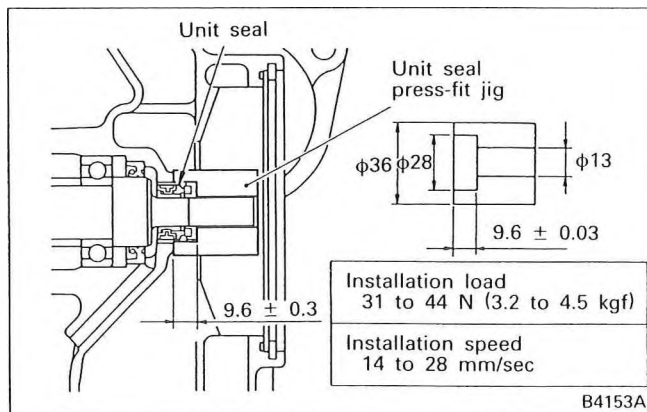
NOTE:

Do not reassemble more than three times even when the specification is met.

5.2.3 Reassembly



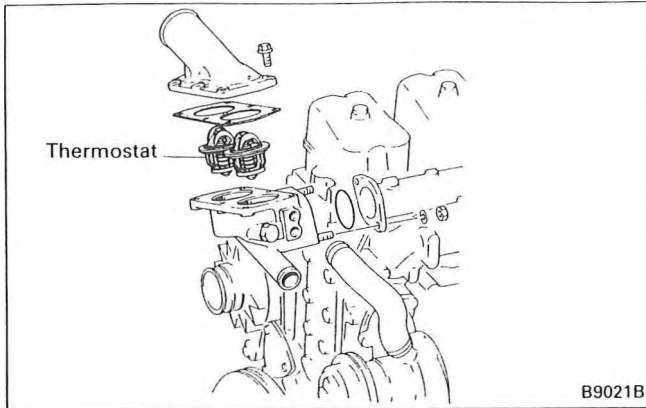
Installation of Unit Seal



To install the unit seal, use the press-fit jig as shown and press-fit the unit seal until the installed dimensions shown are obtained.

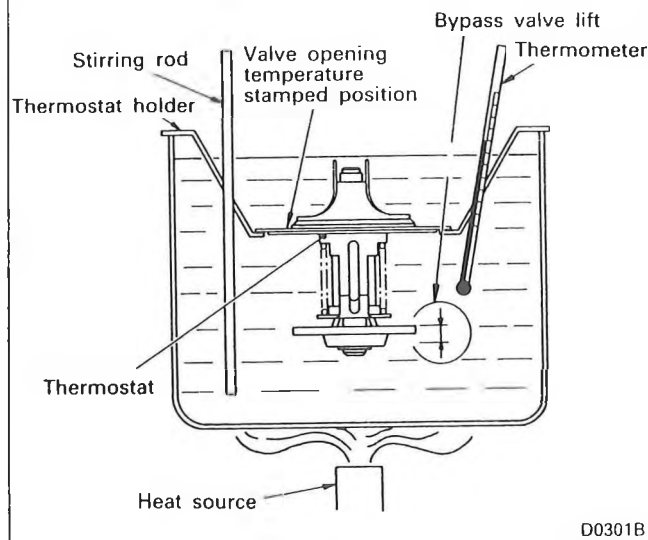
5.3 THERMOSTAT

5.3.1 Removal and Installation



5.3.2 Inspection

Thermostat stamping	76.5
Valve opening temperature (°C)	74.5 to 78.5
Valve lift/temperature (mm/°C)	More than 10/90



Agitate water in the container with the stirrer to obtain uniform temperature. For the inspection, use the following procedures.

(1) Slowly heat water to the thermostat valve opening temperature.

The valve opening temperature is stamped on the thermostat. Its nominal value is the stamped temperature $\pm 2^\circ\text{C}$.

Keep this condition for about five minutes and make sure that the valve is open.

(2) Raise the temperature further to heat the water to the valve lift measuring temperature corresponding to the valve opening temperature. (See the table above.)

Keep this state for five minutes and measure the bypass valve lift.

(3) Lower temperature down to 65°C or below and ensure that the valve is fully closed.

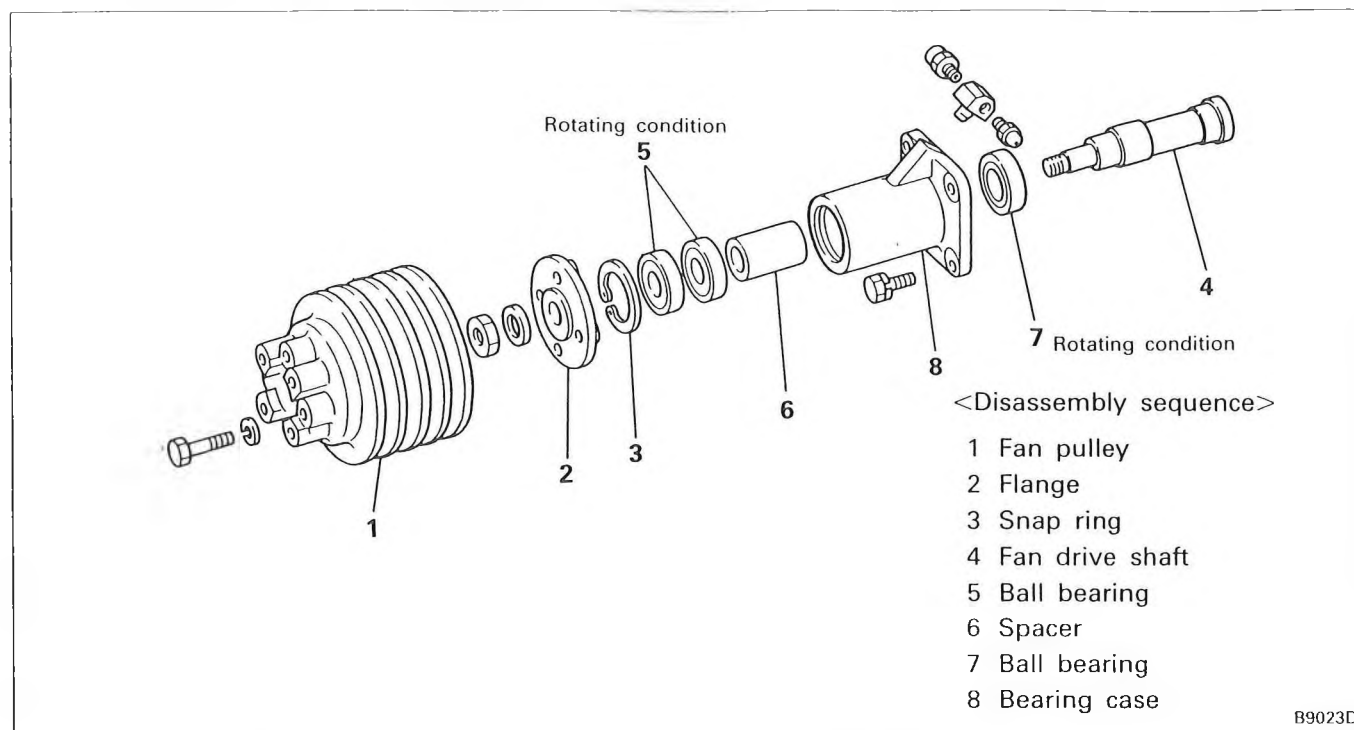
If the thermostat is found defective in any of the above items, replace it with a new one.

NOTE:

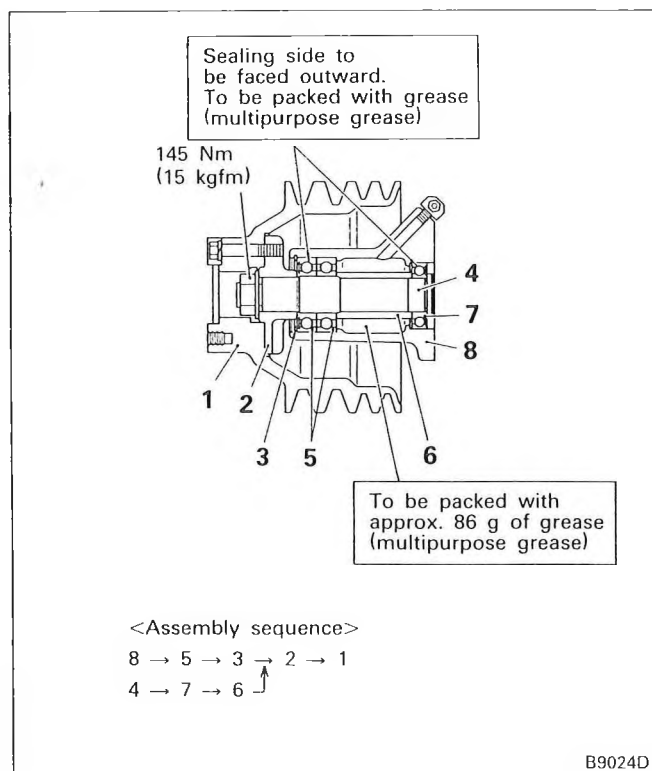
Support the thermostat so that the heat will not directly transfer to it.

5.4 FAN DRIVE

5.4.1 Disassembly and Inspection

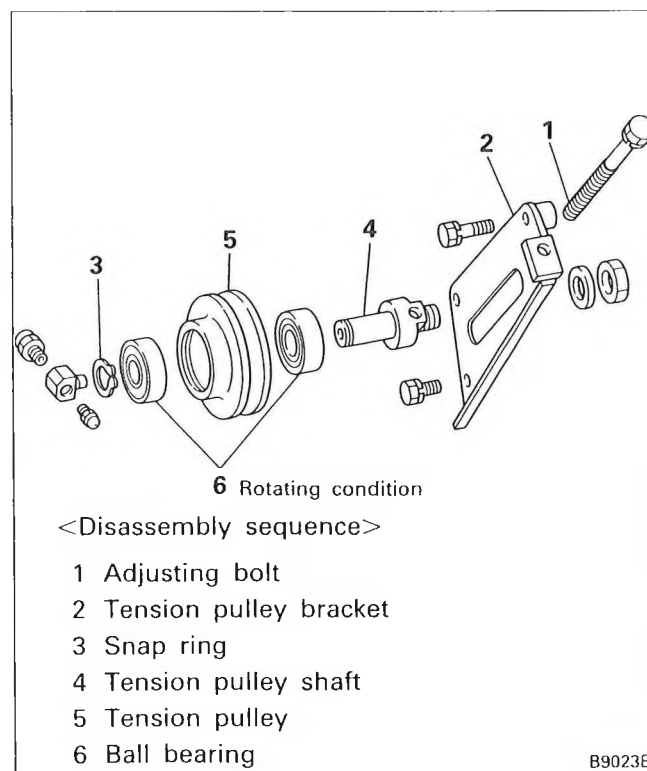


5.4.2 Reassembly

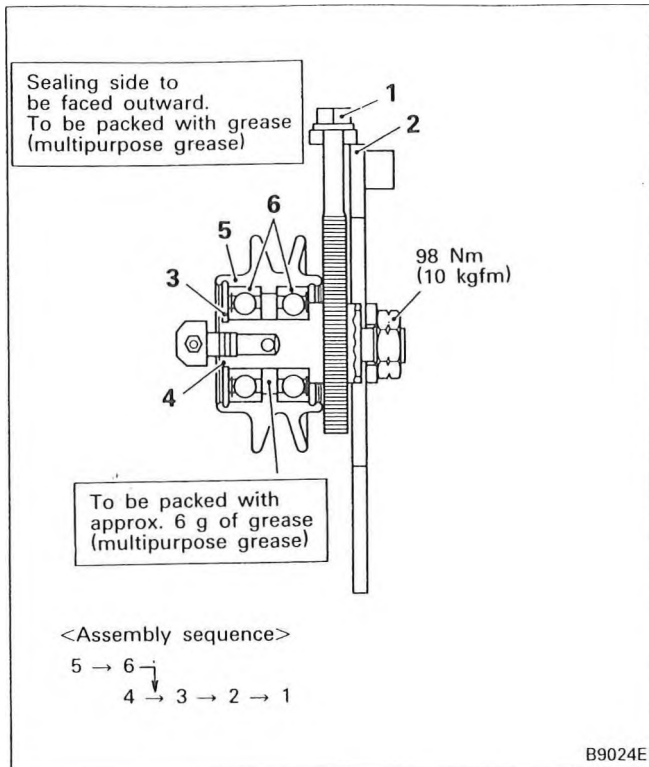


5.5 TENSION PULLEY

5.5.1 Disassembly and Inspection

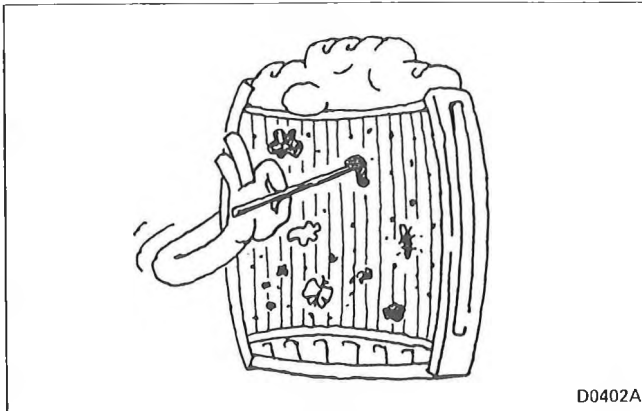


5.5.2 Reassembly

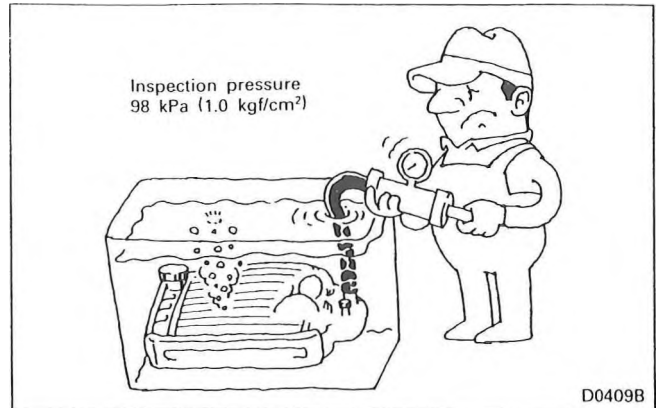


5.6 RADIATOR

5.6.1 Inspection

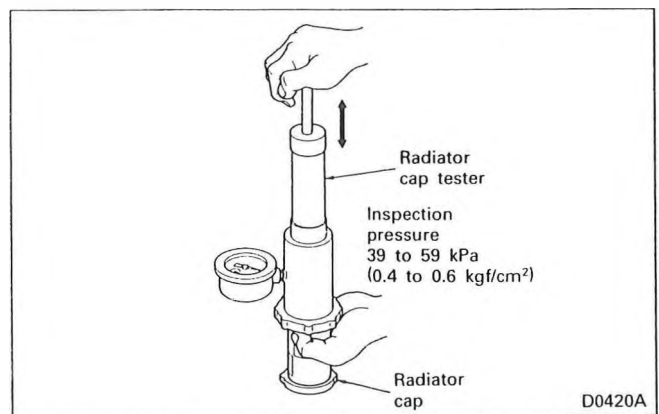


(1) Using a copper wire or similar device, remove dirt, mud, and bugs from the front of radiator core with care to prevent damage to turbings.



(2) Connect a hose to one of the radiator ports, cap the other port, and immerse the radiator into water. Using a radiator cap tester, force the compressed air under the specified inspection pressure from the hose end to check for leaks.

If there is a leak, resolder the point of leakage or replace the radiator.

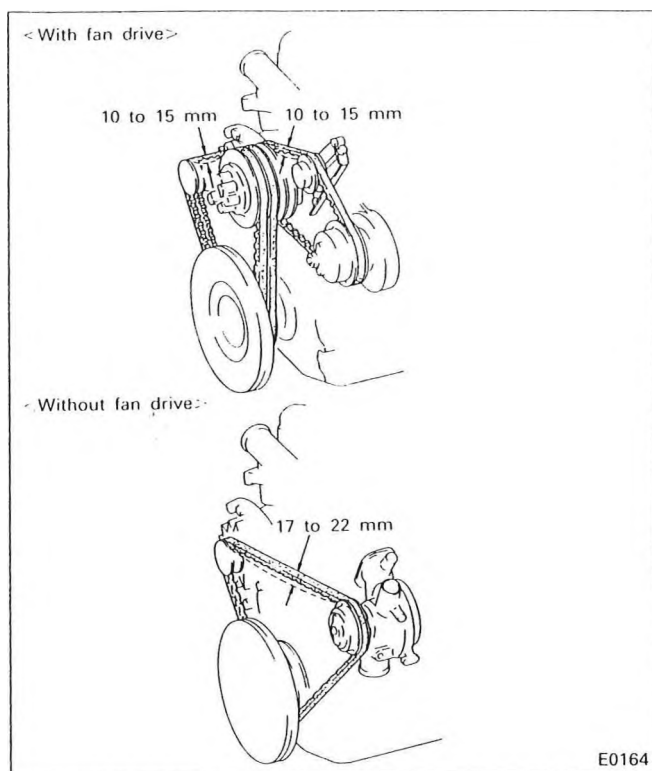


(3) Inspection of radiator cap

Check the spring tension and sealing condition of the pressure valve and vent valve. If defective, replace. Check the pressure valve opening pressure, using a radiator cap tester.

5.7 INSPECTION AND ADJUSTMENT OF V-BELT TENSION

(1) Inspection

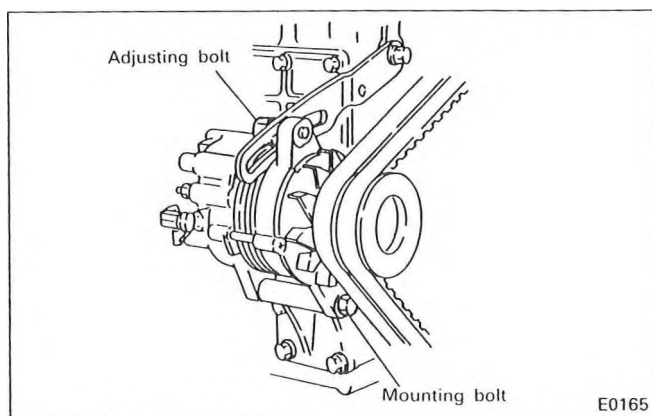


Adjust the belt tension to obtain the specified belt deflection when the center of each belt is pressed with a force of approximately 98 N (10 kgf).

NOTE:

1. A slack belt can be a cause of overheating and undercharge.
2. An excessively tight belt may result in damaged bearings and belts.

(2) Adjustment

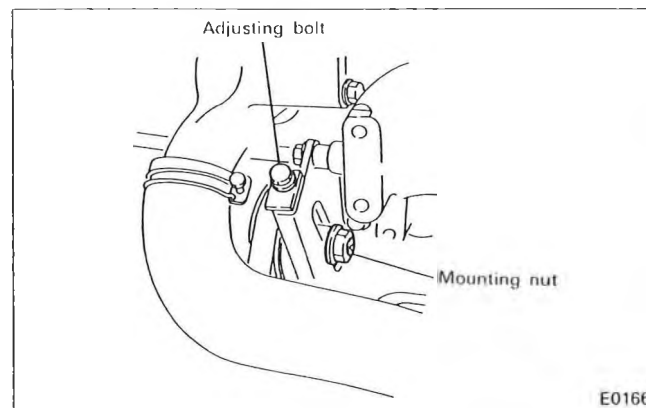


(a) Alternator section

Slightly loosen the alternator mounting bolt and adjusting bolt, then move the alternator to right or left by inserting a tool such as wrench handle.

NOTE:

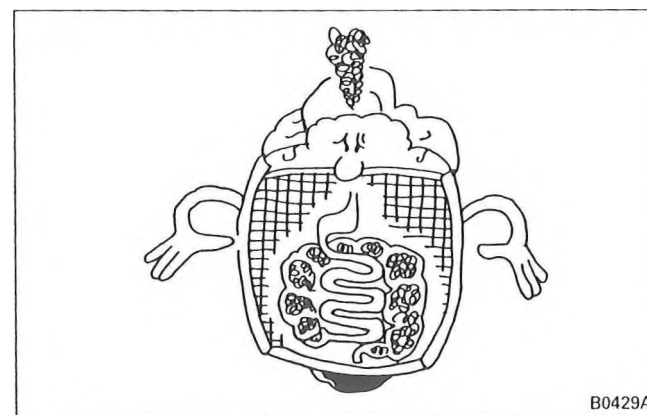
When moving the alternator, try not to damage the stator coil section between the front and rear brackets. The same applies to the bolts.



(b) Tension pulley section

Loosen the idler pulley mounting nut, then adjust by moving the idler pulley by means of the adjusting bolt.

5.8 CLEANING OF COOLING SYSTEM



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

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

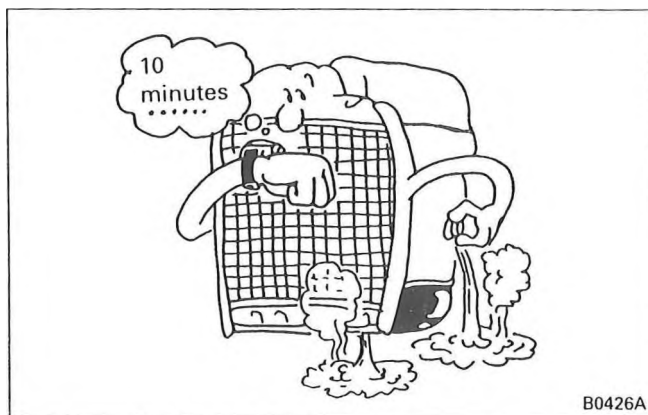
Required properties of city water

Total hardness	300 ppm or less
Sulfate SO ₄	100 ppm or less
Chloride Cl	100 ppm or less
Total dissolved solids	500 ppm or less
PH	6 to 8

NOTE:

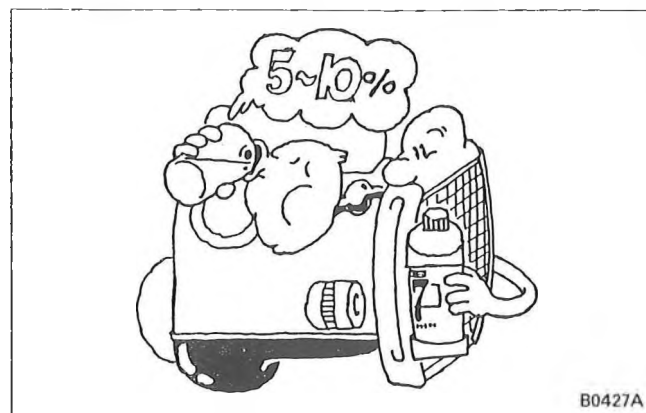
1. Use a cleaning solution if the radiator is seriously obstructed or coolant is seriously contaminated.
2. When the cooling system is cleaned or washed with water, make sure that the coolant temperature is maintained at 90°C; the coolant temperature below the valve opening temperature closes the thermostat resulting in poor coolant circulation.
3. For quicker rise of water temperature, you may cover the radiator front with cardboard, etc.
4. If much rust is found, water may leak from the radiator after cleaning. Check carefully each section of the radiator after cleaning.

Coolant in use	Cleaning interval
FUSO Diesel Long Life Coolant	Every 2 years
Anti-rust, anti-freeze	At time of coolant replacement of every 6 months or before and after use of anti-freeze

(1) Washing with Water

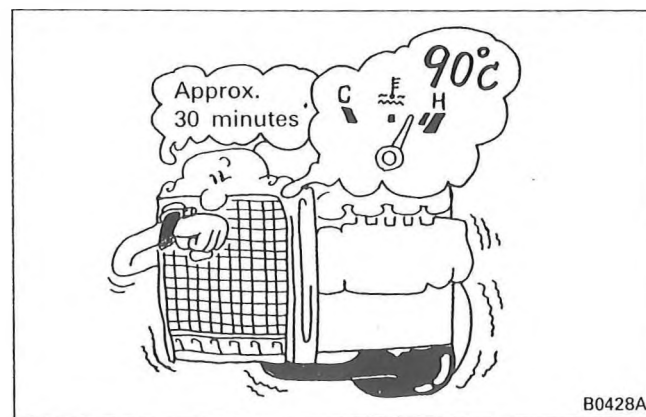
(a) Discharge coolant from the radiator, and crankcase.

(b) After draining the system, fill it with tap water (preferably hot water) and, with the water temperature kept at around 90°C, run the engine at idle for about 10 minutes. Then, discharge water. Continue flushing until the drained water runs clear.

(2) Washing with Cleaning Solution (When radiator clogging or coolant contamination are serious)

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

(b) Ready a mixture of Fuso Radiator Cleaner (Radipet-7 or equivalent: 5 to 10%) and cooling water. Pour the specified amount of mixture into the radiator.



(c) Run the engine to raise the solution temperature to around 90°C. Let the engine run at idle for another 30 minutes, then remove the solution.



(d) After discharging the solution, fill the system with tap water (preferably hot water) and with the water temperature kept at around 90°C, run the engine at idle for about 10 minutes. Then, drain water. Continue flushing until drained water runs clear.

NOTE:

1. If the inside is heavily stained, washing with tap water before charging radiator detergent will be effective.
2. Running the engine at idle for longer than an hour with detergent left in engine could cause damage to the cooling system. Be sure to observe specified cleaning time.
3. After cleaning with detergent, fill with coolant as soon as possible.

(3) Cooling Water



(a) When Long Life Coolant is used:

In order to prevent freezing of cooling water and corrosion of the cooling system, add FUSO Diesel Long Life Coolant at a ratio of 30 to 60% of quantity of water.

Replace the coolant once every two years to retain its anti-freeze and anti-rust effects.

For usage of Long Life Coolant, refer to its instruction manual.

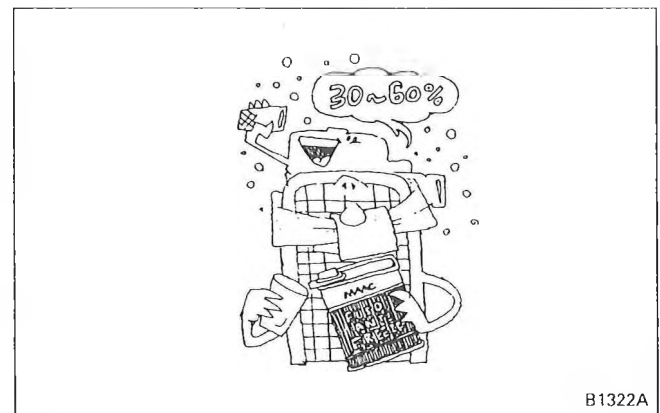
NOTE:

1. Be sure to use **FUSO Diesel Long Life Coolant**.
2. Never mix it with **DIAQUEEN Long Life Coolant** or other commercial long life coolants, anti-freezes or anti-rusts.



(b) When Anti-rust and Anti-freeze are used:

- 1) After cleaning, add Fuso Radiator Anti-rust (Radipet-9B or equivalent) at a ratio of 5% to the coolant quantity to prevent corrosion in summer.



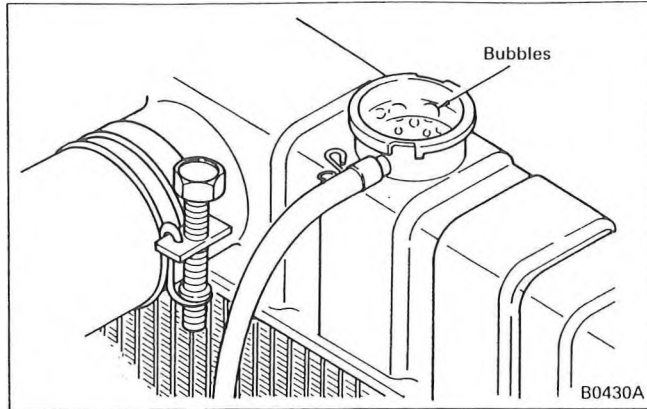
- 2) In winter, add the Fuso Anti-freeze or equivalent at a ratio of 30 to 60% to prevent freezing. For usage of anti-rust and anti-freeze, see respective instruction manuals.

NOTE:

When the anti-rust or anti-freeze is used, never use with other long life coolants.

5.9 GAS LEAK TEST

Air or exhaust gas leaked into the coolant promotes corrosion and rust formation. Perform the following check and, if defects are found, take remedial action.



(1) Inspection

Remove the pressure cap from the radiator, and run the engine to raise the coolant temperature up to around 90°C.

If bubbles continue forming in the coolant under the condition, it indicates that air or exhaust gas has leaked into the coolant.

(2) Causes

(a) If air is trapped in coolant, check cylinder head bolts, water pump mounting bolts, and hose and its connections for looseness. Check also hoses for damage.

(b) If the exhaust gas has leaked into coolant, check the cylinder head gasket or nozzle tube end stake for damage. Check also cylinder head for cracks.

5.10 BLEEDING THE COOLING SYSTEM

(1) With the pressure cap removed from the radiator, let the engine run at idle with coolant temperature of about 90°C to bleed the system completely.

(2) After the system has been bled of air, add coolant to radiator and reserve tank as required.

6. TROUBLESHOOTING

Symptom	Probable cause	Remedy	Ref. group
Overheating	Defective V belt		
	• Incorrect tension	Adjust	
	• Broken belt	Replace	
	Clogged cooling system	Clean	
	Defective thermostat	Replace	
	Defective water pump		
	• Loose shaft to flange engagement	Replace	
	• Loose shaft to impeller engagement		
	• Incorrect impeller to case clearance		
	• Damaged impeller		
Overcooling	Clogged radiator fins	Clean	
	Damaged cooling fan	Replace	
Quick loss of coolant	Low coolant level	Replenish	
	Defective thermostat	Replace	
	Defective radiator hose		
	• Poor hose connection	Correct	
	• Cracked or damaged hose	Replace	
	Defective radiator		
	• Radiator proper not air tight	Replace	
	• Defective pressure cap		
	Defective water pump		
	• Defective unit seal	Replace	
	• Defective oil seal		
	• Poor pump installation (defective gasket)		
	Defective oil cooler	Replace	Group 12
	Poor thermostat case installation (defective gasket)	Replace	
	Poor thermostat cover installation (defective gasket)		
	Poor bypass hose installation		
	Defective heater hose		
	• Poor hose connection	Correct	
	• Cracked or damaged hose	Replace	
	Defective cylinder head gasket	Replace	Group 11

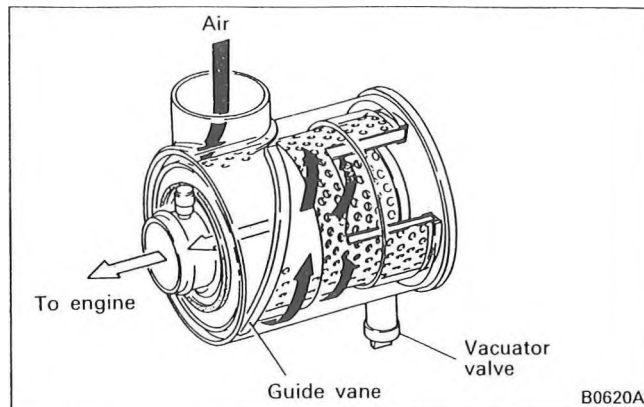
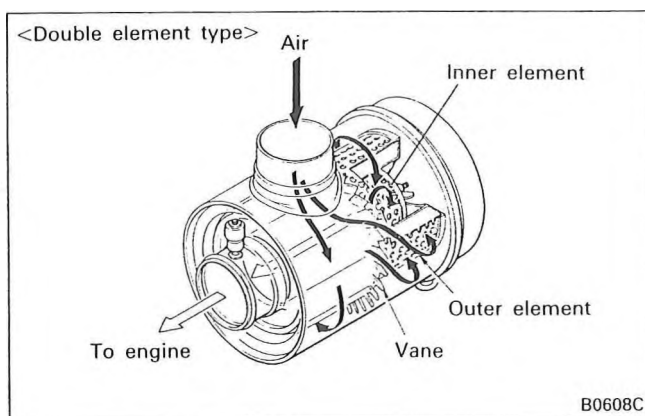
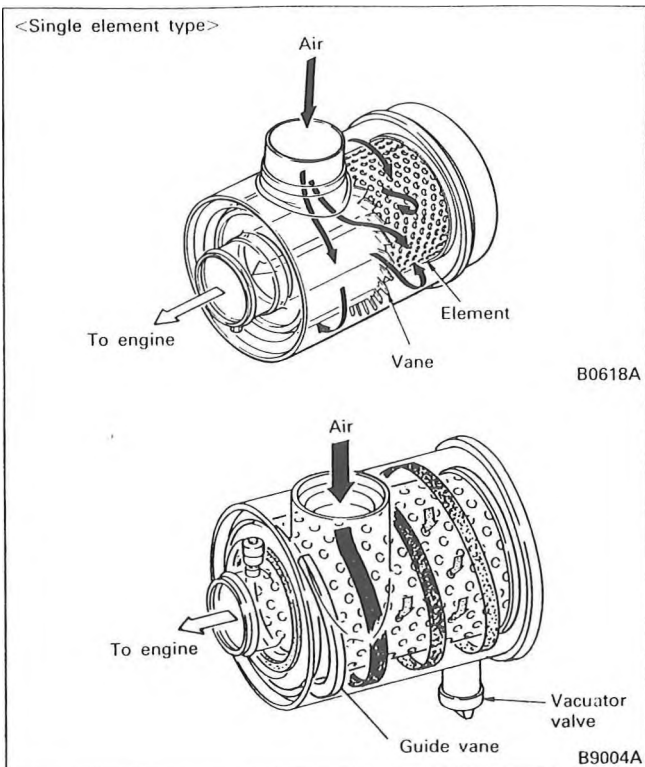
INTAKE AND EXHAUST

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1. GENERAL

(1) Air Cleaner

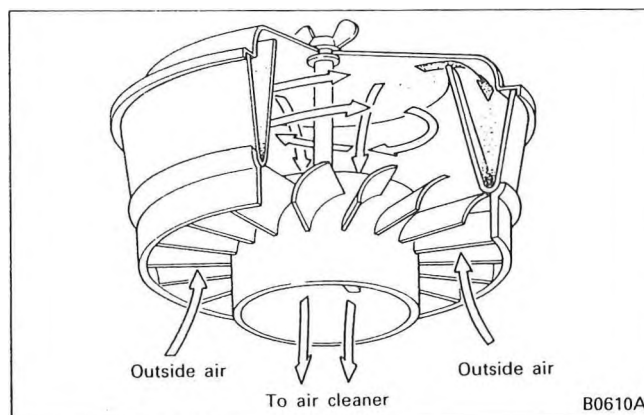


The air cleaner uses a filter paper type element. Because of plastic coating and heat treatment, the element is highly resistant to water and oil. Even if it is contaminated, its functions can be regained by cleaning.

The intake air is given a spin by the element vanes for centrifugal separation of large particles of dust and dirt. Small particles of dust and dirt are filtered out by the filter paper element so that a clean air is drawn into the engine.

The standard air cleaner is a single element type, and the double element type can be effective or operation safety under unusual conditions with a lot of dust and dirt.

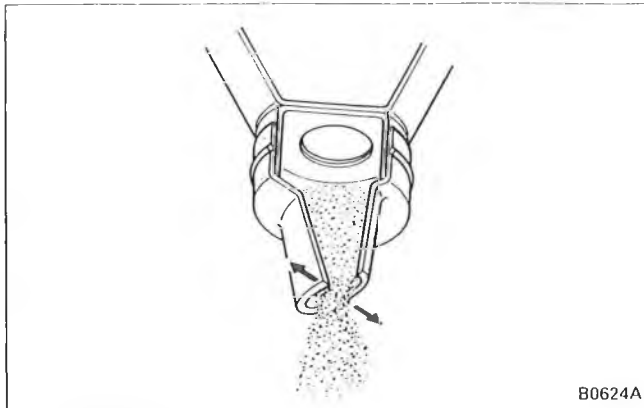
(2) Precleaner



The precleaner, coupled with the air cleaner, collects relatively large particles of dust contained in the air drawn in by engine.

The air entering the precleaner is made to spin by the guide vanes of the precleaner to centrifugally separate large particles of dust before the air is drawn into the air cleaner.

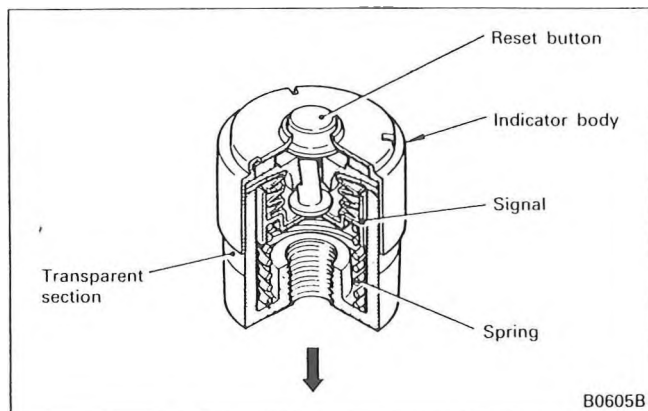
(3) Vacuator Valve



The centrifugally separated particles of dust and dirt are collected at the bottom of the air cleaner. The collected particles of dust and dirt are discharged outside by pulsations of the vacuator valve mounted in the air cleaner.

In the engine speed increases (to 800 rpm or more), the vacuator valve will be closed by a high negative pressure in the air cleaner, so no outside air will be drawn in.

(4) Dust Indicator

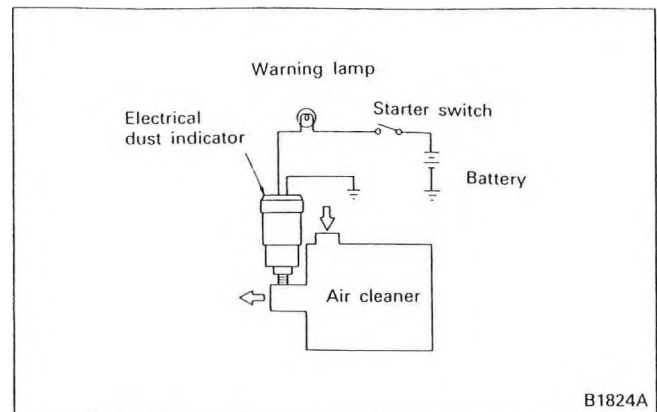


The dust indicator is directly mounted near the outlet of the air cleaner.

The dust indicator 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.

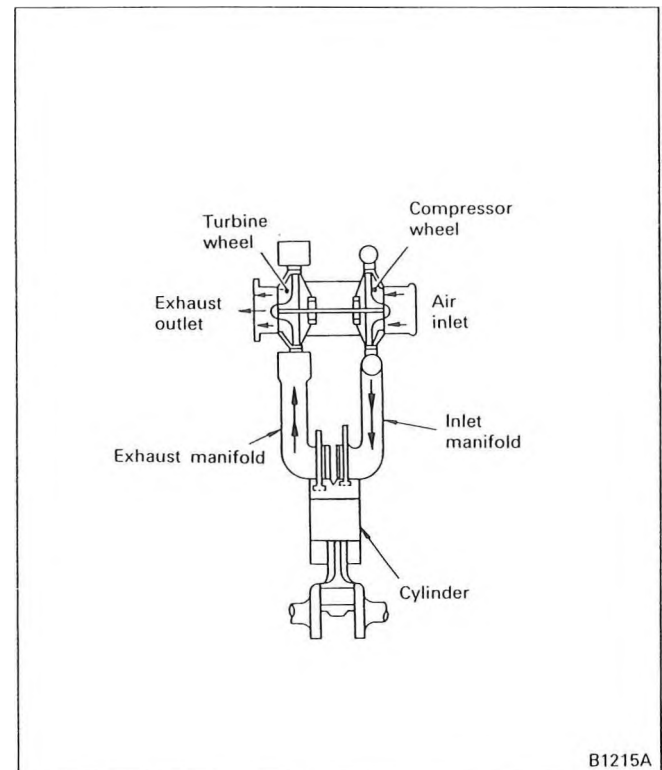
If dust is collected in the element, the suction resistance increases. When the negative pressure reaches 7.47 kPa (762 mmH₂O), or 6.23 kPa (635 mmH₂O) the signal is pulled down against the spring pressure, and the transparent portion of the body changes to red, indicating the time to clean or replace the element.

After the element has been cleaned or replaced, depress the reset button on the top, and the signal will return to its original position.

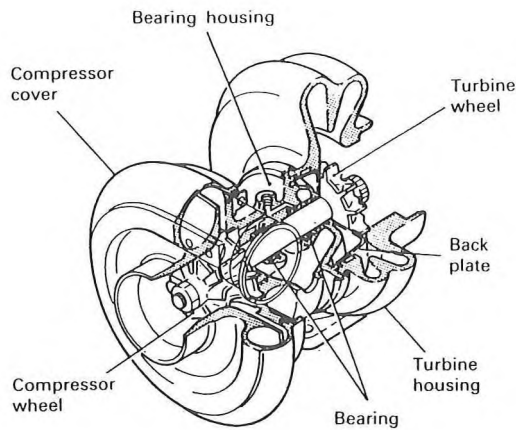


In the electric dust indicator, its electric contact points close at a negative pressure of 6.23 kPa (635 mmH₂O) or 7.47 kPa (762 mmH₂O) to turn on the warning lamp, indicating to the driver the time to clean or replace the element.

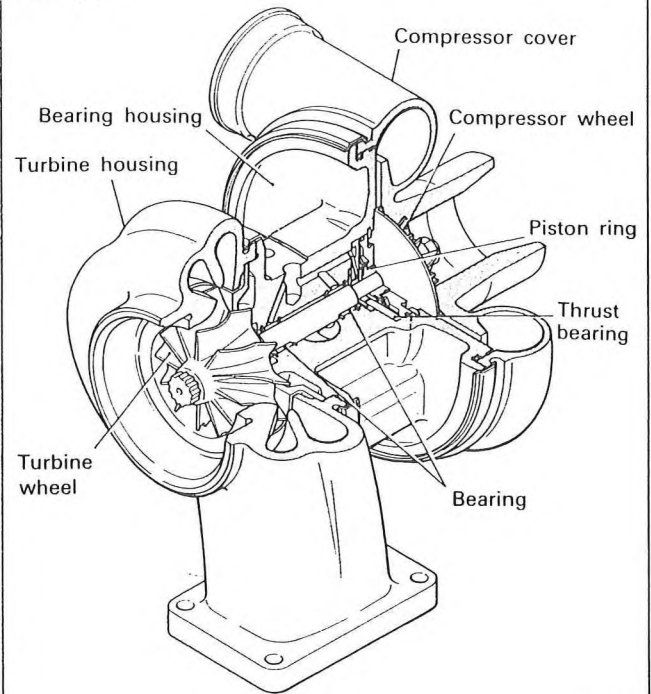
(5) Turbocharger



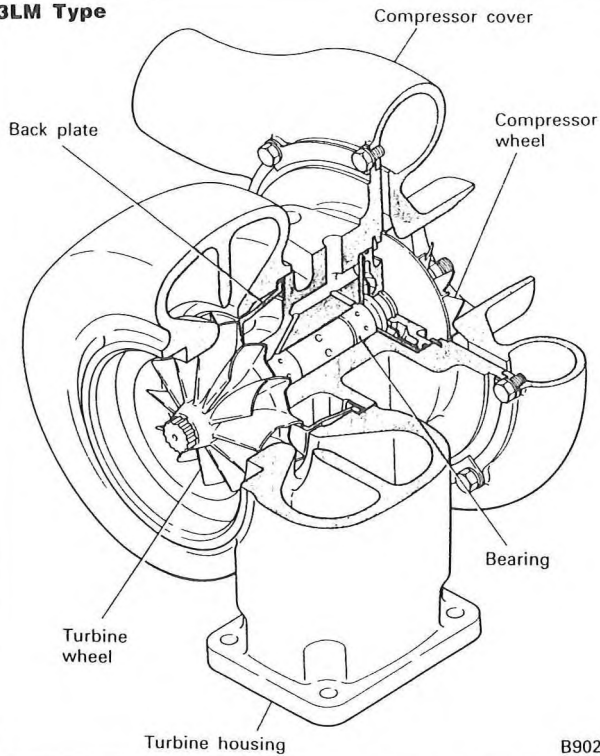
The turbocharger utilizes the energy of the engine-exhaust gas to feed more air into the engine, thereby offering advantages such as boosted engine power output, thrifter fuel consumption, and reduced engine noise.

TD08 Type

B1213A

4LF Type

B1202A

3LM Type

B9026A

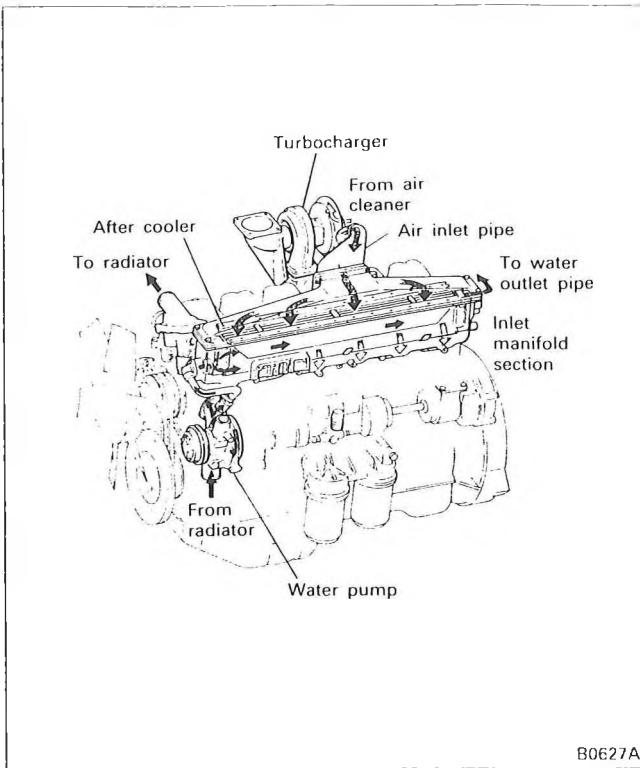
The exhaust gases discharged from the engine cylinders are delivered through the exhaust manifold to the turbocharger, accelerated in the turbine housing, and blown against the turbine wheel. As a result, the turbine wheel turns at a speed of several tens of thousands of revolutions per minute, which spins the compressor wheel. As the compressor wheel spins, the amount of air far larger than that supplied when no turbocharger is installed is forced into the engine cylinders, allowing more fuel to be burnt in the cylinders. This increases the effective pressure during combustion (the pressure forcing pistons down), thus boosting the power output.

The turbocharger is divided into two basic sections: the turbine wheel that is driven by the exhaust gases and the compressor wheel which is supported by the bearing and forces intake air into cylinders. A thrust bearing is mounted on the compressor end.

The lubricating oil is supplied from the oil main gallery at the front end of the engine and routed through oil holes in the bearing housing to lubricate the bearings. The oil is then returned to the engine oil pan through the drain port at the bottom of the bearing housing.

[Refer to Group 12 Lubrication.]

(6) After Cooler



The intake air cooler system, incorporating a plate-and-corrugated-fin type heat exchanger with a built-in inlet manifold, transfers heat from the intake air to the engine coolant.

The system cools off the intake air, whose temperature has gone high due to compression by the turbocharger, through heat exchanging with the engine coolant. This allows the density of intake air to be increased, admitting more air into the engine, which in turn increases the fuel injection rate and improves the combustion efficiency. Thus the fuel economy and output are improved and the exhaust gases are reduced to a minimum.

2. SPECIFICATIONS

Item		Specification		
Air cleaner	Type	(Nippon Donaldson Ltd. product)		
		Cyclone type paper element		
Turbocharger	Model	(Standard)	(Option)	[6D22-TC]
		Mitsubishi TD08	Mitsubishi Schwitzer 3LM or 4LF	Mitsubishi TD08
After cooler	Type	Engine-coolant-cooled, with built-in inlet manifold		

3. SERVICE STANDARDS

3.1 SERVICE STANDARD TABLE

Unit: mm

Description			Nominal value [Basic diameter]	Limit	Correction and remarks
Turbocharger (3LM)	I.D. of bearing inserting portion of bearing housing		–	19.06	Replace.
	Shaft and turbine wheel	Bearing journal O.D.	–	11.18	Replace.
		Shaft concentricity	–	0.015	Replace.
	Piston ring open end clearance		0.015 to 0.18	–	Replace insert.
	Shaft and turbine wheel to turbine housing clearance		0.53 to 1.04	–	Replace.
	Shaft and turbine wheel end play in axial direction		0.05 to 0.13	–	Replace.
	Shaft and turbine wheel to turbine back plate clearance		0.74 to 1.55	–	Replace.
Turbocharger (TD-08)	I.D. of bearing inserting portion of bearing housing		–	20.506	Replace.
	Shaft and turbine wheel	Bearing journal O.D.	–	11.996	Replace.
		Shaft concentricity	–	0.015	Replace.
	Bearing	O.D.		20.382	Replace.
		I.D.		12.042	
		Length		11.94	
	Clearance between compressor wheel and compressor cover		0.08 to 0.28	–	Replace.
	Piston ring end gap in insert		0.05 to 0.25	–	Replace.
	Shaft and turbine wheel to turbine housing clearance		0.39 to 1.0	–	Replace.
	Shaft and turbine wheel end play in axial direction		0.075 to 0.155	–	Replace.
	Shaft and turbine wheel to turbine back plate clearance		0.48 to 0.92	–	Replace.
Turbocharger (4LF)	Bearing housing	Bearing inserting area I.D.	–	22.268	Replace.
		Piston ring inserting area I.D.	–	22.5	
	Shaft and turbine wheel	Piston ring groove width	–	1.68	Replace.
		Bearing journal O.D.	–	14.254	
		Shaft concentricity	–	0.015	

Unit: mm

Description		Nominal value [Basic diameter]	Limit	Correction and remarks
Turbocharger (4LF)	Piston ring groove width of flinger sleeve	–	3.3	Replace.
	Shaft and turbine wheel to turbine housing clearance	0.84 to 1.75	–	Replace.
	Shaft and turbine wheel end play in axial direction	0.08 to 0.152	–	Replace.
	Shaft and turbine wheel to turbine back plate clearance	0.43 to 1.05	–	Replace.
	Clearance between compressor cover and compressor wheel in diametrical direction	0.15	–	Replace.
	Clearance between shaft and turbine wheel and turbine housing in diametrical direction	0.15	–	Replace.
	Piston ring end gap in insert	0.03 to 0.18	–	Replace.
After cooler check pressure		6D22-TC	195 kPa (2 kgf/cm ²)	– Replace.
Dust indicator operating resistance		Standard	7.47 ± 0.57 kPa (762 ± 58 mmH ₂ O)	– Replace.
		Option	6.23 ± 0.57 kPa (635 ± 58 mmH ₂ O)	– Replace.

3.2 TIGHTENING TORQUE TABLE

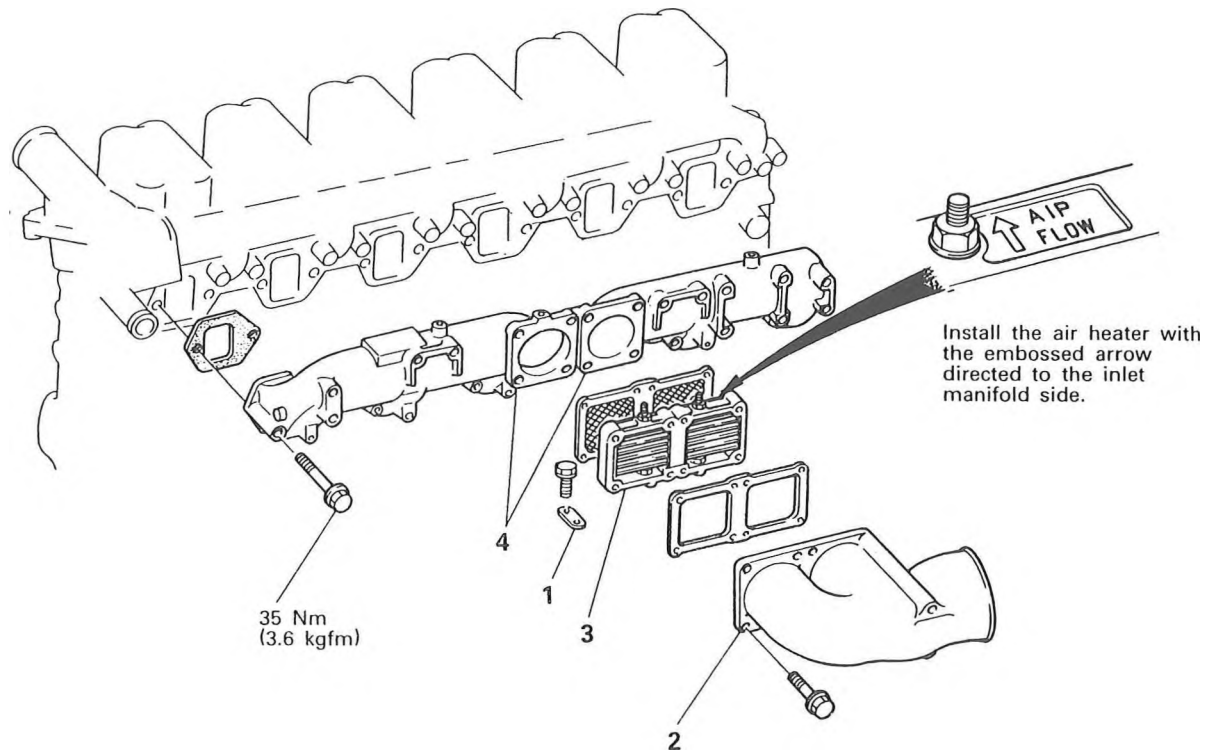
Description		Thread size O.D. x Pitch mm	Tightening torque Nm (kgfm)	Remarks
Inlet manifold bolt <Except 6D22-TC>		M10 x 1.5	35 (3.6)	
Exhaust manifold nut		M10 x 1.25	41 (4.2)	
Turbocharger attaching nut	Attaching nut	M10 x 1.25	26 (2.7)	
	Lock nut	M10 x 1.25	35 (3.6)	
Turbocharger (3LM)	Shaft and turbine wheel attaching nut	–	17 to 20 (1.73 to 2.07)	
	Compressor cover attaching cap screw	–	6.9 (0.7)	
	Turbine housing attaching cap screw	–	17 (1.7)	
Turbocharger (TD-08)	Coupling assembly	–	5.9 (0.6)	Apply MOLYKOTE grease or equivalent to threads
	Shaft and turbine wheel lock nut	–	20 (2)	
Turbocharger (4LF)	V clamp attaching nut	–	11 (1.1)	Apply MOLYKOTE grease or equivalent to threads
	Shaft and turbine wheel lock nut	–	27 (2.8)	

4. SPECIAL TOOL

Tool name	Part No.	Shape	Use
Socket	MH061242	 Width across flats 14 B5341A	Removal and installation of exhaust manifold mounting nut

5. SERVICE PROCEDURES**5.1 REMOVAL AND INSTALLATION OF INTAKE SYSTEM**

<6D22>



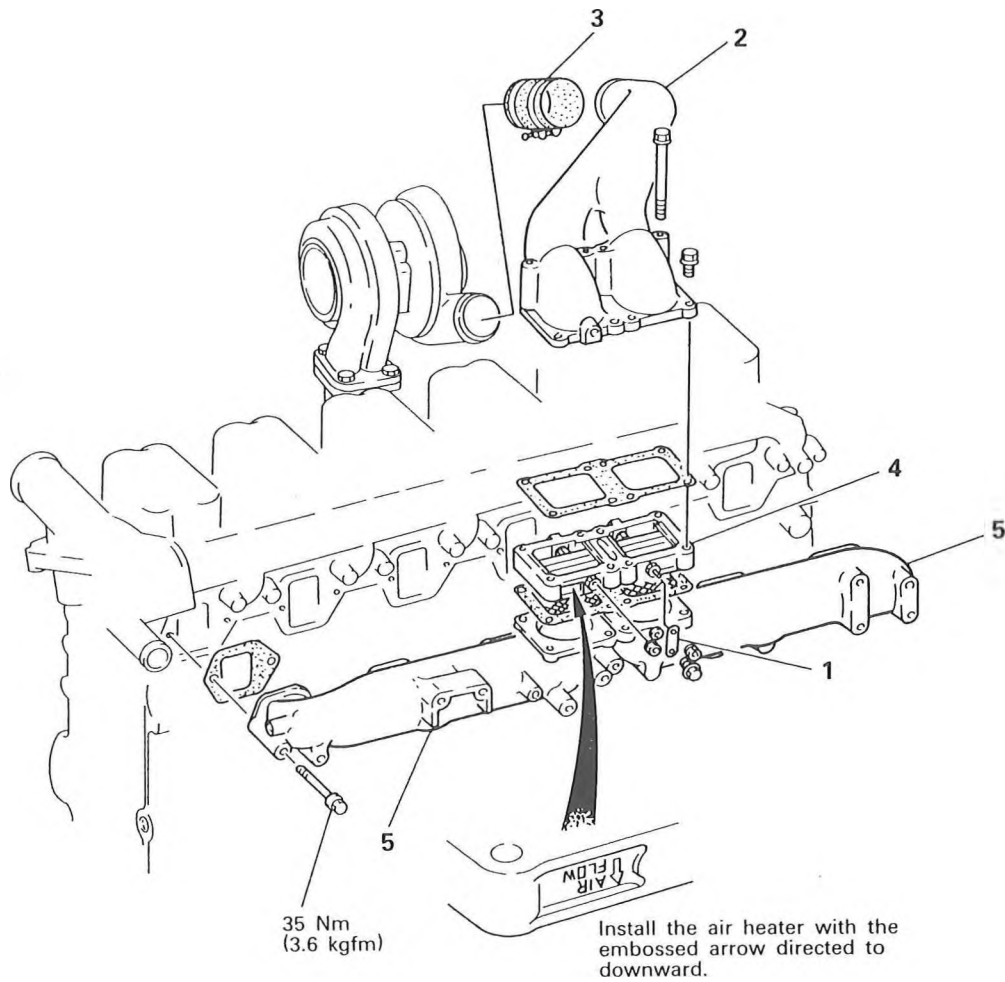
- 1 Earth plate
- 2 Inlet pipe
- 3 Air heater
- 4 Inlet manifold

NOTE:

- 1. Remove all harnesses before disassembly.
- 2. Pay attention to the air heater mounting direction.
- 3. For inspection of air heater, see "Group 16".

B4556A

<6D22-T>



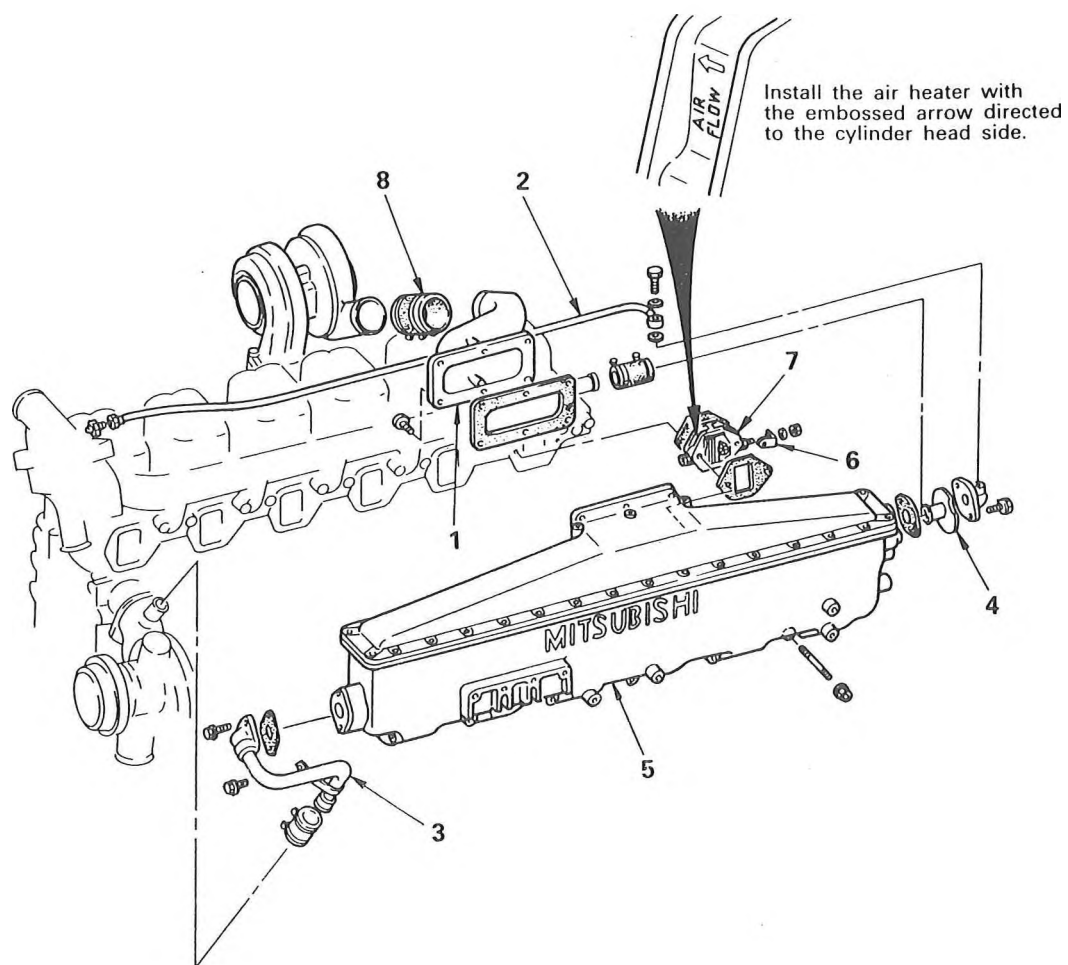
- 1 Earth plate
- 2 Inlet pipe
- 3 Rubber hose
- 4 Air heater
- 5 Inlet manifold

NOTE:

- 1. Remove all harnesses before disassembly.
- 2. Pay attention to air heater mounting direction.
- 3. For inspection of air heater, see "Groupe 16".

B4557A

<6D22-TC>



- 1 Inlet pipe
- 2 Air escape pipe
- 3 Water inlet pipe
- 4 Water return pipe
- 5 After cooler assembly
- 6 Earth plate
- 7 Air heater
- 8 Rubber hose

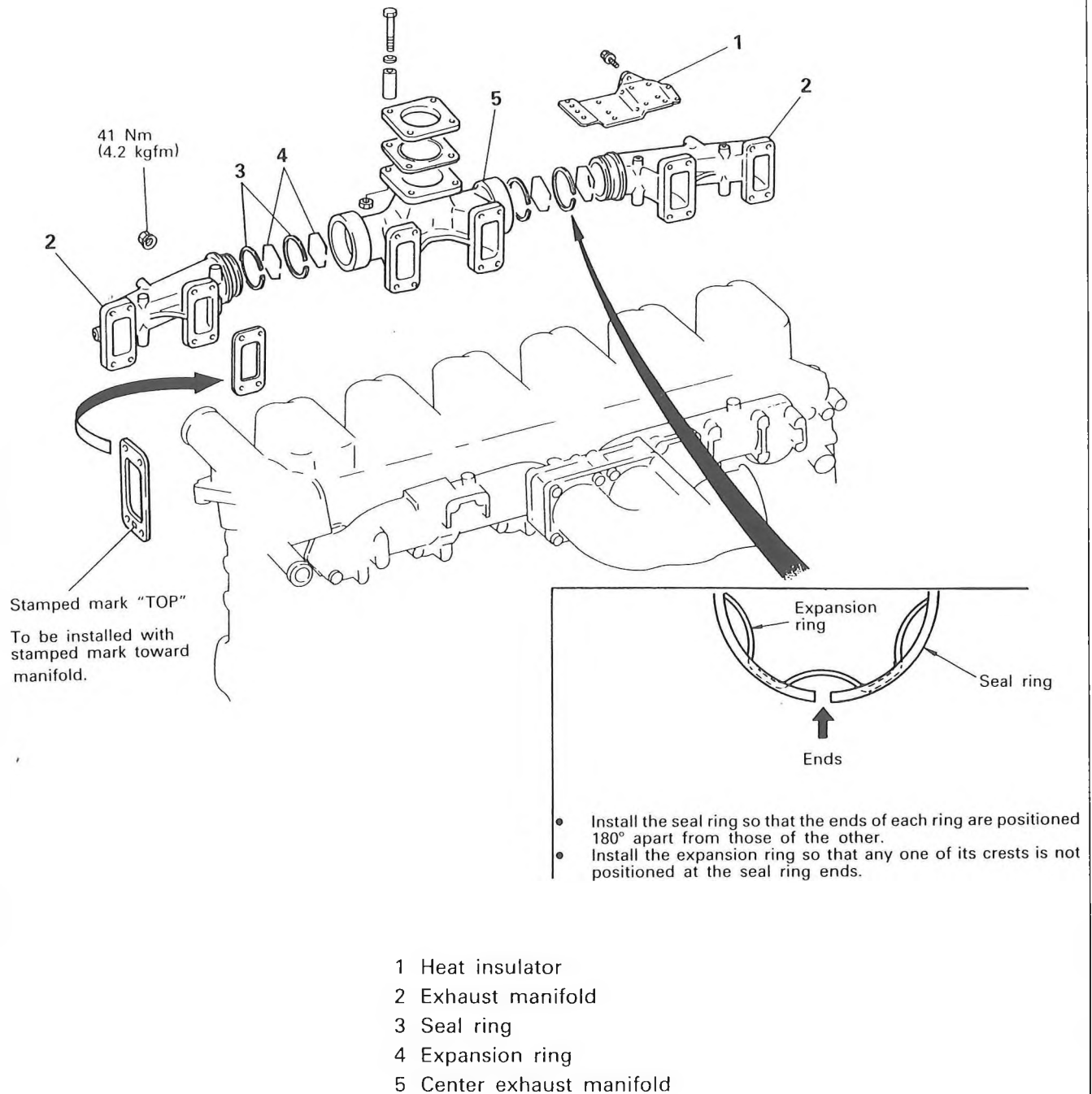
NOTE:

- 1. Remove all harnesses before disassembly.
- 2. Pay attention to air heater mounting direction.
- 3. For inspection of air heater, see "Groupe 16".

B4558A

5.2 REMOVAL AND INSTALLATION OF EXHAUST SYSTEM

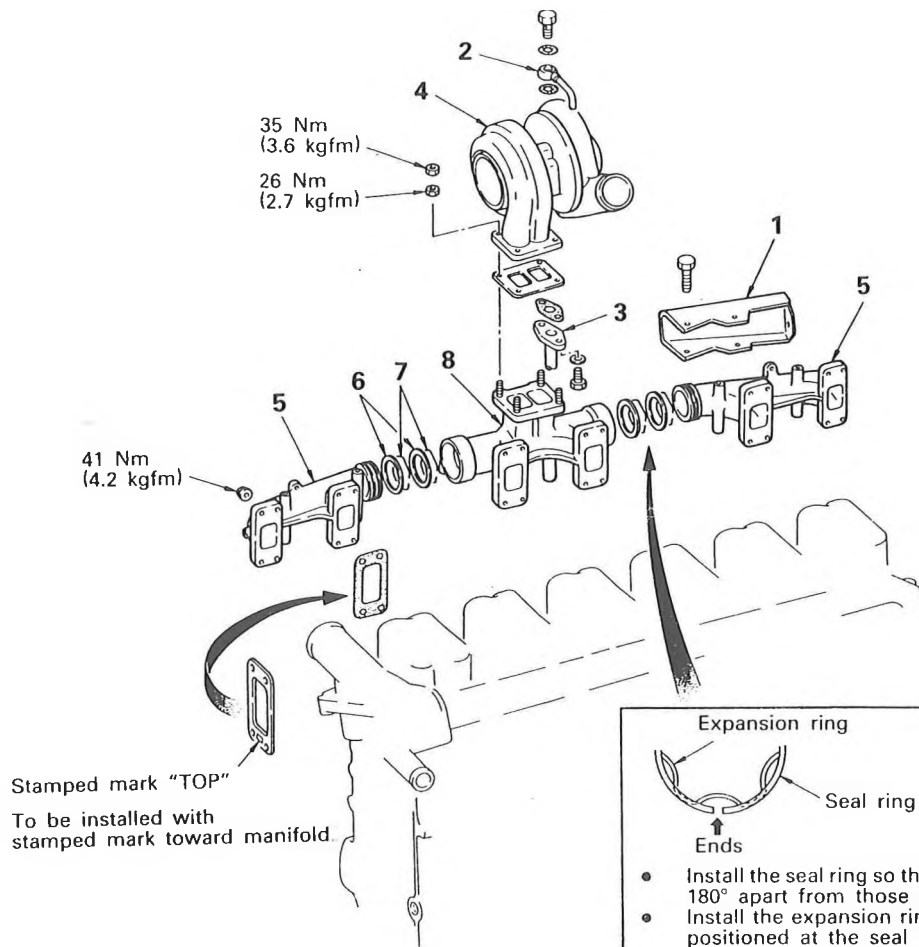
<6D22>



B4560A

The exhaust manifold mounting nuts should be tightened to the specified torque through use of Socket (special tool: MH061242).

<6D22-T, TC>



- 1 Heat insulator
- 2 Oil pipe
- 3 Oil return pipe
- 4 Turbocharger
- 5 Exhaust manifold
- 6 Seal ring
- 7 Expansion ring
- 8 Center exhaust manifold

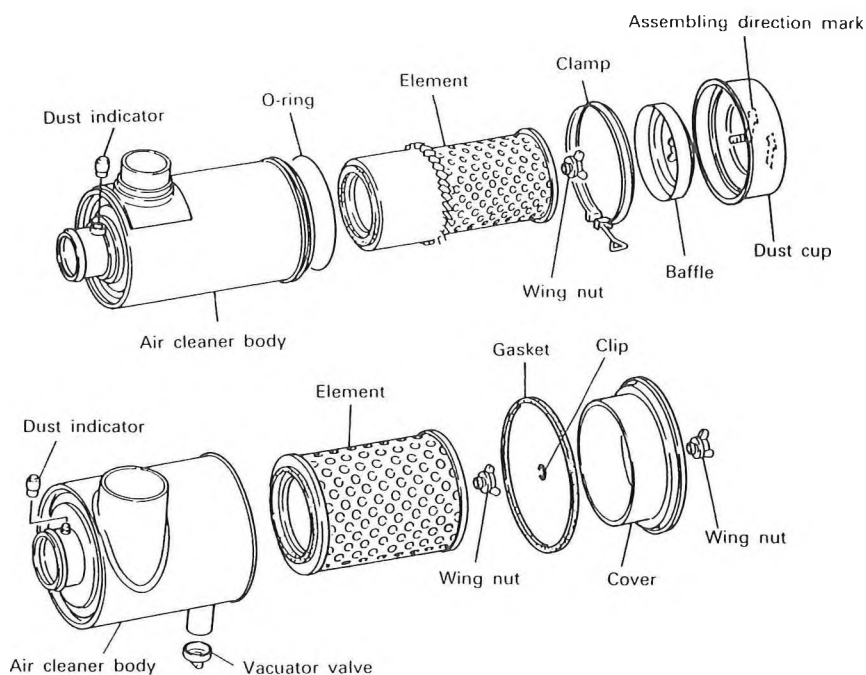
B4561A

The exhaust manifold mounting nuts should be tightened to the specified torque through use of Socket (special tool: MH061242).

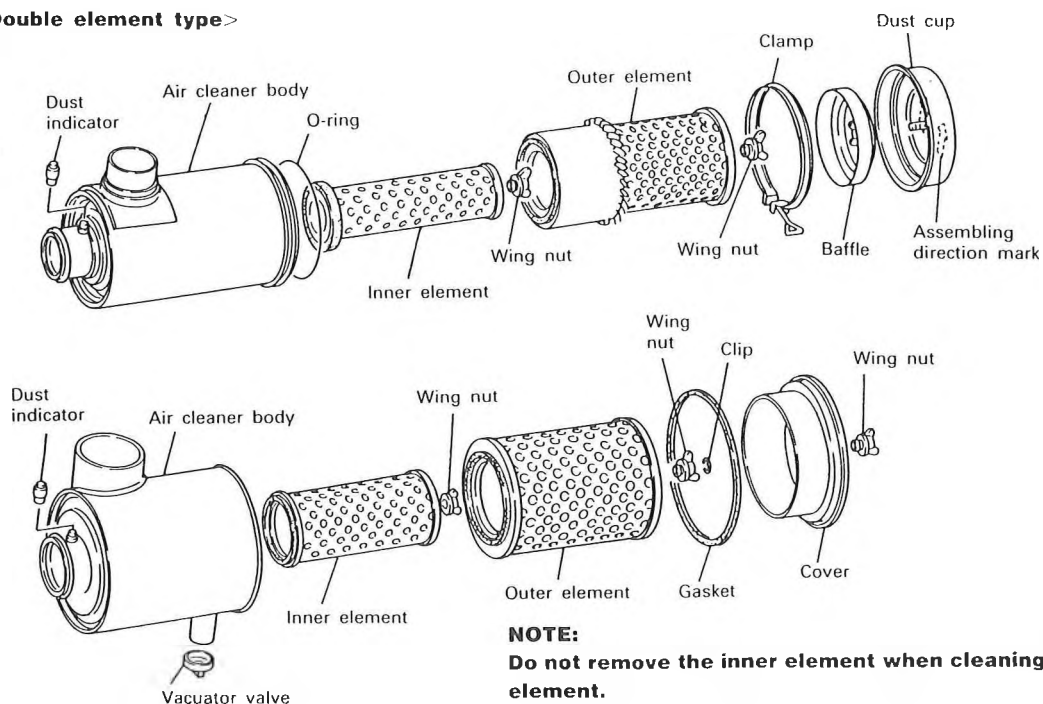
5.3 AIR CLEANER

5.3.1 Disassembly and Reassembly

<Single element type>



<Double element type>

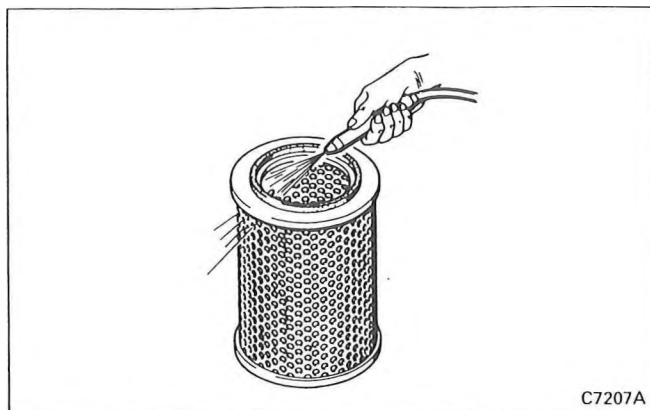


NOTE:
Do not remove the inner element when cleaning the outer element.

E0158

5.3.2 Inspection and Cleaning

(1) When there is Dry Dust on the Element



If there is dry dust on the element, clean the dust by blowing 685 kPa (7 kgf/cm²) or lower compressed air against the element.

Blow the compressed air from inside the element up and down along the frills of the filter paper and clean the whole element evenly.

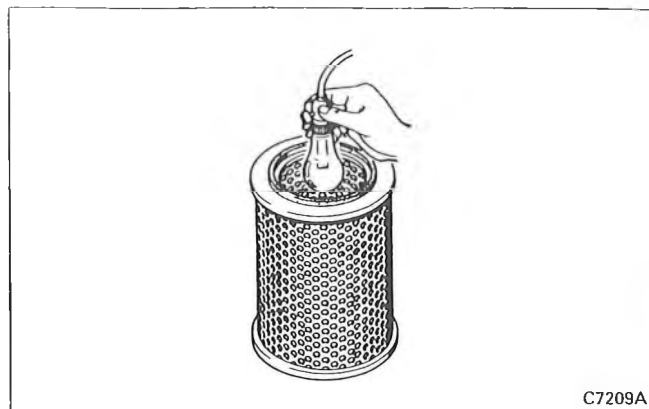
NOTE:

1. Do not strike the element or strike it against a hard object to loosen the dust.
2. Do not clean the inner element.

(2) When there is Moist Dust on the Element

If the element is contaminated with moist soot, replace it regardless of the specified replacement frequency.

(3) Inspection of Element

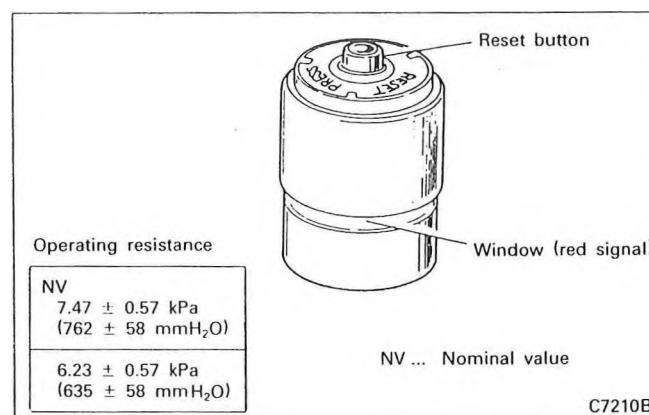


After the element has been cleaned, put an electric lamp inside the element to check for damage and pin holes. If there are thin portions in the filter paper, replace the element. If the packing on the top surface of the element is broken, replace the packing.

(4) Cleaning of Air Cleaner Body

Clean the inside of the air cleaner body and discharge the deposited dust.

(5) 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, or warning lamp lights for the electric type, the dust indicator is normal.

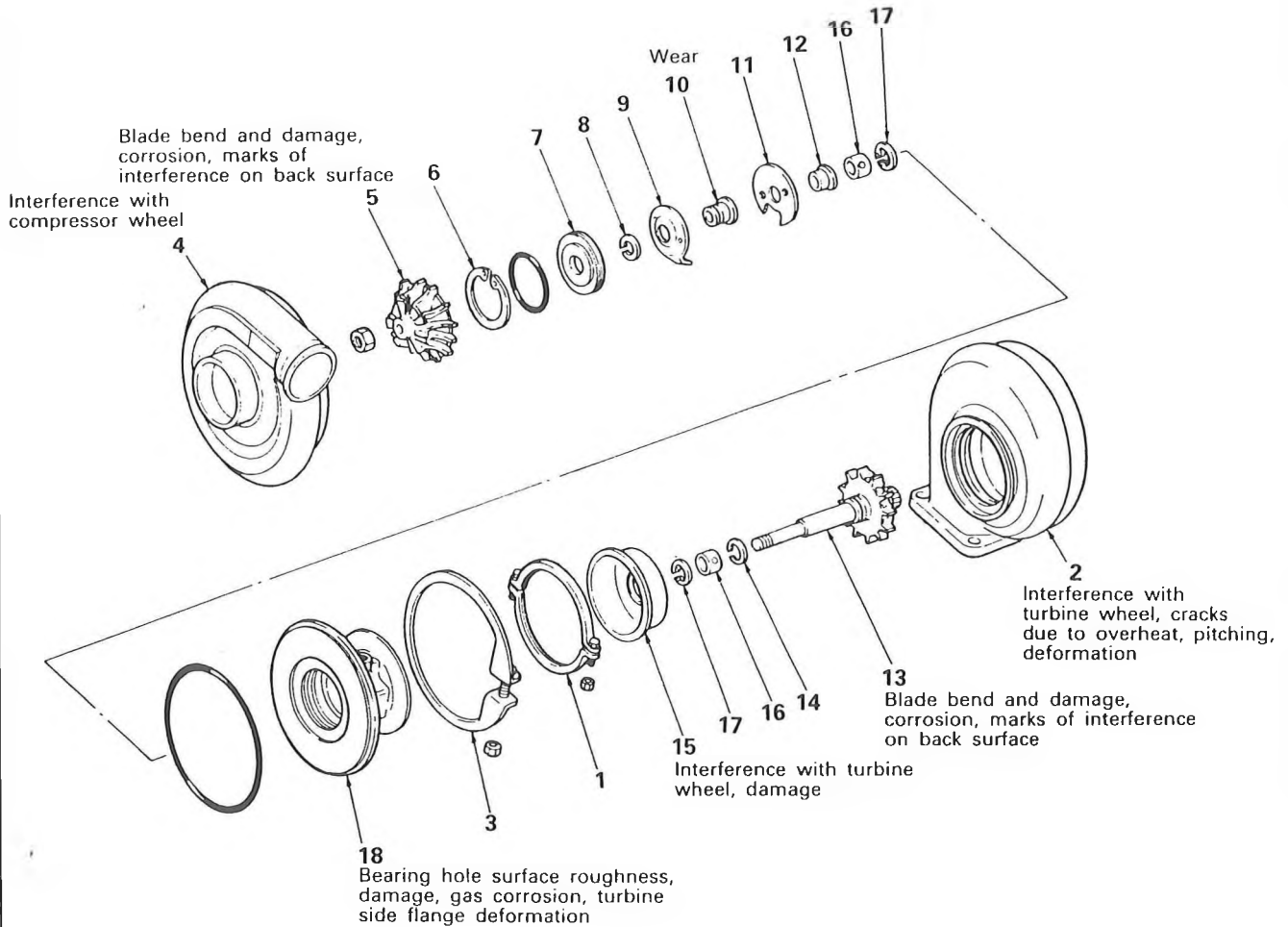
NOTE:

Perform this inspection after cleaning or replacement of the air cleaner element if the element is heavily clogged.

5.4 TURBOCHARGER

5.4.1 TD08 Type Turbocharger

(1) Disassembly

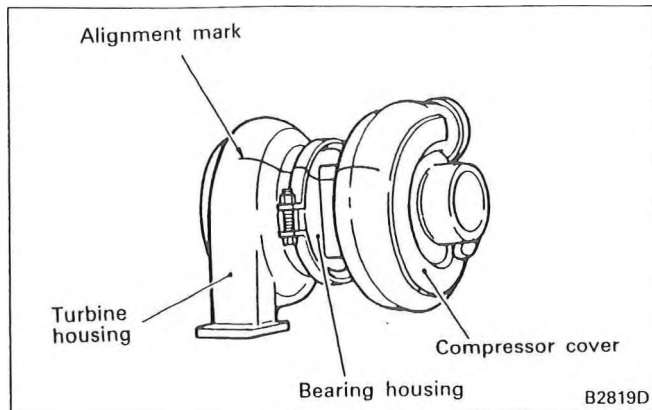


Disassembly sequence

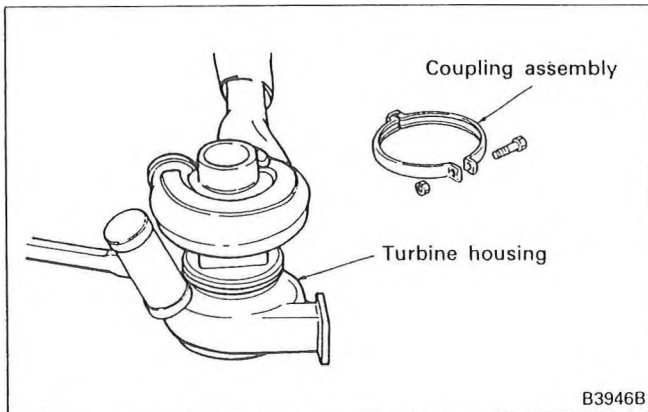
- | | |
|----------------------|----------------------------|
| 1 Coupling assembly | 10 Thrust sleeve |
| ② Turbine housing | 11 Thrust bearing |
| 3 Snap ring assembly | 12 Thrust ring |
| ④ Compressor cover | 13 Shaft and turbine wheel |
| 5 Compressor wheel | 14 Piston ring |
| 6 Snap ring | 15 Turbine back plate |
| ⑦ Insert | 16 Bearing |
| 8 Piston ring | 17 Snap ring |
| 9 Oil deflector | 18 Bearing housing |

For parts with an encircled number, refer to Disassembly Procedure that follows.

C8965B

Disassembly Procedure

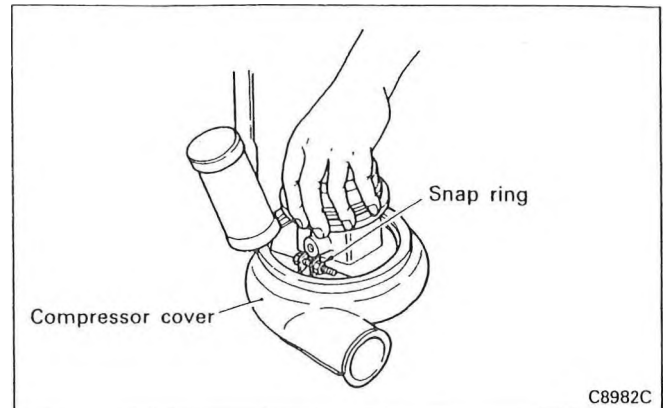
(a) Before disassembling the turbocharger, make alignment marks on the compressor cover, bearing housing, and turbine housing so that they can be properly reassembled.

(b) Removal of turbine housing

To remove the turbine housing, remove the coupling assembly and tap the housing with a plastic hammer or similar tool to prevent damage to it.

NOTE:

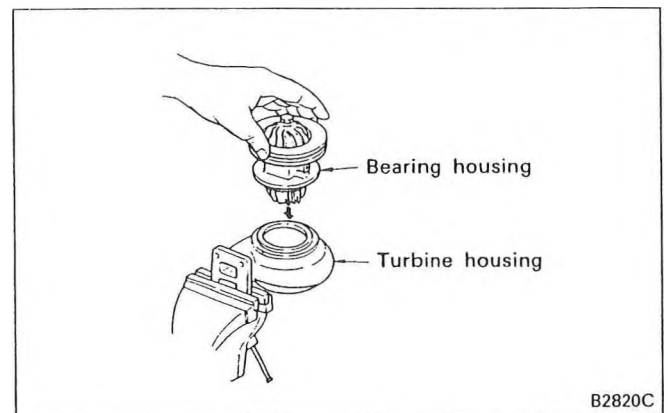
The turbine wheel blades are easy to bend. Use care not to damage them.

(c) Removal of compressor cover

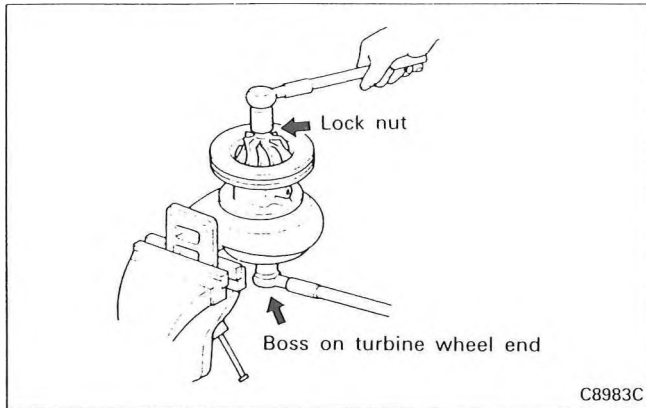
Remove the compressor cover by tapping it with a plastic hammer with the snap ring loosened.

NOTE:

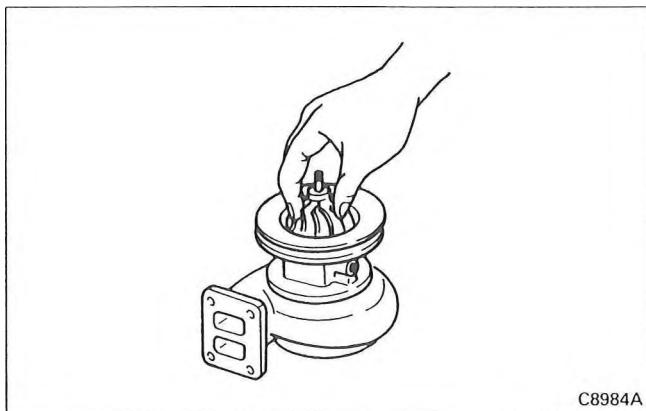
Use care not to damage the compressor wheel during the removal procedure.

(d) Removal of compressor wheel

1) Fit the bearing housing into the turbine housing which is clamped in a vise.

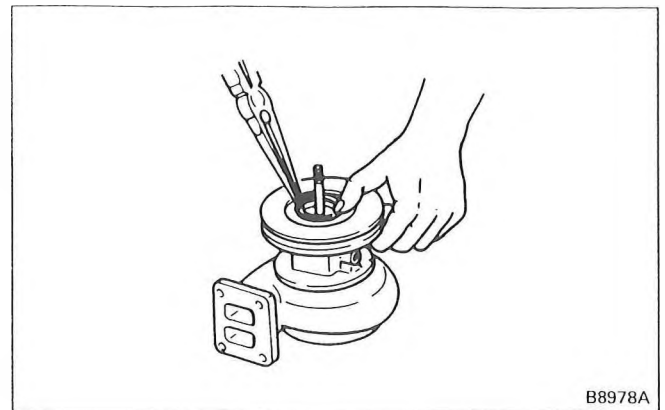


2) While holding the shaft and turbine wheel boss, remove the lock nut that secures the compressor wheel.



3) Remove the compressor wheel.

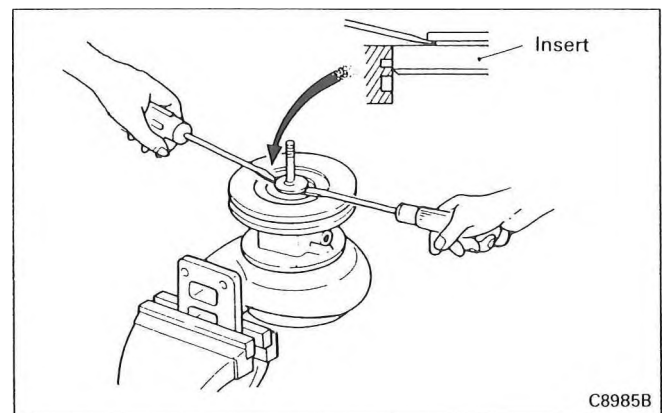
(e) Remove the insert.



1) Remove the snap ring.

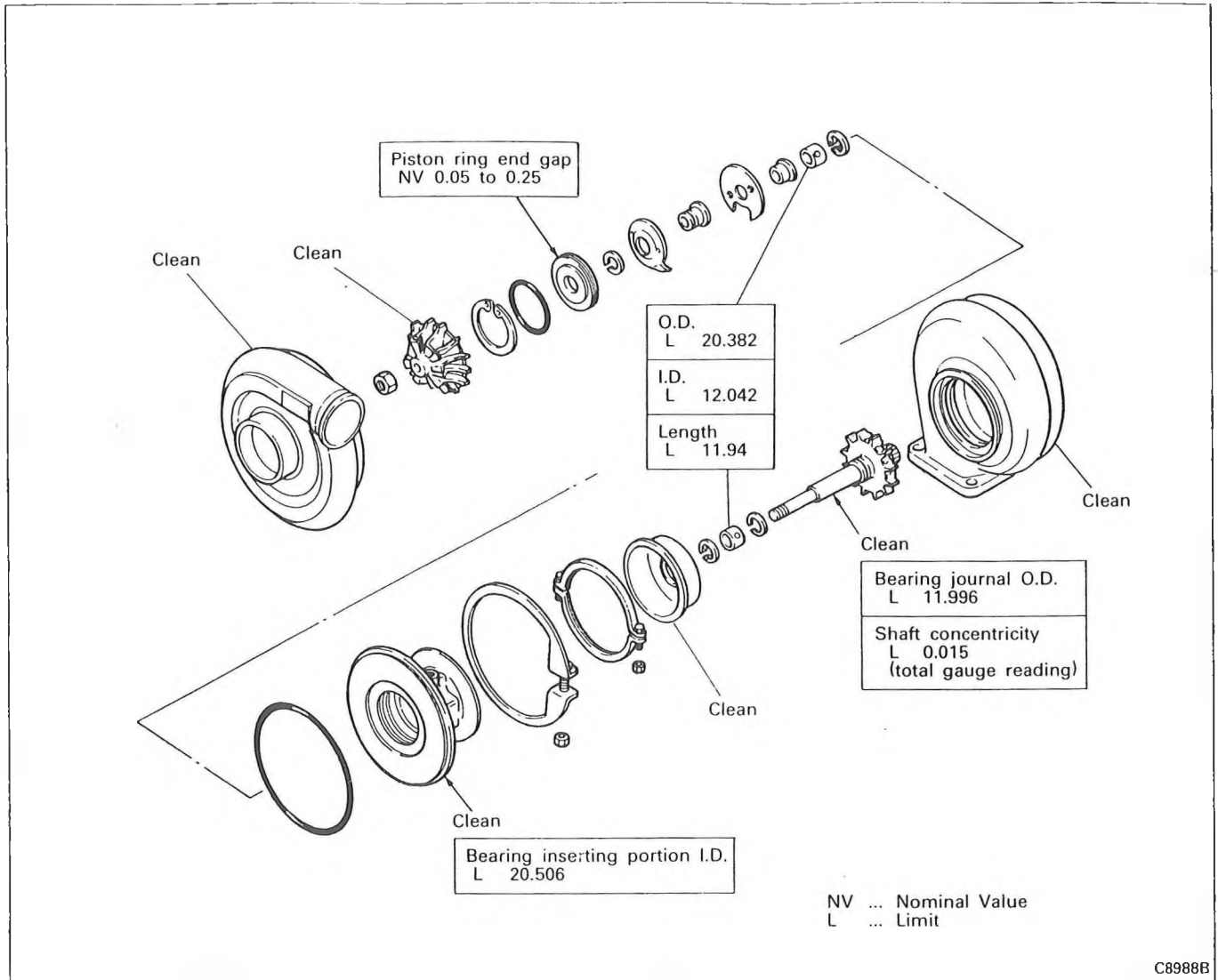
NOTE:

Retain the snap ring by hand to prevent it from springing out when slipping off the snap ring pliers.



2) Fit the tip of a screwdriver into the portion of the insert shown and carefully remove it from the bearing housing.

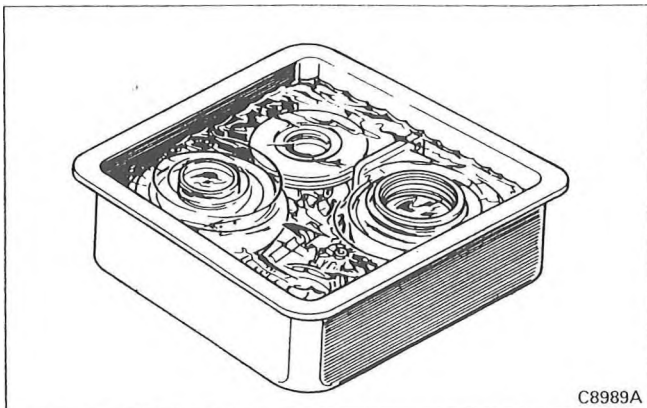
(2) Cleaning and Inspection



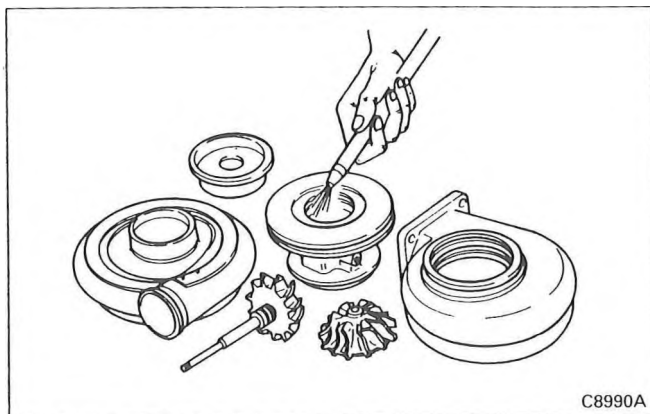
(a) Cleaning

Turbocharger manufacturers use a blasting equipment for cleaning parts at their workshops. As an alternative effective method for overhaul at the dealer's workshop, use the following procedures. When a commercially available neutral detergent is used for cleaning, make sure that it does not contain corrosive component.

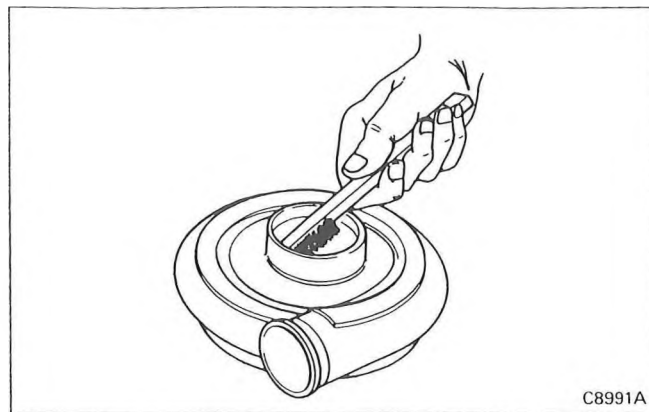
- 1) Before cleaning, visually check the condition of the parts. Check for burns, wear, etc. which could not be identified after washing.



- 2) Immerse all the parts in a non-inflammable solvent (Daido kagaku Kogyo's Dai Cleaner T-30 or equivalent) to clean oily contamination.



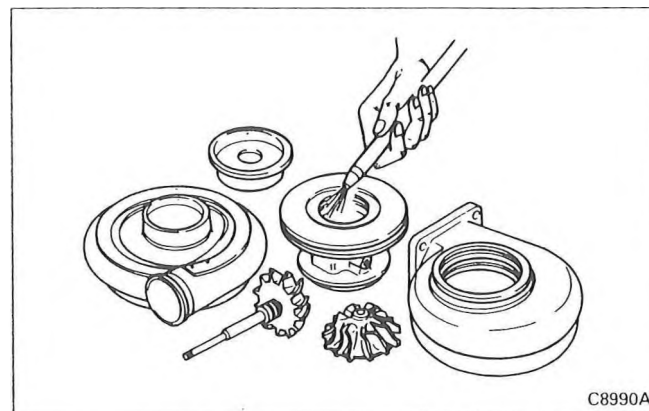
- 3) Blow clean compressed air against the entire internal and external surfaces.



- 4) Clean deposits, using a plastic scraper or bristle brush.

NOTE:

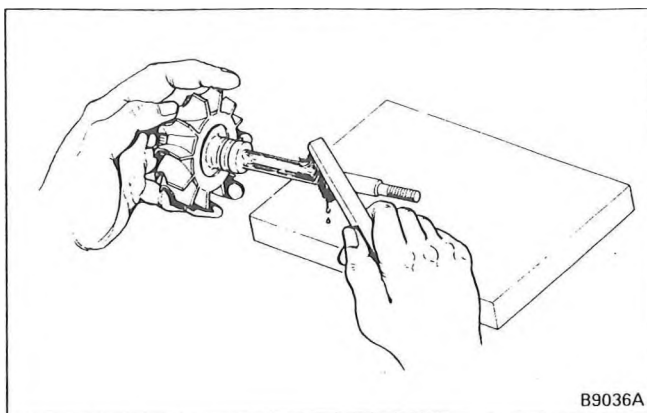
Use care to prevent damage to parts.



- 5) Blow clean compressed air again against the entire internal and external surfaces.

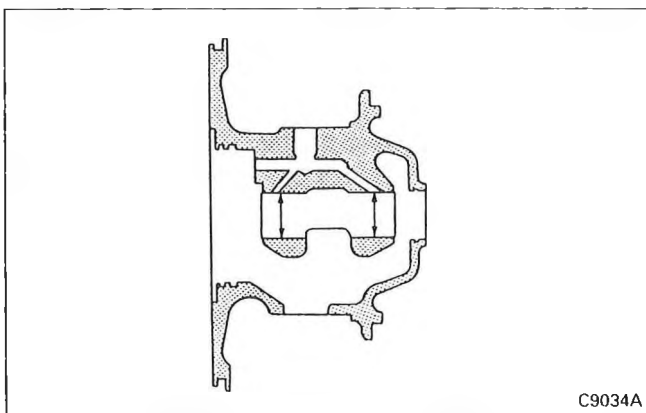
NOTE:

The bearing housing and turbine wheel shaft should be re-immersed in a non-inflammable detergent after Step 4). After deposits have been removed, blow compressed air.

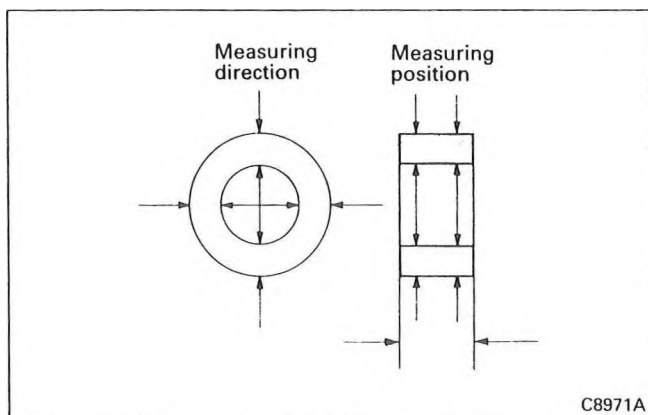


6) To prevent rust, apply engine oil to the entire internal and external surfaces of the bearing housing, turbine housing and turbine backing plate and the shaft portion of the shaft and turbine wheel.

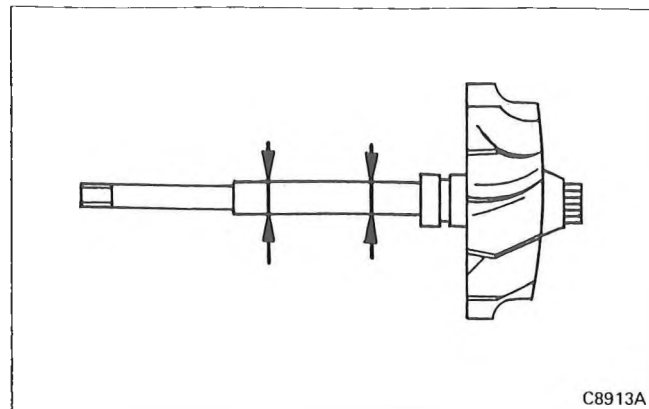
(b) Inspection



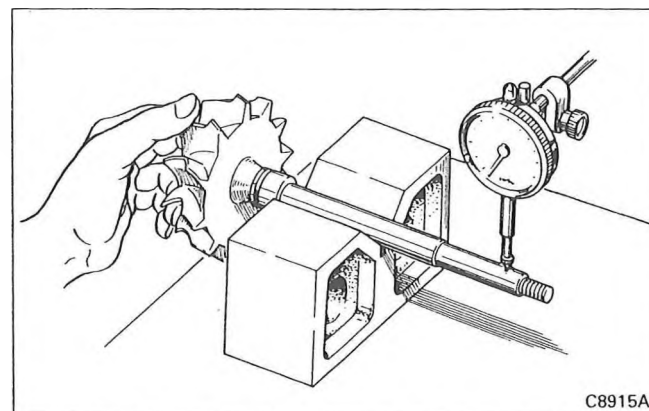
1) If the bearing hole diameter and piston ring hole diameter are beyond the limit, replace the bearing housing.



2) Measure I.D., O.D., and length of the bearing. If the measured values exceed the service limit, replace the bearing.



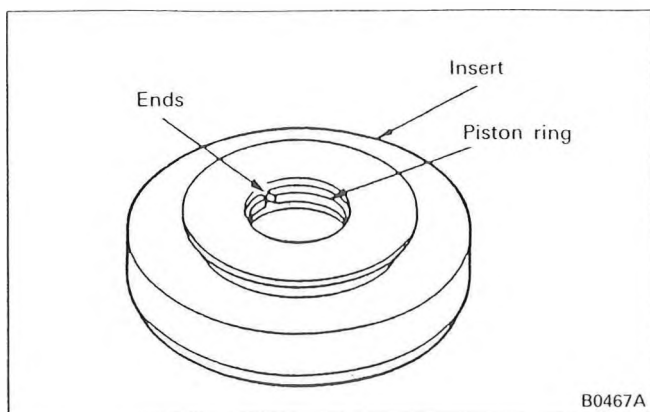
3) Measure the shaft and turbine wheel journal diameter. If the measured diameter is less than the limit, replace the shaft and turbine wheel.



4) Set a dial indicator beside the threaded portion of the shaft to measure the concentricity. If the deflection of the dial indicator is beyond the limit, replace the turbine wheel shaft.

NOTE:

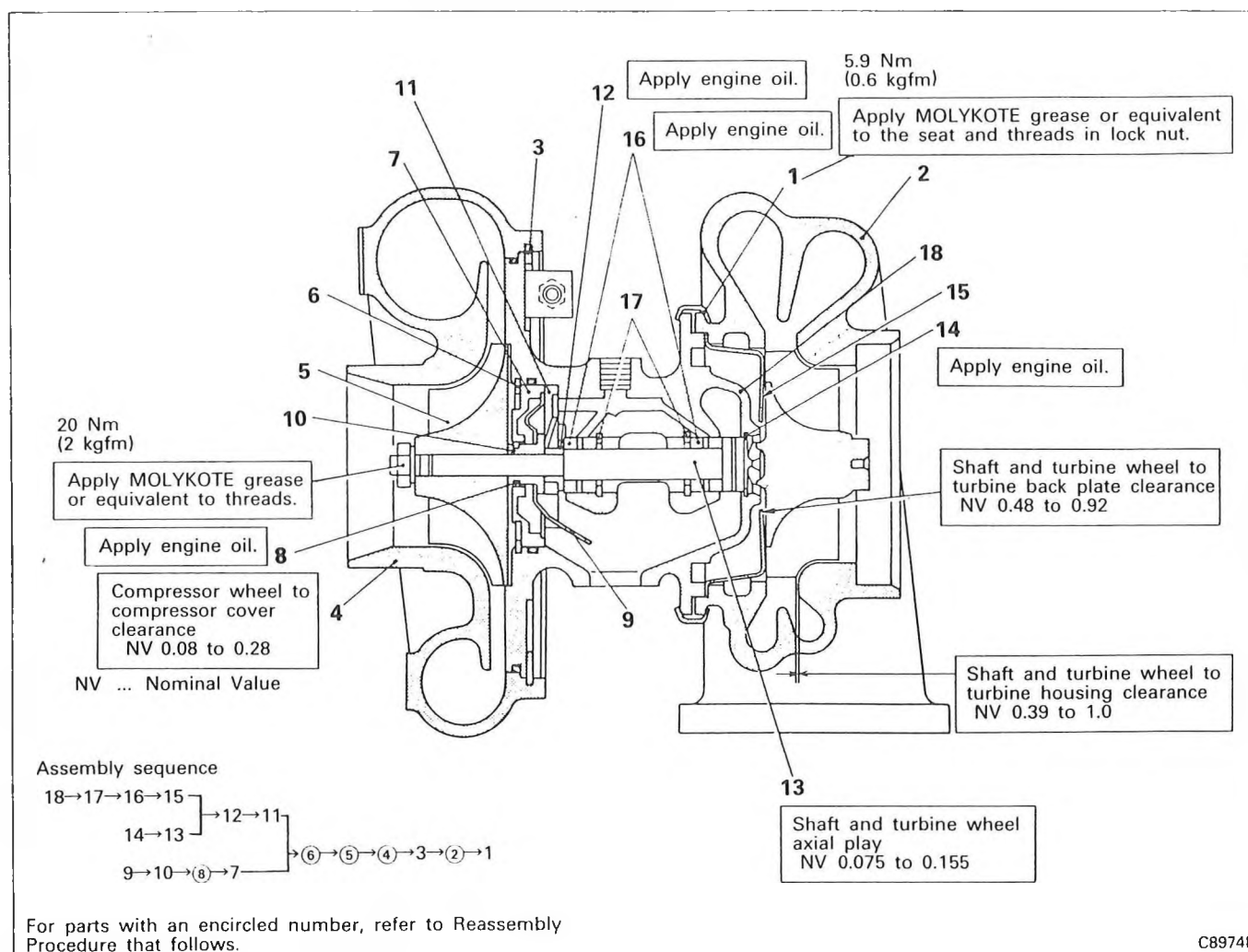
Do not correct but replace a bent shaft.



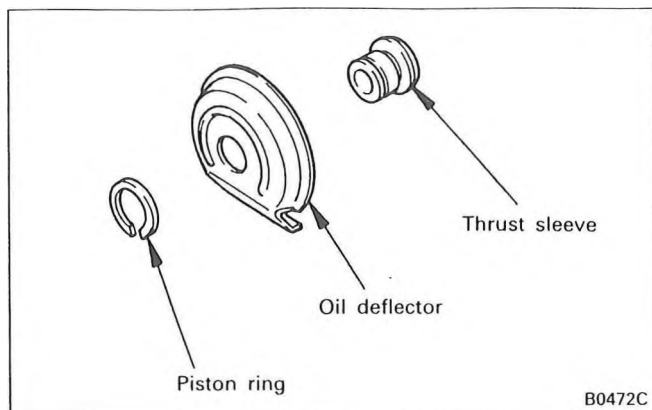
5) Insert

Insert a new piston ring securely in the bore in the insert and measure the end gap of the piston ring. If the end gap is out of specification, replace the insert.

(3) Reassembly



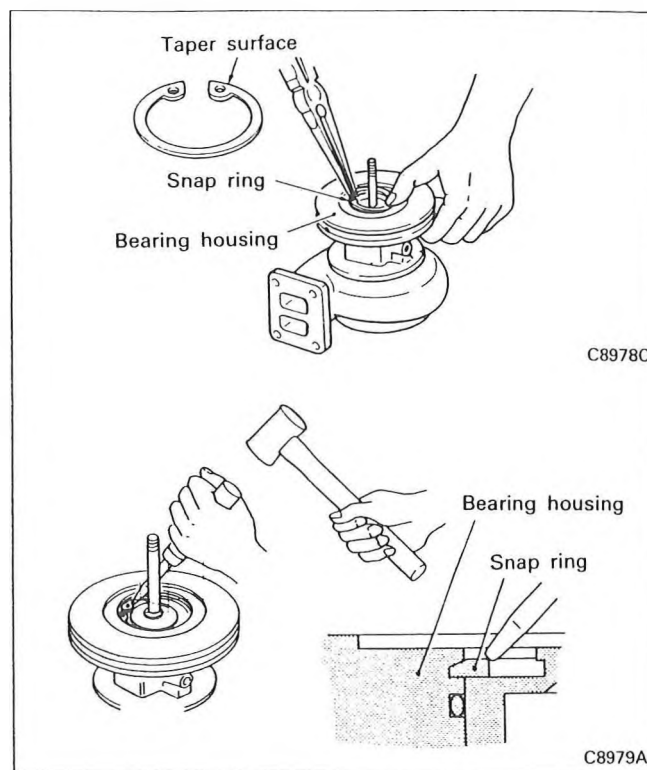
C8974B

Reassembly Procedure**(a) Installation of piston ring**

Set the thrust sleeve into the oil deflector, and install the piston ring.

NOTE:

1. When mounting piston ring to the thrust sleeve, ensure that the ring is not expanded and ring ends are not twisted.
2. If the piston ring is to be replaced with a new one, be sure to replace also the thrust sleeve and shaft and turbine wheel with new ones.

(b) Installation of snap ring

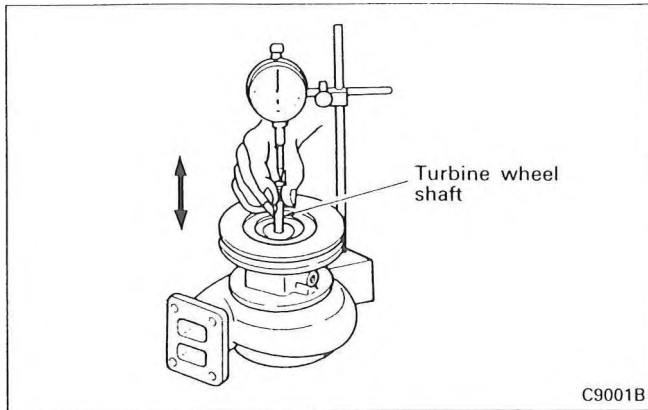
Install the snap ring to the bearing housing with its taper up.

After installation, using a screwdriver drive the snap ring into the groove in the bearing housing by hammering.

NOTE:

1. Retain the snap ring by hand to prevent it from springing out when slipping off the snap ring pliers.
2. Special care must be exercised, when tapping the snap ring into position, to prevent damage to the bearing housing by the screwdriver.

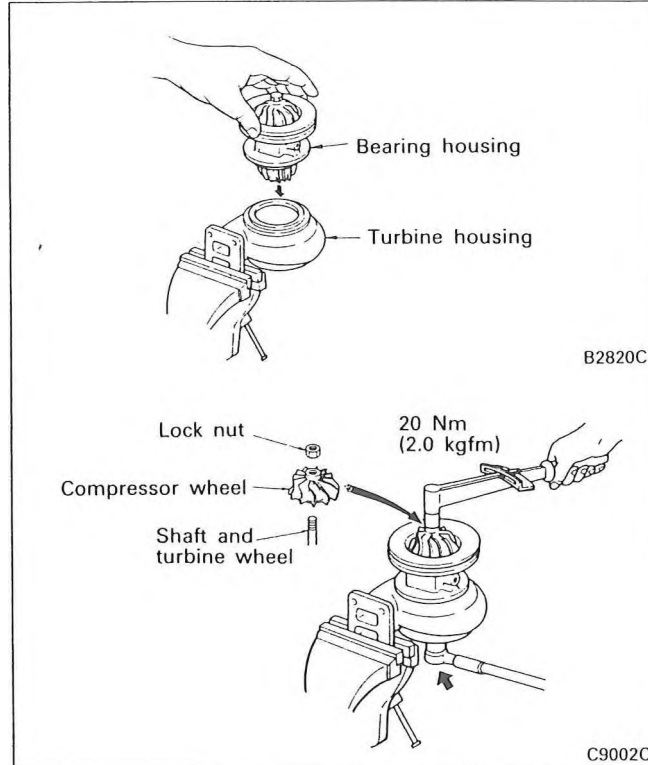
(c) Measurement of clearance between shaft and turbine wheel and turbine housing



Set the dial gauge on the shaft and turbine wheel end. Move the shaft and turbine wheel in the axial direction and measure the clearance between the turbine wheel and turbine housing.

If the clearance is out of specification, disassemble and isolate the cause.

(d) Installation of compressor wheel

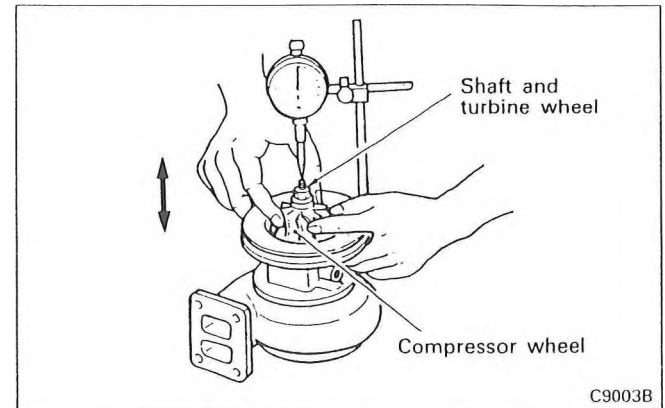


1) Holding the turbine housing in a vice, set the turbine wheel side of the bearing housing into the turbine housing.

2) Coat threads in the shaft and turbine wheel with molybdenum disulfide base grease (NLGI No.2) Li soap and mount the compressor wheel onto the shaft.
3) Holding the boss on the turbine wheel side, tighten the compressor wheel lock nut to the specified torque.

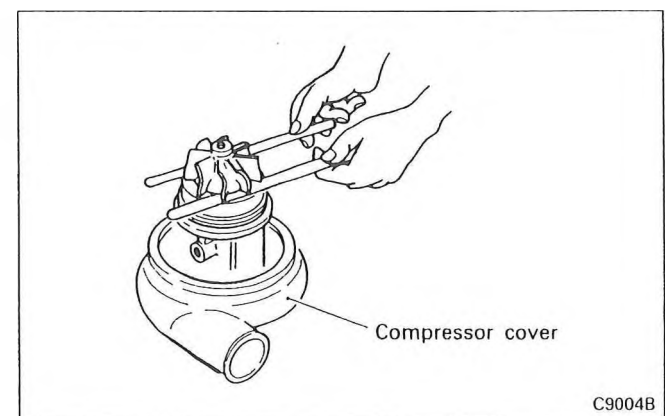
NOTE:

Set the bearing housing carefully to prevent damage on the turbine wheel blades.



(e) Set a dial gauge on the shaft and turbine wheel end.

With compressor wheel moved in the axial direction, measure the end play. If the play is out of specification, disassemble and check to locate the cause.



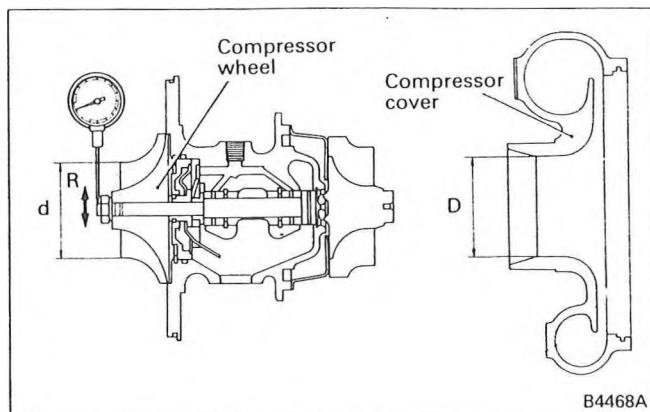
(f) With the turbine housing removed from the bearing housing and compressor cover installed, measure the following.

Using two thickness gauges, measure the clearance between the turbine back plate and turbine wheel back surface. If the clearance is out of specification, disassemble and check to locate the cause.

NOTE:

Be sure to use two thickness gauges and take measurement at the tip of the blades.

(g) Shaft and turbine wheel to compressor cover clearance



Check by the following procedures.

- 1) Move up and down the compressor wheel to measure runout (R)

NOTE:

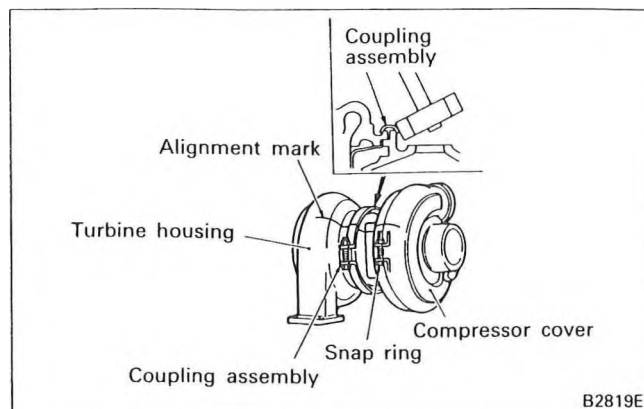
Do not measure runout by turning the compressor wheel.

- 2) Measure compressor cover inside diameter (D) and compressor wheel outside diameter (d) at places indicated in the illustration.
- 3) Calculate the clearance by the equation given below.

If it is out of specification, disassemble and check again.

$$\text{Clearance} = 1/2(D - d - R)$$

(h) Installation of turbine housing and compressor cover



Make sure that the alignment marks are aligned and secure the parts with the coupling assembly and snap ring.

Install the coupling assembly by the following procedures.

- 1) Tighten the coupling assembly to specified torque.
- 2) Hammer the coupling assembly all around.
- 3) Tighten again the coupling assembly to specified torque.
- 4) After reassembly, turn the turbine wheel and compressor wheel by hand and check for smooth rotation.

If the wheels turn heavily, or bind, disassemble, and locate the cause of trouble.

5.4.2 4LF Type Turbocharger

See pages describing the TD08 turbocharger for disassembly, inspection, cleaning and reassembly procedures.

(1) Disassembly

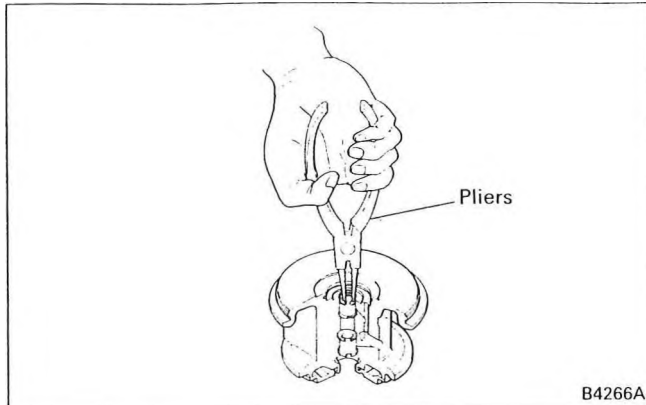
<Disassembly sequence>

1 V-clamp	10 Piston ring	18 Bearing
2 Turbine housing	11 Flinger sleeve	19 Snap ring
3 V-clamp	12 Oil deflector	20 Snap ring
4 Compressor cover	13 Thrust ring	21 Oil control sleeve
5 Compressor wheel	14 Thrust bearing	22 Bearing
6 Shaft and turbine wheel	15 Sleeve	23 Snap ring
7 Piston ring	16 Thrust ring	24 Turbine back plate
8 Snap ring	17 Snap ring	25 Bearing housing
9 Insert		

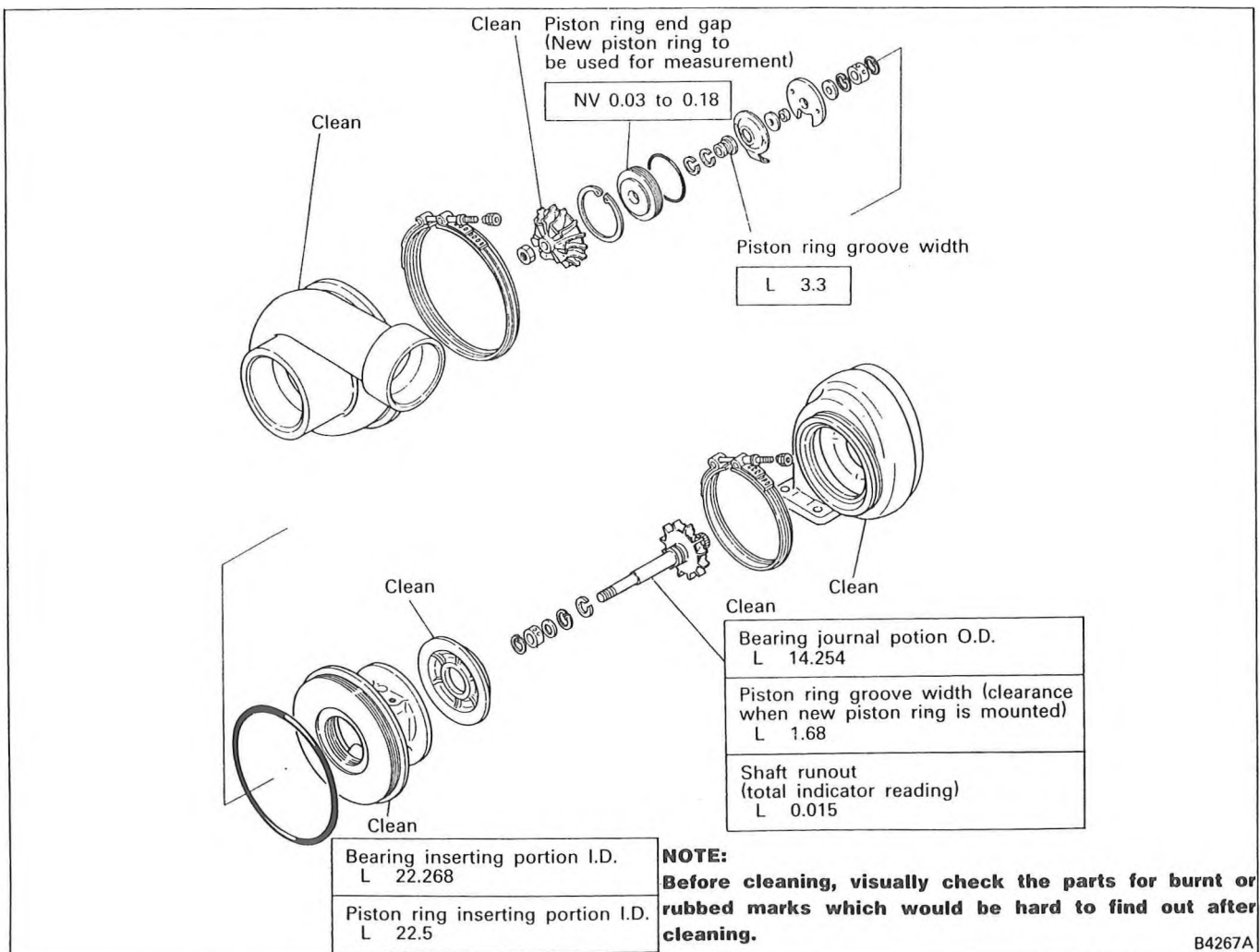
For parts with an encircled number, refer to Disassembly Procedure that follows.

NOTE:

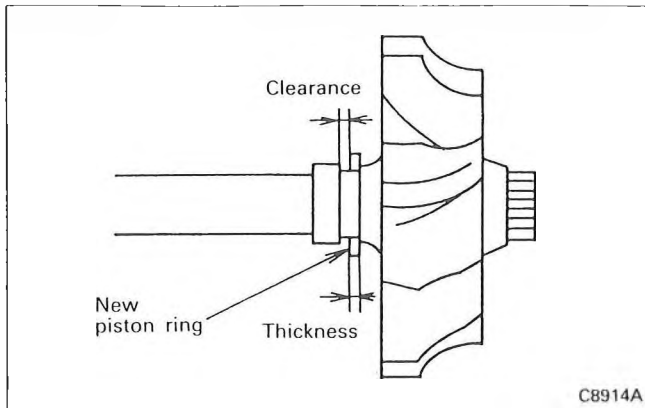
1. Make alignment marks to clarify the positional relationships among the compressor cover, bearing housing and turbine housing before disassembly.
2. The compressor wheel and turbine wheel blades are easily bent. Use care not to allow them to fall and not to strike them.
3. Do not remove the two pins of the bearing housing.

Disassembly Procedure

When the snap ring holding the bearing in position is to be removed, use pliers (tip diameter 1 mm) to prevent damage to the inside of the bearing housing.

(2) Cleaning and Inspection

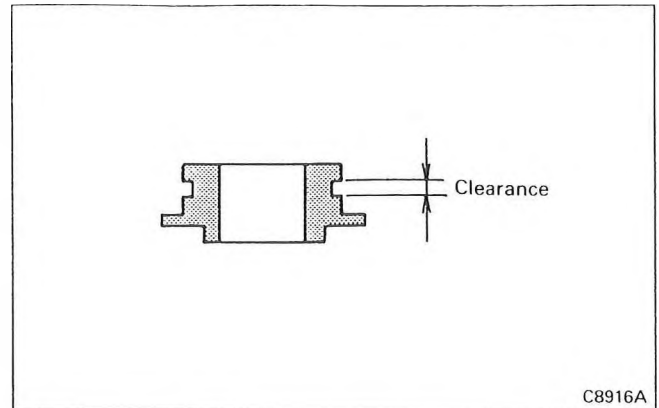
(a) Measurement of piston ring groove width



Install a new piston ring in the piston ring groove and measure the clearance.

If the reading is more than the limit, replace the shaft and turbine wheel.

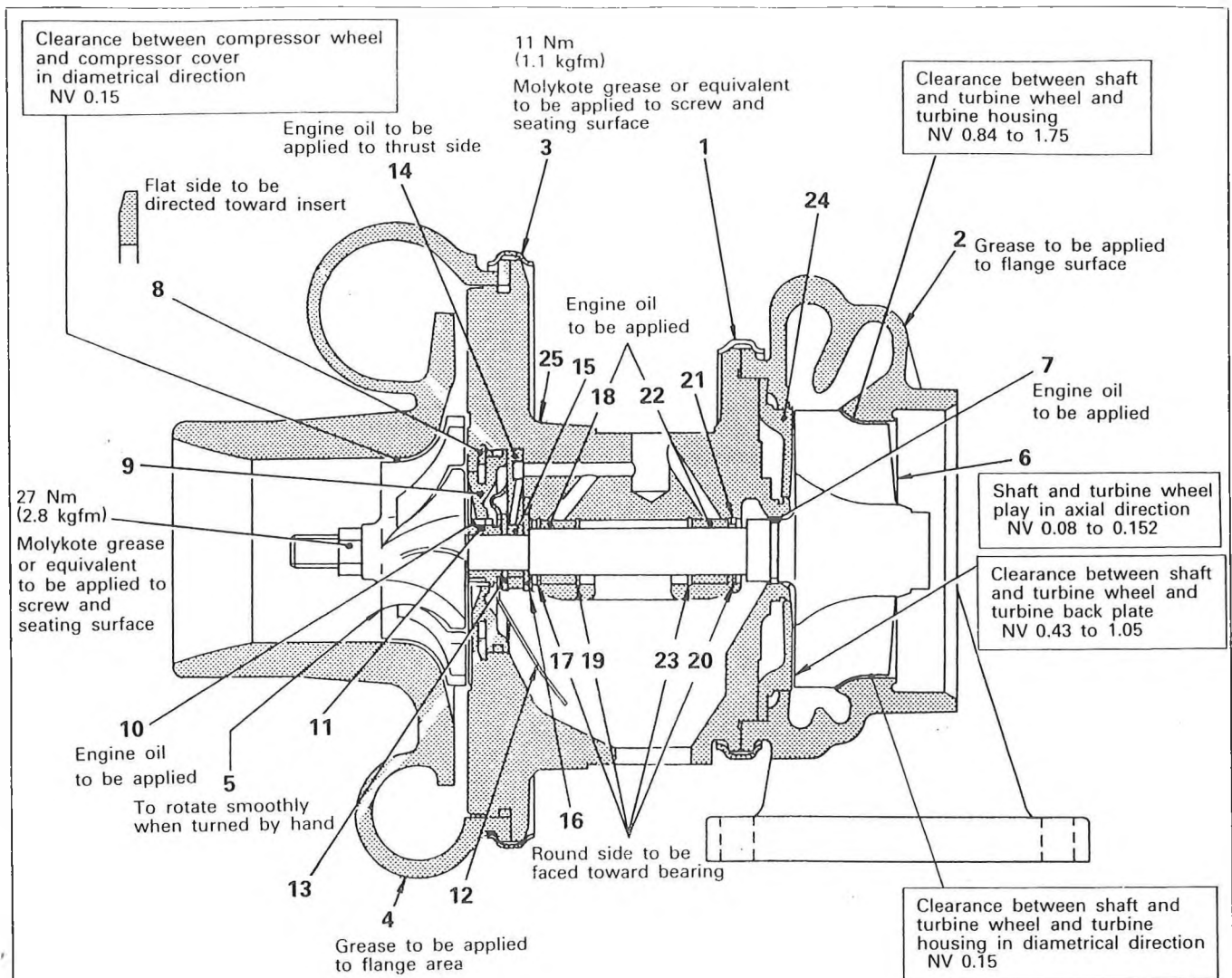
(b) Measurement of flinger sleeve groove width



Measure the piston ring groove width of the flinger sleeve.

If the reading is more than the limit, replace the flinger sleeve.

(3) Reassembly

**NOTE:**

1. The piston ring should always be replaced with a new one.
Since it is easily broken, do not open it more than necessary.
2. Apply engine oil to all sliding surfaces before installation.
3. When the compressor cover and turbine housing are installed, make sure that their alignment marks are in alignment with the marks on the bearing housing.

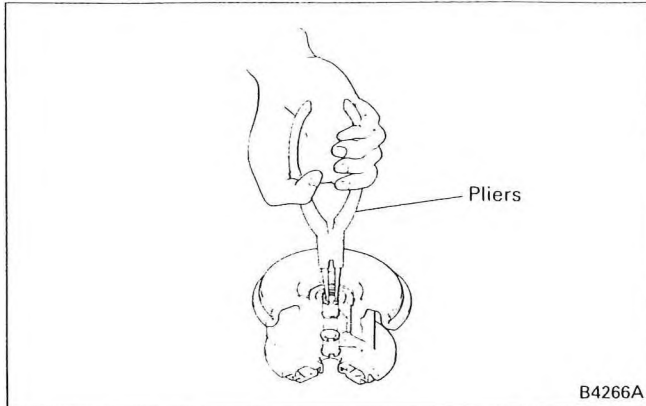
<Assembly sequence>

25→24→23→22→21→20→(19)
 →18→(17)→16→15→(14)
 6→7
 →13→12→9→8→5→4→3→2→1
 11→10

On parts marked o, refer to the assembly procedure described below.

Assembly Procedure

(a) Installing snap rings

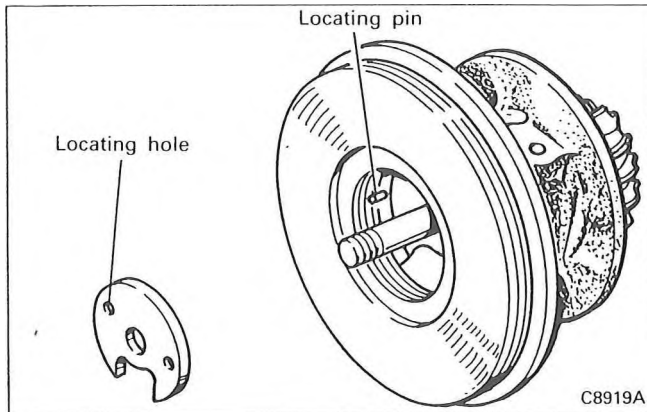


Use pliers (tip diameter 1 mm) in installing snap rings.

NOTE:

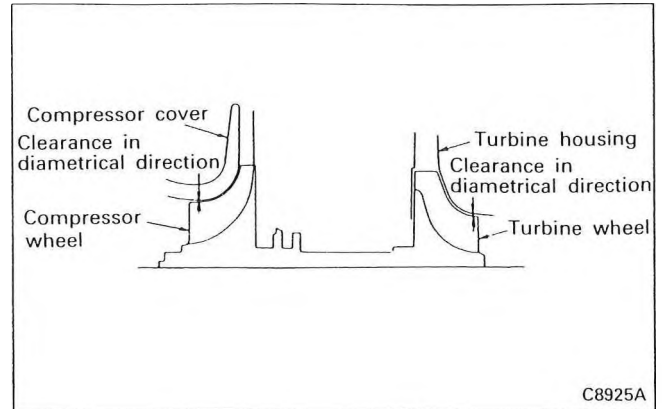
Install each snap ring with its round side toward the bearing.

(b) Installing thrust bearing



To install the thrust bearing, apply engine oil to the thrust receiving side. Press it in with its locating hole in alignment with the locating pin of the bearing housing until it is in flat contact with the bearing housing.

(c) Measuring clearances between shaft and turbine wheel and turbine housing, and compressor wheel and compressor cover in diametrical direction



Measure each clearance with a thickness gauge to check that it is within the nominal value.

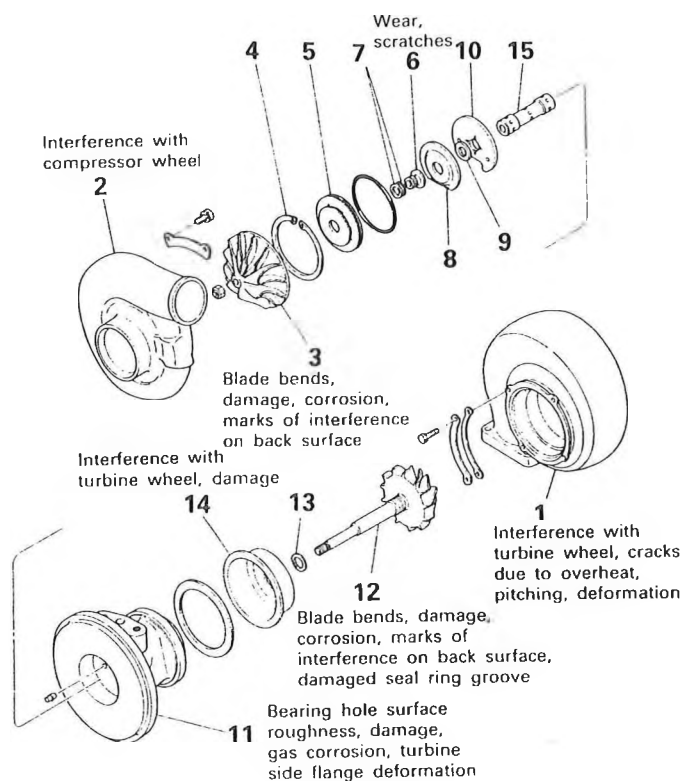
NOTE:

When a clearance is to be measured, press the shaft in the axial direction to minimize the clearance.

5.4.3 3LM Type Turbocharger

See pages describing the TD08 turbocharger for disassembly, inspection, cleaning and reassembly procedures.

(1) Disassembly



<Disassembly sequence>

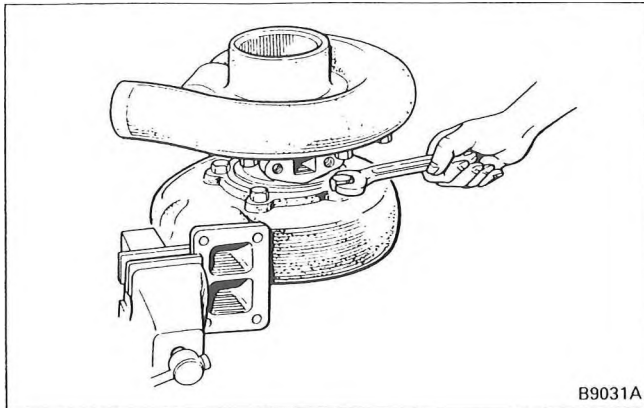
- | | | |
|--------------------|-------------------|----------------------------|
| ① Turbine housing | 6 Flinger sleeve | 11 Bearing housing |
| ② Compressor cover | 7 Piston ring | 12 Shaft and turbine wheel |
| 3 Compressor wheel | 8 Oil deflector | 13 Piston ring |
| 4 Snap ring | 9 Thrust ring | 14 Turbine backing plate |
| 5 Insert | 10 Thrust bearing | 15 Bearing |

For parts with an encircled number, refer to Disassembly Procedure that follows.

NOTE:

1. Before disassembly, make alignment marks to indicate the positional relationships among the compressor cover, bearing housing and turbine housing.
2. The compressor wheel and turbine wheel blades are easily bent. Use care not to allow them to fall and not to strike them.
3. Do not remove the two pins of the bearing housing.

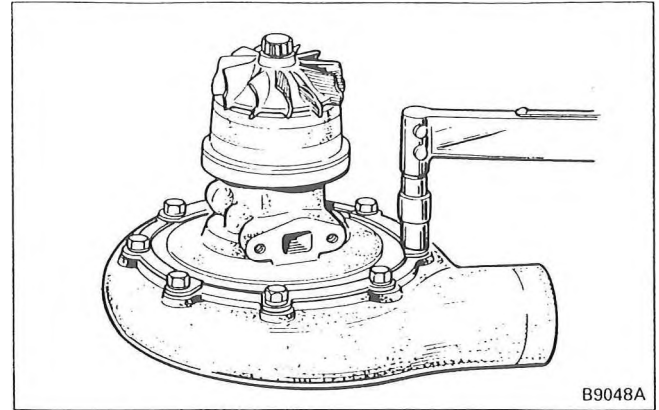
Disassembly Procedure



(a) Remove the turbine housing.

NOTE:

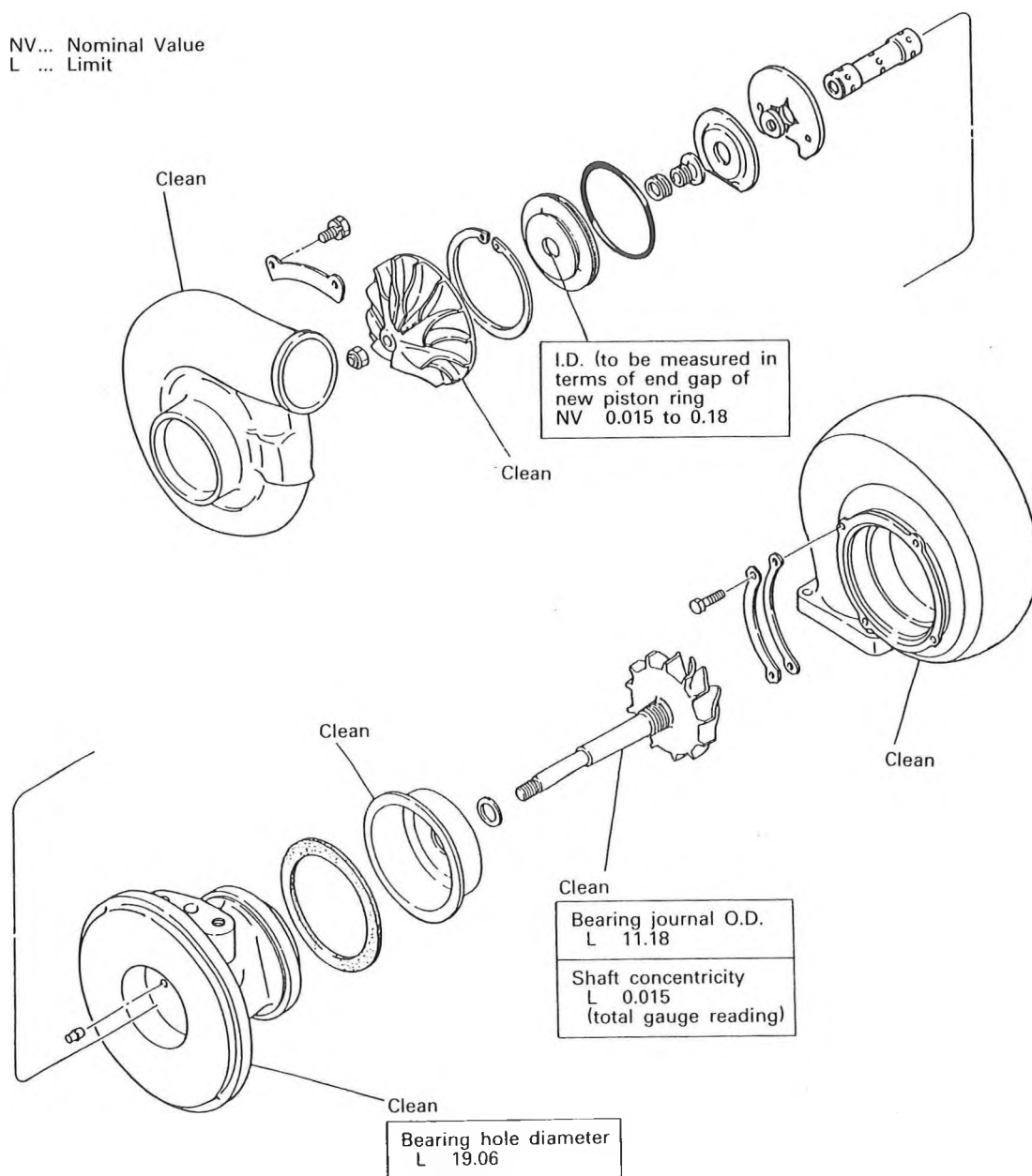
Do not drop and strike the compressor wheel and turbine wheel, as their blades are readily bent.



(b) Remove the compressor cover.

(2) Cleaning and Inspection

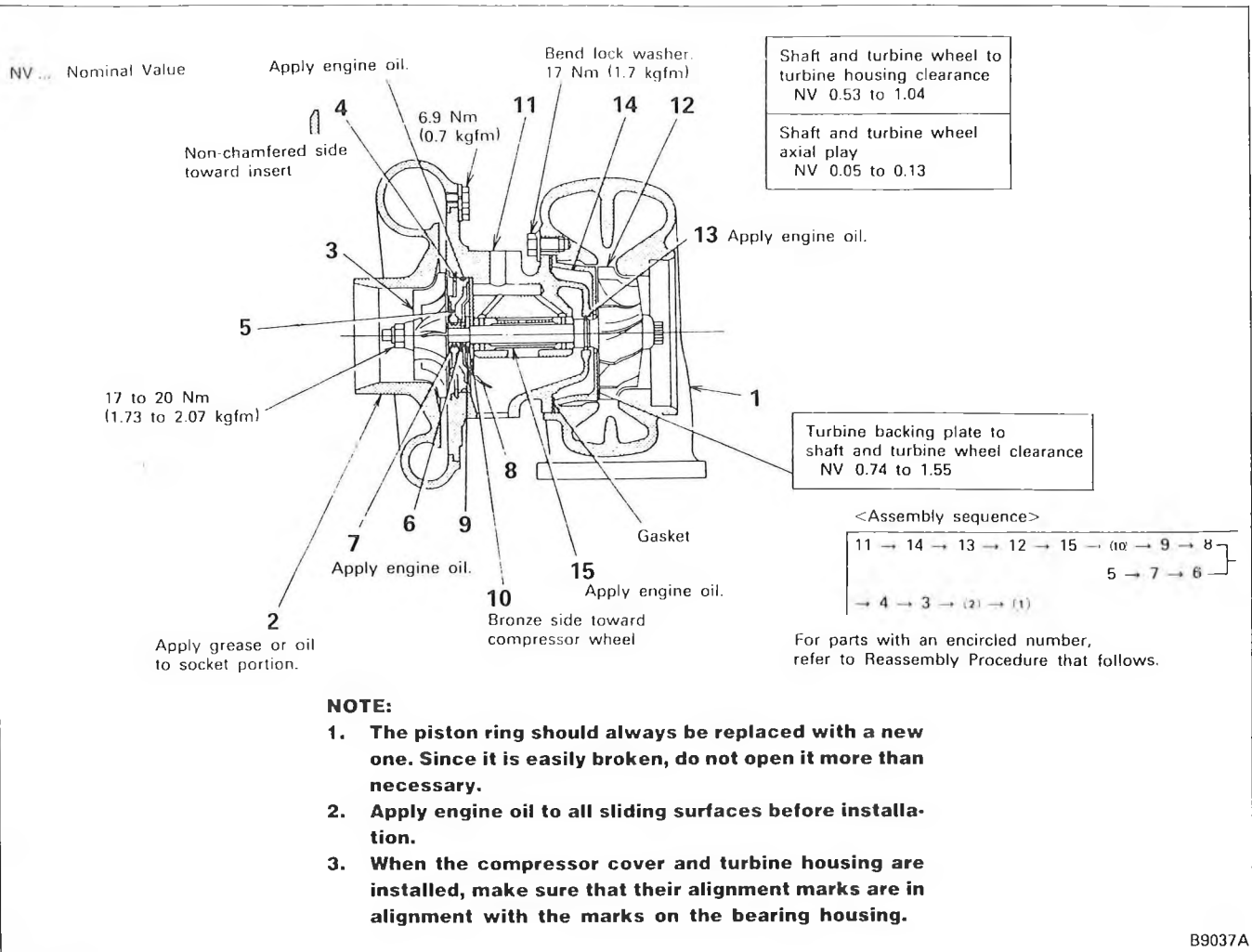
NV... Nominal Value
L ... Limit

**NOTE:**

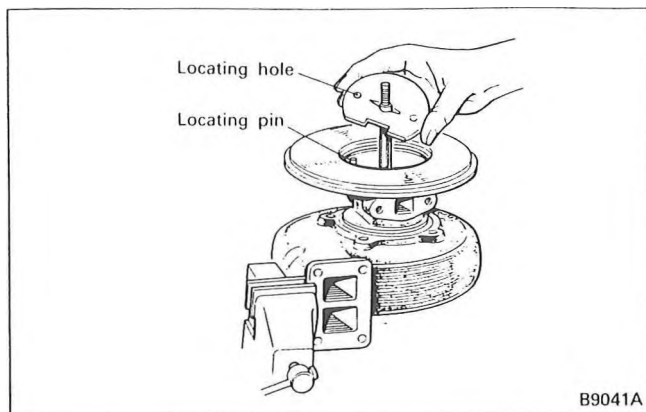
The parts may be cleaned by use of a blast equipment or any other effective methods, but a non-corrosive neutral detergent should be used.

B9034B

(3) Reassembly



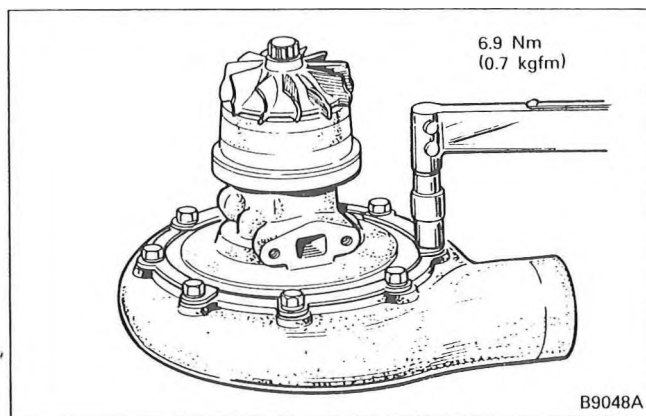
B9037A

Reassembly Procedure

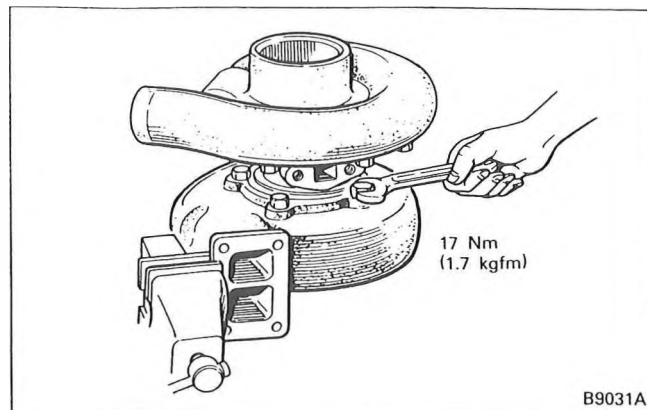
(a) Apply engine oil to both sides of the thrust bearing and thrust ring before assembling them on the turbine wheel shaft. Then install the oil deflector.

NOTE:

Install the thrust bearing with the bronze side up.



(b) Install the compressor cover by tightening the bolts to the specified torque.



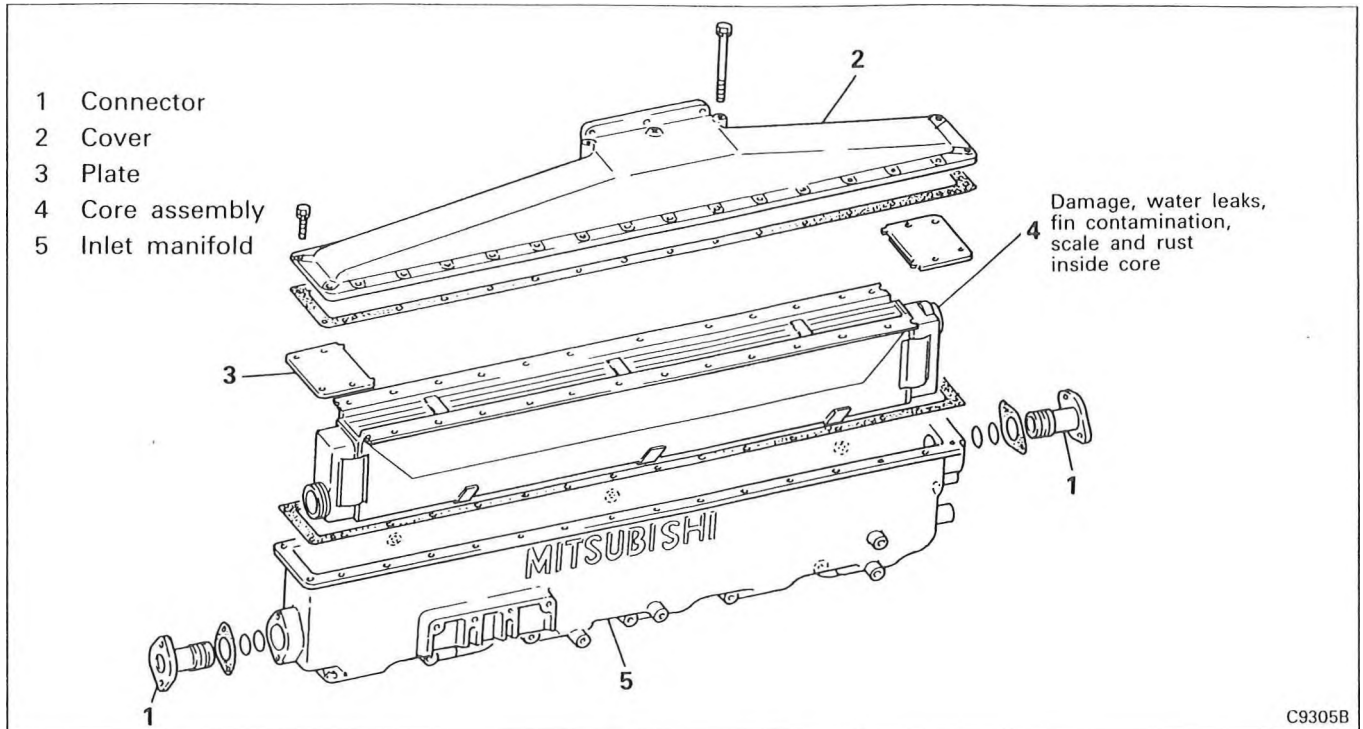
(c) Install the turbine housing tightening the bolts to the specified torque.

NOTE:

Apply an anti-seizure agent to the cap screw.

5.5 AFTER COOLER

5.5.1 Disassembly, Inspection and Reassembly



5.5.2 Air-pressure Test

Conduct the air-pressure test to check for water leaks due to damaged core. To check, apply an air pressure of 195 kPa (2 kgf/cm²) to the core. Replace the core if it is leaking air or otherwise defective.

NOTE:

Never apply pressure over specification.

6. TROUBLESHOOTING

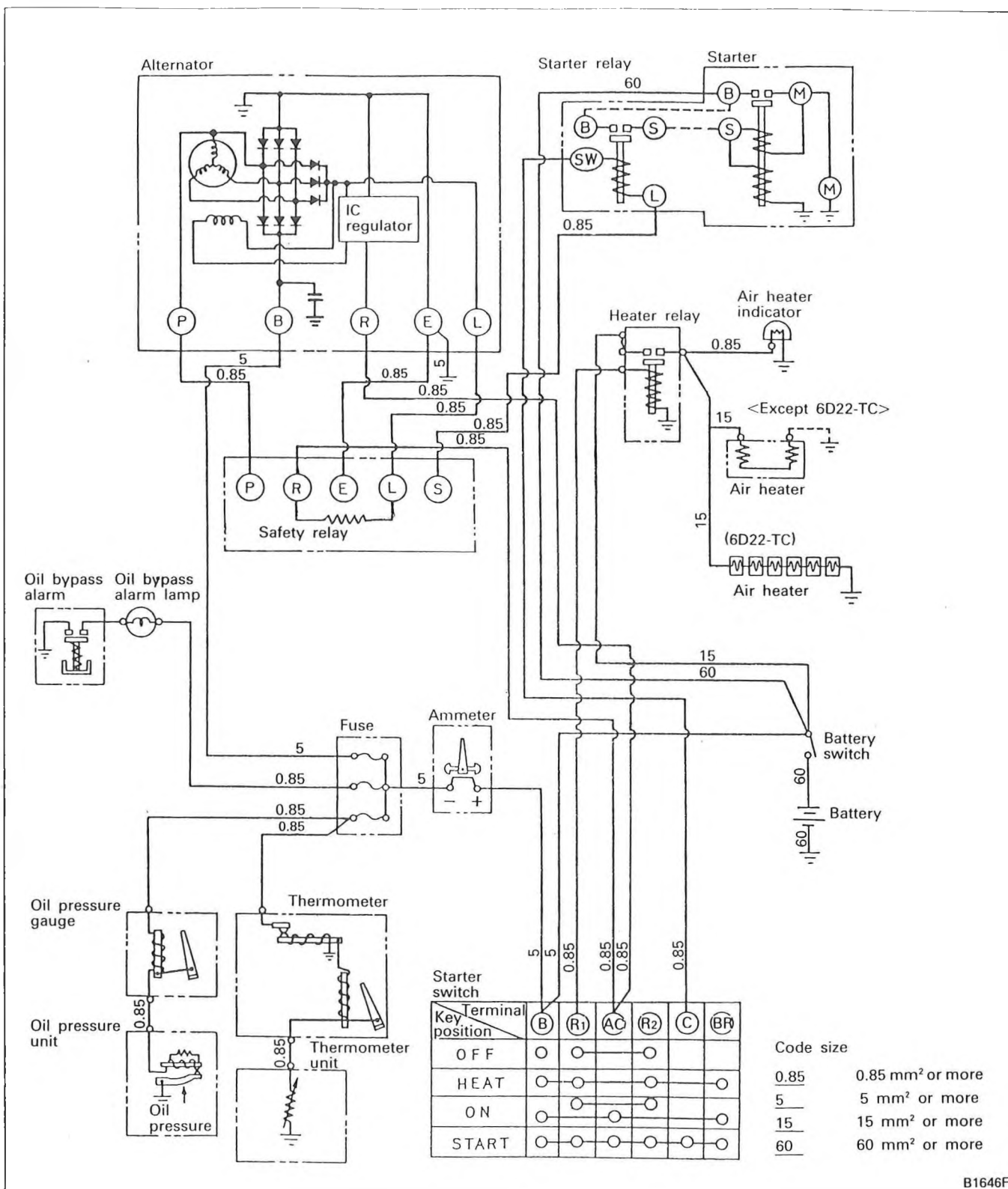
Symptom	Probable cause	Remedy	Ref. group
Low output	Insufficient intake air		
	• Loaded air cleaner element	Clean	
	• Air suction (with dust and other foreign matter) from intake system	Repair	
	• Defective turbocharger		
	• Turbocharger rotation failure		
	• Seized bearing	Replace	
	• Carbon deposit on turbine wheel	Clean	
	• Turbine wheel and turbine back plate interfering	Check	
	• Turbine wheel and turbine housing interfering	Check	
	• Bent shaft and turbine wheel	Replace	
	• Compressor wheel and compressor cover interfering	Check	
	• Seized thrust sleeve and/or thrust bearing	Replace	
	• Incorrect sliding between inside parts due to clogged lubricating oil pipe	Clean, check	
	• Damaged compressor wheel	Replace	
	• Damaged turbine wheel	Replace	
	Low exhaust efficiency		
	• Deformed front pipe, muffler and/or tail pipe (large exhaust resistance)	Replace	
	• Defective turbocharger		
	• Turbocharger rotation failure (See above)	Check	
	• Damaged turbine wheel	Replace	
Whitish and much exhaust gas	Incorrect injection timing	Adjust	Group 13
	Low compression pressure	Check	Group 11
	Low quality fuel	Replace	Group 13
	Defective turbocharger		
	• Oil leaks due to worn piston ring, and/or insert	Replace	
Dark and much exhaust gas	• Damaged oil seal due to clogged oil return pipe	Replace	
	Loaded air cleaner element	Clean	
	Trouble in engine proper	Check	Group 11
	Nonuniform fuel injection amount to cylinders	Adjust	Group 13
	Incorrect injection timing	Adjust	Group 13
Abnormal noise and/or vibration from intake and exhaust system	Poor connection of intake and exhaust systems	Correct	
	Deformed front pipe, muffler or tail pipe (large exhaust resistance)	Replace	
	Defective turbocharger (See above)	Check	

ENGINE ELECTRICAL

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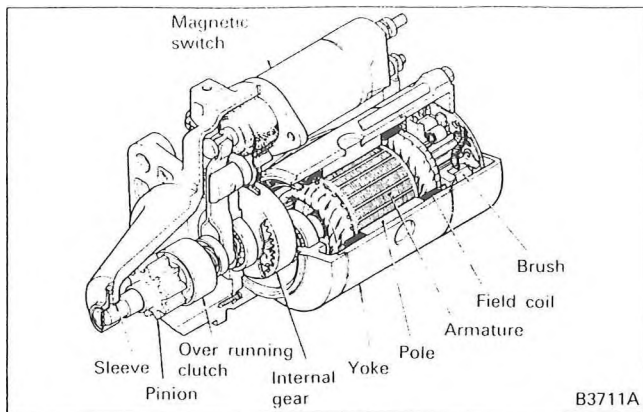
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1. GENERAL



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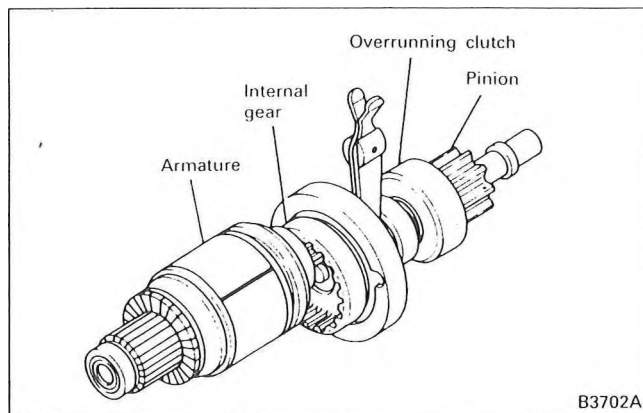
1.1 Starter



The starter is a reduction starter with a built-in reduction gear. Its motor has been downsized with even higher speed capability.

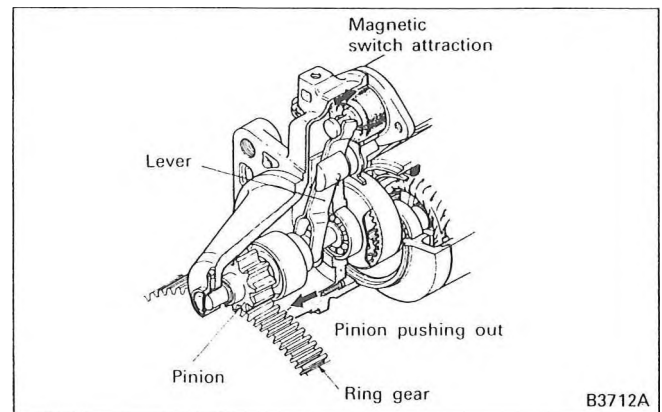
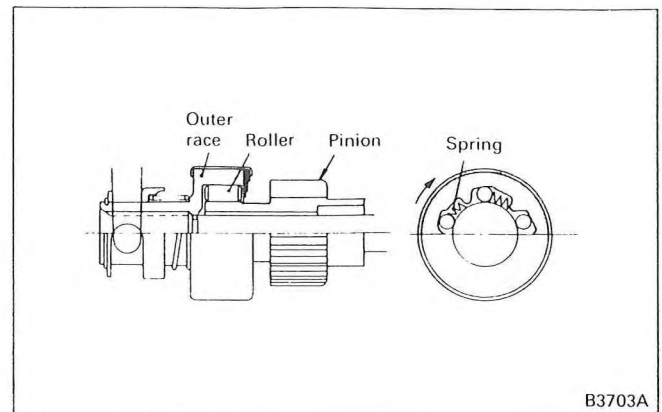
Major components of the starter are: motor section generating power; the overrunning clutch section transmitting armature torque and preventing the engine from overrunning after startup; the magnetic switch section which puts the pinion in mesh with the ring gear and feeds load current into the motor; and, the reduction gear section reducing armature speeds and transmitting torque to the pinion.

(1) Reduction Gear Section



The end of the armature shaft is shaped as a gear and is in mesh with the internal gear. After reduction by the internal gears, the torque is multiplied several times and is transmitted to the pinion.

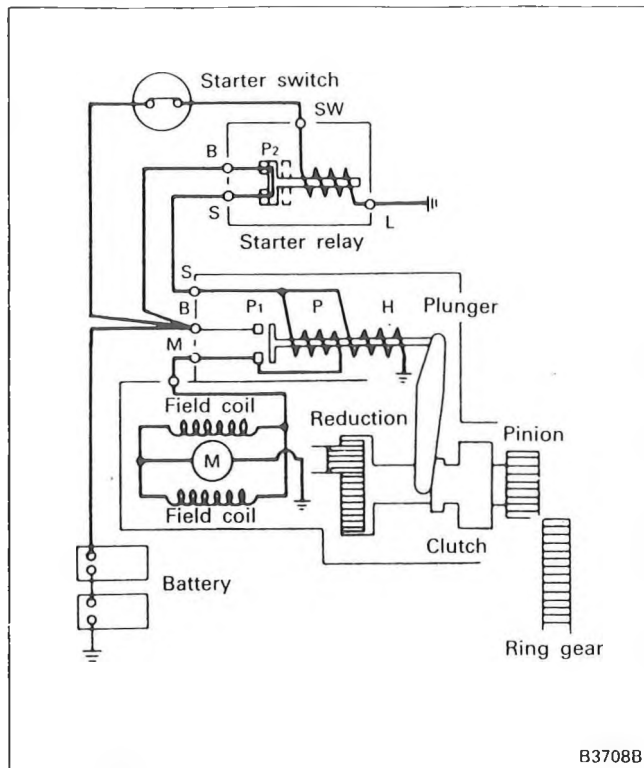
(2) Overrunning Clutch



The overrunning clutch is of roller type.

Each roller is set in the wedge-shaped groove provided by the outer and inner races (pinion) and is pressed by a spring.

The roller is pressed against the narrower side of the groove by the spring transmitting outer race rotation to the pinion by its wedge action. On the other hand, no torque is transmitted from the pinion as the roller moves to the wider side releasing the wedge action.

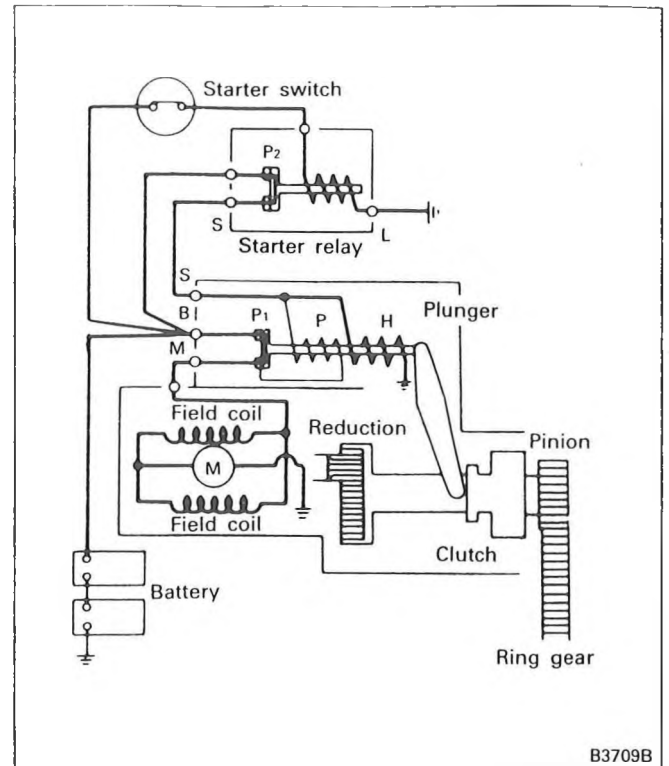
(3) Operation

While the starter switch is ON, current flows from the terminal "SW" of the starter relay to the terminal "L" and closes the contact "P2".

When the contact "P2" closes, current from the battery flows from the terminal "S" of the magnetic switch to the pull-in coil "P" and holding coil "H".

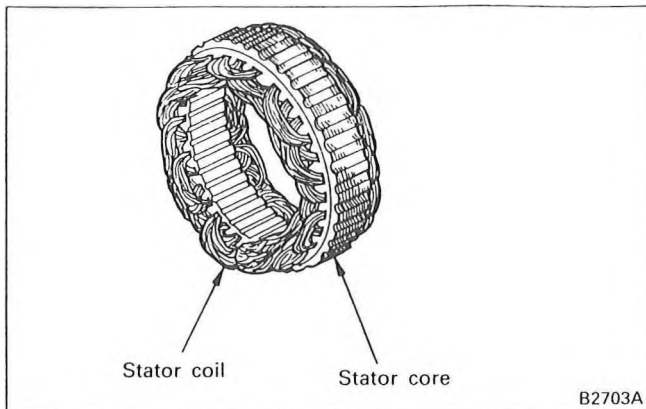
Furthermore, the current that has decreased flows from the terminal "M" to the motor section.

The plunger, attracted by the magnetic flux of the pull-in coil and holding coil, closes the contact "P1" and simultaneously pushes out the pinion turning slowly on weak current.

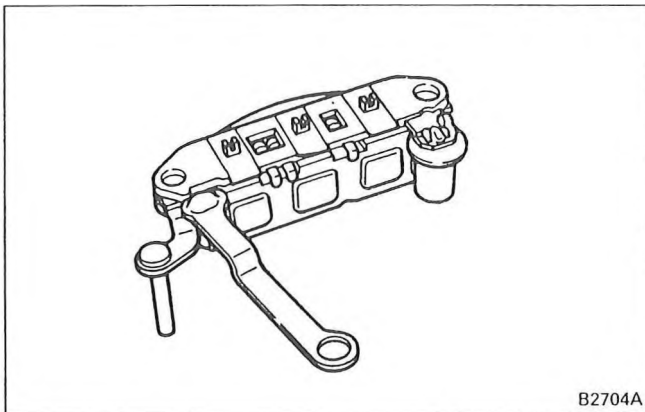


When the pinion comes into complete mesh with the ring gear, the contact "P1" closes and the large current of the battery directly flows to the motor section to turn the pinion powerfully.

In this condition, no current flows to the pull-in coil. The plunger is retained by the holding coil alone.

(b) Stator

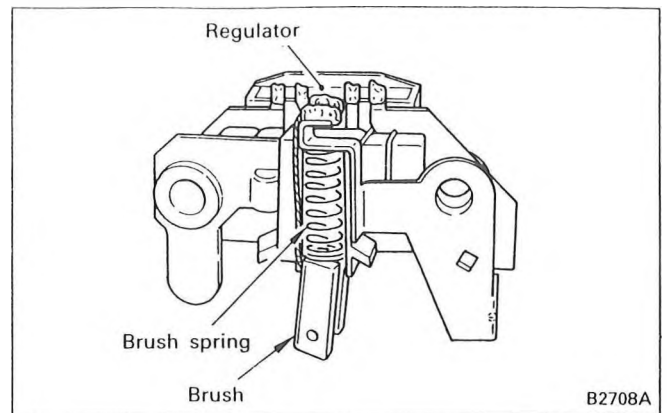
Together with the rotor core, the stator core forms the magnetic flux path. The magnetic flux lines in the stator core are affected by the passage of the rotor core field and generate electricity.

(c) Rectifier

The rectifier mainly consists of 3 diode trios, 6 diodes and 2 heat sinks. It rectifies the AC stator output to DC power.

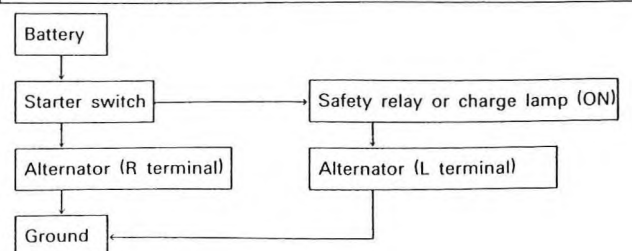
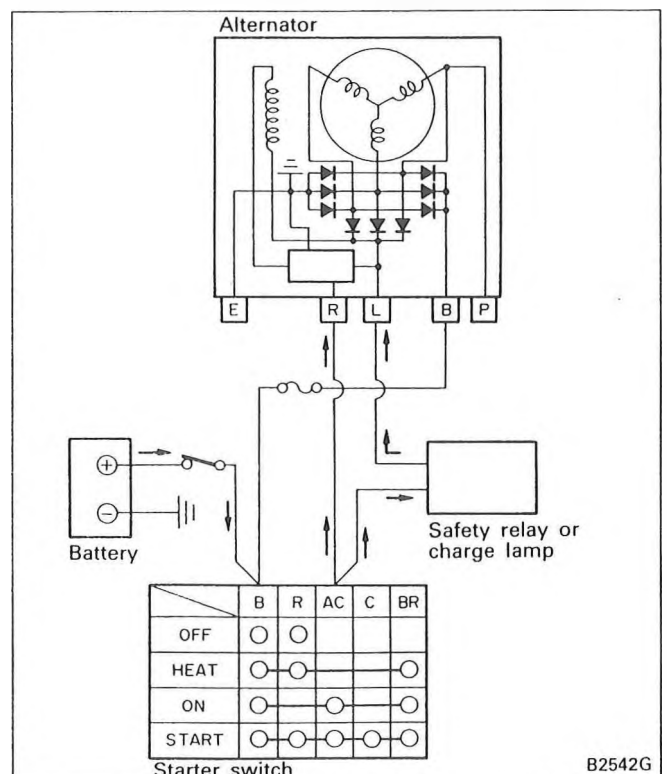
Each heat sink has the (+) or (-) leads from 3 diodes attached to it, performing full wave rectification for 3-phase AC.

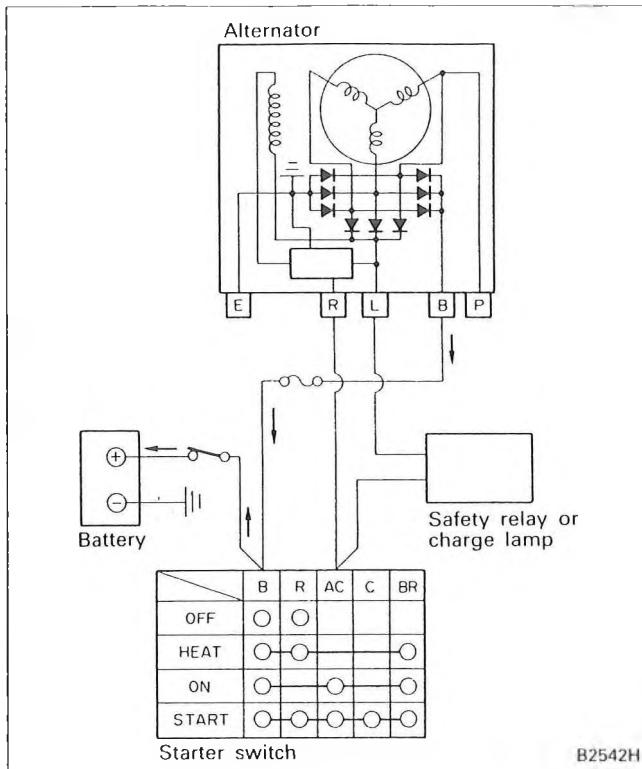
On the 80A alternator, two of rectifiers of this type are provided.

(d) Regulator

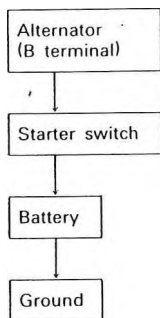
The regulator alters the strength of the field coil field to stabilize output power which varies with engine speed fluctuations.

The regulator is integral with the brush holder. The assembly combines the IC regulator, the brushes and the brush springs.

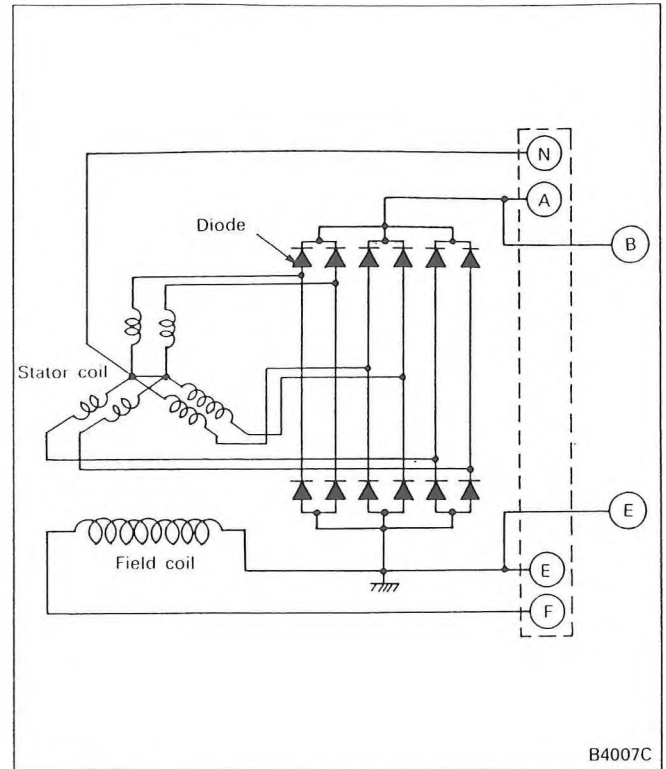
(e) Charging circuit**1) Setting the starter switch to ON**

2) Starting the engine

When the engine is started and the alternator starts generation so that the voltage at the alternator "B" terminal becomes higher than the battery voltage, the current flows as shown below.



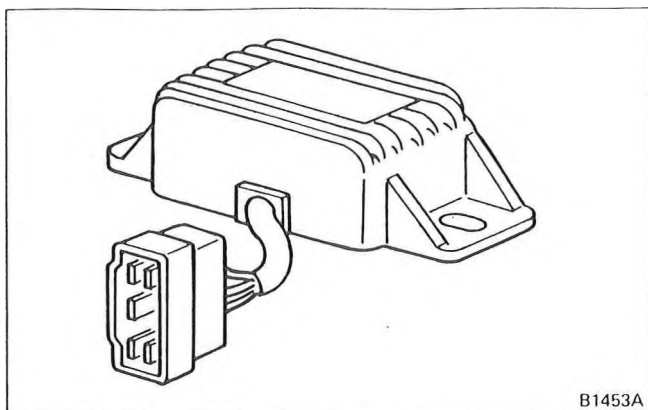
In this way, battery charge is started and at the same time, the charge lamp (if provided) goes out.

(2) 60A Alternator

The 60A alternator is an open type three-phase alternator. The three-phase AC generated in the stator coil is converted into DC by the silicon diodes. A total of 12 diodes (6 on the positive side and 6 on the negative side) are housed in 6 heat sinks, two in each heat sink.

The alternator generated voltage is controlled by the regulator.

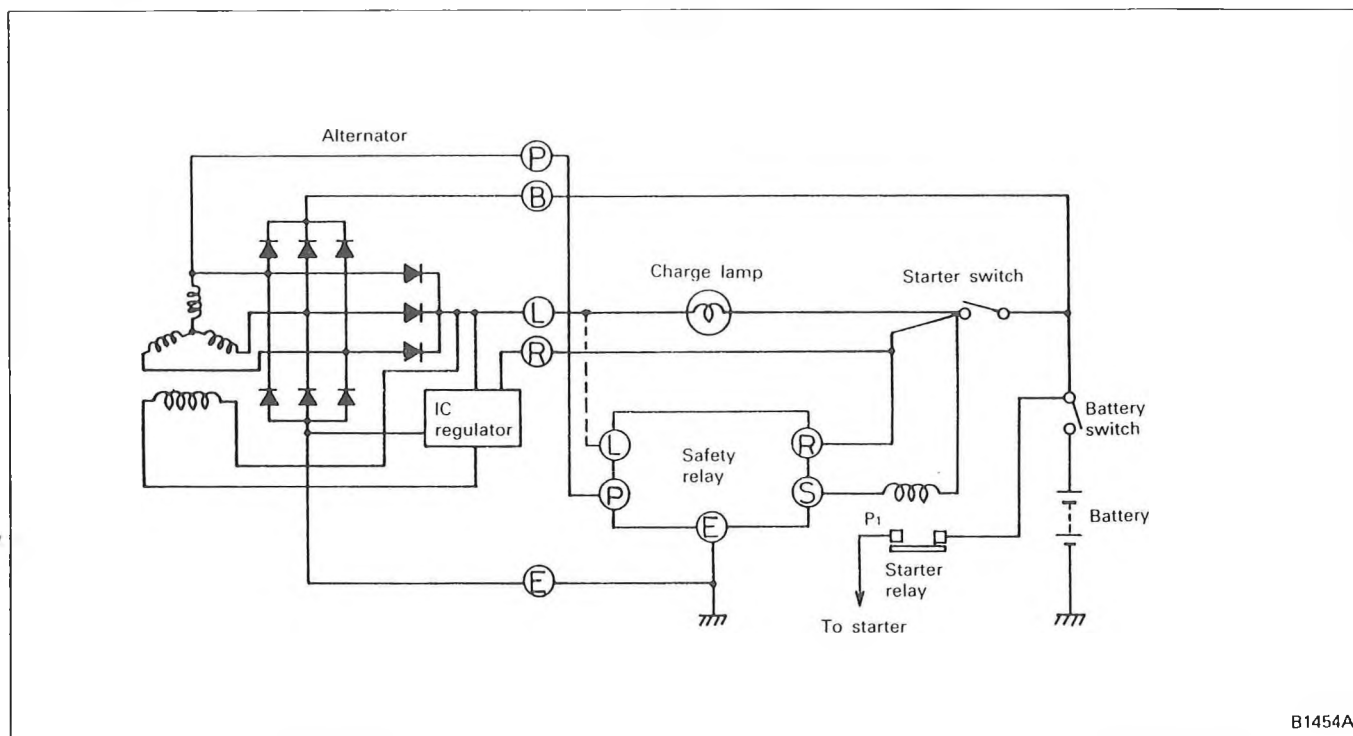
1.3 SAFETY RELAY



B1453A

The alternator rpm is detected and when it exceeds the reference level, the safety relay prevents the starter from operating even if its switch is accidentally turned on during engine revolution.

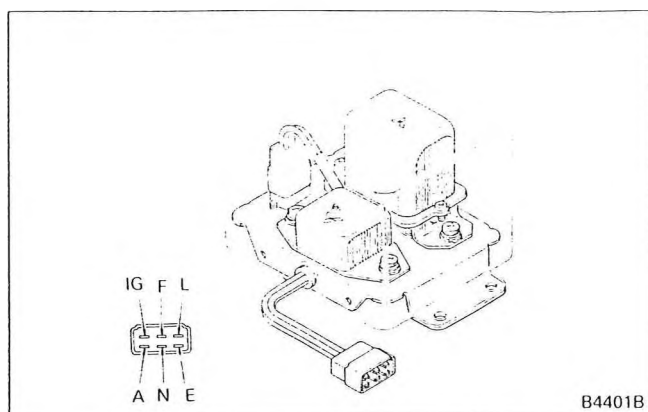
Operation



B1454A

- (1) When the starter switch is set to ON, current flow from the starter relay to terminal "S" and to terminal "E" of the safety relay, closing contact P1. The charge lamp also illuminates if provided.
- (2) As the starter runs and the engine starts running, pulses of frequency 1/10th of the alternator speed appear at terminal "P" of the alternator. The charge lamp goes out.

- (3) When the pulse frequency at terminal "P" exceeds the specified value, continuity between terminals "S" and "E" is lost. Then, the starter does not operate even if the starter switch is set to ON while the engine is running.

1.4 REGULATOR (Model R7T01071)

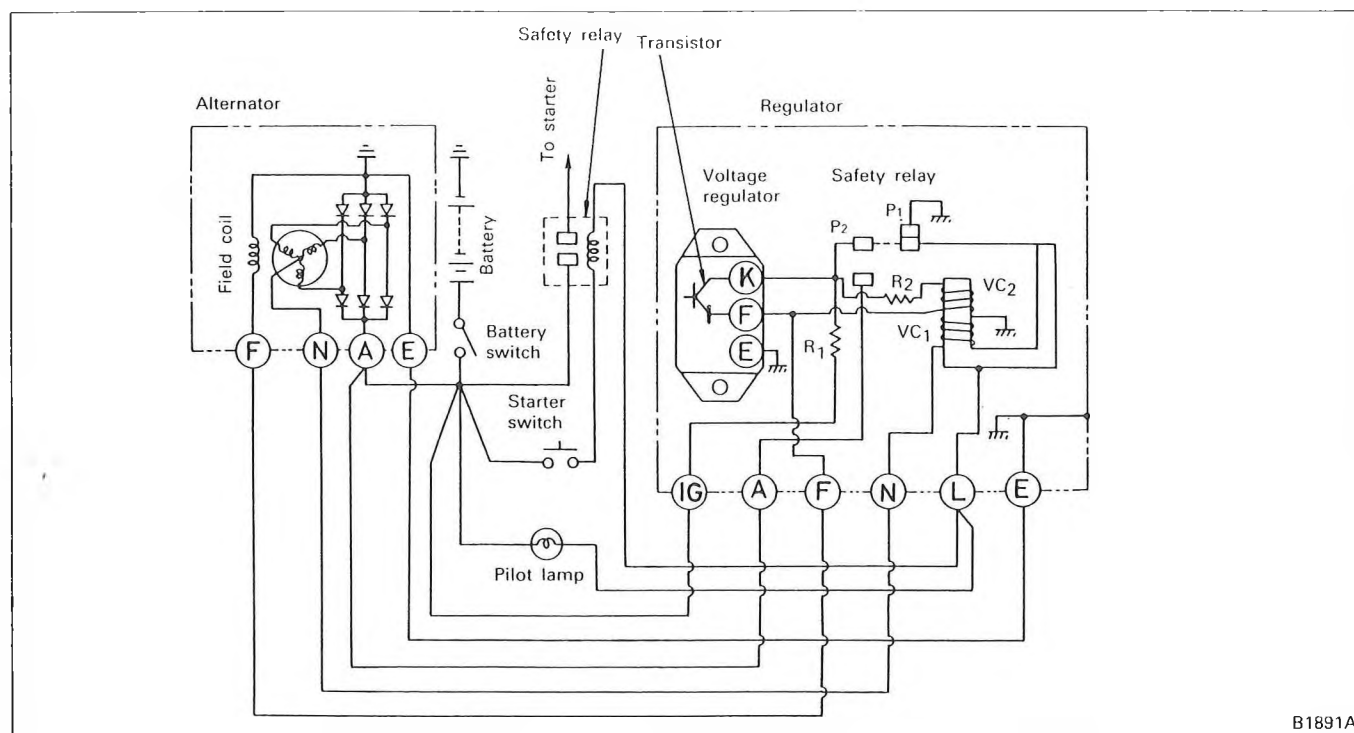
B4401B

Its functions include:

- (1) Voltage regulator
Maintains voltage generated by the generator constant
- (2) Safety relay
Keeps the starter circuit in OFF state even with the starter switch turned on during operation of engine.
- (3) Field relay
Minimizes discharge current to the alternator field coil even when the battery switch is left closed.

Connections of the alternator to the regulator are shown below. Following description of operations is keyed to this figure.

This regulator is combined with the 60A alternator.

Operation of Regulator

B1891A

- (1) The battery switch in ON position causes field current to flow in the circuit as follows:

Battery → Battery switch → Regulator IG terminal → Resistor R₁ → Voltage regulator K terminal → Voltage regulator F terminal → Alternator F terminal → Field coil → Ground

- (2) When the starter switch is set to ON, the starter relay coil is energized with its contact closed. When the starter cranks the engine, the alternator generates

- power, causing a current to flow in the coil VC₁ in the following sequence:

Alternator N terminal → Regulator N terminal → Coil VC₁ → Ground

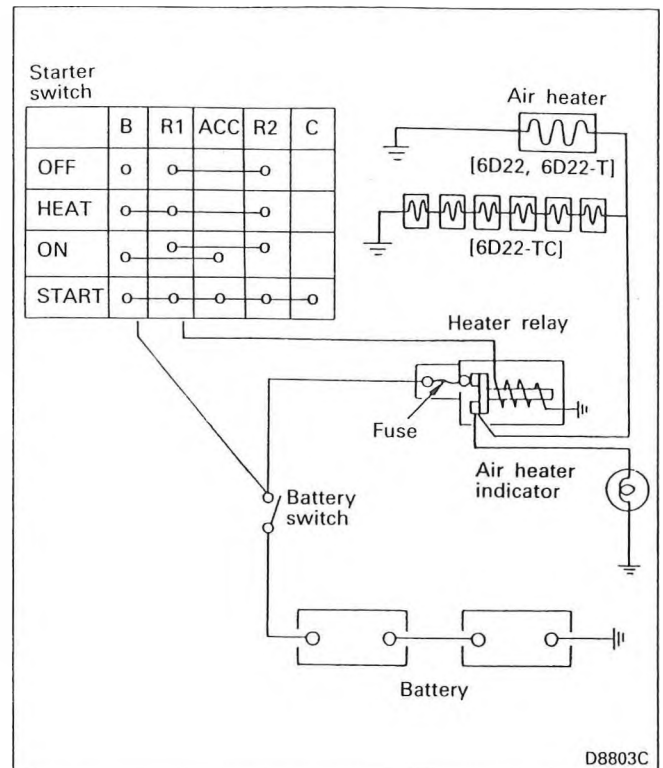
As the coil VC₁ is energized, the contact P₁ is opened. In this state, setting the starter switch to ON with the engine in operation leaves the starter inoperative.

(3) While the engine is in operation, field current flows in the following circuits, with alternator output voltage controlled by the voltage regulator.

Alternator A terminal → Regulator A terminal → Contact P2 → Voltage regulator K terminal → Transistor → Regulator F terminal → Alternator F terminal → Field coil → Ground

If the transistor remains off too long, the alternator N terminal output is decreased and the coil VC1 loses its magnetic force to such an extent that the contact P2 may be opened or P1 closed. The circuit of coil VC2 and resistor R2 keeps P2 closed and P1 open in such a case.

1.5 INTAKE AIR HEATER



The intake air heater is an electric heater which heats the intake air to facilitate engine starting.

Place the starter switch to HEAT position to operate the heater. If current is supplied for about 40 to 60 seconds by keeping the starter switch at HEAT position, the temperature of the intake air heater will exceed 800°C.

The intake air heater circuit has an indicator to let the driver recognize the heat condition. For safety's sake, a fuse is provided in the heater relay.

1.6 AUTOMATIC STOP DEVICE

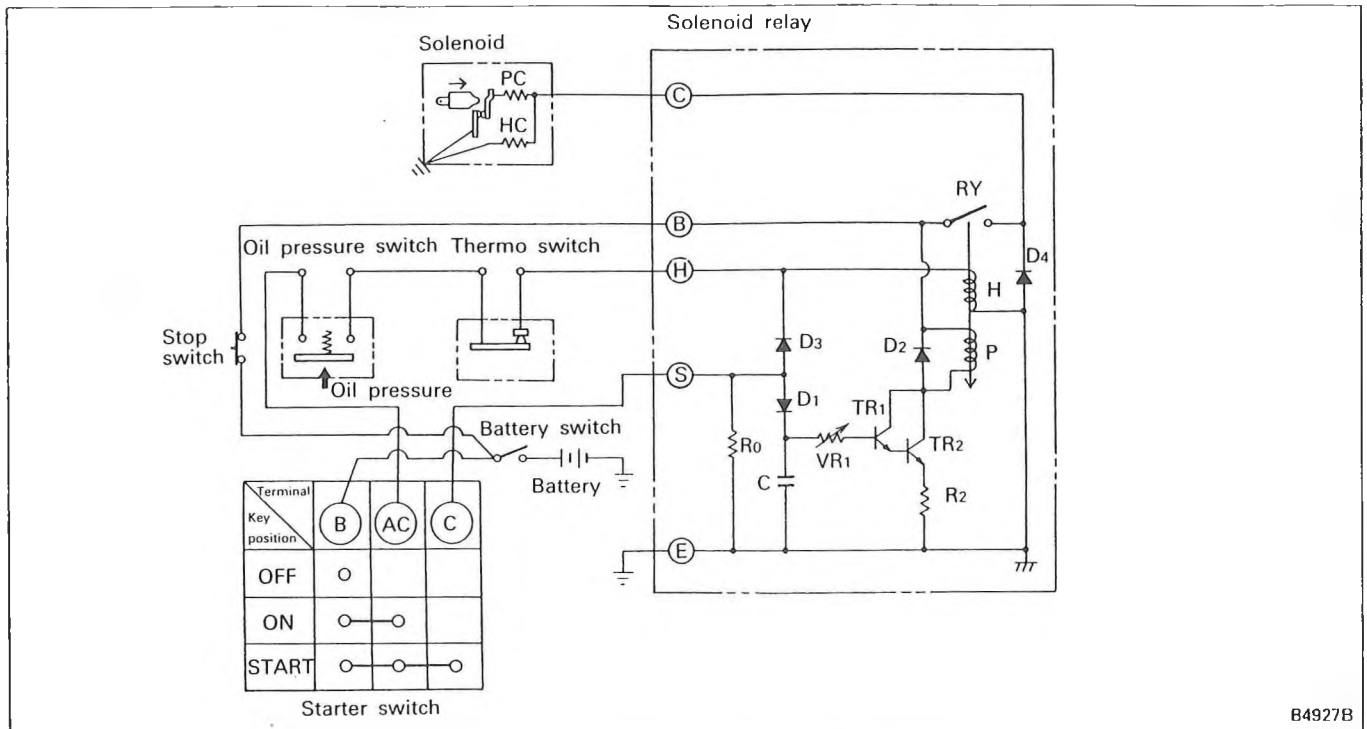
If the coolant temperature rises or the oil pressure falls while the engine is running, this device operates the stop lever of the injection pump governor to cut fuel supply and automatically stops the engine.

3) Thus RY contacts close, the solenoid operates, and the engine stops. When the engine stops, the alternator voltage goes out. At the same time, the stop timer made up of C2 and VR7 holds the solenoid.

(c) Pushbutton stop

To stop the engine during operation, operate the stop switch, and the stop operation is performed as at the time of an automatic stop. (The engine stops regardless of whether the alternator voltage is available.)

(2) Energize-to-run Type



(a) Start circuit

1) When the battery switch is turned ON:

Solenoid relay (B) → RY pull-in coil P → TR1 collector
 TR2 collector

RY contacts do not operate with no input to the base of TR1 and TR2.

2) When the starter switch is placed in the START position:

Starter switch (C) → Solenoid relay (S) → Resistor R0 → Ground
 Diode D3 → RY holding coil H → Ground
 Diode D1 → Capacitor C

When the capacitor C is charged, voltage is applied from VR1 to the base of TR1 actuating TR1.

As voltage is applied to TR1 collector, TR1 emitter, and to TR2 base, a current flows from TR2 collector to TR2 emitter, resistor R2, and ground, causing the RY pull-in coil P to close the RY contacts.

3) When the RY contacts turn ON:

Current flows from solenoid relay ⑥ to RY, solenoid relay ⑦, and the solenoid, activating the solenoid and starting the engine.

4) As the engine starts and starter switch is placed in the ON position, voltage to the solenoid relay ⑤ is cut off; however, TR1 and TR2 stay ON for approximately another 30 seconds by the discharge current of the capacitor C. During capacitor C's discharging, the oil pressure builds up as the engine speed increases, causing the oil pressure switch to turn ON.

This causes the current to flow from the starter ① switch to oil pressure switch, thermo switch, solenoid relay ⑥, RY holding coil H, and to ground, keeping the RY contacts in ON state.

(b) Automatic stop circuit

When the thermo switch and oil pressure switch detect an abnormal condition, each switch turns OFF and the RY contacts open, deactivating the solenoid and stopping the engine.

(c) Pushbutton stop

To stop the engine during operation, operate the stop switch, and the stop operation is performed just as when the automatic stop is performed.

2. SPECIFICATIONS

Item		Specification									
Voltage – Polarity		24V – (–) ground									
Starter (Mitsubishi Electric Corp. products)	Type	Front nose electromagnetic push-in type reduction starter									
	Model	M3T95082			M5T50276			M5T50277		M5T50279	
	Output	24V-5kW			24V-6kW						
	Reduction mechanism	Single stage reduction by internal spur gear									
Starter relay	Model	[Standard] U1T06074			[Option] U1T06071			[Option] U1T07076			
Alternator (Mitsubishi Electric Corp. product)	Type	Alternator with built-in IC regulator					Y-connection alternator with silicon diode rectifier		Alternator with built-in IC regulator		
	Model	A2T 72987	A2T 72986	A2T 73387	A4T 57986	A4T 57987	A4T 65772	A4T 65773	A6T 75386	A6T 75387	
	Output	24V-30A			24V-40A		24V-60A		24V-80A		
Regulator (Voltage regulator) (Safety relay)	Model	–					R7T01071 (RFT24H) (RX-Q2)		–		
Safety relay	Model	R8T30171					–		R8T30171		
Intake air heater	Type	Electric heating type									
	Capacity x quantity	{6D22, 22-T} 2 kW x 1					{6D22-TC} 0.3 kW x 6				
Heater relay	Model	U1T06671									
	Fuse capacity	91 A									

Automatic Stop System [Option]

Item		Specification	
Stop solenoid (Nippon Denso Co., Ltd. product)	Type	Electro magnetic type	
Solenoid relay (Nikko Denki product)	Model	[Energize-to-stop type] 0-25000-5592	[Energize-to-run type] 0-25000-6720
Oil pressure switch	Type	Diaphragm, built-in electric contact	
Thermo switch	Type	Wax type, built-in electric contact	

3. SERVICE STANDARDS**3.1 SERVICE STANDARD TABLE**

Unit: mm

Description			Nominal value [Basic diameter]	Limit	Correction and remarks
Starter (M3T95082)	Commutator O.D.		38.7	38.1	Replace.
	Commutator periphery runout		0 to 0.03	0.1	Replace or correct.
	Depth of groove between segments		0.7 to 0.9	0.3	Replace or correct.
	Brush length		17	11	Replace.
	Brush spring tension		25 to 34 N (2.5 to 3.5 kgf)	18 N (1.8 kgf)	Replace.
	Pinion gap		1 to 3	—	Adjust washers.
	Gear shaft thrust gap		0.1 to 0.5	—	Adjust washers.
	No-load characteristics	Voltage	23V	—	Check.
		Current	110A or less	—	
		Rotating speed	3 100 rpm or more	—	
	Magnet switch operating voltage		16V or less	—	Replace.
Starter (M5T50276) (M5T50277) (M5T50279)	Commutator O.D.		43.2	42.2	Replace.
	Commutator periphery runout		0 to 0.03	0.1	Replace or correct.
	Depth of groove between segments		0.7 to 0.9	0.3	Replace or correct.
	Brush length		23	14	Replace.
	Brush spring tension		25 to 34 N (2.5 to 3.5 kgf)	18 N (1.8 kgf)	Replace.
	Pinion gap	M5T50279	1 to 3	—	Adjust washers.
		M5T50276 M5T50277	4 to 6		
	Gear shaft thrust gap		0.1 to 0.5	—	Adjust washers.
	No-load characteristics	Voltage	23.5V	—	Check.
		Current	110A or less	—	
		Rotating speed	3 300 rpm or more	—	
	Magnet switch operating voltage		16V or less	—	Replace.

Unit: mm

Description		Nominal value (Basic diameter)	Limit	Correction and remarks
Starter relay	Coil resistance	10.4 Ω	–	Replace.
Alternator (A2T72987) (A2T72986) (A2T73387) 30A	Slip ring O.D.	40.8 to 41.2	40.4	Replace.
	Brush spring tension	3.1 to 4.3 N (0.32 to 0.44 kgf)	2 N (0.2 kgf)	Replace.
	Brush length	23	8	Replace.
	Field coil resistance (at 20°C)	Approx. 9 Ω	–	Replace.
	Load characteristics (When cold)	Terminal voltage	27V	Check.
		Current	17A or more	
		Rotating speed	1 500 rpm	
	Load characteristics (When cold)	Terminal voltage	27V	Check.
		Current	26A or more	
		Rotating speed	2 500 rpm	
	IC regulator regulated voltage range (5 000 rpm, 5A or less)		28 to 29V	Replace.
Alternator (A4T57986) (A4T57987) 40A	Slip ring O.D.	40.8 to 41.2	40.4	Replace.
	Brush spring tension	3.1 to 4.3 N (0.32 to 0.44 kgf)	2 N (0.2 kgf)	Replace.
	Brush length	23	8	Replace.
	Field coil resistance (at 20°C)	Approx. 9 Ω	–	Replace.
	Load characteristics (when cold)	Terminal voltage	27V	Check.
		Current	26A or more	
		Rotating speed	1 600 rpm	
	Load characteristics (when cold)	Terminal voltage	27V	Check.
		Current	37A or more	
		Rotating speed	2 500 rpm	
	IC regulator regulated voltage (5 000 rpm, 5A or less)		28 to 29V	Replace.
Alternator (A6T75386) (A6T75387) 80A	Slip ring O.D.	40.8 to 41.2	40.4	Replace.
	Brush spring tension	3.1 to 4.3 N (0.32 to 0.44 kgf)	2 N (0.2 kgf)	Replace.
	Brush length	23	8	Replace.
	Field coil resistance (at 20°C)	Approx. 7.2 Ω	–	Replace.
	Load characteristics (when cold)	Terminal voltage	27V	Check.
		Current	39A or more	
		Rotating speed	1 500 rpm	
	Load characteristics (when cold)	Terminal voltage	27V	Check.
		Current	71A or more	
		Rotating speed	2 500 rpm	
	IC regulator regulated voltage (5 000 rpm, 5A or less)		28 to 29V	Replace.

Unit: mm

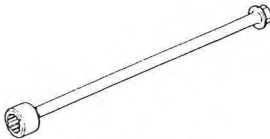
Description			Nominal value [Basic diameter]	Limit	Correction and remarks	
Alternator (A4T65772) (A4T65773) 60A	Slip ring O.D.		46	45.4	Replace.	
	Brush spring tension		3.7 N (0.38 kgf)	2 N (0.2 kgf)	Replace.	
	Brush length		23	8	Replace.	
	Field coil resistance (at 20 °C)		Approx. 13 Ω	—	Replace.	
	Load characteristics (when cold)	Terminal voltage	28V	—	Check.	
		Current	60A or more	—		
		Rotating speed	2 200 rpm	—		
Regulator (R7T01071)	Regulated voltage (Alternator: 4 000 rpm)		28 to 29V	—	Replace.	
Safety relay (R8T30171)	Resistance between L and R terminals		Approx. 200 Ω	—	Replace.	
Intake air heater	Time required for air heater indicator to become red hot		40 to 60 secs.	—	Check.	
Auto- matic stop device	Energize -to-stop type	Solenoid	Pointer clearance	1.5 to 2.0	—	Replace.
			Clearance between stop lever and external stopper	0.4 to 0.5	—	
			Holding coil current	5A or less	—	
		Solenoid relay	Delay time at starting (after 28.5V applied to terminal "B" and "W" and 28.5 V to terminal "A")	13 to 23 seconds	—	Replace.
			Delay time at stopping (after 24V applied to terminal "B" and "W" and no voltage to terminal "A")	25 to 35 seconds	—	
		Thermo switch actuating temperature		93 to 97°C	—	Replace.
		Oil pressure switch actuating pressure		69 to 98 kPa (0.7 to 1.0 kgf/cm ²) or less	—	Replace.
		Oil pressure switch relay (24 V)	Coil resistance	190 to 280 Ω	—	Replace.
			Min. operating voltage	16V or less	—	
		Energize -to-run type	Solenoid	Pointer clearance	1.5 to 2.0	—
	Clearance between stop lever and external stopper			0.4 to 0.5	—	
	Holding coil current			1A or less	—	
	Solenoid relay delay time		26 to 34 seconds	—	Replace.	
	Thermo switch actuating temperature		93 to 97°C	—	Replace.	
	Oil pressure switch actuating pressure		79 to 118 kPa (0.8 to 1.2 kgf/cm ²) or less	—	Replace.	

3.2 TIGHTENING TORQUE TABLE

Description	Thread size O.D. x pitch (mm)	Tightening torque Nm (kgfm)	Remarks
Alternator pulley nut	M17 x 1.5	83 to 105 (8.5 to 11)	
	M20 x 1.5	135 to 160 (13.5 to 16.5)	
Alternator shaft nut	—	345 to 360 (35 to 37)	

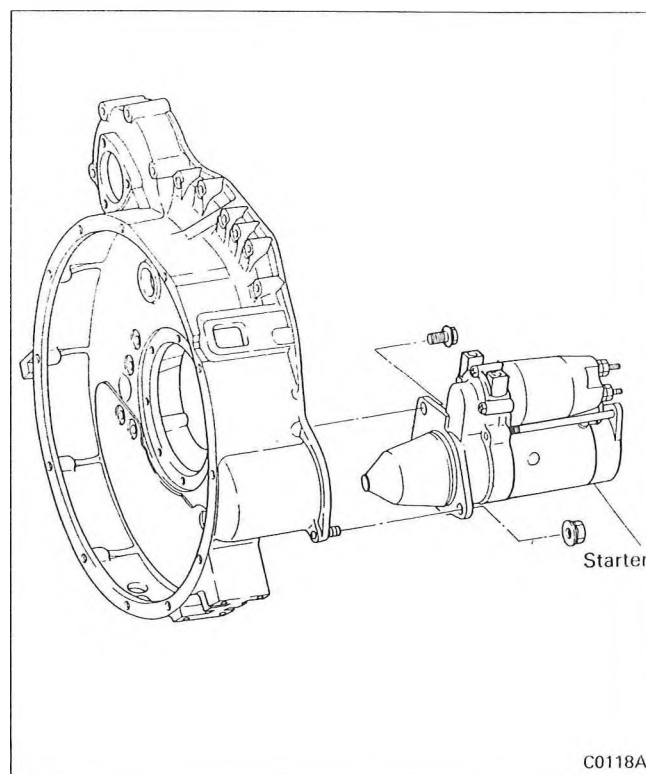
4. SPECIAL TOOL

Unit: mm

Tool name	Part No.	Shape	Use
Socket	31191-06100	 Width across flats 17 B5021A	Removal and installation of starter

5. SERVICE PROCEDURES**NOTE:**

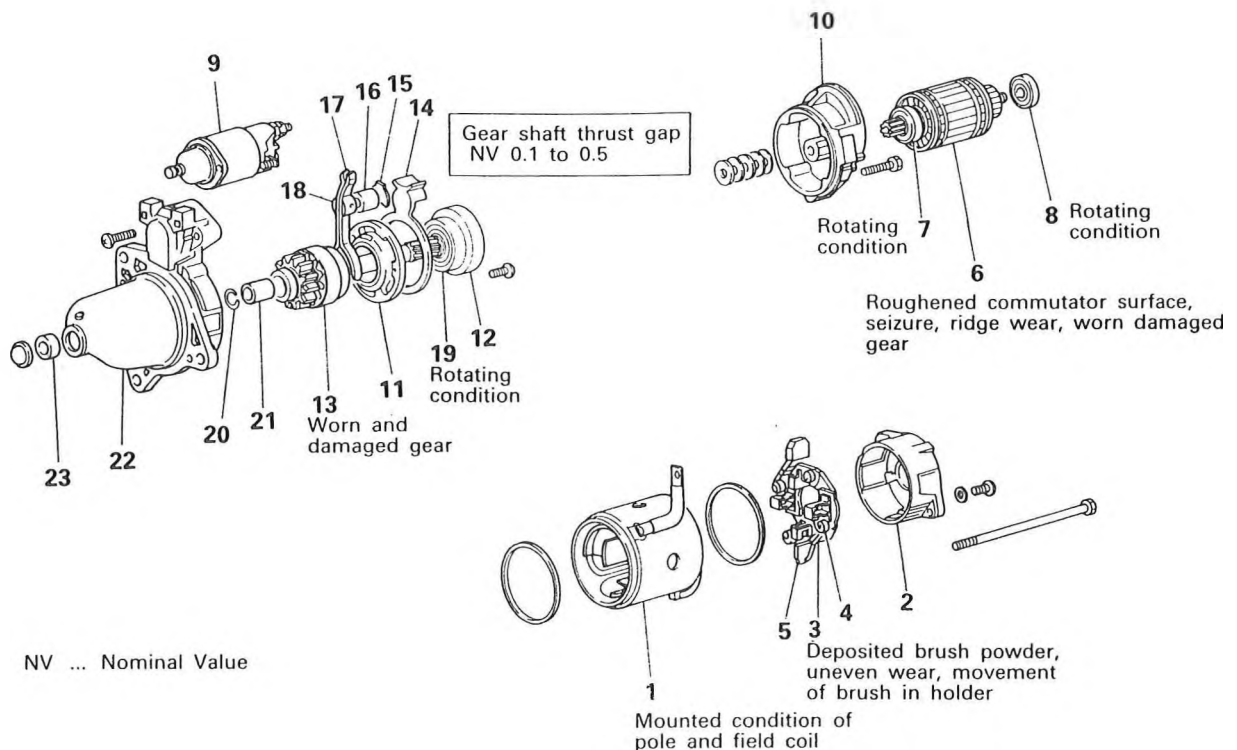
Whenever removing electrical parts from the vehicle, be sure to place the battery switch in OFF position, disconnect the negative battery cable, and wind the cable end with vinyl insulation tape.

5.1 STARTER**5.1.1 Removal and Installation**

The starter mounting bolt on the inner side (crankcase side) can be easily mounted or removed by use of the special tool, Socket.

5.1.2 Disassembly

<M3T>



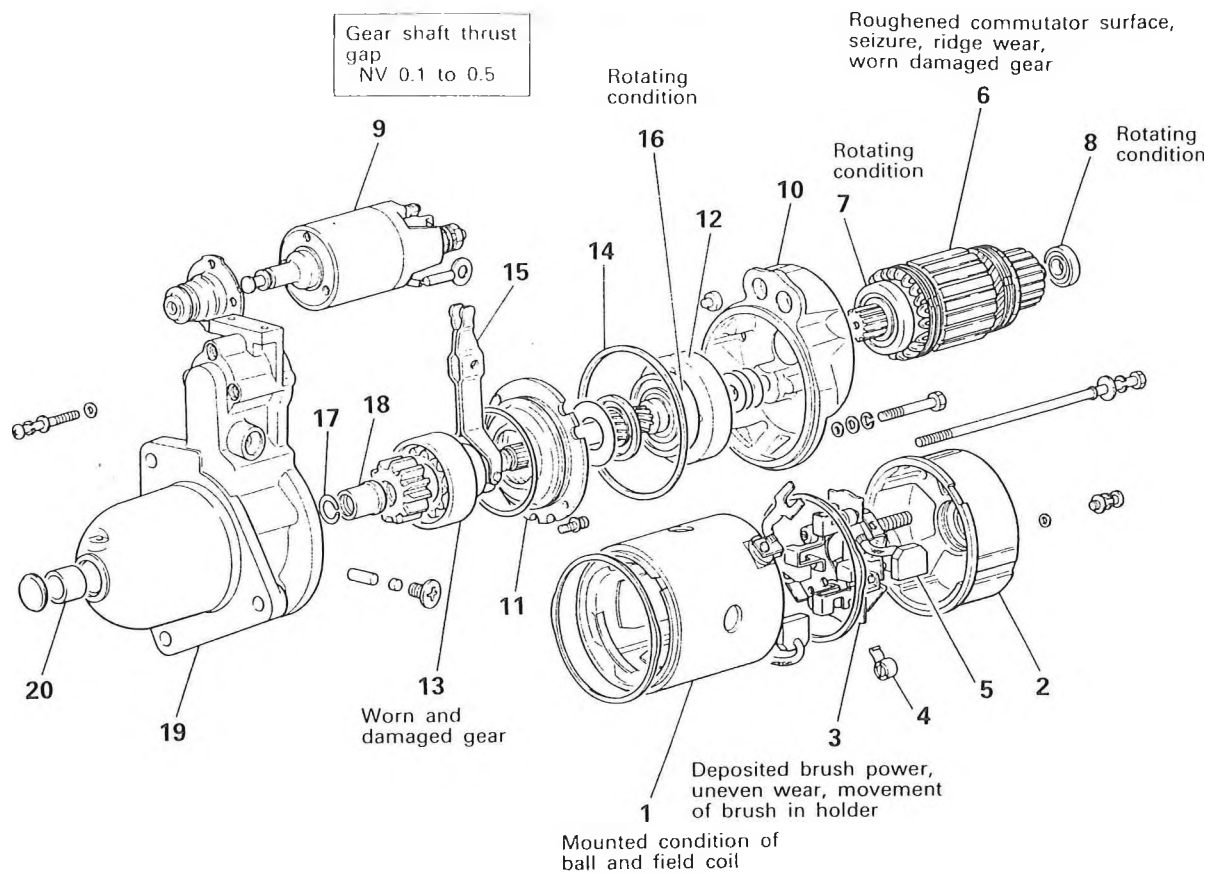
<Disassembly sequence>

- | | |
|-------------------|-------------------------|
| ① Yoke assembly | ⑬ Overrunning clutch |
| 2 Rear bracket | 14 Packing |
| 3 Brush holder | 15 Plate |
| ④ Brush spring | 16 Spacer |
| ⑤ Brush | 17 Lever |
| 6 Armature | 18 Collar |
| * 7 Front bearing | * 19 Gear shaft bearing |
| * 8 Rear bearing | ⑳ Ring |
| ⑨ Magnetic switch | ㉑ Pinion stopper |
| 10 Center bracket | 22 Front bracket |
| ⑪ Gear bracket | * 23 Sleeve bearing |
| ⑫ Gear shaft | |

Part marked with * should not be removed unless defects are evident.
For parts with an encircled number, refer to Disassembly Procedure that follows.

B1104B

<M5T>



<Disassembly sequence>

- | | |
|-------------------|------------------------|
| ① Yoke assembly | ⑪ Gear bracket |
| 2 Rear bracket | ⑫ Gear shaft |
| 3 Brush holder | ⑬ Overrunning clutch |
| ④ Brush spring | 14 Packing |
| ⑤ Brush | 15 Lever |
| 6 Armature | *16 Gear shaft bearing |
| *7 Front bearing | ⑰ Ring |
| *8 Rear bearing | ⑱ Pinion stopper |
| ⑨ Magnetic switch | 19 Front bracket |
| 10 Center bracket | *20 Sleeve bearing |

The parts marked * should not be removed unless there is anything wrong with them.
On parts marked o, refer to the disassembly procedure described below.

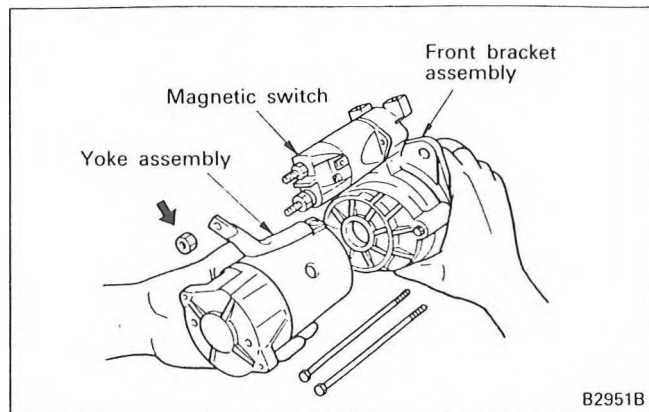
B9071C

Disassembly Procedure

The disassembly procedure for the M3T95082 is described.

The procedure for the other starters is the same.

(1) Removal of Yoke Assembly



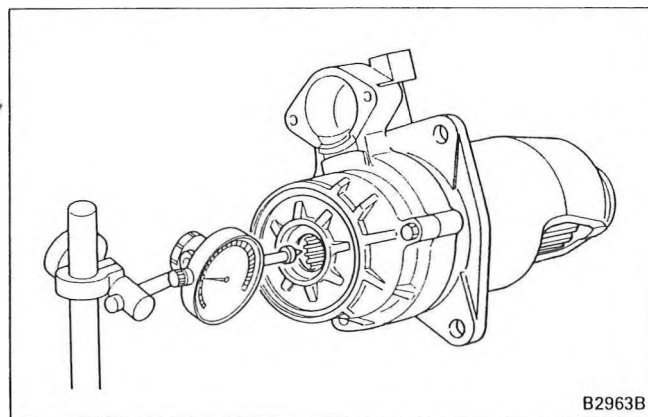
Remove the magnetic switch and separate the front bracket assembly and yoke assembly.

NOTE:

Do not drop the armature.

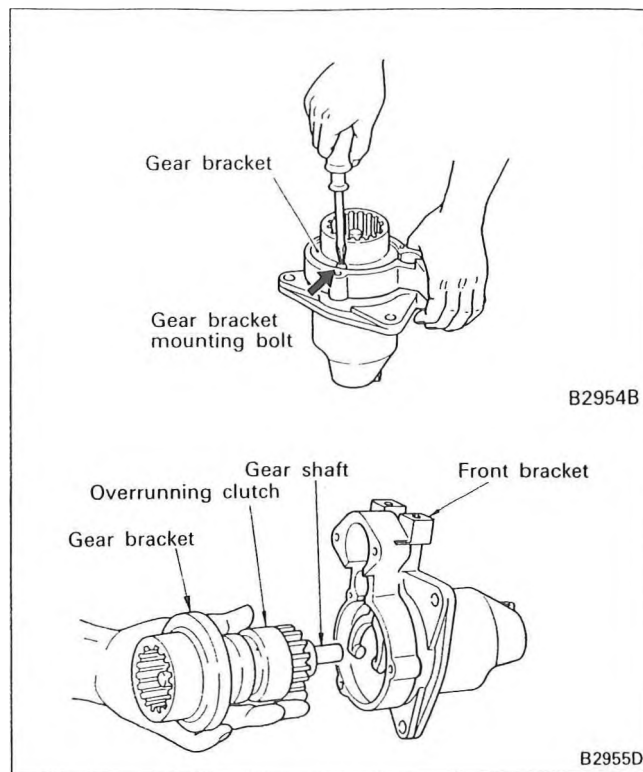
Especially when disassembling with the armature staying in the yoke, do not tilt the yoke assembly.

(2) Inspection of Gear Shaft Thrust Gap

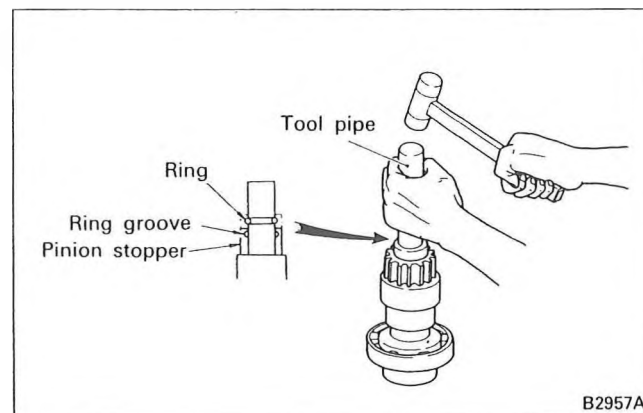


Before disassembly, set the dial indicator as shown to measure the thrust gap in the gear shaft. If the measurement is out of specification, use adjusting washers to obtain correct gap. [For adjustment procedure, refer to Section 5.1.3 (8).]

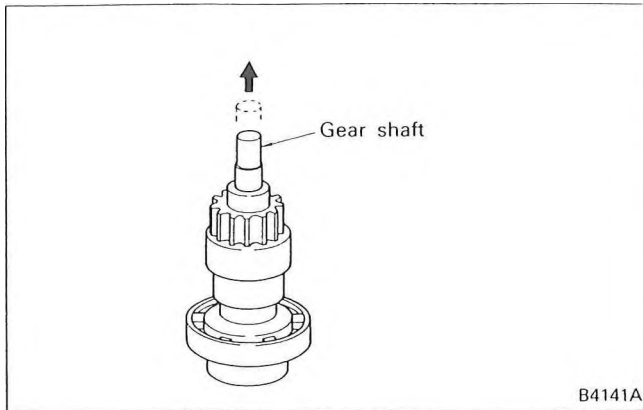
(3) Removal of Overrunning Clutch



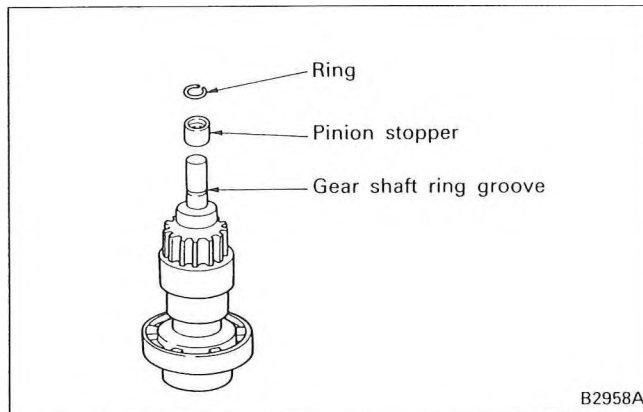
(a) Remove the gear bracket mounting bolt and remove the overrunning clutch, to which the gear shaft and gear bracket remain installed, from the front bracket.



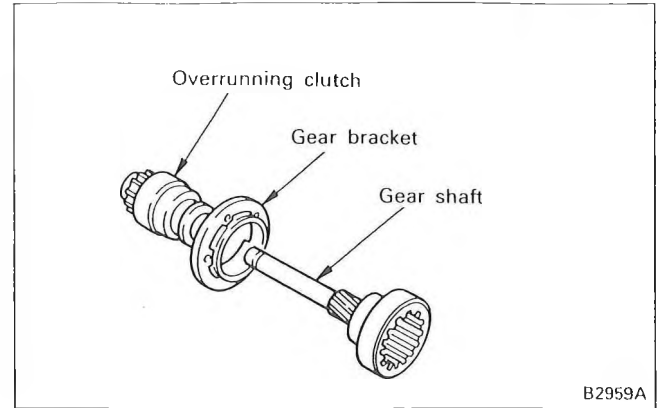
(b) Apply a tool pipe to the pinion stopper and hammer the pinion stopper out toward the pinion side. Then remove the ring and remove the overrunning clutch.

NOTE:

When the ring is removed, keep the gear shaft in overhanging condition.

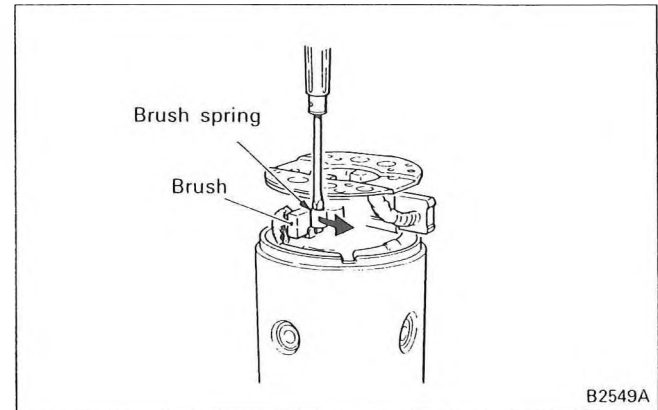


(c) Remove the ring from the ring groove of the gear shaft. Remove the pinion stopper from the gear shaft.



(d) Remove the overrunning clutch and gear bracket from the gear shaft.

(4) Removal of Brush Spring



To remove the brush spring, first release the brush spring and remove the brush.

5.1.3 Inspection

Item		NV	L
Commutator outside diameter	M3T	38.7	38.1
	M5T	43.2	42.2
Commutator outside circumference runout		0 to 0.03	0.1
Depth of groove between segments		0.7 to 0.9	0.3
Short circuit test, coil ground test, open circuit test		—	—

Coil open circuit test
Melted contacts
Loose contact

Coil earth test
Open circuit test

Item		NV	L
Brush spring tension		25 to 34 N (2.5 to 3.5 kgf)	18 N (1.8 kgf)
Brush length	M3T	17	11
	M5T	23	14
Insulation test		—	—

NV ... Nominal Value
L ... Limit

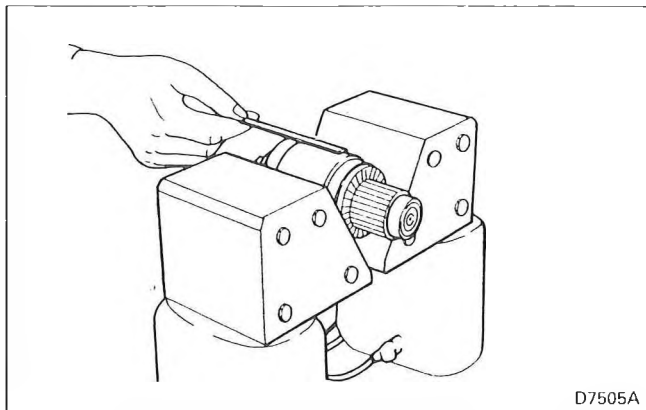
B1104E

Inspection Procedure

The inspection procedure for the M3T95082 starter is described. On the other starters, only the differences are jointly described.

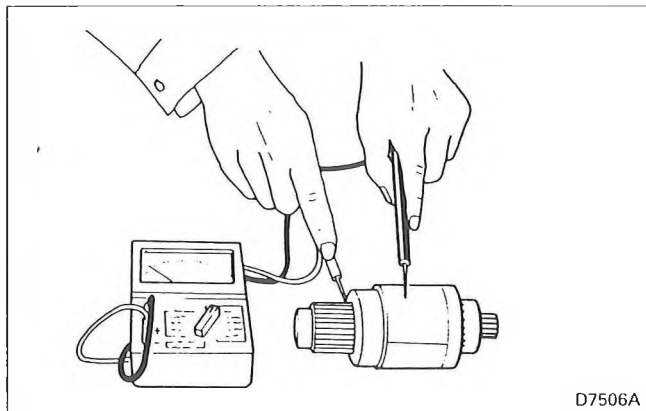
(1) Armature Inspection

(a) Coil short circuit test



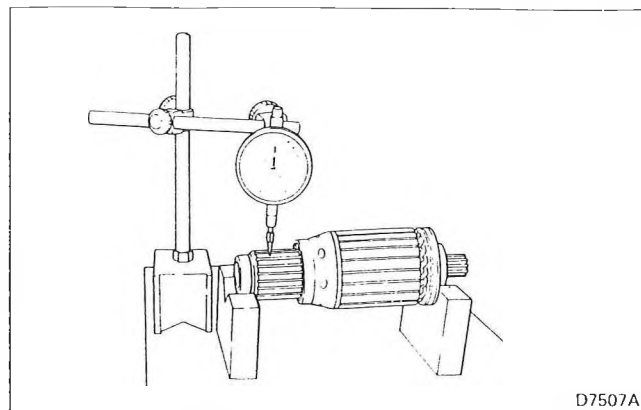
Place the armature on a growler tester. Hold a piece of iron in parallel with the armature and slowly turn armature by hand. If the iron piece is attracted or vibrates, it means there is a short circuit. Replace the armature.

(b) Coil ground test



Check for continuity across the commutator and shaft (or core). If there is a continuity, indicating that the coil is grounded, replace the armature.

(c) Inspection of commutator



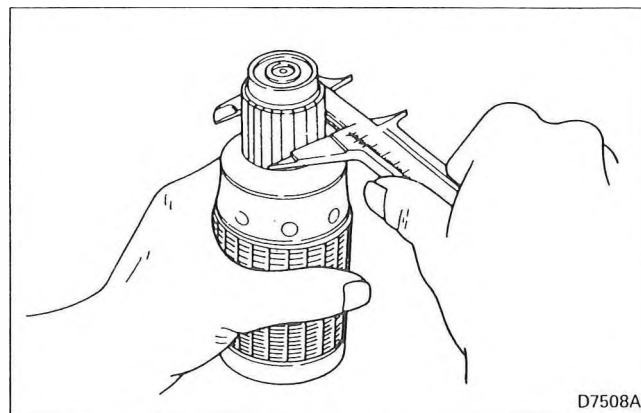
Measure the runout of commutator using a dial gauge and turning the armature by hand.

If the runout exceeds the limit, correct, ensuring that the O.D. limit is not exceeded.

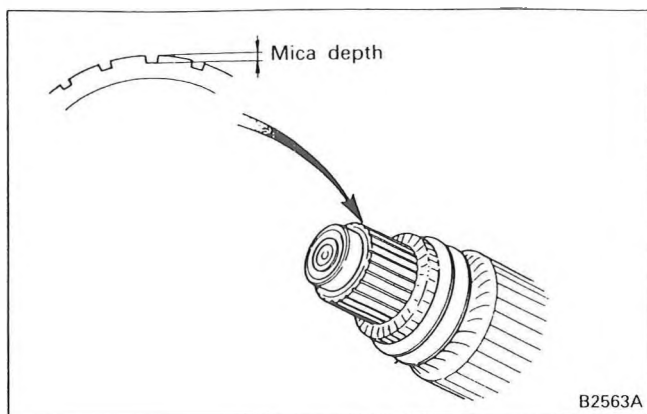
If the commutator surface is rough developing ridge wear, correct with sandpaper (No. 300 to 500).

After correction, make sure to check the runout again.

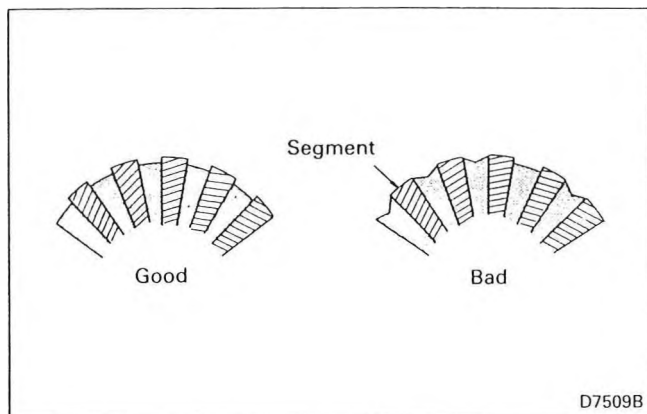
(d) Commutator O.D.



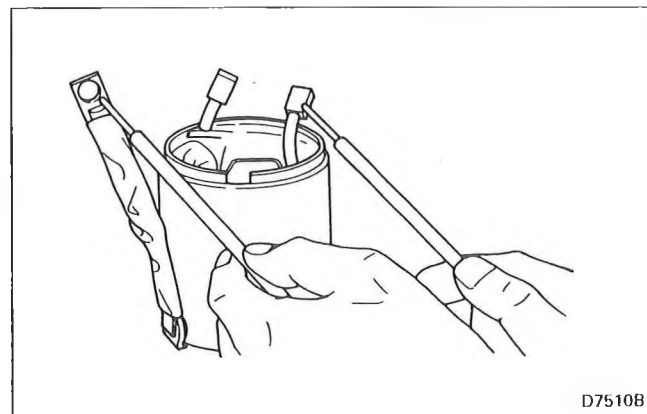
Measure the commutator O.D. If the measurement exceeds the limit, replace the armature.

(e) Mica depth between groove

Measure the Mica depth of groove between segments. If it does not reach the limit, correct.



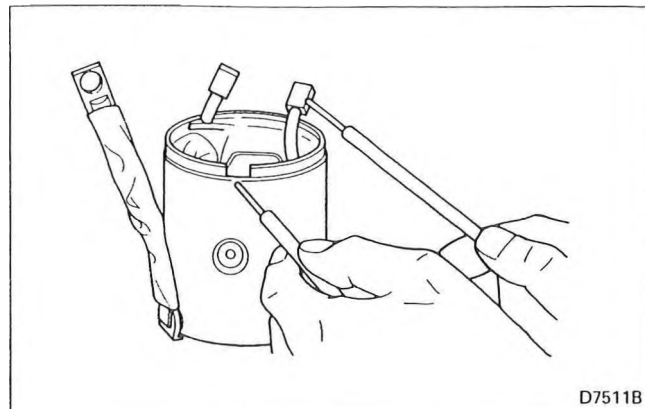
If the segment indicates the faulty condition as shown in the illustration, replace the armature.

(2) Inspection of Field Coil**(a) Coil open circuit test**

Check that there is continuity between the terminal

lead and brush (+).

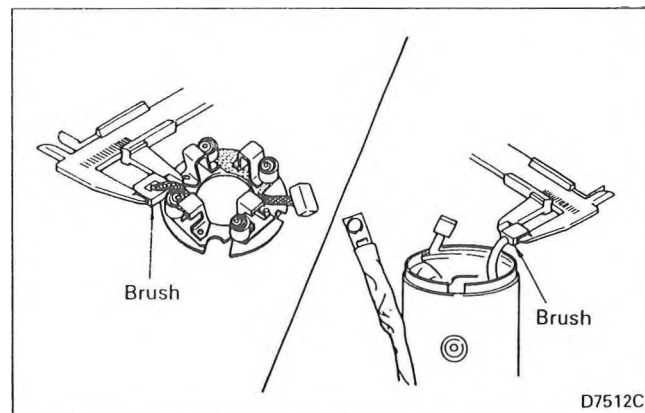
If there is no continuity, indicating an open circuit, replace the yoke assembly.

(b) Coil ground test

Check that there is no continuity between the yoke and brush (+).

If there is continuity indicating that the coil is grounded, check for poor insulation.

If repair is impossible, replace the yoke assembly.

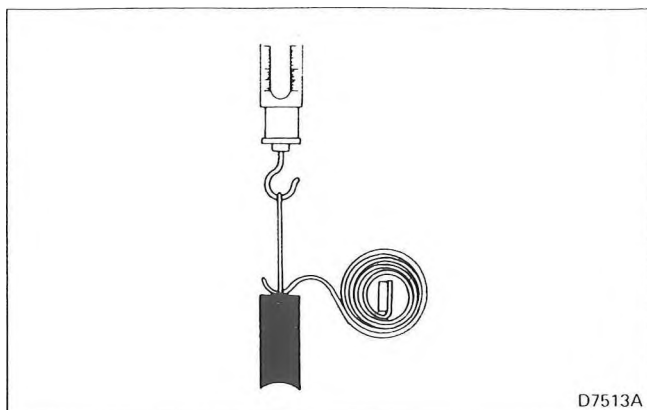
(3) Inspection of Brush

(a) Measure the brush length and, if the measurement is less than the limit, replace the brush as an assembly [(-) side: yoke assembly; (+) side: brush holder assembly].

(b) If the brush is unevenly worn or develops rough surfaces, correct with sandpaper (No. 300 to 500).

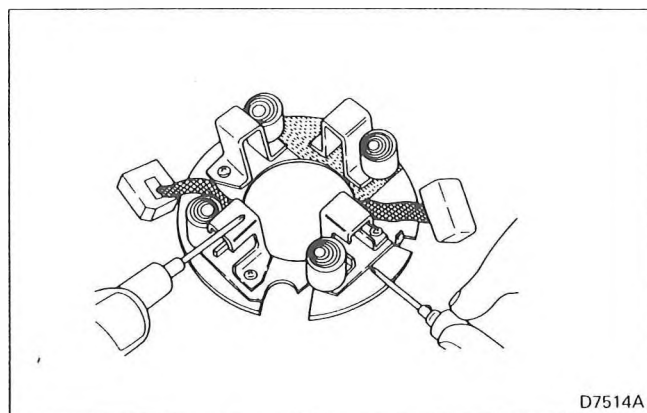
NOTE:

Correct the brush contact surface to a curve of the commutator.

(4) Inspection of Brush Spring

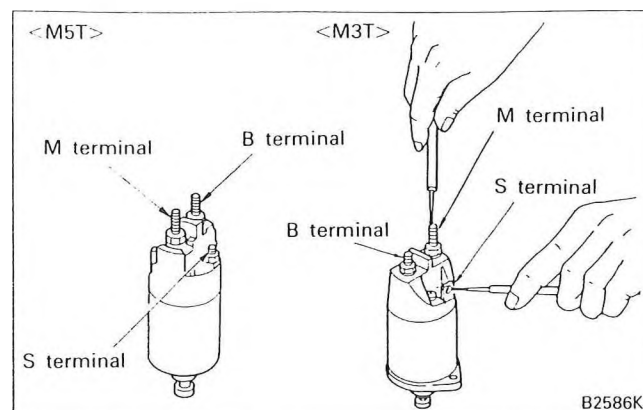
Measure the installed load of the brush spring. Using a new brush read the load at the moment the spring leaves the brush.

If the spring tension is below the limit, replace the spring.

(5) Brush Holder Insulation Test

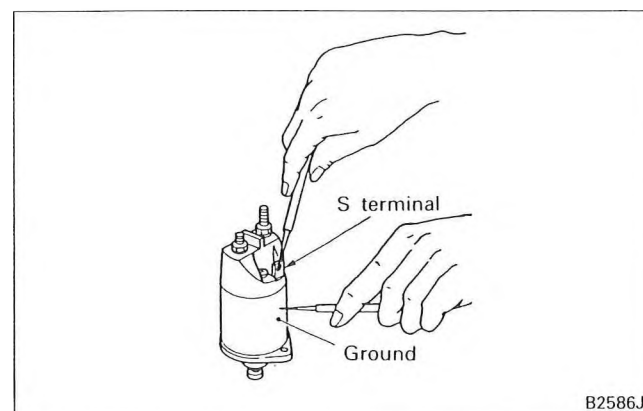
Check to ensure that there is no continuity between the (+) brush holder and (-) holder plate.

If there is continuity, replace the brush holder.

(6) Inspection of Magnetic Switch**(a) Coil open circuit test**

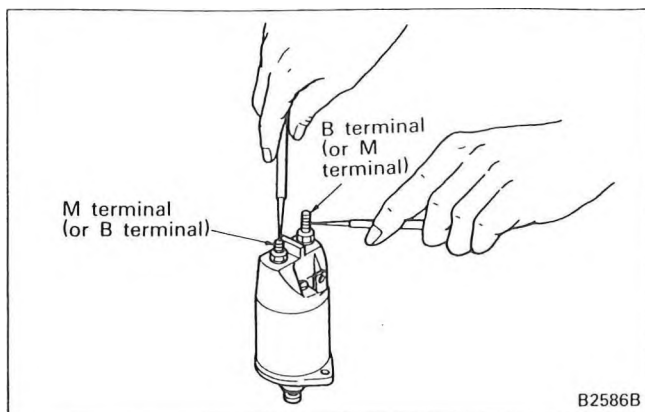
Check that there is a continuity across "S" and "M" terminals.

If there isn't, replace the magnetic switch.

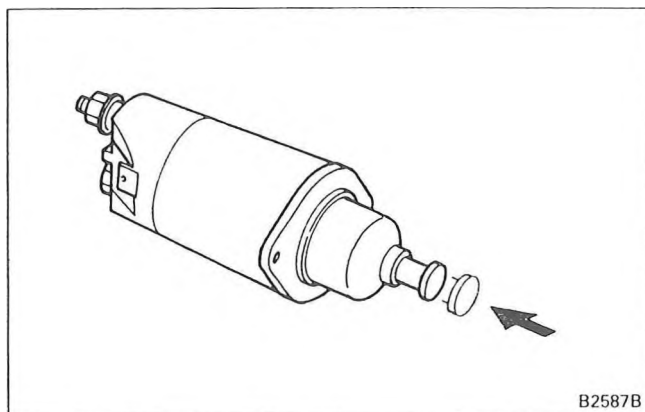


Check to ensure that there is a continuity across "S" and ground terminals.

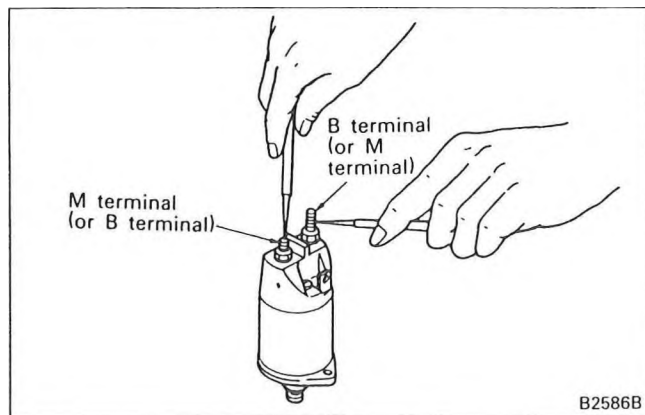
If there isn't, replace the magnetic switch.

(b) Fused contact check

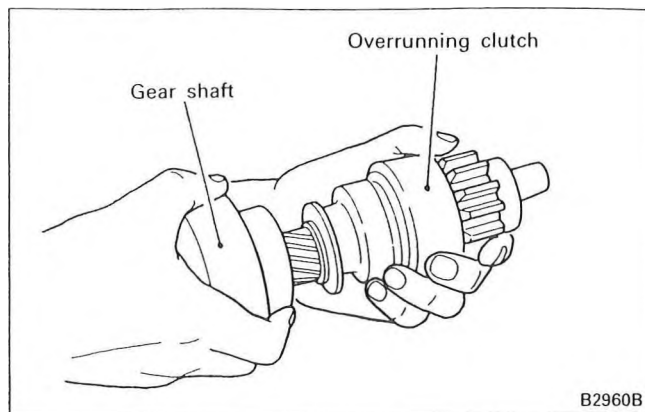
Check that there is no continuity across "B" and "M" terminals. If there is, replace the magnetic switch.

(c) Loose contact test

Close the contact of the magnetic switch as shown.

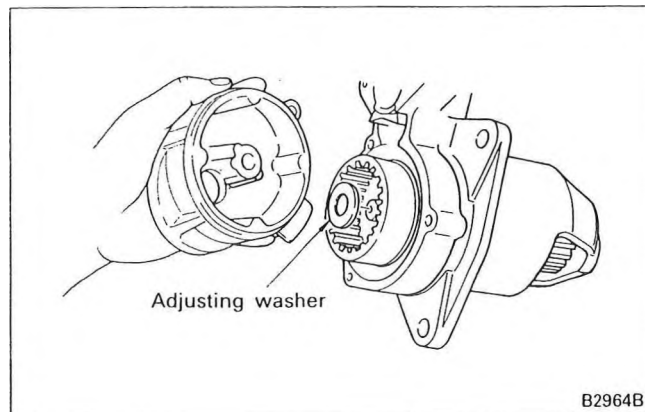


In this condition, check that there is a continuity across "B" and "M" terminals. If there isn't, replace the magnetic switch.

(7) Inspection of Overrunning Clutch

Install the gear shaft to the overrunning clutch and check to see if the gear shaft turns smoothly when turned clockwise (in the drive direction) and locks when turned counterclockwise.

If any unusual condition is noted, replace the overrunning clutch.

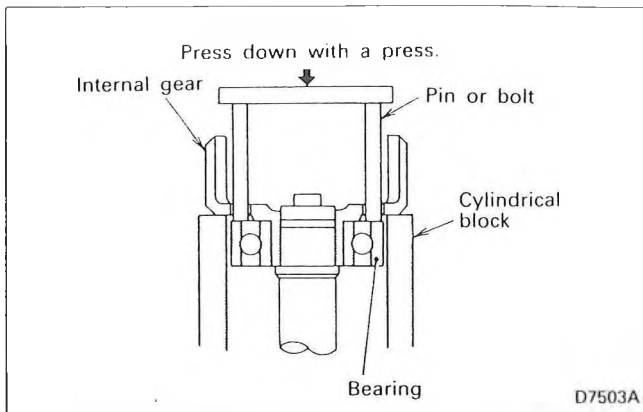
(8) Adjustment of Gear Shaft Thrust Gap

If the thrust gap is out of specification, insert the adjusting washer into the position shown.

[For adjusting procedures, refer to Section 5.1.2 (2).]
(Adjusting washer: 0.25, 0.5 mm)

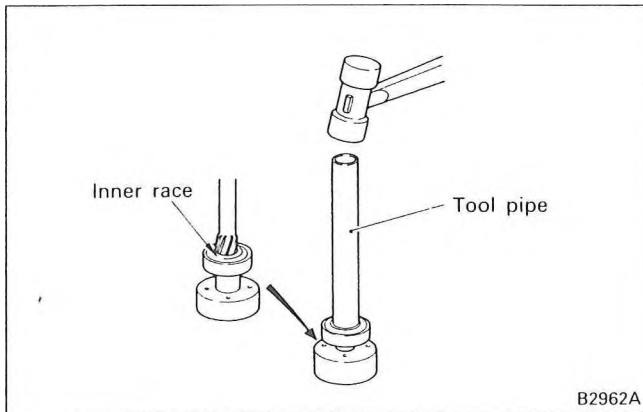
(9) Replacement of Bearings**(a) Replacement of gear bearing**

(Removal)



If the bearing of the gear shaft is defective, put a pin or bolt in each of the four holes (6 mm in diameter) in the internal gear and press down the bearing out of position with a press.

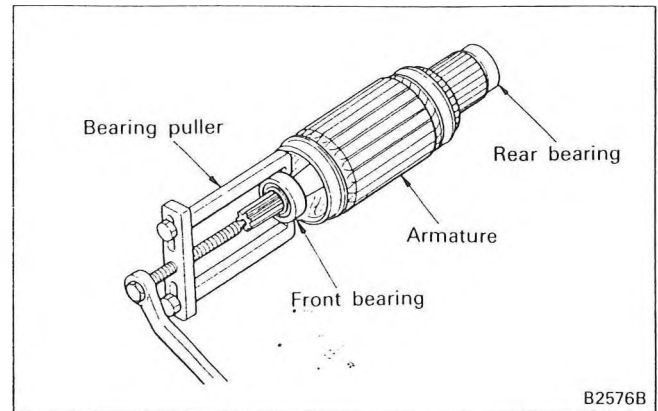
(Installation)



Apply a tool pipe to the bearing inner race and hammer it into position.

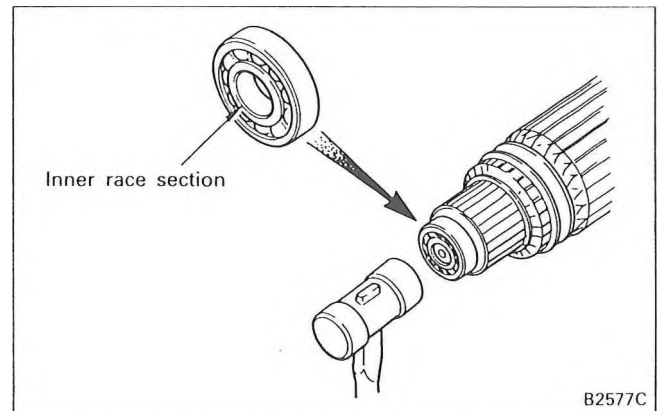
(b) Replacement of front and rear bearings

(Removal)

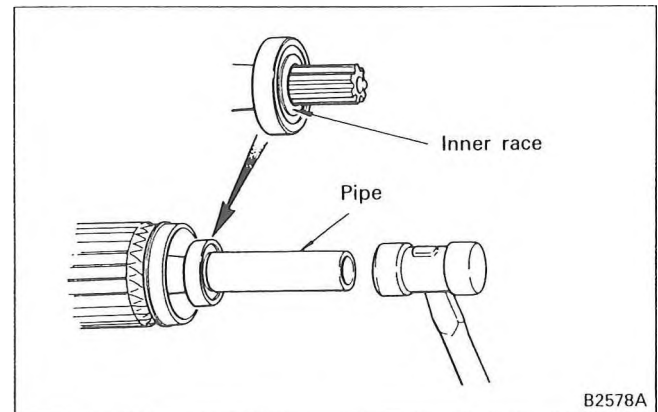


Using the bearing puller, remove the bearings from the armature.

(Installation)



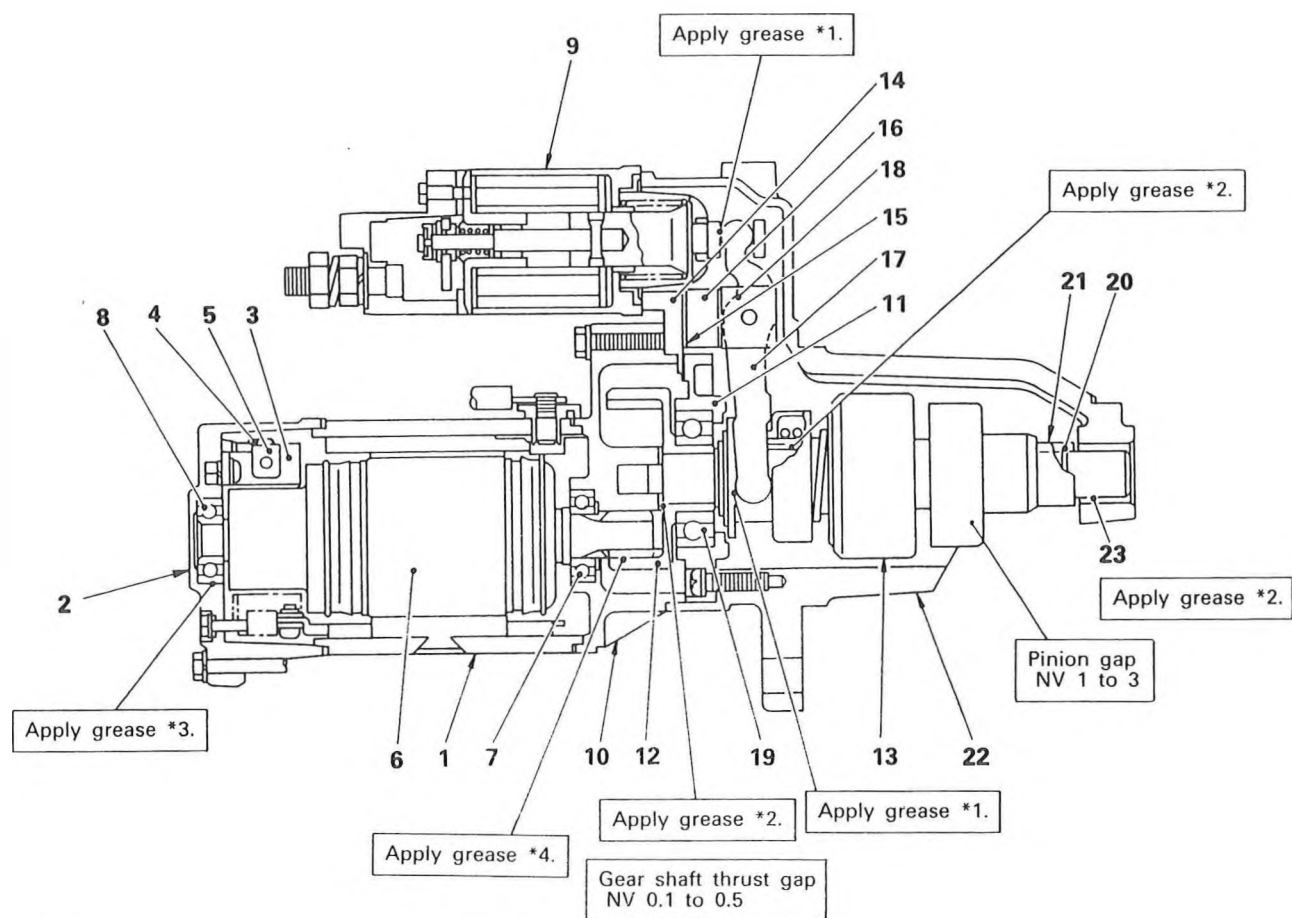
Install the rear bearing by striking its inner race uniformly with a soft hammer.



Install the front bearing applying a pipe of same diameter as its inner race and striking it into position.

5.1.4 Reassembly

<M3T>

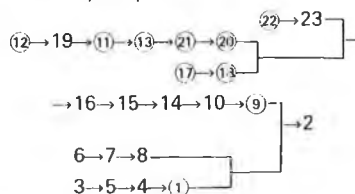


NV ... Nominal Value

(Recommended greases)

- *1: Mystik JT-6 (Kyodo Yushi)
or equivalent
- *2: MULTEMP MS-2 (Kyodo Yushi)
or equivalent
- *3: MULTEMP HD-2 (Kyodo Yushi)
or equivalent
- *4: MOLYCOAT AS-19 (Dow Coning)
or equivalent

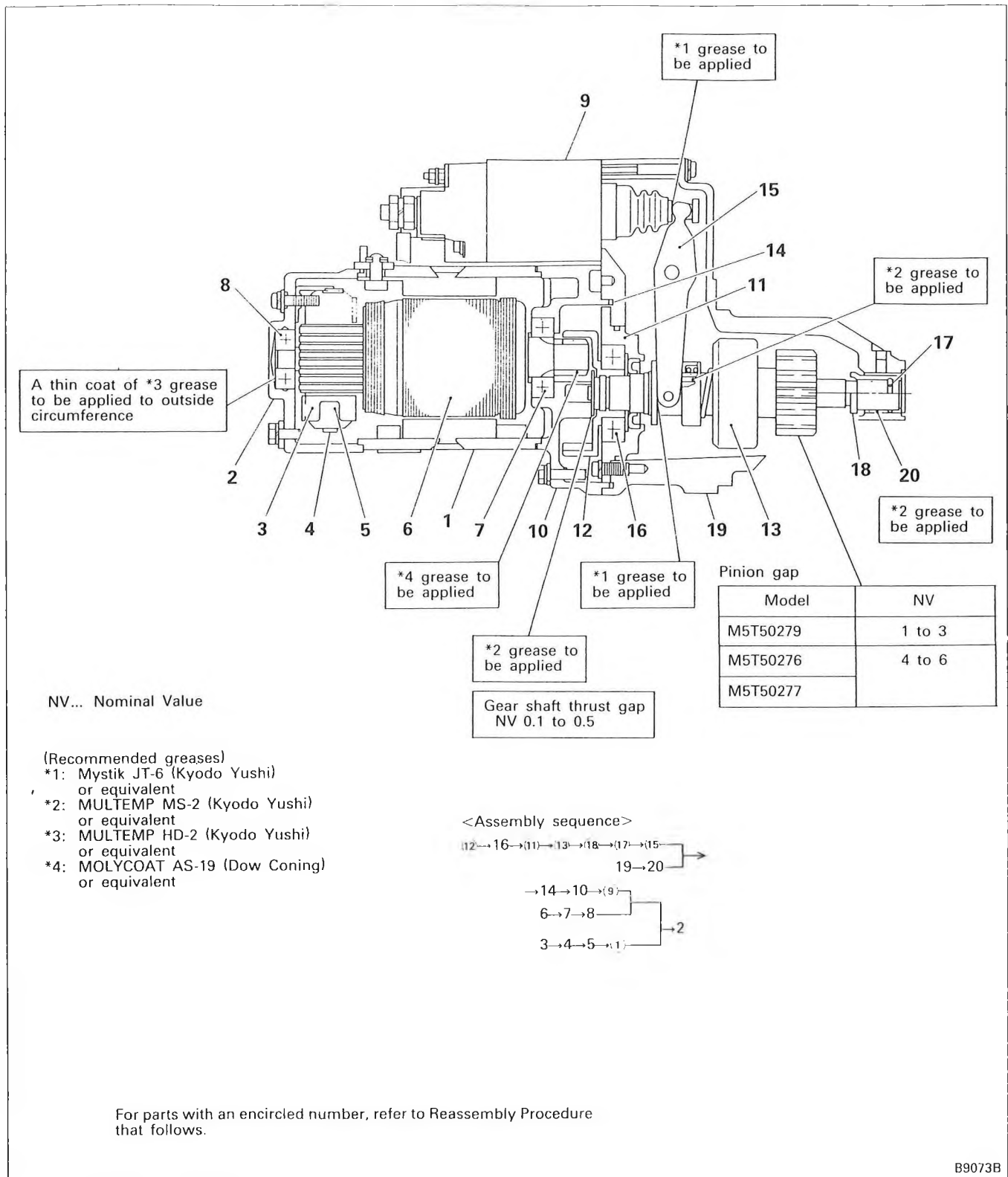
Assembly sequence



For parts with an encircled number, refer to Reassembly Procedure that follows.

D7548C

<M5T>

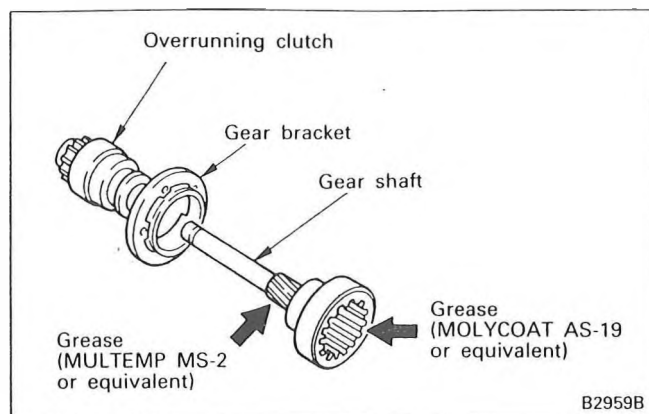


B9073B

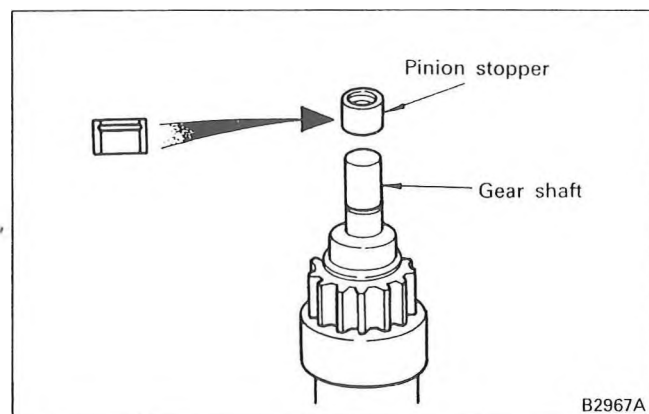
Reassembly Procedure

The reassembly procedure for the M3T95082 starter is described. On the other starters, only the differences are described.

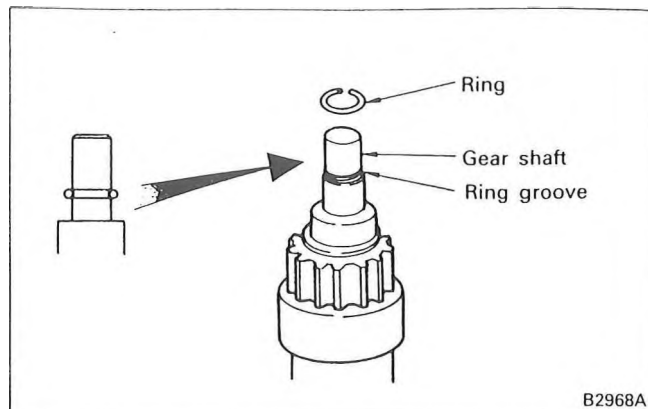
(1) Reassembly the Gear Shaft, Overrunning Clutch, and Gear Bracket in the Following Way



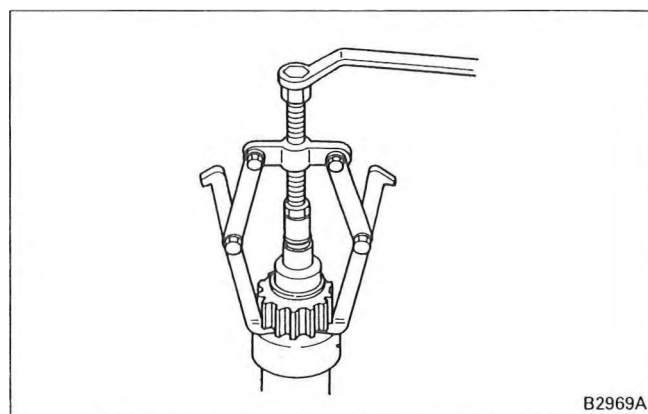
(a) Coat the portions in gear shaft shown with the specified greases and install the gear bracket and overrunning clutch over the gear shaft.



(b) Install the pinion stopper to the gear shaft in the direction shown.



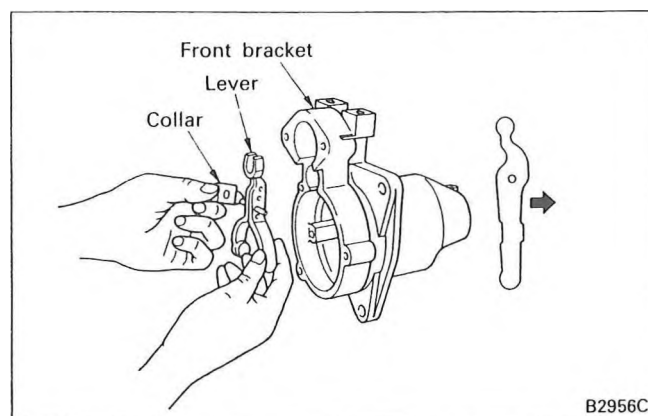
(c) Fit the ring into the ring groove in the gear shaft.



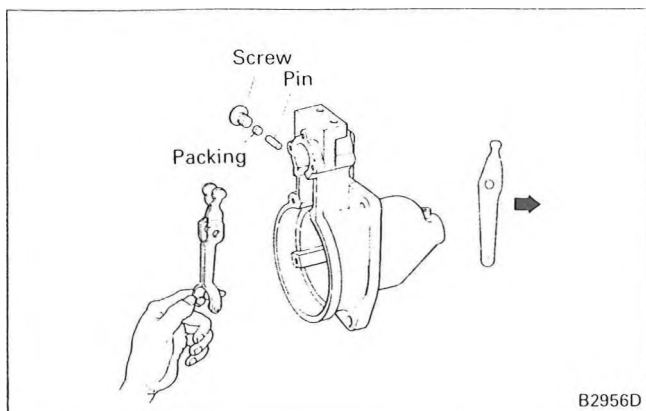
(d) Pull hard the pinion gear toward the ring and secure it by fitting the ring into the ring groove in pinion stopper.

(2) Installation of Lever

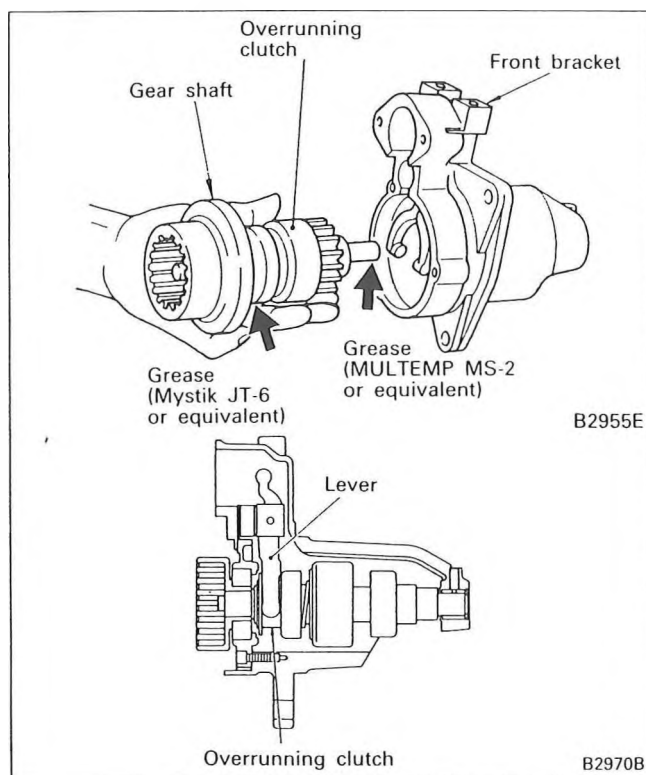
(a) Collar fixed type <M3T>



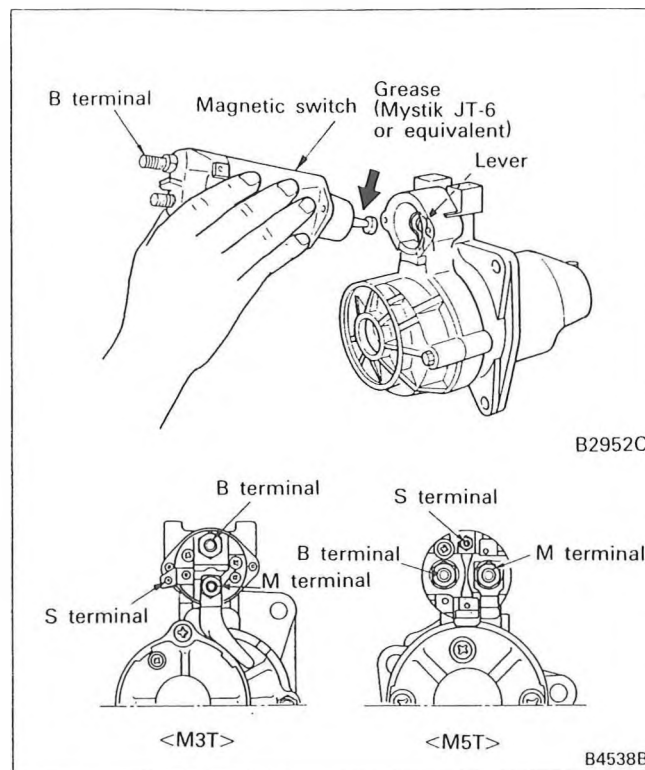
Install the lever in the direction shown, together with the collar, into the front bracket.

(b) Pin fixed type <M5T>

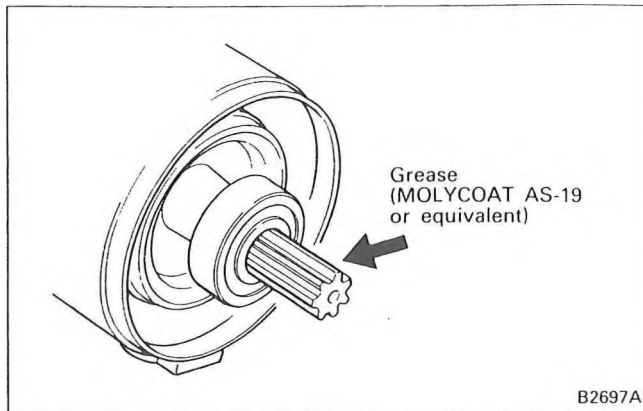
Insert the lever in the direction shown and mount it with the pin from outside the front bracket.

(3) Installation of Overrunning Clutch and Gear Shaft

Before installing the overrunning clutch and gear shaft to the front bracket, be sure to apply the specified greases to the portions indicated. Upon installation, make sure that the lever is wedged into the overrunning clutch.

(4) Installation of Magnetic Switch

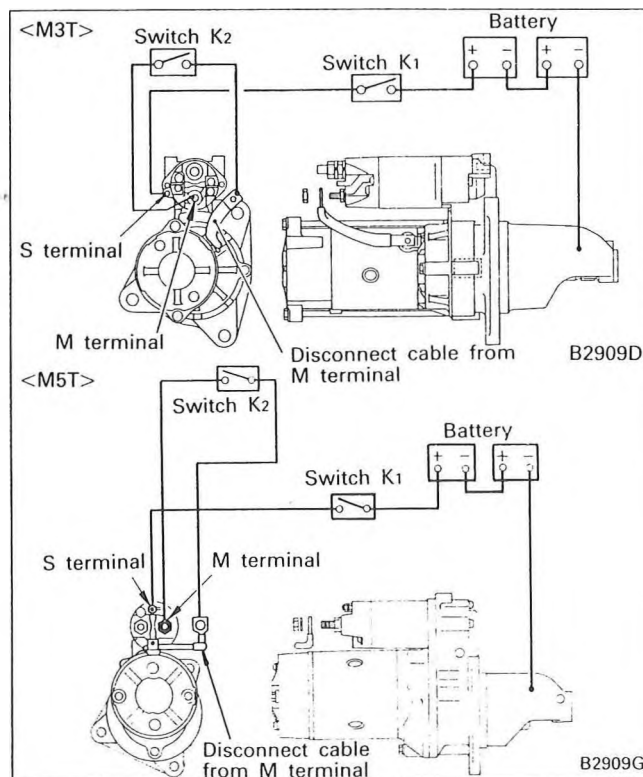
Coat the portion indicated with the specified grease and install the magnetic switch to the lever, ensuring that B terminal faces up for the M3T starter and S terminal faces up for the M5T starter.

(5) Installation of Yoke Assembly

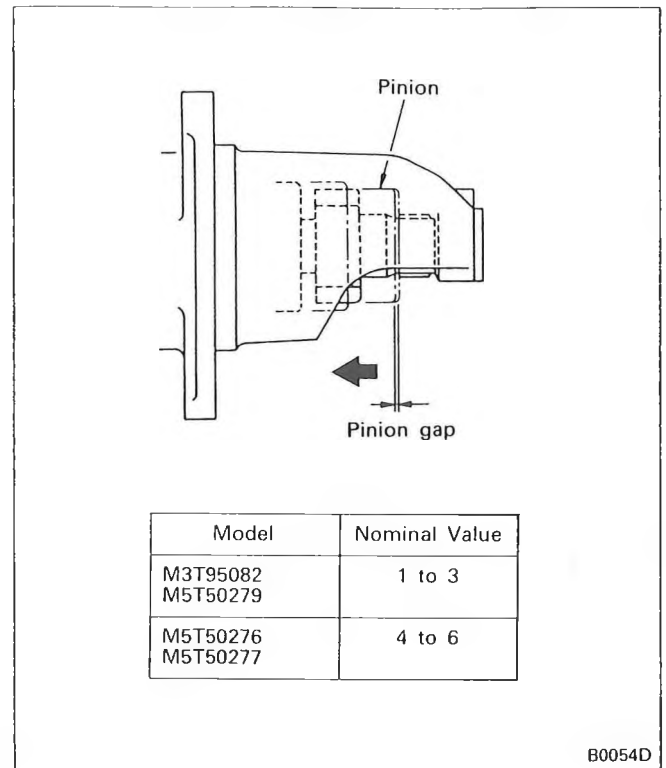
Apply grease to the splines of the armature before mounting the yoke assembly to the center bracket.

NOTE:

When the yoke assembly and center bracket are mounted, the locating notch should be aligned with the projection.

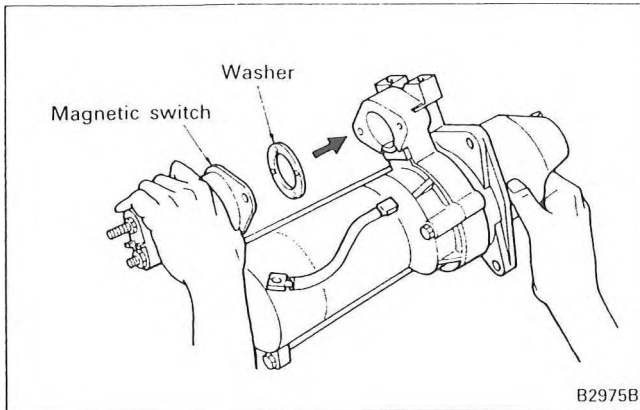
5.1.5 Inspection and Adjustment after Reassembly**(1) Inspection of Pinion Gap**

- Wire the reassembled starter as shown above.
- Turn ON switches K_1 and K_2 to project the pinion.
- Turn OFF switch K_2 to stop pinion from rotating.



Model	Nominal Value
M3T95082 M5T50279	1 to 3
M5T50276 M5T50277	4 to 6

- Measure the axial movement (pinion gap) when the pinion is pushed lightly toward the armature side.

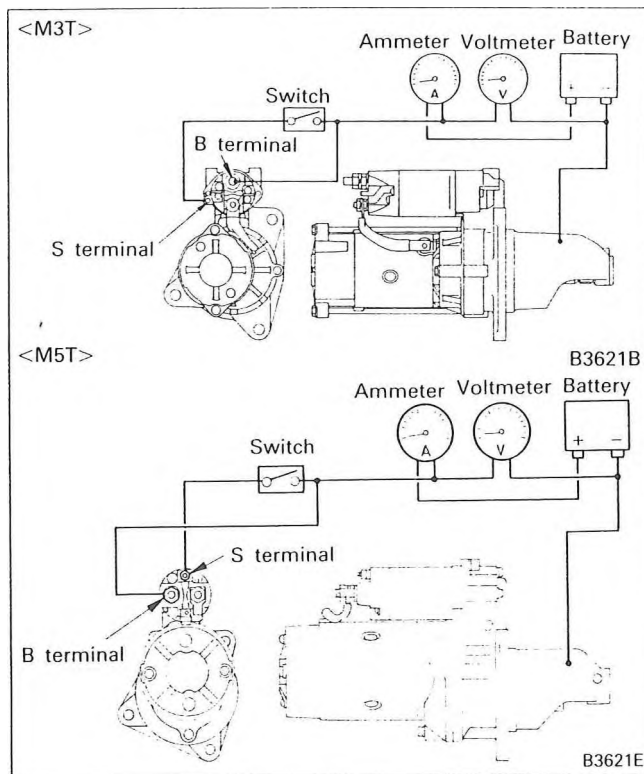


(e) If the measurement is out of specification, increase or decrease the number of washers used at the portion to which magnetic switch is mounted.

Washers

0.25, 0.5, 1.0 mm

(2) Inspection of No-load Characteristics and Magnetic Switch Operating Voltage



(a) Set up a circuit as shown including the ammeter, voltmeter and battery.

NOTE:

1. Use a wire as thick as possible and secure each connection firmly.
2. Apply voltage gradually from 0V up to 24V.

(b) Measure the current and rotating speed when the specified voltage is applied. If the measurement is out of specification, replace the starter.

Measure the rotating speed by illuminating the pinion with strobe light.

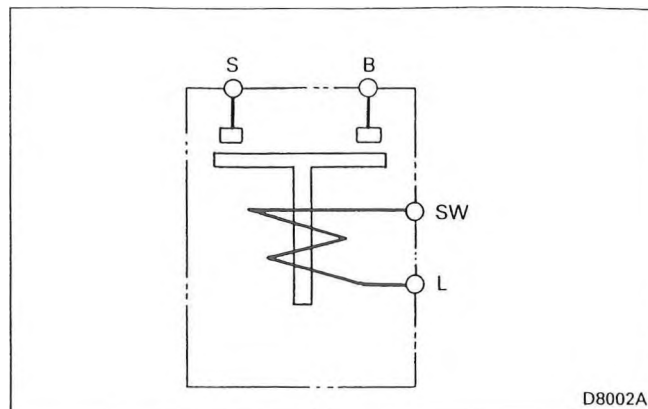
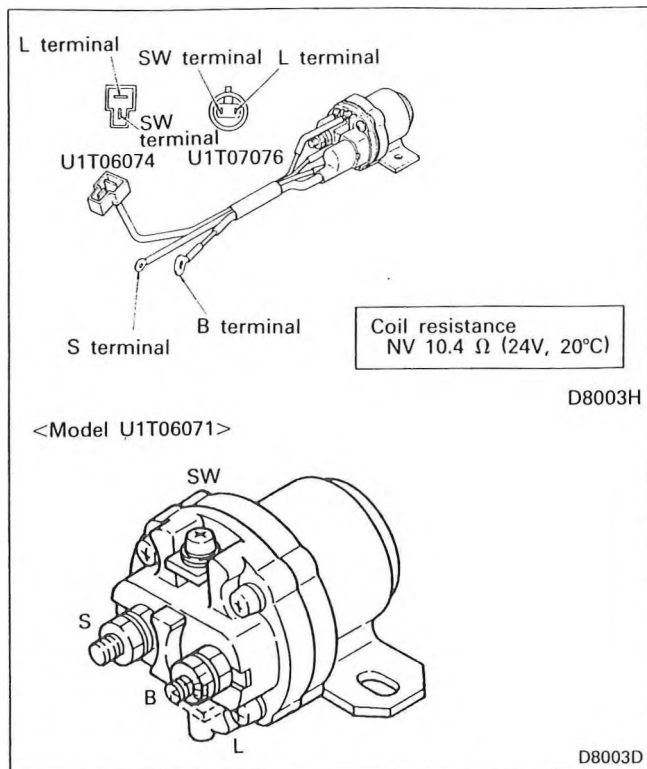
Nominal values (No-load characteristics)

Model	Voltage	Current	Rotating speed
M3T	23 V	110A or less	3 100 rpm or more
M5T	23.5 V	110A or less	3 300 rpm or more

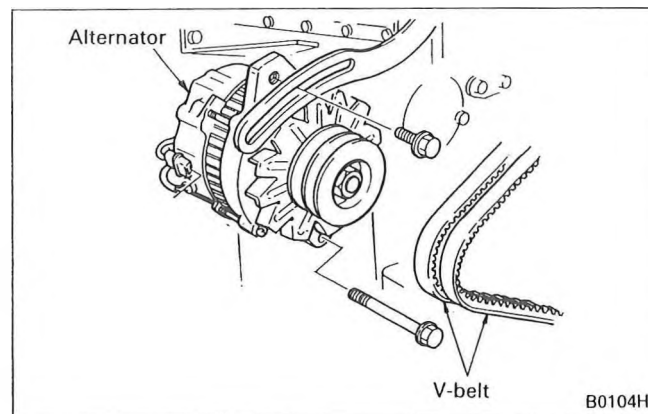
(c) Gradually increase the voltage from 0V and measure the voltage when the pinion springs out and turns.

If the voltage exceeds the specification, replace the starter.

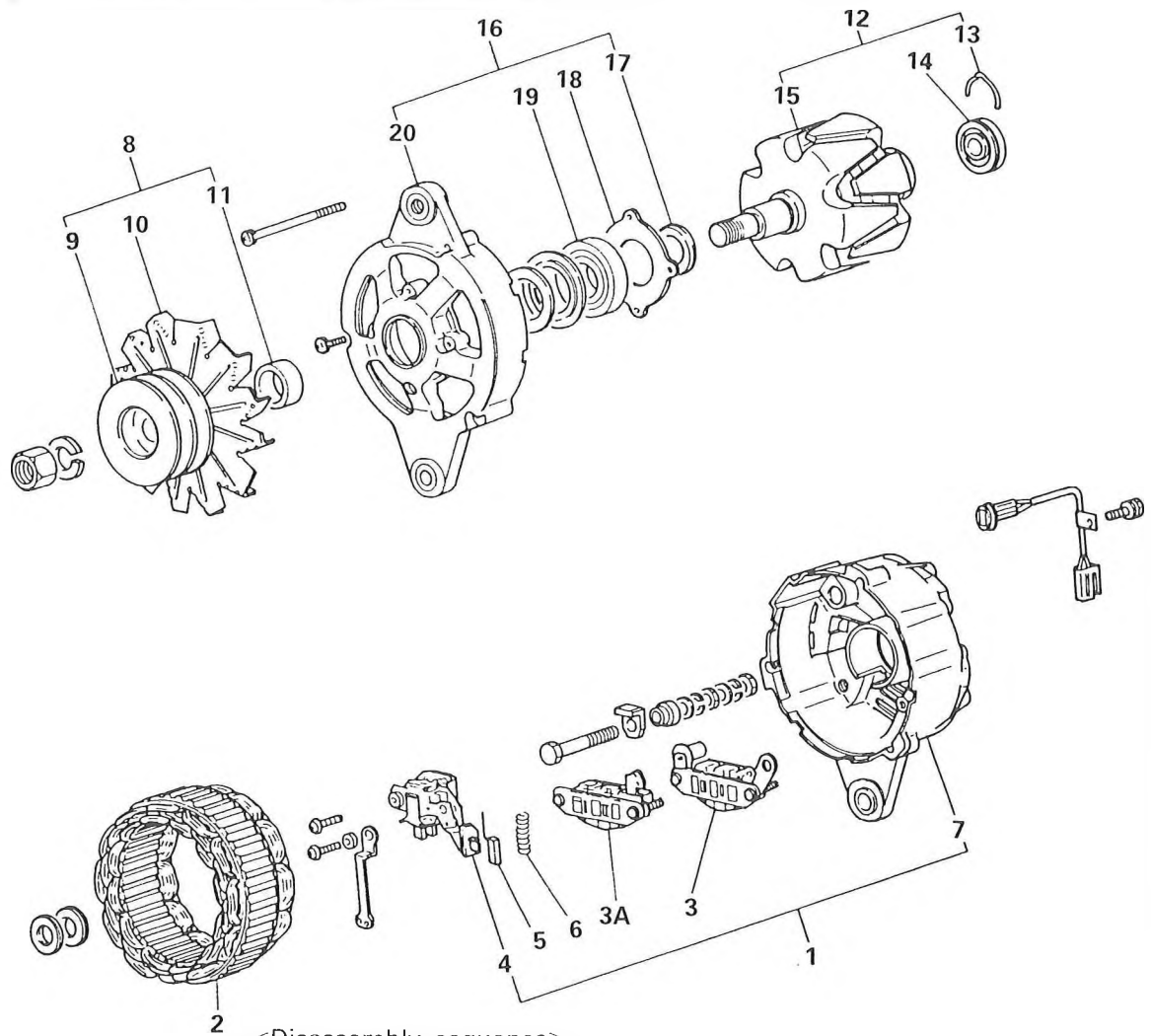
Nominal value (magnetic switch operating voltage)	16V or less
--	-------------

5.2 STARTER RELAY**Inspection Procedure**

- (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 battery voltage (24V) is applied across the SW and L terminals, there is continuity between the B and S terminals.

5.3 30A, 40A, 80A ALTERNATOR**5.3.1 Removal and Installation**

5.3.2 Disassembly



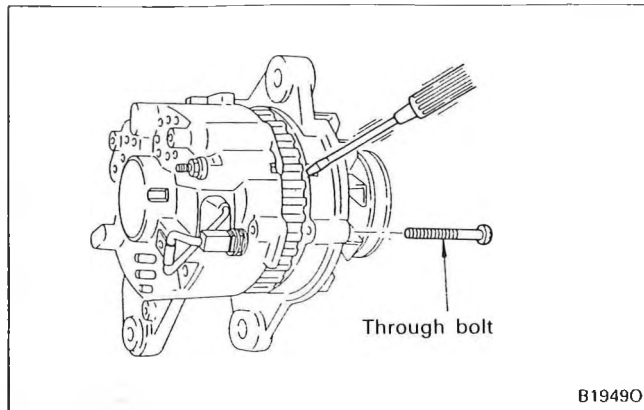
<Disassembly sequence>

- | | |
|---------------------------|-----------------------------|
| (1) Rear bracket assembly | 11 Spacer |
| (2) Stator | 12 Rotor assembly |
| (3) Rectifier | 13 Spring |
| (3A) Rectifier <80A only> | *14 Rear bearing |
| (4) Regulator assembly | (15) Rotor |
| (5) Brush | (16) Front bracket assembly |
| (6) Brush spring | 17 Cover |
| 7 Rear bracket | 18 Cover |
| 8 Pulley and fan | *19 Front bearing |
| (9) Pulley | (20) Front bracket |
| (10) Fan | |

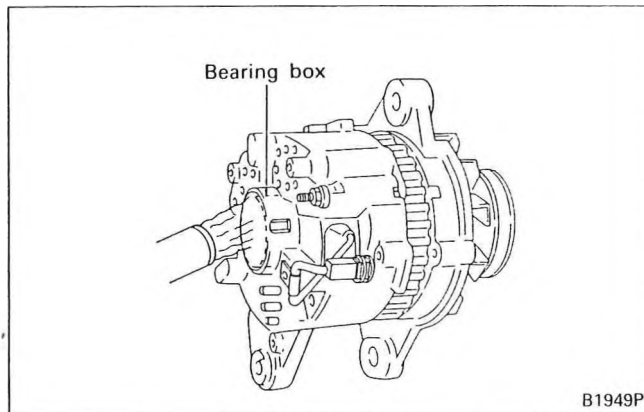
Parts marked with * should not be removed unless defects are evident.

For parts with an encircled number, refer to Disassembly Procedure that follows.

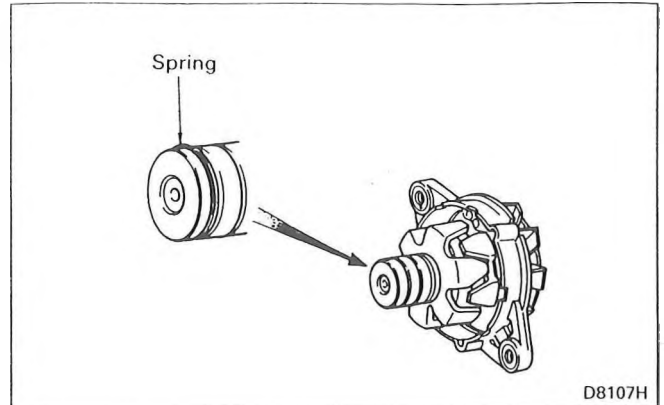
B3907E

Disassembly Procedure**(1) Separation of Front Bracket Assembly from Rear Bracket Assembly**

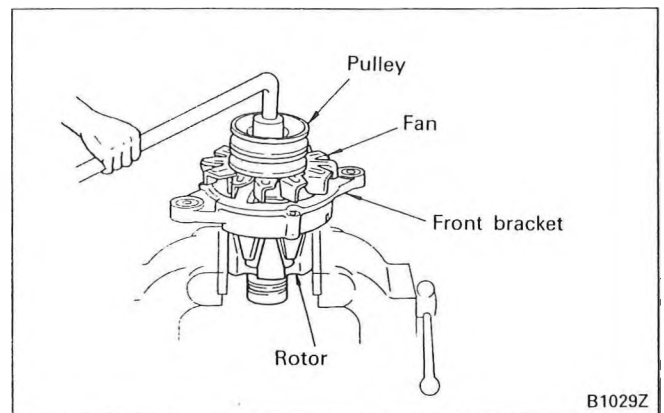
Remove the through bolt and, using a screwdriver, pry off the front bracket assembly from the rear bracket assembly.

NOTE:

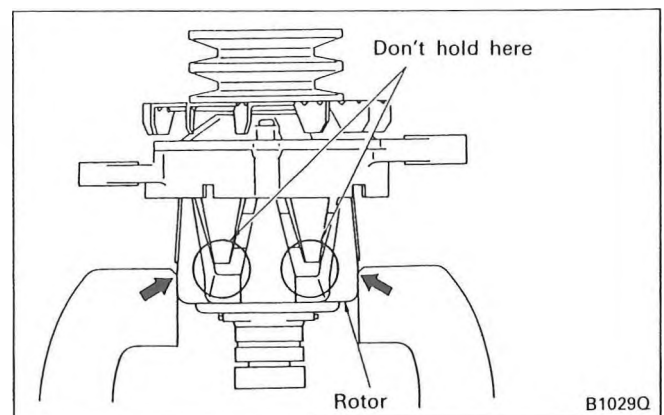
- 1. The rear bearing is tightly fitted. Before separation, therefore, preheat the bearing box of the rear bracket by an air dryer to facilitate separation.**



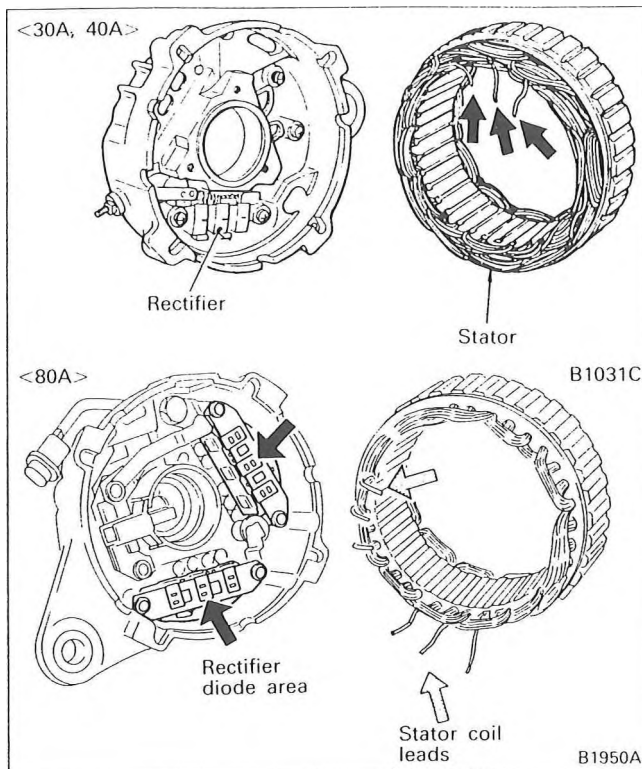
- 2. At time of separation, use care not to lose the spring fitted to the outside of the rear bearing.**

(2) Removal of Pulley

Hold the rotor in a vice, etc. and remove the pulley, fan and front bracket.

NOTE:

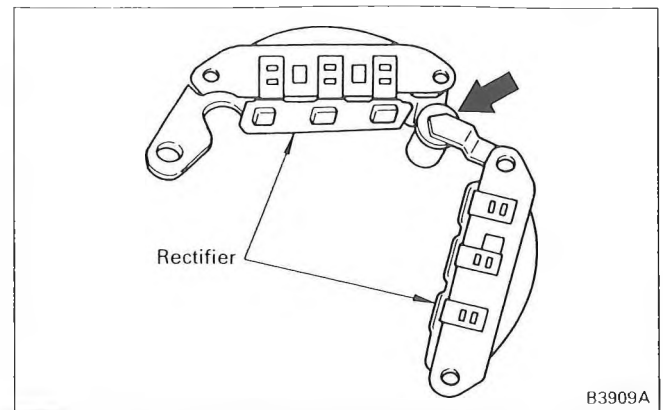
When holding the rotor in a vice, be sure to hold at illustrated portion.

(3) Removal of Stator Coil

To remove the stator coil, unsolder the stator coil leads soldered to the rectifier.

NOTE:

When unsoldering, finish it in a short time (less than 5 seconds) with a soldering iron.

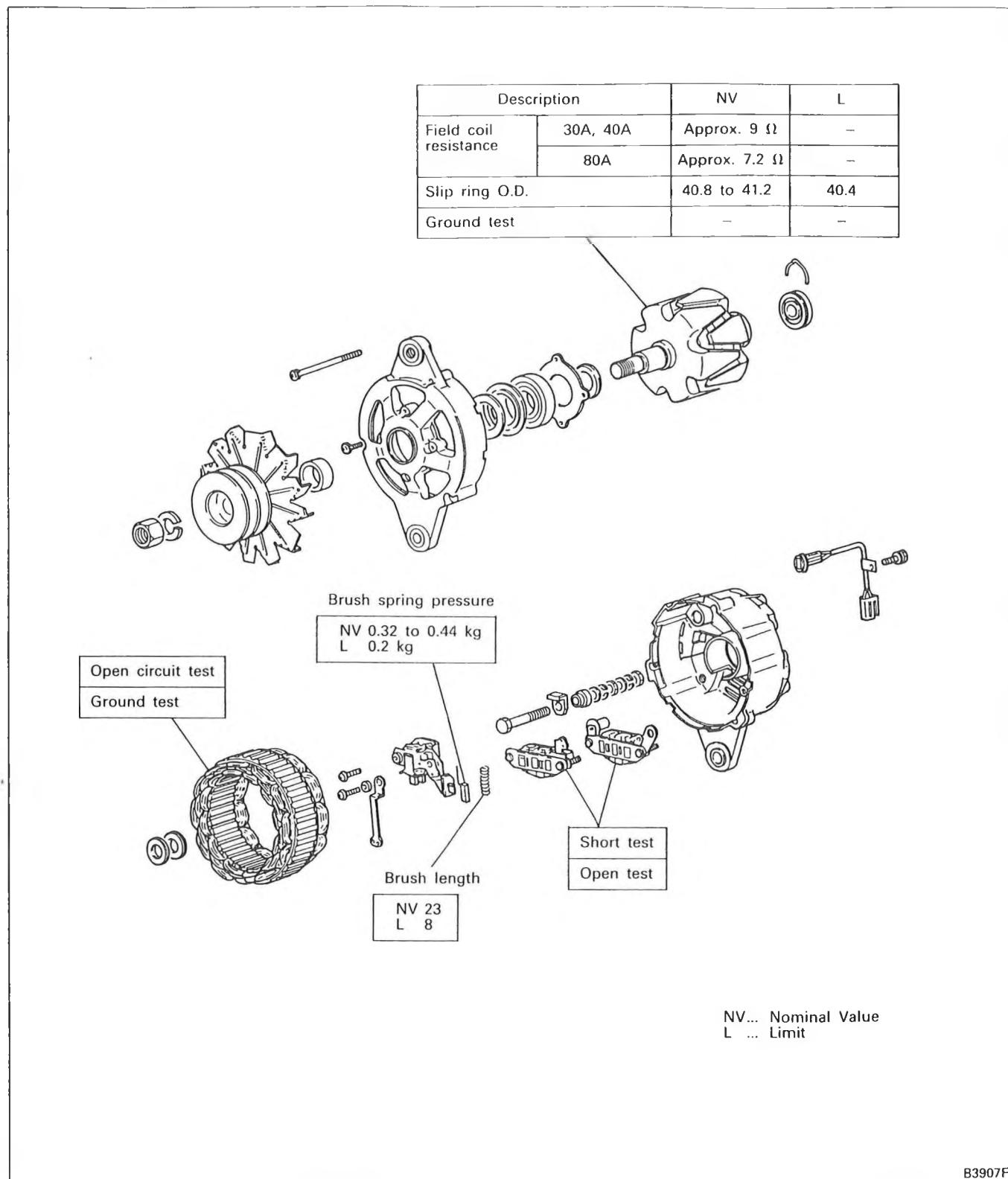
(4) Separation of Rectifier <80A>

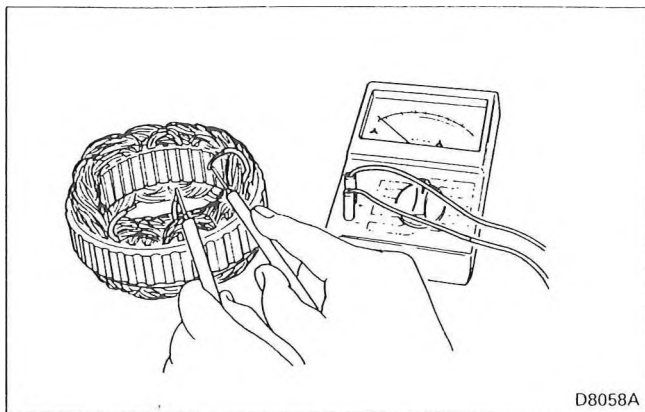
Separate the rectifier by unsoldering the area shown.

NOTE:

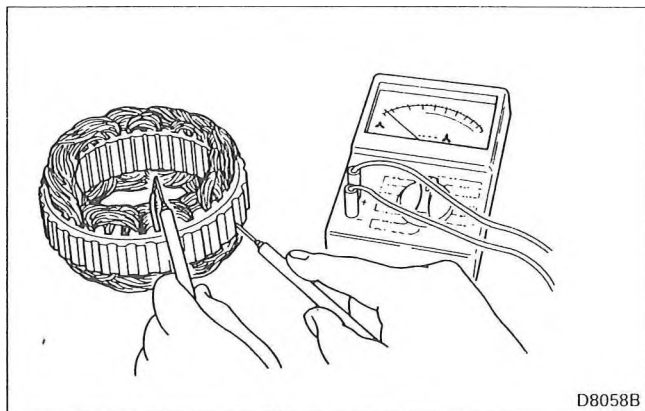
When unsoldering, finish it in a short time (less than 5 seconds) with a soldering iron.

5.3.3 Inspection

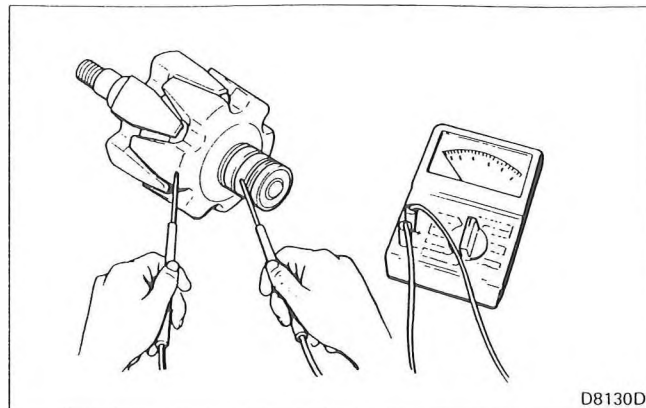


Inspection Procedure**(1) Inspection of Stator****(a) Continuity across leads**

Check that there is continuity across stator leads. If there is no continuity indicating a broken wire, replace the stator.

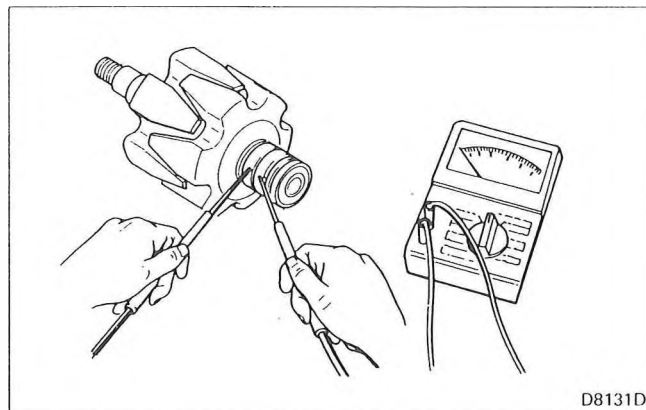
(b) Continuity across stator leads and core

Check that there is continuity across the stator leads and core. If there is, replace the stator as it is grounded.

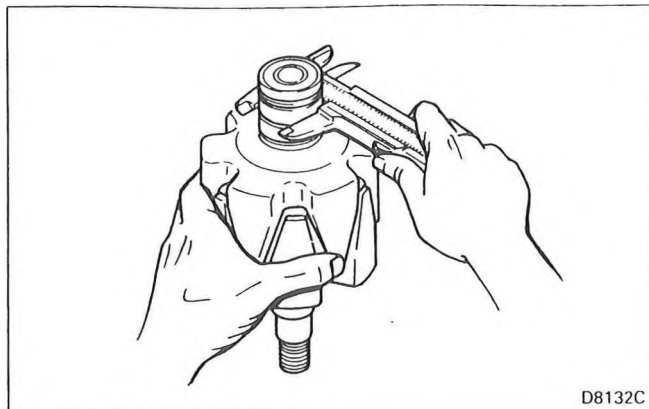
(2) Inspection of Rotor**(a) Continuity between slip ring and core**

Check that there is no continuity between the slip ring and core.

If there is, replace the rotor as it is grounded.

(b) Field coil resistance

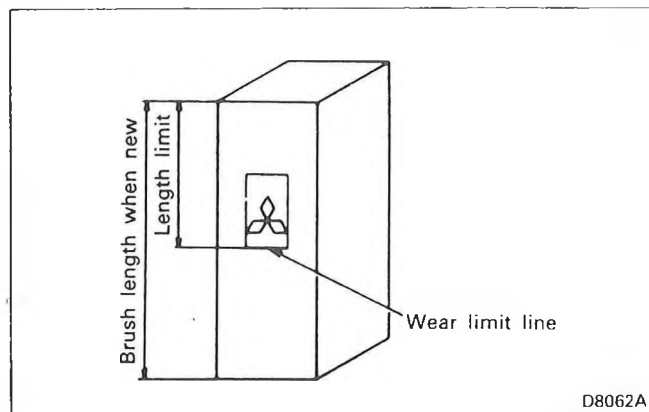
Measure the resistance across slip rings. Replace the rotor if the resistance is not within the specification.

(c) Slip ring O.D.

D8132C

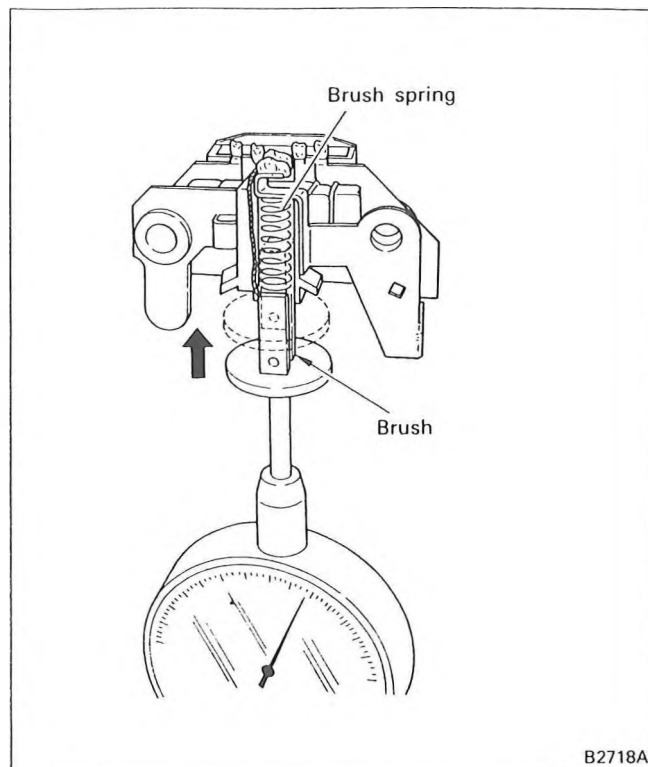
Measure the slip ring O.D. If the slip ring has rough surface or is unevenly worn, correct with sandpaper or lathe.

Correction must be made within the limit of slip ring O.D.

(3) Inspection of Brush and Brush Spring**(a) Inspection of brush**

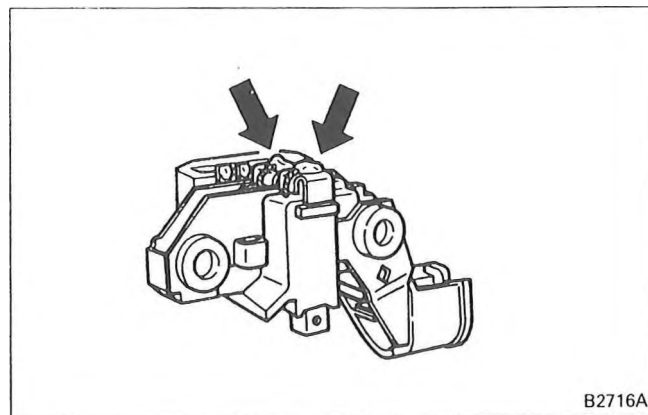
D8062A

Replace the brush if it is worn beyond the limit.

(b) Inspection of brush spring

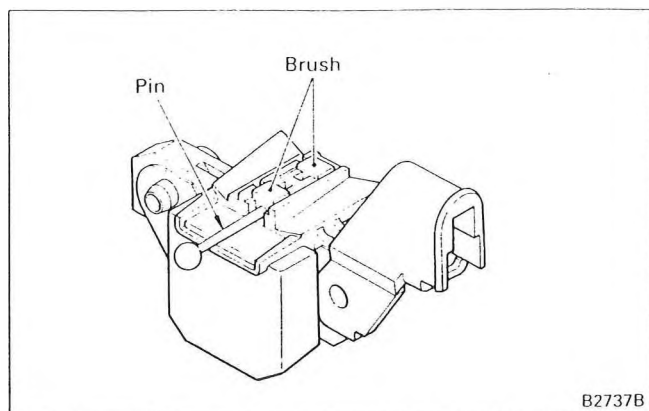
B2718A

If the spring pressure is lower than the limit, replace.

(c) Replacement of brush and brush spring

B2716A

1) Unsolder the position shown in the illustration and remove the brush and brush spring.



2) When soldering the brush, insert a pin into the brush hole and fix to the regulator assembly.

NOTE:

When soldering or unsoldering, work quickly (within about 5 seconds) with a soldering iron.

(4) Inspection of Rectifier

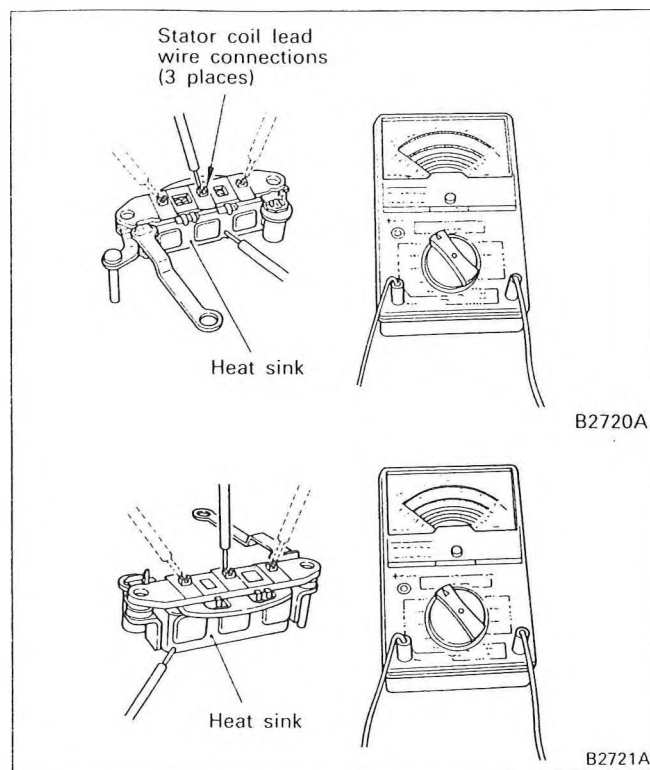
Measure resistance of each diode. Measure both when with the circuit tester (+) probe applied to the diode and when with the (–) probe applied to the diode.

- If resistance is infinite in both cases, the diode is open.
- If resistance is close to zero in both cases, the diode is shorted.

In the case of open or shorted diode, replace the rectifier.

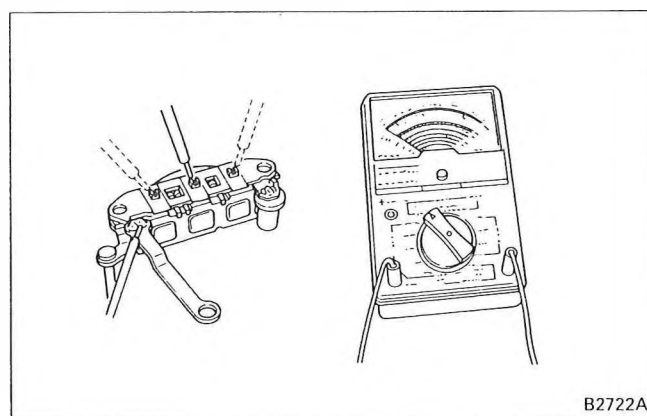
Measure according to the following procedures.

(a) Measurement of diode mounted to heat sink (6 places)



Measure between the heat sink and stator coil lead connections.

(b) Measurement of diode trio (3 places)



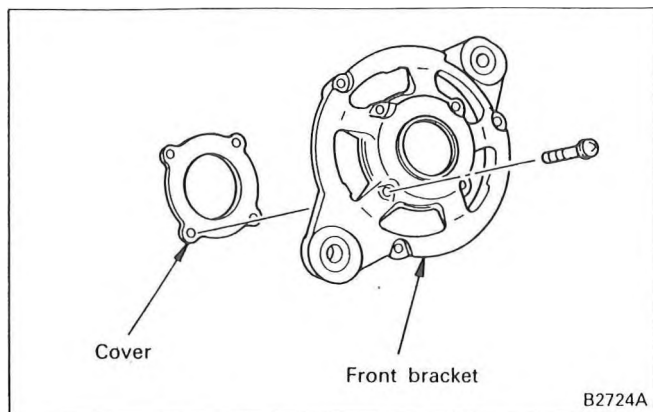
Measure between the plate connecting to the regulator and the stator coil lead connections.

(5) Inspection of Bearings

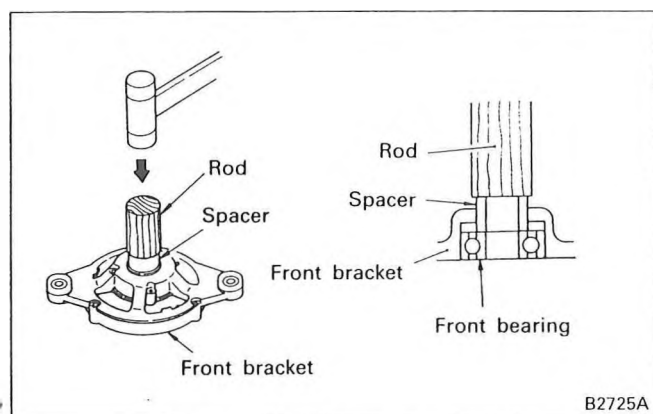
Replace the bearing if defect is evident.

(a) Replacement of front bearing

(Removal)

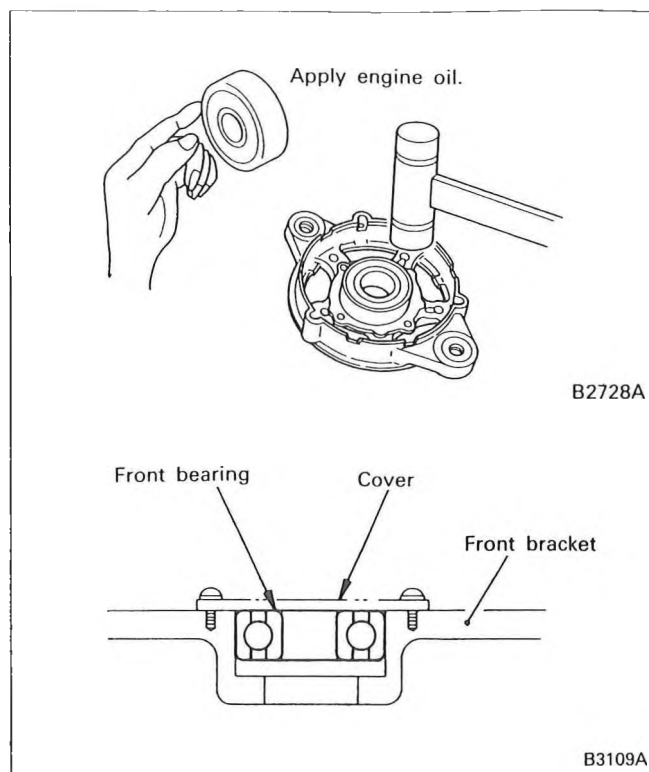


1) Remove the bearing cover.

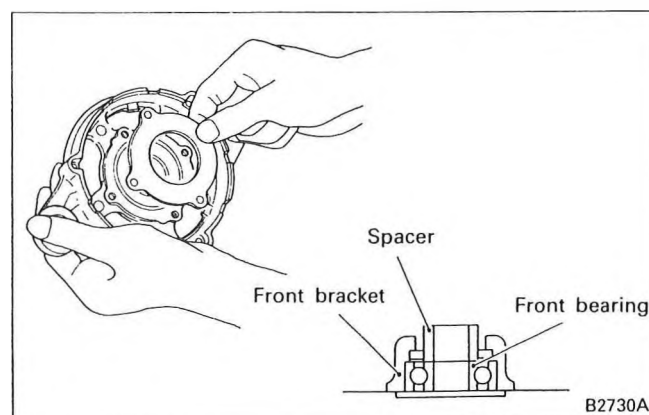


2) Apply a rod to the spacer on the front side of the front bracket and strike out the bearing.

(Installation)



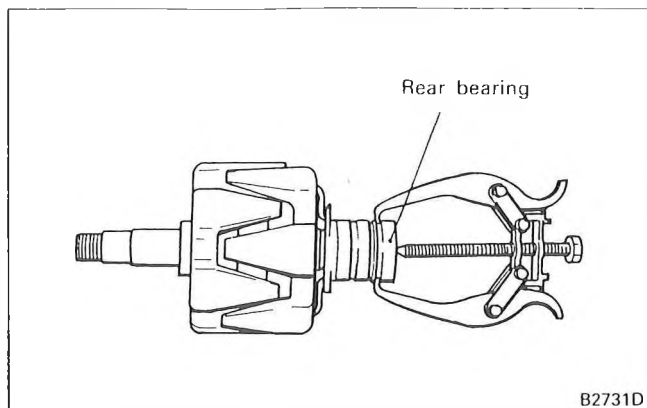
1) Apply a light coat of engine oil to the outside of the bearing and install to the inside of the front bracket using a press. Install flush with the cover mounting portion.



2) Install the cover and strike the spacer with a soft hammer, etc. to make sure that the bearing and cover are in contact with each other. If not, strike the spacer to bring them into contact.

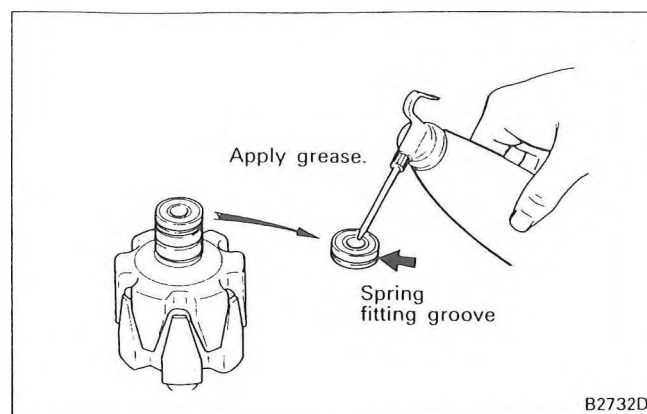
(b) Replacement of rear bearings

(Removal)

**NOTE:**

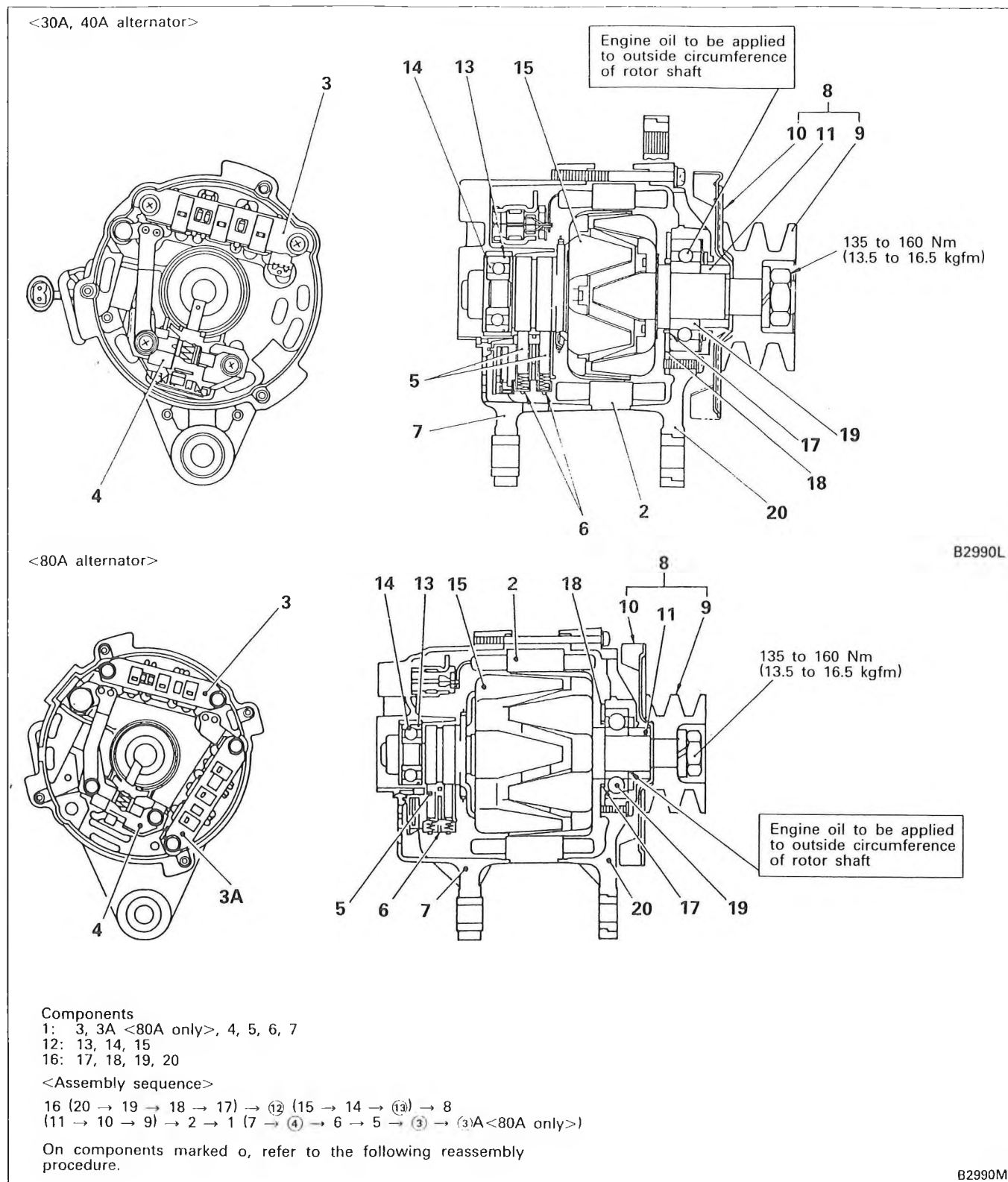
Use care not to cause damage to the slip ring by the bearing puller.

(Installation)



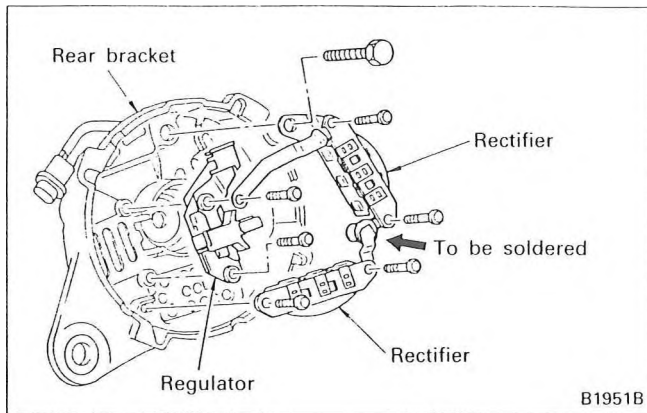
Apply a light coat of engine oil to the inside of the bearing and using a press, install with the spring fitting groove of the bearing facing the rotor field coil side.

5.3.4 Reassembly



B2990L

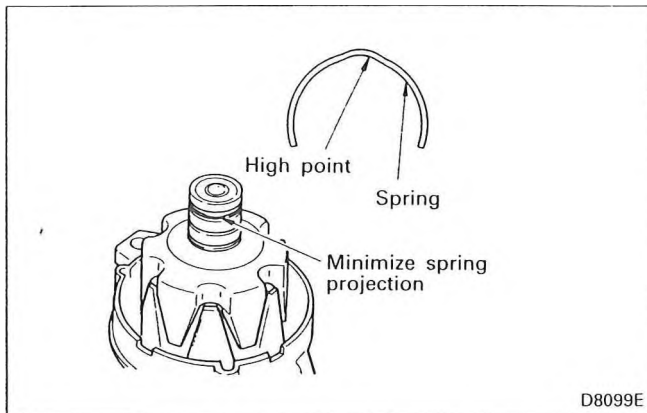
B2990M

Reassembly Procedure**(1) Installation of Rectifier (80A Alternator)**

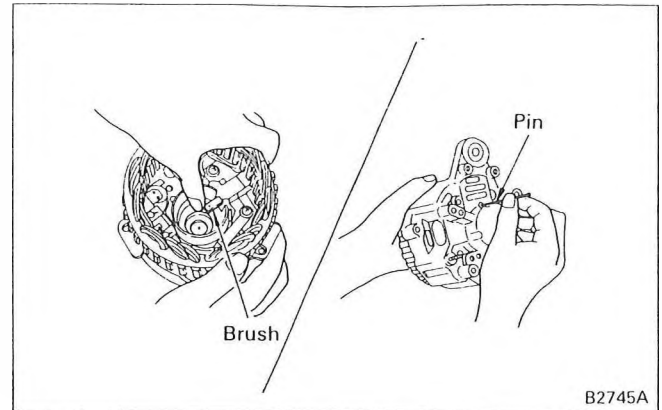
When the rectifiers are to be connected together by soldering, do the soldering with the regulator as well as the rectifiers mounted to the rear bracket.

NOTE:

When soldering, finish it in a short time (less than 5 seconds).

(2) Installation of Spring

Install the spring with its highest point seated in the deepest of the spring fitting groove of the bearing.

Installation of Front Bracket Assembly and Rear Bracket Assembly

(a) Push in the brush by hand and insert the pin into the brush hole from the rear of the rear bracket to fix the brush.

(b) Noting the spring position of the rotor bearing mounted to the front bracket side, install the rear bracket assembly.

NOTE:

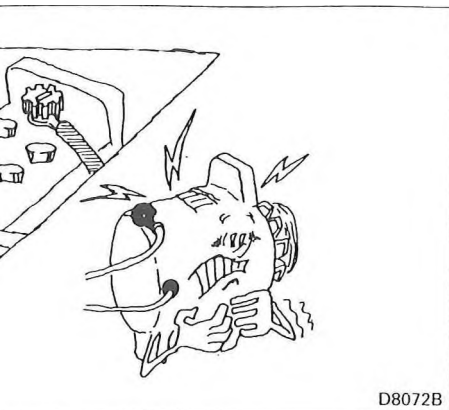
After completion of reassembly, be sure to remove the pin and close the hole.

ENGINE ELECTRICAL – SERVICE PROCEDURES

ction and Adjustment after In- tion

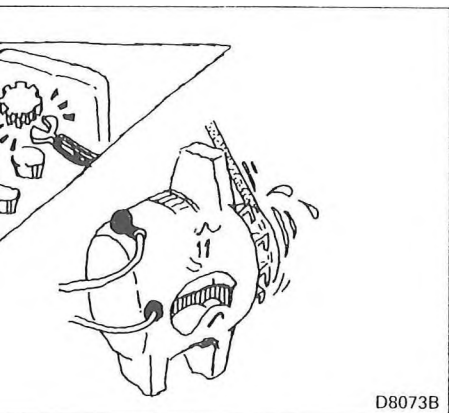
Precautions

the alternator, observe the following

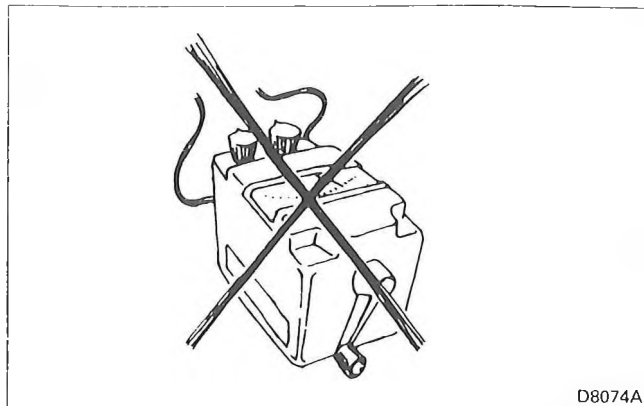


ect the battery reversely.

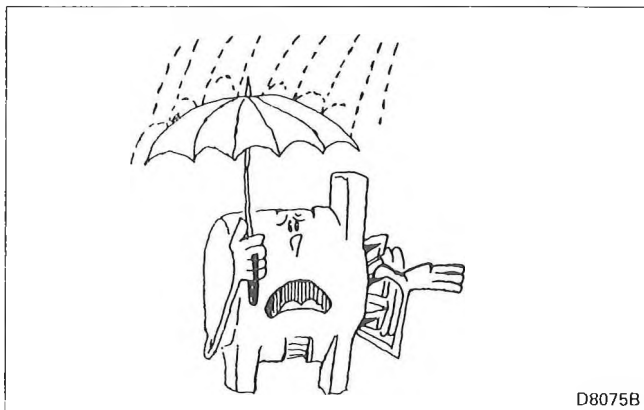
of the battery is reversed when
made, a large current flows from the
nator, damaging the diode and IC



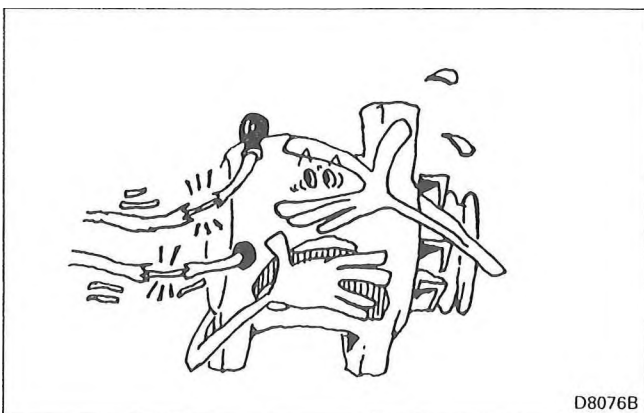
connect the battery terminal connec-
engine is running, or a surge voltage
operating the diode and regulator.



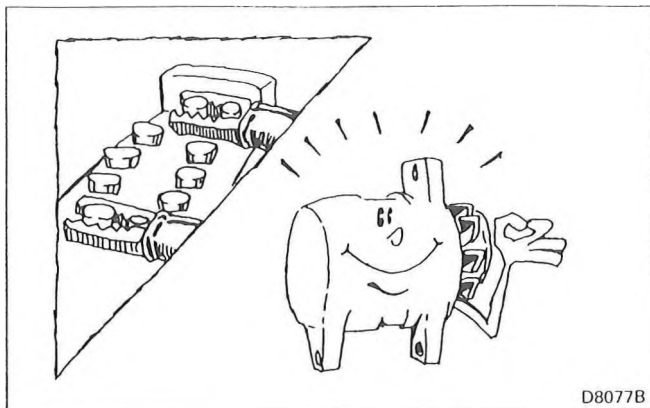
(c) Do not use a megger or other high-voltage
multi-meter, or damaged diode and regulator will
result.



(d) Do not expose the alternator to the water. If the
alternator is exposed to water, short-circuit may
result, causing damaged alternator.



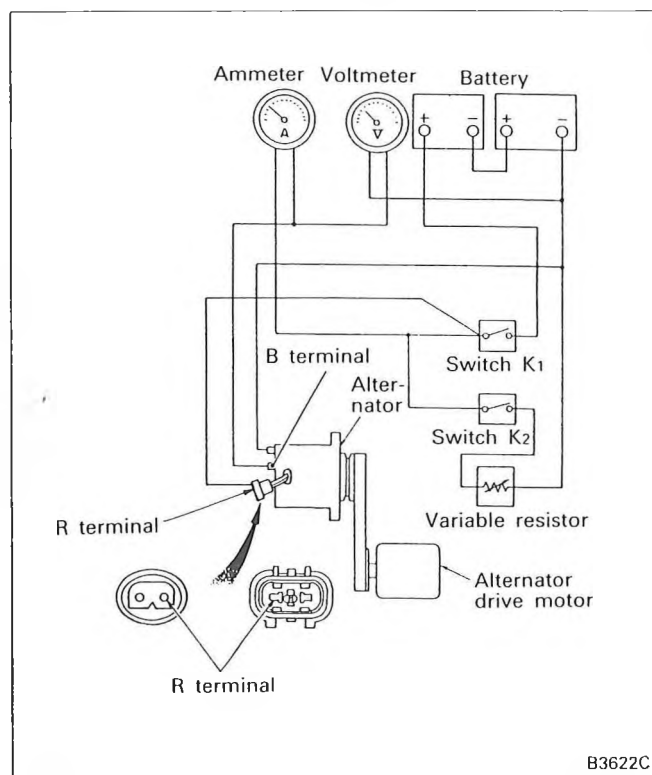
(e) Operating the alternator with its "B" and "L"
terminals shorted results in the damaged diode trio.



(f) When quick-charging the battery with a quick charger, be sure to disconnect terminal connections in advance. Otherwise, a damaged diode and regulator will result.

(2) Performance Test

(a) Test bench inspection



Perform the test using the circuit shown above.

1) With the load resistance set at maximum (meaning that there is almost no load current flowing), close switches K_1 and K_2 .

2) While gradually increasing the alternator speed and reducing the load resistance, measure the current value with the specified terminal voltage and speed. If the measurement is below the specification, check alternator parts.

Nominal value (when alternator is cold)

<30A alternator>

Terminal voltage	27V	27V
Current	17A or more	26A or more
Rotating speed	1 500 rpm	2 500 rpm

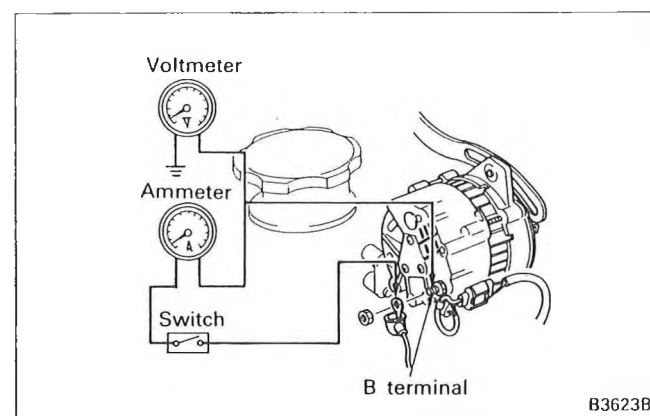
<40A alternator>

Terminal voltage	27V	27V
Current	26A or more	37A or more
Rotating speed	1 600 rpm	2 500 rpm

<80A alternator>

Terminal voltage	27V	27V
Current	39A or more	71A or more
Rotating speed	1 500 rpm	2 500 rpm

(b) On-vehicle inspection



1) Provide a switch between the battery and alternator "B" terminal. With the switch turned off, connect an ammeter (with 60A full-scale to the 30A or 40A alternator and 100A full-scale to the 80A alternator) and voltmeter.

2) Turn on the switch and make sure that the voltmeter indicates the battery voltage.

3) Start up the engine and immediately turn on all lamp switches. Then, increase the engine speed and read the maximum current value when the alternator speed reaches 5 000 rpm.

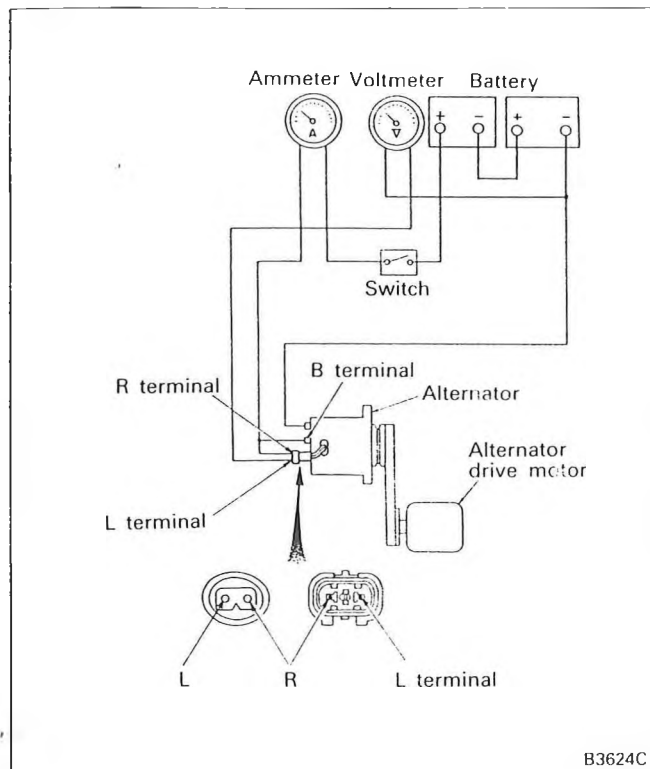
4) If the current reading is 70% or more of the nominal output, the alternator may be regarded as in good condition.

NOTE:

The on-vehicle test is an easier way of inspection; the test bench inspection is necessary for more accurate results.

(3) Inspection of Regulator

(a) Test bench inspection

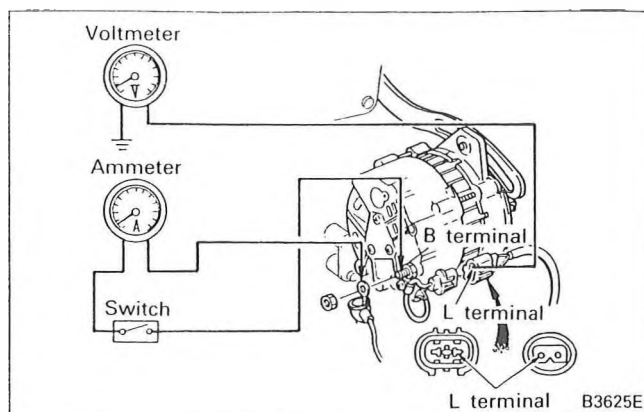


Inspect the regulator regulated voltage as follows using the circuit shown above.

- 1) Use a fully-charged battery. Turn on the switch.
- 2) Gradually increase the alternator speed up to 5 000 rpm. Check that the current value at this speed is 5A or less.
- 3) The regulator is in good condition if the regulated voltage under this condition is within specification. If not, replace the regulator assembly.

Nominal value	28 to 29V
---------------	-----------

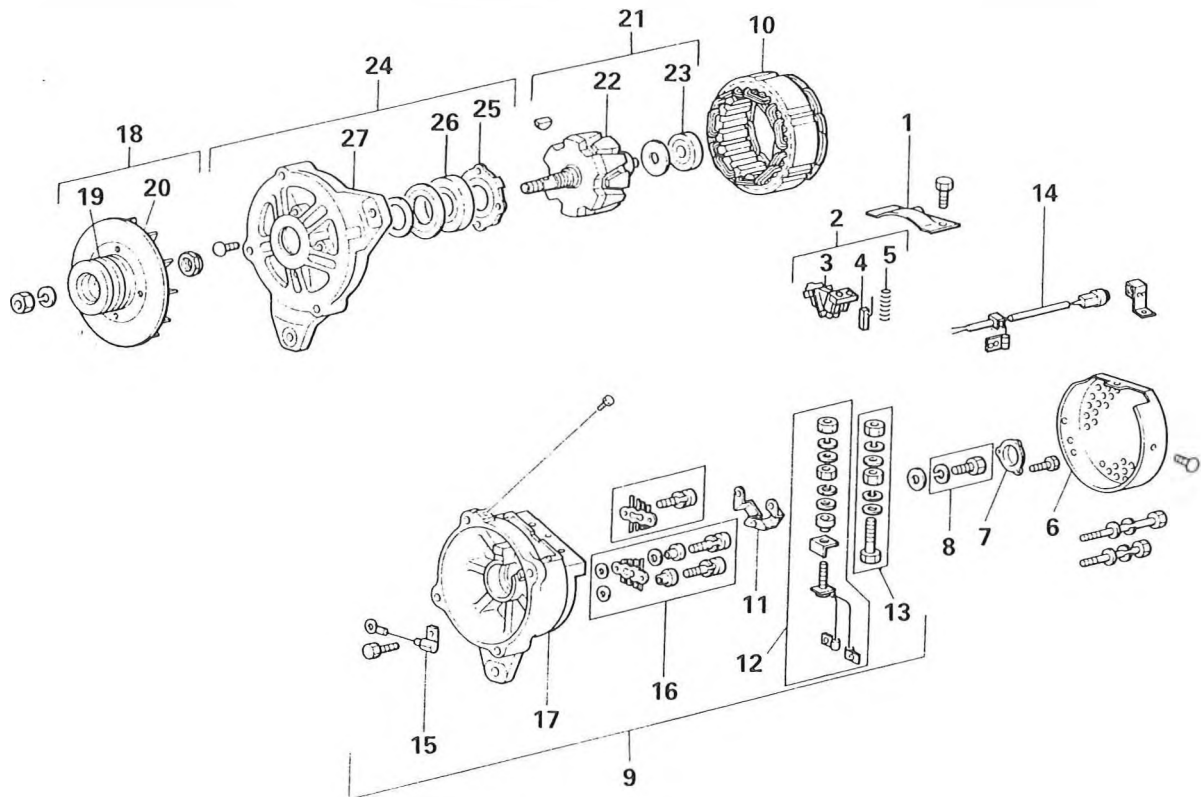
(b) On-vehicle inspection



- 1) Connect a voltmeter and ammeter and provide a switch as shown.
- 2) The regulator is in good condition if the voltmeter registers 0 when the switch turns ON. If the voltmeter pointer deflects, the alternator or wiring is defective.
- 3) With the ammeter terminal shorted to prevent flow of the starter current through it, start the engine.
- 4) Increase the engine speed to around 2 000 rpm and read the regulated voltage value if the charge current is 5A or less.
If the charge current is 5A or more, continue charging for a while or replace the battery with a fully-charged one.
Or, a 1/4 Ω (25W) resistor may be connected in series to the battery to limit the charge current.
- 5) If the measurement is out of specification, replace the regulator assembly.

5.4 60A ALTERNATOR**5.4.1 Removal and Installation**

[Refer to 5.3.1.]

5.4.2 Disassembly

<Disassembly sequence>

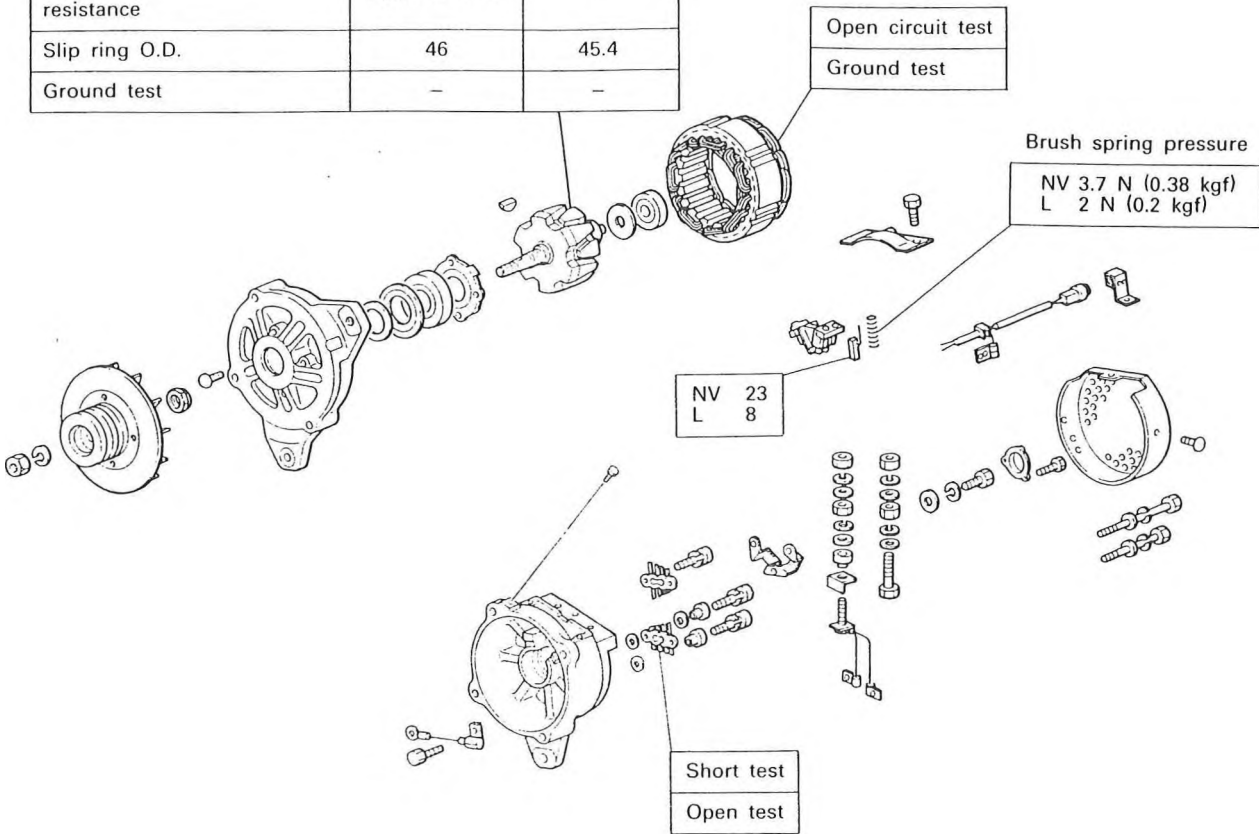
- | | | |
|-------------------------|-----------------------|---------------------------|
| 1 Cover | 10 Stator | *19 Pulley |
| 2 Brush holder assembly | 11 Plate | *20 Fan |
| 3 Brush holder | 12 Lead wire assembly | 21 Rotor assembly |
| 4 Brush | 13 Terminal set | ② Rotor |
| 5 Brush spring | 14 Connector | *23 Rear bearing |
| 6 End cover | 15 Condenser | ②④ Front bracket assembly |
| 7 Cover | 16 Heat sink set | 25 Cover |
| 8 Bolt set | 17 Rear bracket | *26 Front bearing |
| 9 Rear bracket | ①⑧ Pulley assembly | ②⑦ Front bracket |

Parts marked * should not be removed unless anything wrong is evident.

On parts marked o, refer to the disassembly procedure in 5.3.2.

5.4.3 Inspection

Description	NV	L
Field coil resistance	Approx. 13 Ω	–
Slip ring O.D.	46	45.4
Ground test	–	–



Open circuit test
Ground test

Brush spring pressure
NV 3.7 N (0.38 kgf)
L 2 N (0.2 kgf)

NV 23
L 8

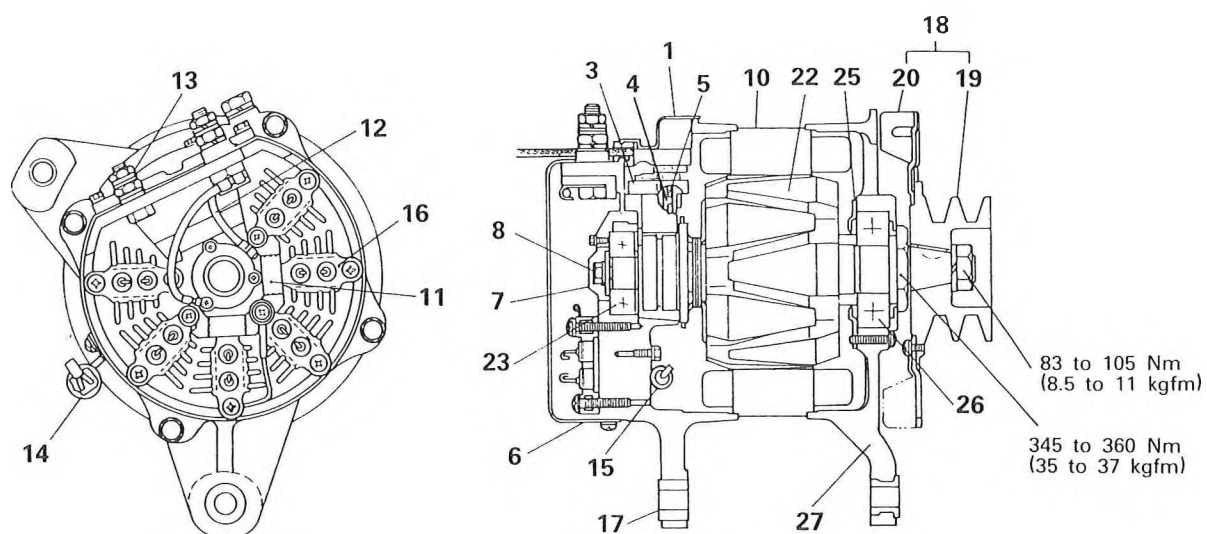
Short test
Open test

NV... Nominal Value
L ... Limit

For the inspection procedure, refer to 5.3.3.
To check the heat sink for a short circuit, no disassembly is required.
The short-circuit can be identified by checking for continuity between the individual connector terminals. [Refer to 5.4.5.]

B4539B

5.4.4 Reassembly



Components

2: 3, 4, 5
 9: 11, 12, 13, 15, 16, 17
 21: 22, 23
 24: 25, 26, 27

<Assembly sequence>

24 (27 → 26 → 25) → 21 (23 → 22) → 18 (20 → 19) → 10 → 9 (17 → 16
 → 15 → 13 → 12 → 11) → 14 → 8 → 7 → 6 → 2 (5 → 4 → 3) → 1

B4543A

5.4.5 Inspection and Adjustment after Reassembly

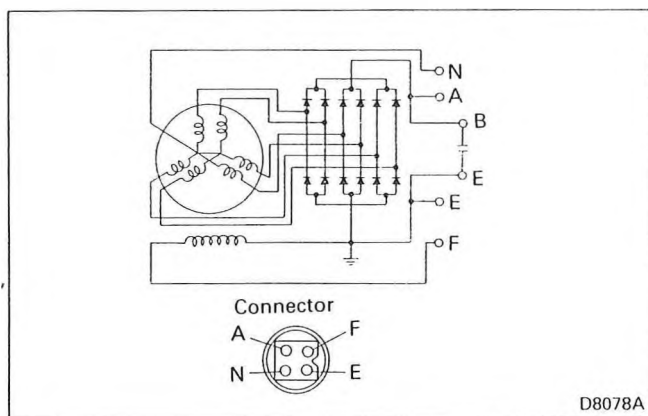
(1) Simple Procedures for Checking Alternator from Outside Inspection by Continuity Tester

Measuring points	Good	Defective
F – E	Tester shows continuity.	No continuity (Brush in poor contact or field coil open-circuited) Resistance 0 (Field coil short-circuited)
N – A	Tester shows continuity when (black) is connected to N and (red) connected to A.	If tester shows no continuity when (black) is connected to N and (red) connected to A, all of three (+) diodes are open-circuited or stator coil open-circuited. If tester shows continuity when (black) is connected to A and (red) connected to N, (+) diodes are short-circuited.
N – E	Tester shows continuity when (black) is connected to E and (red) connected to N.	If tester shows no continuity when (black) is connected to E and (red) connected to N, all three (–) diodes are open-circuited. If tester shows continuity when (black) is connected to N and (red) connected to E, (–) diodes are short-circuited.

NOTE:

The colors in parentheses show the colors of tester lead rods. All three diodes are rarely open-circuited.

Each diode should be tested to determine whether it is good or defective.



Load test

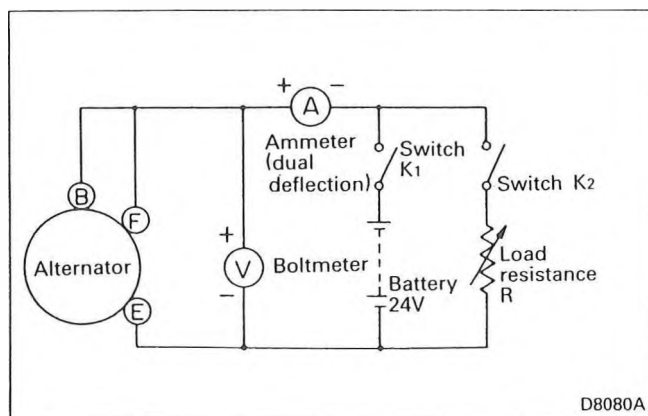
Increase the load resistance R to a maximum and close the switches K1 and K2. Measure the current value when the alternator reaches the specified speed.

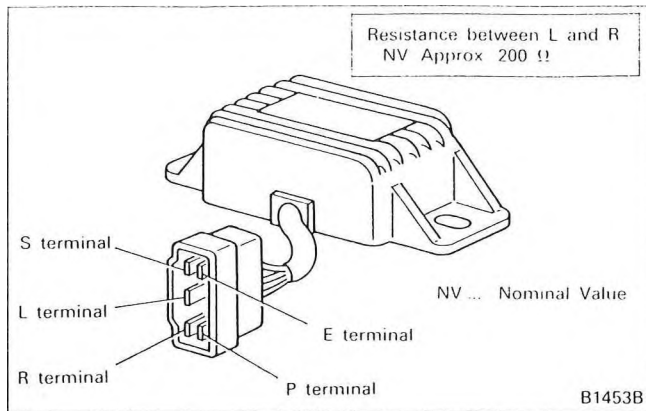
Nominal value

(when alternator is cold)

Terminal voltage	28 V
Current	60 A or more
Rotating speed	2 200 rpm

(2) Performance Test



5.5 SAFETY RELAY [Model R8T30171]**Inspection**

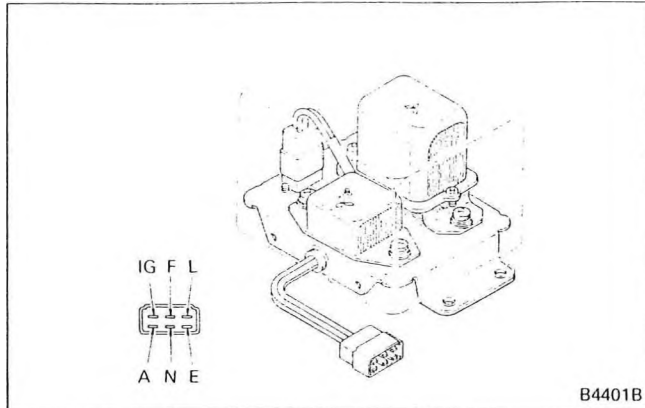
Measure voltage at each terminal in the sequence shown below to identify faulty parts.

(1) On-vehicle Test

Sequence	Engine operation	Voltage at terminal "P"	Voltage at terminal "S"	Voltage at terminal "R" or "L"
1	Starter switch ON	• 1 V or less • (+) diode shorted if close to battery voltage	—	Terminal "R" • Approx. 24 V • If 0 V, wiring is faulty Terminal "L" (with charge lamp) • Approx. 24 V Terminal "L" (without charge lamp) • Approx. 3 V or less • If close to battery voltage, wiring or alternator is faulty
2	During cranking	—	• Approx. 1 V or less • If close to battery voltage, safety relay is faulty (cranking impossible)	—
3	Idling (600 rpm or higher)	• Approx. 13 to 16 V	• A bulb connected between battery and terminal "S" does not come on • If bulb comes on despite normal terminal "P" voltage (shown to left), replace safety relay and test again	—

(2) Off-vehicle Test

The resistance valve between terminals "R" and "L" shall be within specified range.

5.6 REGULATOR [Model R7T01071]**Inspection****(1) Regulated Voltage of Voltage Regulator**

Nominal value (between A and E terminals) ... 28 to 29V with alternator at 4 000 rpm

Battery overcharged ... Voltage too high

Battery discharged ... Voltage too low

NOTE:

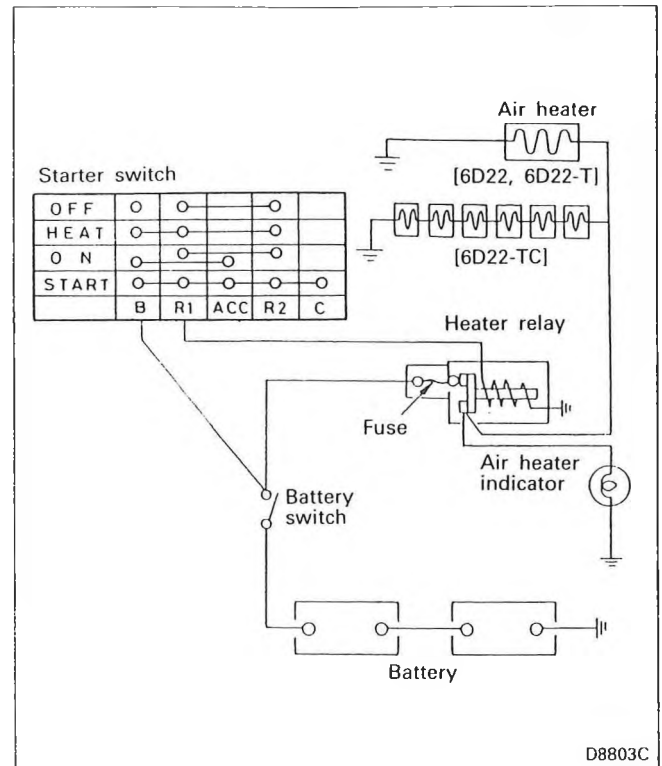
This regulator uses a transistor type voltage regulator, so the regulated voltage cannot be changed. If the regulated voltage is out of the nominal value, replace the regulator.

(2) Voltage Regulator Regulated Voltage Measuring Procedure

- Increase the engine speed until the alternator reaches the specified speed.
- Continue charging until the charging current to the battery falls to less than 10 A (the battery fully charged).
- Measure the voltage across the A and E terminals.
- Measure the voltage across the A terminal and the negative terminal of the battery and check to ensure that there is no difference between the value and the value measured under Item (c).

5.7 PREHEATER**5.7.1 Intake Air Heater****(1) Removal and Installation**

[Refer to Group 15 Intake and Exhaust]

(2) Inspection

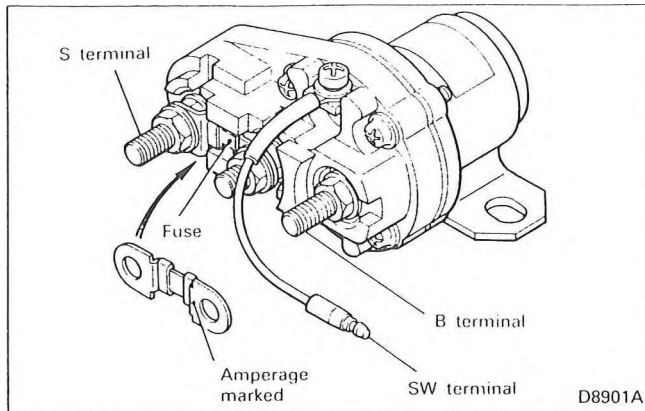
Perform the following inspection and check the function of each part or the wiring if necessary.

- Time required before indicator becomes red-hot:

Standard time

40 to 60 seconds

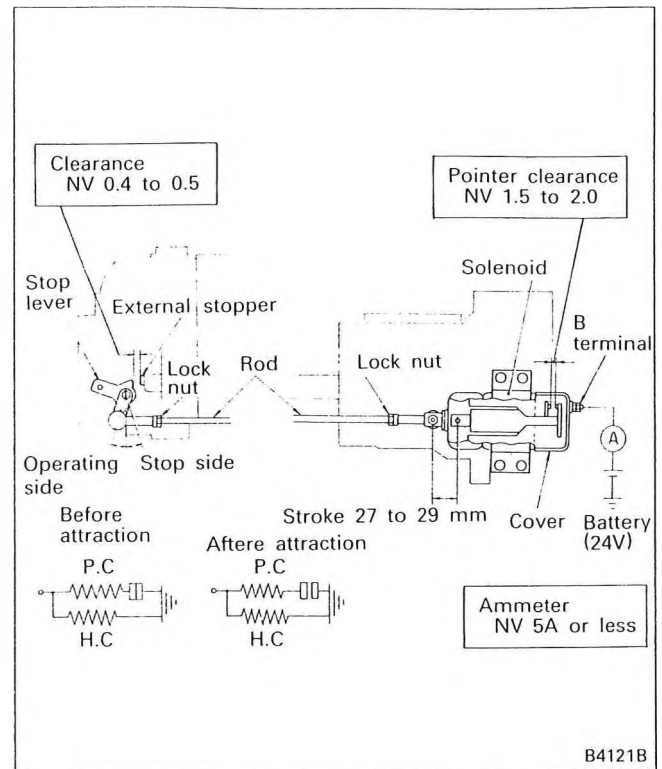
- Check each terminal of the air heater for looseness and the heater element for damage and contact with other parts.

5.7.2 Heater Relay**Inspection**

(1) Check to ensure that there is continuity between the terminals "B" and "S" when 2.3 A exciting current is applied between terminal SW in the figure and body earth.

(2) Check also the heater 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.

5.8 AUTOMATIC STOP DEVICE**5.8.1 Energize-to-stop Type****(1) Stop Solenoid**

(a) Connect the stop lever and solenoid using the rod and remove the solenoid cover.

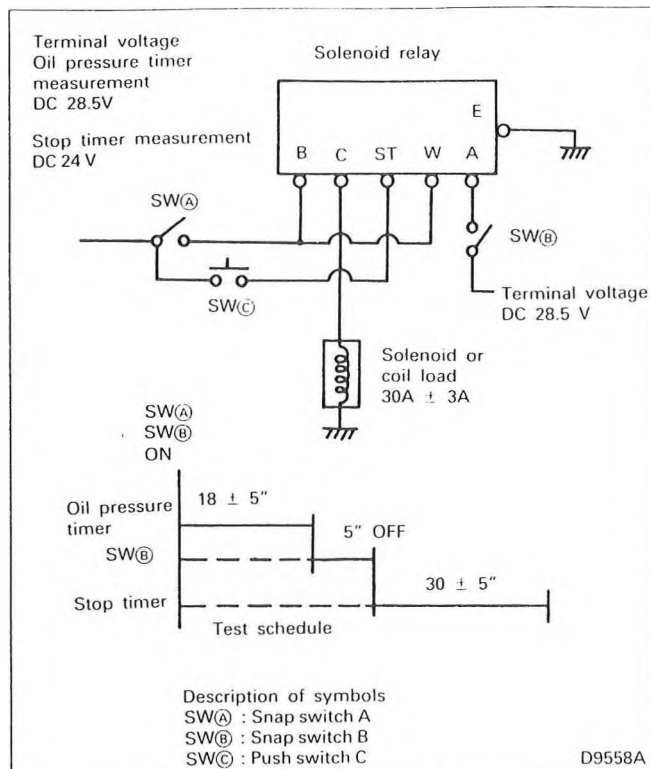
(b) Push manually the stop lever to the stop position and adjust the rod so that the solenoid pointer gap becomes as specified.

(c) Check that the stop lever to external stopper clearance is as specified when the stop lever is on the operation side.

(d) In the state of (c) above, apply specified voltage to solenoid "B" terminal and check that the pointer gap and ammeter reading are as specified. (Stop lever stop side)

(e) Tighten the lock nut of the rod.

(f) Check that the solenoid pointer color has not changed and then install the cover.

(2) Solenoid Relay**(a) Unit test**

After the tests of the above items 1) and 2), allow 5 minutes before making retests. It takes 5 minutes before the capacitor C_1 which is an element of the time constant of the oil pressure timer finishes discharging.

Make connections as shown above and perform the following checks.

1) Oil pressure timer

Set the snap switch A to ON. Operate a stop watch as soon as the snap switch B is set to ON, and measure the time required before the solenoid is operated.

2) Stop timer

Set the snap switch B to OFF 5 seconds after the solenoid has been operated. At the same time, using a stop watch, measure the time required before the solenoid is reset.

The snap switch B is set to OFF 5 seconds after operation of the solenoid because if the solenoid is operated, it takes 5 seconds before the alternator voltage disappears.

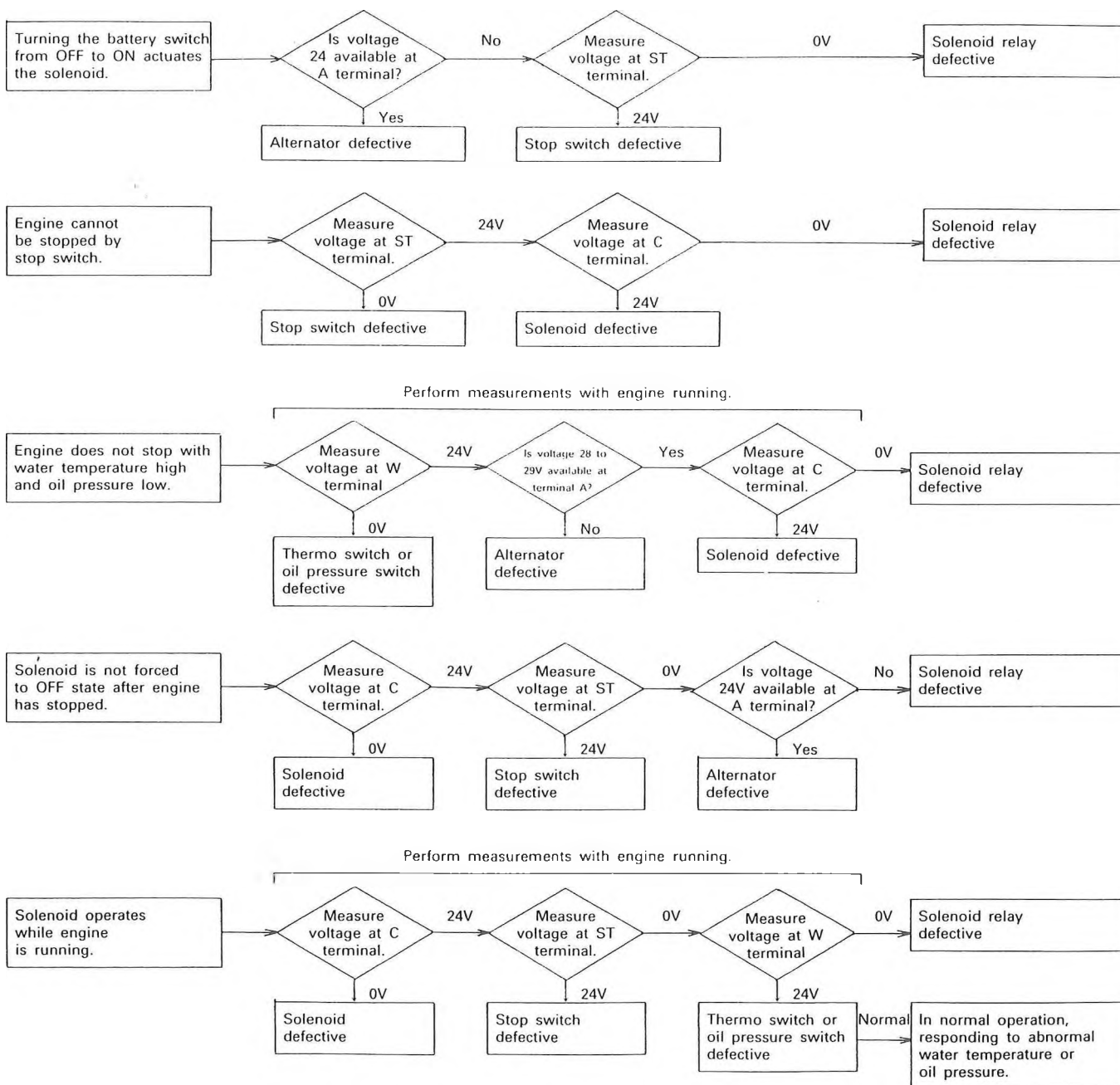
3) Manual stop timer

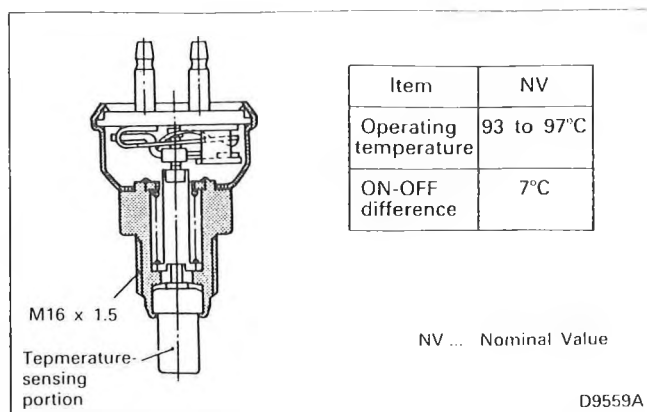
When the push switch C (stop switch) is set to ON, the solenoid will be operated. Operate a stop watch as soon as the stop switch C is set to OFF, and measure the time required before the solenoid is reset.

(b) On-vehicle inspection

Check the solenoid relay according to the following flowcharts and determine whether it is good or not on the basis of the terminal voltage, etc. measured in the individual states.

- The terminal symbols denote those of the solenoid relay.
- The voltage 24V means the battery voltage.

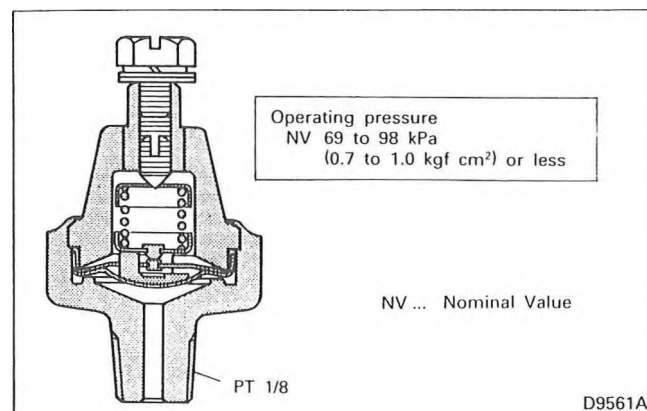
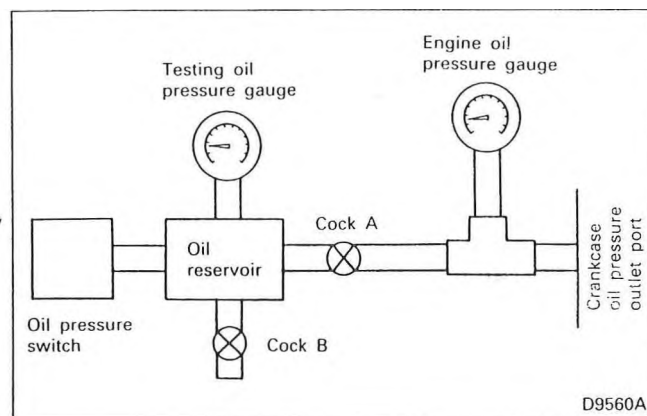


(3) Thermo Switch

The thermo switch 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.

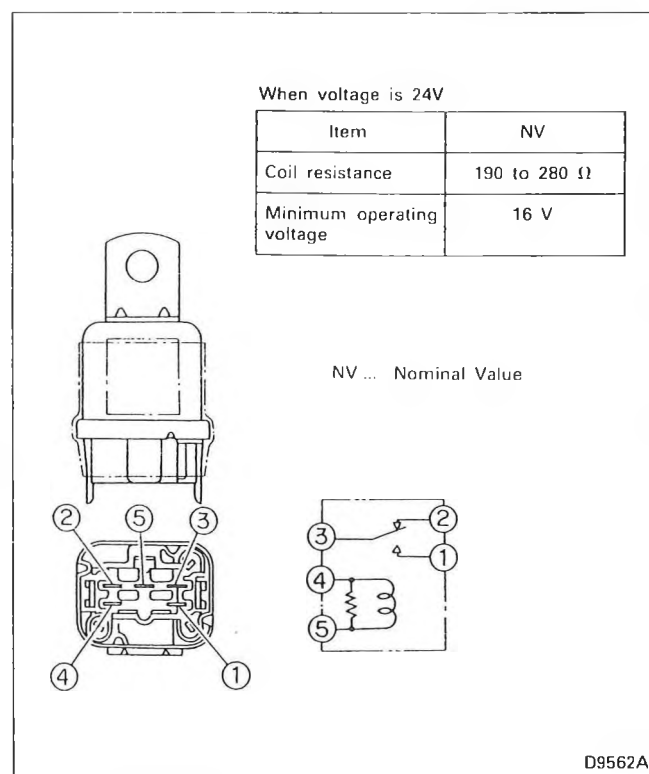
Immerse the temperature-sensing portion in water, heat the water, and check the thermo switch operating temperature with a mercury thermometer.

Heat the water gradually when the temperature approaches near the operating temperature.

(4) 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 passage to the engine and hold the oil pressure directly in the oil reservoir.

Slowly open the cock B to lower the oil pressure and check the oil pressure switch operating oil pressure with the test oil pressure gauge.

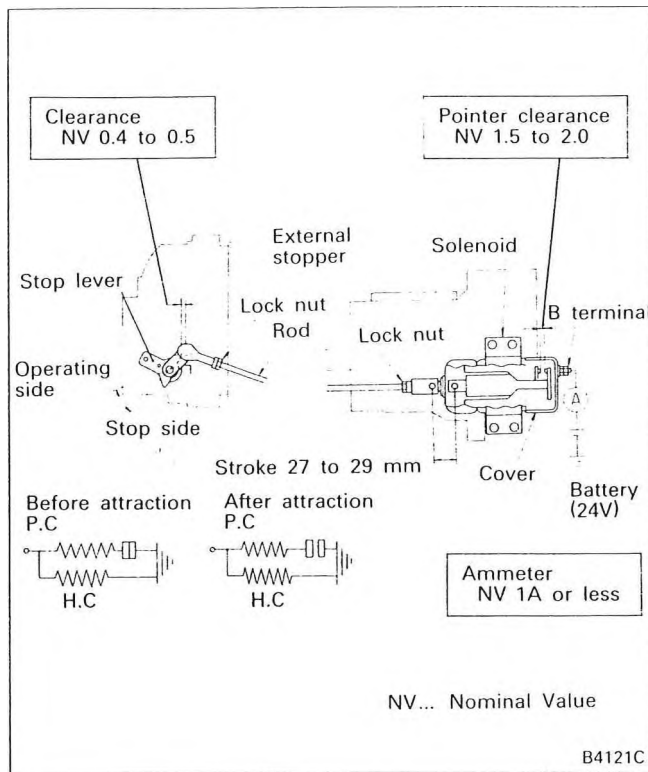
(5) Oil Pressure Switch Relay

(a) Check to ensure that there is continuity between the terminals ② and ③.

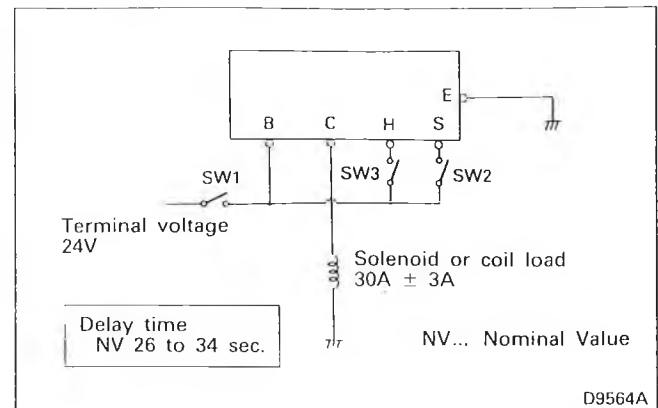
(b) Check to ensure that there is no continuity between the terminals ① and ③.

(c) Check to ensure that there is continuity between the terminals ④ and ⑤ and that the coil resistance has a nominal value.

(d) Check to ensure that when the battery voltage is applied across the terminals ④ and ⑤, there is continuity between the terminals ① and ③ and no continuity between the terminals ② and ③.

5.8.2 Energize-to-run Type**(1) Stop Solenoid**

- Connect the stop lever and solenoid using the rod and remove the solenoid cover.
- Push manually the stop lever to the operation position and adjust the rod so that the solenoid pointer gap becomes as specified. In this state, also check that the stop lever to external stopper clearance is as specified.
- In the state of (b) above, apply specified voltage to solenoid "B" terminal and check that the pointer gap and ammeter reading are as specified. (Stop lever operation side).
- Tighten the lock nut of the rod.
- Check that the solenoid pointer color has not changed and then install the cover.

(2) Solenoid Relay**(a) Unit test**

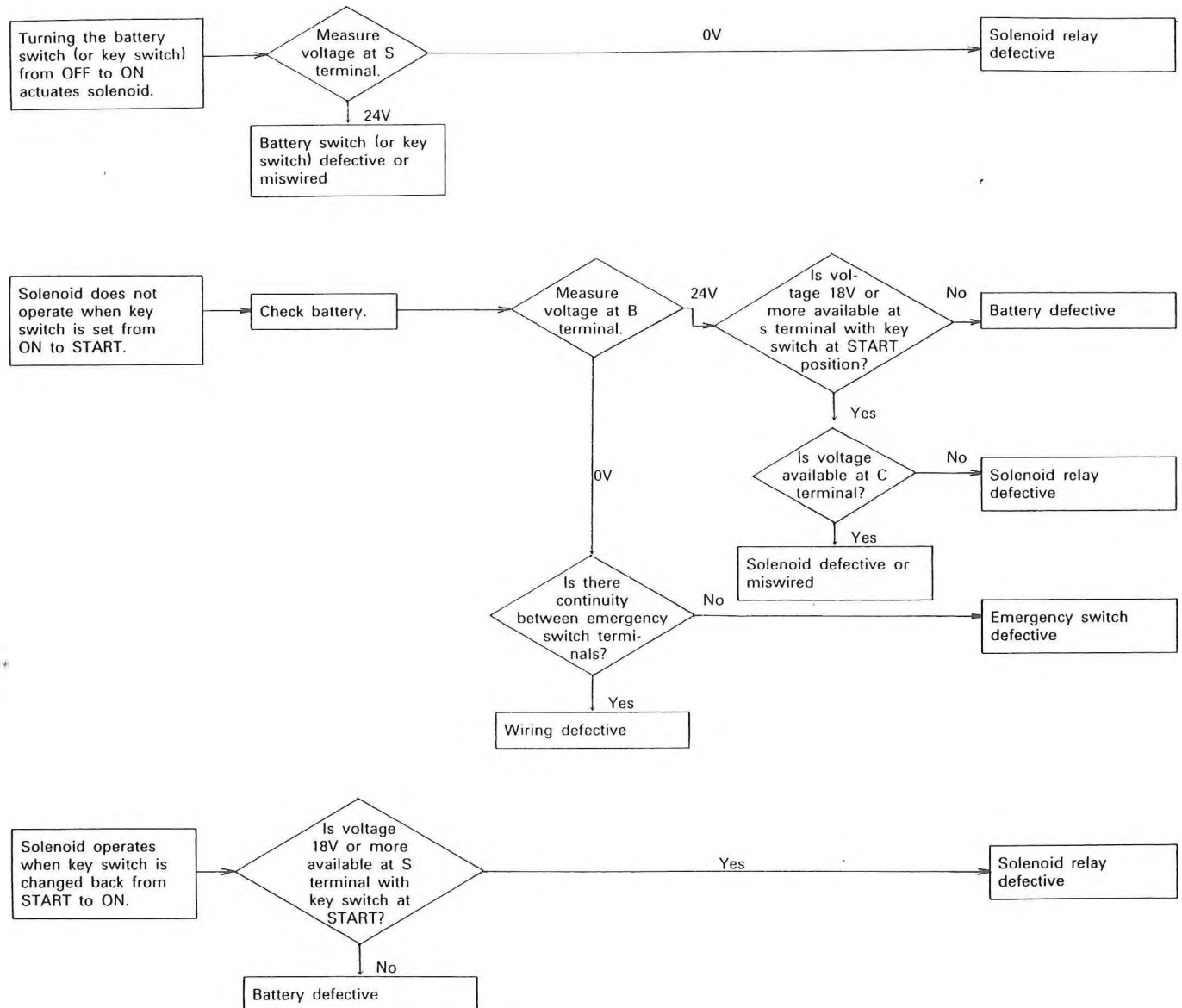
Wire as shown and check the following.

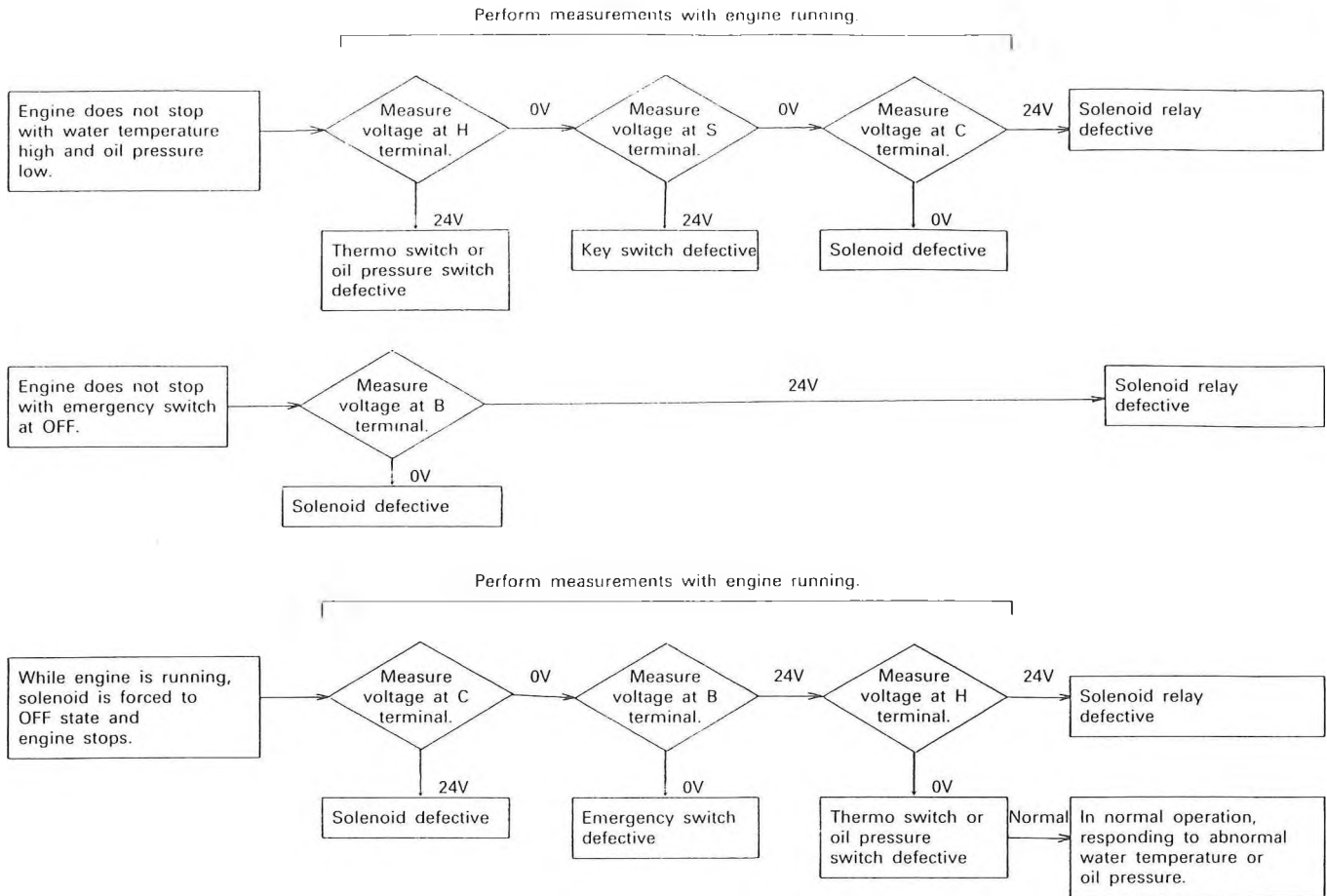
- Relay operation and delay time
 - Check if the solenoid is energized when switches SW1 and SW2 are turned ON.
 - Using a stop watch, measure the time required for the solenoid to return after switch SW2 is turned OFF.
- Relay holding
 - Turn ON switch SW1 and SW2 and, after the solenoid is activated, turn ON the switch SW3.
 - Turn OFF the switch SW2 and make sure that the solenoid remains activated for more than 34 seconds.
 - After verifying 2) above, turn OFF the switch SW3 to ensure that the solenoid returns.

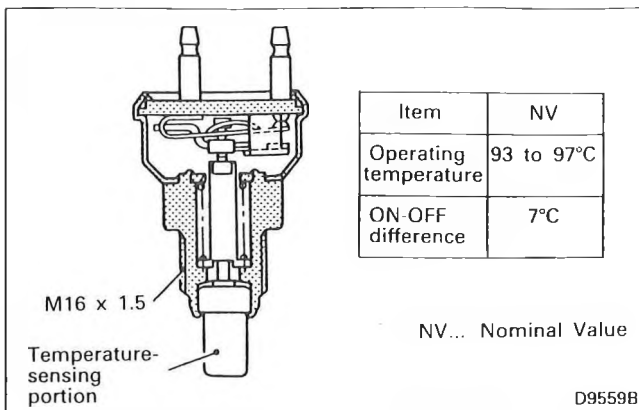
(b) On-vehicle inspection

Check the solenoid relay according to the following flowchart and determine whether it is good or not on the basis of the terminal voltage, etc. measured in the individual states.

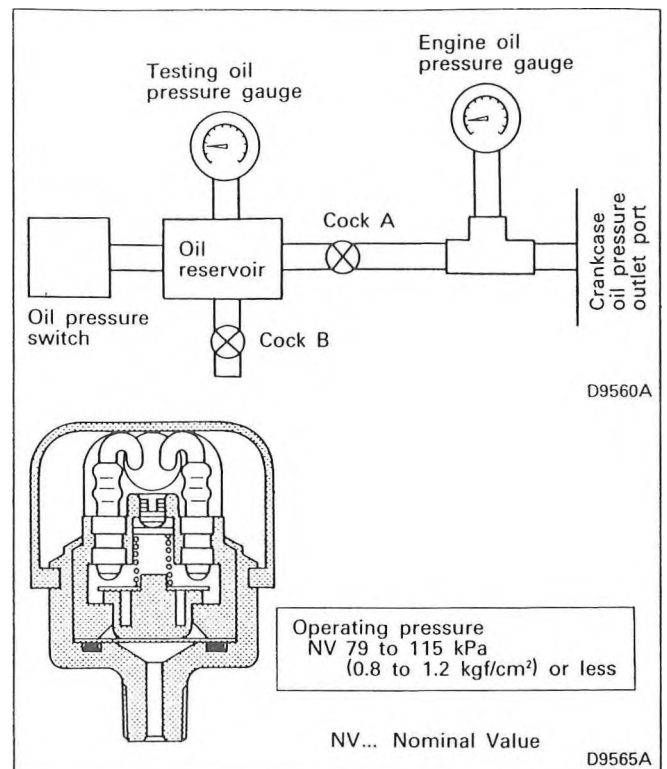
- Terminal symbols denote those of the solenoid relay.
- Voltage 24V means the battery voltage.





(3) Thermo Switch

The thermo switch 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. Heat the water gradually when the temperature approaches near the operating temperature.

(4) 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 passage to the engine and hold the oil pressure directly in the oil reservoir. Slowly open the cock "B" to lower the oil pressure and check the oil pressure switch operating oil pressure with the test oil pressure gauge.

6. TROUBLESHOOTING

Symptom	Probable cause	Remedy	Ref. group
Starter will not start.	Defective battery or low capacity	Replace or charge	
	Defective wiring	Correct	
	• Defective starter wiring		
	• Defective starter relay wiring		
	• Defective magnetic switch wiring		
	• Defective heater relay wiring		
	• Defective starter switch wiring		
	• Defective battery or battery switch wiring		
	Defective magnetic switch	Replace	
	Defective starter relay		
	Worn, damaged, binding brush		
	Defective motor	Replace armature or yoke	
Starter starts but engine does not.	Defective overrunning clutch	Replace	
	Defective heater relay		
	Defective starter switch		
	Pinion not meshing with ring gear	Replace starter relay or starter switch	
	• Incorrect voltage at magnetic switch S terminal		
	• Incorrect voltage at starter relay SW terminal		
	• Worn or damaged pinion	Replace	
	• Worn or damaged ring gear	Replace	Group 11
	Pinion meshes with ring gear but does not rotate	Charge or replace	
	• Defective battery or low capacity		
Alternator is functioning normally but battery is overdischarged.	• Poor brush contact	Replace brush or brush spring	
	• Defective overrunning clutch	Replace	
	Low V-belt tension	Adjust	Group 14
	Damaged V-belt	Replace	
	Defective wiring	Correct	
	• Defective alternator wiring		
	Defective battery	Replace	
Battery is normal but is over-discharged.	Defective alternator	Replace	
	• Open circuit in stator coil		
	• Stator coil and core grounded		
	• Slip ring and rotor core grounded		
	• Defective field coil		
	• Worn slip ring		
	• Worn brush		
	• Defective brush spring		
	• Defective rectifier		
	• Defective regulator		

Symptom	Probable cause	Remedy	Ref. group
Charger lamp does not come on when engine is stopped (starter switch ON).	Defective regulator	Replace	
Premature loss of battery electrolyte. High battery electrolyte temperature.	Defective alternator (see "Battery is normal but is overdischarged".)	Replace	
	Defective regulator		
Engine is hard to start.	Defective wiring	Correct	
	• Defective air heater wiring		
	• Defective heater relay wiring		
	• Defective water temperature sensor wiring		
	Defective heater relay or blown fuse	Replace	

CLUTCH

CONTENTS

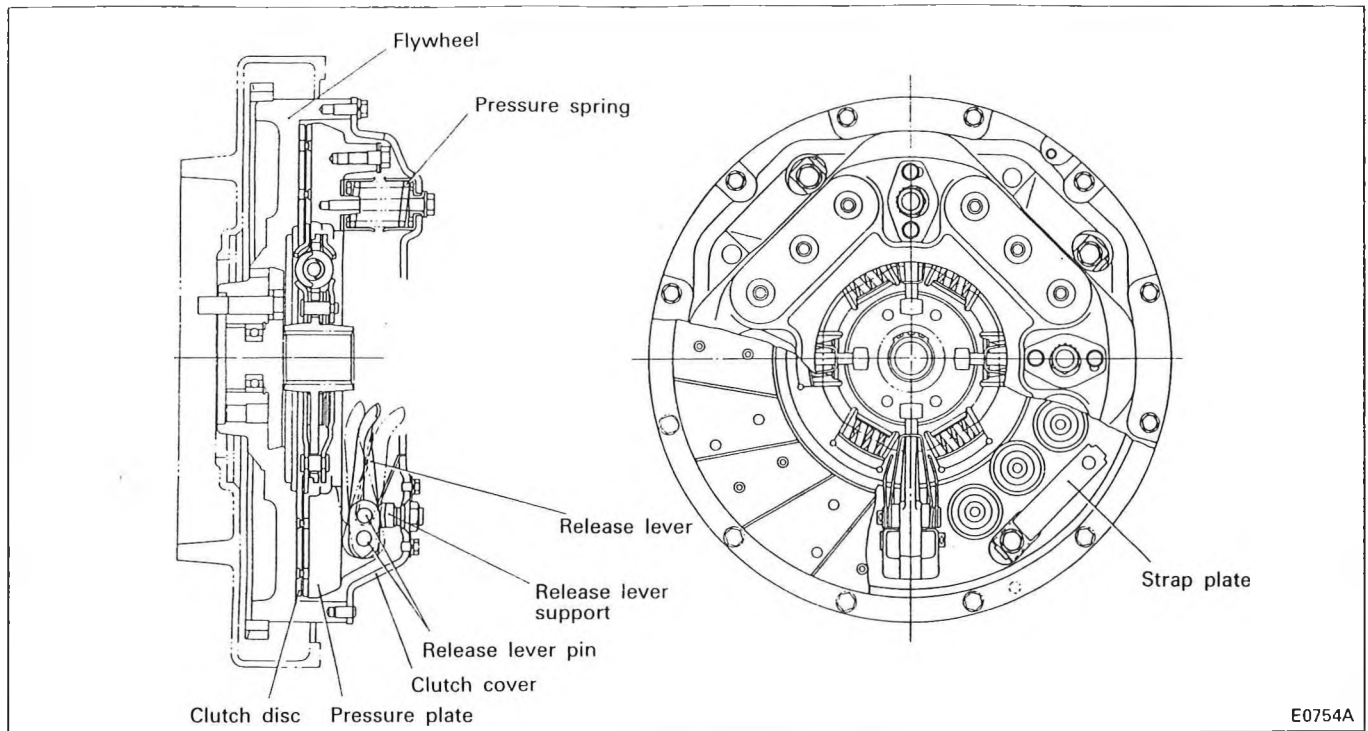
1. GENERAL	2	5.2 CLUTCH PROPER	7
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CAUTION:

When servicing clutch assemblies or components, do NOT create dust by sanding or by cleaning clutch parts with a dry brush or with compressed air. (A water dampened cloth should be used).

The clutch disc contains "Asbestos Fibers" which can become airborne if dust is created during service operations. Breathing dust containing "Asbestos Fibers" may cause serious bodily harm.

1. GENERAL



E0754A

The clutch is a dry single disc type which transmits and disconnects engine power through the clutch shift shaft.

When the operation for clutch disengagement is performed, the clutch release lever is pushed. Since the clutch release lever pivots round the release lever pin in the release lever support provided in the clutch cover, the pressure spring is compressed, causing the clutch disc clamped between the engine flywheel and pressure plate to become free and cuts transmission of power. When the operation for clutch engagement

is performed, the pressure spring force causes the pressure plate to press the clutch disc against the engine flywheel to transmit power.

The clutch consists of a clutch disc, pressure plate and release lever assembly. The clutch disc has a woven facing.

The drive system is the strap drive type which uses a strap plate between the clutch cover and pressure plate to couple them. This system insures smooth engagement and disengagement of the clutch.

2. SPECIFICATIONS

Clutch [Option]

Item		Specification	
Clutch	Type	[6D22] Dry single disc coil spring type	[6D22-T, TC] Dry single disc coil spring type
	Model	C10W41 or C12W43	C12W43
Facing	Material	Woven	Woven
	O.D. x I.D. mm	410 x 250 or 430 x 250	430 x 250
Bearing case	Type	Direct-coupled type	
	Model	PC12	

3. SERVICE STANDARDS

3.1 SERVICE STANDARD TABLE

Unit: mm

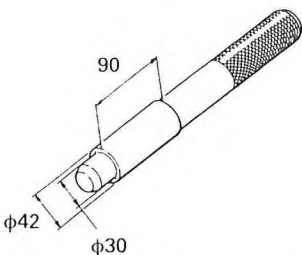
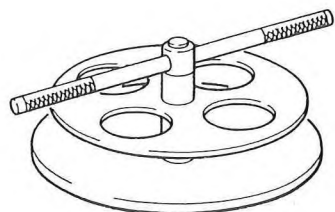
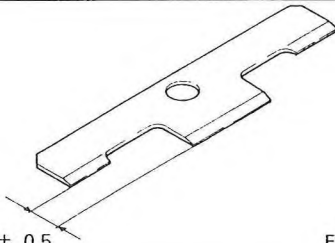
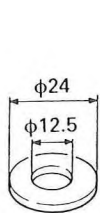
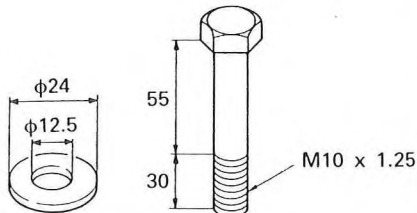
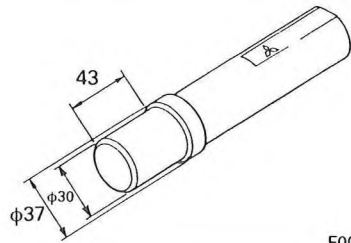
Description			Nominal value [Basic diameter]	Limit	Correction and remarks
Clutch disc	Depth from facing surface to rivet head		2.2 to 2.8	0.2	Replace.
	Flatness		0.6 or less	–	Replace.
	Lateral runout		1.2 or less	–	Replace.
	Vertical runout	C10W41	1.0 or less	1.5	
		C12W43	1.2 or less		
Play in turning direction			0.06 to 0.195	0.42	Replace.
Pressure spring	Free length	C10W41	99.5	–	Replace.
		C12W43	92.1	–	
	Installed load (Installed length: 63)	C10W41	1 205 to 1 325 N (122.6 to 135.4 kgf)	1 070 N (109 kgf)	Replace.
		C12W43	1 425 to 1 570 N (145 to 160.2 kgf)	1 270 N (129 kgf)	
	Spring squareness (In free length state)	C10W41	3.5 or less	5.2	Replace.
		C12W43	3.2 or less	4.8	
Pressure plate	Flatness of friction surface		0.05 or less	0.2	Correct or replace.
	Thickness		59.7 to 59.9	56.8	Replace.
	Strap bolt fitting hole		12.21 to 12.22	12.5	Replace.
Clearance between release lever pin and bushing			[12.7] 0.06 to 0.15	0.3	Replace.
Clearance between strap plate and strap bolt			[12.2] 0.01 to 0.11	0.3	Replace.
Release lever height (Dimension from clutch cover top surface)			36.5 to 37.5 (Difference among four levers: 0.7 or less)	–	Adjust.
Clearance between release fork shaft and needle roller bearing			[30] 0.03 to 0.08	0.2	Replace.

3.2 TIGHTENING TORQUE TABLE

Description	Thread size O.D. x Pitch mm	Tightening torque Nm (kgfm)
Strap bolt	M12 x 1.5	39 to 49 (4 to 5)
Lock plate mounting bolt	M8 x 1.25	9.8 to 15 (1 to 1.5)
Pressure plate and lever assembly mounting bolt	M10 x 1.5	32 to 49 (3.3 to 5.0)
Bearing case mounting bolt	M16 x 2.0	140 (14.2)

4. SPECIAL TOOL

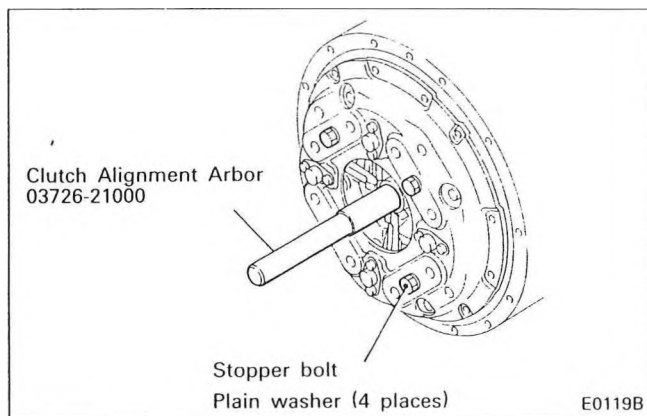
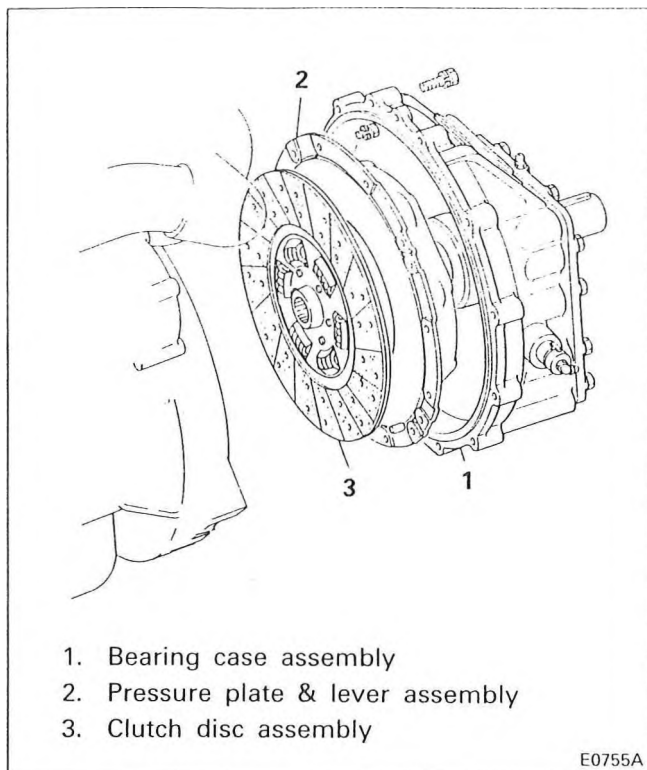
Unit: mm

Tool name	Part No.	Shape	Use
Clutch alignment arbor	03726-21000	 E0012B	Alignment of clutch disc at installation
Clutch installer	MH061331	 E0007A	Removal and installation of clutch cover
Clutch lever aligner	MH061330	 E0013A	Adjustment of release lever height
Plain washer	43502-39200		Removal and installation of clutch proper
Stopper bolt	43502-39100	 E0005B	
Needle roller bearing installer	44590-12600	 F0026A	Installation of needle roller bearing of bearing case

5. SERVICE PROCEDURES

5.1 REMOVAL AND INSTALLATION

(1) Removal



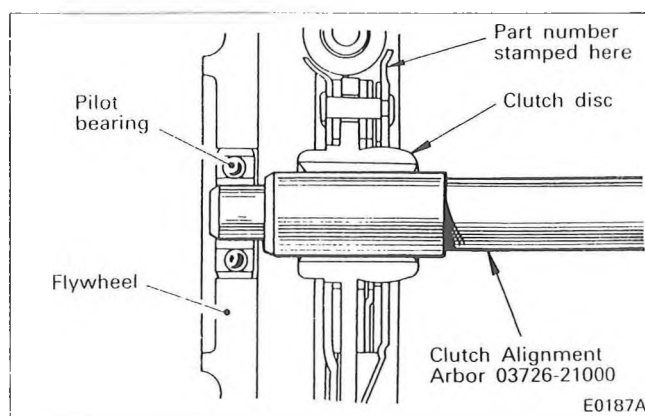
When removing the pressure plate and lever assembly, secure the pressure plate with the special tools, Stopper Bolt and Plain Washer.

Before removing the pressure plate and lever assembly, install the special tool, Clutch Alignment Arbor, to prevent the clutch disc from dropping.

NOTE:

1. Before removing the clutch, be sure to install the stopper bolt and plain washer to prevent the strap plate from being damaged.
2. Use the stopper bolt (M10 x 1.25 – 85 with effective length 30 mm or more) and plain washer (for M12 threads) commercially available.

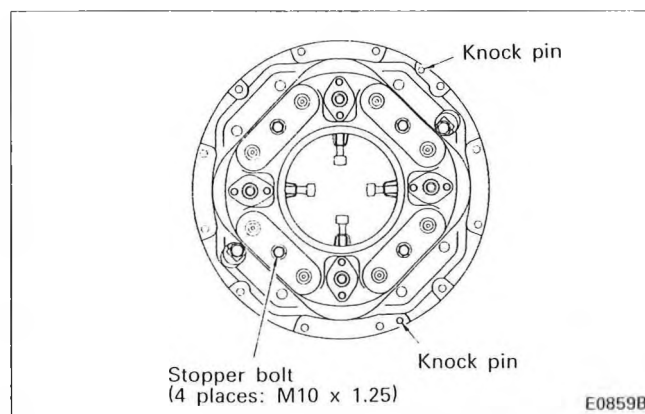
(2) Installation



(a) Install the clutch disc using the special tool, Clutch Alignment Arbor.

NOTE:

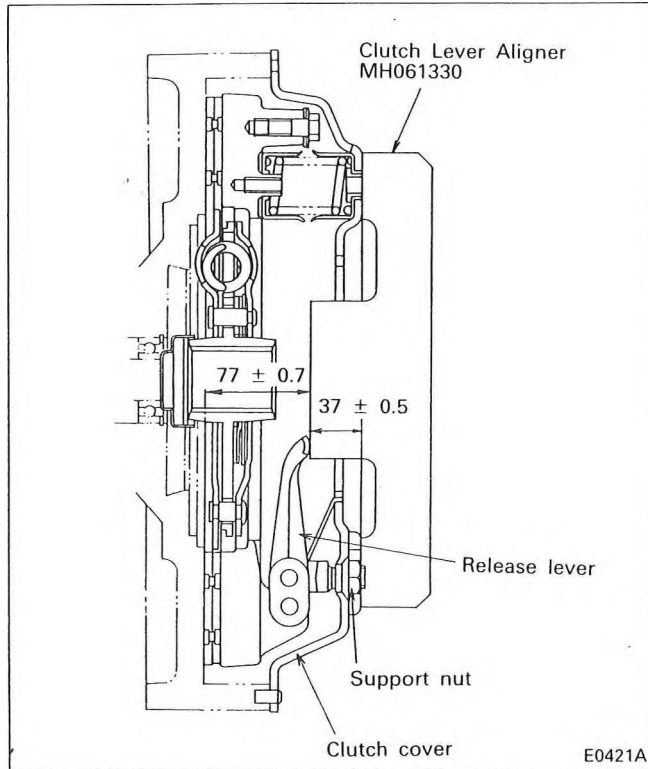
When installing the clutch disc, make sure that it is installed in the correct direction: install it so that its side with the part number stamped is visible.



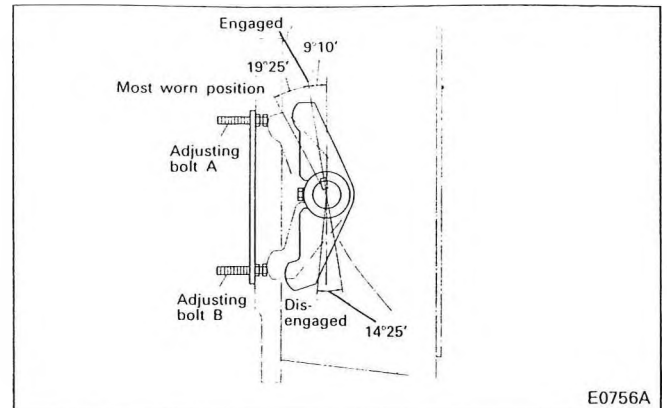
(b) Secure the pressure plate of the pressure plate and lever assembly with the stopper bolts, then install the clutch, aligning it with the knock pins in the flywheel.

NOTE:

1. Before installing the clutch, check and clean the flywheel and repair or replace as necessary.
2. Tighten bolts evenly, in the diagonal order.
3. After installation, be sure to remove the set bolt.

(c) Inspection of release lever height

Using Clutch Lever Aligner (special tool), check the heights of the clutch cover and release lever. Use the support nut for adjustment.

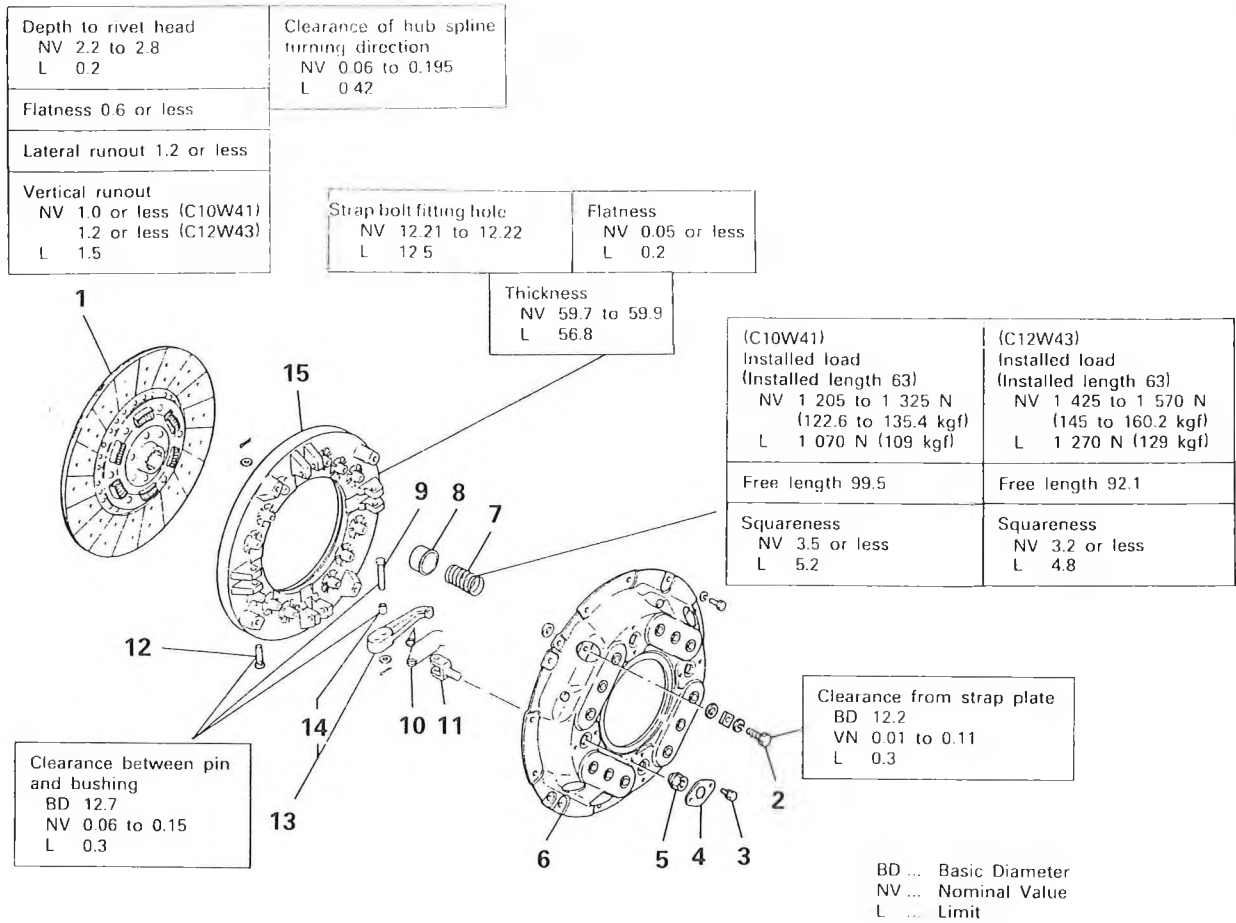
(d) Adjustment after installation of clutch and bearing case

The clutch should be set in the most worn position as wear of the clutch disc during service causes the clutch to slip.

- 1) Move the lever in the direction that the clutch engages. At a position where a click is heard in the clutch, turn the adjusting bolt A until it is blocked by the stopper, and lock it by turning down the bolt another two or three threads.
- 2) From the position where the release bearing has touched the release lever, turn the adjusting bolt B in the direction that the clutch disengages, check to see that the clutch is in disengaged position, and then lock the bolt.

5.2 CLUTCH PROPER

5.2.1 Disassembly and Inspection



<Disassembly sequence>

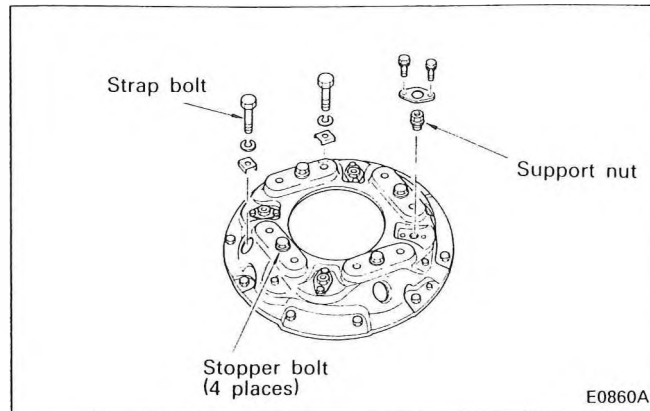
- | | |
|-------------------------------------|------------------------------|
| (1) Clutch disc assembly | 9 Release lever pin |
| (2) Strap bolt | 10 Return spring |
| (3) Lock bolt | 11 Release lever support |
| (4) Lock plate | 12 Release lever pin |
| (5) Support nut | 13 Release lever subassembly |
| (6) Clutch cover (with strap plate) | 14 Bushing |
| (7) Pressure spring | (15) Pressure plate |
| 8 Spring seat | |

For parts with an encircled number, refer to Disassembly and Inspection Procedure that follows.

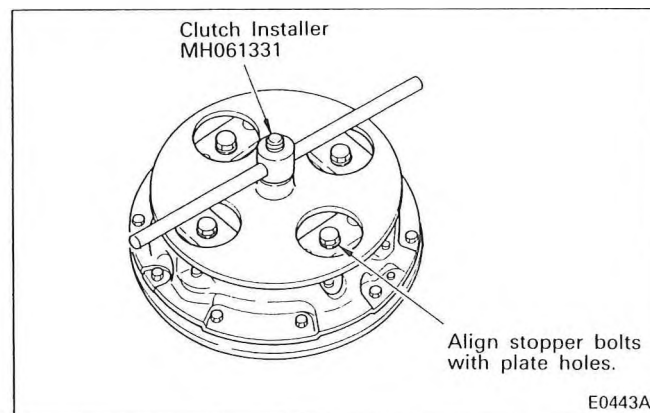
NOTE:

1. Since the clutch cover and pressure plate are balanced, make alignment marks before disassembly.
2. Do not remove the strap plate.

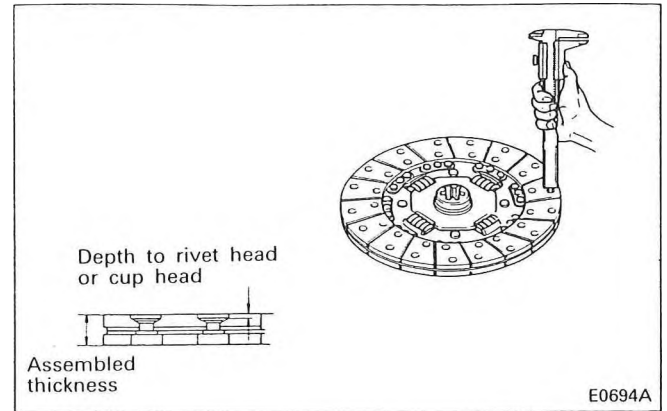
E0757A

Disassembly and Inspection Procedure**(1) Removal of Clutch Cover**

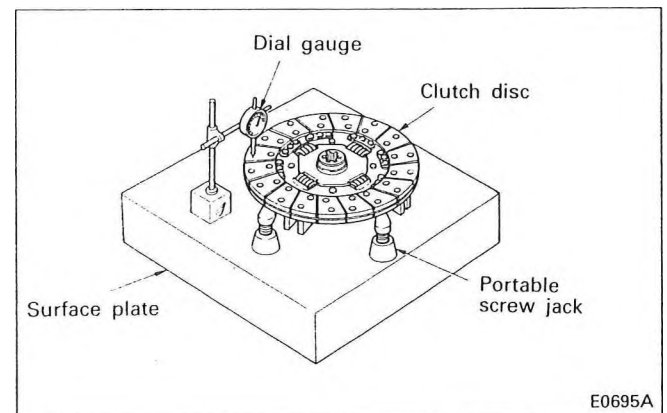
(a) Compress the pressure spring with the stopper bolts and, at the same time, remove the strap bolts, support nuts, and other parts.



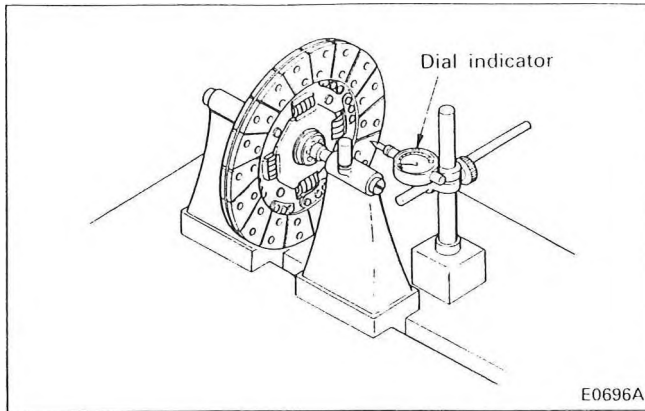
(b) Put alignment marks on the clutch cover and pressure plate. Compress the pressure spring using the special tool, Clutch Installer, and at the same time remove the stopper bolt.
 (c) Gradually loosen the handle of Clutch Installer to remove the clutch cover.

(2) Inspection of Clutch Disc**(a) Facing wear**

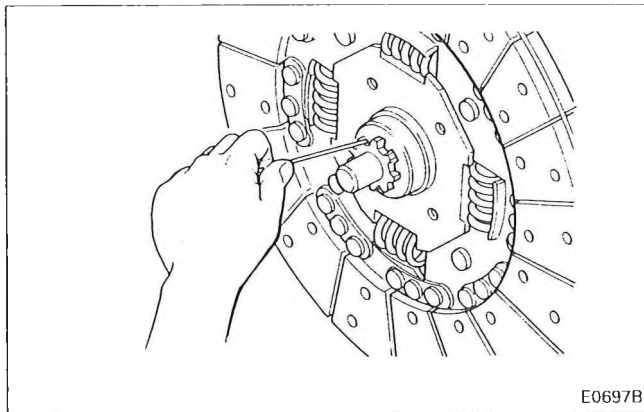
Measure the assembly thickness of facing and the depth from facing surface to rivet head or cup head. If the measurement is below the limit, replace the clutch disc assembly.

(b) Flatness of clutch disc

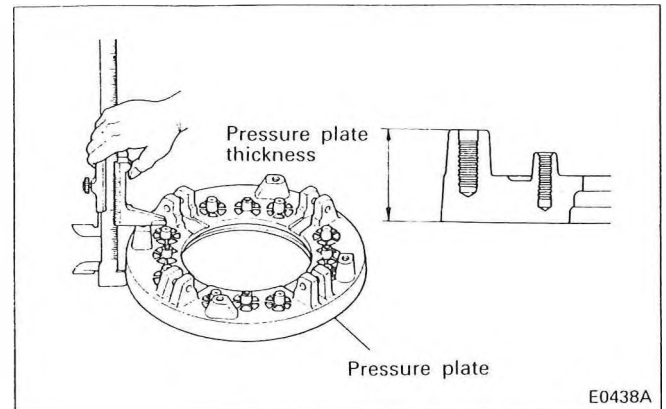
Measure the flatness of facing surface. If it is beyond the limit, correct or replace.

(c) Clutch disc runout

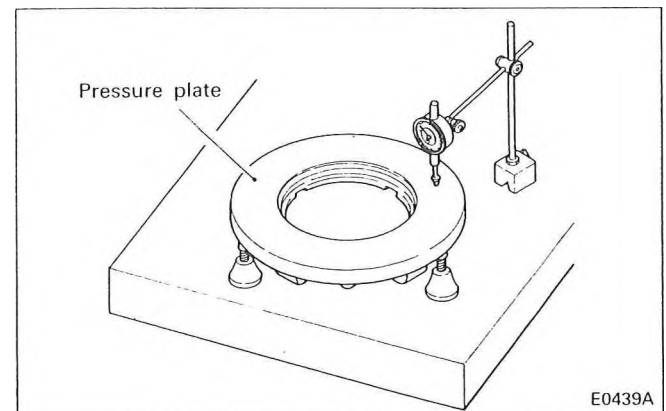
Using the runout tester, measure the clutch disc runout. If the measurement exceeds specification, correct or replace the clutch disc.

(d) Spline play in turning direction

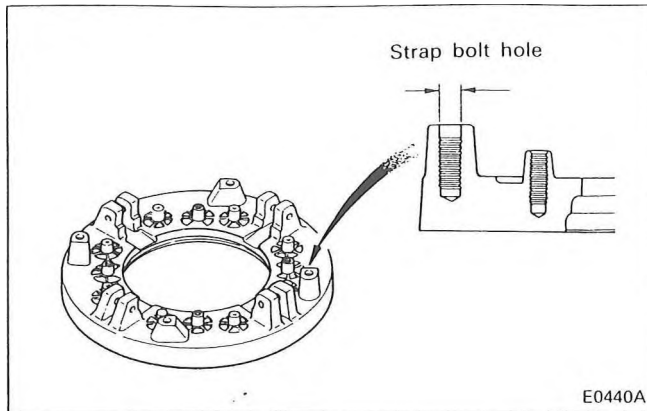
Using a piano wire, measure the play in the turning direction of the clutch disc hub splines and bearing case clutch shaft. If the limit is exceeded, replace the clutch disc.

(3) Inspection of Pressure Plate**(a) Measurement of thickness**

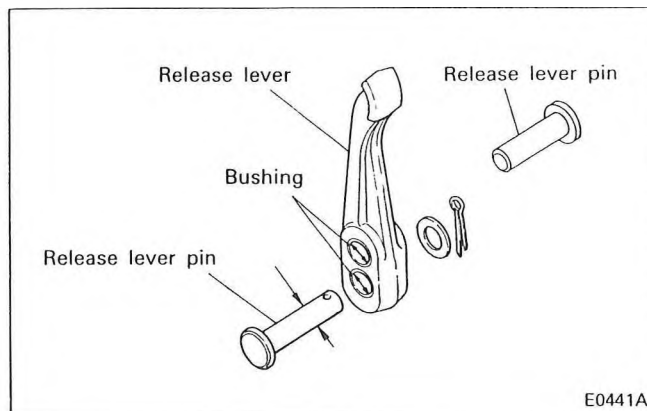
Measure the pressure plate thickness and, if it is below the limit, replace.

(b) Measurement of flatness

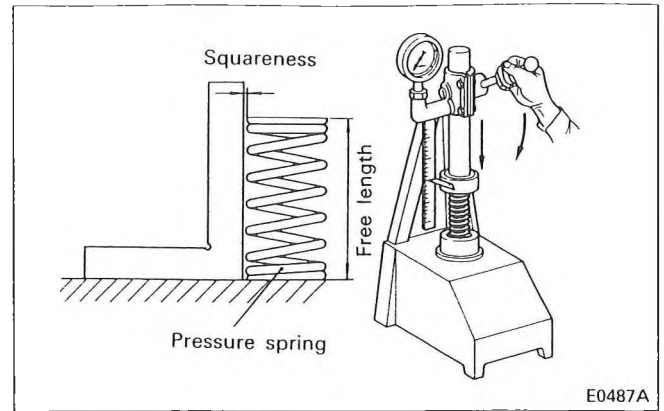
Measure the flatness of the pressure plate friction surface. Regrind or replace if the limit is exceeded.

(c) Strap bolt fitting hole I.D.

Measure the I.D. or strap bolt fitting hole in the pressure plate and, if the limit is exceeded, replace.

(4) Inspection of Release Lever

Measure the release lever pin O.D. and bushing I.D.. Replace if clearance exceeds specification.

(5) Inspection of Pressure Spring

Measure the free length, squareness, and installed load of the pressure spring. If the measurement is below the limit, replace the spring.

32 to 49 Nm
(3.3 to 5.0 kgfm)

2

7

8

13

10

5

11

9

12

1

15

6

4

3

9.8 to 15 Nm
(1 to 1.5 kgfm)

14

Strap plate

2

39 to 49 Nm
(4 to 5 kgfm)

Strap support washer

Strap plate washer

Strap plate

Apply Molybdenum disulfide grease.

<Assembly sequence>

13

14

12

11

9

10

8

7

6

5

4

3

2

1

15

For parts with an encircled number, refer to Reassembly Procedure that follows.

E07546

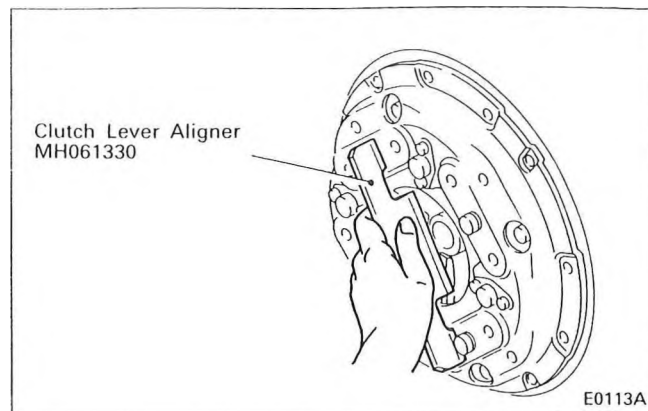
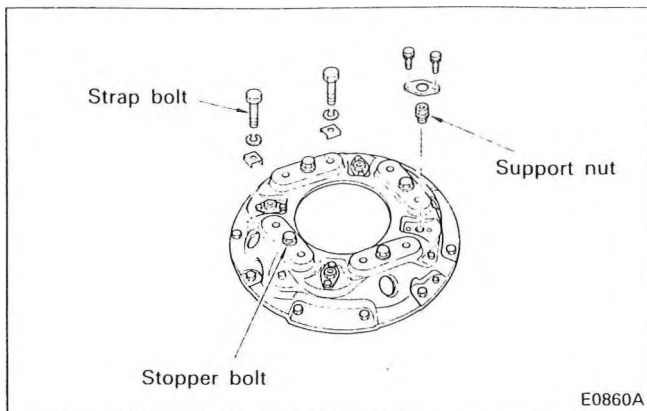
A detailed cross-sectional diagram of a valve assembly. The assembly includes a valve body with a central valve seat and a valve stem. A valve disc is positioned against the seat, and an adjusting washer is located between the disc and the seat. The thickness of the adjusting washer is labeled as 't'. The diagram shows the internal components and the external structure of the valve.

Clutch Installer
MH061331

Align stopper bolts
with plate holes.

E0443A

Friction surface correction amount	Adjusting washer thickness
Less than 1	None required
1 or more and less than 2	One 1.2
2 or more and less than 3	Two 1.2 or one 2.3

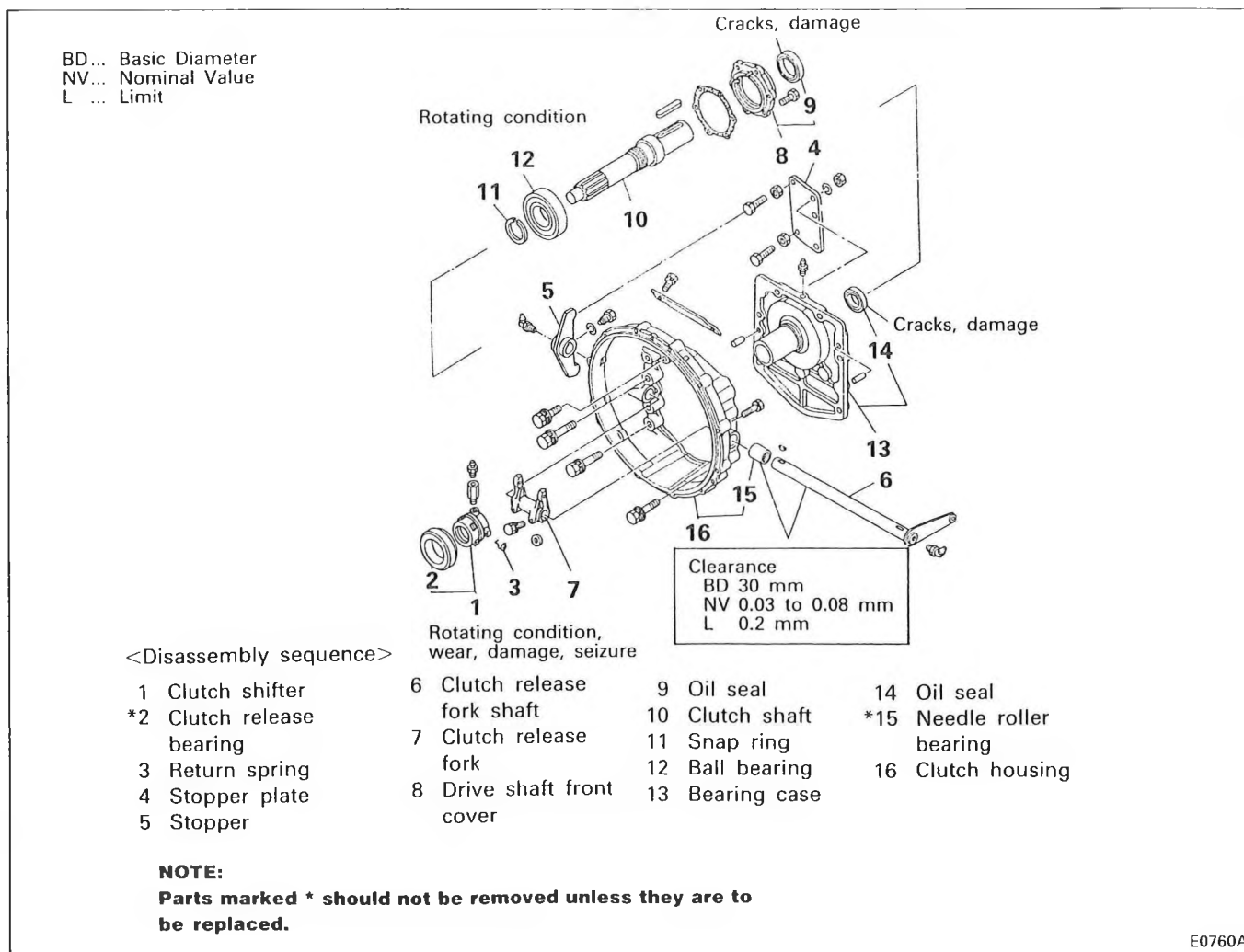


(3) With the pressure spring compressed by the stopper bolts, install the strap bolt, support nut, and other parts.

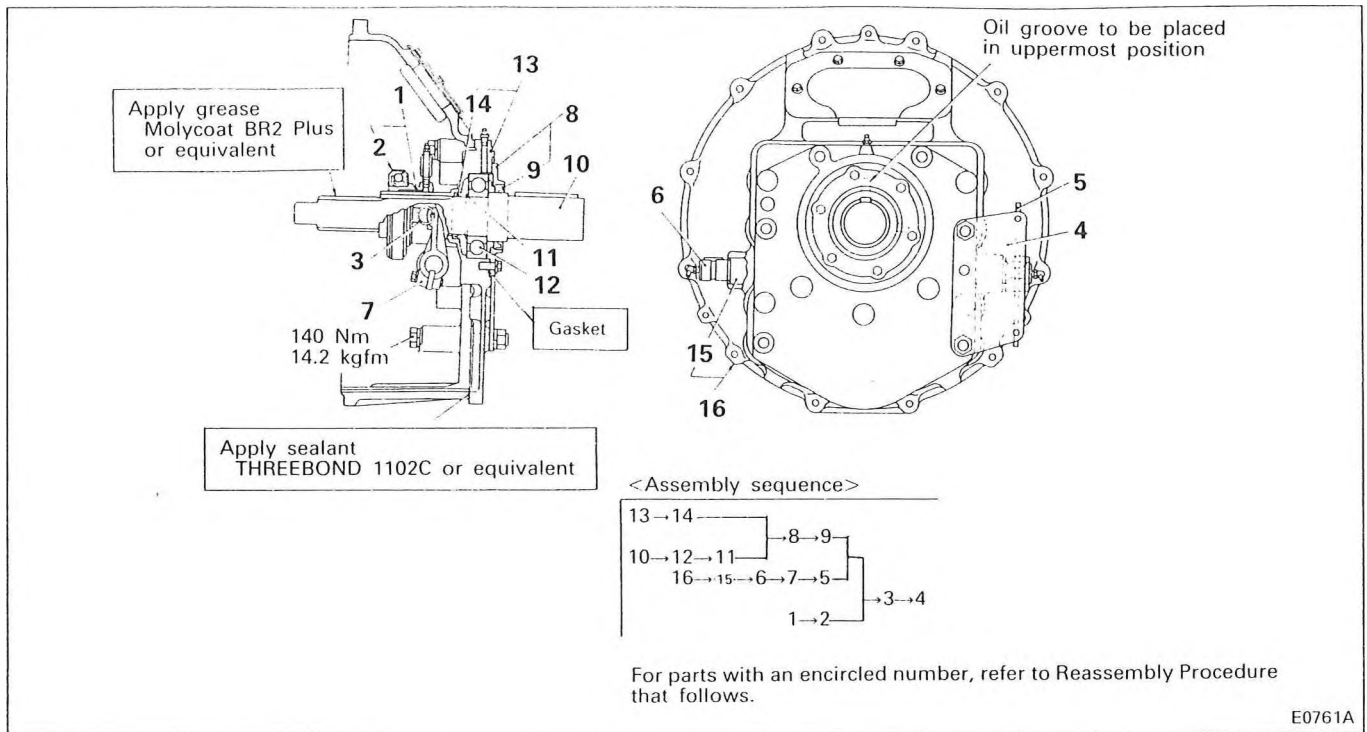
(4) After installing the clutch, check the clutch cover and release lever for height using the special tool, Clutch Lever Aligner.

5.3 BEARING CASE

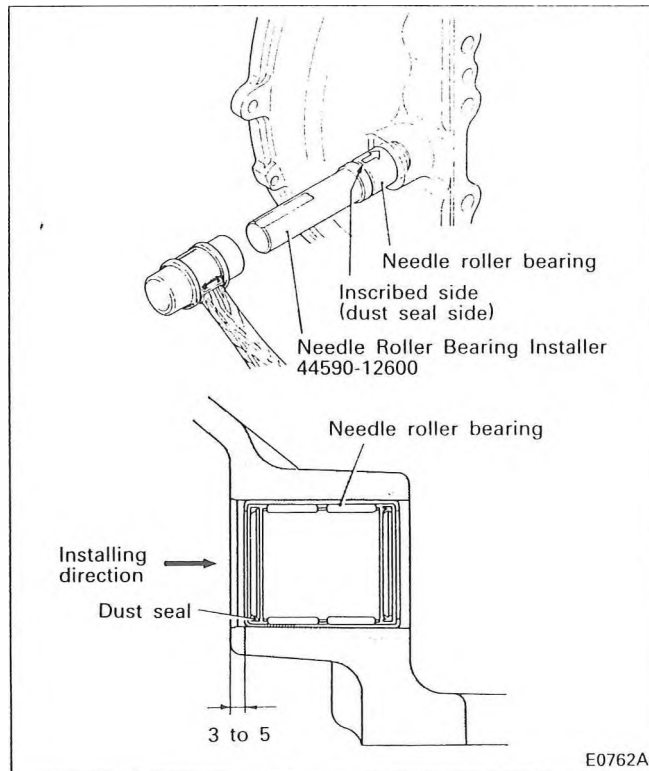
5.3.1 Disassembly and Inspection



5.3.2 Reassembly



Installation of Needle Roller Bearing



Using special tool, the Needle Roller Bearing Installer, install the needle roller bearing in the housing. The needle roller bearing should be pressed in up to the specified dimension with the oil seal side inward and the inscribed side outward.

NOTE:

When installing the needle roller bearing, direct the lip in the correct direction.

6. TROUBLESHOOTING

Symptom	Probable cause	Remedy	Ref. group
Clutch drags when disengaged	Defective clutch proper (Disassemble and check clutch assembly)		
	• Damaged or poorly lubricated pilot bearing	Replace or lubricate	
	• Damaged release bearing	Replace	
	• Uneven height of release lever or its damage	Adjust height or replace	
	• Defective clutch disc	Replace	
	• Damaged or deformed clutch disc		
	• Worn or rusty splines and clutch disc hub	Replace or repair defective parts	
	• Distorted or damaged pressure plate	Grind or replace	
	Distorted or damaged flywheel		Group 11
Clutch slips	Defective clutch proper (Disassemble and check clutch assembly.)		
	• Uneven height of release lever	Adjust	
	• Pressure spring losing proper tension	Replace	
	• Defective clutch disc	Replace	
	• Worn facing		
	• Deformed clutch disc		
	• Hardened facing	Remove hardened surface or replace	
	• Oil on facing	Remove oil or replace	
	• Distorted or damaged pressure plate	Grind or replace	
	Distorted or damaged flywheel		Group 11
Clutch is not smoothly engaged	Defective clutch proper (Disassemble and check clutch assembly)		
	• Defective clutch disc	Replace	
	• Distorted facing	Replace	
	• Hardened facing	Remove hardened surface or replace	
	• Loose rivet	Replace	
	• Oil on facing	Remove oil or replace	
	• Binding clutch disc splines	Correct or lubricate splines	
	• Clutch disc torsion spring losing proper tension or broken	Replace	
	• Uneven height of release lever	Adjust	
	• Pressure spring losing proper tension	Replace	
	• Distorted or damaged pressure plate	Grind or replace	
	Distorted or damaged flywheel		Group 11

Symptom	Probable cause	Remedy	Ref. group
Clutch is noisy when disengaged	Worn, damaged, or poorly lubricated pilot bearing	Replace or lubricate	
	Worn, damaged, or poorly lubricated release bearing		
	Defective clutch disc Worn clutch disc splines	Replace	
	Clutch disc torsion spring losing proper tension or broken		
	Bent strap plate	Replace clutch cover	
Clutch is noisy when engaging	Defective clutch disc Clutch disc torsion spring losing proper tension or broken	Replace	
	Worn clutch disc hub splines		
	Worn splines of clutch shaft	Replace	
	Pressure spring losing proper tension	Replace	
	Low idle speed	Adjust	Group 11

SPECIAL EQUIPMENT

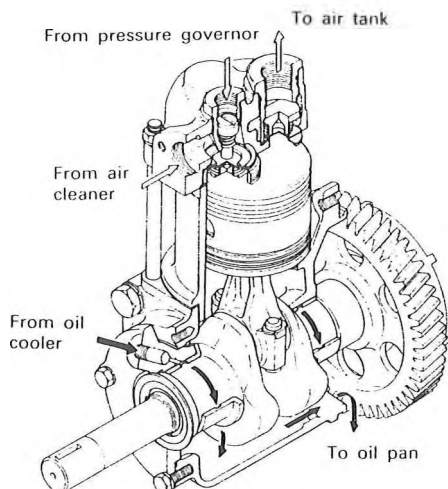
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1. GENERAL

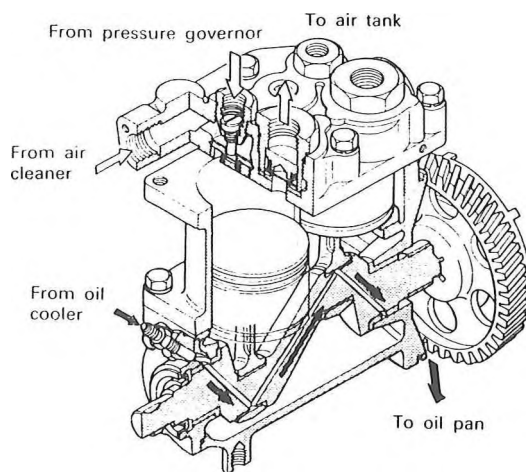
(1) Air Compressor

[1-cylinder Air Compressor]



B4809A

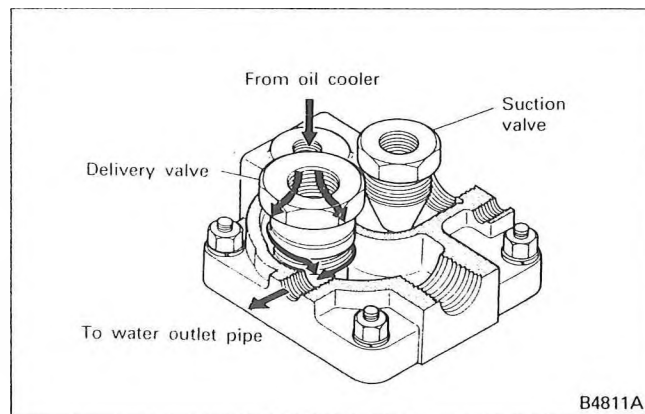
[2-cylinder Air Compressor]



B4810A

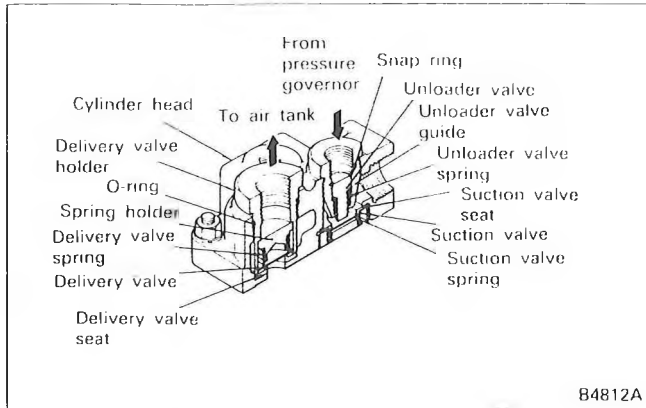
The air compressor, installed at the flywheel housing on the left side of engine, is driven at one-half the engine speed by the timing gear train (injection pump gears) of the engine. A coupling is mounted at the rear end of the air compressor crankshaft to drive the injection pump.

Lubrication is accomplished by the engine oil led through the oil pipe from the engine oil cooler. The engine oil passes through the oil hole in the crankshaft to lubricate bearings. The cylinder liner and connection rod small end are splash-lubricated using crank rotation. Excess oil returns to the oil pan from the hole at the bottom of crankcase through timing gear train.

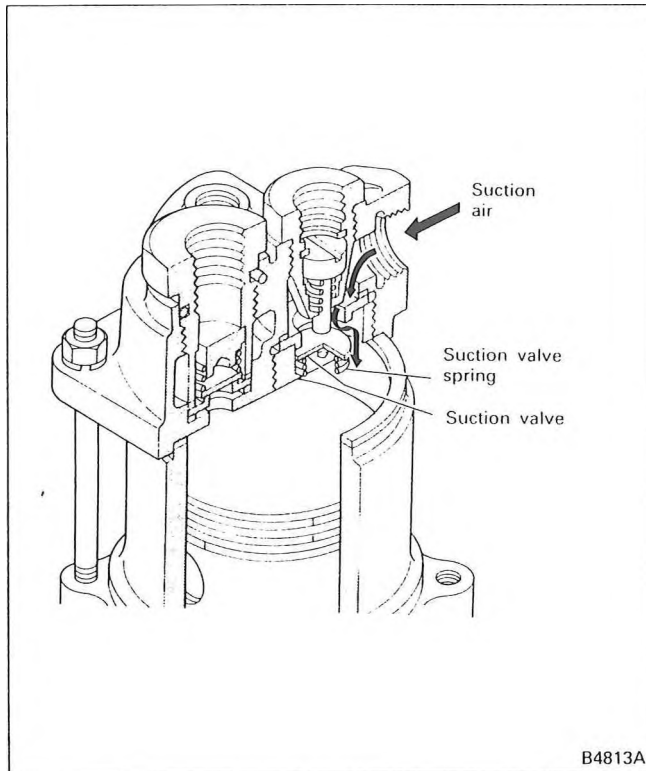


B4811A

The cylinder head is water-cooled to prevent overheating by the compression heat of the air compressor. Coolant led from the oil cooler cools each valve of the cylinder head, then returns to the water outlet pipe.

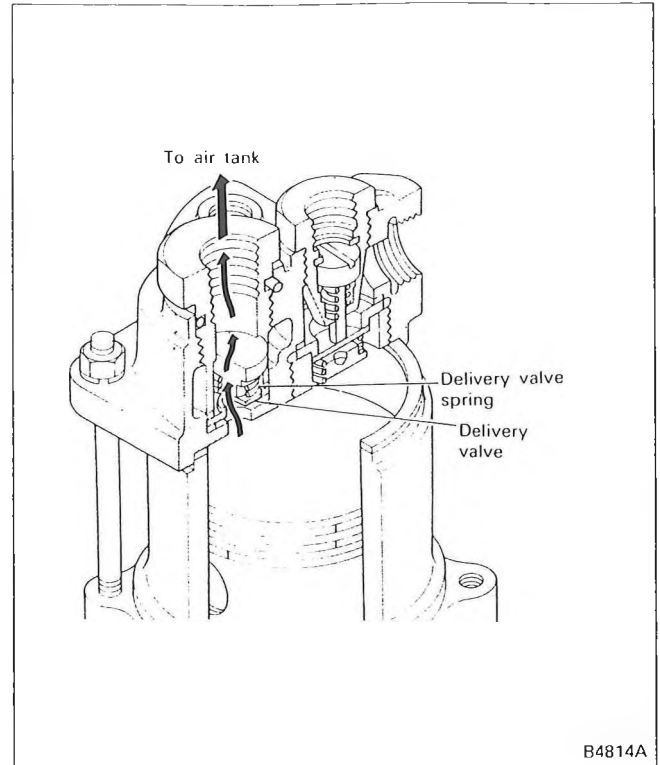


A suction valve, delivery valve, and unloader valve are provided in the cylinder head of the air compressor.

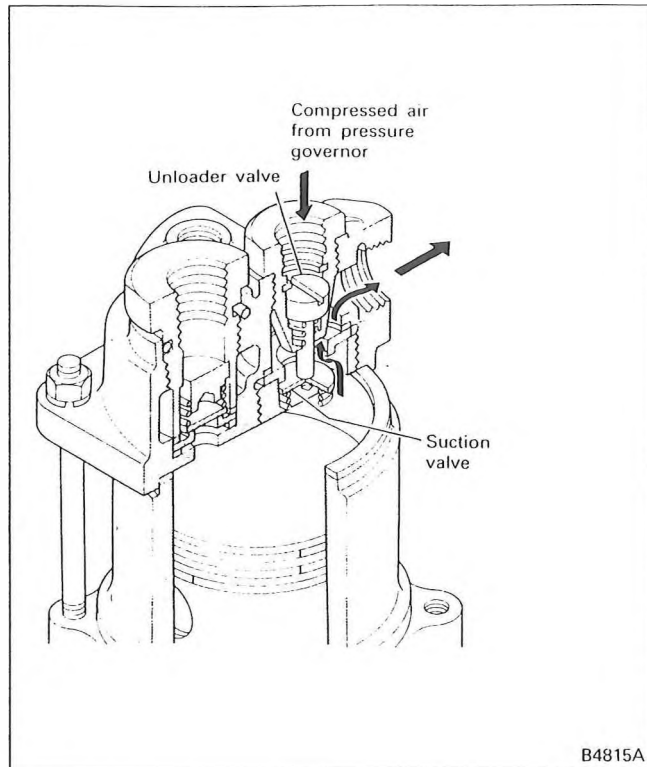


Valves operate as follows:

The suction valve is opened by the negative pressure generated during downward stroke of the piston, which introduces air into the cylinder. When the piston goes upward, the valve is closed by the suction valve spring to compress air.



The compressed air overcomes the force applied by the delivery valve spring to open the delivery valve, being sent under pressure to the air tank.

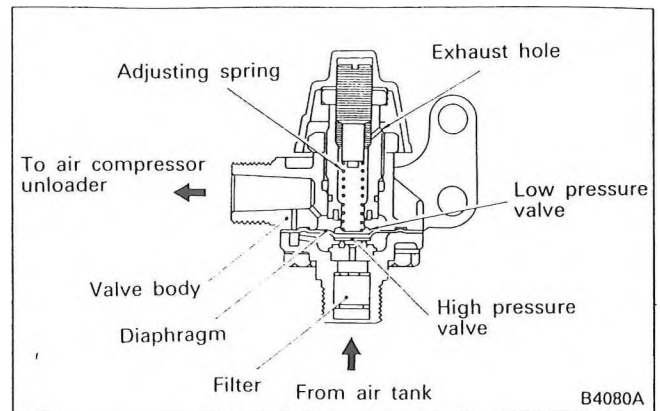


B4815A

The unloader valve, operating with the pressure governor, controls pressure in the air tank. When the air pressure in the air tank exceeds the specified pressure (pressure governor operating pressure), the pressure governor opens to send the compressed air to the unloader valve. The compressed air not only depresses the unloader valve, but keeps the suction valve open, causing the air compressor to operate under no load.

When the air pressure in the air tank falls below specification, the pressure governor resumes operation, discharging compressed air present at top of the unloader. Then the unloader valve spring puts the unloader valve back to its original position, causing the suction valve to begin operation.

(2) Pressure Governor



B4080A

The pressure governor controls compressor operation to keep the air tank pressure within specified limits.

To the high pressure valve of the diaphragm, the same air pressure as in the air tank acts always through the filter, thereby balancing with the adjusting spring force. When the pressure in the air tank increases to exceed that opening pressure of the high pressure valve, the air forces up the high pressure valve seat of the diaphragm. This causes increase of acting area so that the diaphragm moves up quickly to close the seat of the low pressure valve.

When the low pressure valve is closed, air now flows through the valve body to force down the unloader valve of the air compressor, thereby stopping air supply to the air tank.

As the air pressure in the air tank gradually drops, the diaphragm is forced down by the adjusting spring and the low pressure valve opens and the high pressure one closes. As a result, the air on the unloader side is exhausted through the exhaust hole and air supply to the air tank is resumed.

2. SPECIFICATIONS

Item		Specification	
Air Compressor			
Type		Water-cooled 1-cylinder type	Water-cooled 2-cylinder type
Cylinder diameter x stroke	mm	85 x 50	80 x 50
Cylinder capacity	cc	284	502
Turning direction (as viewed from drive side)		Clockwise	Clockwise
Pressure governor			
Type		Diaphragm type	

3. SERVICE STANDARDS**3.1 SERVICE STANDARD TABLE****(1) 1-cylinder Air Compressor**

Unit: mm

Description		Nominal value [Basic diameter]	Limit	Correction and remarks
Suction valve spring	Installed load/ installed length	4.4 N (0.45 kgf)/5	3.5 N (0.36 kgf)/5	Replace.
Delivery valve spring		4.5 N (0.46 kgf)/9.5	3.6 N (0.37 kgf)/9.5	
Cylinder liner to piston clearance	Top portion	[85]	0.27	Replace piston or cylinder liner.
	Skirt portion	[85]	0.18	
Piston ring groove to compression ring clearance		—	0.08	Replace. (Replace piston rings as a set.)
Piston ring open end clearance		—	1.0	Replace. (Replace piston rings as a set.)
Fit between piston pin hole and piston pin		[18]	0.08	Replace.
Piston pin to connecting rod small end clearance		[18]	0.07	Replace piston pin or connecting rod.
End play of crankshaft		—	1.0	Replace.
Crankshaft journal to bearing clearance		[42]	0.1	Replace crankshaft or crankcase.
Crankshaft to connecting rod bearing clearance		[34]	0.1	Replace. (Replace bearing for worn plating.)
End play of connecting rod		—	0.5	Replace crankshaft or connecting rod.
Connecting rod bearing		—	When internal plating is worn to expose copper color.	Replace bearing.

(2) 2-cylinder Air Compressor

Unit: mm

Description		Nominal value [Basic diameter]	Limit	Correction and remarks
Suction valve spring	Installed load/ installed length	4.4 N (0.45 kgf)/5	3.5 N (0.36 kgf)/	Replace.
Delivery valve spring		4.5 N (0.46 kgf)/9.5	3.6 N (0.37 kgf)/9.5	
Cylinder liner to piston clearance	Top portion	[80]	0.29	Replace piston or cylinder liner.
	Skirt portion	[80]	0.17	
Piston ring groove to piston ring clearance		—	0.08	Replace. (Replace piston rings as a set.)
Piston ring open end clearance		—	1.0	Replace. (Replace piston rings as a set.)
Fit between piston pin hole and piston pin		[16]	0.08	Replace.
Piston pin to connecting rod small end clearance		[16]	0.07	Replace piston pin or connecting rod.
End play of crankshaft		—	1.0	Replace.
Crankshaft journal to bearing clearance		[42]	0.1	Replace crankshaft or crankcase.
Crankshaft to connecting rod bearing clearance		[34]	0.1	Replace. (Replace bearing for worn plating.)
End play of connecting rod		—	0.5	Replace crankshaft or connecting rod.
Connecting rod bearing		—	When internal plating is worn to expose copper color.	Replace bearing.

(3) Pressure GovernorUnit: kPa (kgf/cm²)

Description		Nominal value [Basic diameter]	Limit	Correction and remarks
High pressure valve opening pressure	MC802148	72 (7.3) $+3.4 (+0.35)$ $-0.5 (-0.05)$	—	Adjust or replace
	MC802150	78 (8.0) $+3.4 (+0.35)$ $-0.5 (-0.05)$	—	
Low pressure valve opening pressure	MC802148	63 (6.4) $+0.5 (+0.05)$ $-3.4 (-0.35)$	—	
	MC802150	70 (7.1) $+0.5 (+0.05)$ $-3.4 (-0.35)$	—	

3.2 TIGHTENING TORQUE TABLE**(1) Air Compressor**

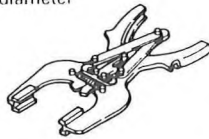
Location tightened		Thread size O.D. x Pitch mm	Tightening torque Nm (kgfm)	Remarks
Cylinder head nut	1 cylinder	M10 x 1.25	23 to 27 (2.3 to 2.8)	
Cylinder head bolt	2 cylinders	M10 x 1.5	39 to 49 (4 to 5)	
Cylinder liner mounting bolt	2 cylinders	M10 x 1.5	25 to 29 (2.5 to 3)	
Bearing holder bolt	1 cylinder	M8 x 1.25	14 to 18 (1.4 to 1.8)	
Bearing holder nut	2 cylinders	M8 x 1.25	14 to 18 (1.4 to 1.8)	
Connecting rod cap nut		M8 x 1.25	23 to 25 (2.3 to 2.6)	
Unloader valve guide		M28 x 1.5	98 to 115 (10 to 12)	
Delivery valve holder		M36 x 1.5	98 to 115 (10 to 12)	Apply 0.2 to 0.3 cc of THREEBOND NEJI LOCK 1323B to three threads
Suction valve holder		M45 x 1.5	98 to 115 (10 to 12)	
Injection pump gear mounting nut		M24 x 1.5	215 (22)	
Joint		PT 1/8	15 to 20 (1.5 to 2.0)	
Tachometer sensor		M16 x 1.5	24 to 35 (2.4 to 3.6)	

(2) Pressure Governor

Location tightened	Thread size O.D. x Pitch mm	Tightening torque Nm (kgfm)	Remarks
Sleeve lock nut	—	15 to 20 (1.5 to 2)	
Adjusting screw lock nut	—	9.8 to 15 (1 to 1.5)	

4. SPECIAL TOOL**Air Compressor**

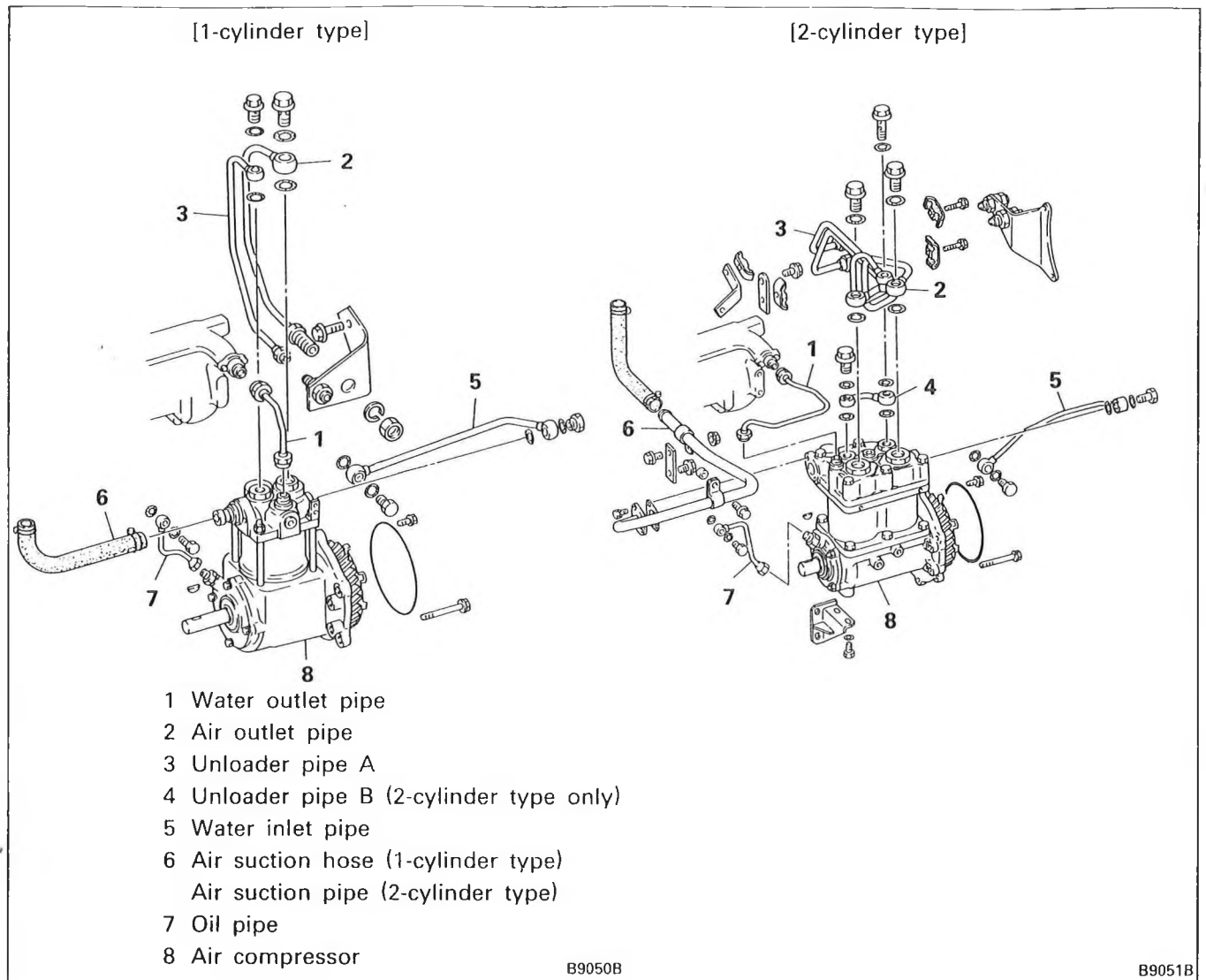
Unit: mm

Tool name	Part No.	Shape	Use
Suction valve tool	MH061263	 13 B5241A	Removal and installation of suction valve holder
Piston ring tool	MH060014	For 60 to 120 diameter  B5231A	Removal and installation of air compressor piston ring

5. SERVICE PROCEDURES

5.1 AIR COMPRESSOR

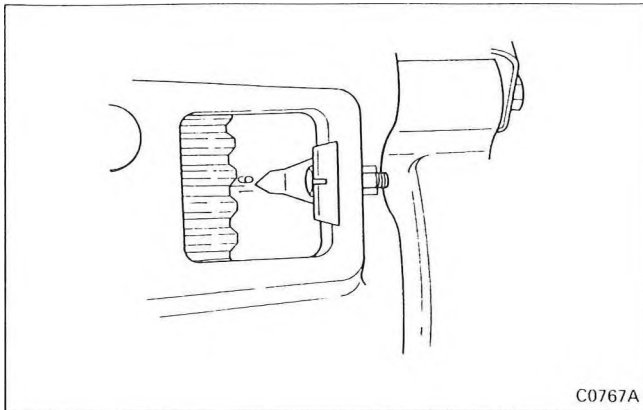
5.1.1 Removal and Installation



NOTE:

1. To remove the air compressor, remove the injection pump beforehand.
2. At installation, the injection pump gear installed on the air compressor should be in mesh as specified.

Installation of Air Compressor

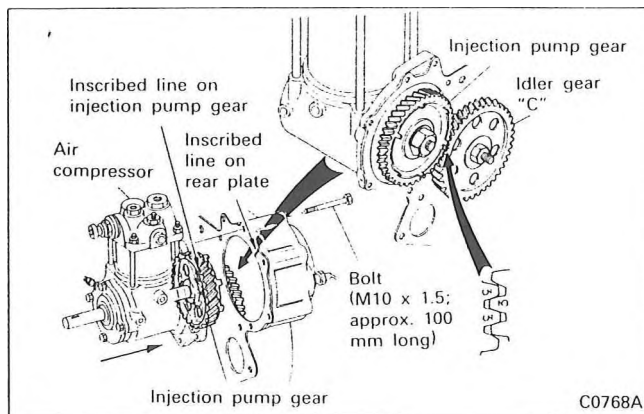


(1) Crank the engine to align the stamped mark "1, 6" on the periphery of the flywheel with the pointer of the inspection window in the flywheel housing and put the piston in the No. 1 cylinder of the engine at top dead center on the compression stroke.

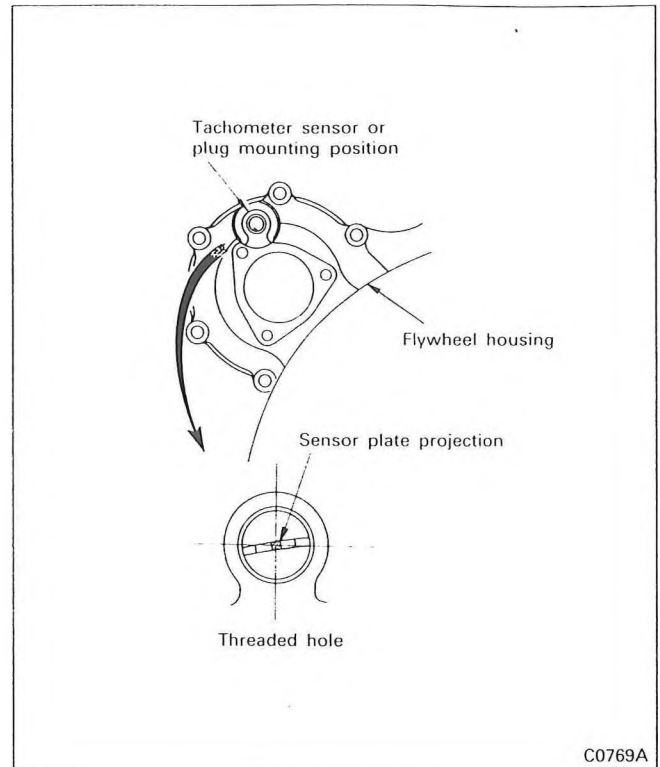
If the piston in the No. 1 cylinder is at top dead center on the compression stroke, the No. 1 cylinder will have a valve clearance. If both inlet and exhaust valves have no valve clearance, the piston in the No. 6 cylinder will be at top dead center on the compression stroke. So let the engine rotate 360°.

NOTE:

When the engine is to be cranked, make sure that it is cranked manually more than 180° in the normal direction.



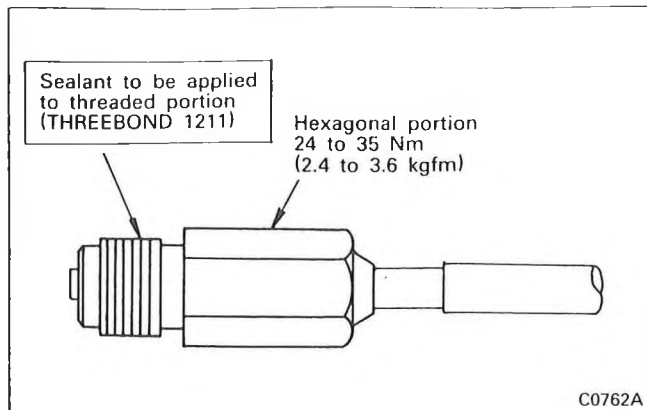
(2) Insert the bolt (M10 x 1.5 about 100 mm long) from the rear end of the flywheel housing to support the air compressor. Using the bolt as a guide, insert the air compressor into the mounting hole of the flywheel housing. At the position where both ends of the injection pump gear and idler gear C have touched each other, align the inscribed line on the rear plate with that on the injection pump gear tooth surface, and then push the air compressor in.



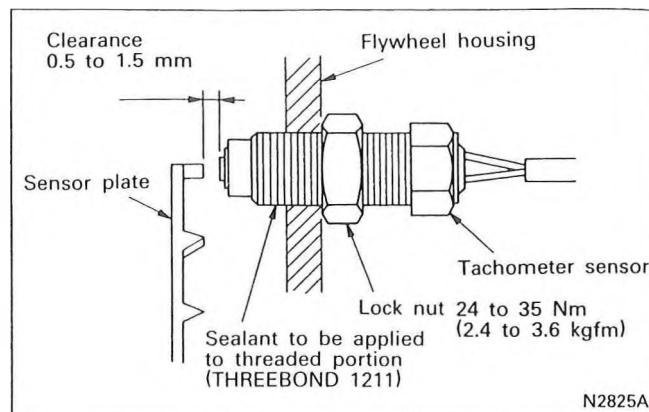
(3) Remove the tachometer sensor or plug. Look through the threaded hole to confirm that the projection on the sensor plate is positioned at the center of the threaded hole, and then secure the air compressor. If the projection on the sensor plate is not positioned at the center of the threaded hole, remove the air compressor and perform Item (3) again. After the air compressor has been installed, install the plug.

NOTE:

If the injection pump gear and idler gear C are misaligned a tooth, about half of the projection on the sensor plate will be hidden from the plug hole.

(4) Installation of Tachometer Sensor**(a) Non-adjustable type**

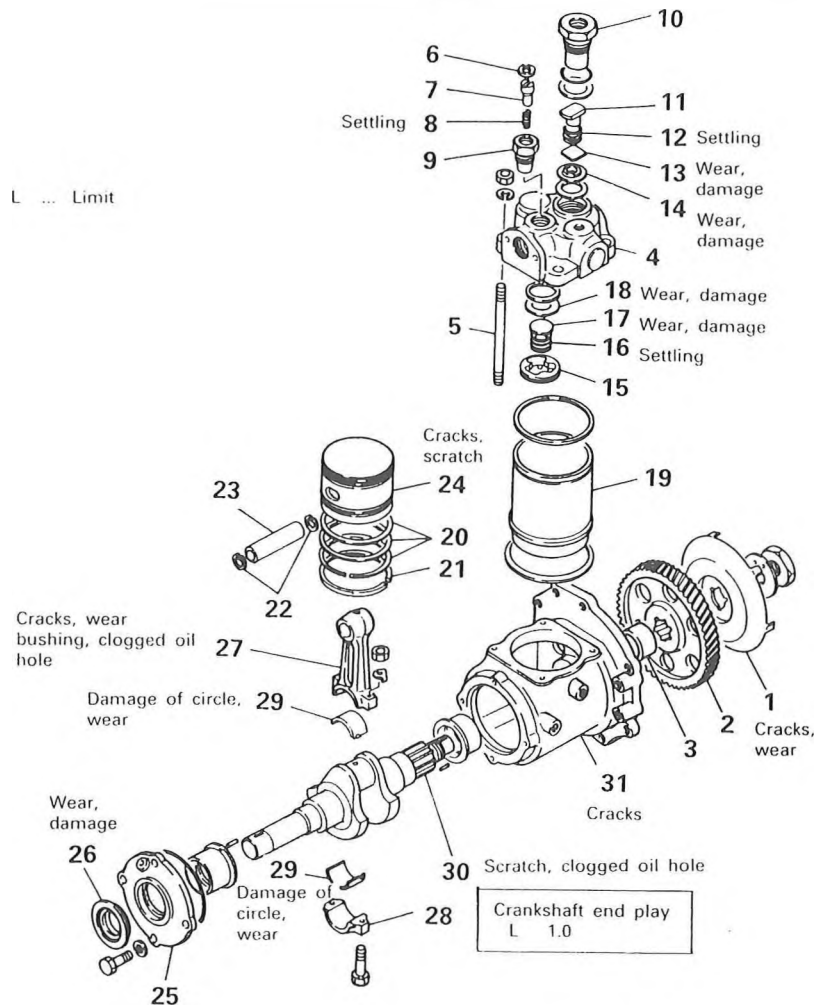
To install the tachometer sensor, apply sealant to the threaded portion of the sensor and screw the sensor in until the hexagonal portion of the sensor seats.

(b) Adjusting type

To mount the tachometer sensor, apply sealant to the threaded portion of the sensor and screw it in until it seats on the sensor plate. Thereafter, back it off two-thirds of a turn (240°) (to make 1.0 mm clearance). Tighten the lock nut to the specified torque.

5.1.2 Disassembly

[1-cylinder Type]



<Disassembly sequence>

- | | | |
|--------------------------|--------------------------|---------------------------|
| 1 Sensor plate | 11 Spring holder | 21 Oil ring |
| 2 Injection pump gear | 12 Delivery valve spring | 22 Snap ring |
| 3 Collar | 13 Delivery valve | 23 Piston pin |
| 4 Cylinder head | 14 Delivery valve seat | 24 Piston |
| 5 Stud bolt | 15 Suction valve holder | 25 Bearing holder |
| 6 Snap ring | 16 Suction valve spring | 26 Oil seal |
| 7 Unloader valve | 17 Suction valve | 27 Connecting rod |
| 8 Valve spring | 18 Suction valve seat | 28 Connecting rod cap |
| 9 Valve guide | 19 Cylinder liner | 29 Connecting rod bearing |
| 10 Delivery valve holder | 20 Compression ring | 30 Crankshaft |
| | | 31 Crankcase |

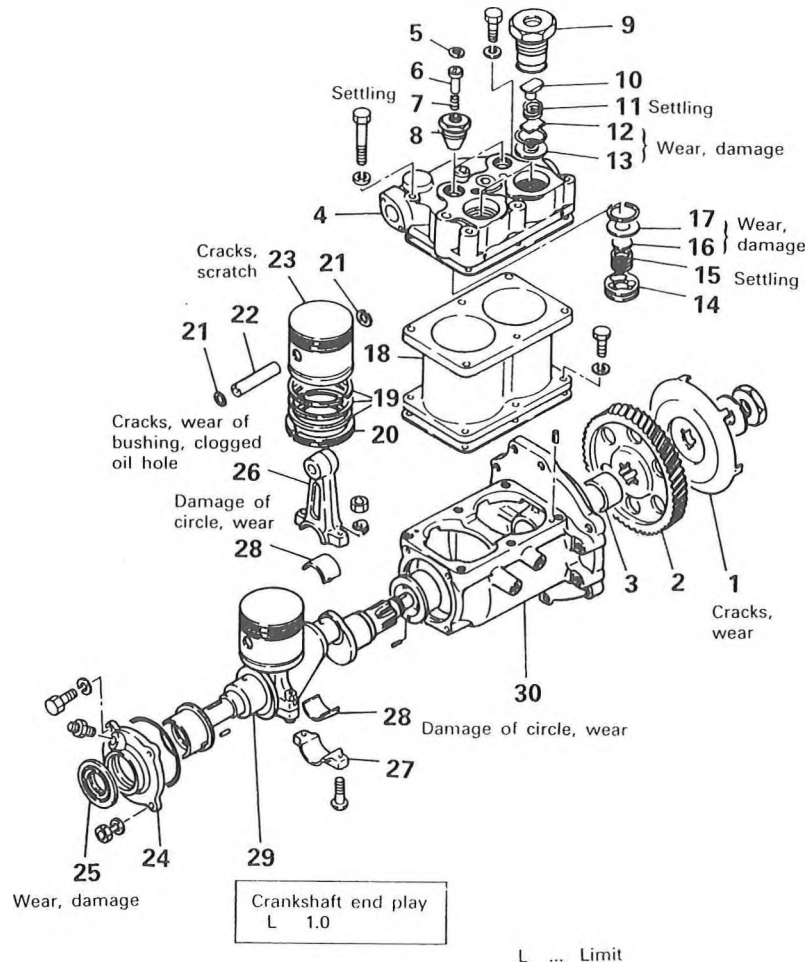
For parts with an encircled number, refer to Disassembly Procedure that follows.

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NOTE:

Do not remove the stud bolt unless trouble is evident.

[2-cylinder Type]



<Disassembly sequence>

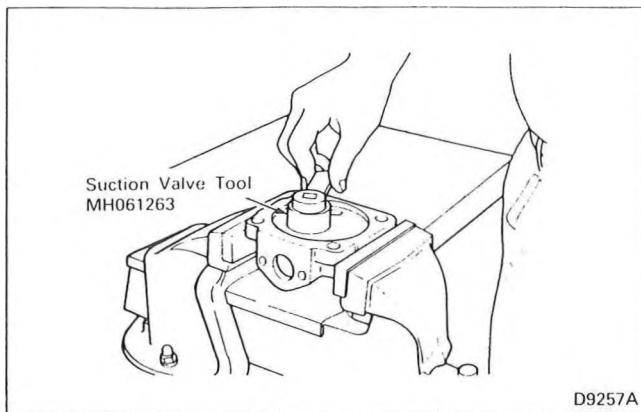
- | | | |
|-----------------------|---------------------------|---------------------------|
| 1 Sensor plate | 11 Delivery valve spring | 21 Snap ring |
| 2 Injection pump gear | 12 Delivery valve | 22 Piston pin |
| 3 Collar | 13 Delivery valve seat | 23 Piston |
| 4 Cylinder head | (14) Suction valve holder | 24 Bearing holder |
| 5 Snap ring | 15 Suction valve spring | 25 Oil seal |
| 6 Unloader valve | 16 Suction valve | 26 Connecting rod |
| 7 Valve spring | 17 Suction valve seat | 27 Connecting rod cap |
| 8 Valve guide | 18 Cylinder liner | 28 Connection rod bearing |
| 9 Valve holder | (19) Compression ring | 29 Crankshaft |
| 10 Spring holder | (20) Oil ring | 30 Crankcase |

For parts with an encircled number, refer to Disassembly Procedure that follows.

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The procedures for disassembly of the 1- and 2-cylinder types are much the same. So only the

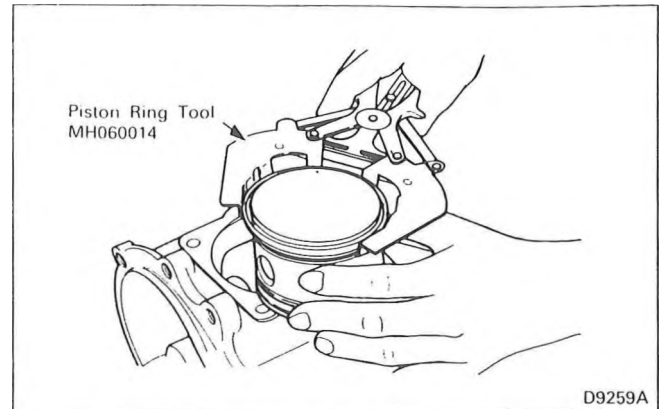
procedures for disassembly of the 1-cylinder type are described below.

Disassembly Procedure

(1) Using Suction Valve Tool (special tool), remove the suction valve holder from the bottom surface of the cylinder head and remove the suction valve spring, suction valve and suction valve seat.

NOTE:

Since the suction valve holder is staked by punching, do not attempt disassembly unless trouble is evident.



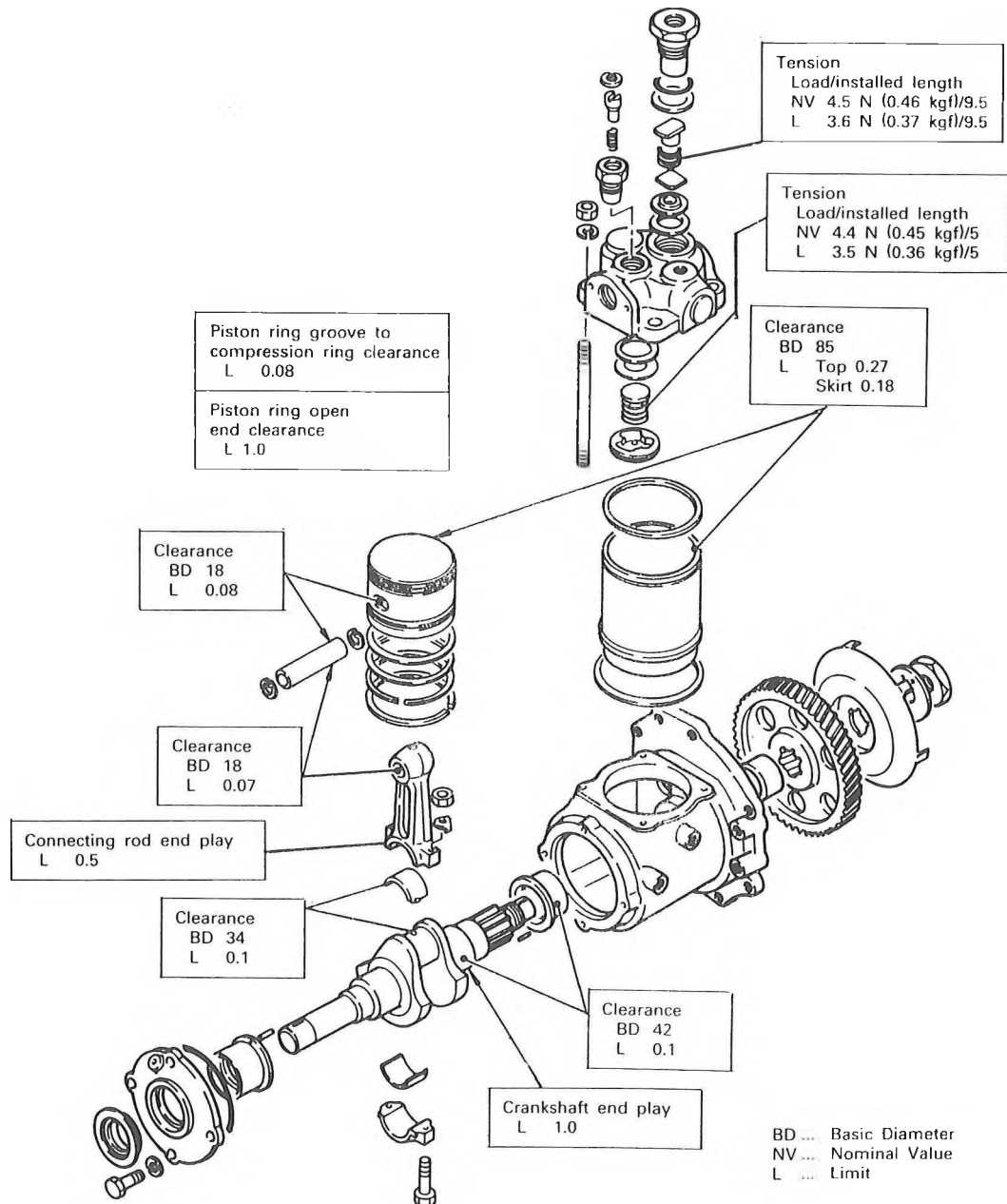
(2) Using Piston Ring Tool (special tool), remove the compression ring and oil ring from the piston.

NOTE:

When a piston ring is removed, do not widen the open ends of the piston ring more than 28 mm for 1-cylinder type and more than 26 mm for 2-cylinder type.

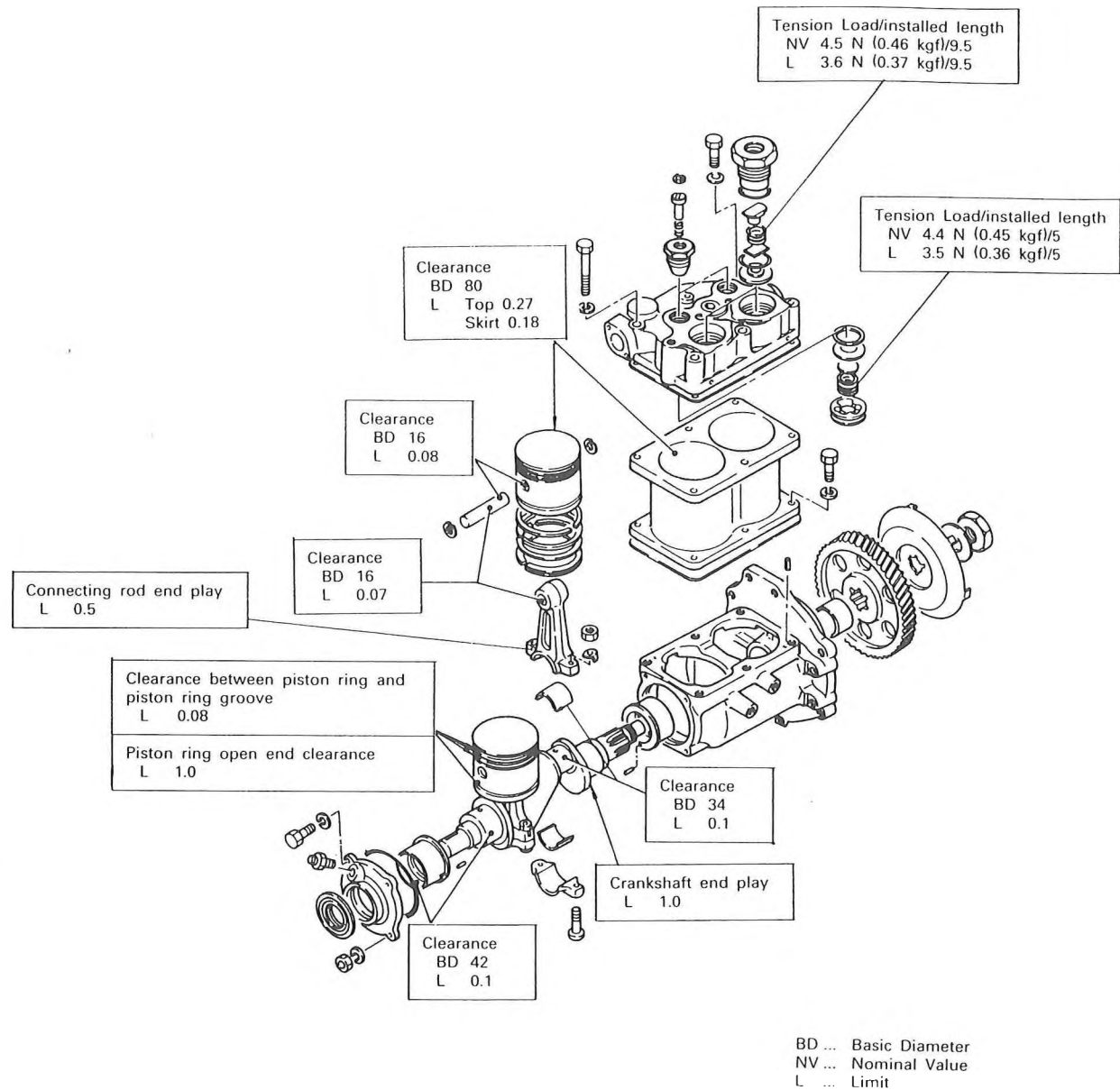
5.1.3 Inspection and Correction

[1-cylinder Type]

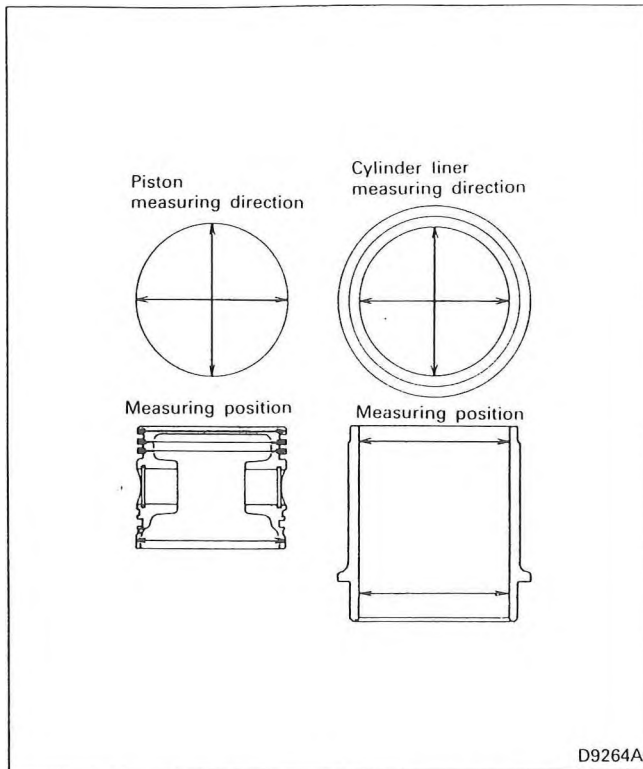


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[2-cylinder Type]

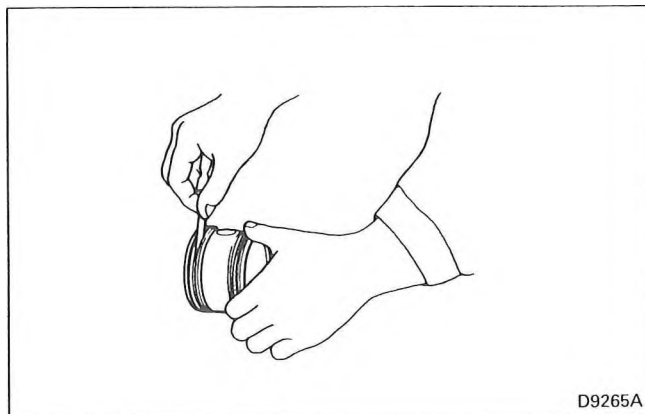


D9253B

(1) Piston and Cylinder Liner

Measure the cylinder liner inside diameter and piston top and skirt outside diameter and calculate the clearance.

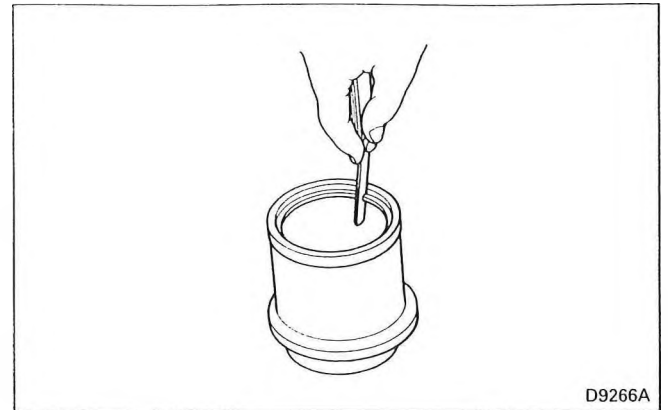
If the clearance is over the limit, replace the piston or cylinder liner.

(2) Piston Ring

(a) Measure the clearance between the piston ring groove and compression ring. If the clearance is over the limit, replace the compression ring or piston.

NOTE:

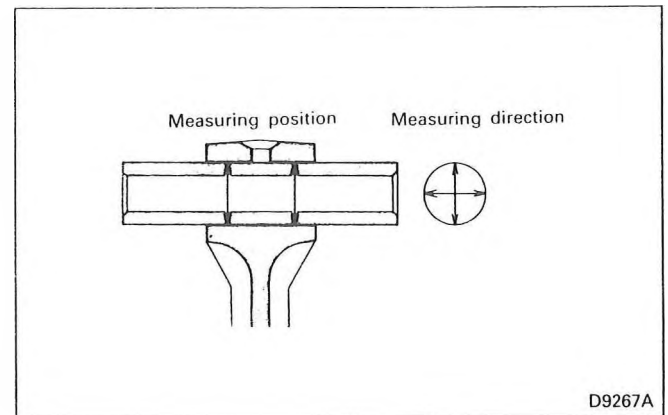
Measure the clearance all around the piston.



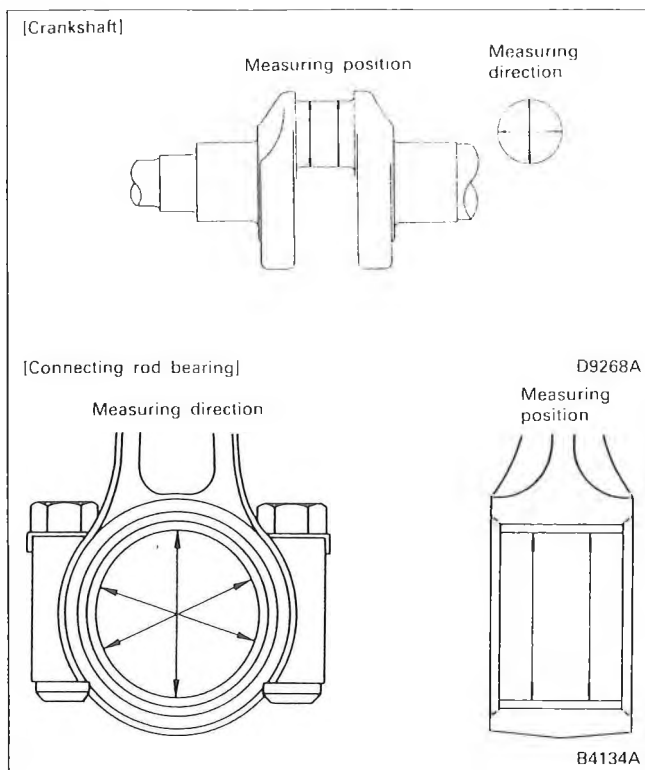
(b) Fit the piston ring over a standard gauge or new cylinder liner and measure the open end clearance. If the clearance is over the limit, replace the piston ring.

NOTE:

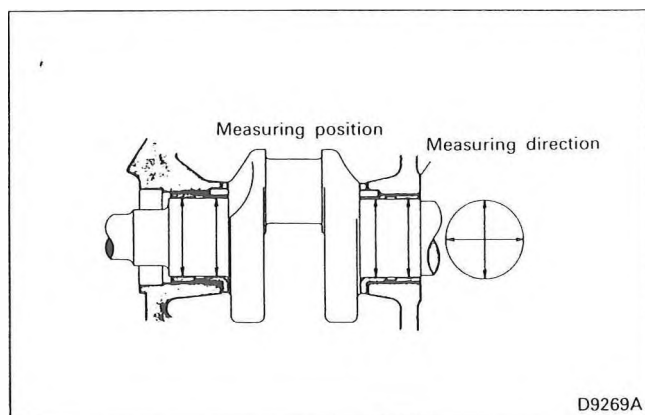
Push the piston in and measure the clearance with the piston ring in horizontal position.

(3) Connecting Rod and Crankshaft

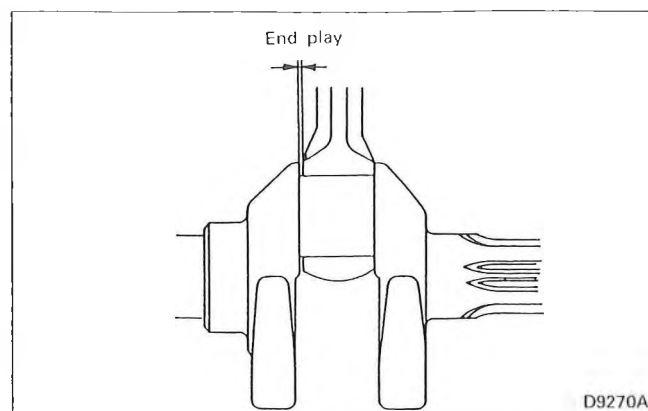
(a) Calculate the clearance from the piston pin outside diameter and connecting rod small end inside diameter. If the clearance is over the limit, replace the piston pin or connecting rod.



(b) Measure the diameter of connecting rod bearing sliding section. If the diameter is smaller than the limit, replace the crankshaft. Replace the connecting rod bearing if the plating layer on its inner surface is worn out and copper color metal appears.

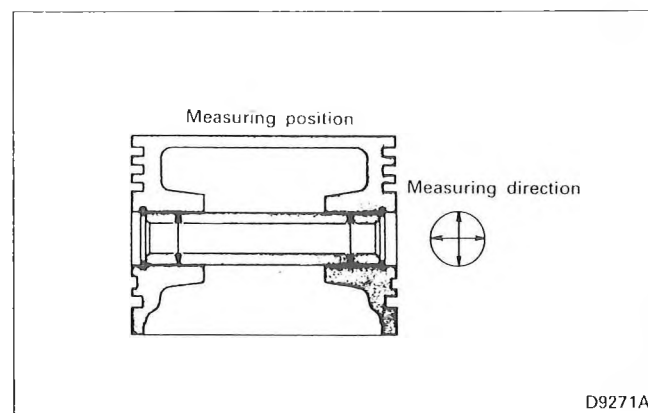


(c) Measure the crankshaft journal outside diameter and bearing inside diameter and calculate the clearance. If the clearance is over the limit, replace parts.

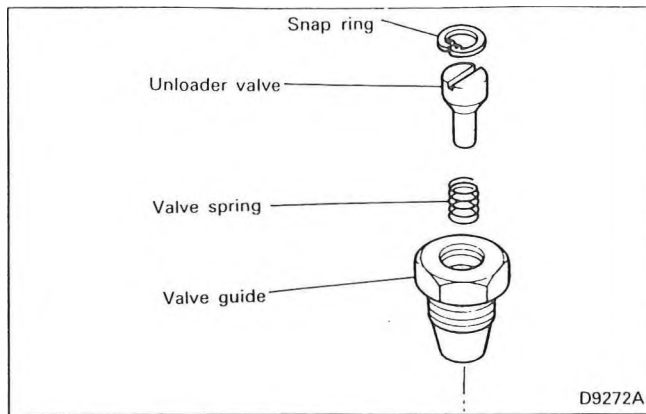


(d) Measure the end play in the connecting rod and crankshaft and, if the play exceeds the limit, replace the connecting rod.

(4) Piston Pin



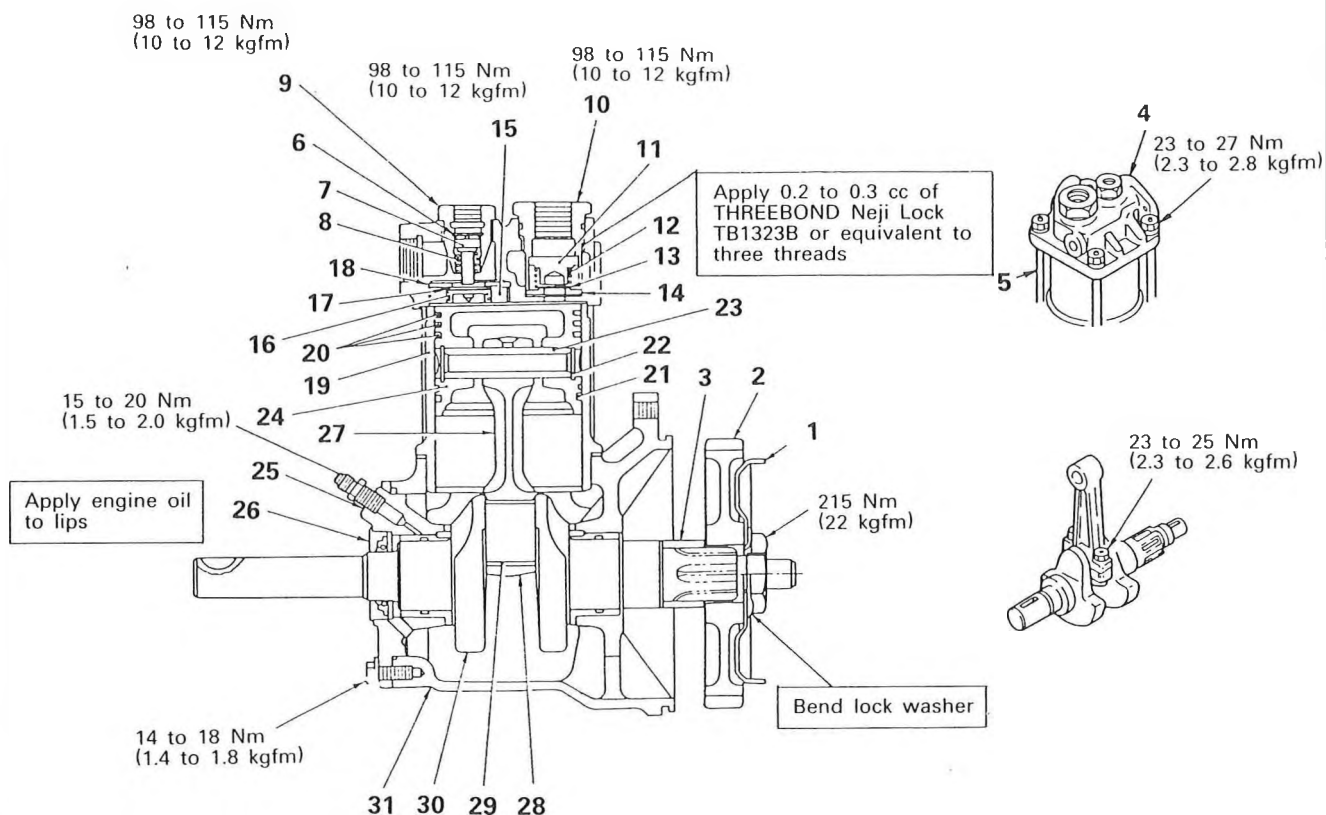
Measure the piston pin outside diameter and the pin fitting hole inside diameter of the piston and calculate the clearance. If the limit is exceeded, replace the piston pin or piston.

(5) Unloader Valve Assembly

If the unloader valve in unloader valve assembly is badly worn, replace the unloader valve assembly.

5.1.4 Reassembly

[1-cylinder Type]



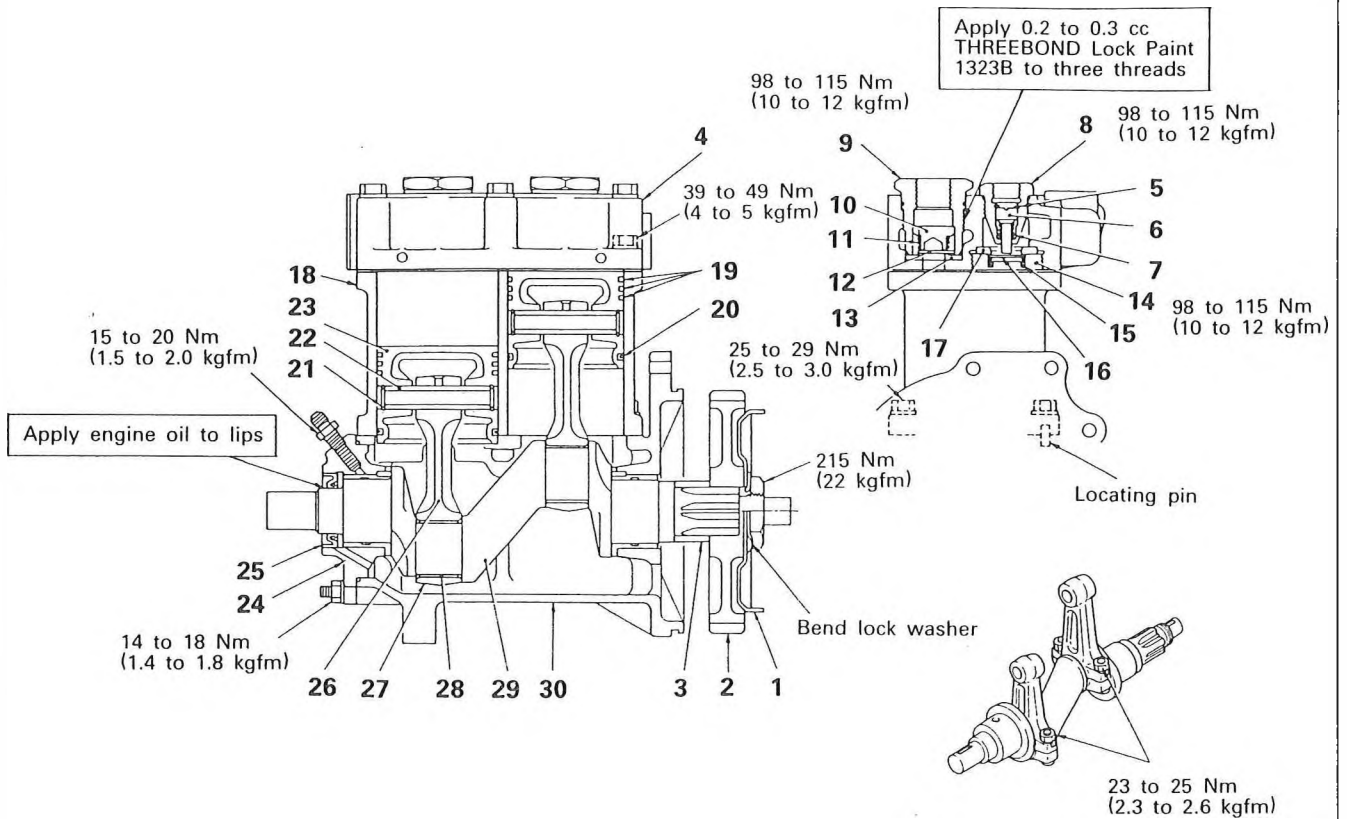
<Assembly sequence>

31→30→29→(28)→(27)→25→26→24→23→22→(21)→(20)→19→5→4→
 3→(2)→(1)
 14→13→12→11→10→18→17→16→(15)→
 8→7→6→9

For reassembly of parts with an encircled number, see procedure
 given in the following.

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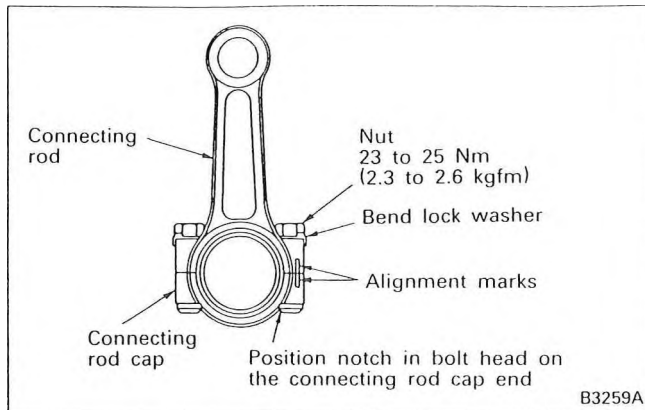
[2-cylinder Type]



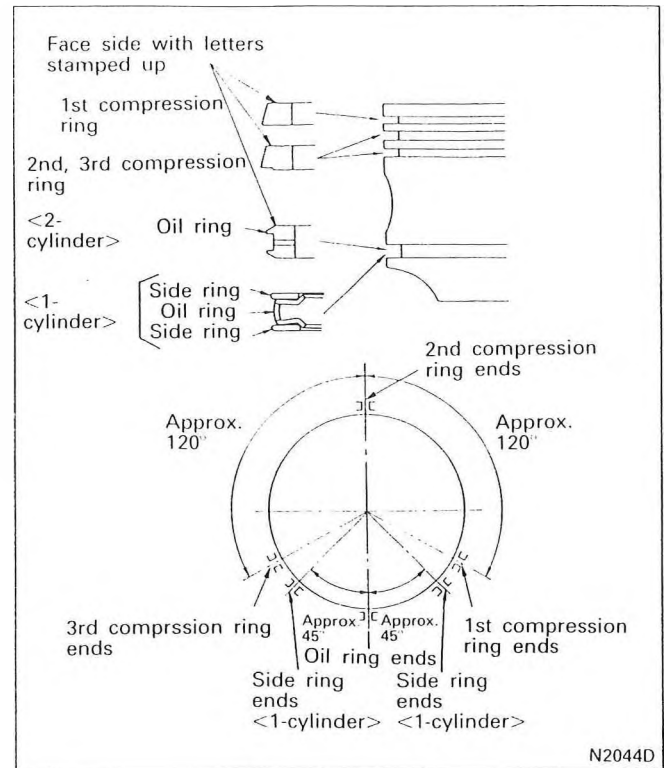
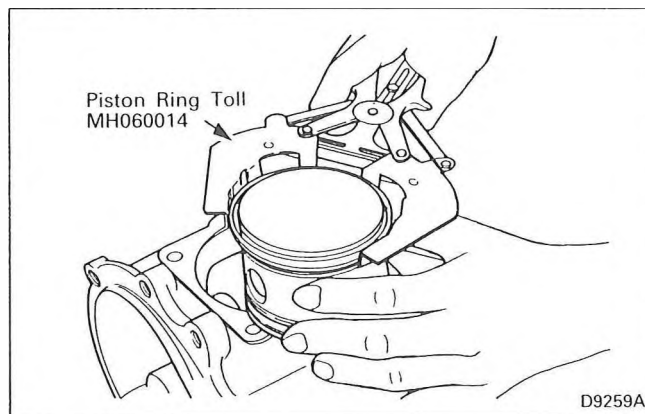
<Assembly sequence>

30→29→24→25→28→(27)→(26)→23→22→21→(20)→19→18→4→3→2→1
 13→12→11→10→9→17→16→15→14→
 8→7→6→5

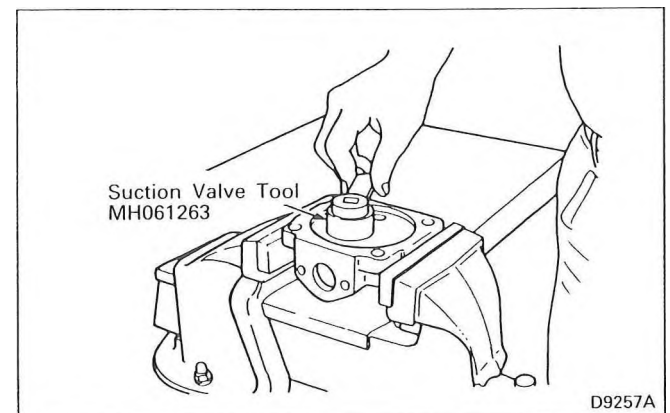
For reassembly of parts with an encircled number, see procedure given in the following.

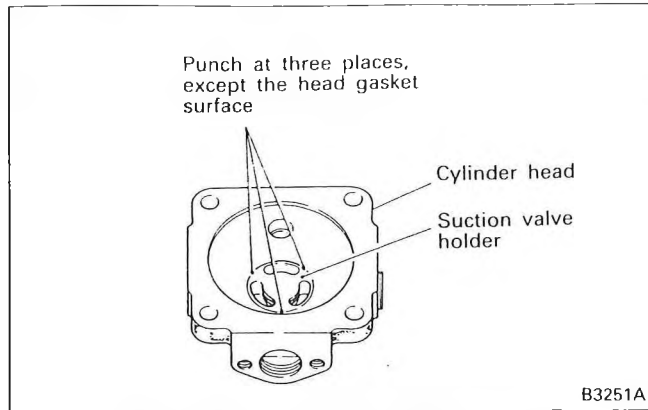
Reassembly Procedure**(1) Assembly of Connecting Rod**

Make sure that the alignment mark on the connecting rod is aligned with that on the connecting rod cap.

(2) Installation of Piston Rings

Make sure that the right piston rings are installed at the right positions and their sides with letters stamped face up. Keep the compression ring ends 120° apart from one another; place the oil ring ends at the center between the ends of compression rings; place the side ring ends 45° further away to the right and left from the oil ring ends.

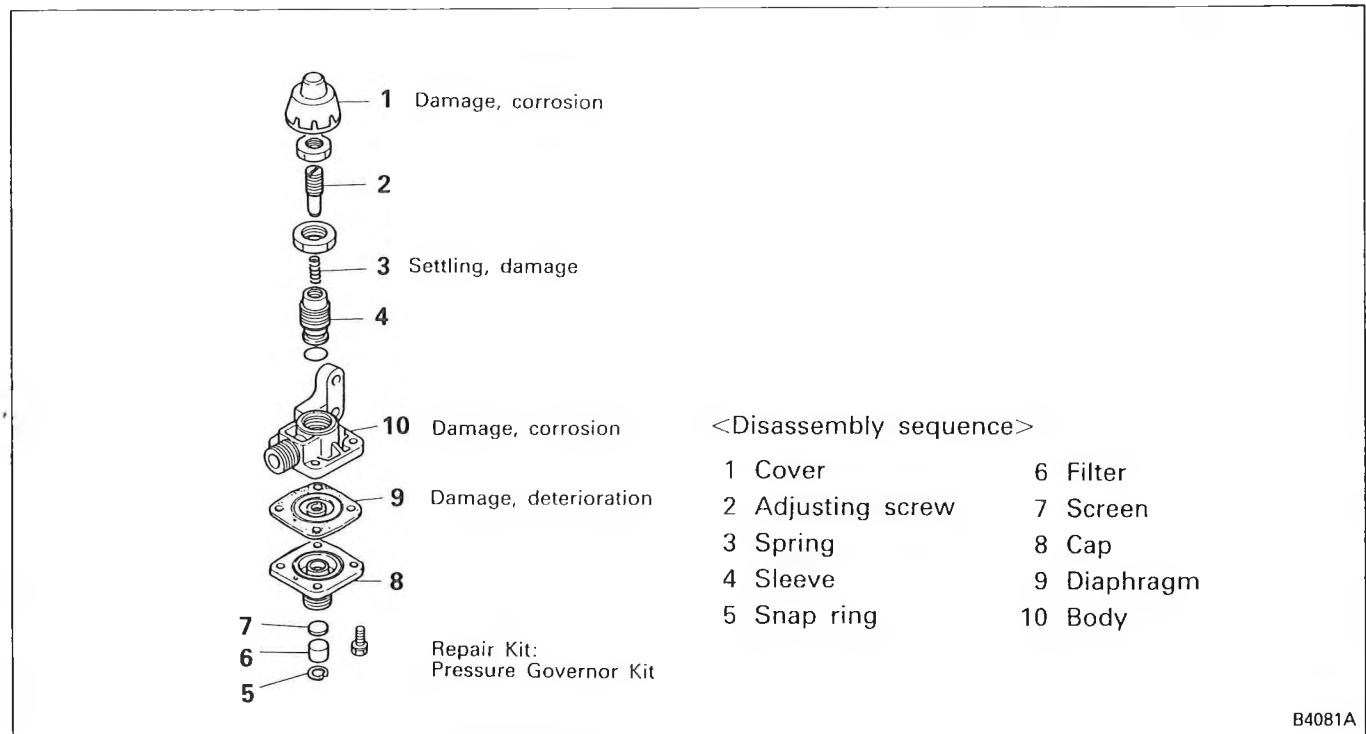
(3) Installation of Suction Valve Holder



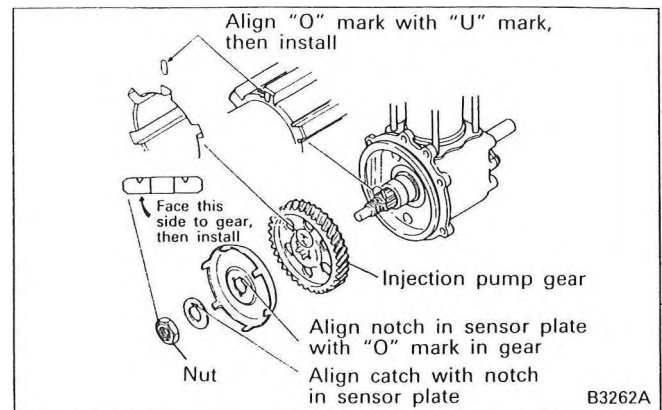
Stake the cylinder head at three places shown over the suction valve holder.

5.2 PRESSURE GOVERNOR

5.2.1 Disassembly and Inspection

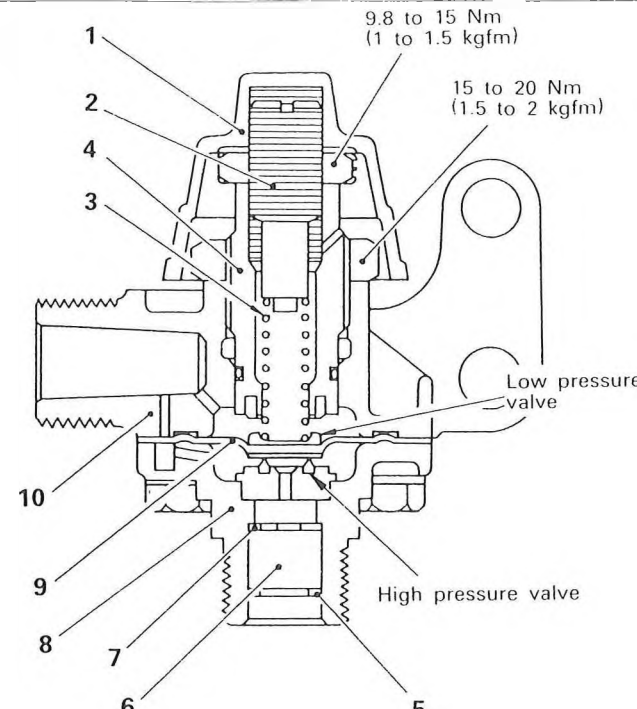


(4) Installation of Injection Pump Gear



Install the injection pump gear, sensor plate, and nut as instructed in the figure.

5.2.2 Reassembly and Adjustment



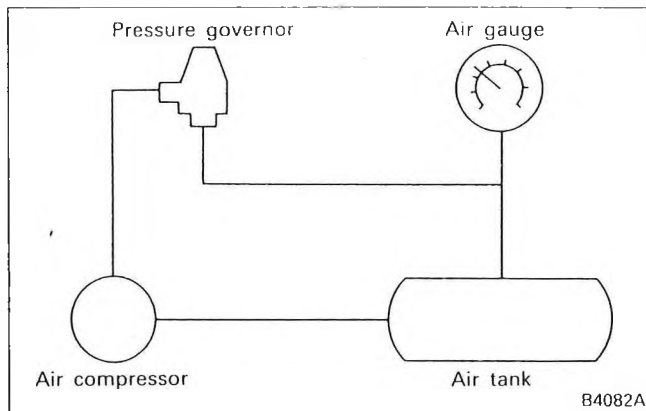
Unit: kPa (kgf/cm²)

Part no.	Nominal value	
	High pressure valve opening pressure	Low pressure valve opening pressure
MC802148	72 (7.3) $+3.4 (+0.35)$ $-0.5 (-0.05)$	63 (6.4) $+0.5 (+0.05)$ $-3.4 (-0.35)$
MC802150	78 (8.0) $+3.4 (+0.35)$ $-0.5 (-0.05)$	70 (7.1) $+0.5 (+0.05)$ $-3.4 (-0.35)$

<Assembly sequence>
10→9→8→7→6→5→4→3→2→1

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Testing



- (1) Connect an air gauge between the pressure governor and air tank.
- (2) Start the engine and increase air pressure slowly while observing the air gauge. Check that the reading of the gauge when it has stabilized is as specified (high pressure valve opening pressure). If not, adjust by adjusting tightening amount of the sleeve. After adjustment, tighten firmly with the lock nut.

- (3) Slowly decrease the air tank pressure and check that the air gauge reading starts to increase when the nominal pressure (low pressure valve opening pressure) is reached.

For adjustment, use the adjusting screw. After adjustment, tighten firmly with the lock nut.

- (4) After tightening the lock nut, check again the high and low pressure valve opening pressures. If they are out of specification, adjust again.

- (5) Install and seal the cover.



6D2

ENGINE

Shop Manual

