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# ENGINE ELECTRICAL

Click on the applicable bookmark to selected the required model year.

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# ENGINE ELECTRICAL

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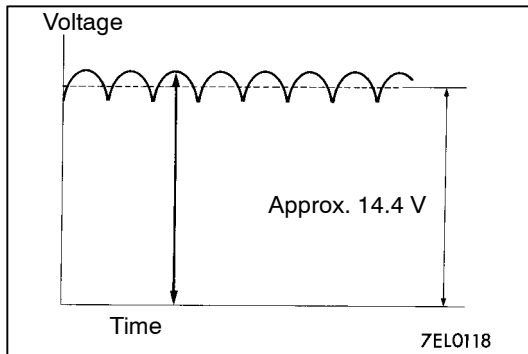
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# CHARGING SYSTEM

16100010433

## GENERAL INFORMATION

The charging system uses the alternator output to keep the battery charged at a constant level under various electrical loads.



## OPERATION

Rotation of the excited field coil generates AC voltage in the stator. This alternating current is rectified through diodes to DC voltage having a waveform shown in the illustration at left. The average output voltage fluctuates slightly with the alternator load condition.

When the ignition switch is turned on, current flows in the field coil and initial excitation of the field coil occurs.

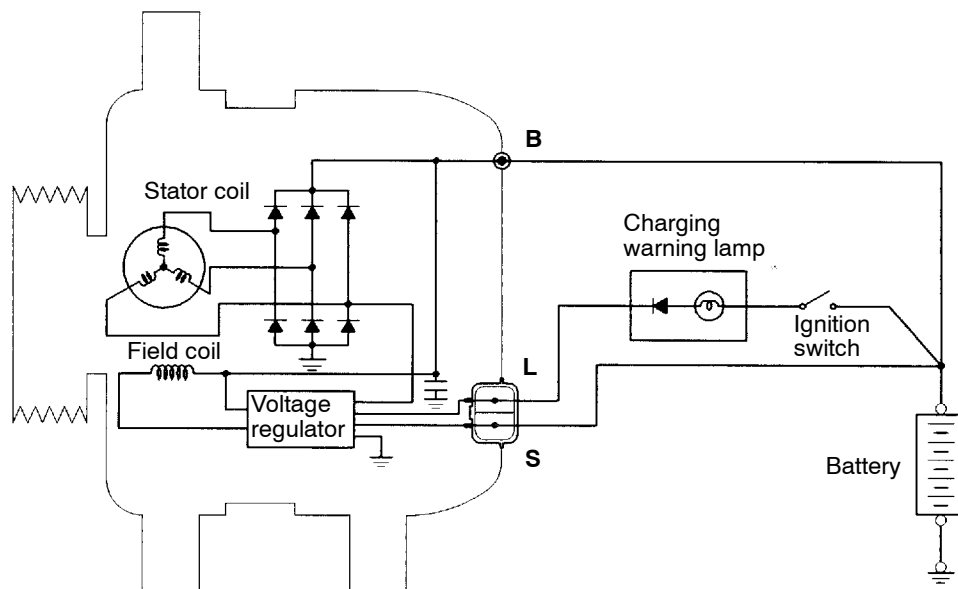
When the stator coil begins to generate power after the engine is started, the field coil is excited by the output current of the stator coil.

The alternator output voltage rises as the field current increases and it falls as the field current decreases. When the battery voltage (alternator S terminal voltage) reaches a regulated voltage

of approximately 14.4 V, the field current is cut off. When the battery voltage drops below the regulated voltage, the voltage regulator regulates the output voltage to a constant level by controlling the field current.

In addition, when the field current is constant, the alternator output voltage rises as the engine speed increases.

## SYSTEM DIAGRAM



7EN1408

**ALTERNATOR SPECIFICATIONS**

Items	6G7	4D5
Type	Battery voltage sensing	Battery voltage sensing
Rated output V/A	12/85	12/75
Voltage regulator	Electronic built-in type	Electronic built-in type

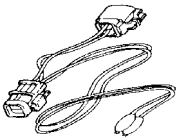
**SERVICE SPECIFICATIONS**

16100030293

Items	Standard value	Limit
Alternator output line voltage drop (at 30A) V	–	Max. 0.3
Regulated voltage ambient temp. at voltage regulator V	–20°C	14.2 – 15.4
	20°C	13.9 – 14.9
	60°C	13.4 – 14.6
	80°C	13.1 – 14.5
Output current	–	70% of normal output current
Rotor coil resistance $\Omega$	Approx. 2 – 5	–
Maximum vacuum (at 3,000 r/min) <4D56> kPa	80	–
Protrusion length of brush mm	–	2

**SPECIAL TOOL**

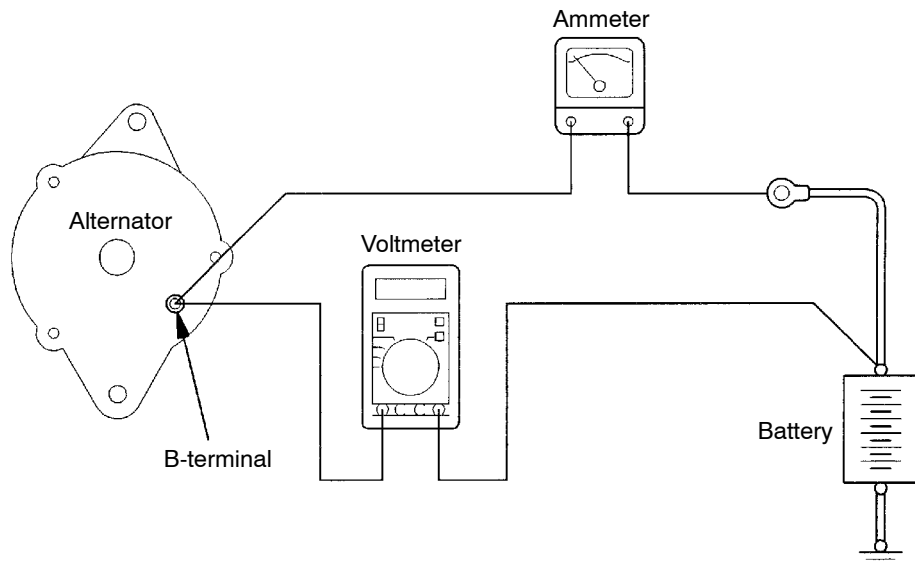
16100060179

Tool	Number	Name	Use
	MD998467	Alternator test harness	Checking the alternator (S terminal voltage)

## ON-VEHICLE SERVICE

16100090512

## ALTERNATOR OUTPUT LINE VOLTAGE DROP TEST



9EN0468

This test determines whether the wiring from the alternator "B" terminal to the battery (+) terminal (including the fusible line) is in a good condition or not.

1. Always be sure to check the following before the test.
  - Alternator installation
  - Alternator drive belt tension (Refer to GROUP 11 – On-vehicle Service.)
  - Fusible link
  - Abnormal noise from the alternator while the engine is running
2. Turn the ignition switch off.
3. Disconnect the negative battery cable.
4. Disconnect the alternator output wire from the alternator "B" terminal and connect a DC test ammeter with a range of 0–100 A in series between the "B" terminal and the disconnected

output wire. (Connect the (+) lead of the ammeter to the "B" terminal, and then connect the (–) lead of the ammeter to the disconnected output wire.)

## NOTE

An inductive-type ammeter which enables measurements to be taken without disconnecting the alternator output wire should be recommended. Using this equipment will lessen the possibility of a voltage drop caused by a loose "B" terminal connection.

5. Connect a digital-type voltmeter between the alternator "B" terminal and the battery (+) terminal. (Connect the (+) lead of the voltmeter to the "B" terminal and the connect the (–) lead of the voltmeter to the battery (+) cable.)

6. Reconnect the negative battery cable.
7. Connect a tachometer or the MUT-II. (Refer to GROUP 11 – On-vehicle Service.)
8. Leave the hood open.
9. Start the engine.
10. With the engine running at 2,500 r/min, turn the headlamps and other lamps on and off to adjust the alternator load so that the value displayed on the ammeter is slightly above 30 A.

Adjust the engine speed by gradually decreasing it until the value displayed on the ammeter is 30 A. Take a reading of the value displayed on the voltmeter at this time.

**Limit: max. 0.3 V**

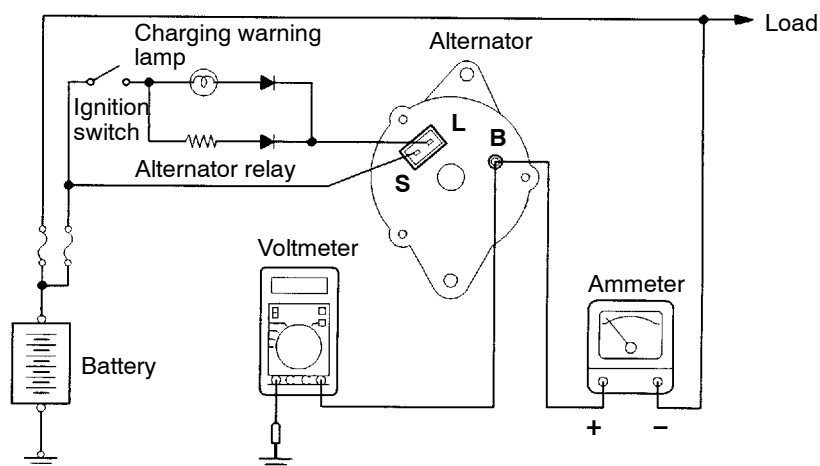
#### NOTE

When the alternator output is high and the value displayed on the ammeter does not decrease until 30 A, set the value to 40 A. Read the value displayed on the voltmeter at this time. When the value range is 40 A, the limit is max. 0.4 V.

11. If the value displayed on the voltmeter is above the limit value, there is probably a malfunction in the alternator output wire, so check the wiring between the alternator “B” terminal and the battery (+) terminal (including fusible link). If a terminal is not sufficiently tight or if the harness has become discolored due to overheating, repair and then test again.
12. After the test, run the engine at idle.
13. Turn off all lamps and the ignition switch.
14. Remove the tachometer or the MUT-II.
15. Disconnect the negative battery cable.
16. Disconnect the ammeter and voltmeter.
17. Connect the alternator output wire to the alternator “B” terminal.
18. Connect the negative battery cable.

## OUTPUT CURRENT TEST

16100100536



7EN0987

This test determines whether the alternator output current is normal.

1. Before the test, always be sure to check the following.

- Alternator installation
- Battery (Refer to GROUP 54 – Battery.)

**NOTE**

The battery should be slightly discharged. The load needed by a fully-charged battery is insufficient for an accurate test.

- Alternator drive belt tension (Refer to GROUP 11 – On-vehicle Service.)
  - Fusible link
  - Abnormal noise from the alternator while the engine is running.
2. Turn the ignition switch off.
  3. Disconnect the negative battery cable.
  4. Disconnect the alternator output wire from the alternator “B” terminal. Connect a DC test ammeter with a range of 0–100 A in series between the “B” terminal and the disconnected output wire. (Connect the (+) lead of the ammeter to the “B” terminal. Connect the (–) lead of the ammeter to the disconnected output wire.)

**Caution**

**Never use clips but tighten bolts and nuts to connect the line. Otherwise loose connections (e.g. using clips) will lead to a serious accident because of high current.**

**NOTE**

An inductive-type ammeter which enables measurements to be taken without disconnecting the alternator output wire should be recommended.

5. Connect a voltmeter with a range of 0–20 V between the alternator “B” terminal and the earth. (Connect the (+) lead of the voltmeter to the “B” terminal, and then connect the (–) lead of the voltmeter to the earth.)
6. Connect the negative battery cable.
7. Connect a tachometer or the MUT-II. (Refer to GROUP 11 – On-vehicle Service.)
8. Leave the hood open.
9. Check that the reading on the voltmeter is equal to the battery voltage.

**NOTE**

If the voltage is 0 V, the cause is probably an open circuit in the wire or fusible link between the alternator “B” terminal and the battery (+) terminal.

10. Turn the light switch on to turn on headlamps and then start the engine.
11. Immediately after setting the headlamps to high beam and turning the heater blower switch to the high revolution position, increase the engine speed to 2,500 r/min and read the maximum current output value displayed on the ammeter.

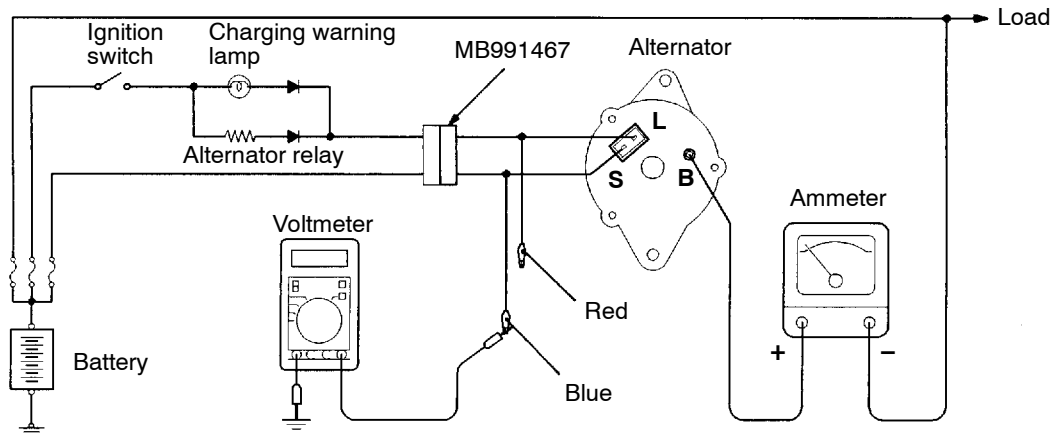
**Limit: 70% of normal current output**

**NOTE**

- For the nominal current output, refer to the Alternator Specifications.
  - Because the current from the battery will soon drop after the engine is started, the above step should be carried out as quickly as possible in order to obtain the maximum current output value.
  - The current output value will depend on the electrical load and the temperature of the alternator body.
  - If the electrical load is small while testing, the specified level of current may not be output even though the alternator is normal. In such cases, increase the electrical load by leaving the headlamps turned on for some time to discharge the battery or by using the lighting system in another vehicle, and then test again.
  - The specified level of current also may not be output if the temperature of the alternator body or the ambient temperature is too high. In such cases, cool the alternator and then test again.
12. The reading on the ammeter should be above the limit value. If the reading is below the limit value and the alternator output wire is normal, remove the alternator from the engine and check the alternator.
  13. Run the engine at idle after the test.
  14. Turn the ignition switch off.
  15. Remove the tachometer or the MUT-II.
  16. Disconnect the negative battery cable.
  17. Disconnect the ammeter and voltmeter.
  18. Connect the alternator output wire to the alternator “B” terminal.
  19. Connect the negative battery cable.

## REGULATED VOLTAGE TEST

16100110539



7EN0988

This test determines whether the voltage regulator is correctly controlling the alternator output voltage.

1. Always be sure to check the following before the test.
  - Alternator installation
  - Check that the battery installed in the vehicle is fully charged. (Refer to GROUP 54 – Battery.)
  - Alternator drive belt tension (Refer to GROUP 11 – On-vehicle Service.)
  - Fusible link
  - Abnormal noise from the alternator while the engine is running
2. Turn the ignition switch to the OFF position.
3. Disconnect the negative battery cable.
4. Use the special tool (Alternator test harness: MB991467) to connect a digital voltmeter between the alternator S terminal and earth. (Connect the (+) lead of the voltmeter to the "S" terminal, and then connect the (–) lead of the voltmeter to a secure earth or to the battery (–) terminal.)
5. Disconnect the alternator output wire from the alternator "B" terminal.

6. Connect a DC test ammeter with a range of 0–100 A in series between the "B" terminal and the disconnected output wire. (Connect the (+) lead of the ammeter to the "B" terminal. Connect the (–) lead of the ammeter to the disconnected output wire.)
7. Reconnect the negative battery cable.
8. Connect a tachometer or the MUT-II. (Refer to GROUP 11 – On-vehicle Service.)
9. Turn the ignition switch to the ON position and check that the reading on the voltmeter is equal to the battery voltage.

## NOTE

If the voltage is 0 V, the cause is probably an open circuit in the wire or fusible link between the alternator "S" terminal and the battery (+) terminal.

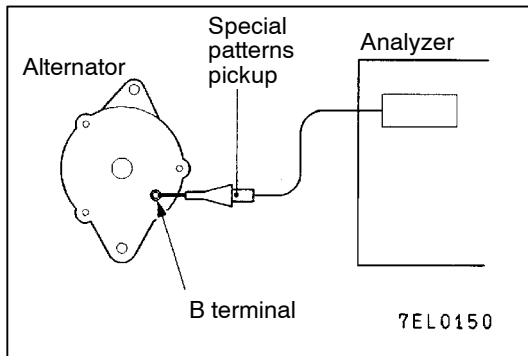
10. Turn all lamps and accessories off.
11. Start the engine.
12. Increase the engine speed to 2,500 r/min.
13. Read the value displayed on the voltmeter when the alternator output current alternator becomes 10 A or less.



14. If the voltage reading conforms to the value in the voltage regulation, then the voltage regulator is operating normally.  
If the voltage is not within the standard value, there is a malfunction of the voltage regulator or of the alternator.
15. After the test, lower the engine speed to the idle speed.
16. Turn the ignition switch off.
17. Remove the tachometer or the MUT-II.
18. Disconnect the negative battery cable.
19. Disconnect the ammeter and voltmeter.
20. Connect the alternator output wire to the alternator "B" terminal.
21. Remove the special tool, and return the connector to the original condition.
22. Connect the negative battery cable.

**Voltage Regulation Table****Standard value:**

Inspection terminal	Voltage regulator ambient temperature °C	Voltage V
Terminal "S"	-20	14.2 – 15.4
	20	13.9 – 14.9
	60	13.4 – 14.6
	80	13.1 – 14.5

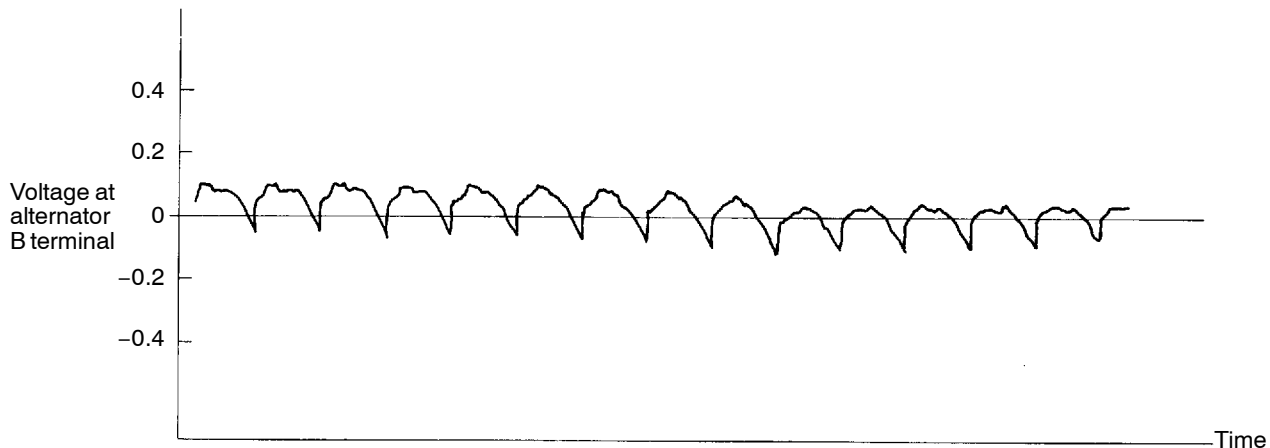
**WAVEFORM CHECK USING AN ANALYZER****MEASUREMENT METHOD**

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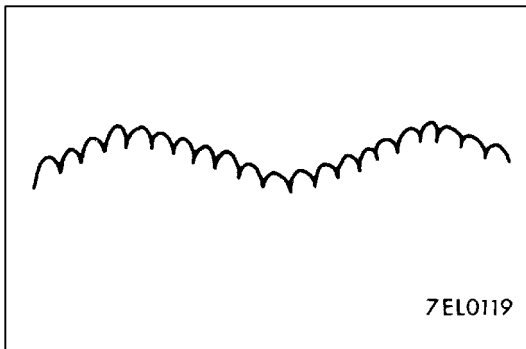
Connect the analyzer special patterns pick-up to the alternator B terminal.

**STANDARD WAVEFORM****Observation Conditions**

FUNCTION	SPECIAL PATTERNS
PATTERN HEIGHT	VARIABLE
VARIABLE knob	Adjust while viewing the waveform.
PATTERN SELECTOR	RASTER
Engine speed	Curb idle speed



7EL0115

**NOTE**






The voltage waveform of the alternator B terminal can undulate as shown at left. This waveform is produced when the regulator operates according to fluctuations in the alternator load (current), and is normal for the alternator.

In addition, when the voltage waveform reaches an excessively high value (approx. 2 V or higher at idle), it often indicates an open circuit due to a blown fuse between alternator B terminal and battery, but not a defective alternator.

## EXAMPLES OF ABNORMAL WAVEFORMS

## NOTE

1. The size of the waveform patterns differs largely, depending on the adjustment of the variable knob on the analyzer.
2. Identification of abnormal waveforms is easier when there is a large output current (regulator is not operating). (Waveforms can be observed when the headlamps are illuminated.)
3. Check the conditions of the charging warning lamp (illuminated/not illuminated). Also, check the charging system totally.

Abnormal waveforms	Problem cause	Abnormal waveforms	Problem cause
<p>Example 1</p>  <p>A7EL0120</p>	Open diode	<p>Example 4</p>  <p>A7EL0123</p>	Short in stator coil
<p>Example 2</p>  <p>A7EL0121</p>	Short in diode	<p>Example 5</p>  <p>A7EL0124</p>	Open supplementary diode
<p>Example 3</p>  <p>A7EL0122</p>	Broken wire in stator coil	<p>NOTE</p> <p>At this time, the charging warning lamp is illuminated.</p>	

**ALTERNATOR**

16100140521

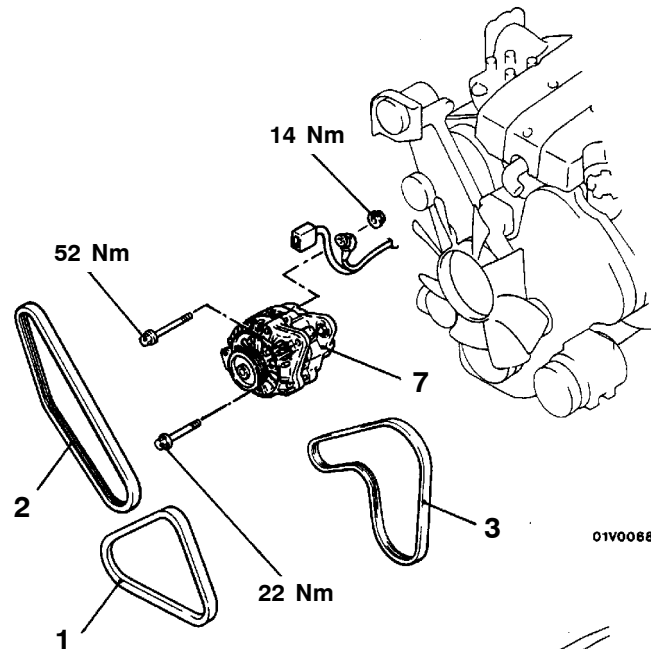
**REMOVAL AND INSTALLATION****Pre-removal Operation**

- Under Cover Removal

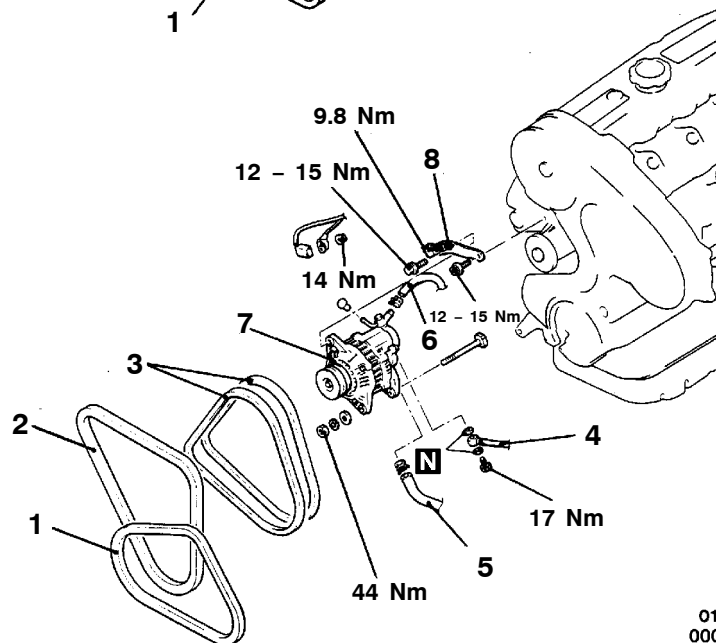
**Post-installation Operation**

- Drive Belt Tension Adjustment (Refer to GROUP 11 – On-vehicle Service.)
- Under Cover Installation

&lt;6G7&gt;



&lt;4D5&gt;

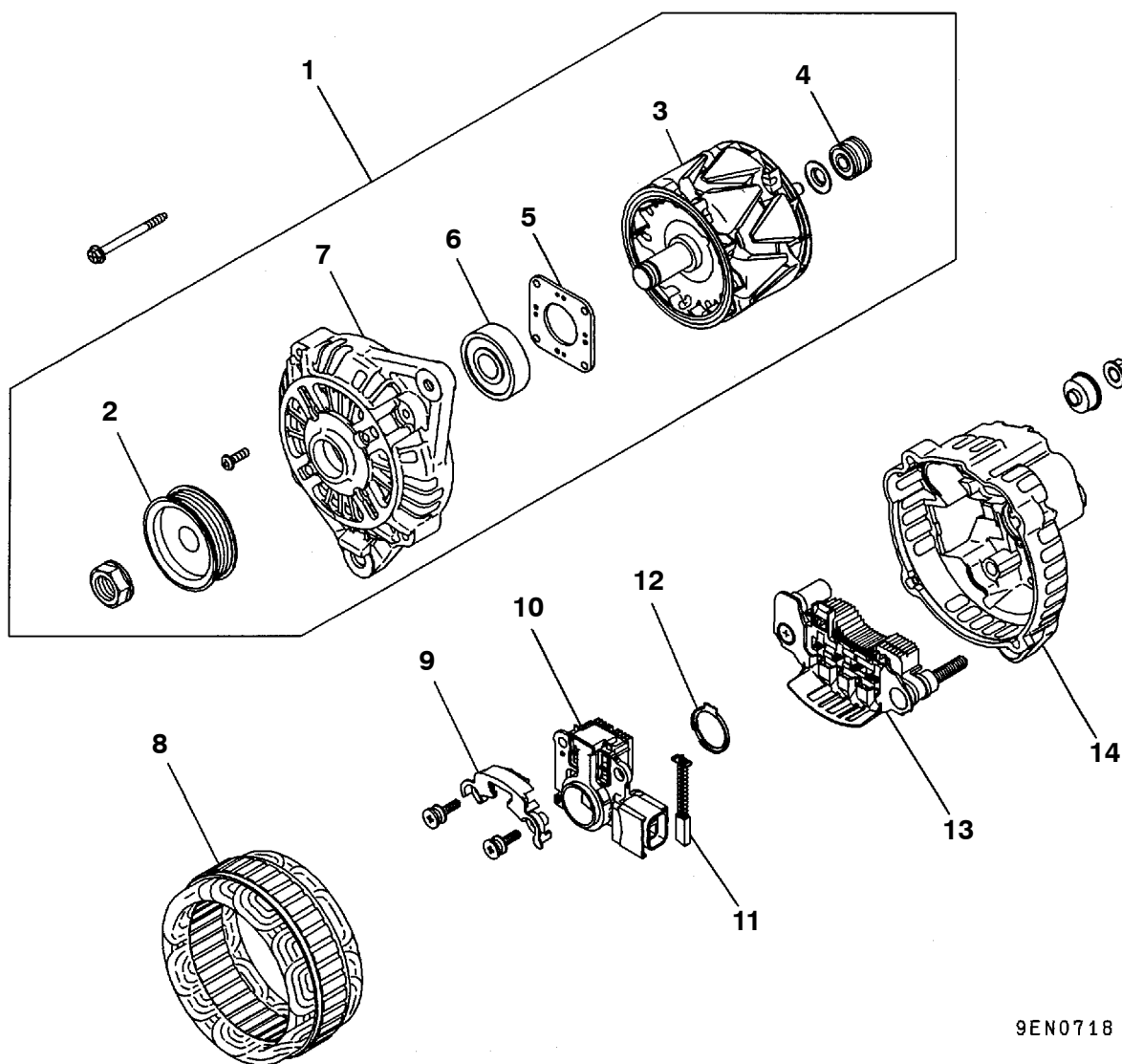
**Removal steps**

1. Drive bolt (for A/C)
2. Drive belt (for power steering)
3. Drive belt (for alternator)
4. Oil pipe connection
5. Oil return hose connection
6. Vacuum hose connection
7. Alternator
8. Alternator brace assembly

## DISASSEMBLY AND REASSEMBLY

16100160336

&lt;6G7&gt;



9EN0718

**Disassembly steps**

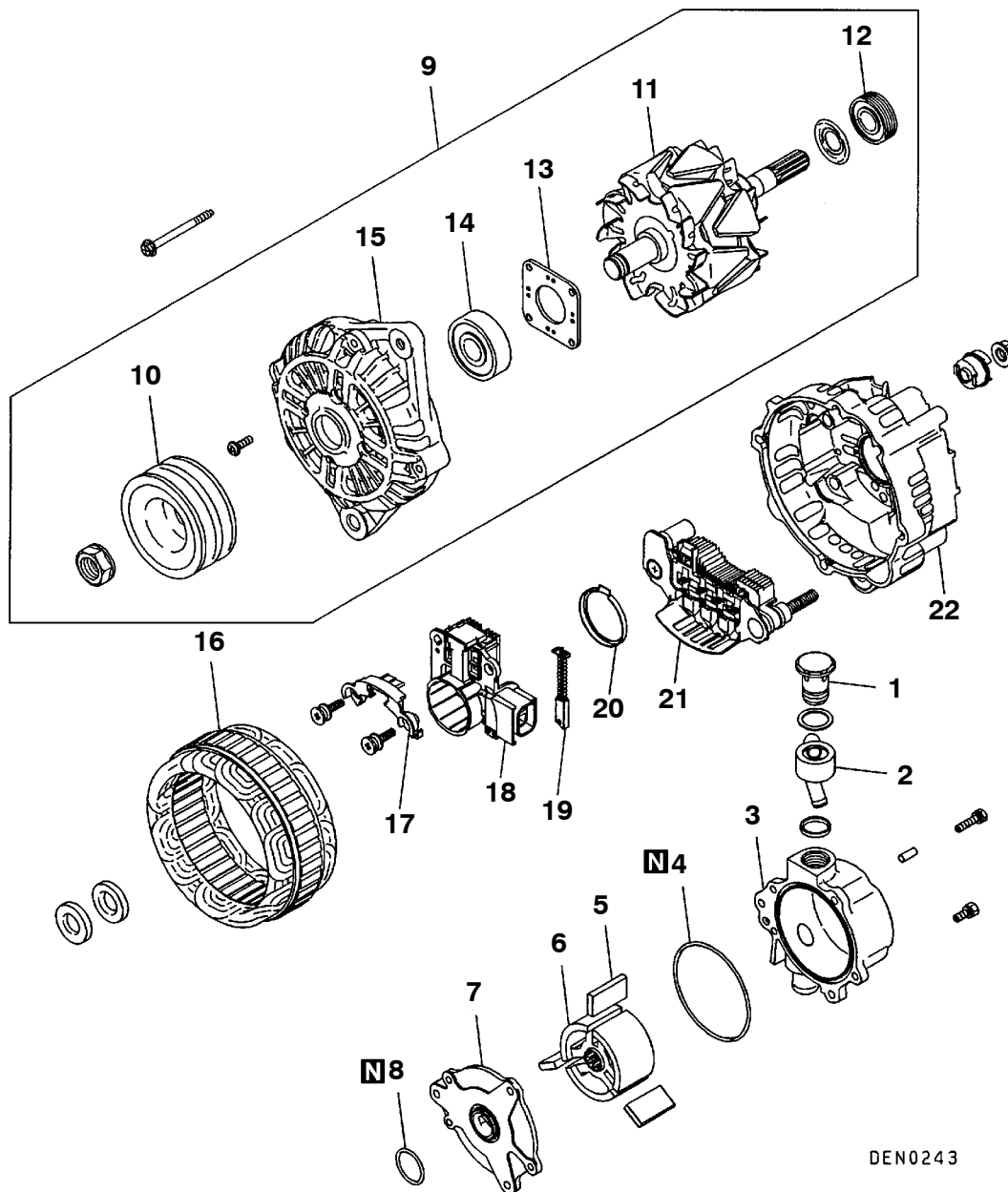
1. Front bracket assembly
2. Pulley
3. Rotor
4. Rear bearing
5. Bearing retainer
6. Front bearing
7. Front bracket



8. Stator
9. Plate
10. Regulator assembly
11. Brush
12. Slinger
13. Rectifier assembly
14. Rear bracket

## DISASSEMBLY AND REASSEMBLY

&lt;4D5&gt;



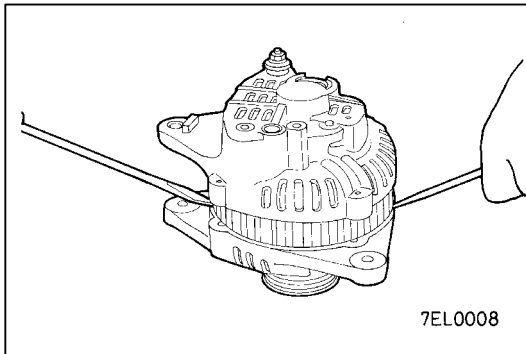
DEN0243

## Disassembly steps

1. Check valve
2. Nipple
3. Vacuum pump housing
4. O-ring
5. Vane
6. Rotor
7. Vacuum pump plate
8. O-ring
9. Front bracket assembly
10. Pulley
11. Rotor

12. Rear bearing
13. Bearing retainer
14. Front bearing
15. Front bracket
16. Stator
17. Plate
18. Regulator assembly
19. Brush
20. Slinger
21. Rectifier assembly
22. Rear bracket

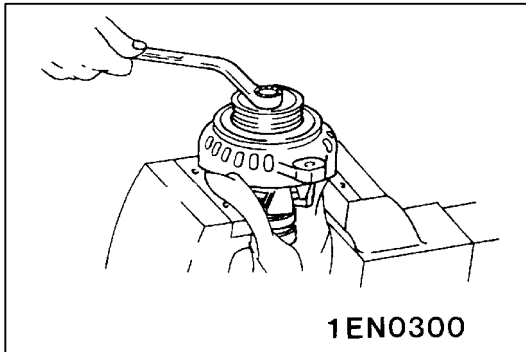


**DISASSEMBLY SERVICE POINTS****◀A▶ FRONT BRACKET REMOVAL**

1. Remove the bolts.
2. Insert a flat-tipped screwdriver between front bracket and stator core and pry downwards.

**Caution**

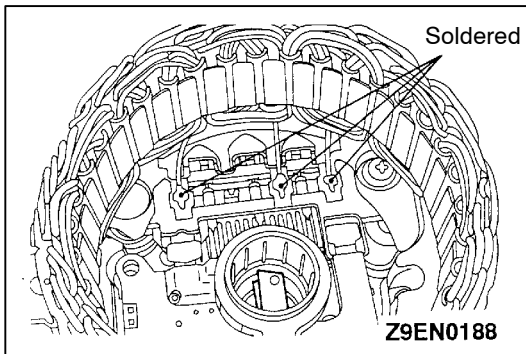
Do not insert a screwdriver too deep, as the stator coil will be damaged.

**◀B▶ PULLEY REMOVAL**

With the pulley side facing up, hold the rotor in a vice and remove the pulley.

**Caution**

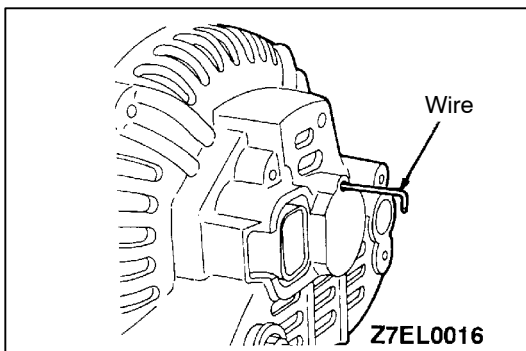
Use care not to damage the rotor.

**◀C▶ STATOR REMOVAL/REGULATOR ASSEMBLY REMOVAL**

1. When removing stator, unsolder three stator leads soldered to main diodes on rectifier.
2. When removing rectifier from brush holder, unsolder two soldered points to rectifier.

**Caution**

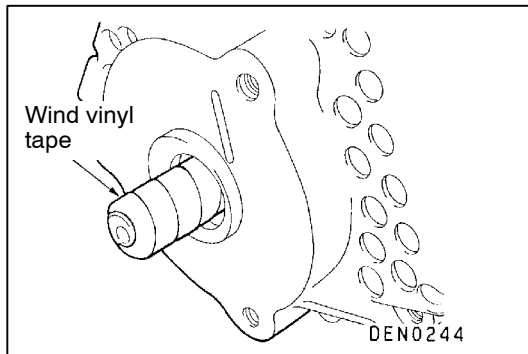
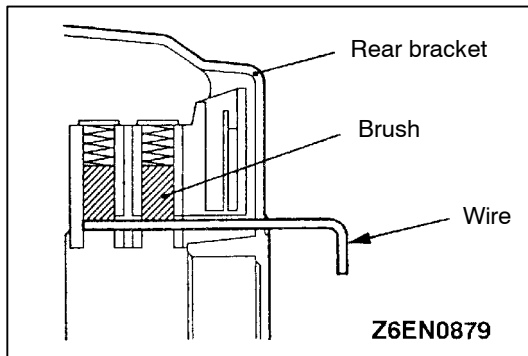
- (1) When soldering or unsoldering, use care to make sure that heat of soldering iron is not transmitted to diodes for a long period. Finish soldering or unsoldering in as short a time as possible.
- (2) Use care that no undue force is exerted to leads of diodes.

**REASSEMBLY SERVICE POINT****▶A◀ REGULATOR ASSEMBLY INSTALLATION**

Install the regulator assembly, insert a wire into the rear bracket hole while pushing in the brush, and hold the brush.

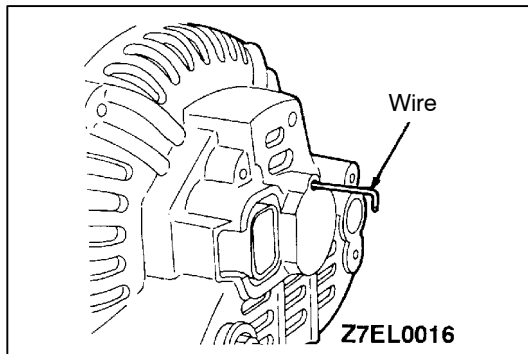
**NOTE**

Inserting a wire holds the brush, so that the rotor can be replaced easily.

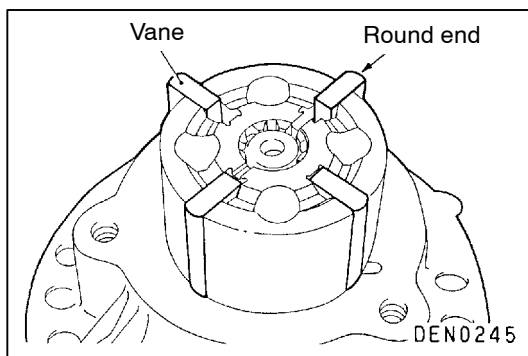


### ►B◄ ROTOR INSTALLATION

1. When installing the rotor on the alternator rear bracket, wrap vinyl tape around the splined shaft to prevent damage to the oil seal. <4D5>

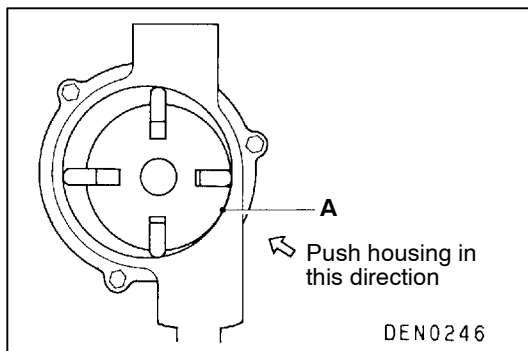


2. After rotor has been installed, remove the wire.



### ►C◄ ROTOR/VANES INSTALLATION <4D5>

1. Carefully check the housing, rotor, etc. for chips and foreign matter. Then, apply engine oil and install.
2. Install the vanes with the round end facing outward.
3. Apply grease to the O-ring and fit in the housing groove so that it will not come out from the groove when the bolts are tightened.



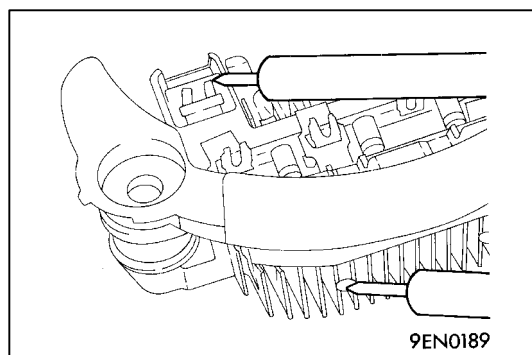
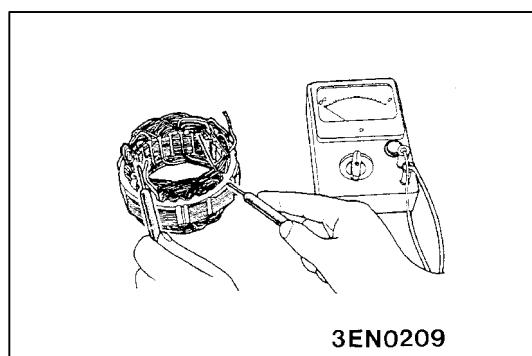
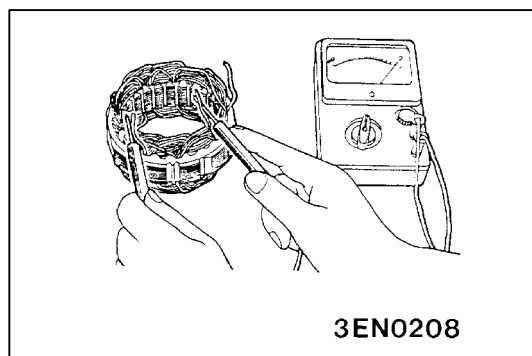
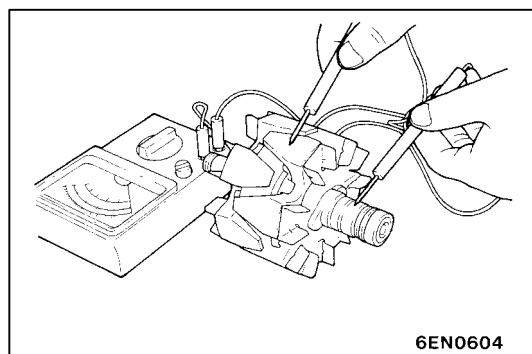
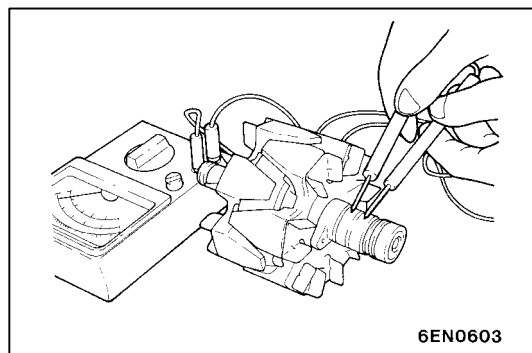
4. When tightening the housing, lightly push it in the direction of arrow so as to minimize the clearance at "A" and tighten the bolts uniformly.

#### NOTE

After assembly, be sure to conduct a performance test to check to see that the maximum vacuum is as specified below.

**Standard value of maximum vacuum:**  
**80.00 kPa or greater at 3,000 r/min**





## INSPECTION

16100170162

### ROTOR

1. Check rotor coil for continuity. Check that there is no continuity between slip rings. If resistance is too small, it means that there is a short circuit. If there is no continuity or if there is a short circuit, replace rotor assembly.

**Resistance value: Approx. 2 – 5  $\Omega$**

2. Check rotor coil for earthing. Check that there is no continuity between slip ring and core. If there is continuity, replace rotor assembly.

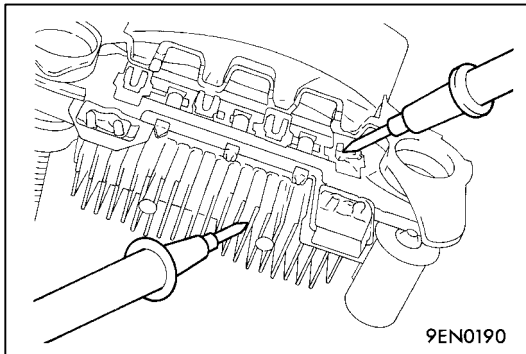
### STATOR

1. Make continuity test on stator coil. Check that there is continuity between coil leads. If there is no continuity, replace stator assembly.

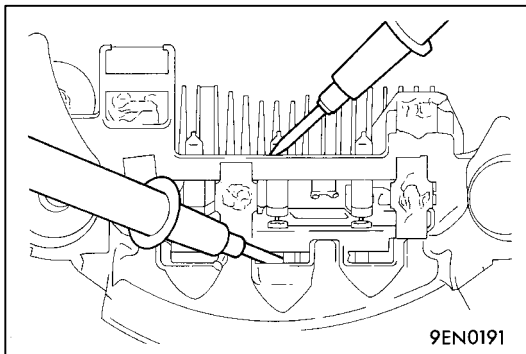
2. Check coil for earthing. Check that there is no continuity between coil and core. If there is continuity, replace stator assembly.

### RECTIFIERS

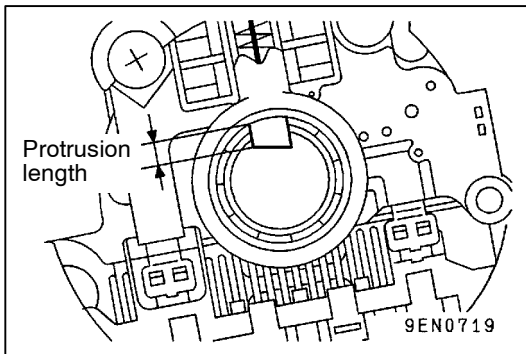
1. Check for continuity between positive rectifier and stator coil lead connection terminal with an ohmmeter. If there is continuity in both directions, diode is shorted. Replace rectifier assembly.



2. Check for continuity between negative rectifier and stator coil lead connection terminal. If there is continuity in both directions, diode is shorted, and rectifier assembly must be replaced.



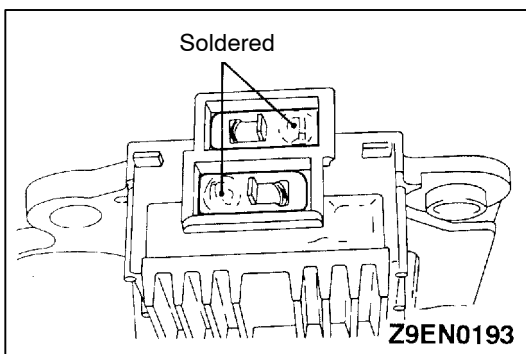
3. Check three diodes for continuity by connecting an ammeter to both ends of each diode. If there is no continuity in both directions, diode is faulty and heatsink assembly must be replaced.



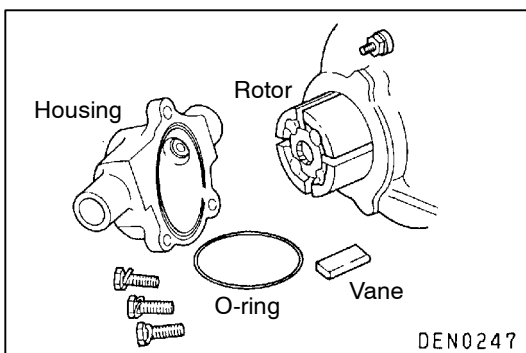
### BRUSH

1. Replace the brush if its protrusion length is less than the limit.

**Limit: min. 2 mm**



2. Unsolder pigtail and remove old brush and spring.



### VACUUM PUMP

Check the following and replace if defective.

1. Check the rotor ends for streaks or damage.
2. Check the housing surface in contact with the rotor for streaks or damage.
3. Check the vanes for damage or breaks.

# STARTING SYSTEM

16200010368

## GENERAL INFORMATION

If the ignition switch is turned to the "START" position, current flows in the pull-in and holding provided inside magnetic switch, attracting the plunger. When the plunger is attracted, the lever connected to the plunger is actuated to engage the starter clutch.

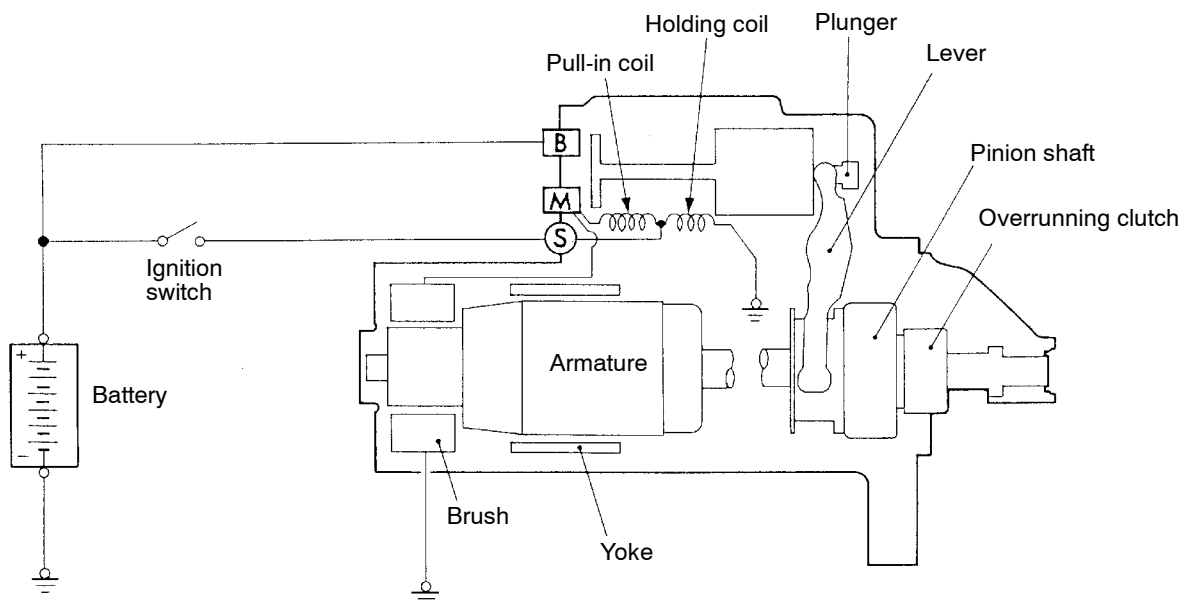
On the other hand, attracting the plunger will turn on the magnetic switch, allowing the B terminal

and M terminal to conduct. Thus, current flows to engage the starter motor.

When the ignition switch is returned to the "ON" position after starting the engine, the starter clutch is disengaged from the ring gear.

An overrunning clutch is provided between the pinion and the armature shaft, to prevent damage to the starter.

## SYSTEM DIAGRAM



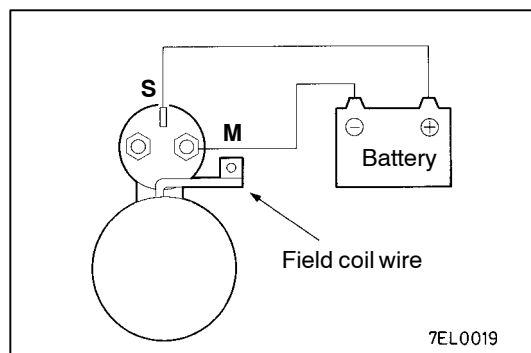
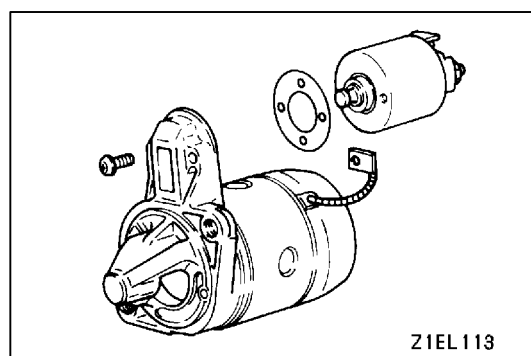
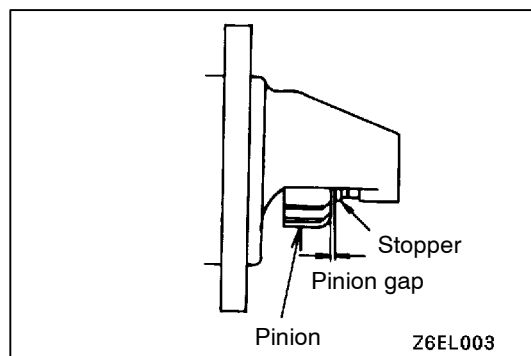
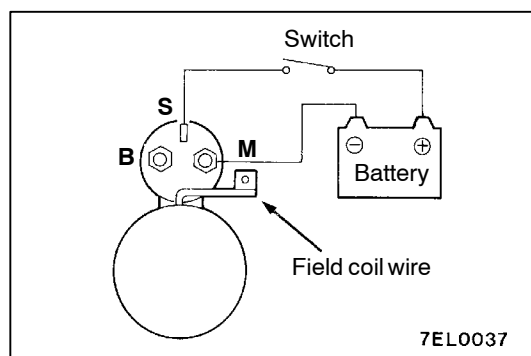
6EN0939

## STARTER MOTOR SPECIFICATIONS

Items	6G7	4D5
Type	Reduction drive with planetary gear	Reduction drive with planetary gear
Rated output kW/V	1.2/12	2.2/12
No. of pinion teeth	8	12

## SERVICE SPECIFICATIONS

Items	Standard value	Limit
Pinion gap mm	0.5 – 2.0	–
Commutator outer diameter mm	29.4	28.8
Commutator runout mm	–	0.05
Commutator undercut mm	0.5	0.2



## STARTER MOTOR

16200110327

### INSPECTION

#### PINION GAP ADJUSTMENT

1. Disconnect field coil wire from M-terminal of magnetic switch.
2. Connect a 12V battery between S-terminal and M-terminal.
3. Set switch to "ON", and pinion will move out.

#### Caution

**This test must be performed quickly (in less than 10 seconds) to prevent coil from burning.**

4. Check pinion to stopper clearance (pinion gap) with a thickness gauge.

**Standard value: 0.5 – 2.0 mm**

5. If pinion gap is out of specification, adjust by adding or removing gaskets between magnetic switch and front bracket.

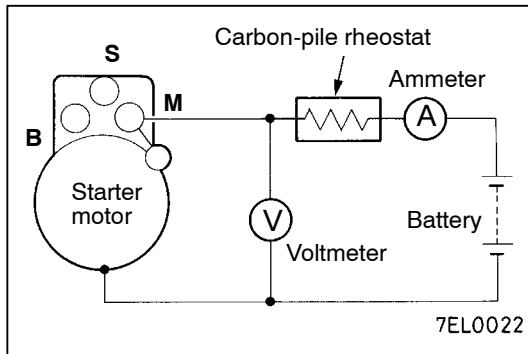
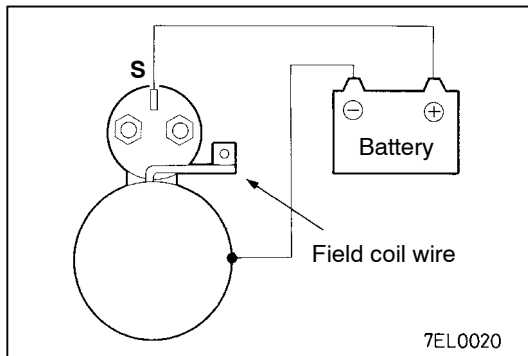
#### MAGNETIC SWITCH PULL-IN TEST

1. Disconnect field coil wire from M-terminal of magnetic switch.
2. Connect a 12V battery between S-terminal and M-terminal.

#### Caution

**This test must be performed quickly (in less than 10 seconds) to prevent coil from burning.**

3. If pinion moves out, then pull-in coil is good. If it doesn't, replace magnetic switch.



### MAGNETIC SWITCH HOLD-IN TEST

1. Disconnect field coil wire from M-terminal of magnetic switch.
2. Connect a 12V battery between S-terminal and body.

#### Caution

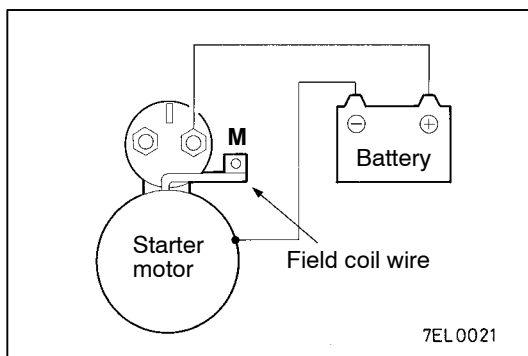
**This test must be performed quickly (in less than 10 seconds) to prevent coil from burning.**

3. Manually pull out the pinion as far as the pinion stopper position.
4. If pinion remains out, everything is in order. If pinion moves in, hold-in circuit is open. Replace magnetic switch.

### FREE RUNNING TEST

1. Place starter motor in a vise equipped with soft jaws and connect a fully-charged 12-volt battery to starter motor as follows:
2. Connect a test ammeter (100-ampere scale) and carbon pile rheostat in series with battery positive post and starter motor terminal.
3. Connect a voltmeter (15-volt scale) across starter motor.
4. Rotate carbon pile to full-resistance position.
5. Connect battery cable from battery negative post to starter motor body.
6. Adjust the rheostat until the battery voltage shown by the voltmeter is 11 V.
7. Confirm that the maximum amperage is within the specifications and that the starter motor turns smoothly and freely.

**Current: max. 90 Amps**



### MAGNETIC SWITCH RETURN TEST

1. Disconnect field coil wire from M-terminal of magnetic switch.
2. Connect a 12V battery between M-terminal and body.

#### Caution

**This test must be performed quickly (in less than 10 seconds) to prevent coil from burning.**

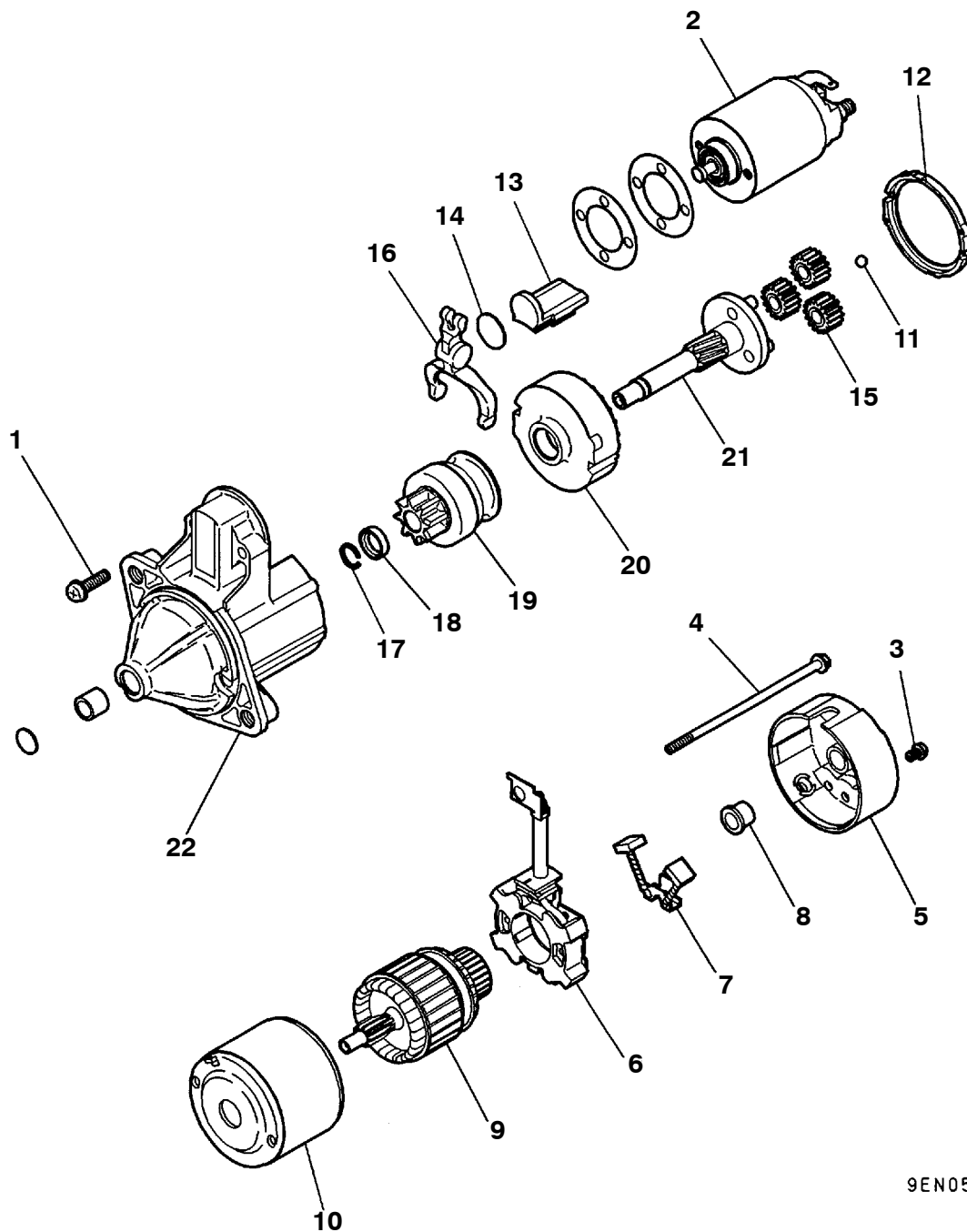
3. Pull pinion out and release. If pinion quickly returns to its original position, everything is in order. If it doesn't, replace magnetic switch.

#### Caution

**Be careful not to get your fingers caught when pulling out the pinion.**

## DISASSEMBLY AND REASSEMBLY &lt;6G7&gt;

16200120290



9EN0541

**Disassembly steps**

◀A▶

1. Screw
2. Magnetic switch
3. Screw
4. Screw
5. Rear bracket
6. Brush holder
7. Brush
8. Rear bearing
9. Armature
10. Yoke assembly
11. Ball

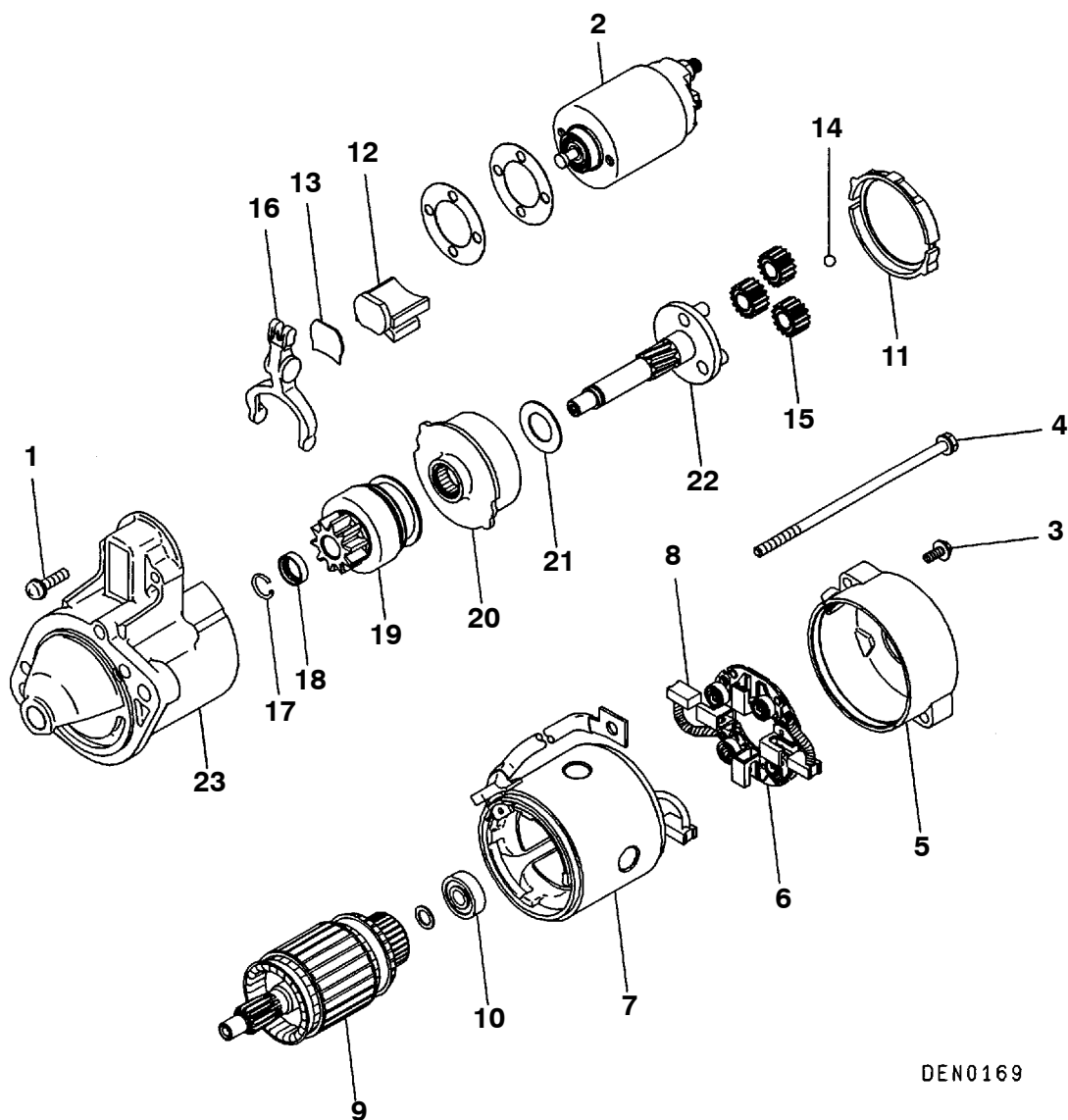
◀B▶

◀B▶

◀C▶  
◀C▶▶A▶  
▶A▶

12. Packing A
13. Packing B
14. Plate
15. Planetary gear
16. Lever
17. Snap ring
18. Stop ring
19. Overrunning clutch
20. Internal gear
21. Planetary gear holder
22. Front bracket

## DISASSEMBLY AND REASSEMBLY &lt;4D5&gt;



DEN0169

## Disassembly steps

◀A▶

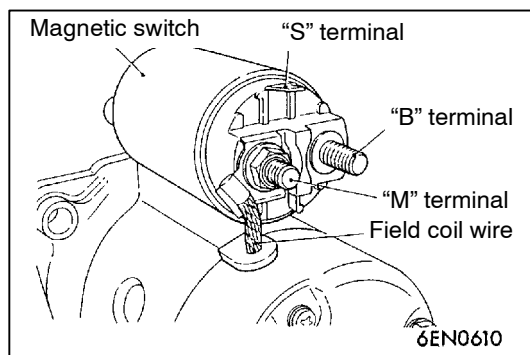
1. Screw
2. Magnetic switch
3. Screw
4. Screw
5. Rear bracket
6. Brush holder
7. Yoke assembly
8. Brush
9. Armature
10. Bearing
11. Packing A
12. Packing B

◀B▶

◀C▶

▶A▶

13. Plate
14. Ball
15. Planetary gear
16. Lever
17. Snap ring
18. Stop ring
19. Overrunning clutch
20. Internal gear
21. Washer
22. Planetary gear holder
23. Front bracket



## DISASSEMBLY SERVICE POINTS

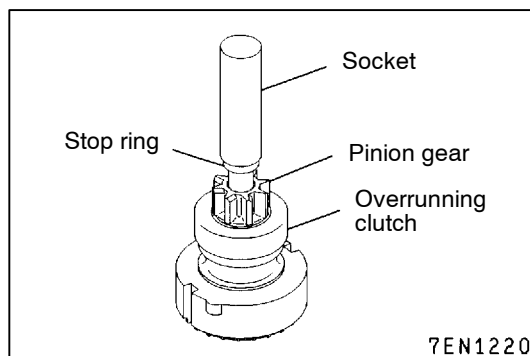
### ◀A▶ MAGNETIC SWITCH REMOVAL

Disconnect field coil wire from "M" terminal of magnetic switch.

### ◀B▶ ARMATURE/BALL REMOVAL

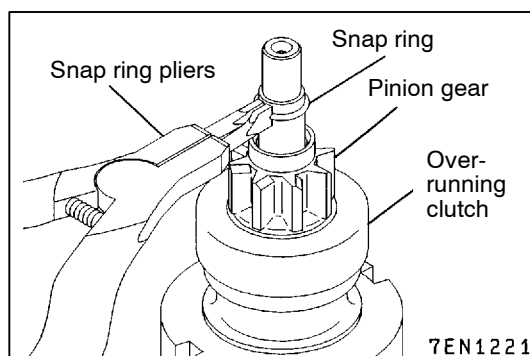
#### Caution

When removing the armature, take care not to lose the ball (which is used as a bearing) in the armature end.



### ◀C▶ SNAP RING/STOP RING REMOVAL

1. Press stop ring off snap ring with a suitable socket.

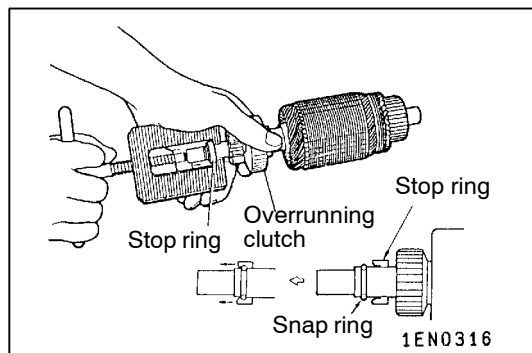


2. Remove snap ring with snap ring pliers and then remove stop ring and overrunning clutch.

## STARTER MOTOR PARTS CLEANING

1. Do not immerse parts in cleaning solvent. Immersing the yoke and field coil assembly and/or armature will damage insulation. Wipe motor assembly with a cloth only.
2. Do not immerse drive unit in cleaning solvent. Overrunning clutch is pre-lubricated at the factory and solvent will wash lubrication from clutch.
3. The drive unit may be cleaned with a brush moistened with cleaning solvent and wiped dry with a cloth.

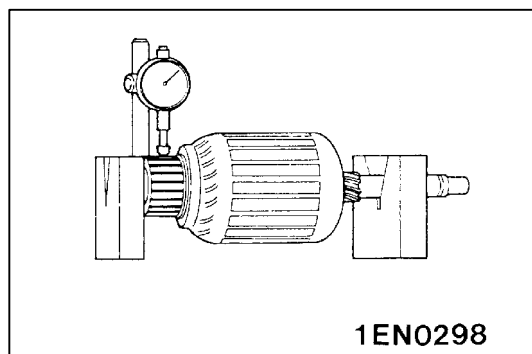




## REASSEMBLY SERVICE POINTS

### ►A◄ STOP RING/SNAP RING INSTALLATION

Using a suitable pulling tool, pull overrunning clutch stop ring over snap ring.



## INSPECTION

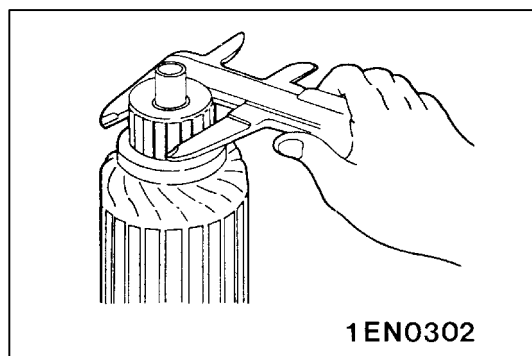
16200130286

### COMMUTATOR CHECK

1. Place the armature in a pair of "V" blocks and check the runout with a dial indicator.

**Standard value: 0.05 mm**

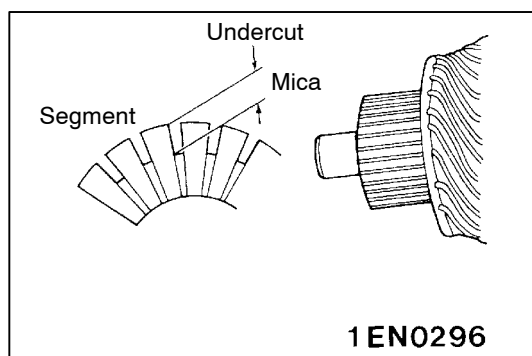
**Limit: 0.1 mm**



2. Measure the commutator outer diameter.

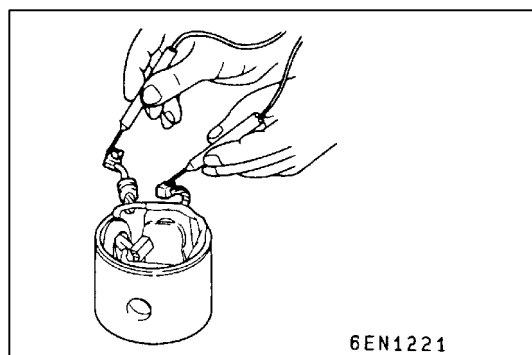
**Standard value: 32.0 mm**

**Limit: 31.0 mm**



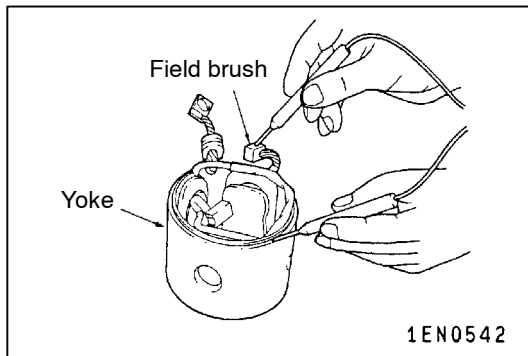
3. Check the undercut depth between segments.

**Standard value: 0.5 mm**

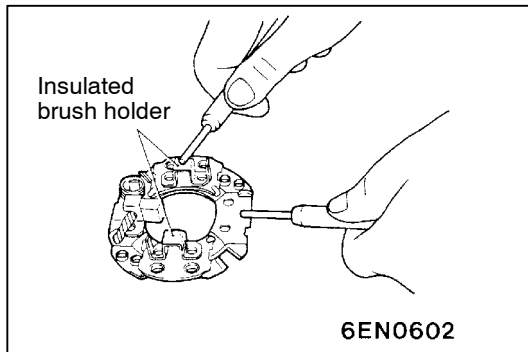


### FIELD COIL OPEN-CIRCUIT TEST <4D5>

Check the continuity between field brushes. If there is continuity, the field coil is in order.

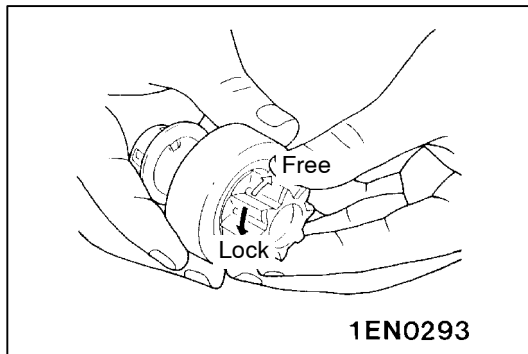
**FIELD COIL GROUND TEST <4D5>**

Check the continuity between field coil brush and yoke. If there is no continuity, the field coil is free from earth.

**BRUSH HOLDER CHECK**

Check the continuity between brush holder plate and brush holder.

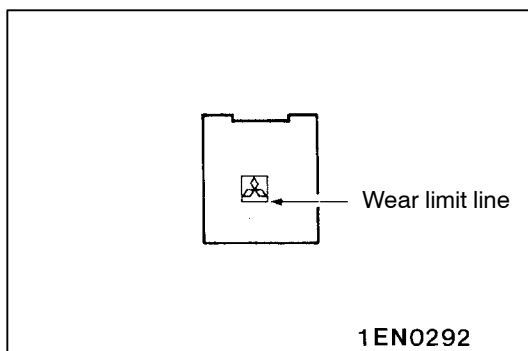
If there is no continuity, the brush holder is in order.

**OVERRUNNING CLUTCH CHECK**

1. While holding clutch housing, rotate the pinion. Drive pinion should rotate smoothly in one direction, but should not rotate in opposite direction. If clutch does not function properly, replace overrunning clutch assembly.
2. Inspect pinion for wear or burrs. If pinion is worn or burred, replace overrunning clutch assembly. If pinion is damaged, also inspect ring gear for wear or burrs.

**FRONT AND REAR BRACKET BUSHING CHECK**

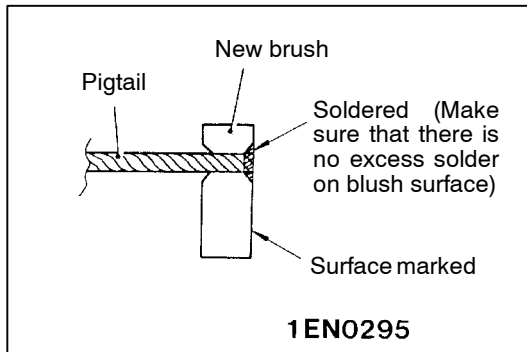
Inspect bushing for wear or burrs. If bushing is worn or burred, replace front bracket assembly or rear bracket assembly.

**BRUSH AND SPRING REPLACEMENT****<6G7>**

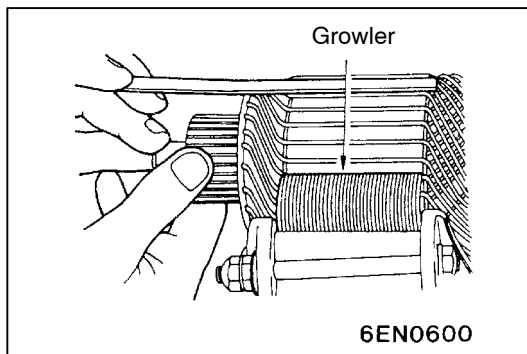
1. Brushes that are worn beyond wear limit line, or oil-soaked, should be replaced.
2. When replacing ground brush, slide the brush from brush holder by prying retaining spring back.

## &lt;4D5&gt;

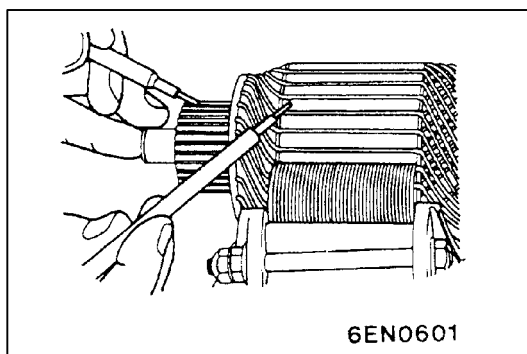
1. Brushes that are worn beyond wear limit line, or are oil-soaked, should be replaced.
2. When replacing field coil brushes, crush worn brush with pliers, taking care not to damage pigtail.



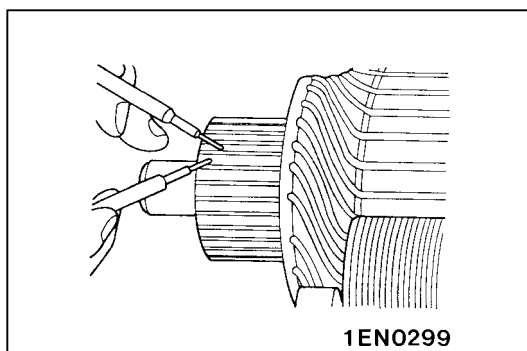
3. Sand pigtail end with sandpaper to ensure good soldering.
4. Insert pigtail into hole provided in new brush and solder it.  
Make sure that pigtail and excess solder do not come out onto brush surface.
5. When replacing ground brush, slide the brush from brush holder by prying retainer spring back.

**ARMATURE TEST****ARMATURE SHORT-CIRCUIT TEST**

1. Place armature in a growler.
2. Hold a thin steel blade parallel and just above while rotating armature slowly in growler. A shorted armature will cause blade to vibrate and be attracted to the core. Replace shorted armature.

**ARMATURE COIL EARTH TEST**

Check the insulation between each commutator segment and armature coil core.  
If there is no continuity, the insulation is in order.

**ARMATURE COIL OPEN-CIRCUIT INSPECTION**

Check the continuity between segments. If there is continuity, the coil is in order.

# IGNITION SYSTEM

16300010392

## GENERAL INFORMATION

The ignition system has three ignition coils (A, B and C) and three power transistors (A, B and C). Each ignition coil and power transistor supply current to each cylinder pair (the No. 3 and No. 6 cylinders, No. 1 and No. 4 cylinders, and No. 2 and No. 5 cylinder).

When the primary current stops suddenly in the ignition coil A, high voltage appears in the secondary side of the coil.

The high voltage ignites a cylinder pair. But, whenever one cylinder is at the compression stroke, the other cylinder is at the compression stroke, the other cylinder is at the exhaust stroke. So fuel mixture burns only at the compression stroke side cylinder.

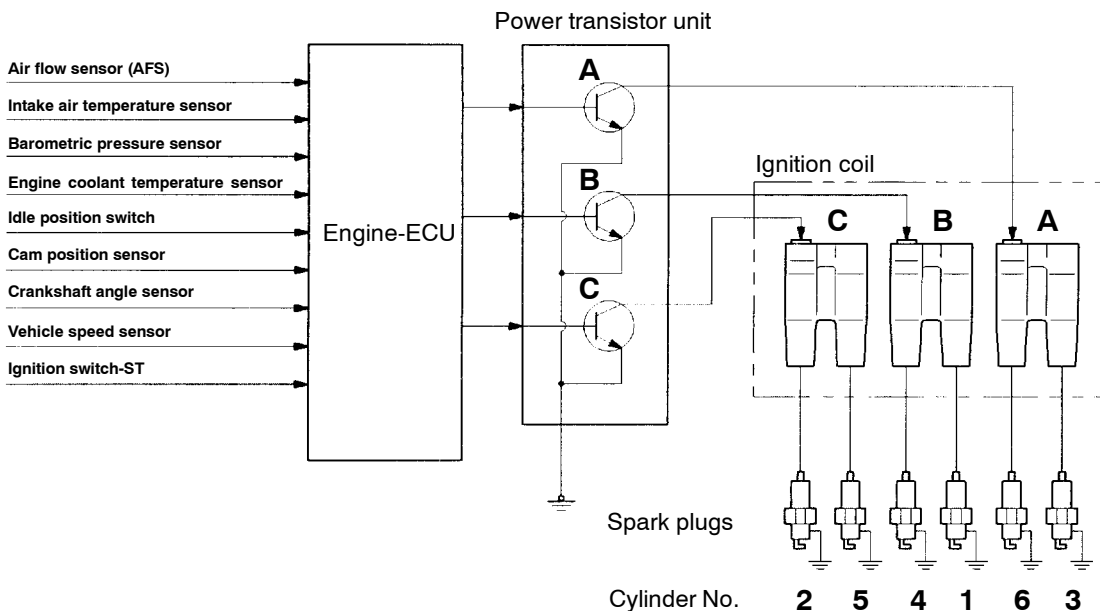
In the same way, when the primary current stops suddenly in ignition coil B, the high voltage thus generated is applied to the spark plugs of the No. 1 and No. 4 cylinders, and when the primary current

stops suddenly in ignition coil C, the high voltage thus generated is applied to the spark plugs of No. 2 and No. 5 cylinders.

The engine-ECU controls the three ignition power transistors (A, B and C) to turn them alternately ON and OFF. This causes the primary currents in the ignition coils (A, B and C) to stop alternately and ignite the spark plugs in the order 1 – 2 – 3 – 4 – 5 – 6.

The engine-ECU determines which the ignition coils should be controlled by means of the signals from the camshaft position sensor which is incorporated in the crankshaft. It also detects the crankshaft position in order to ignite at the most appropriate timing in response to the engine operation conditions.

When the engine is cold or operated at high altitudes, the ignition timing is slightly advanced for optimum performance.



7EN1436

**IGNITION COIL SPECIFICATIONS**

Items	Specifications
Type	Moulded 3-coil
Identification No.	FC0020, FC0021

**SPARK PLUG SPECIFICATIONS**

Items	Specifications
NGK	PFR6J-11
DENSO	PK20PR-P11

**SERVICE SPECIFICATIONS**

16300030336

**IGNITION COIL**

Items	Standard value
Primary coil resistance $\Omega$	0.74 – 0.90
Secondary coil resistance $k\Omega$	20.1 – 27.3

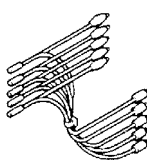
**SPARK PLUG**

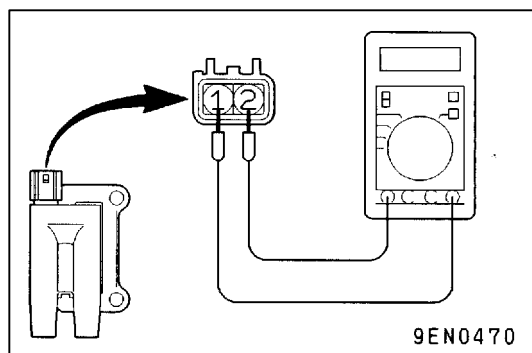
Item	Standard value	Limit
Spark plug gap mm	1.0 – 1.1	1.3

**RESISTIVE CORD**

Item	Limit
Resistance $k\Omega$	Max. 22

**SPECIAL TOOL**

Tool	Number	Name	Use
 B991348	MB991348	Test harness set	Inspection of ignition primary voltage (power transistor connection)

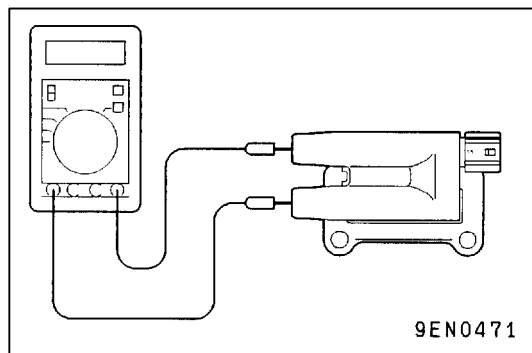
**ON-VEHICLE SERVICE**

16300120439

**IGNITION COIL CHECK****PRIMARY COIL RESISTANCE**

Measure the resistance between the terminals for each cylinder (No.1 – No.4, No.2 – No.5, No.3 – No.6) of the ignition coil as shown in the illustration.

**Standard value: 0.74 – 0.90  $\Omega$**

**SECONDARY COIL RESISTANCE**

Measure the resistance between the high-voltage terminals for each cylinder (No.1 – No.4, No.2 – No.5, No.3 – No.6) of the ignition coil as shown in the illustration.

**Standard value: 20.1 – 27.3 kΩ**

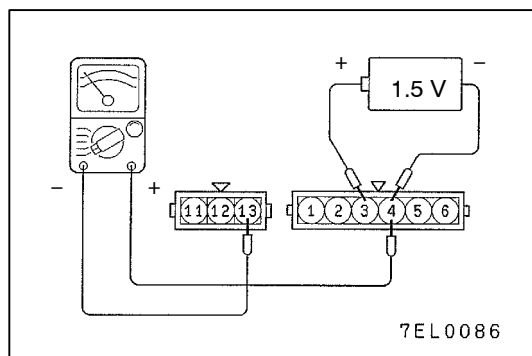
**POWER TRANSISTOR CONTINUITY CHECK**

16300130326

Check for continuity between the power transistor terminals. If the power transistor is defective, replace it.

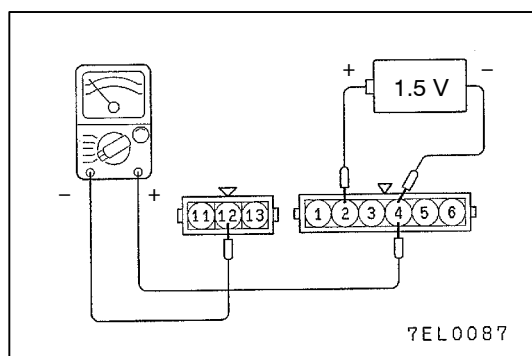
**NOTE**

An analog-type circuit tester should be used.

**No. 1 – No. 4 coil side**

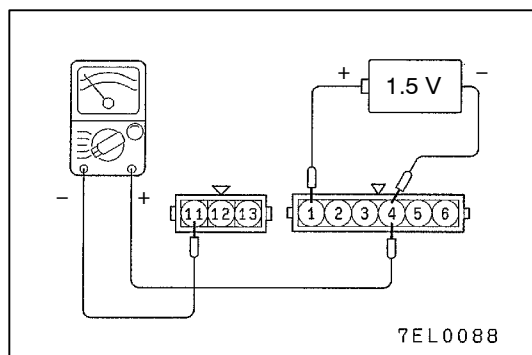
Check the continuity between terminals (4) and (13).

1.5 V Voltage	Terminal No.		
	3	4	13
Applied	⊕	⊖	⊖
Not applied			

**No. 2 – No. 5 coil side**

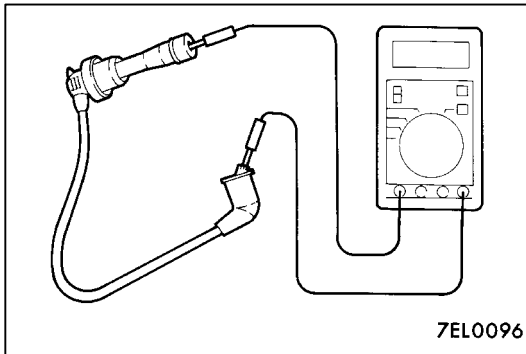
Check the continuity between terminals (4) and (12).

1.5 V Voltage	Terminal No.		
	2	4	12
Applied	⊕	⊖	⊖
Not applied			

**No. 3 – No. 6 coil side**

Check the continuity between terminals (4) and (11).

1.5 V Voltage	Terminal No.		
	1	4	11
Applied	⊕	⊖	⊖
Not applied			

**RESISTIVE CORD CHECK**

16300140138

Measure the resistance of the all spark plug cables.

1. Check cap and coating for cracks.
2. Measure resistance.

**Limit: Max. 22 kΩ**

**SPARK PLUG CHECK**

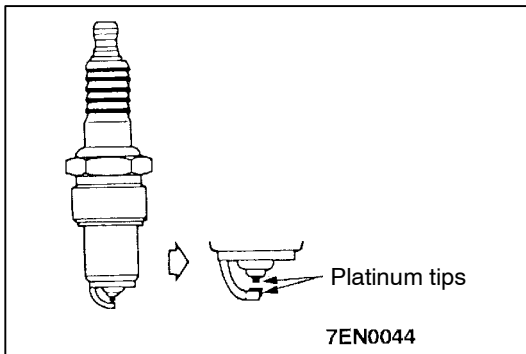
16300150407

1. Remove the air intake plenum.
2. Remove the spark plug cables.

**Caution**

**When pulling off the spark plug cable from the plug always hold the cable cap, not the cable.**

3. Remove the spark plugs.



4. Check the plug gap and replace if the limit is exceeded.

**Standard value: 1.0–1.1 mm**

**Limit: 1.3 mm**

**Caution**

**(1) Do not attempt to adjust the gap of the platinum plug.**

**(2) Always use a plug cleaner and finish cleaning within 20 seconds. Do not use wire brushes. Otherwise, the platinum tip may be damaged.**

5. Clean the engine plug holes.

**Caution**

**Be careful not to allow foreign matter in cylinders.**

6. Install the spark plugs.

## **WAVEFORM CHECK USING AN ANALYZER (Ignition Primary and Secondary Voltage Waveforms) Ignition Secondary Voltage Waveform Check**

16300170519

### **MEASUREMENT METHOD**

1. Clamp the secondary pickup around a spark plug cable.

#### **NOTE**

- (1) The peak of the ignition voltage will be reversed when the spark plug cables of No.1, No.3, No.5 cylinders are clamped and when the spark plug cables of No.2, No.4 and No.6 cylinders are clamped.
  - (2) Because of the two-cylinder simultaneous ignition system, the waves for two cylinder in each group appear during wave observation (No.1 cylinder – No.4 cylinder, No.2 cylinder – No.5 cylinder, No.3 – cylinder – No.6 cylinder). However, wave observation is carried out for the cylinder with the spark plug cable clamped by the secondary pickup.
2. Clamp the spark plug cable with the Trigger pickup.

#### **NOTE**

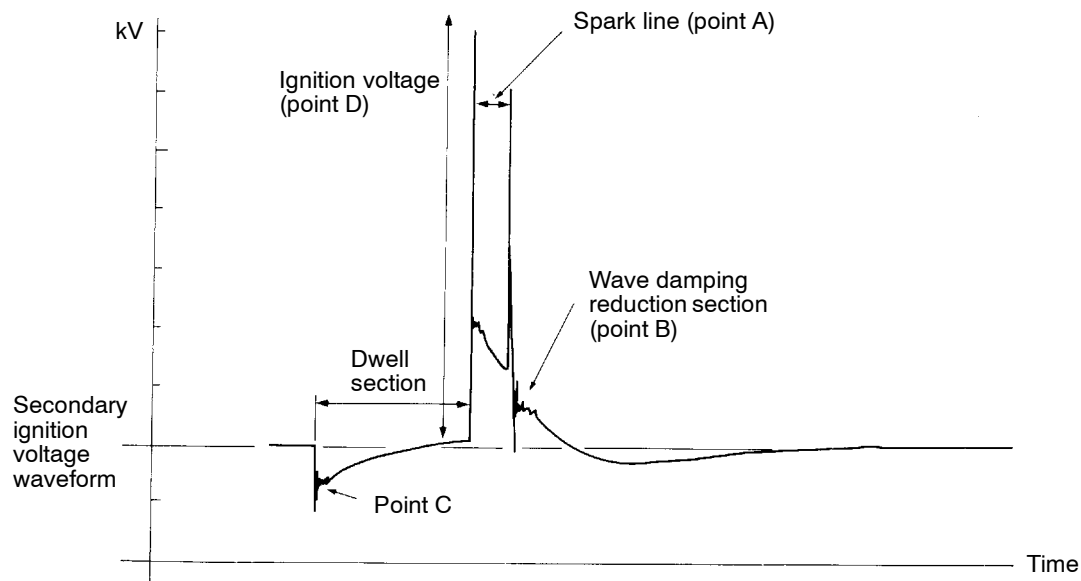
- (1) Clamp the spark plug cable for the No.1, No.3 or No.5 cylinder of the same group with the cylinder that is clamped with the secondary pickup.
- (2) It can be difficult to identify which cylinder waveform is displayed, but the waveform of the cylinder which is clamped with the secondary pickup will be stable, so this can be used as a reference for identification.



## STANDARD WAVEFORM

## Observation Conditions

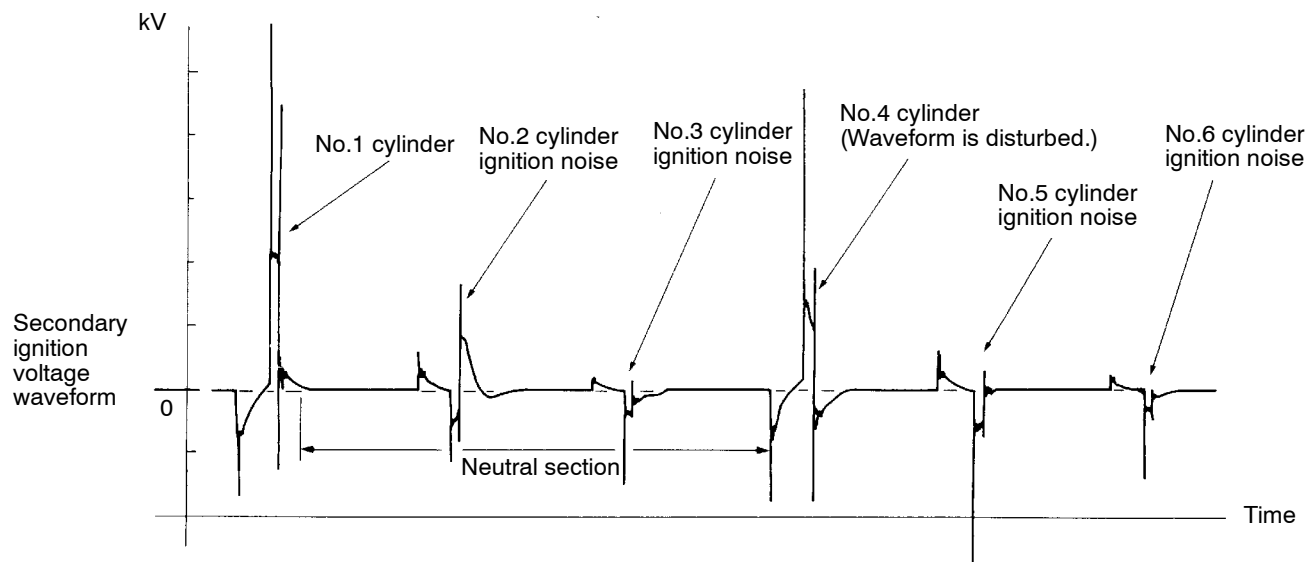
FUNCTION	SECONDARY
PATTERN HEIGHT	HIGH (or LOW)
PATTERN SELECTOR	RASTER
Engine Speed	Curb idle speed



7EL0147

Observation Condition (The only change from previous condition is the pattern selector.)

PATTERN SELECTOR	DISPLAY
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7EL0148

**WAVEFORM OBSERVATION POINTS**

Point A: The height, length and slope of the spark line show the following trends (Refer to abnormal waveform examples, 1, 2, 3 and 4).

Spark line		Plug gap	Condition of electrode	Compression force	Concentration of air mixture	Ignition timing	Spark plug cable
Length	Long	Small	Normal	Low	Rich	Advanced	Leak
	Short	Large	Large wear	High	Lean	Retarded	High resistance
Height	High	Large	Large wear	High	Lean	Retarded	High resistance
	Low	Small	Normal	Low	Rich	Advanced	Leak
Slope		Large	Plug is fouled	–	–	–	–

Point B: Number of vibration in reduction vibration section (Refer to abnormal waveform example 5)

Number of vibrations	Coil and condenser
Three or more	Normal
Except above	Abnormal





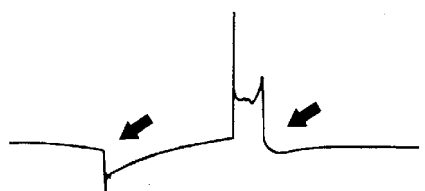
Point C: Number of vibrations at beginning of dwell section (Refer to abnormal waveform example 5)

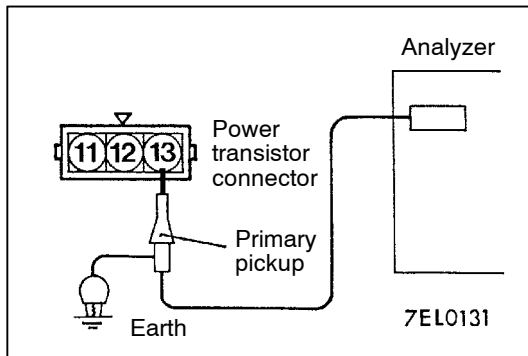
Number of vibrations	Coil
5–6 or higher	Normal
Except above	Abnormal

Point D: Ignition voltage height (distribution per each cylinder) shows the following trends.

Ignition voltage	Plug gap	Condition of electrode	Compression force	Concentration of air mixture	Ignition timing	Spark plug cable
High	Large	Large wear	High	Lean	Retarded	High resistance
Low	Small	Normal	Low	Rich	Advanced	Leak

## EXAMPLES OF ABNORMAL WAVEFORMS

Abnormal waveform	Wave characteristics	Cause of problem
<p>Example 1</p>  <p>01P0215</p>	Spark line is high and short.	Spark plug gap is too large.
<p>Example 2</p>  <p>01P0216</p>	Spark line is low and long, and is sloping. Also, the second half of the spark line is distorted. This could be a result of misfiring.	Spark plug gap is too small.
<p>Example 3</p>  <p>01P0217</p>	Spark line is low and long, and is sloping. However, there is almost no spark line distortion.	Spark plug gap is fouled.
<p>Example 4</p>  <p>01P0218</p>	Spark line is high and short. Difficult to distinguish between this and abnormal waveform example 1.	Spark plug cable is nearly falling off. (Causing a dual ignition)
<p>Example 5</p>  <p>01P0219</p>	No waves in wave damping section.	Layer short in ignition coil



## Ignition Primary Voltage Waveform Check

### MEASUREMENT METHOD

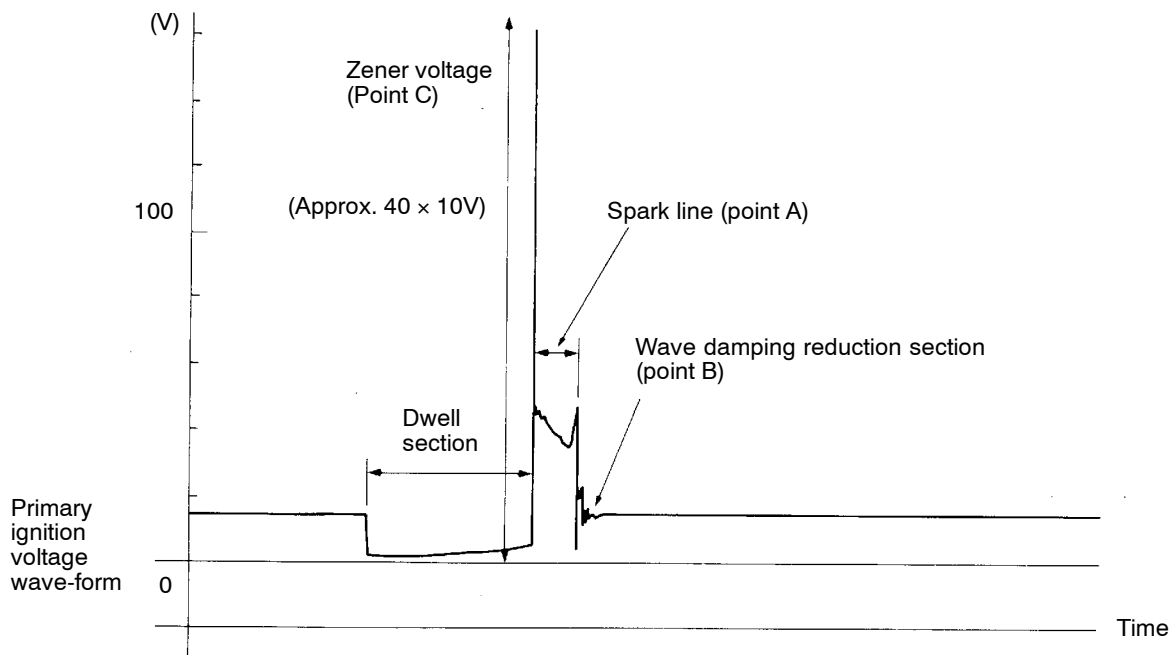
1. Disconnect the power transistor connector and connect the special tool (harness connector: MB991348) in between.
2. Connect the analyzer primary pickup to the power transistor connector terminal 13 when observing the No. 1 – No. 4 cylinder group, terminal 12 for the No. 2 – No. 5 cylinder group, and terminal 11 for the No. 3 – No. 6 cylinder group.
3. Connect the primary pickup earth terminal.
4. Clamp the spark plug cable with the trigger pickup.

### NOTE

- (1) Clamp the spark plug cable for No. 1, No. 3 and No. 5 cylinders of the same group with the cylinder that is connected to the primary pickup.
- (2) The wave-form of either cylinder in the same group will appear at the left edge of the screen.

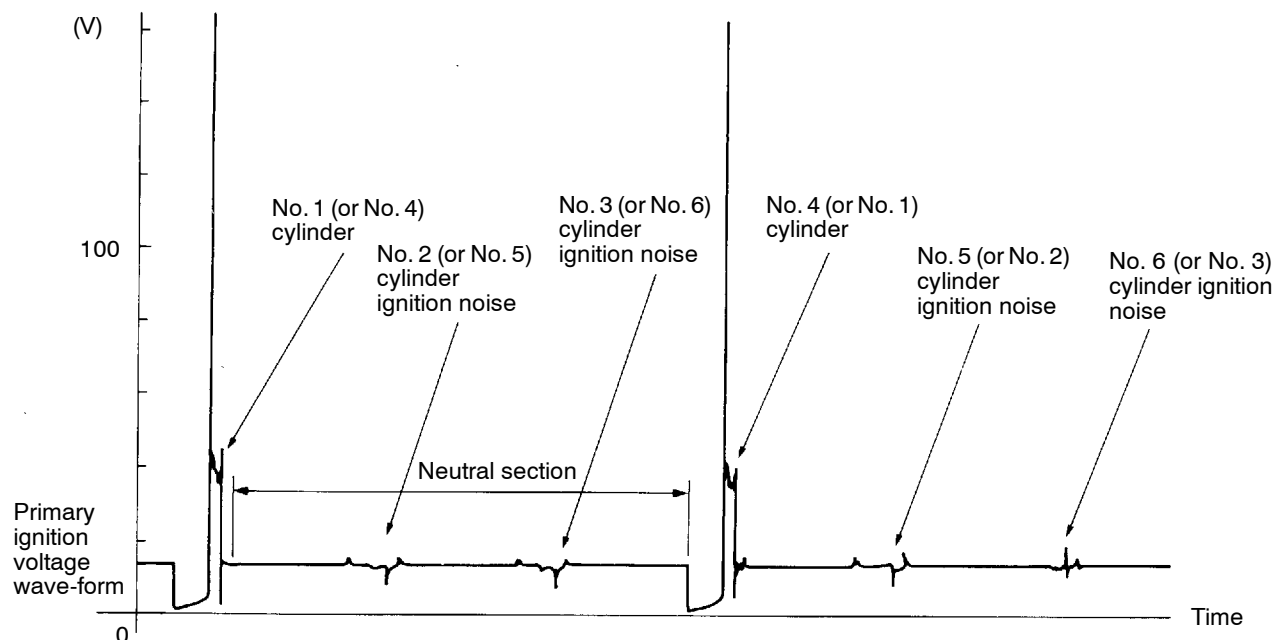
### STANDARD WAVE-FORM Observation Conditions

FUNCTION	SECONDARY
PATTERN HEIGHT	HIGH (or LOW)
PATTERN SELECTOR	RASTER
Engine Speed	Curb idle speed



Observation Conditions (Only pattern selector below changes from the above conditions.)

PATTERN SELECTOR	DISPLAY
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7EL0151

### WAVEFORM OBSERVATION POINTS

Point A: The height, length and slope of the spark line (refer to abnormal waveform examples 1, 2, 3 and 4) show the following trends.

Spark line		Plug gap	Condition of electrode	Compression force	Concentration of air mixture	Ignition timing	High tension cable
Length	Long	Small	Normal	Low	Rich	Advanced	Leak
	Short	Large	Large wear	High	Lean	Retarded	High resistance
Height	High	Large	Large wear	High	Lean	Retarded	High resistance
	Low	Small	Normal	Low	Rich	Advanced	Leak
Slope		Large	Plug is fouled	–	–	–	–

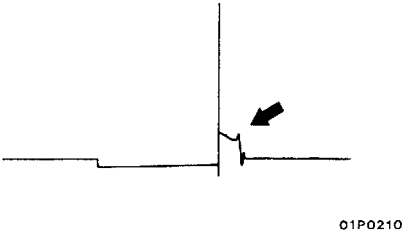
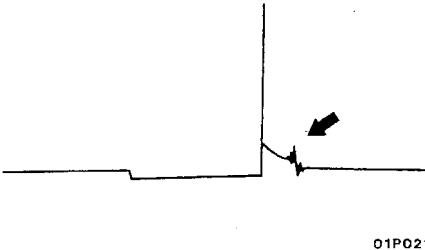
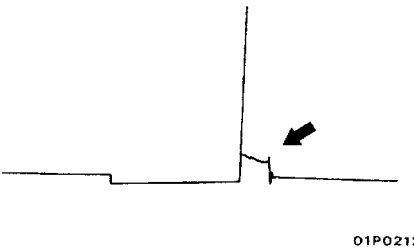
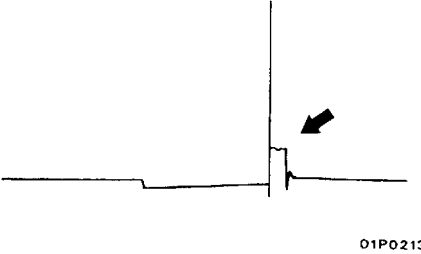
Point B: Number of vibration in reduction vibration section  
(Refer to abnormal waveform example 5)

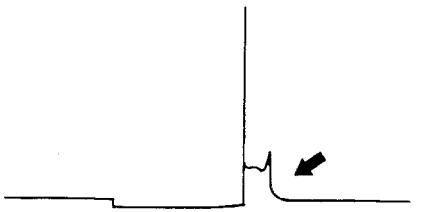
Number of vibrations	Coil, condenser
3 or higher	Normal
Except above	Abnormal

Point C: Height of Zener voltage

Height of Zener voltage	Probable cause
High	Problem in Zener diode
Low	Abnormal resistance in primary coil circuit

### EXAMPLES OF ABNORMAL WAVEFORMS

Abnormal waveform	Wave characteristics	Cause of problem
<p>Example 1</p>  <p>01P0210</p>	Spark line is high and short.	Spark plug gap is too large.
<p>Example 2</p>  <p>01P0211</p>	Spark line is low and long, and is sloping. Also, the second half of the spark line is distorted. This could be a result of misfiring.	Spark plug gap is too small.
<p>Example 3</p>  <p>01P0212</p>	Spark line is low and long, and is sloping. However, there is almost no spark line distortion.	Spark plug gap is fouled.
<p>Example 4</p>  <p>01P0213</p>	Spark line is high and short.	Spark plug cable is nearly falling off. (Causing a dual ignition)

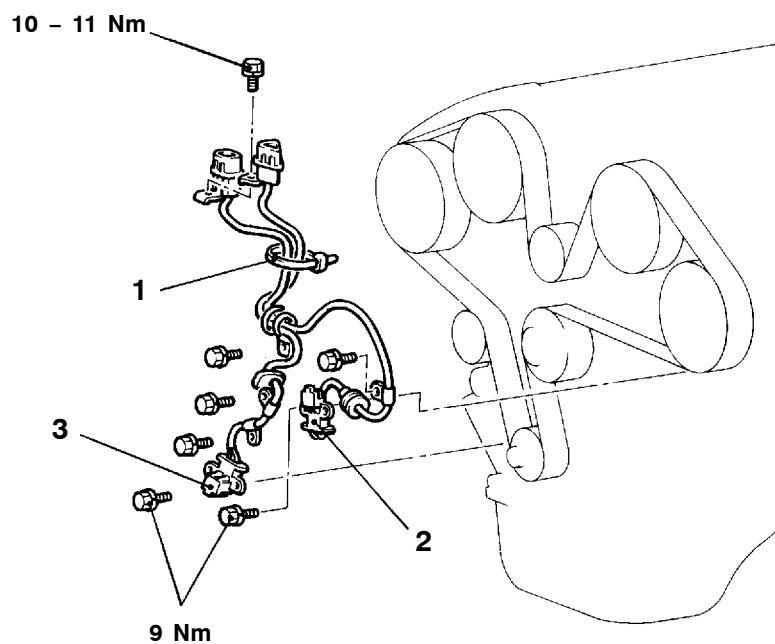
Abnormal waveform	Wave characteristics	Cause of problem
Example 5  01P0214	No waves in wave damping section	Layer short in ignition coil

## CAMSHAFT POSITION SENSOR AND CRANKSHAFT ANGLE SENSOR <6G7>

16300250381

### REMOVAL AND INSTALLATION

**Pre-removal and Post-installation Operation**  
 Removal and Installation of Timing Belt Cover  
 (Refer to GROUP 11A – Timing Belt.)



A16W0056

#### Removal steps

1. Clip
2. Camshaft position sensor
3. Crankshaft angle sensor

# GLOW SYSTEM

16400010029

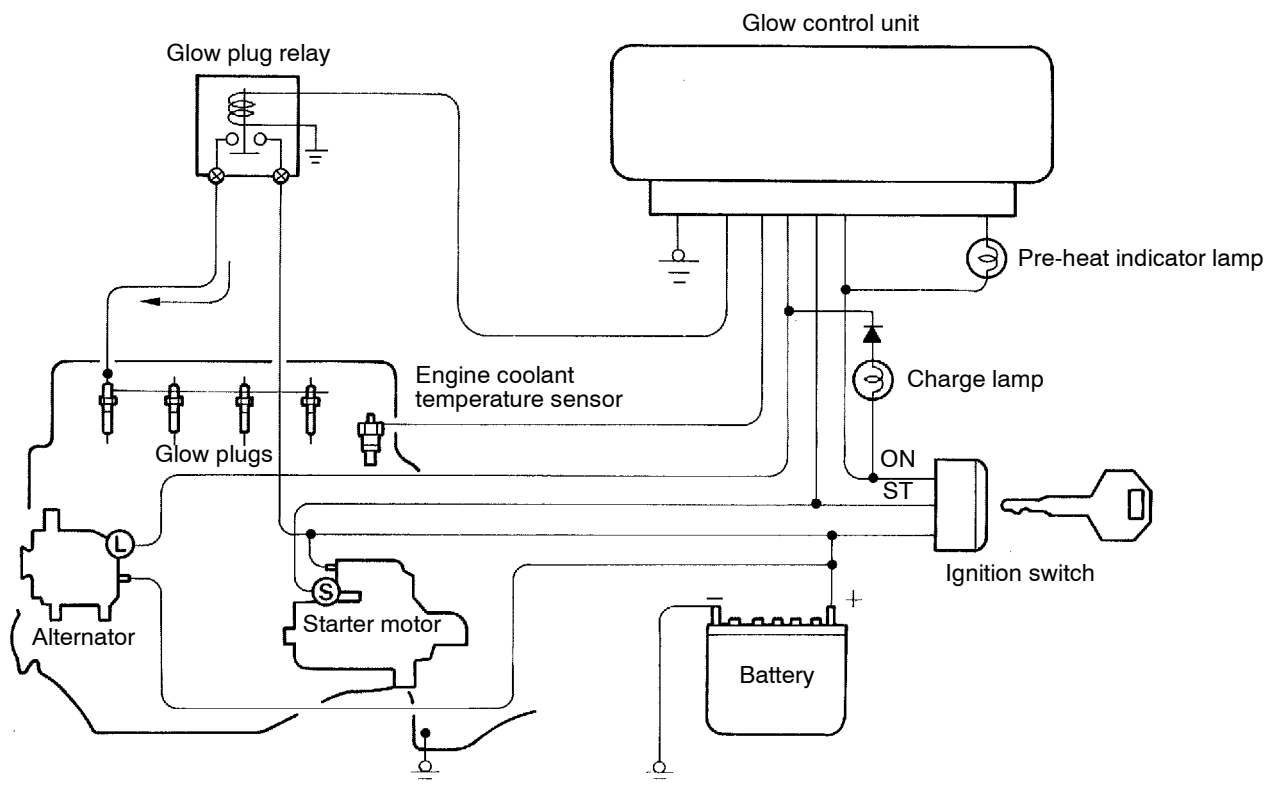
## GENERAL INFORMATION

### SELF-REGULATING GLOW SYSTEM

The self-regulating glow system reduces the time required for starting at low temperatures to provide a degree of starting and operation that is identical to petrol-engine vehicles by preheating the glow plugs at super-quick speed.

The glow control unit controls both the time during which current is supplied to the glow plugs after the ignition switch is turned to the ON position and

also the glow indicator lamp illumination time in accordance with the engine coolant temperature. The resistances of the heating coils which are built into the glow plugs increase as the glow plug temperatures become higher. As a result of this, the flow of current gradually decreases, thus stabilizing the glow plug temperature at the specified temperature.



DEN0062



## SERVICE SPECIFICATIONS

16400030070

Item		Standard value
Resistance between glow plug plate and glow plug body (parallel resistance for 4 glow plugs) (at 20 °C) $\Omega$		0.15 – 0.25
Voltage between glow plug plate and glow plug body V	Immediately after ignition switch is turned to ON (without starting the engine)	9 – 11 (Drops to 0 V after 4 – 8 seconds have passed)
	While engine is cranking	6 or more
	While engine is warming up	12 – 15 (Drops to 0 V when the engine coolant temperature increases to 60 °C or more or if 180 seconds have passed since the engine was started)
Glow plug resistance (at 20 °C) $\Omega$		0.6 – 1.0

## SEALANT

16400050021

Item	Specified sealant	Remark
Engine coolant temperature sensor	3M Nut Locking Part No.4171 or equivalent	Drying sealant

## ON-VEHICLE SERVICE

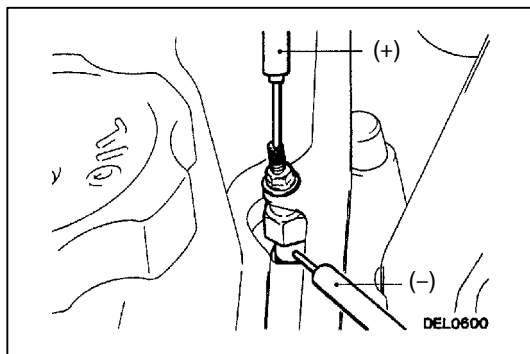
16400100061

## SELF-REGULATING GLOW SYSTEM CHECK

1. Check that the battery voltage is 11 – 13 V.
2. Check that the engine coolant temperature is 40 °C or less.

## NOTE

If the engine coolant temperature is too high, disconnect the engine coolant temperature sensor connector.



3. Measure the resistance between the glow plug plate and the glow plug body (earth).

**Standard value: 0.15 – 0.25  $\Omega$  (at 20 °C)**

## NOTE

The resistance value is the parallel resistance value for the four glow plugs.

4. Connect a voltmeter between the glow plug plate and the glow plug body (earth).
5. Measure the voltage immediately after the ignition switch is turned to ON (without starting the engine).

**Standard value:**

**9 – 11 V (Drops to 0 V after 4 – 8 seconds have passed)**

In addition, check to be sure that the glow indicator lamp (red) illuminates immediately after the ignition switch is turned to ON.

## NOTE

The time during which the voltage appears (energizing time) will depend on the engine coolant temperature.

6. Measure the voltage while the engine is cranking.

**Standard value: 6 V or more**

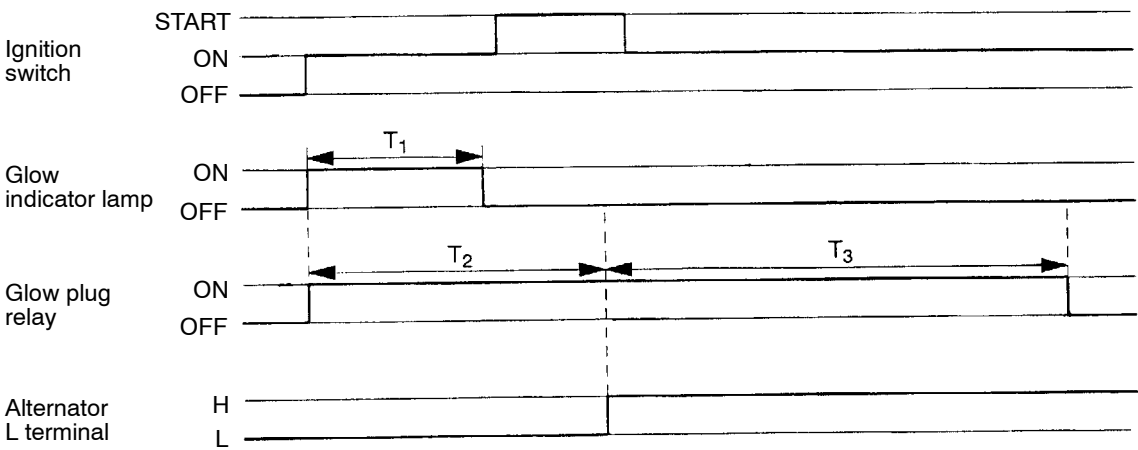
7. Start the engine and measure the voltage while the engine is warming up.

However, if the engine coolant temperature rises above 60 °C or when 180 seconds have passed since the engine was started, the voltage will always return to 0 V. (Refer to the Glow Plug Energization Timing Chart.)

**Standard value: 12 – 15 V**

<Reference>

Glow Plug Energization Timing Chart



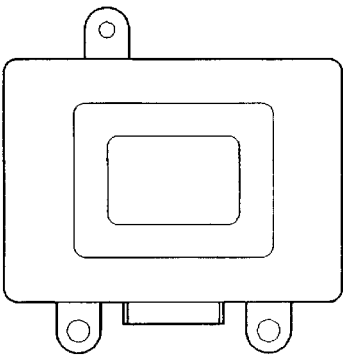
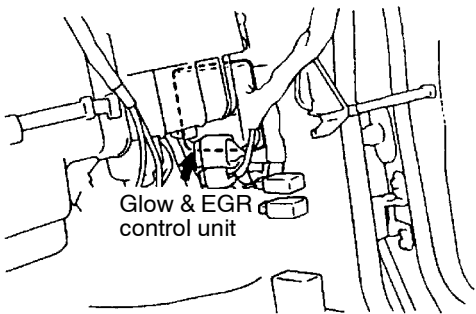
T<sub>1</sub>: Glow indicator lamp  
T<sub>2</sub>: Glow plug relay drive time after ignition switch is turned ON  
T<sub>3</sub>: Glow plug relay drive time after engine starts (after glow)

DEN0063

NOTE  
After glow time T<sub>3</sub> becomes longer as the engine coolant temperature drops.

GLOW & EGR CONTROL UNIT CHECK

16400220064



Glow & EGR control unit

1	2	3	4	5	6	7	8	9	10	11	12	13
14	15	16	17	18	19	20	21	22	23	24	25	26

DEN0294

1. Measure the voltage at the control unit terminals.

## NOTE

- (1) Inspect with the control unit connector connected.
- (2) When measuring the voltage, connect the control unit terminal (26) to the earth.

**Terminal Voltage Reference Table**

Inspection terminal	Inspection item	Inspection condition	Standard value
5	Engine coolant temperature sensor (Engine coolant temperature detection)	Ignition switch "ON" → "OFF"	Engine coolant temperature: -20 °C
			Engine coolant temperature: 0 °C
			Engine coolant temperature: 20 °C
			Engine coolant temperature: 40 °C
			Engine coolant temperature: 80 °C
12	Ignition switch (power supply)	Ignition switch "OFF" → "START"	8 V or more
14	Glow plug relay (glow time control)	Ignition switch "OFF" → "ON" Engine coolant temperature: 40 °C or less (Pre-glow function inspection)	9 – 12 V 0 – 0.5 V after approx. 8 sec. (when engine coolant temperature is 20 °C)
17	Glow indicator lamp	Ignition switch "OFF" → "ON" Engine coolant temperature: 40 °C or less	0 – 1 V 11 – 13 V after approx. 1 sec. (when engine coolant temperature is 20 °C)
23	Alternator charging signal ("L" terminal)	Ignition switch "OFF" → "ON"	1 – 4 V
		Engine is idling	11 V or more
26	Earth	–	–

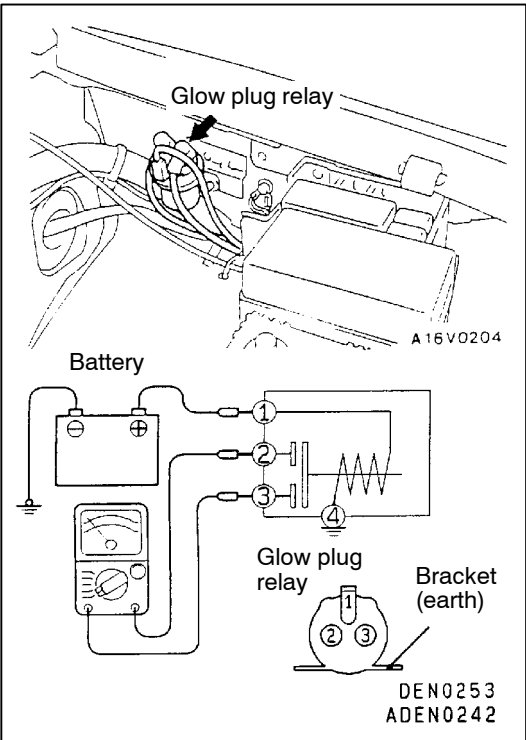
Glow & EGR control unit harness-side connector as seen from the terminal side

13	12	11	10	9	8	7	6	5	4	3	2	1
26	25	24	23	22	21	20	19	18	17	16	15	14

DEM0026

2. Remove the control unit connector and check the continuity between the harness-side connector terminals.

Inspection terminal	Inspection item	Continuity (resistance value)
14 – 26	Glow plug relay	Continuity (approx. 20Ω)



### GLOW PLUG RELAY CHECK

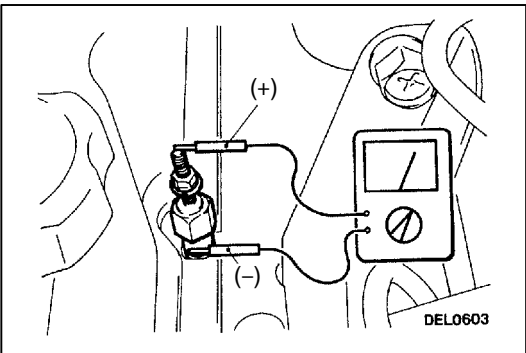
16400250032

1. Check to be sure that there is continuity (approx. 20  $\Omega$ ) between glow plug relay terminal (1) and the bracket (earth).
2. Use jumper cables to connect terminal (1) of the glow plug relay to the battery (+) terminal and the bracket to the battery (-) terminal

#### Caution

- (1) Always be sure to disconnect the harnesses connected to glow plug relay terminals (2) and (3) before using the jumper cables.
  - (2) The terminals of the disconnected harnesses must not be shorted to earth.
  - (3) When connecting the jumper cables, be very careful not to make a mistake in connecting the terminals, as this will cause damage to the relay.
3. Check the continuity between glow plug relay terminals (2) and (3) while disconnecting and connecting the jumper cable at the battery (+) terminal

Jumper cable at battery (+) terminal	Continuity between terminals (2) – (3)
Connected	Continuity (0.01 $\Omega$ or less)
Disconnected	No continuity (infinite resistance)



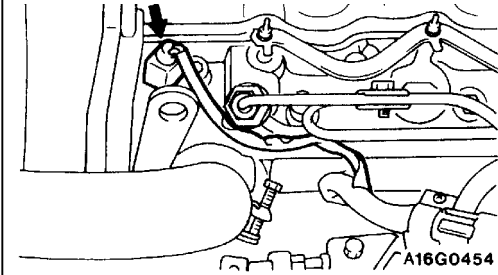
### GLOW PLUG CHECK

16400190082

1. Remove the glow plug plate.
2. Measure the resistance between the glow plug terminals and the body.

**Standard value: 0.6 – 1.0  $\Omega$  (at 20 °C)**

Engine coolant temperature gauge unit  
(engine coolant temperature sensor)

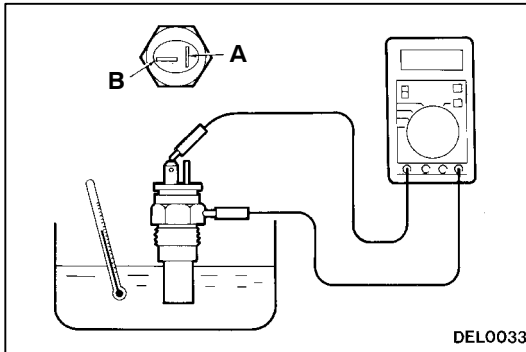


## ENGINE COOLANT TEMPERATURE SENSOR CHECK

16400280031

1. Remove the engine coolant temperature sensor.

2. While the sensor section of the engine coolant temperature sensor is immersed, measure the resistance between (B) terminal and the body.



Temperature (°C)	Resistance value (kΩ)
0	8.6
20	3.25 ± 0.33
40	1.5
80	0.3

3. After applying specified sealant to the threaded portion, tighten to the specified torque.

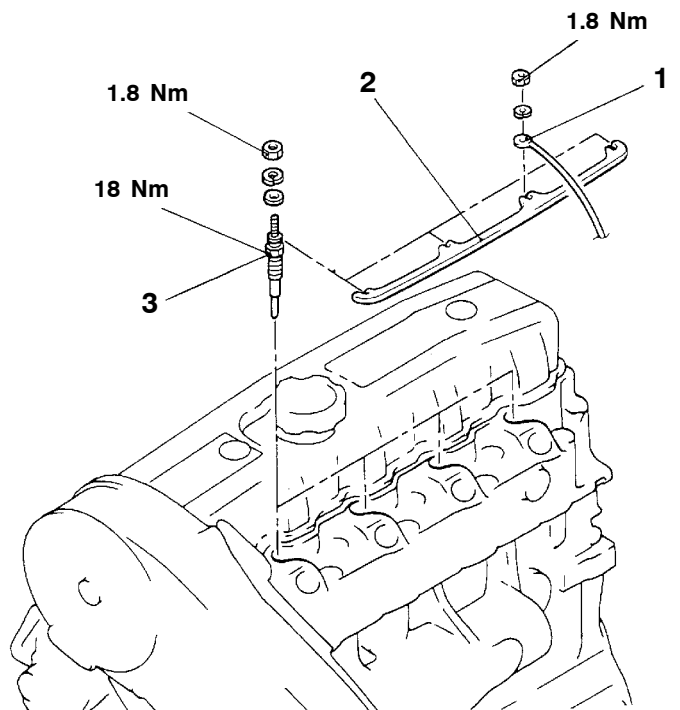
**Specified sealant:**

**3M Nut Locking Part No. 4171 or equivalent**

**Tightening torque: 35 Nm**

**GLOW PLUG**

16400180027

**REMOVAL AND INSTALLATION**

A01V0001

**Removal steps**

1. Connector connection
2. Glow plug plate
3. Glow plug

**REMOVAL SERVICE POINT****◀A▶ GLOW PLUG REMOVAL**

Remove glow plug by hand after loosening with tool as its ceramic part is fragile.

**INSPECTION**

16400190044


- Check for rust on glow plug plate.
- Check glow plug for damage.

**Caution**

**Do not use a plug that has been dropped from a height of 10 cm or more.**

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# ENGINE ELECTRICAL



## CONTENTS

STARTING SYSTEM ..... 2

GENERAL INFORMATION ..... 2

GENERAL ..... 2

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# STARTING SYSTEM

## GENERAL

### OUTLINE OF CHANGE

- The starter has been modified due to the addition of vehicles with 6G72-A/T.

## GENERAL INFORMATION

### STARTER MOTOR SPECIFICATIONS

Items	Specifications
Rated output kw/V	1.3/12

## GROUP 16

# ENGINE ELECTRICAL

## IGNITION SYSTEM

### GENERAL

#### OUTLINE OF CHANGES

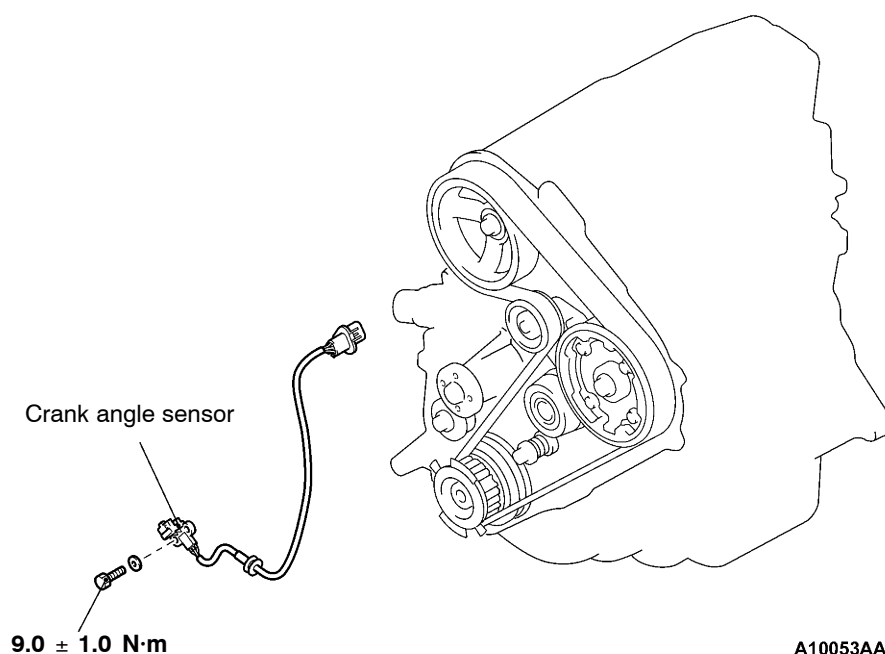
With the modification below by additional emission regulation step III compatible 4D56 engine, the service procedure of the part that is different from previous service procedure has been established.

### CRANK ANGLE SENSOR <4D56-Step III>

#### REMOVAL AND INSTALLATION

**Pre-removal and Post-installation Operation**

- Timing Belt Cover Removal and Installation  
(Refer to GROUP 11B.)



## GLOW SYSTEM

### GENERAL

#### OUTLINE OF CHANGE

Due to the introduction of the electronically-controlled fuel injection pump, the engine-ECU controls the glow system. As for the ECU terminal voltage measurement, refer to GROUP 13D - Troubleshooting.

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## NOTES