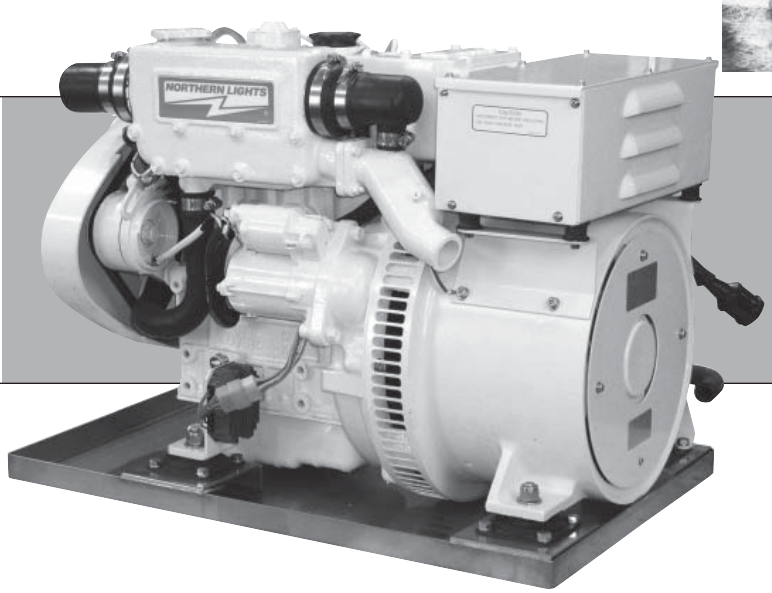

W673-2

For Models: M673L2, M673LD2, and NL673L2

WORKSHOP MANUAL

Marine Generators | Marine Diesel Engines | Land-Based Generators

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WORKSHOP MANUAL

for Models

M673L2, M673LD2, and NL673L2

NOTE: The instructions contained in this workshop manual describe the most suitable working methods to be used with the Special Tools listed under the heading “Special Tools”.

Alaska Diesel Electric reserves the right to carry out any design modifications and, for this reason, the contents of this manual may not apply to your engine. If further information is needed, we suggest that you contact an authorized dealer or the ADE factory.

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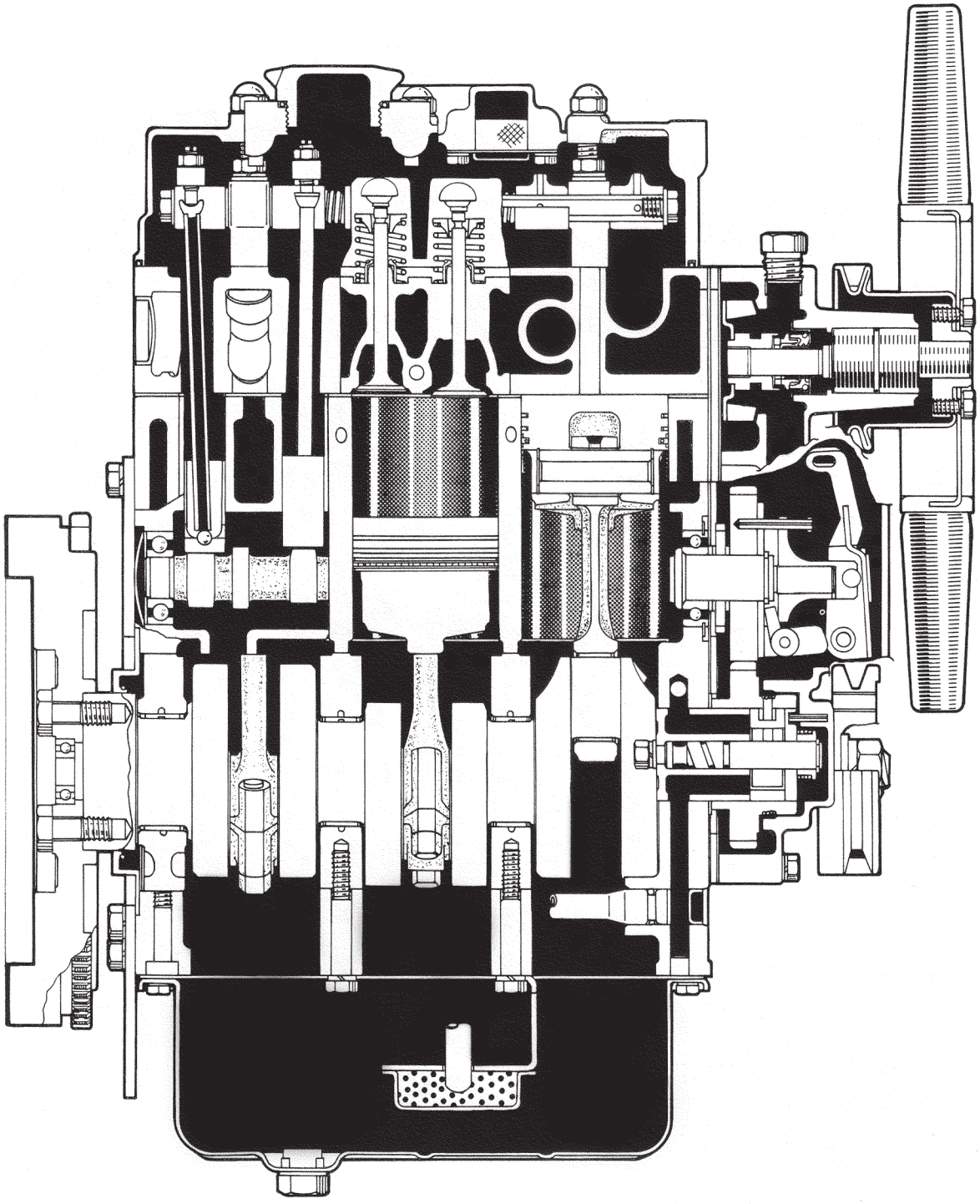
Engine Sectional View

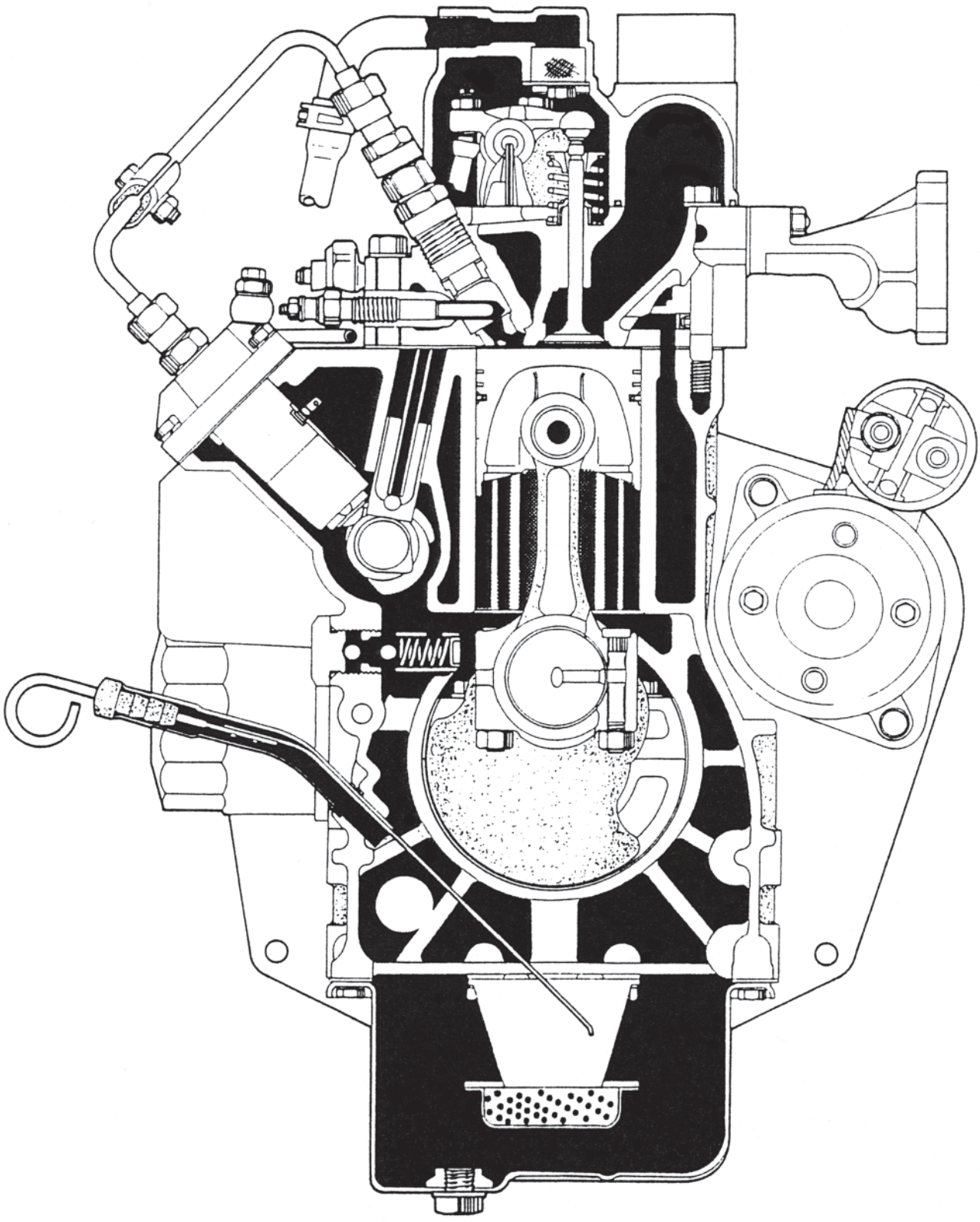
For representational purposes only, your model will vary.



L2002

Engine Sectional View

For representational purposes only, your model will vary.



L2003

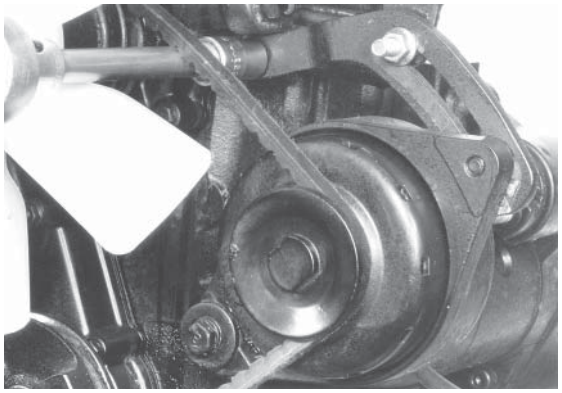
Model 673L2

Type	**4-Cycle Diesel Engine**
Cooling System	**Forced Circulation, Water Cooled**
Cylinder Arrangement	**Vertical Type, In-Row**
Combustion Chamber Type	**Whirlpool Chamber Type**
Number of Cylinders	**3**
Bore x Stroke	**67 x 72 mm**
Total Stroke Volume	**761 cc**
Compression Ratio	**24 : 1**
Performance	
Rated rpm	**1800 rpm**
Rated Output	**9.9 HP / 1800 rpm**
	6 kW @ 1800, 5 kW @ 1500
Fuel System	
Injection Pump Type	**Bosch System**
Nozzle Type	**Throttle Type**
Fuel	**Diesel #2**
Lubricating System	
Lubricating Method	**Trochoid Pump Forced Pressure**
Filtering Method	**Cartridge Full Flow Type**
Lubricating Oil Quantity (with oil filter)	**3.2 ℓ**
Cooling System	
Cooilng Method	**Water-Cooled Forced Circulation Type**
Approximate Cooiling Water	
Capacity (HE)	**2 ℓ**
Air Cleaner	**Dry System**
Electric System	
Battery Capacity	**45 Amp/ hr**
Alternator	**14.8 Amps**

Note: Many specifications in this book are in kgf•m; 1 kgf•m = 7.233 ft•lb

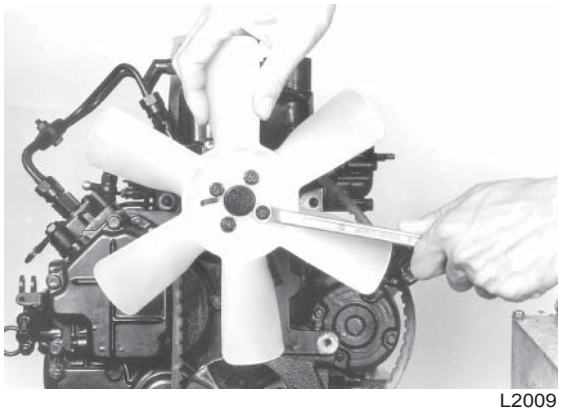
Engine Overall Disassembly

SEQ.	DISASSEMBLY PLACE	DISASSEMBLY ESSENTIALS
1	Alternator	Remove the alternator together with the adjusting plate.



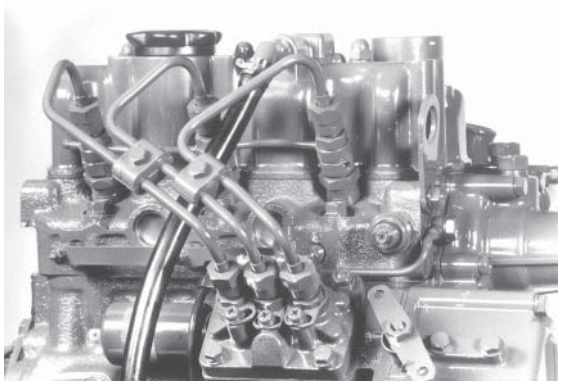
L2008

2	Cooling Fan Fan Pulley	



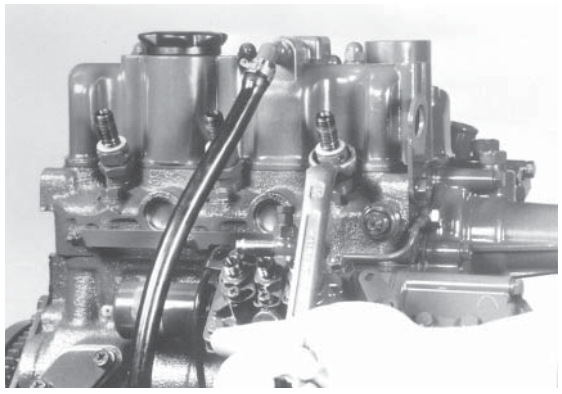
L2009

3	Injection Pipe Return Pipe	



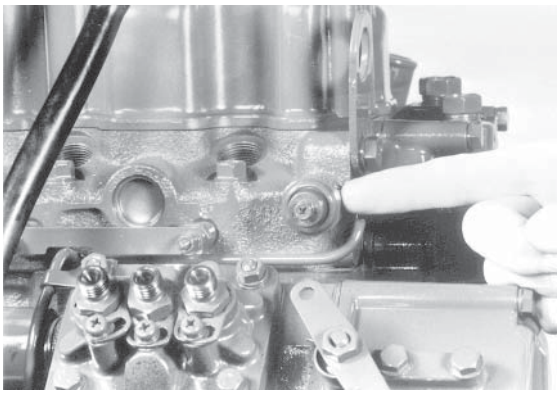
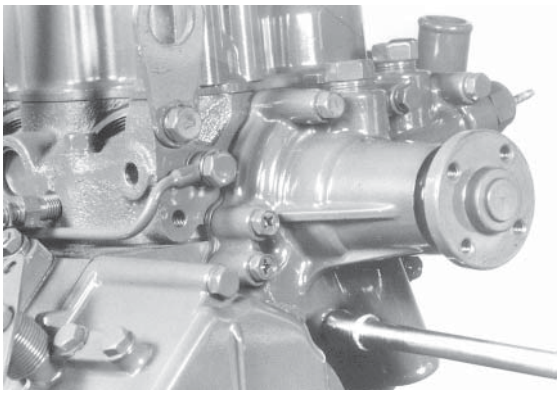
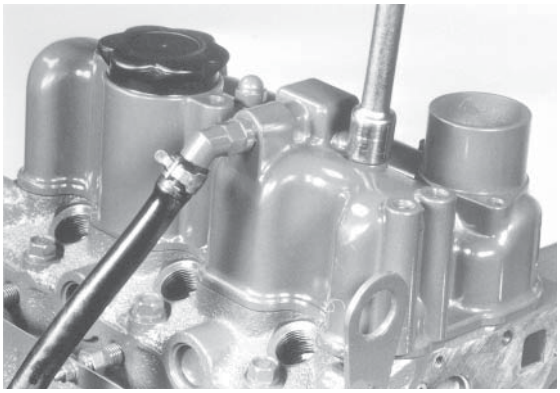
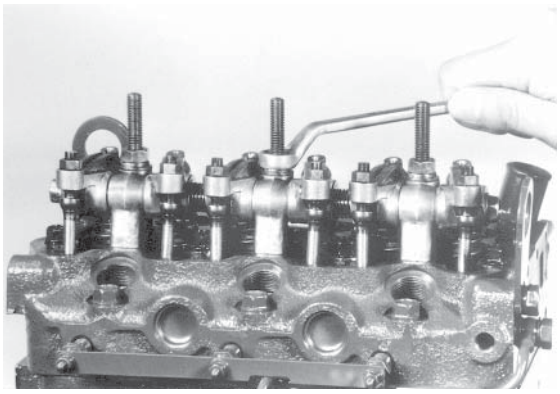
L2010

4	Nozzle and Holder Assembly	

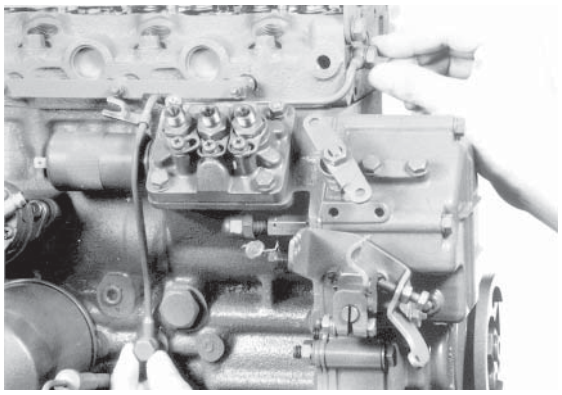
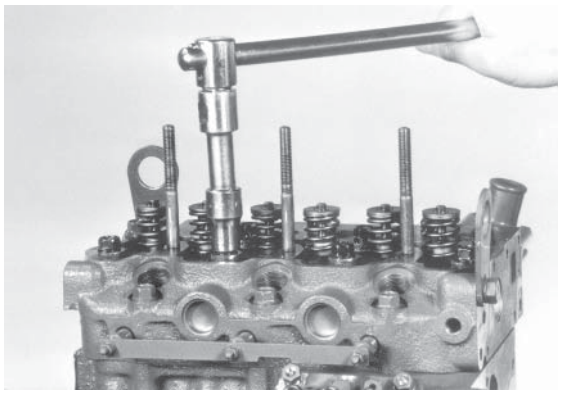
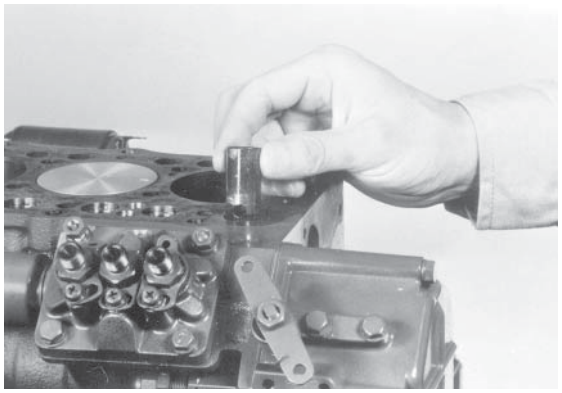
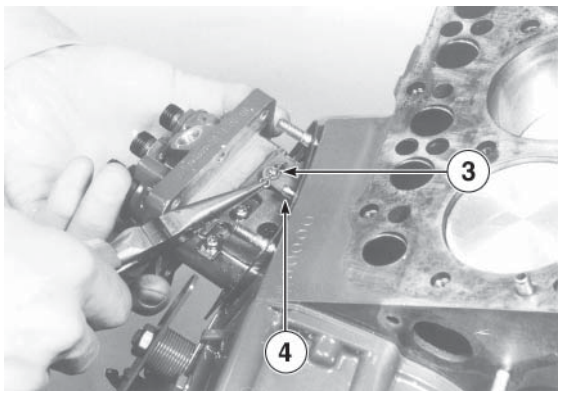


L2011

Engine Overall Disassembly

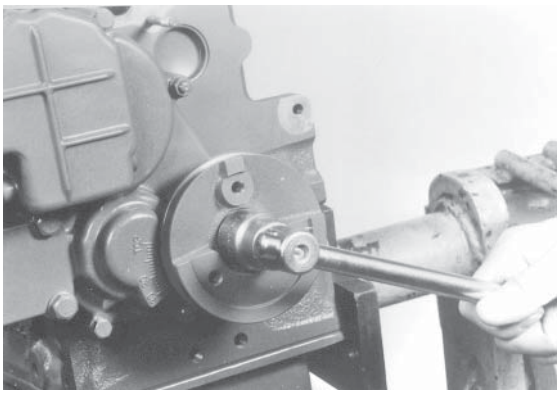
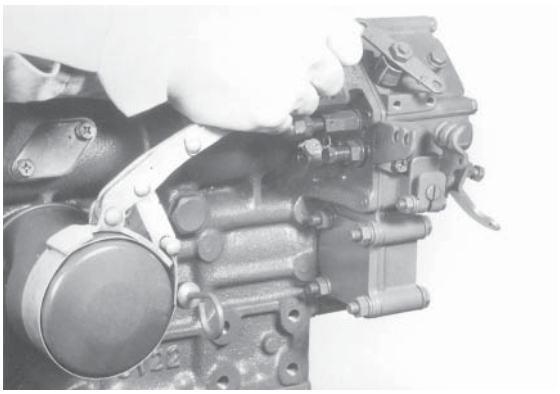
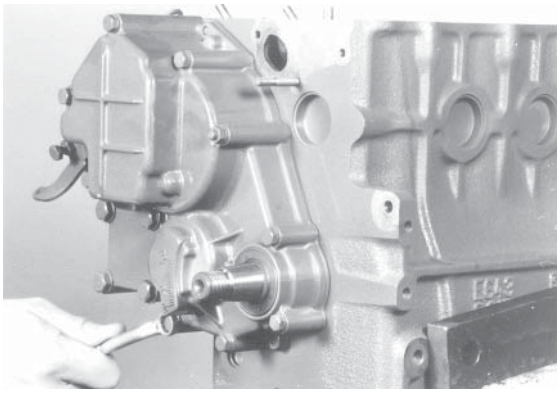
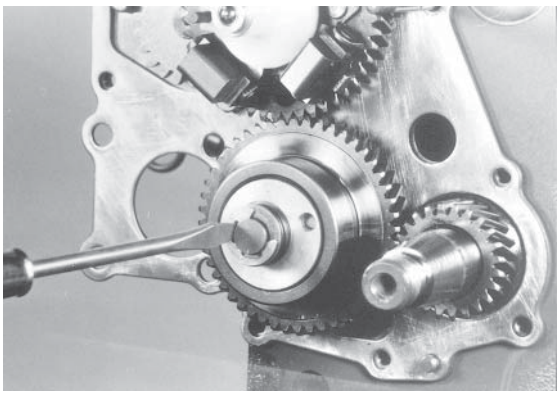
SEQ.	DISASSEMBLY PLACE	DISASSEMBLY ESSENTIALS
5	Oil Pressure Switch	 L2012
6	Water Pump Assembly	 L2013
7	Head Cover	 L2014
8	Rocker Arm Assembly Push Rod	 L2015

Engine Overall Disassembly

SEQ.	DISASSEMBLY PLACE	DISASSEMBLY ESSENTIALS	
9	Oil Pipe	Loosen the eye bolt and disconnect the oil pipe.	 L2016
10	Cylinder Head Assembly	Loosen the bolts uniformally in 2 or 3 passes, and take off the cylinder head.	 L2017
11	Tappets	Pull out the tappets upwardly from the cylinder block.	 L2018
12	Injection Pump Assembly	a. Remove the stop solenoid. b. Remove the bolts and nuts fastening the injection pump. c. Lift up the injection pump and remove the snap pin (3). d. Remove the link from the injection control rack (4) and take away the injection pump.	 L2019

NOTE:
Check the thickness and number of shims at injection pump mounting surface as these serve to adjust the injection timing.

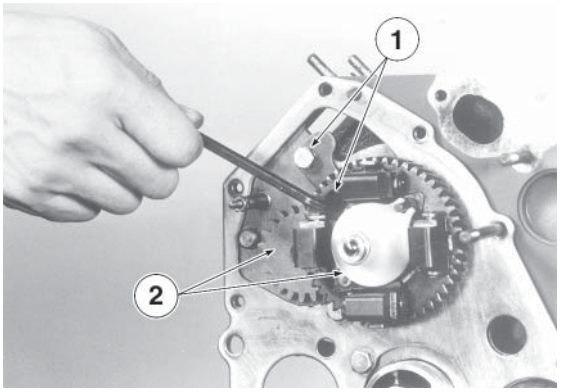
Engine Overall Disassembly

SEQ.	DISASSEMBLY PLACE	DISASSEMBLY ESSENTIALS	
13	Crankshaft Pulley		 L2020
14	Oil Filter		 L2021
15	Timing Gear Case		 L2022
16	Idle Gear Oil Pump Assembly	Remove the E type clip and take away the oil pump and idle gear.	 L2023

Engine Overall Disassembly

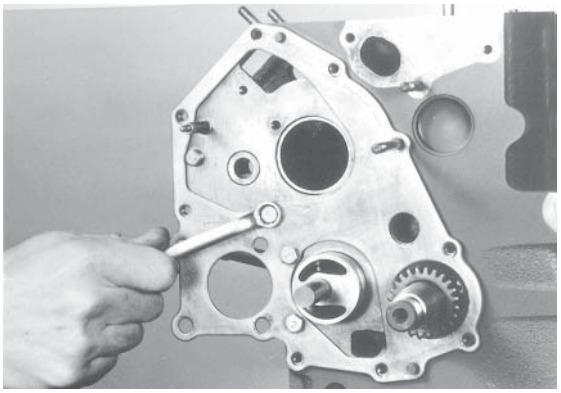
SEQ.	DISASSEMBLY PLACE	DISASSEMBLY ESSENTIALS
17	Camshaft Assembly Plate	a. Remove the bolts (2 pcs) tightening the plate and take away the plate. b. Remove the camshaft assembly.

NOTE:
Do not disturb the oil reservoir clip of the cylinder block (injection cam chamber) when removing the camshaft assembly.

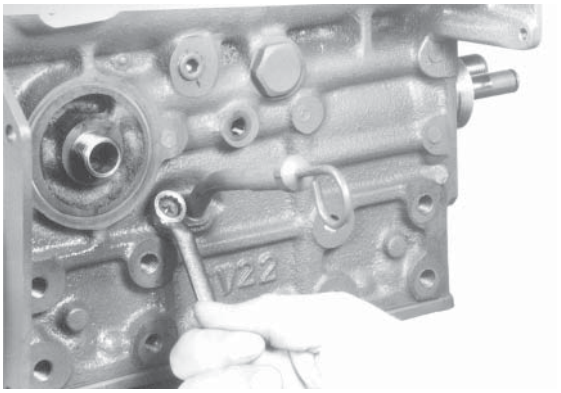


L2024

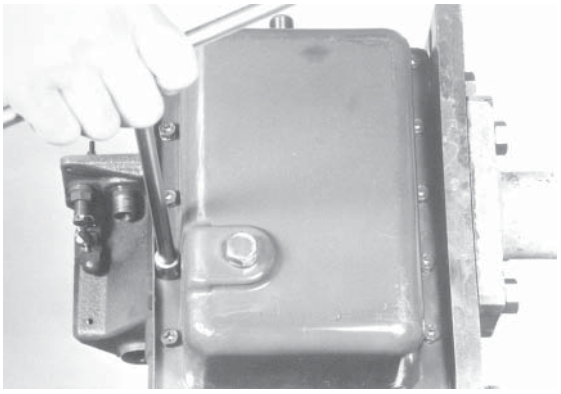
18 Front Plate


L2025

19 Oil Level Gauge
Gauge Guide

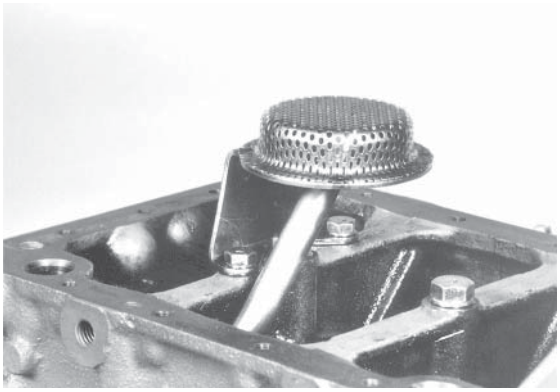

L2026

20 Oil Pan


L2027

Engine Overall Disassembly

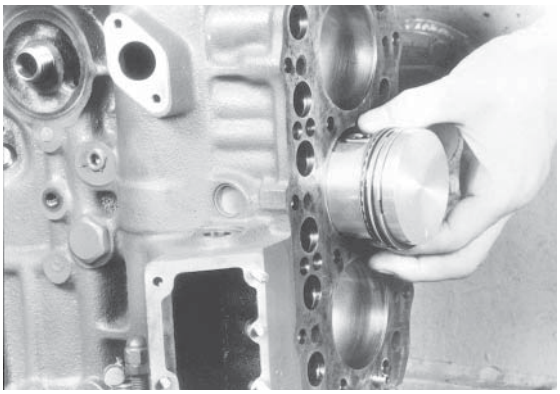
SEQ.	DISASSEMBLY PLACE	DISASSEMBLY ESSENTIALS
21	Suction Filter Suction Pipe	Remove the suction filter and extract the suction pipe.



L2028

22	Connecting Rod Piston	Loosen the nuts, take off the bearing caps, and pull out the pistons and connecting rods toward cylinder head side.

NOTES:
1. Before pulling out, remove the carbon in cylinder.
2. Arrange the removed connecting rods, caps, and bearings in cylinder sequence.



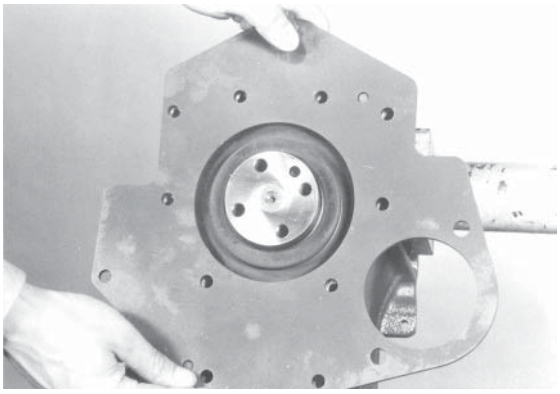
L2029

23	Flywheel	Loosen the bolts and remove the flywheel.

NOTE:
Use care in removing, as one of the 4 bolt holes is offset.

L2030

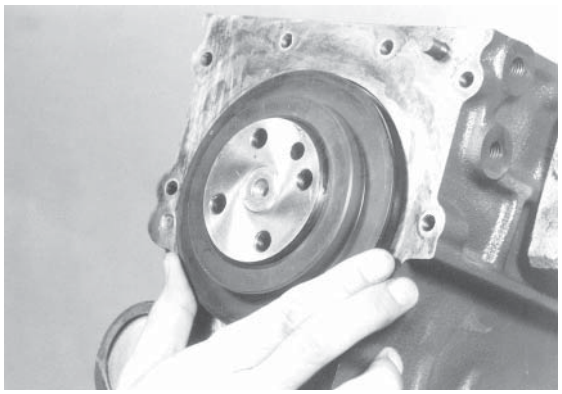
24	Flywheel Housing	



L2031

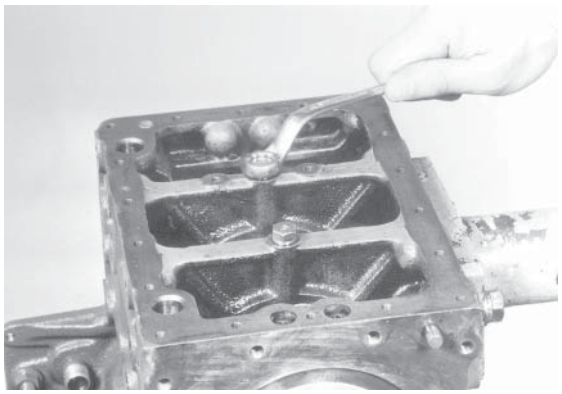
Engine Overall Disassembly

SEQ.	DISASSEMBLY PLACE	DISASSEMBLY ESSENTIALS
25	Oil Seal	



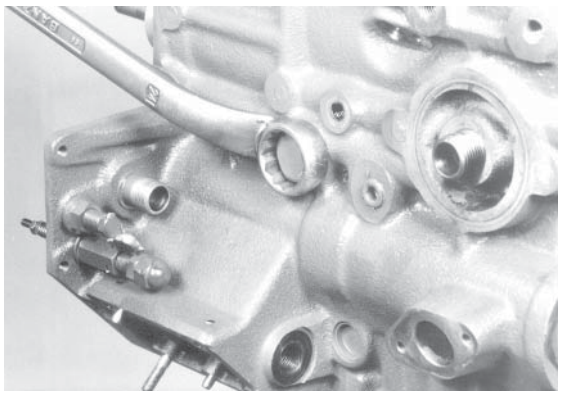
L2032

26	Crankshaft Bearing Holder Assembly	Remove the bolts fixing the bearing holder and extract the crankshaft and bearing holder as an assembly.



L2033

27	Relief Valve Assembly	



L2034

Disassembly, Inspection & Reassembly of Engine Main

Precautionary Matters Prior to Starting Operation

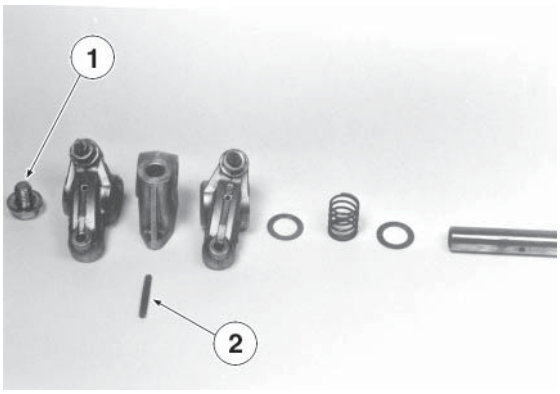
1. Check the cylinder block and cylinder head for water leakage and damage.
2. Blow compressed air through oil holes in all parts to remove any adhered foreign matter and to assure free passage.
3. Wash all parts thoroughly to ensure that they are free from dust, oil stains, carbon, and other foreign matter.
4. Sufficient care shall be taken to remove the carbon from the pistons, cylinder head, and valves so as not to injure other parts (exercise special care on aluminum alloy parts).
5. On parts such as valves, pistons, connecting rods, and bearings that are required to be assembled in proper combination, make sure to arrange them with match marks placed on them beforehand so as to avoid mixing.

Rocker Arm Assembly

INSPECTION AND SERVICING

1 Remove the bolts at both ends of the rocker arm shaft, and take away the rocker arm, rocker arm bracket, spring, and shims.

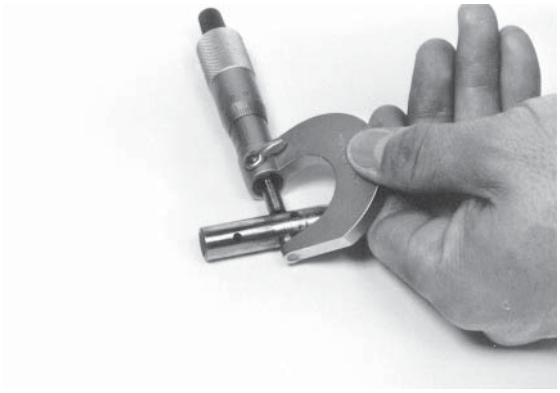
2 Extract the spring pin in the first cylinder rocker arm bracket and take away the rocker arm shaft from the rocker arm bracket.



L2035

3 Rocker Arm Shaft
Measure the outside diameter of the rocker arm shaft with a micrometer, and replace it if found below service limit.

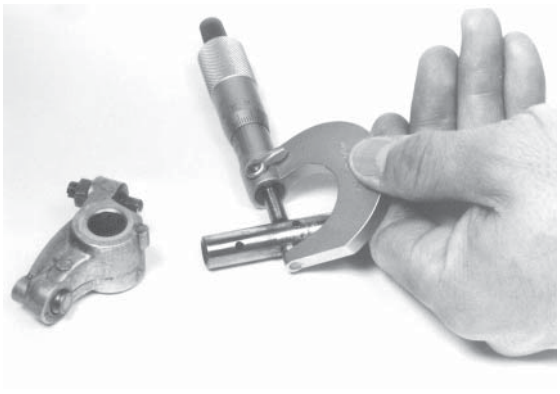
ROCKER ARM SHAFT OUTSIDE DIAMETER (ø)	
Assembly Standard Value	Service Limit
11.65 - 11.67	**11.57**



L2036

4 Rocker Arm to Rocker Arm Shaft Clearance
a. Measure the rocker arm bores.
b. Measure the clearance between rocker arms and rocker arm shaft, and replace those exceeding service limit.

ROCKER ARM TO ROCKER ARM SHAFT CLEARANCE	
(mm)	
Assembly Standard Value	Service Limit
0.032 - 0.068	**0.2**



L2037

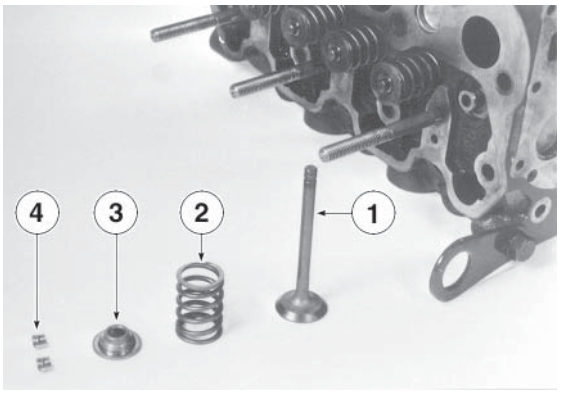
Cylinder Head Assembly

DISASSEMBLY

1 Compress the valve spring with valve spring compressor and remove valve cotter, retainer, spring, and valve.

2 Remove the valve guide seal if required.

1. Valve
2. Spring
3. Retainer
4. Valve Cotter

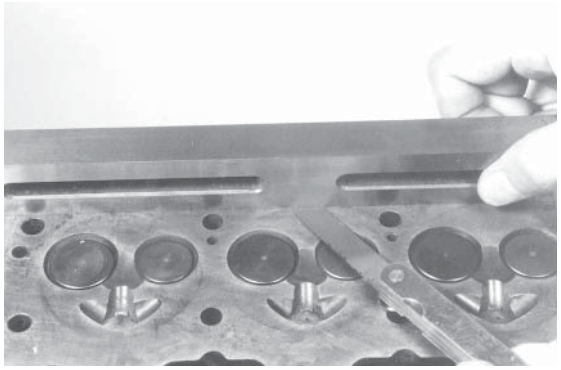


L2038

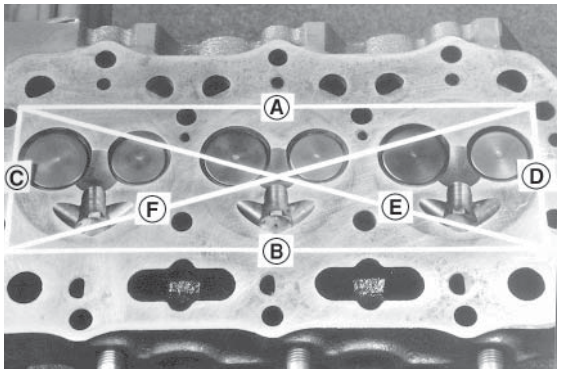
INSPECTION AND SERVICING

1 Cylinder Head Lower Surface Warpage
Place straight edge against the cylinder head lower surface and measure at points A - F (indicated in the drawing) by inserting thickness gauge. If warpage is over the repair required value, correct by use of surface grinder and the like.

CYLINDER HEAD LOWER SURFACE WARPAGE (mm)	
Assembly Standard Value	Repair Required Value
0.05 maximum	**0.12**



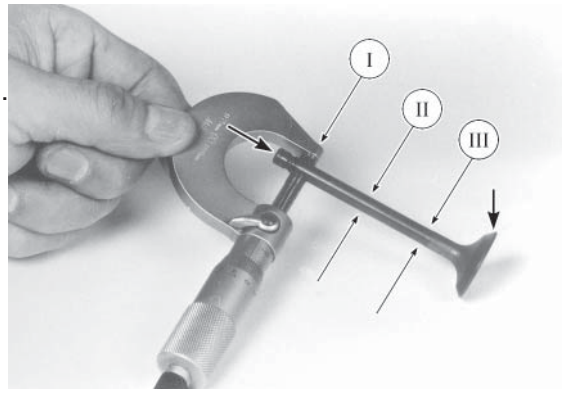
L2039



L2040

2 Intake and Exhaust Valves and Valve Guides
a. Check the head and stem of each valve and replace if found excessively worn, burnt, or deformed.
b. Measure valve stem outside diameter at points I, II, and III with a micrometer and replace if over service limit.

VALVE STEM DIAMETER (mm)			
Intake Valve		Exhaust Valve	
Assembly Std.	Service Limit	Assembly Std.	Service Limit
5.960 - 5.975	**5.9**	**5.940 - 5.955**	**5.9**



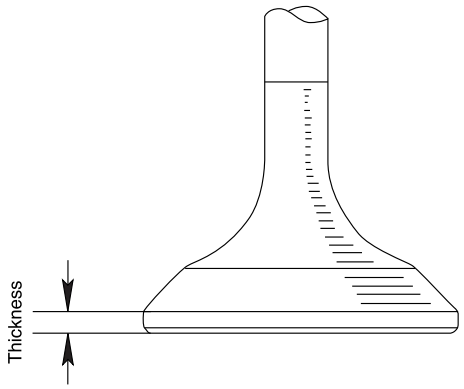
L2041

Cylinder Head Assembly

INSPECTION AND SERVICING

c. If the valve head thickness is found to be under the service limit, replace it.

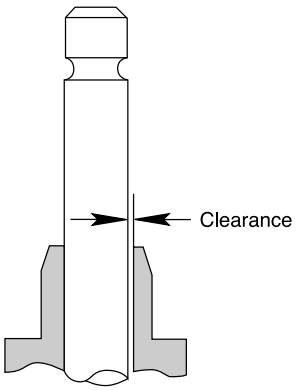
VALVE HEAD THICKNESS (mm)	
Assembly Standard Value	Service Limit
0.925 - 1.075	**0.5**



L2042

d. If the clearance between valve stem and valve guide is found to exceed the service limit, replace it.

VALVE STEM TO VALVE GUIDE CLEARANCE (mm)			
Intake Valve		Exhaust Valve	
Assembly Std.	Service Limit	Assembly Std.	Service Limit
0.025 - 0.052	**0.2**	**0.045 - 0.072**	**0.25**

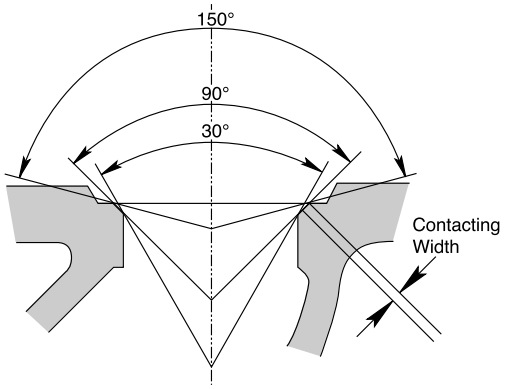


L2043

3 Valve Seat

a. Valve guide serves as standard when correcting valve seat, so make sure to check the valve guide for wear.

VALVE SEAT CONTACTING WIDTH (mm)	
Assembly Standard Value	Repair Required Value
1.59 - 1.80	**2.5**

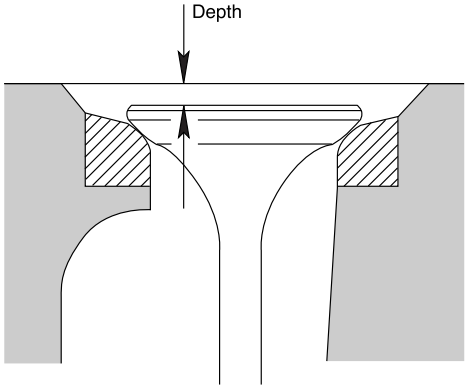


L2044

b. Use 15°, 45°, and 75° seat cutters to correct valve seat and finish such that contacting width conforms to assembly standard value.

c. If seat depth is found to exceed repair limit, replace the valve seat or valve.

VALVE SEAT DEPTH (mm)	
Assembly Standard Value	Repair Required Value
0.7 - 0.9	**1.8**

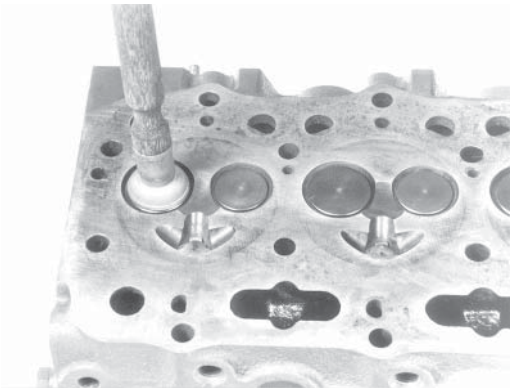


L2045

Cylinder Head Assembly

INSPECTION AND SERVICING

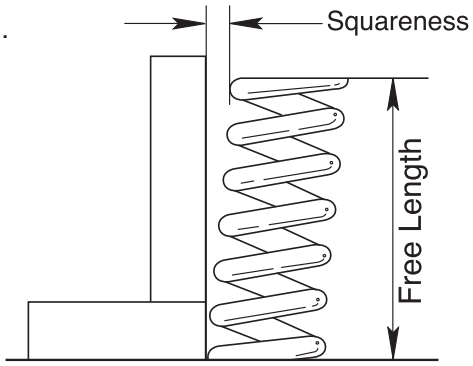
d. Lap the valve seat contact surface by applying compound to valve seat and rotating the lapper.
e. Check to see that the valve contact surface is within standard value and that contact position is not tilted.



L2046

4 a. Check the valve springs visually for presence of damage.
b. Using a square, measure the spring squareness on surface and replace any that are found to exceed the service limit.

	Ass'y std.	Svc. Limit
Squareness (mm)	1.0	1.2
Free Height (mm)	33	31.5
Spring Force (when compressed to 28.3 mm) Kg	6.0	6.0



L2047

5 Combustion Chamber Inspection
Check and clean the combustion chamber interior.

ASSEMBLY

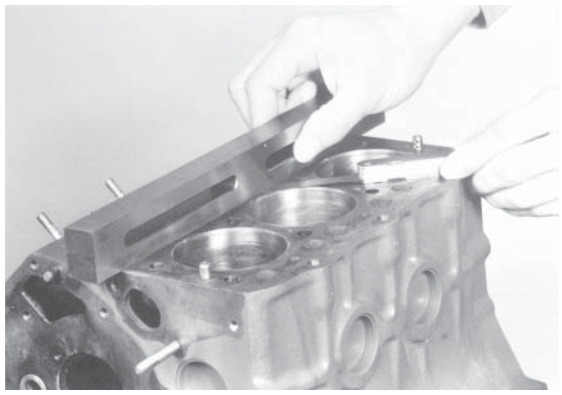
Assemble by performing the disassembly in reverse order, and using care on the following points: When assembling the valves, springs, retainers, and cotters, use care not to damage the valve guide seal.

Cylinder Block

INSPECTION AND SERVICING

1 Check for cracks, damage, block top surface warpage by methods corresponding to those for the cylinder head.

CYLINDER BLOCK TOP SURFACE WARPAGE (mm)	
Assembly Standard Value	Service Limit
0.05 maximum	**0.12**



L2048

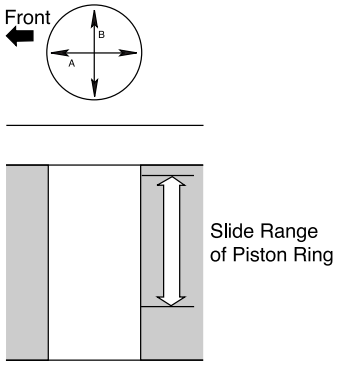
2 Cylinder Bore (inner diameter) Measurement

a. When checked visually, the cylinder bore should be free from scoring, rusting, and corrosion.

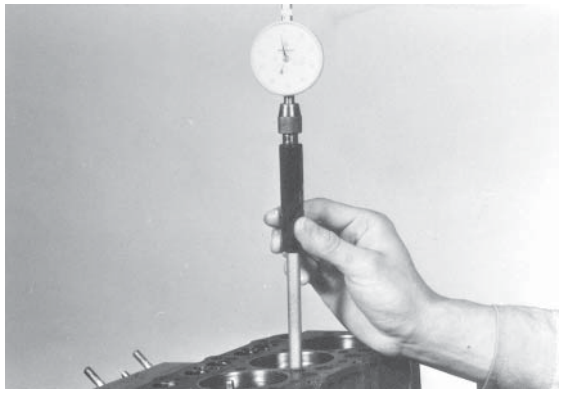
b. The cylinder bore measurement should be made by measuring the upper, middle, and lower parts respectively in crankshaft direction (A) and at right angle direction (B). If over service limit, bore the cylinder.

c. Bore upper part shall be at top ring position when piston is at top dead center and about **10 mm** from cylinder block top surface. Bore lower part at oil ring position at bottom dead center and about **100 mm** from top surface.

d. Measuring should be done with a cylinder gauge (inside dial indicator) which should be properly contacted at right angle to bore wall.



L2049



L2050

Assembly Standard Value	Repair Required Value
67 - 67.019 mm	**67.2 mm**

1st Boring
0.25 mm

Assembly Standard Value	Repair Required Value
67.25 - 67.269 mm	**67.45 mm**

2nd Boring
0.25 mm

Assembly Standard Value	Repair Required Value
67.5 - 67.519 mm	**67.7 mm**

Replace cylinder block

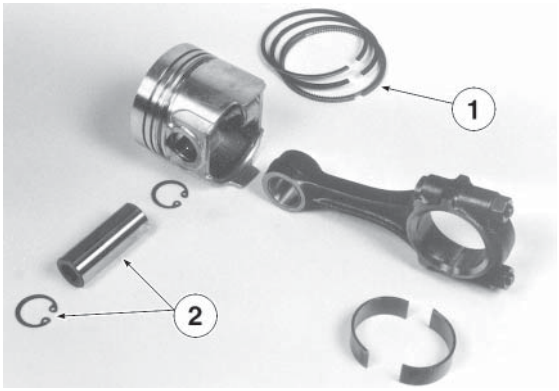
Piston and Piston Rings

DISASSEMBLY

1 Use piston ring tool and remove piston rings.

2 Remove snap rings and pull out piston pin.

NOTE:
Combine pistons, piston pins, and connecting rods in the order of cylinders when storing them.



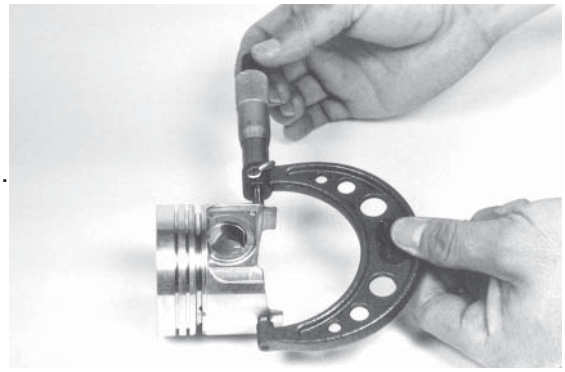
L2051

INSPECTION AND SERVICING

1 Piston

a. Check piston perimeter and replace if cracked, scored, or burnt.

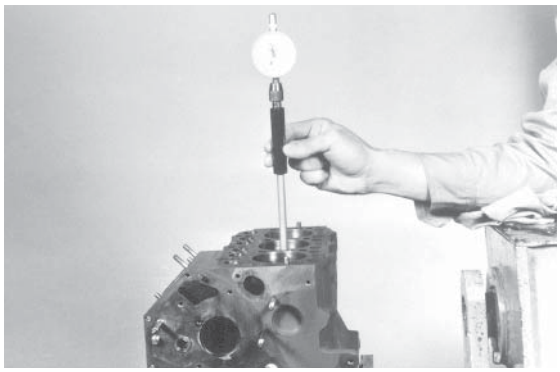
b. Measure long diameter at **10 mm** above piston skirt lower end and cylinder bore at thrust direction. Calculate the clearance and replace piston if over service limit.



L2052

CYLINDER AND PISTON CLEARANCE (mm)	
Assembly Standard Value	Service Limit
0.048 - 0.082	**0.25**

PISTON SKIRT BOTTOM LONG DIAMETER (mm)	
Assembly Standard Value	Service Limit
66.9375 - 66.9525	**66.7**



L2053

c. Measure the piston pin hole diameter and piston pin outside diameter, and replace in case the clearance exceeds the service limit.

L2054

PISTON PIN HOLE TO PISTON PIN CLEARANCE (mm)	
Assembly Standard Value	Service Limit
-0.004 - +0.004	**0.02**

Piston and Piston Rings

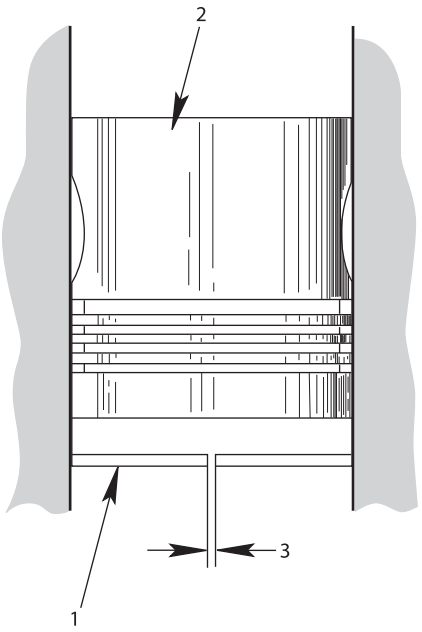
INSPECTION AND SERVICING

2 Piston Rings

a. Replace piston ring if found to be worn or damaged.

b. Insert ring at right angle into cylinder at skirt part where wear is smallest and measure end gap with thickness gauge. Replace if end gap exceeds the service limit.

PISTON RING END GAP (mm)		
	Assembly Std. Value	Service Limit
First Ring	**0.13 - 0.25**	**1.0**
Second Ring	**0.10 - 0.22**	**1.0**
Oil Ring	**0.10 - 0.30**	**1.0**



1. Piston Ring
2. Piston
3. End Gap

L2055

c. Measure the clearance between piston ring groove and ring. Replace if over the service limit.

PISTON RING GROOVE TO RING CLEARANCE (mm)		
	Assembly Std. Value	Service Limit
First Ring	**0.06 - 0.10**	**0.25**
Second Ring	**0.05 - 0.09**	**0.25**
Oil Ring	**0.02 - 0.06**	**0.15**

L2056

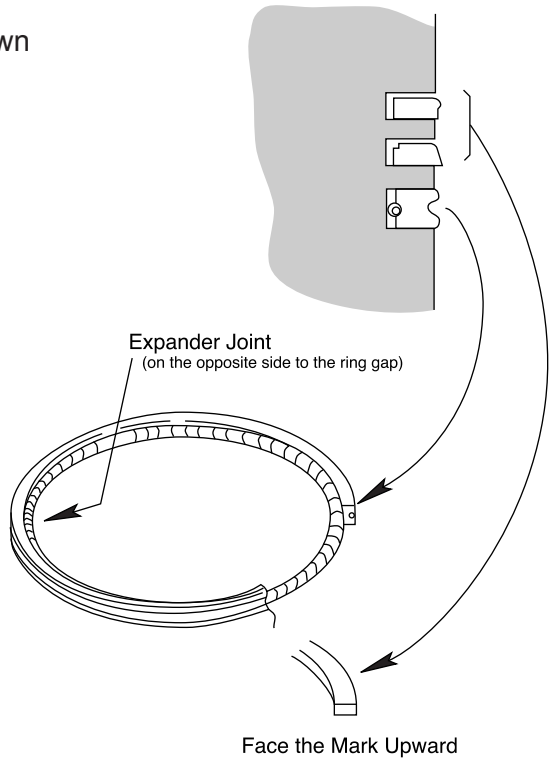
d. In case the cylinder block has been made oversize, use oversize piston ring set.

PISTON RING SIZE	PART CODE NUMBER
S.T.D.	**115107400**
O.S. 0.5	**115107410**

Piston and Piston Rings

INSPECTION AND SERVICING

e. Piston Ring Assembly Procedure
Assemble the piston rings on the piston as shown in the figure at right.



L2057

3 Piston Pin
Measure piston pin outside diameter and replace if service limit is exceeded.

PISTON PIN OUTSIDE DIAMETER (ø)	
Assembly Standard Value	Service Limit
18.998 - 19.002	**19.98**

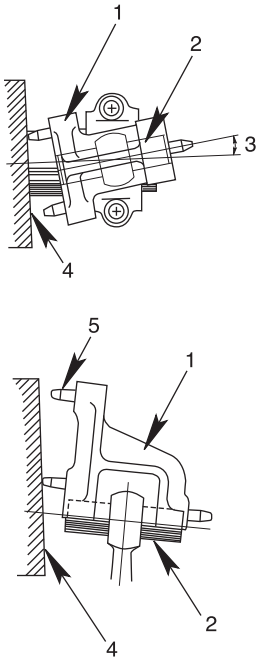
L2058

Connecting Rod

INSPECTION AND SERVICING

1 Inspect for twisting, flatness, and damage. Use connecting rod aligner and measure the twisting and flatness, and repair or replace in case repair required value is exceeded.

CONNECTING ROD TWIST & FLATNESS (mm)		
	Assembly Std. Value	Repair Required
Value Twist (per 100 mm)	**0.08 maximum**	**0.2**
Flatness (per 100 mm)	**0.05 maximum**	**0.15**



1. Gauge
2. Piston Pin
3. Twisting
4. Aligner Flatness
5. Pin

L2059

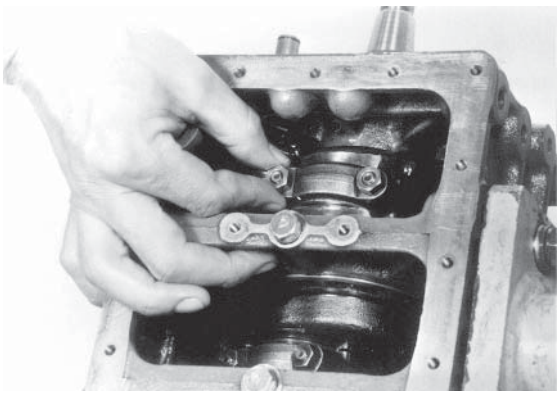
2 Measure connecting rod small end bushing bore and replace if its clearance with piston pin exceeds the service limit.

BUSHING TO PISTON PIN CLEARANCE (mm)	
Assembly Standard Value	Service Limit
0.013 - 0.028	**0.08**

L2060

3 Assemble connecting rod to crankshaft and measure its axial play. If over the service limit, replace the connecting rod.

CONNECTING ROD TO CRANKPIN PLAY (mm)	
Assembly Standard Value	Service Limit
0.1 - 0.3	**0.7**



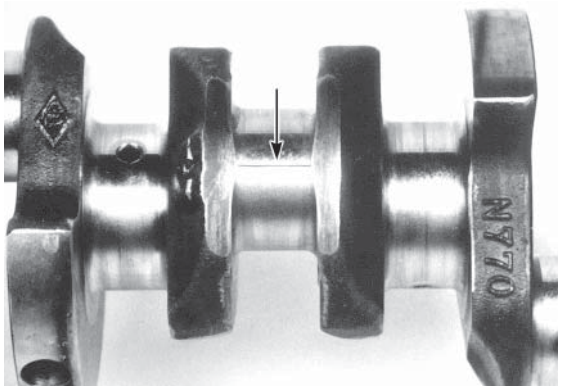
L2061

Connecting Rod Bearing

INSPECTION AND SERVICING

1 Check the bearings and replace any if found peeling, fused, stepped, or showing defective contact.

2 Using Plastigage, measure the oil clearance between crankpin and bearing.
a. Remove oil and dirt adhering to crankpin and bearing.
b. Cut Plastigage to same length as bearing width and place it on crankpin parallel to crankshaft and avoiding oil holes.
c. Assemble connecting rod bearing and connecting rod cap and tighten to specified torque.

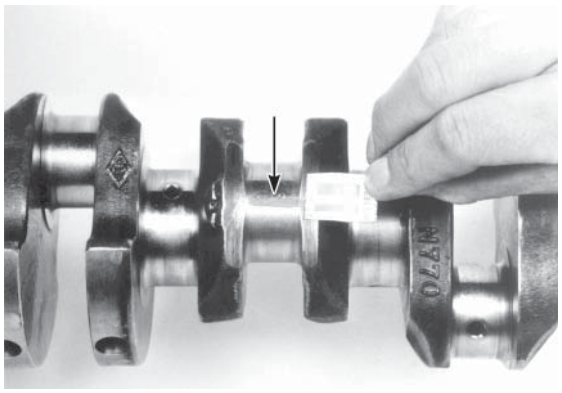


L2062

Tightening Torque	**2.1 - 2.6 kgf-m**

NOTE:
Do not turn connecting rod at this time.

d. Remove connecting rod cap and measure Plastigage width with scale printed on gauge envelope.



L2063

NOTE:
Measure the widest point.

3 In case oil clearance is found to have exceeded the service limit, replace bearing or grind crankpin and replace with undersize bearing.

CRANKPIN TO CONNECTING ROD BEARING CLEARANCE (Oil Clearance) (mm)	
Assembly Standard Value	Service Limit
0.031 - 0.079	**0.2**

Bearing Size	Bearing Code Number	Crankshaft Pin Outside Diameter Finished Size (ø)
S.T.D.	**198517310**	**34.964 - 34.975**
U.S. 0.25	**198517314**	**34.714 - 34.725**
U.S. 0.50	**198517317**	**34.464 - 34.475**

NOTE:
1. In case of grinding crankshaft pin outside diameter, assemble after checking oil clearance.
2. To ensure grinding crankpin to prescribed accuracy, refer to the crankshaft article.

Connecting Rod Bearing

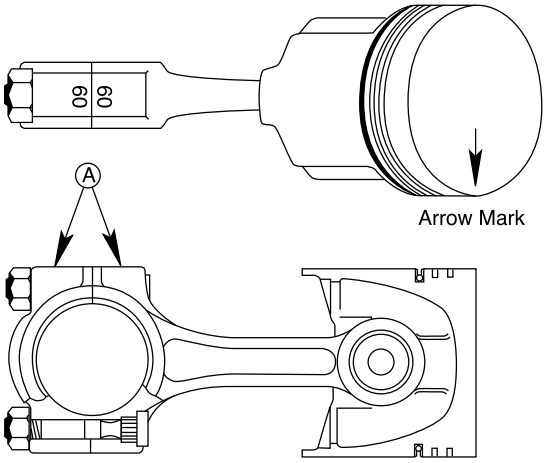
ASSEMBLY

1 Assemble the piston and connecting rod as shown at right (with the arrow mark positioned on the front side and the Mark A on the injection pump side).

2 Note that there are number match marks at the part of the connecting rod marked “A”.

3 Assemble the piston rings on the piston with gap end marks positioned upward.

4 In case the connecting rod or piston and piston pin is replaced, after completing the assembly of rods, pistons, piston rings, and other parts for all cylinders, the weight difference between cylinders shall be within 10 grams.



L2064

Bearing Holder

INSPECTION AND SERVICING

Center Bearing

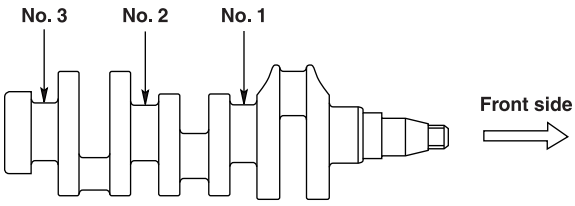
1 Remove bearing holder and replace bearing if found to be peeled, fused, ridged, or showing defective contact.

2 Using Plastigage, measure oil clearance between crankshaft center bearing.

3 In case oil clearance is found to have exceeded the service limit, replace bearing or grind crankshaft and replace with undersize bearing.

L2065

CLEARANCE BETWEEN CRANKSHAFT CENTER JOURNAL AND BEARING (Oil Clearance) (mm)			
Journal No.	Assembly Std. Value		Service Limit
No. 1, 2	**0.035 - 0.088**		**0.2**
No. 3	**0.039 - 0.092**		**0.2**
Metal Size	Journal No.	Metal Part Code No.	Crankshaft Journal Finished Size
S.T.D.	No. 1, 2	**198517330* 198517340**	**42.964 - 42.975**
	No. 3	**198517101* 198517110**	**45.964 - 45.975**
U.S. 0.25	No. 1, 2	**198517334* 198517344**	**42.714 - 42.725**
	No. 3	**198517104* 198517114**	**45.714 - 45.725**
U.S. 0.50	No. 1, 2	**198517337* 198517347**	**42.464 - 42.475**
	No. 3	**198517108* 198517117**	**45.464 - 45.475**



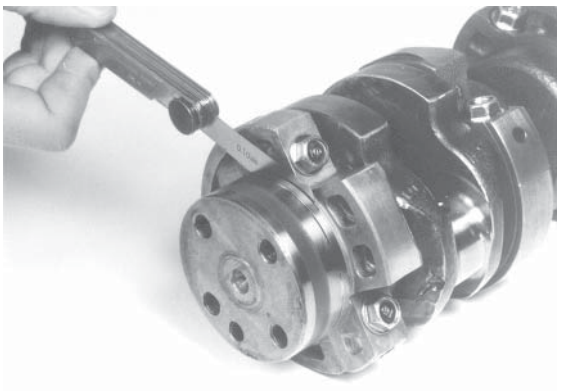
L2066

***Indicates upper metal**

Side Clearance

Measure the clearance between the crankshaft and bearing holder. Replace if the service limit is exceeded.

CRANKSHAFT - BEARING HOLDER CLEARANCE (mm)	
Assembly Standard Value	Service Limit
0.1 - 0.3	**0.5**



L2067

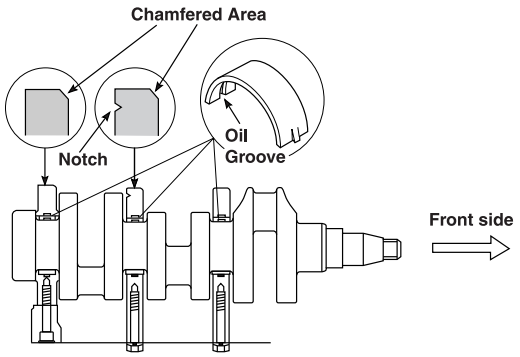
Bearing Holder

ASSEMBLY

1 Facing the large chamfered part to the front side, position the aluminum bearing holder on the flywheel side and cut-identified one on the center (install the holder without cut identification on the front side).

BEARING HOLDER TIGHTENING TORQUE (kgf-m)	
No. 1, No. 2	**2.0 - 2.5**
No. 3	

2 Assemble the bearing with oil groove at upper and the bearing without oil groove at lower side.



L2068

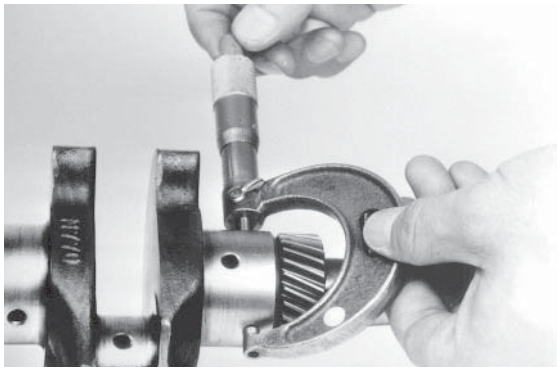
Crankshaft Bearing (Bushing)

1 Inspect bearing (bushing) and replace if found to be peeled, fused, burnt, or contacting defectively.

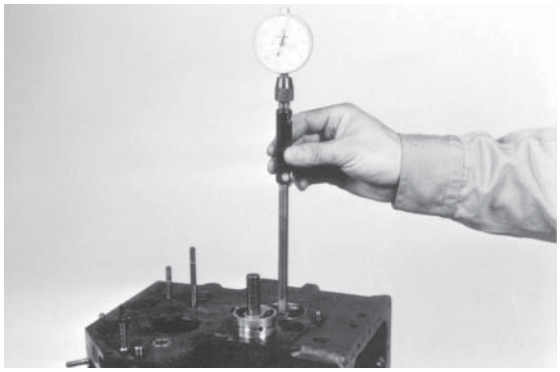
2 Using cylinder gauge and micrometer, measure oil clearance between bearing (bushing) and crankshaft journal.

3 In case oil clearance is found to have exceeded service limit, replace bearing (bushing) or grind crankshaft journal and utilize undersize bearing (bushing).

CLEARANCE (Oil Clearance) BETWEEN CRANKSHAFT JOURNAL AND BEARING (Bushing) (mm)	
Assembly Standard Value	Service Limit
0.035 - 0.102	**0.2**



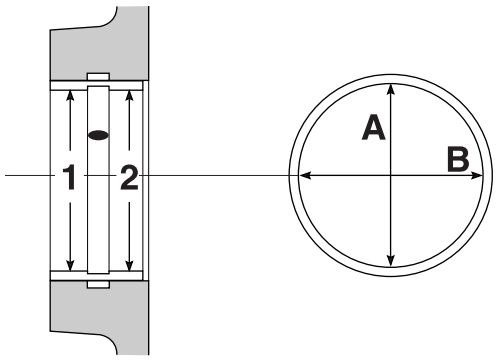
L2069



L2070

Bushing Size	Bushing Code Number	Crankshaft Journal Outside Diameter Finished Size (ø)
S.T.D.	**198517300**	**42.964 - 42.975**
U.S. 0.25	**198517304**	**42.714 - 42.725**
U.S. 0.50	**198517307**	**42.464 - 42.475**

NOTE:
1. As shown at right, measure bearing (bushing) in A and B directions at positions 1 and 2, avoiding oil holes, and calculate maximum difference (oil clearance) with crankshaft journal.
2. When replacing bushing, force it in with press.
3. In case crankshaft journal is ground, check oil clearance before assembling.

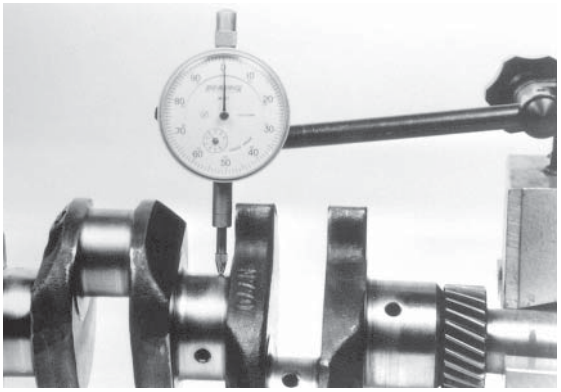


L2071

Crankshaft

INSPECTION AND SERVICING

1 As shown at right, measure crankshaft deflection by supporting the crankshaft on V-blocks and setting dial indicator on crankshaft journal. Slowly turn the shaft once and read the deflection on dial indicator. If over the repair required value, repair or replace.



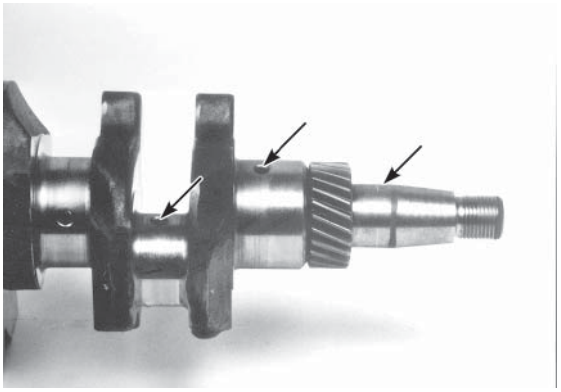
L2072

2 Inspect for damage or wear at crankshaft oil seal contacting surface, and for clogging in oil holes.

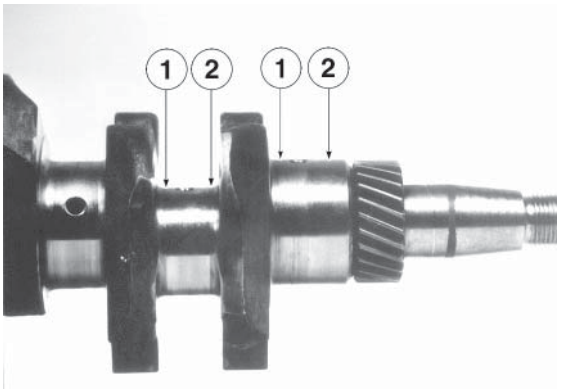
CRANKSHAFT DEFLECTION (mm)	
Assembly Standard Value	Repair Required Value
0.03 maximum	**0.06**

3 Check the crankshaft journals and crankpin parts for damage, eccentric wear (over or tapered), and shaft diameters. In case service limit - repair required value is exceeded, grind the journal and crankpin parts and utilize undersize bearing (bushing) and con-rod bearings.

Avoid oil holes, measure journal and pin at positions 1 and 2, in AA and BB directions.



L2073

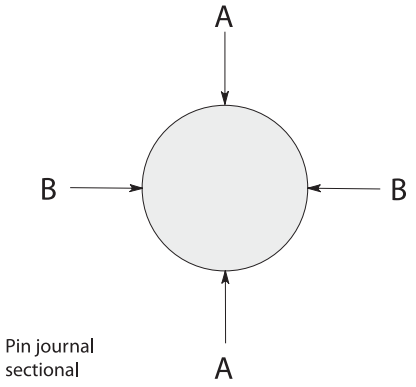


L2074

ECCENTRIC WEAR LIMIT AT CRANKSHAFT JOURNAL AND PIN **0.05 mm**			
CRANKSHAFT JOURNAL SHAFT DIAMETER (ø)			
		Assembly Standard Value	Repair Required Value
S.T.D.	No. 1, 2	**42.964 - 42.975**	**42.90**
	No. 3	**45.964 - 45.975**	**45.90**
U.S. 0.25	No. 1, 2	**42.714 - 42.725**	**42.65**
	No. 3	**45.714 - 45.725**	**45.65**
U.S. 0.50	No. 1, 2	**42.464 - 42.475**	**42.40**
	No. 3	**45.464 - 45.475**	**45.40**

CRANKSHAFT PIN DIAMETER (ø)		
	O.D. Finished Size	Repair Required Value
S.T.D.	**34.964 - 34.975**	**34.90**
U.S. 0.25	**34.714 - 34.725**	**34.65**
U.S. 0.50	**34.464 - 34.475**	***34.40**

***Replace crankshaft if U.S. 0.50 is exceeded.**



Pin journal sectional

L2075

Crankshaft

INSPECTION AND SERVICING

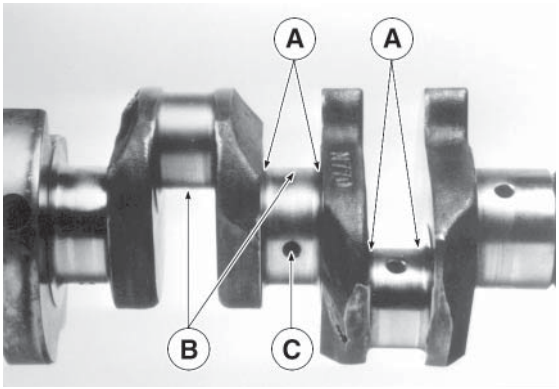
NOTE:
When machining crankshaft to undersize, finish accuracy should be as follows:

A R at pin journal **3 mm** ± 0.2 mm

B Finish accuracy 1.6Z (▽▽▼)

C R at oil hole edge 2R at maximum part
0.5R at minimum part.

Finish with #400 sandpaper.
Lapping shall be performed successively in rotating direction.



L2076

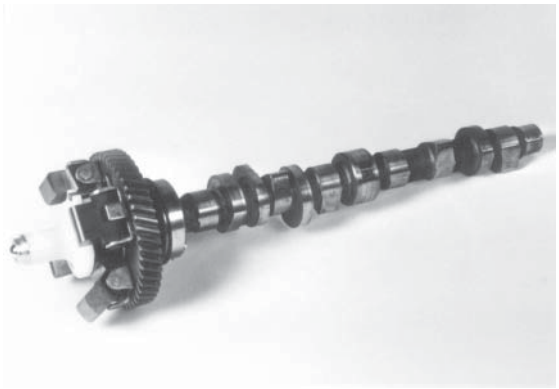
Camshaft Assembly

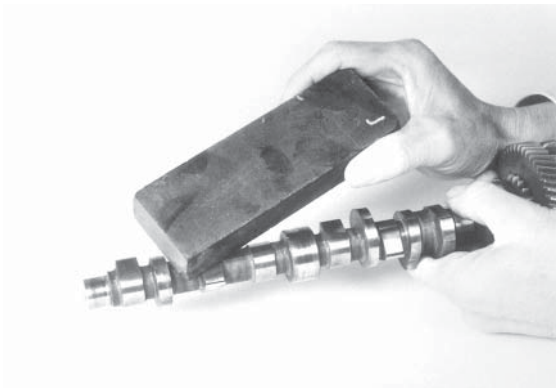
INSPECTION AND SERVICING

1 Inspect the journals and cams and if found to have exceeded the service limit, replace camshaft.

2 In case of small ridges or injuries on cam surface, repair with oil stone.

CAM HEIGHT (mm)		
Assembly Standard Value		Service Limit
Intake/Exhaust Side	**26.565 - 26.620**	**26.1**
Feed Pump Side	**27.900 - 28.000**	**27.0**
Injection Pump Side	**34.480 - 34.520**	**34.3**


L2077


L2078

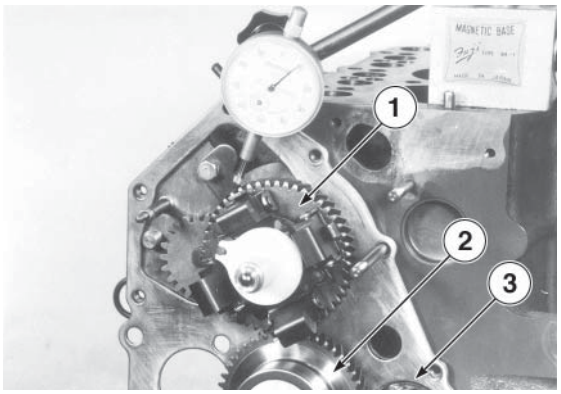
Timing Gear

INSPECTION AND SERVICING

1 Replace any timing gear found with gear surface pitted or worn excessively.

2 Measure the backlash at each gear and replace if exceeding the service limit.

TIMING GEAR BACKLASH (mm)	
Assembly Standard Value	Service Limit
0.08	**0.25**



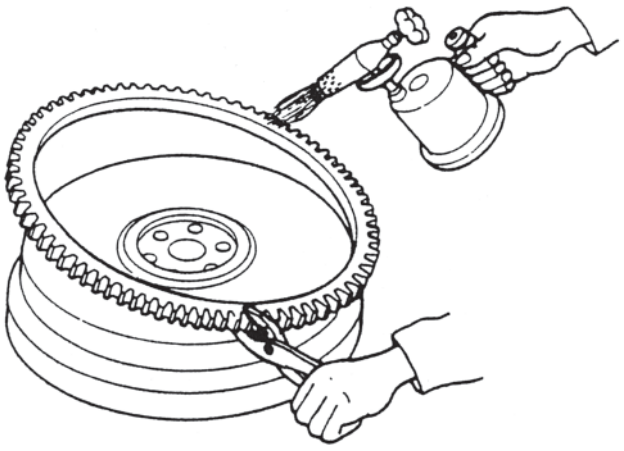
L2079

1. Camshaft gear
2. Idle gear
3. Crankshaft gear

Flywheel and Ring Gear

INSPECTION AND SERVICING

1 Inspect the ring gear and replace if found to be damaged or worn excessively. If worn at very limited part, it can be reused by removing it and replacing it rotated about 90° and then flame fitting. Flame fitting the ring is done by heating and expanding it at 120° to 150° C.



L2080

Oil Pump

DISASSEMBLY

Removal from Engine

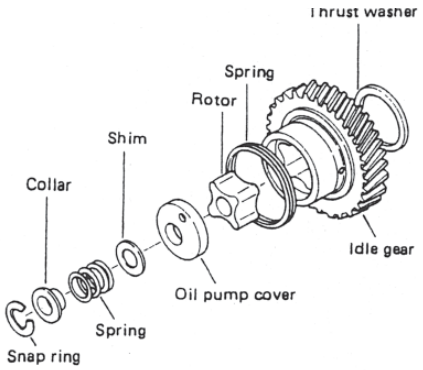
1 Remove snap ring.

2 Take out collar, spring, and shim.

3 Take out idle gear, vane, and oil pump cover together in one unit.

4 Pull out rotor and thrust washer.

5 Pull out oil pump cover from idle gear.



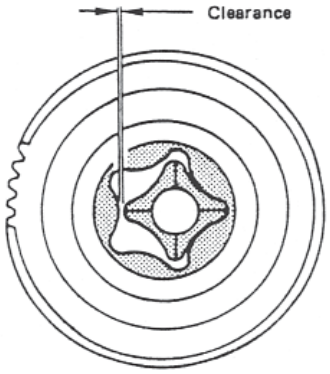
L2081

INSPECTION AND ASSEMBLY

1 Inspect oil pump cover, rotor, and vane, and replace any found badly worn or damaged.

2 In case the clearance (tip clearance) between the rotor and vane exceeds the service limit, replace them.

3 Assemble by performing disassembly in reverse order.
1. Assemble the crankshaft gear and idle gear with their match marks aligned.
2. Adjust the rotor and vane so as to provide **0.1 - 0.15 mm** side clearance (refer to the paragraph of Engine Assembly, p. 40).



L2082

Oil Filter

CONSTRUCTION AND FUNCTION

1 This is a cartridge type oil filter and has good filtering performance.

2 This is full flow type so that in case the filter becomes clogged, the safety valve actuates to continue the oil flow.

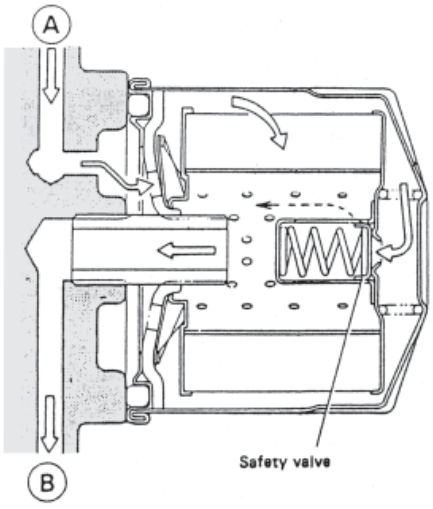
3 Oil sent under pressure by the oil pump enters at part A, passes through part B to lubricate the various parts. In case the element becomes clogged, oil is supplied to the various parts without passing through the element.

Replacement

1 Replace every 250 hours.

2 Apply oil on filter mounting surface and tighten by hand.

3 If removed at any time, do not re-install and use.



L2083

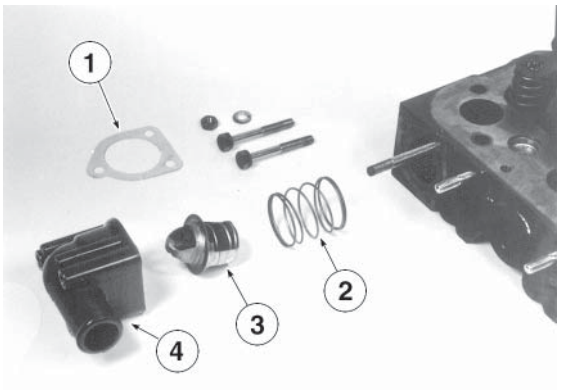
Thermostat

DISASSEMBLY

1 Remove the bolts mounting the thermostat cover to the cylinder head or exhaust manifold on marine engine.

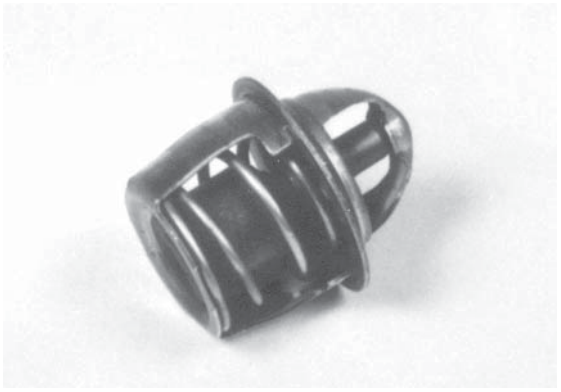
2 Remove the thermostat from the thermostat case.

1. Gasket
2. Spring
3. Thermostat
4. Thermostat Cover



L2084

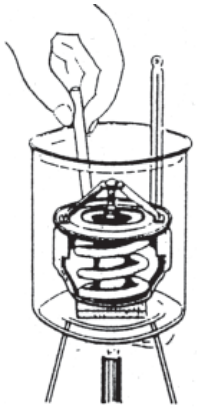
SPECIFICATION	
Type	Wax Pellet Type
Opening Temperature	**73° - 77° C**
Full Open Temperature	**87° C**
Valve Lift (at 85°C water temperature)	**6.0 mm**



L2085

Replace even if only slightly opened at normal temperature. Immerse thermostat in water, raise water temperature gradually and check opening temperature and valve lift.

NOTE:
In case of inspection, it takes the valve **3 - 5** minutes to open.



L2086

ASSEMBLY

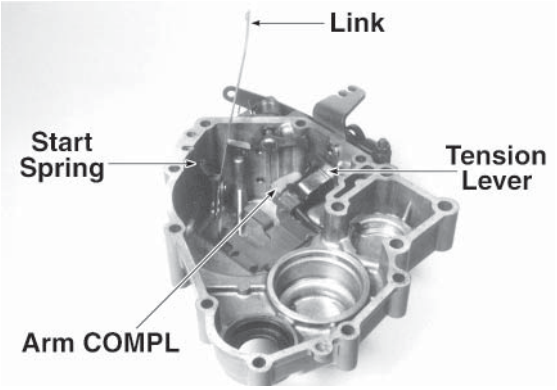
Assemble by performing the disassembly in reverse order.

Governor

CONSTRUCTION AND FUNCTION

1 This is a mechanical, all-speed governor equipped in the gear case. Its main component consists of a flyweight assembly mounted on the camshaft. Flyweight movement is transmitted to the injection pump control rack through slide, control lever, and link. The spring that controls the flyweight movement is hooked on to the arm assembly and tension lever.

By varying the governor lever angle, the spring tensile force is changed to enable controlling of the engine speed.



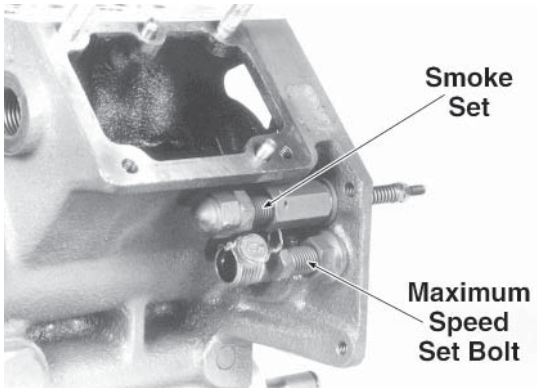
L2087

2 Maximum RPM Set Bolt
No-load maximum speed is restricted by the arm assembly hitting the bolt installed in the cylinder block. (After completing adjustment at the factory, this set bolt is sealed.)

3 Smoke Set and Start Spring
The smoke set, equipped with an angular ratio spring, is installed in the cylinder block and serves to restrict fuel injection quantity at high speed rotation zone and to increase fuel injection quantity for large torque (drive power) at middle speed range.

The start spring is installed between the gear case and link, to automatically increase the fuel injection at the start.

The smoke set has already been adjusted at the factory.



L2088

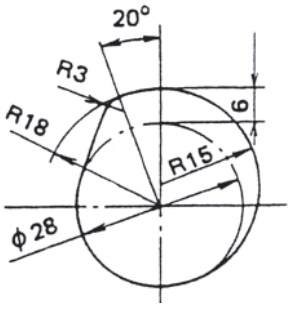
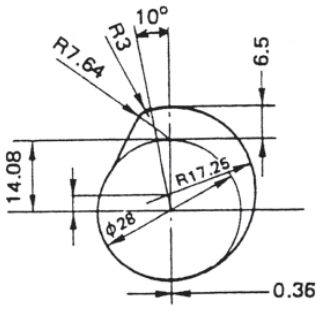
Injection Pump

SPECIFICATIONS

DISASSEMBLY - INSPECTION - ASSEMBLY

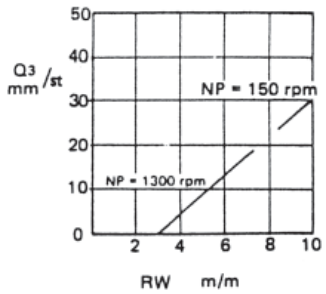
Injection Pump Disassembly, Inspection, and Assembly
If the trouble has been verified to be in the injection pump, do not disassemble other than at a shop specializing in this operation.

INJECTION PUMP ADJUSTMENT CONDITIONS

INJECTION PUMP ADJUSTMENT CONDITIONS		
	Adjustment Conditions	Actual Vehicle Conditions
Nozzle Used	ND - DN12SD12A	ND - DN4PD43
Valve Opening Pressure	**175±5 kg/cm²**	**120±5 kg/cm²**
Injection Pipe	outer diameter ø **6** x inner diameter ø **2** x length **600 mm**	outer diameter ø **6** x inner diameter ø **1.6** x length **260 mm**
Fuel Feed Pressure	**1.0 kg/cm²**	**0.2 kg/cm²**
Cam Profile	 L2089 Adjustment Cam Profile	 L2090 Actual Vehicle Cam Profile
Injection Characteristics		

NP rpm	RW mm	Q mm³/st	Δq
1300	X	8 ± 2	1.3
1300	1.0	0	–
150	MAX	31 ± 5*	–

* Reference value.



L2091

Nozzle and Holder

SPECIFICATIONS

Nozzle	Nozzle Type	Throttle Type
	Needle Valve Diameter	ø **3.5**
	Pintle Diameter	ø **1**
Nozzle Holder	Valve Opening Pressure	**115 - 125 kg/cm²**
	Adjusting Pressure	**125 - 130 kg/cm²**
Nozzle	Injection Angle	**4°**

INSPECTION AND SERVICING

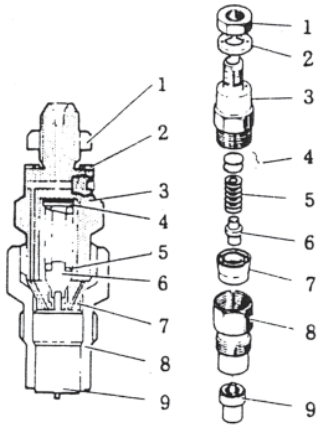
1 Clamp the nozzle holder (body) in vise and disassemble by turning the nozzle out.

NOTE:
When taking off the nozzle, use care not to allow the needle valve to drop out.

2 Wash the nozzle and needle valve, and check for burning and sticking of nozzle, and for fuel leakage from seat. Repair fuel leakage at seat by lapping.

3 Check the upper and lower contacting surfaces of distance piece and correct by lapping to ensure complete contact.

4 Check the push rod for wear at the surface where nozzle needle valve is contacted, and also at spring seat part for crack.



1. Nut
2. Gasket
3. Body
4. Shim
5. Spring
6. Rod
7. Piece
8. Nozzle nut
9. Nozzle

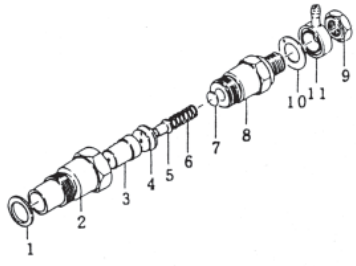
L2092

ASSEMBLY

1 When assembling the new part nozzle assembly, remove rust preventative agent with light oil heated to around **50°** to **60°C** and slide together the body and needle valve until they slide smoothly and lightly.

2 When assembling, set the body upside down and place in the order of the shim, spring, rod piece, and nozzle. Fit on the nozzle nut and tighten.

3 After assembling, check nozzle injection pressure.
a. Using nozzle tester, vary the adjusting washers (shims) so as to have injection start at **120 kg/cm²**.
b. About **10 kg/cm²** increase or decrease can be made with **0.1 mm** washer.



1. Gasket
2. Nozzle nut
3. Nozzle
4. Piece
5. Rod
6. Spring
7. Shim
8. Body
   Tightening torque:
   3.5 – 4.0 kgf-m
9. Nut
   Tightening torque:
   2.5 – 3.0 kgf-m
10. Gasket
11. Eye

L2093

Nozzle and Holder

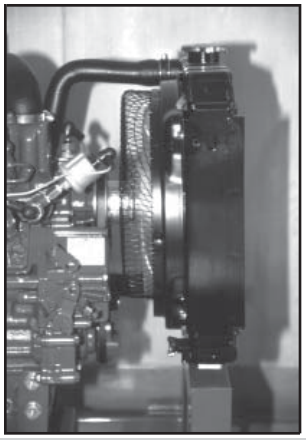
ASSEMBLY

4 a. Spray shall be free from small droplets.
b. Shall be injected in uniform straight line cone shape with nozzle as center line.
c. Place white paper about **30 cm** distant at injection and check injection pattern to see if nearly circular.
d. Maintain oil pressure that is **20 kg/cm^2** lower than designated pressure (**120 kg/cm^2**) and check nozzle tip for dripping of test oil.

Radiator

SPECIFICATIONS

Fin Type	Corrugated
Cooling Water Capacity	**3.3 liters**
Pressure Valve Actuating Pressure	**0.7 - 0.9 kg/cm²**
Negative Pressure Actuating Pressure	**0.04 - 0.05 kg/cm²**



L2094

INSPECTION

1 Check radiator pipe for water leakage and repair or replace and found defective.

2 Check the radiator fins and remove any dust, dirt, or foreign matter found clogging the air passages.

3 Check the radiator cap pressure and negative pressure valves for valve opening pressures and tightness states, and replace if found defective.

4 Check radiator hoses, and replace any found damaged or deteriorated.

5 If the net is found to be clogged, remove and wash, and clean.

Air Cleaner

INSPECTION AND SERVICING

1 After every 25 hours of operation, take out the element and clean by blowing in compressed air (7 kg/cm2 max.) from inner side.

2 In case soot or oil is found adhered on element, soak for about 15 minutes in detergent solution, and after washing several times, rinse thoroughly with clean water. Then use after allowing to dry naturally.

3 When used in dusty places, clean earlier than usual.

4 Replace with new element once every year.

5 After cleaning, shine a light from the element if found to be torn, developed pin holes, or have specially thin places. Also, replace gasket if damaged.

6 Never use any element that is not sufficiently dry.

L2095

Fuel Filter

INSPECTION

If water, dirt, or other foreign matter are found in transparent plastic cup, clean out and if required, replace the element.

INSPECTION AND SERVICING

1 Remove filter ring nut by turning it counter-clockwise.

NOTE:
Use care not to loosen the O-ring between the ring nut and main body when installing, and apply grease when tightening.

2 Apply grease where element contacts main body, and tighten on by hand.

Water Pump Assembly

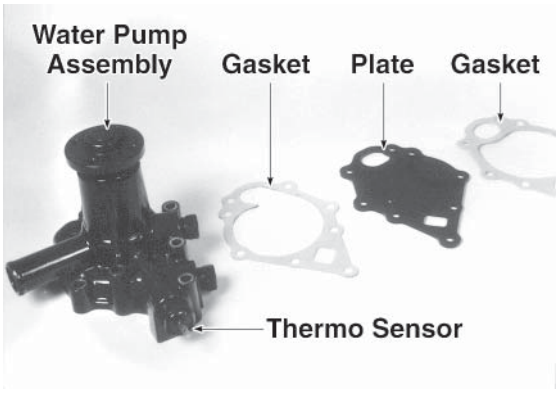
INSPECTION

Replace the assembly when water leakage or abnormal sound (from defective bearing) is noticed.

ASSEMBLY

1 Install the plate with a gasket inserted.

2 Install the thermosensor.



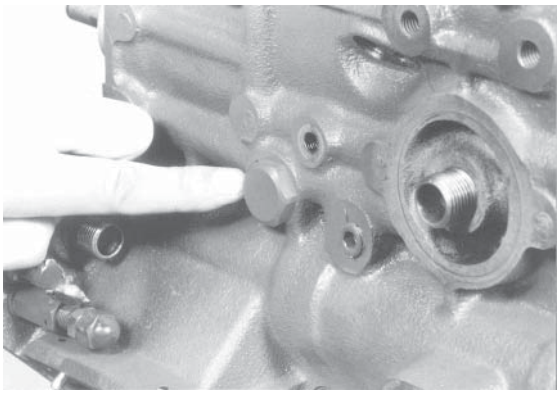
L2096

Assembling Engine

Precautions Before Starting Assembly

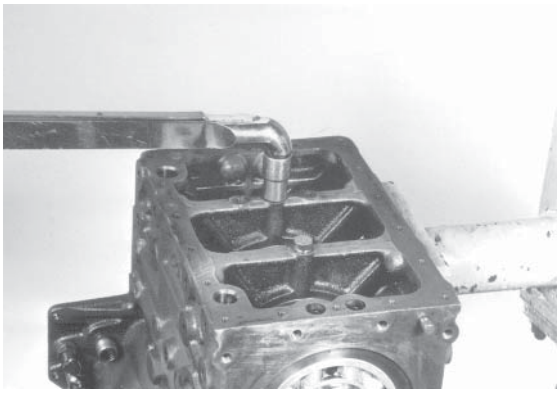
1. Wash all parts to be assembled (take special care on oil passages, bearings, pistons, and cylinder bores).
2. Apply new oil on the cylinder inner walls, and the sliding and rotating parts of pistons and bearings before assembling.
3. Replace gaskets and the like with new parts. Also, use liquid seal where required to prevent oil leakage.
4. On the bolts and nuts that are used on aluminum alloy parts, tighten to the specified torque without forcing.

SEQ.	ASSEMBLY PLACE	ASSEMBLY ESSENTIALS
1	Relief Valve Assembly	Assemble using O-ring. Relief Valve Tightening Torque: **6 - 7 kgf-m**



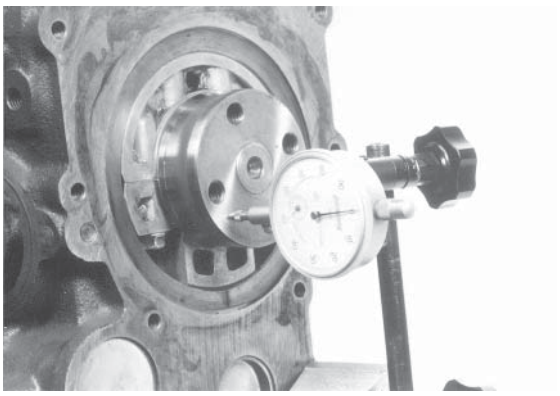
L2100

SEQ.	ASSEMBLY PLACE	ASSEMBLY ESSENTIALS
2	Crankshaft Bearing Holder Assembly	Mount bearing holders from behind the cylinder block and tighten with the bearing holder fixing bolt. Bearing Holder Tightening Torque: **2.5 - 3.0 kgf-m**



L2101

NOTE:
Use a reamer bolt for fixing the bearing holder only on the rear side.

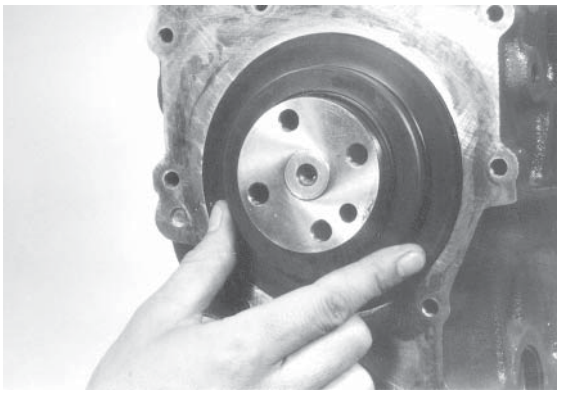


L2102

CRANKSHAFT AXIAL PLAY (mm)	
Assembly Standard Value	Repair Required Value
0.1 - 0.3	**0.5**

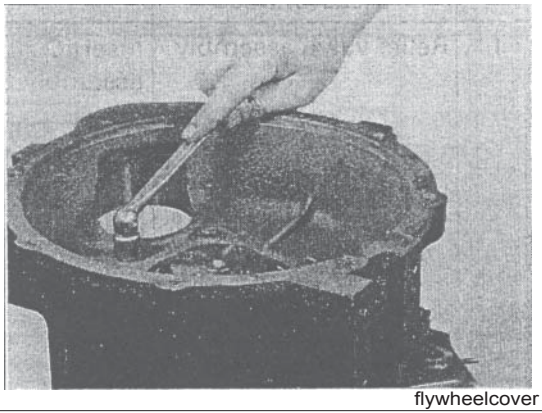
Assembling Engine

SEQ.	ASSEMBLY PLACE	ASSEMBLY ESSENTIALS
3	Oil Seal	Coat the oil seal lip with engine oil and install.



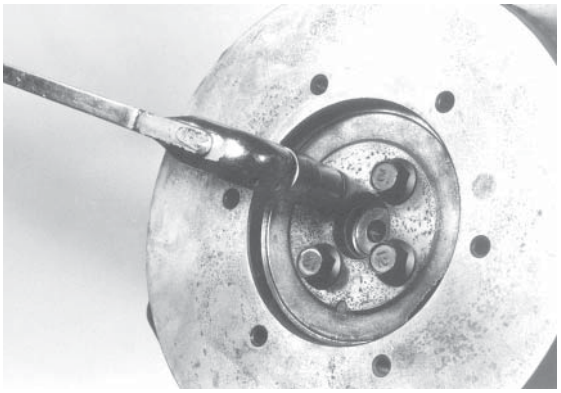
L2103

4	Flywheel cover	Apply sealant to entire mounting surface Flywheel cover Tightening Torque: **2.3 - 2.9 kgf-m** **17 - 21 lb•ft**



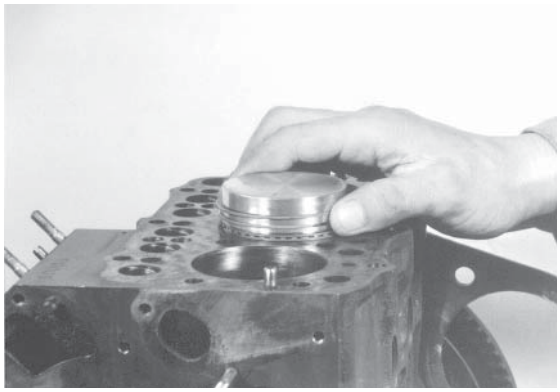
flywheelcover

5	Flywheel	Align to the offset hole and install the flywheel. Flywheel Tightening Torque: **7.0 - 8.0 kgf-m (51-58 lb•ft)**



L2105

6	Piston Connecting Rod	a. Apply engine oil on bearings, piston and piston rings. b. Rotate rings sufficiently to allow oil to get in ring grooves and space the ring end gaps **90°** apart, avoiding piston pin axial and radial directions. c. Insert the piston into cylinder, with the arrow mark on the head facing the front side.



L2106

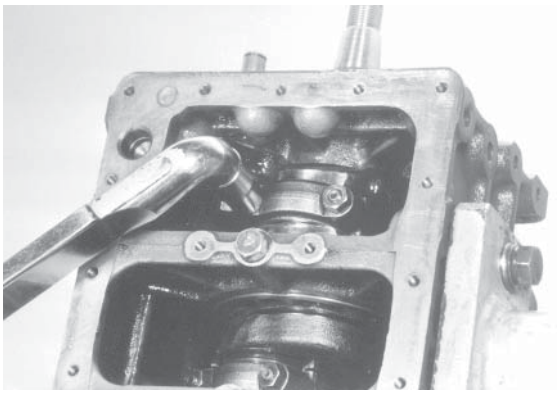
Assembling Engine

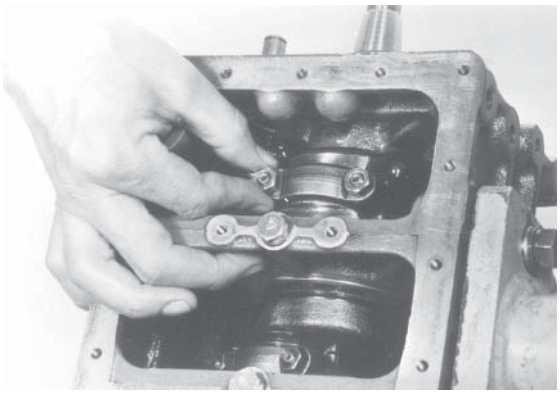
SEQ.	ASSEMBLY PLACE	ASSEMBLY ESSENTIALS

NOTE:
Install from front end in sequence from connecting rod match mark smallest number (figures on the injection pump side).

d. Tighten connecting rod cap to designated torque and check for presence of axial play.

Connecting Rod Tightening Torque:
2.1 - 2.6 kgf-m

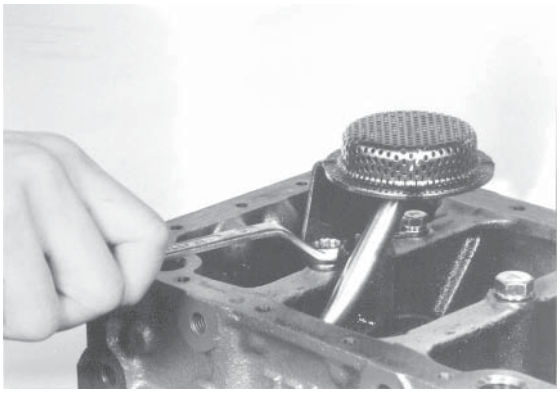

L2107


L2108

NOTE:
1. After tightening, check crankshaft to see that it turns lightly.
2. Axial direction movement shall be **0.1 - 0.3 mm**.

7 Suction Pipe and Suction Filter

a. Install O-ring on suction pipe and insert into cylinder block.


L2109

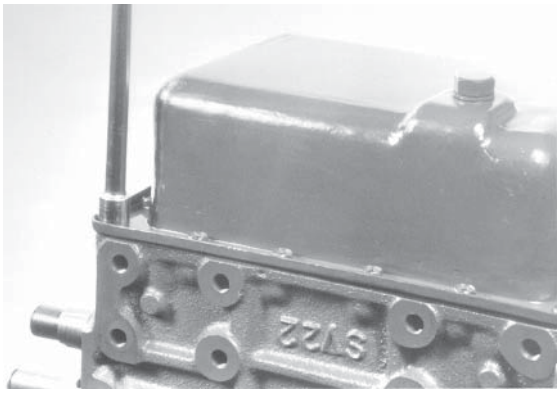
NOTE:
Do not insert excessively (O-ring may be broken).

b. Insert suction pipe end into suction filter and secure suction filter.

Suction Filter Tightening Torque:
0.9 - 1.3 kgf-m

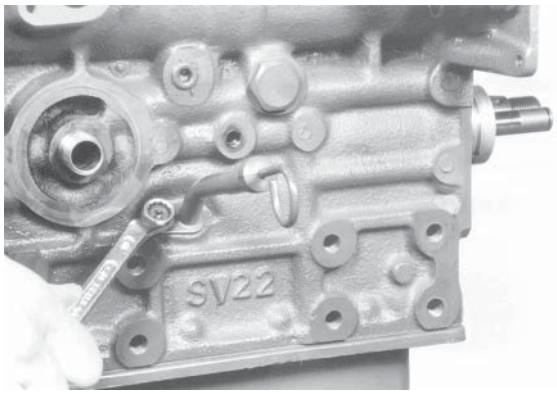
8 Oil Pan

Tighten the oil pan in over-and-across order.


L2110

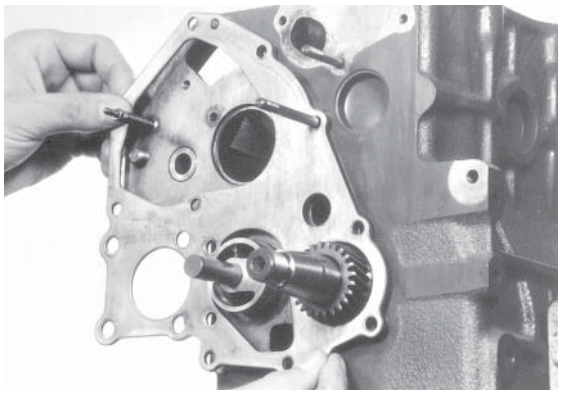
Assembling Engine

SEQ.	ASSEMBLY PLACE	ASSEMBLY ESSENTIALS
9	Oil Level Gauge Gauge Guide	



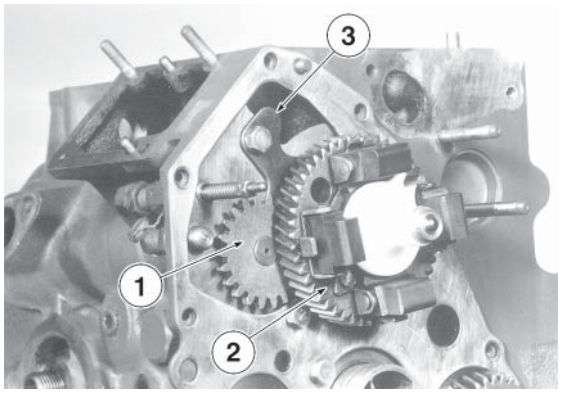
L2111

10	Front Plate	



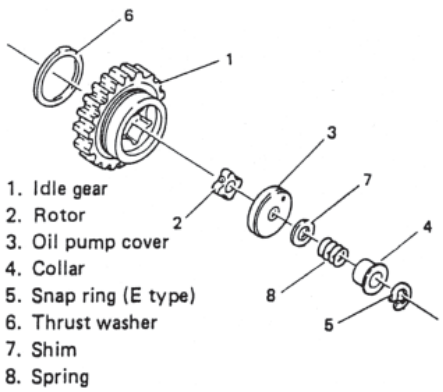
L2112

11	Camshaft Assembly	a. Install camshaft assembly. b. Secure camshaft assembly with plate. Plate Tightening Torque: **0.9 - 1.3 kgf-m**



L2113

12	Idle Gear Oil Pump Assembly	a. Install thrust washer on idle gear shaft. b. Align match mark on idle gear with those on crankshaft and camshaft gears, and install on idle gear shaft. c. Assemble on the rotor.

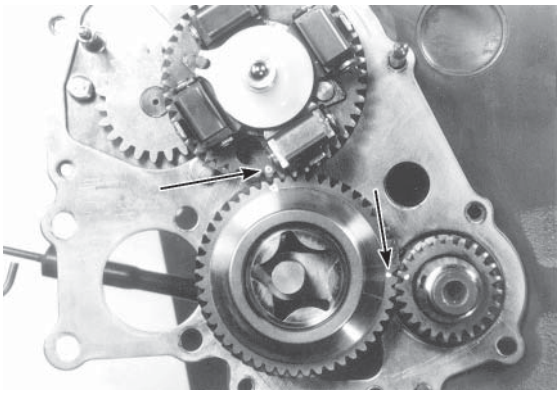


L2114

Assembling Engine

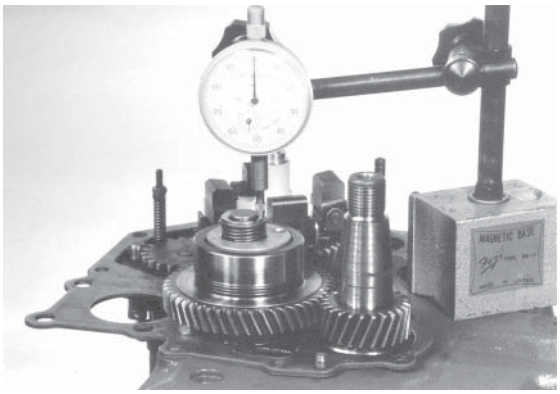
SEQ.	ASSEMBLY PLACE	ASSEMBLY ESSENTIALS

d. Install oil pump cover, shim, spring, and collar and tighten with snap ring.
e. Adjust the side clearance of the oil pump rotor vane to **0.1 - 0.15 mm** with shims.



L2115

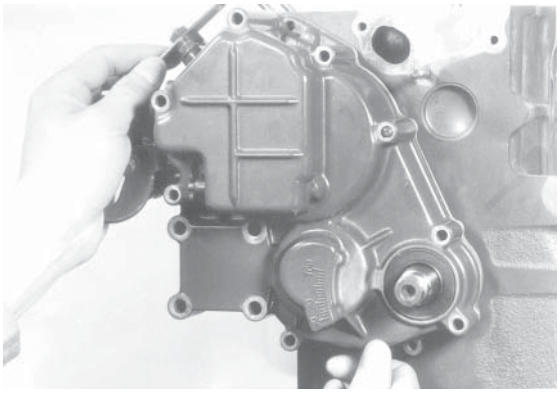
NOTE:
1. Apply grease to both sides of rotor and vane during assembly.
2. Never turn crankshaft until timing gear case is assembled.
3. Turn oil pump cover clockwise and counterclockwise, and set spring pin insertion hole at center motion limit before installing timing gear case.



L2116

13 Timing Gear Case

a. Install start spring.
b. Install while inserting link into cylinder block hole and using care not to damage the oil seal.

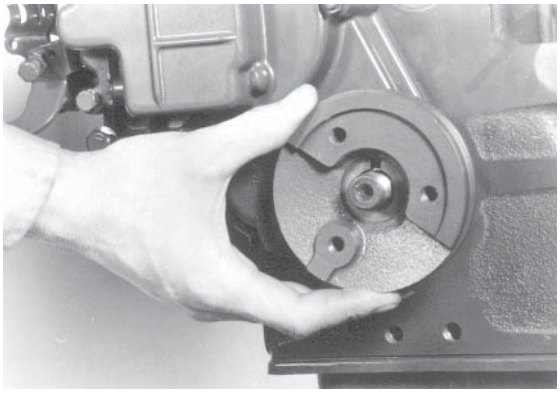


L2117

NOTE:
1. Turn the mechanical stop lever clockwise and fix.
2. Pay attention when inserting so that the spring pin in the case inside is inserted into the oil pump cover pin retaining hole.

14 Crankshaft Pulley

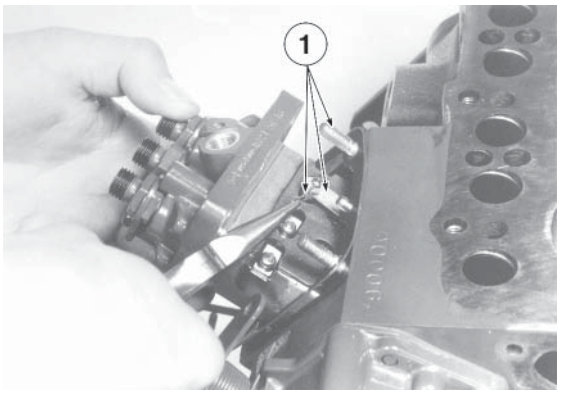
Crankshaft Pulley Tightening Torque:
9.0 - 10.0 kgf-m



L2118

Assembling Engine

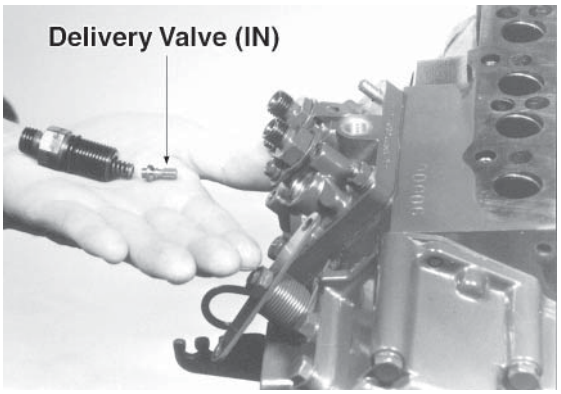
SEQ.	ASSEMBLY PLACE	ASSEMBLY ESSENTIALS
15	Injection Pump Assembly	a. Insert the shims removed at disassembly, connect the link between injection pump control rack and link and secure with snap pin. b. Install injection pump with bolts and nuts.



L2119

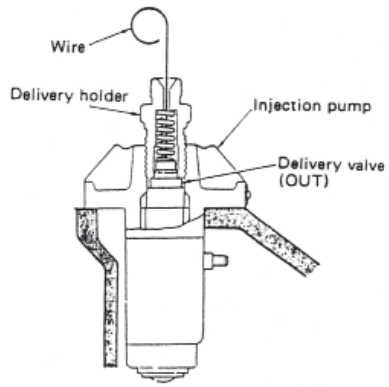
16 Injection Timing Adjustment

Timing should normally be good when installed at above; but, in case injection pump, camshaft assembly, or cylinder block has been replaced, set the injection timing by the following method.



L2120

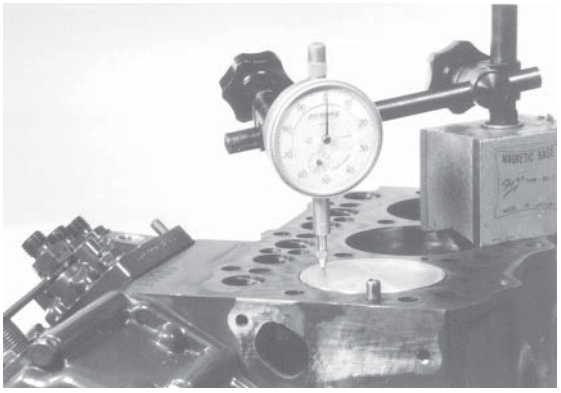
a. Insert **0.5 mm** thickness shim and install as in Seq. 15 above.
b. Remove delivery valve holder from injection pump front side.
c. Pull out delivery valve (IN) and spring and install delivery holder.



L2121

NOTE:
When installing delivery valve holder, adjust with wire such that the delivery valve (OUT) will be properly positioned.

d. Move governor lever toward fuel increase direction, and when fuel is sent in with No. 1 piston (front side) near **25°** before compression top dead center, fuel will flow out from delivery valve.
e. When crankshaft is slowly turned clockwise from condition in (d), fuel will stop flowing out from delivery holder. Read BTDC piston position at this time. Use thinner shims to advance timing and thicker shims to retard.



L2122

Assembling Engine

SEQ.	ASSEMBLY PLACE	ASSEMBLY ESSENTIALS

INJECTION TIME (BTDC)
12° ± 1°

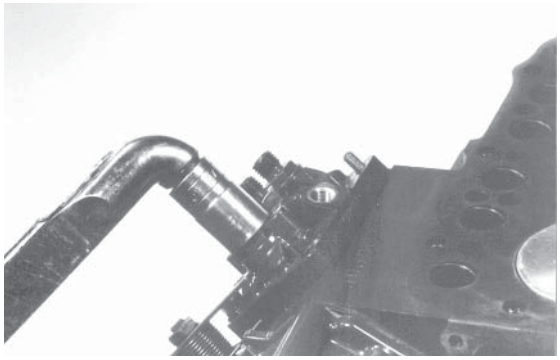
PISTON DISPLACEMENT (BTDC)
1.656 - 2.116 mm

CRANKSHAFT ANGLE (BTDC) vs. PISTON DISPLACEMENT	
Angle (°)	Displacement (mm)
12	**1.069**
13	**1.251**
14	**1.446**
15	**1.656**
16	**1.879**
17	**2.116**
18	**2.367**
19	**2.630**
20	**2.907**

NOTE:
If shim is not required, apply liquid seal and assemble.

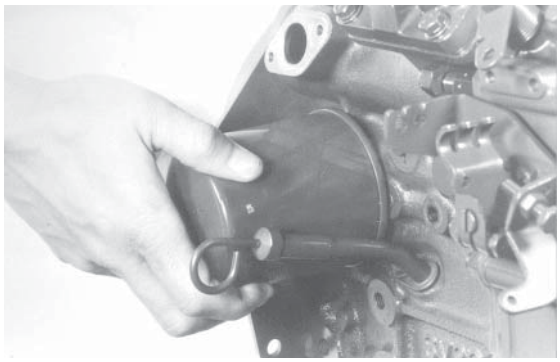
f. Install delivery valve (IN).

Delivery Holder
Tightening Torque:
4.0 - 4.5 kgf-m



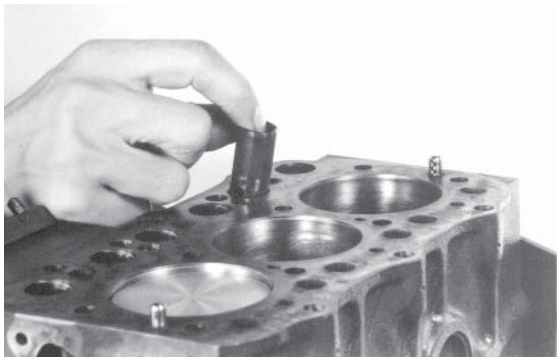
L2123

17 Oil Filter — Apply oil lightly to mounting surface and tighten on by hand.



L2124

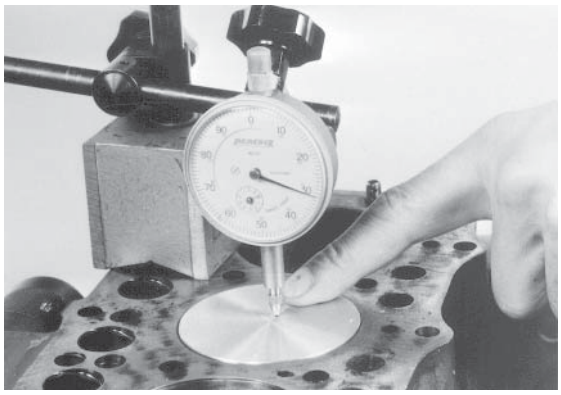
18 Tappet — Oil and assemble in.



L2125

Assembling Engine

SEQ.	ASSEMBLY PLACE	ASSEMBLY ESSENTIALS
19	Cylinder Head Assembly	a. Set piston to top dead center and measure amount protruding out from cylinder block, using depth gauge or dial indicator.

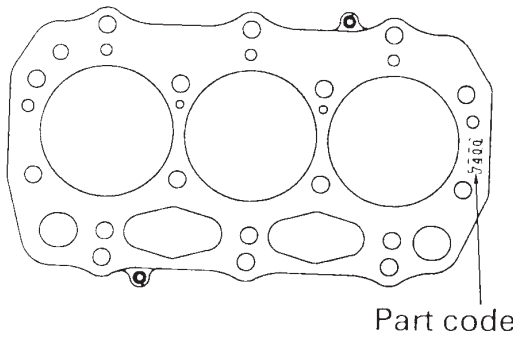


L2126

NOTE:
1. Measure by holding piston lightly with hand.
2. In all cylinders, take amount protruding out most as the standard.

b. Select the head gasket to conform with measurement.

Measured Depression (mm)	Thickness Tightened (mm)
0.25 - 0.40	**0.4**
0.15 - 0.25	**0.5**

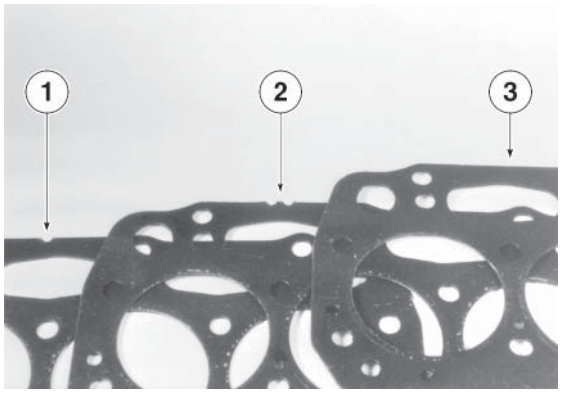


673gasket

NOTE:
1. Last 4 digits of part code number should face upward.

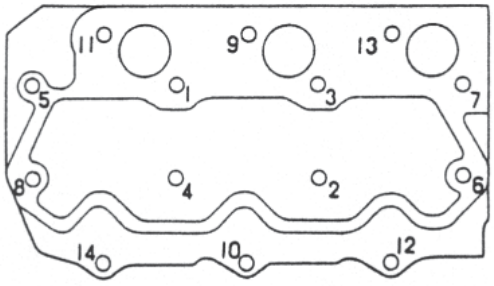
c. Tighten cylinder head in about three passes in sequence shown at right, and finally tighten to designated torque.

Cylinder Head Tightening Torque:
3.5 - 4.0 kgf-m



L2128

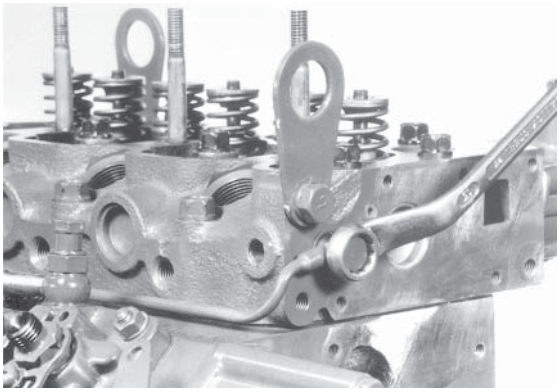
NOTE:
1. Be careful about the locating spring pin.
2. Coat the thread portion with engine oil or grease containing molybdenum disulfide.



L2129

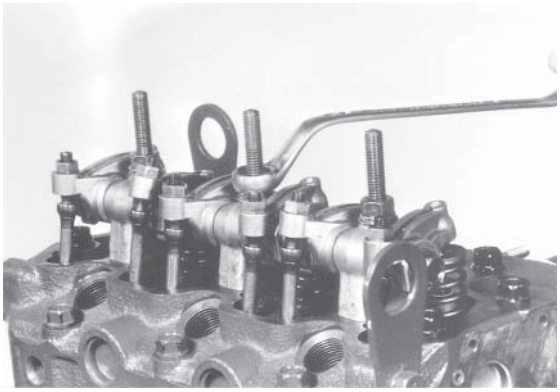
Assembling Engine

SEQ.	ASSEMBLY PLACE	ASSEMBLY ESSENTIALS
20	Oil Pipe	Eye Bolt Tightening Torque: **1.0 - 1.3 kgf-m**



L2130

21	Push Rod Rocker Arm Assembly	Rocker Arm Tightening Torque: **2.0 - 2.5 kgf-m**

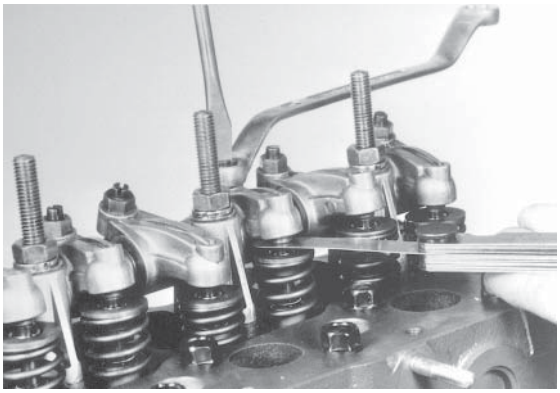


L2131

22	Valve Clearance Adjustment	Loosen nuts and adjust intake and exhaust valves to **0.2 mm** by turning the adjustment screws.

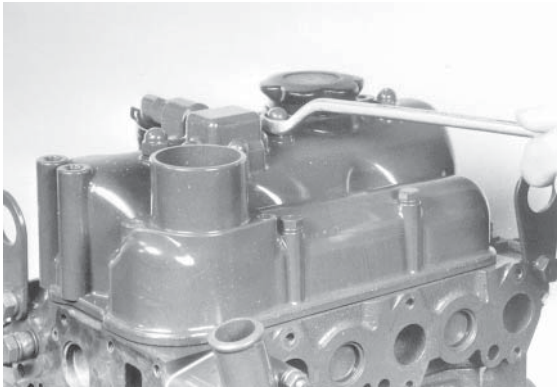
Adjust the inlet and exhaust valves of No. 1 cyl. when the No. 1 cyl. is TDC for compression.
Adjust the inlet and exhaust valves of No. 2 cyl. with the crankshaft turned 240^0 (forward direction) and No. 3 cyl. by 240^0 (forward direction).

NOTE:
1. Make adjustment at cold state.
2. Rock nut tightening torque: 1.2 - 1.6 kgf•m (9-12 lb•ft)



L2132

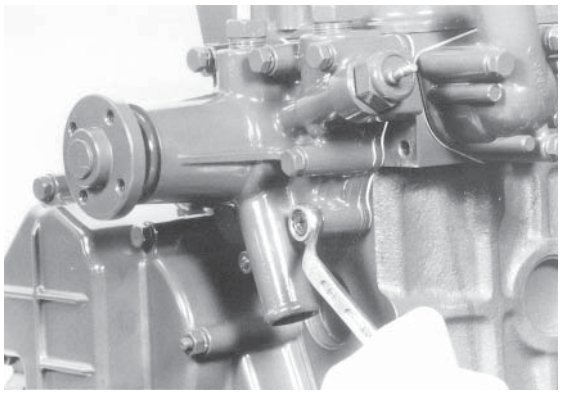
23	Cylinder Head Cover	Tighten the cylinder head cover uniformally taking care of the packing. Head Cover Tightening Torque: **1.0 - 1.2 kgf•m (7.2 - 8.7 ft•lb)**



L2133

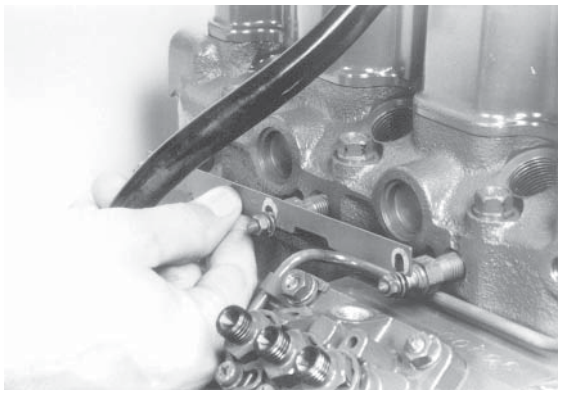
Assembling Engine

SEQ.	ASSEMBLY PLACE	ASSEMBLY ESSENTIALS
24	Water Pump Assembly Thermoswitch	



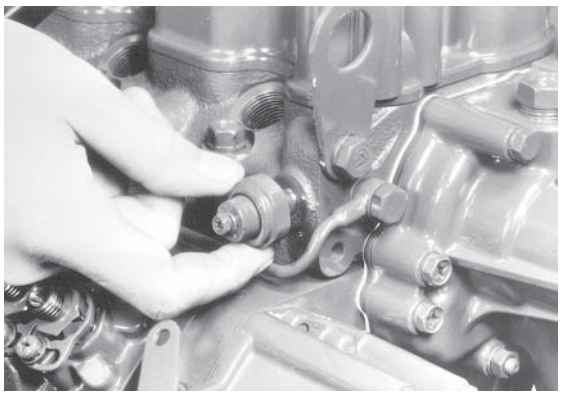
L2134

25	Glow Plug Connector	Glow Plug Tightening Torque: **1.5 - 2.0 kgf-m** **(11 - 14 lb•ft)**



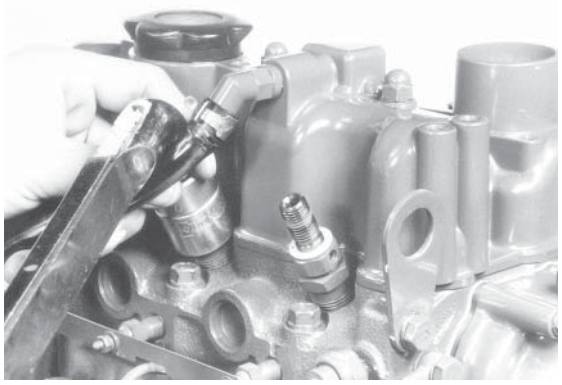
L2135

26	Oil Pressure Switch	Tightening Torque: **1.5 - 2.0 kgf-m** **(11 - 14 lb•ft)**



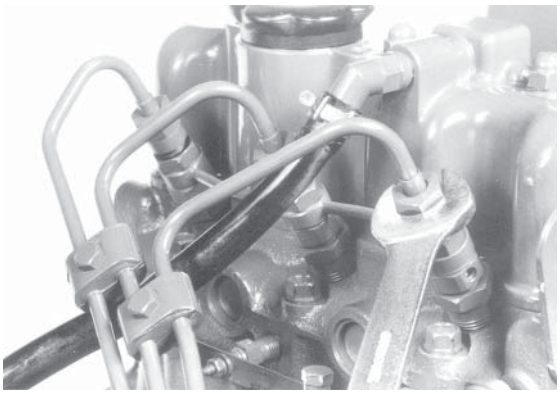
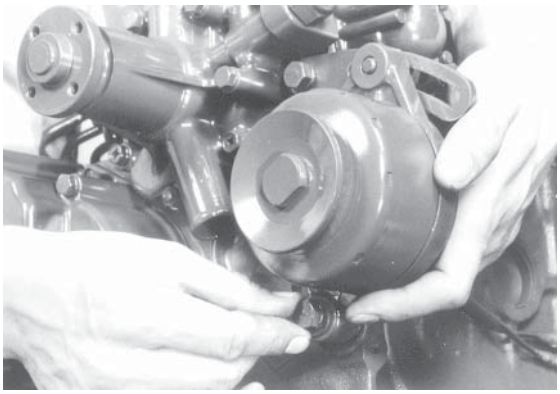
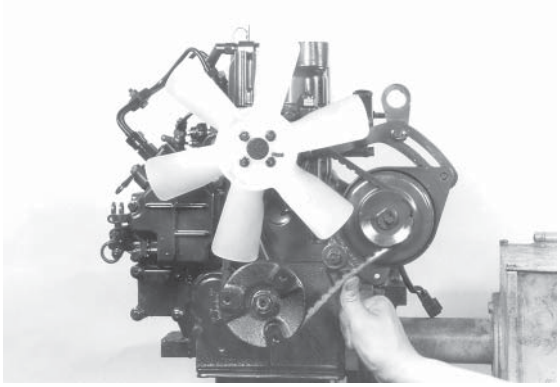
L2136

27	Nozzle and Holder Assembly	Nozzle and Holder Tightening Torque: **6.0 - 7.0 kgf-m** **(43 - 51 lb•ft)**



L2137

Assembling Engine

SEQ.	ASSEMBLY PLACE	ASSEMBLY ESSENTIALS	
28	Return Pipe Injection Pipe	Install return pipe and then install injection pipe.	 L2138
29	Alternator	Alternator Tightening Torque: **2.3 - 2.9 kgf•m** **(17 - 21 lb•ft)**	 L2139
30	V-Belt Fan Pulley Cooling Fan	Adjust alternator such than when belt is pressed midway between crankshaft and alternator pulleys with finger (at about **5 kgf**), belt will deflect **5 mm**.	 L2140

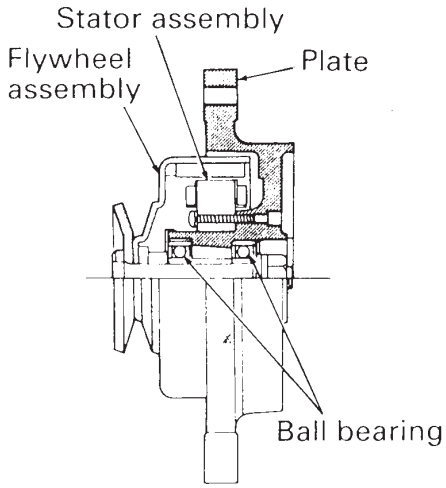
Alternator

SPECIFICATIONS AND PERFORMANCE

Type	GP9175
Rotating Direction	Clockwise (viewed from pulley end)
Working RPM	**1500 - 6500** RPM
Charging Performance	**14 A** at **6000** RPM

CONSTRUCTION

Composed of stator comprising armature coil and coil plate, and flywheel with ferrous magnet.

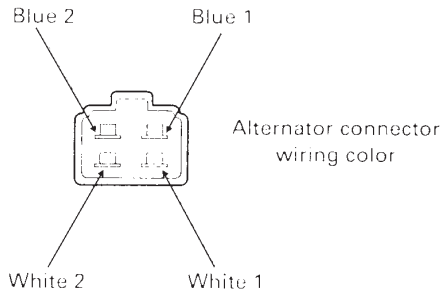


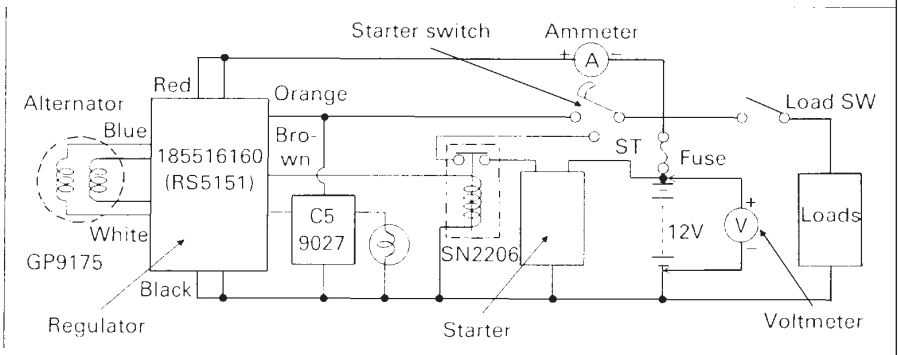
673altinside

Alternator

INSPECTION METHOD

1 Alternator-Regulator Combining Condition





673alt

Check performance using an ammeter and voltmeter.

	Normal	Abnormal	Cause
Relation between charge current and battery terminal voltage	1. Over than 27A at less than 14V 2. 0.5A to 28A at 12 - 15V	More than 27A at battery voltage more than 15V	Improper operation of regulator
		Charge current 0A	Defective alternator or regulator or improper connection
		Flowing charge current but low battery voltage	Defective battery

2 Alternator Performance

		Normal	Abnormal	Cause
No-load voltage (between blue blue) tester reading at operation (about 6000 rpm)		More than AC 45V	Less than AC 45V	Demagnetized flywheel, disconnected coil, or wiring harness
Tester continuity	Between blue & blue of lead wire	Continuity observed	Continuity not observed	Disconnected coil

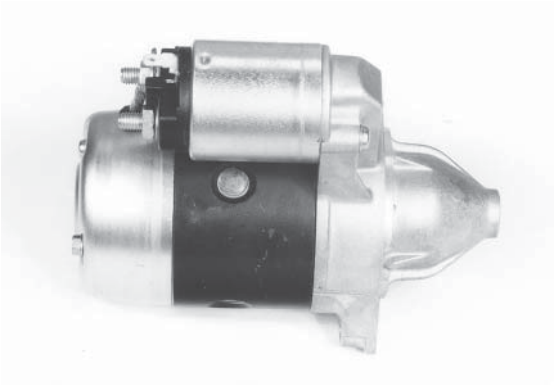
3 Flywheel Rotating Condition

	Normal	Abnormal	Cause
Rotate the flywheel by hand	12 times of repulsion force but rotated relatively smoothly	Noise when rotated	Defective bearing Foreign matter trapped
		Rotated lightly without repulsive force	Demagnetized magnet

Starting Motor

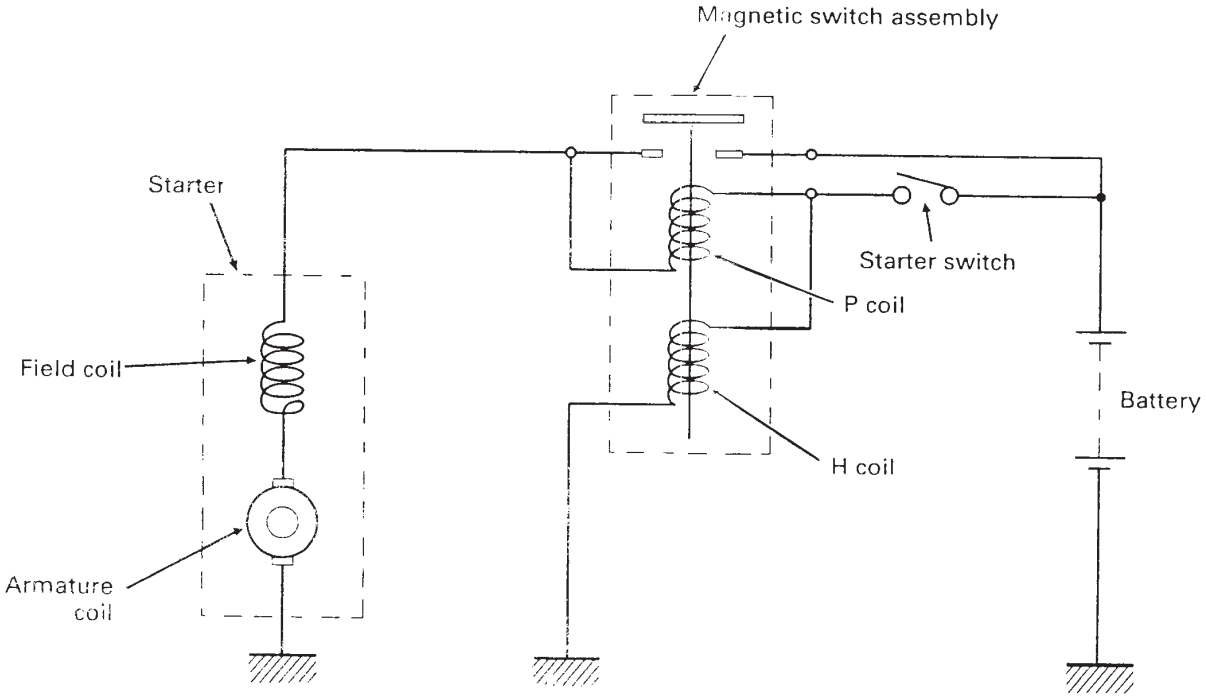
SPECIFICATIONS AND PERFORMANCE

Output	12V - 0.8 kW
Rotating Direction	Clockwise (viewed from pinion side)



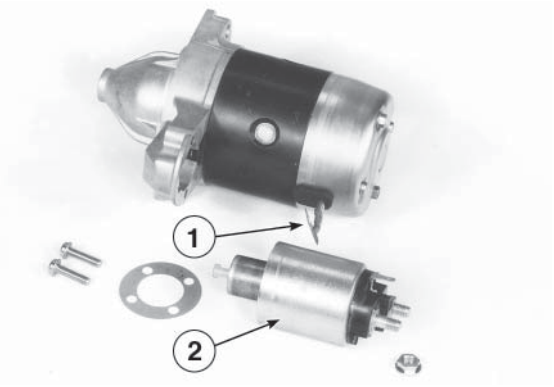
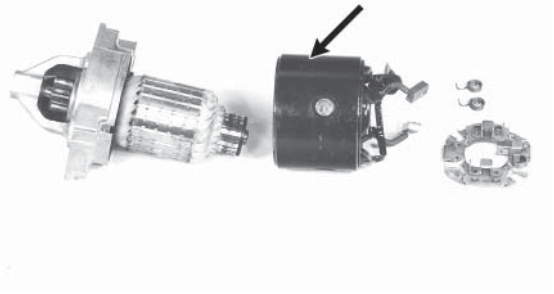
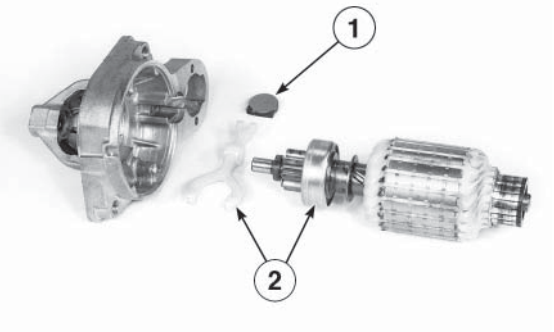
L2145

INTERNAL CONNECTION



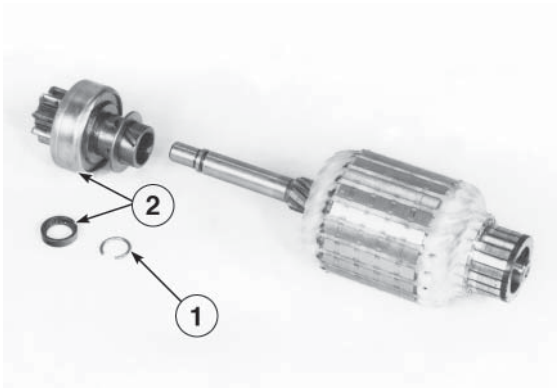
673starterint

Starting Motor

SEQ.	DISASSEMBLY PLACE	DISASSEMBLY ESSENTIALS	
1	Magnetic Switch Assembly	a. Loosen the M terminal nut and remove the connector. b. Remove 2 bolts and take away the switch.	 L2147
2	Rear Bracket	Remove the brush holder fixing screws (2 pcs) and through bolts (2 pcs) and take away rear bracket.	 L2148
3	Yoke Assembly	Remove the plus side brushes (2 pcs) and take away the yoke assembly.	 L2149
4	Armature Lever	a. Remove the rubber packing and plate (metal) from the front bracket. b. Remove the armature lever.	 L2150

Starting Motor

SEQ.	DISASSEMBLY PLACE	DISASSEMBLY ESSENTIALS
5	Overrunning Clutch	a. Move the stop ring inward and remove. b. Remove the stop ring and overrunning clutch.



L2151

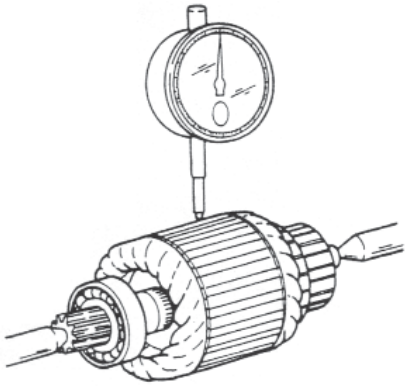
INSPECTION AND SERVICING

1 Armature

a. Shaft Bending

Measure the shaft bending with dial gauge. Supporting the center of both ends of the armature shaft, measure the shaft bend by the sliding of the center bearing metal. While turning the armature quietly by hand, read the dial indication. 1/2 of the reading is the shaft bending.

Bending Limit	**0.1 mm**

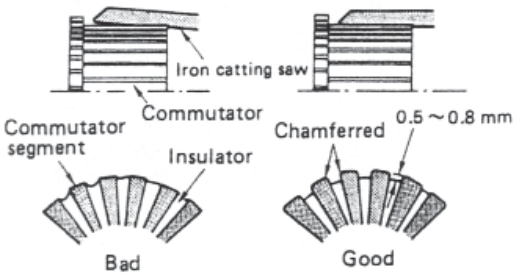


L2152

b. Commutator Surface Inspection

The parts on the commutator where brush is moving and not distinguished clearly. When the sliding area is roughened, correct by grinding with #300 or #500 sand paper. Replace if the run-out of the sliding surface is more than 0.05 mm (measure with dial gauge.)

COMMUTATOR OUTSIDE DIAMETER (ø)	
Standard Value	Service Limit
32	**31**



L2153

c. Commutator Insulator

Measure the commutator insulator depth and correct as shown in the figure if the depth is less than 0.2 mm.

d. Coil Insulation Test

Check for insulation between commutator and shaft. If continuity is noticed, it indicates unsatisfactory insulation of the armature coil and shaft. Replace with new one in such a case.

L2154

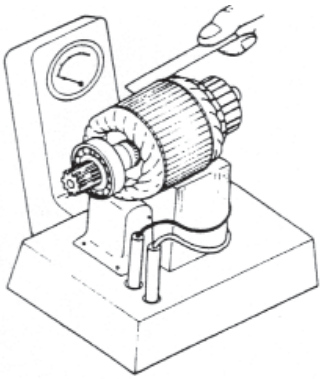
Starting Motor

INSPECTION AND SERVICING

e. Armature Continuity Test
Check the continuity between the armature coil and commutator with a tester. If no continuity is indicated on the tester, it means disconnected wire. Replace with new one in such a case.

L2155

f. Armature Short-Circuit Test
Place the armature on growler tester and rotate the armature while holding iron strip against the armature. If the iron strip vibrates, there is a short-circuit, so replace.



L2156

2 Field Coil

a. Using a tester, check for open-circuit in field coil. Measure continuity between both terminals where brushes of the field coil are connected. If not continuous, there is an open circuit to replace with new part.

L2157

b. Using a tester, check between the field coil and ground. Check for continuity between either field coil terminal and yoke. If continuous, field coil is grounded, so replace with new part.

L2158

Starting Motor

INSPECTION AND SERVICING

3 Brush

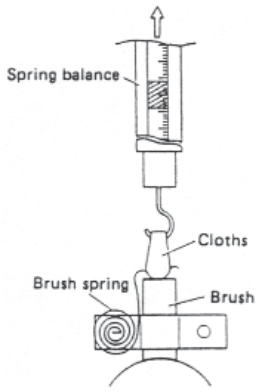
a. If brush height measures less than 11.5 mm, replace.

Standard Size	**17 mm**

L2159

b. Brush Spring Pressure Adjustment
Spring standard pressure is 1.95 kg.
Set brush and spring as shown at right, and pull up with scale, through cloth piece, and measure the load with scale when the brush spring floats up.

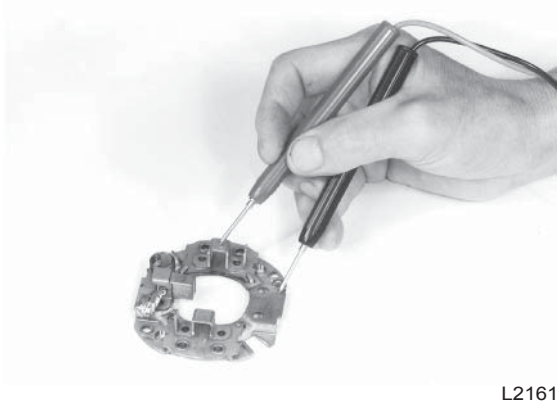
Service Range	**1.66 - 2.24 kgf/lb**



L2160

c. Using a tester, check between the insulated brush holder and the brush base.
Check the continuity between the brush holder (+ side) and the brush holder base (– side and ground). If found continuous, the holder is grounded and must be replaced with a new part.

d. Check Brush Movement
When the brush movement is bad, check brush holder to see if it is bent and check the brush holder sliding surface to see if it is dirty. Correct if bent, and also clean at the same time.



L2161

4 Magnetic Switch

a. Check for an open circuit in the shunt coil with tester. If no continuity is indicated between S terminal and coil case (metal part), there is an open circuit and the part must be replaced.

L2162

Starting Motor

INSPECTION AND SERVICING

c. Check for open circuit in series coil with tester. If no continuity is indicated between S terminal and M terminal, there is an open circuit so replace.

L2163

5 Pinion

a. Check teeth in pinion and if found worn or damaged, replace with new one.

b. Check sliding action of pinion. Correct if the pinion metal is damaged or turned up.

c. If the clutch locks or slides, replace with a new one.

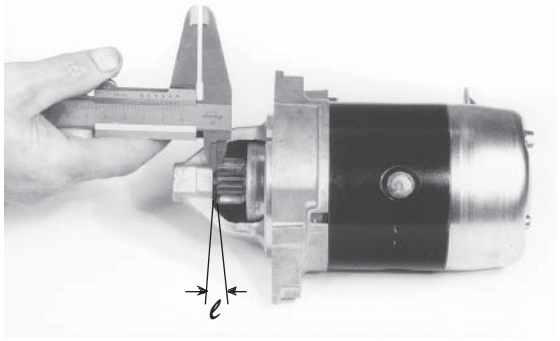
L2164

ASSEMBLY AND ADJUSTMENT

Before starting the assembly, perform an inspection in accordance with the items in “Inspection and Servicing”. Assemble by perfoming the disassembly in reverse order, with attention given to the following places. After assembly, check and adjust the dimension “ℓ”.

* “ℓ” Dimension Check and Adjustment
The “ℓ” dimension is the distance which the pinion is pushed out with the magnetic switch. The dimensions are shown in the figure at right. Measure this dimension in a starting motor at independent condition; off the engine but energized.

1 Connect the battery (+) and (–) terminals to the magnetic switch S terminal and case.



L2165

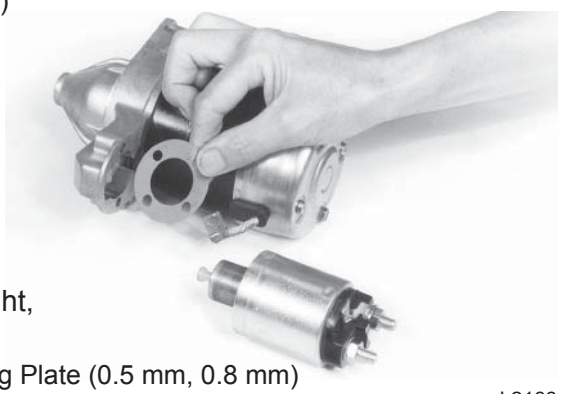
NOTE:
Use a battery of 12V and never allow short-circuit (contact) of (+) and (–) terminals at this time.

2 The pinion advances and stops at the pinion stopper position.

3 Eliminate play when depressed with finger for measurement.

“ℓ” = 0.5 - 2.0 mm

4 Insert the adjusting plate as shown in the figure at right, and adjust if necessary.



“ℓ” dimension Adjusting Plate (0.5 mm, 0.8 mm)

L2166

Trouble Shooting

1 Pinion Fails to Advance when Key Switch is Closed.

Fault Location	Probable Cause	Remedy
Wiring	Open circuit, battery and switch terminal connection loosened.	Repair or retighten.
Key Switch	No current flow due to defective contact.	Correct contacting part or replace.
Starting Motor	Thread part engaged with the armature shaft pinion is stuck and the pinion does not move.	Replace.
Magnetic Switch	Magnetic switch plunger movement defective or coil open or shorted.	Correct or replace.

2 Pinion Meshes and Motor Rotates, but No Rotation Transmitted to Engine.

Fault Location	Probable Cause	Remedy
Starting Motor	Overrunning clutch defective.	Replace.

3 Pinion Meshes with Ring Gear, but Starting Motor Does Not Rotate.

Fault Location	Probable Cause	Remedy
Wiring	Line connecting magnetic switch to battery broken or defective ground. Lead wire connecting magnetic switch to motor tightened improperly.	Correct, retighten, or replace wire.
Starting Motor	Pinion ring engaged improperly. Installation defective. Brush worn, brush spring defective contact. Commutator dirty. Armature or field coil defective. Field coil to brush connection defective.	Replace. Reinstall. Replace. Correct. Repair or replace. Retighten.
Magnetic Switch	Contact not touching properly. Contact contacting surface roughened.	Replace. Replace.

4 Motor Rotates Before Pinion Meshes with Ring Gear.

Fault Location	Probable Cause	Remedy
Starting Motor	Pinion sleeve spring fatigued.	Replace.

5 Motor Fails to Stop After Engine Starts and Key Switch is Turned OFF.

Fault Location	Probable Cause	Remedy
Key Switch	Switch defective.	Replace.
Magnetic Switch	Magnetic switch defective.	Replace.

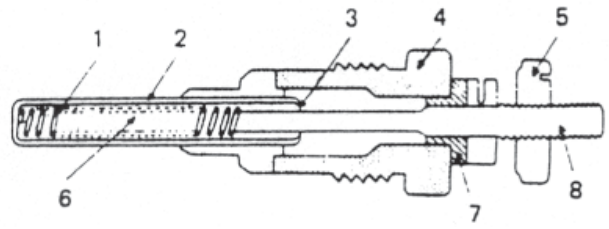
Glow Plug

SPECIFICATIONS AND CONSTRUCTION

Glow Plug Rated Voltage 11V - 9.5A

Heat wire is contained in stainless steel sheath with the fine heat wire in coil form immersed in sintered magnesium oxide powder.

One end of this heat wire is welded on to sheath front tip and the other end to center electrode. Setting key switch to heat (H) and start (S) positions causes air in combustion chamber to heat up for preheating.



1. Heat wire
2. Sheath
3. Asbestos
4. Body
5. Nut
6. Magnesium oxide powder
7. Insulation bushing
8. Center electrode

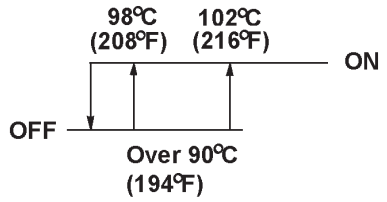
L2167

INSPECTION

1 Remove connector.	Measured Value	Result
2 Connect circuit tester between glow plug center electrode and cylinder head and measure resistance.	0Ω	Shorted
	∞	Disconnected

Temperature Switch

Load Used	12V - 3W
Switch Working Temperature	98° - 102° C (208-216^{0}F)
Switch Reset Temperature	90° C (194^{0}F) ON - OFF



temperature

Oil Pressure Switch

Construction
This is utilized as engine oil pressure warning; the oil pressure lamp turns on to warn when the pressure rises above the designated value. The oil pressure switch consists of a diaphragm and contact points assembled in the interior.

a. Oil pressure switch lighting on pressure is **0.2 - 0.4 kdf/cm^2 (2.8- 5.7 PSI)** or lower.

Battery

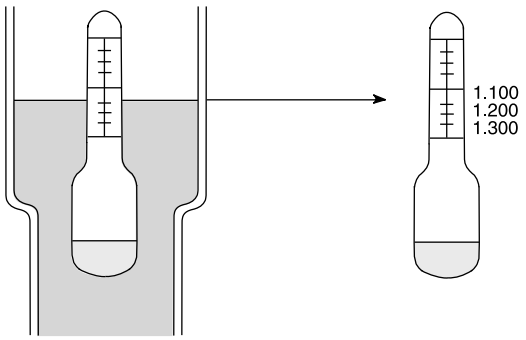
Type	Capacity	Electrolyte Specific Gravity (at 20° C)	Charging Current
38B20R (S)	12V - 28AH	1.28/20°C/Full Charge	3.5A Normal Charging

ELECTROLYTE SPECIFIC GRAVITY AND CHARGING STATE

Electrolyte specific gravity drops down in about straight line ratio with battery discharged amount so that by using a hydrometer and checking the electrolyte specific gravity, it becomes possible to know the remaining capacity.

Specific gravity measured by hydrometer must be corrected for temperature.

Battery electrolyte specific gravity is standard when at 20° C. Since it becomes 0.0007 larger or smaller with each 1° C variation, correction is made with following equation.



L2170

S20 = St + 0.0007 (t - 20)

- S20: Specific Gravity corrected to 20° C
- St: Specific Gravity at Measurement
- t: Temperature at Measurement

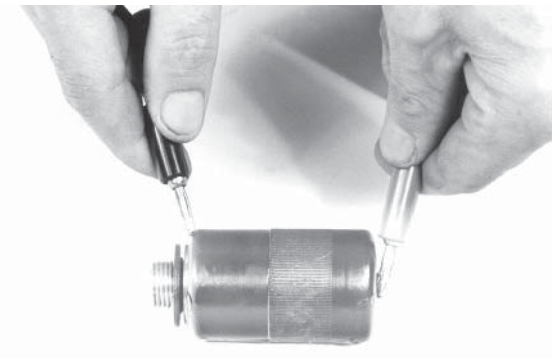
Spec. Grav. (20°C)	Disch. Qty. (%)	Remaining Qty. (%)
1.280	**0**	**100**
1.210	**25**	**75**
1.160	**50**	**50**
1.110	**75**	**25**
1.060	**100**	**0**

The figure at right shows the method for reading specific gravity. The table shows the relation between specific gravity and battery remaining capacity.

Engine Stop Solenoid

INSPECTION

Engine stop solenoid is in normal state if plunger is drawn into main body when one terminal is connected to battery (+) and other terminal to main body.



L2172

L2172

Wiring Harness (wiring)

INSPECTION

1 Disconnect the negative cable of the battery before starting the inspection or service.

2 Be sure to check each wiring for damage of sheath due to vibration, etc, loosened connection, etc. and correct insulation or replace the wiring harness if defective one exists.

3 After completion of service of engine and other parts, confirm that the insertion of each wiring is protected with a vinyl tube, clamping fixtures are covered with vinyl coating to isolate the fixture from the wire (replace fixtures without coating, if any). Careful check is required where wiring is apt to be entrapped.

4 Inspect where plus current is always flowing, specifically with sufficient care to confirm no abnormalities exist in the sheathing.
a. Starting Motor
b. Alternator
c. Key Switch

5 After the inspection, protect the wiring with corrugated tube, or the something similar.

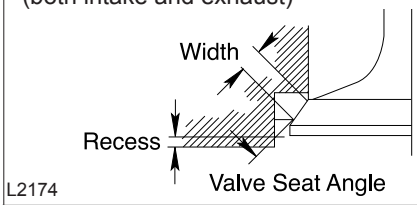
Trouble Shooting

TROUBLE	PROBABLE CAUSE	REMEDY
Engine fails to start.	Key switch defective.	Correct connection and contact.
	Battery insufficiently charged or completely discharged.	Recharge.
	No fuel.	Replenish fuel.
	Air entered in fuel system.	Repair air entry part into fuel.
	Fuel filter clogged.	Replace fuel filter.
	Fuel irregular and improper.	Injection pump defect. Repair at designated factory.
	Glow plug defective.	Replace.
	Lube oil viscosity improper.	Check and replace.
	Air cleaner clogged.	Clean air cleaner.
	No compression.	Check parts and repair.
	Engine stop solenoid defective.	Check wiring or replace.
Engine speed irregular	Air entered the fuel system.	Bleed air from fuel.
	Fuel injection amounts lack uniformity.	Injection pump defect. Repair or replace at certified diesel engine plant.
	Fuel filter clogged.	Replace fuel filter.
	Governor defective.	Check and adjust.
	Engine main body function defective.	Overhaul engine, check and repair various parts.
Engine stops running	Fuel tank empty.	Fill with fuel.
	Fuel filter clogged.	Replace filter.
	Air entered the fuel system.	Repair air entry part into fuel.
	Engine main body function defective.	Check and repair various parts.
Engine overheats	Insufficient cooling water.	Fill water, check and repair leaks.
	Fan belt loose and slipping.	Clean off oil, dirt, repair slack.
	Fan belt damaged.	Replace.
	Radiator clogged.	Clean radiator.
	Radiator fins clogged.	Clean.
	Cooling water passages clogged.	Wash out.
	Thermostat function defective.	Check and replace.
	Lube oil insufficient.	Replenish.
	Overloaded.	Reduce load.

Trouble Shooting

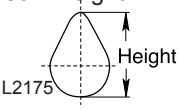
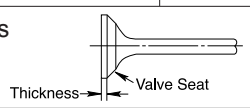
TROUBLE	PROBABLE CAUSE	REMEDY
Engine exhaust color bad (white or blue).	Engine oil excessive.	Check and reduce to proper level.
	Engine oil viscosity too low.	Check and replace.
	Injection timing defective.	Too slow. Correct.
Engine exhaust color bad (black or dark gray).	Improper fuel used.	Check and replace if improper.
	Fuel injection quantity excessive.	Check and adjust if excessive.
	Engine main body function defect.	Check and correct.
	Overloaded.	Reduce load.
	Air cleaner clogged.	Clean element.
Charging defective.	Fan belt loosened.	Correct belt tension.
	Wiring defects.	Check and correct.
	Battery defective.	Replace.
	Alternator defective.	Replace.
Starter fails to operate.	Loosening in various wiring.	Check and reconnect or tighten.
	Battery voltage too low.	Recharge battery.
	Safety switch defective.	Replace.
	Starter trouble.	Check starter and repair.
	Fusible link blown out.	Replace.
Oil pressure lamp fails to extinguish.	Insufficient engine oil.	Replenish to gauge level.
	Pressure switch defective.	Replace switch.
	Lubricating system oil leakage.	Check and retighten.
	Oil filter clogged.	Replace with new part.
	Short-circuit between oil pressure lamp and mano contact.	Repair.
Oil pressure lamp fails to light when key switch is at ON (engine stopped).	Lamp burnt out.	Replace lamp.
	Open circuit between battery and oil pressure.	Repair.

Model 673L2

Large Div.	Sub. Div.	Inspection Item		Standard Size	Assembly Standard	Repair Req. Value	Service Limit	Remarks
Engine Main Body	Cylinder Head	Cylinder compression (kg/cm²)			30	25		Engine 250 rpm
		Cylinder head tightening torque (kgf-m)			3.5 - 4.0			
		Cylinder head mounting surface warpage			0.05	0.12		
		Valve seat depth (both intake and exhaust) 			0.7	1.8		Valve seat 45⁰
		Valve seat width (both intake and exhaust)			1.59 - 1.80	2.5		
	Cylinder Block	Type		Wet type (unit type)				
		Bore		67	67.00 - 67.019	67.2	67.7	
		Cylinder block type surface warping			0.05	0.12		
Main Moving Components	Piston	Skirt-long diameter size		67	66.938 - 66.953		66.7	Oversize (0.25,0.5)
		Clearance with cylinder			0.047 - 0.081		0.25	At 20° C
		Piston hole inside diameter		19	18.996 - 19.002			
		Piston pin hole to pin clearance			–0.004 - +0.008		0.02	
	Piston Pin	Pin outside diameter		19	18.996 - 19.002		18.98	
		Rod small end bushing to pin clearance			0.013 - 0.030		0.08	Oil clearance
	Piston Ring	Piston ring grove to ring clearance	1st ring		0.04 - 0.10		0.25	
			2nd ring		0.05 - 0.09		0.25	
			Oil ring		0.02 - 0.06		0.15	
		Ring width	1st ring	1.5	1.47 - 1.49			
			2nd ring	1.5	1.47 - 1.49			Oversize (0.25,0.5)
			Oil ring	3	2.97 - 2.99			
		Piston ring end gap	1st ring		0.13 - 0.28		1.0	
			2nd ring		0.10 - 0.25			
			Oil ring		0.1 - 0.3			
	Connecting Rod	Large end to small end hole torsion (per 100 mm)			0.08 or less	0.2		
		Large end to small end hole parallel (per 100 mm)			0.05 or less	0.15		
		Con-rod to crankpin axial play			0.1 - 0.3		0.7	
		Con-rod bearing to crankpin clearance			0.031 - 0.079		0.2	Oil clearance

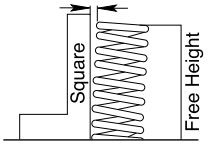
*Numerical values without units indicated in inspection item shall be in mm units.

Model 673L2

Large Div.	Sub. Div.	Inspection Item		Standard Size	Assembly Standard	Repair Req. Value	Service Limit	Remarks
Main Moving Components	Connecting Rod							
		Con-rod tightening torque (kgf-m)			2.1 - 2.6			
		Weight difference after piston assembly (g)		10				
		Small end bushing tightening reserve			–0.013 - +0.05			300 kg
	Crankshaft	Journal diameter	No. 1, 2	ø43	42.964 - 42.975		42.9	
			No. 3	ø46	45.948 - 45.959		45.9	
		Crankpin diameter		ø35	34.964 - 34.975			
		Journal and pin finish accuracy		1.6Z				
		Crankshaft deflection			0.03 or less	0.06		
		Crankshaft axial play			0.1 - 0.3		0.5	
		Bushing (journal brg.) I.D. x O.D.		ø43 x ø47				
		Center bearing tightening reserve	ø43		+0.015 - +0.055			300 kg
			ø46		0 - +0.055			300 kg
		Crank journal to bushing (journal metal) clearance			0.035 - 0.102		0.2	Oil Clear.
		Crank journal to center bearing clearance			0.035 - 0.088			Oil clearance
Valve System	Camshaft	Cam height  L2175	For intake & exhaust		26.565 - 26.620		26.1	
			For injection pump		34.48 - 34.52		34.3	
			For feed pump		27.90 - 28.00		27.0	
		Cam gear backlash			0.08		0.25	
	Valve	Intake valve stem			5.960 - 5.975		5.9	
		Exhaust valve stem			5.940 - 5.955		5.9	
		Valve stem to valve guide clearance	Intake		0.025 - 0.052		0.2	
			Exhaust		0.045 - 0.072		0.25	
		Valve thickness  L2176		1.0	0.925 - 1.075		0.5	
		Valve clearance (intake and exhaust)			0.2	0.5		Cold

*Numerical values without units indicated in inspection item shall be in mm units.

Model 673L2

Large Div.	Sub. Div.	Inspection Item		Standard Size	Assembly Standard	Repair Req. Value	Service Limit	Remarks
Valve System	Valve	Spring force (kg) (Compressed to 28.3 mm in mounting length)			6.9		6.0	
		Free height			33	31.5		
		Squareness 			1.0		1.2	
		Intake valve	Open before TDC	13°				
			Close after BDC	43°				
		Exhaust valve	Open before BDC	43°				
			Close after TDC	13°				
	Push Rod	Overall length		146	145.8 - 146.2			
		Outside diameter		6.3				
	Rocker Arm	Rocker arm shaft wear		11.66	11.65 - 11.67		11.57	
		Rocker arm to shaft clearance				0.032 - 0.068	0.2	Oil clearance
Lubricating System	Oil Pump	Discharge (ℓ /min) Engine 2400 rpm Discharge pressure 3.1 - 5.1 kg/cm^2 oil temperature 50° - 80° C			11/ 12.8			
		Oil pressure switch actuating pressure (kg/cm^2)			0.3	0.2 - 0.4		
		Relief valve opening pressure (kg/cm^2)			3.0 - 5.0			
		Lubricating oil quantity (ℓ)		3.2				
		Tip clearance (rotor to vane gap)			0.01 - 0.15		0.25	
		Side clearance (rotor to cover gap)			0.10 - 0.15			
Fuel System	Injection Pump							
		Pump plunger diameter			ø5.0			
		Pump plunger stroke			6			
		Pump discharge (cc/st)						
			Before top dead center (°)		15.0^0 - 17.0^0			
			Piston displacement (BTDC)		1.656- 2.116			
	Injection Nozzle	Injection pressure (kg/cm^2)		120	115 - 125			
		Injection angle (°)		4°				

*Numerical values without units indicated in inspection item shall be in mm units.

Model 673L2

Large Div.	Sub. Div.	Inspection Item	Standard Size	Assembly Standard	Repair Req. Value	Service Limit	Remarks
Cooling System	Cooling Components	Cooling system	Water cooled forced circulation				
		Cooling water quantity (ℓ)	1.3 (1.37 qts.)				
		Thermostat opening temperature (°C)	75				
		Thermostat full open temperature (°C)	87				
		Pump discharge (ℓ /min) Engine 2400 rpm Water temperature normal	21.2/ 24.8 40				
		V-belt (fan) slack (1 kg at center)		5			
		Radiator cap pressure valve open pressure (kg/cm^2)	1.0				
		Radiator cap vacuum valve open pressure (kg/cm^2)	0.05				
Electric System	Starting Motor						
		Pinion gear number of teeth	8				
		Pinion gear shift system	Magnetic shift system				
		Commutator diameter wear	ø32			ø31.4	
		Commutator diameter eccentric wear		0.05	0.40		
		Armature shaft bending			0.08		
		Brush length	17			11.5	
		Brush spring pressure (kgf)		1.66 - 2.24			

*Numerical values without units indicated in inspection item shall be in mm units.

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