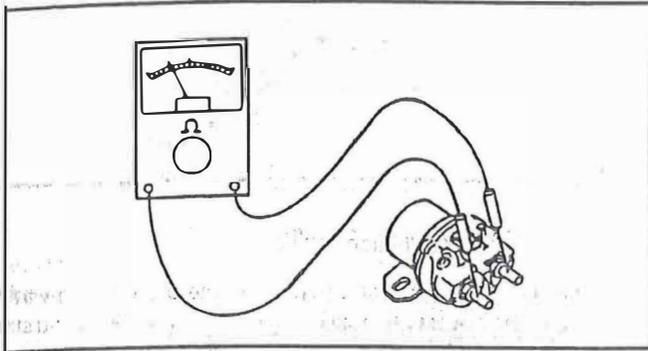


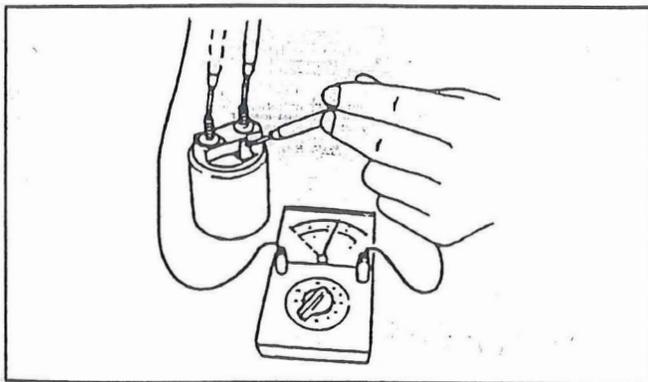
2. Check that the relay is activated when the relay coil is energized. Listen for a clicking sound. Connect battery positive (+) to the coil terminal and battery negative (-) to ground (metal body of the solenoid). Verify continuity between the two (2) contact terminals with the relay coil energized. Replace the relay if there is no continuity.



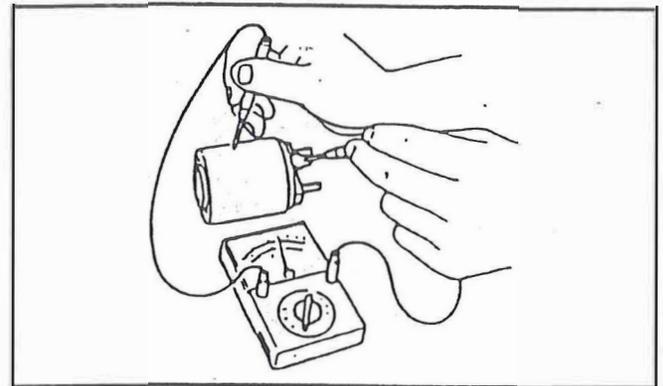
### STARTER SOLENOID CONTINUITY TEST

**NOTE:** Disconnect all wires from the solenoid before performing the following test.

1. Check the continuity between the coil terminal and lower output contact terminal (terminal which connects to starter motor and has buss bar to solenoid coil ground) with the volt-ohmmeter. Replace the solenoid if there is no continuity. Check the continuity between the coil terminal and upper output contact terminal. Replace the solenoid if there is continuity.



2. Check the continuity between the coil terminal and the metal solenoid body (ground) with the volt-ohmmeter. Replace if there is no continuity.



3. Check the continuity between the two (2) contact terminals. Replace the relay if there is continuity (relay coil deenergized).



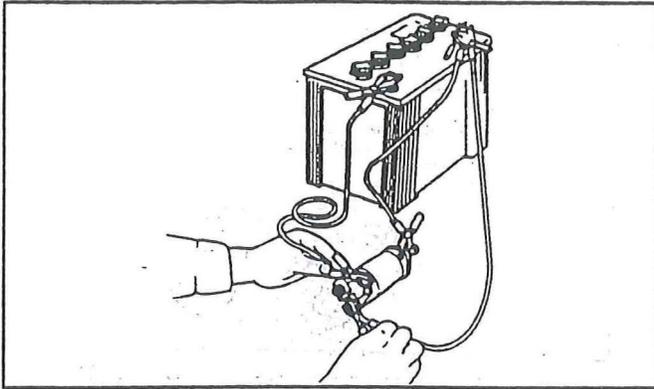
### STARTER SOLENOID COIL TEST

**NOTE:** Disconnect all wires from the solenoid before performing the following test.

1. Coil pull in test.

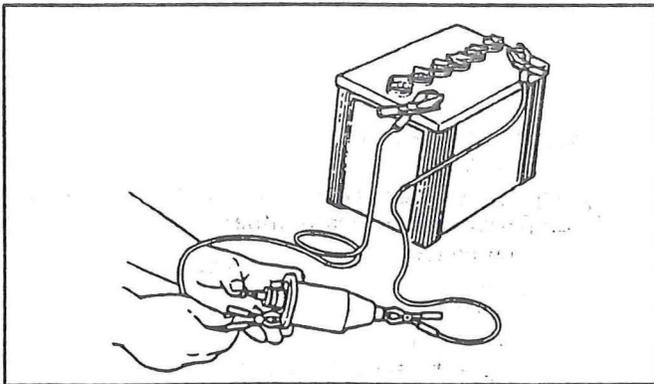
- (1) Remove the starter solenoid from the starter.
- (2) Apply battery voltage to the starter solenoid between the coil terminal and the output contact terminal which was connected to the starter motor. The solenoid plunger should extend. If the plunger does not extend, replace the solenoid.

**NOTE:** Do not energize the coil for more than 10 seconds. Allow the solenoid to cool before repeating the test.



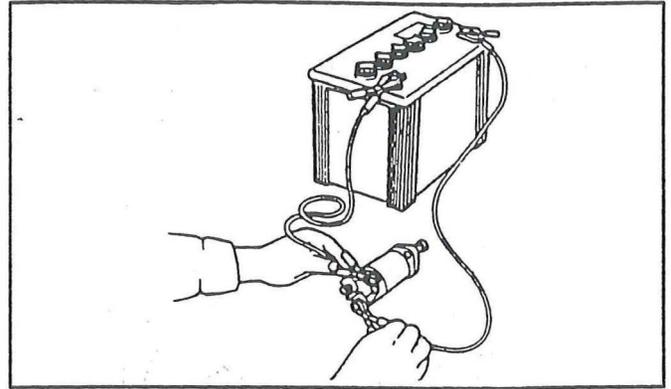
## 2. Coil holding test.

- (1) Remove the starter solenoid from the starter.
- (2) Apply battery voltage to the starter solenoid between the coil terminal and the solenoid body. Connect battery positive (+) to the coil terminal and battery negative (-) to the solenoid metal body (ground). Manually pull the solenoid plunger out.
- (3) Release the plunger. The plunger should remain extended once released. If the plunger returns with battery volts applied, replace the solenoid.



## 3. Plunger return test.

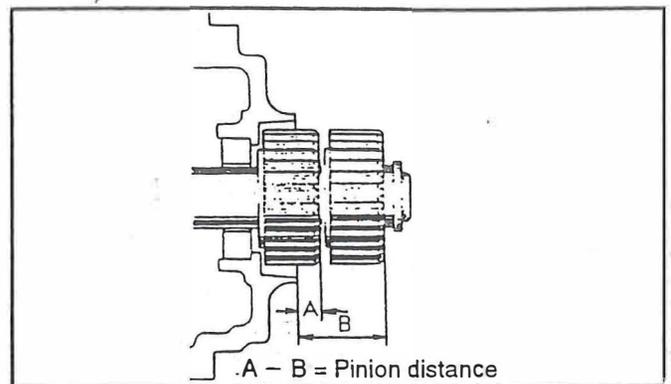
- (1) Remove the starter solenoid from the starter.
- (2) Connect the battery to the starter solenoid between the output contact terminal on the starter solenoid and the solenoid body. Connect battery positive (+) to the output contact terminal (terminal which was connected to the starter motor) and battery negative (-) to the metal body of the solenoid (ground).
- (3) Verify that the plunger extends with battery volts applied and that it retracts immediately after disconnecting the battery. Replace the solenoid if the plunger does not extend and retract as stated.



## 4. Inspection of pinion stroke.

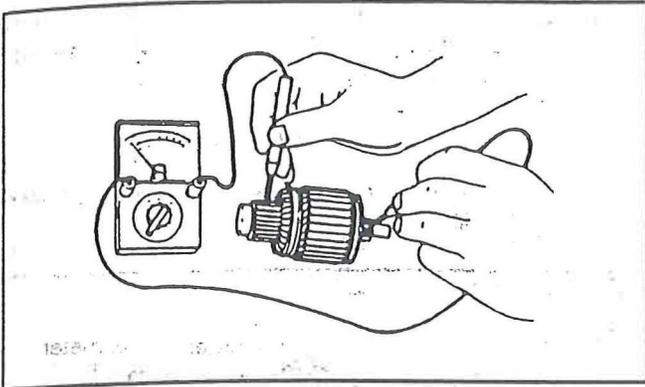
- (1) Install the starter solenoid on the starter. The wire between the starter solenoid output contact terminal and starter motor must remain disconnected for this test.
- (2) When the battery is connected between the coil terminal and ground, the pinion should extend 17 mm (.6693 in). Measure and verify this distance. Connect battery positive (+) to the coil terminal and battery negative (-) to the metal body of the starter (ground).

**NOTE:** Do not energize the coil for more than 20 seconds. Allow the solenoid to cool before repeating the test.

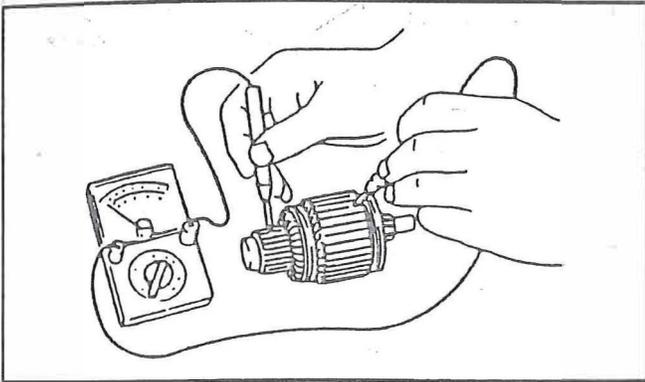


## ARMATURE INSPECTION

1. Check the continuity between each segment of the commutator and the shaft. If there is no continuity, the armature is normal. If there is continuity, replace the armature.



2. Check the continuity between each of the commutator bars and the two (2) segments adjacent to it. Replace the armature if there is continuity between any of the adjacent segments.

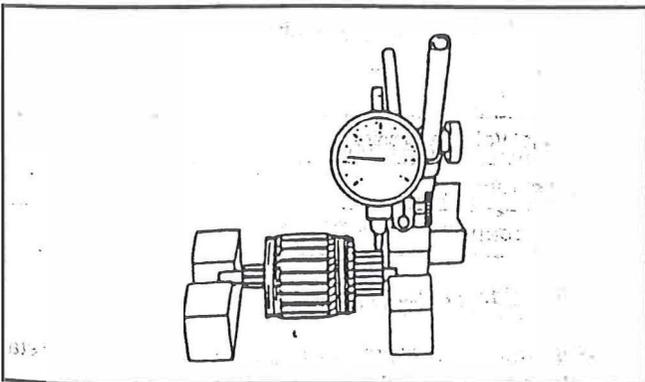


3. Check the runout of the commutator surface with a dial indicator. If the runout is 0.1 mm (.0039 in) or greater, replace the armature or machine the surface so that it is within the standard value.

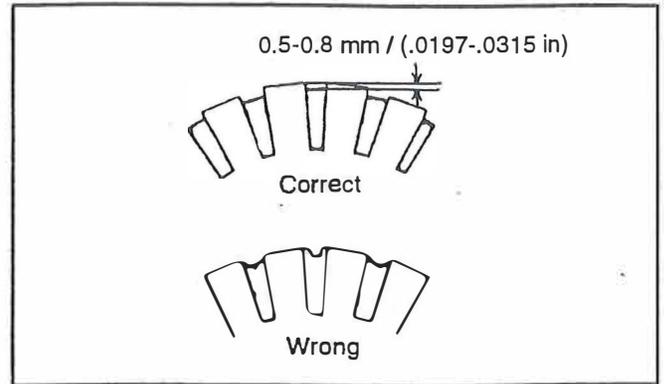
Commutator standard runout : 0.05 mm (.0020 in) or less.

Commutator standard O.D.: 38.7 mm (1.52 in)

Commutator minimum O.D.: 38.1 mm (1.50 in)

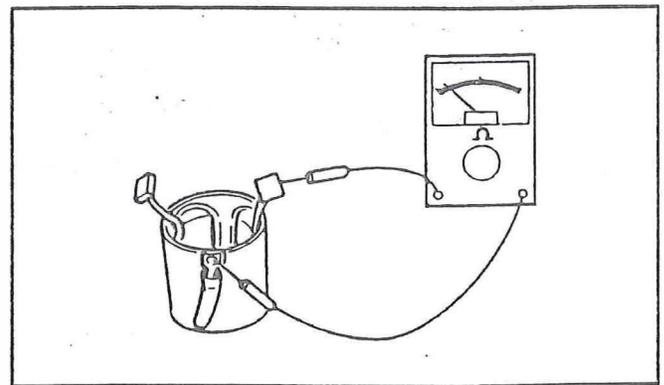


4. Inspect the depth of the mica. Repair (undercut) or replace the armature if the depth is 0.2 mm (.0079 in) or less.  
Standard value: 0.5-0.8 mm (.0197-.0315 in)

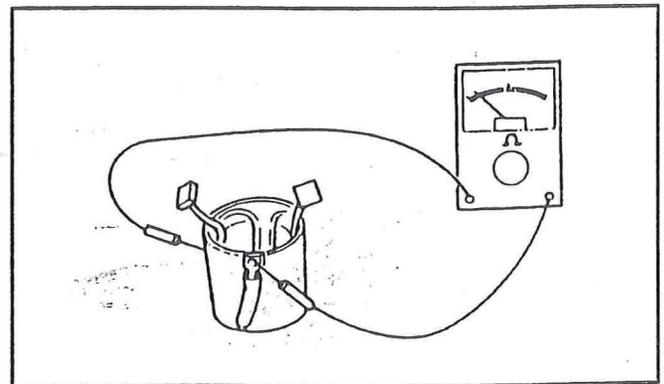


### FIELD COIL INSPECTION

1. Check the continuity between the external lead on the motor frame and each of the brushes with the volt-ohmmeter. Repair or replace the field coil if there is no continuity.

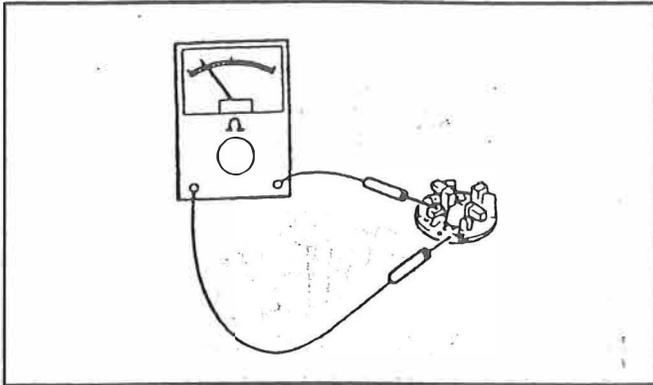


2. Check the continuity between the external lead on the motor frame and the motor frame with a volt-ohmmeter. Replace if there is continuity.

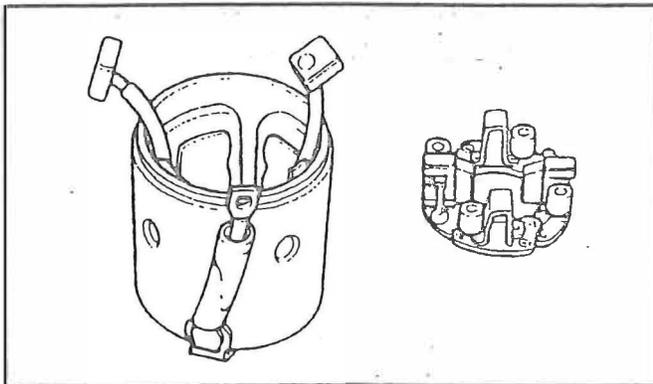


### BRUSH AND BRUSH HOLDER INSPECTION

1. Check the continuity between the insulated brush holder and brush holder frame (mounting plate) with the volt-ohmmeter. Replace the brush holder assembly if there is continuity.



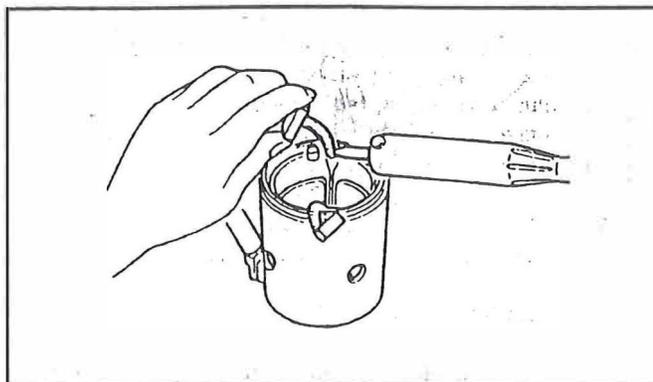
2. Check the condition of the brushes. If the brushes are worn to the limit or is unevenly worn, replace them.  
Wear limit value: 11 mm / (.4331 in)



### BRUSH REPLACEMENT

**NOTE:** Always replace the brush holder when replacing the brushes.

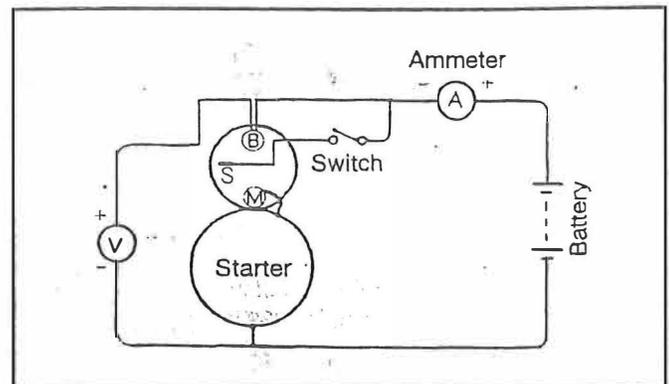
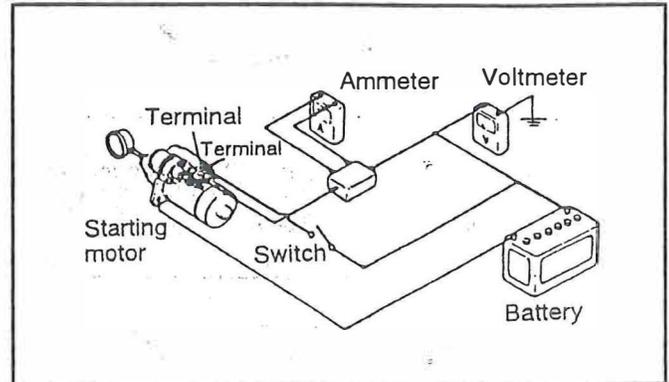
1. Cut the brush wire off at the field coil.
2. Solder a new brush onto the field coil near where the old brush was cut off.



**NOTE:** Use high temperature solder. The melting temperature of the solder should be 285-296°C / (545-564°F). Use a soldering iron with a heat rating of 100W or higher.

### STARTER NO-LOAD BENCH TEST

1. Connect the starter, ammeter, voltmeter and battery as shown in the illustration.



2. Activate the starter. Verify that the starter rotates smoothly and that the voltage, current and speed are at specified values.  
Standard values (off vehicle):

Type (kw)	2.2
Terminal voltage (volts)	11
Current (amps)	180 or less
Speed (rpm)	3800 or higher

### STARTER INSTALLATION

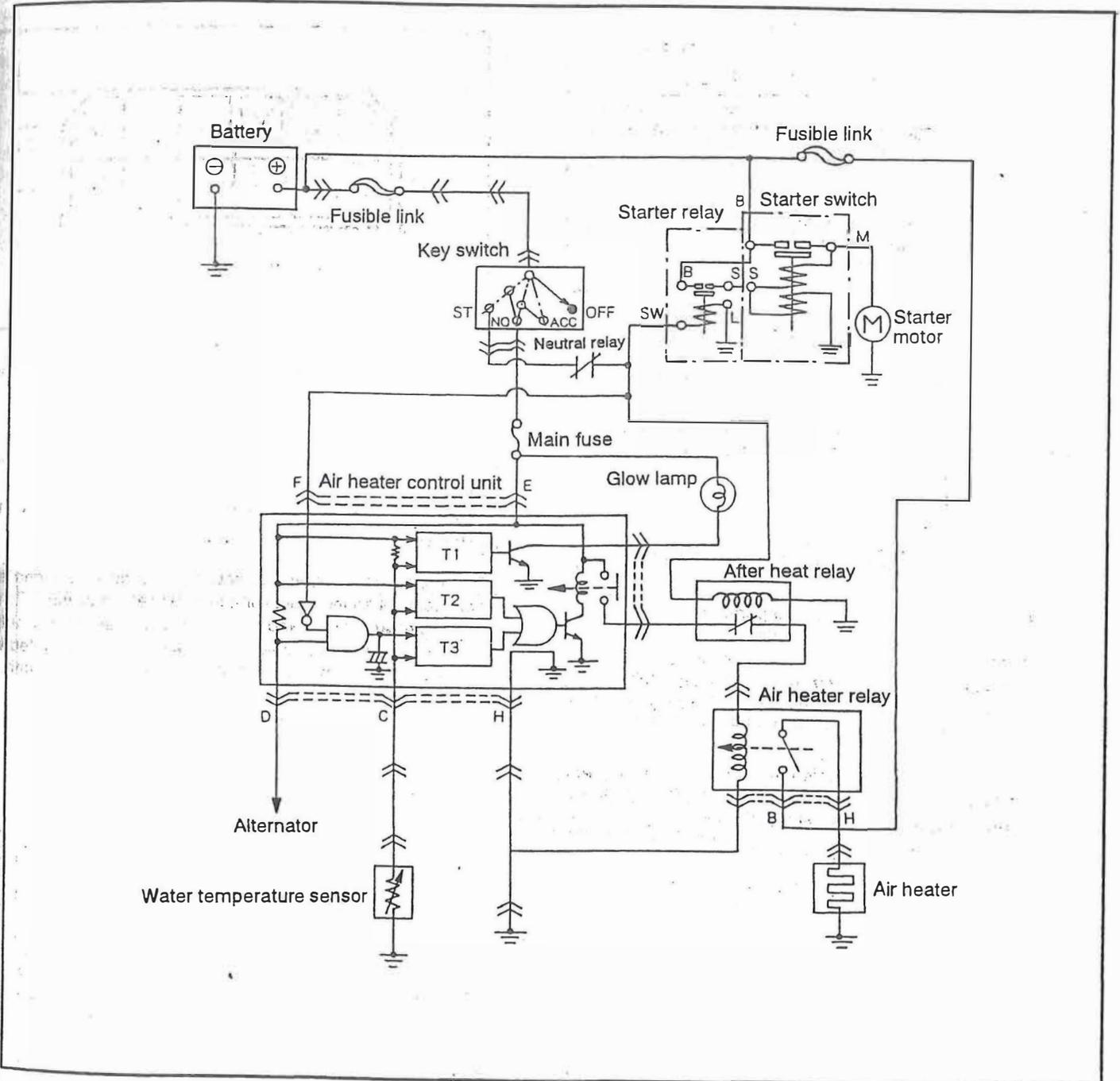
Perform the removal procedures in reverse to install the starter.  
Tightening torque: 7.3-8.8 kgm / (53-64 lbf ft)  
See: "**STARTER ASSEMBLY WIRING LAYOUT**" for wire connections.

## AIR HEATER SYSTEM

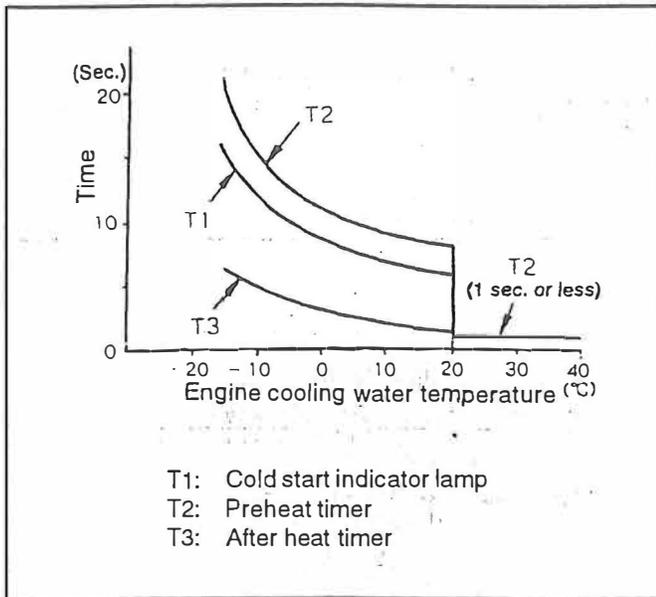
### AIR HEATER PRINCIPAL OF OPERATION

The installation of an air heater in the intake manifold allows the intake air to be warmed prior to entering the combustion chamber. Warmed air aids in igniting the fuel in a cold engine, and cold start characteristics are improved. Air heater operation after engine startup reduces the noise and the white smoke evident immediately after starting a cold engine.

### AIR HEATER SYSTEM DIAGRAM



## AIR HEATER TIMER OPERATION GRAPH



## AIR HEATER DESCRIPTION OF OPERATION

When starting the engine, the control unit regulates the operation time of the air heater according to the engine coolant temperature. Operation of the air heater system is indicated by the illumination of the cold start lamp on the instrument panel. The cold start lamp will extinguish after a short period to indicate that the engine is prepared to start.

The air heater will not operate if the coolant temperature is 20°C / (68°F) or higher.

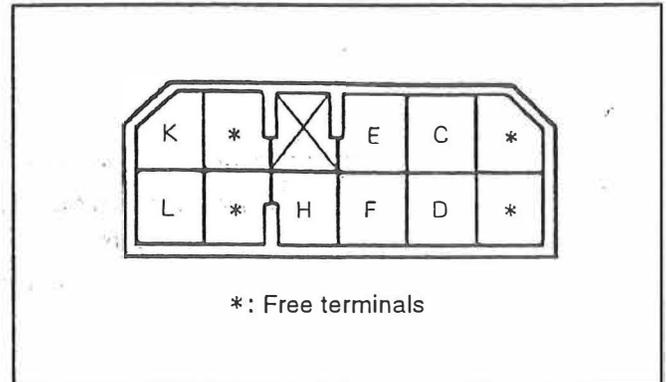
The following functions are also incorporated:

- 1) "Safety circuit" to automatically turn off the air heater element and protect the battery from excessive discharge if the key switch is left in the "ON" position and the engine has not been started.
- 2) "After heat" to reduce noise and smoke levels immediately after starting. At temperatures below 20°C / (68°F) the air heater will operate for a short period after the engine has started.

- 3) "Start bypass" to shut off the air heater element during starter operation. Operation of the air heater is will be terminated temporarily to protect the battery and increase cold start engine cranking speed.

## AIR HEATER CONTROL UNIT INSPECTION

1. Remove the control unit cover and unbolt the control unit. The air heater control unit is located in the engine compartment on the front plate near the starter.

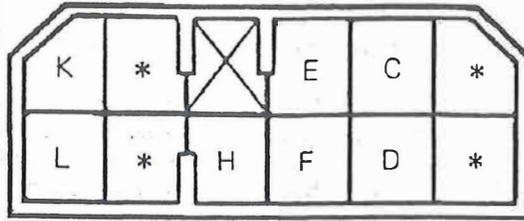


2. Inspect the voltage of each terminal on the unit with a volt meter.

**NOTE:** Connect the negative (-) probe of the volt meter to battery (-) (ground). Connect the positive (+) probe of the volt meter to the points listed. Tests are to be performed with the control unit connected. Insert the probe from behind the connector.

3. Inspect the suspect component, associated wiring and connectors if an incorrect voltage is present. If all input to the control unit are correct and a malfunction is present in an output component, check the output component and associated wiring. If a malfunction is still present replace the control unit.

CONTROL UNIT TEST POINTS AND VALUES



\*: Free terminals

Terminal	Wire color	Component	Measurement conditions		Standard values (volts)
C	Green/red	Coolant temperature sensor	Key switch "ON"	Engine coolant temperature approx. 20°C / (68°F).	Approx. 3-4 volts
				Engine coolant temperature approx. 80°C / (176°F).	Approx. 2-3 volts
D	Green/yellow	Alternator	When key switch is in the "ON" position (ignition) and the engine is not running.		Less than battery volts
			When key switch is in the "ON" position (ignition) and the engine is running. <b>NOTE: Alternator light must be off. Charging system must be functional. Accelerate engine slightly if necessary.</b>		Battery volts
E	Blue/white	Key switch (IGNITION circuit)	When key switch is in the "ON" (ignition) and start positions.		Battery volts
			When key switch is in the "OFF" position.		Zero (0) volts
F	Black/yellow	Key switch (START circuit)	When key switch is in the "START" position.		Battery volts
			When key switch is in the "ON" (ignition) and "OFF" positions.		Zero (0) volts
H	Black	Ground (battery -)	At all times		Zero (0) volts
K	White/red	Cold start indicator lamp	When engine coolant temperature is 20°C or less. * 1	When key switch is turned "ON". Initially, for a period of approx. 2 seconds. * 2	Less than battery volts
				Approx. 2 sec. after key switch is turned "ON". * 2	Battery volts
L	Blue	Air heater relay	When engine coolant temperature is 20°C or less. * 1	When key switch is turned "ON". Initially, for a period of approx. 7 seconds. * 2	Battery volts
				When the key switch is "START" position. * 2	Battery volts
				Approx. 60 sec. after engine switch is turned from "START" to "ON". (Engine not running) * 2	Zero (0) volts
				Other than the above.	Zero (0) volts

Footnotes:

- \* 1. The coolant temperature sensor for the air heater control unit must be bypassed to perform this test when the engine coolant temperature is approximately 20°C / (68°F) or higher. To bypass the coolant temperature sensor, disconnect the green/red wire from the water temperature sensor and install a 800 Ω resistor between the green/red wire and battery (-) (ground).
- \* 2. Voltage and time values listed are for an engine with a coolant temperature of 20°C / (68°F). For other temperature ranges see **TIMER OPERATION GRAPH**.

## AIR HEATER ELEMENT INSPECTION

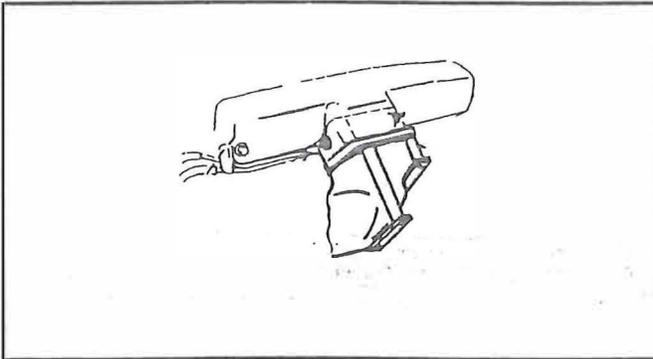
1. Disconnect the wiring to the air heater. Remove the air heater. Isolate the two (2) elements from each other for testing by unbolting one end of one (1) element and insulating it from the connection.

**NOTE:** The two (2) elements are wired in parallel and must be isolated from each other for proper testing. It is not necessary to remove the elements from the housing for testing. Insulate or position the unbolted end of the element away from the other element and away from the connection point on the housing.

2. Check the continuity of each element. Replace the air heater assembly if either of the two (2) elements tests open (no continuity). Measure the resistance between each terminal using a volt-ohmmeter.

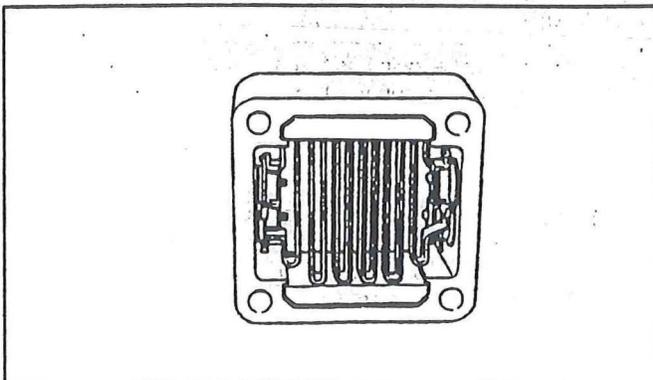
Standard resistance value:  
Approximately 0.053-0.1 ohm ( $\Omega$ ) (each element)

3. Check the continuity between each of the elements and the metal housing. Repair the insulators or replace the air heater if there is continuity.



4. Visually check the air heater for soot and dust.
5. Clean the air heater with water if it is contaminated.

**NOTE:** The air heater must be allowed to dry completely prior to reinstallation.



## AIR HEATER RELAY INSPECTION

### INPUT/OUTPUT VOLTAGE INSPECTION

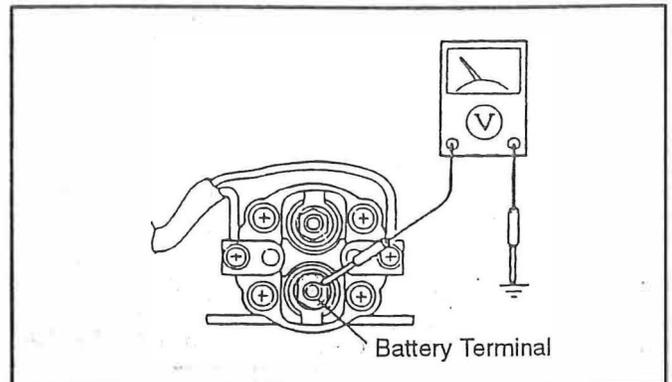
1. Verify that the coolant temperature is 20°C / (68°F) or less.

**NOTE:** "Air heater on time" (the amount of time the air heater relay is energized) will vary with coolant temperature. The coolant temperature sensor for the air heater control unit must be bypassed to perform the following tests when the engine coolant temperature is approximately 20°C / (68°F) or higher. To bypass the coolant temperature sensor, disconnect the green/red wire from the water temperature sensor and install a 800  $\Omega$  resistor between the green/red wire and battery (-) (ground).

2. Check for battery voltage at the relay input contact. Measure the voltage at the B terminal on the air heater relay with a volt-ohmmeter.

Standard value: Battery voltage

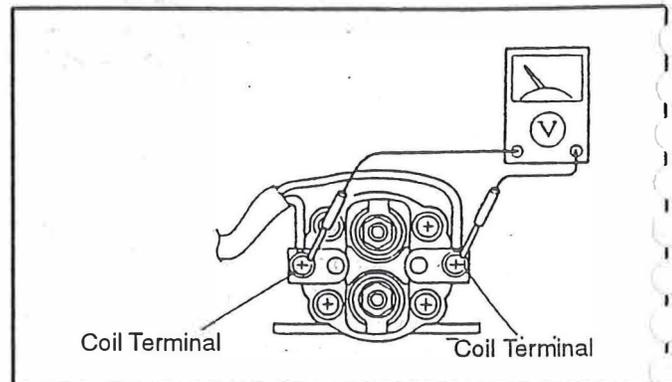
If the correct voltage is not present, check the fusible link and associated wiring.



3. Check for battery voltage at the relay coil. Measure the voltage between the C terminal (white/blue) and the D terminal (black). Measure the voltage with the key switch on.

Standard value: Battery voltage for approximately 7 seconds after the key switch is turned "ON".

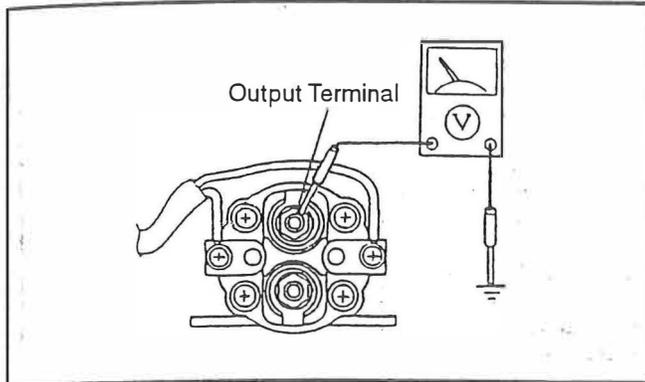
If the correct voltage is not present, check the air heater control the after heat relay and the associated wiring.



4. Check for battery voltage at the relay output contact. Measure the voltage at the A terminal on the air heater relay with the key switch "ON".

Standard value: Battery voltage for approximately 7 seconds after the key switch is turned "ON".

If the correct voltage is not present, the relay may be defective.

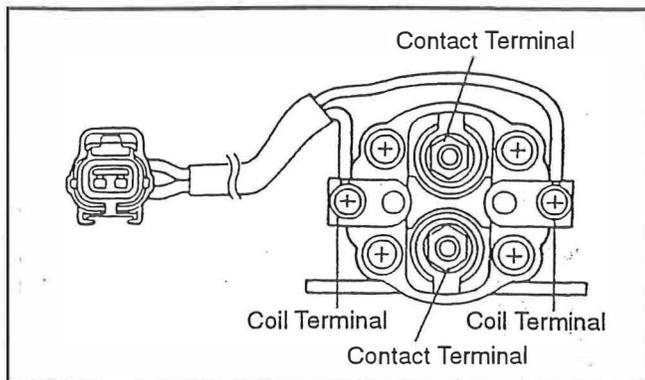


5. Remove the bypass resistor and reconnect the water temperature sensor connector. (If bypass resistor had been installed for testing purposes).

#### AIR HEATER RELAY BENCH TEST

**NOTE:** Disconnect all wires from the relay before performing the following test.

1. Disconnect the battery's (-) terminal.
2. Remove the air heater relay.
3. Check the coil continuity. Verify continuity between the relay coil terminals (wire color: white/blue and black).



4. Verify that there is a continuity between the relay contact terminals, when battery voltage is applied between to relay coil terminals. Verify that there is no continuity between the relay contact terminals, when battery voltage is removed from the relay coil terminals.

5. Replace the relay if it fails any of the above tests.

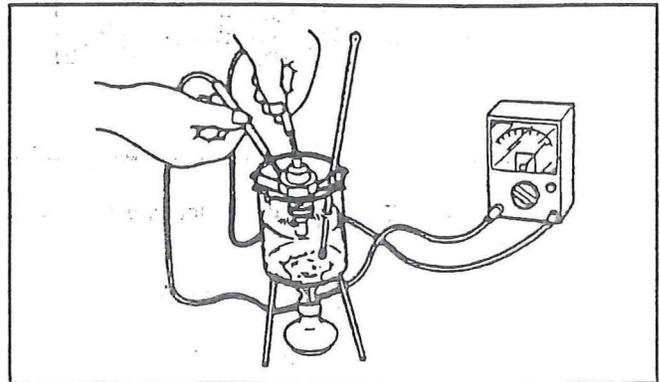
#### COOLANT TEMPERATURE SENSOR INSPECTION

1. Remove the water temperature sensor.



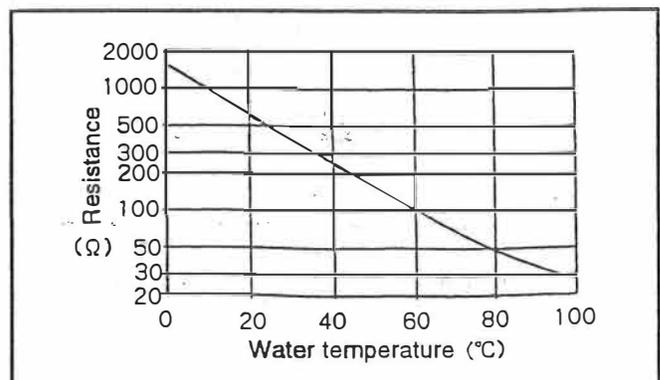
**CAUTION:** The engine coolant can be under pressure. Allow the engine to cool completely and relieve the cooling system pressure before removing the water temperature sensor

2. Test the water temperature sensor as shown in the illustration. Use ice to lower the water temperature. Gradually raise the water temperature by heating the water, and measure the resistance.



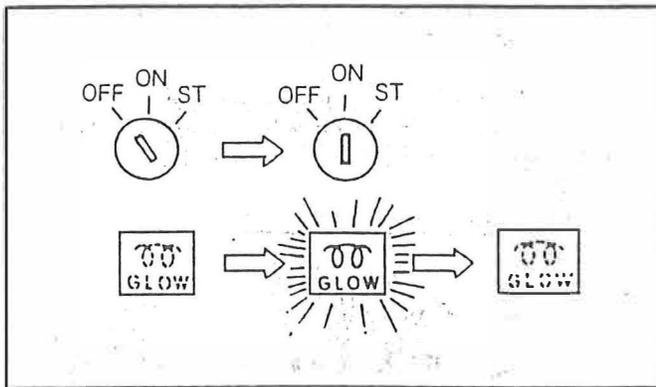
Standard value:

Water temperature	Resistance ( $\Omega$ )
0 °C / (32 °F)	1,860
40 °C / (104 °F)	207-255
80 °C / (176 °F)	46.8-55.2
100 °C / (212 °F)	25.2-30.8



## COLD START INDICATOR LAMP INSPECTION

1. Verify that the cold start indicator lamp on the instrument panel lights for several seconds when the engine switch is turned "ON".

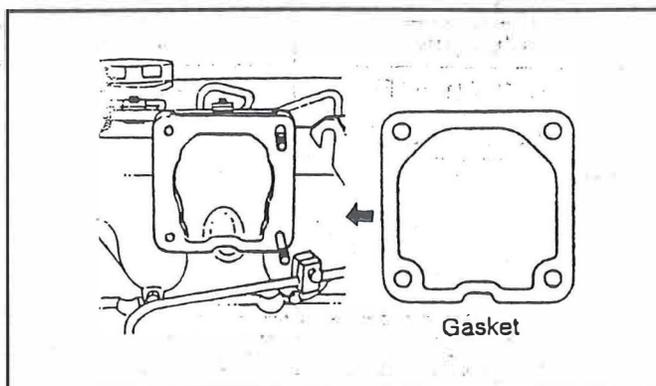


See "TIMER OPERATION GRAPH" for specific operation temperatures and times.

## HEATER ELEMENT AND INTAKE ELBOW INSTALLATION

1. Assemble the air heater using two (2) new gaskets (inner and outer).

**NOTE:** Always use new gaskets when installing the air heater. Be sure to install the gaskets properly as shown in the illustration.



Tightening torque: 1.9-2.6 kgm / (165-225 lbf in)