

ENGINE

Engine Electrical

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Service Precautions

General Procedure

When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Battery

General Description

There are six battery fluid caps at the top of the battery.

Diagnosis

Visual Inspection

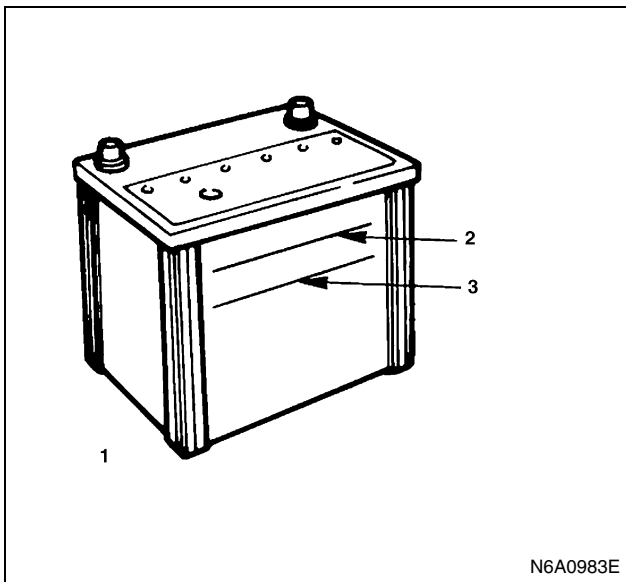
Inspect the battery for obvious physical damage, such as a cracked or broken case, which would permit electrolyte loss.

Replace the battery if obvious physical damage is discovered during inspection.

Check for any other physical damage and correct it as necessary.

Fluid Level Check

The fluid level should be between the upper level line and lower level line on side of the battery.



Legend

1. Battery
2. Upper Level
3. Lower Level

Voltage Check

1. Put voltmeter test leads to battery terminals.
 - a. VOLTAGE IS 12.4V OR ABOVE - Go to "Load Test".
 - b. VOLTAGE IS UNDER 12.4V - Go to procedure 2 below.
2. Determine fast charge amperage from specification.
Fast charge battery for 30 minutes at amperage rate no higher than specified value.
Take voltage and amperage readings after charge.
 - a. VOLTAGE IS ABOVE 16V AT BELOW 1/3 OF AMPERAGE RATE - Replace battery.
 - b. VOLTAGE IS ABOVE 16V AT ABOVE 1/3 OF AMPERAGE RATE - Drop charging voltage to 15V and charge for 10 — 15 hours.
Then go to "Load test".
 - c. VOLTAGE IS BETWEEN 12V AND 16V
- Continue charging at the same rate for an additional 3-1/2 hours. Then go to "Load test".
 - d. VOLTAGE IS BELOW 12V - Replace battery.

Load Test

1. Connect a voltmeter and a battery load tester across the battery terminals.
2. Apply 300 ampere load for 15 seconds to remove surface charge from the battery.
Remove load.
3. Wait 15 seconds to let battery recover. Then apply specified load from specifications (See Main Data and Specifications in this section).
Read voltage after 15 seconds, then remove load.
 - 1) VOLTAGE DOES NOT DROP BELOW THE MINIMUM LISTED IN FOLLOWING TABLE
- The battery is good and should be returned to service.
 - 2) VOLTAGE IS LESS THAN MINIMUM LISTED
- Replace battery.

ESTIMATED TEMPERATURE		MINIMUM VOLTAGE
°F	°C	
70	21	9.6
60	16	9.5
50	10	9.4
40	4	9.3
30	- 1	9.1
20	- 7	8.9
10	- 12	8.7
0	- 18	8.5

The battery temperature must be estimated by feel and by the temperature the battery has been exposed to for the preceding few hours.

On-vehicle Service

Battery Charging

Observe the following safety precautions when charging the battery:

1. Never attempt to charge the battery when the fluid level is below the lower level line on the side of the battery.
In this case, the battery must be replaced.

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2. Pay close attention to the battery during the charging procedure.
Battery charging should be discontinued or the rate of charge reduced if the battery feels hot to the touch.
Battery charging should be discontinued or the rate of charge reduced if the battery begins to gas or spew electrolyte from the vent holes.
3. Battery temperature can have a great effect on battery charging capacity.
4. The sealed battery used on this vehicle may be either quick-charged or slow-charged in the same manner as other batteries.
Whichever method you decide to use, be sure that you completely charge the battery. Never partially charge the battery.

Jump Starting

Jump Starting With An Auxiliary (Booster) Battery

Caution:

Never push or to the vehicle in an attempt to start it. Serious damage to the emission system as well as other vehicle parts will result.
Treat both the discharged battery and the booster battery with great care when using jumper cables. Carefully follow the jump starting procedure, being careful at all times to avoid sparking.

WARNING:

FAILURE TO CAREFULLY FOLLOW THE JUMP STARTING PROCEDURE COULD RESULT IN THE FOLLOWING:

1. **SERIOUS PERSONAL INJURY, PARTICULARLY TO YOUR EYES.**
2. **PROPERTY DAMAGE FROM A BATTERY EXPLOSION, BATTERY ACID, OR AN ELECTRICAL FIRE.**
3. **DAMAGE TO THE ELECTRONIC COMPONENTS OF ONE OR BOTH VEHICLES PARTICULARLY.**

Never expose the battery to an open flame or electrical spark. Gas generated by the battery may catch fire or explode.

Remove any rings, watches, or other jewelry before working around the battery. Protect your eyes by wearing an approved set of goggles.

Never allow battery fluid to come in contact with your eyes or skin.

Never allow battery fluid to come in contact with fabrics or painted surfaces.

Battery fluid is a highly corrosive acid.

Should battery fluid come in contact with your eyes, skin, fabric, or a painted surface, immediately and thoroughly rinse the affected area with clean tap water. Never allow metal tools or jumper cables to come in contact with the positive battery terminal, or any other metal surface of the vehicle. This will protect against a short circuit.

Always keep batteries out of the reach of young children.

Jump Starting Procedure

1. Set the vehicle parking brake.
If the vehicle is equipped with an automatic transmission, place the selector lever in the "PARK" position.
If the vehicle is equipped with a manual transmission, place the shift lever in the "NEUTRAL" position.
Turn "OFF" the ignition.
Turn "OFF" all lights and any other accessory requiring electrical power.
2. Look at the built-in hydrometer. (If equipped)
If the indication area of the built-in hydrometer is completely clear, do not try to jump start.
3. Attach the end of one jumper cable to the positive terminal of the booster battery.
Attach the other end of the same cable to the positive terminal of the discharged battery.
Do not allow the vehicles to touch each other.
This will cause a ground connection, effectively neutralizing the charging procedure.
Be sure that the booster battery has a 12 volt rating.
4. Attach one end of the remaining cable to the negative terminal of the booster battery.
Attach the other end of the same cable to a solid engine ground (such as the A/C compressor bracket or the generator mounting bracket) of the vehicle with the discharged battery.
This ground connection must be at least 450 mm (18 in) from the battery of the vehicle whose battery is being charged.

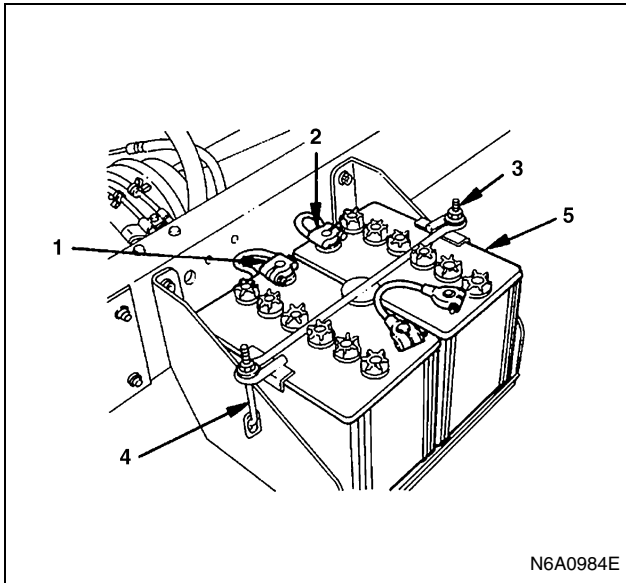
WARNING:

NEVER ATTACH THE END OF THE JUMPER CABLE DIRECTLY TO THE NEGATIVE TERMINAL OF THE DEAD BATTERY.

5. Start the engine of the vehicle with the good battery.
Make sure that all unnecessary electrical accessories have been turned "OFF".
6. Start the engine of the vehicle with the dead battery.
7. To remove the jumper cables, follow the above directions in the reverse order.
Be sure to first disconnect the negative cable from the vehicle with the discharged battery.

Removal

1. Negative cable
2. Positive cable
3. Retainer screw and rods
4. Retainer
5. Battery



Installation

To install the battery, follow the removal procedure in the reverse order, noting the following points:

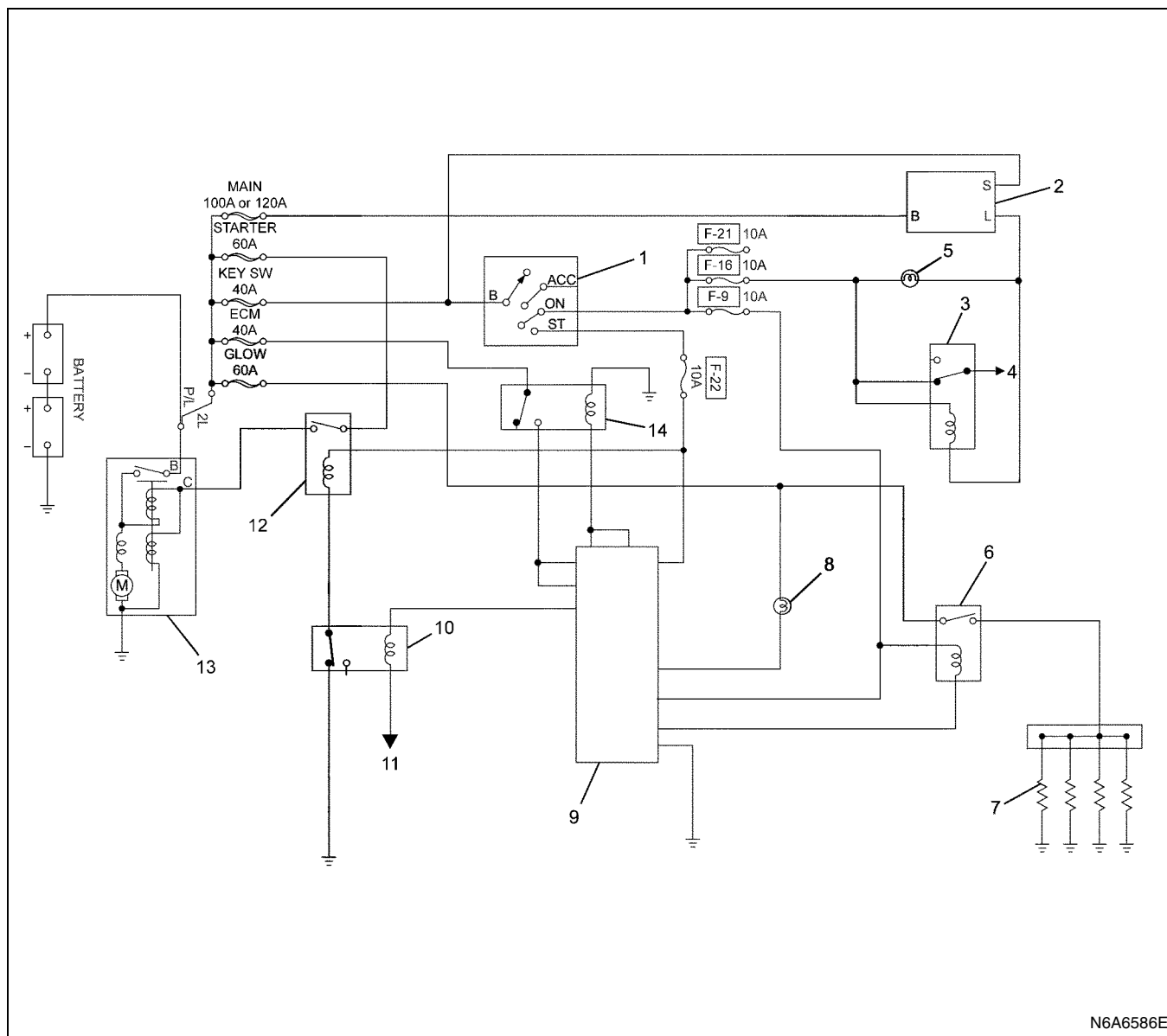
1. Make sure that the rod is hooked on the body side.

Charging System

General Description

The main charging system components are the batteries, the generator and the battery discharge indicator light circuit. The generator is a 110-amp, selfrectifying type with a built-in regulator. The battery discharge indicator light is mounted in the instrument panel. For more details on this circuit, refer to "Meter and Warning/Indicator Lights" in Section 8.

Circuit Diagram



N6A6586E

Legend

- | | |
|-----------------------------------|-------------------------------------|
| 1. Engine Control Switch | 8. Glow Plug Indicator Light |
| 2. Generator (Integral Regulator) | 9. ECM |
| 3. Charge Relay | 10. Starter Cut Relay |
| 4. To Heater and A/C Relay | 11. To Exhaust Brake Solenoid Valve |
| 5. Low Charge Indicator Light | 12. Starter Relay |
| 6. Glow Plug Relay | 13. Starter |
| 7. Glow Plugs | 14. ECM Main Relay |

Maintenance

The most common indication of charging system troubles is an undercharged or overcharged battery. Since the battery itself may be defective, the first step should be to check its condition as described under "Diagnosis of Battery." In the case of an undercharged battery, check for battery drain caused by grounds or by accessories left turned on.

Keep the generator and all other electrical system terminals clean and tight. A loose or badly corroded terminal connection will create excessive resistance in the system and result in hard starting, dim lights etc. Inspect the generator system at regular intervals and correct any potential causes of trouble before vehicle performance is affected.

Diagnosis of Charging System

Trouble in the charging system will be evidenced as one or more of the following three conditions:

1. The battery discharge warning light will stay on.
2. An undercharged battery as evidenced by slow cranking.
3. An overcharge, or overvoltage, condition.

Undercharged Battery

Inspection

1. Accessories to be sure none were left on for extended periods.
2. Drive belt for proper tension. Refer to "Drive Belt" in Section 6B.
3. The ECM main relay has been ON stuck at the ignition switch OFF position. (Battery voltage is consumed.)
4. Battery. Refer to "Diagnosis of Battery" earlier in this section.
5. Wiring and connections for corrosion or looseness.

Overcharge (or Overvoltage) condition

A charging rate in excess of 29.5-volts for a prolonged period may cause early electrical system failure. Blown fuses, light bulbs burned out, and even battery failure may result. If this condition exists, test the generator as described under "Generator Output Tests" later in this section.

Noisy Generator

Inspection

1. Drive pulley for looseness.
 2. Mounting bolts for looseness.
 3. Bearings for dirt, damage, or wear.
- Generator noise may also be caused by worn or damaged diodes and/or starter.

Electrical Tests

Before performing the following generator electrical tests on the vehicle, be certain that the system wiring is not defective and generator belts are not slipping. Also, the battery must be fully charged for a valid test of the charging system.

Notice:

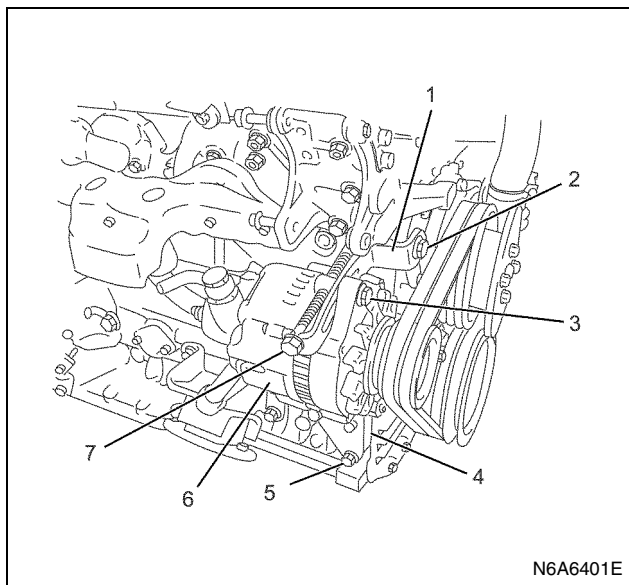
To avoid damage to the vehicle electrical system, always observe the following precautions:

- Do not polarize the generator.
- Do not short across or ground any of the terminals in the charging circuit except as specifically instructed herein.
- NEVER operate the generator with the output terminal open-circuited.
- Be sure the generator and battery have the same ground polarity.
- When connecting a charger or booster battery to the vehicle battery, connect negative to negative and positive to positive.

1. With the engine control switch "ON" and engine not running, connect a voltmeter from terminal "E" to ground. The voltmeter should read zero volts.
2. With the engine control switch "ON" and engine not running, connect a voltmeter from terminal "B" to ground. The voltmeter should read at least 24 volts.
3. With the engine control switch "ON" and the engine not running, connect a voltmeter from white wire side of the connector to ground. The voltmeter should show 24 volts.
4. With the engine control switch "ON" and the engine not running, the "charge" light should be on. This shows that the other circuit in the connection is working.
5. With the engine running and the headlight high beams turned on, read the voltage at the "B" post on the generator. The voltage should be at least 24 volts.
6. If steps 1 through 4 are not OK, check connectors in the harness for looseness or corrosion and retest.
7. If step 5 voltage is low, substitute a known good regulator and test again. If the voltage is still low, bench test the generator.

Generator

Component



Legend

1. Generator Adjusting Bracket
2. Bracket Mounting Bolt
3. Generator Adjusting Nut
4. Generator Bracket
5. Generator Bracket Mounting Bolt
6. Generator
7. Generator Adjusting Bolt (Model equipped with A/C only)

Repair Instruction

Description of Generator

The generator is a 24 volt, 50A or 60A or 80A, model with a solid state regulator mounted to the brush holder. The generator must be disassembled to remove the regulator or brush holder assembly. The generator rotor bearings contain enough grease to eliminate periodic lubrication. Two brushes carry current through two slip rings to the field coil.

The stator windings are assembled on the inside of a laminated core that forms part of the generator frame. A rectifier bridge connected to the stator windings contains six diodes that change the stator AC voltages to a DC voltage.

The vacuum pump is attached to the rear of the generator.

Generator Output Tests

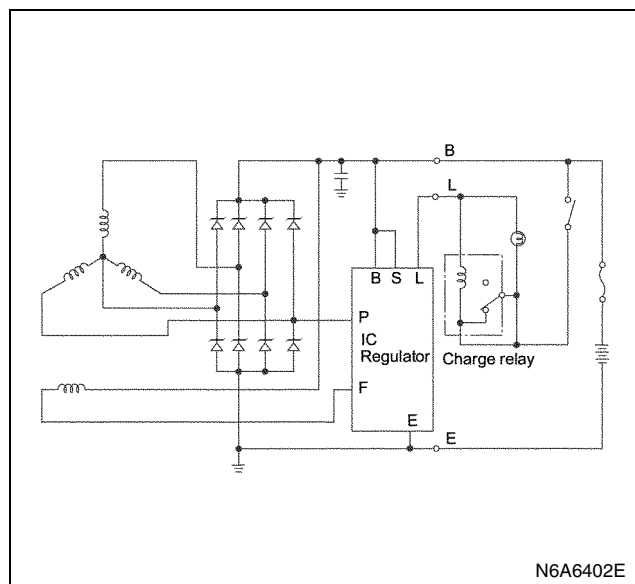
To check the generator in a test stand, proceed as follows:

Important:

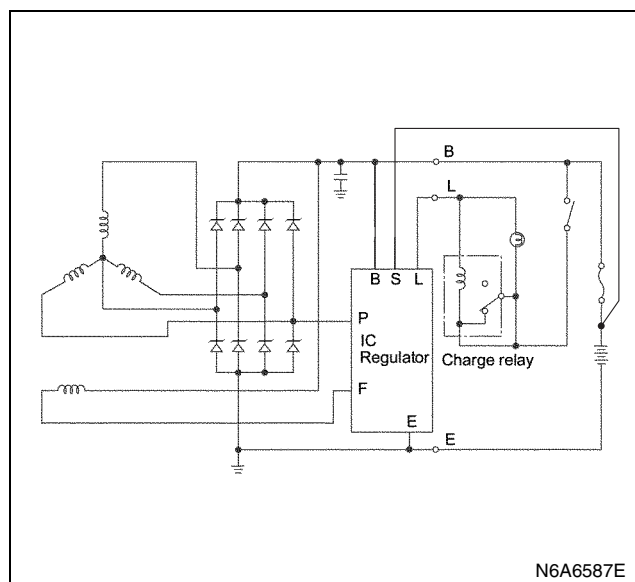
- Use a fully charged battery when performing these tests.

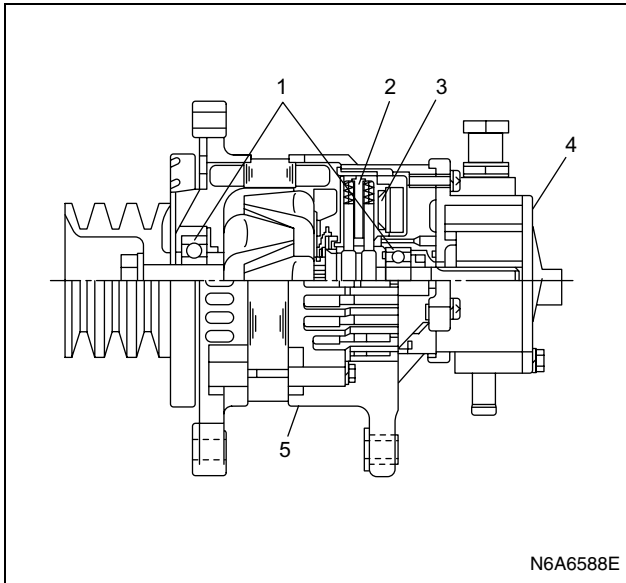
1. Connect an ammeter from the positive (+) battery side to the generator output wire. This is 8 mm (0.032 in) (black) wire. Leave the carbon pile disconnected.
2. Slowly increase the generator speed and observe the voltage meter. If voltage is uncontrolled with speed and increases above 30 volts on a 24-volt system, replace the regulator and check the rotor winding. If the voltage is below 30 volts, connect the carbon pile across the battery.
3. Run the generator at 5,000 RPM and adjust the carbon pile to obtain maximum current output, which should be more than 42A (50A) or 50A (60A) or 75A (80A) at 28 to 29 volts.
4. If the output is not within 10 amperes of the rated output, check the rotor winding, rectifier bridge, and stator as described later under "Inspection" and "Electrical Bench Tests."

50A Model



60A, 80A Model





Legend

1. Ball Bearings
2. Brush Holder
3. Voltage Regulator
4. Vacuum Pump
5. Generator

Notice:

- Before performing the generator output test, inspect all charging system components, wires and terminals for wear or damage. Repair or replace any parts found defective.

Removal

- Disconnect the battery negative cable.
 - Remove the A/C compressor. (Refer to "Engine Assembly" in Section 6A)
1. Electrical wiring at the generator.
 2. Vacuum and oil hoses attached to the rear of the vacuum pump.
 3. Loosen the lower mounting bolts.
 4. Loosen the adjusting nut.
 5. Drive belts.
 6. Adjusting bolts.
 7. Generator.

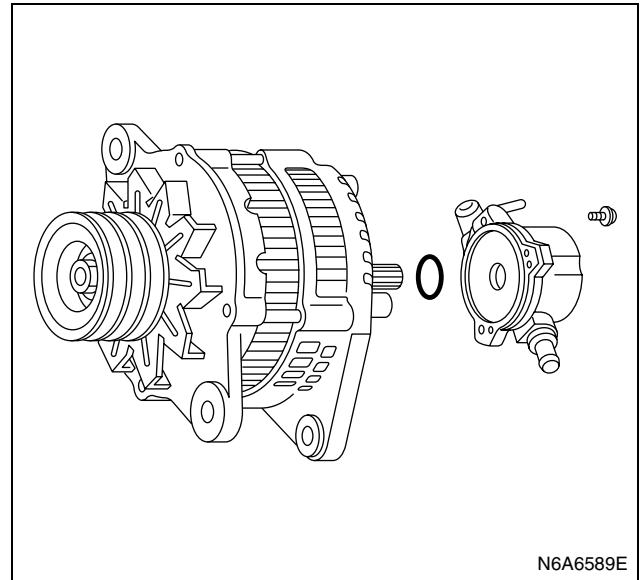
Inspection

- Mount brackets for damage.
- Drive belts for wear or damage.

Disassembly

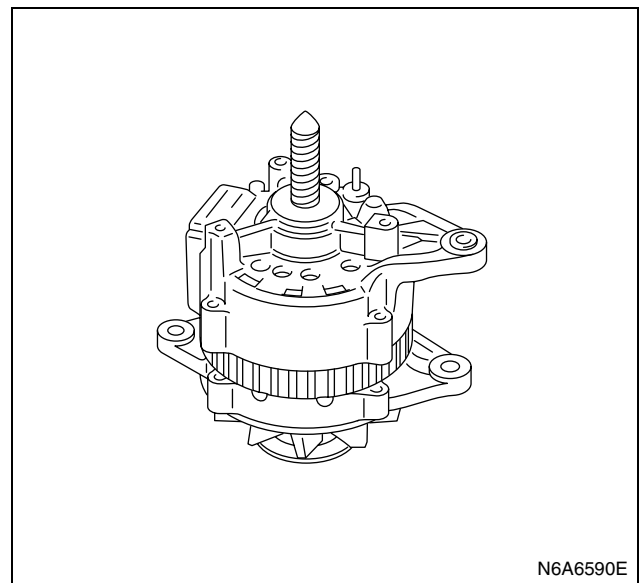
1. Vacuum pump assembly.

- Remove the vacuum pump screws attached to the back of the generator. Remove the vacuum pump in the direction in line with the rotor shaft. Remove the side plate fixing bolts and the side plate, then remove the rotor and vanes.



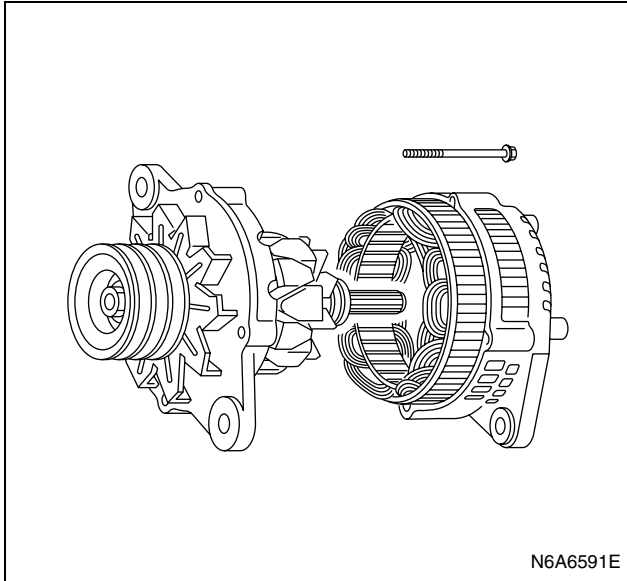
2. Through bolts.

- Tape the rotor shaft splines to prevent accidental damage.



- Separate the front cover assembly from the rear cover assembly. When separating the front and rear cover assemblies, be sure the stator assembly stays seated in the rear cover.

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3. Pulley and rotor assembly.

- Be sure not to damage the oil seal when removing the pulley and rotor assembly from the rear cover assembly.

4. Rear cover and stator assembly.

5. Pulley nut.

- Clamp the rotor assembly in a vise to remove the pulley nut.

6. Pulley.

7. Fan.

8. Spacer.

9. Rotor and rear bearing.

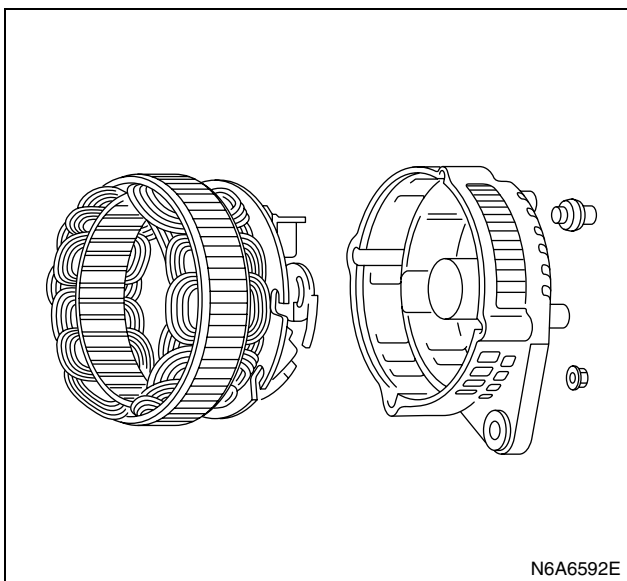
10. Bearing retainer.

11. Front ball bearing.

12. Front cover.

13. Rear cover.

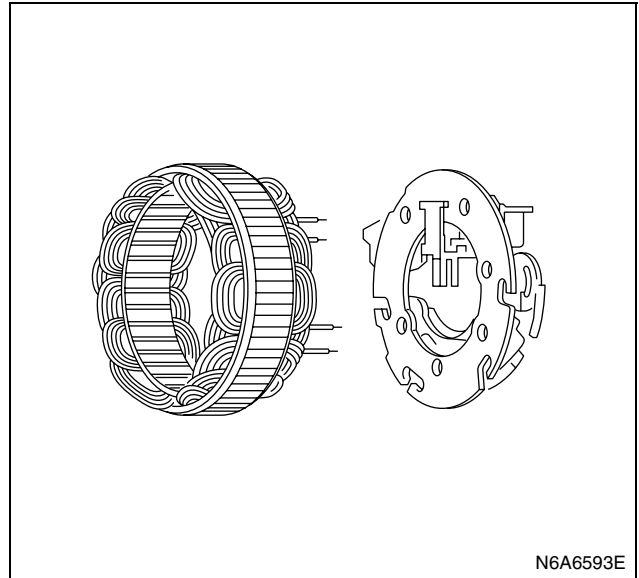
- Remove nuts at the rear cover battery terminal and diode brush regulator assembly.



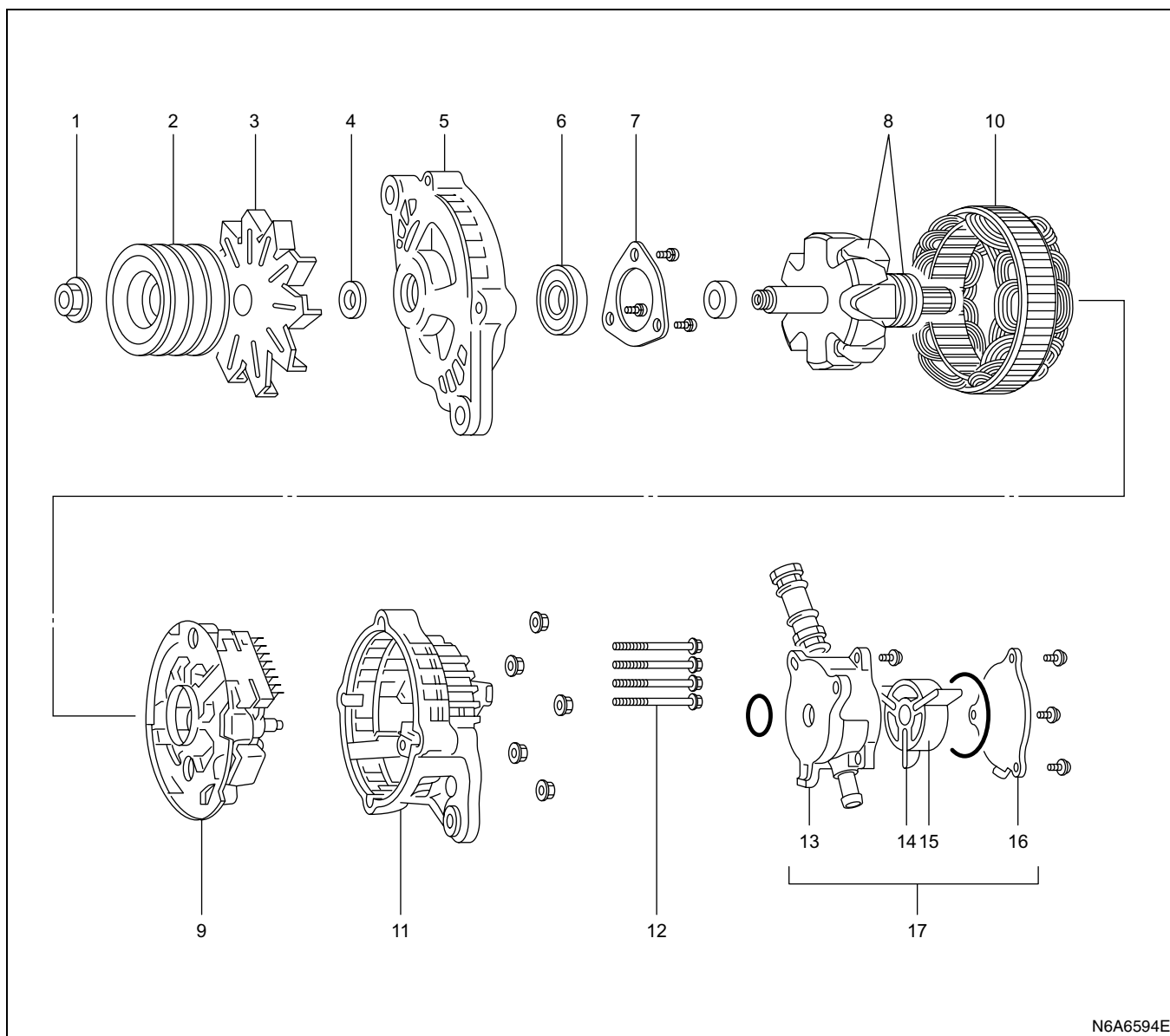
14. Stator and diode brush regulator assembly

15. Diode brush regulator assembly.

- Separate the diode brush regulator assembly from the stator by melting the solder on the stator coils, diodes and N terminal leads. When melting solder, hold the lead wire with long-nose pliers to prevent heat from being transferred to the diodes.



16. Stator.



N6A6594E

Legend

- | | |
|-----------------------------------|--------------------------|
| 1. Nut | 10. Stator |
| 2. Pulley | 11. Rear Cover |
| 3. Fan | 12. Through Bolt |
| 4. Spacer | 13. Housing |
| 5. Front Cover | 14. Vane |
| 6. Front Ball Bearing | 15. Pump Rotor |
| 7. Bearing Retainer | 16. Side Plate |
| 8. Rotor and Rear Bearing | 17. Vacuum Pump Assembly |
| 9. Diode Brush Regulator Assembly | |

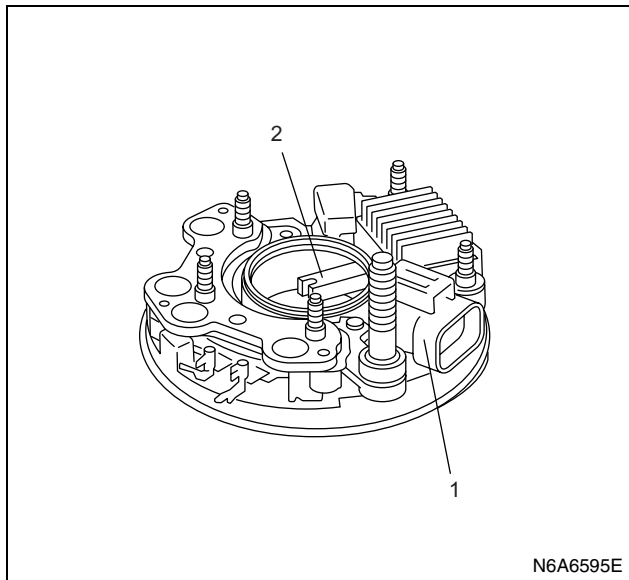
Important:

- Separate the stator and rear cover. Be sure you identify the proper position of the insulated washers to prevent improper installation.

Inspection

- All metal parts except the voltage rectifier bridge, stator, rotor and bearing assemblies in a suitable solvent.

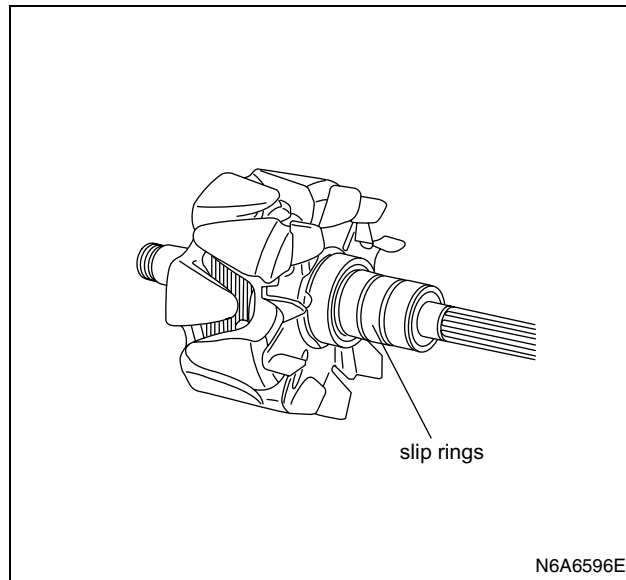
- Wipe or blow the components dry.
- Brush holder and brushes. The brushes have a line that indicates their limit. If the brushes are shorter than 6.5 mm (0.256 in) replace the brushes.



Legend

1. Brush Holder
2. Brushes

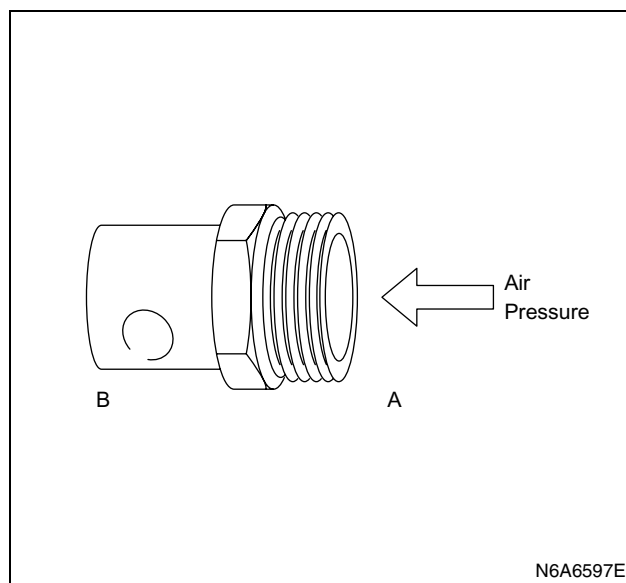
- Voltage regulator for damage or corrosion.
- Bearings and spacer. Rotate the bearing and check for roughness or excessive drag. If in doubt about the bearing, replace it.
- Rotor and stator windings for burned insulation or broken terminal connectors, wires, etc. Burned insulation may appear as very dark or blackened wiring, and sometimes charred paint or a combination of the two. Replace the rotor or stator if the windings are burned.
- Generator frames. Check for distortion, cracks or damage. Replace as necessary.
- Rotor slip rings. If the rings are dirty, clean them with 500–600 grain or finer polishing cloth. Clean the slip rings with rubbing alcohol if the rings are contaminated. Spin the rotor and hold the polishing cloth against the rings until they are clean. Slip rings which are rough, scored, or out-of-round, must be machined in a lathe to 31.7 mm (1.248 in). Finish the slip rings with 500 – 600 grain or finer polishing cloth and blow away all dust particles after the machining process.



- All vacuum pump components for wear, damage or other abnormal conditions.
- Check valve.
 - 1) Carefully force the valve from the “B” side as shown in the illustration. The valve must move smoothly. If it does not, the check valve must be replaced.
 - 2) Apply compressed air to the “A” side.

Air Pressure	kPa (kg/cm ² / psi)
98 – 490 (1 – 5/14 – 71)	

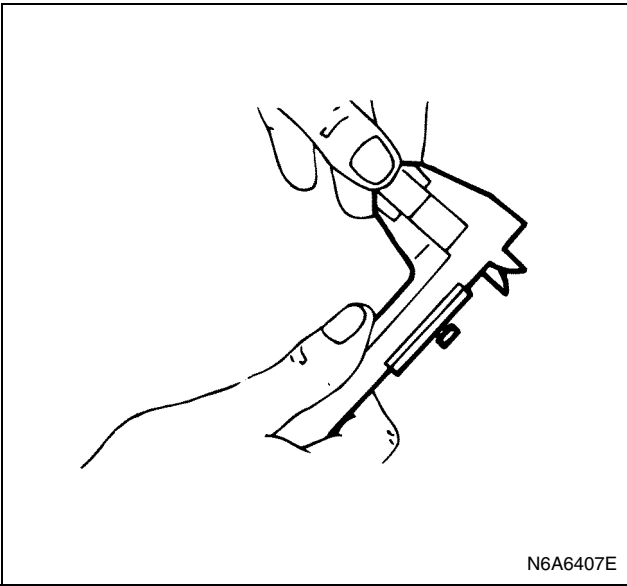
Check for air leakage from the check valve. If there is air leakage, the valve must be replaced.



- Oil seal (O-ring). Check the inner face of the rear cover for traces of oil leakage. Be sure the inner face of the oil seal is not worn or damaged. If worn or damaged, use a screwdriver to remove the oil seal (O-ring) from the rear cover. Install a new oil seal (O-ring) using an oil seal installer or equivalent.

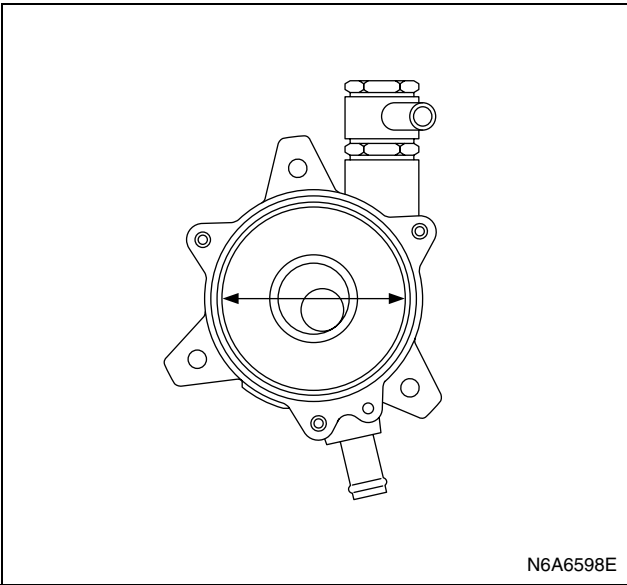
Measure

The length of the vanes	mm (in)
17.0 – 18.0 (0.669 – 0.709)	



Replace the housing if not within these specifications.

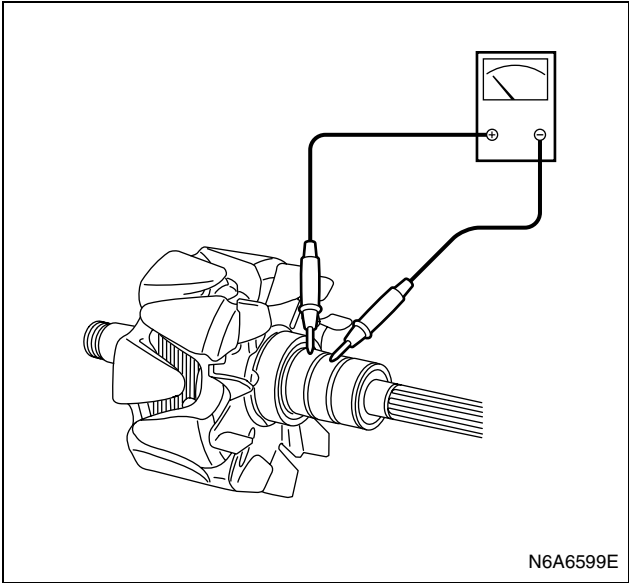
The inside diameter of the vacuum pump housing	mm (in)
69.5 – 69.6 (2.736 – 2.740)	



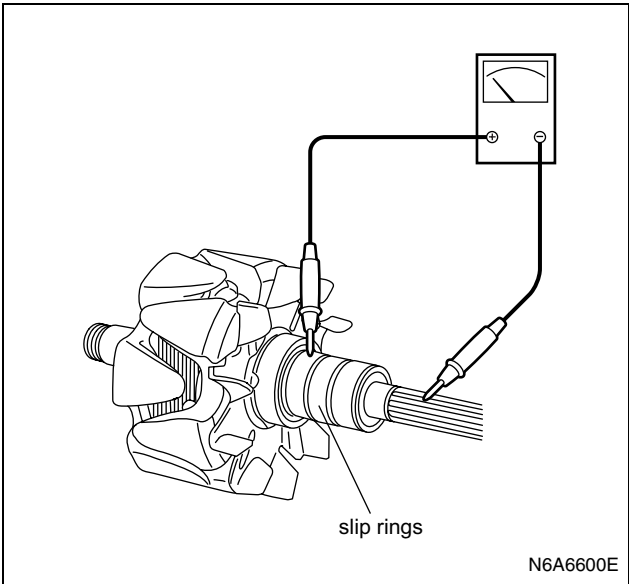
Electrical Bench Tests (Generator)

- Measure the rotor coil resistance.

Rotor Coil Resistance at 20°C (68°F)		ohms
Standard	50A	7.6
	60A	9.2
	80A	10.2



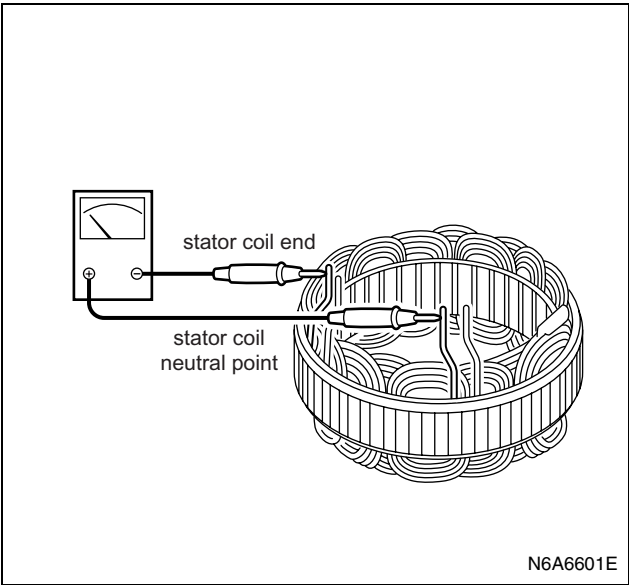
- Check for continuity between the slip rings and the rotor core or shaft. If there is continuity, the entire rotor assembly must be replaced.



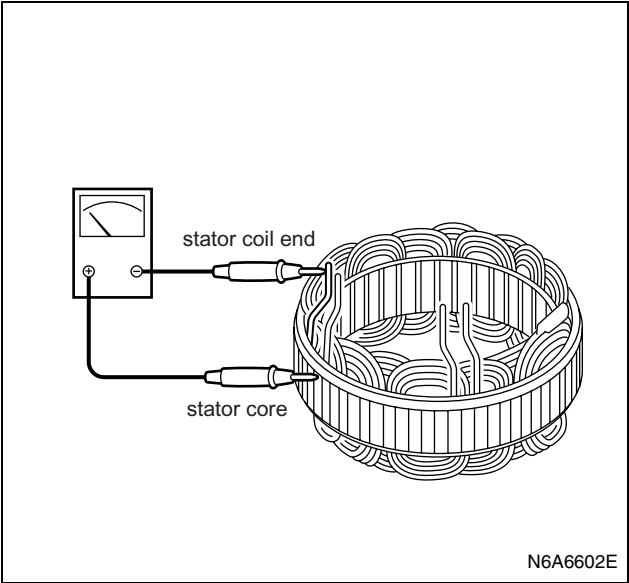
Stator Coil Assembly

- 1. Check for continuity across the stator coils
If there is no continuity, the stator coils must be replaced.

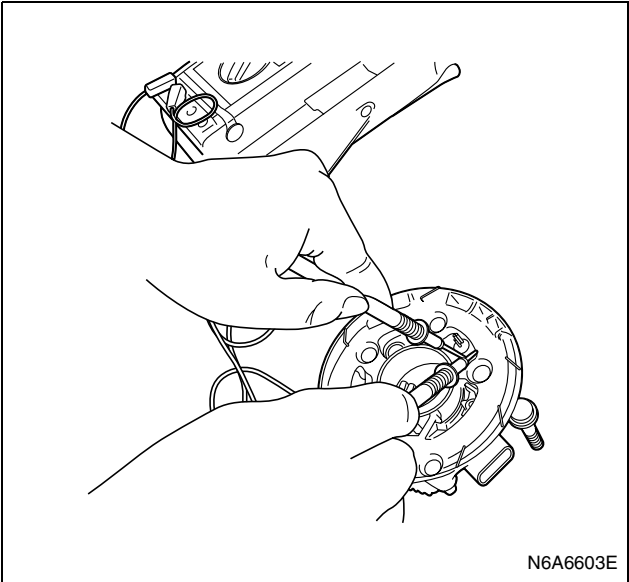
Resistance Between Stator coil neutral point and the Coil Ends (Reference)			mm (in)
Standard	50A		0.195
	60A		0.137
	80A		0.073



- 2. Check for continuity between each stator coil end and the stator core.
If there is continuity, the stator coils must be replaced.

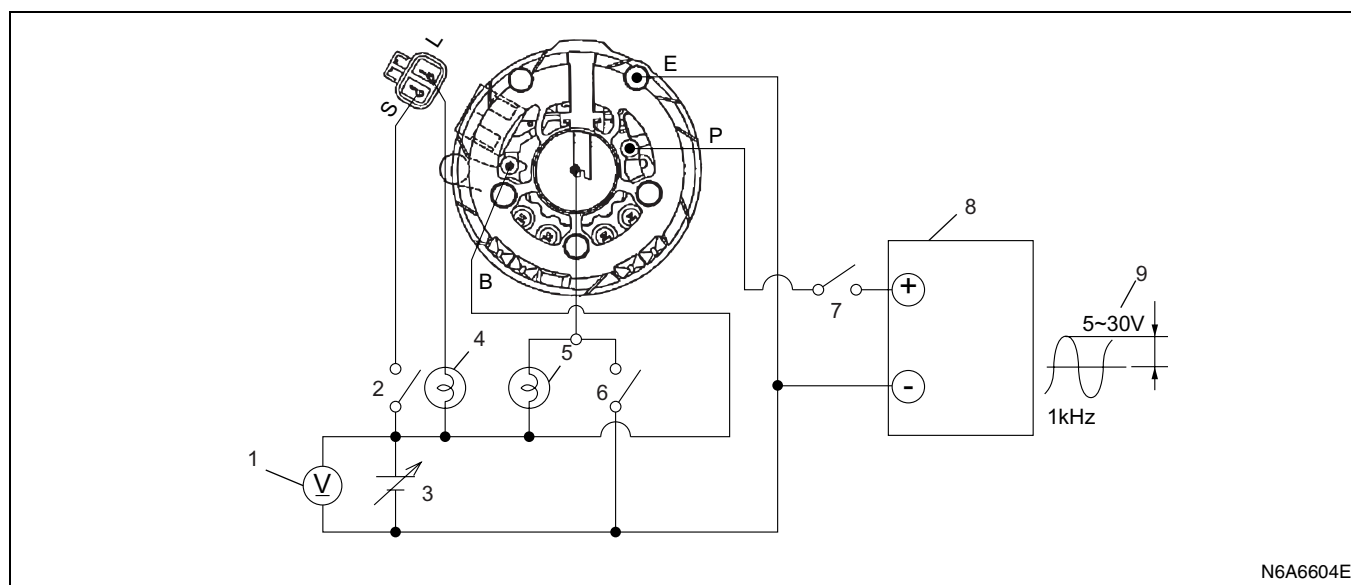


Rectifier



Tester wire					
E	+	-	BAT	+	-
U, V, and WN			U, V, and WN		
+	-----	Conductivity	+	-----	No conductivity
-	No conductivity	-----	-	Conductivity	-----
Negative side diode check			Positive side diode check		

Rectifier Assembly



Legend

- | | |
|------------------------------|--------------------|
| 1. Voltmeter | 6. Switch 3 |
| 2. Switch 1 | 7. Switch 2 |
| 3. DC Regulated Power Supply | 8. Pulse Generator |
| 4. Lamp 2 | 9. Output Signal |
| 5. Lamp 1 | |

Test circuit

Refer to the judgment criteria shown in the Table below.
Carefully check Items 1 – 5. If all the items are OK, the
IC regulator is normal.

Circuit components

1	DC regulated power supply	0 – 30 volts variable with output of 1 ampere or more
2	Lamps (2)	24 volts, 1.8 watts
3	Switches (3)	-----
4	DC voltmeter	0 – 60 volts, 0.5 grade
5	Pulse generator (Oscillator)	5 – 30 volts output at a frequency of 1kHz

Judgment criteria

No.	Switch 1	Switch 2	Switch 3	Voltmeter reading	Lamp condition		Remarks
					Lamp 1	Lamp 2	
1	ON	OFF	OFF	24V	On (dim)	ON	Initial excitation check
2	ON	ON	OFF		On or flashing	OFF	Full excitation check
3	ON	ON	OFF	32V	Off or on (dim)		Lamp 1 off or dimly lit when the voltmeter shows less than 24 volts or 32 volts
4	OFF	ON	OFF	24V	On or flashing	ON	Stator and brush separation check
5	ON	ON	ON	36V	On		Excess voltage check

Reassembly

Important:

- When connecting the stator coil leads and diode leads using solder, use long-nose pliers and work as quickly as possible to prevent the heat from transferring to the diodes.

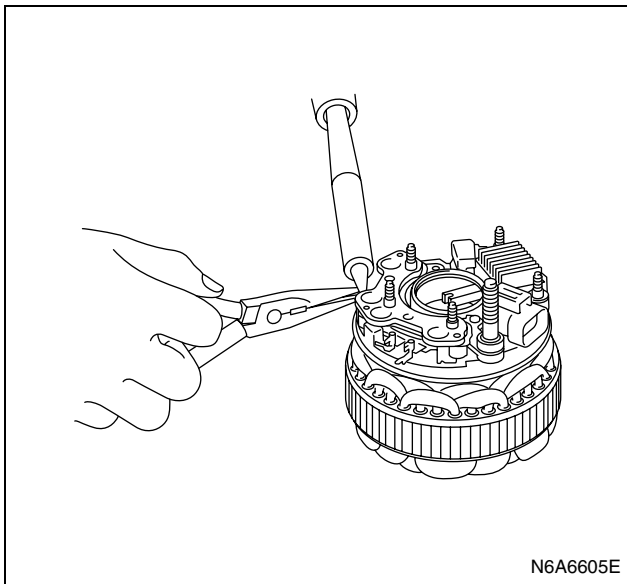
- Stator.
- Diode brush regulator assembly.
- Stator and diode brush regulator assembly.
- Rear cover.
- Front cover.
- Front ball bearing.
- Bearing retainer.
- Rotor and rear bearing.
- Spacer.
- Fan.
- Pulley.
- Pulley nut.

Tighten:

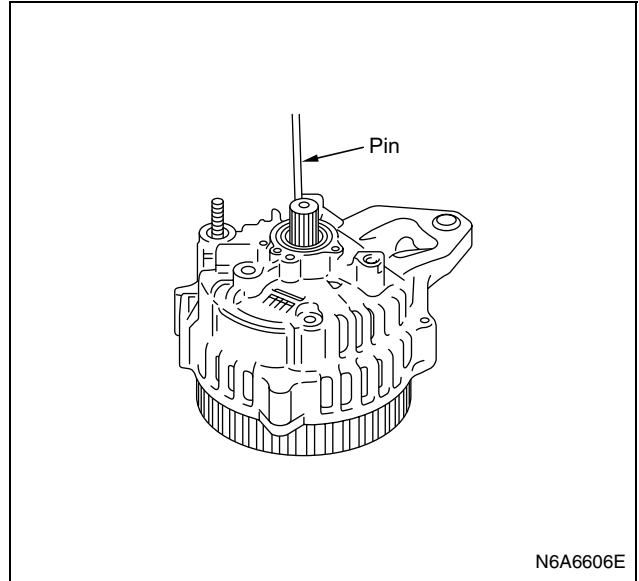
Pulley nut (50A) to 98.0 N·m (10 kg·m/72.3 lb·ft)

Pulley nut (60A, 80A) to 107.8 N·m (11 kg·m/79.5 lb·ft)

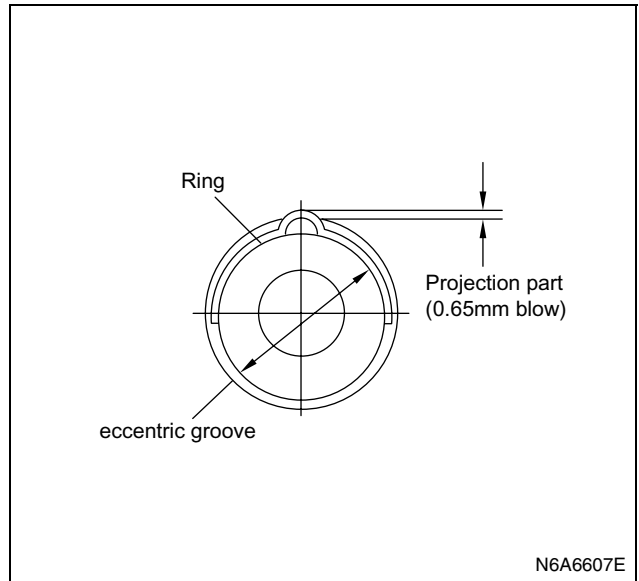
- Rear cover and stator assembly.
Use a pair of long-nose plier to connect the stator coil leads and the rectifier leads.
Finish the work as quickly as possible to prevent the rectifier from heat transferred by the soldering.



Insert the pin from the outside of the rear cover. Press the brushes into the brush holder. Complete the assembly procedure.



- Pulley and rotor assembly.
 - Install the pulley and rotor assembly
The rear ball bearing is pressed into the wheel eccentric groove. The bearing ring projects from the groove.
During installation, rotate the bearing to the point of minimum bearing ring projection.



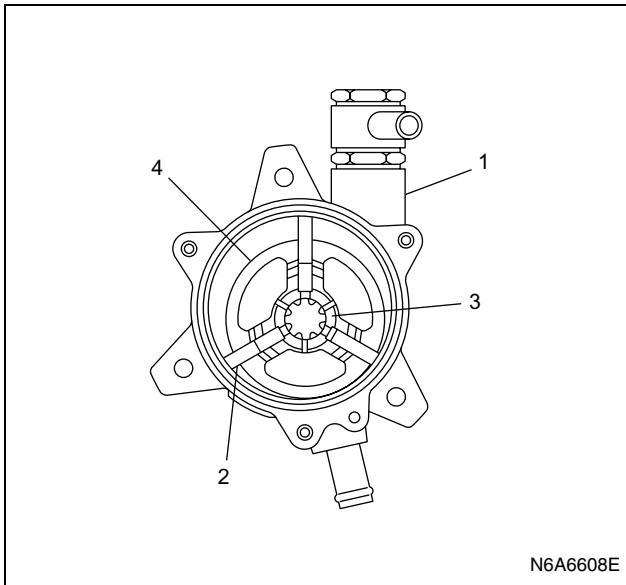
- Through bolts.
 - Place a guide bar through the holes in the front cover and rear cover flange for proper alignment. Install the through bolts.
 - Remove the tape from the splines.

Tighten:

Through bolts to 4 N·m (0.4 kg·m/35 lb·in)

- Vacuum pump assembly.

- Position the rotor, with the serrated boss turned up, on the housing.



Legend

1. Housing
2. Vane
3. Serrated Boss
4. Pump Rotor

- Install 5 cc (0.016 oz) engine oil in the filler port, then check that the generator pulley can be turned smoothly by hand.

Installation

1. Generator.

Tighten:

Bracket Mount Bolt to 48 N·m (4.9 kg·m/35.4 lb·ft)

2. Adjusting bolts.

Tighten:

Adjusting Nut to 24 N·m (2.4 kg·m/17 lb·ft)

3. Drive belts.

Tighten:

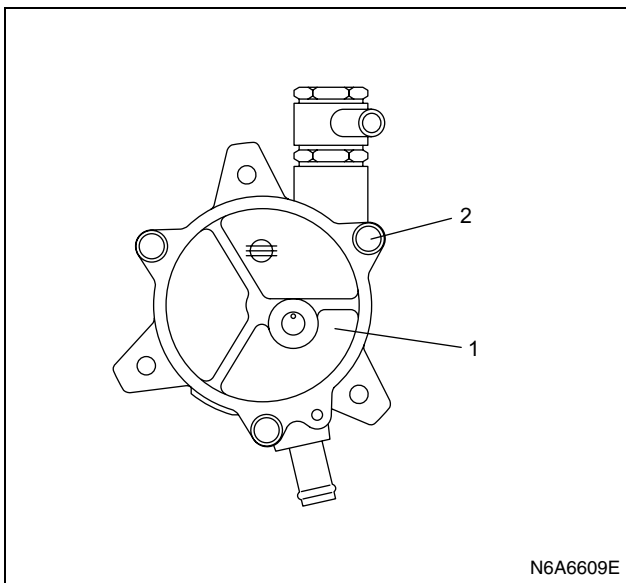
Lower mount bolt to 40 N·m (4.1 kg·m/30 lb·ft)

4. Vacuum and oil hoses at the vacuum pump.
5. Electrical wiring at the generator.

- Battery negative cable.

6. Install the A/C compressor. (Refer to “Engine Assembly” in Section 6A.)

- Align the holes in the housing and rotor.
- Install vanes into the slits in pump rotor.
The vanes must be installed with the round side turned outward.
- After installation of O-ring, install the side plate.



Legend

1. Side Plate
2. Bolt

- Install the vacuum pump assembly to the back of the generator with 3 screws.

Tighten:

Vacuum pump screws to 7 N·m (0.7 kg·m/61 lb·in)

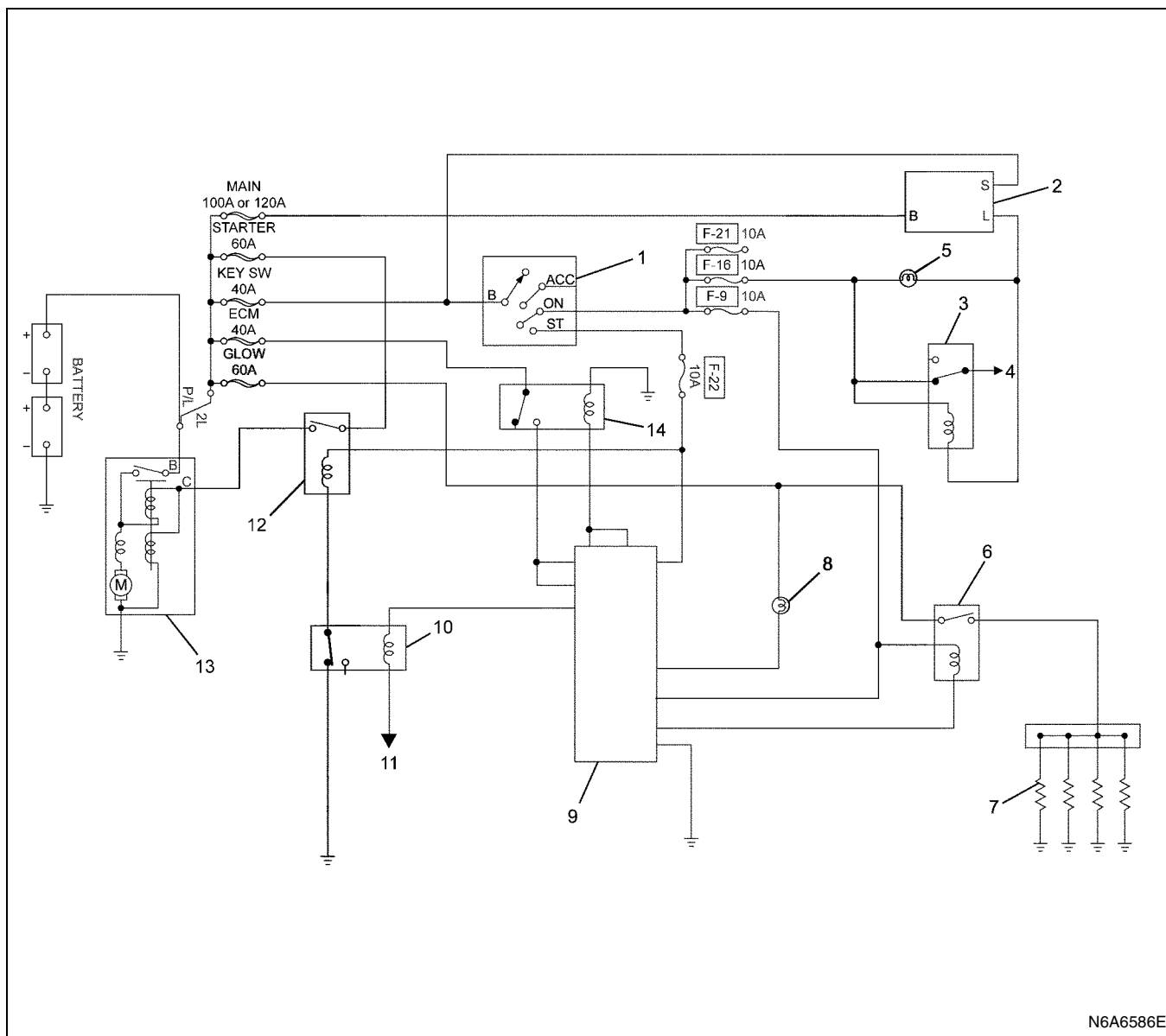
Main Data and Specifications

Rated Voltage	24 V
Rated Output	50/60/80 amp
Rated Output at 5000 RPM	More than 42/50/75 amp
Regulated Voltage	28.0 – 29.0 V
Brush Length	
Standard	25 mm (0.984 in)
Limit	6.5 mm (0.256 in)
Slip Ring Diameter	
Standard	31.7 mm (1.248 in)
Limit	30.6 mm (1.205 in)
Generator Pulley Direction (Viewed From Pulley Side) Clockwise Pulley	
Pulley Diameter	82 mm (3.23 in)
Generator Weight (With Vacuum Pump)	50A: 7.4 kg (16.3 lb) 60A: 9.0 kg (19.8 lb) 80A: 9.6 kg (21.2 lb)
Maximum Vacuum Pump Output	90.7 kPa (0.29 kg/cm ² / 13.2 psi)
Vacuum Pump Vane	
Standard Length	17.0 – 18.0 mm (0.669 – 0.709 in)
Vacuum Pump Housing Inside Diameter	
Standard	69.5 – 69.6 mm (2.736 – 2.740 in)

Starting System

General Description

Circuit Diagram



N6A6586E

Legend

- | | |
|-----------------------------------|-------------------------------------|
| 1. Engine Control Switch | 8. Glow Plug Indicator Light |
| 2. Generator (Integral Regulator) | 9. ECM |
| 3. Charge Relay | 10. Starter Cut Relay |
| 4. To Heater and A/C Relay | 11. To Exhaust Brake Solenoid Valve |
| 5. Low Charge Indicator Light | 12. Starter Relay |
| 6. Glow Plug Relay | 13. Starter |
| 7. Glow Plugs | 14. ECM Main Relay |

Starter and Glow Plug Relays

The starter is a 4.5 kilowatt, reduction drive model.

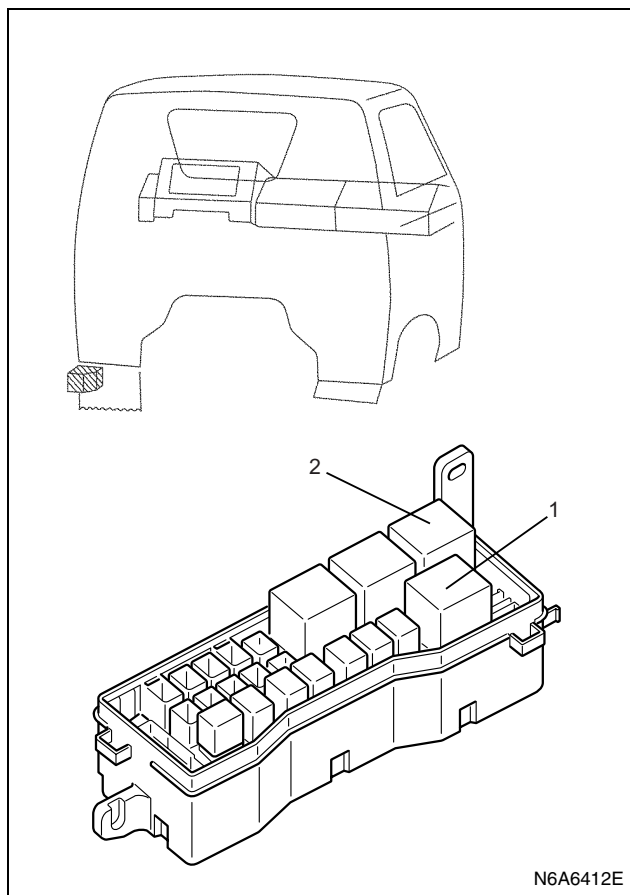
The gear housing and armature end bearing housings are aluminum. The brush assembly has replaceable brushes. The commutator bars are mica insulated and are undercut.

The starter circuit starts at the batteries. The battery cable goes to the large terminal on the starter.

From that terminal wires lead to the engine control switch and the starter relay.

From the engine control switch the starter circuit goes through Fuse #3 and the transmission neutral switch to the starter relay. When the engine control switch is turned to start and the transmission neutral switch is closed, the starter relay closes to complete the circuit from the batteries to the starter solenoid. The starter circuit is also connected to the Engine Control Module (ECM). The Engine Control Module (ECM) operates when the engine control switch is turned to the "ON" position.

The starter and glow plug relays are located on the frame at the left rear side of the cab.



Legend

1. Starter Relay
2. Glow Plug Relay

Maintenance

Keep the starter's exterior clean. Remove corrosion from the terminals, leads, and connectors.

Tighten the starter to engine mounting bolts and the electrical cable retaining nuts.

Diagnosis of Starting System

1. No Cranking, No Sound

- Discharged batteries. Turn on the headlights and check the brightness. If the headlights are dim, charge the batteries. Check for the cause of the discharged batteries.
- Sulfated battery terminals. Turn on the headlights. The headlights will be bright. Attempt to start the engine. The headlights will be very dim or go out. Clean all the battery terminals and cable ends.
- A starter that draws too much current.
- Starter relay won't work. Attempt to start and listen for a "click" at the starter relay. If there is no "click," check the starter relay control terminals with a test light. If the test light shows that power is getting to the starter relay, check the ground circuit with the test light. If the ground circuit is OK, replace the starter relay.
- Engine control switch start circuit won't close.

With the engine control switch turned to start, check the starter relay with a test light. If the test light doesn't come on, check the starter circuit at the engine control switch with the test light. If the test light comes on, check the harness for an open and repair. If the test light does not come on, replace the engine control switch.

- Starter relay power circuit isn't closing. Attempt to start. The starter relay "clicks." Check the secondary terminals with a test light. If the test light lights on the battery side only, replace the starter relay. If the test light lights on both terminals, check for an open at the starter.
- Starter clicks when start is attempted. Check all power connections for corrosion. Clean connections if corrosion is present. Terminal on starter should have at least 18 volts on it when cranking the engine. If voltage is OK, replace the starter.
- Starter cut relay

If the problem found, repair the following circuit as necessary.

- Starter cut relay ground circuit. (Between starter cut relay and ECM.)
- ECM power supply circuit. (Between fuse 10 A and starter cut relay circuit.)

- Neutral switch or inhibitor switch

If the problem found, repair the following circuit as necessary.

- Neutral switch or inhibitor switch ground circuit. (Between Frame-LH and neutral switch.)
- Starter relay power supply circuit. (Between fuse 10 A and starter relay.)
- Starter relay ground circuit. (Between starter cut relay and diode.)

2. Slow Cranking, Solenoid Clicks or Chatters

- Discharged batteries. Turn on the headlights and check the brightness. If the headlights are dim, charge the batteries. Check for cause of discharged batteries.
- Corrosion on the battery terminals. Check for corrosion. Hint: Test for warm terminals. Clean all the battery terminals and connectors.
- Loose or dirty connections. Measure the cranking voltage at the battery terminals. If the voltage is less than 18 volts, load test the battery. If the battery is bad, replace the battery. If the battery is good, repair the starter.

If the voltage is 18 volts or more, measure the voltage from the battery NEGATIVE terminal to the engine block. If the voltage is 0.5 volt or more, repair the ground cable and connections.

If the voltage is less than 0.5 volt, measure the voltage at the battery cable terminal on the starter. If the voltage is 18 volts or more, repair the starter. If the voltage is less than 18 volts, clean and tighten the positive cable connections. If the voltage is still less than 18 volts, replace the positive cable.

On-vehicle Service: Starter System

Maintenance

Keep starter terminals and all other terminals in the electrical system clean and tight. A loose or corroded connection or terminal will cause excessive resistance in the system that will result in hard starting.

At regular intervals, inspect the starting system to locate and correct potential causes of trouble before the system performance is affected.

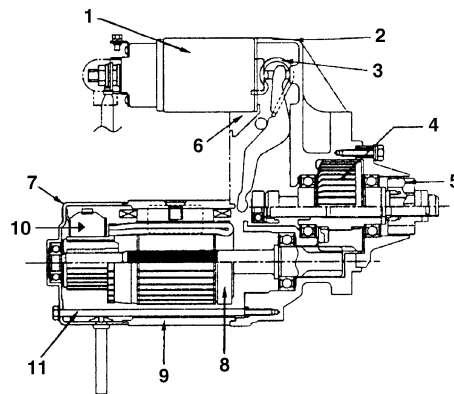
Starting motors do not require lubrication except during overhaul.

Starter

Components

Starting Motor

S25—505G



N6A6516E

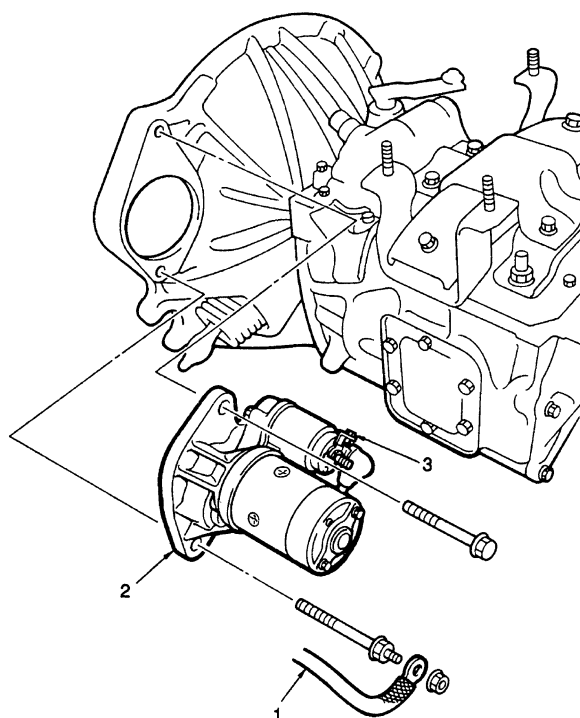
Legend

- | | |
|--------------------|------------------|
| 1. Magnetic Switch | 7. Rear Cover |
| 2. Gear Case | 8. Armature |
| 3. Torsion Spring | 9. Yoke |
| 4. Clutch | 10. Brush |
| 5. Pinion | 11. Through Bolt |
| 6. Dust Cover | |

On-vehicle Service

Component

Starter



N6A0988E

Legend

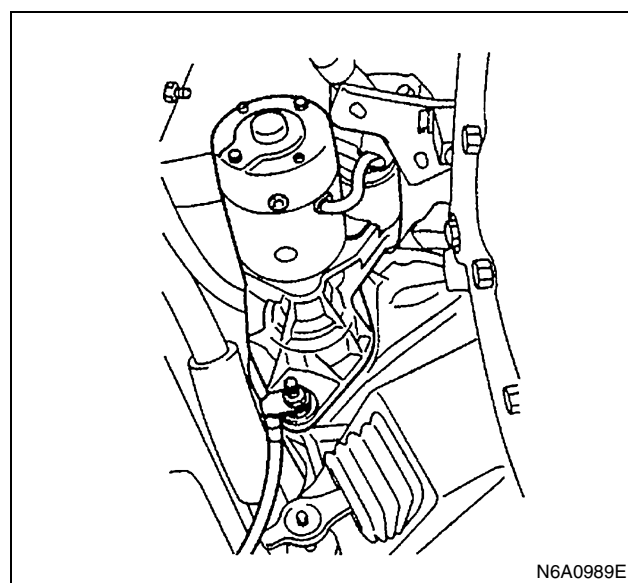
- | | |
|------------------------|-----------------------------|
| 1. Starter Earth Cable | 3. Starter Wiring Connector |
| 2. Starter Assembly | |

Removal

Preparation

- Disconnect the battery ground cable (both batteries).

1. Starter Earth Cable



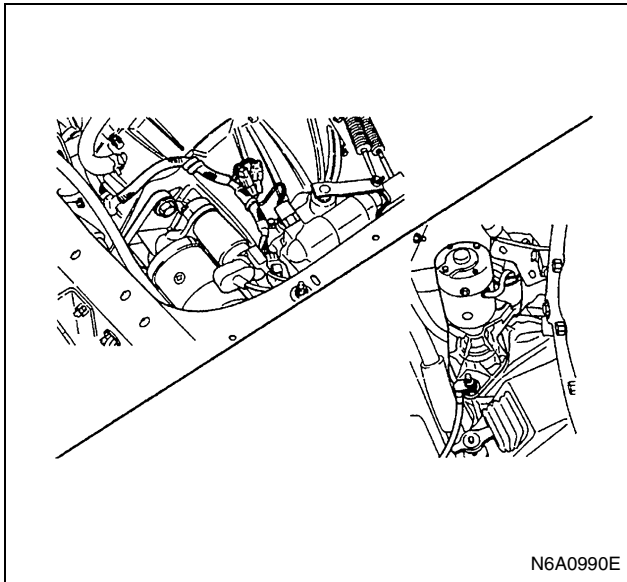
N6A0989E

- Disconnect the starter earth cable at the starter motor.

6D-24 Engine Electrical

- Disconnect the front frame harness connector somewhere near the control box of the transmission, remove each clip that fastens the harness.

2. Starter Assembly

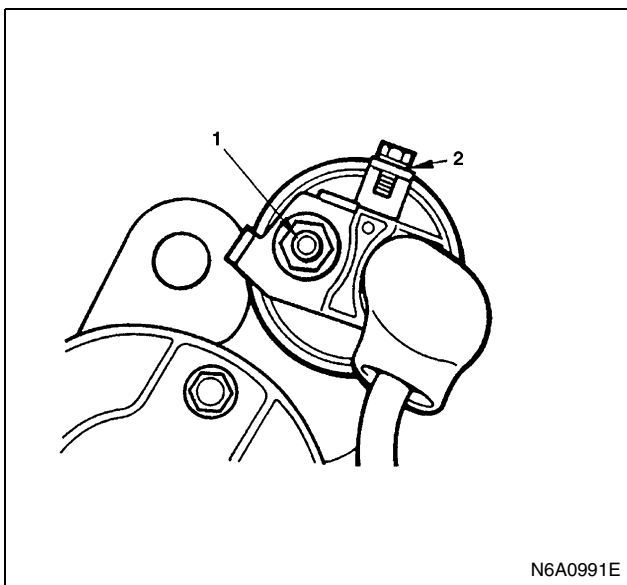


- Remove the starter assembly from flywheel housing.

3. Starter Wiring Connector

Installation

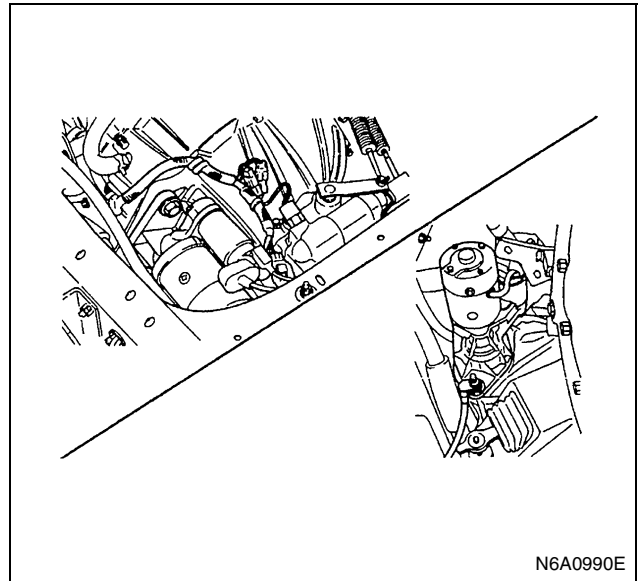
1. Starter Wiring Connector



Legend

1. Terminal B
2. Terminal S

2. Starter Assembly



- Install the starter to the flywheel housing.

Tighten:

Starter bolt to 76 N·m (7.7 kg·m / 56.1 lb·ft)

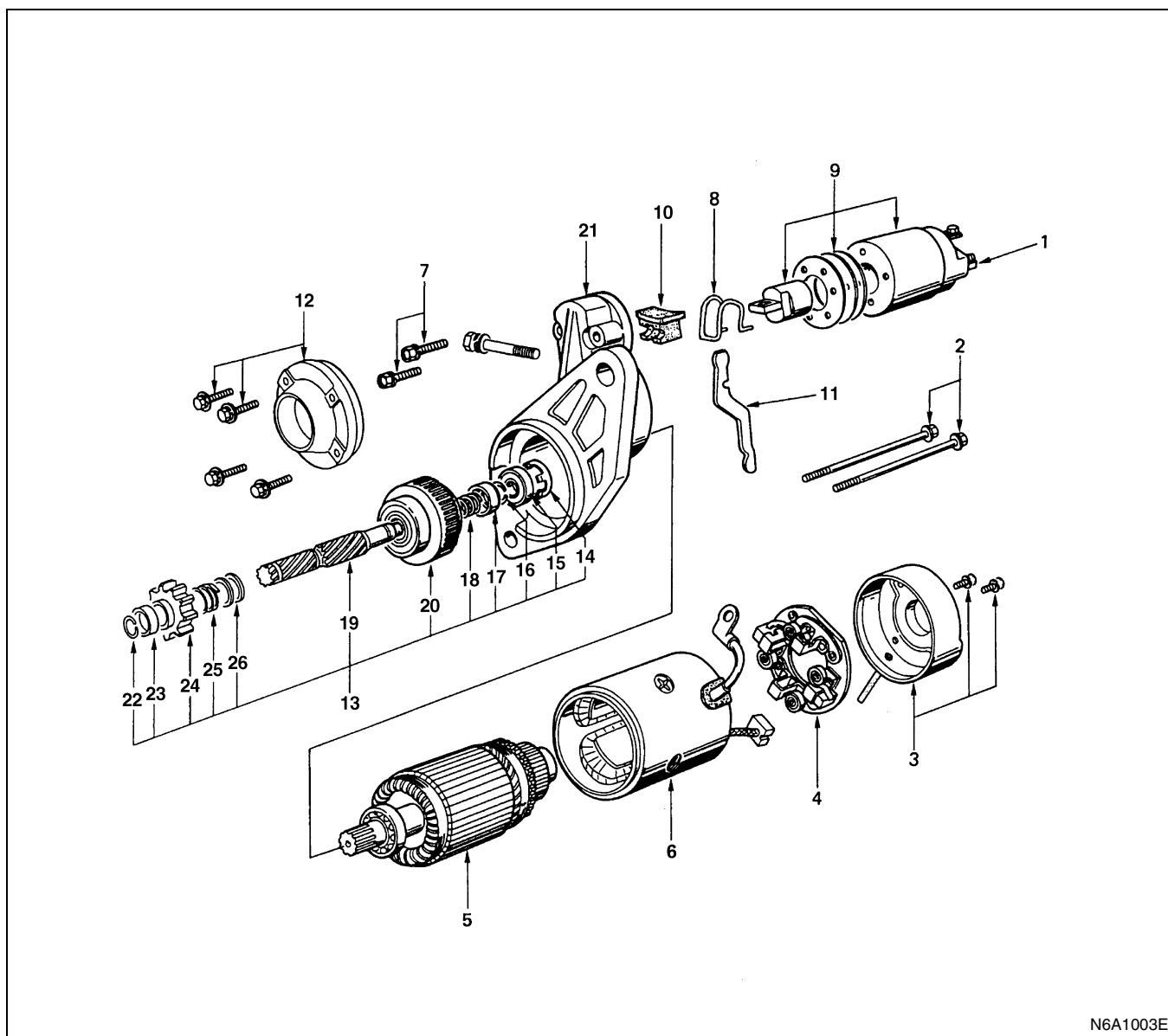
3. Starter Earth Cable

- Connect the earth cable to the starter motor.
- Connect the battery ground cable.

Unit Repair

Component

S25-505G

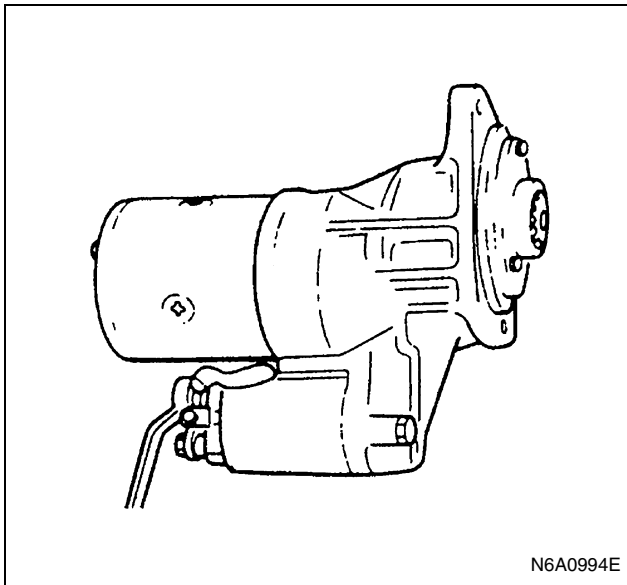


N6A1003E

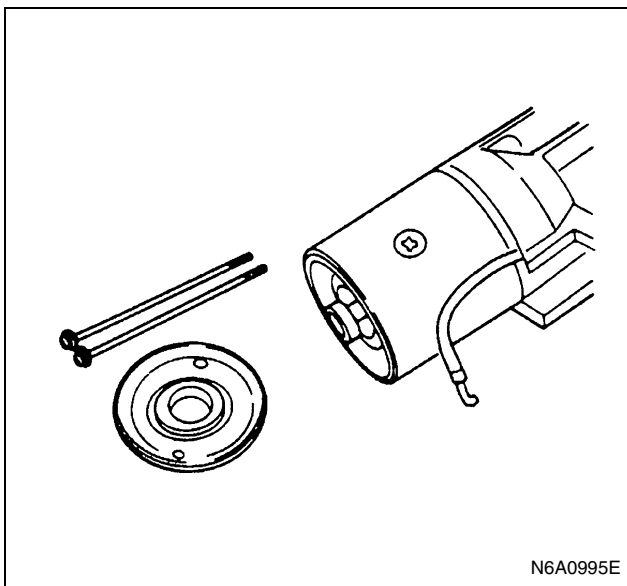
Legend

- | | |
|-----------------------------|-------------------------|
| 1. Lead Wire Nut | 14. Bearing Holder |
| 2. Through Bolt | 15. Ball Bearing |
| 3. Rear Cover | 16. Pinion Stopper Clip |
| 4. Brush Holder | 17. Pinion Stopper |
| 5. Armature | 18. Return Spring |
| 6. Yoke | 19. Pinion Shaft |
| 7. Bolt | 20. Pinion Clutch |
| 8. Torsion Spring | 21. Gear Case |
| 9. Magnetic Switch Assembly | 22. Clip |
| 10. Dust Cover | 23. Pinion Stopper |
| 11. Shift Lever | 24. Pinion |
| 12. Bearing Retainer | 25. Cushion Spring |
| 13. Clutch Assembly | 26. Washer |

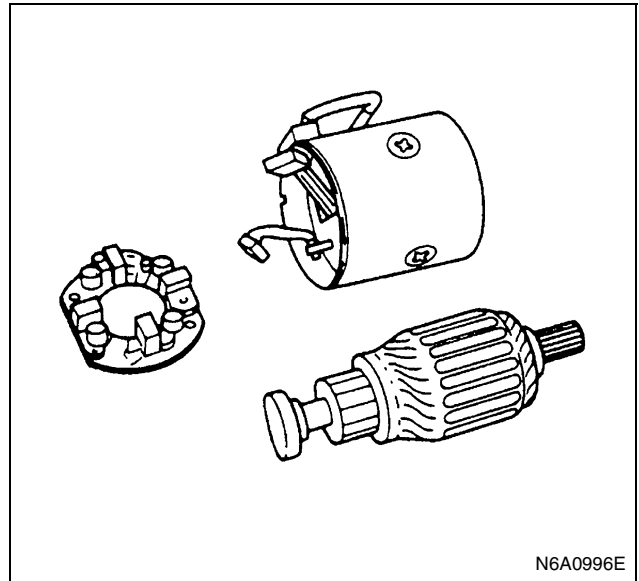
Disassembly



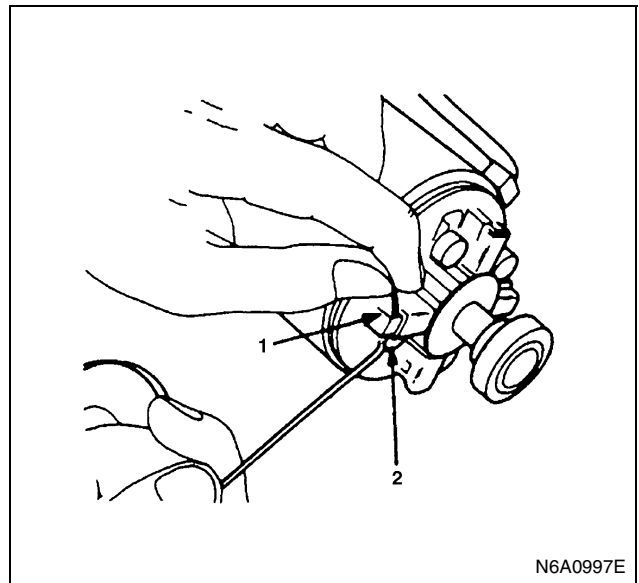
1. Lead Wire Nut
Disconnect the lead wire at the magnetic switch.
2. Through Bolt



3. Rear Cover
Remove the through bolts, then remove the rear cover.
4. Brush Holder



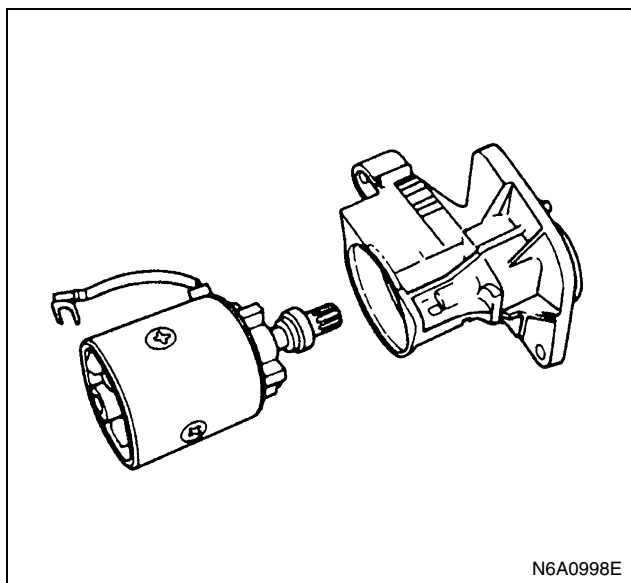
5. Armature
6. Yoke
Remove the brush holder and pull the armature assembly from the yoke.
Remove the four brushes from the brush holders.



Legend

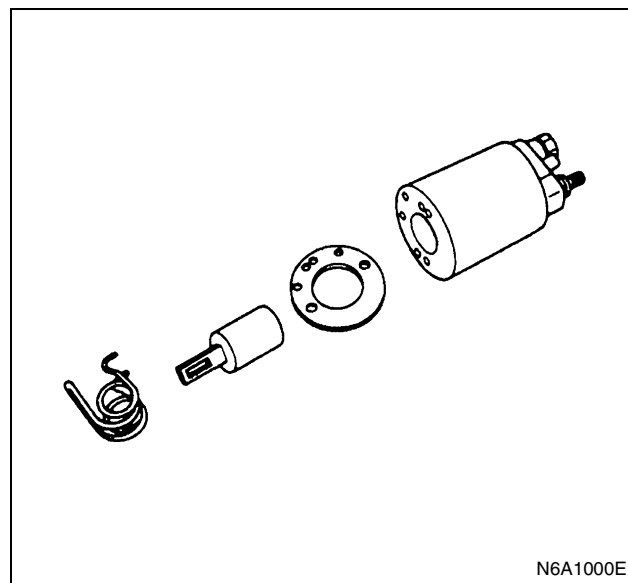
1. Brush
2. Brush Spring

Remove the yoke along with the armature and the brush holder from the drive housing.

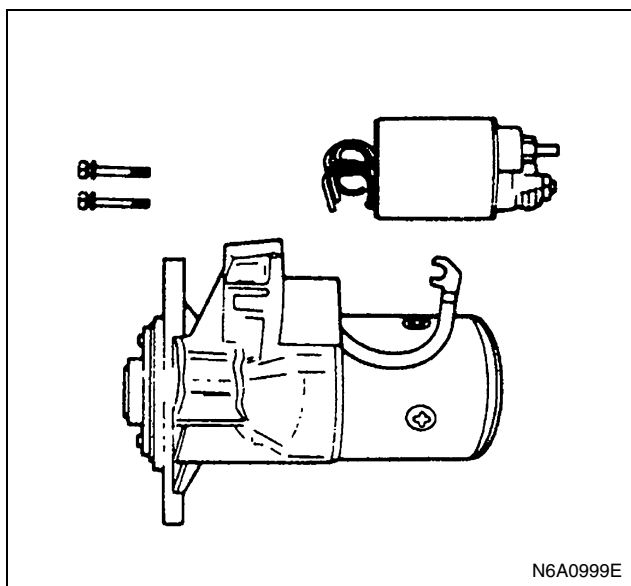


Remove the brushes and commutator carefully so as not to allow them in contact with the adjacent parts.

7. Bolt
8. Torsion Spring
9. Magnetic Switch Assembly

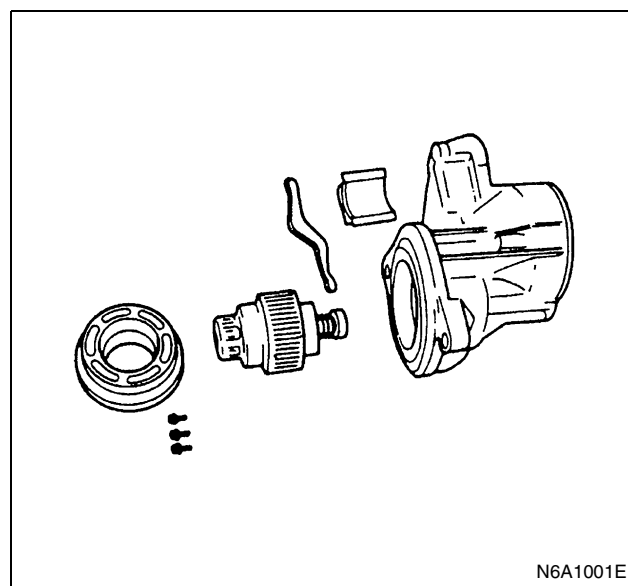


10. Dust Cover
11. Shift Lever
12. Bearing Retainer
13. Clutch Assembly

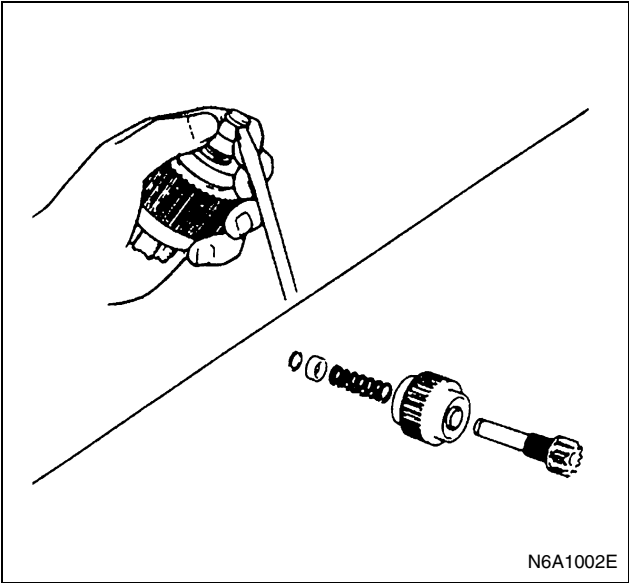


Remove the magnetic switch bolts, then remove the switch from the shift lever.

Remove the torsion spring from the magnetic switch.



- 1) Remove the bearing retainer.
 - 2) Remove the clutch assembly from the gear case.
 14. Bearing Holder
 15. Ball Bearing
 16. Pinion Stopper Clip
 17. Pinion Stopper
 18. Return Spring
 19. Pinion Shaft
 20. Pinion Clutch
- Use a screwdriver to remove the stopper clip. Then disassemble the clutch assembly.



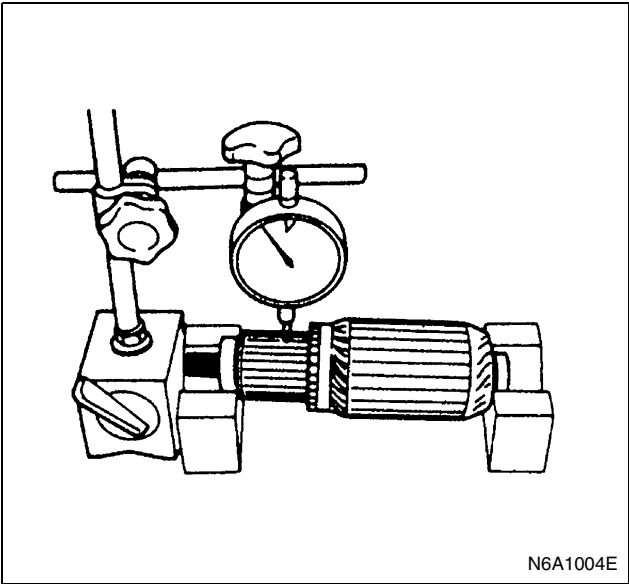
Inspection and Repair

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

Armature

- 1. Measure the commutator run-out.
Replace the commutator if the measured run-out exceeds the specified limit.

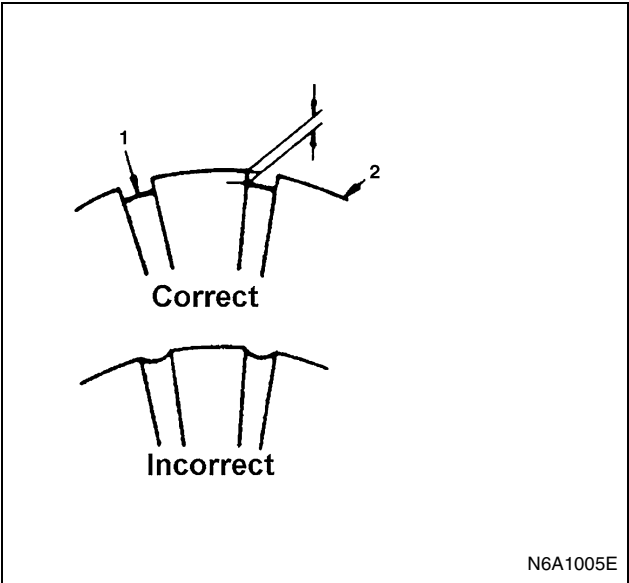
Commutator Run-Out		mm (in)
Standard	Limit	
0.05 (0.002) or less	0.2 (0.008)	



- 2. Check the commutator mica segments for excessive wear.
- 3. Measure the mica segment depth.

Mica Segment Depth		mm (in)
Standard	Limit	
0.5 — 0.8 (0.020 — 0.031)	0.2 (0.008)	

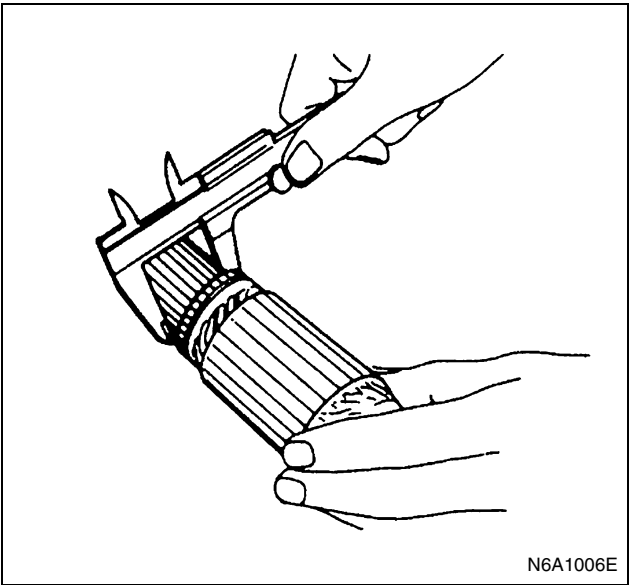
If the mica segment depth is less than the standard but more than the limit, the commutator may be reground.
If the mica segment depth is less than the limit, the commutator must be replaced.



Legend

- 1. Insulator
- 2. Commutator Segments

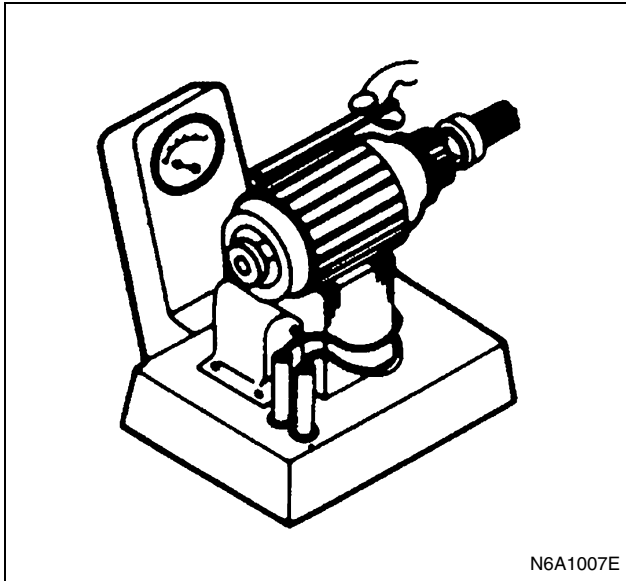
- 4. Measure the commutator outside diameter.



Commutator Outside Diameter			mm (in)
Model	Yoke Diameter	Standard	Limit
S25-505G	φ90	36.5 (1.437)	35.5 (1.398)

If the measured outside diameter is less than the specified limit, the commutator must be replaced.

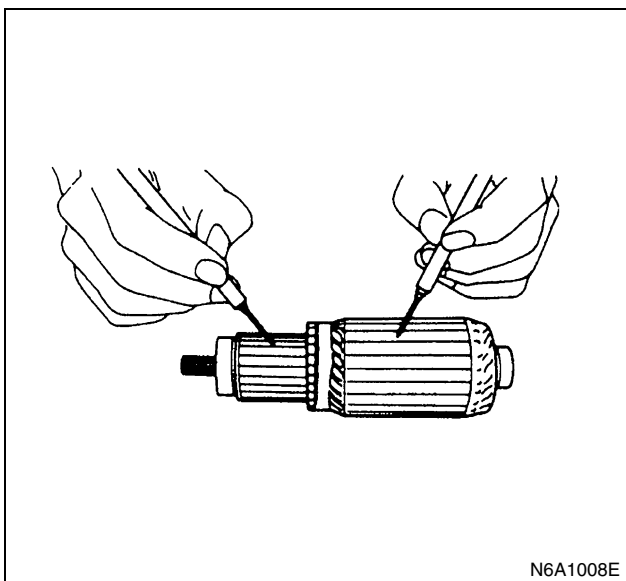
- Test the armature for short circuiting.



N6A1007E

- Place the armature in a growler tester.
- Hold a hacksaw blade against the armature core.
If the armature has a short circuit, the hacksaw blade will vibrate.
Replace the armature if there is a short circuit.

- Use a circuit tester to check the armature for grounding.



N6A1008E

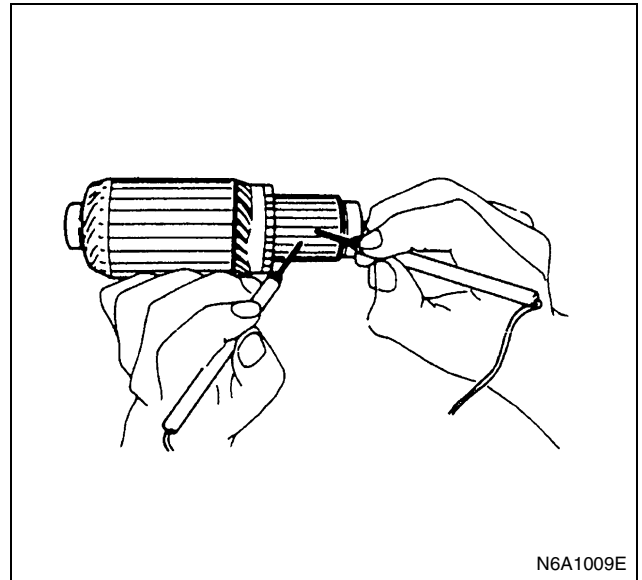
- Hold one probe of the circuit tester against the commutator segment.

- Hold the other circuit tester probe against the armature core.

If the circuit tester indicates continuity, the armature is grounded.

The armature must be replaced.

- Use the circuit tester to check the armature for continuity.



N6A1009E

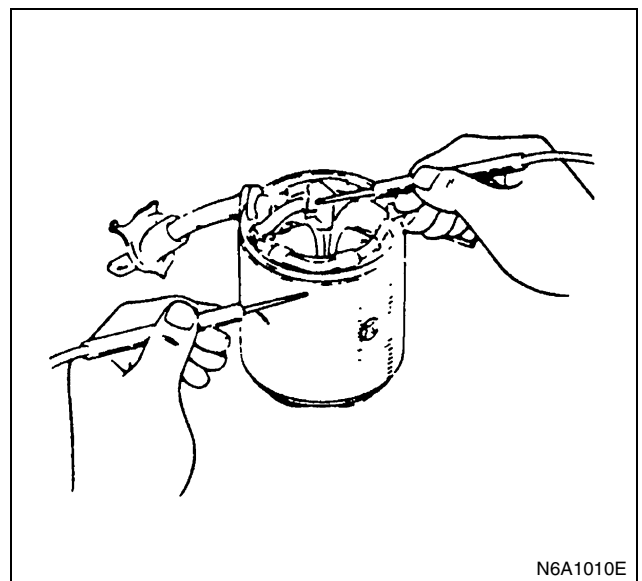
- Hold the circuit tester probes against two armature core segments.
- Repeat Step 1 at different segments of the armature core.

There should be continuity between all segments of the armature core.

If there is not, the armature must be replaced.

Yoke

- Use a circuit tester to check the field winding ground.

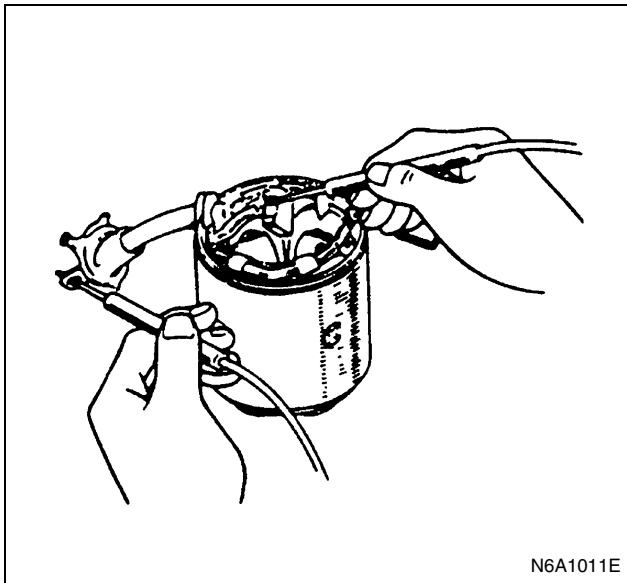


N6A1010E

- Hold one circuit tester probe against the field winding end or brush.

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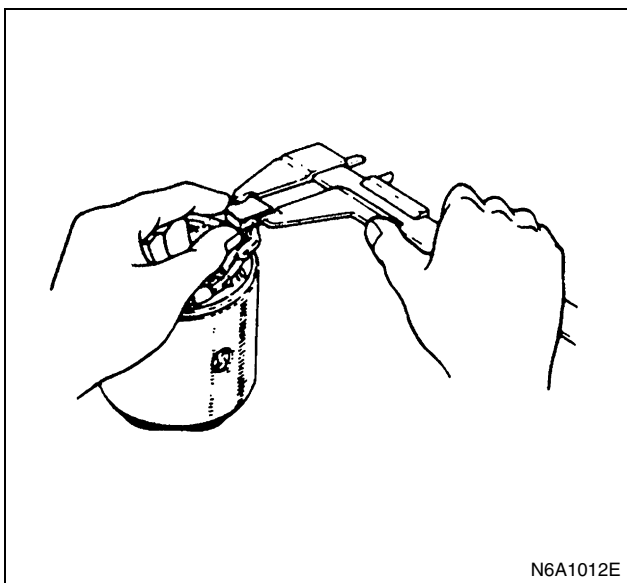
- 2) Hold the other circuit tester probe against the bare surface of the yoke body.
There should be no continuity.
If there is continuity, the field coil is grounded.
The yoke must be replaced.
2. Use the circuit tester to check the field winding continuity.



- 1) Hold one circuit tester probe against the "C" terminal lead wire.
- 2) Hold the other circuit tester probe against the field winding brush.
There should be continuity.
If there is no continuity, the yoke must be replaced.

Brush and Brush Holder

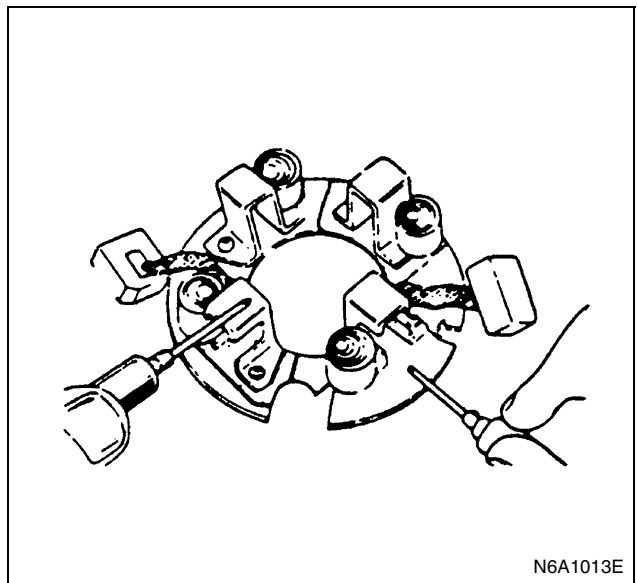
1. Use a vernier caliper to measure the brush length (four brushes).



Replace the brushes as a set if one or more of the brush length is less than the specified limit.

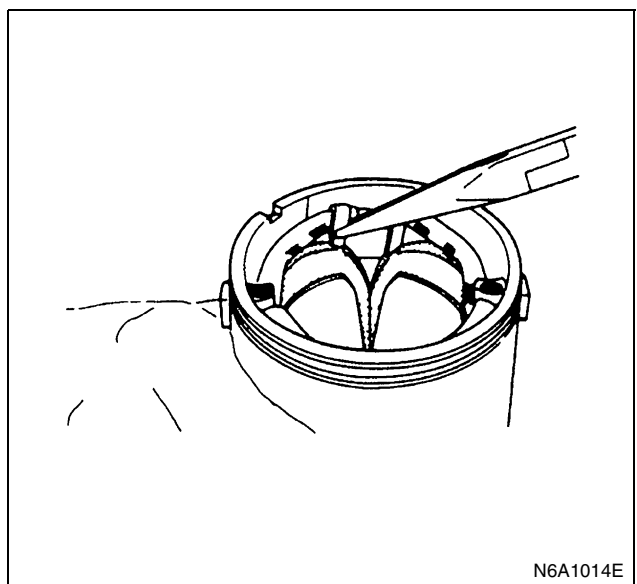
Brush Length			mm (in)
Model	Yoke Diameter	Standard	Limit
S25-505G	φ90	15.0 (0.591)	10.5 (0.413)

2. Use a circuit tester to check the brush holder insulation.

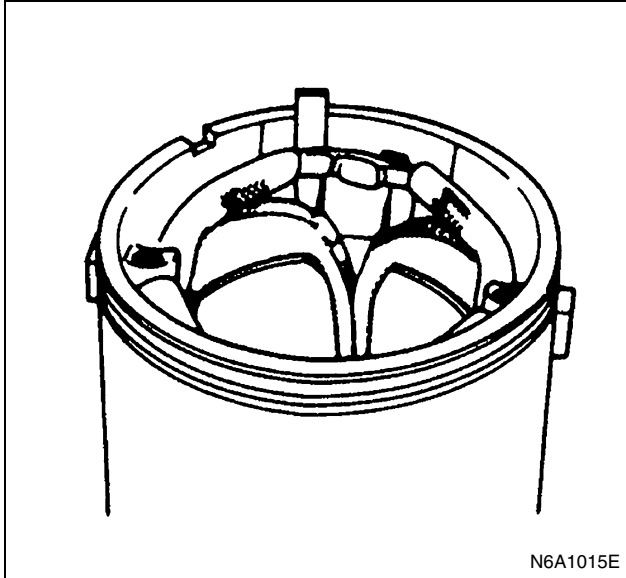


Touch one probe to the holder plate and the other probe to the positive brush holder.
There should be no continuity.

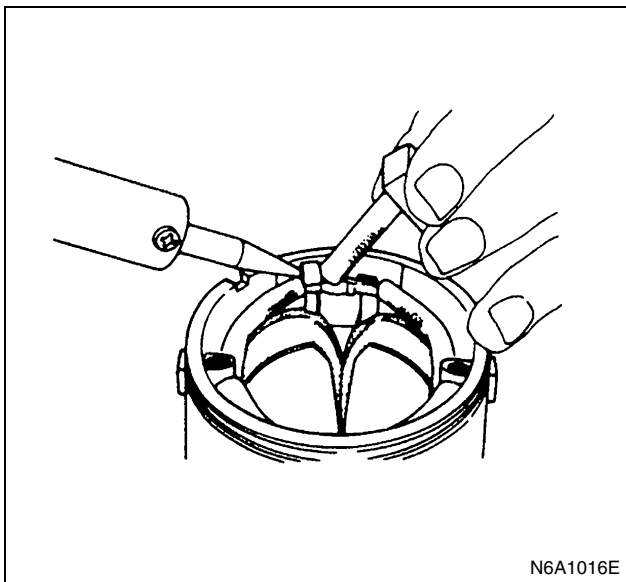
3. Inspect the brushes for excessive wear.
If the negative brushes have excessive wear, the entire brush holder assembly must be replaced.
If the positive brushes have excessive wear, only the brushes must be replaced.
 - 1) Use a pair of side cutters to cut the lead wire from the brush.



- 2) File away any foreign material clinging to the edge of the lead wire.
- 3) Remove the brushes from the brush holder.
- 4) Install the new brushes.
- 5) Straighten the bent portion of the clip.



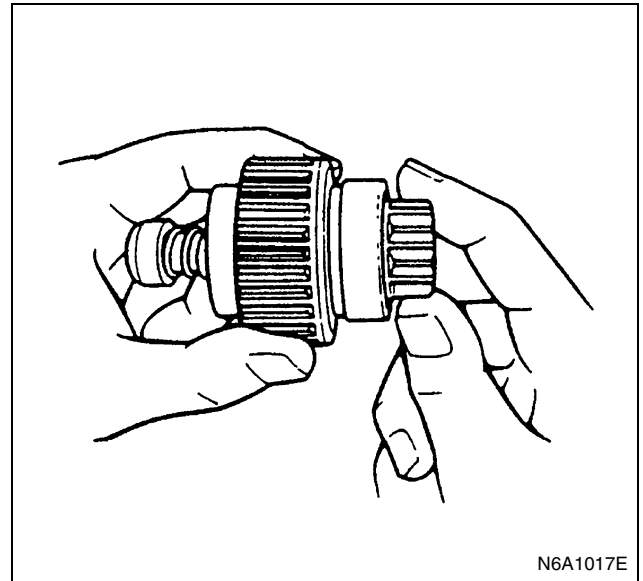
- 6) File away any foreign material clinging to the clip surface.
- 7) Place the lead wire in the clip.
- 8) Bend the clip shut.
- 9) Solder the brush lead.



- 10) Repeat the procedure for each of the brushes.

Overrunning Clutch

1. Inspect the overrunning clutch gear teeth for excessive wear and damage. Replace the overrunning clutch if necessary.
2. Rotate the pinion clockwise.

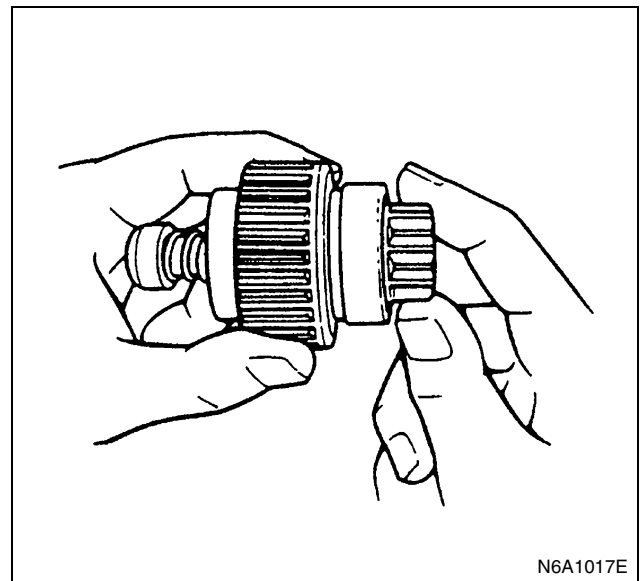


It should turn smoothly.

3. Try to rotate the pinion in the opposite direction. The pinion should lock.

Ball Bearing

Inspect the bearings for excessive wear and damage. Replace the bearings if necessary.



Magnetic Switch

The following tests must be performed with the starter motor fully assembled.

The yoke lead wire must be disconnected from the "C" terminal.

To prevent coil burning, complete each test as quickly as possible (within three to five seconds).

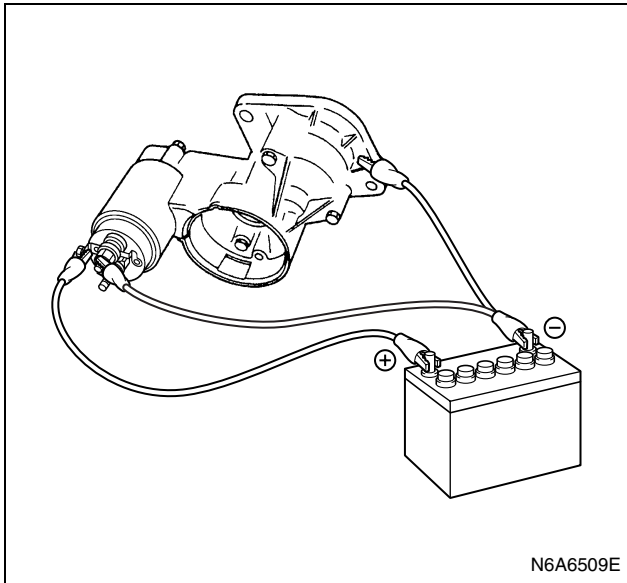
Temporarily connect the magnetic switch between the clutch and the housing and run the following test. Complete each test within three to five seconds.

1. Pull-Out Test

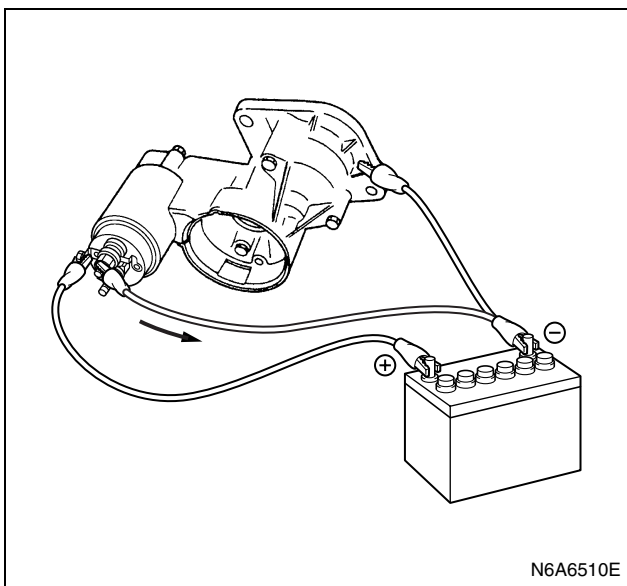
Connect the battery negative terminal with the magnetic switch body and the C terminal. When

6D-32 Engine Electrical

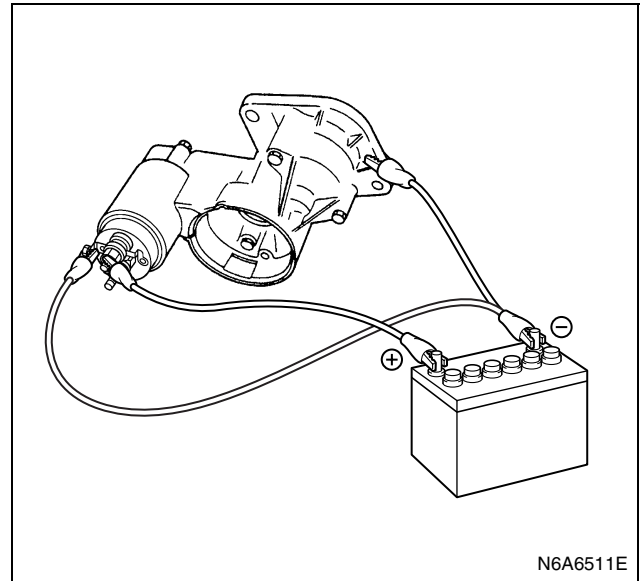
current is applied to the 50 terminal from the battery positive terminal, the pinion should flutter.



2. Hold-in Maintenance Test
Disconnect the lead at the C terminal. The pinion should continue to flutter.



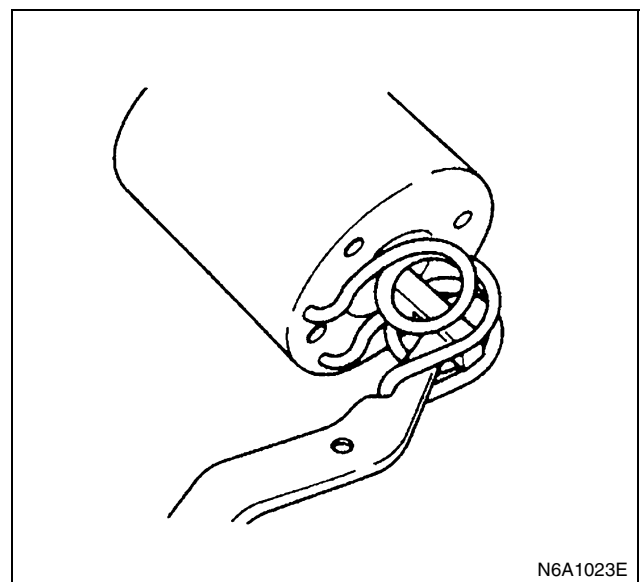
3. Return Test
Connect the battery negative leads to the starter body and the 50 terminal.



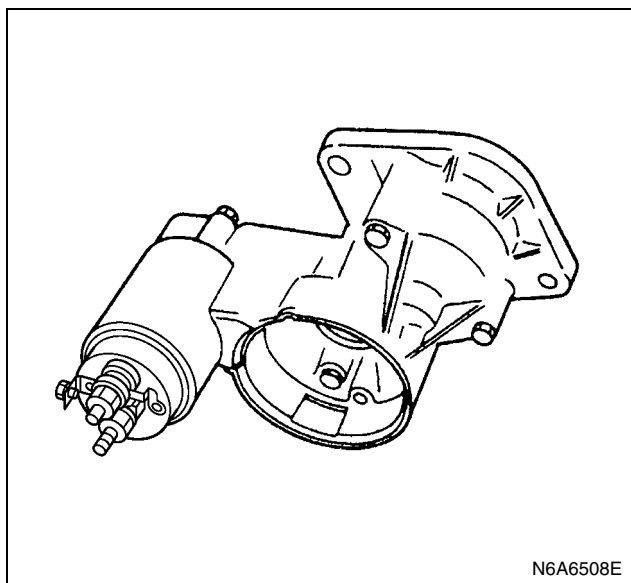
Connect the battery positive lead at the C terminal.
The pinion should return to its home position.

Reassembly

1. Gear Case
2. Magnetic Switch Assembly
3. Torsion Spring
4. Shift Lever
 - 1) Attach the torsion spring to the hole in the magnetic switch as illustrated.



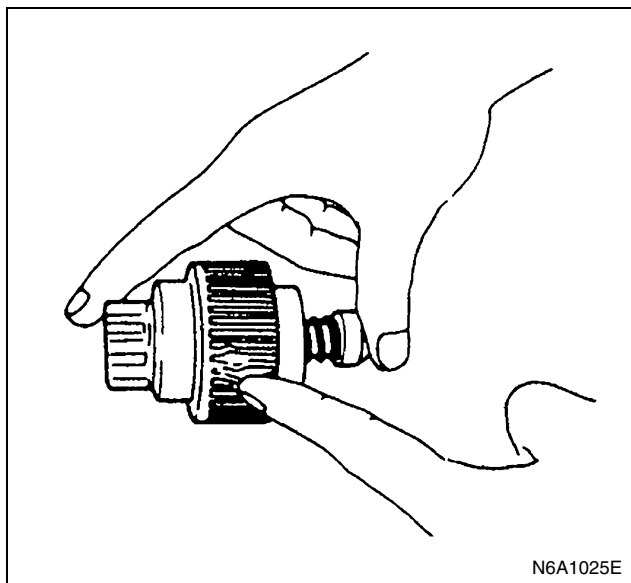
- 2) Insert the shift lever into the plunger hole of the magnetic switch.
5. Dust Cover
Install the dust cover.
6. Bolt
Install the magnetic switch assembly in the gear case and tighten the bolt to the specified torque.

**Tighten:**

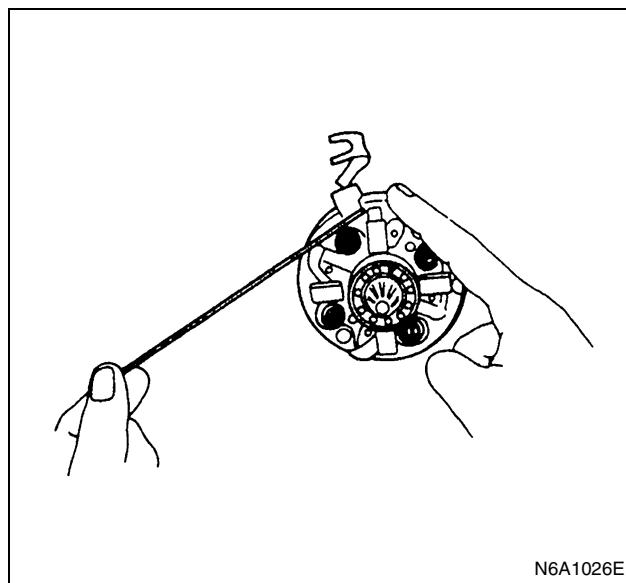
Gear case bolt to 8 N·m (0.8 kg·m / 69 lb·in)

7. Pinion Clutch
8. Pinion Shaft

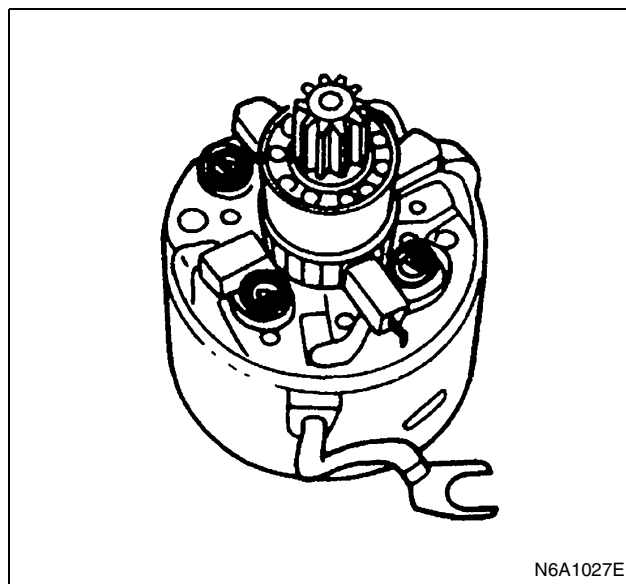
Apply a coat of grease to the pinion clutch gear and install the pinion assembly to the armature shaft.



9. Return Spring
10. Pinion Stopper
11. Pinion Stopper Clip
12. Ball Bearing
13. Bearing Holder
14. Clutch Assembly
15. Bearing Retainer
16. Armature
17. Yoke
18. Brush Holder

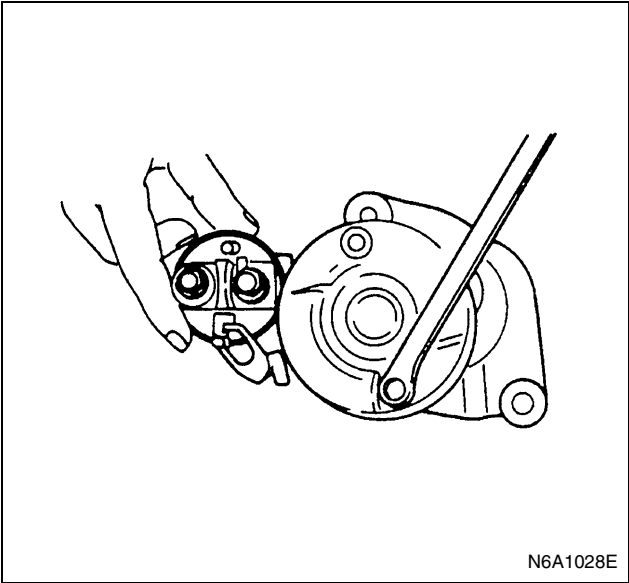


- 1) Twist the holder spring and hold it.
- 2) Install the brush to the brush holder.
- 3) Repeat step 1 and 2 for the remaining holders.
- 4) Install the brush holder assembly to the yoke.



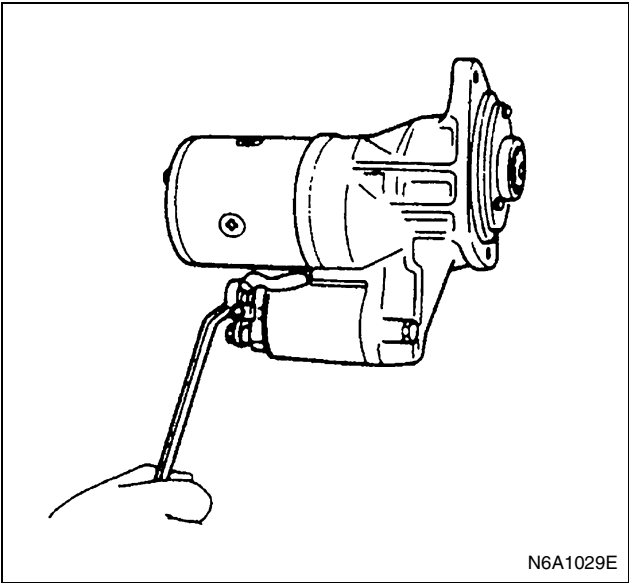
Take care not to damage the commutator face and the brushes.

19. Rear Cover
 20. Through Bolt
- Install the through bolts in the rear cover and tighten them to the specified torque.



Tighten:
Through bolt to 6 N·m (0.6 kg·m / 52 lb-in)

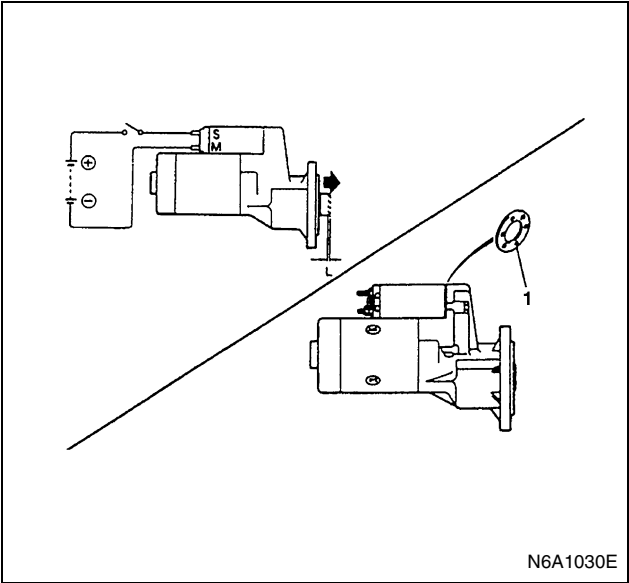
21. Lead Wire Nut
Connect the lead wire in the magnetic switch and tighten the terminal nut to the specified torque.



Tighten:
Lead wire terminal nut to 10 N·m (1.0 kg·m / 87 lb-in)

Pinion Jump-out dimension

- Connect the (+) cable of battery to terminal S and the (-) cable to terminal M. Turn the switch on, and measure pinion travel dimension “L” in thrust direction from the jump-out position.



Legend
1. Spacer

In measuring the dimension, pull the pinion out a little in the arrow direction.

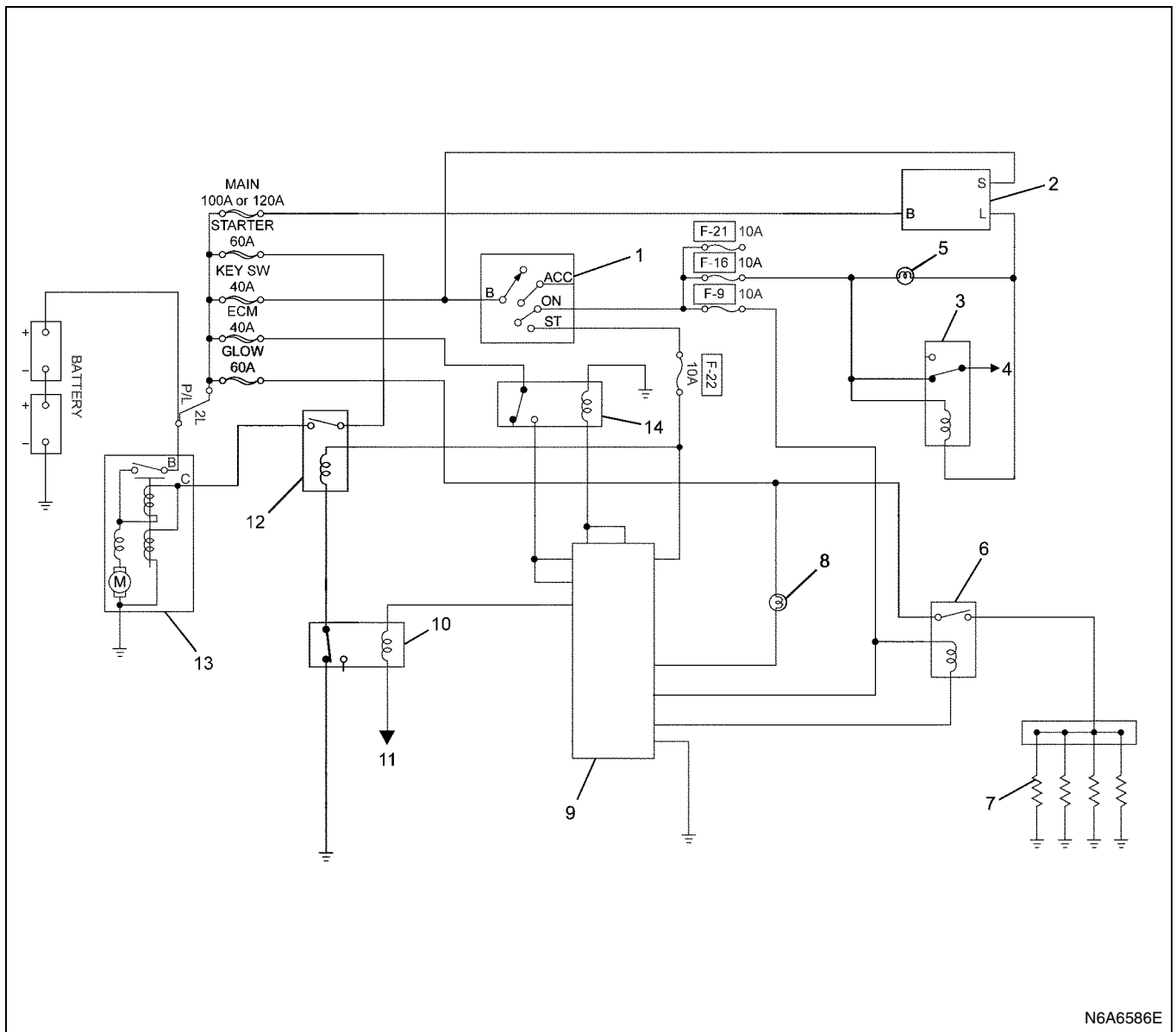
mm (in)	
Dimension	Standard
L	0.3 — 0.1 (0.01 — 0.004)

If the measured value is out of standard, adjust the of shims.

Preheating System

Glow Plug Replacement

Circuit Diagram



N6A6586E

Legend

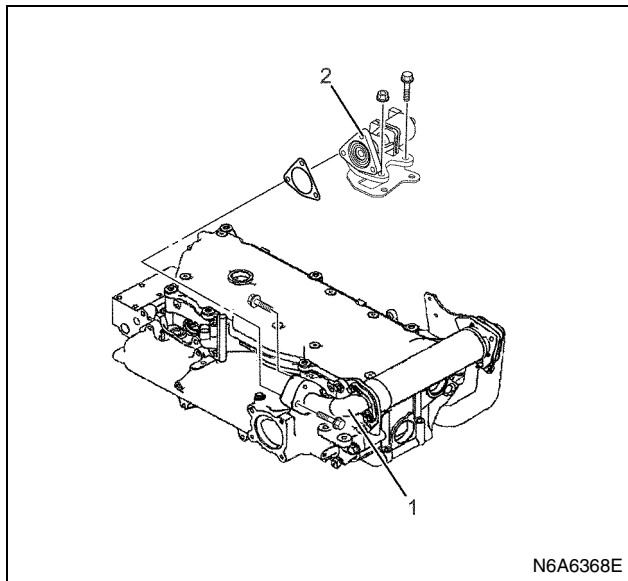
- | | |
|-----------------------------------|-------------------------------------|
| 1. Engine Control Switch | 8. Glow Plug Indicator Light |
| 2. Generator (Integral Regulator) | 9. ECM |
| 3. Charge Relay | 10. Starter Cut Relay |
| 4. To Heater and A/C Relay | 11. To Exhaust Brake Solenoid Valve |
| 5. Low Charge Indicator Light | 12. Starter Relay |
| 6. Glow Plug Relay | 13. Starter |
| 7. Glow Plugs | 14. ECM Main Relay |

Precautions during maintenance

Adequate care should be taken as over-tightening the glow plug could lead to damage.

Removal

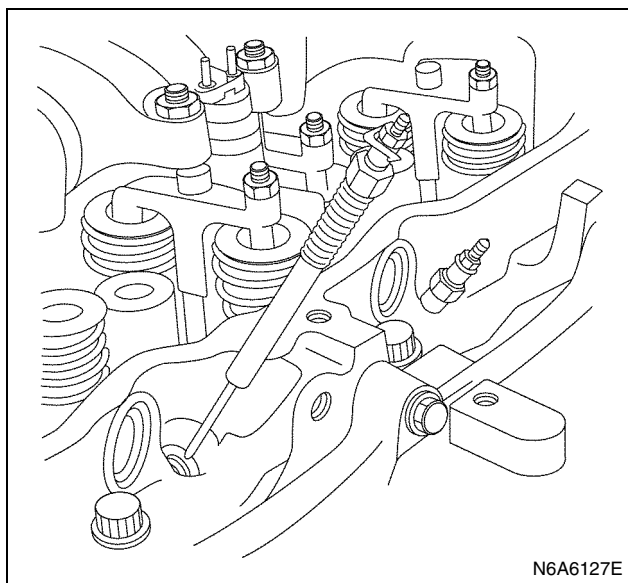
1. Remove the engine harness, the throttle position sensor, the EGR valve, the pressure sensor, and all of the fuel injector connectors.
2. Remove the EGR valve and the EGR adapter.
3. Tape the EGR case holes shut to prevent the entry of foreign material.



Legend

1. EGR Adapter
2. EGR Valve

4. Remove the glow connector.
5. Remove the glow plug.



Installation

1. Install the glow plug.

Tighten:

Glow plug to 20 N·m (2.0 kg·m/15 lb·ft)

2. Install and tighten the glow connector with the designated torque.

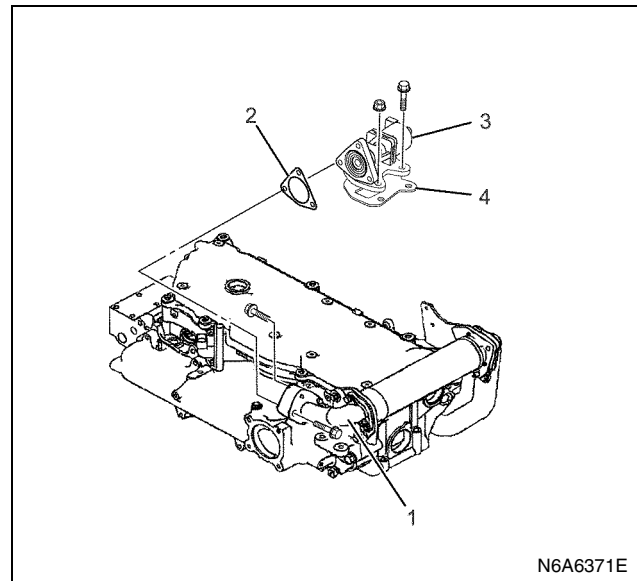
Tighten:

Glow connector to 12 N·m (1.2 kg·m/10 lb·ft)

3. Install the EGR valve and the EGR adapter.

Tighten:

EGR valve and adapter to 24 N·m (2.4 kg·m/17 lb·ft)



Legend

1. EGR Adapter
2. EGR Valve Gasket
3. EGR Valve
4. EGR Valve Gasket

4. Attach the engine harness connectors. Each composite connector should make a loud click when it is securely attached.

Service Precautions

Adequate care should be taken as over-tightening the glow plug could lead to damage.

Explanations on Functions and Operation

The preheating system consists the ECM, the glow relay, glow plugs and the glow indicator lamp. The preheating system is operated when the engine coolant temperature is low, and make the engine easy to start.

Functional check

Refer to Section 6E (Glow Control System Check). Except the glow plug.

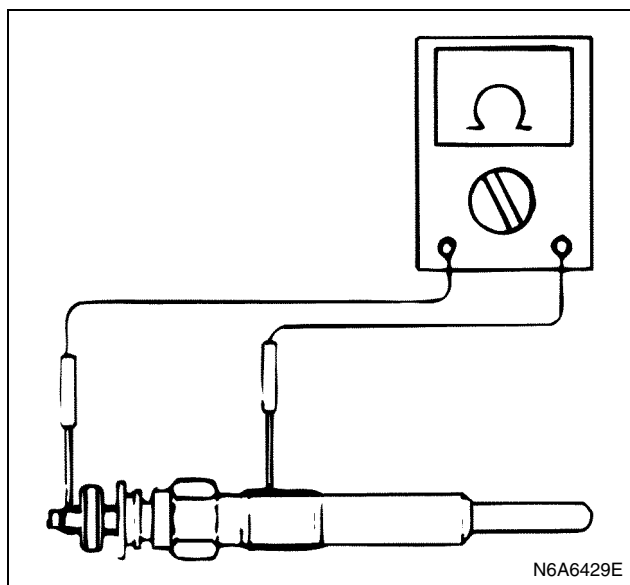
Glow plug check

- Use the circuit tester and measure the resistance of the glow plug.
- If the measured value deviates from the specified value, then replace the glow plug.

Resistance value of glow plug is approximately less than 6Ω.

Caution:

Use a set of four glow plugs from the same manufacturer.



A List of Defective Phenomena

- The glow indicator lamp does not light up.
- Preheating does not work.
- The preheating time is too long or too short.

Trouble Shooting

1. The glow indicator lamp does not light up.

Condition	Possible Cause	Correction
The glow indicator lamp does not light up.	Slow blow fuse has blown.	Replace the slow blow fuse.
	Fuse is unavailable.	Replace the fuse.
	Indicator valve is burnt out.	Replace the indicator valve.
	Engine control system is faulty.	Refer to Section 6E.

2. Preheating does not work.

Condition	Possible Cause	Correction
Preheating does not work.	Slow blow fuse has blown.	Replace the slow blow fuse.
	Defective or faulty glow plug relay connector contact.	Re-mount or replace the glow plug relay.
	Engine control system is faulty.	Refer to Section 6E.

3. Preheating time is too long or too short.

Condition	Possible Cause	Correction
The Preheating time is too long or too short.	Thermosensor fault and break in circuit or short circuit.	Replace the thermosensor. Repair the circuit.
	Fault in glow plug.	Replace or tighten the glow plug.
	Engine control system is faulty.	Refer to Section 6E.

Main Data and Specifications

Preheating device model	Glow plug
Glow plug rated voltage (V)	24