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# ***YANMAR***

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# ***SERVICE MANUAL***

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## ***MARINE DIESEL ENGINE***

**MODEL 6LYA-UTE,STE**

## FOREWORD

This service manual has been compiled for engineers engaged in sales, service, inspection and maintenance. Accordingly, descriptions of the construction and functions of the engine are emphasized in this manual while items which should already be common knowledge are omitted.

One characteristic of a marine diesel engine is that its performance in a vessel is governed by the applicability of the vessel's hull construction and its steering system.

Engine installation, fitting out and propeller selection have a substantial effect on the performance of the engine and the vessel. Moreover, when the engine runs unevenly or when trouble occurs, it is essential to check a wide range of operating conditions — such as installation to the hull and suitability of the ship's piping and propeller — and not just the engine itself. To get maximum performance from this engine, you should completely understand its functions, construction and capabilities, as well as proper use and servicing.

Use this manual as a handy reference in daily inspection and maintenance, and as a text for engineering guidance.

### **METRIC**

ALL DIMENSIONS IN MILLIMETERS  
UNLESS OTHERWISE SPECIFIED

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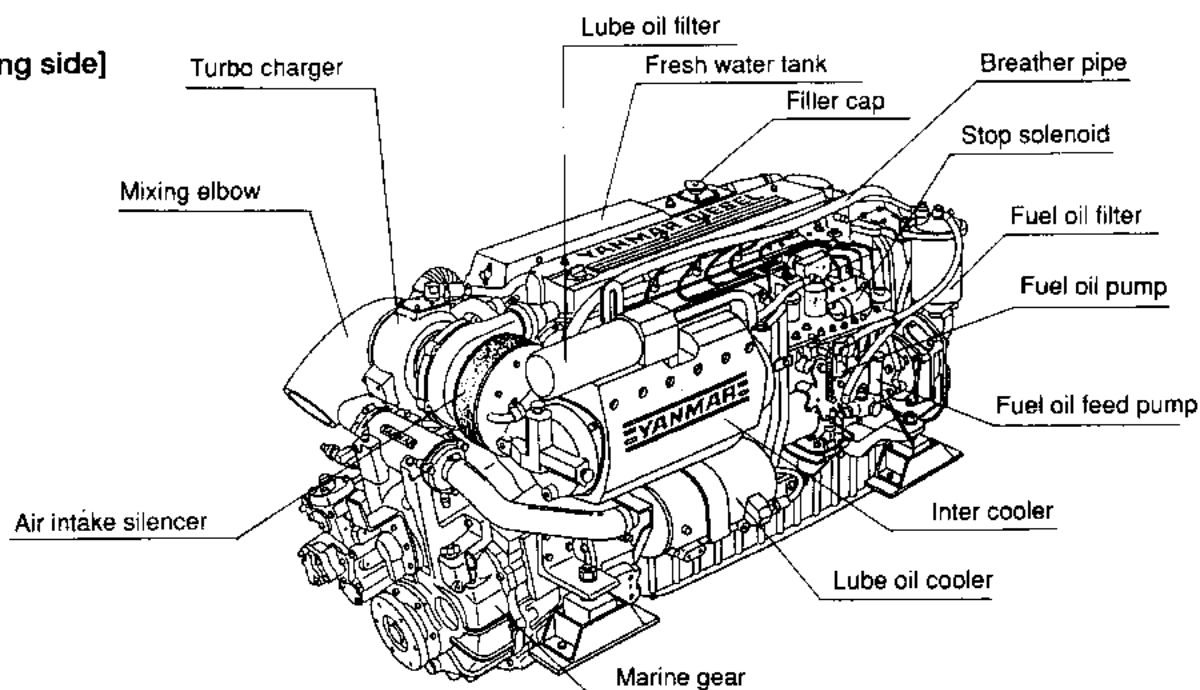
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CHAPTER 1  
**GENERAL**

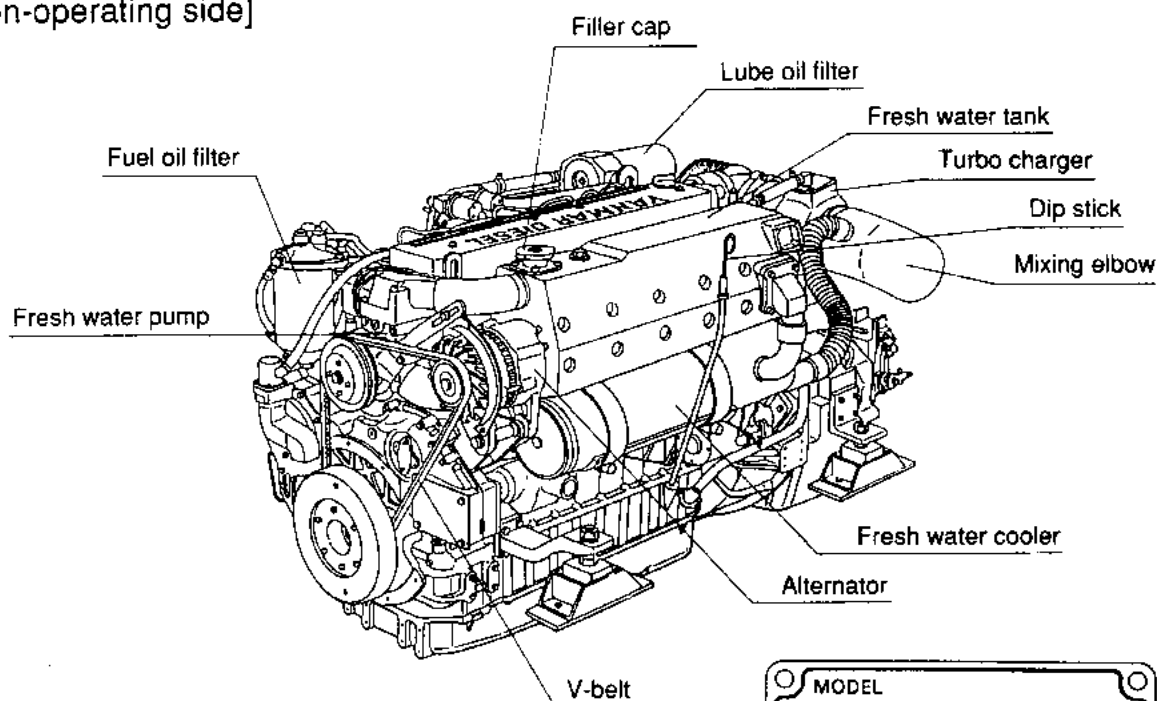
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# 1. Exterior Views

[Operating side]



[Non-operating side]



(This illustration shows Ynmar KMH6A marine gear)

A name plate such as the one shown above is attached to each engine showing the output, rpm, and engine number.

MODEL	
CONTRATING Kw	rpm
SPEED OF PROP. SHAFT	rpm
MAX OUTPUT Kw	rpm
ENG. NO.	
<b>YANMAR DIESEL ENGINE CO., LTD.</b> <small>MADE IN JAPAN</small>	

## 2. Specifications

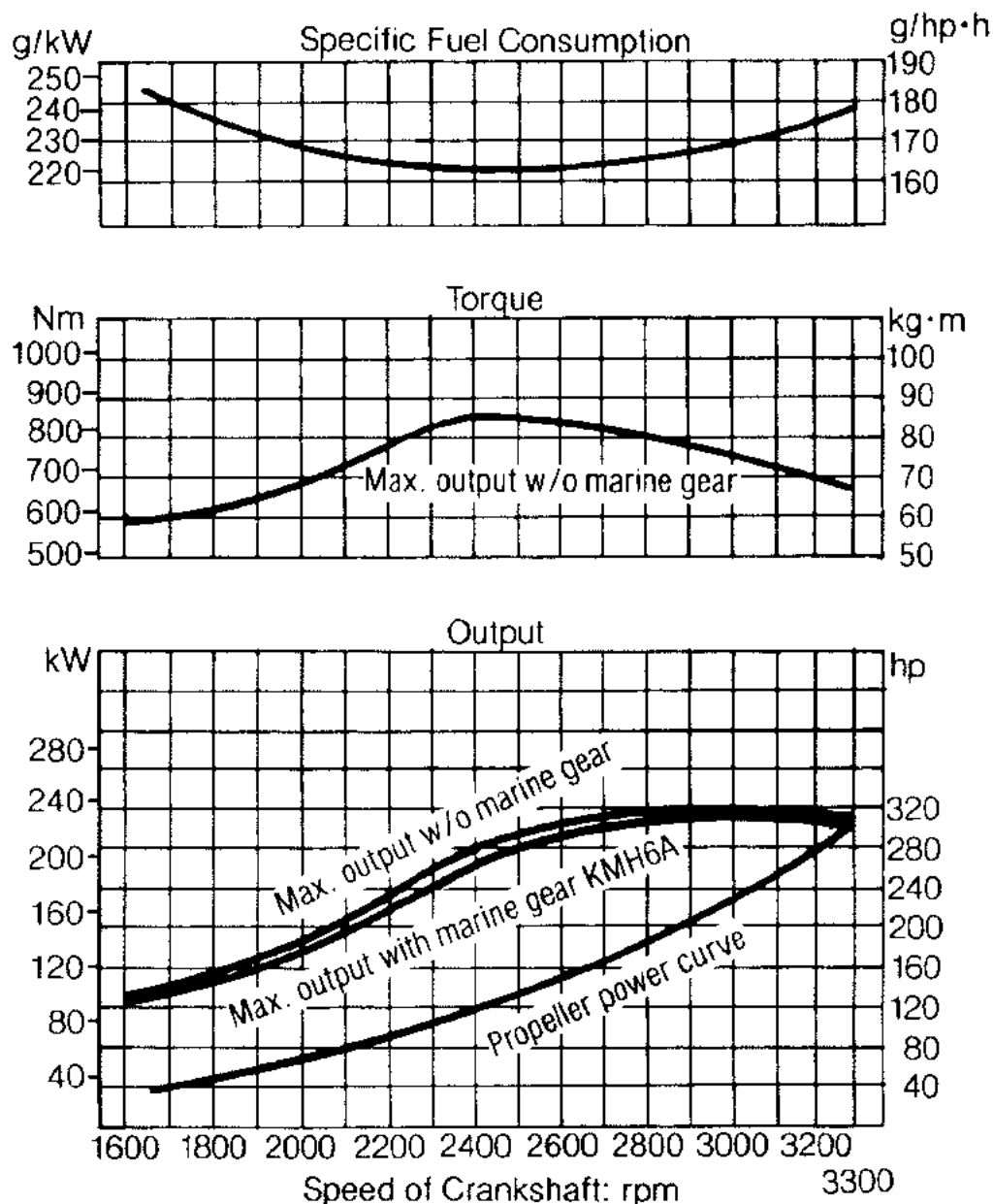
### Engine

Model			6LYA-UTE	6LYA-STE
Type			Vertical 4-cycle water cooled diesel engine	
Combustion system			Direct injection	
Aspiration			Exhaust gas Turbocharger	
Number of cylinders			6	
Bore x stroke		mm	100×110	
Displacement		ℓ	5.184	
One hour rating output (DIN6270B) flywheel output	Output/crankshaft speed	KW/rpm (HP/rpm)	231.7/3300 (315/3300)	257.4/3300 (350/3300)
	Brake mean effective pressure	MPa (kgf/cm <sup>2</sup> )	1.62 (16.6)	1.81 (18.4)
	Piston speed	m/sec. (ft./sec.)	12.1	
Continuous rating output (DIN6270A) flywheel output	Output/crankshaft speed	KW/rpm (HP/rpm)	191.2/3100 (260/3100)	213.2/3100 (290/3100)
	Brake mean effective pressure	kg/cm <sup>2</sup>	1.43 (14.6)	1.59 (16.2)
	Piston speed	m/sec.	11.4	
Compression ratio			15.20 (Effective : 14.0)	
Max rpm at no load		rpm	3720±25	
Min rpm at no load		rpm	700±25	
Fire order			120° 120° 120° 120° 120° 120° 1 → 4 → 2 → 6 → 3 → 5 → 1	
Fuel injection pump			In-line type YPES 6AL	In-line type YPES 6AL II
Fuel injection timing(b.T.D.C)		degree	13±1	
Fuel injection pressure		MPa(kg/cm <sup>2</sup> )	25.48+0.98 (260+10)	
Fuel injection nozzle			Hole type (YDLA-PL) 5 X 0.34 X 140°	
Direction of rotation		Crankshaft	Counter clockwise viewed from stern	
Power take off			At flywheel side	
Cooling system			Constant high temperature fresh water colling Fresh water : Centrifugal pump Sea water : Rubber impeller pump	
Lubrication system			Forced lubrication with trocoid pump	
Starting system	Starting motor		DC12V, 2.5kw	
	AC generator		DC12V 80A	
Turbocharger	Type		RHC7W(IHI)	
	Cooling system		Water cooling	
Air cooler system		Type	Sea water cooled plate fin type (Sea water : 1 pass, Air : 2 pass)	

Marine gear	Model			KMH6A (YANMAR)			HSW800A2 (HURTH)					MG5050A(TWINDISC)					Clutch less		
	Type			10° down angle with hydraulic multi-wet plate type			8° down angle with hydraulic multi-wet plate type					10° down angle with hydraulic multi-wet plate type					—		
	Reduction ratio (Ahead/Astern)		i / i	1.58/1.58	1.92/1.92	2.26/2.26	1.2	1.4	1.6	2.0	2.5	1.12	1.5	1.8	2.04	2.5	—		
	Propeller rotational speed, S type		rpm	2087	1718	1457	2750	2357	2063	2650	1320	2946	2200	1833	1618	1320	—		
	Standard propeller (dia. X pitch X no. of blades)		mm	—			—					—					—		
	Propeller shaft dia. X Countershaft dia.		mm	—			—					—					—		
	Lubrication system		mm	Forced lubrication with gear pump													—		
	Lube oil	Total	ℓ	4.0			—					—					—		
		Effective	ℓ	0.3			—					—					—		
	Cooling system			Seawater cooling			Seawater cooling					Seawater cooling					—		
	Weight		N (kg)	1000 (102)			{64}					{80}					—		
Engine dimensions		(L)X(W)X(H)	mm	1316X721X709		1316X721X709		1316X707X709					1316X707X709					1013X707X709	
Flywheel dimensions		mm	φ 392X65.9																
*8 Engine dry weight (Clutch type/Catalog)		N (kg)	6000(612)			5630(574)					5780(590)					5000(510)			

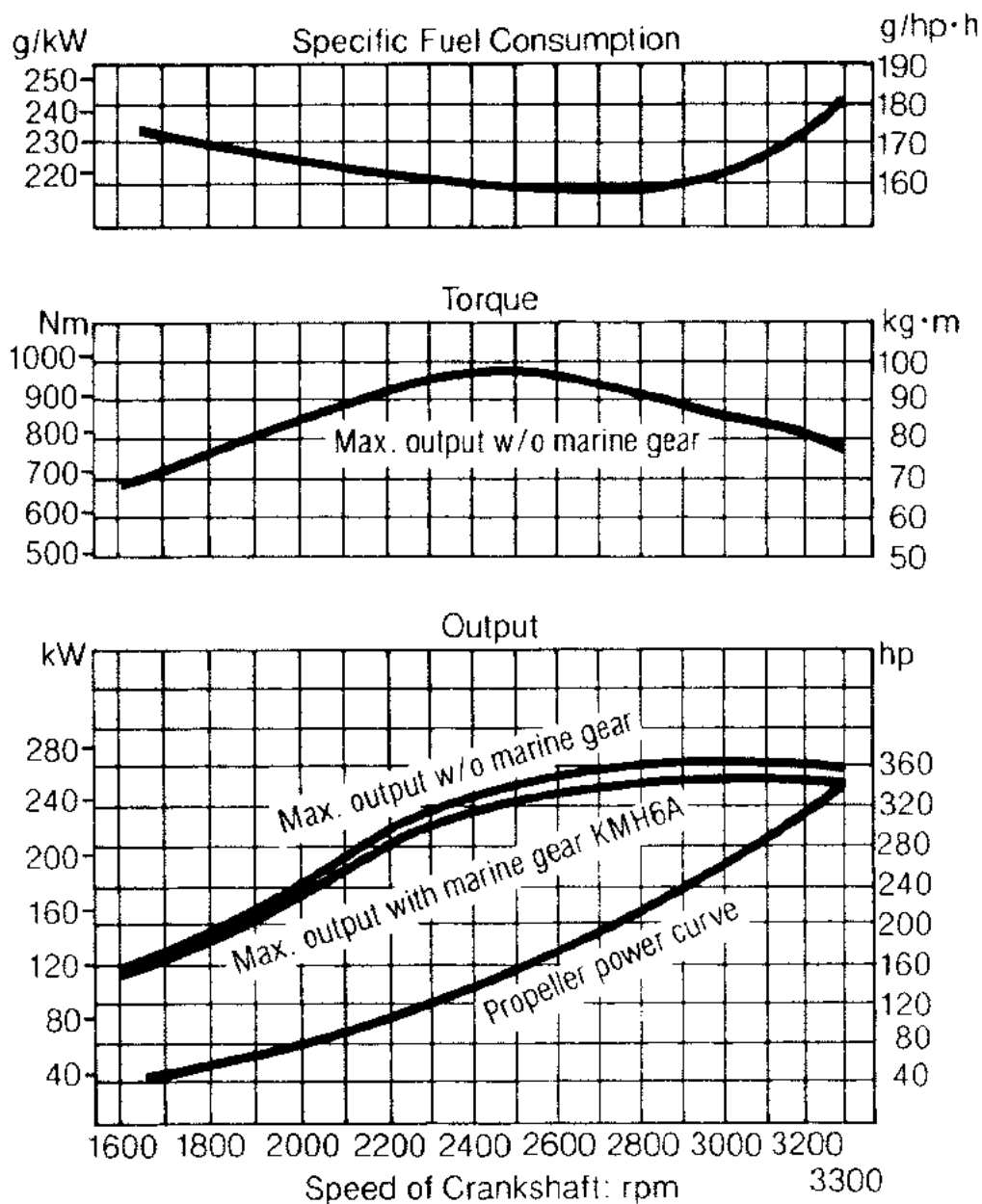
## 3. Performance Curves

[6LYA-UTE]



Note : 1. Above data are measured at crankshaft and show the averaged performance as tested at our laboratory.  
2. Power loss of the marine gear KMH6A is 3%.

[6LYA-STE]



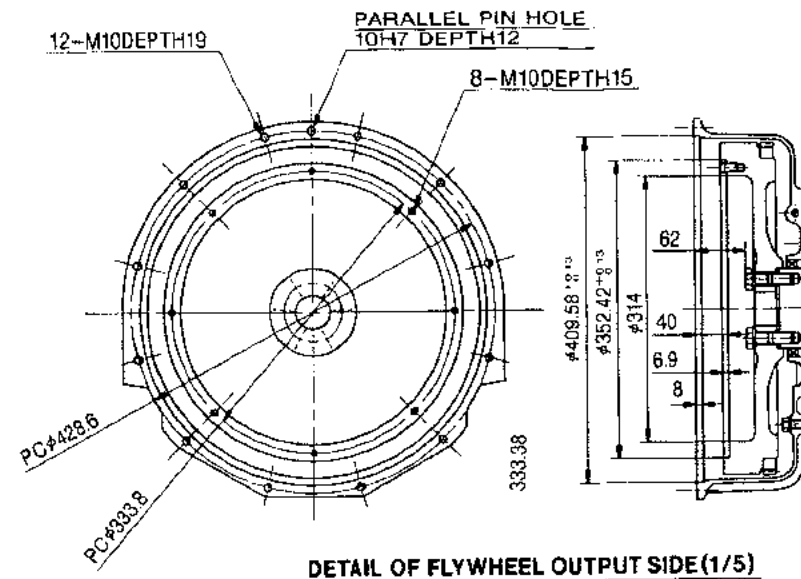
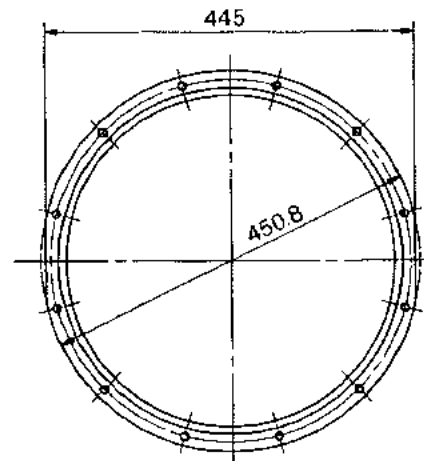
Note : 1. Above data are measured at crankshaft and show the averaged performance as tested at our laboratory.  
2. Power loss of the marine gear KMH6A is 3%.



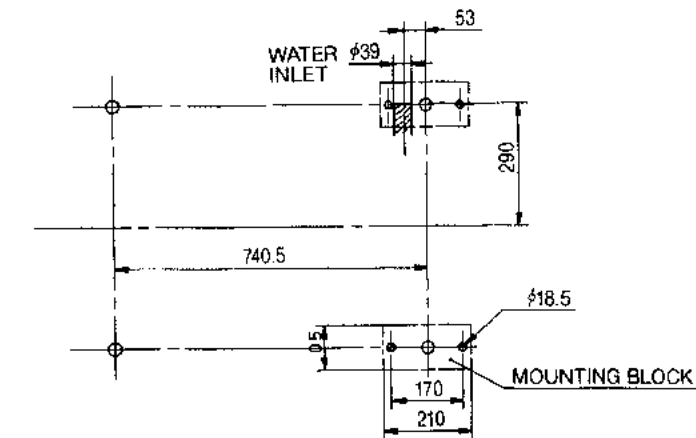
## 4. Dimensions

[6LYA-UTE, STE]

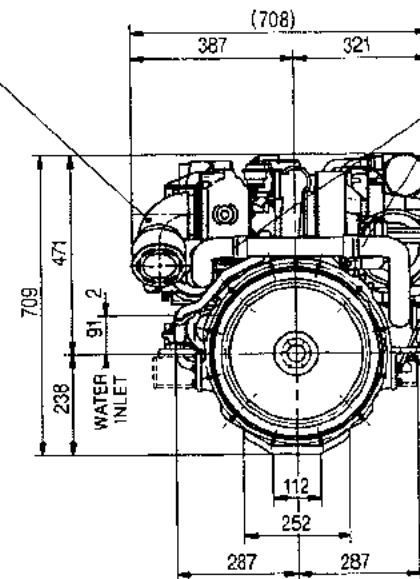
**NOTICE**  
THE MOUNTING FLANGE WIDTH  
OF TRANSMISSION SHOULD BE 445.



DETAIL OF FLYWHEEL OUTPUT SIDE (1/5)



MIXING ELBOW  
RUBBER HOSE  
INNER DIA. 51INCH



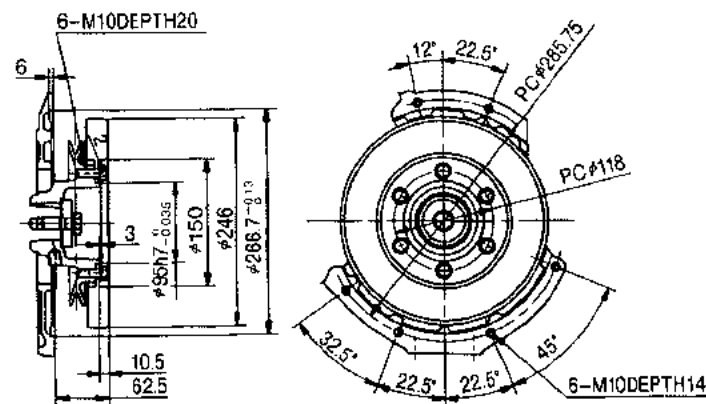
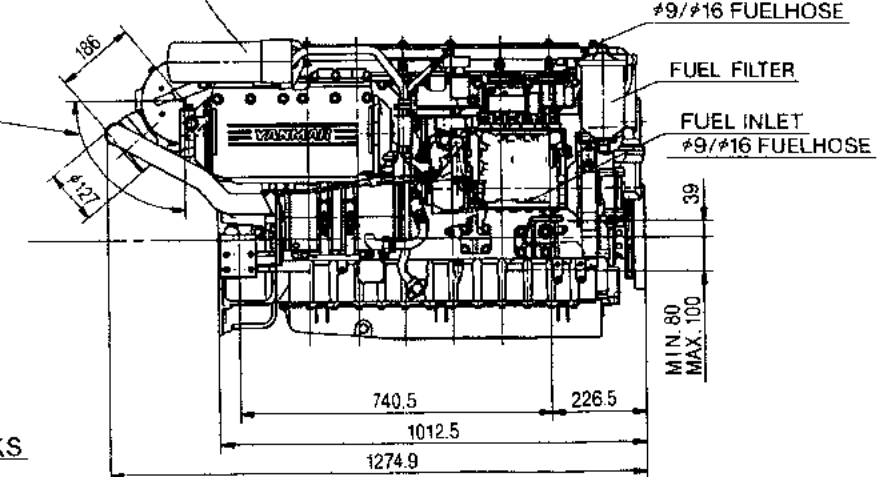
THESE RUBBER HOSES SHOULD  
BE CONNECTED TO THE OILCOOLER  
OF MARIN GEAR.  
WATER PASSAGE AREA IS  
OVER 12.5cm<sup>2</sup>

MIXING ELBOW  
V-BAND TYPE AT EXHAUST INLET.  
ALLOWABLE INSTALLATION ANGLE  
BETWEEN 0° TO 90° DEGREE.

MOUNTING BRACKETS (REAR SIDE)  
SHOULD BE USED ONLY FOR  
TRANSPORTATION.

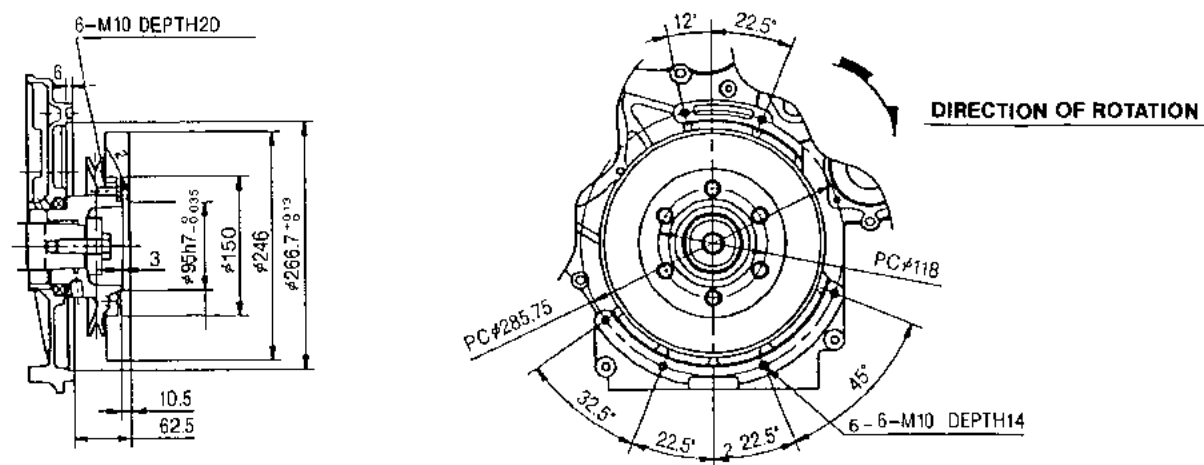
**NOTE**  
DWG. SHOWS MOUNTING BLOCKS  
AT COMPRESSED HEIGHT.  
(COMPRESSED BY APPROX X3mm)

LUB. OIL FILTER

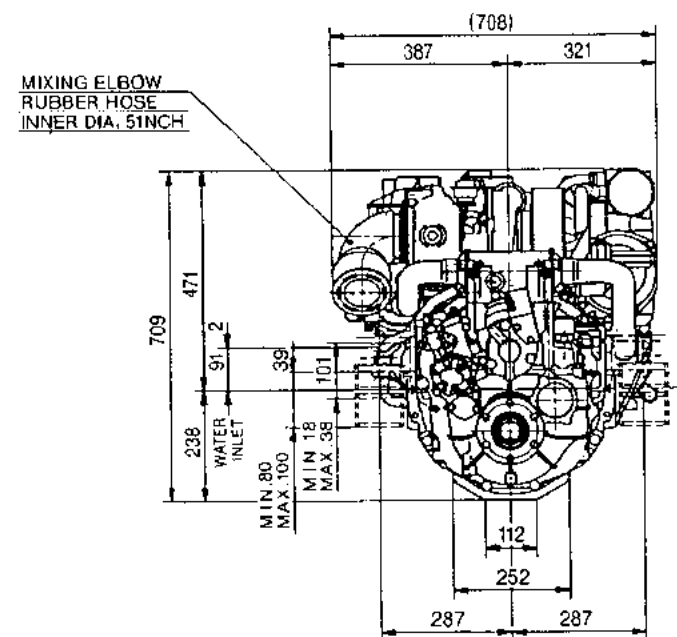
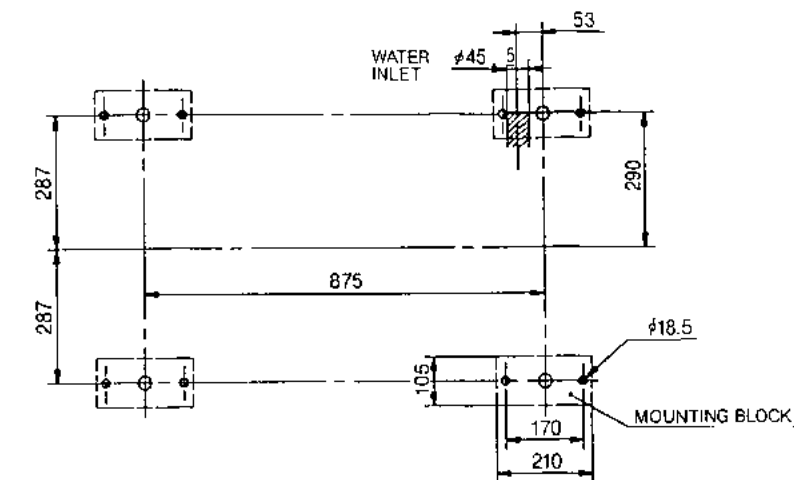


DETAIL OF FRONT COUPLING (1/5)

[6LYA-UTE, STE] With KMH6A marine gear

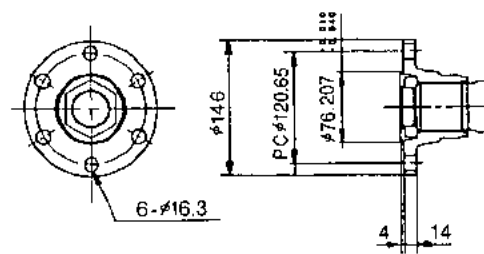
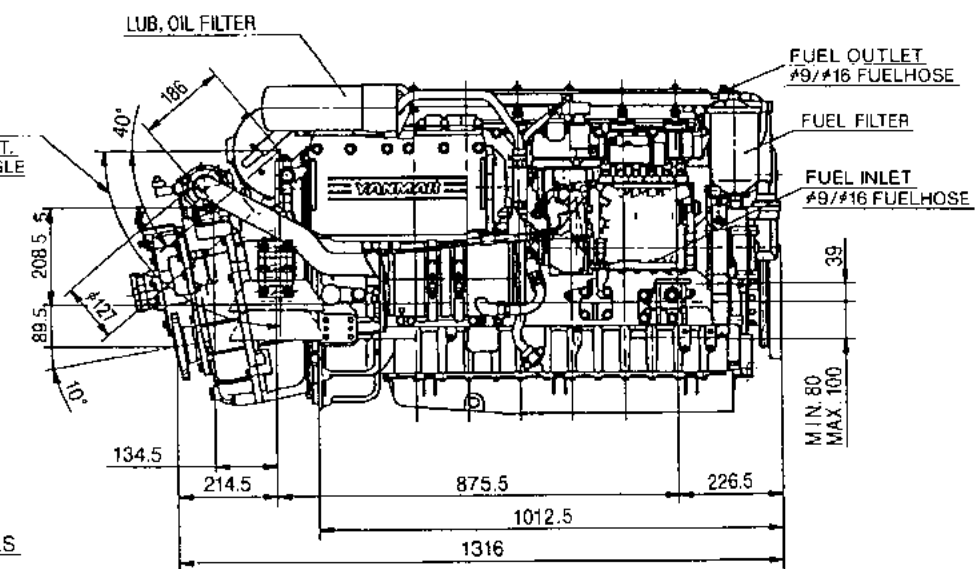


DETAIL OF FRONT COUPLING (1/5)



MIXING ELBOW  
V-BAND TYPE AT EXHAUST INLET.  
ALLOWABLE INSTALLATION ANGLE  
BETWEEN 0° TO 90° DEGREE.

NOTE  
DWG. SHOWS MOUNTING BLOCKS  
AT COMPRESSED HEIGHT.  
(COMPRESSED BY APPROX X3mm)



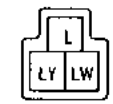
DETAIL OF FRONT COUPLING (1/5)

## 5. Wiring Diagrams

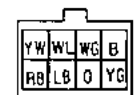
### (1) New B-type Instrument panel

(Color coding)

R	Red
B	Black
W	White
Y	Yellow
L	Blue
G	Green
O	Orange
Lg	Light green
Lb	Light blue
Br	Brown
P	Pink
Gr	Gray
Pu	Purple



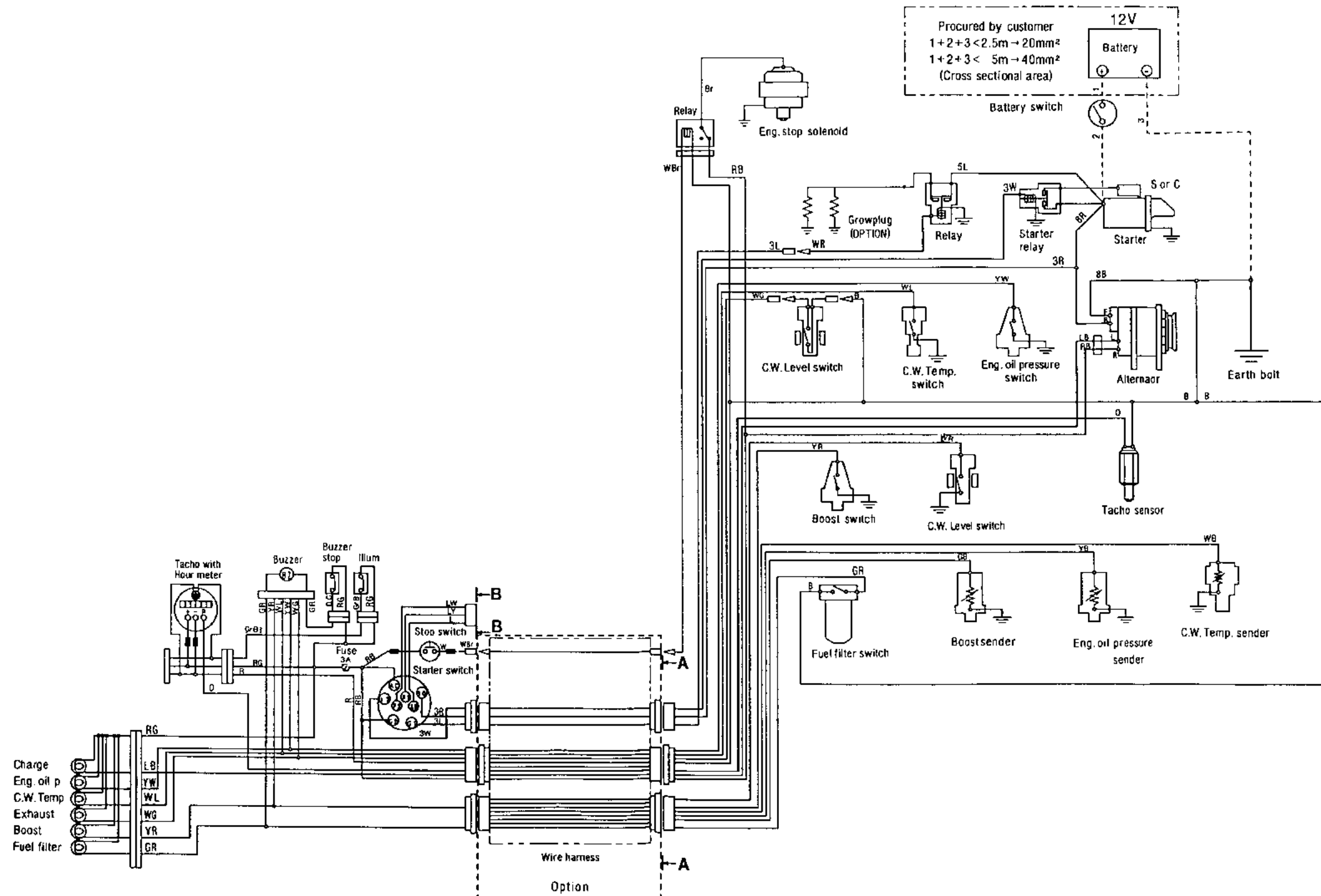
Details of  
coupler



Details of  
coupler

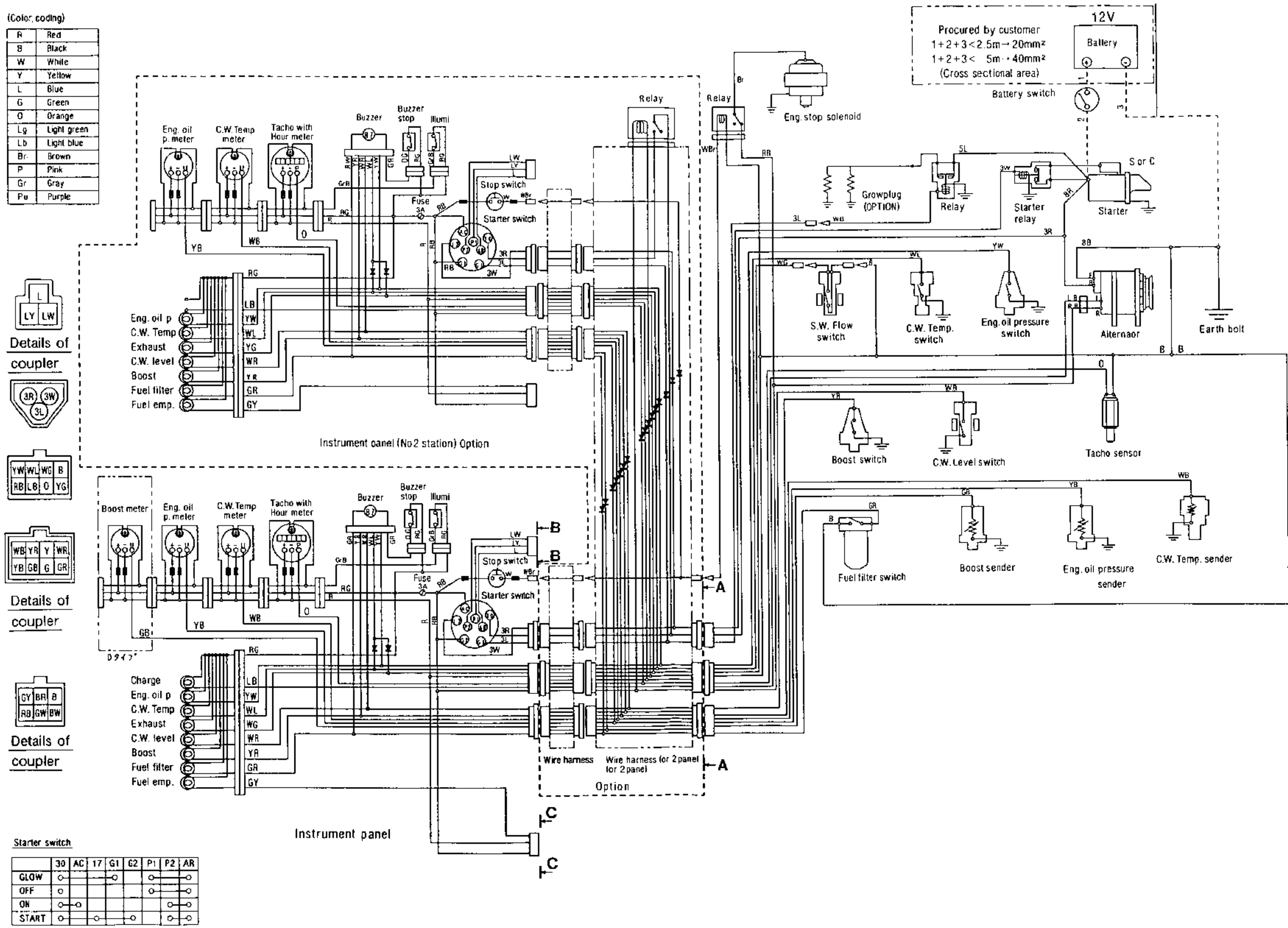
Starter switch

	30	AC	17	G1	G2	P1	P2	AR
GLOW	○	○	○	○	○	○	○	○
OFF	○	○	○	○	○	○	○	○
ON	○	○	○	○	○	○	○	○
START	○	○	○	○	○	○	○	○

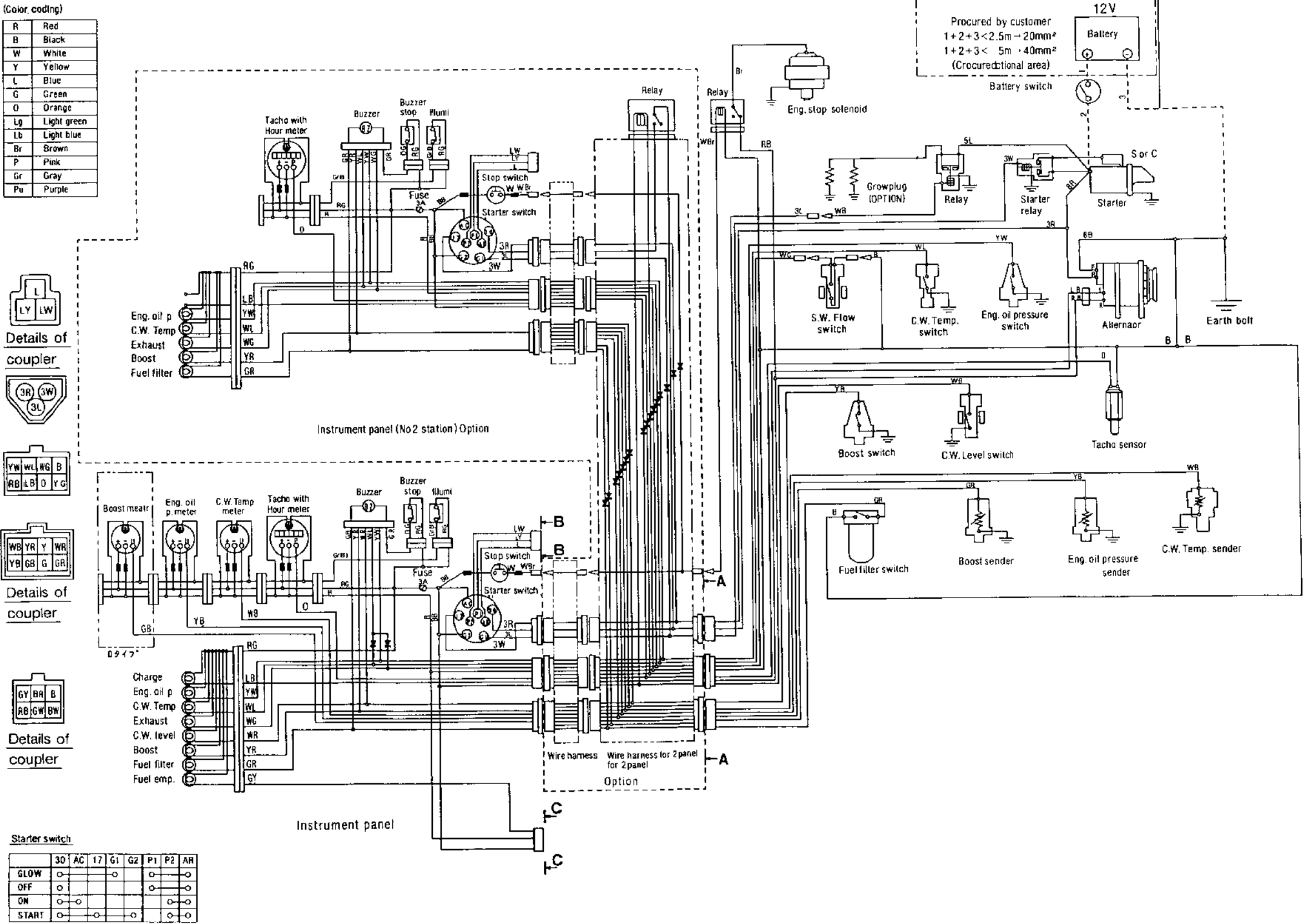


Instrument panel

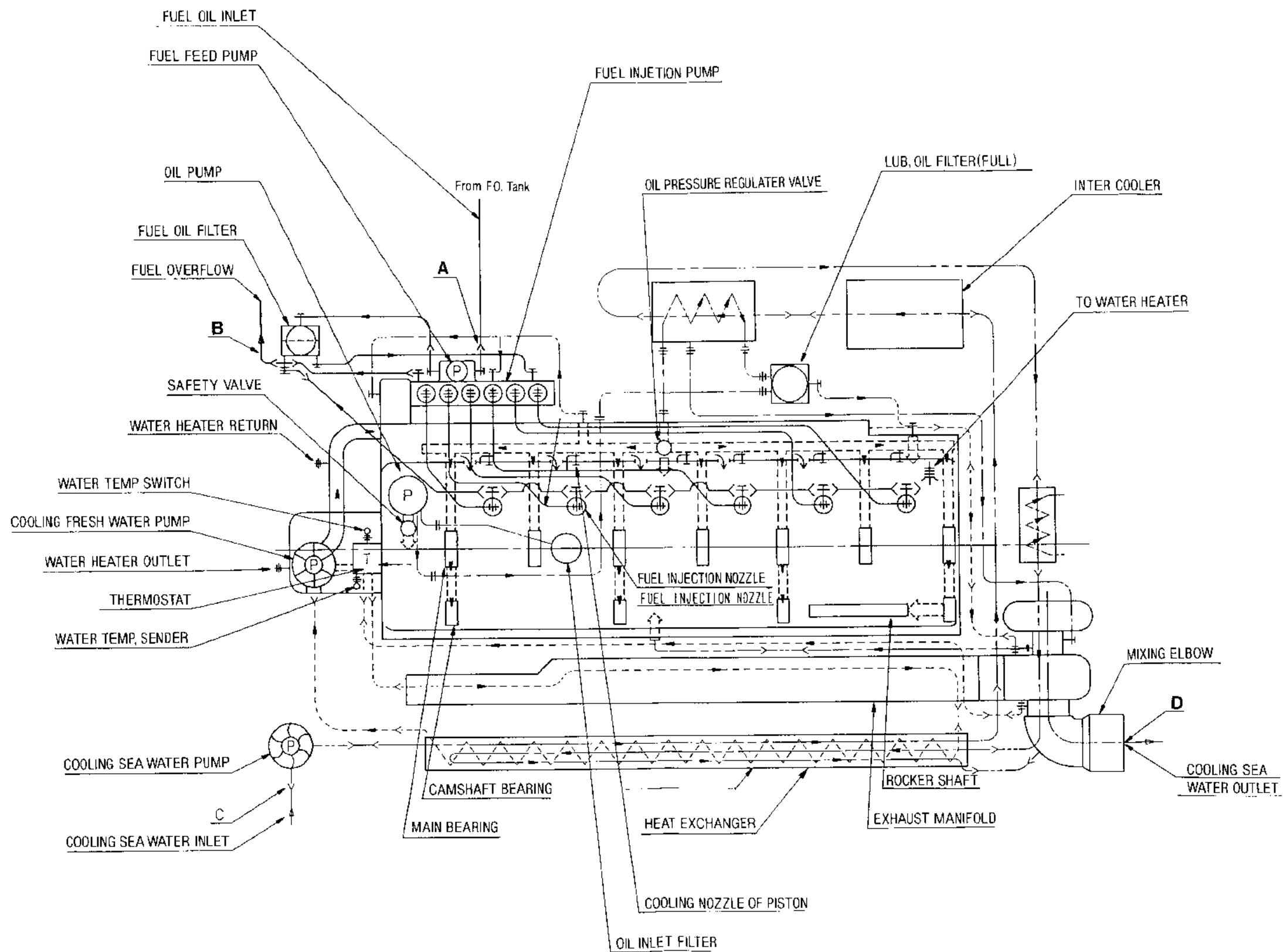
(2) New C-type Instrument panel



(3) New D-type instrument panel



## 6. Piping Diagrams

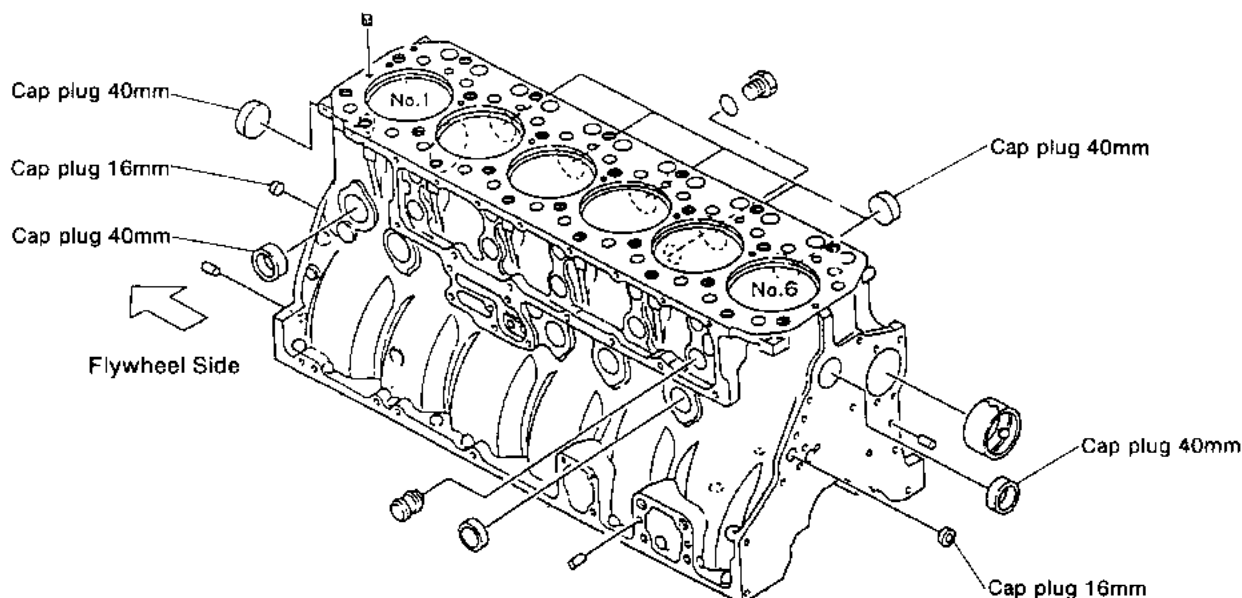


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# 1. Cylinder Block

The cylinder block is a thin-skinned, (low-weight), short skirt type with rationally placed ribs. The side walls are waver shaped to maximize rigidity for strength and low noise.



## 1-1 Inspection of parts

Make a visual inspection to check for cracks on engines that have frozen up, overturned or otherwise been subjected to undue stress. Perform a color check on any portions that appear to be cracked, and replace the cylinder block if the crack is not repairable.

## 1-2 Cleaning of oil holes

Clean all oil holes, making sure that none are clogged up and the blind plugs do not come off.

Color check kit

	Quantity
Penetrant	1
Developer	2
Cleaner	3



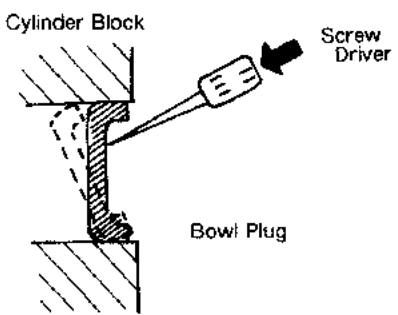
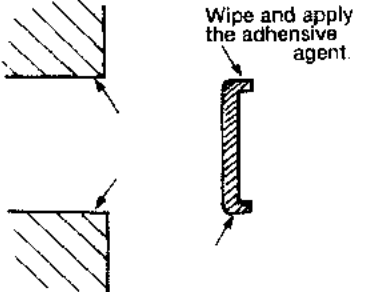
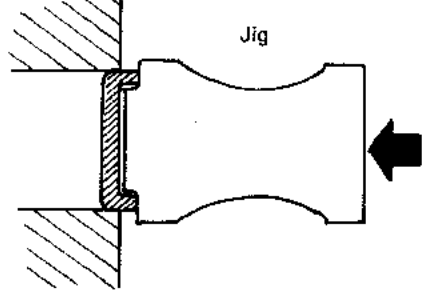
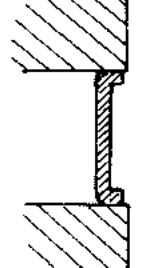
## 1-3 Color check procedure

- (1) Clean the area to be inspected.
- (2) Color check kit  
The color check test kit consists of an aerosol cleaner, penetrant and developer.
- (3) Clean the area to be inspected with the cleaner.  
Either spray the cleaner on directly and wipe, or wipe the area with a cloth moistened with cleaner.
- (4) Spray on red penetrant  
After cleaning, spray on the red penetrant and allow 5 ~ 10 minutes for penetration. Spray on more red penetrant if it dries before it has been able to penetrate.
- (5) Spray on developer  
Remove any residual penetrant on the surface after the penetrant has penetrated, and spray on the developer. If there are any cracks in the surface, red dots or a red line will appear several minutes after the developer dries.  
Hold the developer 300~400mm away from the area being inspected when spraying, making sure to coat the surface uniformly.
- (6) Clean the surface with the cleaner.

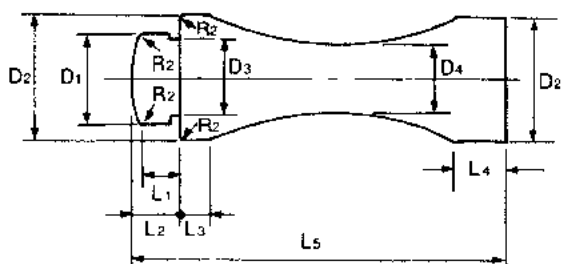
**NOTE :** Without fail, read the instructions for the color check kit before use.



### 1-4 Replacement of cup plugs

Step No.	Description	Procedure	Tool or material used
1	 <p>Cylinder Block</p> <p>Screw Driver</p> <p>Bowl Plug</p>	<p>Remove the bowl plug using by a screw driver and hammer.</p> <p>Hit the bowl plug by screw driver and hammer tap tightly obliquely from the upper side.</p>	<ul style="list-style-type: none"> <li>·Screw driver</li> <li>·Hammer</li> </ul>
2	 <p>Wipe and apply the adhesive agent.</p>	<p>Wipe the cylinder block and bowl plug fitting portion clean.</p> <p>Apply an adhesive agent (acrylic) on the periphery of the bowl plug and the cylinder block inside.</p>	<ul style="list-style-type: none"> <li>·Thinner</li> <li>·Adhesive agent (or Three bond 1386B)</li> </ul>
3	 <p>Jig</p>	<p>Insert the bowl plug using by the jig and hammer.(Set the jig straightly.)</p>	<ul style="list-style-type: none"> <li>·Jig</li> <li>·Hammer</li> </ul>
4		<p>Do not supply water into the cylinder block for two hours after the bowl plug are set.</p>	

<Note> Design of Jig



mm

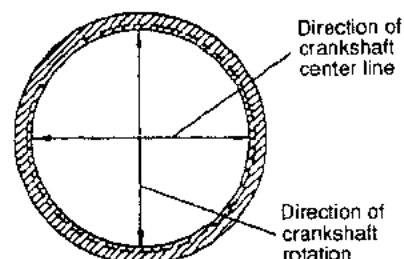
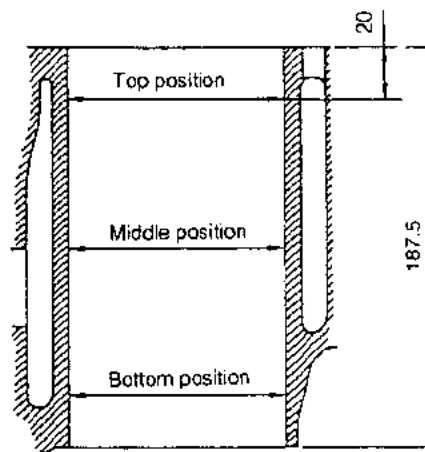
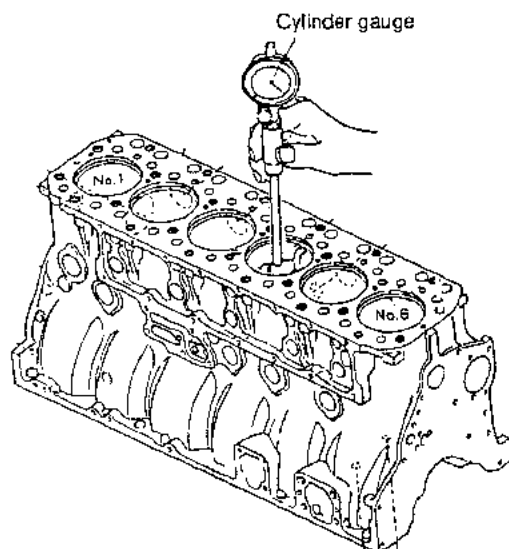
Plug dia	D1	D2	D3	D4	L1	L2	L3	L4	L5
φ 16	12.0	20.0	10.0	10.0	2.5	4.0	20.0	30.0	150.0
φ 40	36.0	48.0	34.0	28.0	8.5	10.0	20.0	30.0	150.0

### 1-5 Cylinder bore measurement

Measure the bore diameter with a cylinder gauge at the positions shown in the figure.

Replace the cylinder bore when the measured value exceeds the wear limit. Measurement must be done at least at 3 positions as shown in the figure, namely, top, middle and bottom positions in both directions along the crankshaft rotation and crankshaft center lines.

mm



mm

	Standard	Wear limit
Cylinder bore dia.	$\phi 100.03 \sim \phi 100.00$	$\phi 100.07$
Cylinder roundness	$-0.005 \sim +0.025$	0.04

## 2. Cylinder Sleeve

### 2-1. Cylinder Sleeve

The rigidity of the cylinder sleeve is increased by employing a dry type sleeve.

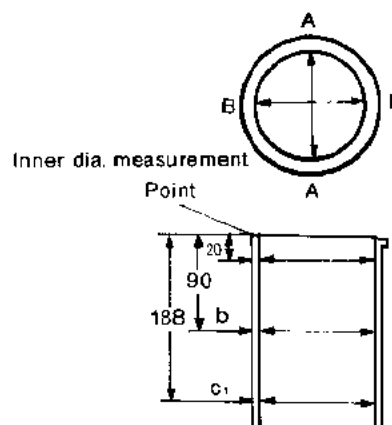
The wear resistance of the cylinder sleeve is also increased by employing new material.

### 2-2. Measurement of sleeve

Measure the inner diameter of each cylinder sleeve using a cylinder gauge. If the inner diameter exceeds the limit specified in the table below, replace the sleeve.

mm

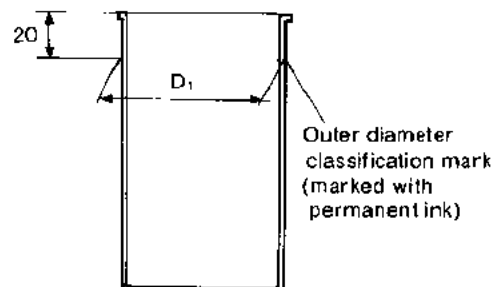
		Nominal dimension	Limit dimension
Inner diameter of cylinder sleeve	L	$\phi 100.020 \sim \phi 100.030$	$\phi 100.050$
	M	$\phi 100.010 \sim \phi 100.019$	
	S	$\phi 100.000 \sim \phi 100.009$	
Circularity of cylinder sleeve		Less than 0.03	—
Cylindricity of cylinder sleeve		Less than 0.02	—



NOTE: Be sure to measure inner diameter of cylinder sleeve at points "a", "b", and "c" in directions "A" and "B"

### 2-3. Insertion of cylinder sleeve

Classification of cylinder sleeve outer dia.	Outer diameter classification mark A, B, C at position 20mm below top
Classification of cylinder block	Block identification mark A, B, and C on top surface of block operating side



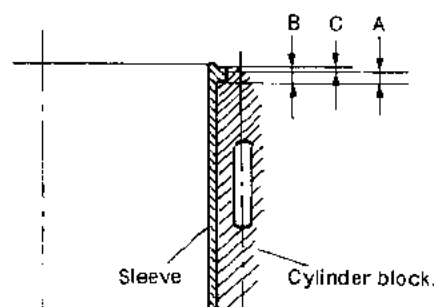
Block inner dia.		Combination	Sleeve outer dia.	
Dimension Tolerance $\phi 103$		Clearance: 10~30 $\mu$	Dimension	
Mark	Tolerance		Mark	Tolerance
A	+0.030 +0.020		A	+0.010 0
B	+0.020 +0.010		B	0 -0.010
C	+0.010 0		C	-0.010 -0.020

### 2-4. Measurement of projection

Check that the flange of each cylinder is slightly projecting from the top of the cylinder block.

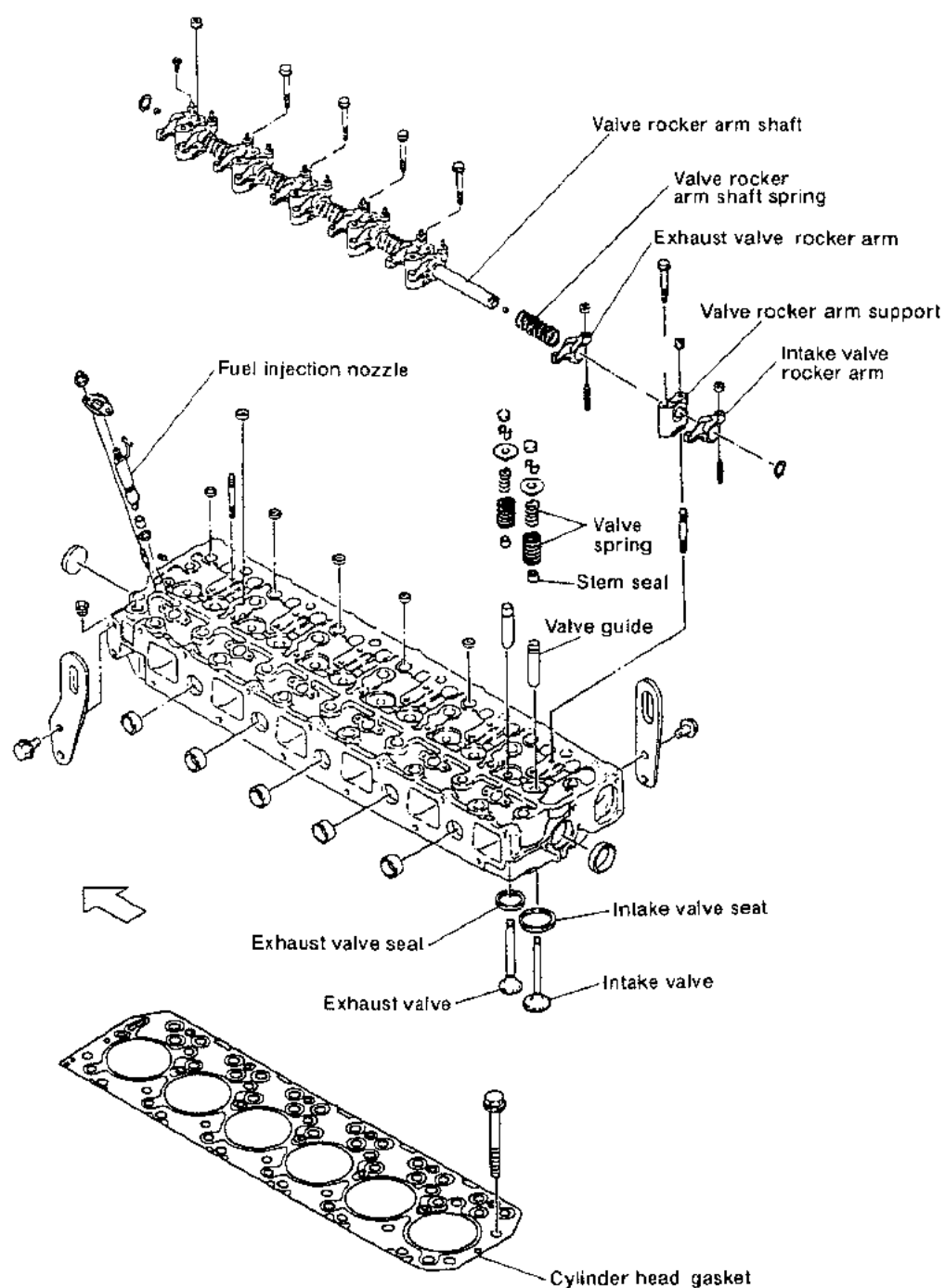
mm

Cylinder block hole depth : A	4.960~5.000
Cylinder sleeve flange thickness : B	5.025~5.050
Cylinder sleeve projection : C	0.025~0.09



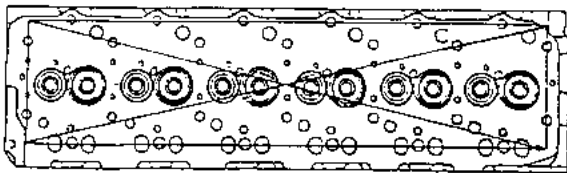
## 3. Cylinder Head

The cylinder head is of 6-cylinder integral construction, mounted with 26 bolts. Special alloy stellite with superior resistance to heat and wear is fitted on the seats, and the area between the valves is cooled by a water jet.



3-1 Inspecting the cylinder head

The cylinder head is subjected to very severe operating conditions with repeated high pressure, high temperature and cooling. Thoroughly remove all the carbon and dirt after disassembly and carefully inspect all parts.

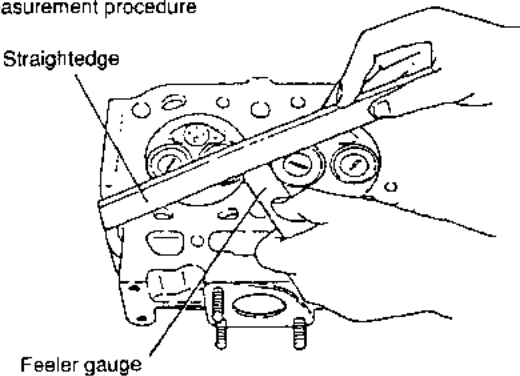


3-1.1 Distortion of the combustion surface

Carefully check for cylinder head distortion as this leads to gasket damage and compression leaks.

- (1) Clean the cylinder head surface.
- (2) Place a straight-edge along each of the four sides and each diagonal. Measure the clearance between the straight-edge and combustion surface with a feeler gauge.

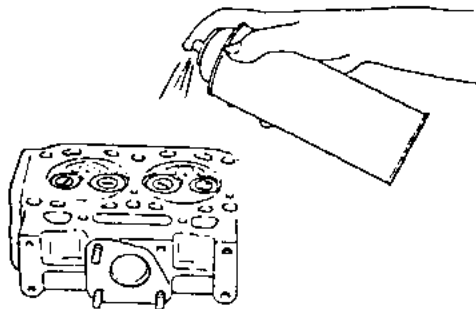
Measurement procedure



	Standard	limit
Cylinder head distortion	0.05(0.0019) or less	0.20

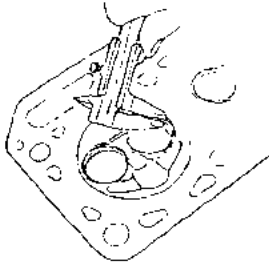
3-1.2 Checking for cracks in the combustion surface

Remove the fuel injection nozzle, intake and exhaust valve and clean the combustion surface. Check for discoloration or distortion and conduct a color check test to check for any cracks.



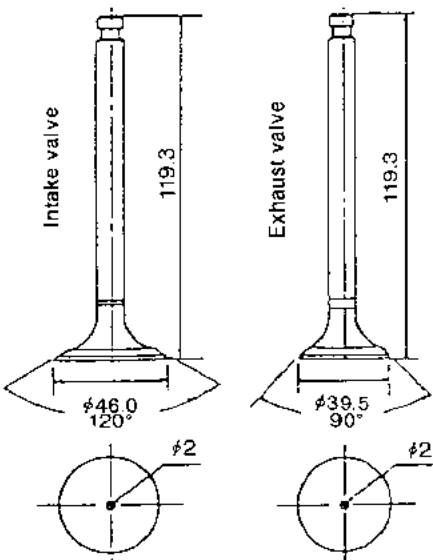
3-1.3 Checking the intake and exhaust valve seats

Check the surface of the valve seats. If they are too wide, or if the surfaces are rough, correct to the following standards:



Seat angle	Intake	120°
	Exhaust	90°
Seat width	Standard	Wear limit
Intake	1.731	2.32
Exhaust	2.121	2.73

Standard dimension

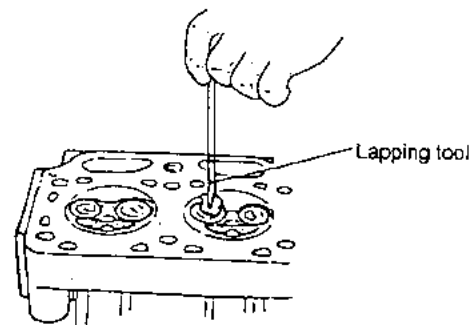
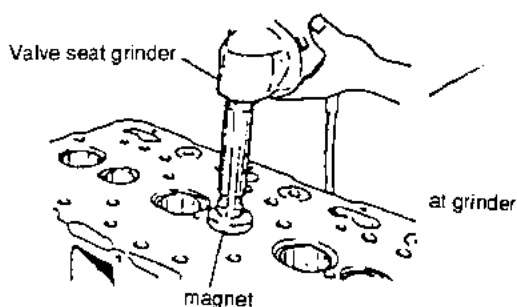


### 3-2 Valve seat correction procedure

The most common method for correcting unevenness of the seat surface with a seat grinder is as follows:

(1) Use a seat grinder to make the surface even.

As the valve seat width will be enlarged, first use a 70° grinder, then grind the seat to the standard dimension with a 15° grinder.

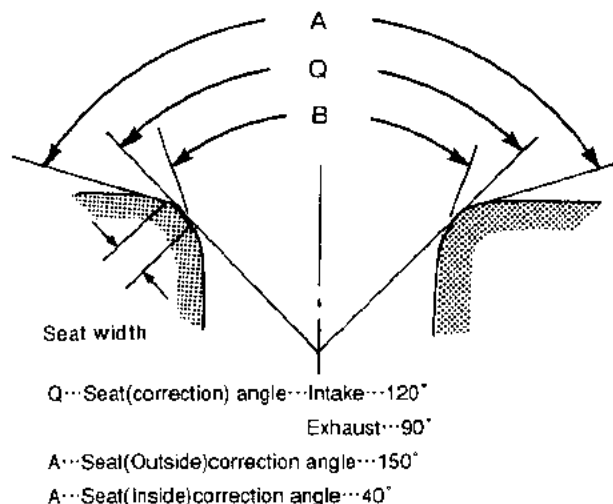


**NOTE :** Clean the valve and cylinder head with light oil or the equivalent after valve seat finishing is completed and make sure that there are no grindings remaining.

**NOTE :** Measure valve distortion after valve seat refinishing has been completed, and replace the valve and valve seat if it exceeds the tolerance.

Seat grinder	Intake valve	30°
	Exhaust valve	45°

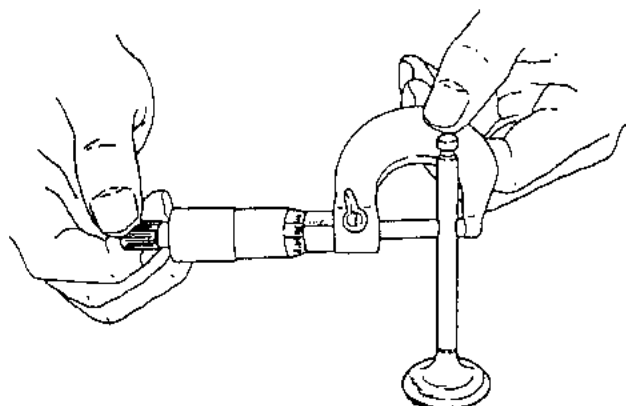
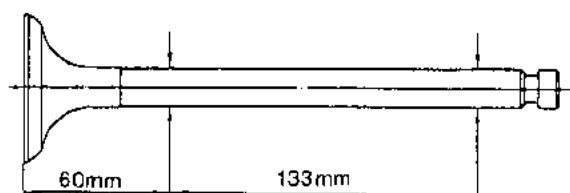
**NOTE :** When seat adjustment is necessary, be sure to check the valve and valve guide. If the clearance exceeds the tolerance, replace the valve or the valve guide, and then grind the seat.



### 3-3 Intake/exhaust valves, valve guides

#### 3-3.1 Wearing and corrosion of valve stem

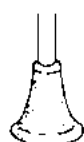
Replace the valve if the valve stem is excessively worn or corroded.



mm

Valve stem outside dia.	Standard	Wear limit
Intake	φ 8.960 ~ φ 8.975	φ 8.9
Exhaust	φ 8.940 ~ φ 8.955	φ 8.9

Lapping tool  
Use a rubber cap type lapping tool for cylinders without a lapping tool groove slit.



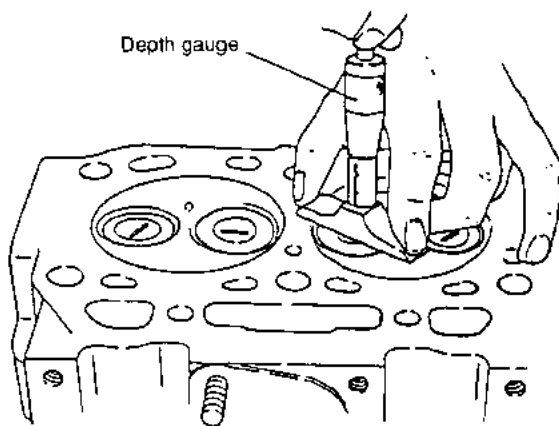
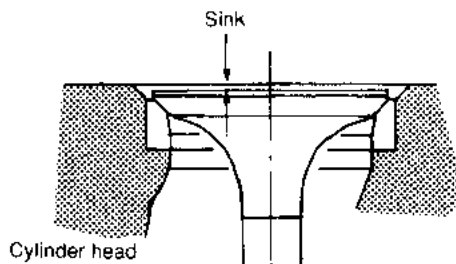
### 3-3.2 Inspection of valve seat wear and contact surface

Inspect for valve seat scratches and excessive wear. Check to make sure the contact surface is normal. The seat angle must be checked and adjusted if the valve seat contact surface is much smaller than the width of the valve seat.

**NOTE:** Keep in mind the fact that the intake and discharge valve have different diameters.

### 3-3.3 Valve sinking

Over long periods of use and repeated lappings, combustion efficiency may drop. Measure the sinking distance and replace the valve and valve seat if the valve sink exceeds the tolerance.



		mm	
		Standard	Limit
Valve Sink and Project	Intake	(Project) 0.6~0.8	(Sink) 0.6
	Exhaust	(Sink) 0.2~0.4	(Sink) 1.8

#### (1) Measuring inner diameter of valve guide.

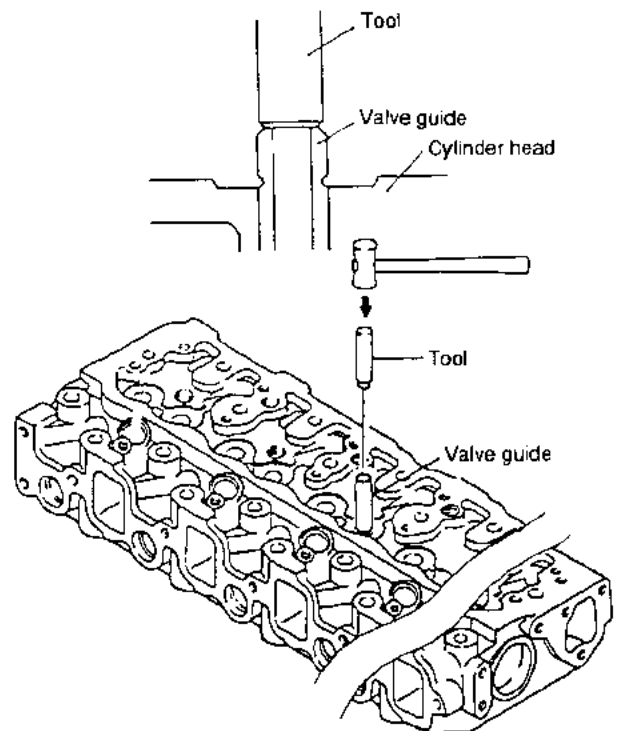
Measure the inner diameter of the valve guide and replace it if it exceeds the wear limit.

		mm	
		Standard	Wear limit
Valve guide inside dia.	Intake	$\phi 9.00 \sim \phi 9.015$	$\phi 9.1$
	Exhaust	$\phi 9.00 \sim \phi 9.015$	$\phi 9.1$

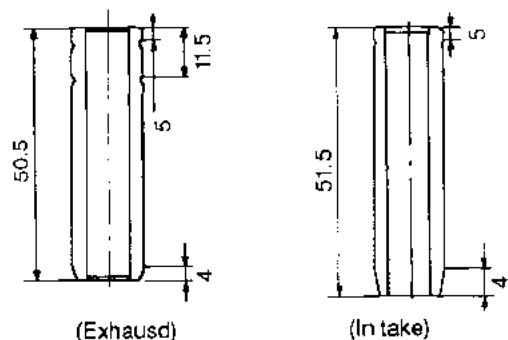
**NOTE:** The inner diameter standard dimensions are measured after insertion.

#### (2) Replacing the valve guide

Use the insertion tool and tap in the guide with a mallet.

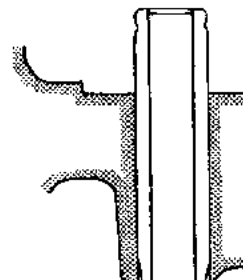


The intake valve guide and exhaust valve guide are of different shapes/dimensions.



#### (3) Valve guide projection

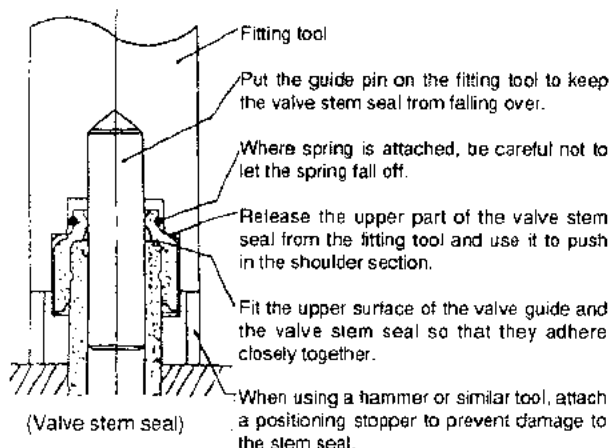
The bottom of the valve guide should be aligned with the bottom of the cylinder head.



#### (4) Valve stem seals

The valve stem seals in the intake/exhaust valve guides cannot be re-used once they are removed - be sure to replace them.

When assembling the intake/exhaust valves, apply an adequate quantity of engine oil on the valve stem before inserting them.

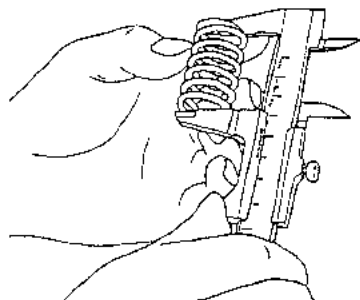


### 3-4 Valve springs

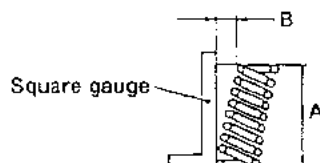
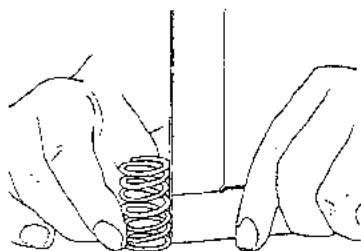
#### 3-4.1 Checking valve springs

(1) Check the spring for scratches or corrosion.

(2) Measure the free length of the spring.

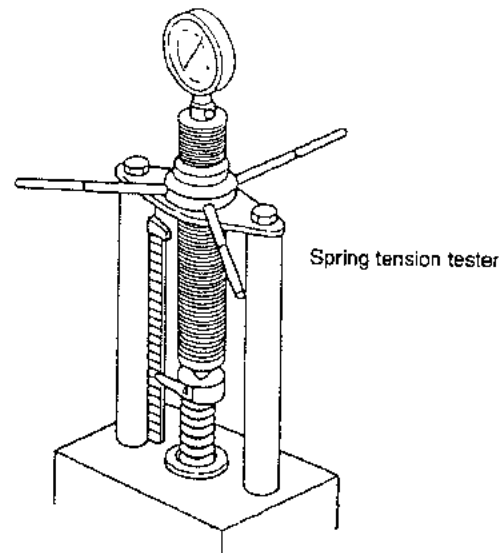


(3) Measure inclination.



	mm
Inclination	Limit 1.2

(4) Measure spring tension.

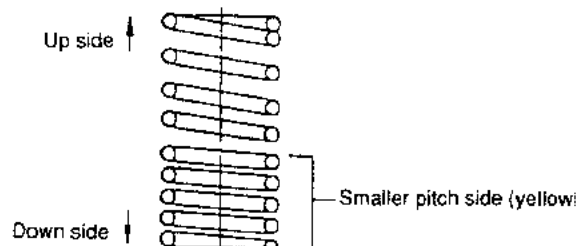


(Inside)	mm	
Valve spring	Standard	Wear limit
Free length	44.75	43.50
Length when attached	35.75	—
Load when attached	7.5kg	6.2kg

(Outside)	mm	
Valve spring	Standard	Wear limit
Free length	45.15	43.7
Length when attached	37.50	—
Load when attached	12.86kg	12.50kg

Assembling valve springs.

The side with the smaller pitch (painted yellow) should face down (cylinder head).



**NOTE :** The pitch of the valve spring is not even. The side with the smaller pitch (yellow) should face down (cylinder head) when assembled.

#### (5) Spring retainer and spring cotter

Inspect the inside face of the spring retainer, the outside surface of the spring cotter, the contact area of the spring cotter inside surface and the notch in the head of the valve stem. Replace the spring retainer and spring cotter when the contact area is less than 70%, or when the spring cotter has been recessed because of wear.

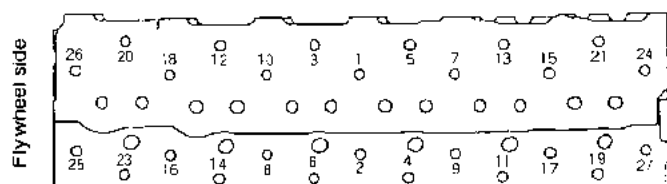


### 3-5 Assembling the cylinder head

Partially tighten the bolts in the specified order and then tighten to the specified torque, being careful that the head does not get distorted.

- (1) Clean out the cylinder head bolt holes.
- (2) Check for foreign matter on the cylinder head surface where it comes in contact with the block.
- (3) Coat the head bolt threads and nut seats with lube oil.
- (4) Use the positioning pins to line up the head gasket with the cylinder block.
- (5) Match up the cylinder head with the head gasket and mount.

Exhaust manifold side



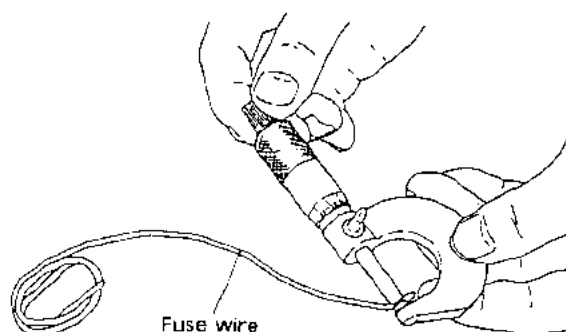
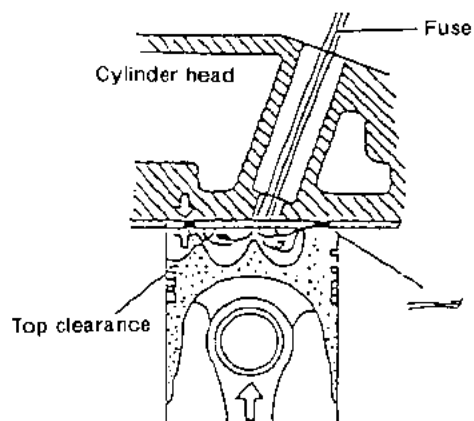
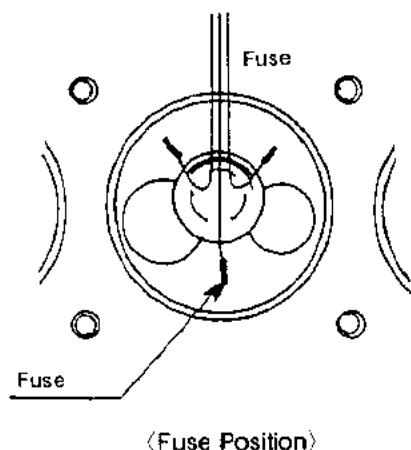
Intake manifold side

kg-m

	First	Second
Tightening torque	15.0~16.0	20.0~22.0

### 3-6 Measuring top clearance

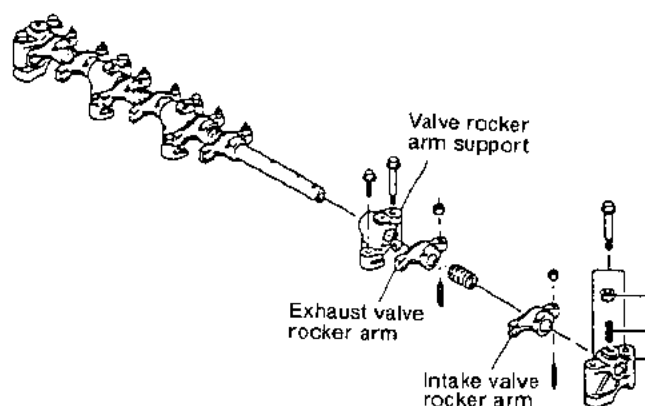
- (1) Place a high quality fuse (φ1.5mm, 10mm long) in three positions on the flat part of the piston head.
- (2) Assemble the cylinder head gasket and the cylinder block and tighten the bolts in the specified order to the specified torque.
- (3) Turn the crank, (in the direction of engine revolution), and press the fuse against the piston until it breaks.
- (4) Remove the head and take out the broken fuse.
- (5) Measure the three positions where each fuse is broken and calculate the average.  
(0.71~0.75mm is ideal)



	mm
Top clearance	0.71~0.89

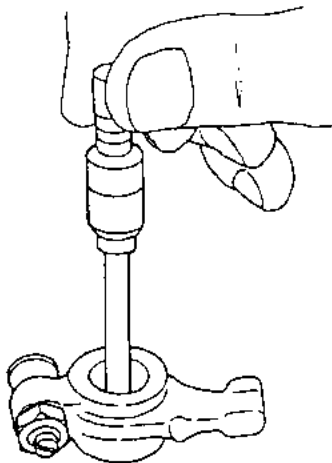
### 3-7 Intake and exhaust valve arms

Valve arm and valve arm bushing wear may change opening/closing timing of the valve, and may in turn affect engine performance according to the extent of the change.



**(1) Rocker arm shaft and valve arm bushing**

Measure the outer diameter of the shaft and the inner diameter of the bearing, and replace if wear exceeds the limit.



		Standard	Wear limit
Intake and exhaust valve rocker arm shaft outside dia.	A	18.459~18.479	18.35
Intake and exhaust valve rocker arm inside dia.	B	18.500~18.520	18.60
Valve rocker arm shaft and bushing clearance at assembly		0.012~0.061	0.15

mm

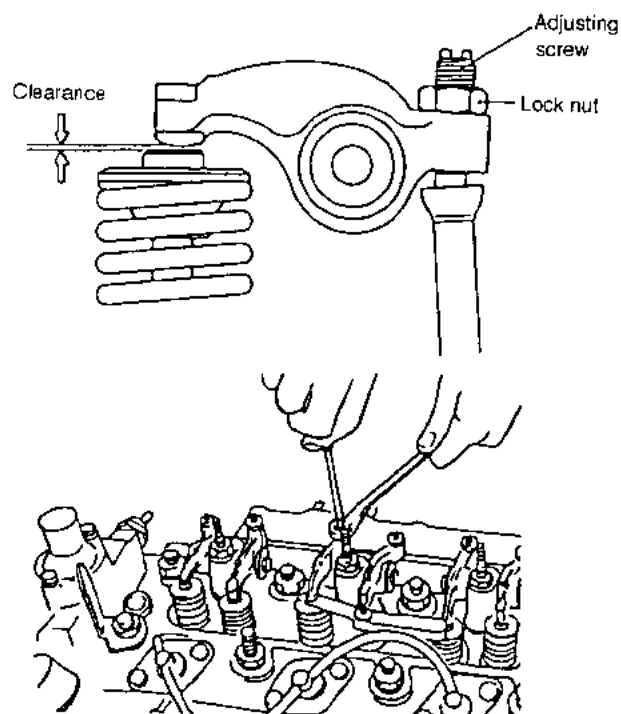
Replace the rocker arm shaft bushing if it moves and replace the entire rocker arm if there is no tightening clearance.

**(2) Valve spring**

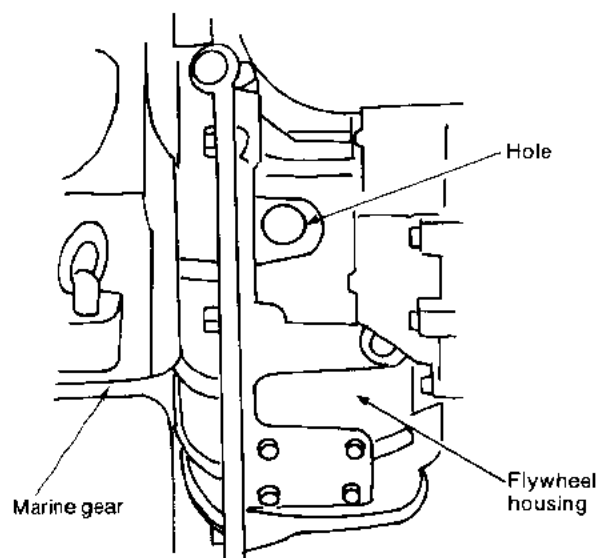
Check the valve spring and replace it if it is corroded or worn.

**(3) Rocker arm and cotter wear**

Inspect the contact surface of the Rocker arm and replace it if there is abnormal wear or flaking.

**(4) Inspect the contact surface of the valve clearance adjustment screw and push rod and replace if there is abnormal wear or flaking.**

- (2) Be sure that the opening and closing angles for both the intake and the exhaust valves are checked when the timing gear is disassembled.

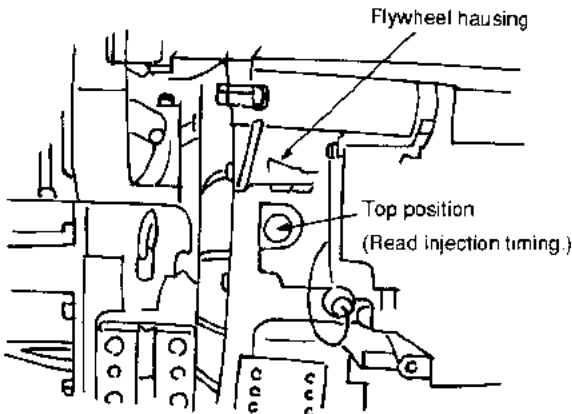
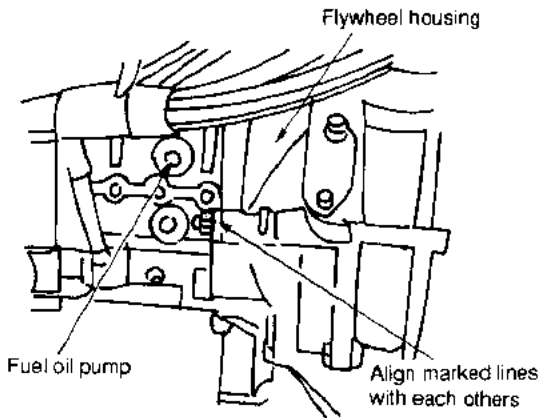
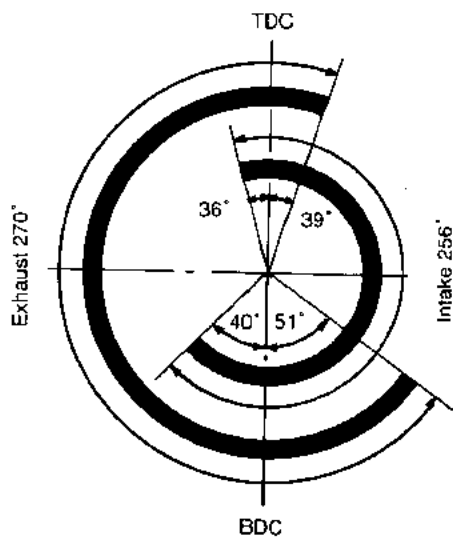
**3-8 Adjustment of valve clearance**

- (1) Make adjustments when the engine is cool.

	mm	
	6LYA-UTE	6LYA-STE
Intake valve clearance	0.1	0.1
Exhaust valve clearance	0.4	0.5

Intake valve	Open	Crank angle: Before T.D.C.	$36^{\circ} \pm 5$
	Close	Crank angle: After B.D.C.	$40^{\circ} \pm 5$
Exhaust valve	Open	Crank angle: Before B.D.C.	$51^{\circ} \pm 5$
	Close	Crank angle: After T.D.C.	$39^{\circ} \pm 5$

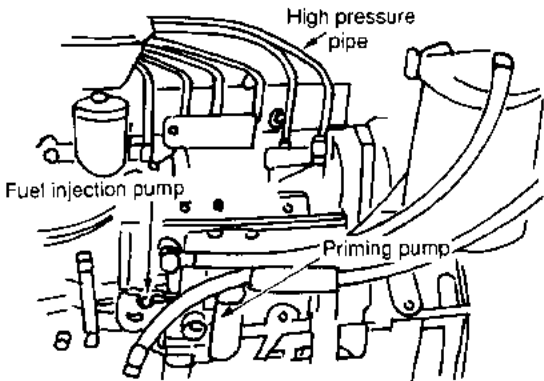
Vale opening diagram



3-9 Checking and adjusting the fuel injection timing

- 1) Remove the high-pressure fuel oil pipe from the fuel injection pump.
- 2) While manually turning the flywheel slowly, check that the timing of the fuel flowing out of the discharge valve holder of the cylinder injection pump conforms to the specified timing by visually inspecting the flywheel and indicator.
- 3) Check the fuel injection timing of all the cylinders by following the step (2) above. (If the observed timing does not confirm to the specified timing, consult the nearest YANMAR dealer.)

Inspection Schedule	Every 2500 service hrs (or annually)
Fuel injection timing	13°±1

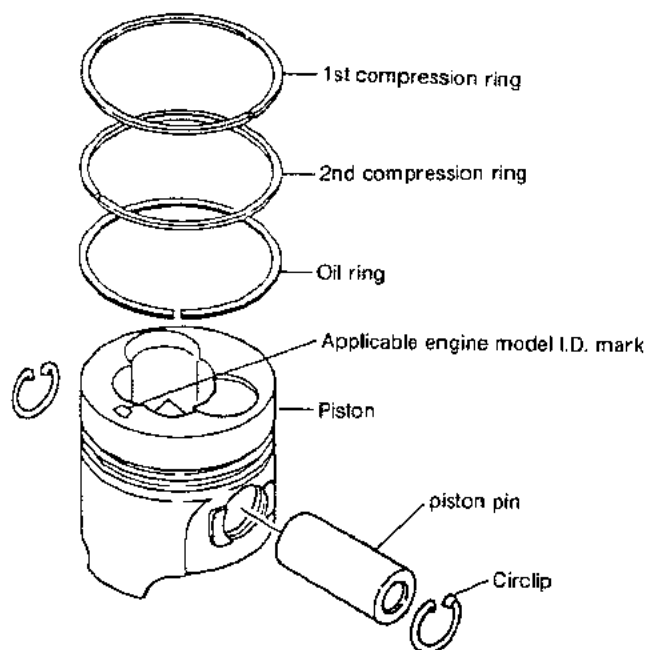


## 4. Piston and Piston Pins

Pistons are made of a special light alloy with superior thermal expansion characteristics, and the top of the piston forms a swirl type toroidal combustion chamber. The opposite face of the piston combustion surface is oil-jet cooled.

Piston for engines with superchargers have a valve res for the intake and exhaust valves.

The clearance between the piston and cylinder liner is kept at the proper value by the piston cylinder liner property fit effected during assembly at the Yanmar factory.



### IMPORTANT:

Piston shape differs among engine models. If an incorrect piston is installed, combustion performance will drop. Be sure to check the applicable engine model identification mark (I.D. Mark) on the piston to insure use of the correct part.

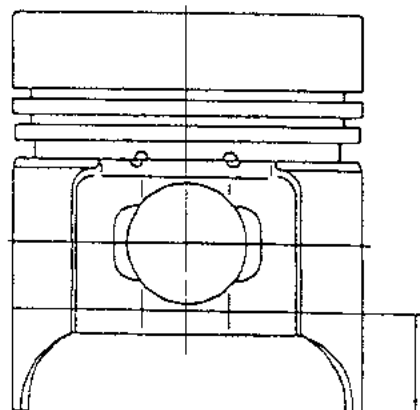
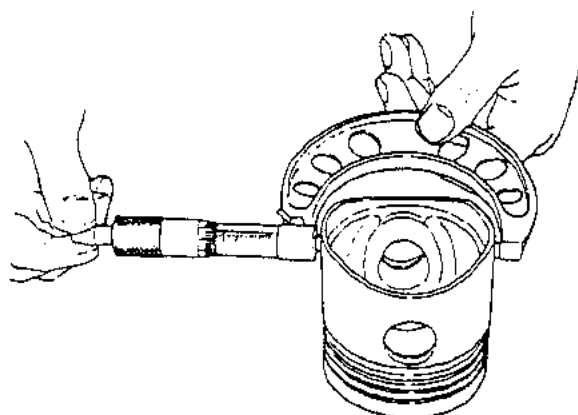
### 4-1 Piston

#### 4-1.1 Piston head and combustion surface

Remove the carbon that has accumulated on the piston head and combustion surface, taking care not to scratch the piston. Check the combustion surface for any damage.

#### 4-1.2 Measurement of piston outside diameter/ inspection

- (1) Replace the piston if the outsides of the piston or ring grooves are worn.
- (2) Measure the piston 22mm from the bottom at right angles to the piston pin.



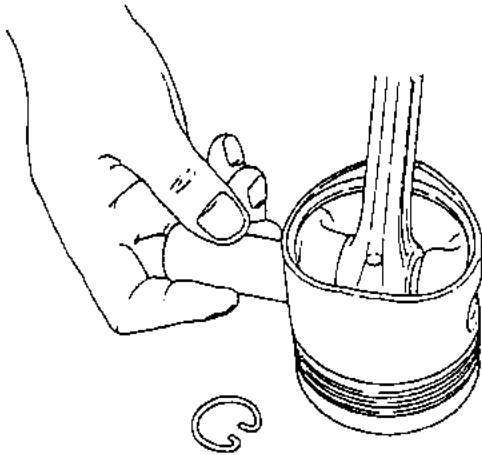
	Mark	Standard dimension	Limit dimension
Piston outer dia.	ML	99.910~99.915	99.790
	MS	99.910~99.915	

mm

Combination		Piston	
		ML	MS
Cylinder sleeve	L	○	×
	M	○	○
	S	×	○

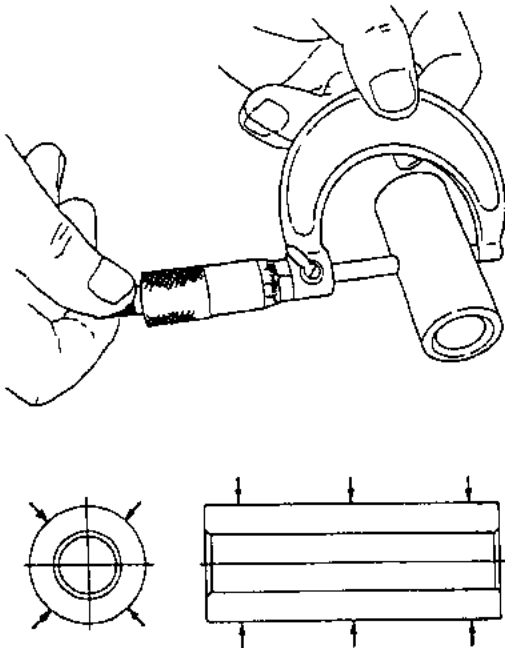
4-1.3 Replacing the piston

A floating type piston pin is used in this engine. The piston pin can be pressed into the piston pin hole at room temperature (coat with oil to make it slide in easily).



4-2 Piston pin

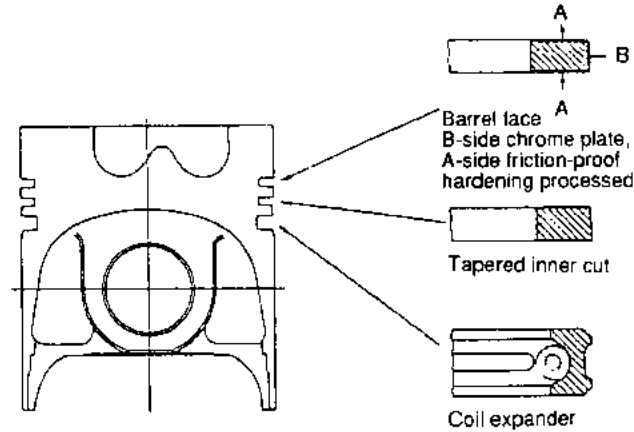
Measure the outer diameter and replace the pin if it is excessively worn.



	mm	
	Standard	Wear limit
Piston pin insert hole dia.	$\phi 37.000$	$\phi 37.020$
Piston pin outside dia.	$\phi 36.989 \sim \phi 37.000$	$\phi 36.964$
Standard clearance	$0 \sim 0.022$	$0.045$

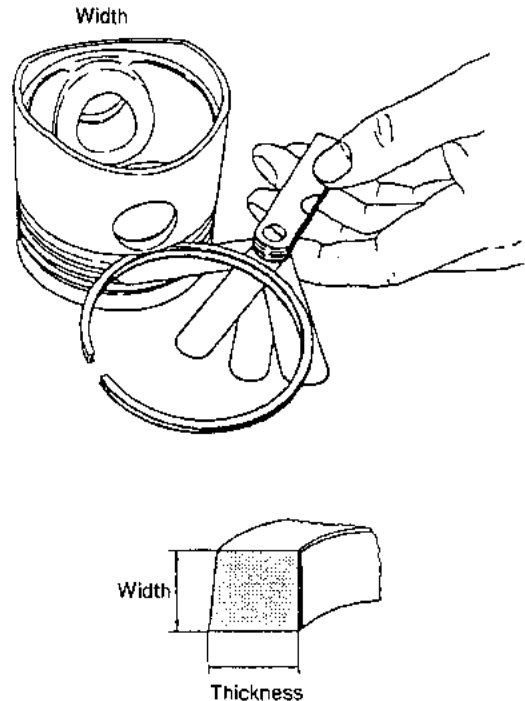
4-3 Piston rings

There are 2 compression rings and 1 oil ring.



4-3.1 Measuring the rings.

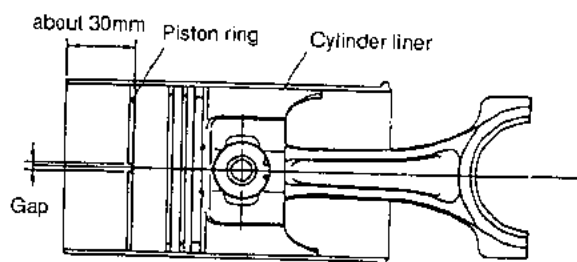
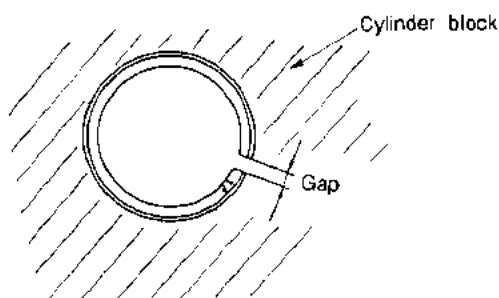
Measure the thickness and width of the rings, and the ring-to-groove clearance after installation. Replace if wear exceed the limit.



		mm	
		Standard	Wear limit
First piston ring	Groove width	2.025~2.040	—
	Ring width	1.970~1.990	—
	Groove and ring clearance	0.090~0.125	0.2
Second piston ring	Groove width	2.025~2.040	—
	Ring width	1.970~1.990	—
	Groove and ring clearance	0.035~0.070	0.2
Oil ring	Groove width	3.020~3.035	—
	Ring width	2.97~2.99	—
	Groove and ring clearance	0.030~0.065	0.15

#### 4-3.2 Measuring piston ring gap

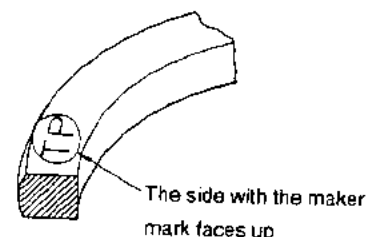
Press the piston ring onto a piston liner and measure the piston ring gap with a gauge. Press on the ring about 30mm from the bottom of the liner.



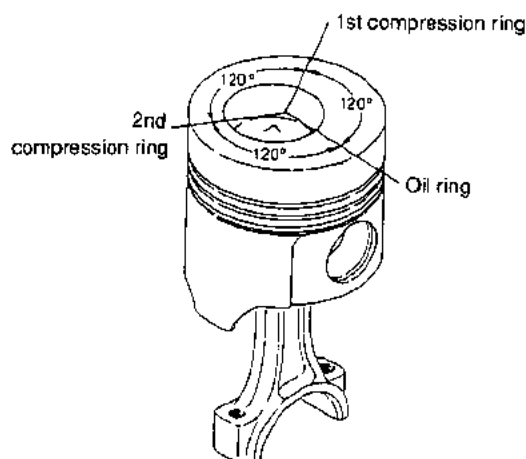
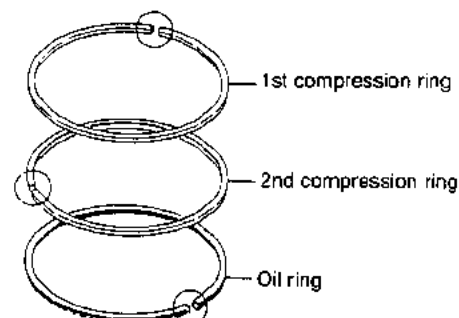
mm		
	Standard	Wear limit
First piston ring gap	0.25~0.40	1.5
Second piston ring gap	0.25~0.40	1.5
Oil ring gap	0.20~0.40	1.5

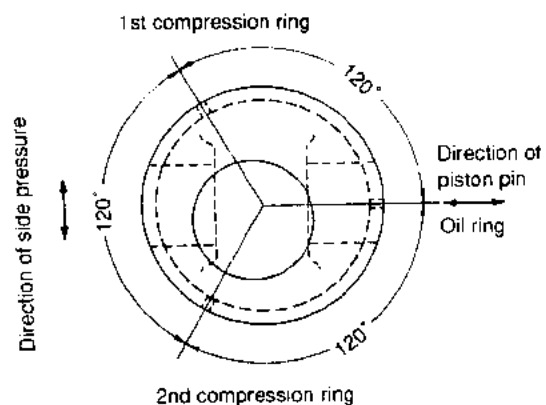
#### 4-3.3 Replacing the piston rings

- (1) Thoroughly clean the ring grooves when replacing piston rings.
- (2) The side with the manufacturer's mark (near piston ring gap) should face up.

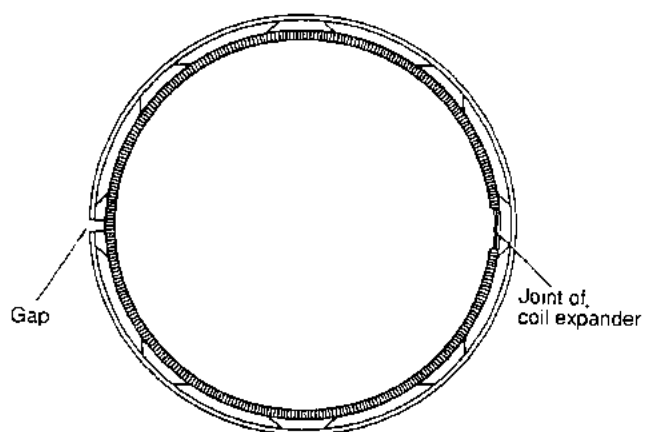


- (3) After fitting the piston ring, make sure it moves easily and smoothly.
- (4) Stagger the piston rings at 120° intervals, making sure none of them line up with the piston.



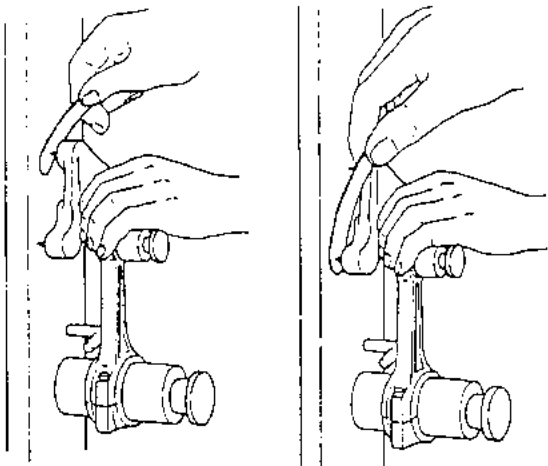
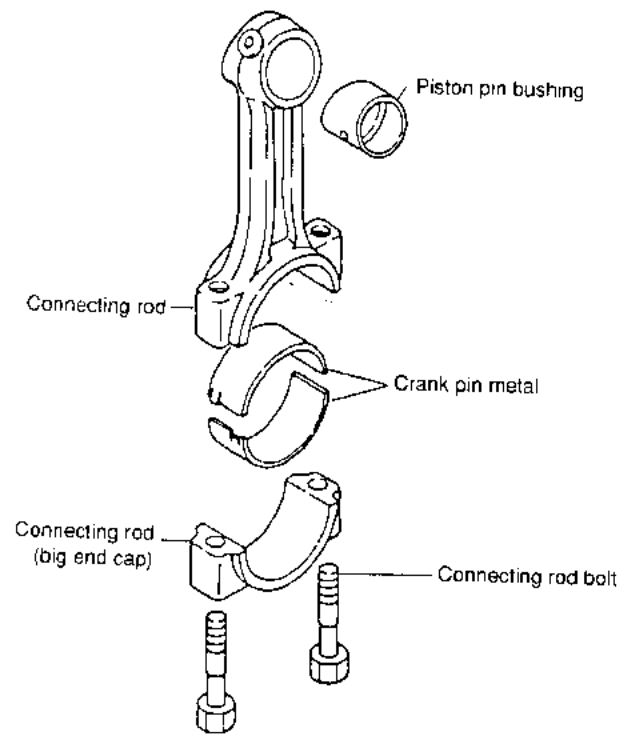


(5) The oil ring is provided with a coil expander. The coil expander joint should be opposite (staggered 180°) the oil ring gap.



# 5. Connecting Rod

The connecting rod is made of high-strength forged carbon steel.  
The large end with the aluminium metal can be separated into two and the small end has a 2-layer copper alloy coil bushing.

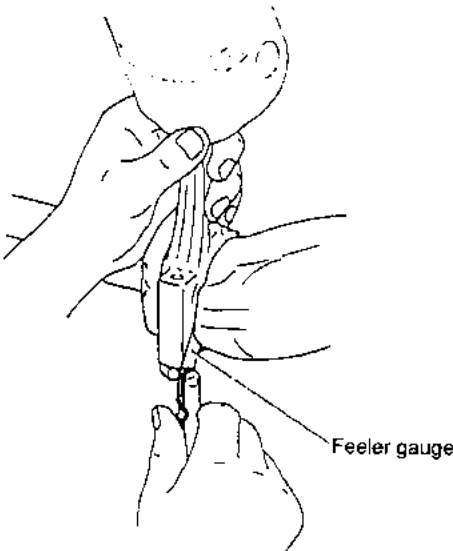


Measuring twist and parallelity

	mm	
	Standard	Wear limit
Connecting rod twist and parallelity	0.05	0.07

## 5-1.2 Checking thrust clearance

Fit the respective crank pins to the connecting rod and check to make sure that the clearance in the crankshaft direction is correct.

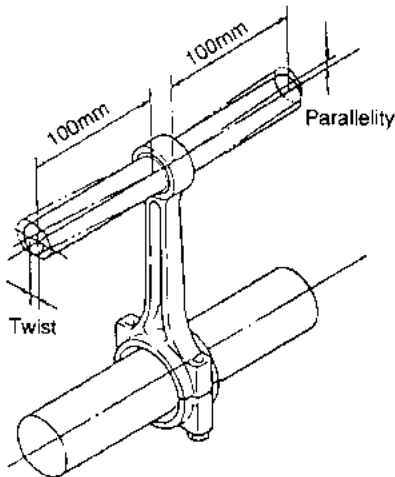


	mm	
	Standard	Wear limit
Connecting rod side clearance	0.20~0.40	0.45

## 5-1 Inspecting the connection rod

### 5-1.1 Twist and parallelism of the large and small ends

Insert the measuring tool into the large and small ends of the connecting rod. Measure the extent of twist and parallelism and replace if they exceed the tolerance.





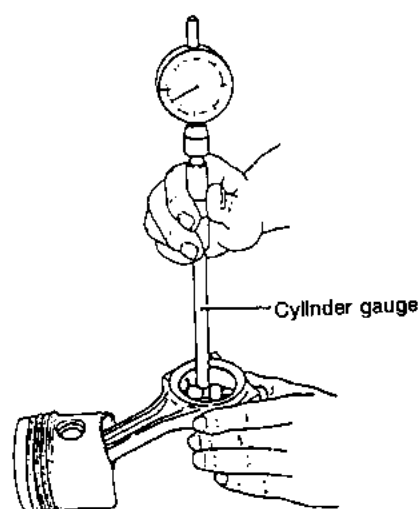
## 5-2 Crank pin bearing

### 5-2.1 Checking crank pin bearing

Check for flaking, melting or seizure on the contact surface.

### 5-2.2 Measuring crank pin oil clearance

Use a plastic gauge.

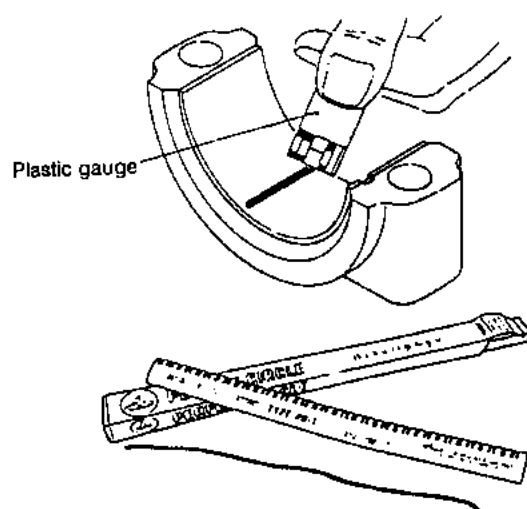


#### Procedure

- (1) Use the press gauge (Plastigage) for measuring oil clearance in the crank pin.
- (2) Mount the connecting rod on the crank pin (tighten to specified torque).

Connecting rod tightening torque	13.5~14.5kg-m
----------------------------------	---------------

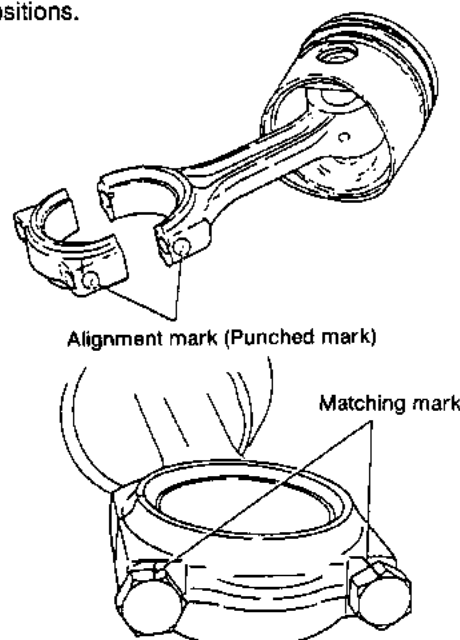
- (3) Remove the connecting rod and measure the broken plastic gauge with measuring paper.



### 5-2.3 Precautions on replacement of crank pin bearing

- (1) Wash the crank pin bearing.
- (2) Wash the large end cap, mount the crank pin bearing and make sure that it fits tightly on the large end cap.
- (3) When assembling the connecting rod, match up the large end and large end cap number. Coat the bolts with engine oil and gradually tighten them alternately to the specified torque.

If a torque wrench is not available, make match marks on the bolt heads and large end cap (to indicate the proper torque position) and retighten the bolts to those positions.



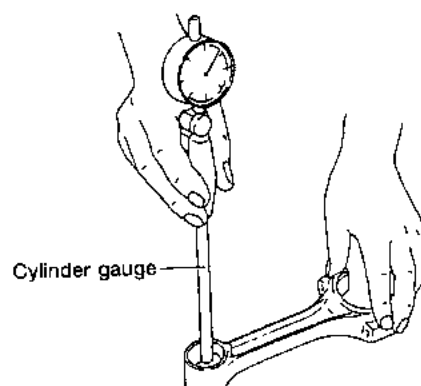
- (4) Make sure there is no sand, metal cuttings or other foreign matter in the lube oil, and that the crankshaft is not scratched. Take special care in cleaning the oil holes.

	mm	
	Standard	Wear limit
Crank pin bearing inside dia	$\phi 65.000 \sim \phi 65.042$	65.10
Crank pin and crank pin bearing clearance	0.036~0.090	0.16

## 5-3 Piston pin bearing

### (1) Measuring piston pin clearance.

Excessive piston pin bearing wear may result in damage to the piston or the piston itself.



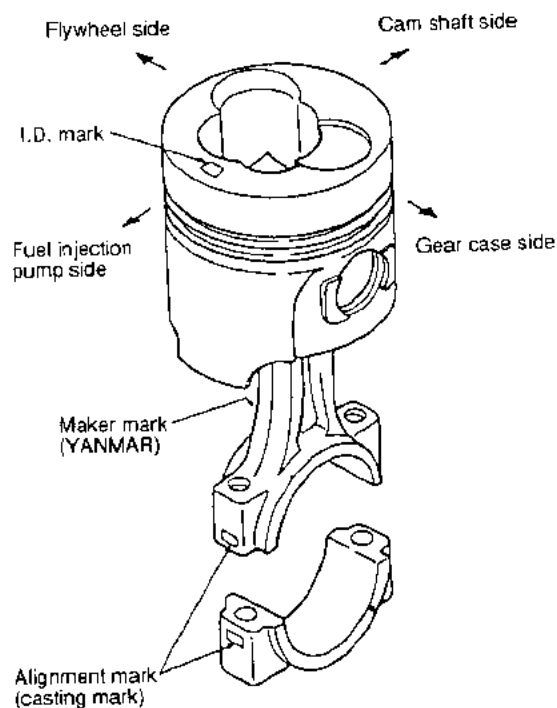
	mm	
	Standard	Wear limit
Pin pin bearing inside dia	$\phi 37.030 \sim \phi 37.050$	$\phi 37.100$
Piston pin and bearing oil clearance	0.030~0.061	0.11

Since the small end in 4JH2 Series is tapered, bush insertion is extremely difficult. Any minor mistake will cause abnormalities such as twist and bite. Do not insert the bush on-site.

(No piston pin bush spare part is available. It is included in the con-rod assembly supplied as a spare part.)

#### 5-4 Assembling piston and connecting rod

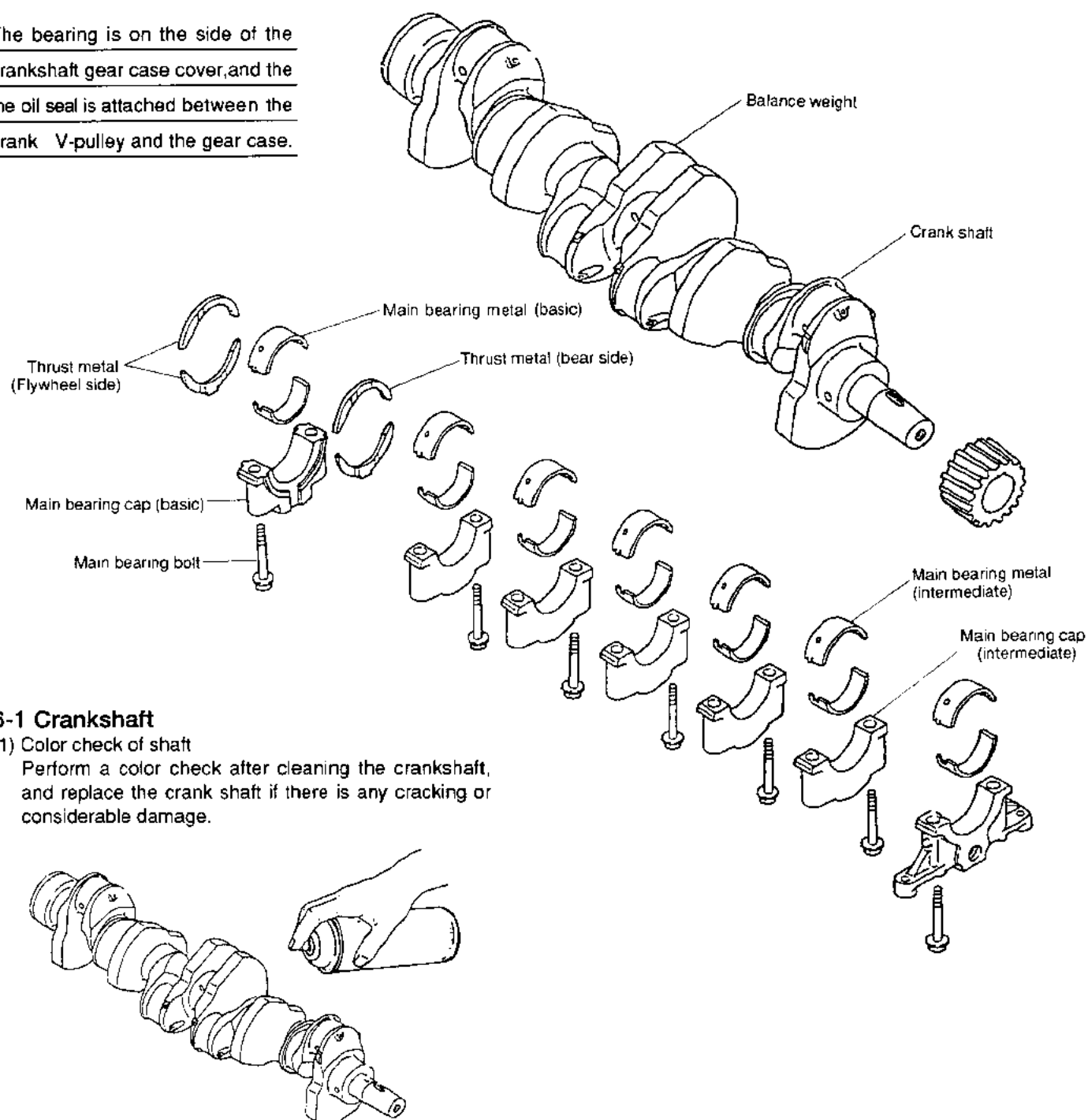
The piston and connecting rod should be assembled so that the match mark on the connecting rod large end faced the fuel injection pump side and the combustion chamber above the piston is close to the fuel injection pump.



## 6. Crankshaft and Main Bearing

The crank pin and crankjournal have been induction hardened for superior durability, and the crankshaft is provided with four balance weights for optional balance. The crankshaft main bearing is of the hanger type. The upper metal (cylinder block side) is provided with an oil groove. There is no oil groove on the lower metal (bearing cap side). The bearing cap (location cap) of the flywheel side has a thrust metal which supports the thrust load.

The bearing is on the side of the crankshaft gear case cover, and the oil seal is attached between the crank V-pulley and the gear case.



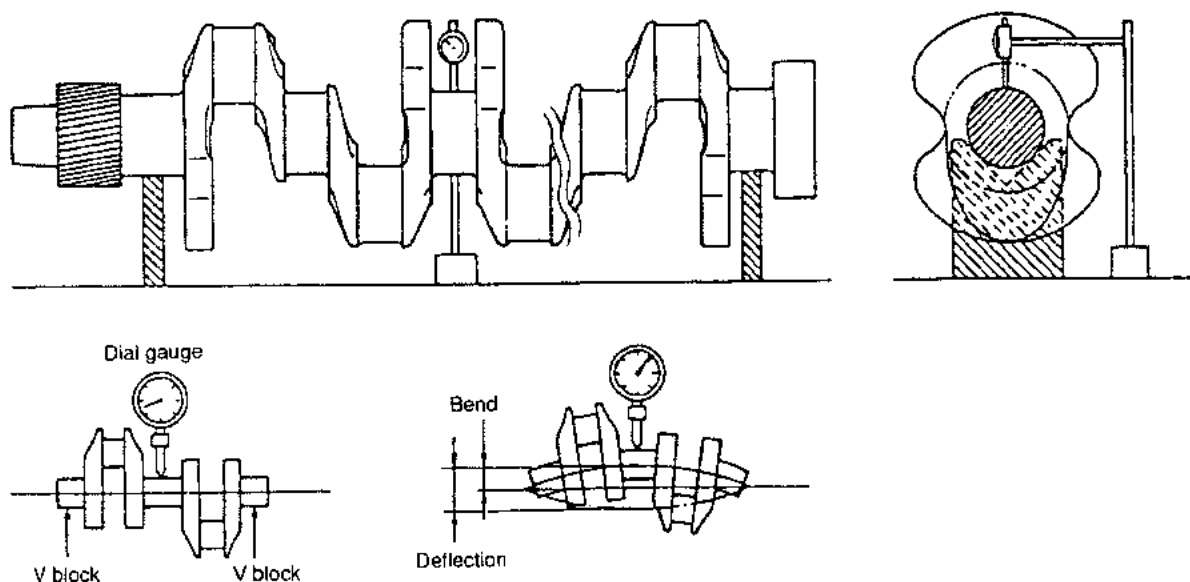
### 6-1 Crankshaft

#### (1) Color check of shaft

Perform a color check after cleaning the crankshaft, and replace the crank shaft if there is any cracking or considerable damage.

## (2) Bending of the crankshaft

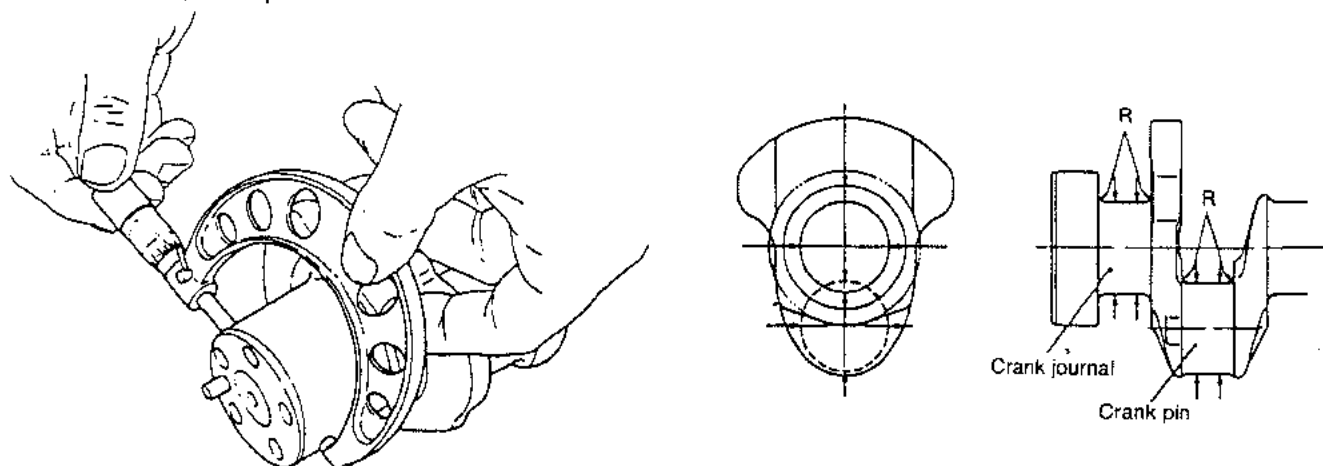
Support the crankshaft with V-blocks at both ends of the journals. Measure the deflection of the center journal with a dial gauge while rotating the crankshaft to check the extent of crankshaft bending.



mm	
Crankshaft bend	Less than 0.03

## (3) Measuring the crank pin and journal

Measure the extent of journal wear (roundness, taper).  
 Regrind it to the proper shape if it is within the outer diameter limit, and replace if not.



		mm	
		Standard	Wear limit
Crank pin	Outside dia.	$\phi 64.952 \sim 64.964$	$\phi 64.90$
	Bushing inside dia.	$\phi 65.000 \sim \phi 65.042$	$\phi 65.10$
	Crank pin and bearing oil clearance	0.036~0.093	$\phi 0.16$
Crank journal	Outside dia.	$\phi 74.952 \sim \phi 74.964$	$\phi 74.90$
	Bushing inside dia.	$\phi 75.000 \sim \phi 75.045$	$\phi 75.10$
	Crank journal and bearing oil clearance	0.036~0.093	0.15
Fillet rounding of crank pin and journal		3.500~3.800(0.1377~0.1496)	---

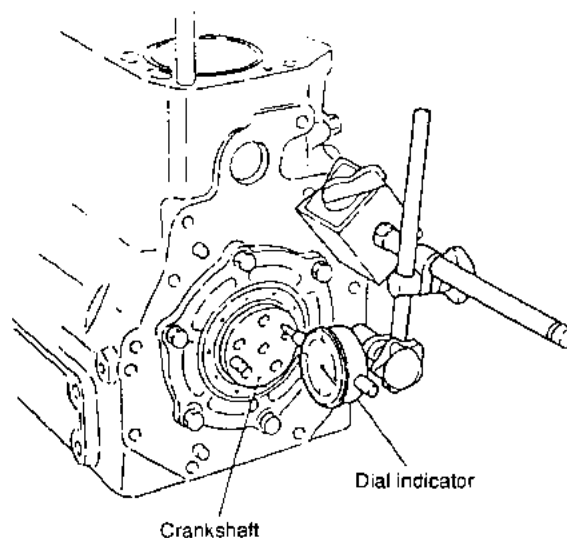
**(4) Checking side clearance of the crankshaft**

After assembling the crankshaft, tighten the main bearing cap to the specified torque, and move the crankshaft to one side, placing a dial gauge on one end of the shaft to measure thrust clearance.

This measurement can also be effected by inserting the gauge directly into the clearance between the thrust bearing and crankshaft thrust surface.

Replace the thrust bearing if it is worn beyond the limit.

	mm	
	Standard	Wear limit
Crankshaft side gap	0.132~0.223	0.29



**6-2 Main bearing**

**(1) Inspecting the main bearing**

Check for flaking, seizure or burning of the contact surface and replace if necessary.

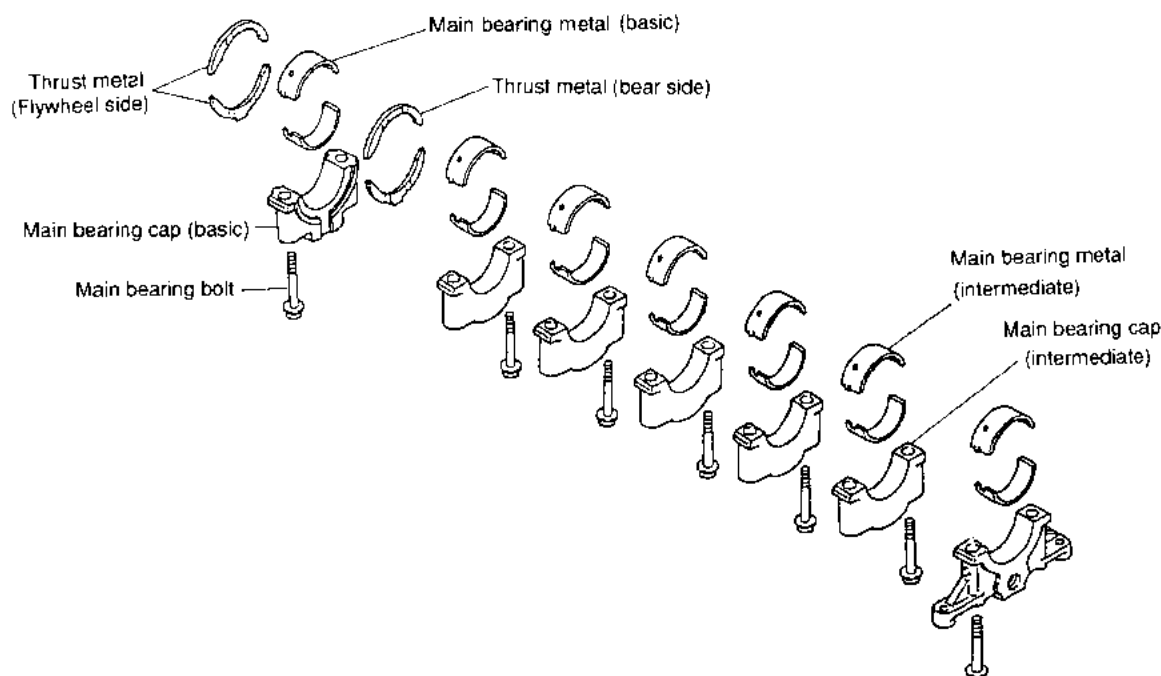
**(2) Measuring the inner diameter of metal**

Tighten the cap to the specified torque and measure the inner diameter of the metal.

**NOTE :** When assembling the bearing cap, keep the following in mind.

- 1) The lower metal (cap side) has no oil groove.
- 2) The upper metal (cylinder block side) has an oil groove.
- 3) Check the cylinder block alignment No.
- 4) The "FW" on the cap lies on the flywheel side.

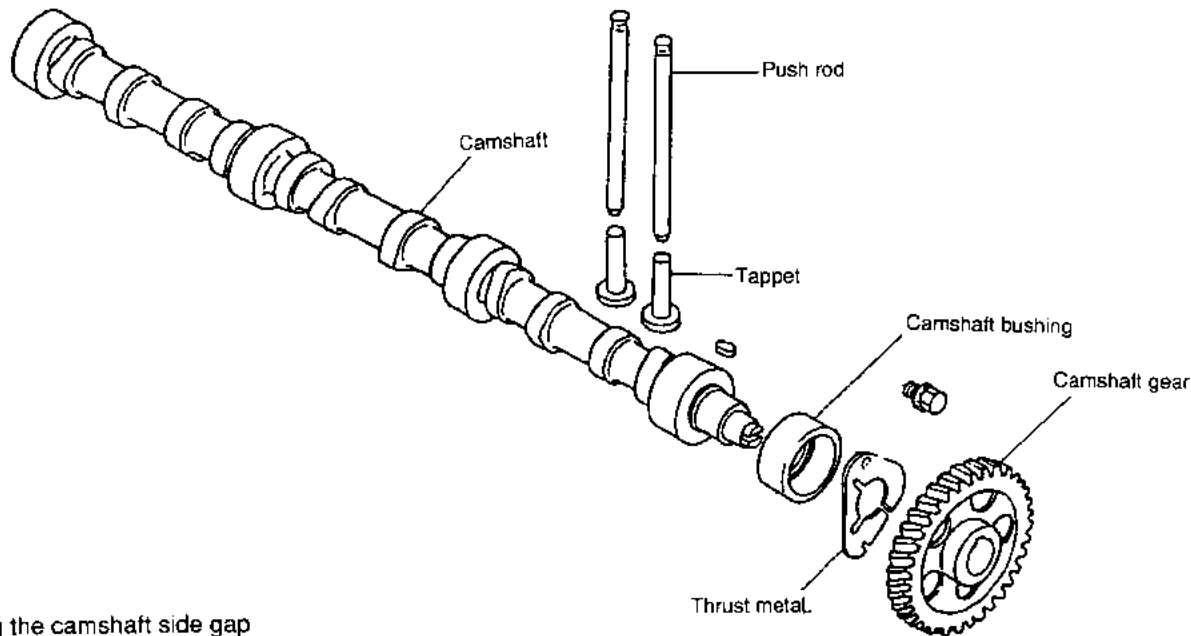
Bearing cap bolt tightening torque	23~25kgf·m
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# 7. Camshaft and Tappets

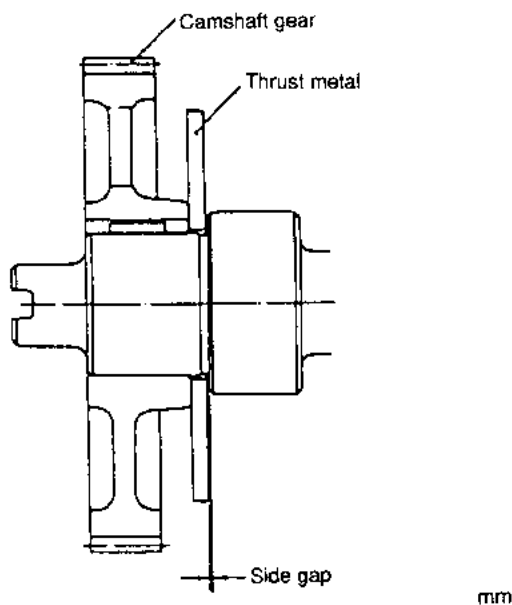
## 7-1 Camshaft

The camshaft is normalized and the cam and bearing surfaces are surface hardened and ground. The cams have a curve that minimized the repeated shocks on the valve seats and maximizes valve seat life.



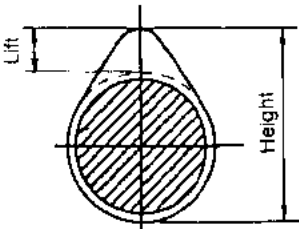
(1) Checking the camshaft side gap

The load is received by the standard bearing near the end of the camshaft by the cam gear, resulting in rapid wear of the end of the bearing and enlargement of the side gap. Therefore, measure the thrust gap before disassembly. As the cam gear is shrink-fitted to the cam, be careful when replacing the thrust bearing.



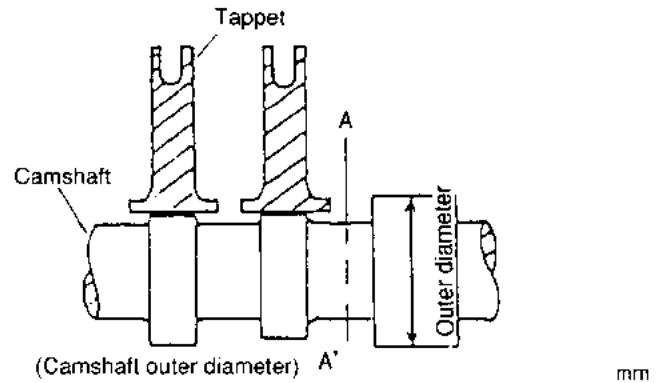
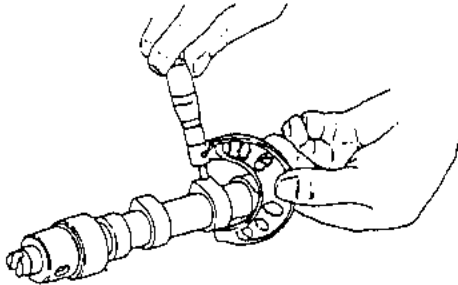
	Standard	Wear limit
Camshaft side gap	0.05~0.20	0.29

(2) Measure the camshaft height, and replace the cam if it is worn beyond the limit.



Camshaft height		mm	
Engine model		Standard	Wear limit
Lift	Intake cam	6.5	6.1
	Exhaust cam		

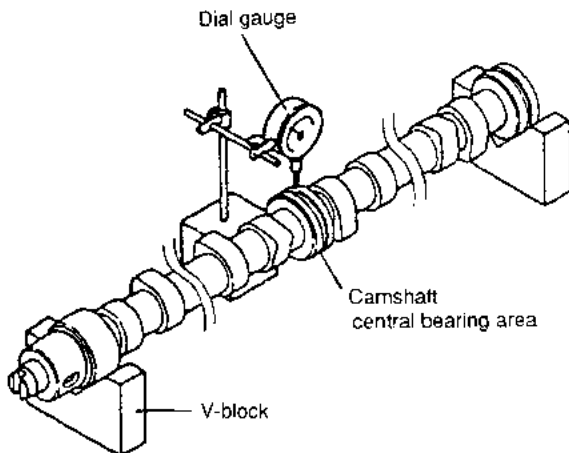
- (3) Measure the camshaft outer diameter and the camshaft bearing inner diameter. Replace if they exceed the wear limit or are damaged.



	Standard			Wear limit
	Gear case side	Intermediate	Flywheel side	
Camshaft journal outside dia.	$\phi 56.910 \sim \phi 56.940$	$\phi 56.910 \sim \phi 56.940$	$\phi 56.910 \sim \phi 56.940$	$\phi 56.80$
Oil clearance	0.040~0.140	0.040~0.140	0.040~0.140	0.2

#### (4) Bending of the crankshaft

Support both ends of the crankshaft with V-blocks, place a dial gauge against the central bearing areas and measure bending. Replace if excessive.

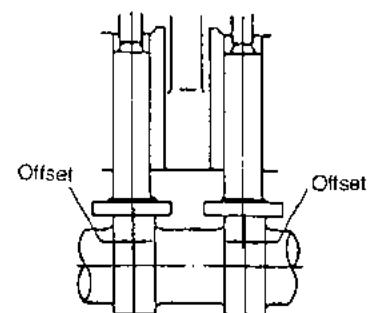
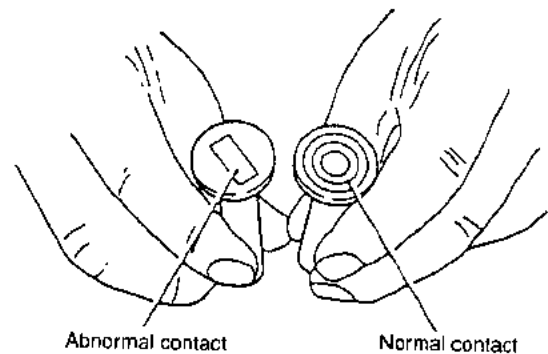


NOTE : The reading on the dial gauge is divided by two to obtain the extent of bending.

	Wear limit
Camshaft deflection	0.02

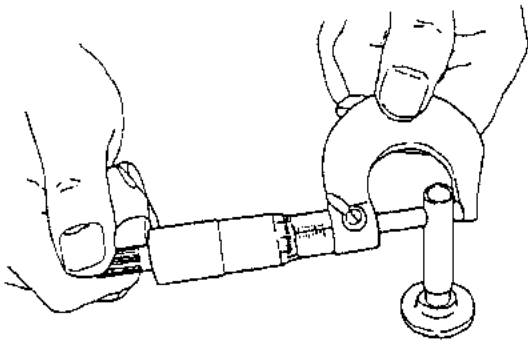
#### 7-2 Tappets

- (1) The tappets are offset to rotate during operation and thereby prevent uneven wearing. Check the contact of each tappet and replace if excessively or unevenly worn.



NOTE : When removing tappets, be sure to keep them separate for each cylinder and intake/exhaust valve.

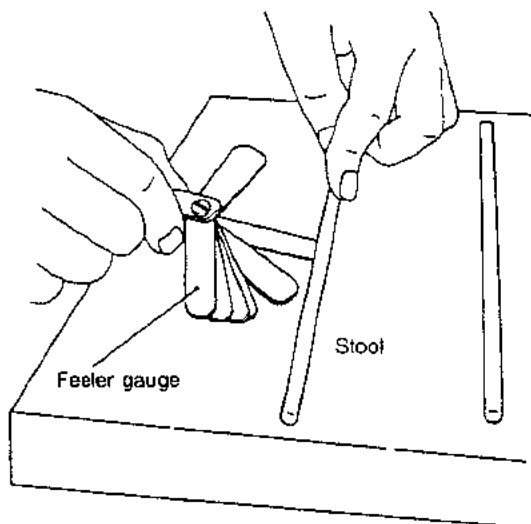
- (2) Measure the outer diameter of the tappet, and replace if worn beyond the limit.



	Standard	Wear limit
Tappet stem outside dia.	$\phi 14.218 \sim 14.233$	$\phi 14.17$
Tappet guide hole inside dia. (cylinder block)	$\phi 14.249 \sim \phi 14.270$	$\phi 14.30$
Tappet stem and guide hole oil clearance	0.016~0.052	0.10

- (3) Measuring push rods.

Measure the length and bending of the push rods.



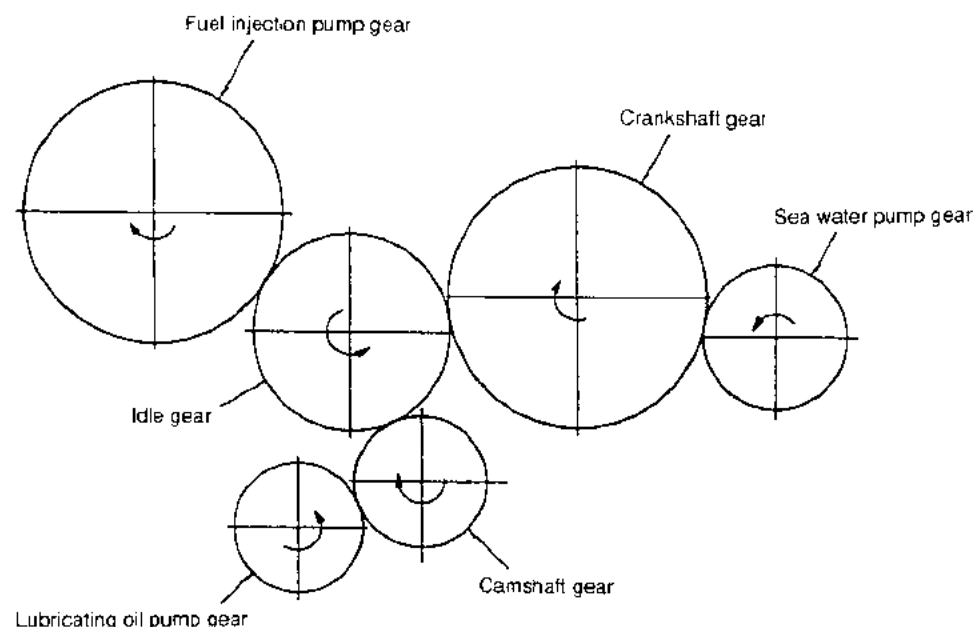
mm

	Standard	Wear limit
Push rod length	178.25~178.75	—
Push rod bend	Less than 0.03	0.3
Push rod dia.	8.5	—



## 8. Timing Gear

The timing gear is helical type for minimum noise and specially treated for high durability.



	No. of teeth	Face width	Spiral angle	Center distance	Back lash	Back lash Wear limit
Camshaft gear	48	22.5	left	137.290~137.352	0.08~0.16	0.25
Idle gear	51	20.0	right	103.786~103.848	0.08~0.16	0.25
Crankshaft gear	24	40.0	left	103.786~103.848	0.08~0.16	0.25
Lubricating oil pump gear	24	14.0	right	100.929~100.991	0.08~0.16	0.25
Idle gear	29	13.5	right	137.290~137.352	0.08~0.16	0.25
Fuel injection pump gear	48	15.0	left			

### 8-1 Inspecting the gears

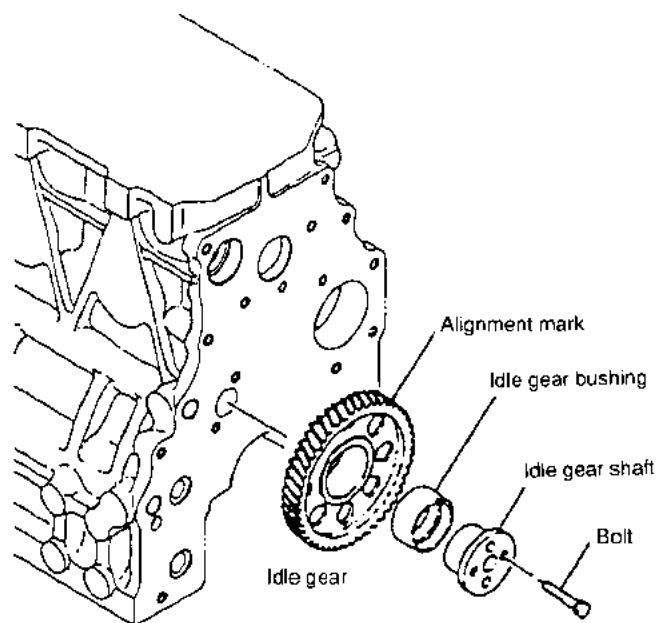
- (1) Inspect the gears and replace if the teeth are damaged or worn.
- (2) Measure the backlash of all gears that mesh, and replace the meshing gears as a set if wear exceeds the limit.

**NOTE:** If backlash is excessive, it will not only result in excessive noise and gear damage, but also lead to bad valve and fuel injection timing and a decrease in engine performance.

#### (3) Idling gear

The bushing is pressure fitted into the idling gear. Measure the bushing inner diameter and the outer diameter of the shaft, and replace the bushing or idling gear shaft if the oil clearance exceeds the wear limit. A, B and C are inscribed on the end of the idling gear. When assembling, these marks should align with those on the cylinder block.

Alignment mark  
Idle gear  
Idle gear bushing  
Idle gear shaft

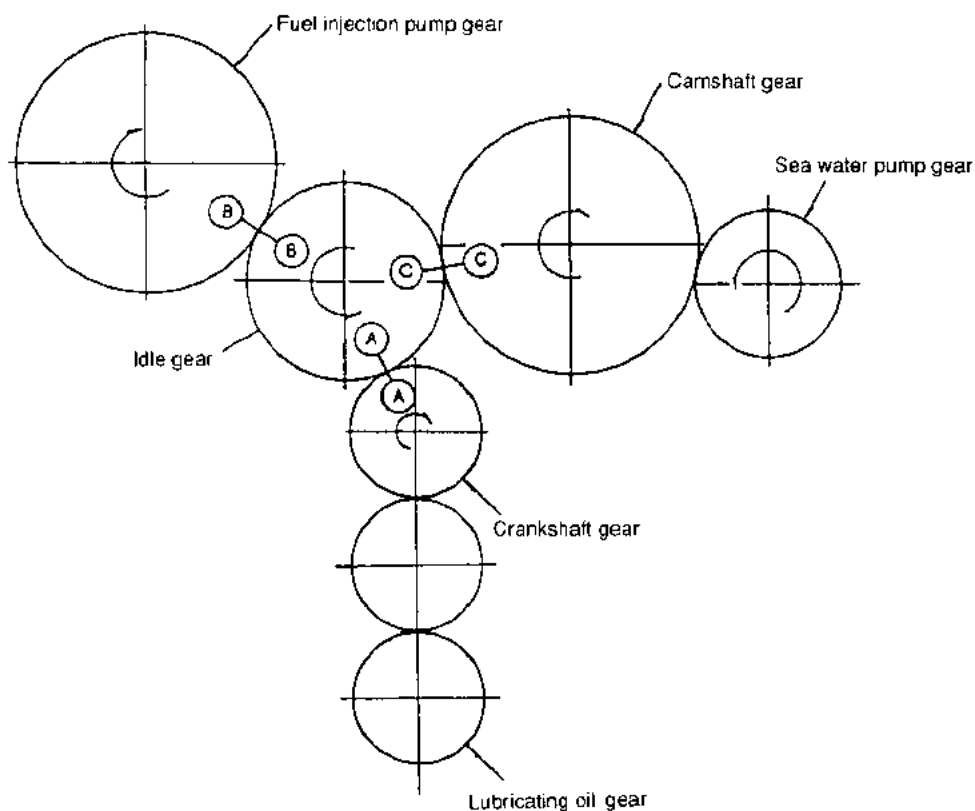


	Standard	Wear limit
Idle shaft dia.	45.950~45.975	45.88
Idle shaft bushing inside dia.	46.000~46.025	—
Idle shaft and bushing oil clearance	0.025~0.075	0.15

mm

### 8-2 Gear timing marks

Match up the timing marks on each gear when assembling (A, B and C).



## 9. Flywheel

The function of the flywheel is through inertia, to rotate the crankshaft in a uniform and smooth manner by absorbing the turning force created during the combustion stroke of the engine, and by compensating for the decrease in turning force during the other strokes.

The flywheel is mounted and secured by 6 bolts on the crankshaft end at the opposite end to the gear case; it is covered by the mounting flange (flywheel housing) which is bolted to the cylinder block.

The fitting surface for the damper disc is on the crankshaft side of the flywheel. The rotation of the crankshaft is transmitted through this disc to the input shaft of the reduction and reversing gear. The reduction and reversing gear is fitted to the mounting flange.

The flywheel's unbalanced force on the shaft center must be kept below the specified value for the crankshaft as the

flywheel rotates with the crankshaft at high speed.

To achieve this, the balance is adjusted by drilling holes in the side of the flywheel, and the unbalanced momentum is adjusted by drilling holes in the circumference.

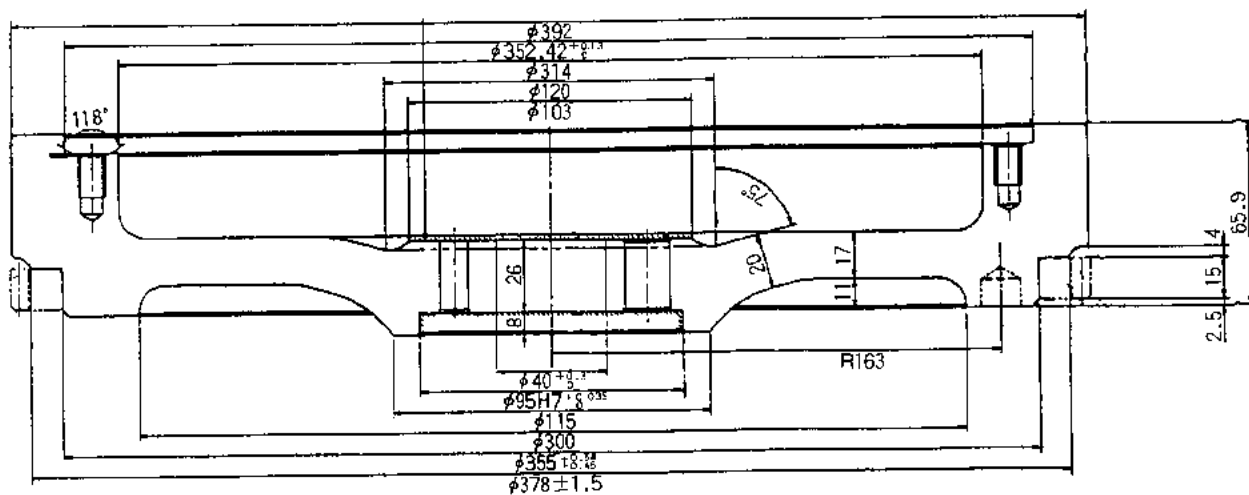
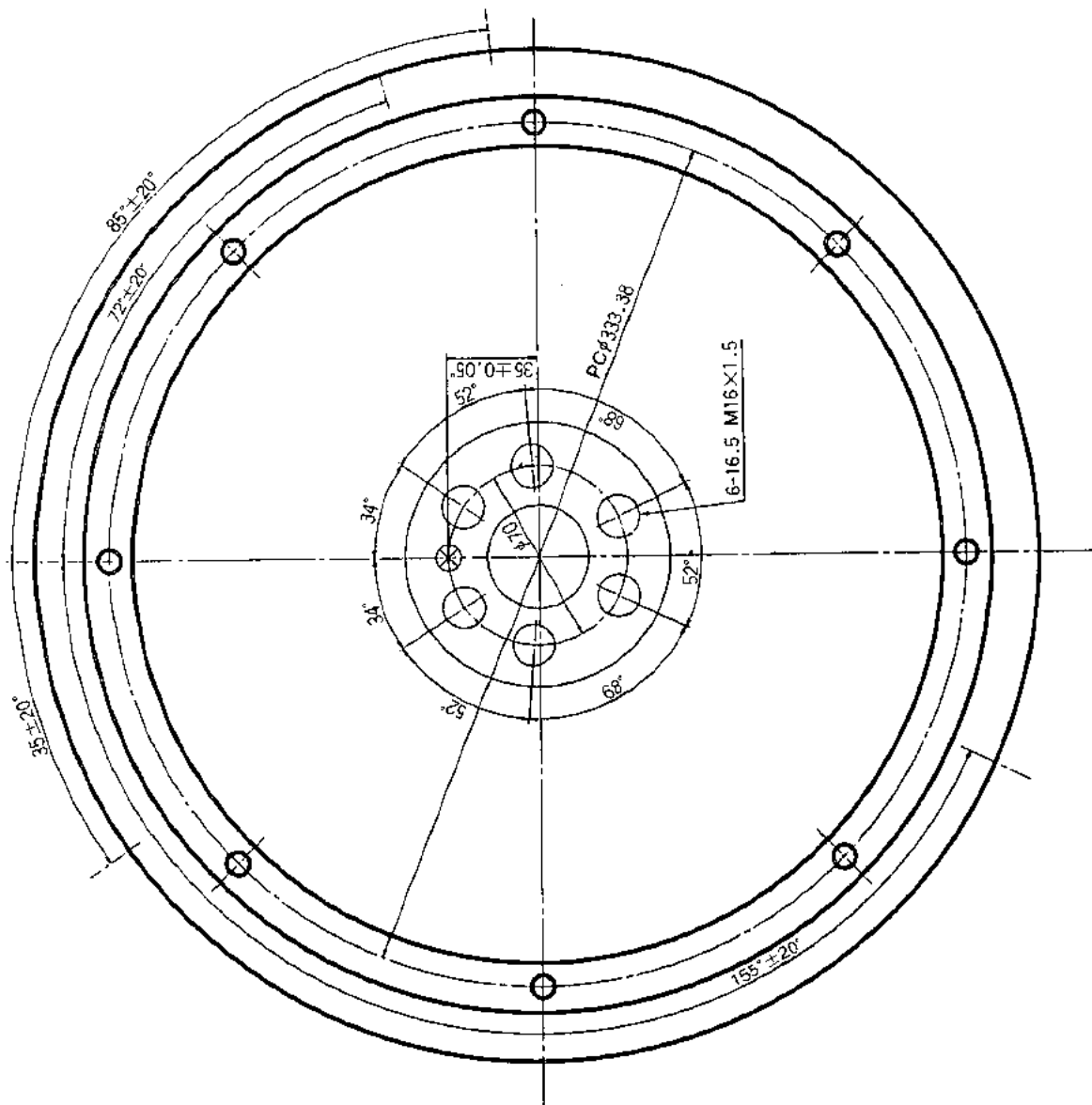
The ring gear is shrink fitted onto the circumference of the flywheel, and this ring gear serves to start the engine by meshing with the starter motor pinion.

The stamped letter and line which show top dead center of each cylinder are positioned on the flywheel circumference, and by matching these marks with the arrow mark at the hole of the flywheel housing, the rotary position of the crankshaft can be ascertained in order to adjust tappet clearance or fuel injection timing.

### 9-1 Specifications of flywheel

Outside dia. of flywheel		mm	φ 392
Width of flywheel		mm	65.9
Weight of flywheel (including ring gear)		kg	28.1
GD <sup>2</sup> value		kg·m <sup>2</sup>	2.94
Fixing part of crankshaft	Pitch circle dia. of bolts	mm	70
	No. of thread holes		6-M16
	Fit joint dia.	mm	φ 95.00~φ 95.035
Ring gear	Center dia.	mm	φ 387
	No of teeth		129

### 9-2 Dimensions of flywheel and mounting flange

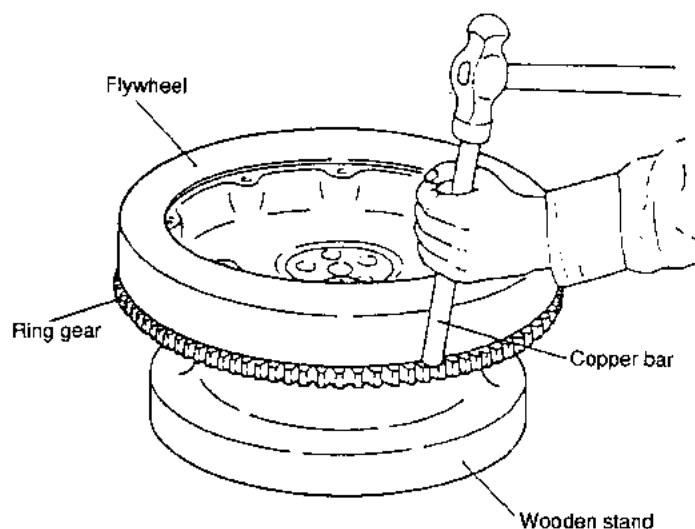
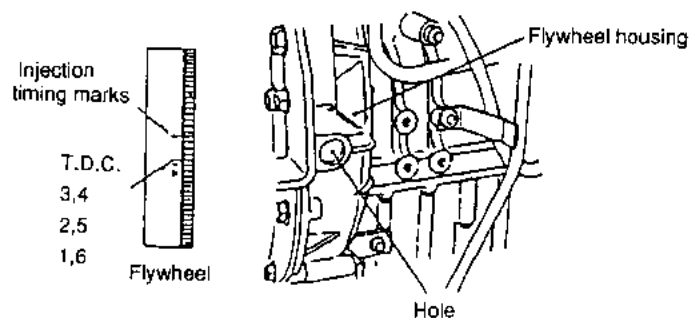


### 9-3 Ring gear

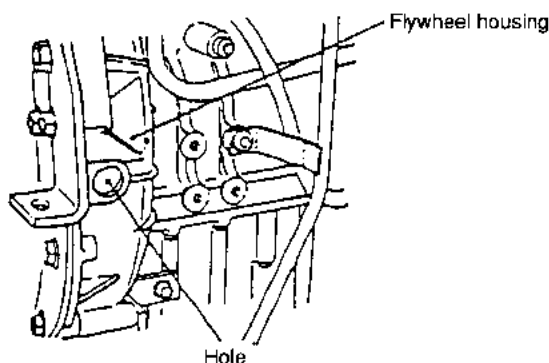
When replacing the ring gear due to excessive wear or damaged teeth, heat the ring gear evenly at its circumference, and after it has expanded drive it gradually off the flywheel by tapping it with a hammer, a copper bar or something similar around the whole circumference.

mm	
Interference of ring gear	0.21~0.45

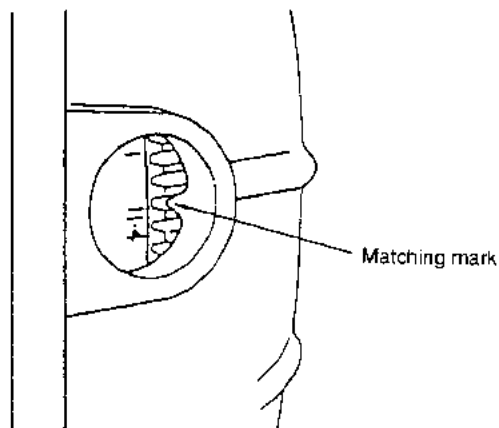
### 9-4 Position of top dead center and fuel injection timing



#### (2) Matching mark



The matching mark is made at the hole of the flywheel housing.



# FUEL INJECTION EQUIPMENT

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## 2. Fuel injection Pump Specifications

Injection system specifications				
	Item		6LYA-UTE	6LYA-STE
General	a	Rotation direction	Clockwise viewed from drive side	←
	b	Injection sequence	1-4-2-6-3-5-1	1-4-2-6-3-5-1
	c	Injection interval	60°±30'	60°±30'
	d	Drive system	Gear	←
	e	Lubrication system	Forced lubrication	←
	f	fuel cut method	Cutting by stop solenoid	←
	g	Boost compensator canceling	Manual operation by cancel lever	←
Fuel injection pump	a	Cam profile type	AL11V188	AL12V200
	b	Plunger dia., winding direction, and lead angle	φ 10.0mm. clockwise 45°	φ 10.5mm. clockwise 43.8°
	c	Cam lift at starting of CYL1 injection	4.0±0.05mm	4.0±0.05mm
	d	Delivery valve oil returning amount	59mm <sup>3</sup> /st	55mm <sup>3</sup> /st
	e	Angleich cutting	0.30mm	0.30mm
	f	Delivery valve spring constant	12kgf/cm <sup>2</sup>	4.7kgf/cm <sup>2</sup>
	g	Damping valve	1.262kgf/mm	1.262kgf/mm
	h	Damping valve	employed	←
	i	Allowable speed (limit for plunger housing)	1800rpm	1850rpm
	j	Overflow pressure	2.0kgf/cm <sup>2</sup>	2.0kgf/cm <sup>2</sup>
	k	Allowable pipe inside pressure	828kgf/cm <sup>2</sup>	950kgf/cm <sup>2</sup>
Governor	a	Number and weight of governor weight	2weights 245gf	2weights 245gf
	b	Governor spring constant, free length	0.77kgf/mm. 63mm	0.77kgf/mm. 63mm
	c	Start spring constant, free length	0.734kgf/mm. 10.5mm	0.843kgf/mm. 8.2mm
	d	Angleich spring constant	13.9kgf/mm	25kgf/mm
	e	Governor lever type	3-shaft type	←
	f	Lever ratio	Low speed 1:1 Middle and high speed 1:1	Low speed 1:1 Middle and high speed 1:2
	g	Boost compensator spring constant	2.56kgf/mm	2.56kgf/mm
Feed pump	a	Cam profile type	AL50DFP34	AL50DFP39
	b	Fuel delivery	7.6cc/rev	7.6cc/rev
	c	Delivery pressure	2.3~3.8kgf/cm <sup>2</sup>	2.3~3.8kgf/cm <sup>2</sup>
	d	Suction head	1.0m	1.0mm



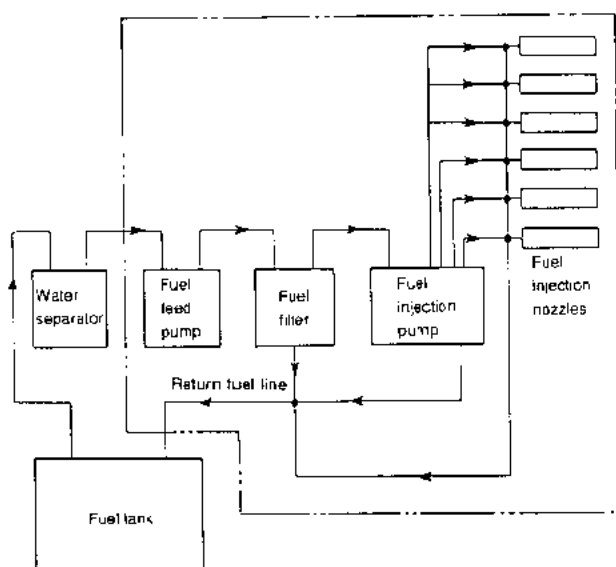
## 3. Fuel supply System

### 3-1 Fuel supply system

The YPES-6AL(for 6LYA-UTE) and YPES-6AL2(for 6LAY-STE) fuel injection pumps are in-line. The engine gears drive the camshaft via the timing gears.

The camshaft then drives the feed pump, pumping fuel from the tank to the filter at a pressure of 1-2kg/cm<sup>2</sup>. The filtered fuel is fed to the reservoir in the pump housing, where the plunger raises its pressure.

The fuel then passes through the injection pipe for injection into each cylinder via the fuel injection nozzle.



The Model YPES-6AL(for 6LYA-UTE) and YPES-6AL2 (for 6LAY-STE) fuel injection pump is an in-line pump with a governor.

A camshaft is built into the pump. There are a drive cam for the fuel feed pump and tappet-drive cams for the plunger.

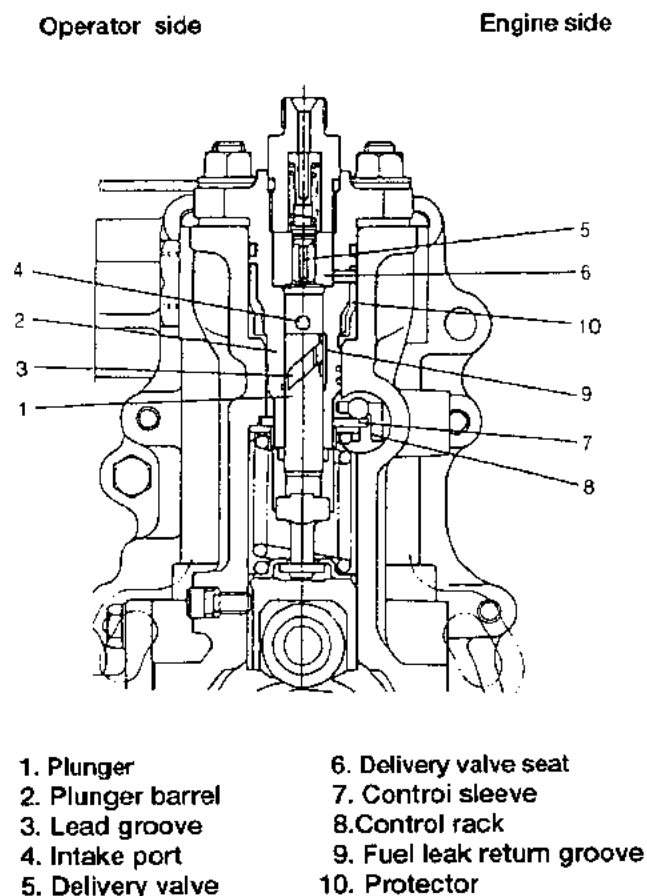
A pump driving gear is mounted on the drive side of the camshaft, and a governor weight on the opposite side.

As the plunger rises, the fuel oil opens the delivery valve and passes through the high pressure pipe to the fuel injection nozzle.

When the control rack is connected to the governor lever moves, the control sleeve turns the plunger.

This changes the point at which the helix (lead groove) opens the port and thereby controls the amount of fuel injected.

### 3-2 Functioning of fuel injection pump



- |                   |                            |
|-------------------|----------------------------|
| 1. Plunger        | 6. Delivery valve seat     |
| 2. Plunger barrel | 7. Control sleeve          |
| 3. Lead groove    | 8. Control rack            |
| 4. Intake port    | 9. Fuel leak return groove |
| 5. Delivery valve | 10. Protector              |

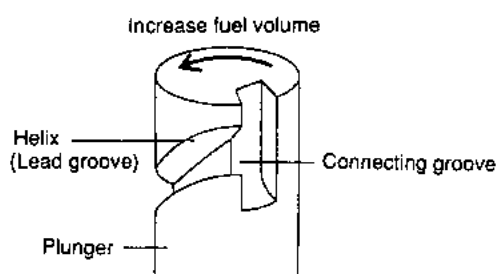
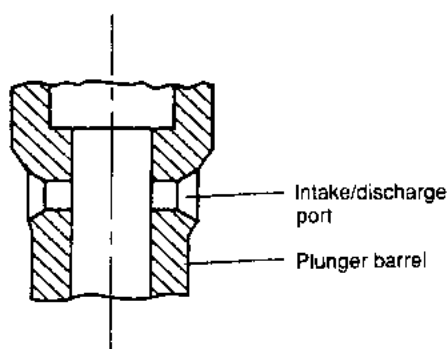
The fuel injection pump supplies pressurized fuel to the injection nozzles through the action of the plunger. The plunger reciprocates in the plunger barrel with a fixed stroke and is lapped for a precise fit. A lead groove is helically cut in the plunger, and this leads to a connecting groove which rises to the top of the plunger.

The integrate plunger barrel, the plunger barrel and the flange case for the delivery valve holder, equips a port for intake and discharge. The injection volume of individual cylinders can therefore be adjusted by rotating the integrate plunger barrel.

The fuel comes through this port into the plunger chamber, is pressurized by the plunger, opens the delivery valve, flows to the fuel injection nozzle through the fuel injection pipe and is injected into the combustion chamber. Fuel injection ends when the pressurized fuel has been discharged. This happens when the lead groove lines up with the port, (as the plunger rises and the pressure in the fuel injection pipe drops).

The control sleeve groove is fitted to the plunger flange. The control knob of the control sleeve is inserted in the control rack groove.

The rack controls the plunger, allowing continuous changes in the volume of fuel injected from zero to maximum. A fuel lead return hole is provided in the plunger barrel. This returns fuel which leaks through the gap between the plunger and the barrel to the fuel lines, preventing dilution of the lubricant in the cam chamber.

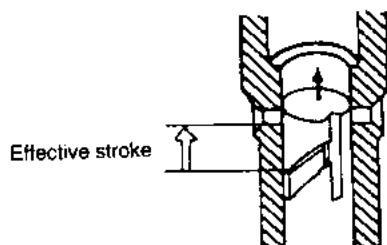


### 3-3 Injection volume control

#### (1) Full injection volume position

When the rack is set at maximum setting, maximum volume of fuel is discharged. Injection occurs when the top of the plunger lines up with the intake port in the barrel. At this time, the lead groove which is positioned at the widest stroke part, lines up with the discharge port, prolonging the injection time and increasing the volume of fuel injected.

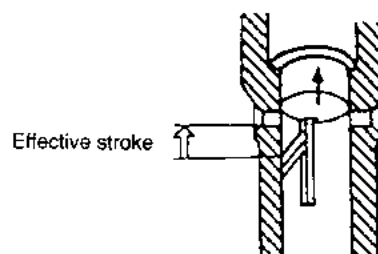
This setting is normally used for starting and max. output operation.



#### (2) Half injection volume position

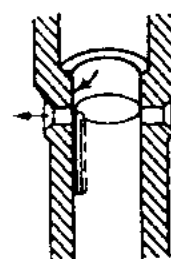
Discharge ends earlier as the rack is moved towards zero from the maximum setting.

The fuel injection volume is decreased accordingly.



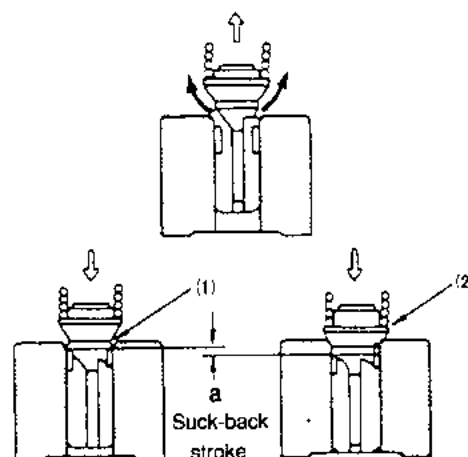
#### (3) No fuel injection

With the rack set near zero, the intake/discharge port in the barrel is always open, so no fuel is pressurized, (even though the plunger continues to reciprocate).



The delivery valve at the top of the plunger prevents fuel in the fuel injection pipe from flowing back to the plunger chamber and sucks up fuel from the nozzle valve to prevent after-drip.

When the plunger lead lines up with the discharge port of the plunger barrel, the injection pressure drops, and the delivery valve is brought down by the delivery valve spring.

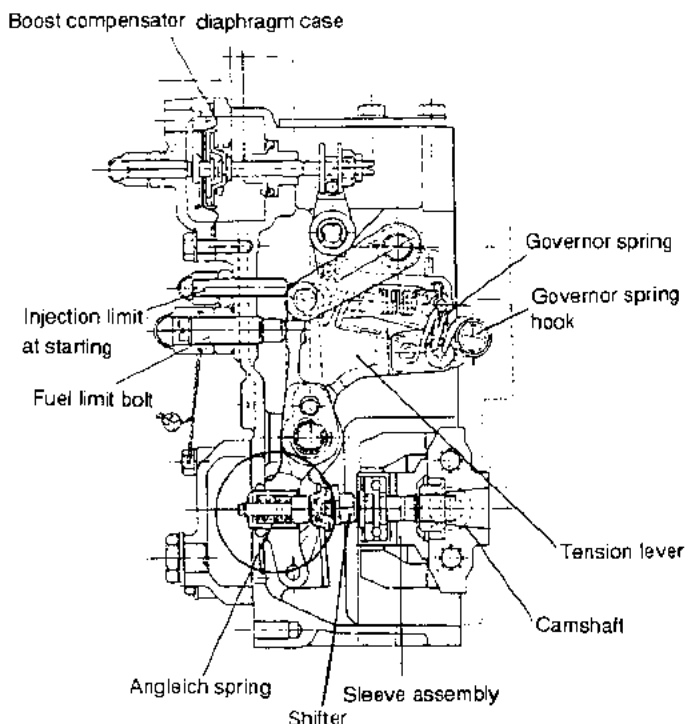


At the same time, the suck-back collar (1) blocks off the fuel injection pipe and the delivery chamber, and the valve continues descending until the seat (2) comes in contact with the barrel. The fuel oil pressure in the fuel

injection pipe decreases proportionately with the lowering of the valve (due to increased volume). This accelerates the closing of the nozzle valve, and sucks up fuel from the nozzle to prevent dripping. The result is a longer nozzle life and improved combustion efficiency.

### 3-4 Governor construction

Diesel engines are used in extremely varied conditions, with a wide range of loads and rpms. The governor has the important function of controlling the fuel injection quantity. It quickly responds to changes in rpm by adjusting the position of the control rack.



The governor weight is mounted on the end of the fuel injection pump cam shaft. It rotates around the governor support pin, driven by the cam shaft, and is forced outwards by the centrifugal force acting on the weight.

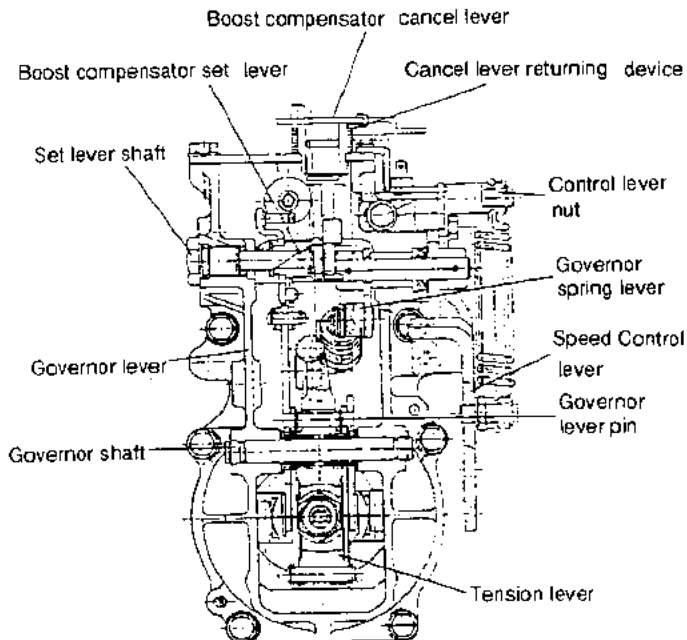
The thrust force on the cam shaft due to this centrifugal force acts on the lower part of the tension lever via the sleeve. An excess fuel spring for starting is mounted on the bottom of the tension lever.

One end of the governor spring is hooked to the right upper end of the tension lever, and the other end to the spring lever on the control lever shaft.

The spring lever and control lever are mounted on the same shaft, so by turning the control lever towards full, the governor spring is pulled and the load gradually rises.

The tension lever cam move freely around the governor shaft on the player bearing. As the speed increases and the shifter is pushed to the left, the tension lever rotates clockwise. And when the speed falls, the tension lever rotates counterclockwise.

YPES-6AL (for 6LYA-UTE) and YPES-6AL2 (for 6LYA-STE) fuel injection pump is equipped with the all speed type governor. The governor is available in 2 types: one has the torque rise spring (angleich spring), and the other has the smoke cut spring (angleich spring)



The governor lever rotates smoothly on the same governor shaft. The bottom part of this lever is in contact with the sleeve through the shifter, which is itself in contact with the bottom of the tension lever through the excess fuel spring. It therefore moves with the tension lever according to the rise or fall of the engine speed.

The top of the governor lever is connected to the fuel pump control rack through the governor link. The movement of the lever controls the volume of fuel injected by the pump. As the speed increased, the lever rotates clockwise and moves the control rack to reduce fuel, and when the speed falls the lever rotates counterclockwise to cause the control rack to pass more fuel.

Thus, the engine speed is controlled.

The top of the tension lever comes in contact with the stopper built into the top of the governor case to limit the maximum fuel injection volume.

#### Note :

1. The governor is factory-adjusted at the specified output and rotational speed, and then sealed by lacing wire. Do not disassemble or readjust the governor, unless absolutely necessary. If disassemble is needed for some reasons, be sure to adjust the governor using a pump tester, and be sure to seal the governor after adjustment.
2. When the governor is disassembled, remove the plug, and supply 400cc lube oil.

### 3-5 Types of governor according to structure

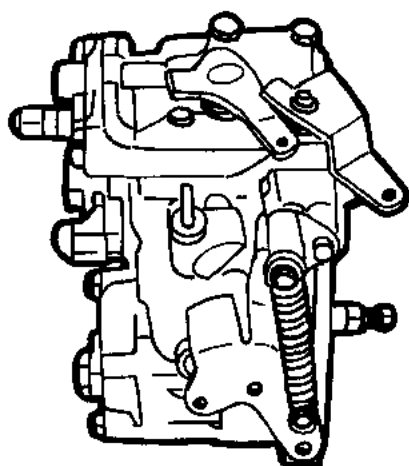
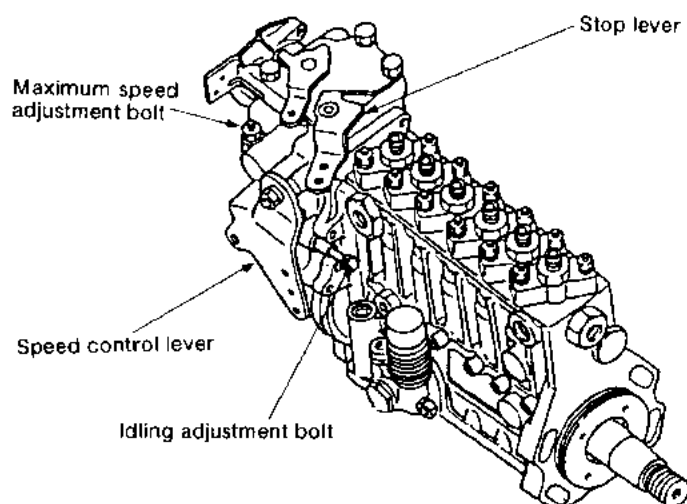
A number of different governors are equipped with the series fuel injection pump. Each is designed in accordance with individual engine structures and parts.

#### (1) Shape of control and stop levers

The control and stop levers that operate the governor have different shapes depending on engine design and method of attachment, as seen in the pictures below. The motion of the control lever is regulated by the maximum speed adjustment bolt and the idling adjustment bolt. These maintain the necessary engine speed.

#### (2) Engine stop device

The stop lever can be operated by a push-pull cable, magnetic solenoid or a stop motor. The governor is equipped in one of three designs depending on the intended purpose.



(Governor Side)

#### (3) Torque rise equipment

This governor can be equipped with an angleich spring for torque rise.

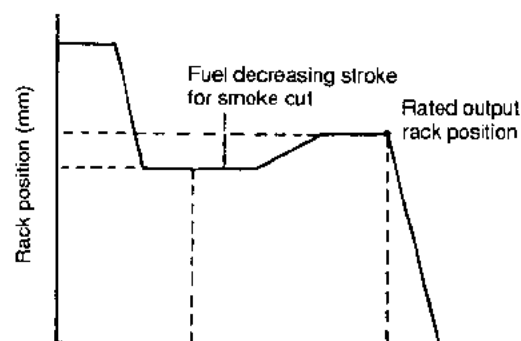
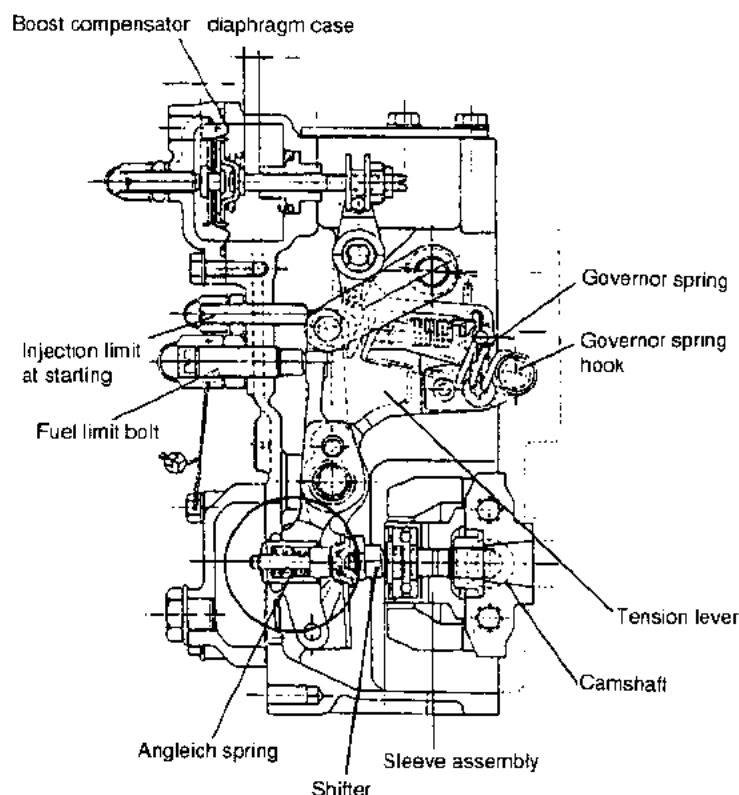
It is therefore suitable for use with various engines.

#### (4) Smoke cut device

##### (4)-1 Angleich spring

This governor can be equipped with the smoke cut spring (angleich spring) which reduces injection at low- and middle speed ranges.

The smoke cut spring decreases fuel injection to minimize black smoke, which would otherwise occur just after the engine is started or an idling engine is started rapidly, (the speed control lever is tuned to "FULL"), as for a marine engine.



Cam speed (rpm)

[Smoke cut]

#### (4)-2 Boost compensator

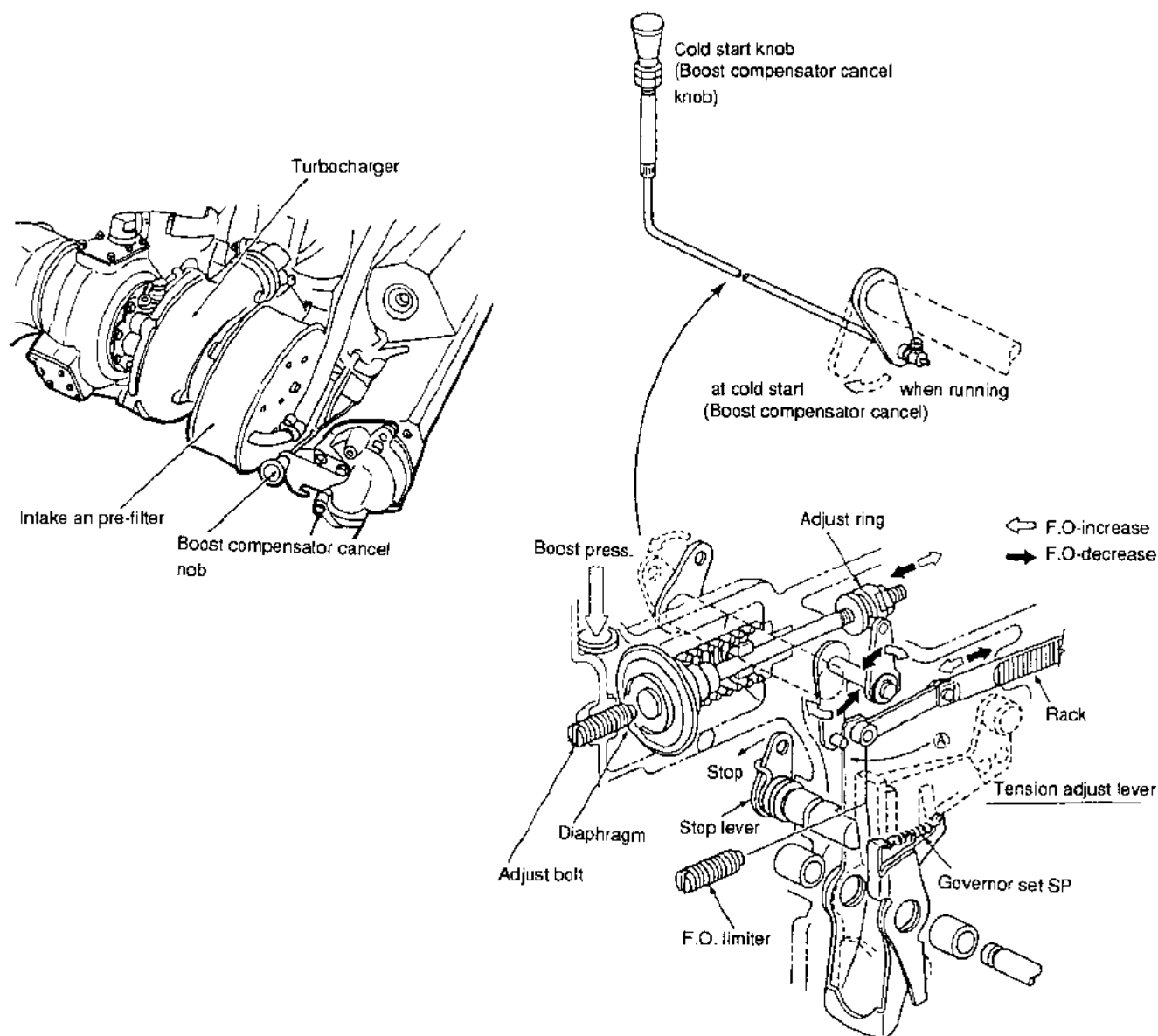
##### (4)-2-1 Objective of compensator

The boost compensator is a device mounted to the fuel injection pump for engines equipped with a turbocharger.

The amount of air sent from the intake manifold by the linking function of the turbocharger increase in proportion to the amount of fuel injected from the injection pump (4LH-STE). The boost compensator controls the injection quantity by responding to changes in pressure.

##### (4)-2-2 Outline of structure and principle of operation

1. When the regulator handle is operated during abrupt acceleration, the control rack moves to the increase side as far as A.
2. Increase of engine speed drive the turbocharger to increase boosting pressure. This boosting pressure pushes the diaphragm in the boost compensator, moving the control rack to the fuel increase side by means of the boost compensator lever.

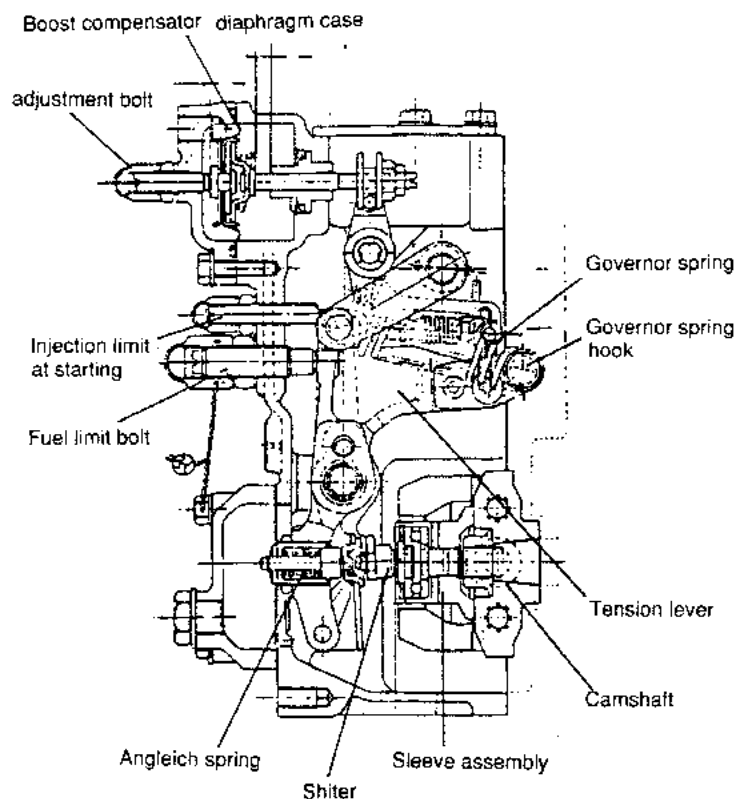


#### (4)-2-3 Operation of cancel knob

1. Since the boost compensator is the device that limits the fuel injection amount for starting the engine in cold temperatures (below  $-5^{\circ}\text{C}$ ), it is necessary to cancel the function of the boost compensator and increase the fuel injection amount.
2. If the engine is hard to start in cold temperatures, start the engine by pulling the cancel knob (cold start knob).
3. Once the engine is started, push the knob back into resume the function of the boost compensator.

#### (4)-2-4 Adjustment of boost compensator

The initial rack of the boost compensator has been adjusted properly at the time of shipment. However, the acceleration can be increased at the request of the customer. Watch the color of the exhaust while making the adjustment.



#### <Procedure>

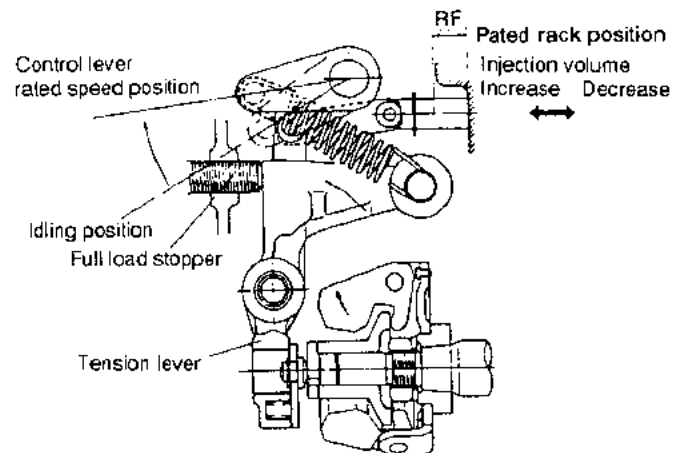
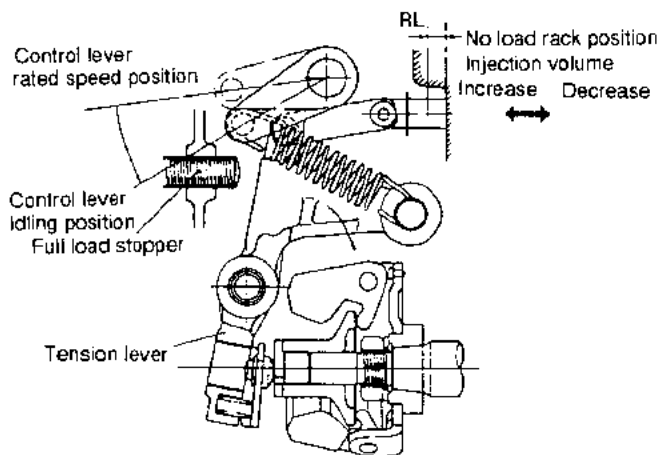
Remove the cap nut of adjust bolt with the blade-type screw driver.

Right turn	Large effect on boost comp.	<ul style="list-style-type: none"> <li>• Higher acceleration</li> <li>• More black exhaust</li> </ul>
Left turn	Small effect on boost comp.	<ul style="list-style-type: none"> <li>• Lower acceleration</li> <li>• Less black exhaust</li> </ul>

### 3-6. Idling and Maximum speed

#### (1) Idling

Idling is controlled by the governor and excess fuel springs because this governor is not equipped with an idling spring (however some engines are equipped with an idle control spring for torque decrease). As the control lever is returned to the idling position after engine starting, the governor spring tension falls and the tension lever descends clockwise. The governor weight load keeps the governor spring and the excess fuel spring load in equilibrium to maintain the idling speed.



#### (3) Adjustment of fuel injection timing

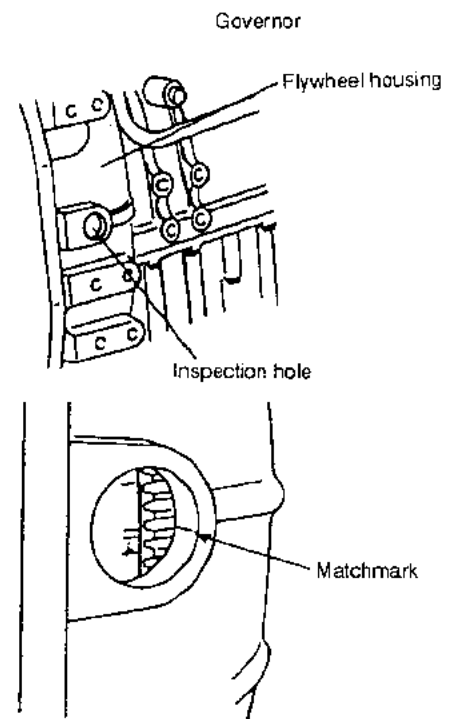
- 1) Remove fuel injection pipe from the fuel injection pump.
- 2) While manually and slightly turning the flywheel, check that the fuel injection starts at the specified point ( $13.5 \pm 0.5^\circ$  before top dead center) by monitoring the indicated value through the inspection hole on the flywheel housing.
- 3) Check fuel injection timing for each cylinder.
- 4) If the fuel injection timing is not appropriate, adjust the timing. To advance the timing incline the pump away from the engine.

**NOTE:** Depending on specifications, the governor can be provided with an idling spring.

#### (2) Maximum speed

The angle of the control lever is set for the engine speed. The governor keeps the engine speed constant by the adjusting speed when the load changes.

For example, if the operator moves the control lever with the link from the idling position to max. output, the governor spring tension increases, the tension lever is pulled until it comes in contact with the full load stopper, the movement of the governor lever is transmitted to the control rack via the link, maintaining the full load rack position, and engine speed increases until the governor weight thrust load and governor spring tension come into equilibrium at full load max. speed.



## 4. Fuel Injection Nozzle

When fuel oil pumped by the fuel injection pump reaches the injection nozzle, it pushes up the nozzle valve (held down by spring), and is injected into the combustion chamber at high pressure.

The fuel is atomized by the nozzle to mix uniformly with the air in the combustion chamber. How well the fuel is mixed with high temperature air directly affects combustion efficiency, engine performance and fuel economy.

Accordingly, the fuel injection nozzles must be kept in top condition to maintain performance and operating efficiency.

### 4-1 Functioning of fuel injection nozzle

Fuel from the fuel injection pump passes through the oil port in the nozzle holder, and enters the nozzle body reservoir.

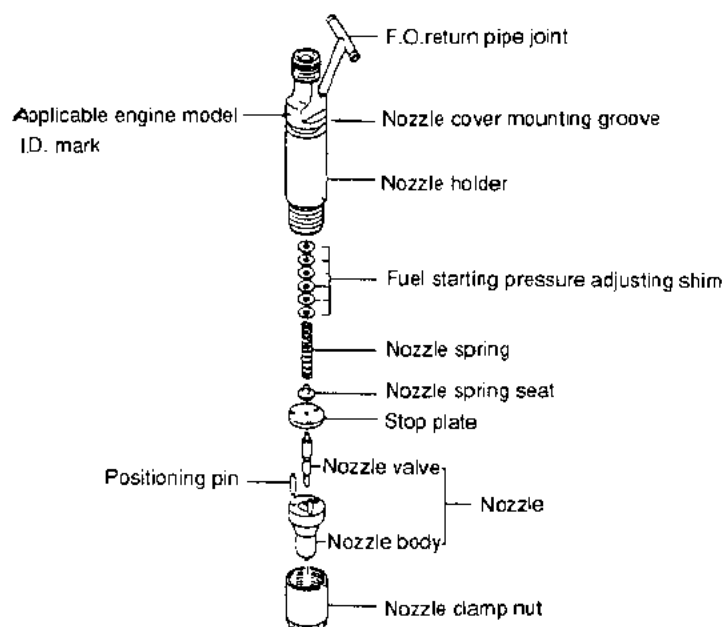
When oil reaches the specified pressure, it pushes up the nozzle valve (held by the nozzle spring), and is injected through the small hole on the tip of the nozzle body.

The nozzle valve is automatically pushed down by the nozzle spring and closed after fuel is injected.

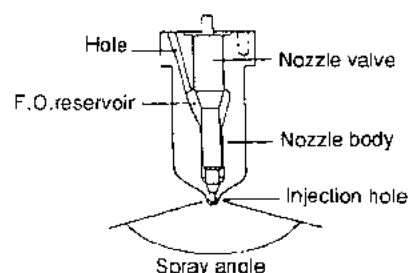
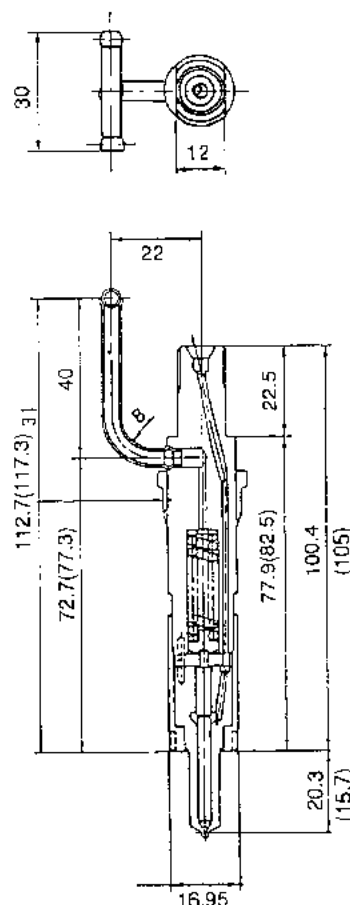
Oil that leaks from between the nozzle valve and nozzle body goes from the hole on top of the nozzle spring body goes from the hole on top of the nozzle spring through the oil leakage fitting and back into the fuel tank.

Adjustment of injection starting pressure is effected with the adjusting shims.

#### (1) Hole type fuel injection nozzle



Engine model	6LYA-UTE	6LYA-STE
Nozzle I.D. Mark	YDLLA145PL345KO	YDLLA145PL355KO
Spray angle	145°	145°
No. of injection hole X dia	5 X $\phi$ 0.34	5 X $\phi$ 0.35
Nozzle opening pressure	240~250kgf/cm <sup>2</sup>	260~270kgf/cm <sup>2</sup>

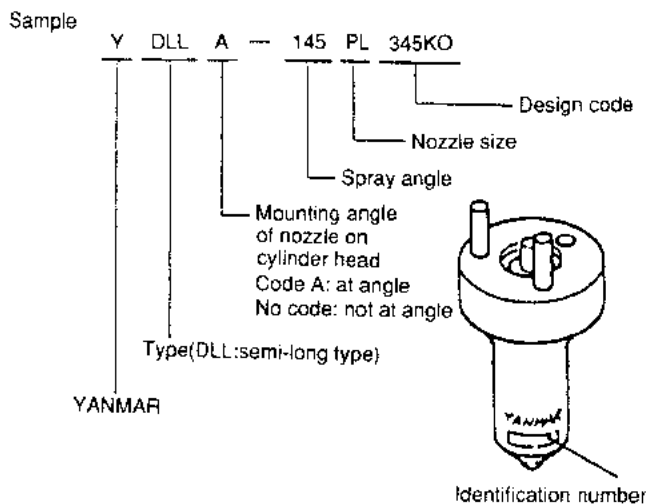




## Nozzle body identification number

The type of nozzle can be determined from the number inscribed on the outside of the nozzle body.

## 1) Hole type fuel injection nozzles

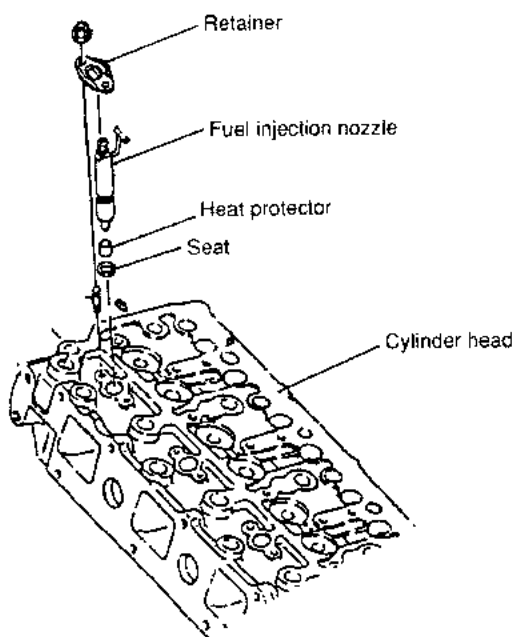


## 4-2 Fuel injection nozzle disassembly

**NOTE:** 1. Disassemble fuel injection nozzle in a clean area as for the fuel injection pump.

2. When disassembling more than one fuel injection nozzle, keep the parts for each injection nozzle separate for each cylinder (i.e. the nozzle for cylinder 1 must be remounted in cylinder 1).

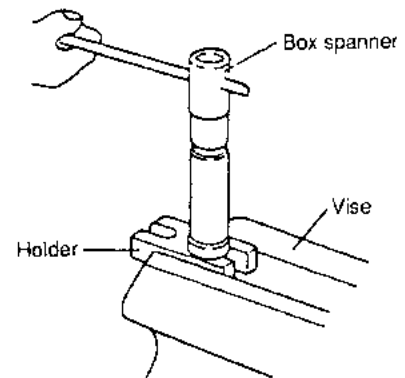
(1) When removing the injection nozzle from the cylinder head, remove the high pressure fuel pipe, fuel return pipe, etc., the injection nozzle retainer nut, and then the fuel injection nozzle.



## (2) Put the nozzle in a vise

**NOTE:** Use the special nozzle holder for the hole type injection nozzle so that the high pressure mounting threads are not damaged.

## (3) Remove the nozzle nut



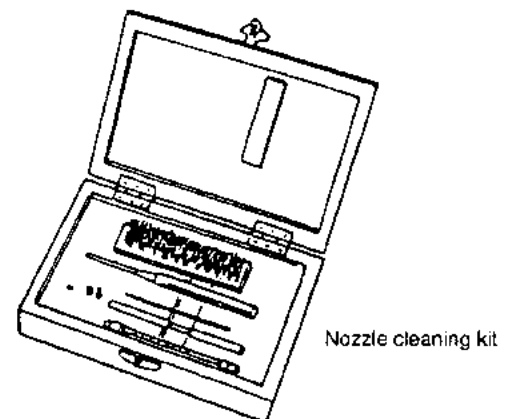
## (4) Remove the inner parts

**NOTE:** Be careful not to lose the spring seat, adjusting shims or other small parts.

## 4-3 Fuel injection nozzle inspection

## 4-3.1 Washing

- (1) Be sure to use new diesel oil to wash the fuel injection nozzle parts.
- (2) Wash the nozzle in clean diesel oil. (Nozzle cleaning kits such as the one shown in the illustration below are sold by tool manufacturers).

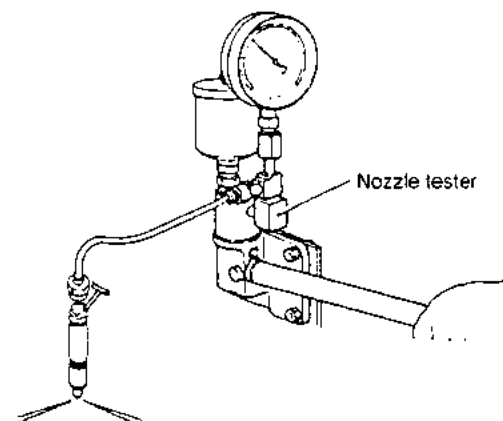


- (3) Clean off the carbon on outside of the nozzle body with a brass brush

## 4-4 Adjusting fuel injection nozzle

### 4-4.1 Adjusting opening pressure

Mount the fuel injection nozzle on the nozzle tester and use the handle to measure injection starting pressure. If it is not at the specified pressure, use the adjusting shims to increase/decrease pressure (both hole and pintle types).



#### Injection starting pressure

kg/cm<sup>2</sup>

Injection starting pressure	6LYA-UTE : 240~250
	6LYA-STE : 260~270

### 4-4.2 Injection test

After adjusting the nozzle to the specified starting pressure, check the fuel spray condition and seat oil tightness.

#### (1) Check seat oil tightness

After two or three injections, gradually increase the pressure up to 20 kg/cm<sup>2</sup> before reading the starting pressure, maintain the pressure for 5 seconds, and make sure that no oil is dripping from the tip of the nozzle.

Test the injection with a nozzle tester; retighten and test again if there is excessive oil leakage from the overflow coupling.

Replace the nozzle as a set if oil leakage is still excessive.

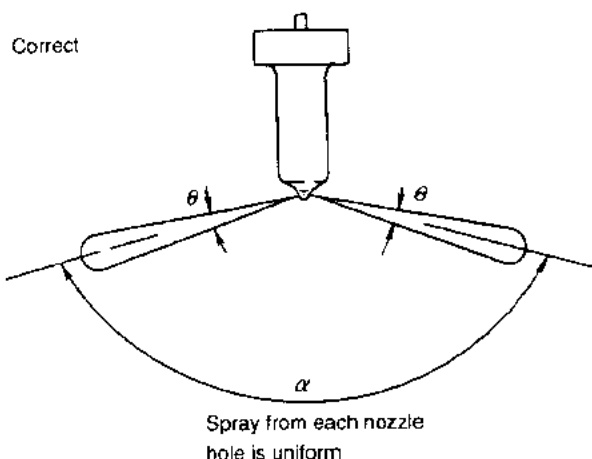
#### (2) Injection spray condition

Operate the nozzle tester lever once to twice a second and check for abnormal injection.

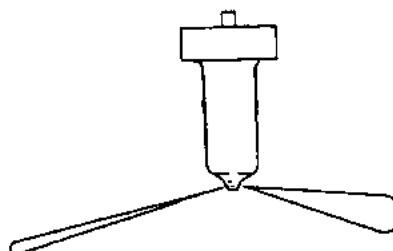
#### 1) Hole type nozzles

Replace hole type nozzles that do not satisfy the following conditions:

- Proper spray angle ( $\theta$ )
- Correct injection angle ( $\alpha$ )
- Complete atomization of fuel
- Prompt starting/stopping of injection



Poor



- Excessive difference in spray angle ( $\theta$ )
- Excessive difference in injection angle ( $\alpha$ )
- Incomplete atomization
- Sluggish starting/stopping of injection

## 5. Fuel Feed Pump

### Fuel Feed Pump Design and Function

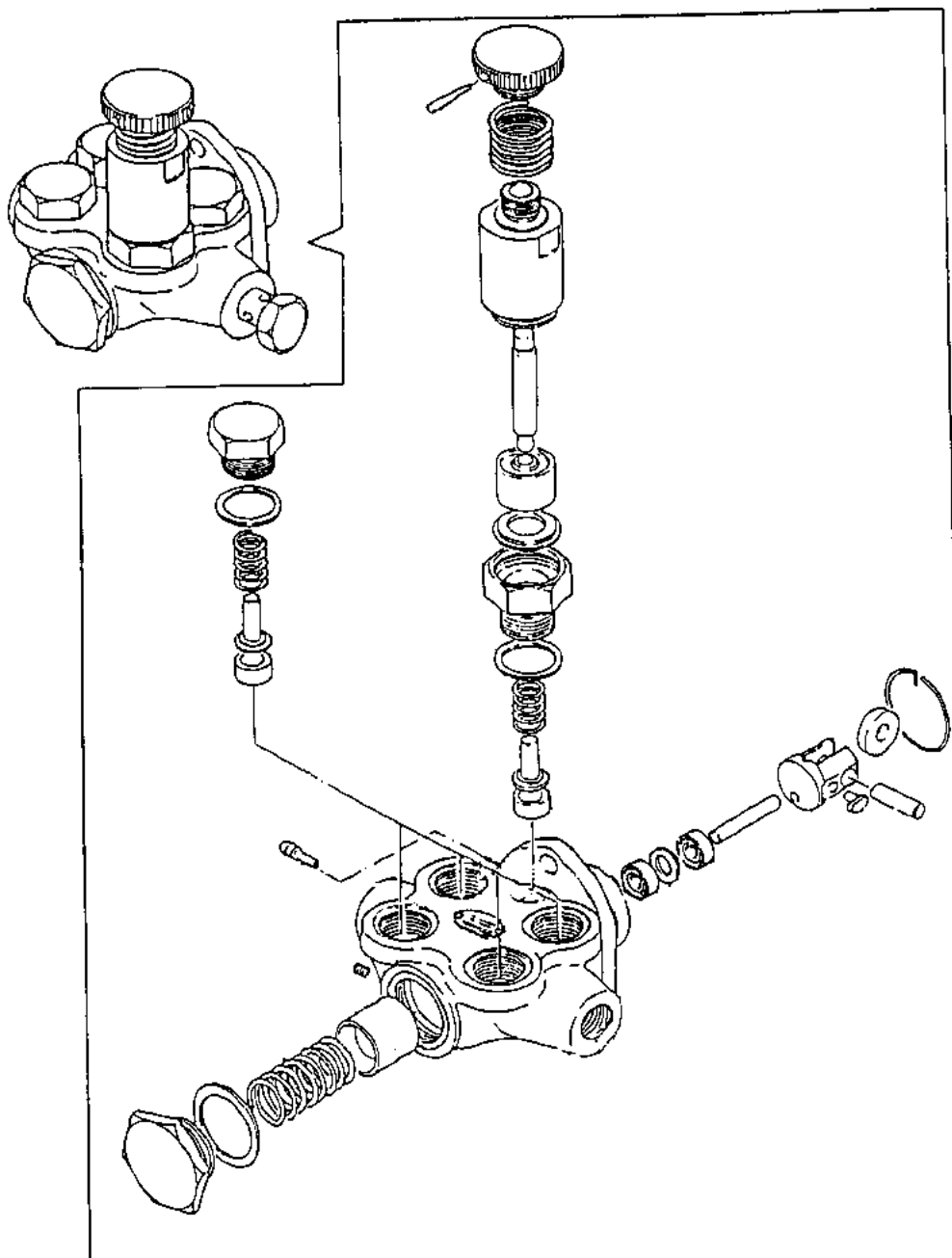
The fuel feed pump consists of a priming pump, which extracts air from the fuel system and is used manually to feed fuel while the engine is stopped, and a feed pump, which supplies fuel while the engine is running.

The fuel feed pump is driven by an eccentric cam on the fuel camshaft.

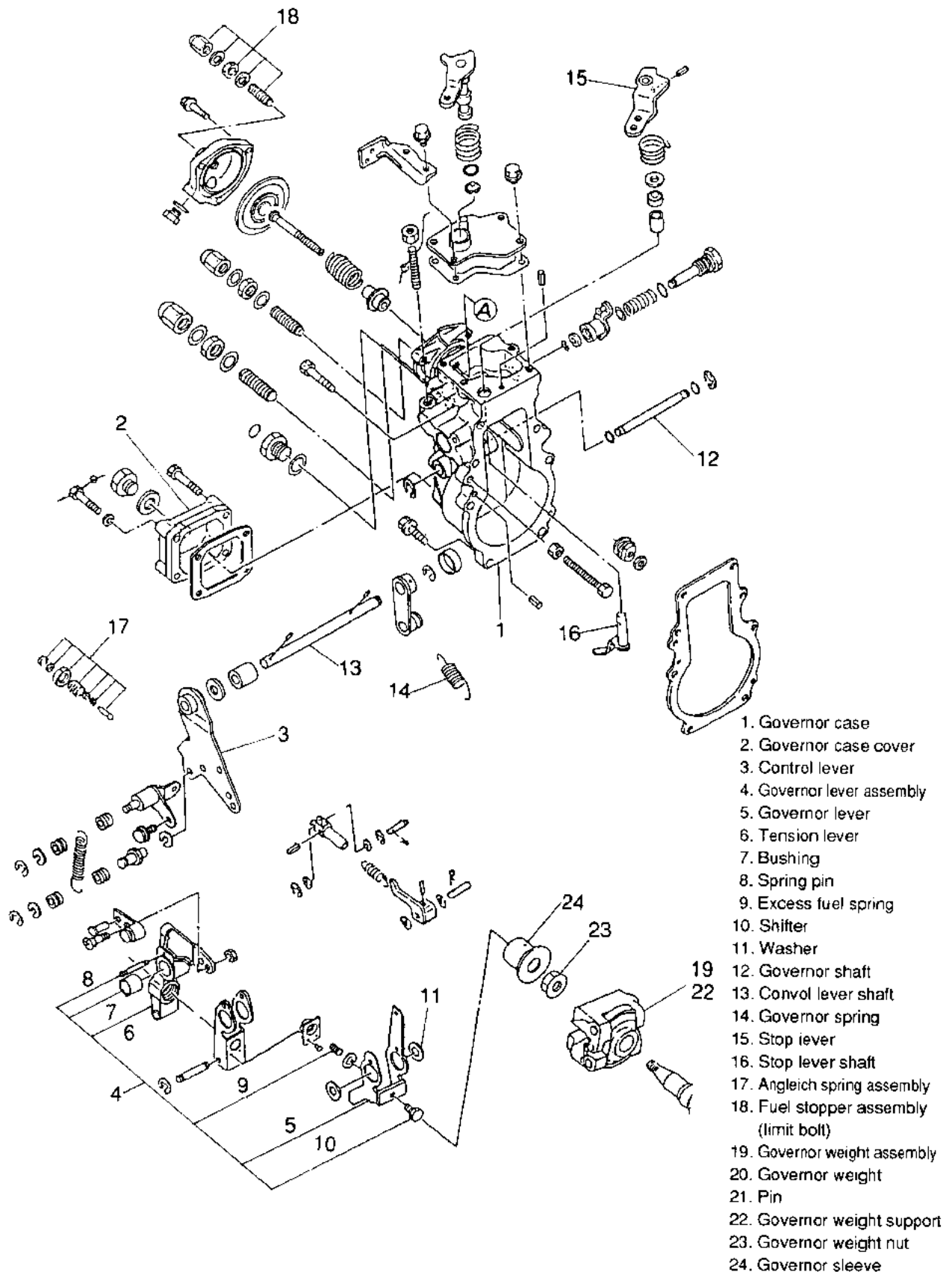
When the cam pushes on the piston via the roller guide, the fuel in the piston chamber passes through the dis-

charge valve and flows behind the piston. The suction valve closes under pressure and prevents the fuel from flowing back to the tank.

When the cam is lowered, the piston is pushed back by the piston spring and the fuel behind the piston chamber is forced to the fuel pump. The negative pressure which develops in the piston chamber makes the suction valve open and fills the piston chamber with fuel.

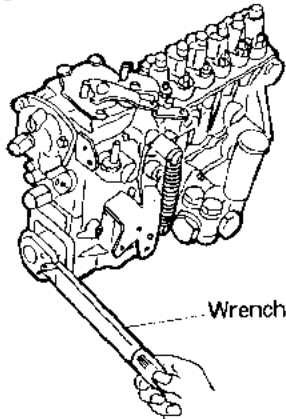


## 6. Disassembly, Reassembly and Inspection of Governor

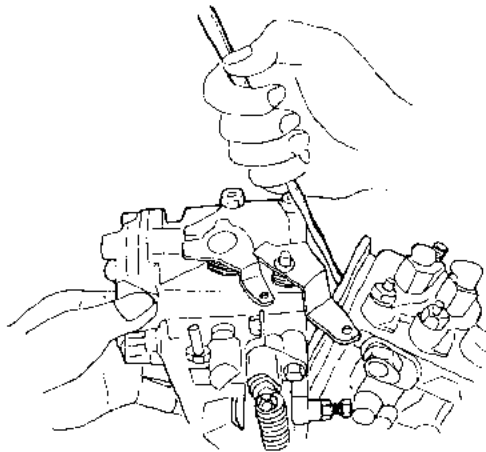


### 6-1 Governor disassembly

- (1) Remove the governor case cover.
- (2) Remove the angleich spring assembly.

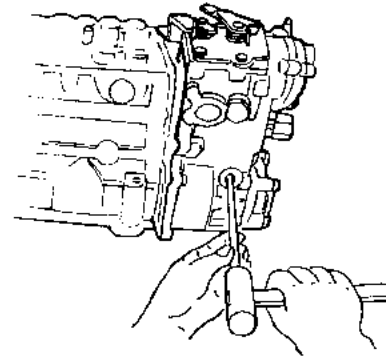


- (3) Remove the governor case bolt. Remove the governor case (parallel pin) from the fuel pump unit while lightly tapping the governor case with a wooden hammer. Make a gap between the governor case and fuel pump by moving only the moving parts of the governor lever.

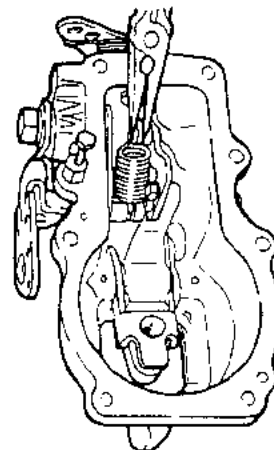


- (4) Remove the connecting spring by inserting needle nosed pliers between the fuel pump and governor case.
- (5) Slide the governor case and fuel pump apart and pull out the link pin of the fuel control rack.
- (6) Remove the snap-rings on both ends of the governor lever shaft.

- (7) Put a rod in one end of the governor lever shaft, and tap the governor shaft until the O-ring comes out from the other side of the governor case.
- (8) After removing the O-ring, lightly tap the end of the shaft from which you removed the O-ring, and remove the governor lever shaft. Then remove the governor shaft assembly and washer.



- (9) Unhook the governor spring from the tension lever and control lever shaft.

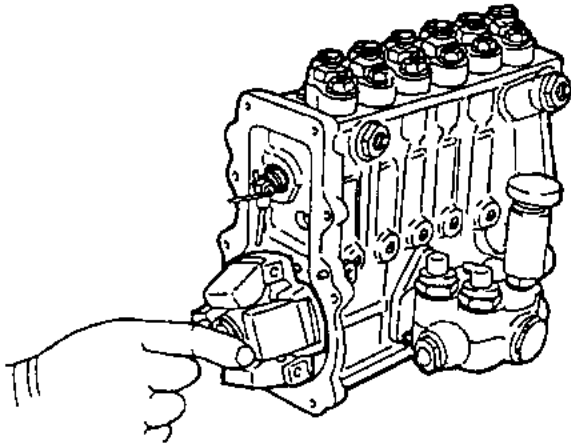


*Note: The governor assembly consists of the governor lever, tension lever, bushing, throttle spring and shifter, and is normally not disassembled. The spring pin is removed when you replace the shifter or throttle spring.*

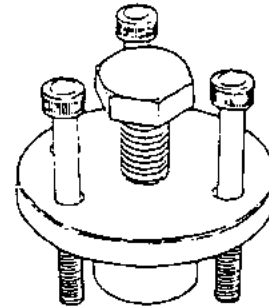
- (10) When you need to pull out the control lever shaft, remove the control lever tightening nut, lightly tap the control lever shaft with a wooden hammer, and pull it out from the inside of the governor case.

**NOTE:** Do not remove the fuel limit nut from the governor case unless necessary.

- (11) Pull out the governor sleeve at the end of the fuel camshaft by hand.



- (13) Remove the governor weight assembly from the fuel pump cam. Use the governor weight pulling tools.



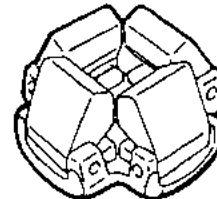
**NOTE:** The governor weight assembly is made up of the governor weight, support and pin. Do not disassemble.

## 6-2 Inspection of governor

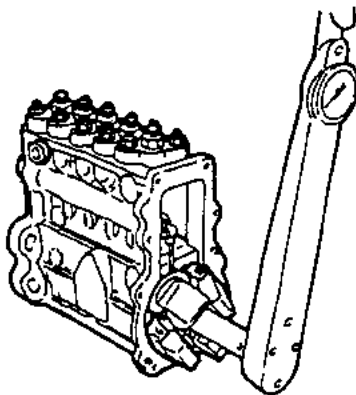
### Inspection of governor weight assembly

Replace if:

- (1) It does not open and close smoothly.

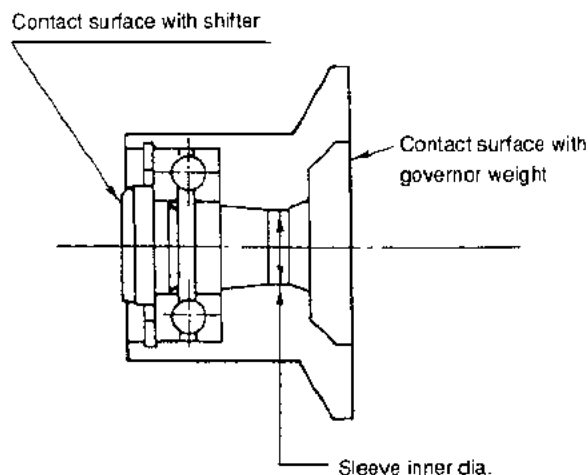


- (12) Remove the governor weight nut and washer with a box spanner, stopping it with the hole in the fuel pump coupling or holding the coupling with a vise. Screw the governor weight nut back in, (two or three times).



- (2) The contact surface with governor sleeve is extremely worn.  
 (3) The governor weight support/pin is worn or the caulking is loose.  
 (4) The governor weight support stopper is excessively worn.

**NOTE:** Be careful as the taper fit comes apart after removing the nut ... the governor weight may fly out.

**Inspection of governor sleeve**

Replace if:

- (1) The contact surface with the governor weight is worn or there is pitching.
- (2) The contact surface with the shifter is considerably worn or there is pitching.
- (3) The governor sleeve does not move smoothly above the cam shaft due to governor sleeve inner dia. wear or other reasons.

**Inspection of governor lever assembly**

- (1) Measure the clearance between the governor shaft and bushing, and replace if it exceeds the limit.

mm	
Standard Clearance	Limit
0.065~0.124	0.5

- (2) Inspect the shifter contact surface, and replace the shifter (always disassemble by removing the pin) if it is worn or scorched.
- (3) Disassemble and replace excess fuel springs that are settled, broken or corroded by pulling the spring pin.
- (4) Check link parts for bends or kinks that will cause malfunctioning, and replace any parts as necessary.

**NOTE:** 1. Side gap on top of governor lever shaft.

mm	
Standard side gap	0.4~0.8

2. Replace the governor lever, tension lever, bushing, shifter and throttle spring as an assembly.

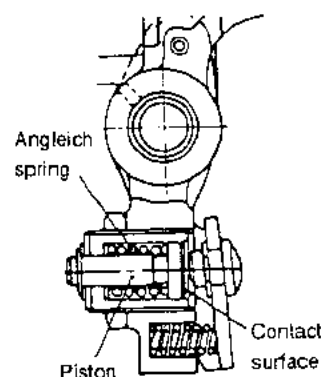
**Inspection of springs**

- (1) Check the governor spring and other springs and replace if they are broken, settled or corroded.
- (2) Measure the free length of the governor spring, and replace if it exceeds the limit.  
See the service data sheet for the free length of the governor spring.

**Inspection of angleich spring assembly.**

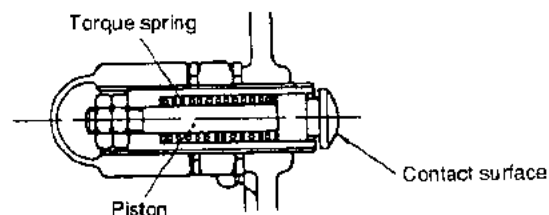
Replace if:

- (1) There is wear to the sliding surface of the piston or the surface which contacts with the shifter.
- (2) If the assembly is broken.

**Inspection of torque spring assembly.**

Replace if:

- (1) The tip of the piston or the contact surface are worn.
- (2) The torque spring is broken.

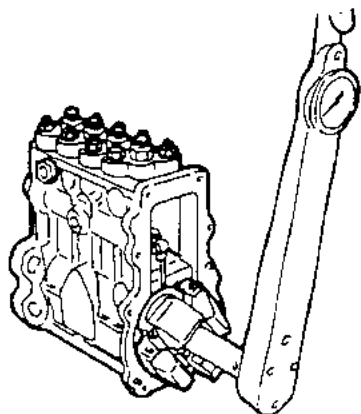


### 6-3 Assembling the governor

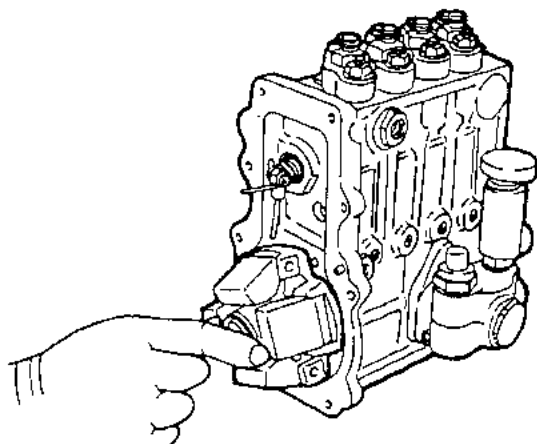
Inspect all parts after disassembly and replace any parts as necessary. Before starting reassembly, clean both the new parts and parts to be reused, and put them in order. Be sure to readjust the unit after reassembly to obtain the specified performance.

- (1) Insert the governor weight assembly to the taper portion at the end of the fuel pump camshaft. Stop it through the hole in the fuel pump coupling or by holding the coupling with a vise. Mount the spacer, and tighten the governor weight nut.

Governor weight tightening torque	4.0~4.5kg·m
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- (2) Open the governor weight and insert the sleeve in the end of the fuel pump camshaft.



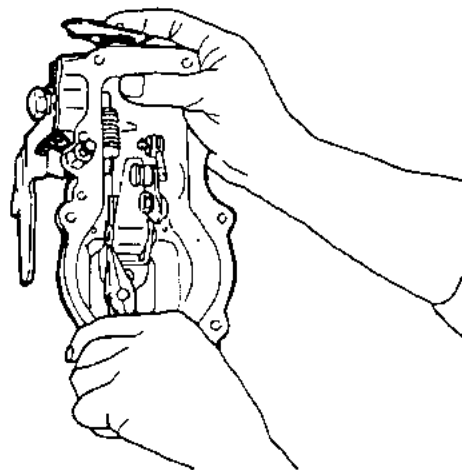
**NOTE:** Make sure that the sleeve moves smoothly after insertion.

- (3) When the control lever shaft has been removed, lightly tap the control lever shaft and washer from inside the governor case, using an appropriate plate.  
 (4) If the governor has been disassembled, tap in the spring pin.  
 (5) Mount the governor link to the governor lever assembly.

**NOTE:** 1. Make sure that the correct governor link mounting holes are used, and that it is mounted in the correct direction.

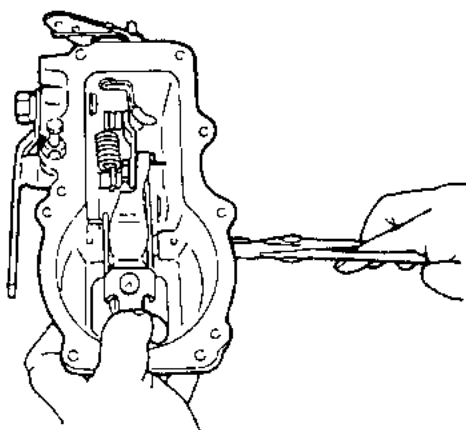
2. Make sure that the governor link moves smoothly.

- (6) Hook the governor spring on the control lever shaft and tension lever hooks.





- (7) Put the governor lever shaft assembly in the governor case, insert the governor lever shaft until the O-ring groove protrudes from out the opposite side of the governor case, and fit the O-ring.

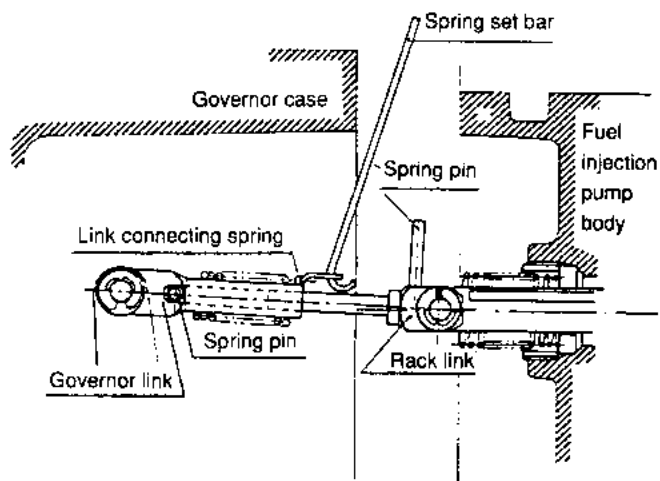


**NOTE:** 1. Fit the O-ring to the side you tapped it in from.  
2. Coat the O-ring with the silicon oil for protection during insertion.  
3. Don't forget to place washers on both sides of the governor lever.

- (8) After mounting the O-ring, tap the governor lever in the opposite direction, and mount the E-shaped stop rings on the grooves at both ends.

**NOTE:** After mounting the governor lever assembly, make sure that it moves smoothly.

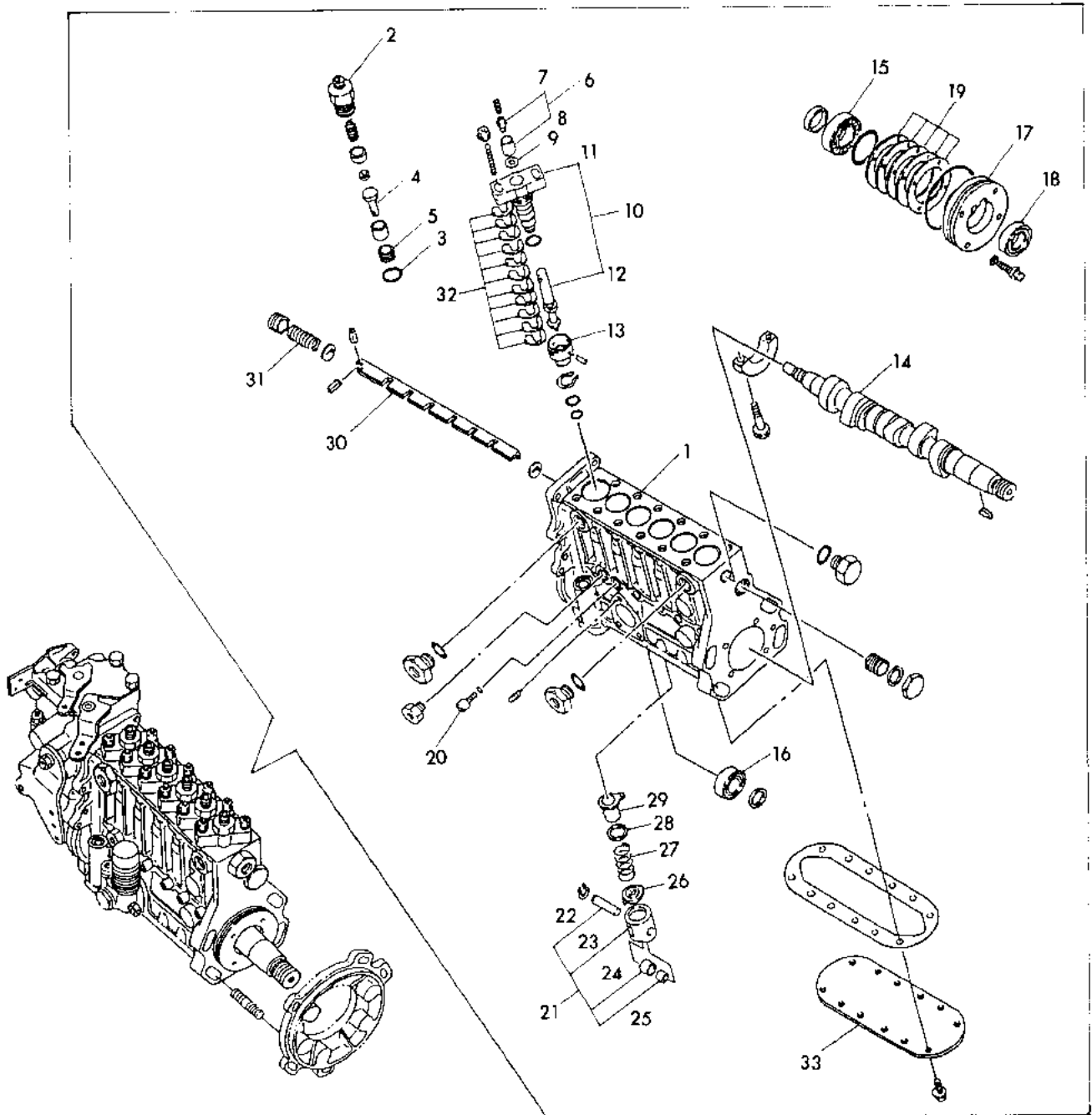
- (9) Insert the rack link in the governor link, hook the link connecting spring on the spring pin of the governor link side with the spring set bar, and connect the governor link with the rack link.



- (10) Fit the link connecting spring to the spring pin at the rack link with the spring set bar by pushing the rack link into the governor link.
- (11) Mount the governor case to the fuel pump unit, lightly tapping it with a wooden hammer, and tighten the bolts.
- (12) Mount the governor case cover.
- (13) Insert the control lever to the control lever shaft, and tighten the nut.

**NOTE:** Move the control lever back and forth to make sure that the entire link moves smoothly.

## 7. Disassembly, Reassembly and Inspection of Fuel injection pump



1. Fuel injection pump body
2. Delivery valve holder
3. O-ring
4. Delivery valve stopper
5. Delivery valve spring
6. Delivery valve assembly
7. Delivery valve
8. Delivery valve seat
9. Packing
10. Plunger assembly
11. Plunger barrel

12. Plunger
13. Protector
14. Fuel injection pump camshaft
15. Bearing
16. Bearing
17. Bearing holder
18. Oil seat
19. Adjusting shims
20. Tappet stopper
21. Tappet assembly
22. Pin

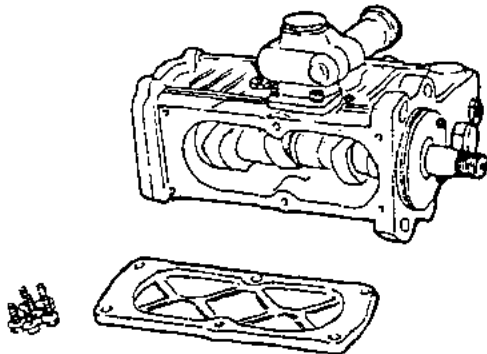
23. Roller guide
24. Roller
25. Bushing
26. Plunger spring seat B
27. Plunger spring
28. Plunger spring seat A
29. Control sleeve
30. Control rack
31. Aux. spring
32. Adjusting shims
33. Pump bottom cover

### 7-1 Disassembly of fuel injection pump

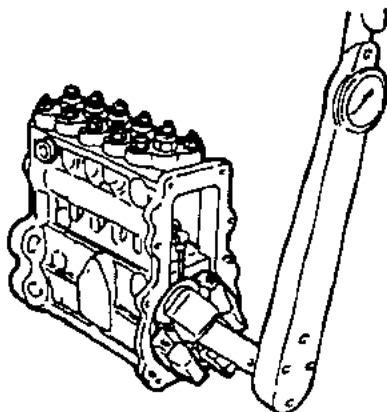
When disassembling the fuel pump, separate the parts for each cylinder and be careful not to get them mixed up. Be especially careful to keep the plunger/plunger barrel, delivery valve/delivery valve seat and other assemblies separate for each cylinder (the parts of each assembly must be kept together and put back in the same cylinder).

#### Preparation

1. Wash off the dirt and grease on the outside of the pump with cleaning oil (kerosene or diesel oil) before disassembly.
2. Perform the work in a clean area.
3. Take off the fuel pump bottom cover and remove the lubrication oil.
4. Turn the fuel pump upside down to drain the fuel oil.

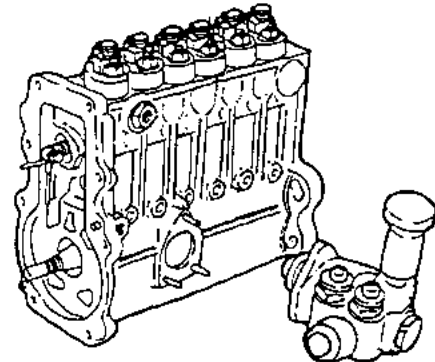


- (1) Loosen the nut with a box spanner and take it off. Hold the unit either by the hole in the fuel pump coupling or by placing the coupling in a vice, and take out governor weight assembly.

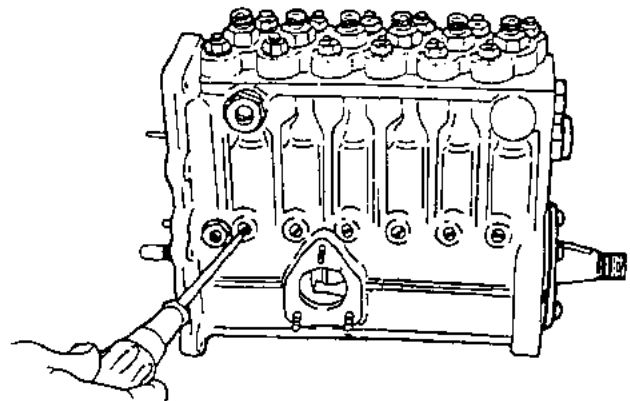


- (2) Remove the fuel feed pump.

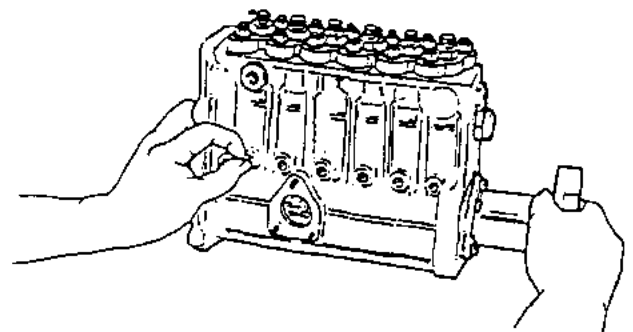
**NOTE:** Do not disassemble the fuel feed pump. See instructions for fuel feed pump for details.



- (3) Remove the roller guide clamping bolts.

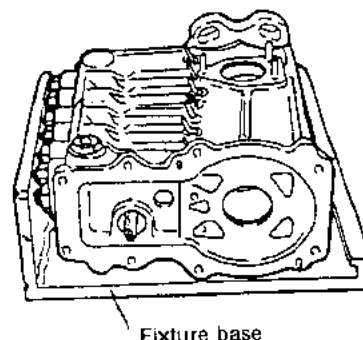
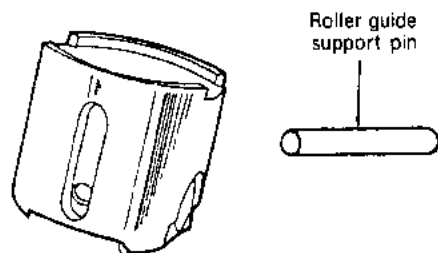


- (4) Turn the camshaft and push the roller guide support pin into the hole on the stopper groove of the roller guide.



NOTE: If the camshaft does not turn, put double nuts or a coupling on the end of camshaft.

(9) Install the fuel injection pump on the pump fixture base.

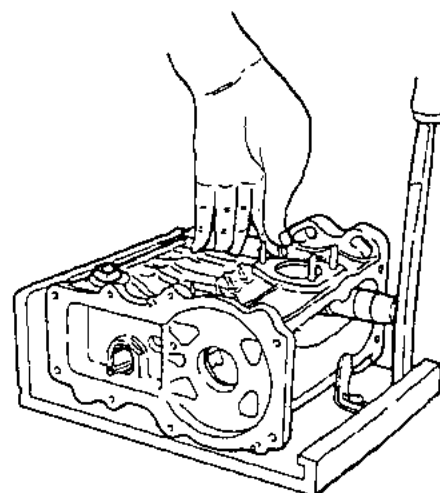
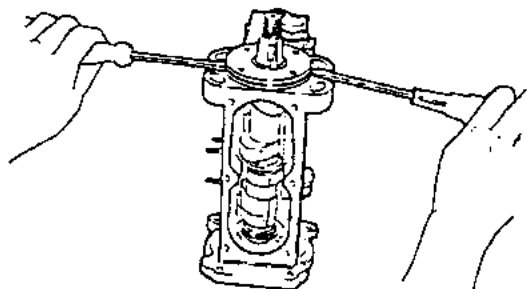


(5) Remove the camshaft woodruff key.

(6) Remove the 4 bolts of the bearing holder.

(7) Place a screwdriver in the two grooves on the camshaft bearing holder mounting surface, and pull out the camshaft bearing holder.

(10) Push the roller guide from underneath with the roller guide push lever and pull out the pushed support pin [item (4)].

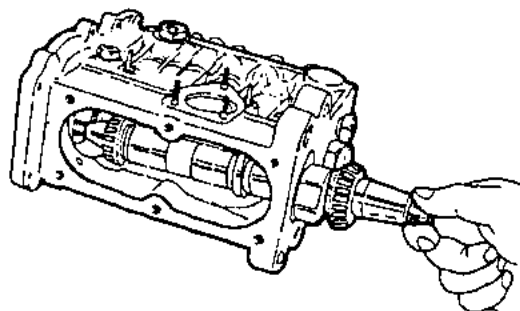


NOTE: 1. Be careful not to damage the oil seal with the threaded part of the camshaft.

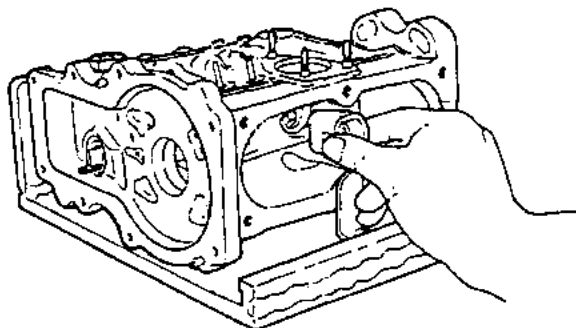
2. Be careful not to lose the shims between the pump and bearing holder.

NOTE: The plunger spring may make the roller guide and plunger, etc. fly out when the plunger support plate is removed.

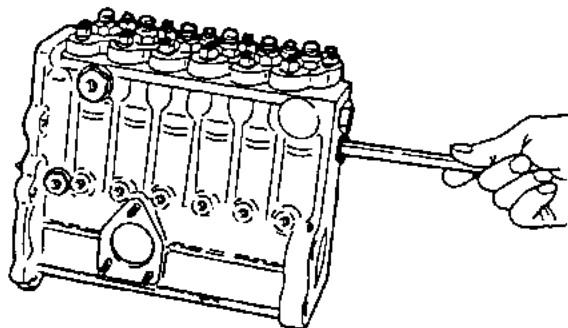
(8) Put a plate against the governor end side of the camshaft and tap it lightly. Pull out the camshaft and drive side bearing.



- (11) Remove the parts of the roller guide by hand in the following order: plunger spring seat B, plunger, spring plunger spring seat A and control sleeve.

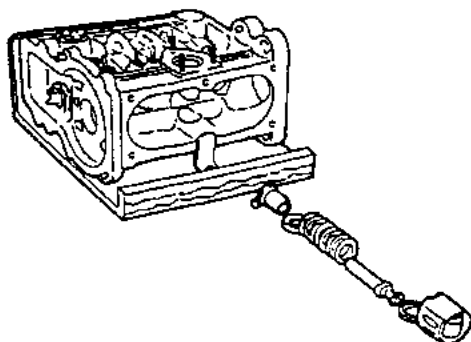


- (12) Remove the control rack.

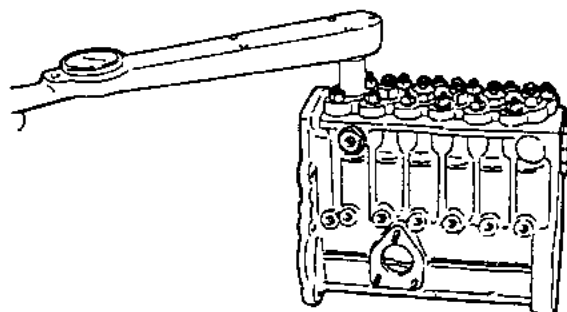


NOTE : Be careful not to lose the spring and seats attached to the control rack.

- (13) Remove the delivery valve holder.



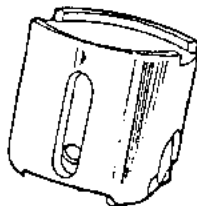
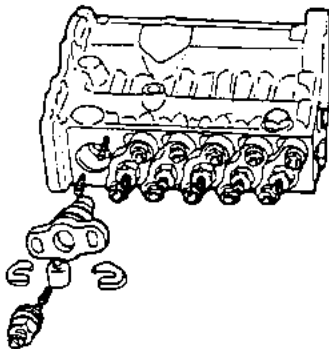
NOTE: All of the roller guides will fall out when the fuel pump is stood up. So, first remove the roller guide support pin and roller guide for one cylinder at a time.



- (14) Remove the delivery valve assembly.

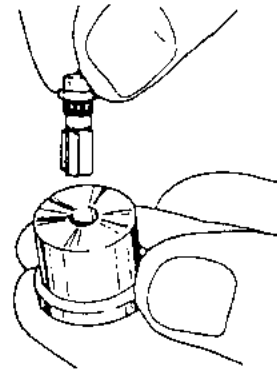
NOTE : 1. Be careful not to lose the delivery valve packing, delivery valve spring, delivery valve stopper and other small parts.  
2. Keep the delivery valve assemblies for each cylinder clearly separate.

- (15) Push up the lower part of plunger barrel from the bottom of the pump, and take out the plunger barrel from the top of pump.



**NOTE:** Keep each plunger barrel and plunger taken out before as a set.

- (2) Inspection of delivery valve



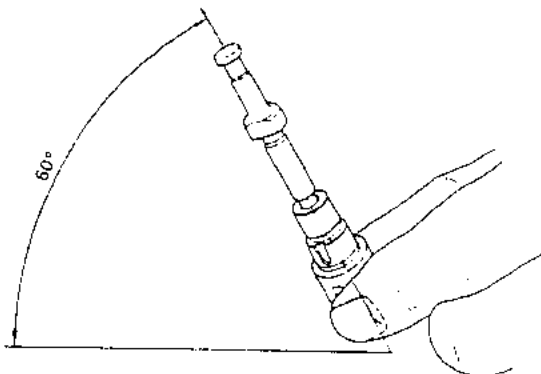
- 1) Replace as a set if the delivery valve suck-back collar or seat is scratched, scored, scuffed, worn, etc.
- 2) The valve is in good condition if it returns when released after being pushed down with your finger (while the holes in the bottom of the delivery guide seat are covered). Replace if necessary.
- 3) Likewise, the valve should completely close by its own weight when you take your finger off the holes in the bottom of the delivery guide sheet.

**NOTE:** When fitting new parts, wash with diesel oil and perform the above inspection.

## 7-2 Inspection of fuel injection pump

### (1) Inspection of plunger

- 1) Thoroughly wash the plungers, and replace plungers that have scratched on the plunger lead or are discolored.
- 2) The plunger is in good condition if it slides down smoothly when it is tilted at about 60°. Repeat this several times while turning the plunger. Repair or replace if it slides down too quickly or if it stops part way.



### (3) Inspection of pump

- 1) Inspect for extreme wear of the roller guide sliding surface. Scratches on the roller pin sliding surface are not a problem.
- 2) Inspect the plunger barrel seat. If there are burrs or discoloration, repair or replace as this will lead to dilution of the lubricant.

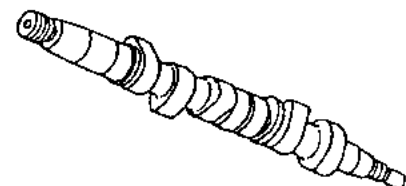
### (4) Inspection of fuel camshaft and bearings

#### 1) Fuel camshaft

Inspect for scratches or wear of camshaft, deformation of key grooves and deformation of screws on both ends, and replace if necessary.

#### 2) Bearings

Replace if the taper rollers or outer race surface are flaked or worn.

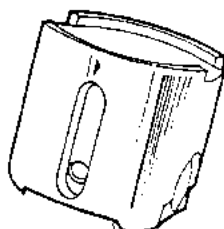


**NOTE:** Replace fuel camshafts and bearings together.

## (5) Inspection of roller guide assembly

## 1) Roller

Replace if the surface is worn or flaked.



## 2) Roller guide

Replace if the roller pin hole and the surface in contact with the plunger side is extensively worn or there are many scratches.

## 3) Replace if the play of the roller guide assembly pin/roller is 0.2mm or more.

## 4) Roller pin

Replace the roller pin if its play in the radial direction is great.

## (6) Inspection of rack and control sleeve

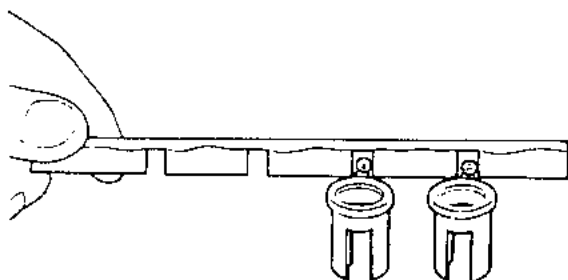
## 1) Rack

Inspect the bending of the rack and wear or deformation of its fit with ball of control sleeve.

## 2) Control sleeve

inspect for wear or deformation of the ball and fit to the plunger.

**NOTE:** Rack resistance increases if the fitting or sliding surfaces are not in good working order, and this affects the condition of the engine (rough rpm, over running, etc.)



## (7) Inspection of plunger spring and delivery spring

Inspect springs for scratches, cracks, breakage, uneven wear and rust.

## (8) Inspection of oil seals

Inspect oil seals to see if they are burred or scratched.

## (9) Inspection of roller guide stop

Inspect the side of the tip, replace if excessively worn.

## (10) Replacement of O-ring

Replace if they are removed.

## 7-3 Reassembly of fuel injection pump

## Preparation

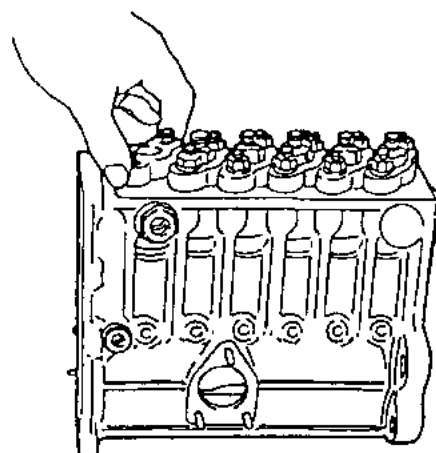
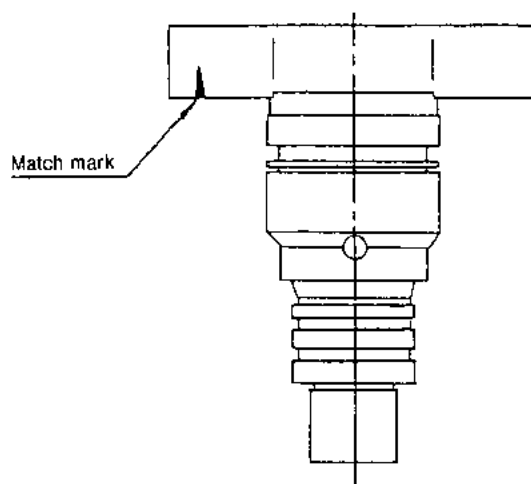
After inspection, arrange and clean all parts.

See Inspection of Fuel Pump for inspection procedure.

- (1) Turn the match mark on the flange of plunger barrel to face left from driving side of the pump, insert the plunger barrel from the top of the pump, adjust it with the match mark on pump body, and tighten the nuts.

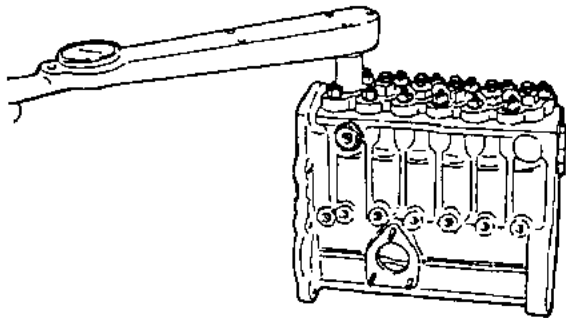
tightening torque	2.6~2.8kg·m
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**NOTE:** Coat the silicon O-ring with oil.



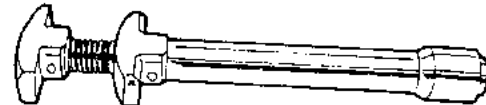
- (2) Insert the packing, delivery valve assembly, spring, and stopper from the top of the pump, in that order, and tighten the delivery valve holder.

Delivery valve holder tightening torque	6.0~6.5kg·m
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- (7) Mount the plunger spring seat B on the head of the plunger, and fit the plunger in the lower part of pump. The match mark R-1 on the plunger flange should be on the left as seen from the driving side of the pump.

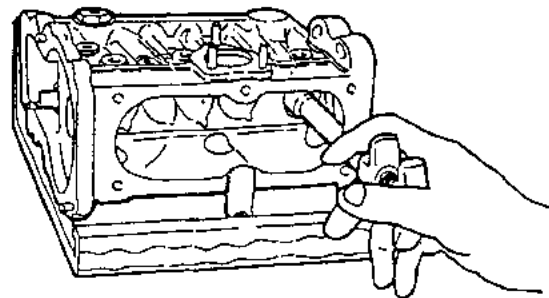
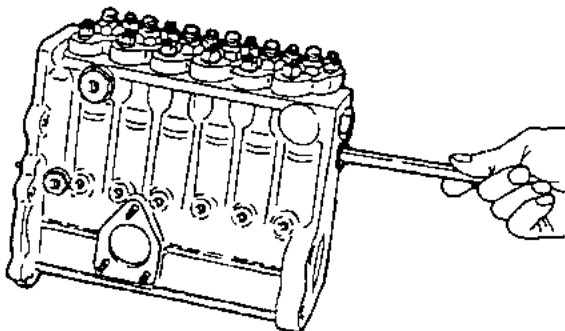
**NOTE:** This is important, because if the plunger is mounted in opposite direction, the spill way will be reversed.



Plunger insert device

- (3) Place the control rack.

**NOTE:** Do not forget the rack Aux. spring



- (4) Place the control sleeve from the bottom of the pump. Make sure the rack moves smoothly through a full cycle.

- (5) Mount the plunger spring seat A.

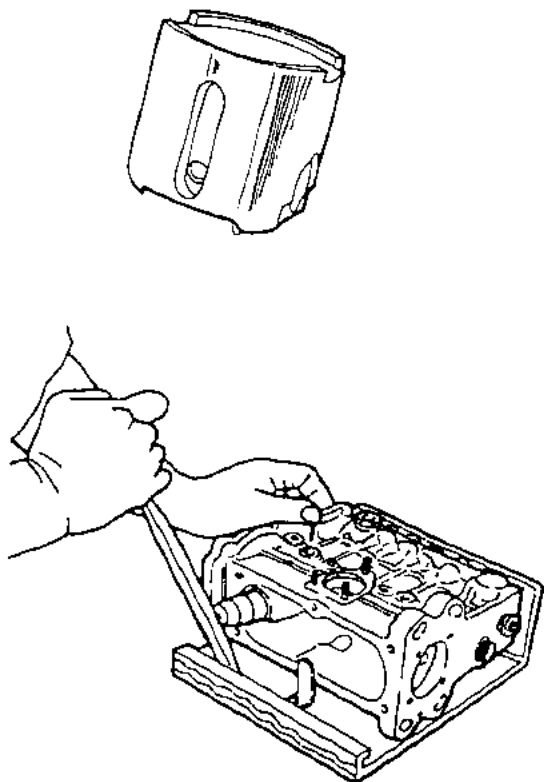
**NOTE:** 1. Be sure to mount the seat A with the hollow side facing down.

2. Check again to make sure that the rack moves easily.

- (6) Mount the plunger spring.

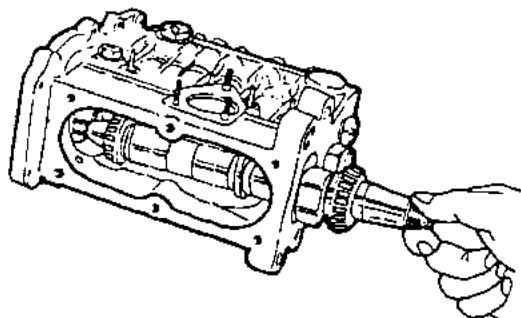


- (8) Insert the roller guide, pushing it up from the bottom of the pump with the roller guide push lever, and insert the support pin in the hole on the roller groove.



**NOTE:** Check the movement of the rack. If the movement is heavy, the plunger spring may be out of place. Insert a screwdriver and bring it to the correct position. Fit the shims when replacing the roller guide assembly and tighten the lightly.

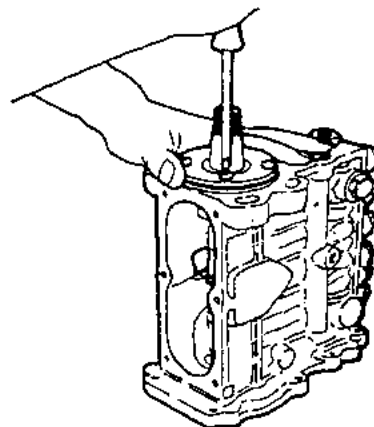
- (9) Fit the bearings to both ends of the camshaft, and insert from the driving side.



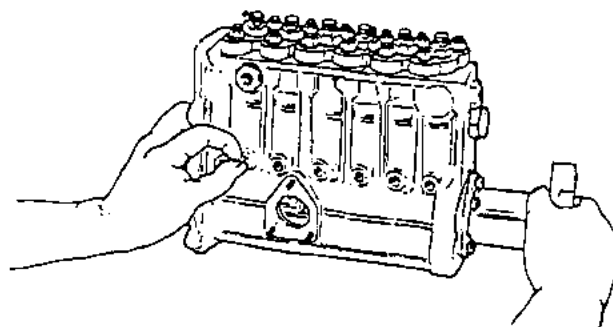
- (10) Fit the oil seal on the inside of the bearing holder and mount the bearing holder.

**NOTE:** Coat the camshaft and the oil seal with silicon oil to prevent the oil seal from being scratched.

tightening torque	0.6~0.7kg·m
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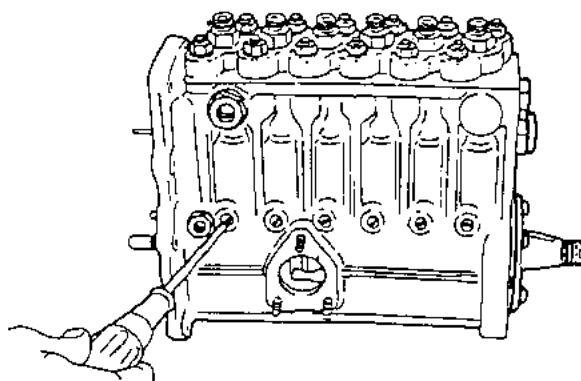


- (11) Tap in the camshaft woodruff key.  
(12) Mount double nuts or a coupling on the end of the camshaft, and pull out the roller guide support pin as you turn the camshaft.



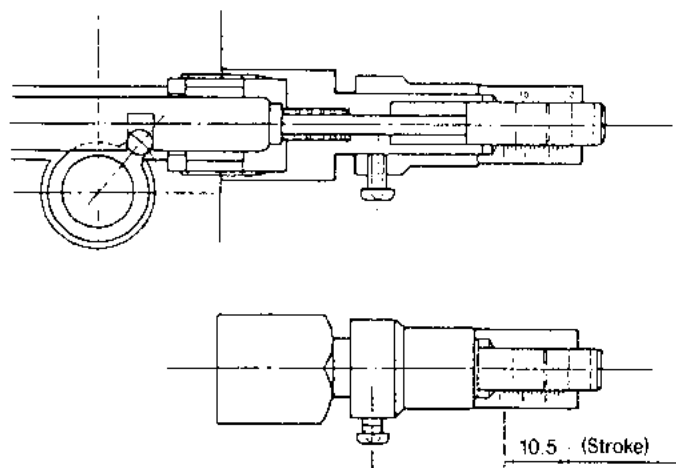
- (13) Make sure that the roller guide stop groove is in the correct position, and tighten the roller guide stop bolts.

tightening torque	0.6~0.7kg·m
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## 7-4 Adjustment of pre-stroke

- (1) Remove the delivery valve holder of No.1 cylinder. Remove the delivery valve spring, delivery valve and gasket.
- (2) Screw the pre-stroke measuring device in the screw hole on the top of pump.
- (3) Set the control rack to the full throttle position, find the bottom dead center of the plunger while rotating the pump by hand, and set the dial indicator to zero.

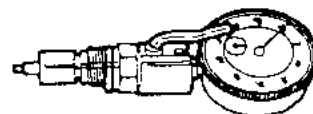
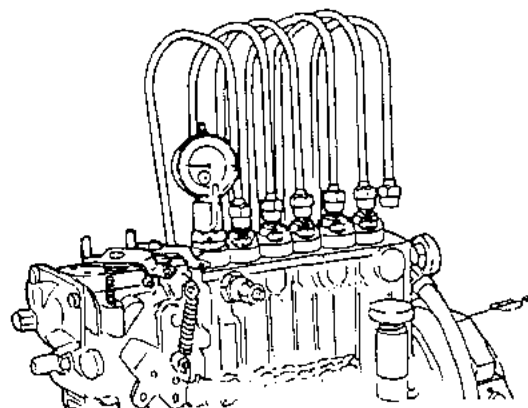


## (14) Check the control rack stroke

Make sure the rack position is at  $10.5 \pm 1$  mm on the indicator scale when the governor control lever is set at the maximum operating position. If it is not at this value, change the link connecting the governor and control rack.

**NOTE:** Links are available in 1 mm increments.

- (15) Remove the plug in the oil filler port of the governor case, and fill the lube oil.



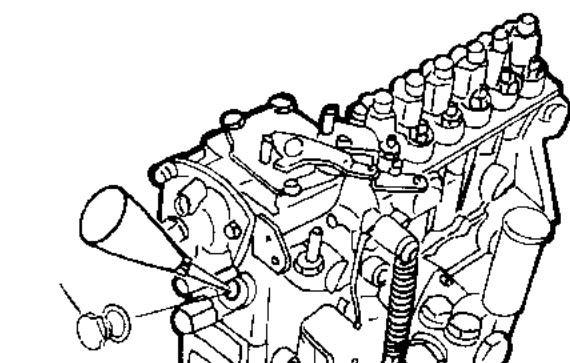
Pre-stroke measuring device

- (4) Slowly rotate the pump in the normal rotation direction by hand, and measure the plunger lift until fuel flow stops from the overflow pipe on the measuring device.

Pre-stroke	See separate service data
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- (5) If the measured pre-stroke is not standard, adjust by changing the shim thickness between the flange of the plunger barrel and pump body.

	mm
Adjusting shims thickness	1.5
	1.6
	1.7
	1.8
	1.9
	2.0
	2.1
	2.2
	2.3
	2.4
	2.5



- (16) Complete fuel oil piping and operate the pump tester to purge the line of air.

- (17) Set the oil feed pressure from the pump tester to the injection pump at the pressure specified in the separate service data sheet.

- (6) Repeat the above procedure to adjust the prestroke of each cylinder.
- (7) After adjustment is completed insert the gasket, delivery valve, delivery valve holder and spring. Tighten the delivery valve holder.

Delivery valve holder tightening torque	6.0~6.5kg·m
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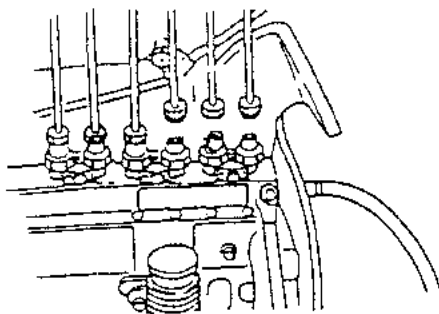
### 7-5 Adjusting injection timing

After adjusting the pre-stroke for all cylinders, check/adjust the injection timing.

- (1) Set the governor control lever in the operating position (bring the plunger to the effective injection range), turn the camshaft clockwise, and check the injection starting time (FID) of cylinder No.1 (start of fuel discharge from the delivery retainer).

Cylinder No.	Count from the drive side
Direction of rotation	Right looking from drive side

- (2) Now set the tester needle on the flywheel scale in a position where it is easy to read, and check the injection timing several times according to the injection order.



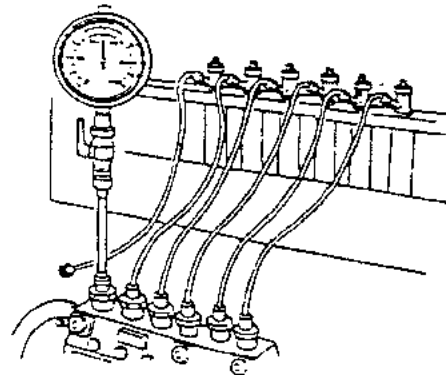
No. of cylinders	3
Injection order	1-4-2-6-3-5-1
Injection interval	60°
Allowable deviation	±30°

- (3) Readjust the pre-stroke of cylinders that are not within the allowable deviation (increasing the adjusting shim thickness makes the injection timing slower, and decreasing makes it faster).  
The change in injection timing effected by the adjusting shims is as follows:

Change in shim thickness	Change in injection timing	
	Cam angle	Crank angle
0.1 mm	0.4°	0.8°

### 7-6 Plunger pressure test

- (1) Mount the pressure gauge to the delivery retainer of the cylinder to be tested.

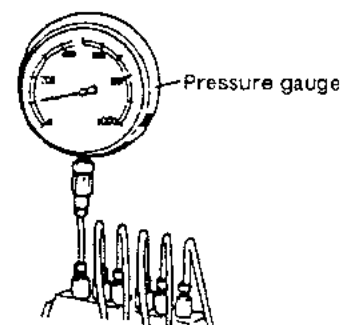


Max. pressure gauge reading	1000kg/cm <sup>2</sup>
Connecting screw dimensions	M12 x 1.5

- (2) Set the governor control lever in the stop position, operate the injection pump at about 2000 rpm, and make sure that the pressure gauge reading is 500 kg/cm<sup>2</sup> (7110 lb/in.<sup>2</sup>) or more. All the time lightly move the control rack toward full throttle (drive side). Replace the plunger if the pressure does not reach this value.
- (3) Immediately release the rack after the pressure has stopped injection.  
At the same time, check to see that oil is not leaking from the delivery retainer or fuel injection piping, and that there is not extreme drop in pressure.

### 7-7 Delivery valve pressure test

- (1) Perform the plunger pressure test in the same way, bringing the pressure to about 120 kg/cm<sup>2</sup> (1706 lb/in.<sup>2</sup>), and then stopping injection.



- (2) After the pressure has risen to the above value, measure the time it takes to drop from 100 ~ 90 kg/cm<sup>2</sup>.

100 → 90 kg/cm<sup>2</sup>5 seconds  
(to drop 10 kg/cm<sup>2</sup>)

If the pressure drops faster than this, wash the delivery valve, and retest. Replace the delivery valve if the pressure continues to drop rapidly.

## 7-8 Adjusting injection volume (uniformity of each cylinder)

The injection volume is determined by the fuel injection pump rpm and rack position. Check and adjust to bring it to the specified value.

### 7-8.1 Measuring injection volume

#### (1) Preparation

Set the pump rpm, rack position and measuring stroke to the specified value and measure:

Pump RPM	See separate service data
Pump rotating direction	Right looking from drive side
Rack indicator scale reading	See separate service data

#### (2) Measuring injection volume

Measure the injection volume at the standard stroke, and adjust as follows if it is not within the specified value.

Measuring stroke	
Specified injection volume at standard rack position	See injection pump service data
Nonuniformity of cylinders	

### 7-8.2 Adjustment injection volume

- (1) Adjustment of injection volume: loosen the two nuts on the flange of the plunger barrel, and turn the plunger barrel to the right or left.
- (2) Measure the injection volume of each cylinder again. Repeat this process until the injection volume for every cylinder is the same. (within the specified limit)
- (3) After completing the measurements, retighten the nuts of plunger barrel flange.

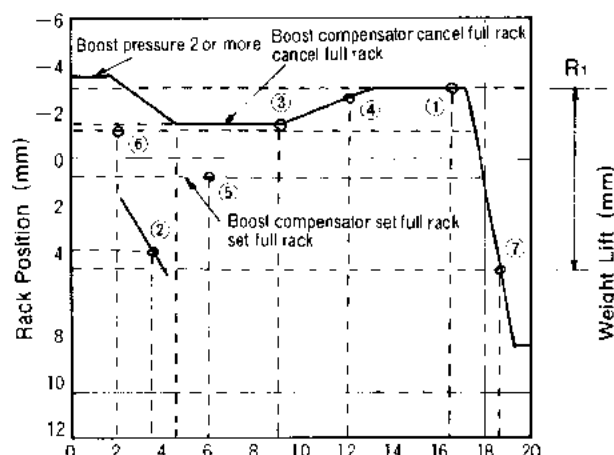
Tightening torque	2.6~2.8 kg·m
-------------------	--------------

- (4) If not aligned with the match mark, make a new match mark.

## 7-9 Adjustment of governor

### 7-9.1 Adjusting the fuel limit bolt

- (1) Adjust the tightness of the fuel limit bolt to bring the rack position to the specified value ( $R_1$ ) with the governor control lever all the way down towards the fuel increase position. Keep the pump at rated 1650 rpm.

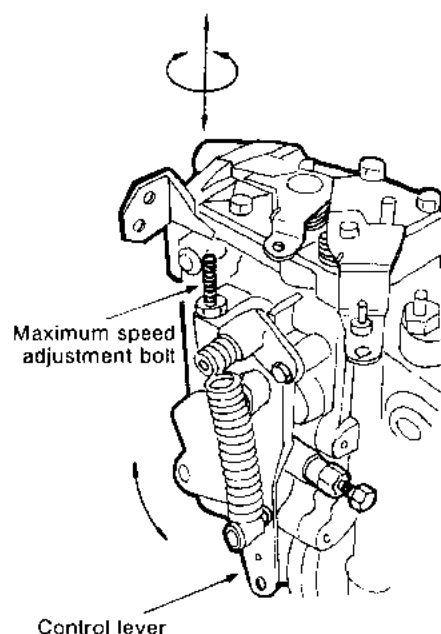


- (2) Measure fuel injection volume at rack position ( $R_1$ ).

- (3) If the injection volume is at the specified value, tighten the fuel limit bolt lock nut.

### 7-9.2 Adjusting RPM limit bolt

- (1) Gradually loosen the governor control lever while keeping the pump drive condition in the same condition as when the fuel limit bolt was adjusted, and adjust the tightness of the RPM limit bolt to the point where the rack position just exceeds the specified value ( $R_1$ ).

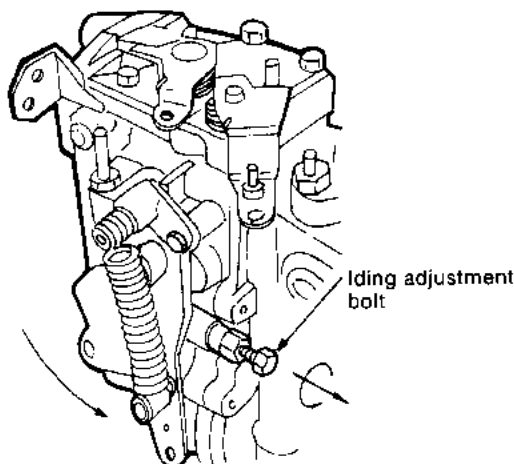


## (2) Check maximum RPM at no load

Further increase rpm, and make sure that rack position ( $R_2 = R_1 - L$ ) corresponding to maximum rpm at no load is within specified value ( $N_2$ ).

No load max. RPM (Pump RPM)	See separate service data
--------------------------------	---------------------------

## 7-9.3 Adjusting idling

(1) Maintain the pump rpm at specified rpm ( $N_3$ ).

Idling rpm (Pump RPM)	See separate service data
-----------------------	---------------------------

- (2) Measure the injection volume as you lower the governor control lever to the idling position, and adjust the position of the control lever with the idling adjustment bolt to bring it to the specified value.

Measuring stroke	See separate service data
Idling injection volume	

## 7-9.4 Check the injection volume when starting

- (1) Make sure the control rack moves smoothly as you gradually reduce idling rpm.
- (2) Next, fix the governor control lever at full load position with the pump at the specified rpm ( $N_4$ ). Make sure that the control rack is in the maximum position. Measure the injection volume and check to make sure it is within the specified value.

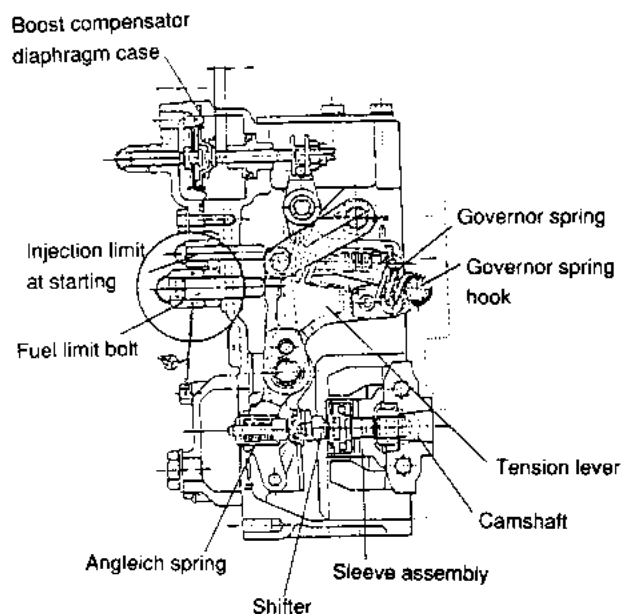
Pump rpm ( $N_4$ )	200 rpm
Rack indicator scale	13.5~14.5
Measuring stroke	500st
Injection volume	See separate service data

## 7-9.5 Check injection stop

Drive the pump at no load maximum rpm ( $N_2$ ). With governor control lever in the full load position, operate the stop lever on the governor case, and make sure that injection to all cylinders is stopped.

## 7-10 Adjustment of torque rise

There are some models which obtain torque rise with angleich and torque springs incorporated in the fuel injection pump as an injection volume increasing mechanism.



## 7-10.1 Models with angleich spring

For models with an angleich spring, perform this adjustment after finishing the speed limit bolt adjustment.

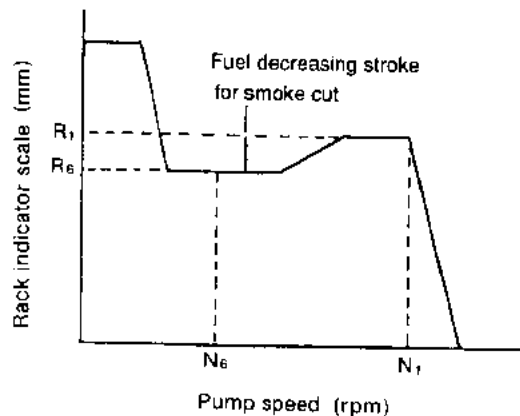
- (1) The angleich spring is used as an assembly.
- (2) Bring the governor control lever to the full load position, and keep the pump speed at the specified peak torque.
- (3) Remove the governor case cover in this state and screw the angleich spring assembly to the tension lever. Screw in from the contact position with the governor lever (when control lever starts to move), so that the injection volume at torque rise is within the specified values ( $\theta$  deg.)
- (4) After completing the above, tighten the lock nut to the specified torque, and mount the governor case cover.

**NOTE:** Make sure that the angleich bolt does not turn with the locknut during tightening.

- (5) Bring the fuel injection pump back to the rated speed. Make sure that the control rack smoothly displaces the torque rise stroke, and that rack position ( $R_1$ ) and injection value are within the specified value at ( $N_1$ ) rpm.

## 7-10.2 Smoke cut spring

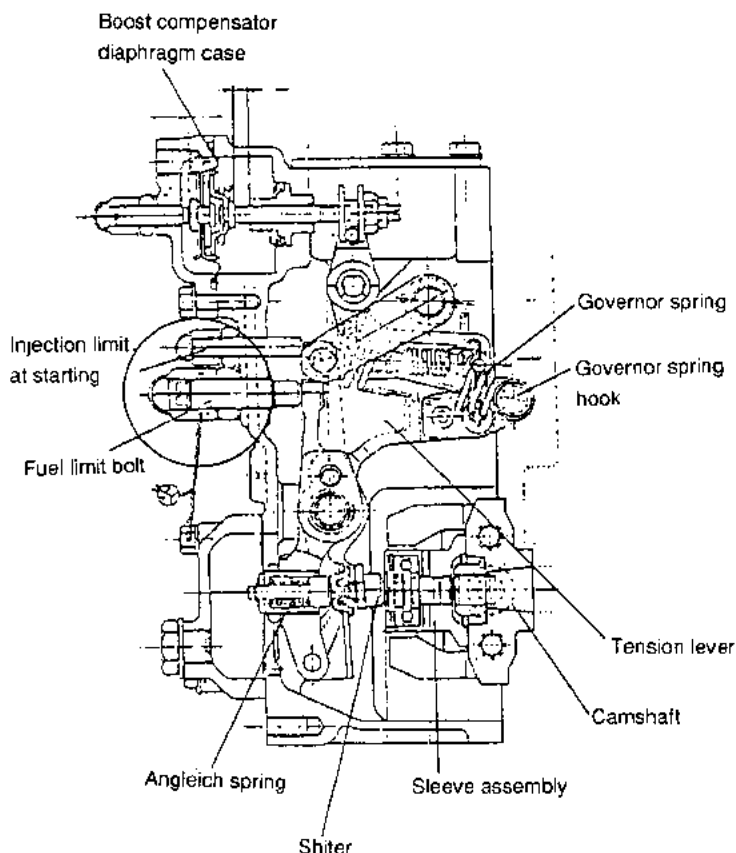
The smoke cut spring is used in the form of spring loaded assembly.



- (1) Turn the control lever to "FULL LOAD", and keep the fuel injection pump at the specified smoke cut spring control revolutions (N<sub>6</sub>).
- (2) Remove the rear cover from the governor. Screw the smoke cut spring assy. in the thread of the tension lever until it comes into contact with the angleich lever. Further screw in the smoke cut spring assy. to the position in which the specified injection is attached (R<sub>6</sub>). (The smoke cut lever moves in the direction of "DECREASE of injections").
- (3) Tighten the lock nut to the specified tightening torque. Attach the governor rear cover.

Lock nut tightening torque	2.5-3.0kg·m
----------------------------	-------------

- (4) Run the fuel injection pump at the rated revolutions (N<sub>1</sub>) once again. Check whether the control rack smoothly changes fuel decreasing strokes. Finally, make sure that rack position (R<sub>1</sub>) and injection at revolutions (N<sub>1</sub>) meet the specification.



Before Adjusting the smoke cut spring assembly, adjust

- (1) the fuel limit bolt, and
- (2) the revolution limit bolt.

## 8. Automatic Advancing Timer

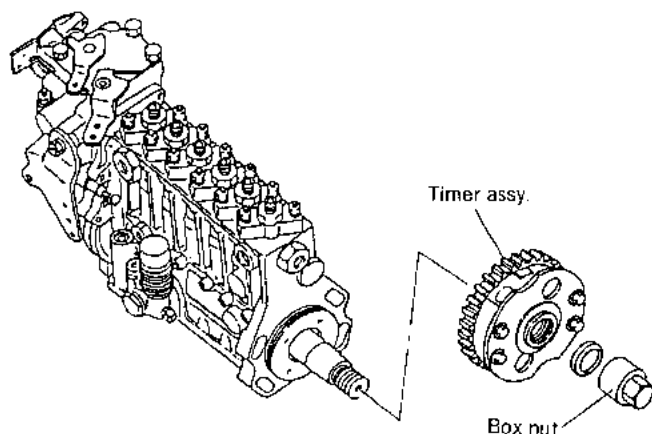
### 8-1 Timer construction

The faster the engine speed, the larger the crank angle is during ignition delay. This results in a delay in ignition time and thus a decrease in engine output.

When an engine is used from low to high speed, the injection timing must be changed according to engine speed to maintain it at the optimum timing.

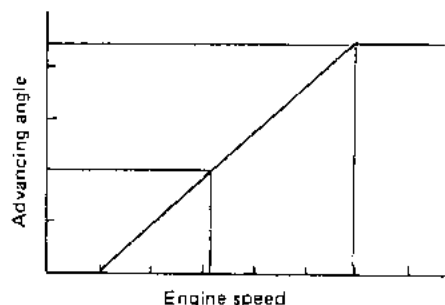
The automatic timer uses centrifugal force to automatically adjust injection timing.

Model Identification code Advanced angle	See separate service data
--	---------------------------

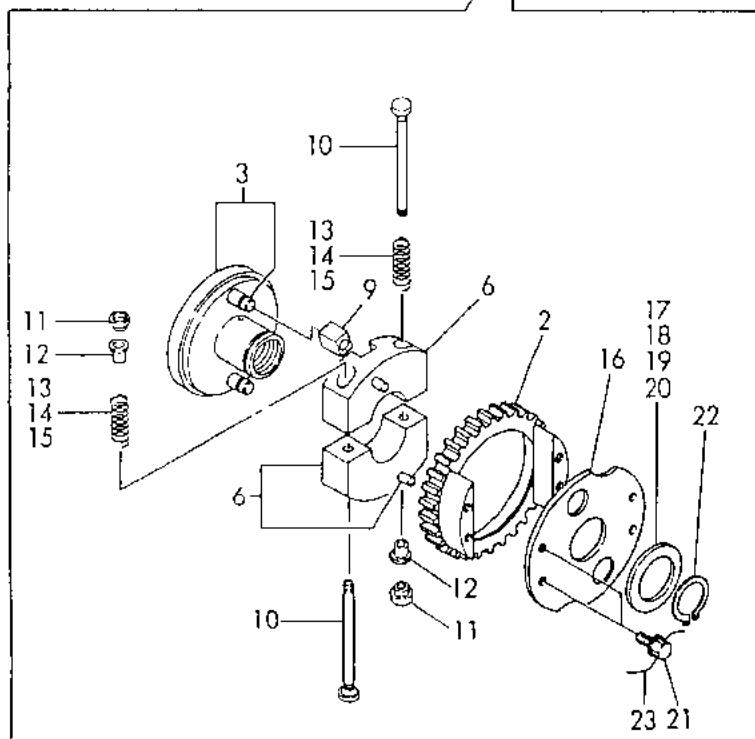


### 8-2 Function and characteristics of timer

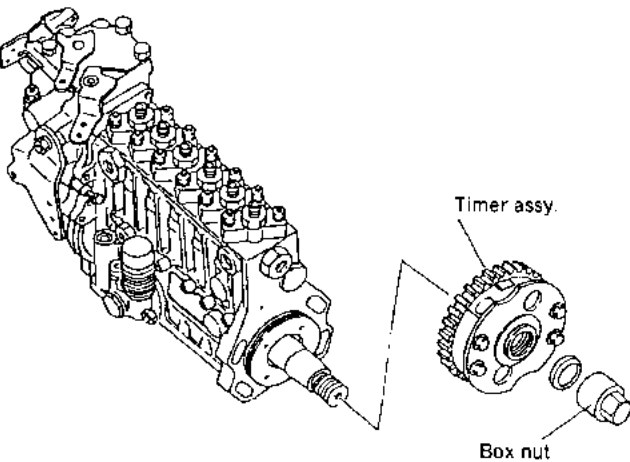
The flyweights are pressed against the center of the flyweight by the springs. As speed increases, the centrifugal force of the two flyweights increases, compresses the timer springs, and the relative position of the timer gear and hub changes according to the function of the retainer guide groove of the weight and the weight guide of the timer gear, changing the injection timing. Accordingly, as the spring is compressed (according to the rise in speed advancing the timing), the advancing angle remains proportional to speed.



The advancing characteristics can be changed by changing the profile of the retainer guide groove of the weight and the spring constant and setting force of the spring.



8-3 Timer disassembly



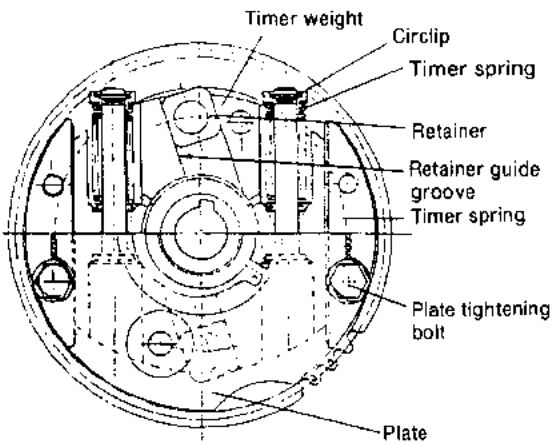
- (1) Remove the camshaft box nut.
- (2) Use a timer extractor to remove the remove the timer assembly.
- (3) The retainers and weights can be removed when you take off the circlip and plate tightening bolts and separate the timer gear and timer hub.

*Note: As the advancing angle has been set at the factory, do not disassemble the timer unless necessary.*

8-4 Timer inspection

- (1) Inspect the timer spring, and replace if there is excessive settling or corrosion.
- (2) Inspect the retainer guide groove of the timer weight, retainer, and gear it comes in contact with, and replace if wear is excessive or movement is not smooth.
- (3) Inspect the circlip, and replace if there is excessive wear.

*Note: Recheck advancing angle when replacing weight or spring, and readjust as necessary with adjusting shims.*



8-5 Timer reassembly

- (1) Fix the plate by the tightening bolts.

		kg-m
Tightening torque	2.3-2.7	

- (2) Mount the timer assembly on the fuel injection pump camshaft, and tighten the box nut with a socket wrench.,

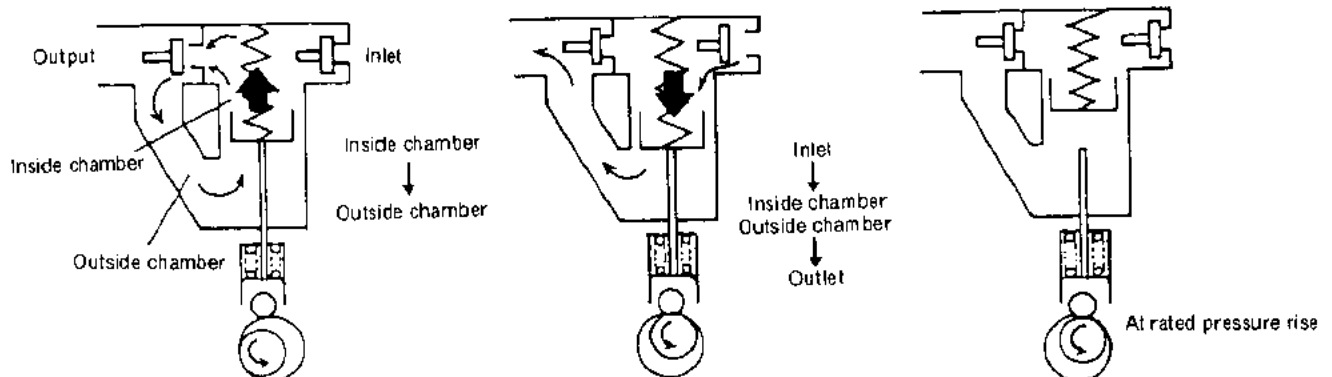
		kg-m
Tightening torque	12.5-13.5	



## 9. Fuel Feed Pump

### Automatic pressure control mechanism

As the delivery pressure of the fuel pump climbs, the pressure at the back of the piston also rises, overcoming the piston spring force, and hindering the lowering of the piston. Thus, the fuel flow automatically stops, and the fuel pressure is maintained within a fixed range.



When the outside chamber pressure overcomes the piston spring force, the piston is pushed up and separated from the push rod.

### 9-1 Fuel Feed Pump Disassembly

Follow the procedure below to disassemble the fuel feed pump.

- (1) Remove the piston spring stopper plug, and pull out the piston and piston spring.
- (2) Remove the snap ring, and pull out the tappet assembly.
- (3) Pull out the inter-spindle.
- (4) Remove the priming pump.
- (5) Remove the discharge valve spring stopper, and remove the valve and spring from inside.
- (6) Remove the O-ring.

**NOTE:** Play in the valve seat hinders the opening and closing of the valve, causing insufficient fuel supply and abnormal wear of the tappets and camshaft.

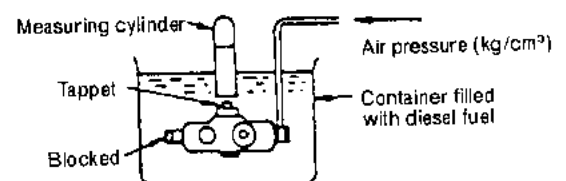
### 9-2 Fuel Feed Pump Inspection

- (1) Block the priming pump with your finger and check whether the pressed-in piston returns by spring force. If the piston returns, the piston does not have enough negative pressure. Always replace the priming pump as a set.
- (2) Check the piston spring for cuts, cracks, uneven wear and rust.
- (3) If the piston, inter-spindle, or tappet assembly are extremely worn, replace the part.
- (4) Check the contact surface of the valve and valve seat for defects.
- (5) When there is play in a valve seat which has been caked into the feed pump body, the whole fuel pump body must be replaced.

### 9-3 Fuel Feed Pump Reassembly

- (1) To reassemble the fuel feed pump, follow the assembly procedure in reverse order.
- (2) When the pump has been reassembled, perform the air-tightness test.

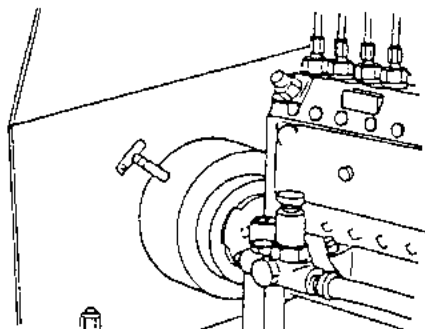
Apply 3 kg/cm<sup>2</sup> of air pressure to the discharge outlet of the pump, and check for air leaks from the O-ring. If air is leaking, replace the O-ring.



## 9-4 Fuel Feed Pump Adjustment

### 9-4.1 Testing procedures for the fuel feed pump

Set the fuel feed pump on the injection pump, and operate the assembled unit on the pump tester.

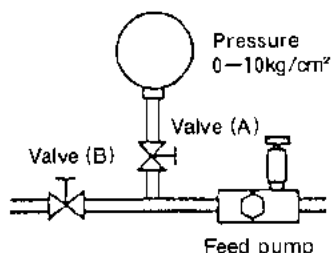
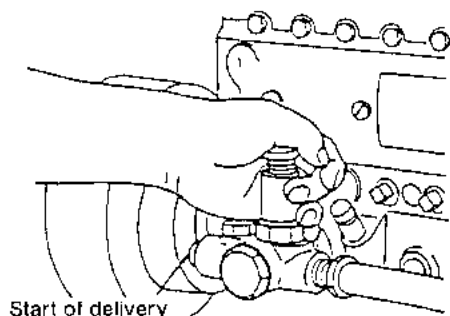


Fuel piping should be provided directly from the tank, not through the delivery pump of the tester.

#### (1) Suction test for the priming pump

Loosen the handle of the priming pump, and push the handle at 60 - 100 strokes/minute. If fuel comes out of the delivery side of the feed pump after about 30 strokes, the priming pump is normal. If it takes longer, replace the priming pump as a set.

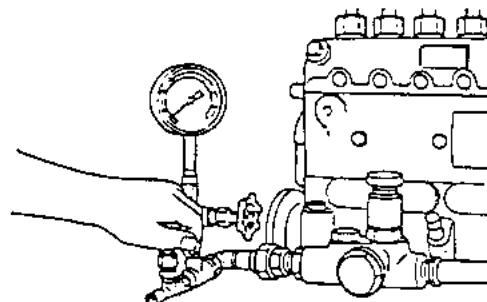
Suction head	1m	Within 30 strokes
Suction pipe dia.	φ 8	



Equipment for feed pump test

#### (2) Max. delivery feed volume test

You will need the special equipment for conducting max. delivery pressure and delivery volume tests.



Max. delivery pressure test

- NOTE: 1. Do not run the equipment for more than 5 minutes since the fuel injection pump may be damaged if operated in noninjection condition.  
2. Operate the injection pump at the specified rpm, and read the pressure gauge indicator when valve B is tightened completely. Tighten valve A so that the pressure gauge indicator does not move when the pressure is applied.

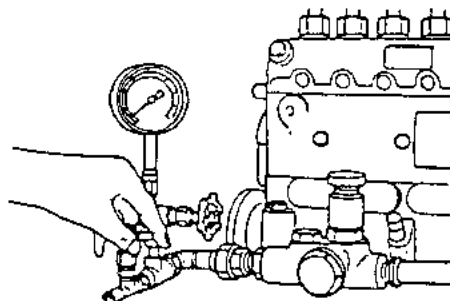
- Volume pressure (kg/cm<sup>2</sup>) : 2.2—3.2
- rpm : 600

Replace the piston spring if it is defective.

#### (3) Delivery test

Operate the fuel injection pump at the specified rpm, open valve (B) until the pressure gauge indicator shows 1 kg/cm<sup>2</sup>, and measure the delivery rate for one minute.

- Volume (ℓ/min.) : over 1.8
- Back pressure (kg/cm<sup>2</sup>) : 1
- rpm : 1000



Delivery test

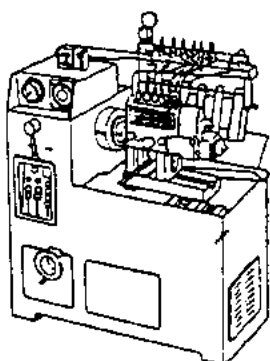
## 10. Adjustment of Fuel Injection Pump and Governor

Adjust the fuel injection pump after completing reassembly. The pump itself must be readjusted with a special pump tester when you have replaced major parts such as the plunger assembly, roller guide assembly, fuel camshaft, etc. Procure a pump tester like the one illustrated below.

### 10-1 Preparations

Prepare for adjustment of fuel injection pump as follows:

- (1) Adjusting nozzle assembly and inspection of injection starting pressure.



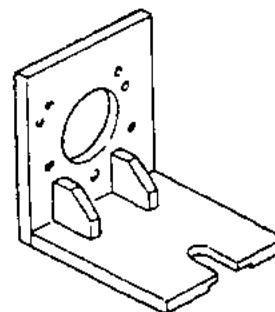
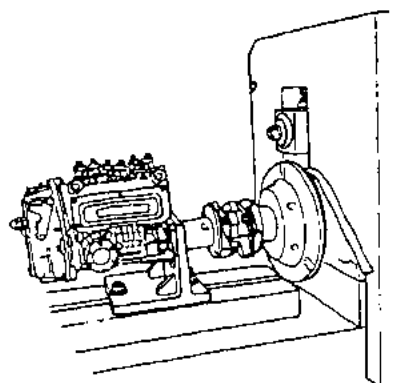
Adjusting nozzle type	See separate service data
Injection starting pressure	

- (2) Adjusting injection pipe.

mm(in.)

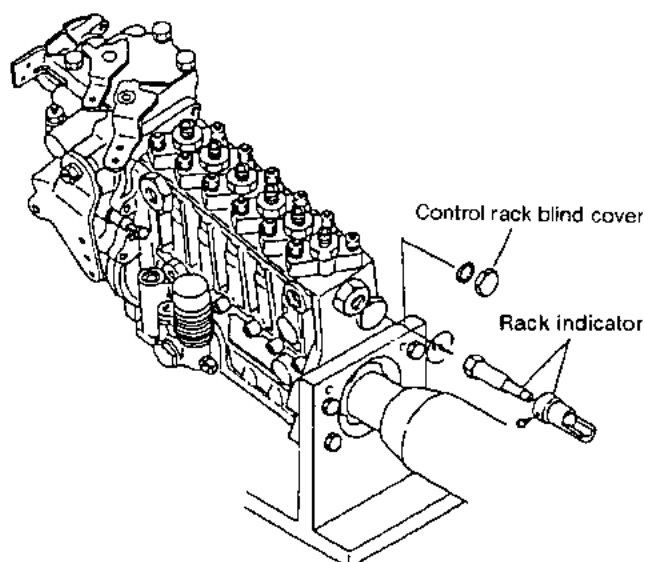
Inner dia./outer dia. × length	See separate service data
Minimum bending radius	

- (3) Mount the fuel injection pump on the pump tester platform.

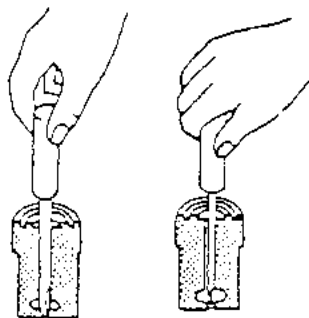


- (4) Remove the control rack blind cover and fit the rack indicator.

Next, turn the pinion from the side of the pump until the control rack is at the maximum drive side position, and set it to the rack indicator scale standard position. Then make sure that the control rack and rack indicator slide smoothly.

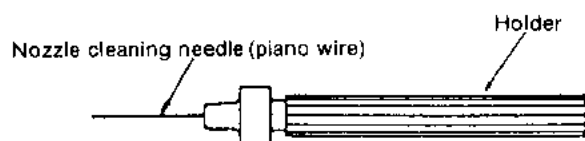


- (5) Clean the nozzle seat with cleaning spray.



- (6) Clean off the carbon on the tip of nozzle with a piece of wood.

- (7) Clean hole type nozzles with a nozzle cleaning needle.



## 10-2 Nozzle inspection

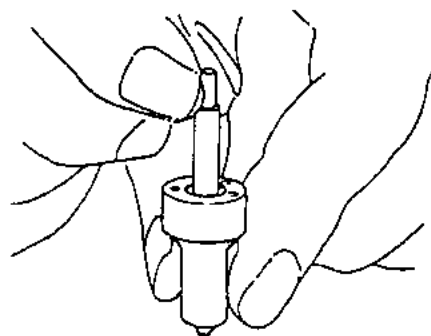
- (1) Inspect for scratches/wear

Inspect oil seals for abnormal scratches or wear and replace the nozzle if the nozzle sliding surface or seat are scratched or abnormally worn.

- (2) Check nozzle sliding

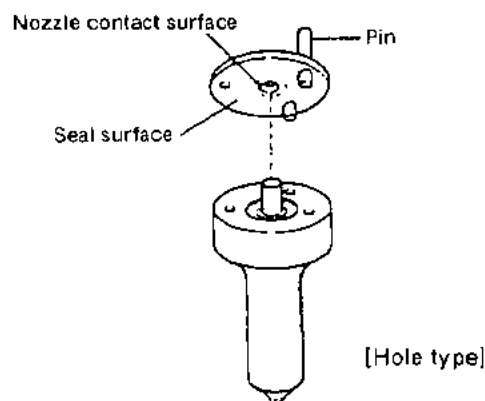
Wash the nozzle and nozzle body in clean diesel oil and make sure that when the nozzle is pulled out about half way from the body, it slides down by itself when released.

Rotate the nozzle a little; replace the nozzle/nozzle body as a set if there are some place where it does not slide smoothly.



- (3) Inspecting stop plate (inter-piece)

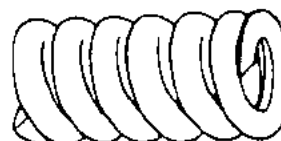
Check for scratches/wear in seals on both ends, check for abnormal wear on the surface where it comes in contact with the nozzle; replace if the stop plate is excessively worn.



mm	
Nozzle contact surface wear limit	0.1

- (4) Inspecting nozzle spring

Replace the nozzle spring if it is extremely bent, or the surface is scratched or rusted.



- (5) Nozzle holder

Check the oil seal surface for scratches/wear; replace if the wear is excessive.

## 10-3 Fuel injection nozzle reassembly

The fuel injection nozzle is reassembled in the opposite order to disassembly.

- Insert the adjusting shims, nozzle spring and nozzle spring seat in the nozzle holder, mount the stop plate with the pin, insert the nozzle body/nozzle set and tighten the nut.
- Use the special holder when tightening the nut for the hole type nozzle as in disassembly.

kg-m (ft-lb)	
Nozzle nut tightening torque	
Hole type nozzle	4 ~4.5

# 11. Fuel Filter

The fuel filter is installed between the fuel feed pump and fuel injection pump, and removes dirt/foreign matter from the fuel pumped from the fuel tank.

The fuel filter element must be changed periodically. The fuel pumped by the fuel feed pump goes around the element, is fed through the pores in the filter and discharged from the center of the cover. Dirt and foreign matter in the fuel are deposited in the element.

## 11-1 Fuel filter specifications

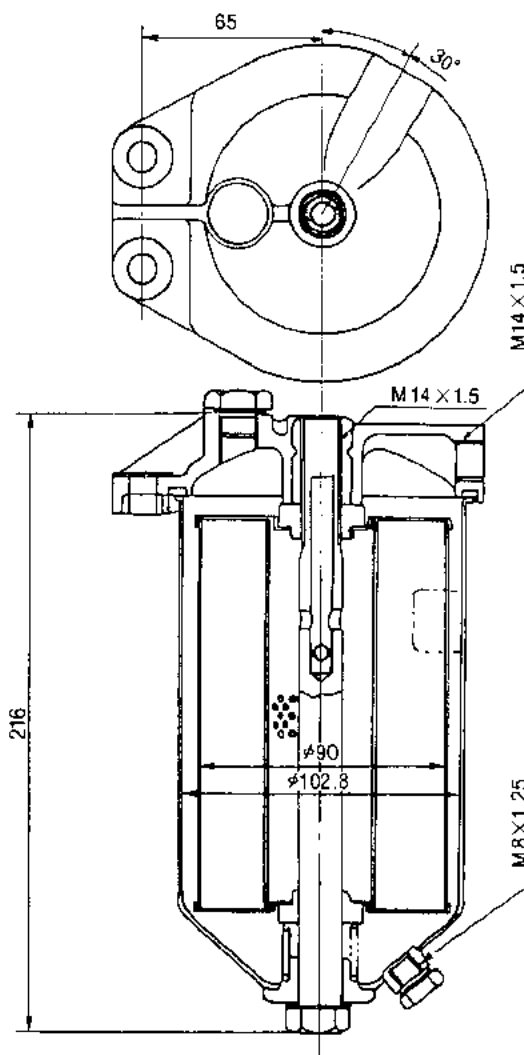
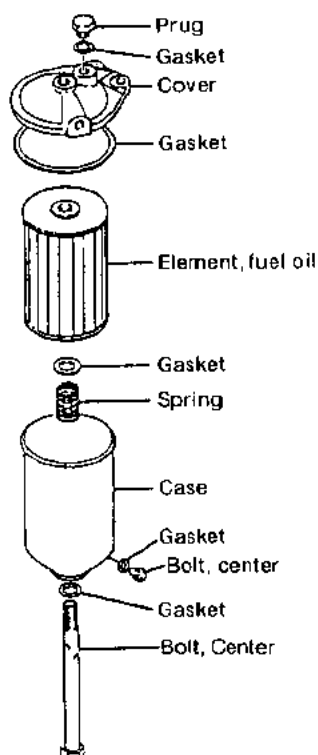
Filtering method	filter paper Element
Filtering area	4,000 cm <sup>2</sup>
Element	Max 45 $\mu$ , Ave. 35 $\mu$

## 11-2 Fuel filter inspection

The fuel strainer must be cleaned occasionally. If there is water or foreign matter in the strainer bowl, disassemble the strainer and wash with clean fuel oil to completely remove foreign matter. Replace the element every 300 hours of operation.

Replace the filter prior to this if the filter is very dirty, deformed or damaged.

Element changes	every 300 hours
-----------------	-----------------



# INTAKE AND EXHAUST SYSTEM

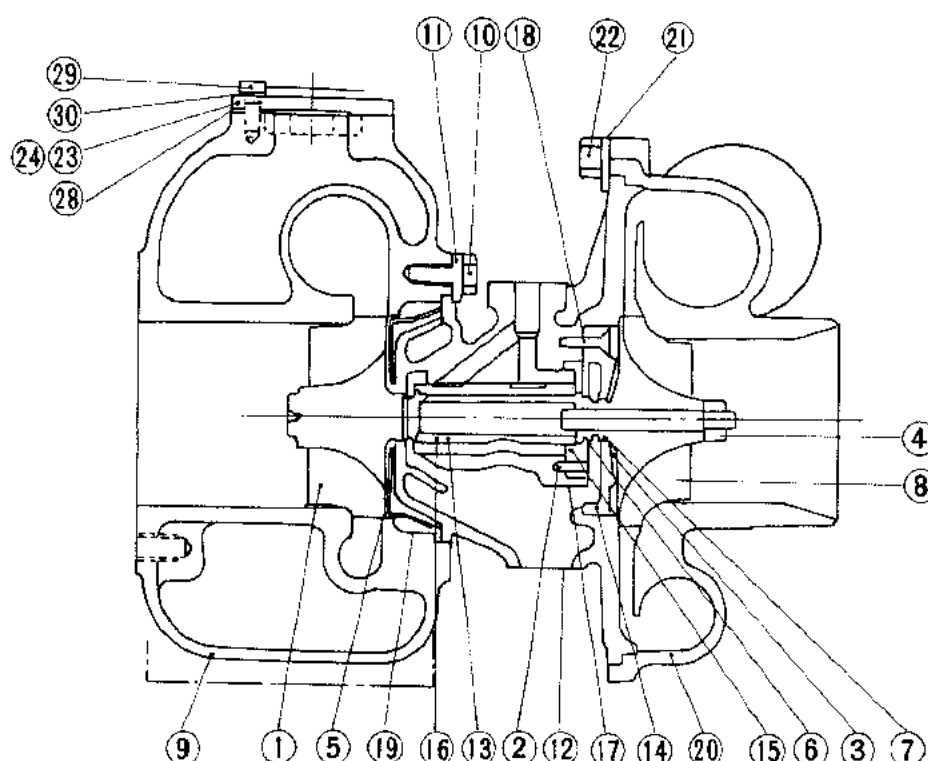
1. Turbocharger.....	4-2
1-1 Specifications .....	4-2
1-2 Construction .....	4-2
1-3 Structure and Function .....	4-3
1-4 Interchangeability of turbocharger components .....	4-3
1-5 Interchangeability of turbochargers .....	4-3
1-6 Service Standards .....	4-4
1-7 Procedures for Periodical Checking .....	4-5
1-8 Disassembly Procedure .....	4-7
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1-10 Reassembly Procedure.....	4-11
1-11 Procedure for After Reassembly .....	4-13
1-12 Troubleshooting .....	4-14

# 1. Turbocharger

## 1-1 Specifications

Turbocharger maker	ISHIKAWAJIMA-HARIMA HEAVY INDUSTRIAL CO.,LTD.(IHI)	
Turbine type	Radial flow	
Blower type	Centrifugal	
Bearing type	Full floating	
Lubrication method	Outer lubrication	
Cooling method	Water cooled	
Turbocharger model	RHC7W	
Applicable engine model	6LYA-UTE	6LYA-STE

## 1-2 Construction



No.	Part Names	No.	Part Names	No.	Part Names
1	Turbine shaft	11	Turbine side pressure plate	21	Blower side pressure plate
2	Thrust bush	12	Bearing housing	22	Flange hexagon bolt (M8)
3	Oil thrower	13	Round R type snap ring	23	Blind lid
4	Shaft-end nut	14	Seal plate	24	Blind lid (for cooling water port)
5	Seal ring (turbine side)	15	Thrust metal	25	Protective hardware
6	Seal ring (blower side, large)	16	Floating metal	26	Bending washer
7	Seal ring (blower side, small)	17	Across head machine screw (M3)	27	Hexagon bolt (M6)
8	Blower impeller	18	Across head machine screw (M4)	28	Packing
9	Turbine housing	19	Radiation shield	29	Hexagon bolt (M8)
10	Hexagon bolt (M8)	20	Blower housing	30	Spring washer

### 1-3 Structure and Function

#### 1-3.1 Outline for Structure and Function

##### (1) Turbine

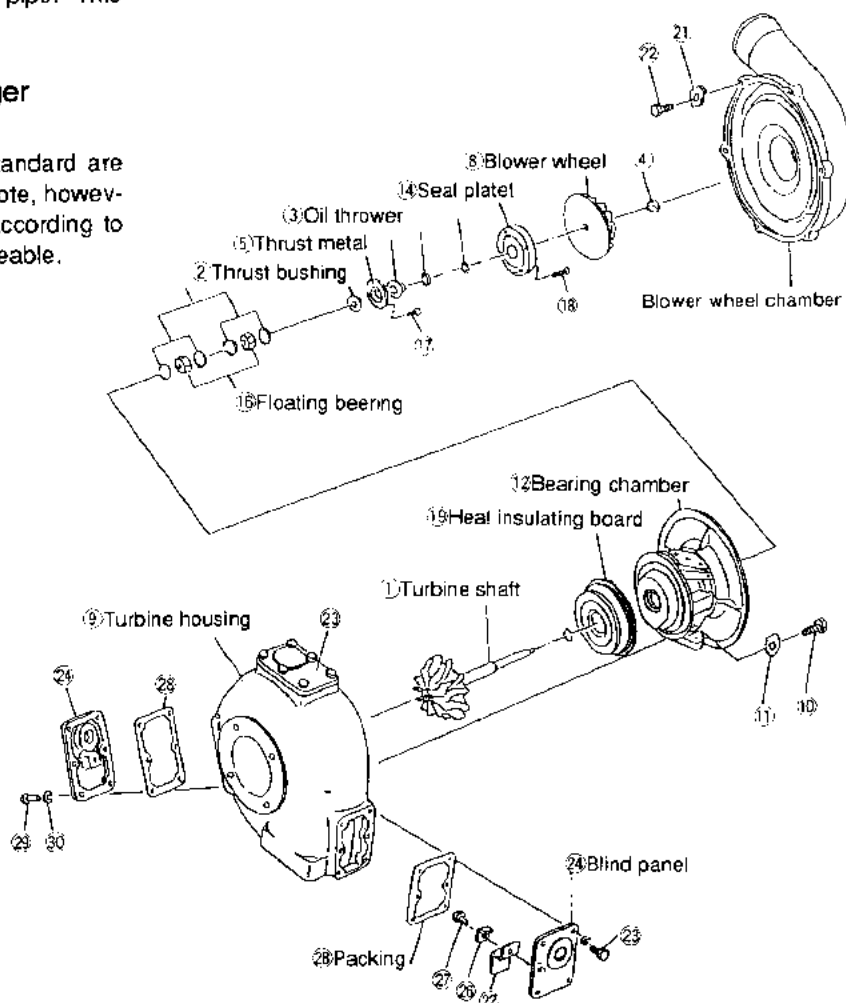
The exhaust gas coming from the engine passes through the turbine nozzle where it accelerates and hits the turbine blades giving the power to turn the turbine shaft. This is the turbine. A seal ring and a heat protection plate are attached to protect the bearing from negative effects of the gas.

##### (2) Blower

The blower impeller, which is attached to the turbine shaft, sucks up the air from the turbine rotation, compresses it, and sends it through the suction pipe. This is the blower.

#### 1-4 Interchangeability of turbocharger components

The inspection procedures and adjustment standard are identical for all turbocharger models. Please note, however, that the asterisked (\*) components differ according to the turbocharger model and are not interchangeable.



##### (3) Bearing

###### (1) Thrust bearing

The turbine shaft is subjected to continuous thrust, and is made to remain stationary under it.

###### (2) Radial bearing

A floating type bearing is used. Unlike the stationary type bearing usually used, there is an oil film on both the inner and outer surfaces of the bearing and dragging occurs. Because of this the slippage speed of the bearing is lower than the rotation speed of the turbine shaft which results in greater stability.

#### 1-5 Interchangeability of turbochargers

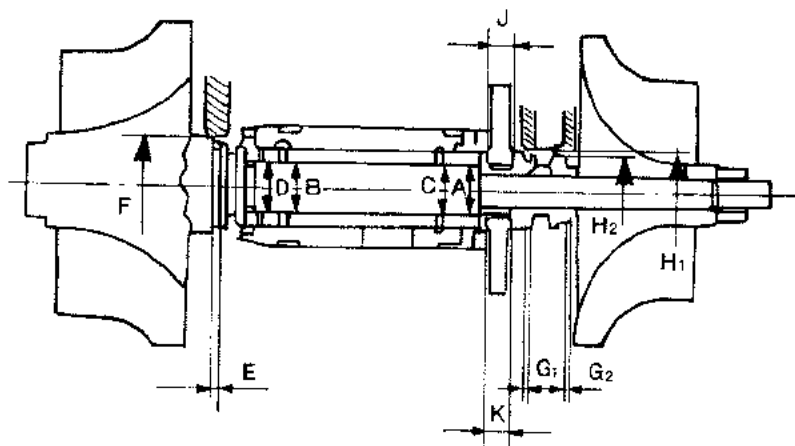
The IHI-make turbocharger used for the 6LYA-UTE and 6LYA-STE series differ according to the engine model. Care should therefore be taken to assemble only components for the turbocharger used in your engine when replacing parts. The use of incorrect turbocharger components will detract from the performance of the engine. Turbocharger models can be distinguished by their name plates.

Turbocharger model name plate		Specification
SPEC		Turbocharger model name
SERIAL No. RHC7		"IHI" serial No.
PARTS No.		YANMAR part No.



## 1-6 Service Standards

## 1-6.1 Service Standards



(mm)

Check Point		Limit	Remarks
Turbine shaft	Turbine shaft journal outside diameter (A)	12.28	
	Turbine side seal ring groove width (E)	1.63	
	Blower side seal ring groove width (G1)	1.75	
	Blower side seal ring groove width (G2)	1.52	
	Runout of turbine shaft	0.011	
Bearing	Floating metal inside diameter (C)	12.36	
	Floating metal outside diameter (D)	16.98	
	Inside diameter of bearing fitting ring (B)	17.11	
Thrust bearing	Thrust metal width (J)	4.48	
	Thrust bush groove clearance (K)	4.68	
Seal ring insertion	Turbine side (Bearing housing) (F)	18.55	
	Blower side (seal plate) (H1)	16.05	
	Blower side (seal plate) (H2)	14.05	
Axial play of rotor		0.11	Service standard 0.06~0.09
Cross play of rotor		0.215	Service standard 0.11~0.18

## 1-6.2 Tightening Torque

Item	Tightening Torque (kg-cm)	Remarks
Turbine housing fitting bolt (M8)	285 $\pm$ 10	
Blower housing fitting bolt (M8)	230 $\pm$ 10	
Thrust metal fitting screw (M3)	13 $\pm$ 1	
Seal plate fitting screw (M4)	38 $\pm$ 3	
Blower impeller fitting nut (M8)	80 $\pm$ 5	Left-hand thread
Protective hardware fitting bolt (M6)	40 $\pm$ 5	

## 1-7 Procedures for Periodical Checking

## 1-7.1 Schedule

Periodically check the overall condition and cleanness of the turbocharger.

The frequency of checks depends upon the conditions of use. Consult the table below.

Item	Schedule		
	Every 6 months or 1,500hr	Every 12 months or 3,000hr	Every 24 months or 6,000hr
Check of rotor rotation	○		
Check of rotor play		○	
Overhaul, cleaning and check			○
Check and cleaning of air filter	Refer to engine operation manual		
Check and cleaning of oil filter			
Change of engine oil			

## 1-7.2 Checking procedures

## (1) Check of rotor rotation

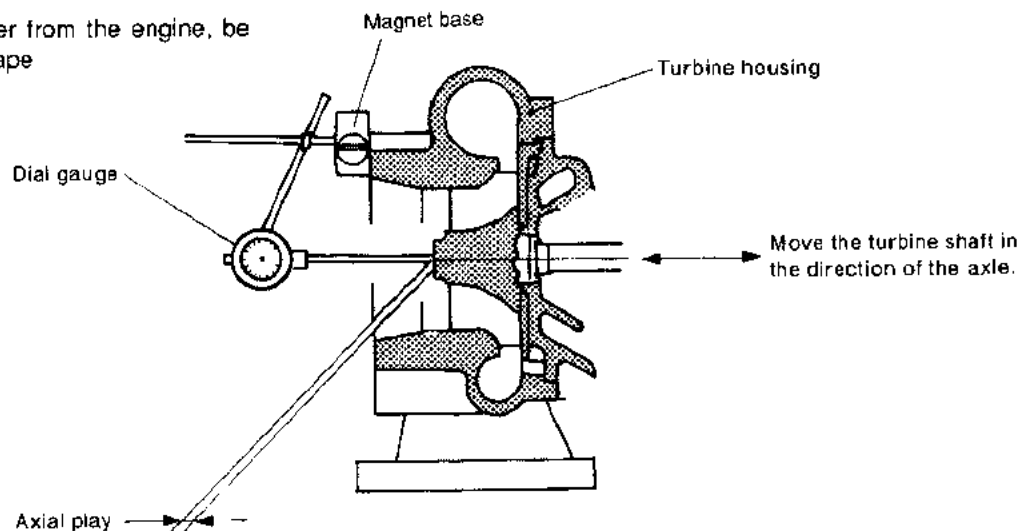
Listen for abnormal sounds during rotation. Place a sound bar to the case of the turbocharger and gradually increase the speed of rotation while listening. A high pitched sound emitted continuously for 2~3 seconds is abnormal. In this instance a problem with the metal and rotor is indicated, and the turbocharger should be replaced or disassembled and repaired.

## [2] Check of rotor play

Remove the turbocharger from the engine and check the axial play and cross play in accordance with the following procedures.

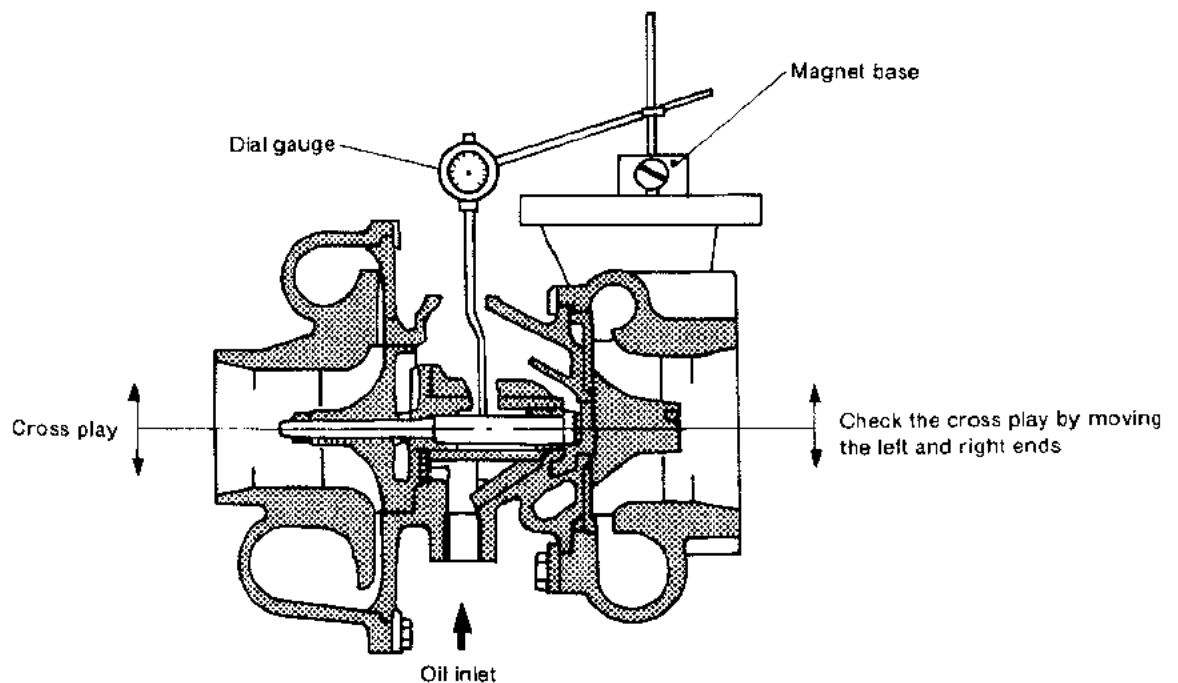
When removing the turbocharger from the engine, be sure to seal off the oil inlet with tape

## (1) Axial play of rotor



Service standard : 0.06~0.09mm/m  
Limit: 0.11mm/m

## (2) Cross play of rotor

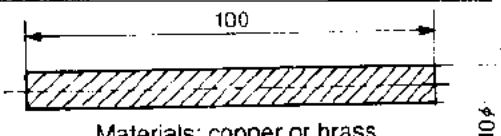
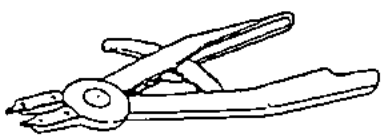

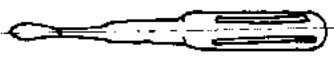
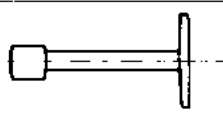
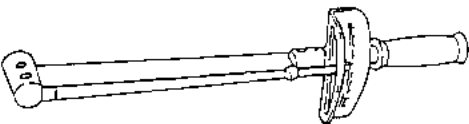
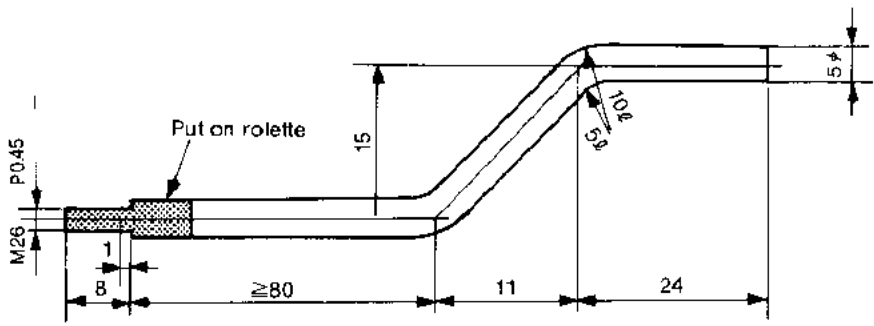


Service standard : 0.11~0.18mm/m  
Limit: 0.215mm/m

## 1-8 Disassembly Procedure

### 1-8.1 Preparation for Disassembly

In addition to the all-purpose tools necessary for the assembly and disassembly of the turbocharger, some specialized tools shown below are needed.

Name of Tool	Use	Remarks
Bar	Used for removing thrust metal and thrust bush	 <p>Materials: copper or brass</p>
Pliers	Used for attachment and removal of the round R type snap ring of floating metal	
Pliers	Used for attachment and removal of seal ring	
Torque driver for torque bolts (+) (5kgcm~50kgcm)	Used for attachment and removal of thrust metal and seal plate	<p>Local supply</p>  <p>(26LTDH or comparable type)</p>
Box wrench	Used to set turbine shaft	 <p>Box alone is also fine.</p>
Torque wrench (Single use)	Used for tightening nuts M8 (13mm→285kg/cm <sup>2</sup> ) M8 (13mm→230kg/cm <sup>2</sup> ) M8 (13mm→80kg/cm <sup>2</sup> ) M6 (10mm→40kg/cm <sup>2</sup> )	
Measurement needle	Used to measure axial play and cross play.	<p>Attach to dial gauge.</p> 

**1-8.2 Check for Disassembly**

- (1) Check to see if the blower impeller is touching the turbine housing and if it is running smoothly.
- (2) Measure the rotor play Refer to 3-2) checking procedure.
  - (1) Axial play of rotor  
Limit 0.11 mm
  - (2) Cross play of rotor  
Limit 0.215 mm

**1-8.3 Disassembly**

The angle of attachment for the turbine housing, bearing housing, and blower housing is fixed and marks should be made before removing the turbocharger from the engine to insure accurate reassembly.

**[1] Removal of blower housing**

- (1) Remove M8 mounting bolt (22) and blower side pressure plate (21).
- (2) Remove blower housing (20).

*Note-1 ) Liquid gasket has been applied to the mounting-surface of the blower housing (20) and bearing housing (12).*

*Note-2) Be careful not to scratch or damage blower impeller when removing the blower housing.*

**[2] Removal of blower impeller**

- (1) Use box spanner (14mm) to remove turbine shaft (1) and shaft-end nut (4).

*Note: The shaft-end nut tightens when screwed to the left.  
Be careful to turn it in the correct direction when removing.*

- (2) Remove blower impeller (8).

**[3] Removal of turbine housing**

- (1) Remove hexagon bolt (10) and turbine side pressure plate (11).
- (2) Remove turbine housing (8).

**[4] Removal of turbine shaft**

- (1) Press down lightly with your hand on the radiation shield (19) and pull out turbine shaft (1).

*Note: When there is difficulty removing the shaft tap lightly with a wooden hammer on the blower side shaft end.*

- (2) Remove the radiation shield (19).

**[5] Removal of seal plate**

- (1) Loosen the across head machine screw (M4) (18) with the torque driver.
- (2) Remove seal plate (14). Pry out the M6 bolts with a screwdriver.

*Note: Liquid gasket has been applied to the seal plate and the bearing housing.*

- (3) Remove the oil thrower (3) from the seal plate.

**[6] Removal of thrust metal and thrust bush**

- (1) Loosen the across head machine screw (M3) (17) with the torque driver.
- (2) Use the bar to remove the thrust metal (15) and thrust bush (2).

**[7] Removal of floating metal**

- (1) Remove the round R type snap ring (13) from the bearing housing (12) with the stop ring pliers.
- (2) Remove floating metal (16) from the bearing housing (12).

**[8] Removal of seal ring**

- (1) Remove seal ring (turbine side) (5) from turbine shaft (1).
- (2) Remove the seal ring (blower side, large) (6) and the seal ring (blower side, small) (7) from the oil thrower (3).

## 1-9 Cleaning and Checking Procedure

### 1-9.1 Cleaning

#### (1) Check before cleaning

Before cleaning check the disassembled parts for seizure, wear, foreign matter, and degree of carbon deposit. Particularly where there is damage check the area carefully and determine the cause.

#### <Checking Procedure>

Item to check	Part
Carbon deposit	1) Turbine shaft ①, seal ring part (turbine side), and blade back. 2) Bearing housing ⑫, radiation shield ⑬ inner wall of bearing housing
Lubrication	1) Turbine shaft ①, Journal and thrust bush (wear, seizure, ②, Oil thrower ③ abnormal color) 2) Floating metal ⑭ and thrust metal ⑮ 3) Bearing housing ⑫ support ring
Oil leakage	1) Turbine housing ⑨ inner wall 2) Bearing housing ⑫ outer circumference and radiation shield ⑬ attachment part 3) Turbine shaft ①, Turbine side seal ring and blade back 4) Blower housing ⑯ inner wall 5) Blower impeller ⑧ back 6) Seal plate ⑭ surface and seal ring insertion

#### (2) Cleaning procedure

Be sure to observe the following when cleaning

Item	Cleaning materials
(1) Turbine shaft	1. Necessary tools (1) Bucket (500×500) (2) Heat source Use steam or gas burner. (3) Brush 2. Cleaning agent Use a commercially available carbon remover.
(2) Turbine housing	1. Necessary tools Same as for turbine shaft 2. Cleaning agent Same as for turbine shaft
(3) Blower impeller and Blower housing	1. Necessary tools (1) Bucket (500×500) (2) Brush 2. Cleaning agent
(4) Miscellaneous	(1) Clean all other parts with diesel oil. (2) Use pressurized air to clean the lube oil passage.

## 1-9.2 Checking Procedure

### [1] Blower housing ②

Check the housing and attachment points for scratches and cracks which may have been caused by a blow to the housing or by contact with the impeller. Replace if damaged.

### [2] Turbine housing ⑨

Check for scratches and cracks which may have been caused by a blow to the housing or by contact with the turbine blades. Check also for oxidation or deterioration of the casting or misshaping due to heat.

### [3] Blower impeller ⑧

Check for scratches, nicks, corrosion, or bending. Replace if damaged.

### [4] Turbine shaft ①

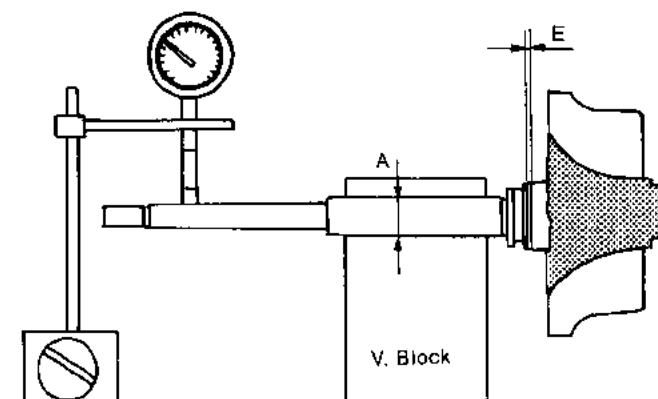
- (1) Check the turbine blades for scratches, nicks, heat discoloration, or bending. Check to see if the shaft is bent or if there is heat discoloration or wear of the journal, and check for scratches or wear of the seal ring groove. Replace if damaged.
- (2) Measure the outside diameter (A) of the turbine shaft journal and the width (E) of the seal ring groove, and replace if in excess of limit measurement.

Journal outside diameter (A)

Limit 12.28 mm

Seal ring groove width (E)

Limit 1.63 mm



- (3) Check for deflection of turbine shaft and replace if greater than 0.011mm.

### [5] Radiation shield ⑩

Check for scratches, heat discoloration, and wear. Replace if damaged.

### [6] Thrust bush ②, oil thrower ③, and thrust metal ⑬

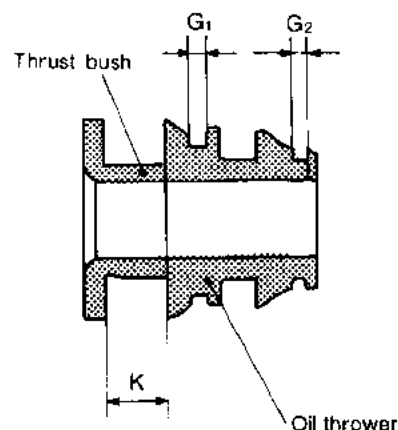
Check for scratches, wear, and discoloration. Replace damaged parts even if within the specified time limit.

#### (1) Thrust bush

Measure the clearance (K) of the thrust bush groove.

Replace if it exceeds the limit.

Limit 4.68 mm



#### (2) Oil thrower

Measure the widths (G1)(G2) of the seal ring groove.

Replace if it exceeds the limit.

Limit G1 1.75 mm G2 1.52 mm

#### (3) Thrust metal

Measure the thrust metal range (J) and replace if in excess of limit.

Limit 4.48 mm

### [7] Floating metal ⑬

- (1) Check for wear, discoloration, and scratches. Replace if damaged.
- (2) Measure the inside diameter (C) and outside (D) of the floating metal. Replace if in excess of limit.

Limit Outside dia.(D):16.98mm  
Inside dia.(C):12.36mm

### [8] Bearing housing ⑫

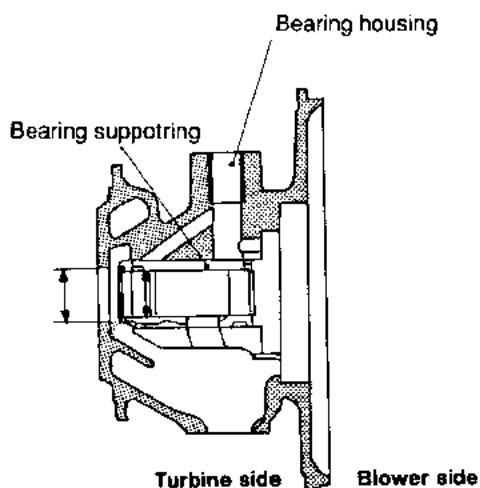
- (1) Check for scratches or cracks and oxidation or deterioration of the casting.
- (2) Check the round R ⑬ type snap ring and replace if cracked or broken.
- (3) Measure (B) and (F) shown in diagram of the bearing housing. Replace if in excess of limit.

• Bearing housing inside dia.(B)

Limit 17.11 mm

• Turbine side seal ring insertion (F)

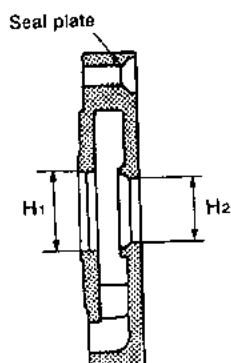
Limit 18.55 mm



#### [9] Seal plate ⑭

- (1) Check the seal plate and points of attachment for scratches and cracks. Replace if damaged.
- (2) Measure the seal ring insertion on the blower side (H1) (H2) and replace if in excess of limit.

Limit H1 16.05 mm, H2 14.05 mm



- (10) Check the seal rings ⑤, ⑥, and ⑦ for wear and bending.

Replace if damaged.

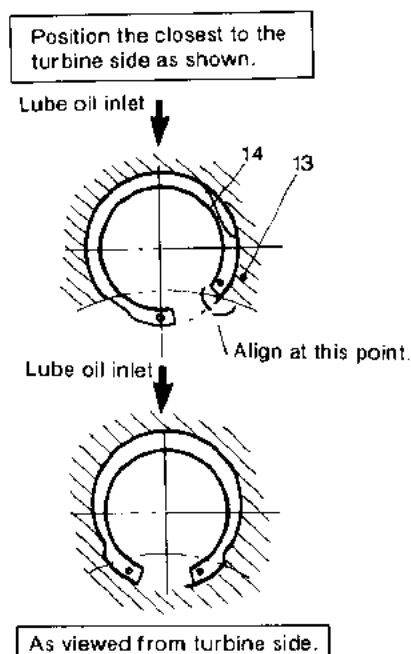
- (11) Replace across head machine screw (M3) ⑰ and across head machine screw (M4) ⑱.

## 1-10 Reassembly Procedure

### 1-10.1 Preparation for Reassembly

- (1) Have ready all-purpose tools, specialized tools, liquid gasket (Three bond No.1215) and lock tight No.242.
- (2) Be sure to replace the following parts with new ones at the time of reassembly.

- seal ring (Turbine side) : 1 pcs
- seal ring (Blower side) : 2 pcs
- screw (M3) : 4 pcs
- screw (M4) : 4 pcs



### 1-10.2 Reassembly

- (1) Assemble floating metal

- (1) Use snap ring pliers to attach the inside round R type snap ring ⑬ to bearing housing ⑫.
- (2) Put floating metal ⑯ into bearing housing ⑫.
- (3) Use snap ring pliers to attach the outside round R type snap ring ⑭ to bearing housing ⑬.

*Note 1) Refer to the diagram at the above right for placement of round R type snap ring.*

Place the snap ring with the rounded surface on the metal side.

*Note 2) Coat the floating metal with engine oil before assembling.*



## [2] Assemble turbine shaft

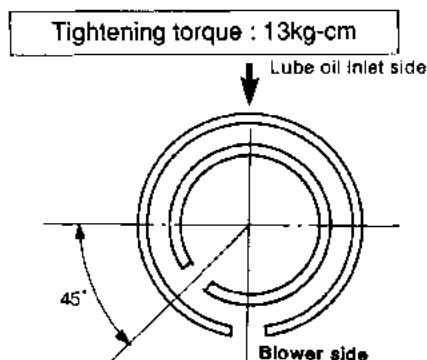
- (1) Insert seal ring ⑤ in turbine shaft ①.
- (2) Attach the radiation shield ② to the bearing housing ⑫.
- (3) Coat the journal of the turbine shaft with engine oil and insert it into the bearing housing from the turbine side.

**Note:** Be careful not to scratch the floating metal with the turbine shaft.

Adjust the gap of the seal ring to the oil side, align the center of the shaft with the center of the ring and insert.

## [3] Fit thrust metal

- (1) Insert thrust bush ② into the turbine shaft ①.
- (2) Coat the thrust metal ⑮ with engine oil and attach to bearing housing ⑫.
- (3) Apply lock tight to the across head machine screw (M3) ⑰ use the torque driver to screw into the thrust metal.



## [4] Fit seal plate

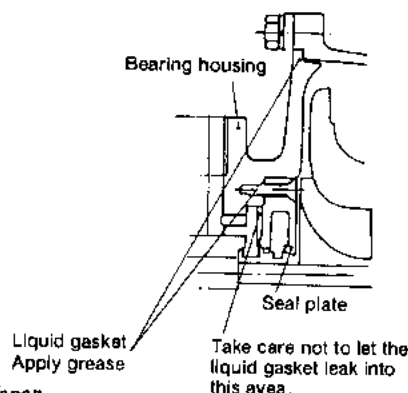
- (1) Insert seal ring into oil thrower ③.
- (2) Insert oil thrower ③ into seal plate ⑭.

**Note:** Adjust the gap in the seal ring to match the diagram.

- (3) Coat the flange surface of the seal plate ⑭ on the turbine side with liquid gasket (Three bond No.1215).

**Note:** Refer to the diagram at the right for the places to grease.

(Thickness of coat: 0.1~0.2mm)



- (4) Attach the seal plate ⑭ to the bearing housing ⑫.
- (5) Coat the across head machine screw (M4) ⑱ with lock tight and attach to the seal plate using the torque driver.

Tightening torque: 38±3kg-cm

## [5] Fit blower housing

- (1) Insert the blower impeller ⑧ into the turbine shaft ①.
- (2) Use the box spanner (14mm) to screw the shaft-end nut ④ into the end of the turbine shaft ① on the turbine side.

**Note:** Be careful to turn to the left to tighten.

Tightening torque: 80±5kg-cm

## [6] Fit turbine housing

- (1) Assemble the turbine housing ⑨ and the bearing housing ⑫ aligning the guide marks made before disassembly.

**Note:** When assembling newly replaced parts, align by checking the position of the oil inlet and outlet and the exhaust gas inlet.

- (2) Attach the turbine side pressure plate ⑪ and tighten the hexagon bolt (M8) ⑩.

Tightening torque: 285±5kg-cm

## [7] Fit blower housing

- (1) Coat the flange surface of the bearing housing ⑫ on the blower side with liquid gasket (Three Bond No.1215).

**Note:** Refer to concerned page for the spot to grease.

Thickness of coat: 0.1~0.2mm

- (2) Assemble the seal plate ⑭ and the blower housing ⑬ aligning the guide marks made at the time of disassembly.

**Note:** When assembling newly replaced parts, align by checking the position of the oil inlet and outlet and the air outlet.

- (3) Attach the blower side pressure plate ⑯ and tighten the hexagon bolt (M8) ⑲.

Tightening torque: 230 10kg-cm

## [8] Measure rotor play

Refer to 1-7.2) for measuring procedure.

When rotor play does not comply with the standards, either the assembly is incorrect or a mismatched part has been used. Disassemble and begin again.

- (1) Service standard for axial play of rotor:

0.06~0.09mm

- (2) Service standard for cross play of rotor:

0.11~0.18mm

### 1-11 Procedure for After Reassembly

Be sure to observe the following points at the time turbocharger is hooked up the engine and thereafter.

Be especially careful to avoid getting dust, dirt or other foreign matter inside the turbocharger.

#### (1) Hooking up the turbocharger

##### 〈Lube Oil System〉

- (1) At the time the turbocharger is attached to the engine, add new oil at the oil inlet. Turn the turbine shaft by hand making sure that the journal metal and the thrust metal are lubricated.
- (2) Clean dust, dirt, or other foreign matter out of the oil inlet and outlet pipes from the engine and check for damage.
- (3) Securely attach the oil pipe making sure there is no leakage at the connection.

##### 〈Intake System〉

- (1) Check for dust, dirt, or other foreign matter inside the intake system.
- (2) Check for air leakage at the connection of the intake duct and the air cleaner.

##### 〈Exhaust System〉

- (1) Check for dust, dirt, or other foreign matter inside the exhaust system.
- (2) The bolts and nuts used are heat-resistant copper ones.  
Other all-purpose bolt and nuts should not be used.  
Apply seizure retardant to all nuts and bolts.  
(Use heat-resistant copper hexagon bolts for the turbine housing.)
- (3) Securely attach the exhaust pipe making sure there is no gas leakage at the connection.

## 1-12 Troubleshooting

When there is trouble with the turbocharger, it cannot perform with maximum efficiency, and the engine output will be reduced. When engine performance is poor, first check all of the engine parts to determine if there is a problem on the engine side. Next, check the turbocharger in accordance with the following table.

## [1] Exhaust color is black

## &lt;Insufficient quantity of air intake&gt;

Cause	Countermeasure
1) Clogged air cleaner element. 2) Air inlet is blocked. 3) Leakage in intake system.	<ul style="list-style-type: none"> <li>• Clean or replace element.</li> <li>• Correct the condition.</li> <li>• Check and repair.</li> </ul>

## &lt;Turbocharger is not turning&gt;

Cause	Countermeasure
1) Dirty oil has collected on the seal on the turbine side reducing the movement of the turbine shaft. 2) Metal seizure <ul style="list-style-type: none"> <li>• Insufficient oil or supply pipe is clogged.</li> <li>• Oil temperature is too high.</li> <li>• Imbalanced revolution.</li> <li>• Insufficient warmup or abrupt stop (no load) from operation at load.</li> </ul> 3) Contact or damage to turbine blades or blower impeller. <ul style="list-style-type: none"> <li>• Revolving too quickly.</li> <li>• Exhaust temperature is too high.</li> <li>• Presence of foreign matter.</li> <li>• Worn metal.</li> <li>• Inaccurate assembly.</li> </ul>	<ul style="list-style-type: none"> <li>• Change the engine oil, and disassemble and clean the turbocharger.</li> <li>• Disassemble turbocharger and repair.</li> <li>• Check the engine oil system and repair any damaged parts.</li> <li>• Change engine oil.</li> <li>• Replace revolving parts or clean.</li> <li>• Review and follow precautions for operation in the operation manual.</li> <li>• Check and adjust engine parts.</li> <li>• Remove any foreign matter and check and repair air cleaner and engine parts.</li> <li>• Disassemble and repair turbocharger. Reassemble.</li> </ul>

## &lt;Consequences of exhaust resistance&gt;

Cause	Countermeasure
1) Exhaust leaks before entering turbocharger resulting in inadequate revolution. 2) The exhaust pipe is bent or blocked resulting in inadequate revolution.	<ul style="list-style-type: none"> <li>• Check attachment and correct.</li> <li>• Correct.</li> </ul>

## [2] Exhaust color is white

Cause	Countermeasure
1) The oil return pipe is clogged or the pipe is bent causing the oil to flow into the blower side or the turbine side. 2) Seal ring has become worn or damaged due to worn metal.	<ul style="list-style-type: none"> <li>• Repair or replace.</li> <li>• Disassemble and repair turbocharger.</li> </ul>

## [3] Oil supply drops suddenly

Cause	Countermeasure
1) Seal ring has become worn or damaged due to worn metal.	<ul style="list-style-type: none"> <li>• Disassemble and repair turbocharger.</li> </ul>

## [4] Insufficient output

Cause	Countermeasure
1) Exhaust leaks before entering turbocharger resulting in inadequate revolution. 2) The exhaust pipe is bent or blocked resulting in inadequate revolution.	<ul style="list-style-type: none"> <li>• Check attachment and correct.</li> <li>• Correct.</li> </ul>

# LUBRICATION SYSTEM

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## 1. Lubrication System

The lube oil in the oil pan is pumped up through the intake filter and intake piping by the lube oil pump, through the holes in the cylinder body and on to the discharge filter.

The lube oil which flows from the holes in the cylinder body through the bracket to the oil element is filtered and sent to the oil cooler. It returns from the oil cooler to the bracket, the pressure is regulated, and it is fed back to main gallery in the cylinder body.

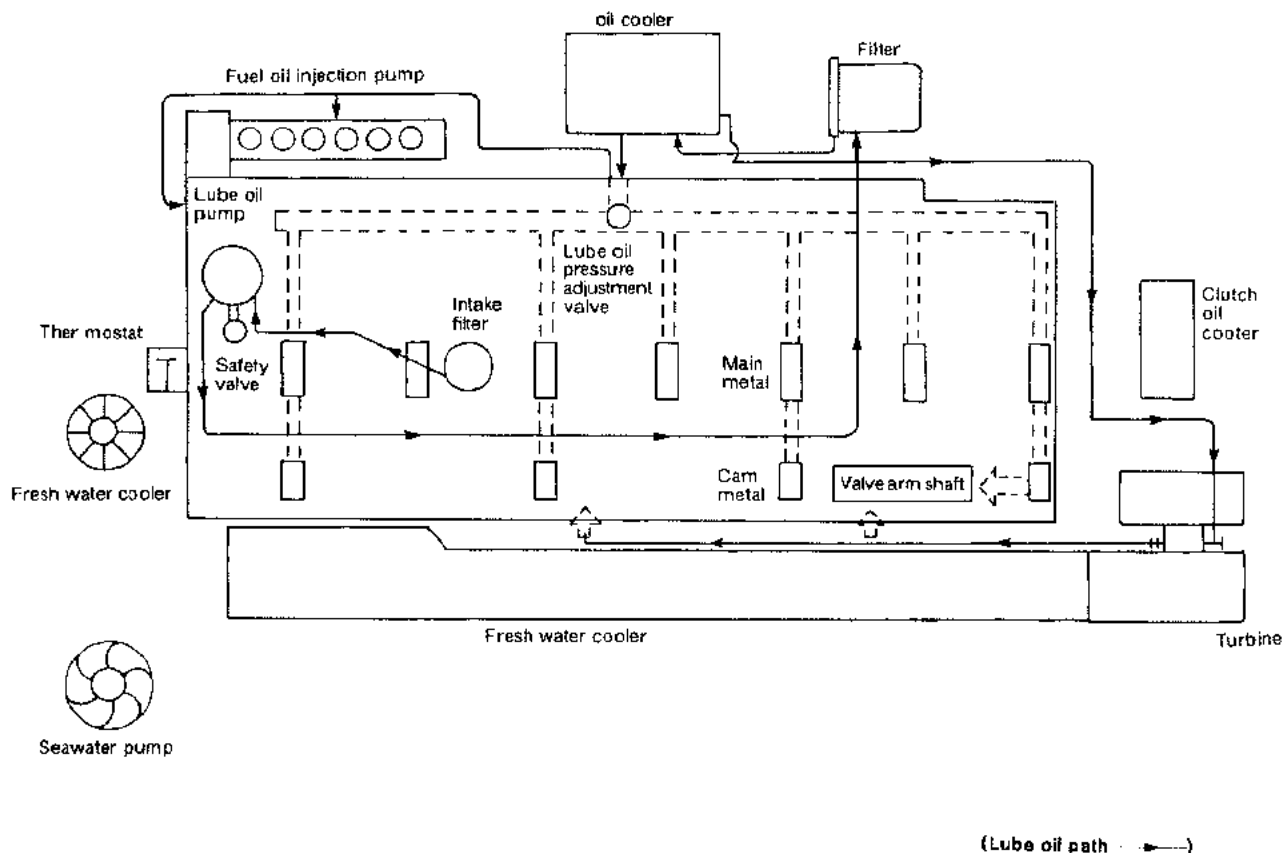
The lube oil which flows in the main gallery goes to the crankshaft journal, lubricates the crank pin from the crankshaft journal, and a portion of the oil is fed to the camshaft bearings.

Lube oil is sent from the gear case camshaft bearings through the holes in the cylinder body and cylinder head to the valve arm shaft to lubricate the valve arm and valves.

Lube oil is also sent from the main gallery to the piston cooling nozzle to cool the piston surface, and is sent through the intermediate gear bearings and respective gears.

Lube oil for the fuel injection pump is sent by pipe from the main gallery to the fuel injection pump.

Part of the lube oil is sent from the oil cooler discharge to the supercharger in engines fitted with one, and is then piped back from the supercharger to the oil pan.



## 2. Lube Oil Pump

### 2-1 Lube oil pump construction

The gear type lube oil pump is mounted on the gear case side engine plate, and the pump is driven by the crankshaft gear.

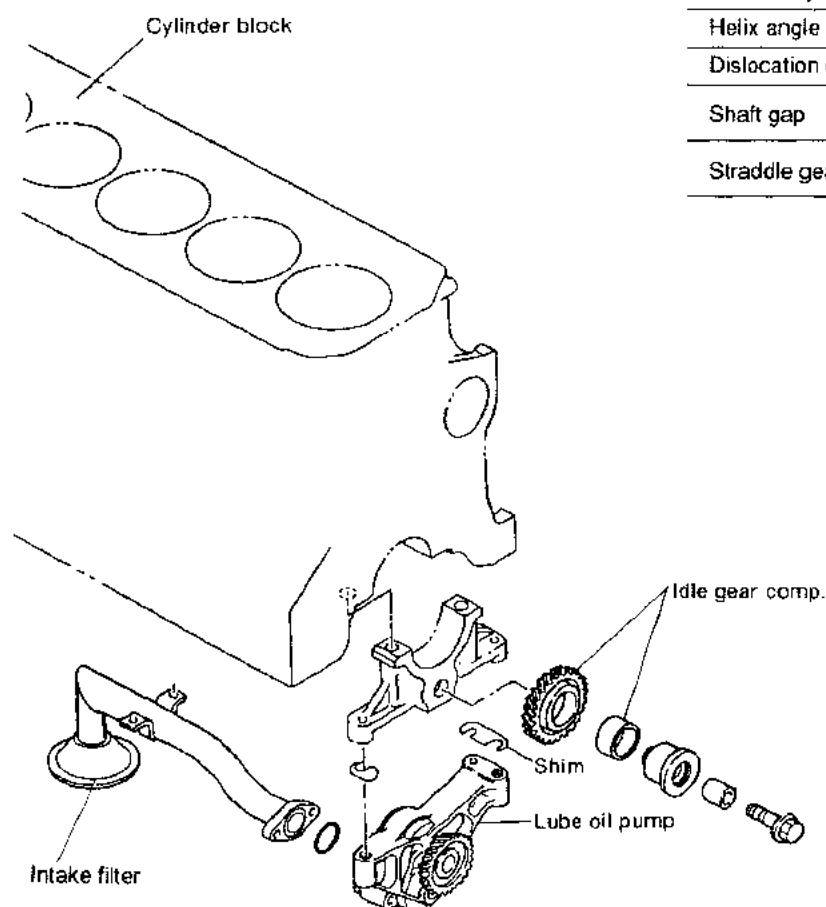
The lube oil flows from the intake filter mounted on the bottom of the cylinder body through the holes in the cylinder body and engine plate, and out from the holes in the engine plate and cylinder body to the discharge filter.

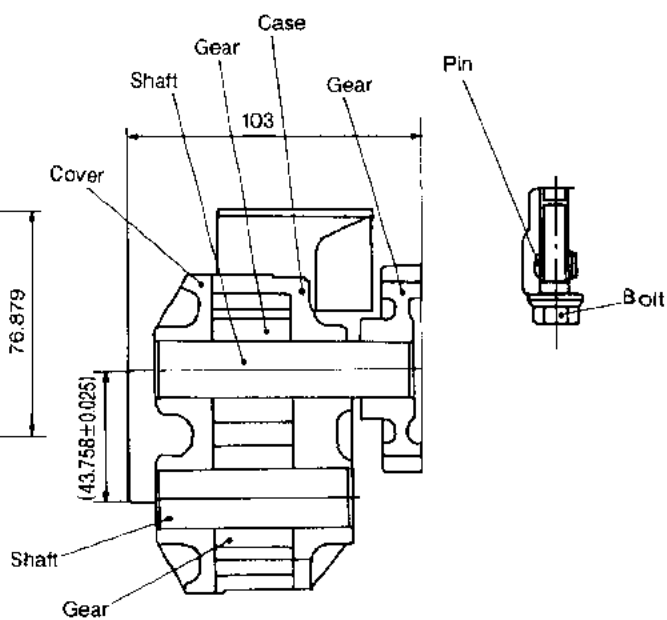
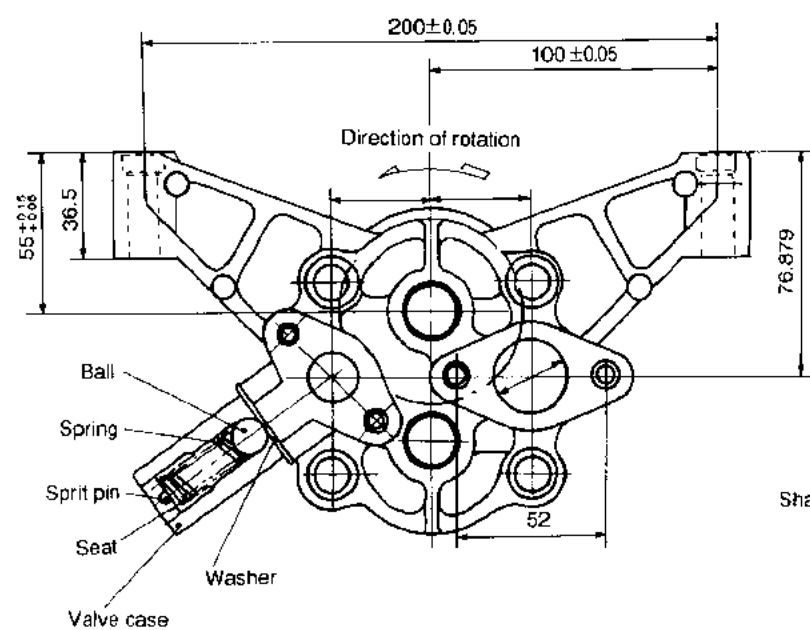
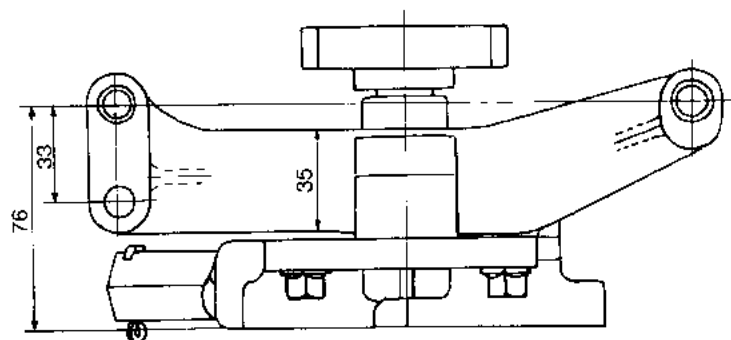
The lube oil pump is fitted with a pressure regulating valve which maintains the discharge pressure at 3kg/cm<sup>2</sup>.

### 2-2 Specifications of lube oil pump

Pump efficiency test	
Theoretical delivery	32.8 cc/rev
Delivery	94.5 l/min or more
Delivery pressure	8 kg/cm <sup>2</sup>
Pump speed	3200 rpm

Specification of head gear	
Module	2.5
Angle of pressure	20°
Number of teeth	24
Standard pitch dia.	66.203 mm
Helix angle & direction	25°left
Dislocation coefficient	0.028
Shaft gap	73.363 <sup>+0.048</sup> <sub>0</sub> mm
Straddle gear(no. of teeth)	19.610 <sup>0</sup> <sub>-0.04(3)</sub> mm





### 2-3 Removal

- (1) Drain the engine oil.
- (2) Remove the oil pan by screwing draw bolts in the thread holes in the oil pan.
- (3) Remove the oil pump drive gear.
- (4) Remove the oil inlet and outlet pipes.
- (5) Remove the oil pump.

### 2-4 Inspection

Remove the oil pump cover and measure the oil pump gear-to-oil pump body and the gear-to-cover clearances. If the measured value exceeds the service limit or if there is local wear, replace the oil pump assembly.

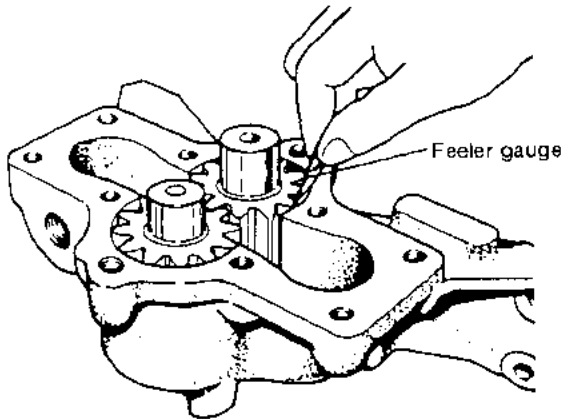
Gear-to-pump clearance

Service limit: 0.098 mm

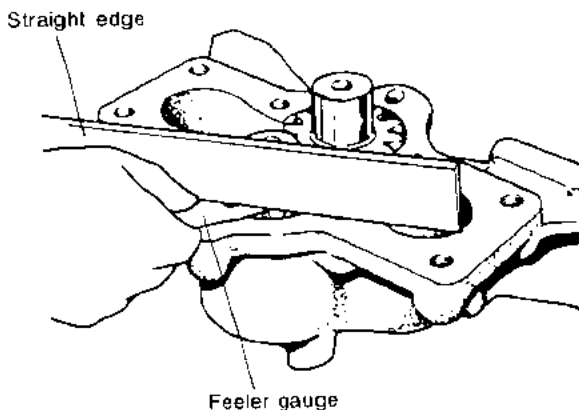
Gear-to-cover clearance

Service limit: 0.093 mm

Measuring the oil pump gear-to-pump body clearance



Measuring the oil pump gear-to pump cover clearance



- Note:* 1. The oil pump should be disassembled only when oil pressure does not rise sufficiently even after adjusting with the pressure regulator valve.
2. When assembling, make sure that the drive shaft (gear) rotates smoothly.

### 2-5 Installation

- (1) Install the oil pump drive gear on the oil pump.
- (2) Use a new gasket and install the oil pump on the cylinder block.

- Note:* 1. Get the surface of the oil pump drive gear and the surface of the idle gear flush and tighten temporarily. Rotate the crankshaft so that the engagement of the teeth is parallel. The tighten the pump bolts.
2. Check the backlash of the drive gear.  
Backlash: 0.08-0.16 mm.

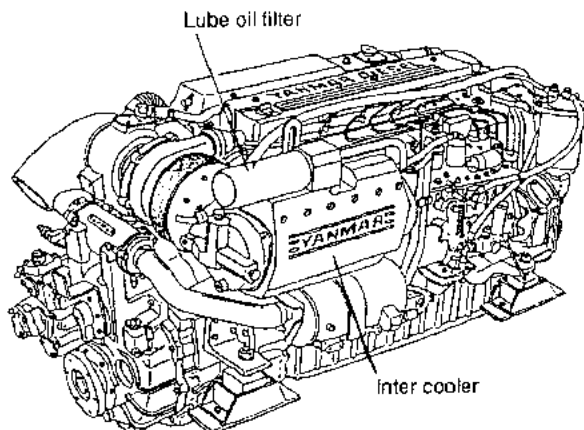
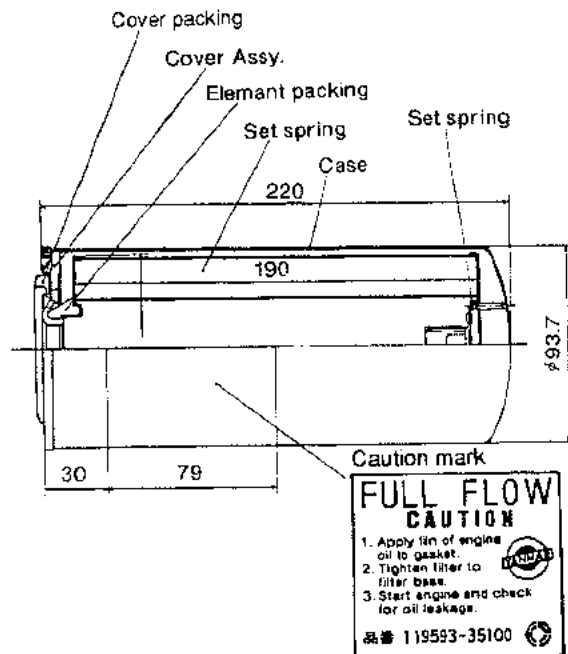
- (3) Torque the oil pump drive gear to 5.0 kg-m.
  - (4) Use new gaskets and attach the oil inlet and outlet pipes.
  - (5) Use a new gasket and install the oil pan.
- Note :* 1. Coat the three faced matching corner with liquid sealant.
2. Tighten after securely matching with the surface of the cylinder block.
- (6) Install all drain plugs and pour in the recommended oil to the upper level.



## 3. Lube Oil Filter

### 3-1 Lube oil filter construction

The lube oil filter is a full-flow paper element type, mounted to the top of the cylinder body with the lube oil cooler. The cartridge type filter is easy to remove. To prevent seizure in the event of the filter clogging, a bypass circuit is provided in the oil filter.



### Specifications

1 Pressure loss	0.3kg/cm <sup>2</sup> or less (50 ℓ /min SAF#30 80°C)
2 Relief valve pressure(Open)	1.8±0.2kg/cm <sup>2</sup>
3 Filtration surface	5800cm <sup>2</sup>
4 Pressure tightness	Element 12kg/cm <sup>2</sup> or more Spinon 20kg/cm <sup>2</sup> or more
5 Impulse pressure tightness	Pulse pressure 0⇒9kg/cm <sup>2</sup> 4×10 <sup>4</sup> times when there are no problems

Type	Full flow, paper element
------	--------------------------

### 3-2 Lube oil filter replacement

#### (1) Period

The paper element will get clogged up with dirt after long hours of usage.

Replace the filter according to the following standard, as the dirt in unfiltered oil will of course have a detrimental affect on the engine.

Oil filter replacement period	Every 250 hours of engine operation
-------------------------------	-------------------------------------

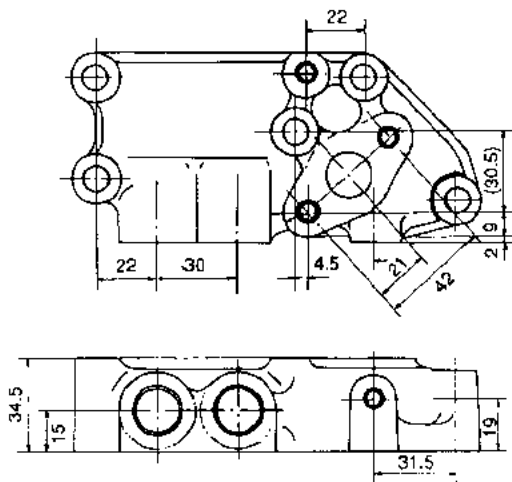
#### (2) Replacement

- 1) Remove the lube oil filter with the special tool.
- 2) Clean the filter mounting surface on the filter bracket and mounting screws.
- 3) Coat the filter rubber packing with lube oil.
- 4) Screw in the filter until the rubber packing comes in contact with the bracket mounting surface, and then 2 ~3 turns more.
- 5) Run the engine after mounting the filter, and make sure that there is no oil leakage.

# 4. Oil Pressure Control Valve

## 4-1 Oil pressure control valve construction

Lube oil travels from the filter attachment part to the lube oil cooler where it is cooled and sent on to the main gallery of the cylinder body. Adjust the pressure of the valve located just before the entrance to the main gallery. When the pressure of the lube oil entering the main gallery of the cylinder body exceeds the standard, the pressure control valve piston opens an escape outlet and allows excess oil to drain into the oil pan.



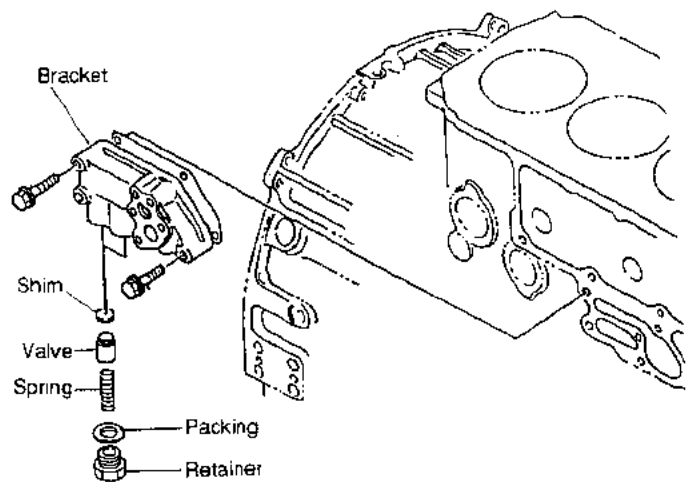
Regulating pressure	3.5~4.5kg/cm <sup>2</sup>
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## 4-2 Oil pressure control valve replacement

The control valve has been adjusted and assembled at the factory, so it should not be disassembled without good reason.

If the oil pressure control valve is disassembled due to spring trouble, etc., mount a pressure gauge on the oil pressure sender unit mounting washer, and adjust the pressure with adjustment shims until it is at the specified value.

Width of the adjustment shim
t = 0.2 mm
t = 0.5 mm
t = 1.0 mm



## 5. Lube Oil Cooler

### 5-1 Lube oil cooler construction

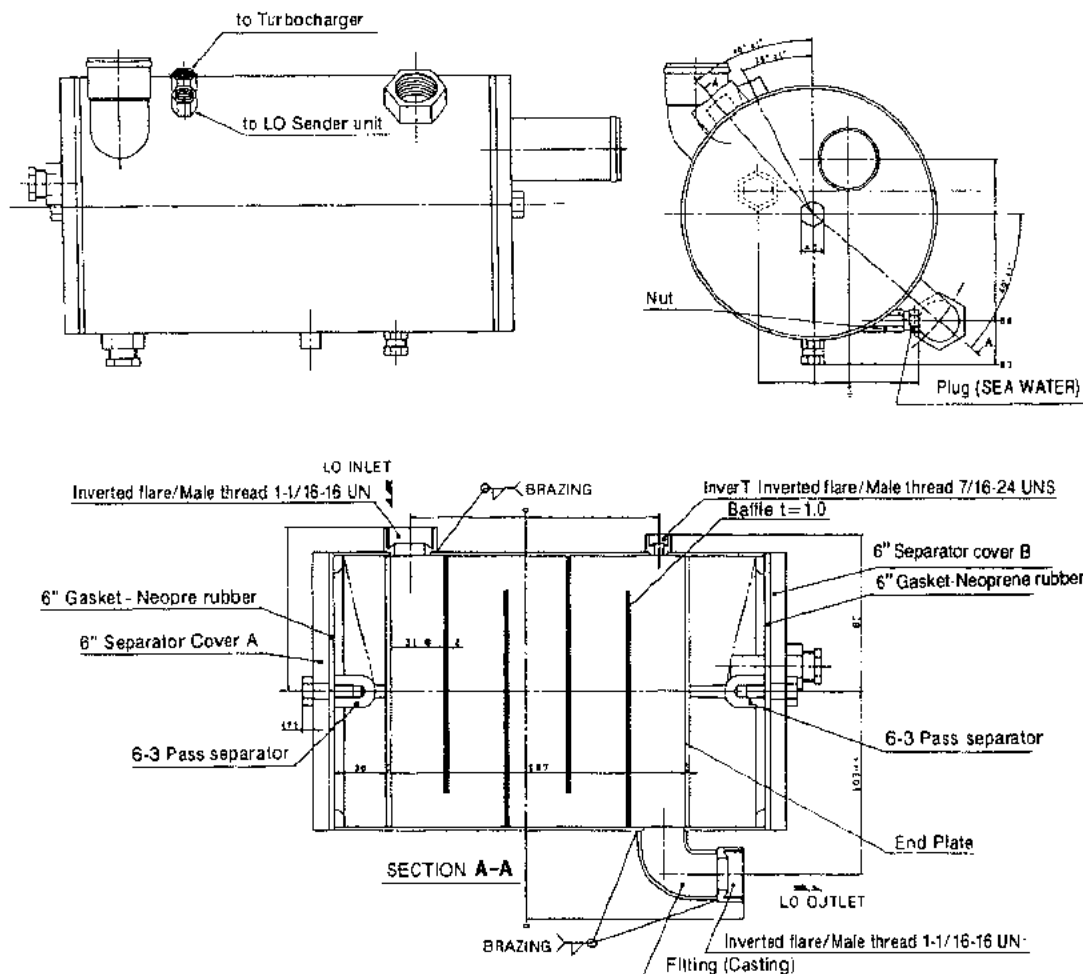
The spiral thread of the inner pipe is in contact with the inner surface of the outer pipe. This forms a spiral passageway.

The lube oil flows through this passageway and is cooled by the cooling water (sea water) flowing through the inner pipe.

There are two such pipes, connected side by side, designed so that the lube oil and sea water flow in the opposite directions.

Amount of heat: 45000kcal/h  
Temp. of sea water  
(Cooler inlet): 45°C  
Sea water flow: 10000ℓ/h  
Oil flow: 5847ℓ/h  
Target temp of oil: 100°C

Bundle length	167mm
No. of tubes	313
Small tube diameter	6.35mm
Tube material	90-10 Copper nickel
Body length	248mm
Body Diameter	155.6mm
Body Material	STD. DWV
No. of baffles	8
Cut off low	5
Baffle spacing	31.8mm
No. of passes	3



### 5-2 Inspecting the lube oil cooler

- (1) Clean the inside of the sea water pipes with a wire brush to prevent the build-up of scale.
- (2) If the rubber hose connection or welds are corroded, repair or replace the cooler.
- (3) Apply the following water pressures to the sea water and lube oil lines to check for any leakage. Repair or replace the cooler if there are any leaks.

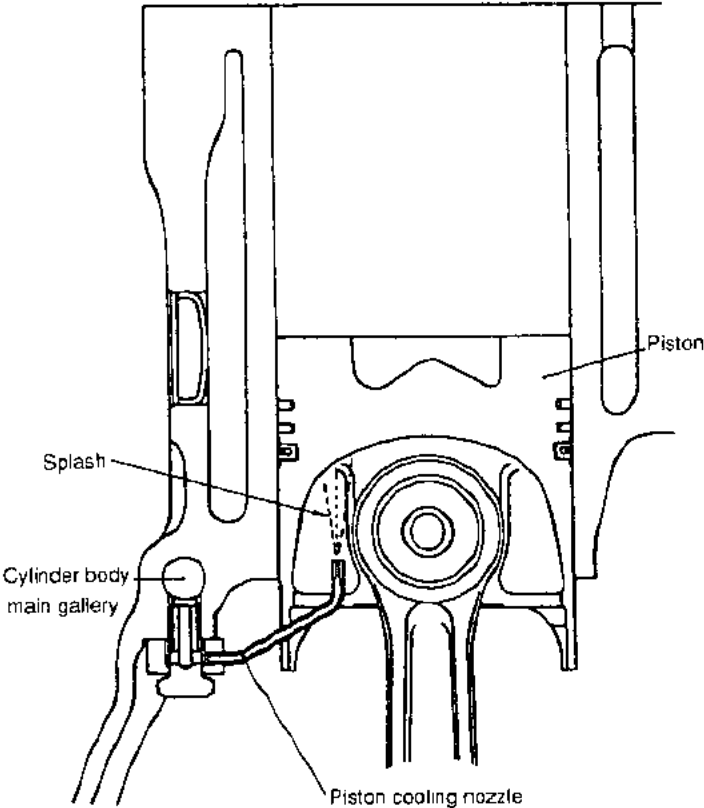
- (4) When cleaning the inside of the tube, use a nylon brush which will fit inside.

	Test pressure
Lubricating oil circuit	3 kg/cm <sup>2</sup>
Sea water circuit	3 kg/cm <sup>2</sup>

# 6. Piston Cooling Nozzle

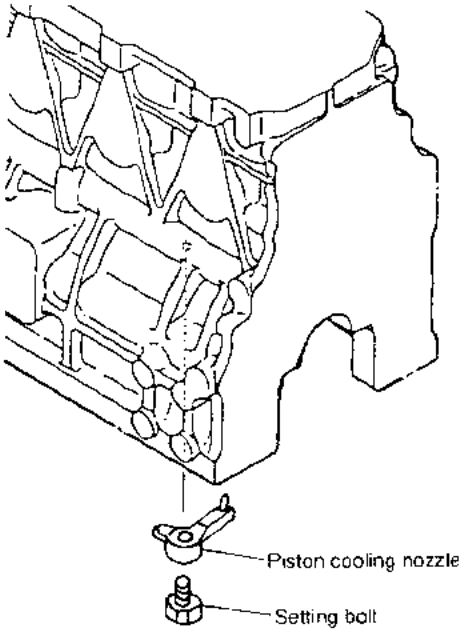
## 6-1 Piston cooling nozzle construction

A nozzle made from steel piping is mounted on the lower part of cylinder body main gallery. Lube oil from the main gallery is sprayed out in a jet from the steel tip ( $\phi 1.77\text{mm}$ ) of this pipe. This jet spray cools the piston surface when the piston goes down.



## 6-2 Inspection of piston cooling nozzle

- (1) Check the nozzle tip hole to see if it is clogged up with dirt or other foreign matter, and clean.
- (2) Inspect the pipe mounting to see if it is or may become loose or come off due to vibration, etc., and replace if necessary.

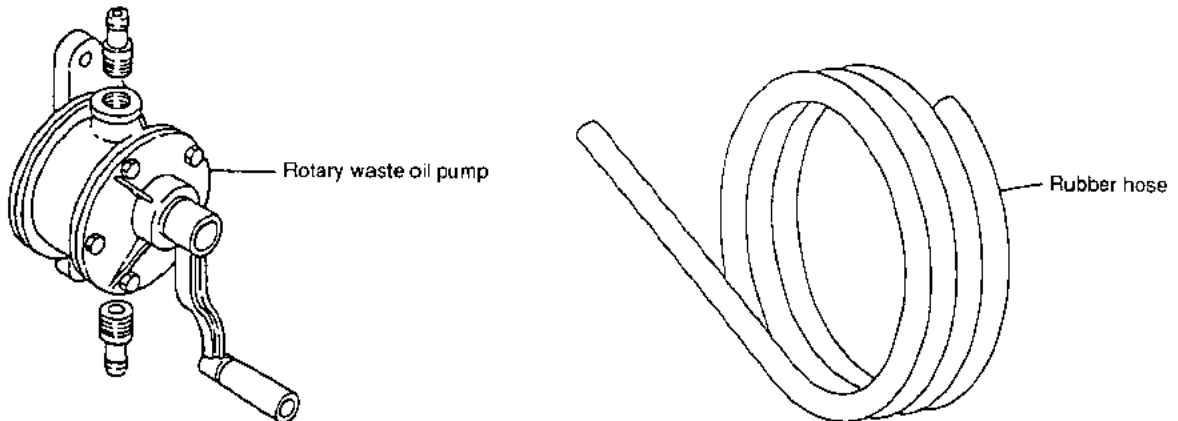


Oil injection volume	3.5~4.0 l /min.
Oil injection pressure	4.5 kg/cm <sup>2</sup>

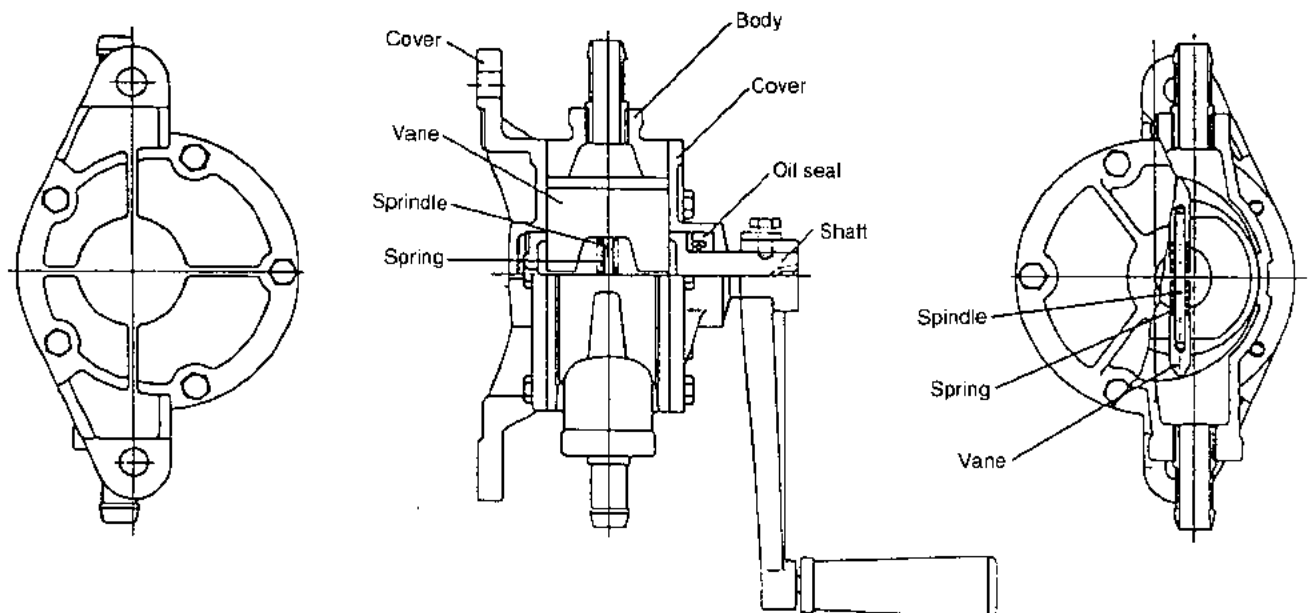
## 7. Rotary Waste Oil Pump (Optional)

A rotary waste oil pump to pump out waste oil during oil changing is available as an option.

This is a vane type pump. Turning the handle rotates the vanes and pumps out lube oil.



### 7-1 Construction



Rotary waste oil pump

Delivery capacity of one stroke	0.13 ℓ
Delivery pressure	1.5 kg/cm <sup>2</sup> or below
Suction head	less than 1m

### 7-2 Inspecting the waste oil pump

- (1) Disassemble the waste oil pump and check for spring breakage or vane damage when there is an extreme drop in discharge volume, and replace if necessary.
- (2) Replace the oil seal if there is excessive oil leakage from the handle shaft.
- (3) Replace the impeller if there is an excessive gap between the impeller and the covers on both sides of casing. This will cause a drop in discharge volume.
- (4) The hose coupling is coated with adhesive and screwed in. It therefore cannot be disassembled.

# COOLING WATER SYSTEM

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# 1. Cooling Water System

## 1-1 System

The cooling water system is of the indirect sea water cooled, fresh water circulation type. The cylinders, cylinder heads, turbocharger and are cooled with fresh water, and the lube oil cooler, inter-cooler and fresh water cooler, (heat exchanger) use sea water.

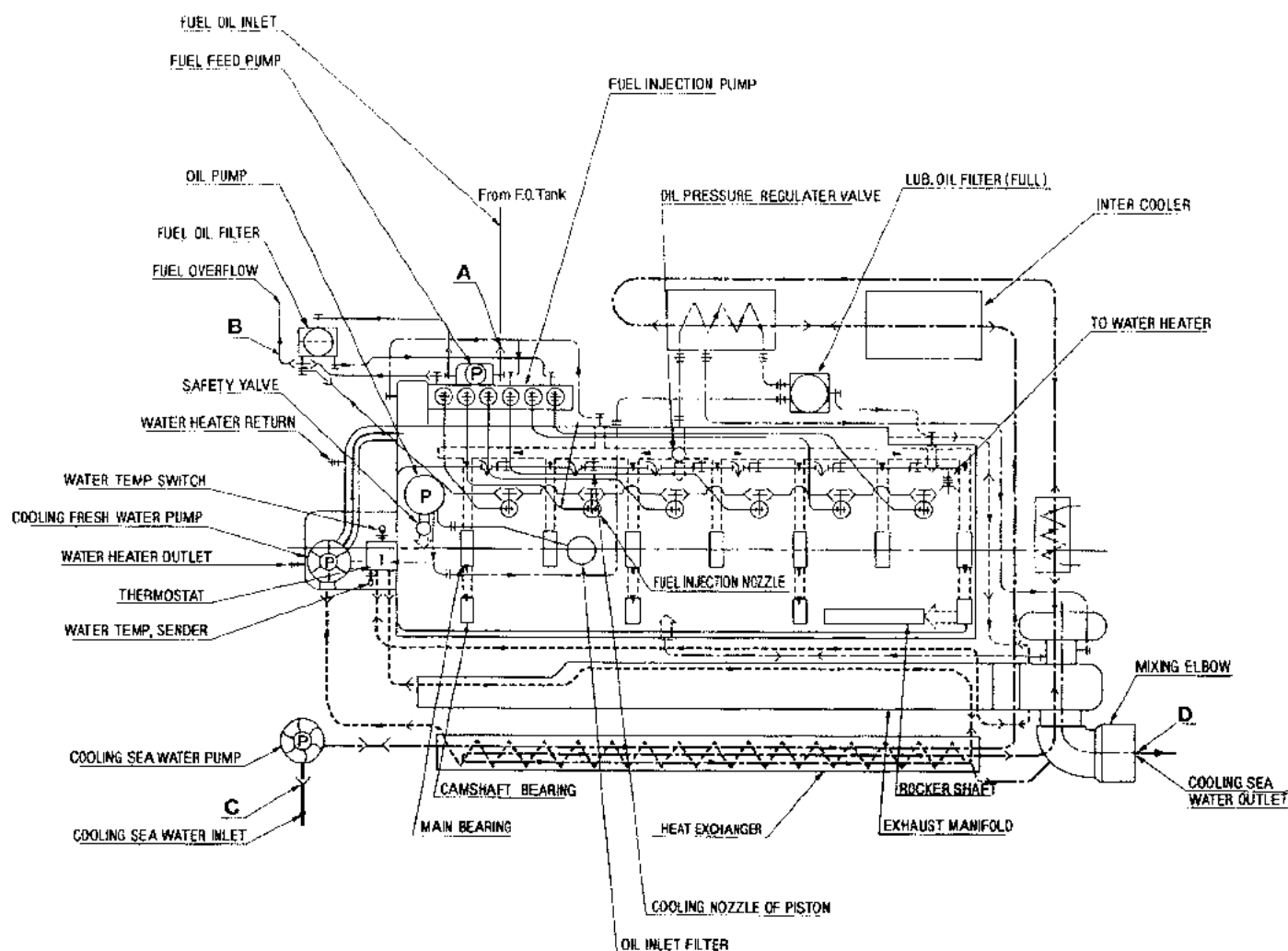
Sea water pumped in from the sea by the sea water pump cools the lube oil in the lube oil cooler and then goes to the heat exchanger, where it cools the fresh water. Then it is sent to the mixing elbow and is discharged from the ship with the exhaust gas.

Fresh water is pumped by the fresh water pump from the fresh water tank to the cylinder jacket to cool the cylinder, turbocharger and then the cylinder head. The fresh water pump body also serves as a discharge passageway (line) at the cylinder head outlet, and is fitted with a thermostat.

The thermostat is closed when the fresh water temperature is low, immediately after the engine is started and during low load operation, etc.

Then the fresh water flows to the fresh water pump inlet, and is circulated inside the engine with out passing through the heat exchanger.

When the temperature of the fresh water rises, the thermostat opens, fresh water flows to the head exchanger, and it is then cooled by the sea water in the tubes as it flows through the cooling pipe. The temperature of the fresh water is thus kept within a constant range by the thermostat.



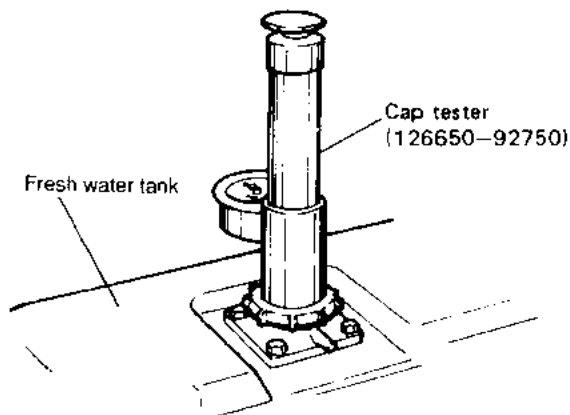
**1-2 Water leakage test (Fresh water)**

- (1) Fill with fresh water up to the upper surface of the water tank.
- (2) Install the cap tester on the filler neck.
- (3) Operate the pump and set the pressure at  $0.9 \pm 0.15$  kg/cm<sup>2</sup> (13  $\pm$  2 psi), and inspect for water leakage.

*Note : Be careful when applying pressure because excessive pressure will damage the matching surface packings of the cooling water system as well as the hoses.*

Places for inspection (while applying pressure): various hose connections, cooling water pump, each packing section.

If the gauge needle drops even when water leakage is not found in these places, water may be leaking from the cylinder head, head gasket or inside the block.

**Water Leakage Test****1-4 Anti-Corrosion Agent**

In fresh water cooled diesel engines, anti-corrosion maintenance of the fresh water cooling system is very important. Conduct anti-corrosion maintenance with the following points in mind:

- Prevent solid matter from getting into the fresh water cooling system and clean the system periodically with scale solvent solution.
- Always use clean soft water. The salt in seawater will accelerate corrosion.
- Use anti-corrosion agent mixed with soft water as coolant.

**1-5. Antifreeze**

On cold days (of less than 5°C), use antifreeze (antifreezing solution). Since freezing of cooling water can be prevented by use of antifreeze, draining out the cooling water everyday can be omitted if antifreeze is used.

After rinsing cooling system feed in cooling water mixed with antifreeze.

**1-3 Removing Scale (During Disassembly)**

- (1) Dilute scale solvent with approximately 10 times its weight of water (seawater may be used for the seawater circuit). Stir it and dissolve the agent to make cleaning solution.
- (2) Immerse the disassembled parts in this cleaning solution for 5-15 hours. Then take the parts out and thoroughly wash with water. It is recommended to prepare a solution with approximately 1 % of this scale solvent neutralization agent to wash the parts in before washing with water.

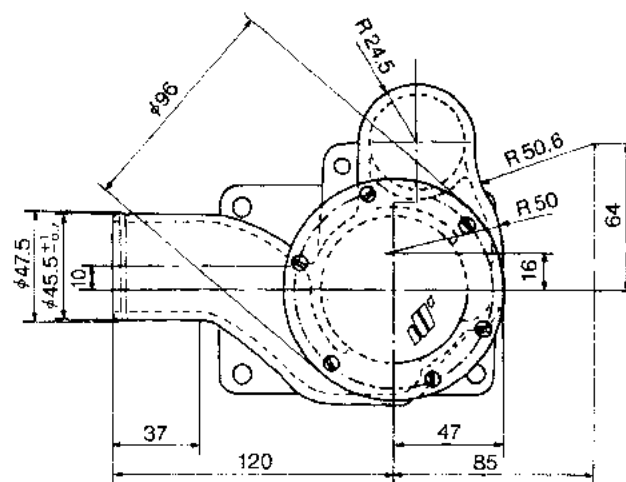
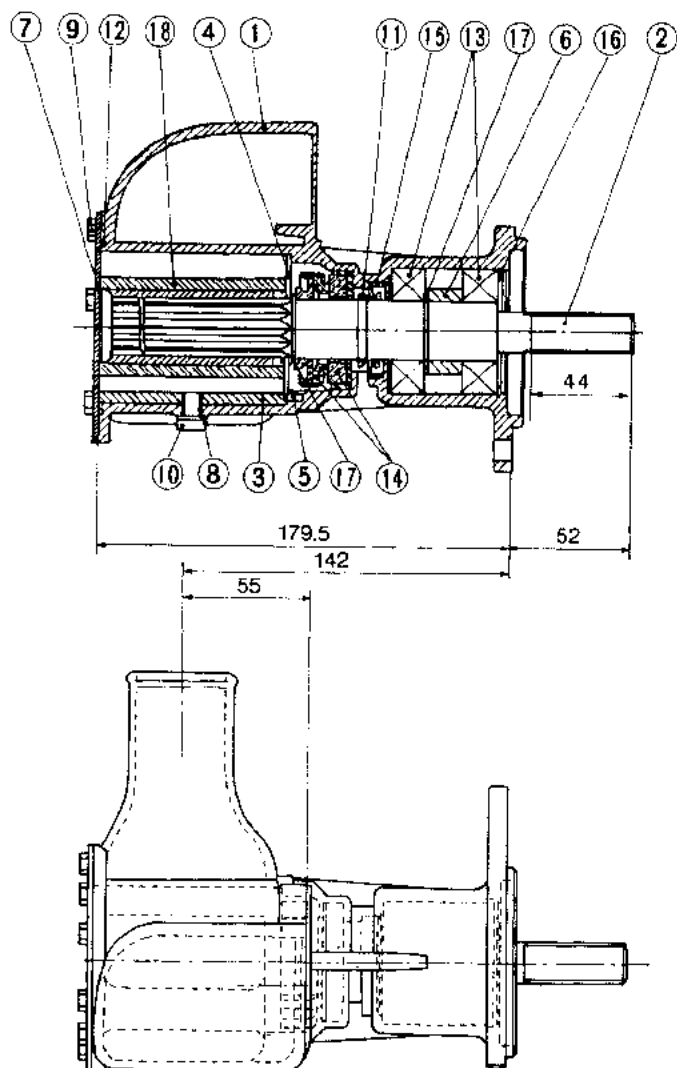


## 2. Sea Water Pump

### 2-1 Sea water pump construction and functioning

The sea water pump has a rubber impeller. The sea water pump is mounted to the gear case, and the drive gear on the end of the sea water pump shaft meshes with the camshaft gear to drive the pump.

The rubber impeller should be replaced periodically in accordance with the maintenance schedule. The rubber impeller is enclosed by a cover attached by 6 bolts. When attaching the cover, do not forget to attach an O-ring between the pump body and cover.



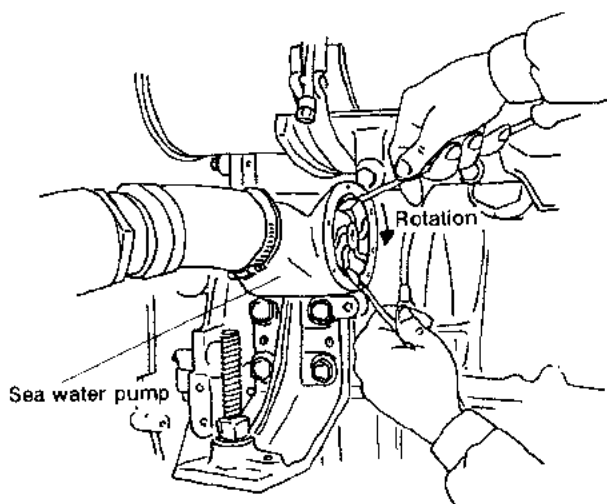
#### Parts list for pump

Item	Description	Nos.
1	Body	1
2	Shaft	1
3	Cam	1
4	Wear plate	1
5	pin	1
6	Spacer	1
7	Endcover	1
8	Washer	1
9	Screw	6
10	Screw	1
11	O-ring	1
12	O-ring	1
13	Ball bearing	2
14	Mech. seal	1
15	Lip seal	1
16	Retaining ring	1
17	Retaining ring	2
18	Impeller	1

Spline data		mm
Profile	JIS D2001	
Dimension	17×15×1	
Tolerance	Flank Class a	
Pressure angle	20	
Modulus	1	
No of splines	15	
Addendum mod.	0.8	
Pitch dia.	15	
Inner dia.	14.6	

## 2-2 Sea water pump disassembly

- (1) Remove the rubber hose from the sea water pump outlet and then the sea water pump assembly from the gear case.
- (2) Remove the sea water pump cover and take out the O-ring, impeller and wear plate.
- (3) Remove the mechanical seal side stop ring.
- (4) Insert pliers from the drive gear long hole and remove the stop ring that holds the bearings.
- (5) Lightly tap the pump shaft from the impeller side and remove the pump shaft, bearings, and drive gear as a set.
- (6) Remove the oil seal and mechanical seal if necessary.



## 2-3 Sea water pump inspection

- (1) **Rubber impeller**  
If there is damage or wear on the impeller, replace it.
- (2) **Wear plate**  
Inspect the wear plate, and if the side surface is worn or if it is deformed, replace it.
- (3) **Pumphousing**  
If there is excessive wear on the inner surface of the housing or on the sliding surface of the impeller, replace it.
- (4) **Mechanical seal**  
If there is a large amount of water leakage from the drain pipe replace the mechanical seal. (Cooling water leakage : less than 3cc/h)

**NOTE:** 1. Be careful not to damage each sliding surface while replacing  
 2. Coat the sliding surface of the mechanical seal with a small amount of high quality silicon oil to prevent early leakage due to insufficient fit.  
 3. Coat the seal bore with liquid sealant.

- (5) **Bearing**  
Inspect the bearing for wear or damage.

## 2-4 Sea water pump reassembly

- (1) When replacing the mechanical seal, Coat the sliding surface with a good quality silicon oil, taking sufficient care not to cause any scratches.
- (2) When replacing the oil seal, coat with grease and insert.
- (3) Mount the pump shaft, ball bearing and gear assembly to the pump unit and fit the bearing stop ring. Be sure not to forget the water O-ring when doing this.

**NOTE:** Coat the shaft with grease.

- (4) After inserting the mechanical seal stop ring, mount the wear plate and impeller.
- NOTE:** 1. When inserting the impeller make sure it lies in the proper direction.  
 2. Coat the inside of pump body impeller housing with grease.
- (5) Mount the O-ring between the pump body and side cover.

**NOTE:** Replace the O-ring.

## 3. Fresh Water Pump

### 3-1 Fresh water pump construction

The fresh water pump is of the centrifugal (volute) type, and circulates water from the fresh water tank to the cylinder head.

The fresh water pump consists of the pump body, impeller, pump shaft, bearing unit and mechanical seal. The V pulley on the end of the pump shaft is driven by a V belt from the crankshaft.

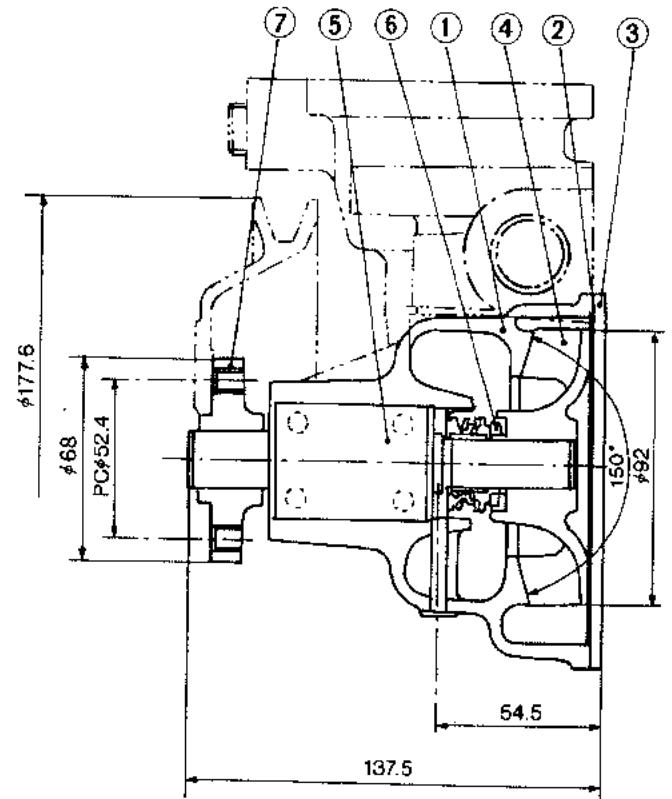
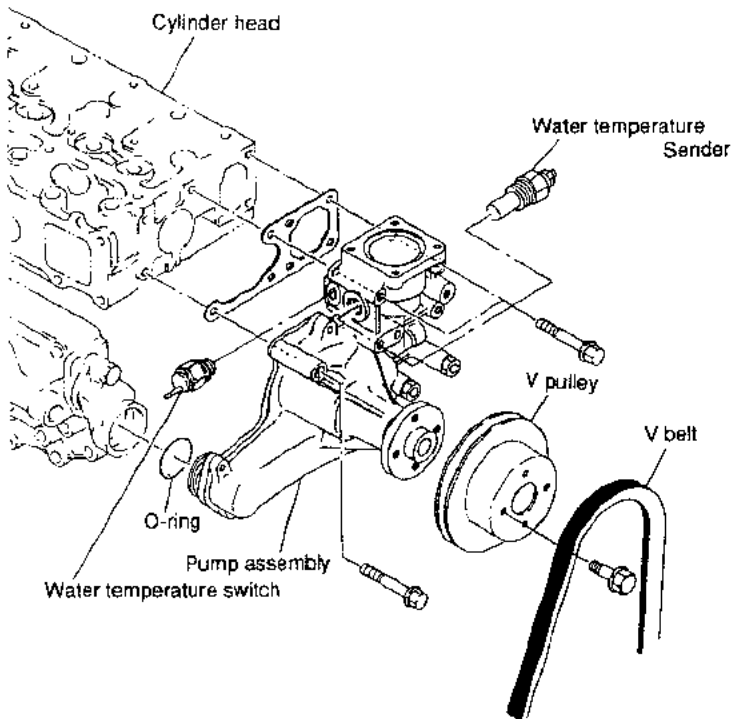
The bearing unit assembled in the pump shaft uses grease lubricated ball bearings and cannot be disassembled.

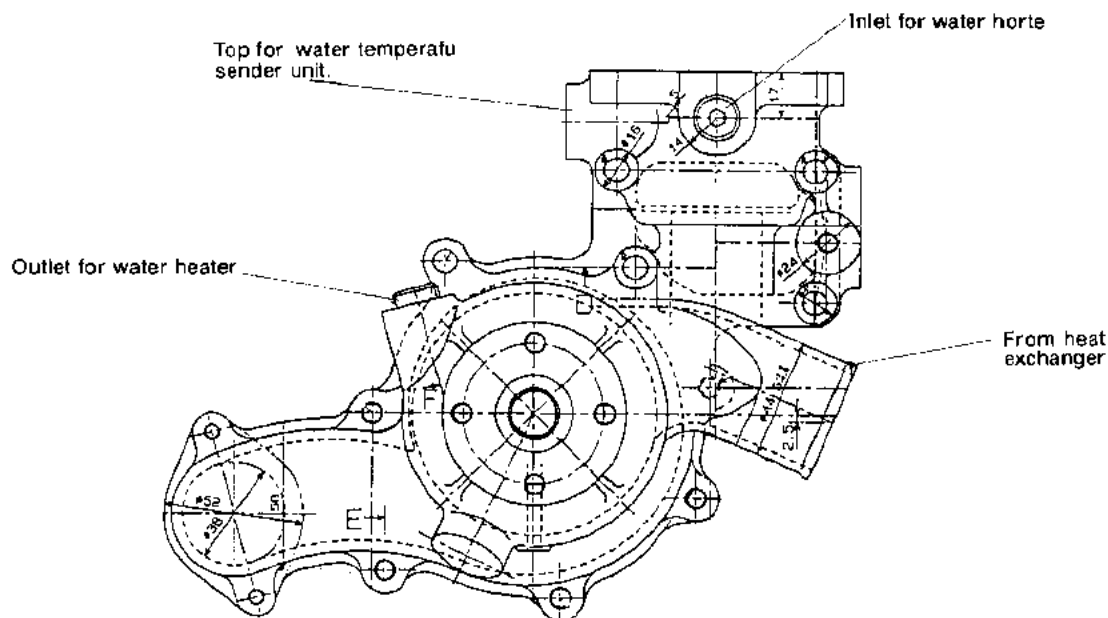
The totally enclosed mechanical seal spring presses the impeller seal mounted on the impeller side away from the pump body side. This prevents water from leaking along the pump shaft.

As the impeller and pulley flanges are press fit assembled, they cannot be disassembled.

#### Parts list for pump

	Parts	
1	Casing	1
2	Packing	1
3	Cover	1
4	Impeller	1
5	Shaft bearing	1
6	Mechanical seal	1
7	Pulley seat	1





### 3-2 Specifications of fresh water pump

Crank shaft speed (max.)	3500
Pump shaft speed	2970-3030 rpm
Delivery capacity	350 ℓ /min
Total head	6.6mAq

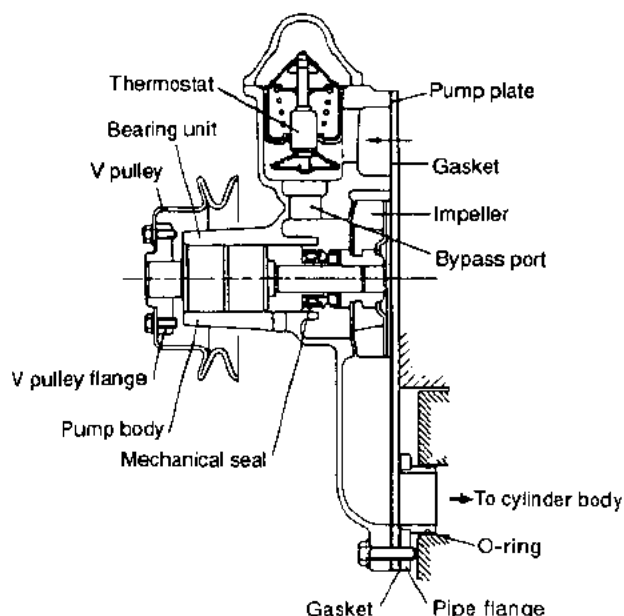
### 3-3 Fresh water pump disassembly

- (1) Do not disassemble the fresh water pump. It is difficult to disassemble and, once disassembled, even more difficult to reassemble. Replace the pump as an assembly in the event of trouble.
- (2) When removing the fresh water pipe as an assembly from the cylinder intake pipe O-ring.
- (3) When the fresh water pump body and cylinder intake flange and/or fresh water pump and pump plate are disassembled, retighten to the specified torque.

Tightening torque for pump setting bolts	70~110 kg-cm
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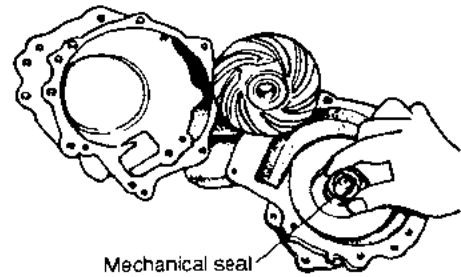
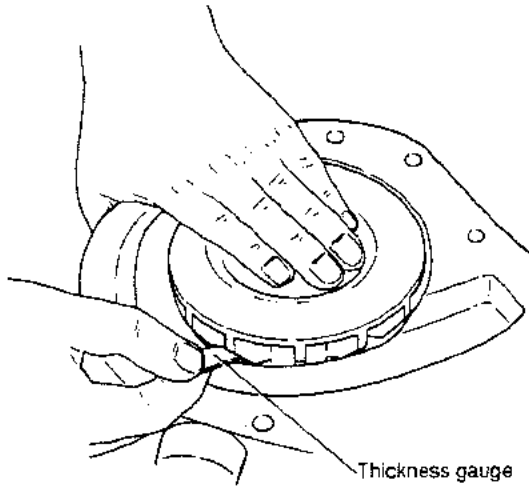
### 3-4 Fresh water pump inspection

- (1) Bearing unit inspection  
Rotate the impeller smoothly. If the rotation is not smooth or abnormal noise is heard due to excessive bearing play or contact with other parts, replace the pump as an assembly.
- (2) Impeller inspection  
Check the impeller blade, and replace if damaged or corroded, or if the impeller blade is worn due to contact with pump body.

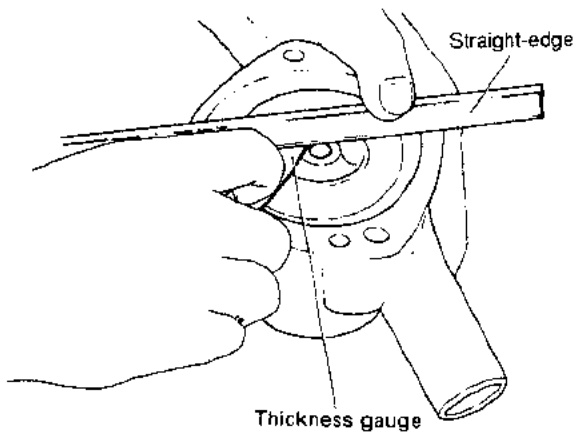


- (3) Check the holes in the cooling water and bypass lines, clean out any dirt or other foreign matter and repair as necessary.
- (4) Replace the pump as an assembly if there is excessive water leakage due to mechanical seal or impeller seal wear or damage.
- (5) Inspect the fresh water pump body and flange, clean off scale and rust, and replace if corroded.
- (6) Measure the clearance between the impeller and the pump body, and the impeller and the plate. Measure the clearance between the impeller and the pump body by pushing the impeller all the way towards the body, and inserting the body. Measure the clearance between the impeller and the plate (pump body bracket) by placing a straight-edge against the end of the pump body and inserting a thickness gauge between the impeller and the straight-edge.

Measuring clearance between impeller and pump body.



Measuring clearance between impeller and pump body bracket.

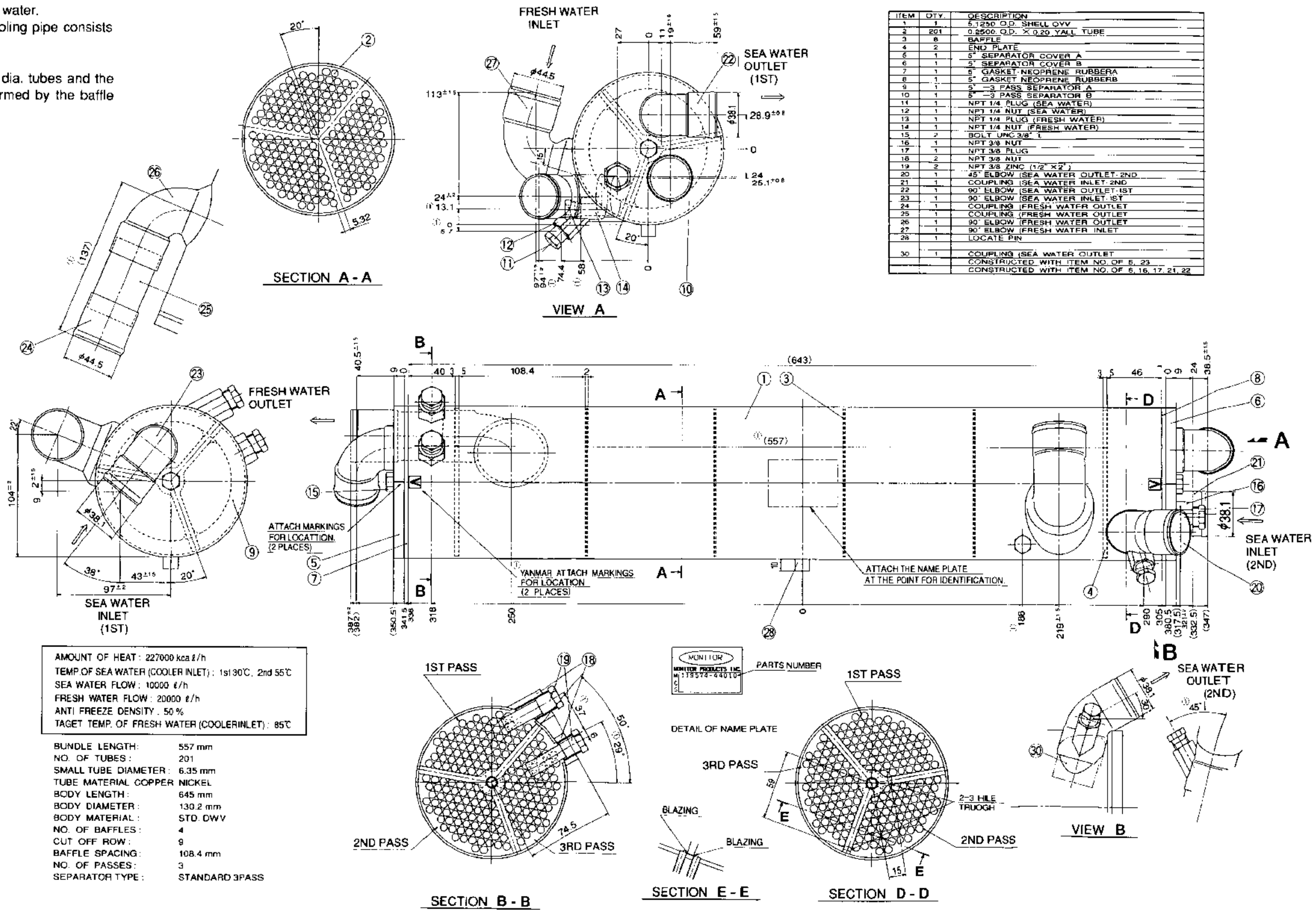


	mm	
	Standard	Wear limit
Clearance between impeller and body	0.3~1.1	1.5
Clearance between impeller and plate	1.5	—

# 4. Fresh Water Cooler

## 4-1 Fresh water cooler construction

The fresh water cooler cools the hot fresh water that has cooled the inside of the engine with sea water.  
The inside of the fresh water cooler cooling pipe consists of 201 small dia. tubes and baffle plates.  
The sea water flows through the small dia. tubes and the fresh water flows through the maze formed by the baffle plates.



## 4-2 Specifications of heat exchanger

Bundle length	550mm
No. of tubes	201
Small tube Dia.	6.35mm
Tube material	Copper nickel
Body length	645mm
Body diameter	130.2mm
Body material	STD.DWV
No. of baffles	4
Cut off row	9
Baffle spacing	108.4mm
No. of passes	3
Separator type	Standard 3pass

## 4-3 Disassembly and reassembly of the fresh water cooler

Remove the covers on both sides gasket (S).

**NOTE:** Replace the gasket (S) when you have removed the covers.

## 4-4 Fresh water cooler inspection

### (1) Cooling pipe inspection

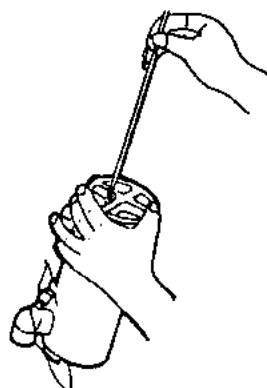
- 1) Inspect the inside of the tubes for rust or scale build up from sea water, and clean with a wire brush if necessary.

**NOTE:** Disassemble and wash when the cooling water temperature reaches 85°C.

- 2) Check the joints at both ends of the tubes for looseness or damage, and repair if loose. Replace if damaged or corroded.
- 3) Check tubes and replace if leaking.
- 4) Clean any scale or rust off the outside of the tubes. When cleaning the inside of the tube, use a nylon brush which will fit inside.

### (2) Fresh water cooler body inspection

- 1) Check heat exchanger body and side cover for dirt and corrosion. Replace if excessively corroded, or cracked.
- 2) Inspect sea water and fresh water inlets and outlets, retighten any joints as necessary and clean the insides of the pipes.

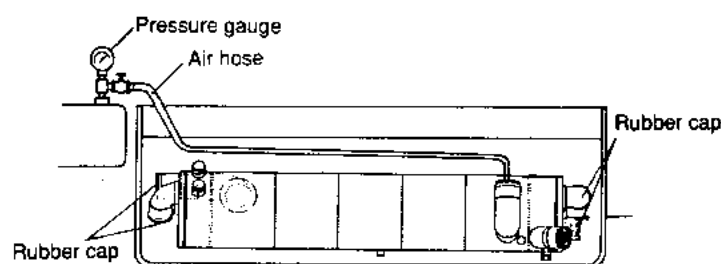


### (3) Fresh water cooler body water leakage test

#### 1) Compressed air/water tank test

Fit rubber covers on the fresh water and sea water inlets and outlets.

Place the Fresh water cooler in a water tank, feed in compressed air from plug on sea water inlet (2nd) and check for any (water) leakage, (air bubbles).



Test pressure	2kg/cm <sup>2</sup> (28.44 lb/in. <sup>2</sup> )
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## 5. Pressure Cap and Sub Tank

### 5-1 Pressure cap construction

The pressure cap mounted on the fresh water filler neck incorporates a pressure control valve. The cap is mounted on the filler neck cap by placing it on the locking tab and rotating. The top seal of the cap seals the top of the filler neck, and the pressure valve seals the lock seat.

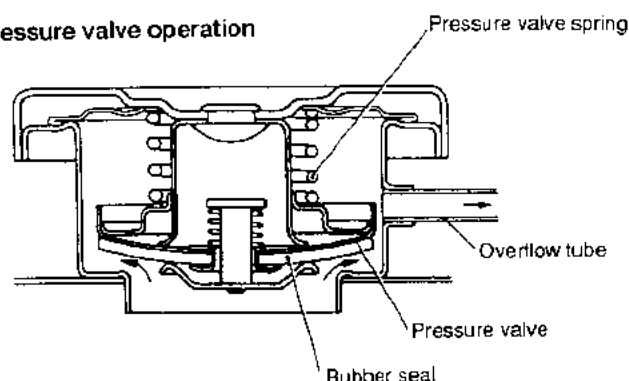
### 5-2 Pressure cap pressure control

The pressure valve and vacuum seal both seal the valve seat when the pressure in the fresh water system is within the specified value of  $0.9\text{kg/cm}^2$  ( $12.80\text{lb/in.}^2$ ). This seals the fresh water system.

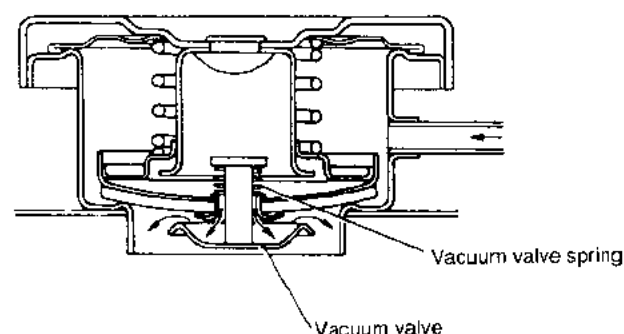
When the pressure within the fresh water system exceeds the specified value, the pressure valve opens, and steam is discharged through the overflow pipe.

When the fresh water is cooled and the pressure within the fresh water system drops below the normal valve, atmospheric pressure opens the vacuum valve, and air is drawn in through the overflow pipe.

#### Pressure valve operation



#### Vacuum valve operation



The sub tank, (which will be described later), keeps the water level from dropping due to discharge of steam when the pressure valve opens.

#### Action of pressure control valve

Pressure valve	Open at $0.9\text{ kg/cm}^2\text{G}$
Vacuum valve	Open at $0.05\text{ kg/cm}^2\text{G}$ or below

### 5-3 Pressure cap inspection

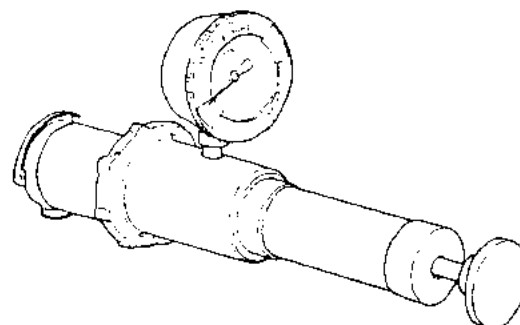
#### Precautions

Do not open the pressure cap while the engine is running or right after stopping because high temperature steam will be blown out. Remove the cap only after the water has had a chance to cool down.

- (1) Remove scale and rust, check the seat and seat valve, etc. for scratches or wear, and the spring for corrosion or settling. Replace if necessary.

*NOTE: Clean the pressure cap with fresh water as it will not close completely if it is dirty.*

- (2) Fit the adapter on the tester to the pressure cap. Pump until the pressure gauge is within the specified pressure range ( $0.75\sim1.05\text{kg/cm}^2$  ( $10.67\sim14.91\text{lb/in.}^2$ )) and note the gauge reading. The cap is normal if the pressure holds for six seconds. If the pressure does not rise, or drops immediately, inspect the cap and repair or replace as necessary.



### 5-4 Function of the sub tank

The pressure valve opens to discharge steam when the steam pressure in the fresh water tank exceeds  $0.9\text{kg/cm}^2$  ( $12.80\text{lb/in.}^2$ ).

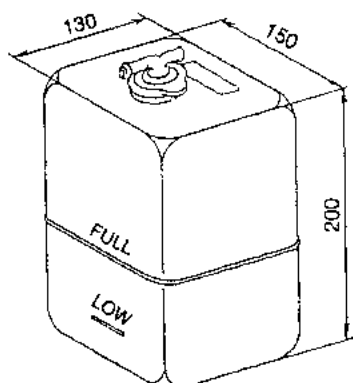
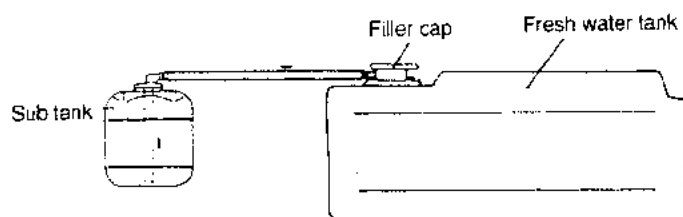
This consumes water. The sub tank maintains the water level by containing this discharge.

Steam discharged into the sub tank condenses into water, and the water level in the sub tank rises.

When the pressure in the fresh water system drops below the normal valve, the water in the sub tank is sucked back into the fresh water tank to raise the water back to its original level.

The sub tank facilitates long hours of operation without water replacement and eliminates the possibility of burns when the steam is ejected from the filler neck because the pressure cap does not need to be removed.





### 5-5 Specifications of sub tank

Subtank capacity	Overall capacity	3.4 ℓ ( in. <sup>3</sup> )
	Full-scale position	1.5 ℓ ( in. <sup>3</sup> )
	Low-scale position	0.43 ℓ (12.20 in. <sup>3</sup> )

### 5-6 Mounting the sub tank

- (1) The sub tank is mounted at approximately the same height as the heat exchanger (fresh water tank).  
(allowable difference in height: 300mm (11.8110in.) or less)
- (2) The overflow pipe should be less than 1000mm (39.3701in.) long, and mounted so that it does not sag or bend.

*Note : Make sure that the overflow pipe of the sub tank is not submerged in bilge, water in the bilge will be siphoned into the fresh water tank when the water is being cooled.*

### 5-7 Precautions on usage of the sub tank

- (1) Check the sub tank when the engine is cool and refill with fresh water as necessary to bring the water level between the low and full marks.
- (2) Check the overflow pipe and replace if bent or cracked.  
Clean out the pipe if it is clogged up.

## 6. Thermostat

### 6-1 Functioning of thermostat

The thermostat opens and closes a valve according to changes in the temperature of the fresh water inside the engine, controlling the volume of water flowing to the heat exchanger from the cylinder head, and in turn maintaining the temperature of the fresh water in the engine at a constant level.

The thermostat is bottom bypass type. It is located in a position connected with the cylinder head outlet line at the top of the top of fresh water pump unit.

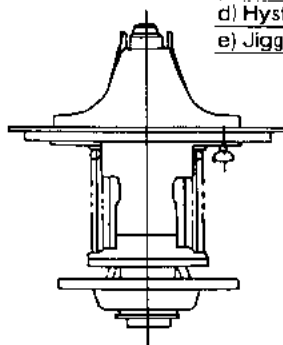
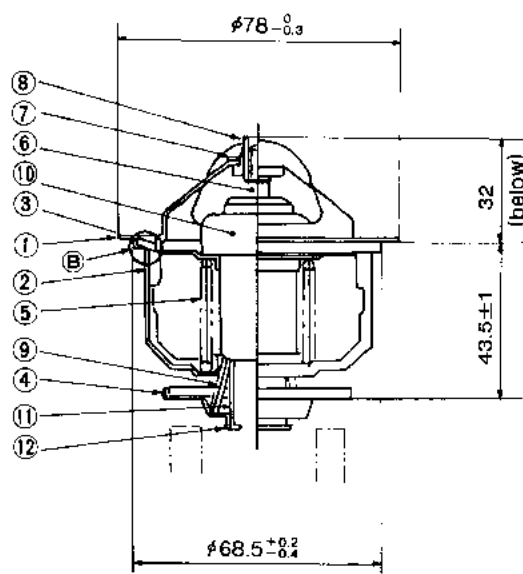
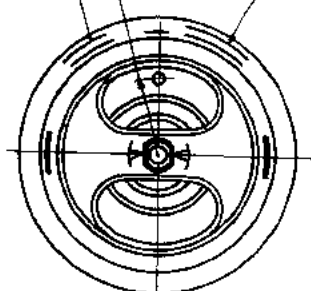
When the fresh water temperature is low (75.0~78.0°C or less), the thermostat is closed, and fresh water goes from the bypass line to the fresh water pump intake and circulates in the engine.

When the fresh water temperature exceeds the above temperature, the thermostat opens, and a portion of the water is sent to the heat exchanger and cooled by sea water, the other portion going from the bypass line to the fresh water pump intake.

The bypass line is closed off as the thermostat valve opens, and is completely closed when the fresh water temperature reaches 81.5°C (valve lifts 4mm (0.1575in.)), sending all of the water to the heat exchanger.

⑬ Jigle valve (R21.5 or greater)

Date of manufacture      Open valve temperature



No.	Item	Material	Measurement
1	Seat	SUS430	t1
2	Attachment frame	SUS430	t1
3	Valve	SUS430	t0.8
4	Bypass valve	SUS430	t0.6
5	Spring	SUS304	φ 3
6	Piston	SUS304	φ 6.4
7	Stopper	C3604B	φ 14
8	Adjustment fittings	C3604B	φ 8
9	Helper spring	SUS304	φ 1.8
10	Pellet	Ass'y	
11	Pipe	SUS304	φ 15, 11
12	E snap ring	SUS304	E9
13	Jigle valve	SUS430	φ 5.3

### 6-2 Thermostat construction

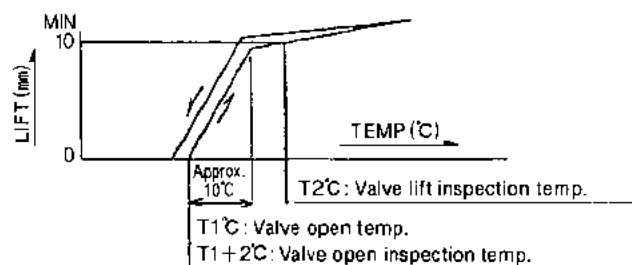
The thermostat used in this engine is of the wax pellet type, with a solid wax pellet located in a small chamber.

When the temperature of the cooling water rises, the wax melts and increases in volume. This expansion and contraction is used to open and close the valve.

### 6-3 Characteristics of thermostat

Opening temperature	76.5°C
Full open temperature	90°C
Valve lift at full open	8mm
Diameter	50mm

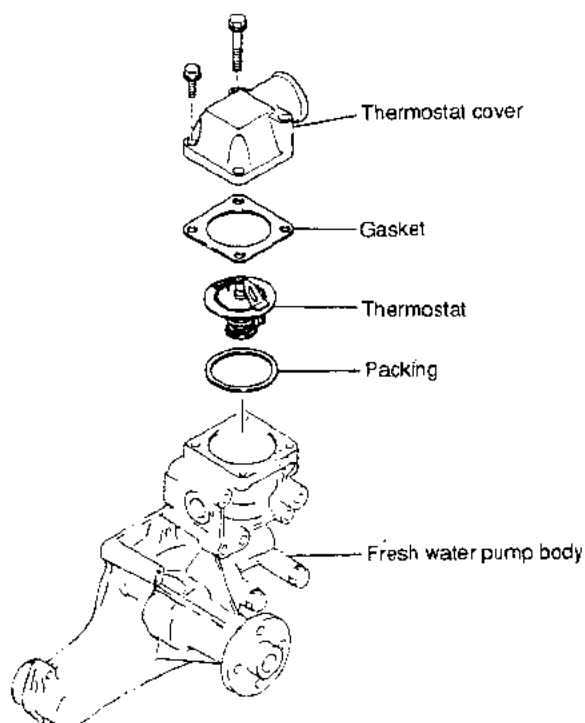
- Valve diameter: φ50
- Leak hole: Jigle valve
- Ability:
  - a) Temperature – Stretch feature



- b) Time: Within 90 seconds
- c) Amount of water leakage: Cooling water 0.2kg/cm<sup>2</sup> (20KPa) at pressure of 10/min. or lower.
- d) Hysteresis: At lift 2mm within 3.5°C.
- e) Jigle valve feature: Closed valve pressure: 10mmHg or lower.  
Amt. of air flow with closed valve: 10ℓ/min. or greater.

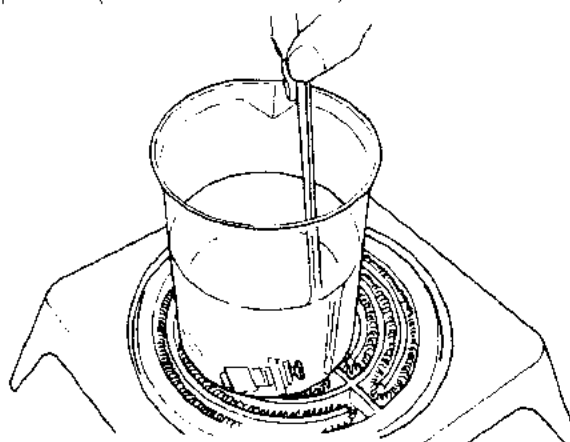
### 6-4 Thermostat inspection

Remove the thermostat cover on top of the fresh water pump and take out the thermostat. Clean off scale and rust and inspect, and replace if the characteristics (performance) have changed, or if the spring is broken, deformed or corroded.



### 6-5 Testing the thermostat

- (1) Put the thermostat in a breaker with fresh water, and heat it on an electric stove. The thermostat is functioning normally if it starts to open between 75~78°C, and opens 8mm (0.3150in.) or more at 90°C. Replace the thermostat if it is not functioning normally.
- (2) Normally, the thermostat should be inspected every 500 hours of operation, but it should be inspected before this if the cooling temperature rises abnormally or white smoke is emitted for a long time after engine starting.
- (3) Replace the thermostat every year or 2000 hours of operation (whichever comes first).

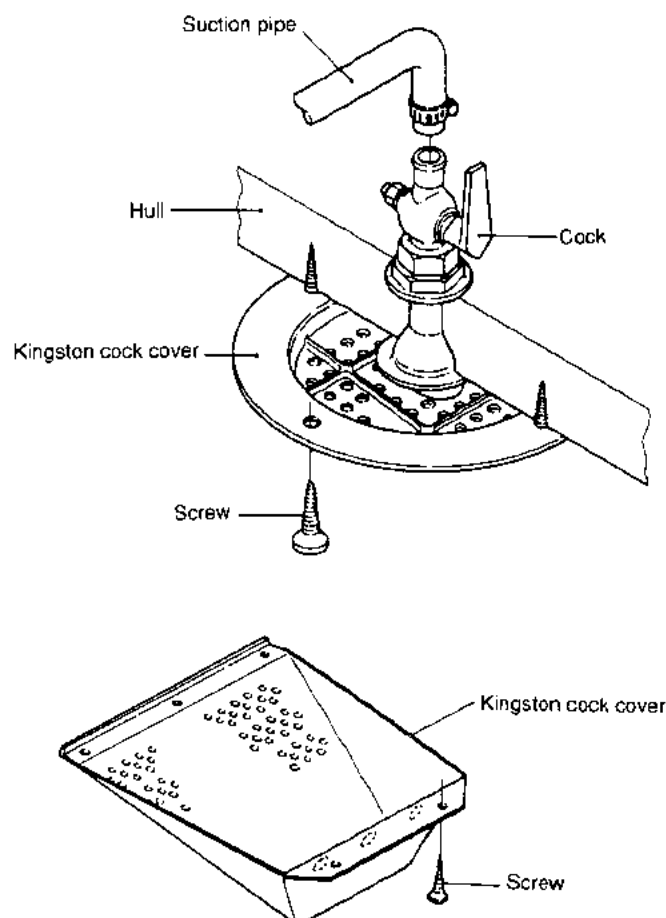


## 7. Kingston Cock (Optional)

### 7-1 Construction

The Kingston cock, installed on the bottom of the hull, controls the intake of cooling water into the boat. The Kingston cock serves to filter the water so that mud, sand, and other foreign matter in the water does not enter the water pump.

Numerous holes are drilled in the water side of the Kingston cock, and a scoop strainer is installed to prevent the sucking in of vinyl, etc.



### 7-3 Inspection

When the cooling water volume has dropped and the pump is normal, remove the vessel from the water and check for clogging of the Kingston cock.

If water leaks from the cock, disassemble the cock and inspect if for wear, and repair or replace it.

### 7-2 Handling precautions

Caution the user to always close the Kingston cock after each day of use and to confirm that it is open before beginning operation.

If the Kingston cock is left open, water will flow in reverse and the vessel will sink if trouble occurs with the water pump.

On the other hand, if the engine is operated with the Kingston cock closed, cooling water will not be able to get in, resulting in engine and pump trouble.

# REDUCTION AND REVERSING GEAR

<b>1. Specification and System</b> .....	<b>7-2</b>
1-1. Marine Gears (YANMAR MODEL : KMH6A) .....	7-2
<b>2. Reassembly and disassembly (KMH6A)</b> .....	<b>7-6</b>
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The reduction and reversing gear for YANMAR Model KM6A is explained in detail in.

Chapter 8, For details on other types of clutches [HURTH-HSW800(A2), TWINDISC-MG5050(A)] refer to the service manuals supplied by the makers.

# 1. Specification and System

## 1-1. Marine Gears (YANMAR MODEL : KMH6A)

There are 3 standard types of clutches for the 6LYA-UTE and 6LYA-STE model which are shown in the specifications. The KMH6A is explained here. Refer to the service manuals provided by the manufacturers for details on other types of clutches.

### 1-1.1 Major Specifications

1	Type	Constant mesh gear with hydraulic multi-disc (wet type)		
2	Model	KMH6A		
3	Reduction ratio	1.58	1.92	2.26
4	Revolution speed (Input)	3300	3300	3300
5	Revolution speed (Output)	2087	1718	1457
6	Reversing system	Constant mesh gear		
7	Clutch	Multi wet plate type		
8	Lube oil	API Service grade CD (#30)		
9	Weight	105kg		
10	Lube system	Forced lubrication with hydraulic pump		
11	Cooling system	Sea water multi pipe		
12	LO capacity	4.0 ℓ		
13	Hydraulic oil set up pressure	28±0.5kgf/cm <sup>2</sup> at 3300rpm oil temp. 60°C		

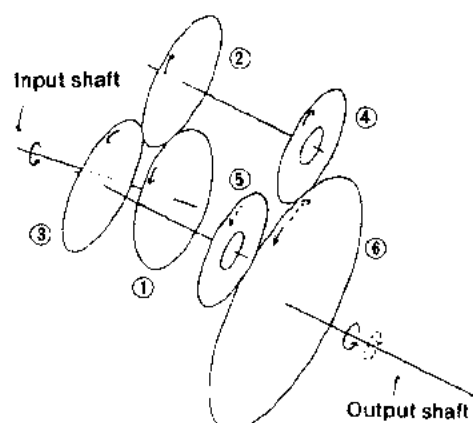
### 1-1.2 Power Transmission

Output shaft counterclockwise (viewed from stern side)

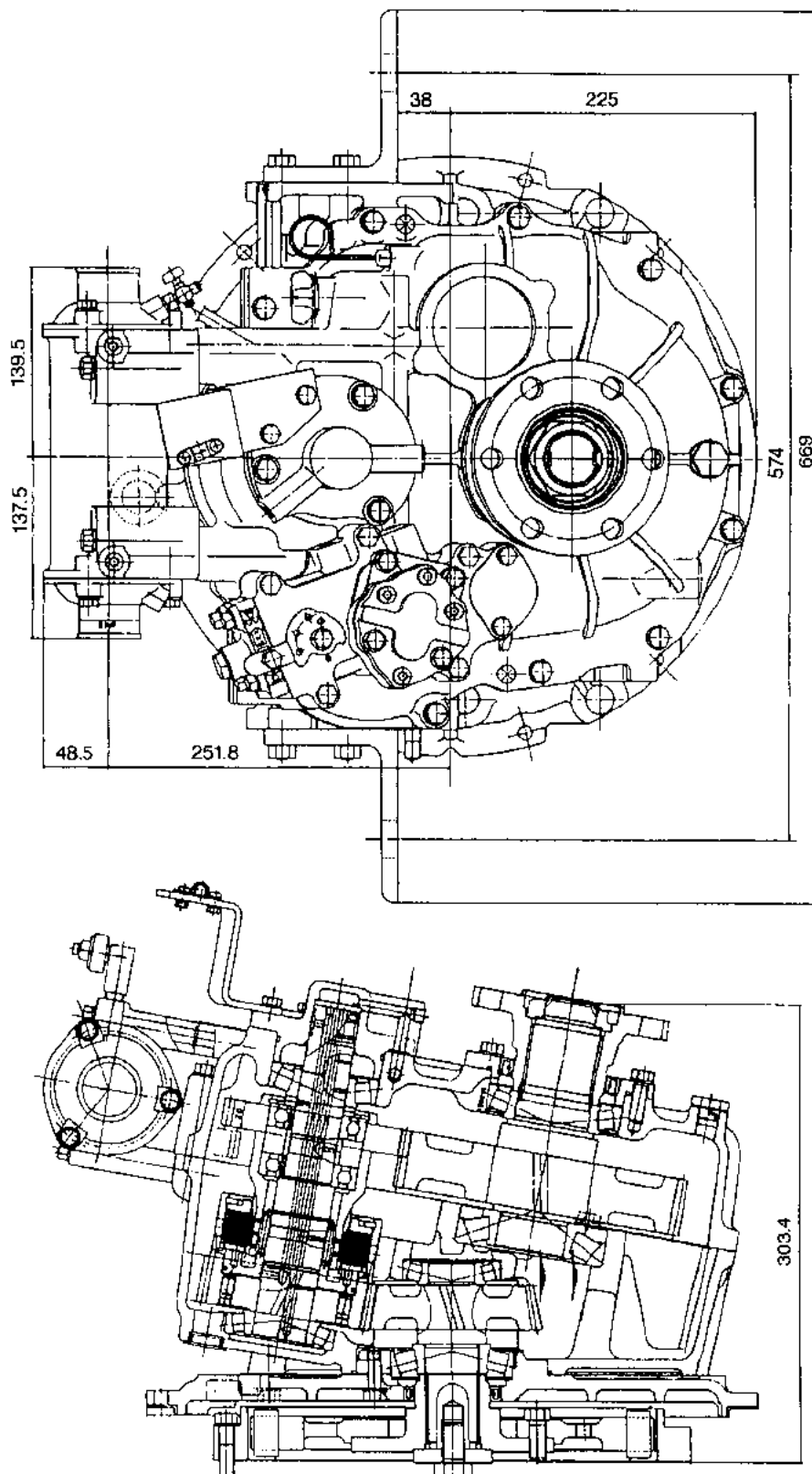
Engine→①→②→④→⑥

Output shaft clockwise (Viewed from stern side)

Engine→①→②→③→⑤→⑥



1-1.3. Sectional View

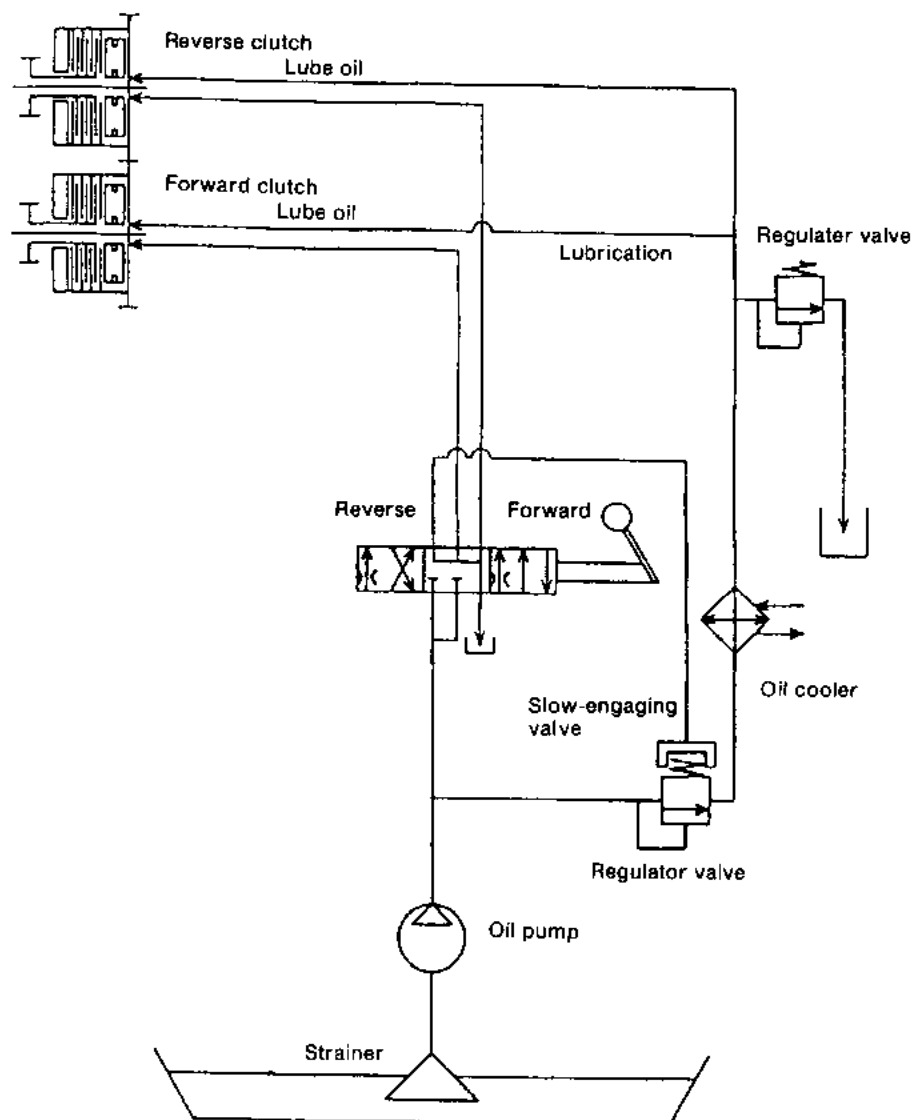


### 1-1.4 Hydraulic System

The lube oil, as shown in the hydraulic diagram, is sucked up through the strainer from the oil pan. The pressure is regulated by the hydraulic pressure adjust valve and the oil flow switched to each clutch by the forward/reverse switch valve. The pressure of the remaining oil other than the oil sent to the clutch is regulated by the lube oil pressure adjust valve for lubricating bearings and other parts. The gear faces and thrust bearings are lubricated by splash system. The hydraulic oil switched by the forward/reverse switch valve is sent to the forward/reverse

hydraulic cylinder for each respective motion. For smooth clutch engagement, it is possible to direct the hydraulic oil to the slow-engaging valve through the orifice of the switch valve to cause the pressure in the hydraulic cylinder to rise gradually.

When the switch lever is returned to the neutral position, the hydraulic oil pressing the slow-engaging valve and hydraulic cylinder is drained immediately to release the engagement.



### 1-1.5 Structure

The clutch is the hydraulic wet type multi-disc type and the spline of the forward/reverse pinion meshes with the steel plate of the internal circumference spline. The external circumference of the friction plate meshes with the internal circumference of the clutch housing.

The steel plates and friction plates are assembled by turns and when hydraulic pressure is applied to the hydraulic

cylinder, the steel plate and friction plate are press-fitted to make the clutch engage for power transmission.

When hydraulic oil is drained, the hydraulic cylinder is pressed back by the force of the internal spring, causing the steel plate and friction plate to be separated and release the engagement automatically.



### 1-1.6 Handling of Emergency Bolts

How to handle emergency bolts

- 1) Should the clutch become non-operable due to a failure in its hydraulic pressure system during operation, stop the engine.  
Remove the blanking cover of the clutch. First, tighten uniformly and loosely the two emergency bolts at the rotating part of the clutch turning them clockwise, and then retighten them firmly.
- 2) When this is done, the clutch is connected to the propeller counterclockwise-rotation side. The clutch becomes operable at a low speed (1000rpm or lower) for emergency use.

(Precaution)

High speed operation may cause seizure of the clutch disc or metal.

(Precautions)

- 1) When tightening the emergency bolts, turn and stop the engine at the position where each bolt comes in line with each hole for it. And then tighten the two bolts uniformly.
- 2) When the emergency bolts are used, the clutch is connected to the propeller clockwise-rotation side.  
No neutral and propeller clockwise rotation operations become available.  
Remember this when starting the engine or approaching a pier.
- 3) After returning to port using the emergency bolts, ask the nearest YANMAR dealer to service the engine as soon as possible.

### 1-1.7 Service Standard

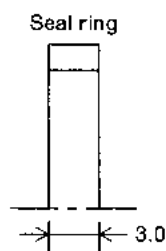
#### 1) Periodic Inspection

Check the marine gear periodically according to the following list.

Inspection interval	Check item	Procedure
Every day	Oil level	Completely insert the dipstick to check the oil level before starting the engine.
On oil change	Oil strainer	Clean.
Every 5000hrs.	Oil cooler	Clean the inside of the cooling pipe and cooler.
Every 2 years	Rubber block	Check for cracks and wear visually.

#### 2) Wear Limit of Major Parts

Part name	Measuring position	Wear limit	Measure
Friction plate, gear	Backlash	0.5	Replace
Steel plate pinion	Backlash	0.5	Replace
Seal ring	Width	0.8	Replace



#### 3) Parts to be replaced

Bearings	Replace them when rotation is not smooth or noise is caused by rotation.
Packings	Replace all on disassembly.
Rubber packings(O-rings, square rings)	Replace all on disassembly.
Rubber blocks	Replace them when a crack or wear is found.
Oil seal	Replace it when a scratch or wear is found on the surface.

## 2. Reassembly and disassembly (KMH6A)

### 2-1. Reassembly

#### 1. Disassembling marine gear and accessories

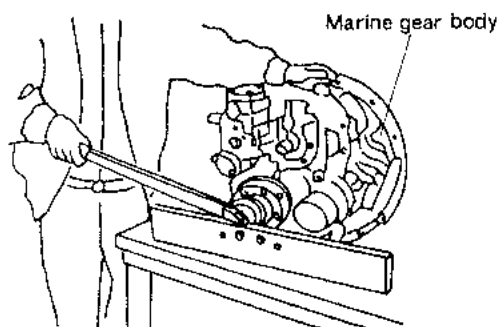
- (1) Remove the remote control cable and pipes and then remove the clutch from the engine.
- (2) Drain out the lube oil inside the clutch through the drain plug.
- (3) Remove the oil cooler.
- (4) Remove the oil pump.

(Caution):

When removing the oil pump, do not loosen the hexagon socket head cap screw.

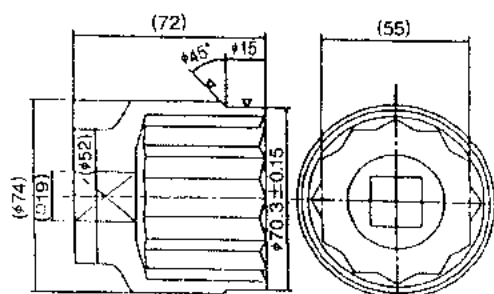
#### (5) Remove the output shaft coupling.

- 1) Raise the caulking (at two positions) of the locking nut with a chisel.
- 2) Fix the output shaft coupling to a work bench so that it cannot rotate.
- 3) Loosen the locking nut and remove the output shaft coupling.



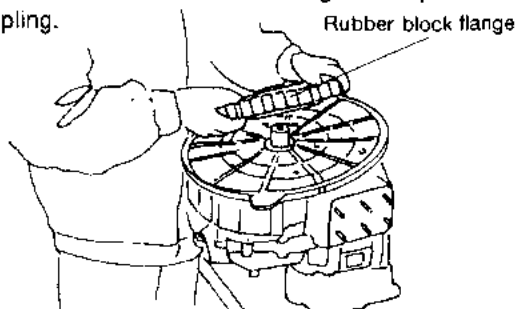
(Caution):

Make sure to use the type of a socket as shown below for the locking nut.

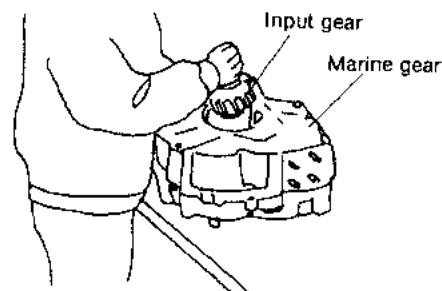


#### (6) Remove the input shaft coupling and input gear

- 1) Loosen the hexagon nut at the center of the input shaft and remove the rubber block flange and input shaft coupling.



- 2) Remove the mounting flange and take out the input gear.

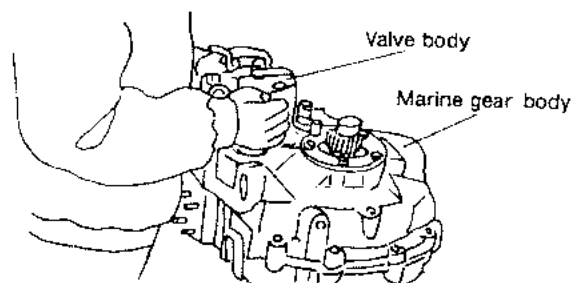


#### (7) Remove the support cover.

(Caution):

Be sure not to damage the shaft seal ring.

#### (8) Remove the valve body.



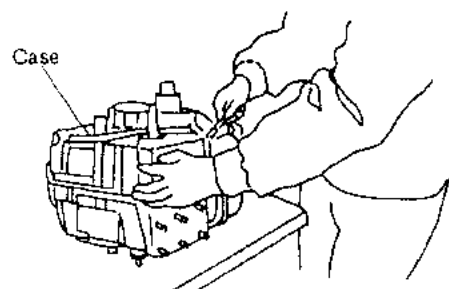
(Caution):

Be sure not to damage the shaft seal ring.

#### (9) Remove the output cover.

#### (10) Remove the case.

- 1) Remove all tightening bolts.
- 2) Couple bolts to screw holes and pull out Case B horizontally.

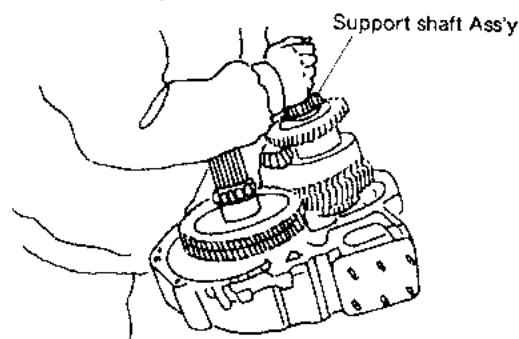


- (11) Take out the support shaft assembly and output shaft assembly.

(Caution):

The pinion gear of the support shaft assy can slip off easily.

Be careful not to drop it.

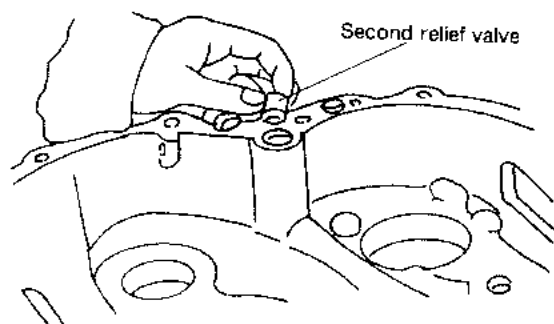


- (12) Take out the outer race of bearings from the case.

(Caution):

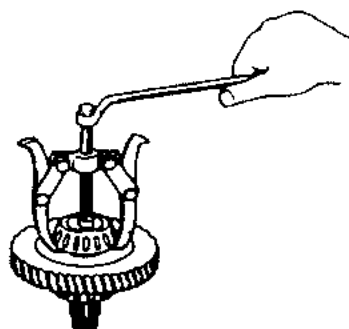
The outer race be taken out easily by warming the case with oil.

- (13) Take out the second relief valve from case B.



## 2-2. Disassembling input and output gears

- (1) Take out the bearing inner race from the input and output gears.



(Caution):

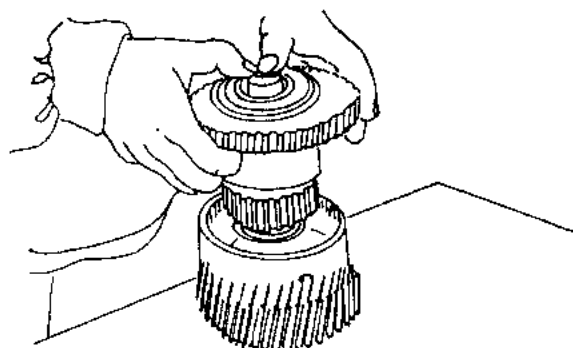
Do not disassemble the output and input gears because they are shrunk.

## 2-3. Disassembling support shafts A and B

- (1) Remove the seal rings from the support shafts.

(Caution):

Make sure not to flaw the seal ring because it is made of resin.

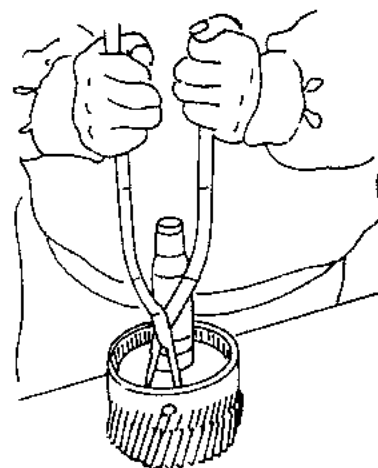


- (2) Remove the pinion gears from the support shafts.

(Caution):

The pinion gear bearings can easily be taken out by removing the circlip of the gear.

- (3) Remove the circlip of the driven gear to take out the back plate, friction plate, and steel plate.



- (4) Remove the circlip of the shaft by pressing the return spring several millimeters in a direction so that the spring goes away from the spring.

(Caution):

When the circlip is removed, the spring jumps up. Be careful.

- (5) Remove the hydraulic actuation cylinder.

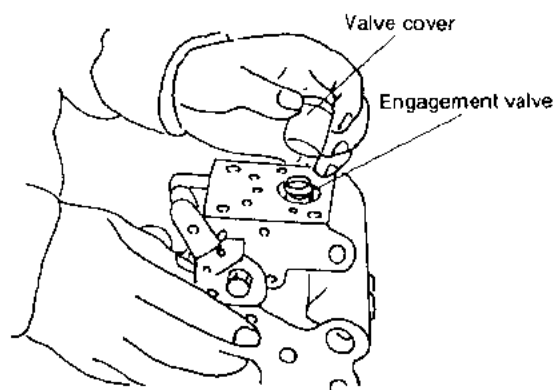
- 6) Remove the bearing inner race on the engine side using a pulley remover.

(Caution):

Do not disassemble the support shaft and drive (driven) gear because they are shrunk.

#### 2-4. Disassembling valve body

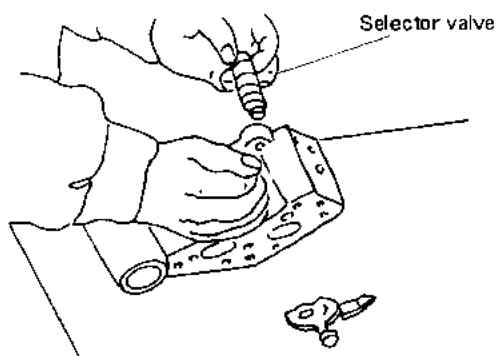
- (1) Remove the strainer lid and then remove the spring and strainer.  
(2) Remove the valve cover and then take out the loose engagement valve, inner and outer relief springs, and relief valve.



- (3) Remove bolts of the selector valve to take out the selector lever V.

(Caution):

Both the detent-use ball and the spring jump out. Be careful not to lose them.



## 3. Cautions for Reassembly

### 3-1. Cautions for Reassembly

- (1) Reassembly can be made by installing the parts in the reverse order to disassembly.

Clean all parts and take care not to include dust or metal chips. Also note the following points:

- 1) Replace the parts found to be defective due to oil leakage, etc. during the check before disassembly.
- 2) If a bearing makes abnormal sounds, check it for discoloration or abnormal wear of the rolling contact surface. Replace if the bearing is defective.
- 3) Replace all the parts which exceed the wear limit.
- 4) Take care to install the hydraulic pump in the correct direction.
- 5) Clean O-rings and other rubber parts in cleaning oil or wipe off dust. Apply grease to them before reassembly.
- 6) Replace all the packings.
- 7) There are two types of pinion gears with a reduction gear ratio of 1-58 (The axial position of the gears is different.) Make sure to use the correct one for assembly.

- 8) Assemble cases applying liquid packing (silicone-base) to the mating faces after oil is eliminated.

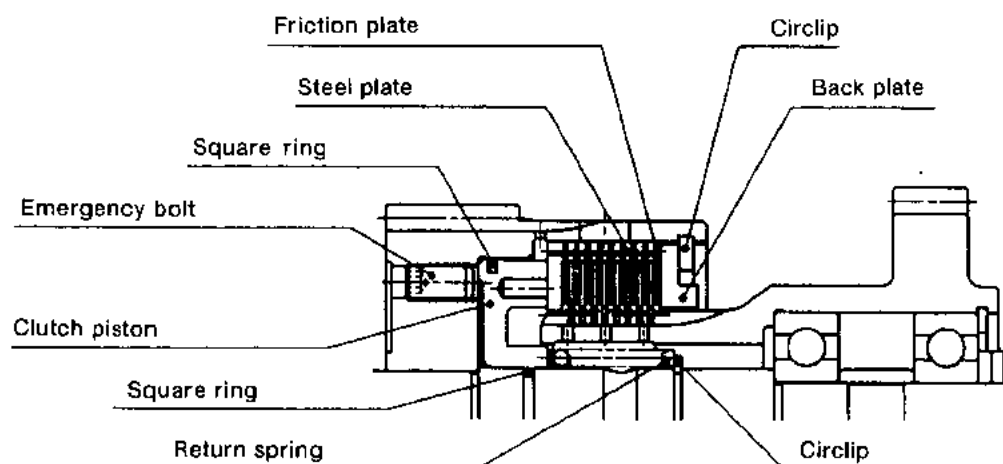
- 9) Assemble the case and the valve body applying liquid packing (silicone-base) to the mating faces after oil is eliminated.

(Caution):

*Make sure not to let the liquid packing flow into the oil hole of the valve body.*

- 10) Apply caulking to the output shaft nut at two positions after it has been tightened so that it will not rotate.
- 11) When installing the marine gear to the engine, always apply silicone oil to the rubber block.
- 12) Tighten bolts and nuts according to the torque listed in the tightening torque list.
- 13) Replace O-rings, square rings, oil seals, stoppers (split pins, bend washers) and other consumable parts at every disassembly.
- 14) Check for oil leakage and bolt tightness during oper

### (2) Reassembly of Clutch



#### Cautions for Clutch Reassembly

- 1) Apply grease to the square ring before assembling it to the hydraulic cylinder and shaft.
- 2) When installing the hydraulic cylinder, take special care not to catch the square ring in the clearance.
- 3) Assemble the friction plate and steel plate by turns. Be sure to keep the warp of steel plates in the same direction. (Spline is provided on the inner side of the steel plate.)

- 4) Both ends should have friction plates. (The number of friction plates is larger than steel plates by one piece.)
- 5) Couple the emergency bolts to the drive gear, and not to the drive gear.

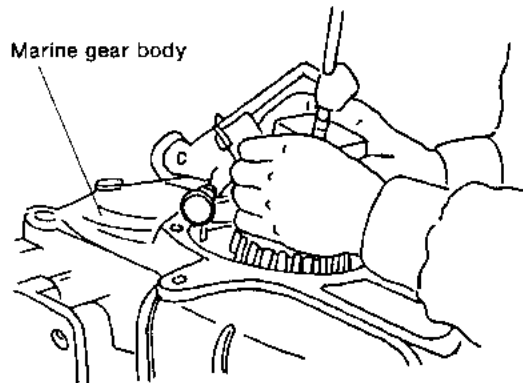
(Caution):

*Apply liquid packing (Silicone-base) to screw threads of the emergency bolts.*

(3) Shim adjustment

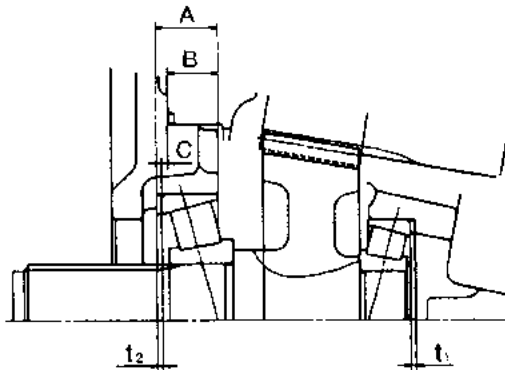
1) Input shaft

Measure backlash of the input and drive gears and adjust shim thickness  $t_1$  to make the backlash 0.12-0.20mm wide.



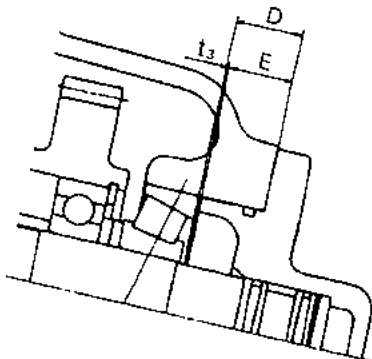
- After shim thickness  $t_1$  is determined, measure dimensions of A, B, and C to determine shim thickness  $t_2$ .

$$t_2 = (A - B - C) \pm 0.05\text{mm}$$



2) Support Shaft (A)

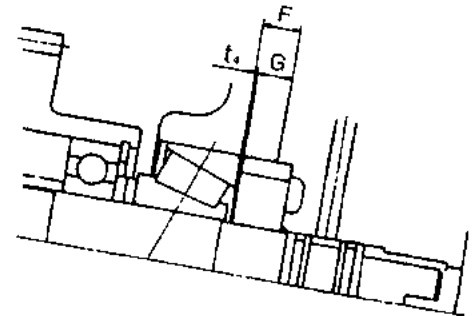
Adjust the clearance to the taper roller bearings.



- Measure D and E dimensions to determine shim thickness  $t_3$

$$t_3 = (D - E)\text{mm}$$

3) Support Shaft (B)

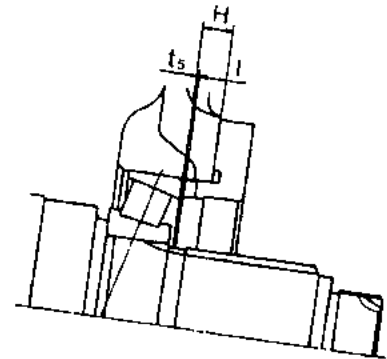


Adjust the clearance to the taper roller bearings.

- Measure F and G dimensions to determine shim thickness  $t_4$

$$t_4 = (F - G) \pm 0.05\text{mm}$$

4) Output Shaft



Adjust the clearance to the taper roller bearings.

- Measure F and G dimensions to determine shim thickness  $t_5$

$$t_5 = (F - G) \pm 0.1\text{mm}$$

## (4) Handling of Hydraulic Pump

Be sure to follow the instructions below for clutch disassembly and inspection and handling of the hydraulic pump.

- 1) Replace the hydraulic pump assembly and packing as one unit.
- 2) When removing the hydraulic pump from the clutch, remove only the pump fixing bolts and DO NOT loosen the assembly bolts of the pump. (Remove the hexagon bolts, but do not loosen the hexagon socket head bolt. If these bolts are loosened, the pump may not be reused.)
- 3) If the pump has been disassembled for any reason, tighten the bolts uniformly to ensure that the shaft turns lightly.
- 4) Do not handle the pump with a cloth or cloth gloves. This may cause clogging in the oil circuit.
- 5) Before reassembling the pump, supply oil to the pump and confirm that it turns lightly.
- 6) Install the pump and packing to the clutch and tighten the fixing bolts temporarily. Take care not to twist the joint of the pump coupling.
- 7) Strictly observe the tightening torque of  $210 \pm 20 \text{ kgf-cm}$ . Do not use the double-headed wrench for tightening the bolts. (Overtightening will cause pump seizure.)

## 3-2 Tightening Torque of Major Bolts

(kgf-m)

portion	KMH6A
Hydraulic pump installation bolts	M8 $2.1 \pm 0.2$
Input shaft coupling tightening bolts	M12 $9.0 \pm 1.0$
Input shaft stopper plate tightening bolts	M16 $23 \pm 1.5$
Output shaft nut	M40 $70 \pm 2.5$
Output shaft coupling bolt	M16 $23 \pm 1.5$

## 3-3 Standard Tightening Torque

(kgf-m)

Material	M8×1.25	M10×1.5
FC or steel material	$2.6 \pm 0.2$	$5.0 \pm 0.5$
Aluminum material	$2.1 \pm 0.2$	$4.0 \pm 0.2$

# REMOTE CONTROL(OPTIONAL)

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# 1. Remote Control System (Option)

## 1-1 Construction of remote control system

The remote control permits one handed control of the engine speed, changing from forward to reverse, and stopping.

Fittings which allow for easy connection of the remote control cables with the fuel injection pump and transmission are provided with the remote control set.

The use of Morse remote control cables, clamps and a remote control head, are also provided for. The device to stop the engine is electric and will be explained under the section on electrical equipment.

Use only Super-Responsive Morse Control Cables.

These are designed specifically for use with Morse control heads. This engineered system of Morse cables, control head and engine connection kits ensures dependable, smooth operation with an absolute minimum of backlash.

Too many bends (turns) in the cable or bends at too extreme an angle will make it difficult to turn the handle.

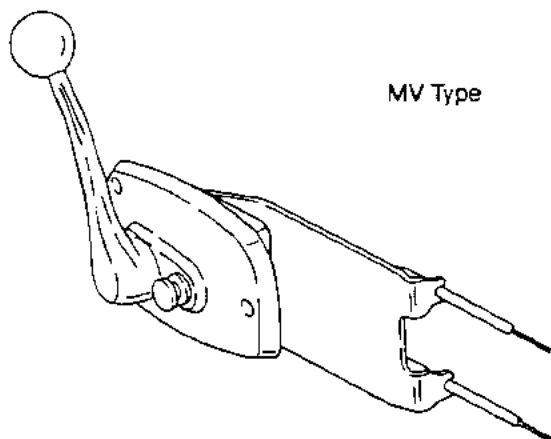
Reroute the cable to reduce the number of bends or enlarge the bending radius as much as possible (to 200mm or more).

Check for loose cable bracket/clamp bolts or nuts and retighten as necessary.

Check cable connection screwheads, cable sleeves and their metal parts for rust or corrosion. Clean off minor rust and wax or grease the parts. Replace if the parts are heavily rusted or corroded.

## 1-2 Remote control device components

	Morse description	Yanmar Part No.
Remote control head	Morse MV side mounting single lever	128170-86500

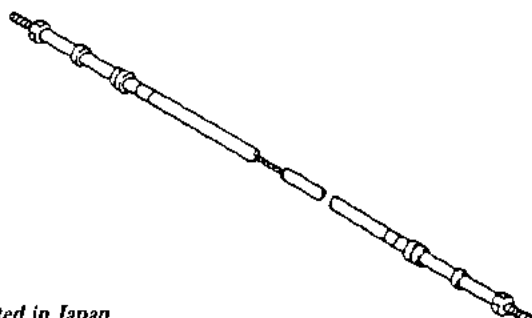


MV Type

The MV type controller has been designed so that operation of the clutch and throttle can be effected with one lever. When the button next to the control lever is pulled out with the lever in the central position, it holds the clutch in the neutral position so that the throttle can be opened all the way and warm up the engine.

When the engine is warmed up, return the handle to the central position and push the button back in. Control of the clutch and throttle is thus effected with one handle.

### (2) Remote control cable

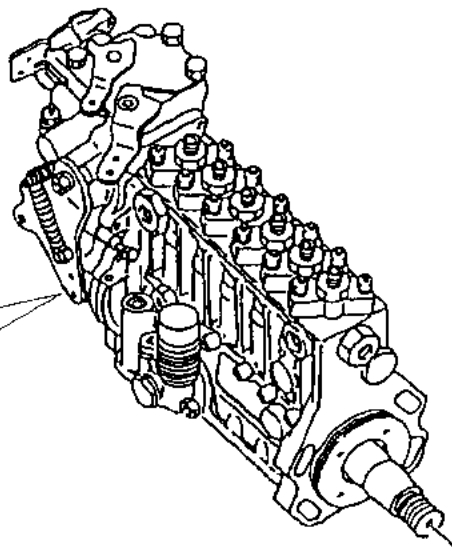
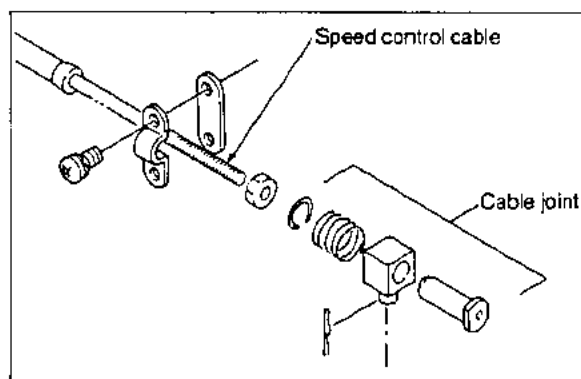


## 2. Remote Control Installation

### 2-1 Speed control

Move the control lever all the way to full throttle several times, and then return. The throttle lever on the engine must lightly push against the idle stop when it is returned. If it is properly adjusted, the knob can be easily pulled out when the lever is in the neutral position, and will automatically return when the control lever is brought back to the neutral position. If the control lever

presses too hard against the knob, it may not return automatically, in which case the cable end must be adjusted as explained for the clutch. The knob cannot be pulled out when the lever is not in the neutral (central) position.



### 2-2 Ahead-neutral-astern control

Move the lever several times. The movement of the clutch lever on the transmission must coincide with the forward, neutral and reverse on the control lever.

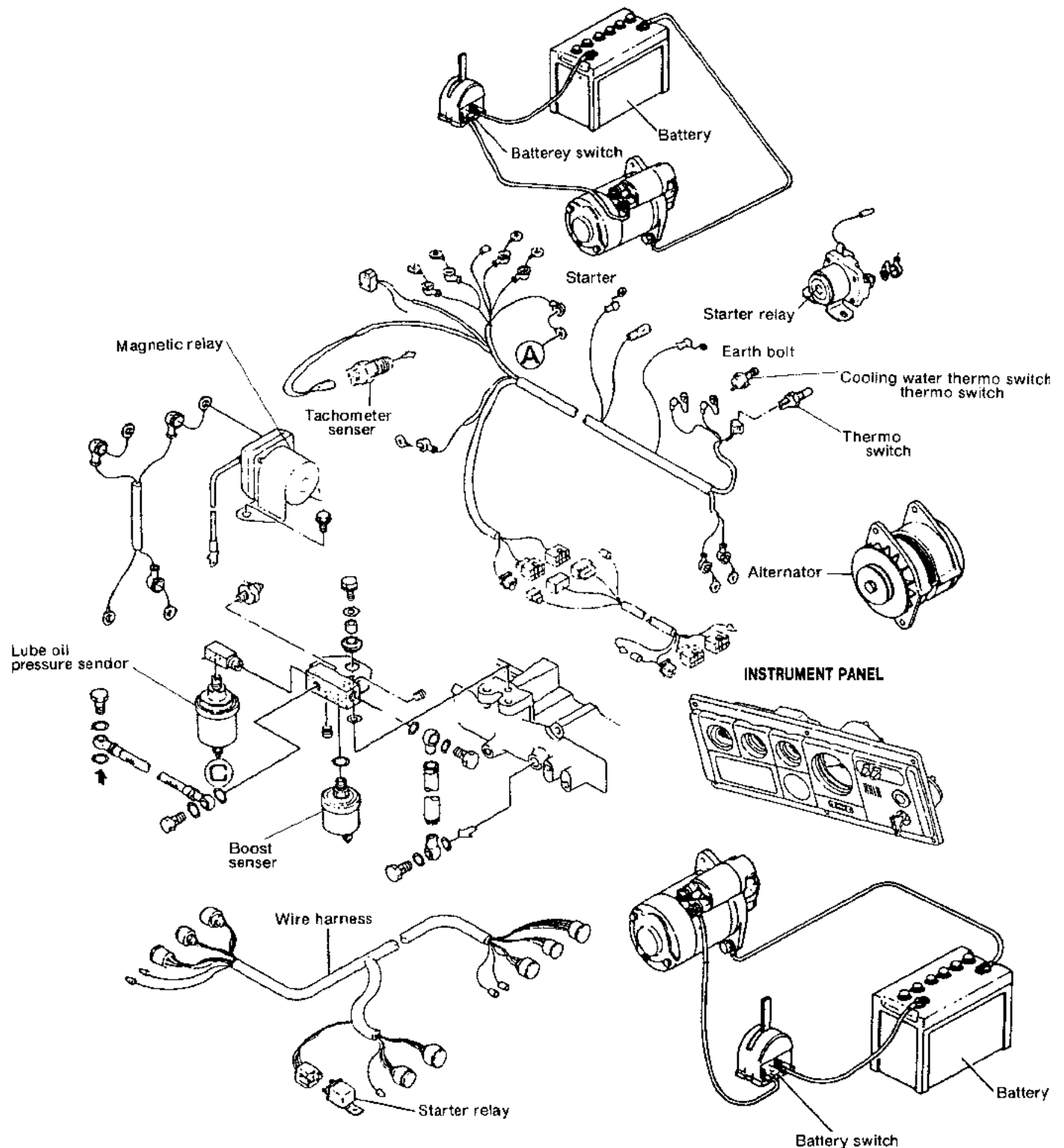
If they do not coincide, adjust the fittings as necessary (first transmission side, then controller side).

# ELECTRICAL SYSTEM

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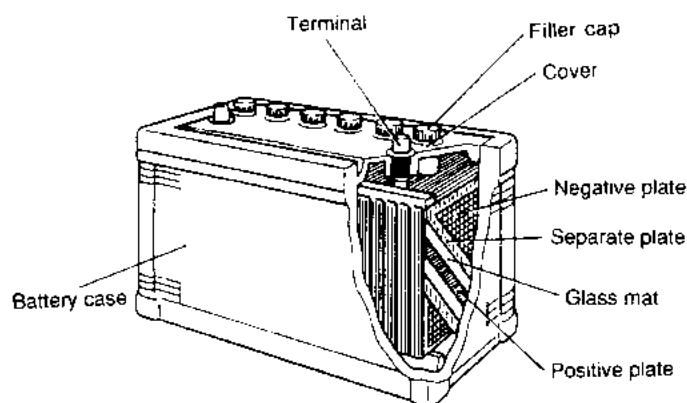
# 1. System Diagram

## 1-1 System diagram of electric parts



## 2. Battery

### 2-1 Construction



The battery utilizes chemical action to convert chemical energy to electrical energy. This engine uses a lead acid battery which stores a fixed amount of power that can be used when required. After use, the battery can be recharged and used again.

As shown in the figure, a nonconductive container is filled with dilute sulfuric acid electrolyte. Lead dioxide positive plates and lead dioxide negative plates separated by glass mats are stacked alternately in the electrolyte. The positive and negative plates are connected to their respective terminals.

Power is removed from the battery by connecting the load across these two terminals.

When the battery is discharging, an electric current flows from the positive plates to the negative plates. When the battery is being charged, electric current is passed through the battery in the opposite direction by an external power source.

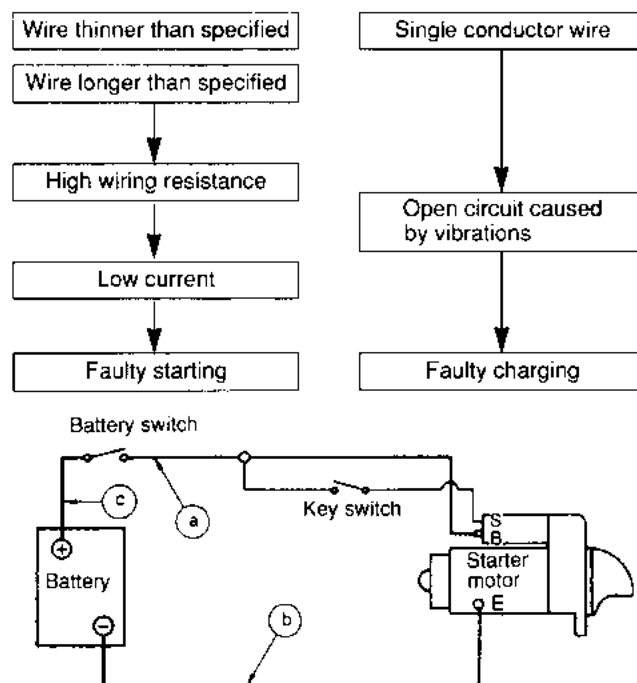
### 2-2 Battery capacity and battery cables

#### 2-2.1 Battery capacity

Battery capacity	standard	12V-120AH
	cold weather	12V-150AH
Full charged specific gravity		1.26

#### 2-2.2 Battery cable

Wiring must be performed with the specified electric wire. Thick, short wiring should be used to connect the battery to the starter, (soft automotive low-voltage wire [AV wire]). Using wire other than that specified may cause the following troubles:



The overall lengths of the wire between the battery (+) terminal and the starter (B) terminal, and between the battery (-) terminal and the starter (E) terminal, should be determined according to the following table.

Voltage system	Allowable wiring voltage drop	Conductor cross-section area	a+b+c allowable length
12V	0.2V or less/100A	20mm <sup>2</sup>	UP to 3.5m
		40mm <sup>2</sup>	UP to 7 m

*Note: Excessive resistance in the key switch circuit (between the battery and start [S] terminals) can cause improper pinion engagement. To prevent this, follow the wiring diagram carefully.*

### 2-3 Inspection

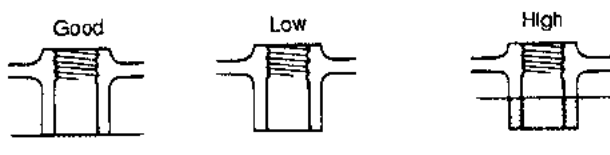
The quality of the battery governs the starting performance of the engine. Therefore the battery must be routinely inspected to ensure that it functions perfectly at all times.

#### 2-3.1 Visual inspection

- (1) Inspect the case for cracks, damage and electrolyte leakage.
  - (2) Inspect the battery holder for tightness, corrosion, and damage.
  - (3) Inspect the terminals for rusting and corrosion, and check the cables for damage.
  - (4) Inspect the caps for cracking, electrolyte leakage and clogged vent holes.
- Correct any abnormal conditions found. Clean off rusted terminals with a wire brush before reconnecting the battery cable.

### 2-3.2 Checking the electrolyte

#### (1) Electrolyte level

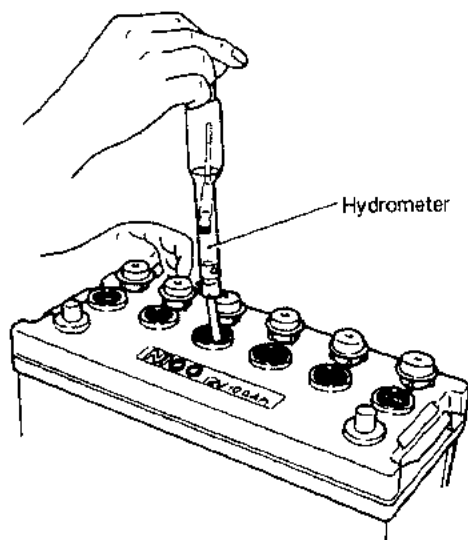


Check the electrolyte level every 7 to 10 days. The electrolyte must always be 10~20mm (0.3937~0.7874in.) over the top of the plates.

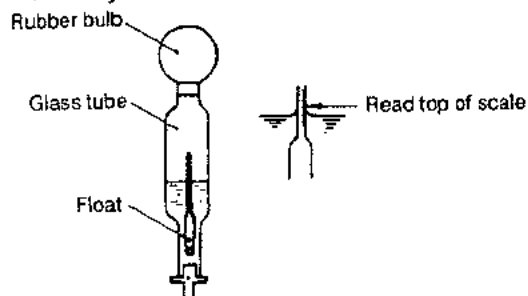
- NOTES: 1. The "LEVEL" line on a transparent plastic battery case indicates the height of the electrolyte.  
2. Always use distilled water to bring up the electrolyte level.  
3. When the electrolyte has leaked out, add dilute sulfuric acid with the same specific gravity as the electrolyte.

#### (2) Measuring the specific gravity of the electrolyte

- 1) Draw some of the electrolyte up into a hydrometer.



- 2) Take the specific gravity reading at the top of the scale of the hydrometer.



- 3) The battery is fully charged if the specific gravity is 1.260 at an electrolyte temperature of 20°C. The battery is discharged if the specific gravity is 1.200

(50%). If the specific gravity is below 1.200, recharge the battery.

- 4) If the difference in the specific gravity among the cells of the battery is  $\pm 0.01$ , the battery is OK.
- 5) Measure the temperature of the electrolyte. Since the specific gravity changes with the temperature, 20°C is used as the reference temperature. Reading the specific gravity at 20°C  

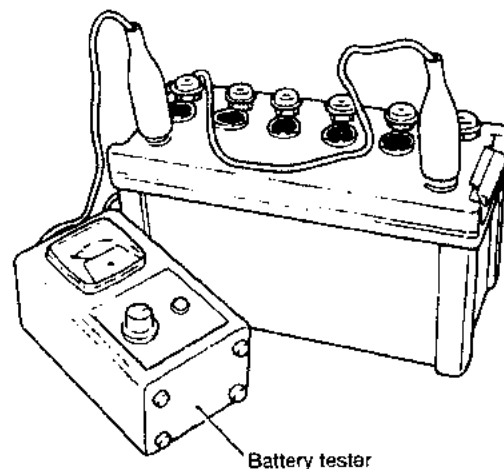
$$S_{20} = S_t + 0.0007(t - 20)$$

$$S_{20}$$
: Specific gravity at the standard temperature of 20°C  

$$S_t$$
: Specific gravity at the electrolyte at t°C  
0.0007: Specific gravity change per 1°C  
t: Temperature of electrolyte

### 2-3.3 Voltage test

Using a battery tester, the amount of discharge can be determined by measuring the voltage drop which occurs while the battery is being discharged with a large current.



- (1) Connect the tester to the battery.  
12V battery tester  
Adjust the current (A).
- (2) Connect the (+) lead of the tester to the (+) battery terminal, and the (-) tester lead to the (-) battery terminal.
- (3) Push the TEST button, wait 5 seconds, and then read the meter.  
• Repeat the test twice to make sure that the meter indication remains the same.

### 2-3.4 Washing the battery.

- (1) Wash the outside of the battery with a brush while running cold or warm water over the battery. (Make sure that no water gets into the battery.)
- (2) When the terminals or other metal parts are corroded due to exposure to electrolyte leakage, wash off all the acid.
- (3) Check the vent holes of the caps and clean if clogged.
- (4) After washing the battery, dry it with compressed air, connect the battery cable, and coat the terminals with grease. Since the grease acts as an insulator, do not coat the terminals before connecting the cables.

## 2-4 Charging

### 2-4.1 Charging methods

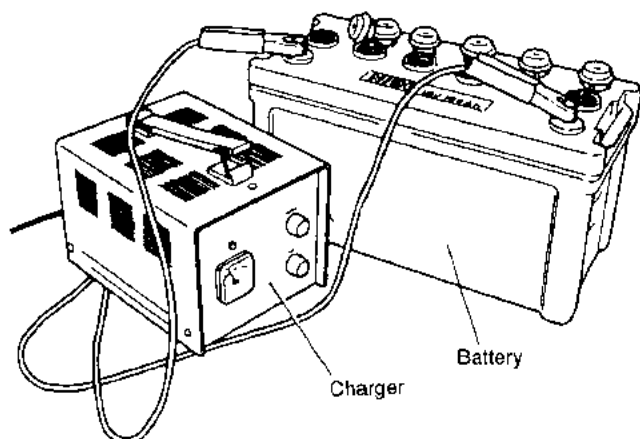
There are two methods of charging a battery: normal and rapid.

Rapid charging should only be used in emergencies.

- Normal charging...Should be conducted at a current of 1/10 or less of the indicated battery capacity (10A or less for a 100AH battery).
- Rapid charging...Rapid charging is done over a short period of time at a current of 1/5 ~ 1/2 the indicated battery capacity (20A ~ 50A for a 100AH battery). However, since rapid charging causes the electrolyte temperature to rise too high, special care must be exercised.

### 2-4.2 Charging procedure

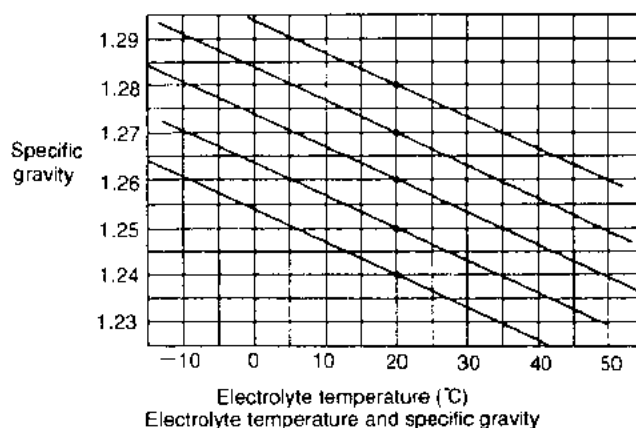
- (1) Check the specific gravity and adjust the electrolyte level.
- (2) Disconnect the battery cables.
- (3) Connect the red clip of the charger to the (+) battery terminal and connect the black clip to the (-) terminal.



- (4) Set the current to 1/10 ~ 1/5 of the capacity indicated on the outside of the battery.
- (5) Periodically measure the specific gravity during charging to make sure that the specific gravity remains at a high fixed value. Also check whether gas is being generated.

### 2-4.3 Charging precautions

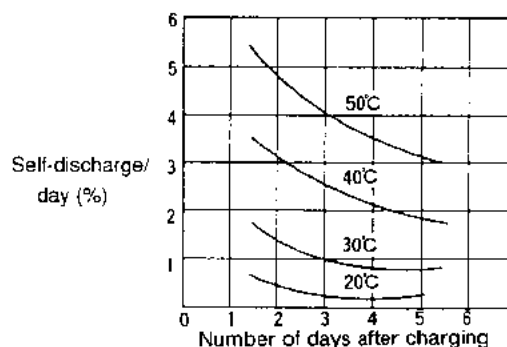
- (1) Remove the battery caps to vent the gas during charging.
- (2) While charging, ventilate the room and prohibit smoking, welding, etc.
- (3) The electrolyte temperature should not exceed 45°C during charging.
- (4) Since an alternator is used on this engine, when charging with a charger, always disconnect the battery (+) cable to prevent destruction of the diodes. (Before disconnecting the (+) battery cable, disconnect the (-) battery cable [ground side].)



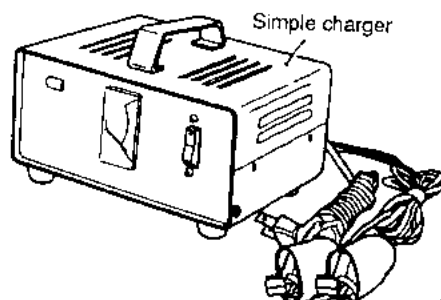
## 2-5 Battery storage precautions

The life of a battery depends considerably on how it is handled. Generally speaking, however, after about two years its performance will deteriorate, starting will become difficult, and the battery will not fully recover its original charge even after recharging. Then it must be replaced.

- (1) Since the battery will self-discharge about 0.5% / day even when not in use, it must be charged 1 or 2 times a month when it is being stored.



- (2) If charging by the engine alternator is insufficient because of frequent starts and stops, the battery will rapidly lose power. Charge the battery as soon as possible after it is used under these conditions.
- (3) An easy-to-use battery charger that permits home charging is available from Yanmar. Take proper care of the battery by using the charger as a set with a hydrometer. When the specific gravity has dropped to about 1.16 and the engine will not start, charge the battery up to a specific gravity of 1.26 (24 hours).
- (4) Before putting the battery in storage for long periods, charge it for about 8 hours to prevent rapid aging.



## 3. Starter Motor

The starter motor is installed on the flywheel housing. When the starting button is pushed, the starter motor pinion flies out and engages the ring gear of the flywheel. Then the main contact is closed, current flows, and the engine is started.

After the engine starts, the pinion automatically returns to its initial position when the starting button is released.

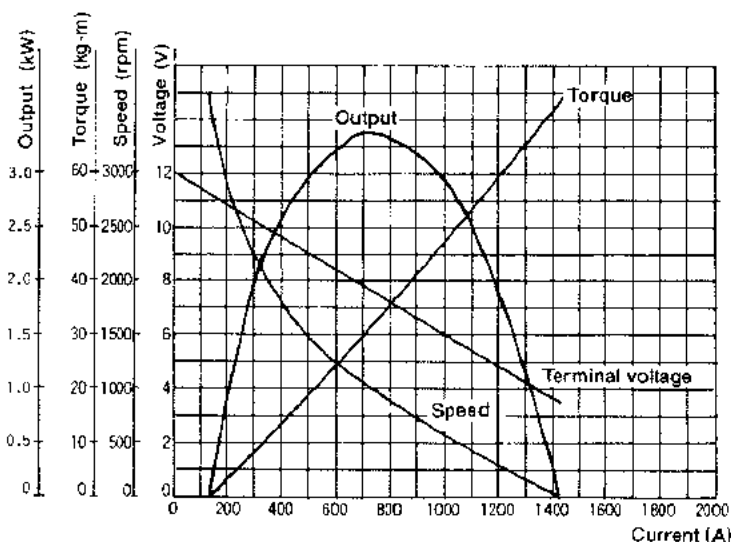
Once the engine starts, the starting button should be released immediately. Otherwise, the starter motor may be damaged or burned out.

### 3-2 Features

- (1) The starter motor is compact and produces high output through high speed revolutions. It has increased torque by employing a reduction gear to reduce the speed between the armature and the pinion.
- (2) The use of ball bearings at the armature shaft (front and rear sides) and the needle bearings for the gear shaft (rear side) has boosted the durability of the starter motor.

### 3-1 Specifications and Performance

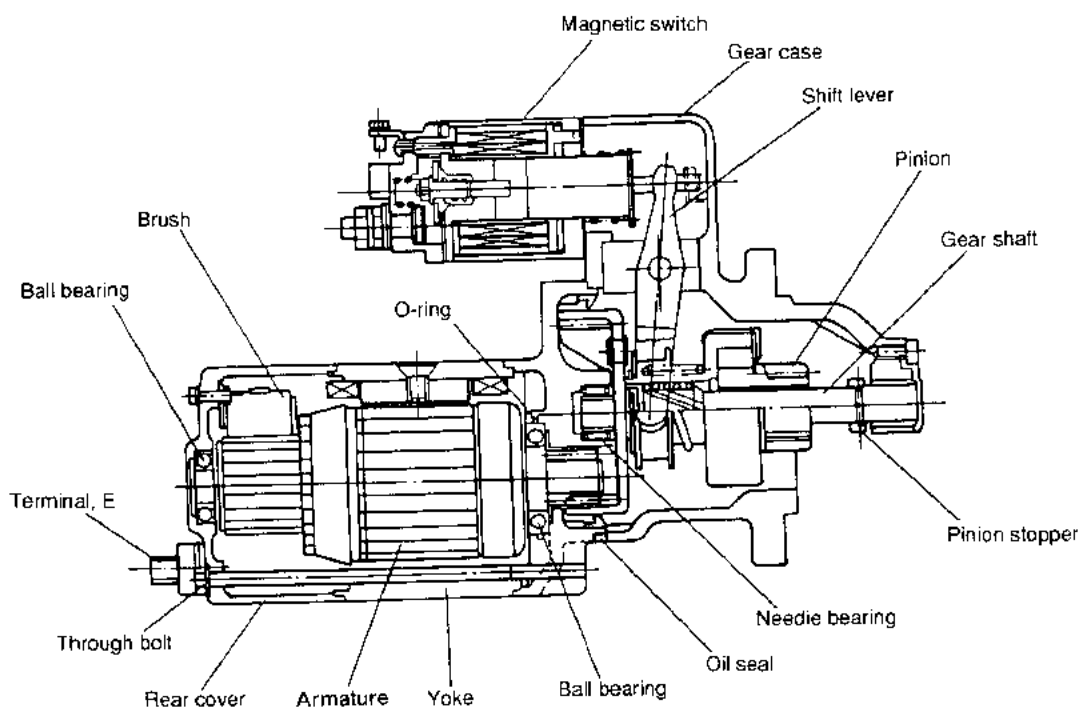
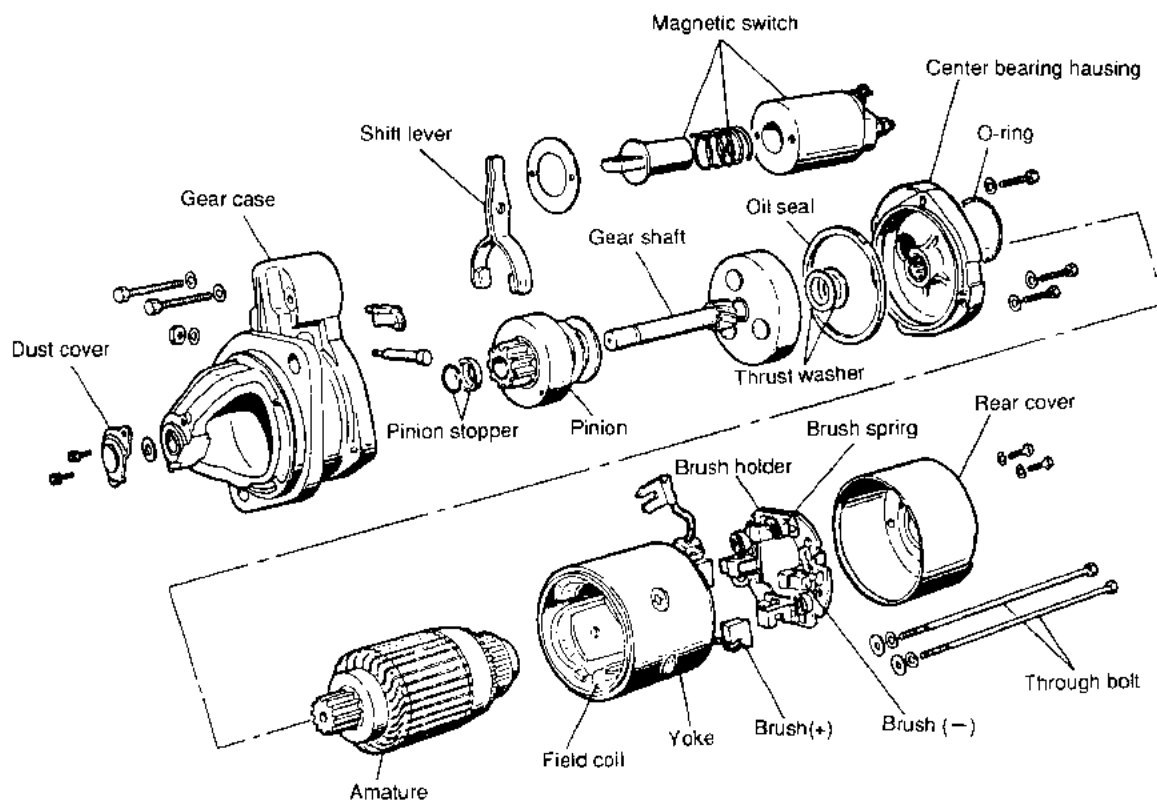
Engine model		6LYA-UTE,STE
Model		S13-68A
Rating (sec.)		30
Output (kW)		3
Direction of rotation (viewed from pinion side)		Clockwise
Weight kg (lb.)		7.5
Clutch system		Overrunning
Engagement system		Magnetic shift
No. of pinion teeth		11
Pinion flyout voltage (V)		8 or less
No-load	Terminal voltage (V)	12
	Current (A)	180 or less
	Speed (rpm)	3000 or more
Loaded characteristics	Terminal voltage (V)	9
	Current (A)	500A MAX.
	Speed (rpm)	1270 or more
	Torque kg-m	1.7 or more



Performance curves

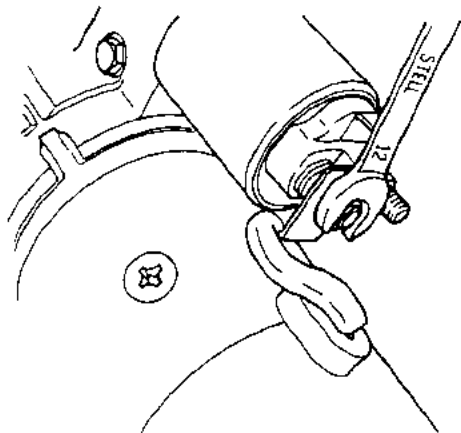


### 3-3 Construction

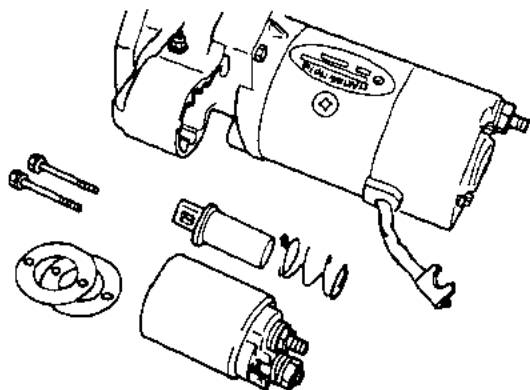
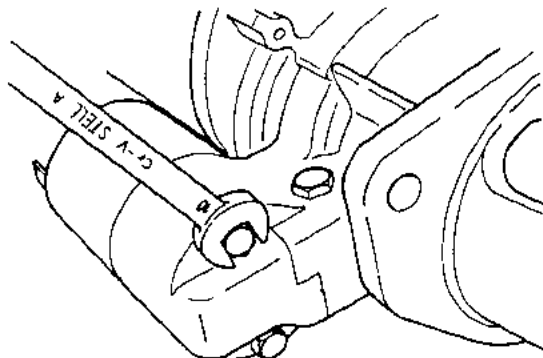


## 3-4 Disassembly

- (1) Disconnect the magnetic switch wiring.  
Loosen the M8, nut and disconnect the magnetic switch wiring.

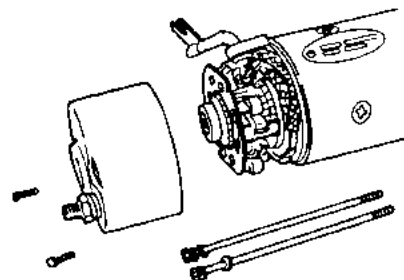
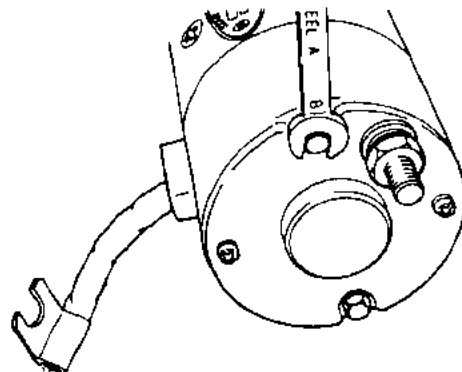


- (2) Remove the magnetic switch.  
Remove the two M6 bolts.



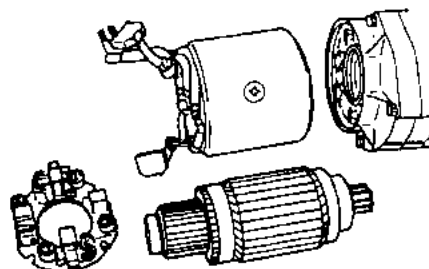
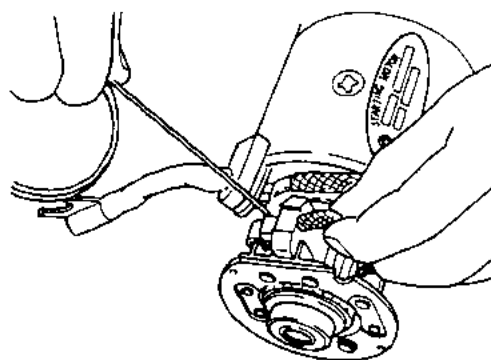
- (3) Remove the rear cover.

- 1) Remove the two screws holding the brush holder.
- 2) Remove the two M5 through bolts.
- 3) Remove the rear cover, using the minus (—) driver.



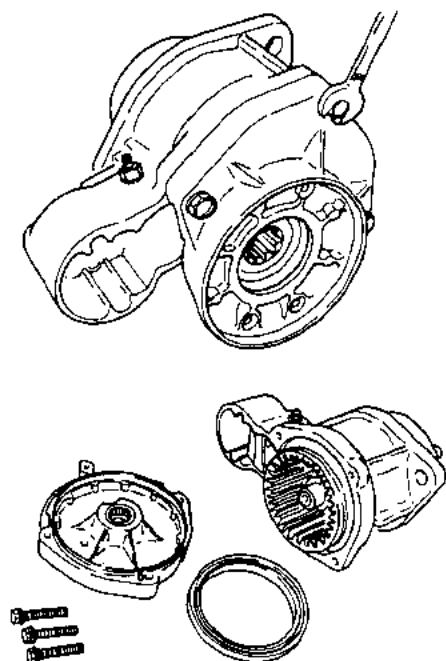
- (4) Remove the brush holder.

- 1) Float the minus (—) brush from the commutator.
- 2) Remove the plus (+) brush from the brush holder.
- 3) Remove the armature from the yoke.



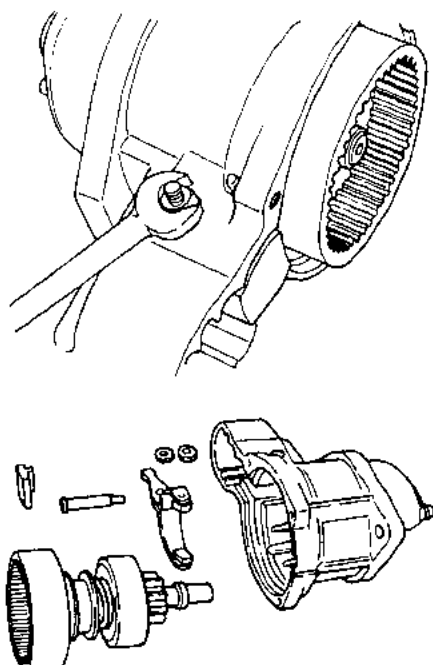
(5) Remove the center bearing housing.

- 1) Remove the three M6 bolts from the gear case.
- 2) Remove the center bearing housing and oil seal from the gear case.



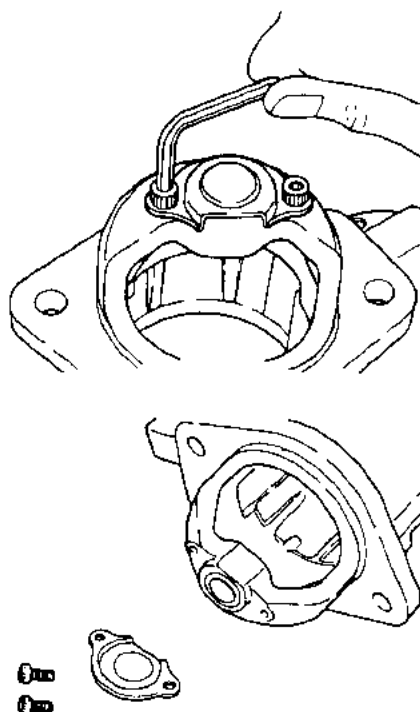
(6) Remove the shift lever pin.

- 1) Remove the M6 bolt from the gear case.
- 2) Remove the shift lever pin from gear case.



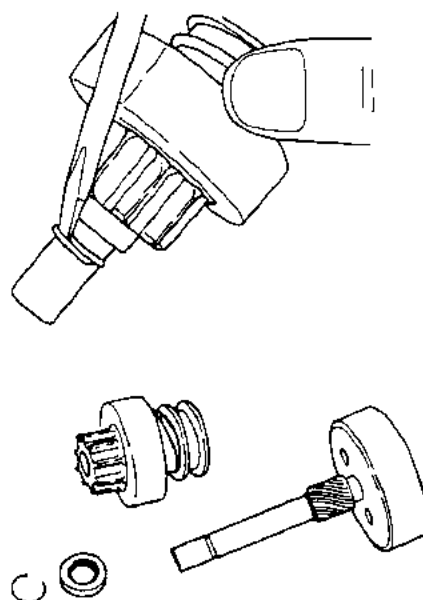
(7) Remove the dust cover.

- 1) Remove the two M5 bolts.
- 2) Remove the dust cover from the gear case.



(8) Remove the pinion.

- 1) Slide the pinion stopper to the pinion side.
- 2) Remove the pinion stopper clip, using the minus (—) driver.
- 3) Remove the pinion from the gear shaft.



## 3-5 Maintenance standard

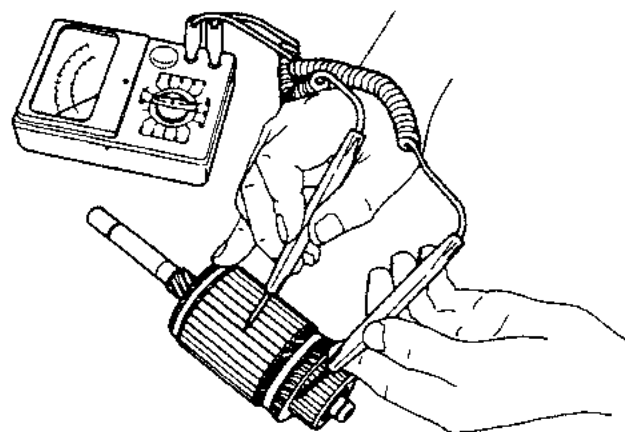
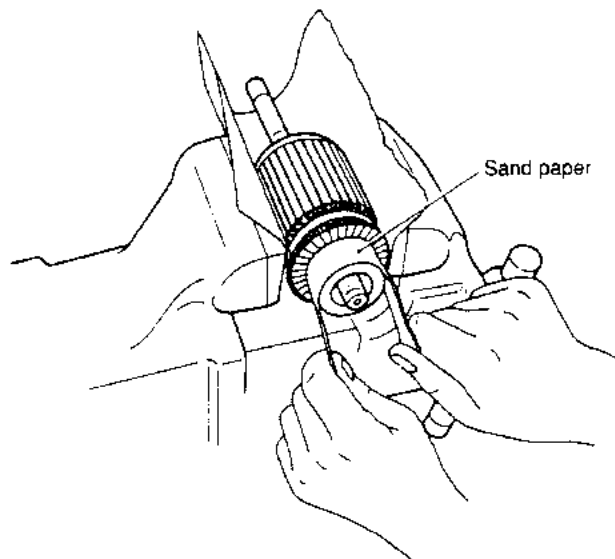
Model				SI3-68A
Brush	Standard spring load		kg	3.2
	Standard height		mm	18
	Wear limit		mm	6.5
Magnetic switch	Series coil resistance		Ω	0.21
	Shunt coil resistance		Ω	0.67
Commutator	Outside diameter	Maintenance standard	mm	37
		Wear limit	mm	36
	Deflection	Repair limit	mm	0.1
		Repair accuracy	mm	0.05
	Mica undercut	Maintenance standard	mm	0.2
		Repair limit	mm	0.5~0.8
Standard dimension	Armature shaft diameter	Deflection	mm	below 0.08
	Pinion sliding section	Shaft diameter	mm	15.950~15.968
		Hole diameter	mm	16.03~16.05
	Gearcase	Shaft diameter	mm	15.950~15.968
		Hole diameter	mm	16.0~16.018

### 3-6 Inspection

#### 3-6.1 Armature

##### (1) Commutator.

Inspect the surface of the commutator. If corroded or pitted, sand with #500 ~ #600 sandpaper. If the commutator is severely pitted, grind it to within a surface roughness of at least 0.1mm (0.0039 in) by turning it on a lathe. Replace the commutator if damage is irreparable.

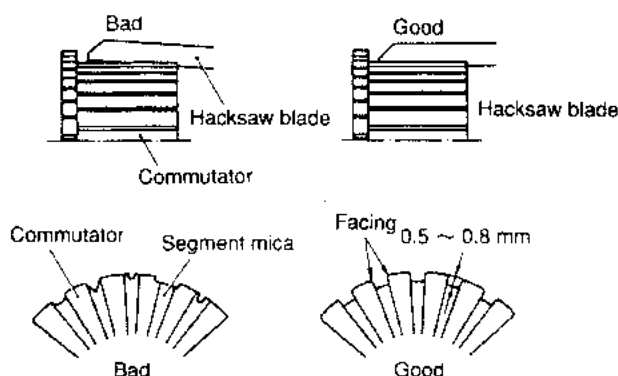


Kind of test	Check point	Normal	Abnormal
Continuity	Commutator between armature	YES	NO (Broken or disconnected coil)
Insulation	Commutator between armature or shaft	NO	YES (Short-circuit)

Model	SI3-68A	
	Maintenance standard	Wear limit
Commutator outside diameter	$\phi 37$	$\phi 36$
Deflection	Repair limit 0.1	Repair accuracy 0.05

##### (2) Mica undercut

Check the mica undercut, correct with a hacksaw blade when the undercut is too shallow.

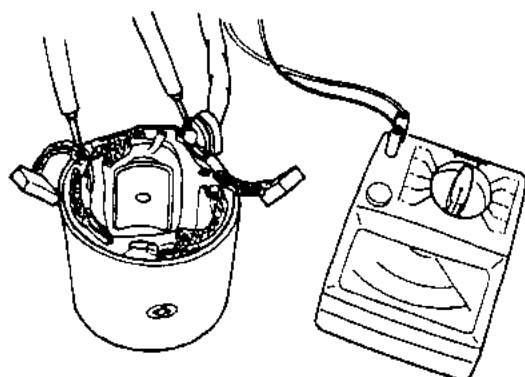


	Maintenance standard	Repair limit
Mica undercut	0.2	0.5 ~ 0.8

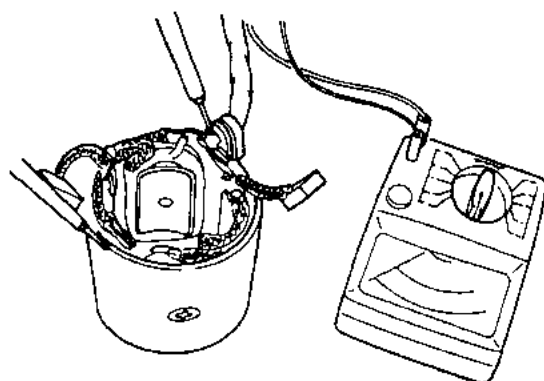
mm (in.)

### 3-6.2 Field coil

#### (1) Field coil continuity and ground test.



Field coil insulation test



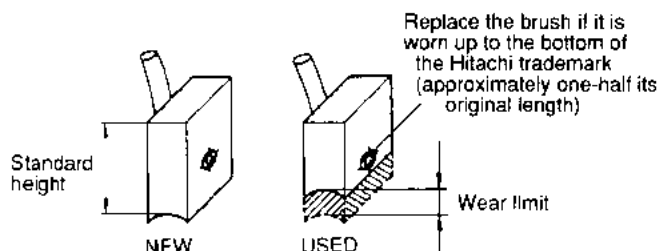
Field coil continuity test

Kind of test	Check point	Normal	Abnormal
Continuity	Terminal between field coil	YES	NO (Wiring broken)
Insulation	Field coil between yoke	NO	YES (Short-circuit)

### 3-6.3 Brush

#### (1) Brush dimensions

Replace brushes which have been worn beyond the specified wear limit.

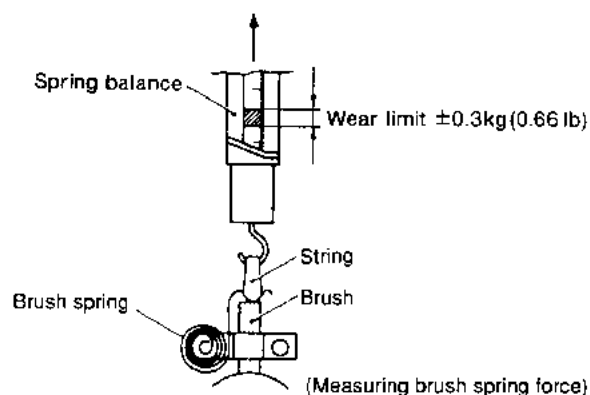


	mm
	S13-68A
Brush standard height	18
Wear limit	6.5

- (2) Brush appearance and movement in brush holder If the outside of the brush is damaged, replace it. If the movement of the brushes in the brush holder is hampered because the holder is rusted, repair or replace the holder.

#### (3) Brush spring

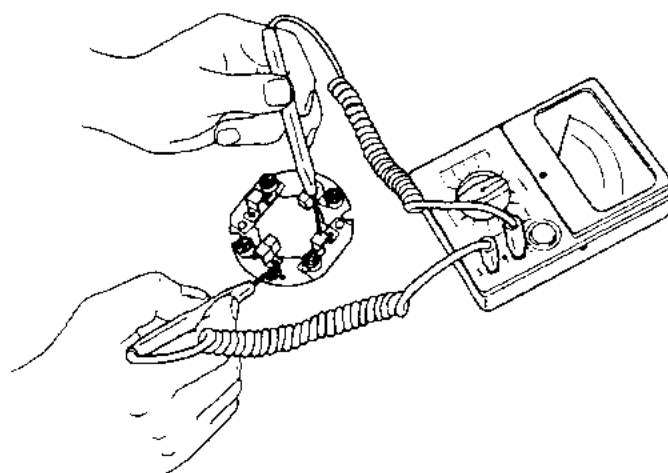
Since the brush spring pushes the brush against the commutator while the motor is running, a weak or defective spring will cause excessive brush wear, resulting in sparking between the brush and the commutator during operation. Measure the spring force with a spring balance; replace the spring when the difference between the standard value and the measured value exceeds  $\pm 0.3\text{kg}$  (0.66 lb)



	S13 68A
Standard spring load	3.2kg

#### (4) Brush holder ground test

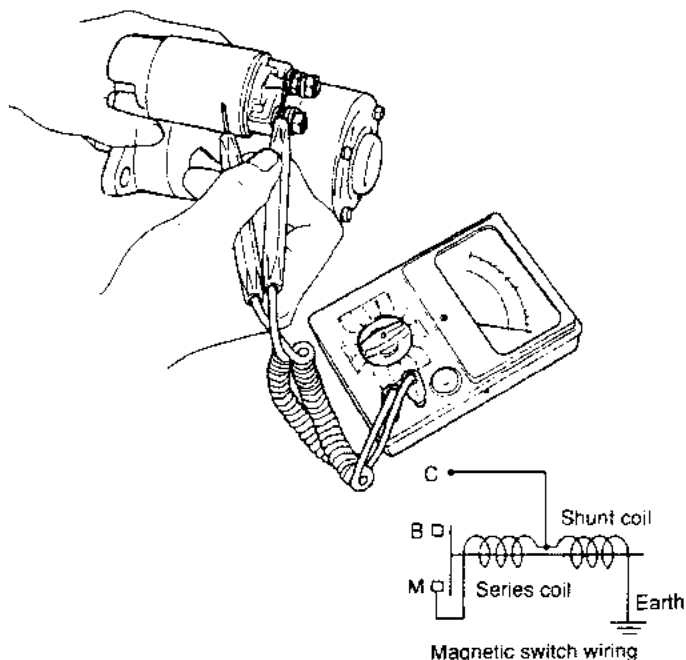
Check for continuity between the insulated brush holder and the base of the brush holder assembly. Continuity indicates that these two (—between +) points are grounded and that the holder must be replaced.



### 3-6.4 Magnetic switch

#### (1) Shunt coil continuity test

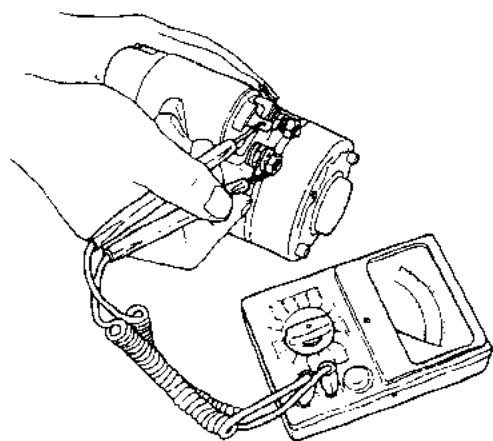
Check for continuity between the S terminal and the magnetic switch body (metal part). Continuity indicates that the coil is open and that the switch must be replaced.



	S13-68A
Coil resistance (at 20°C)	0.62Ω

#### (2) Series coil continuity test

Check for continuity between the S terminal and M terminal. Continuity indicates that the coil is open and that it must be replaced.



	S13-68A
Resistance value (at 20°C)	0.21Ω

### 3-6.5 Pinion

- (1) Inspect the pinion teeth and replace the pinion if the teeth are excessively worn or damaged.
- (2) Check if the pinion slides smoothly; replace the pinion if faulty.
- (3) Inspect the springs and replace if faulty.

### 3-6.6 Ball bearing

- (1) Check whether the ball bearing makes any abnormal sound and replace the ball bearing if necessary.

### 3-7 Reassembly precautions

Reassemble the starter motor in the reverse order of disassembly, paying particular attention to the following:

- (1) Lubrication  
Lubricate each bearing and spline with high quality "Hitachi Electrical Equipment Grease A". The following lubricants may be used in place of Hitachi Electrical Equipment Grease A.

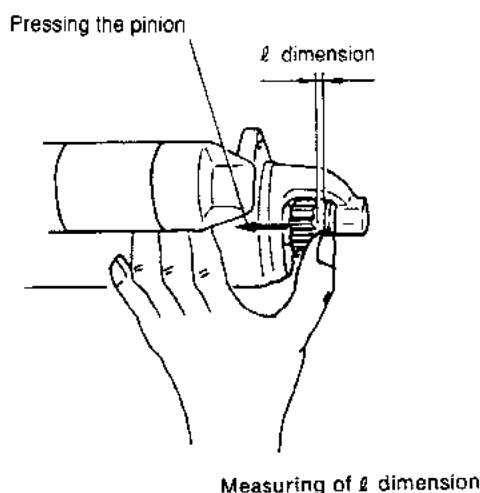
Magnetic switch plunger	Shell	Aeroshell No.7
Bearing and spline	Shell	Albania Grease No.2
Reduction gear	Shell	Aeroshell No.7
Sliding of shift lever	Shell	Aeroshell No.7

### 3-8 Adjustment and performance test

- (1) L-size measurement (gap between pinion and pinion stopper)

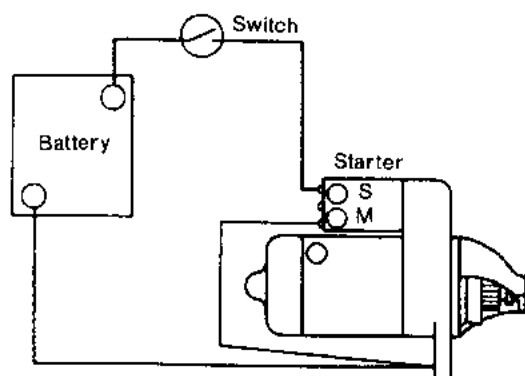
When the pinion is at the projected position, measure the gap between the pinion and pinion stopper. This check should be made with the pinion pressed back lightly to take up any play in the engagement linkage.

		mm
	Starter motor	ℓ dimension
	S13-68A	0.3~1.5



## (2) Pinion movement

After complete assembly of the starter motor, connect up the motor as in Fig.

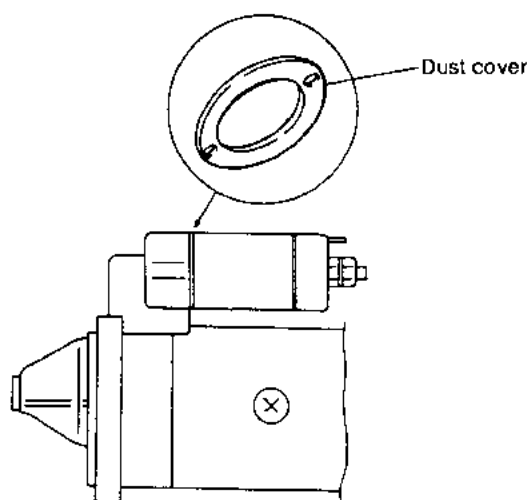


## (3) Plunger movement

Adjustment made by adjusting stroke of magnetic plunger to the prescribed value.

## 1) Shim adjusting.

Adjust the  $\ell$ -dimension dust cover at the magnetic switch attach section.



## (4) Thrust gap of armature

No adjustment type.

## (5) Thrust gap of gear shaft

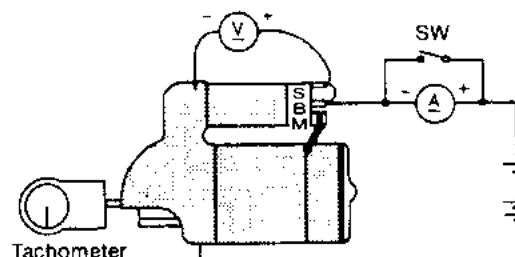
	mm		
	Normal gap	Wear limit	Kind of thrust washer
Thrust gap of gearshaft	0.05~0.3	Over 0.7	Thickness 0.25

## 3-9 Testing

## 3-9.1 No load test

Test procedure

- (1) Connect the positive side of the ammeter (A) to the positive terminal of the battery, and connect the negative side of the ammeter to the B terminal of the starter.



- (2) Connect the negative terminal of the battery to the body of the starter.
- (3) Connect the positive side of the voltmeter (V) to the B terminal of the starter, and connect the negative side of the voltmeter to the body of the starter.
- (4) Attach the tachometer.
- (5) Connect the B terminal of the starter to the S terminal of the magnetic switch.
  - The magnetic switch should begin operation, and the speed, current, and voltage should be at the prescribed values.
  - A fully charged battery must be used.
  - Since a large current flows when the starter is operated, close the protection circuit switch before initial operation, then open the switch and measure the current after the starter reaches a constant speed.



### 3-10 Troubleshooting

#### (1) Pinion fails to advance when the starting switch is closed

Problem	Cause	Corrective action
wiring	Open or loose battery or switch terminal	Repair or retighten
Starting switch	Threaded part connected to pinion section of armature shaft is damaged, and the pinion does not move	Repair contacts, or replace switch
Starter motor	Threaded part connected to pinion section of armature shaft is damaged, and the pinion does not move	Replace
Magnetic switch	Plunger of magnetic switch malfunctioning or coil shorted	Repair or replace

#### (2) Pinion is engaged and motor rotates, but rotation is not transmitted to the engine

Problem	Cause	Corrective action
Starting motor	Overrunning clutch faulty	Replace

#### (3) Motor rotates at full power before pinion engages ring gear

Problem	Cause	Corrective action
Starter motor	Torsion spring permanently strained	Replace

#### (4) Pinion engages ring gear, but starter motor fails to rotate

Problem	Cause	Corrective action
wiring	Wires connecting battery and magnetic switch open or wire connecting ground, magnetic switch and motor terminals loose	Repair, retighten, or replace wire
Starter motor	Pinion and ring gear engagement faulty Motor mounting faulty Brush worn or contacting brush spring faulty Commutator dirty Armature, field coil faulty Field coil and brush connection loose	Replace Remount Replace Repair Repair or replace Retighten
Magnetic switch	Contactor contact faulty Contactor contacts pitted	Replace Replace

#### (5) Motor fails to stop when starting switch is opened after engine starts

Problem	Cause	Corrective action
Starting switch	Switch faulty	Replace
Magnetic switch	Switch faulty	Replace

## 4. Alternator

The alternator serves to keep the battery constantly charged. It is installed on the cylinder block by a bracket, and is driven from the V-pulley at the end of the crankshaft by a v-belt.

The type of alternator used in this engine is ideal for high speed engines with a wide range of engine speeds. It contains diodes that convert AC to DC, and an IC regulator that keep the generated voltage constant even when the engine speed changes.

### 4-1 Features

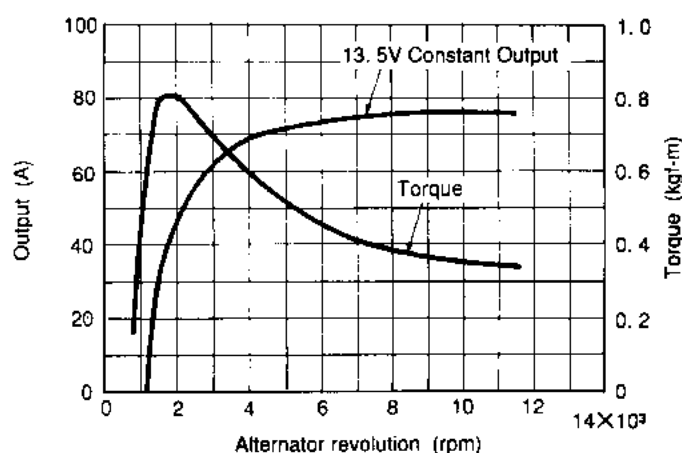
The alternator contains a regulator using an IC, and has the following features.

- (1) The IC regulator is self-contained, and has no moving parts (mechanical contact points). It therefore has superior features such as freedom from vibration, no fluctuation of voltage during use, and no need for readjustment.  
Also, it is of the over-heating compensation type and can automatically adjust the voltage to the most suitable level depending on the operating temperature.
- (2) The regulator is integrated within the alternator to simplify external wiring.
- (3) It is an alternator designed for compactness, lightness of weight, and high output.
- (4) A newly developed U-shaped diode is used to provide increased reliability and easier checking and maintenance.
- (5) As the alternator is to be installed on board, the following measures are taken to provide salt-proofing.
  - 1) The front and rear covers are salt-proofed.
  - 2) Salt-proof paint is applied to the diode.
  - 3) The terminal, where the inboard harness is connected to the alternator, is nickel plated.

### 4-2 Specifications

Model of alternator	LR180-03B (HITACHI)
Model of IC regulator	TRIZ-63 (HITACHI)
Battery voltage	12V
Nominal output	12V/80A
Earth polarity	Negative earth ( $\ominus$ )
Direction of rotation (viewed from pulley end)	Clockwise
Weight	54kg
Rated speed	5000rpm
Operatirry speed	1200~9000
Speed for 13.5V	1200 or less
Output current at 20°C	over $75 \pm 3A/5000$ rpm
Regulated voltage	$14.5 \pm 0.3V$ (Standard temperature voltage gradient, $-0.01/^\circ C$ )

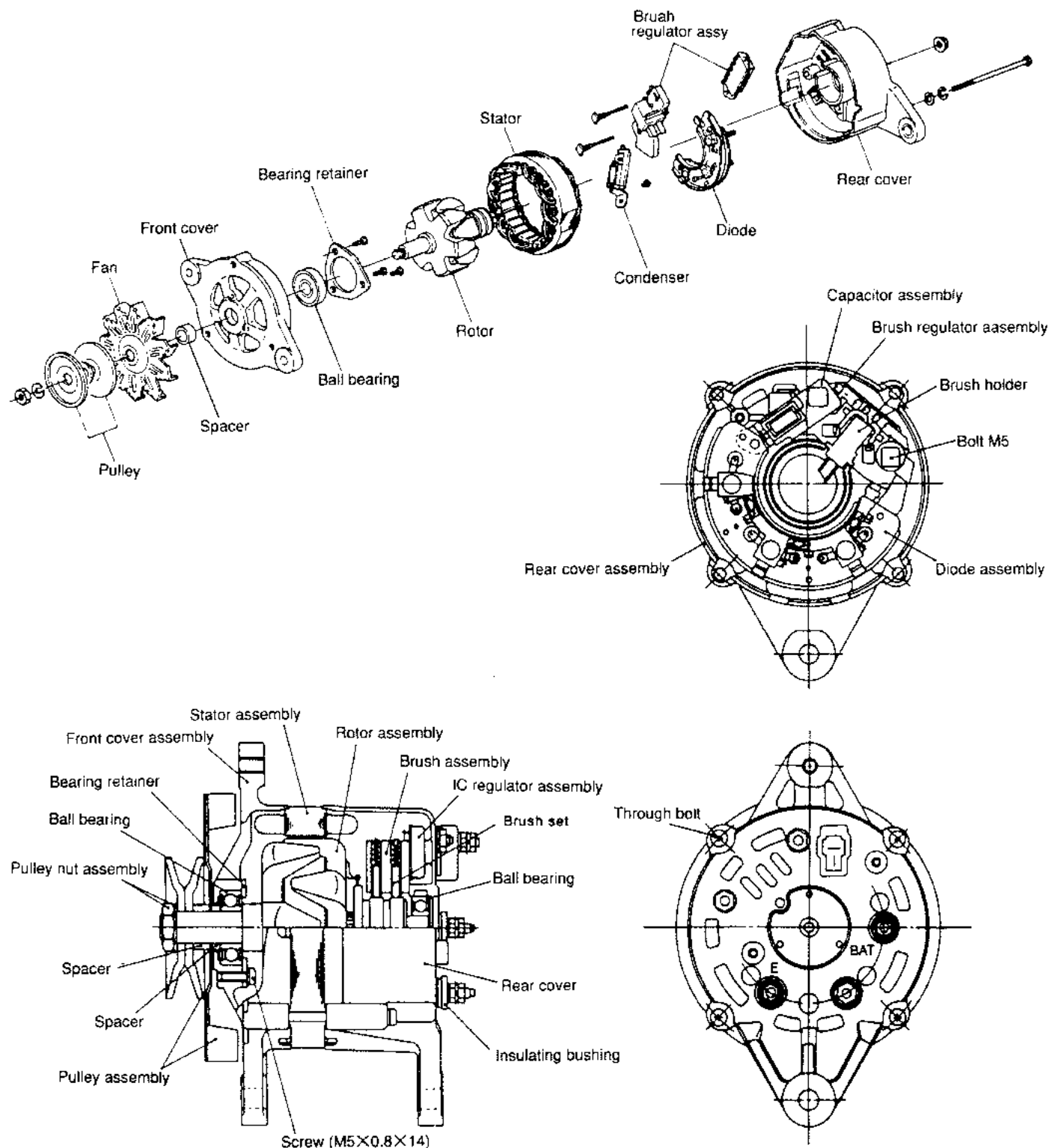
### 4-3 Characteristics



#### 4-4 Construction

This is a standard rotating field type three-phase alternator.

It consists of six major parts: the pulley, fan, front cover, rotor, stator and rear cover. The IC regulator is an integral part of the alternator.



### 4-5 Alternator functioning

#### (1) IC regulator

The IC regulator is the transistor ( $Tr_1$ ) which is series-connected with the rotor. The IC regulator controls the output voltage of the generator by breaking or conducting the rotor coil (exciting) current.

When the output voltage of the generator is within the standard value, the transistor ( $Tr_1$ ) turns on. When the voltage exceeds the standard value, the Zener diode goes on and the transistor ( $Tr_1$ ) turns off.

With the repeated turning on and off of the transistor, the output voltage is kept at the standard value. (Refer to the circuit diagram below.)

#### (2) Charge lamp

When the transistor ( $Tr_1$ ) is on, the charge lamp key switch is turned to ON, and current flows to  $R_1$ ,  $R_4$  and to  $Tr_1$  to light the lamp. When the engine starts to run and output voltage is generated in the stator coil, the current stops flowing to this circuit, turning off the charge lamp.

#### (3) Circuit diagram

### 4-6 Handling precautions

(1) Be careful of the battery's polarity (+, - terminals), and do not connect the wrong terminals to the wrong cables, or the battery will be short-circuited by the generator diode.

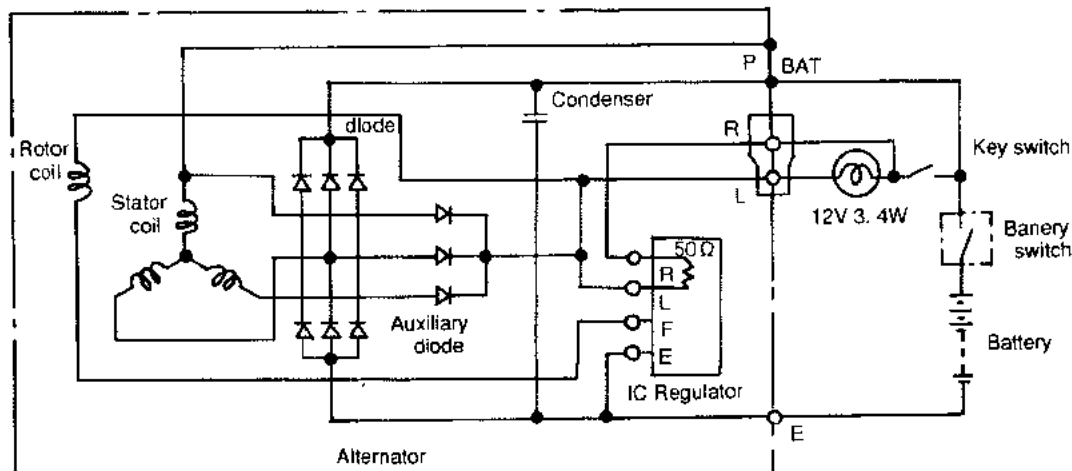
In this case too much current will flow, the IC regulator and diodes burn out, and the wire harness will burn.

(2) Make sure of the correct connection of each terminal.

(3) When quick-charging, etc., disconnect either the battery terminal on the AC generator or the terminal on the battery.

(4) Do not short-circuit the terminals.

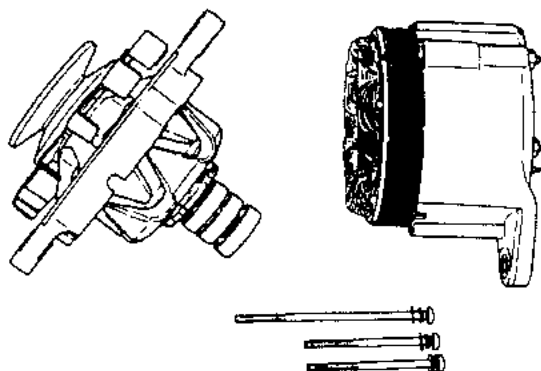
(5) Do not conduct any tests using high tension insulation resistance. (The diodes and IC regulator will burn out.)



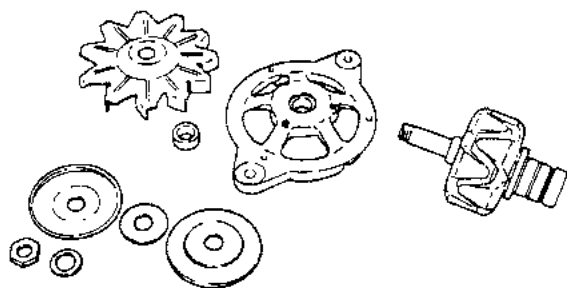
Connection diagram

#### 4-7 Disassembling the alternator

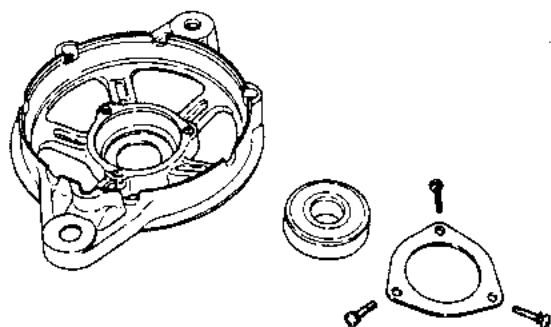
- (1) Remove the through-bolt, and separate the front assembly from the rear assembly.



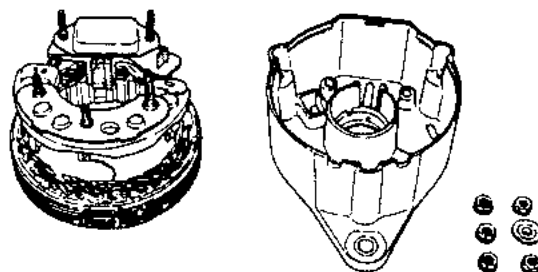
- (2) Remove the pulley nut, and pull out the rotor from the front cover.



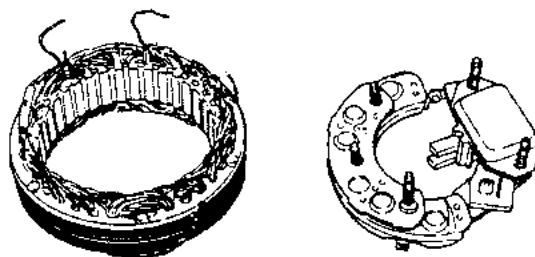
- (3) Remove the  $\phi 5\text{mm}$  ( $\phi 0.1969\text{ in.}$ ) screw from the front cover, and then remove the ball bearing.



- (4) Remove the nut, the brush-holder, and diode fixing nut at the BAT, and the terminal screws of the rear cover. Separate the rear cover from the stator (with the diode and brush holder).

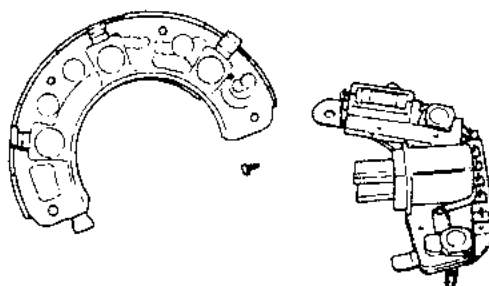


- (5) Disconnect the soldered joint of the stator lead wire, and remove the diode and brush regulator assemblies from the stator at the same time.

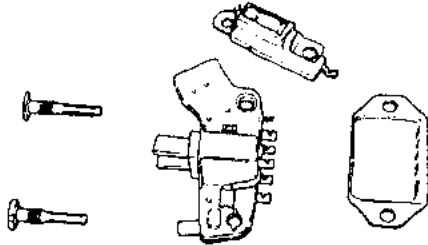


- (6) Separating the regulator

- 1) To separate the regulator, remove the  $\phi 3\text{ mm}$  ( $\phi 0.1181\text{ in.}$ ) rivet which keeps the diode assembly and the brushless regulator in place, and the soldered joint of the L-terminal.



- 2) To replace the IC regulator, disconnect the soldered joint of the IC regulator and pull out the two bolts. Do not remove these two bolts except when replacing the IC regulator.



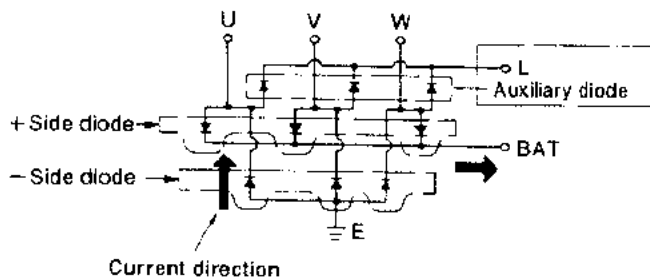
#### 4-8 Inspection and adjustment

##### (1) Diode

Between terminals		BAT ( + side diode)	
	Tester wire	+ side	- side
U.V.W.	+ side	No continuity	Continuity
	- side	Continuity	

Between terminals		E ( - side diode)	
	Tester wire	+ side	- side
U.V.W.	+ side	Continuity	No continuity
	- side	No continuity	

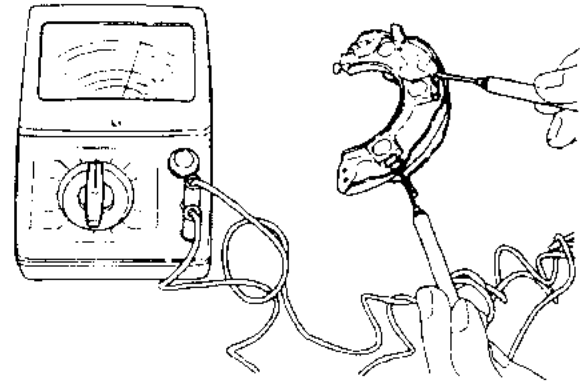


U.V.W.: terminal from the stator coil

Current flows only in one direction in the diode as shown in Fig.181. Accordingly, when there is continuity between each terminal (e.g. BAT and U), the diode is in normal condition (photo). When there is no continuity, the diode is defective.

When the tester is connected in the reverse of above, there should be no continuity. If there is, the diode is defective.

After repeating the above test, if any diode is found to be defective, replace the diode assembly. Since there is no terminal on the auxiliary diode, check the continuity between both ends of the diode.



**CAUTION:** Do not use high tensile insulation resistance for testing. The diode may burn out.

##### (2) Rotor

Inspect the slip ring surface, rotor coil continuity and insulation.

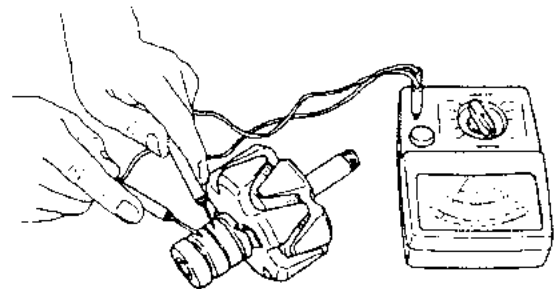
###### 1) Inspecting the slip ring surface

Check if the surface of the slip ring is sufficiently smooth. If the surface is rough, grind the surface with No. 500-600 sand paper. If it is contaminated with oil, etc., wipe the surface clean with alcohol.

	Standard	Wear limit
Slip ring outer dia.	φ 31.6 mm	φ 30.6 mm

###### 2) Rotor coil continuity test

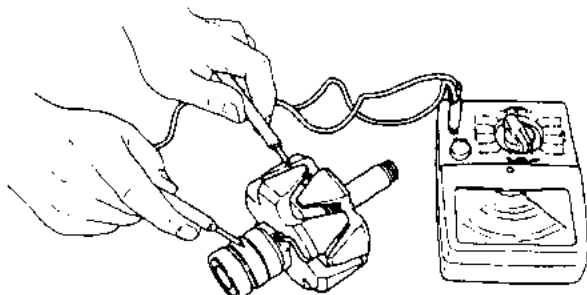
Check the continuity in the slip ring with the tester. If there is no continuity, there is a wire break. Replace the rotor coil.



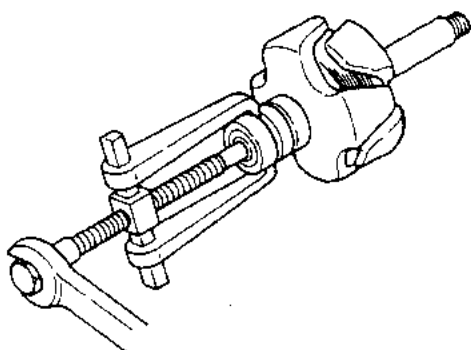
Resistance value	Approx. 2.8 Ω at 20°C
------------------	-----------------------

## 3) Rotor coil insulation test

Check the continuity between the slip ring and the rotor core, or the shaft. If there is continuity, insulation inside the rotor is defective, causing a short with the earth circuit. Replace the rotor coil.



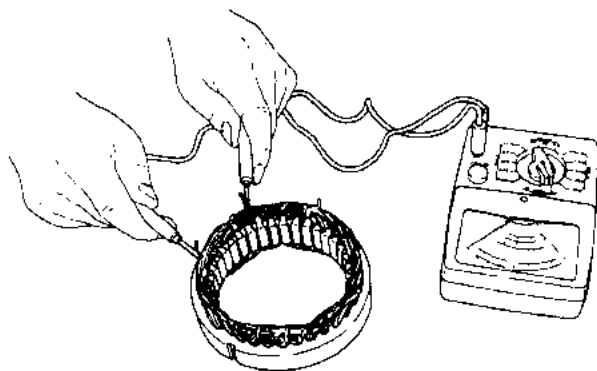
## 4) Check the rear side ball bearing. If the rotation of the bearing is heavy, or produces abnormal sounds, replace the ball bearing.



## (3) Stator

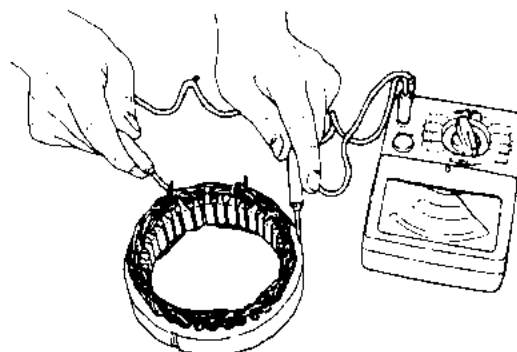
## 1) Stator coil continuity test

Check the continuity between each terminal of the stator coil. If there is no continuity, there is a wire break in the stator coil. Replace the stator coil.



## 2) Stator coil insulation test

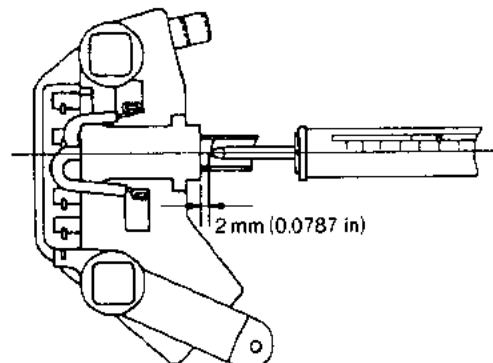
Check the continuity between the terminals and the stator core. If there is continuity, insulation of the stator coil is defective. This will cause a short-circuit with the earth core. Replace the stator coil.



## (4) Brush

The brush is hard and wears slowly, but when it is worn beyond the allowable limit, replace it. When replacing the brush, also check the strength of the brush spring.

To check, push the spring down to 2mm (0.0787 in.) from the end surface of the brush holder, and read the gauge.

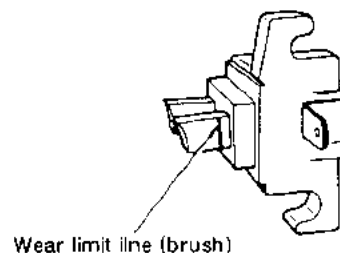


Brush spring strength	110~26.5
-----------------------	----------

## (5) Brush wear

Check the brush length.

The brush wears very little, but replace the brush if worn over the wear limit line printed on the brush.



mm (in.)		
	Maintenance standard	Wear limit
Brush length	16	9

Resistance value

Approx. 0.031  $\Omega$  at 20°C  
1-phase resistance

## (6) IC regulator

Connect the variable resistance, two 12V batteries, resistor, and voltmeter as Shown in the diagram.

## 1) Use the following measuring devices.

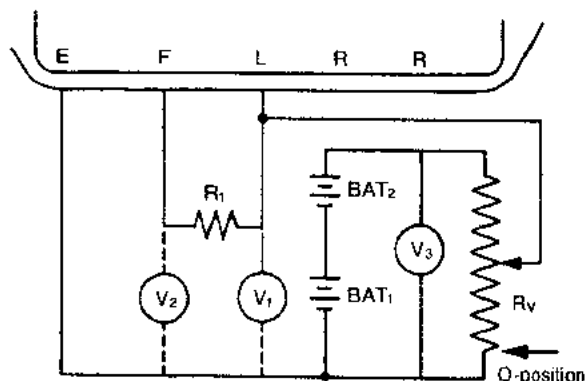
Resistor ( $R_1$ ) 100  $\Omega$ , 2W, 1pc.  
 Variable resistor ( $R_v$ ) 0-300  $\Omega$ , 12W, 1pc.  
 Battery ( $BAT_1$ ,  $BAT_2$ ) 12V, 2pcs.  
 DC voltmeter 0-30V, 0.5 class 1pc.  
 (measure at 3 points)

## 2) Check the regulator in the following sequence, according to the diagram.

a) Check  $V_3$  ( $BAT_1 + BAT_2$  voltage). If the voltage is 20-26V, both  $BAT_1$  and  $BAT_2$  are normal.

b) While measuring  $V_2$  (F-E terminal voltage), move  $R_v$  gradually from the O-position. Check if there is a point where the  $V_2$  voltage rises sharply from below 2.0V to over 2.0V. If there is no such point, the regulator is defective. Replace the regulator. If there is a sharp voltage rise when testing, return the  $R_v$  to the O-position, and connect the voltmeter to the V<sub>1</sub> position.

c) While measuring  $V_1$  (voltage between L-E terminals), move  $R_v$  gradually from the O-position. There should be a point where the voltage of  $V_1$  rises sharply by 2-6V. Measure the voltage of  $V_1$  just before this sharp voltage rise. This is the regulating voltage of the regulator. If this voltage of  $V_1$  is within the standard limit, the regulator is normal. If the voltage deviates from the limit, the regulator is defective. Replace the regulator.



## 4-9 Reassembling the alternator

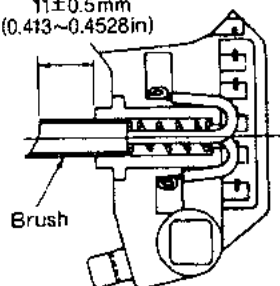
Reassembly is done in the reverse order of disassembly. For reassembly, be careful of the following points. (Refer to 4-7 disassembling alternator).

## (1) Assembling the brush regulator

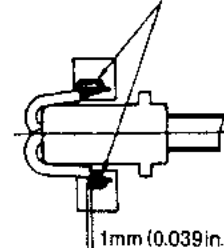
## 1) Solder the brush.

Position the brush as shown in the drawing and solder it. Be careful not to let the solder drip into the pig tail (lead wire).

11±0.5mm  
(0.413~0.4528in.)



Wind the wire 1.5 times around the terminal groove.



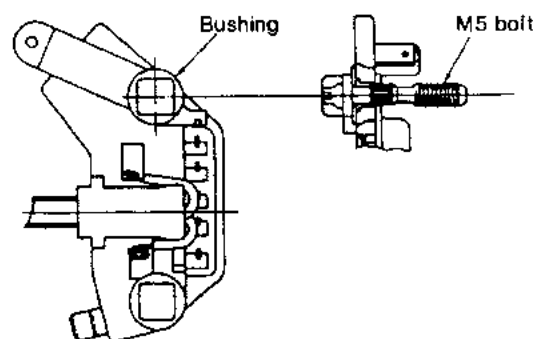
Mount the insulation tube on the terminal surface.

NOTES: 1. Use non-acid type paste.

2. The soldering iron temperature is 300 ~ 350 °C.

2) Mount the IC regulator on the brush holder as illustrated, and press in the M5 bolt. Do not forget to assemble the bushing and the connecting plate at the same time.

(If the bushing is left out, the output terminal will be earthed and the battery short-circuited).



NOTES: 1. Insertion pressure is 100kg (220.5 lbs.)

2. Insert vertically.

(2) Connecting the brush regulator assembly and diode

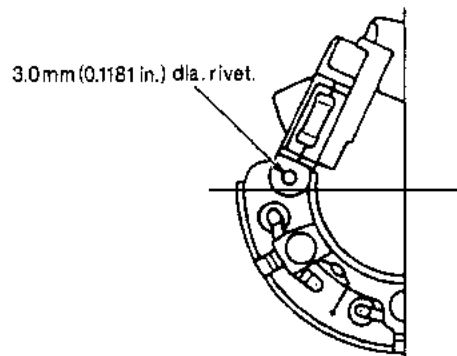
## 1) Check the rivets

Place the rivets as shown in the figure, and then calk them using the calking tool.

Calking torque	500kg
----------------	-------

## 2) Connect the brush to the diode.

Insert the brush side terminal into the diode terminal, calk it, and then solder into place.



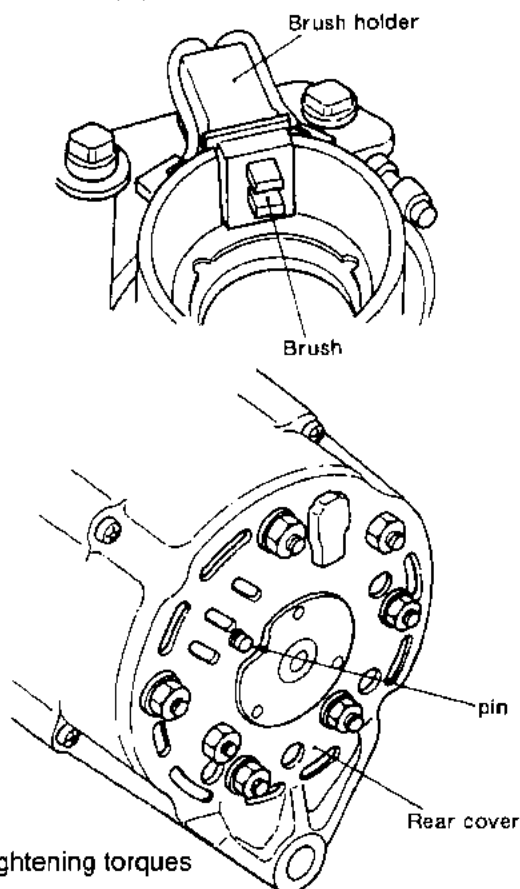
Rivetting pressure	500kg
--------------------	-------



## (3) Assembling the rear cover

Insert pins from the outside of the rear cover. Install the brush on the brush holder, then attach the rear cover.

After assembly, pull out the pins.



## (4) Tightening torques

Positions	Tightening torque kg-cm
Brush holder fixing	32—40
Diode fixing	32—40
Bearing retainer fixing	32—40
Pulley nut tightening	450~600
Through-bolt tightening	32—40

## (1) Measuring devices

DC voltmeter	0—15V or 0—30V, 0.5 Class, 1pc.
DC ammeter	0—100A, 1.0 Class 1pc.
Variable resistor	0—0.25 $\Omega$ , 1kW, 1pc
Lamp	12V, 3W
100 $\Omega$ resistor	3W
0.25 $\Omega$ resistor	25W

## (2) Measuring the regulating voltage

- 1) When measuring devices are connected in the performance test circuit as shown above, the charge lamp lights.
- 2) Close SW<sub>2</sub> while keeping SW<sub>1</sub> open and run the AC generator. When the revolutions of the generator are gradually raised, the charge lamp goes off.
- 3) Raise the revolutions of the AC generator, and read the voltmeter gauge when the revolutions reach about 5,000 rpm.

**NOTES:** 1. Make sure that the ammeter indication at this time is less than 5A. If the indication is over 5A, connect the 0.25  $\Omega$  resistor. The voltmeter indication at this time must be within the prescribed regulating voltage value.

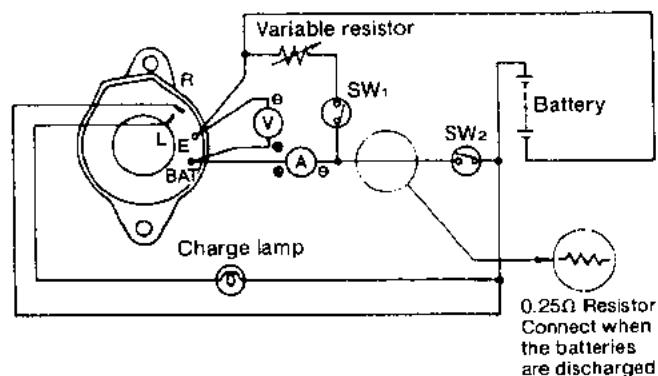
2. Raise the AC generator revolutions high to make sure the regulating voltage does not fluctuate along with changes in the revolution speed.

## (3) Precautions for measuring the regulating voltage

- 1) When measuring the voltage, measure the voltage between the AC generator BAT terminal, or Battery + terminal, and AC generator E-terminal.
- 2) Use a fully charged battery.
- 3) Measure the voltage quickly.
- 4) Keep SW<sub>1</sub> open for measurement.

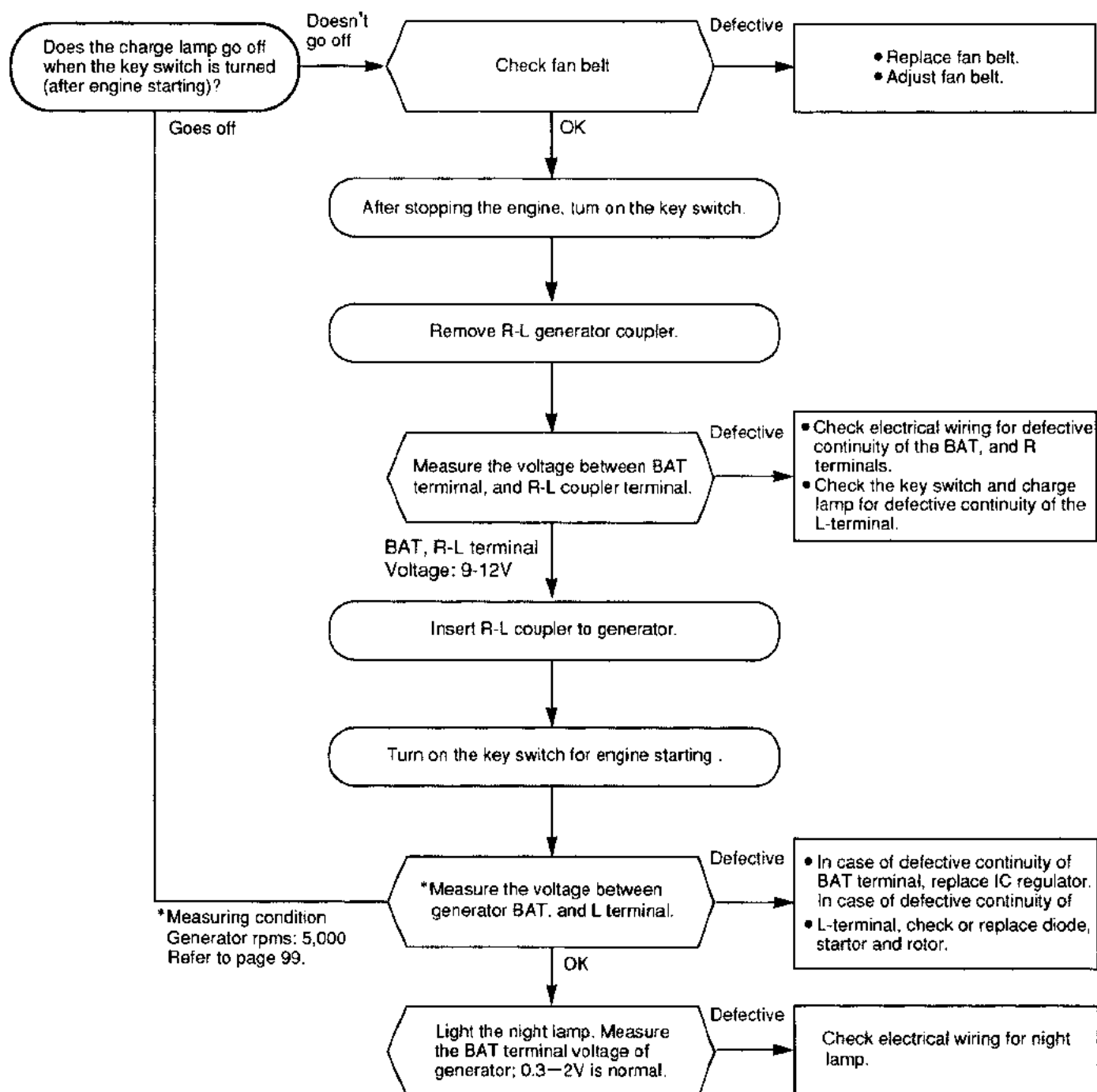
## 4-10 Performance test

Conduct a performance test on the reassembled AC generator as follows. The following is the circuit for the performance test.

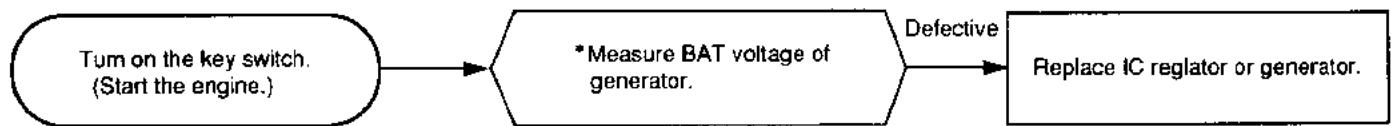


## 4-11 Troubleahooting

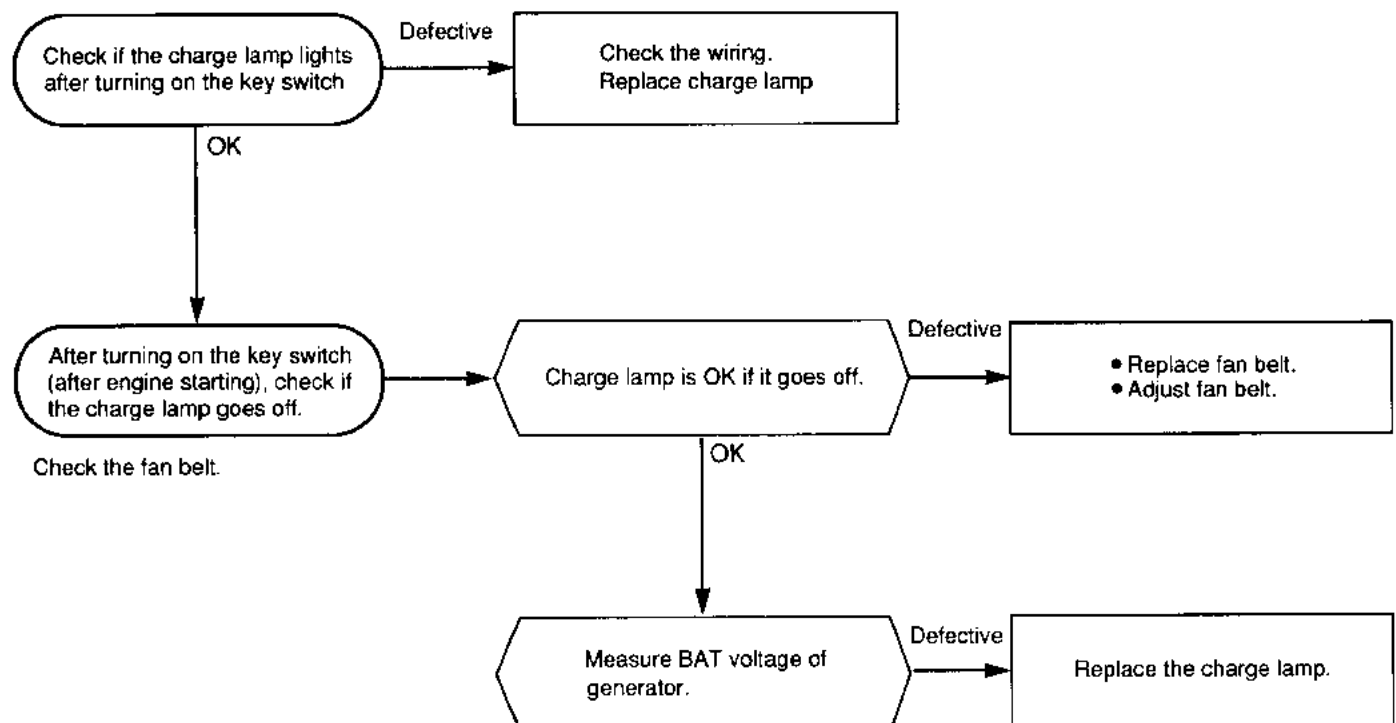
### (1) Charging failure



## (2) Overcharging



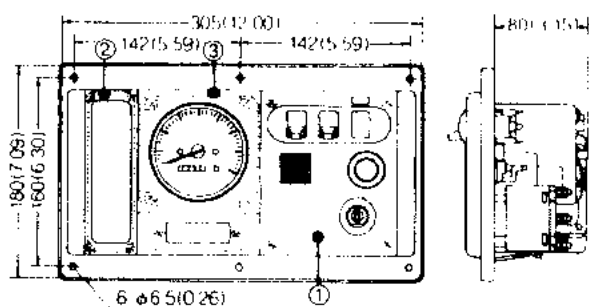
## (3) Charge lamp failure



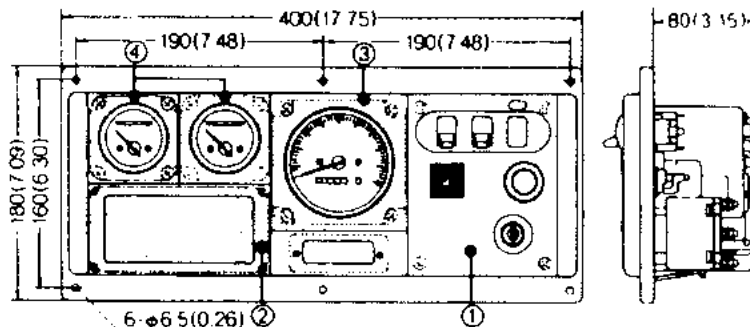
## 5. Instrument Panel

No.	Model		New B-type	New C-type	New D-type
①	Switch unit	Key switch (Starter switch)	●	●	●
		Engine stop switch	●	●	●
		Alarm buzzer (C.W. temp., L.O. pressure)	●	●	●
		Alarm buzzer stop switch	●	●	●
		Illumination switch for tachometers	●	●	●
②	Alarm lamp unit	Battery not charging	●	●	●
		C.W. high temperature	●	●	●
		L.O. low pressure	●	●	●
		Clutch oil pressure	●	●	●
		L.O. filter clogged	—	●	●
③	Tachometer unit	Tachometer with hour meter	●	●	●
		L.O. pressure meter	—	●	●
④	Sub meter unit	C.W. temperature meter	—	●	●
		Boost meter (Turbo)	—	—	●
⑤	Clock unit	Quartz clock	—	—	●

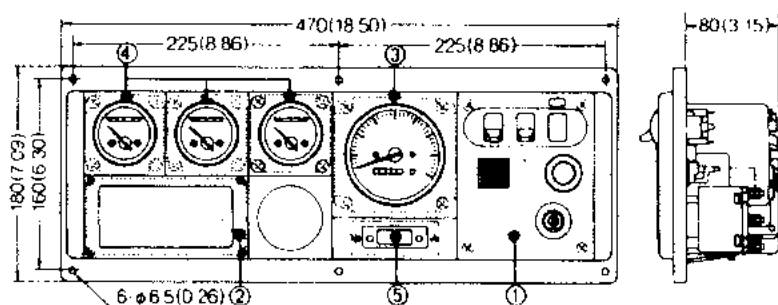
New B-type



New C-type



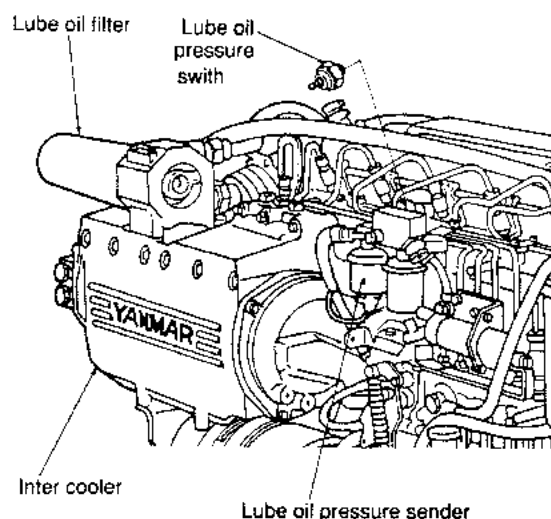
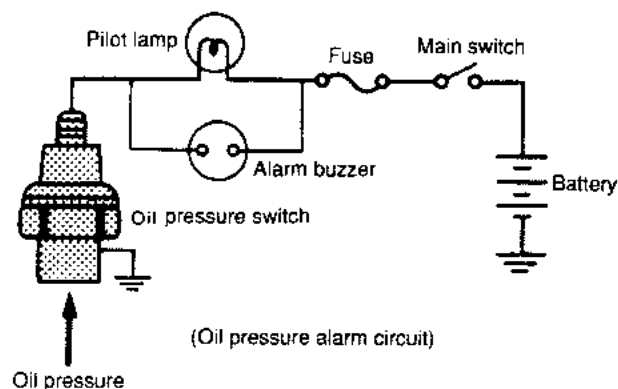
New D-type



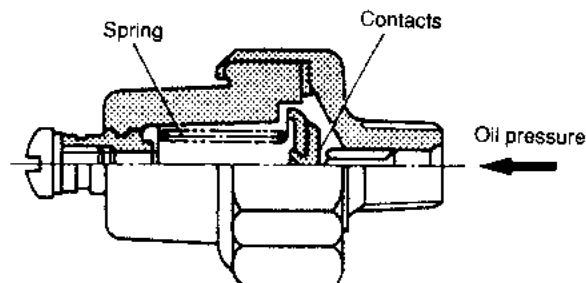
## 6. Warning Devices

### 6-1 Oil pressure alarm

If the engine oil pressure is below  $0.1 \sim 0.3 \text{ kg/cm}^2$  ( $1.42 \sim 4.26 \text{ lb/in.}^2$ ), with the main switch in the ON position, the contacts of the oil pressure switch are closed by a spring, and the lamp is illuminated through lamp → oil pressure switch → ground circuit system. If the oil pressure is normal, the switch contacts are opened by the lubricating oil pressure and the lamp remains off.



Oil pressure switch



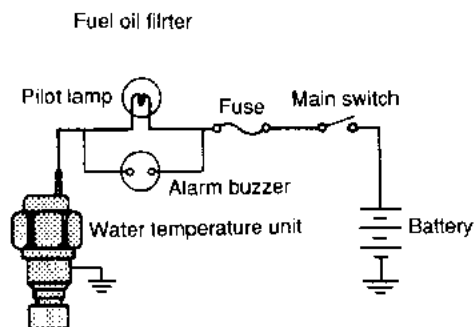
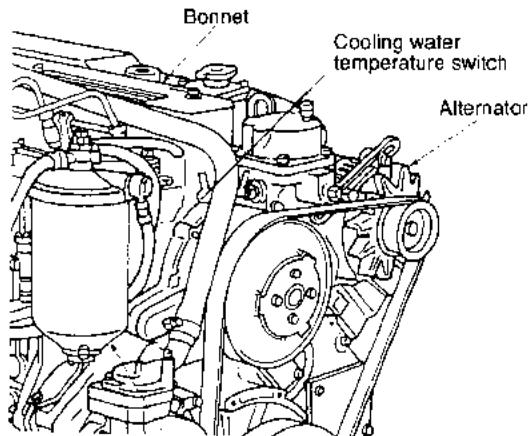
Rated voltage	12V
Operation pressure	$0.1 \sim 0.3 \text{ kg/cm}^2$ ( $1.422 \sim 4.286 \text{ lb/in.}^2$ )
Lamp capacity	5W

### Inspection

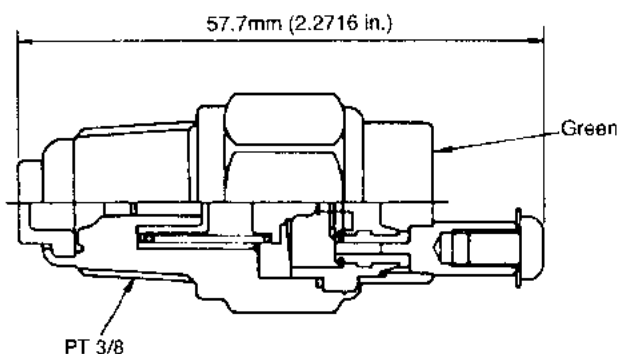
Problem	Inspection item	Inspection method	Corrective action
Lamp not illuminated when main switch set to ON	1. Oil pressure lamp blown out	(1) Visual inspection (2) Lamp not illuminated even when main switch set to ON position and terminals of oil pressure switch grounded	Replace lamp
	2. Operation of oil pressure switch	Lamp illuminated when checked as described in (2) above	Replace oil pressure switch
Lamp not extinguished while engine running	1. Oil level low	Stop engine and check oil level with dipstick	Add oil
	2. Oil pressure low	Measure oil pressure	Repair bearing wear and adjust regulator valve
	3. Oil pressure faulty	Switch faulty If abnormal at (1) and (2) above	Replace oil pressure switch
	4. Wiring between lamp and oil pressure switch faulty	Cut the wiring between the lamp and switch and wire with separate wire	Repair wiring harness

### 6-2 Cooling water temperature alarm

A water temperature lamp and water temperature gauge, backed up by an alarm in the instrument panel, are used to monitor the temperature of the engine cooling water. A high thermal expansion material is set on the end of the water temperature unit. When the cooling water temperature reaches a specified high temperature, the contacts are closed, and an alarm lamp and buzzer are activated at the instrument panel.



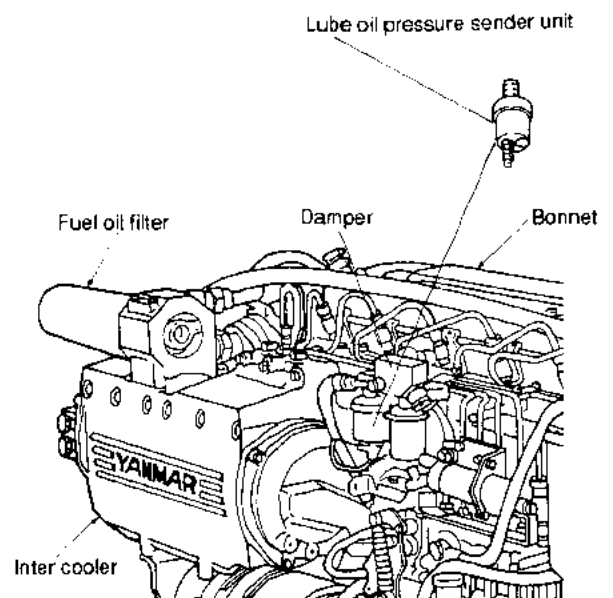
(Water temperature alarm circuit)



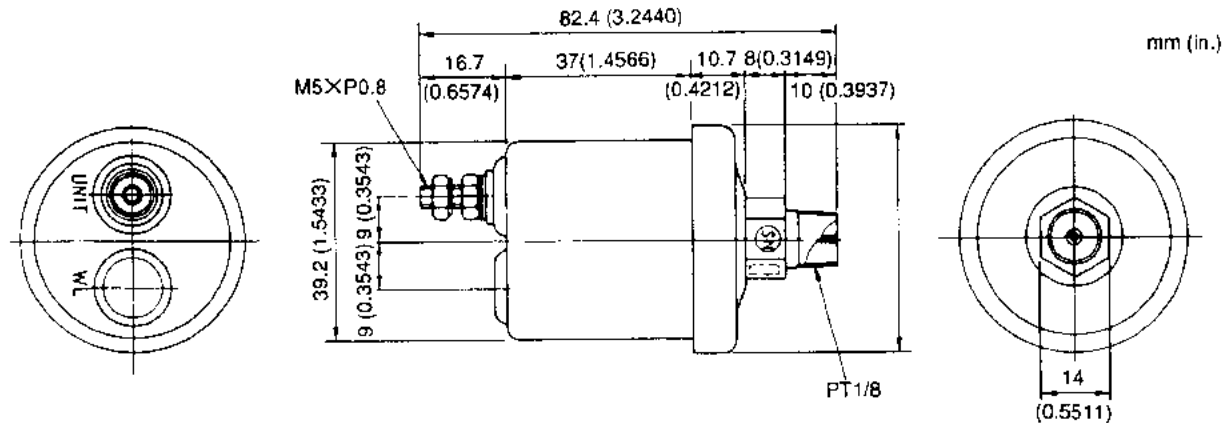
Operating temperature	ON	93 ~ 97°C (199 ~ 206°F)
	OFF	88°C (190°F) or high
Electric capacity	DC 12V, 1A	
Response time	within 60 sec.	
Indication color	Green	
Tightening torque	2.40 ~ 3.20 kg-m (17.35 ~ 23.14 ft-lb)	

### 6-3 Sender unit for lube oil pressure gauge

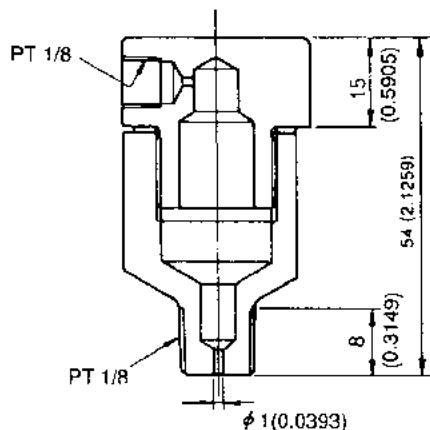
The sender unit for the lube oil pressure gauge has a mounting seat for mounting on the intake manifold. Oil pressure is measured when the oil enters into the main gallery after being fed from the lube oil cooler and passing through oil pressure control valve. Make sure to mount a vibration damper when mounting the oil pressure sender unit.



### Lube oil pressure sender unit



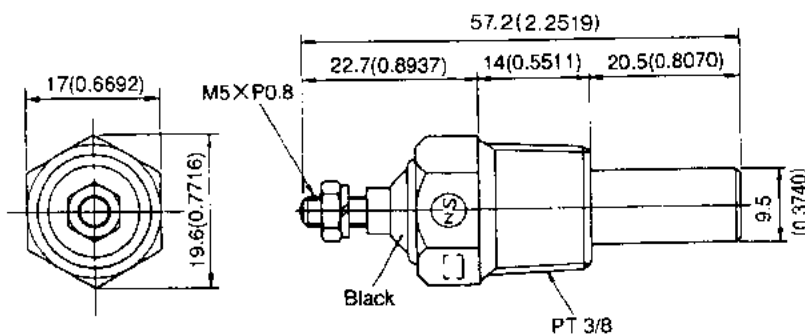
### Damper



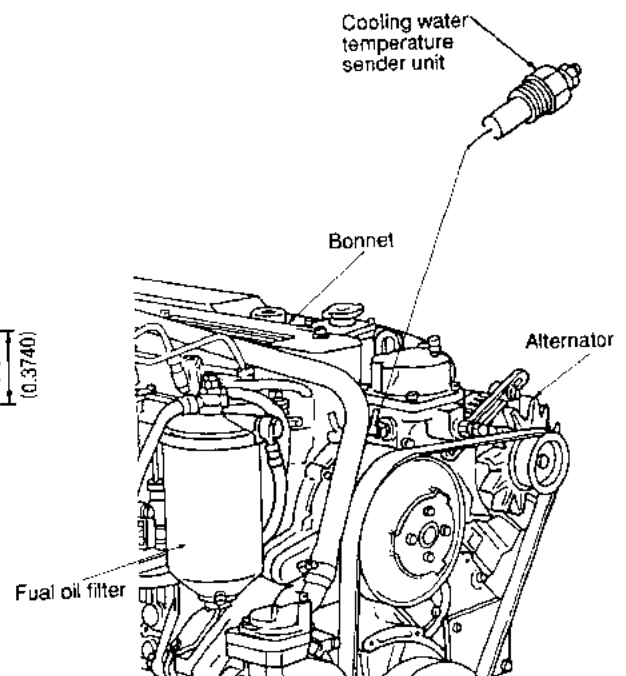
Type	Resistance switch
Rated voltage	DC 12 / DC 24
Max. operating pressure	8kg/cm <sup>2</sup> (113.76 lb/in. <sup>2</sup> )

### 6-4 Sender unit for the cooling water temperature gauge

The water temperature sender unit has a mounting seat for mounting on the thermostat housing. Water temperature is measured when the cooling water flows into the thermostat housing after leaving the cylinder head.



Type	Thermistor switch
Rated voltage	12V/24V

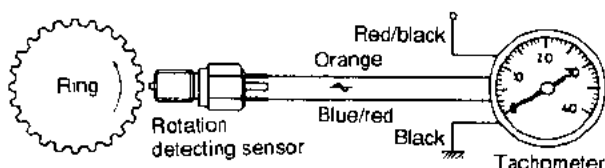
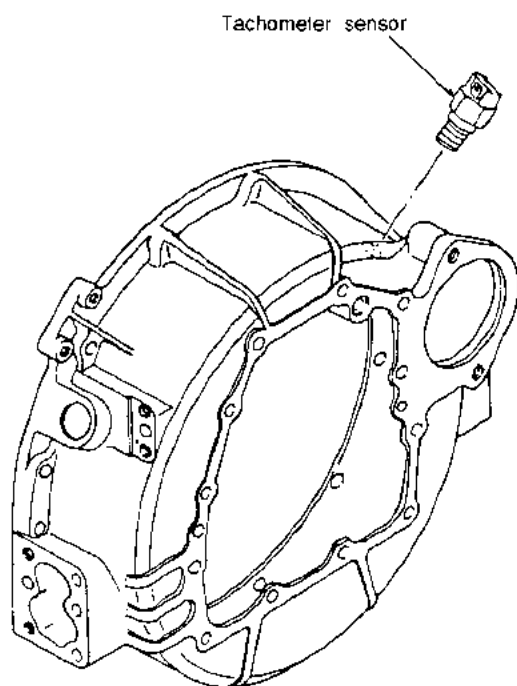


## 7. Tachometer

### 7-1 Construction of tachometer

The tachometer indicates the number of revolutions per minute by means of an electrical input signal which is generated as a pulse signal from the magnetic pickup sensor (MPU sensor).

The function of the sensor is to convert the rotary motion into an electrical signal by means of counting the number of teeth of the ring gear connecting with the flywheel housing.

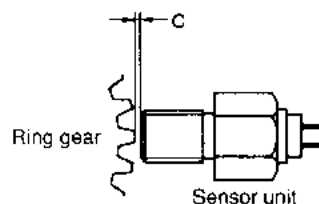
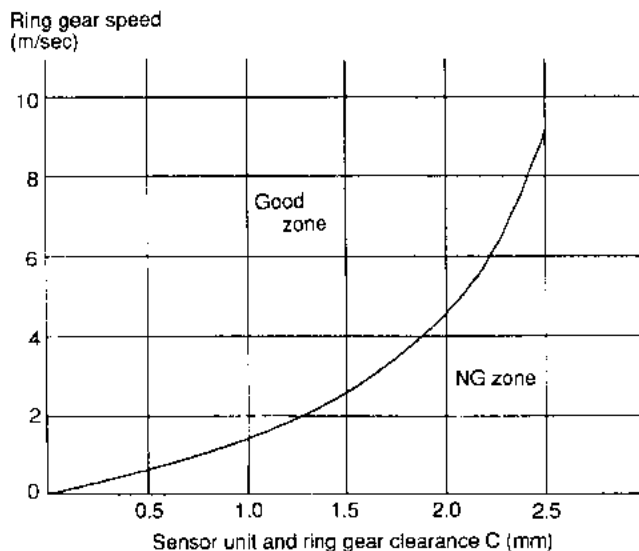


### 7-2 Specifications and dimensions of tachometer

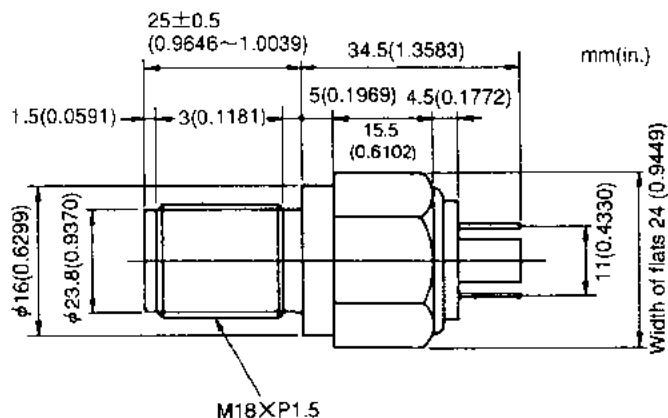
#### (1) Specifications

Rated voltage		DC 12V
Range of operating voltage		10~25V
Illumination		3.4W/12V
Ring gear	No. of teeth	127
	Module	2.54

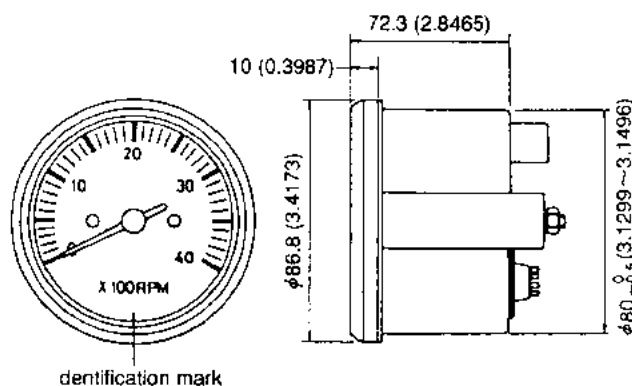
#### (2) Sensitivity limit of sender unit



#### (3) Dimensions of sensor unit



#### (4) Dimensions and shape of tachometer

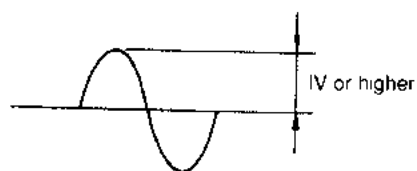




### 7-3 Measurement of sensor unit characteristics

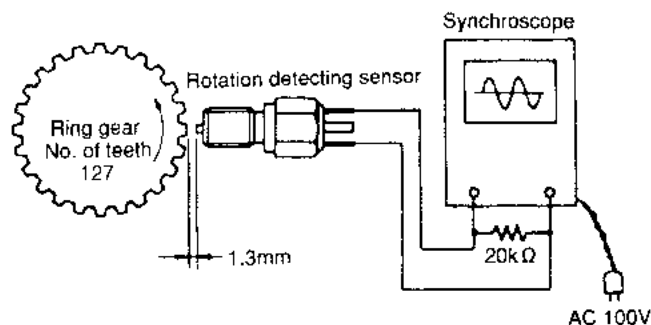
#### (1) Measurement of output voltage

Output voltage	1.0V or higher
----------------	----------------



#### Measuring conditions

Number of teeth of ring gear	129
Gap between the ring gear and sensor	1.3mm (0.0511 in.)
Resistance	20k $\Omega$
Speed of ring gear	500 rpm (approx. 800Hz)
Measuring temperature	20°C (68°F)
Measuring instrument	Synchroscope

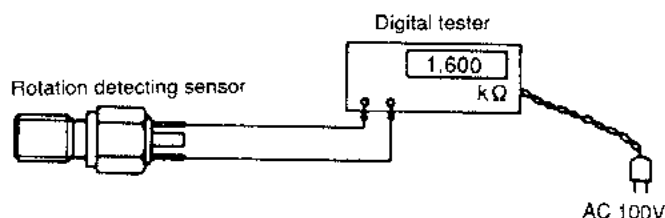


\*Check the output wave pattern and number of pulses when carrying out the output voltage measurement.

#### (2) Measurement of internal resistance

#### Measuring conditions

Measuring temperature	20°C (68°F)
Measuring instrument	Digital tester



### 7-4 Diagnosis

Fault	Diagnosis	Remedy
Does not function well. 1) Pointer does not move. 2) Functions intermittently.	Check if there is an open-circuit cable connection at the rear of the meter, a loose or disconnected terminal or bad continuity due to corrosion.	Yes Make good the connection.
	Disconnect at the instrument terminals, and measure the voltage between the cable terminals. (To be 10~16V) ↓ Satisfactory	No If the input voltage is abnormal, check the cause. (e.g. short-circuit, disconnection or blown fuse, etc.)
	Check if the sensor is loosely fitted. ↓ No	Yes Fix the sensor securely.
	Measure the internal resistance of the sensor. (To be 1.6 $\pm$ 0.1k $\Omega$ at 20°C) ↓	No Replace the sensor.
	Measure the output voltage of the sensor. (To be 1V or higher at 20°C)	No Replace the sensor.

# DISASSEMBLY AND REASSEMBLY

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# 1 . Disassembly and Reassembly Precautions

This chapter explains the main points necessary for disassembly and reassembly. A detailed description of the procedures is not included and handling is left to the individual owner.

## (1) Disassembly

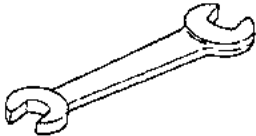
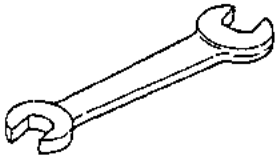
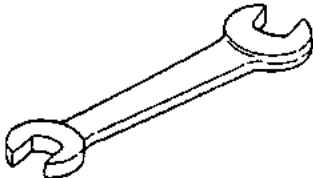
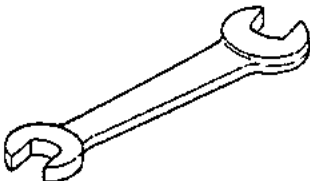
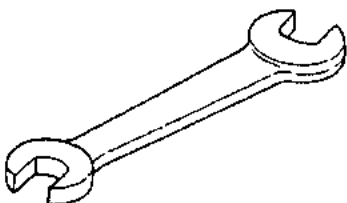
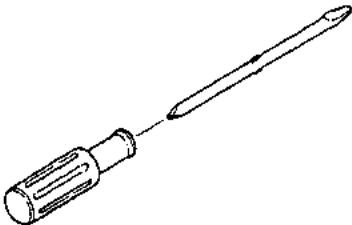

- Take sufficient time to accurately pin-point the cause of the trouble, and disassemble only those parts which are necessary.
- Be careful to keep all disassembled parts in order.
- Prepare disassembly tools.  
Prepare a cleaner and cleaning can.
- Clear an adequate area for parts and prepare a container(s).
- Drain cooling water (sea water, fresh water) and lube oil.
- Close the Kingston cock.

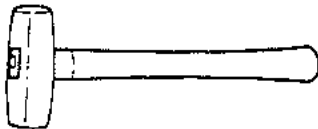
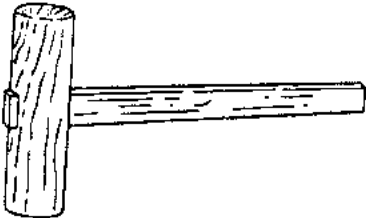
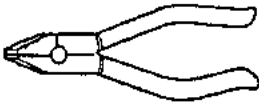

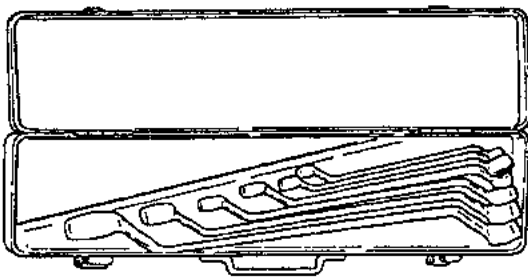
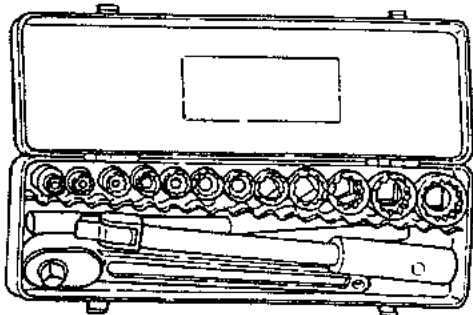
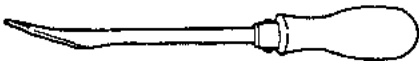
## (2) Reassembly

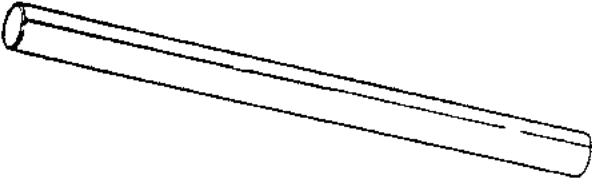
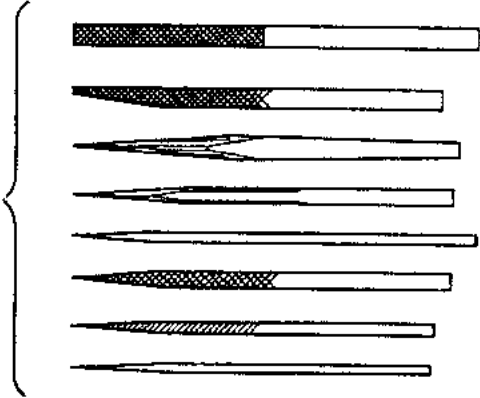

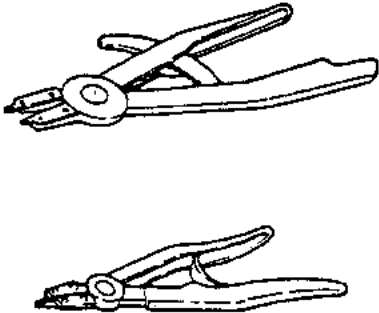
- Sufficiently clean and inspect all parts to be assembled.
- Coat sliding and rotating parts with new engine oil when assembling.
- Replace all gaskets and O-rings.
- Use a liquid packing agent as necessary to prevent Oilwater leaks.
- Check the oil and thrust clearances, etc. of parts when assembling.
- Make sure you use the correct bolt/nut/washer.
- Tighten main bolts/nuts to the specified torque. Be especially careful not to overtighten the aluminum alloy part mounting bolts.
- Align match marks (if any) when assembling. Make sure that the correct sets of parts are used for bearings, pistons, and other parts where required.

## 2. Disassembly and Reassembly Tools

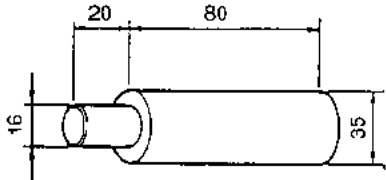
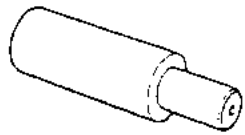
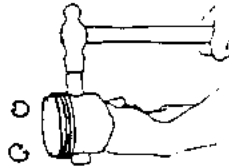
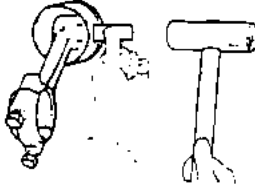
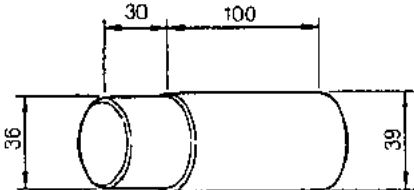
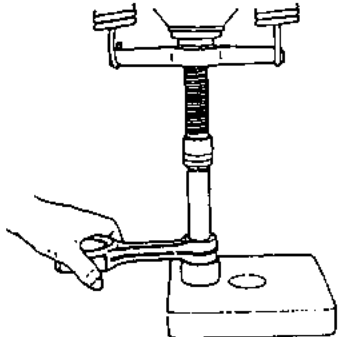
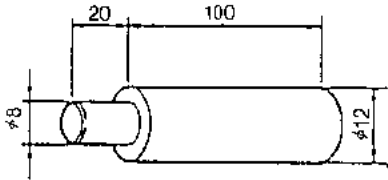
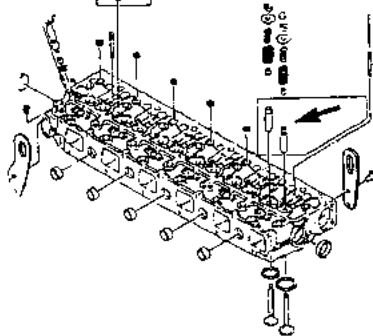

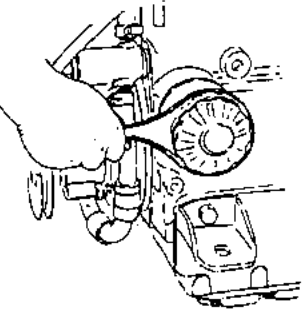
The following tools are required when disassembling and reassembling the engine.  
Please use them as instructed.

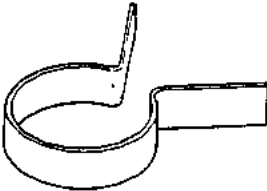
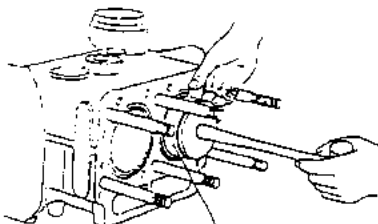

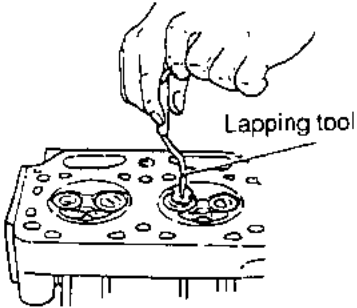


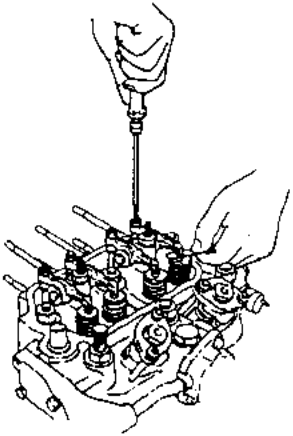
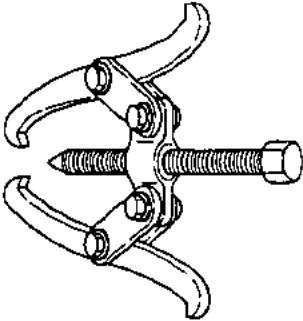
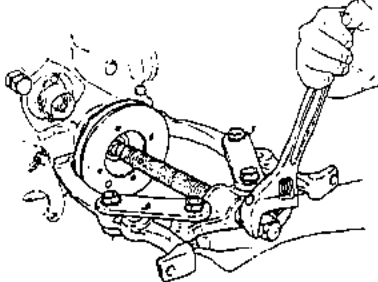
Name of tool	Illustration	Remarks
Wrench		Size : 10X13
Wrench		Size : 11X13
Wrench		Size : 12X14
Wrench		Size : 17X19
Wrench		Size : 22X24
Screwdriver		
Steel hammer		Local supply

Name of tool	Illustration	Remarks
Copper hammer		Local supply
Mallet		Local supply
Nippers		Local supply
Pliers		Local supply
Offset wrench		Local supply 1 set
Box spanner		Local supply 1 set
Scraper		Local supply

Name of tool	Illustration	Remarks
Lead rod		Local supply
File		Local supply 1 set
Rod spanner for hexagon socket head screws		Local supply Size : 6 mm (0.2362in.) 8 mm (0.3150in.) 10 mm (0.3937in.)
Starling Pliers Hole type Shaft type	 <p>S—O</p> <p>H4~H8</p> <p>S=Hole type H=Shaft type</p>	Local supply

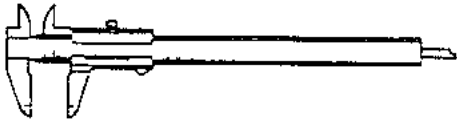
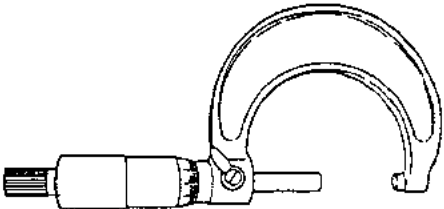
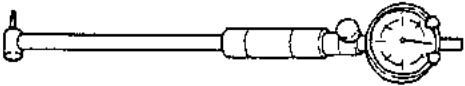
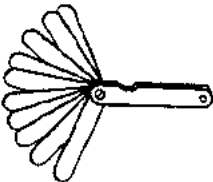
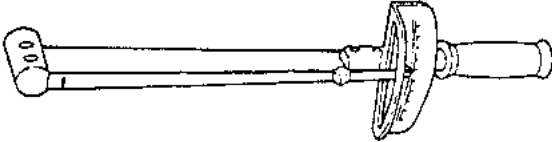
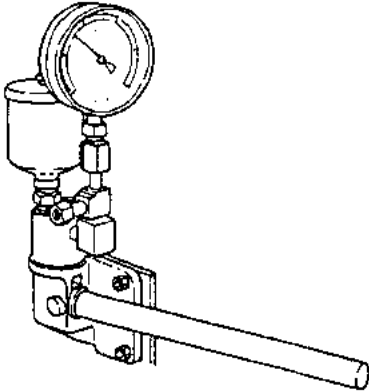
## 2-1 Special Handtools

Name of tool	Illustration	Remarks
Piston pin insertion/ extraction tool		<p>mm</p>  <p>Piston pin extractor</p>  <p>Extraction of piston pin</p>  <p>Insertion of piston pin</p>
Connecting rod small end bushing insertion/ extraction tool		<p>mm</p>  <p>Extraction</p>
Intake and exhaust valve guide insertion/ extraction tool		<p>mm</p> 
Oil filter wrench		

Name of tool	Illustration	Remarks
Piston ring compressor		 Piston pin extractor
Valve lapping handle		 Lapping tool
Valve lapping powder		
Feeler gauge		
Pulley puller		 Local supply Removing the coupling



## 2-2 Measuring Instruments

Name of tool	Shape and size	Application
Vernier calipers		0.05mm 0~150mm
Micrometer		0.01mm 0~25mm 25~50mm 50~75mm 75~100mm 100~125mm 125~150mm
Cylinder gauge		0.01mm 18~35mm 35~60mm 50~100mm 100~150mm
Thickness gauge		0.05~2mm
Torque wrench		0~35kg-m.
Nozzle tester		0~500kg/cm <sup>2</sup> .

### 2-3 Other material

Items		Usual Contents	Features and application
Liquid gasket	Three Bond No.1 TB1101	200g (1kg also aviable)	Non-drying liquid gasket; solventless type, easy to remove, superior in seawater resistance, applicable to various mating surfaces.
	Three Bond No.2 TB1102	200g (1kg also aviable)	Non-drying liquid gasket; easy to apply, superior in water resistance and oil resistance, especially superior in gasoline resistance.
	Three Bond No.3 TB1103	150g	Drying film. low viscosity and forming of thin film, appropriate for mating surface of precision parts.
	Three Bond No.4 TB1104	200g (1kg also aviable)	Semi-drying viscoelastic material, applicable to non-flat surface having many indentations and protrusions, superior in heat resistance, water resistance, and oil resistance.
	Three Bond No.10 TB1211	100g	Solventless type silicone-base sealant, applicable to high temperature areas. (—50°C to 250)
	Three Bond TB1212	100g	Silicone-base, non-fluid type, thick application possible.
Adhesive	Lock tight TB1401	200g	Prevention of loose bolts, gas leakage, and corrosion. Torque required to loosen bolt: 10 to 20% larger than tightening torque.
	Lock tight SUPER TB1330B	50g	Excellent adhesive strength locks bolt semipermanently.
Seal Tape		5m round tape	Sealing material for threaded parts of various pipes. Ambient temperature range: —150°C to 200°C
O-ring kit		$\phi$ 1.92-m dia.:1 $\phi$ 2.42-m dia.:1 $\phi$ 3.12-m dia.:1 $\phi$ 3.52-m dia.:1 $\phi$ 5.72-m dia.:1	O-ring of any size can be prepared, whenever required. (Including adhesive, release agent, cutter, and jig)
EP lubricant (molybdenum disulfate)	Brand name (LOWCOL PASTE)	50g	For assembly of engine cylinders, pistons, metals, shafts, etc. Spray type facilitates application work.
	Brand name (PASTE SPRAY)	330g	
	Brand name (MOLYPASTE)	50g	Prevention of seizure of threaded parts at high temperature. Applicable to intake and exhaust valves. (stem, guide, face)

Items		Usual Contents	Features and application
Scale solvent	Scale solvent	1 box (4kg×4removers)	<ul style="list-style-type: none"> <li>• The scale solvent removes scale in a short time. (1 to 10 hours)</li> <li>• Prepare water (seawater is possible) in an amount that is about 10 times the weight of the solvent. Mix the solvent with water.</li> <li>• Just dipping disassembled part into remover mixture removes scale. To shorten removal time, stir remover mixture.</li> <li>• If cleaning performance drops, replace remover mixture with new remover mixture.</li> <li>• Neutralize used mixture, and then dispose of it. To judge cleaning performance of mixture, put pH test paper into mixture. If test paper turns red, remover mixture is still effective.</li> </ul>
	Neutralizer (caustic soda)	1 box (2kg×4 neutralizers)	
	pH test paper		
Antirust		2 ℓ	Add antirust to fresh water system. Then operate engine for approximately 5 minutes. Antirust will be effective for 6 months.
Anti freeze		2 ℓ	Add antifreeze to fresh water system in cold areas to operate engine.
Cleaning agent		1kg×20	<ul style="list-style-type: none"> <li>• The cleaning agent removes even carbon adhering to disassembled parts.</li> <li>• If a cleaning machine is used, prepare 4 to 6% mixture of 60° to 80℃ to ensure more effective cleaning.</li> </ul>

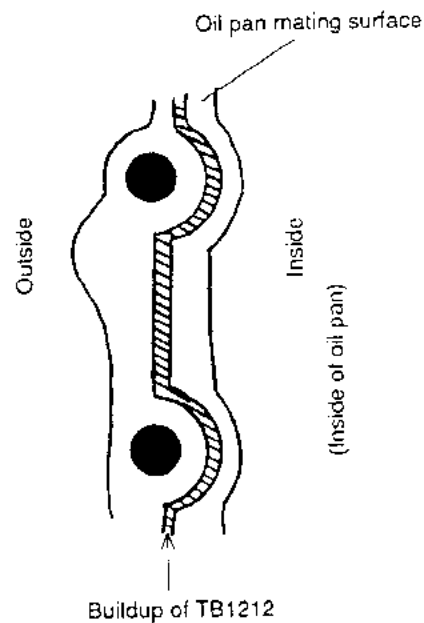
Items	Usual Contents	Features and application
Cleaning agent for turbocharger	4 ℓ×4	Special cleaning agent that requires no water, specially designed for blower of turbocharger and intercooler.
	18 ℓ×1	
	15sets : 1, 500cc×6	

**Cautions:**

It is recommended that the liquid gasket of Three Bond TB1212 should be used for service work.

Before providing service, observe the cautions below:

- (1) Build up each gasket equally.
- (2) For a bolt hole, apply liquid gasket to the inside surface of the hole.
- (3) Conventionally, Three Bond TB1104(gray) or Three Bond TB1102(yellow) is used for paper packings though the use of only these bonds is not effective.
- (4) If conventional packings are used, do not use a liquid packing.



## 3. Disassembly and Reassembly

The procedure for disassembling engine parts (fresh water tank, lube oil cooler, fuel oil filter, etc.) is explained in the section on disassembly. The procedure for reassembling is not explained in detail in the reassembly section, however it is performed as for disassembly but in the reverse order.

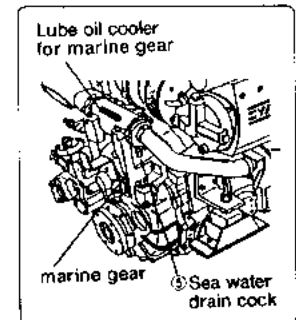
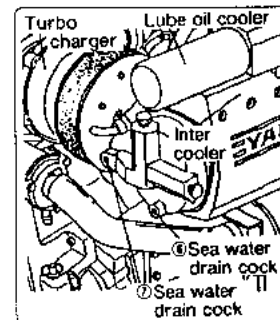
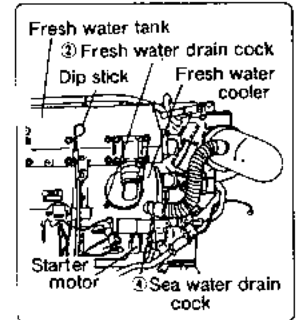
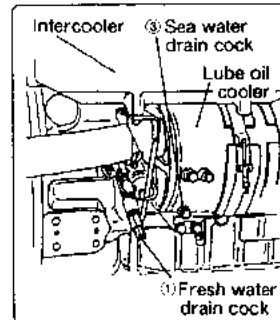
### 3-1 Disassembly

For engines mounted in an engine room, remove the piping and wiring connecting them to the ship.

- (1) Remove the remote control cable (from engine and marine gearbox).
- (2) Unplug the extension cord for the instrument panel from the engine.
- (3) Remove the wiring between the starting motor and the battery.
- (4) Remove the exhaust rubber hose from the mixing elbow.
- (5) Remove the fresh water sub-tank rubber hose from the filler cap.
- (6) Remove the cooling water (sea water) pump sea water intake hose (after making sure the Kingston cock is closed).
- (7) Remove the fuel oil intake rubber hose from the fuel feed pump.
- (8) Disassemble the propeller shaft coupling.
- (9) If a driven coupling is mounted to the front drive coupling, disassemble.
- (10) Remove the flexible mount nut, lift the engine, and remove it from the engine base.  
(Leave the flexible mount attached to the engine base.)

#### 3-1.1 Drain cooling water

- (1) Open the sea water drain cock between the sea water pump and lube oil cooler to drain the sea water.
- (2) Open the cylinder body drain cock to drain the fresh water from the cylinder head and cylinder body.
- (3) Open the fresh water drain cock on the lower part of the fresh water cooler to drain the fresh water.



#### 3-1.2 Drain lube oil

Remove the dip stick, and drain the lube oil using by drain pump from the engine.

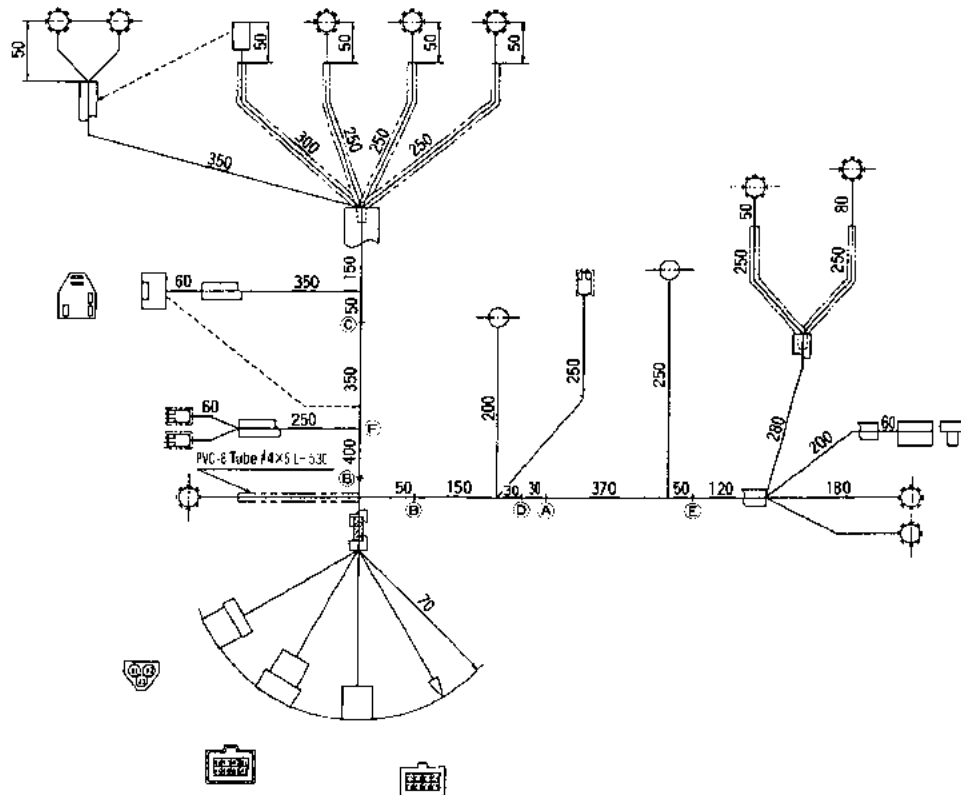
**NOTE:** If a lube oil supply/discharge pump is used /or the engine, the intake hose is placed in the dip stick guide, and for the clutch side (gearbox) it is placed in the oil hole on top of the case.

## 3-1.3 Removing (electrical) wiring

Remove the wiring from the engine.

(mm)

Be careful to keep the coupler dry when storing.

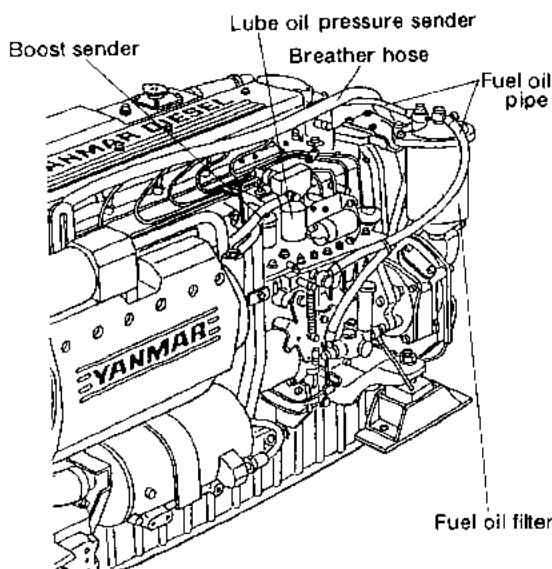


## 3-1.4 Removing the fuel oil filter &amp; fuel oil pipe

- (1) Remove the fuel oil pipe (fuel oil filter-fuel feed pump, fuel injection pump-fuel injection nozzle).
- (2) Remove the fuel oil filter (with bracket) from the intake manifold.

## 3-1.5 Removing the intake silencer

- (1) Remove the breather hose connected between gear case and intake silencer.
- (2) Remove the lube oil pressure sender and boost sender.

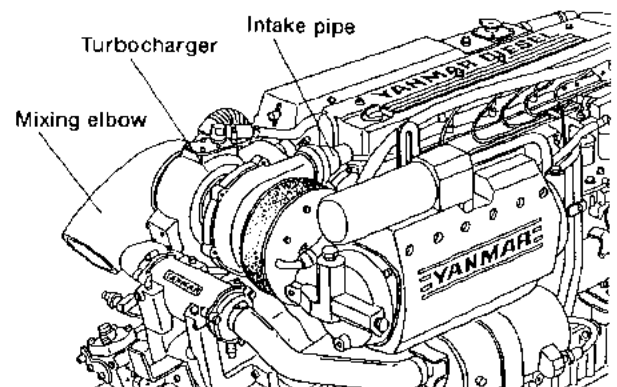


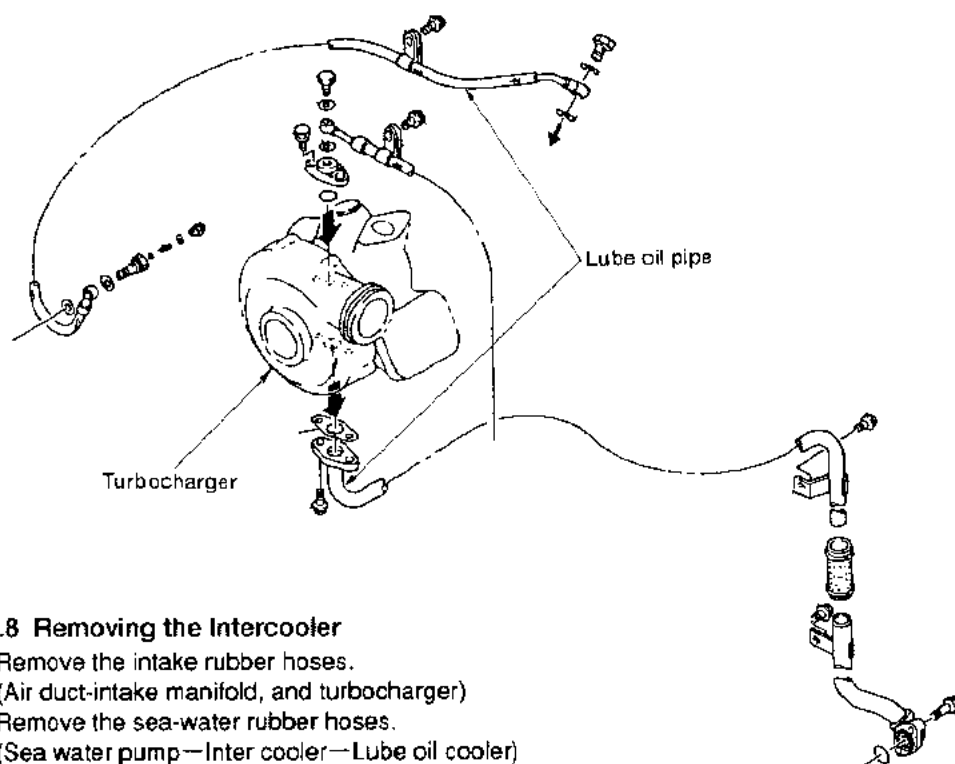
## 3-1.6 Removing the mixing elbow

- (1) Remove cooling water (sea water) pipe rubber (heat exchanger-mixing elbow).
- (2) Remove the mixing elbow from the turbocharger.
- (3) Remove the other outside pipes (fresh water line, sea-water line, lube oil line, fuel oil line).

## 3-1.7 Removing the turbocharger

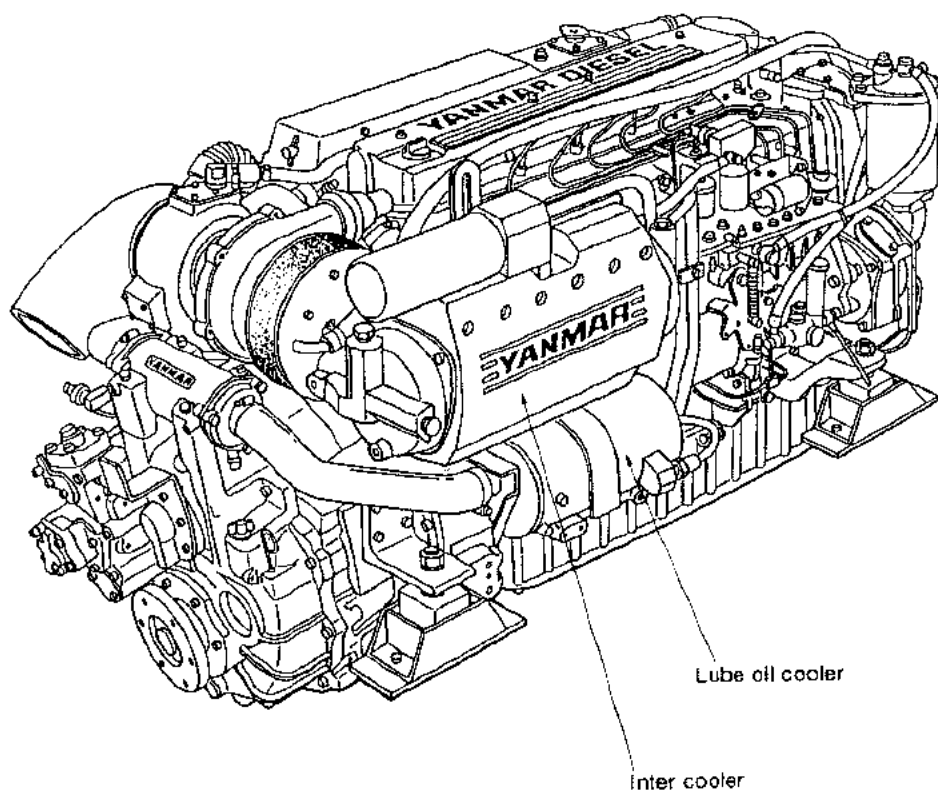
- (1) Remove the intake pipe (turbine—intake manifold).
- (2) Remove the oil pan side rubber hose for the turbine lube oil return pipe from the oil pan, and the vibration stop from the flywheel housing.
- (3) Remove the turbine lube oil pipe (lube oil cooler—turbine).
- (4) Remove the turbine from the cooling water tank.





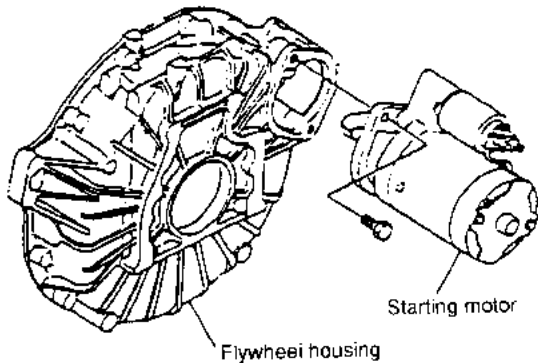
### 3-1.8 Removing the Intercooler

- (1) Remove the intake rubber hoses.  
(Air duct-intake manifold, and turbocharger)
- (2) Remove the sea-water rubber hoses.  
(Sea water pump—Inter cooler—Lube oil cooler)
- (3) Remove the intercooler



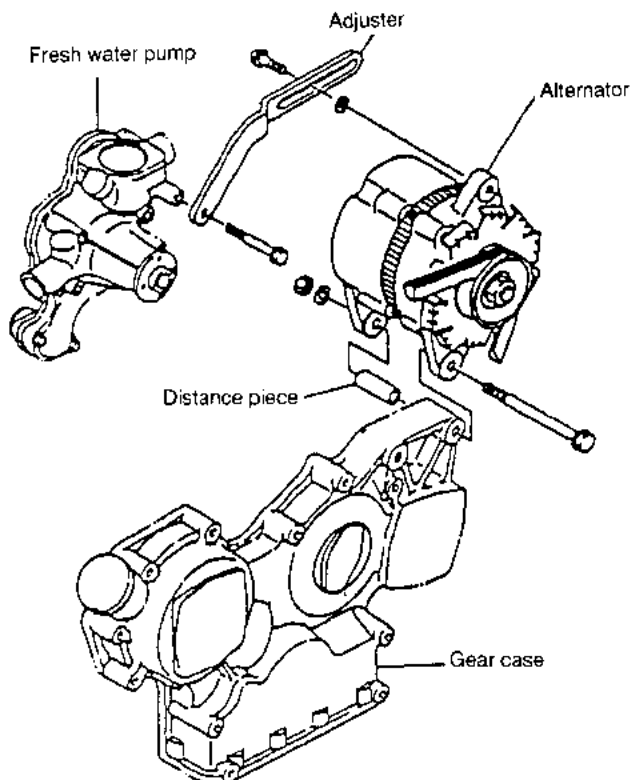
### 3-1.9 Removing the starting motor

Remove the starting motor from the flywheel housing.



### 3-1.10 Removing the alternator

- (1) Loosen the alternator adjuster bolt and remove the V-belt.
- (2) Remove the adjuster from the fresh water pump, and remove the alternator from the gear case (with distance piece).

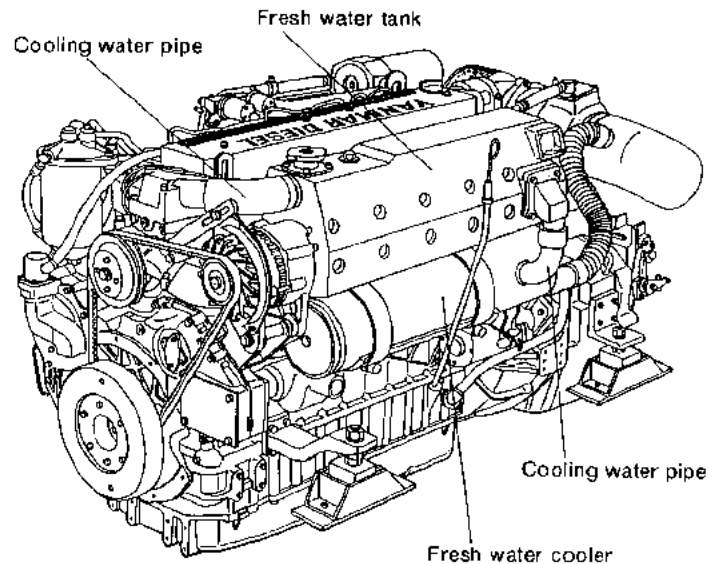


### 3-1.11 Removing the cooling water pipe

- (1) Remove the cooling water (sea water) pipe (lube oil cooler).
- (2) Remove the cooling water (fresh water) pipe (fresh water tank—fresh water pump, fresh water tank pump—fresh water cooler).
- (3) Remove the cooling water pipe (lube Oil cooler—marine gearbox).

### 3-1.12 Removing the cooling water pipe

Remove the fresh water tank and fresh water cooler with packing.





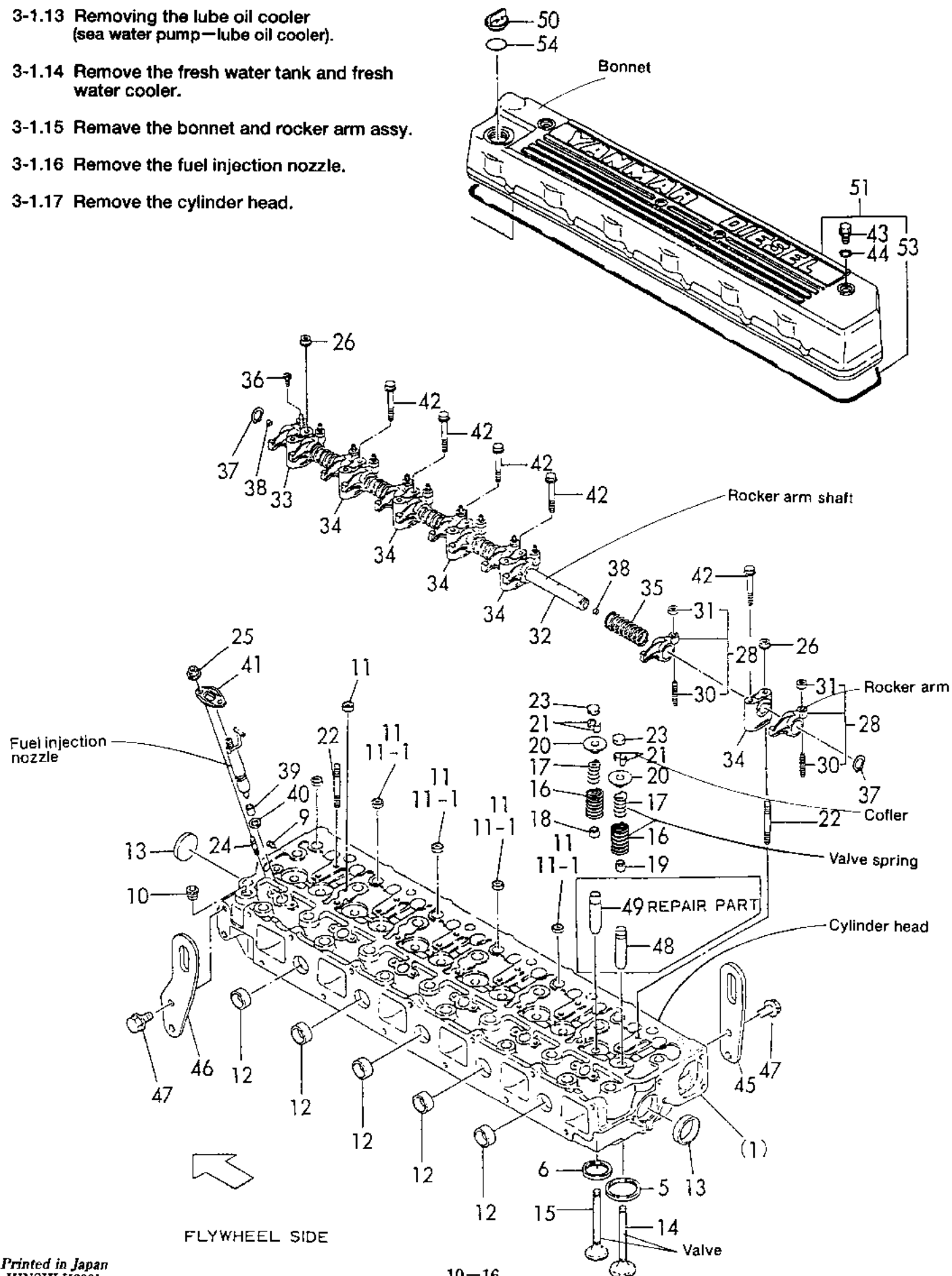
3-1.13 Removing the lube oil cooler  
(sea water pump—lube oil cooler).

3-1.14 Remove the fresh water tank and fresh  
water cooler.

3-1.15 Remove the bonnet and rocker arm assy.

3-1.16 Remove the fuel injection nozzle.

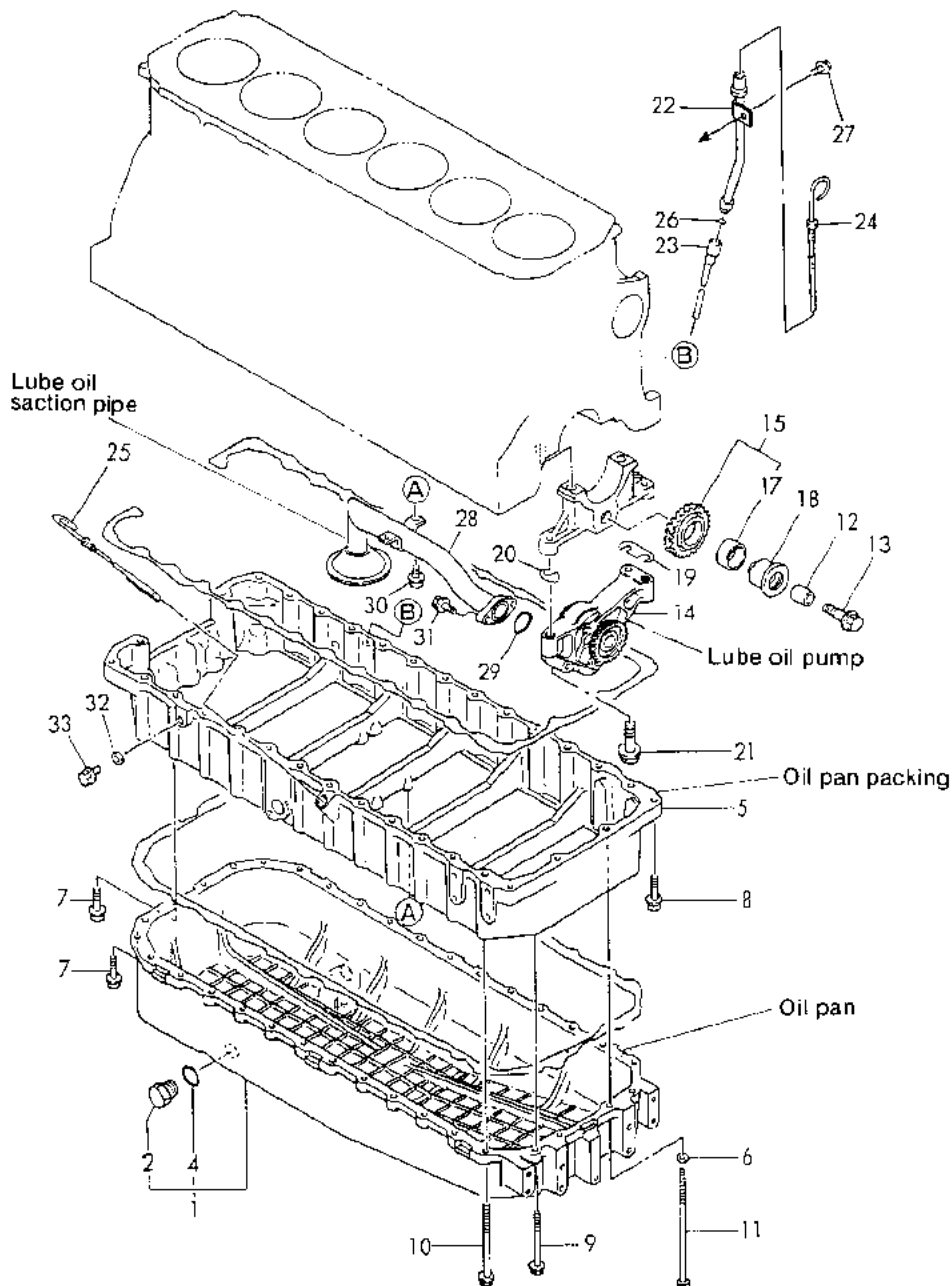
3-1.17 Remove the cylinder head.



3-1.18 Remove the marine gear.

3-1.19 Remove the front pulley, and fresh water pump pulley.

3-1.20 Place a wooden plank on the ground, and lay the cylinder block upside down on it. The feet of the cylinder block should rest firmly on the wooden surface. Care should be taken to position the cylinder block securely so that it will not become scratched or damaged.



3-1.21 Remove the oil pan and the intermediate for the oil pan.

3-1.22 Loosen the connecting rod bolt and remove the big end bearing cap. Turn the crank and remove the cylinders one at a time.

3-1.23 Remove the lube oil pump.

3-1.24 Loosen the attachment bolt for the main bearing cap. After doing this, perform the following.

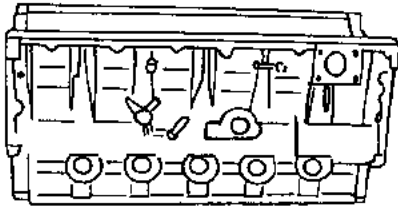
3-1.25 Remove the crank shaft.

3-1.26 Take out the connecting rod and remove the piston.

### 3-2 Reassembly

#### 3-2.1 Cylinder block

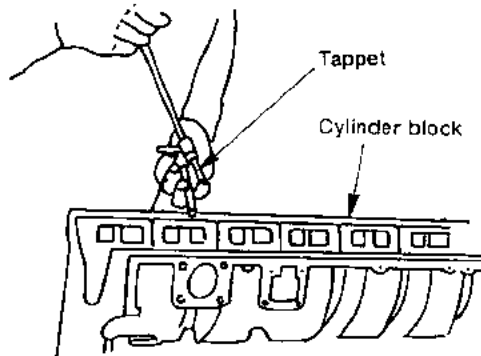
Completely clean each oil hole. After cleaning, check that no scaling remains on cylinder block.



Cylinder block

#### 3-2.2 Tappet

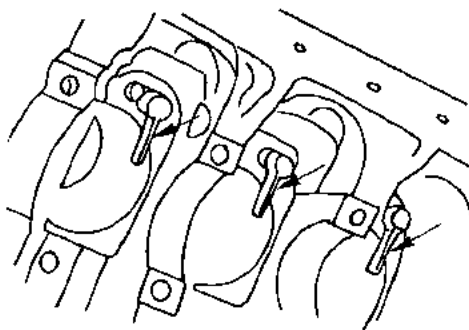
Fit each tappet.  
Check that each tappet is fitted to appropriate cylinder and valve (exhaust or intake).  
Before fitting, apply engine oil to each tappet. After fitting, check that each tappet operates smoothly.



Tappet fitting

#### 3-2.3 Piston cooling nozzle

Fit each cooling nozzle to piston.  
Check that nozzle end is positioned on piston head side.  
Also check that nozzle does not touch cylinder block.  
Tightening torque : 2.0kgf-m

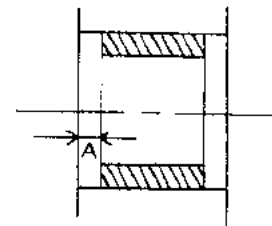


Piston cooling nozzle

#### 3-2.4 Cam shaft bearing

(1) Fit each cam shaft bearing as follows:

- 1) Apply lube oil to outer surface of each bearing and fitting area of cylinder block, and then press-fit metal into its position using driving tool.  
Check position of each oil hole. More than 2/3 area of hole should be aligned.



Anti-flywheel side: A=2  
Intermediate position: A=1.5  
Flywheel side: A=0.5

- 2) After press-fitting, check each bearing for distortion by measuring, inner diameter of bearing.

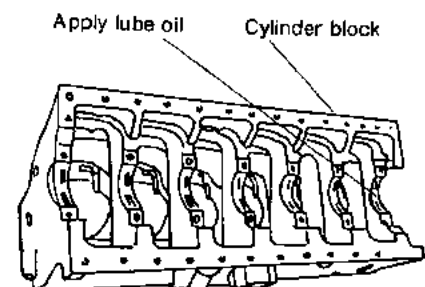
(mm)	
Inner diameter after press-fitting	$\phi 57 \begin{matrix} +0.05 \\ +0.02 \end{matrix}$

**Note :** To remove cam shaft bearing

1. Attach plate to cam shaft bearing, and tap off bearing using copper hammer.
2. Completely clean each bearing hole on cylinder block before press-fitting each bearing.

#### 3-2.5 Crankshaft

- (1) Apply engine oil to each crank journal hole of cylinder block and each block side main bearing, and then fit shaft to cylinder block.  
Bearings having an oil groove should be positioned on upper side (block side).  
Fit thrust metal so that oil grooves are respectively positioned outside.

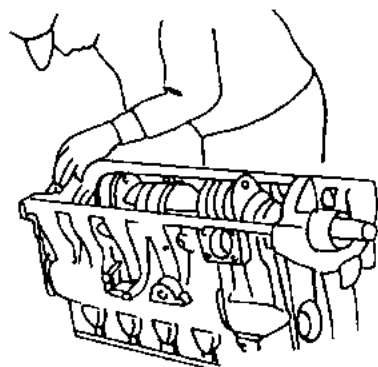


Fitting of upper bearings

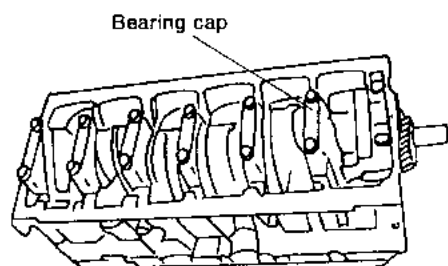
- (2) Apply engine oil to each crank pin and crank journal, and fit each journal to main bearing.
- (3) Fitting caps
  - 1) Apply engine oil to both surfaces of each cap side main bearing, and then fit each main bearing to the cap.

- 2) Apply lube oil to bolt bearing surfaces and threaded parts of each bearing cap.  
Fit each bearing cap to each journal of crankshaft, and apply specified torque to tighten each bearing cap bolt.  
Check that each bolt is equally tightened.

Bearing cap bolt (M15, 14 bolts) tightening torque	$24 \pm 1 \text{ kgf-m}$
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Fitting of thrust bearings



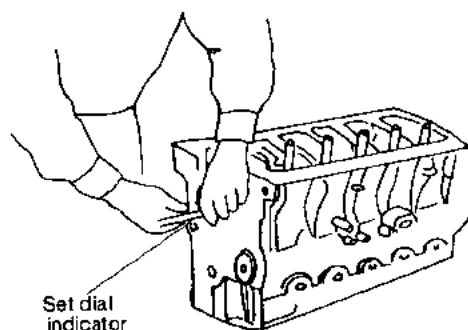
Fitting of bearing caps

Check that arrow marked on each bearing cap is positioned on flywheel side, and matchmark on each cylinder is correctly aligned.

- 3) Check that crankshaft rotates smoothly.
- 4) Measure side clearance of crankshaft.

(mm)

Side clearance of crankshaft	$0.132 \sim 0.223$
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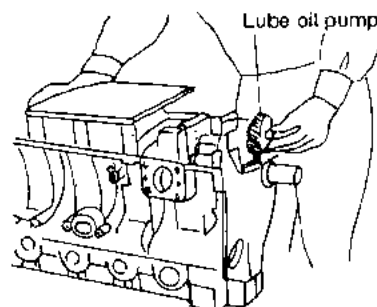


Measurement of side clearance

### 3-2.6 Lube oil pump

- (1) Fit lube oil pump idle gear.  
Side clearance: 0.10 to 0.30mm

Tightening torque	$11 \pm 1.0 \text{ kgf-m}$
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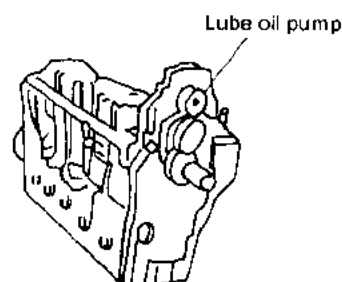


Fitting of lube oil pump idle gear

- (2) Fit lube oil pump while adjusting position of positioning pin.  
Secure pump by tightening 3 bolts of M10×55mm
- (3) Measure gear backlash between lube oil pump and idle gear, and check that backlash satisfies value specified below:

(mm)

Gear backlash	$0.17 \pm 0.09$
---------------	-----------------



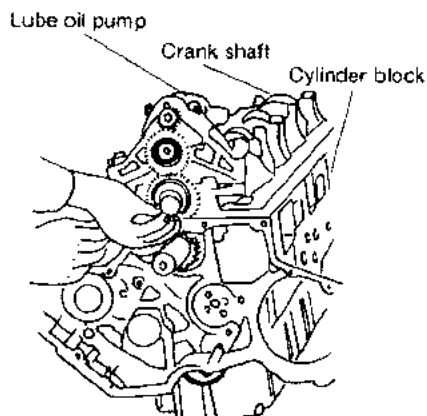
Fitting of lube oil pump

### 3-2.7 Gear case

Apply liquid gasket to gear case, and then fit gear case to cylinder body while adjusting position of dowel pin. Secure gearcase by tightening bolt listed below:

M8×20mm, 5 bolts

M8×45mm, 1 bolt



Fitting of gear case

### 3-2.8 Cam shaft

1) Apply lube oil to bearing of cam shaft, and then fit cam shaft.

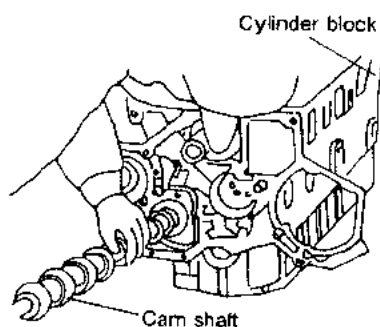
2) Fit thrust plate, and secure it by tightening 2 bolts of M8×16mm

(mm)	
Side clearance	0.05~0.20

**Note:** If cam gear is removed from cam shaft, fit thrust metal before fitting gear.

Heat cam gear to between 180° and 200°C, and then press-fit it.

Interference: 0.023 to 0.060mm



Fitting of cam shaft

### 3-2.9 Cylinder sleeve

(1) Completely clean sleeve fitting area of each cylinder block.

(2) Completely clean outer surface of each cylinder sleeve. Then tap cylinder sleeve into cylinder block

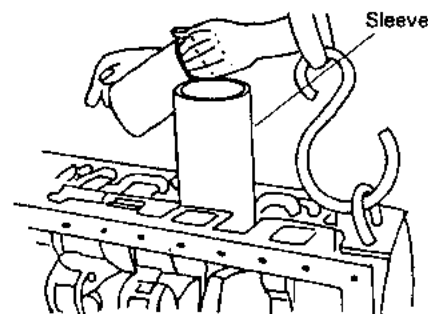
**Note :** 1. Before inserting each cylinder sleeve, check cylinder No. and fitting direction.

Insert sleeve into position on which identical size, such as A, B, or C, is marked. Size is marked on each sleeve and lower side of cylinder block on operating side. For detailed description on size mark, refer to Sec. 4-3.

2. After completing cylinder sleeve insertion, do not turn cylinder block upside down to face cylinder head side downward.

(3) Measure projection of each cylinder sleeve, and check that protrusion length satisfies value specified below:

(mm)	
Sleeve projection	0.025~0.09



Insertion of cylinder sleeve

### 3-2.10 Piston assembly

(1) Fit connecting rod to each piston while checking direction of piston.

For detailed description, refer to Sec. 3-3-4.

(2) Fit piston rings and oil ring to each piston while checking that cutouts of rings are offset 120° from each other.

(3) Apply engine oil to sleeve, outer surface of piston, and rod metal.

(4) Adjust crankshaft pin of corresponding piston to top position.

(5) Check direction of piston.

(6) Insert piston into cylinder using piston insertion tool.

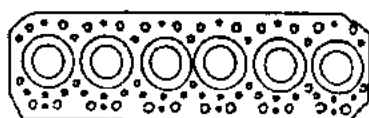
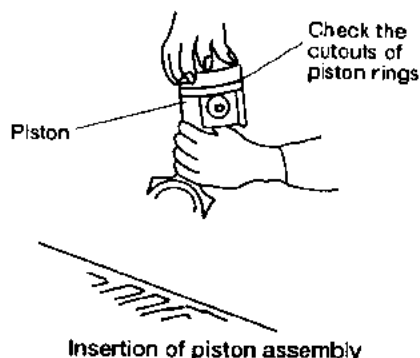
(7) After insertion, remove tool.

Then rotate crankshaft by pressing piston edge using hammer until piston reaches bottom dead center.

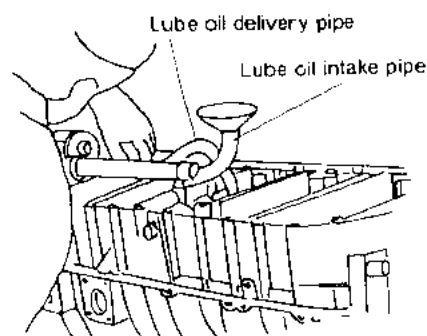
(8) Install cap on big end while checking matchmarks, and then tighten rod bolts.

Before tightening rod bolts, apply lube oil to bolt bearing surface.

**Note :** Selectively fit each piston and sleeve.



Fitting of piston assembly



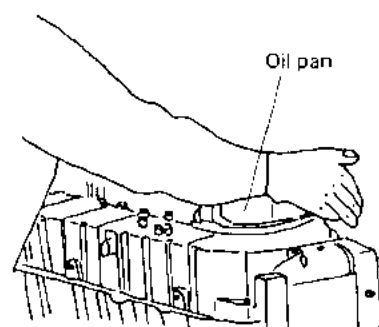
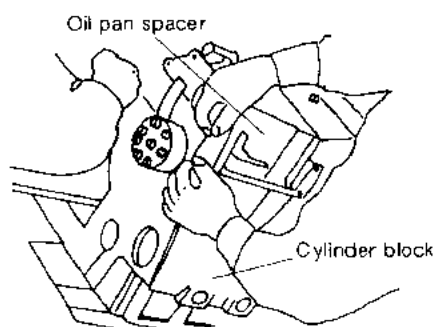
### 3-2.13 Oil pan

Apply liquid gasket to oil pan, and then fit oil pan.  
Secure oil pan by tightening bolts listed below:

- M8×25mm, 4 bolts
- M8×120mm, 26 bolts
- M8×190mm, 2 bolts
- M8×90mm, 2 bolts

### 3-2.11 Oil pan spacer

Apply liquid gasket to oil pan spacer, and then fit spacer.  
Secure spacer by tightening 4 bolts of M8×35mm



### 3-2.14 Flywheel housing

Fit flywheel housing while adjusting position of 2 parallel pins. Secure housing by tightening bolts listed below:

- M10×25mm, 8 bolts
- M10×30mm, 4 bolts

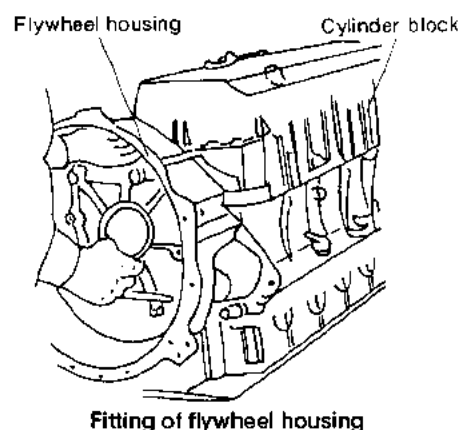
### 3-2.12 Lube oil intake pipe and delivery pipe

(1) Fit lube oil delivery pipe first, and then intake pipe.  
Secure delivery and intake pipes by tightening bolts listed below:

- M8×25mm, 2 bolts
- M8×16mm, 2 bolts

(2) Insert other end of lube oil delivery pipe into oil pan spacer. Secure pipe by tightening bolts of M8×25mm.

(mm)	
Spigot joint runout	less than 0.25
Surface runout	less than 0.15



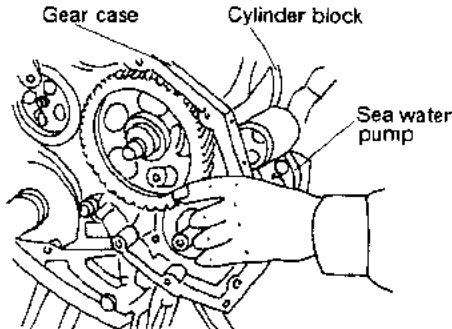
Fitting of flywheel housing

### 3-2.15 Seawater pump

Fit seawater pump to gear case. Secure pump by tightening bolts and nuts listed below:

**M8×20mm, 2 bolts**

**M8, 2 nuts**

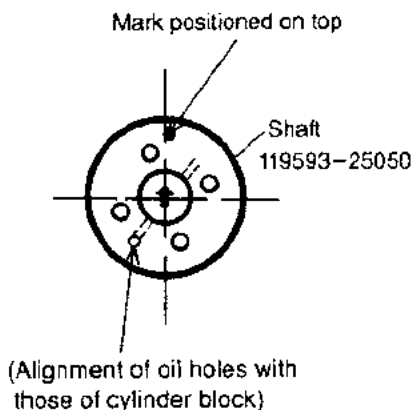


Fitting of seawater pump

### 3-2.16 Idle gear

- (1) Fit idle gear and shaft, and secure them by tightening 2 bolts of **M8×25mm**.
- (2) Measure side clearance of idle gear, and check that clearance satisfies value specified below : 0.1~0.3mm

*Note :* Align oil holes with those of cylinder block (see figure).



### 3-2.17 Lube oil pressure regulating valve

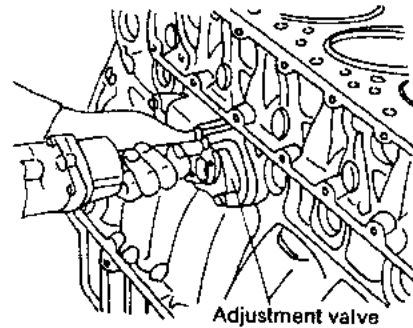
Fit lube oil pressure regulating valve assembly, and secure it by tightening bolts listed below:

**M8×40mm, 1 bolt**

**M8×45mm, 4 bolts**

Lube oil pressure of engine: 4.5+0.5kgf-cm<sup>2</sup>

Oil temperature: 85°C at 3,000r.p.m.



Fitting of adjustment valve

### 3-2.18 Cooling water passage cover

Apply liquid gasket to cooling water passage cover, and then fit cover. Secure cover by tightening bolts listed below:

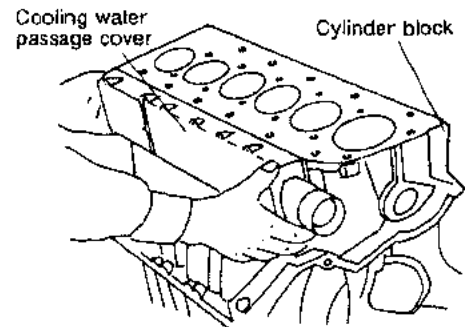
**M8×18mm, 2 bolts**

**M8×30mm, 10 bolts**

**M8×45mm, 2 bolts**

**M8×50mm, 1 bolt**

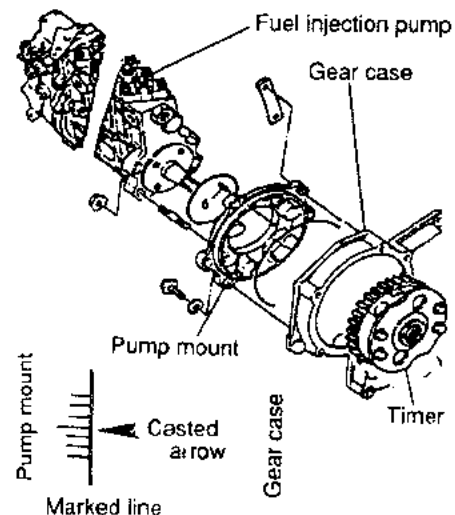
**1 pipe joint**



Fitting of cooling water passage cover

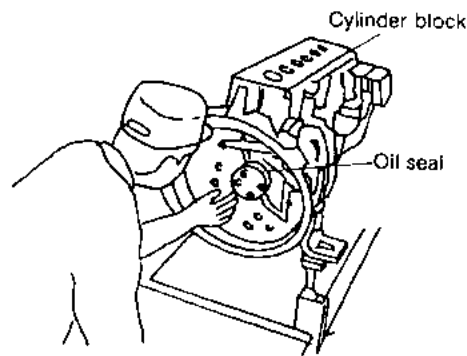
### 3-2.19 Fuel injection pump

- (1) Fit pump mount to fuel injection pump. Then fit fuel injection pump assembly to gear case. Align arrow mark with original point. (Original point should be checked before disassembly.) Fit pump assembly to cylinder block, and secure it by tightening 2 bolts of **M10×80mm**.
- (2) Fit timer to gear case, and secure timer by tightening 1 nut of **M18×1.5mm**.



## 3-2.20 Oil seal

- (1) Insert the oil seal into the flywheel housing. (Use the special tool for insertion.) Grease the outer circumference of the lip portion of the oil seal.  
Spigot joint runout  $\leq 0.25$



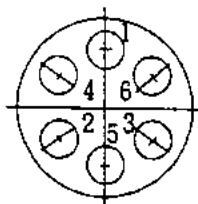
Fitting of oil seal

## 3-2.21 Flywheel

- (1) Fit flywheel while adjusting position of dowel pin. It is convenient to use 2 bolts of M10. Apply engine oil to bolts and bolt bearing surfaces. Secure flywheel by tightening bolts listed below:  
M16×47mm, 6 bolts

Tightening torque  
 $30 \pm 1 \text{ kgf-m}$

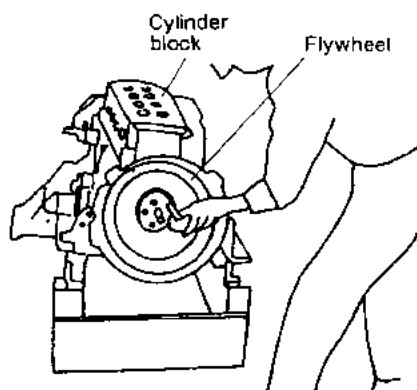
Tightening torque



M14×35mm, 6 bolts

(mm)

Surface runout	0.1 or less
Spigot joint runout	0.2 or less



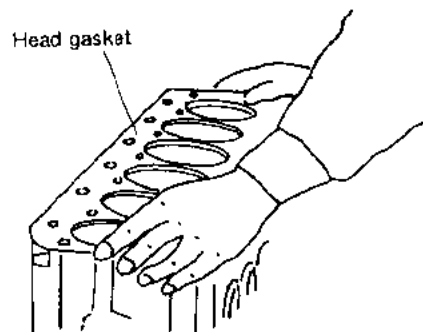
Fitting of flywheel

## 3-2.22 Cylinder head assembly

- (1) Correctly fit head gasket.

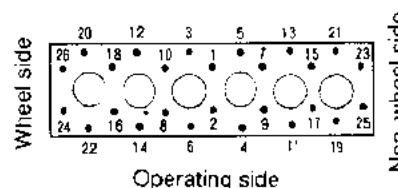
t=1.3

Check that each positioning pin is properly inserted into pin hole.



Fitting of head gasket

- (2) Fit cylinder head to cylinder block while checking that each positioning pin is properly inserted into pin hole.  
(3) Apply lube oil to screwed area of head bolt and bolt bearing surface.  
• Sequentially tighten bolts in order of ascending number (see figure below).



- Loosely tighten bolts twice, and then finally tighten them.

Head bolt: M14×121mm

Number of head bolts: 26

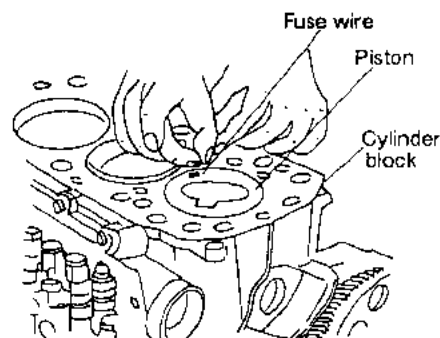
(kgf-m)

Tightening torque	1st time	2nd time	3rd time
Cylinder head	11	17	21

- (4) Measure top clearance, and check that it does not exceed range specified below:

(mm)

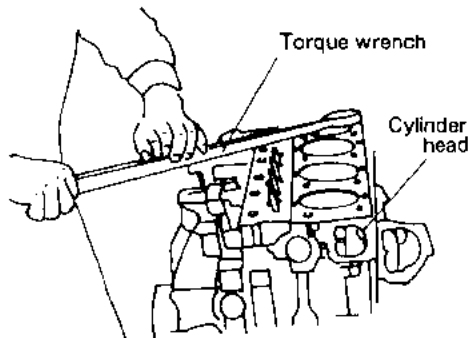
Top clearance	$0.8 \pm 0.09$
---------------	----------------





**Note :** 1. Check that cylinder head fitting surface on cylinder block are not fouled. Also check inside of each cylinder for dust, dirt, and foreign material.  
2. Head identification No. is marked on upper surface on wheel side (left side of nozzle hole).

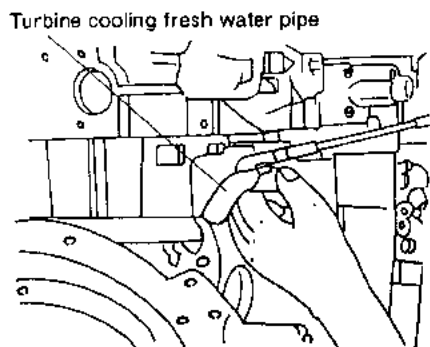
It is also possible that intake manifold is fit to cylinder head first, and then cylinder head complete with manifold is fit to cylinder block.



Tightening of cylinder head

### 3-2.23 Turbine cooling fresh water (CWF) pipe

Fit turbine cooling fresh water pipe to cooling water passage cover.



Fitting of turbine cooling fresh water pipe

### 3-2.24 Intercooler

Apply liquid gasket to inlet side of intercooler, and then fit intercooler. Secure intercooler by tightening bolts listed below:

M8×16mm, 1 bolt	M8×70mm, 1 bolt
M8×20mm, 1 bolt	M8×80mm, 4 bolts

Fitting of intercooler

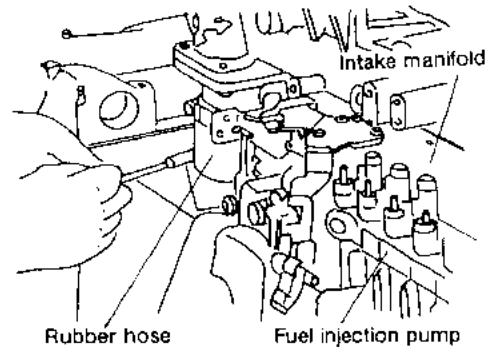
### 3-2.25 Intake manifold

(1) Fit intake manifold assembly, and secure it by tightening bolts listed below:

M8×20mm, 6 bolts

M8×70mm, 7 bolts

(2) Fit air duct and rubber hose.

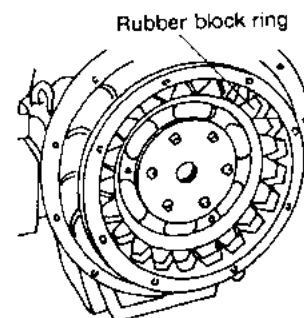


Rubber hose from intercooler to intake manifold

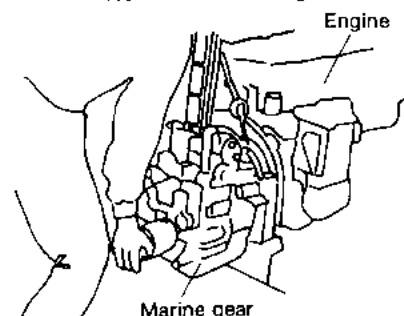
### 3-2.26 Marine gear

The explanation below is for Yanmar Marine Gear (Mode KMH6A)

- (1) Fit rubber block ring to flywheel, and then secure it by tightening 8 bolts of M10.
- (2) Lift clutch using marine gear lifting equipment.
- (3) Apply lube oil to clutch shaft (spline) and flange shaft hole.
- (4) Connect mounting flange of marine gear housing to mounting flange of fly wheel by tightening 12 bolts of M10.
- (5) Remove marine gear lifting equipment and wire rope from marine gear.
- (6) Connect pipe to marine gear.



Rubber block ring



Fitting of marine gear

**3-2.27 Push rod, valve arm shaft assembly**

- (1) Check condition of each push rod. If there is no abnormality, properly fit push rod to tappet.

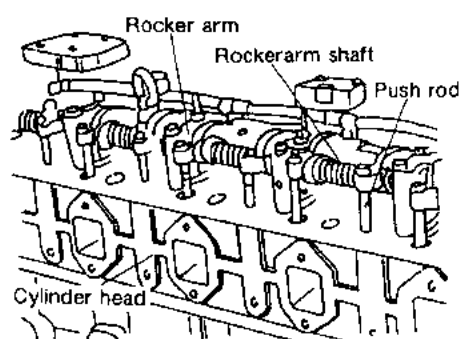
- (2) Fit valve arm shaft assembly. Do not forget to fit valve cap.

Secure valve arm shaft assembly by tightening bolts and nuts listed below:

Collar bolt: M8×65mm, 6 bolts M18×65mm, 6 bolts

Stud bolt: M8×65mm, 2 bolts Nut: M8, 4 nuts

Valve arm shaft support tightening torque (M8)	2.6±0.3kgf-m
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Fitting of valve arm shaft assembly

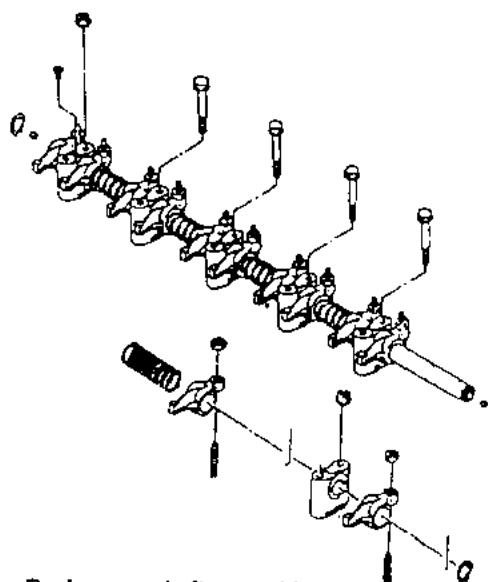
- (3) Measure valve clearances, and check that they satisfy values specified below:

Valve clearance: 0.1mm for intake valve, 0.4mm for exhaust valve

After adjusting valve clearances, apply lube oil to each valve arm, and then fit bonnet.

- (4) Fit bonnet, and secure it by tightening 10 bolts of M8×25mm.

- (5) Fit lifting eye bolts to gear and wheel sides of bonnet.



Rocker arm shaft assembly

**3-2.28 Fresh water pump**

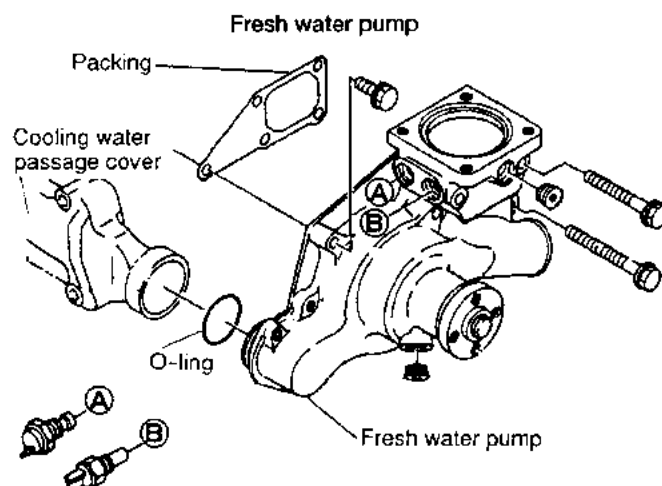
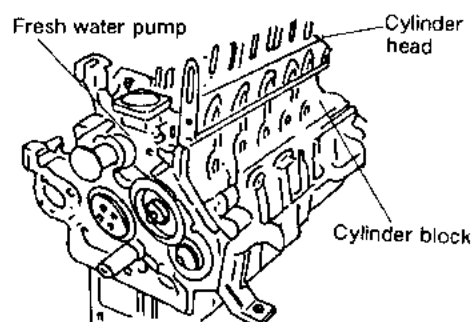
- (1) Apply liquid gasket to both sides of packing.

- (2) Fit fresh water pump to pump fitting surface on cylinder head.

Then secure pump by tightening bolts listed below:

M8×30mm, 1 bolt M8×80mm, 2 bolts M8×95mm, 2 bolts

- (3) Before tightening bolts, attach O-ring to area connected to cooling water passage cover bend.

**3-2.29 Gear case cover**

- (1) Apply liquid gasket to gear case, and then fit gear case cover to gear case while adjusting position of 2 parallel pins.

- (2) For gear case equipped with tachometer, fit gear case cover while aligning groove.

- (3) Fit inspection hole cover of fuel injection pump drive gear, and secure cover by tightening washer based bolts. Applicable bolts for each area are as follows:

M8×40mm, 1 bolt, for stiffness

M8×45mm, 4 bolts, for gear case cover

M8×45mm, 3 bolts, for cover

M8×50mm, 2 bolts, for cover to cap

M8×55mm, 1 bolt, for cover

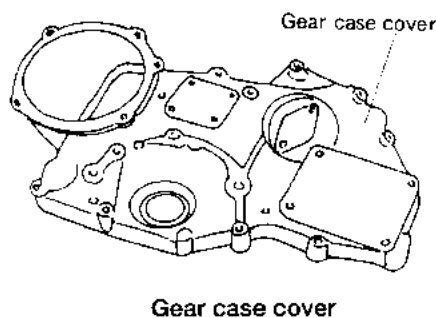
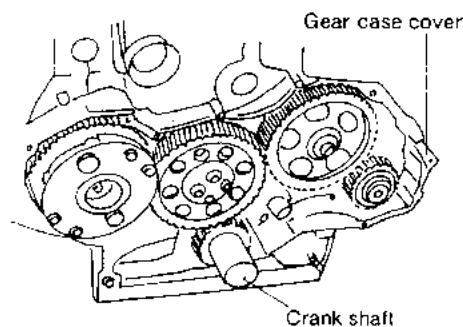
M8×70mm, 1 bolt, for cover

M8×75mm, 2 bolts,

M8×18mm, 2 bolts, for tachometer cap

M8×20mm, 2 bolts, for FIP timing

M8×20mm, for CSW-P



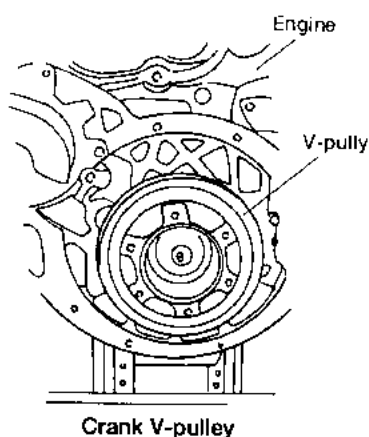
## 3-2.30 Crank V-pulley

- (1) Fit front mount, and secure it by tightening bolts listed below:

M8×20mm, 1 bolt	M8×70mm, 2 bolts
M8×25mm, 2 bolts	M8×85mm, 1 bolt
M8×55mm, 1 bolt	M8×115mm, 2 bolts
M8×65mm, 1 bolt	M10×25mm, 1 bolt

- (2) Fit crank pulley, and secure it by tightening crank pulley bolt.

Crank pulley bolt (M14×35mm) tightening torque	16±1kgf-m
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**Note :** While fitting front mount or crank pulley, take care not to attach dust, dirt, or foreign material to tapered area of crankshaft and tapered hole of V-pulley

To fit viscous-type damper, position "6LY" mark outside.

## 3-2.31 Fuel injection valve

- (1) Fit nozzle protector to end of fuel injection valve, and then fit fuel injection valve complete.  
Replace nozzle protector with new one every time when fuel injection valve is disassembled.
- (2) Loosely tighten fuel injection valve tightening nut.
- (3) Tighten tightening nut by applying torque specified below:

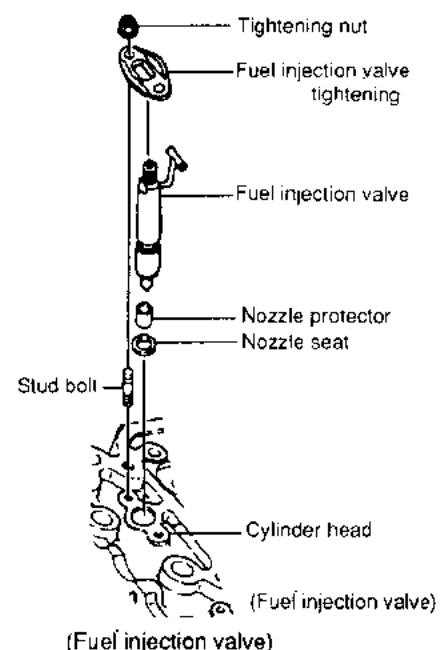
Pressure nut (M6) tightening torque	0.7 to 1.0kgf-m
-------------------------------------	-----------------

Stud bolt: M6×25mm, 12 bolts

Nozzle tightening nut: M6, 12 nuts

- (4) Finally tighten fuel injection valve.

Valve tightening torque	3.5kgf-m
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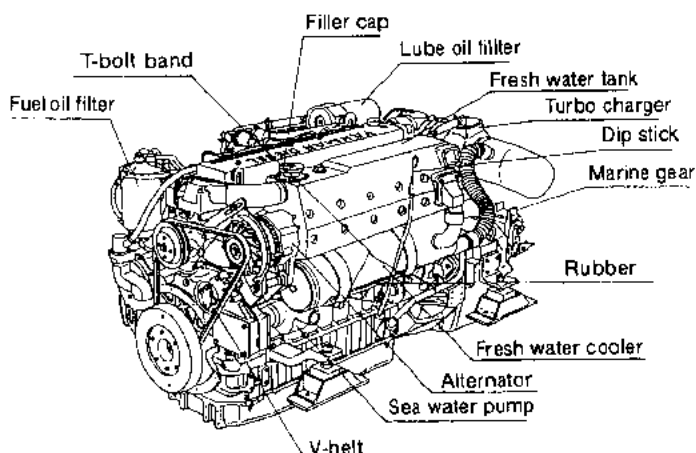


### 3-2.32 Fresh Water Tank

Secure the fresh water tank securely with bolts.

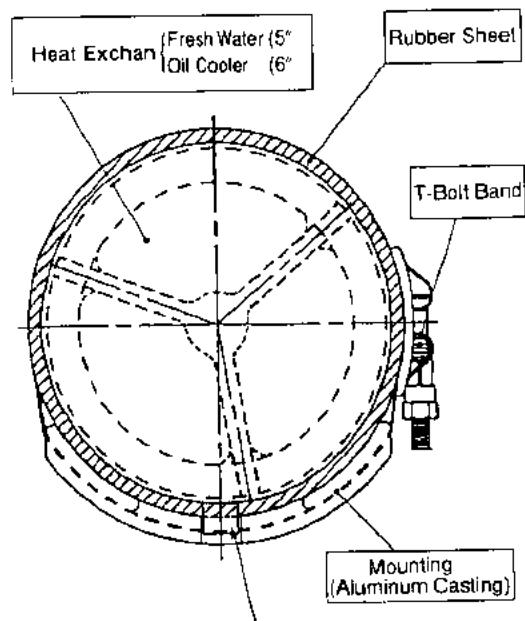
### 3-2.33 Fresh Water Cooler

Place two rubber sheets under the fresh water cooler and secure firmly with T-bolt band.



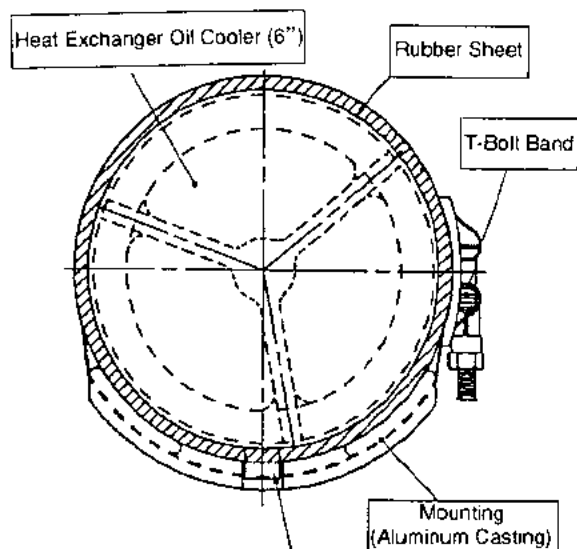
### 3-2.34 Lube oil cooler

Install the Lube oil cooler. Connect the pipe between the lube oil cooler and the lube oil filter.

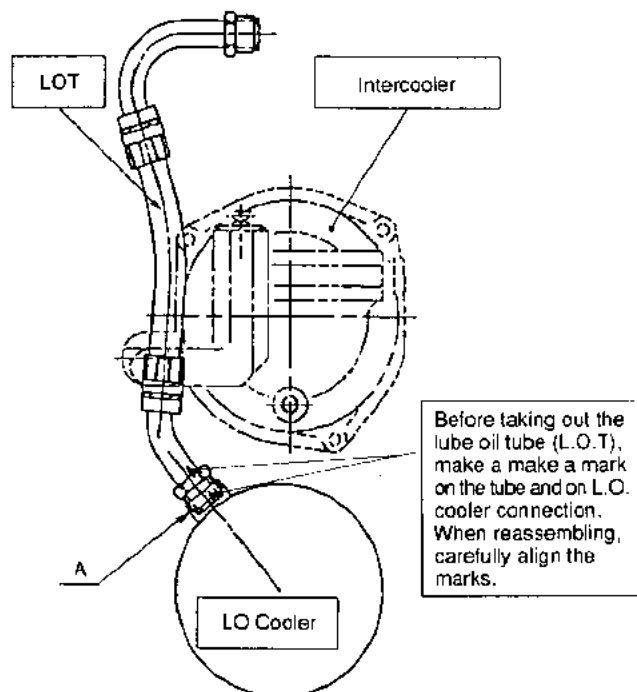


Check to see that the positioning pin is inserted in the hole.

- Put the cooler wrapped in the rubber sheet on the mounting, and tighten the T-bolt bands (2).

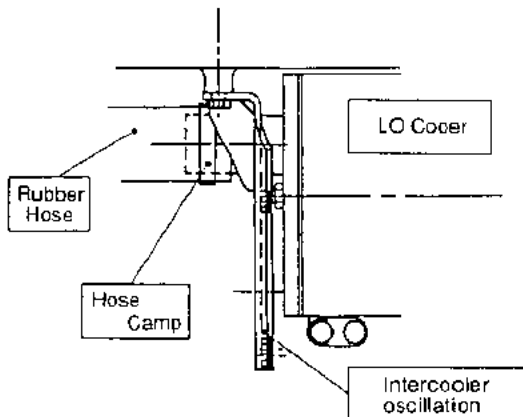


Check to see that the positioning pin is inserted in the hole.



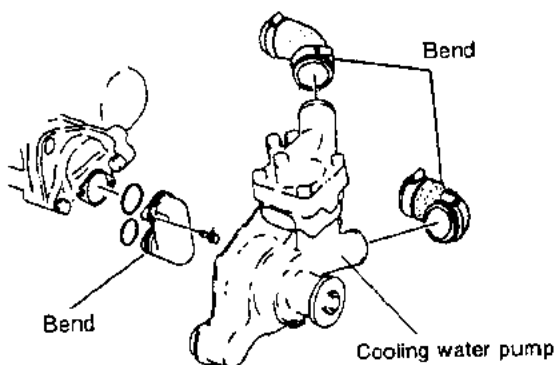
- Before installing the intercooler, be sure that the A section has been tightened securely.

- Close the rubber hose connected to the LO cooler at the left side of the intercooler oscillation preventer.



### 3-2.35 Cooling water bend

- (1) Fit bends to cooling water pump and cooling water cooler.
- (2) Fit bends to intercooler and oil cooler.

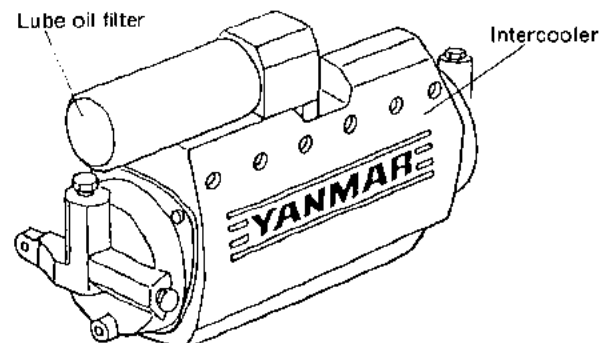


### 3-2.36 Air duct

- (1) Fit air duct to outlet of turbine, and secure duct by tightening bolts listed below:  
**M6×35mm, 2 bolts**  
**M6×70mm, 4 bolts**
- (2) Fit air duct to inlet of cooler.
- (3) Fit air duct to intake manifold inlet, and tighten duct by tightening 2 bolts of **M6×25mm**.

### 3-2.37 Intercooler steady brace

Fit steady braces to intercooler and oil cooler.



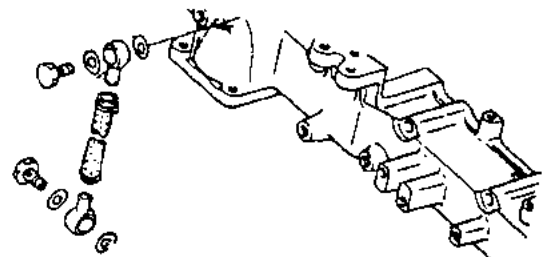
### 3-2.38 Boost output pipe

Fit boost output pipe.

Ball joint: M10, 2 joints

Pipe joint bolt: M10, 2 bolts

Fuel pipe: 1

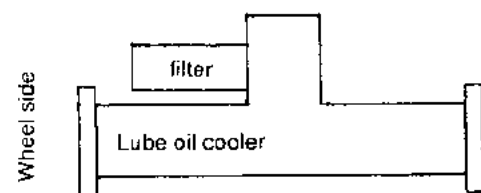


### 3-2.39 Lube oil cooler assembly

Fit lube oil cooler assembly.

Cooler assembly can be removed or refit together with lube oil filter as an assembly.

*Note : Before removing cooler assembly, be sure to drain oil.*

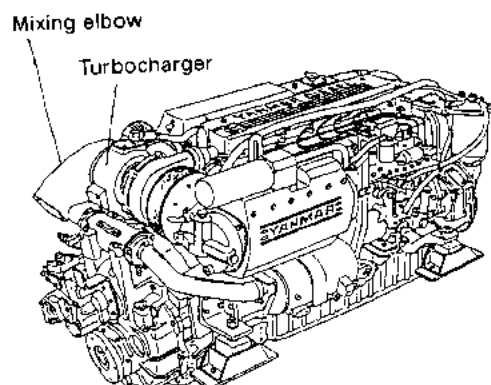


Viewed from operating side

Tighten filter using filter wrench until filter is seated properly.

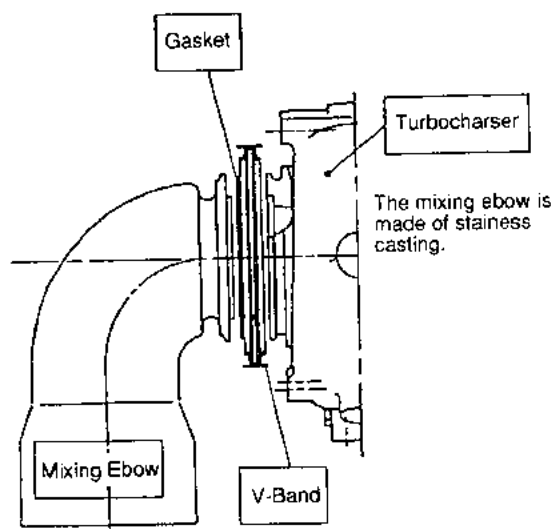
**3-2.40 Turbocharger**

Install the turbocharger and the attached lube oil pipe.

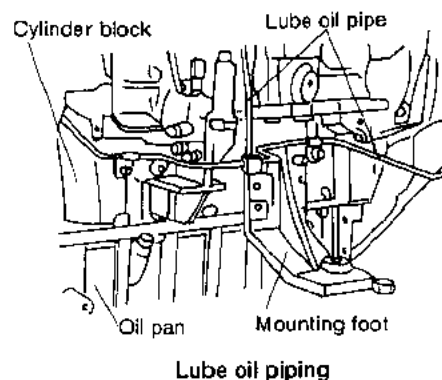
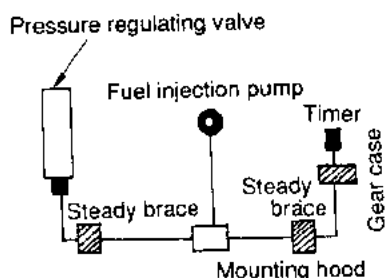
**3-2.41 Mixing Elbow**

Install the mixing elbow.

• Structure of Exhaust Outlet and V-Band

**3-2.42 Lube oil pipe**

Connect lube oil pipe to fuel injection pump.

**3-2.43 Alternator**

(1) Loosely tighten alternator.

**M8×20mm**, 2 bolts, for connection of mount to gear case

**M8×20mm**, 4 bolts, for connection of bracket to alternator

**M10**, 1 nut, for adjuster

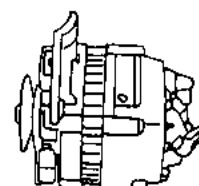
**M8×25mm**, 1 bolt

(2) Fit cooling water pump pulley, and secure it by tightening 4 bolts of **M8×18mm**.

(3) Engage belt with alternator. Check that belt is engaged properly.

(4) Insert bar or equivalent tool into clearance between alternator and cylinder block. Then adjust tension of fan belt by lifting alternator using tool.

Finally tighten alternator and alternator fitting stay.



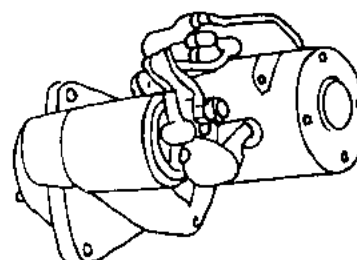
Alternator

Belt tension	10 to 15mm deflection when 70 to 80 lbs is applied
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**3-2.44 Starting motor**

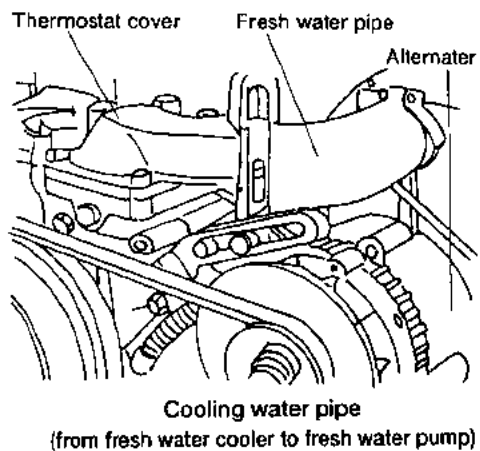
Fit flywheel housing and spigot joint to starting motor. Then fit starting motor assembly to engine, and secure it by tightening bolt.

Washer based bolt: **M12×30mm**, 2 bolts



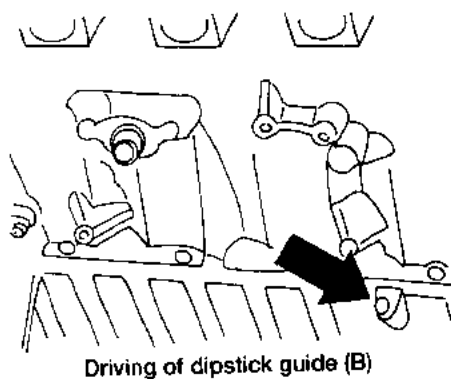
### 3-2.45 Cooling water pipe

- (1) Connect cooling water pipe to turbine.
- (2) Connect cooling water pipe from fresh water cooler to fresh water pump.

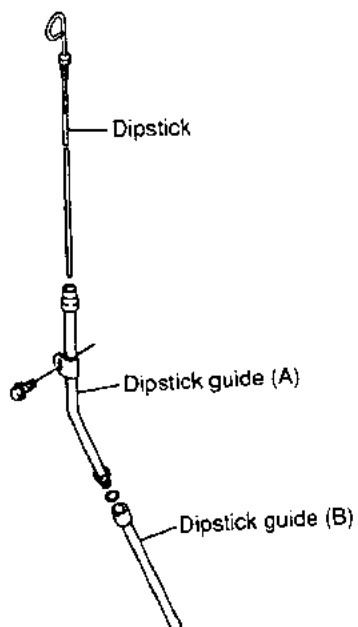


### 4-2.46 Dipstick

- (1) Drive dipstick guide (B) into oil pan spacer.
- (2) Apply LOCTITE to dipstick guide (A) and then fit them to engine.



Driving of dipstick guide (B)



## 4. Bolt/nut tightening torque

Main Bolt and Nut Tightening Torque

(Maintenance torque)

No.	Name	Screw dia. Xpitch	Material	Tightening torque
1	Head bolt	M14×1.5	10B35	(11→17→21±1) 12→18→23±1 kg-m
2	Rod bolt	M12×1.25	SCM435	(14±0.5) 14±0.5 kg-m
3	Flywheel retainer bolt	M16×1.5	SCM435	30±1 kg-m
4	Metal cap retainer bolt	M15×1.5	SCM435	(24±1) 26±1 kg-m
5	Crank V-pulley fastening bolt	M14×1.5	SCM435	16±1 kg-m
6	Nozzle fastening nut	M6×1	S40C (2 types)	0.4~0.5 kg-m
7	Timer fastening nut (in-line centralized pump)	M18×1.5	S45C	13±1 kg-m
8	Lube oil filter (full-flow) Fuel oil filter	1-12 UNF 1-12 UNS	—	Tighten filter using filter wrench until it is completely seated on its seat.
9	Idling shaft bolt (Idling gear)	M8×1.25	SCM435	3.8±0.2 kg-m
10	Idling shaft retainer bolt (Lube oil pump)	M12×1.75	SCM435	11±1 kg-m
11	V-band for turbocharger (at compressor outlet) (at turbine outlet)	1/4-28 UNF	SUS304	1st torque: 0.6~0.7 kg-m After tapping external surface using plastic hammer: Final torque: 0.9 kg-m

General tightening torque (without lubricant)

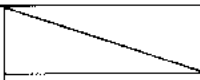
(kg-m)

No.	Name	Screw dia. Xpitch	Tightening torque	
1	Hexagon bolt (7T) Hexagon nut	M 6 ×1 M 8 ×1.25 M10×1.5 M12×1.75	1.1±0.1 2.6±0.3 5.0±0.5 9.0±1.0	① When the tightened part is aluminum : 80% of specified torque. ② For 4T and nut : 60% of specified torque.
2	PT plug	1 / 8 1 / 4 3 / 8 1 / 2	1.0 2.0 3.0 6.0	If SEELOCKMEC is used, torque is specified separately.
3	Pipe joint bolt	M 8 M12 M14 M16	1.5±0.2 3.0±0.5 4.5±0.5 5.5±0.5	



## Quality control

(mm)

No.	Item (part)			Standard value (notes)		Combustion		
1	Combustion	Top clearance		0.8±0.09		Gasket t=1.3		
2		Injection timing		13°±1° bTDC (FID)				
3		Injection pressure		260 <sup>+10</sup> <sub>0</sub> kg/cm²		Initial value		
4		Amount of nozzle spray		1.8±0.1				
5		Valve timing	Intake	Open	b TDC 36±5°			
				Close	a BDC 40±5°			
			Exhaust	Open	UTE	b BDC 66±5°		
					STE	b BDC 58±5°		
				Close	UTE	a TDC 54±5°		
					STE	a TDC 46±5°		
6	Valve clearance	Intake	0.1±0.03 (in cold condition)					
		Exhaust	UTE	0.4±0.03 (in cold condition)				
			STE	0.5±0.03 (in cold condition)				
7	Valves	Cam shaft hole coaxial (Contiguity)		φ 0.015				
8		Cam shaft profile		Lift error(mm)	Contiguity error (mm)			
		accuracy	buffer	±0.02	±0.006			
			Other than above	±0.04	±0.008			
9	Valve sink and project	Intake	(Project) 0.7±0.1					
Exhaust		(Sink) 0.3±0.1						

No.	Item (part)			Standard value (notes)						Combustion	
10	Head gasket	Liner	Liner flange	5 $\begin{smallmatrix} +0.050 \\ +0.025 \end{smallmatrix}$						(Gap between contiguity bore and liner $\leq 30 \mu$ )	
		thickness	Depth of cylinder block step	5 $\begin{smallmatrix} +0 \\ -0.040 \end{smallmatrix}$							
11	Head gasket	Lamination gasket thickness (at tightening)		1.30 $\pm$ 0.05							
12	L O C	Liner distortion	Before tightening	$\leq 0.005$ (radius)						Toppling	
			After tightening	$\leq 0.015$ (radius)							
13		Piston-Sleeve clearance	Clearance	0.088~0.108							
			Actively fitted	Piston Sleeve	L (Blue)	ML M(White)	MS S(Yellow)	S			
14		Sleeve-Cylinder block clearance	Clearance	0.010~0.030						Loose fit	
			Actively fitted	Sleeve Cylinder block	A A	B B	C C	C	Align marks and assemble		
15		Clearance of piston ring (B)	Top	0.105~0.135							
			2nd	0.055~0.085							
			Oil	0.030~0.060							
		Ring tension (kg)	Top	1.70~2.30 (Surface pressure 2.02)							
			2nd	1.11~1.59 (Surface pressure 1.71)							
			Oil	3.25~4.55 (Surface pressure 13)							
16		Rod toppling		$\leq \phi 0.03/100$							
17		Piston jet nozzle (amt. of oil sprayed)		3.5~4.0 ℓ /min						Oil pressure 4.5kg/cm <sup>2</sup>	
18		Abnormal sounds, vibration	Total backlash of gear training		0.12 $\pm$ 0.04						LOP Idle gear~LOP 0.17 $\pm$ 0.09
19	Accuracy of crank shaft and block hole		Crank shaft roughness		$\phi 0.02$						
			Crank shaft almost	Journal	0.8S						
				Pin	0.8S						
				Crank shaft vibration		$\phi 0.02$ (Forward/astern journal)					

No.	Item (part)		Standard value (notes)	Combustion	
20	Miscellaneous	Delivery of Lube oil pump	$\geq 94.5 \text{ } \ell / \text{min}$	Condition Np=3200rpm (NE=3200rpm) Pressure : 8 kg/cm <sup>2</sup> ±0.1 Oil Temp. : 100±2°C	
21		Delivery of fresh water pump	$\geq 350 \text{ } \ell / \text{min}$	Condition Np=3250±33rpm H=6.6mAq Fluid: Fresh water 80°C	
22		pressure valve	L.O. adjustment valve	4.5±0.5kg/cm <sup>2</sup>	3000rpm, Adjustment valve
			L.O. cooler discrepancy	—	
23		Thermostat valve open temp.	76.5±2°C	10mm or more at 90°C fully open	
24	Combustion	Compression ratio	15.2±0.5 (apparent) 14.0±0.5 (Effective)		
25		Clearance measurement (Piston bowl, Valve recess, Head )	60.7±0.9cc		
26	Top clearance	Block heights	289.975 <sup>+0.05</sup> <sub>0</sub>	Gasket thickness see No.17	
27		Piston heights	59.565±0.03		
28		Rod end pitch, large, small	176 <sup>+0.05</sup> <sub>0</sub>		
29		Crank radius	55±0.025		
30		Delivery of seawater pump	$\geq 215 \text{ } \ell / \text{min}$	Condition Np=3000±30rpm H=10mAq Fluid : Seawater30°C	

## Assembly Quality (Clearance, Interference)

No.	Item	Parts	Parts dimension	Standard value (notes)	Combustion
1-9	Crank gear	Gear inner dia.	50 $\begin{smallmatrix} -0.017 \\ -0.001 \end{smallmatrix}$	Interference 0.069~0.096	Shrink fit temp. 180~200°C
		Shaft dia.	50 $\begin{smallmatrix} +0.079 \\ +0.069 \end{smallmatrix}$		
	Cam shaft metal	Block cam shaft hole	61H7 $\begin{smallmatrix} +0.030 \\ 0 \end{smallmatrix}$	Interference 0.030~0.100	
		Metal outer dia.	61 $\begin{smallmatrix} +0.100 \\ +0.000 \end{smallmatrix}$		
	Valve guide (Intake/Exhaust)	Hole dia.	13.5H7 $\begin{smallmatrix} +0.018 \\ 0 \end{smallmatrix}$	0~0.029	
		Guide outer dia.	13.5P6 $\begin{smallmatrix} +0.029 \\ +0.018 \end{smallmatrix}$		
	Cam gear	Gear inner dia.	30 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$	Interference 0.023~0.060	Shrink fit temp. 180~200°C
		Shaft dia.	30 $\begin{smallmatrix} +0.060 \\ +0.044 \end{smallmatrix}$		
	Valve seat (Intake) (SUH3, Stellite)	Head	47.5 $\begin{smallmatrix} +0.016 \\ 0 \end{smallmatrix}$	Interference 0.038~0.070	Expansion fit
		Seat outer dia.	47.5 $\begin{smallmatrix} +0.070 \\ +0.054 \end{smallmatrix}$		
	Valve seat (Exhaust) (SUH35, Stellite)	Head	42 $\begin{smallmatrix} +0.016 \\ 0 \end{smallmatrix}$	Interference 0.038~0.070	Expansion fit
		Seat outer dia.	42 $\begin{smallmatrix} +0.070 \\ +0.054 \end{smallmatrix}$		
	Balancer gear (Crank shaft)	Gear inner dia	—		
		Shaft dia	—		
	Balancer gear (A)	Gear inner dia	—		
		Shaft dia	—		
	Balancer gear (B)	Gear inner dia	—		
		Shaft dia	—		
10-14	Crank shaft	Crank shaft standard width	34H7 $\begin{smallmatrix} +0.025 \\ 0 \end{smallmatrix}$	0.132~0.223	Side clearance 0.1775±0.0451
		Standard metal width	29 $\begin{smallmatrix} -0.09 \\ 0.14 \end{smallmatrix}$ or 2.5 $\begin{smallmatrix} -0.05 \\ 0 \end{smallmatrix}$		
	Connecting rod	Crank shaft width	34 $\begin{smallmatrix} +0.10 \\ 0 \end{smallmatrix}$	0.20~0.40	
		Width of large end	34 $\begin{smallmatrix} -0.20 \\ -0.30 \end{smallmatrix}$		
	Cam shaft	Cam shaft standard width	4.2 $\begin{smallmatrix} +0.15 \\ +0.05 \end{smallmatrix}$	0.05~0.20	
		Thrust metal width	4.2 $\begin{smallmatrix} 0 \\ -0.05 \end{smallmatrix}$		
	Idle gear (Timing)	Mount width	29 $\begin{smallmatrix} +0.2 \\ +0.1 \end{smallmatrix}$	0.10~0.30	
		Gear width	29 $\begin{smallmatrix} 0 \\ -0.1 \end{smallmatrix}$		
	Idle gear (LO-P)	Mount width	15 $\begin{smallmatrix} +0.2 \\ +0.1 \end{smallmatrix}$	0.10~0.30	
		Gear width	15 $\begin{smallmatrix} 0 \\ -0.1 \end{smallmatrix}$		

No.	Item	Parts	Parts dimension	Standard value (notes)	Combustion
15	Main bearing	Metal inner dia.	75 $\begin{smallmatrix} +0.045 \\ 0 \end{smallmatrix}$	0.036~0.093	Shrink fit temp. 180~200°C
		Journal dia.	75 $\begin{smallmatrix} -0.036 \\ -0.048 \end{smallmatrix}$		
16	Cam shaft	Metal inner dia.	57 $\begin{smallmatrix} +0.050 \\ -0.020 \end{smallmatrix}$	0.04~0.14	
		Journal dia.	57 $\begin{smallmatrix} -0.060 \\ -0.090 \end{smallmatrix}$		
17	Crank pin	Width of large end (Metal inner dia.)	65 $\begin{smallmatrix} +0.045 \\ 0 \end{smallmatrix}$	0.036~0.093	
		Crank pin dia.	65 $\begin{smallmatrix} -0.036 \\ -0.048 \end{smallmatrix}$		
18	Piston pin metal	Metal inner dia.	37 $\begin{smallmatrix} +0.050 \\ +0.030 \end{smallmatrix}$	0.030~0.061	Shrink fit temp. 180~200°C
		Piston pin outer dia.	37h5 $\begin{smallmatrix} 0 \\ -0.011 \end{smallmatrix}$		
19	Piston pin	Piston pin hole	37h5 $\begin{smallmatrix} +0.011 \\ 0 \end{smallmatrix}$	0~0.022	Expansion fit
		Piston pin outer hole	37h5 $\begin{smallmatrix} 0 \\ -0.011 \end{smallmatrix}$		
20	Tappet	Tappet hole dia.	14.2 $\begin{smallmatrix} +0.070 \\ +0.040 \end{smallmatrix}$	0.016~0.052	Expansion fit
		Tappet outer dia.	14.2 $\begin{smallmatrix} +0.033 \\ +0.018 \end{smallmatrix}$		
21	Valve arm	Valve arm inner dia.	18.5 $\begin{smallmatrix} +0.021 \\ 0 \end{smallmatrix}$	0.020~0.062	
		Valve arm shaft outer dia.	18.5 $\begin{smallmatrix} -0.020 \\ -0.041 \end{smallmatrix}$		
22	Idle gear (Timing)	Metal inner dia.	46 $\begin{smallmatrix} +0.025 \\ 0 \end{smallmatrix}$	0.025~0.075	
		Mount outer dia.	46 $\begin{smallmatrix} -0.025 \\ -0.050 \end{smallmatrix}$		
23	Idle gear (LO-P)	Metal inner dia.	φ38H6 $\begin{smallmatrix} +0.016 \\ 0 \end{smallmatrix}$	0.025~0.057	
		Mount outer dia.	φ38f6 $\begin{smallmatrix} -0.025 \\ -0.041 \end{smallmatrix}$		
24	Intake valve	Valve guide hole dia.	9H7 $\begin{smallmatrix} +0.015 \\ 0 \end{smallmatrix}$	0.025~0.055	Valve stem: Tufftrid treatment Seat: Stellite
		Valve dia. (Stem)	9 $\begin{smallmatrix} -0.025 \\ -0.040 \end{smallmatrix}$		
25	Exhaust valve	Valve guide hole dia.	9H7 $\begin{smallmatrix} +0.015 \\ 0 \end{smallmatrix}$	0.045~0.075	Valve stem: Tufftrid treatment Seat: Stellite
		Valve dia. (Stem)	9 $\begin{smallmatrix} -0.045 \\ -0.060 \end{smallmatrix}$		
26	L.O. pressure adjustment valve	Hole dia.	16H8 $\begin{smallmatrix} +0.027 \\ 0 \end{smallmatrix}$	0.040~0.087	
		Valve outer dia.	16 $\begin{smallmatrix} -0.04 \\ -0.06 \end{smallmatrix}$		
27	Ring (Top)	Groove width	2.0 $\begin{smallmatrix} +0.110 \\ +0.095 \end{smallmatrix}$	0.105~0.135	
		Ring thickness	2.0 $\begin{smallmatrix} -0.110 \\ -0.025 \end{smallmatrix}$		
28	Ring (2nd)	Groove width	2 $\begin{smallmatrix} +0.060 \\ +0.045 \end{smallmatrix}$	0.055~0.085	
		Ring thickness	2 $\begin{smallmatrix} -0.010 \\ -0.025 \end{smallmatrix}$		
29	Ring (Oil)	Groove width	3 $\begin{smallmatrix} +0.035 \\ +0.020 \end{smallmatrix}$	0.030~0.060	
		Ring thickness	3 $\begin{smallmatrix} -0.010 \\ -0.025 \end{smallmatrix}$		

## 5. Test running

### 5-1. Preliminary Precautions

Before making a test run, make sure of the following points.

- (1) Warm the engine up.
- (2) Remove any precipitation from the F.O. filter, Water separator, and F.O. tank.
- (3) Use only lube oil recommended by Yanmar.
- (4) Be sure to add Yanmar anti-rust agent to fresh cooling water.
- (5) During cold weather, add Yanmar anti-freeze to the cooling water.
- (6) Provide good ventilation in the engine room.

### 5-2 Check Points and Precautions During Running

Step	Item	Instructions	Pro and Precautions
1	Checks before operation	<ol style="list-style-type: none"> <li>1) Make sure that the Kingston Cock is open.</li> <li>2) Make sure there is enough lube oil and (fresh) cooling water.</li> <li>3) Operate the remote control handle and check if the devices connected to the engine side work properly.</li> </ol>	<ol style="list-style-type: none"> <li>3) Lamp should go off when engine is running.</li> </ol>
2	No load operation: warm up operation	<ol style="list-style-type: none"> <li>1) When the engine is started, check the following: <ul style="list-style-type: none"> <li>• there is no water and no oil leakage.</li> <li>• exhaust gas does not leak when the engine is started.</li> <li>• there are no abnormal indications on the instrument panel.</li> <li>• there is no abnormality in cooling water discharge, engine vibrations, or engine sounds.</li> </ul> </li> <li>2) To warm up the engine, operate at low revolutions for about 5 minutes, then raise the revolutions to the rated rpms and then to max. rpms.</li> </ol>	<ul style="list-style-type: none"> <li>• Fix leaks if any.</li> <li>• Check the intake/exhaust valves, F.O. injection valve, and cylinder head.</li> </ul> <ol style="list-style-type: none"> <li>2) Do not raise the engine revolutions abruptly.</li> </ol>
3	Cruising (load) operation	<ol style="list-style-type: none"> <li>1) Do not operate the engine at full load yet, but raise the rpms gradually for about 10 minutes until they reach rated rpms.</li> <li>2) Make sure that exhaust color and temperature are normal.</li> <li>3) Check the instrument panel and see if the water temperature and oil pressure are normal.</li> </ol>	
4	Stopping the engine	<ol style="list-style-type: none"> <li>1) Before stopping the engine, operate it at 650-700 rpms for about 5 minutes.</li> <li>2) Raise engine rpms to 1,800 just before stopping the engine and idle the engine for about 3-4 seconds.</li> </ol>	<ol style="list-style-type: none"> <li>1) Stopping the engine suddenly during high speed operation increases the temperature of engine parts.</li> <li>2) This procedure prevents carbon from being deposited on the valve seats, etc.</li> </ol>
5	Checks after stopping the engine	<ol style="list-style-type: none"> <li>1) Check again for water and oil leaks.</li> <li>2) Make sure that no nuts and bolts are loose.</li> <li>3) Close the Kingston and fuel cocks.</li> <li>4) When the temperature is expected to fall below freezing, drain the cooling water (sea water).</li> <li>5) Turn off the battery switch.</li> </ol>	<ol style="list-style-type: none"> <li>1) Check the oil seal area.</li> <li>2) Especially the engine installation bolts.</li> <li>4) Drain from the sea water pump.</li> </ol>

# TROUBLESHOOTING

1.Troubleshooting .....	11-1
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# 1. Troubleshooting

It is important to thoroughly understand each system and the function of all of the parts of these systems. A careful study of the engine mechanism will make this possible. When problems arise, it is important to carefully observe and analyze the indications of trouble in order to save time in determining their cause. Begin by checking the most easily identifiable causes of difficulty. Where the cause of the difficulty is not readily apparent, make a thorough examination of the system from the very beginning, proceeding until the point of trouble can be determined. While experience is an important factor in pinpointing engine problems, careful study and understanding of the engine mechanism combined with good common sense will help you to rapidly become more expert at troubleshooting.

Chart 1

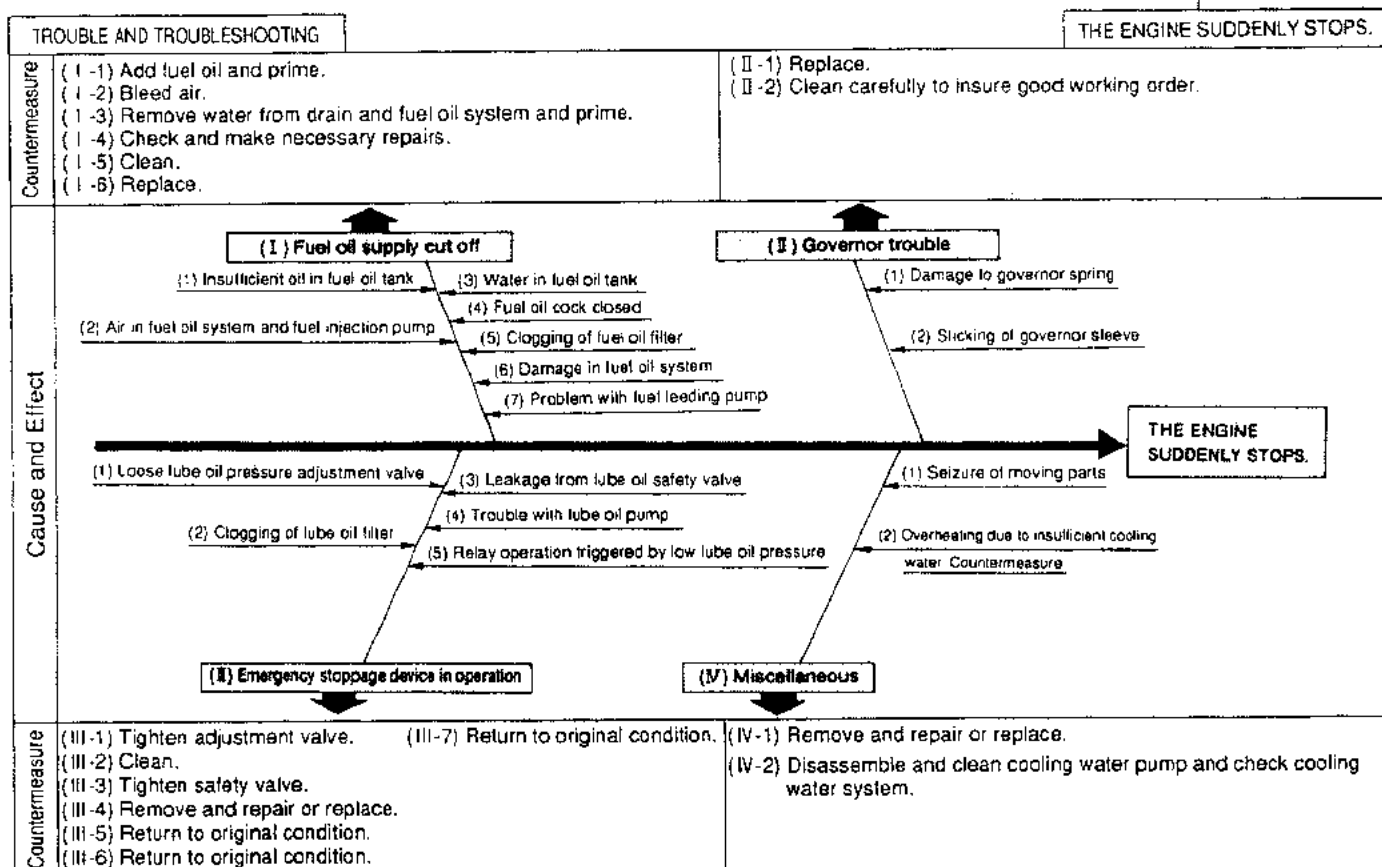
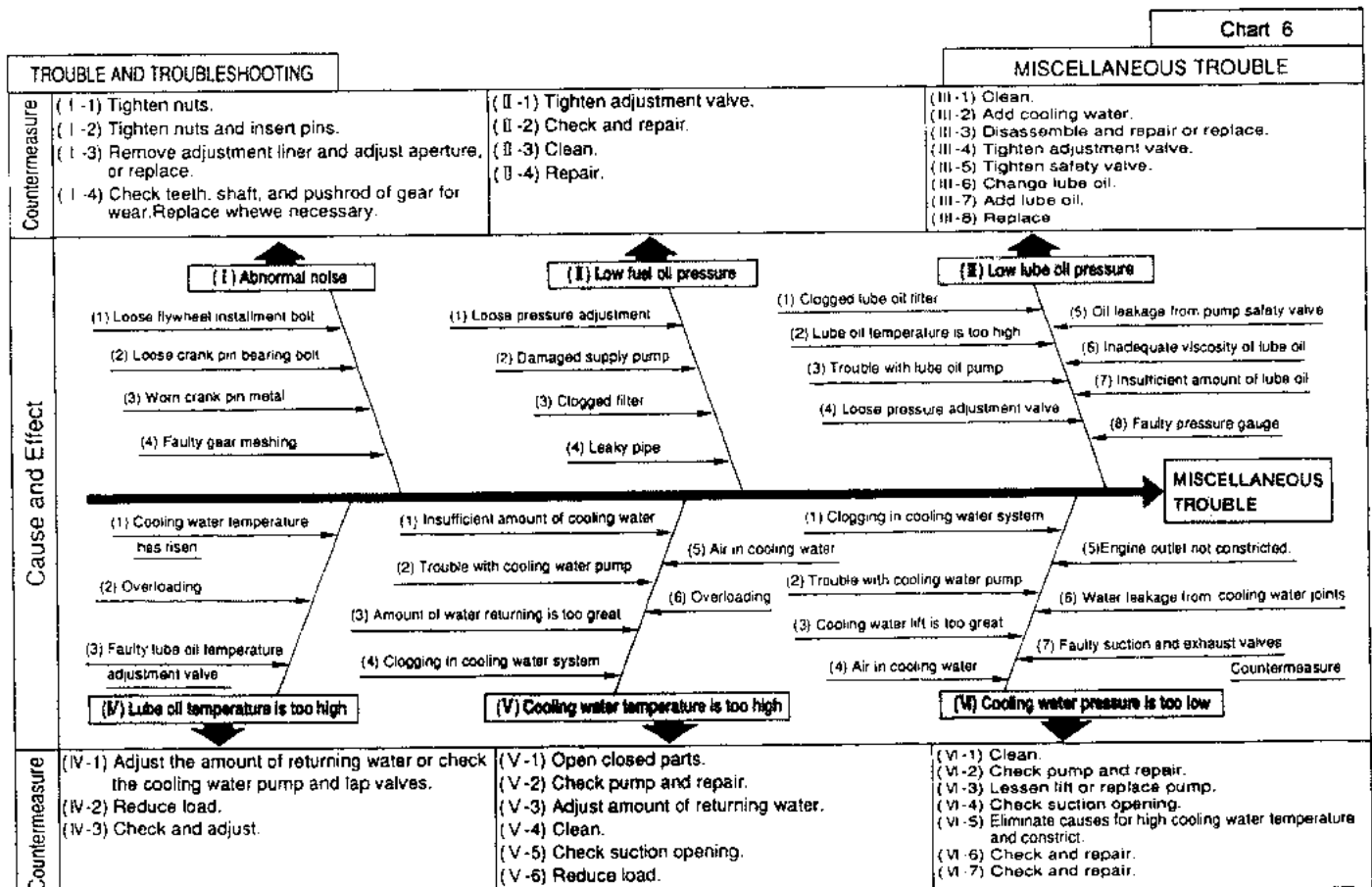
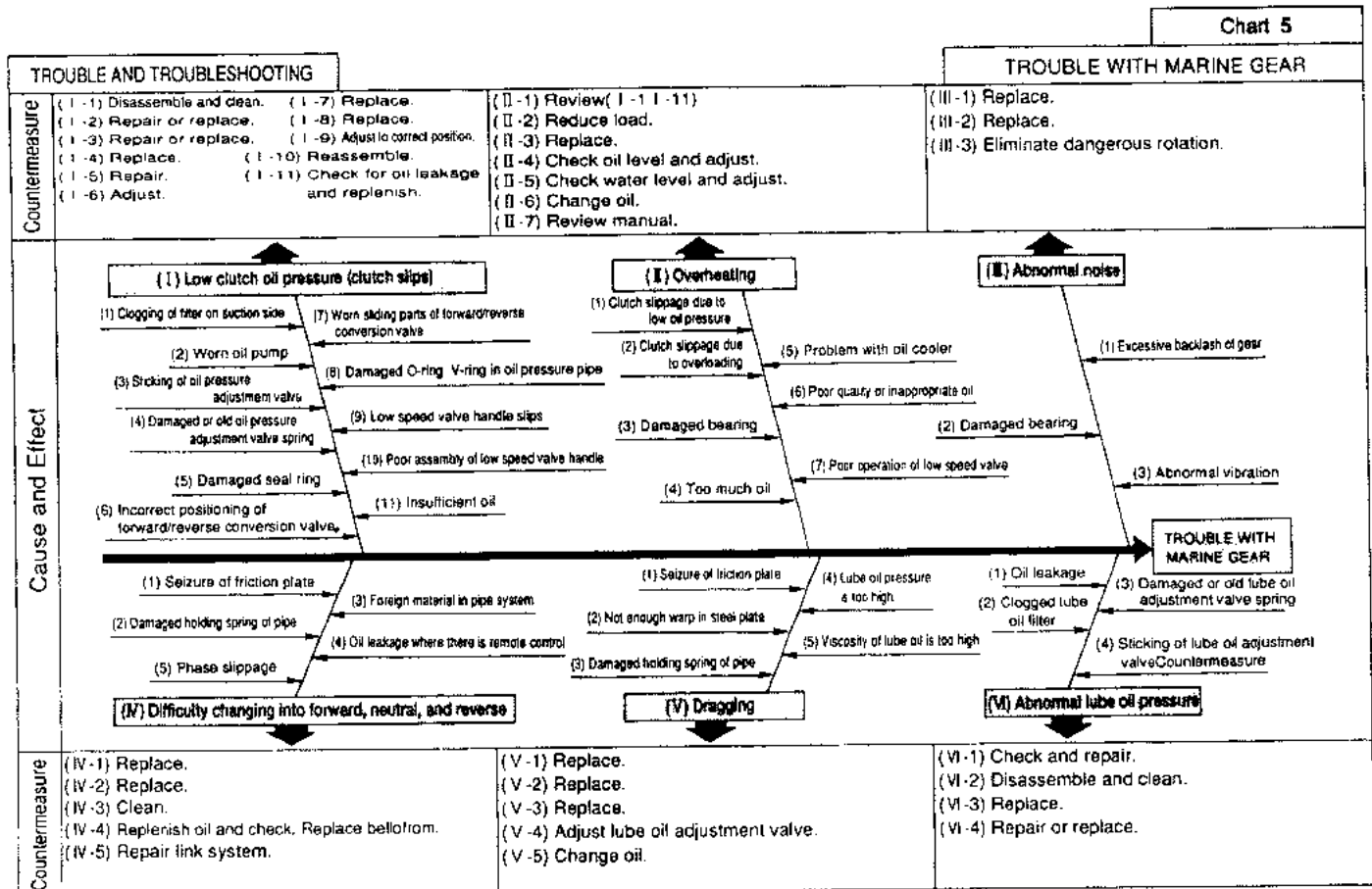


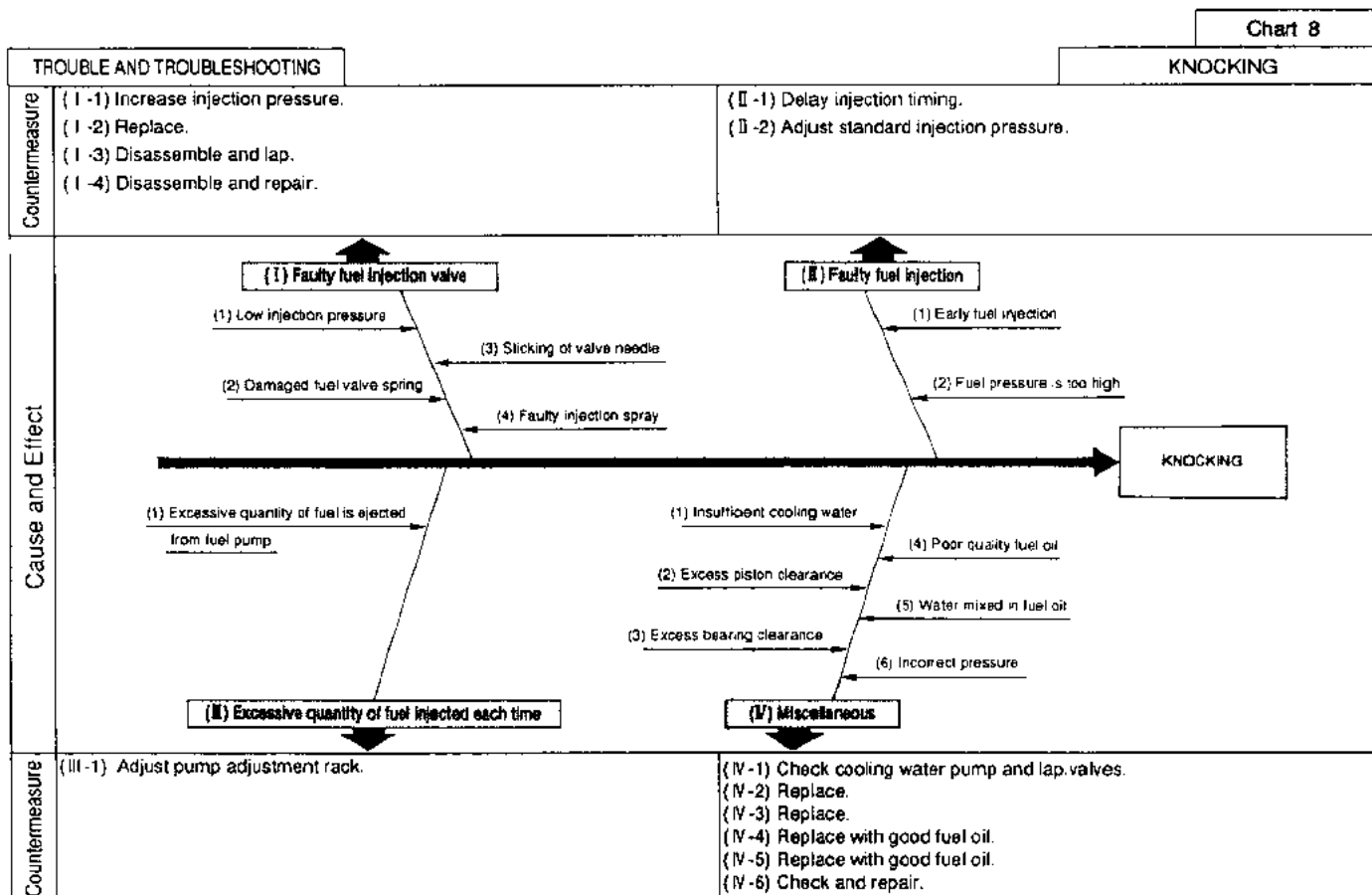
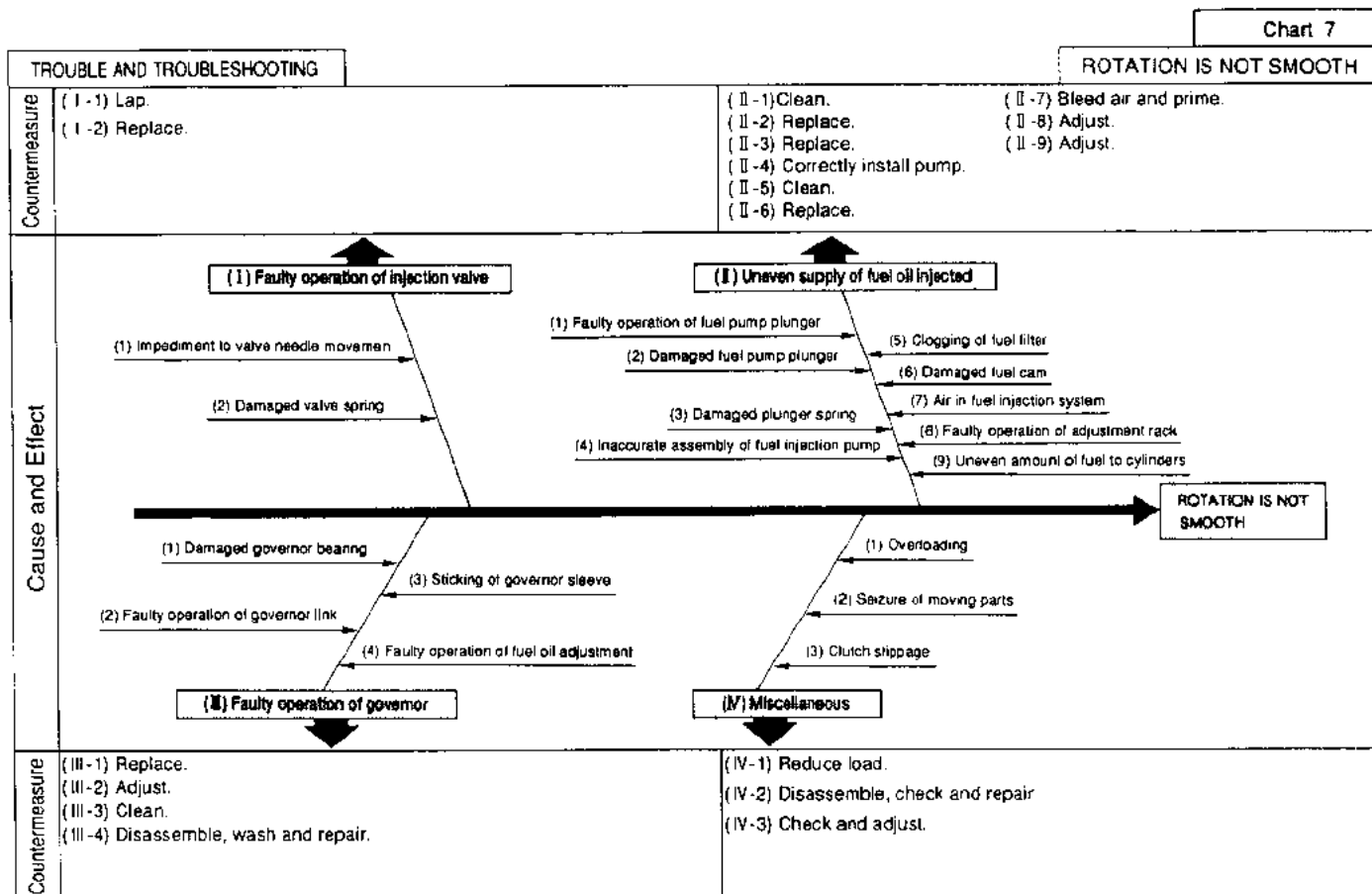


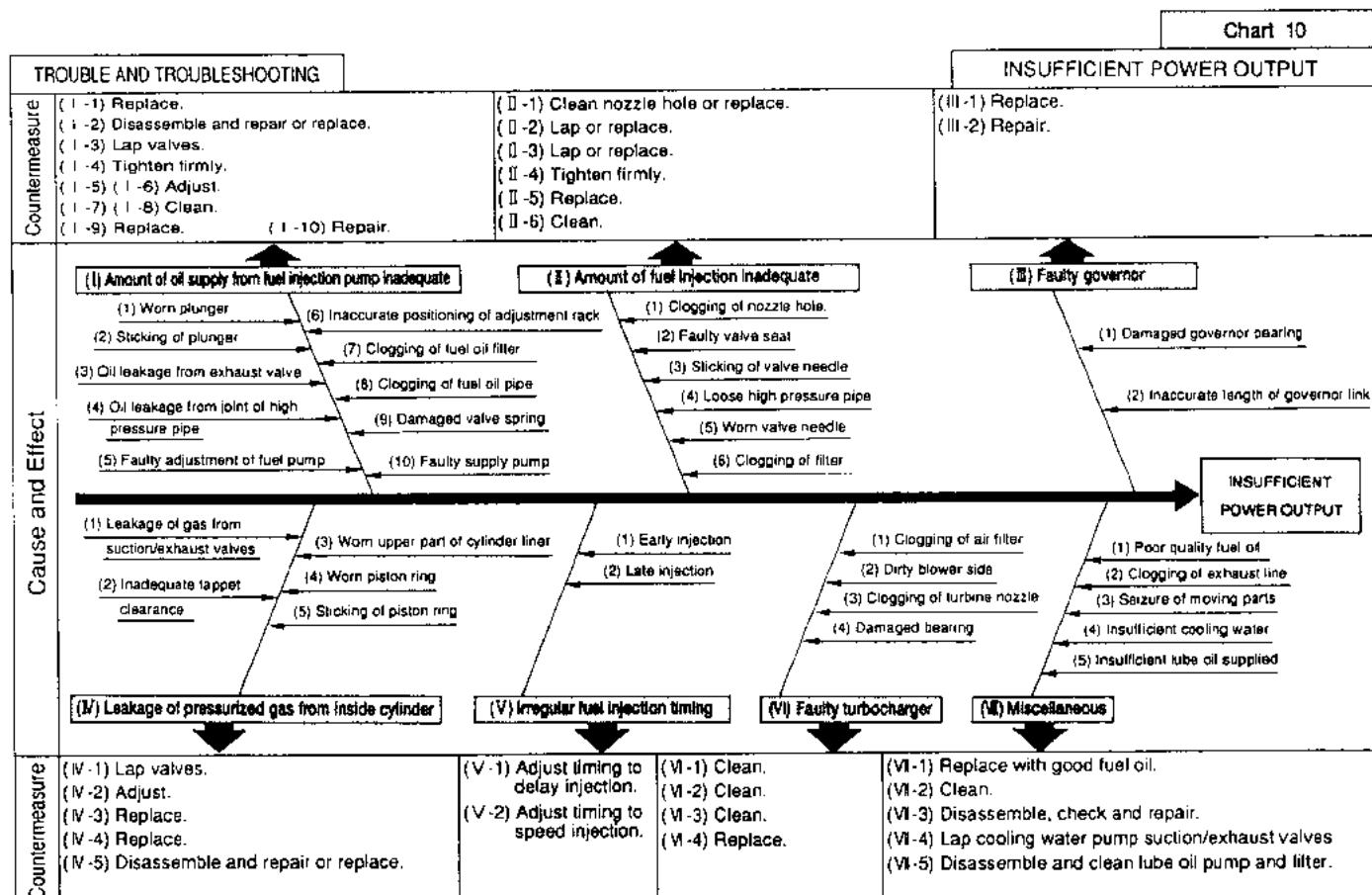
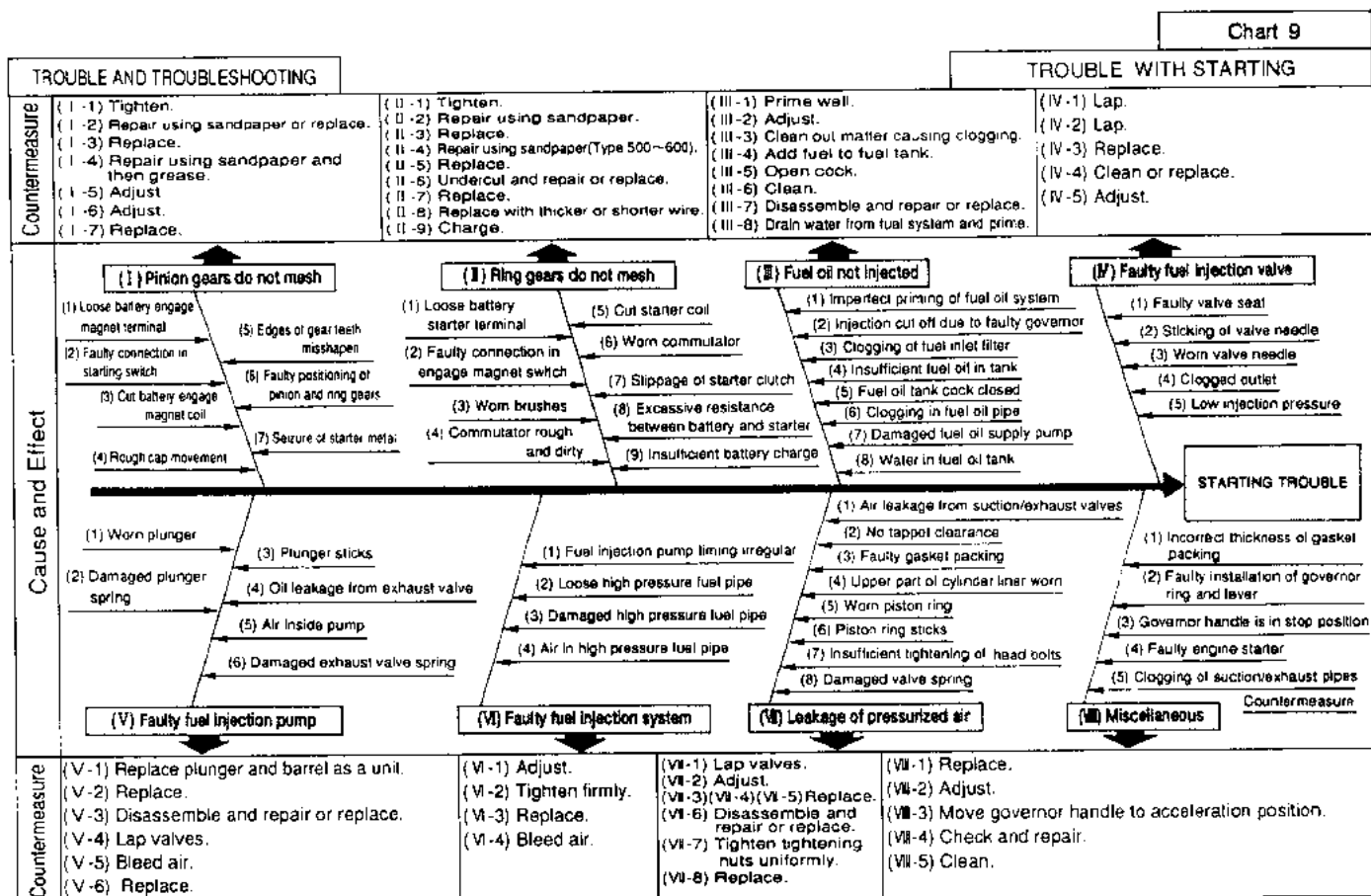
Chart 2	
TROUBLE AND TROUBLESHOOTING	CYLINDER OUTPUTS UNEVEN COUNTERMEASURE
Countermeasure	(I-1) Bleed air. (I-2) Disassemble and clean. (I-3) Replace. (I-4) Repair or replace. (I-5) Replace. (I-6) Tighten firmly. (I-7) Disassemble and clean and repair or replace.
Cause and Effect	
Countermeasure	(II-1) Check and repair. (II-2) Replace. (II-3) Adjust. (II-4) Adjust. (II-5) Clean.

Chart 3	
TROUBLE AND TROUBLESHOOTING	POOR EXHAUST COLOR
Countermeasure	(I-1) Check, repair or replace. (I-2) Replace. (I-3) Check, repair or replace. (I-4) Adjust. (I-5) Adjust. (II-1) Clean. (II-2) Check, Repair or replace. (II-3) Adjust. (II-4) Check, Repair or replace. (II-5) Clean.
Cause and Effect	
Countermeasure	(III-1) Clean. (III-2) Clean. (III-3) Clean. (III-4) Replace. (IV-1) Reduce load. (IV-2) Adjust quantity of oil. (IV-3) Clean. (IV-4) Clean. (IV-5) Replace with new oil. (IV-6) Clean.

Chart 4	
TROUBLE AND TROUBLESHOOTING	TROUBLE WITH THE TURBOCHARGER
Countermeasure	(I-1) Clean. (I-2) Clean. (I-3) Repair. (I-4) Repair. (I-5) Adjust exhaust pipe temperature. (I-6) Admit fresh air to engine room. (I-7) Where there is an intercooler, increase the cooling water and clean fin. (I-8) Open door or install ventilation duct. (I-9) Replace. (I-10, 11, 12) Clean. (I-13) Clean or replace piping. (I-14) Replace. (II-1) Lap valves. (II-2) Check and adjust injection timing. (II-3) Disassemble and check injection pump. (II-4) Repair or replace faulty parts. (II-5) Disassemble and check injection valve. (II-6) Repair or replace faulty parts. (III-1) Replace. (III-2) Replace. (III-3) Clean and repair or replace. (III-4) Replace. (III-5) Replace. (III-6) Tighten. (III-7) Reassemble.
Cause and Effect	
Countermeasure	(V-1) Replace. (V-2) Repair or replace. (V-3) Clean. (V-4) Repair or replace. (V-5) Stabilize load, or replace turbine nozzle. (V-6) Repair. (V-7) Clean. (V-8) Replace. (V-9) Clean. (V-10) Replace. (V-11) Replenish lube oil when insufficient. (V-12) Increase amount of cooling water. (VI-1) Adjust combustion. (VI-2) Insure proper operation. (VI-3) Clean. (VI-4) Increase cooling water in air cooler. (VI-5) Clean cooler blades. (VI-6) Adjust temperature of exhaust system. (VI-7) Let fresh air into engine room. (VII-1) Replace with proper lube oil. (VII-2) This occurs when improper oil is mixed in. Replace oil. (VII-3) Replace. (VII-4) Replace. (VII-5) Raise temperature of cooling water.







### **YANMAR DIESEL AMERICA CORP.**

901 CORPORATE GROVE DRIVE, BUFFALO GROVE, IL 60089-4508, U.S.A.

TEL : 708-541-1900

FAX : 708-541-2161

### **YANMAR EUROPE B.V.**

BRUGPLEIN 11, 1332 BS ALMERE-DE VAART, P.O.BOX 30112, 1303 AC Almere, The Netherlands

TEL : 036-5324924

FAX : 036-5324916

TELEX : 70732 YMR A NL

### **YANMAR ASIA (SINGAPORE) CORPORATION PTE LTD.**

4 TUAS LANE, SHINGAPORE 2263

TEL : 861-5077

FAX : 861-5189

TELEX : RS 35854 YANMAR



# **YANMAR DIESEL ENGINE CO.,LTD.**

### **OVERSEAS OPERATIONS DIVISION**

1-1, 2-chome, Yaesu, Chuo-ku, Tokyo 104, Japan

Telex: 0222-4733

Telephone 03-3275-4941

Facsimile: 03-3275-4969 Cable: YANMAR TOKYO