

ENGINE ELECTRICAL

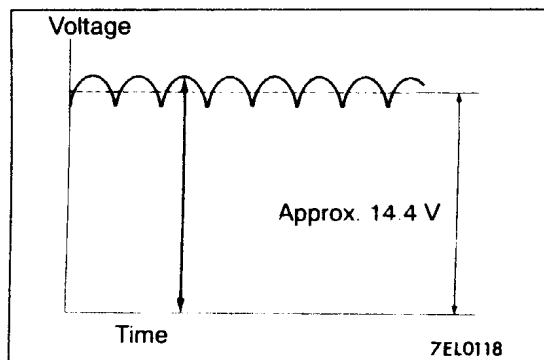
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CHARGING SYSTEM

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.

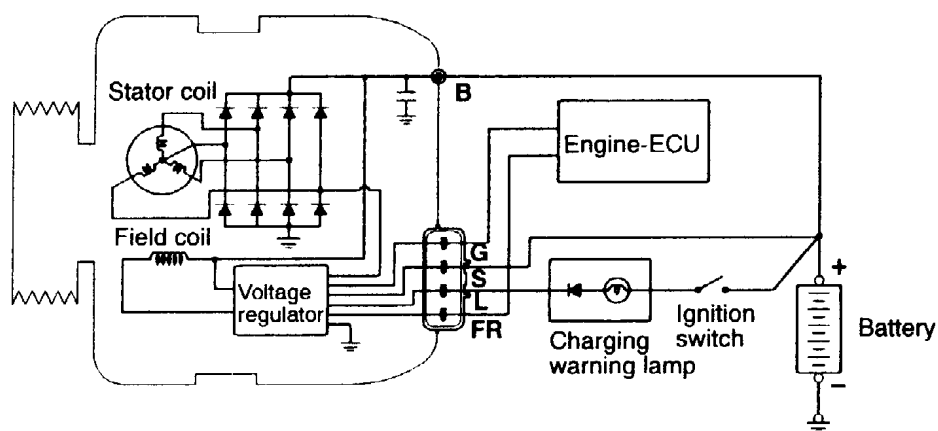
The alternator output voltage rises as the field current increases and it falls as the field current decreases. When the battery voltage (alternator S terminal voltage) reaches a regulated voltage

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.

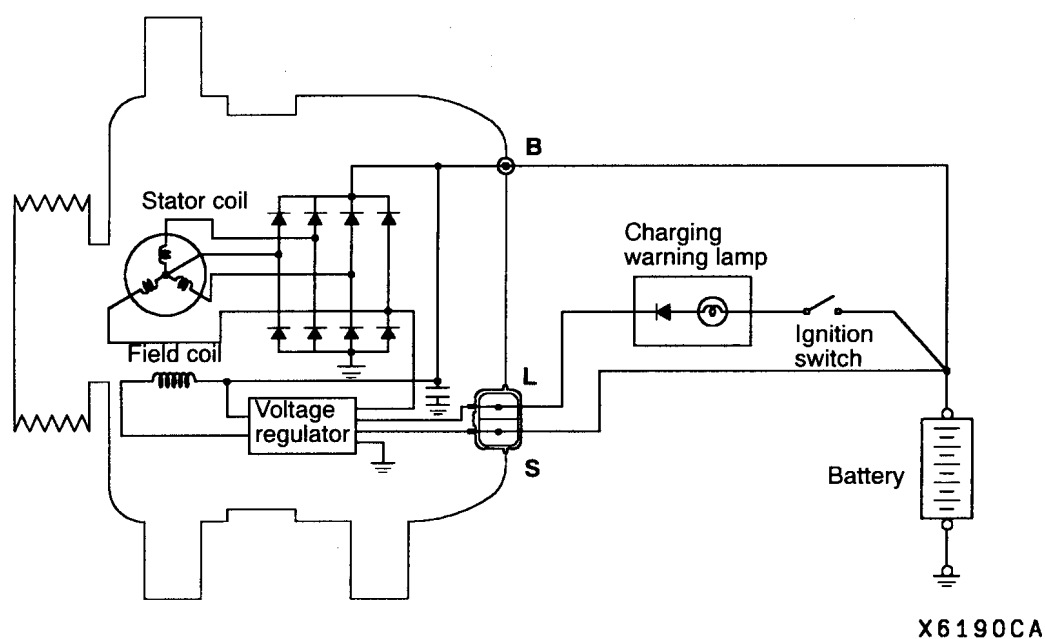
SYSTEM DIAGRAM

<6G7>



9EN0870

<4D5, 4M4>



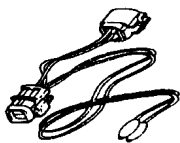
ALTERNATOR SPECIFICATIONS

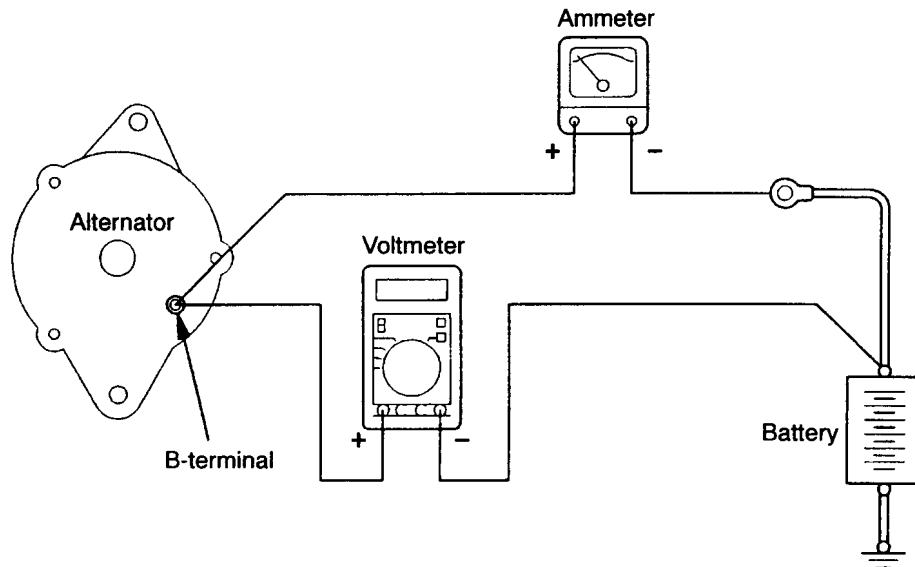
Items	6G7, 4M4	4D5
Type	Battery voltage sensing	Battery voltage sensing
Rated output V/A	12/125	12/105
Voltage regulator	Electronic built-in type	Electronic built-in type

SERVICE SPECIFICATIONS

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 Ω		Approx. 2 – 5	–
Maximum vacuum (at 3,000 r/min) <4D56> kPa		90.6	–
Protrusion length of brush mm	6G7, 4D5	–	2
	4M4	–	5

SPECIAL TOOL

Tool	Number	Name	Use
	MD998467	Alternator test harness	Checking the alternator (S terminal voltage) <4D5, 4M4>
	MB991519	Alternator test harness	Checking the alternator (S terminal voltage) <6G7>

ON-VEHICLE SERVICE**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
 - 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 0–150 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.
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

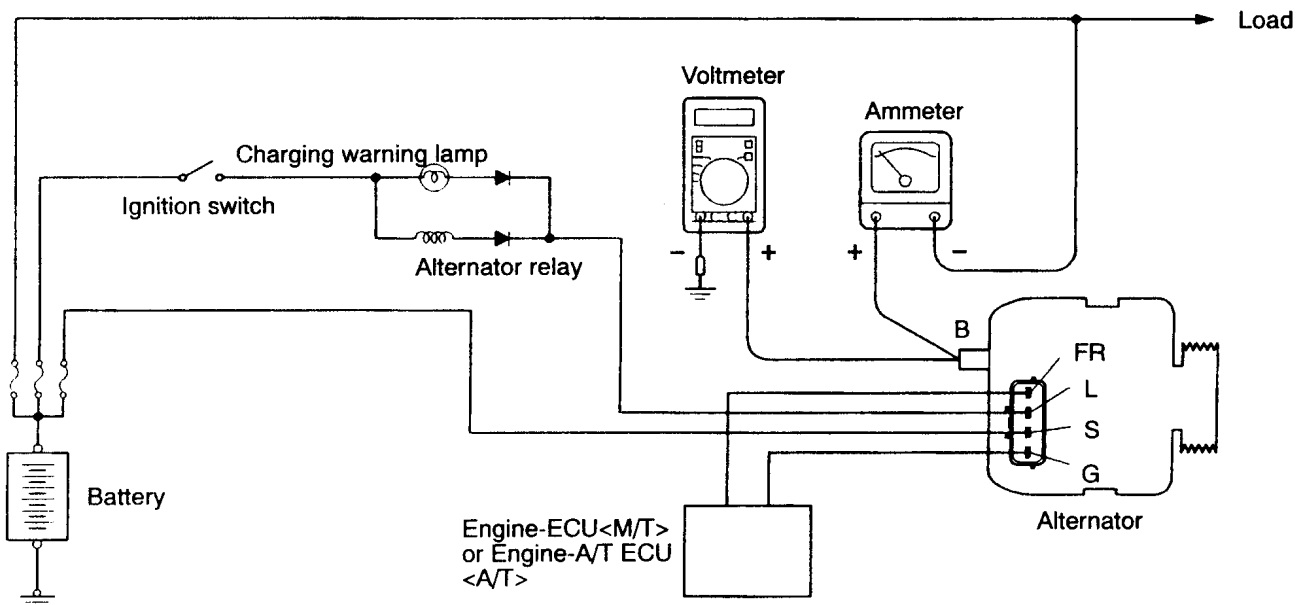
NOTE

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.

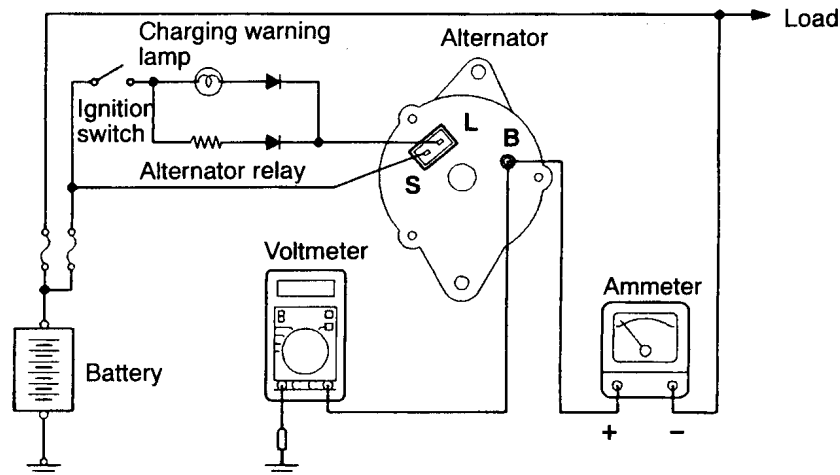
OUTPUT CURRENT TEST

<6G7>



6EN1162

<4D5, 4M4>



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

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
 - 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.
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

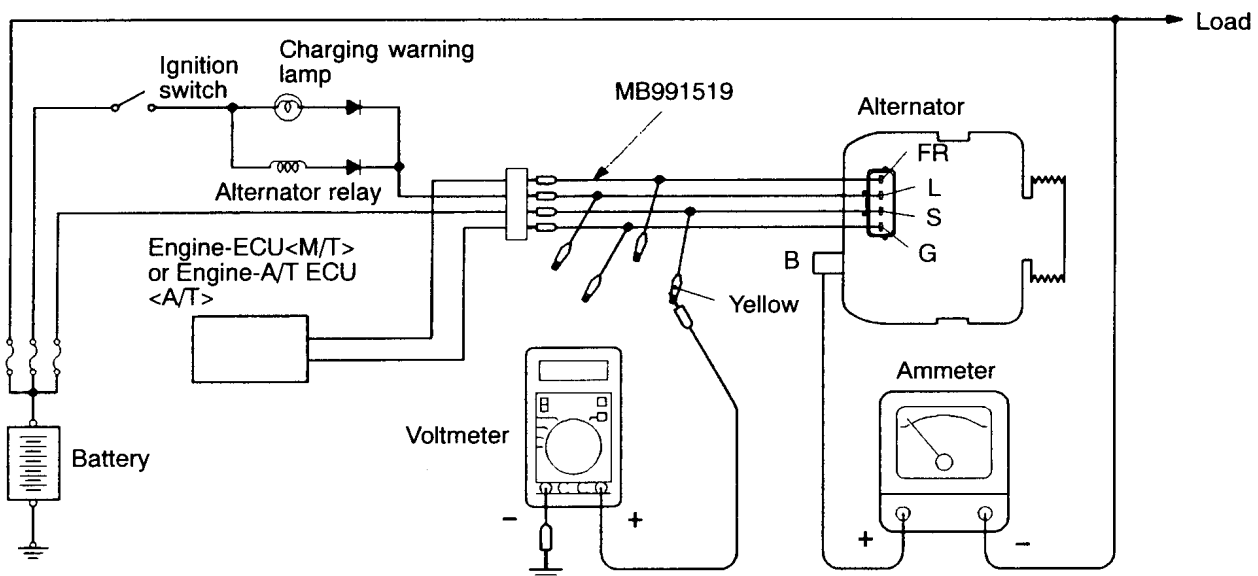
- For the nominal current output, refer to the Alternator Specifications.
- Because the current from the battery will soon drop after the engine is started, the above step should be carried out as quickly as possible in order to obtain the maximum current output value.
- The current output value will 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.

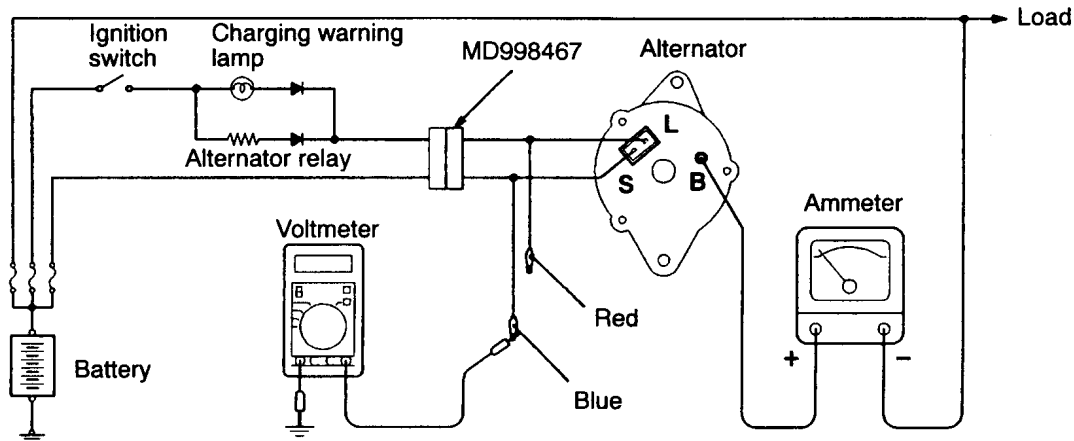
12. The reading on the ammeter should be above the limit value. If the reading is below the limit value and the alternator output wire is normal, remove the alternator from the engine and check the alternator.
13. Run the engine at idle after the test.
14. Turn the ignition switch off.
15. Remove the 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

<6G7>



<4D5, 4M4>



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.
 - Alternator drive belt tension
 - 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. Use the special tool (Alternator test harness: MD998467 or MB991519) 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.
9. Turn the ignition switch to the ON position and check that the reading on the voltmeter is equal to the battery voltage.

NOTE

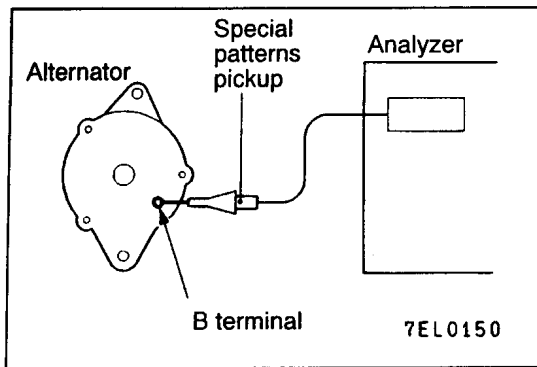
If the voltage is 0 V, the cause is probably an open circuit in the wire or fusible link between the alternator "S" terminal and the battery (+) terminal.

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

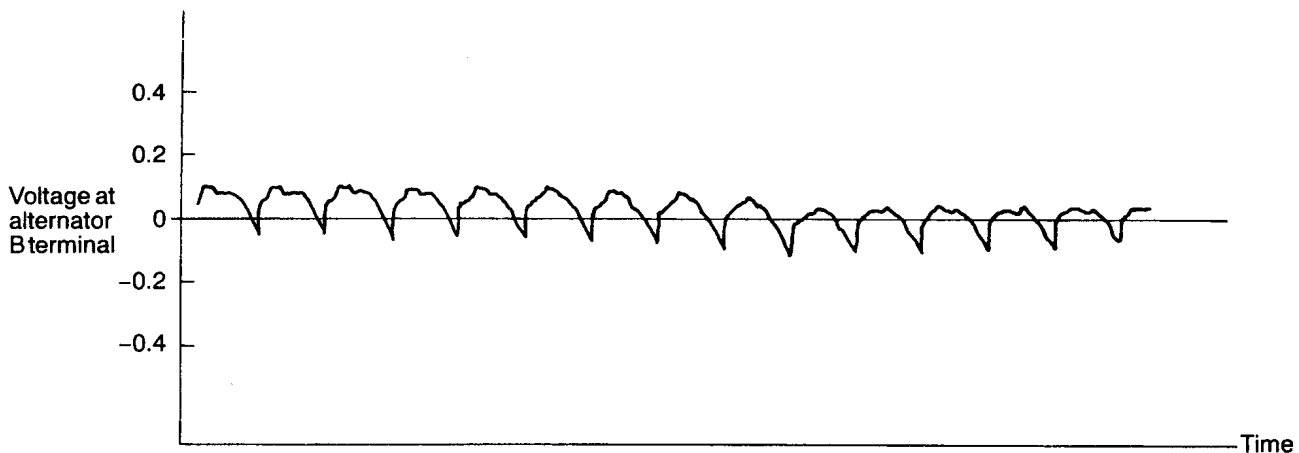
MEASUREMENT METHOD

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

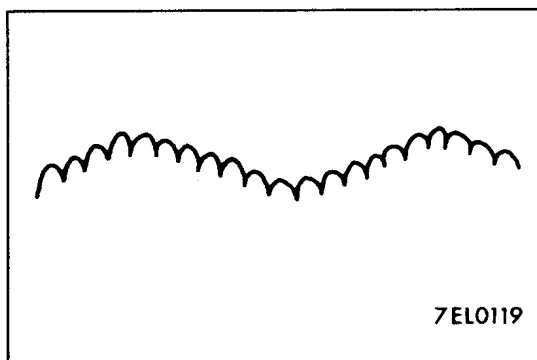
STANDARD WAVEFORM

Observation Conditions

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



7EL0115



7EL0119

NOTE

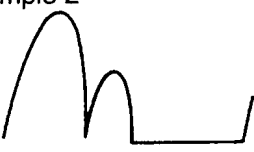
The voltage waveform of the alternator B terminal can undulate as shown at left. This waveform is produced when the regulator operates according to fluctuations in the alternator load (current), and is normal for the alternator.

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 brown 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
Example 1  A7EL0120	Open diode	Example 4  A7EL0123	Short in stator coil
Example 2  A7EL0121	Short in diode	Example 5  A7EL0124	Open supplementary diode
Example 3  A7EL0122	Broken wire in stator coil	NOTE At this time, the charging warning lamp is illuminated.	

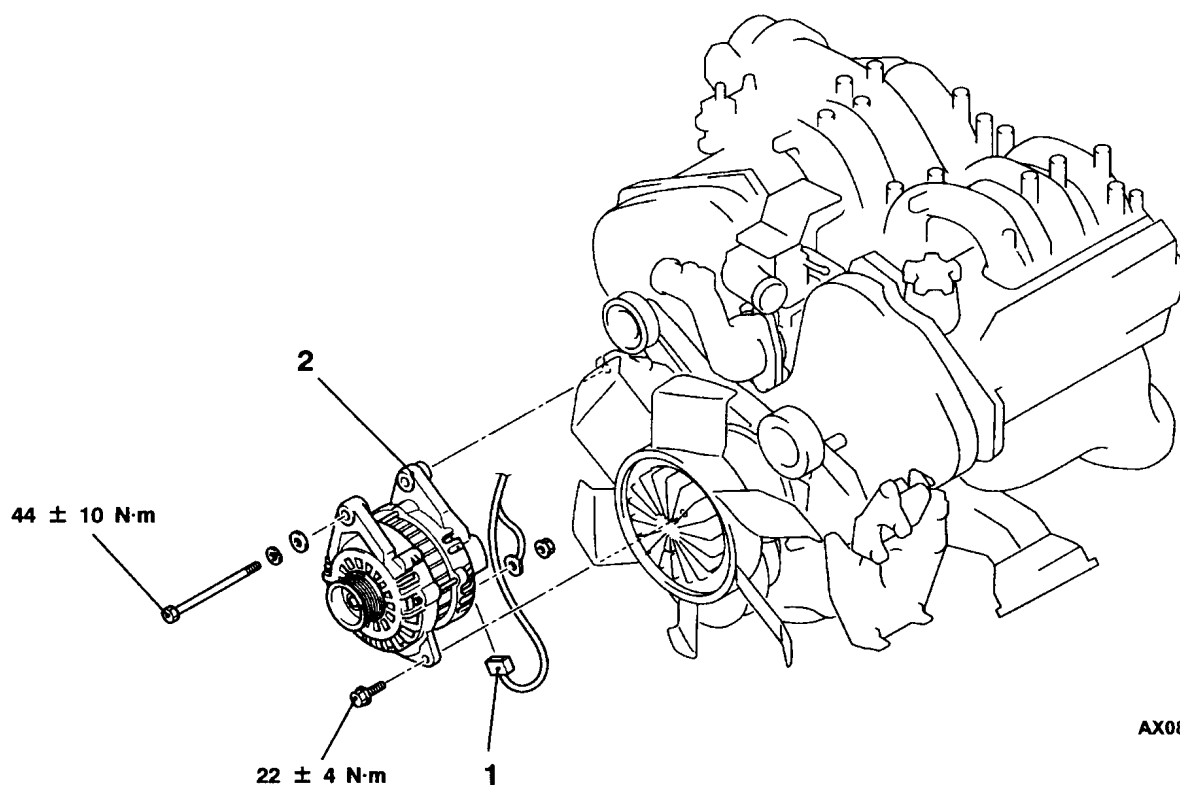
ALTERNATOR

REMOVAL AND INSTALLATION

<6G7>

Pre-removal and Post-installation Operation

- Air Cleaner Assembly Removal and Installation (Refer to GROUP 15.)
- Drive Belt Removal and Installation (Refer to GROUP 11A.)



AX0882CA

Disassembly steps

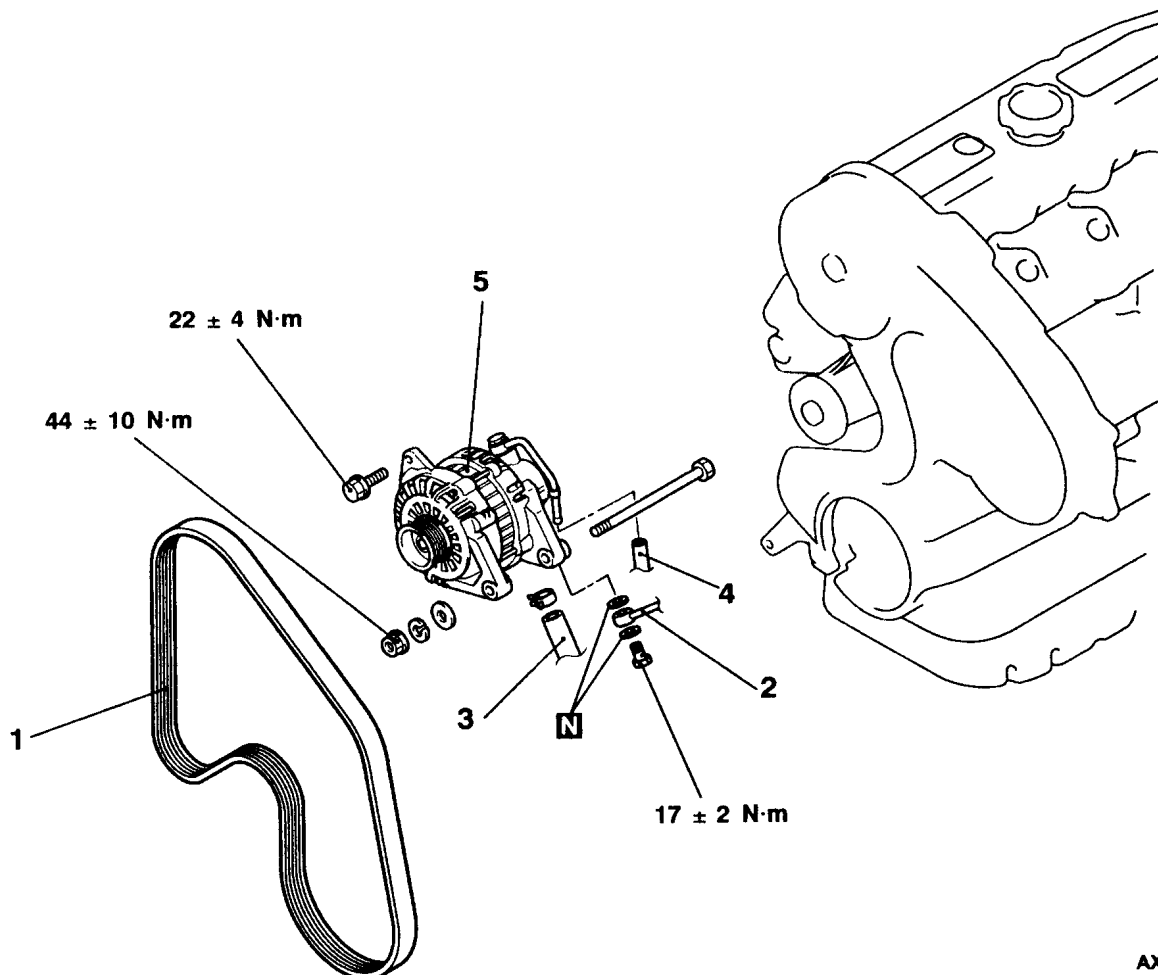
1. Alternator connector
2. Alternator

<4D5>

Pre-removal Operation
 Under Cover Removal

Post-installation Operation

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



AX1783CA

Disassembly steps

1. Drive belt
2. Oil pipe connection
3. Oil return hose connection

4. Vacuum hose connection
5. Alternator

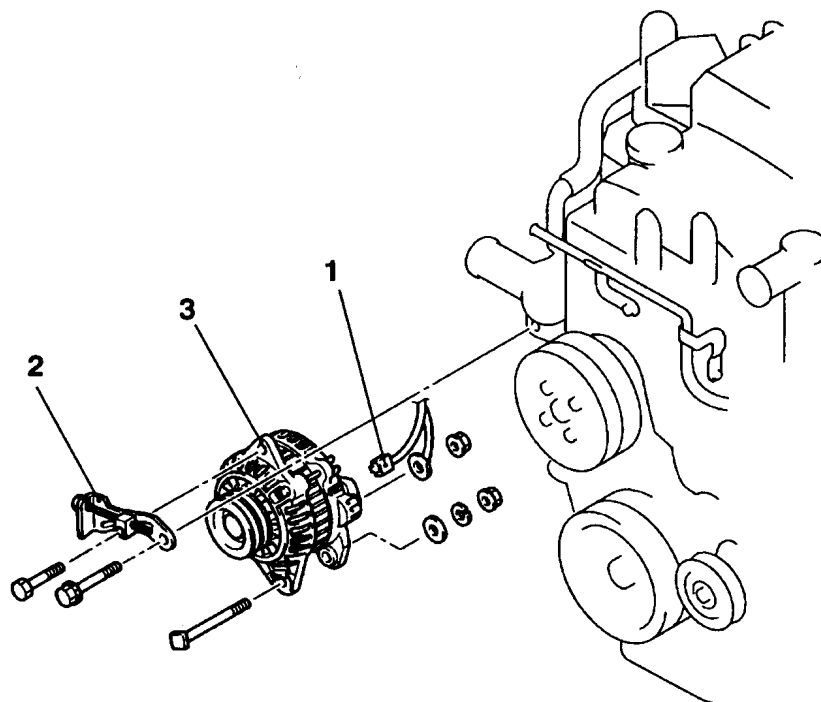
<4M4>

Pre-removal Operation

- Air Cleaner Assembly Removal (Refer to GROUP 15.)
- Drive Belt Removal (Refer to GROUP 11C.)

Post-installation Operation

- Drive Belt Installation (Refer to GROUP 11C.)
- Drive Belt Tension Adjustment (Refer to GROUP 11C – On-vehicle Service.)
- Air Cleaner Assembly Installation (Refer to GROUP 15.)



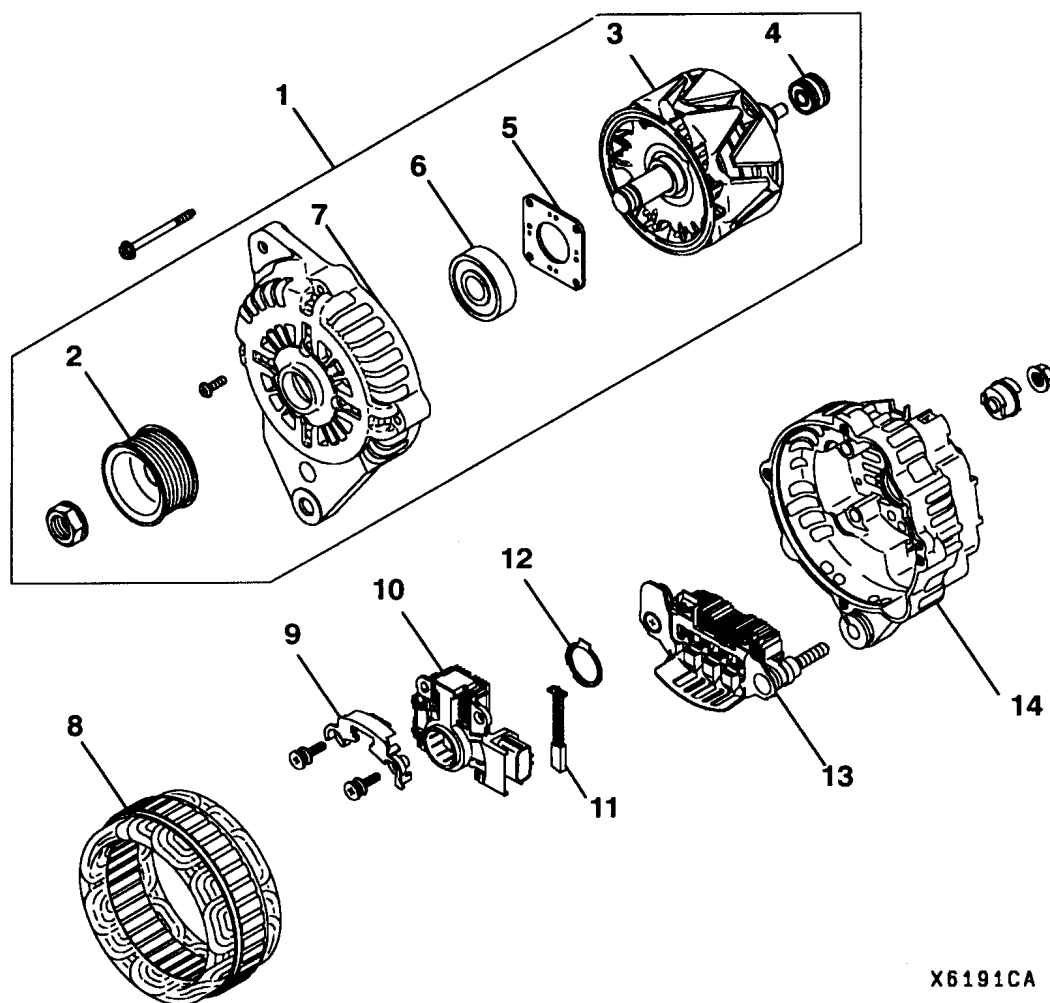
AX0883CA

Disassembly steps

1. Alternator connector
2. Adjusting plate
3. Alternator

DISASSEMBLY AND REASSEMBLY

<6G7>



X6191CA

Disassembly steps



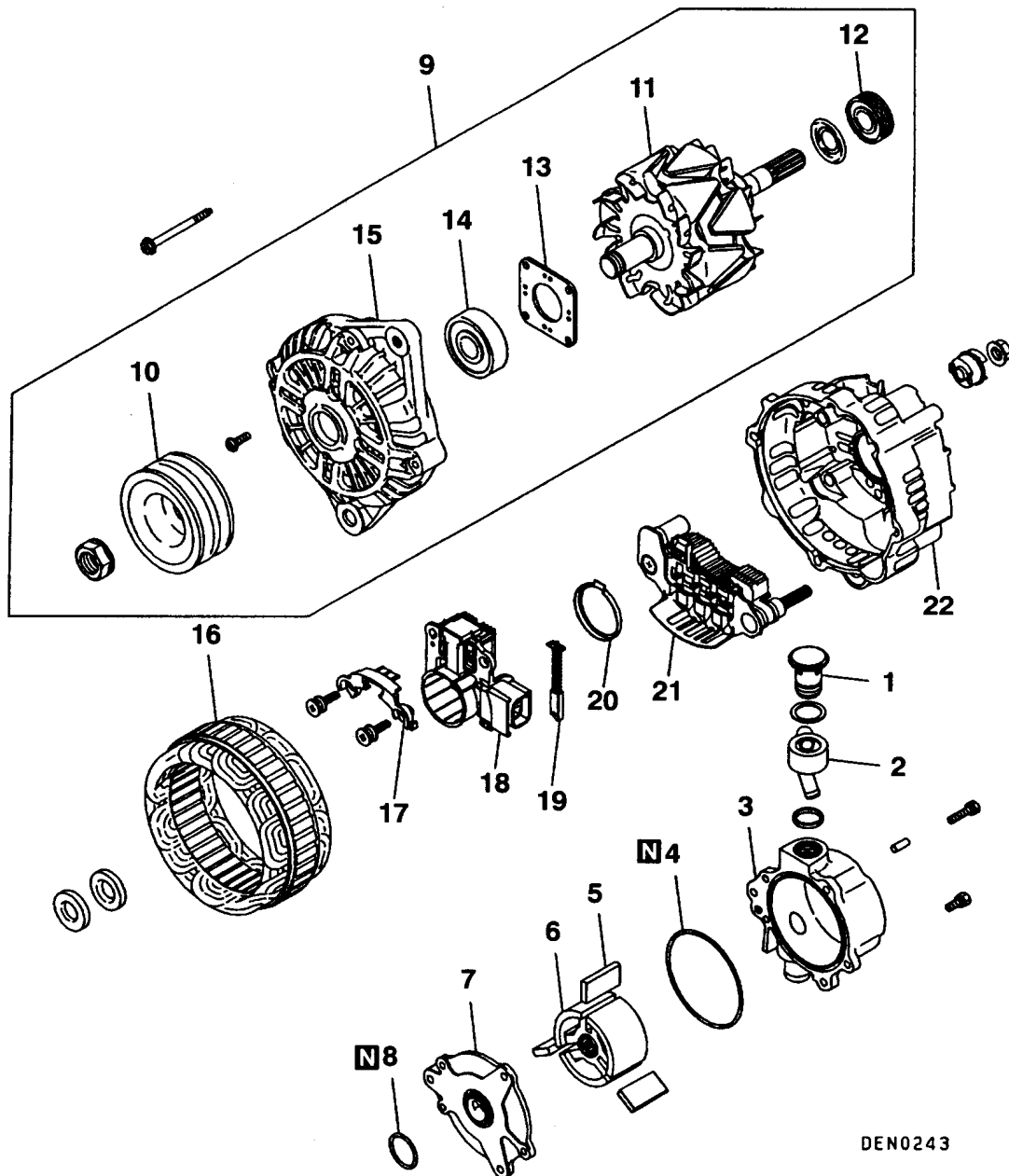
1. Front bracket assembly
2. Pulley
3. Rotor
4. Rear bearing
5. Bearing retainer
6. Front bearing
7. Front bracket



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

DISASSEMBLY AND REASSEMBLY

<4D5>



DEN0243

Disassembly steps

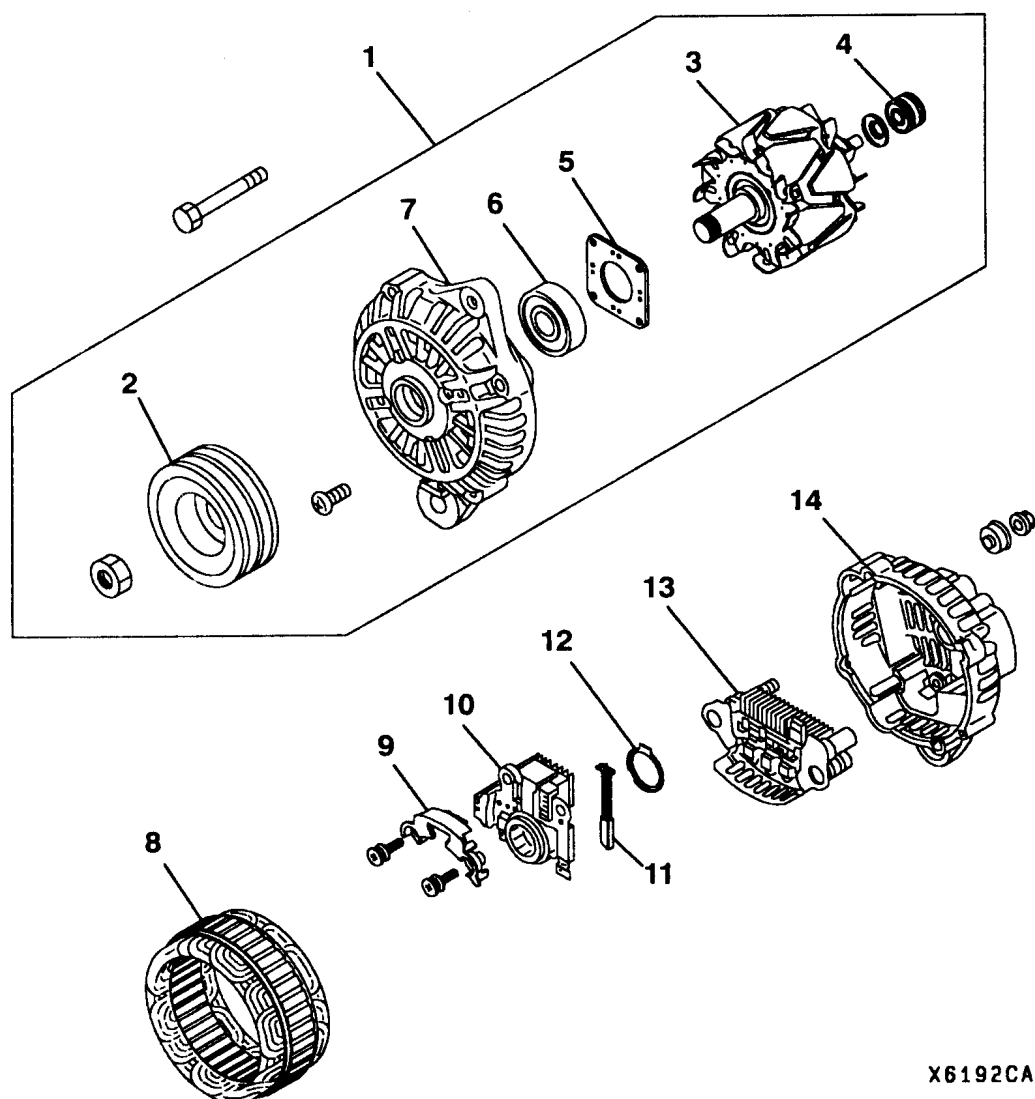
1. Check valve
2. Nipple
3. Vacuum pump housing
4. O-ring
5. Vane
6. Rotor
7. Vacuum pump plate
8. O-ring
9. Front bracket assembly
10. Pulley
11. Rotor

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 AND REASSEMBLY

<4M4>



X6192CA

Disassembly steps

◀A▶
◀B▶

▶B◀

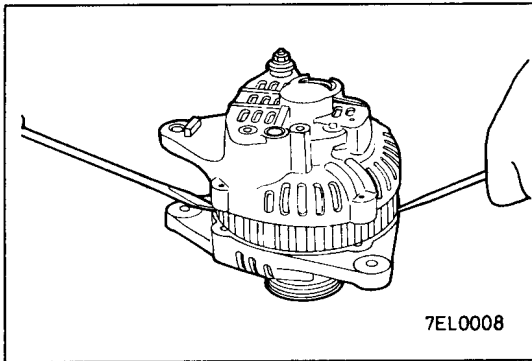
1. Front bracket assembly
2. Pulley
3. Rotor
4. Rear bearing
5. Bearing retainer
6. Front bearing
7. Front bracket

◀C▶

◀C▶

▶A◀

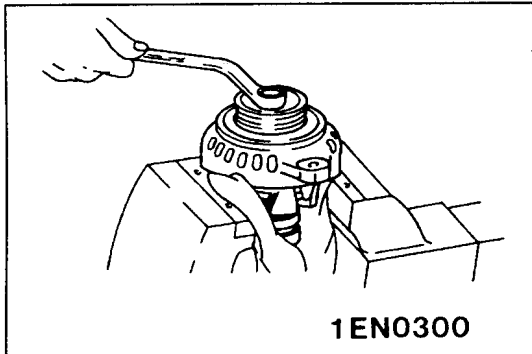
8. Stator
9. Plate
10. Regulator assembly
11. Brush
12. Slinger
13. Rectifier assembly
14. Rear bracket

**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

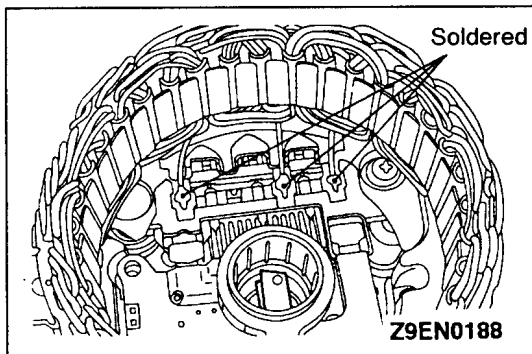
Do not insert a screwdriver too deep, as the stator coil will be damaged.

**◀B▶ PULLEY REMOVAL**

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

Caution

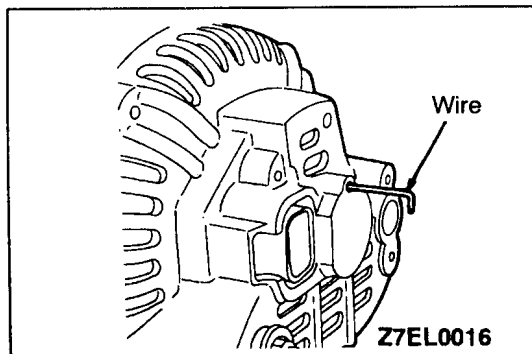
Use care not to damage the rotor.

**◀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

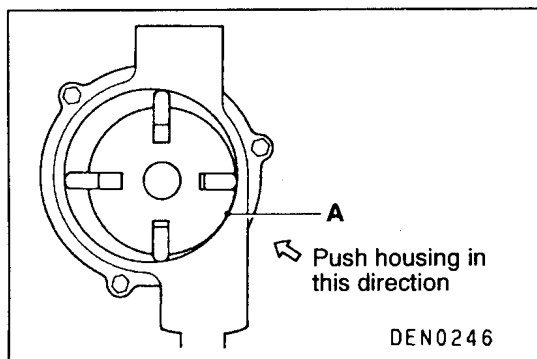
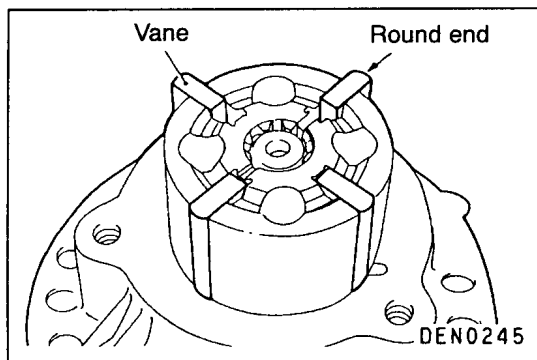
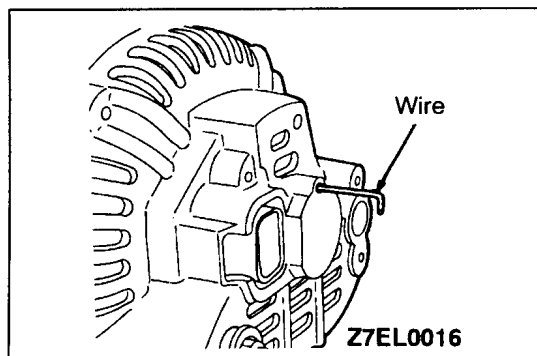
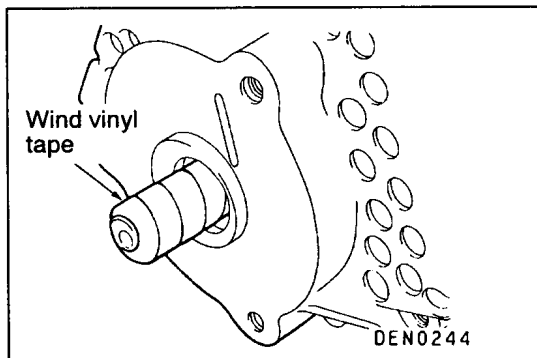
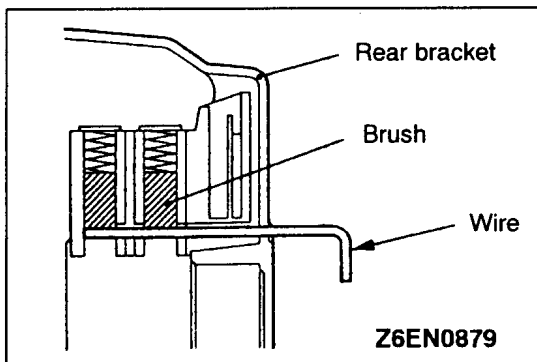
- (1) When soldering or unsoldering, use care to make sure that heat of soldering iron is not transmitted to diodes for a long period. Finish soldering or unsoldering in as short a time as possible.
- (2) Use care that no undue force is exerted to leads of diodes.

**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.

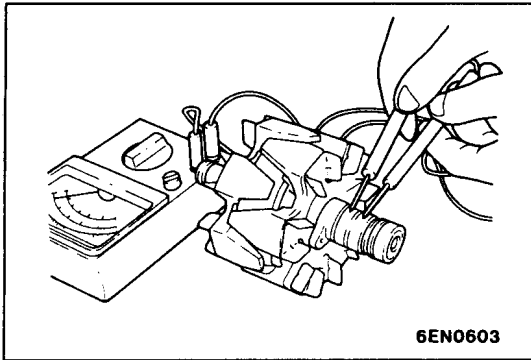
►C◄ ROTOR/VANES INSTALLATION <4D5>

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:
90.6 kPa or greater at 3,000 r/min

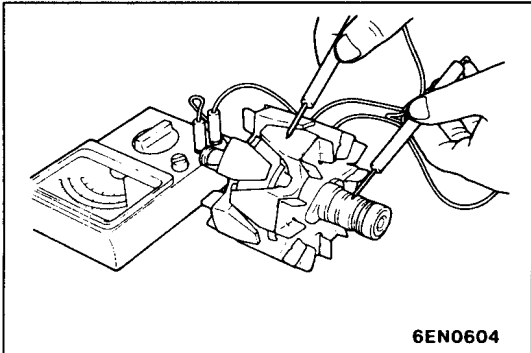


INSPECTION

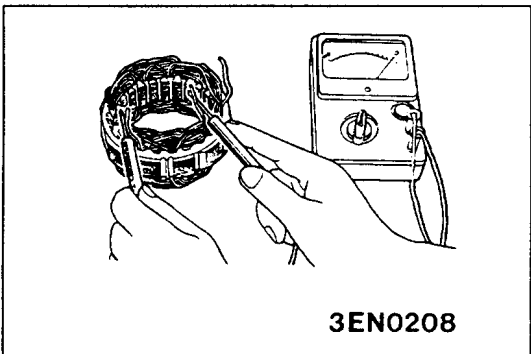
ROTOR

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 Ω

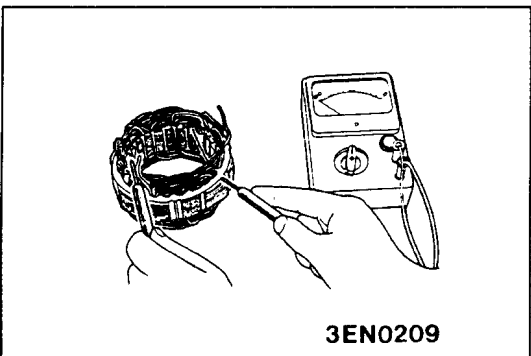


2. Check rotor coil for earthing. Check that there is no continuity between slip ring and core. If there is continuity, replace rotor assembly.

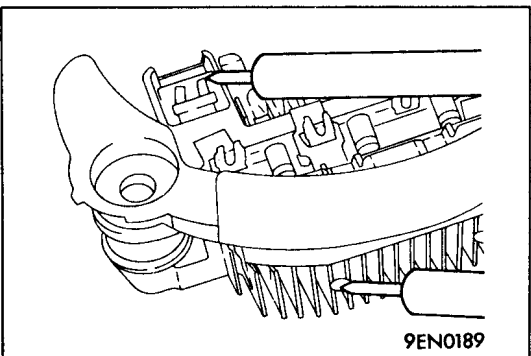


STATOR

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

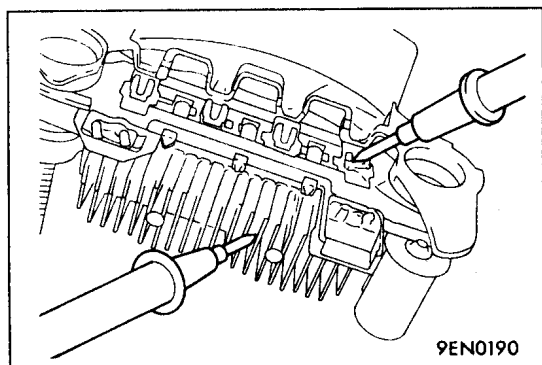


2. Check coil for earthing. Check that there is no continuity between coil and core. If there is continuity, replace stator assembly.

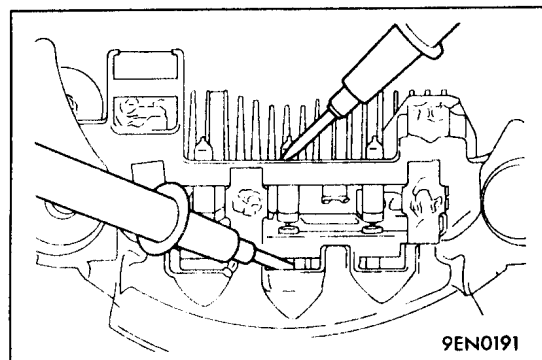


RECTIFIERS

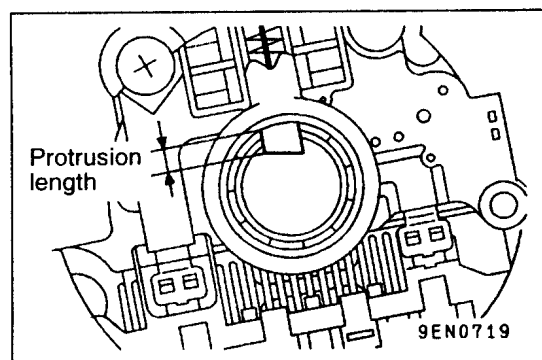
1. Check for continuity between positive rectifier and stator coil lead connection terminal with an ohmmeter. If there is continuity in both directions, diode is shorted. Replace rectifier assembly.



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.



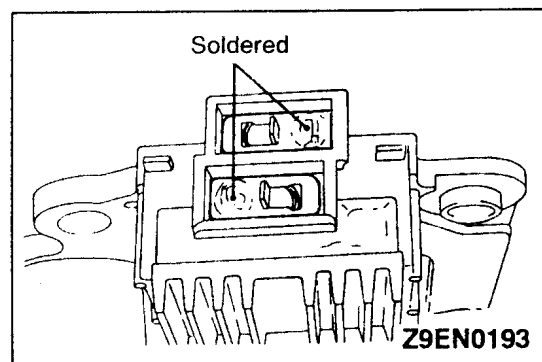
3. Check three diodes for continuity by connecting an ammeter to both ends of each diode. If there is no continuity in both directions, diode is faulty and heatsink assembly must be replaced.



BRUSH

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

Limit: min. 2 mm <6G7, 4D5>
min. 5 mm <4M4>

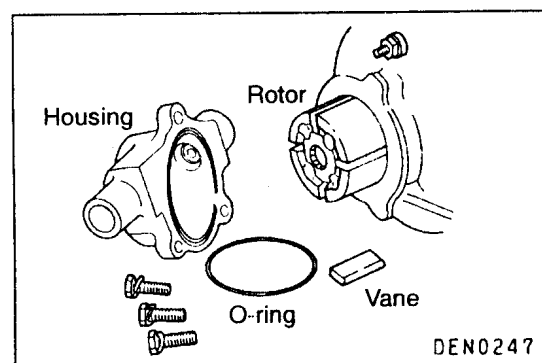


2. Unsolder pigtail and remove old brush and spring.

VACUUM PUMP <4D5>

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.

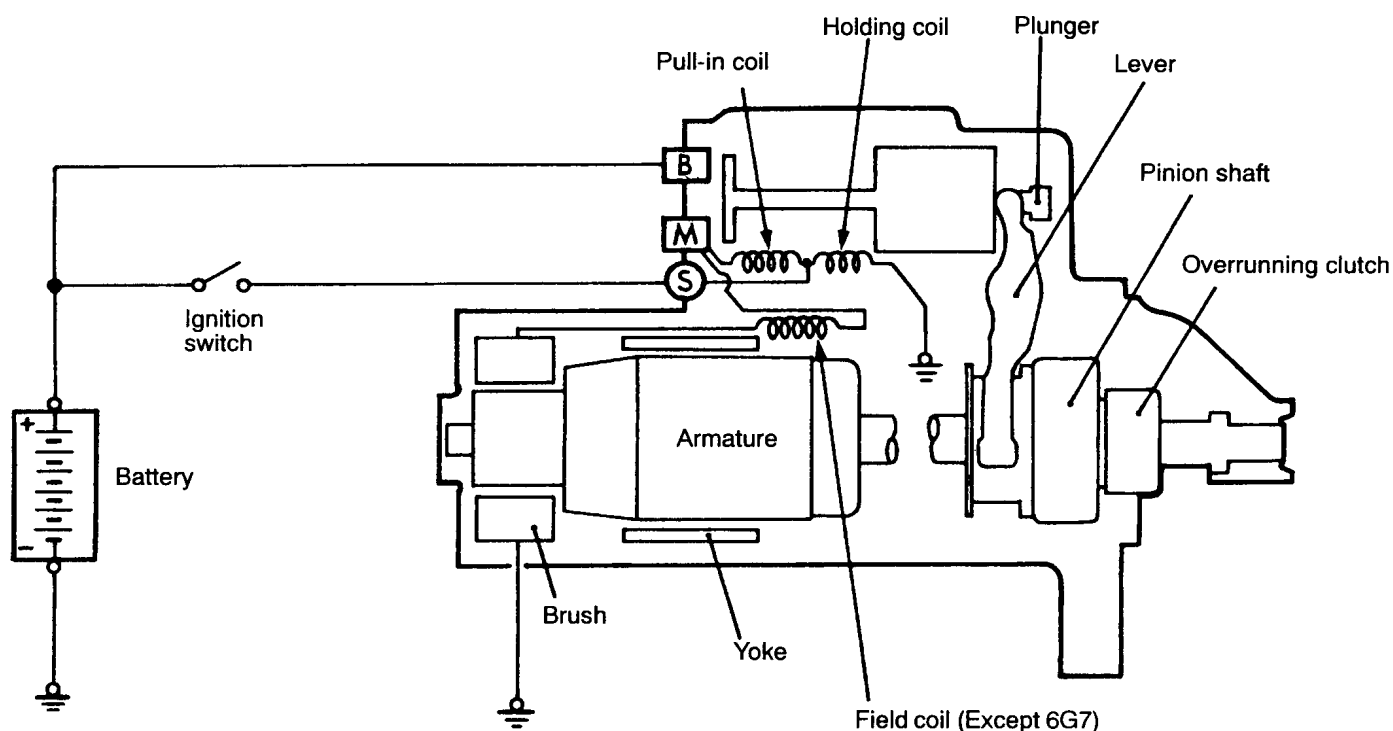
On the other hand, attracting the plunger will turn on the magnetic switch, allowing the B terminal

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



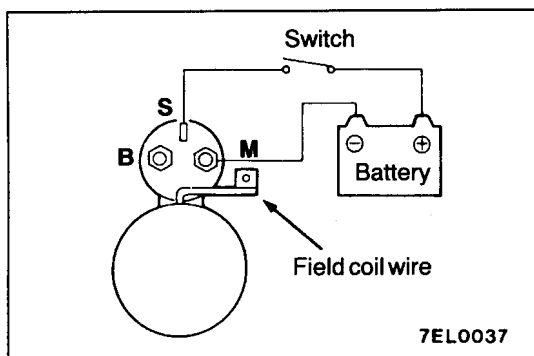
1EN0532

STARTER MOTOR SPECIFICATIONS

Items	6G7	4D5, 4M4
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	6G7	29.4	28.8
	4D5, 4M4	32	31.4
Commutator runout mm		0.05	0.1
Commutator undercut mm		0.5	0.2



STARTER MOTOR

16200110327

INSPECTION

PINION GAP ADJUSTMENT

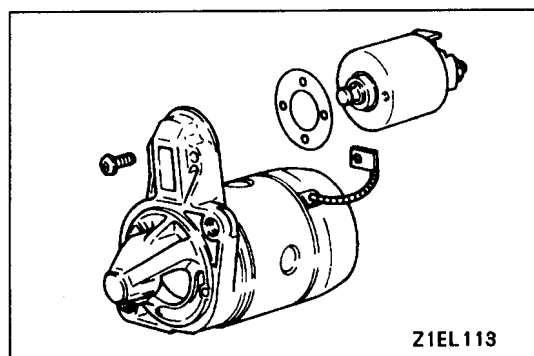
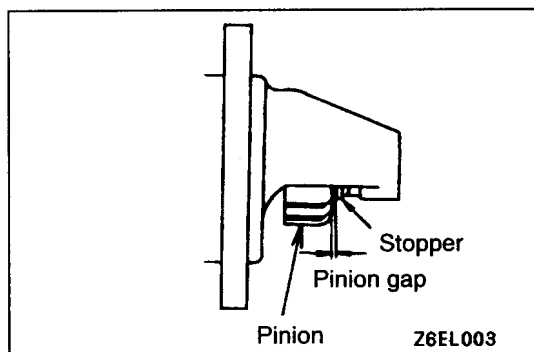
1. Disconnect field coil wire from M-terminal of magnetic switch.
2. Connect a 12V battery between S-terminal and M-terminal.
3. Set switch to "ON", and pinion will move out.

Caution

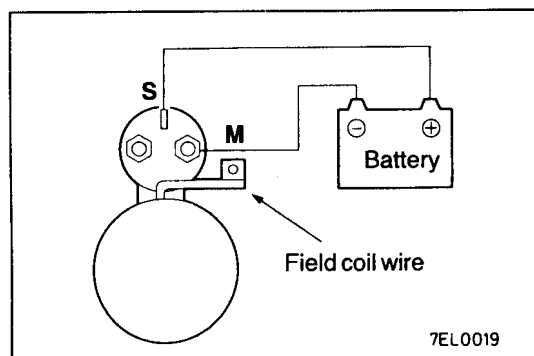
This test must be performed quickly (in less than 10 seconds) to prevent coil from burning.

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.



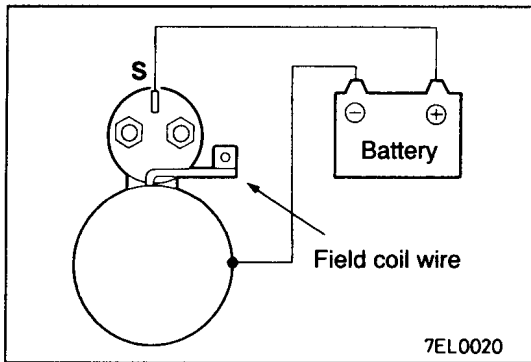
MAGNETIC SWITCH PULL-IN TEST

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.

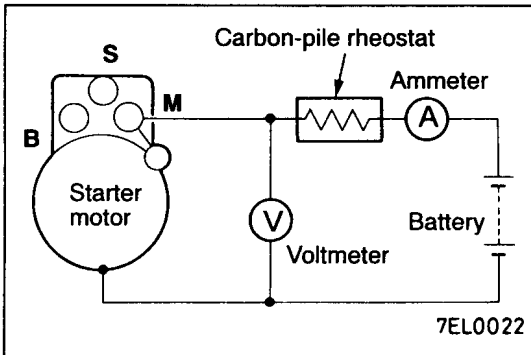
3. Manually pull out the pinion as far as the pinion stopper position.
4. If pinion remains out, everything is in order. If pinion moves in, hold-in circuit is open. Replace magnetic switch.

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 (6G7)

max. 130 Amps (4D5, 4M4)

**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.

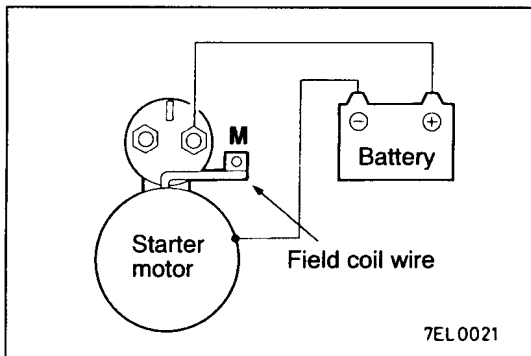
Caution

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.

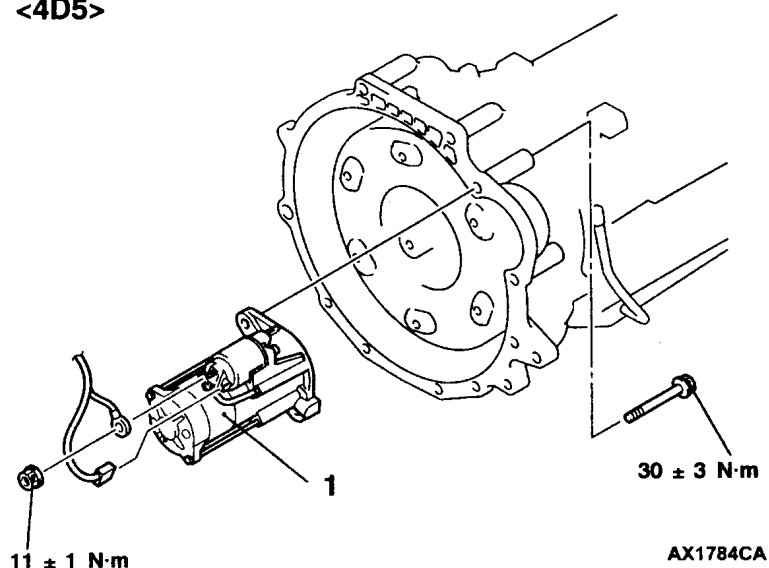
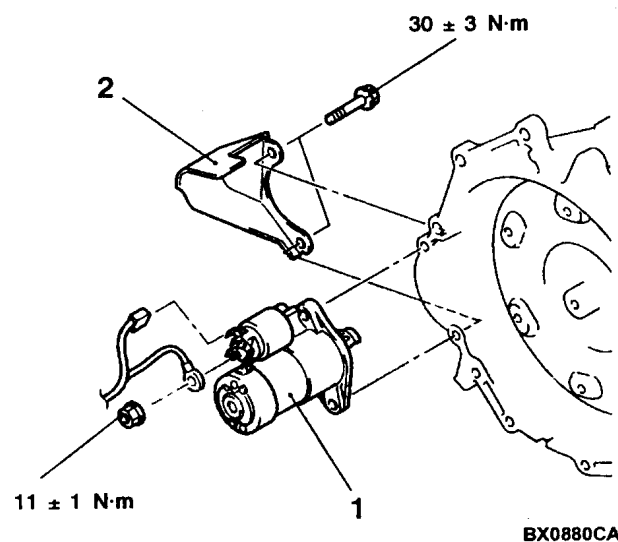


REMOVAL AND INSTALLATION

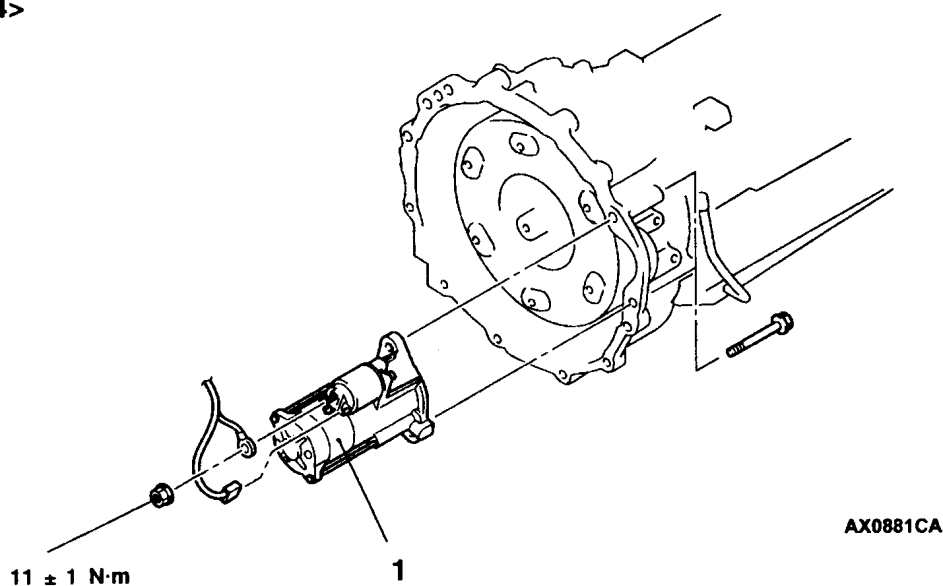
Pre-removal and Post-installation Operation
Under Cover Removal and Installation

<6G7>

<4D5>



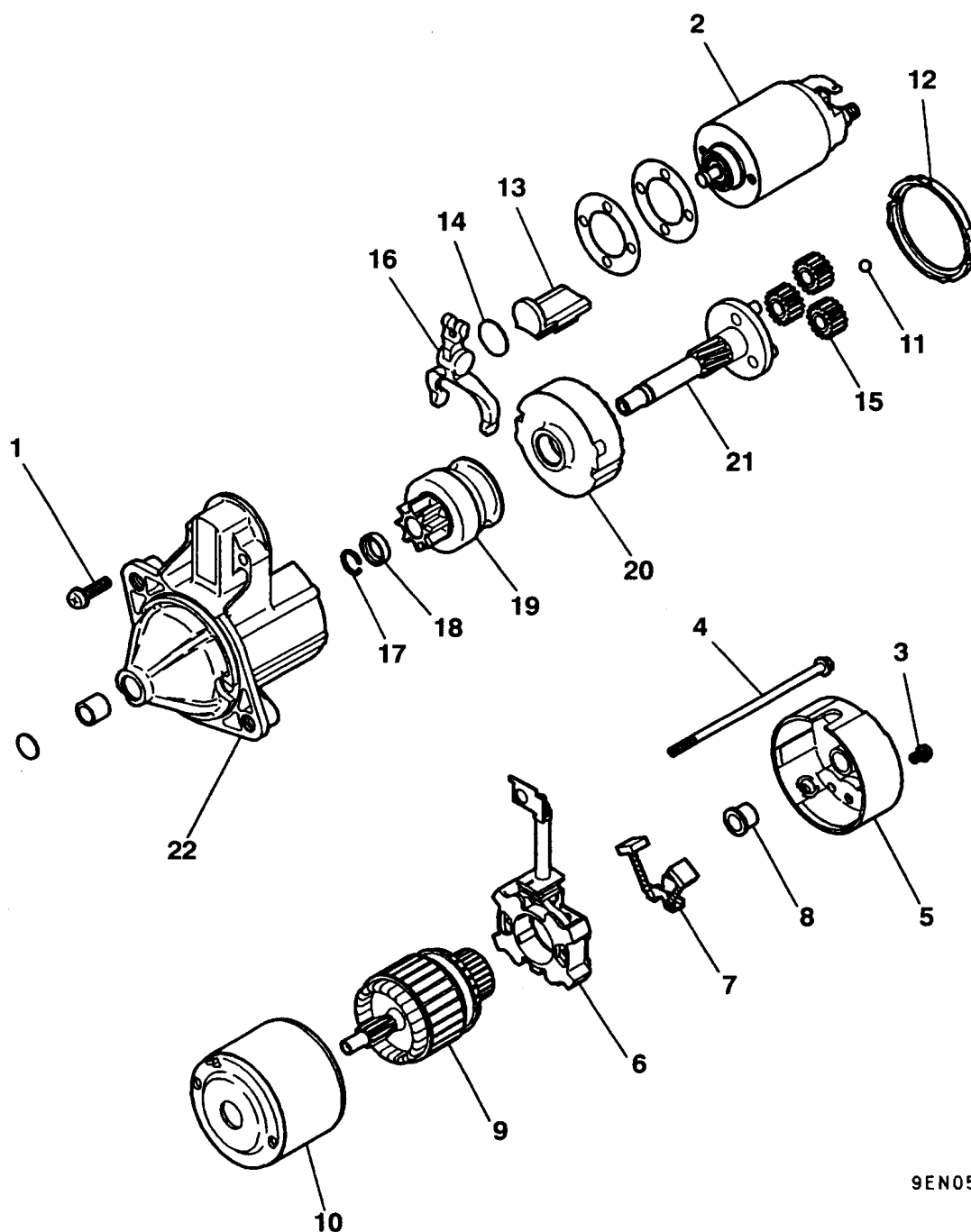
<4M4>

**Disassembly steps**

1. Starter motor assembly
2. Starter cover

DISASSEMBLY AND REASSEMBLY <6G7>

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

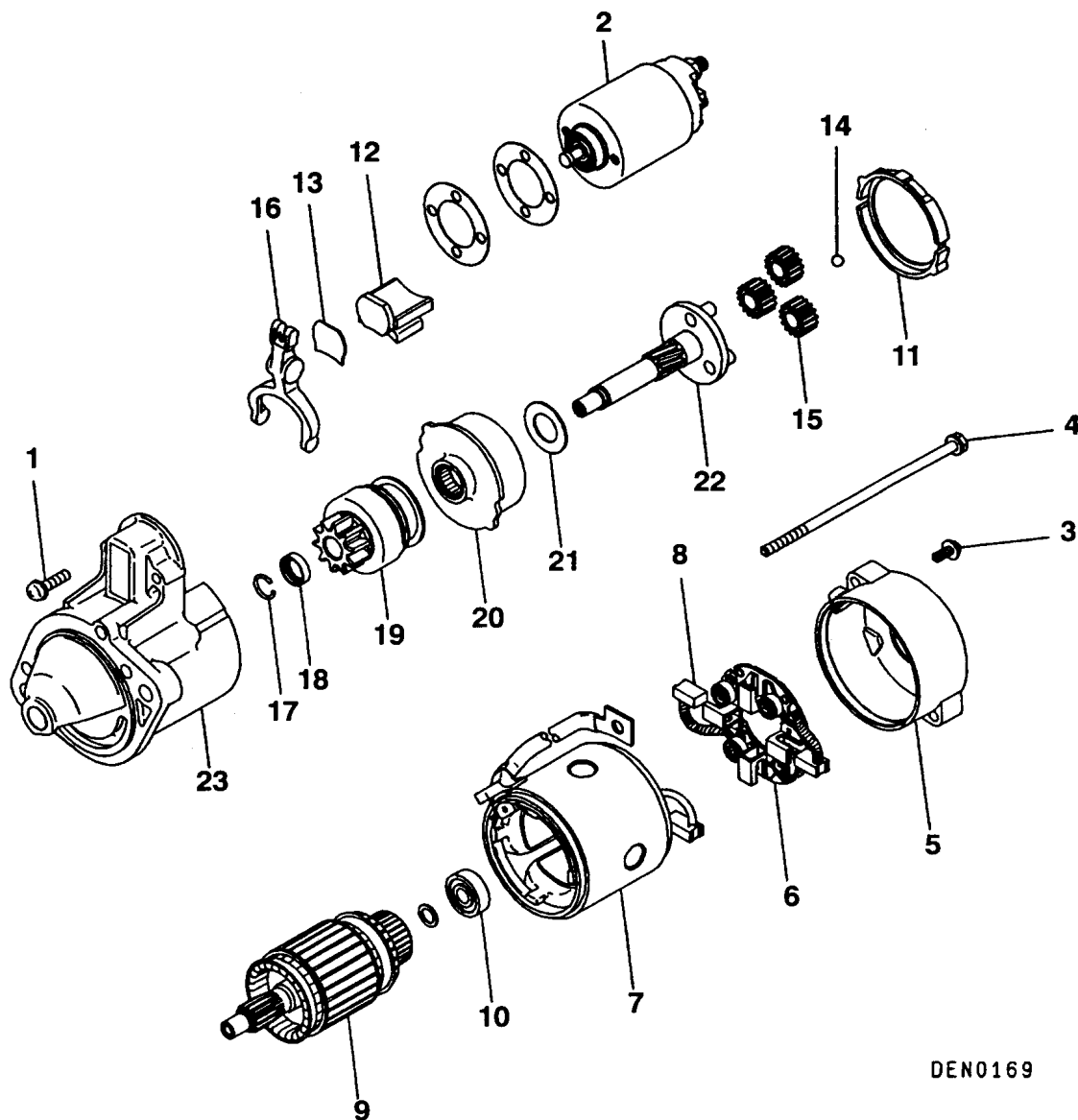
◀C▶
◀C▶▶A▶
▶A▶

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

◀B▶

◀B▶

<4D5>



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▶

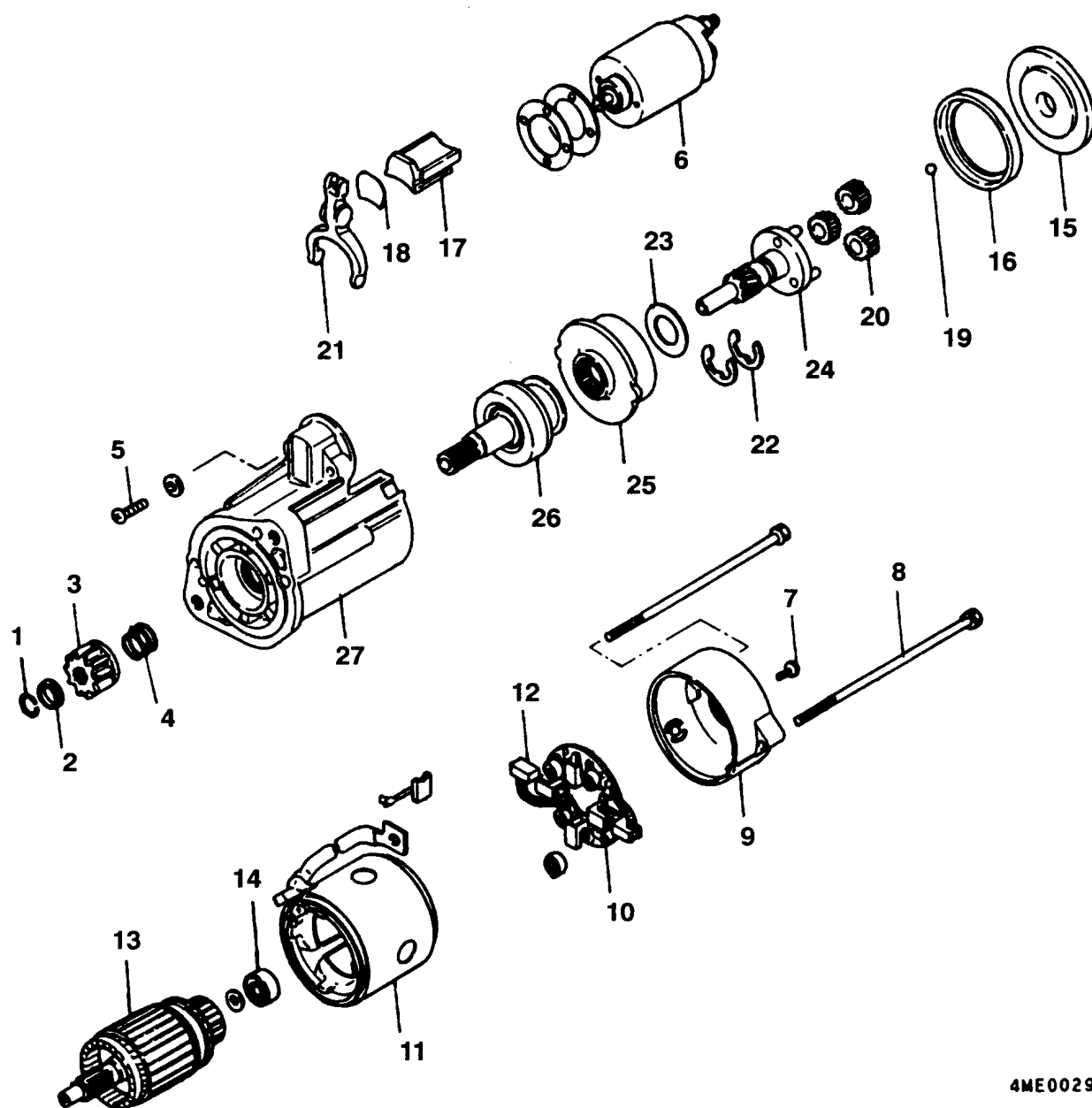
◀C▶

▶A▶

▶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

<4M4>



4ME0029

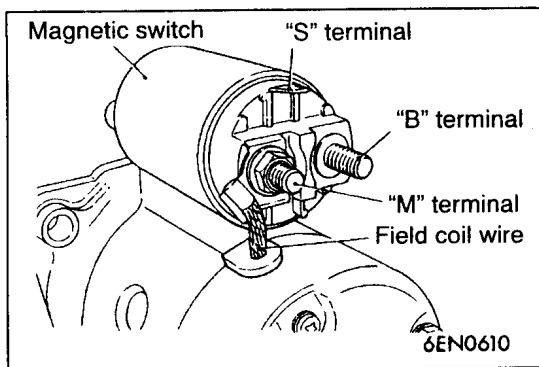
Disassembly steps

<D> >B<

1. Stopper ring
2. Pinion stopper
3. Pinion
4. Spring
5. Screw
6. Magnetic switch
7. Screw
8. Screw
9. Rear bracket
10. Brush holder assembly
11. Yoke assembly
12. Brush
13. Armature
14. Rear bearing

<E>

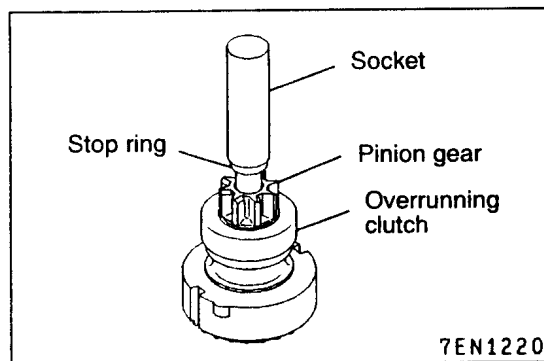
15. Cover
16. Rubber packing A
17. Rubber packing B
18. Plate
19. Ball
20. Planetary gear
21. Lever
22. Washer
23. Washer
24. Gear shaft
25. Internal gear
26. Overrunning clutch
27. Front bracket

**DISASSEMBLY SERVICE POINTS****◀A▶ MAGNETIC SWITCH REMOVAL**

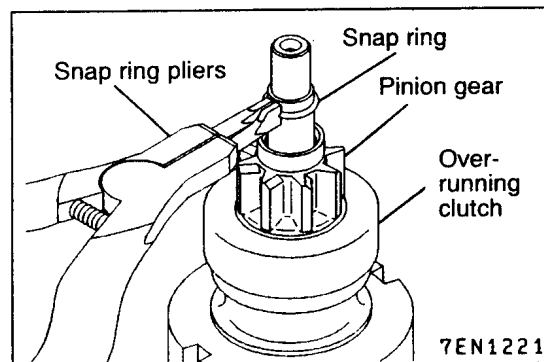
Disconnect field coil wire from "M" terminal of magnetic switch.

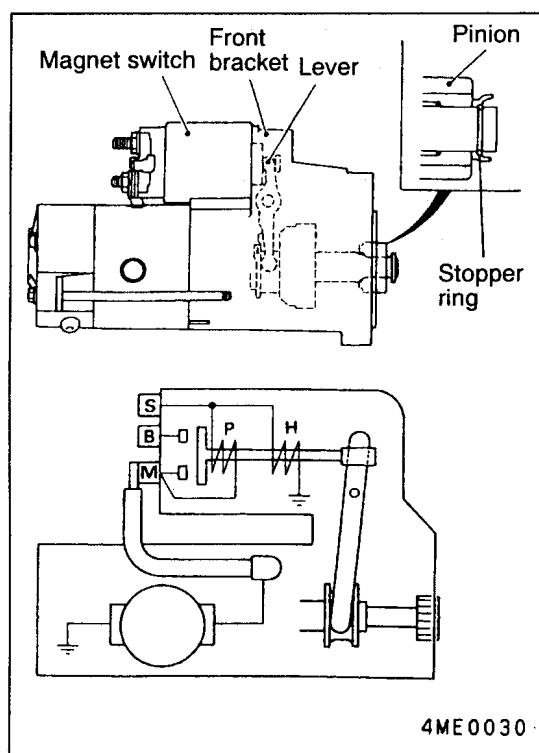
◀B▶ ARMATURE/BALL REMOVAL**Caution**

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.



**◀D▶ PINION REMOVAL <4M4>**

Remove the pinion with power supplied to the starter and the pinion in its popped-out position.

Caution

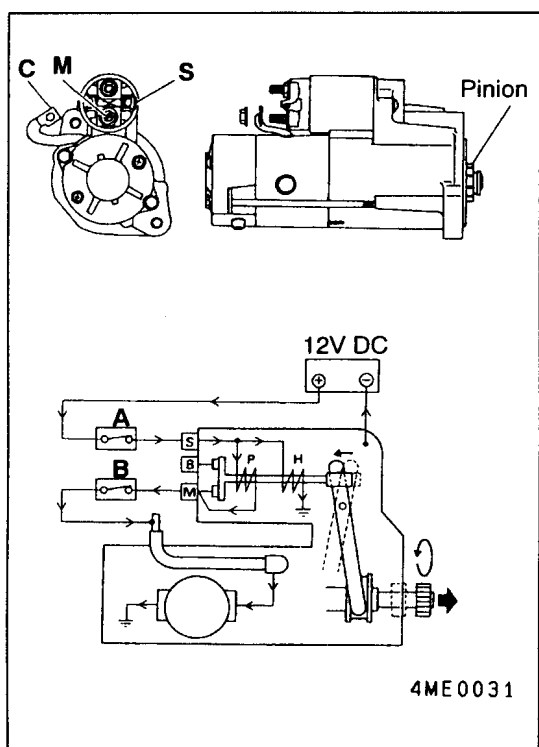
1. When power is supplied to the starter, the pinion pops out and rotates. Keep your hands away from the pinion at this time.
2. The magnet switch may be extremely hot after inspection. Be careful not to touch it.
3. Do not supply power to the pull-in coil P for more than 10 seconds. Do not supply power to the holding coil H for more than 30 seconds. If these time limits are exceeded, the coil(s) may overheat and burn out.
4. The pinion must be popped out electrically by supplying power to the starter. Do not pop out the pinion by pulling the lever since the front bracket and lever may be damaged when the stopper ring is removed.
5. When the starter is energized, current of more than 100A flows. Thus, heavy-duty cables (as thick as booster cables) must be used to connect the starter for inspection, and all connections must be securely tightened.

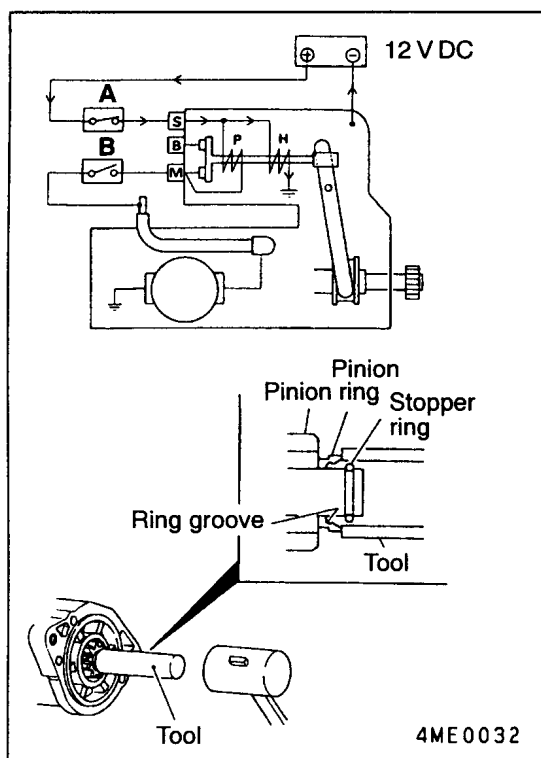
1. Connect the starter as shown in the illustration. Here,
A: Switch,
B: Switch,
C: Cable,
M: Starter M terminal,
S: Starter S terminal.

NOTE

The following procedure must be carried out with power supplied to the starter. Thus, the pinion must be removed within 30 seconds of turning ON the power.

2. Supply power to the starter by turning ON switches A and B. The pinion will pop out and rotate.





3. Within 5 seconds of the pinion's rotation, turn OFF switch B to stop the pinion from rotating.

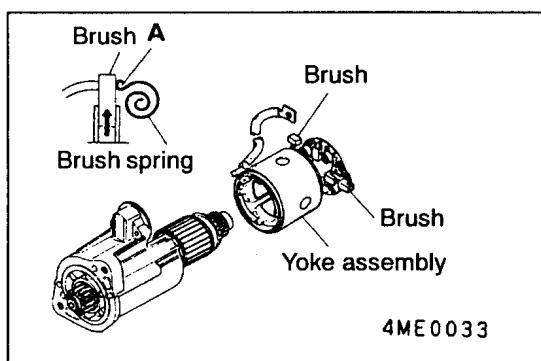
Caution

With switches A and B turned ON, power is supplied to both the pull-in coil P and holding coil H. No voltage is applied to starter terminal B, so current flows in the pull-in coil while the pinion is rotating. To prevent the pull-in coil from burning out, switch B must therefore be turned OFF within 5 seconds of the pinion's rotation.

4. Apply a suitable tubular tool to the pinion stopper.
5. Lightly tap the tubular tool with a hammer to remove the stopper ring from the pinion stopper ring groove.
6. Remove the stopper ring and pinion.
7. Turn OFF switch A to cut the supply of power to the starter.

Caution

When the starter power is cut, the pinion may pop in, causing the stopper ring to go back into the ring groove. If this occurs, switch ON the starter power and repeat the procedure.

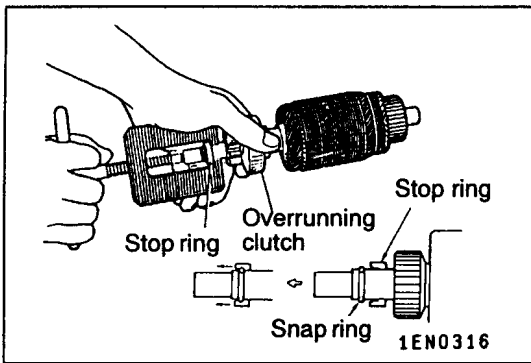


◀E▶ YOKE ASSEMBLY REMOVAL <4M4>

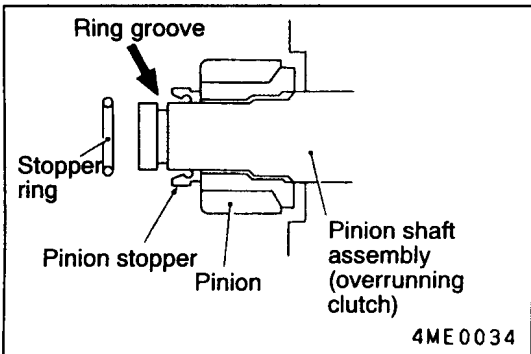
1. Pull the brush spring at point A and raise the brush.
2. After raising the brush, hold it in place with the brush spring as shown in the illustration.
3. Remove the yoke assembly.

STARTER MOTOR PARTS CLEANING

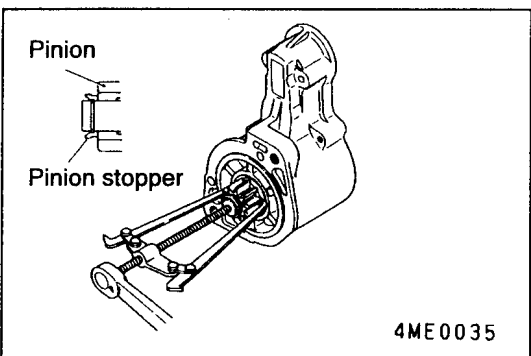
1. Do not immerse parts in cleaning solvent. Immersing the yoke and field coil assembly and/or armature will damage insulation. Wipe motor assembly with a cloth only.
2. Do not immerse drive unit in cleaning solvent. Overrunning clutch is pre-lubricated at the factory and solvent will wash lubrication 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**

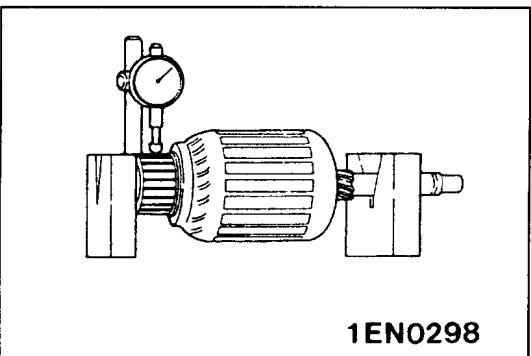
Using a suitable pulling tool, pull overrunning clutch stop ring over snap ring.

**►B◄ PINION INSTALLATION**

1. Install the pinion and the pinion stopper in the direction shown in the illustration.
2. Install the stopper ring in the ring groove of the pinion shaft assembly (overrunning clutch).



3. Pulling the pinion hard, secure the pinion stopper to the stopper ring.

**INSPECTION**

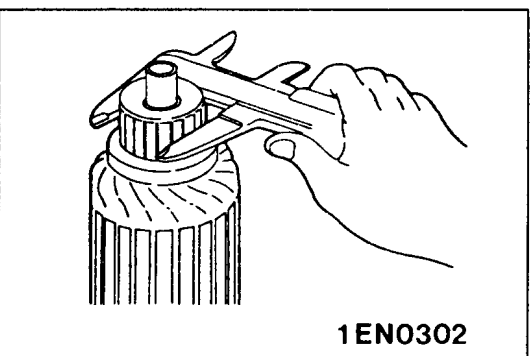
16200130286

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

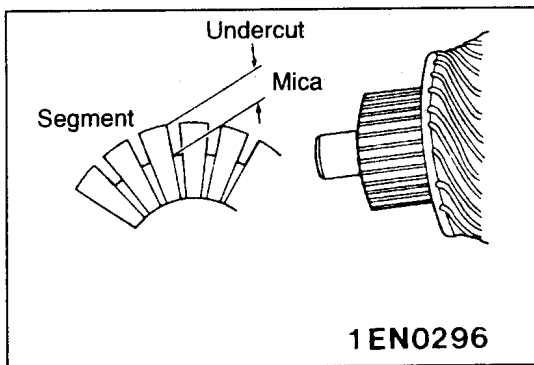
Limit: 0.1 mm



2. Measure the commutator outer diameter.

Standard value: 29.4 mm

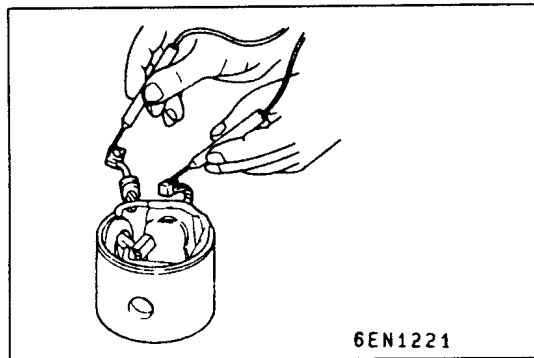
Limit: 28.8 mm



3. Check the undercut depth between segments.

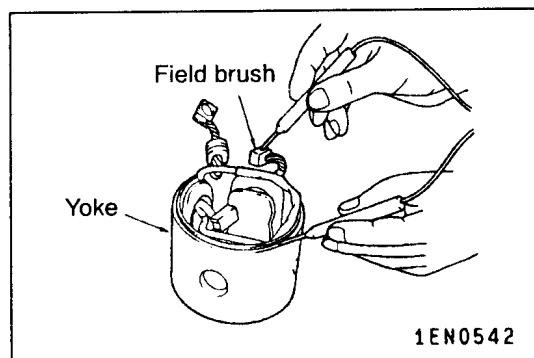
Standard value: 0.5 mm

Limit: 0.2 mm



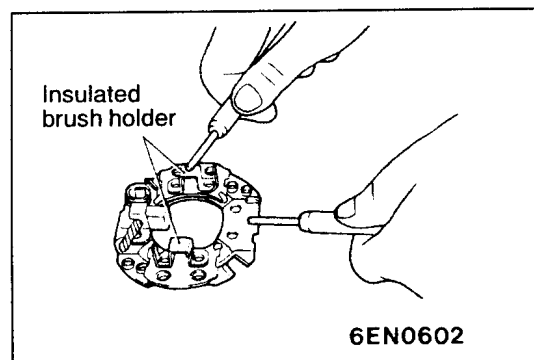
FIELD COIL OPEN-CIRCUIT TEST <4D5, 4M4>

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



FIELD COIL GROUND TEST <4D5, 4M4>

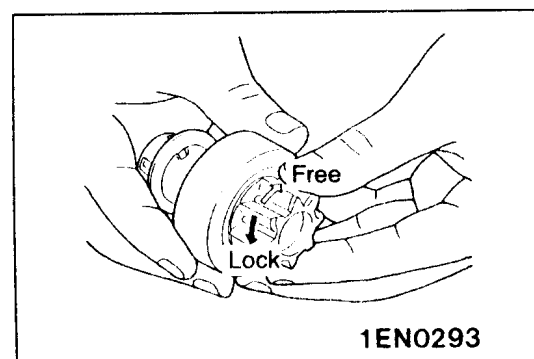
Check the continuity between field coil brush and yoke. If there is no continuity, the field coil is free from earth.



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.

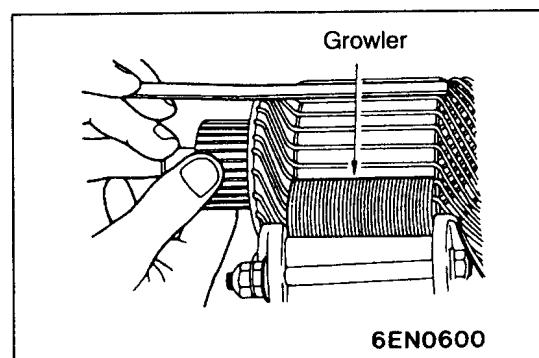
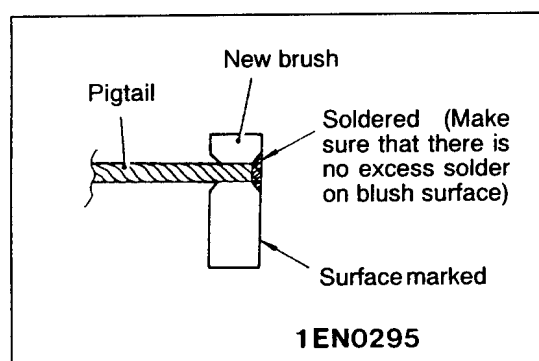
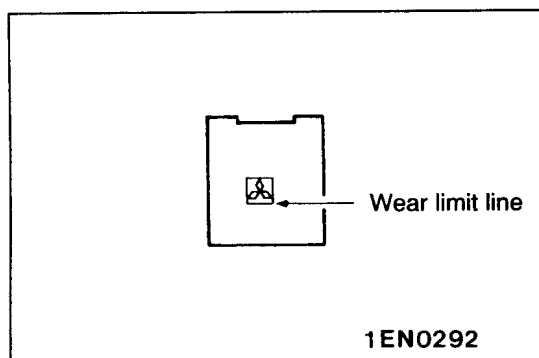
<4D5>

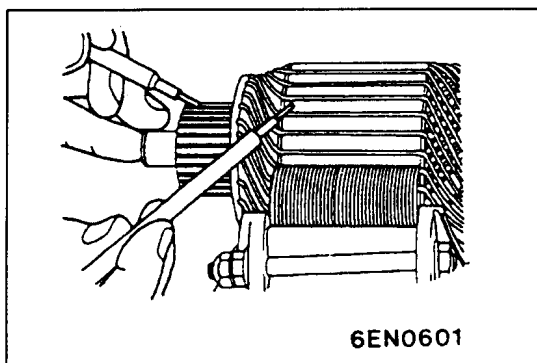
1. Brushes that are worn beyond wear limit line, or are oil-soaked, should be replaced.
2. When replacing field coil brushes, crush worn brush with pliers, taking care not to damage pigtail.

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**

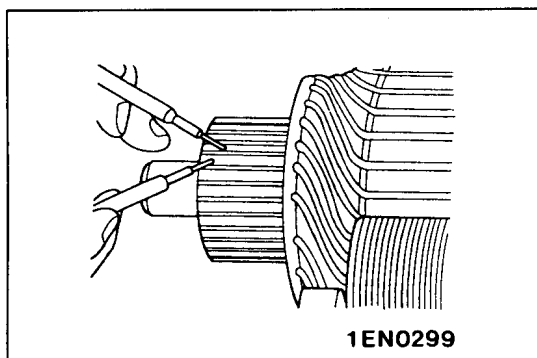
1. Place armature in a growler.
2. Hold a thin steel blade parallel and just above while rotating armature slowly in growler. A shorted armature will cause blade to vibrate and be attracted to the core. Replace shorted armature.



**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

GENERAL INFORMATION

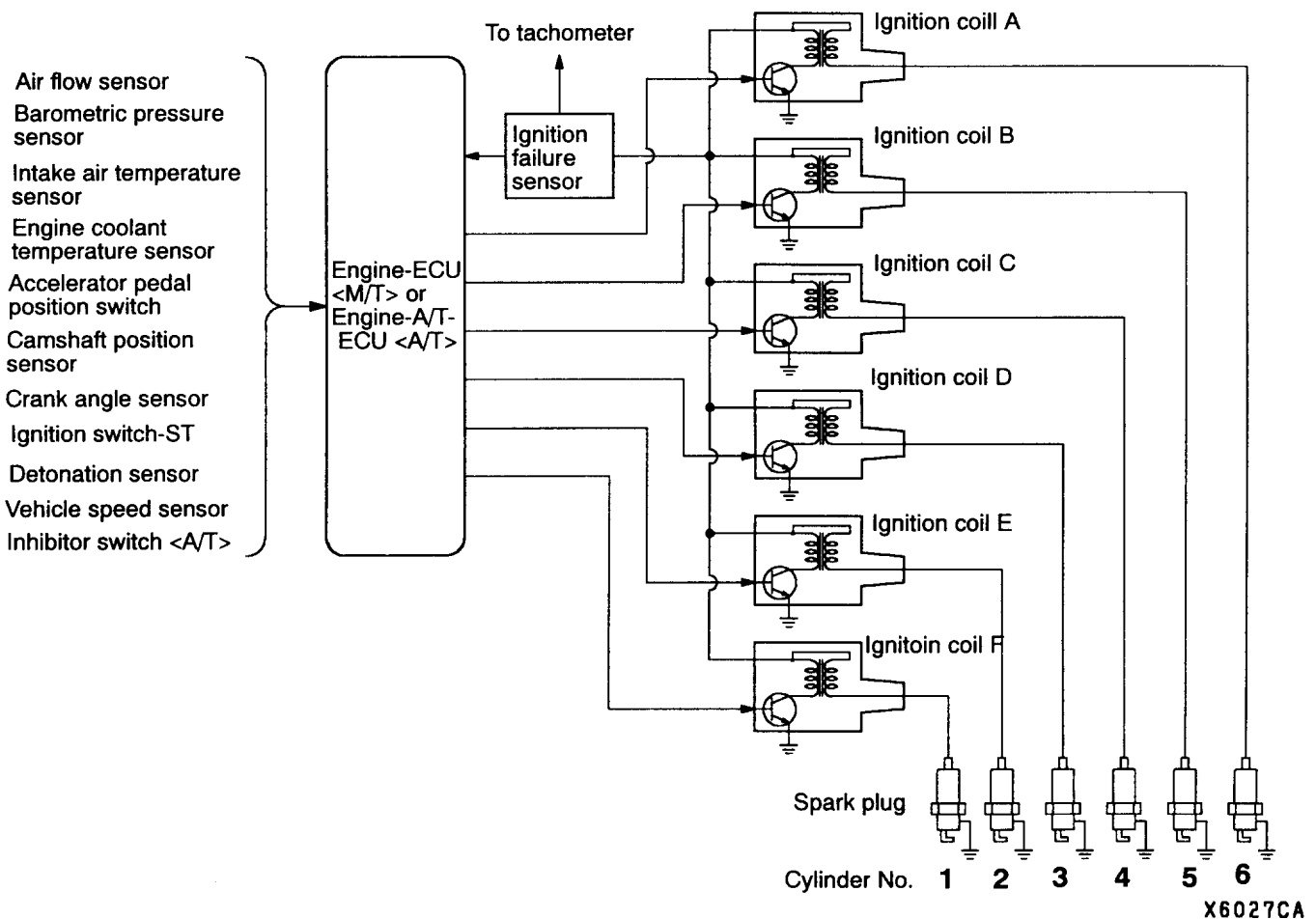
This system is equipped with four ignition coils with built-in power transistors for each of the cylinders. Interruption of the primary current flowing in the primary side of an ignition coil generates a high voltage in the secondary side of the ignition coil. The high voltage thus generated is applied to the spark plugs to generate sparks.

The engine-ECU <M/T> or engine-A/T-ECU <A/T> turns the power transistors inside the ignition coils alternately on and off. This causes the primary currents in the ignition coils to be alternately interrupted and allowed to flow to fire the cylinders in the order 1 – 2 – 3 – 4 – 5 – 6.

The engine-ECU <M/T> or engine-A/T-ECU <A/T> determines which ignition coil should be controlled by means of the signals from the camshaft position sensor and the crank angle sensor. It also detects the crankshaft position, in order to provide ignition at the most appropriate timing in response to the engine operation conditions.

When the engine is cold or running at high altitudes, the ignition timing is slightly advanced to provide optimum performance. Furthermore, if knocking occurs, the ignition timing is gradually retarded until knocking ceases.

SYSTEM DIAGRAM



IGNITION COIL SPECIFICATION

Items	Specification
Type	Molded 6-coil

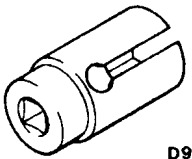
SPARK PLUG SPECIFICATION

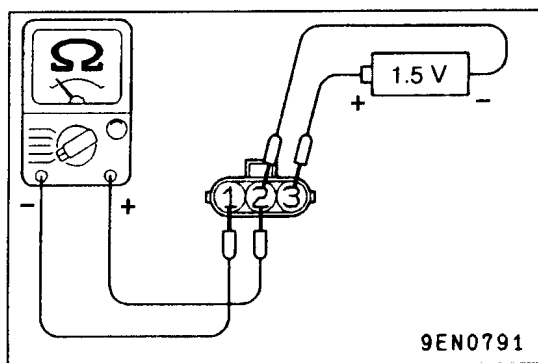
Items	6G7
NGK	IZFR5B

SERVICE SPECIFICATIONS**SPARK PLUG**

Items	Standard value	Limit
Spark plug gap mm	0.5 – 0.6	0.75
Spark plug insulation resistance MΩ	–	1

SPECIAL TOOL

Tool	Number	Name	Use
 D998773	MD998773	Detonation sensor wrench	Detonation sensor removal and installation

**ON-VEHICLE SERVICE****IGNITION COIL (WITH BUILT-IN POWER TRANSISTOR) CHECK****PRIMARY COIL AND POWER TRANSISTOR CONTINUITY CHECK****NOTE**

1. An analogue-type circuit tester should be used.
2. Connect the negative (–) probe of the circuit tester to terminal 1.

Caution

This test must be performed quickly (in less than 10 seconds) to prevent coil from burning and power transistor from breakage.

Voltage: 1.5V	Terminal No.		
	1	2	3
When current is flowing			
When current is not flowing			

SECONDARY COIL CHECK

NOTE

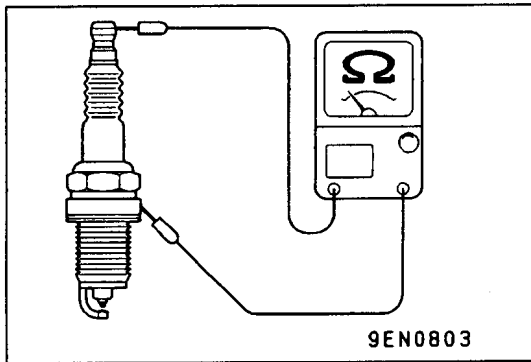
It is impossible to check the secondary coil through the continuity check as a diode is integrated in the secondary coil circuit of this ignition coil. So, check the secondary coil in the following procedure.

1. Disconnect the ignition coil connector.
2. Remove the ignition coil and install a new spark plug to the ignition coil.
3. Connect the ignition coil connector.
4. Earth the side electrode of the spark plug and crank the engine.
5. Check that spark is produced between the electrodes of the spark plug.
6. If no spark is produced, replace the ignition coil with a new one and recheck.
7. If spark is produced with the new ignition coil, replace the old one as it is faulty. If no spark is produced again, the ignition circuit is suspected as faulty. Check the ignition circuit.

SPARK PLUG CHECK AND CLEANING

Caution

1. The spark plug gap for iridium plugs should not be adjusted.
2. Cleaning iridium plugs may result in damage to the iridium tip. Therefore, if cleaning is necessary because the plug is sooty, use a plug cleaner, and do not clean the plug for more than 20 seconds in order to preserve the electrodes. A wire brush should never be used.
3. The spark plugs in GDI engines are special iridium plugs in which the electrodes can become black even when the plugs are working normally. Carbon which may become deposited on these plugs burns off more readily than with conventional plugs, and so should not cause any problems with spark plug performance. Judgement of whether a spark plug is operating normally or not should be made by checking the insulation resistance.



1. Remove the ignition coils.
2. Remove the spark plugs.
3. Check the spark plug gap. Replace the spark plug if the gap exceeds the limit.

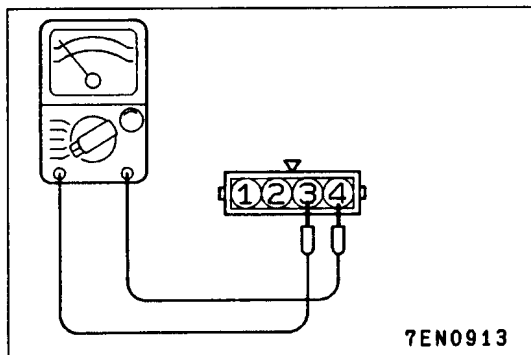
Limit: 0.75 mm

Standard value: 0.5 – 0.6 mm

4. Measure the spark plug insulation resistance. Replace the spark plug if the measured value is lower than the limit value.

Limit: 1 MΩ

5. Clean the spark plug holes.
6. Install the spark plugs.
7. Install the ignition coils.



IGNITION FAILURE SENSOR CHECK

NOTE

An analog-type ohmmeter should be used. Check that the resistance between terminals 3 and 4 is at the standard value.

Standard value: 0.1 Ω or less.

CAMSHAFT POSITION SENSOR CHECK

Refer to GROUP 13A – Troubleshooting. <6G7>

CRANK ANGLE SENSOR CHECK

Refer to GROUP 13A – Troubleshooting. <6G7>

DETONATION SENSOR CHECK

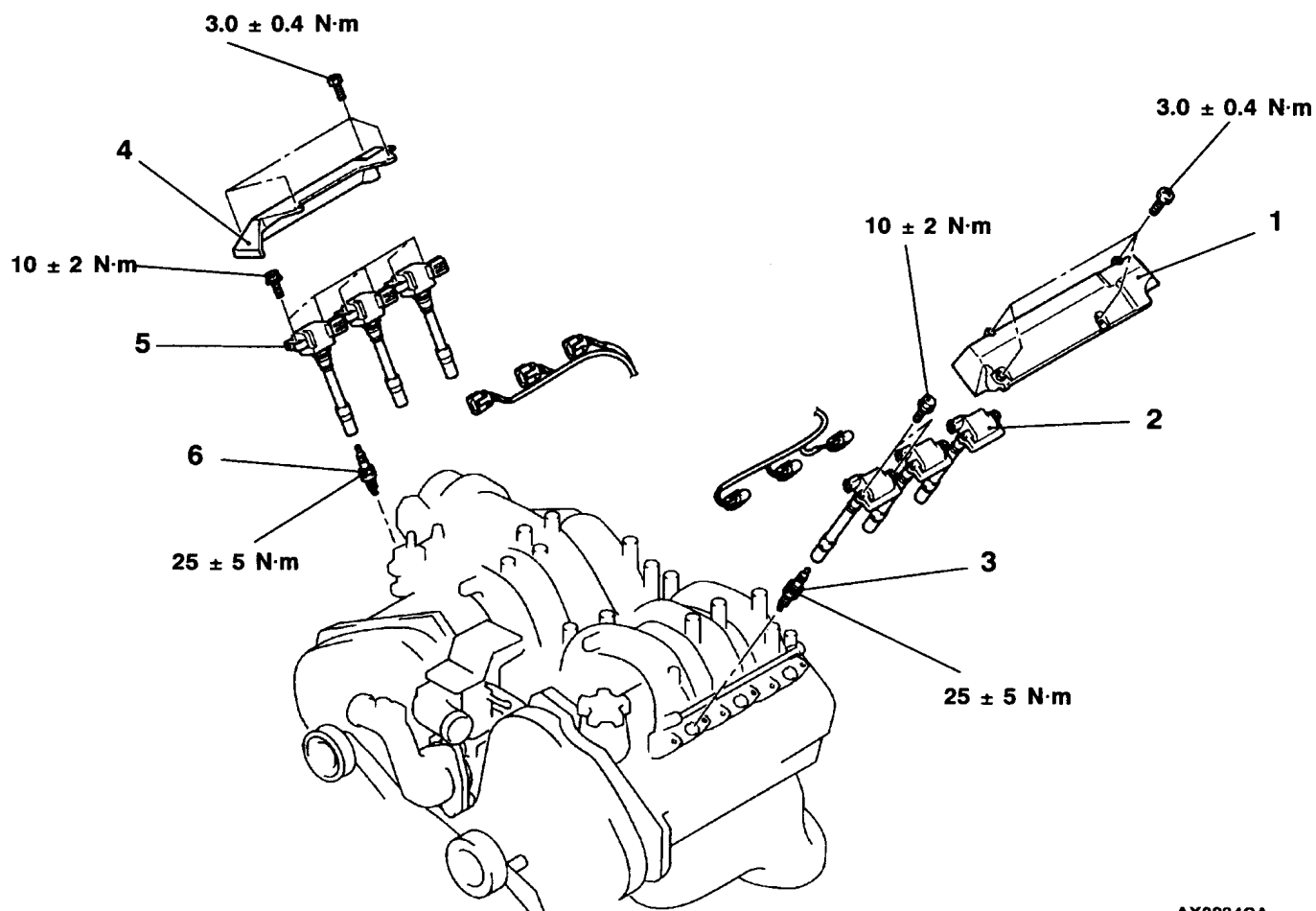
Check the detonation sensor circuit if self-diagnosis code, No. 31 is shown.

NOTE

For information concerning the self-diagnosis codes, refer to GROUP 13A – Troubleshooting. <6G7>

IGNITION COIL<6G7>**REMOVAL AND INSTALLATION****Pre-removal and Post-installation Operation**

- Engine Cover Removal and Installation
- Air Cleaner Assembly Removal and Installation (Refer to GROUP 15.)



AX0884CA

Removal steps <Left bank>

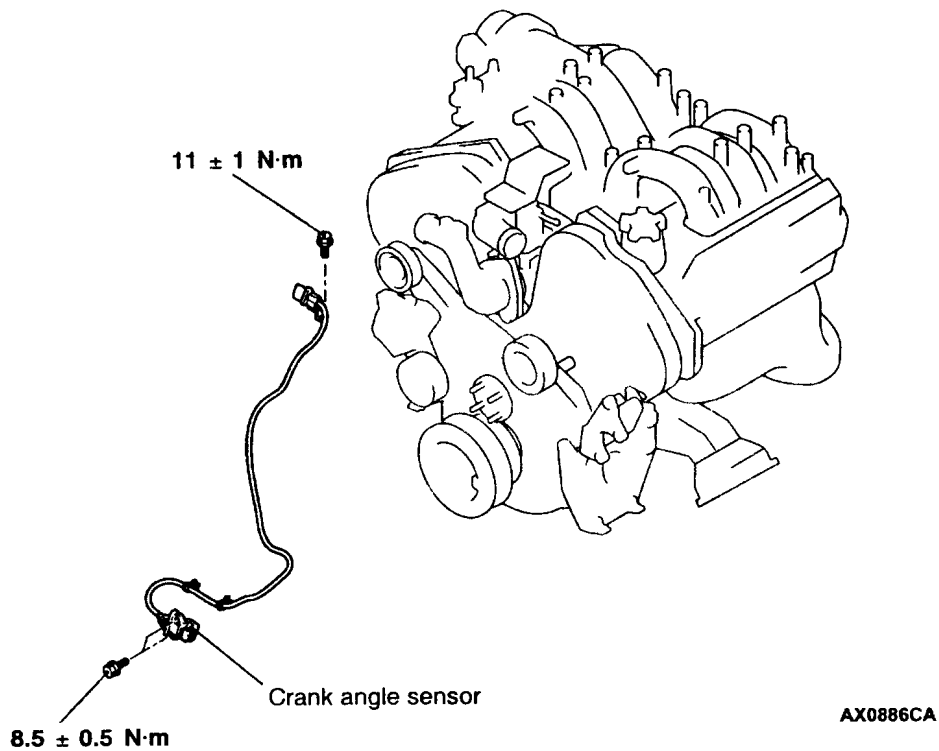
1. Center cover, left
2. Ignition coil
3. Spark plug

Removal steps <Right bank>

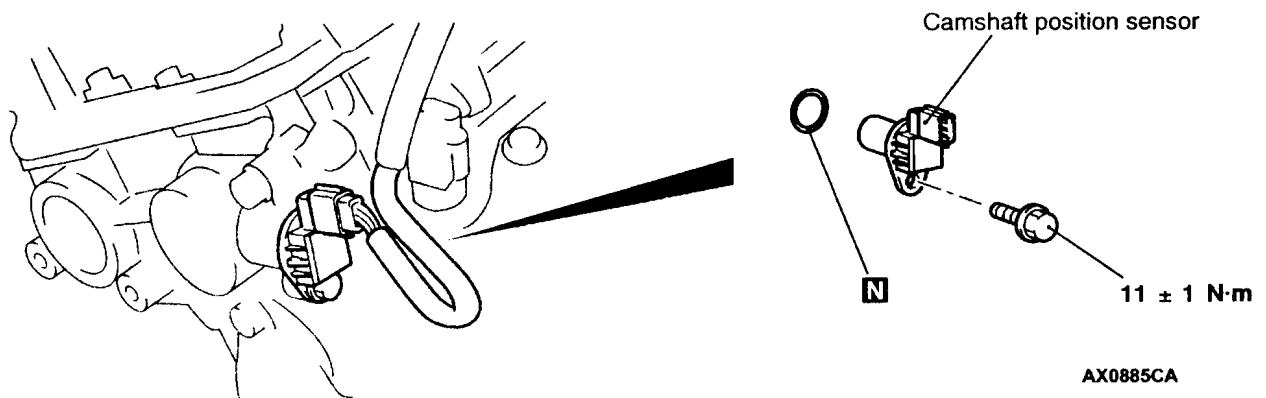
- Throttle body (Refer to GROUP 13A.)
- 4. Center cover, right
- 5. Ignition coil
- 6. Spark plug

CRANK ANGLE SENSOR<6G7>**REMOVAL AND INSTALLATION**

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

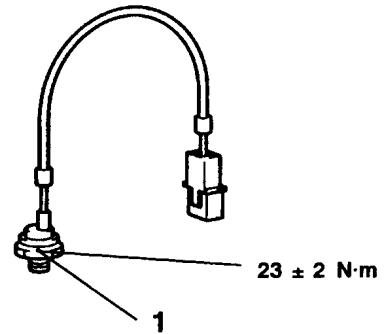
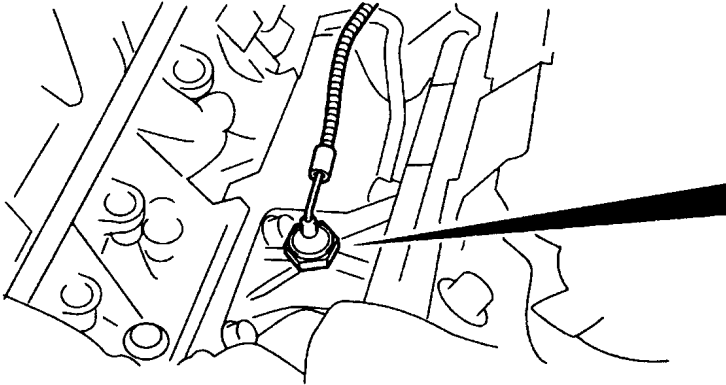
**CAMSHAFT POSITION SENSOR <6G7>****REMOVAL AND INSTALLATION**

Pre-removal and Post-installation Operation
Engine Cover Removal and Installation (Refer to GROUP 11.)



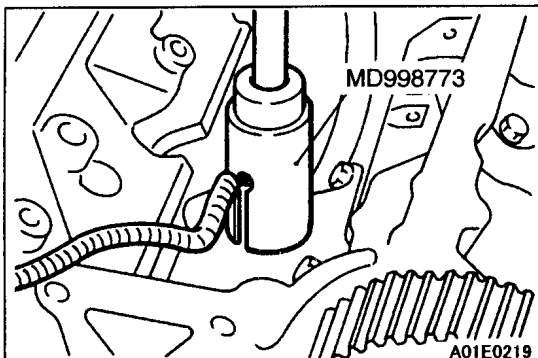
DETONATION SENSOR <6G7>**REMOVAL AND INSTALLATION**

Pre-removal and Post-installation Operation
Intake Manifold Removal and Installation (Refer to GROUP 15.)



AX0887CA

◀A▶ ▶A◀ 1. Detonation sensor

**REMOVAL SERVICE POINT**

◀A▶ DETONATION SENSOR REMOVAL

INSTALLATION SERVICE POINT

▶A◀ DETONATION SENSOR INSTALLATION

GLOW SYSTEM

16400010029

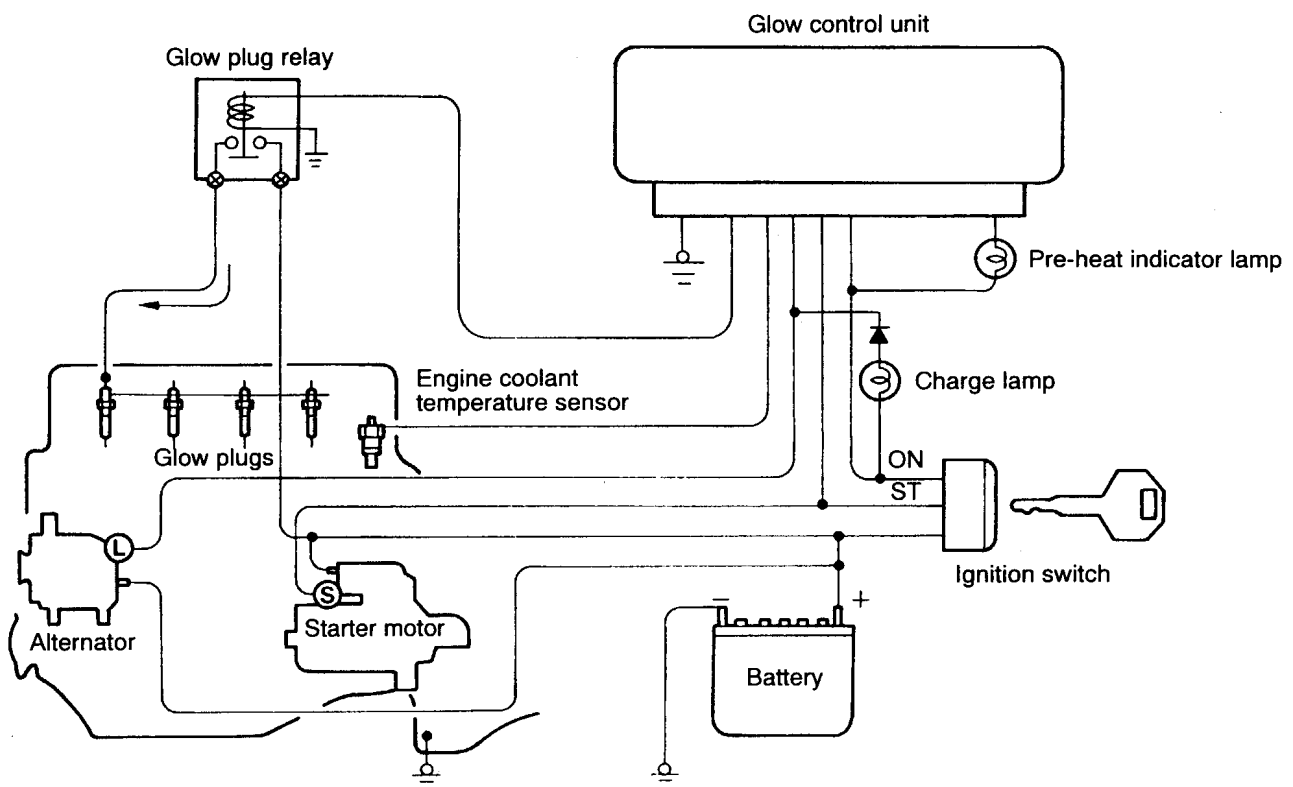
GENERAL INFORMATION

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) Ω	4D5	0.15 – 0.25	
	4M4	0.05 – 0.07	
Voltage between glow plug plate and glow plug body V	Immediately after ignition switch is turned to ON (without starting the engine)	4D5	9 – 11 (Drops to 0 V after 4 – 8 seconds have passed)
		4M4	9 – 11 (Drops to 0 V after approx. 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) Ω	4D5	0.6 – 1.0	
	4M4	Approx. 1.1	

ON-VEHICLE SERVICE

16400100061

SELF-REGULATING GLOW SYSTEM CHECK

<4D5>

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 Ω (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:

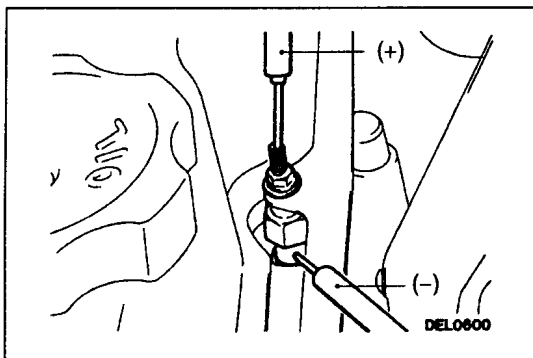
9 – 11 V (Drops to 0 V after 4 – 8 seconds have passed)

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.



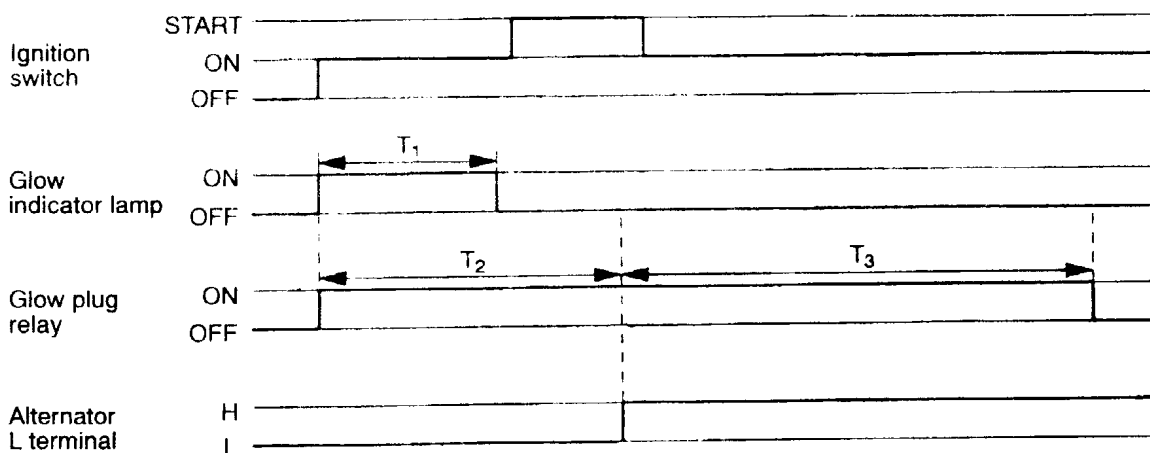
Standard value: 6 V or more

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_1 : Glow indicator lamp

T_2 : Glow plug relay drive time after ignition switch is turned ON

T_3 : Glow plug relay drive time after engine starts (after glow)

DEN0063

NOTE

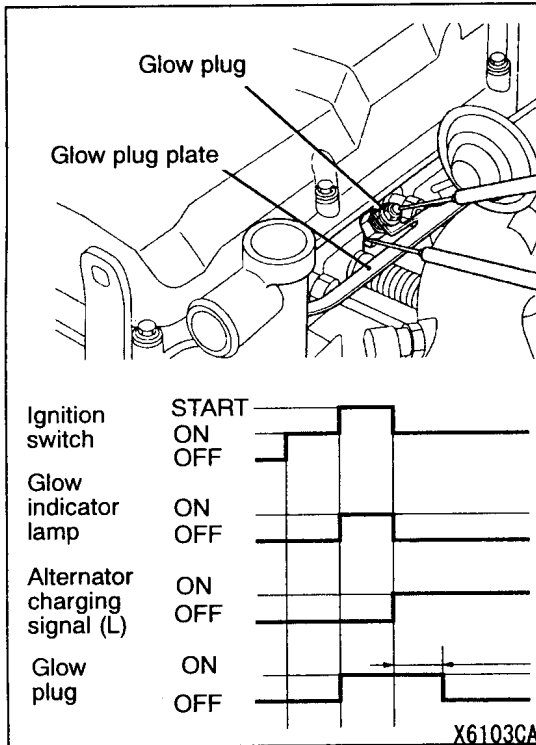
After glow time T_3 becomes longer as the engine coolant temperature drops.

<4M4>

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: 0.05 – 0.07 Ω (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 approx. 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.

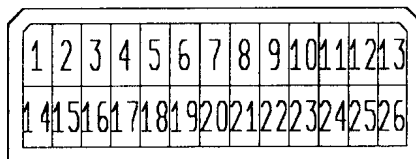
6. Measure the voltage while the engine is cranking.

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

GLOW & EGR-CONTROL UNIT CHECK



X6206CA

<Measure the voltage at the control unit terminals.>

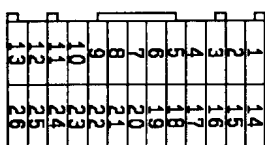
NOTE

- (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 "OFF" → "ON"	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 "LOCK(OFF)" → "START"	8 V or more
14	Glow plug relay (glow time control)	Ignition switch "LOCK(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 "LOCK(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 "LOCK(OFF)" → "ON"	1 – 4 V
		Engine is idling	11 V or more
26	Earth	–	–

Harness-side connector

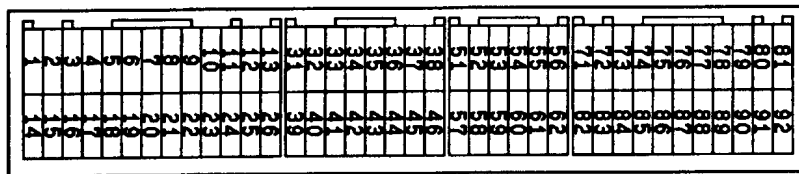


X6105CA

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)

ENGINE-ECU CHECK



W6106AQ

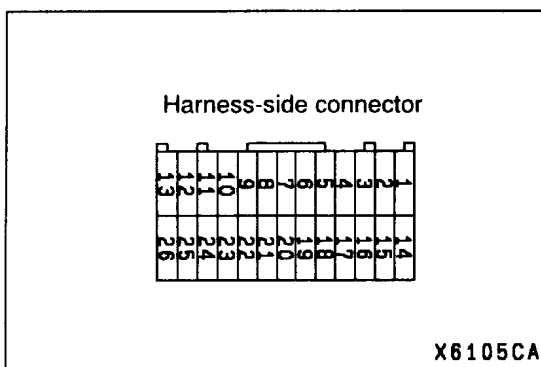
<Measure the voltage at the control unit terminals.>

NOTE

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

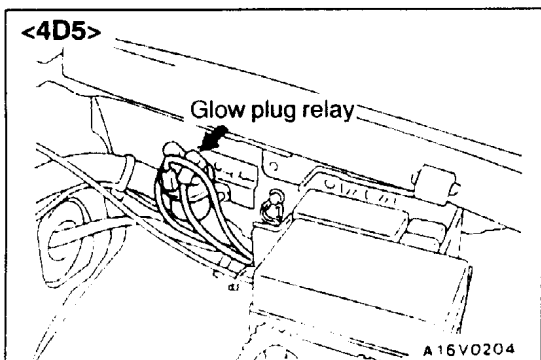
Terminal Voltage Reference Table

Inspection terminal	Inspection item	Inspection condition	Standard value
83	Engine coolant temperature sensor (Engine coolant temperature detection)	Ignition switch "LOCK (OFF)" → "ON"	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
82	Ignition switch (power supply)	Ignition switch "LOCK (OFF)" → "START"	8 V or more
16	Glow plug relay (glow time control)	Ignition switch "LOCK (OFF)" → "ON" (Pre-glow function inspection)	9 – 12 V 0 – 0.5 V after approx. 8 sec. (when engine coolant temperature is 20 °C)
		After starting engine (After-glow function check)	12 V 0 V approx. 180 sec. (when engine coolant temperature is 20 °C)
4	Glow indicator lamp	Ignition switch "LOCK (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)
82	Alternator charging signal ("L" terminal)	Ignition switch "LOCK (OFF)" → "ON"	0 V
		Engine is idling	11 V or more
	Charge lamp	Ignition switch "LOCK (OFF)" → "ON" Immediately after the glow indicator lamp turns off and on.	12 V 0 V approx. 6 sec. (When engine coolant temperature is 20 °C)
26	Earth	–	–



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

Inspection terminal	Inspection item	Continuity (resistance value)
13 – 16	Glow plug relay	Continuity (approx. 3Ω)



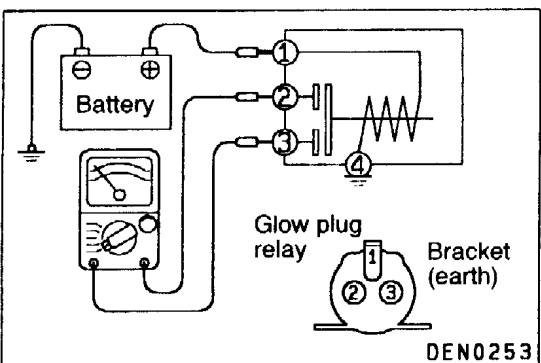
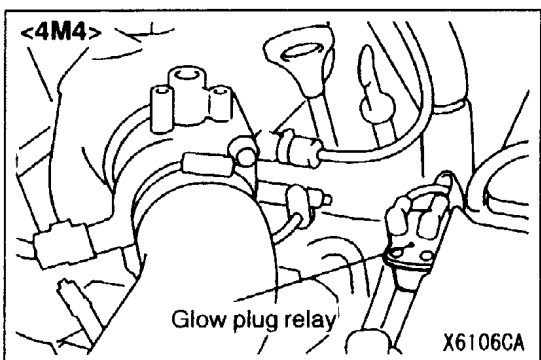
GLOW PLUG RELAY CHECK

16400250032

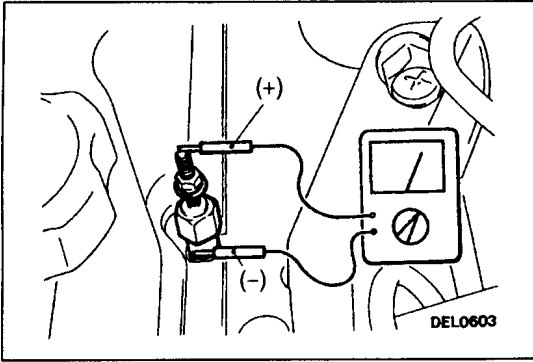
1. Check to be sure that there is continuity (approx. 20 Ω) between glow plug relay terminal (1) and the bracket (earth).
2. Use jumper cables to connect terminal (1) of the glow plug relay to the battery (+) terminal and the bracket to the battery (-) terminal

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 Ω 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 Ω (at 20 °C) <4D5>Approx. 1.1 Ω (at 20 °C) <4M4>**ENGINE COOLANT TEMPERATURE SENSOR CHECK**

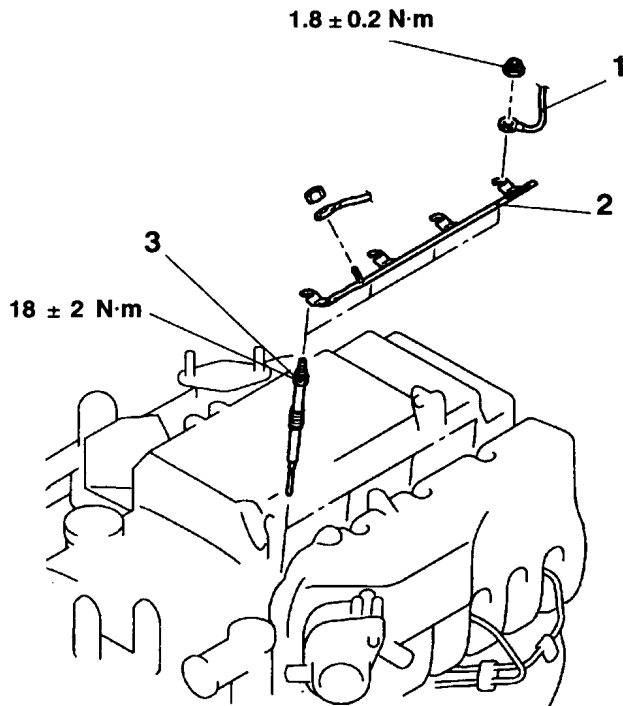
Refer to GROUP 13B – On-vehicle service <4D5> or GROUP 13C – On-vehicle service <4M4>

GLOW PLUG

REMOVAL AND INSTALLATION

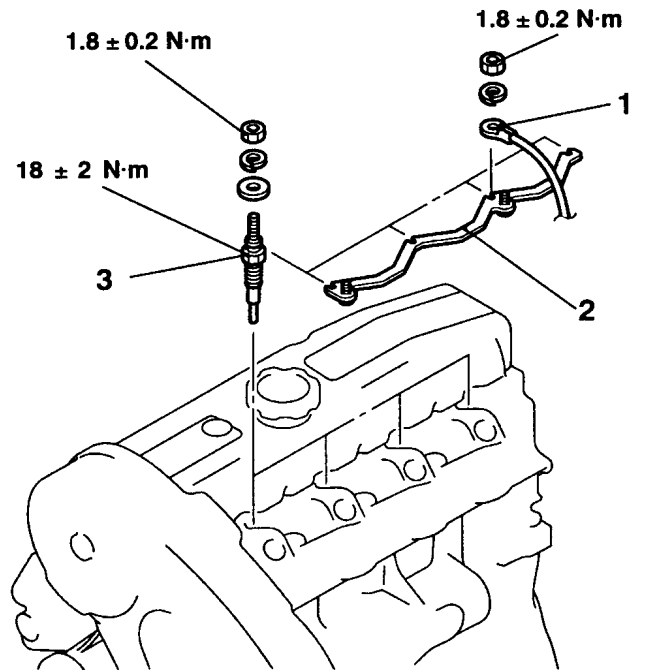
Pre-removal and Post-installation Operation
 EGR Pipe Removal and Installation (Refer to GROUP 17.)

<4M4>



BX0888CA

<4D5>



AX1785CA

Removal steps

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

REMOVAL SERVICE POINT

◀A▶ GLOW PLUG REMOVAL

The ceramic part of the glow plug can be easily damaged. When removing the glow plug, first loosen the plug with a wrench until the last one thread or more is remained, then remove it with your finger.

Caution

The glow plug, which has been dropped from a height of 10 cm or more, can not be reused.