CHAPTER 9

ELECTRICAL SYSTEM

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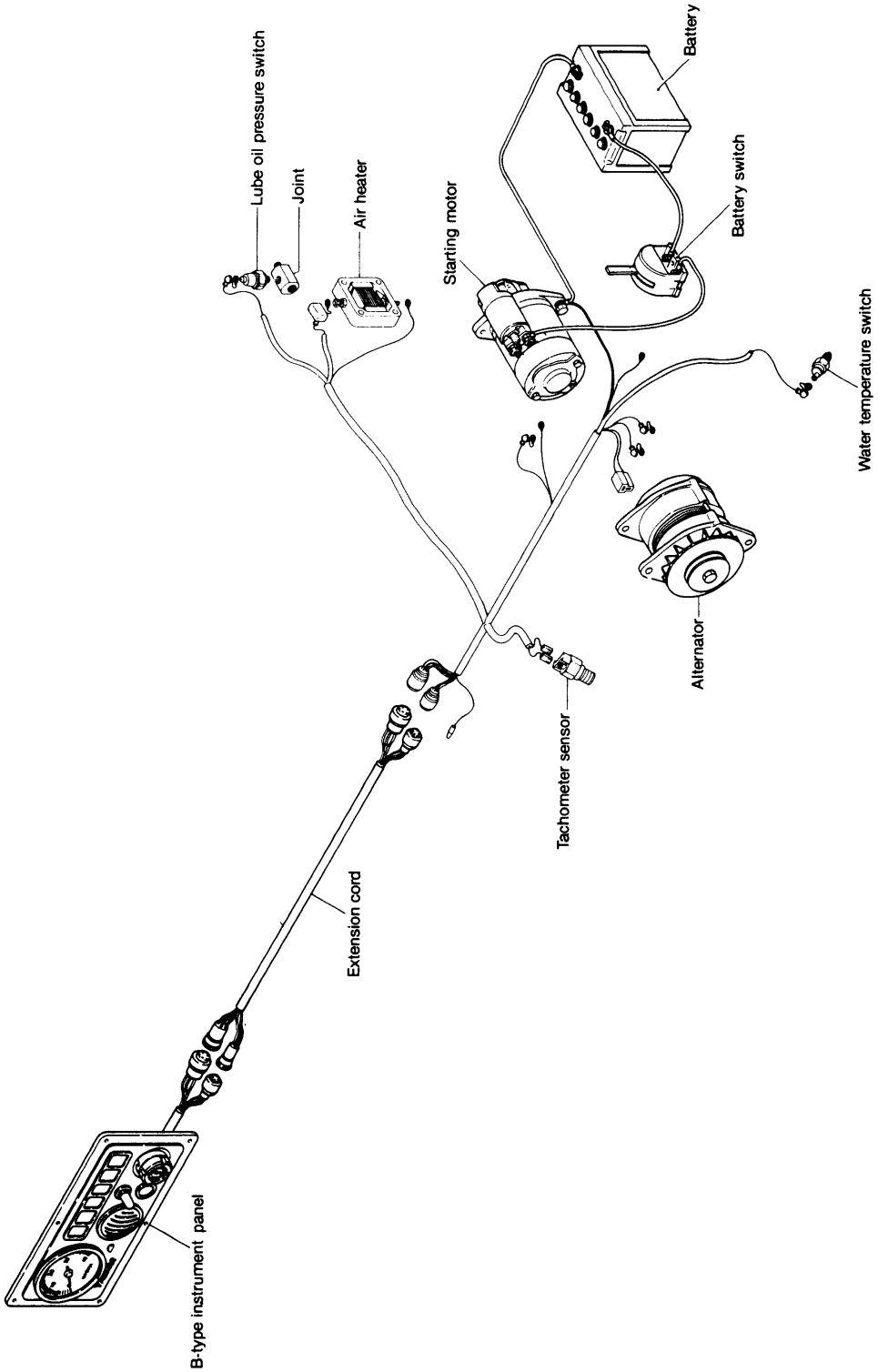
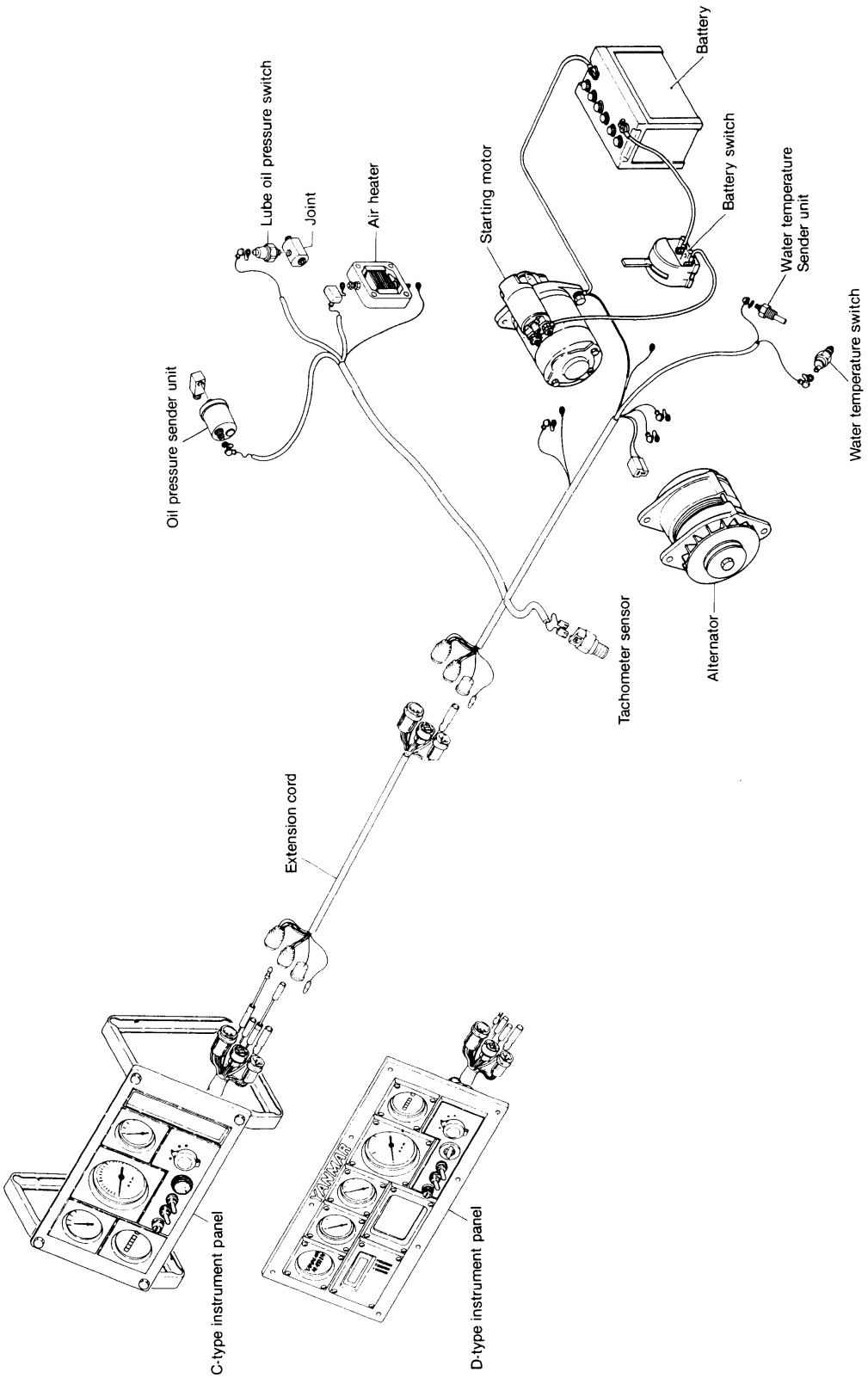
1. Electrical System

1-1 System diagrams of electric parts

1-1.1 B-type instrument panel



1-1.2 C-type and D-type instrument panel



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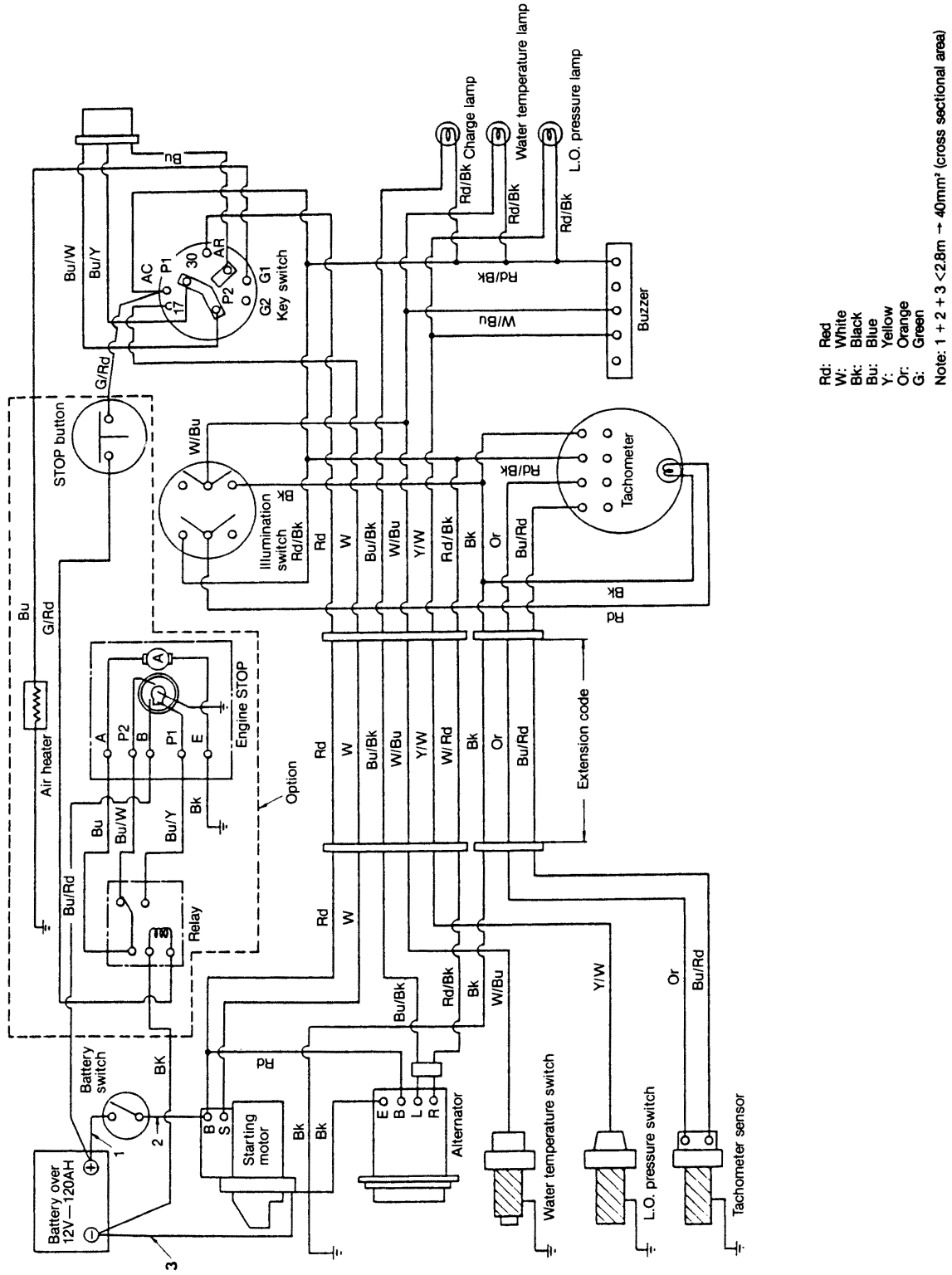
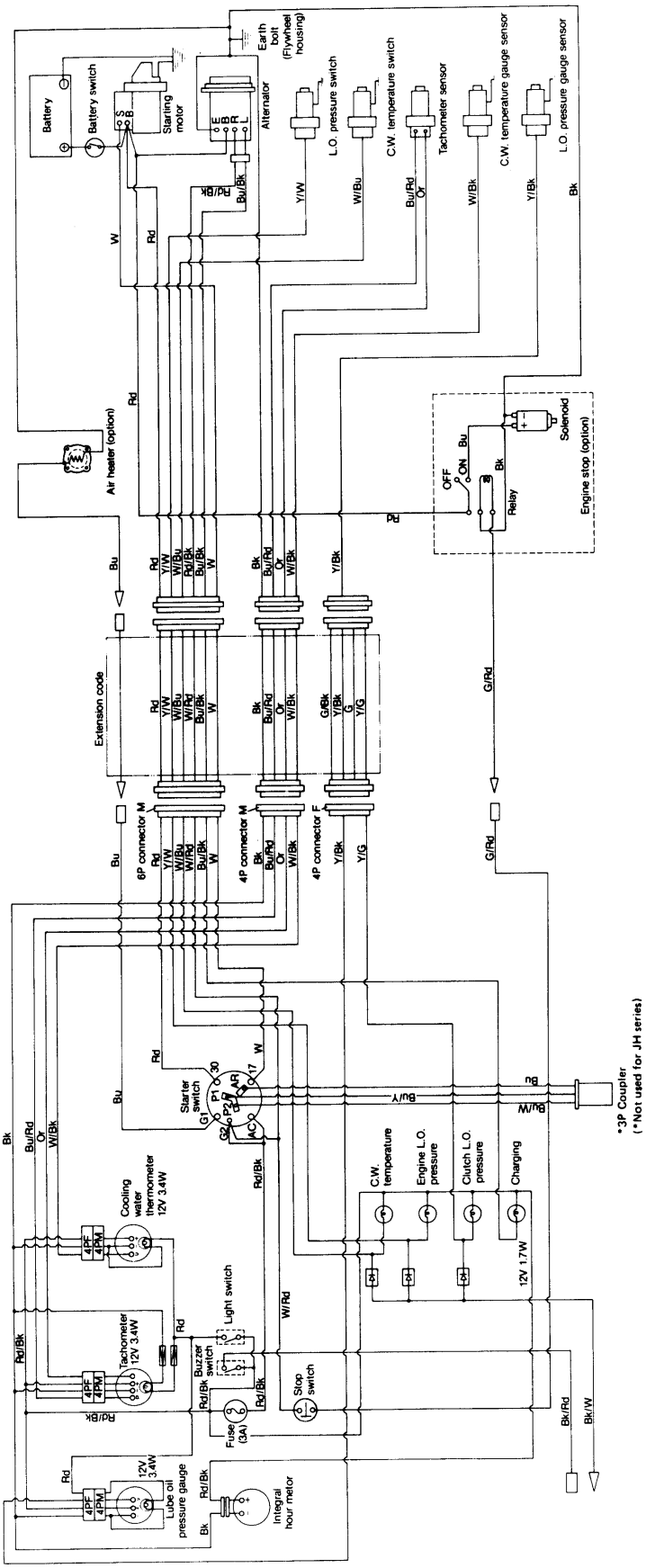
1-2 Wiring diagram

1-2.1 For B-type instrument pannel



1-2.2 For C-type instrument pannel



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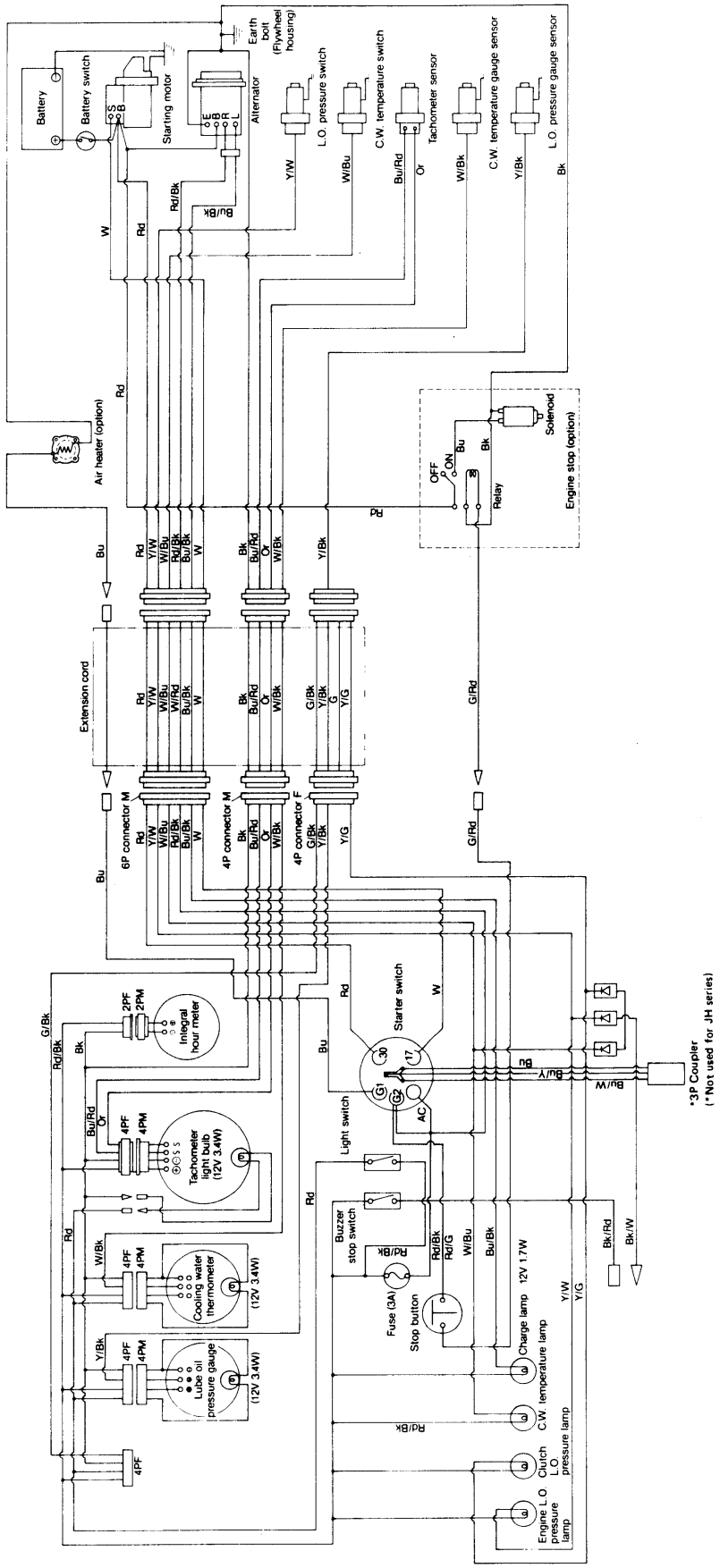
1-2.3 For D-type instrument pannel



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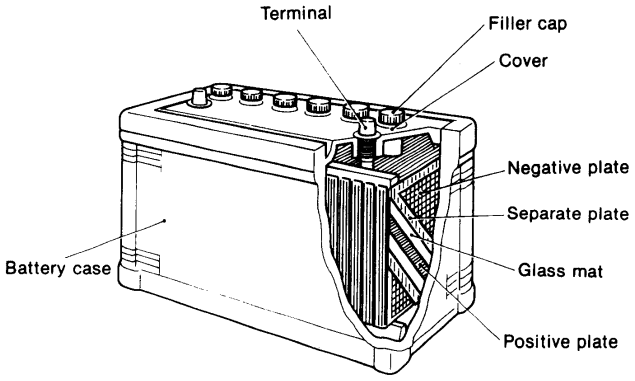
2. Battery

2-1 Construction



The battery utilizes chemical action to convert chemical energy to electrical energy. This engine uses a lead acid battery which stores a fixed amount of power that can be used when required. After use, the battery can be recharged and used again.

As shown in the figure, a nonconductive container is filled with dilute sulfuric acid electrolyte. Lead dioxide positive plates and lead dioxide negative plates separated by glass mats are stacked alternately in the electrolyte. The positive and negative plates are connected to their respective terminals.

Power is removed from the battery by connecting the load across these two terminals.

When the battery is descharging, an electric current flows from the positive plates to the negative plates. When the battery is being charged, electric current is passed through the battery in the opposite direction by an external power source.

2-2 Battery capacity and battery cables

2-2.1 Battery capacity

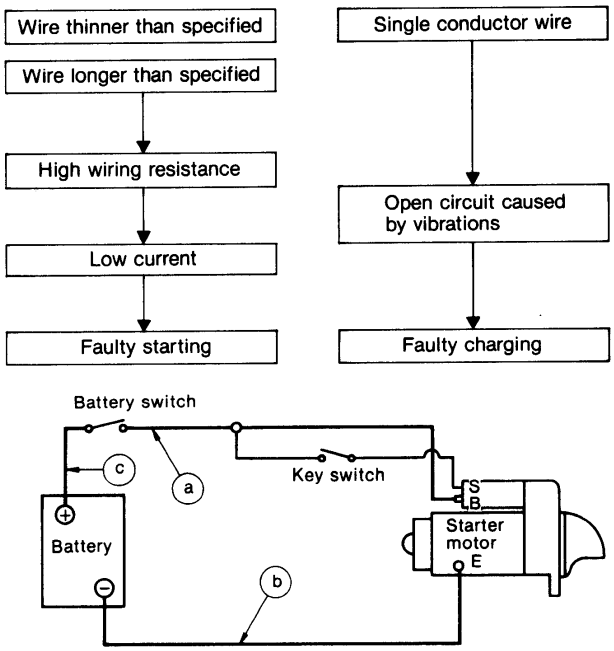
Since the battery has a minimum capacity of 12V, 70AH, it can be used for 100 ~ 150AH.

Battery capacity	minimum	12V — 100AH
	standard	12V — 120AH
	cold weather	12V — 150AH
Full charged specific gravity		1.26

2-2.2 Battery cable

Wiring must be performed with the specified electric wire. Thick, short wiring should be used to connect the battery to the starter, (soft automotive low-voltage wire [AV wire]).

Using wire other than that specified may cause the following troubles:



The overall lengths of the wire between the battery (+) terminal and the starter (B) terminal, and between the battery (–) terminal and the starter (E) terminal, should be determined according to the following table.

Voltage system	Allowable wiring voltage drop	Conductor cross-section area	a + b + c allowable length
12V	0.2V or less/100A	20mm² (0.0311 in.²)	Up to 2.5m (98.43 in.)
		40mm² (0.062 in.²)	Up to 5m (196.87 in.)

Note: Excessive resistance in the key switch circuit (between the battery and start [S] terminals) can cause improper pinion engagement. To prevent this, follow the wiring diagram carefully.

2-3 Inspection

The quality of the battery governs the starting performance of the engine. Therefore the battery must be routinely inspected to ensure that it functions perfectly at all times.

2-3.1 Visual inspection

(1) Inspect the case for cracks, damage and electrolyte leakage.
(2) Inspect the battery holder for tightness, corrosion, and damage.
(3) Inspect the terminals for rusting and corrosion, and check the cables for damage.
(4) Inspect the caps for cracking, electrolyte leakage and clogged vent holes.
Correct any abnormal conditions found. Clean off rusted terminals with a wire brush before reconnecting the battery cable.

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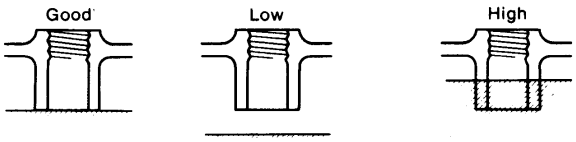
2-3.2 Checking the electrolyte

(1) Electrolyte level

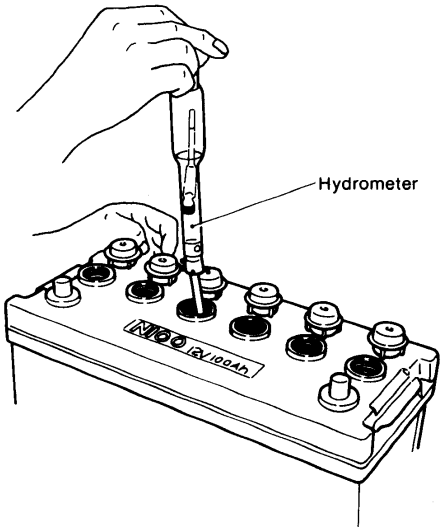


Check the electrolyte level every 7 to 10 days. The electrolyte must always be 10 ∿ 20mm (0.3937 ∿ 0.7874in.) over the top of the plates.

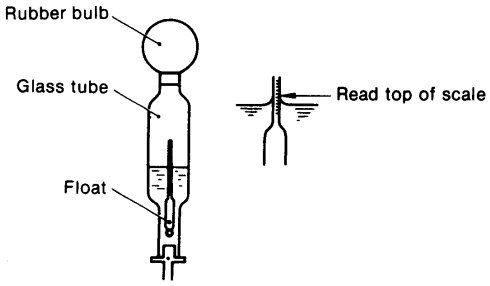
NOTES: 1. The "LEVEL" line on a transparent plastic battery case indicates the height of the electrolyte.
2. Always use distilled water to bring up the electrolyte level.
3. When the electrolyte has leaked out, add dilute sulfuric acid with the same specific gravity as the electrolyte.

(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.



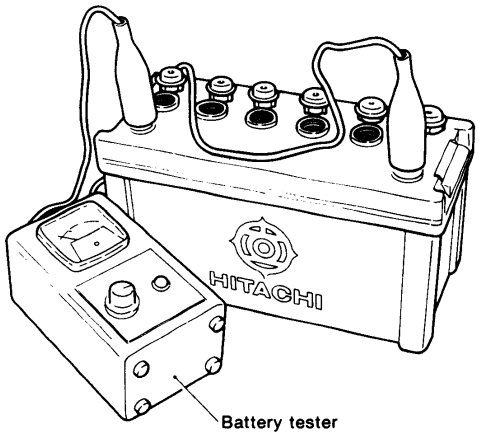
3) The battery is fully charged if the specific gravity is 1.260 at an electrolyte temperature of 20°C. The battery is discharged if the specific gravity is 1.200 (50%). If the specific gravity is below 1.200, recharge the battery.

4) If the difference in the specific 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 of 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.

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2-4 Charging

2-4.1 Charging methods

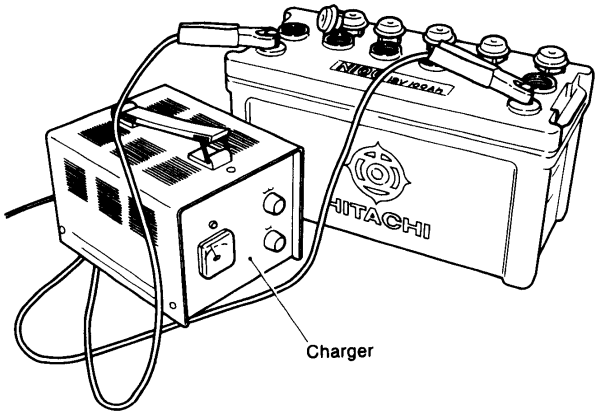
There are two methods of charging a battery: normal and rapid.

Rapid charging should only be used in emergencies.

- Normal charging...Should be conducted at a current of 1/10 or less of the indicated battery capacity (10A or less for a 100AH battery).
- Rapid charging...Rapid charging is done over a short period of time at a current of 1/5 ~ 1/2 the indicated battery capacity (20A ~ 50A for a 100AH battery). However, since rapid charging causes the electrolyte temperature to rise too high, special care must be exercised.

2-4.2 Charging procedure

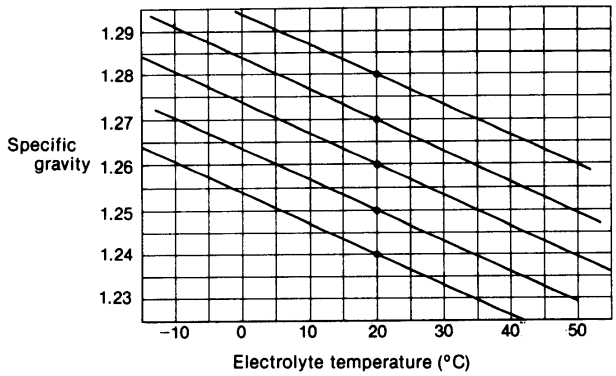
(1) Check the specific gravity and adjust the electrolyte level.
(2) Disconnect the battery cables.
(3) Connect the red clip of the charger to the (+) battery terminal and connect the black clip to the (−) terminal.



(4) Set the current to 1/10 ~ 1/5 of the capacity indicated on the outside of the battery.
(5) Periodically measure the specific gravity during charging to make sure that the specific gravity remains at a high fixed value. Also check whether gas is being generated.

2-4.3 Charging precautions

(1) Remove the battery caps to vent the gas during charging.
(2) While charging, ventilate the room and prohibit smoking, welding, etc.
(3) The electrolyte temperature should not exceed 45°C during charging.
(4) Since an alternator is used on this engine, when charging with a charger, always disconnect the battery (+) cable to prevent destruction of the diodes.
(Before disconnecting the (+) battery cable, disconnect the (−) battery cable [ground side].)

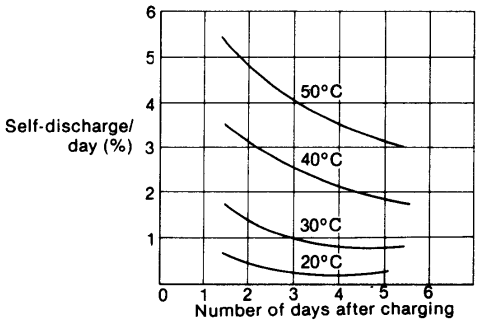


Electrolyte temperature and specific gravity

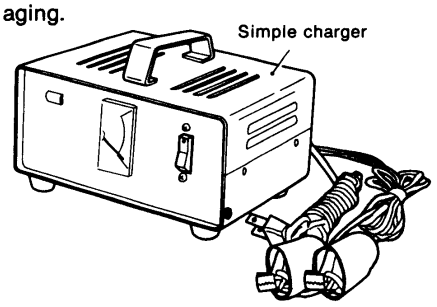
2-5 Battery storage precautions

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 alternator is insufficient because of frequent starts and stops, the battery will rapidly lose power.
Charge the battery as soon as possible after it is used under these conditions.
(3) An easy-to-use battery charger that permits home charging is available from Yanmar. Take proper care of the battery by using the charger as a set with a hydrometer.
When the specific gravity has dropped to about 1.16 and the engine will not start, charge the battery up to a specific gravity of 1.26 (24 hours).
(4) Before putting the battery in storage for long periods, charge it for about 8 hours to prevent rapid aging.



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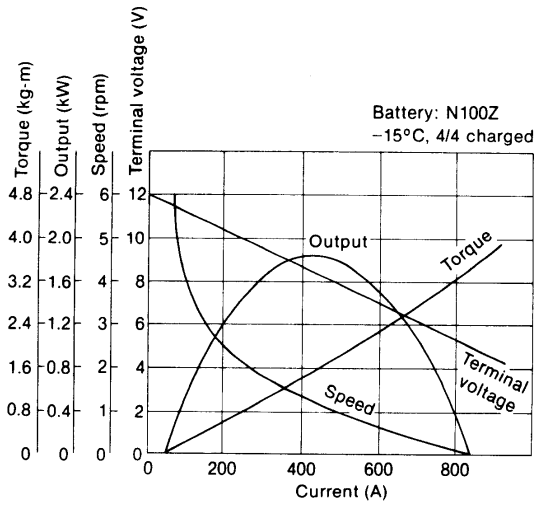
3. Starter Motor

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 Performance.

Engine model		4JHE, 4JH-TE 4JH-HTE,4JH-DT(B)E
Model		S12-77A
Rating (sec.)		30
Output (kW)		1.8
Direction of rotation (viewed from pinion side)		Clockwise
Weight kg (lb.)		9.3 (20.5)
Clutch system		Overrunning
Engagement system		Magnetic shift
No. of pinion teeth		15
Pinion flyout voltage (V)		8 or less
No-load	Terminal voltage (V)	12
	Current (A)	90 or less
	Speed (rpm)	4000 or greater
Loaded characteristics	Terminal voltage (V)	8.5
	Current (A)	420
	Torque kg-m (ft.-lb.)	1.35 (9.76) or greater



S12-77A Performance curves

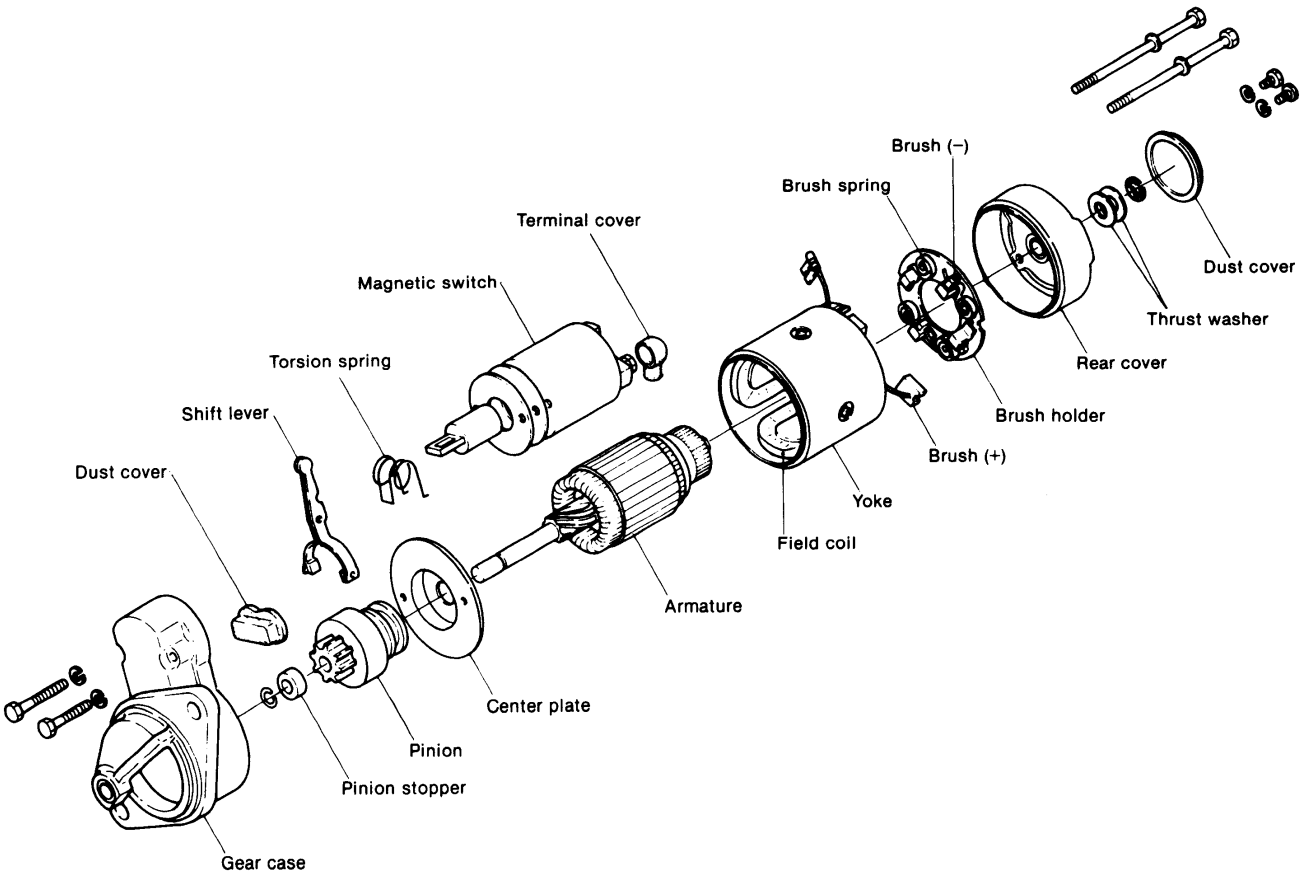
3-2 Construction

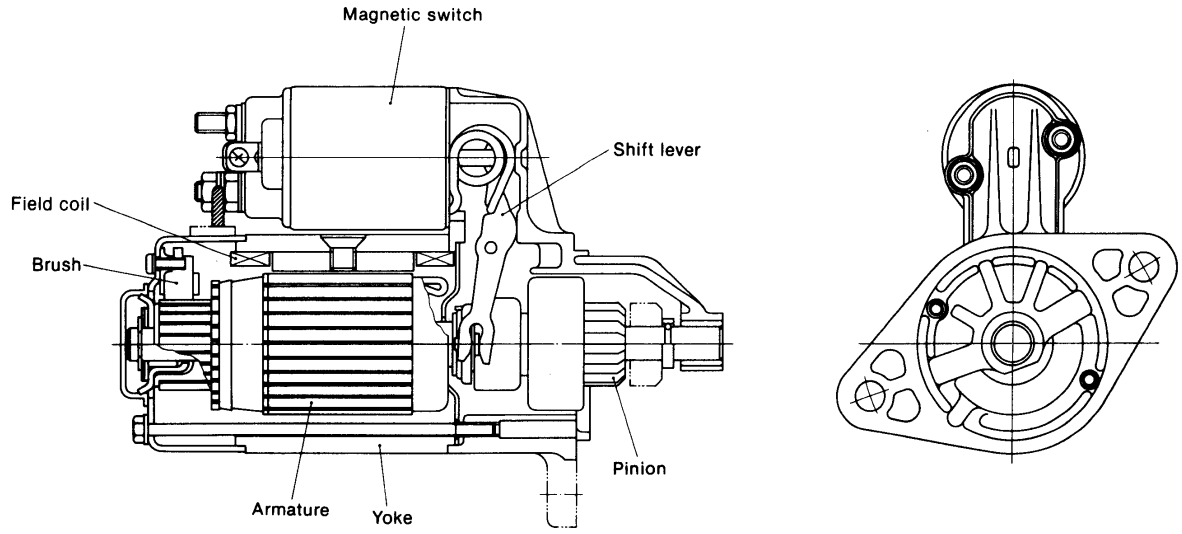
The starter motor described in this section is a conventional pre-engaged 4-brush 4-pole starter motor with a screw roller drive clutch.
The starter motor is composed of three major parts, as follows:

(1) Magnetic switch
Moves plunger to engage and disengage pinion and, through the engagement lever, opens and closes the main contact (moving contact) to stop the starter motor.

(2) Motor
A continuous current series motor which generates rotational drive power.

(3) Pinion
Transfers driving power from motor to ring gear. An overspeed clutch is employed to prevent damage if the engine should run too fast.





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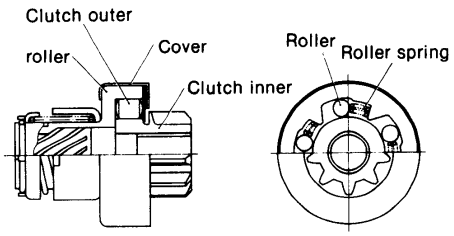
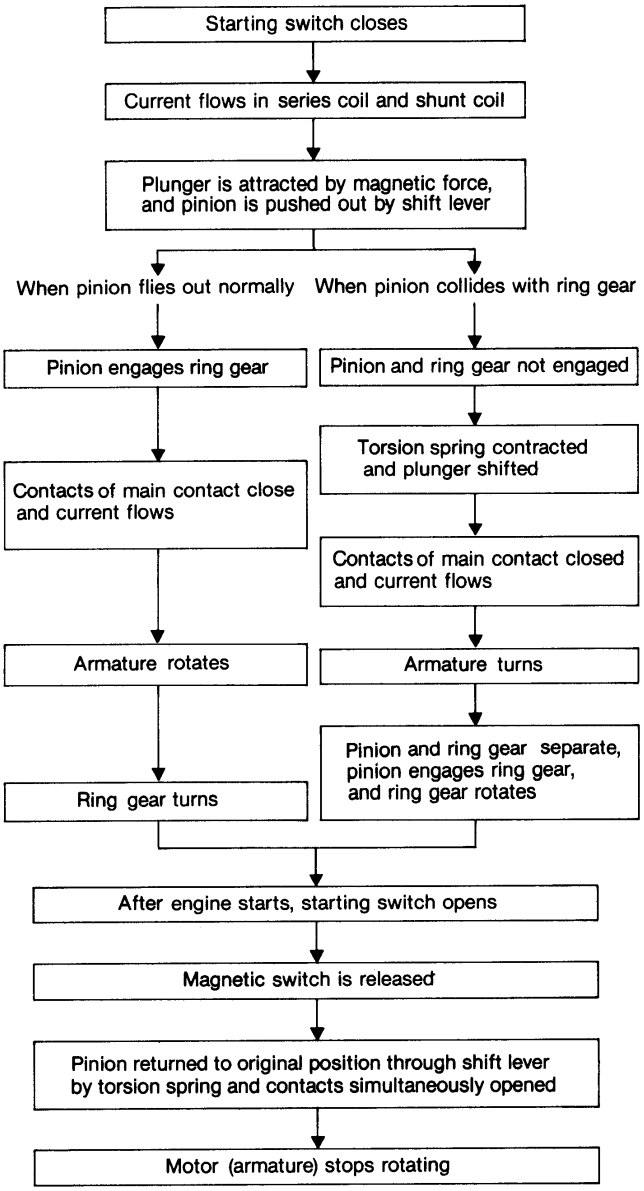
To prevent the motor receiving a shock when the engine starts and over-runs, the starter motor has an over-running clutch.

Over-running clutch



3-3 Operation



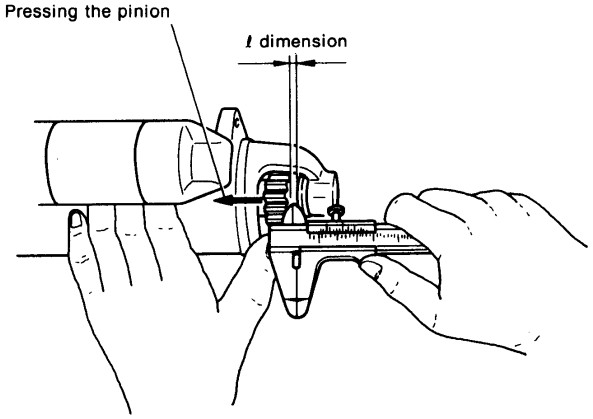
3-4 Adjustment and performance test

3-4.1 L-size measurement (gap between pinion and pinion stopper)

When the pinion is at the projected position, measure gap between 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 (in.)

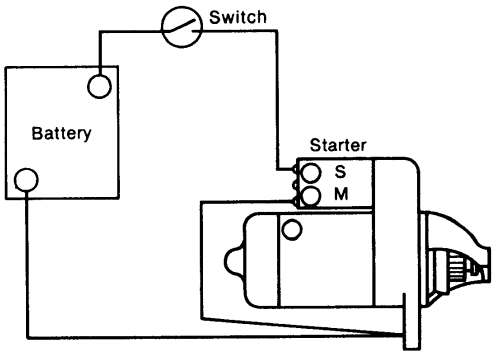
	Starter motor	ℓ dimension
	S12-77A	0.2 ~ 1.5 (0.0079 ~ 0.0591)



Measuring of ℓ dimension

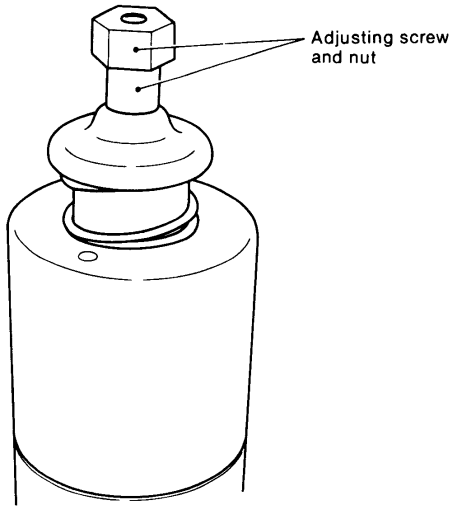
3-4.2 Pinion movement

After complete assembly of the starter motor, connect up the motor as in Fig.

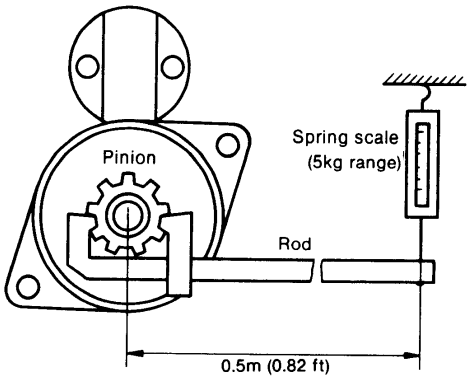


3-4.3 Plunger movement

Adjustment made by adjusting stroke of magnetic plunger to the prescribed value.
Adjust the ℓ-dimension by adjusting screw and nut.

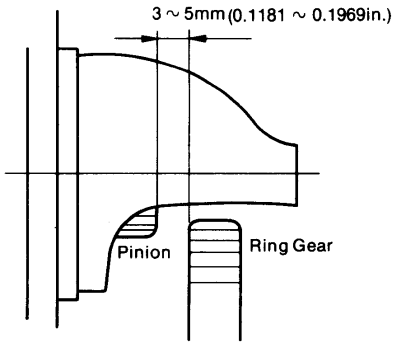


3-4.4 Pinion lock torque measurement



3-4.5 Mesh clearance

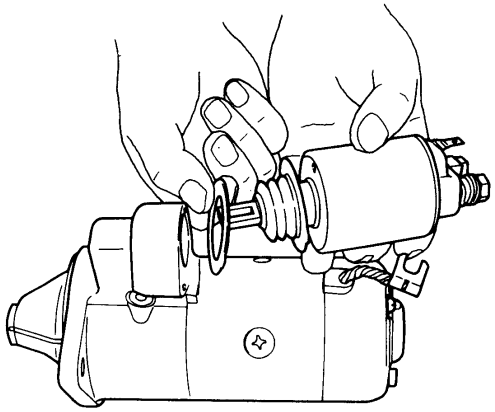
Mesh clearance is the distance between the flywheel ring gear and starter motor pinion in the rest position. This clearance should be between 3mm (0.1181in.) to 5mm (0.1969in.).



3-5 Disassembly

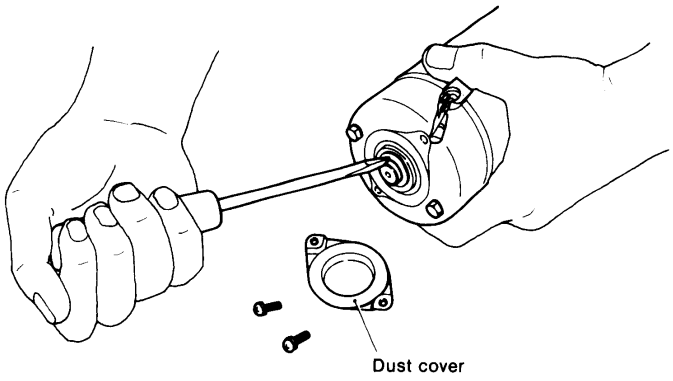
3-5.1 Magnetic switch

(1) Disconnect magnetic switch wiring.
(2) Remove through bolt mounting magnetic switch.
(3) Remove magnetic switch.

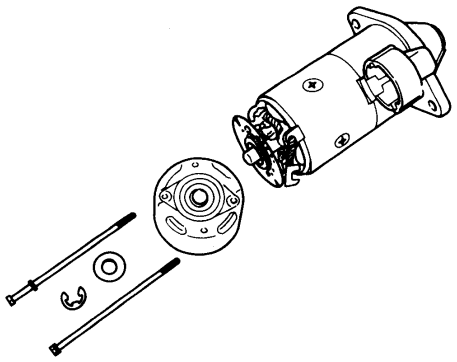


3-5.2 Rear cover

(1) Remove dust cover.



(2) Remove E-ring, and remove thrust washer (be careful not to lose the washer and shim).
(3) Remove the two through bolts holding the rear cover and the two screws holding the brush holder.
(4) Remove rear cover.



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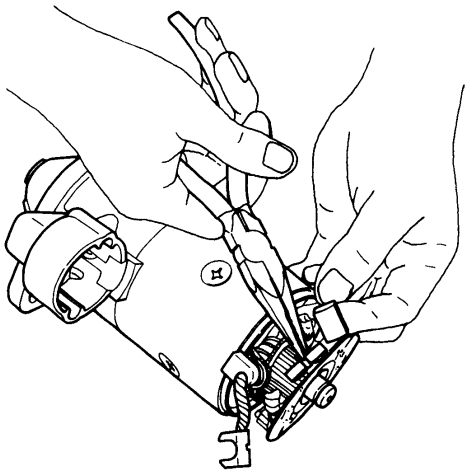
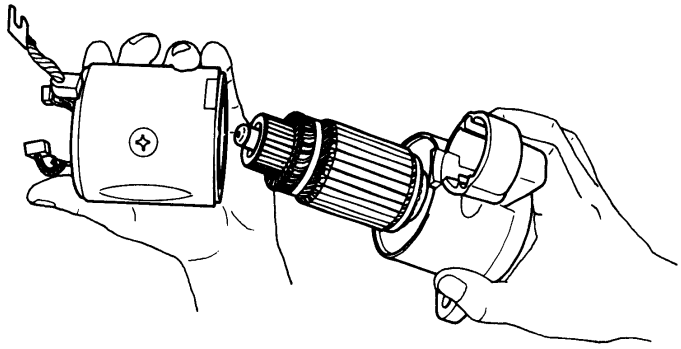
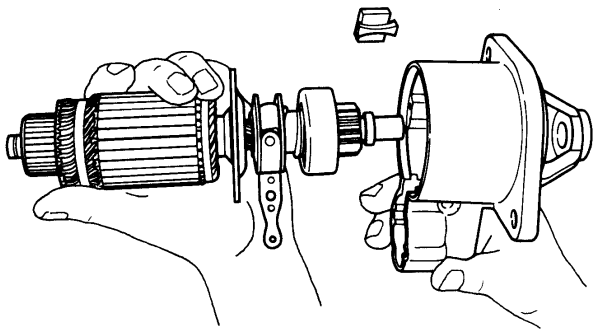
3-5.3 Brush holder
(1) Float (−)brush from the commutator.
(2) Remove (+)brush from the brush holder.
(3) Remove brush holder.



3-5.4 Yoke
(1) Remove yoke. Pull it out slowly so that it does not strike against other parts.

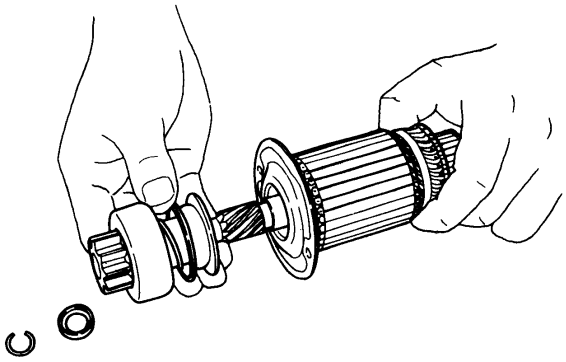


3-5.5 Armature
(1) Slide pinion stopper to pinion side.



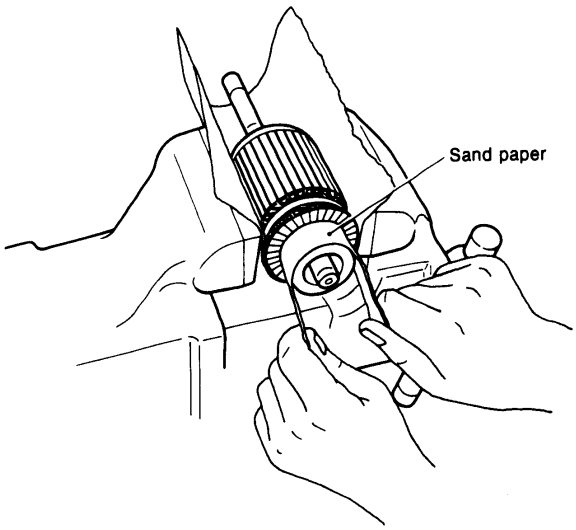
(2) Remove the pinion stopper clip.

3-5.6 Pinion
(1) Slide the pinion stopper to the pinion side.
(2) Remove the pinion stopper clip.
(3) Remove the pinion from the armature.



3-6 Inspection

3-6.1 Armature
(1) Commutator
Inspect the surface of the commutator. If corroded or pitted, sand with #500 ~ #600 sandpaper. If the commutator is severely pitted, grind it to within a surface roughness of at least 0.4 by turning it on a lathe. Replace the commutator if damage is irreparable.



	S12-77A	
	Maintenance standard	Wear limit
Commutator outside diameter	ø43 (1.693)	ø40 (1.575)
Commutator run-out	Within 0.03 (0.0012)	0.2 (0.0079)
Difference between maximum diameter and minimum diameter	Repair limit 0.4 (0.0157)	Repair accuracy 0.05 (0.002)

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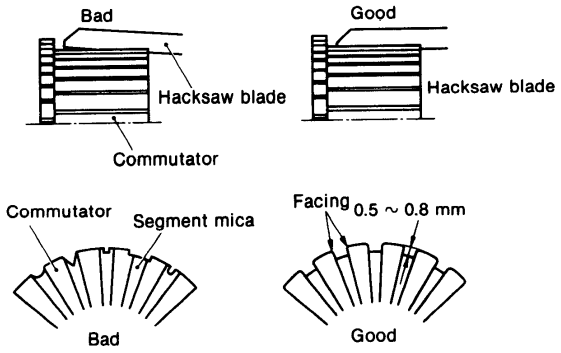
(2) Mica undercut
Check the mica undercut, correct with a hacksaw blade when the undercut is too shallow.

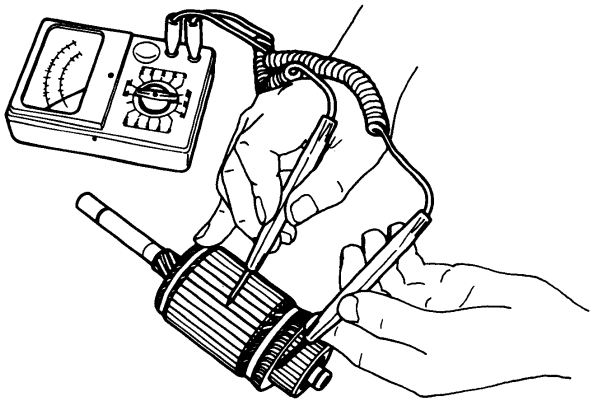


mm (in.)

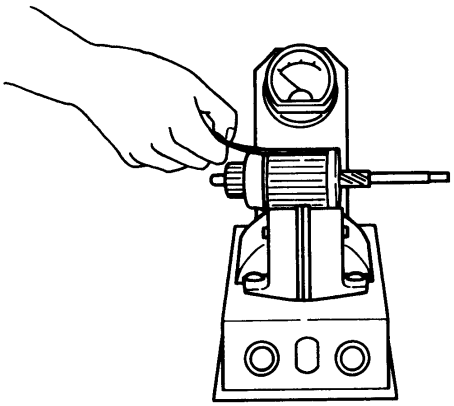
	Maintenance standard	Repair limit
Mica undercut	0.2 (0.0079)	0.5 ~ 0.8 (0.0197 ~ 0.0315)

(3) Armature coil ground test
Using a tester, check for continuity between the commutator and the shaft (or armature core). Continuity indicates that these points are grounded and that the armature must be replaced.
1) Short test...existence of broken or disconnected coil.
2) Insulation test...between commutator and armature core or distortion shaft.

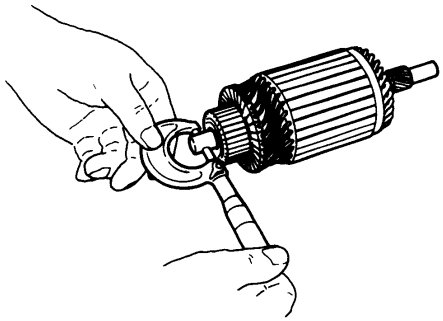
Checking commutator for insulation defects.



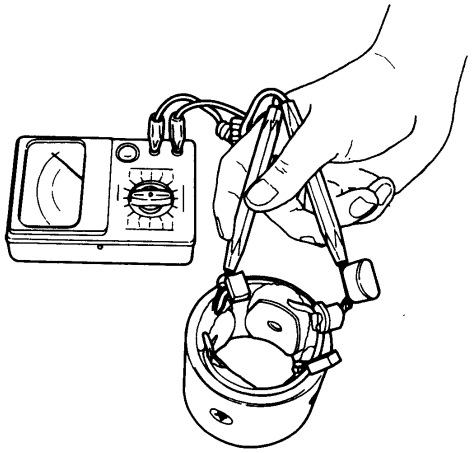
Checking armature windings for insulation faults.



(4) Armature shaft outside diameter
Measure the outside diameter of the armature shaft at four locations: front, center, end, and pinion. Replace the armature if the shaft is excessively worn.
Check the bend of the shaft; replace the armature if the bend exceeds 0.08mm (0.0031in.)



3-6.2 Field coil
(1) Open test
Check for continuity between the terminals connecting the field coil brushes. Continuity indicates the coil is open and must be replaced.



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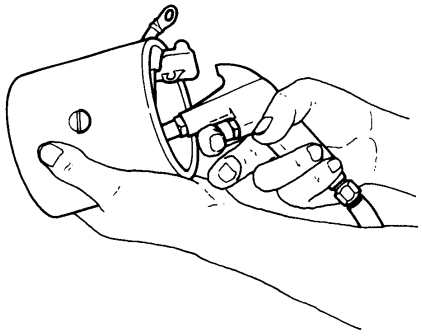
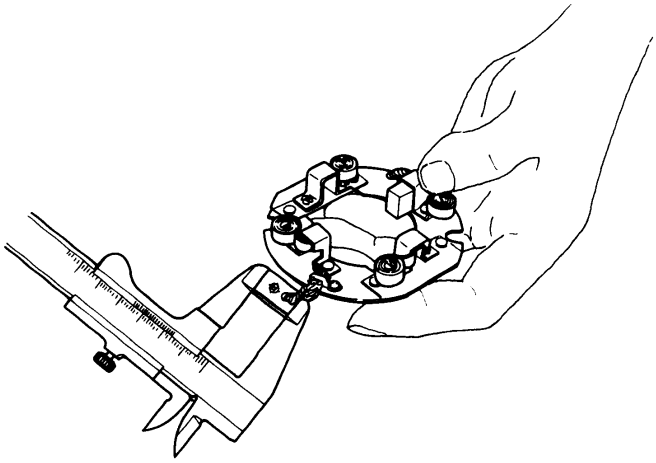
(2) Short test
Check for continuity between the yoke and any field coil terminal. Continuity indicates that the coil is shorted and it must be replaced.

(3) Cleaning the inside of the yoke
If any carbon powder or rust has collected on the inside of the yoke, blow the yoke out with dry compressed air.
*Do not remove the field coil from the yoke.

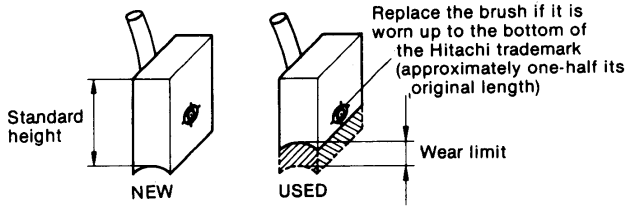


3-6.3 Brush

The brushes are quickly worn down by the motor. When the brushes are defective, the output of the motor will drop.



(1) Brush dimensions
Replace brushes which have been worn beyond the specified wear limit.

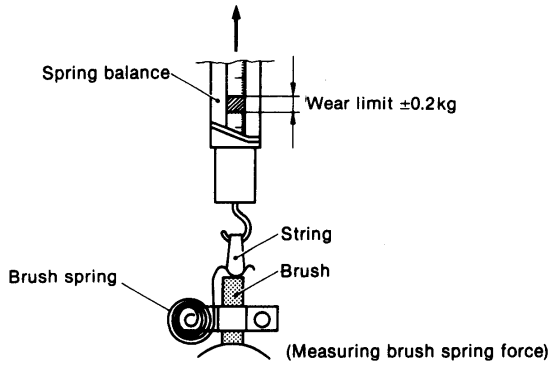


mm (in.)

	S12-77A
Brush standard height	22 (0.8661)
Wear limit	8 (0.3150)

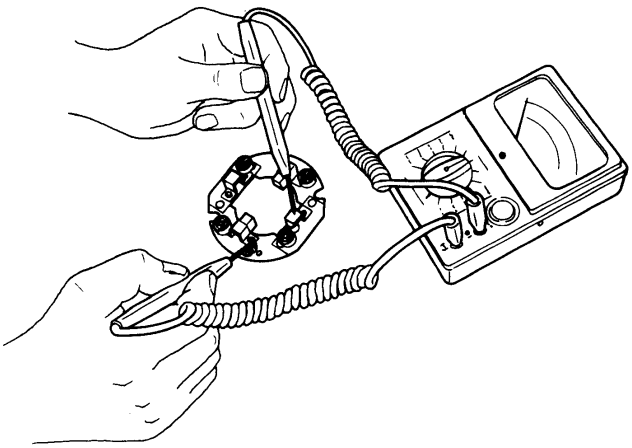
(2) Brush appearance and movement in brush holder
If the outside of the brush is damaged, replace it. If the movement of the brushes in the brush holder is hampered because the holder is rusted, repair or replace the holder.

(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 ±0.2kg.



	S12-77A
Standard spring load	0.85kg (1.8737 lb)

(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 points are grounded and that the holder must be replaced.



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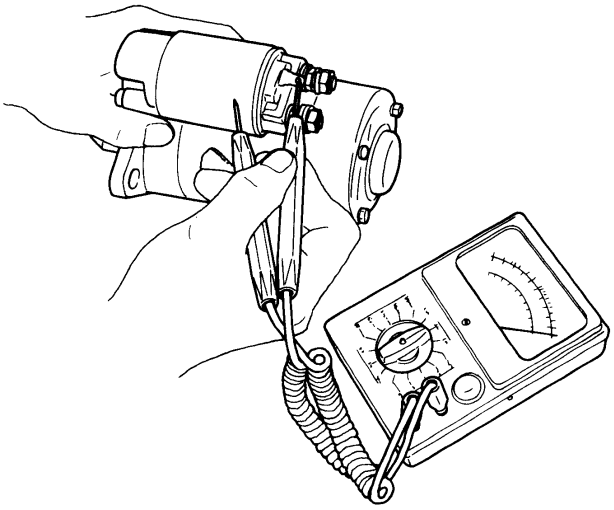
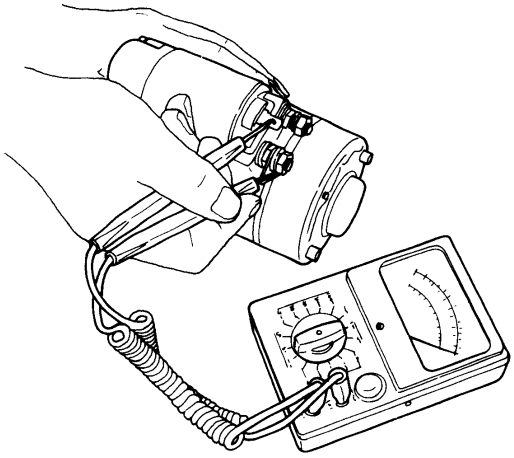
3-6.4 Magnetic switch

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



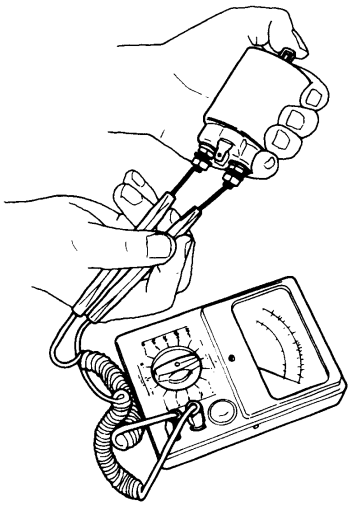
	S12-77A
Coil resistance (at 20°C)	0.590Ω

(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.



	S12-77A
Resistance value (at 20°C)	0.267Ω

(3) Contactor contact test
Push the plunger with your finger and check for continuity between the M terminal and B terminal. Continuity indicates that the contact is faulty and that the contactor must be replaced.



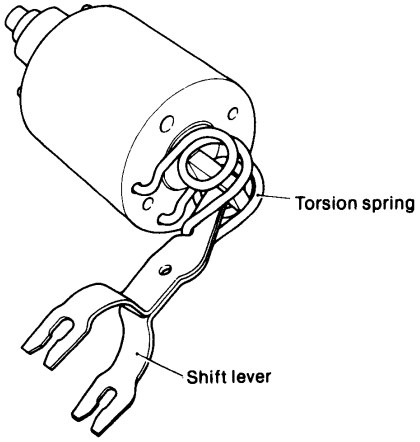
3-6.5 Pinion

(1) Inspect the pinion teeth and replace the pinion if the teeth are excessively worn or damaged.
(2) Check if the pinion slides smoothly; replace the pinion if faulty.
(3) Inspect the springs and replace if faulty.
(4) Replace the clutch if it slips or seizes.

3-7 Reassembly precautions

Reassemble the starter motor in the reverse order of disassembly, paying particular attention to the following:

(1) Torsion spring and shift lever
Hook the torsion spring into the hole in the magnetic switch and insert the shift lever into the notch in the plunger of the magnetic switch (through the torsion spring).



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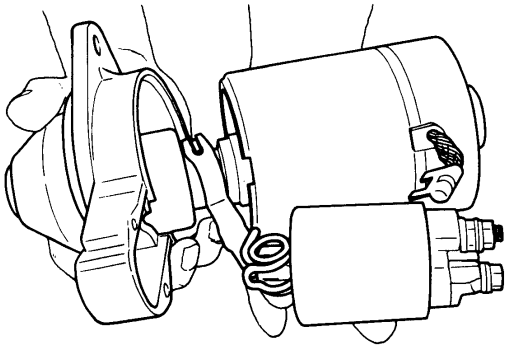
(2) Mounting the magnetic switch
Attach the shift lever to the pinion; assemble the gear case as shown below.
Do not forget to install the dust cover before assembling the gear case.
After reassembly, check by conducting no-load operation.



(3) Lubrication
Lubricate each bearing and spline (points indicated in the figure below) with high quality "Hitachi Electrical Equipment Grease A"
The following lubricants may be used in place of Hitachi Electrical Equipment Grease A.

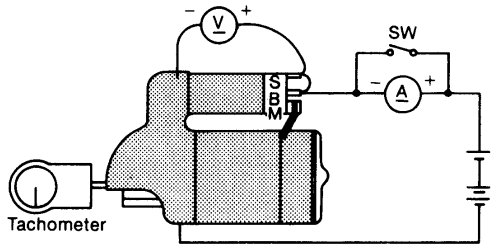
Magnetic switch plunger	Shell	Aeroshell No. 7
Bearing and spline	Shell	Albania Grease No. 2

3-8 Testing

3-8.1 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.

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3-9 Maintenance standard

				S12-77A
Brush	Standard spring load		kg (lb)	0.85 (1.8737)
	Standard height		mm (in.)	22 (0.8661)
	Wear limit		mm (in.)	8 (0.3150)
Magnetic switch	Series coil resistance		Ω	0.267
	Shunt coil resistance		Ω	0.590
Commutator	Outside diameter	Maintenance standard	mm (in.)	ø43 (1.193)
		Wear limit	mm (in.)	ø40 (1.575)
	Difference between maximum diameter and maximum diameter	Repair limit	mm (in.)	0.4 (0.0157)
		Repair accuracy	mm (in.)	0.05 (0.002)
	Mica undercut	Maintenance standard	mm (in.)	0.2 (0.0079)
		Repair limit	mm (in.)	0.5 ~ 0.8 (0.0197 ~ 0.0315)
Standard dimension	Rear side bearing	Shaft diameter	mm (in.)	14.950 ~ 14.968 (0.5886 ~ 0.5893)
		Bearing inside diameter	mm (in.)	15.000 ~ 15.018 (0.5906 ~ 0.5913)
	Intermediate bearing	Shaft diameter	mm (in.)	20.350 ~ 20.368 (0.7972 ~ 0.7980)
		Bearing inside diameter	mm (in.)	20.500 ~ 20.518 (0.8071 ~ 0.8080)
	Pinion sliding section	Shaft diameter	mm (in.)	13.950 ~ 13.968 (0.5492 ~ 0.5499)
		Pinion inside diameter	mm (in.)	14.030 ~ 14.050 (0.5524 ~ 0.5531)
	Pinion side bearing	Shaft diameter	mm (in.)	13.950 ~ 13.968 (0.5492 ~ 0.5499)
		Bearing inside diameter	mm (in.)	14.000 ~ 14.018 (0.5512 ~ 0.5519)

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3-10 Various problems and their remedies

(1) Pinion fails to advance when the starting switch is closed

Problem	Cause	Corrective action
Wiring	Open or loose battery or switch terminal	Repair or retighten
Starting switch	Threaded part connected to pinion section of armature shaft is damaged, and the pinion does not move	Repair contacts, or replace switch
Starter motor	Threaded part connected to pinion section of armature shaft is damaged, and the pinion does not move	Replace
Magnetic switch	Plunger of magnetic switch malfunctioning or coil shorted	Repair or replace

(2) Pinion is engaged and motor rotates, but rotation is not transmitted to the engine

Problem	Cause	Corrective action
Starting motor	Overrunning clutch faulty	Replace

(3) Motor rotates at full power before pinion engages ring gear

Problem	Cause	Corrective action
Starter motor	Torsion spring permanently strained	Replace

(4) Pinion engages ring gear, but starter motor fails to rotate

Problem	Cause	Corrective action
Wiring	Wires connecting battery and magnetic switch open or wire connecting ground, magnetic switch and motor terminals loose	Repair, retighten, or replace wire
Starter motor	Pinion and ring gear engagement faulty Motor mounting faulty Brush worn or contacting brush spring faulty Commutator dirty Armature, field coil faulty Field coil and brush connection loose	Replace Remount Replace Repair Repair or replace Retighten
Magnetic switch	Contactor contact faulty Contactor contacts pitted	Replace Replace

(5) Motor fails to stop when starting switch is opened after engine starts

Problem	Cause	Corrective action
Starting switch	Switch faulty	Replace
Magnetic switch	Switch faulty	Replace

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4. Alternator Standard, 12V/55A

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

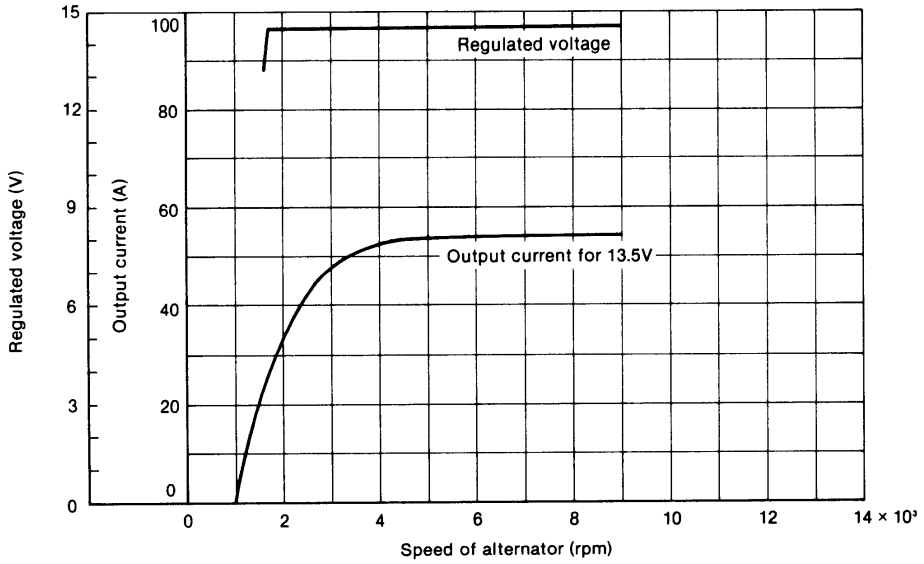
The alternator contains a regulator using an IC, and has the following features.

(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	LR155-20 (HITACHI)
Model of IC regulator	TRIZ-63 (HITACHI)
Battery voltage	12V
Nominal output	12V/55A
Earth polarity	Negative earth (⊖)
Direction of rotation (viewed from pulley end)	Clockwise
Weight	4.3kg (9.5lb.)
Rated speed	5000 rpm
Operating speed	1000 ~ 9000
Speed for 13.5V	1000 or less
Output current at 20°C	over 53A/5000 rpm
Regulated voltage	14.5 ±0.3V (Standard temperature voltage gradient, −0.01/°C)

4-3 Characteristics



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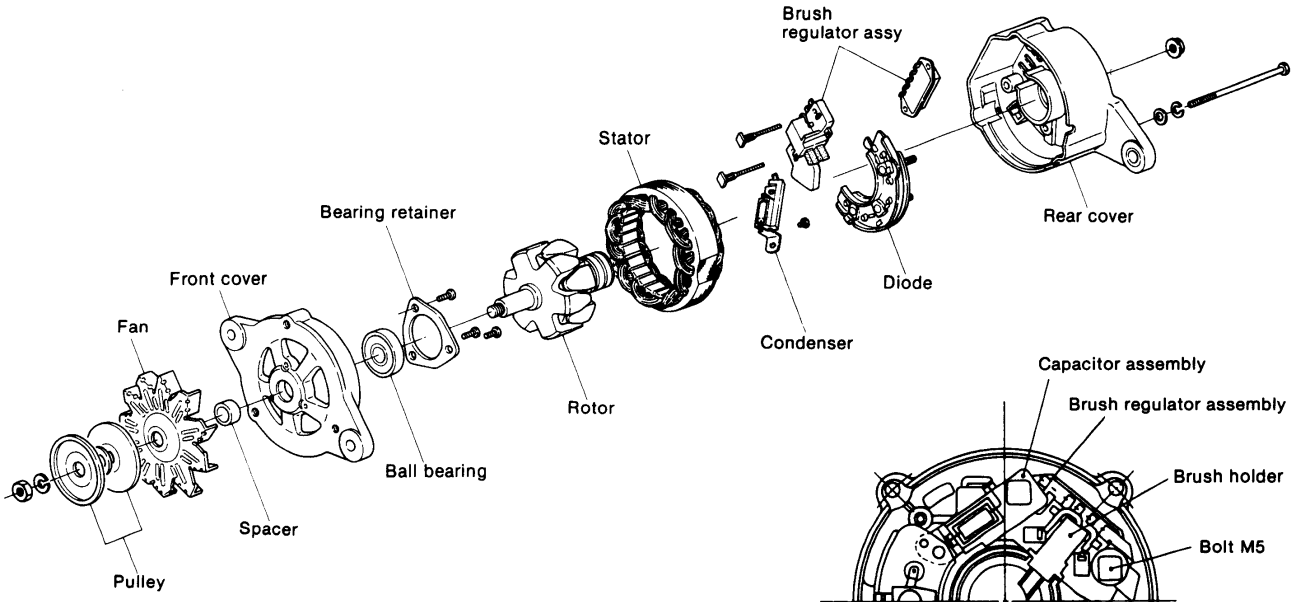
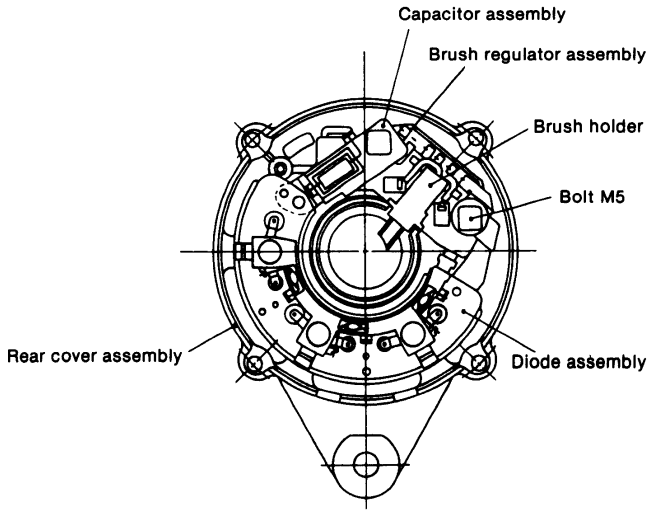
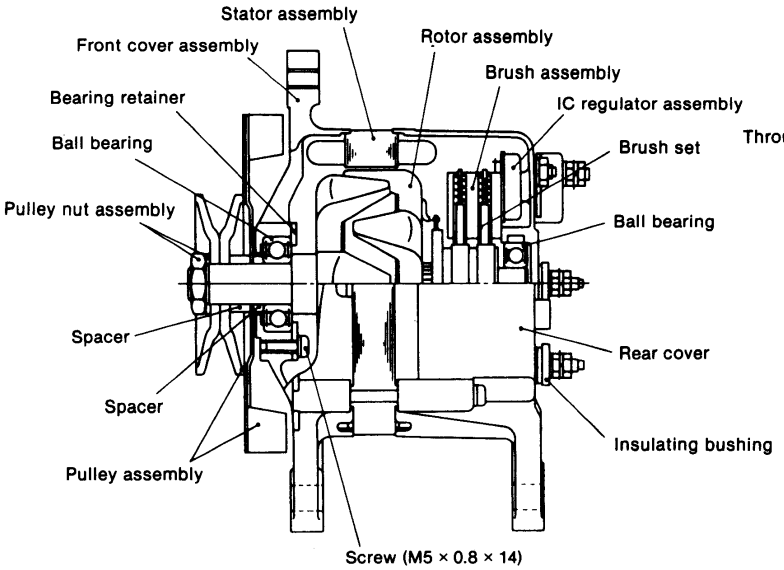
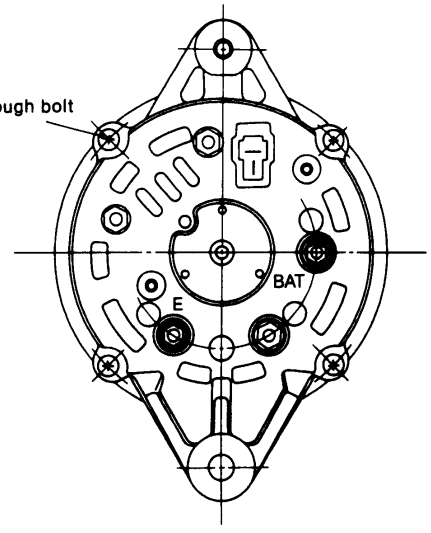
4-4 Construction

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

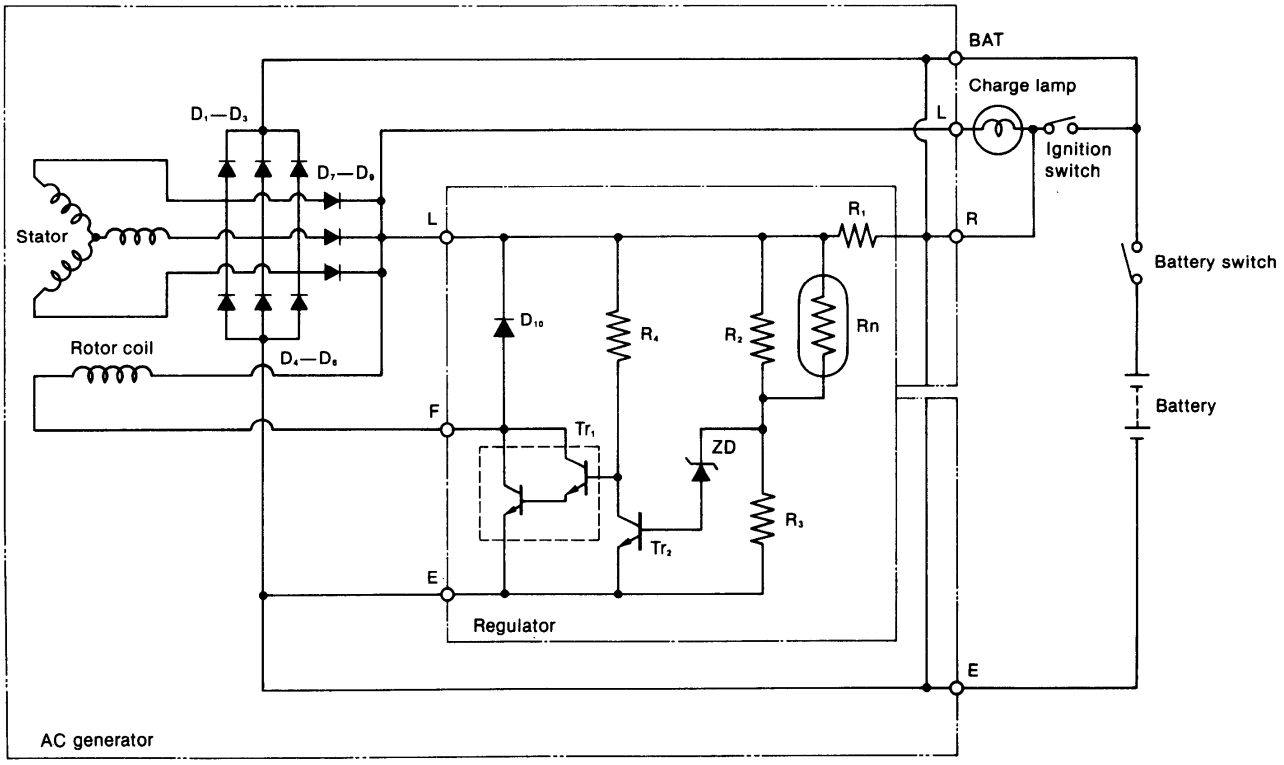
(1) IC regulator
The IC regulator is the transistor (Tr_1) which is series-connected with the rotor. The IC regulator controls the output voltage of the generator by breaking or conducting the rotor coil (exciting) current.
When the output voltage of the generator is within the standard value, the transistor (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 turned to ON, and current flows to R_1, R_4 and to Tr_1 to light the lamp. When the engine starts to run and output voltage is generated in the stator coil, the current stops flowing to this circuit, turning off the charge lamp.

(3) Circuit diagram

4-6 Handling precautions

(1) Be careful of the battery's polarity (+, − terminals), and do not connect the wrong terminals to the wrong cables, or the battery will be short-circuited by the generator diode.
In this case too much current will flow, the IC regulator and diodes burn out, and the wire harness will burn.
(2) Make sure of the correct connection of each terminal.
(3) When quick-charging, etc., disconnect either the battery terminal on the AC generator or the terminal on the battery.
(4) Do not short-circuit the terminals.
(5) Do not conduct any tests using high tension insulation resistance. (The diodes and IC regulator will burn out.)



BAT:	Generator output terminal	D_1—D_6:	Output commutation diode
D_{10}:	IC protecting diode	R_1—R_4:	Resistor
L:	Charge lamp terminal	D_7—D_8:	Charging lamp switching diode
ZD:	Zener diode	F:	To supply current to rotor coil
E:	Earth	Rn:	Thermistor (Temperature gradient resistance)
Tr_1, Tr_2:	Transistor		

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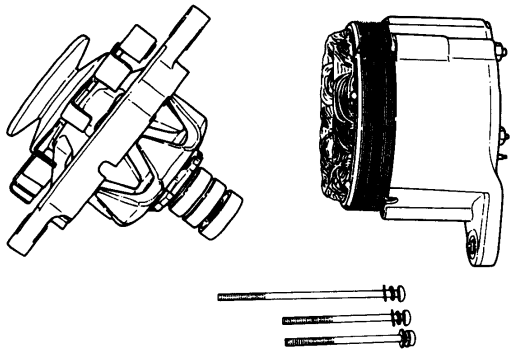
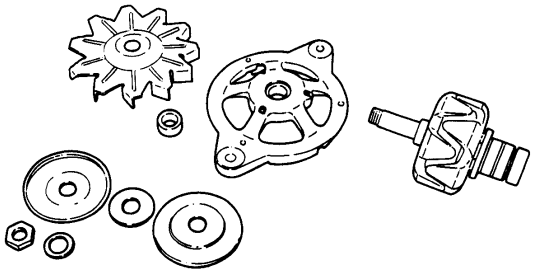
4-7 Disassembling the alternator

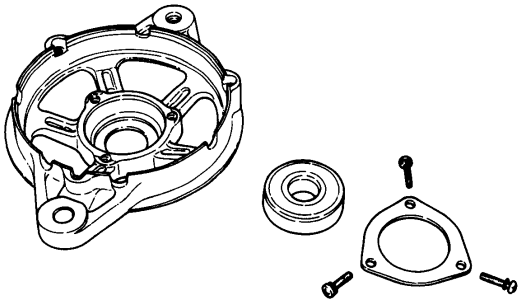
(1) Remove the through-bolt, and separate the front assembly from the rear assembly.



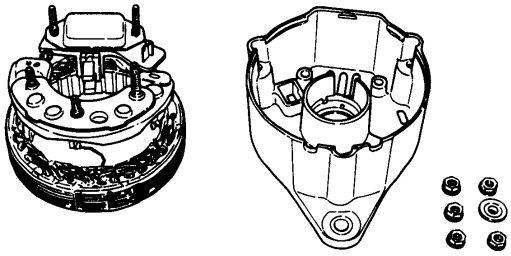
(2) Remove the pulley nut, and pull out the rotor from the front cover.



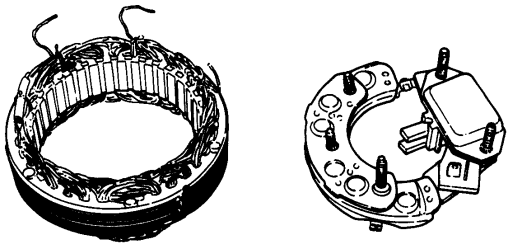
(3) Remove the ø5mm (ø0.1969in.) screw from the front cover, and then remove the ball bearing.



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

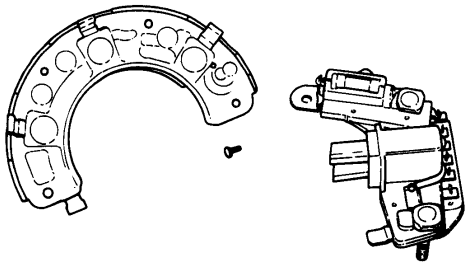


(5) Disconnect the soldered joint of the stator lead wire, and remove the diode and brush regulator assemblies from the stator at the same time.



(6) Separating the regulator

1) To separate the regulator, remove the ø3mm (ø0.1181in.) rivet which keeps the diode assembly and the brushless regulator in place, and the soldered joint of the L-terminal.



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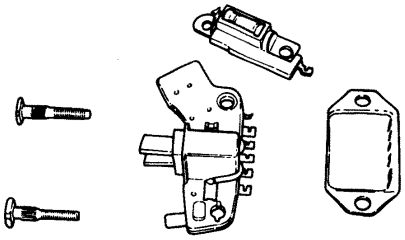
2) To replace the IC regulator, disconnect the soldered joint of the IC regulator and pull out the two bolts. Do not remove these two bolts except when replacing the IC regulator.

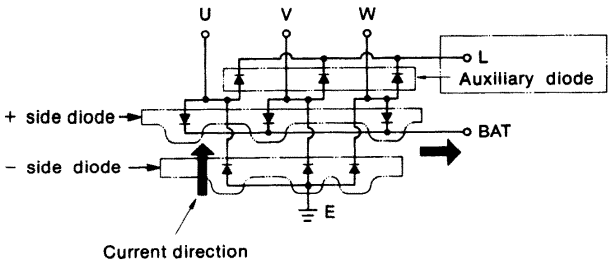


4-8 Inspection and adjustment

(1) Diode

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

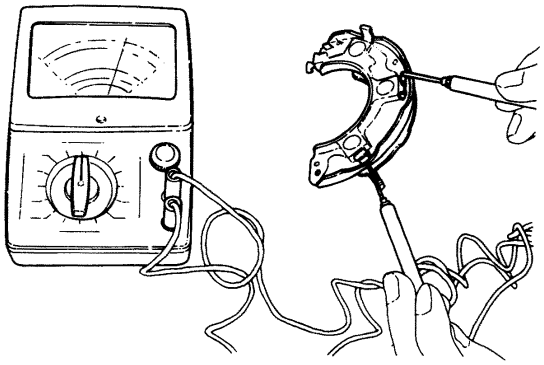
Between terminals		E (− side diode)	
	Tester wire	+ side	− side
U.V.W.	+ side		Continuity
	− side	No continuity	



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 and U), the diode is in normal condition (photo). When there is no continuity, the diode is defective.
When the tester is connected in the reverse of above, there should be no continuity. If there is, the diode is defective.

After repeating the above test, if any diode is found to be defective, replace the diode assembly. Since there is no terminal on the auxiliary diode, check the continuity between both ends of the diode.



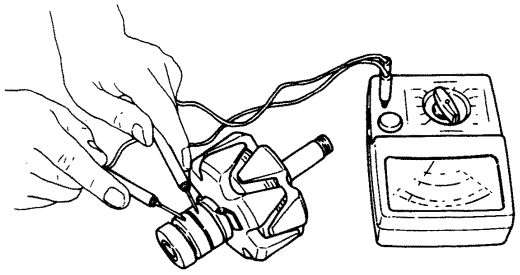
CAUTION: Do not use high tensile insulation resistance such as meggers, etc. for testing. The diode may burn out.

(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.	ø31.6mm (1.2441in.)	ø30.6mm (1.2049in.)

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. 3.34Ω at 20°C

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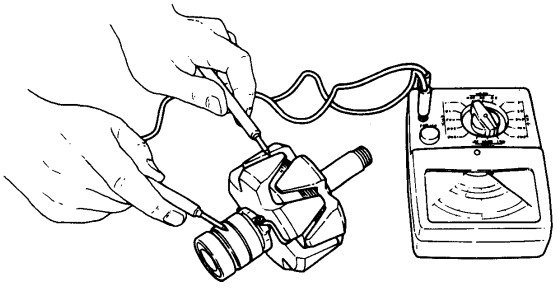
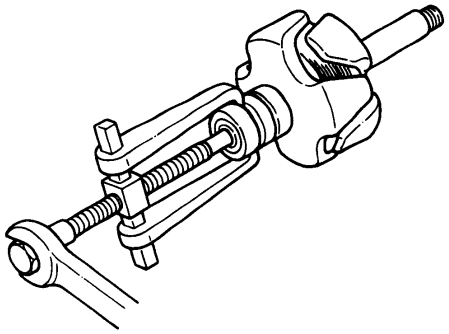
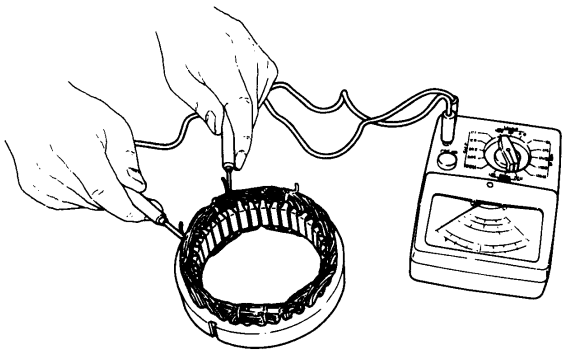
3) Rotor coil insulation test
Check the continuity between the slip ring and the rotor core, or the shaft. If there is continuity, insulation inside the rotor is defective, causing a short with the earth circuit. Replace the rotor coil.



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

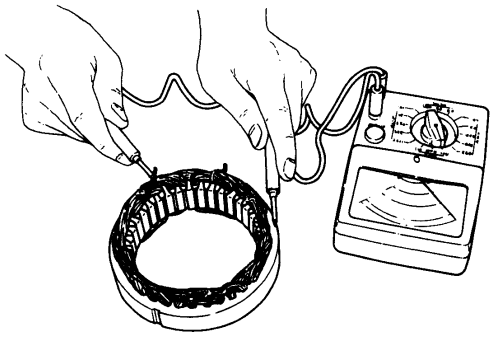


(3) Stator
1) Stator coil continuity test
Check the continuity between each terminal of the stator coil. If there is no continuity, there is a wire break in the stator coil. Replace the stator coil.

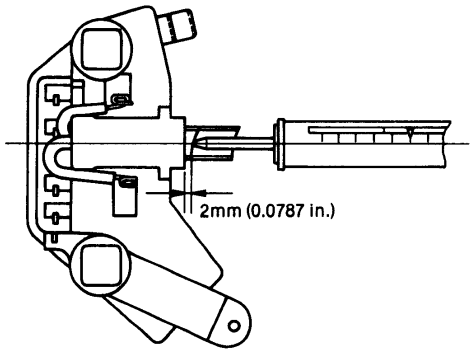


Resistance value	Approx. 0.077Ω at 20°C 1-phase resistance

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.

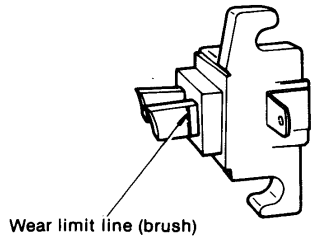


(4) Brush
The brush is hard and wears slowly, but when it is worn beyond the allowable limit, replace it. When replacing the brush, also check the strength of the brush spring.
To check, push the spring down to 2mm (0.0787in.) from the end surface of the brush holder, and read the gauge.



Brush spring strength	255—345g (0.56 ∼ 0.76lb.)

(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 (0.6299)	9 (0.3543)

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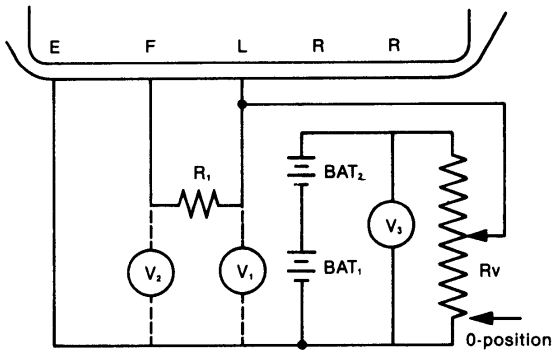
(6) IC regulator

Connect the variable resistance, two 12V batteries, resistor, and voltmeter as shown in the diagram.

1) Use the following measuring devices.

Resistor (R_1)	100Ω, 2W, 1pc.
Variable resistor (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 0-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 0-position, and connect the voltmeter to the V_1 position.
   c) While measuring V_1 (voltage between L-E terminals), move Rv gradually from the 0-position. There should be a point where the voltage of V_1 rises sharply by 2—6V. Measure the voltage of V_1 just before this sharp voltage rise. This is the regulating voltage of the regulator. If this voltage of V_1 is within the standard limit, the regulator is normal. If the voltage deviates from the limit, the regulator is defective. Replace the regulator.

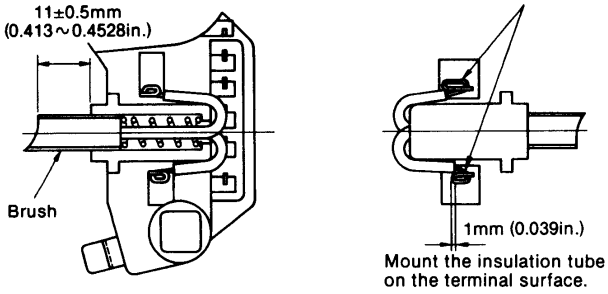


4-9 Reassembling the alternator

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

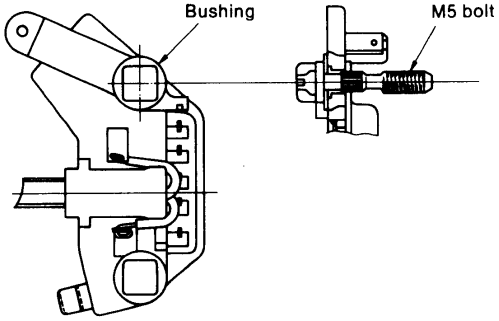
(1) Assembling the brush regulator

1) Solder the brush.
   Position the brush as shown in the drawing and solder it. Be careful not to let the solder drip into the pig tail (lead wire).



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

2) Mount the IC regulator on the brush holder as illustrated, and press in the M5 bolt. Do not forget to assemble the bushing and the connecting plate at the same time.
   (If the bushing is left out, the output terminal will be earthed and the battery short-circuited).



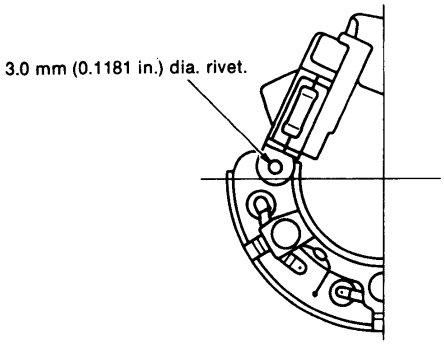
NOTES: 1. Insertion pressure is 100kg (220.5 lbs.)
2. Insert vertically.

(2) Connecting the brush regulator assembly and diode

1) Check the rivets
   Place the rivets as shown in the figure, and then calk them using the calking tool.

Calking torque	500kg (1102 lbs.)

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 (1102 lbs.)

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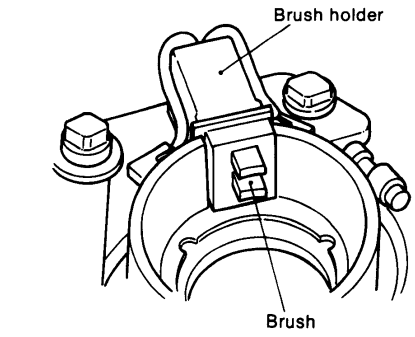
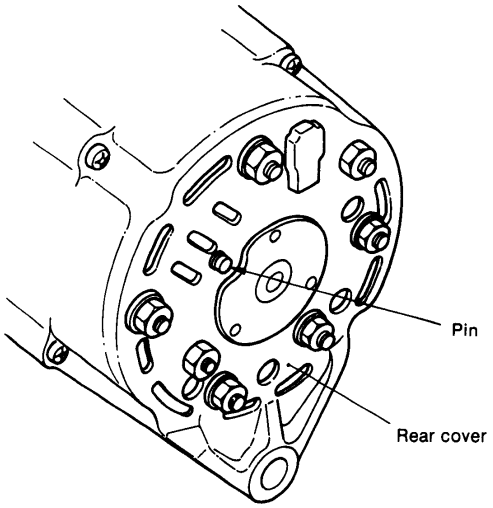
(3) Assembling the rear cover

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.



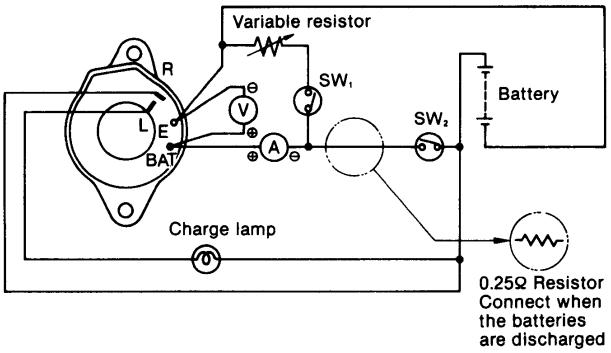


(4) Tightening torques

Positions	Tightening torque kg-cm (ft-lb)
Brush holder fixing	32—40 (2.31 ~ 2.89)
Diode fixing	32—40 (2.31 ~ 2.89)
Bearing retainer fixing	32—40 (2.31 ~ 2.89)
Pulley nut tightening	400—600 (28.93 ~ 43.40)
Through-bolt tightening	32—40 (2.31 ~ 2.89)

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.
Variable 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_1 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 the indication is over 5A, connect the 0.25Ω resistor. The voltmeter indication at this time must be within the prescribed regulating voltage value.

2. Raise the AC generator revolutions high to make sure the regulating voltage does not fluctuate along with changes in the revolution speed.

(3) Precautions for measuring the regulating voltage

1) When measuring the voltage, measure the voltage between the AC generator BAT terminal, or Battery + terminal, and AC generator E-terminal.
2) Use a fully charged battery.
3) Measure the voltage quickly.
4) Keep SW_1 open for measurement.

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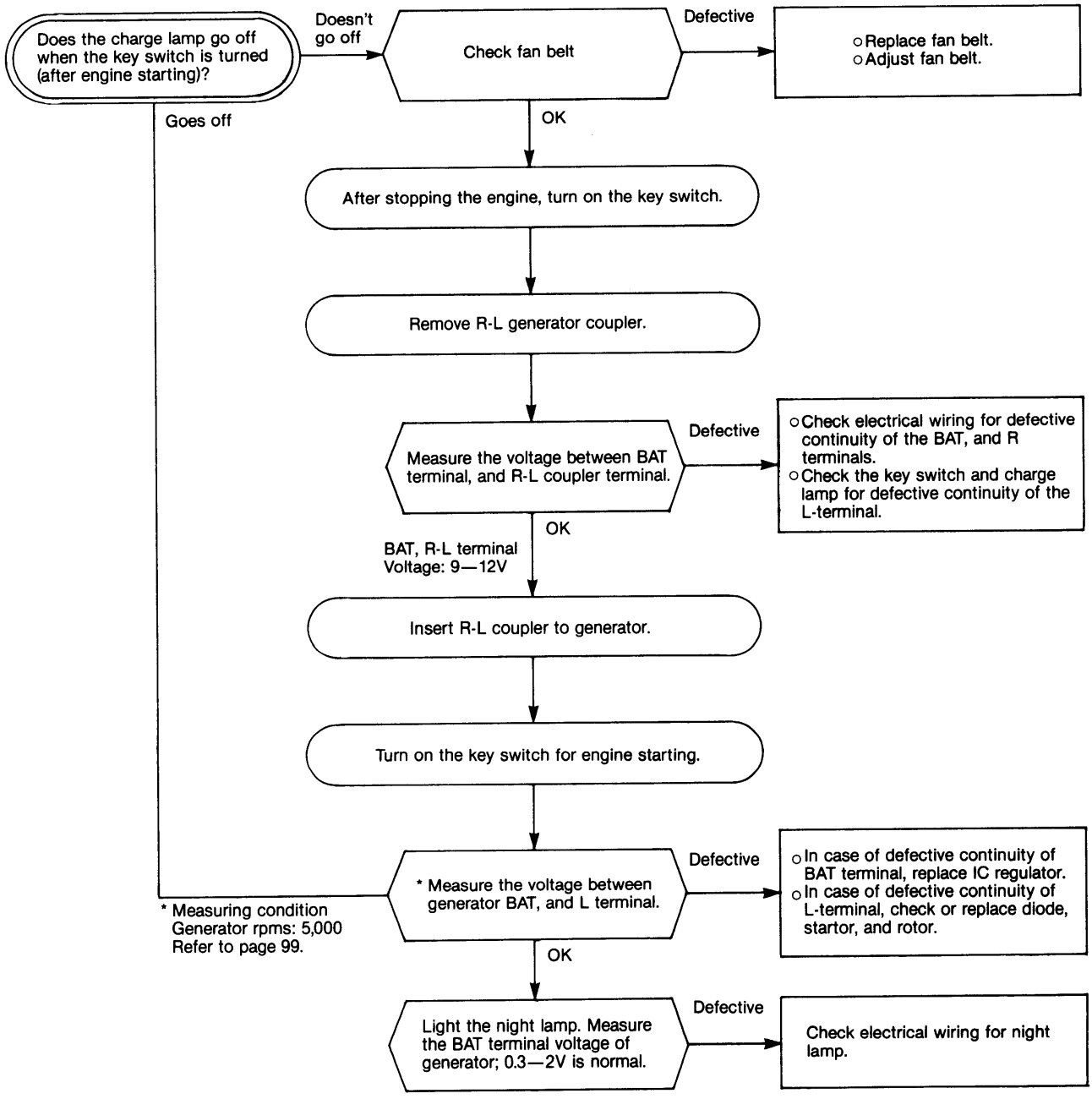
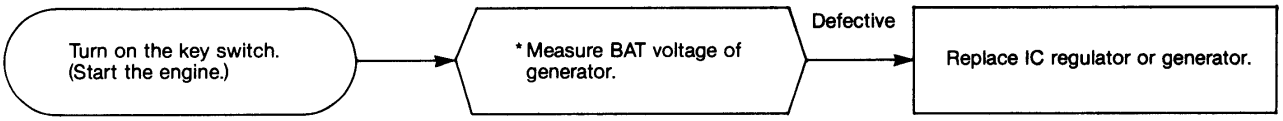
4-11 Troubleshooting

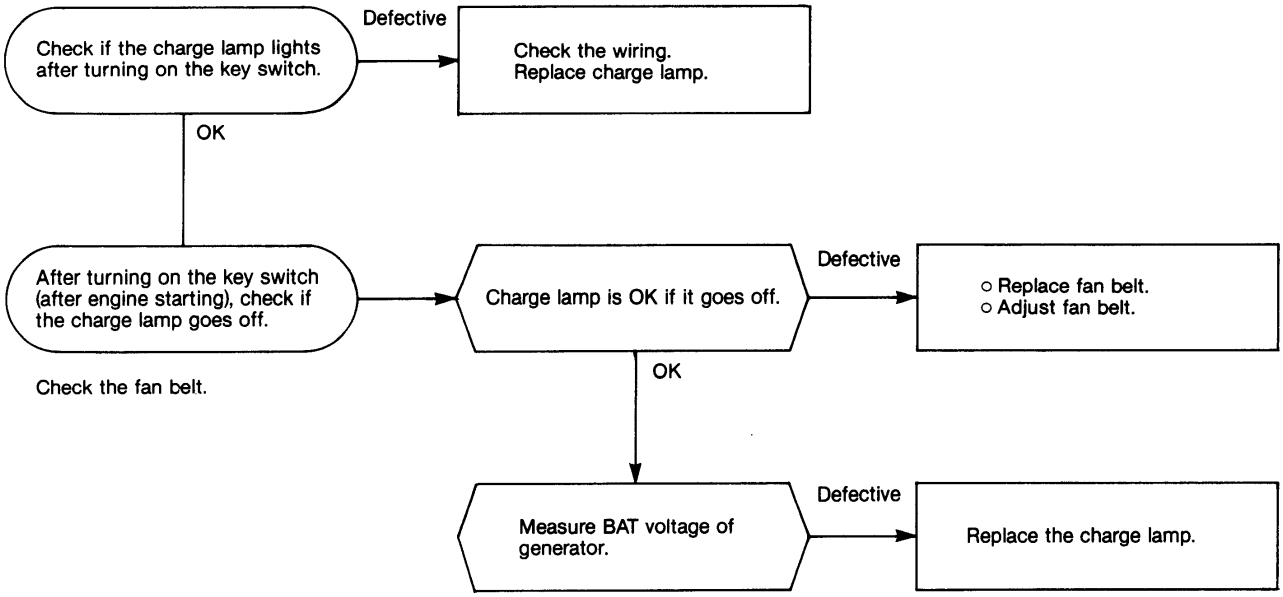
(1) Charging failure



(2) Overcharging



(3) Charge lamp failure



5. Instrument panel and wiring codes

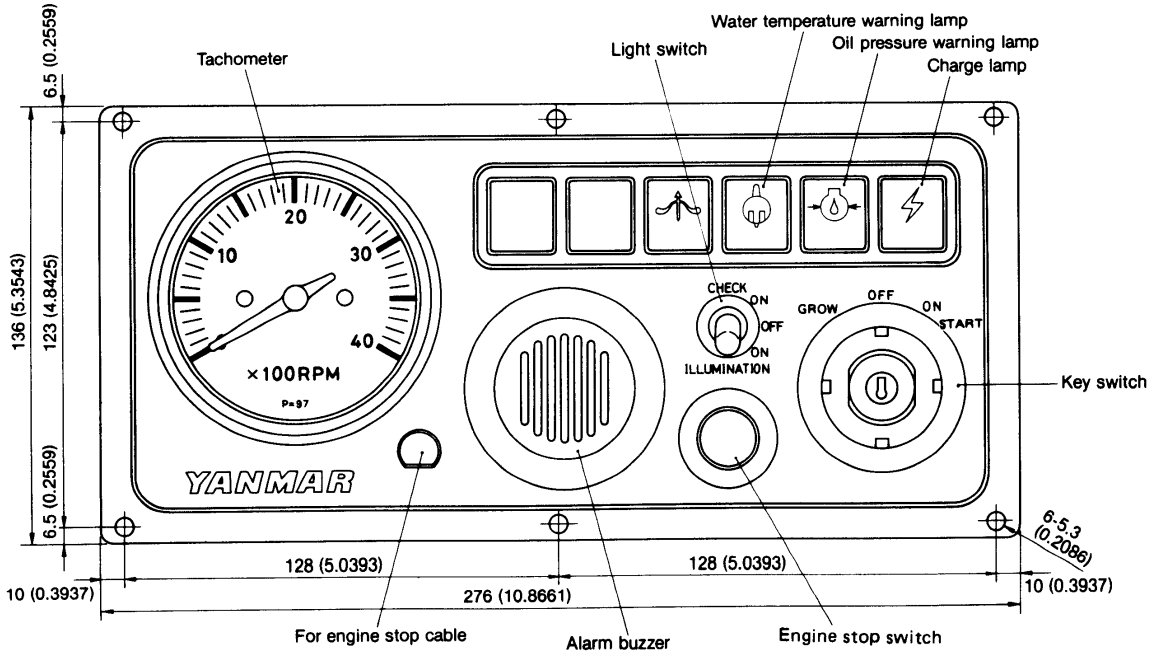
There are three types of instrument panels and wire harnesses and expansion (extension) cords as follows:
Make sure to use the correct parts when making replacements.

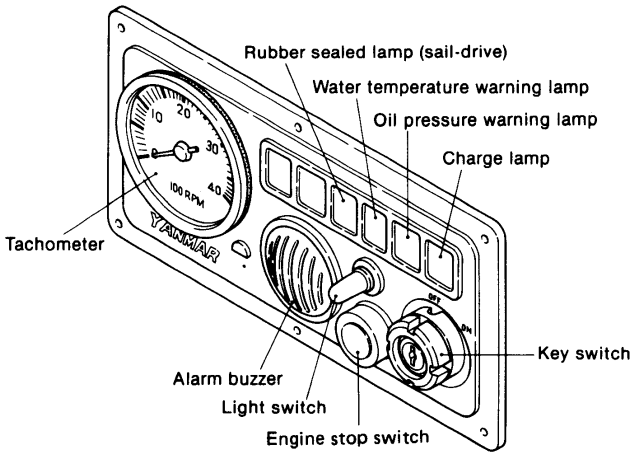
5-1 B-type instrument panel and wire harness

5-1.1 B-type instrument panel

Type	B-type	C-type	D-type
Instrument panel	124411-91190	129470-91100	124411-91180
Wire harness	129470-77920	129470-77930	
Extension cord 4M	129772-77500	129470-77500	
Extension cord 2M	129470-77510	129470-77520	
Extension cord 6M	129470-77530	129470-77540	

mm (in.)





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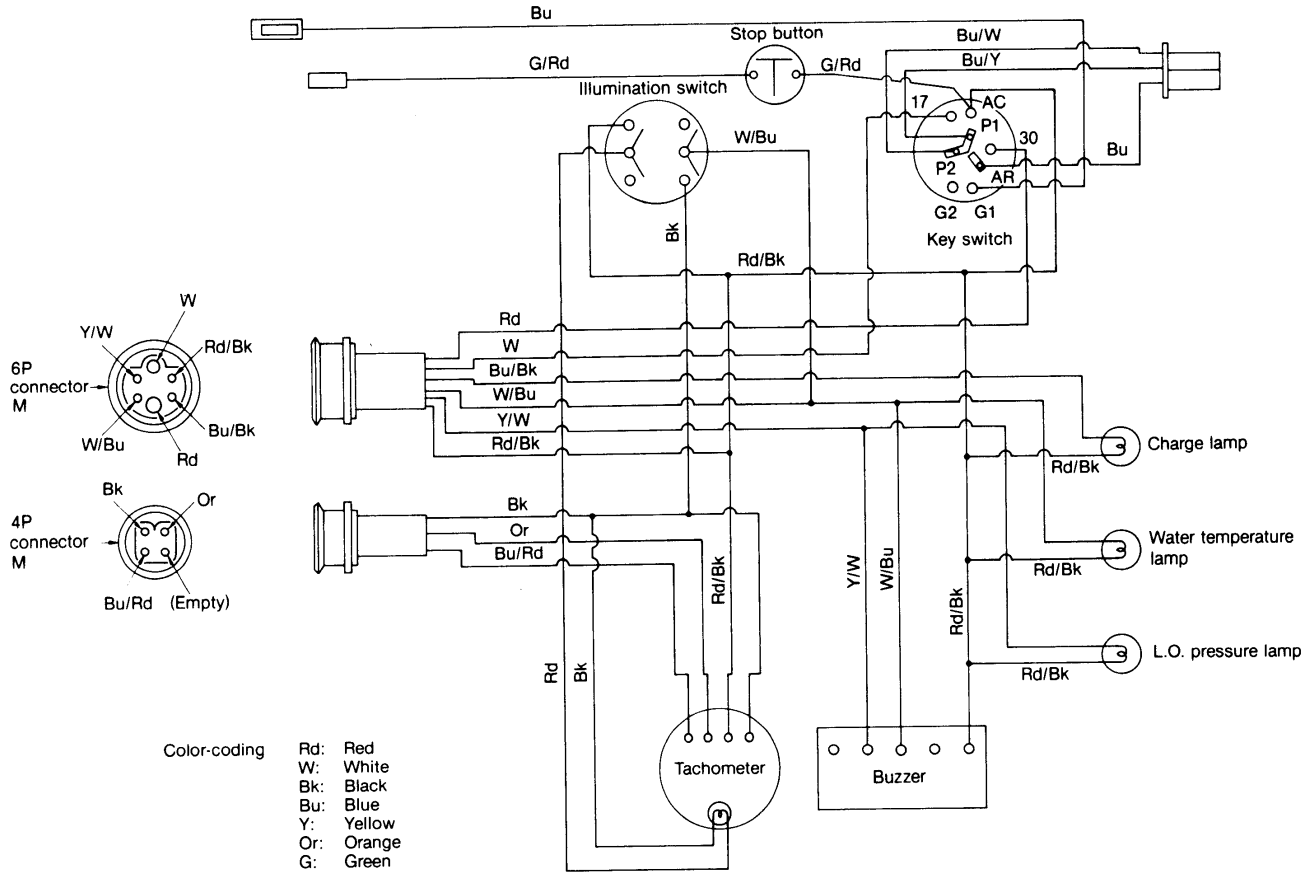
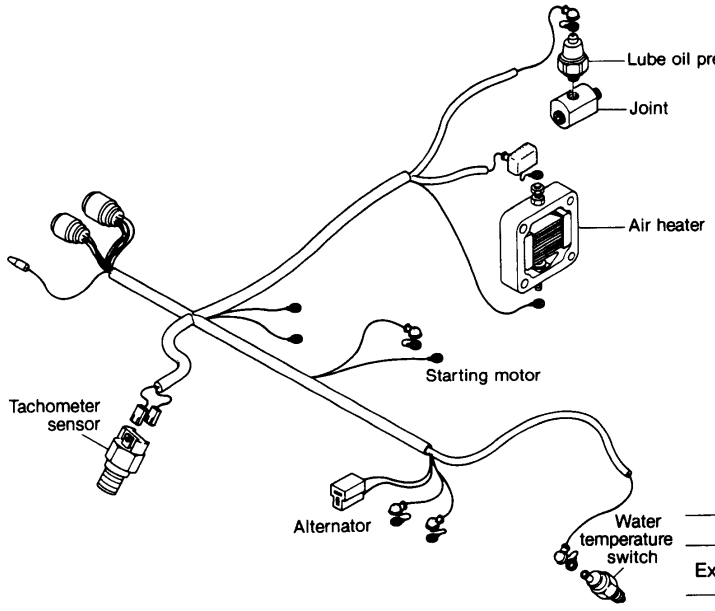
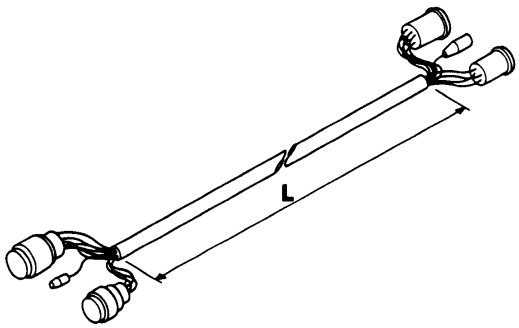


5-1.2 Wire harness for B-type instrument panel



5-1.3 Extension cord for B-type instrument panel



mm (in.)

	Part code No.	L
Extension cord 4M	129772-77500	3750 ∼ 3850 (147.63 ∼ 151.57)
Extension cord 2M	129470-77510	1750 ∼ 1850 (68.89 ∼ 72.83)
Extension cord 6M	129470-77530	5750 ∼ 5850 (226.38 ∼ 230.31)

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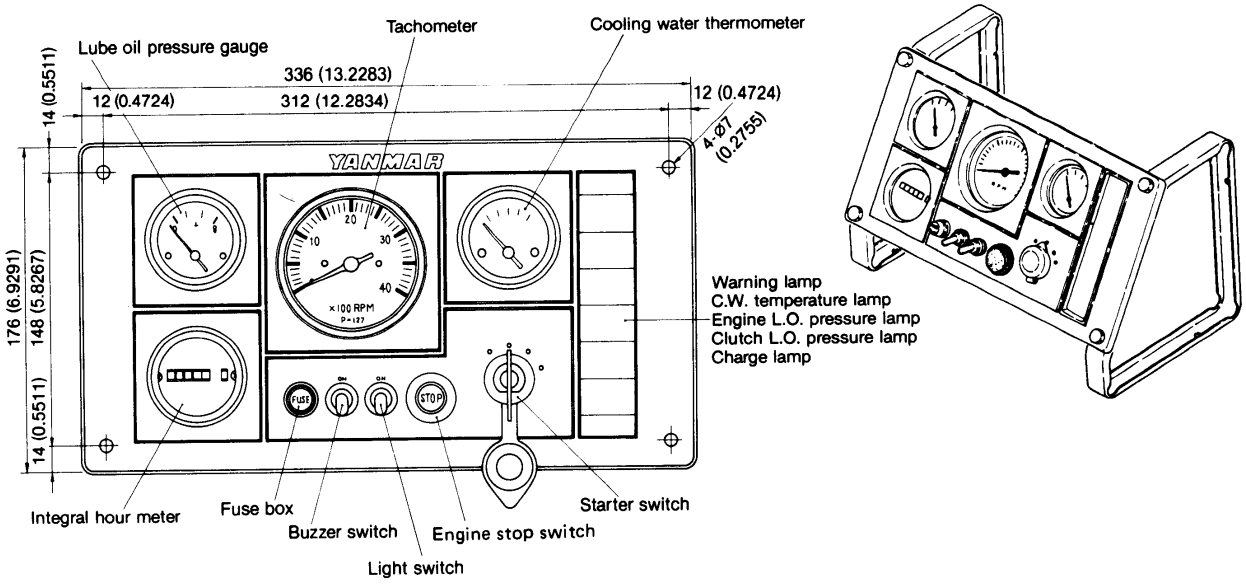
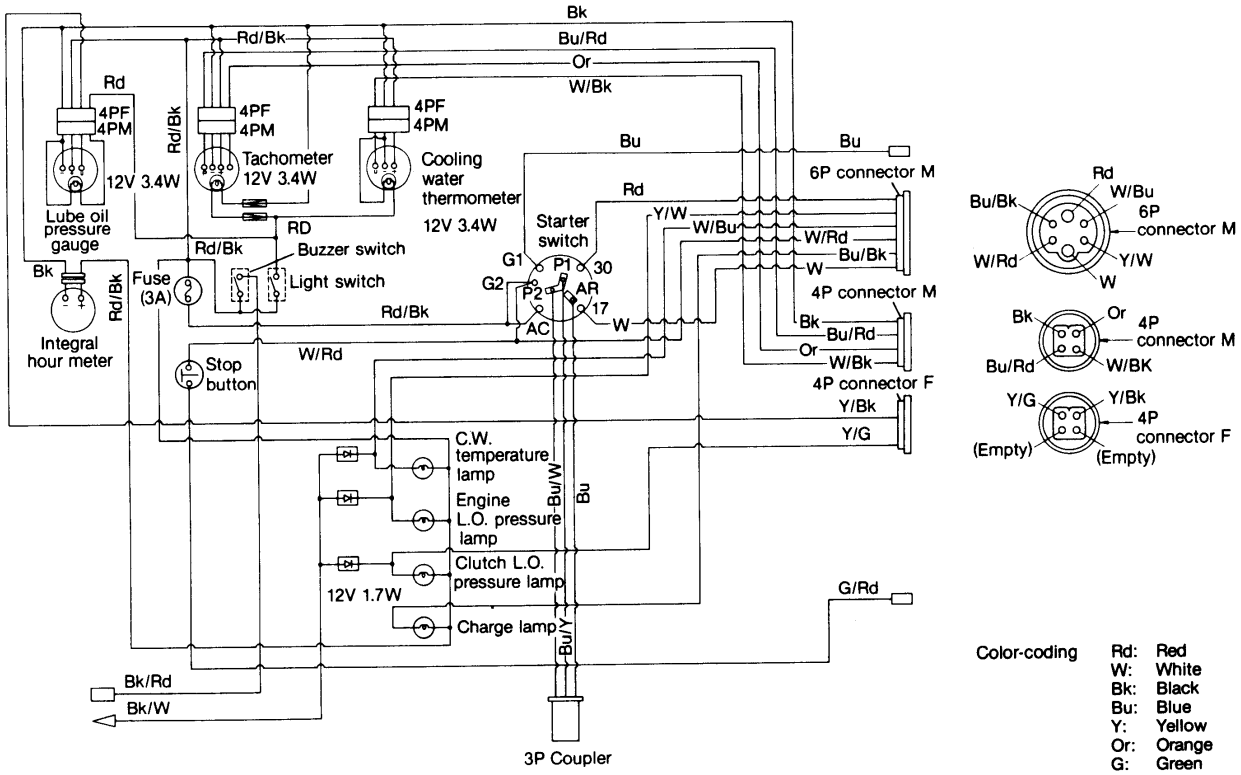
5-2 C-type, D-type instrument panel and wire harness

5-2.1 C-type instrument panel

mm (in.)





Color-coding

Rd:	Red
W:	White
Bk:	Black
Bu:	Blue
Y:	Yellow
Or:	Orange
G:	Green

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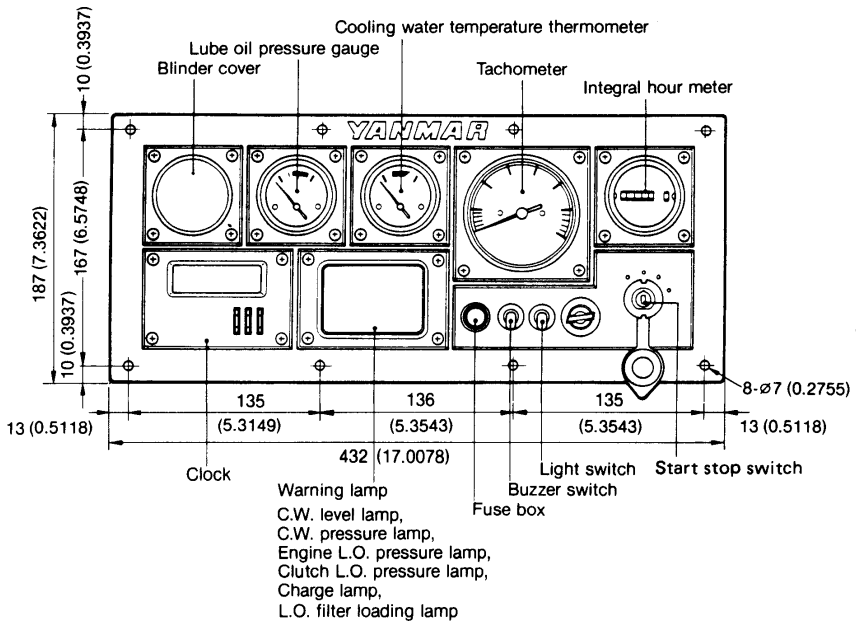
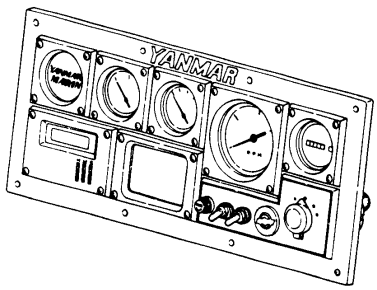
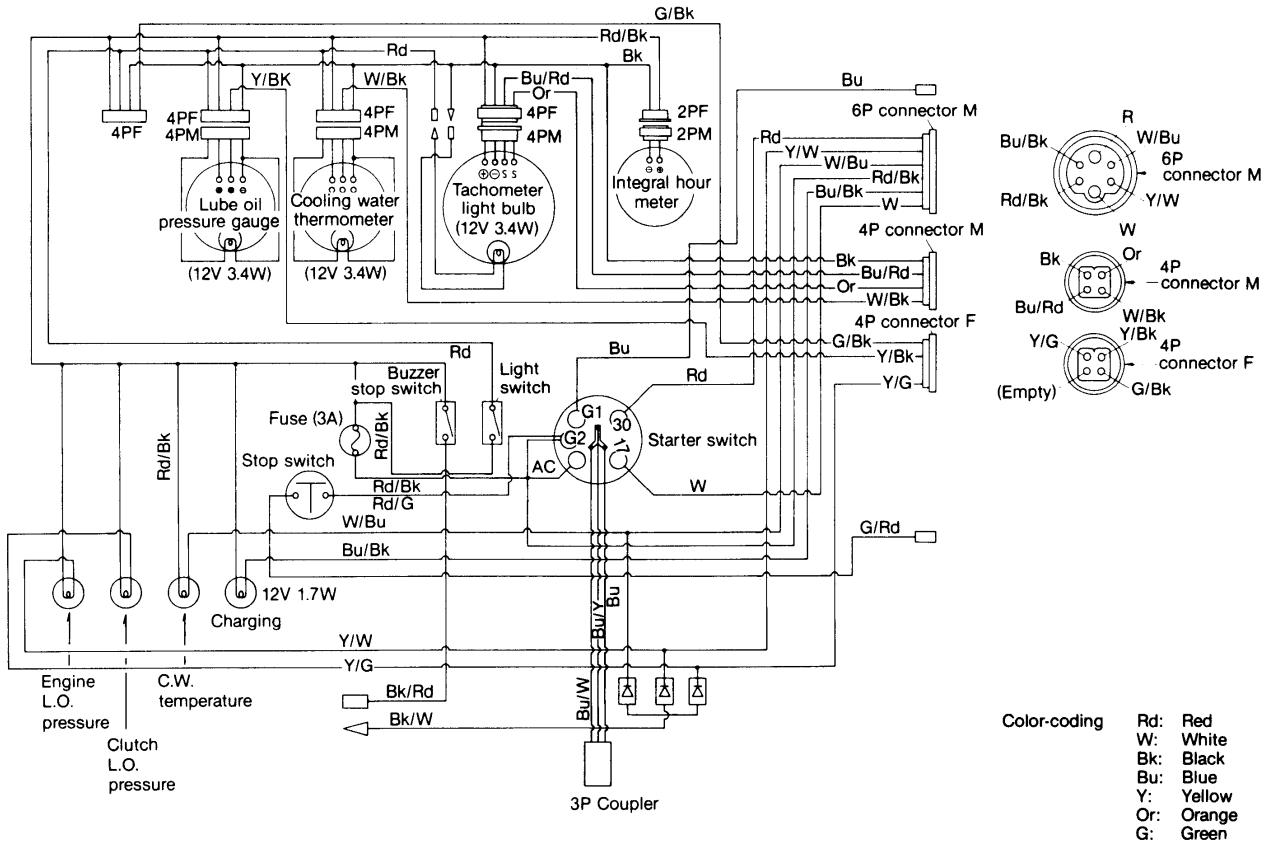
5-2.2 D-type instrument pannel

mm (in.)







Color-coding

Rd:	Red
W:	White
Bk:	Black
Bu:	Blue
Y:	Yellow
Or:	Orange
G:	Green

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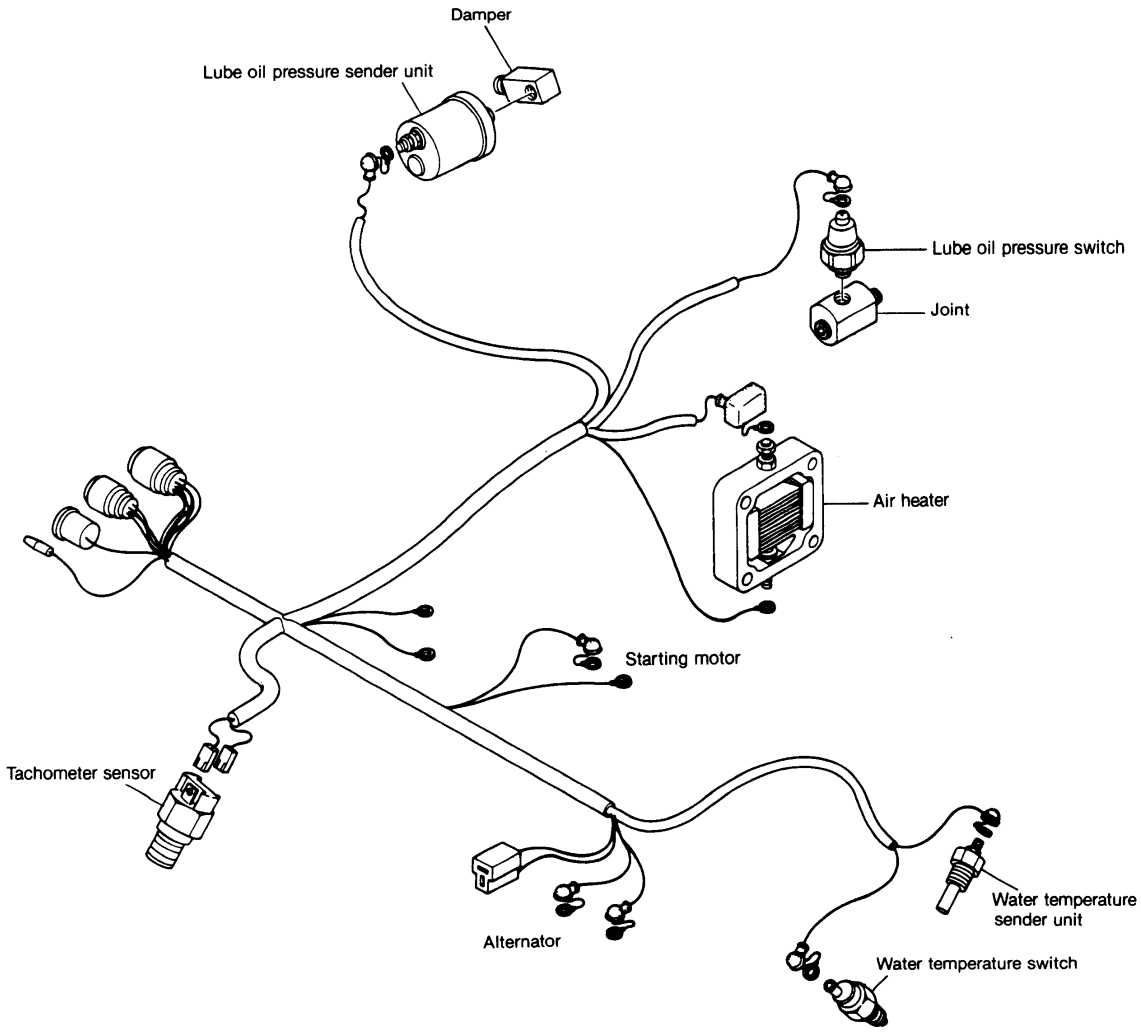
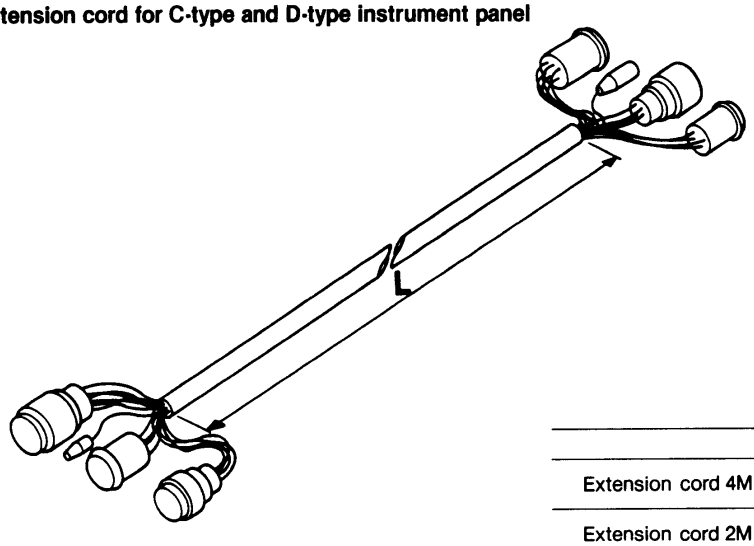
5-2.3 Wire harness for C-type and D-type instrument panel



5-2.4 Extension cord for C-type and D-type instrument panel



mm (in.)

	Part code No.	L
Extension cord 4M	129470-77930	3750 ∼ 3850 (147.63 ∼ 151.57)
Extension cord 2M	129470-77520	1750 ∼ 1850 (68.89 ∼ 72.83)
Extension cord 6M	129470-77540	5750 ∼ 5850 (226.38 ∼ 230.31)

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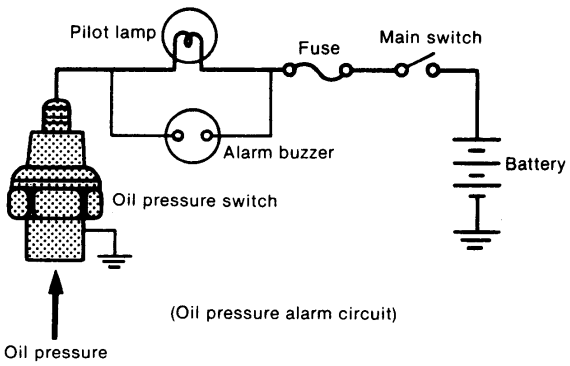
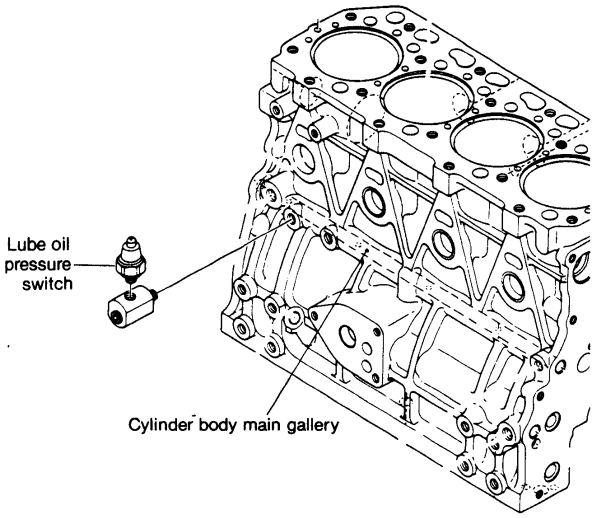
6. Warning Devices

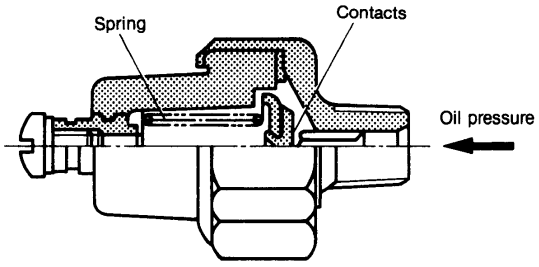
6-1 Oil pressure alarm

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



Part No.	124060-39451
Rated voltage	12V
Operation pressure	0.1 ~ 0.3kg/cm² (1.422 ~ 4.266lb/in.²)
Lamp capacity	5W

Inspection

Problem	Inspection item	Inspection method	Corrective action
Lamp not illuminated when main switch set to ON	1. Oil pressure lamp blown out	(1) Visual inspection (2) Lamp not illuminated even when main switch set to ON position and terminals of oil pressure switch grounded	Replace lamp
	2. Operation of oil pressure switch	Lamp illuminated when checked as described in (2) above	Replace oil pressure switch
Lamp not extinguished while engine running	1. Oil level low	Stop engine and check oil level with dipstick	Add oil
	2. Oil pressure low	Measure oil pressure	Repair bearing wear and adjust regulator valve
	3. Oil pressure faulty	Switch faulty if abnormal at (1) and (2) above	Replace oil pressure switch
	4. Wiring between lamp and oil pressure switch faulty	Cut the wiring between the lamp and switch and wire with separate wire	Repair wiring harness

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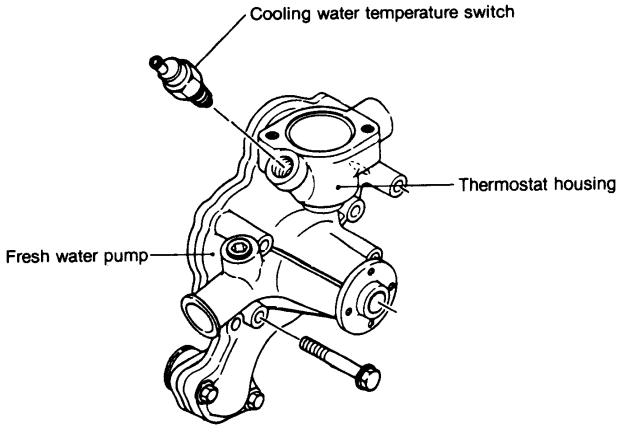
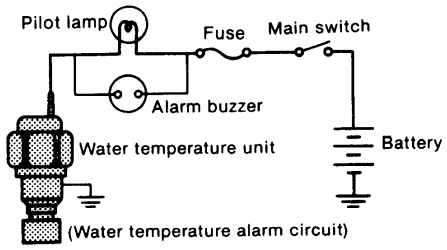
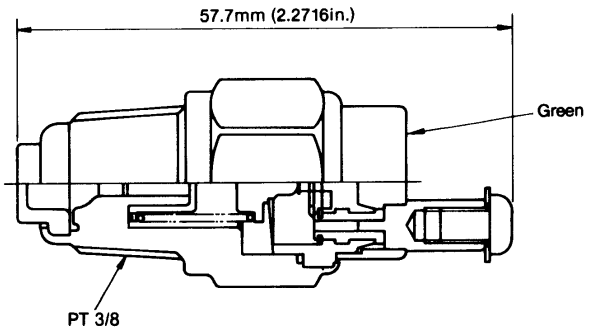
6-2 Cooling water temperature alarm

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°C (199 ~ 206°F)
	OFF	88°C (190°F) or high
Electric capacity		DC 12V, 1A
Response time		with in 60 sec.
Indication color		Green
Part code No.		127610-91350
Tightening torque		2.40 ~ 3.20kg-m (17.35 ~ 23.14ft-lb)

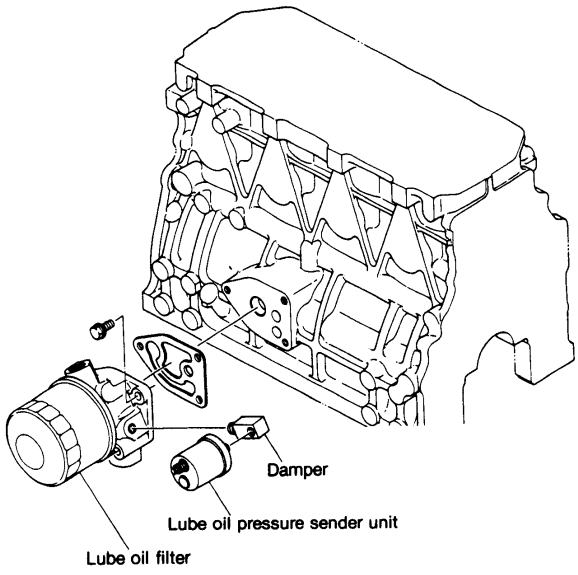






6-3 Sender unit for lube oil pressure gauge

The sender unit for the lube oil pressure gauge has a mounting seat for mounting on the lube oil filter bracket. 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.



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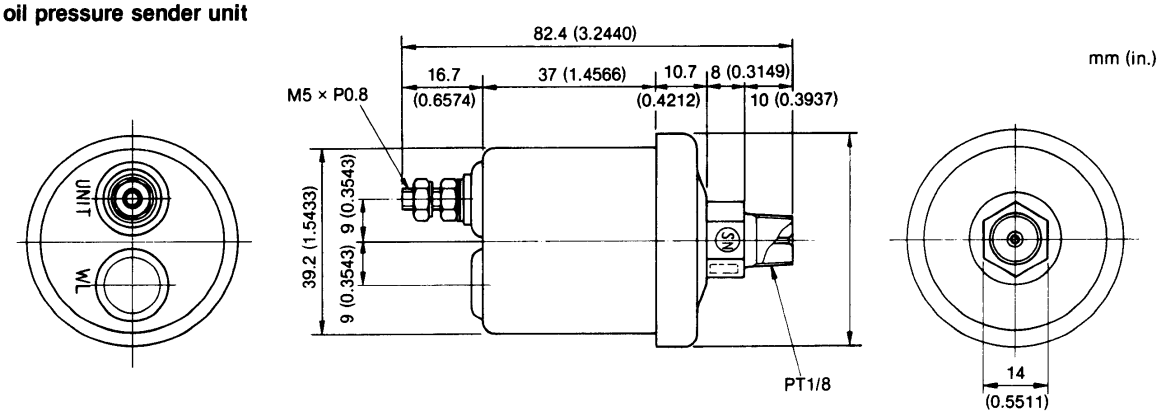
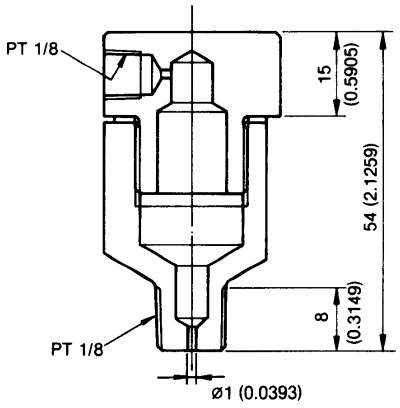
Lube oil pressure sender unit



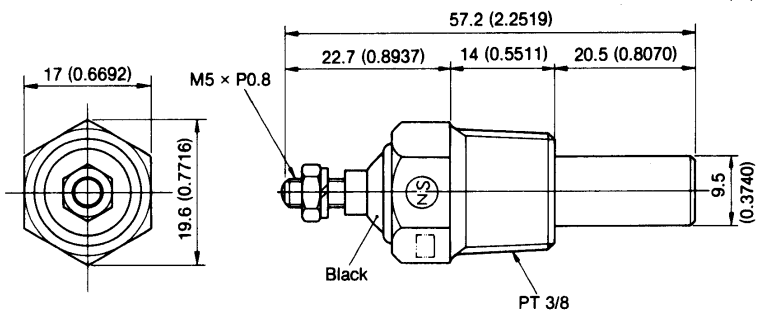
Damper

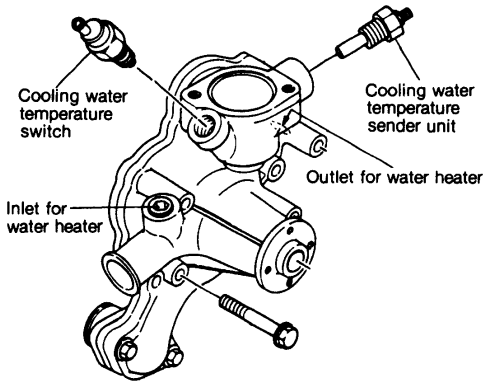


Type	Resistance switch
Rated voltage	DC 12/DC 24
Max. operating pressure	8kg/cm² (113.76 lb/in.²)
Part code No.	144626-91560

6-4 Sender unit for the cooling water temperature gauge

The water temperature sender unit has a mounting seat for mounting on the fresh water pump unit. 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
Part code No.	144626-91570

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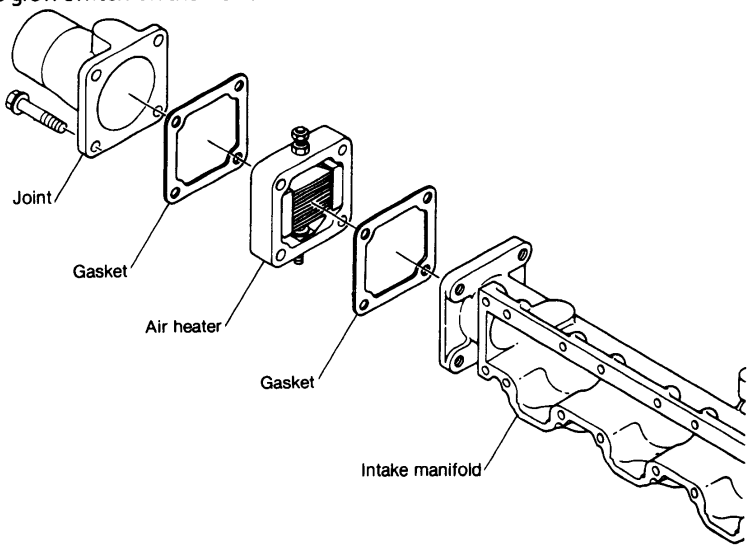
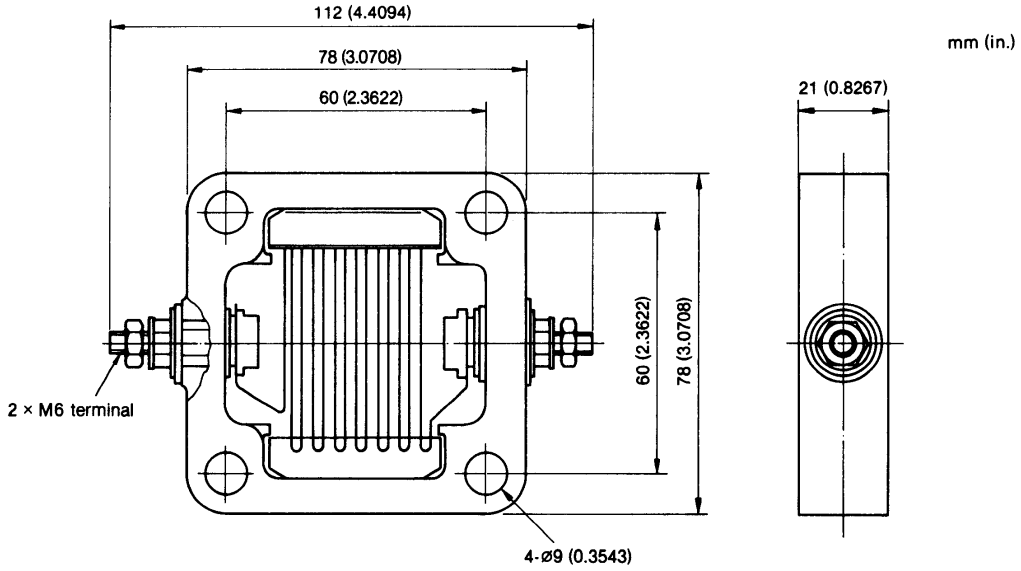
7. Air Heater (Optional)

An air heater is available for warming intake air during starting in cold areas during winter. The air heater is mounted between the intake manifold and intake manifold coupling.
The device is operated by the glow switch on the instrument panel.





Rated output	400W
Rated current	33.3A
Rated voltage	DC 12V
Rated operating time	Engine operation: 60 sec. Engine stop: 30 sec.
Range of operating temperature	+50°C ~ 30°C (122°F ~ −22°F)
Part code No.	129400-77500

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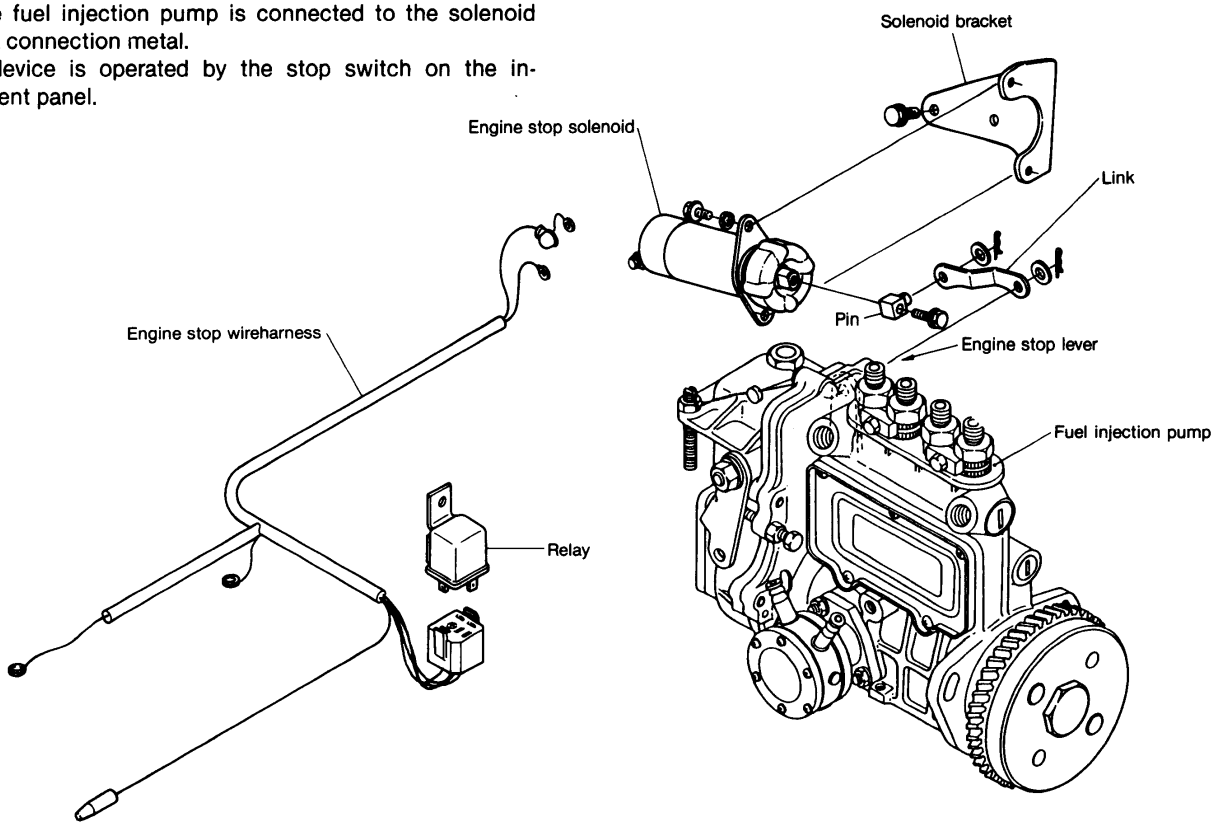
8. Electric type Engine Stopping Device (Optional)

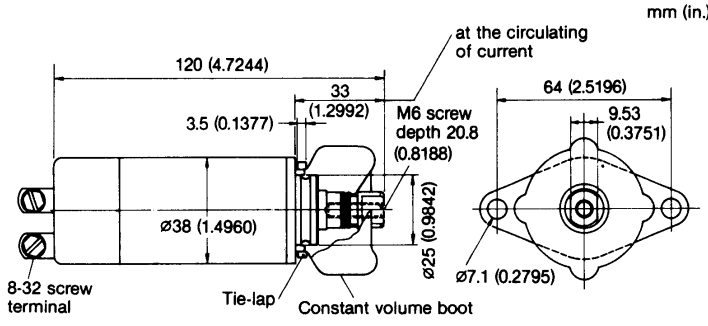
To employ the electric engine stop device, the stop lever of the fuel injection pump is connected to the solenoid with a connection metal.
The device is operated by the stop switch on the instrument panel.

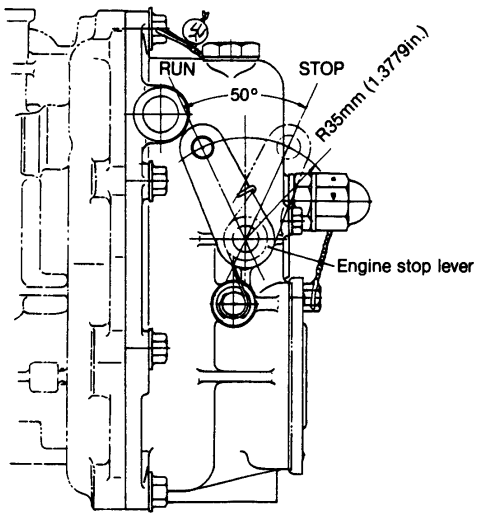


8-1 Solenoid

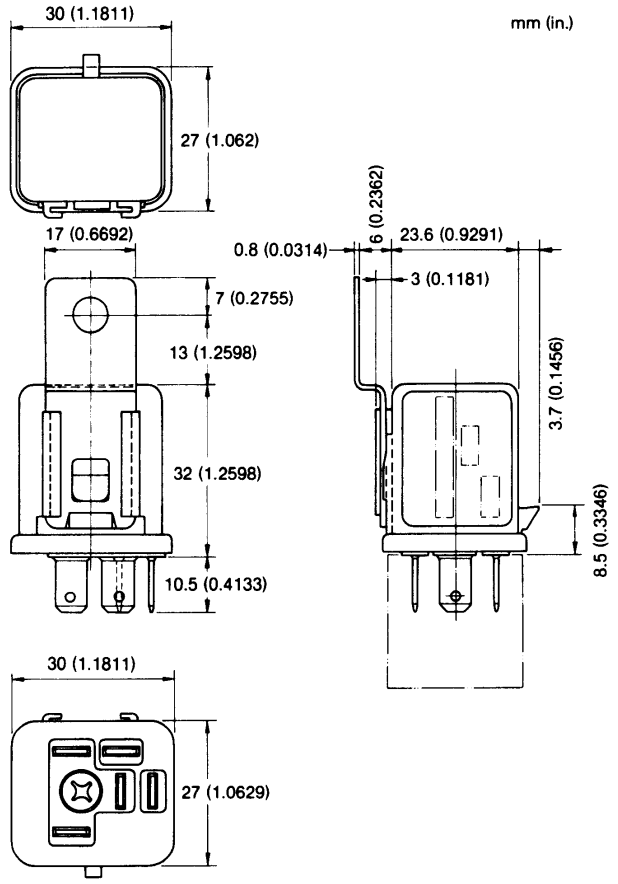
Solenoid model	1502-12A7U1B
Rated voltage	12V
Loaded current	30A
Loaded force	9kg (19.84lb)
No-load current	0.7A
No-load force	4kg (8.82lb)

mm (in.)



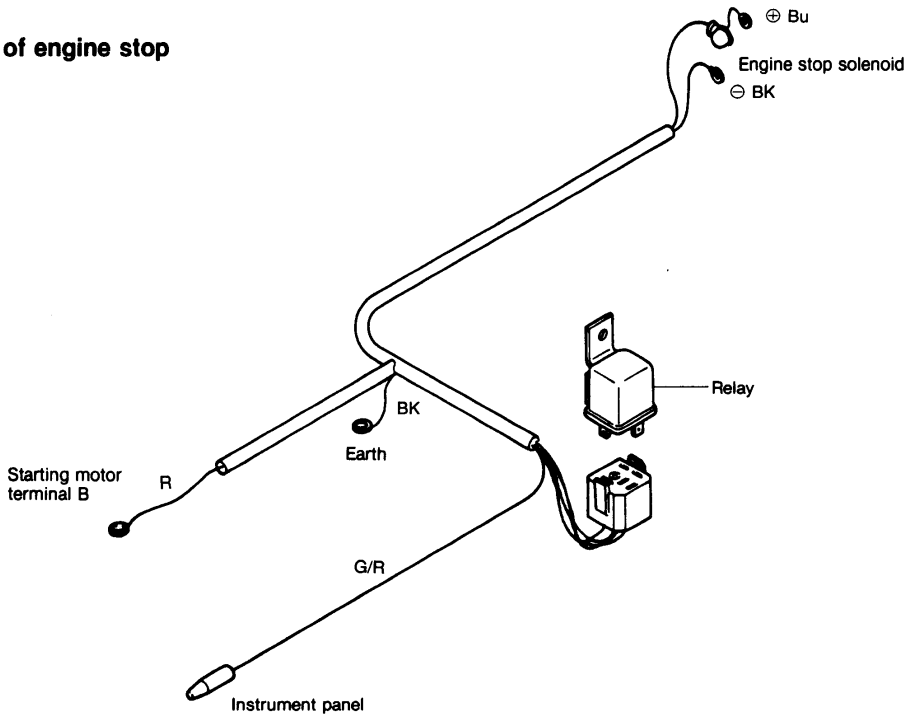


8-2 Relay



Rated voltage	12V
Contact current	Lamp: 20A, extra-lamp: 25A
Range of operation	−30°C ∼ +90°C (−22°F ∼ 194°F)
Part code No.	124617-91850

8-3 Wire harness of engine stop



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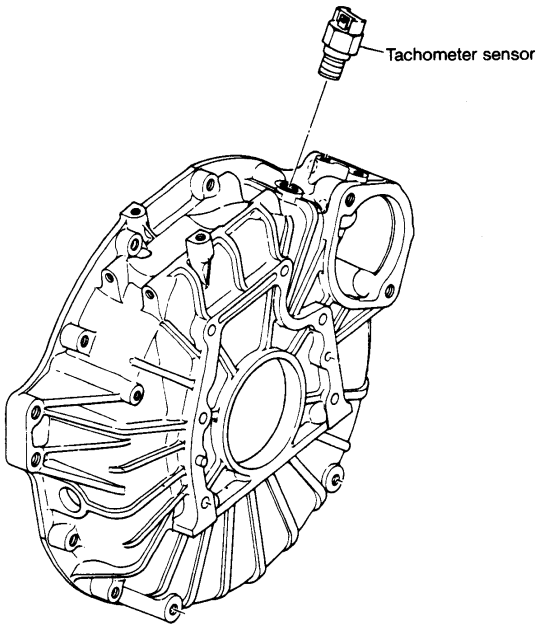
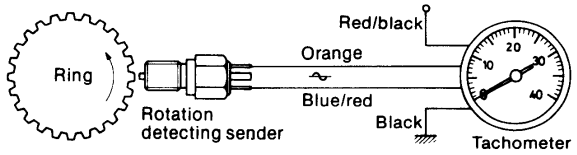
9. Tachometer

9-1 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 sender (MPU sender).
The function of the sender 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.



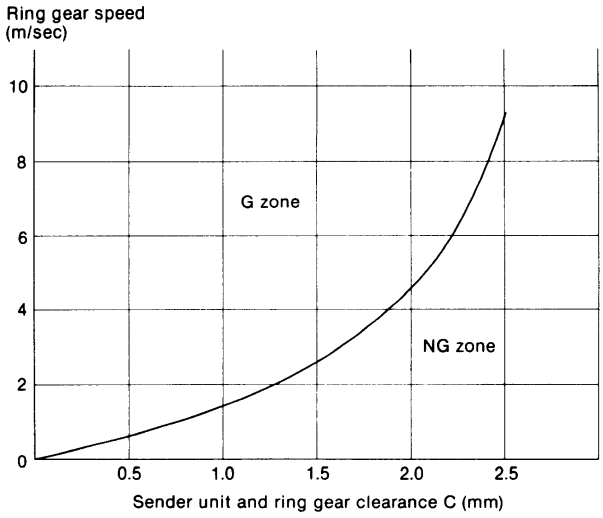


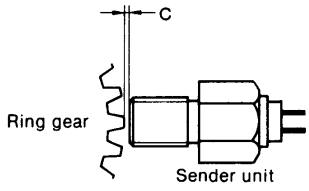
9-2 Specifications and dimensions of tachometer

(1) Specifications

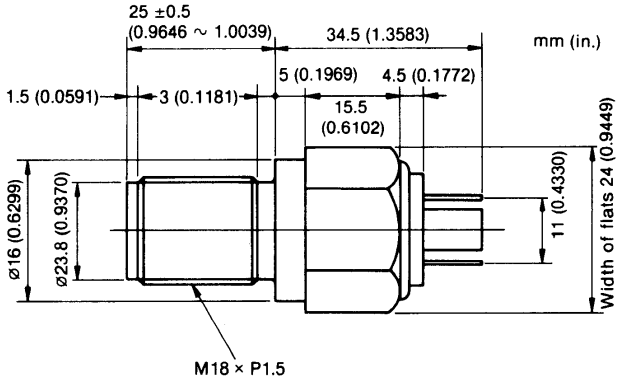
Rated voltage		DC 12V
Range of operating voltage		10 ~ 15V
Illumination		3.4W/12V
Ring gear	No. of teeth	127
	Module	2.54
Part No. of tachometer		120130-91200 (128696-91100)
Part No. of sender unit		128170-91160

(2) Sensitivity limit of sender unit

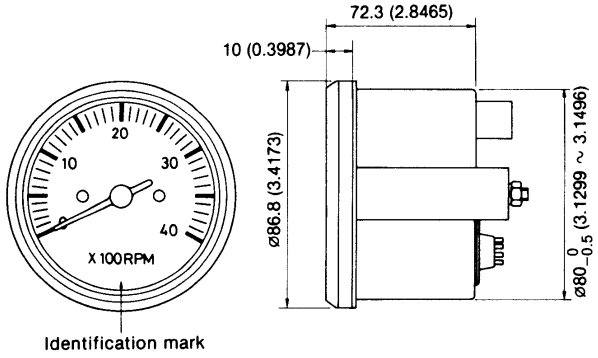




(3) Dimensions of sender unit



(4) Dimensions and shape of tachometer



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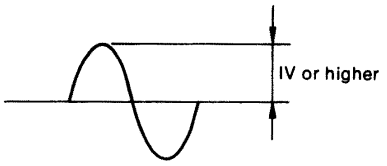
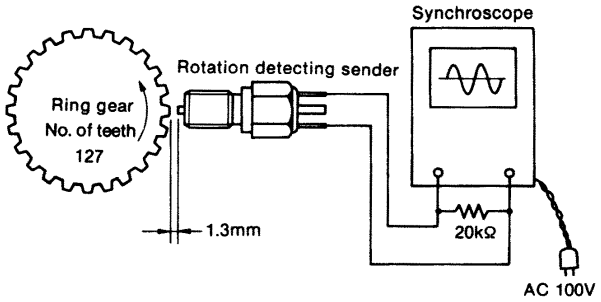
9-3 Measurement of sensor unit characteristics

(1) Measurement of output voltage

Output voltage	1.0V or higher





Measuring conditions

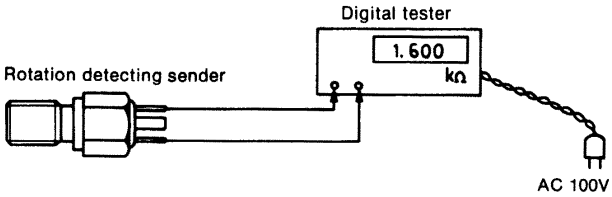
Number of teeth of ring gear	127
Gap between the ring gear and sender	1.3mm (0.0511 in.)
Resistance	20kΩ
Speed of ring gear	500 rpm (approx. 800Hz)
Measuring temperature	20°C (68°F)
Measuring instrument	Synchroscope

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

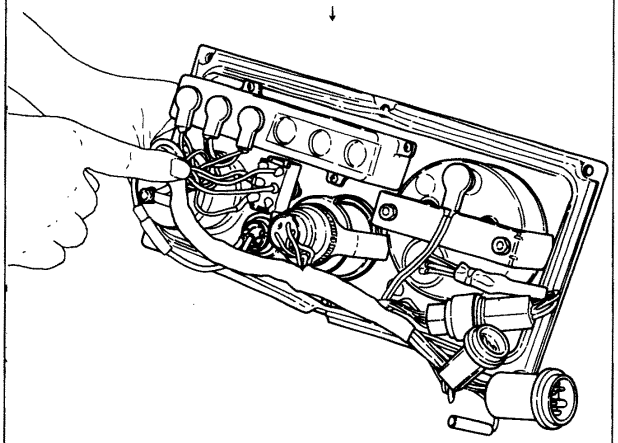
(2) Measurement of internal resistance

Measuring conditions

Measuring temperature	20°C (68°F)
Measuring instrument	Digital tester



9-4

Fault	Diagnosis		Remedy
Does not function well. 1) Pointer does not move. 2) Functions intermittently.	Check if there is an open-circuit cable connection at the rear of the meter, a loose or disconnected terminal, or bad continuity due to corrosion. ↓ 	Yes	Make good the connection.
	Disconnect at the instrument terminals, and measure the voltage between the cable terminals. (To be 10 ~ 16V) ↓ Satisfactory	No	If the input voltage is abnormal, check the cause. (e.g. short-circuit, disconnection, or blown fuse, etc.)

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	Check if the sender is loosely fitted. ↓ No	Yes	Fix the sender securely.
	Measure the internal resistance of the sender. (To be 1.6 ±0.1kΩ at 20°C) ↓	No	Replace the sender.
	Measure the output voltage of the sender. (To be 1V or higher at 20°C)	No	Replace the sender.

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10. Alternator 12V/80A (OPTIONAL)

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 keeps the generated voltage constant even when the engine speed changes.

10-1 Features

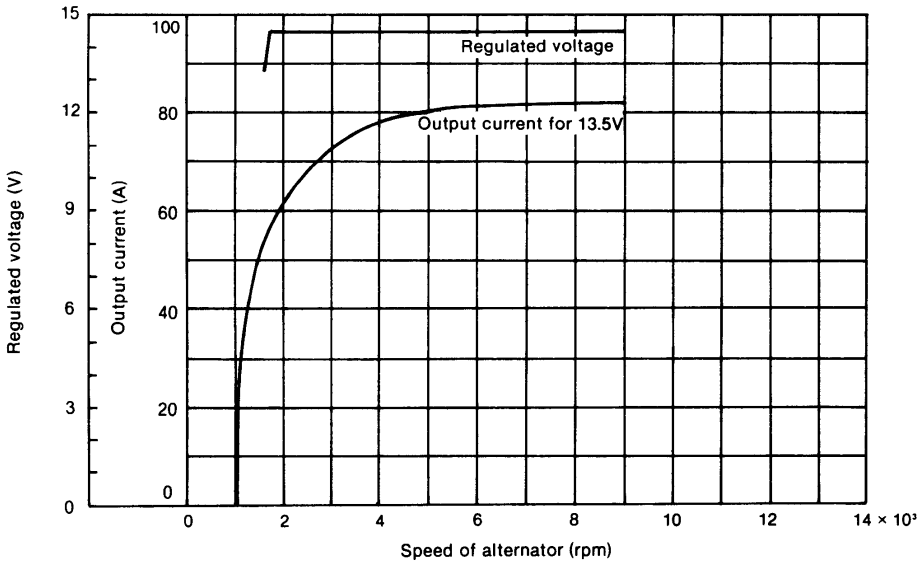
The alternator contains a regulator using an IC, and has the following features.

(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.

10-2 Specifications

Model of alternator	LR180-03 (HITACHI)
Model of IC regulator	TRIZ-63 (HITACHI)
Battery voltage	12V
Nominal output	12V/80A
Earth polarity	Negative earth (⊖)
Direction of rotation (viewed from pulley end)	Clockwise
Weight	5.8kg (12.8lb.)
Rated speed	5000 rpm
Operating speed	1000 ~ 9000
Speed for 13.5V	1000 or less
Output current at 20°C	over 78A/5000 rpm
Regulated voltage	14.5 ±0.3V (Standard temperature voltage gradient, −0.01/°C)

10-3 Characteristics



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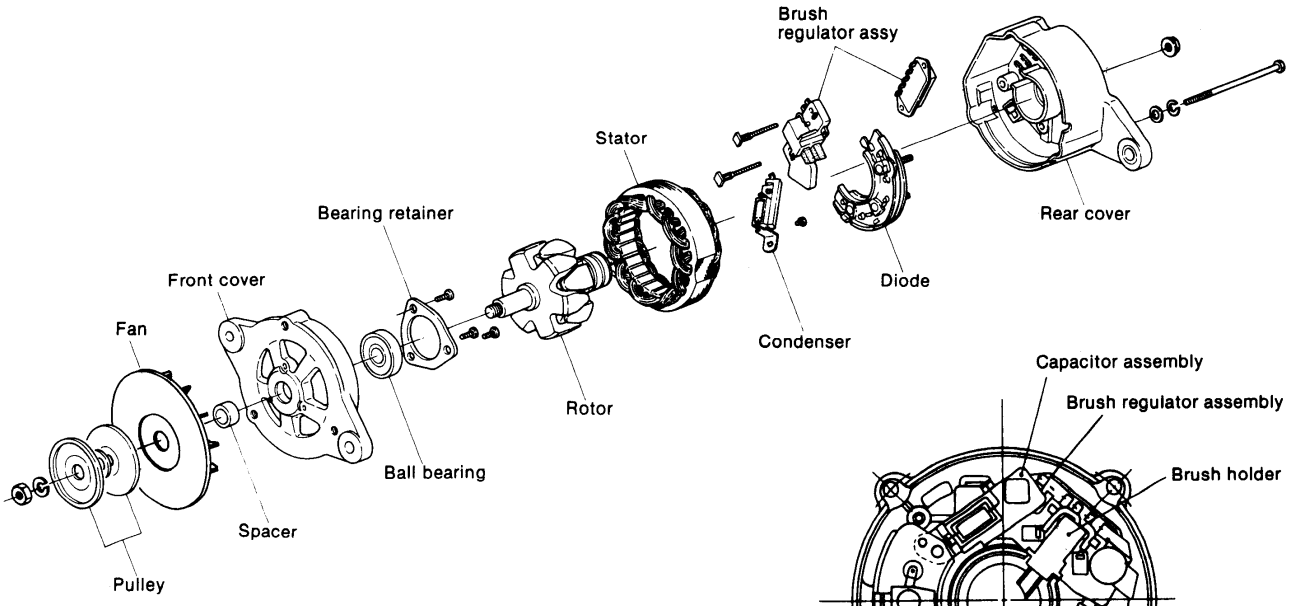
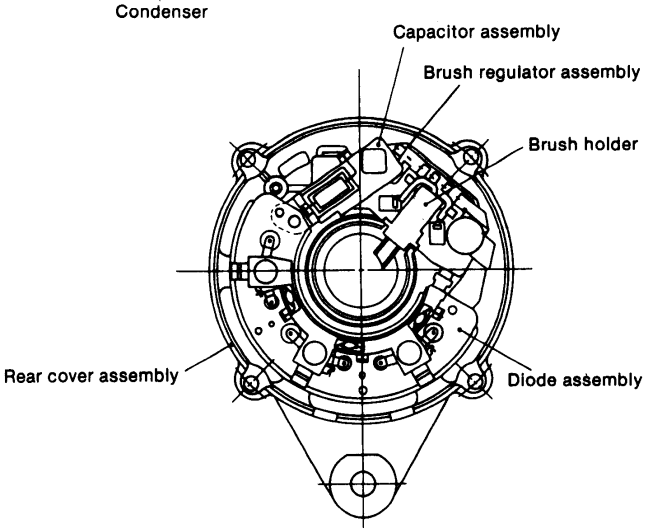
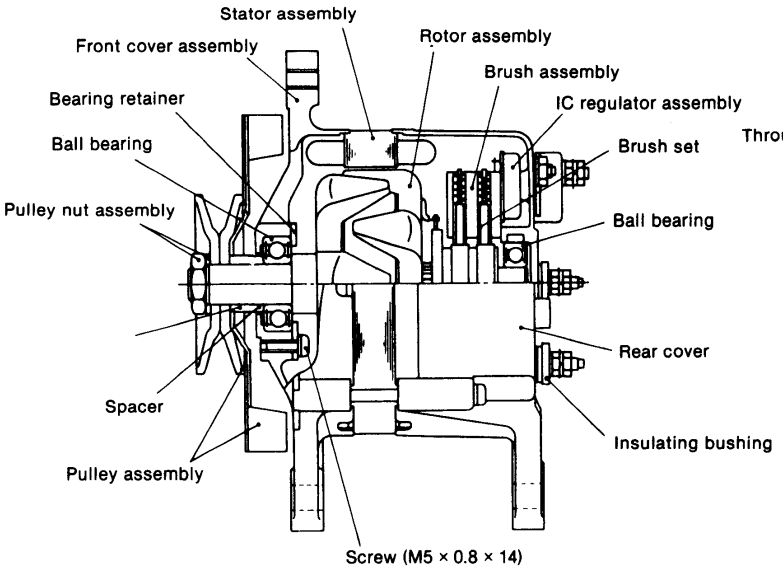
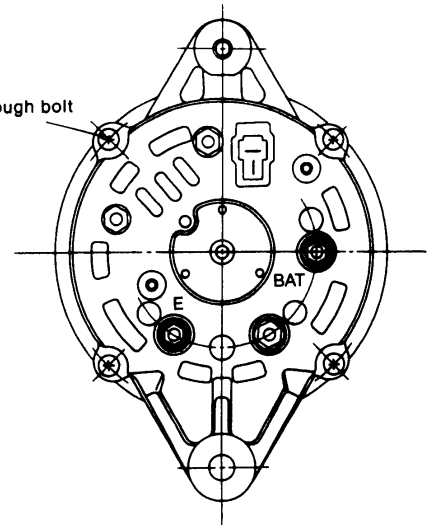
10-4 Construction

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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10-5 Alternator functioning

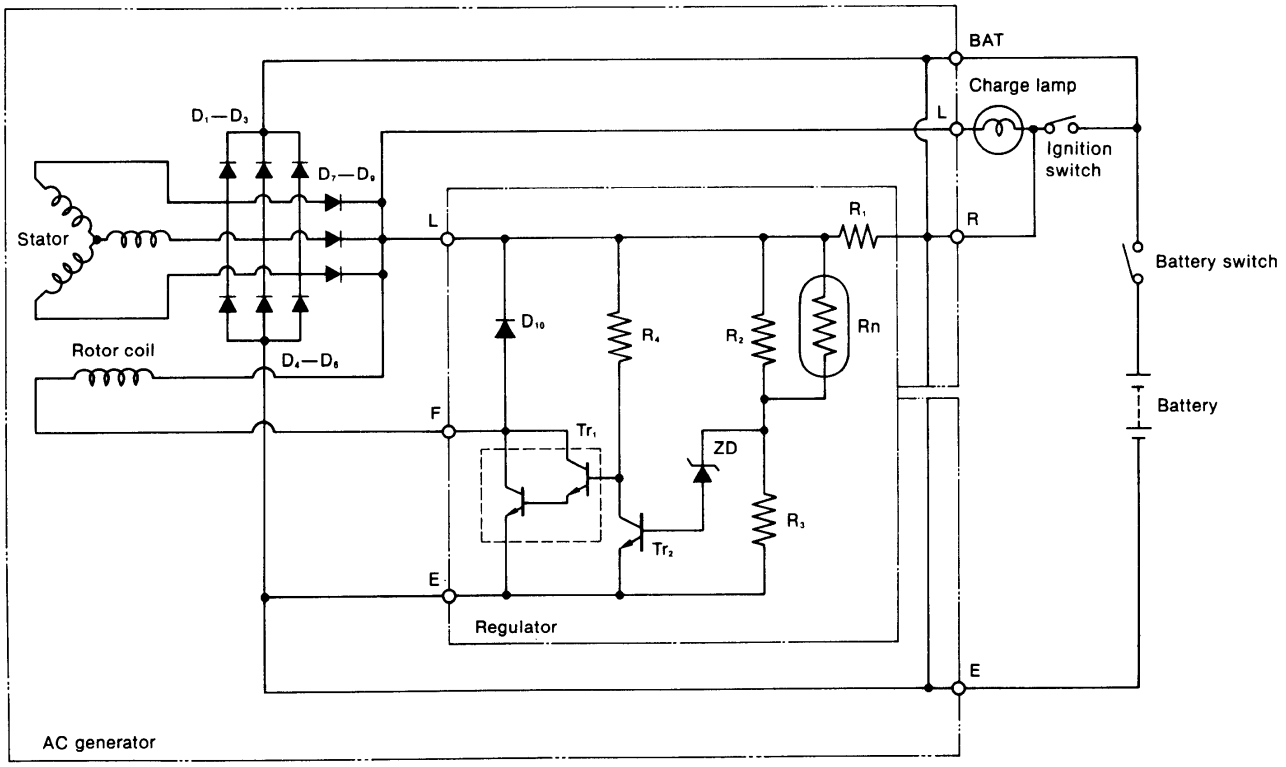
(1) IC regulator
The IC regulator is the transistor (Tr_1) which is series-connected with the rotor. The IC regulator controls the output voltage of the generator by breaking or conducting the rotor coil (exciting) current.
When the output voltage of the generator is within the standard value, the transistor (Tr_1) turns on. When the voltage exceeds the standard value, the Zener diode goes on and the transistor (Tr_1) turns off.
With the repeated turning on and off of the transistor, the output voltage is kept at the standard value. (Refer to the circuit diagram below.)

(2) Charge lamp
When the transistor (Tr_1) is on, the charge lamp key switch is turned to ON, and current flows to R_1, R_4 and to Tr_1 to light the lamp. When the engine starts to run and output voltage is generated in the stator coil, the current stops flowing to this circuit, turning off the charge lamp.

(3) Circuit diagram

10-6 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.)



BAT:	Generator output terminal	D_1—D_6:	Output commutation diode
D_{10}:	IC protecting diode	R_1—R_4:	Resistor
L:	Charge lamp terminal	D_7—D_9:	Charging lamp switching diode
ZD:	Zener diode	F:	To supply current to rotor coil
E:	Earth	Rn:	Thermistor (Temperature gradient resistance)
Tr_1, Tr_2:	Transistor		

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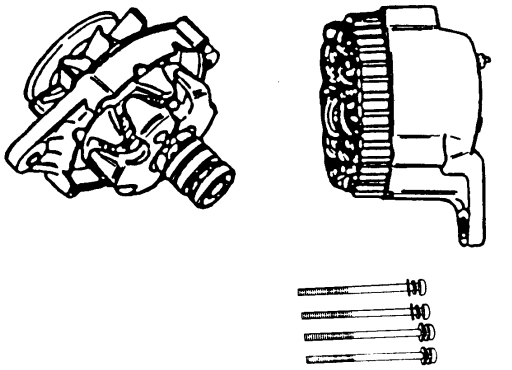
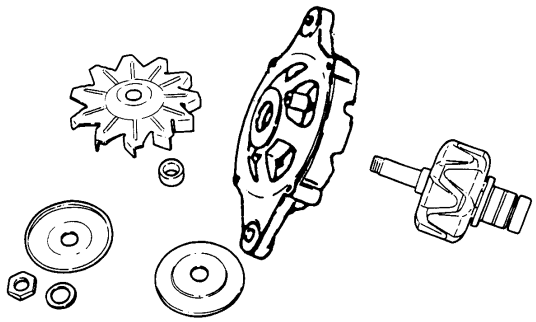
10-7 Disassembling the alternator

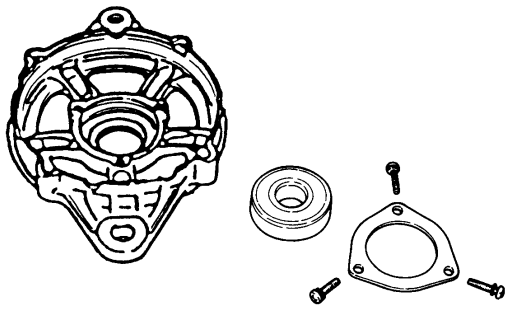
(1) Remove the through-bolt, and separate the front assembly from the rear assembly.



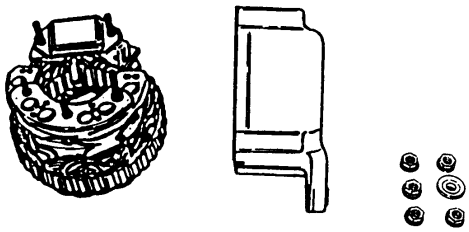
(2) Remove the pulley nut, and pull out the rotor from the front cover.



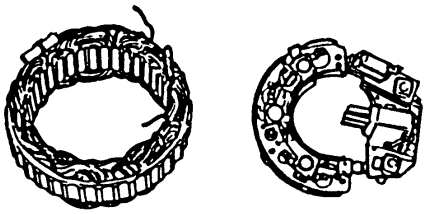
(3) Remove the ø5mm (ø0.1969in.) screw from the front cover, and then remove the ball bearing.



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

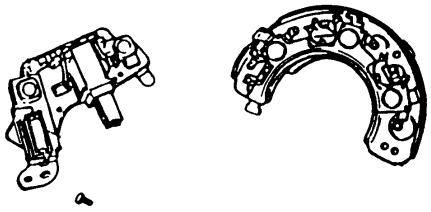


(5) Disconnect the soldered joint of the stator lead wire, and remove the diode and brush regulator assemblies from the stator at the same time.



(6) Separating the regulator

1) To separate the regulator, remove the ø3mm (ø0.1181in.) rivet which keeps the diode assembly and the brushless regulator in place, and the soldered joint of the L-terminal.



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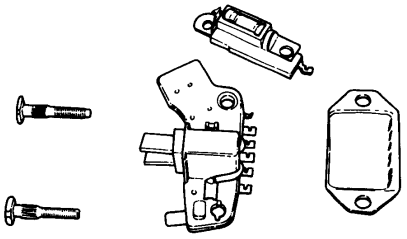
2) To replace the IC regulator, disconnect the soldered joint of the IC regulator and pull out the two bolts. Do not remove these two bolts except when replacing the IC regulator.

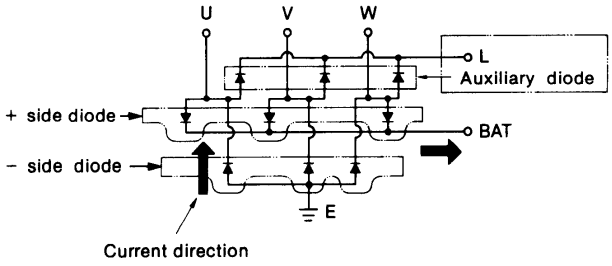


10-8 Inspection and adjustment

(1) Diode

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

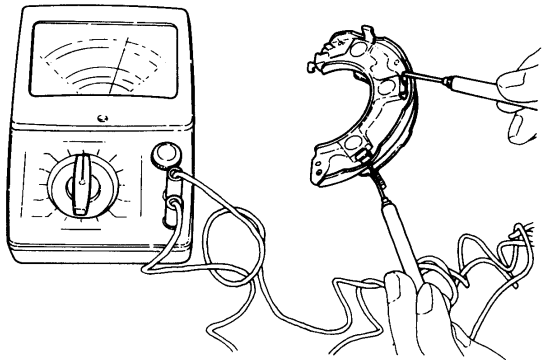
Between terminals		E (− side diode)	
	Tester wire	+ side	− side
U.V.W.	+ side		Continuity
	− side	No continuity	



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 and U), the diode is in normal condition. When there is no continuity, the diode is defective.
When the tester is connected in the reverse of above, there should be no continuity. If there is, the diode is defective.

After repeating the above test, if any diode is found to be defective, replace the diode assembly. Since there is no terminal on the auxiliary diode, check the continuity between both ends of the diode.



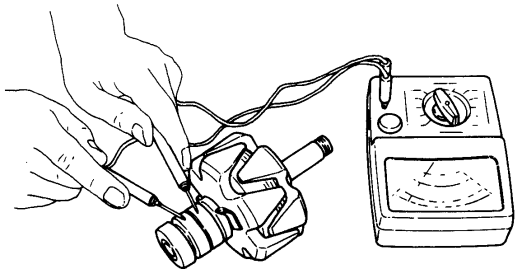
CAUTION: Do not use high tensile insulation resistance such as meggers, etc. for testing. The diode may burn out.

(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.	ø31.6mm (1.2441in.)	ø30.6mm (1.2049in.)

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. 2.58Ω at 20°C

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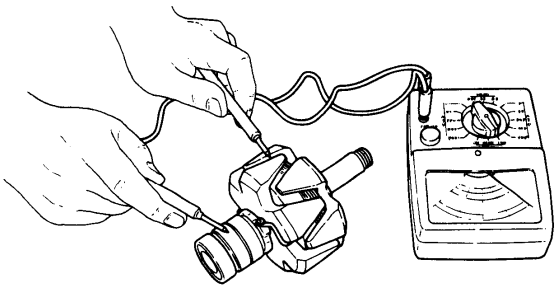
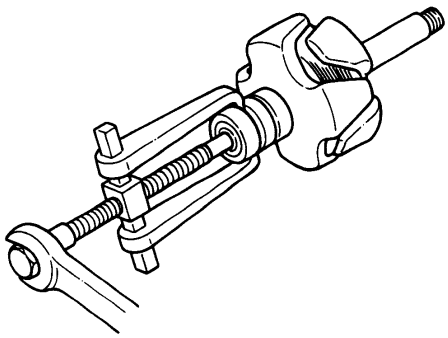
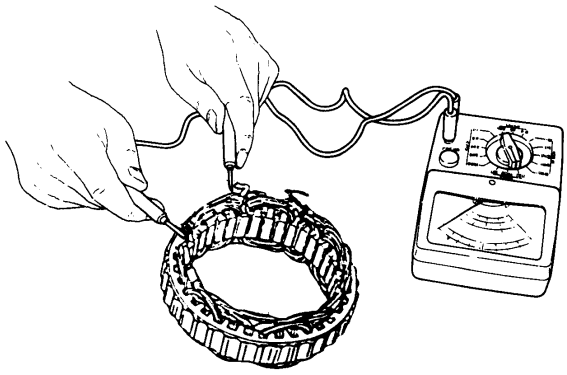
3) Rotor coil insulation test
Check the continuity between the slip ring and the rotor core, or the shaft. If there is continuity, insulation inside the rotor is defective, causing a short with the earth circuit. Replace the rotor coil.



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

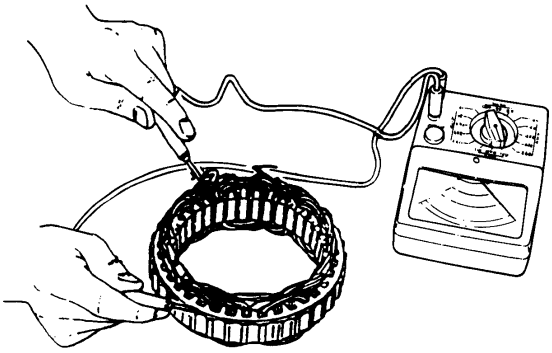


(3) Stator
1) Stator coil continuity test
Check the continuity between each terminal of the stator coil. If there is no continuity, there is a wire break in the stator coil. Replace the stator coil.

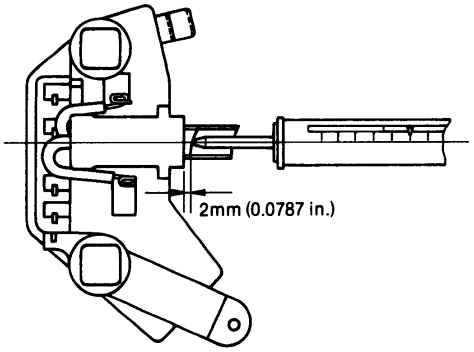


Resistance value	Approx. 0.041Ω at 20°C u, v-phase resistance
	Approx. 0.036Ω at 20°C w-phase resistance

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.

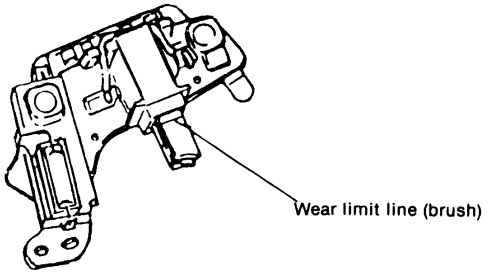


(4) Brush
The brush is hard and wears slowly, but when it is worn beyond the allowable limit, replace it. When replacing the brush, also check the strength of the brush spring.
To check, push the spring down to 2mm (0.0787in.) from the end surface of the brush holder, and read the gauge.



Brush spring strength	255—345g (0.56 ~ 0.76lb.)

(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 (0.6299)	9 (0.3543)

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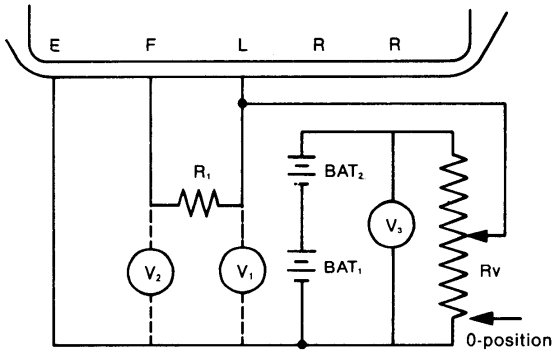
(6) IC regulator

Connect the variable resistance, two 12V batteries, resistor, and voltmeter as shown in the diagram.

1) Use the following measuring devices.

Resistor (R_1)	100Ω, 2W, 1pc.
Variable resistor (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 0-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 0-position, and connect the voltmeter to the V_1 position.
   c) While measuring V_1 (voltage between L-E terminals), move Rv gradually from the 0-position. There should be a point where the voltage of V_1 rises sharply by 2—6V. Measure the voltage of V_1 just before this sharp voltage rise. This is the regulating voltage of the regulator. If this voltage of V_1 is within the standard limit, the regulator is normal. If the voltage deviates from the limit, the regulator is defective. Replace the regulator.

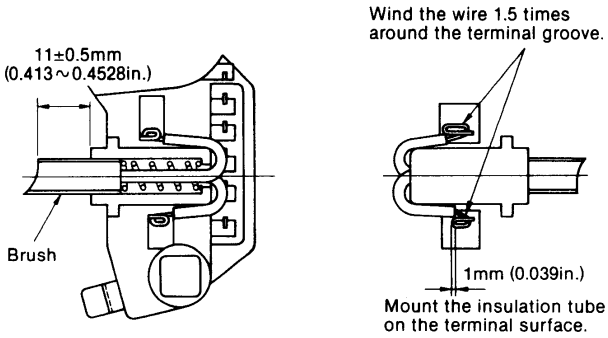


10-9 Reassembling the alternator

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

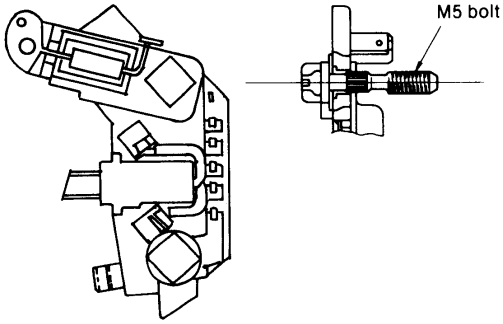
(1) Assembling the brush regulator

1) Solder the brush.
   Position the brush as shown in the drawing and solder it. Be careful not to let the solder drip into the pig tail (lead wire).



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

2) Mount the IC regulator on the brush holder as illustrated, and press in the M5 bolt. Do not forget to assemble the bushing and the connecting plate at the same time.
   (If the bushing is left out, the output terminal will be earthed and the battery short-circuited).



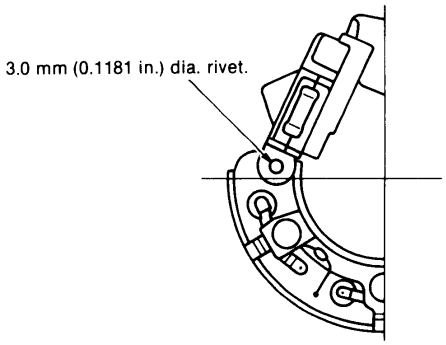
NOTES: 1. Insertion pressure is 100kg (220.5 lbs.)
2. Insert vertically.

(2) Connecting the brush regulator assembly and diode

1) Check the rivets
   Place the rivets as shown in the figure, and then calk them using the calking tool.

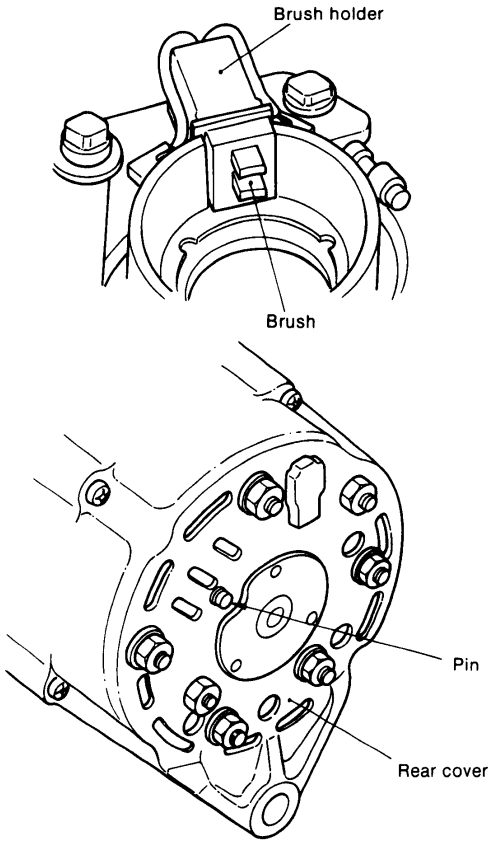
Calking torque	500kg (1102 lbs.)

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 (1102 lbs.)

(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.

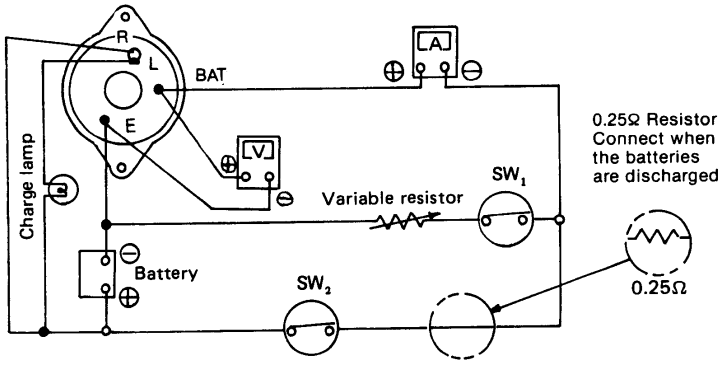


(4) Tightening torques

Positions	Tightening torque kg-cm (ft-lb)
Brush holder fixing	32–40 (2.31~2.89)
Diode fixing	60–70 (4.33~5.05)
Bearing retainer fixing	32–40 (2.31~2.89)
Pulley nut tightening	400–600 (28.93~43.40)
Through-bolt tightening	32–40 (2.31~2.89)

10-10 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.
Variable 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_1 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 the indication is over 5A, connect the 0.25Ω resistor. The voltmeter indication at this time must be within the prescribed regulating voltage value.
2. Raise the AC generator revolutions high to make sure the regulating voltage does not fluctuate along with changes in the revolution speed.

(3) Precautions for measuring the regulating voltage
1) When measuring the voltage, measure the voltage between the AC generator BAT terminal, or Battery + terminal, and AC generator E-terminal.
2) Use a fully charged battery.
3) Measure the voltage quickly.
4) Keep SW_1 open for measurement.

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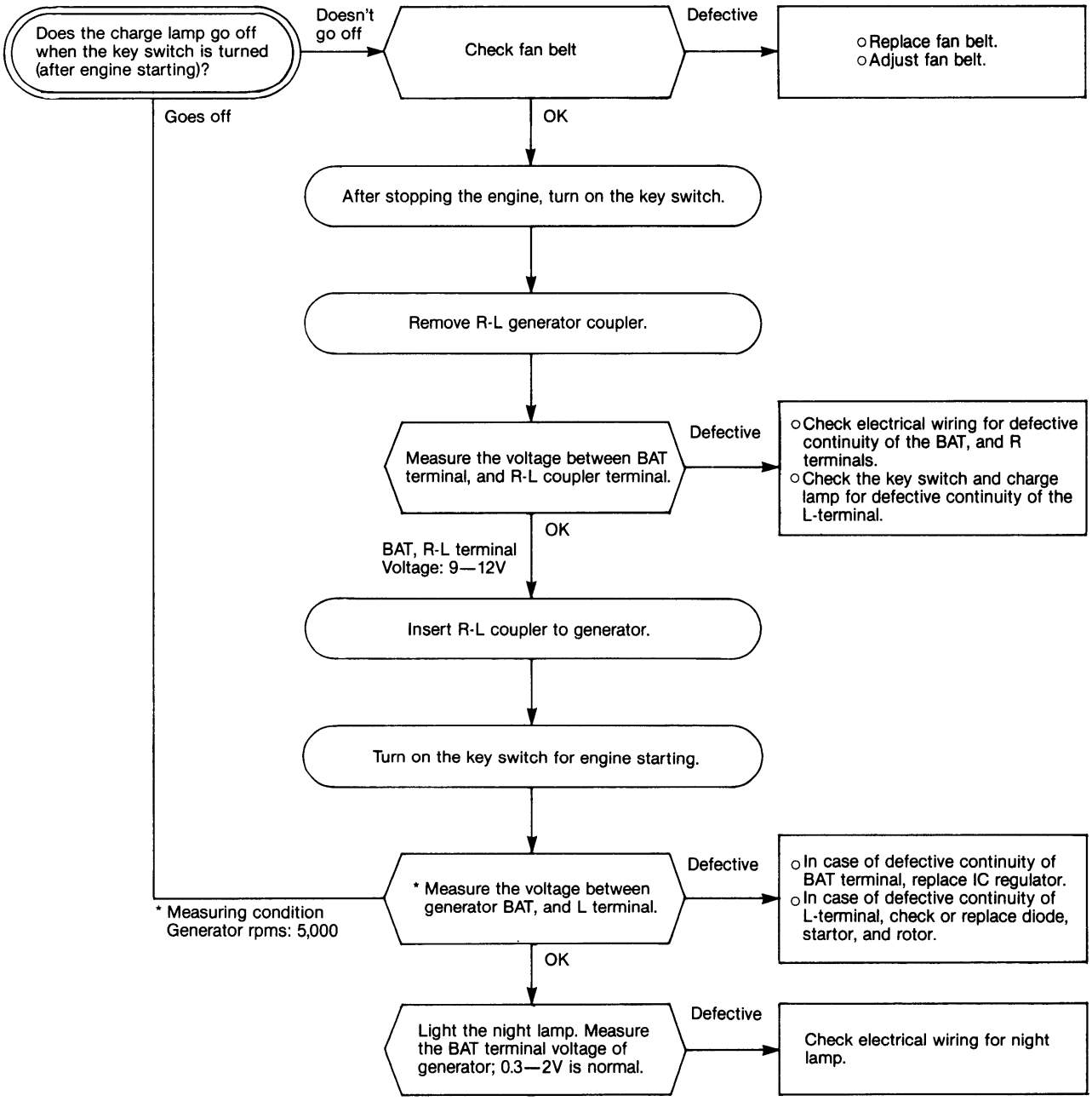
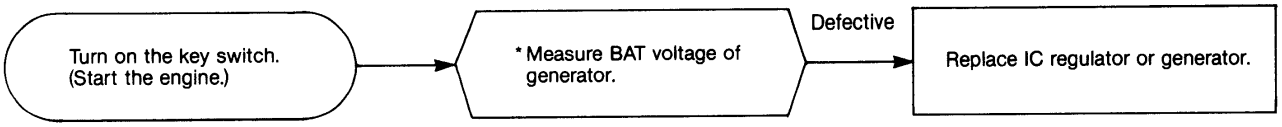
10-11 Troubleshooting

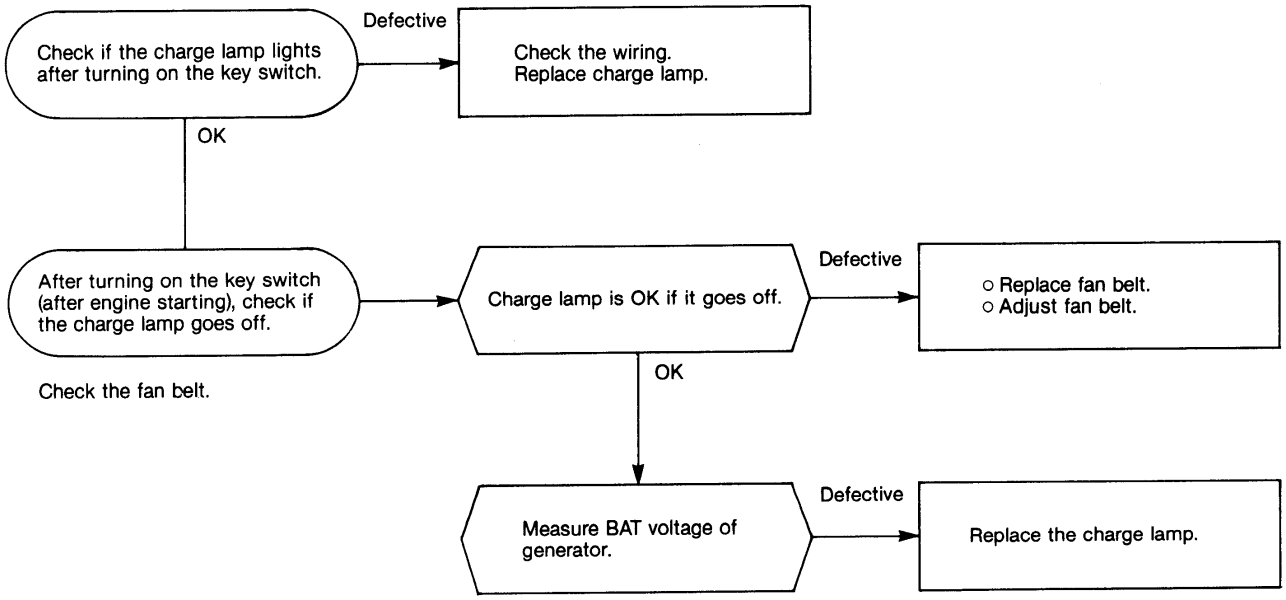
(1) Charging failure



(2) Overcharging



(3) Charge lamp failure



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CHAPTER 10

DISASSEMBLY AND REASSEMBLY

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1. Disassembly and Reassembly Precautions

(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 container(s).
- Drain cooling water (sea water, fresh water) and lube oil.
- Close the Kingston cock.

(2) Reassembly
- Sufficiently clean and inspect all parts to be assembled.
- Coat sliding and rotating parts with new engine oil when assembling.
- Replace all gaskets and O-rings.
- Use a liquid packing agent as necessary to prevent oil/water leaks.
- Check oil and thrust clearances, etc. of parts when assembling.
- Make sure you use the correct bolt/nut/washer. Tighten main bolts/nuts to specified torque. Be especially careful not to overtighten the aluminum alloy part mounting bolts.
- Align match mark (if any) when assembling. Make sure that the correct set of parts is used for bearings, pistons, and other parts for which a property fit is used.

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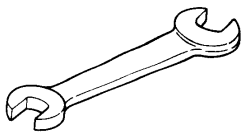
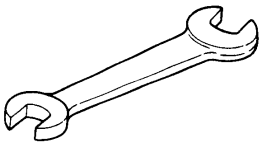
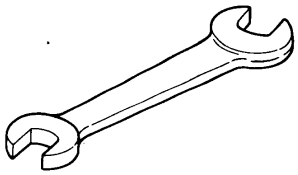
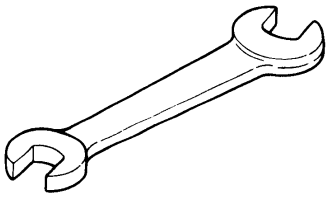
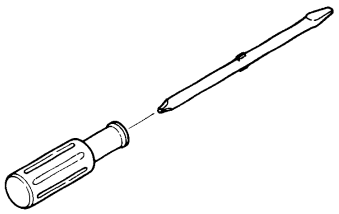
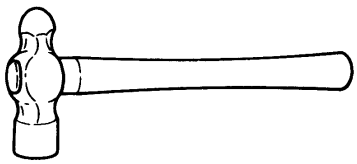
2. Disassembly and Reassembly Tools

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

2-1. General Handtools

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

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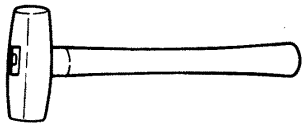
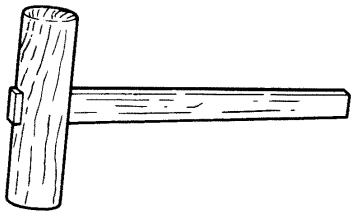
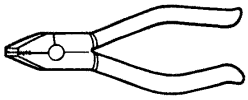
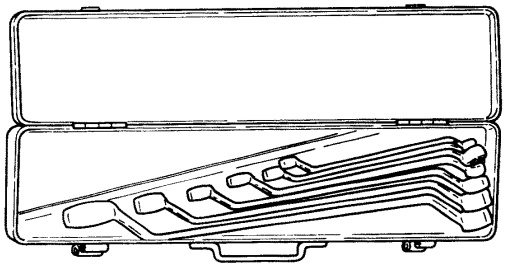
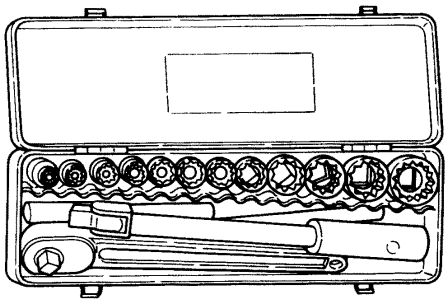
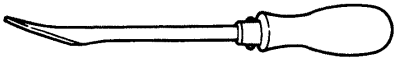
Name of tool	Illustration	Remarks
Copper hammer		Local supply
Mallet		Local supply
Nippers		Local supply
Pliers		Local supply
Offset wrench		Local supply 1 set
Box spanner		Local supply 1 set
Scraper		Local supply

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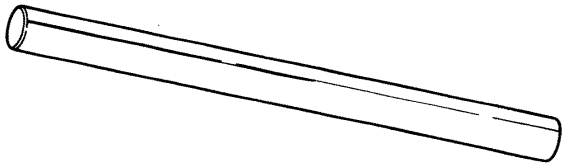
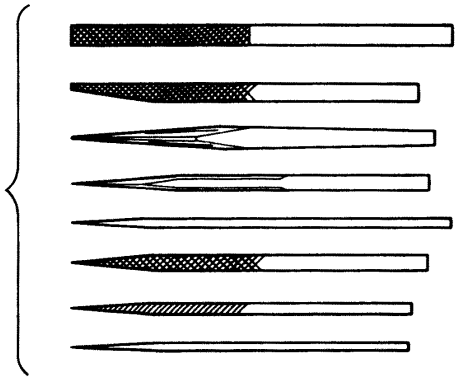
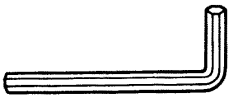
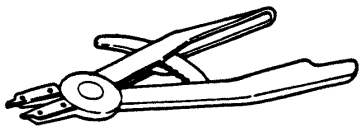
Name of tool	Illustration	Remarks
Lead rod		Local supply
File		Local supply 1 set
Rod spanner for hexagon socket head screws		Local supply Size: 6mm (0.2362in.) 8mm (0.3150in.) 10mm (0.3937in.)
Starling Pliers Hole type Shaft type	 S—0  H4 ∼ H8 S = Hole type H = Shaft type	Local supply

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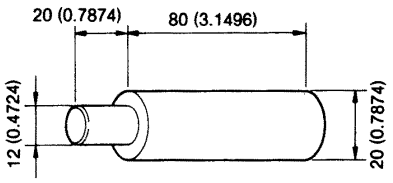
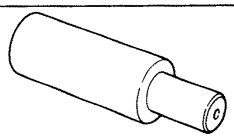
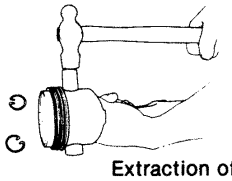
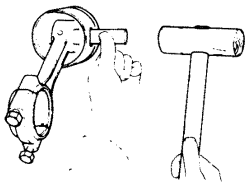
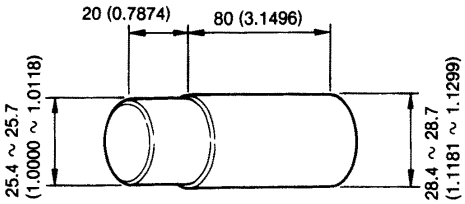
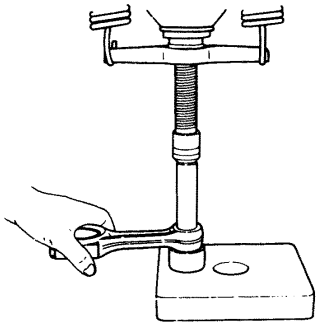
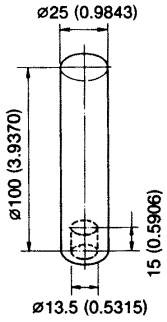
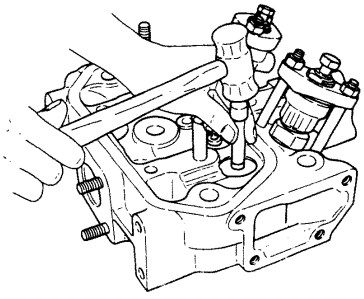
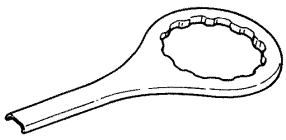
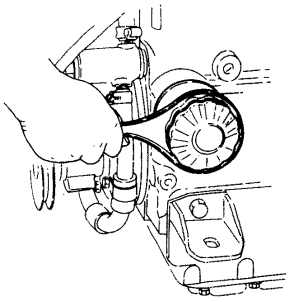
2-2 Special Handtools

Name of tool	Shape and size	Application
Piston pin insertion/ extraction tool	mm (in.)  Part No. 128670-92260	 Piston pin extractor  Extraction of piston pin  Insertion of piston pin
Connecting rod small end bushing insertion/ extraction tool	mm (in.) 	 Extraction
Intake and exhaust valve insertion/ extraction tool	mm (in.) 	
Lubricating oil No.2 filter case remover		

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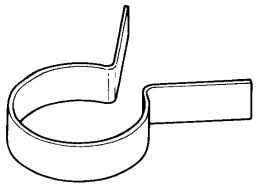
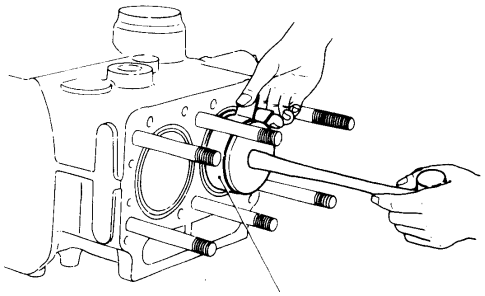
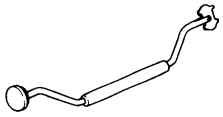
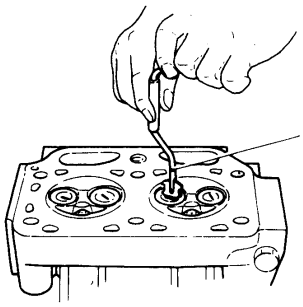
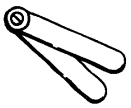
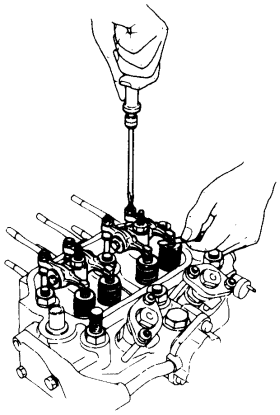
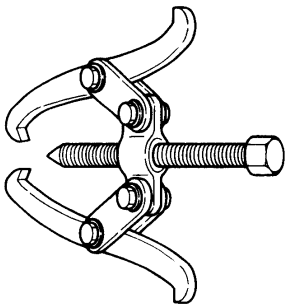
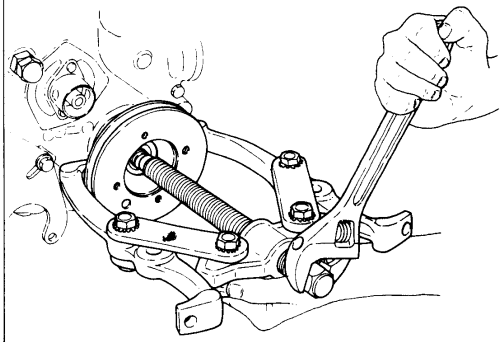
Name of tool	Shape and size	Application
Piston ring compressor		 Piston insertion guide
Valve lapping handle		 Lapping tool
Valve lapping powder		
Feeler gauge		
Pulley puller	 Local supply	 Removing the coupling

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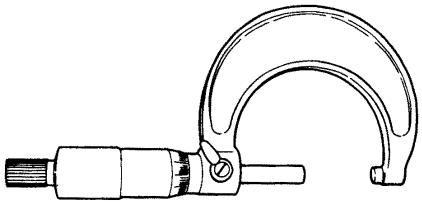
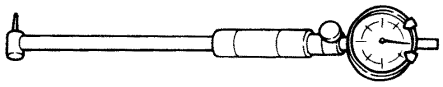
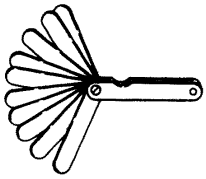
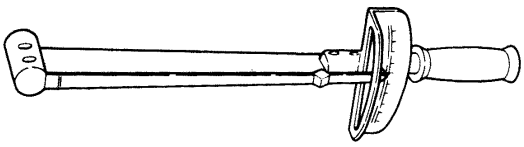
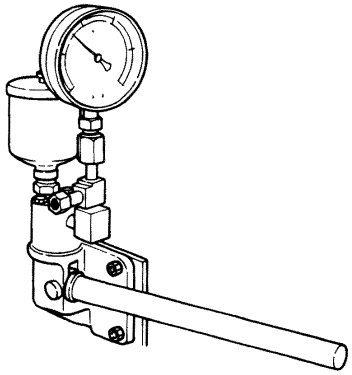
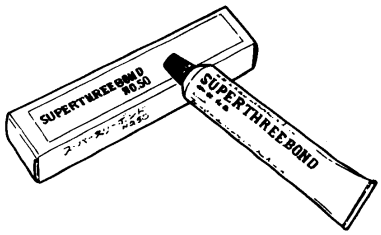
2-3 Measuring Instruments

Name of tool	Shape and size	Application
Vernier calipers		0.05mm (0.0020in.), 0 ~ 150mm (0 ~ 5.9055in.)
Micrometer		0.01mm (0.0004in.) 0 ~ 25mm (0 ~ 0.9843in.), 25 ~ 50mm (0.9843 ~ 1.9685in.), 50 ~ 75mm (1.9685 ~ 2.9528in.), 75 ~ 100mm (2.9528 ~ 3.9370in.), 100 ~ 125mm (3.9730 ~ 4.9213in.). 125 ~ 150mm (4.9213 ~ 5.9055in.).
Cylinder gauge		0.01mm (0.0004in.), 18 ~ 35mm (0.7087 ~ 1.3780in.), 35 ~ 60mm (1.3780 ~ 2.3622in.), 50 ~ 100mm (1.9685 ~ 3.9370in.).
Thickiness gauge		0.05 ~ 2mm (0.0020 ~ 0.0787in.)
Torque wrench		0 ~ 13kg-m. (0 ~ 94ft-lb)
Nozzle tester		0 ~ 500kg/cm² (0 ~ 7111.7lb/in.²)

2-4 Other

Supplementary packing agent

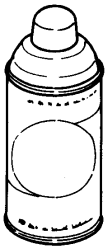


Type	Use
"Three Bond 3B8-005"	White. Since "Three Bond 3B8-005" is a nonorganic solvent, it does not penetrate asbestos sheets made principally or completely of asbestos. Always use it with grey asbestos sheet packing for complete oil tightness. When "Three Bond 3B8-005" is difficult to obtain, use silicon nonsolvent type "Three Bond No. 50."
"Three Bond No. 50"	Grey. Silicon nonsolvent type liquid packing. Semidry type packing agent coated on mating faces to prevent oil and gas leakage. Does not penetrate asbestos sheet and assures complete oil tightness.
"Three Bond No. 1"	Reddish brown. Paste type wet viscous liquid packing. Ideal for mating faces which are removed but reinstalled. Particularly used to prevent water leakage and to prevent seizing of bolts and nuts.

Products of Three Bond Co., Ltd.

The surface to be coated must be thoroughly cleaned with thinner or benzene and completely dry. Moreover, coating must be thin and uniform.

Paint



Color spray

Only Metallic Ecole Silver is used on this engine.

Wipe the surface to be painted with thinner or benzene, shake the spray can well, push the button at the top of the can and spray the paint onto the surface from a distance of 30 ~ 40 cm.

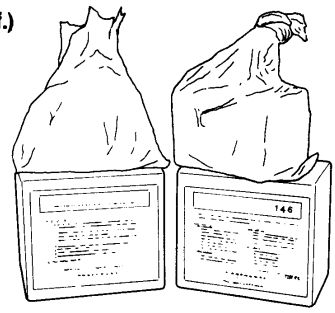
Paint

Type
White paint
(Mixed oil paint)

Usage point
Cylinder liner
insertion hole

Use
Paint parts that contact with the cylinder body when inserting the cylinder liner to prevent rusting and water leakage.

Yanmar cleaner (Ref.)



Cooling passage cleaner is mixed by adding one part "Unicon 146" to about 16 parts water (specific gravity ratio). To use, drain the water from the cooling system, fill the system with cleaner, allowing it to stand overnight (10 ~ 15 hours). Then drain out the cleaner, refill the system with water, and operate the engine for at least one hour.

NEJI LOCK SUPER 203M: a locking agent for screws (Ref.)

For coating on screws and bolts to prevent loosening, rusting, and leaking. To use, wipe off all oil and water on the threads of studs, coat the threads with screw lock, tighten the stud bolt, and allow them to stand until the screw lock hardens. Use screw lock on the oil intake pipe threads, oil pressure switch threads, fuel injection timing shim faces, and front axle bracket mounting bolts.

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3. Disassembly and Reassembly

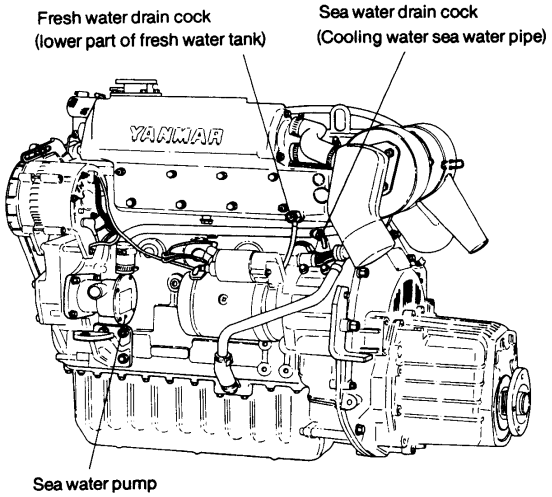
3-1 Disassembly

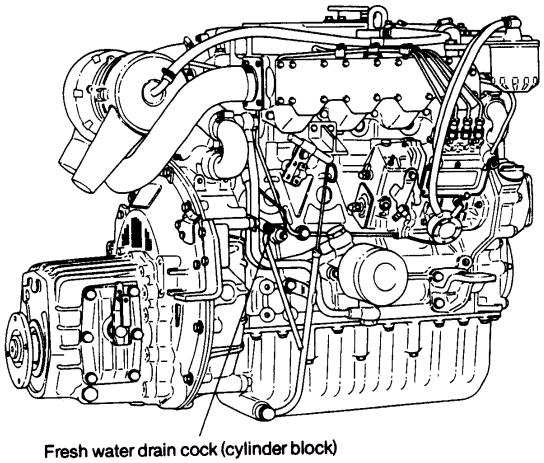
For engines mounted in an engine room, remove the piping and wiring connecting them to the ship.

(1) Remove the remote control cable (from engine and marine gearbox).
(2) Unplug the extension cord for the instrument panel from the engine.
(3) Remove the wiring between the starting motor and the battery.
(4) Remove the exhaust rubber hose from the mixing elbow.
(5) Remove the fresh water sub-tank rubber hose from the filler cap.
(6) Remove the cooling water (sea water) pump sea water intake hose (after making sure the Kingston cock is closed).
(7) Remove the fuel oil intake rubber hose from the fuel feed pump.
(8) Remove the body fit (reamer) bolts and disassemble the propeller shaft coupling and thrust 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 form the cylinder head and cylinder body.
(3) Open the fresh water drain cock on the lower part of the fresh water tank to drain the fresh water.





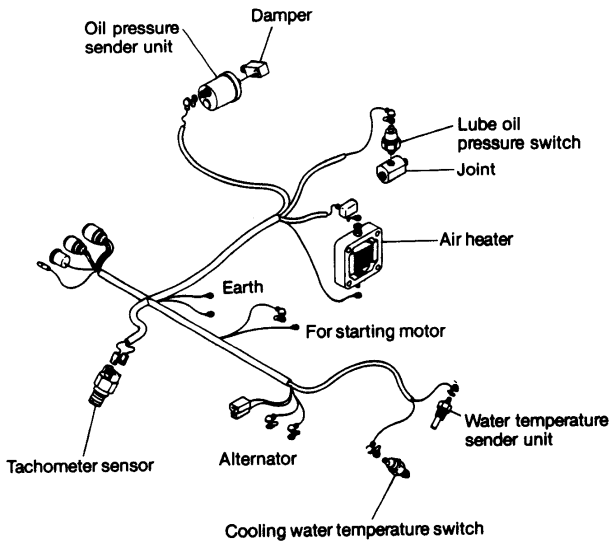
3-1.2 Drain lube oil

(1) Remove the pipe coupling bolt which holds the lube oil dip stick guide, and drain the lube oil from the engine.
(2) Remove the drain plug on the lower part of the crank case control side, and drain the lube oil from the marine gearbox.

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

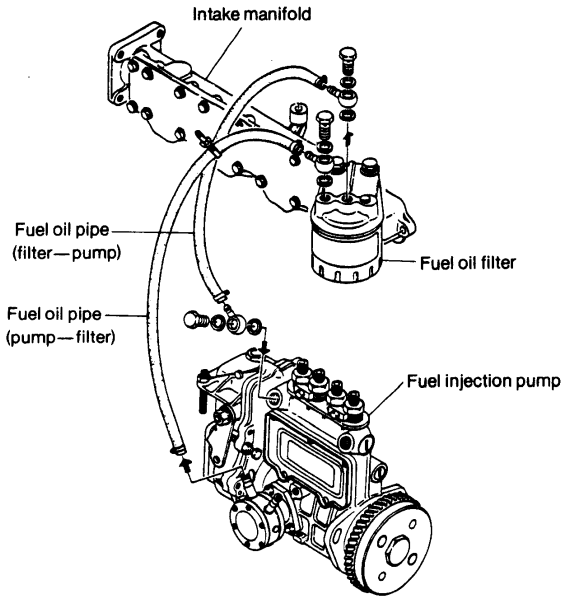
3-1.3 Removing (electrical) wiring

Remove the wiring from the engine.



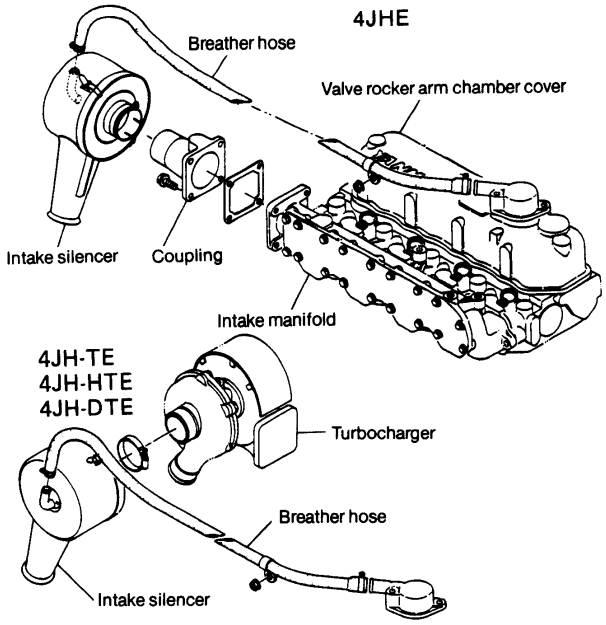
3-1.4 Removing the fuel oil filter & fuel oil pipe

(1) Remove the fuel oil pipe (fuel oil filter—fuel feed pump, fuel oil filter—fuel injection pump).
(2) Remove the fuel oil filter (with bracket) from the intake manifold.



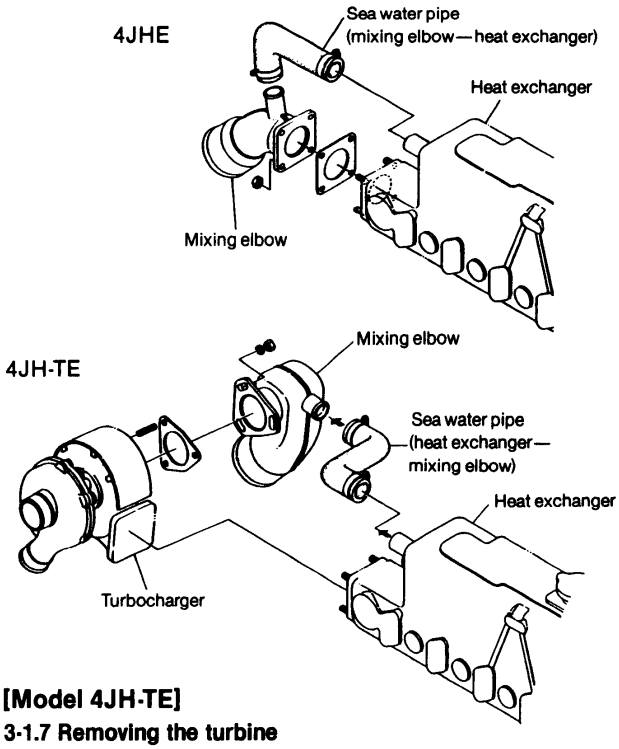
3-1.5 Removing the intake silencer

(1) Remove the breather hose attached to the intake silencer—valve rocker arm chamber cover.
(2) Remove the intake silencer
4JHE: from the intake manifold intake coupling
4JHE, 4JH-HTE, 4JH-DTE:
from the blower side of the turbocharger



3-1.6 Removing the mixing elbow

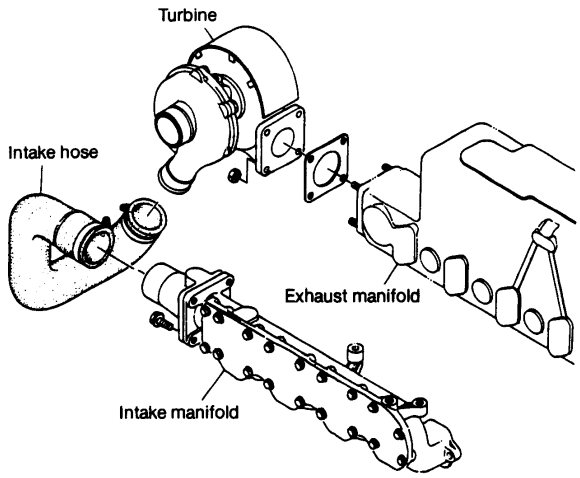
(1) Remove cooling water (sea water) pipe rubber hose (heat exchanger—mixing elbow).
(2) Remove the mixing elbow
4JHE: from exhaust manifold outlet
4JH-TE: from turbocharger outlet



[Model 4JH-TE]

3-1.7 Removing the turbine

(1) Remove the intake rubber hose (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 exhaust manifold.



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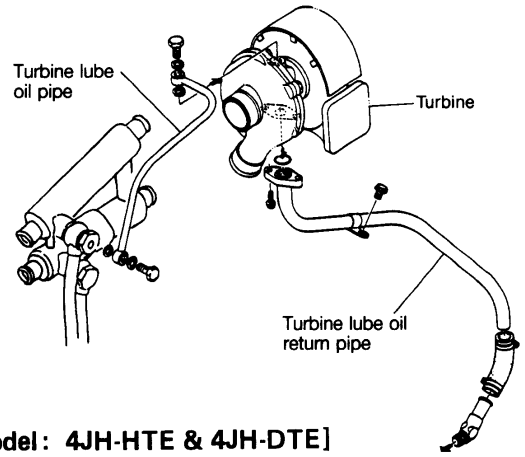
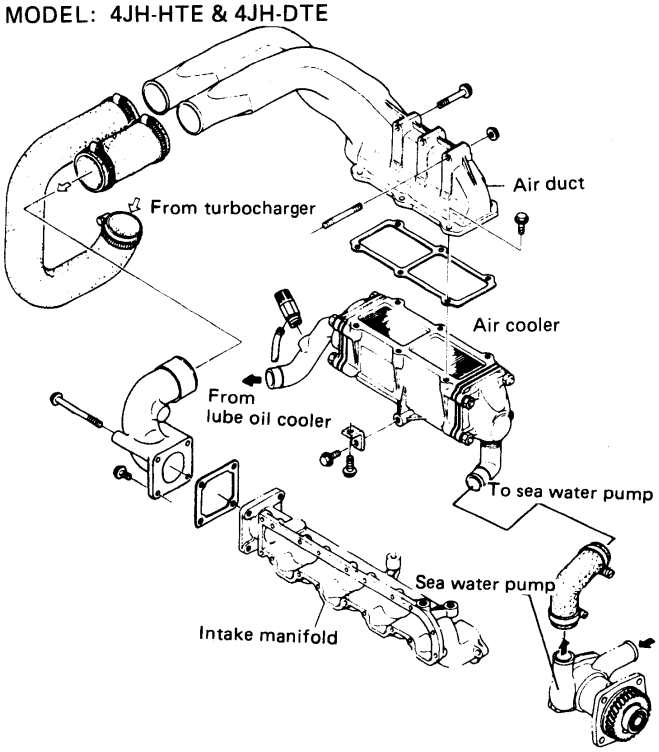


[Model: 4JH-HTE & 4JH-DTE]

Removing the air cooler

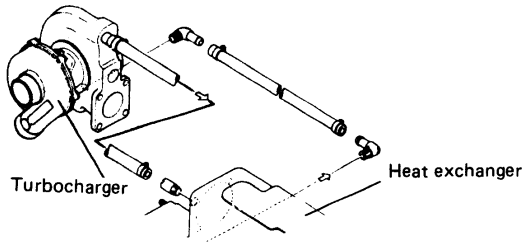
(1) Remove the intake rubber hoses.
(Air duct-intake manifold, and turbocharger)
(2) Remove the sea-water rubber hoses.
(Sea water pump — Air cooler — Lube oil cooler)
(3) Remove the air cooler from the heat exchanger, and cylinder block.

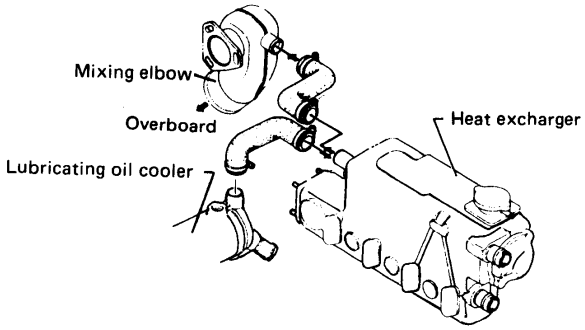
MODEL: 4JH-HTE & 4JH-DTE

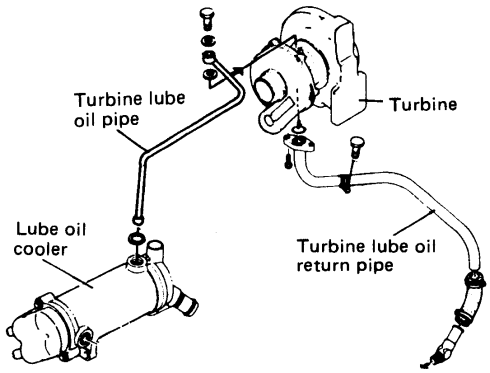


Removing the mixing elbow and the turbocharger.

(1) Remove the fresh water hoses.
(Turbocharger — heat exchanger)
(2) Remove the lube oil pipes.
(Lube oil cooler—Turbocharger—Lube oil pump)
(3) Remove the sea water hose.
(Mixing elbow — heat exchanger)
(4) Remove the mixing elbow from turbocharger.
(5) Remove the air duct rubber hose.
(Air duct — Turbocharger)
(6) Remove the turbocharger from exhaust manifold.

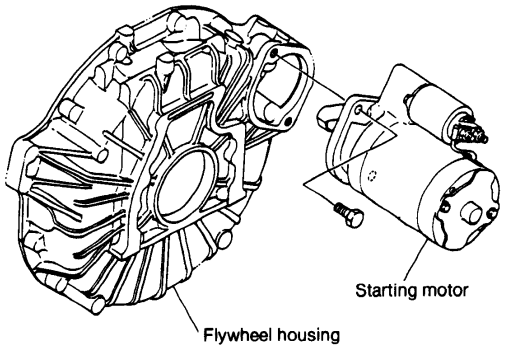






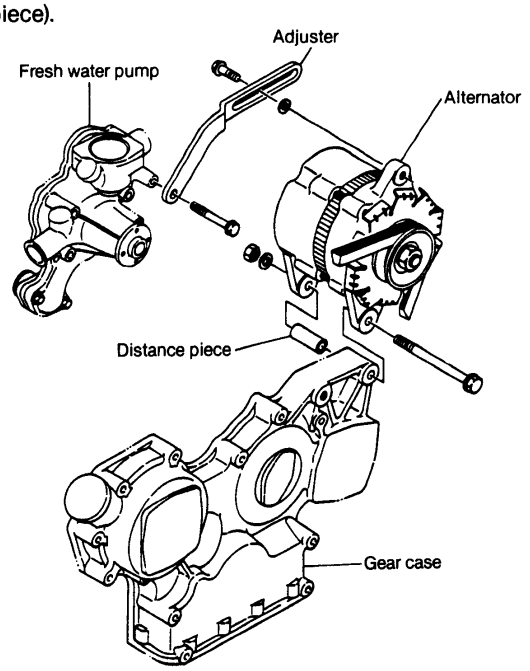
3-1.8 Removing the starting motor

Remove the starting motor from the flywheel housing.



3-1.9 Removing the alternator

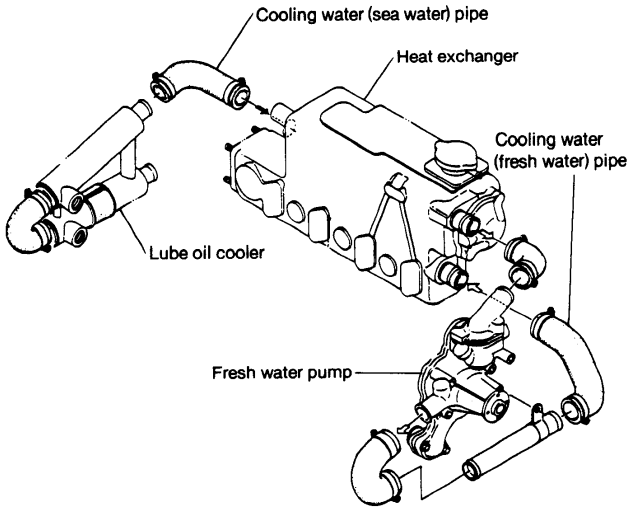
(1) Loosen the alternator adjuster bolt and remove the V-belt.
(2) Remove the adjuster from the fresh water pump, and remove the alternator from the gear case (with distance piece).



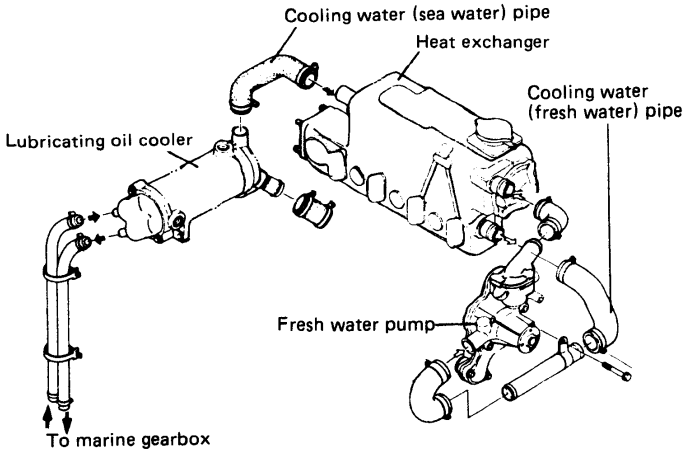
3-1.10 Removing the cooling water pipe

(1) Remove the cooling water (sea water) pipe (lube oil cooler — heat exchanger).
(2) Remove the cooling water (fresh water) pipe (heat exchanger — fresh water pump, fresh water pump — fresh water tank).
(3) Remove the cooling water pipe (lube oil cooler — marine gearbox)

[Model: 4JHE, 4JH-TE]

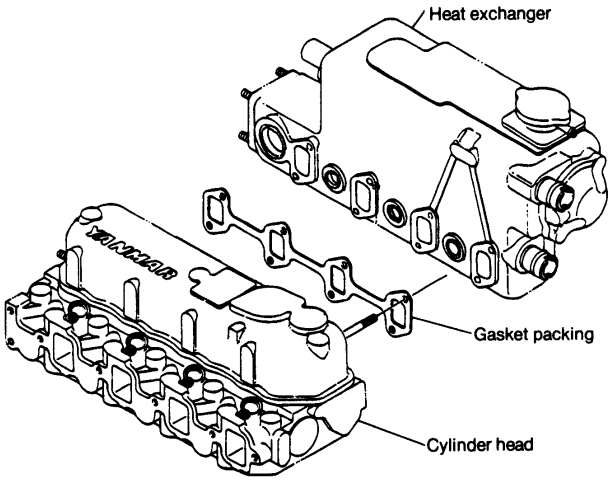


[Model: 4JH-HTE, 4JH-DTE]



3-1.11 Removing the heat exchanger (exhaust manifold, fresh water tank unit)

Remove the heat exchanger and gasket packing.



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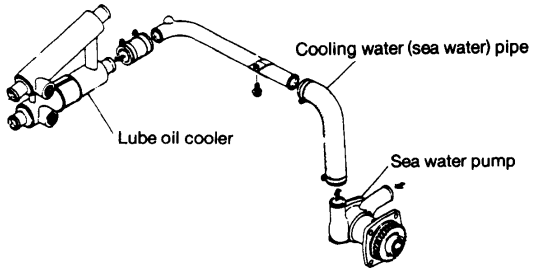
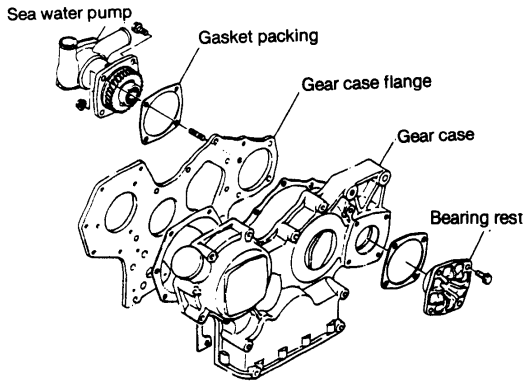
3-1.12 Removing the cooling water (sea water) pipe (sea water pump—lube oil cooler).



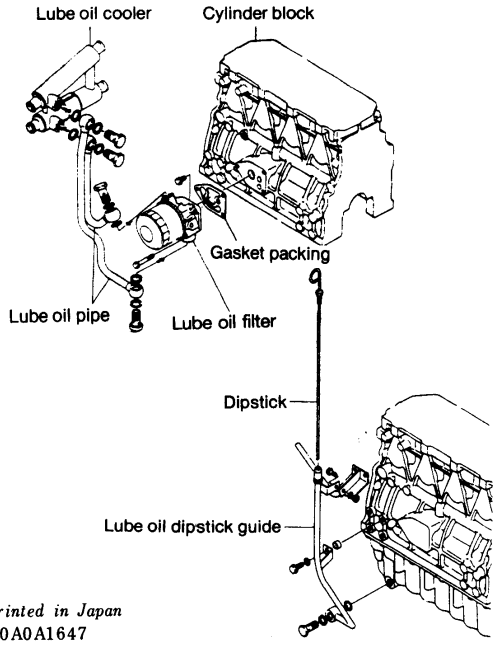
3-1.13 Removing the sea water pump

(1) Pull out the bearing mounts, receptacles from the sea water pump mounting side and from the opposite side of the gear case.
(2) Remove the sea water pump.



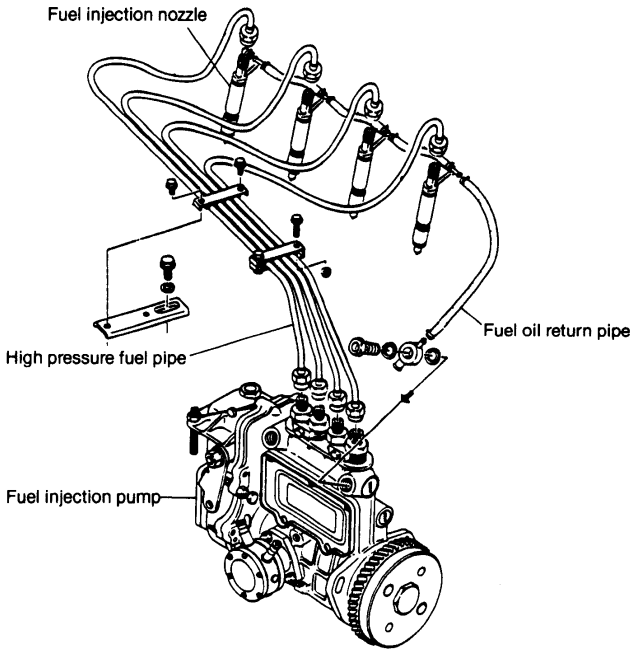
3-1.14 Removing the lube oil filter

(1) Remove the lube oil pipe (lube oil cooler—filter bracket, filter bracket—lube oil cooler).
(2) Remove the filter bracket (with lube oil filter element) from the cylinder block.
(3) Remove the lube oil pipe (cylinder block—fuel injection pump).
(4) Remove the lube oil dipstick and guide.



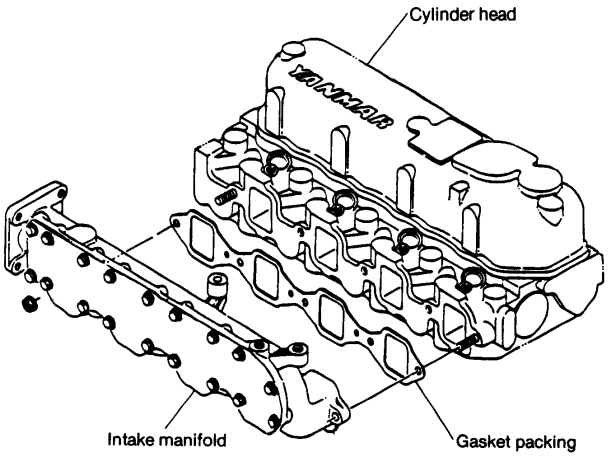
3-1.15 Removing the high pressure fuel pipe

(1) Remove the high pressure fuel pipe vibration stop from the intake manifold.
(2) Loosen the box nuts on both ends of the high pressure fuel pipe and remove the high pressure fuel pipe.
(3) Remove the fuel oil return pipe (fuel injection nozzle—fuel injection pump).



3-1.16 Removing the intake manifold

(1) Remove the governor speed remote control bracket.
(2) Remove the intake manifold and gasket packing.



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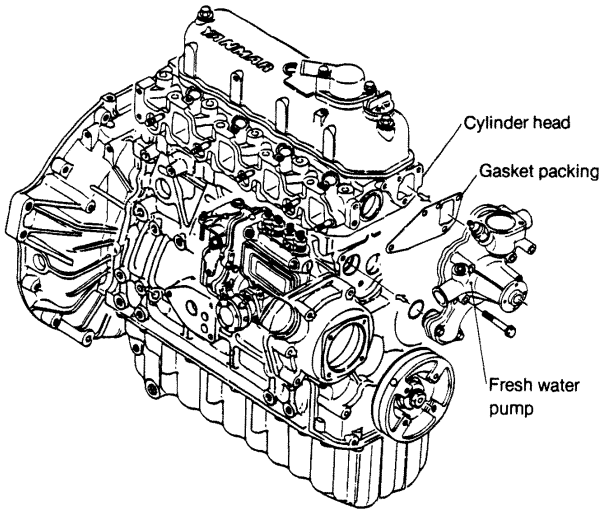
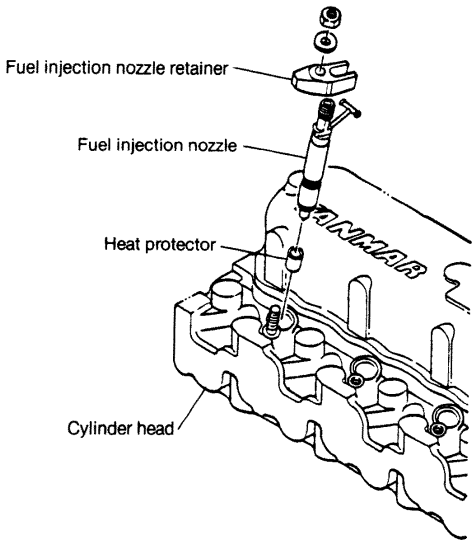
3-1.17 Removing the fresh water pump

Remove the fresh water pump, gasket packing and O-ring.



3-1.18 Removing the fuel injection nozzles

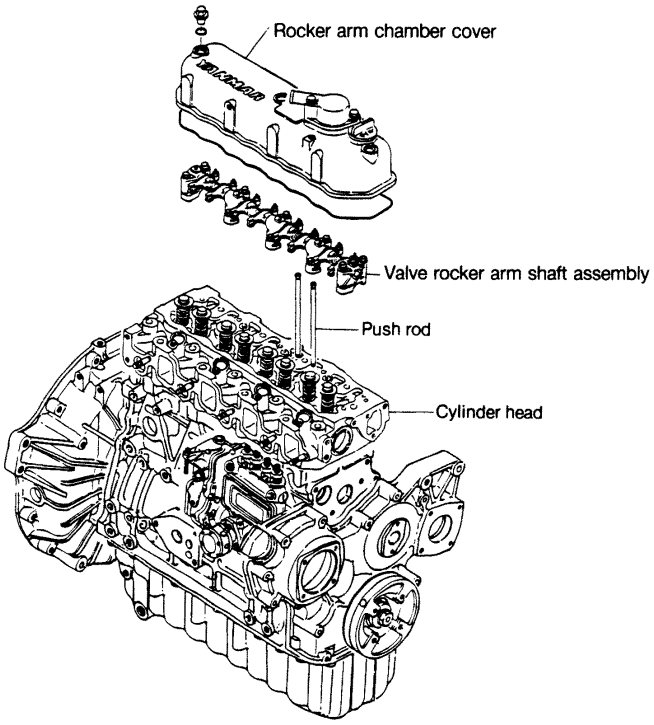
Remove the fuel injection nozzle retainer nut, and pull out the fuel injection nozzle retainer and fuel injection nozzle.



NOTE: If the heat protector stays in the cylinder head, make a note of the cylinder no. and be sure to remove it when you disassemble the cylinder head.

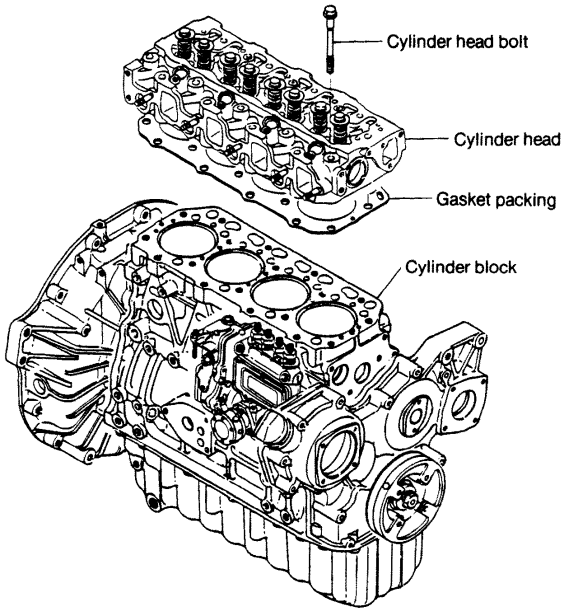
3-1.19 Removing the valve elbow shaft assembly

(1) Remove the valve elbow chamber cover.
(2) Remove the valve elbow shaft support mounting bolts(s), and remove the entire valve elbow shaft assembly.
(3) Pull out the push rods.



3-1.20 Remvoing the cylinder head

(1) Remove the cylinder head bolts with a torque wrench, and remove the cylinder head.
(2) Remove the cylinder gasket packing.



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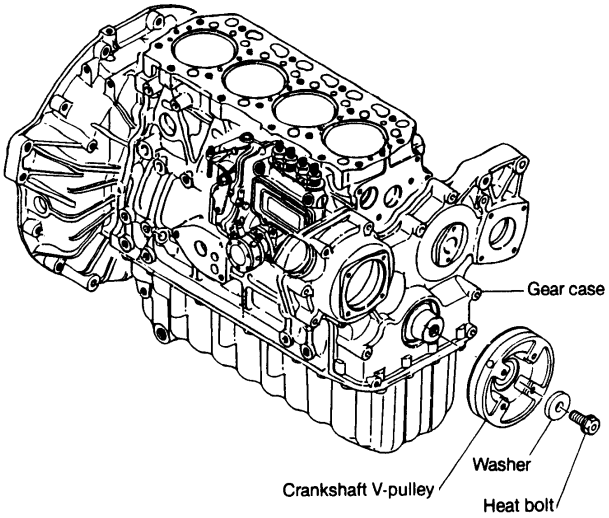
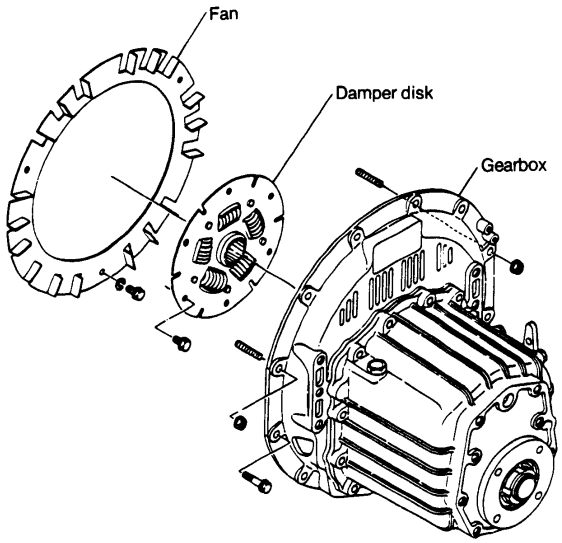
3-1.21 Removing the crankshaft V-pulley

Remove the hex bolts holding the crankshaft V-pulley, and remove the crankshaft V-pulley with an extraction tool.



3-1.22 Removing the marine gearbox

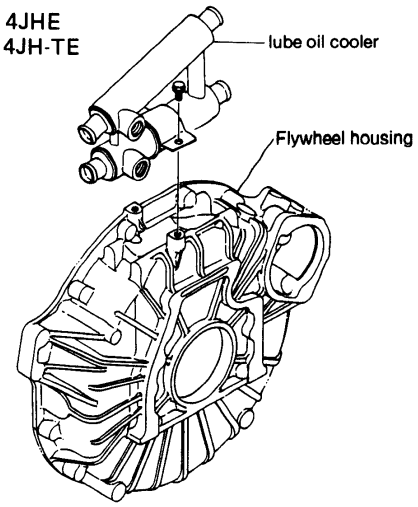
(1) Remove the hex bolts from the clutch case flange, and remove the gearbox assembly.
(2) Remove the damper disk from the flywheel.
(3) Remove the fan from the flywheel.



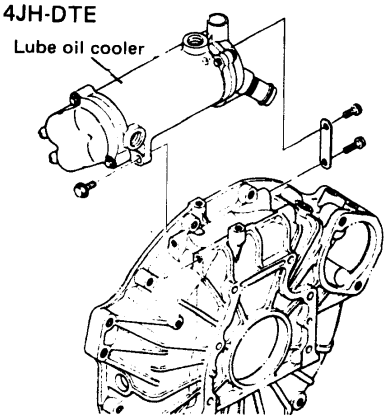
3-1.23 Removing the lube oil cooler

Remove the lube oil cooler from the upper part of the flywheel housing.

MODEL: 4JHE
4JH-TE

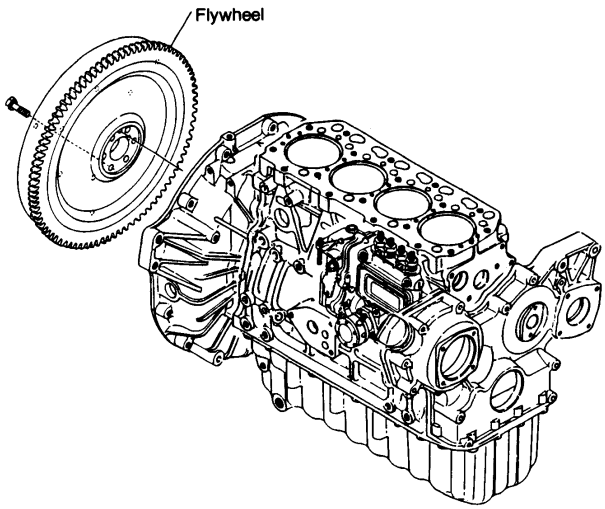


MODEL: 4JH-HTE
4JH-DTE



3-1.24 Removing the flywheel

Remove the flywheel mounting bolts and then the flywheel.



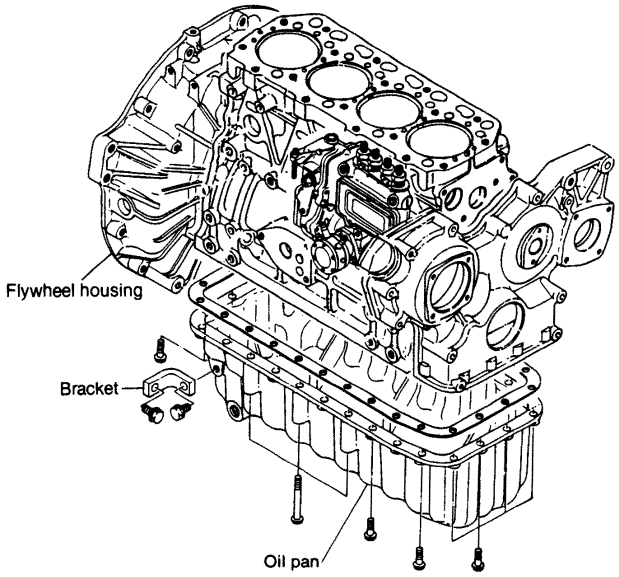
NOTE: Be careful not to scratch the ring gear.

3-1.25 Turning the engine over

(1) Place a wood block of appropriate size on the floor, and stand up the engine on the flywheel housing.
(2) Remove the engine mounting feet.

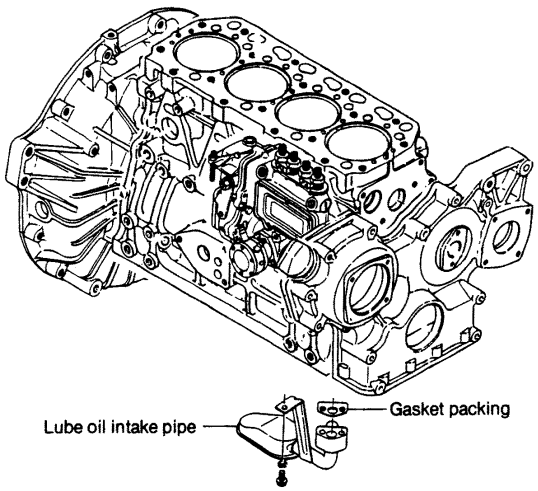
3-1.26 Removing the oil pan

(1) Remove the bracket holding the oil pan and clutch housing.
(2) Remove the oil pan and gasket packing.



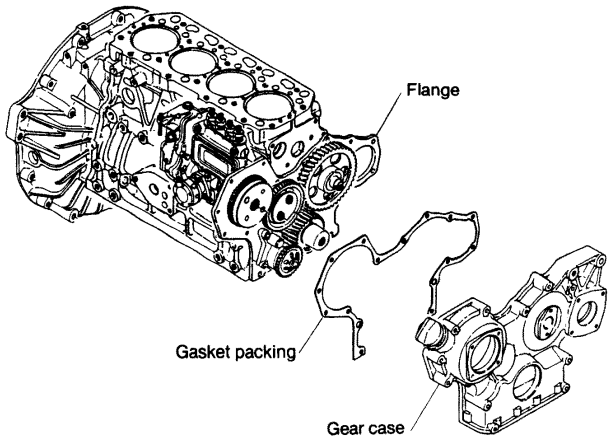
3-1.27 Removing the lube oil intake pipe

Remove the lube oil intake pipe and gasket packing.



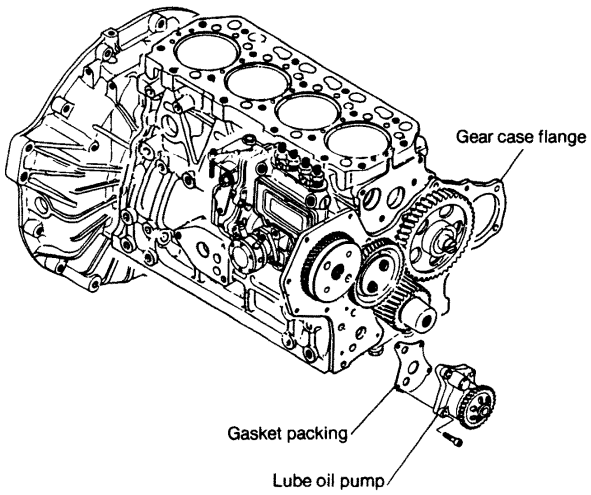
3-1.28 Removing the gear case

Remove the gear case mounting bolts, and remove the gear case from the cylinder block.



3-1.29 Removing the lube oil pump

Remove the lube oil pump and gasket packing from the gear case flange.



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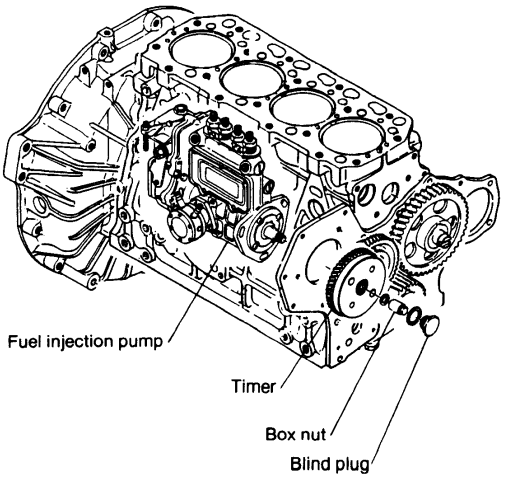
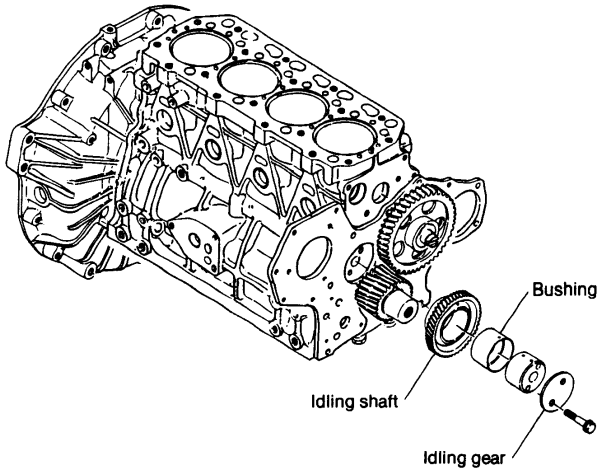
3-1.30 Remove the fuel injection pump

(1) Remove the blind plug mounted to the hub of the automatic advancing timer.
(2) Remove the box nut, and pull out the fuel oil pump drive gear/automatic advancing timer assembly with an extraction tool.
(3) Remove the fuel injection pump and O-ring from the gear case flange.



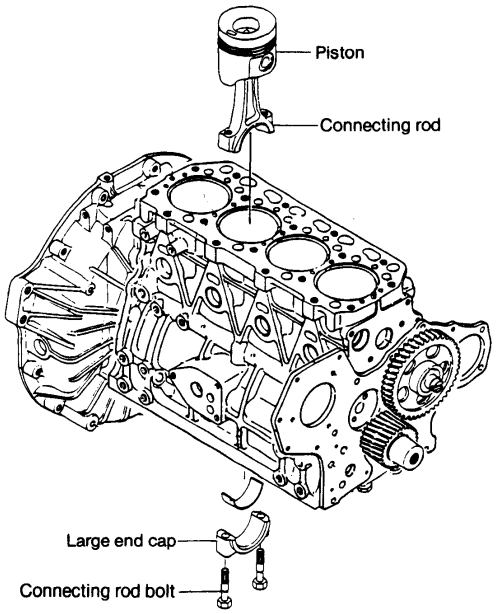
3-1.31 Removing the idling gear

Remove the two hex bolts holding the idling shaft, and pull out the idling gear and idling shaft.



3-1.32 Removing the pistons and connecting rods

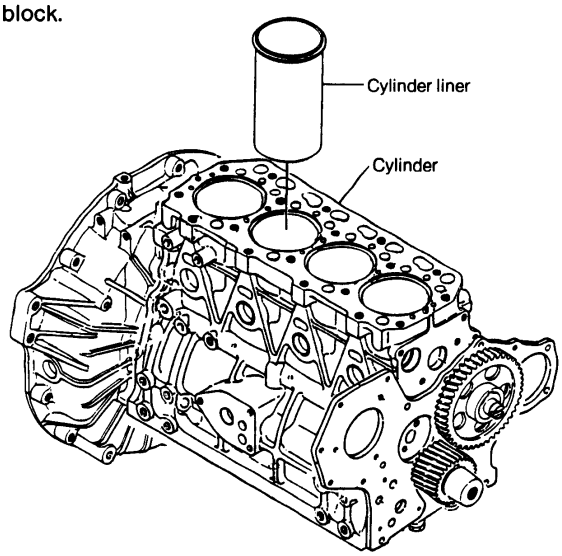
(1) Remove the connecting rod bolt and the large end cap.
(2) Push the connecting rod from the bottom and pull out the piston connecting rod assembly.



NOTE: Place a tool against the piston cooling nozzle to make sure the nozzle position does not change and it does'nt get scratches.

3-1.33 Removing the cylinder liner

Remove the cylinder liner from the top of the cylinder block.



NOTE: If it is difficult to pull out the liner, tap the bottom of the liner with a plastic hammer.

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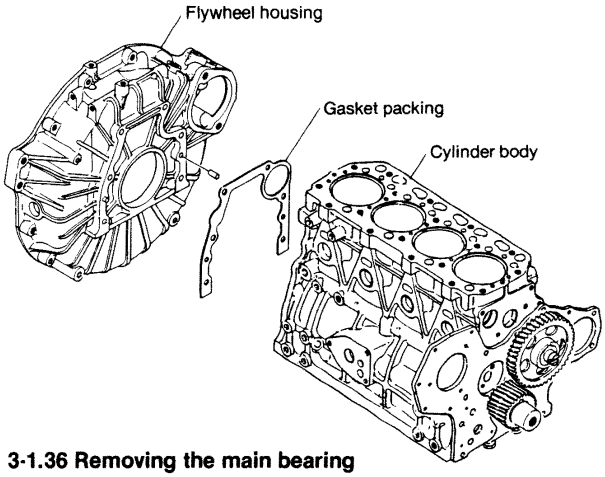
3-1.34 Turning the engine over

Place a wood block of suitable size on the floor and turn the engine over, with the cylinder head mounting surface facing down.

NOTE: Make sure that the cylinder head positioning pins on the cylinder block do not come in contact with the wood block.

3-1.35 Removing the flywheel housing

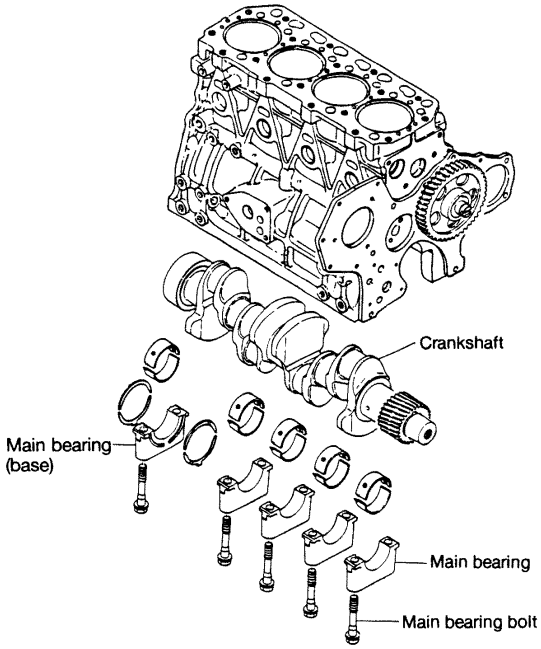
Remove the flywheel housing from the cylinder block.



3-1.36 Removing the main bearing

(1) Remove the main bearing bolts.
(2) Remove the main bearing cap and lower main bearing metal.

NOTE: The thrust metal (lower) is mounted to the standard main bearing cap. Be sure to differentiate between mounting surfaces.



3-1.37 Removing the crankshaft

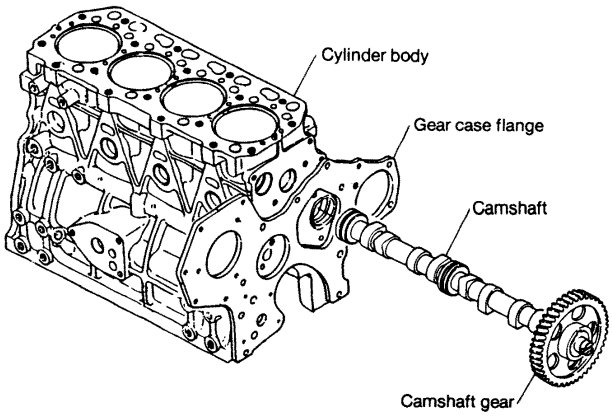
(1) Remove the crankshaft

NOTE: 1. The thrust metal (upper) is mounted to the standard main bearing. However, in some cases the thrust metal (upper) may be mounted to the crankshaft.
2. Remove the main bearing metal (upper) from the cylinder block.

3-1.38 Removing the camshaft

(1) Loosen the thrust rest mounting bolts out of the holes in the camshaft gear, and remove.
(2) Pull out the camshaft gear and camshaft assembly from the cylinder block.

NOTE: The camshaft gear and camshaft are shrunk fit. They must be heated to 180—200°C to disassemble.

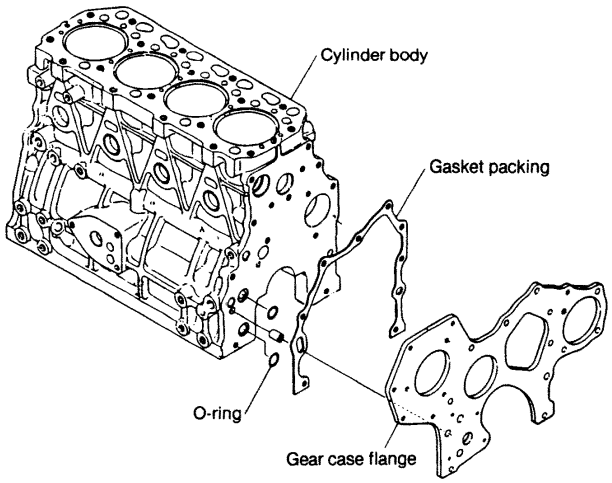


3-1.39 Removing the tappets

Remove the tappets from the tappet holes in the cylinder block.

3-1.40 Removing the gear case flange

(1) Remove the gear case flange from the cylinder block.
(2) Remove the two O-rings from the lube oil passage.



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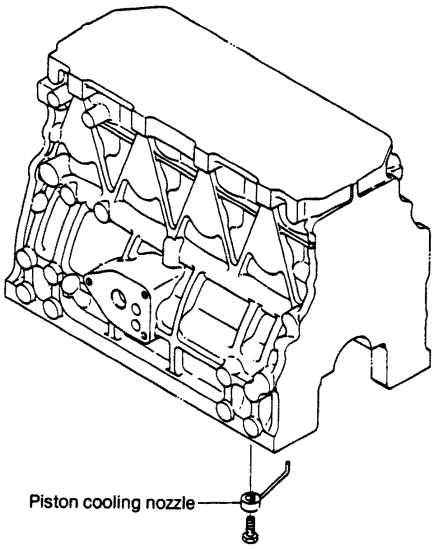
3-1.41 Removing the piston cooling nozzle

Remove the piston cooling nozzle mounting nut and then the piston cooling nozzle from the cylinder block.

3-2 Reassembly

3-2.1 Mounting the piston cooling nozzle

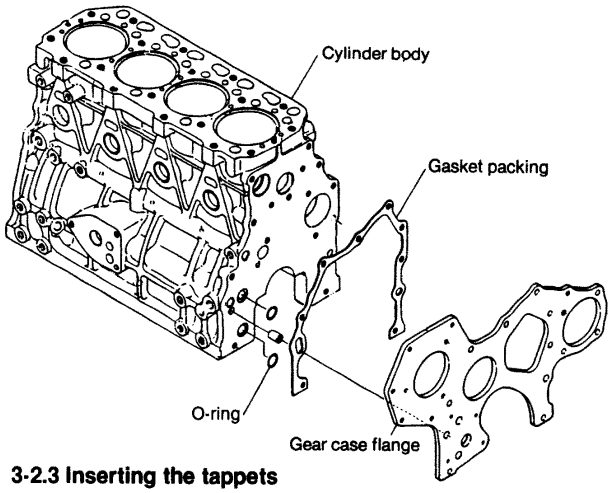
Turn the cylinder block upside down and place it on appropriate wood blocks. Mount the piston cooling nozzles.



3-2.2 Mounting the gear case flange

Mount the gear case flange, gasket packing and lube oil line O-ring onto the cylinder block.

NOTE: 1. When mounting the gear case flange, match up the two cylinder block pipe knock pins.
2. Be sure to coat the cylinder block lube oil line O-ring with grease when assembling, so that it does not get out of place.



3-2.3 Inserting the tappets

Coat the inside of the cylinder block tappet holes and the outside circumference of the tappets with engine oil, and insert the tappets in the cylinder block.

NOTE: Separate the tappets to make sure that they are reassembled in the same cylinder, intake/exhaust manifold as they came from.

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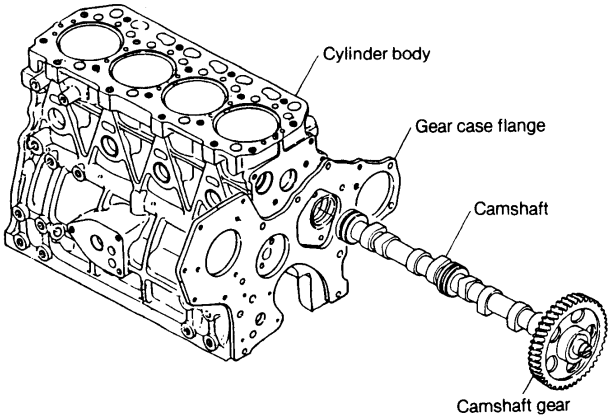
3-2.4 Mounting the camshaft

(1) If the camshaft and camshaft gear have been disassembled, shrink fit the camshaft and camshaft gear [heat the camshaft gear to 180—200°C (356—392°F) in the hot oil and press fit].

NOTE: When mounting the camshaft and camshaft gear, be sure not to forget assembly of the thrust rest. Also make sure they are assembled with the correct orientation.

(2) Coat the cylinder block camshaft bearings and camshaft with engine oil, insert the camshaft in the cylinder block, and mount the thrust rest with the bolt.



(3) Measure the camshaft side gap.

mm (in.)

Camshaft side gap	0.05 ~ 0.25 (0.0020 ~ 0.0098in.)

(4) Make sure that the camshaft rotates smoothly.

3-2.5 Mounting the crankshaft

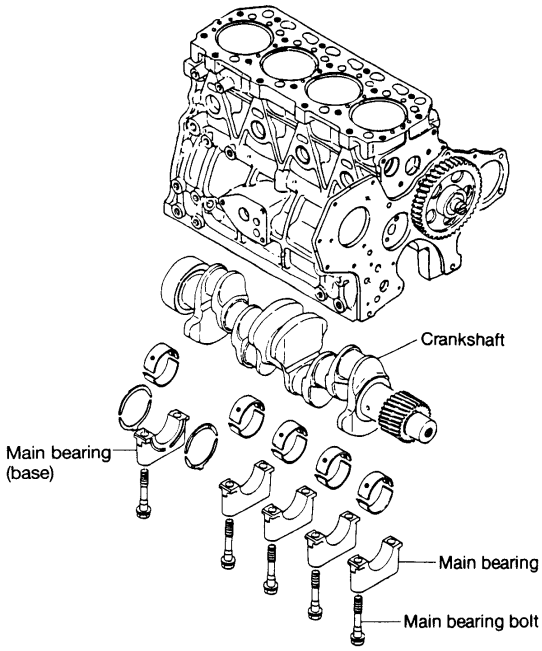
(1) The crankshaft and crankshaft gear are shrink fitted. If the crankshaft and crankshaft gear have been disassembled, they have to be shrink fitted [heat the crank shaft gear to 180°—200°C (356—392°F) in the hot oil and press fit].

(2) Coat the cylinder block crank journal holes and upper part of the main bearing metal with oil and fit the upper main bearing metal onto the cylinder block.

NOTE: 1. Be sure not to confuse the upper and lower main bearing metals. The upper metal has an oil groove.
2. When mounting the thrust metal, fit it so that the surface with the oil groove slit faces outwards, (crankshaft side).

(3) Coat the crank pin and crank journal with engine oil and place them on top of the main bearing metal.

NOTE: 1. Align the crankshaft gear and camshaft gear with the "A" match mark.
2 Position so that the crankshaft gear is on the gear case side.
3. Be careful not to let the thrust metal drop.



3-2.6 Mounting the main bearing metal with engine oil, and mounting the main bearing cap.

NOTE: 1. The lower main bearing metal does not have an oil groove.
2. The standard bearing thrust metal is fitted with the oil groove slit facing outwards.

(2) Coat the main bearing cap bolt washer contact surface and threads with engine oil, place them on the crankshaft journal, and tighten the main bearing bolts to the specified torque.

kg-m (ft-lb)

Main bearing bolt tightening torque	9.5 ~ 10.5 (68.7 ~ 75.9)

NOTE: 1. The main bearing cap should be fitted with the arrow near the embossed letters "FW" on the cap pointing towards the flywheel.
2. Make sure you have the correct cylinder alignment no.

(3) Measure the crankshaft side clearance.

mm (in.)

Crankshaft side clearance	0.090 ~ 0.271 (0.0035 ~ 0.0107)

(4) Make sure that the crankshaft rotates smoothly and easily.

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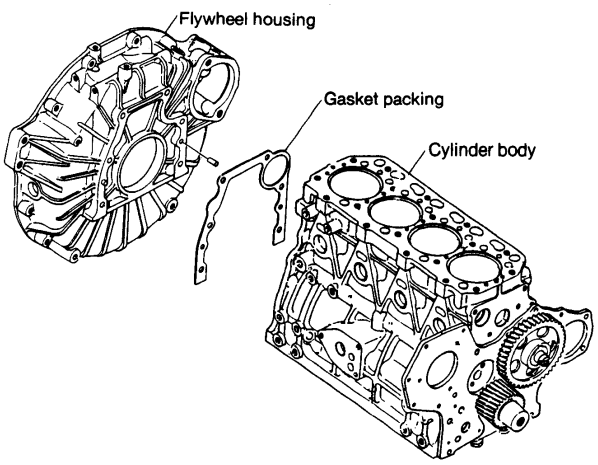
3-2.7 Mounting the flywheel housing

(1) Press fit the oil seal in the flywheel housing, and coat the lip of the oil seal with engine oil.
(2) Mount the flywheel housing and gasket packing, matching them up with the cylinder block positioning pins.

NOTE: Trim the gasket packing if it protrudes onto the oil pan mounting surface.

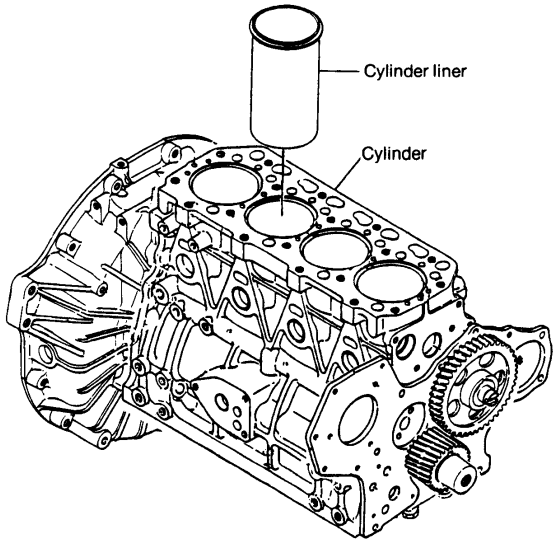


3-2.8 Stand up the cylinder block

On wood blocks, with the flywheel housing facing down. Take care that the gearbox mounting surface does not get scratched.

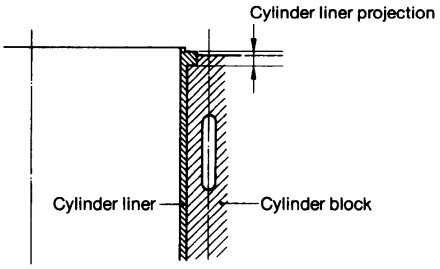
3-2.9 Inserting the cylinder liners

(1) Thoroughly clean the cylinder block mounting holes and contact surfaces.
(2) After thoroughly cleaning the outside of the cylinder liner, carefully insert it in to the cylinder block by hand (do not force).



NOTE: 1. Make sure that each liner is put back into its original cylinder.
2. Do not turn over the engine (with the cylinder head mounting surface facing down) after the liners have been inserted.

(3) Measuring cylinder liner projection



mm (in.)

Cylinder liner projection	0.03 ~ 0.09 (0.0012 ~ 0.0035)

(4) Measuring cylinder liner inner dia.

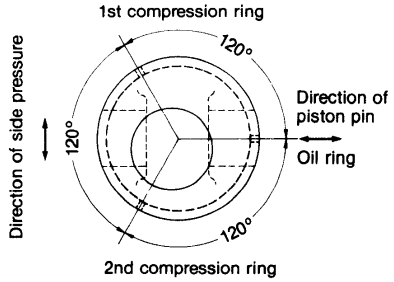
Cylinder liner distortion after insertion	0.03mm or less (0.0012in. or less)

3-2.10 Mounting the piston and connecting rod

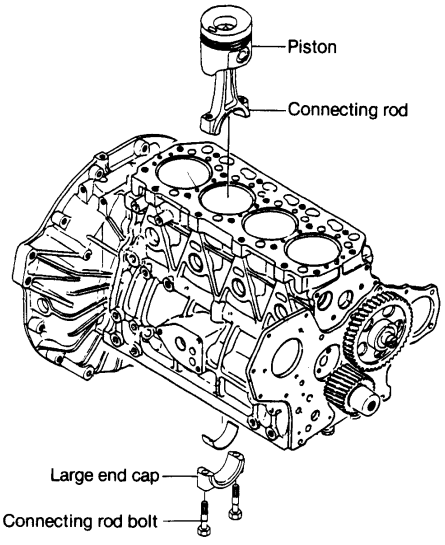
(1) Reassemble the piston and connecting rod.

NOTE: When reassembling the piston and connecting rod, make sure that the parts are assembled with the correct orientation.

(2) Each ring opening (piston/oil rings) should be staggered at gaps of 120°.



(3) Coat the outside of the piston and the inside of the connecting rod crank pin metal with engine oil and insert the piston with the piston insertion tool.



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NOTE: 1. Insert the piston so that the match mark on the large end of the connecting rod faces the fuel feed pump, and the manufactuer's mark on the stem points toward the flywheel.
2. After inserting the piston, make sure the combustion chamber hollow is facing the fuel feed pump, looking from the top of the piston.

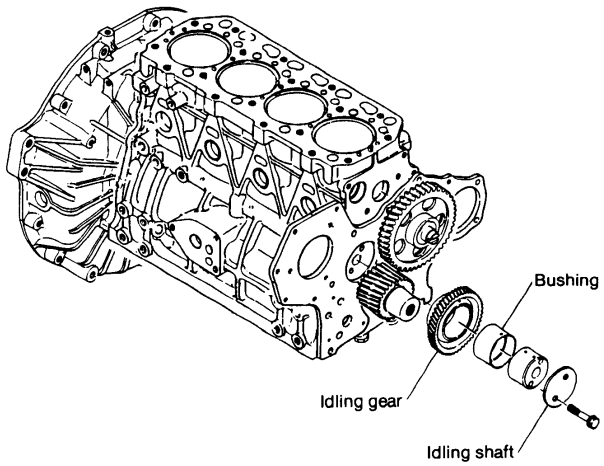
(4) Align the large end match mark, mount the cap, and tighten the connecting rod bolts.

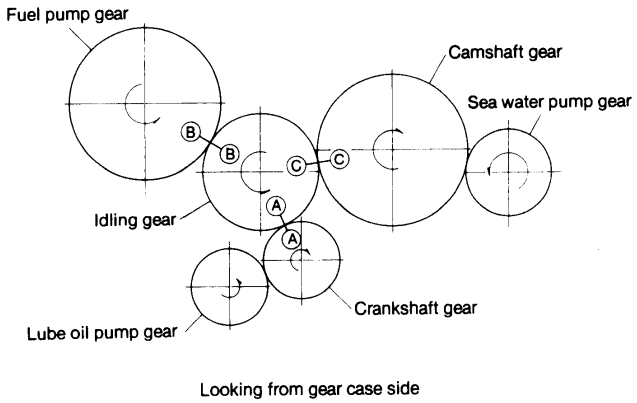
	kg-m (ft-lb)
Connecting rod bolt tightening torque	4.5 ~ 5.0 (32.5 ~ 36.2)

NOTE: If a torque wrench is not available, match up with the mark made before disassembly.

3-2.11 Mounting the idling gear

(1) Fit the idling gear so that the side of the idling shaft with two oil holes faces up.
(2) Align the "A" and "C" camshaft gear and crankshaft gear match marks, match up with idling shaft retaining plate, and tighten the bolts.
(3) Measure the idling gear, camshaft gear and crankshaft gear backlash.



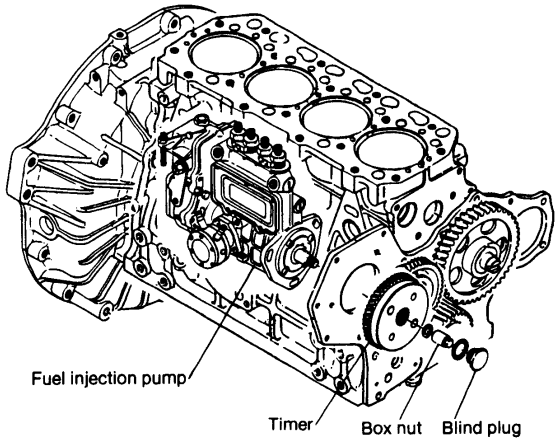


Looking from gear case side

3-2.12 Mounting the fuel injection pump

Lightly fit the fuel injection pump on the gear case.

NOTE: 1. Be careful not to scratch the O-ring between the fuel injection pump and gear case flange.
2. Tighten the fuel injection pump all the way after adjusting injection timing.



3-2.13 Mounting the fuel feed pump drive gear and automatic advancing timer.

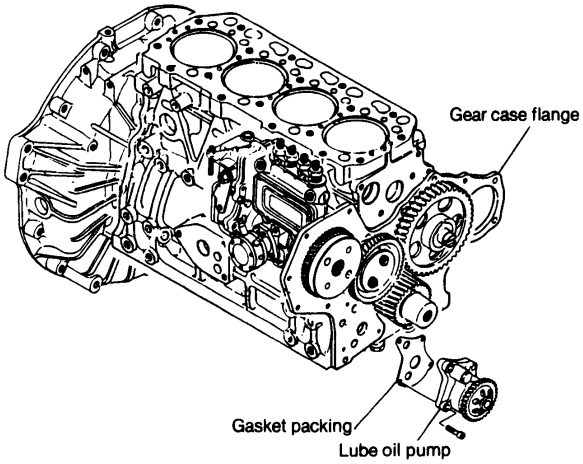
(1) When the drive gear and automatic advancing timer have been disassembled, coat all sliding parts in both assemblies with grease.
(2) Align the "B" match marks on the fuel pump drive gear and idling gear.
(3) Tighten all box nuts holding the fuel feed pump to the specified torque.

	kg-m (ft-lb)
Box nut tightening torque	6 ~ 7 (43.4 ~ 50.6)

(4) Grease parts around the box nuts (lithium grease) and tighten the blind plug.
(5) Measure the backlash of the fuel feed pump drive gear.

3-2.14 Mounting the lube oil pump

(1) Mount the lube oil pump on the gear case flange.
(2) Measure the backlash of the lube oil pump drive gear.



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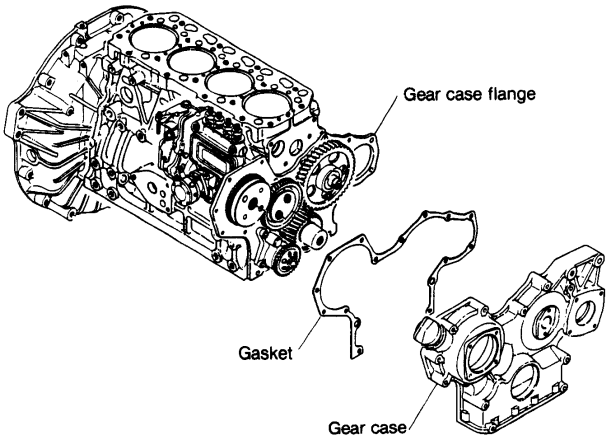
3-2.15 Mounting the gear case

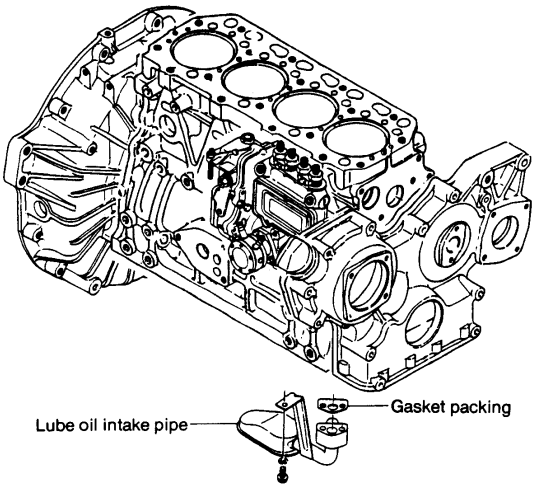
(1) Coat the inside and outside of the oil seals with engine oil, and press fit them into the gear case.
(2) Position the two pipe knock pins, and tighten the bolts holding the gear case and gasket packing.

NOTE: Trim the gasket packing if it protrudes onto the oil pan mounting surface.



3-2.16 Mounting the lube oil intake pipe

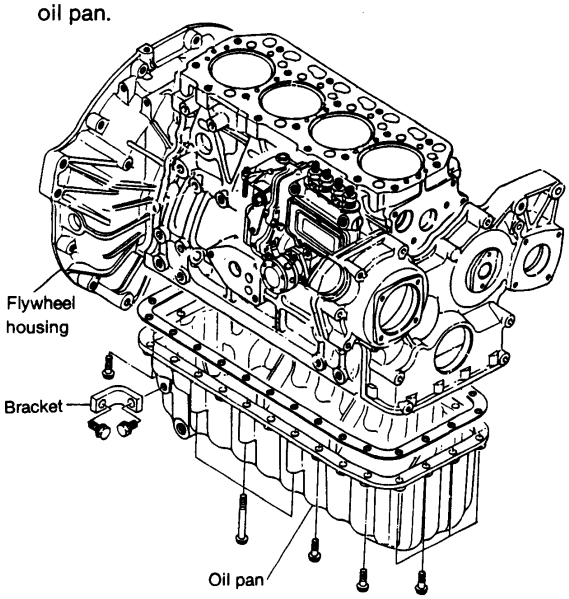
Mount the lube oil intake pipe on the bottom of the cylinder block, using new packing.



	kg-m (ft-lb)
lube oil intake pipe tightening torque	2.6 (18.8)

3-2.17 Mounting the oil pan

(1) Coat with three bond (3B-1114) the surfaces of the gear case, gear case flange and flywheel that contact with the cylinder block.
(2) Tighten the gasket packing/oil pan bolts.
(3) Mount the bracket that connects the flywheel with the oil pan.

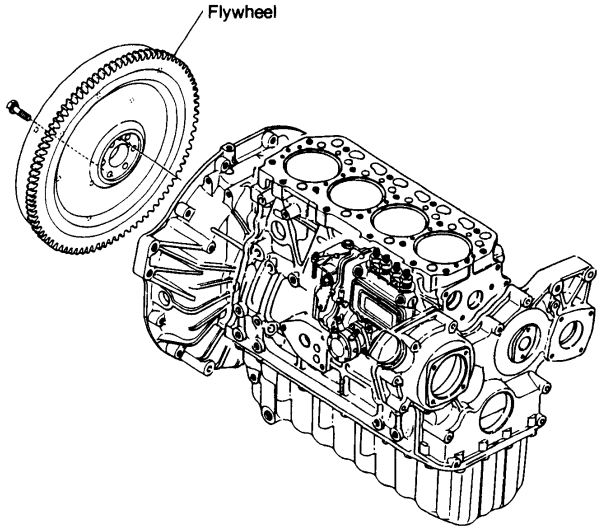


3-2.18 Mounting the engine mounting feet and turning the engine upright.

Place suitable wood blocks below the oil pan and turn the engine upright.

3-2.19 Mounting the flywheel

(1) Coat the flywheel mounting bolt threads with engine oil.
(2) Align the positioning pins, and tighten the flywheel bolts to the specified torque.



	kg-m (ft-lb)
Flywheel mounting bolt tightening torque	7.0 ~ 8.0 (50.6 ~ 57.9)

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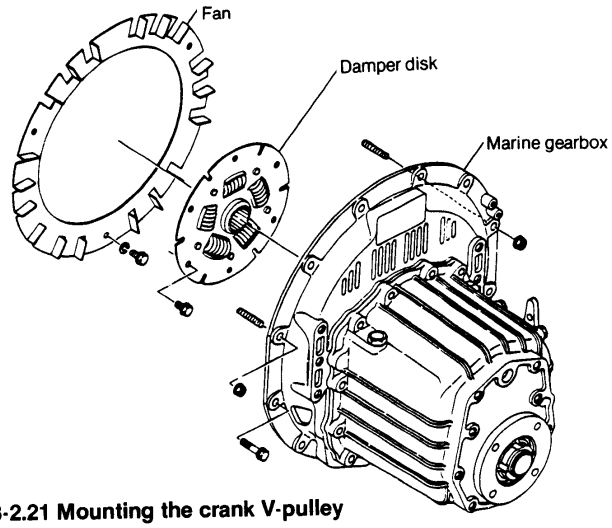
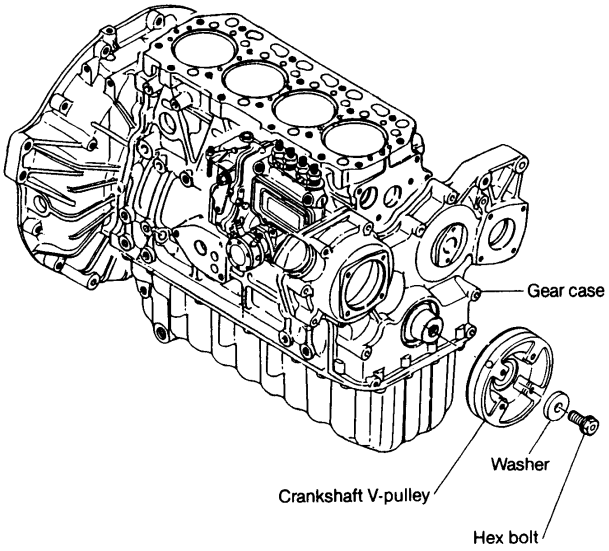
3-2.20 Mounting the marine gearbox

(1) Mount the fan and damper disk to the flywheel.
(2) Align the damper disk with the input shaft spline and insert. Tighten the flywheel housing and flange.



3-2.21 Mounting the crank V-pulley

(1) Coat the oil seal and the section of the shaft with which it comes in contact with oil.
(2) Tighten to the specfied torque.



kg-m (ft-lb)

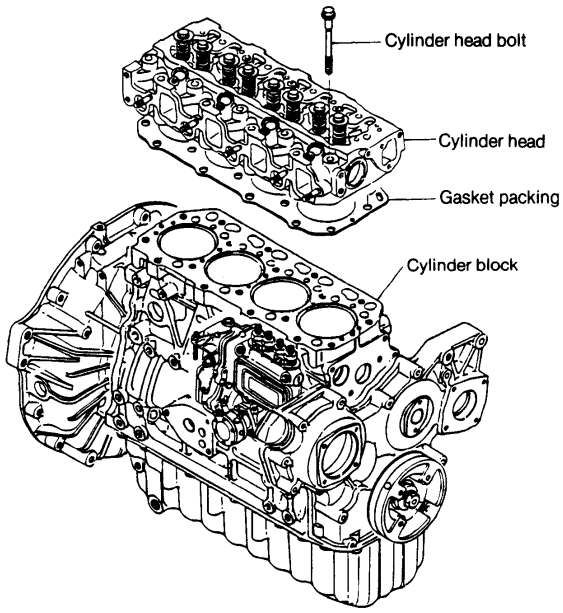
V-pulley tightening torque	11.5 ~ 12.5 (83.2 ~ 90.4)

3-2.22 Mounting the cylinder head

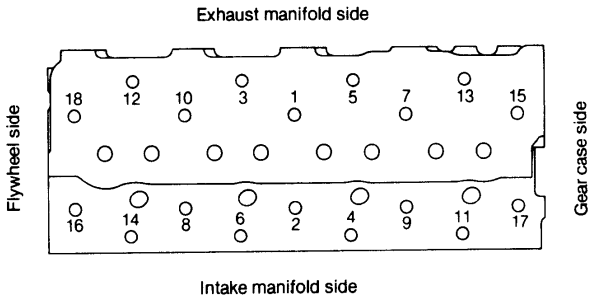
(1) Fit the gasket packing against the cylinder block, aligning it with the cylinder block positioning pins.

NOTE: The side on which the engine model is inscribed should face up (cylinder head side).

(2) Lift the cylinder head horizontally and mount, aligning with the cylinder head gasket.
(3) Coat the mounting bolt washers and threads with engine oil, and lightly tighten the bolts in the specified order. Then tighten completely, in the same order.



Tightening order



kg-m (ft-lb)

	Partial	Complete
Cylinder bolt tightening torque	3.5 ~ 4.5 (25.3 ~ 32.5)	7.5 ~ 8.5 (54.2 ~ 61.5)

(4) Measure the top clearance.

mm (in.)

Top clearance	0.71 ~ 0.89 (0.0279 ~ 0.0350)

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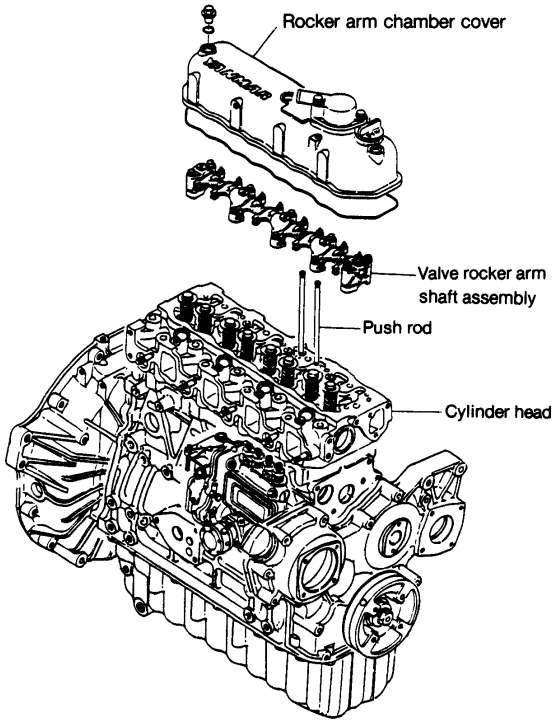
3-2.23 Mounting the valve rocker arm shaft assembly pushrod

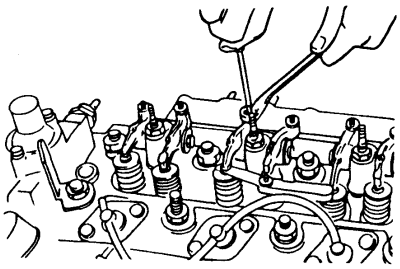
(1) Fit the pushrod to the tappet.
(2) Mount the valve rocker arm shaft assembly.

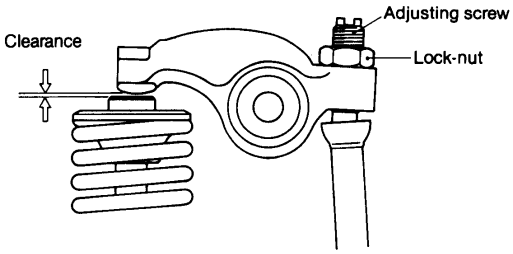
kg-m (ft-lb)

Valve rocker arm shaft support tightening torque	2.4 ~ 2.8 (17.4 ~ 20.4)

(3) Adjust valve clearance.







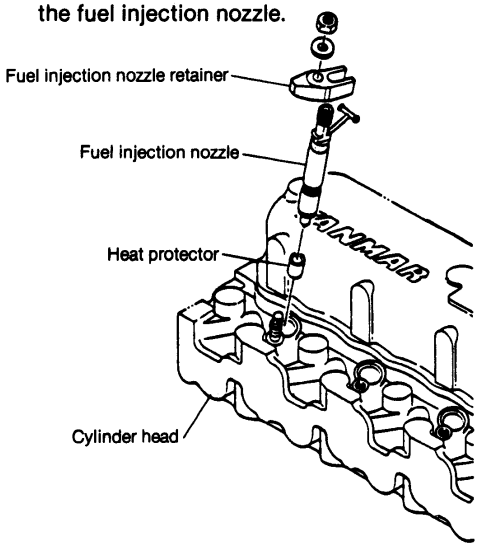
mm (in.)

Intake/discharge valve clearance	0.2 (0.0079)

(4) Coat the valve rocker arm and valve spring with engine oil, and mount the valve rocker arm chamber cover.

3-2.24 Mounting the fuel injection nozzle

(1) Mount the injection nozzle tip heat protector, and then the fuel injection nozzle.



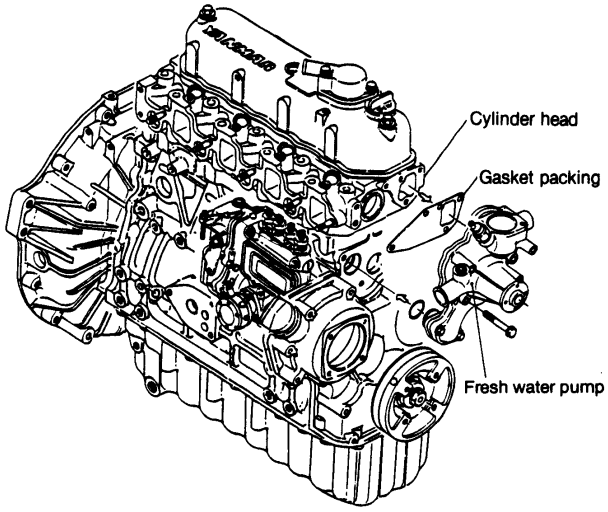
(2) Tighten the fuel injection nozzle retainer nut to the specified torque.

kg-m (ft-lb)

Fuel injection nozzle retainer tightening torque	2.0 ~ 3.0 (14.5 ~ 21.7)

3-2.25 Mounting the fresh water pump

(1) Thoroughly coat both sides of the packing with adhesive.
(2) Replace the O-ring for the connecting pipe which is inserted in the cylinder block, and tighten the fresh water pump to the specified torque.

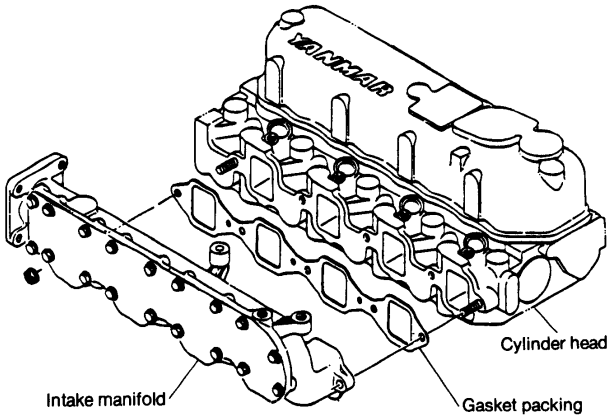


kg-m (ft-lb)

Fresh water pump tightening torque	0.7 ~ 1.1 (5.0 ~ 8.0)

3-2.26 Mounting the intake manifold

(1) Thoroughly clean the inside of the intake manifold, and mount the gasket packing and intake manifold.
(2) Mount the governor remote control bracket.

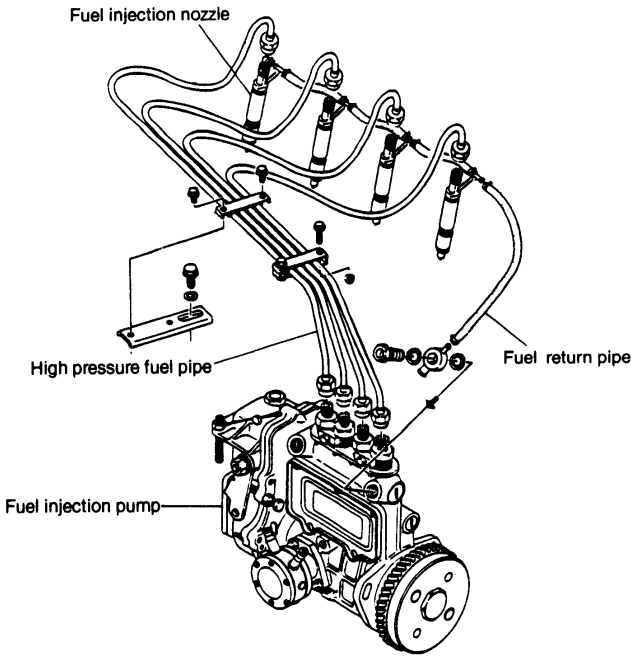


3-2.27 Mounting the high pressure fuel pipe and fuel oil return pipe

(1) Mount the high pressure fuel pipe and then the high pressure fuel pipe vibration stop.

NOTE: Lightly tighten the box nuts on both ends of the high pressure fuel pipe. Completely tighten after adjusting the injection timing.

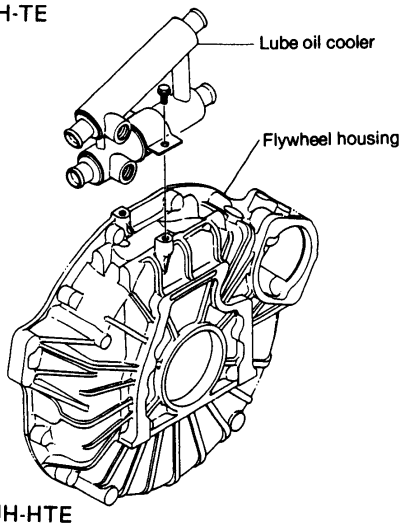
(2) Mount the fuel oil return pipe with the hose clamp (fuel injection nozzle—fuel injection pump)



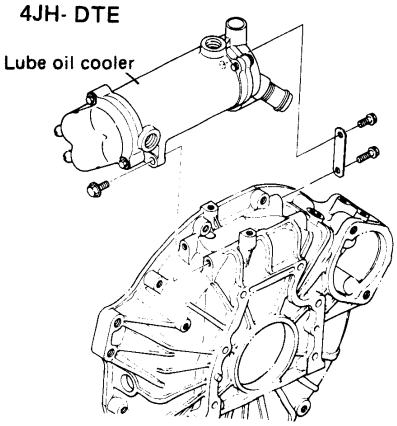
3-2.28 Mounting the lube oil cooler

Mount the lube oil cooler to the top of the flywheel housing with the bracket.

MODEL: 4JHE
4JH-TE

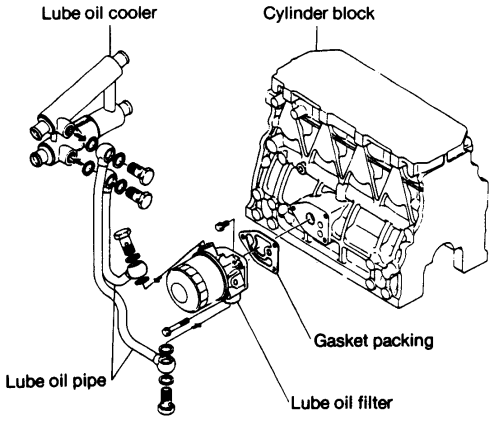


MODEL: 4JH-HTE
4JH- DTE



3-2.29 Mounting the lube oil filter

(1) Mount the filter bracket and packing on the cylinder block.
(2) Mount the filter element with the filter remover mounting tool.



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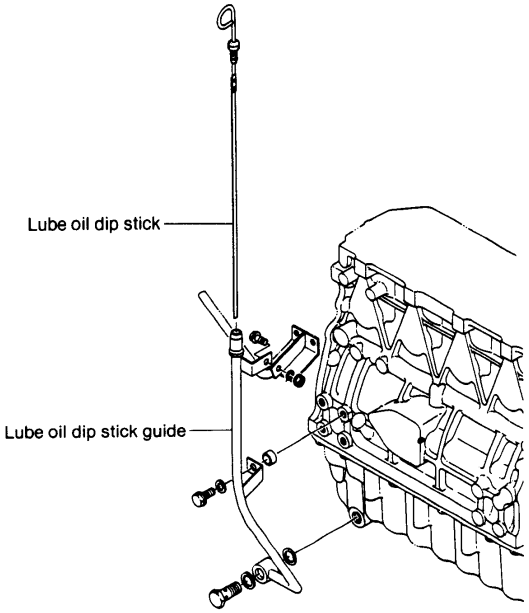
3-2.30 Mounting the lube oil pipe

(1) Mount the lube oil pipe (filter—lube oil cooler, lube oil cooler—filter).
(2) Mount the lube oil pipe (cylinder block—fuel injection pump).

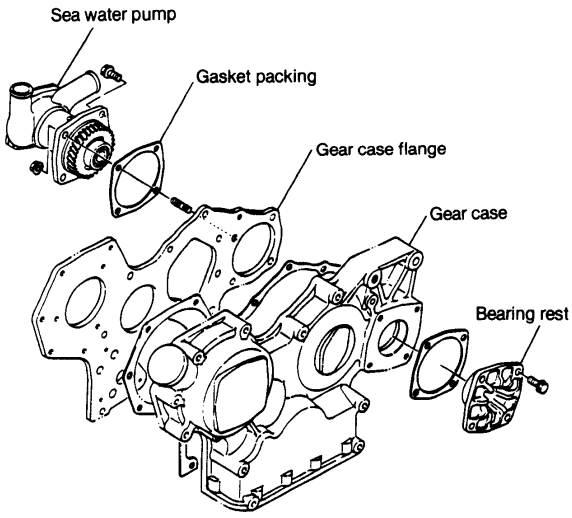
3-2.31 Mounting the dipstic guide

Mount the dipstick and dipstick guide.



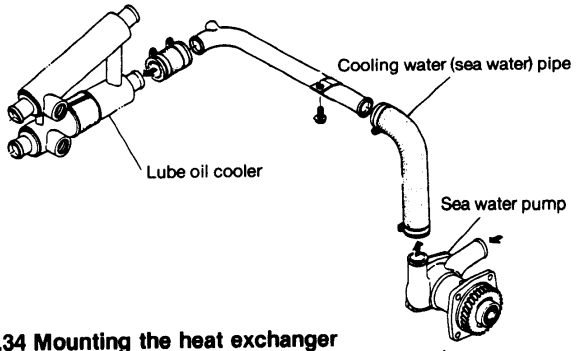
3-2.32 Mounting the sea water pump

(1) Mount the sea water pump assembly to the gear case flange.
(2) Lightly tap the gear case side bearing rest with a wood hammer, and tighten the mounting bolts.



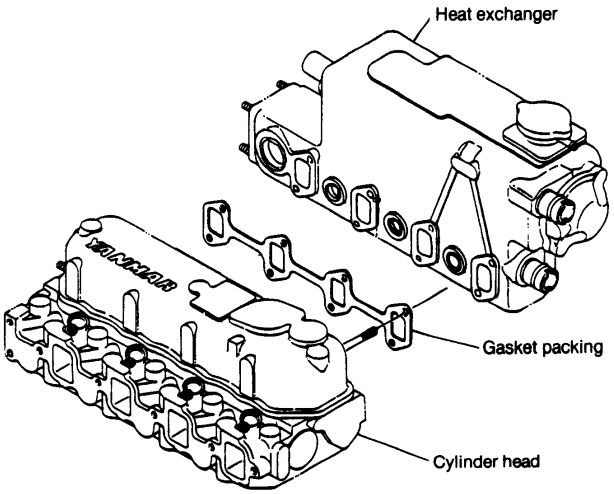
3-2.33 Mounting the cooling sea water pipe

Mount the cooling water pipe with the hose clamp (sea water pump—lube oil cooler).



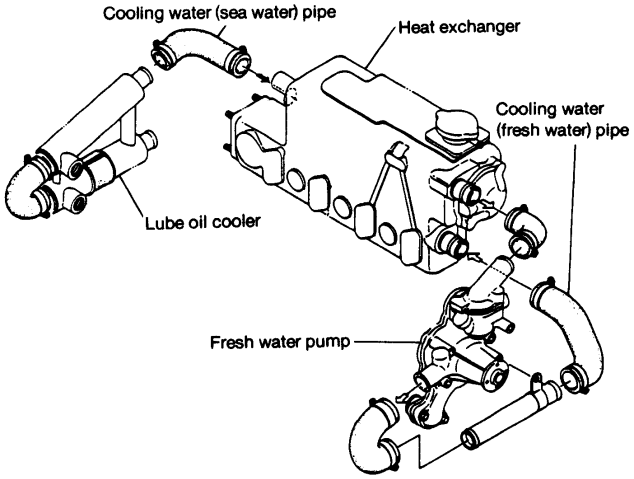
3-2.34 Mounting the heat exchanger (exhaust manifold, fresh water tank unit).

Mount the gasket packing and exhaust manifold.

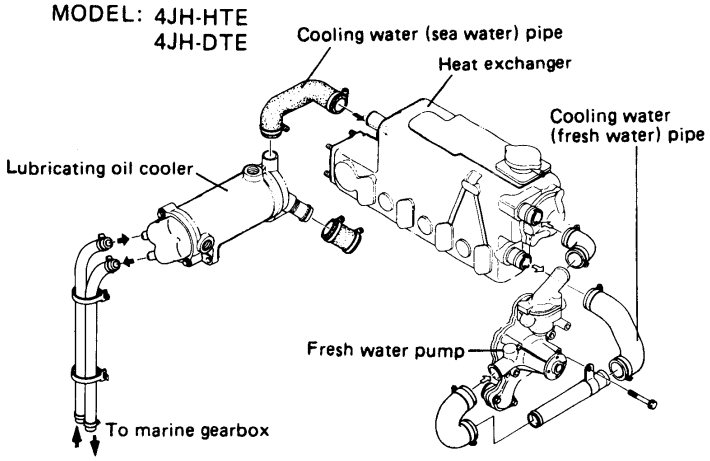


3-2.35 Mounting the cooling water pipe

(1) Mount the cooling fresh water pipe with the hose clamp (fresh water tank — fresh water pump, fresh water pump—heat exchanger).
(2) Mount the cooling sea water pipe with the hose clamp (lube oil cooler —heat exchanger).
(3) Mount the cooling sea water pipe with the hose clamp (lube oil cooler —marine gearbox).

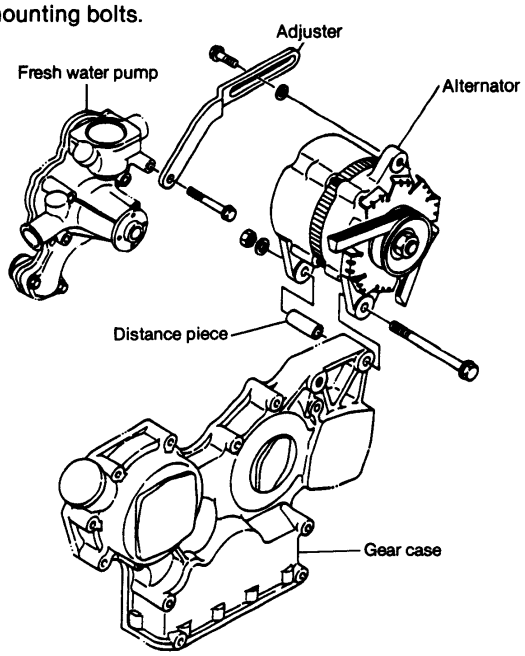


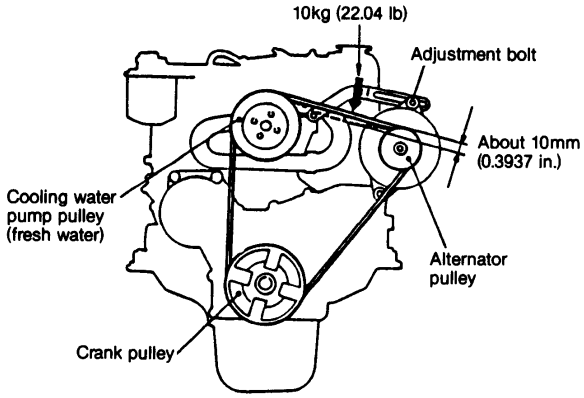
MODEL: 4JH-HTE
4JH-DTE



3-2.36 Mounting the alternator

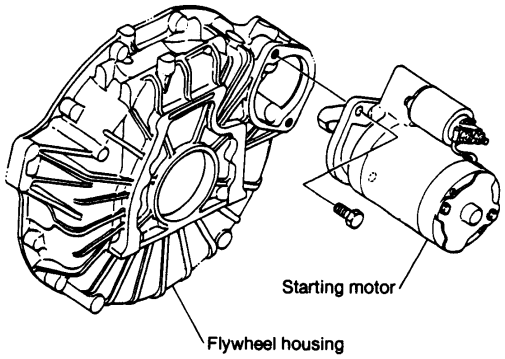
(1) Mount the adjuster on the fresh water pump, the distance piece on the gear case, and then the alternator.
(2) Adjust V-belt tension with the adjuster, and tighten the mounting bolts.





3-2.37 Mounting the starting motor

Fit the starting motor in the flywheel housing.



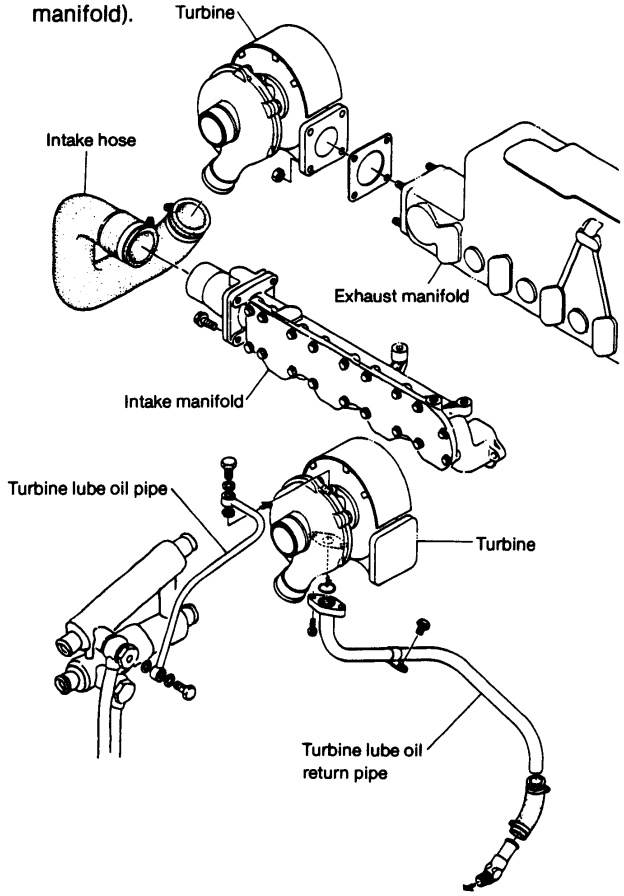
[Model 4JH-TE]

3-2.38 Mounting the turbine

(1) Mount the turbine on the exhaust manifold.

NOTE: First make sure to tighten the turbine lube oil return pipe.

(2) Mount the lube oil pipe (lube oil cooler—turbine).
(3) Insert the rubber hose at the end of the lube oil return pipe (turbine—oil pan) into the elbow on the oil pan, and mount with the hose grip.
(4) Mount the intake rubber hose (turbine—intake manifold).



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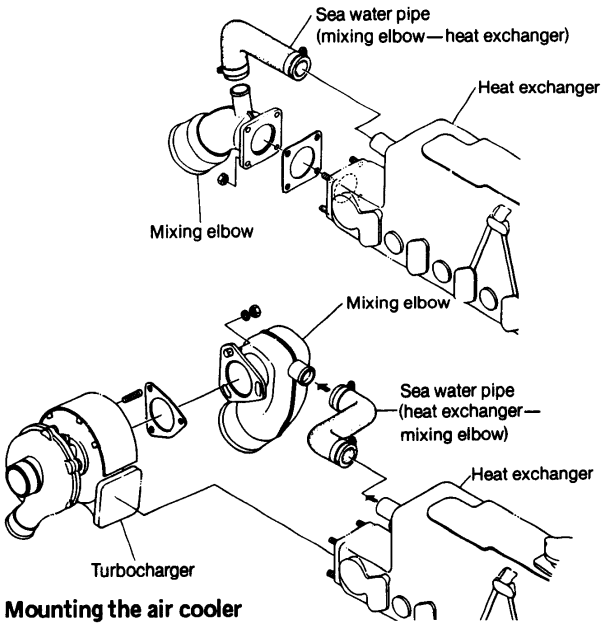
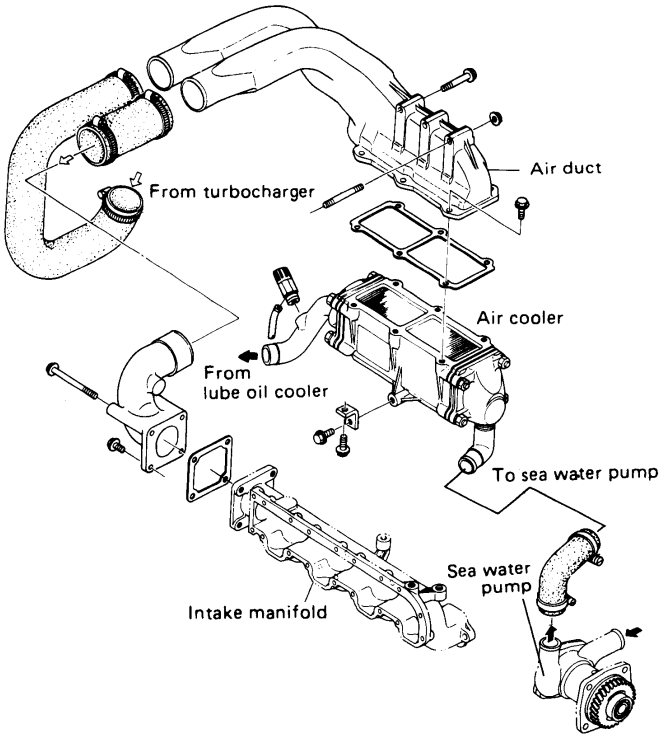
3-2.39 Mounting the mixing elbow

(1) Mount the mixing elbow on the exhaust manifold outlet for model 4JHE, and on the turbocharger outlet for model 4JE-TE.
(2) Mount the cooling sea water pipe rubber hose with the hose grip (heat exchanger—mixing elbow).



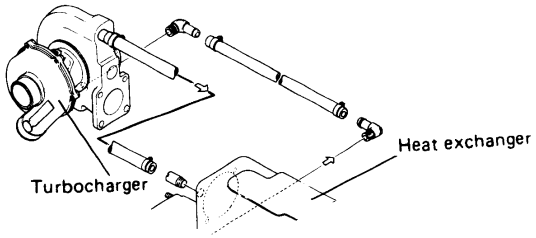
Mounting the air cooler

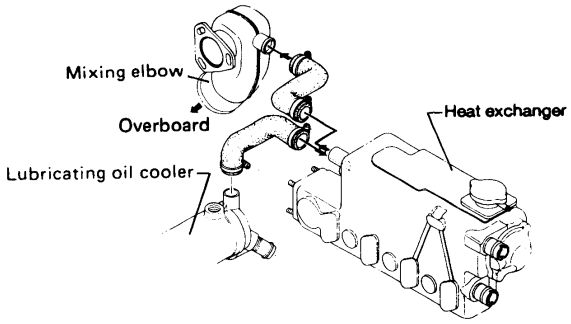
(1) Mount the air cooler on the heat excharger, and cylinder block.
(2) Mount the sea-water rubber hoses.
(Lube oil cooler — Air cooler — Sea water pump)
(3) Mount the intake rubber hoses
(Intake manifold, and turbocharger — Air duct)

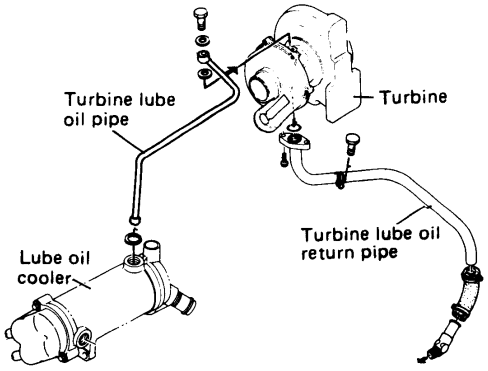


Mounting the mixing elbow and the turbocharger

(1) Mount the turbocharger on the exhaust mainfold.
(2) Mount the air duct rubber hose.
(Turbocharger — Air duct)
(3) Mount the mixing elbow on the turbocharger.
(4) Mount the sea water hose.
(Heat exchanger — Mixing elbow)
(5) Mount the lube oil pipes.
(Lube oil pump — Turbocharger — Lube oil cooler)
(6) Mount the fresh water hoses.
(Heat exchanger — Turbocharger)

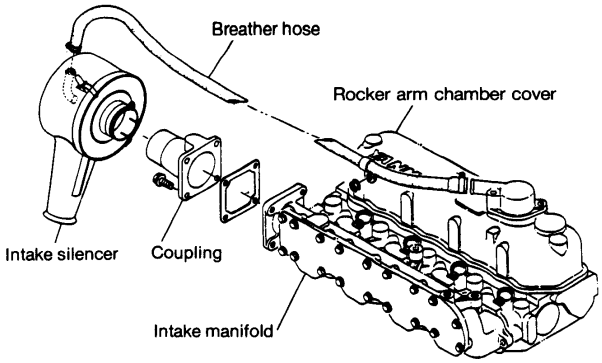


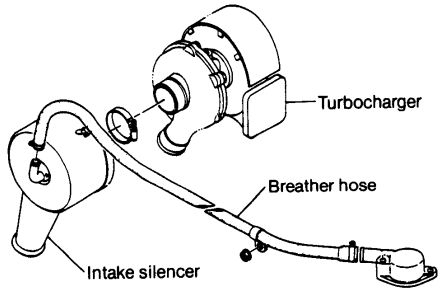




3-2.40 Mounting the intake silencer

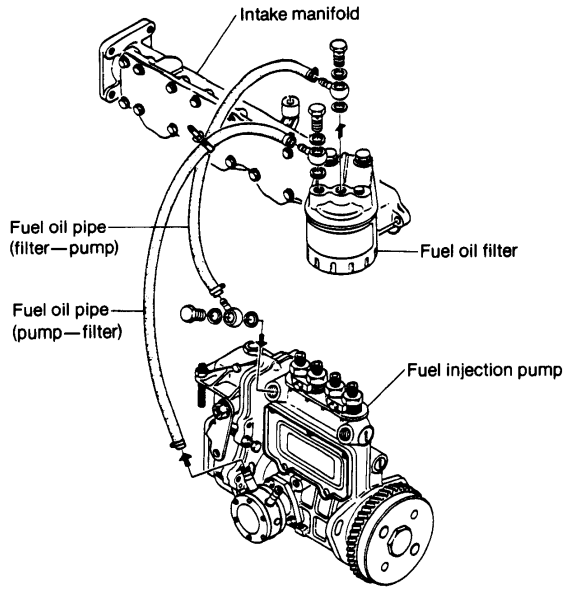
(1) Mount the intake silencer on the intake manifold inlet coupling for model 4JHE, and on the turbocharger blower side for model 4JH-TE.
(2) Mount the breather hose with the hoe clamp (intake silencer—valve rocker arm chamber cover).





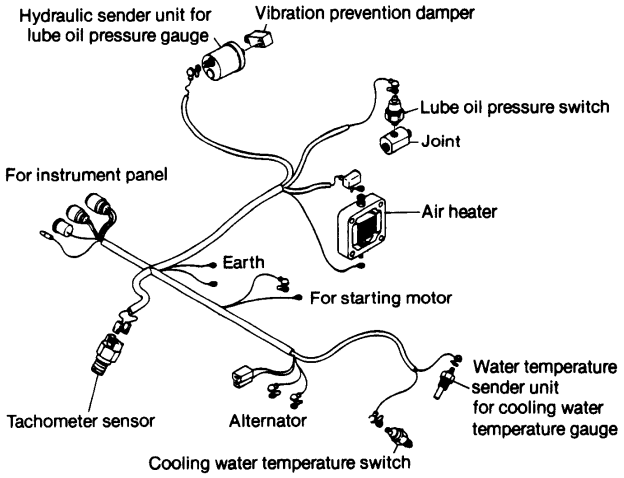
3-2.41 Mounting the fuel filter and fuel oil pipe

(1) Mount the fuel filter.
(2) Mount the fuel oil pipe (fuel feed pump—fuel filter, fuel filter—fuel injection pump).



3-2.42 Electrical Wiring

Connect the wiring to the proper terminals, observing the color coding to make sure the connections are correct.



3-2.43 Installation in the ship and completion of the piping and wiring

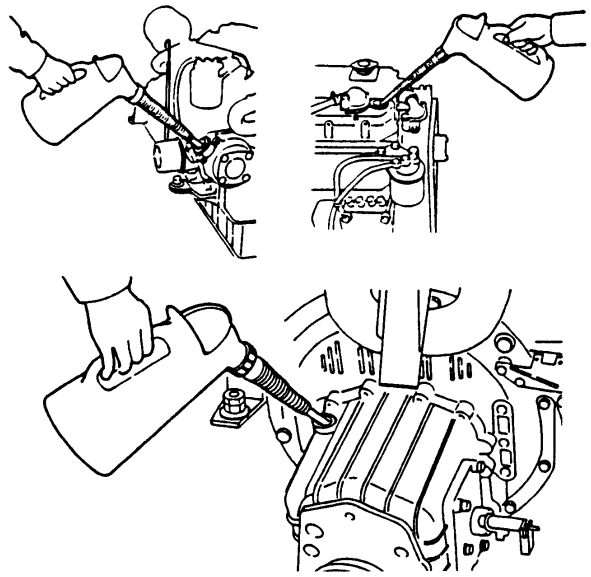
Mount the engine in the ship after all engine assembly has been completed. Connect the cooling water, fuel oil and other piping on the ship and the exhaust hoses. Connect the battery, instrument panel, remote control and other wiring.

3-2.44 Filling with lube oil

Fill the engine with lube oil from the supply port on top of the gear case and the marine gearbox supply port on top of the clutch case.

l (in.³)

Lube oil capacity	Engine	6.5 (396.63)
	Gearbox	1.2 (73.22)



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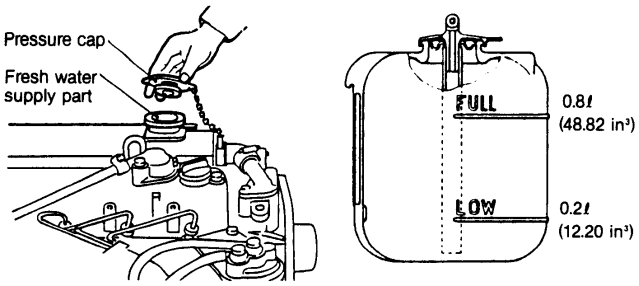
3-2.45 Filling with cooling water

(1) Open the fresh water tank cap and fill with water.

	ℓ (in.³)
Fresh water tank capacity	6.0 (366.12)

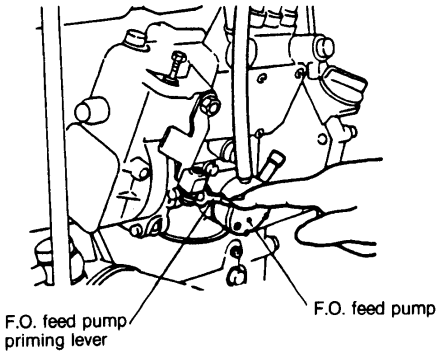
(2) Fill with water until the level in the sub-tank is between the full and low marks.

	ℓ (in.³)	
	Full	Low
Sub-tank capacity	0.8 (48.82)	0.2 (12.20)

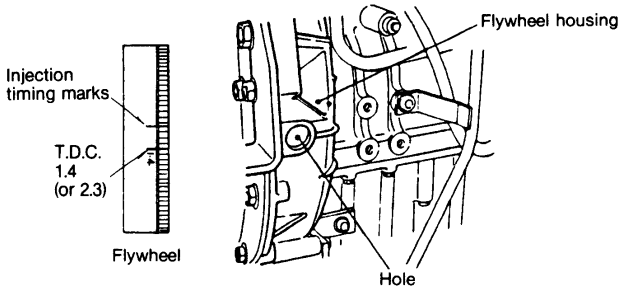


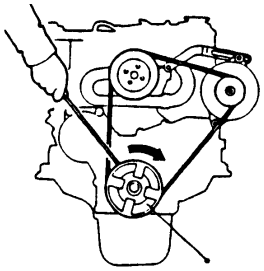
3-2.46 Check fuel injection timing

(1) Open the fuel tank cock and shift the fuel feed pump priming lever for air bleeding.



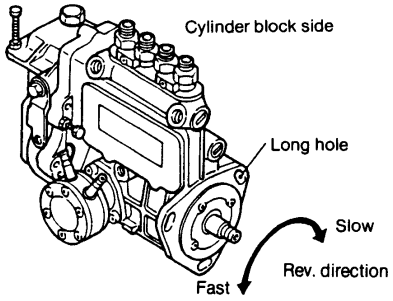
(2) Check injection timing by turning the flywheel and looking through the inspection hole in the flywheel housing.





(3) If injection timing is off, change the mounting position using the long hole in the injection pump mounting flange. Turning the fuel feed pump towards the cylinder block slows timing down, while movement in the other directon makes it faster.

Fuel injection timing (FID)	4JH-E	E/#00101 ~ 00574, b.TDC 8 ~ 10° E/#00575 and after, b.TDC 11 ~ 13°
	4JH-TE 4JH-HTE 4JH-DTE	b.TDC 11 ~ 13°



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4. Bolt/nut tightening torque

Engine

Description	Thread dia. × pitch mm	Tightening torque kg-m (ft-lb)	Wrench mm (in.)
Cylinder head bolts	M10 × 1.25	7.5 ~ 8.5 (54.24 ~ 61.48)	14 (0.5512)
Connecting rod bolts	M9 × 1.0	4.5 ~ 5.0 (32.54 ~ 36.16)	13 (0.5118)
Flywheel bolts	M10 × 1.25	7.0 ~ 8.0 (50.63 ~ 57.86)	17 (0.6693)
Crankshaft V-pulley bolts	M14 × 1.5	11.5 ~ 12.5 (83.17 ~ 90.41)	22 (0.8661)
Main bearing bolts	M12 × 1.5	9.5 ~ 10.5 (68.71 ~ 75.94)	17 (0.6693)
Fuel pump automatic timer box nuts	M12 × 1.75	6.0 ~ 7.0 (43.39 ~ 50.63)	13 (0.5112)

Turbocharger (RHB52)

Description	Thread dia. × pitch mm	Tightening torque kg-m (ft-lb)	Wrench mm (in.)
Turbine chamber bolts	M6	10.0 ~ 11.0 (72.33 ~ 79.56)	10 (0.3937)
Blower chamber bolts	M5	3.5 ~ 4.5 (25.31 ~ 32.54)	8 (0.3150)
Thrust metal bolts	M3	0.7 ~ 0.9 (5.06 ~ 6.50)	—
Seal plate screws	M3	0.7 ~ 0.8 (5.06 ~ 5.78)	—
Blower blade nuts	M5	1.8 ~ 2.2 (13.01 ~ 15.91)	8 (0.3150)

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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	Precautions
1	Checks before operation	1) Make sure that the Kingston Cock is open. 2) Make sure there is enough lube oil and (fresh) cooling water. 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) Glow plug is provided to aid engine starts. When the lube oil temperature is raised to allow the engine to start, the pilot lamp goes off. 2) When the engine is started, check the following: • there is no water and no oil leakage. • gas does not leak when the engine is started. • there are no abnormal indications on the instrument panel. • there is no abnormality in cooling water discharge, engine vibrations, or engine sounds. 3) 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.	1) Even if one glow plug should break, the remaining plug works. 2) • Fix leaks if any. • Check the intake/exhaust valves, F.O. injection valve, and cylinder head. 3) 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. 2) Make sure that exhaust color and temperature are normal. 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. 2) Raise engine rpms to 1,800 just before stopping the engine and idle the engine for about 3—4 seconds.	1) Stopping the engine suddenly during high speed operation increases the temperature of engine parts. 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. 2) Make sure that no nuts and bolts are loose. 3) Close the Kingston and fuel cocks. 4) When the temperature is expected to fall below freezing, drain the cooling water (sea water). 5) Turn off the battery switch.	1) Check the oil seal area. 2) Especially the engine installation bolts. 4) Drain from the sea water pump.

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