YANMAR

HINSI-H8-011-1

# SERVICE MANUAL

## MARINE DIESEL ENGINE

6LY2-STE
6LY2A-STP
6LYA-STP

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## MARINE DIESEL ENGINE

MODEL

6LY2-STE

6LY2A-STP

6LYA-STP

| Publication No. | HINSHI - H8 - 011 - 1 |
|---|---|

# History of Revision

| Manual Name | Service Manual for Marine Diesel Engine |
|---|---|
| Engine Model : | **6LY2-STE/6LY2A-STP/6LYA-STP** |

| Number of revision | Date of revision | Reason for correction | Outline of correction | Ccorrection item No (page) | Corrected by |
|---|---|---|---|---|---|
| • 1st revised edition Jun., 2001 (Publication No. HINSHI-H8-011-1)<br>6LY2A-STP and 6LYA-STP added<br>• Revised pages : 1-2, 1-3, 1-4, 1-5, 1-6, 1-7, 1-8, 1-9, 1-10, 1-11, 2-4, 2-6, 2-7, 2-8, 2-9, 2-10, 2-11, 2-12, 2-13, 2-14, 2-15, 2-26, 3-3, 3-11, 5-2, 5-6, 7-2, 7-6, 9-6, 10-1, 10-6, 10-30, 10-31, 10-32, 10-34, 10-35, 10-36, 10-37, cover pages and back page.<br>• Added pages : 1-1-2, 1-1-3, 1-1-4, 1-1-5, 1-1-6, 1-1-7, 1-3-2, 1-4-2, 1-4-3, 1-7-2, 2-4-2, 3-33-2, 10-31-2 and History of Revision. | | | | | |
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# FOREWORD

This service manual has been complied 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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# INDEX





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CHAPTER 1

# GENERAL



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# ■ For Safe Servicing

- Most accidents are caused by failing to observe basic safety rules and precautions. To prevent accidents, it is important to recognize the signs of approaching problems, and eliminate the problems in the early stage before they can cause accidents.
  Please read this manual carefully before starting repairs or maintenance to fully understand safety precautions and appropriate inspection and maintenance procedures. Attempting a repair or maintenance job without sufficient knowledge may cause an unexpected accident.

- It is impossible to cover every possible danger in repair or maintenance in the manual. Sufficient consideration for safety is required in addition to the matters marked ⚠ CAUTION. Especially for safety precautions in a repair or maintenance job not described in this manual, receive instructions from a knowledgeable leader.

- Safety marks used in this manual and their meanings are as follows:

| | |
|---|---|
| ⚠ DANGER | **DANGER indicates an imminently hazardous situation which, if not avoided, WILL result in death or serious injury.** |
| ⚠ WARNING | **WARNING indicates a potentially hazardous situation which, if not avoided, COULD result in death or serious injury.** |
| ⚠ CAUTION | **CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.** |

- Any matter marked **[NOTICE]** in this manual is especially important in servicing. If not observed, the product performance and quality may not be guaranteed.

# ■ Precautions for Safe Servicing

## (A) Service Shop (Place)

**⚠WARNING**

### ● Place allowing sufficient ventilation

Jobs such as engine running, part welding and polishing the paint with sandpaper should be done in a well-ventilated place.

**[Failure to Observe]**

**Very dangerous for human body due to the possibility of inhaling poisonous as or dust.**

**⚠CAUTION**

### ● Sufficiently wide and flat place

The floor space of the service shop for inspection and maintenance should be sufficiently wide and flat without any holes.

**[Failure to Observe]**

**An accident such as a violent fall may be caused.**

**⚠CAUTION**

### ● Clean, orderly arranged place

No dust, mud, oil or parts should be left on the floor surface.

**[Failure to Observe]**

**An unexpected accident may be caused.**

**⚠CAUTION**

### ● Bright, safety illuminated place

The working place should be illuminated sufficiently and safely.

For a job in a dark place where it is difficult to see, use a portable safety lamp.

The bulb should be covered with a wire cage for protection.

**[Failure to Observe]**

**The bulb may be broken accidentally causing ignition of leaking oil.**

**⚠CAUTION**

### ● Place equipped with a fire extinguisher

Keep a fast aid kit and fire extinguisher close at hand in preparation for fire emergencies.



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## (B) Working Wear

**⚠CAUTION**

### ● Wears for Safe Operation

Wear a helmet, working clothes, safety shoes and other safety protectors suited to the job. It is especially important to wear well-fitting work clothes.

**[Failure to Observe]**
**A serious accident such as trapping by a machine may occur.**

## (C) Tooks to Be Used

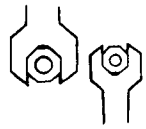
**⚠WARNING**

### ● Appropriate holding and lifting

Never operate when the engine is supported with blocks or wooden pieces or only with a jack.
To lift and hold the engine, always use a crane with a sufficient allowance in limit load or a rigid jack.

**[Failure to Observe]**
**A serious accident may occur.**

**⚠WARNING**



### ● Use of Appropriate Tools

Use tools appropriate for the jobs to be done. Use a correctly sized tool for loosening or tightening a machine part.

**[Failure to Observe]**
**A serious accident such as trapping by a machine may occur.**

## (D) Use of Genuine Parts, Oil and Grease

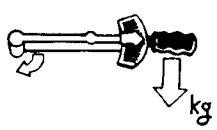
**⚠CAUTION**

### ● Always use genuine parts.

**[Failure to Observe]**
**Shortening of engine life or an unexpected accident may arise.**

## (E) Bolt and Nut Tightening Torque

**⚠WARNING**

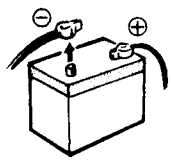



### ● Always tighten to the specified torque if designated in the manual.

**[Failure to Observe]**
**Loosening or falling may cause parts damage or injury.**

## (F) Electrical Parts

**⚠ WARNING**

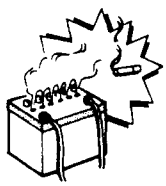


### ● Harness Short-circuit

Disconnect the battery negative ⊖ terminal before starting the service job.

**[Failure to Observe]**
**Short-circuiting of a harness may occur to start a fire.**

**⚠ WARNING**



### ● Battery Charging

Since flammable gas is generated during battery charging, keep anything which could cause a fire away from the battery.

**[Failure to Observe]**
**Explosion may occur.**

**⚠ WARNING**

### ● Battery Electrolyte

Since the electrolyte is diluted sulfuric acids, do not let it be splashed onto clothes or skin.

**[Failure to Observe]**
**The clothes or skin may be burnt.**

## (G) Waste Treatment

**⚠ CAUTION**

**Observe the following instructions with regard to waste disposal. Negligence of each instruction will cause environmental pollution.**

- Waste fluids such as engine oil and cooling water shall be discharged into a container without spillage onto the ground.
- Do not let waste fluids be discharged into the sewerage, a river or the sea.
- Harmful wastes such as oil, fuel, solvents, filterelements and battery shall be treated according to the respective laws and regulations.
  Ask a qualified collecting company for example.



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## (H) Handling the Product

**⚠WARNING**

### ● Supplying the Fuel

When supplying the fuel, always keep any fire source like a cigarette or match away.

**[Failure to Observe]**
**A fire or explosion may arise.**

**⚠WARNING**

### ● Pay attention to hot portions.

Do not touch the engine during running or immediately after it is stopped.

**[Failure to Observe]**
**Scalding may be caused by a high temperature.**

**⚠WARNING**

### ● Pay attention to the rotating part.

Never bring clothes or a tool close to the rotating part during engine running.

**[Failure to Observe]**
**Injury may be caused by entrapping.**

**⚠CAUTION**

### ● Safety Label Check

Pay attention to the product safety label.
A safety label (caution plate) is affixed on the product for calling special attention to safety.
If it is missing or illegible, always affix a new one.

## California Proposition 65 Warning

Diesel engine exhaust and some of its constitutions are known to the State of California to cause cancer, birth defects, and other reproductive harm.

## California Proposition 65 Warning

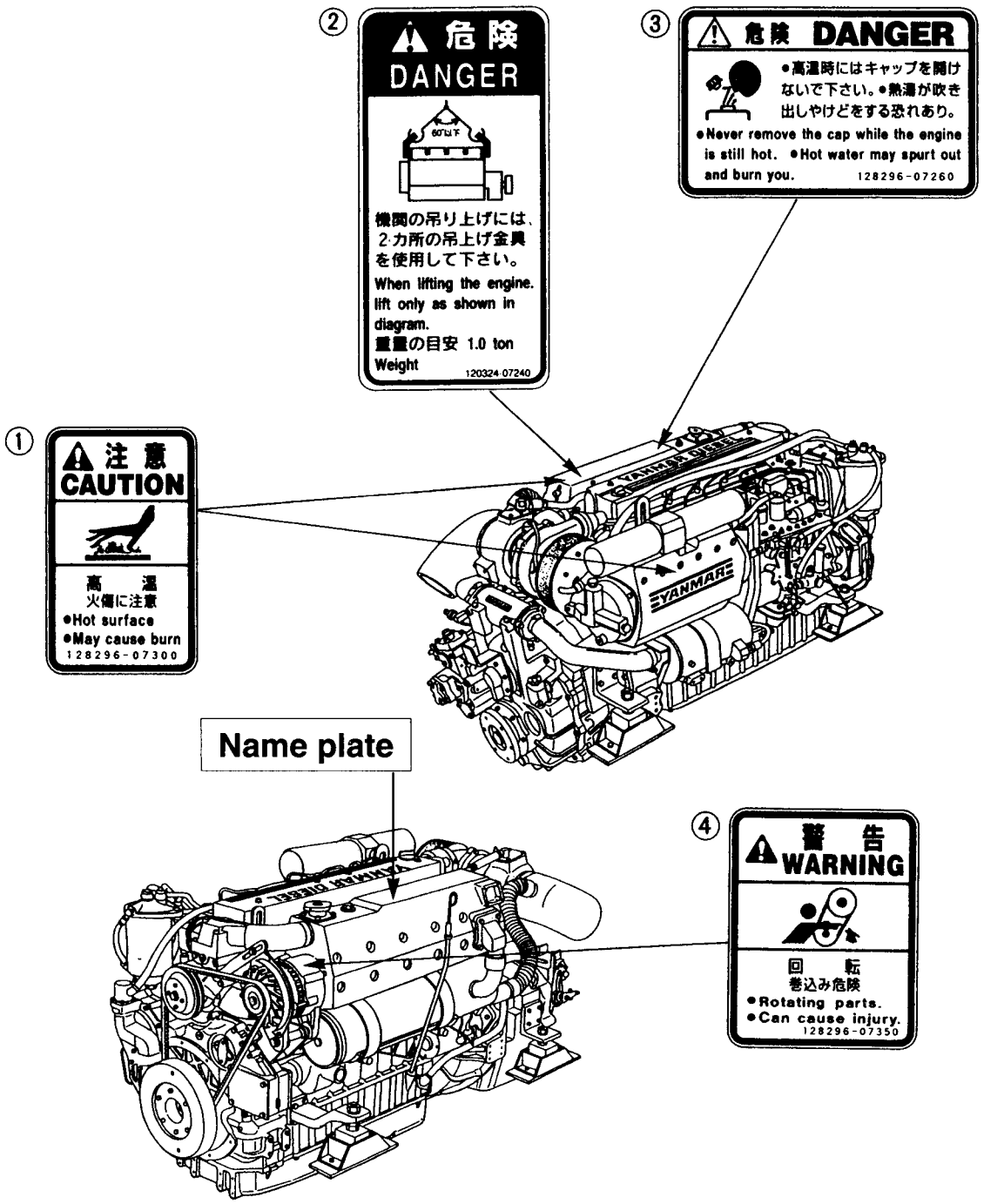
Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm.

# ■ Location of Product Safety Labels

To insure safe operation, warning device labels have been attached. Their location is shown in the diagram below. Keep the labels from becoming dirty or torn and replace them if they are lost or damaged.
Also, replace labels when parts are replaced, ordering them in the same way as for the parts

Warning Device Labels, Parts Numbers

| No. | Part Code No. |
|---|---|
| ① | 128296-07300 |
| ② | 120324-07240 |
| ③ | 128296-07260 |
| ④ | 128296-07350 |



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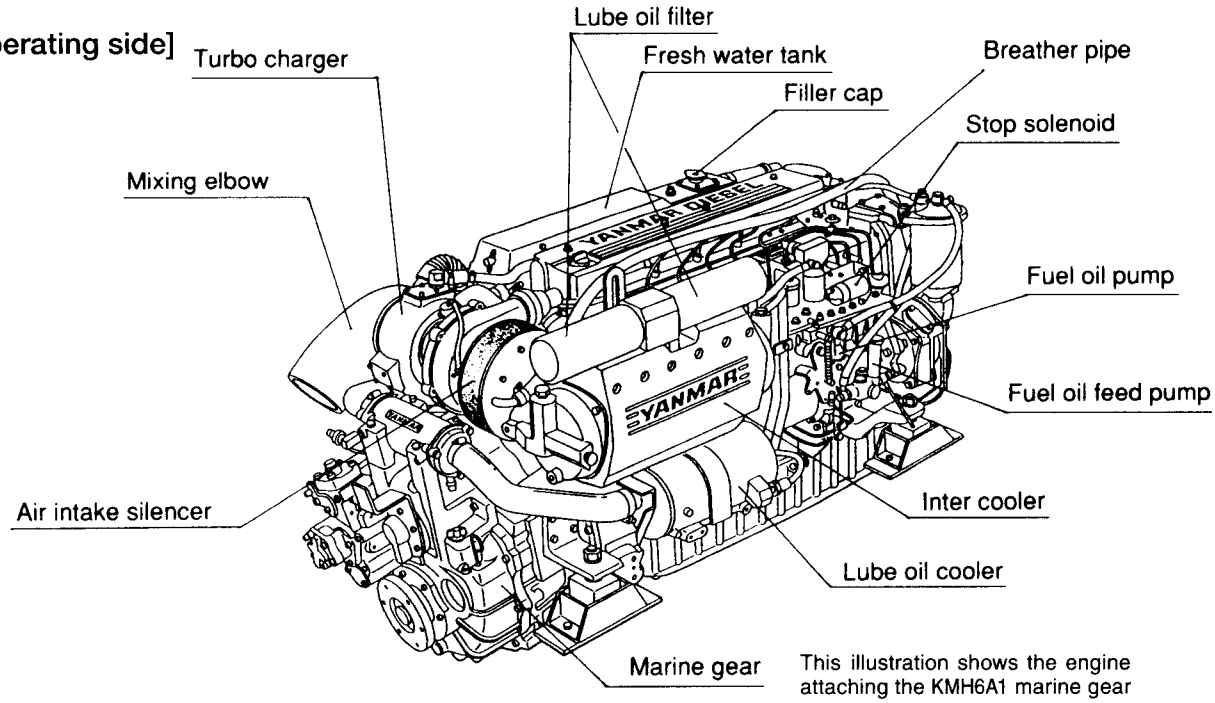
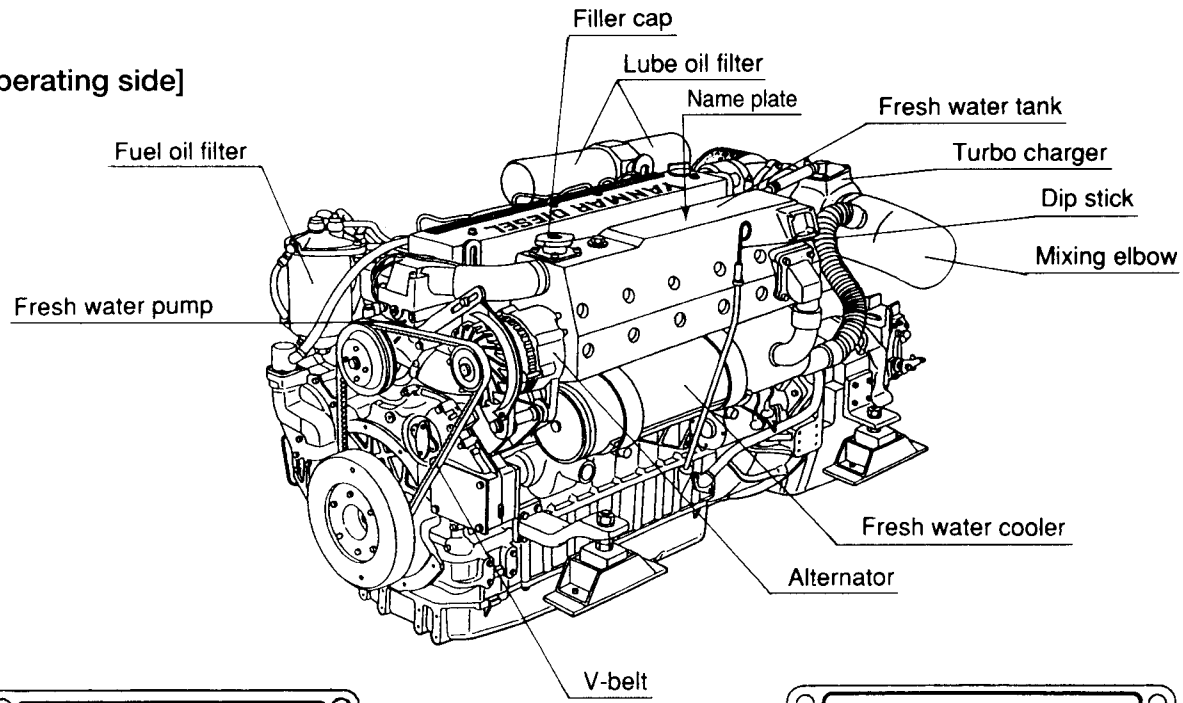
# 1. Exterior Views

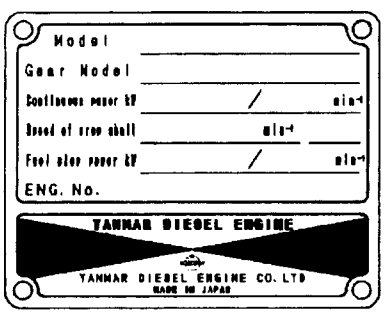
**[Operating side]**




This illustration shows the engine attaching the KMH6A1 marine gear

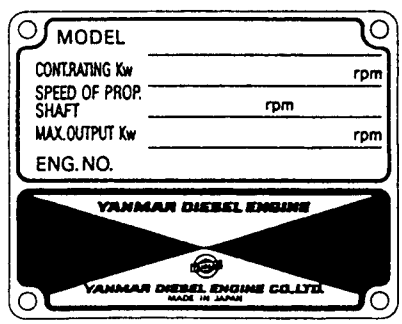
**[Non-operating side]**




For 6LY2A-STP/6LYA-STP

The name plate attached on the engine.




For 6LY2-STE

# 2. Specifications

## • 6LY2-STE

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Engine model | | 6LY2-STE | | | | | | | |
| Type | | Vertical water coo;ed 4-cycle diesel engine | | | | | | | |
| No. of clinders | | 6 | | | | | | | |
| Bore × Stroke (mm) | | φ105.9 × 110 | | | | | | | |
| Displacement (ℓ) | | 5.813 | | | | | | | |
| Max. output at crankshaft kw(hp)/rpm. | | 309(420)/3300 | | | | | | | |
| Cont. rating output at crankshaft. kw(hp)/rpm. | | 257(350)/3100 | | | | | | | |
| High idling (rpm) | | 3720±25 | | | | | | | |
| Low idling (rpm) | | 700±25 | | | | | | | |
| Combustion system | | Direct injection | | | | | | | |
| Starting system | | Electric starting | | | | | | | |
| Cooling system | | Fresh water cooling | | | | | | | |
| Lubrication system | | Totally enclosecl and forced lubrication system with gear pump | | | | | | | |
| Direction of rotation | | Counterclockwise when viewed from flywheel side | | | | | | | |
| Marine gear (Option) | Model | KMH6A1 (Optional) | | | ※MG5061A (TWIN DISC made) | | | | |
| | Type | 10° Angle | | | 7° Angle | | | | |
| | Reduction ratio (Ahead/Astern) | Oil pressure, wet type, Multi-disc type | | | Oil pressure, wet type, Multi-disc type | | | | |
| | | 1.58 | 1.92 | 2.26 | 1.13 | 1.54 | 1.75 | 2.00 | 2.47 |
| Lube oil capacity | Engine (ℓ) | Full 20.0 / Effective 8.0 | | | | | | | |
| | Marine gear (ℓ) | Full 4.0 / Effective 0.3 (For KMH6A1) | | | | | | | |
| Cooling water capacity (ℓ) | | 20 | | | | | | | |
| Subtank capacity (ℓ) | | 1.5 | | | | | | | |
| Turbochager | Model | RHC7W (IHI made) | | | | | | | |
| Type | | Water cooled | | | | | | | |
| Dry weight (kg) | | 642 | | | | | | | |
| Recommended battery capacity | | 12V-120AH | | | | | | | |
| Recommended type of remote control handle | | Single lever type (Option) | | | | | | | |
| Engine installation style | | On the flexible engine mount | | | | | | | |

(Note) 1. Rating condition : ISO 3046-1. 2. 1hp = 0.7355 kW.
※Local supply.



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## ● 6LY2A-STP/6LYA-STP

| Engine model | | | 6LYA-STP | 6LY2A-STP |
|---|---|---|---|---|
| Type | | | Vertical water cooled 4-cycle diesel engine | |
| No. of clinders | | | 6 | |
| Bore × Stroke | | mm | 100×110 | 105.9×110 |
| Displacement | | ℓ | 5.184 | 5.813 |
| Fuel stop power at crankshaft | | kw(hp)/rpm | *272 (370) / 3300<br>**264 (359) / 3300 | *324 (440) / 3300<br>**315 (427) / 3300 |
| Cont. power at crankshaft. | | kw(hp)/rpm | 213 (290) / 3100 | 257 (350) / 3100 |
| High idling | | rpm | 3720±25 | 3670±25 |
| Low idling | | rpm | 700±25 | |
| Combustion system | | | Direct injection | |
| Starting system | | | Electric starting | |
| Cooling system | | | Fresh water cooling | |
| Lubrication system | | | Forced lubrication system with gear pump | |
| Direction of rotation (crankshaft) | | | Counter clockwise (viewed from flywheel side) | |
| Lube oil capacity | All | ℓ | 20 | |
| | Oil pan | ℓ | 18(including oil filter capacity)(oil pan 16.4) | |
| Cooling water capacity | | ℓ | Engine:20, Subtank :1.5 | |
| Turbochager | Model | | RHC7W (IHI made) | |
| | Type | | Water cooled turbine housing | |
| Dry mass(gear less) | | kg | 530 | 535 |
| Recommended battery capacity | | | 12V×120Ah | |
| Recommended type of remote control handle | | | Single lever type | |
| Engine installation style | | | On the flexible engine mount | |

**(Note)** 1. Rating condition : ISO 3046-1, 8665 2. 1hp = 0.7355 kW
3. Fuel condition : Density at 15℃ = 0.860, Fuel oil temperature *: 25℃ at the fuel injection pump inlet
**: ISO 8665 (Fuel oil temp. 40℃ at the fuel injection pump inlet)

## ● Marine gear (Option)

### • For 6LYA-STP

| Model | | | KMH6A | | | HSW800A2 | | | | | MG5050A | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type | | | 10°Angle | | | 8°Angle | | | | | 10°Angle | | | | |
| | | | wet and multi-disc | | | | | | | | | | | | |
| Reduction ratio | | | 1.58 | 1.92 | 2.26 | 1.2 | 1.4 | 1.6 | 2.0 | 2.5 | 1.12 | 1.5 | 1.8 | 2.04 | 2.5 |
| Lube oil capacity | Full | ℓ | 4.0 | | | Refer to the maker's manual | | | | | | | | | |
| | Effective | ℓ | 0.3 | | | | | | | | | | | | |

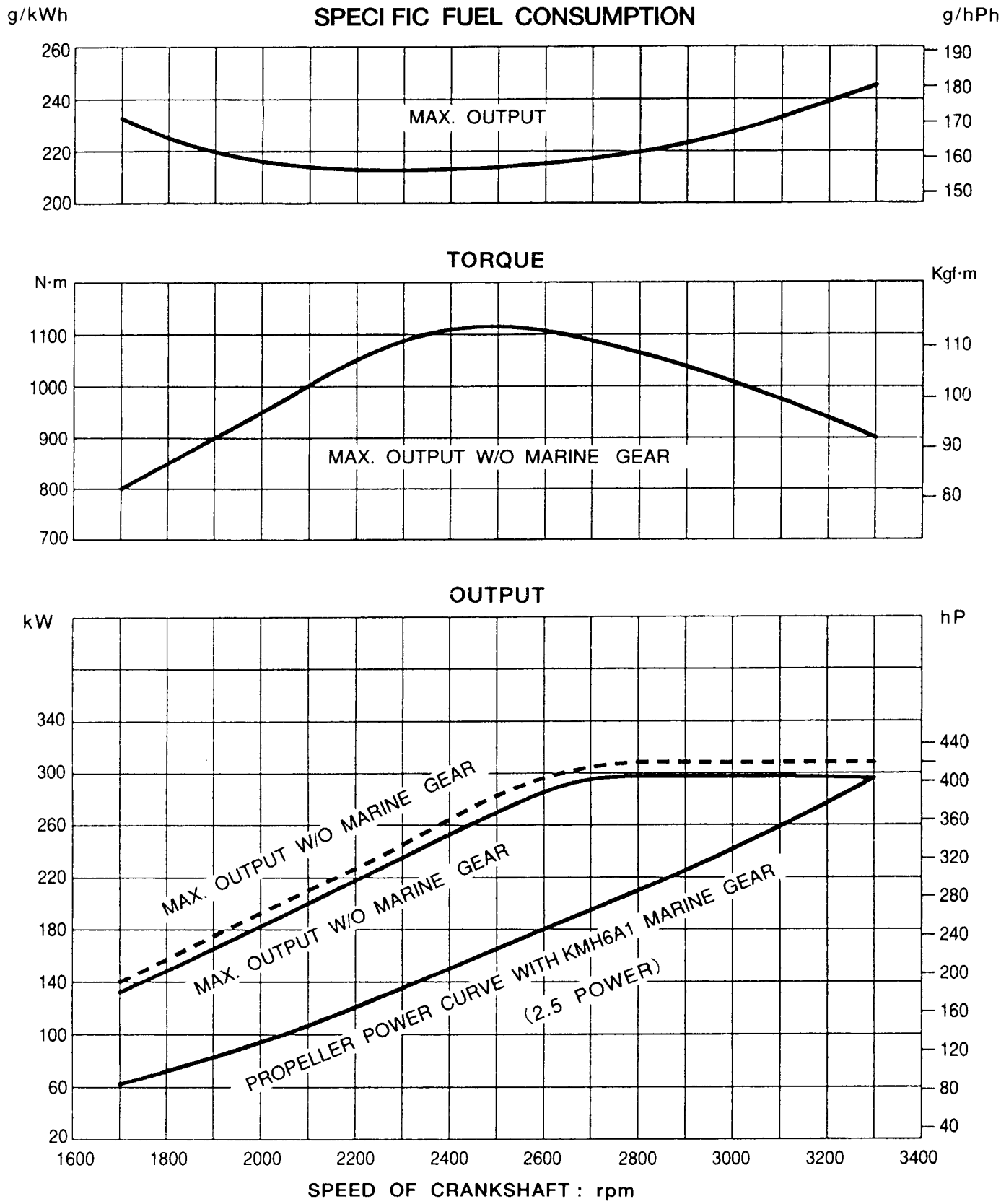
### • For 6LY2A-STP

| Model | | | KMH6A1 | | | MG5061A | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Type | | | 10° Angle | | | 7° Angle | | | | |
| | | | wet and multi-disc | | | | | | | |
| Reduction ratio | | | 1.58 | 1.92 | 2.26 | 1.13 | 1.54 | 1.75 | 2.00 | 2.47 |
| Lube oil capacity | Full | ℓ | 4.0 | | | Refer to the maker's manual | | | | |
| | Effective | ℓ | 0.3 | | | | | | | |

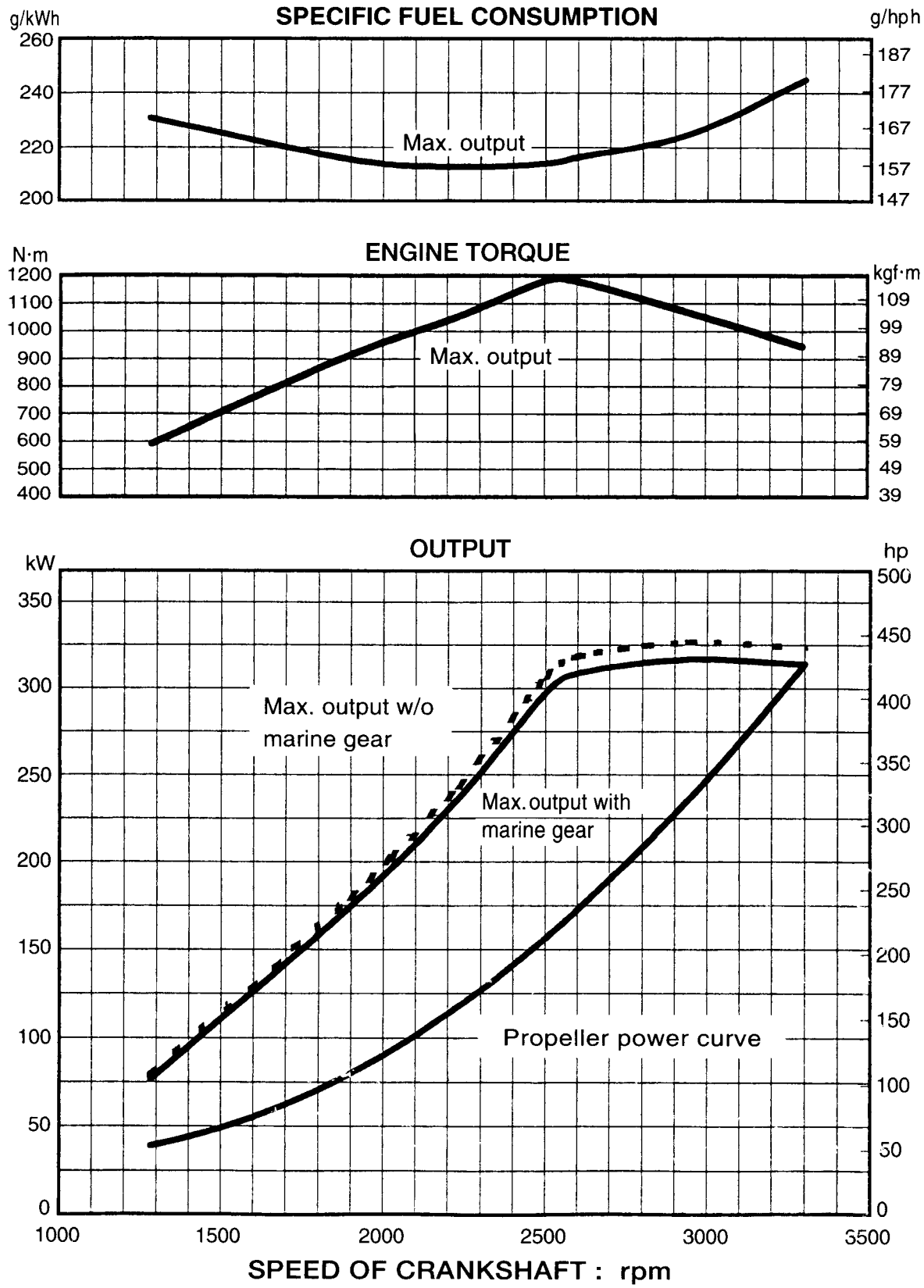
**(Note)**
Reduction ratio :
Both afead and astern

# 3. Performance Curve

〔6LY2-STE (Max. output : 309kW/3300rpm)〕



〔6LY2A-STP (Fuel stop power : 324kW/3300rpm)〕



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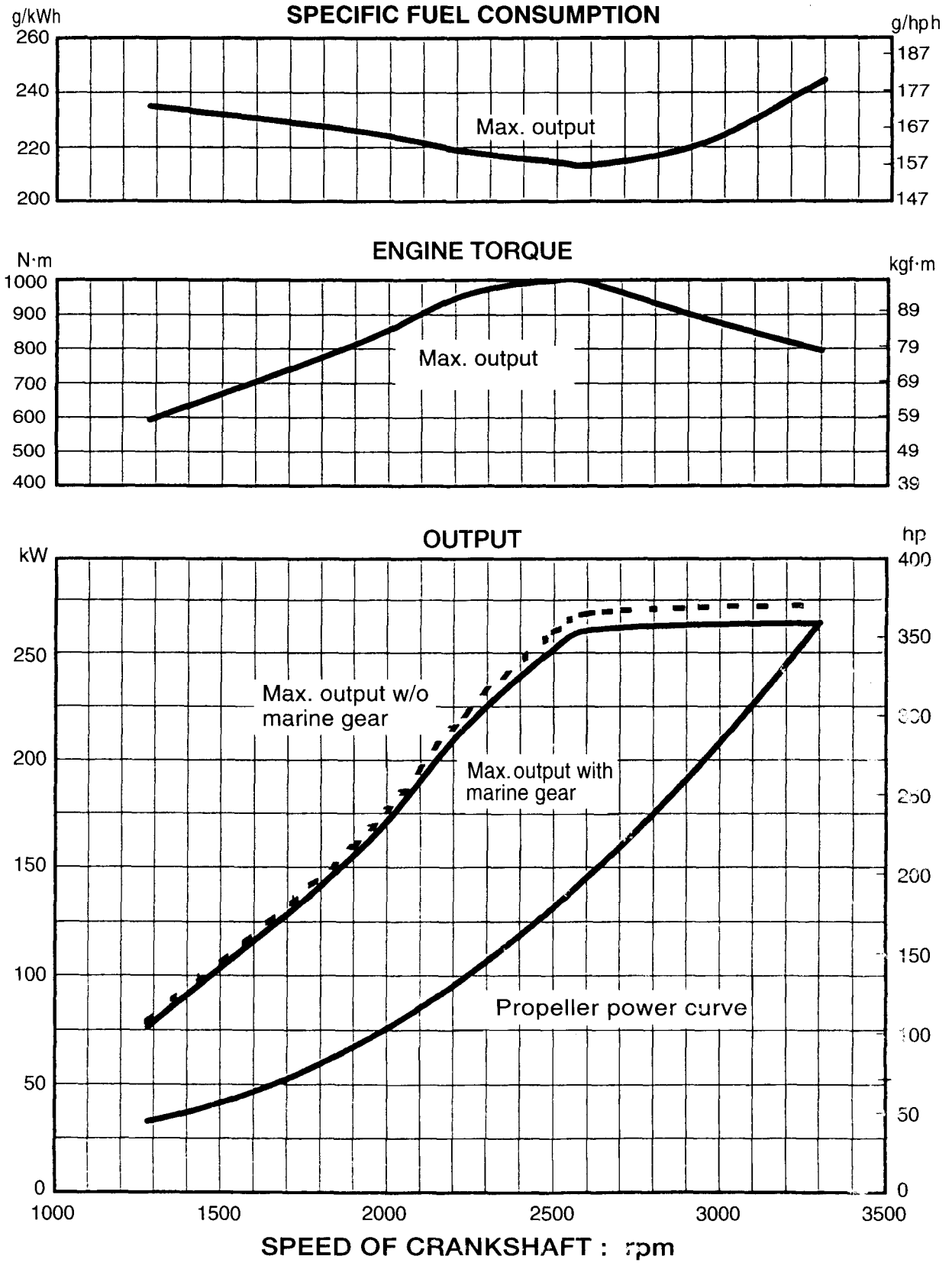
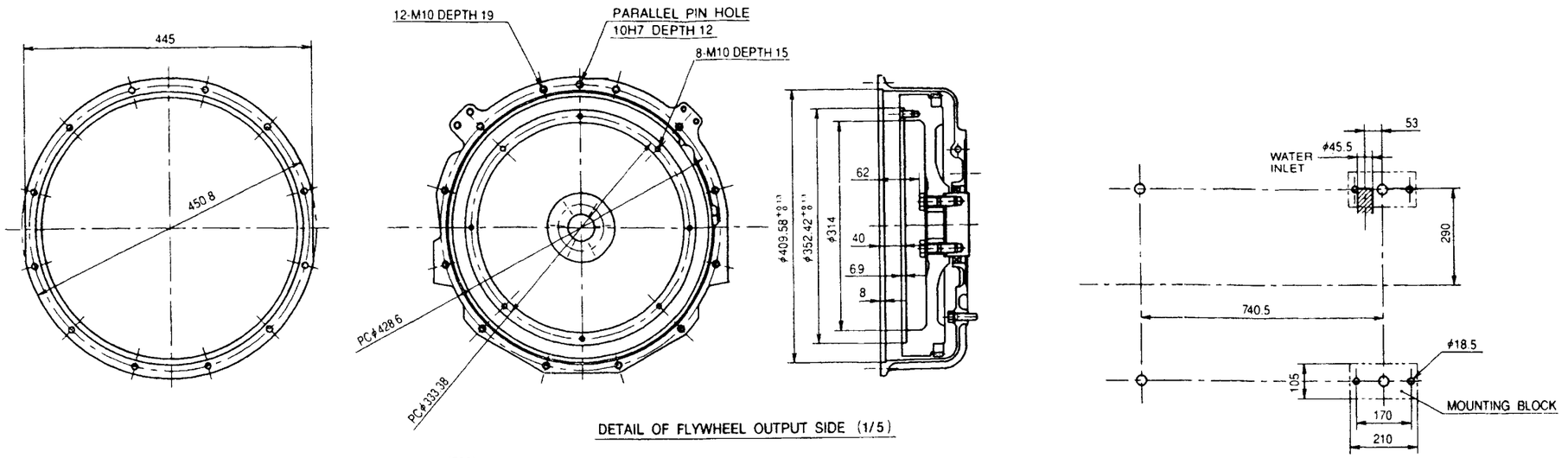
〔6LYA-STP (Fuel stop power : 272kW/3300rpm)〕

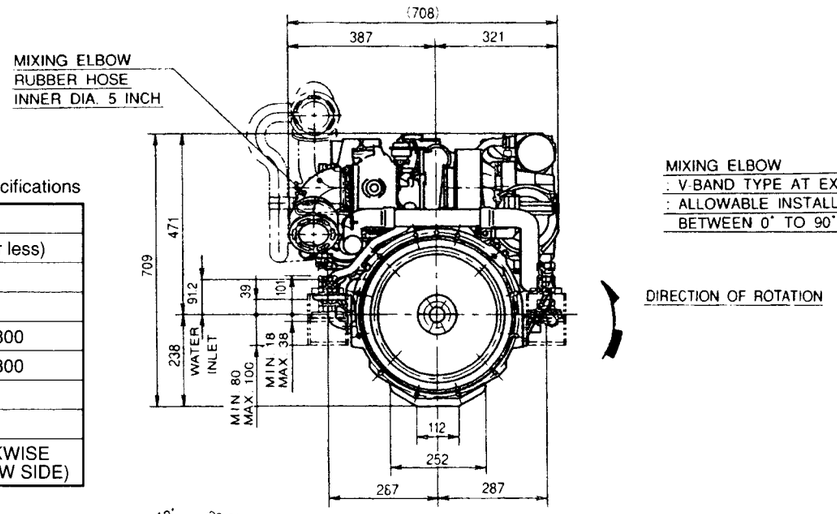


# 4. Dimensions

## 6LY2-STE / 6LY2A-STP / 6LYA-STP Outline

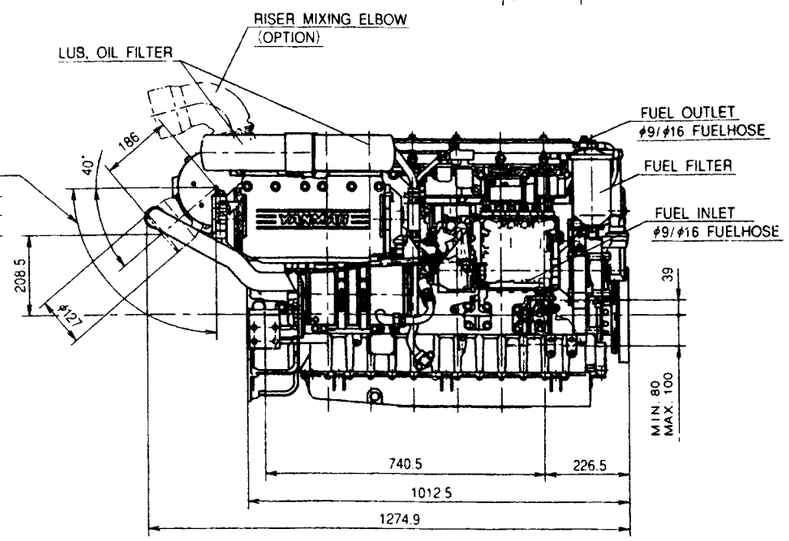



DETAIL OF FLYWHEEL OUTPUT SIDE (1/5)



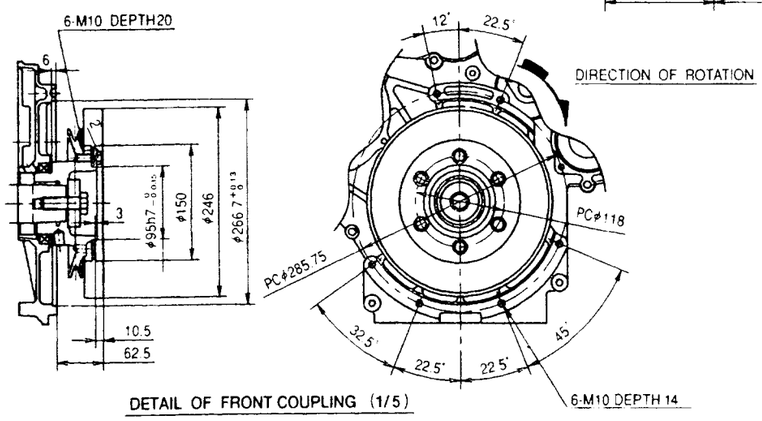







*,**: See 2, Specifications

| SPECIFICATIONS | | |
|---|---|---|
| MODEL | | 6LYA-STP (Gear less) |
| CONT. POWER (FLYWHEEL OUTPUT) | hp/rpm | 290/3100 |
| | kw/rpm | 213/3100 |
| FUEL STOP POWER (FLYWHEEL OUTPUT) | hp/rpm | *370, **359/3300 |
| | kw/rpm | *272, **264/3300 |
| NUMBER OF CYLINDER | | 6 |
| DRY MASS | kg | 530 |
| DIRECTION OF CRANKSHAFT ROTATION | | COUNTER CLOCKWISE (VIEWED FROM F/W SIDE) |



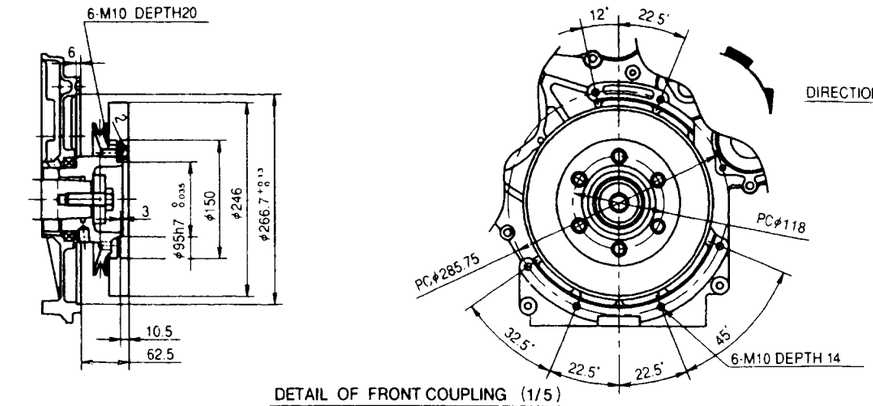

DETAIL OF FRONT COUPLING (1/5)

*,**: See 2, Specifications

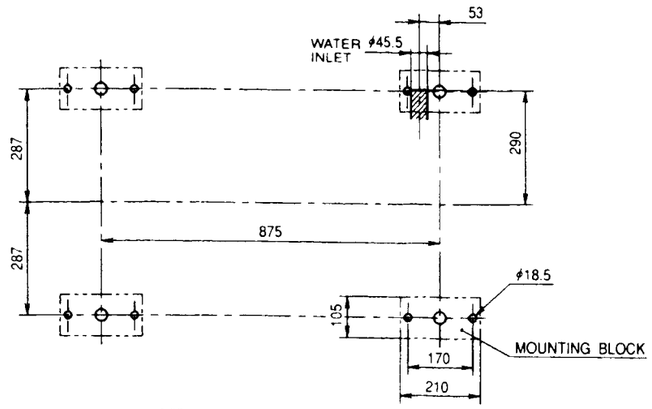
| SPECIFICATIONS | | |
|---|---|---|
| MODEL | | 6LY2-STE |
| CONT. RAITING OUTPUT (FLYWHEEL OUTPUT) | hp/rpm | 350/3100 |
| | kw/rpm | 257/3100 |
| MAX OUTPUT (FLYWHEEL OUTPUT) | hp/rpm | 420/3300 |
| | kw/rpm | 309/3300 |
| NUMBER OF CYLINDER | | 6 |
| DRY MASS | kg | 535 |
| DIRECTION OF CRANKSHAFT ROTATION | | COUNTER CLOCKWISE AT FLYWHEEL SIDE |

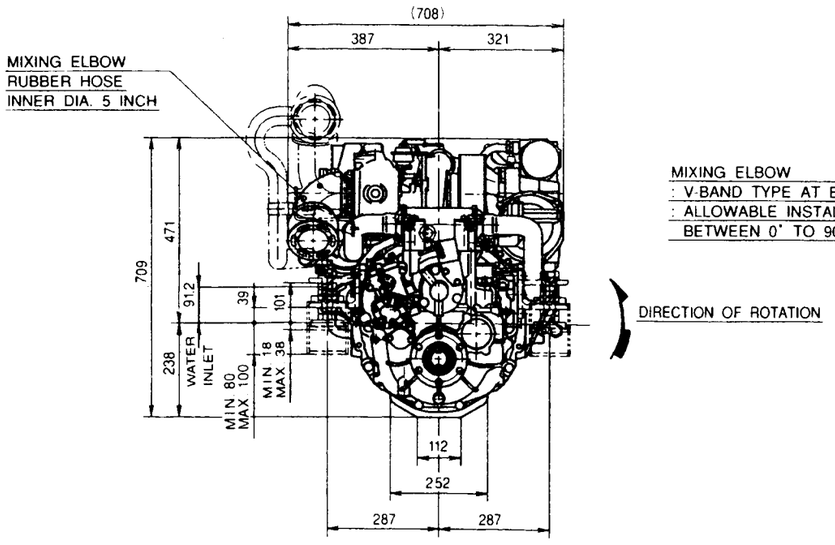
| SPECIFICATIONS | | |
|---|---|---|
| MODEL | | 6LY2A-STP (Gear less) |
| CONT. POWER (FLYWHEEL OUTPUT) | hp/rpm | 350/3100 |
| | kw/rpm | 257/3100 |
| FUEL STOP POWER (FLYWHEEL OUTPUT) | hp/rpm | *440, **427/3300 |
| | kw/rpm | *324, **315/3300 |
| NUMBER OF CYLINDER | | 6 |
| DRY MASS | kg | 535 |
| DIRECTION OF CRANKSHAFT ROTATION | | COUNTER CLOCKWISE (VIEWED FROM F/W SIDE) |

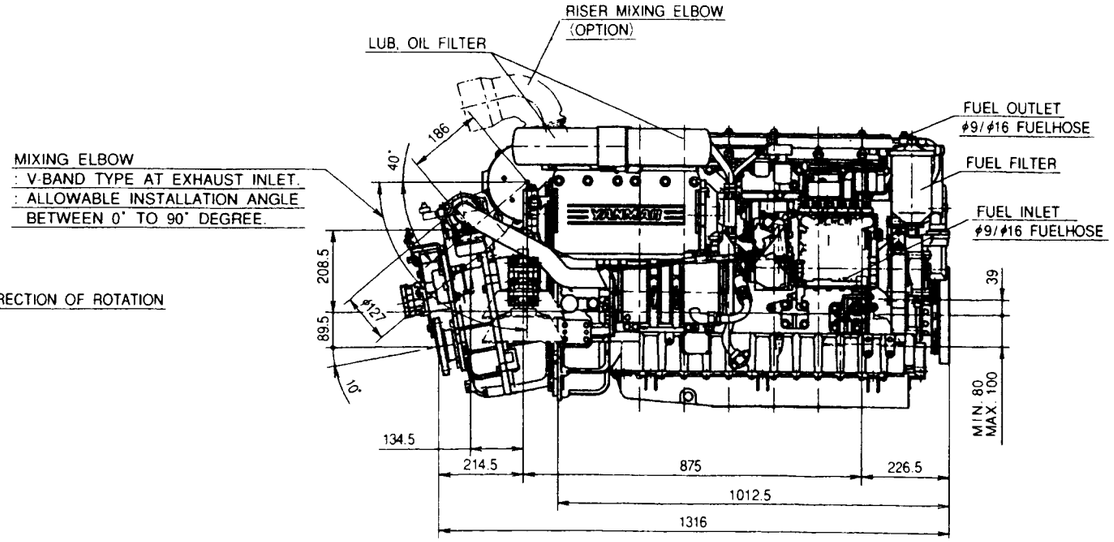
## 〔6LY2-STE/6LY2A-STP〕 Outline (KMH6A1 marine gear)

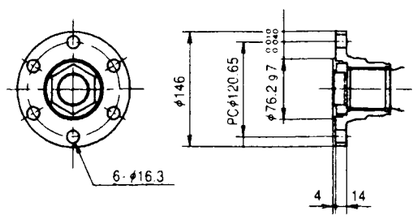



DETAIL OF FRONT COUPLING (1/5)




DETAIL OF COUPLING (1/5)

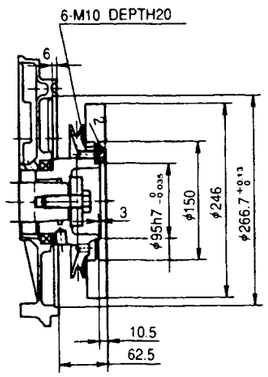
*,**: See 2, Specifications

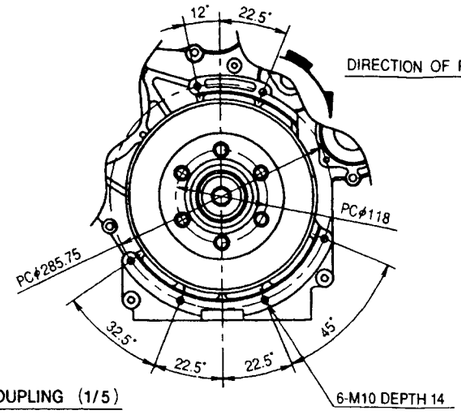
| SPECIFICATIONS | | | | |
|---|---|---|---|---|
| MODEL | | 6LY2-STE | | |
| CONT. RAITING OUTPUT (FLYWHEEL OUTPUT) | hp/rpm | 350/3100 | | |
| | kw/rpm | 257/3100 | | |
| MAX OUTPUT (FLYWHEEL OUTPUT) | hp/rpm | 420/3300 | | |
| | kw/rpm | 309/3300 | | |
| NUMBER OF CYLINDER | | 6 | | |
| REDUCTION RATIO (BOTH AHEAD AND ASTERN) | | 1.58 | 1.92 | 2.26 |
| DRY MASS | kg | 637 | | |
| DIRECTION OF CRANKSHAFT ROTATION | | COUNTER CLOCKWISE (VIEWED FROM F/W SIDE) | | |

| SPECIFICATIONS | | | | |
|---|---|---|---|---|
| MODEL | | 6LY2A-STP | | |
| CONT. POWER (FLYWHEEL OUTPUT) | hp/rpm | 350/3100 | | |
| | kw/rpm | 257/3100 | | |
| FUEL STOP POWER (FLYWHEEL OUTPUT) | hp/rpm | *440, **427/3300 | | |
| | kw/rpm | *324, **315/3300 | | |
| NUMBER OF CYLINDER | | 6 | | |
| REDUCTION RATIO (BOTH AHEAD AND ASTERN) | | 1.58 | 1.92 | 2.26 |
| DRY MASS | kg | 637 | | |
| DIRECTION OF CRANKSHAFT ROTATION | | COUNTER CLOCKWISE (VIEWED FROM F/W SIDE) | | |

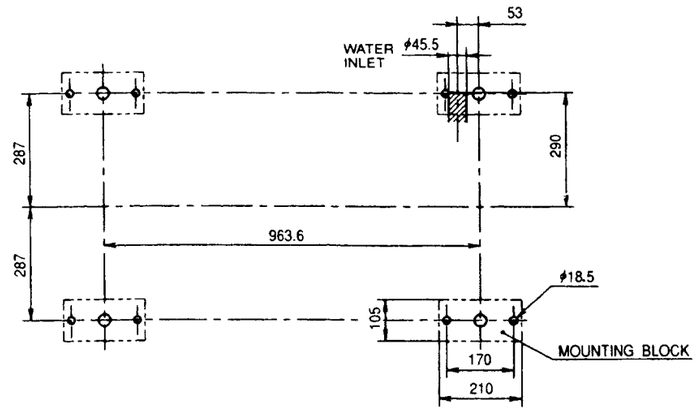
## 〔6LY2-STE/6LY2A-STP〕

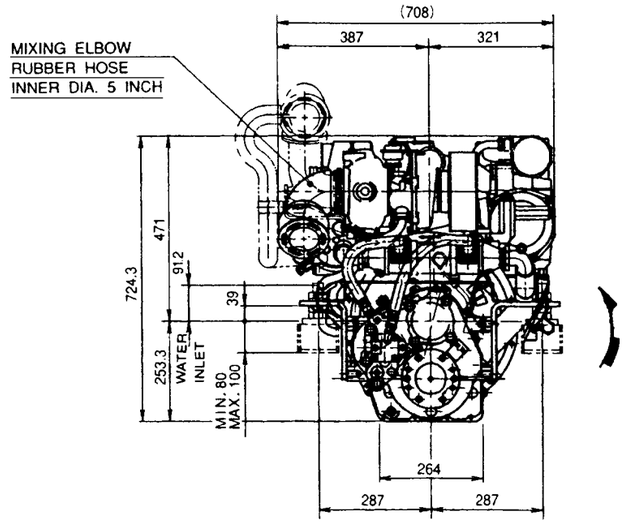
### Outline (MG5061A marine gear)

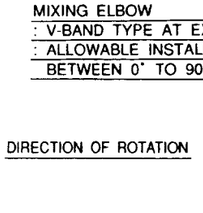


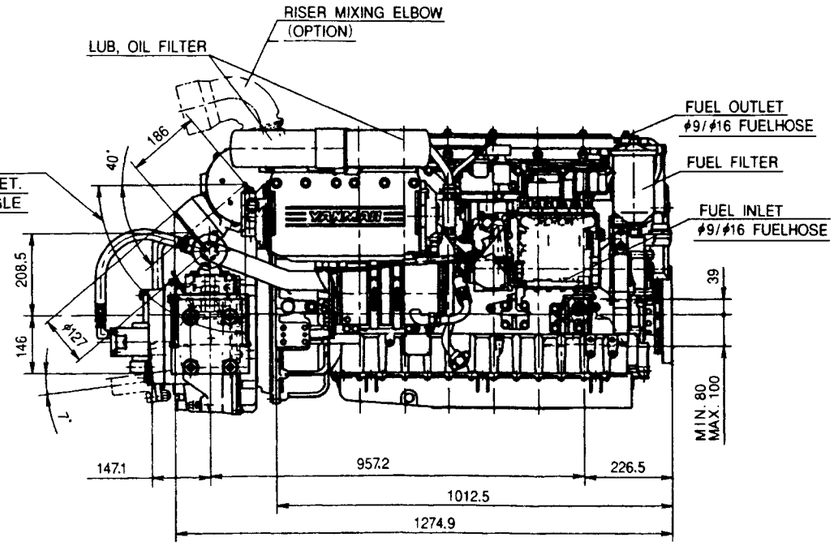



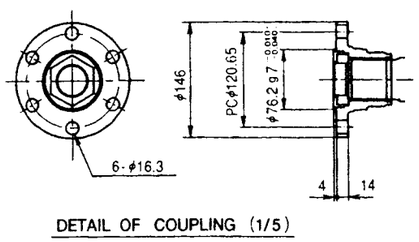

DETAIL OF FRONT COUPLING (1/5)



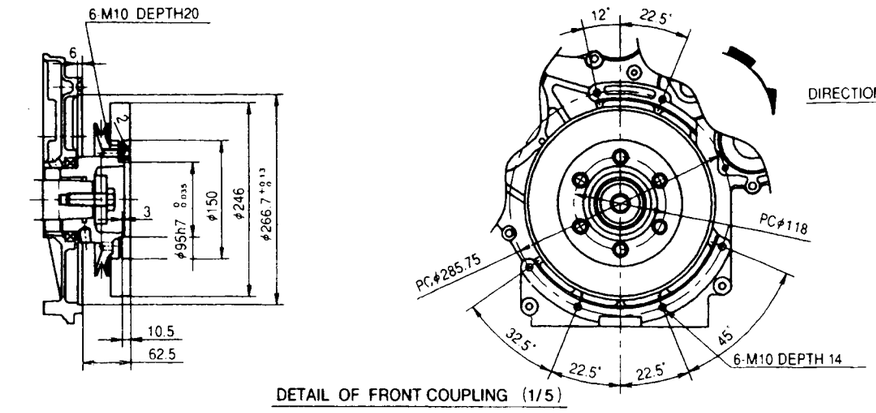

DETAIL OF COUPLING (1/5)

*,**: See 2, Specifications

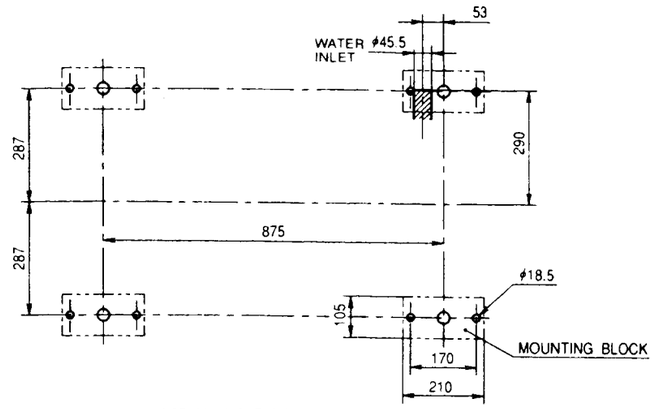
| SPECIFICATIONS | | | | | | |
|---|---|---|---|---|---|---|
| MODEL | | 6LY2-STE | | | | |
| CONT. RAITING OUTPUT (FLYWHEEL OUTPUT) | hp/rpm | 350/3100 | | | | |
| | kw/rpm | 257/3100 | | | | |
| MAX OUTPUT (FLYWHEEL OUTPUT) | hp/rpm | 420/3300 | | | | |
| | kw/rpm | 309/3300 | | | | |
| NUMBER OF CYLINDER | | 6 | | | | |
| REDUCTION RATIO (BOTH AHEAD AND ASTERN) | | 1.13 | 1.54 | 1.75 | 2.00 | 2.47 |
| DRY MASS | kg | 633 | | | | |
| DIRECTION OF CRANKSHAFT ROTATION | | COUNTER CLOCKWISE (VIEWED FROM F/W SIDE) | | | | |

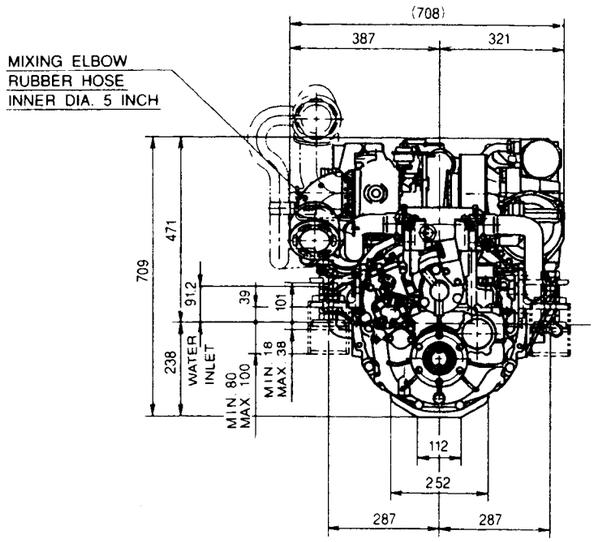
| SPECIFICATIONS | | | | | | |
|---|---|---|---|---|---|---|
| MODEL | | 6LY2A-STP | | | | |
| CONT. POWER (FLYWHEEL OUTPUT) | hp/rpm | 350/3100 | | | | |
| | kw/rpm | 257/3100 | | | | |
| FUEL STOP POWER (FLYWHEEL OUTPUT) | hp/rpm | *440, **427/3300 | | | | |
| | kw/rpm | *324, **315/3300 | | | | |
| NUMBER OF CYLINDER | | 6 | | | | |
| REDUCTION RATIO (BOTH AHEAD AND ASTERN) | | 1.13 | 1.54 | 1.75 | 2.00 | 2.47 |
| DRY MASS | kg | 633 | | | | |
| DIRECTION OF CRANKSHAFT ROTATION | | COUNTER CLOCKWISE (VIEWED FROM F/W SIDE) | | | | |

## 〔6LYA-STP〕 Outline (KMH6A marine gear)

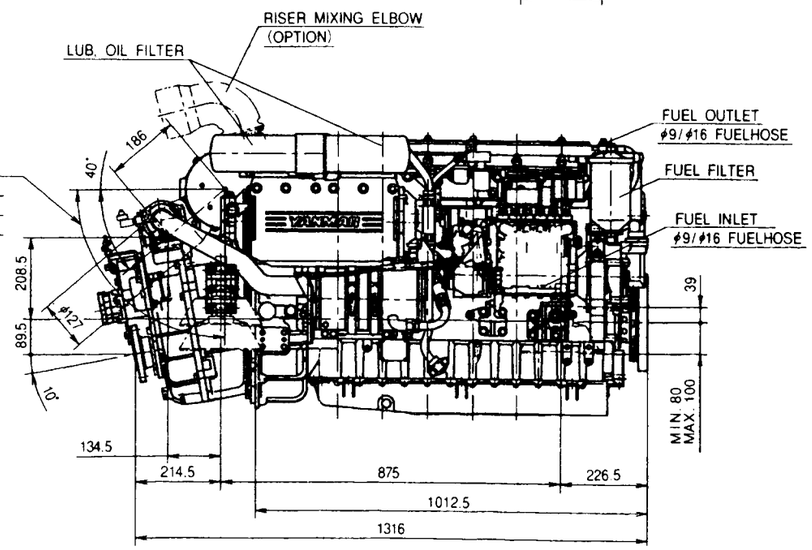


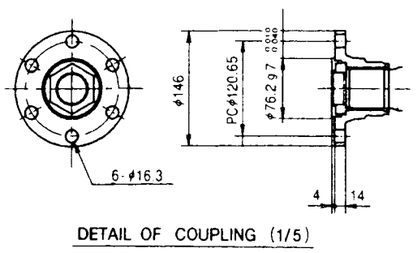

DETAIL OF FRONT COUPLING (1/5)




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



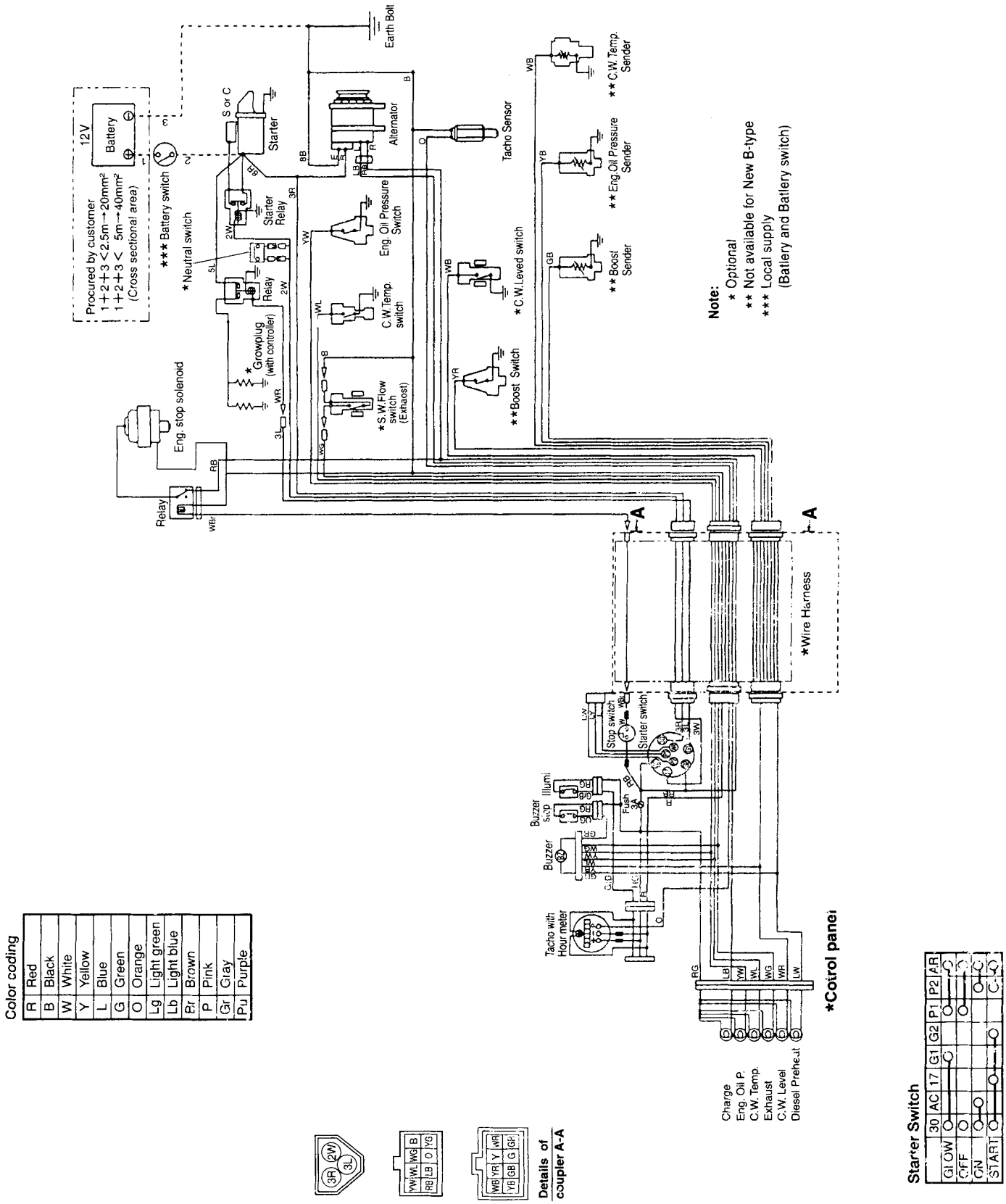

DETAIL OF COUPLING (1/5)

*,**: See 2, Specifications

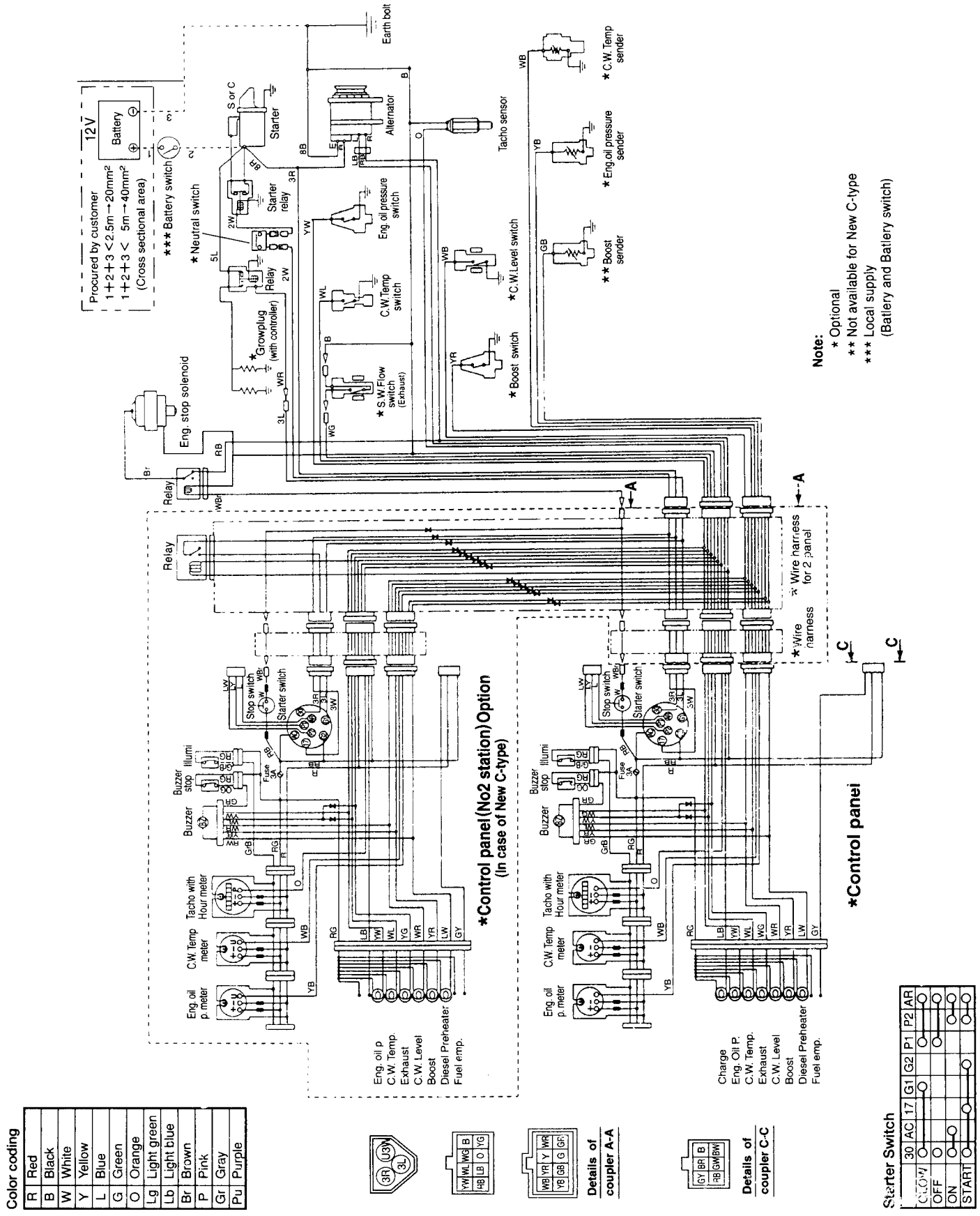
| SPECIFICATIONS | | | | |
|---|---|---|---|---|
| MODEL | | 6LYA-STP | | |
| CONT. POWER (FLYWHEEL OUTPUT) | hp/rpm | 290/3100 | | |
| | kw/rpm | 213/3100 | | |
| FUEL STOP POWER (FLYWHEEL OUTPUT) | hp/rpm | *370, **359/3300 | | |
| | kw/rpm | *272, **264/3300 | | |
| NUMBER OF CYLINDER | | 6 | | |
| REDUCTION RATIO (BOTH AHEAD AND ASTERN) | | 1.58 | 1.92 | 2.26 |
| DRY MASS | kg | 632 | | |
| DIRECTION OF CRANKSHAFT ROTATION | | COUNTER CLOCKWISE (VIEWED FROM F/W SIDE) | | |

# 5. Wiring Diagrams

## (1) New B-type Control panel



## (2) New C-type Control panel



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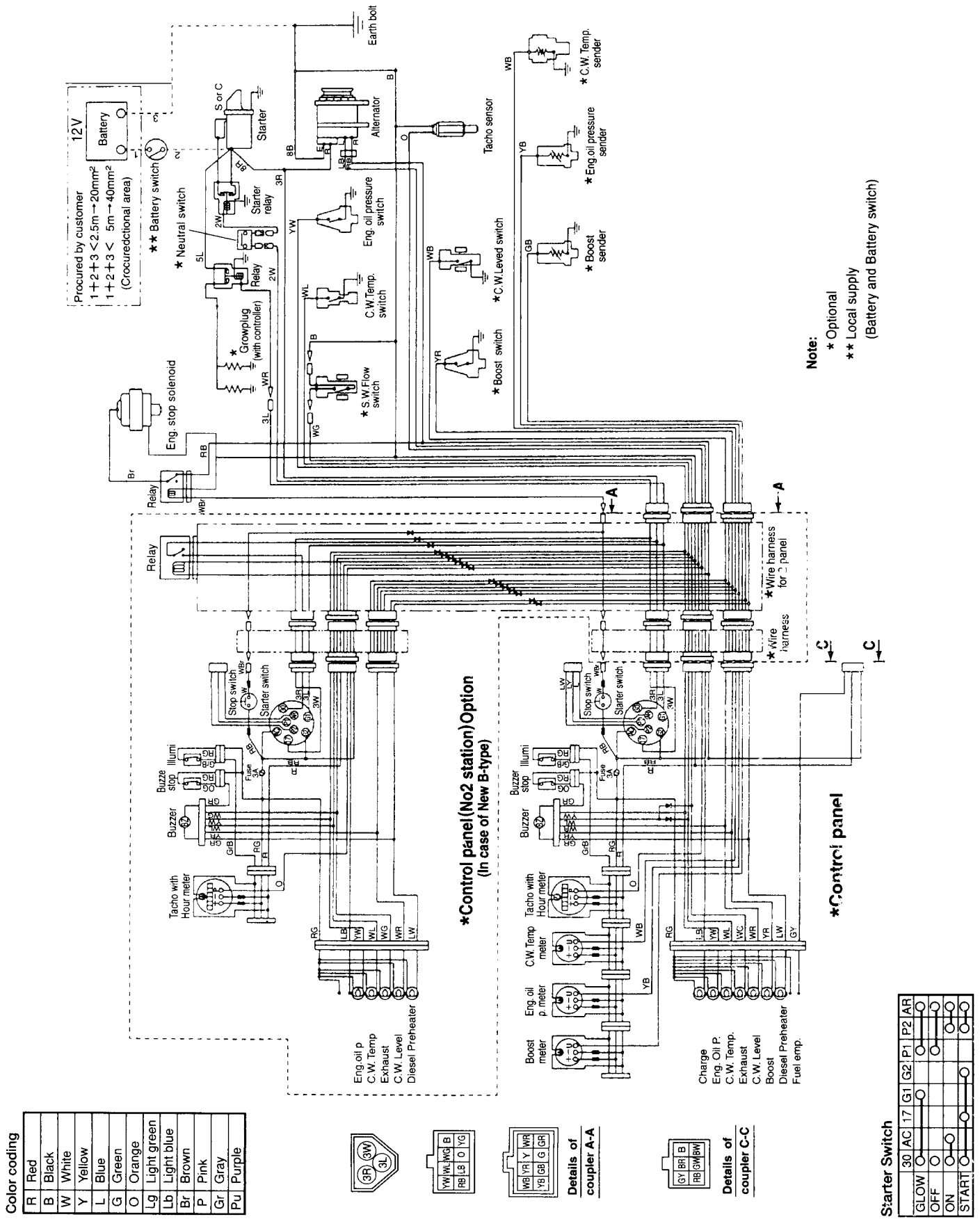
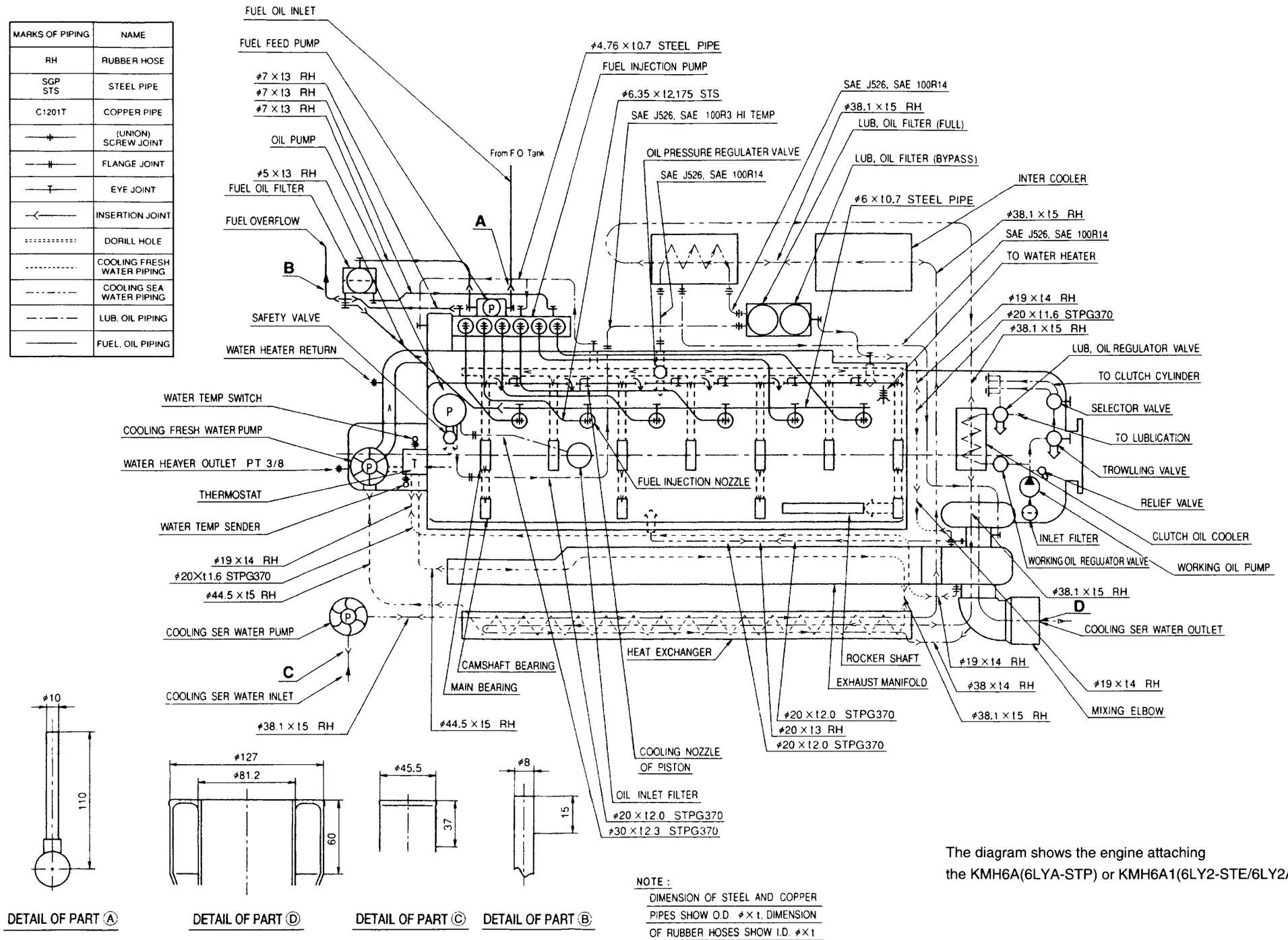
## (3) New D-type Control panel



# 6. Piping Diagrams

| MARKS OF PIPING | NAME |
|---|---|
| RH | RUBBER HOSE |
| SGP<br>STS | STEEL PIPE |
| C1201T | COPPER PIPE |
| | (UNION)<br>SCREW JOINT |
| | FLANGE JOINT |
| | EYE JOINT |
| | INSERTION JOINT |
| | DORILL HOLE |
| | COOLING FRESH<br>WATER PIPING |
| | COOLING SEA<br>WATER PIPING |
| | LUB. OIL PIPING |
| | FUEL. OIL PIPING |




The diagram shows the engine attaching
the KMH6A(6LYA-STP) or KMH6A1(6LY2-STE/6LY2A-STP)

CHAPTER 2

# INSPECTION AND SERVICING OF BASIC ENGINE PARTS

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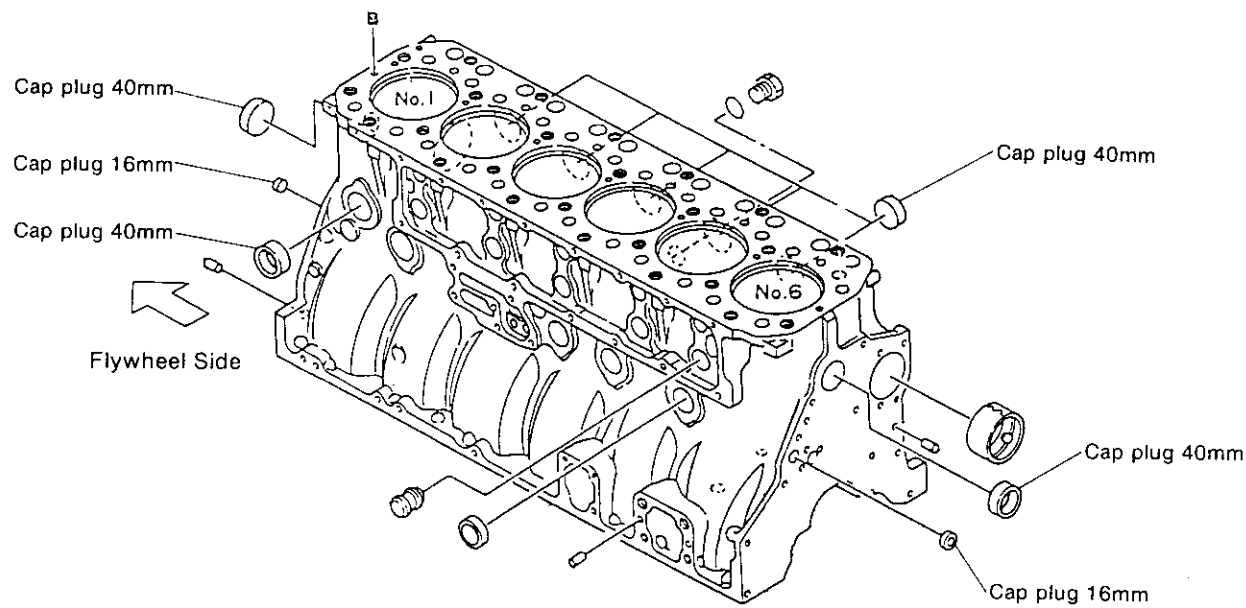
# 1. Cylinder Block

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




## 1-1 Inspection of parts

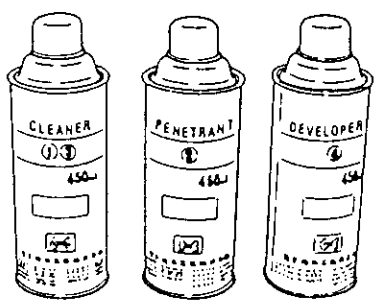
Make a visual inspection to check for cracks on engines that have frozen up, overturned or otherwise been subjected to undue stress. Perform a color check on any portions that appear to be cracked, and replace the cylinder block if the crack is not repairable.

## 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 |

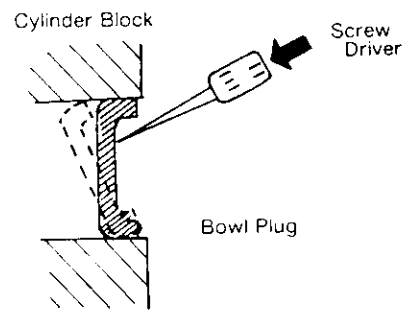
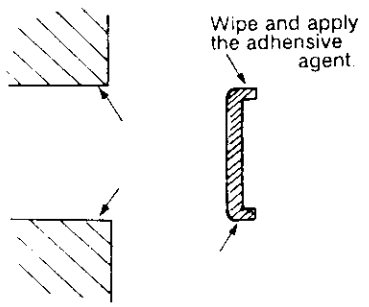
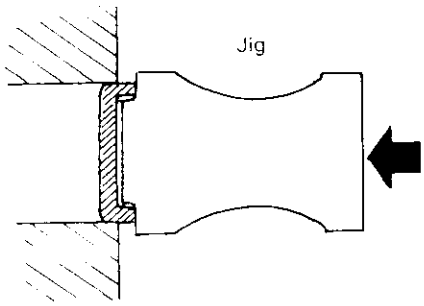
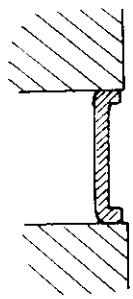



## 1-3 Color check procedure

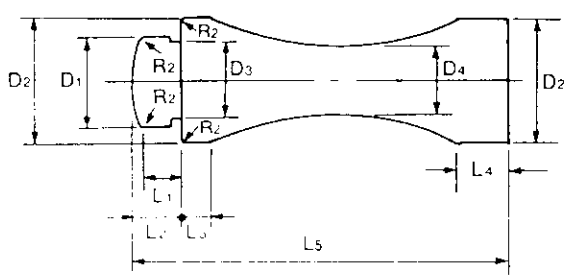
(1) Clean the area to be inspected.
(2) Color check kit
The color check test kit consists of an aerosol cleaner, penetrant and developer.
(3) Clean the area to be inspected with the cleaner.
Either spray the cleaner on directly and wipe, or wipe the area with a cloth moistened with cleaner.
(4) Spray 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 |  | Remove the bowl plug using by a screw driver and hammer.<br>Hit the bowl plug by screw driver and hammer tap lightly obliquely from the upper side. | ·Screw driver<br>·Hammer |
| 2 |  | Wipe the cylinder block and bowl plug fitting portion clean.<br>Apply an adhensive agent (acrylic) on the periphery of the bowl plug and the cylinder block inside. | ·Thinner<br>·Adhesive agent<br>(or Three bond 1386B) |
| 3 |  | Insert the bowl plug using by the jig and hammer.(Set the jig straightly.) | ·Jig<br>·Hammer |
| 4 |  | Do not supply water into the cylinder block for two hours after the bowl plug are set. | |

<Note> Design of Jig




mm

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



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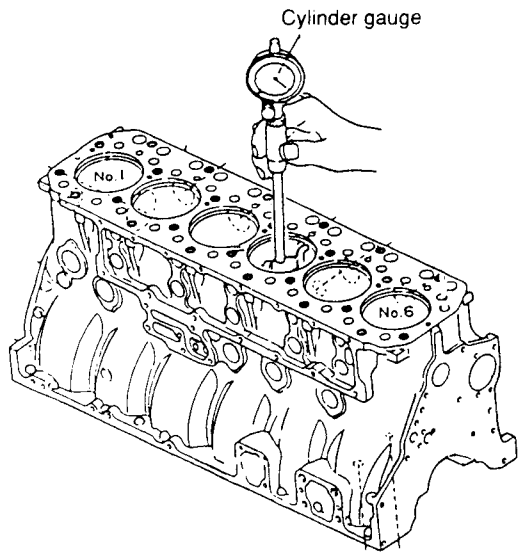
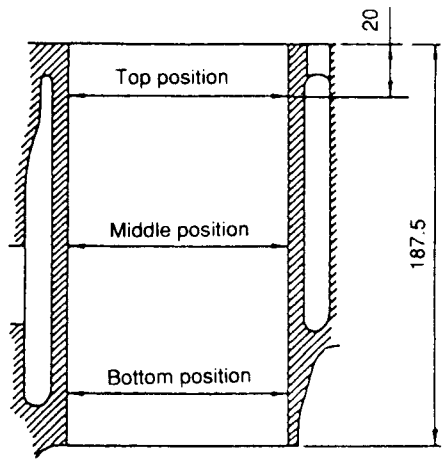
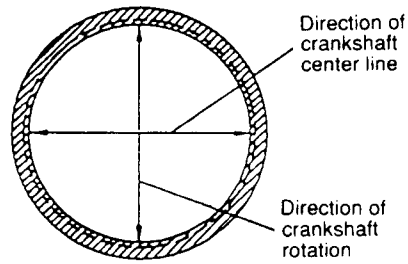
## 1-5 Cylinder bore measurement

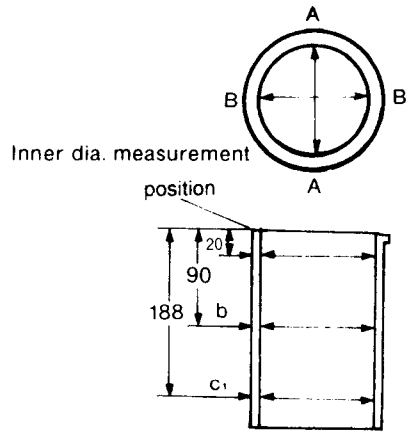
### ● 6LY2-STE/6LY2A-STP

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

| | | Nominal dimension | Limit dimension |
|---|---|---|---|
| Inner diameter of cylinder | L | $\phi$105.920~$\phi$105.930 | $\phi$105.950 |
| | M | $\phi$105.910~$\phi$105.919 | |
| | S | $\phi$105.900~$\phi$105.909 | |
| Circularity of cylinder bore | | Less than 0.03 | — |
| Cylindricity of cylinder bore | | Less than 0.02 | — |

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

## ● 6LYA-STP

### Cylinder Sleeve

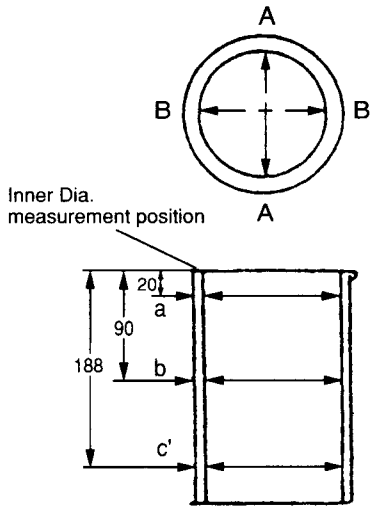
The rigidity of the cylinder sleeve is increased by employing a dry type sleeve.
The wear resistance of the cylinder sleeve is also increased by employing new material.

### 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 | 100mm +0.03 or less +0.02 or more | 0.15 |
| | M | 100mm +less than 0.02 +0.01 or more | |
| | S | 100mm +less than 0.01 +0 or more | |
| Circularity of cylinder sleeve | | 0.03 or less | —— |
| Cylindricity of cylinder sleeve | | 0.02 or less | —— |

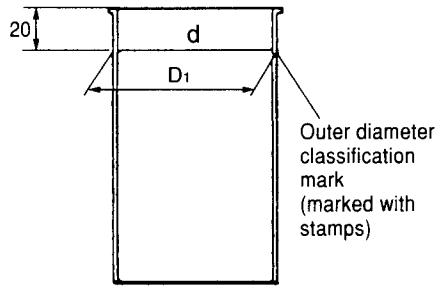


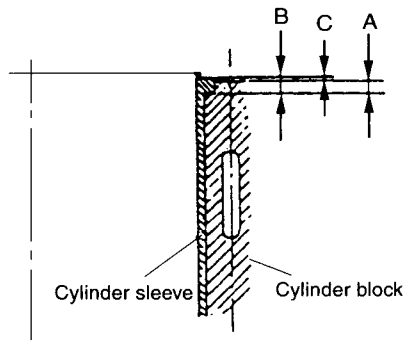

Note: Be sure to measure inner diameter of cylinder sleeve at points "a", "b", and "c" in directions "A" and "B" .

### 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 | | Clearance: 10 to 30 μ | Dimension | |
| Mark | Tolerance(difference from 103mm dia.) | | 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 |




### 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 | $5^{0}_{-0.040}$ |
| Cylinder sleeve flange thickness : B | $5^{+0.050}_{+0.025}$ |
| Cylinder sleeve protrusion : C | 0.025~0.09 |



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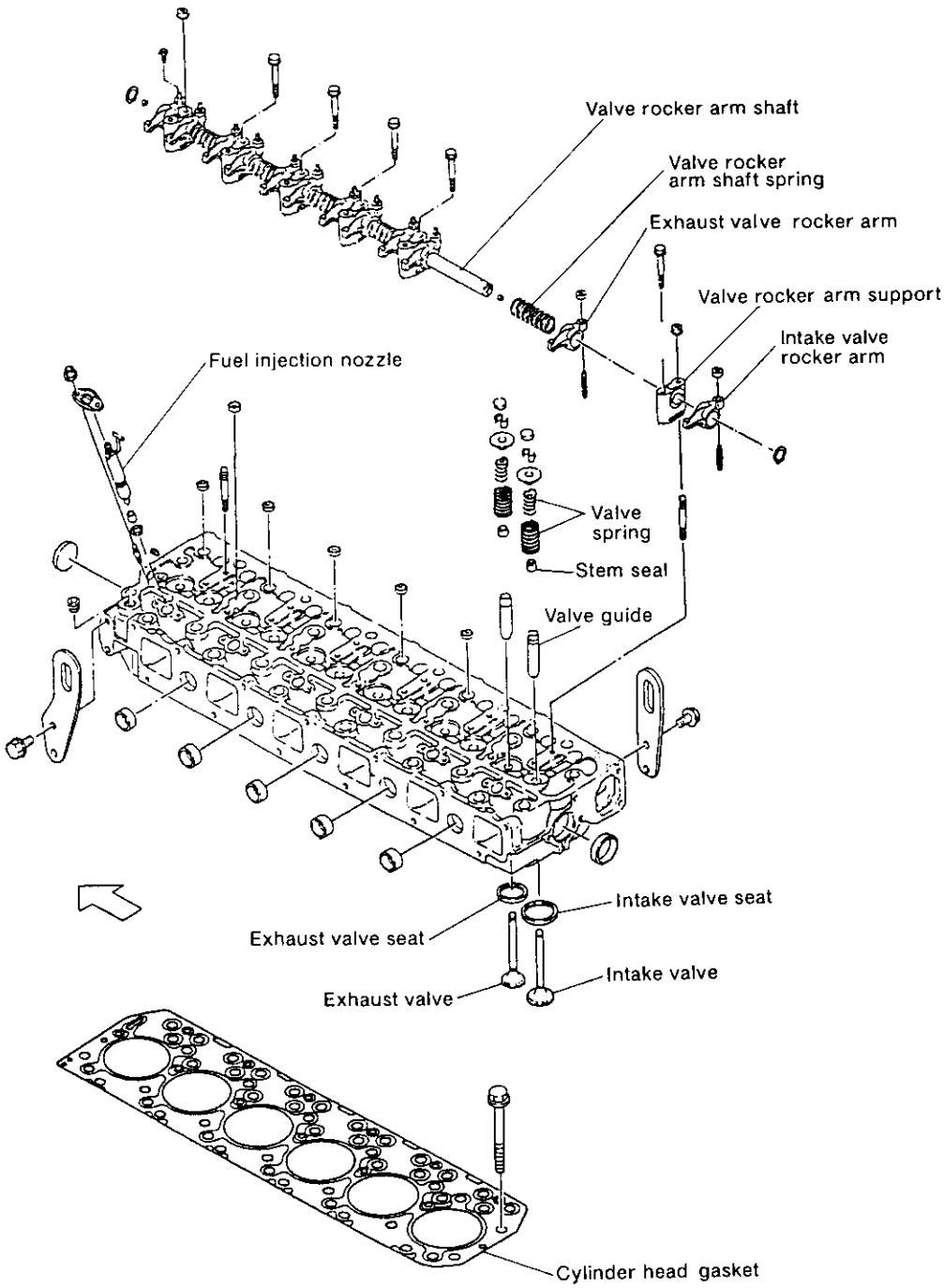
# 2. Cylinder Head

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.



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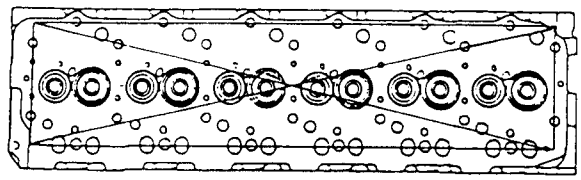
## 2-1 Inspecting the cylinder head

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.

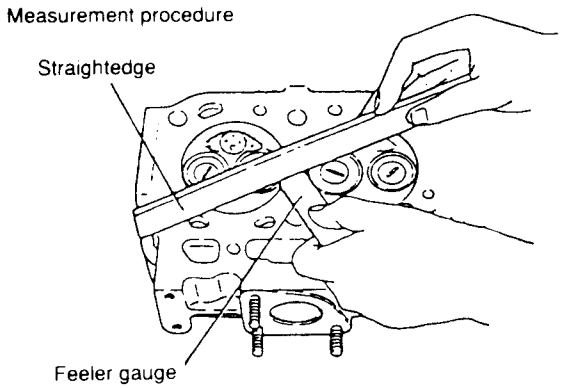


### 2-1.1 Distortion of the combustion surface

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.

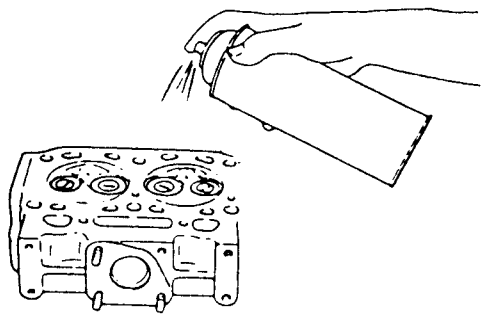



mm

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

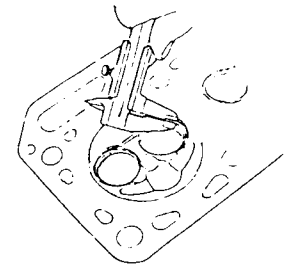
### 2-1.2 Checking for cracks in the combustion surface

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.



### 2-1.3 Checking the intake and exhaust valve seats

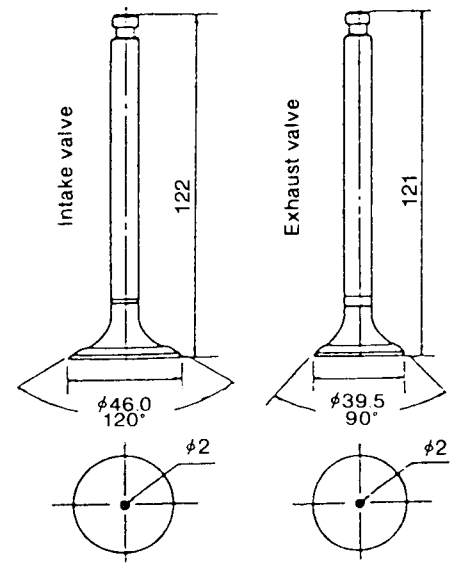
Check the surface of the valve seats.
If they are too wide, or if the surfaces are rough, correct to the following standards:



| | | |
|---|---|---|
| Seat angle | Intake | 120° |
| | Exhaust | 90° |

| Seat width | Standard | Wear limit |
|---|---|---|
| Intake | 1.731 | 2.32 |
| Exhaust | 2.121 | 2.73 |

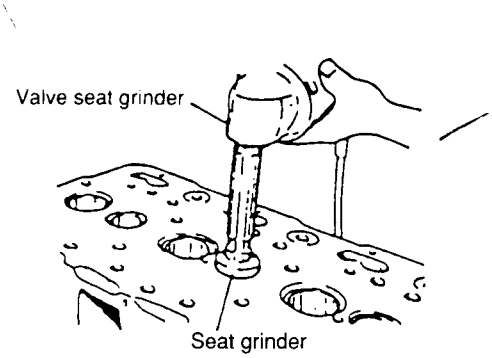
Standard dimension



## 2-2 Valve seat correction procedure

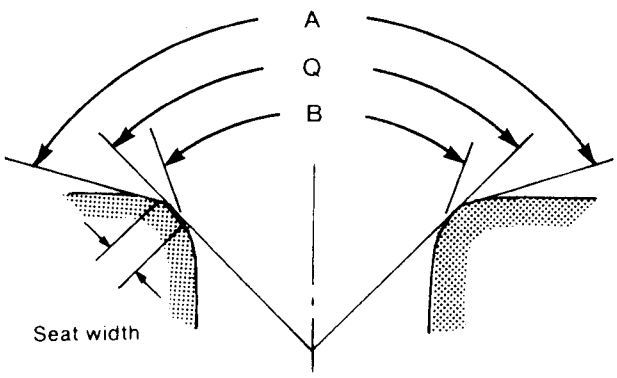
The most common method for correcting unevenness of the seat surface with a seat grinder is as follows:

(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 (45° for exhaust), (30° for intake) using the seat grinder with 15° chanfer.




| | | |
|---|---|---|
| Seat grinder | Intake valve | 30° |
| | Exhaust valve | 45° |

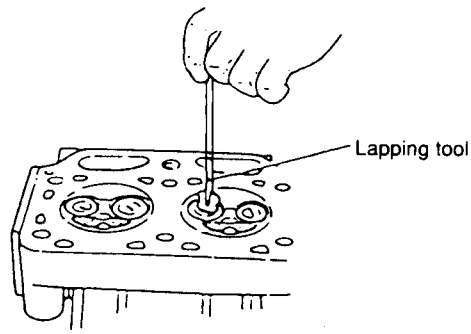
*NOTE : When seat adjustment is necessary, be sure to check the valve and valve guide. If the clearance exceeds the tolerance, replace the valve or the valve guide, and then grind the seat.*




Q···Seat(correction) angle···Intake···120°
(standard angle) Exhaust···90°
A···Seat(Outside)correction angle···150°
B···Seat(Inside)correction angle···40° (exhaust)
20° (intake)

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

*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.*

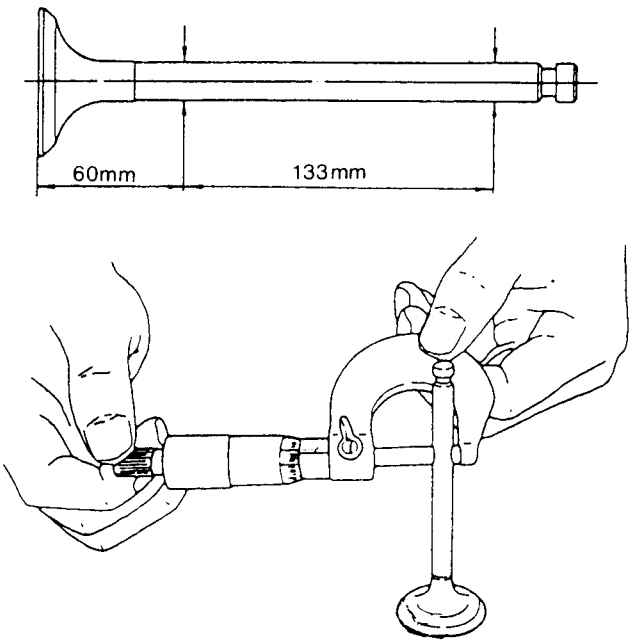



*NOTE : Measure valve distortion after valve seat refinishing has been completed, and replace the the valve and valve seat if it exceeds the tolerance.*

## 2-3 Intake/exhaust valves, valve guides

### 2-3.1 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 | φ8.960～φ8.975 | φ8.9 |
| Exhaust | φ8.940～φ8.955 | φ8.9 |



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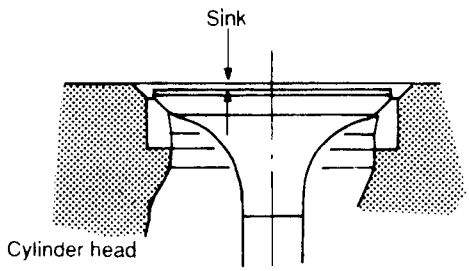
### 2-3.2 Inspection of valve seat wear and contact surface

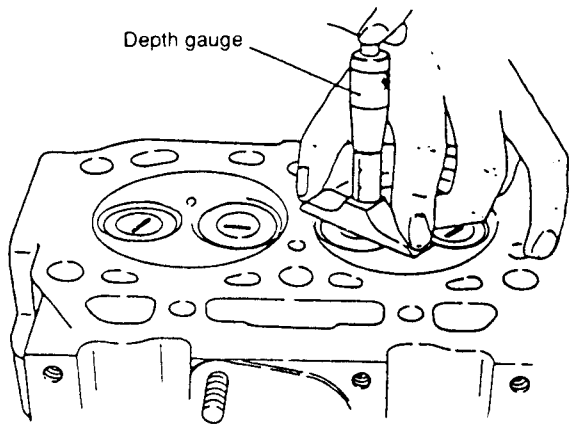
Inspect for valve seat scratches and excessive wear. Check to make sure the contact surface if normal. The seat angle must be checked and adjusted if the valve seat contact surface is much smaller than the width of the valve seat.

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

### 2-3.3 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 | (Protrusion) 0.6~0.8 | (Sink) 0.6 |
| | Exhaust | (Sink) 0.2~0.4 | (Sink) 1.8 |

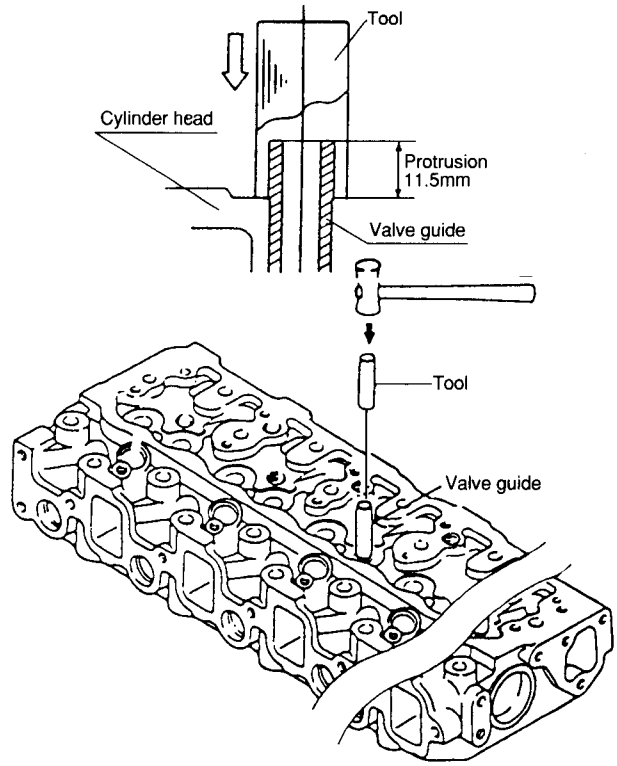
(1) Measuring inner diameter of valve guide.
Measure the inner diameter of the valve guide and replace it if it exceeds the wear limit.

mm

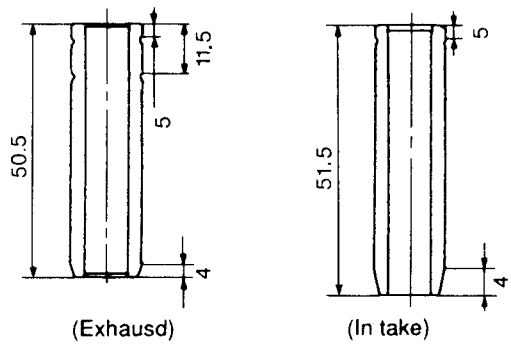
| | | Standard | Wear limit |
|---|---|---|---|
| Valve guide inside dia. | Intake | $\phi$ 9.00~$\phi$ 9.015 | $\phi$ 9.1 |
| | Exhaust | $\phi$ 9.00~$\phi$ 9.015 | $\phi$ 9.1 |

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

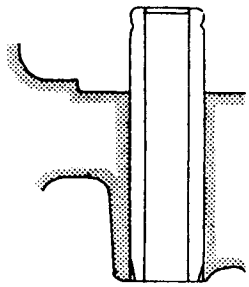
(2) Replacing the valve guide
Use the insertion tool and tap in the guide with a mallet.



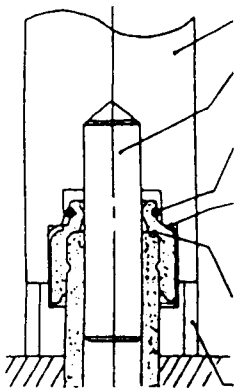

The intake valve guide and exhaust valve guide are of different shapes/dimensions.




(3) Valve guide projection
The bottom of the valve guide should be aligned with the bottom of the cylinder head.



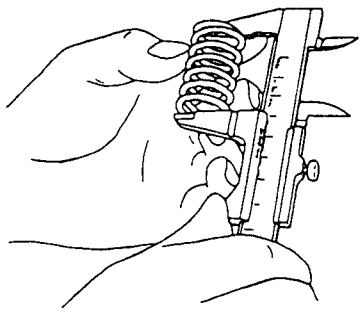
(4) Valve stem seals
The valve stem seals in the intake/exhaust valve guides cannot be re-used once they are removed - be sure to replace them.
When assembling the intake/exhaust valves, apply an adequate quantity of engine oil on the valve stem before inserting them.



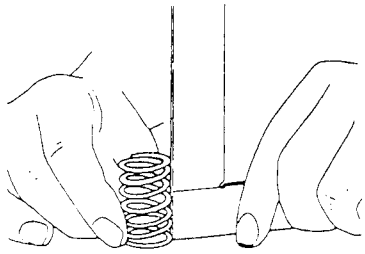

## 2-4 Valve springs

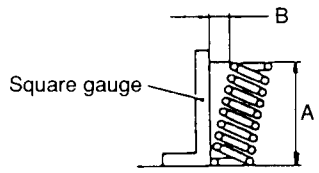
### 2-4.1 Checking valve springs

(1) Check the spring for scratches or corrosion.
(2) Measure the free length of the spring.



(3) Measure inclination.

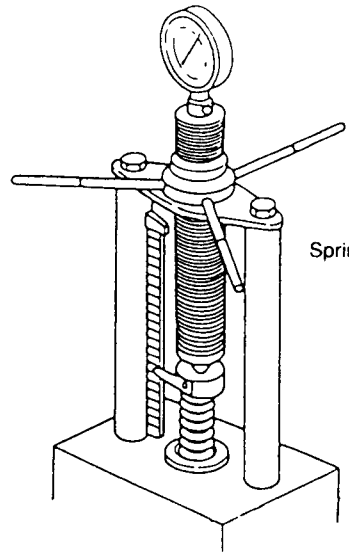





mm

| | Limit |
|---|---|
| Inclination | 1.2 |

(4) Measure spring tension.



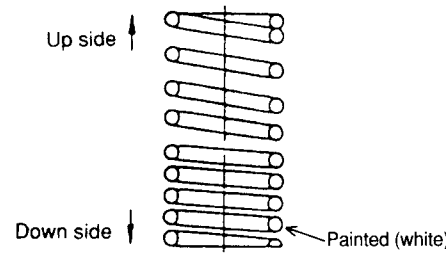

(Inside) mm

| 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 white) should face down (cylinder head).




*NOTE : The pitch of the valve spring is not even. The side with the smaller pitch (painted white) 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.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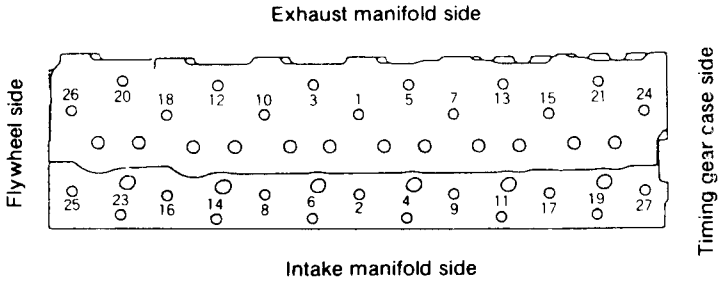
## 2-5 Assembling the cylinder head

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.



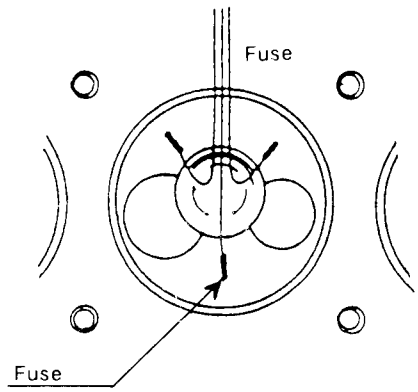

N·m(kgf·m)

| | First | Second | Final |
|---|---|---|---|
| Tightening torque | 118 (12) | 177 (18) | 216~236 (22.0~24.0) |

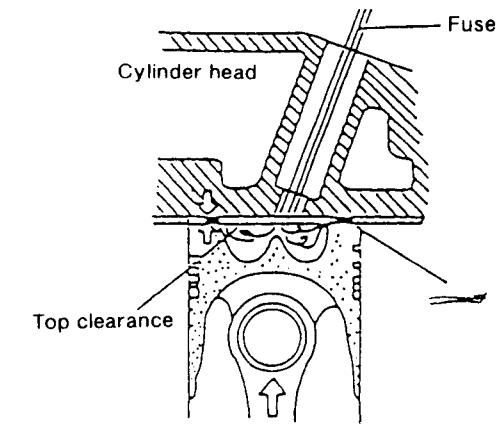
Apply engine oil to the thread and seat.

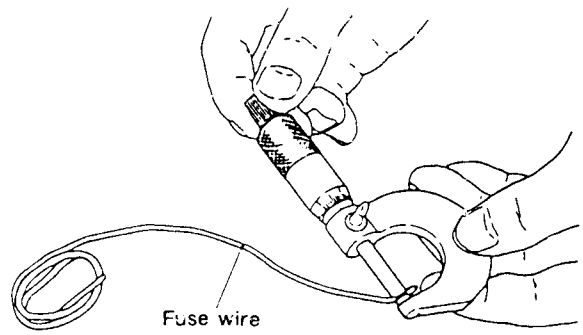
## 2-6 Measuring top clearance

(1) Place a high quality fuse ($\phi$1.5mm,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)




〈 Fuse Position 〉



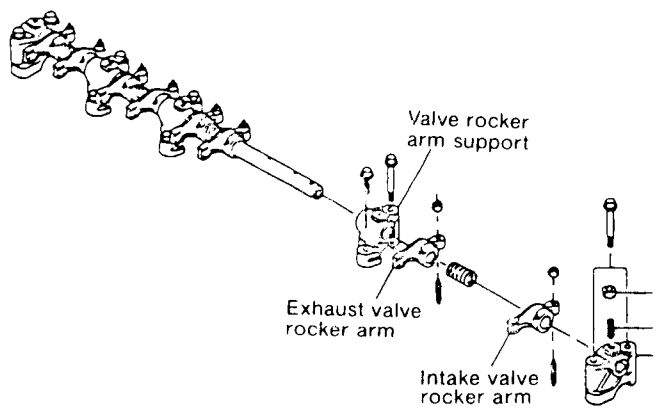




mm

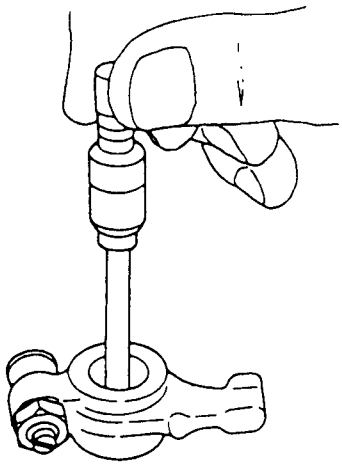
| | |
|---|---|
| Top clearance | 0.70~0.90 (6LY2-STE/6LY2A-STP)<br>0.71~0.89 (6LYA-STP) |

## 2-7 Intake and exhaust valve rocker arms

Valve rocker arm and valve rocker 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 rocker arm bushing**
Measure the outer diameter of the shaft and the inner diameter of the bushing, and replace if wear exceeds the limit.



mm

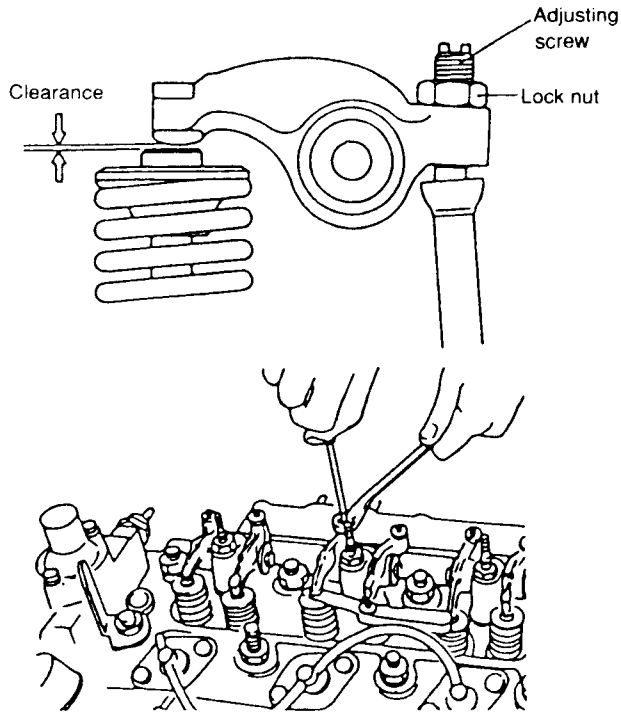
| | Standard | Wear limit |
|---|---|---|
| Intake and exhaust valve rocker arm shaft outside dia. A | 18.459~18.479 | 18.35 |
| Intake and exhaust valve rocker arm inside dia. B | 18.500~18.520 | 18.60 |
| Valve rocker arm shaft and bushing clearance at assembly | 0.012~0.061 | 0.15 |

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

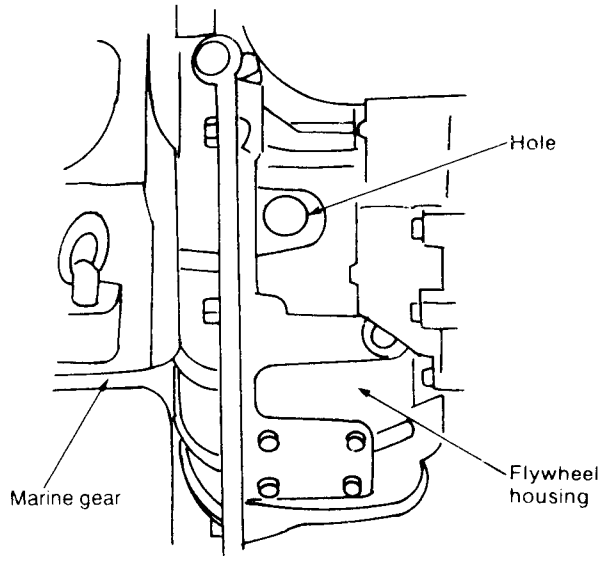
**(2) Valve spring**
Check the valve spring and replace it if it is corroded or worn.

**(3) Rocker arm and cotter wear**
Inspect the contact surface of the Rocker arm and replace it if there is abnormal wear of 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.




## 2-8 Adjustment of valve clearance

(1) Make adjustments when the engine is cool.

mm

| | |
|---|---|
| Intake valve clearance | 0.1 |
| Exhaust valve clearance | 0.5 |

| — | — | — | 6LY2-STE/6LY2A-STP | 6LYA-STP |
|---|---|---|---|---|
| Intake valve | Open | b.T.D.C. | 59°±5° | 36°±5° |
| | Open | a.B.D.C. | 63°±5° | 40°±5° |
| Exhaust valve | Open | b.B.D.C. | 58°±5° | 58°±5° |
| | Close | a.T.D.C. | 46°±5° | 46°±5° |



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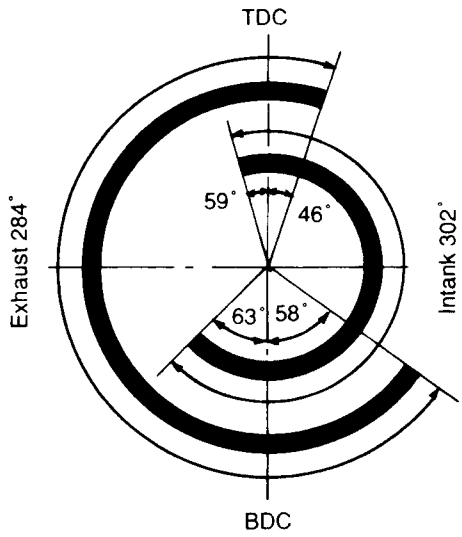
Valve timing diagram (6LY2-STE/6LY2A-STP)



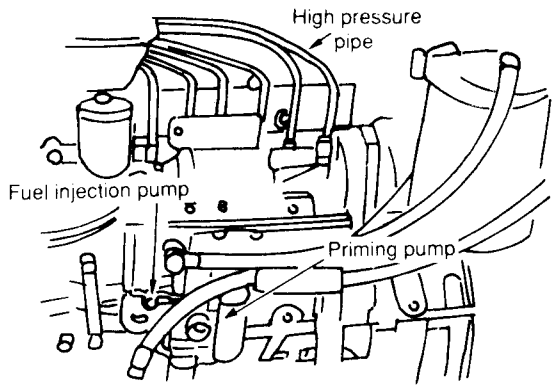

## 2-9 Checking and adjusting the fuel injection timing

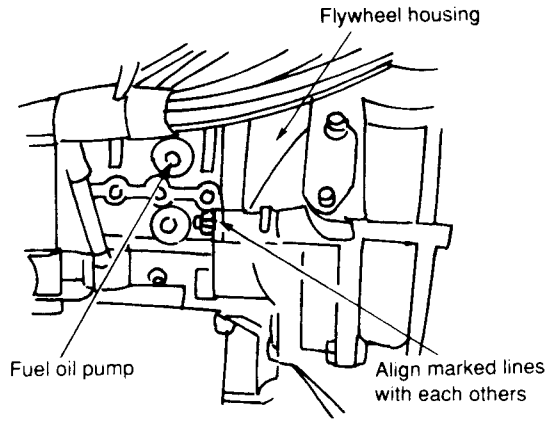
1) Remove the high-pressure fuel oil pipe from the fuel injection pump.

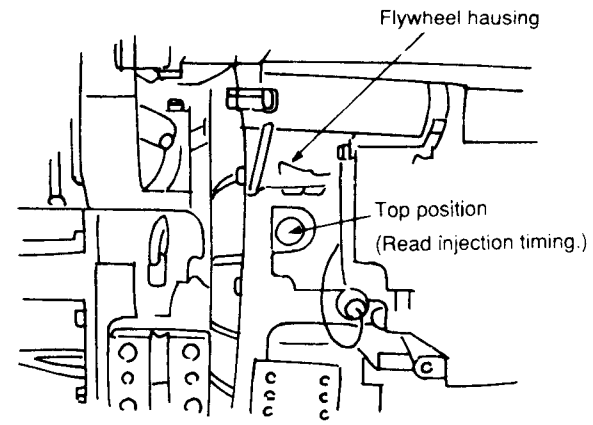
2) While manually turning the flywheel slowly, check that the timing of the fuel flowing out of the delivery valve holder of the cylinder injection pump conforms to the specified timing by visually inspecting the flywheel and indicator.

3) Check the fuel injection timing of all the cylinders by following the step 2) above.

| Inspection Schedule | Every 2000 service hrs |
|---|---|
| Fuel injection timing | b.T.D.C 15°±1° (6LY2-STE/6LY2A-STP)<br>b.T.D.C 13°±1° (6LYA-STP) |

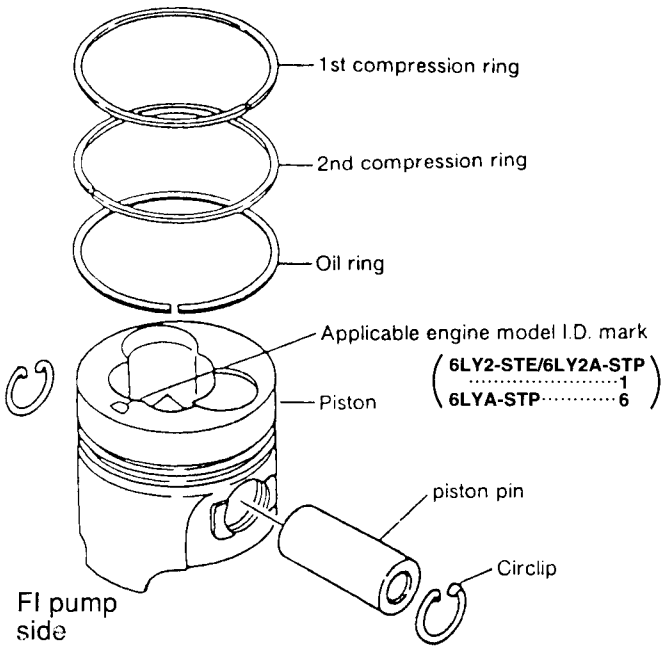


# 3. Piston and Piston Pins

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 ress for the intake and exhaust valves.
The clearance between the piston and cylinder liner is kept at the pronper valve by the piston cylinder liner property fit effected during assembly at the Yanmmar 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.*

● 6LYA-STP mm

| — | Mark | Specified | Wear limit |
|---|---|---|---|
| Piston outer dia. | L | 99.922 or more ~ 99.932 or less | 99.900 |
| | ML | 99.917 or more ~ 99.922 less | |
| | MS | 99.912 or more ~ 99.917 less | |
| | S | 99.902 or more ~ 99.912 less | |

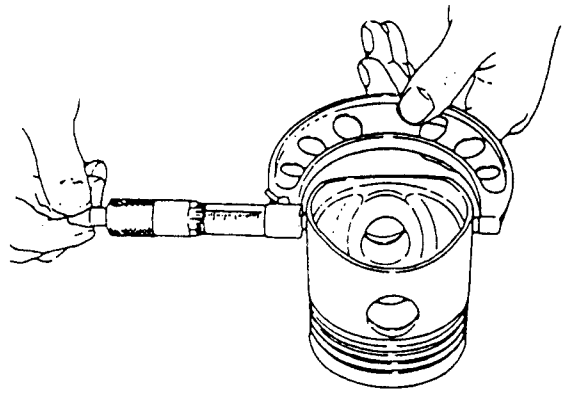
## 3-1 Piston

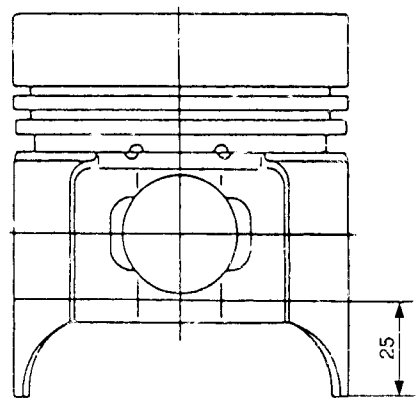
### 3-1.1 Piston head and combustion surface

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.

### 3-1.2 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 25mm from the bottom at right angles to the piston pin.






● 6LY2-STE/6LY2A-STP mm

| — | Mark | Specified | Wear limit |
|---|---|---|---|
| Piston outer dia. | L | 105.799 or more ~ 105.809 or less | 105.770 |
| | ML | 105.794 or more ~ 105.799 less | |
| | MS | 105.789 or more ~ 105.794 less | |
| | S | 105.779 or more ~ 105.789 less | |

| Combination | | | |
|---|---|---|---|
| Piston | | | |
| L | ML | MS | S |
| L | M | S | |
| Cylinder (Sleeve) | | | |



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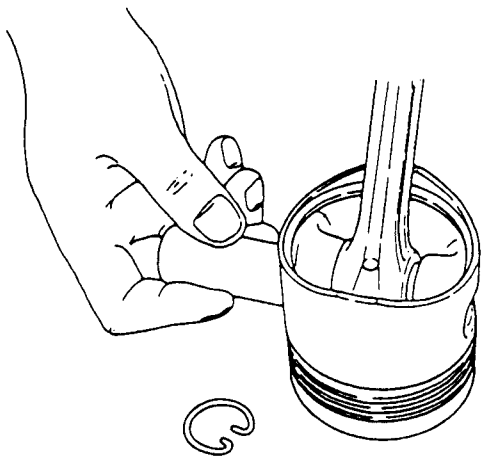
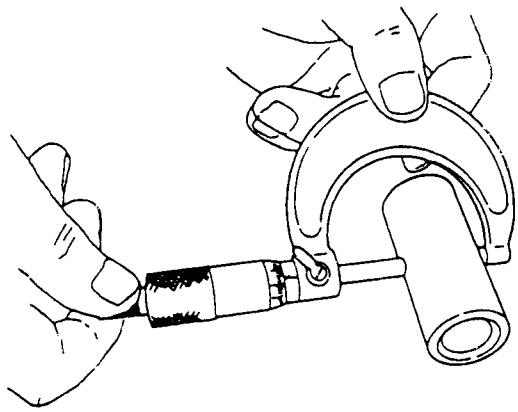
### 3-1.3 Replacing the piston

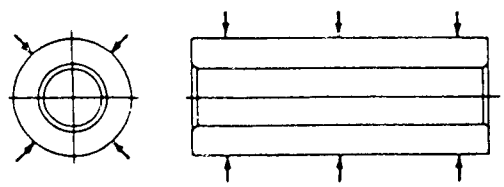
A floating type piston pin is used in this engine. The piston pin can be pressed into the piston pin hole at room temperature (coat with oil to make it slide in easily).



## 3-2 Piston pin

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



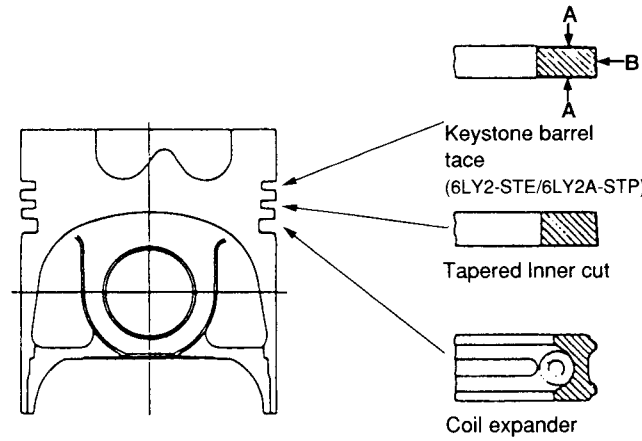


mm

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

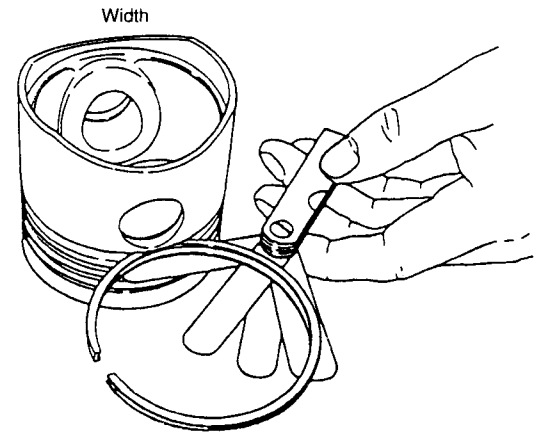
## 3-3 Piston rings

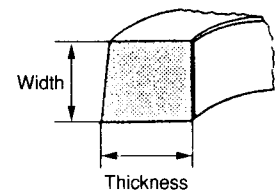
There are 2 compression rings and 1 oil ring.




### 3-3.1 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.



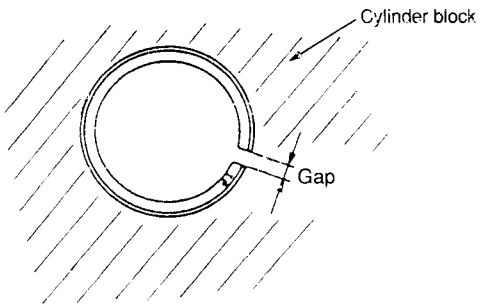



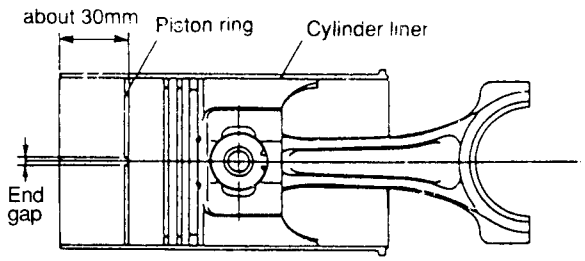
mm

| | | | Standard | Wear limit |
|---|---|---|---|---|
| 6LY2-STE/6LY2A-STP | Top ring (Keystone) | Groove width | (2.6026~2.6046) | — |
| | | — | — | — |
| | | — | — | — |
| | 2nd | Groove width | 2.570~2.585 | — |
| | | Ring width | 2.470~2.490 | — |
| | | Clearance | 0.080~0.115 | 0.15 |
| | Oil | Groove width | 4.010~4.025 | — |
| | | Ring width | 3.970~3.990 | — |
| | | Clearance | 0.020~0.055 | 0.15 |
| 6LYA-STP | Top ring | Groove width | 2.095~2.110 | — |
| | | Ring width | 1.975~1.990 | — |
| | | Clearance | 0.105~0.135 | 0.15 |
| | 2nd | Groove width | 2.045~2.060 | — |
| | | Ring width | 1.975~1.990 | — |
| | | Clearance | 0.055~0.085 | 0.15 |
| | Oil | Groove width | 3.020~3.035 | — |
| | | Ring width | 2.970~2.990 | — |
| | | Clearance | 0.030~0.065 | 0.15 |

### 3-3.2 Measuring piston ring end gap

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



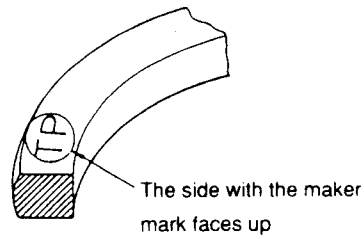




mm

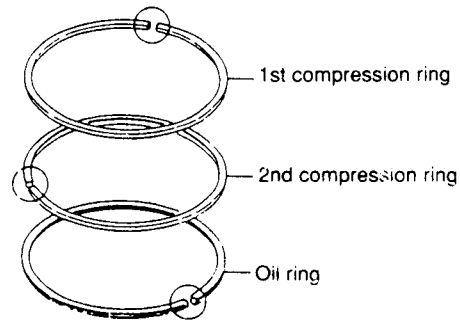
| | Standard | Wear limit |
|---|---|---|
| First piston ring gap | 0.25~0.40 | 1.5 |
| Second piston ring gap | 0.25~0.40 | 1.5 |
| Oil ring gap | 0.20~0.40 | 1.5 |

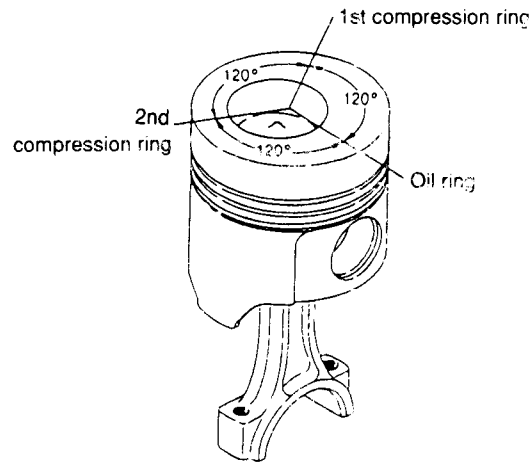
### 3-3.3 Replacing the piston rings

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




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




Pay attention so that the piston ring ends are not overlapped at the same position.



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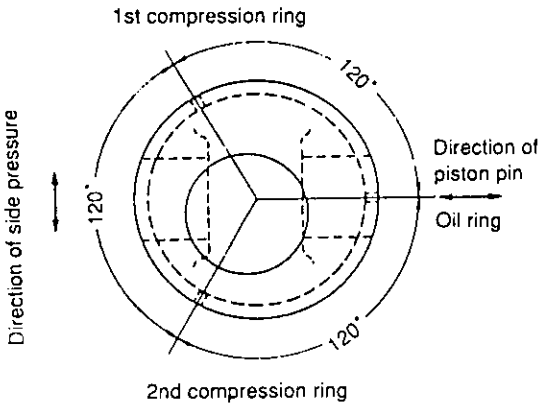
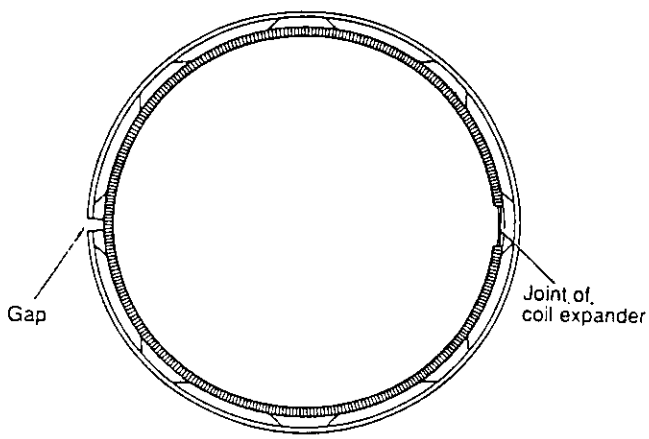
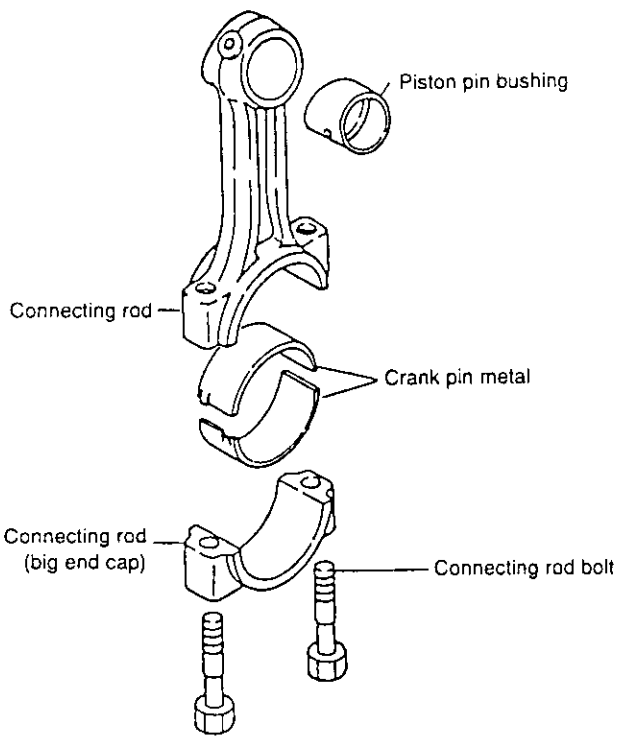



(5) The oil ring is provided with a coil expander. The coil expander joint should be opposite (staggered 180°) the oil ring gap.



# 4. Connecting Rod

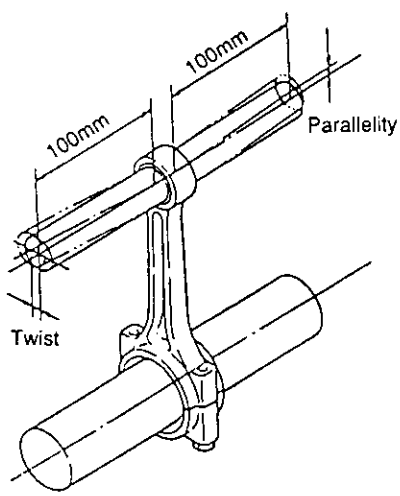
The connecting rod is made of high-strength forged carbon steel.
The large end with the aluminium metal can be separated into two and the small end has a 2-layer copper alloy coil bushing.

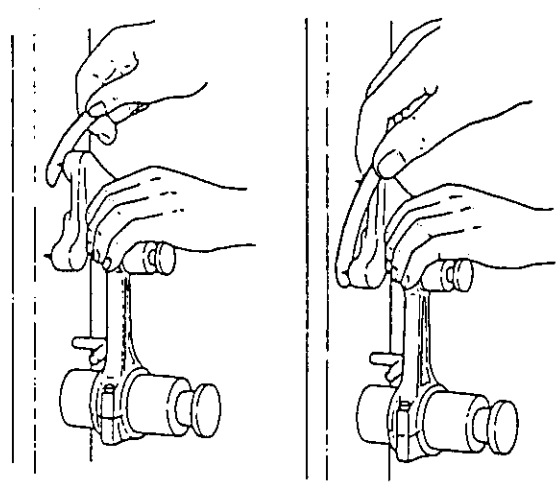



## 4-1 Inspecting the connection rod

### 4-1.1 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.



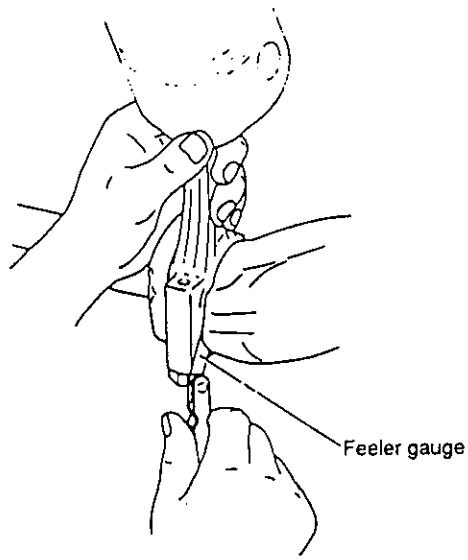
Measuring twist and parallelity

mm

| | Standard | Wear limit |
|---|---|---|
| Connecting rod twist and parallelity | 0.05 | 0.07 |

### 4-1.2 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 |



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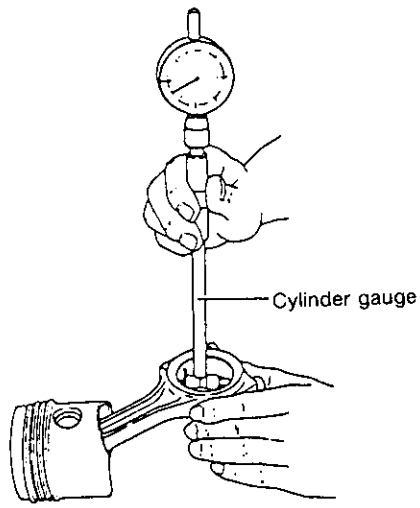
## 4-2 Crank pin bearing

### 4-2.1 Checking crank pin bearing

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

### 4-2.2 Measuring crank pin oil clearance

Use a plastic gauge.

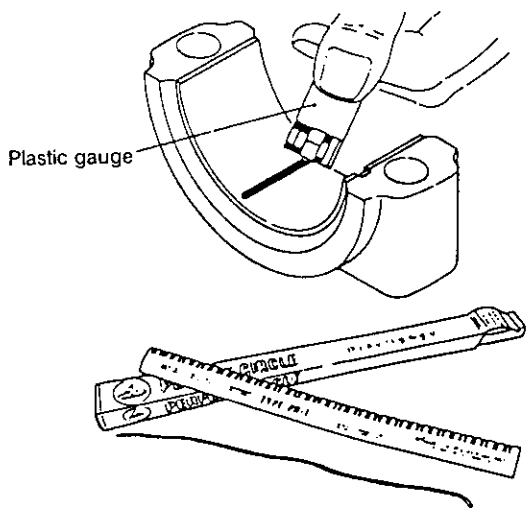



**Procedure**

(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).

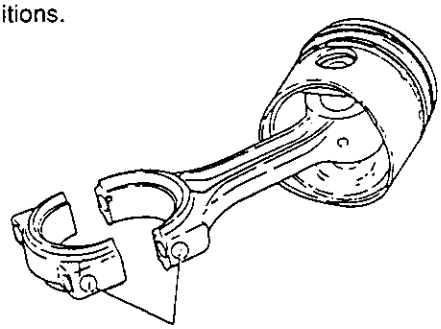
| | |
|---|---|
| Connecting rod tightening torque | 13.5~14.5kg-m |

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

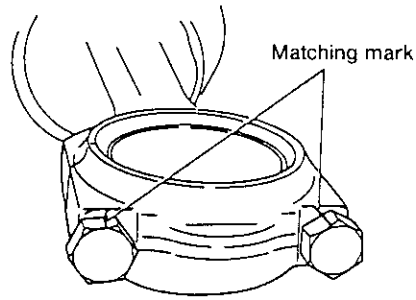



### 4-2.3 Precautions on replacement of crank pin bearing

(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.



Alignment mark (Punched mark)



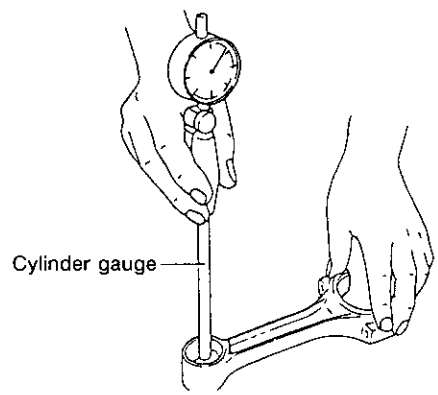

(4) Make sure there is no sand, metal cuttings or other foreign matter in the lube oil, and that the crankshaft is not scratched. Take special care in cleaning the oil holes.

mm

| | Standard | Wear limit |
|---|---|---|
| Crank pin bearing inside dia | $\phi$ 65.000~ $\phi$ 65.042 | 65.10 |
| Crank pin and crank pin bearing clearance | 0.036~0.093 | 0.16 |

## 4-3 Piston pin bearing

(1) Measuring piston pin clearance.
Excessive piston pin bearing wear may result in damage to the piston or the piston inself.



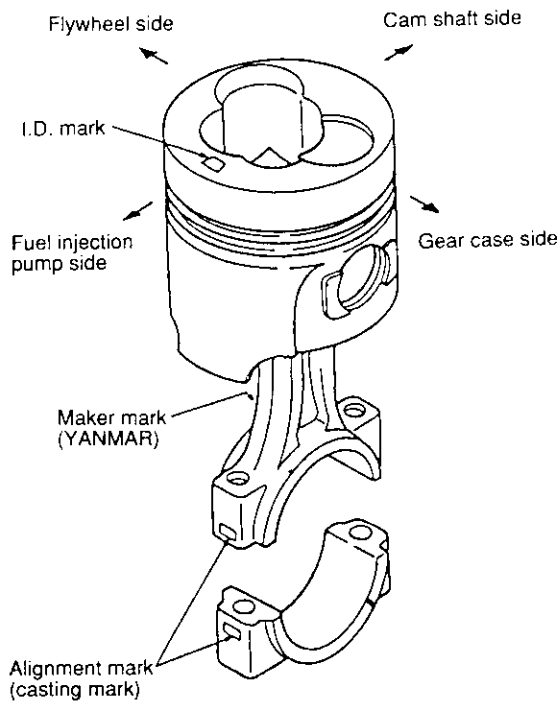
mm

| | Standard | Wear limit |
|---|---|---|
| Piston pin bearing inside dia | $\phi$37.025~ $\phi$37.040 | $\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.)

## 4-4 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.





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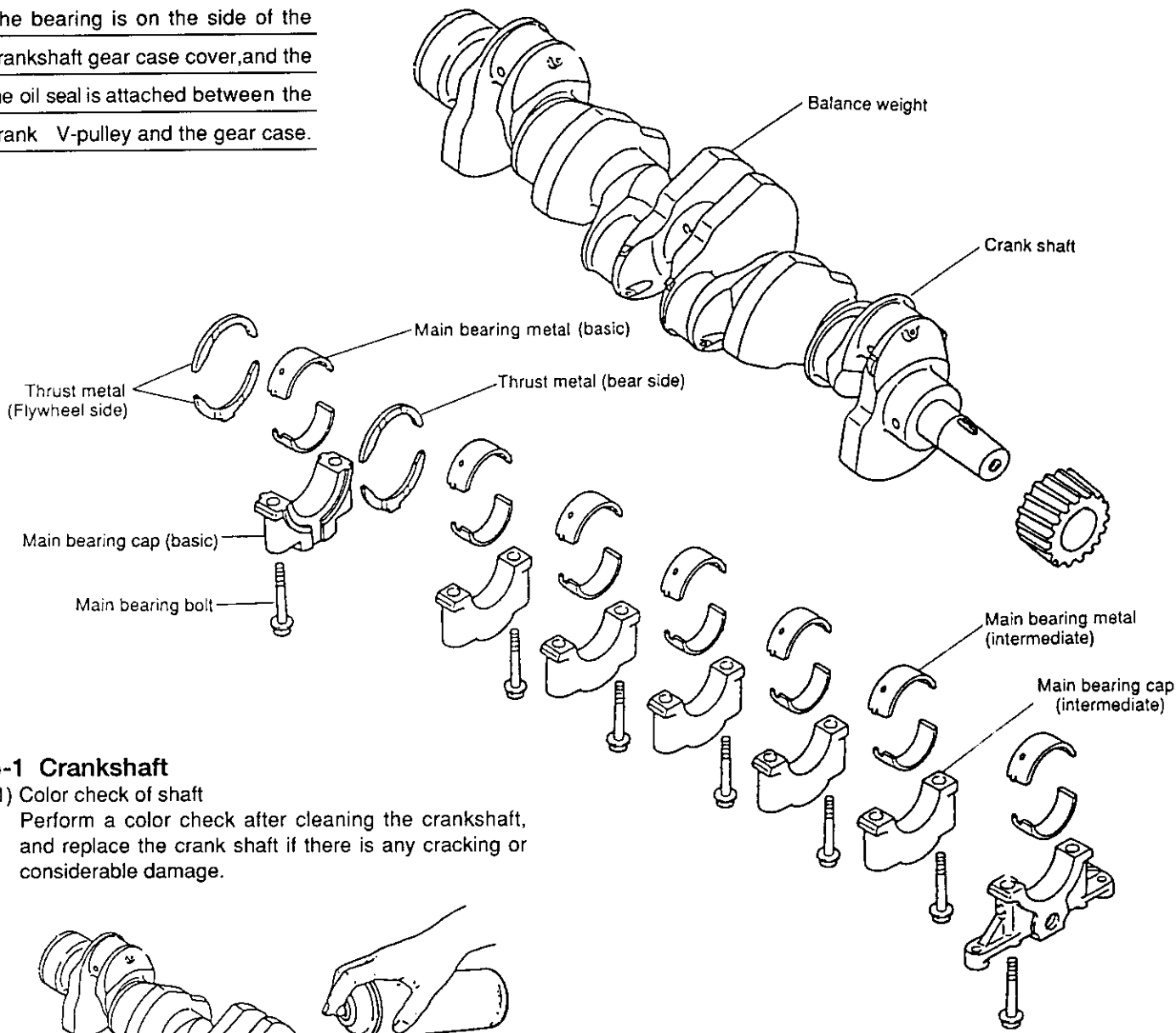
# 5. Crankshaft and Main Bearing

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.

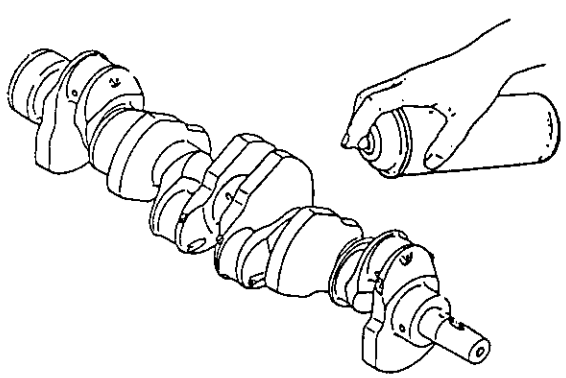
The bearing is on the side of the crankshaft gear case cover,and the the oil seal is attached between the crank V-pulley and the gear case.




## 5-1 Crankshaft

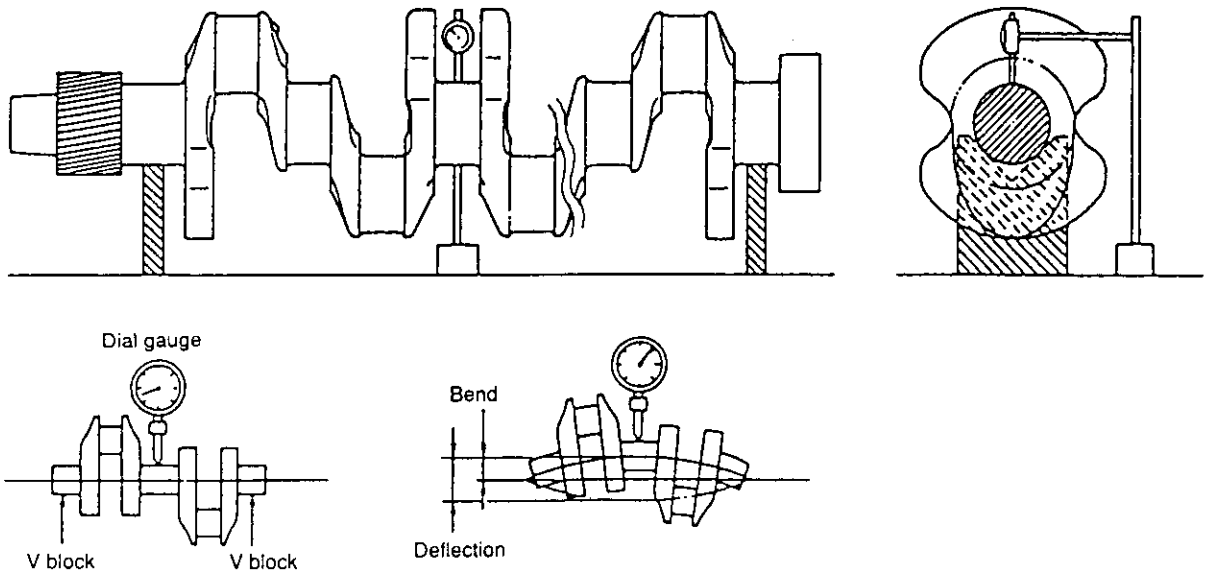
(1) Color check of shaft

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.

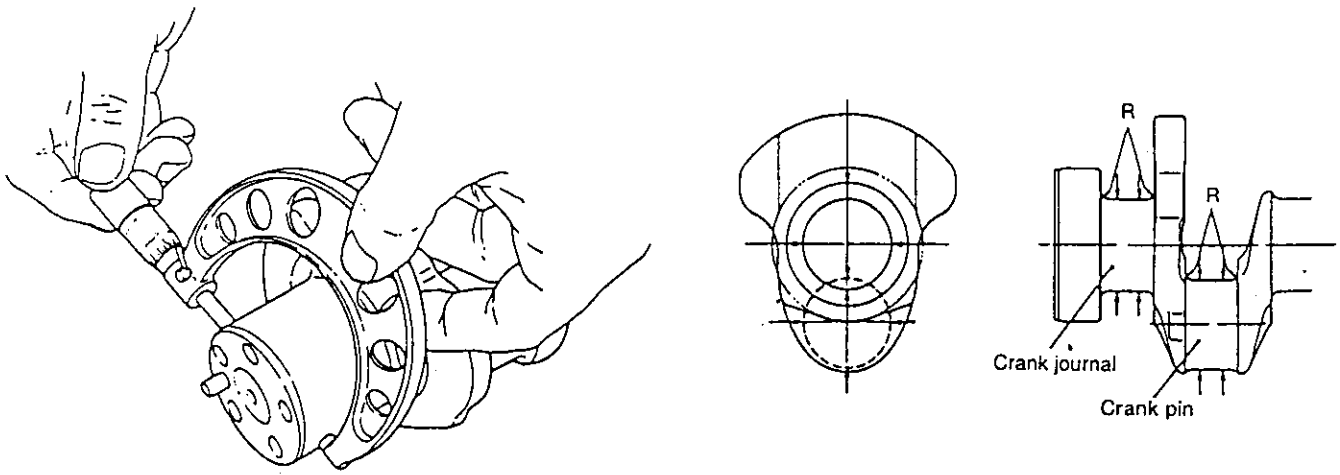



mm

| | |
|---|---|
| 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$64.952~64.964 | $\phi$64.90 |
| | Bushing inside dia. | $\phi$65.000~$\phi$65.042 | $\phi$65.10 |
| | Crank pin and bearing oil clearance | 0.036~0.093 | $\phi$0.16 |
| Crank journal | Outside dia. | $\phi$74.952~$\phi$74.964 | $\phi$74.90 |
| | Bushing inside dia. | $\phi$75.000~$\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) | —— |



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

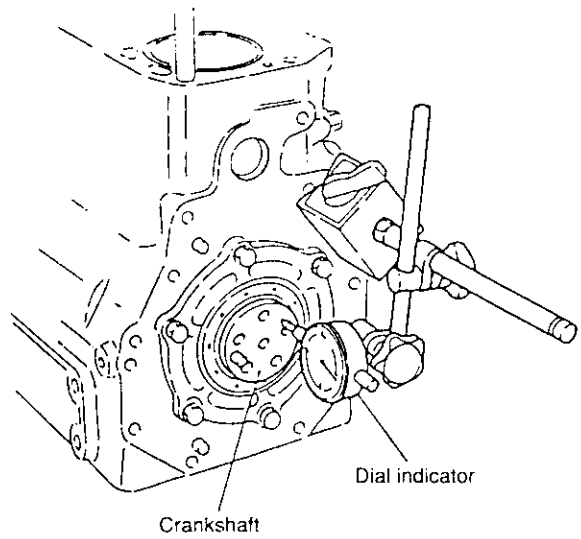
After assembling the crankshaft, tighten the main bearing cap to the specified torque, and move the crankshaft to one side, placing a dial gauge on one end of the shaft to measure thrust clearance.

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 |




## 5-2 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.

| Bearing cap bolt tightening torque | 25~27kgf-m |
|---|---|

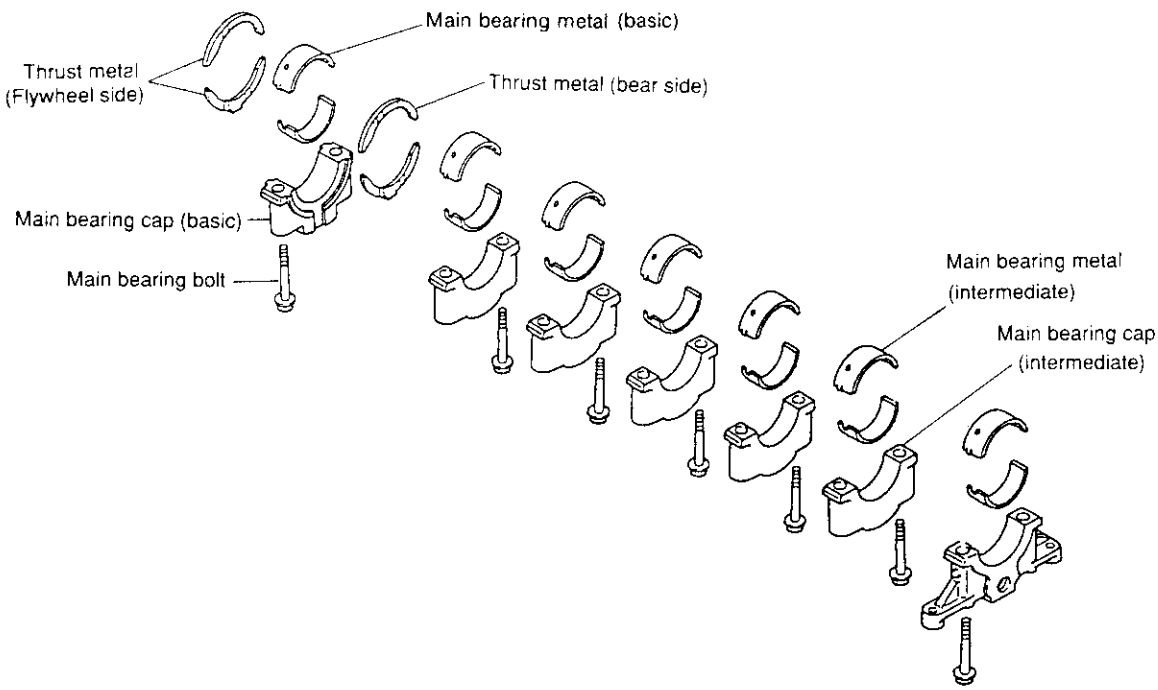
*NOTE : When assembling the bearing cap, keep the following in mind.*

*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.*

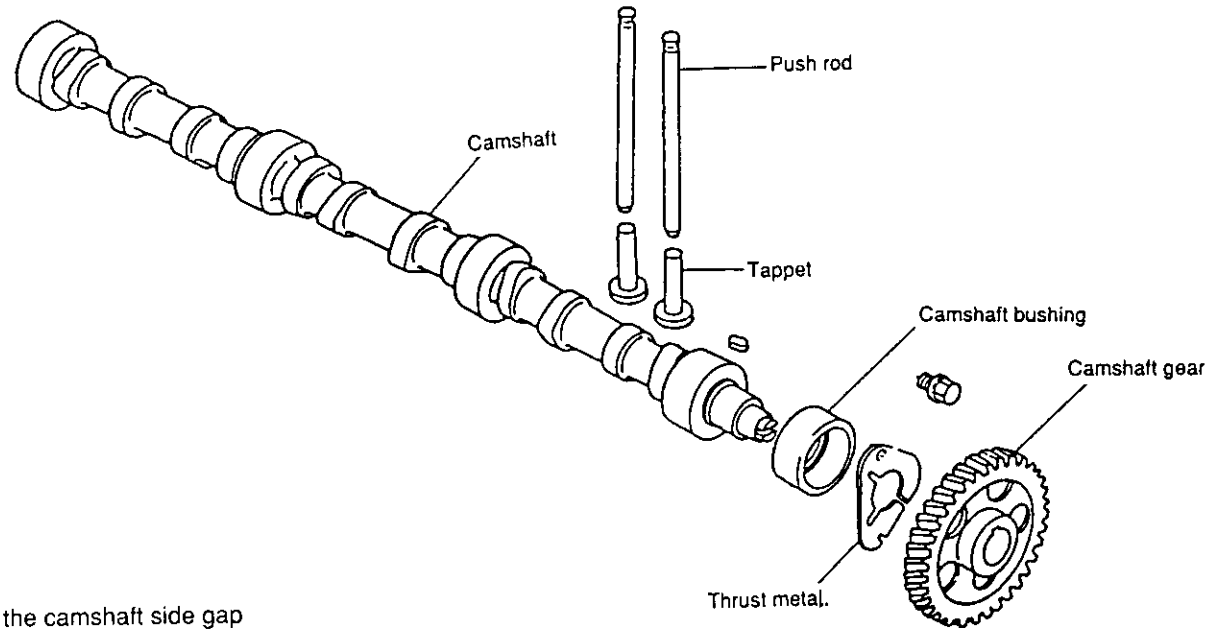
*4)The "FW" on the cap lies on the flywheel side.*



# 6. Camshaft and Tappets

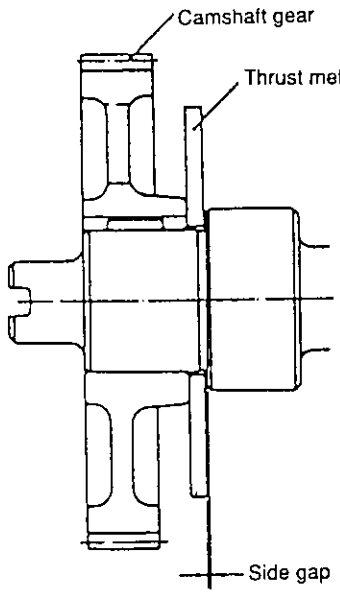
## 6-1 Camshaft

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

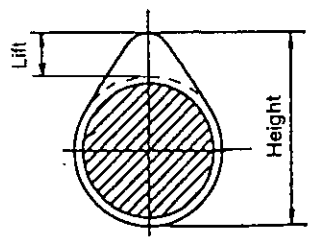
The load is received by the standard bearing near the end of the camshaft by the cam gear, resulting in rapid wear of the end of the bearing and enlargement of the side gap. Therefore, measure the thrust gap before disassembly. As the cam gear is shrink-fitted to the cam, be careful when replacing the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




mm

| | 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 | | |



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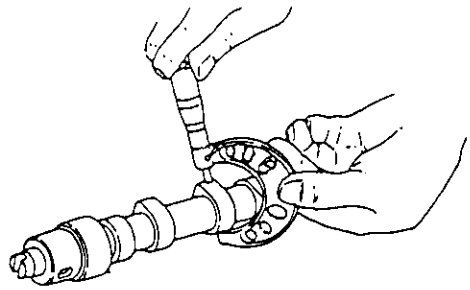
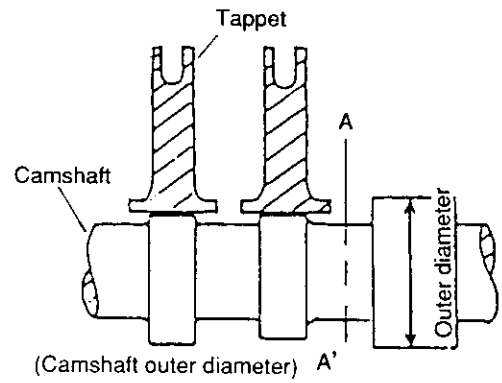
(3) Measure the camshaft outer diameter and the camshaft bearing inner diameter. Replace if they exceed the wear limit or are damaged.

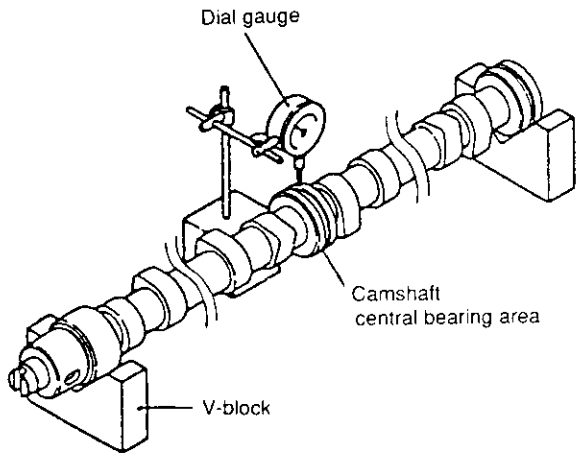





mm

| | Standard | | | Wear limit |
|---|---|---|---|---|
| | Gear case side | Intermediate | Flywheel side | |
| Camshaft journal outside dia. | ϕ56.910~ϕ56.940 | ϕ56.910~ϕ56.940 | ϕ56.910~ϕ56.940 | ϕ56.80 |
| 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.



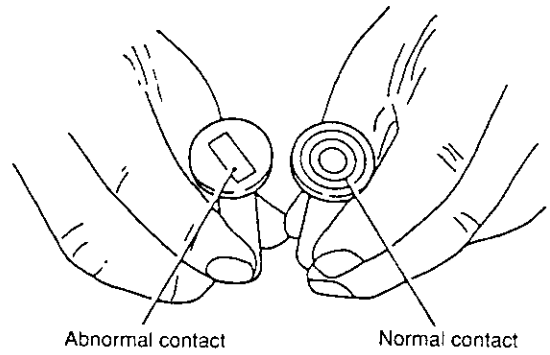

*NOTE : The reading on the dial gauge is divided by two to obtain the extent of bending.*

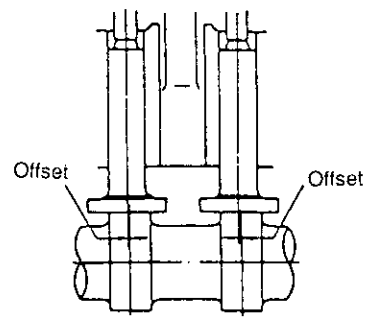
mm

| | Wear limit |
|---|---|
| Camshaft deflection | 0.02 |

## 6-2 Tappets

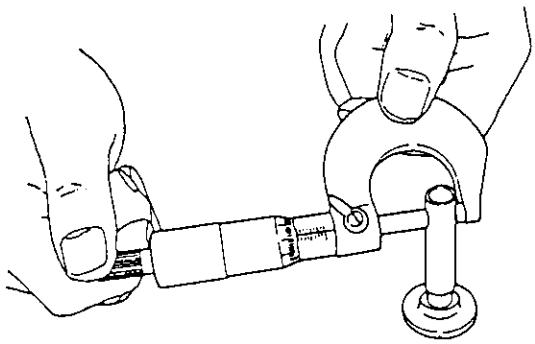
(1) The tappets are offset to rotate during operation and thereby prevent uneven wearing. Check the contact of each tappet and replace if excessively or unevenly worn.



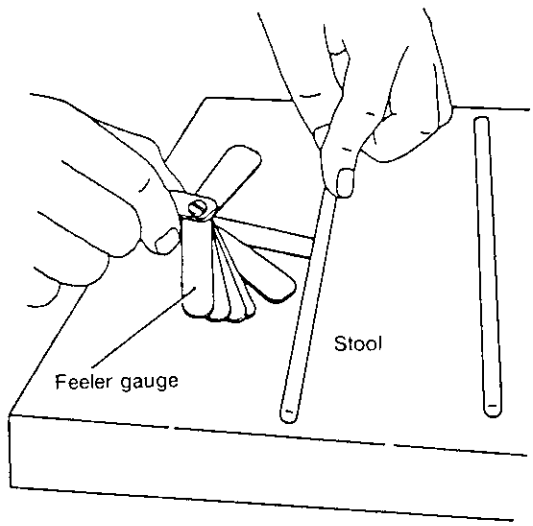

*NOTE : When removing tappets, be sure to keep them separate for each cylinder and intake/exhaust valve.*

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



| | Standard | Wear limit |
|---|---|---|
| Tappet stem outside dia. | $\phi$ 14.218~14.233 | $\phi$ 14.17 |
| Tappet guide hole inside dia. (cylinder block) | $\phi$ 14.249~$\phi$ 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 | — |



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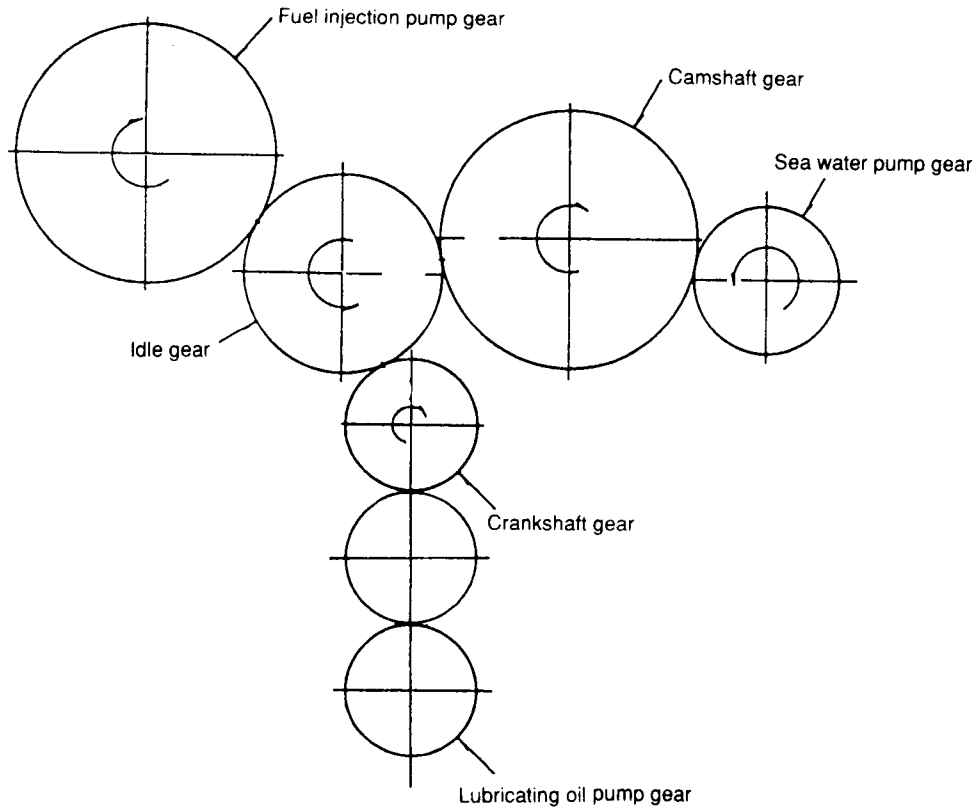
# 7. Timing Gear

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 | | | |
| Idle gear | 51 | 20.0 | right | 137.290~137.352 | 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 | 103.786~103.848 | 0.08~0.16 | 0.25 |
| Idle gear | 29 | 13.5 | right | 100.929~100.991 | 0.08~0.16 | 0.25 |
| Fuel injection pump gear | 48 | 15.0 | left | 137.290~137.352 | 0.08~0.16 | 0.25 |

## 7-1 Inspecting the gears

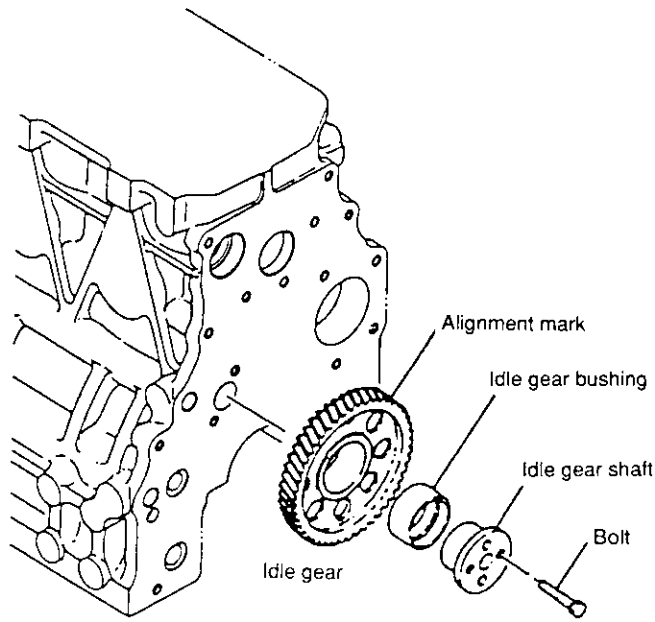
(1) Inspect the gears and replace if the teeth are damaged or worn.
(2) Measure the backlash of all gears that mesh, and replace the meshing gears as a set if wear exceeds the limit.

*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) Idle gear

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

Alignment mark
Idle gear
Idle gear bushing
Idle gear shaft

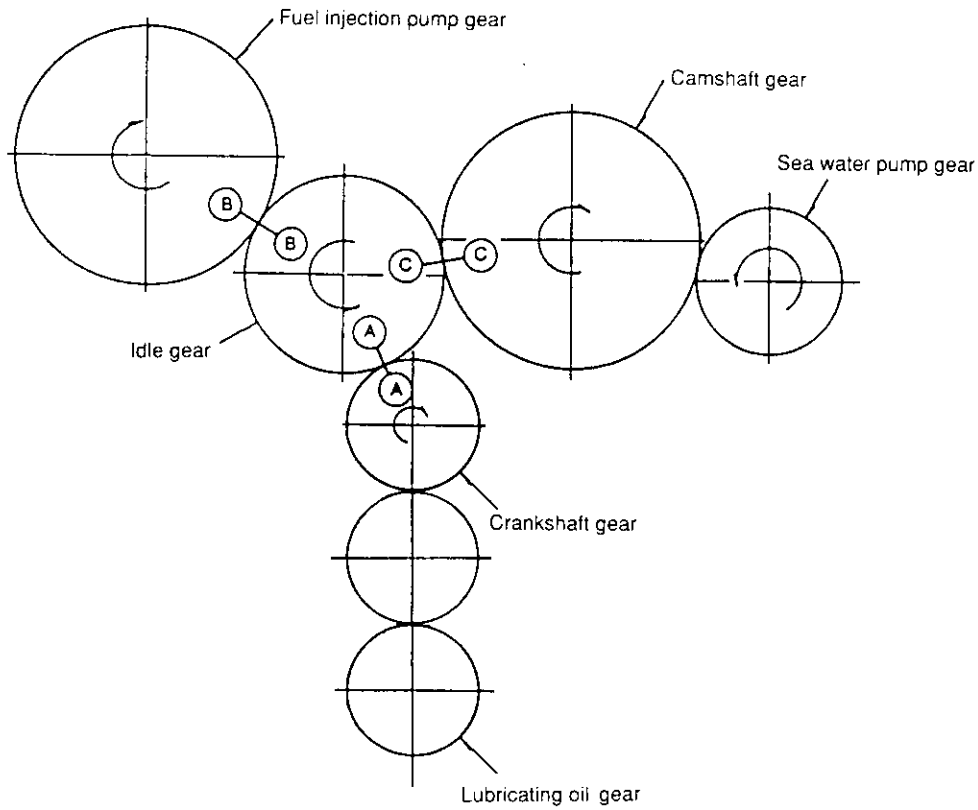



mm

| | 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 |

## 7-2 Gear timing marks

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



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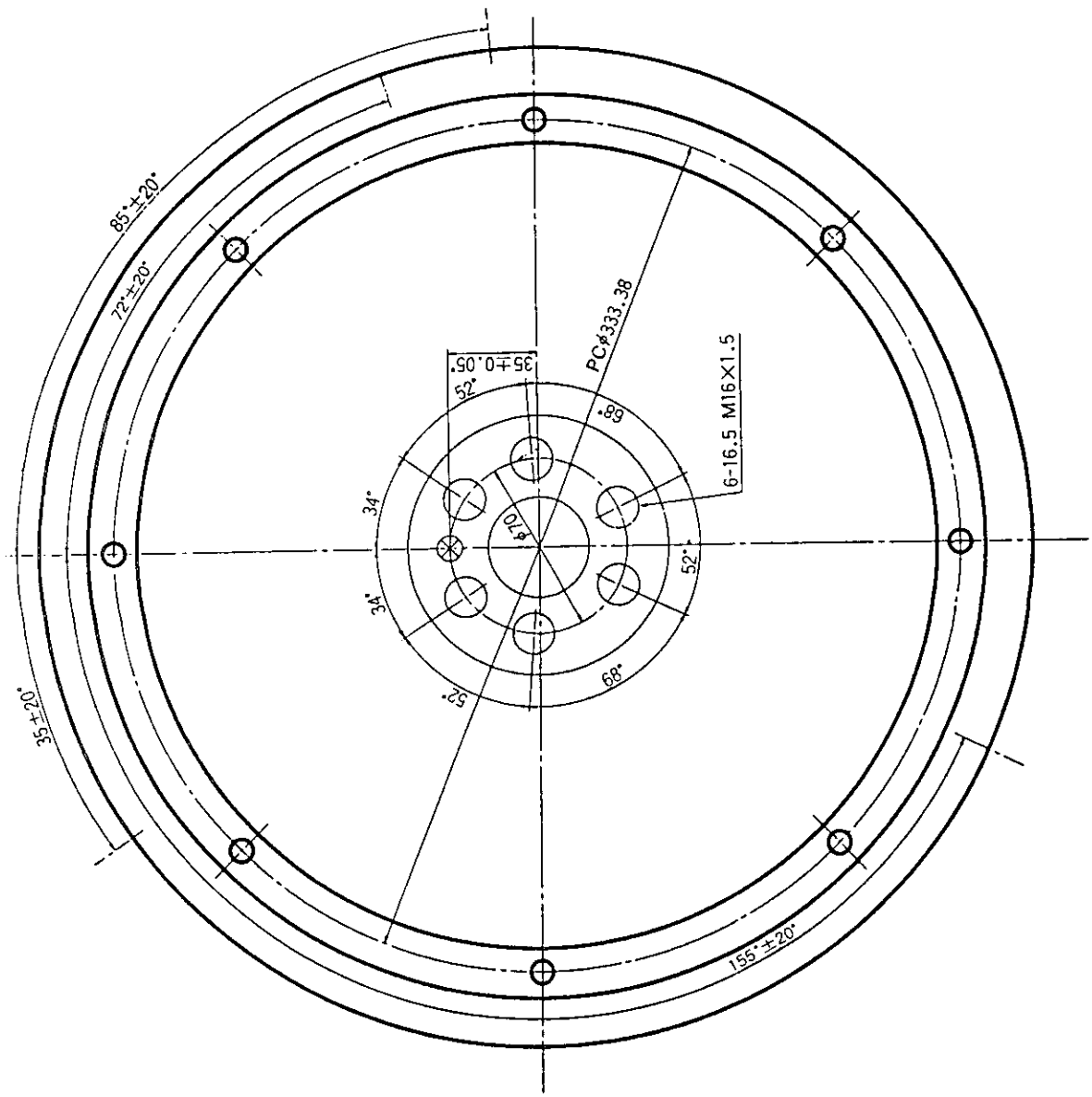
# 8. Flywheel

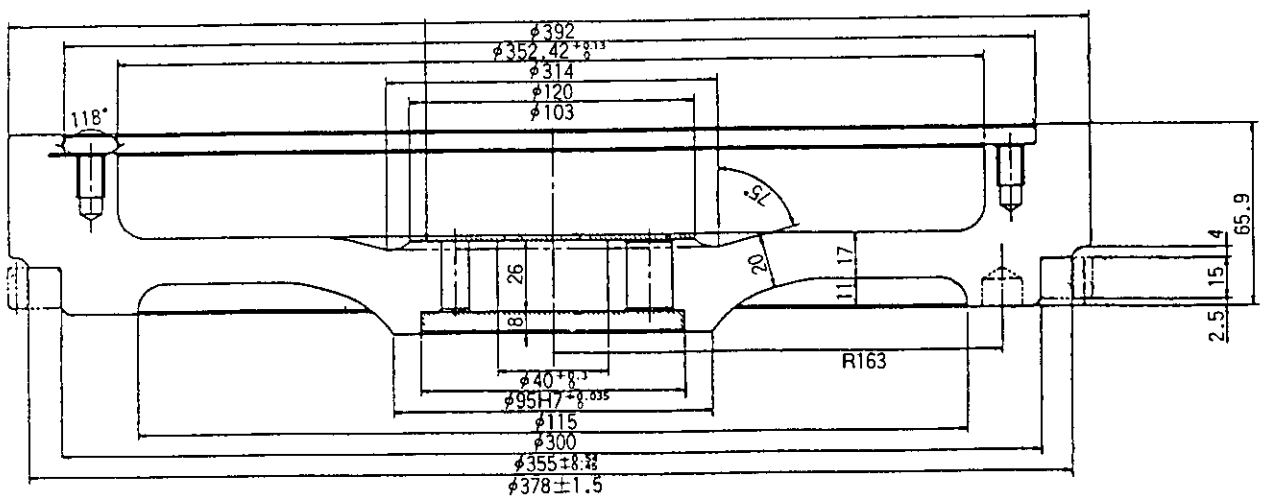
The function of the flywheel is through inertia, to rotate the crankshaft in a uniform and smooth manner by absorbing the turning force created during the combustion stroke of the engine, and by compensating for the decrease in turning force during the other strokes.
The flywheel is mounted and secured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

## 8-1 Specifications of flywheel

| | | | |
|---|---|---|---|
| Outside dia. of flywheel | | mm | $\phi$ 392 |
| Width of flywheel | | mm | 65.9 |
| Weight of flywheel (including ring gear) | | kg | 28.1 |
| $GD^2$ value | | $kg \cdot m^2$ | 2.94 |
| Fixing part of crankshaft | Pitch circle dia. of bolts | mm | 70 |
| | No. of thread holes | | 6-M16 |
| | Fit joint dia. | mm | $\phi$ 95.00~$\phi$ 95.035 |
| Ring gear | Center dia. | mm | $\phi$ 387 |
| | No of teeth | | 129 |

## 8-2 Dimensions of flywheel and mounting flange



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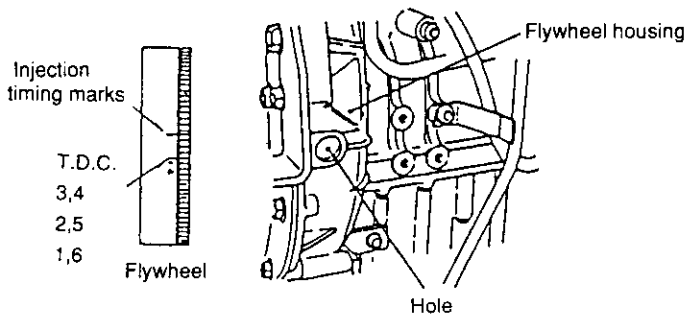
## 8-3 Ring gear

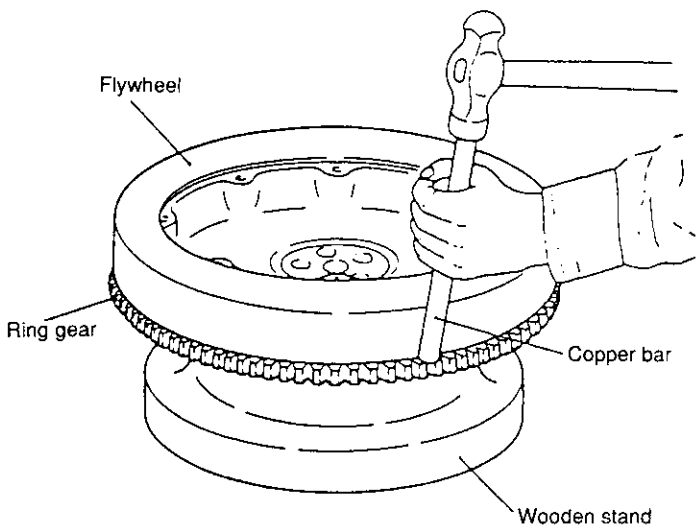
When replacing the ring gear due to excessive wear or damaged teeth, heat the ring gear evenly at its circumference, and after it has expanded drive it gradually off the flywheel by tapping it with a hammer, a copper bar or something similar around the whole circumference.

mm

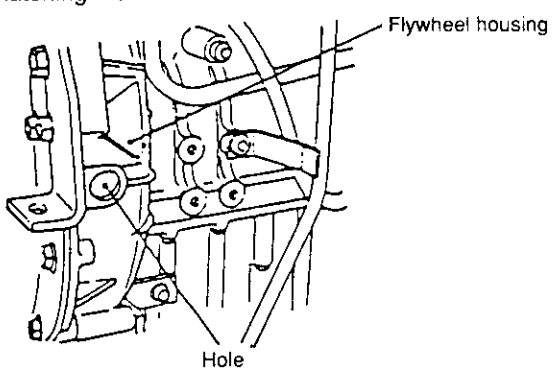
| | |
|---|---|
| Interference of ring gear | 0.21~0.45 |

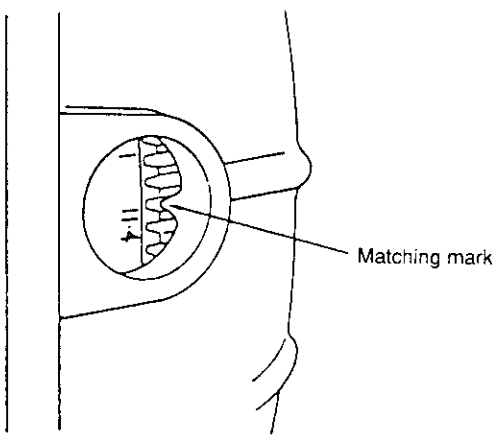
## 8-4 Position of top dead center and fuel injection timing




(2) Matching mark




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

CHAPTER 3

# FUEL INJECTION EQUIPMENT

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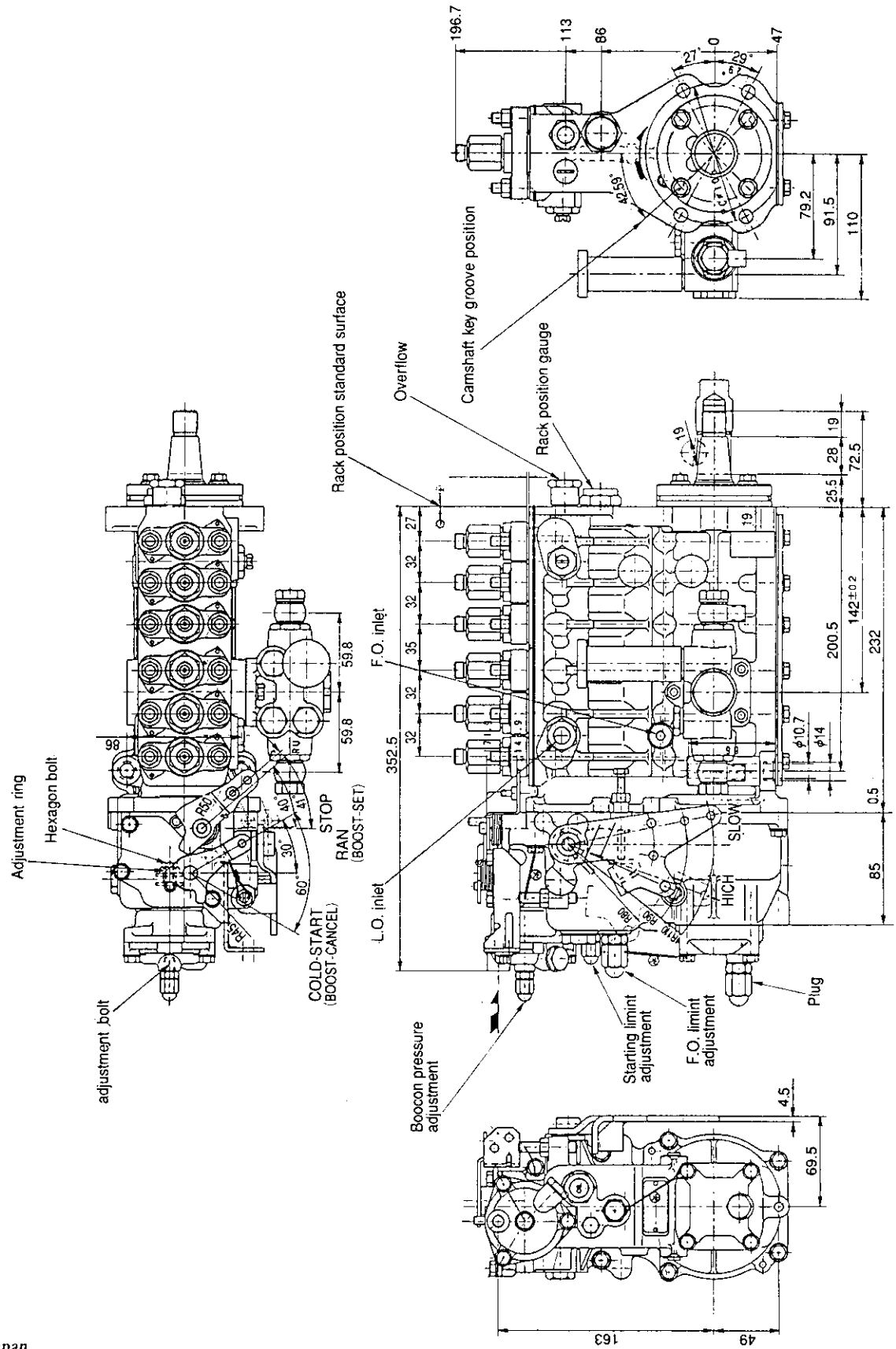
# 1. Fuel injection Pump Construction



# 2. Fuel injection Pump Specifications

| Injection system specifications | | | | | |
|---|---|---|---|---|---|
| | Description | | | 6LY2-STE/6LY2A/STP | 6LYA-STP |
| General | a | Rotation direction | | Clockwise viewed from drive side | |
| | b | Injection order | | 1-4-2-6-3-5-1 | |
| | c | Interval | deg. | 60±0.5 | |
| | 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 for plunger | | AL12V200 | |
| | b | Plunger dia helix. lead deg | mm, deg.(clockwise) | φ11.0, 31.63° | φ10.5, 43.8 |
| | c | Lift to port close (no.1 plunger) | mm | 3.5±0.05 | 4.0±0.05 |
| | d | Delivery valve retraction vol. | $mm^3$/st | 70 | 55 |
| | e | Angleich cutting | mm | 0.30 | |
| | f | Delivery valve opening press | MPa($kgf/cm^2$) | 0.468 (4.78) | |
| | g | Delivery valve spring const. | N/mm(kgf/mm) | 9.26 (0.944) | 12.38 (1.262) |
| | h | Damping valve | | employed | |
| | i | Allowable max pump speed | rpm | 1850 | |
| | j | Overflow pressure | MPa ($kgf/cm^2$) | 0.2(2.0) | |
| | k | Allowable pipe inside pressure | MPa ($kgf/cm^2$) | 100 (1020) | 93 (950) |
| Governor | a | Number and mass of governor weight | Piecesxgr | 2×245 | |
| | b | Governor spring constant, free length | N/mm (kgf/mm), mm | 9.3(0.95),65 | 7.6(0.77),63 |
| | c | Start spring constant, free length | N/mm (kgf/mm), mm | 8.26 (0.843), 82 | |
| | d | Angleich spring constant | N/mm (kgf/mm) | 24.5 (25) | |
| | e | Idling subspring constant | N/mm (kgf/mm) | — | |
| | f | Governor lever type | | 3-shaft type | |
| | g | Lever ratio | | Low speed 1:1<br>Middle and high speed 1:2 | |
| | h | Boost compensator spring constant | N/mm (kgf/mm) | 25.1(2.56) | |
| Feed pump | a | Cam profile type | | AL50DFP39 | |
| | b | Fuel delivery | $cm^3$/rev | 7.6 | |
| | c | Delivery pressure | MPa($kgf/cm^2$) | 0.23~0.37(2.3~3.8) | |
| | d | Suction head | mAq | 1.0 | |



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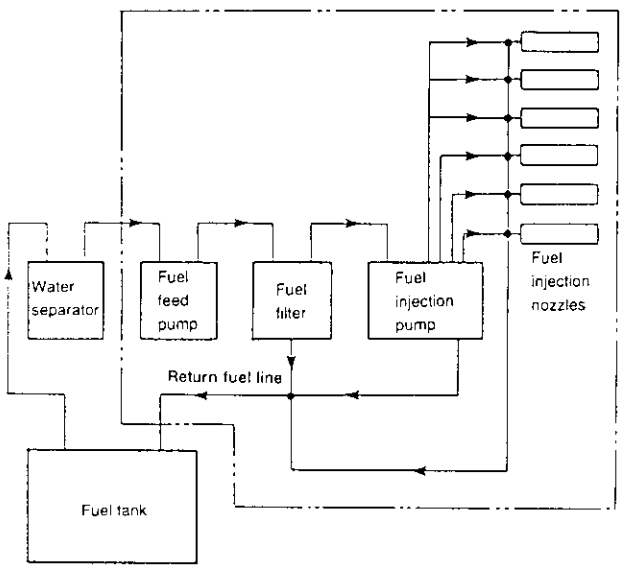
# 3. Fuel supply System

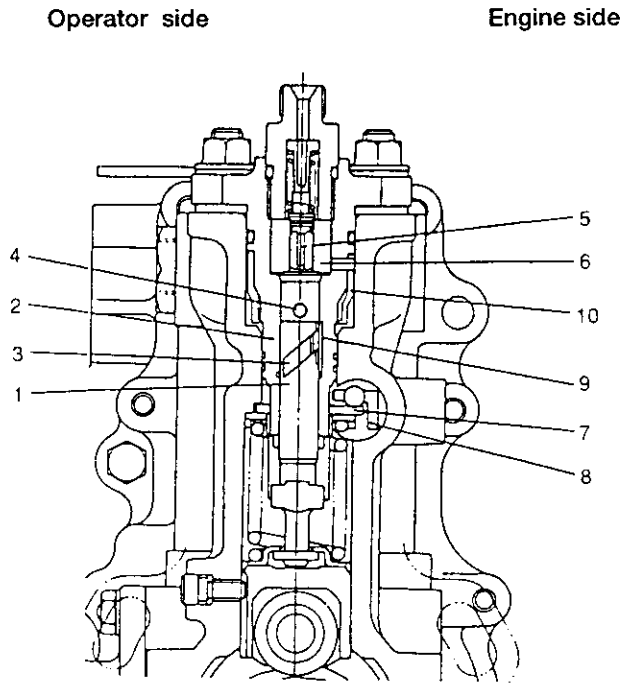
## 3-1 Fuel supply system

The YPES-6AL2 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/cm². 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-6AL2 fuel injection pump is an in-line pump witha 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.

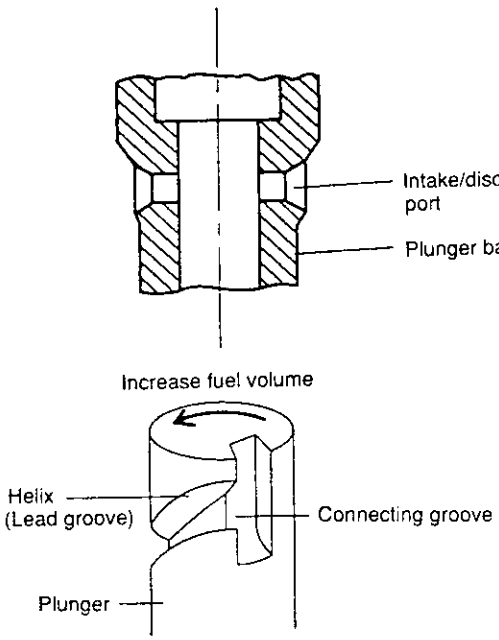
## 3-2 Functioning of fuel injection pump




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

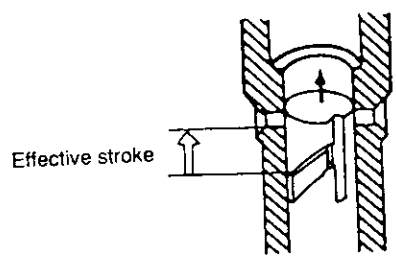
The fuel injection pump supplies pressurized fuel to the injection nozzles through the action of the plunger. The plunger reciprocates in the plunger barrel with a fixed stroke and is lapped for a precise fit. A lead groove is helically cut in the plunger, and this leads to a connecting groove which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

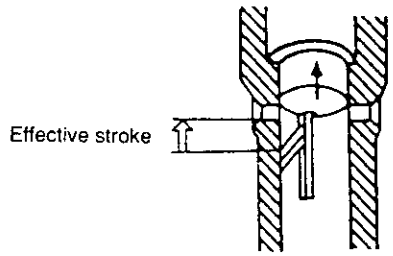



## 3-3 Injection volume control

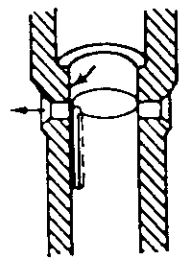
**(1) Full injection volume position**
When the rack is set at maximum setting, maximum volume of fuel is discharged. Injection occurs when the top of the plunger lines up with the intake port in the barrel. At this time, the lead groove which is positioned at the widest stroke part, lines up with the discharge port, prolonging the injection time and increasing the volume of fuel injected.
This setting is normally used for starting and max. output operation.



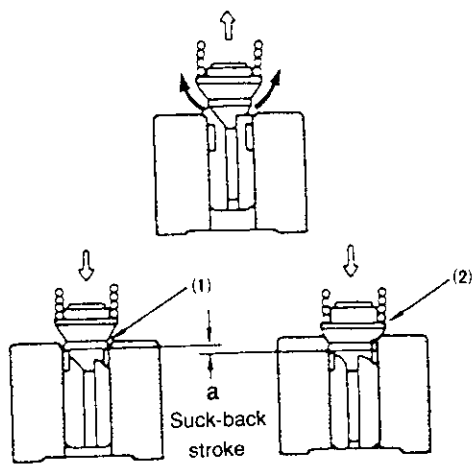

**(2) Half injection volume position**
Discharge ends earlier as the rack is moved towards zero from the maximum setting.
The fuel injection volume is decreased accordingly.




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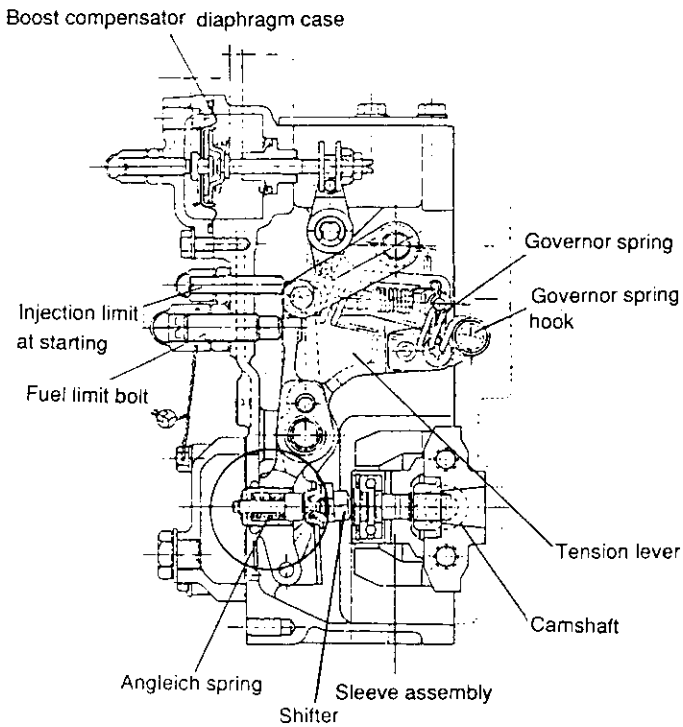
injection pipe decreases proportionately with the lowering of the valve (due to increased volume).
This accelerates the closing of the nozzle valve, and sucks up fuel from the nozzle to prevent dripping.
The result is a longer nozzle life and improved combustion efficiency.

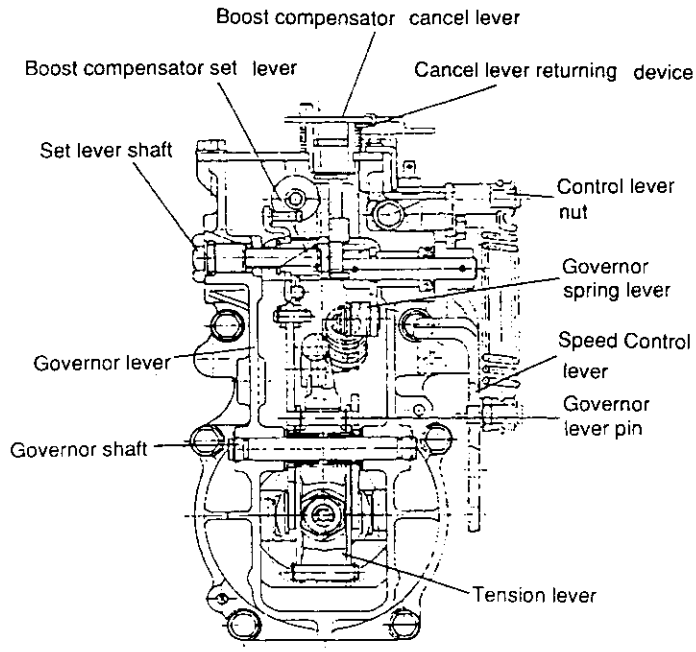
## 3-4 Governor construction

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-6AL2 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

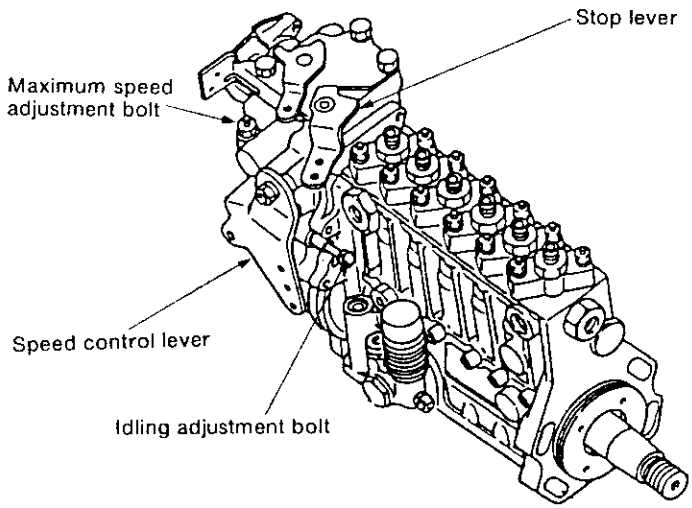
A number of different governors are equipped with the series fuel injection pump. Each is designed in accordance with individual engine structures and parts.

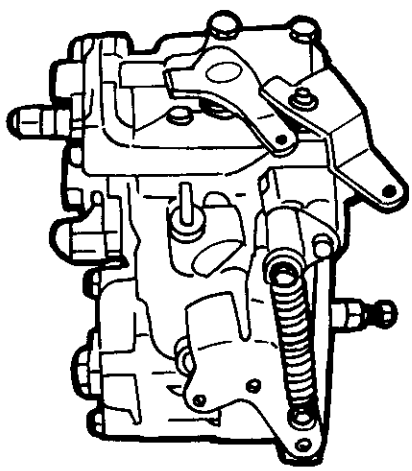
**(1) Shape of control and stop levers**

The control and stop levers that operate the governor have different shapes depending on engine design and method of attachment, as seen in the plctures 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)

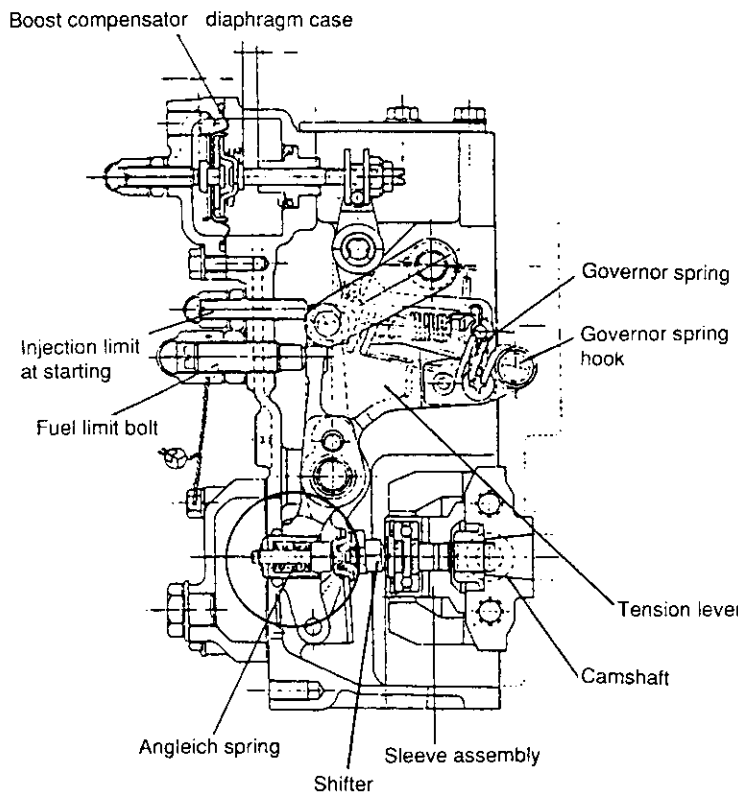
**(3) Torque rise equipment**

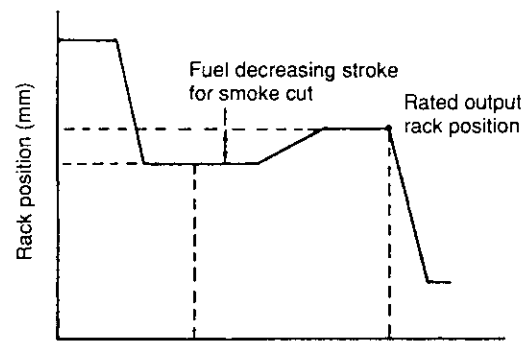
This governor can be equipped with an angleich spring for torque rise.
It is therefore suitable for use with various engines.

**(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.




[Smoke cut]



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### (4)-2 Boost compensator

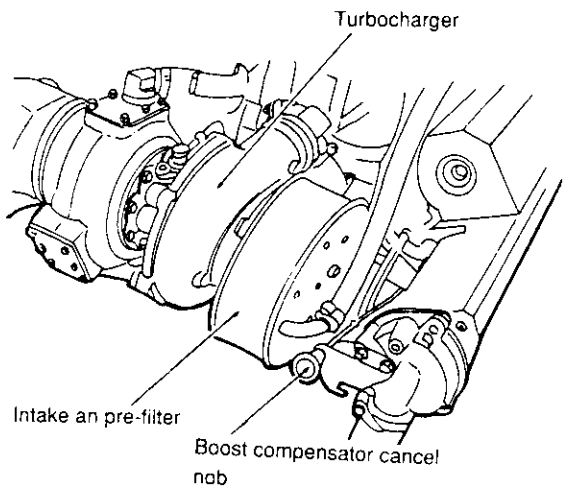
#### (4)-2-1 Objective of compensator

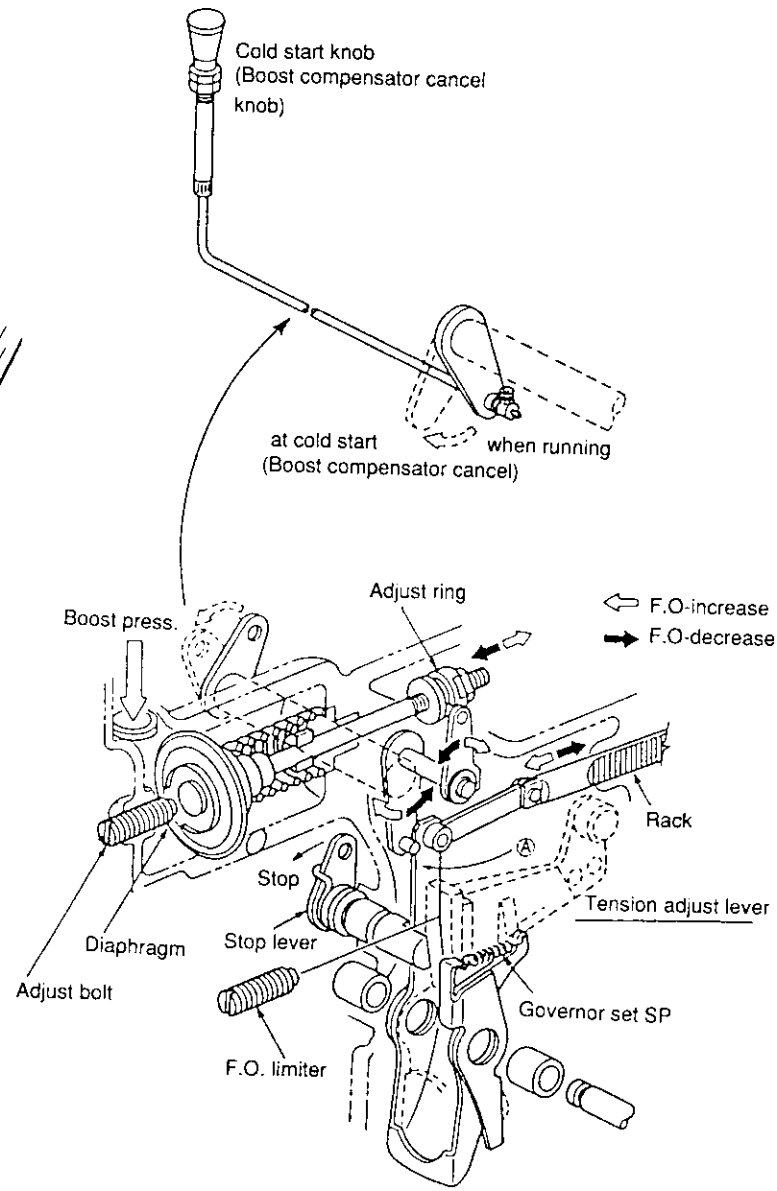
The boost compensator is a device mounted to the fuel injection pump for engines equipped with a turbocharger.

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. 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 diaphram in the boost compensator, moving the control rack to the fuel increase side by means of the boost compensator lever.



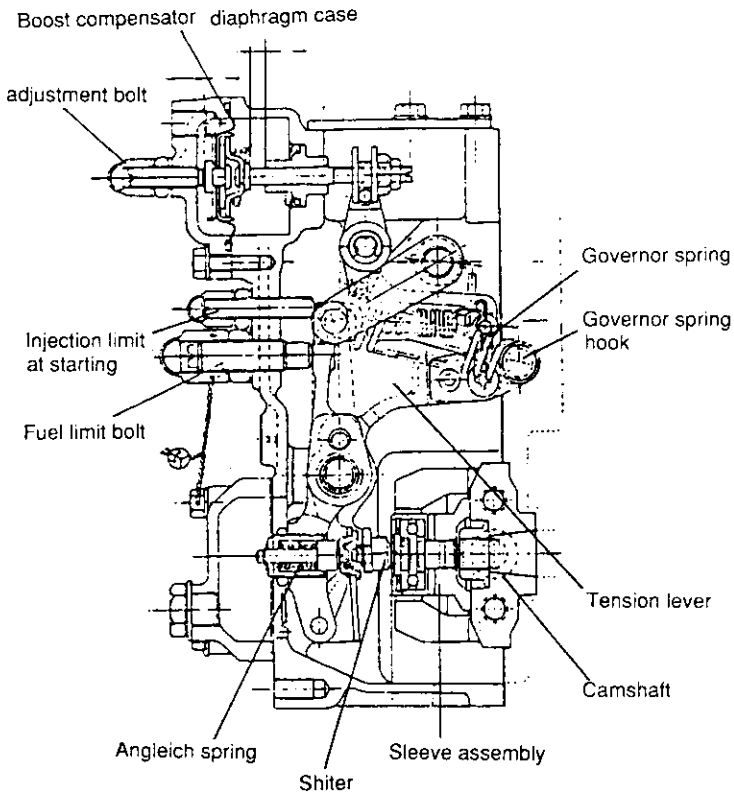



### (4)-2-3 Operation of cancel knob

1. Since the boost compensator is the device that limits the fuel injection amount for starting the engine in cold temperatures (below −5°C), it is necessary to cancel the function of the boost compensator and increase the fuel injection amount.
2. If the engine is gard 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. | ·Higher acceleration<br>·More black exhaust |
| Left turn | Small effect on boost comp. | ·Lower acceleration<br>·Less black exhaust |



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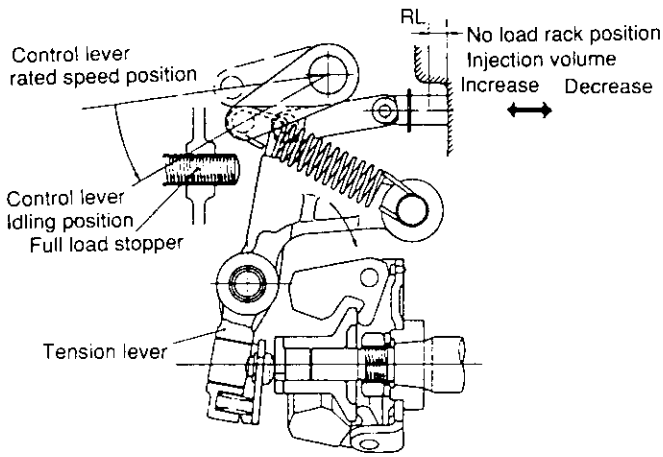
## 3-6. Idling and Maximum speed

### (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.

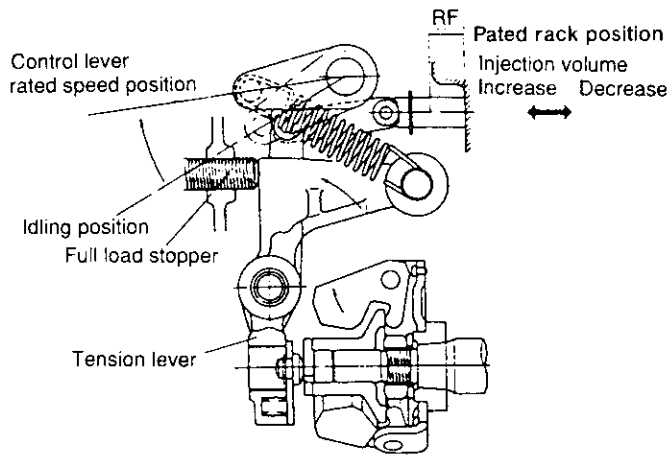



*NOTE: Depending on specifications, the governor can be provided with an idling spring.*

### (2) Maximum speed

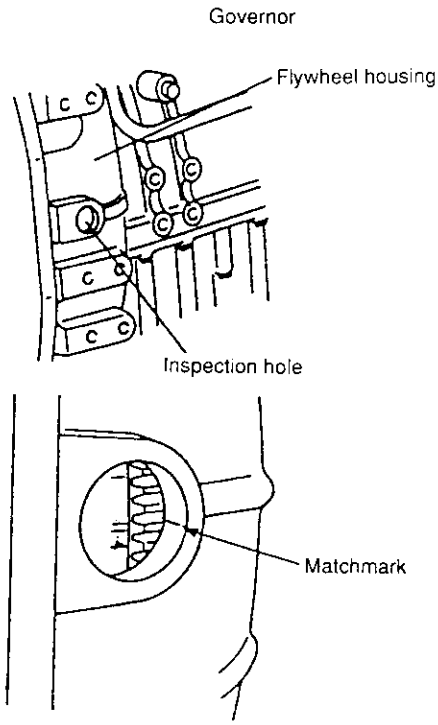
The angle of the control lever is set for the engine speed. The governor keeps the engine speed constant by the adjusting speed when the load changes.

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.




### (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±0.5° 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.



# 4. Fuel Injection Nozzle

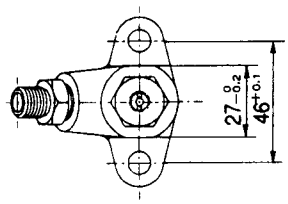
When fuel oil pumped by the fuel injection pump reaches the injection nozzle, it pushes up the nozzle valve (held down by spring), and is injected into the combustion chamber at high pressure.
The fuel is atomized by the nozzle to mix uniformly with the air in the combustion chamber. How well the fuel 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.

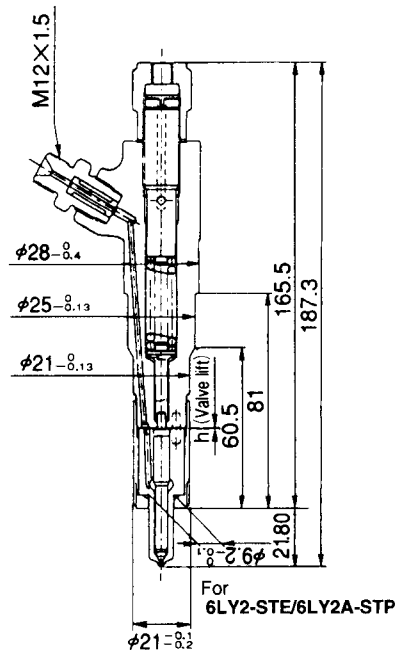
## 4-1 Functioning of fuel injection nozzle

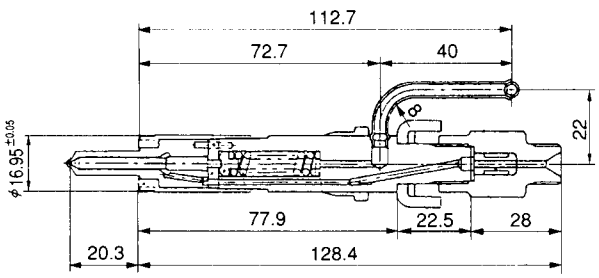
Fuel from the fuel injection pump passes through the oil port in the nozzle holder, and enters the nozzle body reservoir.
When oil reaches the specified pressure, it pushes up the nozzle valve (held by the nozzle spring), and is injected through the small hole on the tip of the nozzle body.
The nozzle 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

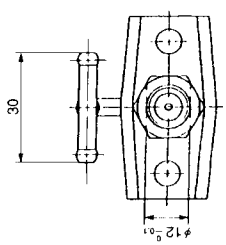
| | | | |
|---|---|---|---|
| Engine model | | 6LY2-STE/6LY2A-STP | 6LYA-STP |
| Nozzle I.D. Mark | | YDLLA145S345LZ | YDLLA140PL355KO |
| Spray angle | | 145° | 140° |
| No. of injection hole×dia | | 5× $\phi$ 0.34 | 5× $\phi$ 0.35 |
| Nozzle opening pressure | | 28.4~29.4MPa(290~300kgf/cm²) | 25.5~26.5MPa(260~270kgf/cm²) |
| Tightening Torque | Nozzle tightening nut | 68.6~73.5N·m (7.0~7.5kgf·m²) | 39.2~44.1N·m(4.0~4.5kgf·m²) |
| | High pressure pipe joint | 5.39~58.8N·m (5.5~6.0kgf·m) | ← |
| | Adjusted screw cap | 49.0~53.9 N·m (5.0~5.5kgf·m) | — |
| Nozzle lift | | 0.31~0.33mm | 0.29~0.31mm |
| Body mark | | CK | BF |
| Transfer pump press | | 0.23~0.37MPa(2.3~3.8kgf/cm²) | ← |

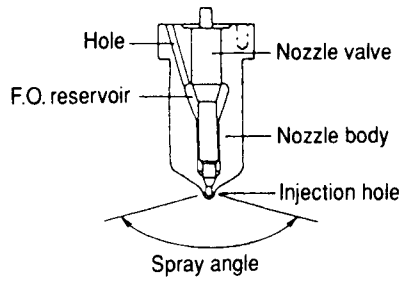



For 6LY2-STP



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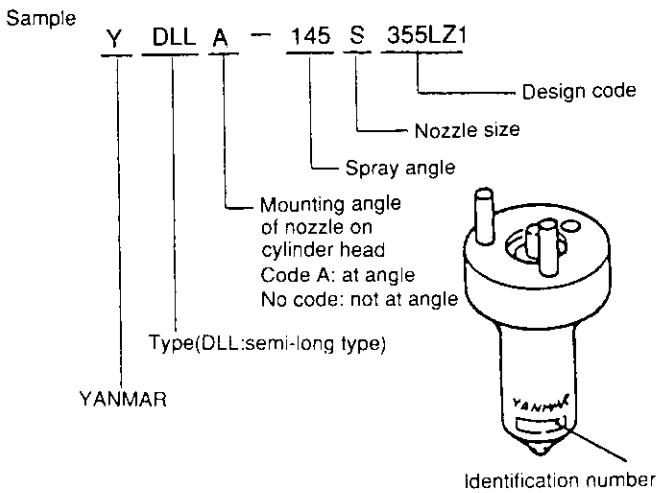
Nozzle body identification number
The type of nozzle can be determined from the number inscribed on the outside of the nozzle body.

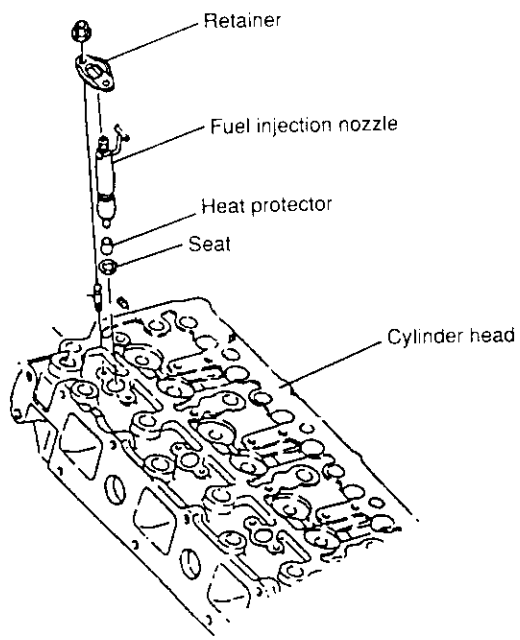
1) Hole type fuel injection nozzles




## 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).*

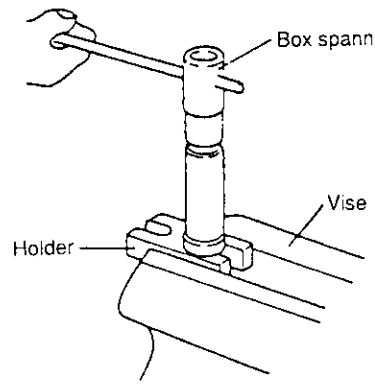
(1) When removing the injection nozzle from the cylinder head, remove the high pressure fuel pipe, fuel return pipe, etc., the injection nozzle retainer nut, and then the fuel injection nozzle.




**(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**



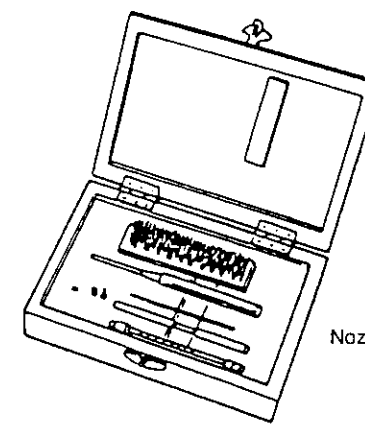

(4) Remove the inner parts

*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 cleanlng kits such as the one shown in the illustration below are sold by tool manufacturers).

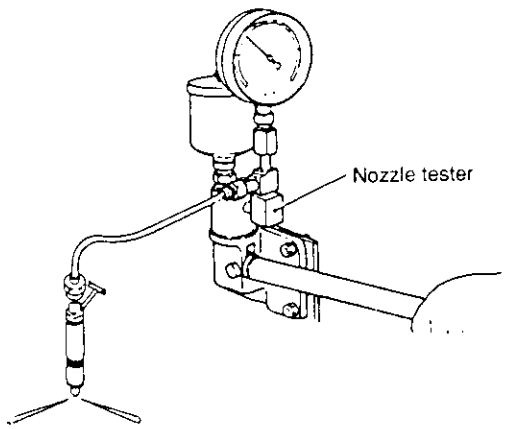

Nozzle cleaning kit

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

## 4-4 Adjusting fuel injection nozzle

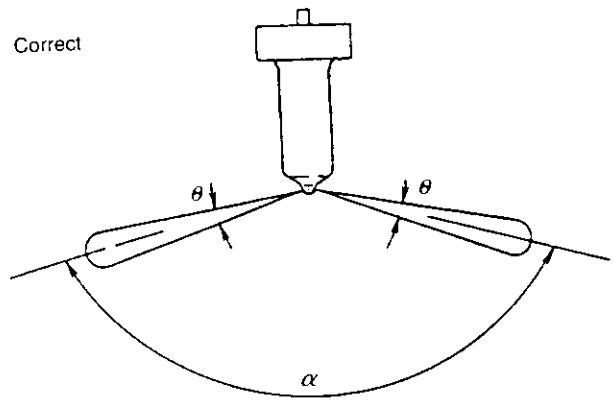
### 4-4.1 Adjusting opening pressure

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).

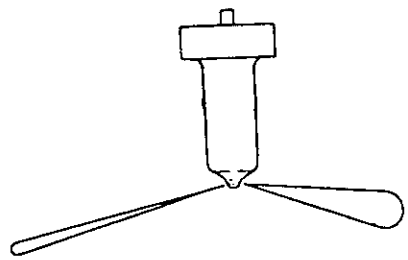



**Injection starting pressure** kg/cm²

| | |
|---|---|
| Injection starting pressure | 290~300 |




Spray from each nozzle hole is uniform




- Excessive difference in spray angle (θ)
- Excessive difference in injection angle ( a )
- Incomplete atomization
- Sluggish starting/stopping of injection

### 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/cm2 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 folowing conditions:

- Proper spray angle ( θ )
- Correct injection angle ( α )
- Complete atomization of fuel
- Prompt starting/stopping of injection



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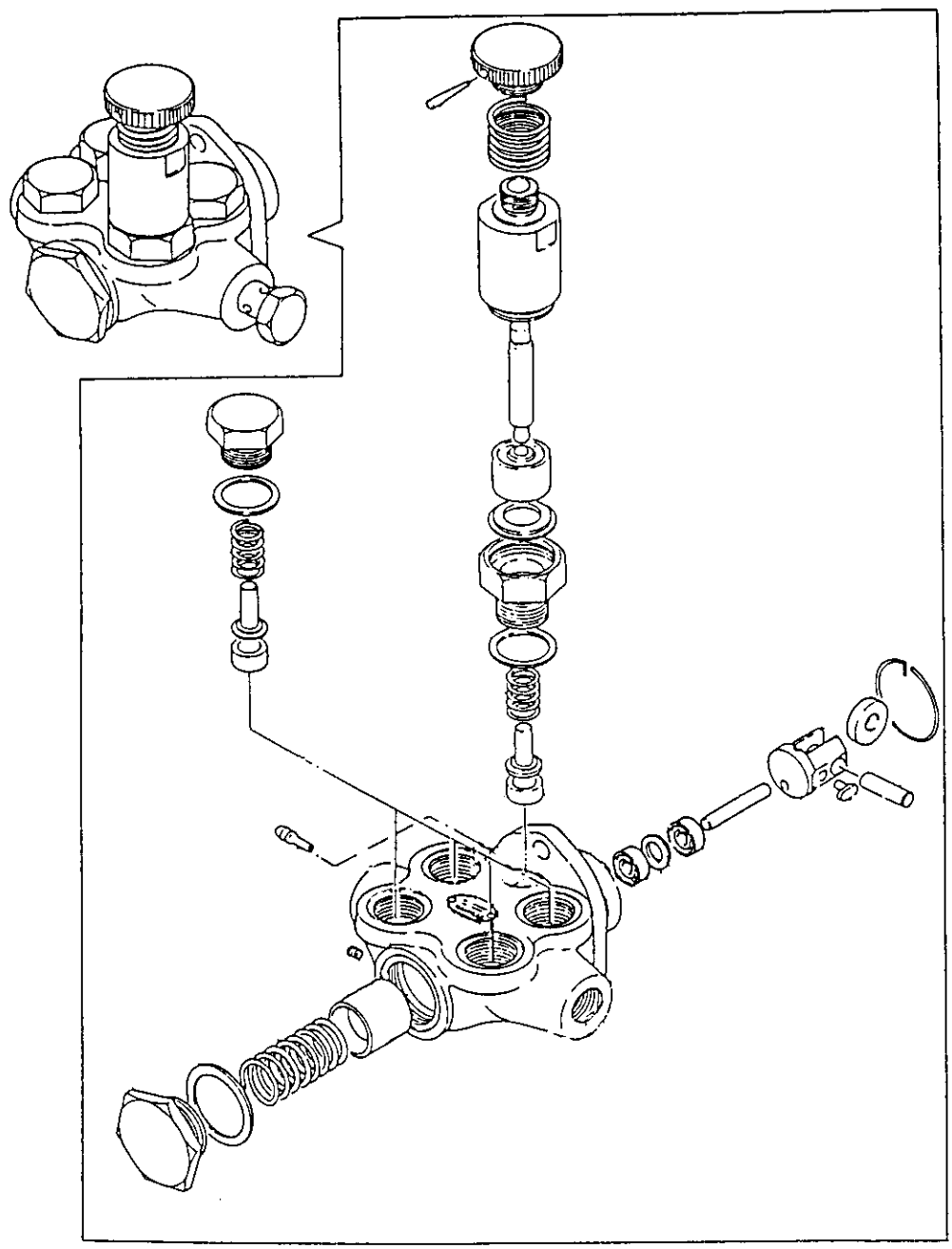
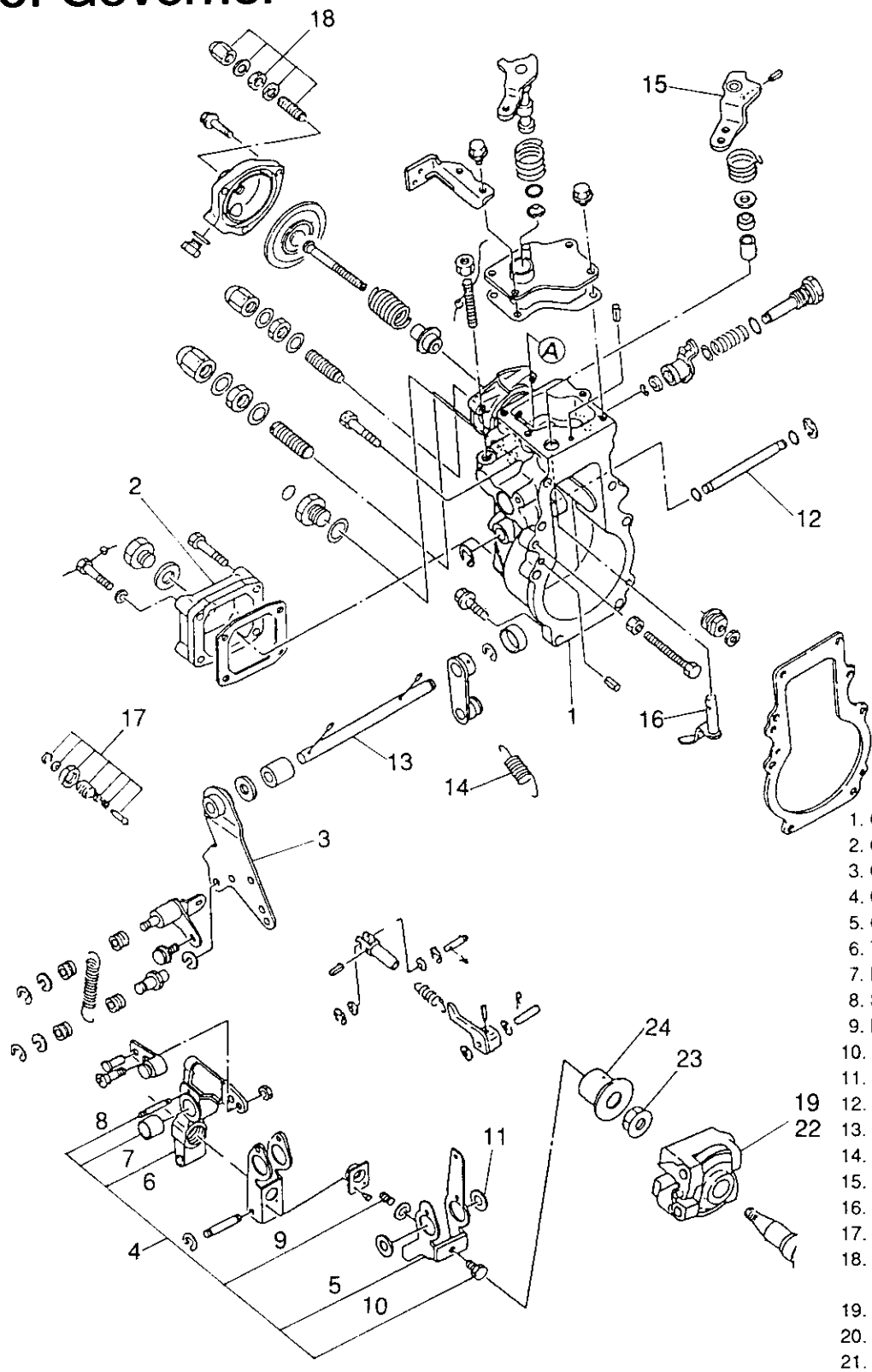
# 5. Fuel Feed Pump

## 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 discharge 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




1. Governor case
2. Governor case cover
3. Control lever
4. Governor lever assembly
5. Governor lever
6. Tension lever
7. Bushing
8. Spring pin
9. Excess fuel spring
10. Shifter
11. Washer
12. Governor shaft
13. Convol lever shaft
14. Governor spring
15. Stop iever
16. Stop lever shaft
17. Angleich spring assembly
18. Fuel stopper assembly (limit bolt)
19. Governor weight assembly
20. Governor weight
21. Pin
22. Governor weight support
23. Governor weight nut
24. Governor sleeve



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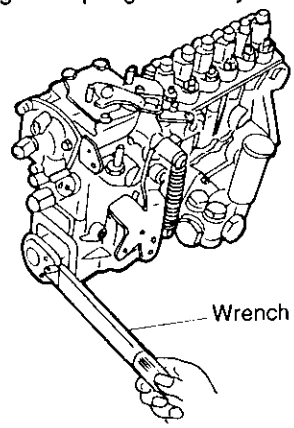
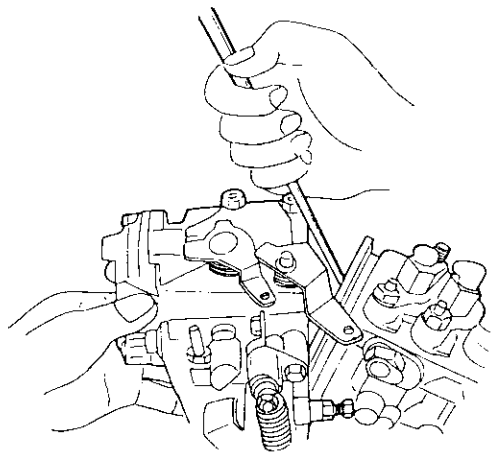
## 6-1 Governor disassembly

(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.



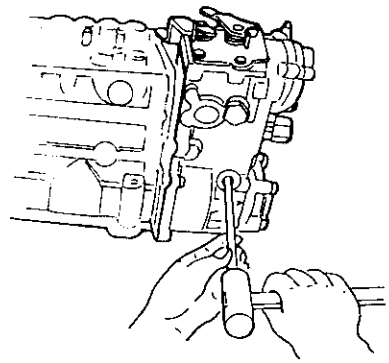
(4) Remove the connecting spring by inserting needle nosed pliers between the fuel pump and governor case.

(5) Slide the governor case and fuel pump apart and pull out the link pin of the fuel control rack.

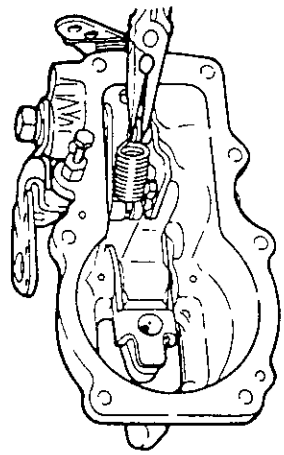
(6) Remove the snap-rings on both ends of the governor lever shaft.

(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.

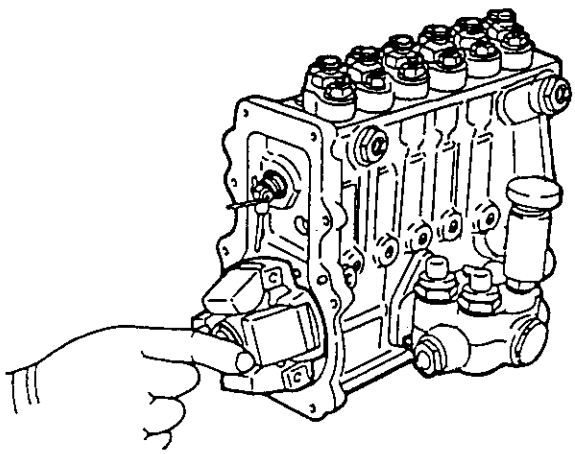


*Note: The governor assembly consists of the governor lever, tension lever, bushing, throttle spring and shifter, and is normally not disassembled.*
*The spring pin is removed when you replace the shifter or throttle spring.*

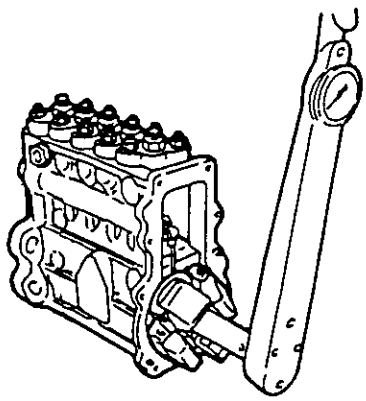
(10) When you need to pull out the control lever shaft, remove the control lever tightening nut, lightly tap the control lever shaft with a wooden hammer, and pull it out from the inside of the governor case.

*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.

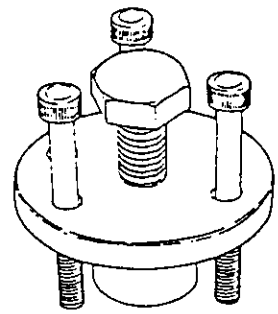


(12) Remove the governor weight nut and washer with a box spanner, stopping it with the hole in the fuel pump coupling or holding the coupling with a vise. Screw the governor weight nut back in, (two or three times).



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

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



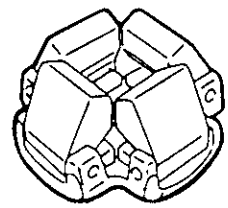
*NOTE: The governor weight assembly is made up of the governor weight, support and pin. Do not disassemble.*

## 6-2 Inspection of governor

**Inspection of governor weight assembly**

Replace if:

(1) It does not open and close smoothly.



(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.



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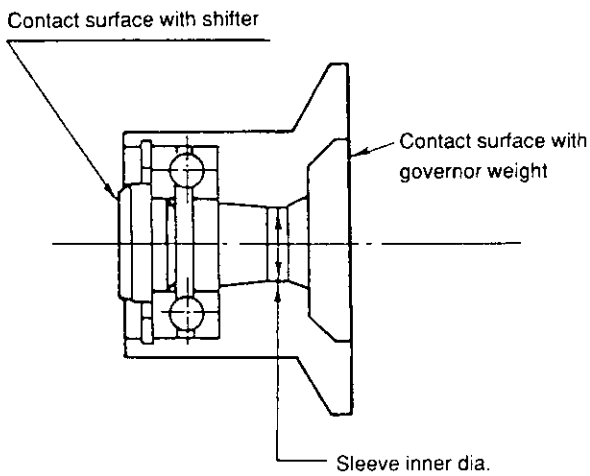



Replace if:

(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.*

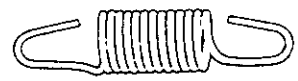
mm

| Standard side gap | 0.4~0.8 |
|---|---|

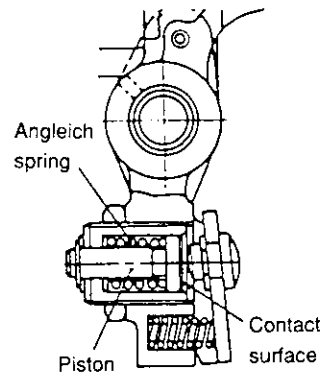
*2. Replace the governor lever, tension lever, bushing, shifter and throttle spring as an assembly.*

**Inspection of springs**

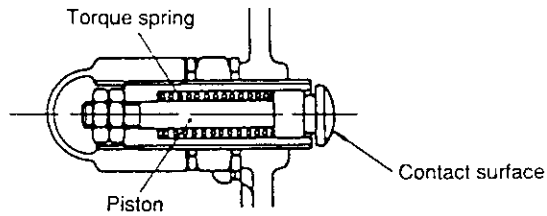
(1) Check the governor spring and other springs and replace if they are broken, settled or corroded.
(2) Measure the free length of the governor spring, and replace if it exceeds the limit.
See the service data sheet for the free length of the governor spring.



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.

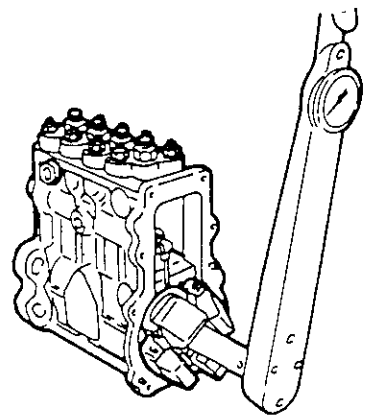


## 6-3 Assembling the governor

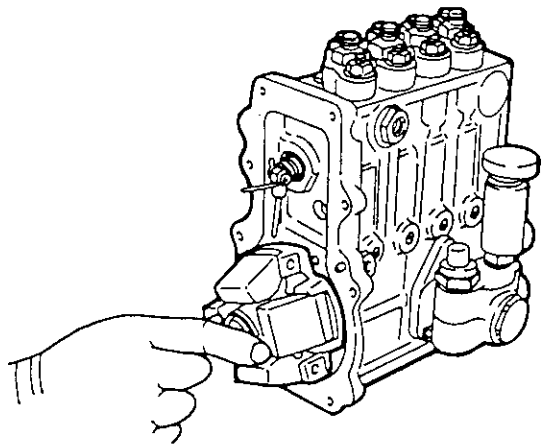
Inspect all parts after disassembly and replace any parts as necessary. Before starting reassembly, clean both the new parts and parts to be reused, and put them in order.
Be sure to readjust the unit after reassembly to obtain the specified performance.

(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 |



(2) Open the governor weight and insert the sleeve in the end of the fuel pump camshaft.

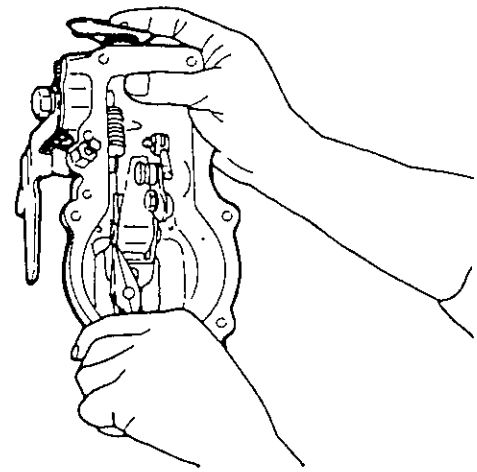


*NOTE: Make sure that the sleeve moves smoothly after insertion.*

(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.





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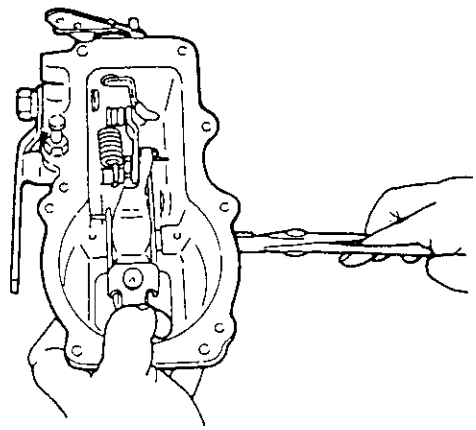
(7) Put the governor lever shaft assembly in the governor case, insert the governor lever shaft until the O-ring groove protrudes from out the opposite side of the governor case, and fit the O-ring.

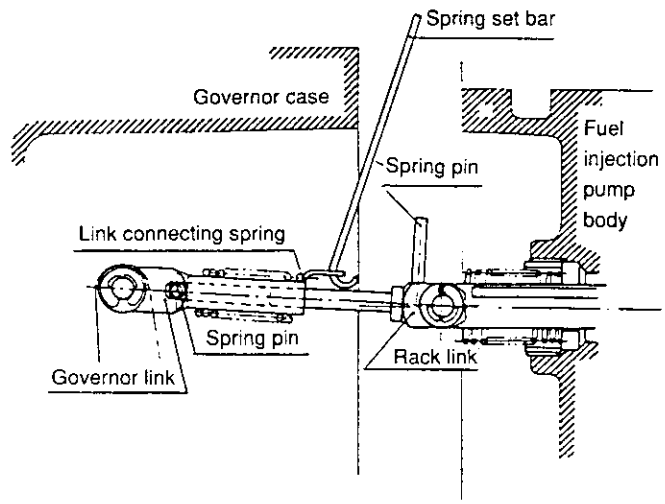


*NOTE: 1. Fit the O-ring to the side you tapped it in from.*
*2. Coat the O-ring with the silicon oil for protection during insertion.*
*3. Don't forget to place washers on both sides of the governor lever.*

(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.

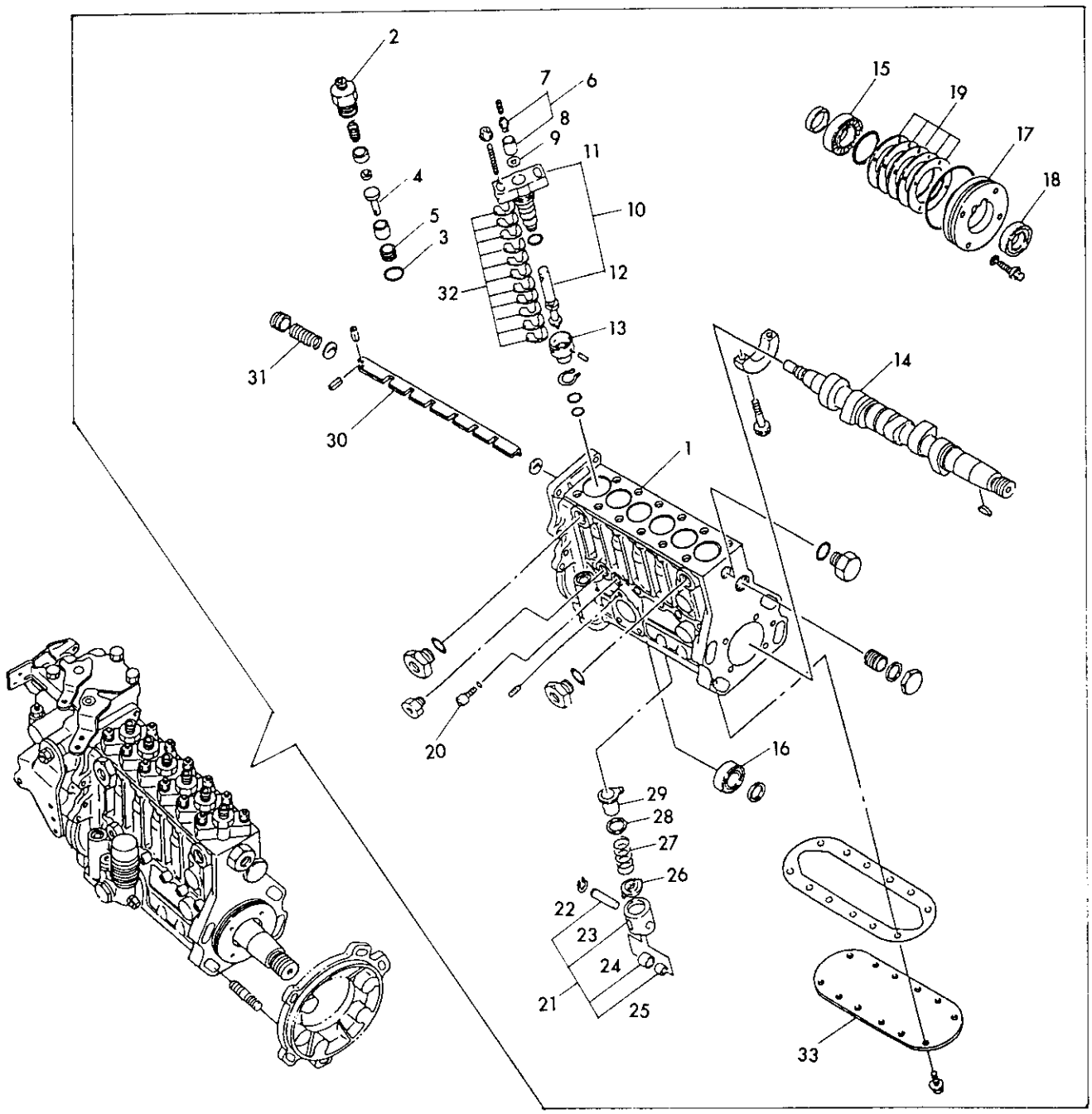
(11) Mount the governor case to the fuel pump unit, lightly tapping it with a wooden hammer, and tighten the bolts.

(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. Auz. spring
32. Adjusting shims
33. Pump bottom cover



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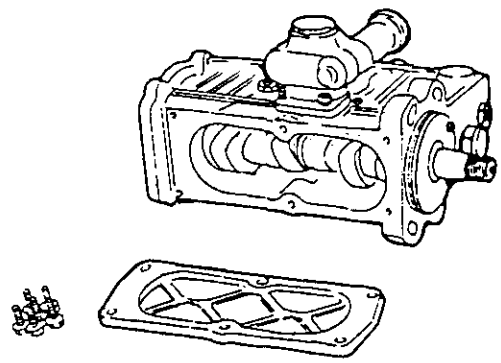
## 7-1 Disassembly of fuel injection pump

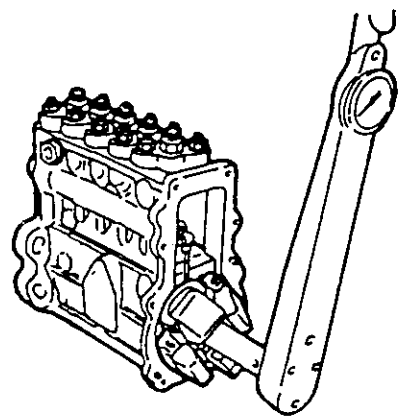
When disassembling the fuel pump, separate the parts for each cylinder and be careful not to get them mixed up.
Be especially careful to keep the plunger/plunger barrel, delivery valve/delivery valve seat and other assemblies separate for each cylinder (the parts of each assembly must be kept together 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 of the fuel pump bottom cover and remove the lubrication oil.
4. Turn the fuel pump upside down to drain the fuel oil.

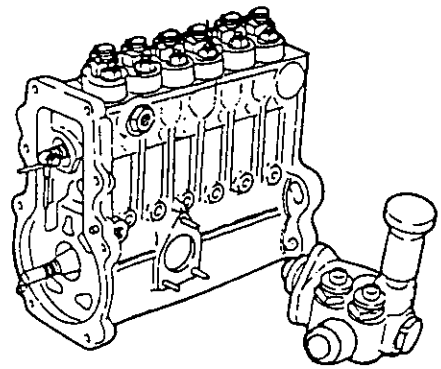


(1) Loosen the nut with a box spanner and take it off.
Hold the unit either by the hole in the fuel pump coupling or by placing the coupling in a vice, and take out governor weight assembly.

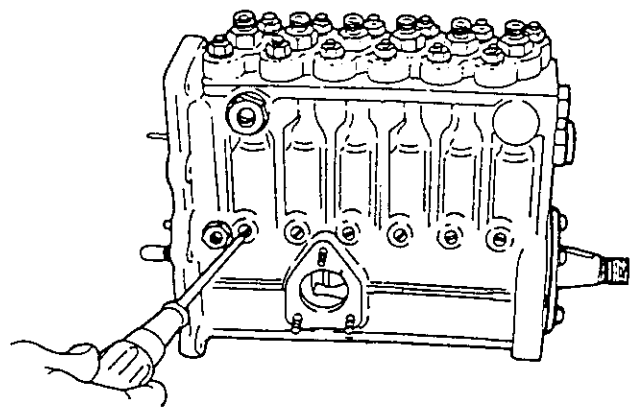


(2) Remove the fuel feed pump.

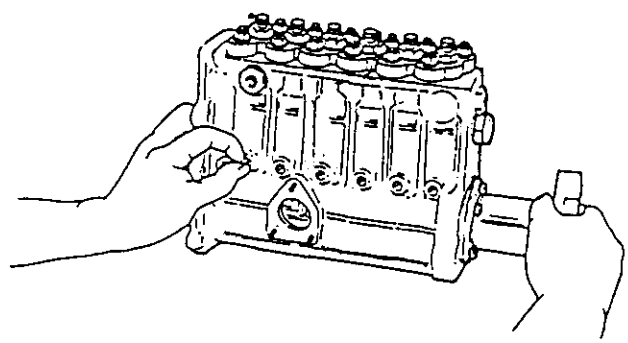
*NOTE: Do not disassemble the fuel feed pump. See instructions for fuel feed pump for details.*



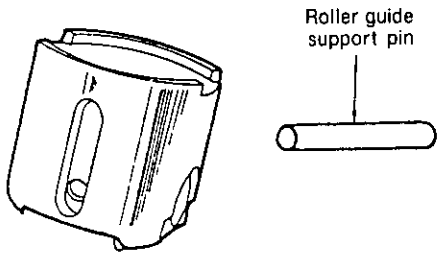
(3) Remove the roller guide clamping bolts.



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



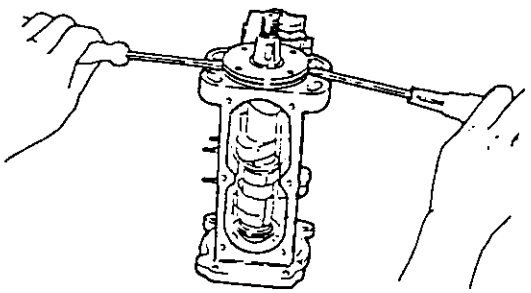
*NOTE: If the camshaft does not turn, put double nuts or a coupling on the end of camshaft.*




(5) Remove the camshaft woodruff key.

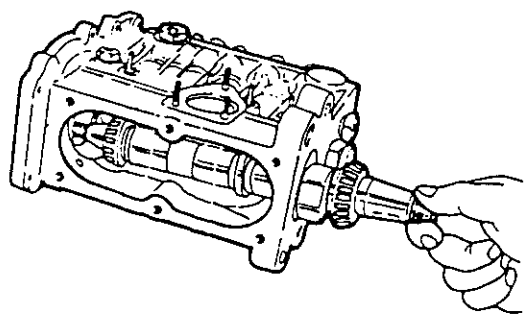
(6) Remove the 4 bolts of the bearing holder.

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

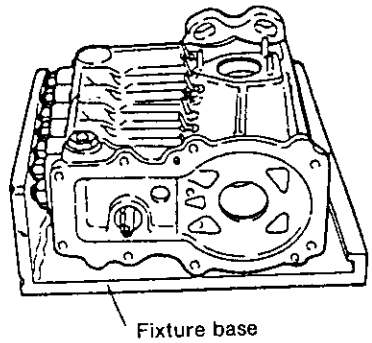


*NOTE: 1. Be careful not to damage the oil seal with the threaded part of the camshaft.*
*2. Be careful not to lose the shims between the pump and bearing holder.*

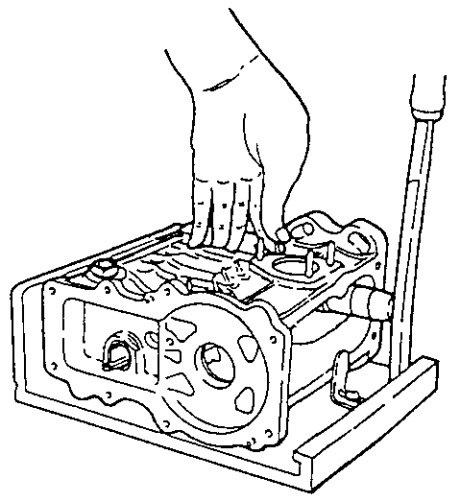
(8) Put a plate against the governor end side of the camshaft and tap it lightly. Pull out the camshaft and drive side bearing.



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




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



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



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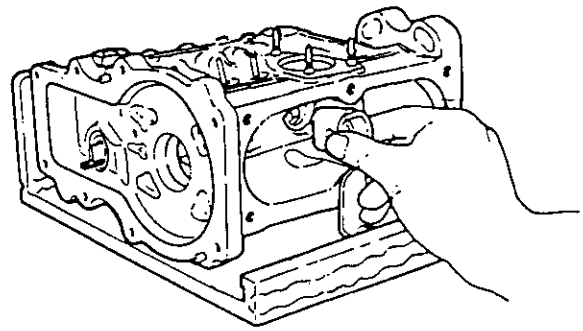
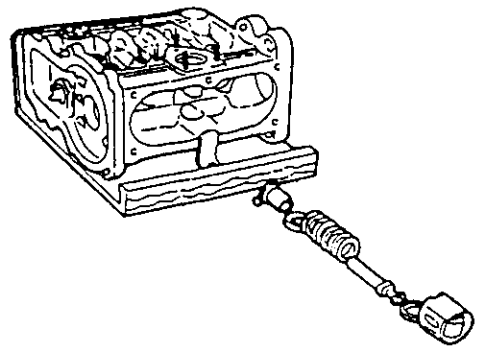
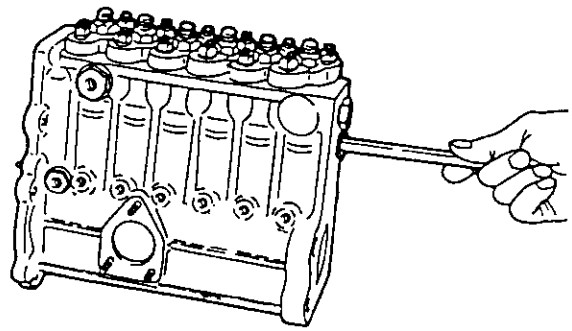
(11) Remove the parts of the roller guide by hand in the following order: plunger spring seat B, plunger, spring plunger spring seat A and control sleeve.





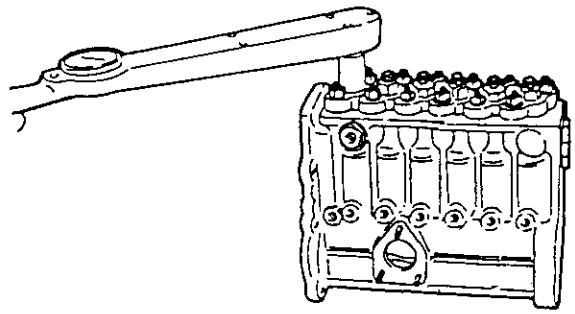
*NOTE: All of the roller guides will fall out when the fuel pump is stood up. So, first remove the roller guide support pin and roller guide for one cylinder at a time.*

(12) Remove the control rack.



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

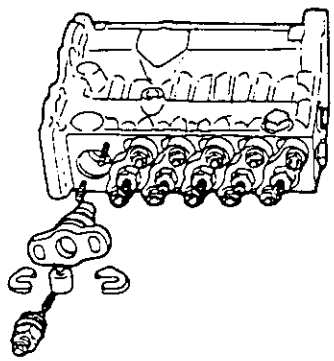
(13) Remove the delivery valve holder.

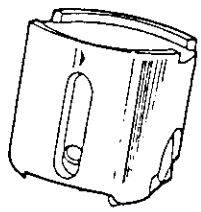


(14) Remove the delivery valve assembly.

*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.





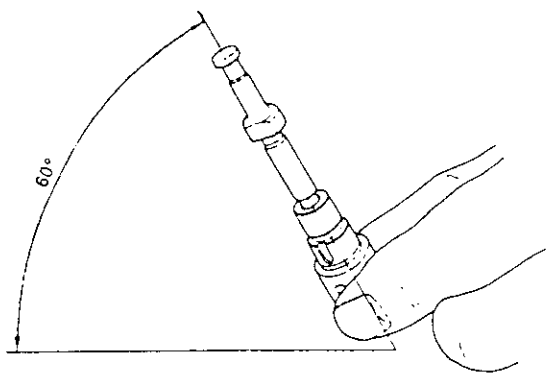
*NOTE: Keep each plunger barrel and plunger taken out before as a set.*

## 7-2 Inspection of fuel injection pump

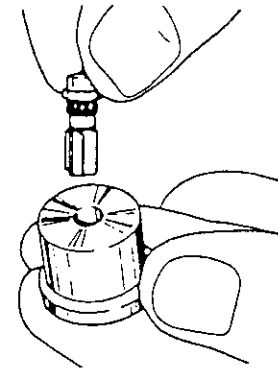
(1) Inspection of plunger

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.




(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.*

(3) Inspection of pump

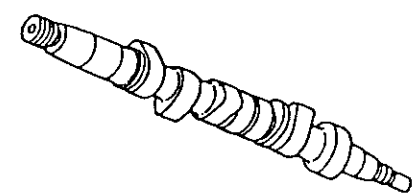
1) Inspect for extreme wear of the roller guide sliding surface. Scratches on the roller pin sliding surface are not a problem.

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.*



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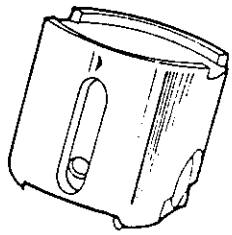
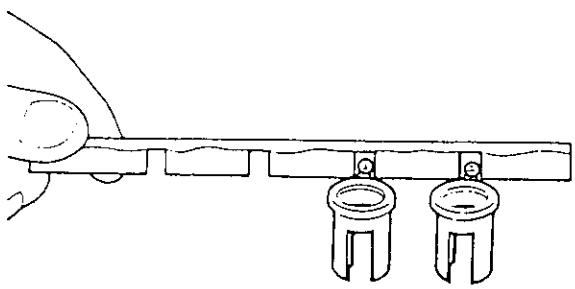
(5) Inspection of roller guide assembly
1) Roller
Replace if the surface is worn or flaked.



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

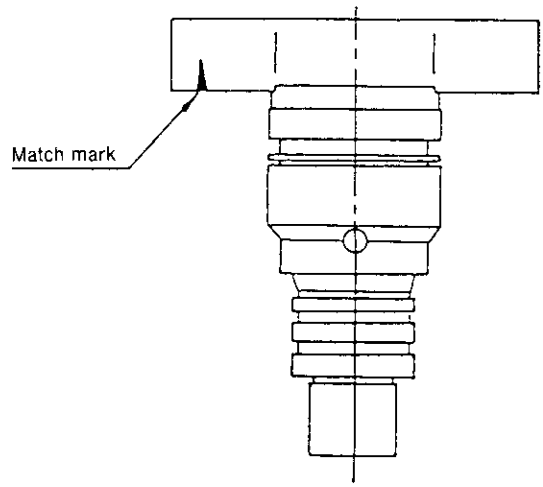
**Preparation**

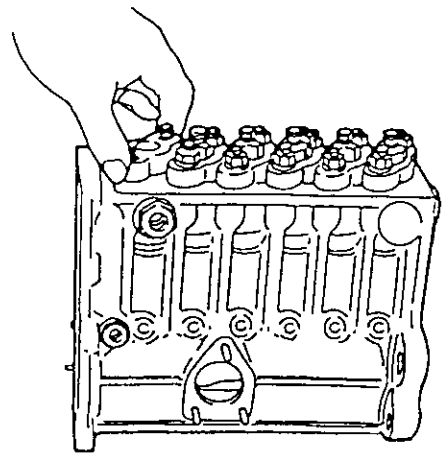
After inspection, arrange and clean all parts.
See Inspection of Fuel Pump for inspection procedure.

(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 |

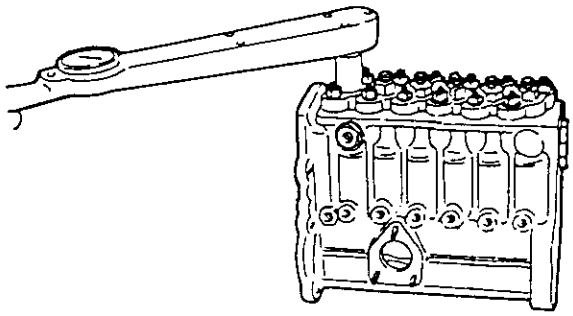
*NOTE: Coat the silicon O-ring with oil.*



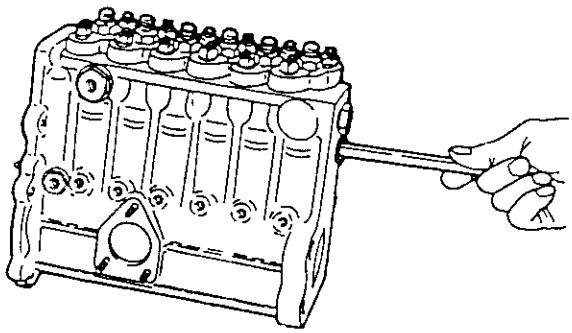
(2) Insert the packing, delivery valve assembly, spring, and stopper from the top of the pump, in that order, and tighten the delivery valve holder.

| | |
|---|---|
| Delivery valve holder tightening torque | 6.0~6.5kg·m |



(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.

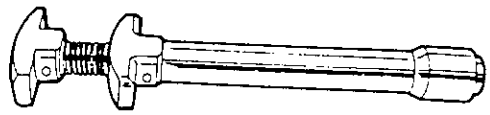
(5) Mount the plunge spring seat A.

*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.

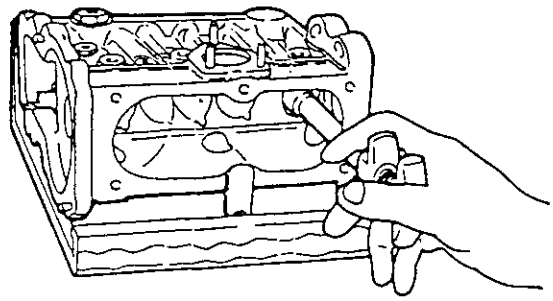
(6) Mount the plunger spring.

(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





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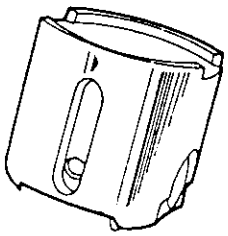
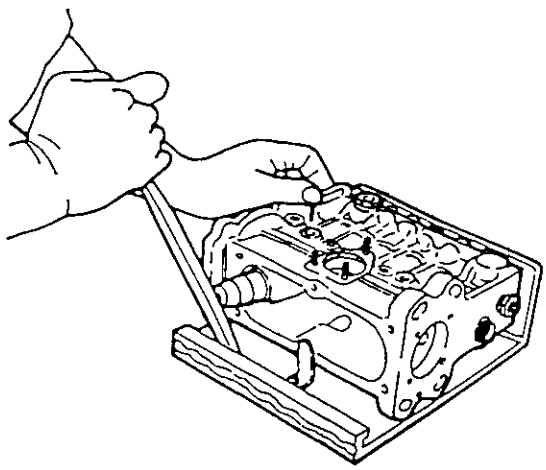
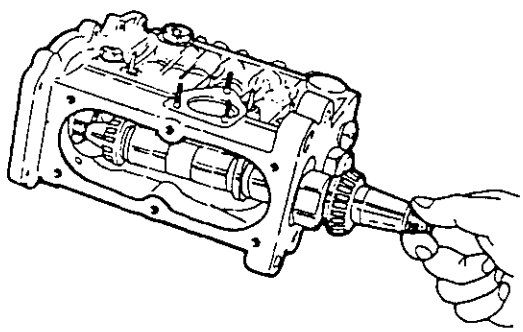
(8) Insert the roller guide, pushing it up from the bottom of the pump with the roller guide push lever, and insert the support pin in the hole on the roller groove.





*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.*

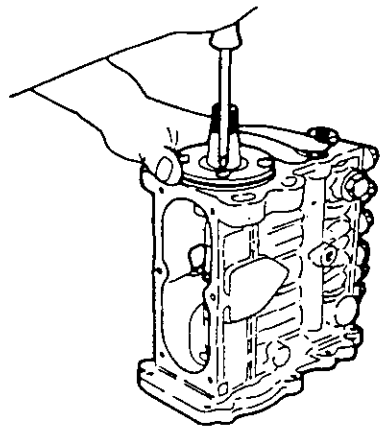
(9) Fit the bearings to both ends of the camshaft, and insert from the driving side.



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

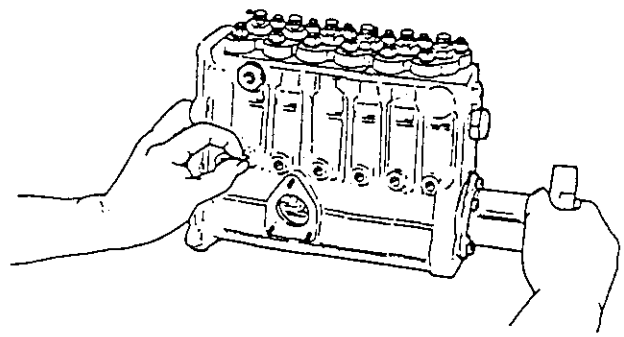
*NOTE: Coat the camshaft and the oil seal with silicon oil to prevent the oil seal from being scratched.*

| | |
|---|---|
| tightening torque | 0.6~0.7kg·m |



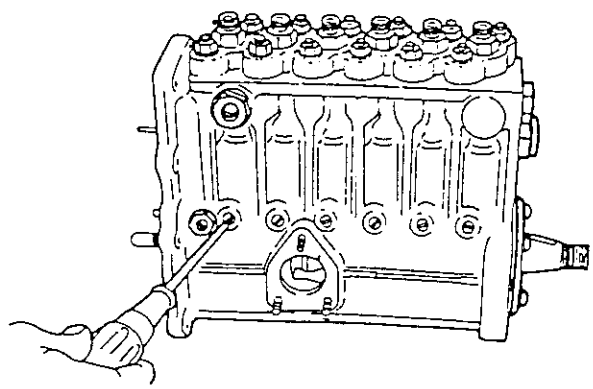
(11) Tap in the camshaft woodruff key.

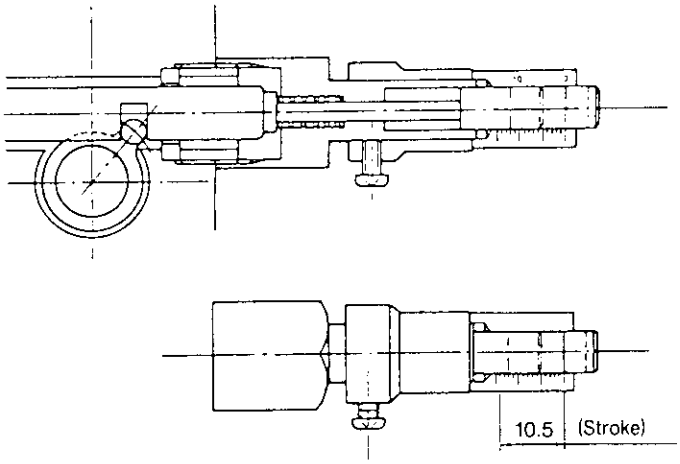
(12) Mount double nuts or a coupling on the end of the camshaft, and pull out the roller guide support pin as you turn the camshaft.



(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 |

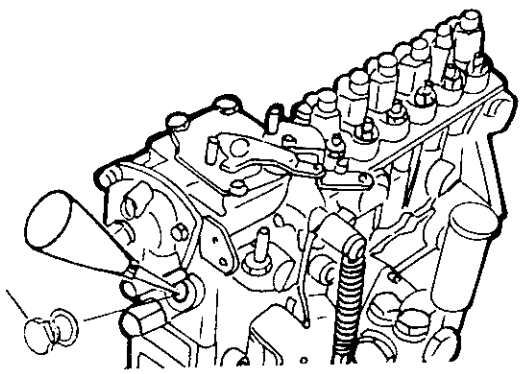





(14) Check the control rack stroke
Make sure the rack position is at 10.5±1 mm on the indicator scale when the governor control lever is set at the maximum operating position.
If it is not at this value, change the link connecting the governor and control rack.

*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.

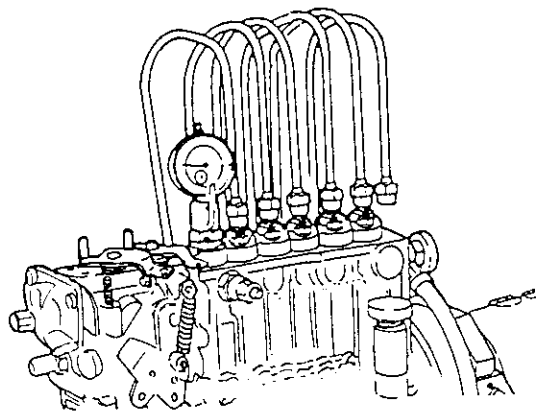


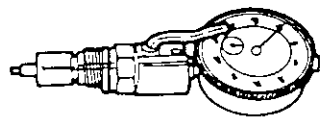
(16) Complete fuel oil piping and operate the pump tester to purge the line of air.

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

## 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.





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 |

(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 |



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(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 |

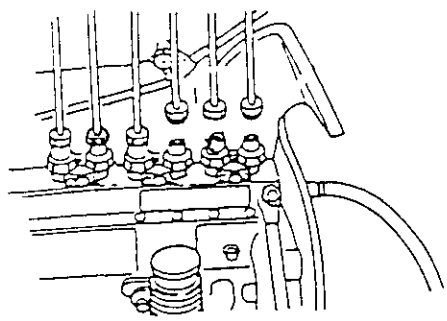
## 7-5 Adjusting injection timing

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.



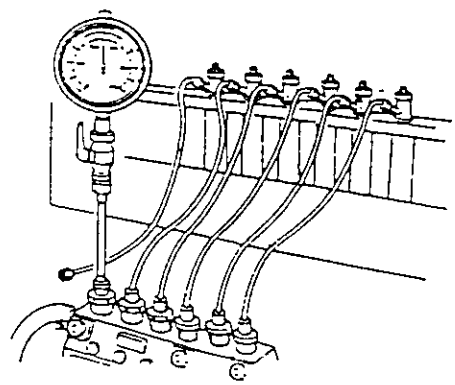
| | |
|---|---|
| No. of cylinders | 6 |
| Injection order | 1-4-2-6-3-5-1 |
| Injection interval | 60° |
| Allowable deviation | ±30' |

(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.



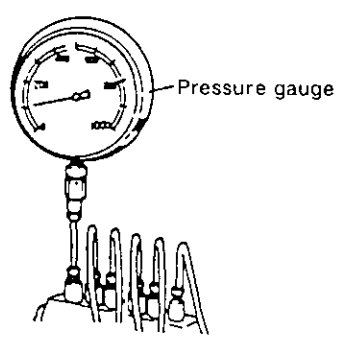
| | |
|---|---|
| Max. pressure gauge reading | 1000kg/cm² |
| Connecting screw dimensions | M12 x 1.5 |

(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/cm2 (7110 lb/in.2) 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/cm2 (1706 lb/in.2), 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/cm².

| | |
|---|---|
| 100 → 90 kg/cm² | 5 seconds (to drop 10 kg/cm²) |

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 | *See injection pump service data* |
| Specified injection volume at standard rack position | |
| 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.

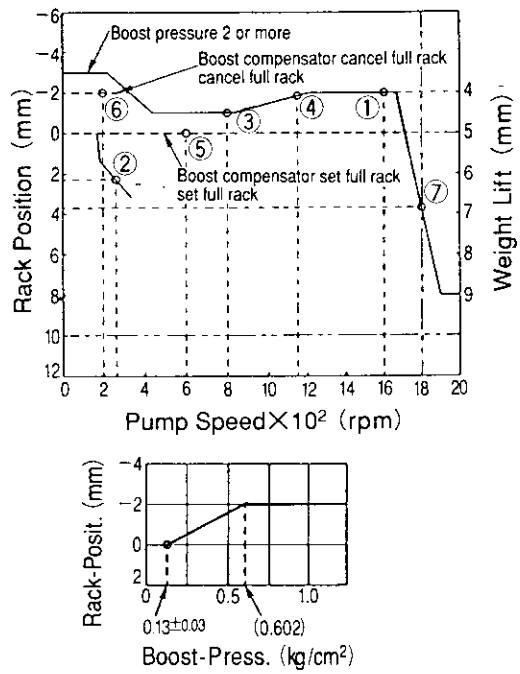
| | |
|---|---|
| Tightening torque | 2.6~2.8kg·m |

(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.

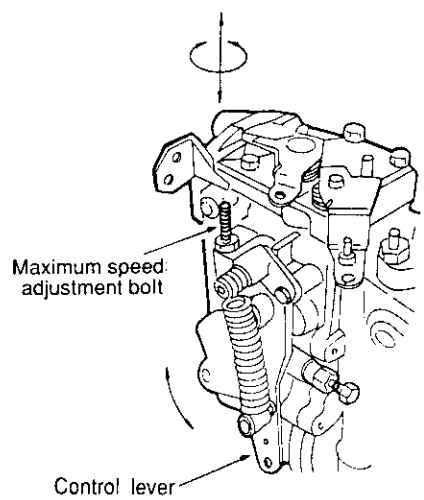



(2) Measure fuel injection volume at rack position ($R_1$).

(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 ($R_1$).



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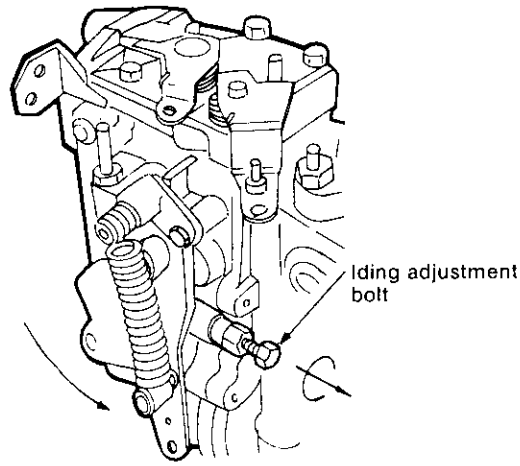
(2) Check maximum RPM at no load
Further increase rpm, and make sure that rack position ($R_2 = R_1 - L$) corresponding to maximum rpm at no load is within specified value ($N_2$).

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

### 7-9.3 Adjusting idling

(1) Maintain the pump rpm at specified rpm (N3).




| | |
|---|---|
| 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 (N4).
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.

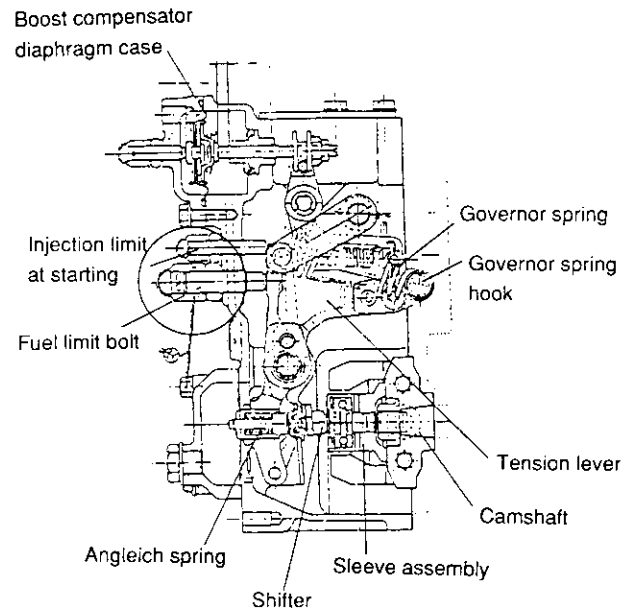
| | |
|---|---|
| Pump rpm (N4) | 200 rpm |
| Rack indicator scale | 13.5~14.5 |
| Measuring stroke | 500st |
| Injection volume | *See separate service data* |

### 7-9.5 Check injection stop

Drive the pump at no load maximum rpm (N2). 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 in 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.

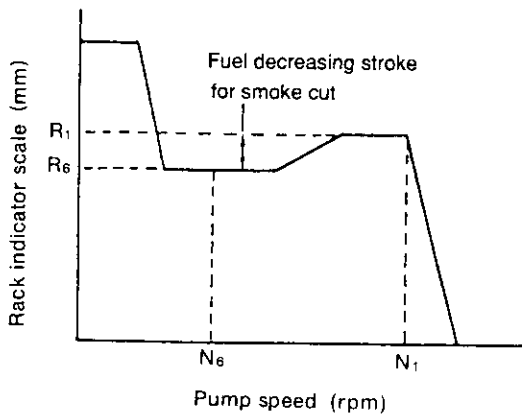
(1) The angleich spring is used as an assembly.
(2) Bring the governor control lever to the full load position, and keep the pump speed at the specified peak torque.
(3) Remove the governor case cover in this state and screw the angleich spring assembly to the tension lever. Screw in from the contact 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 iocknut 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 (R1) and injection value are within the specified value at (N1) rpm.

### 7-10.2 Smoke cut spring

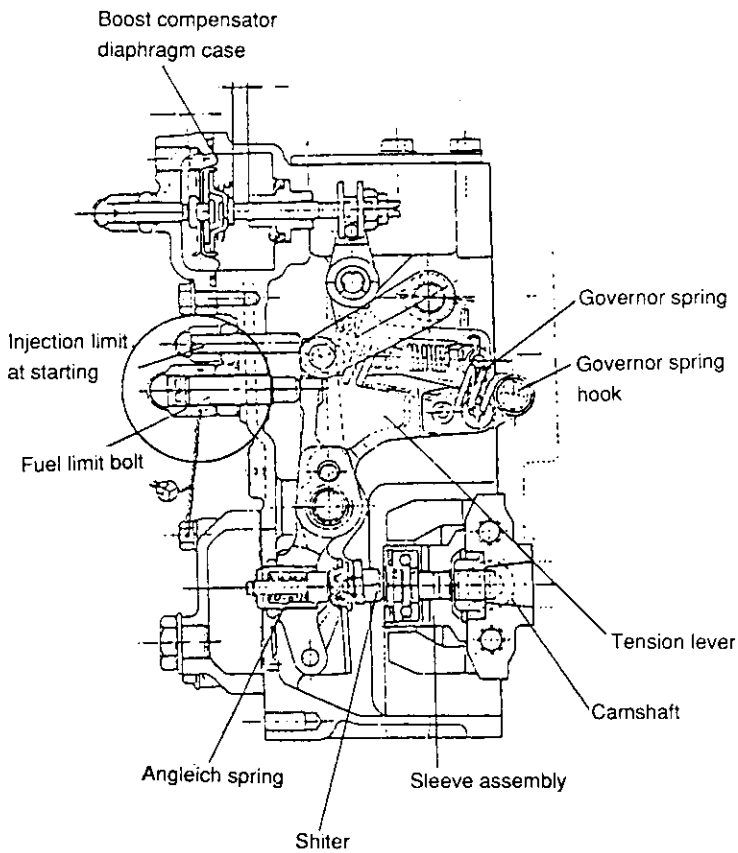
The smoke cut spring is used in the form of spring loaded assembly.




(1) Turn the control lever to "FULL LOAD", and keep the fuel injection pump at the specified smoke cut spring control revolutions (N6).
(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 (R6). (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 (N1) once again. Check whether the control rack smoothly changes fuel decreasing strokes.
Finally, make sure that rack position (R1) and injection at revolutions (N1) meet the specification.




**Before Adjusting the smoke cut spring assembly,adjust**
(1) the fuel limit bolt, and
(2) the revolution limit bolt.



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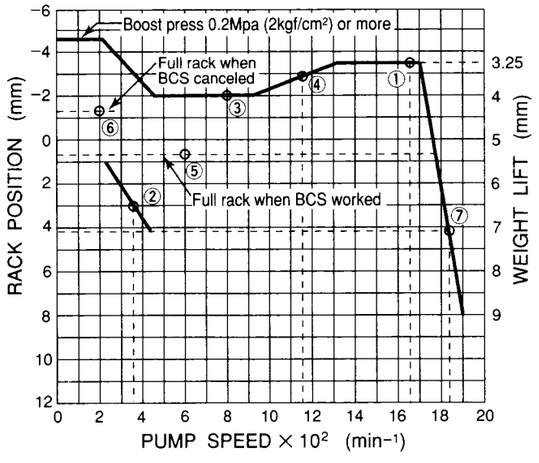
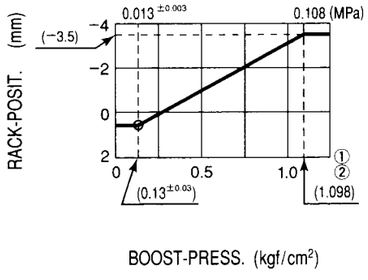
# Service Data

## ● 6LY2-STE/6LY2A-STP

| | | Rack position (mm) | Pump speed (rpm) | Calibration data (Manufacturer STD) Averageinject. qty. (mm³/st) | Calibration data (Manufacturer STD) Max. variation between cyls. (%) | Remarks |
|---|---|---|---|---|---|---|
| Ajustment of injection quantity | ⑥ | (−1.4) | 200 | (140) | —— | BCS cancel |
| | ⑤ | (0.6) | 600 | 82±3 | —— | BCS works |
| | ③ | (−2) | 1000 | 182±3.5 | —— | Inverted angleich |
| | ① | −3.5±0.2 | 1650 | 177±3 | ±3 | Max. (fuel stop) rating |
| | ② | (3) | 350 | 9±3 | ±15 | Low idle |
| | ⑦ | (4.2) | 1835 | 20±5 | —— | Max. idle |
| | ④ | (−2.9) | 1150 | (190) | —— | Measuring point |
| Test conditions for adjustment inj. pump | Nozzle, nozzle holder assy. | | | D19575−53100(CK) | | —— |
| | Nozzle | | | 5−φ0.34 (YDLLA145S 345LZ) | | —— |
| | Nozzle holder | | | For 3S15 | | —— |
| | Nozzle opening press. | | | 28.4∼29.4MPa (290∼300kgf/cm²) | | —— |
| | Transfer pump press. | | | 0.23MPa (2.3kgf/cm²) | | —— |
| | Injection pipe | | | φ6.35×φ2×580mm | | —— |
| | Test fuel oil | | | Diesel fuel oil JIS No.2 | | —— |
| | Fuel temp | | | 40℃ | | —— |

- Direction of rotation : Clockwise (viewed from driving side)
- Injection order : 1-4-2-6-3-5-1 (No1 from driving side)

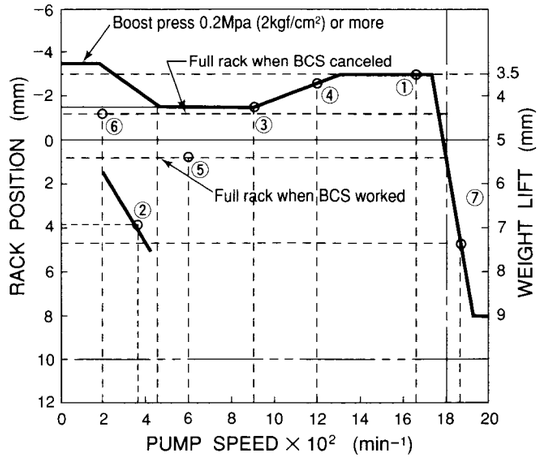


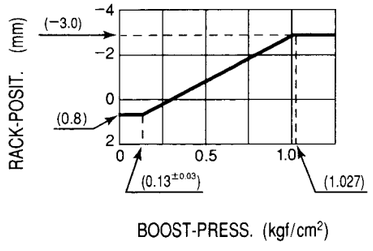




## ● 6LYA-STP

| | | Rack position (mm) | Pump speed (rpm) | Calibration data (Manufacturer STD) Averageinject. qty. (mm³/st) | Calibration data (Manufacturer STD) Max. variation between cyls. (%) | Remarks |
|---|---|---|---|---|---|---|
| Ajustment of injection quantity | ⑥ | (−1.2) | 200 | 120±30 | —— | BCS cancel |
| | ⑤ | (0.8) | 600 | 73±3 | —— | BCS works |
| | ③ | (−1.5) | 900 | 135±4 | —— | Inverted angleich |
| | ① | −3.0±0.2 | 1650 | 132±2 | ±3 | Max. (fuel stop) rating |
| | ② | (3.9) | 350 | 9±3 | ±15 | Low idle |
| | ⑦ | (5.2) | 1860 | 8∼15 | —— | Max. idle |
| | ④ | —— | (1200) | (Expected 145) | —— | Measuring point |
| Test conditions for adjustment inj. pump | Nozzle, nozzle holder assy. | | | D19574−53200 | | —— |
| | Nozzle | | | 5−0.35 (YDLLA140 PL355KO) | | —— |
| | Nozzle holder | | | For 6LY | | —— |
| | Nozle opening press. | | | 25.5∼26.5MPa (260∼270kgf/cm²) | | —— |
| | Transfer pump press. | | | 0.23MPa (2.3kgf/cm²) | | —— |
| | Injection pipe | | | φ6.35×φ2×621mm | | —— |
| | Test fuel oil | | | Diesel fuel oil JIS No.2 | | —— |
| | Fuel temp. | | | 40℃ | | —— |

- Direction of rotation : Clockwise (viewed from driving side)
- Injection order : 1-4-2-6-3-5-1 (No1 from driving side)

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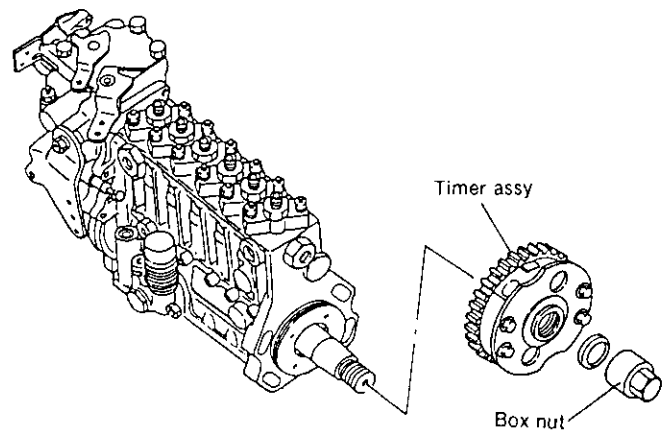
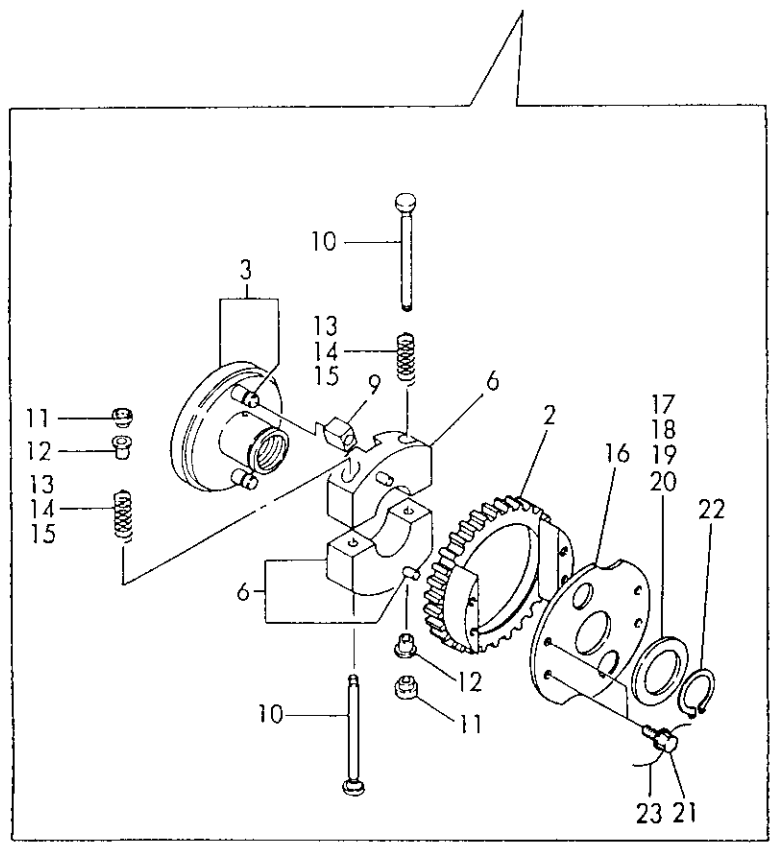
# 8. Automatic Advancing Timer

## 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.

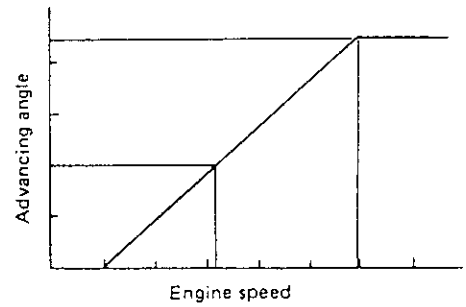
| | |
|---|---|
| Model<br>Identification code<br>Advanced angle | *See separate service data* |



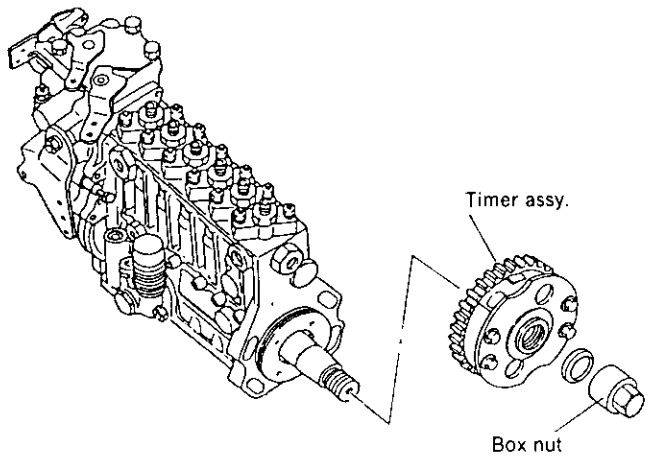

## 8-2 Function and characteristics of timer

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



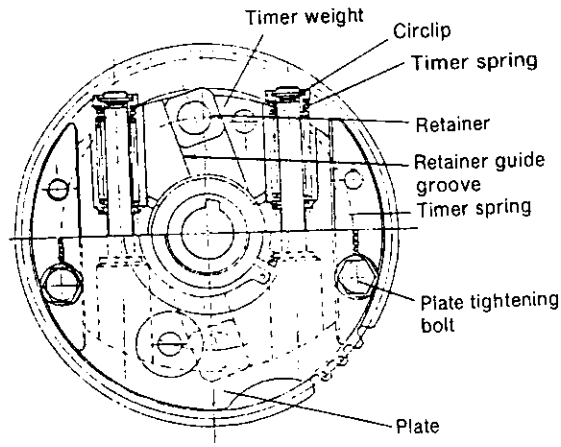

(1) Remove the camshaft box nut.
(2) Use a timer extractor to remove the remove the timer assembly.
(3) The retainers and weights can be removed when you take off the circlip and plate tightening bolts and separate the timer gear and timer hub.

***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 |



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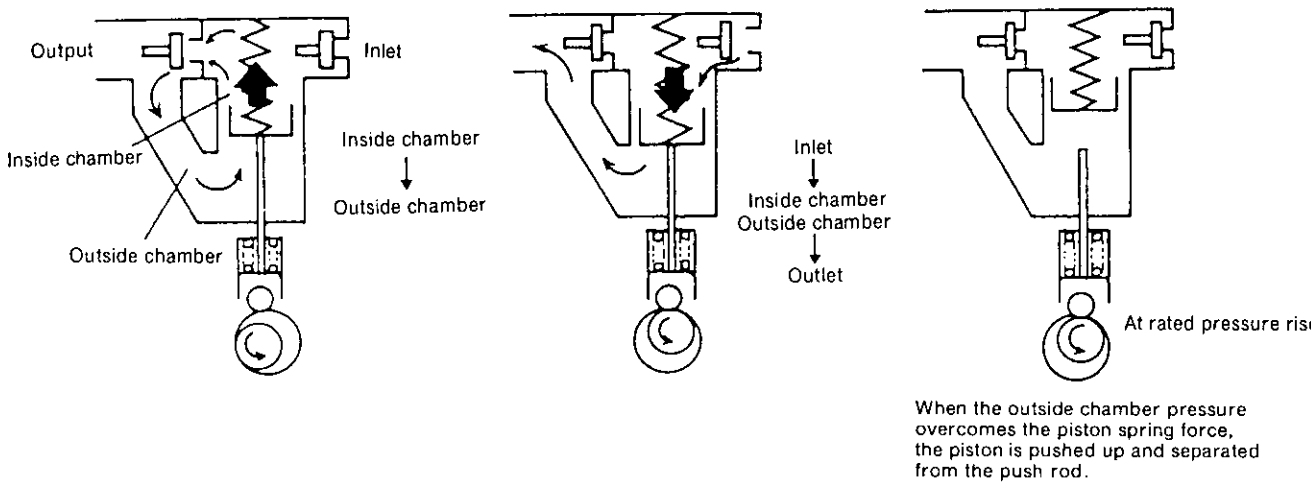
# 9. Fuel Feed Pump

## 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.

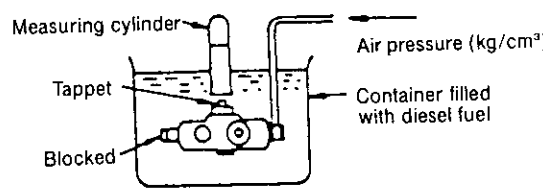
## 9-2 Fuel Feed Pump Inspection

(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 calked into the feed pump body, the whole fuel pump body must be replaced.

*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.*

## 9-3 Fuel Feed Pump Reassembly

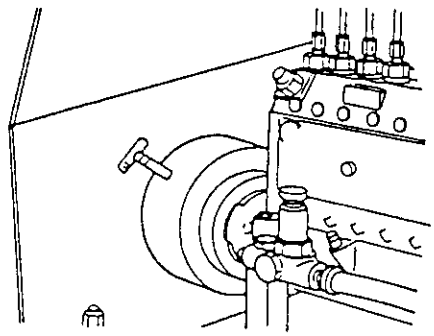
(1) To reassemble the fuel feed pump, follow the assembly procedure in reverse order.
(2) When the pump has been reassembled, perform the air-tightness test.
Apply 3 kg/cm² of air pressure to the discharge outlet of the pump, and check for air leaks from the O-ring. If air is leaking, replace the O-ring.



## 9-4 Fuel Feed Pump Adjustment

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

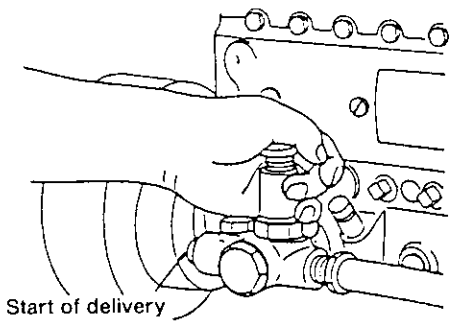
Set the fuel feed pump on the injection pump, and operate the assembled unit on the pump tester.

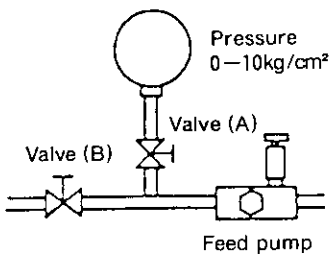


Fuel piping should be provided directly from the tank, not through the delivery pump of the tester.

(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.

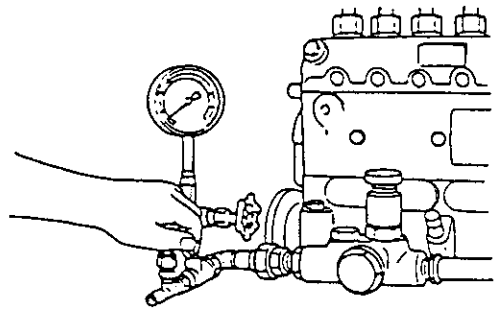
| | | |
|---|---|---|
| Suction head | 1m | Within 30 strokes |
| Suction pipe dia. | $\phi$ 8 | |




**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**

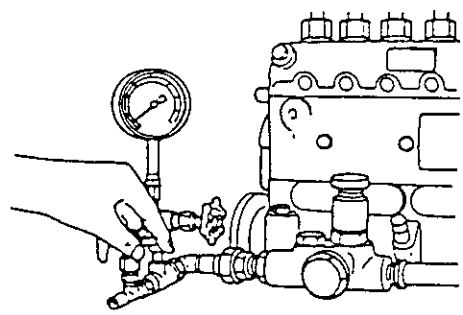
*NOTE:1. Do not run the equipment for more than 5 minutes since the fuel injection pump may be damaged if operated in noninjection condition.*
*2. Operate the injection pump at the specified rpm, and read the pressure gauge indicator when valve B is tightened completely. Tighten valve A so that the pressure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

- **Volume pressure (kg/cm²) : 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/cm2, and measure the delivery rate for one minute.

- Volume ( $\ell$ /min.) : over 1.8
- Back pressure (kg/cm²) : 1
- rpm: 1000



**Delivery test**



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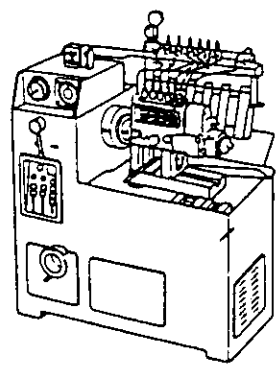
# 10. Adjustment of Fuel Injection Pump and Governor

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.



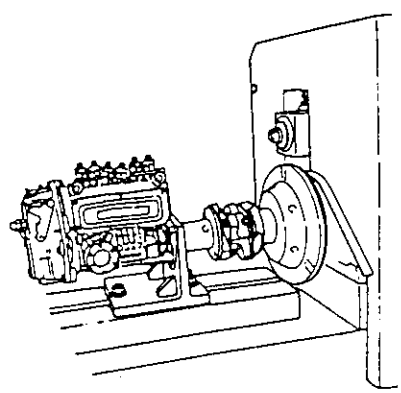
| | |
|---|---|
| Adjusting nozzle type | *See separate service data* |
| Injection starting pressure | |

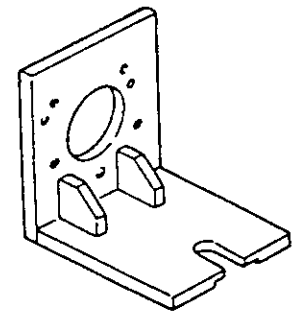
(2) Adjusting injection pipe.

mm(in.)

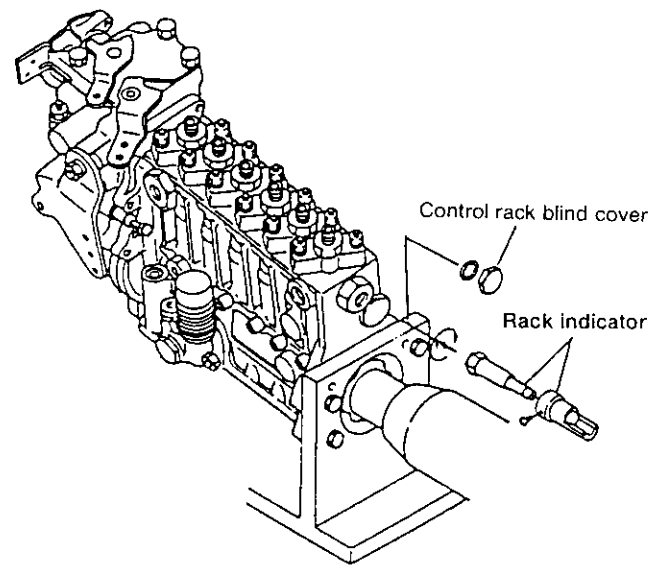
| | |
|---|---|
| Inner dia./outer dia. × length | *See separate service data* |
| Minimum bending radius | 25(0.98) |

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

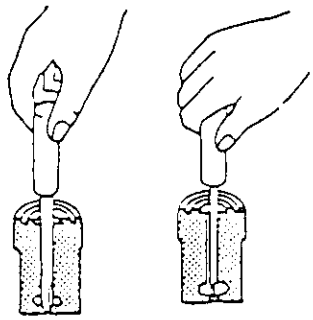




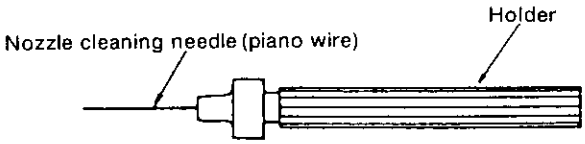
(4) Remove the control rack blind cover and fit the rack indicator.
Next, turn the pinion from the side of the pump until the control rack is at the maximum drive side position, and set it to the rack indicator scale standard position. Then make sure that the control rack and rack indicator slide smoothly.



(5) Clean the nozzle seat with cleaning spray.

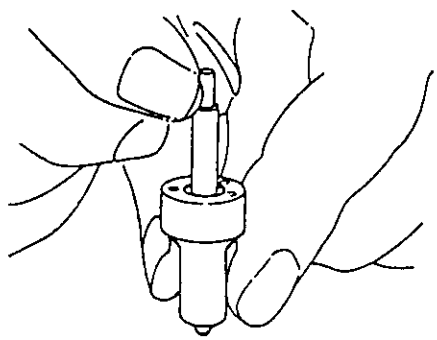


(6) Clean off the carbon on the tip of nozzle with a piece of wood.
(7) Clean hole type nozzles with a nozzle cleaning needle.

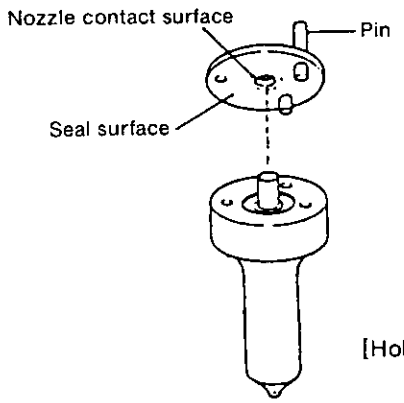



## 10-2 Nozzle inspection

(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 swhere it does not slide smoothly.



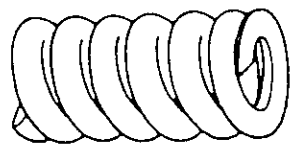
(3) Inspecting stop plate (inter-piece)
Check for scratches/wear in seals on both ends, check for abnormal wear on the surface where it comes in contact with the nozzle; replace if the stop plate is excessively worn.




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.

(1) 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.
(2) Use the special holder when tightening the nut for the hole type nozzle as in disassembly.

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



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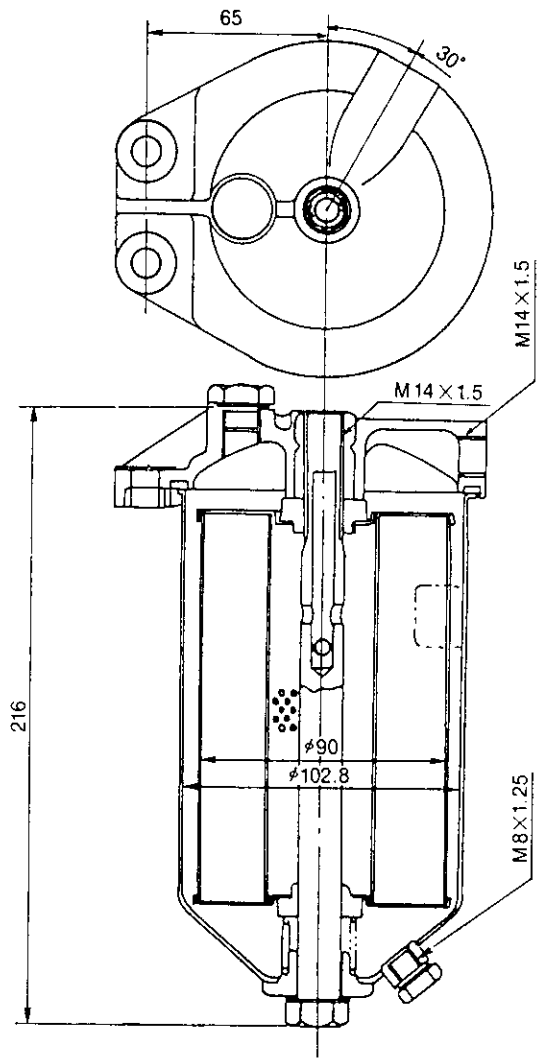
# 11. Fuel Filter

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.



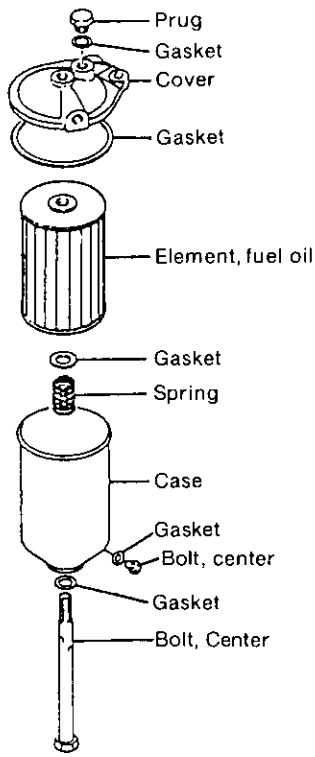

## 11-1 Fuel filter specifications

| | |
|---|---|
| Filtering method | filter paper Element |
| Filtering area | 4,000 cm² |
| Element | Max 45 μ, Ave. 35 μ |

## 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 |



CHAPTER 4

# TURBOCHARGER SYSTEM

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# 1. Construction and Function

## 1-1 Outline

### 1-1.1 Turbine

Exhaust gas coming out of the engine is accelerated of its flowing speed through the nozzle of the turbine wheel chamber and blown against the turbine wheel to give a torque to the turbine shaft.
This us called a turbine, in which seal rings and shrouds are assembled for protection of bearings from gas.

### 1-1.2 Blower

The blower impeller mounted on the turbine shaft receives the torque force of the turbine shaft, sucks in the air and compresses it to be sent into the air feed pipe.
This is called a blower.

### 1-1.3 Bearings

(1) Thrust metal
Thrusting force is applied to the turbine shaft at all times. The thrust metal prevents the shaft from being shifted by this thrusting force.

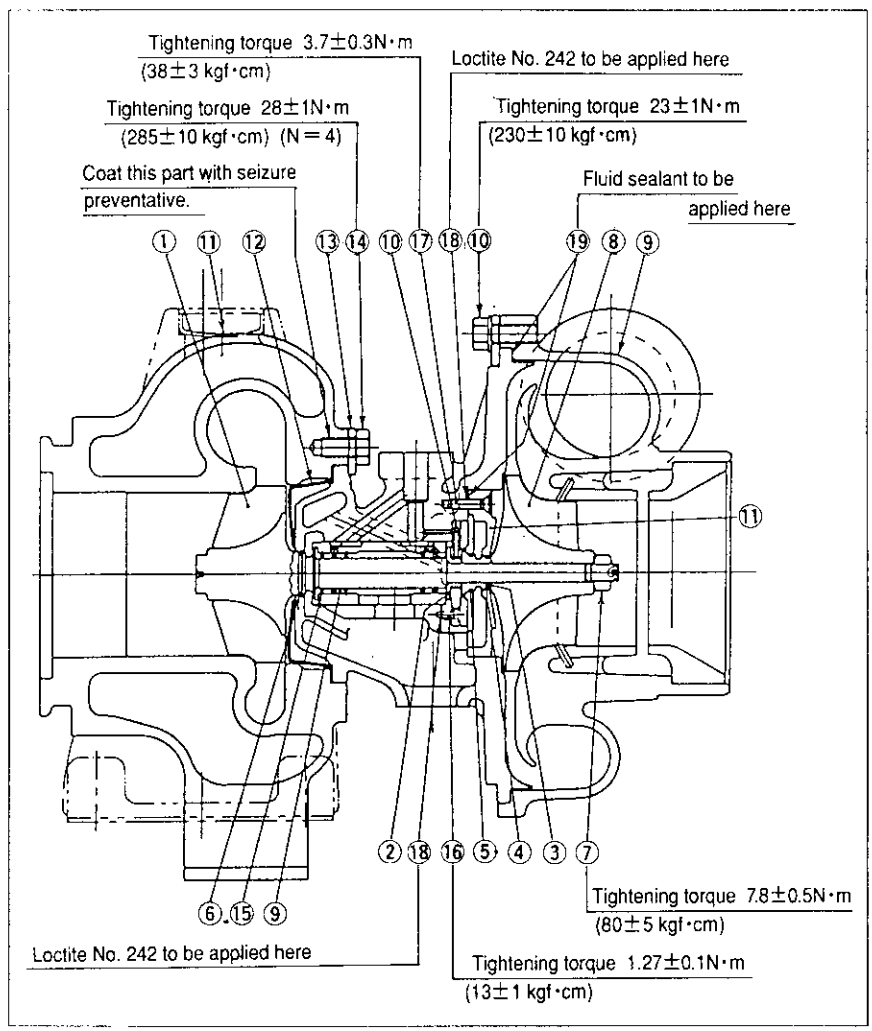
(2) Radial metal
Unlike an ordinary fixed type metal, the floating metal has double oil films at the inside and outside faces of the bearing which follows the metal rotation. Accordingly, the sliding speed on the bearing face becomes lower than the turbine shaft rotating speed, thus heightening the effect of dynamic stability.

### 1-1.4 Sealing mechanism at blower side

For prevention of air and oil leakage, the back side of the blower impeller is lined with double wall and provided with a seal ring and oil defensive plate.

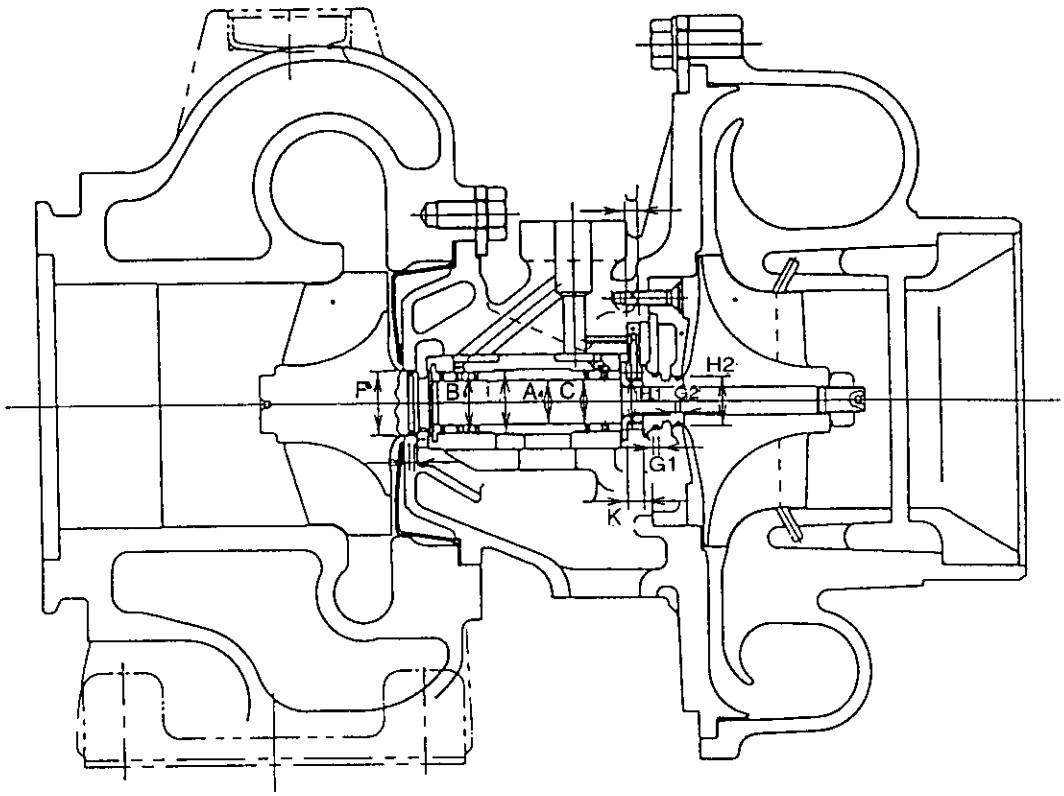
| NO. | Name | Q'ty |
|---|---|---|
| 1 | Turbine shaft | 1 |
| 2 | Thrust bush | 1 |
| 3 | Oil thrower | 1 |
| 4 | Compressor-side seal ring (small) | 1 |
| 5 | Compressor-side seal ring (large) | 1 |
| 6 | Turbine-side seal ring | 1 |
| 7 | Shaft end nut | 1 |
| 8 | Compressor impeller | 1 |
| 9 | Floating metal | 2 |
| 10 | Thrust bearing | 1 |
| 11 | Compressor housing | 1 |
| 12 | Flange hexagon bolt (M8) | 6 |
| 13 | Turbine housing | 1 |
| 14 | Shroud | 1 |
| 15 | Turbine-side pressure plate | 8 |
| 16 | Hexagon bolt (M8) | 8 |
| 17 | Retaining ring | 3 |
| 18 | TORX T across-head machine screw 54(M3) | 3 |
| 19 | TORX T across-head machine screw 54(M4) | 4 |
| 20 | Adhesive (Locktight) | — |
| 21 | Fluid sealant | — |

**Sectional View (RHC7W Turbocharger)**



# 2. Standards for Maintenance and Check

## 2-1 Standards for Maintenance and Check




(Unit : mm)

| | Check Item | Limit of Use | Remarks |
|---|---|---|---|
| Turbine Shaft | Turbine shaft journal O.D. (A) | 12.280 | |
| | Turbine-side seal ring groove width (E) | 1.630 | |
| | Blower-side seal ring groove width (G1) | 1.750 | |
| | Blower-side seal ring groove width (G2) | 1.520 | |
| | Turbine shaft runout | 0.011 | |
| Bearings | Floating metal I.D. (C) | 12.360 | |
| | Floating metal O.D. (D) | 16.980 | |
| | Bearing base I.D. (B) | 17.110 | |
| Thrust metal bearing | Thrust metal width (J) | 4.480 | |
| | Thrust bush groove-to-groove dimension (K) | 4.680 | |
| Seal ring inserting parts | Turbine side (Bearing wheel chamber) (F) | 18.550 | |
| | Blower side (seal plate) (H1) | 16.050 | |
| | (H2) | 14.050 | |
| Play in rotor axial direction | | 0.110 | Maintenance standard 0.06 ~ 0.09 |
| Play in rotor radial direction | | 0.215 | Maintenance standard 0.11 ~ 0.18 |



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## 2-2 Tightening Torque

| Item | Tightening Torque (kgf/cm) | N・m |
|---|---|---|
| Turbine shaft runout (M8) | 285±10 | 28±1 |
| Blower wheel chamber set bolt (M8) | 230±10 | 23±1 |
| Thrust metal setscrew (M3) | 13±1 | 1.27±0.1 |
| Sealing plate setscrew (M4) | 38±3 | 3.7±0.3 |
| Blower impeller set nut (M8) | 80±5 | 7.8±0.5 |
| Actuator set bolt (M8) | 285±10 | 28±1 |
| Valve case cover set bolt (M8) | 285±10 | 28±1 |

# 3. Periodical Checking Procedure

## 3-1 Periodical Checking Interval

Check the entire status and contamination of turbocharger at regular intervals.
The checking intervals vary depending on the conditions of use. Perform checking work at the intervals as shown below according to individual purposes of use.

| Purpose of Use | Checking Intervals | | |
|---|---|---|---|
| For Marine Use / Check Item | Every 6 months or 1,500operating hrs. | Every 12 months or 3,000operating hrs. | Every 24 months or 6,000operating hrs. |
| Rotation of rotor | ○ | | |
| Play of rotor | | ○ | |
| Disassembly, cleaning and checking of entire supercharger | | | ○ |

## 3-2 Checking Procedure

(1) Checking of rotation of rotor

Check the rotation of the rotor by hearing whether it produces an abnormal sound or not during rotation.
When using a listening rod, tap the tip of it closely to the turbocharger case and pick up the engine speed gradually.
If a high-pitched sound is heard successively every 2-3 seconds, it means that the rotation of rotor is abnormal.
When such a symptom is observed, the metal and rotor may be in trouble. In such case, the turbocharger should be replaced or disassembled and repaired,



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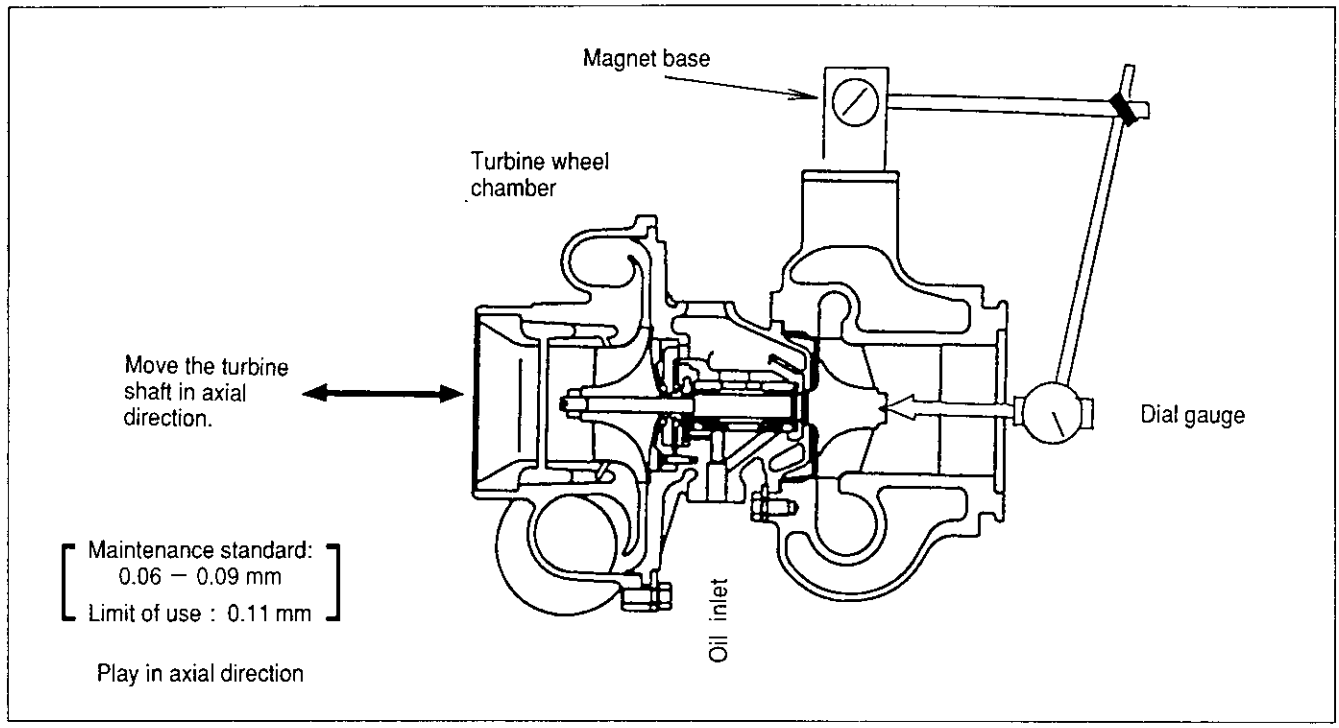
(2) Checking of play of rotor

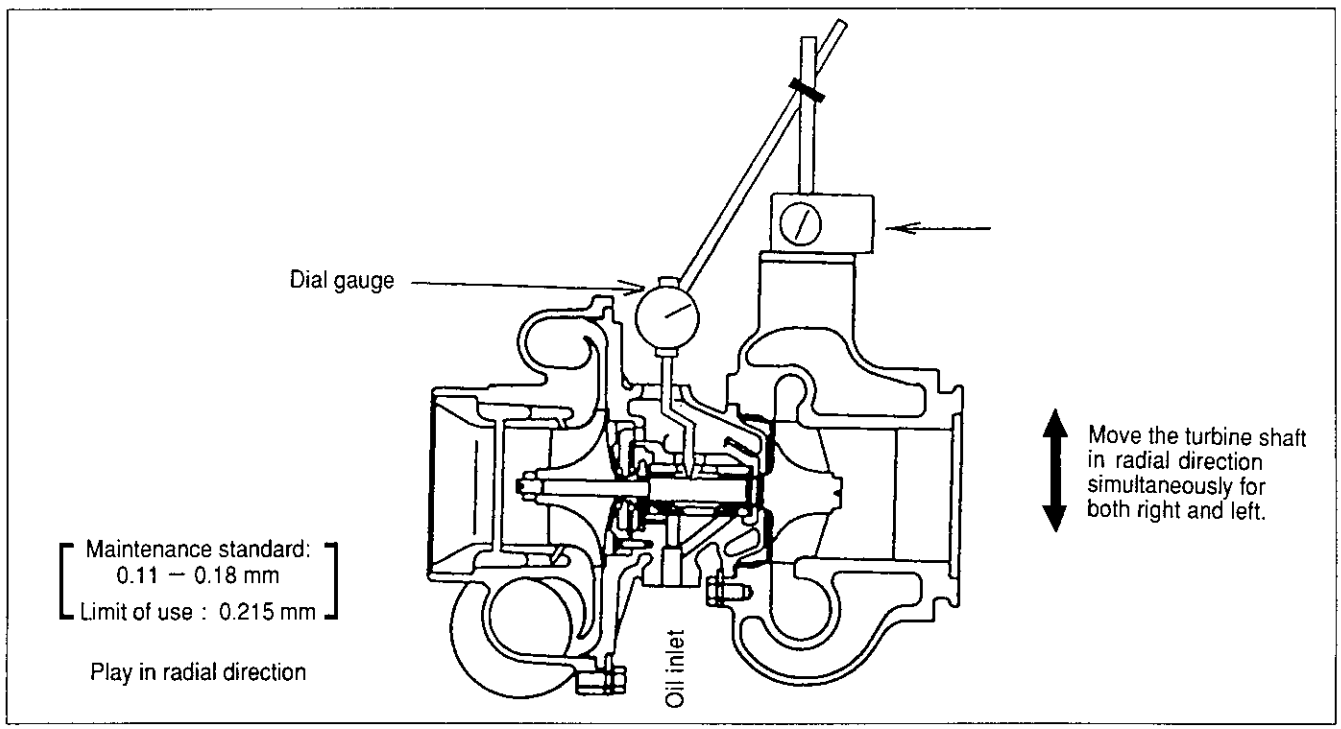
Dismount the turbocharger from the engine, and check the play of the rotor in axial and radial directions in the procedure below.

When the turbocharger is dismounted from the engine, cover the oil holes by gummed tape or the like.

1) Play of rotor in axial direction



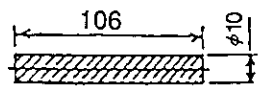
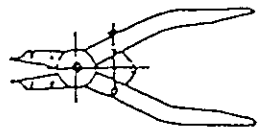
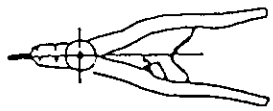
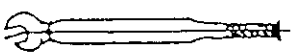
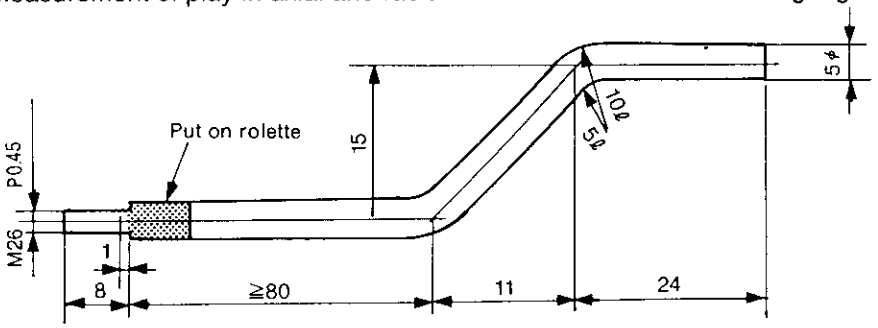

2) Play of rotor in radial direction



# 4. Disassembly Procedure

## 4-1 Preparations for disassembly

When assembling and disassembling the turbocharger, the special tools as shown below are necessary in addition

| Name of Tool | Purpose of Use | Remarks |
|---|---|---|
| Bar | Removal of thrust metal and thrust bush |  Material : Copper or brass |
| Pliers | Mounting and dismounting of retaining ring of floating metal |  |
| Pliers | Mounting and dismounting of seal ring |  |
| Torque screwdriver for<br>TORX bolt (Universal type)<br>5kg/cm~50kg/cm | Mounting of seal plate (38kgf-cm) 3.7±0.3 N-m for M4<br>Mounting of thrust metal (13 kgf-cm) 1.27+1 N-m for M3 | Available in the market<br>  <br>(Type: Equivalent to TORX TT20) |
| Torque wrench<br>(Single-purpose type) | Mounting of turbine housing (285 kg-cm) 28+1 N-m for M8<br>Mounting of compressor housing (230 kg-cm) 23+1 N-m for M8<br>Tightening of shaft end nut (13mm, 80 kg-cm) for M8 | Available in the market<br>  |
| Box wrench | Fixing of turbine shaft (14 mm x 12 sq.) |  Only box part of the wrench will do. |
| Measuring probe | Measurement of play in axial and radial directions | Set it to dial gauge.<br>  |



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## 4-2 Check before Disassembly

(1) Make sure that the turbine wheel and the blower wheel are out of contact with their cases, and check to see if the rotor rotates smoothly.

(2) **Measure the play of rotor.**
See the description in 3-2) for the measurement.

1) Play of rotor in axial direction

| Limit of use : 0.110 mm |
|---|

2) Play of rotor in radial direction

| Limit of use : 0.215 mm |
|---|

## 4-3 Disassembly

Since the assembling angles of the turbine wheel chamber, bearing wheel chamber and blower wheel chamber of the supercharger have been set according to the set-up posture to the engine, put match marks on them before disassembly.

### 4-3-1 Disconnection of boost hose

(1) Move the clip to the center of the boost hose

(2) Disconnect the boost hose from the blower wheel chamber and the waste gate actuator.

### 4-3-2 Dismounting of blower wheel chamber

(1) Remove the M8 hexgon bolt and blower side pressure plate.

(2) Dismount the blower wheel chamber.

**Note-1 :** Liquid gasket has been applied to the mounting surface of the blower housing and bearing housing.

**Note-2 :** Pay attention not to damage the blower wheel when disassembling the blower wheel chamber.

### 4-3-3 Dismounting of blower wheel

(1) Fit the box wrench (14 mm) to the turbine-side end of the turbine shaft ①, and remove the shaft end nut ⑦.

**Note :** The shaft end nut has left-hand thread. Pay attention to the turning direction.

(2) Dismount the blower wheel ⑧.

### 4-3-4 Removal of turbine housing

(1) Remove the (M8)hexagon bolt 44 and turbine side pressure plate.

(2) Remove the turbine housing.

### 4-3-5 Removal of turbine shaft

(1) Press down lightiy with your hand on the radiation ation shield 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.

### 4-3-6 Removal of seai plate

(1) Loosen the M4 TORX T across-head machine screw used for attachment and removal of seal plate with the TORX screwdrier.

(2) Remove the seal plate.

**Note :** Screw 2 pcs of M6 bolts into the screw holes used for removing the seal plate, and then use the bolts as handles to lift out the plate.

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

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

### 4-3-7 Removal of thrust bearing and thrust bush

(1) Using the TORX screwdriver (TT20), loosen the TORX T across-head machine screw off the thrust bearing and thrust bush.

(2) Remove the thrust bearing and the thrust bush ② with use of the copper bar.

### 4-3-8 Removal of floating metal

(1) Remove the blower-side floating metal from the bearing wheel chamber.

(2) Remove the turbine-side retaining ring from the bearing wheel chamber by means of the stop ring pliers.

(3) Remove the turbine-side floating metal from the bearing wheel chamber.

(4) Remove the turbine's far-side and the blower's far-side retaining rings from the bearing wheel chamber by means of the stop ring pliers.

### 4-3-9 Removal of seal ring

(1) Remove the turbine-side seal ring ⑥ from the turbine shaft ①.

(2) Remove the blower-side seal ring ④⑤ from the oil thrower ③.

# 5. Cleaning and Checking Procedure

## 5-1 Cleaning

### 5-1.1 Checking before cleaning

Before cleaning, visually check the disassembled parts for any seizure, wear, foreign matters or carbon deposits. Closely check for the above-mentioned abnormalities in case of any trouble, and pinpoint the cause of trouble at this stage.

〈Major Check Items〉

| Check Item | Position to Be Checked |
|---|---|
| Carbon deposits | 1) Turbine shaft ①, turbine-side seal ring, and turbine wheel backside.<br>2) Mounts for bearing wheel chamber and shroud,and bearing wheel chamber inside wall. |
| Lubrication<br>(wear, seizure, discoloration, etc.) | 1) Turbine shaft ①, journal and thrust bush ②, and oil thrower ③.<br>2) Floating metal and thrust bearing.<br>3) Bearing wheel chamber, and inner periphery of bearing snap ring. |
| Oil leak | 1) Turbine wheel chamber inside wall.<br>2) Outer periphery of bearing wheel chamber, and shroud mount.<br>3) Turbine shaft ①, turbine-side seal ring, and turbine wheel backside.<br>4) Blower wheel chamber inside wall.<br>5) Blower wheel chamber ⑧ backside.<br>6) Sealing plate 11 surface and sealing ring insertion groove. |



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## 5-1.2 Cleaning procedure

In cleaning the parts, keep the following points in mind.

| Section | Tools and Detergent | Cleaning Procedure |
|---|---|---|
| (1) Turbine Shaft | 1. Turbine ShaftTools<br>1) Washing bucket (500×500)<br>2) Heat source : steam or gas burner<br>3) Brush<br>2. Detergent : carbon remover sold in the market may be used. | 1) Immerse the turbine shaft in the washing bucket and heat the solution. Do not beat the wheel for removal of carbon deposit.<br>2) Immerse the parts until dirt deposits become soft by penetration of detergent.<br>3) When the deposits get soft, remove them with use of a plastic spatula or bristle brush.<br>4) Protect the bearing surface of the turbine shaft and the seal ring groove from damage during cleaning.<br>5) Incomplete cleaning will leave residual deposits which may cause an imbalance in shaft rotation. Do not use a wire brush for cleaning. |
| (2) Turbine Wheel Chamber | 1. Tools : Same as for cleaning the turbine shaft<br>2. Detergent : Same as for cleaning the turbine shaft | 1) Apply cleaning fluid to heavily soiled parts of the turbine housing.<br>2) Use a plastic scraper or a stiff natural bristle brush to clean. |
| (3) Blower Wheel Chamber | 1. Tools<br>1) Washing bucket (500×500)<br>2) Brush<br>2. Detergent | 1) Immerse the parts until dirt deposits become soft by penetration of detergent.<br>2) When the deposits get soft, remove them with use of a plastic spatula or bristle brush. Do not use a wire brush. |
| (4) Others | (1) Wash all the other parts with gas oil.<br>(2) Clean the lube oil passages by blowing compressed air.<br>(3) In the cleaning work, pay close attention not to damage the parts and get them rusted. | |

## 5-2 Checking Procedure

### 5-2.1 Blower wheel chamber

Check the chamber surface for any scratch, nick, crack, etc. which may be caused by contact with the rotating wheel. If any of the defects is found, replace the chamber with new one.

### 5-2.2 Turbine wheel chamber

Check the chamber surface for any scratch caused by contact with rotating wheel, removal of casting skin due to oxidization, thermal deformation, crack, etc. If any of the defects is found, replace the chamber with new one.

### 5-2.3 Blower wheel ⑧

Check it for any scratch by contact, defect, corrosion, deformation, etc. If any, replace the wheel with new one.

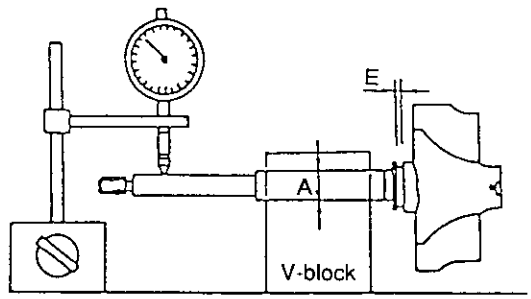
### 5-2.4 Turbine shaft ①

(1) Check the turbine wheel for any scratch by contact, defect, thermal discoloration, deformation, etc. Check also the shaft for any bend, journal's thermal discoloration or unusual wear, seal ring groove's scratch or wear, etc. If any of the defects is found, replace the shaft with new one.

(2) Measure the outer diameter (A) of the turbine shaft journal and the seal ring groove width (E). If they are worn more than the limit of use, replace them with new ones.

| Journal O.D. (A) |
|---|
| Limit of use : 12.28 mm |

| Seal ring groove width (E) |
|---|
| Limit of use : 1.63 mm |




(3) Check the turbine shaft for runout, and if it exceeds 0.011mm, replace the shaft with new one.

### 5-2.5 Shroud 42

Check the shroud for any scratch by contact, thermal deformation, corrosion, etc. If any of the defects is found, replace the shroud with new one.

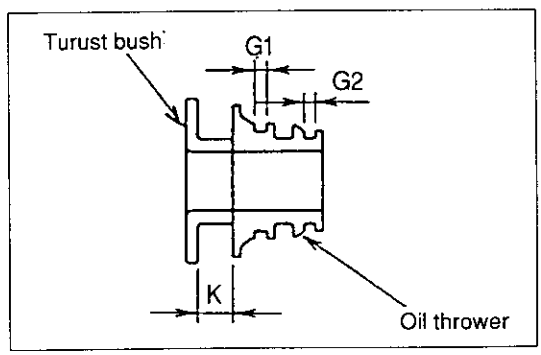
### 5-2.6 Thrust bush②, oil thrower③ and thrust bearing

Check these parts for scratch, discoloration, etc. Replace any defective part with new one even if it is still within the limit of use.

(1) Thrust bush ②

Measure the thrust bush groove-to-groove dimension (K). If it is found greater than the limit of use, replace the bush with new one.

| Limit of use : 4.68 mm |
|---|



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(2) Oil thrower ③
Measure the widths (G1)(G2) of the seal ring groove.
Replace if it exceeds the limit.

| Limit of use : (G1) 1.75mm (G2) 1.52mm |
|---|

(3) Thrust bearing 22
Measure the thrust bearing width (I), and if it is found greater than the limit of use, replace the bearing with new one.

| Limit of use : 4.48mm |
|---|

### 5-2.7 Floating metal 21

(1) Check the floating metal for any abnormal wear, discoloration, scratch, etc. If any of the defects is found, replace the metal with new one.
(2) Measure the metal I.D. (C) and O.D. (D), and if they are found greater than the limits of use, replace the metal with new one.

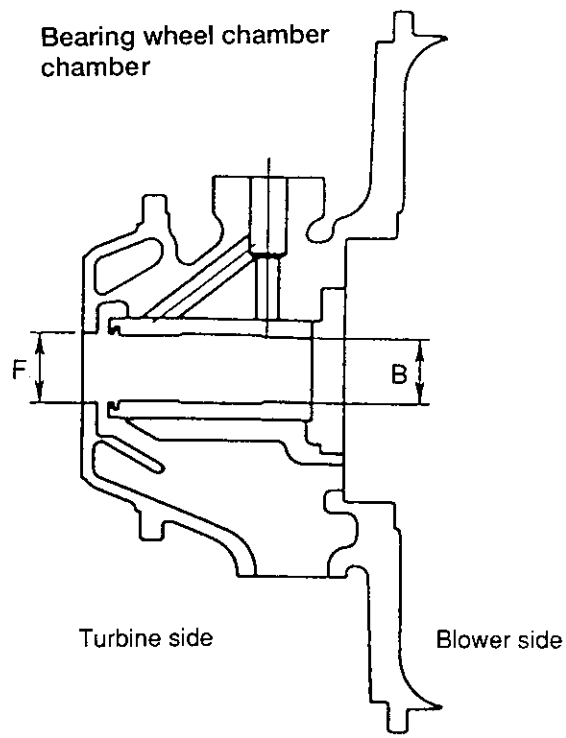
| Limits of use : O.D. (D) ; 16.98 mm<br>I.D. (C) ; 12.36 mm |
|---|

### 5-2.8 Bearing wheel chamber

(1) Check the chamber for any removal of casting skin due to oxidation, nick, crack, etc. If any of the defects is found, replace the chamber with new one.
(2) Check the retaining metal for any breakage, crack, etc. If any of the defects is found, replace the metal with new one.
(3) Measure the dimensions (B) and (F) of the chamber as shown in the figure, and if they are found greater than the limits of use, replace the chamber with new one.

| Bearing wheel chamber I.D. (B)<br>Limit of use : 17.11 mm |
|---|

| Turbine-side seal ring insertion hole (F)<br>Limit of use : 18.55 mm |
|---|

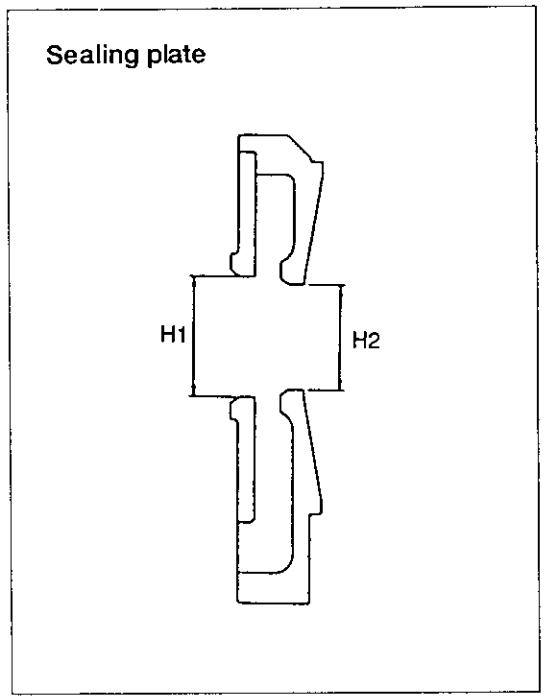


### 5-2.9 Sealing plate

(1) Check the plate for any scratch by contact, nick, crack, etc. on its surface. If any of the defects is found, replace the sealing plate with new one.

(2) Measure the seal ring insertion hole (H1)(H2), and if it is found greater than the limit of use, replace the sealing plate with new one.

| Limit of use : 14.05 mm |
|---|




### 5-2.10 Wastegate actuator

(1) Check for damage (marks, scratches, bent shape) and replace together with the turbine housing as a unit.

(2) Check the wastegate actuator by gradually introducing a stream of low-pressure air. If it fails to operate or if operation is not smooth, replace together with the turbine housing.

### 5-2.11 Check seal rings ④,⑤,⑥

Replace if damaged.

### 5-2.12 Check bolts for damage and replace any faulty ones.

Replace M3TORX T acrosshead machine screw and M4TORX T across-head machine screw.



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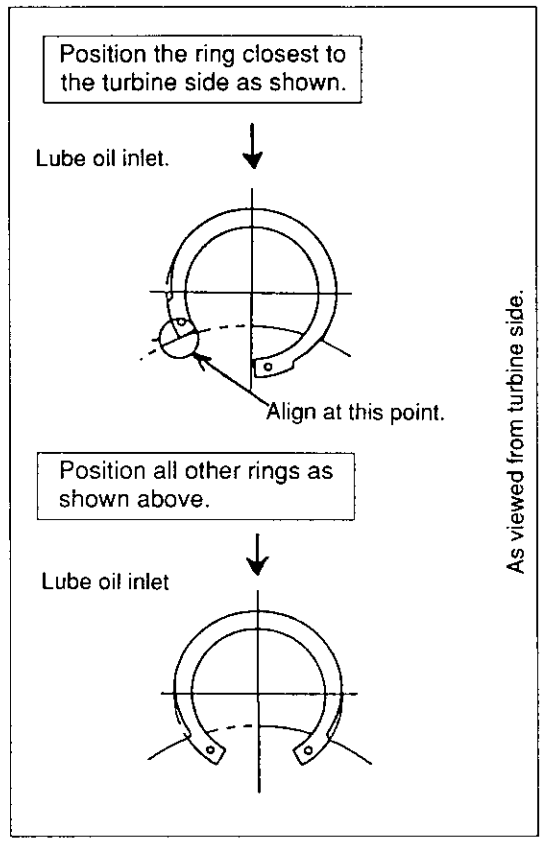
# 6. Reassembling procedure

## 6-1 Preparations for Reassembly

(1) When reassembling the turbocharger, prepare the general and special tools, fluid sealant (Three Bond No.1215) and Locktite No.242.

(2) Replace the following parts without fail before reassembling.

| | |
|---|---|
| Blower-side seal ring (small) | ④ × 1 pc |
| Blower-side seal ring (large) | ⑤ × 1 pc |
| M3 pan-head screw | 4 pcs |
| M4 pan-head screw | 4 pcs |




## 6-2 Reassembling procedure

### 6-2.1 Reassembling of floating metal

(1) Set the inner retaining ring to the bearing wheel chamber with use of the stop ring pliers.
(2) Fit the turbine-side floating metal into the bearing wheel chamber.
(3) Set the turbine-side outer retaining ring into the bearing wheel chamber with use of the stop ring pliers.
(4) Fit the blower-side floating metal into the bearing wheel chamber.

Note 1 : Set the retaining ring so that its round side faces the metal side.

Note 2 : Apply engine oil to the floating metal before reassembling.

### 6-2.2 Reassembling of turbine shaft

(1) Fit the seal ring ⑥ to the turbine shaft 1.
(2) Mount the shroud to the turbine side of the bearing wheel chamber.
(3) Apply engine oil to the turbine shaft journal and insert the shaft into bearing wheel chamber from its turbine side.

Note : Use due care not to damage the floating metal by the turbine shaft. When inserting the shaft, face the cut of the seal ring toward the oil inlet and align the ring with the turbine shaft.

### 6-2.3 Mounting of thrust metal

(1) Fit the thrust bush (2) to the turbine shaft (1).
(2) Apply engine oil to the metal of the thrust bearing, and mount the bearing to the bearing wheel chamber.
(3) M3 TORX T across-head machine screw.
Fix the thrust metal with use of the TORX screwdriver.

Tightening torque : 13±1 kgf-cm

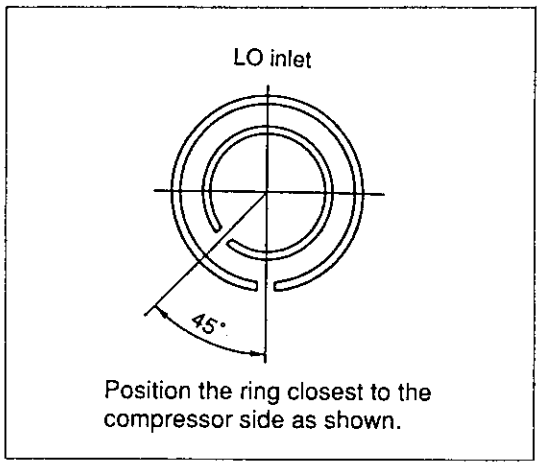
### 6-2.4 Mounting of sealing plate

(1) Fit the seal ring ④,⑤ to the oil thrower ③.
(2) Set the oil thrower ③ in the sealing plate.
**Note:** Adjust the gap in the seal ring to match the diagram.
(3) Apply fluid sealant (Three Bond No.1207) to the tur bine-side flange face of the sealing plate.
Note : Apply the sealant to the spots as shown at right.

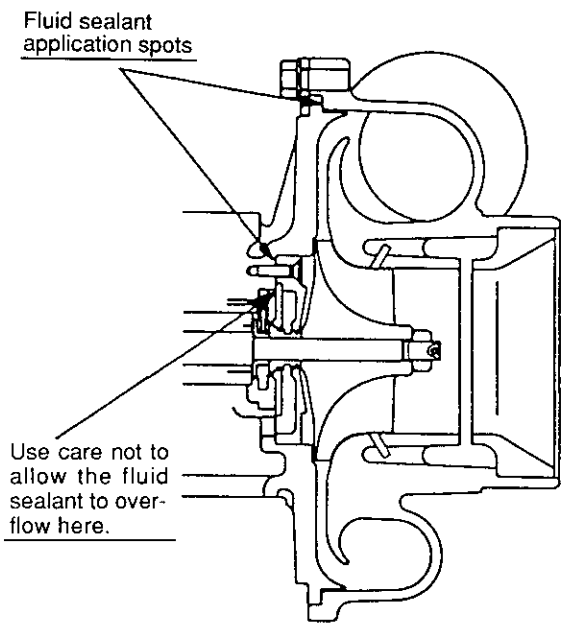
| Thickness of sealant : 0.1-0.2 mm |
|---|

(4) Mount the sealing plate to the bearing wheel chamber.
(5) TORX T across-head machine screw.

| Tightening torque : 38±3 kgf-cm |
|---|



Position the ring closest to the compressor side as shown.




### 6-2.5 Mounting of blower wheel

(1) Fit the blower wheel ⑧ to the turbine shaft ①.
(2) Apply the box wrench (14mm) to the turbine-side end of the turbine shaft ①, and tighten the shaft end nut ⑦.
**Note:** Pay attention to the tightening direction of the nut, which has left-hand threads.

| Tightening torque : 80±5 kgf-cm |
|---|

### 6-2.6 Mounting of turbine housing

(1) Assemble the turbine housing and the bearing housing aligning the guide marks made before disassembly.
**Note:** When the parts have been replaced, make sure that the oil inlet and outlet and air outlet are in their specified positions.
(2) Attach the turbine side pressure plate and tighten M8 Hexagon bolt with the torque wrench.

| Tightening torque : 285±10 kgf-cm |
|---|

### 6-2.7 Mounting of blower wheel chamber

(1) Apply fluid sealant (Three Bound No.1207) to the blower-side flange face of the bearing wheel chamber.

| Thickness of sealant : 0.1-0.2 mm |
|---|



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(2) Align the match markings and fit the blower wheel chamber to the bearing wheel chamber.

**Note :** When the parts have been replaced, make sure that the oil inlet and outlet and the air outlet are in their specified positions.

(3) Attach the blower side pressure plate and tighten M8 Hexagon bolt with the torque wrench.

| Tightening torque : 230±10 kgf-cm |
|---|

### 6-2.8 Connection of boost hose

(1) Fit the clip to the center of the boost hose.
(2) Insert the boost hose into the blower wheel chamber and the waste gate actuator.
(3) Move the clip up to the nipples of the blower wheel cham ber and the waste gate actuator in order to prevent the boost hose from slipping off.

### 6-2.9 Measurement of play of rotor

For the procedure of measurement, see 3-2) Checking procedure.
Play of the rotor beyond the maintenance standard is considered due to wrong reassembly or use of unspecified parts. It is therefore necessary to disassemble and reassemble the rotor.

(1) Play of rotor in axial direction

| Maintenance standard : 0.06 - 0.09 mm |
|---|

(2) Play of rotor in radial direction

| Maintenance standard : 0.11 - 0.18 mm |
|---|

# 7. Handling After Reassembly

In mounting the supercharger to the engine or handling the mounted turbocharger, keep the following points in mind.
Use particular care to prevent any foreign matters from coming into the turbocharger.

## 7-1 Precautions for mounting the turbocharger to the engine

### 〈Lubrication System〉

(1) Before mounting to the engine, pour fresh engine oil from the oil filler port, and turn the turbine shaft by hand to lubricate the floating metal and thrust metal.

(2) Clean up the oil inlet pipe and outlet pipe running from the engine, and check them for any crush or dust and dirt remaining in the pipes.

(3) Connect the oil pipes securely to their connections part not to allow any oil leak from the connections.

### 〈Suction System〉

(1) Make sure that there is no rubbish or foreign matter in the suction system.

(2) Mount the supercharger securely not to allow any air leak at the suction air duct and air cleaner connecting parts.

### 〈Exhaust System〉

(1) Make sure that there is no rubbish or foreign matter in the exhaust system.

(2) The bolts and nuts made of heat-resisting steel are used for the exhaust system. Do not confuse them with ordinary bolts and nuts used for other systems. Apply anti-seizure agent to the lock bolts and nuts.
(Heat-resisting bolts are use for the turbine wheel chamber.)

(3) Connect the exhaust pipes securely not to allow any gas leak at the connections.



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# 8. Troubleshooting

If the turbocharger gets in trouble, it can not perform as expected and a specified engine power can not be attained. In this case, first check up each part of the engine for any trouble, and when it is confirmed that there is no problem with the engine, then check the turbocharger, referring to the tables below, and take proper measures.

## 8-1 Exhaust gas is dense

### 〈Insufficient amount of suction air〉

| Possible cause | Correction |
|---|---|
| 1) Air cleaner element is clogged. | ○ Replace or clean the element. |
| 2) Air take-in port is blocked up. | ○ Remove obstruction. |
| 3) Air leaks at pipe connection. | ○ Check and repair the pipe. |

### 〈Supercharger does not operate〉

| Possible cause | Correction |
|---|---|
| 1) Impurities contained in oil precipitate at seal of turbine and hamper smooth rotation of turbine shaft. | ○ Change the engine oil and disassemble and clean the turbocharger. |
| 2) Seizure of metal<br>○ Insufficient oil feed or clogging of pipe<br>○ Too high oil temperature<br>○ Imbalance in rotating part<br>○ Insufficient warm-up operation or abrupt stopping of operation under load (No-load operation) | ○ Disassemble and repair the turbocharger.<br>○ Check the engine oil system, and repair the trouble spot and at the same time change the oil.<br>○ Replace or clean the rotating part.<br>○ Observe the operating precautions described in operation manual. |
| 3) Contact or breakage of turbine wheel or blower wheel<br>○ Over-rotation<br>○ Excessive rise of exhaust gas temperature<br>○ Entry of foreign matters<br>○ Wear of metal<br>○ Wrong reassembly | ○ Check each part of the engine and repair as required.<br>○ Disassemble the wheels and remove foreign matters completely and at the same time check the air cleaner and the engine and repair as required.<br>○ Disassemble and repair the turbocharger.<br>○ Reassemble the turbocharger. |

〈Effect of exhaust gas resistance〉

| Possible cause | Correction |
|---|---|
| 1) Rotating speed does not pick up due to exhaust gas leak before the turbocharger. | ○ Check the pipe connection and repair as required. |
| 2) Turbocharger fails to increase its speed due to deformed or blocked deformation or exhaust gas pipe. | ○ Repair the pipe to normal state. |

## 8-2 Whitish exhaust gas

| Possible cause | Correction |
|---|---|
| 1) Oil flows into blower side or turbine side due to clogged or deformed oil return pipe. | ○ Repair or replace the pipe. |
| 2) Seal ring is worn abnormally or broken due to excessive metal abrasion. | ○ Dissemble and repair the turbocharger. |

## 8-3 Too early oil shortage

| Possible cause | Correction |
|---|---|
| 1) Seal ring is worn abnormally or broken due to excessive metal abrasion. | ○ Disassemble and repair the turbocharger. |

## 8-4 Output drop

| Possible cause | Correction |
|---|---|
| 1) Gas leaks at part (s) in exhaust gas system. | ○ Disassemble and repair the turbocharger. |
| 2) Air leaks at discharge side of blower. | |
| 3) Clogging of air cleaner element. | ○ Clean or replace the element. |
| 4) Turbocharger is contaminated or damaged. | ○ Disassemble and repair or replace the turbocharger. |

## 8-5 Poor follow-up of supercharger

| Possible cause | Correction |
|---|---|
| 1) Carbon deposits stuck on turbine side (wheel seal) hampers smooth rotation of turbine shaft. | ○ Change the engine oil and at the same time disassemble and clean the turbocharger. |
| 2) Incomplete oil combustion. | ○ Check the engine combustion system and restore its combustion state. |



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## 8-6 Unusual sound or vibration

〈Unusual sound〉

| Possible cause | Correction |
|---|---|
| 1) If gas passage gets too narrow due to blockage of nozzle in turbine wheel chamber or gas flow speed is too fast, air discharged from blower is blocked and it flows reversely. (This phenomenon is generally called "surging".) | ○ Disassemble and clean the turbocharger. |
| 2) Rotating part is in contact. | ○ Disassemble and repair or replace the turbocharger. |

〈Unusual vibration〉

| Possible cause | Correction |
|---|---|
| 1) Connection between turbocharge and suction or exhaust pipe or oil pipe is loosened. | ○ Check installation state of the turbocharger, and restore the loose part. |
| 2) Turbine wheel or blower wheel is broken due to trouble with metal, contact of rotating part with peripheral part(s) or entry of foreign matter. | ○ Disassemble and repair or replace the turbocharger. In the case of entry of foreign matter, remove it completely. |
| 3) Imbalance in rotating part(s). | ○ Repair or replace the rotating part(s). |

CHAPTER 5

# LUBRICATION SYSTEM




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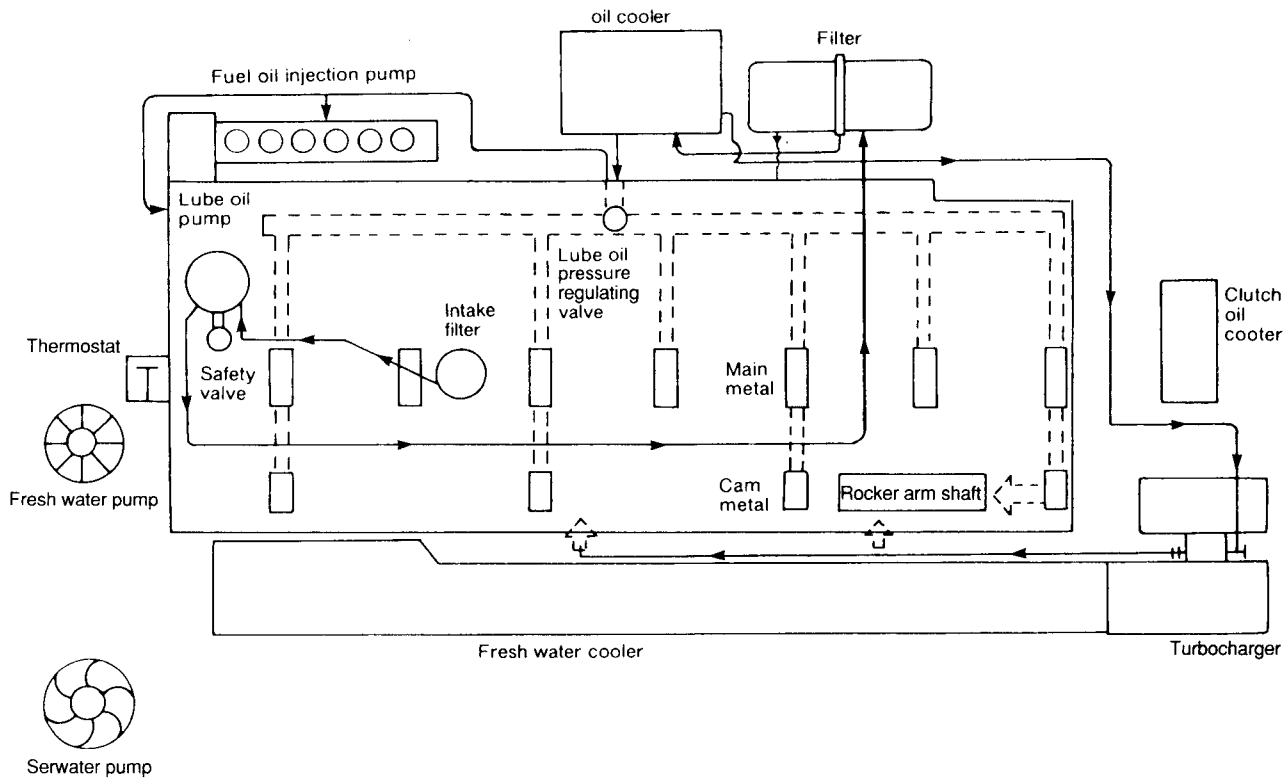
# 1. Lubrication System

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 rocker arm shaft to lubricate the rocker 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 turbocharger in engines fitted with one, and is then piped back from the turbocharger to the oil pan.




(Lube oil path ——►——)

# 2. Lube Oil Pump

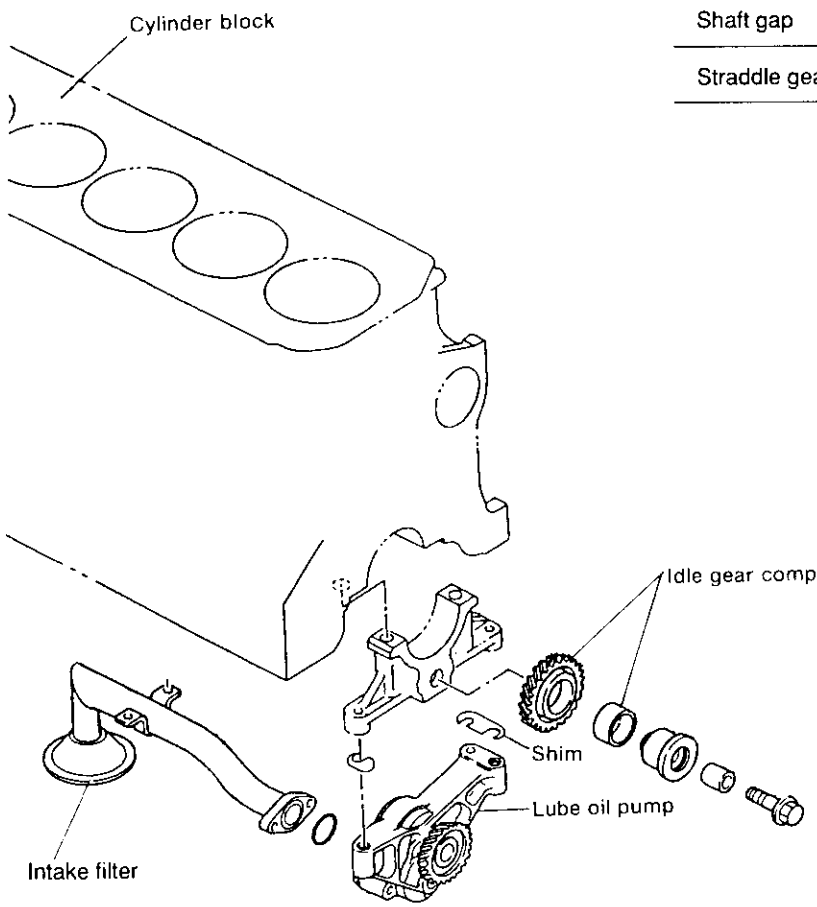
## 2-1 Lube oil pump construction

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/cm².

## 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/cm² |
| 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 | $73.363^{+0.048}_{0}$ mm |
| Straddle gear(no. of teeth) | $19.610^{0}_{-0.04(3)}$ mm |



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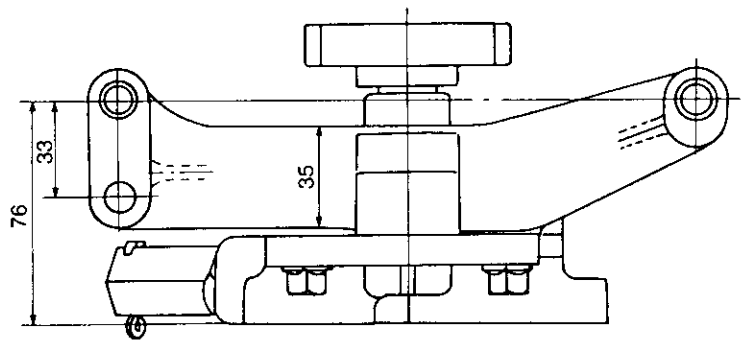
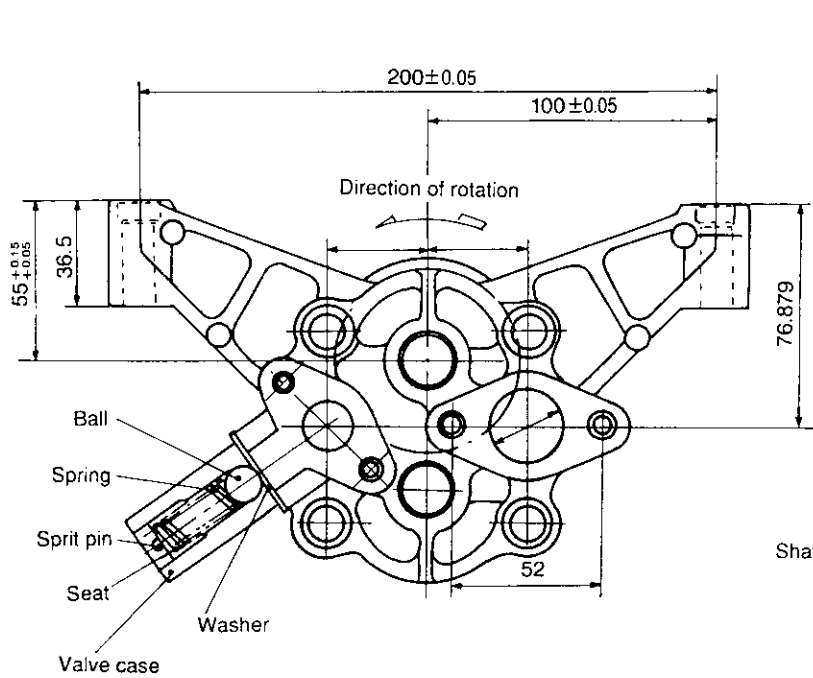
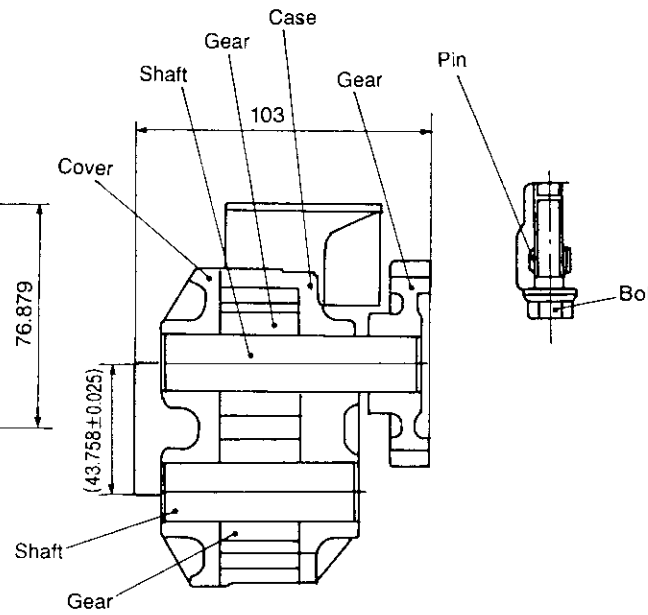

33
35
76


200±0.05
100±0.05
Direction of rotation
55 +0.15 +0.05
36.5
76.879
Ball
Spring
Sprit pin
Seat
Washer
Valve case
52


Case
Gear
Shaft
Gear
Pin
103
Cover
Bol
(43.758±0.025)
Shaft
Gear

## 2-3 Removal

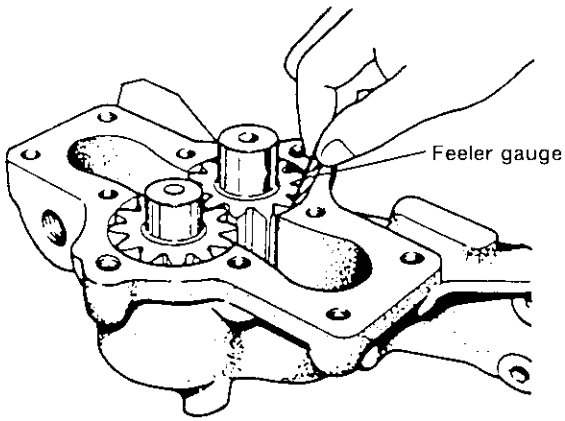
(1) Drain the engine oil.
(2) Remove the oil pan by screwing draw bolts in the thread holes in the oil pan.
(3) Remove the oil pump drive gear.
(4) Remove the oil inlet and outlet pipes.
(5) Remove the oil pump.

## 2-4 Inspection

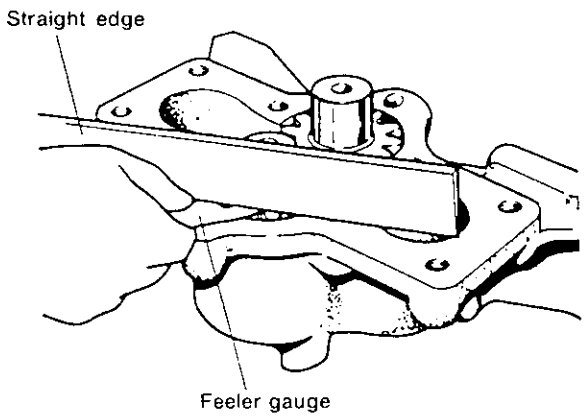
Remove the oil pump cover and measure the oil pump gear-to-oil pump body and the gear-to-cover clearances. If the measured value exceeds the service limit or if there is local wear, replace the oil pump assembly.

Gear-to-pump clearance
Service limit: 0.098 mm
Gear-tocover 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 Instllation

(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 temtemporarily. 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.*



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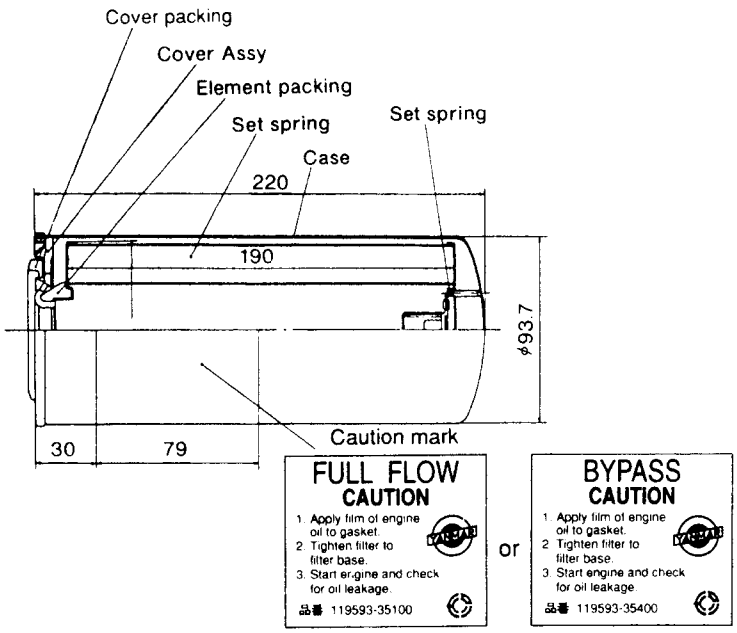
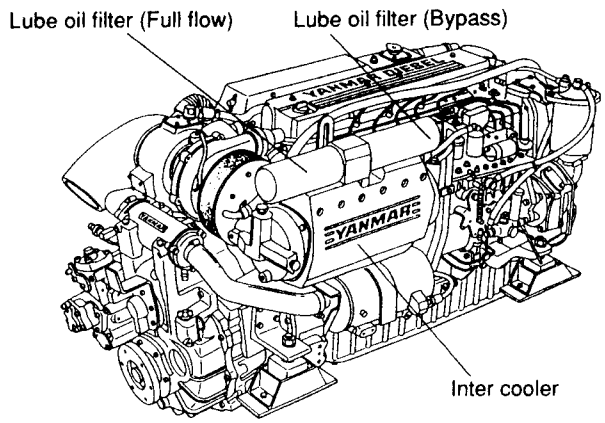
# 3. Lube Oil Filter

## 3-1 Lube oil filter construction

The lube oil filters are a full-flow paper element type and bypass 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.




## 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 (first time 50 hrs) |

(2) Replacement
1) Remove the lube oil filter with the filter wrench.
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 by hand and tighten an additional about 3/4 of a turn using the filter wrench (clockwise).
5) Run the engine after mounting the filter, and make sure that there is no oil leakage.

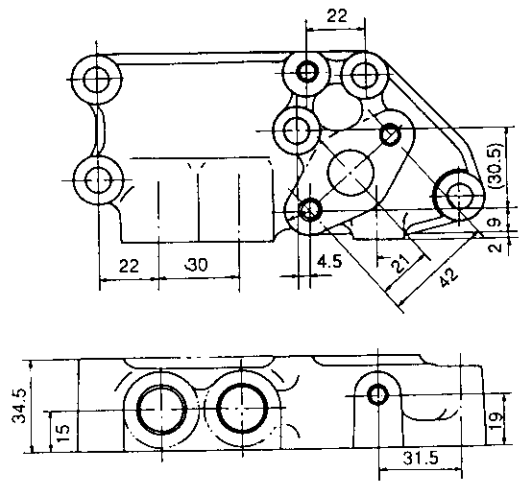
### Specifications

| | Full Flow | By pass |
|---|---|---|
| 1 Pressure loss | 0.03MPa(0.3kgf/cm²) or less | 3.4 ℓ /min flow |
| | (50 ℓ /min, SAE#30, 80℃) | (Differential press. In/out 0.44MPa(4.5kgf/cm²), SAE#30, 80℃) |
| 2 Relief valve pressure(Open) | 0.18±0.02MPa(1.8±0.2kgf/cm²) | 0.18±0.02MPa(1.8±0.2kgf/cm²) |
| 3 Filtration surface | 5700cm² | 5800cm² |
| 4 Pressure tightness | Element 12kgf/cm² or more | Element 12kgf/cm² or more |
| | Spin on 20kgf/cm² or more | Spin on 20kgf/cm² or more |
| 5 Impulse pressure tightness | Pulse pressure 0⇔9kgf/cm² | Pulse pressure 0⇔9kgf/cm² |
| | 4×10⁴ times when there are no problems | 4×10⁴ times when there are no problems |

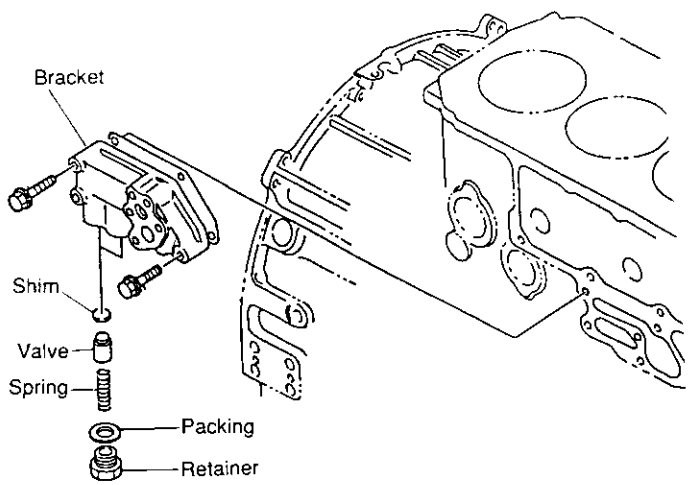
# 4. Oil Pressure Control Valve

## 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/cm² |




## 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 |



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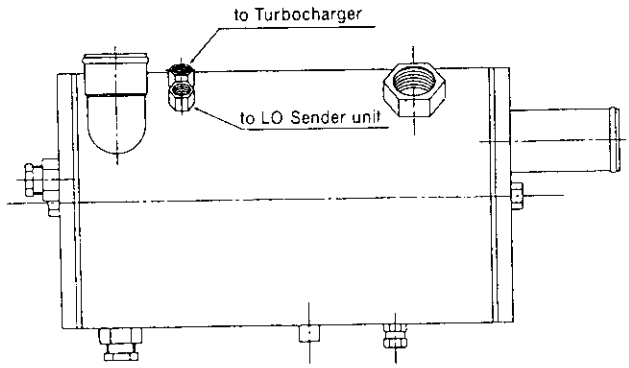
# 5. Lube Oil Cooler

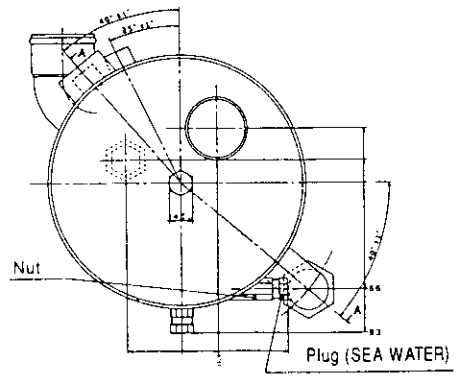
Amount of heat: 45000kcal/h
Temp. of sea water
(Cooler inlet): 45℃
Sea water flow: 10000ℓ/h
Oil flow: 5847ℓ/h
Target temp of oil: 100℃

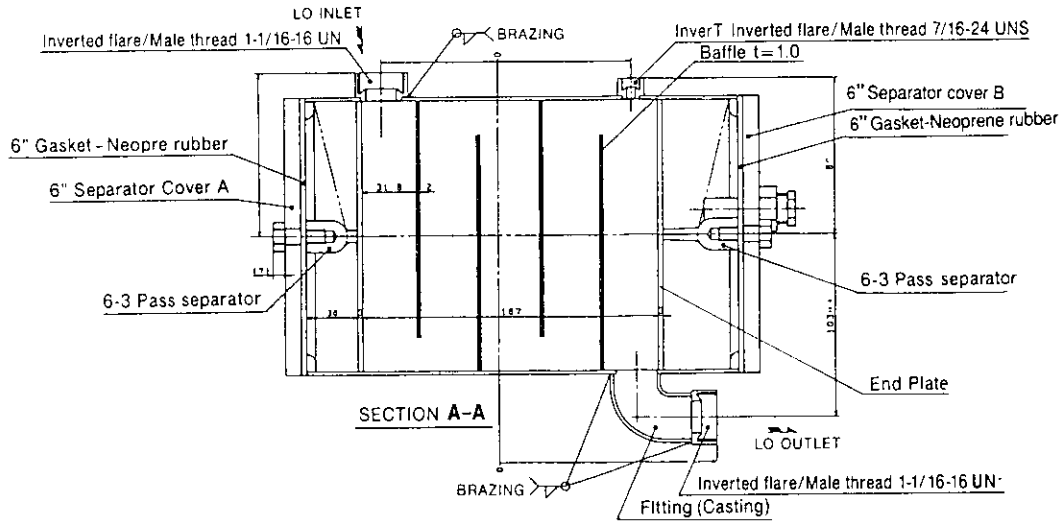
## 5-1 Lube oil cooler construction

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.

| | |
|---|---|
| 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

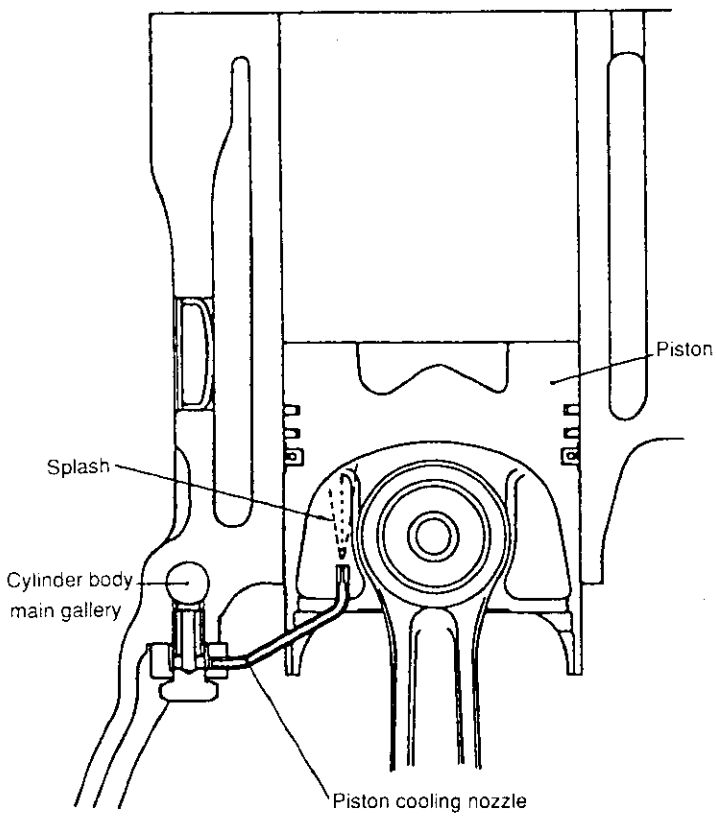
(1) Clean the inside of the sea water pipes with a wire brush to prevent the build-up of scale.
(2) If the rubber hose connection or welds are corroded, repair or replace the cooler.
(3) Apply the following water pressures to the sea water and lube oil lines to check for any leakage. Repair or replace 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/cm² |
| Sea water circuit | 3 kg/cm² |

# 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$1.77mm) of this pipe. This jet spray cools the piston surface when the piston goes down.

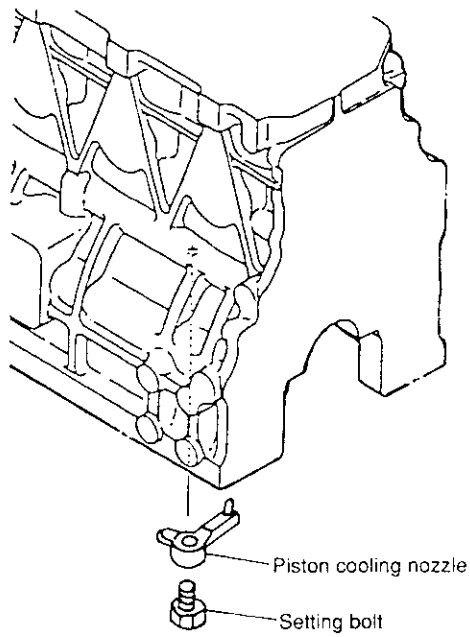



| | |
|---|---|
| Oil injection volume | 3.5~4.0 ℓ /min. |
| Oil injection pressure | 4.5 kg/cm² |

## 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.



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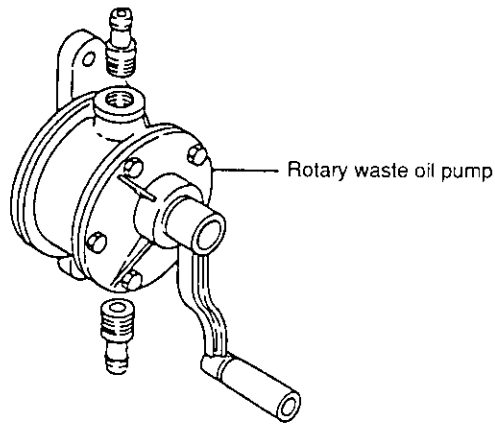
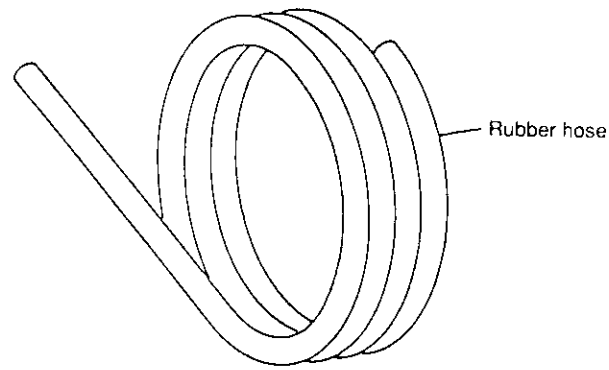
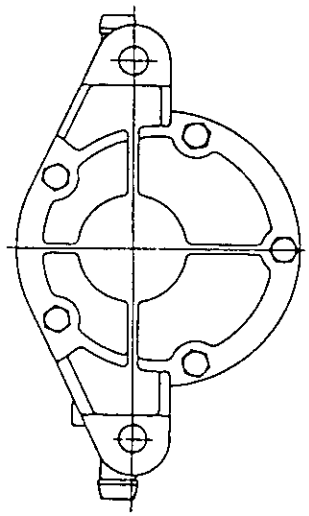
# 7. Rotary Waste Oil Pump (Optional)

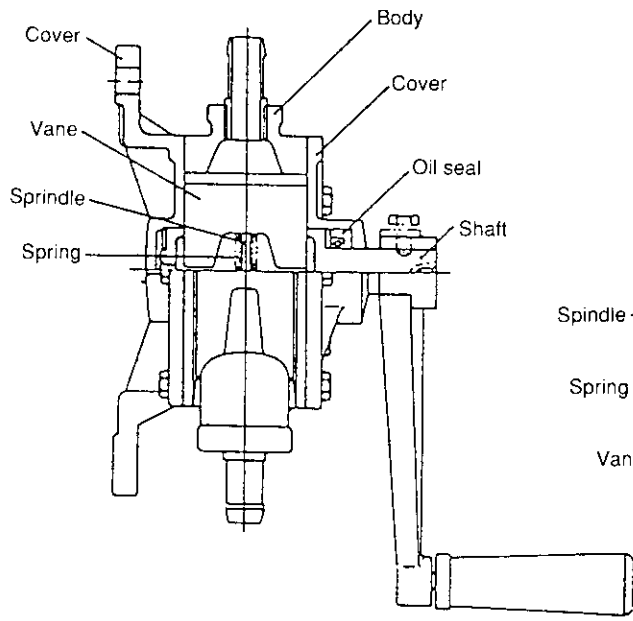
A rotary waste oil pump to pump out waste oil during oil changing is available as an option.
This is a vane type pump. Turning the handle rotates the vanes and pumps out lube oil.

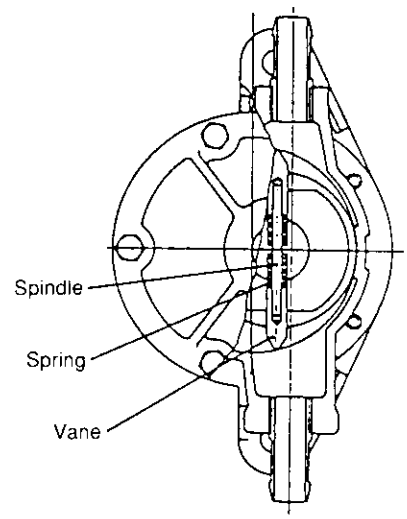



## 7-1 Construction






Rotary waste oil pump

| | |
|---|---|
| Delivery capacity of one stroke | 0.13 ℓ |
| Delivery pressure | 1.5 kg/cm² 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.

CHAPTER 6

# 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.

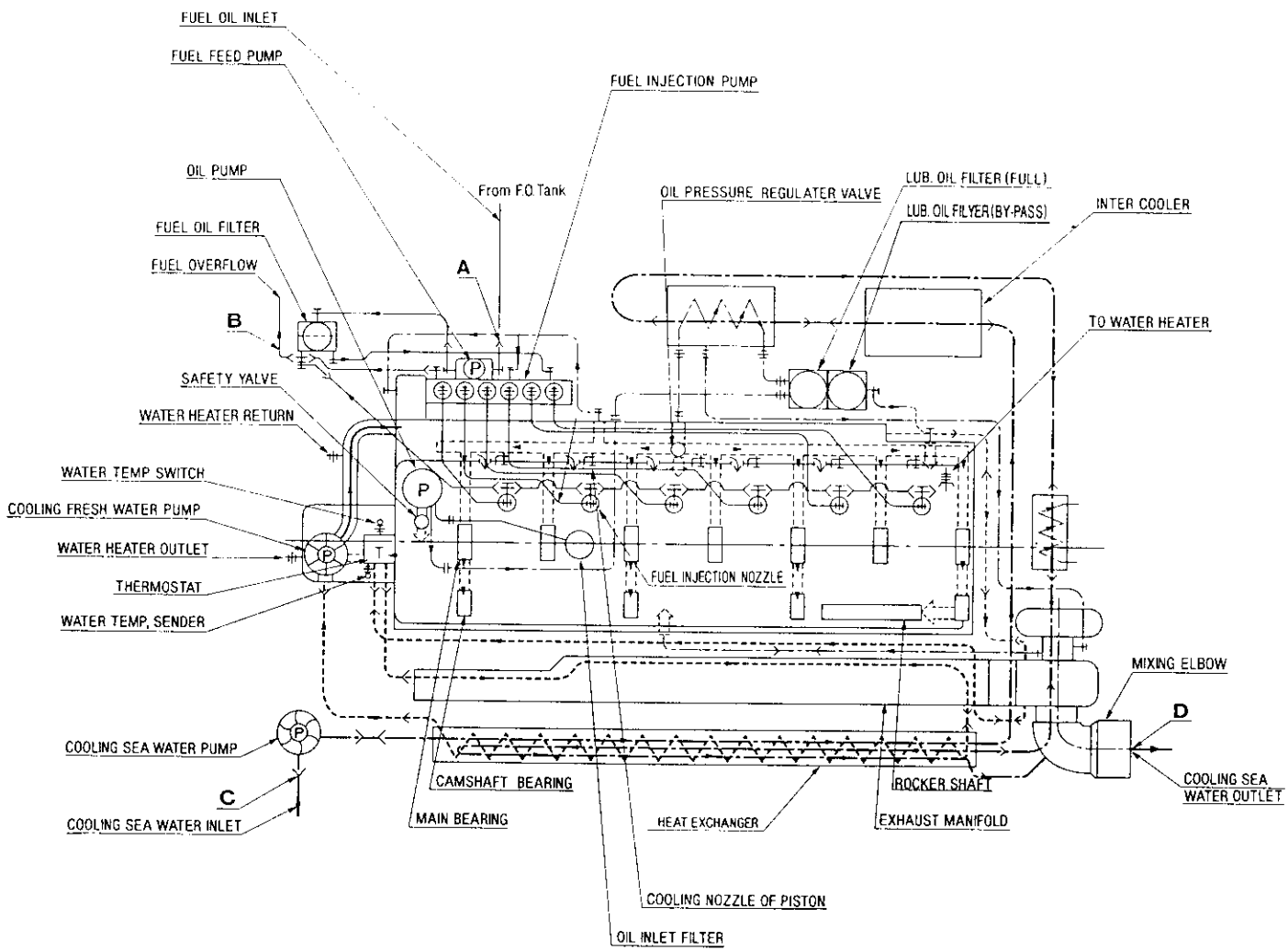
Sea water pumped in from the sea by the sea water pump cools the lube oil in the lube oil cooler and then goes to the heat exchanger, where it cools the fresh water. Then it is sent to the mixing elbow and is discharged from the ship with the exhaust gas.

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 eater 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.



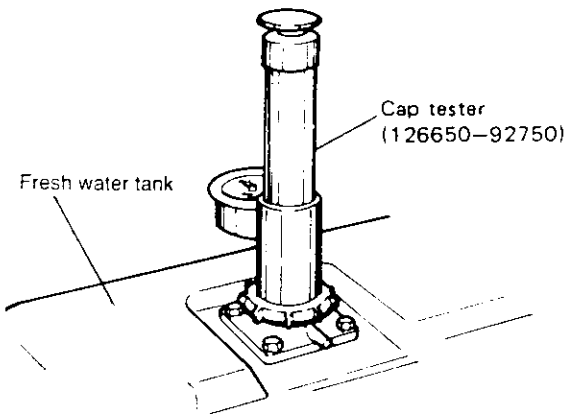
## 1-2 Water leakage test (Fresh water)

(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±0.15 kg/cm² (13±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




## 1-3 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.

## 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℃), 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.



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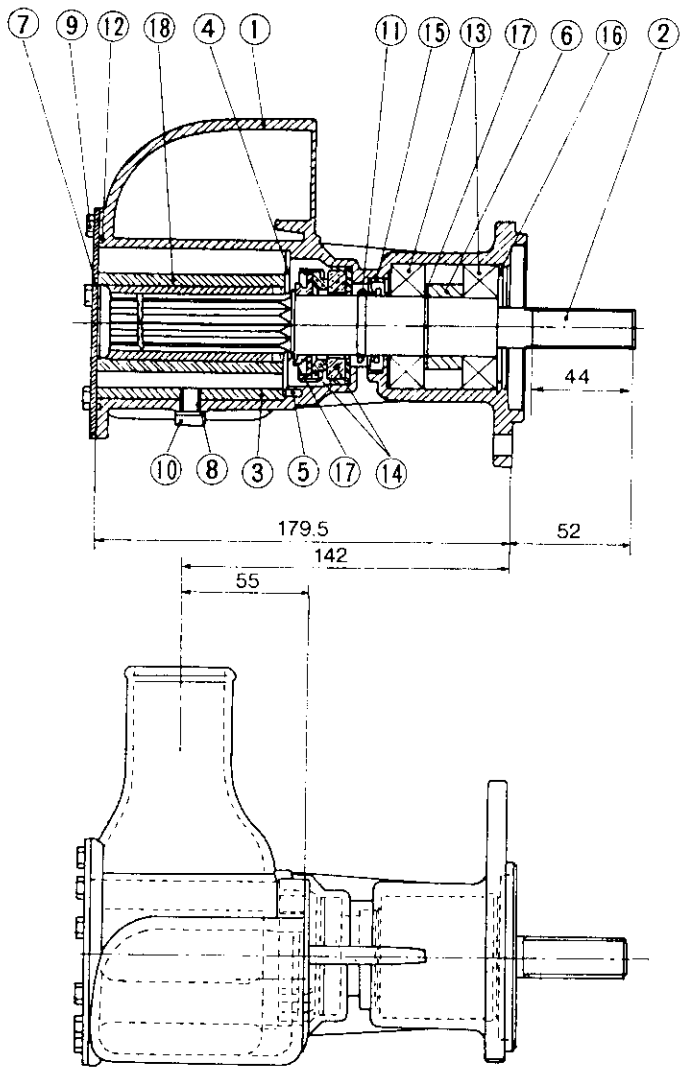
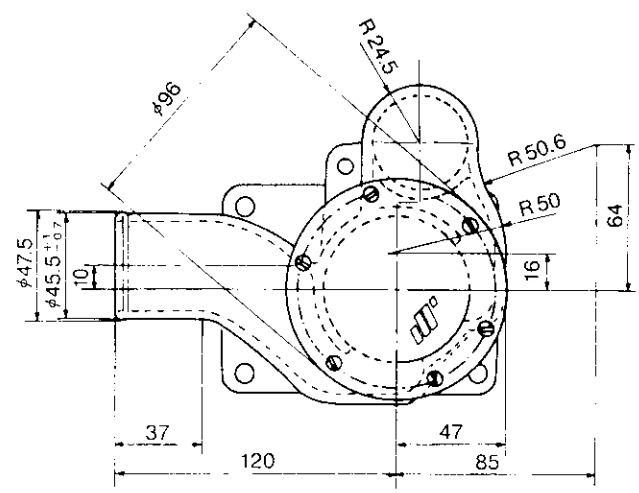
# 2. Sea Water Pump

## 2-1 Sea water pump construction and functioning

The sea water pump has a rubber impeller. The sea water pump fs 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

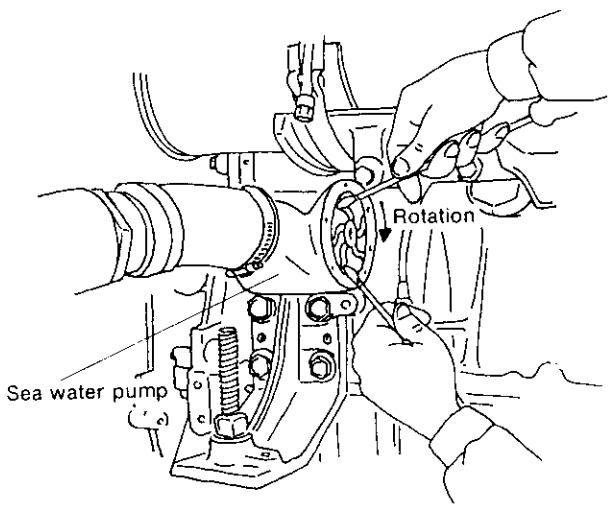
| Item | Description | Nos. |
|---|---|---|
| 1 | Body | 1 |
| 2 | Shaft | 1 |
| 3 | Cam | 1 |
| 4 | Wear plate | 1 |
| 5 | pin | 1 |
| 6 | Spacer | 1 |
| 7 | Endcover | 1 |
| 8 | Washer | 1 |
| 9 | Screw | 6 |
| 10 | Screw | 1 |
| 11 | O-ring | 1 |
| 12 | O-ring | 1 |
| 13 | Ball bearing | 2 |
| 14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

**Spline data** mm

| | |
|---|---|
| Profite | JIS D2001 |
| Dimension | 17X15X1 |
| 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.*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# 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.

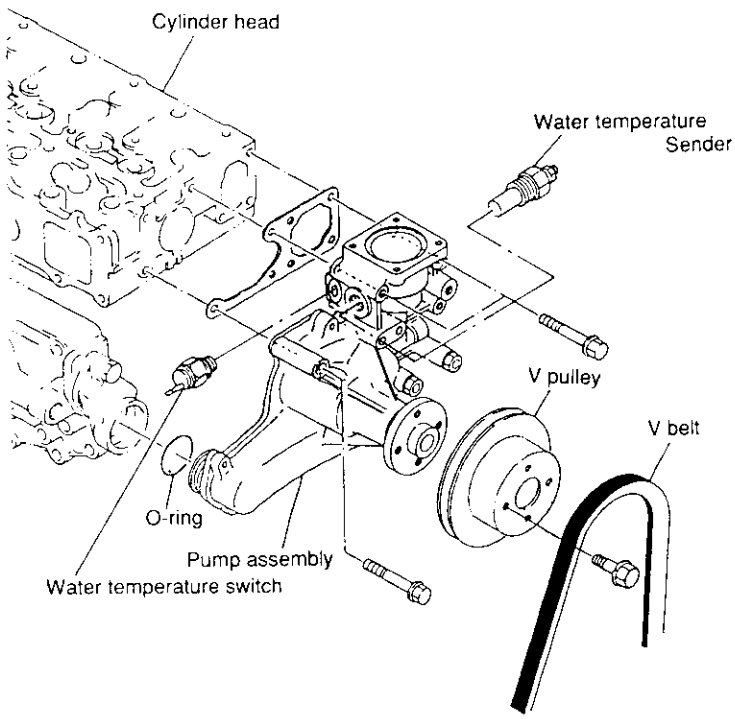
The bearing unit assembled in the pump shaft uses grease lubricated ball bearings and cannot be disassembled.

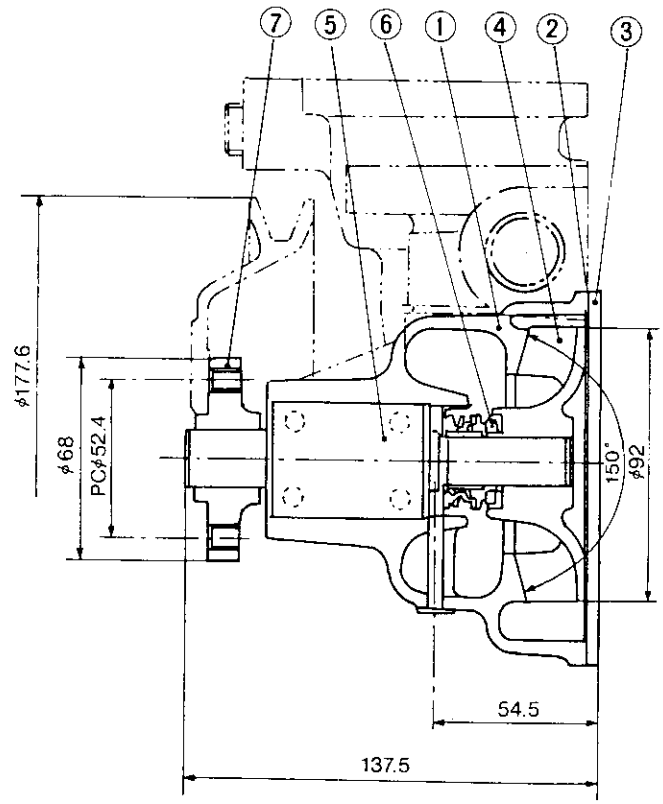
The totally enclosed mechanical seal spring presses the impeller seal mounted on the impeller side away from the pump body side. This prevents water from leaking along the pump shaft.

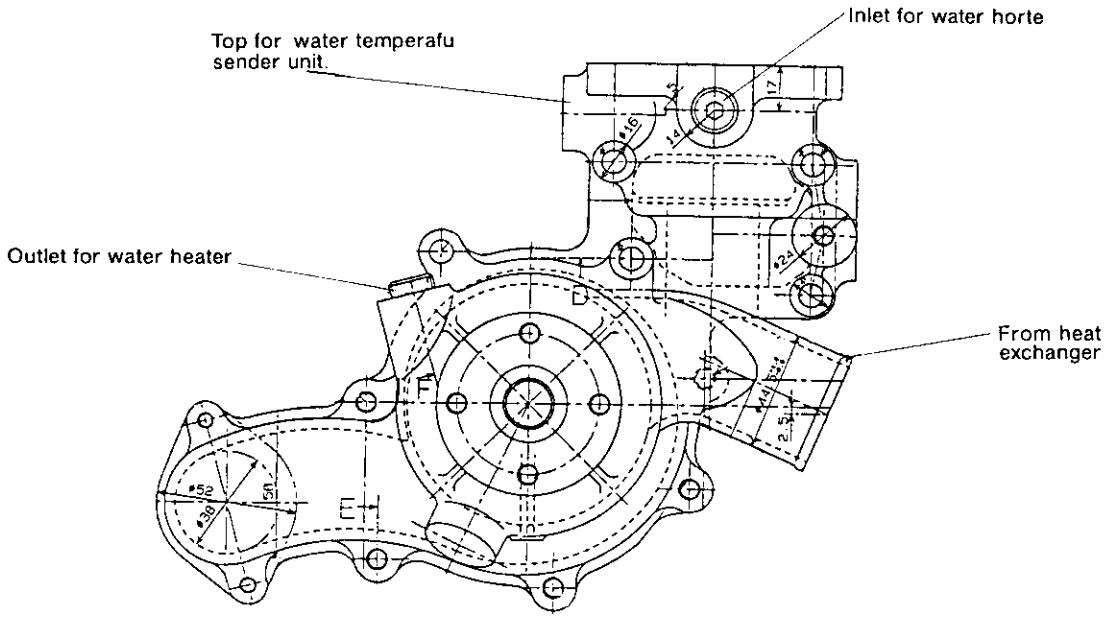
As the impeller and pulley flanges are press fit assembled, they cannot be disassembled.

**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 |

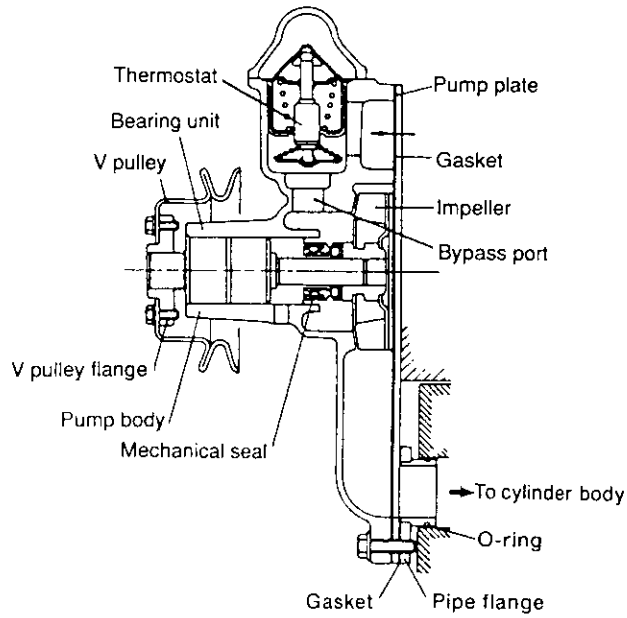
## 3-3 Fresh water pump disassembly

(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 |

## 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 and 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.



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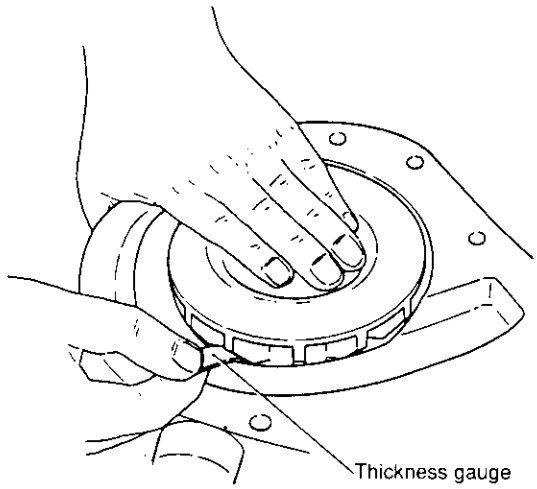
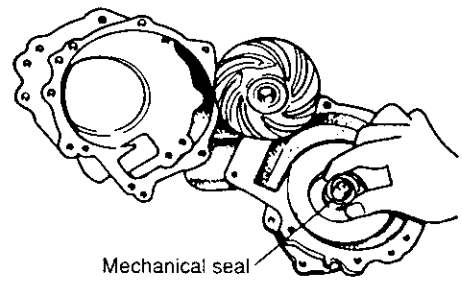
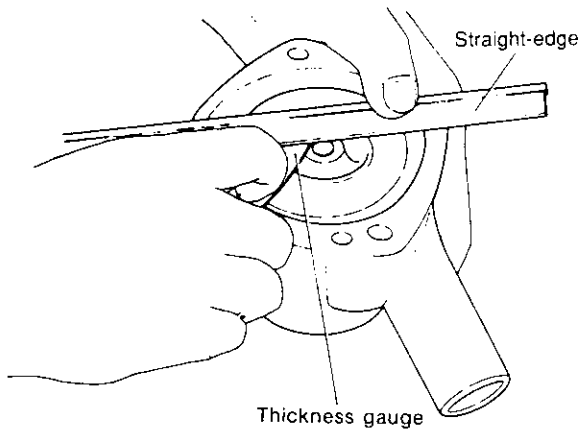
Measuring clearance between impeller and pump body.




Measuring clearance between impeller and pump body bracket.



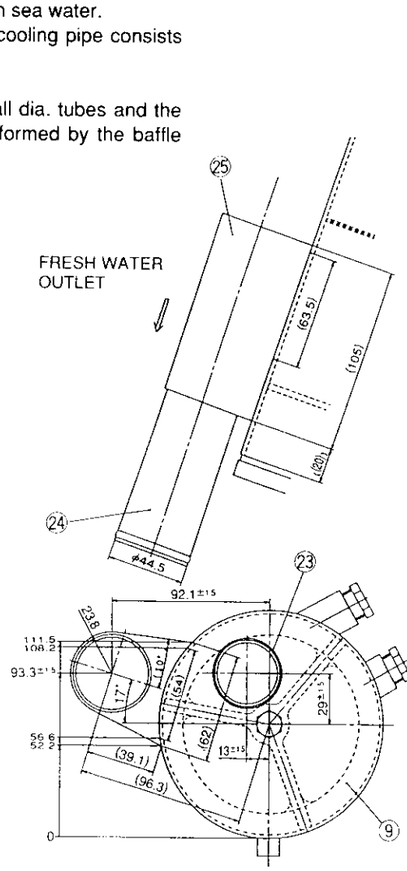

mm

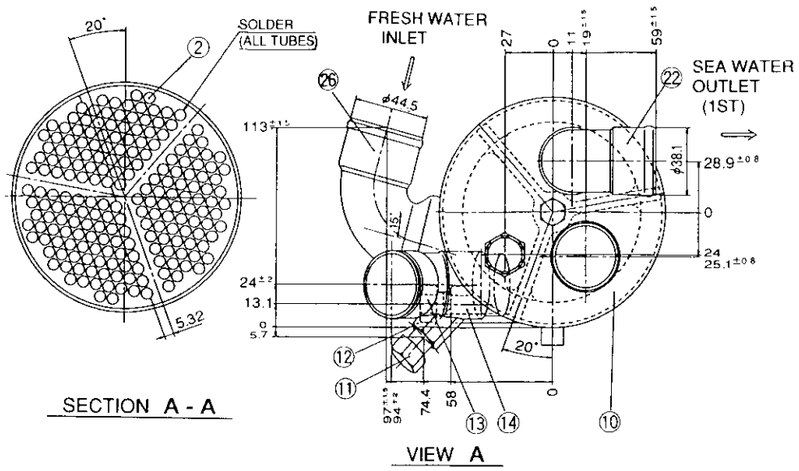
| | Standard | Wear limit |
|---|---|---|
| Clearance between impeller and body | 0.3~1.1 | 1.5 |
| Clearance between impeller and plate | 1.5 | — |

# 4. Fresh Water Cooler

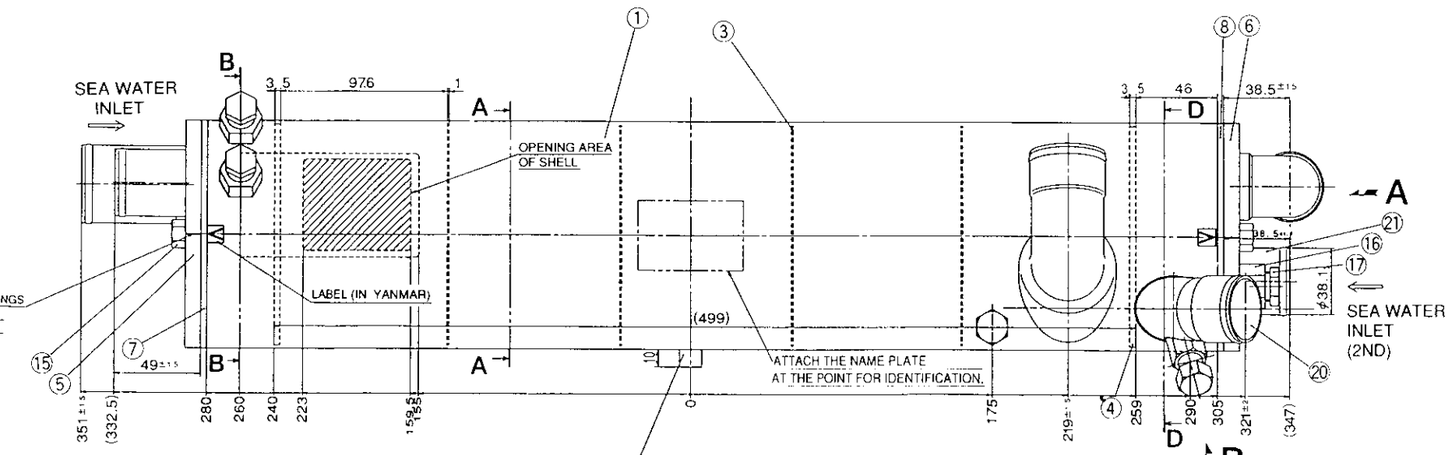
## 4-1 Fresh water cooler construction

The fresh water cooler cools the hot fresh water that has c circulated 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.



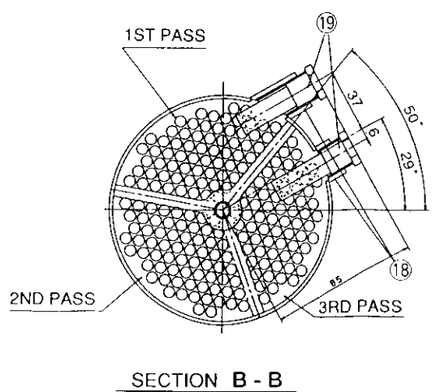



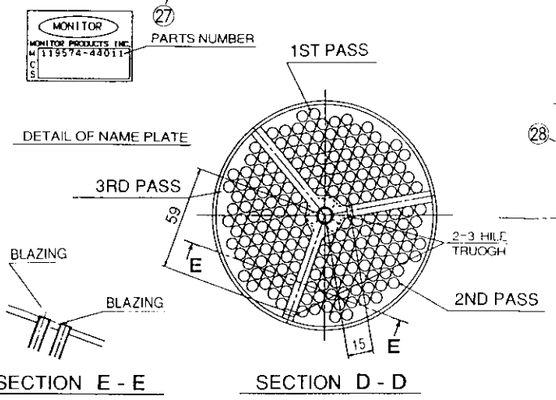

| ITEM | QTY | DESCRIPTION |
|---|---|---|
| 1 | 1 | 5.125 O.D. SHELL-DWV |
| 2 | 201 | 0.250 O.D. × 0.20 WALL TUBE |
| 3 | 8 | BAFFLE |
| 4 | 2 | END PLATE |
| 5 | 1 | 5" SEPARATOR COVER A |
| 6 | 1 | 5" SEPARATOR COVER B |
| 7 | 1 | 5" GASKET-NEOPRENE RUBBER A |
| 8 | 1 | 5" GASKET NEOPRENE RUBBER B |
| 9 | 1 | 5" −3 PASS SEPARATOR A |
| 10 | 1 | 5" −3 PASS SEPARATOR B |
| 11 | 1 | NPT 1/4 PLUG (SEA WATER) |
| 12 | 1 | NPT 1/4 NUT (SEA WATER) |
| 13 | 1 | NPT 1/4 PLUG (FRESH WATER) |
| 14 | 1 | NPT 1/4 NUT (FRESH WATER) |
| 15 | 2 | BOLT UNC 3/8" |
| 16 | 1 | NPT 3/8 NUT |
| 17 | 1 | NPT 3/8 PLUG |
| 18 | 2 | NPT 3/8 NUT |
| 19 | 2 | NPT 3/8 ZINC (1/2" ×2") |
| 20 | 1 | 45° ELBOW (SEA WATER OUTLET 2ND |
| 21 | 1 | COUPLING (SEA WATER INLET 2ND |
| 22 | 1 | 90° ELBOW (SEA WATER OUTLET 1ST |
| 23 | 1 | 90° ELBOW (SEA WATER INLET 1ST |
| 24 | 1 | COUPLING (FRESH WATER OUTLET |
| 25 | 1 | COUPLING (FRESH WATER OUTLET |
| 26 | 1 | 90° ELBOW (FRESH WATER INLET |
| 27 | 1 | LOCATE PIN |
| 28 | 1 | COUPLING (SEA WATER OUTLET |
| | | SEPARATOR COVER A CMP. |
| | | SEPARATOR COVER B CMP. |

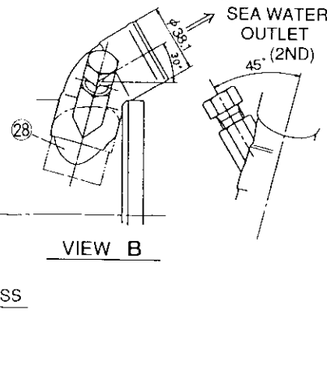



| | |
|---|---|
| AMOUNT OF HEAT : | 227000 kca ℓ/h |
| TEMP.OF SEA WATER (COOLER INLET) : | 1st 30℃, 2nd 55℃ |
| SEA WATER FLOW : | 10000 ℓ/h |
| FRESH WATER FLOW : | 20000 ℓ/h |
| ANTI FREEZE DENSITY : | 50 % |
| TARGET TEMP. OF FRESH WATER (COOLER INLET) : | 85℃ |

| | |
|---|---|
| BUNDLE LENGTH: | 499 mm |
| NO. OF TUBES : | 201 |
| SMALL TUBE DIAMETER : | 6.35 mm |
| TUBE MATERIAL COPPER | NICKEL |
| BODY LENGTH : | 585 mm |
| BODY DIAMETER : | 130.2 mm |
| BODY MATERIAL : | STD. DWV |
| NO. OF BAFFLES : | 4 |
| CUT OFF ROW : | 9 |
| BAFFLE SPACING : | 97.6 mm |
| NO. OF PASSES : | 3 |
| SEPARATOR TYPE : | STANDARD 3PASS |



## 4-2 Specifications of heat exchanger

| | |
|---|---|
| Bundle length | 499mm |
| No. of tubes | 201 |
| Small tube Dia. | 6.35mm |
| Tube material | Copper nickel |
| Body length | 585mm |
| Body diameter | 130.2mm |
| Body material | STD.DWV |
| No.of baffles | 4 |
| Cut off row | 9 |
| Baffle spacing | 97.6mm |
| 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

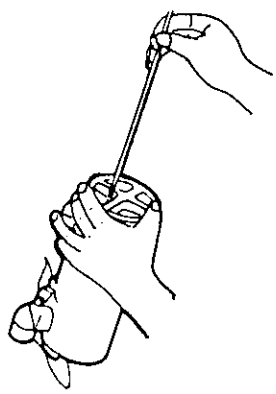
1) Inspect the inside of the tubes for rust or scale build up from sea water, and clean with a wire brush if necessary.

***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.

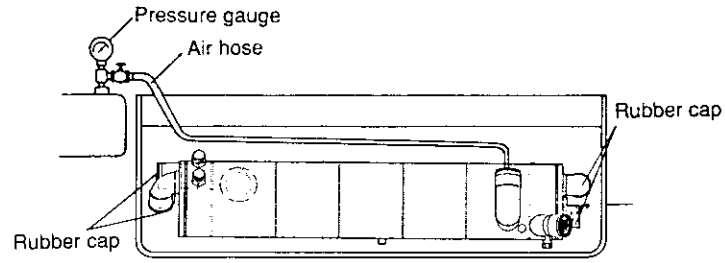
(2) Fresh water cooler body inspection

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/cm²(28.44 lb/in.²) |

# 5. Pressure Cap and Sub Tank

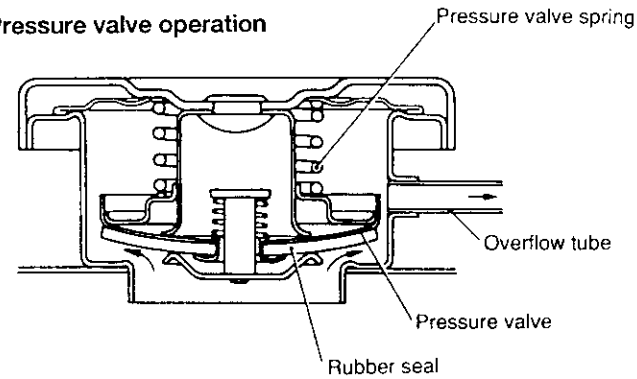
## 5-1 Pressure cap construction

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.

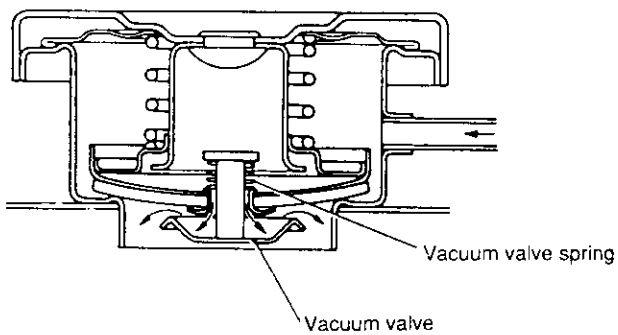
## 5-2 Pressure cap pressure control

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 0.9kg/cm2 (12.80lb/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 kg/cm²G |
| Vacuum valve | Open at 0.05 kg/cm²G or below |

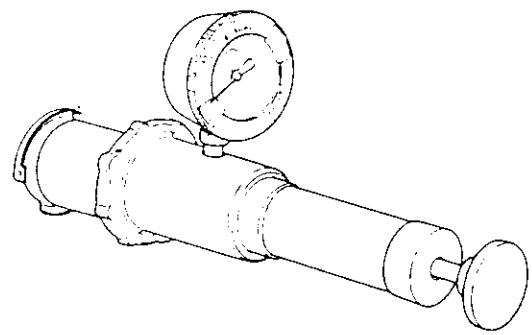
## 5-3 Pressure cap inspection

**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 (0.75~1.05kg/cm²(10.67~14.91 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 0.9kg/cm² (12.80lb/in.²).
This consumes water. The sub tank maintains the water level by contaring 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.



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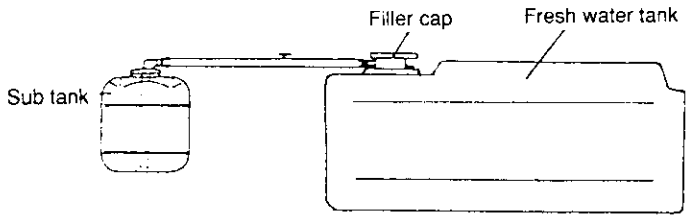
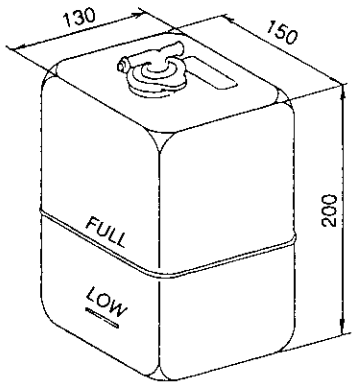



## 5-5 Specifications of sub tank

| | | |
|---|---|---|
| Subtank capacity | Overall capacity | 3.4 ℓ ( in³) |
| | Full-scale position | 1.5 ℓ ( in.³) |
| | Low-scale position | 0.43 ℓ (12.20 in.³) |

## 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

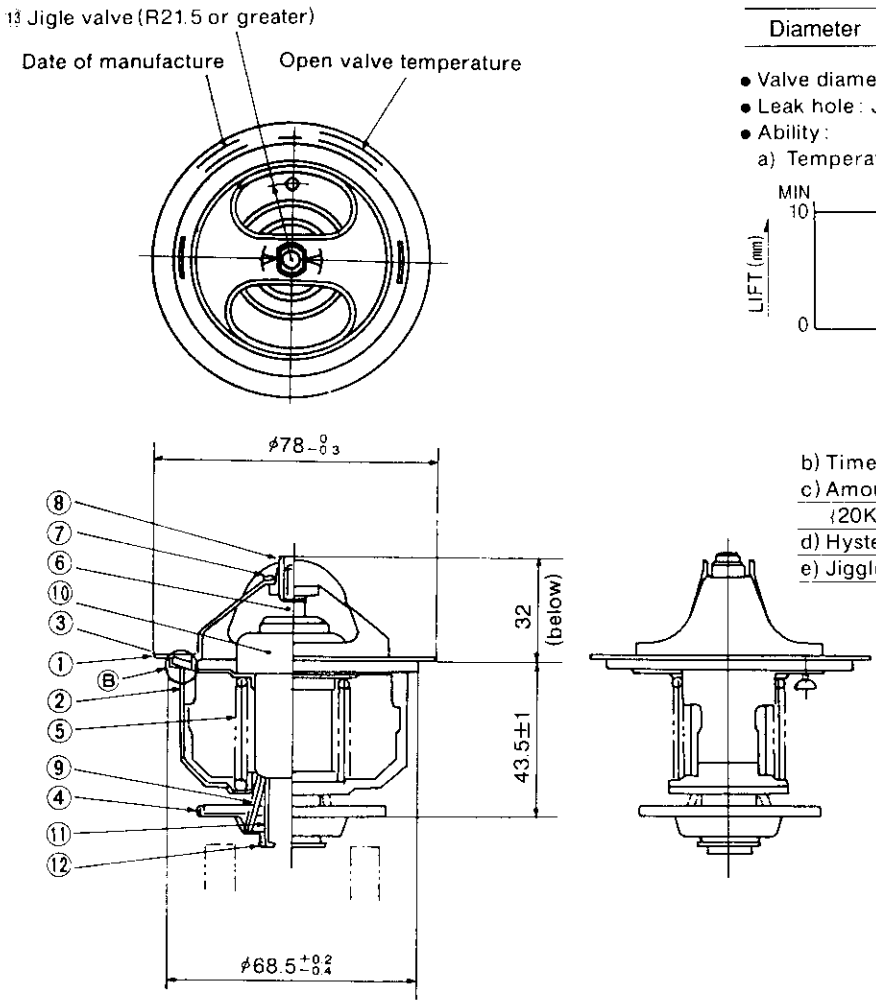
The thermostat opens and closes a valve according to changes in the temperature of the fresh water inside the engine, controlling the volume of water flowing to the heat exchanger from the cylinder head, and in turn maintaining the temperature of the fresh water in the engine at a constant level.

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.




| 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 | φ3 |
| 6 | Piston | SUS304 | φ6.4 |
| 7 | Stopper | C3604B | φ14 |
| 8 | Adjustment fittings | C3604B | φ8 |
| 9 | Helper spring | SUS304 | φ1.8 |
| 10 | Pellet | Ass'y | — |
| 11 | Pipe | SUS304 | φ15, t1 |
| 12 | E snap ring | SUS304 | E9 |
| 13 | Jigle valve | SUS430 | φ5.3 |

## 6-2 Thermostat construction

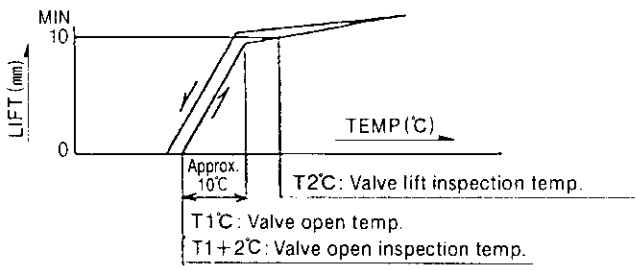
The thermostat used in this engine is of the wax pellet type, with a solid wax pellet located in a small chamber. When the temperature of the cooling water rises, the wax melts and increases in volume This expansion and contraction is used to open and close the valve.

## 6-3 Characteristics of thermostat

| | |
|---|---|
| Opening temperature | 71°C |
| Full open temperature | 85°C |
| Valve lift at full open | 8 mm |
| Diameter | 50mm |

- Valve diameter : φ50
- Leak hole : Jiggle valve
- Ability :

a) Temperature – Stretch feature




b) Time: Within 90 seconds

c) Amount of water leakage: Cooling water 0.2kg/cm² {20KPa} at pressure of 1ℓ/min. or lower.

d) Hysteresis: At lift 2mm within 3.5°C.

e) Jiggle valve feature : Colsed valve pressure; 10mmHg or lower.
Amt, of air flow with closed valve; 10ℓ/min. or greater.



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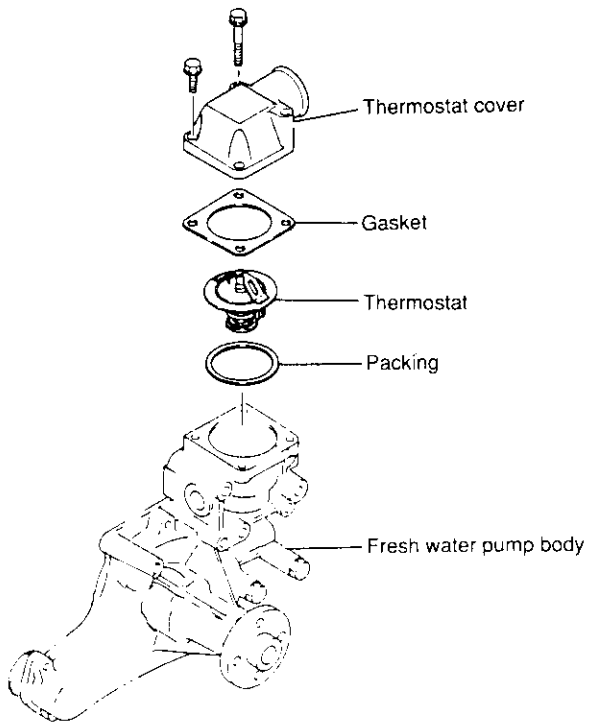
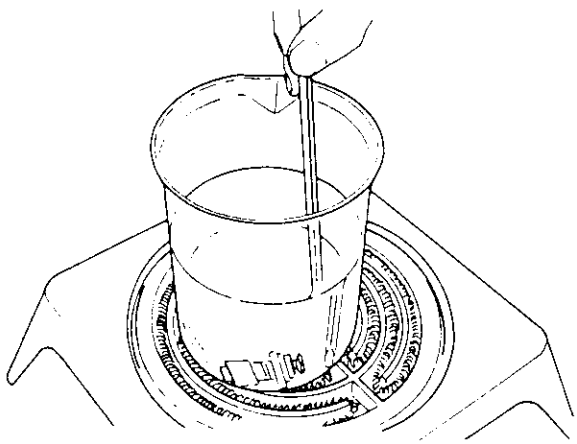
## 6-4 Thermostat inspection

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

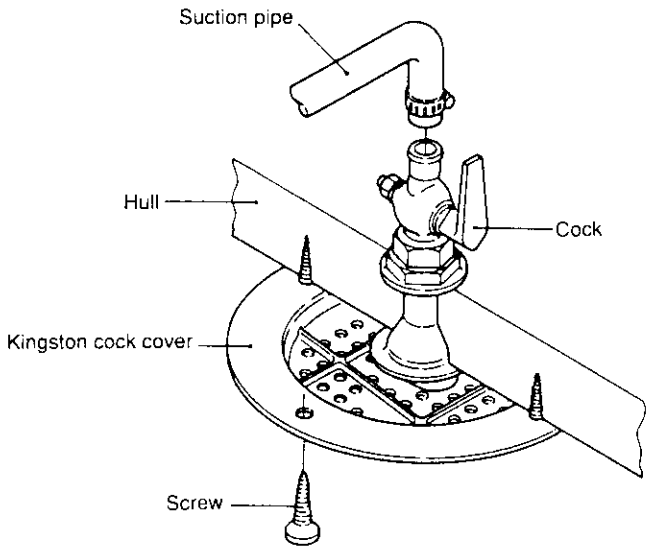
(1) Put the thermostat in a breaker with fresh water, and heat it on an electric stove. The thermostat is functioning normally if it starts to open between 69.5~72.5 °C, and opens 8mm (0.3150in.) or more at 85°C. Replace the thermostat if it is not functioning normally.
(2) Normally, the thermostat should 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).

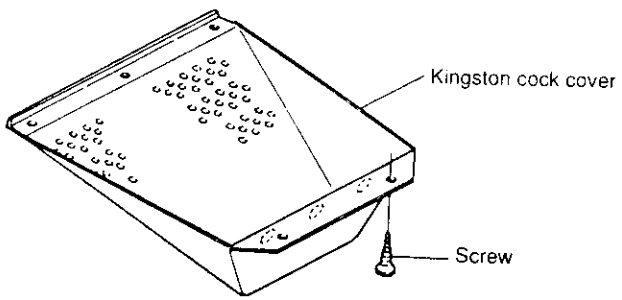


# 7. Kingston Cock (Optional)

## 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.




## 7-2 Handling precautions

Cautions 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.

## 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.



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CHAPTER 7

# REDUCTION AND REVERSING GEAR



The reduction and reversing gear for YANMAR Model KMH6A1 is explained in detail in.


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# 1. Specification and System

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

There are 2 standard types of clutches for the **6LY2-STE** and 6LY2A-STP which are shown in the specifications. The KMH6A(**1**) is explained here. Refer to the service manuals provided by the manufacturers for details on other type of clutche. (KM6A for 6LYA-STP)

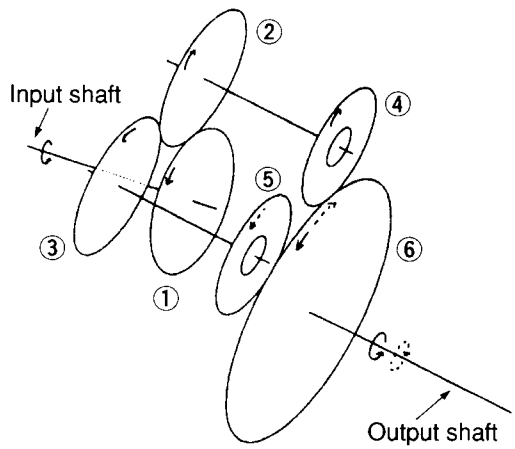
### 1-1.1 Major Specifications

| | | | | |
|---|---|---|---|---|
| 1 | Type | Constant mesh gear with hydraulic multi-disc (wet type) | | |
| 2 | Model | KMH6A(1) | | |
| 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 glade CD (#30) | | |
| 9 | Mass | 1000N (102kg) | | |
| 10 | Lube system | Forced lubrication with hydraulic pump | | |
| 11 | Cooling system | Sea water multi pipe | | |
| 12 | LO capacity (Full) | 4.0 ℓ | | |
| 13 | Hydraulic oil set up pressure | 3.14±0.049MPa(32±0.5kgf/cm²) at 3300rpm oil temp. 60°C (KMH6A1)<br>2.75±0.049MPa(28±0.5kgf/cm²) at 3300rpm oil temp. 60°C (KMH6A) | | |

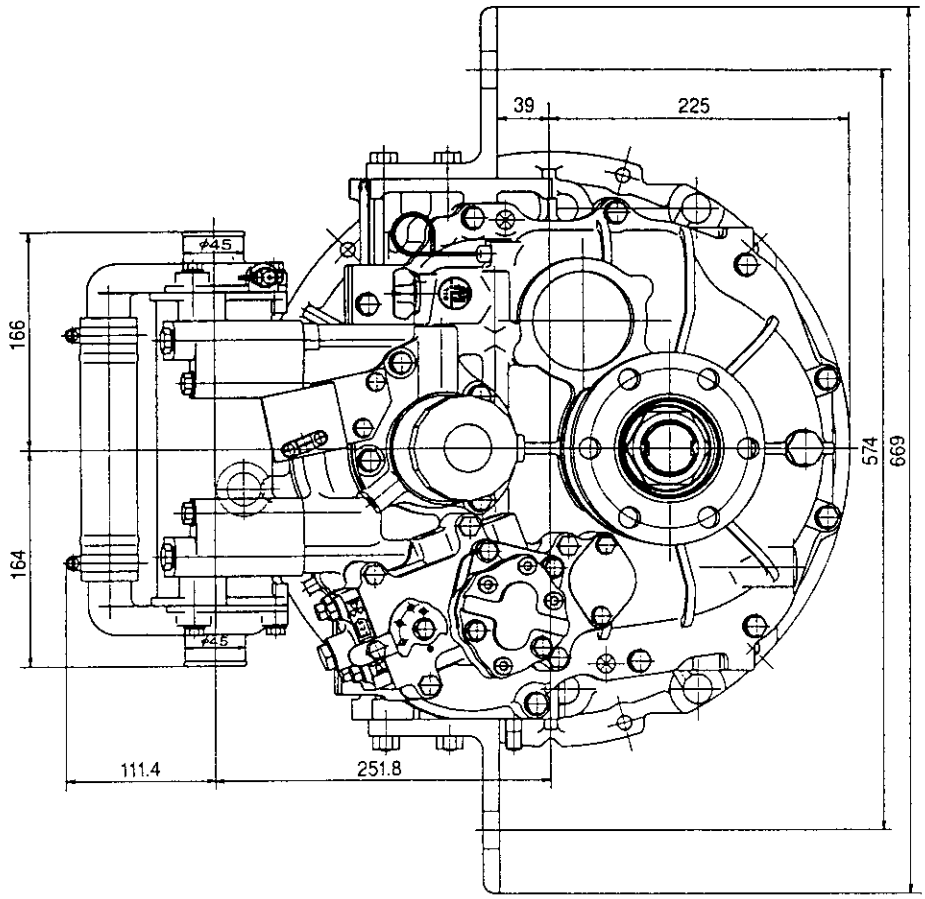
### 1-1.2 Power Transmission

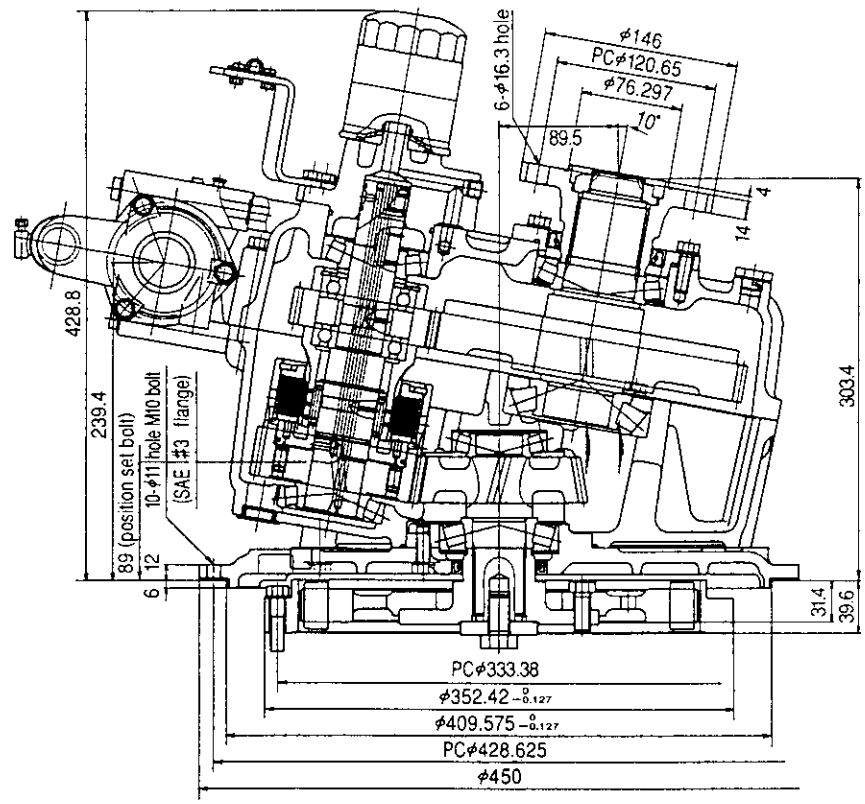
Output shaft counterclockwise (viewed from stern side)
Engine→①→②→④→⑥

Output shaft clockwise (Viewed from stern side)
Engine→①→②→③→⑤→⑥



### 1-1.3. Sectional View



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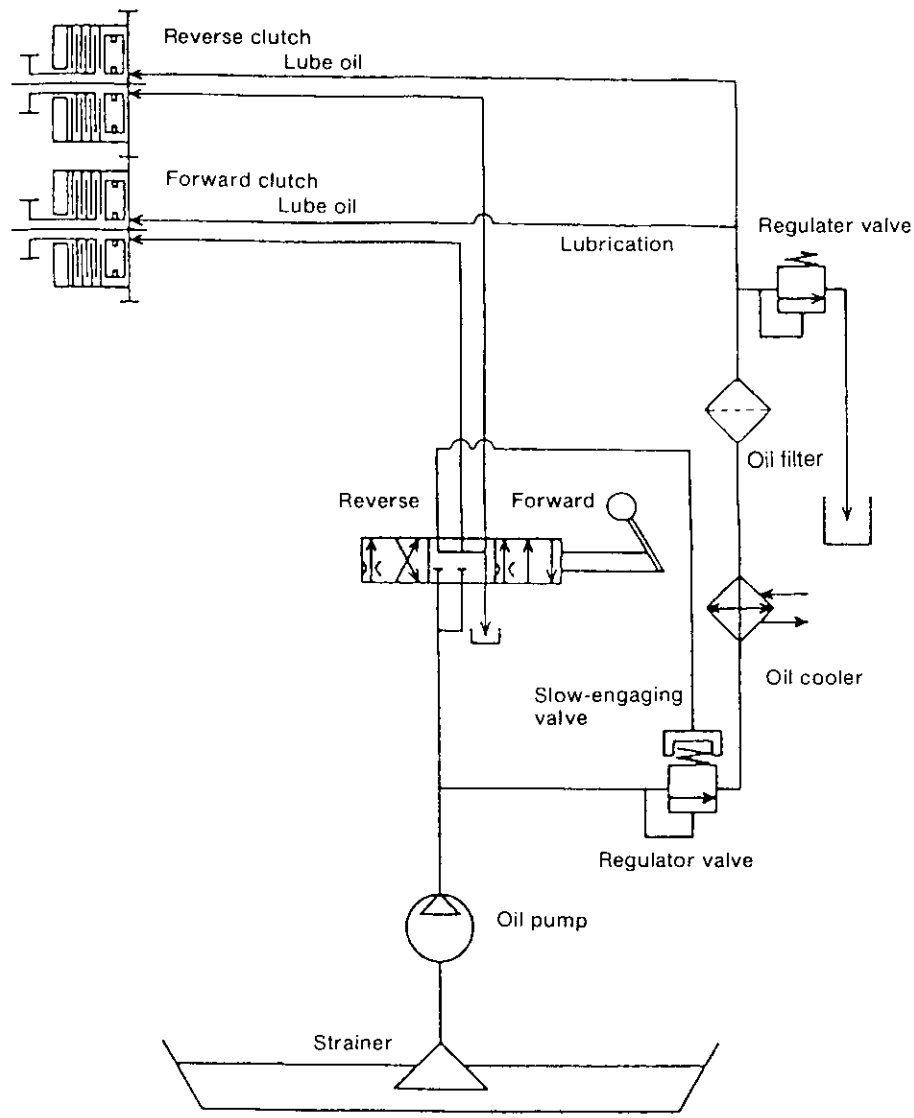
### 1-1.4 Hydraulic System

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.

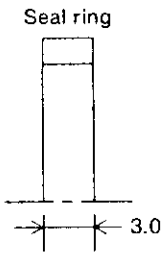
### 1-1.7 Service Standard

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 1000hrs. | Oil filter | Replace filter element |
| 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. |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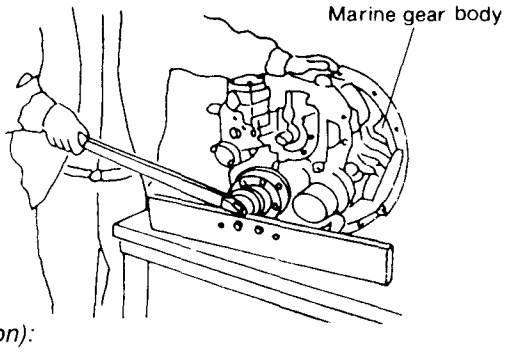
# 2. Reassembly and disassembly (KMH6A(1))

## 2-1. Disassembly

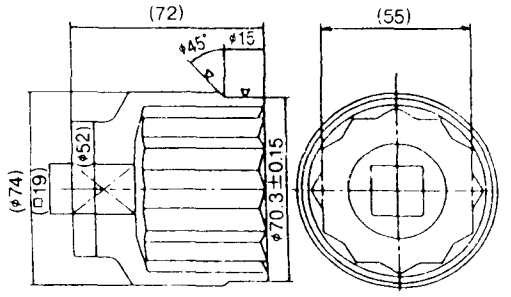
1. Disassembling marine gear and accessories
(1) Remove the remote control cable and pipes and then remove the clutch from the engine.
(2) Drain out the lube oil inside the clutch through the drain plug.
(3) Remove the oil cooler.
(4) Remove the oil pump.

*(Caution):*
*When removing the oil pump, do not loosen the hexagon socket head cap screw.*

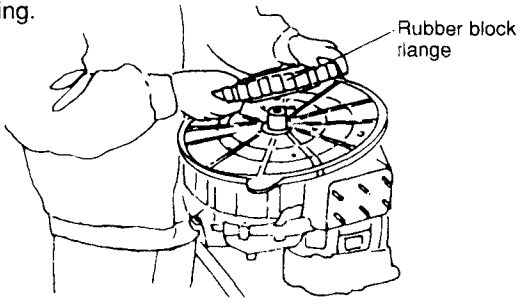
(5) Remove the output shaft coupling.
1) Raise the caulking (at two positions) of the locking nut with a chisel.
2) Fix the output shaft coupling to a work bench so that it cannot rotate.
3) Loosen the locking nut and remove the output shaft coupling.



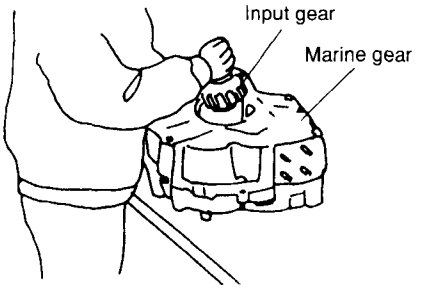

*(Caution):*
*Make sure to use the type of a socket as shown below for the locking nut.*




(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.



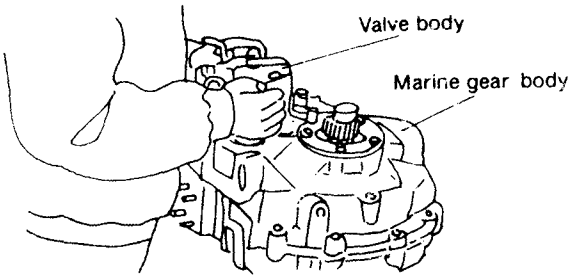

2) Remove the mounting flange and take out the input gear.




(7) Remove the support cover.

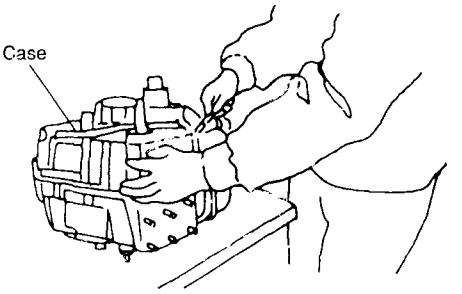
*(Caution):*
*Be sure not to damage the shaft seal ring.*

(8) Remove the valve body.

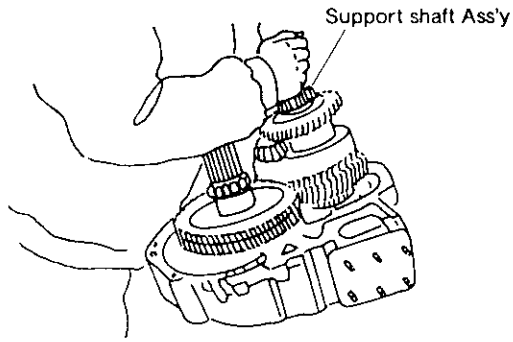



*(Caution):*
*Be sure not to damage the shaft seal ring.*

(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.

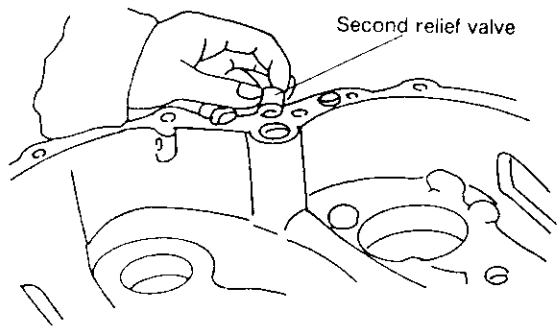


(11) Take out the support shaft assembly and output shaft asssembly.
*(Caution):*
*The pinion gear of the support shaft assy can slip off easily.*
Be careful not to drop it.



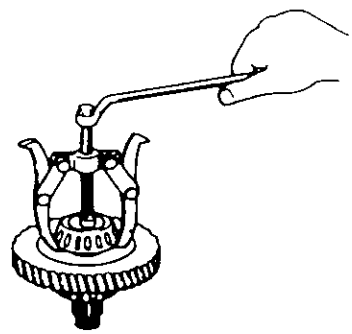

(12) Take out the outer race of bearings from the case.
*(Caution):*
*The outer race be taken out easily by warming the case with oil.*

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




## 2-2. Disassembling input and output gears

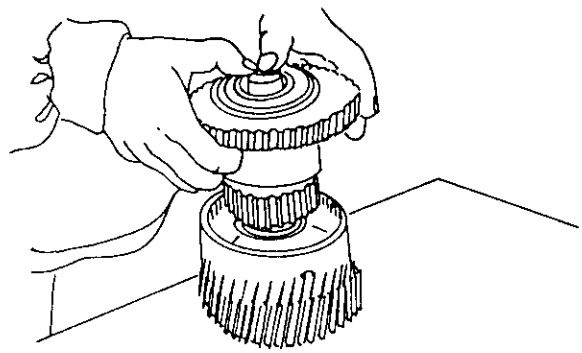
(1) Take out the bearing inner race from the input and output gears.



*(Caution):*
*Do not disassemble the output shaft and output gears because they are shrunk.*

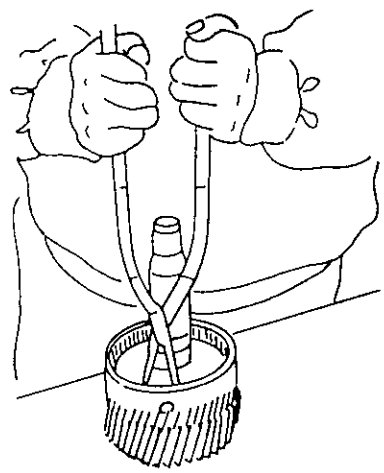
## 2-3. Disassembling support shafts A and B

(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 springseveral 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.



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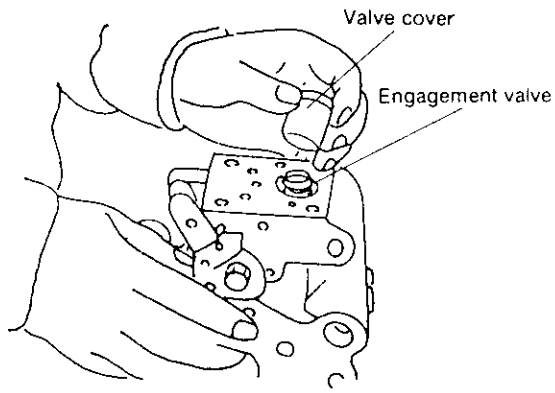
6) Remove the bearing inner race on the engine side using a pulley remover.

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

## 2-4. Disassembling valve body

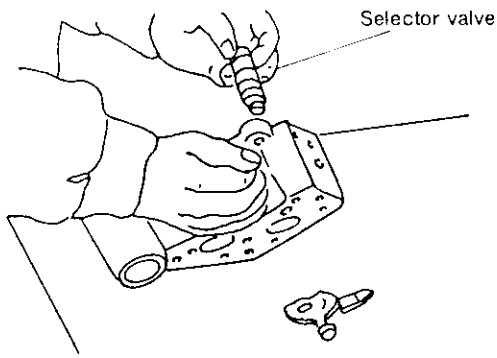
(1) Remove the strainer lid and then remove the spring and strainer.

(2) Remove the valve cover and then take out the slow engagement valve, inner and outer relief springs, and relief valve.




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

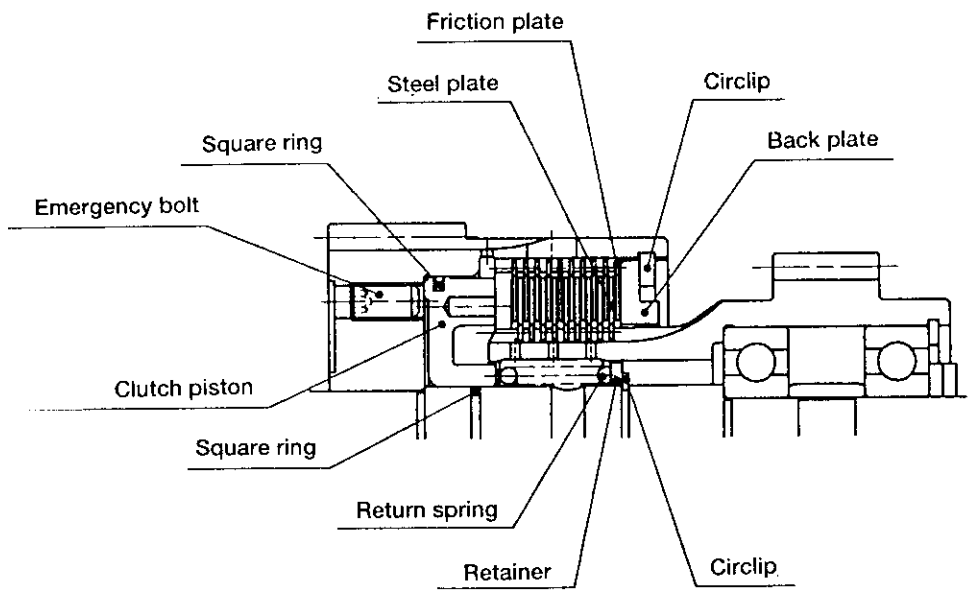
(1) Reassembly can be made by installing the parts in the reverse order to disassembly.
Clean all parts and take care not to include dust or metal chips. Also note the following points:

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 posi tions 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.*



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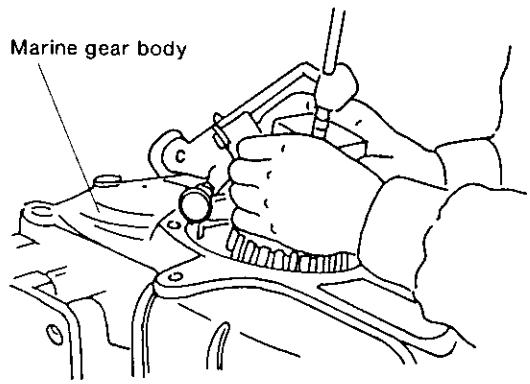
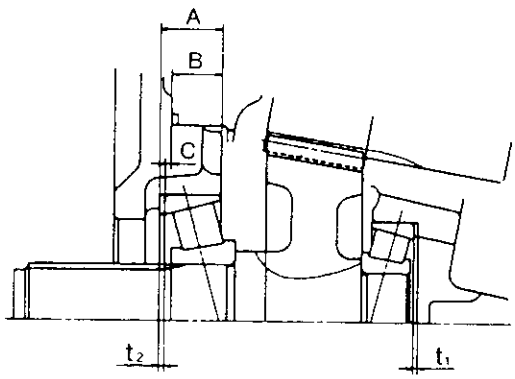
**(3) Shim adjustment**

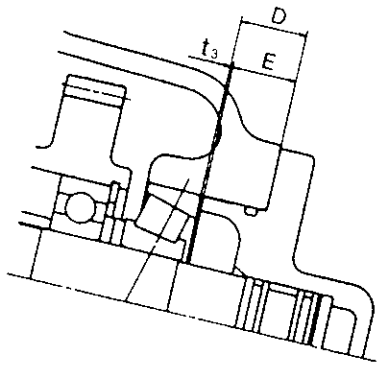
1) Input shaft
Measure backlash of the input and drive gears and adjust shim thickness t1 to make the backlash 0.12-0-20mm wide.




- After shim thickness t1 is determined, measure dimensions of A, B, and C to determine shim thickness $t_2$.
  $t_2=(A-B-C)\pm0.05$mm

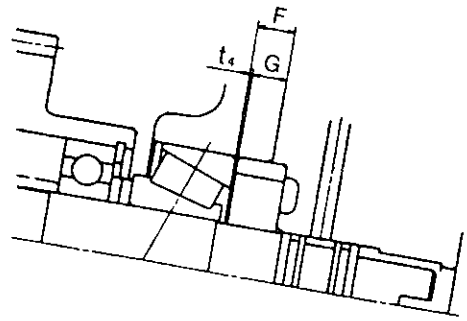



2) Support Shaft (A)
Adjust the clearance to the taper roller bearings.




- Measure D and E dimensions to determine shim thickness $t_3$
  $t_3 = (D-E)$mm

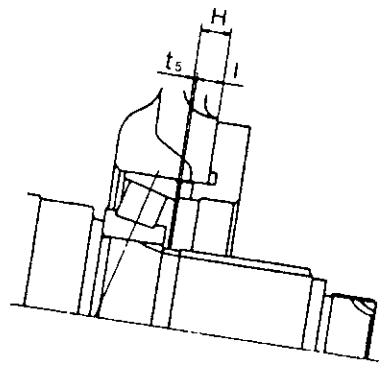
3) Support Shaft (B)




Adjust the clearance to the taper roller bearings.

- Measure F and G dimensions to determines shim thickness $t_4$
  $t_4 = (F-G)\pm0.05$mm

4) Output Shaft




Adjust the clearance to the taper roller bearings.

- Measure F and G dimensions to determines shim thickness $t_5$
  $t_5 = (F-G)\pm0.1$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±20kgf-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 | KMH6A1 |
|---|---|
| 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 mateial | $2.1^{\pm 0.2}$ | $4.0^{\pm 0.2}$ |



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CHAPTER 8

# REMOTE CONTROL(OPTIONAL)




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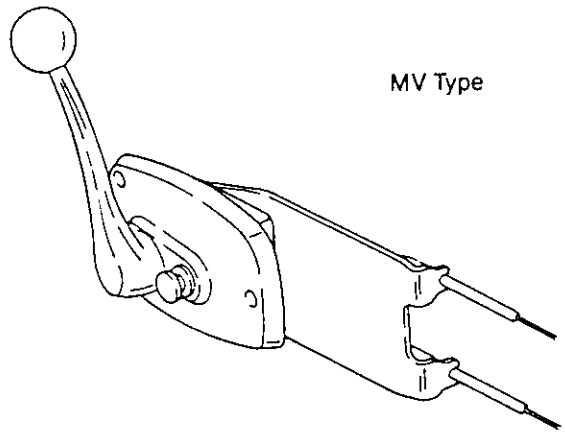
# 1. Remote Control System (Option)

## 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.

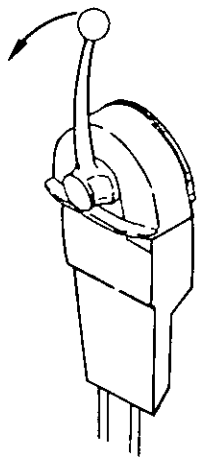
## 1-2 Remote control device components

| | Morse description | |
|---|---|---|
| Remote control head | MV type | MT-3 type |



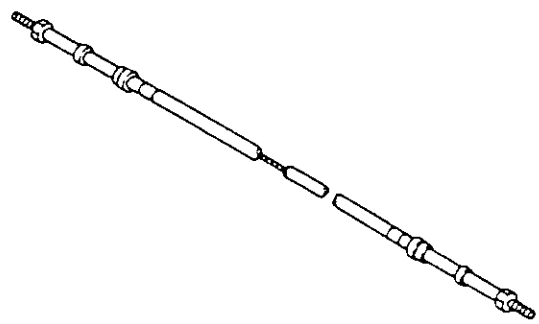
MV Type

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.



The Morse Model MT-3 Control provides both shift and throttle operation for outboards, inboard/outboards, of inboards with the marine gear (clutch) with light shifting loads of 6.5kg max. It can be used with Morse Cables.

(2) Remote control cable

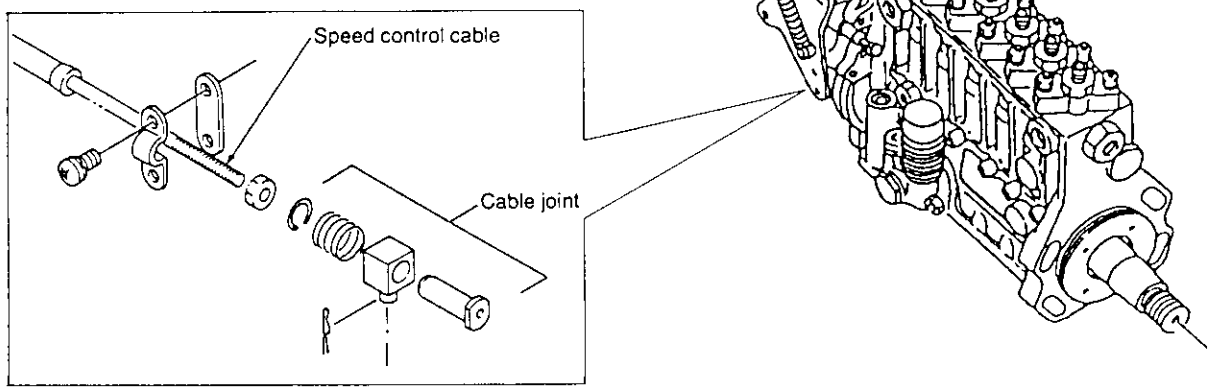


Use only Super-Responsive Morse Gontrol Cables.
These are designed specifically for use with Morse control heads. This engineered system of Morse cables,controf head and engine connection kits ensures dependable, smooth operatton with an absolute minimum of backlash.
Too many bends (turns) in the cable or bends at too extreme an angle wtll make it difficult to tum 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 ther 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.

# 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 property 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).



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CHAPTER 9

# ELECTRICAL SYSTEM




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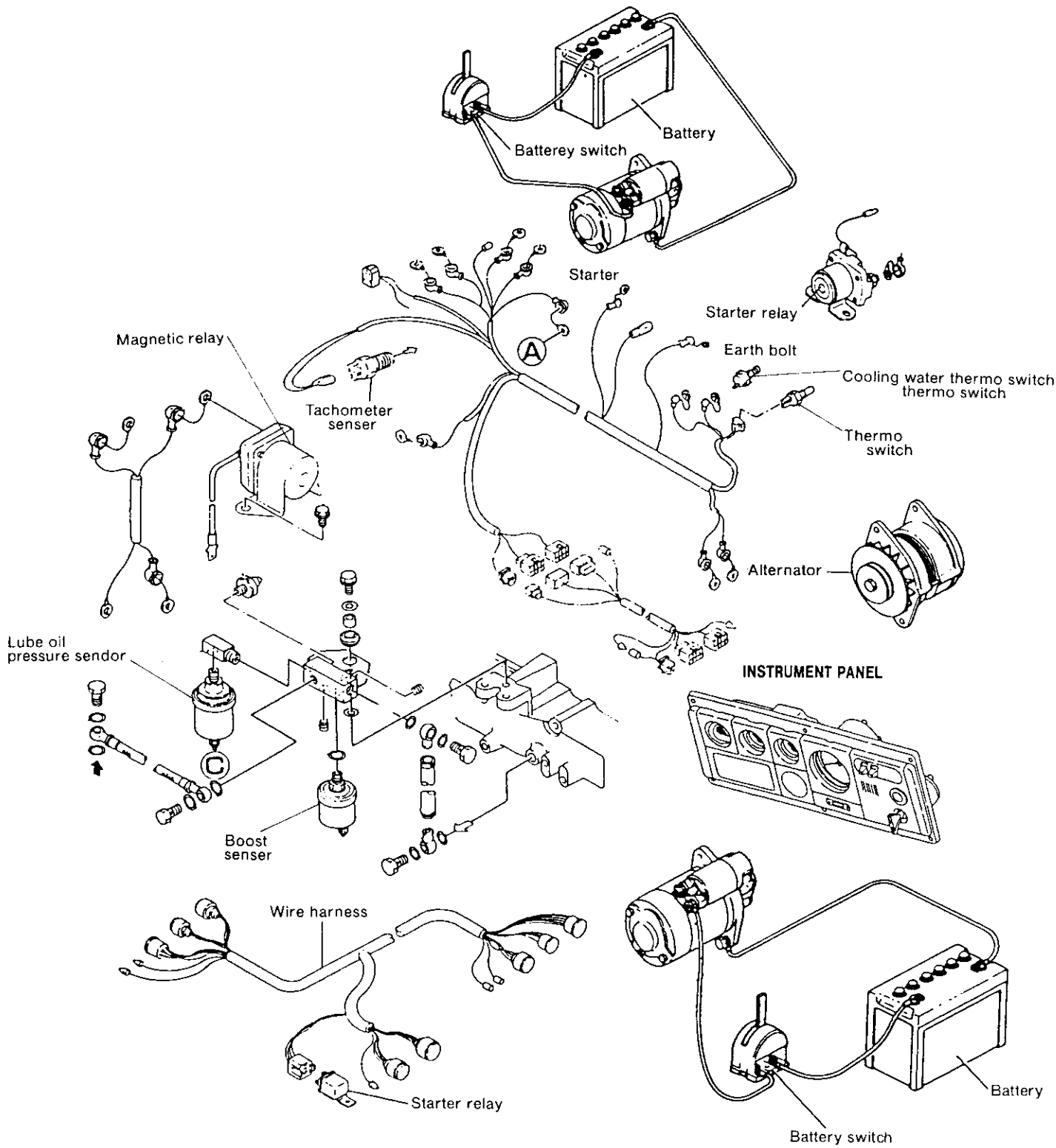
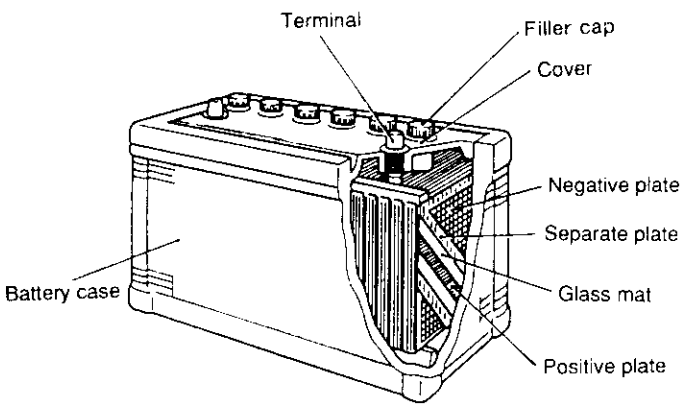
# 1. System Diagram

## 1-1 System diagram of electric parts



# 2. Battery

## 2-1 Construnction




The battery utilizes chemical action to convert chemical energy to electrical energy. This engine uses a fead 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 eiectric 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.

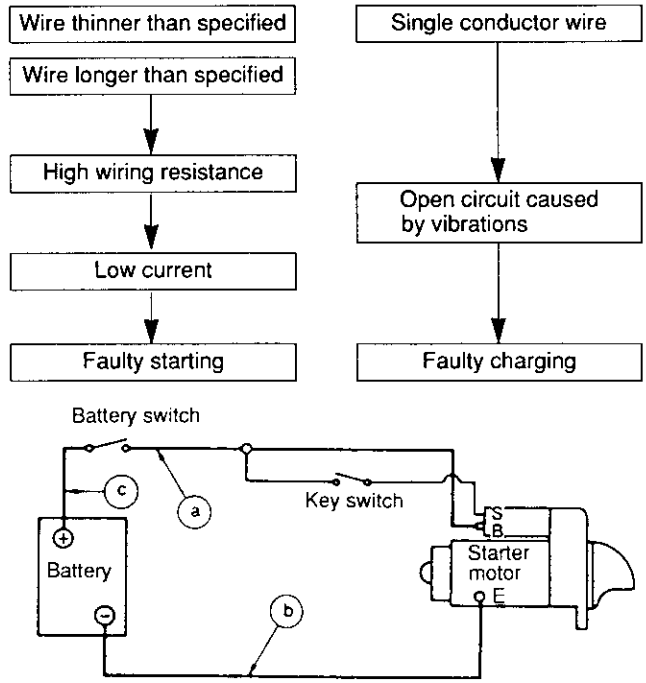
## 2-2 Battery capacity and battery cables

### 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

Wirlng 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 wirirg voltage drop | Conductor cross-section area | a+b+c allowable length |
|---|---|---|---|
| 12V | 0.2V or less/100A | 20mm² | UP to 3.5m |
| | | 40mm² | 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 inspaction

(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.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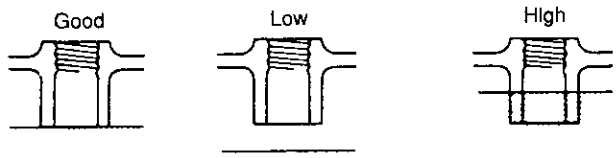
### 2-3.2 Checking the electrolyte

(1) Electrolyte level

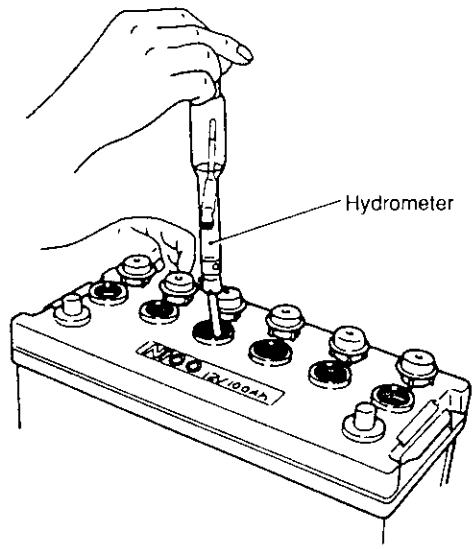



Check the electrolyte level every 7 to 10 days. The electrolyte must always be 10~20mm (0.3937~0.7874in.) over the top of the plates.

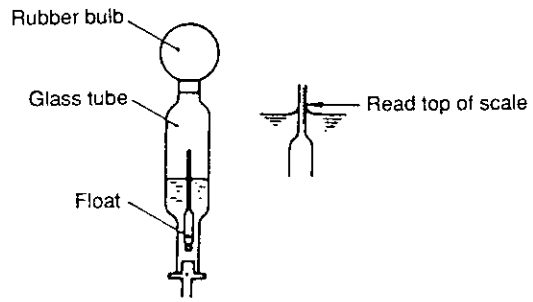
*NOTES: 1. The "LEVEL" line on a transparent plastic battery case indicates the height of the electrolyte.*
*2. Always use distilled water to bring up the electrolyte level.*
*3. When the electrolyte has leaked out, add dilute sulfuric acid with the same specific gravity as the electrolyte.*

(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.



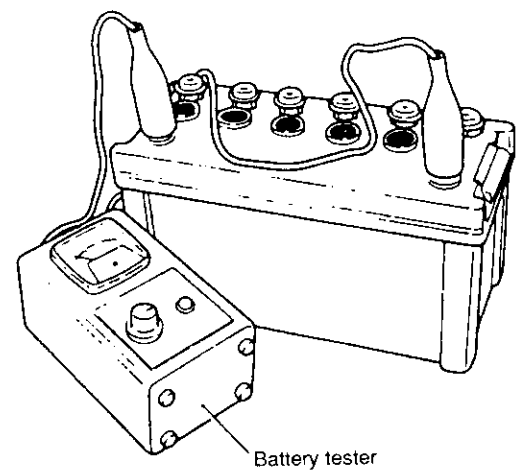

3) The battery is fully charged if the specific gravity is 1.260 at an electrolyte temperature of 20°C. The battery is discharged if the specific gravity is 1.200 (50%). If the specific gravity is below 1.200, recharge the battery.

4) If the difference in the apecitic gravity among the cells of the battery is ±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
$S_{20} = St + 0.0007(t-20)$
$S_{20}$: Specific gravity at the standard temperature of 20 °C
St: 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

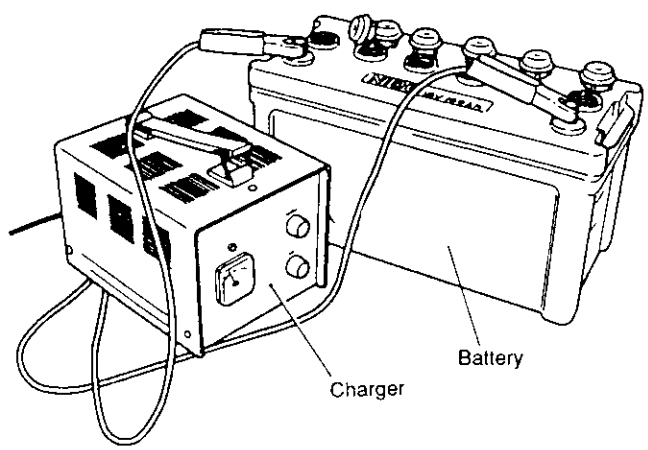
There are two methods of charging a battery: normal and rapid.

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 ~5OA 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

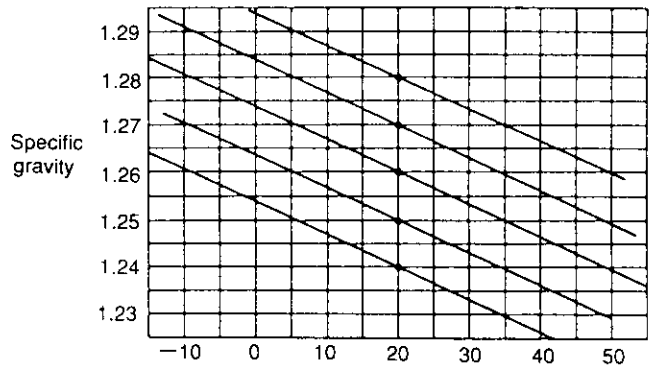
(1) Check the specific gravity and adjust the electrolyte level.
(2) Disconnect the battery cables.
(3) Connect the red clip of the charger to the (+) battery terminal and connect the black clip to the (—) terminal.




(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℃ during chareing.
(4) Since an altemator 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].)

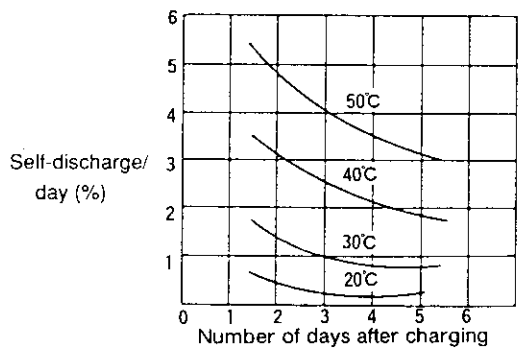



Electrolyte temperature and specific gravity

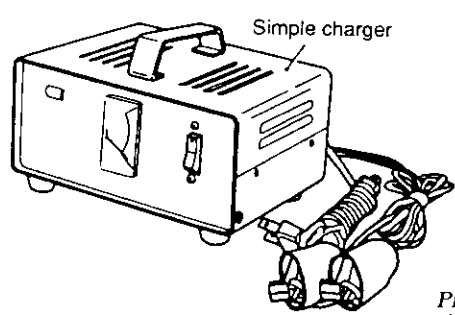
## 2-5 Battery storage precautions

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 altemator 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.



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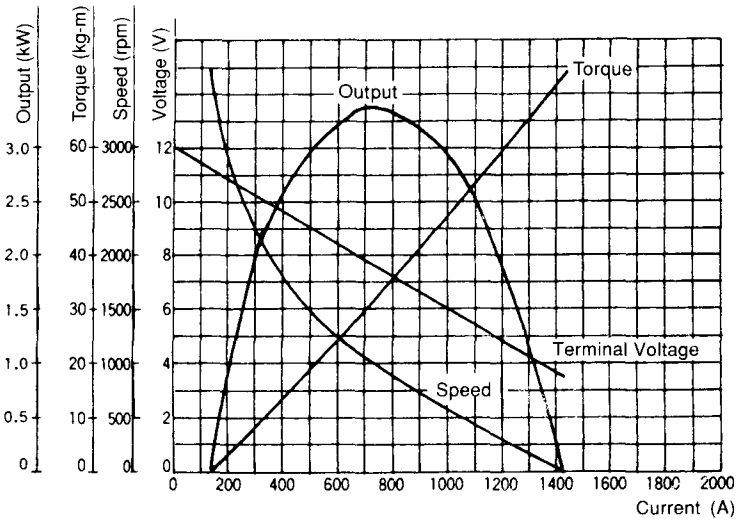
# 3. Starter Motor

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.

## 3-1 Specifications and Perfofmance

| Engine model | | 6LY2-STE/6LY2A-STP/6LYA-STP |
|---|---|---|
| Model | | S13-68A |
| Rating (sec.) | | 30 |
| Output (kW) | | 3 |
| Direction of rotation (viewed from pinion side) | | Clockwise |
| Mass kg | | 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 |

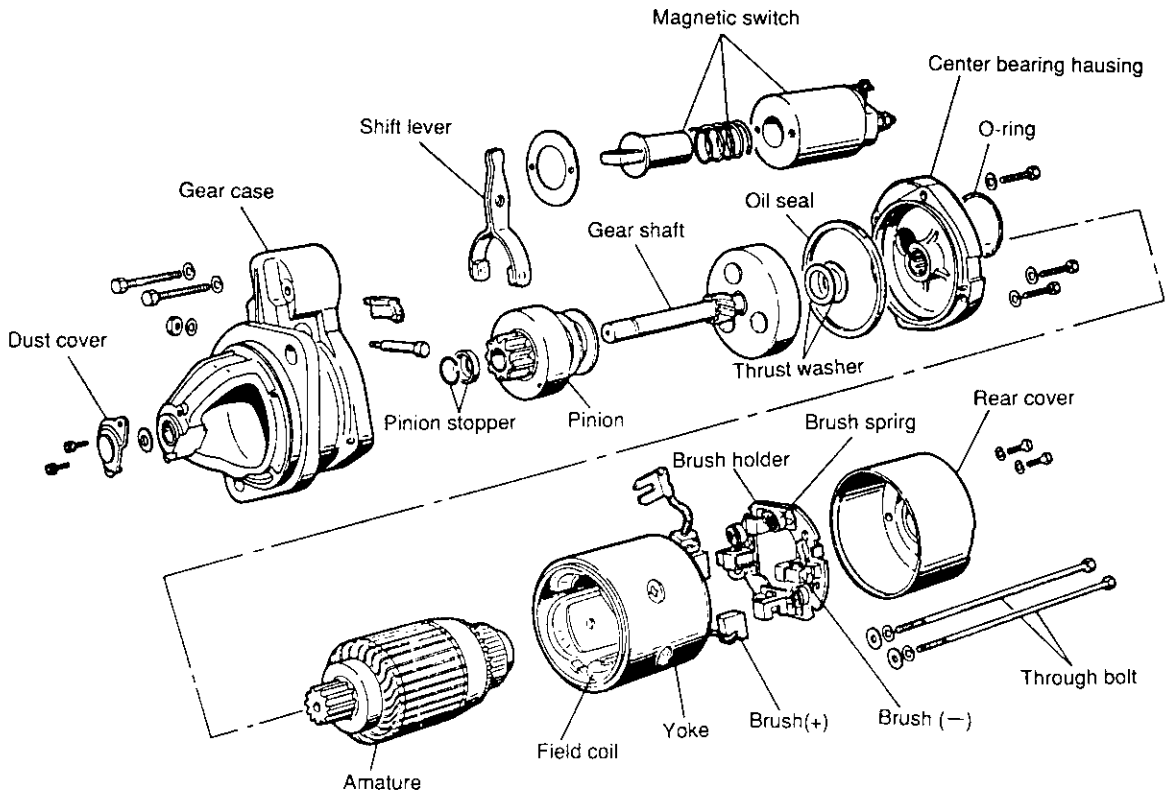


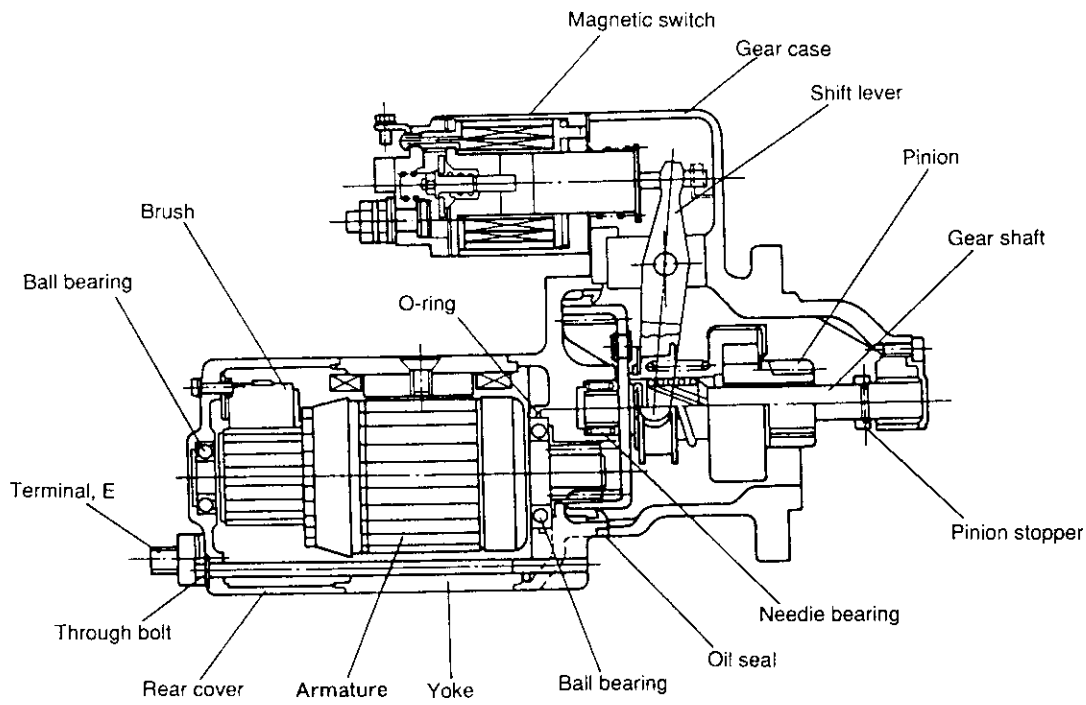

Performance curves

### 3-2 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.

## 3-3 Construction



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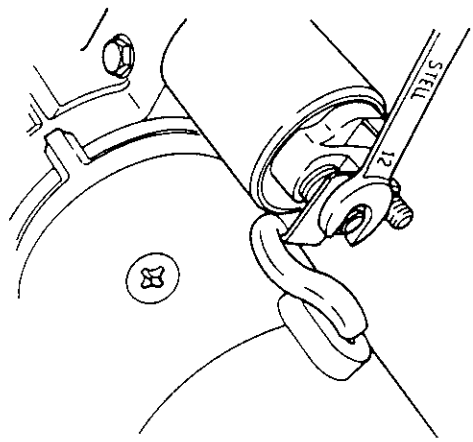
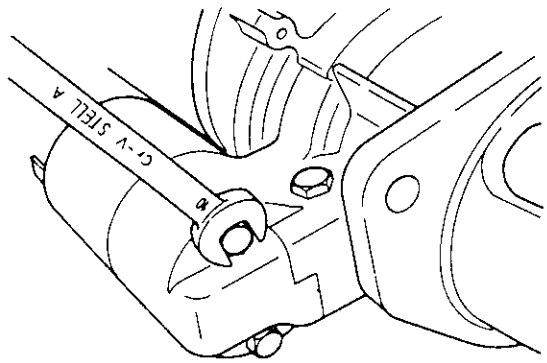
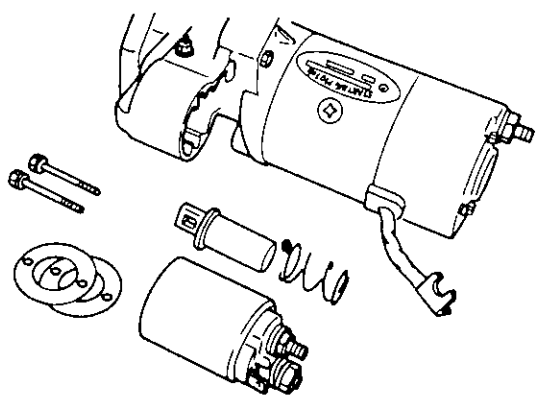
## 3-4 Disassembly

(1) Disconnect the magnetic switch wiring.
Loosen the M8, nut and disconnect the magnetic switch wiring.

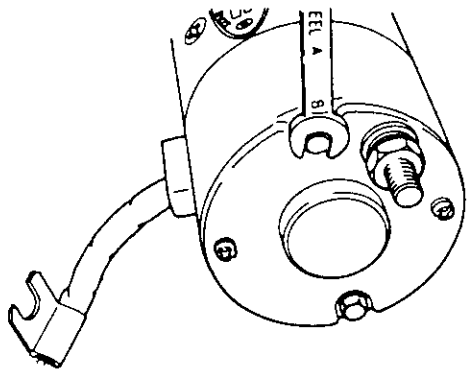


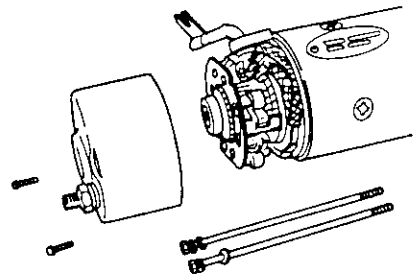
(2) Remove the magnetic swtich.
Remove the two M6 bolts.



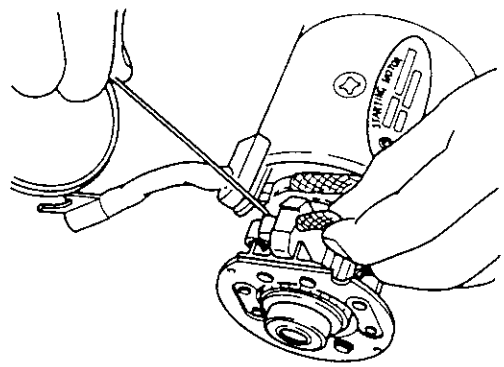


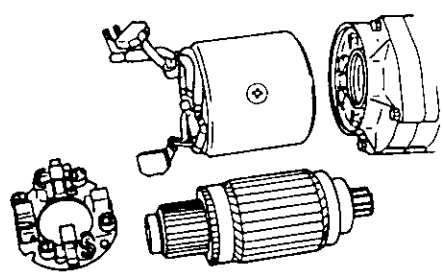
(3) Remove the rear cover.
1) Remove the two screws holding the brush holder.
2) Remove the two M5 through bolts.
3) Remove the rear cover, using the minus (−) driver.



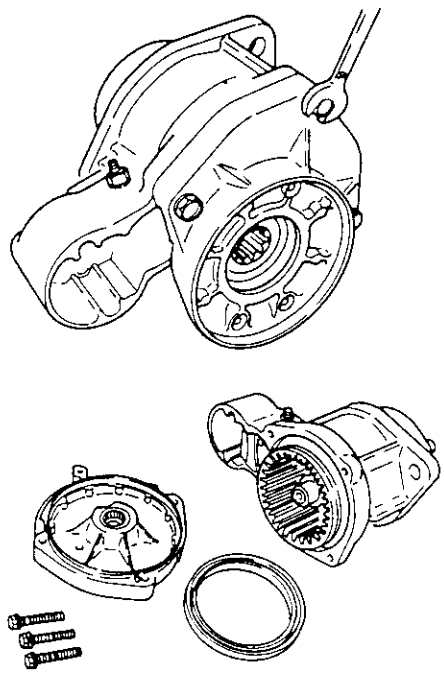


(4) Remove the brush holder.
1) Float the minus (−) brush from the commutator.
2) Remove the plus (+) brush from the brush holder.
3) Remove the armature form the yoke.

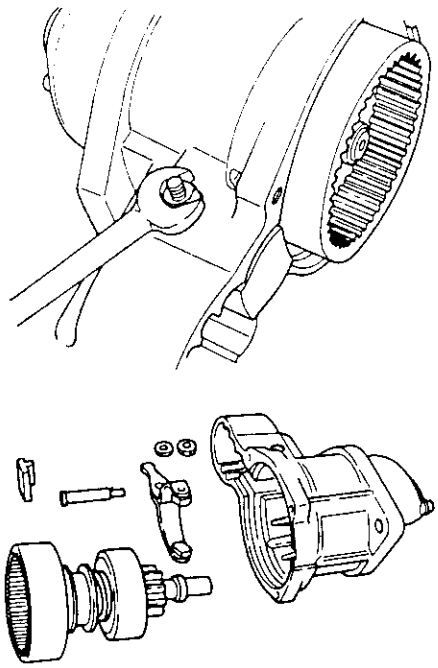




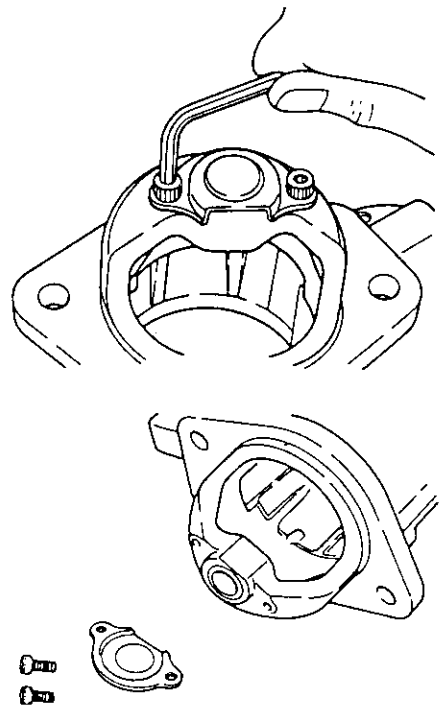
(5) Remove the center bearing housing.
1) Remove the three M6 bolts trom the gear case.
2) Remove the center bearing housing and oil seal from the gear case.



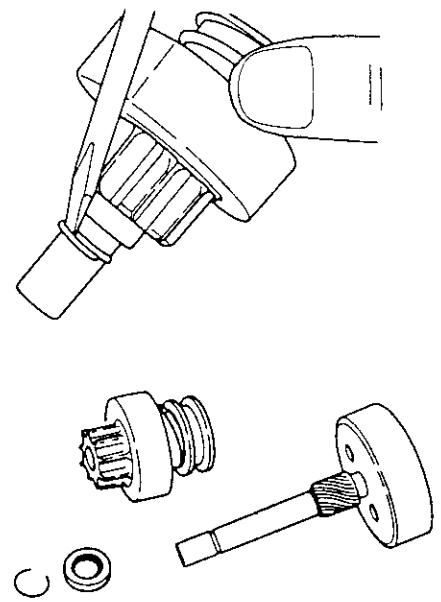
(6) Remove the shift lever pin.
1) Remove the M6 bolt from the gear case.
2) Remove the shift lever pin from gear case.



(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.





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## 3-5 Maintenance standard

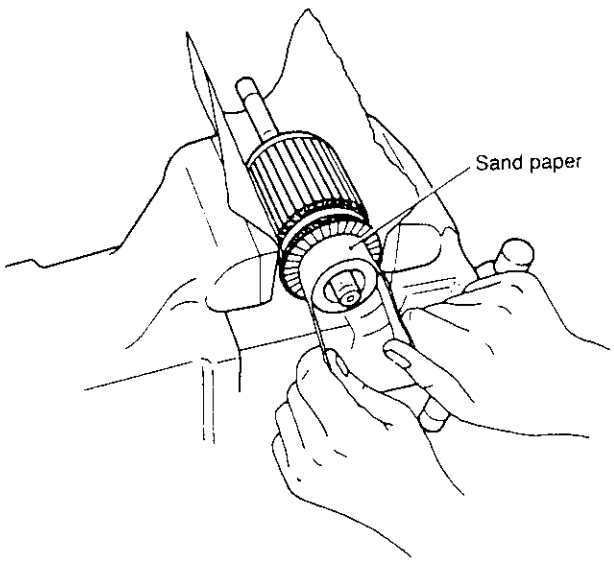
| Model | | | | SI3-68A |
|---|---|---|---|---|
| Brush | Standard spring load | | kg | 3.2 |
| | Standard height | | mm | 18 |
| | Wear limit | | mm | 6.5 |
| Magnetic switch | Series coil resistance | | Ω | 0.21 |
| | Shunt coil resistance | | Ω | 0.67 |
| Commutator | Outside diameter | Maintenance 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.

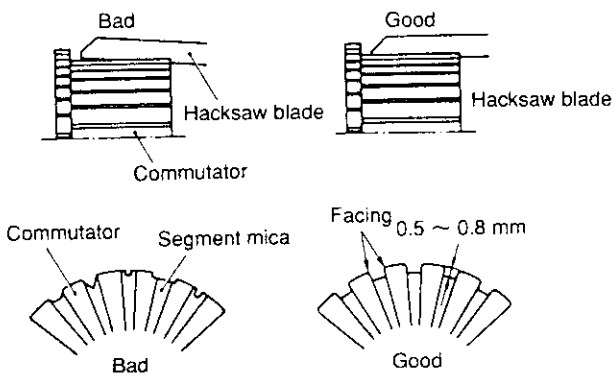
Inspect the surface of the oommutator. If corroded or pitted, sand with #500 ~ #600 sandpaper. If the commutator is severely pitted, grind it to within a surface roughness of at least 0.1mm (0.0039 in) by turning it on a lathe. Replace the commutator if damage is irreparable.




| Model | SI3-68A | |
|---|---|---|
| | Maintenance standard | Wear limit |
| Commutator outside diameter | $\phi$ 37 | $\phi$ 36 |
| Deflection | Repair limit 0.1 | Repair accuracy 0.05 |

(2) Micaundercut

Check the mica undercut, correct with a hacksaw blade when the undercut is too shallow.



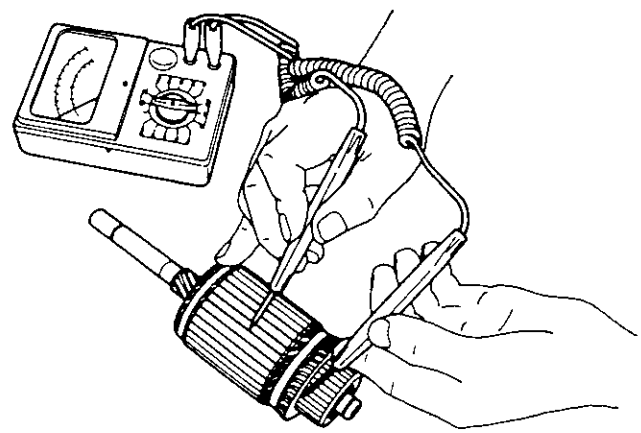

mm (in.)

| | Maintenance standard | Repair limit |
|---|---|---|
| Mica undercut | 0.2 | 0.5 ~ 0.8 |

(3) Armature coil continuity and ground test

Using a tester check for continuity betweea the commutator and the shaft (or armature core). Continuity indicates that these points are grounded and that the armature must be replaced.

Checking commutator for insulation defects.



| Kind of test | Check point | Normal | Abnormal |
|---|---|---|---|
| Continuity | Commutator between armature | YES | NO (Broken or disconnercted coil) |
| Insulation | Commutator between armature or shaft | NO | YES (Short-circuit) |



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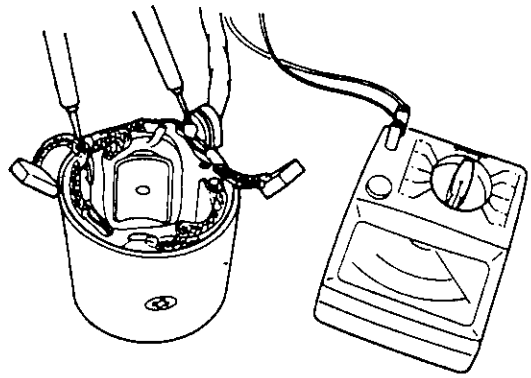
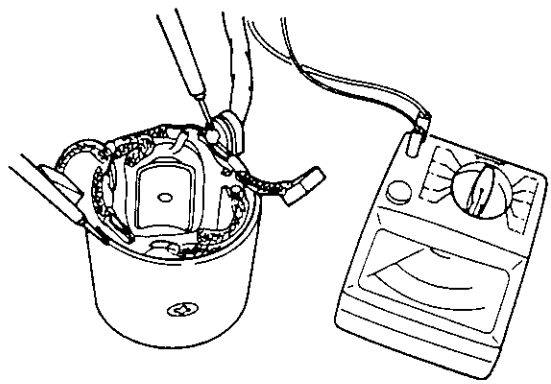
### 3-6.2 Field coil

(1) Field coil continuity and ground test.



**Field coil insulation test**



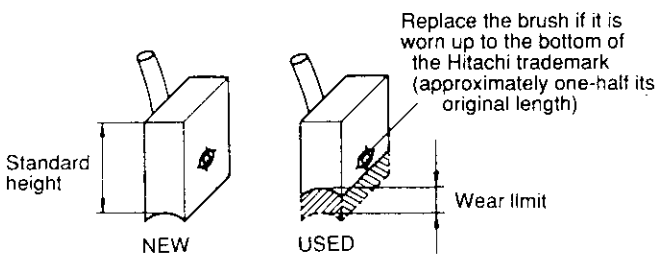
**Field coil continuity test**

| 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.



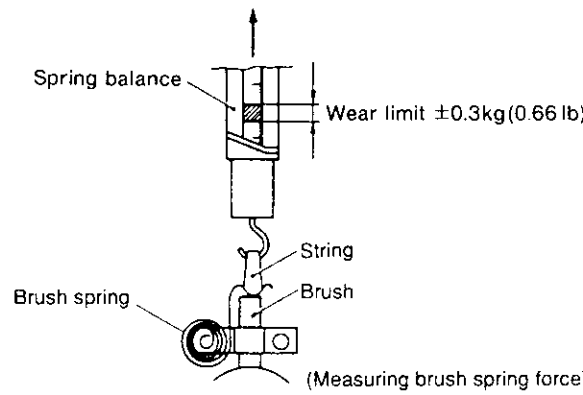

mm

| | 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

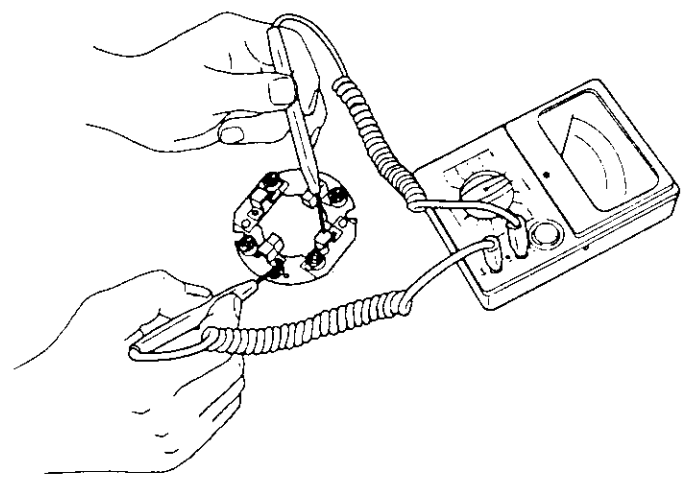
Since the brush spring pushes the brush against the commutator while the motor is running, a weak or defective spring will cause excessive brush wear, resulting in sparking between the brush and the commutator during operation. Measure the spring force with a spring balance; replace the spring when the difference between the standard value and the measured value exceeds ±0.3kg (0.66 lb)




| | S13 68A |
|---|---|
| Standard spring load | 3.2kg |

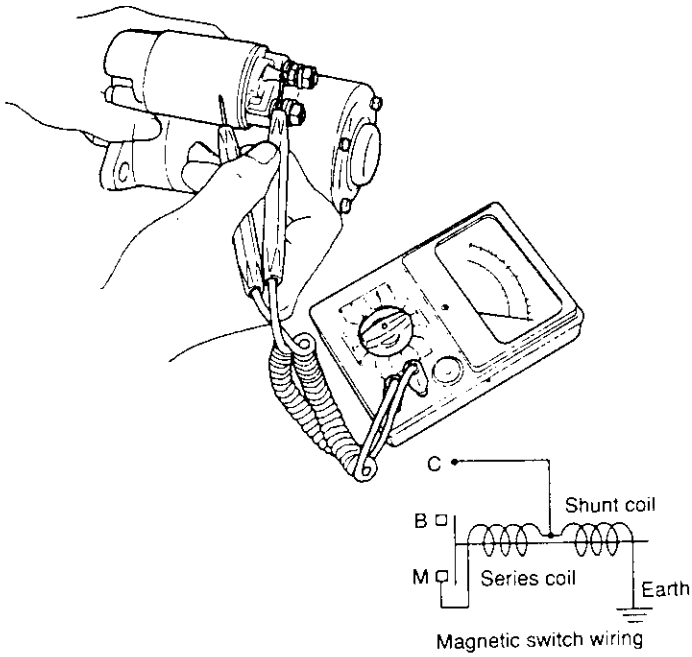
(4) Brush holder ground test

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

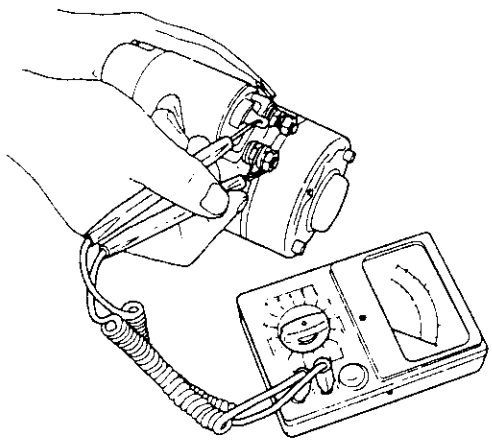
(1) Shunt coil continuity test
Check for continuity between the S terminal and the magnetic switch body (metal part). Continuity indicates that the coil is open and that the swtich must be replaced.



Magnetic switch wiring

| | 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; replaca 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.

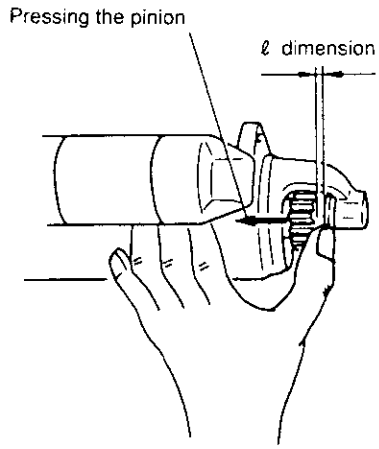
| | | |
|---|---|---|
| Magnetic switch plunger | Shell | Aeroshell No.7 |
| Bearing and spline | Shell | Albania Grease No.2 |
| Reduction gear | Shell | Aeroshell No.7 |
| Sliding of shift lever | Shell | Aeroshell No.7 |

## 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 |



Measuring of ℓ dimension



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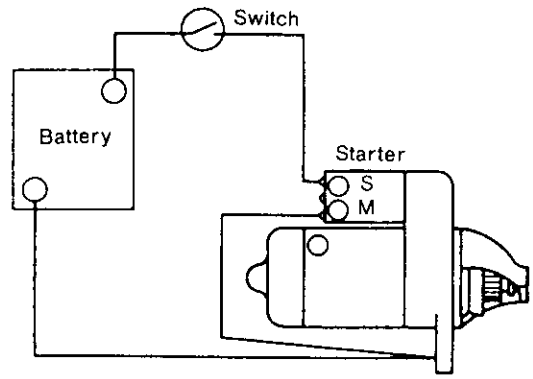
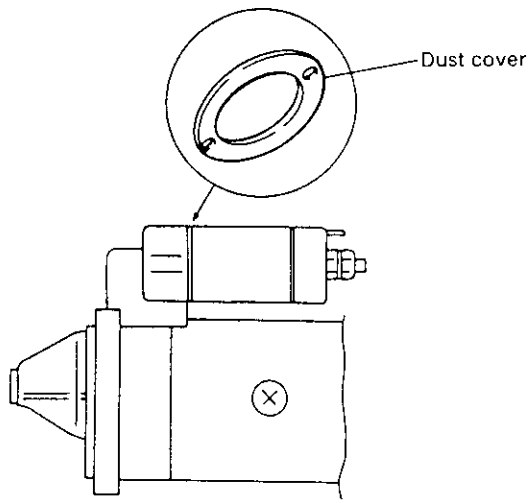
(2) Pinion movement
After complete assembly of the starter motor, connect up the motor as in Fig.




(3) Plunger movement
Adjustment made by adjusting stroke of magnetic plunger to the prescribed value.
1) Shim adjusting.
Adjust the ℓ-dimension dust cover at the magnetic switch attach section.




(4) Thrust gap of armature
No adjustment type.

(5) Thrust gap of gear shaft

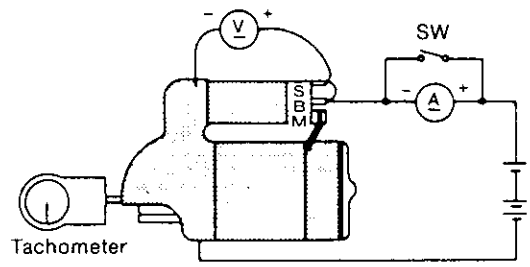
mm

| | 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 sdvance when the startirng 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<br>Motor mounting faulty<br>Brush worn or contacting brush spring faulty<br>Commutator dirty<br>Armature, field coil faulty<br>Field coil and brush connection loose | Replace<br>Remount<br>Replace<br>Repair<br>Repair or replace<br>Retighten |
| Magnetic switch | Contactor contact faulty<br>Contactor contacts pitted | Replace<br>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 |



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# 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

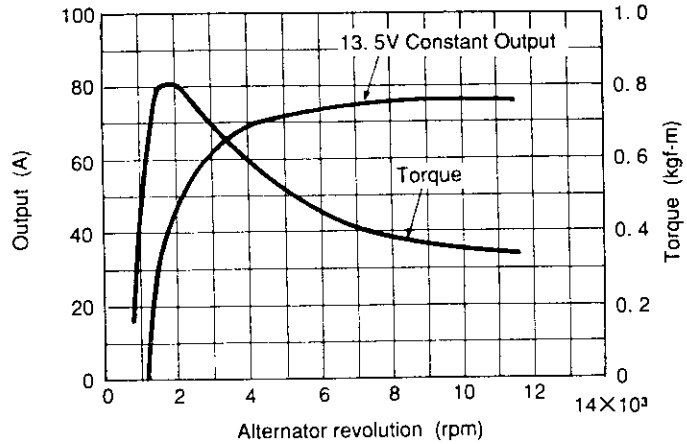
The alternator contains a regulator using an IC, and has the following features.

(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

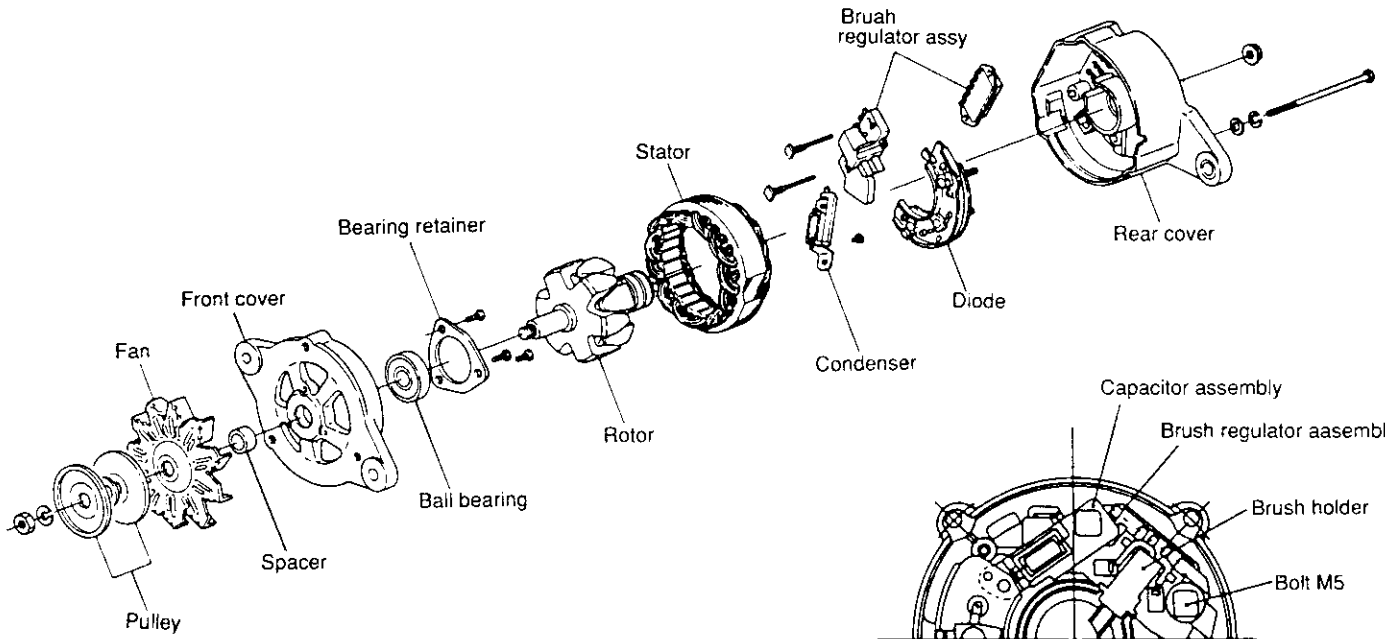
| | |
|---|---|
| Model of alternator | LR180-03B (HITACHI) |
| Model of IC regulator | TRIZ-63 (HITACHI) |
| Battery voltage | 12V |
| Nominal output | 12V/80A |
| Earth polarity | Negative earth ( $\theta$ ) |
| Direction of rotation (viewed from pulley end) | Clockwise |
| Weight | 54kg |
| Rated speed | 5000rpm |
| Operatirry speed | I200~9000 |
| Speed for 13.5V | 1200 or less |
| Output current at 20℃ | over 75±3A/5000 rpm |
| Regulated voltage | 14.5±0.3V(Standard temperature voltage gradient, -0.01/℃) |

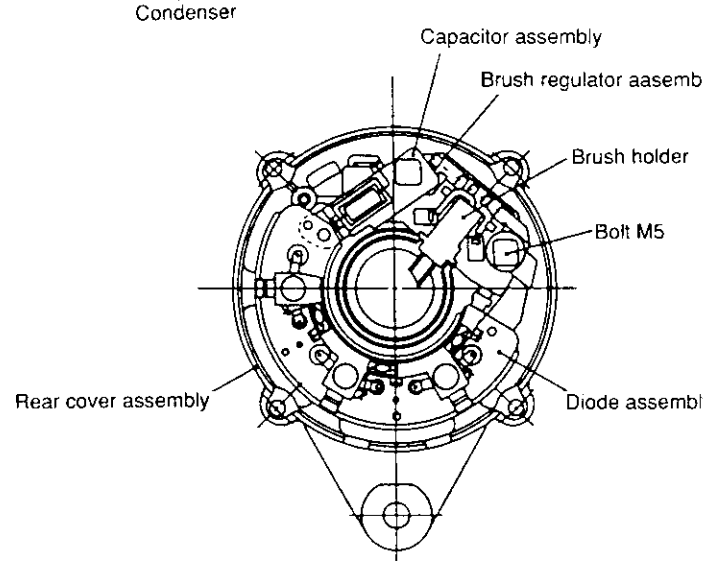
## 4-3 Characteristics

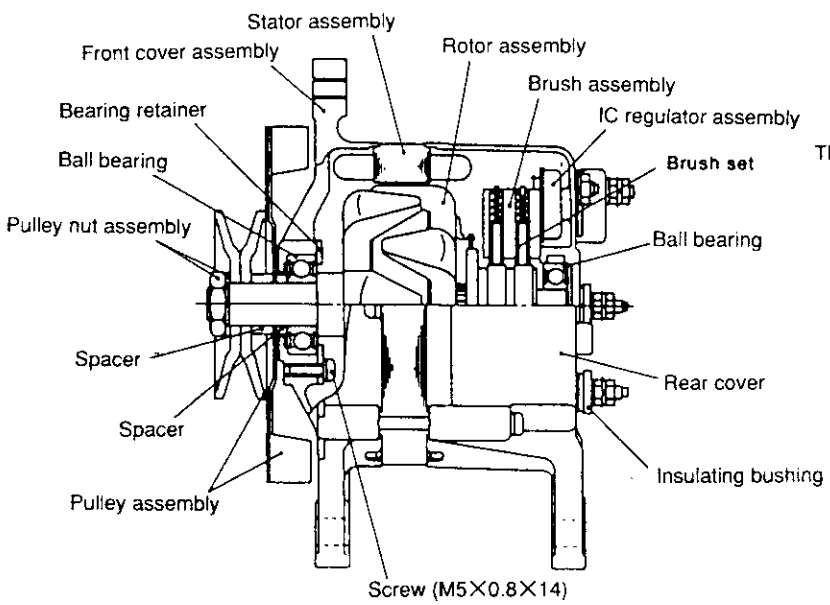


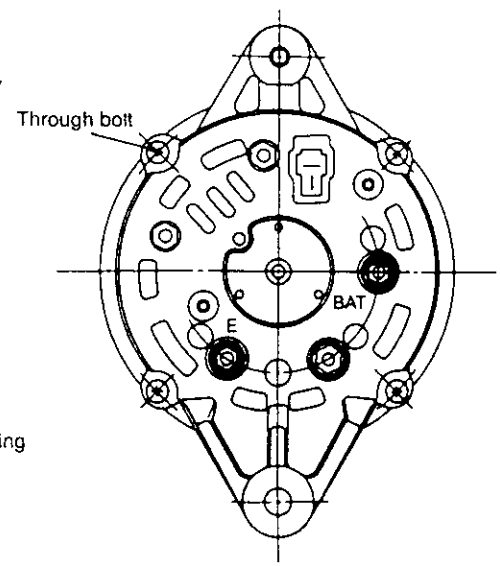
## 4-4 Construction

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.



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## 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 furned 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

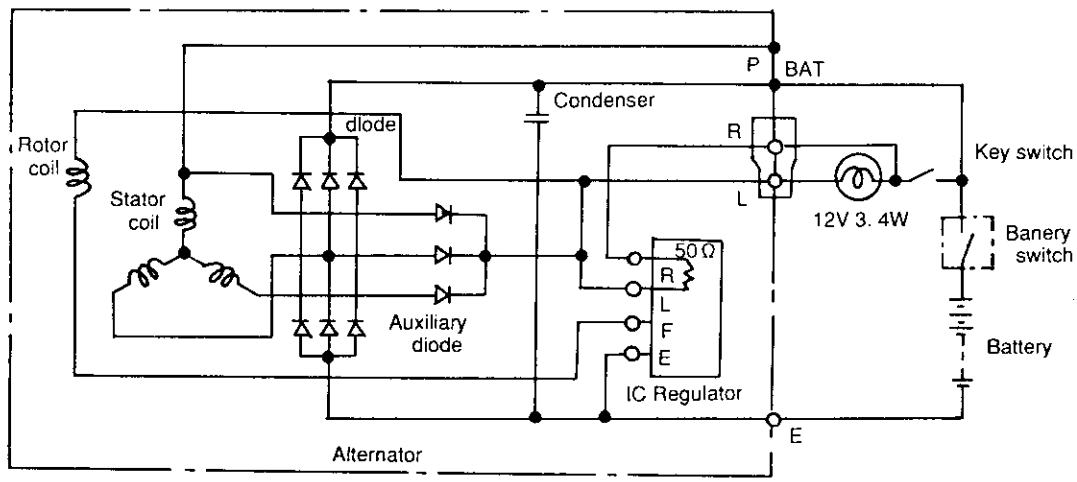
(1) Be careful of the battery's polarity (+, — terminals), and do not connect the wrong terminals to the wrong cables, or the battery will be short-circuited by the generator diode.
In this case too much current will flow, the IC regulator and diodes burn out, and the wire harness will burn.

(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.

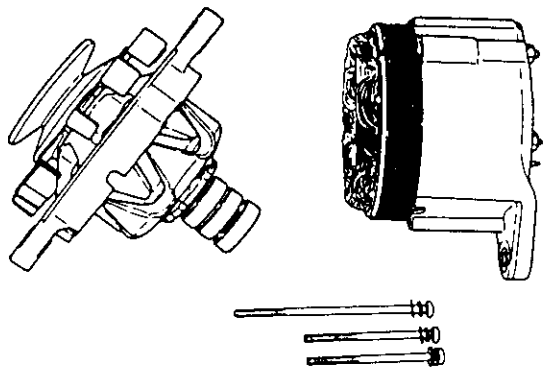
(5) Do not conduct any tests using high tension insulation resistance. (The diodes and IC regulator will burn out.)



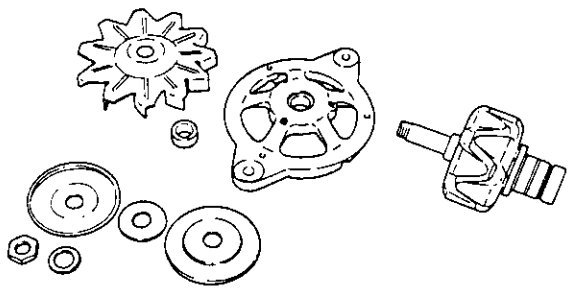

Connection diagram

## 4-7 Disassembling the alternator

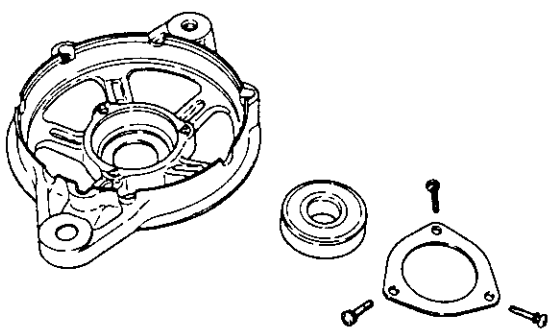
(1) Remove the through-bolt, and separate the front assembly from the rear assembly.



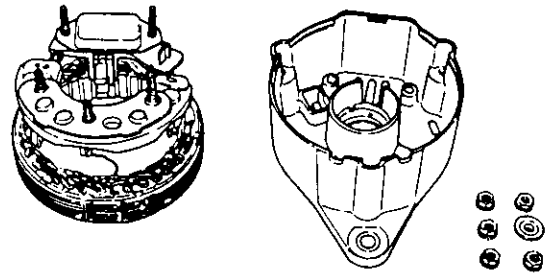
(2) Remove the pulley nut, and pull out the rotor from the front cover.



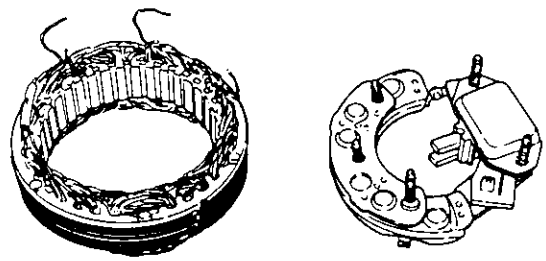
(3) Remove the $\phi$5mm ($\phi$0.1969 in.) screw from the front cover, and then remove the ball bearing.



(4) Remove the nut, the brush-holdar, and diode fixing nut at the BAT, and the terminal scraws of the rear cover. Separate the rear cover from the stator (with the diode and brush holder).

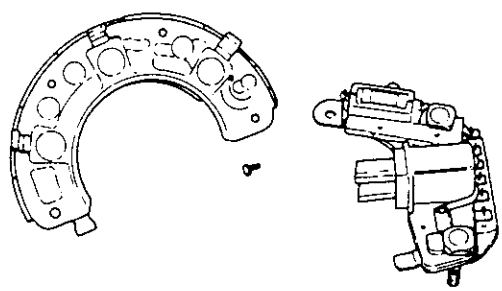


(5) Disconnect the soldered joint of the stator lead wire, and remove the diode and brush regulator assemblies from the stator at the same time.



(6) Separating the regulator

1) To separate the regulator, remove the $\phi$3 mm ($\phi$ 0.1181in.) rivet which keeps the diode assembly and the brushless regulator in place, and the soldered joint of the L-terminal.





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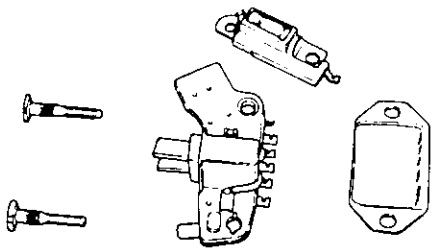
2) To replace the IC regulator, disconnect the soldered joint of the IC regulator and pull out the two bolts. Do not remove these two tnlts except when replacing the IC regulator.

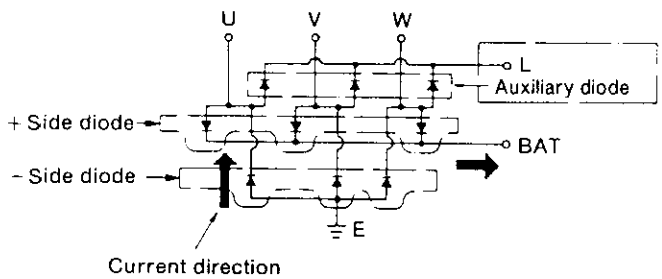


## 4-8 Inspection and adjustment

(1) Diode

| Between terminals | | BAT ( + side diode) | |
|---|---|---|---|
| | Tester wire | + side | − side |
| U.V.W. | + side | | No continuity |
| | − side | Continuity | |

| Between terminals | | E ( − side diode) | |
|---|---|---|---|
| | Tester wire | + side | − side |
| U.V.W. | + side | | Continuity |
| | − side | No continuity | |

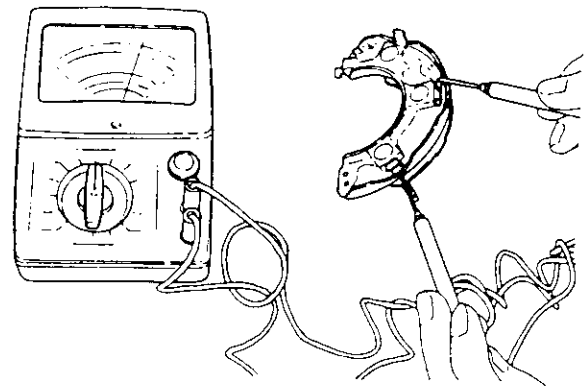



U.V.W.: terminal from the stator coil

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 aM 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 aound to be defective, replace the diode assembly. Since there is no terminal on the auxiliary dlode, 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.

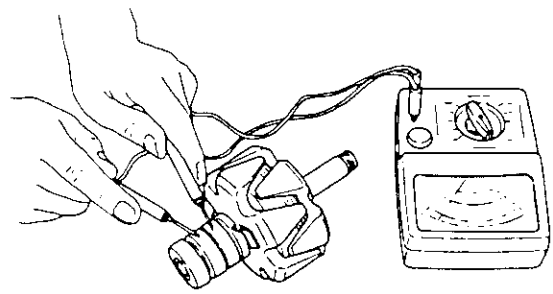
1) Inspecting the slip ring surface

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. | $\phi$ 31.6 mm | $\phi$ 30.6 mm |

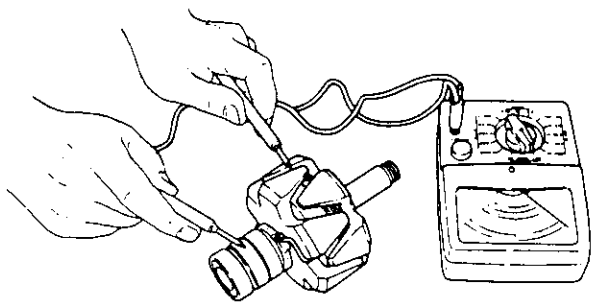
2) Rotor coil continuity test

Check the continuity in the slip ring with the tester. If there is no continuity, there is a wire break. Replace the rotor coil.

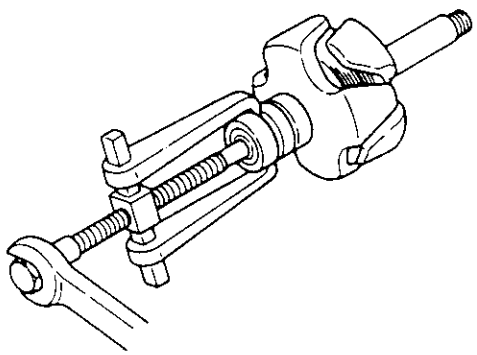


| Resistance value | Approx. 2.8 Ω at 20℃ |
|---|---|

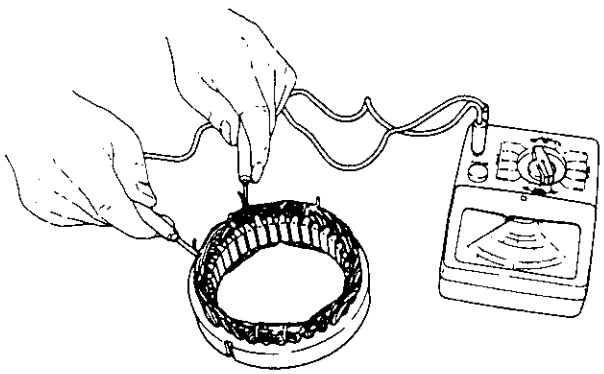
3) Rotor coil insulation test
Check the continuity between the slip ring and the rotor core, or the shaft. If there is continuity, insulation inside the rotor is defective, causing a short with the earth circuit. Replace the rotor coil.



4) Check the rear side ball bsaring. If the rotation of the bearing is heavy, or produces abnormal sounds, replace the ball bearing.

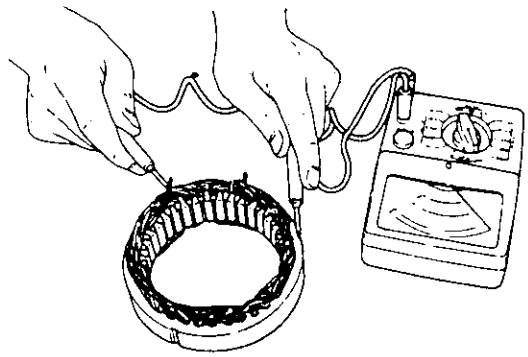


(3) Stator
1) Stator coil continuity test
Check the continuity between each terminal of the stator coil. If there is no continuity, there is. a wire break in the stator coil. Replace the stator coil.

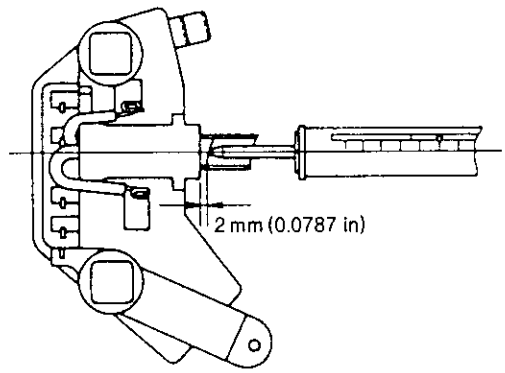


| | |
|---|---|
| Resistance value | Approx. 0.031 Ω at 20℃<br>1-phase rasistance |

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.

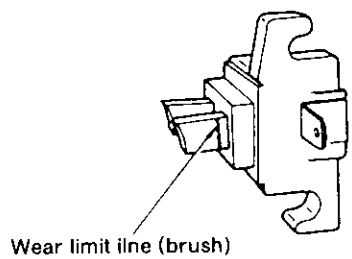


(4) Brush
The brush is hard and wears slowly, but when it is worn beyond the allowable limit, replace it. When replacing the brush, also check the strength of the brush spring.
To check, push the spring down to 2mm (0.0787in.) from the end surface of the brush holder, and read the gauge.




| | |
|---|---|
| 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 |



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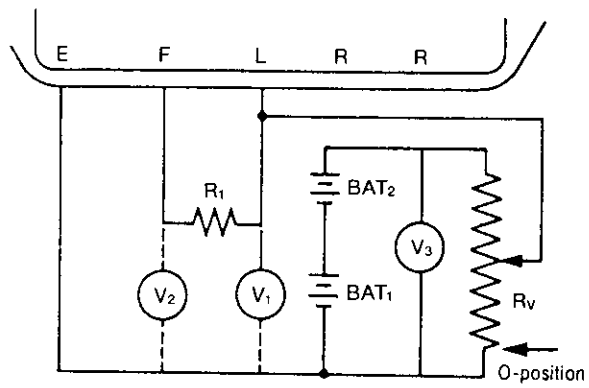
(6) IC regulator
Connect the varlable resistance, two 12V batteries, resistor, and voltmeter as Shown in the diagram.

1) Use the following measuring devices.

| | |
|---|---|
| Resistor ($R_1$) | 100Ω, 2W, 1pc. |
| Variable resigtor (Rv) | 0-300Ω, 12W, 1pc. |
| Battery ($BAT_1$, $BAT_2$) | 12V, 2pcs. |
| DC voltmeter | 0-30V, 0.5 class 1pc. (measure at 3 points) |

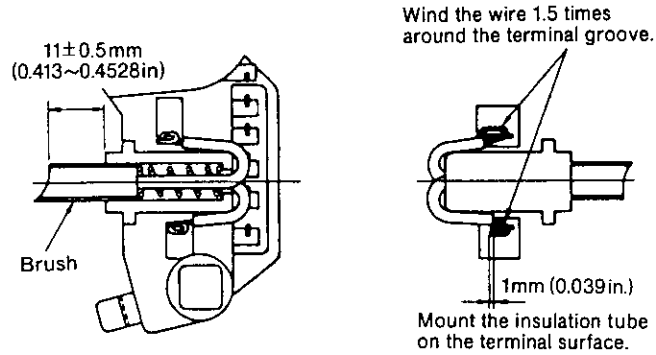
2) Check the regulator in the following sequence, according to the diagram.
a) Check $V_3$ ($BAT_1 + BAT_2$ voltage). If the voltage is 20-26V, both $BAT_1$ and $BAT_2$ are normal.
b) While measuring $V_2$ (F-E terminal voltage), move Rv gradually from the O-position. Check if there is a point where 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 Rv to the O-position, and connect the voltmeter to the V, position.
c) While measuring V, (voltage between L-E terminals), move Rv gradually from the O-position. There should be a point where the voltage of V, rises sharply by 2-6V. Measure the voltage of V, just before this sharp voltage rise. This is the regulating voltage of the regulator. If this voltage of V, 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

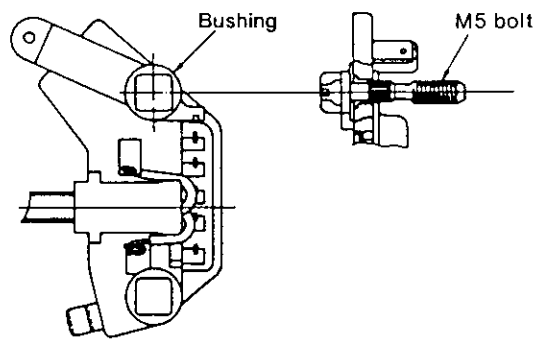
Reassembly is done in the reverse order of disassembly. For reassembly, be careful of the following points. (Refer to 4-7 disassembling altemator).

(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 drlp into the pig tail (lead wire).




*NOTES: 1. Use non-acid type paste.*
*2. The soldering iron temperature is 300 ~ 350℃.*

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).

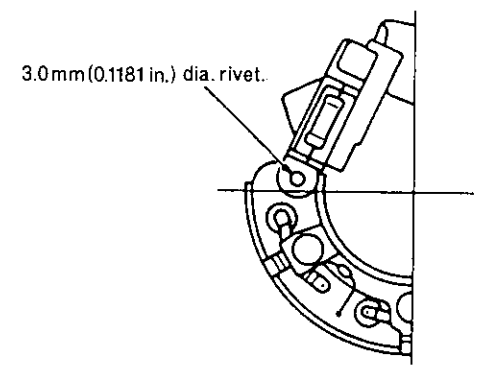



*NOTES: 1. Insertion pressure is 100kg (220.5 lbs.)*
*2. Insert vertically.*

(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.

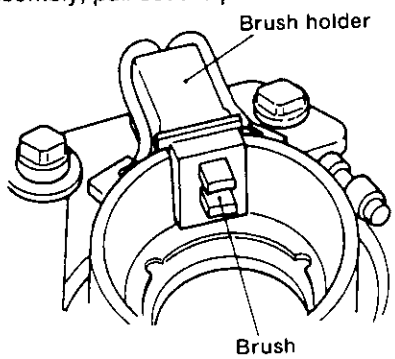
| | |
|---|---|
| Calking torque | 500kg |

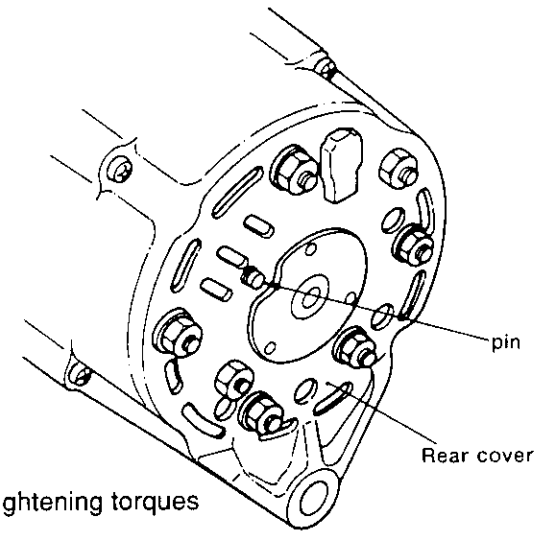
2) Connect the brush to the diode.
Insert the brush side terminal into the diode terminal, calk it, and then solder into place.




| | |
|---|---|
| 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.



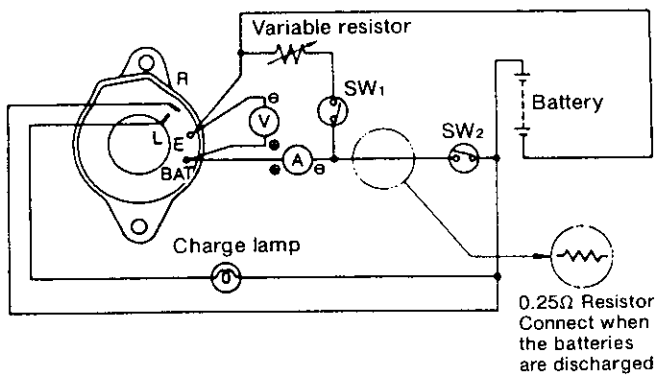




(4) Tightening torques

| Positions | Tightening torque kg-cm |
|---|---|
| Brush holder fixing | 32—40 |
| Diode fixing | 32—40 |
| Bearing ratainer fixing | 32—40 |
| Pulley nut tightening | 450~600 |
| Through-bolt tightening | 32—40 |

## 4-10 Performance test

Conduct a performance test on the reassembled AC generator as follows. The following is the circuit for the performance test.




(1) Measuring devices

| | |
|---|---|
| DC voltmeter | 0—15V or 0—30V, 0.5 Class, 1pc. |
| DC ammeter | 0—100A, 1.0 Class 1pc. |
| Varlable resistor | 0—0.25Ω, 1kW, 1pc |
| Lamp | 12V, 3W |
| 100Ω resistor | 3W |
| 0.25Ω 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 $SW_2$ while keeping SW, 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 rpms.

***NOTES:*** *1. Make sure that the ammeter indication at this time is less than 5A. If fhe indication is over 5A, connect the 0.25Ω fesistor. The voltmeterindication 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 ragulating 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 SWI open for measurement.



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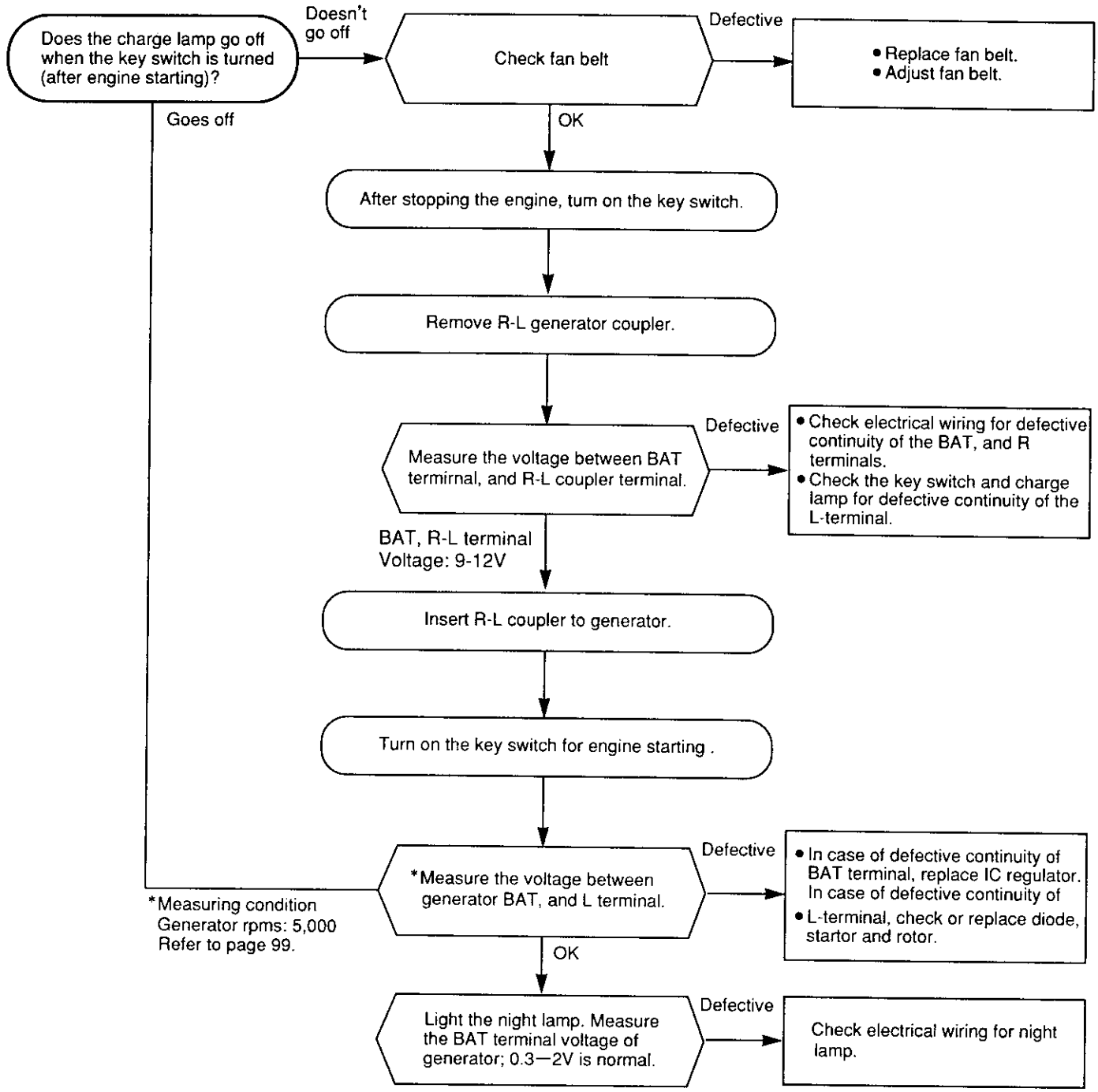
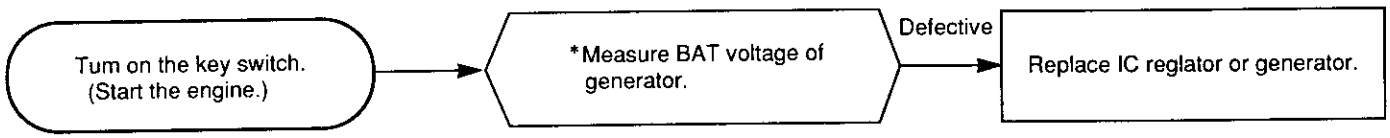
## 4-11 Troubleahooting

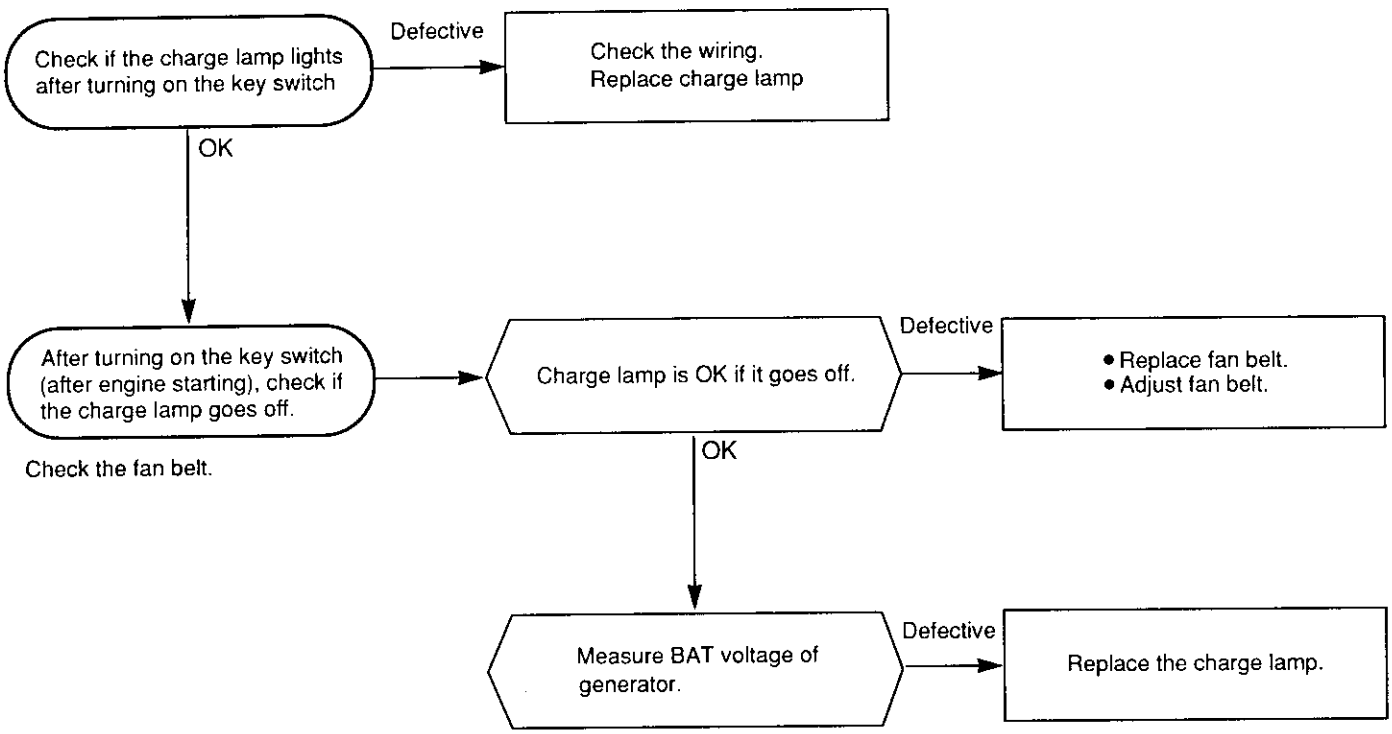
(1) Charging failure



(2) Overcharging




(3) Charge lamp failure



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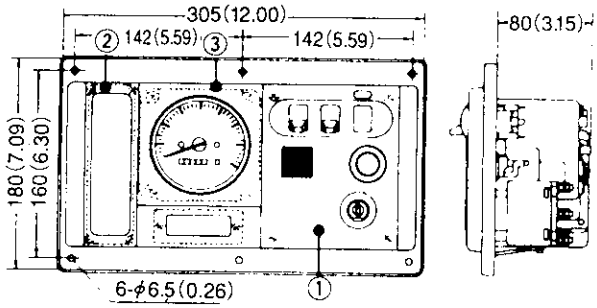
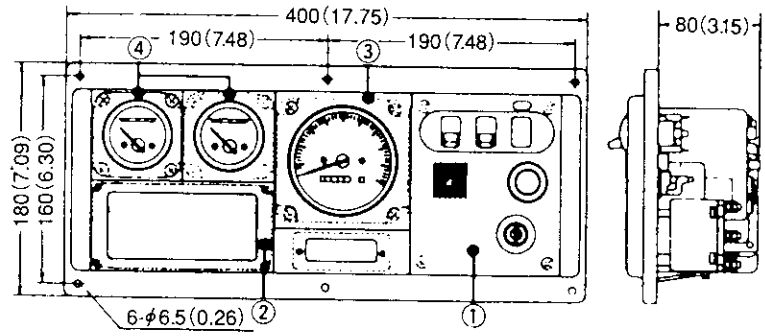
# 5. Instrument Panel

| 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 | ● | ● | ● |
| ④ | Sub meter unit | LO. pressure meter | — | ● | ● |
| | | C.W. temperature meter | — | ● | ● |
| | | Boost meter (Turbo) | — | — | ● |
| ⑤ | Clock unit | Quartz clock | — | — | ● |

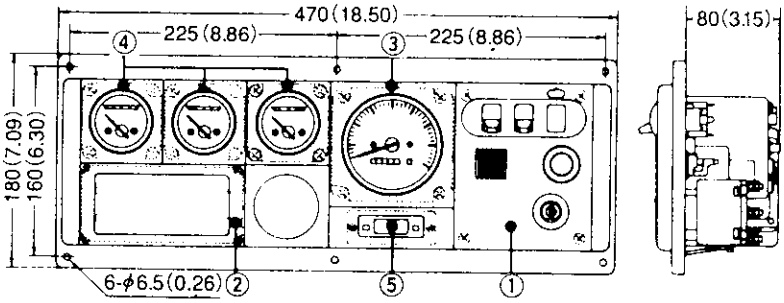
New B-type




New C-type



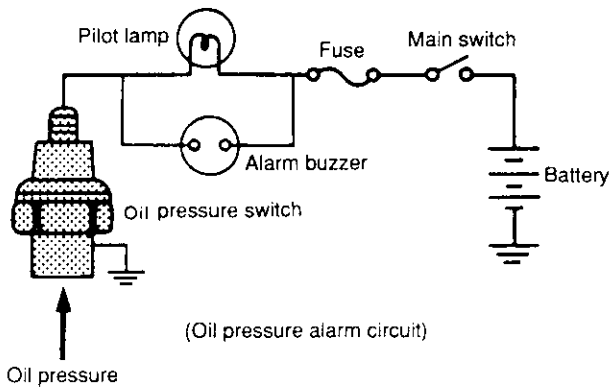

New D-type

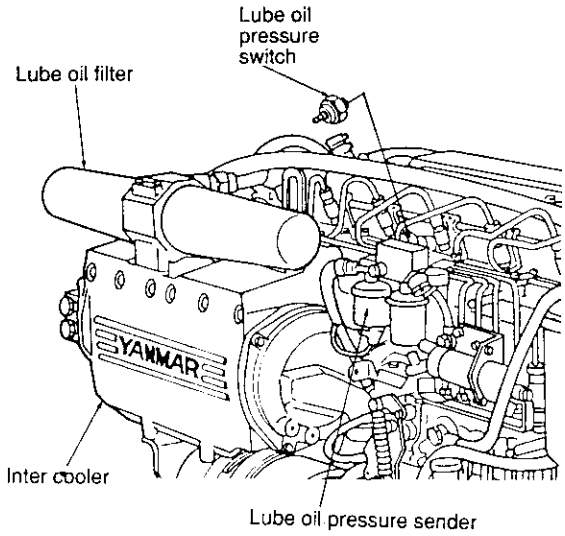


# 6. Warning Devices

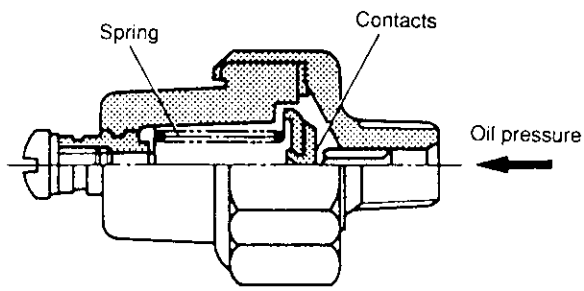
## 6-1 Oil pressure alarm

If the engine oil pressure is below 0.1~0.3 kg/cm² (1.42 ~ 4.26 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 | 0.1~0.3kg/cm² (1.422 ~4.286lb/n.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<br>(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 |



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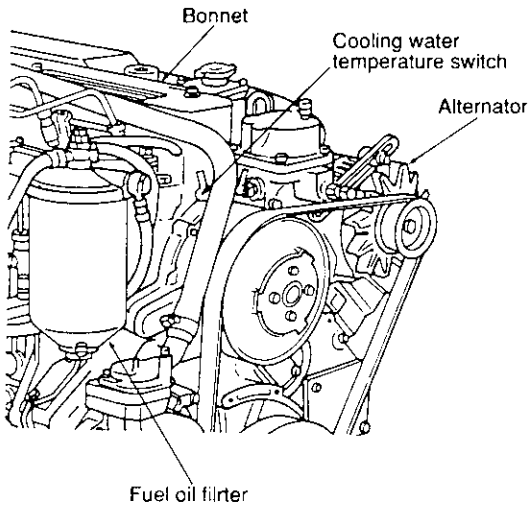
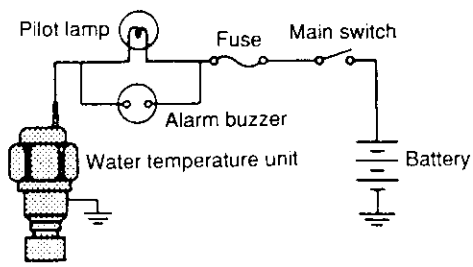
## 6-2 Cooling water temperature alarm

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.

| | | |
|---|---|---|
| Operating temperature | ON | 93 ~97℃ (199 ~206°F) |
| | OFF | 88℃ (190°F) or high |
| Electric capacity | | DC 12V, 1A |
| Response time | | with in 60 sec. |
| Indication color | | Green |
| Tightening torque | | 2.40 ~ 3.20 kg-m (17.35 ~ 23.14 ft-lb) |

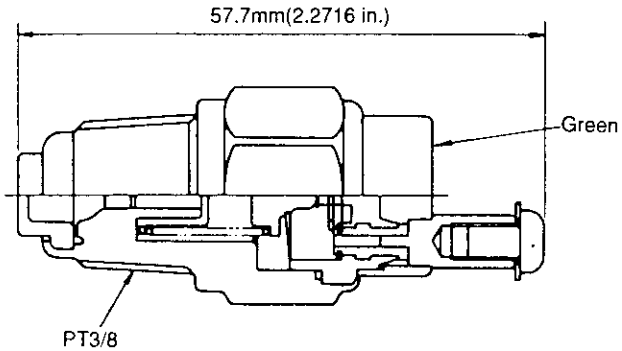


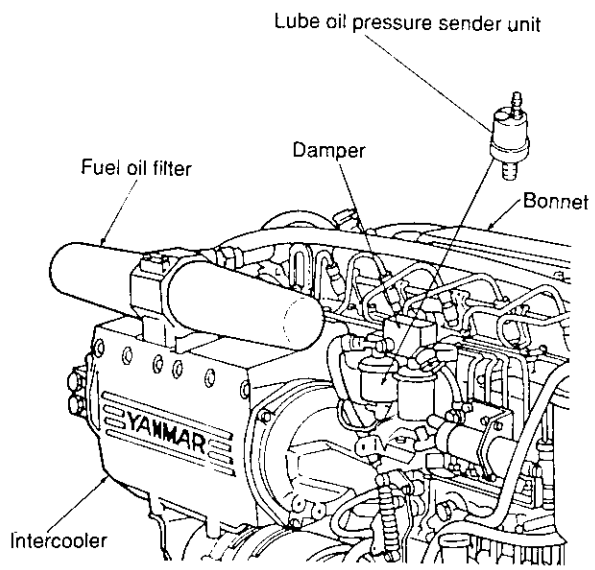




(Water temperature alarm circuit)

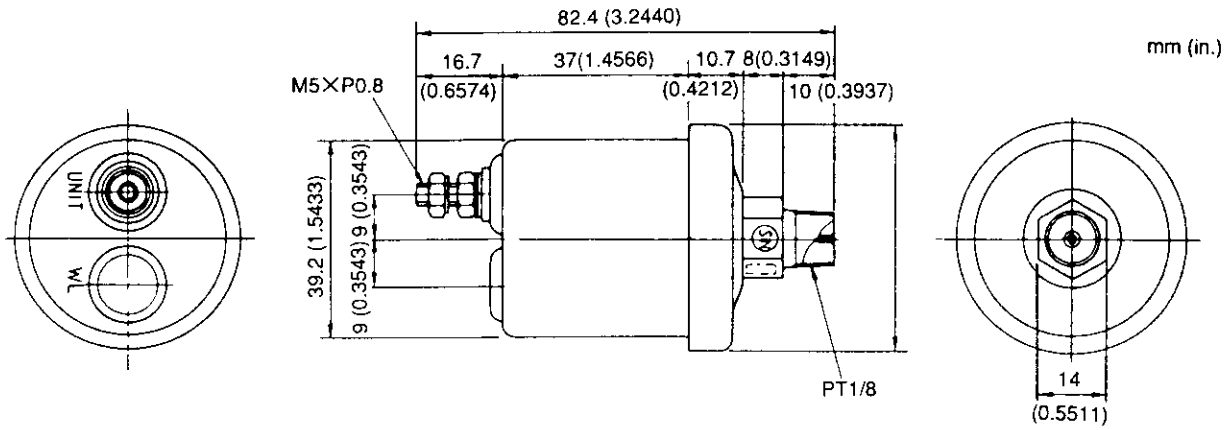
## 6-3 Sender unit for lube oil pressure gauge

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.

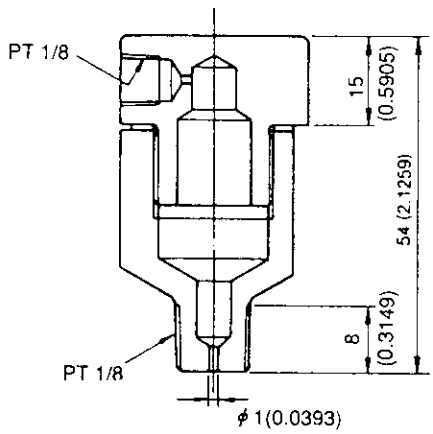


**Lube oil pressure sender unit**



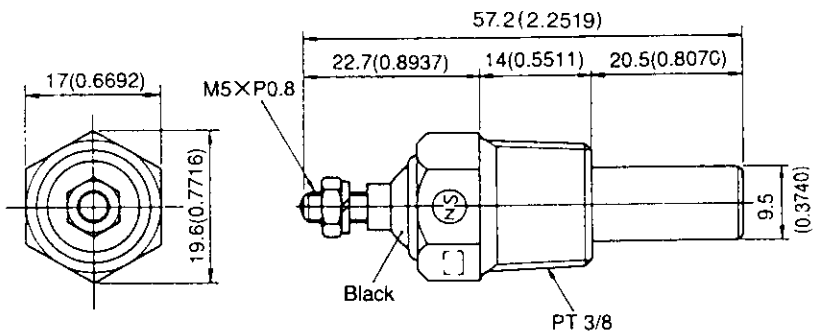

**Damper**



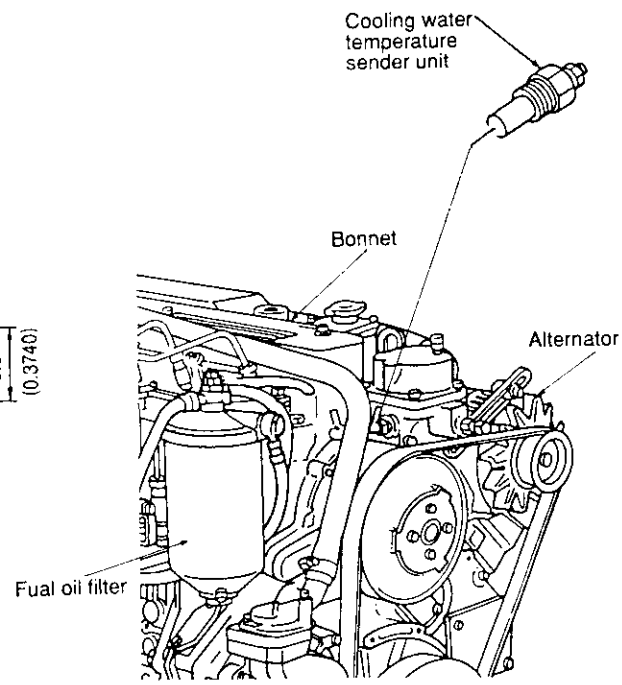

| Type | Resistance switch |
|---|---|
| Rated voltage | DC 12 / DC 24 |
| Max. operating pressure | 8kg/cm²(113.76 lb/in.²) |

## 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 |



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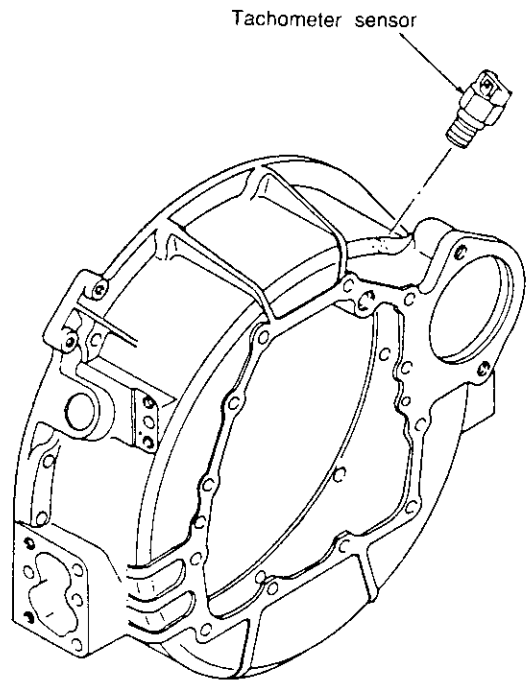
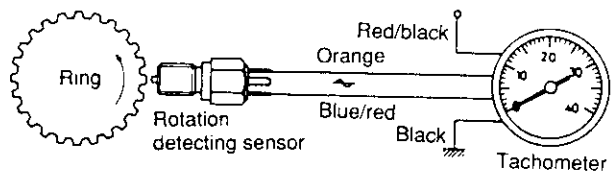
# 7. Tachometer

## 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.



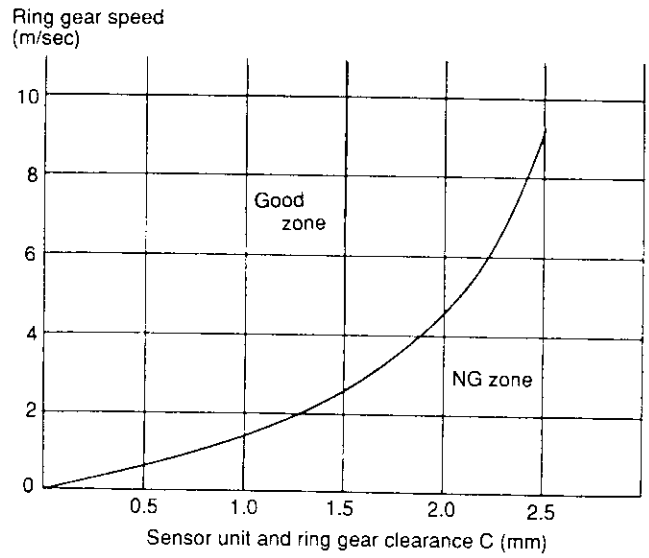



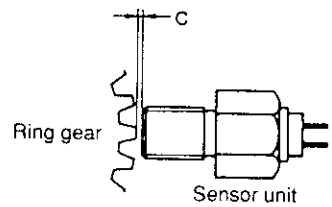

## 7-2 Specifications and dimensions of tachometer

(1) Specifications

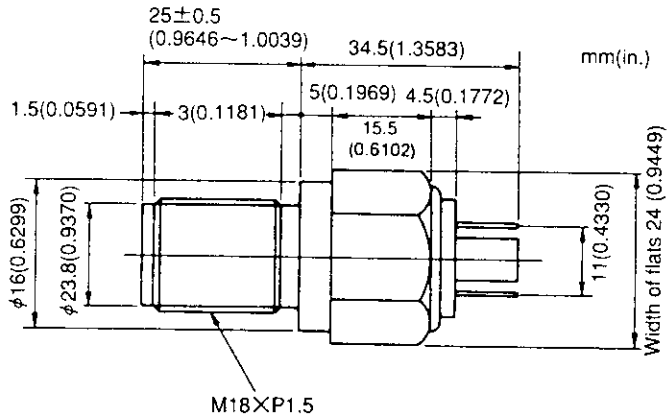
| | | |
|---|---|---|
| Rated voltage | | DC 12V |
| Range of operating voltage | | 10~25V |
| Illumination | | 3.4W/12V |
| Ring gear | No. of teeth | 127 |
| | Module | 2.54 |

(2) Sensitivity limit of sender unit

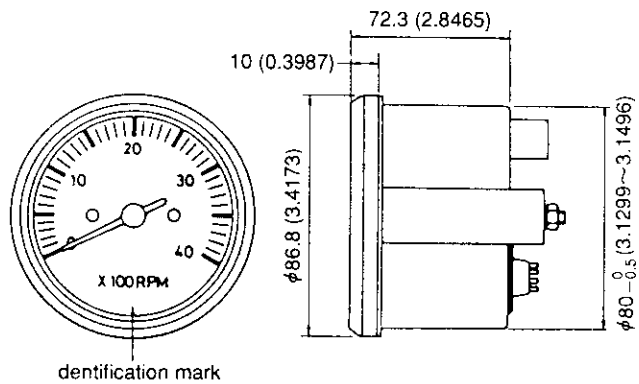



(3) Dimensions of sensor unit



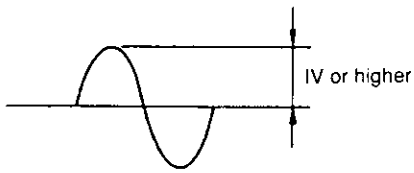

(4) Dimensions and shape of tachometer



## 7-3 Measurement of sensor unit characteristics

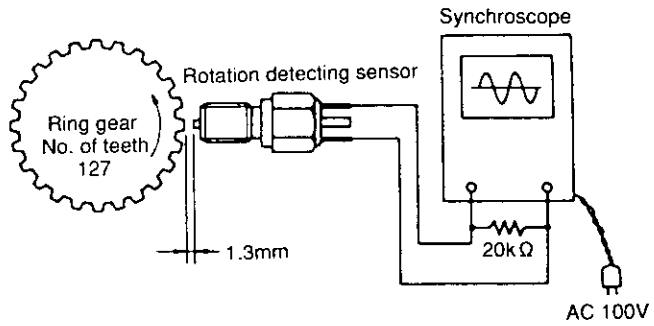
(1) Measurement of output voltage

| 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 | 20kΩ |
| Speed of ring gear | 500 rpm (approx. 800Hz) |
| Measuring temperature | 20℃(68℉) |
| Measuring instrument | Synchroscope |

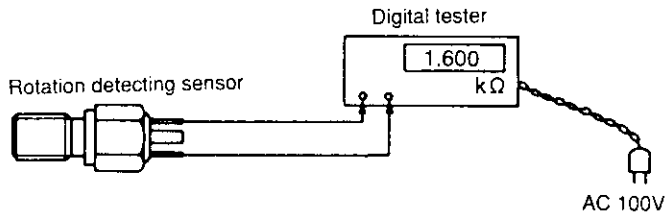



*Check the output wave pattern and number of pulses when carrying out the output voltage measurement.

(2) Measuremen of internal resistance

**Measuring conditions**

| | |
|---|---|
| Measuring temperafure | 20℃ (68℉) |
| Measuring instrument | Digital tester |




## 7-4 Diagnosis

| Fault | Diagnosis | Remedy |
|---|---|---|
| Does not function well.<br>1) Pointer does not move.<br>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)<br>↓ 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.<br>↓ No | Yes Fix the sensor securely. |
| | Measure the internal resistance of the sensor.<br>(To be 1.6 ±0.1kΩ at 20℃)<br>↓ | No Replace the sensor. |
| | Measure the output voltage of the sensor.<br>(To be 1V or higher at 20℃) | No Replace the sensor. |



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CHAPTER 10

# 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

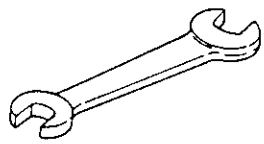
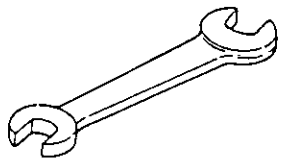
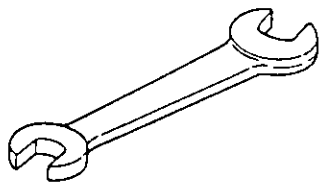
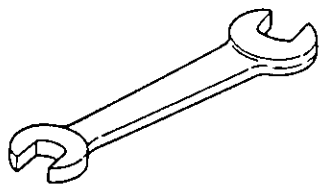
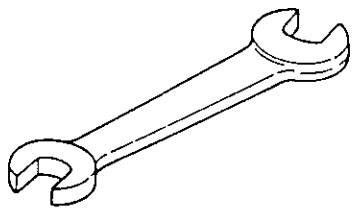
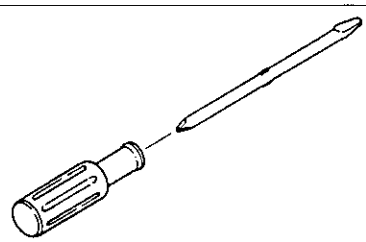
- Take sufficient time to accurately pin-point the cause of the trouble, and disassemble only those parts which are necessary.
- Be careful to keep all disassembled parts in order.
- Prepare disassembly tools.
  Prepare a cleaner and cleaning can.
- Clear an adequate area for parts and prepare a con tainer(s).
- Drain cooling water (sea water, fresh water) and lube oil.
- Close the Kingston cock.

### (2) Reassembly

- Sufficiently clean and fnspect all parts to be assembled.
- Coat sliding and rotating parts witt new engine oil when assembling.
- Replace all qaskets and O-rings.
- Use a liquid packing agent as necessary to prevent Oilhuater leaks.
- Check the oil and thrust clearances, etc. of parti when assembling.
- Make sure you use the correct bolt/nut/washer.
- Tighten main bolts/nuts to the specified torque. Be especially careful n.ot to overtighten the aluminum
- alloy part mounting bolts.
- Align match marks (if any) when assembling. Make sure that the correct sets of parts are ised for bear-ings, pistons, and other parts where required.

# 2. Disassembly and Reassembly Tools

The following tools are required when disassembling and reassembling the e.ngine.
Please use them as instructed.

| Name of tool | Illustration | Remarks |
|---|---|---|
| Wrench |  | Size : 10×13 |
| Wrench |  | Size : 11×13 |
| Wrench |  | Size : 12×14 |
| Wrench |  | Size : 17×19 |
| Wrench |  | Size : 22×24 |
| Screwdriver |  | |
| Steel hammer |  | Local supply |



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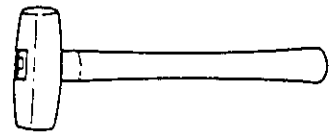
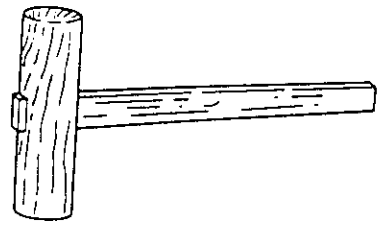
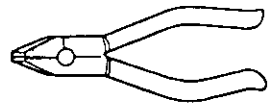
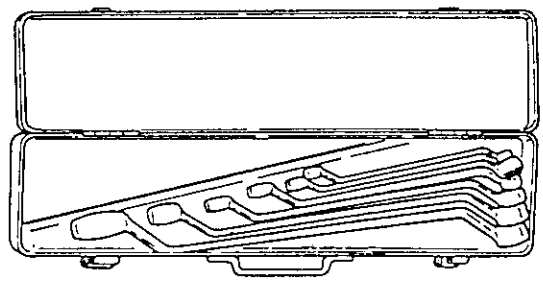
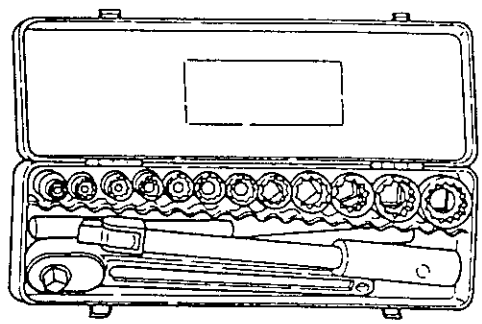
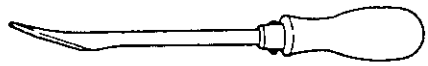
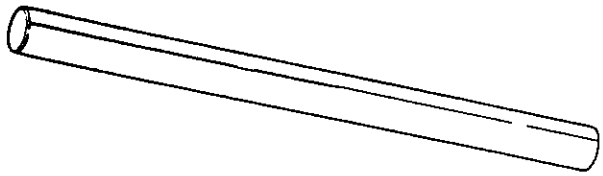
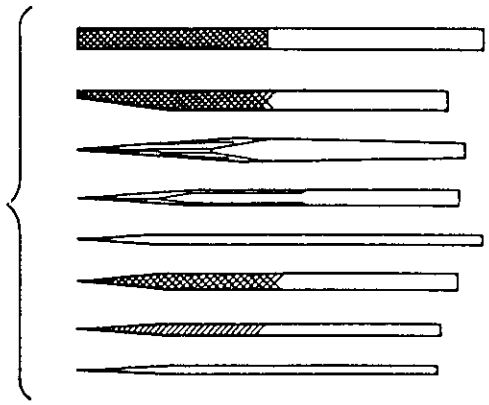
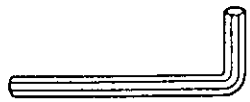
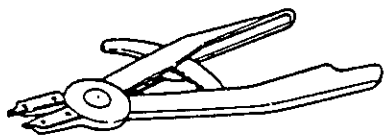
| Name of tool | Illustration | Remarks |
|---|---|---|
| Copper hammer |  | Local supply |
| Mallet |  | Local supply |
| Nippers |  | Local supply |
| Pliers |  | Local supply |
| Offset wrench |  | Local supply 1 set |
| Box spanner |  | Local supply 1 set |
| Scraper |  | Local supply |

| Name of tool | Illustration | Remarks |
|---|---|---|
| Lead rod |  | Local supply |
| File |  | Local supply 1 set |
| Rod spanner for hexagon socket head screws |  | Local supply<br>Size : 6 mm (0.2362in.)<br>8 mm (0.3150in.)<br>10 mm (0.3937in.) |
| Starling Pliers<br>Hole type<br>Shaft type | S—0<br>  <br>H4~H8<br>  <br>S=Hole type<br>H=Shaft type | Local supply |



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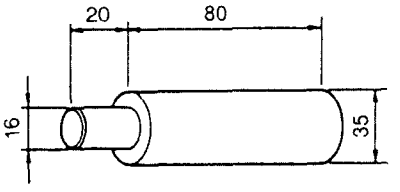
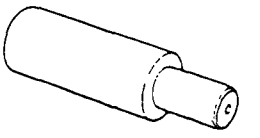
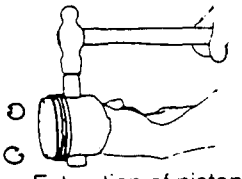
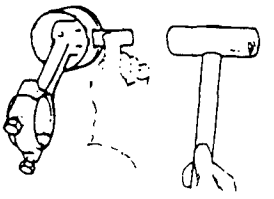
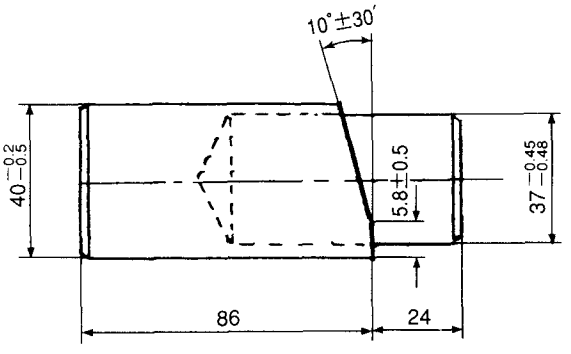
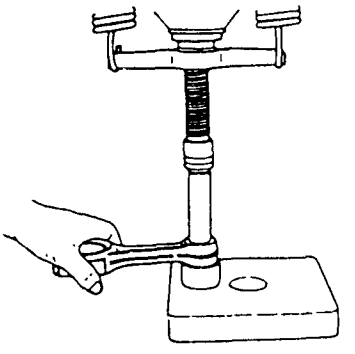
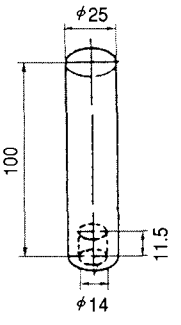
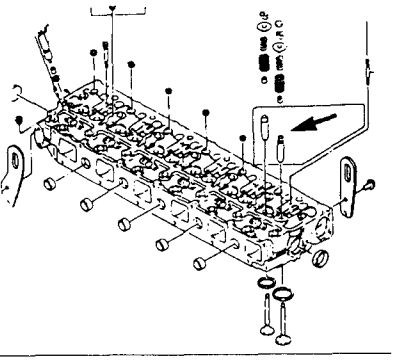
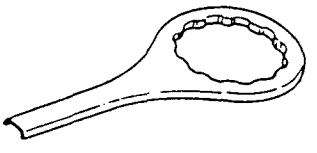
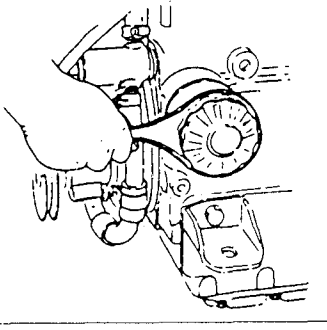
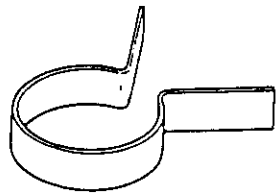
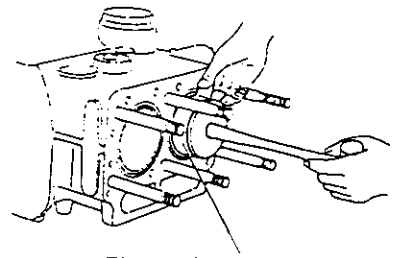
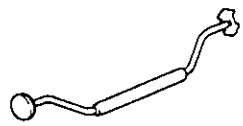
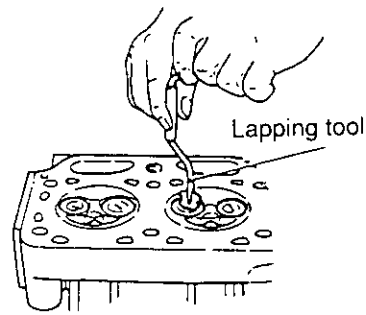
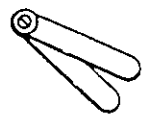
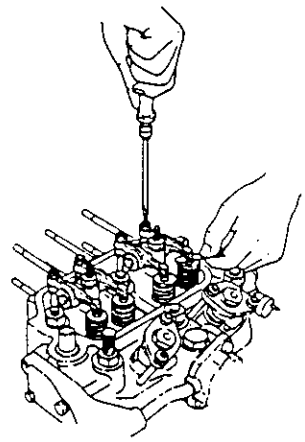
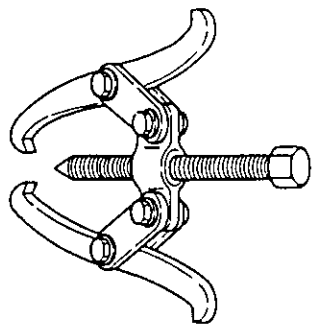
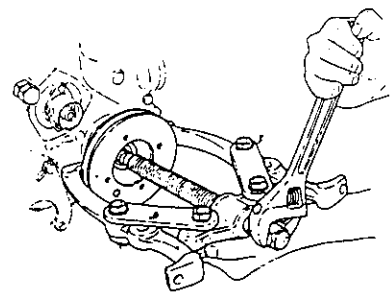
## 2-1 Special Handtools

| Name of tool | Illustration | Remarks |
|---|---|---|
| Piston pin insertion/ extraction tool | mm<br>  |  <br>Piston pin extractor<br>  <br>Extraction of piston pin<br>  <br>Insertion of piston pin |
| Connecting rod small end bushing insertion/ extraction tool | mm<br>  |  <br>Extraction |
| Intake and exhaust valve guide insertion tool | mm<br>  |  |
| 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 |



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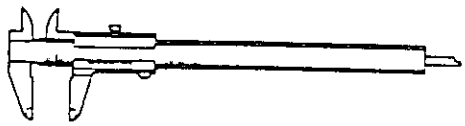
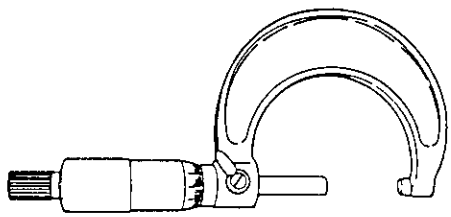
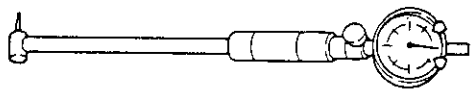
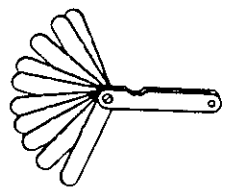
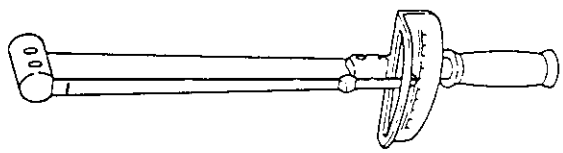
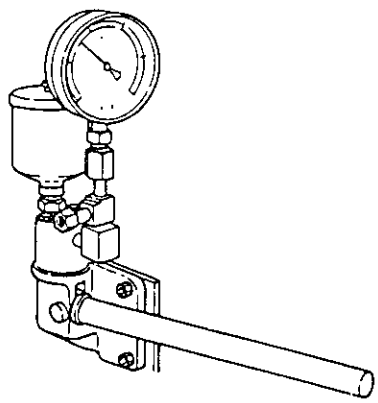
## 2-3 Measuring Instruments

| Name of tool | Shape and size | Application |
|---|---|---|
| Vernier calipers |  | 0.05mm<br>0~150mm |
| Micrometer |  | 0.01mm<br>0~25mm<br>25~50mm<br>50~75mm<br>75~100mm<br>100~125mm<br>125~150mm |
| Cylinder gauge |  | 0.01mm<br>18~35mm<br>35~60mm<br>50~100mm<br>100~150mm |
| Thickiness gauge |  | 0.05~2mm |
| Torque wrench |  | 0~35kg-m. |
| Nozzle tester |  | 0~500kg/cm². |

## 2-4 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<br>$\phi$ 2.42-m dia.:1<br>$\phi$ 3.12-m dia.:1<br>$\phi$ 3.52-m dia.:1<br>$\phi$ 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) |



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| Items | | Usual Contents | Features and application |
|---|---|---|---|
| Scale solvent | Scale solvent | 1 box (4kg×4removers) | • The scale solvent removes scale in a short time. (1 to 10 hours)<br>• Prepare water (seawater is possible) in an amount that is about 10 times the weight of the solvent. Mix the solvent with water.<br>• Just dipping disassembled part into remover mixture removes scale. To shorten removal time, stir remover mixture.<br>• If cleaning performance drops, replace remover mixture with new remover mixture.<br>• 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. |
| | 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 | • The cleaning agent removes even carbon adhering to disassembled parts.<br>• If a cleaning machine is used, prepare 4 to 6% mixture of 60° to 80℃ to ensure more effective cleaning. |

| Items | Usual Contents | Features and application |
|---|---|---|
| Cleaning agent for turbocharger | 4 ℓ×4 | Special cleaning agent that requires no watar, 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.

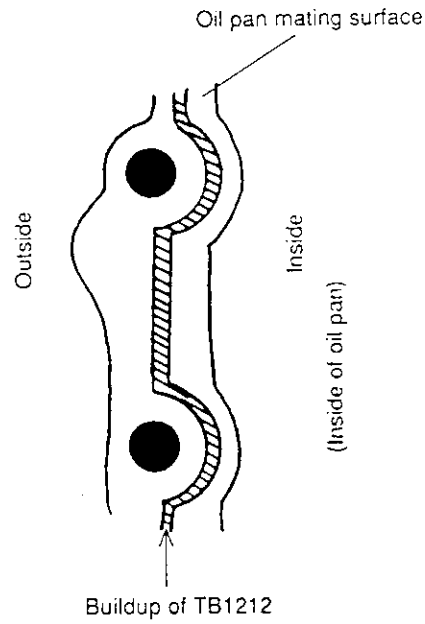
Before providing service, observe the cautions below:

(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.



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# 3. Disassembly and Reassembly

The procedure for disassembling engineparts (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.

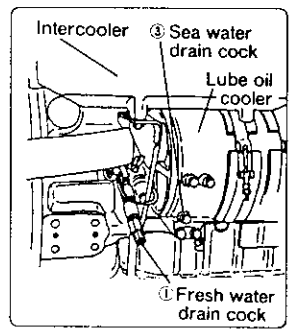
## 3-1 Disassembly

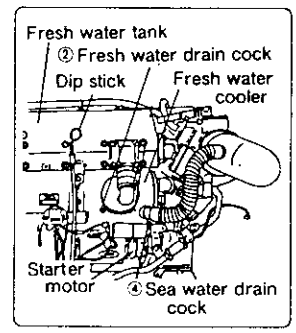
For engines mounted in an engine room, remove the piping and wiring connecting them to the ship.

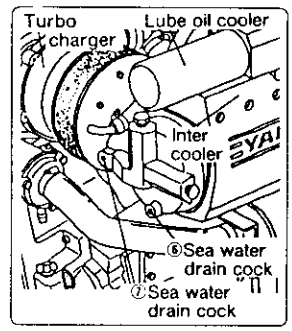
(1) Remove the remote control cable (from engine and marine gearbox).
(2) Uunplug the extension cord for the instrument panel from the engine.
(3) Remove the wiring between the starting motor and the battery.
(4) Remove the exhaust rubber hose from the mixing elbow.
(5) Remove the fresh water sub-tank 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.)

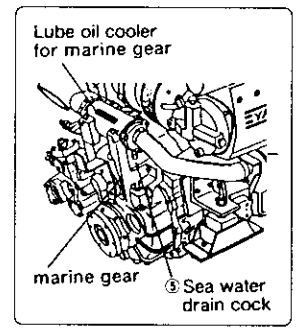
### 3-1.1 Drain cooling water

(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.

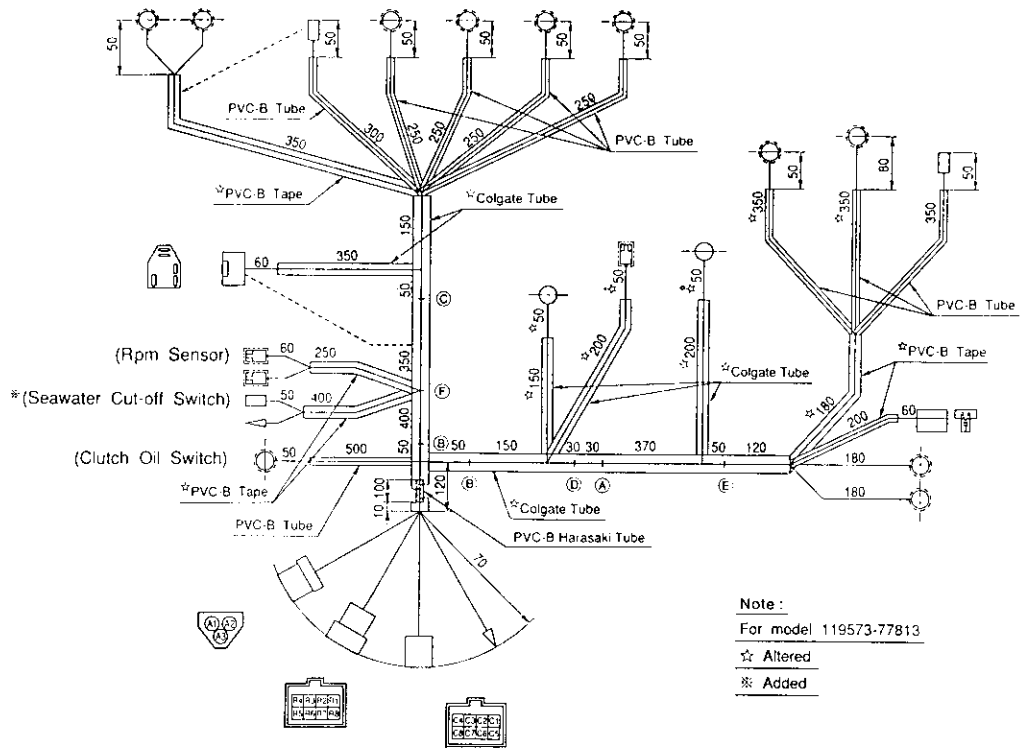
*NOTE: If a lube oil supply/discharge pump is used /or the engine, the intake hose is placed in the dip stick guide, and for the clutch side (gearbox) it is placed in the oil hole on top of the case.*

### 3-1.3 Removing (electrical) wiring

(mm)

Remove the wiring from the engine.
Be careful to keep the coupler bry when storing.

| Wire dia. (mm) | Wire color | Junction | Notes |
|---|---|---|---|
| 2 | W | | Starter S |
| 3 | R | J=19 | Starter B |
| 3 | L | | Starter(Air Heater etc.) |
| 0.85 | YW | | Lube oil pressure switch |
| 0.85 | WL | | Cooling water temp.switch |
| 0.85 | WG | | Sea water shortage switch ⊣ ※ |
| 0.85 | B | J=17 | ⊖Panel |
| 0.85 | YG | | Sail drive / Marine gear lube oil press switch |
| 0.85 | O | | Tacho meter sensor |
| 0.85 | LB | | Alternator L (charge) |
| 0.85 | RB | | Alternator R (System AC⊣) |
| 1.25 | GL | | Cooling mater level switch ※ |
| 0.85 | YR | | Boost switch ※ |
| 0.85 | WB | | Cooling water temp "U" |
| 0.85 | YB | | Lube oil press. "U" |
| 0.85 | GB | | Boost "U" |
| 0.85 | WBr | | Engine stop |
| 8 | B | | ⊖ |
| 0.85 | B | J=17 | ⊣Tacho pulse |
| 8 | R | | ⊣Alternator |
| 0.85 | B | J=44 | Stop relay⊣ |
| 2 | R | J=A2 | Stop relay⊣ |
| 2 | Br | | Stop solenoid⊣ |
| 2 | B | J=17 | Stop solenoid⊣ |
| 0.85 | B | J=44 | Sea water shortage switch⊣ ※ |

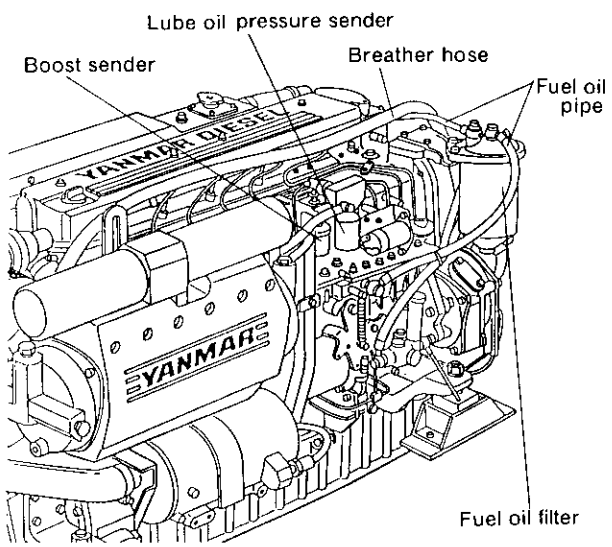



### 3-1.4 Removing the fuel oil filter & fuel oil pipe

(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 silencercer

(1) Remove the breather hose conneted between gear case and intake silencer.
(2) Remove the lube oil pressure sender and boost sender.

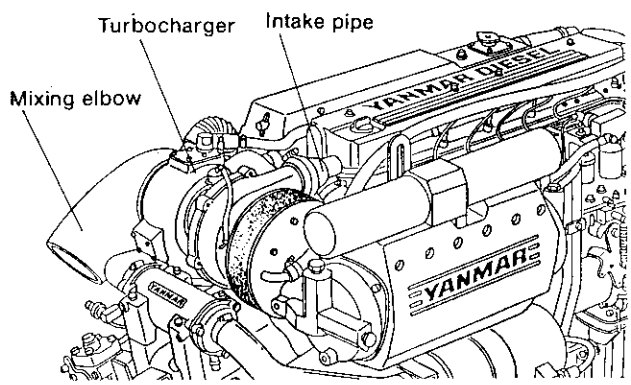



### 3-1.6 Removing the mixing elbow

(1) Remove coolrng 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.



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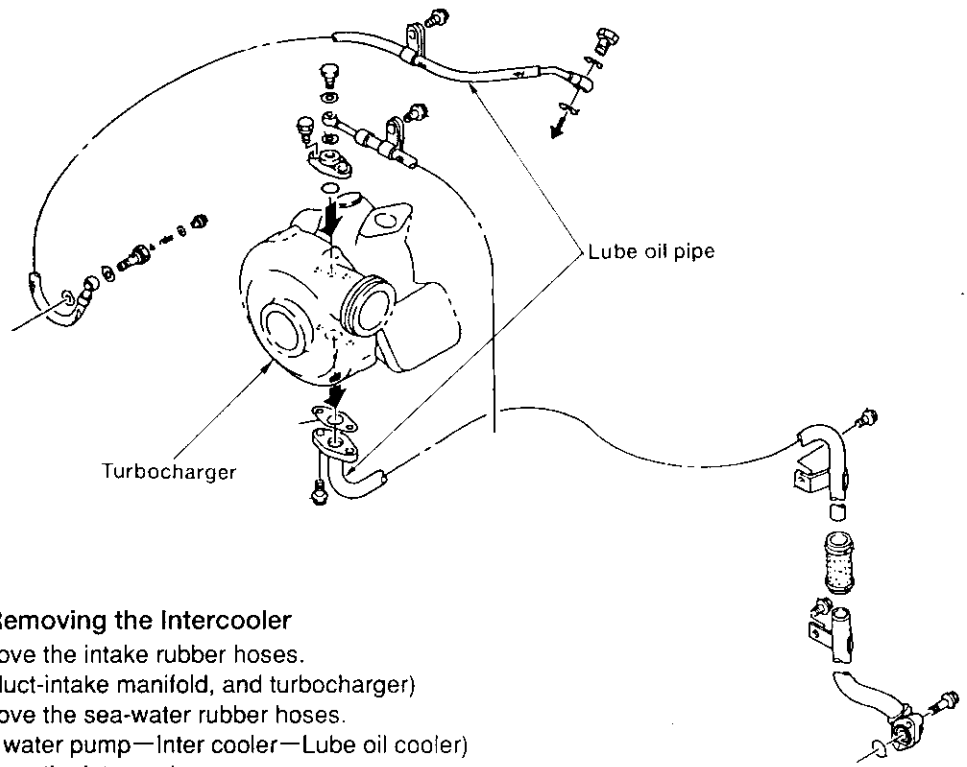
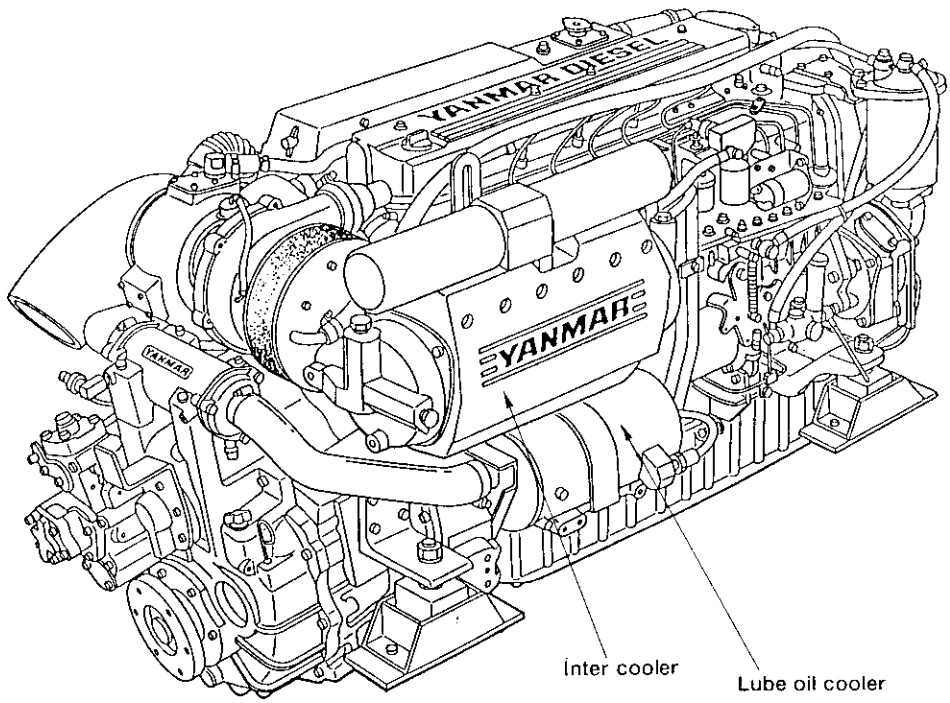


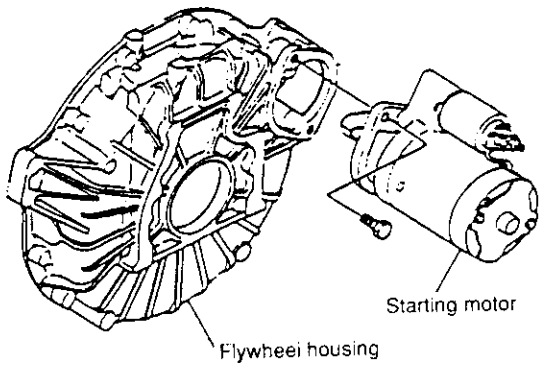

### 3-1.8 Removing the Intercooler

(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

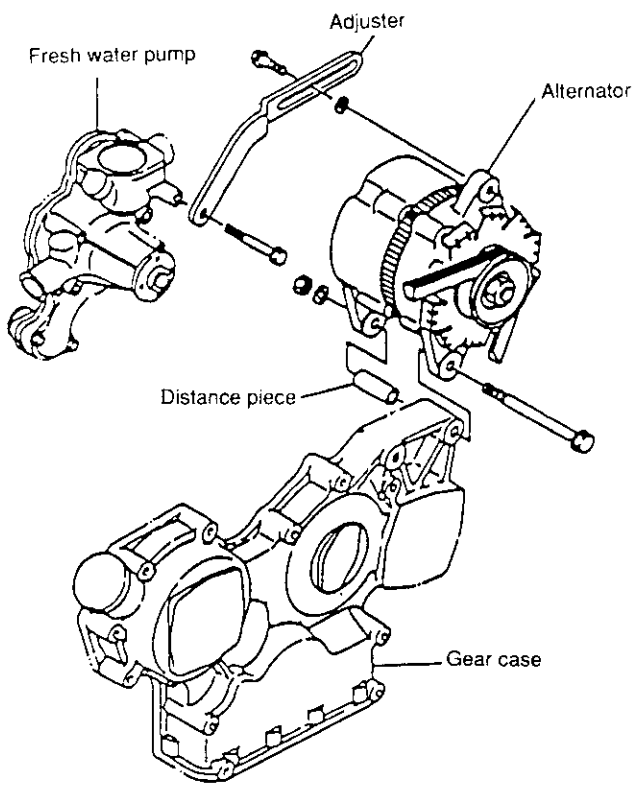
Remove the starting motor from the flywheel housing.




### 3-1.10 Removing the alternator

(1) Loosen the alternator adjuster bolt and remove the V-be24lt.

(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

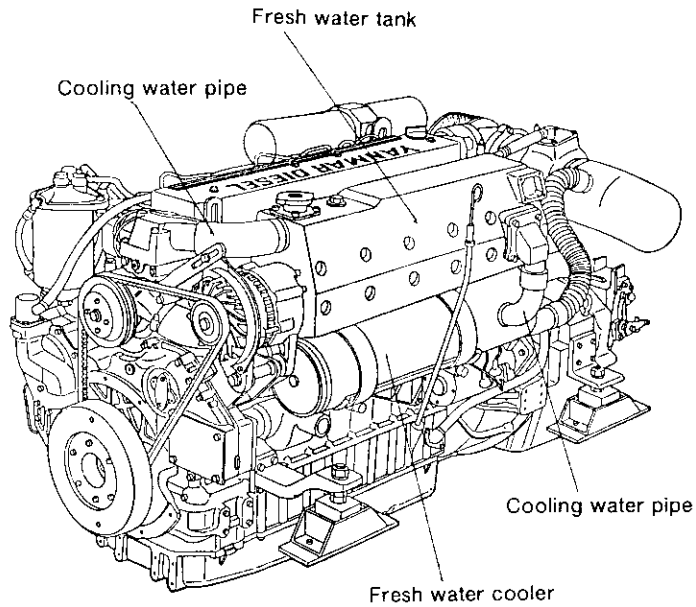
(1) Remove the cooling water (sea water) pipe (lube oil cooler).

(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.



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**3-1.13 Removing the lube oil cooler (sea water pump—lube oil cooler).**

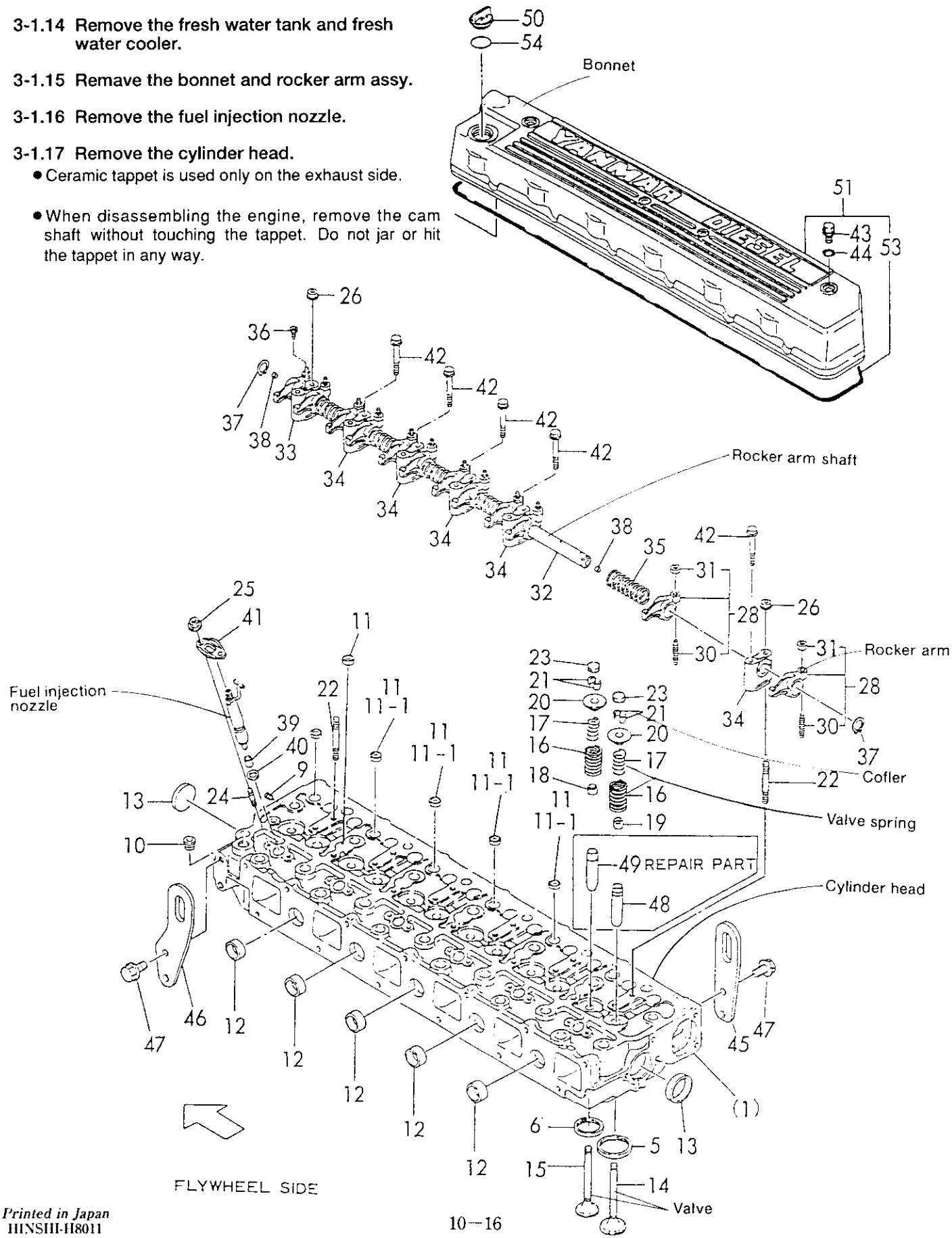
**3-1.14 Remove the fresh water tank and fresh water cooler.**

**3-1.15 Remave the bonnet and rocker arm assy.**

**3-1.16 Remove the fuel injection nozzle.**

**3-1.17 Remove the cylinder head.**

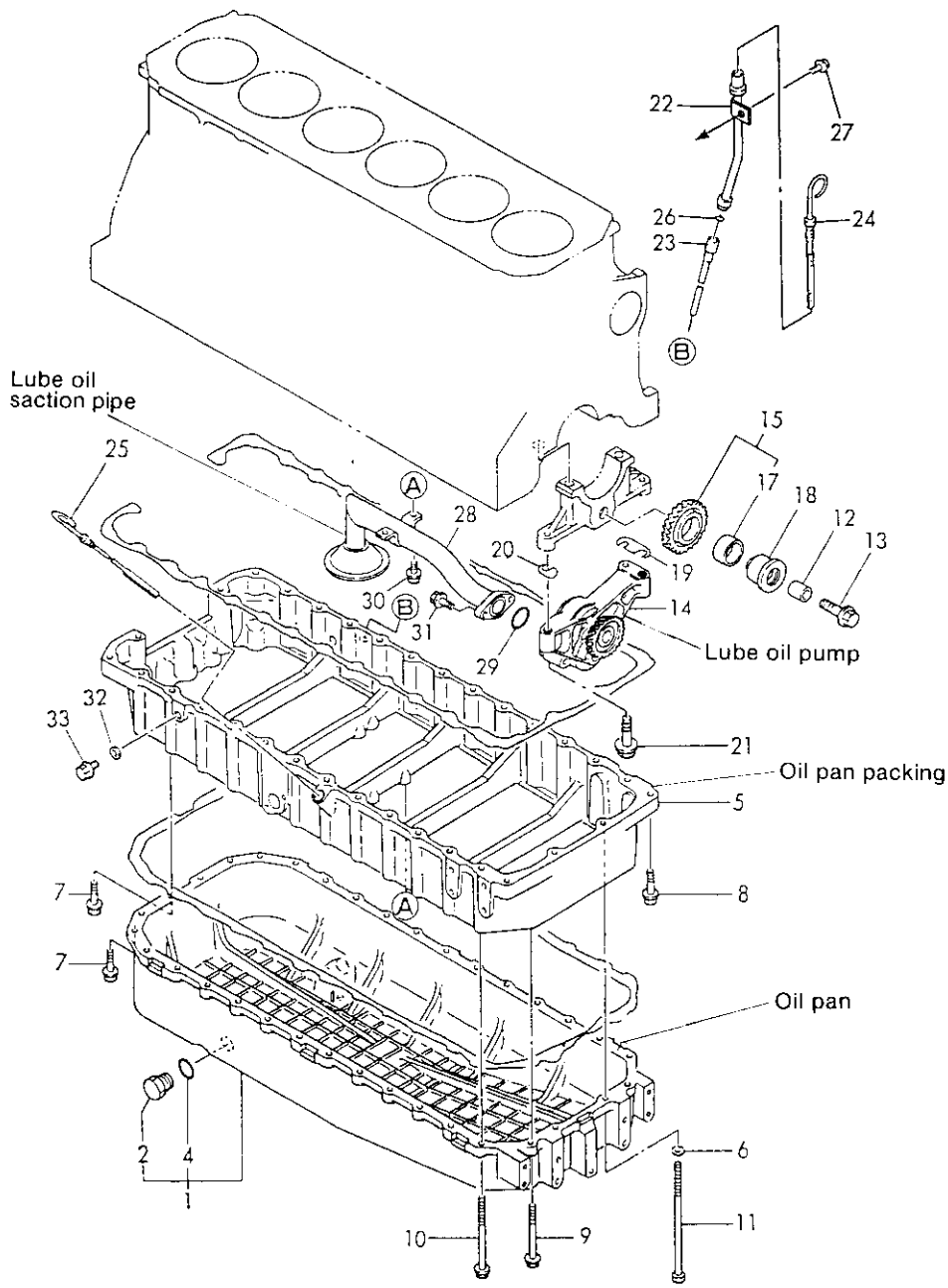
- Ceramic tappet is used only on the exhaust side.
- When disassembling the engine, remove the cam shaft without touching the tappet. Do not jar or hit the tappet in any way.



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 firmy 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.



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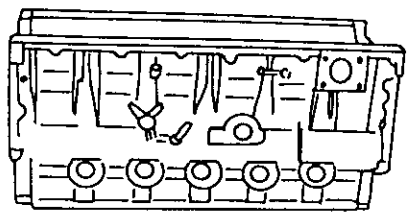
## 3-2 Reassembly

### 3-2.1 Cylinder block

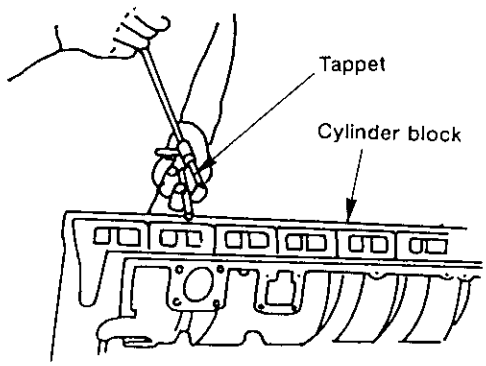
Completely clean each oil hole. After cleaning, check that no scaling remains on cylinder block.



Cylinder block

### 3-2.2 Tappet

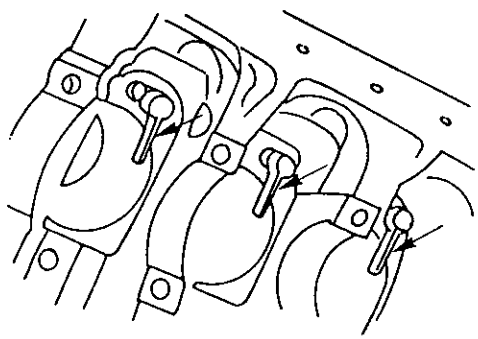
Fit each tappet.
Check that each tappet is fitted to appropriate cylinder and valve (exhaust or intake).
Before fitting, apply engine oil to each tappet.After fitting, check that each tappet operates smoothly.




Tappet fitting

### 3-3.3 Piston cooling nozzle

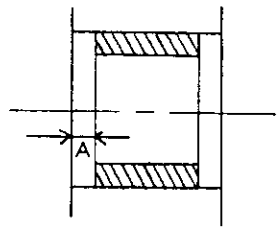
Fit each cooling nozzle to piston.
Check that nozzle end is positioned on piston head side.
Also check that nozzle does not touch cylinder block.
Tightening torque : 2.0kgf-m



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.

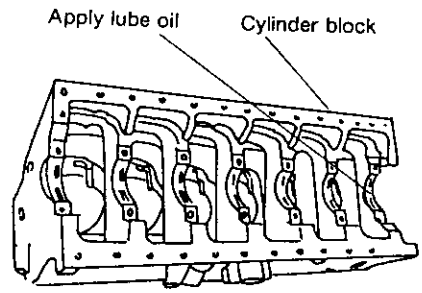
(mm)

| | |
|---|---|
| Inner diameter after press-fitting | $\phi 57^{+0.05}_{+0.02}$ |

*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.

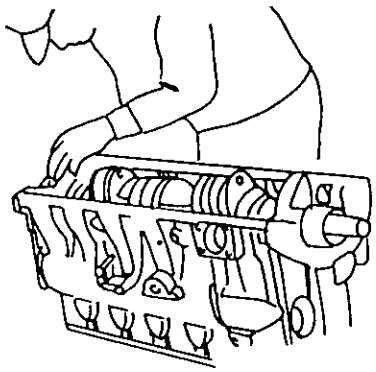



Fitting of upper bearings

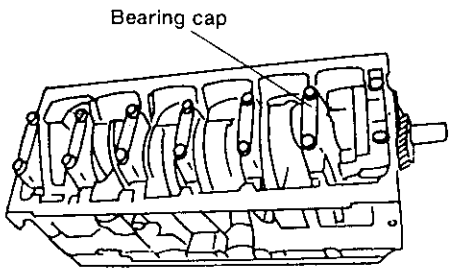
(2) Apply engine oil to each crank pin and crank journal, and fit each journal to main bearing.
(3) Fitting caps
1) Apply engine oil to both surfaces of each cap side main bearing, and then fit each main bearing to the cap.

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 ± 1kgf-m |



Fitting of thrust bearings



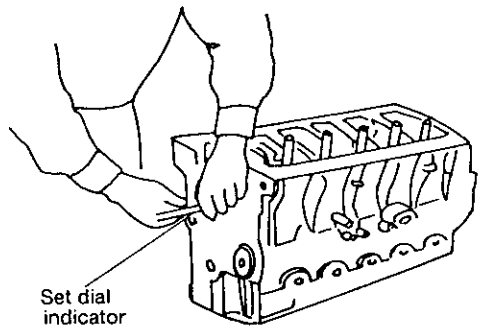

Fitting of bearing caps

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 | 0.132~0.223 |

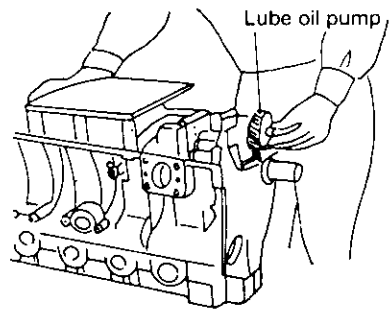



Measurement of side clearance

### 3-2.6 Lube oil pump

(1) Fit lube oil pump idle gear.
Side clearance: 0.10 to 0.30mm

| | |
|---|---|
| Tightening torque | $11^{\pm 1.0}$ kgf-m |

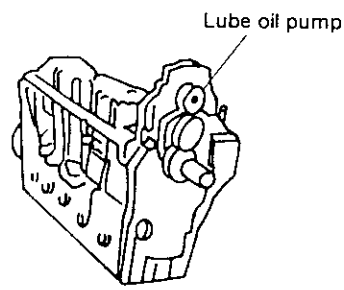



Fitting of lube oil pump idle gear

(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



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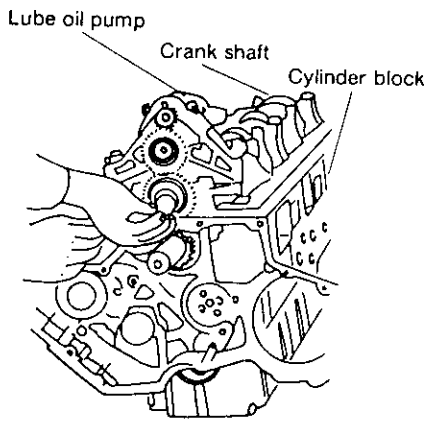
### 3-2.7 Gear case

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**

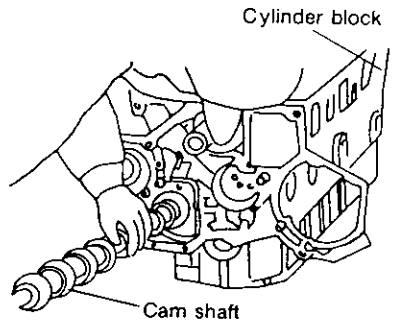
### 3-2.8 Cam shaft

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*

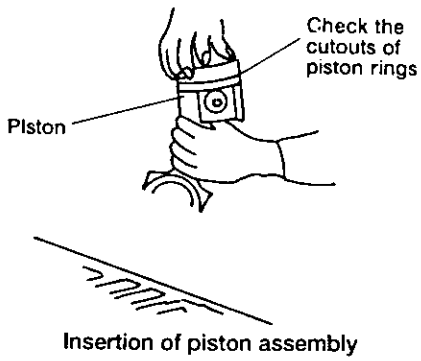



**Fitting of cam shaft**

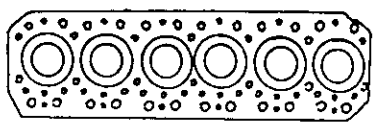
### 3-2.9 Piston assembly

(1) Fit connecting rod to each piston while checking direc tion of piston.
For detailed description, refer to Sec. 3-3-4.
(2) Fit piston rings and oil ring to each piston while check ing 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.*



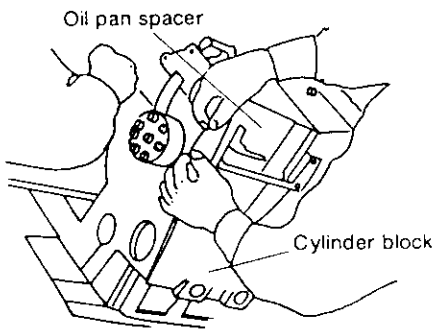

Insertion of piston assembly



Fitting of piston assembly

### 3-2.10 Oil pan spacer

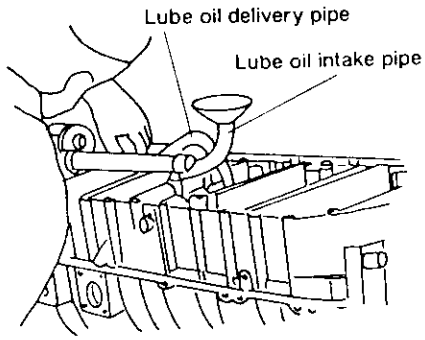
Apply liquid gasket to oil pan spacer, and than fit spacer. Secure spacer by tightening 4 bolts of **M8×35mm**




### 3-2.11 Lube oil intake pipe and delivery pipe

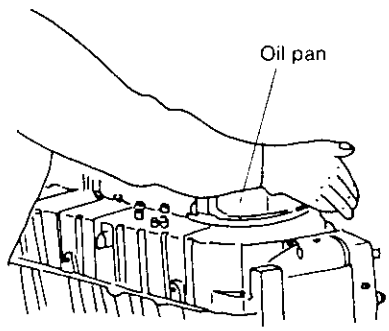
(1) Fit lube oil delivery pipe first, and then intake pipe. Secure delivery and intake pipes by tightening bolts listed below:
**M8×25mm**, 2 bolts
**M8×16mm**, 2 bolts

(2) Insert other end of lube oil delivery pipe into oil pan spacer. Secure pipe by tightening bolts of **M8×25mm**.




### 3-2.12 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

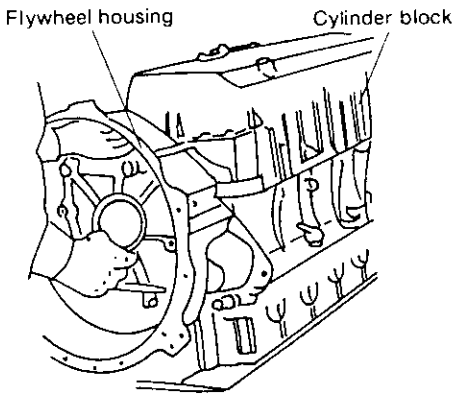



### 3-2.13 Flywheel housing

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

(mm)

| | |
|---|---|
| Spigot joint runout | less than 0.25 |
| Surface runout | less than 0.15 |




Fitting of flywheel housing



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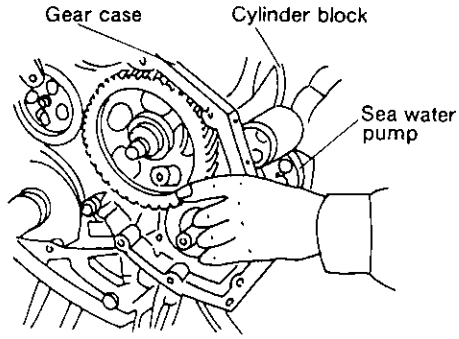
### 3-2.14 Seawater pump

Fit seawater pump to gear case. Secure pump by tightening bolts and nuts listed below:

**M8×20mm**, 2 bolts
**M8**, 2 nuts

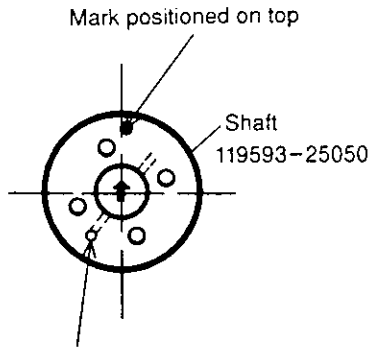



Fitting of seawater pump

### 3-2.15 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).*



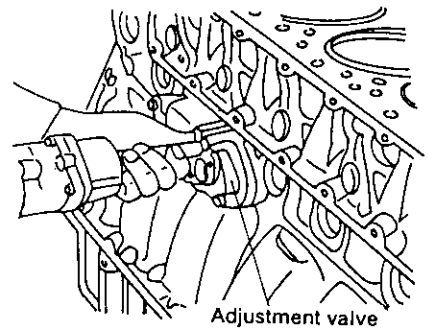

(Alignment of oil holes with those of cylinder block)

### 3-2.16 Lube oil presure 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-cm²
Oil temperature: 85℃at 3,000r.p.m.

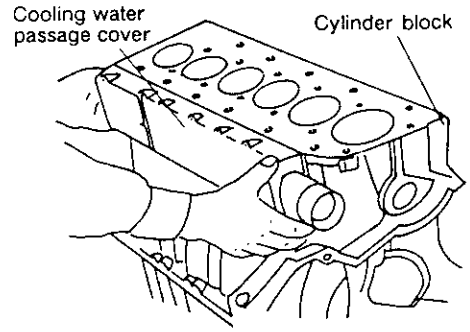



Fitting of adjustment valve

### 3-2.17 Cooling water passage cover

Apply liquid gasket to cooling water passage cover, and then fit cover. Secure cover by tightening bolts listed below:

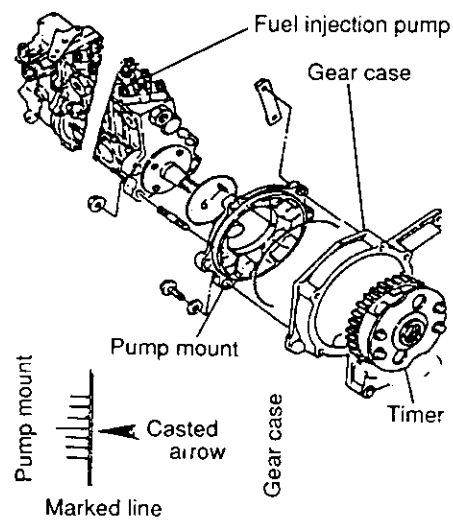
**M8×18mm**, 2 bolts
**M8×30mm**, 10 bolts
**M8×45mm**, 2 bolts
**M8×50mm**, 1 bolt
1 pipe joint




Fitting of cooling water passage cover

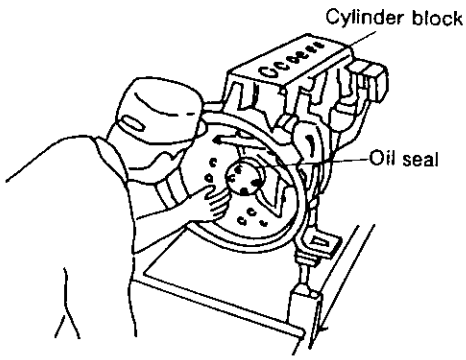
### 3-2.18 Fuel injection pump

(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**.



### 3-2.19 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≦0.25



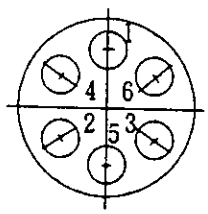

Fitting of oil seal

### 3-2.20 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±1kgf-m |

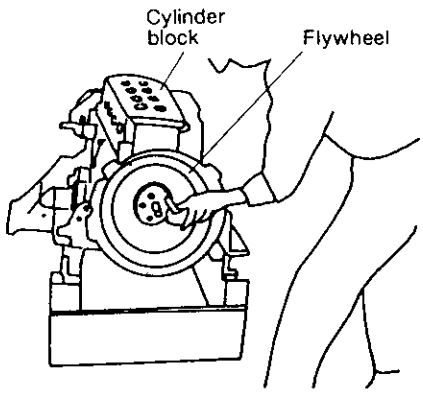
Tightening torque




M14×35mm, 6 bolts

(mm)

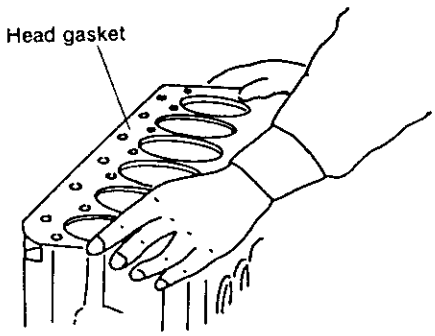
| | |
|---|---|
| Surface runout | 0.1 or less |
| Spigot joint runout | 0.2 or less |




Fitting of flywheel

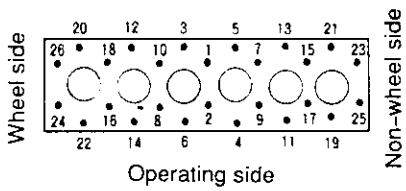
### 3-2.21 Cylinder head assembly

(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).



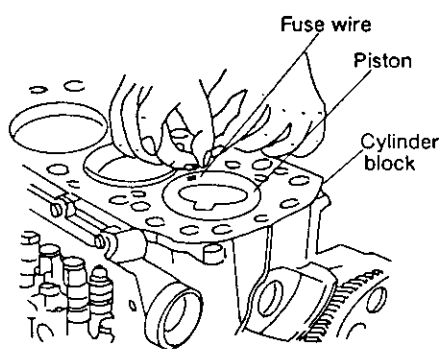

- Loosely tighten bolts twice, and then finally tighten them.
Head bolt: **M14×121mm**
Number of head bolts: 26

(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 | $0.8^{\pm 0.09}$ |



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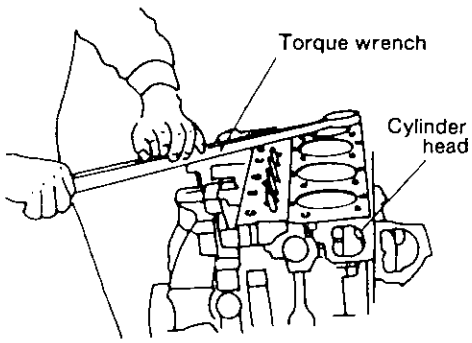
*Note : 1. Check that cylinder head fitting surface on cylinder block are not fouled. Also check inside of each cylinder for dust, dirt, and foreign material.*
*2. Head identification No. is marked on upper surface on wheel side (left side of nozzle hole)*

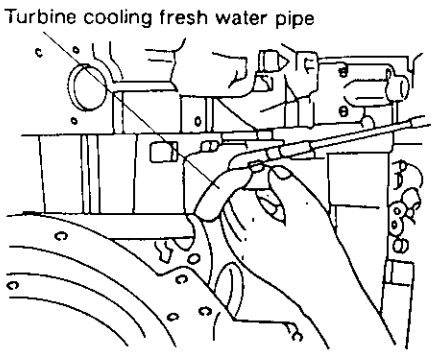
It is also possible that intake manifold is fit to cylinder head first, and then cylinder head complete with manifold is fit to cylinder block.




Tightening of cylinder head

### 3-2.22 Turbine cooling fresh water (CWF) pipe

Fit turbine cooling fresh water pipe to cooling water passage cover.




Fitting of turbine cooling fresh water pipe

### 3-2.23 Intercooler

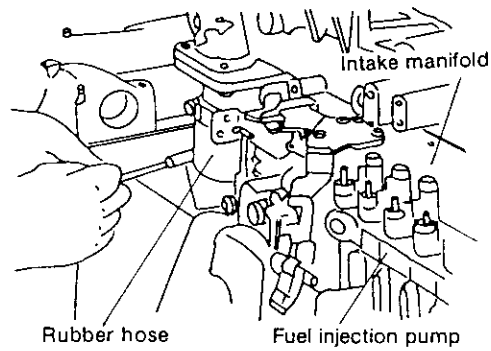
Apply liquid gasket to inlet side of intercooler, and then fit intercooler. Secure intercooler by tightening bolts listed below:

**M8×16mm**, 1 bolt **M8×70mm**, 1 bolt
**M8×20mm**, 1 bolt **M8×80mm**, 4 bolts

Fitting of intercooler

### 3-2.24 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.

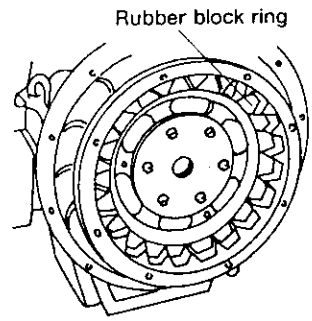



Rubber hose from intercooler to intake manifold

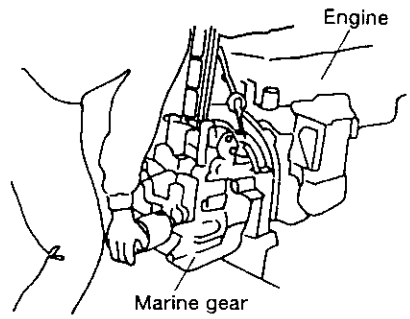
### 3-2.25 Marine gear KMH6A1

The explanation below is for Yanmar Marine Gear (Mode KMH6A1)

(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

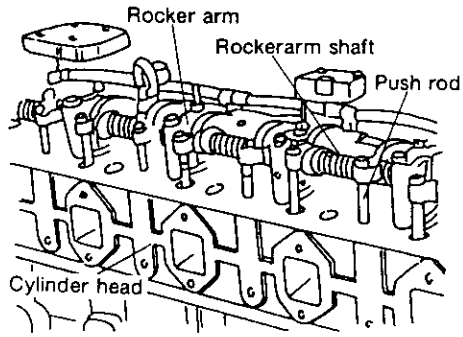



Fitting of marine gear

### 3-2.26. 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$^{\pm 0.3}$kgf-m |

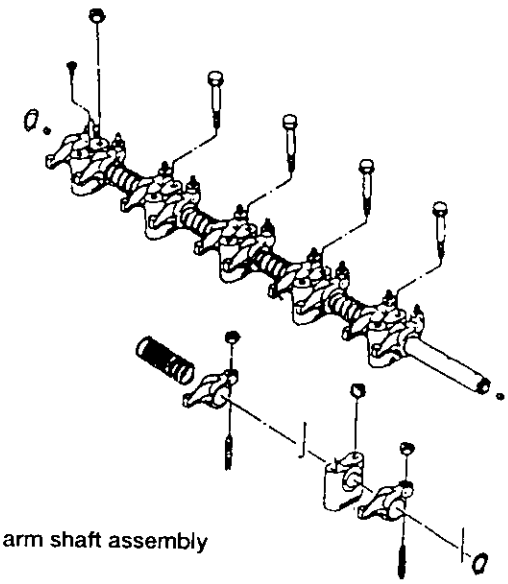



Fitting of valve arm shaft assembly

(3) Measure valve clearances, and check that they satisfy values specified below:

| |
|---|
| Valve clearance: 0.1mm for intake valve, 0.4mm for exhaust valve |

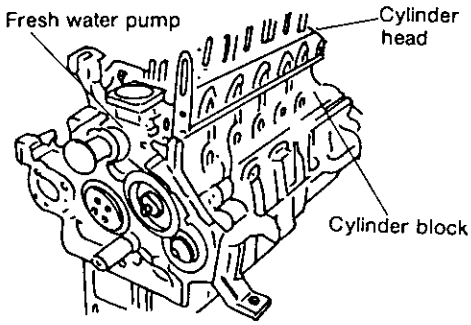
After adjusting valve clearances, apply lube oil to each valve arm, and then fit bonnet.
(4) Fit bonnet, and secure it by tightening 10 bolts of M8×25mm.
(5) Fit lifting eye bolts to gear and wheel sides of bonnet.



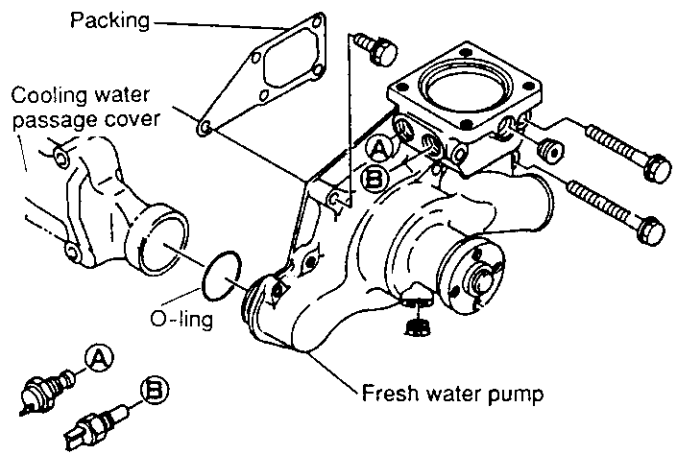
Rocker arm shaft assembly

### 3-2.27 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.




Fresh water pump




### 3-2.28 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



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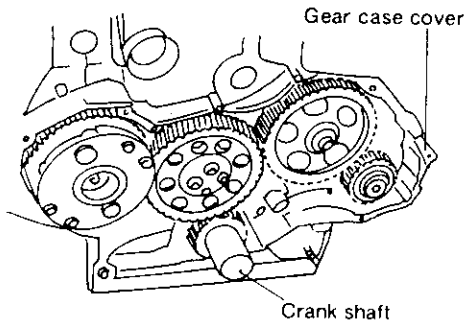
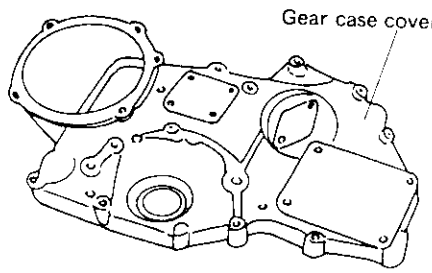



**Localizing of gear train**




**Gear case cover**

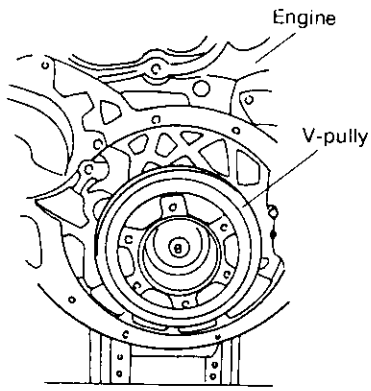
### 3-2.29 Crank V-pulley

(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 | $16^{\pm 1}$kgf-m |




**Crank V-pulley**

*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.

### 3-2.30 Fuel injection valve

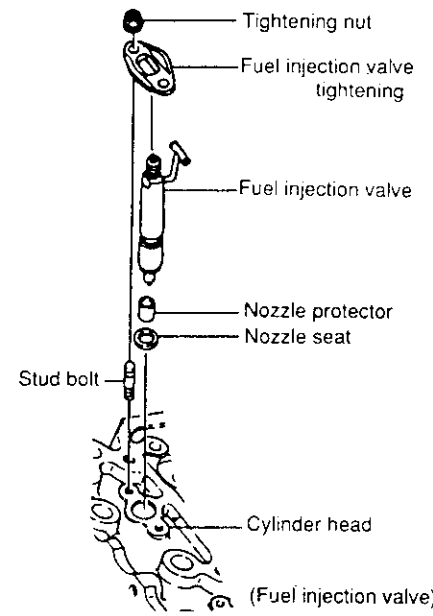
(1) Fit nozzle protector to end of fuel injection valve, and then fit fuel injection valve complete.
Replace nozzle protector with new one every time when fuel injection valve is disassembled.
(2) Loosely tighten fuel injection valve tightening nut.
(3) Tighten tightening nut by applying torque specified 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 |



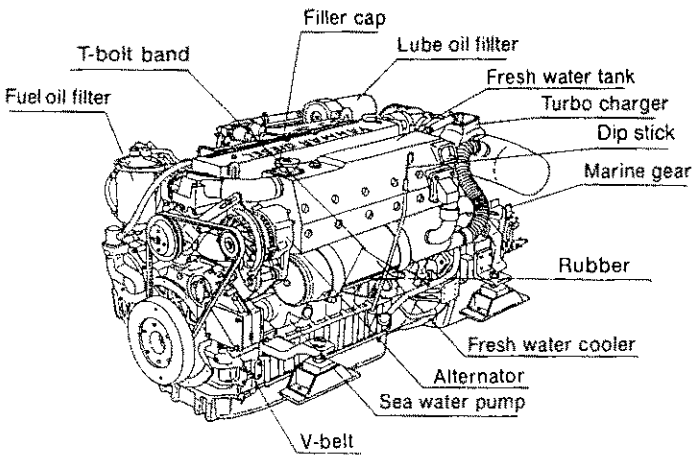

(Fuel injection valve)

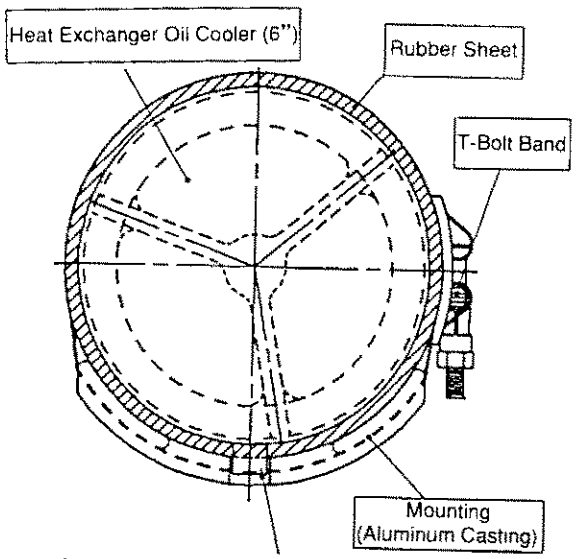
### 3-2.31 Fresh Water Tank

Secure the fresh water tank securely with bolts.

### 3-2.32 Fresh Water Cooler

- Tightening torque for the fresh water cooler retainer bolt : 2.6kgf•m
- Place two rubber sheets under the fresh water cooler and secure firmlyl with T-bolt band.



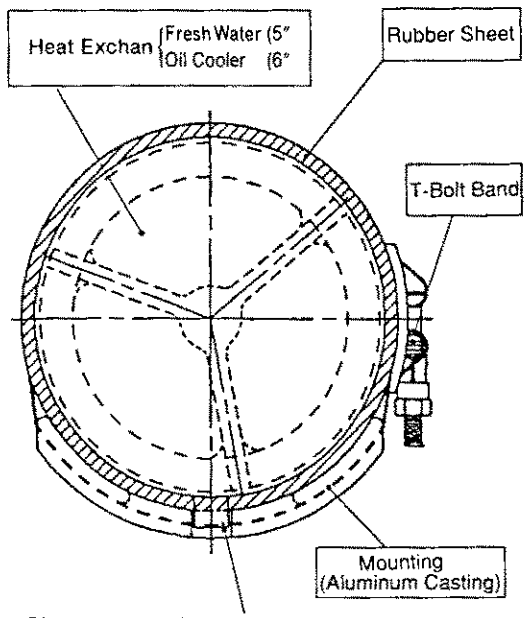




Check to see that the positioning pin is inserted in the hole.

Check to see that the positioning pin is inserted in the hole.

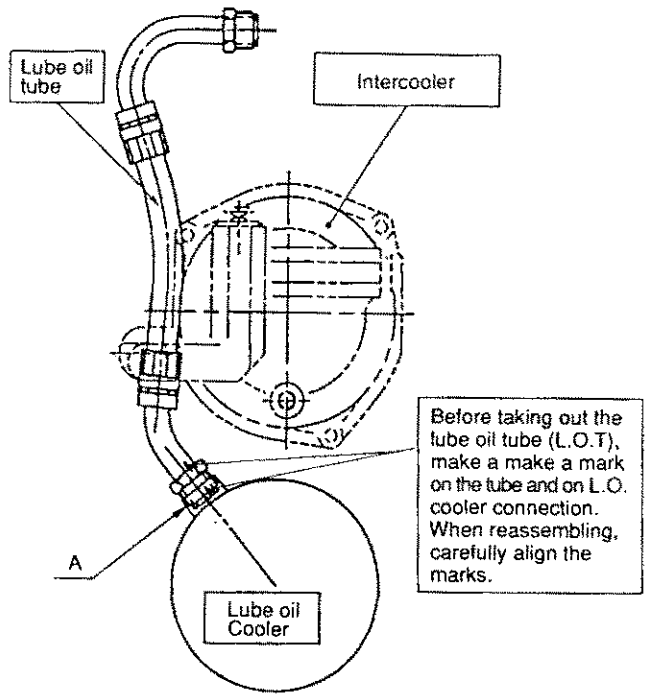
### 3-2.33 Lube oil cooler

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).
- Tightening torque for nut : 0.6kgf•m
- Put the cooler wrapped in the rubber sheet on the mounting, and tighten the T- bolt bands (2).




- Before installing the intercooler, secure section B with the tightening tool and then completely tighten section A.



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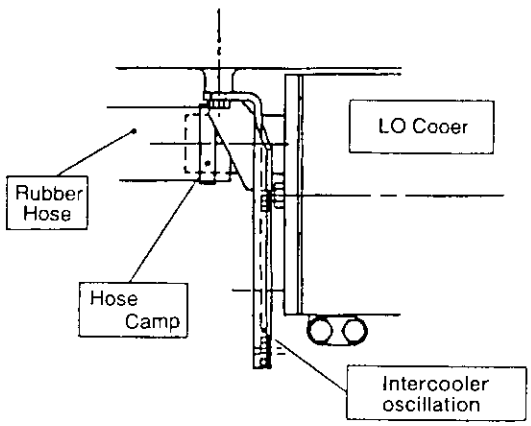
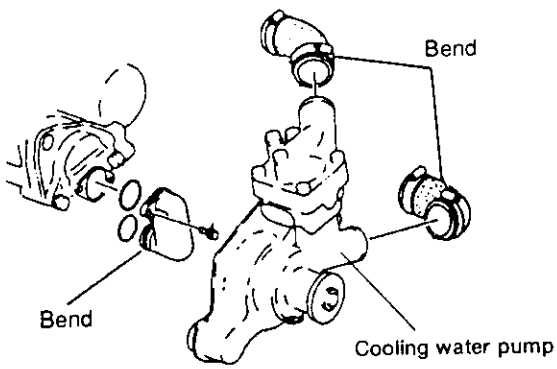
- Close the rubber hose connected to the LO cooler at the left side of the intercooler oscillation preven ter.




### 3-3.34 Cooling water bend

(1) Fit bends to cooling water pump and cooling water cooler.
(2) Fit bends to intercooler and oil cooler.

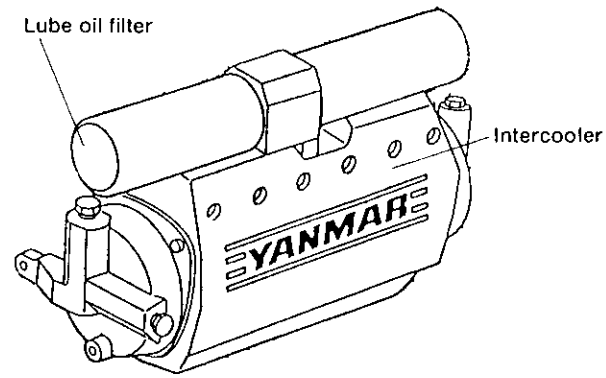



### 3-3.35 Air duct

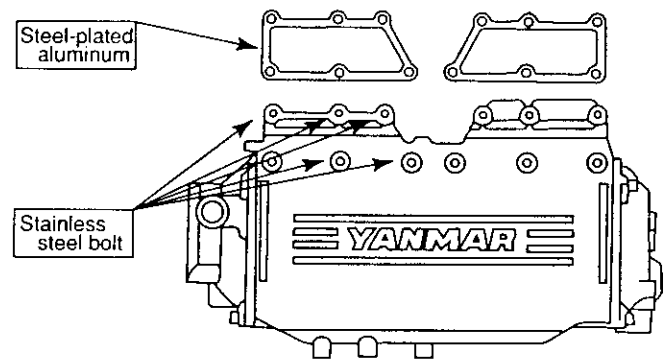
(1) Fit air duct to outlet of turbine, and secure duct by tightening bolts listed below:
**M6×35mm**, 2 bolts
**M6×70mm**, 4 bolts
(2) Fit air duct to inlet of cooler.
(3) Fit air duct to intake manifold inlet, and tighten duct by tightening 2 bolts of
**M6×25mm.**

### 3-2.36 Intercooler steady brace

Fit steady braces to intercooler and oil cooler.



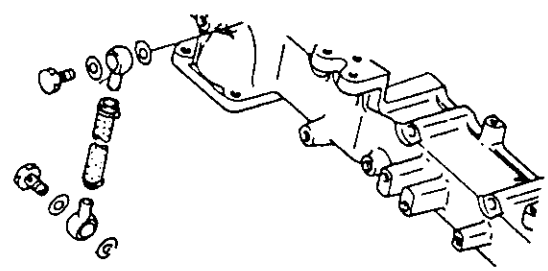

- The bolt on the air duct side is stainless steel.
  M8×150 (3)
  M8×155 (3)
- The packing on the air duct side is steel-plated aluminum.




*Note :*
- *The attachment place for the LO filter (by-pass, full flow) is the opposite of that for 6LY(A)-UTE,STE.*

### 3-2.37 Boost output pipe

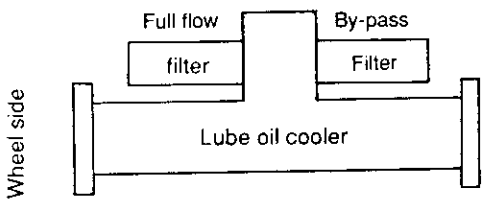
Fit boost output pipe.
Ball joint: M10, 2 joints
Pipe joint bolt: M10, 2 bolts
Fuel pipe: 1



### 3-2.38 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.*

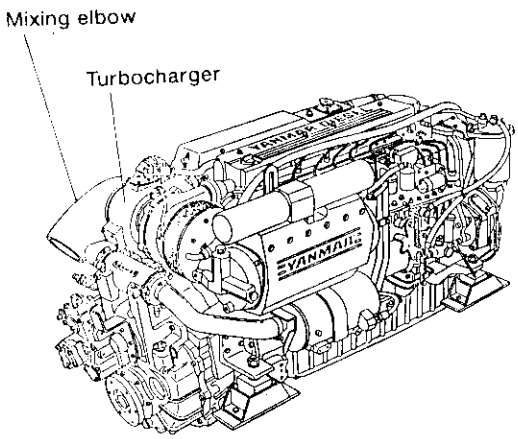



**Viewed from operating side**

**Tighten filter using filter wrench until filter is seated properly.**

### 3-2.39 Turbocharger

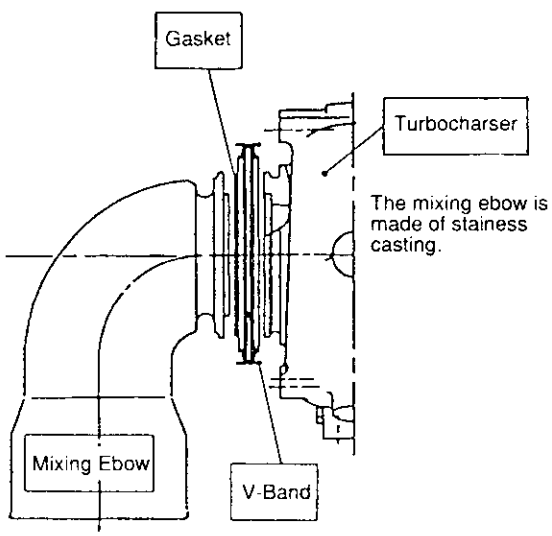
Install the turbocharger and the attached lube oil pipe.




### 3-2.40 Mixing Elbow

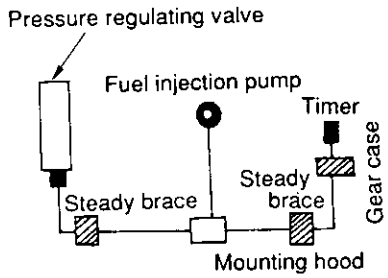
Install the mixing elbow.

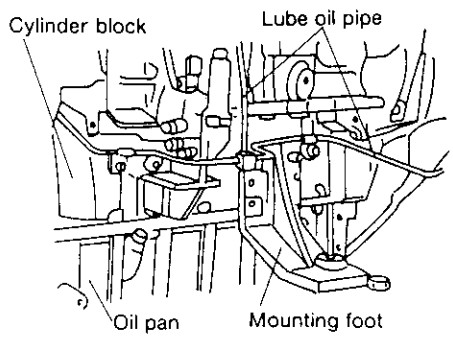
- Structure of Exhgust Outlet and V-Band




### 3-2.41 Lube oil pipe

Connect lube oil pipe to fuel injection pump.

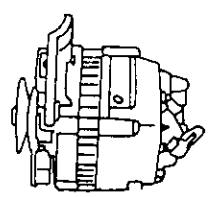



**Lube oil piping**

### 3-2.42 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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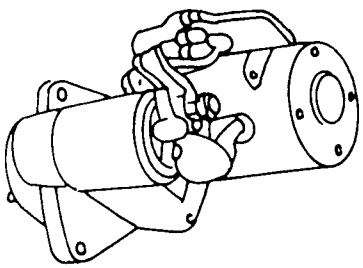
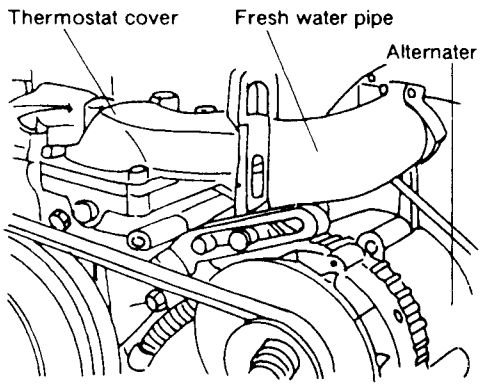
### 3-2.43 Starting motor

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



### 3-2.44 Cooling water pipe

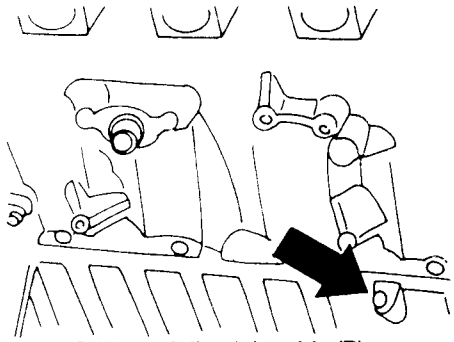
(1) Connect cooling water pipe to turbine.
(2) Connect cooling water pipe from fresh water cooler to fresh water pump.



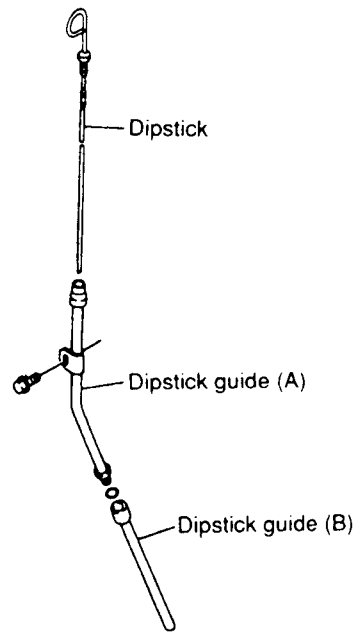

**Cooling water pipe**
**(from fresh water cooler to fresh water pump)**

### 3-2.45 Dipstick

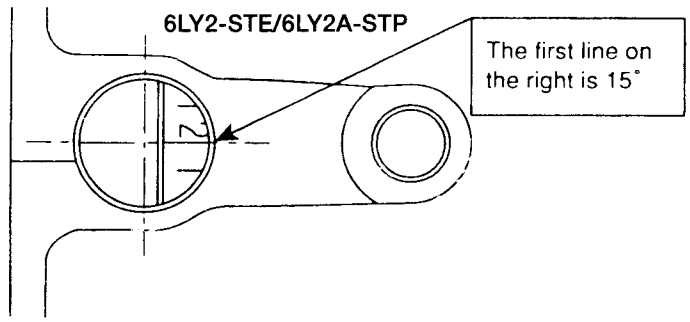
(1) Drive dipstick guide (B) into oil pan spacer.
(2) Apply LOCTITE to dipstick guide (A) and then fit them to engine.

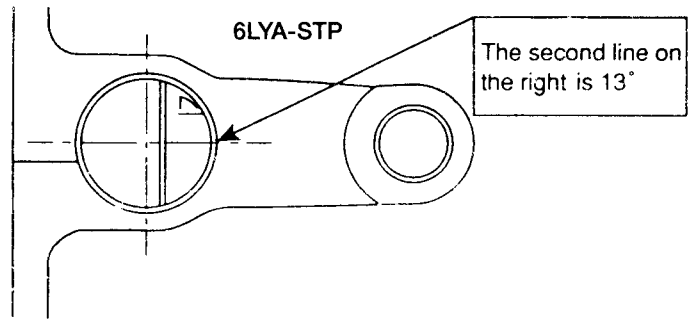


**Driving of dipstick guide (B)**




*Note :*
*FOP injection timing*
- *6LY2-STE, 6LY2A-STP : 15°bTDC. 6LYA-STP : 13° bTDC, and care should be taken when positioning the alignment mark.*



# 4. Main parts spec./ tightening torque

## 4-1. Quality Control Points

(Unit: mm)

### ● 6LY2-STE/6LY2A-STP

| No. | Item (part) | | | Standard value (notes) | | Remarks |
|---|---|---|---|---|---|---|
| 1 | Combustion | Top clearance | | 0.8±0.10 | | Gasket t=1.3 |
| 2 | | Injection timing | | 15° ±1° bTDC(FID) | | ——— |
| 3 | | Injection pressure | | $28.4^{+1.0}_{0}$MPa ($290^{+10}_{0}$kgf/cm²) | | Nozzle opening press. |
| 4 | | Max. variation of injection between cylinders (%) | Max. rating | ±3% | | Np=1650rpm |
| | | | Low idle | ±15% | | Np=350rpm |
| 5 | | Swirl percentage | | 2.03±0.1 (by simple method) | | Processing depth: 28 |
| 6 | | Protrusion of nozzle tip | | 4.16±0.1(Nozzle tip) | | from cylinder head surface |
| 7 | | Valve timing | Intake Open | bTDC 59° ±5° | | ——— |
| | | | Intake Close | aBDC 63° ±5° | | ——— |
| | | | Exhaust Open | bBDC 58° ±5° | | ——— |
| | | | Exhaust Close | aTDC 46° ±5° | | ——— |
| 8 | | Piston bowl capacity (Piston, recess (Incl. intake/exhaust valve recess) | | 57.5±0.9cm³ | | ——— |
| 9 | Head gasket | Valve clearance | Intake | 0.1±0.05 (in cold state) | | ——— |
| | | | Exhaust | 0.5±0.05 (in cold state) | | ——— |
| 10 | | Valve and piston chasing clearance | Intake | 1.42 (6° Crank shaft) | | ——— |
| | | | Exhaust | 1.26 (6° Crank shaft) | | ——— |
| 11 | | Cam shaft hole excentricity | | φ0.015 | | ——— |
| 12 | | Cam profile accuracy | | Lift | Profile variation | ——— |
| | | | Damping portion | ±0.02 | ±0.006 | ——— |
| | | | Other than above | 0.04 | ±0.008 | ——— |
| 13 | | Valve sinking | Intake | 0.7±0.1(Protrusion) | | See 2.3.2 |
| | | | Exhaust | 0.3±0.1(Sinking) | | See 2.3.2 |
| 15 | | Cylinder block surface (finished accuracy) | Flatness | 0.03(500mm²) 0.05 (whole surface) | | ——— |
| | | | Roughness | 8 μRmax | | ——— |
| 16 | | Cylinder head surface (finished accuracy) | Flatness | 0.01(□100) 0.07(whole surface) | | ——— |
| | | | Roughness | 8 μRmax | | ——— |
| 17 | | Head gasket thickness (at tightening) | | 1.30±0.05 | | ——— |
| 18 | | Cylinder liner | Roundness | 0.015 | | For top ring tracing |
| | | | Cylinder city | 0.025 | | |



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## ● 6LYA-STP

| No. | Item (part) | | | Standard value (notes) | | Remarks |
|---|---|---|---|---|---|---|
| 1 | Combustion | Top clearance | | 0.8±0.09 | | Gasket t=1.3 |
| 2 | | Injection timing | | 13° ±1° bTDC(FID) | | ——— |
| 3 | | Injection pressure | | $25.5^{+1.0}_{0}$MPa ($260^{+10}_{0}$ kgf/cm²) | | Nozzle opening press. |
| 4 | | Max. variation between cylinders (%) | Max. rating | ±3% | | Np=1650rpm |
| | | | Low idle | ±15% | | Np=350rpm |
| 5 | | Swirl percentage | | 1.6±0.1 (by simple method) | | Processing depth: 28 |
| 6 | | Protrusion of nozzle tip | | 1.8±0.1(Nozzle tip) | | from cylinder head surface |
| 7 | | Valve timing | Intake Open | bTDC 36° ±5° | | ——— |
| | | | Intake Close | aBDC 40° ±5° | | ——— |
| | | | Exhaust Open | bBDC 58° ±5° | | ——— |
| | | | Exhaust Close | aTDC 46° ±5° | | ——— |
| 8 | | Piston bowl capacity (Piston, recess (Incl. intake/exhaust valve recess) | | 51.6±0.9cm³ | | ——— |
| 9 | Head gasket | Valve clearance | Intake | 0.1±0.03 (in cold state) | | ——— |
| | | | Exhaust | 0.5±0.03 (in cold state) | | ——— |
| 10 | | Valve and piston chasing clearance | Intake | 1.42 (6° Crank shaft) | | ——— |
| | | | Exhaust | 1.26 (6° Crank shaft) | | ——— |
| 11 | | Cam shaft hole excentricity | | φ0.015 | | ——— |
| 12 | | Cam profile accuracy | | Lift | Profile variation | ——— |
| | | | Damping portion | ±0.02 | ±0.006 | ——— |
| | | | Other than above | 0.04 | ±0.008 | ——— |
| 13 | | Valve sinking | Intake | 0.7±0.1(Protrusion) | | See 2.3.2 |
| | | | Exhaust | 0.3±0.1(Sinking) | | See 2.3.2 |
| 15 | | Cylinder block surface (finished accuracy) | Flatness | 0.03(500mm²) 0.05 (whole surface) | | ——— |
| | | | Roughness | 8 μRmax | | ——— |
| 16 | | Cylinder head surface (finished accuracy) | Flatness | 0.01(□100) 0.07(whole surface) | | ——— |
| | | | Roughness | 8 μRmax | | ——— |
| 17 | | Head gasket thickness (at tightening) | | 1.30±0.05 | | ——— |
| 18 | | Cylinder liner | Roundness | 0.015 | | For topring tracing |
| | | | Cylinder city | 0.025 | | |

| No. | Item (part) | | Standard value (notes) | Remarks |
|---|---|---|---|---|
| 19 | Roughness of cylinder sliding face | | 3～5.5 μmRz | Silicard |
| 20 | Piston-cylinder clearance | Clearance | 0.111～0.131mm | 6LY2-STE/6LY2A-STP |
| | | Selection of piston and cylinder | Piston: L / ML / MS / S<br>Cylinder: L / M / S | |
| 21 | Between piston and cylinder sleeve | Clearance | 0.088～0.108mm | 6LYA-STE |
| | | Combination of piston and cylinder sleeve | Piston: L / ML / MS / S<br>Sleeve: L / M / S | |
| | Between cylinder sleeve and cylinder block | Clearance | 0.010～0.030mm | |
| | | Combination of sleeve and block | Sleeve: A / B / C<br>Block: A / B / C | |
| 22 | Piston-ring (B) clearance | Top | Half keystone | |
| | | 2nd | 0.080～0.115mm | |
| | | Oil | 0.020～0.055mm | |
| 23 | Total backlash of gear training | | 0.12±0.04mm | LOP idle gear～LOP 0.17±0.09 |
| 24 | Delivery of Lube oil pump | | ≧94.5 ℓ/min | Condition Np=3200rpm (NE=3200rpm)<br>Pressure : 8kg/cm²±0.1<br>Oil Temp. : 100±2℃ |
| 25 | Delivery of fresh water pump | | ≧350 ℓ/min | Condition Np=3250±33rpm<br>H=6.6mAq<br>Fluid : Fresh water 80℃ |
| 26 | Setting pressure | L.O. press. regulating valve | 0.490±0.049MPa (5.0±0.5kg/cm²) | 3000rpm, at sender unit |
| 27 | Thermostat valve open temp. | | 71±2℃ | 10mm or more at 85℃ fully open |
| 28 | Delivery of seawater pump | | ≧215 ℓ/min | Condition Np=3000±30rpm<br>H=10mAq<br>Fluid : Seawater 30℃ |

| No. | Item (part) | | Standard value (notes) | Remarks |
|---|---|---|---|---|
| 35 | Miscellaneous | Compression ratio | 15.2±0.5 (Appearance)<br>14.0±0.5 (Effective) | |
| 36 | | Clearance measurement (Piston bowl, Valve recess, Head concave part) | 67.9±0.9cc | |
| 37 | Top clearance | Block heights | $289.975\ ^{+0.05}_{0}$ | Gasket thickness see No.17 |
| 38 | | Piston heights | 59.565±0.03 | |
| 39 | | Rod end pitch, large, small | $176\ ^{+0.05}_{0}$ | |
| 40 | | Crank radius | 55±0.025 | |
| 41 | Delivery of seawater pump | | ≧215 ℓ/min | Condition Np=3000±30 rpm<br>H=10mAq<br>Fluid : Seawater 30℃ |



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## 4-2. Dimension of Main Parts

mm

| No. | Item | | Parts | Parts dimension | Standard | Remarks |
|---|---|---|---|---|---|---|
| 1 | Interference | Crank gear | Gear inner dia. | $50\ ^{-0.001}_{-0.017}$ | Interference 0.069~0.096 | Shrink fit temp 180~200℃ Oil remove |
| | | | Shaft dia. | $50\ ^{+0.079}_{+0.068}$ | | |
| 2 | | Cam shaft metal | Blockcam shaft hole | $61H7\ ^{+0.030}_{0}$ | Interference 0.030~0.100 | ——— |
| | | | Metal outer dia. | $61\ ^{+0.100}_{+0.000}$ | | |
| 3 | | Valve guide (Intake/Exhaust) | Hole dia. | $13.5H7\ ^{+0.018}_{0}$ | 0~0.029 | ——— |
| | | | Guide outer dia. | $13.5P6\ ^{+0.029}_{+0.018}$ | | |
| 4 | | Cam gear | Gear inner dia. | $30\ ^{+0.021}_{0}$ | Interference 0.023~0.060 | Shrink fit temp. 180~200℃ Oil remove |
| | | | Shaft dia. | $30\ ^{+0.060}_{+0.044}$ | | |
| 5 | | Valve seat (Intake) (SUH3, Stellite) | Head | $47.5\ ^{+0.016}_{0}$ | Interference 0.038~0.070 | Shrinkage fit. |
| | | | Seat outer dia. | $47.5\ ^{+0.070}_{+0.054}$ | | |
| 6 | | Valve seat (Intake) (SUH3, Stellite) | Head | $42\ ^{+0.016}_{0}$ | Interference 0.038~0.070 | Shrinkage fit. |
| | | | Seat outer dia. | $42\ ^{+0.070}_{+0.054}$ | | |
| 7 | | Balancer gear (Crank shaft) | Gear inner dia | ——— | ——— | ——— |
| | | | Shaft dia | ——— | | |
| 8 | | Balancer gear(A) | Gear inner dia | ——— | ——— | ——— |
| | | | Shaft dia | ——— | | |
| 9 | | Balancer gear(B) | Gear inner dia | ——— | ——— | ——— |
| | | | Shaft dia | ——— | | |
| 10 | Side clearance | Crank shaft | Crank shaft standard width | $34H7\ ^{+0.025}_{0}$ | 0.132~0.223 | Side clearance 0.1775±0.0451 |
| | | | Standard metal width | $29\ ^{-0.09}_{-0.14}$ $2.5\ ^{0}_{-0.05}$ | | |
| 11 | | Connecting rod | Crank shaft width | $34\ ^{+0.010}_{0}$ | 0.20~0.40 | ——— |
| | | | Width of large end | $34\ ^{-0.20}_{-0.30}$ | | |
| 12 | | Cam shaft | Cam shaft standard width | $4.2\ ^{+0.15}_{+0.05}$ | 0.05~0.20 | ——— |
| | | | Thrust metal width | $4.2\ ^{0}_{+0.05}$ | | |
| 13 | | Idle gear(Timing) | Mount width | $29\ ^{+0.2}_{+0.1}$ | 0.10~0.30 | ——— |
| | | | Gear width | $29\ ^{0}_{-0.1}$ | | |
| 14 | | Idle gear(LO-P) | Mount width | $15\ ^{+0.2}_{+0.1}$ | 0.10~0.30 | ——— |
| | | | Gear width | $15\ ^{0}_{-0.1}$ | | |
| 15 | | Main bearing | Metal inner dia. | $75\ ^{+0.045}_{0}$ | 0.036~0.093 | ——— |
| | | | Journal dia. | $75\ ^{-0.036}_{-0.048}$ | | |

mm

| No. | Item | Parts | Parts dimension | Standard | Remarks |
|---|---|---|---|---|---|
| 16 | Cam shaft | Metal inner dia. | 57 $^{+0.050}_{-0.020}$ | 0.04~0.14 | ——— |
| | | Journal dia. | 57 $^{-0.060}_{-0.090}$ | | |
| 17 | Crank pin | Width of large end | 65 $^{+0.045}_{0}$ | 0.036~0.093 | ——— |
| | | Crank pin dia. | 65 $^{-0.036}_{-0.048}$ | | |
| 18 | Piston pin metal | Metal inner dia. | 37 $^{+0.040}_{+0.025}$ | 0.025~0.051 | ——— |
| | | Piston pin outer dia. | 37h5 $^{0}_{-0.011}$ | | |
| 19 | Piston pin | Piston pin hole | 37h5 $^{+0.011}_{0}$ | 0~0.022 | ——— |
| | | Piston pin outer dia. | 37h5 $^{0}_{-0.011}$ | | |
| 20 | Tappet | Tappet hole dia. | 14.2 $^{+0.070}_{-0.049}$ | 0.016~0.052 | ——— |
| | | Tappet outer dia. | 14.2 $^{+0.033}_{+0.018}$ | | |
| 21 | Valve rocker arm | Rocker arm inner dia. | 18.5 $^{+0.021}_{0}$ | 0.020~0.062 | ——— |
| | | Rocker arm shaft outer dia. | 18.5 $^{-0.020}_{-0.041}$ | | |
| 22 | Idle gear (Timing) | Metal inner dia. | 46 $^{+0.025}_{0}$ | 0.025~0.075 | ——— |
| | | Mount outer dia. | 46 $^{-0.025}_{-0.050}$ | | |
| 23 | Idle gear (LO-P) | Metal inner dia. | 38H6 $^{+0.016}_{0}$ | 0.025~0.057 | ——— |
| | | Mount outer dia. | 38f6 $^{-0.025}_{-0.041}$ | | |
| 24 | Intake valve | Valve guide hole dia. | 9H7 $^{+0.015}_{0}$ | 0.025~0.055 | Valve stem : Tufftrid treatment<br>Seat : Stellite |
| | | Valve dia. | 9 $^{-0.025}_{-0.040}$ | | |
| 25 | Exhaust valve | Valve guide hole dia. | 9H7 $^{+0.015}_{0}$ | 0.045~0.075 | Valve stem : Tufftrid treatment<br>Seat : Stellite |
| | | Valve dia. | 9 $^{-0.045}_{-0.060}$ | | |
| 26 | L.O. pressure regulating valve | Hole dia. | 16H8 $^{+0.027}_{0}$ | 0.040~0.087 | ——— |
| | | Valve outer dia. | 16 $^{-0.040}_{-0.060}$ | | |
| 27 | Ring (2nd) | Groove width | 2.5 $^{+0.085}_{+0.070}$ | 0.080~0.115 | ——— |
| | | Ring width | 2.5 $^{-0.010}_{-0.030}$ | | |
| 28 | Ring (Oil) | Groove width | 4.0 $^{+0.025}_{+0.010}$ | 0.020~0.055 | ——— |
| | | Ring width | 4.0 $^{-0.010}_{-0.030}$ | | |



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| No. | Item | | Parts | Parts dimension | Standard | Remarks |
|---|---|---|---|---|---|---|
| 31 | Circle runout of the flywheel and flywheel housing | Flywheel circle runout | ——— | ——— | 0.2 (TIR) | ——— |
| | | | ——— | ——— | | |
| 32 | | Flywheel face runout | ——— | ——— | 0.1 (full circle) | ——— |
| | | | ——— | ——— | | |
| 33 | | Flywheel housing circle runout | ——— | ——— | 0.25 (TIR) | ——— |
| | | | ——— | ——— | | |
| 34 | | Flywheel housing face runout | ——— | ——— | 0.15 (TIR) | ——— |
| | | | ——— | ——— | | |

## 4-3. Bolt / Nut Tightening torque

N·m (kgf·m)

| No. | Name | Screw dia.×pitch | Material | Apply engine oil to the screw and seat | Tightening torque |
|---|---|---|---|---|---|
| 1 | Head bolt | M14×1.5 | 10B35 | (Yes) · No | (118→177−226±10)<br>(12→18→23±1) |
| 2 | Rod bolt | M12×1.25 | SCM435 | (Yes) · No | 137±4.9 (14±0.5) |
| 3 | Flywheel bolt | M16×1.5 | SCM435 | (Yes) · No | 294±10 (30±1) |
| 4 | Metal cap bolt | M15×1.5 | SCM435 | (Yes) · No | 255±10 (26±1) |
| 5 | Crank V-pulley bolt | M16×1.5 | SCM435 | (Yes) · No | 226±10 (23±1) |
| 6 | Nozzle nut | M8×1.25<br>M6×1 (6LYA-STP) | S40C | Yes · (No) | 10~12 (1.0~1.2)<br>3.9~4.9 (0.4~0.5)(6LYA-STP) |
| 7 | Timer nut (fuel injection pump) | M18×1.5 | S45C | (Yes) · No | 127±10(13±1) |
| 8 | Lube oil filter (full-flow)<br>Lube oil filter (by-pass)<br>Fuel oil filter | 1-12UNF<br>M25 ×1.5<br>1-14UNS | —— | —— | Screw it into the installation surface until contact by hand and further fasten by about 3/4 turns using filter wrench |
| 9 | Idler shaft bolt (Idler gear) | M8×1.25 | SCM435 | (Yes) · No | 37±2 (3.8±0.2) |
| 10 | Idler shaft bolt (Lube oil pump) | M12×1.75 | SCM435 | (Yes) · No | 108±10 (11±1) |
| 11 | V-band for turbocharger | 1/4-28UNF | SUS304 | Apply molybdenum to the screw. | 1st torque : 5.9~6.9(0.6~0.7) After tapping external surface using plastic hammer : Final torque : 8.8 (0.9) |
| 12 | Exhaust manifold installing bolt | M8×1.25 | S45C | Yes · (No) | 25±2 (2.6±0.2) |

### The standard bolts for general use (Not apply engine oil)

N·m (kgf·m)

| No. | Name | Screw dia. × pitch | Torque | Tightening torque |
|---|---|---|---|---|
| 1 | Standard<br>(JIS standard 7T) | M6×1<br>M8×1.25<br>M10×1.5<br>M12×1.75 | 11±1 (1.1±0.1)<br>2.5±2.9 (2.6±0.3)<br>49±4.0 (5.0±0.5)<br>88±10 (9.0±1.0) | ①When the tightened part is aluminum : 80% of specified torque.<br>②For 4T and lock nut : 60% of specified torque of 7T bolts. |
| 2 | PT plug | 1/8<br>1/4<br>3/8<br>1/2 | 10 (1.0)<br>20 (2.0)<br>29 (3.0)<br>59 (6.0) | If SEALOCKMEC is used, torque is specified separately. |
| 3 | Ball joint bolt | M 8<br>M12<br>M14<br>M16 | 15±2 (1.5±0.2)<br>29±4.9 (3.0±0.5)<br>44±4.9 (4.5±0.5)<br>54±4.9 (5.5±0.5) | —— |



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# 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 | 1) Make sure that the Kingston Cock is open.<br>2) Make sure there is enough lube oil and (fresh) cooling water.<br>3) Operate the remote control handle and check if the devices connected to the engine side work properly. | 3) Lamp should go off when engine is running. |
| 2 | No load operation; warm up operation | 1) When the engine is started, check the following:<br>• there is no water and no oil leakage.<br>• exhaust gas does not leak when the engine is started.<br>• there are no abnormal indications on the instrument panel.<br>• there is no abnormality in cooling water discharge, engine vibrations, or engine sounds.<br>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. | • Fix leaks if any.<br>• Check the intake/exhaust valves, F.O. injection valve, and cylinder head.<br>2) Do not raise the engine revolutions abruptly. |
| 3 | Cruising (load) operation | 1) Do not operate the engine at full load yet, but raise the rpms gradually for about 10 minutes until they reach rated rpms.<br>2) Make sure that exhaust color and temperature are normal.<br>3) Check the instrument panel and see if the water temperature and oil pressure are normal. | |
| 4 | Stopping the engine | 1) Before stopping the engine, operate it at 650-700 rpms for about 5 minutes.<br>2) Raise engine rpms to 1,800 just before stopping the engine and idle the ehgine for about 3-4 seconds. | 1) Stopping the ergine suddenly during high speed operation increases the temperature of engine parts.<br>2) This procedure prevents carbon from being deposited on the valve seats, etc. |
| 5 | Checks after stopping the engine | 1) Check again for water and oil leaks.<br>2) Make sure that no nuts and bolts are loose.<br>3) Close the Kingston and fuel cocks.<br>4) When the temperature is expected to fall below freezing, drain the cooling water (sea water).<br>5) Turn off the battery switch. | 1) Check the oil seal area.<br>2) Especially the engine installation bolts.<br>4) Drain from the sea water pump. |

CHAPTER 11

# TROUBLESHOOTING



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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

TROUBLE AND TROUBLESHOOTING — THE ENGINE SUDDENLY STOPS.

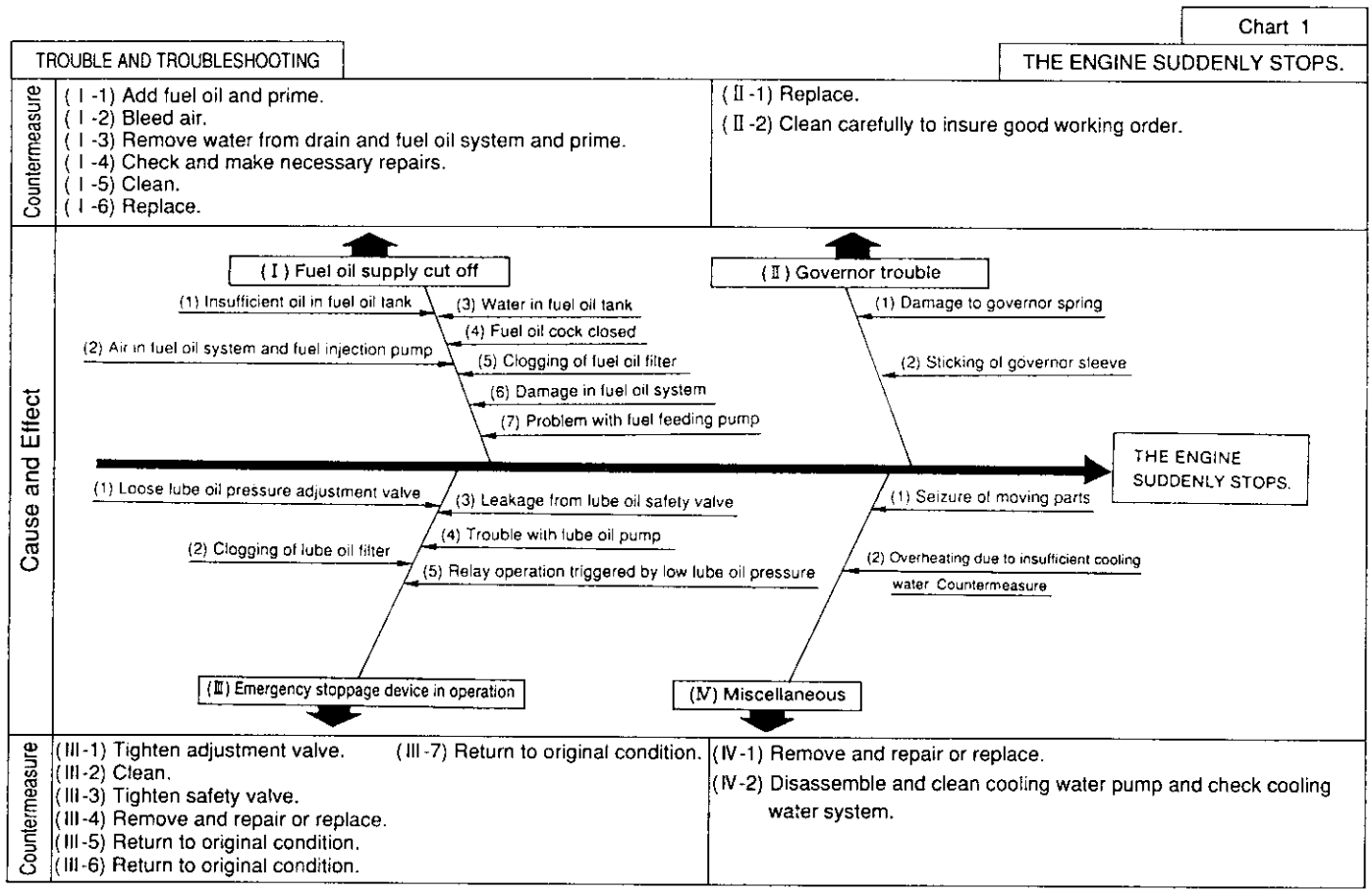
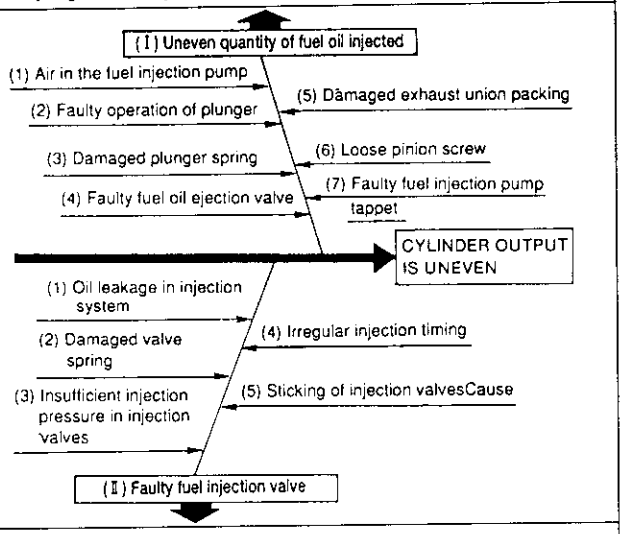


Chart 2

TROUBLE AND TROUBLESHOOTING — CYLINDER OUTPUTLS 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



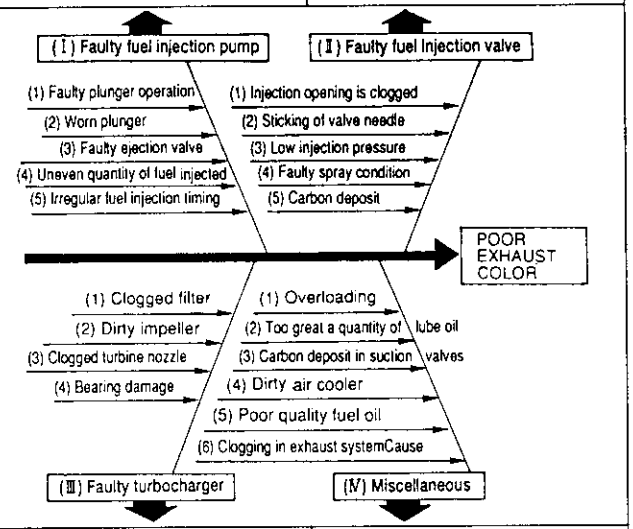

Countermeasure
(II-1) Check and repair.
(II-2) Replace.
(II-3) Adjust.
(II-4) Adjust.
(II-5) Clean.

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



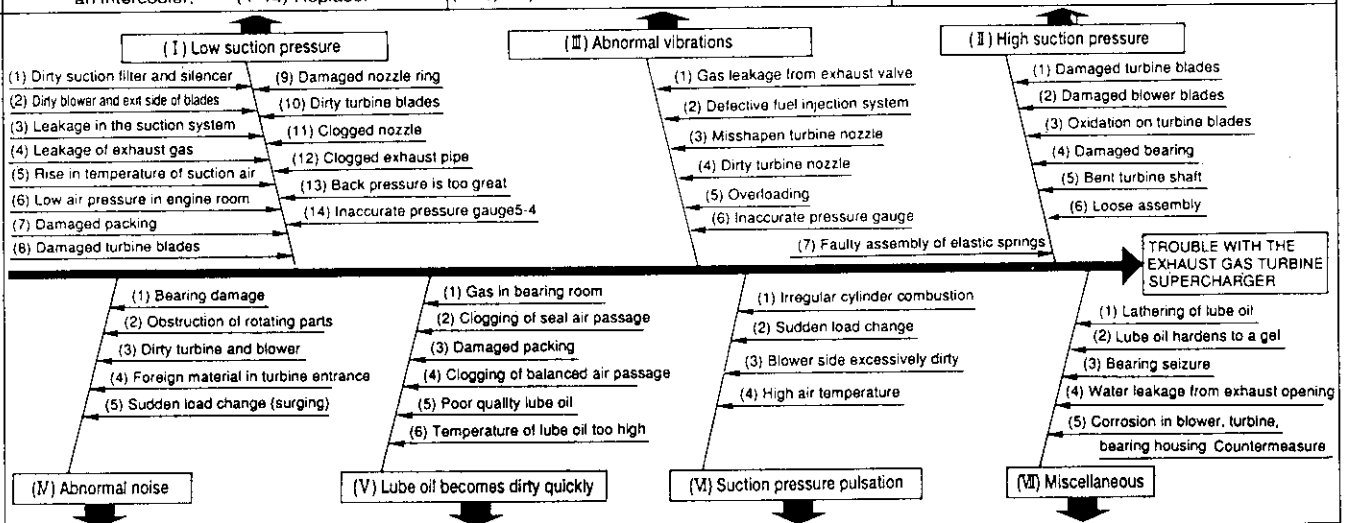

Countermeasure
(III-1) Clean.
(III-2) Clean.
(III-3) Clean.
(III-4) Replace.
(IV-1) Reduce load.
(IV-2) Adjust quanity of oil.
(IV-3) Clean.
(IV-4) Clean.
(IV-4) Replace.with new oil.
(IV-4) Clean.

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. ○Admit fresh air to engine room. ○Where there is an intercooler, increase the cooling water and clean fin.
(I-6) Open door or install ventilation dact.
(I-7,8,9) 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. ○Disassemble and check injection pump. Repair or replace faulty parts. ○Disassemble and check injection valve. Repair or replace faulty parts.
(II-3) Replace.
(II-4) Clean.
(II-5) Reduce load.
(II-6) Replace.
(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
(IV-1) Replace.
(IV-2) Repair or replace.
(IV-3) Clean.
(IV-4) Repair or replace.
(IV-5) Stabilize load, or replace turbine nozzle.
(V-1) Repair.
(V-2) Clean.
(V-3) Replace.
(V-4) Clean.
(V-5) Replace.
(V-6) ○Replenish lube oil when insufficient. ○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. ○Clean cooler blades. ○Adjust temperature of exhaust system. ○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.



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Chart 5

TROUBLE AND TROUBLESHOOTING

TROUBLE WITH MARINE GEAR

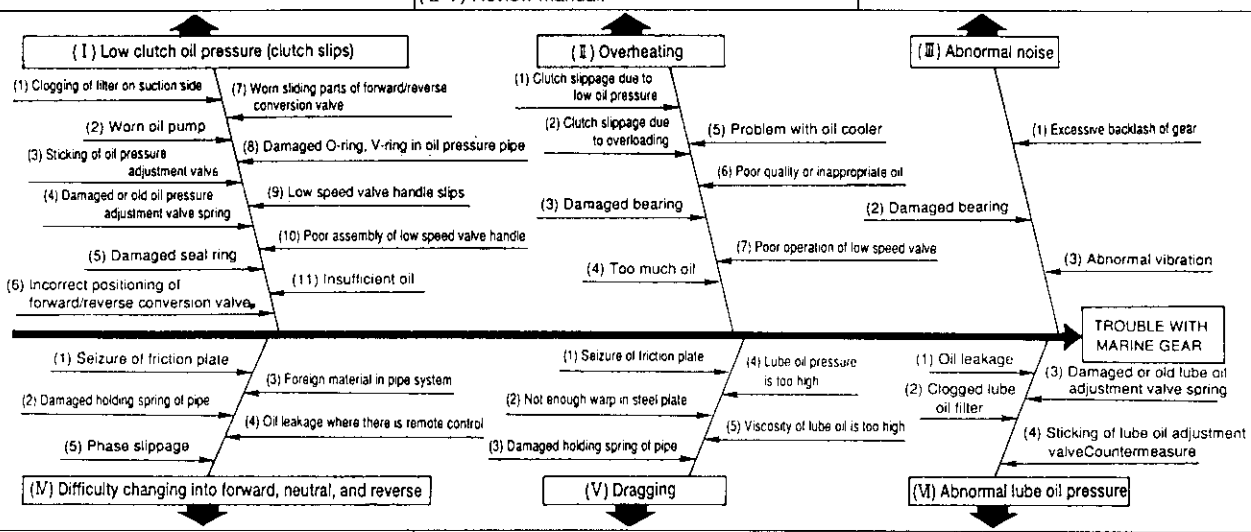
Countermeasure

(Ⅰ-1) Disassemble and clean.
(Ⅰ-2) Repair or replace.
(Ⅰ-3) Repair or replace.
(Ⅰ-4) Replace.
(Ⅰ-5) Repair.
(Ⅰ-6) Adjust.
(Ⅰ-7) Replace.
(Ⅰ-8) Replace.
(Ⅰ-9) Adjust to correct position.
(Ⅰ-10) Reassemble.
(Ⅰ-11) Check for oil leakage and replenish.

(Ⅱ-1) Review(Ⅰ-1 Ⅰ-11)
(Ⅱ-2) Reduce load.
(Ⅱ-3) Replace.
(Ⅱ-4) Check oil level and adjust.
(Ⅱ-5) Check water level and adjust.
(Ⅱ-6) Change oil.
(Ⅱ-7) Review manual.

(Ⅲ-1) Replace.
(Ⅲ-2) Replace.
(Ⅲ-3) Eliminate dangerous rotation.

Cause and Effect




Countermeasure

(Ⅳ-1) Replace.
(Ⅳ-2) Replace.
(Ⅳ-3) Clean.
(Ⅳ-4) Replenish oil and check. Replace bellofrom.
(Ⅳ-5) Repair link system.

(Ⅴ-1) Replace.
(Ⅴ-2) Replace.
(Ⅴ-3) Replace.
(Ⅴ-4) Adjust lube oil adjustment valve.
(Ⅴ-5) Change oil.

(Ⅵ-1) Check and repair.
(Ⅵ-2) Disassemble and clean.
(Ⅵ-3) Replace.
(Ⅵ-4) Repair or replace.

Chart 6

TROUBLE AND TROUBLESHOOTING

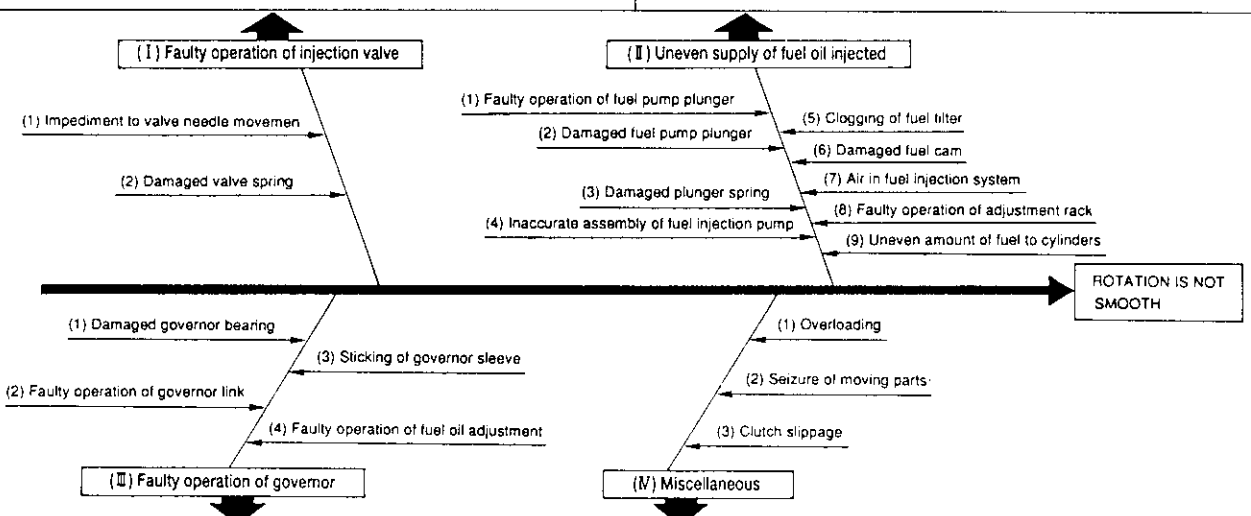
ROTATION IS NOT SMOOTH

Countermeasure

(Ⅰ-1) Lap.
(Ⅰ-2) Replace.

(Ⅱ-1)Clean.
(Ⅱ-2) Replace.
(Ⅱ-3) Replace.
(Ⅱ-4) Correctly install pump.
(Ⅱ-5) Clean.
(Ⅱ-6) Replace.
(Ⅱ-7) Bleed air and prime.
(Ⅱ-8) Adjust.
(Ⅱ-9) Adjust.

Cause and Effect




Countermeasure

(Ⅲ-1) Replace.
(Ⅲ-2) Adjust.
(Ⅲ-3) Clean.
(Ⅲ-4) Disassemble, wash and repair.

(Ⅳ-1) Reduce load.
(Ⅳ-2) Disassemble, check and repair.
(Ⅳ-3) Check and adjust.

Chart 7

TROUBLE AND TROUBLESHOOTING

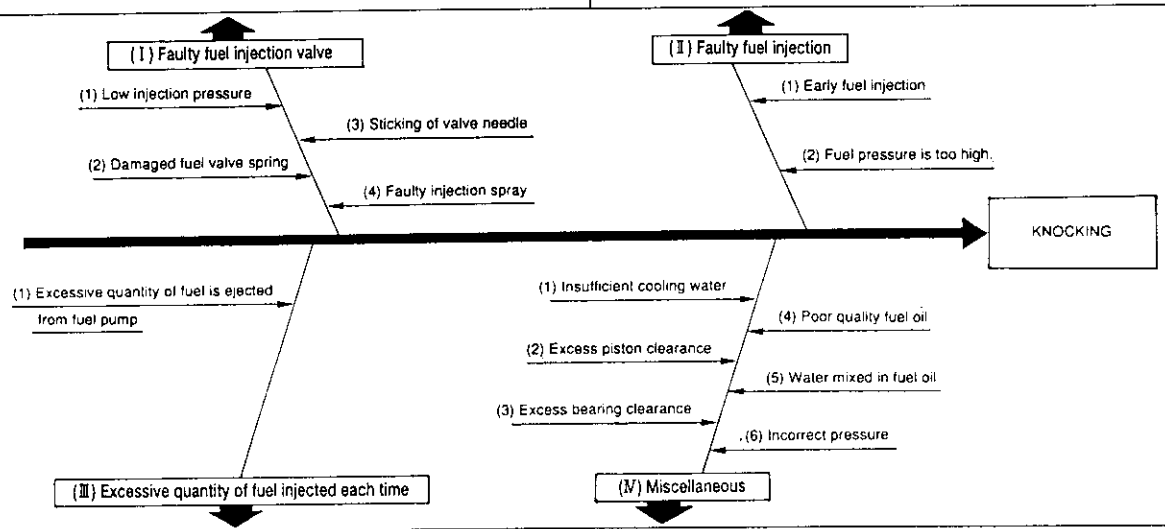
KNOCKING

**Countermeasure**

(Ⅰ-1) Increase injection pressure.
(Ⅰ-2) Replace.
(Ⅰ-3) Disassemble and lap.
(Ⅰ-4) Disassemble and repair.

(Ⅱ-1) Delay injection timing.
(Ⅱ-2) Adjust standard injection pressure.

**Cause and Effect**




**Countermeasure**

(Ⅲ-1) Adjust pump adjustment rack.

(Ⅳ-1) Check cooling water pump and lap valves.
(Ⅳ-2) Replace.
(Ⅳ-3) Replace.
(Ⅳ-4) Replace with good fuel oil.
(Ⅳ-5) Replace with good fuel oil.
(Ⅳ-6) Check and repair.

Chart 8

TROUBLE AND TROUBLESHOOTING

TROUBLE WITH STARTING

**Countermeasure**

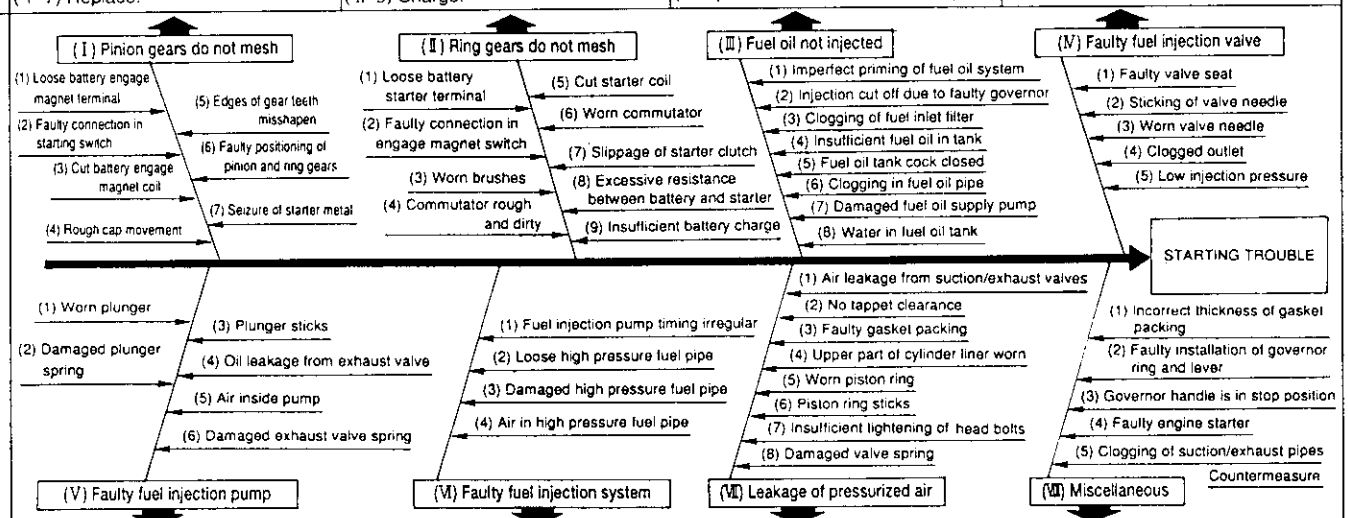
(Ⅰ-1) Tighten.
(Ⅰ-2) Repair using sandpaper or replace.
(Ⅰ-3) Replace.
(Ⅰ-4) Repair using sandpaper and then grease.
(Ⅰ-5) Adjust.
(Ⅰ-6) Adjust.
(Ⅰ-7) Replace.

(Ⅱ-1) Tighten.
(Ⅱ-2) Repair using sandpaper.
(Ⅱ-3) Replace.
(Ⅱ-4) Repair using sandpaper(Type 500~600).
(Ⅱ-5) Replace.
(Ⅱ-6) Undercut and repair or replace.
(Ⅱ-7) Replace.
(Ⅱ-8) Replace with thicker or shorter wire.
(Ⅱ-9) Charge.

(Ⅲ-1) Prime well.
(Ⅲ-2) Adjust.
(Ⅲ-3) Clean out matter causing clogging.
(Ⅲ-4) Add fuel to fuel tank.
(Ⅲ-5) Open cock.
(Ⅲ-6) Clean.
(Ⅲ-7) Disassemble and repair or replace.
(Ⅲ-8) Drain water from fuel system and prime.

(Ⅳ-1) Lap.
(Ⅳ-2) Lap.
(Ⅳ-3) Replace.
(Ⅳ-4) Clean or replace.
(Ⅳ-5) Adjust.

**Cause and Effect**




**Countermeasure**

(Ⅴ-1) Replace plunger and barrel as a unit.
(Ⅴ-2) Replace.
(Ⅴ-3) Disassemble and repair or replace.
(Ⅴ-4) Lap valves.
(Ⅴ-5) Bleed air.
(Ⅴ-6) Replace.

(Ⅵ-1) Adjust.
(Ⅵ-2) Tighten firmly.
(Ⅵ-3) Replace.
(Ⅵ-4) Bleed air.

(Ⅶ-1) Lap valves.
(Ⅶ-2) Adjust.
(Ⅶ-3)(Ⅶ-4)(Ⅶ-5)Replace.
(Ⅶ-6) Disassemble and repair or replace.
(Ⅶ-7) Tighten tightening nuts uniformly.
(Ⅶ-8) Replace.

(Ⅷ-1) Replace.
(Ⅷ-2) Adjust.
(Ⅷ-3) Move governor handle to acceleration position.
(Ⅷ-4) Check and repair.
(Ⅷ-5) Clean.



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Chart 9

TROUBLE AND TROUBLESHOOTING — INSUFFICIENT POWER OUTPUT

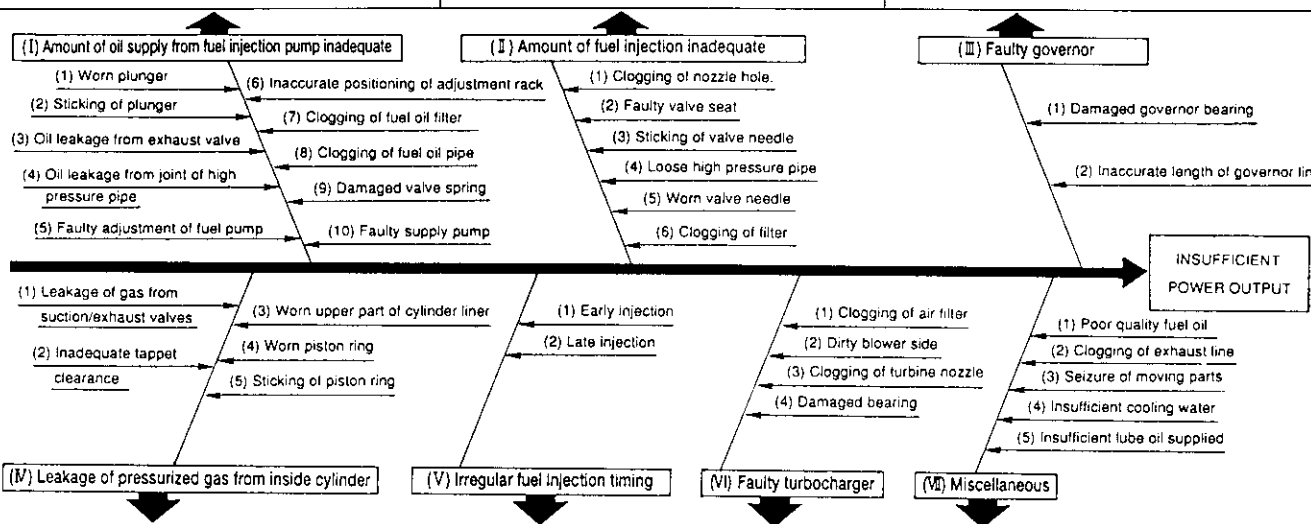
**Countermeasure**

(Ⅰ-1) Replace.
(Ⅰ-2) Disassemble and repair or replace.
(Ⅰ-3) Lap valves.
(Ⅰ-4) Tighten firmly.
(Ⅰ-5) (Ⅰ-6) Adjust.
(Ⅰ-7) (Ⅰ-8) Clean.
(Ⅰ-9) Replace. (Ⅰ-10) Repair.

(Ⅱ-1) Clean nozzle hole or replace.
(Ⅱ-2) Lap or replace.
(Ⅱ-3) Lap or replace.
(Ⅱ-4) Tighten firmly.
(Ⅱ-5) Replace.
(Ⅱ-6) Clean.

(Ⅲ-1) Replace.
(Ⅲ-2) Repair.

**Cause and Effect**




**Countermeasure**

(Ⅳ-1) Lap valves.
(Ⅳ-2) Adjust.
(Ⅳ-3) Replace.
(Ⅳ-4) Replace.
(Ⅳ-5) Disassemble and repair or replace.

(Ⅴ-1) Adjust timing to delay injection.
(Ⅴ-2) Adjust timing to speed injection.

(Ⅵ-1) Clean.
(Ⅵ-2) Clean.
(Ⅵ-3) Clean.
(Ⅵ-4) Replace.

(Ⅶ-1) Replace with good fuel oil.
(Ⅶ-2) Clean.
(Ⅶ-3) Disassemble, check and repair.
(Ⅶ-4) Lap cooling water pump suction/exhaust valves.
(Ⅶ-5) Disassemble and clean lube oil pump and filter.

Chart 10

TROUBLE AND TROUBLESHOOTING — MISCELLANEOUS TROUBLE

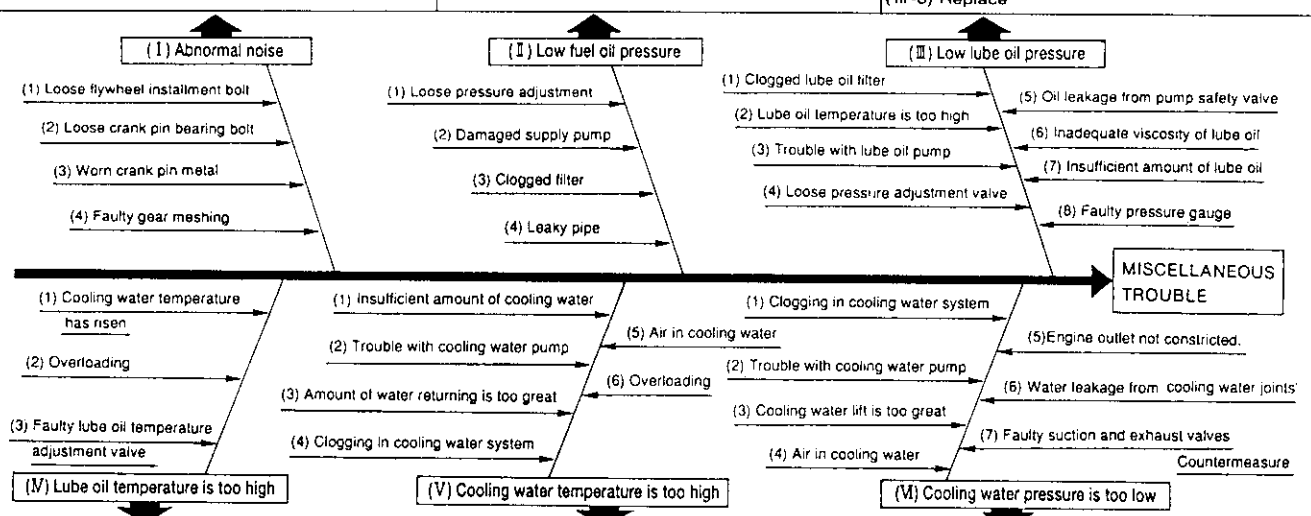
**Countermeasure**

(Ⅰ-1) Tighten nuts.
(Ⅰ-2) Tighten nuts and insert pins.
(Ⅰ-3) Remove adjustment liner and adjust aperture, or replace.
(Ⅰ-4) Check teeth, shaft, and pushrod of gear for wear.Replace whewe necessary.

(Ⅱ-1) Tighten adjustment valve.
(Ⅱ-2) Check and repair.
(Ⅱ-3) Clean.
(Ⅱ-4) Repair.

(Ⅲ-1) Clean.
(Ⅲ-2) Add cooling water.
(Ⅲ-3) Disassemble and repair or replace.
(Ⅲ-4) Tighten adjustment valve.
(Ⅲ-5) Tighten safety valve.
(Ⅲ-6) Change lube oil.
(Ⅲ-7) Add lube oil.
(Ⅲ-8) Replace

**Cause and Effect**




**Countermeasure**

(Ⅳ-1) Adjust the amount of returning water or check the cooling water pump and lap valves.
(Ⅳ-2) Reduce load.
(Ⅳ-3) Check and adjust.

(Ⅴ-1) Open closed parts.
(Ⅴ-2) Check pump and repair.
(Ⅴ-3) Adjust amount of returning water.
(Ⅴ-4) Clean.
(Ⅴ-5) Check suction opening.
(Ⅴ-6) Reduce load.

(Ⅵ-1) Clean.
(Ⅵ-2) Check pump and repair.
(Ⅵ-3) Lessen lift or replace pump.
(Ⅵ-4) Check suction opening.
(Ⅵ-5) Eliminate causes for high cooling water temperature and constrict.
(Ⅵ-6) Check and repair.

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