

ENGINE ELECTRICAL

CONTENTS

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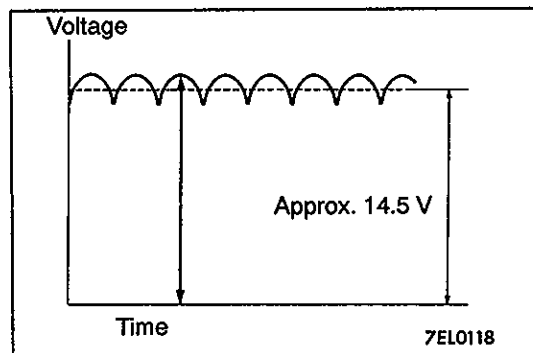
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CHARGING SYSTEM

16100010143

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.

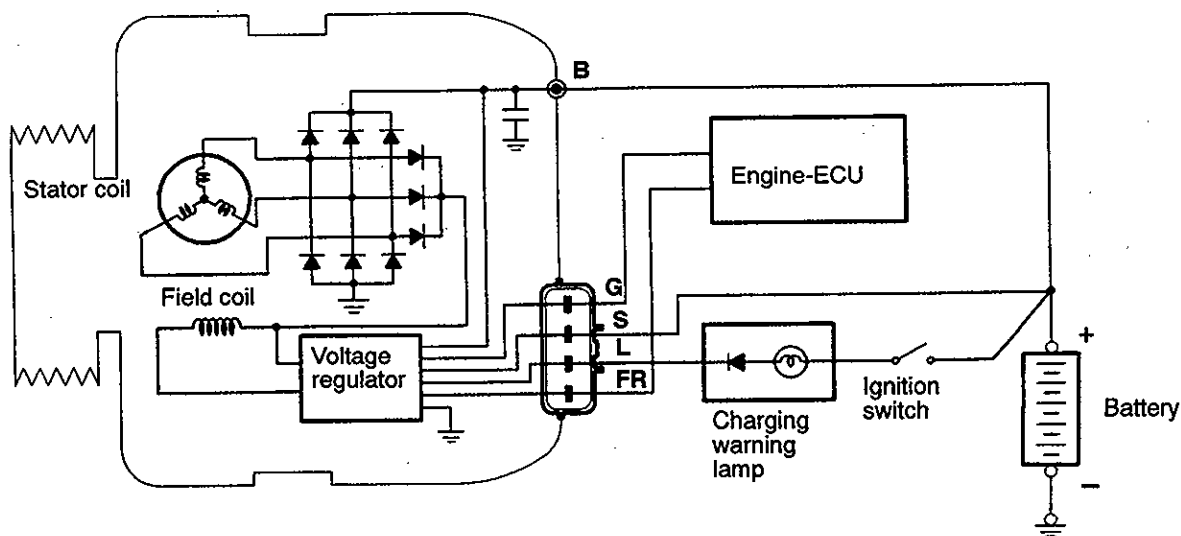
When the stator coil begins to generate power after the engine is started, the field coil is excited by the output current of the stator coil.

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 approx. 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



6EN1147

ALTERNATOR SPECIFICATIONS

Items	4G1	4G9
Type	Battery voltage sensing	Battery voltage sensing
Rated output V/A	12/80, 12/90*	12/80, 12/90*
Voltage regulator	Electronic built-in type	Electronic built-in type

NOTE

*: A/T – vehicles for cold climate


SERVICE SPECIFICATIONS

16100030101

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	–

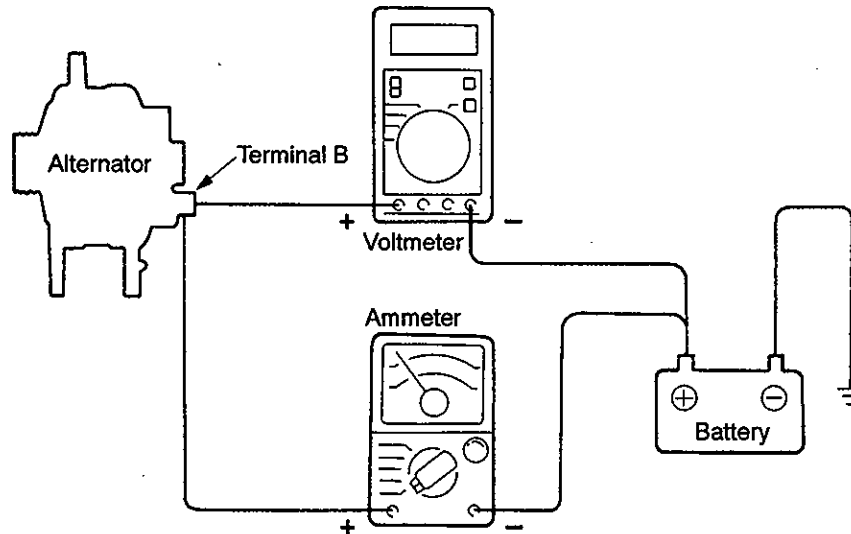
SPECIAL TOOL

16100060056

Tool	Number	Name	Use
	MB991519	Alternator harness connector	Checking the alternator (S terminal voltage)

ON-VEHICLE SERVICE

ALTERNATOR OUTPUT LINE VOLTAGE DROP TEST



5EL0015

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

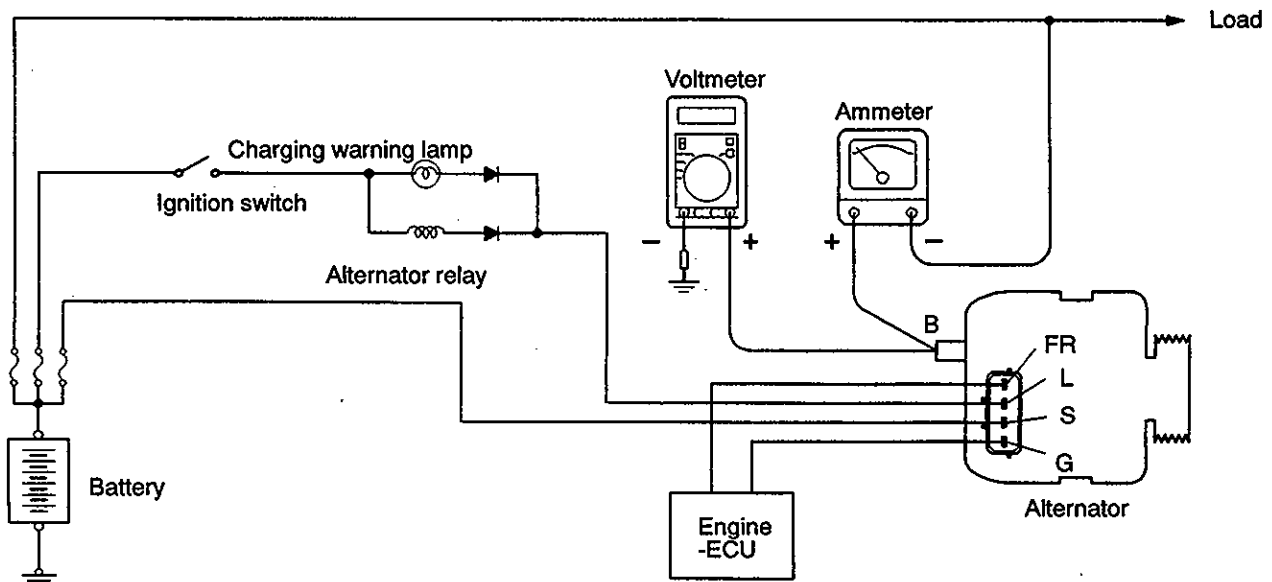
NOTE

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

16100100147



6EN1162

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.

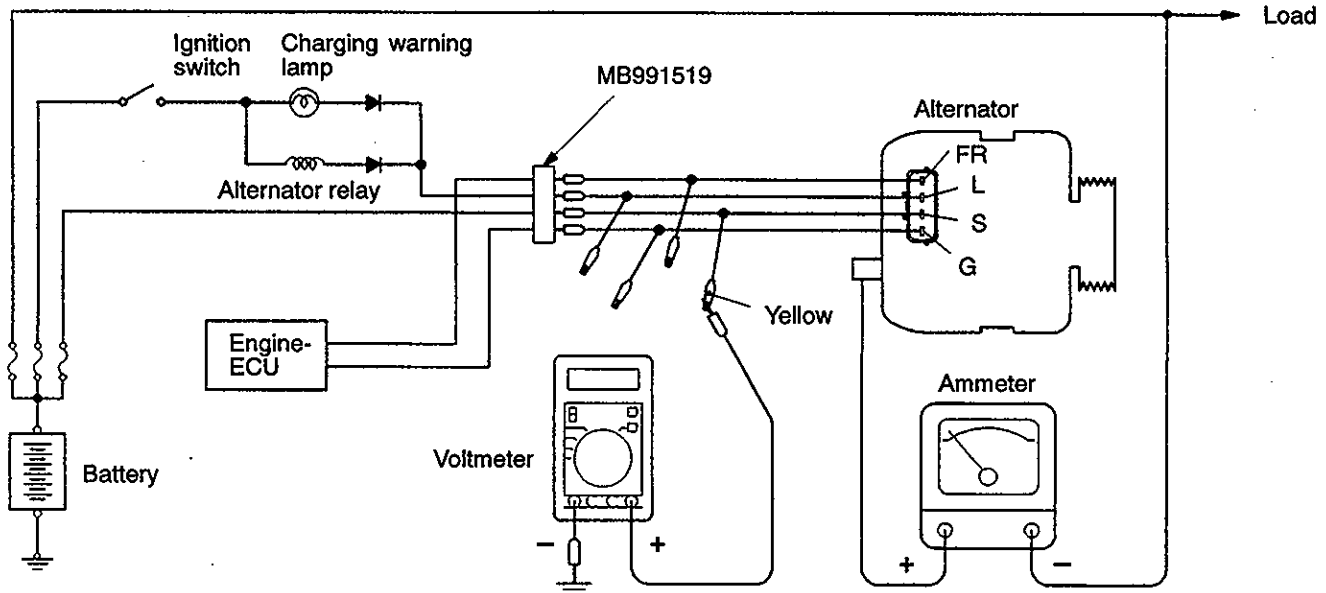
(17) Disconnect the ammeter and voltmeter.

(18) Connect the alternator output wire to the alternator "B" terminal.

(19) Connect the negative battery cable.

REGULATED VOLTAGE TEST

16100110140



6EN1163

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: 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. (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.

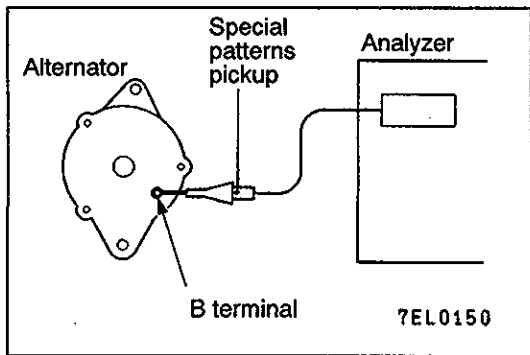
(21) Remove the special tool, and return the connector to the original condition.

(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

16100120037

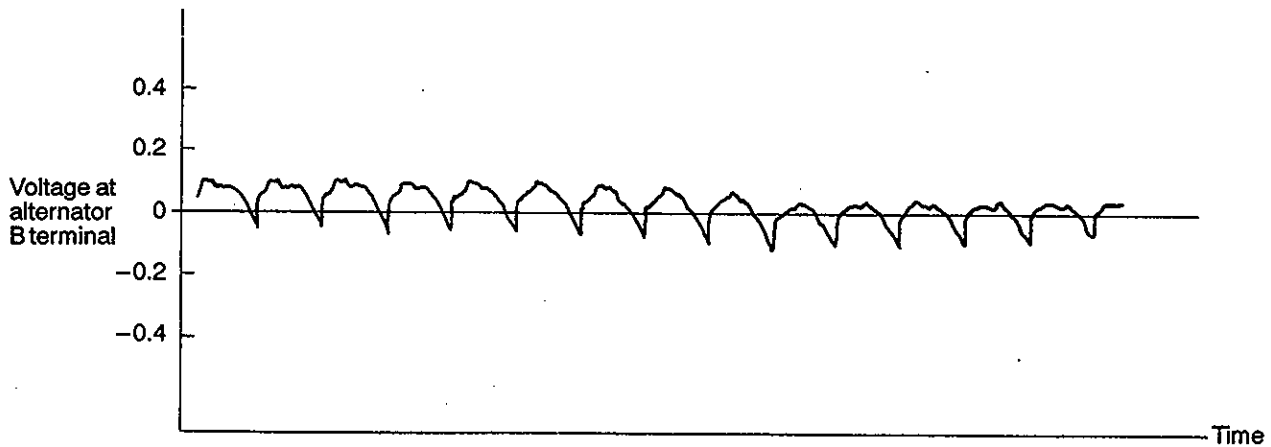
MEASUREMENT METHOD

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

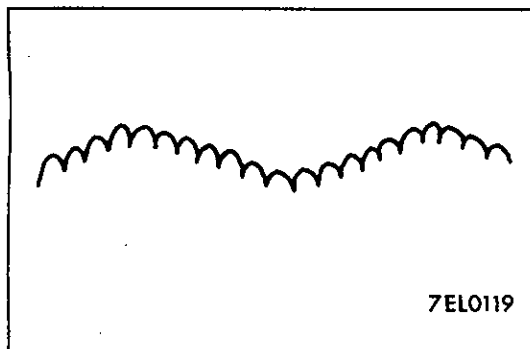
STANDARD WAVEFORM

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



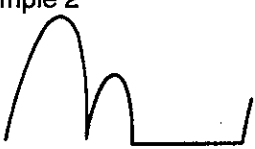


NOTE

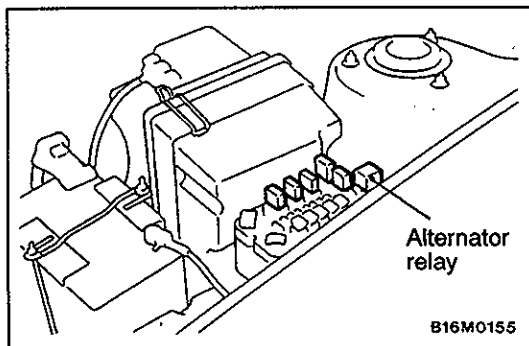
The voltage waveform of the alternator B terminal can undulate as shown at left. This waveform is produced when the regulator operates according to fluctuations in the alternator load (current), and is normal for the alternator.

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.

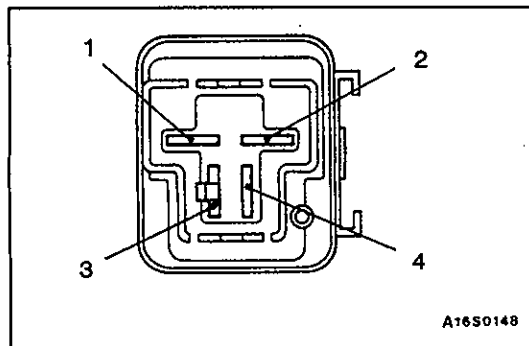
Abnormal waveforms	Problem cause	Abnormal waveforms	Problem cause
<p>Example 1</p>  <p>A7EL0120</p>	<ul style="list-style-type: none"> • Open diode 	<p>Example 4</p>  <p>A7EL0123</p>	<ul style="list-style-type: none"> • Short in stator coil
<p>Example 2</p>  <p>A7EL0121</p>	<ul style="list-style-type: none"> • Short in diode 	<p>Example 5</p>  <p>A7EL0124</p>	<ul style="list-style-type: none"> • Open supplementary diode
<p>Example 3</p>  <p>A7EL0122</p>	<ul style="list-style-type: none"> • Broken wire in stator coil 	<p>At this time, the charging warning lamp is illuminated.</p>	



ALTERNATOR RELAY CONTINUITY CHECK

16100190014

1. Remove the alternator relay from the relay box inside the engine compartment.
2. Set the circuit tester to the Ω range and check that there is continuity when the (+) terminal of the tester is connected to terminal 4 of the alternator relay and the (-) terminal is connected to terminal 2.
3. Next, check that there is no continuity when the (+) terminal is connected to terminal 2 and the (-) terminal is connected to terminal 4.
4. If the continuity checks in steps 2 and 3 show a defect, replace the alternator relay.



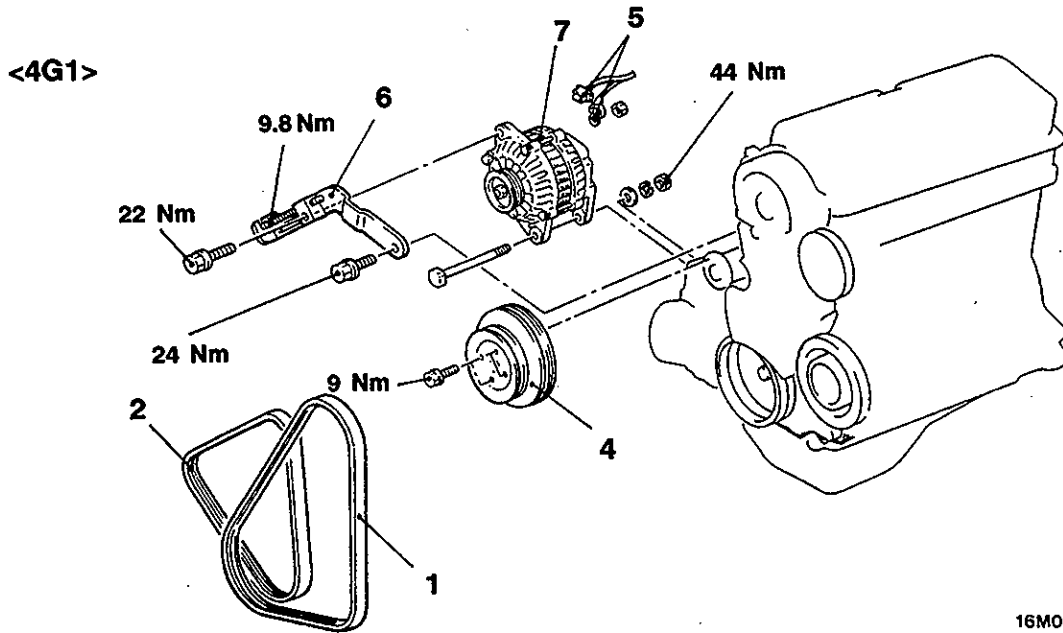
ALTERNATOR

16100140163

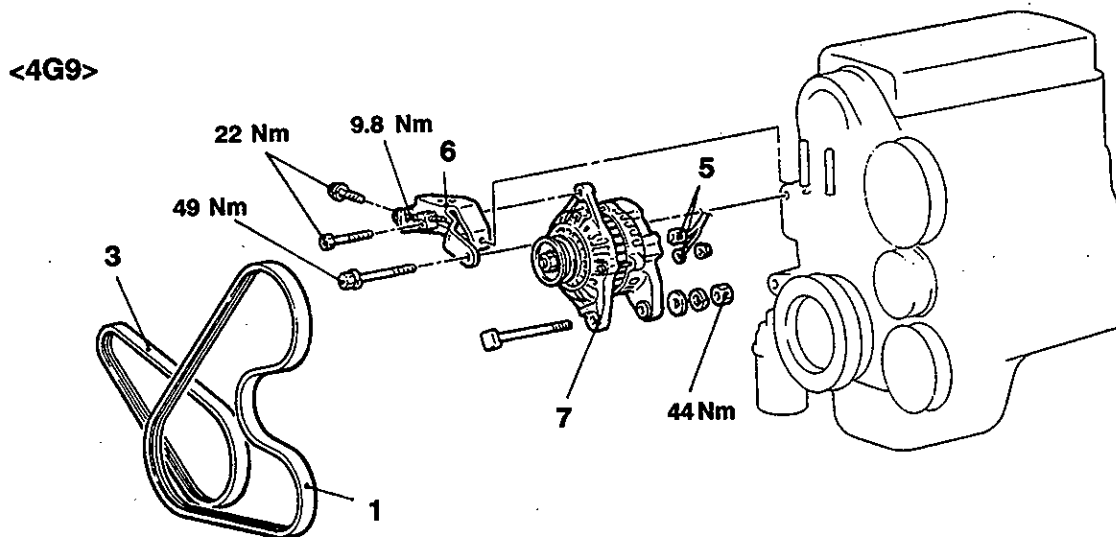
REMOVAL AND INSTALLATION

Post-Installation Operation

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



16M0204



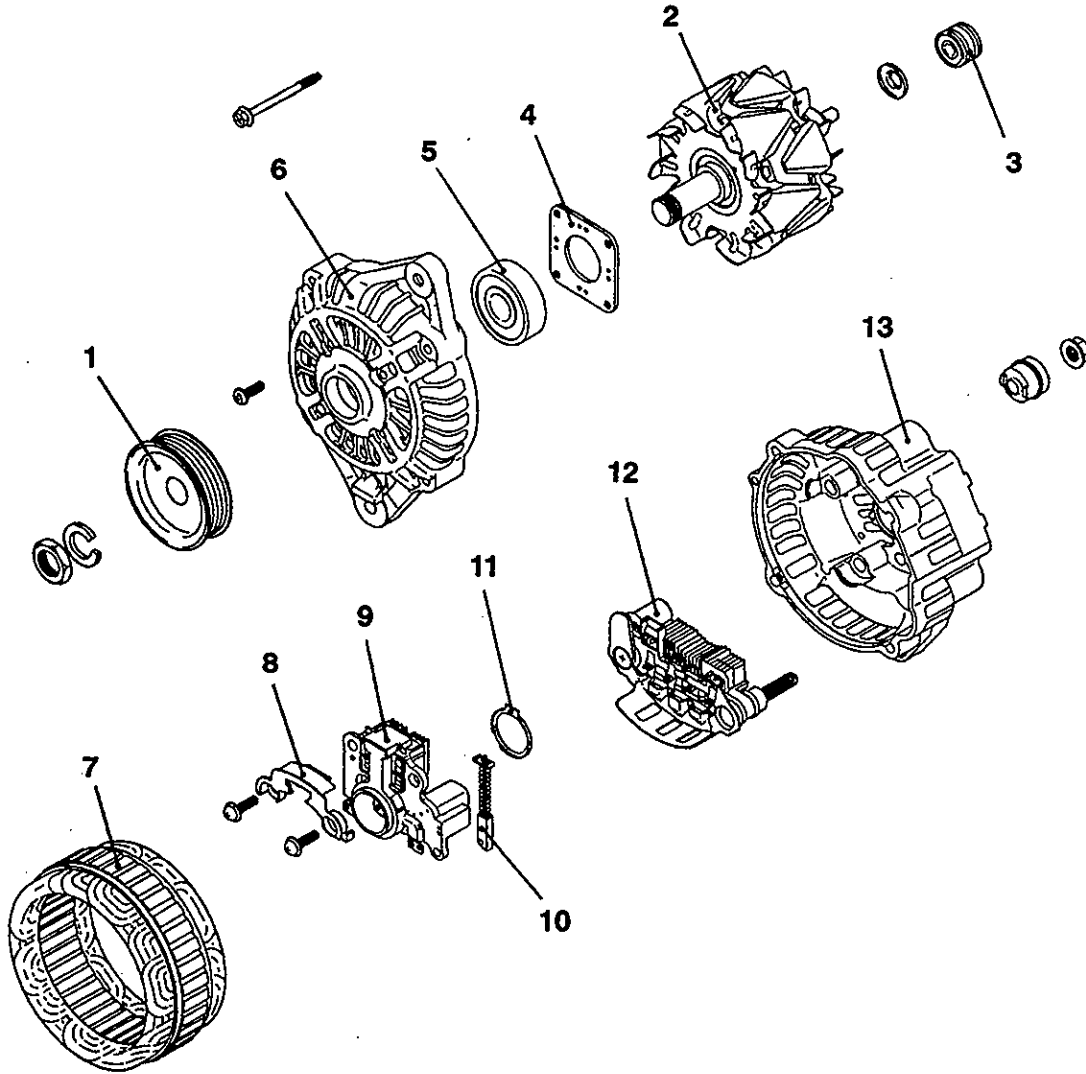
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Removal steps

1. Drive belt (Air conditioner and power steering)
2. Drive belt (Alternator and water pump) <4G1>
3. Drive belt (Alternator) <4G9>
4. Water pump pulley <4G1>
5. Alternator connector
6. Alternator brace
7. Alternator

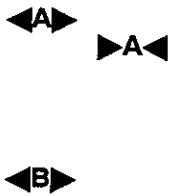
DISASSEMBLY AND REASSEMBLY

16100160121



Z6EN0878

Disassembly steps



- 1. Alternator pulley
- 2. Rotor assembly
- 3. Rear bearing
- 4. Bearing retainer
- 5. Front bearing
- 6. Front bracket
- 7. Stator

- 8. Plate
- 9. Regulator and brush holder
- 10. Brush
- 11. Slinger
- 12. Rectifier
- 13. Rear bracket

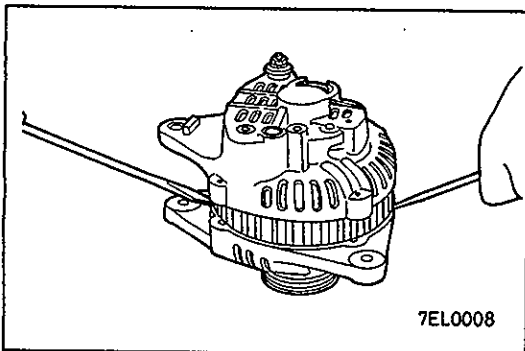
DISASSEMBLY SERVICE POINTS

◀A▶ ALTERNATOR PULLEY REMOVAL

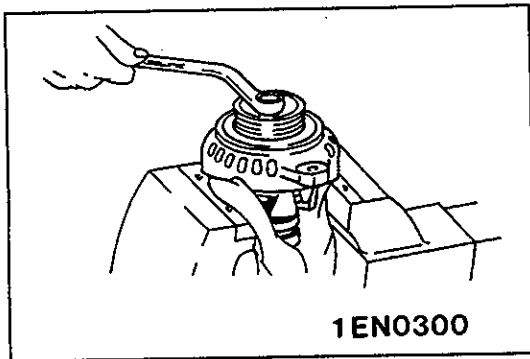
- (1) Remove the bolts.
- (2) Insert a flat-tipped screwdriver between front bracket and stator core and pry downwards.

Caution

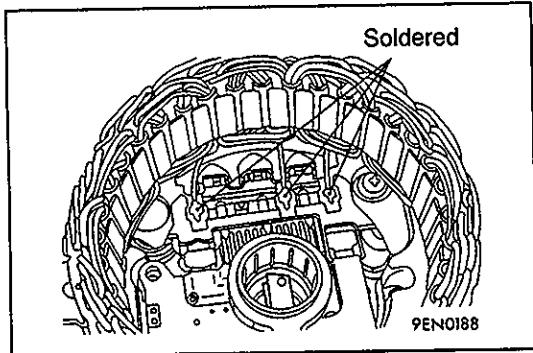
Do not insert a screwdriver too deep, as the stator coil will be damaged.



7EL0008



- (3) Clamp the rotor in a vice with soft jaws.
- (4) After removing the nut, remove the pulley and front bracket from the rotor.

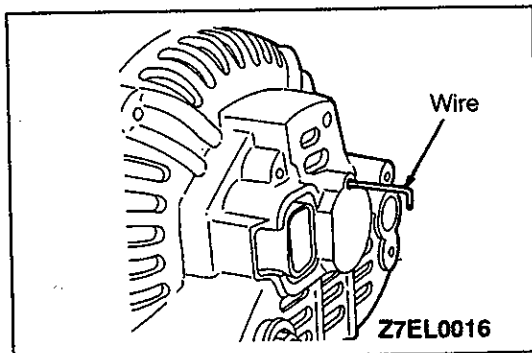


◀B▶ STATOR REMOVAL

- (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

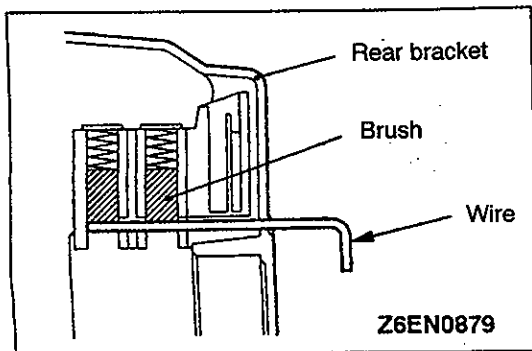
1. When soldering or unsoldering, use care to make sure that heat of soldering iron is not transmitted to diodes for a long period. Finish soldering or unsoldering in as short a time as possible.
2. Use care that no undue force is exerted to leads of diodes.



REASSEMBLY SERVICE POINT

▶A▶ ROTOR ASSEMBLY INSTALLATION

Before rotor is attached to rear bracket, insert wire through small hole made in rear bracket to lift brush. After rotor has been installed, remove the wire.

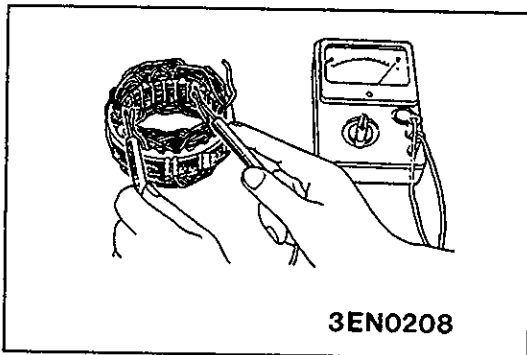
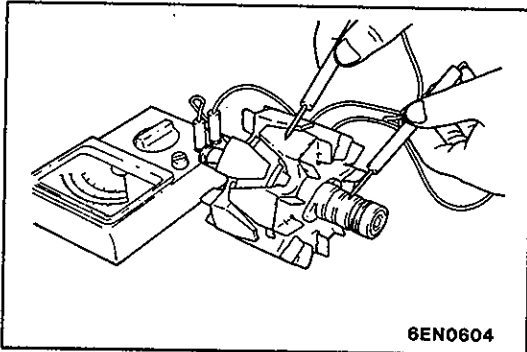
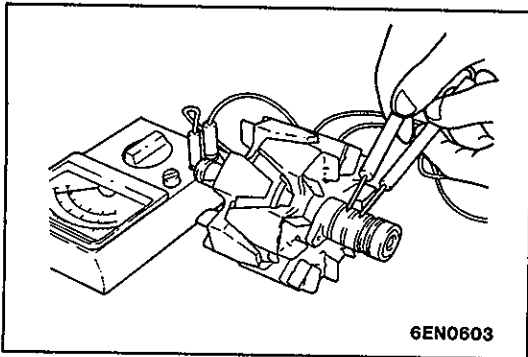


INSPECTION**ROTOR**

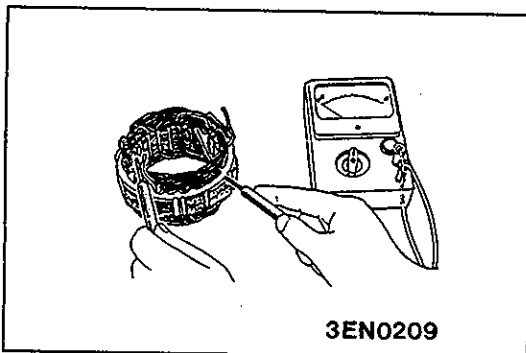
- (1) Check rotor coil for continuity. Check that there is no continuity between slip rings. If resistance is too small, it means that there is a short circuit. If there is no continuity or if there is a short circuit, replace rotor assembly.

Resistance value: Approx. 2 – 5 Ω

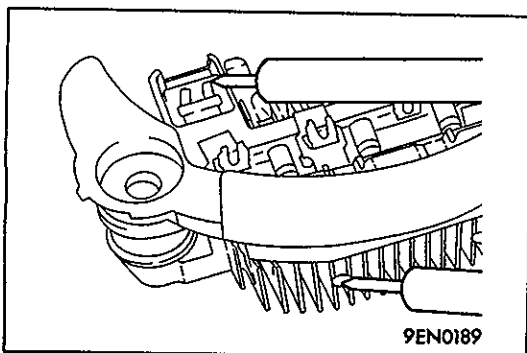
- (2) Check rotor coil for earthing. Check that there is no continuity between slip ring and core. If there is continuity, replace rotor assembly.

**STATOR**

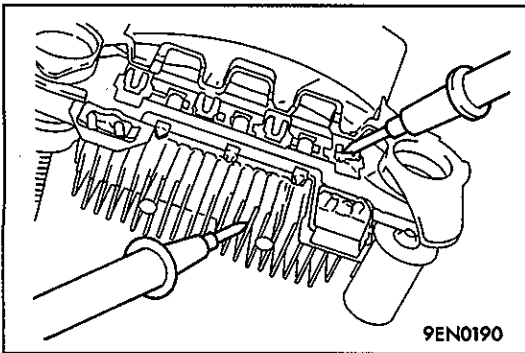
- (1) Make continuity test on stator coil. Check that there is continuity between coil leads. If there is no continuity, replace stator assembly.



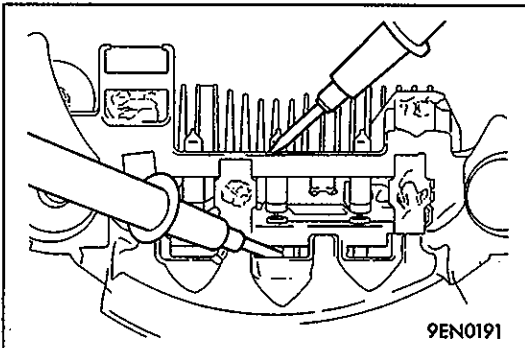
- (2) Check coil for earthing. Check that there is no continuity between coil and core. If there is continuity, replace stator assembly.

**RECTIFIERS****(1) Positive Rectifier Test**

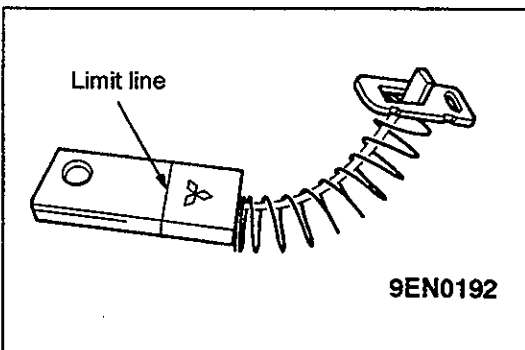
Check for continuity between positive rectifier and stator coil lead connection terminal with an ohmmeter. If there is continuity in both directions, diode is shorted. Replace rectifier assembly.

**(2) Negative Rectifier Test**

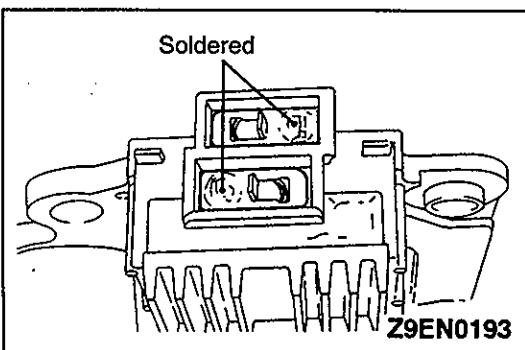
Check for continuity between negative rectifier and stator coil lead connection terminal. If there is continuity in both directions, diode is shorted, and rectifier assembly must be replaced.

**(3) Diode Trio Test**

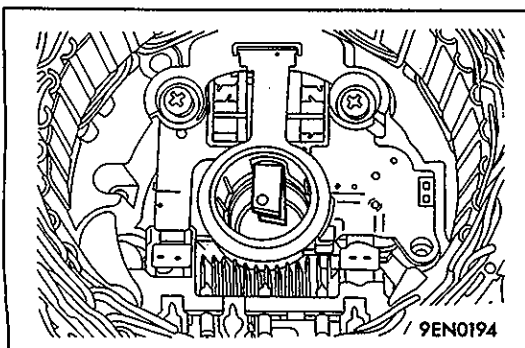
Check three diodes for continuity by connecting an ammeter to both ends of each diode. If there is no continuity in both directions, diode is faulty and heatsink assembly must be replaced.

**BRUSH REPLACEMENT**

- (1) Replace brush by the following procedures if it has been worn to limit line.



- (2) Unsolder pigtail and remove old brush and spring.



- (3) When installing a new brush, push the brush in the brush holder as shown in the illustration, and solder the lead wire.

STARTING SYSTEM

16200010122

GENERAL INFORMATION

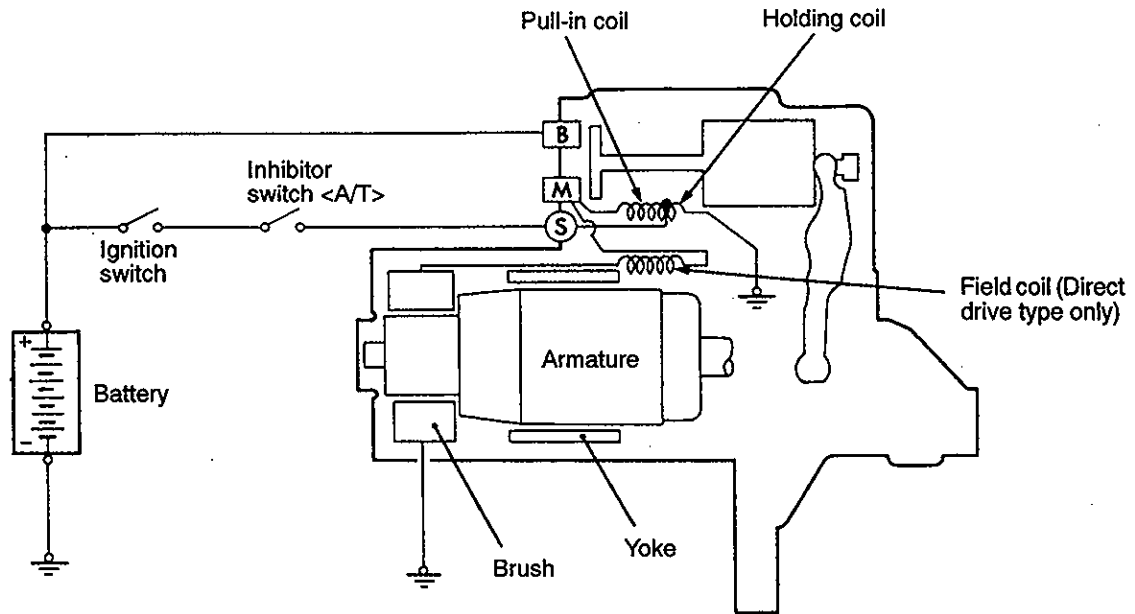
If the ignition switch is turned to the "START" position, current flows in the coil provided inside magnetic switch, attracting the plunger. When the plunger is attracted, the lever connected to the plunger is actuated to engage the starter clutch. On the other hand, attracting the plunger will turn 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



9EN0288

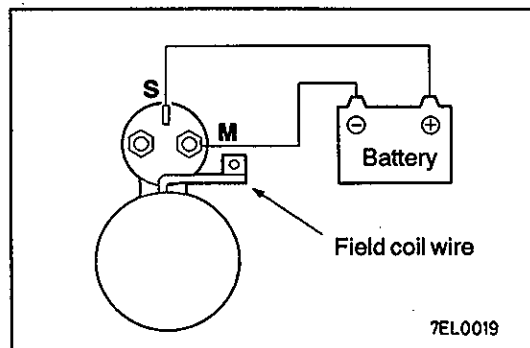
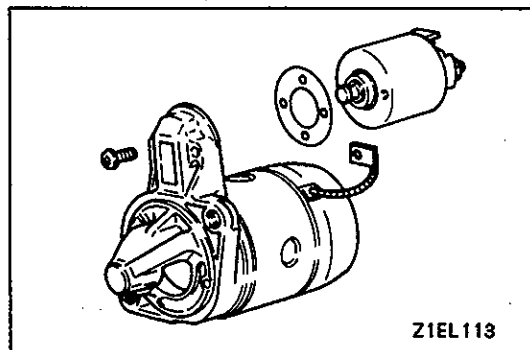
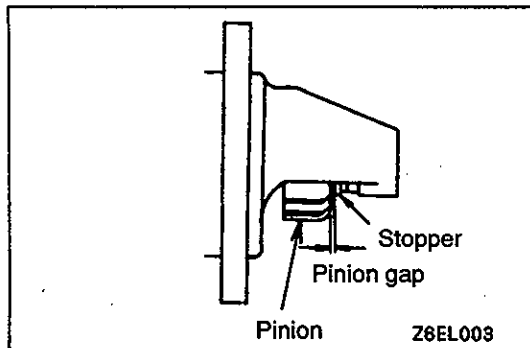
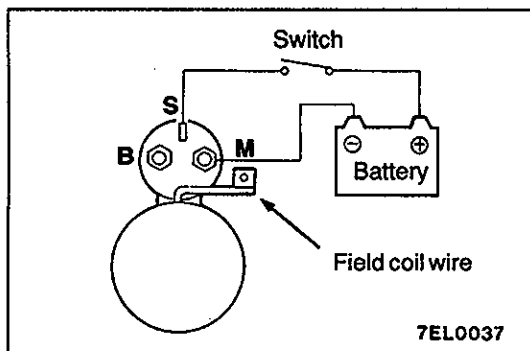
STARTER MOTOR SPECIFICATIONS

Items	4G1 – M/T – standard models	4G1 – M/T – models for cold climate, 4G1 – A/T, 4G9 – M/T, 4G9 – A/T – standard models	4G9 – A/T – models for cold climate
Type	Direct drive	Direct drive	Reduction drive with planetary gear
Rated output kW/V	0.7/12	0.9/12	1.0/12
No. of pinion teeth	8	8	8

SERVICE SPECIFICATIONS

16200030081

Items		Standard value	Limit
Pinion gap mm		0.5–2.0	–
Commutator outer diameter mm	Direct drive type	32.0	31.4
	Reduction drive type	29.4	28.8
Commutator runout mm		–	0.05
Commutator undercut mm		0.5	0.2



STARTER MOTOR

16200110112

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.

Pinion gap: 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.

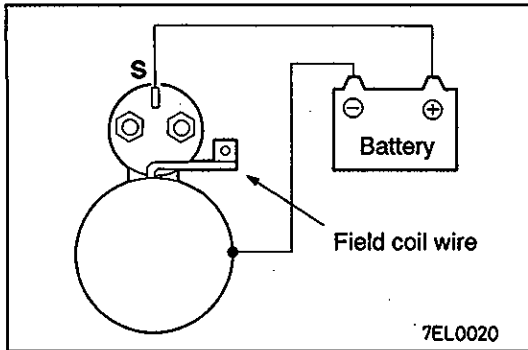
MAGNETIC SWITCH PULL-IN TEST

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.

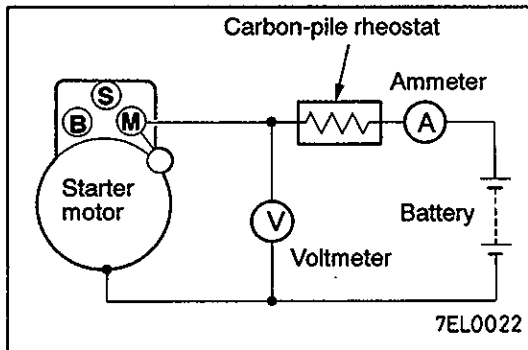
**MAGNETIC SWITCH HOLD-IN TEST**

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.

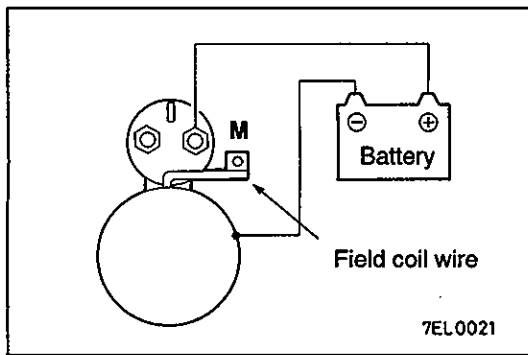
3. Manually pull out the pinion as far as the pinion stopper position.
4. If pinion remains out, everything is in order. If pinion moves in, hold-in circuit is open. Replace magnetic switch.

**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 11.5 V (for the direct drive type) or 11 V (for reduction drive type).
7. Confirm that the maximum amperage is within the specifications and that the starter motor turns smoothly and freely.

Current:

- max. 60 Amps (Direct drive type)**
- max. 90 Amps (Reduction drive type)**

**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.

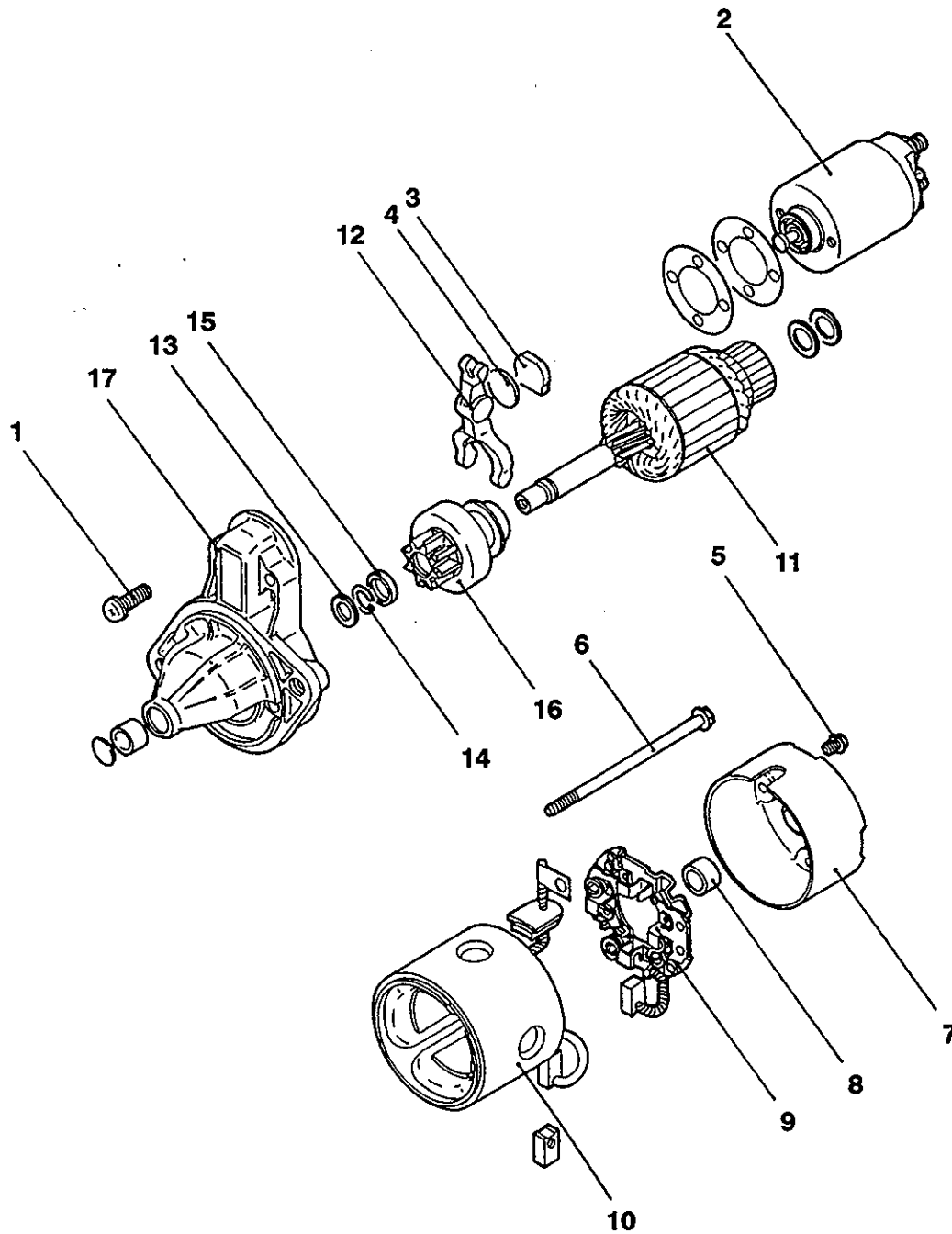
3. Pull pinion out and release. If pinion quickly returns to its original position, everything is in order. If it doesn't, replace magnetic switch.

Caution

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

DISASSEMBLY AND REASSEMBLY <DIRECT DRIVE TYPE>

16200120085



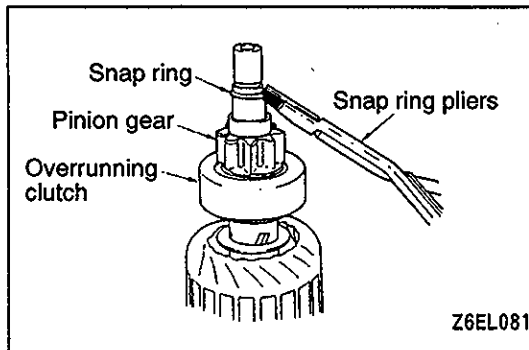
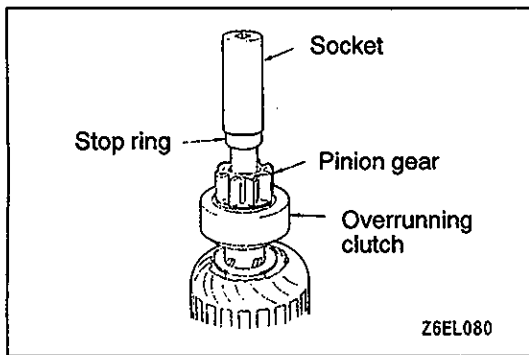
D9EN0186

Disassembly steps

- 1. Screw
- 2. Magnetic switch
- 3. Packing
- 4. Plate
- 5. Screw
- 6. Through bolt
- 7. Rear bracket
- 8. Rear bearing

- 9. Brush holder assembly
- 10. Yoke assembly
- 11. Armature
- 12. Lever
- 13. Washer
- 14. Snap ring
- 15. Stop ring
- 16. Overrunning clutch
- 17. Front bracket





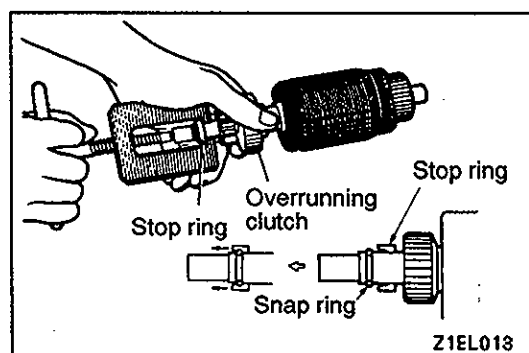
DISASSEMBLY SERVICE POINTS

◀▶ 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

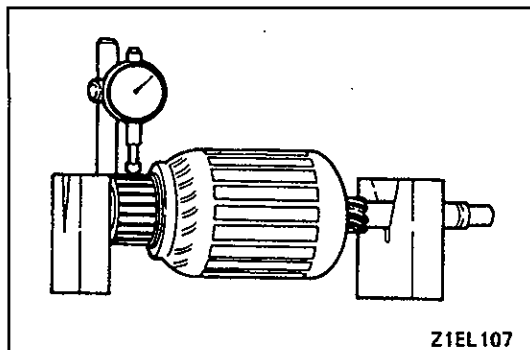
1. Do not immerse parts in cleaning solvent. Immersing the yoke and field coil assembly and/or armature will damage insulation. Wipe these parts with a cloth only.
2. Do not immerse drive unit in cleaning solvent. Overrunning clutch is pre-lubricated at the factory and solvent will wash lubrication from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



REASSEMBLY SERVICE POINTS

▶◀ STOP RING/SNAP RING INSTALLATION

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

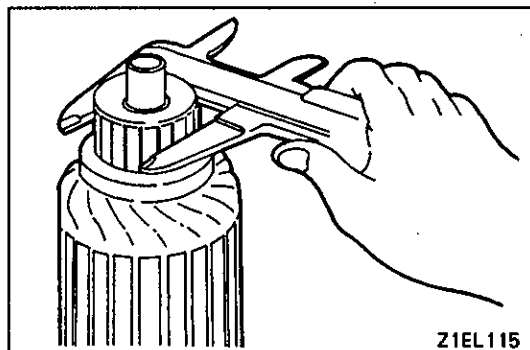
**INSPECTION**

16200130088

COMMUTATOR

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

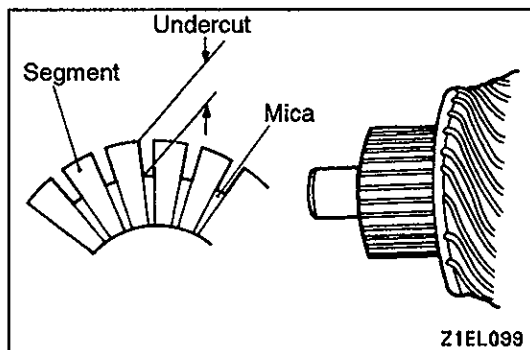
Limit: 0.05 mm



2. Measure the commutator outer diameter.

Standard value: 32.0 mm

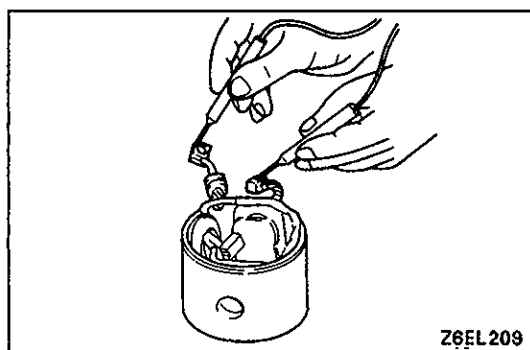
Limit: 31.4 mm



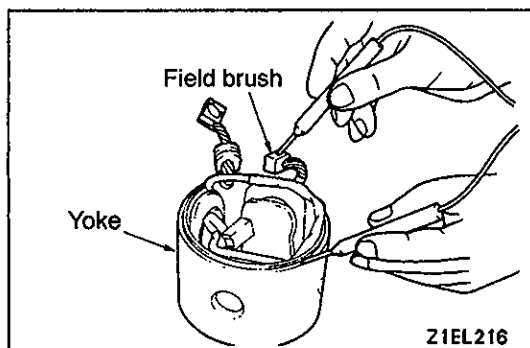
3. Check the undercut depth between segments.

Standard value: 0.5 mm

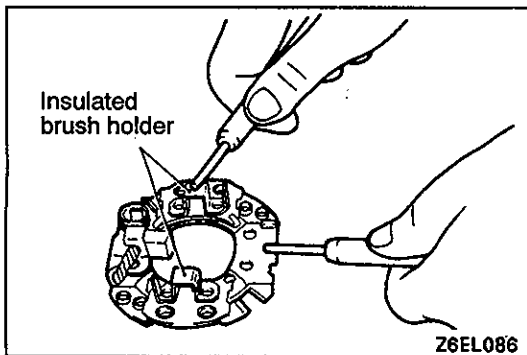
Limit: 0.2 mm

**FIELD COIL OPEN-CIRCUIT TEST**

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

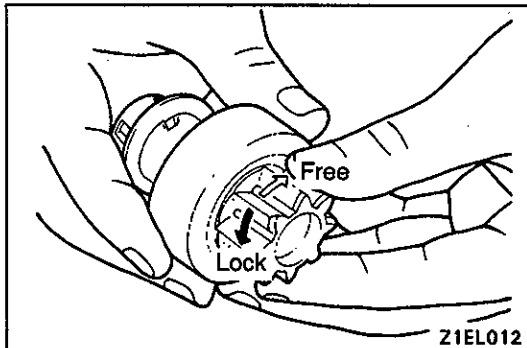
**FIELD COIL GROUND TEST**

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

**BRUSH HOLDER**

Check the continuity between brush holder plate and brush holder.

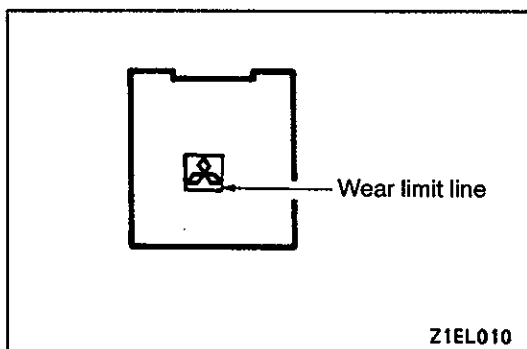
If there is no continuity, the brush holder is in order.

**OVERRUNNING CLUTCH**

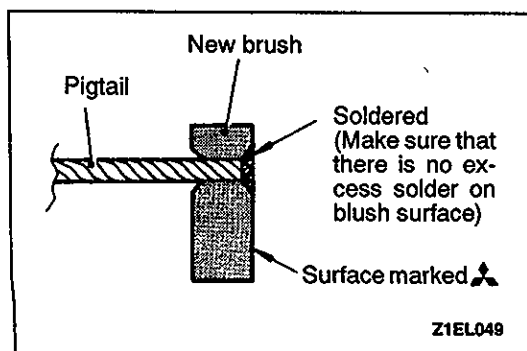
1. While holding clutch housing, rotate the pinion. Drive pinion should rotate smoothly in one direction, but should not rotate in opposite direction. If clutch does not function properly, replace overrunning clutch assembly.
2. Inspect pinion for wear or burrs. If pinion is worn or burred, replace overrunning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

FRONT AND REAR BRACKET BUSHING

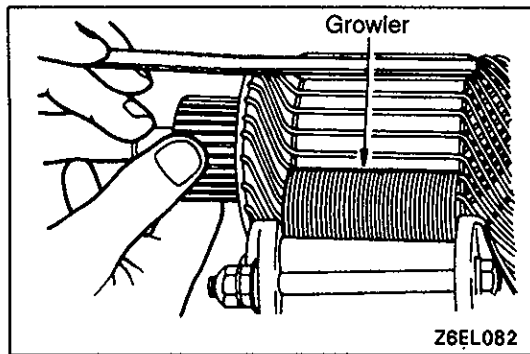
Inspect bushing for wear or burrs. If bushing is worn or burred, replace front bracket assembly or rear bracket assembly.

**BRUSH AND SPRING REPLACEMENT**

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.



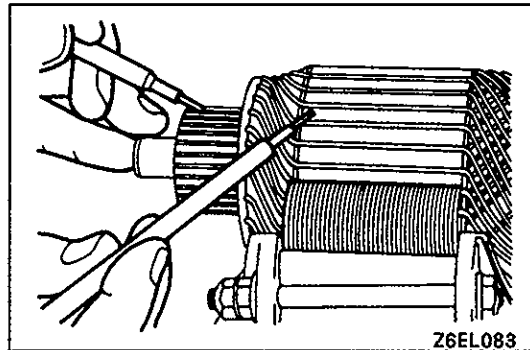
3. Sand pigtail end with sandpaper to ensure good soldering.
4. Insert pigtail into hole provided in new brush and solder it.
Make sure that pigtail and excess solder do not come out onto brush surface.
5. When replacing ground brush, slide the brush from brush holder by prying retainer spring back.



ARMATURE TEST

ARMATURE SHORT-CIRCUIT TEST

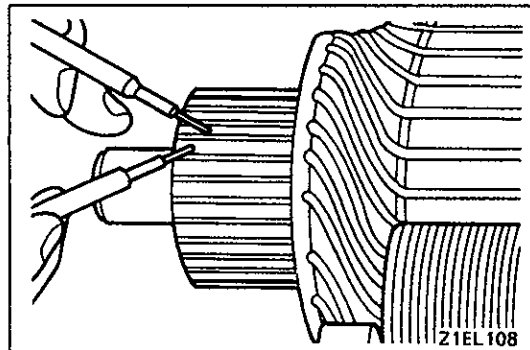
1. Place armature in a growler.
2. Hold a thin steel blade parallel and just above while rotating armature slowly in growler. A shorted armature will cause blade to vibrate and be attracted to the core. Replace shorted armature.



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.

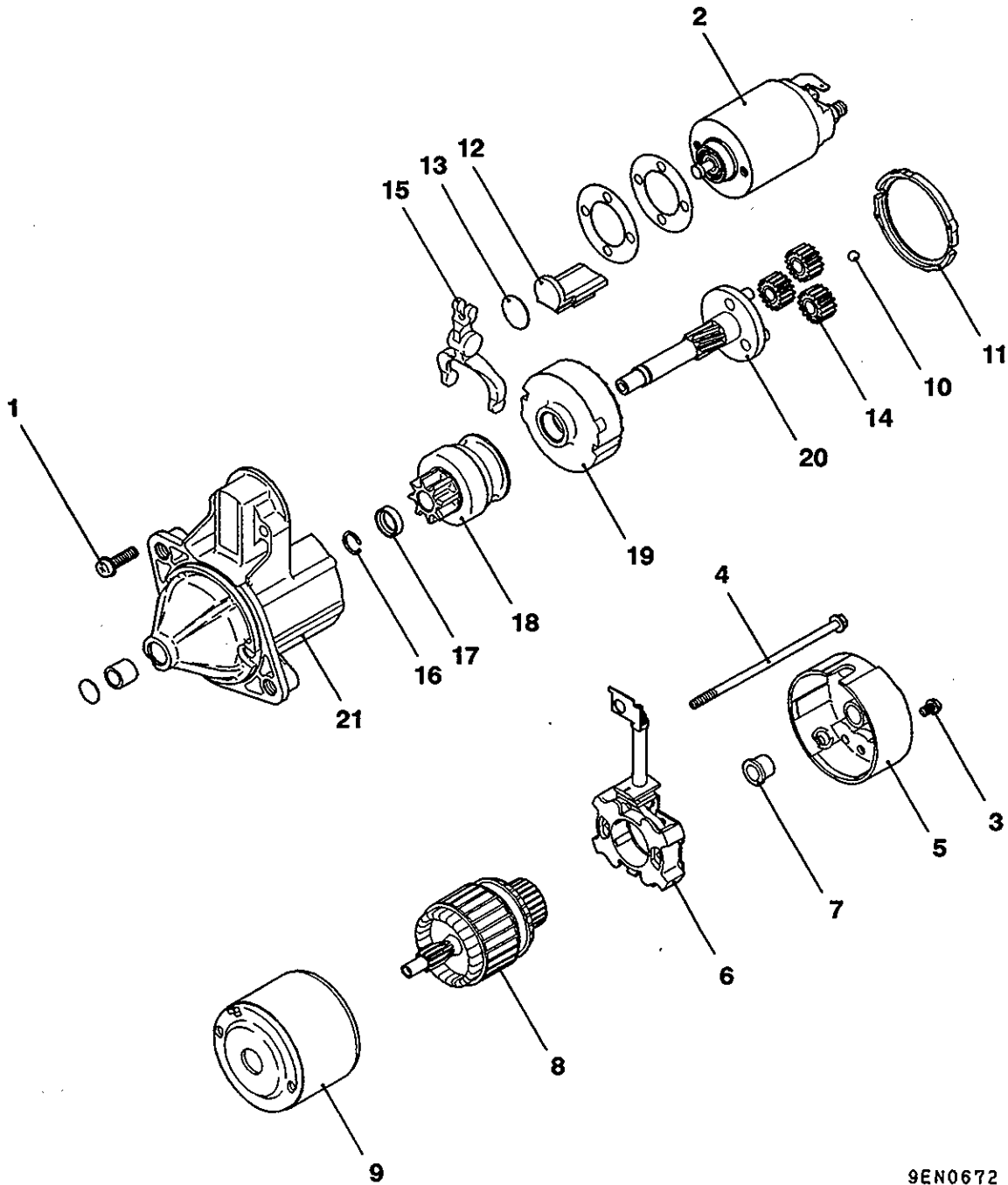


ARMATURE COIL OPEN-CIRCUIT INSPECTION

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

DISASSEMBLY AND REASSEMBLY <REDUCTION DRIVE TYPE>

16200120153



9EN0672

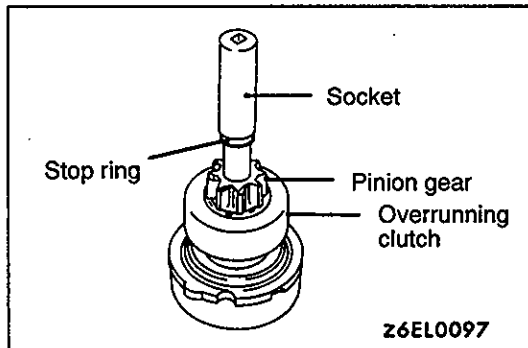
Disassembly steps

- | | |
|--------------------|---------------------------|
| 1. Screw | 12. Packing B |
| 2. Magnetic switch | 13. Plate |
| 3. Screw | 14. Planetary gear |
| 4. Screw | 15. Lever |
| 5. Rear bracket | 16. Snap ring |
| 6. Brush set | 17. Stop ring |
| 7. Rear bearing | 18. Overrunning clutch |
| 8. Armature | 19. Internal gear |
| 9. Yoke assembly | 20. Planetary gear holder |
| 10. Ball | 21. Front bracket |
| 11. Packing A | |

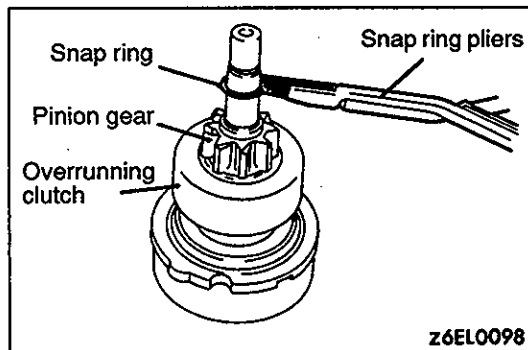


DISASSEMBLY SERVICE POINTS**◀A▶ ARMATURE/BALL REMOVAL****Caution**

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

**◀B▶ SNAP RING/STOP RING REMOVAL**

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



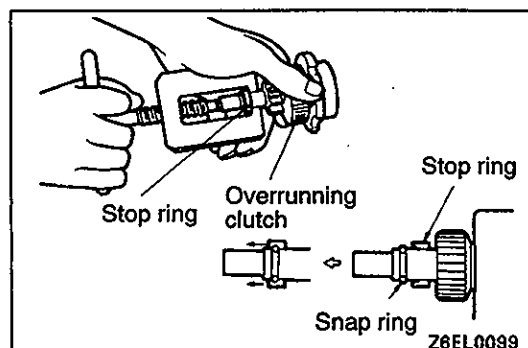
2. Remove snap ring with snap ring pliers and then remove stop ring and overrunning clutch.

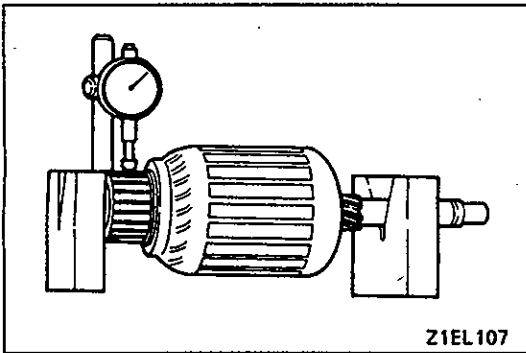
STARTER MOTOR PARTS CLEANING

1. Do not immerse parts in cleaning solvent. Immersing the motor assembly 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.





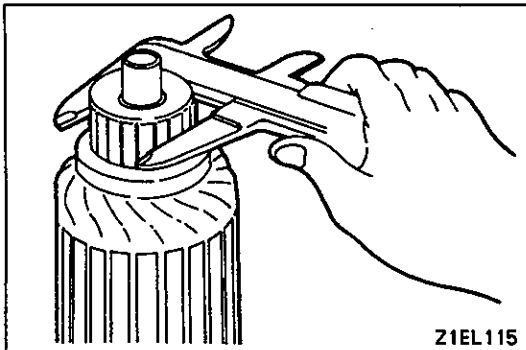
Z1EL107

INSPECTION COMMUTATOR

16200130156

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

Limit: 0.05 mm

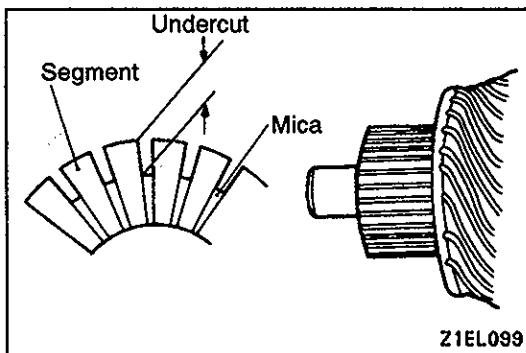


Z1EL115

2. Measure the commutator outer diameter.

Standard value: 29.4 mm

Limit: 28.8 mm

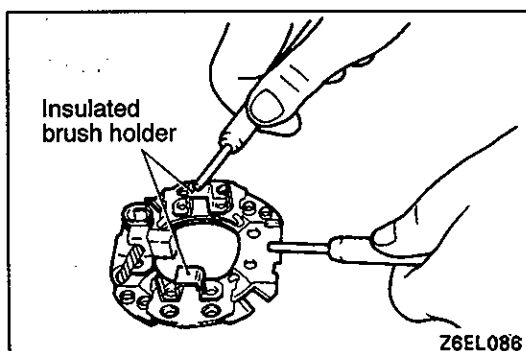


Z1EL099

3. Check the undercut depth between segments.

Standard value: 0.5 mm

Limit: 0.2 mm

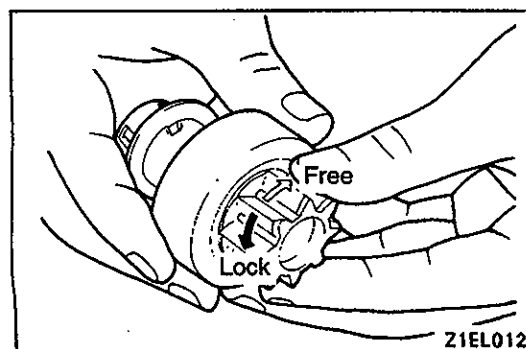


Z6EL086

BRUSH HOLDER

Check the continuity between brush holder plate and brush holder.

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



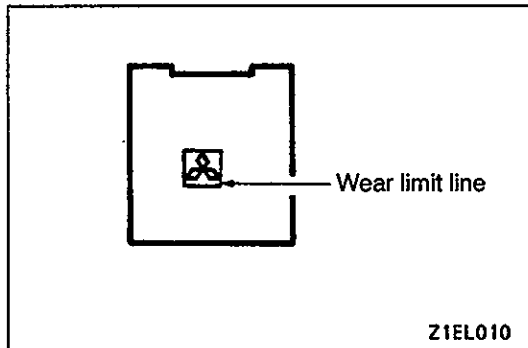
Z1EL012

OVERRUNNING CLUTCH

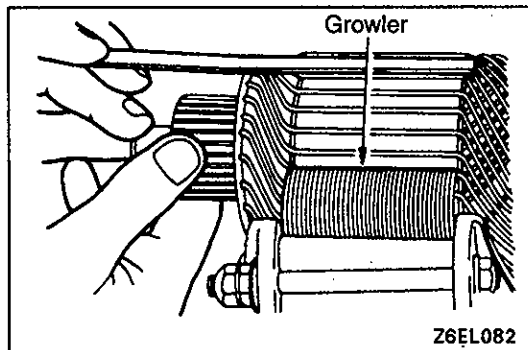
1. While holding clutch housing, rotate the pinion. Drive pinion should rotate smoothly in one direction, but should not rotate in opposite direction. If clutch does not function properly, replace overrunning clutch assembly.
2. Inspect pinion for wear or burrs. If pinion is worn or burred, replace overrunning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

FRONT AND REAR BRACKET BUSHING

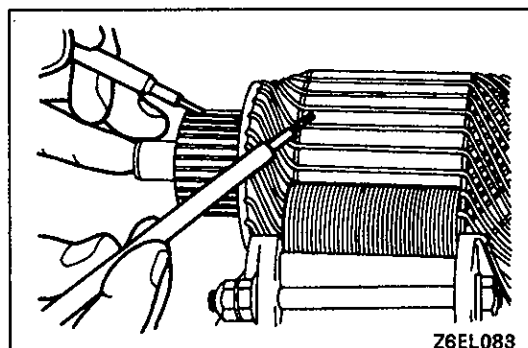
Inspect bushing for wear or burrs. If bushing is worn or burred, replace front bracket assembly or rear bracket assembly.

**BRUSH SET REPLACEMENT**

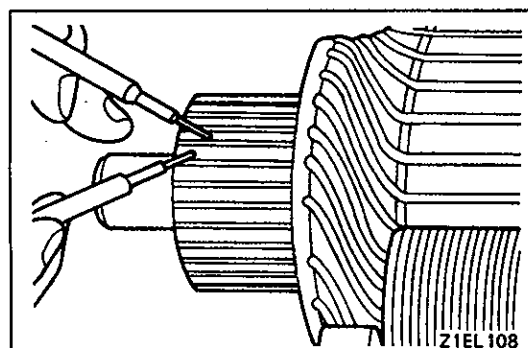
Brushes that are worn beyond wear limit line, or are oil-soaked, should be replaced.

**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

16300010118

GENERAL INFORMATION

<4G1>

Interruption of the primary current flowing in the primary side of the ignition coil generates high voltage in the secondary side of the ignition coil. The high voltage thus generated is directed by the distributor to the applicable spark plug. The engine firing order is 1–3–4–2 cylinders.

On application of high voltage, the spark plug generates a spark to ignite the compressed air fuel mixture in the combustion chamber.

The engine-ECU makes and breaks the primary current of the ignition coil to regulate the ignition timing.

The engine-ECU detects the crankshaft position

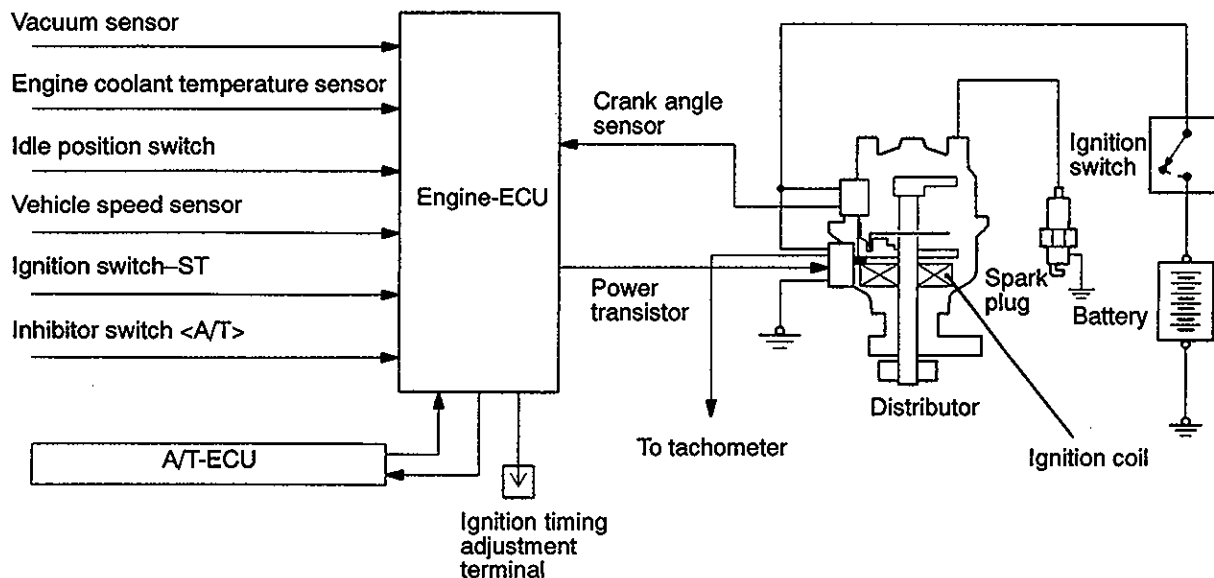
by the crank angle sensor incorporated in the distributor to provide ignition at the most appropriate timing for the engine operating condition.

When the engine is cold or operated at a high altitude, the ignition timing is slightly advanced to provide optimum performance to the operating condition.

Furthermore, if knocking occurs, the ignition timing is gradually retarded until knocking ceases.

When the automatic transmission shifts gears, the ignition timing is also retarded in order to reduce output torque, thereby alleviating shifting shocks.

SYSTEM DIAGRAM



1FU1152

<4G9>

This system is equipped with two ignition coils (A and B) with built-in power transistors for the No. 1 and No. 4 cylinders and the No. 2 and No. 3 cylinders respectively.

Interruption of the primary current flowing in the primary side of ignition coil A generates a high voltage in the secondary side of ignition coil A.

The high voltage thus generated is applied to the spark plugs of No. 1 and No. 4 cylinders to generate sparks. At the time that the sparks are generated at both spark plugs, if one cylinder is at the compression stroke, the other cylinder is at the exhaust stroke, so that ignition of the compressed air/fuel mixture occurs only for the cylinder which is at the compression stroke.

In the same way, when the primary current flowing in ignition coil B is interrupted, the high voltage thus generated is applied to the spark plugs of No. 2 and No. 3 cylinders.

The engine-ECU turns the two power transistors

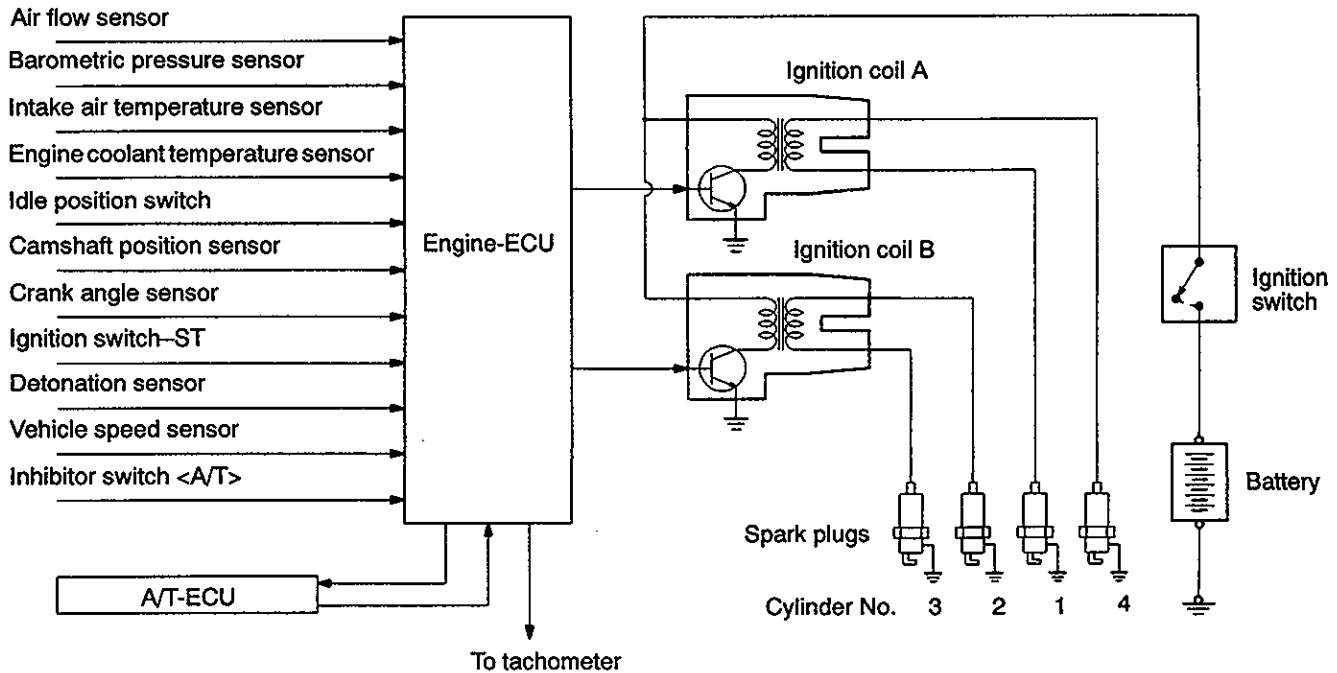
inside the ignition coils alternately on and off. This causes the primary currents in the ignition coils to be alternately interrupted and allowed to flow to fire the cylinders in the order 1–3–4–2.

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



DISTRIBUTOR SPECIFICATIONS

Items	4G1
Type	Contact pointless with built-in ignition coil
Advance mechanism	Electronic
Firing order	1-3-4-2

IGNITION COIL SPECIFICATIONS

Items	4G1	4G9
Type	Molded single-coil with a built-in distributor	Molded 2-coil

SPARK PLUG SPECIFICATIONS

Items	4G1	4G9 – except MVV	4G9-MVV
NGK	BPR5ES-11	BKR6E-11	BKR5E-11
NIPPON DENSO	W16EPR11	K20PR-U11	K16PR-U11
CHAMPION	RN11YC4	RC9YC4	RC12YC4

SERVICE SPECIFICATIONS

16300030121

IGNITION COIL

Items	4G1	4G9 – except MVV	4G9-MVV
Primary coil resistance Ω	0.5-0.7	-	-
Secondary coil resistance $k\Omega$	15-22	14-21	20-30

SPARK PLUG

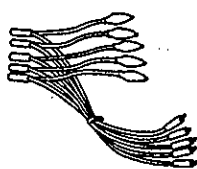
Items	4G1, 4G9
Spark plug gap mm	1.0-1.1

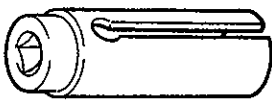
RESISTIVE CORD

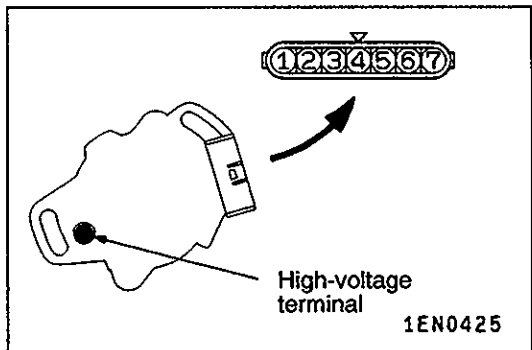
Items	4G1, 4G9
Resistance $k\Omega$	max. 22

SPECIAL TOOL

16300060070

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

Tool	Number	Name	Use
	MD998770	Oxygen sensor wrench	Detonation sensor removal and installation

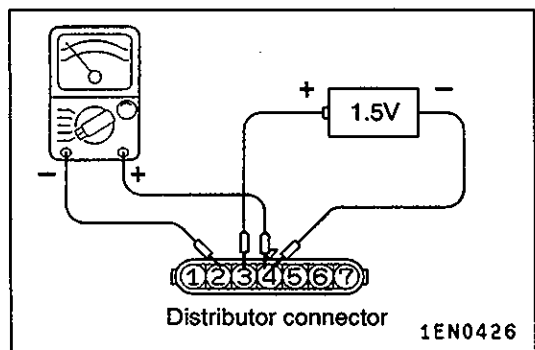


ON-VEHICLE SERVICE

16300120149

IGNITION COIL CHECK <4G1>

1. Measurement of the primary coil resistance
Measure the resistance between connector terminal 1 and 2 of the distributor.
Standard value: 0.5–0.7 Ω
2. Measurement of secondary coil resistance
Measure the resistance between the high-voltage terminals and connector terminals 1.
Standard value: 15–22 kΩ



POWER TRANSISTOR CONTINUITY CHECK <4G1>




16300130104

NOTE

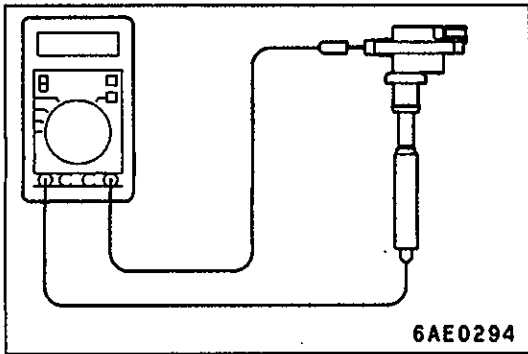
1. An analogue-type circuit tester should be used.
2. Connect the negative (–) prove of the circuit tester to terminal 2.

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.		
	2	3	4
When current is flowing			
When current is not flowing			

Replace the power transistor if there is a malfunction.



IGNITION COIL (WITH BUILT-IN POWER TRANSISTOR) CHECK <4G9>

16300120156

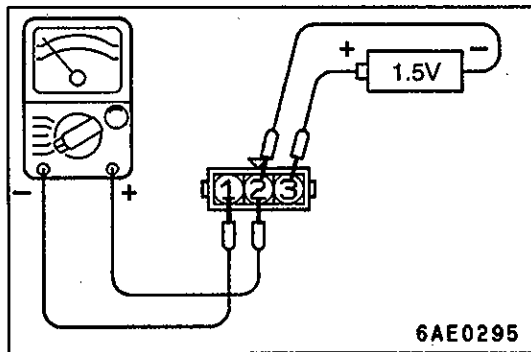
Check by the following procedure, and replace if there is a malfunction.

SECONDARY COIL RESISTANCE CHECK

Measure the resistance between the high-voltage terminals of the ignition coil.

Standard value:

- 14 – 21 kΩ <except MVV>
- 20 – 30 kΩ <MVV>



PRIMARY COIL AND POWER TRANSISTOR CONTINUITY CHECK

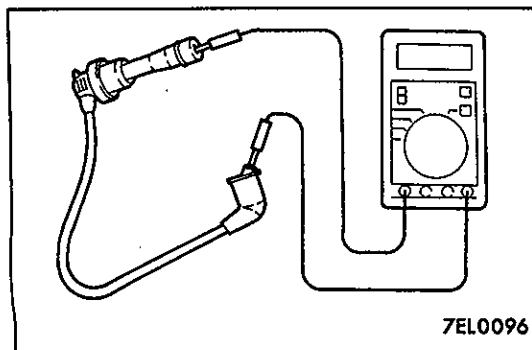
NOTE

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 breaking.

Voltage: 1.5V	Terminal No.		
	1	2	3
When current is flowing	○	⊖ — ⊕	⊕
When current is not flowing			



RESISTIVE CORD CHECK

16300140039

Measure the resistance of the all spark plug cables.

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

Limit: Max. 22 kΩ

DETONATION SENSOR CHECK <4G9> 16300180062

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

NOTE

For information concerning the self-diagnosis codes, after to GROUP 13A – Troubleshooting.

SPARK PLUG CHECK AND CLEANING 16300150056

1. Remove the spark plug cables.

Caution

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

2. Remove the spark plugs.
3. Check for burned out electrode or damaged insulator. Check for even burning.
4. Remove carbon deposits with wire brush or plug cleaner. Remove sand from plug screw with compressed air.
5. Use a plug gap gauge to check that the plug gap is within the standard value range.

Standard value: 1.0–1.1 mm

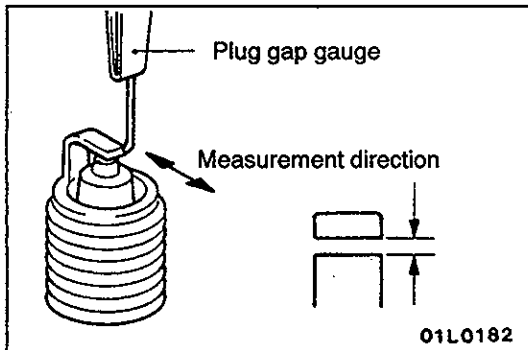
If the plug gap is not within the standard value range, adjust by bending the earth electrode.

6. Clean the engine plug holes.

Caution

Be careful not to allow foreign matter in cylinders.

7. Install the spark plugs.



CRANK ANGLE SENSOR <4G1>, CAMSHAFT POSITION SENSOR, CRANK ANGLE SENSOR <4G9> CHECK

16300260223

Refer to GROUP 13A – Troubleshooting.

WAVEFORM CHECK USING AN ANALYZER

16300170199

Ignition Secondary Voltage Check

<4G1>

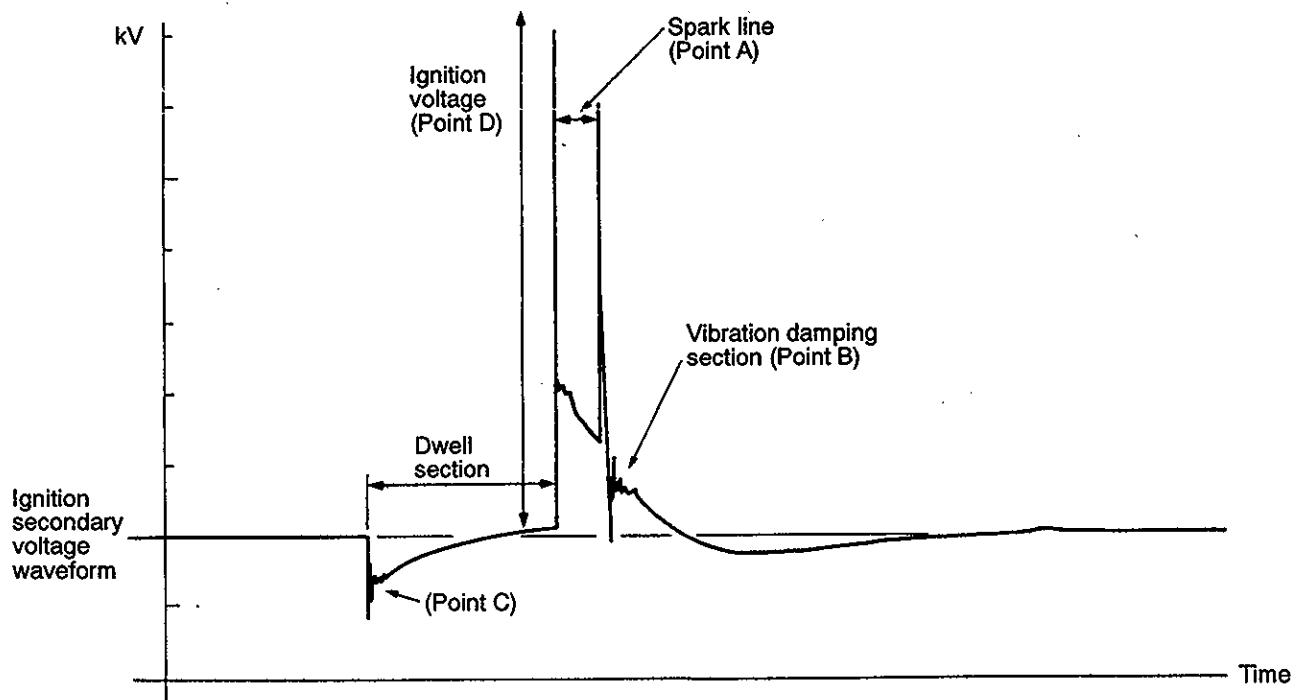
MEASUREMENT METHOD

1. Clamp the spark plug cable of the No. 1 cylinder with the secondary pickup and check the waveform.
2. Connect the secondary pickup to the other cylinders in turn and check the waveforms for each cylinder.

STANDARD WAVEFORM

Observation Conditions

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



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





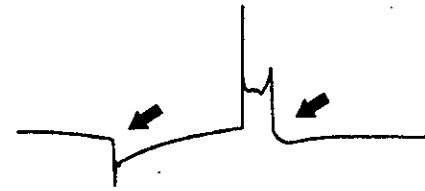
Point C: Number of vibrations at beginning of dwell section (Refer to abnormal waveform example 5)

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>	<p>Spark line is high and short.</p>	<p>Spark plug gap is too large.</p>
<p>Example 2</p>  <p>01P0216</p>	<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.</p>	<p>Spark plug gap is too small.</p>
<p>Example 3</p>  <p>01P0217</p>	<p>Spark line is low and long, and is sloping. However, there is almost no spark line distortion.</p>	<p>Spark plug gap is fouled.</p>
<p>Example 4</p>  <p>01P0218</p>	<p>Spark line is high and short. Difficult to distinguish between this and abnormal waveform example 1.</p>	<p>Spark plug cable is nearly falling off. (Causing a dual ignition)</p>
<p>Example 5</p>  <p>01P0219</p>	<p>No waves in wave damping section.</p>	<p>Layer short in ignition coil</p>

<4G9>

MEASUREMENT METHOD

1. Clamp the SECONDARY PICKUP around the spark plug cable.

NOTE

1. The peak ignition voltage will be reversed when the spark cables No. 2 and No. 4, or No. 1 and No. 3 cylinders are clamped.
 2. Because of the two-cylinder simultaneous ignition system, the waveforms for two cylinders in each group appear during waveform observation (No. 1 cylinder – No. 4 cylinder, No. 2 cylinder – No. 3 cylinder). However, waveform observation is only applicable for the cylinder with the spark plug cable clamped by the secondary pickup.
 3. Identifying which cylinder waveform is displayed can be difficult. For reference, remember that the waveform of the cylinder attached to the secondary pickup will be displayed as stable.
2. Clamp the spark plug cable with the trigger pickup.

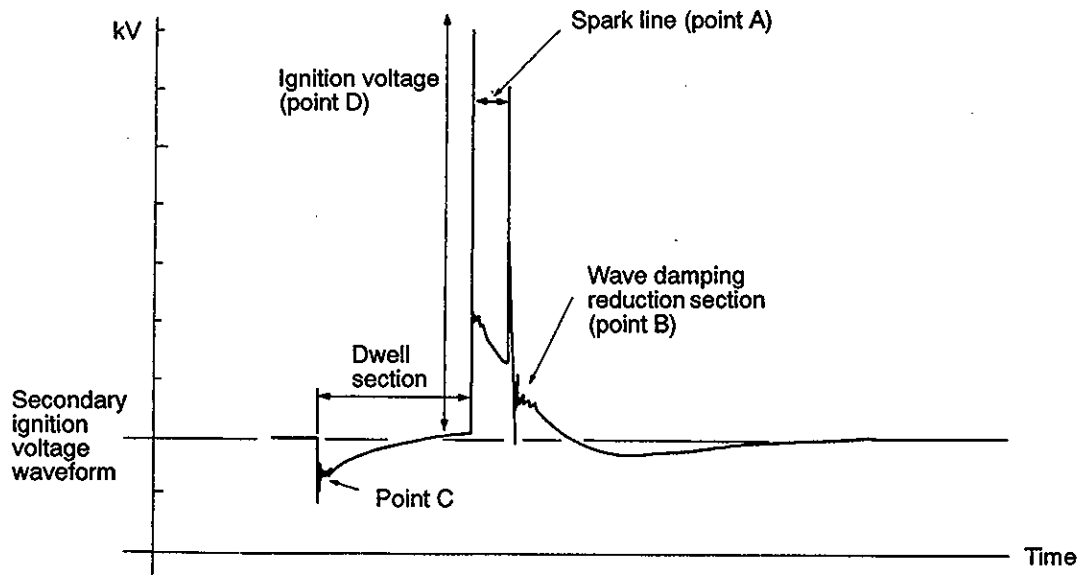
NOTE

Clamp the trigger pickup to the same spark plug cable clamped by the secondary pickup.

STANDARD WAVEFORM

Observation Conditions

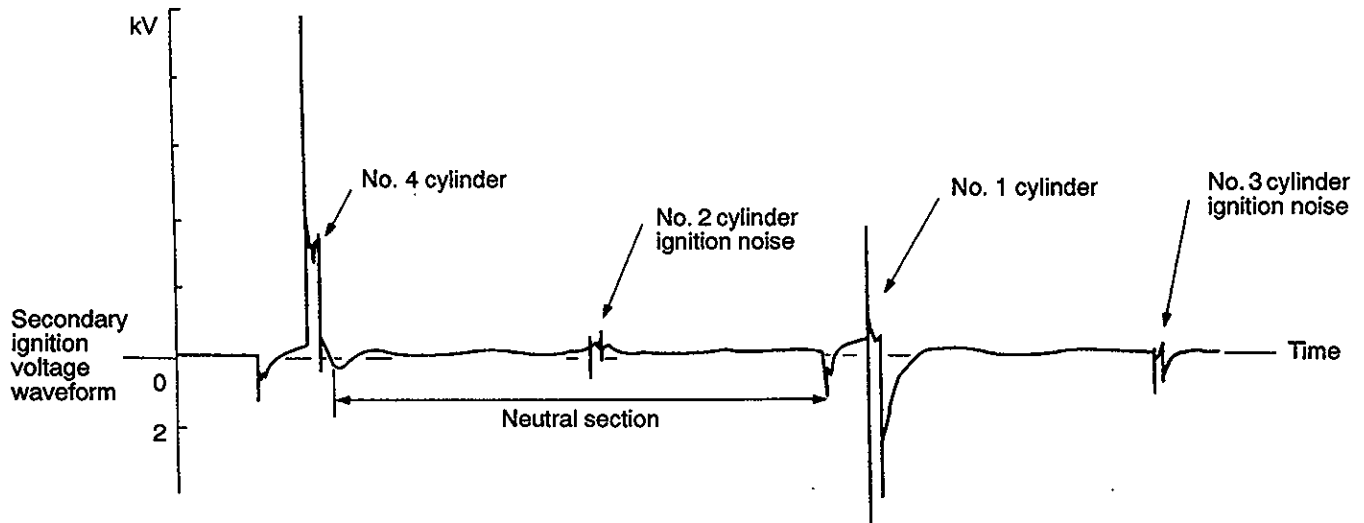
Function	Secondary
Pattern height	High (or Low)
Pattern selector	Raster
Engine revolutions	Curb idle speed



7EL0147

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

Pattern selector	Display
------------------	---------



6EL0183

WAVEFORM OBSERVATION POINTS

For waveform observation points, refer to P.16-36.

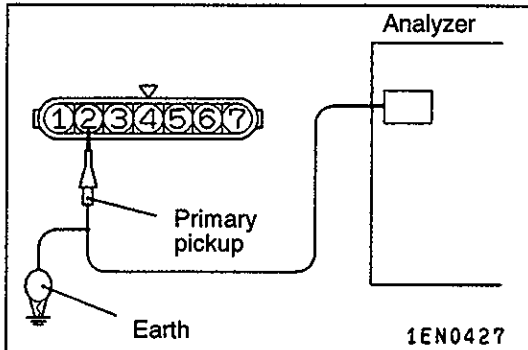
EXAMPLES OF ABNORMAL WAVEFORMS

For examples of abnormal waveforms, refer to P.16-37.

Ignition Primary Voltage Waveform Check <4G1>

MEASUREMENT METHOD

1. Disconnect the distributor connector and connect the special tool (test harness: MB991348) in between. (All of the terminals should be connected.)



2. Connect the analyzer primary pickup to the distributor connector terminal 2.
3. Connect the primary pickup earth terminal.
4. Clamp the spark plug cable with the trigger pickup.

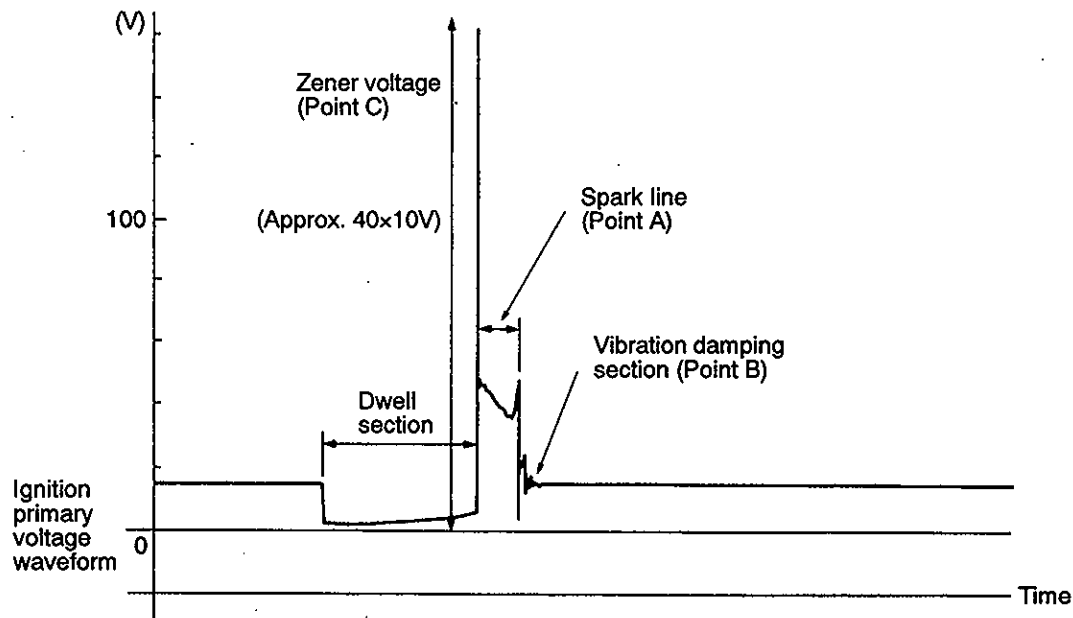
NOTE

The waveform of the cylinder clamped to the trigger pickup will appear at the left edge of the screen.

STANDARD WAVEFORM

Observation conditions

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

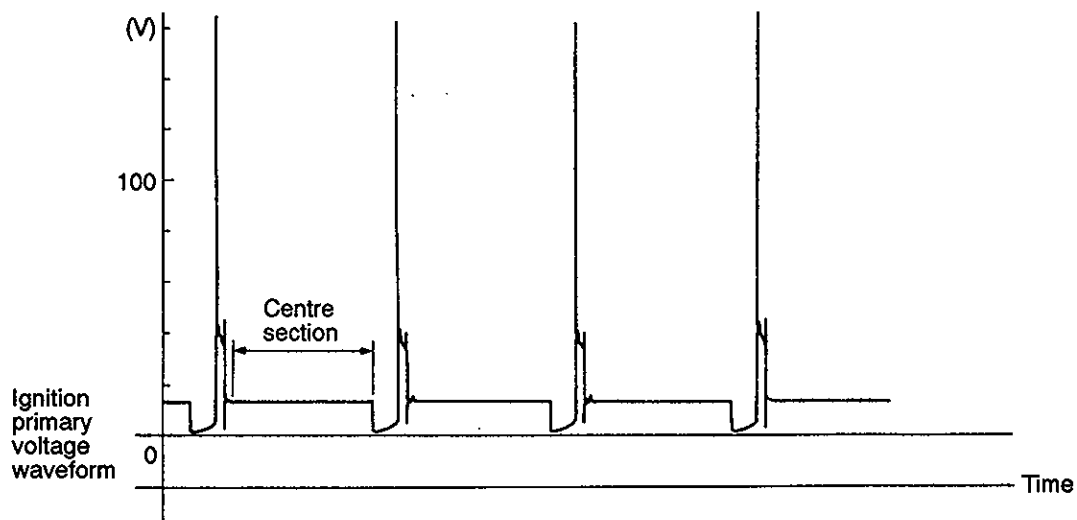


7EL0132

Observation conditions

(Only the pattern selector shown below changes from the previous conditions)

PATTERN SELECTOR	DISPLAY
------------------	---------



9EL0006

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	–	–	–	–





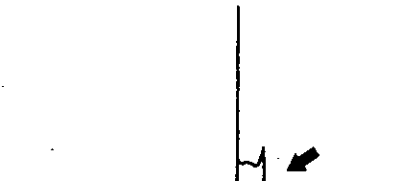
Point B: Number of vibration in reduction vibration section
(Refer to abnormal waveform example 5)

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

Point C: Height of Zener voltage

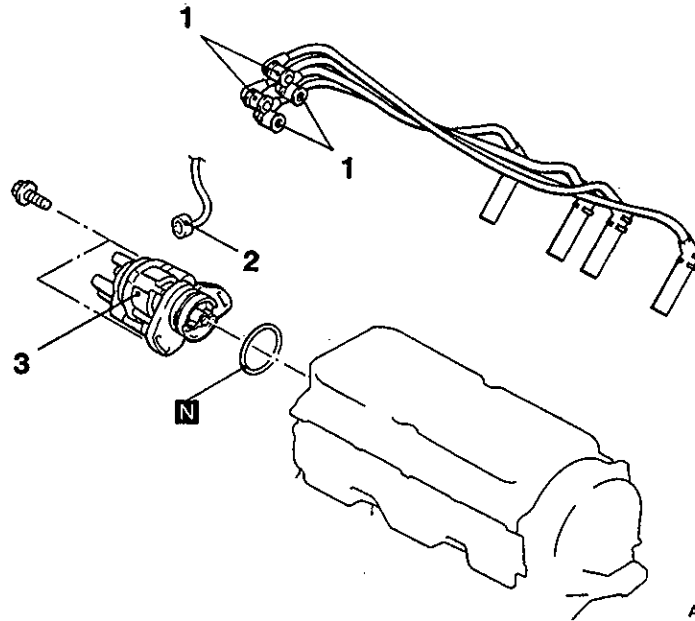
Height of Zener voltage	Probable cause
High	Problem in Zener diode
Low	Abnormal resistance in primary coil circuit

EXAMPLES OF ABNORMAL WAVEFORMS

Abnormal waveform	Wave characteristics	Cause of problem
<p>Example 1</p>  <p>01P0210</p>	<p>Spark line is high and short.</p>	<p>Spark plug gap is too large.</p>
<p>Example 2</p>  <p>01P0211</p>	<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.</p>	<p>Spark plug gap is too small.</p>
<p>Example 3</p>  <p>01P0212</p>	<p>Spark line is low and long, and is sloping. However, there is almost no spark line distortion.</p>	<p>Spark plug gap is fouled.</p>
<p>Example 4</p>  <p>01P0213</p>	<p>Spark line is high and short.</p>	<p>Spark plug cable is nearly falling off. (Causing a dual ignition)</p>
<p>Example 5</p>  <p>01P0214</p>	<p>No waves in wave damping section</p>	<p>Layer short in ignition coil</p>

DISTRIBUTOR <4G1>**REMOVAL AND INSTALLATION****Post-Installation Operation**

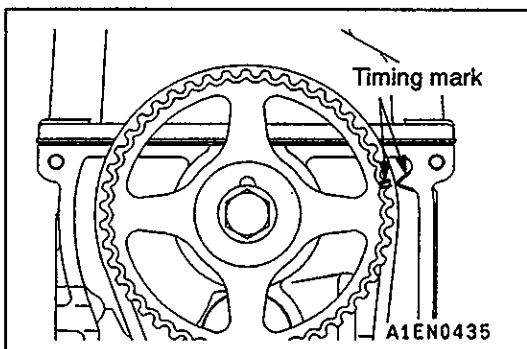
- Engine Adjustment
(Refer to GROUP 11 – On-vehicle Service.)



A16M0206

Removal steps

1. Spark plug cable connection
2. Distributor connector
3. Distributor

**INSTALLATION SERVICE POINT****▶A◀ DISTRIBUTOR INSTALLATION**

1. Remove the timing belt upper cover.
2. Turn the crankshaft clockwise to align the timing marks.

NOTE

The No.1 cylinder will be at compression top dead centre if the timing mark on the camshaft sprocket is aligned with the timing mark on the cylinder head.

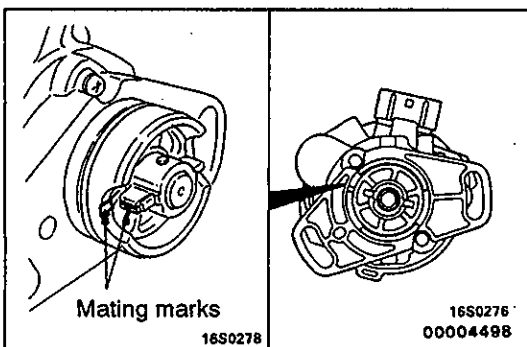
3. Align the mating mark on the distributor housing side with the mating mark on the coupling side.
4. Install the distributor to the engine.

INSPECTION

16300260254

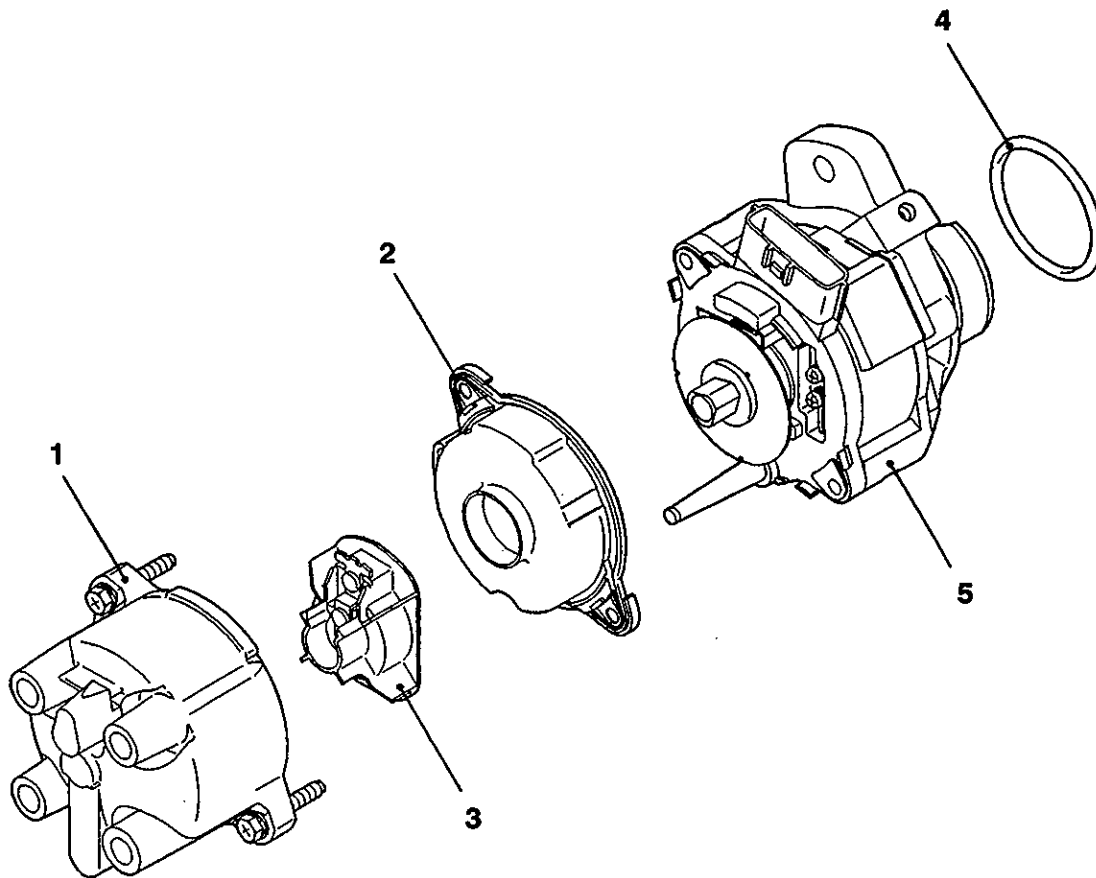
CAMSHAFT POSITION SENSOR, CRANKSHAFT POSITION SENSOR CHECK

Refer to GROUP 13A – Troubleshooting.



DISASSEMBLY AND REASSEMBLY

16300220078



1EN0428

1. Distributor cap
2. Packing
3. Rotor
4. O-ring
5. Distributor housing

INSPECTION

16300230040

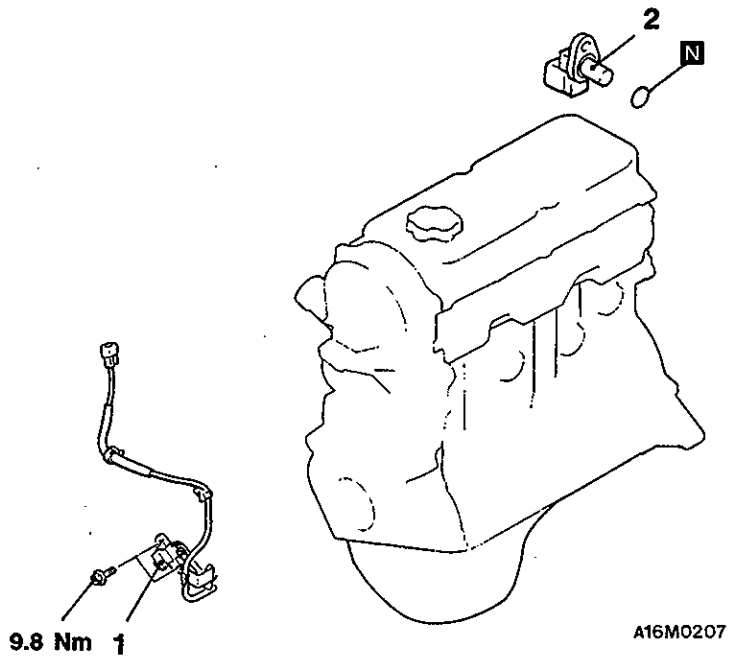
Check the following points; repair or replace if a problem is found.

CAP, ROTOR

1. There must be no cracking in the cap.
2. There must be no damage to the cap's electrode or the rotor's electrode.
3. Clean away any dirt from the cap and rotor.

**CAMSHAFT POSITION SENSOR AND CRANK ANGLE SENSOR
<4G9>**

16300250121

REMOVAL AND INSTALLATION

1. Crank angle sensor
2. Camshaft position sensor

INSPECTION

16300260247

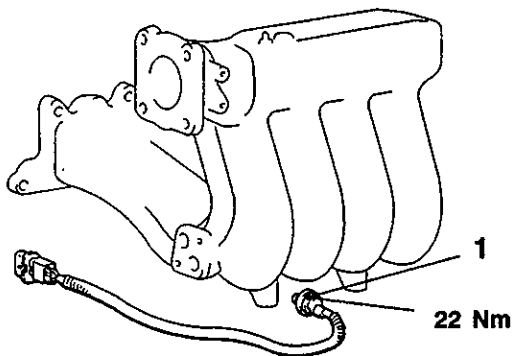
**CAMSHAFT POSITION SENSOR, CRANK ANGLE
SENSOR CHECK**

Refer to GROUP 13A – Troubleshooting.

DETONATION SENSOR <4G9>

16300280113

REMOVAL AND INSTALLATION



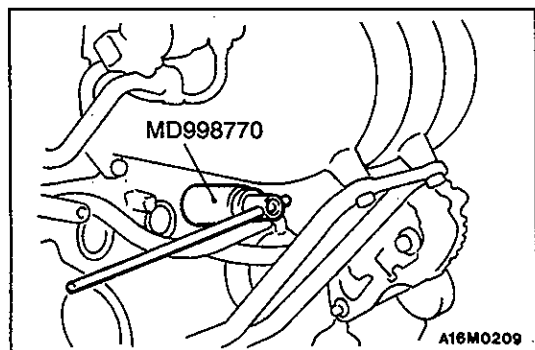
A16M0208



1. Detonation sensor

Caution

Do not subject the detonation sensor to any shocks.



A16M0209

REMOVAL SERVICE POINT

◀▶ **DETONATION SENSOR REMOVAL**

INSPECTION

DETONATION SENSOR CHECK

Refer to GROUP 13A – Troubleshooting.

16300290048

NOTES