SERVICE MANUAL

MODEL
SD22 & SD33
DIESEL ENGINE

NISSAN

NISSAN MOTOR CO., LTD.
TOKYO, JAPAN

SECTION EE

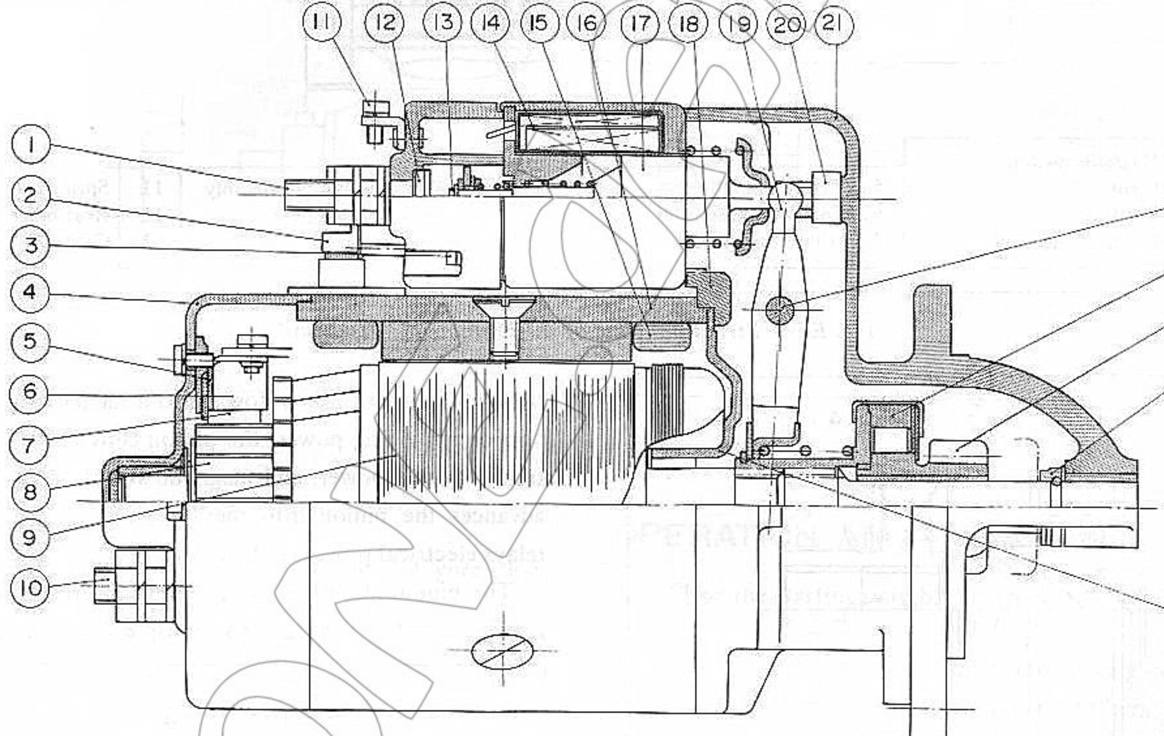
ENGINE ELECTRICAL SYSTEM

EE

STARTER MOTOR

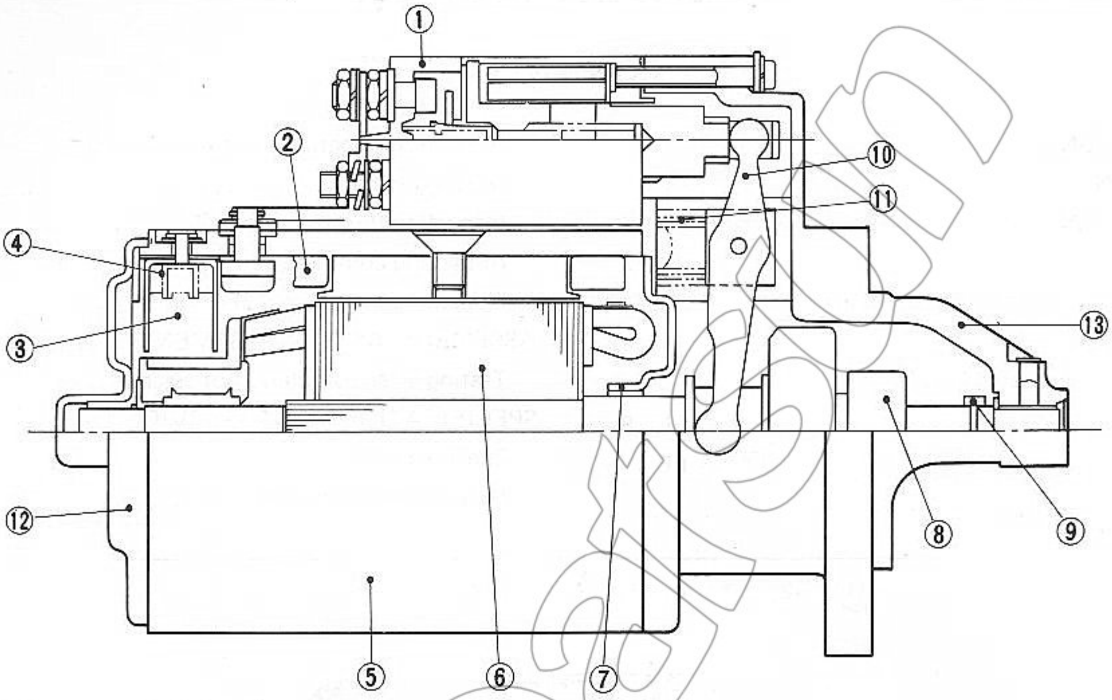
CONTENTS

CONSTRUCTION



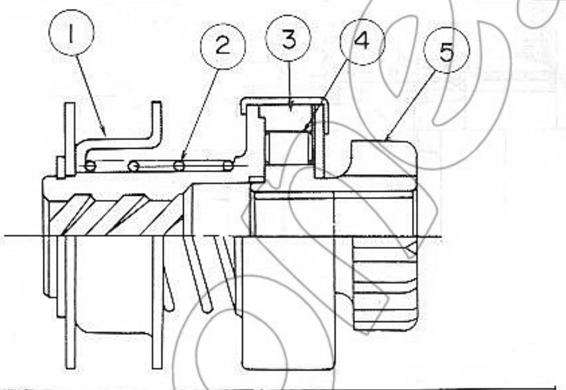
1	Terminal M	14	Magnetic switch coil
2	Lead	15	Field coil assembly
3	Screw	16	Yoke assembly
4	Rear cover	17	Plunger
5	Brush holder assembly	18	Cap
6	Brush spring	19	Shift lever
7	Brush	20	Adjusting screw
8	Commutator	21	Gear case assembly
9	Armature assembly	22	Shift lever pin set
10	Terminal E	23	Clutch
11	Terminal S	24	Pinion
12	Fixed contact (main)	25	Pinion stopper set
13	Moving contact (main)	26	Center bearing assembly

Fig. EE-1 Structural view of starter motor (Hitachi)



1	Magnetic switch	5	Yoke assembly	8	Pinion & clutch assembly	11	Spring set
2	Field coil	6	Armature assembly	9	Pinion stopper set	12	Rear bracket
3	Brush	7	Center bracket	10	Shift lever	13	Gear case
4	Brush spring						

Fig. EE-2 Structural view of starter motor (Mitsubishi)

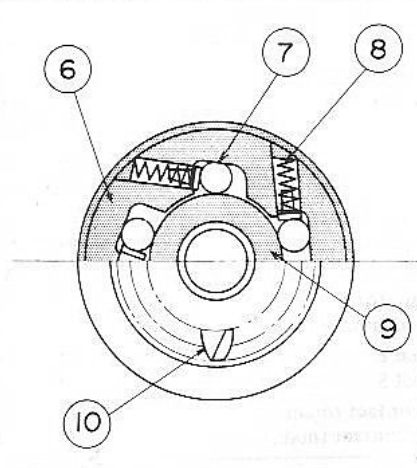


1	Pinion sleeve	4	Roller
2	Pinion sleeve spring	5	Pinion
3	Clutch outer		

Fig. EE-3 Pinion clutch

The starter motor drives the crankshaft by means of the ring gear of the engine flywheel, thereby developing combustion chamber compression required for starting. As the compression ratio in diesel engines is much higher than that of gasoline engine, the starter motor must provide greater output. The starter mostor is a d-c series wound type producing high starting torque. The construction can be broken down into three parts, the motor portion providing power, the pinion clutch portion which transmits this power, and magnetic switch portion which advances the pinion into mesh with the ring gear and relays electrical power to the motor portion.

The pinion clutch starter motor is an overrunning type having operation similar to a multiple disc configuration.



6	Clutch outer
7	Roller
8	Spring
9	Pinion collar
10	Pinion

Fig. EE-4

Since the clutch outer portion (containing rollers) is tapered, the rollers provide locking while the starting motor is delivering power to the engine. When the engine starts and its speed goes beyond that of the starter motor, power is not transmitted in reverse to the starter motor.

CONNECTION

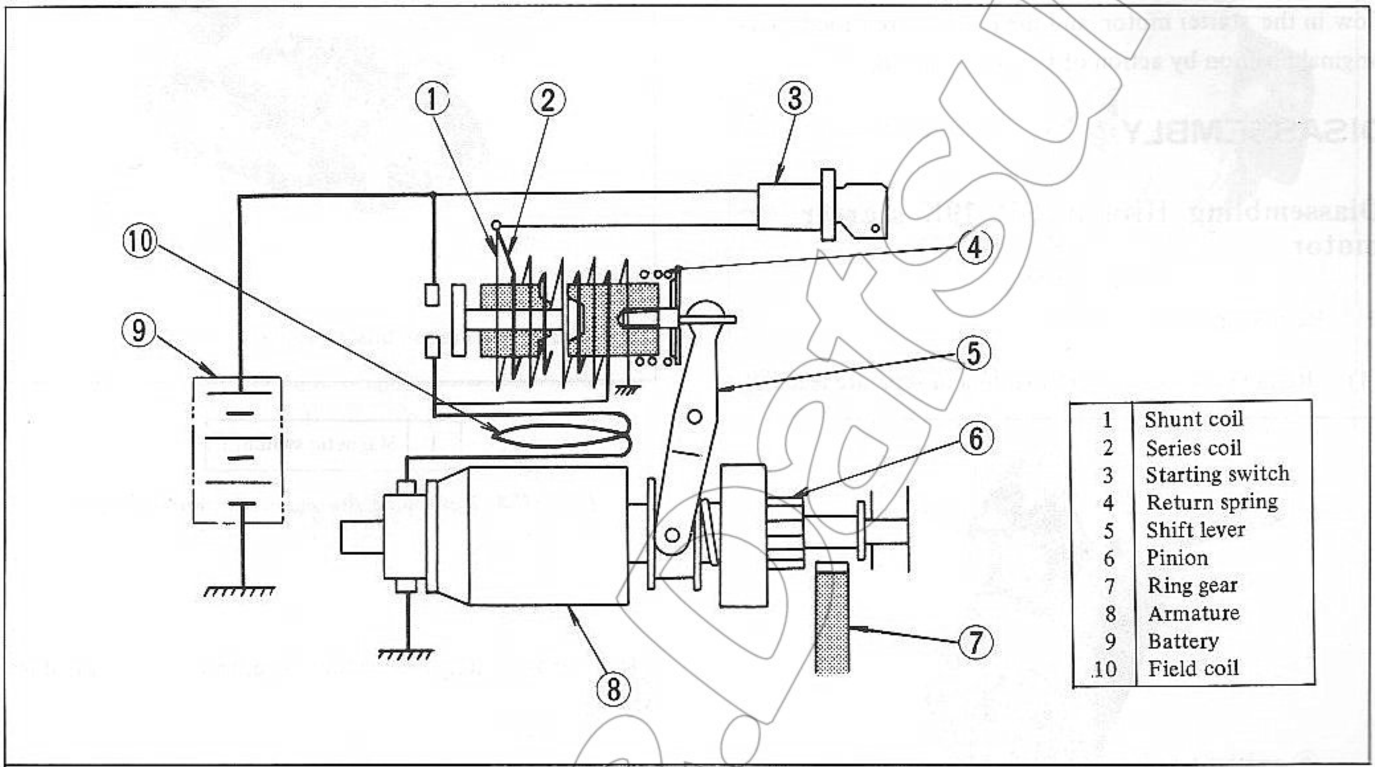


Fig. EE-5 Starter motor connection

Connections are made in accordance with Figure EE-5. Match terminal coding and tighten the terminals carefully so that vibration does not result in loosening. Applied wiring should conform to the following table. Of course, heavier wiring may be used.

Connecting Section	Applied wiring [cross-sectional area of copper mm^2 (sq in)]
Battery (+) terminal-Magnetic switch (B) terminal	30 (0.047) or more. However, two lengths to be used when run is more than 5 m (17 ft)
Starting switch - Magnetic switch (C) terminal	5.5 (0.009) or more. However, two lengths to be used when run is more than 10 m (33 ft)
Starting switch - Main switch terminal	

OPERATION AND FUNCTION

1. Close the starting switch.

2. Current flows in the shunt coil (holding coil) and series coil (pull-in coil) of the magnetic switch. Current passing through the series coil (pull-in coil) flows through the starter motor itself.

3. The plunger of the magnetic switch is attracted, the pinion is advanced by action of the shift lever, and the armature begins to turn slowly.

4. The pinion begins to mesh with the flywheel ring gear.

5. When the pinion to ring gear mesh is complete, the moving contact strikes the fixed contact, thereby forming an electrical path between terminals B and M.

6. Primary current flows in the starter motor , pinion mesh is completed, and the ring gear is driven.

7. The engine starts.

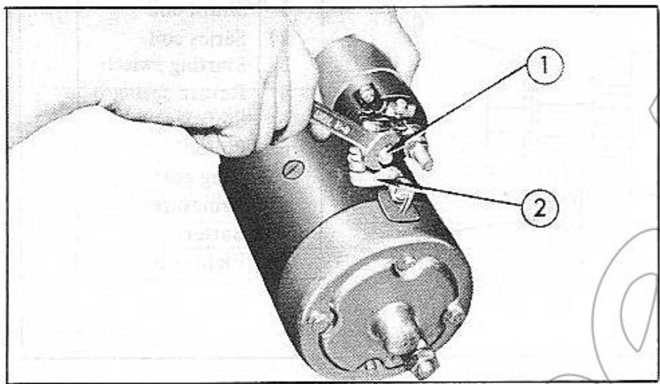
8. When the starter switch is released, current ceases to flow in the starter motor and the pinion is returned to its original position by action of the return spring.

DISASSEMBLY

Diassembling Hitachi S12-19K starter motor

1. Removing magnetic switch

(1) Remove nut ① of terminal M and separate lead ②.



1	(M) terminal nut	2	Connector bar

Fig. EE-6 Removing the connector bar

(2) Remove cotter pin ① holding the shift lever pin. Extract shift lever pin ② from gear case ③.

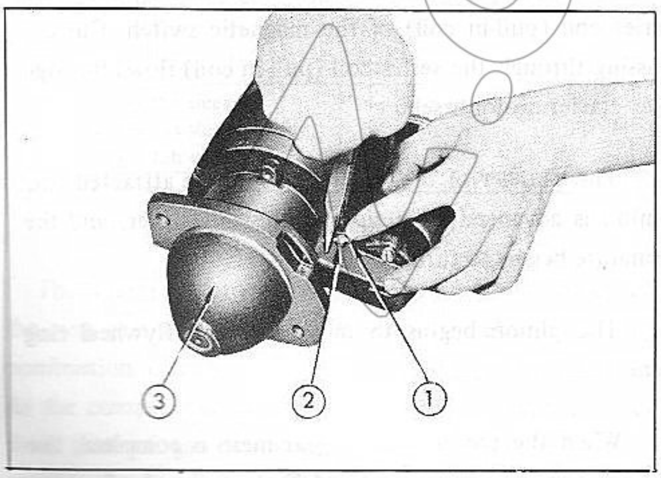
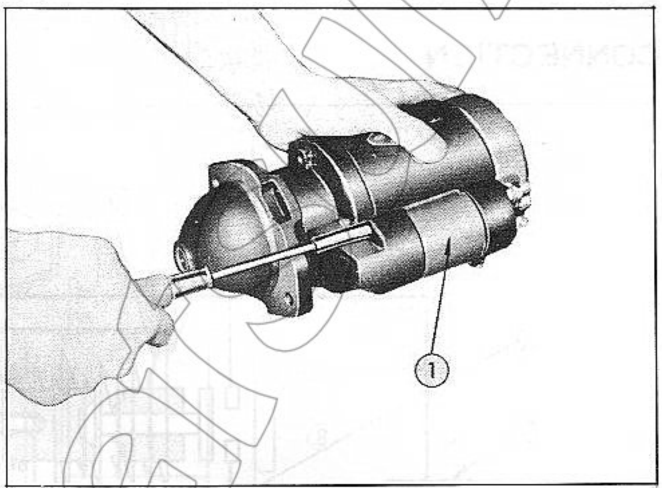


Fig. EE-7 Removing the shift lever pin

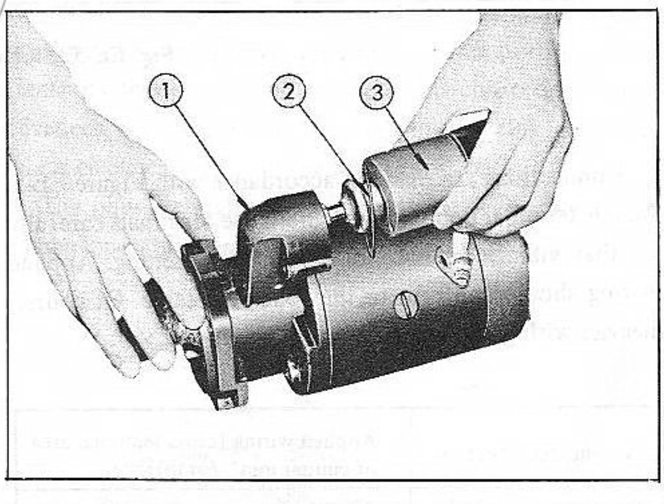
(3) Remove the magnetic switch mounting bolts.



1	Magnetic switch

Fig. EE-8 Removing the magnetic switch holder

(4) Separate magnetic switch assembly ③ and the dust seal ②.



1	Gear case	3	Magnetic switch assembly
2	Dust seal		

Fig. EE-9 Removing magnetic switch assembly

2. Removing rear cover

(1) Remove the two through bolts ①.

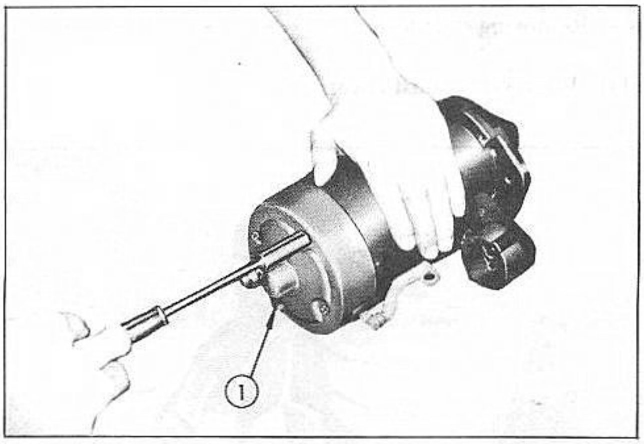


Fig. EE-10 Removing the through bolts from the rear cover

(2) Remove the two screws and separate rear cover ①.

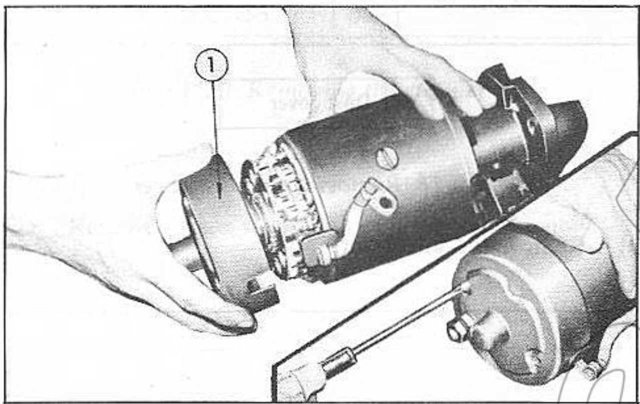


Fig. EE-11 Removing dust cover

3. Removing brush holder

(1) Remove the two field coil terminal screws ①.

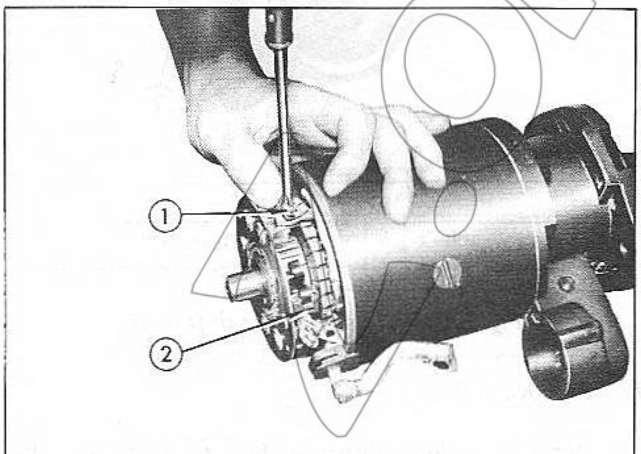
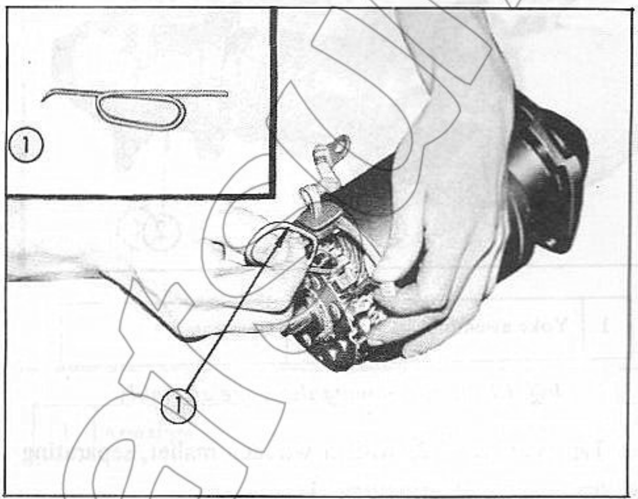


Fig. EE-12 Removing the terminal screws

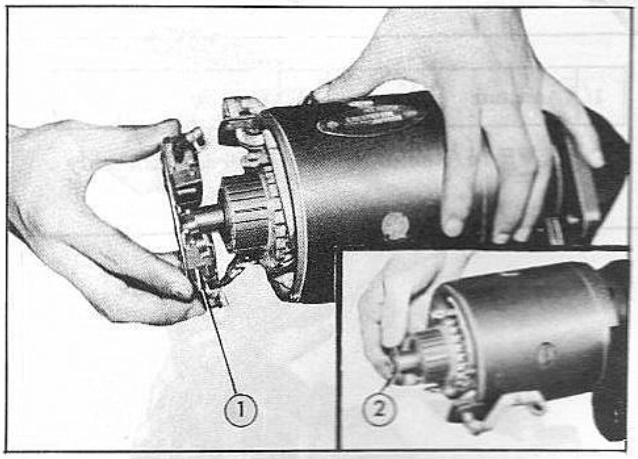
(2) Use a suitable tool to lift the brush and brush spring as shown in the Figure EE-13.



1	Tool

Fig. EE-13 Raising brush

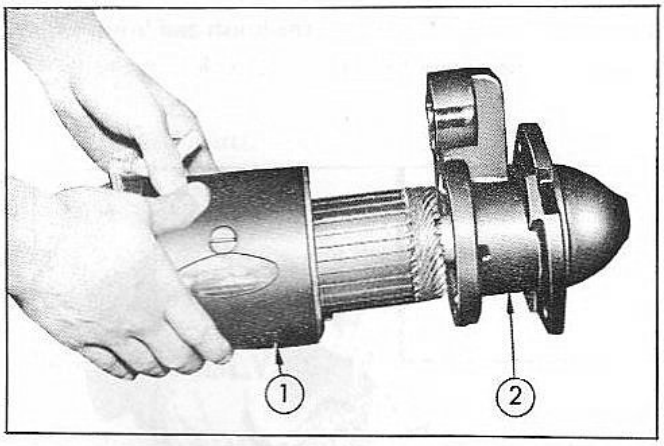
(3) Remove brush holder ① and thrust washer ②.



1	Brush holder	2	Thrust washer

Fig. EE-14 Removing the brush holder

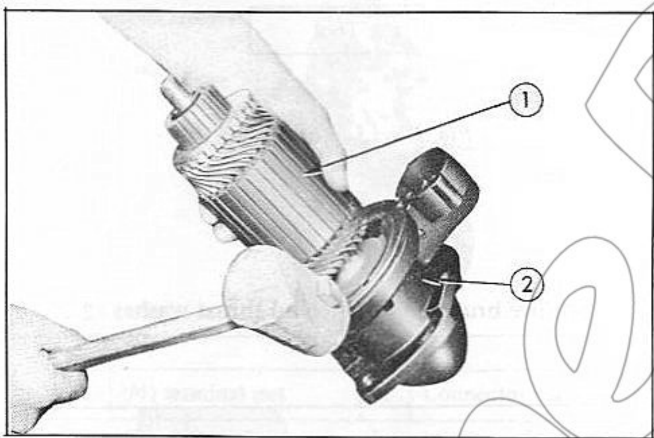
4. Separate the yoke and gear case.



1	Yoke assembly	2	Gear case

Fig. EE-15 Removing the yoke assembly

5. Tap gear case ② with a wooden mallet, separating the gear case and armature ①



1	Armature	2	Gear case

Fig. EE-16 Removing the pinion case assembly

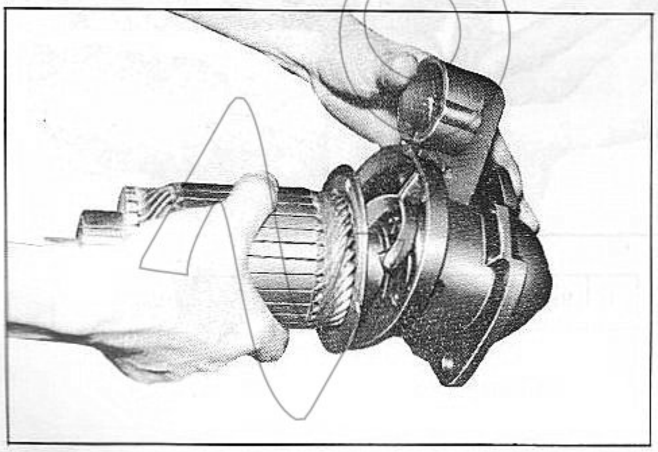
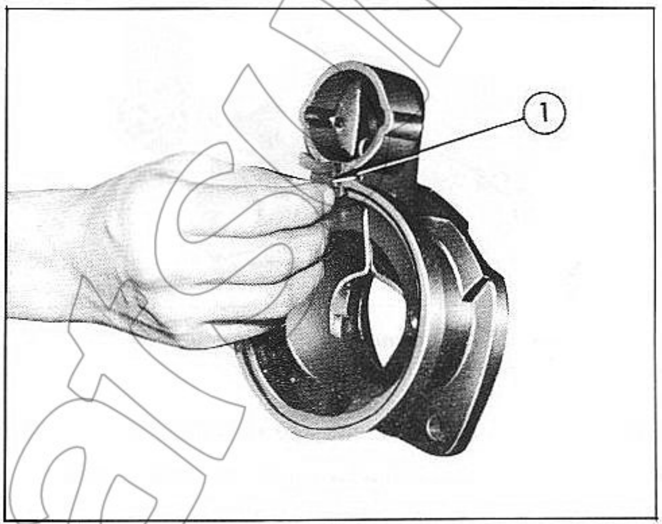


Fig. EE-17 Removing the armature shaft

6. Removing shift lever

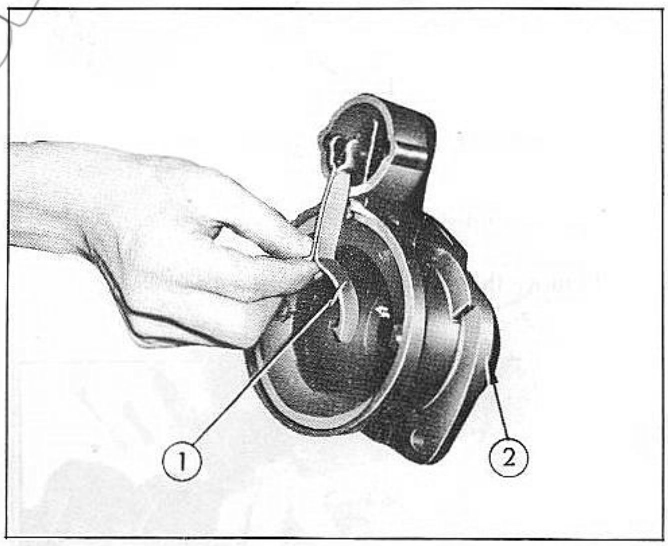
(1) Remove the dust cover.



1	Dust cover

Fig. EE-18 Removing the dust cover

(2) Remove the shift lever.

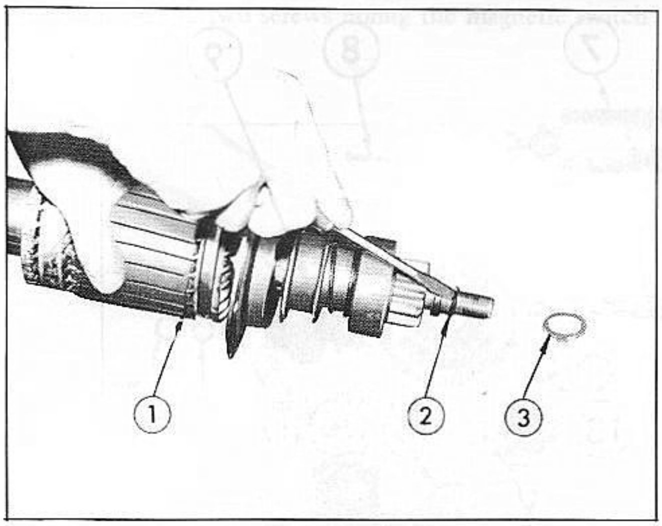


1	Shift lever	2	Gear case

Fig. EE-19 Removing the shift lever

7. Removing pinion

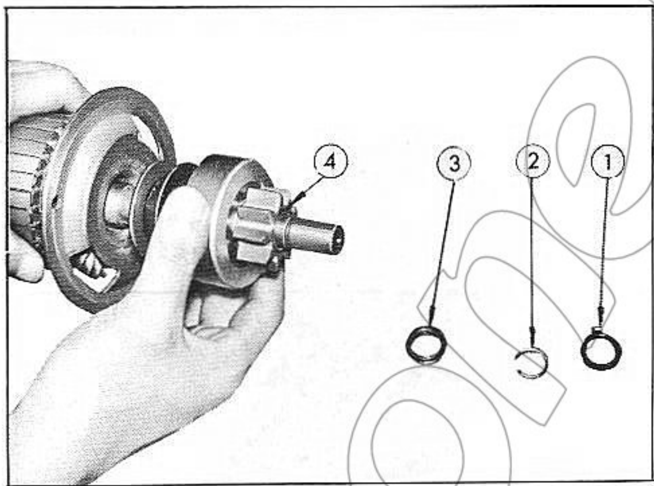
(1) Remove pinion stopper washer ③ attached to the end of the armature and pinion stopper screw ② by using a screwdriver.



1 2	Armature Pinion stopper clip	3	Pinion stopper washer

Fig. EE-20 Removing the stopper pin

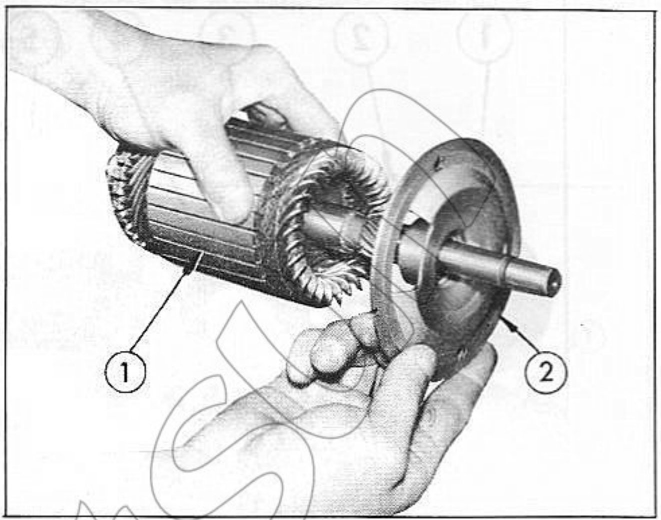
(2) Remove pinion stopper ③ and pinion assembly ④.



1 2	Pinion stopper washer Pinion stopper clip	2 4	Pinion stopper Pinion assembly

Fig. EE-21 Removing the pinion stopper

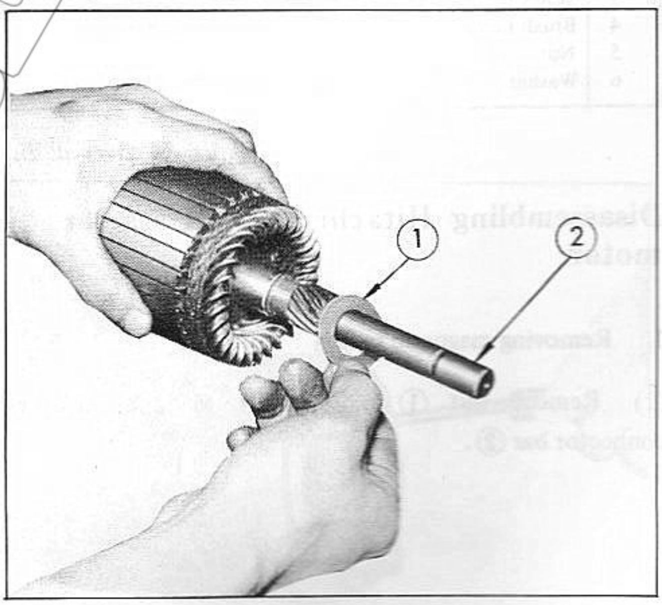
8. Remove center bearing ② from armature shaft ①.



1	Armature	2	Center bearing

Fig. EE-22 Removing the center bearing

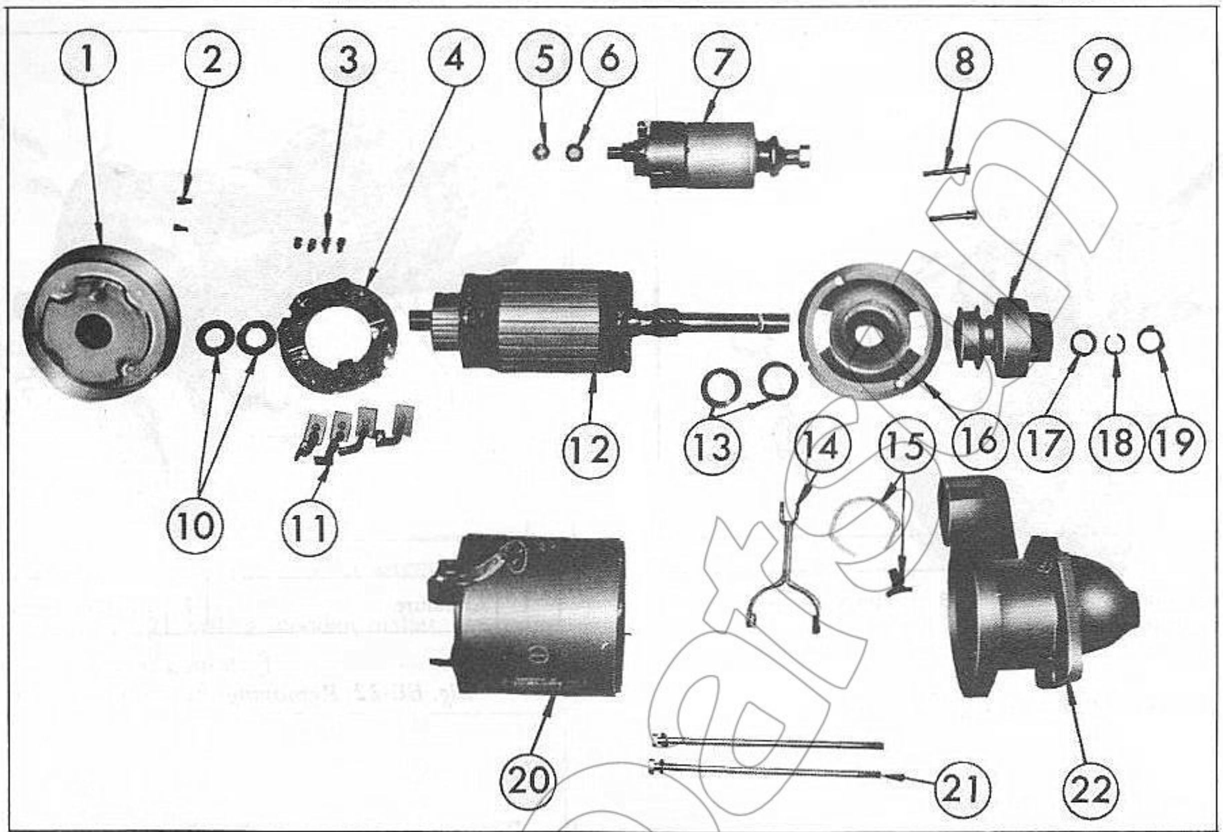
9. Remove the thrust washer from the armature shaft.



1	Adjusting washer	2	Armature shaft

Fig. EE-23 Removing the thrust washer

All of the above component parts are illustrated in Figure EE-24.



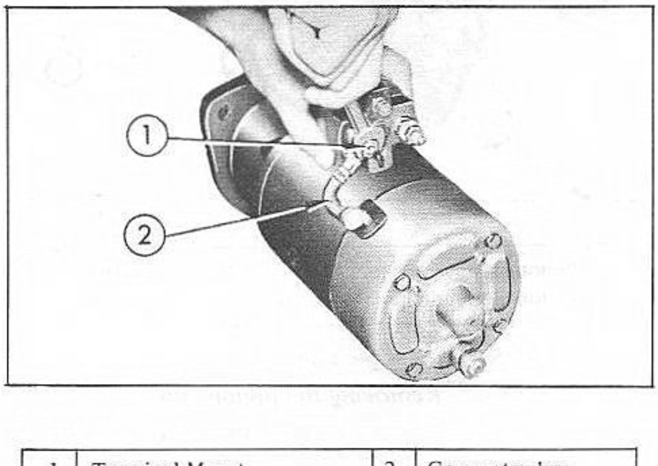
1	Rear cover assembly	7	Magnetic switch assembly	13	Thrust washer	19	Pinion stopper washer
2	Screw	8	Screw	14	Shift lever	20	Yoke assembly
3	Screw	9	Pinion and clutch assembly	15	Dust seal	21	Through bolt
4	Brush holder	10	Thrust washer	16	Center bearing	22	Gear case assembly
5	Nut	11	Brush	17	Pinion stopper		
6	Washer	12	Armature assembly	18	Pinion stopper clip		

Fig. EE-24 Over-all disassembly of the starter motor

Disassembling Hitachi S13-04K starter motor

1. Removing magnetic switch

(1) Remove nut ① of terminal M and separate connector bar ②.



1	Terminal M nut	2	Connector bar

Fig. EE-25 Removing the connector bar

(2) Remove the two screws holing the magnetic switch assembly.

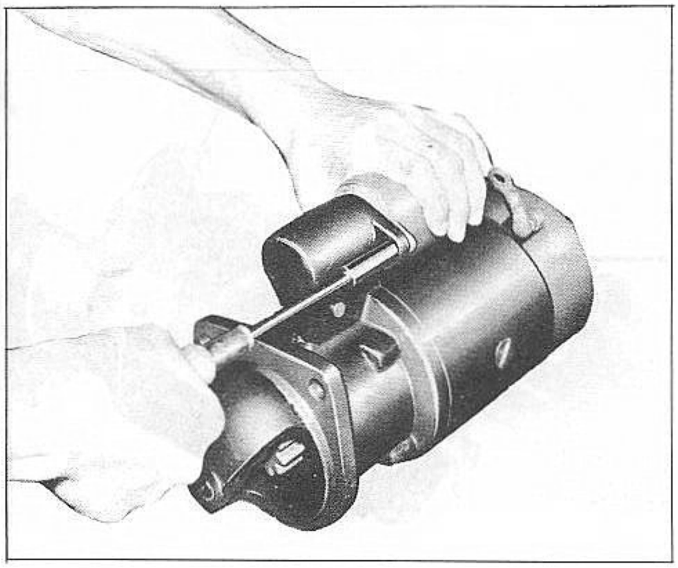
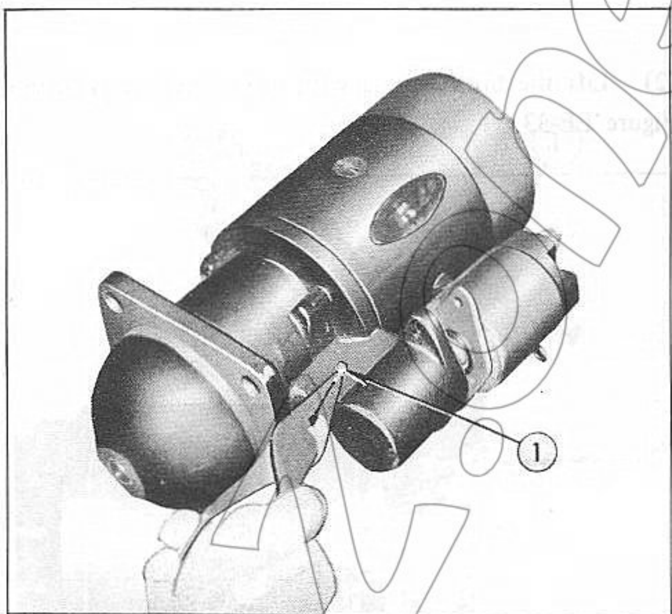


Fig. EE-26 Removing the magnetic switch holder

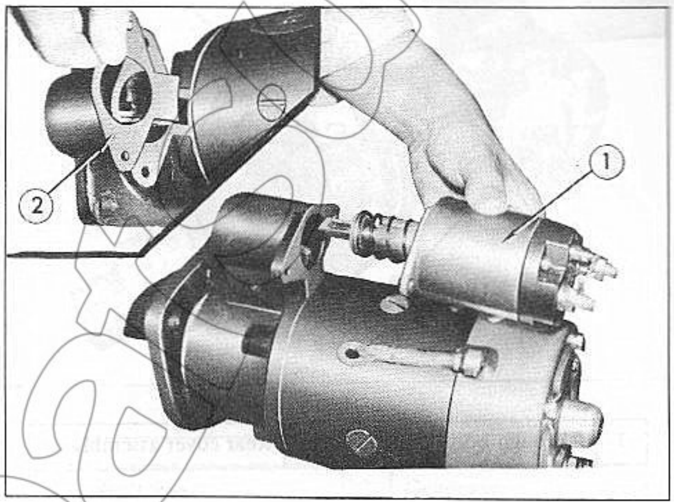
(3) Remove the cotter pin ① and extract the shift lever pin.



1	Cotter pin

Fig. EE-27 Removing the cotter pin

(4) Remove the magnetic switch assembly ① and dust seal ②.



1	Magnetic switch assembly	2	Dust seal

Fig. EE-28 Removing the magnetic switch assembly

2. Removing rear cover

(1) Remove the four screws.

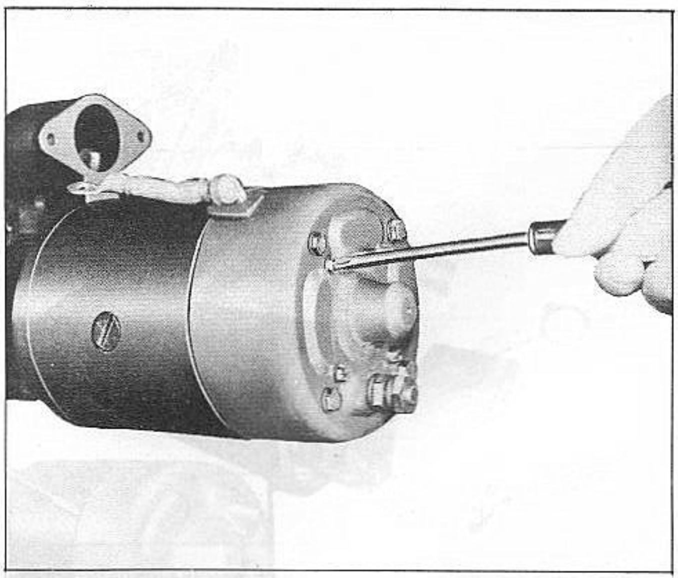
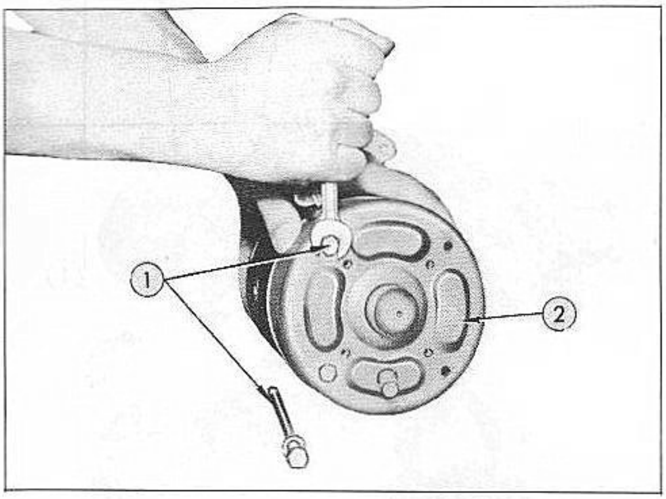


Fig. EE-29

(2) Remove the four through bolts.



1	Through bolt	2	Rear cover assembly

Fig. EE-30 Removing the through bolts from the rear cover

(3) Remove the rear cover assembly by prying carefully with a screwdriver or other tool.

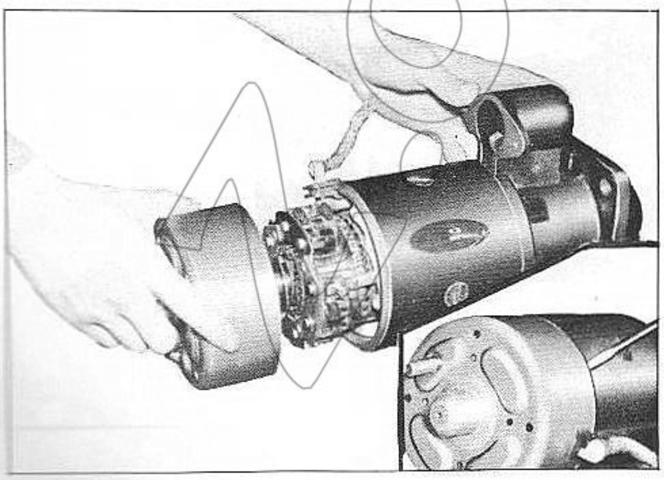
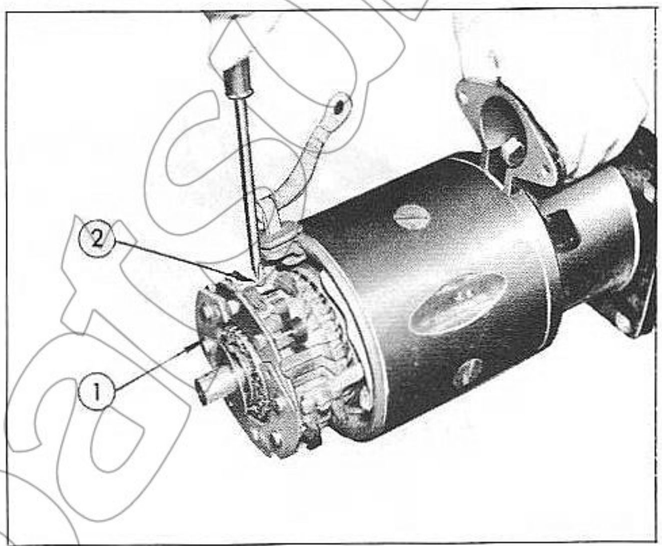


Fig. EE-31 Removing the rear cover assembly

3. Removing brush holder

(1) Remove brush and field coil terminal screws.



1	Brush holder	2	Screw

Fig. EE-32

(2) Lift the brush spring with a wire as shown in the Figure EE-33.

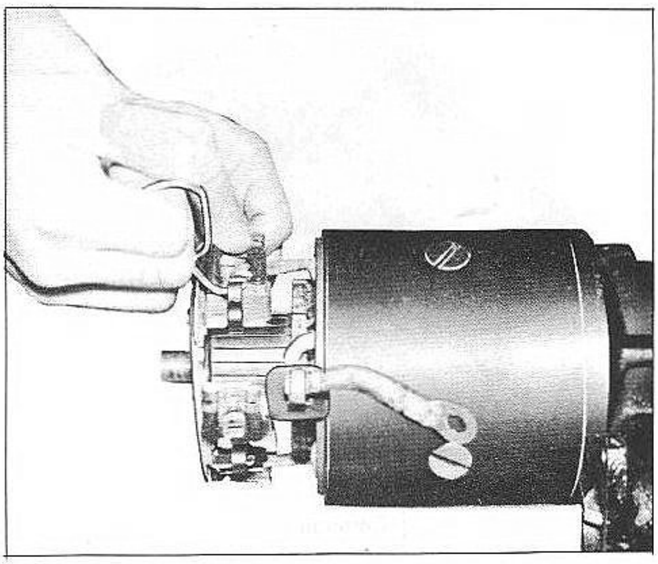
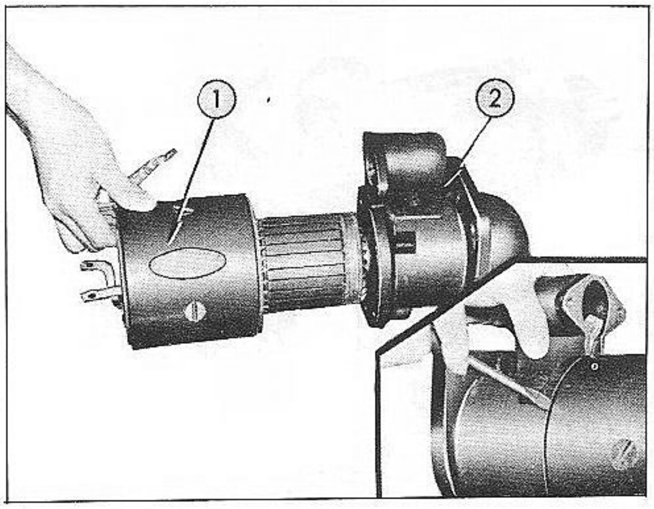


Fig. EE-33 Raising brush

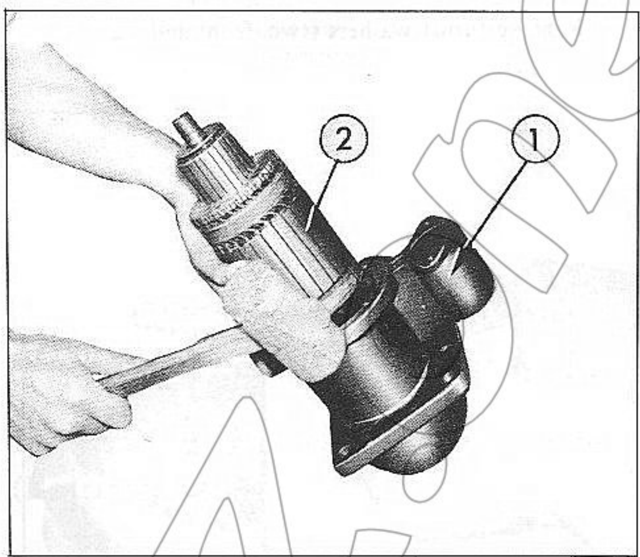
4. Remove the yoke assembly from the gear case.



1	Yoke assembly	2	Gear case

Fig. EE-34 Removing yoke assembly

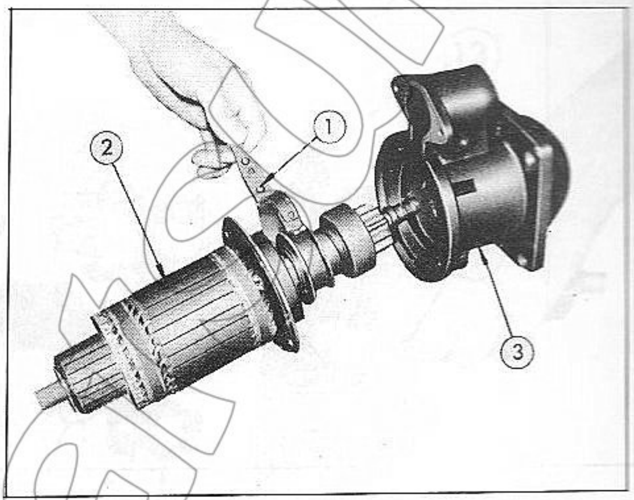
5. Separate the gear case and armature ② by tapping gear case ① with a wooden mallet.



1	Gear case	2	Armature

Fig. EE-35 Removing the pinion case assembly

6. Remove shift lever ①.

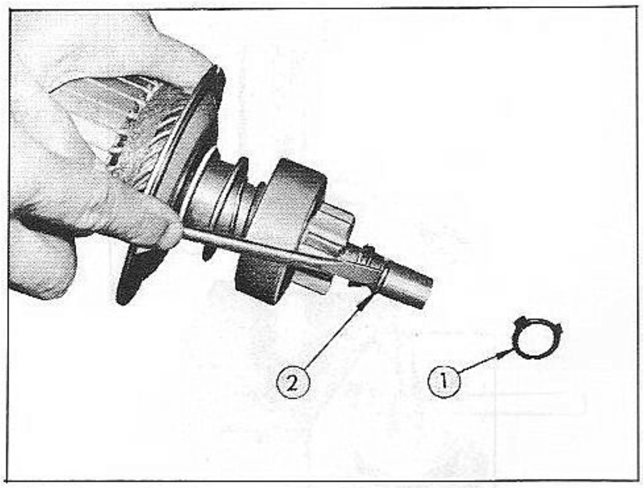


1 2	Shift lever Armature	2	Gear case

Fig. EE-36 Removing the shift lever

7. Pulling pinion from armature

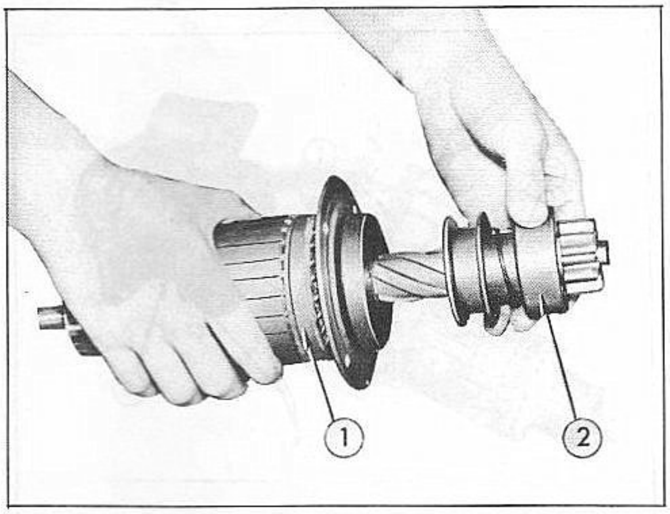
(1) Remove the pinion stopper washer ③ and pinion stopper clip ② by using a screwdriver or other tool.



1	Pinion stopper washer	2	Pinion stopper clip

Fig. EE-37 Removing the stopper pin

(2) Remove the pinion assembly ① from the armature ②.

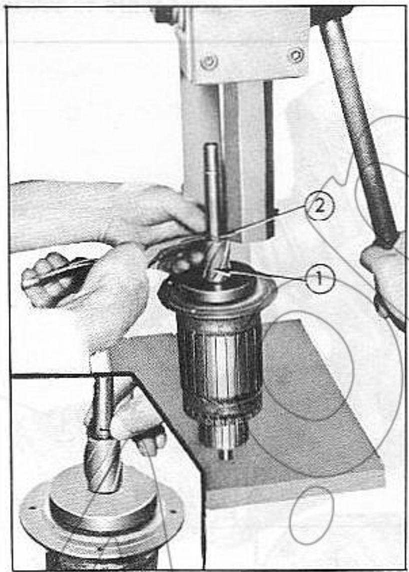


1	Armature	2	Pinion assembly

Fig. EE-38 Removing the pinion assembly

8. Removing advance sleeve

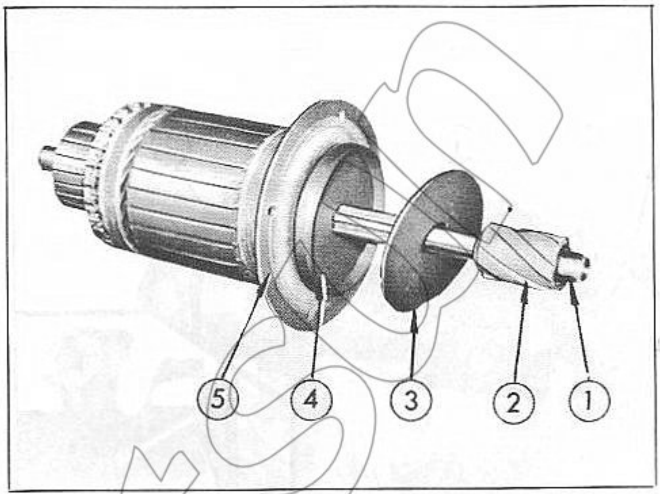
(1) Apply pressure to advance sleeve ① with a press, removing clip ②.



1	Advance sleeve
2	Clip

Fig. EE-39 Removing clip

(2) Remove the advance sleeve from the armature shaft.



1	Armature shaft	4	Pressure equalizer
2	Advance sleeve	5	Center bearing
3	Lock washer		

Fig. EE-40 Removing advance sleeve

9. Remove spring washer ③, pressure equalizer ④, and center bearing assembly ⑤.

10. Remove thrust washers (two, front and rear) on the armature shaft.

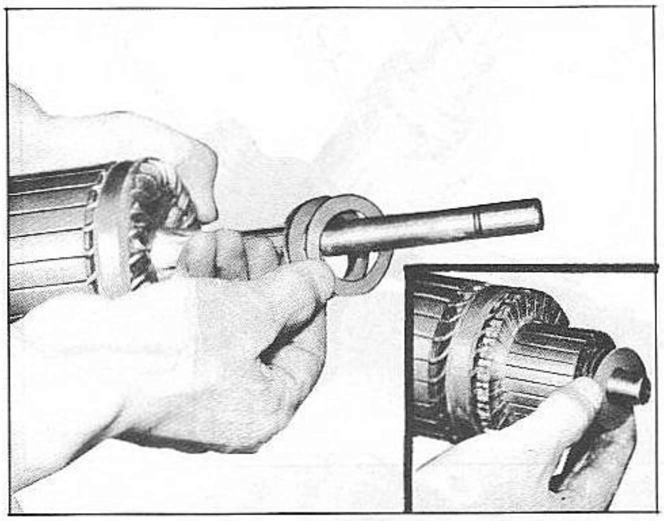
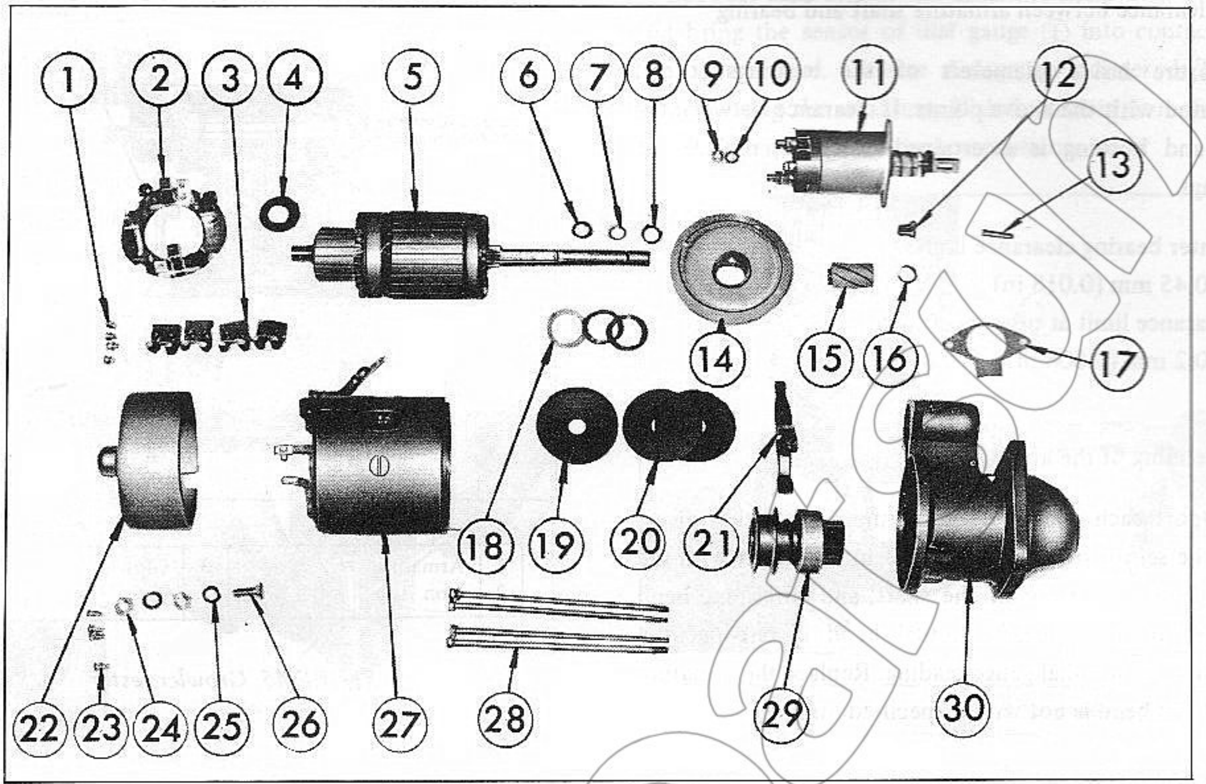


Fig. EE-41 Removing thrust washer

All of the above component parts are illustrated in Figure EE-42.



1	Screw	11	Magnetic switch assembly	21	Shift lever
2	Brush holder	12	Screw	22	Rear cover assemlby
3	Brush	13	Shift lever pin	23	Screw
4	Thrust washer	14	Center bearing assembly	24	Nut
5	Armature assembly	15	Advance sleeve	25	Washer
6	Pinion stopper	16	Clip	26	Screw
7	Pinion stopper clip	17	Dust cover	27	Yoke assembly
8	Pinon stopper washer	18	Thrust washer	28	Through bolt
9	Nut	19	Pressure equalizer	29	Pinion assembly
10	Washer	20	Lock washer	30	Gear case assembly

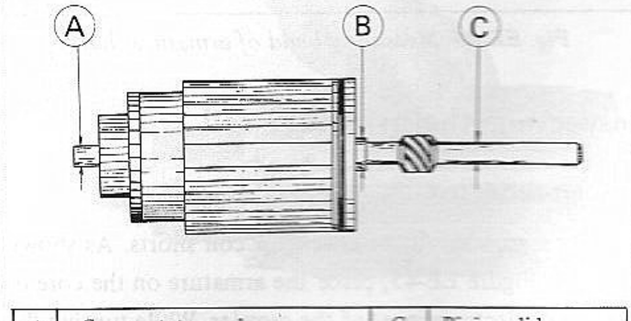
Fig. EE-42 Over-all disassembly of the starter motor

INSPECTION AND CORRECTIVE ACTION

Inspection armature shaft and bushing (Bearing metal)

1. Wear on the armature shaft

Measure the armature shaft diameter at the commutator end (A), center bearing (B), pinion slide (C), and pinion end. If wear exceeding 0.1 mm (0.004 in) is found, replace the armature assembly.



A	Commutator end	C	Pinion slide
B	Center bearing		

Fig. EE-43 Measuring armature shaft outer diameter

2. Clearance between armature shaft and bearing

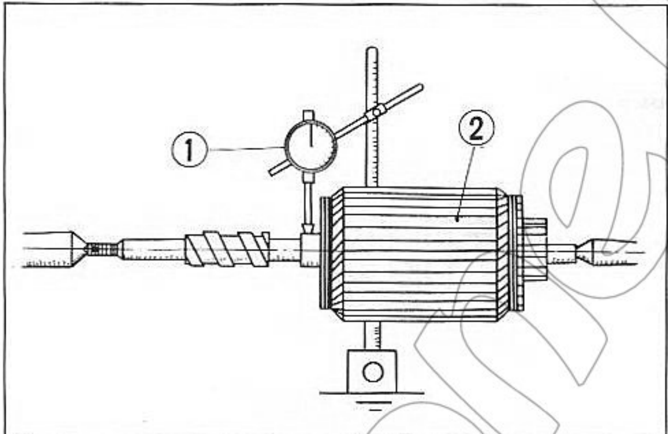
Measure inside diameters of the bushings (three) associated with the above points. If clearance between the shaft and bushing is ascertained excessive, replace the bushings.

Center bearing clearance limit:
0.45 mm (0.018 in)
Clearance limit at other positions:
0.2 mm (0.008 in)

3. Bending of the armature shaft

Support each end of the armature shaft with a pivot, bring the sensor of a dial gauge ① into contact with the center bearing portion of the shaft, and determine bend while rotating the shaft. Actual bend is one-half the deflection of the dial gauge reading. Replace the armature shaft if the bend is not within specified limits.

Bend limit: 0.1 mm (0.004 in)



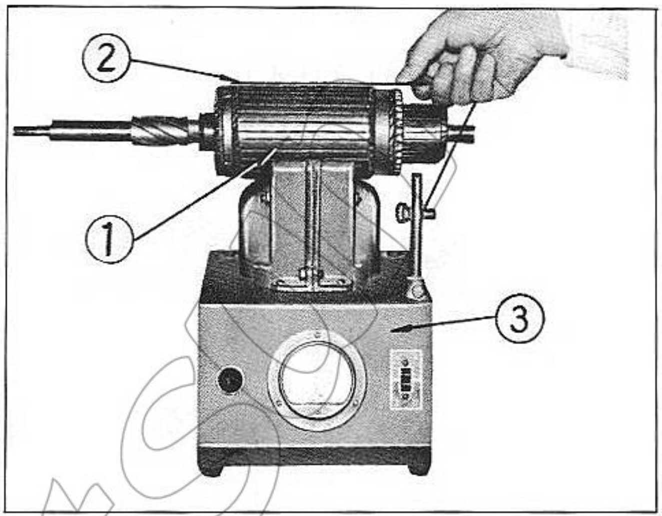
1	Dial gauge	2	Armature shaft

Fig. EE-44 Measuring bend of armature shaft

Inspecting the armature coil

Short-circuit test

Use growler ③ to check for coil shorts. As shown in the Figure EE-45, place the armature on the core of the AC electromagnet of the growler. While turning the armature by hand, place a thin strip of iron over the core grooves in turn. The iron strip should be attracted. If vibration (buzzing) occurs, the corresponding portion is shorted. Replace the armature assembly.

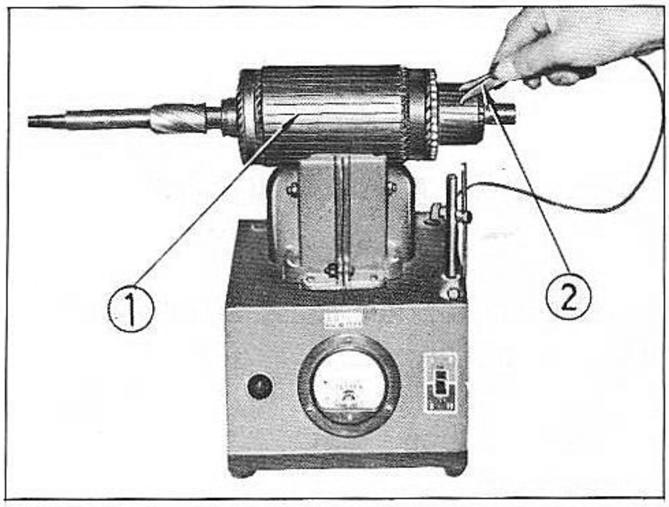


1 2	Armature Iron strip	3	Glowler

Fig. EE-45 Growler tester

Open test

By making use of test leads ② and the voltmeter attached to the growler, measure the voltage between adjacent segments of the commutator. If all points have the same voltage, there are no shorts. If a reading is low, however, the coil insulation is poor. A zero reading indicates that the coil is open.

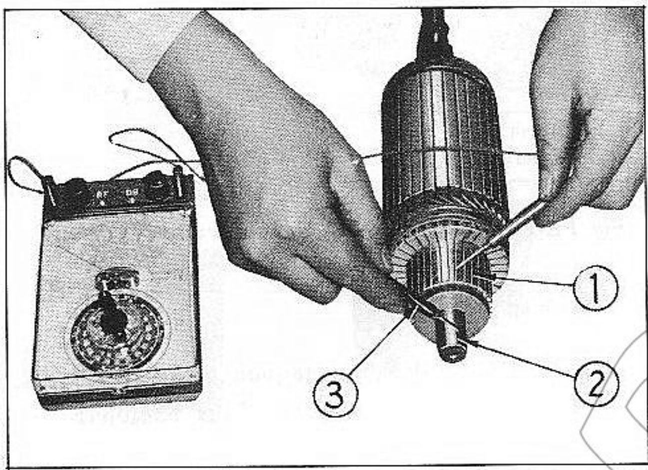


1	Armature	2	Test lead

Fig. EE-46 Disconnection test

Insulation test

Connect the test leads to the commutator and armature shaft. Continuity indicates that insulation between the commutator and armature shaft is faulty. Replace the armature assembly. This procedure is a simple means of checking the insulation. A megger may also be used if necessary, in which readings above one megohm are acceptable.

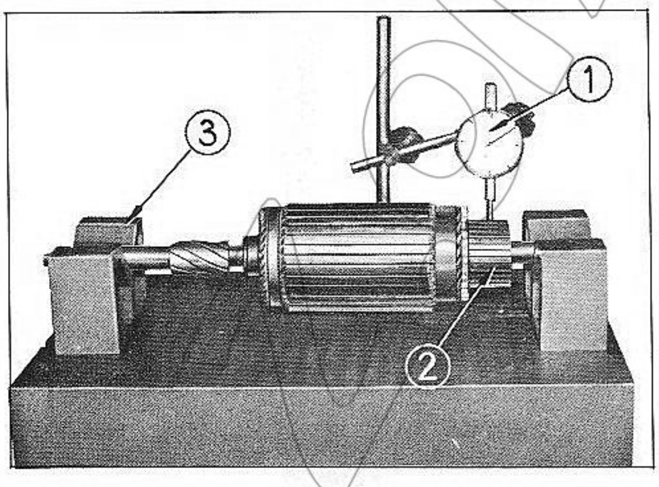


1 2	Commutator Armature shaft	3	Test cord

Fig. EE-47 Insulation test

Inspecting commutator

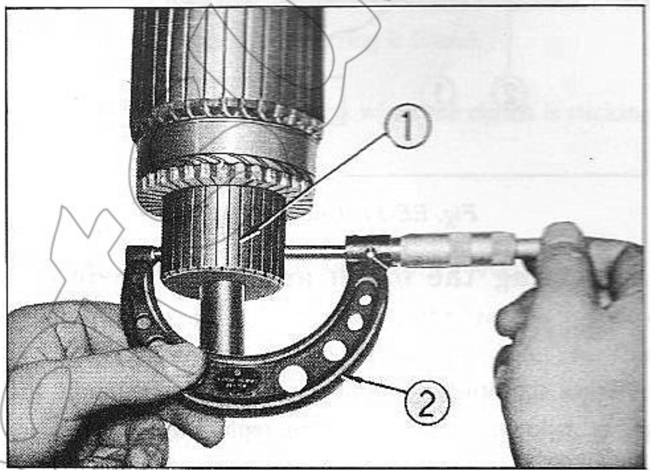
1. Measuring commutator wear and eccentricity



1 2	Dial gauge Commutator	3	V-block

Fig. EE-48 Uneven commutator wear

Support each end of the armature shaft with V-block, and bring the sensor of dial gauge ① into contact with the commutator. Observe dial gauge pointer deflection while turning the armature. If deflection is more than 0.4 mm (0.016 in), rework the commutator.



1	Commutator	2	Micrometer

Fig. EE-49 Measuring outer diameter commutator

2. Mica undercut

Measure commutator mica undercut with a depth gauge. If the measured value is less than 0.2 mm (0.008 in), recut to obtain a depth between 0.5 and 0.8 mm (0.020 and 0.031 in). Undercut the mica by using a saw blade having the appropriate thickness as shown in Figure EE-50. Undercutting results in sharp segment corners. Bevel these corners as shown in Figure EE-51.

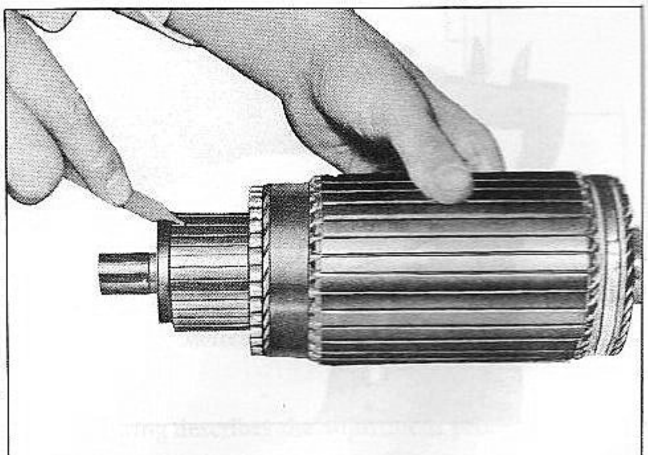
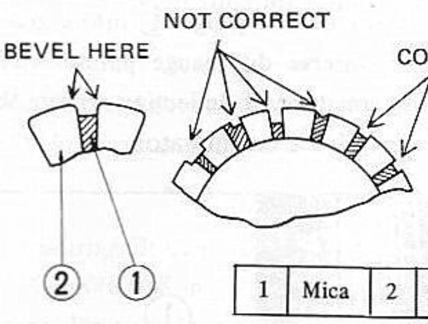


Fig. EE-50 Undercutting



1	Mica	2	Segments

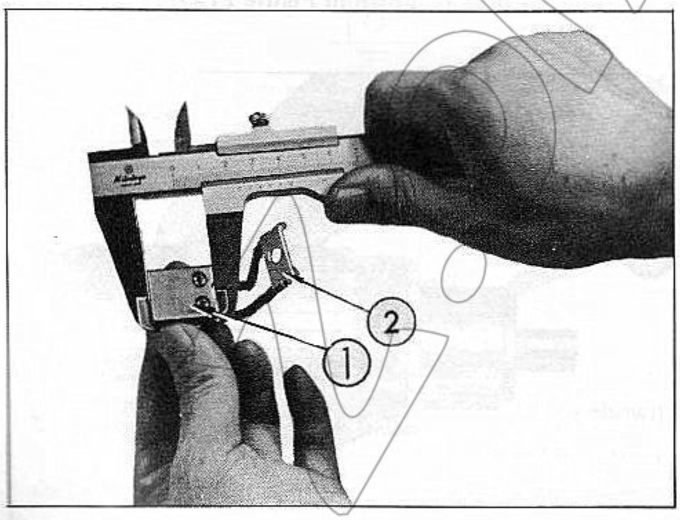
Fig. EE-51 Undercuting mica

Inspecting the brush and brush spring

1. Brush

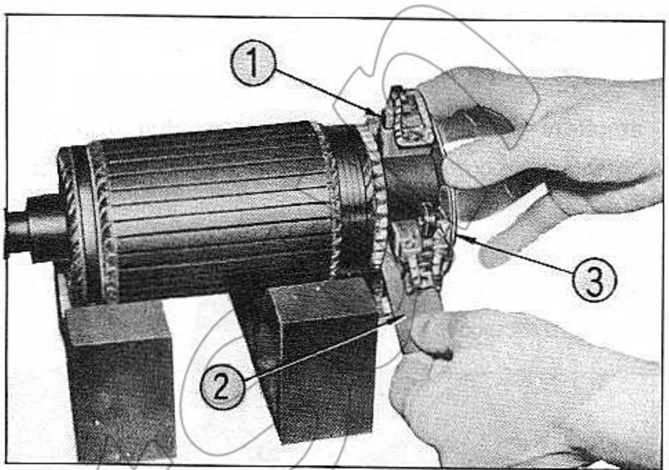
When the brush is worn beyond the specified limit, the pigtail is loose, or wear is uneven, replace the brush. When the brush has been replaced or the commutator reworked, commutator and brush surface dressing is required. Dressing is accomplished by clamping the armature is a vise, wrapping sandpaper (#400) around the commutator, and installing the end cover with brushes.

Nominal brush height		
	S13-04K	21 mm (0.827 in)
	S12-19K	20 mm (0.787 in)
	M005T-22671	19 mm (0.748 in)
Wear limit		
	S13-04K	13 mm (0.512 in)
	S12-19K	13 mm (0.512 in)
	M005T-22671	13 mm (0.512 in)



1	Brush	2	Pig tail

Fig. EE-52 Measuring brush height



1 2	Brush Emery paper	3	Rear cover

Fig. EE-53 Adjusting brush and commutator contact

2. Brush spring

Measure the brush spring tension by using a spring scale. Replace the brush spring if its tension is not satisfactory. Also, replace the brush spring if deformation is evident.

Nominal brush spring tension		
	S13-04K	1.8 kg (3.96 lb)
	S12-19K	0.85 kg (1.87 lb)
	M005T-22671	2.0 kg (4.4 lb)
Tension limit		
	S13-04K	0.94 kg (2.07 lb)
	S12-19K	0.76 kg (1.68 lb)
	M005T-22671	1.5 kg (3.3 lb)

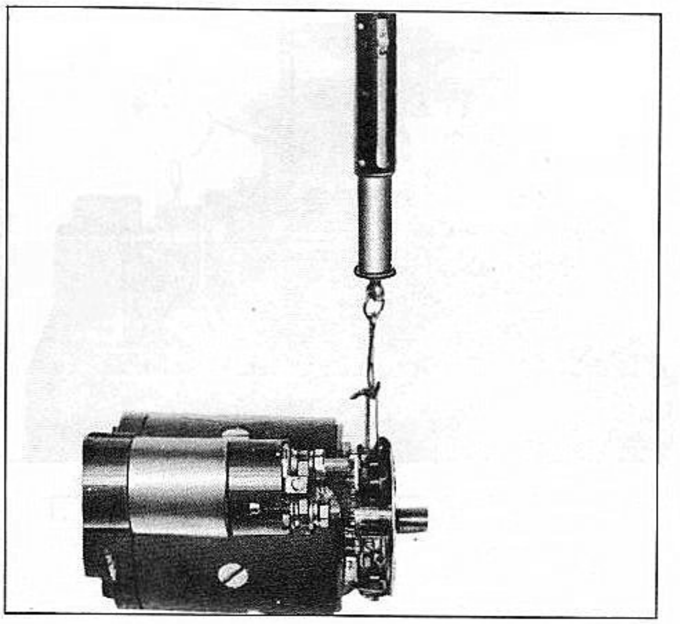


Fig. EE-54 Measuring brush spring tension

Inspecting the field coil

1. Disconnection

Connect a continuity tester across the field coil terminals. Lack of continuity indicates an open field coil. (Note that the field coil ground terminal should be disconnected during this test.)

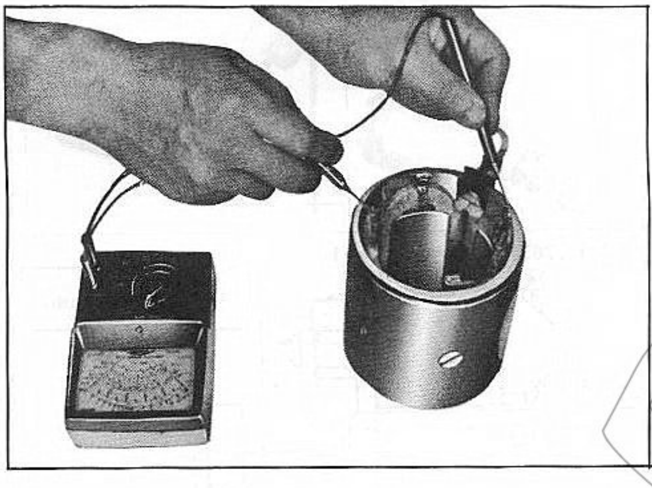


Fig. EE-55 Disconnection test

2. Insulation test

Connect a megger between the field coil terminals and the yoke or core. The indicated resistance must be more than one megohm.

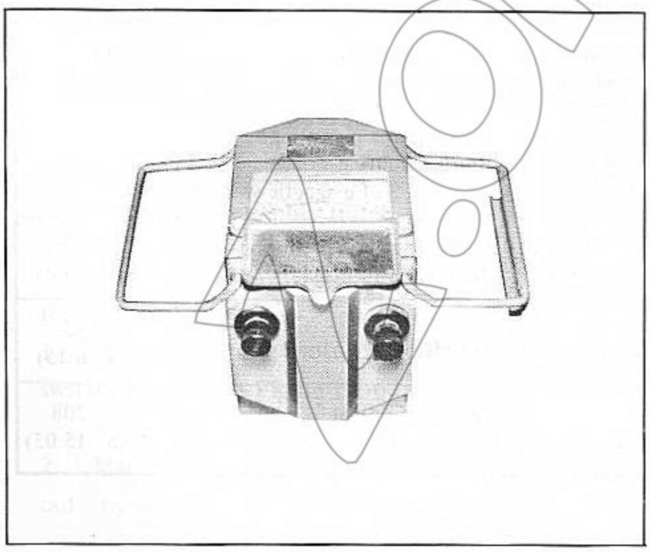


Fig. EE-56 Megger

Pinion

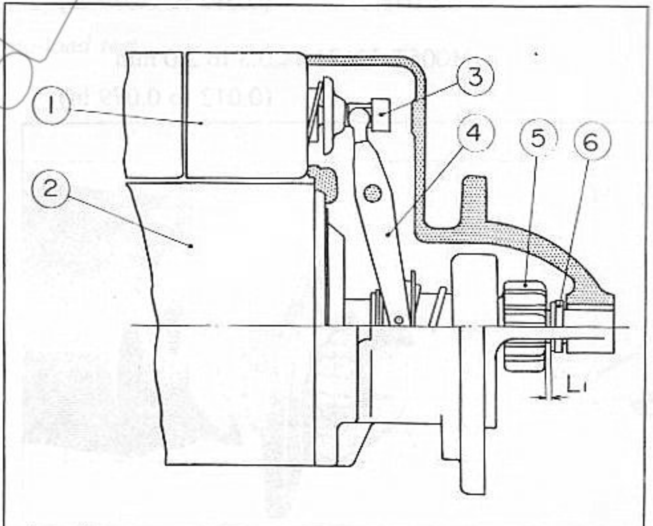
1. Check the pinion teeth. If wear or damage is evident, replace the pinion.

2. Make sure that the pinion action is smooth. Dress the pinion if scoring or burring is found.

3. Replace defective parts when the clutch is sticking or slipping.

ASSEMBLY AND ADJUSTMENT

Starter motor reassembly is the reverse of disassembly. After completing reassembly, refer to this chapter and adjust the pinion plunger gap. With the pinion fully advanced by the magnetic switch, i.e., when the plunger gap is zero, adjust clearance between the pinion and the pinion stopper to a value described in the following step 2.

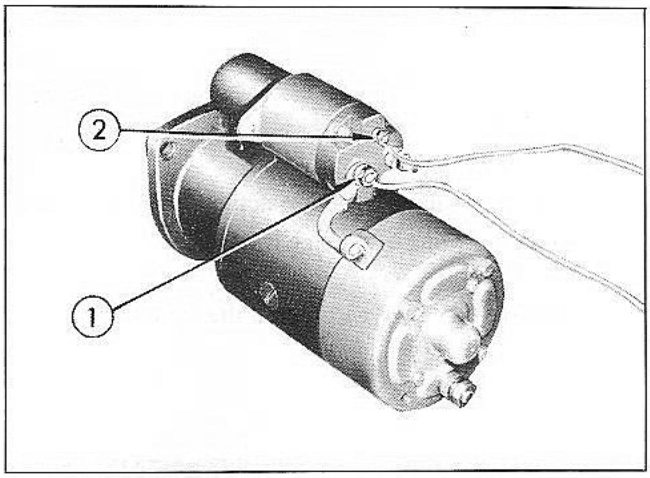


1	Magnetic switch	4	Shift lever
2	Yoke assembly	5	Pinion
3	Adjusting screw	6	Pinion stopper

Fig. EE-57 Adjusting clearance when the magnetic switch plunger gap is zero

The following describes the adjustment procedures.

1. Connect terminals M and S to a battery as shown in the Figure EE-58.



1	Terminal M	2	Terminal C

Fig. EE-58

2. Measure the gap between the pinion and pinion stopper with slide caliper or thickness gauge.

Pinion plunger gap

S12-19K } ..... 0.3 to 1.5 mm
S13-04K } (0.012 to 0.059 in)

M005T-22671 .. 0.3 to 2.0 mm
(0.012 to 0.079 in)

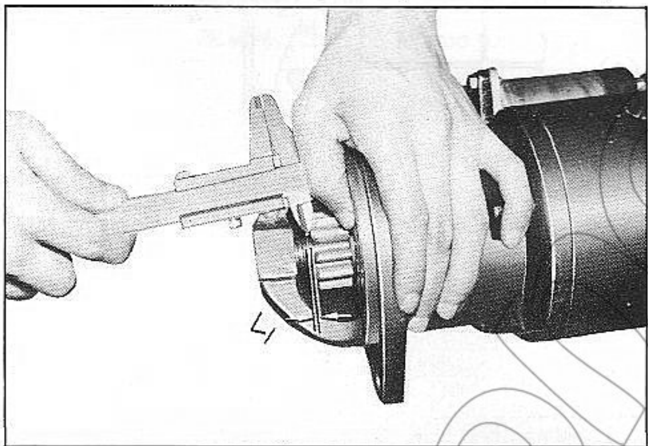
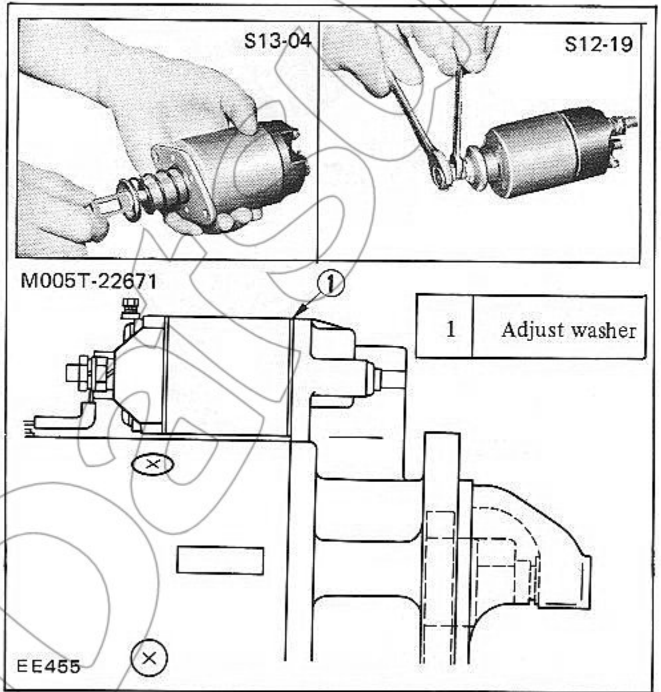


Fig. EE-59 Measuring gap between the pinion and pinion stopper

3. If the gap is not correct, readjust the gap (Refer to Figure EE-60).

(1) Readjust by turning the adjusting screw.
.... Hitachi S12-19K, S13-04K

(2) Adjust the gap between the gear case and magnetic switch by adding adjust washer(s). Adjust washers are available in two different sizes, 0.5 mm (0.02 in) and 0.25 mm (0.01 in). .... Mitsubishi M005T-22671



1	Adjust washer

Fig. EE-60

4. Tightening torque values during reassembly are shown in the following table.

Thread diameter mm (in)	Location	Tightening torque kg-cm (ft-lb)
4 (0.157)	Brush holder mounting Brush mounting Terminal S of magnetic switch	17 - 24 (1.23 - 1.74)
5 (0.197)	Magnetic switch mounting Terminal B of magnetic switch	35 - 50 (2.53 - 3.62)
6 (0.236)	Through bolt	60 - 85 (4.34 - 6.15)
8 (0.315)	Ground terminal Terminal M of magnetic switch	145 - 208 (10.5 - 15.05)

Testing after completion of assembly

Conduct performance tests after reassembling the starter motor.

No-load test

Make connections shown in Figure EE-61. Test the starter motor, making sure that values shown below are obtained.

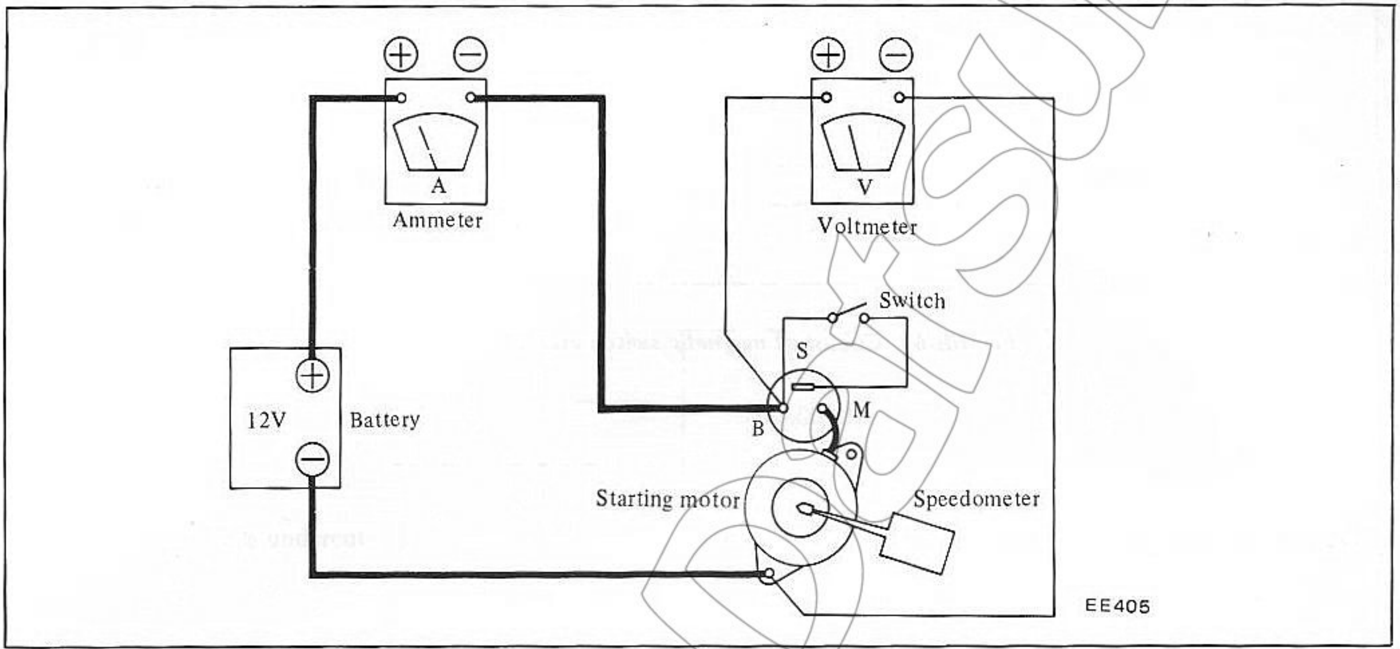


Fig. EE-61 Circuit of no-load test

Item		Hitachi S13-04K	Hitachi S12-19K	Mitsubishi M005T-22671
No-load terminal voltage	(V)	12	12	11.5
No-load current	(A)	Less than 80	Less than 80	Less than 100
No-load speed	(rpm)	More than 4,500	More than 6,500	More than 3,700

Magnetic switch assembly test

Test magnetic switch assembly after performance test.

1. Connect starting motor in series with battery and switch as shown in Figure EE-62.

2. Make sure that pinion assembly is quickly pushed out by means of magnetic switch when switch (described in step 1 above) is turned "ON".

3. With switch on, push pinion back to remove all slack and measure the clearance " " between pinion front edge and pinion stopper. The clearance should be held within 0.3 to 1.5 mm (0.012 to 0.059 in) for Hitachi S12-19K, S13-04K, and 0.3 to 2.0 mm (0.012 to 0.079 in) for Mitsubishi M005T-22671. See Figure EE-62. If necessary, adjust (Refer to Figure EE-60).

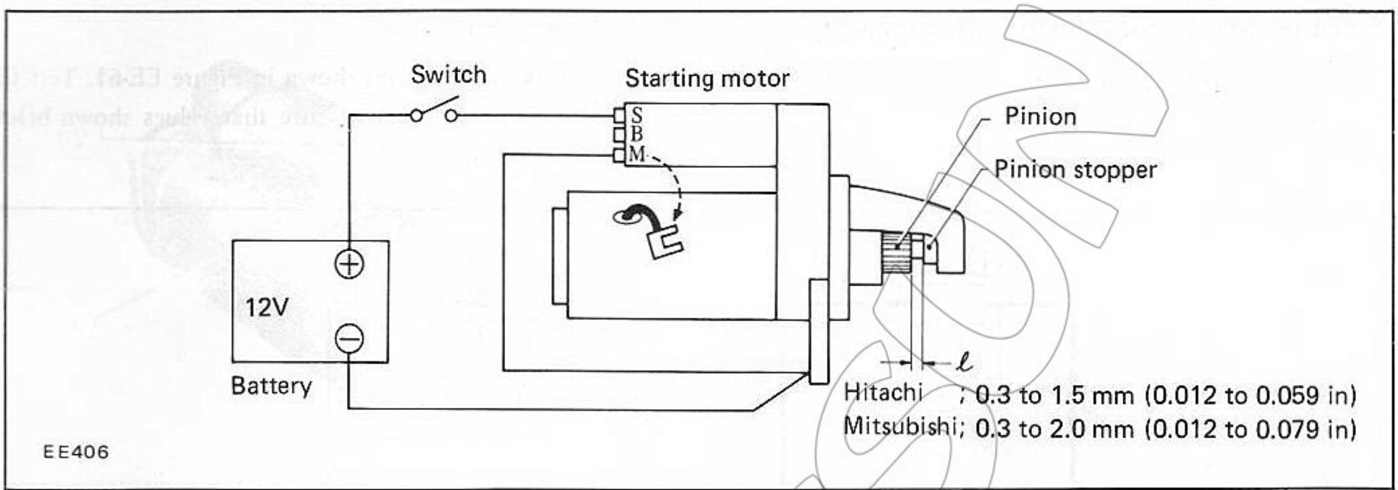


Fig. EE-62 Circuit of magnetic switch assembly test

SPECIFICATIONS AND SERVICE DATA

Specifications

Starter motor

Type		S12-19K	M0055T-22671	S13-04K
Engine model		SD22		SD33
Vehicle and fork lift models		330, C240, 140	FD104, FD105	FD106, FD107
System voltage	(V)	12	12	12
No-load				
Current	(A)	Less than 55	Less than 100	Less than 80
Revolution	(rpm)	More than 6,500	More than 3,700	More than 4,500
Terminal voltage	(V)	12	11.5	12
Magnetic switch				
Series coil resistance	(Ω)	0.25	0.154	0.13
Shunt coil resistance	(Ω)	0.78	0.964	0.44

Maintenance standards

Hitachi S12-19K starter motor

Item			Nominal dimension mm (in)	Maintenance standard mm (in)	Repair limit mm (in)	Wear limit mm (in)
Brush	Brush height		20 (0.787)	—	—	13 (0.512)
	Brush spring tension		—	0.85 kg (1.87 lb)	—	—
Commutator	Commutator outer diameter		43 (1.693)	—	—	40 (1.575)
	Difference between maximum and minimum diameters		—	0.05 (0.0020)	0.4 (0.0157)	—
	Mica undercut		—	0.5 to 0.8 (0.0197 to 0.0315)	0.2 (0.0079)	—
Clearance between shaft and bushing	Commutator end bearing	Bushing diameter	15 (0.591)	0.030 to 0.100 (0.0012 to 0.0039)	0.2 (0.0079)	—
		Shaft diameter				
	Center bearing	Hole diameter	20.5 (0.807)	0.250 to 0.320 (0.0098 to 0.0126)	0.45 (0.0177)	—
		Shaft diameter	20.3 (0.799)			
	Pinion sliding part	Hole diameter	14 (0.551)	0.030 to 0.100 (0.0012 to 0.0039)	0.2 (0.0079)	—
		Shaft diameter				
	Pinion end bearing	Hole diameter	14 (0.551)	0.030 to 0.100 (0.0012 to 0.0039)	0.2 (0.0079)	—
		Shaft diameter				
Armature shaft	Shaft outer diameter wear limit		—	—	—	0.1 (0.0039)
	Shaft bending		—	—	0.1 (0.0039)	—
Clearance between the pinion and pinion stopper when the contactor is closed completely			—	0.3 to 1.5 (0.012 to 0.0591)	—	—

Hitachi S13-04K starter motor

Item			Nominal dimension mm (in)	Maintenance standard mm (in)	Repair limit mm (in)	Wear limit mm (in)
Brush	Brush height		21 (0.827)	———	———	13 (0.512)
	Brush spring tension		———	1.8 kg (3.96 lb)	———	———
Commutator	Commutator outer diameter		50 (1.969)	———	———	47 (1.850)
	Difference between maximum and minimum diameters		———	———	0.4 (0.0157)	———
	Mica undercut		———	0.5 to 0.8 (0.0197 to 0.0315)	0.2 (0.0079)	———
Clearance between shaft and bushing	Commutator end bearing	Bushing diameter / Shaft diameter	16 (0.630)	0.030 to 0.100 (0.0012 to 0.0039)	0.2 (0.0079)	———
	Center bearing	Hole diameter / Shaft diameter	26.0 (1.024) / 26.1 (1.028)	0.250 to 0.320 (0.0098 to 0.0126)	0.45 (0.0018)	———
	Pinion sliding part	Hole diameter / Shaft diameter	14 (0.551)	0.030 to 0.100 (0.0012 to 0.0039)	0.2 (0.0079)	———
	Pinion end bearing	Hole diameter / Shaft diameter	14 (0.551)	0.030 to 0.100 (0.0012 to 0.0039)	0.2 (0.0079)	———
Armature shaft	Shaft outer diameter wear limit		———	———	———	0.1 (0.0039)
	Shaft bending		———	———	0.1 (0.0039)	———
Clearance between the pinion and pinion stopper when the contactor is closed completely			———	0.3 to 1.5 (0.012 to 0.0591)	———	———

Mitsubishi M005T-22671 Starter motor

Item			Nominal dimension mm (in)	Maintenance standard mm (in)	Repair limit mm (in)	Wear limit mm (in)
Brush	Brush height		19 (0.748)	——	——	13 (0.512)
	Brush spring tension		——	2 kg (4.4 lb)	——	1.5 kg (3.3 lb)
Commutator	Commutator outer diameter		43.2 (1.701)	——	——	42.2 (1.66)
	Difference between maximum and minimum diameters		——	0.03 (0.001)	0.2 (0.008)	——
	Mica undercut		——	0.5 (0.020)	0.2 (0.008)	——
Clearance between shaft and bushing	Commutator end bearing	Bushing diameter / Shaft diameter	14.2 (0.559)	0.050 to 0.104 (0.002 to 0.004)	0.2 (0.008)	——
	Center bearing	Hole diameter	20.6 (0.811)	0.220 to 0.355 (0.009 to 0.014)	0.45 (0.018)	——
		Shaft diameter	20.3 (0.799)			
	Pinion sliding part	Hole diameter / Shaft diameter	14.2 (0.559)	0.050 to 0.104 (0.002 to 0.004)	0.2 (0.008)	——
	Pinion end bearing	Hole diameter / Shaft diameter	12.2 (0.480)	0.034 to 0.104 (0.001 to 0.004)	0.2 (0.008)	——
Armature shaft	Shaft outer diameter wear limit		——	——	——	0.05 (0.002)
	Shaft bending		——	——	0.1 (0.004)	——
Clearance between the pinion and pinion stopper when the contactor is closed completely			——	0.3 to 2.0 (0.012 to 0.079)	——	——

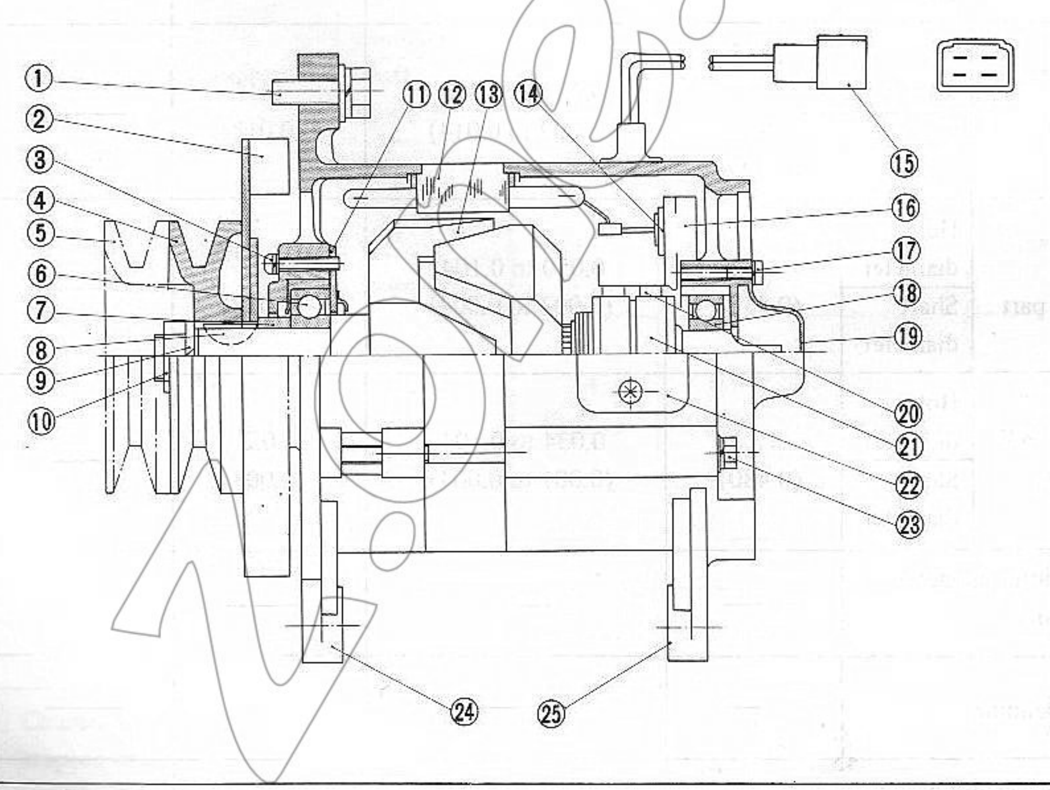
ALTERNATOR AND REGULATOR

CONTENTS

ALTERNATOR

CONSTRUCTION

The alternator is an independently excited, air cooled, three phase, AC type. Rectification is made by internal diodes with direct current supplied to the exterior. The alternator consists of the stator having three windings, the rotor with winding, the pulley, the front and end covers which support the rotor, brushes and slip rings which supply power to the rotor coil and other components.

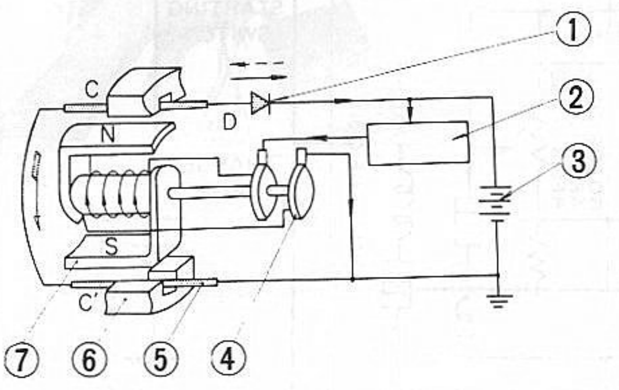


1	Setting bolt
2	Fan
3	Bearing retainer screw
4	Pulley
5	Pulley
6	Ball bearing (front)
7	Spacer
8	Key
9	Lock washer
10	Nut
11	Bearing retainer
12	Stator
13	Rotor
14	Diode
15	Male terminal (CN connector)
16	SR holder
17	Screw
18	Ball bearing (rear)
19	Bearing cover
20	Brush
21	Slip ring
22	Brush cover
23	Through bolt
24	Front cover
25	Rear cover

Fig. EE-63 Alternator

Operation

Alternator



1	Diode	5	Stator coil
2	Voltage regulator	6	Stator
3	Battery	7	Magnet
4	Slip ring		

Fig. EE-64 Alternator operating principles

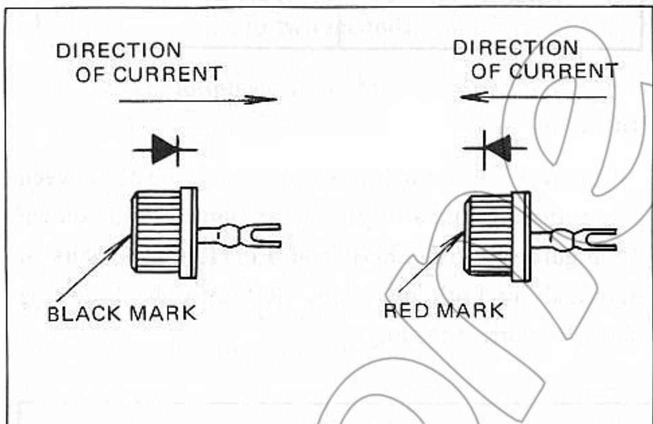


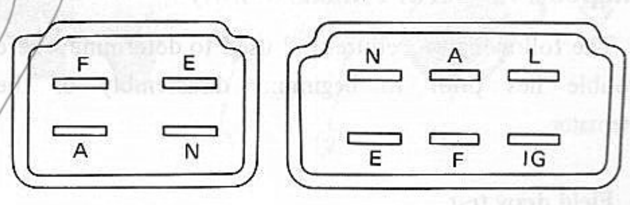
Fig. EE-65 Forward direction of diodes

Magnet (rotor coil) ⑦ excited through slip rings ④ rotates within the stator ⑥, inducing AC power in the three windings of the stator coil ⑤. This three-phase power is rectified by six diodes ① (of which three are P-N types and three are N-P types). Output is in the form of direct current.

Diodes

The diodes allow current to flow in one direction but block it in the opposite direction. Their function is the same as that of the commutator and cut-out relay in ordinary DC generator. The diodes have a mark and color coding which show the forward direction. Black indicates an N-P type (forward direction from case to terminal) while red indicates a P-N type (forward direction from terminal to case).

Connections



1	CN-4P-AM (alternator side)	2	CN-6P-AM (regulator side)

Fig. EE-66 CN connector

Terminal code	Wiring color	Terminal code	Wiring color
N	Yellow	A	White
F	White-black	L	White-red
E	Black	IG	White-blue

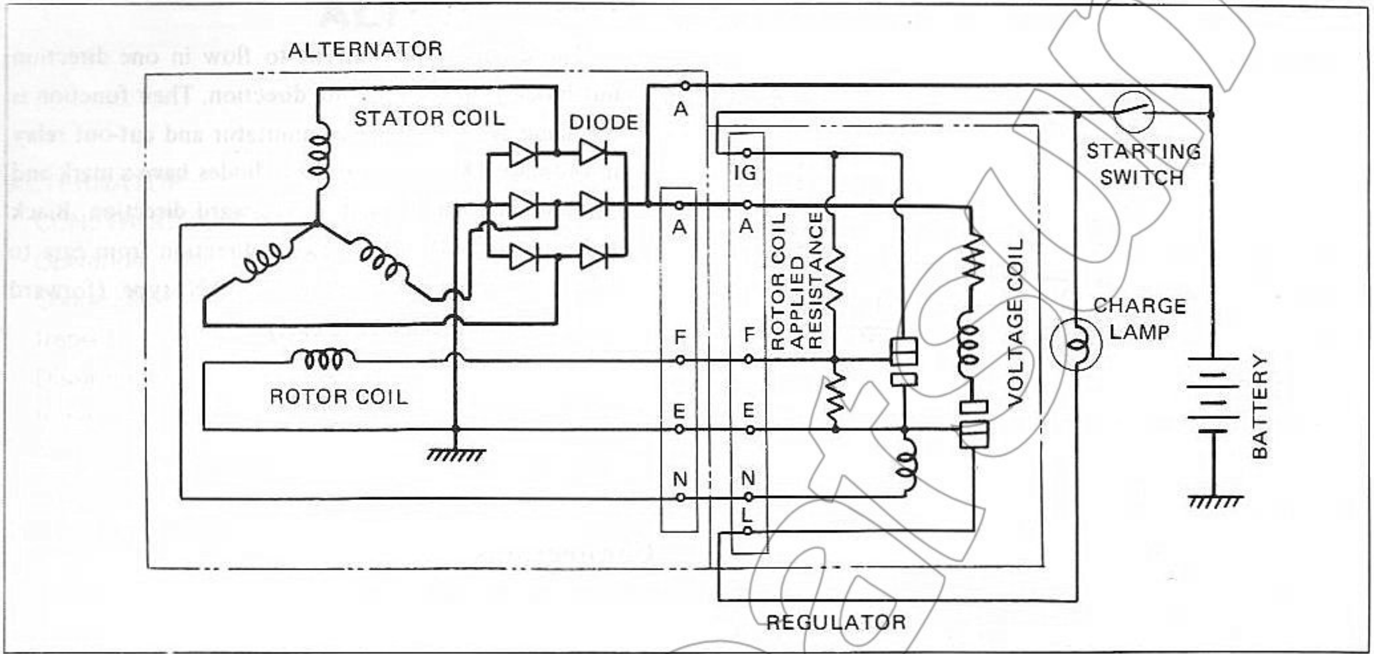


Fig. EE-67 Connection diagram

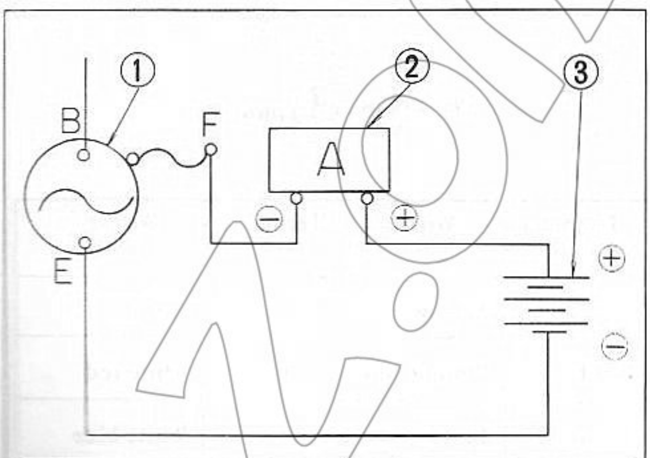
Inspection before disassembly

The following procedures are used to determine where trouble lies prior to beginning disassembly of the alternator .

Field draw test

Make connections as shown in Figure EE-68 and measure current flowing through the field.

Current shown in the following table is acceptable.



1	Alternator	3	Battery (12 V)
2	Ammeter		

Fig. EE-68 Measuring field current

Model	Current
Hitachi	Approx. 2.4A

Inspecting diode

Determine whether or not continuity exists between the various terminals by using an ohmmeter as shown in Figures EE-69, EE-70 and EE-71. Check pairs of terminals in both directions. Refer to the following table for correct readings.

Ohmmeter test lead polarity		Result
(+)	(−)	
Terminal A	Terminal E	Continuity
Terminal E	Terminal A	No continuity
Terminal A	Terminal N	Continuity
Terminal N	Terminal A	No continuity
Terminal N	Terminal E	Continuity
Terminal E	Terminal N	No continuity

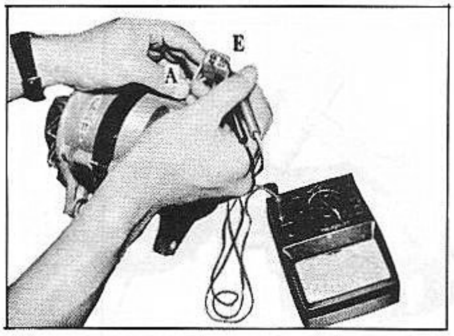
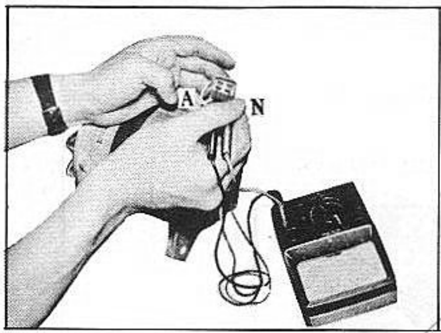


Fig. EE-69



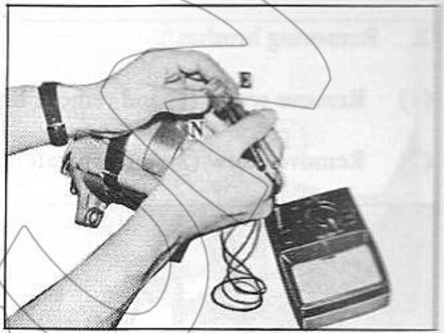


Fig. EE-70
Diode check

Fig. EE-71

Precautions during disassembly and reassembly

1. A wooden mallet may be used to remove the cover. Note, however, that the diode portion of the end cover and the fan should not be struck.

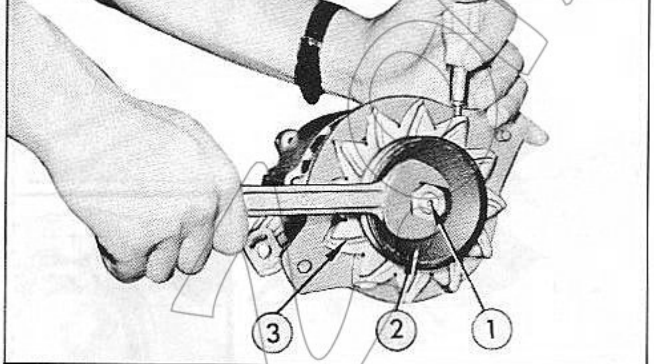
2. When unsoldering or soldering connections between diodes and the stator coils, use long nose pliers as a heat sink and a comparatively large soldering iron. Minimize the operation time during which the soldering iron is applied. (Internal temperatures above 150° C (302° F) will destroy the diodes.) With a 100 to 200 watt soldering iron, the length of heat application should be limited to two seconds.

3. When terminals have been disassembled, do not forget to reassemble the insulator.

Disassembly

1. Removing fan

(1) Check fan rotation with a screwdriver or other tool and remove pulley nut ①.



1	Nut	2	Pulley	3	Fan

Fig. EE-72 Removing the pulley

(2) Remove pulley ①, fan ②, and fan base ③, as well as key ④ and spacer ⑤.

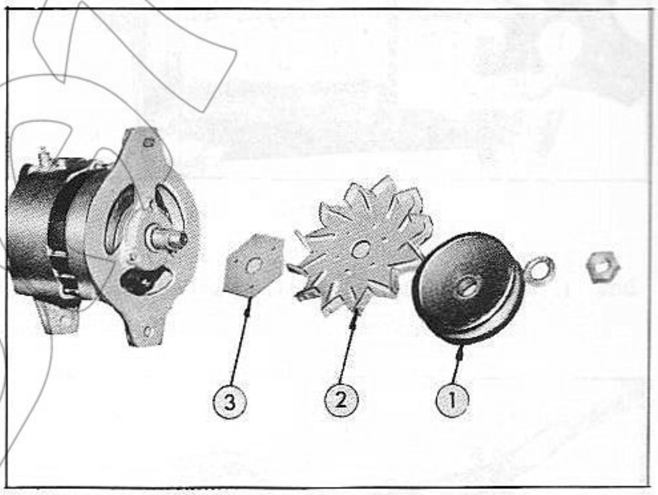
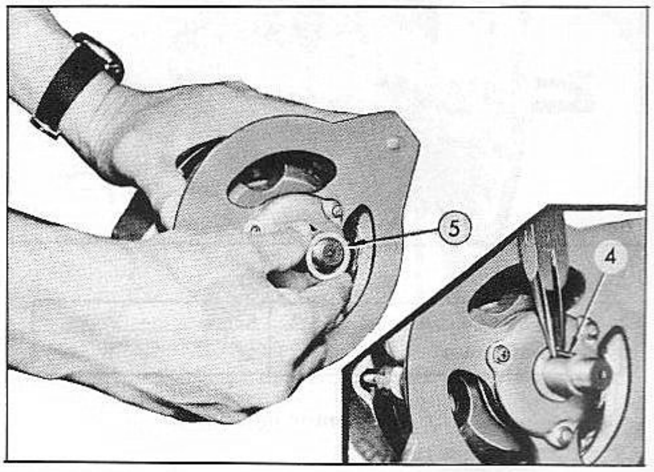


Fig. EE-73 Removing pulley



1	Pulley	4	Key
2	Fan	5	Spacer
3	Fan base		

Fig. EE-74

2. Removing brushes

(1) Remove screw ① and remove brush cover ②.

(2) Remove screw ③ and separate the two brushes.

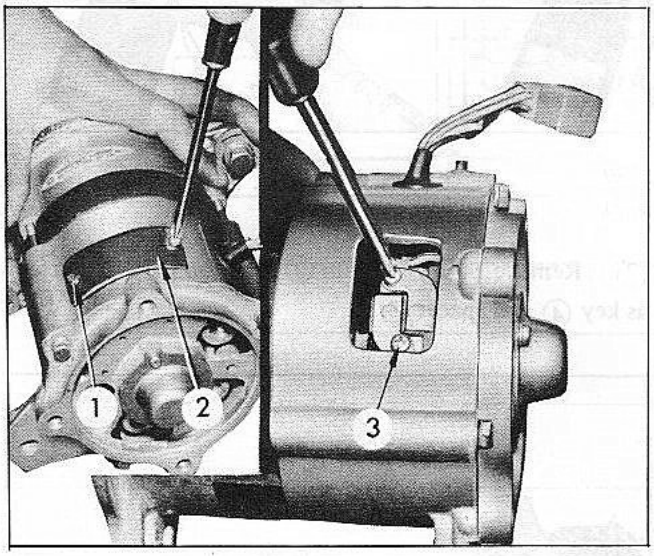
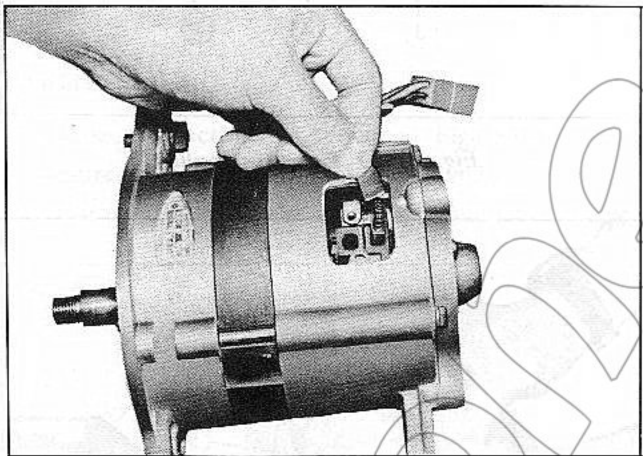


Fig. EE-75



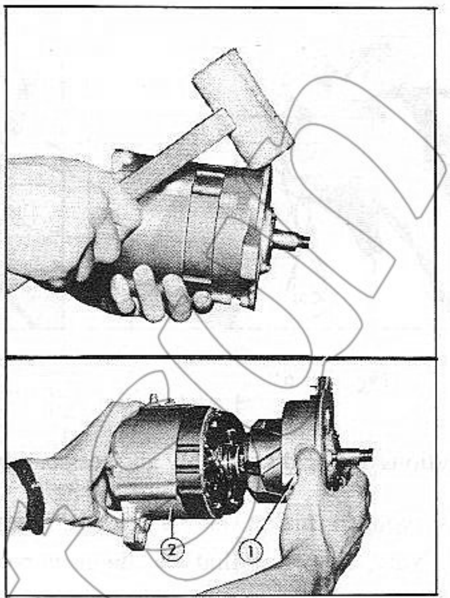
1 2	Screw Brush cover	3	Screw

Fig. EE-76 Removing brushes

3. Separating front and rear

(1) Remove the three bolts.

(2) Separate the alternator into front ① and rear ②.



1	Front cover
2	Rear cover

Fig. EE-77

4. Removing front cover

(1) Remove the three bearing retainer screws ① and separate front cover ②.

(2) Remove felt seal ③.

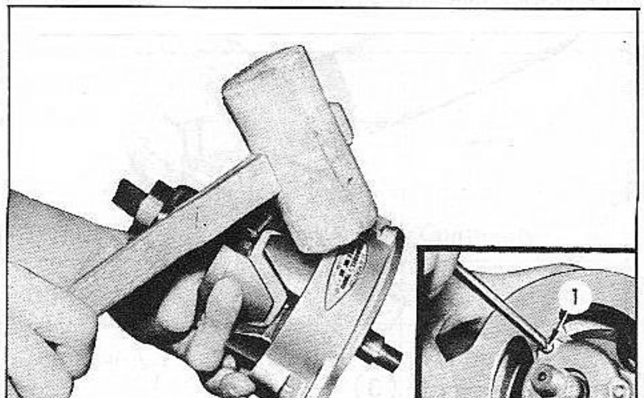
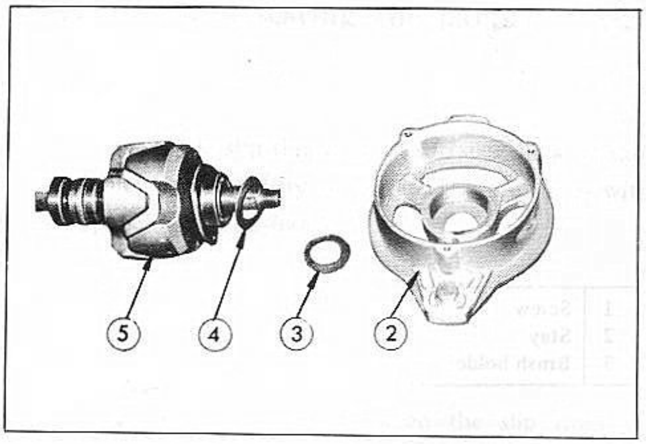


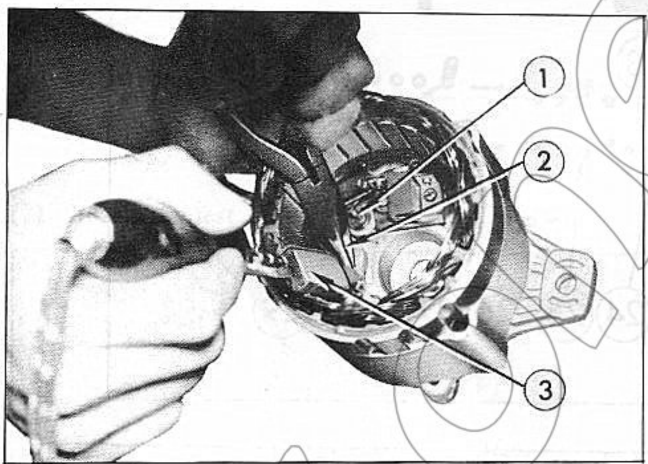
Fig. EE-78 Removing front cover



1	Bearing retainer screw	4	Packing retainer
2	Front cover	5	Rotor
3	Packing		

Fig. EE-79

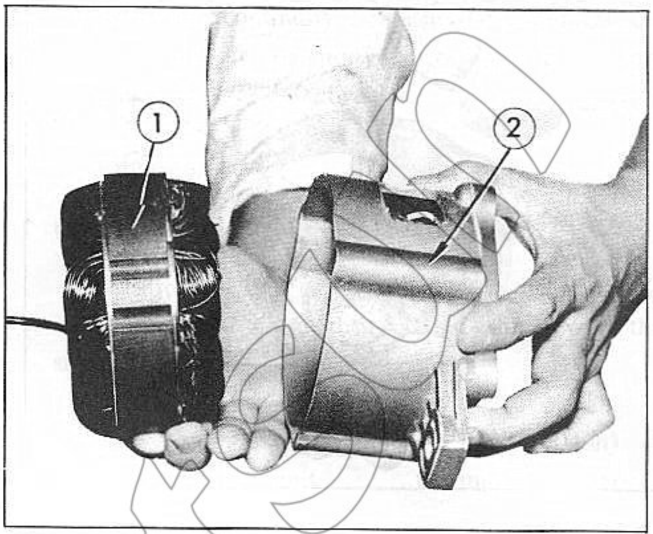
5. Unsolder lead and diode connections. Do not allow the diodes to become excessively hot.



1	Diode	3	Soldering iron
2	Long nose pliers		

Fig. EE-80 Unsoldering stator and diode connections

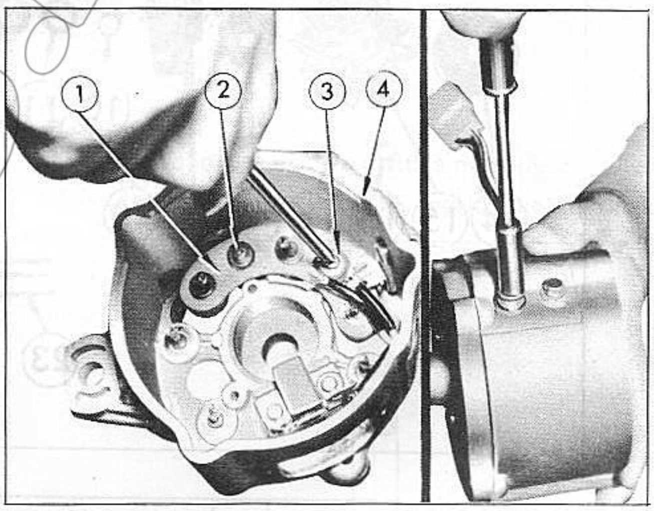
6. Separate stator ① and rear cover ②.



1	Stator	2	Rear cover

Fig. EE-81 Separating stator and rear cover

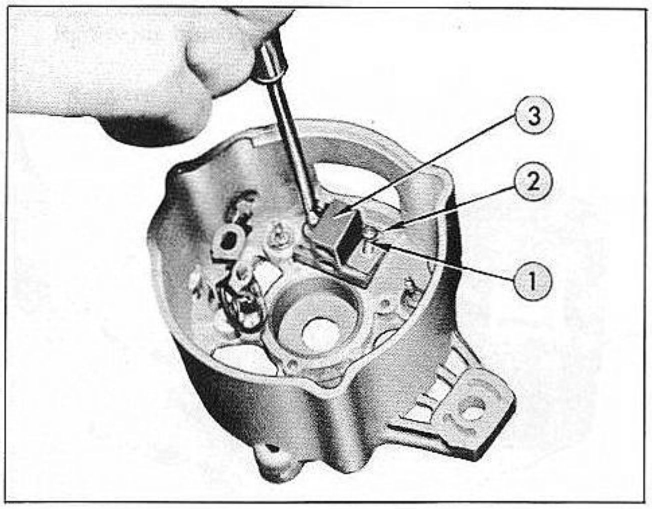
7. Remove the two screws ② of SR holder ① and remove the SR holder from the rear cover.



1	SR Holder	3	Insulator
2	Screw	4	Rear cover

Fig. EE-82 Removing SR holder

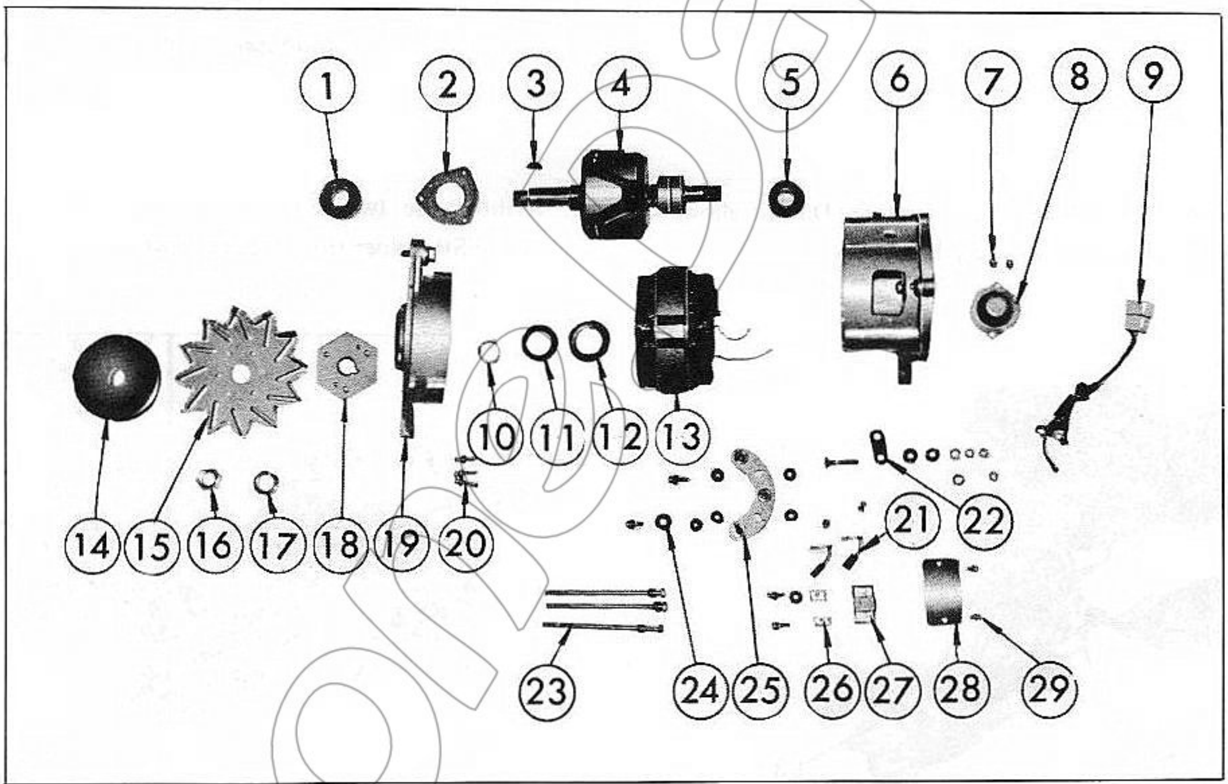
8. Remove the two screws ① and separate brush holder ③.



1	Screw
2	Stay
3	Brush holder

Fig. EE-83 Removing brush holder

9. When replacing the bearings, refer to "Replacing bearings" described on page EE-35 for the procedure.



1	Ball bearing	9	Lead assembly	17	Lock washer	25	SR holder
2	Bearing retainer	10	Spacer	18	Fan base	26	Terminal plate
3	Key	11	Packing	19	Front cover	27	Brush holder
4	Rotor assembly	12	Packing retainer	20	Screw	28	Brush cover
5	Ball bearing	13	Stator assembly	21	Brush assembly	29	Screw
6	Rear cover	14	Pulley	22	Terminal insulator		
7	Screw	15	Fan	23	Through bolt		
8	Shaft cover	16	Nut	24	Insulating washer		

Fig. EE-84 Disassembly of Hitachi alternator

Inspecting and testing the parts

Rotor

1. Check the slip ring friction surfaces, making sure that they are not dirty or pitted. Dress surfaces with sandpaper (#500 or #600).

2. Rotor coil

(1) Open test

Check for continuity between the slip rings. If continuity does not exist, the rotor coil is open and must be replaced.

Rotor coil resistance .... 5 Ω

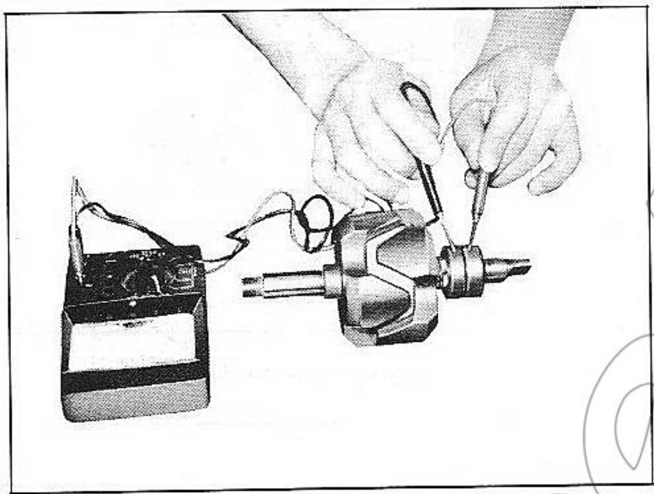


Fig. EE-85 Open test

(2) Insulation test

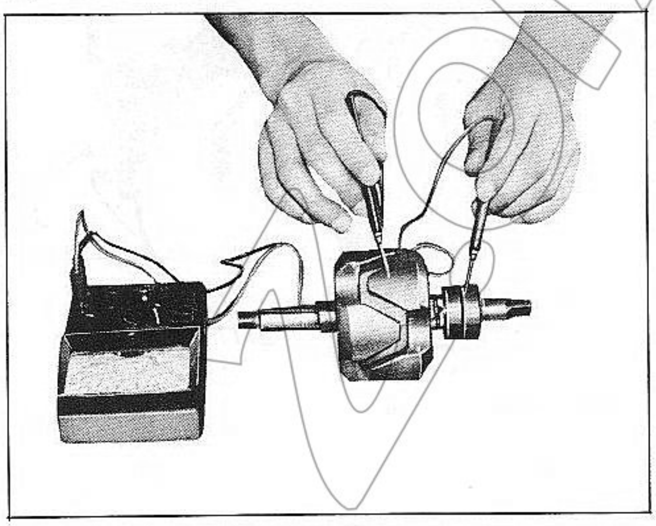


Fig. EE-86 Insulation test

Check for continuity between the slip rings and shaft or core. If continuity exists, the slip rings are grounded. Replace defective parts.

3. Slip rings

(1) Slip ring deflection

Measure slip ring deflection with a dial gauge. If deflection is not within the specified value, rework the slip rings.

Nominal deflection	0.1 mm (0.004 in)
Repair limit	0.3 mm (0.012 in)

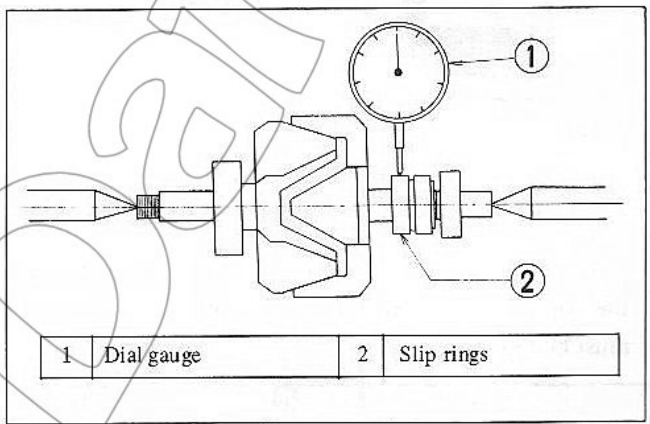


Fig. EE-87 Slip ring deflection

(2) Slip ring diameter

Measure slip ring diameter with a micrometer. When wear exceeds the specified limit, replace the slip rings.

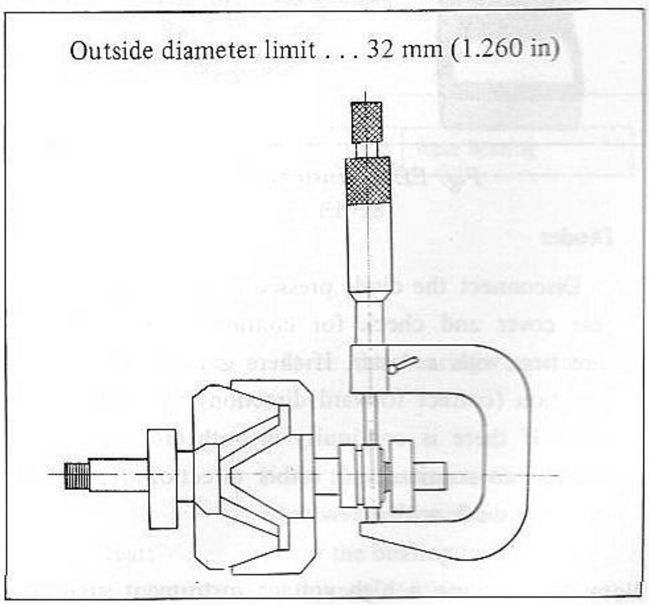


Fig. EE-88

Stator

1. Open test for stator coil

Check continuity of the three terminals. If continuity does not exist, replace the stator coil.

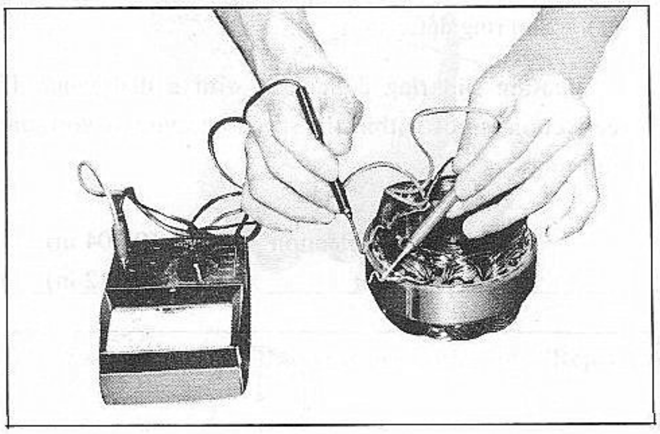


Fig. EE-89 Open test

2. Insulation test for stator coil

Check continuity between the three terminals and the core. If continuity exists, the coil is grounded and must be replaced.

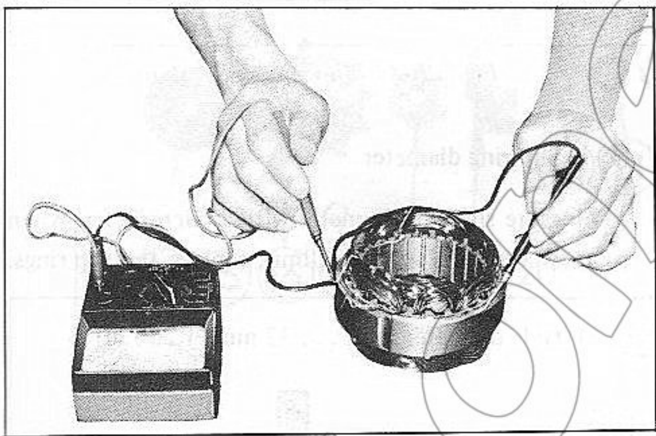


Fig. EE-90 Insulation test

Diodes

Disconnect the diode pressed in the SR holder and rear cover and check for continuity in the reverse direction with a tester. If there is continuity in one direction (correct forward direction), the diode is all right. If there is continuity in both directions, or if there is no continuity in either direction, replace the defective diode with a new one.

Note: Do not use a high voltage instrument such as a megger in checking the diodes.

Ohmmeter probes		Result
(+)	(−)	
Diode	SR holder	Continuity
SR holder	Diode	No continuity
Diode	Rear cover	Continuity
Rear cover	Diode	No continuity

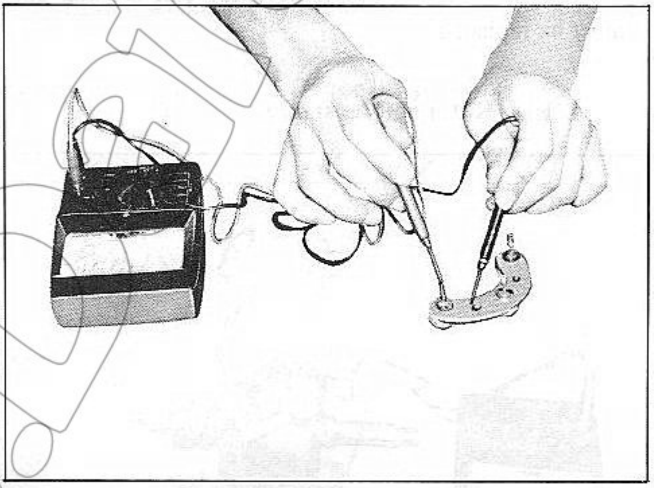


Fig. EE-91 Checking diodes on SR holder side

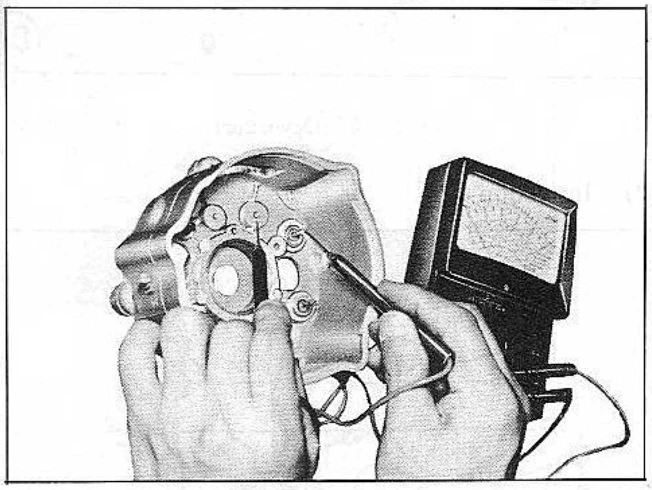


Fig. EE-92 Checking diodes on rear cover side

Brush and brush spring

1. Brush

Replace brushes worn beyond the specified limit, those with a loose pigtail, or those with uneven wear.

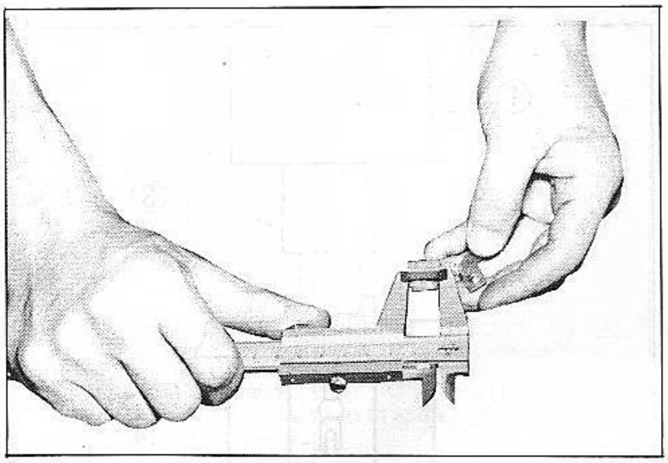


Fig. EE-93 Measuring brush height

Nominal dimension
14.5 mm (0.571 in)
Wear limit
7.5 mm (0.295 in)

2. Brush spring

Inspect the brush spring, making sure that it is not weak or deformed. Replace those adjudged defective.

Nominal tension
0.3 kg (0.662 lb)
Usable limit
0.16 kg (0.22 lb)

Spring pressure test

With brush projected approximately 2 mm (0.079 in) from brush holder measure brush spring pressure by a spring balance. Normally rated pressure of a new brush spring is 255 to 345 gr (9.0 to 12.2 oz).

When brush is worn, pressure decreases approximately 20 gr (0.7 oz) per 1 mm (0.0394 in) wear

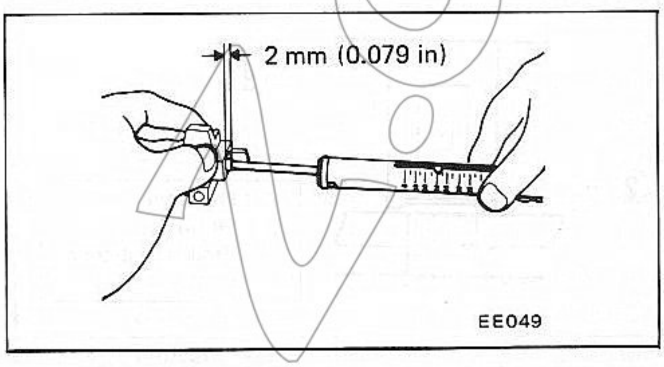


Fig. EE-94 Measuring spring pressure

Replacement of parts

Replacing bearings

1. Removal

To remove the two ball bearings from the rotor, use a press or ball bearing puller.

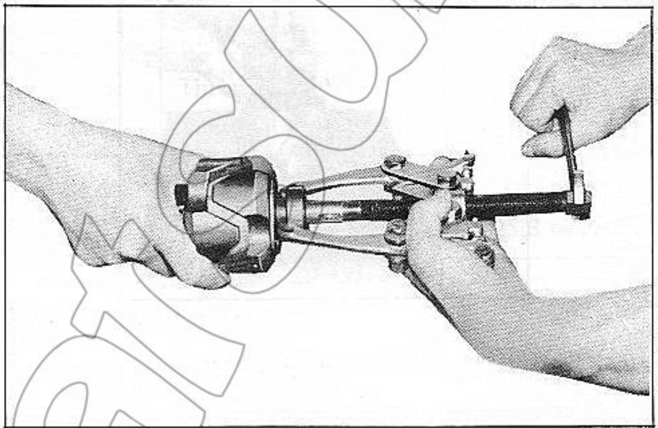
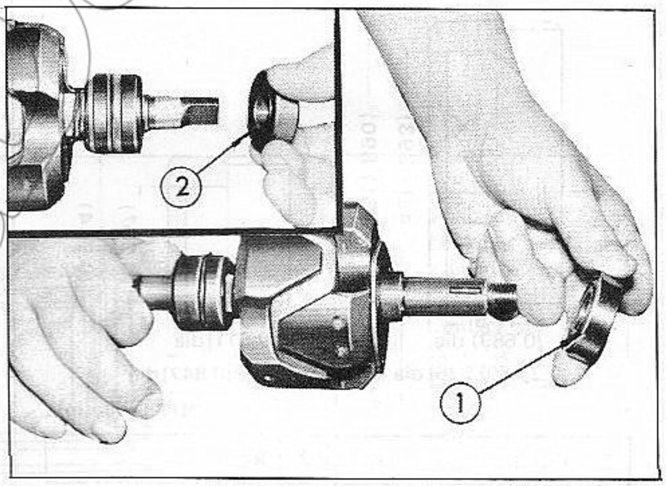


Fig. EE-95 Removing bearings



1	Front bearing	2	Rear bearing

Fig. EE-96

2. Installation

Use a press to force the bearings onto the rotor shaft.

Front: Force the bearing to the point at which it contacts the spacer.
Rear: Force the bearing to a point 17.5 mm (0.689 in) from the end of the shaft.

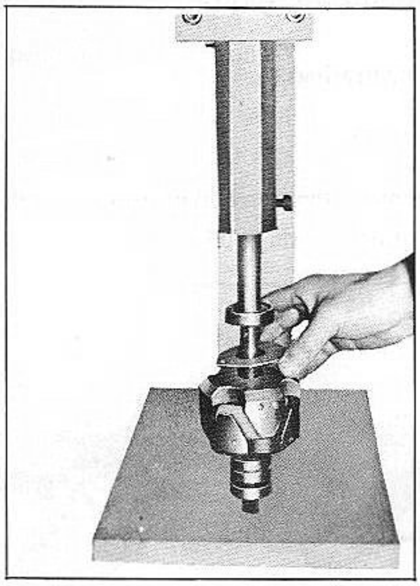
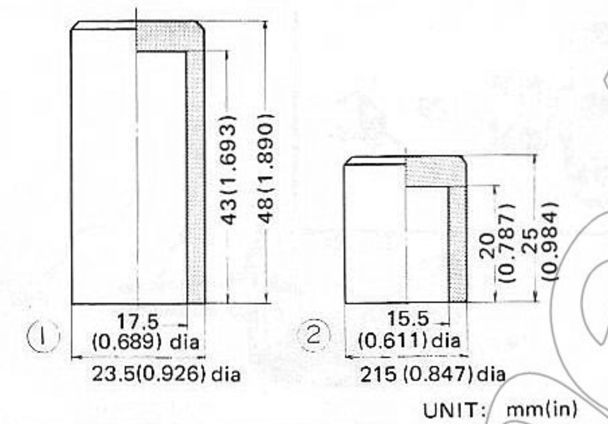


Fig. EE-97 Installing bearings



1	Front	2	Rear

Fig. EE-98 Bearing installation tool

Replacing diodes

1. Removing diodes

For both the rear cover and SR holder, place the side without diode leads upward and force out the diodes with a tool and press.

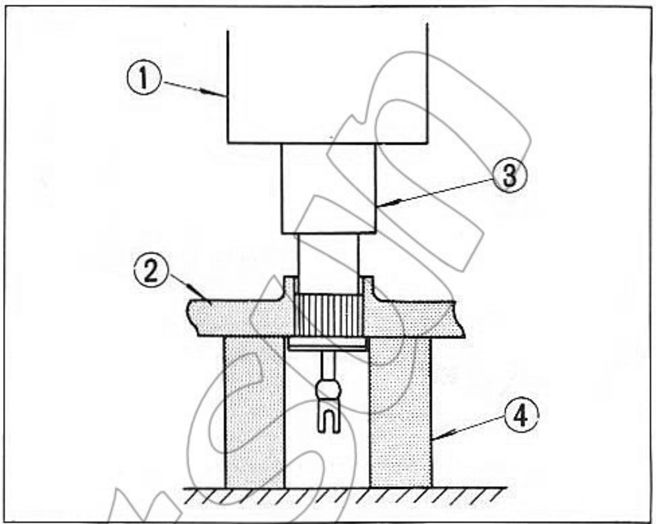
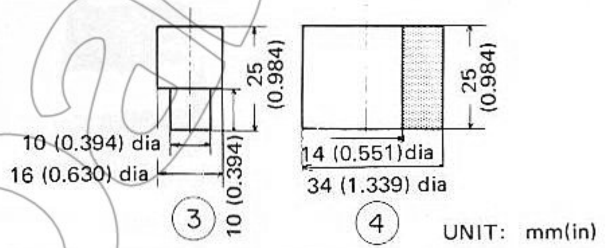


Fig. EE-99 Remvoing diodes

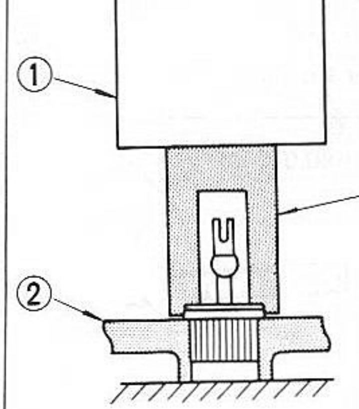


1	Press ram	3	Diode removal tool
2	SR holder	4	Diode removal tool

Fig. EE-100 Diode removal tool

2. Installing diodes

Place the tool against the new diode and force it into place with the press. Make sure that the diode orientation is correct.



1	Press ram
2	SR holder
3	Diode installation tool

Fig. EE-101 Installing diodes

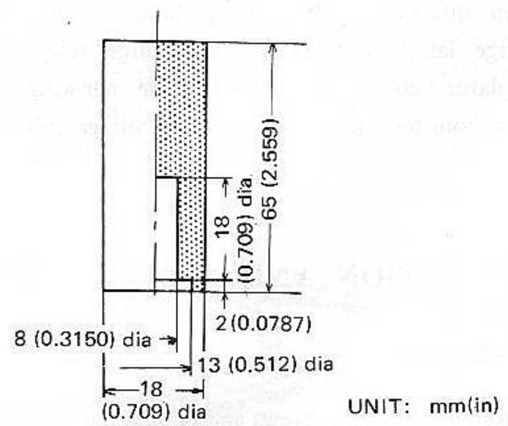


Fig. EE-102 Diode installation tool

Assembly and adjustment

Reassembly is the reverse of disassembly. There are no places requiring special adjustment. Assembly tightening torques are shown in the following table.

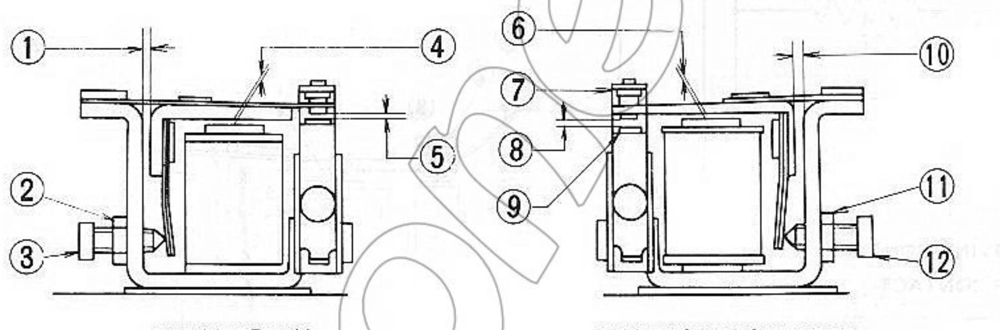
Thread diameter mm (in)	Location	Tightening torque kg-cm (ft-lb)
4 dia (0.157)	Brush holder mounting SR holder mounting Bearing retainer mounting	16 to 20 (1.16 to 1.45)
5 dia (0.197)	Through bolt Terminal nut	30 to 35 (2.17 to 2.53)
12 dia (0.472)	Pulley nut	350 to 400 (25.3 to 28.9)

Performance test

Testing is made by combining the alternator with the regulator. For adjustment, refer to information on adjustment of the regulator.

REGULATOR

CONSTRUCTION



1	Yoke gap
2	Lock nut
3	Adjusting screw
4	Core gap
5	Contact gap
6	Core gap
7	Lower contact
8	Contact gap
9	Upper contact
10	Yoke gap
11	Lock nut
12	Adjusting screw

Fig. EE-103 Regulator

The regulator functions to control current supplied to the rotor coil of the alternator, thereby holding the output voltage of the alternator constant. A tirrill configuration (contact) is used to make and break the circuit. Included are the voltage regulator and the charge relay which keeps the battery from discharging when the alternator voltage is below that of the battery and which serves to indicate via charge lamp or ammeter the discharge state.

Voltage regulator

When the alternator voltage rises above the nominal value, current proportional to voltage of the voltage coil of the voltage regulator flows, magnetic attraction increases and overcomes spring force, and the moving contact is pulled away from the lower contact. This inserts resistance RF in series with the rotor coil of the alternator and thereby reduces rotor coil current. The alternator output voltage drops as a result.

When the generator voltage falls below the nominal value, current flowing in the voltage coil decreases, magnet attraction becomes less, and the armature spring force again brings the moving contact against the lower contact. This action shorts resistance RF and current in the rotor coil increases. The generator output voltage rises as a result. When the generator speed is low or the load large, the generator voltage is held at a fixed level by repeating this sequence. When the generator speed increases even more, the moving contact separates from the lower contact as rotor coil resistance is inadequate. Current flowing in the voltage coil continues to rise, causing strong attraction of the armature and thus shifting the moving contact to the upper contact, forming a circuit which shorts the rotor coil. This action drops the output voltage of the generator. When the generator speed is high and the load light, the generator voltage is held to a fixed level by repeating this sequence.

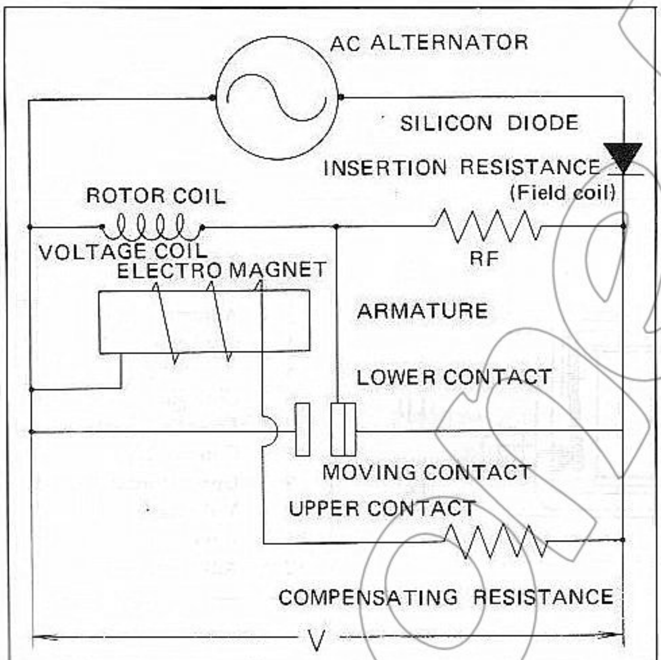


Fig. EE-104 Regulator principles

Charge relay (Refer to Fig. EE-67)

When the starter switch is closed, a portion of the battery current flows through the charge lamp to ground, lighting the charge lamp. The remainder of the current flows from terminals IG through the contacts from terminal F to terminal F of the generator and through the rotor coil. When the generator voltage rises and voltage at terminal A goes to 8 to 10V, the charge relay contacts open interrupting the charge lamp circuit. When the charge lamp contacts of the charge relay open, the regulator voltage coil contacts close, allowing current to flow from terminal A through the voltage coil to ground.

INSPECTION AND ADJUSTMENT

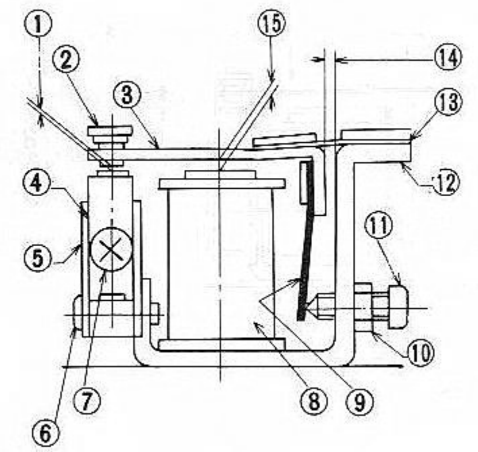
Inspection

Remove the two screws and detach the regulator cover. Check the contacts, polishing them with sandpaper (#500 or #600) is necessary.

Adjustment

1. Voltage regulator

Check the various gaps. When values are not correct, adjust in order of core gap and contact gap. Yoke gap adjustment is unnecessary as it is fixed at 0.9 mm (0.035 in).

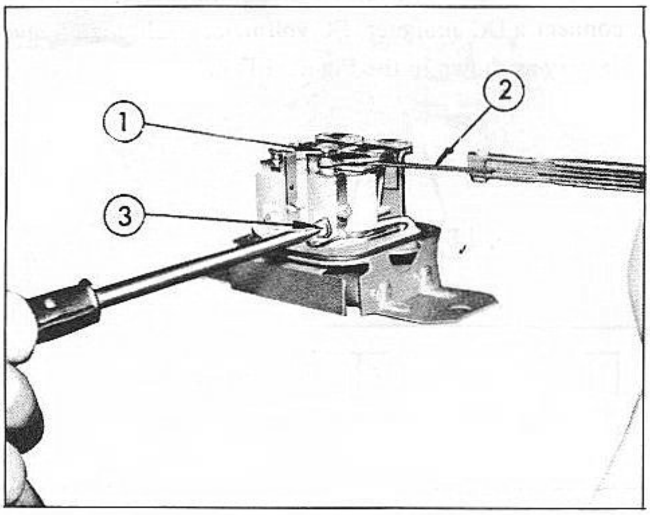


1	Point gap	9	Spring
2	Lower contact	10	Locknut
3	Armature	11	Adjusting screw
4	Upper contact	12	Yoke
5	Contact set	13	Spring
6	Screw	14	Yoke gap
7	Screw	15	Core gap
8	Coil		

Fig. EE-105 Voltage regulator

(1) Adjusting core gap

Loosen the screws holding the contacts to the yoke, adjusting the core gap to 0.6 to 1.0 (0.024 to 0.039 in) as indicated by thickness gauge.

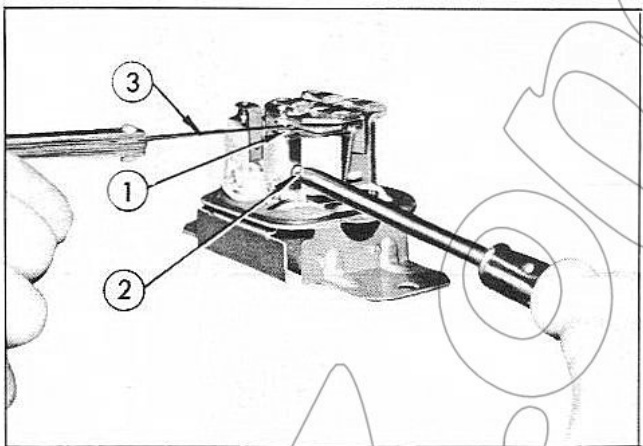


1	Contacts	2	Thickness gauge	3	Screw

Fig. EE-106 Adjusting core gap

(2) Adjusting point gap

Loosen the screws holding the upper contact. Move the upper contact up or down to obtain a gap of 0.35 to 0.45 mm (0.014 to 0.018 in) as indicated by thickness gauge.

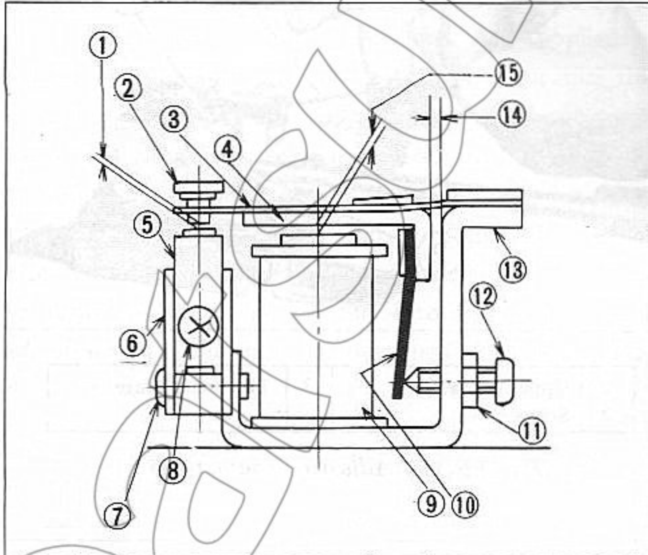


1 2	Upper contact Screw	3	Thickness gauge

Fig. EE-107 Adjusting contact gap

2. Charge relay

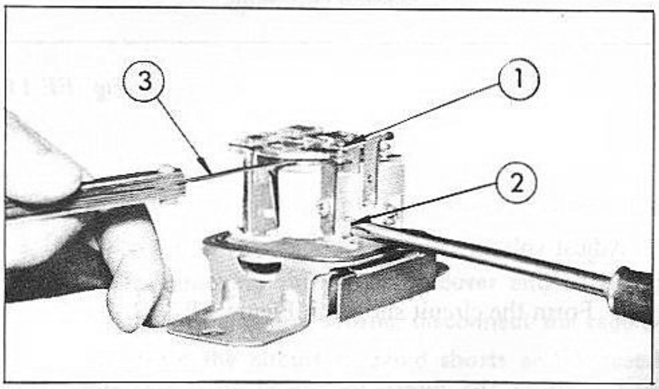
Measure the gaps. If measured values are not as specified, adjust in the order of core gap and contact gap. The procedure is the same as that for the voltage regulator. Yoke gap adjustment is unnecessary as the gap is fixed to 0.9 mm (0.035 in).



1	Point gap	9	Coil
2	Charge relay contact	10	Spring
3	Spring	11	Lock nut
4	Armature	12	Adjusting nut
5	Voltage regulator contact	13	Yoke
6	Contact set	14	Yoke gap
7	Screw	15	Core gap
8	Screw		

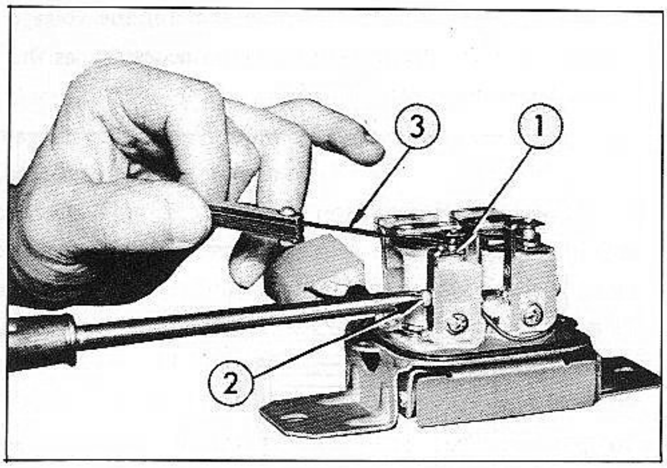
Fig. EE-108 Charge relay

Charge relay	Gap mm (in)
Yoke gap	[0.9 (0.035)] Fixed
Core gap	0.8 to 1.0 (0.031 to 0.039)
Contact gap	0.4 to 0.6 (0.012 to 0.016)



1 2	Contacts Thickness gauge	3	Screw

Fig. EE-109 Adjusting core gap



1 2	Upper contact Screw	3	Thickness gauge

Fig. EE-110 Adjusting contact gap

Performance test

Performance test procedure

Combine the regulator with a normal alternator and connect a DC ammeter, DC voltmeter, tachometer, and battery as shown in the Figure EE-111.

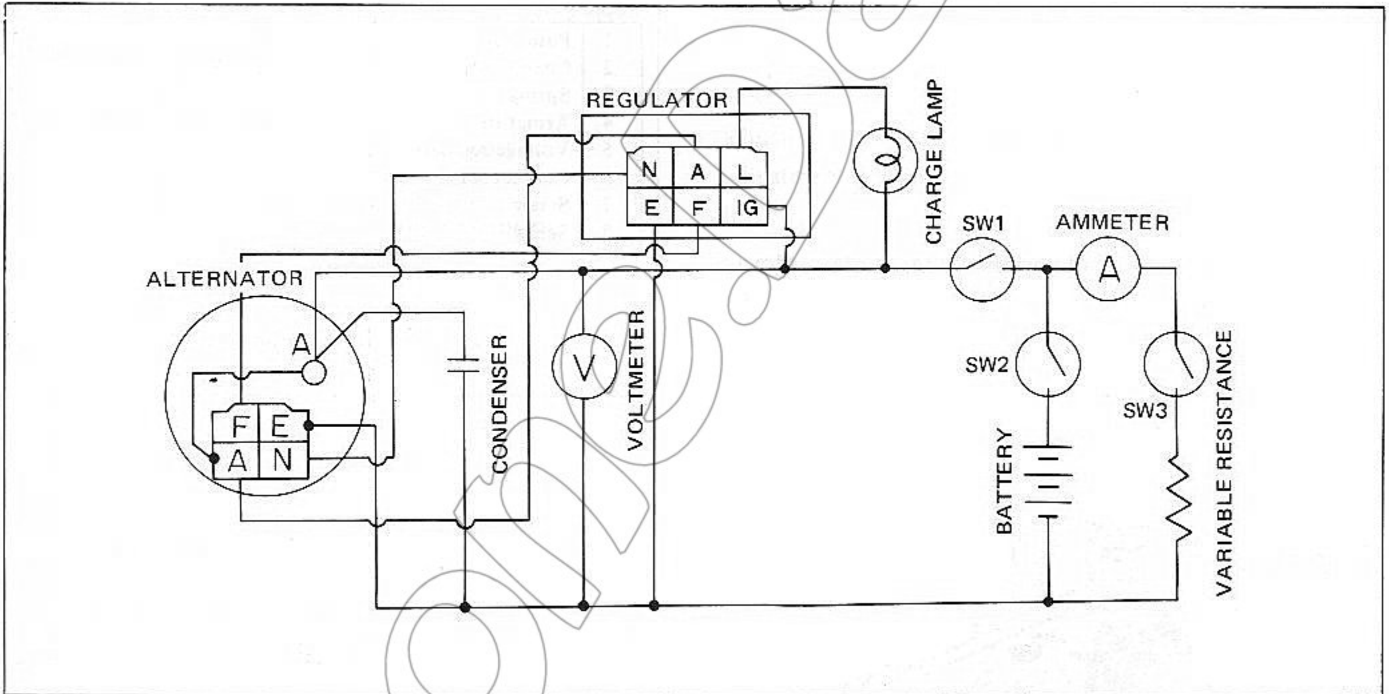


Fig. EE-111 Connections

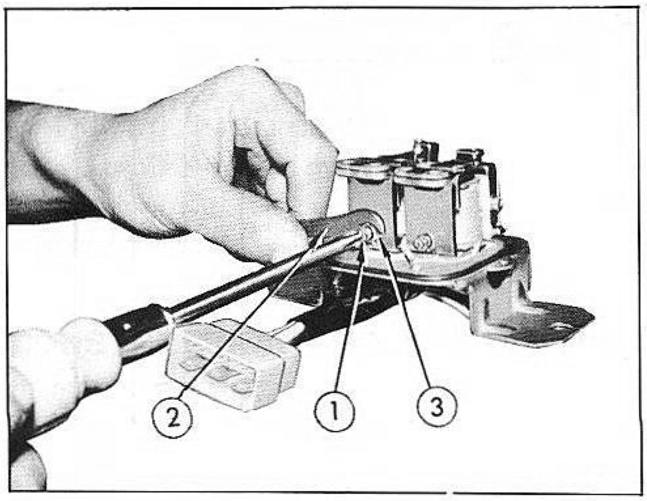
Adjust voltage

Form the circuit shown in Figure EE-112.

1. Bring the alternator speed to 2,500 rpm. The voltmeter indication at this time is the adjust voltage.

2. When the adjust voltage is not within 13.8 to 14.8V, adjust in accordance with the following.

When the voltage is high, loosen the lock nut and turn in the adjusting screw. Reverse this procedure when the voltage is low. Retighten the lock nut upon completion of adjustment.



1	Adjusting screw	3	Lock nut
2	Wrench		

Fig. EE-112

The difference between the voltage at which the lower contact operates and that at which the upper contact operates should be such that a rise of zero to 0.5 V is realized as shown in Figure EE-113. When the difference is more than 0.5 V (less than 0 V), the core gap should be made smaller (larger).

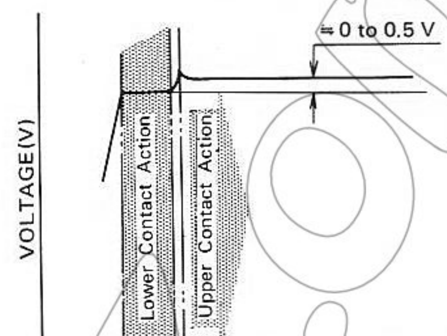


Fig. EE-113

Charge relay

The operating voltage of the charge relay is 8 to 10 V at terminal A of the alternator, but is actually 4 to 5 V as only half of the voltage at terminal A is applied to terminal N shown in the Figure EE-114 to measure this operating voltage. Make the resistance of the rheostat maximum, close the switch, and slowly decrease the resistance. As the resistance is decreased a point at which the charge lamp goes out will be found. This point represents the operating voltage of the charge relay. If the operating voltage is not in the 4 to 5 V range, make adjustment in the manner described for the voltage regulator.

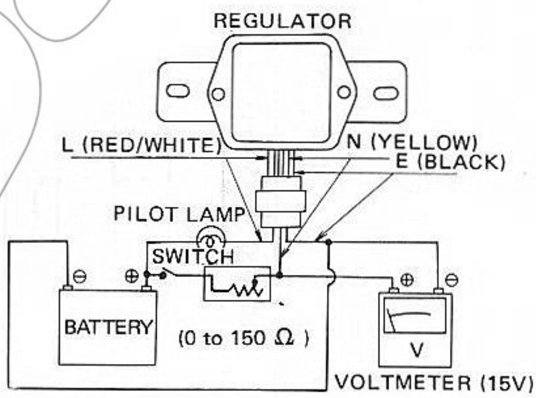


Fig. EE-114 Circuit for measuring charge relay operating voltage

Note: a. After completion of adjustment, replace the cover and recheck operation.

b. In removing the regulator cover and changing the adjusting screw setting, disconnect the regulator from the circuit to avoid shorts and proceed with the check.

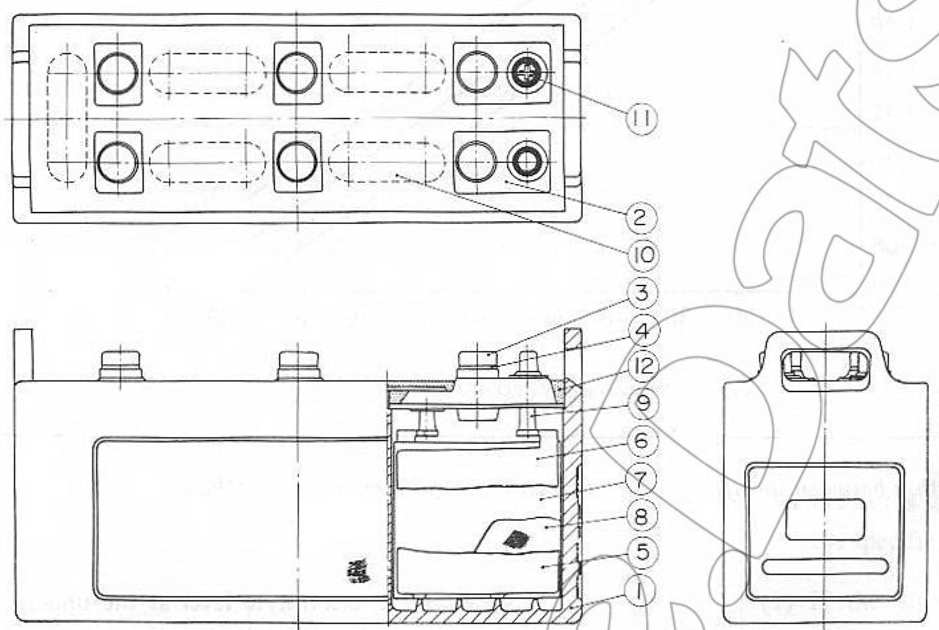
SPECIFICATIONS AND SERVICE DATA

				LT140-91	LT150-04	LT125-16	LT135-22	LT135-24
Alternator	Model			LT140-91	LT150-04	LT125-16	LT135-22	LT135-24
	Vehicle and Fork lift model			330		C240, 140	FD104, FD105	FD106, FD107
	Nominal rating		V-A	12-40	12-50	12-25	12-35	12-35
	Ground polarity			Negative				
	Minimum revolution under no load (when 14 volts are applied)		rpm	Less than 1,000			Less than 1,040	
	Output current		A/rpm	40/5,000	50/5,000	25/5,000	35/5,000	
	Pulley ratio			1.73				1.77
	Brush	Wear limit	mm (in)	7.5 (0.295)				
		Spring pressure	kg (lb)	0.3 (0.66)				
	Slip ring	Outer diameter	mm (in)	More than 31 (1.22)				
		Deflection repair limit	mm (in)	0.3 (0.012)				
Regulator	Model			TLIZ-61B			TLIZ-71B	
Regulator – Voltage regulator	Regulating voltage		V	13.8 to 14.8 at 20°C (68°F)				
	Voltage coil resistance		Ω	10.3 at 20°C (68°F)				
	Rotor coil inserting resistance		Ω	10				
	Voltage coil series resistance		Ω	31				
	Smoothing resistance		Ω	40				
	Core gap		mm (in)	0.6 to 1.0 (0.024 to 0.039)				
	Point gap		mm (in)	0.35 to 0.45 (0.014 to 0.018)				
Regulator – Charge relay	Release voltage		V	4.2 to 5.2 at "N" terminal				
	Voltage coil resistance		Ω	31.9 at 20°C (68°F)				
	Core gap		mm (in)	0.8 to 1.0 (0.031 to 0.039)				
	Point gap		mm (in)	0.4 to 0.6 (0.016 to 0.024)				

BATTERY

CONTENTS

CONSTRUCTION AND OPERATION



1	Battery tank
2	Cover
3	Fluid port plug
4	Fluid port packing
5	Anode plate
6	Cathode plate
7	Separator
8	Glass mat
9	Pole
10	Connection box
11	Terminal
12	Port sealing compound

Fig. EE-115 Structural view

As shown in Figure EE-115, the battery consists of cathode plates, anode plates, separators, electrolyte, and battery jar. The anode plates and cathode plates are arranged alternately with a separator between each anode plate and cathode plate. There is one more cathode plate than anode plates. In addition, a glass mat is applied to protect each side of the anode plates. A battery jar containing a set of plates in referred to a "cell" (single battery). In a 12 V battery, for example, there are six cells connected in series with a(+) terminal on one end and a(-) terminal on the other end.

Battery capacity is usually given in "AH" (Ampere hours), which represents the electric energy discharge rate up to a specified final voltage:

Capacity (AH) = Discharge Current (A) × Discharge Hours (H). Battery capacity changes in relation to discharge rate (Discharge current).

"Such-and-such Ampere hours" should usually be used in referring to battery capacity. "20 hour-rate, 100 AH", for example, indicates that when discharged for 20 hours, the capacity of this battery is 100 AH, or more specifically, the battery can be discharged at the rate of 5 Amperes for 20 consecutive hours.

Checking the amount of charge (Discharge)

Checking specific gravity

As the battery discharges, the specific gravity of the electrolyte drops proportionately to the amount of discharge. Therefore, it is possible to check the discharge condition of a battery by measuring the specific gravity of the battery electrolyte. Moreover, through this measurement it is also possible, where necessary, to determine how much electrical power remains in the battery.

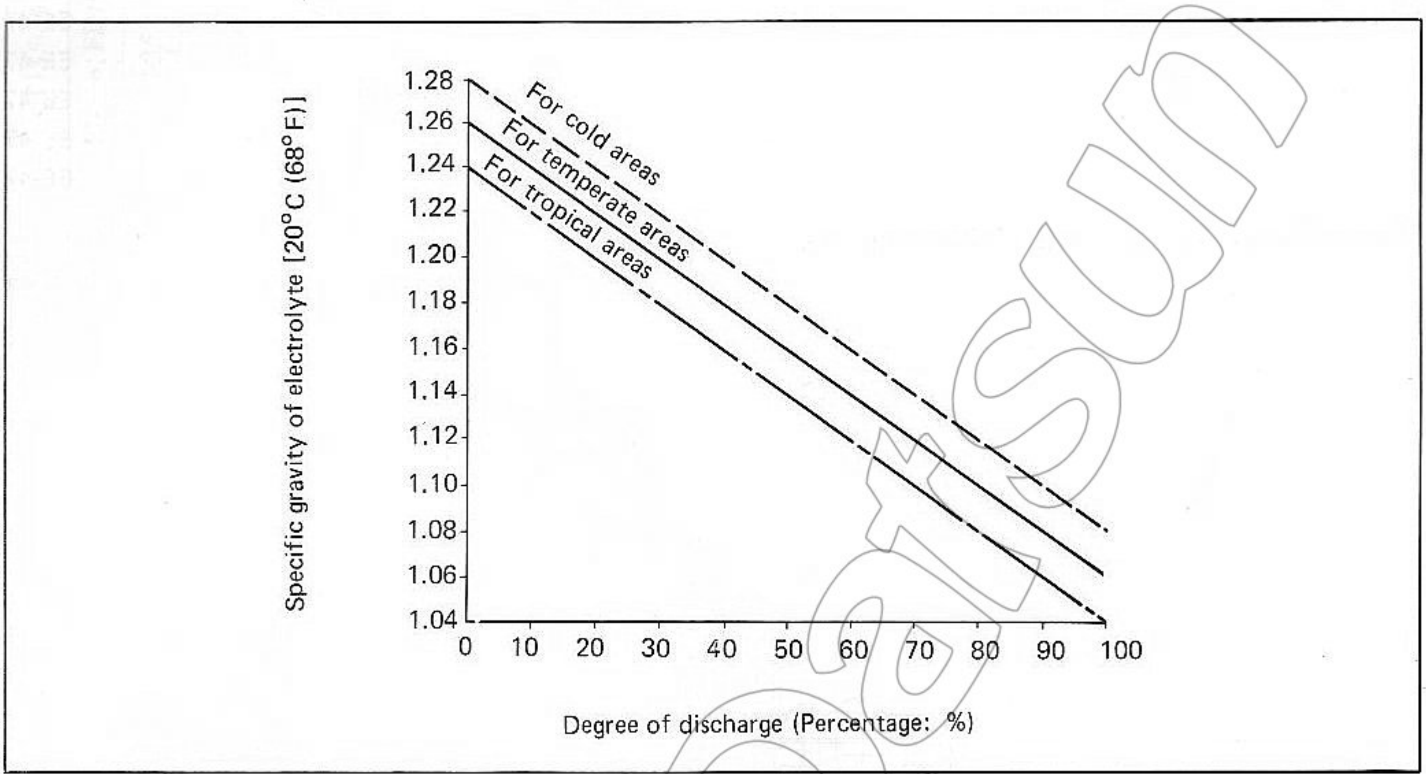


Fig. EE-116 Proportion between specific gravity of electrolyte and amount of discharge

1. Measuring specific gravity

A syringe hydrometer is required to measure the specific gravity of the electrolyte as shown in Figure EE-116. Place the syringe hydrometer so that the glass tube is upright and, by suction, slowly draw electrolyte up into the tube.

Measure the electrolyte level at the upper surface (A), raised on the side of the glass tube by surface tension, and read the scale float floating freely within the tube at the proper specific gravity level. In reading the scale float, your line of sight should be even with the level of the electrolyte. (See Figure EE-117.)

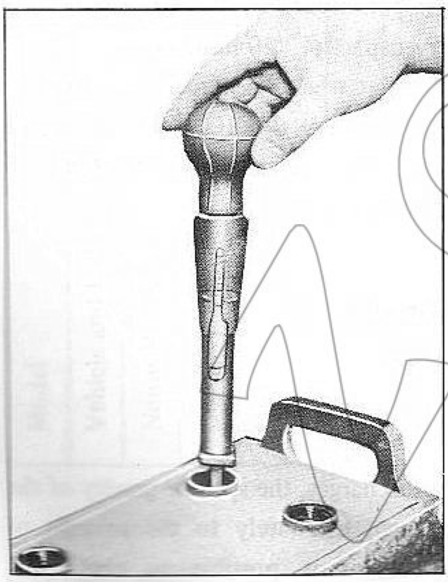
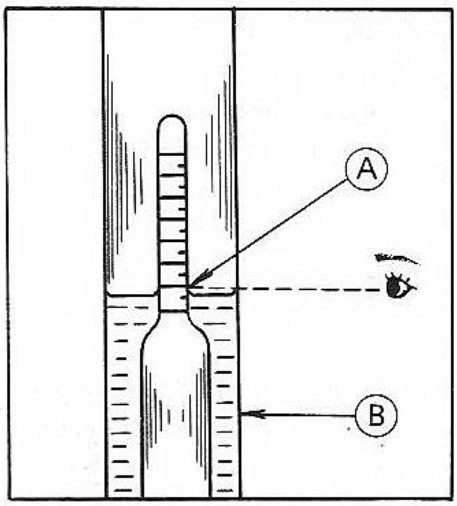


Fig. EE-117 Measuring specific gravity



A	Float
B	Glass tube

Fig. EE-118 Reading the hydrometer

2. Change in specific gravity due to temperature change

The specific gravity of dilute sulfuric acid used as battery electrolyte changes depending upon its temperature. Standard electrolyte measurement is based upon a temperature of 20° C (68° F). To obtain accurate specific gravity measurements, the values obtained from actual measurement should be converted to a value corresponding to standard temperature of 20° C (68° F).

Therefore, the temperature of the electrolyte should also be measured when measuring specific gravity.

Specific gravity changes 0.0007 for every 1° C (1.8° F) change in temperature.

Conversion is as follows:

$$S20 = 0.0007 (t - 20)$$

Where, S20 = Specific gravity of electrolyte at standard temperature (20° C)

St = Specific gravity obtained at t° C

t = Electrolyte temperature (° C) at the time of measurement

3. Determining the amount of charge by specific gravity and corrective action.

Electrolyte Specific Gravity (20° C (68° F))		Charge Condition	Corrective Action
1.	1.290 or more	Specific gravity is too high	Adjust the specific gravity while charging (1) No correction is required if the variation in specific gravity among the tank is less than 0.015
2.	1.280 - 1.250	Satisfactory	(2) If the variation exceeds 0.015, apply a high discharge test and if the result of the test is satisfactory, charge and adjust the specific gravity while charging (1) If the electrolyte temperature is low, charge the battery. If specific gravity is not uniform, adjust it while charging
3.	1.250 - 1.220	Acceptable	(2) Check the operation of the charging circuit (alternator and regulator) and check other electrical equipment for shortcircuit, loose wires, or corrosion
4.	1.220 or less	Unsatisfactory	(1) Charge the battery additionally (2) If the specific gravity is not uniform, adjust it while charging
5.	Specific gravity varies more than 0.025	(A) Tank with low specific-gravity (B) Electrolyte overflows (C) Excess electrolyte or infiltration of water (D) Natural consumption (E) Cracked tank	(1) Charge the battery until voltage and specific gravity remain constant for 2 hours or longer (2) Adjust specific gravity to 1.275 to 1.285 while charging to tanks. (3) Let the battery sit for 12-96 hours and apply a high rate discharge test (4) If the voltage between the tanks still varies, replace the battery more than 0.15 V with new one.

Checking the battery with voltage

1. Measuring with a voltmeter

The drop in voltage due to discharge of the battery is as shown in Figure EE-118. As shown in the figure, there is a sudden drop in voltage at the initial phase of discharge.

Voltage becomes stable, however, before it reaches final voltage. Since voltage variation for each cell is within 2.1 to 1.75 V, it is extremely difficult to ascertain the exact condition of the battery except at full discharge. In any case when the total voltage of the battery is less than 12 V, an additional charge is required.

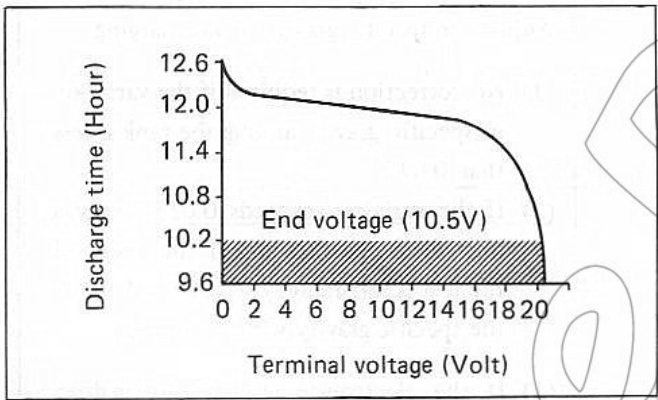


Fig. EE-119 Discharge characteristic curve

2. Measuring with an Ex-cell tester

This method of measurement is based on determination of the extent of drop in voltage resulting from application of a strong discharge current. Attach one of the two tester arms to each end of the single battery cell (Connection box. For batteries with imbedded connection boxes, insert the tester arms into the single cell until they contact the connection boxes). Current flows through the resistance connecting both tester arms. When this occurs, make sure that terminal voltage exceeds 1.90 V. If voltage difference between cells exceeds 0.15 V, check the battery in the manner outlined in the table on page EE-44.

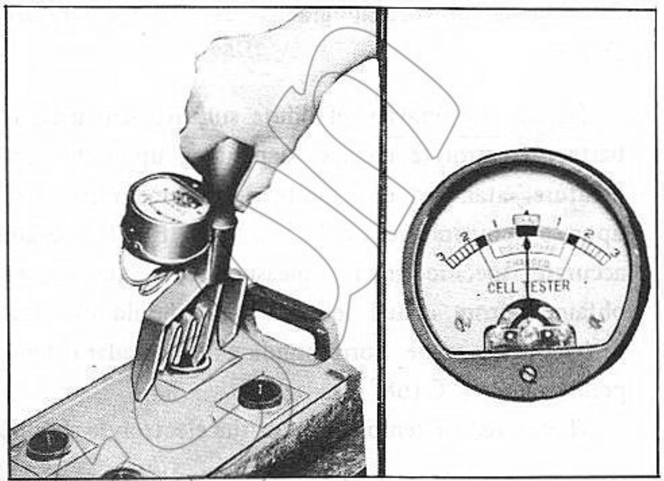


Fig. EE-120 Measurement with an Ex-cell tester

Normal charging

Battery charging can be generally classified into two types: "Initial Charge" and "Re-charge". The former refers to the charge applied for the first time after the new battery has been assembled at the factory prior to delivery and, therefore, does not apply to general repair.

When the discharge rate exceeds the amount of charge provided by the generator during engine operation, the battery gradually discharges and the specific gravity of the electrolyte, therefore, is gradually reduced. To rectify this situation, a regular check on the specific gravity of the electrolyte is required. If the specific gravity has been extensively reduced, the battery should be recharged. A charge should be applied to a battery which is to be used after having not been used for a long period of time. The charge in this case is referred to as "Recharge" or "Regular Charge". Recharging is required if the specific gravity of the electrolyte is less than 1.200 [20° C (68° F)]. The methods of charging that can be applied are: constant-current charge, constant-voltage charge, and quick (booster) charge. The constant-current charge is the most popular of these methods.

Preparation

1. After dismounting the battery from the vehicle, thoroughly clean and dry the outside of the battery. (Use fresh clean water)

2. Adjust the electrolyte to the prescribed level

Check to make sure that the electrolyte level in each cell is at the prescribed height (10 to 13 mm (0.3937 to 0.5118 in) above the plates. If the electrolyte level is low, add distilled water.

3. Connect a charger to the battery

Any regular charger such as a selenium rectifier, tungar rectifier, or mercury-arc rectifier should be provided. Make sure that the battery is connected to the charger correctly: the (+) terminal of the battery should be connected to the (+) terminal of the charger, and the (-) terminal of the battery to the (-) terminal of the charger. When charging several batteries at one time, they should be connected in series as shown in Figure EE-120.

Note: a. It should be noted that if the battery and charger connections are reversed, current flows in the reverse direction, and the battery is over-discharged and change in polarization (charging the anode plate to cathode plate or vice-versa). When reverse current has been applied for only a short time, the reduced charge in the battery may be recovered by correct charging. Frequent application of reverse current may, however, shorten the service life of the battery.

b. Be sure to leave the electrolyte port plugs off while charging.

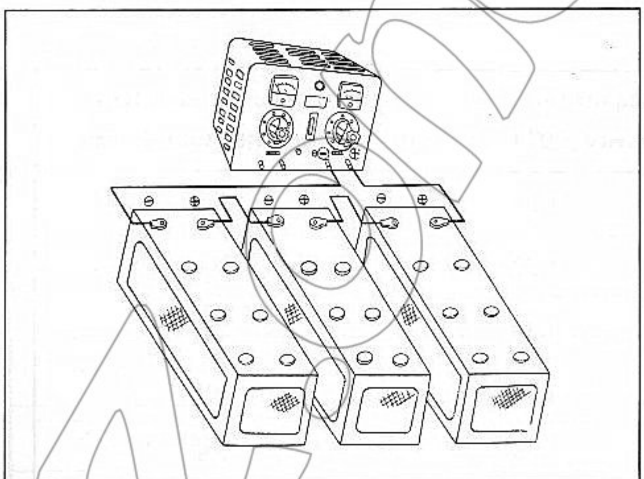


Fig. EE-121 Charging battery

Precautions during charging

1. Be careful to loose the plugs while charging the battery.

2. Proper ventilation should be provided when charging, especially during the final stages of charging when a large amount of gas is produced. Keep fire away from the battery. If the gas (oxygen and hydrogen gas mixture) happens to catch fire, the battery may be damaged.

3. Make sure that the temperature of the electrolyte does not rise above 45° C (113° F). If there is a danger of excessive temperature rise, reduce the current for a short time, or temporarily stop charging until the temperature of the electrolyte is reduced, then start charging again.

4. If the electrolyte level drops, add distilled water to the electrolyte.

Charging

1. Constant-current charge

This method of charging by applying constant-end current is the most widely used of all charging methods.

Charging is accomplished using a charging current equivalent to 1/10 of the 20-hour capacity rate of the battery. The charge should be applied continuously until the terminal voltage and specific gravity of the electrolyte both reach their respective maximum values (checked every 30 minutes), with constant terminal voltage and electrolyte specific gravity maintained during three consecutive checking periods. In the final charging stages, the voltage in each cell reaches 2.5 to 2.7 V and the specific gravity of the electrolyte reaches 1.270 to 1.290 at 20° C (68° F).

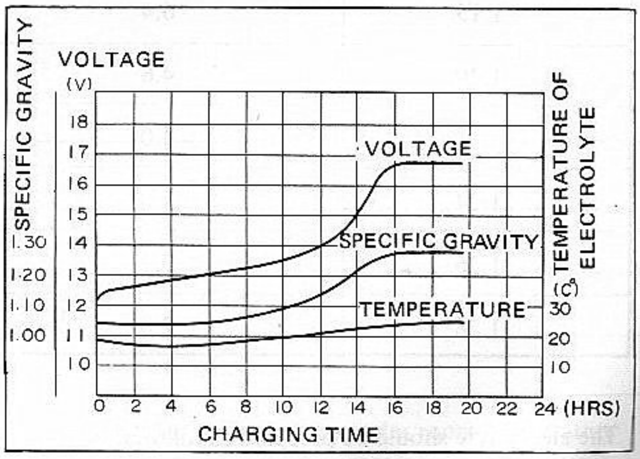


Fig. EE-122 Constant-current charge characteristics

If the specific gravity measured after charging is higher than that prescribed, add distilled water to adjust specific gravity. If the difference in specific gravity between cells exceeds 0.015, continue the charge, and adjust specific gravity of the electrolyte in each cell to the prescribed value while charging. When distilled water or sulfuric acid has been added, be sure that the battery is charged for at least 30 more minutes so that the newly added water or sulfuric acid is well circulated. (Refer to the section on "Electrolyte Composition".)

2. Constant-voltage charge

In this method, charging is accomplished by maintaining the voltage of the charger at a constant value higher than the voltage of the battery. A large initial current is applied which is gradually reduced as the amount of charge in the battery increases.

The rate of reduction in the current depends upon the characteristics of the charger and the condition of the battery. Charging voltage is applied at a rate of 2.3 to 2.4 V (constant voltage). If the specific gravity is adjusted upon completion of constant-voltage charge, the constant-current charge must be repeated.

3. Quick charge (Booster charge)

This charging method is one in which a comparatively large current is applied within a very short time to charge a battery which has been discharged. A quick charger is applied.

Quick charging should be applied only in an emergency under proper supervision. Daily use of the quick charge method may adversely affect the battery. Moreover, it should be noted that quick (booster) charging results in a more pronounced rise in temperature of the electrolyte than does a regular charge. When charging the battery while it is mounted, remove the AC generator or battery (+) terminal before beginning the charge.

Electrolyte composition

To adjust the specific gravity of the electrolyte after charging, drain a portion of the electrolyte and add distilled water (to lower the specific gravity) or dilute sulfuric acid (to raise the specific gravity) to adjust the specific gravity of the electrolyte to the prescribed value.

The amount of water or sulfuric acid added should be equal to the amount of electrolyte removed. A dilute sulfuric acid having a specific gravity of less than 1.40 (and distilled water) should be provided. However, if dilute sulfuric acid having the prescribed specific gravity is not available, prepare an electrolyte from refined, concentrated sulfuric acid (Specific gravity: 1.838 to 1.840 in accordance with the mixing ratio shown in the following table:

Required specific gravity (20° C (68° F))	Ratio of distilled water to concentrated sulfuric acid	Required specific gravity (20° C (68° F))	Ratio of distilled water to concentrated sulfuric acid
1.15	6.4	1.30	2.6
1.20	4.6	1.32	2.4
1.22	4.0	1.34	2.2
1.24	3.6	1.36	1.9
1.26	3.2	1.38	1.8
1.28	2.8	1.40	1.7

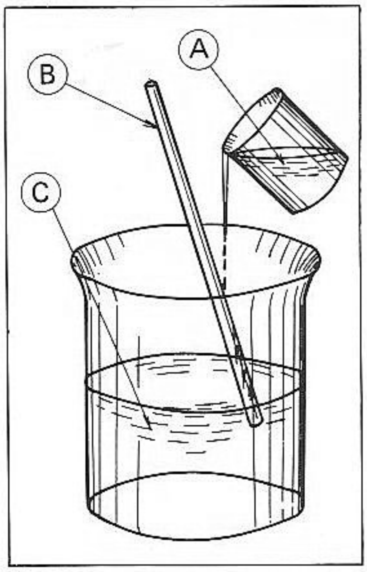
The electrolyte should be prepared as follows:

1. Prepare a sulfuric acid-proof receptacle made of glass, porcelain, lead-plated material, or ebonite.

2. Procedure

Pour distilled water into the receptacle and add concentrated sulfuric acid little by little while stirring.

Note: Be sure to add sulfuric acid to distilled water. In every case, do not add distilled water to sulfuric acid. This results in excessive heat and may result in damage or injury.



A	Concentrated sulfuric acid
B	Glass bar
C	Distilled water

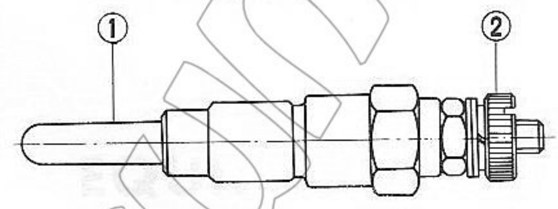
Fig. EE-123 Composing eletrolyte

GLOW PLUGS

Specifications

Type: Rotor type

Construction and operation



1	Heating body	2	Terminal

Fig. EE-124 Construction

The glow plugs are located on the right side of the cylinder head. By energizing the glow plugs prior to attempting to start the engine, the heat coils become red hot, thereby preheating the combustion chambers.

Inspection

Visual

Visually check the glow plugs, replacing those exhibiting defects.

Resistance

Measure glow plug resistance, replacing those which do not have resistance within 1.45 to 1.75Ω.

Specifications

Type	Sheathed type
Rated voltage (V)	10.5
Rated current (A)	6.5
Method of connection	Parallel
Temperature rise vs time	Twenty seconds to reach 800° C (1,472° F) under room temperature of 20° C (68° F)