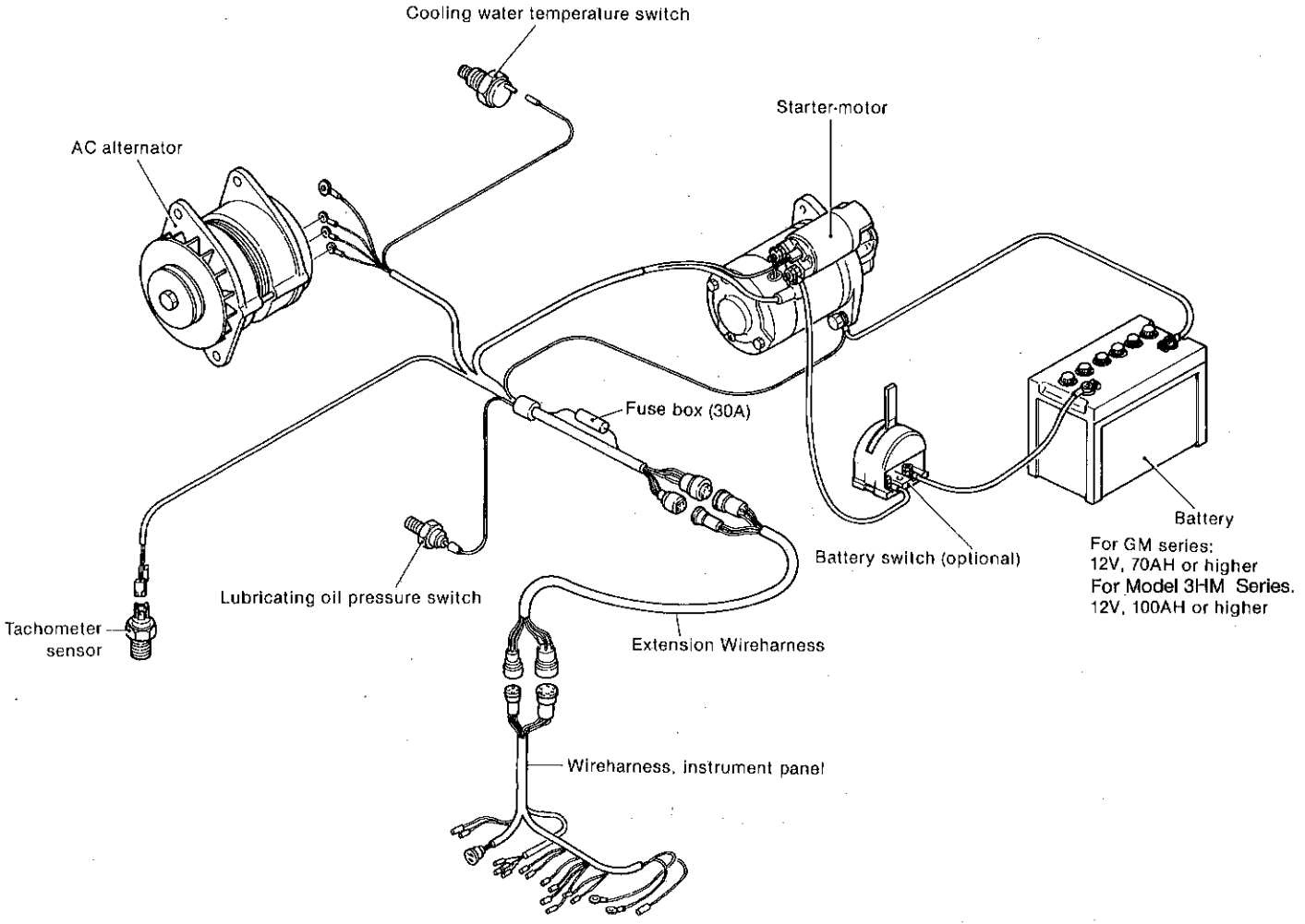
CHAPTER 12

ELECTRICAL SYSTEM

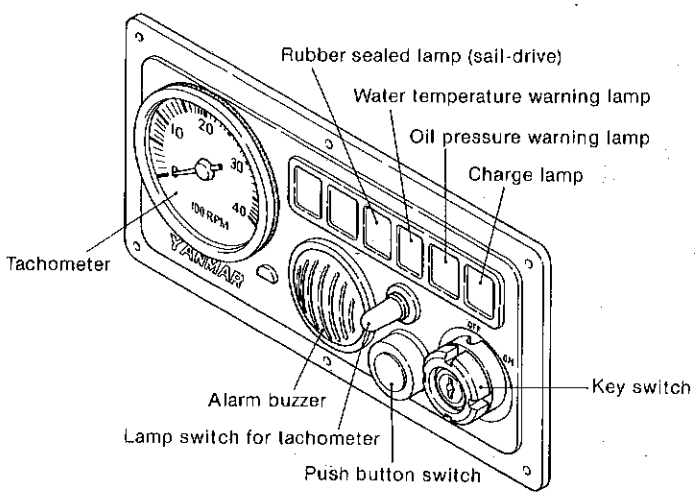
Printed in Japan
0000A0A1361

1. Electrical System

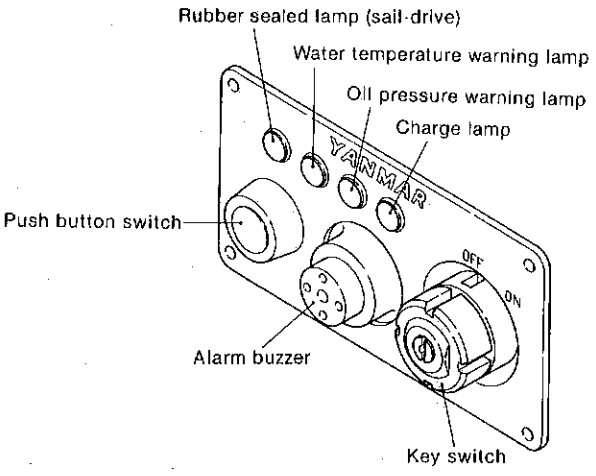
1-1 System diagram of electric parts



B-type instrument panel (large)

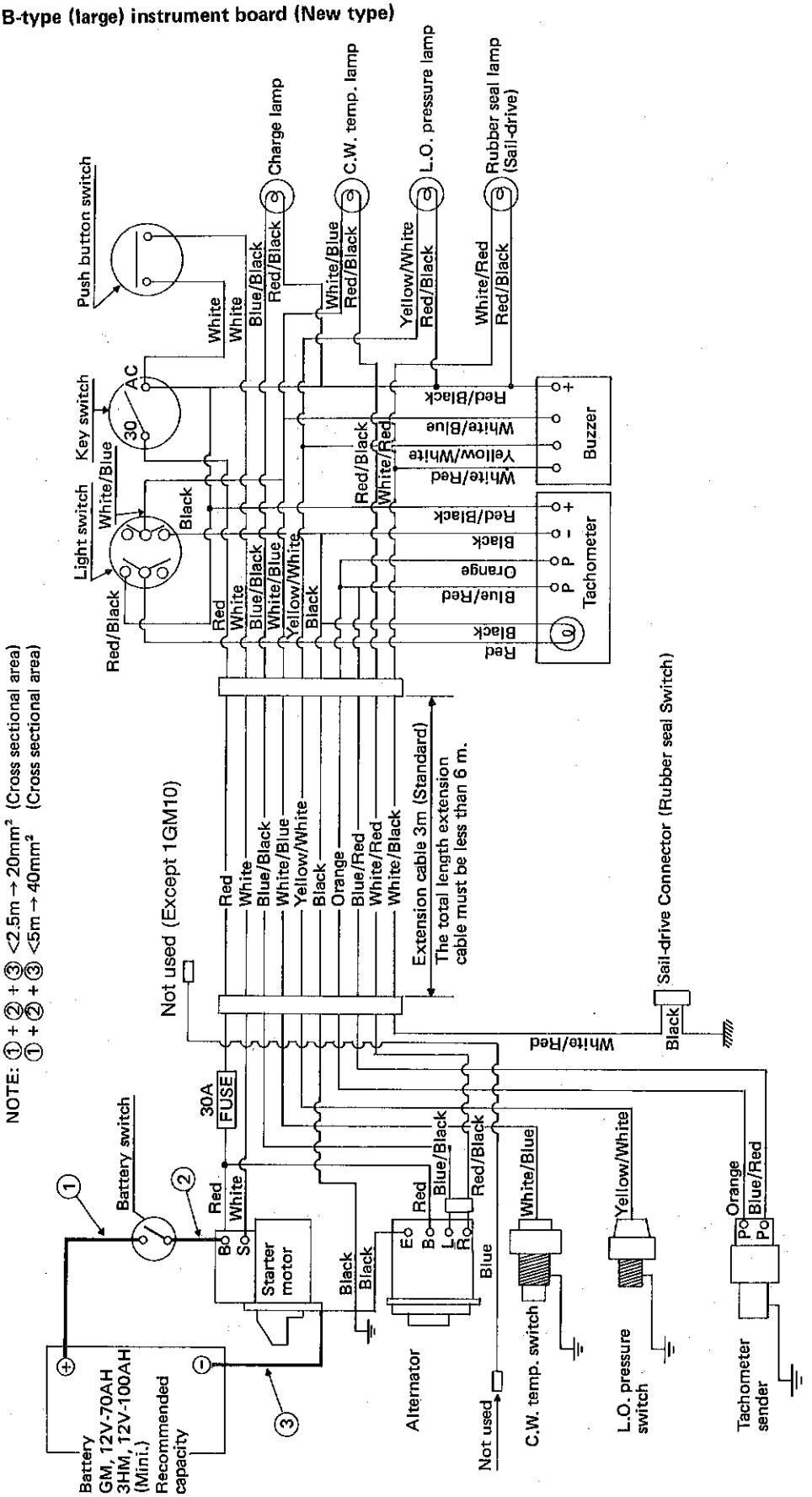


A-type instrument panel (small)



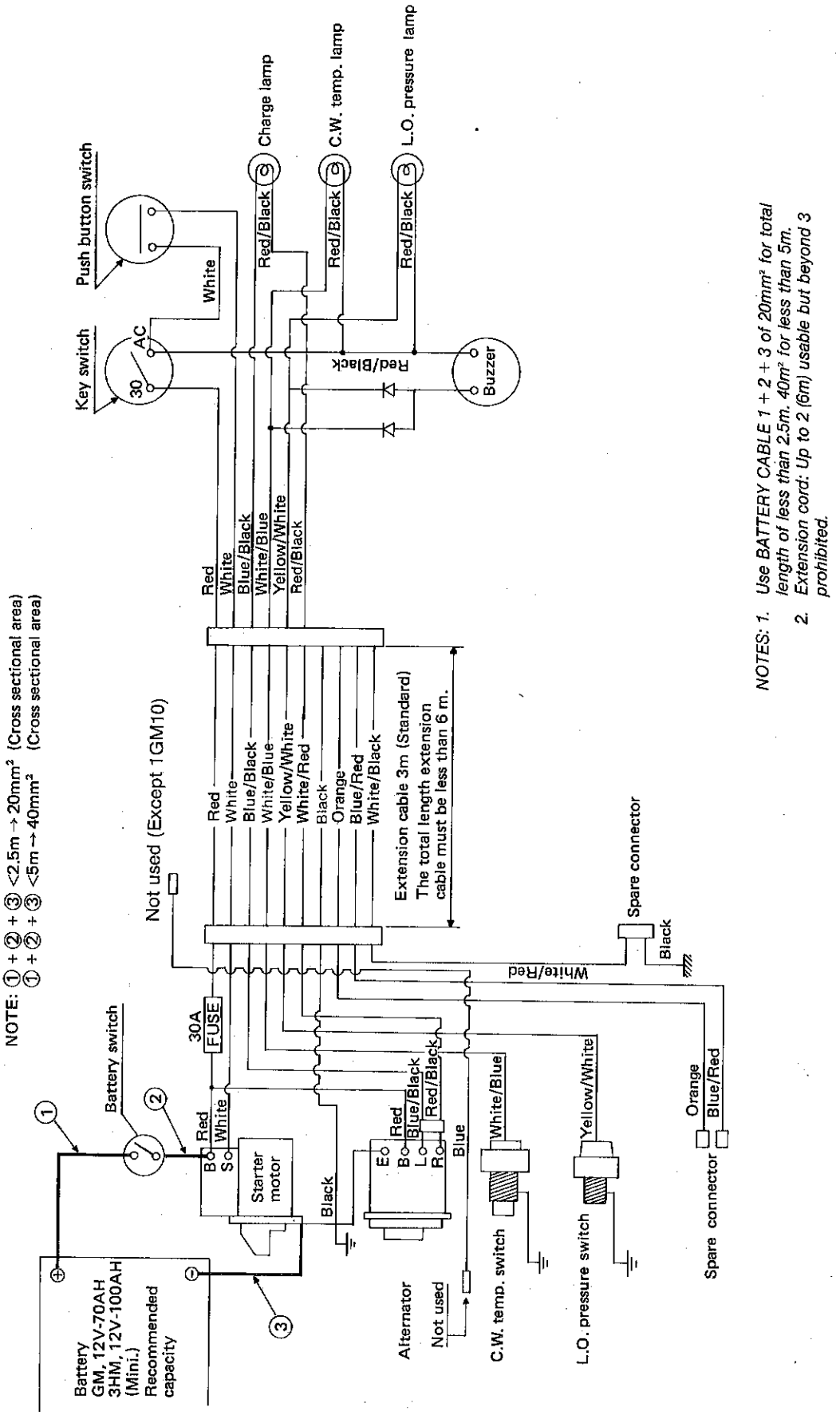
1-2. Wiring diagram

1-2.1 For the B-type (large) instrument board (New type)



Printed in Japan
0000A0A1361

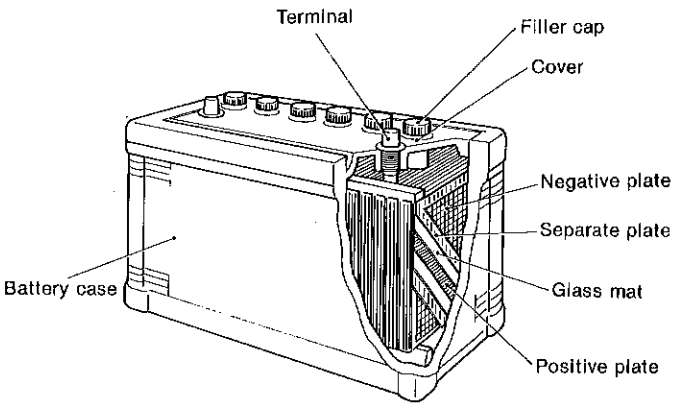
1-2.2 For the A-type (small) instrument board (New type)



NOTES: 1. Use BATTERY CABLE 1 + 2 + 3 of 20mm² for total length of less than 2.5m. 40m² for less than 5m.
2. Extension cord: Up to 2 (6m) usable but beyond 3 prohibited.

2. Battery

2-1 Construction



The battery utilizes chemical action to convert chemical energy to electrical energy. This engine uses a lead acid battery which stores a fixed amount of power that can be used when required. After use, the battery can be recharged and used again.
As shown in the figure, a nonconductive container is filled with dilute sulfuric acid electrolyte. Lead dioxide positive plates and lead dioxide negative plates separated by glass mats are stacked alternately in the electrolyte. The positive and negative plates are connected to their respective terminals.
Power is removed from the battery by connecting the load across these two terminals.
When the battery is discharging, an electric current flows from the positive plates to the negative plates. When the battery is being charged, electric current is passed through the battery in the opposite direction by an external power source.

2-2 Battery capacity and battery cables

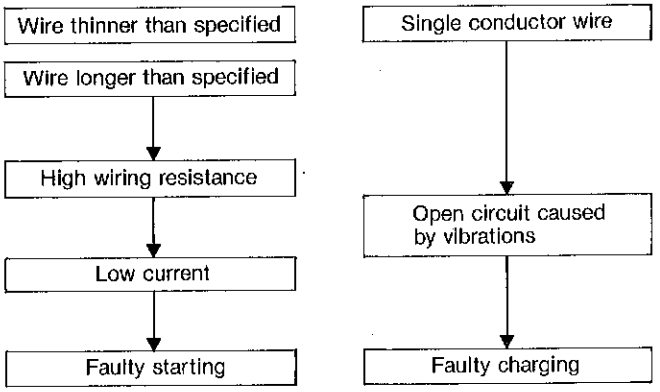
2-2.1 Battery capacity

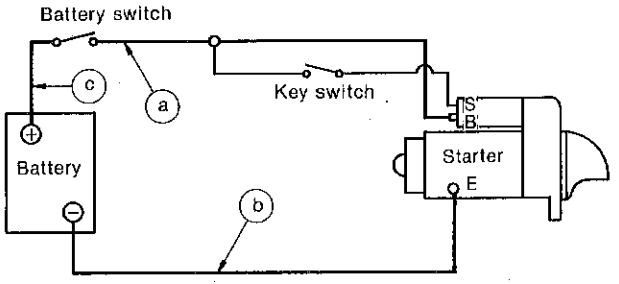
Since the battery has a minimum capacity of 12V, 70AH, it can be used for 100 ~ 150AH.

	1GM10(C) 2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
Minimum battery capacity	12V 70AH	12V 100AH
Fully charged specific gravity	1.26	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 wiring between the battery (+) terminal and the starter (B) terminal, and between the battery (−) terminal and the starter (E) terminal should be based on 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 battery and start (S) terminals) can cause improper pinion engagement. To prevent this, follow the wiring diagram exactly.

2-3 Inspection

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

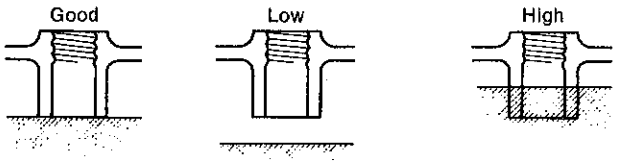
2-3.1 Visual inspection

(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.

Printed in Japan
0000A0A1361

2-3.2 Checking the electrolyte

(1) Electrolyte level

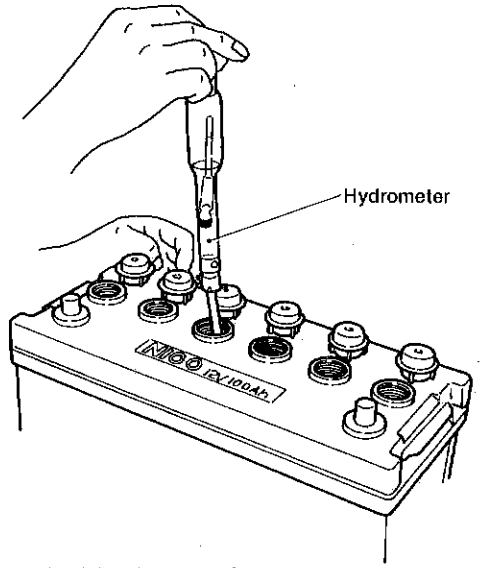


Check the electrolyte level every 7 to 10 days. The electrolyte must always be 10 ~ 20mm over the tops of the plates.

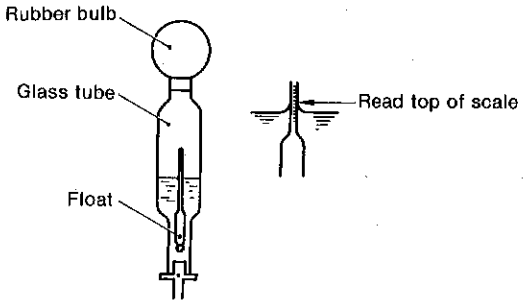
NOTES: 1) The "LEVEL" line on a transparent plastic battery case indicates the height of the electrolyte.
2) Always use distilled water to bring up the electrolyte level.
3) When the electrolyte has leaked out, add dilute sulfuric acid with the same specific gravity as the electrolyte.

(2) Measuring the specific gravity of the electrolyte

1) Draw some of the electrolyte up into a hydrometer.



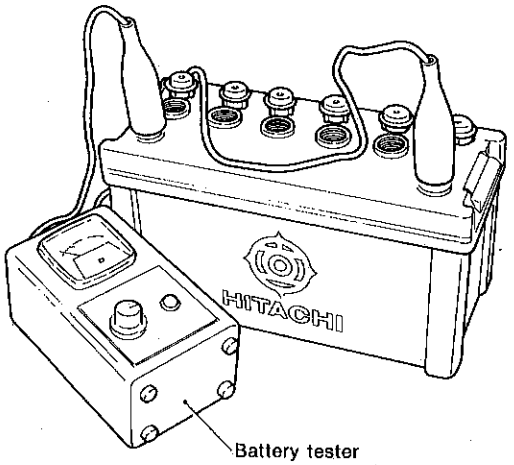
2) Take the specific gravity reading at the top of the scale of the hydrometer.



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.

Printed in Japan
0000A0A1361

2-4 Charging

2-4.1 Charging methods

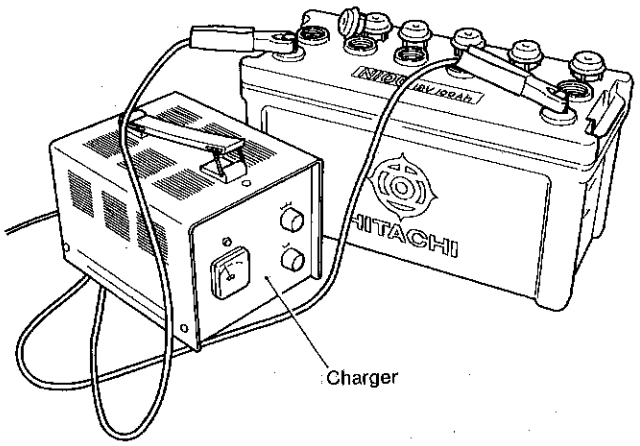
There are two methods of charging a battery: normal and rapid.

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

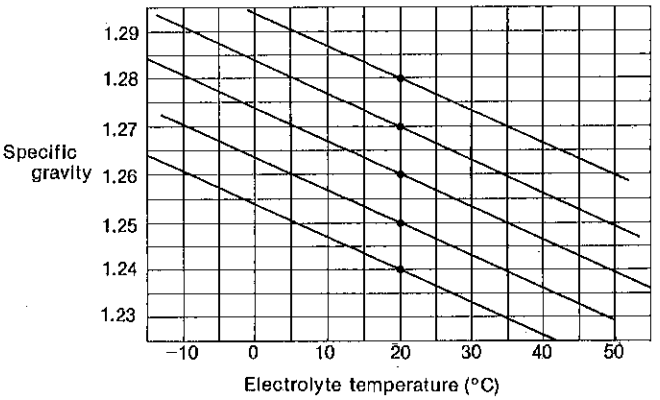
(1) Check the specific gravity and adjust the electrolyte level.
(2) Disconnect the battery cables.
(3) Connect the red clip of the charger to the (+) battery terminal and connect the black clip to the (−) terminal.



(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].)

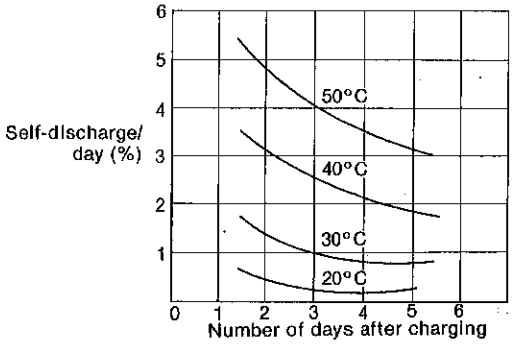


Electrolyte temperature and specific gravity

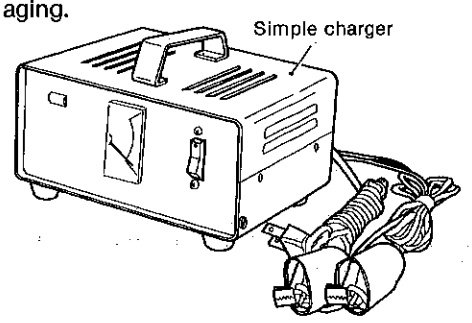
2-5 Battery storage precautions

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.



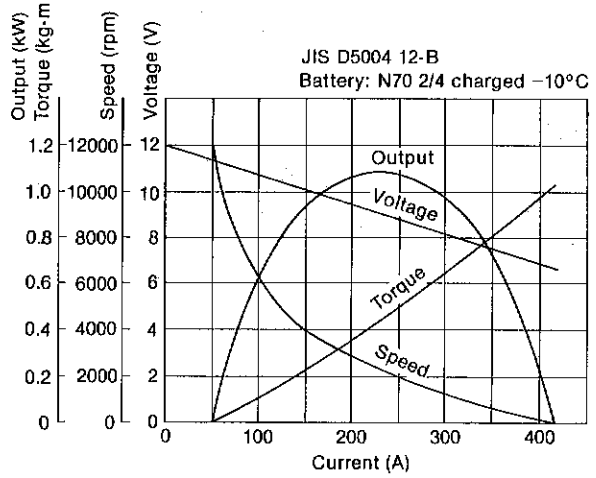
Printed in Japan
0000A0A1361

3. Starter Motor

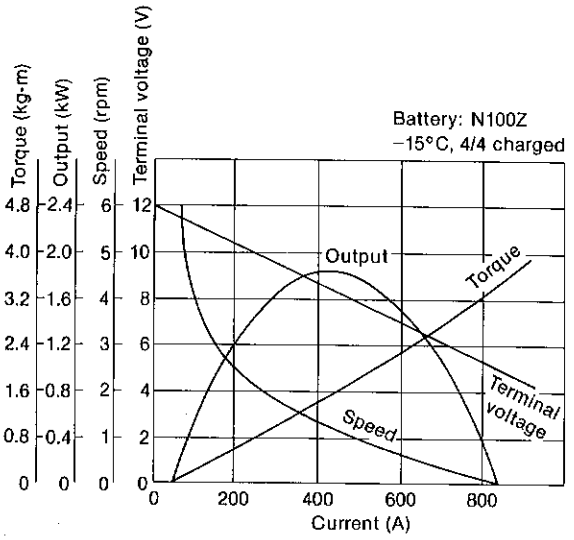
The starter motor is installed on the flywheel housing. When the starting button is pushed, the starter motor pinion flies out and engages the ring gear of the flywheel. Then the main contact is closed, current flows, and the engine is started.
After the engine starts, the pinion automatically returns 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		1GM10(C) 2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
Model		S114-303	S12-77A
Rating (sec)		30	30
Output (kW)		1.0	1.8
Direction of rotation (viewed from pinion side)		Clockwise	Clockwise
Weight kg (lb)		4.4 (9.7)	9.3 (20.5)
Clutch system		Overrunning	Overrunning
Engagement system		Magnetic shift	Magnetic shift
No. of pinion teeth		9	15
Pinion flyout voltage (V)		8 or less	8 or less
No-load	Terminal voltage (V)	12	12
	Current (A)	60 or less	90 or less
	Speed (rpm)	7000 or greaer	4000 or greater
Loaded characteristics	Terminal voltage (V)	6.3	8.5
	Current (A)	460 or less	420
	Torque kg-m(ft-lb)	0.9 (6.51) or greater	1.35 (9.76) or greater



S114-303 Performance curves



S12-77A Performance curves

3-2 Construction

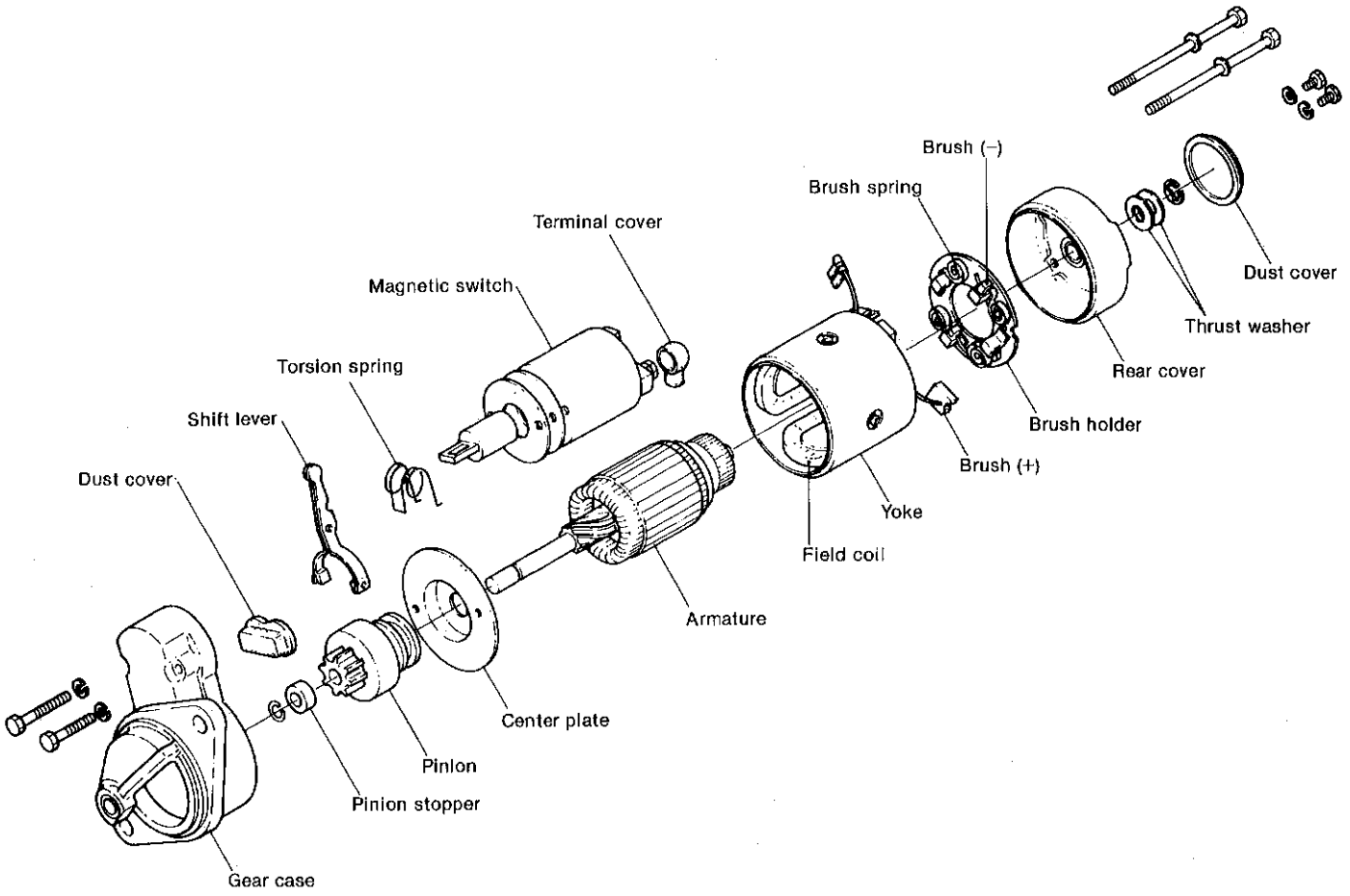
The starter motor described in this section is a conventional pre-engaged 4-brush 4-pole starter motor with a screw roller drive clutch.
The starter motor is composed of three major parts, as follows:

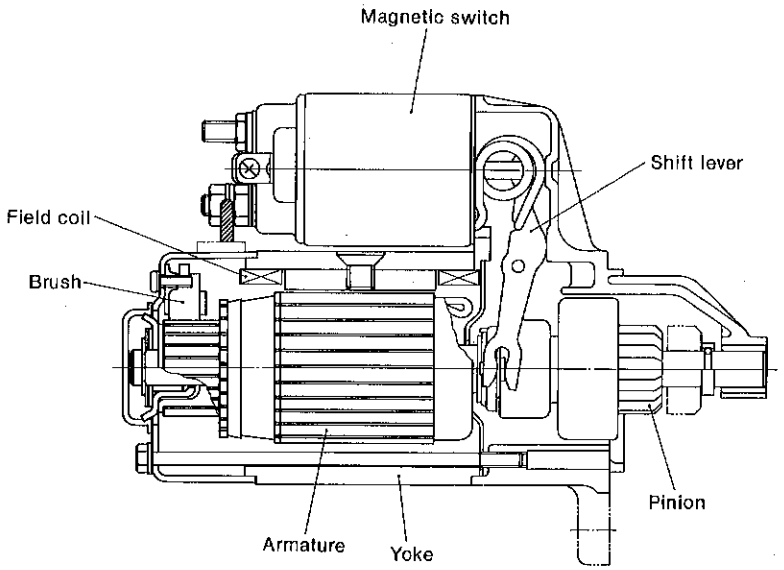
(1) Magnetic switch
Moves plunger to engage and disengage pinion, and through the engagement lever, opens and closes main contact (moving contact) to stop the starter motor.

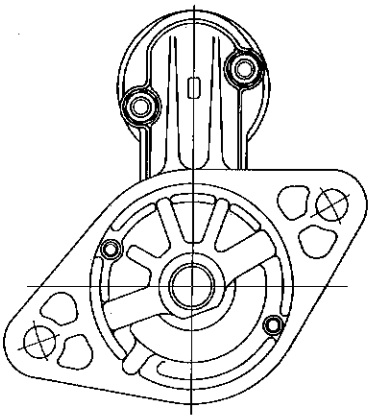
(2) Motor
A continuous current series motor which generates rotational drive power.

(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.

Printed in Japan
0000A0A1361



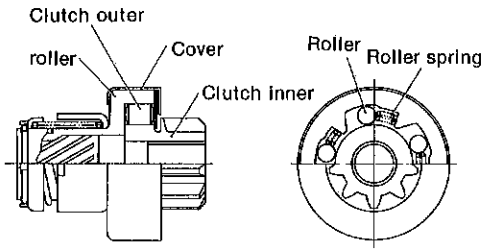




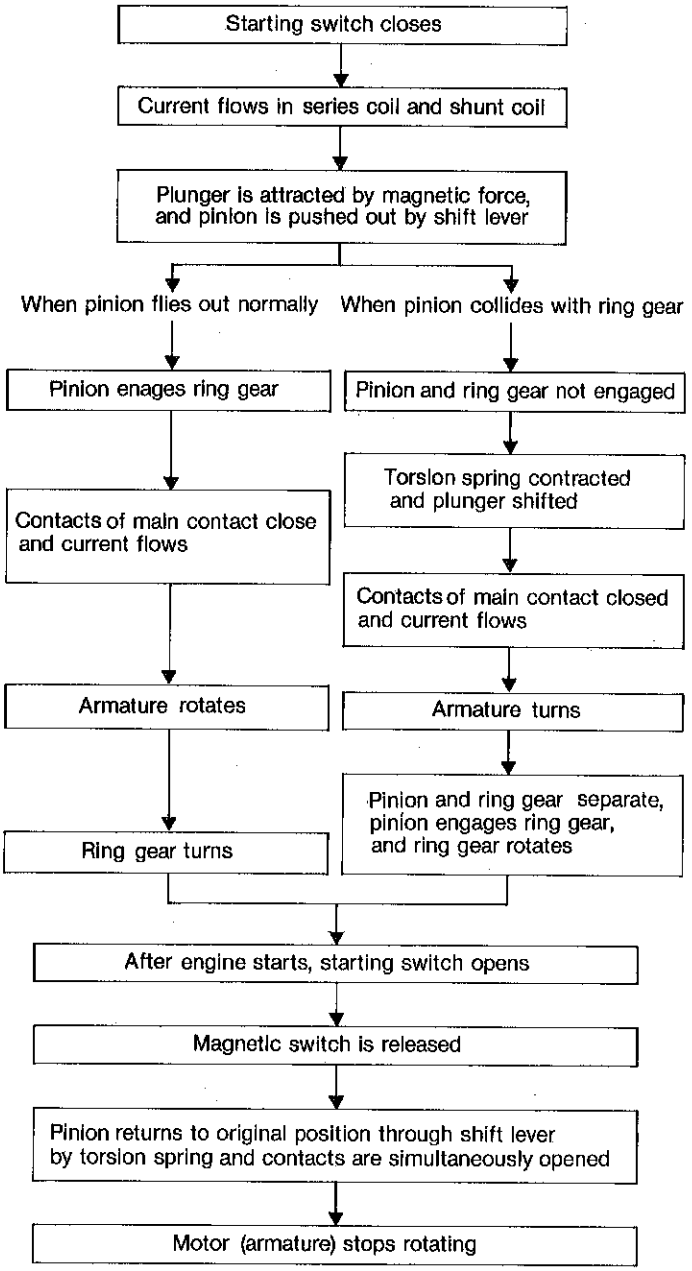
Printed in Japan
0000A0A1361

To prevent the motor receiving a shock which will occur as the engine starts and over-runs, this starter motor is installed with an over-running clutch.

Over-running clutch



3-3 Operation



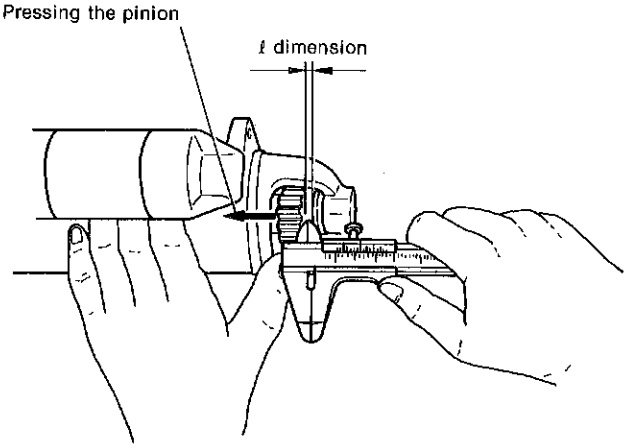
3-4 Adjustment and performance test

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

When the pinion is at the projected position, measure 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.)

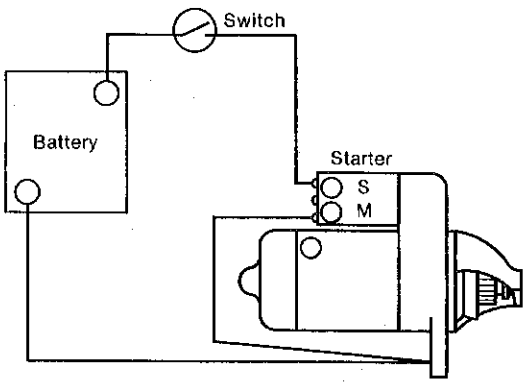
Starter motor	ℓ dimension
S114-303	0.3 ~ 2.5 (0.0118 ~ 0.0984)
S12-77A	0.2 ~ 1.5 (0.0079 ~ 0.0591)



Measuring of ℓ dimension

3-4.2 Pinion movement

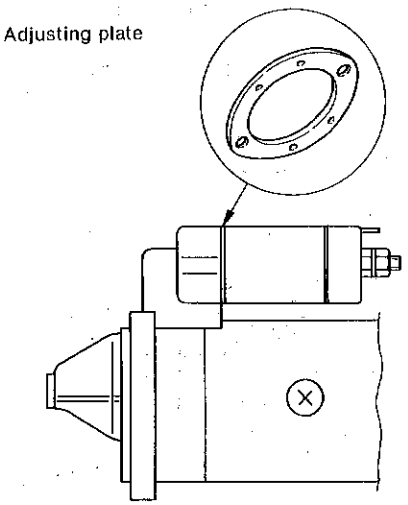
After complete assembly of the starter motor, connect up the motor as in Fig.



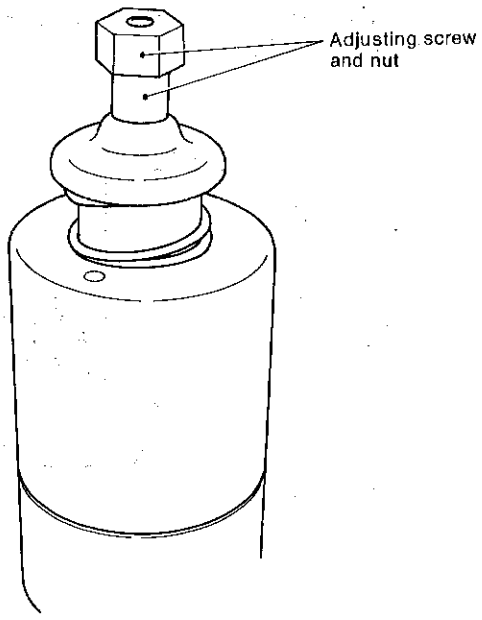
3-4.3 Plunger movement

Adjustment made by adjusting stroke of magnetic plunger to the prescribed value.

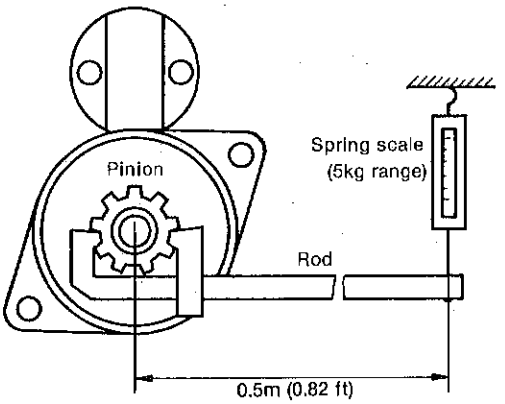
(1) Shim adjusting type (S114-303)
Adjust the ℓ-dimension installing shim (Adjusting plate) at the magnetic switch attach section.
There are two kind of shim [Thickness 0.5mm (0.0197in.), 0.8mm (0.0315in.)]



(2) Adjusting screw type (S12-77A)
Adjust the ℓ-dimension by adjusting screw and nut.

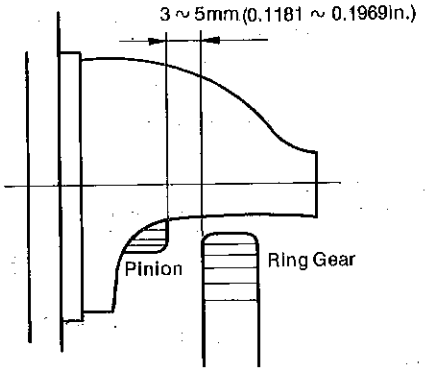


3-4.4 Pinion lock torque measurement



3-4.5 Mesh clearance

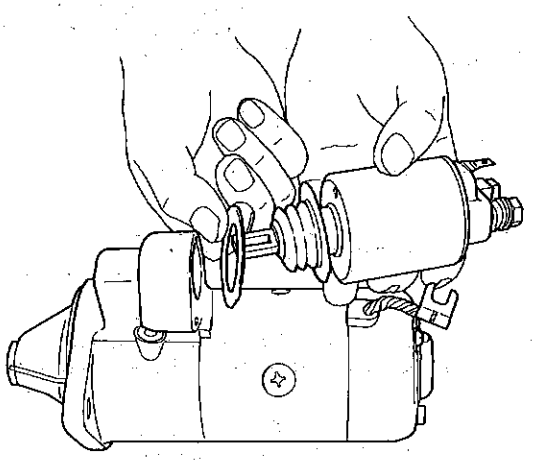
Mesh clearance is the distance between the flywheel ring gear and starter motor pinion in the rest position. This clearance should be between 3mm (0.1181in.) to 5mm (0.1969in.).



3-5 Disassembly

3-5.1 Magnetic switch

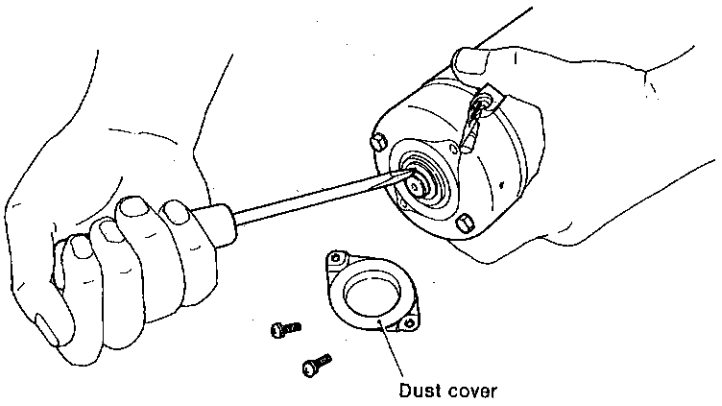
(1) Disconnect magentic switch wiring.
(2) Remove through bolt mounting magnetic switch.
(3) Remove magnetic switch.



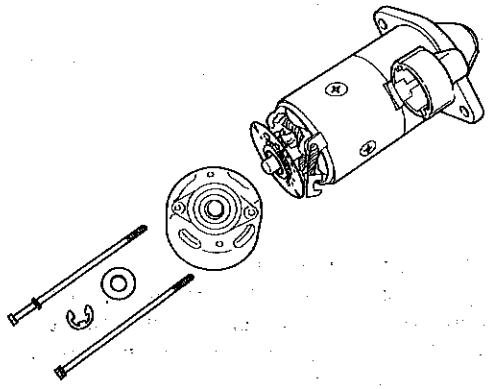
Printed in Japan
0000A0A1361

3-5.2 Rear cover

(1) Remove dust cover.

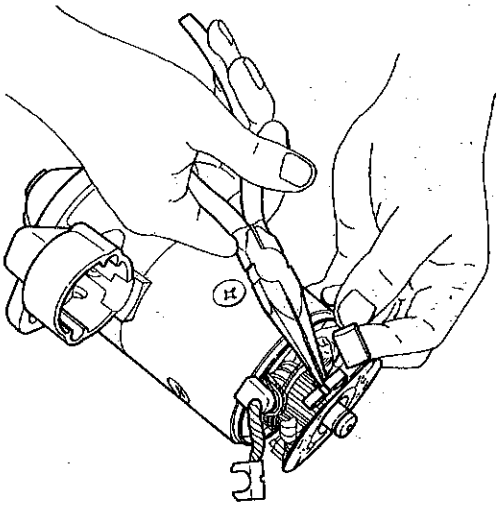


(2) Remove E-ring, and remove thrust washer (be careful not to lose the washer and shim).
(3) Remove the two through bolts holding the rear cover and the two screws holding the brush holder.
(4) Remove rear cover.



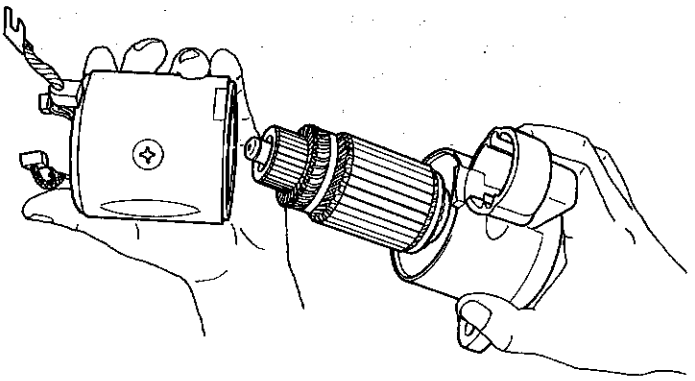
3-5.3 Brush holder

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



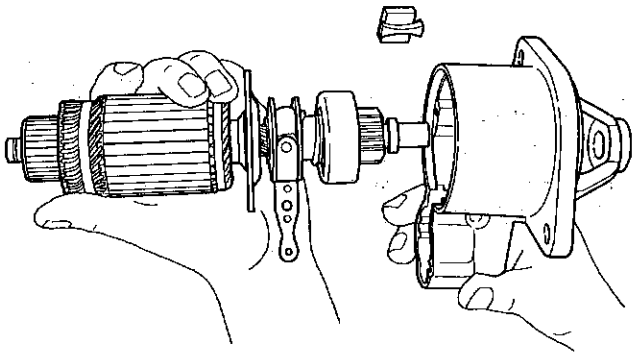
3-5.4 Yoke

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



3-5.5 Armature

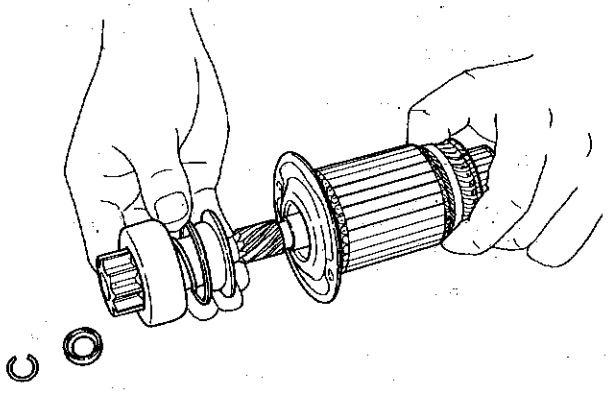
(1) Slide pinion stopper to pinion side.



(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.

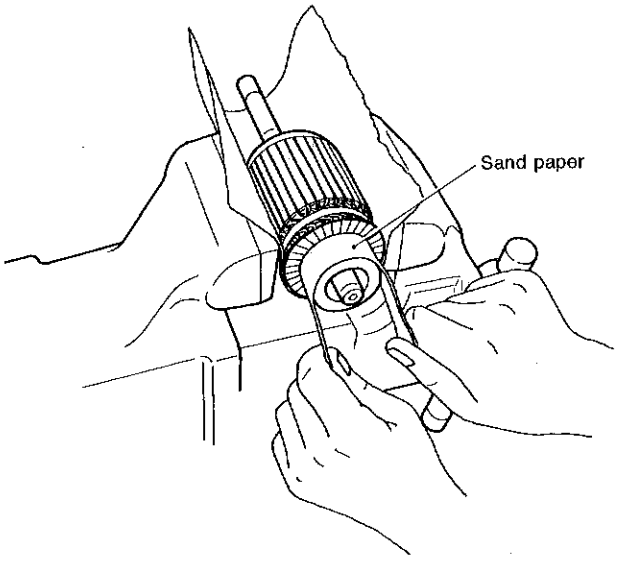


3-6 Inspection

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.

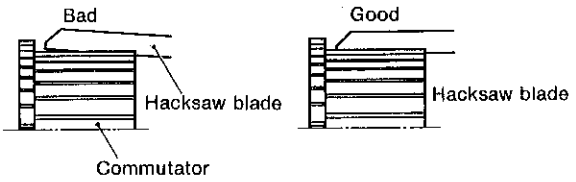


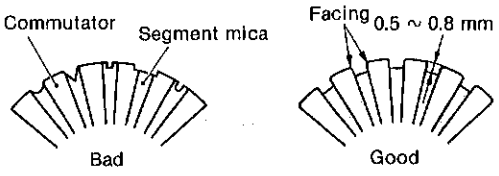
mm (in.)

	S114-303		S12-77A	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Commutator outside diameter	ø33 (1.299)	ø32 (1.260)	ø43 (1.693)	ø40 (1.575)
Commutator run-out	Within 0.03 (0.0012)	0.2 (0.0079)	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)	Repair limit 0.4 (0.0157)	Repair accuracy 0.05 (0.002)

(2) Mica undercut

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





mm (in.)

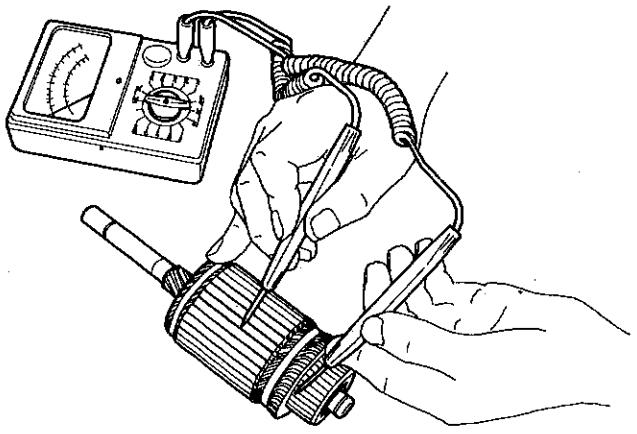
	Maintenance standard	Repair limit
Mica undercut	0.2 (0.0079)	0.5 ~ 0.8 (0.0197 ~ 0.0315)

(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.

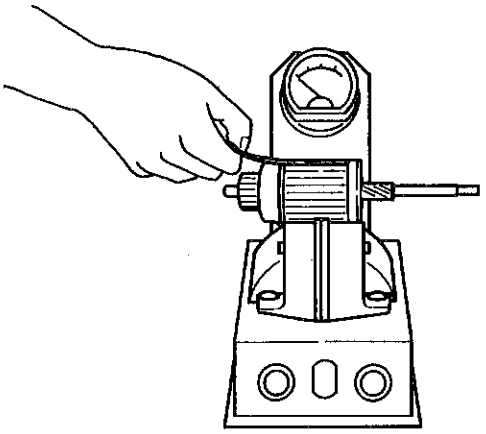
1) Short test...existence of broken or disconnected coil.
2) Insulation test...between commutator and armature core or distortion shaft.

Checking commutator for insulation defects.

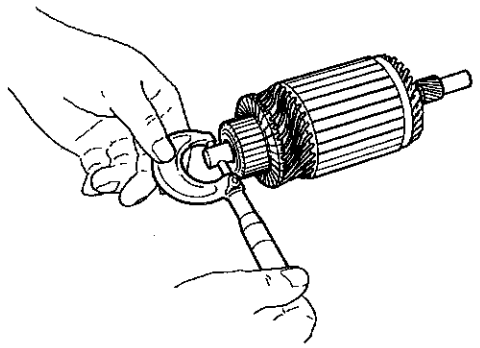


Printed in Japan
0000A0A1361

Checking armature windings for insulation faults.

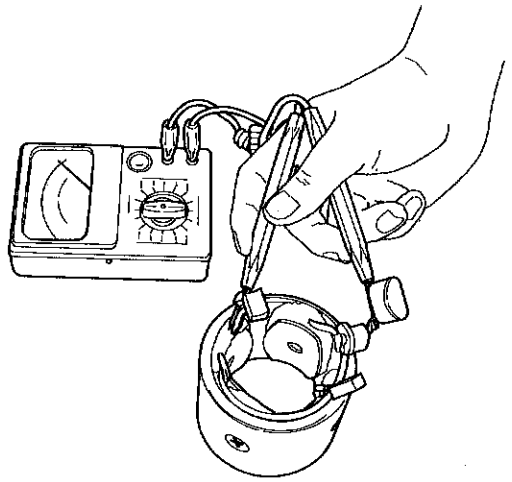


(4) Armature shaft outside diameter
Measure the outside diameter of the armature shaft at four locations: front, center, end, and pinion. Replace the armature if the shaft is excessively worn.
Check the bend of the shaft; replace the armature if the bend exceeds 0.08mm (0.0031in.)



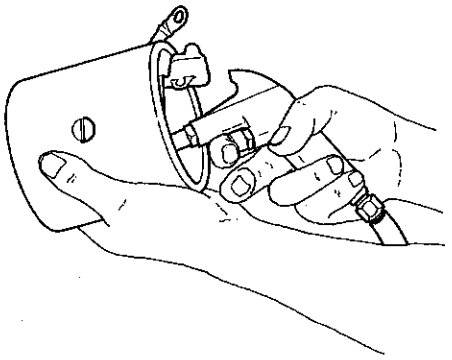
3-6.2 Field coil

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



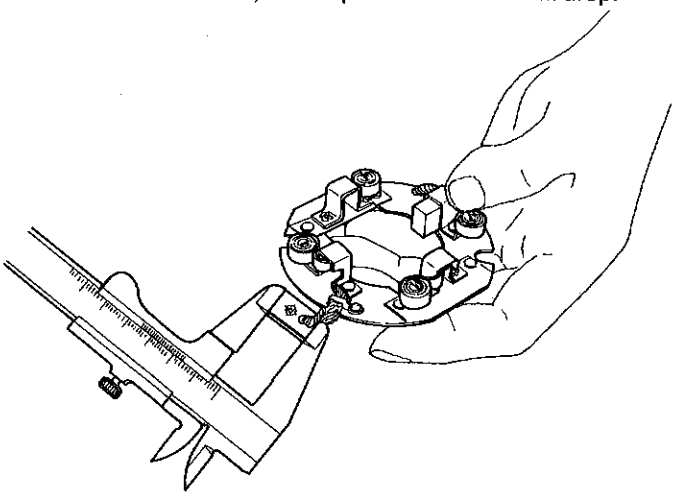
(2) Short test
Check for continuity between the yoke and any field coil terminal. Continuity indicates that the coil is shorted and that it must be replaced.

(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.

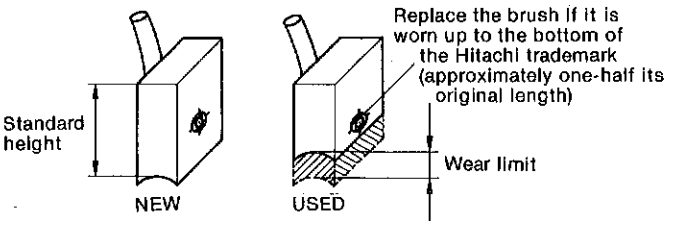


3-6.3 Brush

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.



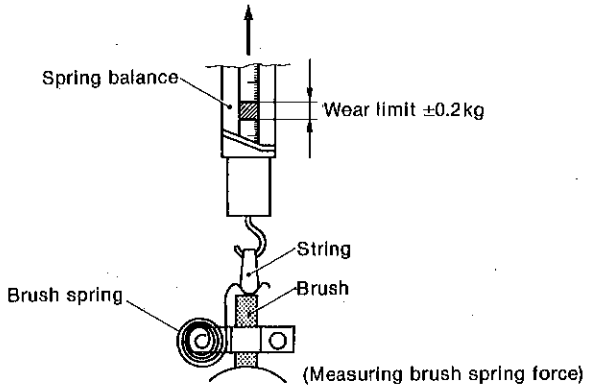
mm (in.)

	S114-303	S12-77A
Brush standard height	16 (0.6299)	22 (0.8661)
Wear limit	4 (0.1575)	8 (0.3150)

Printed in Japan
0000A0A1361

(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.

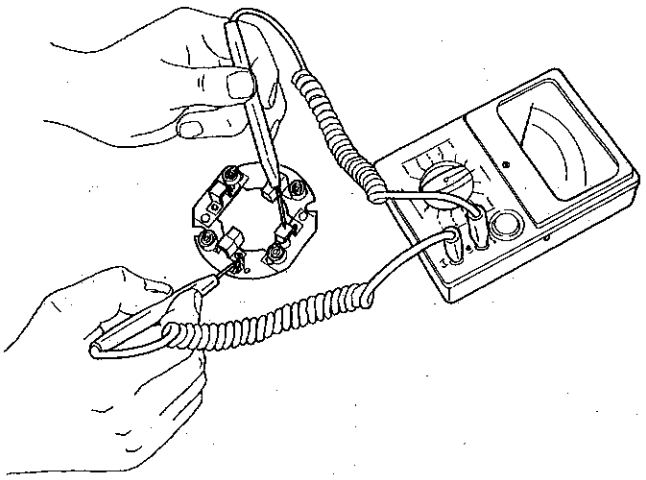
(3) Brush spring
Since the brush spring pushes the brush against the commutator while the motor is running, a weak or defective spring will cause excessive brush wear, resulting in sparking between the brush and the commutator during operation. Measure the spring force with a spring balance; replace the spring when the difference between the standard value and the measured value exceeds ±0.2kg.



(Measuring brush spring force)

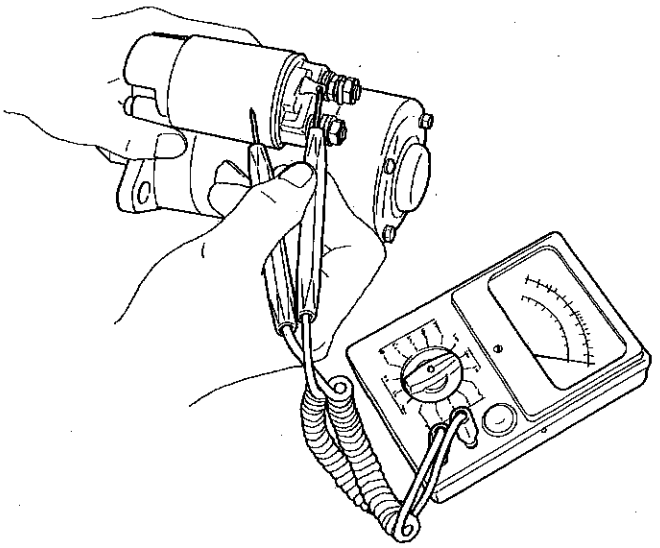
	S114-303	S12-77A
Standard spring load	1.6kg (3.527 lb)	0.85kg (1.8737 lb)

(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.



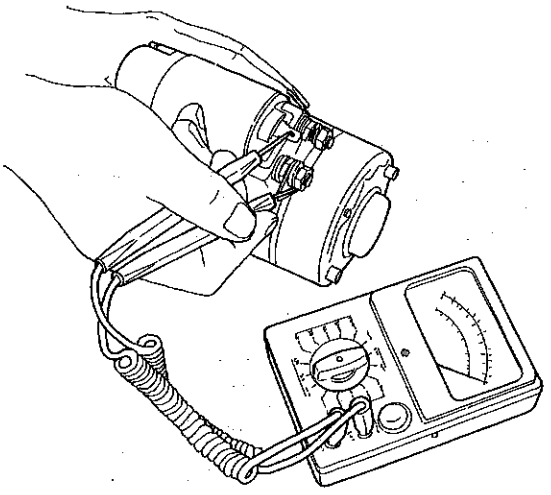
3-6.4 Magnetic switch

(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.



	S114-303	S12-77A
Coil resistance (at 20°C)	0.694Ω	0.590Ω

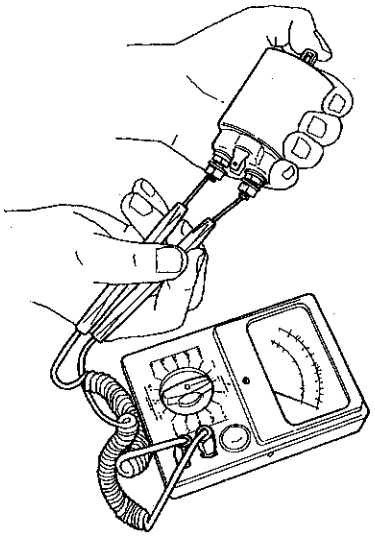
(2) Series coil continuity test
Check for continuity between the S terminal and M terminal. Continuity indicates that the coil is open and that it must be replaced.



	S114-303	S12-77A
Resistance value (at 20°C)	0.324Ω	0.267Ω

Printed in Japan
0000A0A1361

(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.



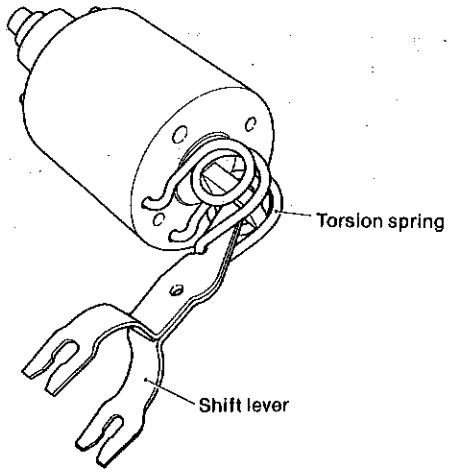
3-6.5 Pinion

(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.

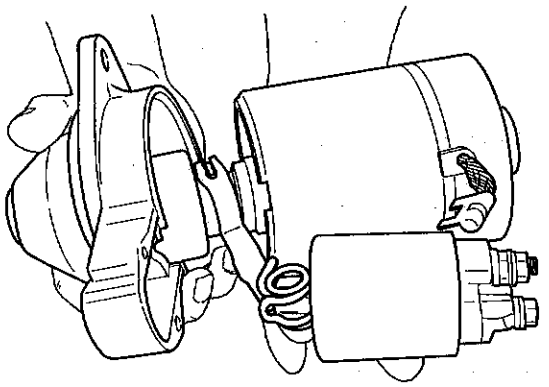
3-7 Reassembly precautions

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.



(2) Mounting the magentic 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

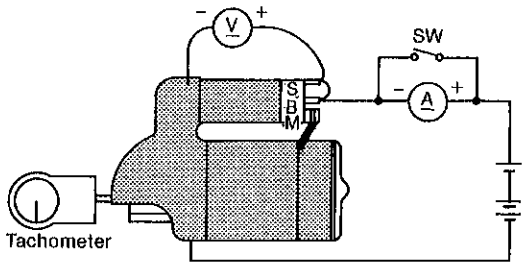
Printed in Japan
0000A0A1361

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 operating, and the speed, current, and voltage should be the prescribed values.
- A fully charged battery must be used.
- Since a large current flows when the starter is operated, close the protection circuit switch before initial operation, then open the switch and measure the current after the starter reaches a constant speed.

3-9 Maintenance standard

				S114-303	S12-77A
Brush	Standard spring load		kg (lb)	1.6 (3.527)	0.85 (1.8737)
	Standard height		mm (in.)	16 (0.6299)	22 (0.8661)
	Wear limit		mm (in.)	12 (0.472)	8 (0.3150)
Magnetic switch	Series coil resistance		Ω	0.324	0.267
	Shunt coil resistance		Ω	0.694	0.590
Commutator	Outside diameter	Maintenance standard	mm (in.)	ø33 (1.299)	ø43 (1.193)
		Wear limit	mm (in.)	ø32 (1.260)	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.)	12.450 ~ 12.468 (0.4902 ~ 0.4909)	14.950 ~ 14.968 (0.5886 ~ 0.5893)
		Bearing inside diameter	mm (in.)	12.500 ~ 12.527 (0.4921 ~ 0.4932)	15.000 ~ 15.018 (0.5906 ~ 0.5913)
	Intermediate bearing	Shaft diameter	mm (in.)	—	20.250 ~ 20.268 (0.7972 ~ 0.7980)
		Bearing inside diameter	mm (in.)	—	20.500 ~ 20.518 (0.8071 ~ 0.8080)
	Pinion sliding section	Shaft diameter	mm (in.)	12.450 ~ 12.468 (0.4902 ~ 0.4909)	13.950 ~ 13.968 (0.5492 ~ 0.5499)
		Pinion inside diameter	mm (in.)	12.530 ~ 12.550 (0.4933 ~ 0.4941)	14.030 ~ 14.050 (0.5524 ~ 0.5531)
	Pinion side bearing	Shaft diameter	mm (in.)	12.450 ~ 12.468 (0.4902 ~ 0.4909)	13.950 ~ 13.968 (0.5492 ~ 0.5499)
		Bearing inside diameter	mm (in.)	12.500 ~ 12.527 (0.4921 ~ 0.4932)	14.000 ~ 14.018 (0.5512 ~ 0.5519)

Printed in Japan
0000A0A1361

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

Printed in Japan
0000A0A1361

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

4-1 Features

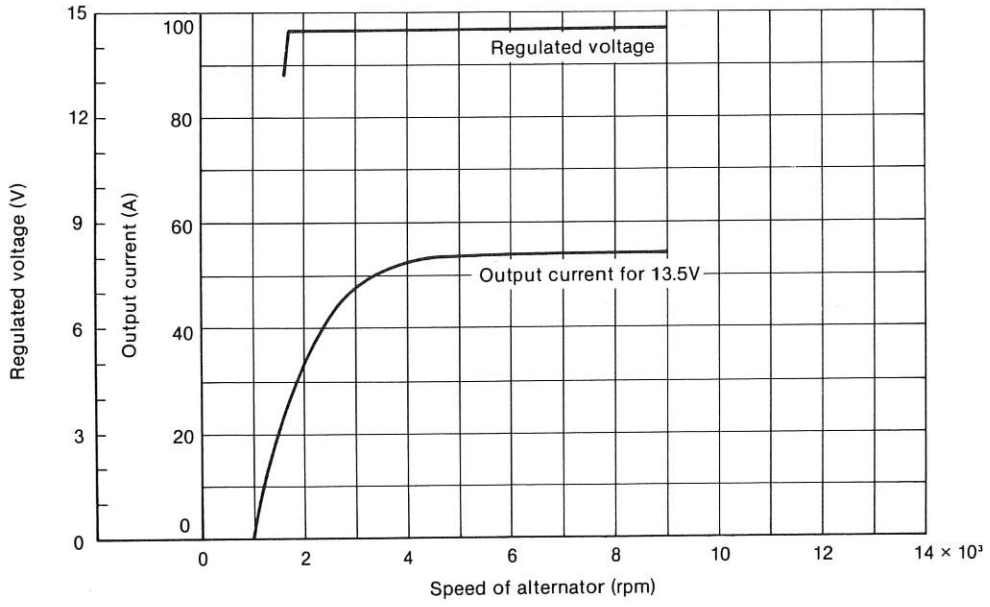
The alternator contains a regulator using an IC, and has the following features.

(1) The IC regulator is self-contained, and has no moving parts (mechanical contact point). 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) The alternator is 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)

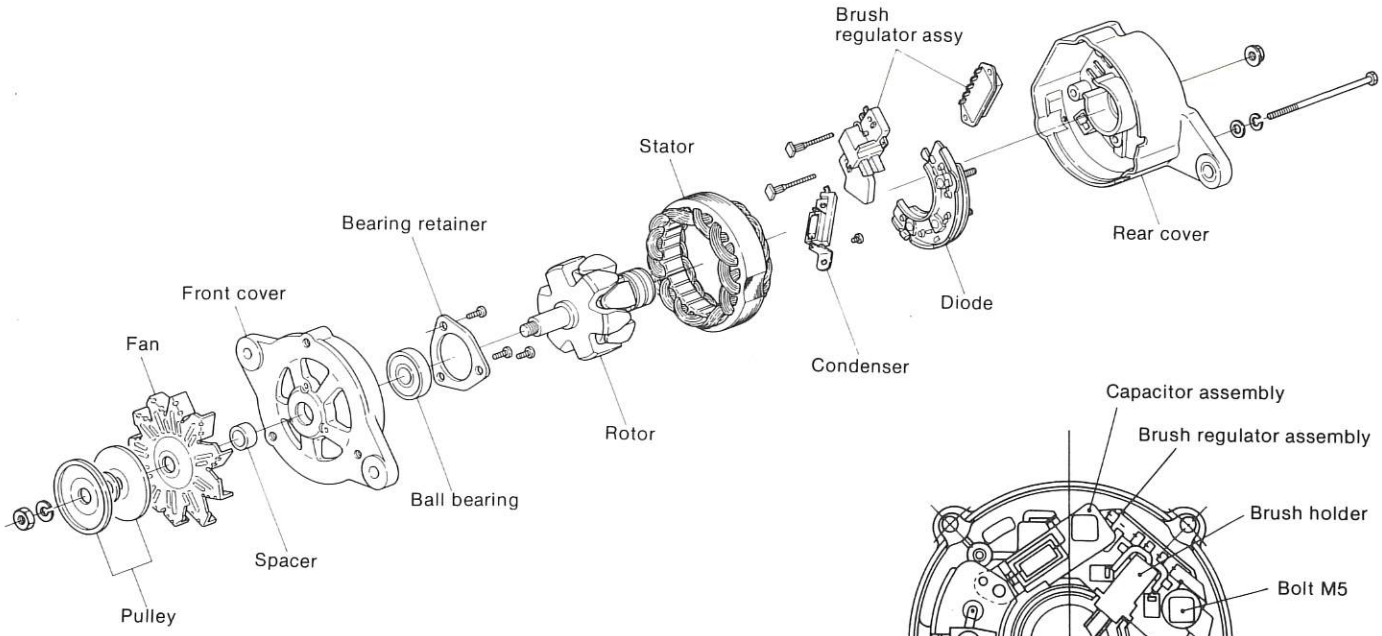
4-3 Characteristics

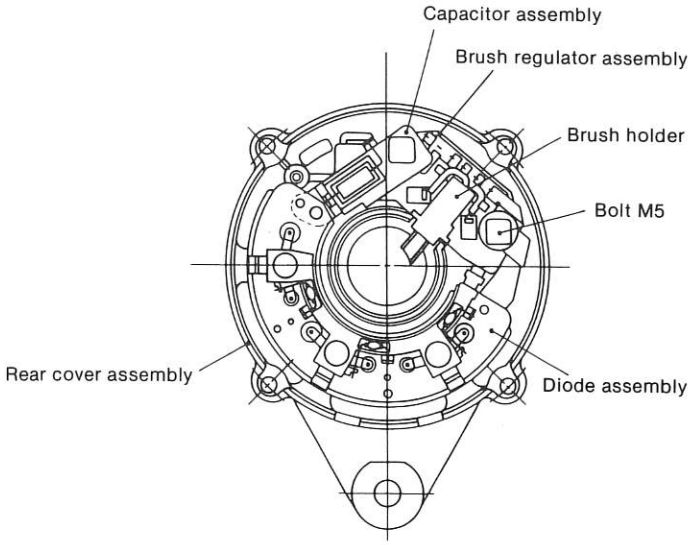


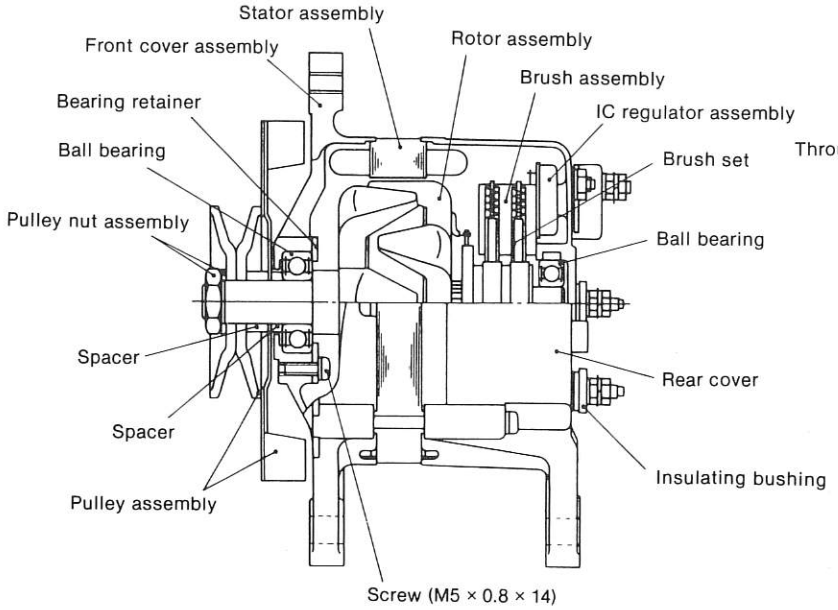
Printed in Japan
0000A0A1361

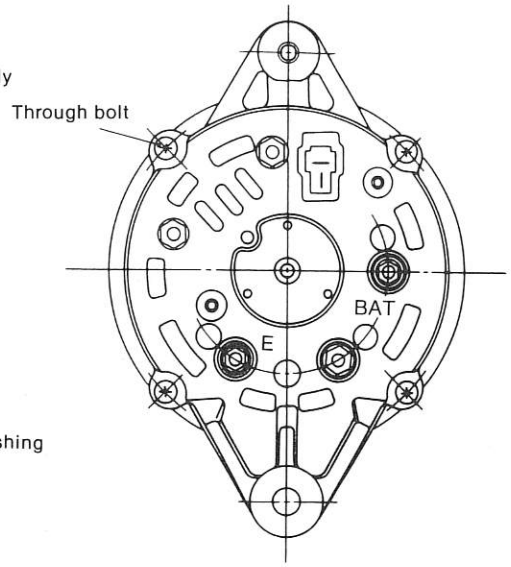
4-4 Construction

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.









Alternator functioning

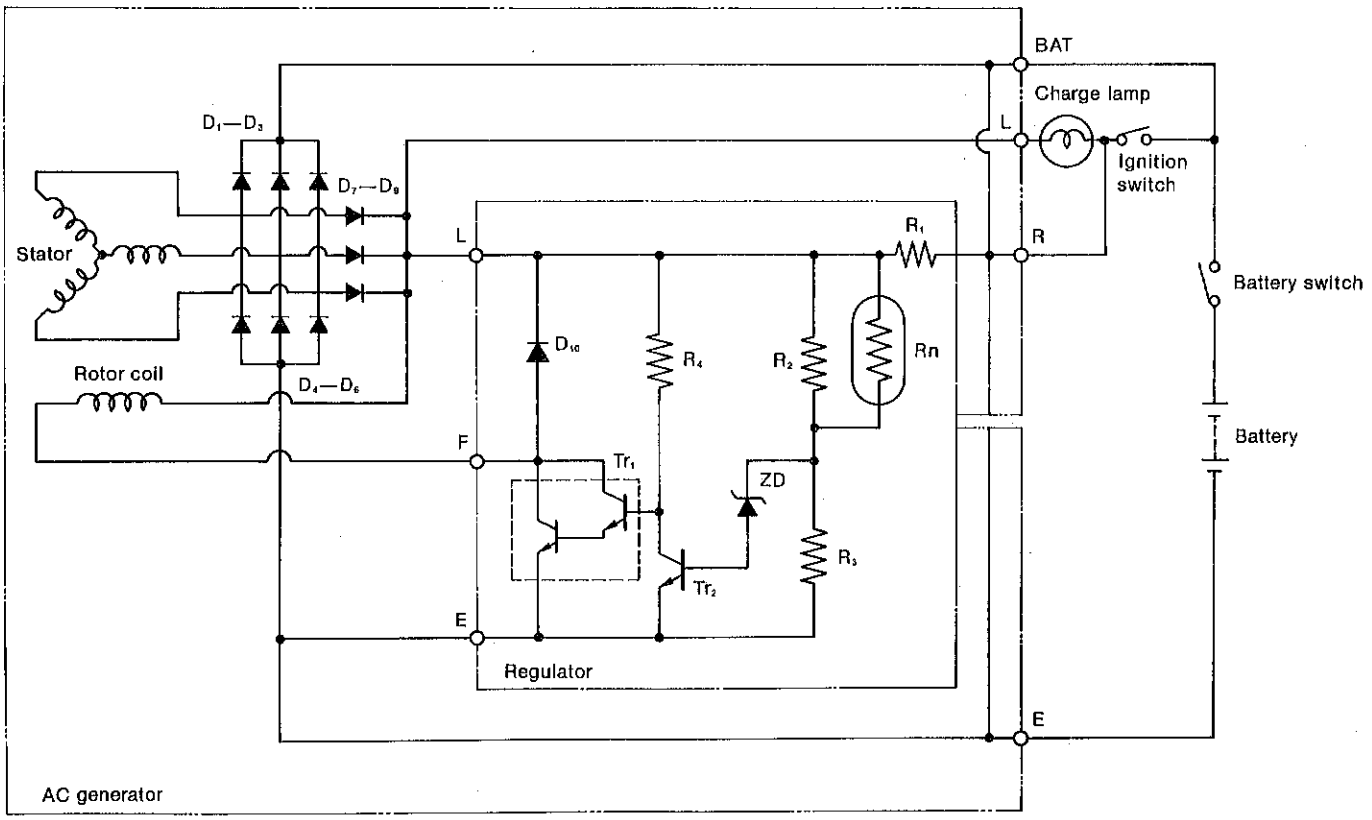
(1) IC regulator
The IC regulator is the transistor (Tr_1) which is series-connected with the rotor. The IC regulator controls the output voltage of the generator by breaking or conducting the rotor coil (exciting) current.
When the output voltage of the generator is within the standard value, the transistor (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.)

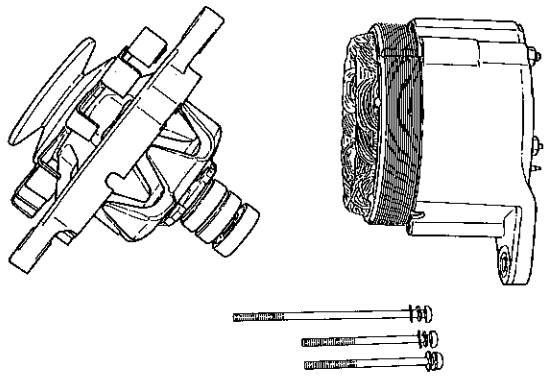


BAT:	Generator output terminal	D_1—D_6:	Output commutation diode
D_{10}:	IC protecting diode	R_1—R_4:	Resistor
L:	Charge lamp terminal	D_7—D_9:	Charging lamp switching diode
ZD:	Zener diode	F:	To supply current to rotor coil
E:	Earth	Rn:	Thermistor (Temperature gradient resistance)
Tr_1, Tr_2:	Transistor		

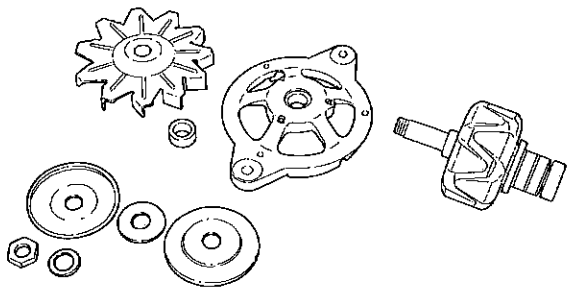
Printed in Japan
0000A0A1361

4-7 Disassembling the alternator

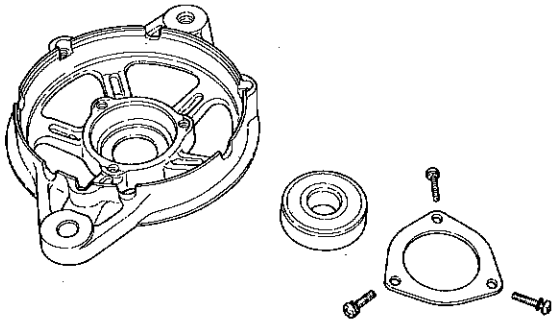
(1) Remove the through-bolt, and separate the front assembly from the rear assembly.



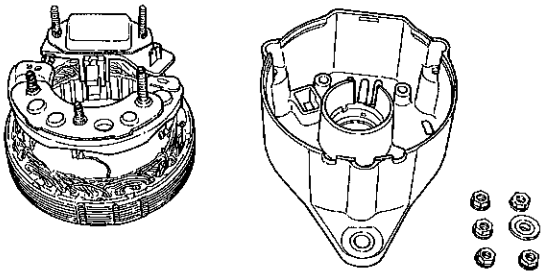
(2) Remove the pulley nut, and pull out the rotor from the front cover.



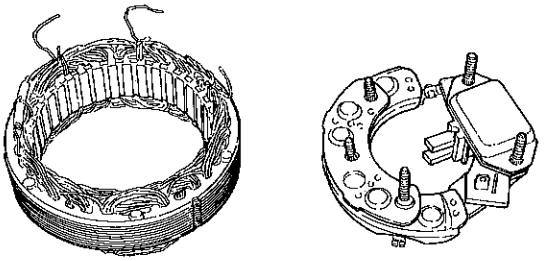
(3) Remove the ø5mm screw from the front cover, and then remove the ball bearing.



(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).

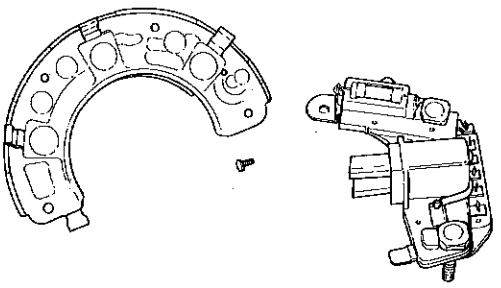


(5) Disconnect the soldered joint of the stator lead wire, and remove the diode and brush regulator assemblies from the stator at the same time.



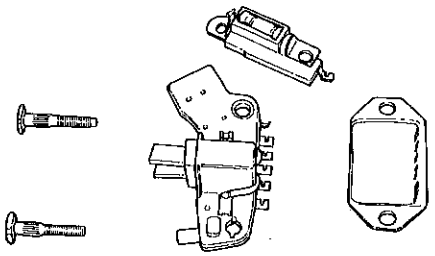
(6) Separating the regulator

1) To separate the regulator, remove the ø3.0mm rivet which keeps the diode assembly and the brushless regulator in place, and the soldered joint of the L-terminal.



Printed in Japan
0000A0A1361

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

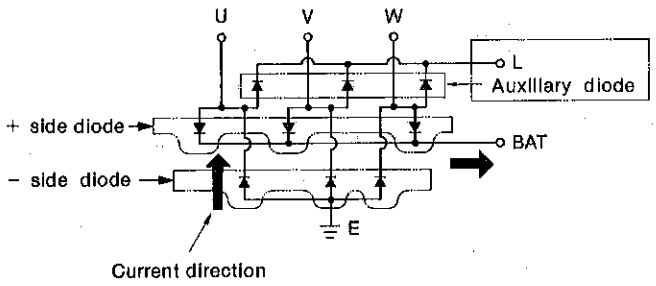


4-8 Inspection and adjustment

(1) Diode

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

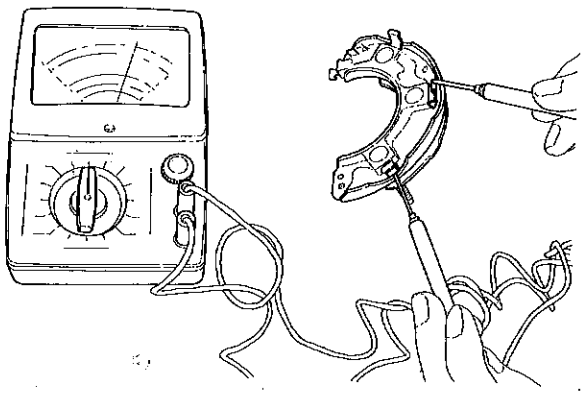
Between terminals		E (− side diode)	
	Tester wire	+ side	− side
U.V.W.	+ side		Continuity
	− side	No continuity	



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.



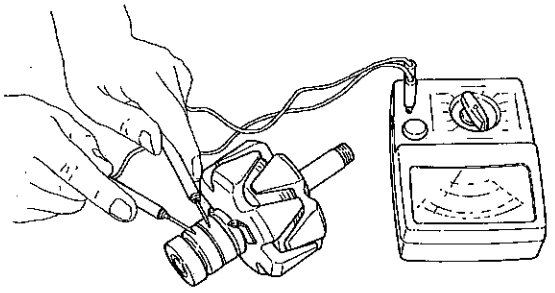
CAUTION: Do not use high tensile insulation resistance such as meggers, etc. for testing. Otherwise, the diode may burn out.

(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.)

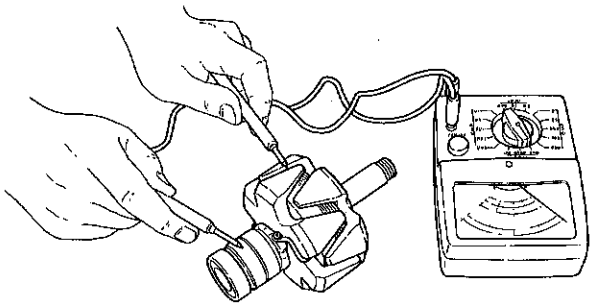
2) Rotor coil continuity test
Check the continuity in the slip ring with the tester. If there is no continuity, there is a wire break. Replace the rotor coil.



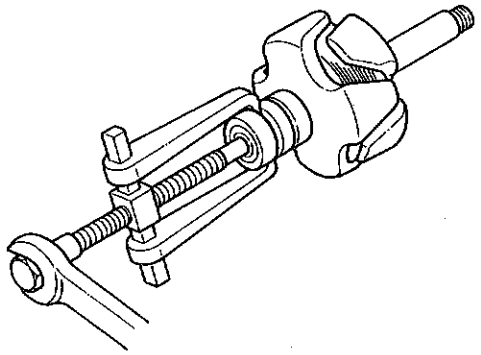
Resistance value	Approx. 3.34Ω at 20°C

Printed in Japan
0000A0A1361

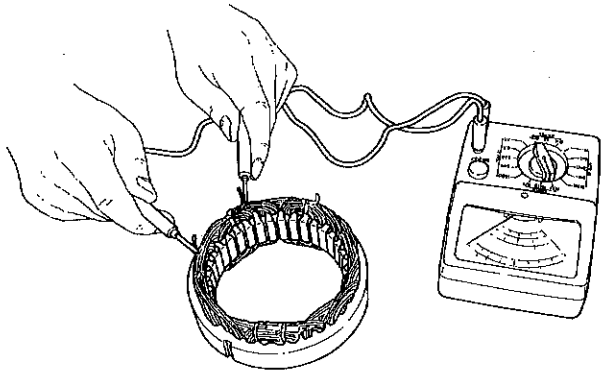
3) Rotor coil insulation test
Check the continuity between the slip ring and the rotor core, or the shaft. If there is continuity, insulation inside the rotor is defective, causing a short-circuit with the earth circuit. Replace the rotor coil.



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

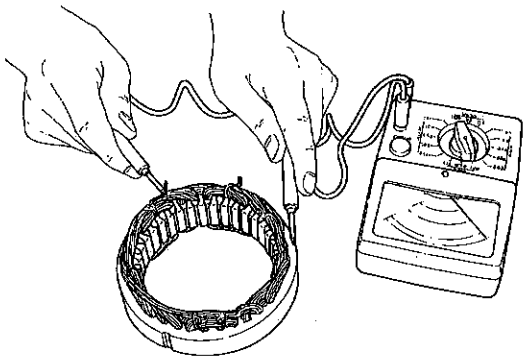


(3) Stator
1) Stator coil continuity test
Check the continuity between each terminal of the stator coil. If there is no continuity, there is a wire break in the stator coil. Replace the stator coil.

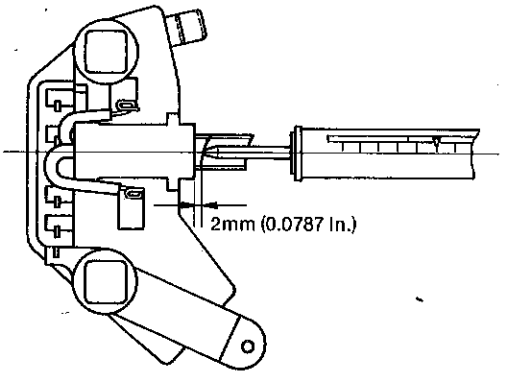


Resistance value	Approx. 0.077Ω at 20°C 1-phase resistance

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.

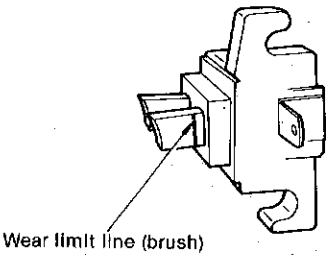


(4) Brush
The brush is hard and wears slowly, but when it is worn beyond the allowable limit, replace it. When replacing the brush also check the strength of the brush spring. To check, push the spring down to 2mm from the end surface of the brush holder, and read the gauge.



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)

Printed in Japan
0000A0A1361

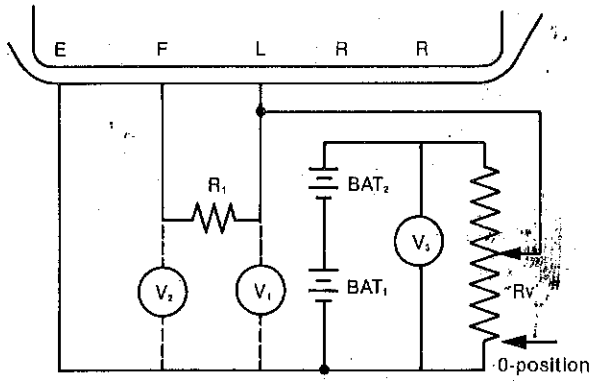
(6) IC regulator

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. (to 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.

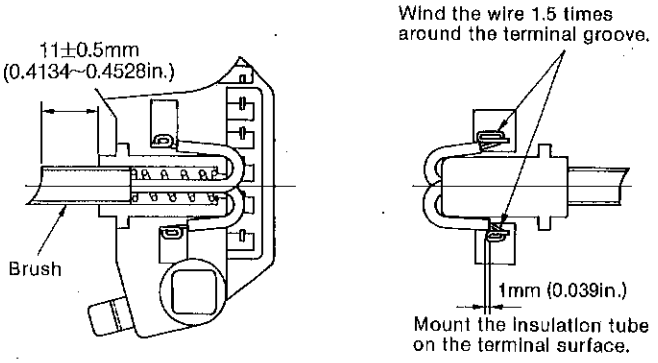


4-9 Reassembling the alternator

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

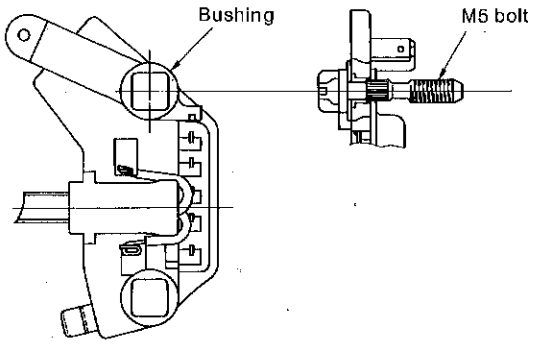
(1) Assembling the brush regulator

1) Solder the brushes.
   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).



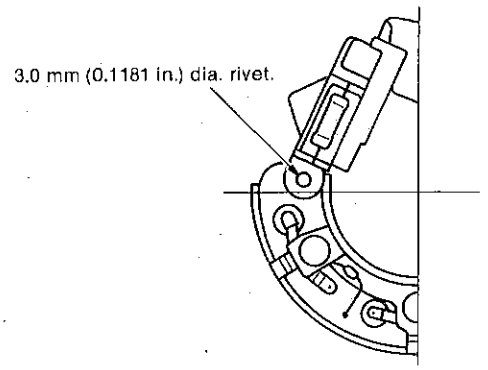
NOTES: 1. Insertion pressure is 100kg (220.5 lbs.)
2. Insert vertically.

(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.)

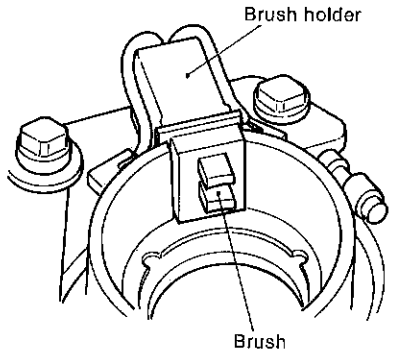
2) Connect the brush to the diode.
   Insert the brush side terminal into the diode terminal, calk it, and then solder into place.

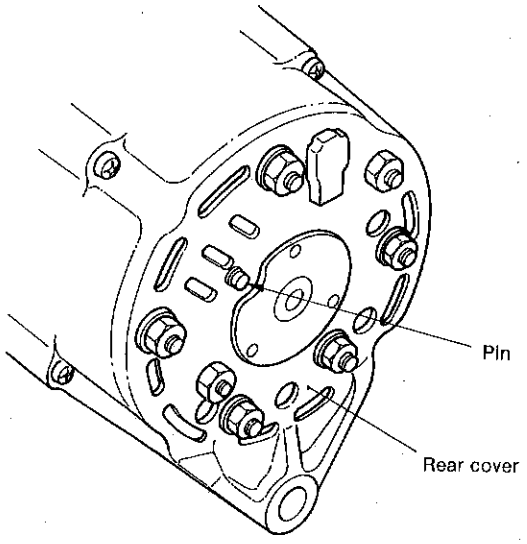


Rivetting pressure	500kg (1102 lbs.)

Printed in Japan
0000A0A1361

(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.



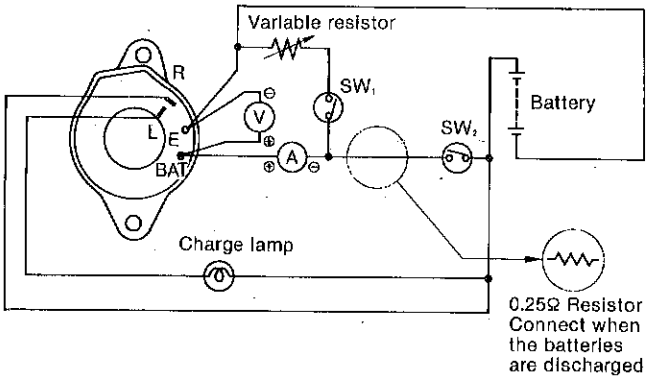


(4) Tightening torques

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.

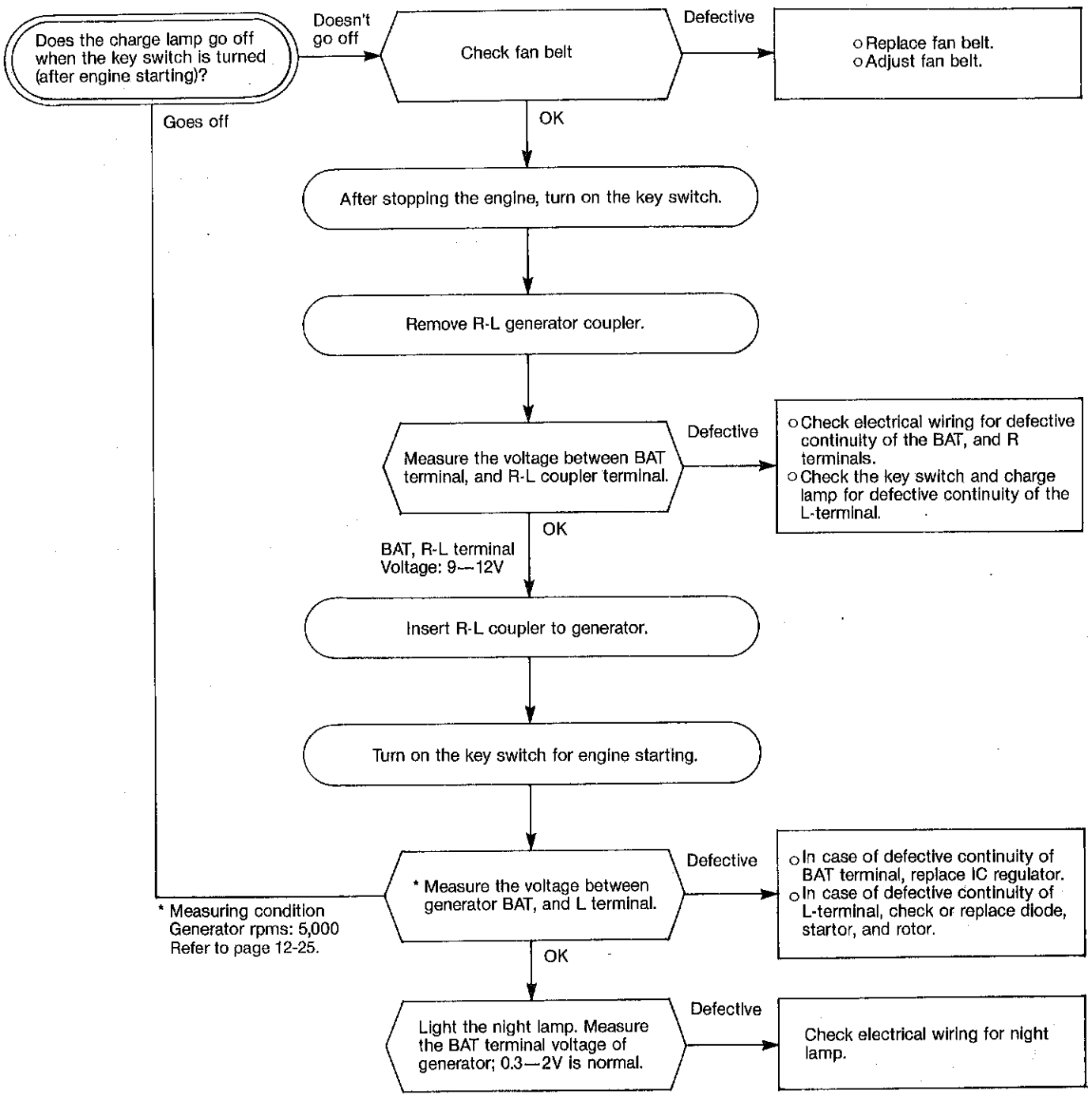
NOTES: 1. Make sure that the ammeter indication at this time is less than 5A. If the indication is over 5A, connect the 0.25Ω resistor. The voltmeter indication at this time must be within the prescribed regulating voltage value.
2. Raise the AC generator revolutions high to make sure the regulating 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.

Printed in Japan
0000A0A1361

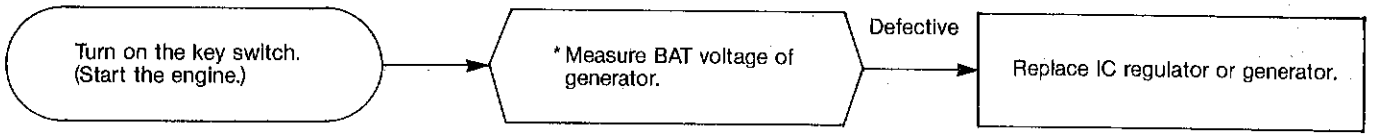
4-11 Troubleshooting

(1) Charging failure

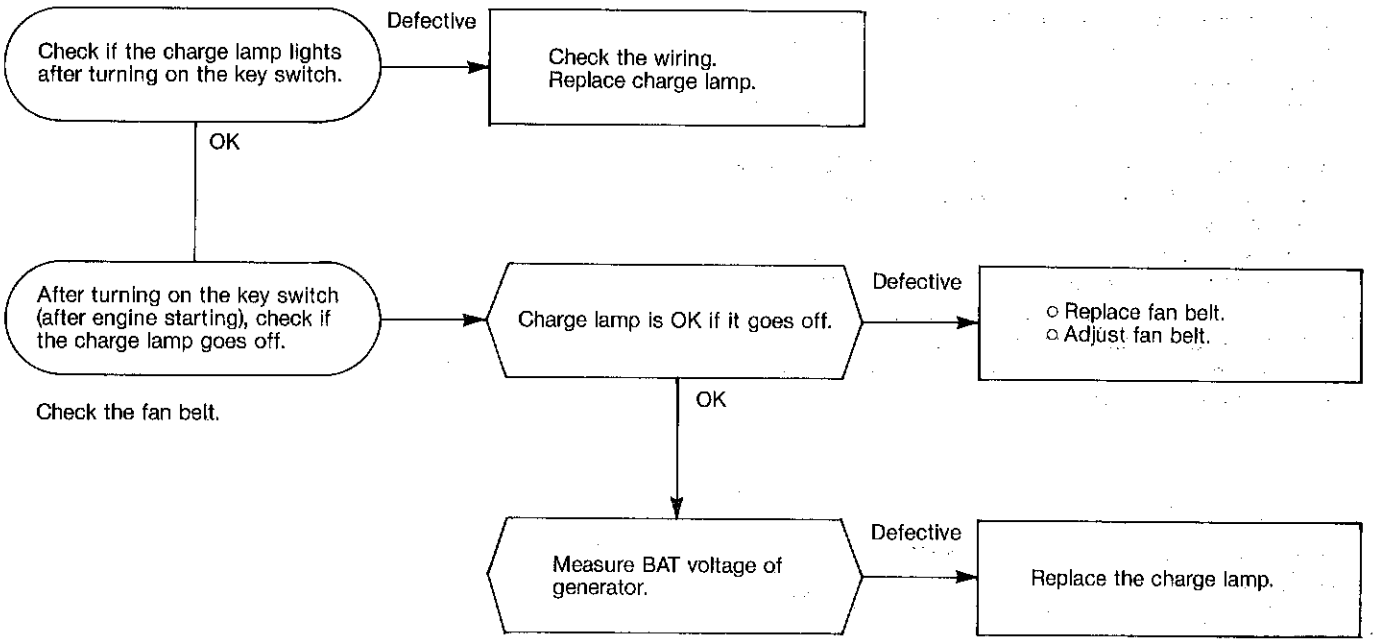


Printed in Japan
0000A0A1361

(2) Overcharging



(3) Charge lamp failure



Printed in Japan
0000A0A1361

4A. Alternator, Option, 12V/35A [Except 1GM10(C)]

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 having 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.

4A-1. Features

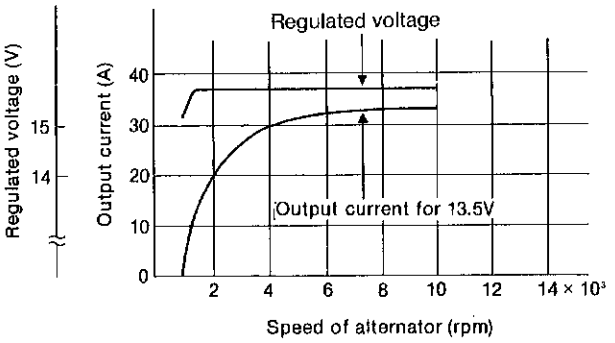
The alternator contains a regulator using an IC, and has the following features.

(1) The IC regulator, which is self-contained, has no moving part (mechanical contact point), therefore it 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 compensating 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, light 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 countermeasures 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 harness inboard is connected to the alternator, is nickel plated.

4A-2. Specifications

Model of alternator	LR135-105 (HITACHI)
Model of IC regulator	TR1Z-63 (HITACHI)
Battery voltage	12V
Nominal output	12V, 35A
Earth polarity	Negative earth
Direction of rotation (viewed from pulley end)	Clockwise
Weight	3.5 kg (7.7 lb)
Rated speed	5000 rpm
Operating speed	900 ~ 8000 rpm
Speed for 13.5V	900 rpm or less
Output current (when heated)	5000 rpm 32±2A
Regulated voltage	14.5±0.3V (at 20°C, Full battery)
Standard temperature/ voltage gradient	-0.01V/°C

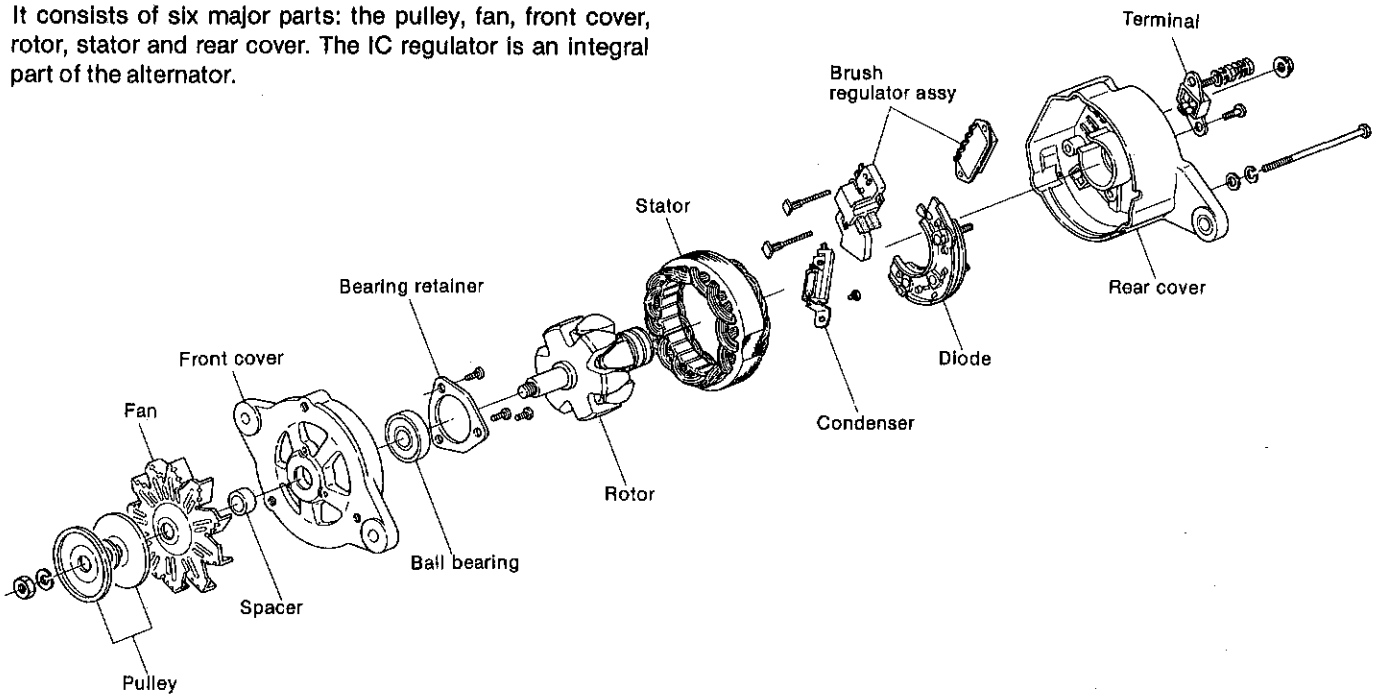
4A-3. Characteristics

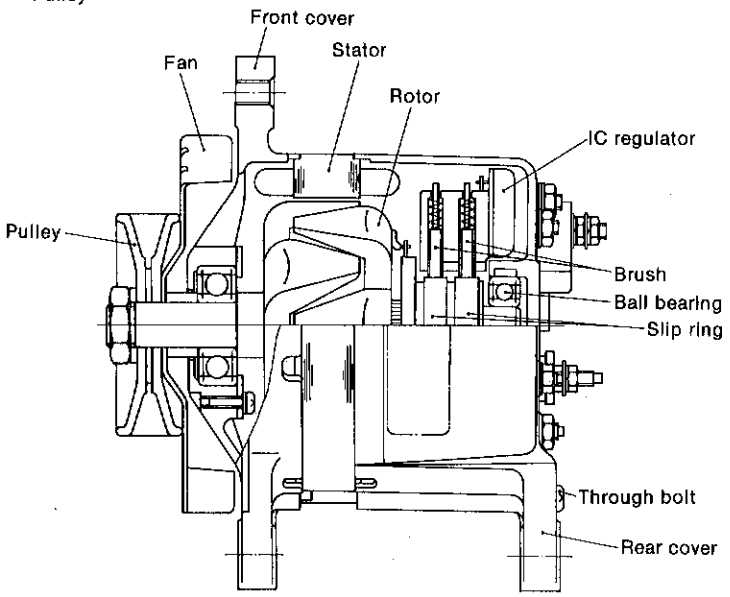


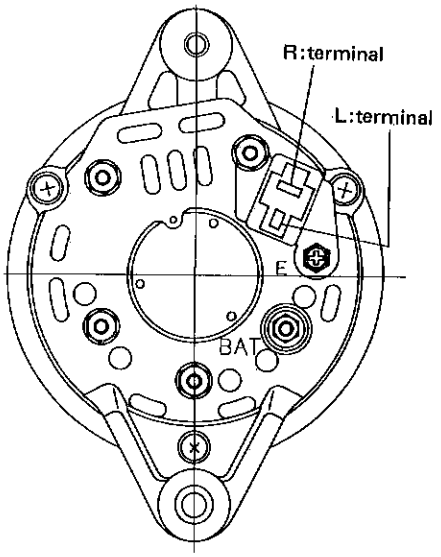
Printed in Japan
0000A0A1361

4A-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.



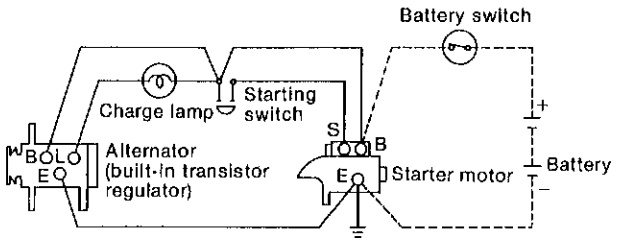




Printed in Japan
0000A0A1361

4A-5.Wiring

(1) Wiring diagram



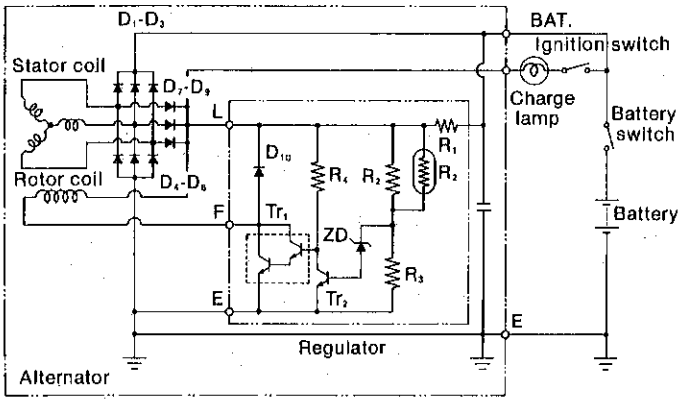
(2) Terminal connections

The alternator has the following terminals. Connect these terminals as indicated below.

Symbol	Terminal name	Connection to external wiring
B	Battery terminal	To battery (+) side
E	Ground terminal	To battery (−) side
L	Lamp (charge) terminal	To charge lamp terminal

4A-6. Circuit diagram

4A-6.1 Circuit diagram



BAT: Battery output terminal
L: Charge lamp terminal
E: Earth
$D_1 \sim D_6$: Diodes for rectifying the output current
$D_7 \sim D_9$: Diodes for switching the charge lamp
D_{10}: Diode for protecting the IC
ZD: Zener diode
Tr_1, Tr_2: Transistors
$R_1 \sim R_2$: Resistors
F: Rotor current
Rn: Thermistor (resistors with current/temperature gradient)

4A-6.2 Principle of IC regulator function

The IC regulator controls the output voltage of the alternator by switching the rotor current (exciting current) on or off by means of the transistor Tr_1 which is connected in series with the rotor coil.

When the output voltage of the alternator is within the regulated values, transistor Tr_1 is "ON" but when the voltage is outside the regulated value, the Zener diode ZD comes "ON", and regulates the output voltage rise by turning transistor Tr_1 "OFF".

The output voltage is kept within the regulated values by repeating the "ON"—"OFF" operation.

4A-7. Alternator handling precautions

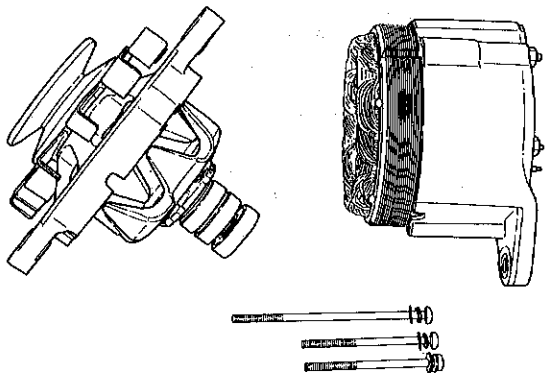
(1) Pay attention to the polarity of the battery; be careful not to connect it in reverse polarity. If the battery is connected in reverse polarity, the battery will be shorted by the diode of the alternator, an overcurrent will result, the diodes and transistor regulator will be destroyed, and the wiring harness will be burned.
(2) Connect the terminals correctly.
(3) When charging the battery from outside, such as during rapid charging, disconnect the alternator B terminal or the battery terminals.
(4) Do not short the terminals.
(5) Never test the alternator with a high voltage meter.

4A-8. Alternator disassembly

Disassemble the alternator as follows.

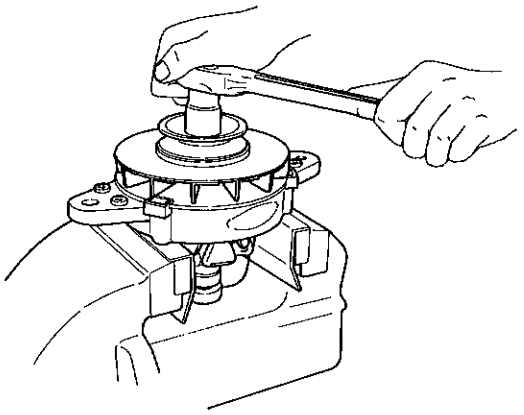
The major points of disassembly are the removal of the cover, the separation of the front and rear sides, and detailed disassembly.

(1) Remove the cover attached to the rear cover, remove the through bolts, and disassemble into front and rear sides.

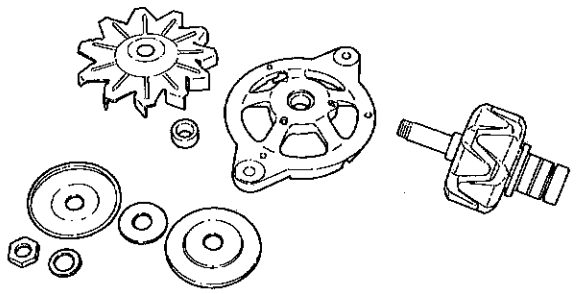


Printed in Japan
0000A0A1361

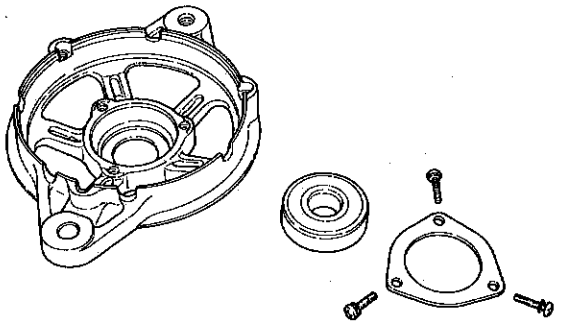
(2) When disassembling the front side pulley and fan, front cover and rotor, clamp the rotor in a vice within copper plates and loosen the pulley nut, as shown in the figure.



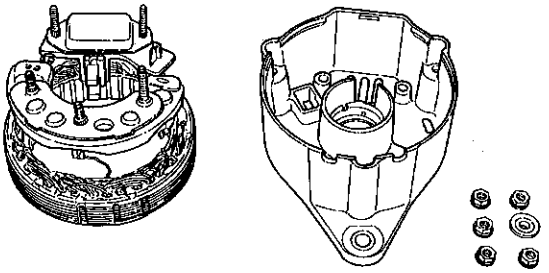
(3) When the fan and pulley have been removed, the rotor can be pulled from the front cover by hand.



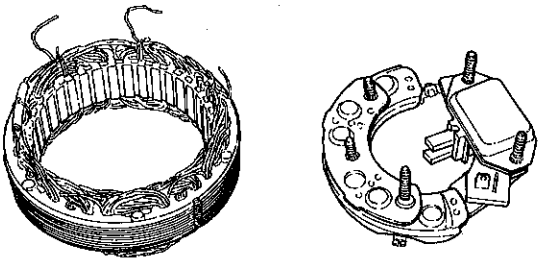
(4) Next, remove the bearing attached to the front cover. Loosen the bearing protector mounting bolts (M4) and pull the bearing by applying pressure to the bearing from the front cover.



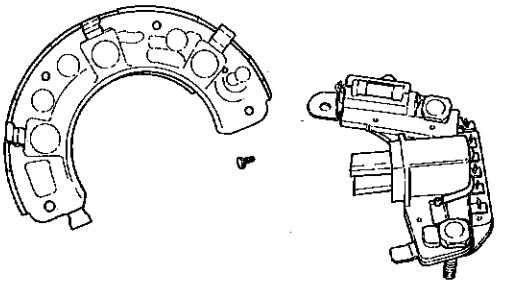
(5) Remove the nut at the threaded part of the BAT terminal on the rear cover, the fixing nut of the diode, and the bolt of E terminal.
After removing the L terminal assembly, separate the alternator into rear cover and stator (with attached diode and brush holder).



(6) Unsolder the lead wire connection and remove the diode assembly together with the regulator assembly.

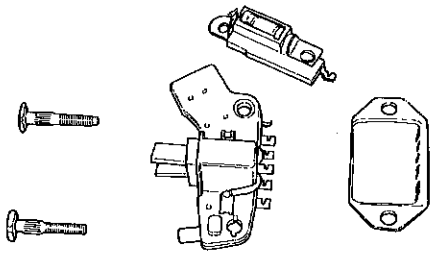


(7) Separate the diode assembly and the brush regulator assembly by removing the 3mm dia rivet which connects these two parts and then unsolder the L terminal connection.

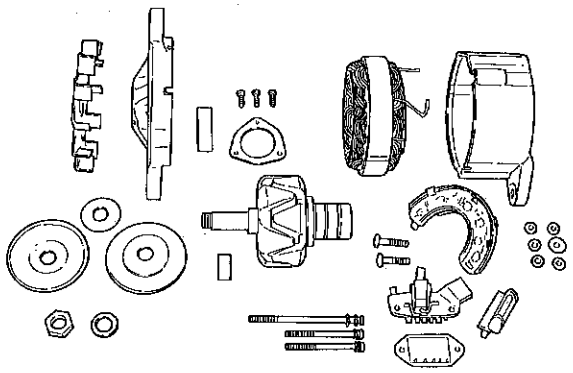


Printed in Japan
0000A0A1361

(8) When replacing the IC regulator, it can be removed by unsoldering the regulator's terminals and removing two bolts. Never remove these two bolts except when the regulator is replaced.



(9) When (1)—(8) above are completed, the alternator is completely disassembled.

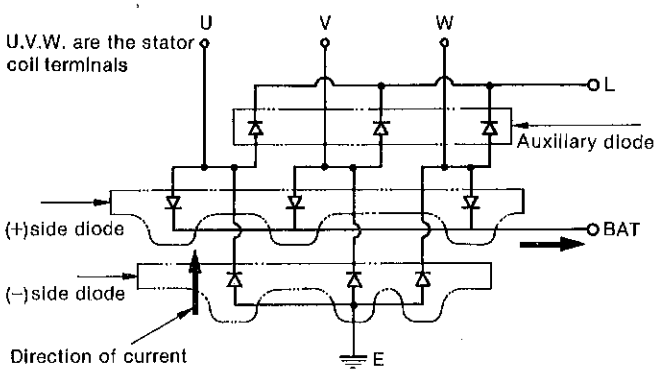


4A-9. Inspection and adjustment

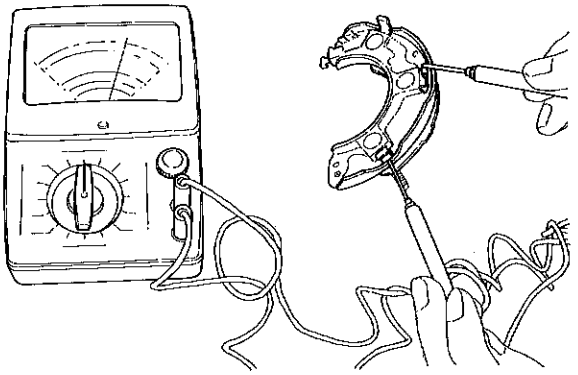
4A-9.1 Diodes

Between terminal		BAT (+ side diode)	
	Tester pin	(+)side	(−)side
U.V.W	(+)side	—	Continuity No
	(−)side	Continuity Yes	—

Between terminal		E (− side diode)	
	Tester pin	(+) side	(−) side
U.V.W	(+) side	—	Continuity Yes
	(−) side	Continuity No	—



Electric current flows only in one direction in the diode as shown on the previous page. By testing the continuity between terminals (e.g. BAT and U) with the continuity tester, (as shown in the picture), the diode is determined as usable when the continuity is "Yes", but is faulty when it "No".
Connect the tester in the reverse way, and then the diode is usable when continuity is "No", but faulty when "Yes". If a faulty diode is found in this test, replace it with a complete new diode assembly.
As the auxiliary diode does not have a terminal, check the continuity between its ends.



Diode short test

CAUTION: If a high voltage meter is used, a high voltage will be applied to the diode and the diode will be destroyed. Therefore, never test the diodes with a high voltage meter, etc.

4A-9.2 Rotor

(1) Slip ring wear
Because the slip rings wear very little, the diameter of the rings must be measured with a micrometer. Replace the rings (rotor assembly) when wear exceeds the maintenance standard by 1mm. (0.0393in.)

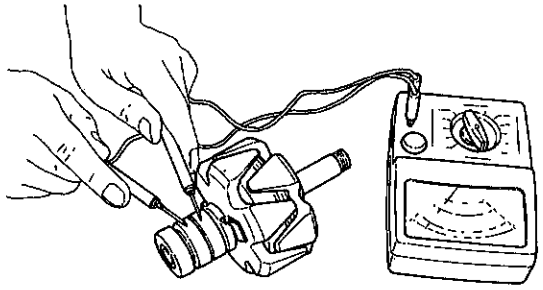
mm (In.)

	Maintenance standard	Wear limit
Slip ring outside diameter	ø31.6 (1.2441)	ø30.6 (1.2047)

(2) Slip ring roughness
The slip ring should be smooth with no surface oil, etc. If the surface of the rings is rough, polish with #500 ~ #600 sandpaper, and if the surface is soiled, clean with a cloth dipped in alcohol.

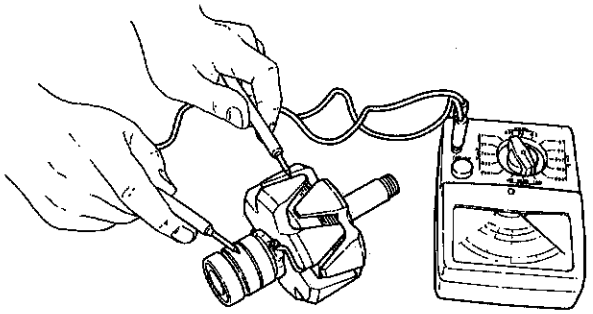
(3) Rotor coil short test
Check the continuity between the rotor coil and slip ring with a tester. The resistance should be near the prescribed value.
If the resistance is extremely low, there is a layer short at the rotor coil; if the resistance is infinite, the coil is open. In either case, replace the rotor.

Printed in Japan
0000A0A1361



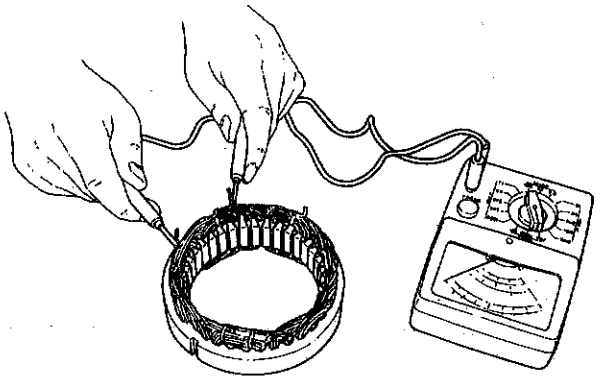
Resistance value	Approx. 3.1Ω (at 20°C)	LR135-105

(4) Rotor coil ground test
Check the rotor coil for grounding with a tester, or by checking the continuity between one slip ring and the rotor core or shaft.
Usable if the continuity is "No".
If "Yes", replace it as the rotor coil is grounded.



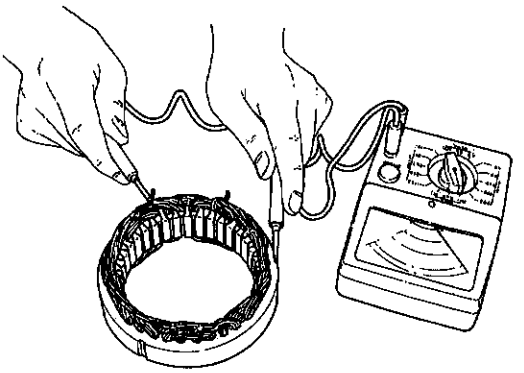
4A-9.3 Stator coil

(1) Stator coil short test
Check the continuity between the terminals of the stator coil. Measure the resistance between the output terminals with a tester. The resistance should be near the prescribed value.
If the stator coil is open, indicated by infinite resistance, it must be replaced.



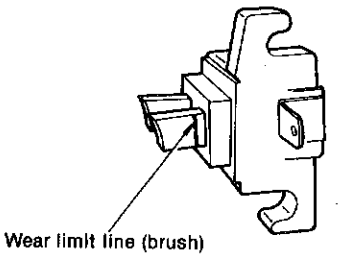
Resistance value	Approx. 0.16Ω (at 20°C) 1-phase resistance	LR135-105

(2) Stator coil ground test
Check the continuity between one of the stator coil leads and the stator core.
The stator coil is good if the resistance is infinite. If the stator core is grounded, indicated by continuity, it must be replaced.



4A-9.4 Brush

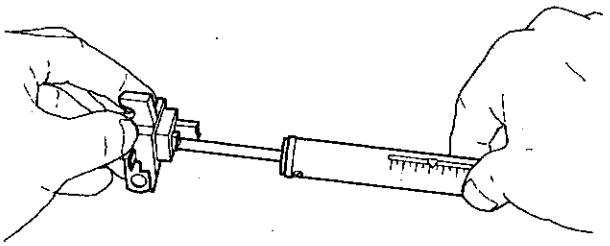
(1) Brush wear
Check the brush length.
The brush wears very little, but replace the brush if worn over the wear limit line printed on the brush.



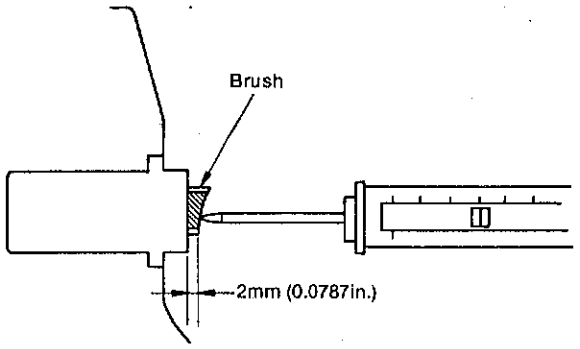
mm (in.)

	Maintenance standard	Wear limit
Brush length	16 (0.6299)	9 (0.3543)

(2) Brush spring pressure measurement.
Measure the pressure with the brush protruding 2mm from the brush holder, as shown in the figure. The spring is normal if the measured value is over 150 gr.
Confirm that the brush moves smoothly in the holder.



Printed in Japan
0000A0A1361



Brush spring strength	300 ±45g (0.562 ~ 0.761 lb) (New brush)

4A-9.5 Checking IC regulator unit

Connect the wiring as shown in the diagram below using a variable register, two 12V batteries, register and ammeter.

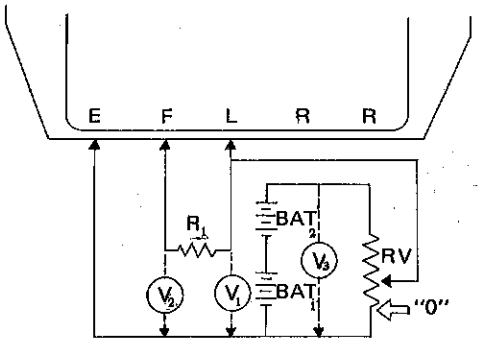
(1) Prepare the following measuring devices

1) Resistor (R_1) 100Ω 2W – 1
2) Variable resistor (Rv) 0-300Ω 12W – 1
3) Battery (BAT_1, BAT_2) 12V – 2
4) DC voltmeter 0 ~ 30V 0.5 class – 1
   (to measure at 3 points)

(2) Check the regulator in the following sequence.

1) Check V_3 (total voltage of BAT_1 plus BAT_2).
   When the value is between 20V and 26V, BAT_1 and BAT_2 are normal.
2) When measuring V_2 (Voltage between F – E terminals), shift the variable resistor gradually from the "0" position. Check if the V_2 voltage changes sharply from below 2.0V to over 2.0V.
   If there is no sharp voltage change, the regulator is faulty and must be replaced.
   When there is sharp voltage change, stop the variable registor at that point.
3) Measure V_1 (voltage between L – E terminals).
   The V_1 voltage is the regulated voltage of the regulator
   ...Confirm that the value is within the standard range.

Adjusted voltage	14.3±0.3V (at 20°C, with 2 batteries)

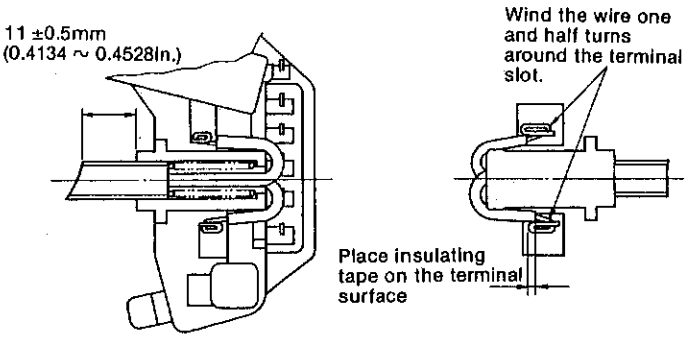


4A-10 Reassembly precautions

After inspection and servicing, reassemble the parts in the reverse order of disassembly, paying careful attention to the following items:

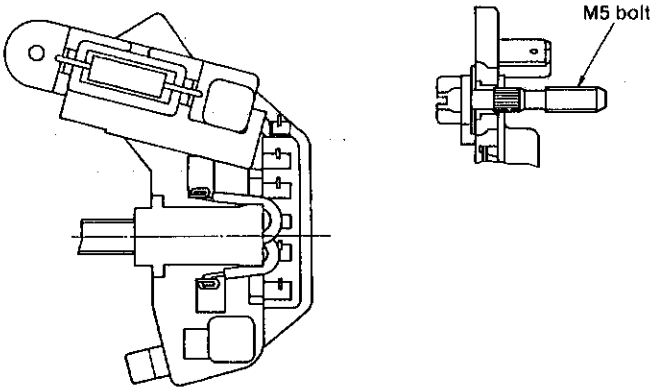
(1) Brush regulator assembly

1) Soldering the brush
   Solder the brush after setting it as shown in the figure. Take care that solder does not flow into the pig-tail (lead wire).



NOTES: 1) Use non-acid flux for soldering.
2) The temperature of the soldering bit is to be 300 to 350°C.

2) Assembly of IC regulator
   Place the IC regulator on the brush holder as shown in the figure, and insert the M5 bolt.
   After inserting the bolt, solder the brush holder to the IC regulator.

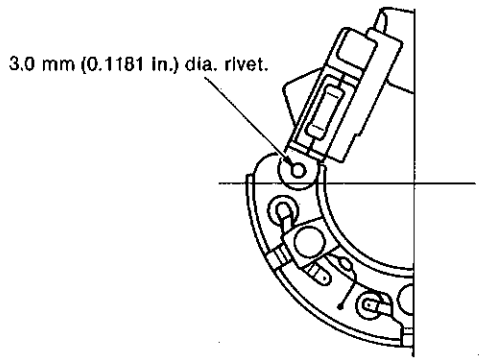


NOTES: 1) Insertion pressure is 100 kg (220.5 lbs)
2) Insert vertically.

(2) Connecting the brush regulator assembly to the diode.

1) Fixing with rivet
   Insert a 3mm dia. rivet as shown in the figure, and fix it by using the appropriate tool

Printed in Japan
0000A0A1361



Rivetting pressure	500 kg (1102 lbs)

(3) Assembling rear cover
Assemble the rear cover after inserting the pin from outside and fitting the brush into the brush holder.

(4) Tightening torque of each part

kg-cm (ft-lb)

Fixing flange holder	32 ~ 40 (2.31 ~ 2.89)
Fixing diode	32 ~ 40 (2.31 ~ 2.89)
Fixing bearing retainer	16 ~ 20 (1.16 ~ 1.45)
Tightening pulley nut	350 ~ 400 (25.32 ~ 28.93)
Tightening through bolt	32 ~ 40 (2.31 ~ 2.89)

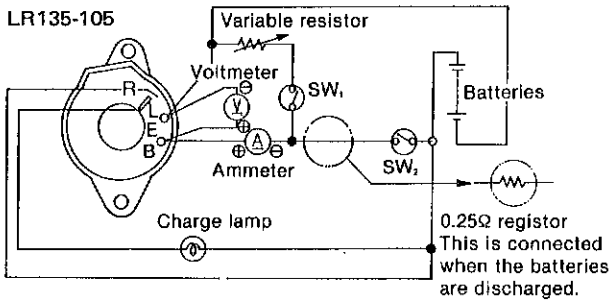
4A-11 Alternator performance test

4A-11.1 Test equipment

Test equipment	Quantity	Specifications
Battery	1	12V
DC voltmeter	1	0 ~ 30V Range 0.5
DC ammeter	1	0 ~ 50A Range 1.0
Variable resistor	1	0 ~ 0.25Ω capacity: 1 kW
Switch	2	Switch capacity: 40A
Tachometer	1	
0.25Ω resistor	1	25W

4A-11.2 Performance test circuit

When the circuit is connected the charge lamp will light.



4A-11.3 Performance test

(1) Speed measurement at 13.5V.
1) Run the alternator up to a speed of approx. 1500 rpm with SW_1 and SW_2 open.
Then reduce speed gradually and measure the rpm when the voltage reaches 13.5V.
2) This value is called the "rpm at 13V" and is acceptable if 1000 rpm or below.
(The alternator speed at which the lamp goes on or off is 1500 rpm, or 1000 rpm or below, respectively, and there are different conditions for each of the two cases.)

(2) Voltage measurement. Acceptable within the range of 14.3 ±1.3V and when the generator rpm is 5000, SW_1 is open and SW_2 is closed, the temperature is 20°C and using two batteries.
(Confirm that the ammeter is 5A or below. If over 5A, connect the 0.25Ω resistor.)

(3) Measurement of output current
1) In the circuit shown in figure, set the variable resistor at the minimum value, close SW_2 and SW_1, and run the alternator.
2) While keeping the voltage at 13.5V by adjusting the variable resistor, increase the alternator speed, and measure the current at 2500 rpm and 5000 rpm.

Acceptable current values	32A at 5000 rpm	LR135-105

(4) Remarks on performance test
a) For the test leads, use cable with a cross-sectional area of 8mm² or more and with a length not exceeding 2.5m between the alternator B terminal and the positive terminal of the battery, and between the S terminal and the negative terminal of the battery.
b) Switches with low contact resistance are to be used in the circuit.

4A-12. Standards of adjustment

	LR135-105
Standard height of brush	16mm (0.6299in.)
Limit of reduced height	9mm (0.3543in.)
Strength of brush spring	255 ~ 345g (0.56 ~ 0.76 lb)
Standard dimension of shaft at front end	15mm (0.5906in.)
Part No. of ball bearing	6302 BM
Standard dimension of shaft at rear end	12mm (0.4724in.)
Part No. of ball bearing	6201 SD
Resistance of rotor coil (at 20°C)	3.1Ω
Resistance of stator coil single phase (at 20°C)	1.6Ω
Standard O.D. of slip ring	31.6mm (1.244in.)
Limit of reduced size (diameter)	1mm (0.0394in.)
Limit of swing correction	0.3mm (0.0118in.)
Accuracy of swing correction	0.05mm (0.0070in.)

Printed in Japan
0000A0A1361

4A-13. Alternator troubleshooting and repair

(1) Failure to charge

Problem	Cause	Corrective action
Wiring, current	Open, shorted, or disconnected	Repair or replace
Alternator	Open, grounded, or shorted coil Terminal insulator missing Diode faulty	Replace Repair Replace
Transistor regulator	Transistor regulator faulty	Replace regulator

(2) Battery charge insufficient and discharge occurs easily

Problem	Cause	Corrective action
Wiring	Wiring shorted or loose, wiring thickness or length unsuitable	Repair or replace Replace
Generator	Rotor coil layer short Stator coil layer short; One phase of stator coil open Slip ring dirty V-belt loose Brush contact faulty Diode faulty	Replace Replace Clean or polish Retighten Repair Replace

(3) Battery overcharged

Problem	Cause	Corrective action
Battery	Electrolyte low or unsuitable	Add distilled water Adjust specific weight Replace
Transistor regulator	Regulator transistor shorted	Replace regulator

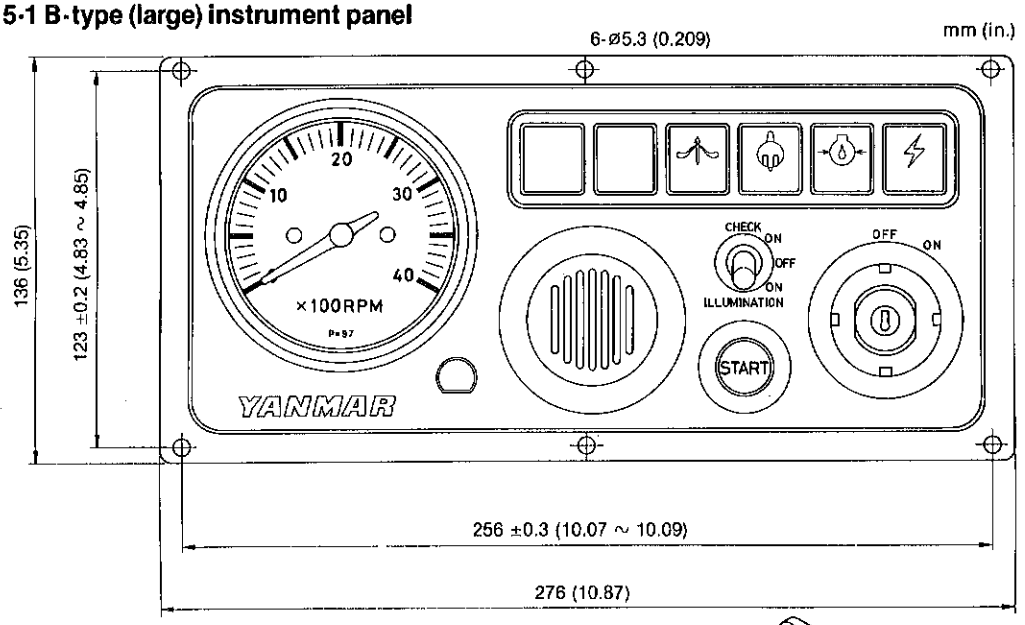
(4) Current charge unstable

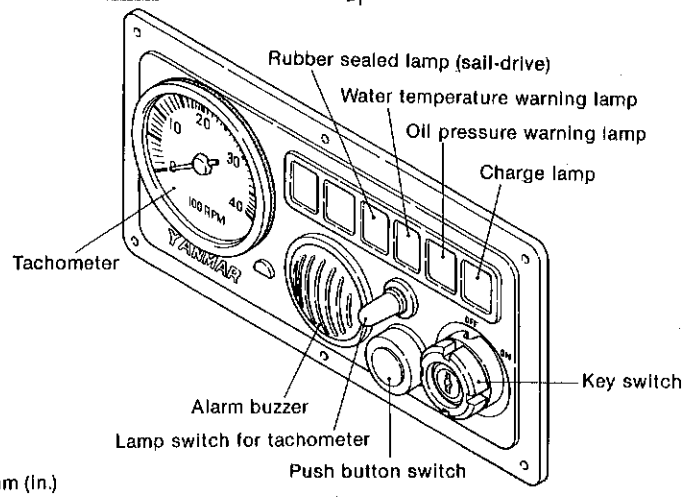
Problem	Cause	Corrective action
Wiring	Wiring shorted at a break in the covering due to hull vibration or intermittent contact at break	Repair or replace
Alternator	Layer short Balance spring damaged Slip ring dirty Coil open	Replace Replace Replace Repair or replace

Printed in Japan
0000A0A1361

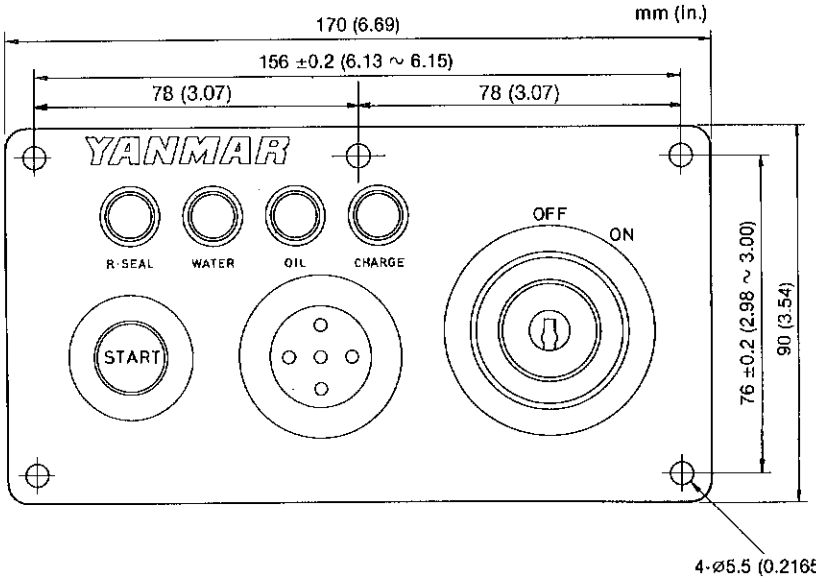
5. Instrument Panel

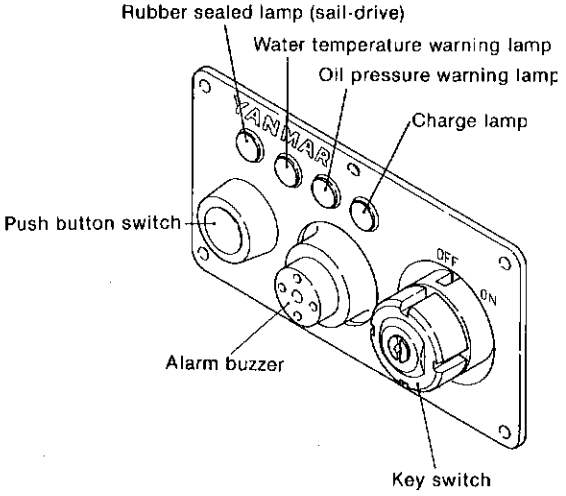
5-1 B-type (large) instrument panel





5-2 A-type (small) instrument panel

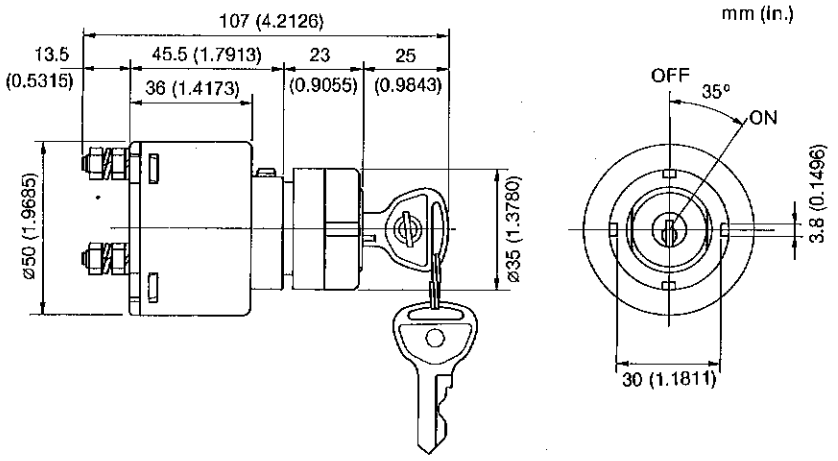




Printed in Japan
0000A0A1361

5-3 Key switch

(1) Construction and dimensions of key switch.

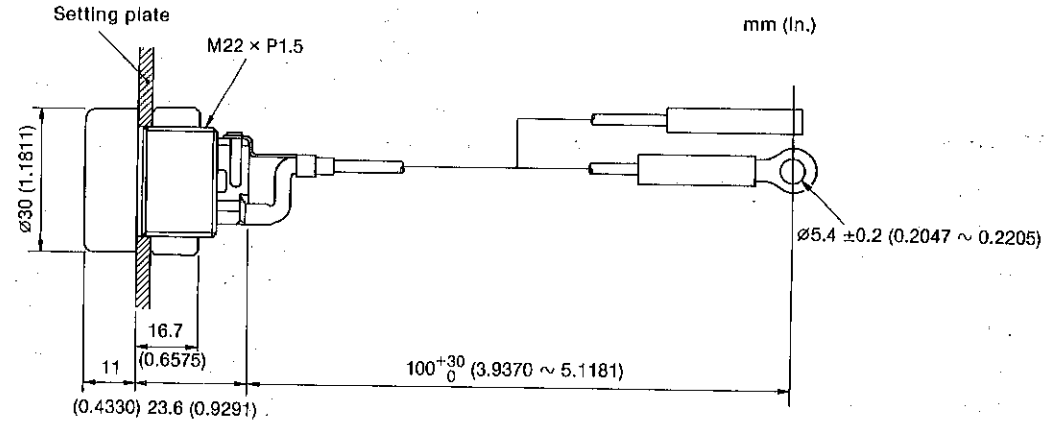


(2) Specifications of key switch

	All models
Rated voltage	DC 12V
Rated current	25A
Range of operating voltage	DC 10 ~ 30V
Part No.	124070-91250

5-4 Push button switch

(1) Construction and dimensions of key switch.



(2) Specifications of push button switch

	All models
Rated voltage	DC 12V
Rated load	20A (within 30 seconds)
Part No.	124070-91300

Printed in Japan
0000A0A1361

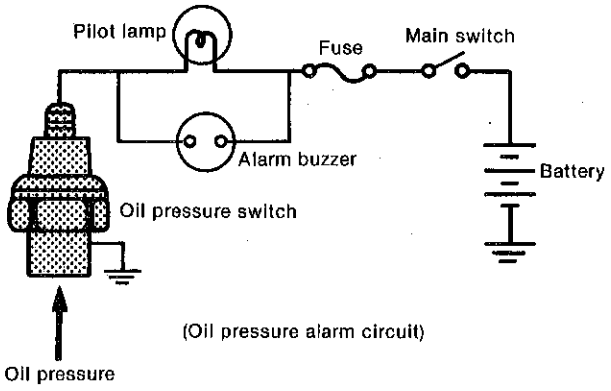
5-5 Warning devices

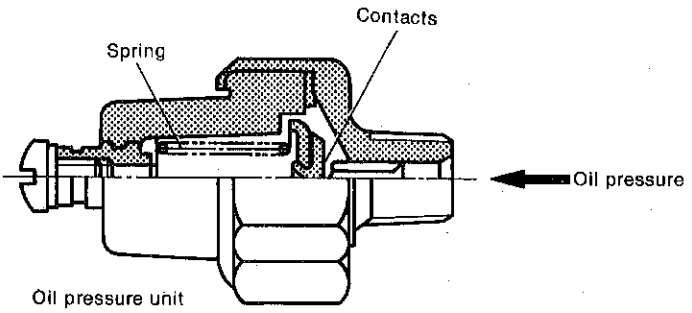
5-5.1 Oil pressure alarm

If the engine oil pressure is below 0.2 ±0.1 kg/cm² (1.422 ~ 4.266 lb/in²), 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 the 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 unit specifications

	All models
Part No.	124060-39451
Rated voltage	12V
Operating pressure	0.2 ±0.1 kg/cm² (1.422 ~ 4.266 lb/in.²)
Lamp capacity	5W



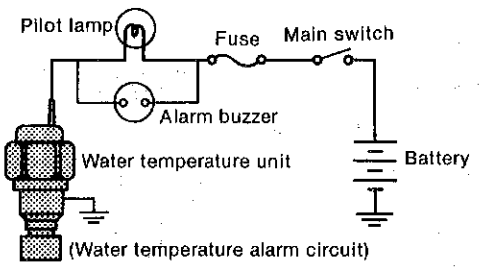


Inspection

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

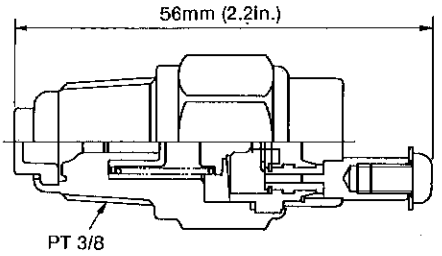
5-5.2 Cooling water temperature alarm

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.



Printed in Japan
0000A0A1361

Water temperature switch



Direct Sea Water Cooling Type

Operating temperature		Current capacity	Response time	Indication color	Parts code
ON	OFF				
65±2°C (154 ~ 148°F)	58°C (140°F) or more	DC12V 1A	Within 60 sec.	White	128275-91340

Fresh Water Cooling Type

Operating temperature		Current capacity	Response time	Indication color	Parts code
ON	OFF				
95°C(202~193°F)	88°C(187°F) or higher	DC 12V 1A	Within 60 sec.	Green	127610-91350

Pilot lamp: 12V, 3.4W

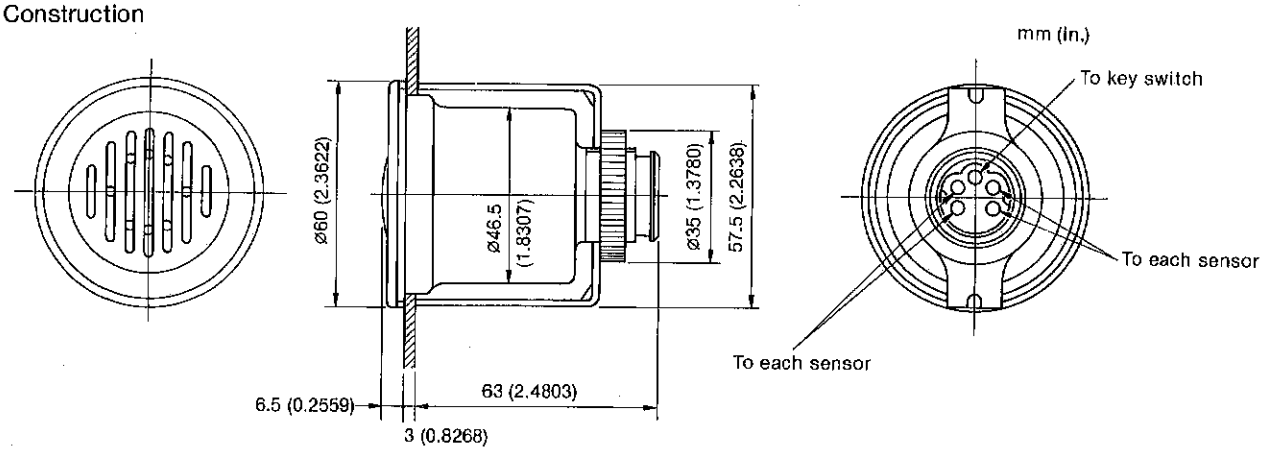
The parts of the alarm circuit which must be checked are the open pilot bulb, fuse, and wiring. To check, disconnect the wiring at the water temperature unit side and ground the cord—the pilot lamp is normal if the pilot lamp illuminates. Moreover, be sure the check the color of the code after replacing.

5-6 Alarm buzzer

The alarm buzzer sounds when the engine oil pressure, cooling water temperature, or charging becomes abnormal. The trouble source is indicated by illumination of the appropriate alarm lamp simultaneously with the sounding of the buzzer.

5-6.1 Buzzer for B-type instrument boad

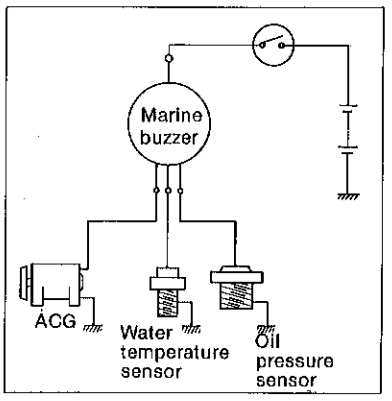
(1) Construction



(2) Specifications

Model	WI1-05
Voltage	12V
Current consumption	100mA or below [at 12V, 15 ~ 30°C (59 ~ 86°F)]
Range of operating voltage	10 ~ 15V
Sound output	75dB (A) [at 1m, 12V, 15 ~ 30°C (59 ~ 86°F)]
Frequency	3 ±0.5kHz [at 12V, 15 ~ 30°C (59 ~ 86°F)]
Weight	0.2kg (0.44 lb)
Part No.	104271-91351

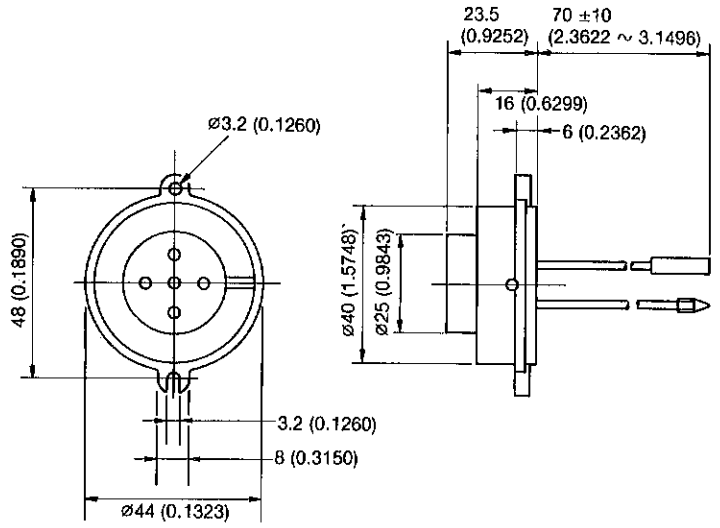
(3) Wiring diagram



Printed in Japan
0000A0A1361

5-6.2 Buzzer for A-type instrument panel

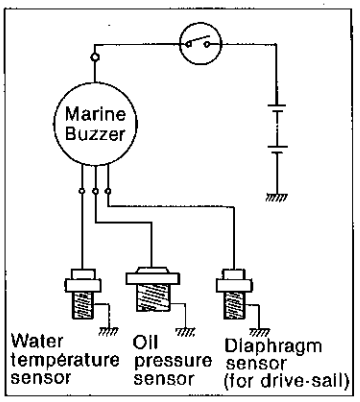
(1) Construction



(2) Specifications

Operating voltage	DC 10 ~ 15V
Rated voltage	DC 12V
Current	50 mA or below
Lead wire	49N (5kgf) or more, 15 seconds
Voltage for starting action	1V or more
Basic frequency of sound	$3.0^{+1.0}_{-0.5}$ kHz
Sound output	θ = 0 ~ 45° 70dB or below
Current consumption	50 mA or below
Part No.	128270-91350

(3) Wiring diagram



5-6.3

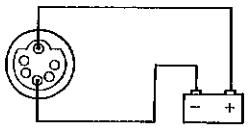
Normal operation is as follows:

	Alarm buzzer	Charge lamp	Oil pressure lamp	Water temperature lamp
Main switch ON, engine stopped	Alarm	Illuminated	Illuminated	Extinguished
Main switch ON, engine running	No alarm	Extinguished	Extinguished	Extinguished
Key switch OFF, engine stopped	No alarm	Extinguished	Extinguished	Extinguished

* The condition of the lamp can be checked by using the check switch.

Printed in Japan
0000A0A1361

5-7

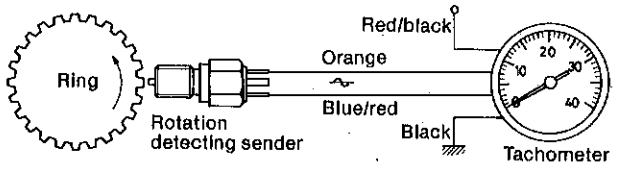
Fault	Diagnosis		Remedy
Warning lamp does not light.	Check if there is a loose or open-circuit connection at the coupling connector between the instrument panel and the relay harness.	Yes	Make good the connection.
	↓ No		
	Take out the lamp from P box case and check if it is unserviceable.	Yes	Replace the lamp. (G-1 amp 12V 3.4W)
	↓ No		
	It must be an open-circuit connection in the harness.		Replace the harness.
Buzzer does not sound.	Check if there is a loose or open-circuit connection at the coupling connector between the instrument panel and the relay harness.	Yes	Make good the connection.
	↓ No		
	Check if the buzzer is serviceable.		Replace the buzzer.
	(Fig.) 		
	↓ Yes		
	It must be an open-circuit connection in the harness.		Replace the harness.
Other switches and items do not operate.	Check if there is a loose or open-circuit connection at the coupling connector between the instrument panel and the relay harness.		Make good the connection.
	↓ No		
	Check the continuity of the individual switch when the switch is closed by the tester.		Replace the defective item.
	↓ OK		
	It must be an open-circuit connection in the harness.		Replace the harness.

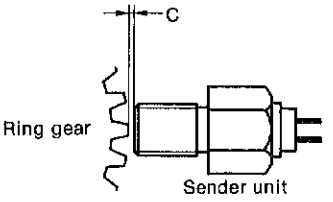
Printed in Japan
0000A0A1361

6. Tachometer

6-1 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 by the number of teeth of the ring gear fitted to the flywheel housing.



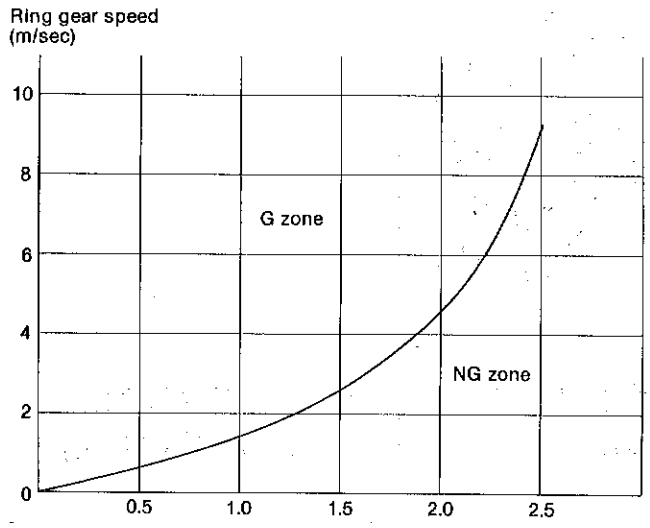


6-2 Specifications and dimensions of tachometer

(1) Specifications

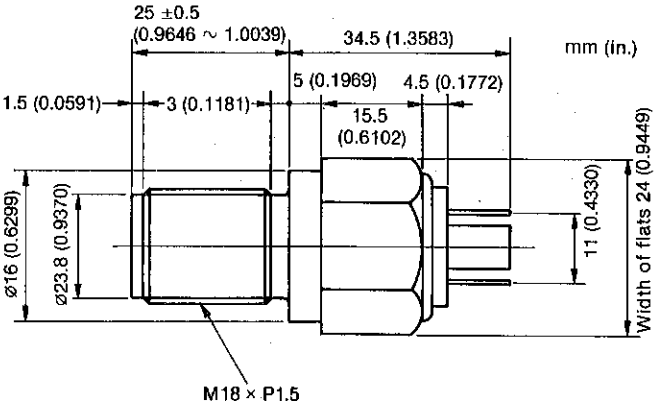
		1GM10(C) 2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
Rated voltage		DC 12V	
Range of operating voltage		10 ~ 15V	
Illumination		3.4W/12V	
Ring gear	No. of teeth	97	114
	Module	2.54	2.54
Part No. of tachometer		128170-91100	128670-91100
Part No. of sender unit		128170-91160	128170-91160

(2) Sensitivity limit of sender unit

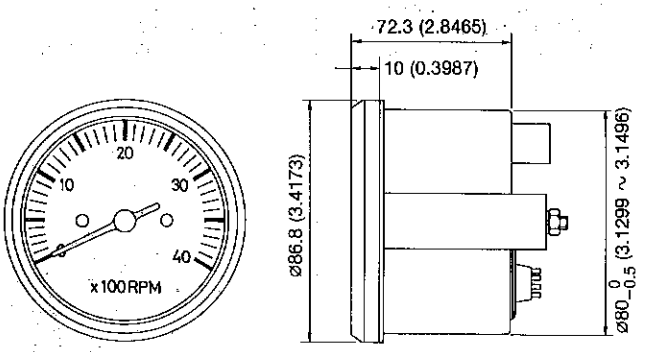


Sender unit and ring gear clearance C (mm)

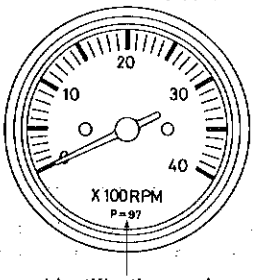
(3) Dimensions of sender unit



(4) Dimensions and shape of tachometer

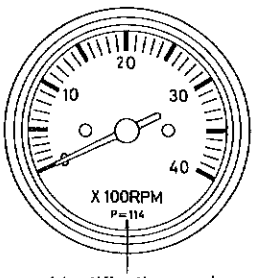


For models 1GM10(C), 2GM20(F)(C), 3GM30(F)(C)



Identification mark

For model 3HM35(F)(C)



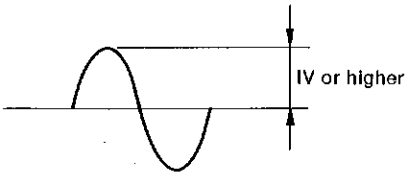
Identification mark

Printed in Japan
0000A0A1361

6-3 Measurement of sensor unit characteristics

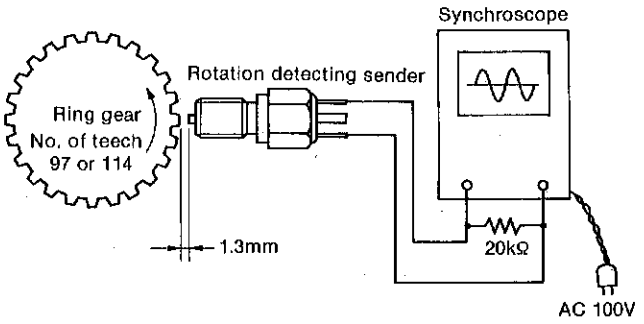
(1) Measurement of output voltage

Output voltage	1.0V or higher



Measuring conditions

Number of teeth of ring gear:	97,114
Gap between the ring gear and sender:	1.3mm (0.0511in.)
Resistance:	20kΩ
Speed of ring gear:	500 rpm (approx. 800Hz)
Measuring temperature:	20°C
Measuring instrument:	Synchroscope

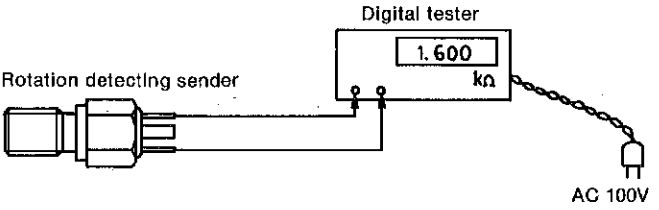


*Check the output wave pattern and number of pulses when carrying out the output voltage measurement.

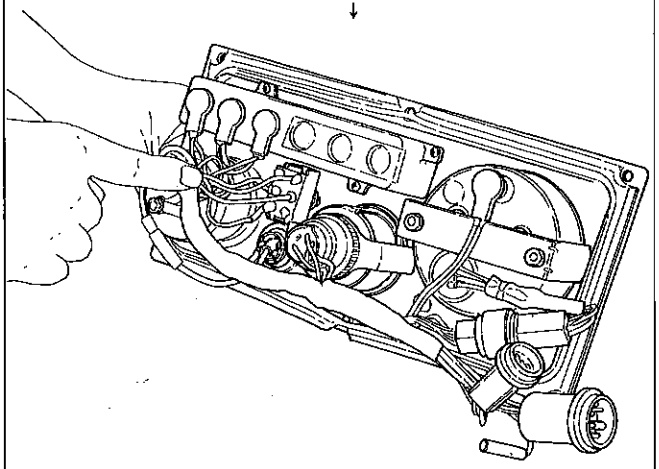
(2) Measurement of internal resistance

Measuring conditions

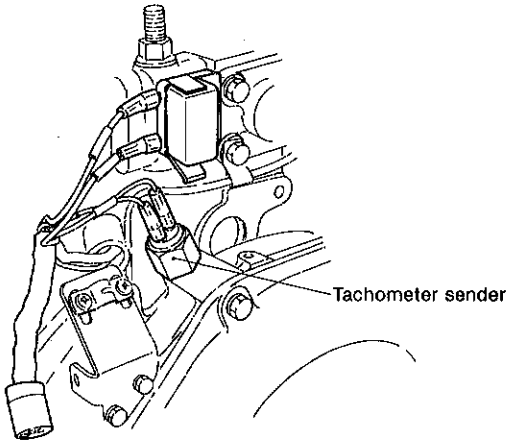
Measuring temperature:	20°C
Measuring instrument:	Digital tester



6-4

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. shot-circuit, disconnection, or blown fuse, etc.)

Printed in Japan
0000A0A1361

	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.

Printed in Japan
0000A0A1361