

## Section 5

# The Charging System

### Charging System

The charging system has two essential functions:

- Generate electrical power to run the vehicle's electrical systems
- Generate current to recharge the vehicle's battery

**Electrical power** - At low engine speeds, the battery may supply some of the power the vehicle needs. At high engine speeds, the charging system handles all of the vehicle's electrical requirements.

**Charging** - Alternator (generator) output is higher than battery voltage to recharge the battery.

### Charging System

The alternator supplies power for the vehicle when the engine is running and engine speed is above idle.

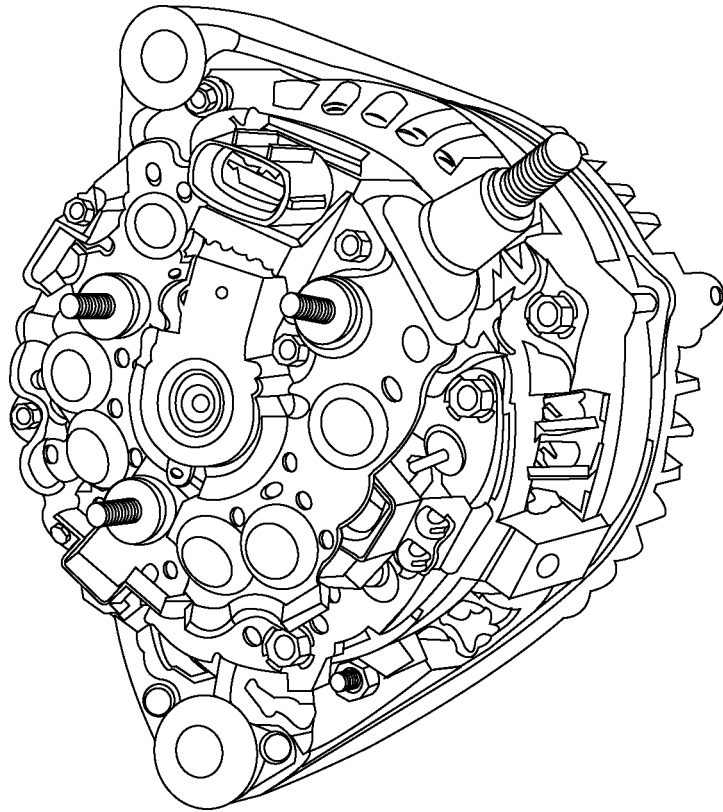


Fig. 5-01  
TL623f501

### Charging System Components

These components make up the charging system:

- Alternator
- Voltage regulator
- Battery
- Charging indicator

#### Charging System Components

This figure shows the major components of the charging system.

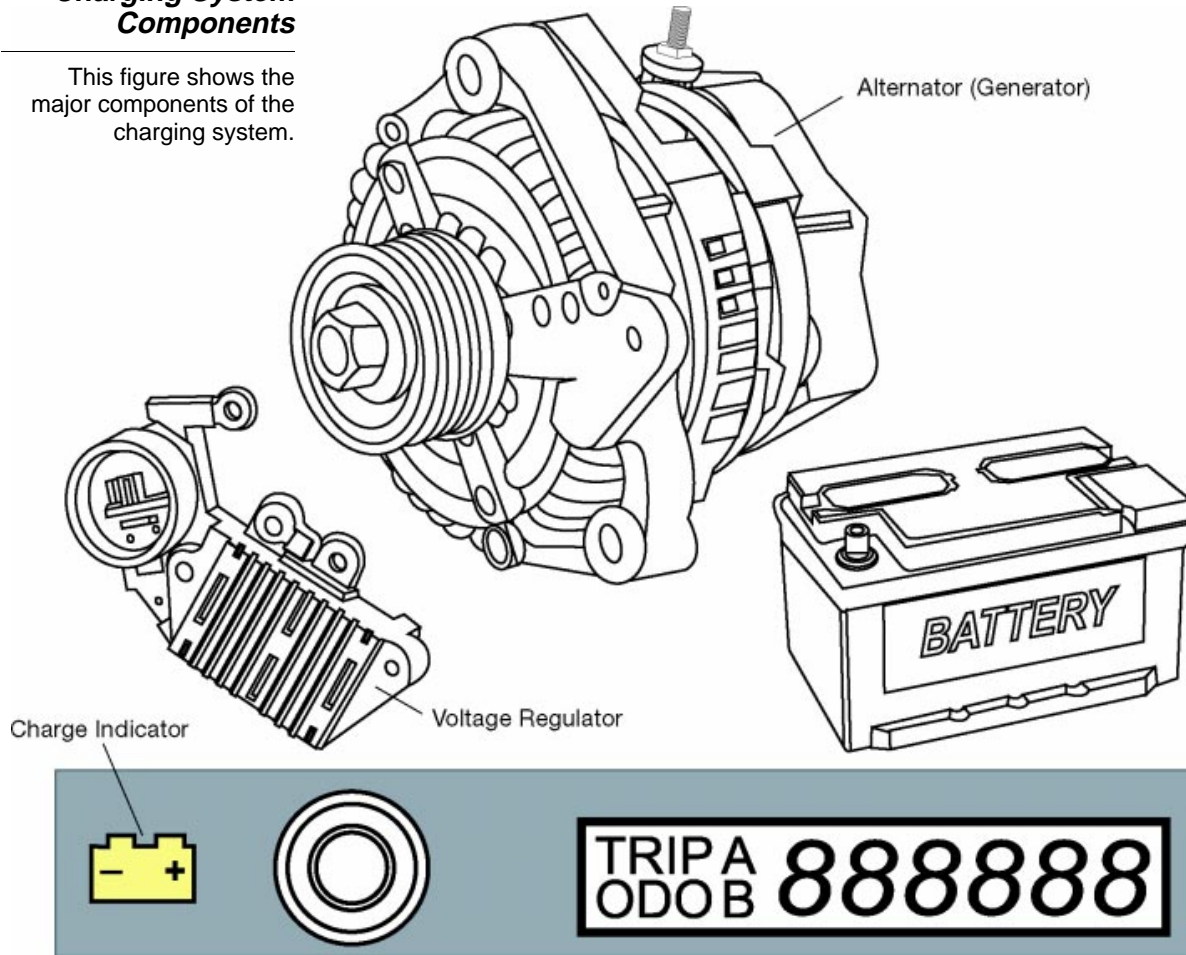


Fig. 5-02  
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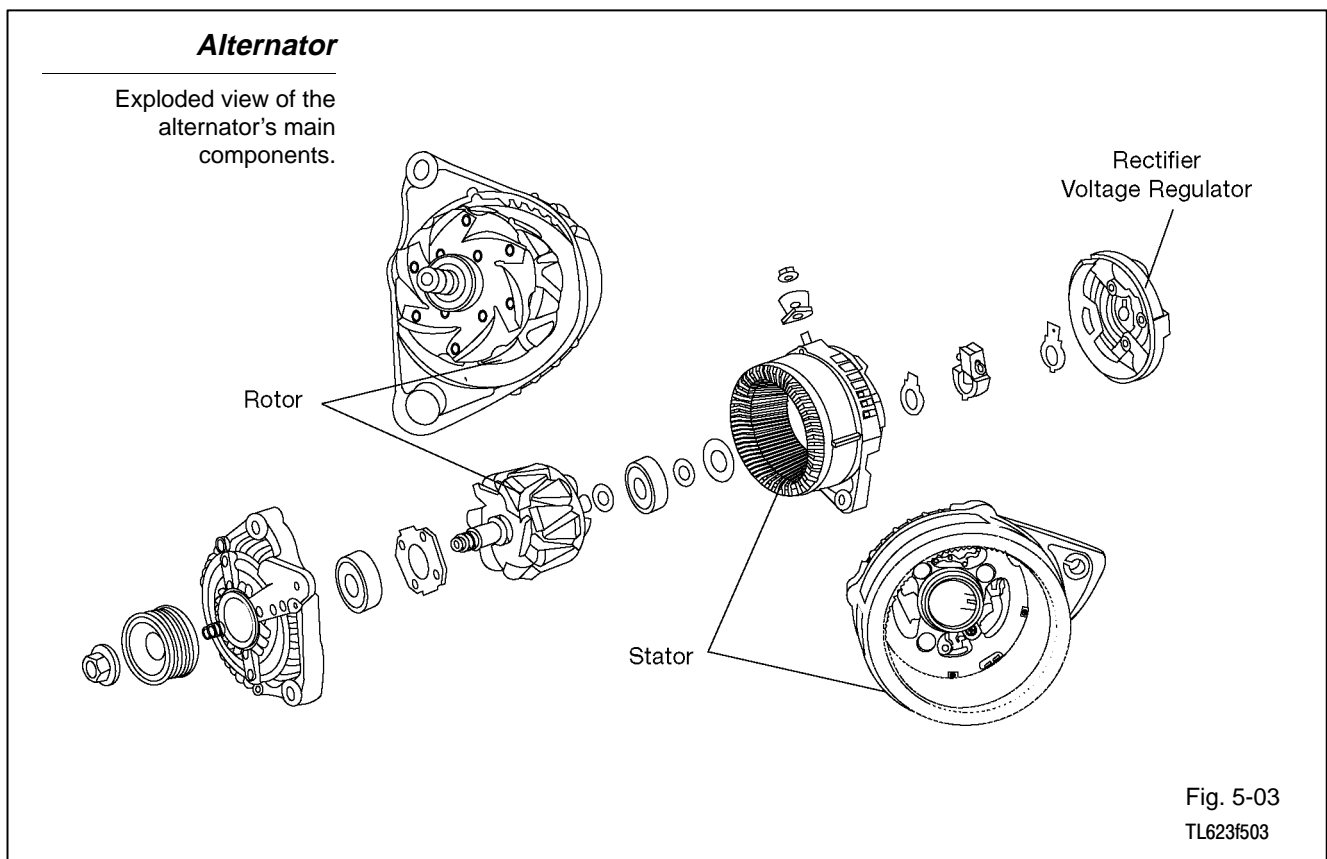
**Alternator** The alternator contains these main components:

- Stator (attached to alternator housing, remains stationary)
- Rotor (spins inside the stator)
- Rectifier
- Voltage regulator

Slip rings and brushes make an electrical connection to the spinning rotor.

The alternator generates electricity through these steps:

- Engine power drives the alternator rotor through a pulley and drive belt.
- The alternator rotor spins inside the windings of the stator.
- The stator windings generate an alternating current.
- Rectifier diodes change the alternating current (AC) into direct current (DC).



**Voltage Regulator** The voltage regulator controls the alternator's output current to prevent over-charging and under-charging of the battery. It does this by regulating the current flowing from the battery to the rotor's field coil.

Today's IC voltage regulator is a fully electronic device, using resistors and diodes.

***Voltage Regulator***

The voltage regulator controls the alternator's output current.

Voltage Regulator

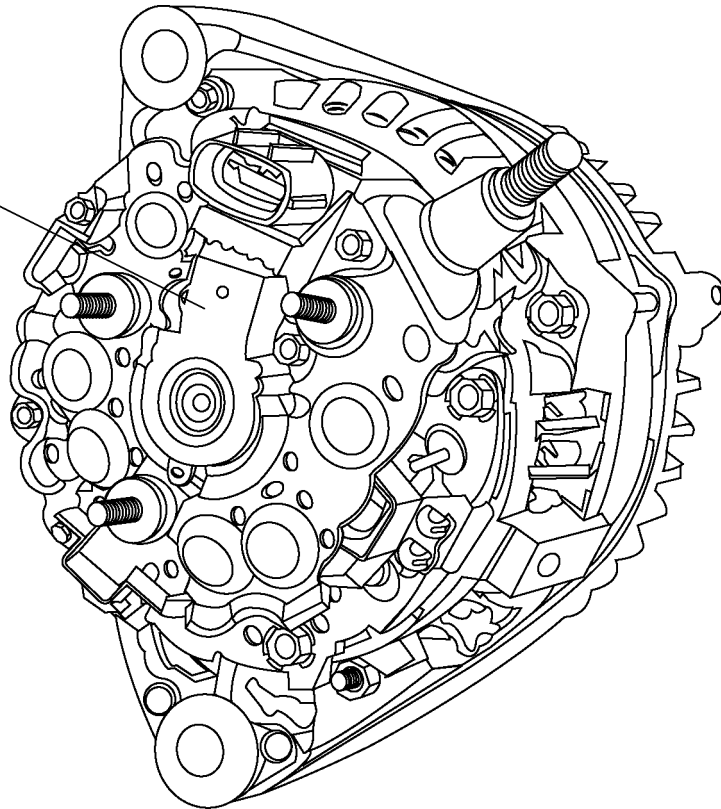


Fig. 5-04  
TL623f504

**Battery** The battery supplies current to energize the alternator field coil. The battery also acts as a voltage stabilizer. The battery must always remain attached to the electrical system while the engine is running.

***Battery***

The battery supplies current to energize the alternator's field coil.

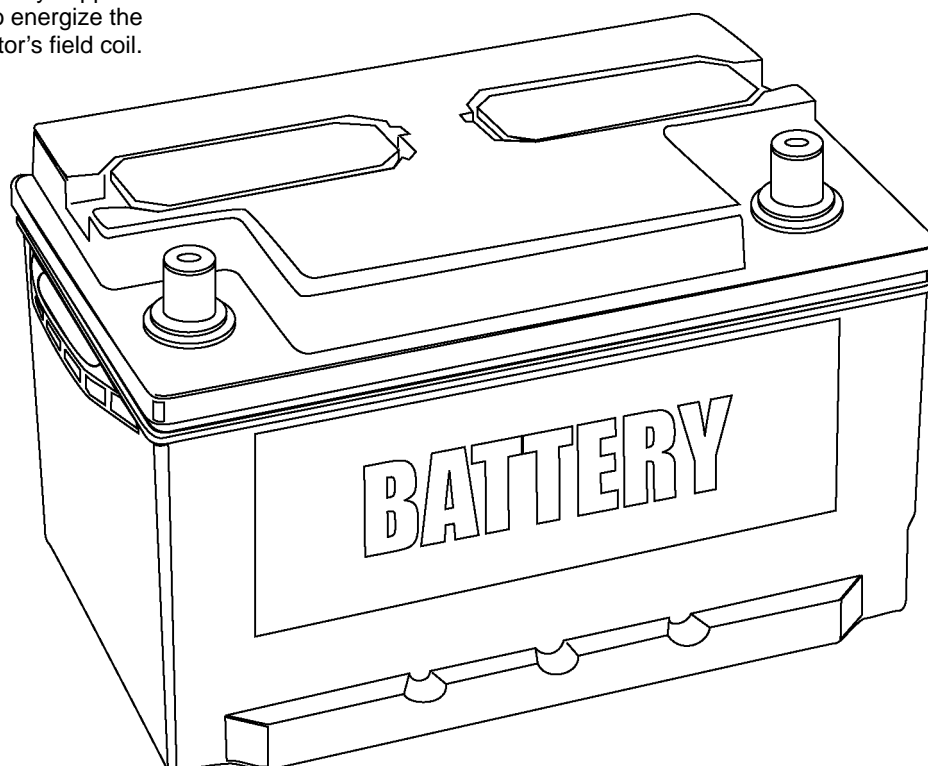


Fig. 5-05  
TL623f505

**Charging Indicator** The charging indicator is usually an ON/OFF warning lamp. When the system is running, the light should be OFF. The lamp lights when the charging system is not providing sufficient charge.

### Charging Indicator

The charging indicator lights when the charging system is not supplying enough power to charge the battery.

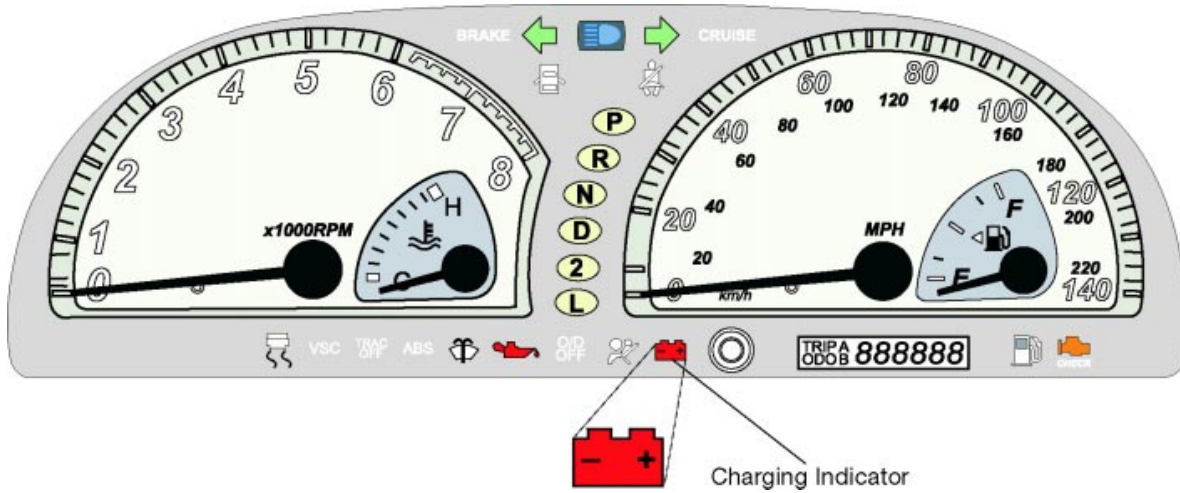


Fig. 5-06  
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**Charging System Operation**

Current in the charging system changes for these three different operating conditions:

- Ignition switch to ON - engine stopped
- Ignition switch to ON - engine running alternator output below desired voltage
- Ignition switch to ON - engine running alternator output above desired voltage

**Ignition switch to ON - engine stopped:**

- As soon as the ignition switch is turned to ON, the IC regulator causes a current of about 0.2 amps through the rotor's field coil.
- The IC regulator turns on the charging indicator.
- There is no output from the stator because the rotor is not turning.

**Ignition Switch to ON - Engine Stopped**

The IC regulator causes a small current through the alternator rotor field coil.

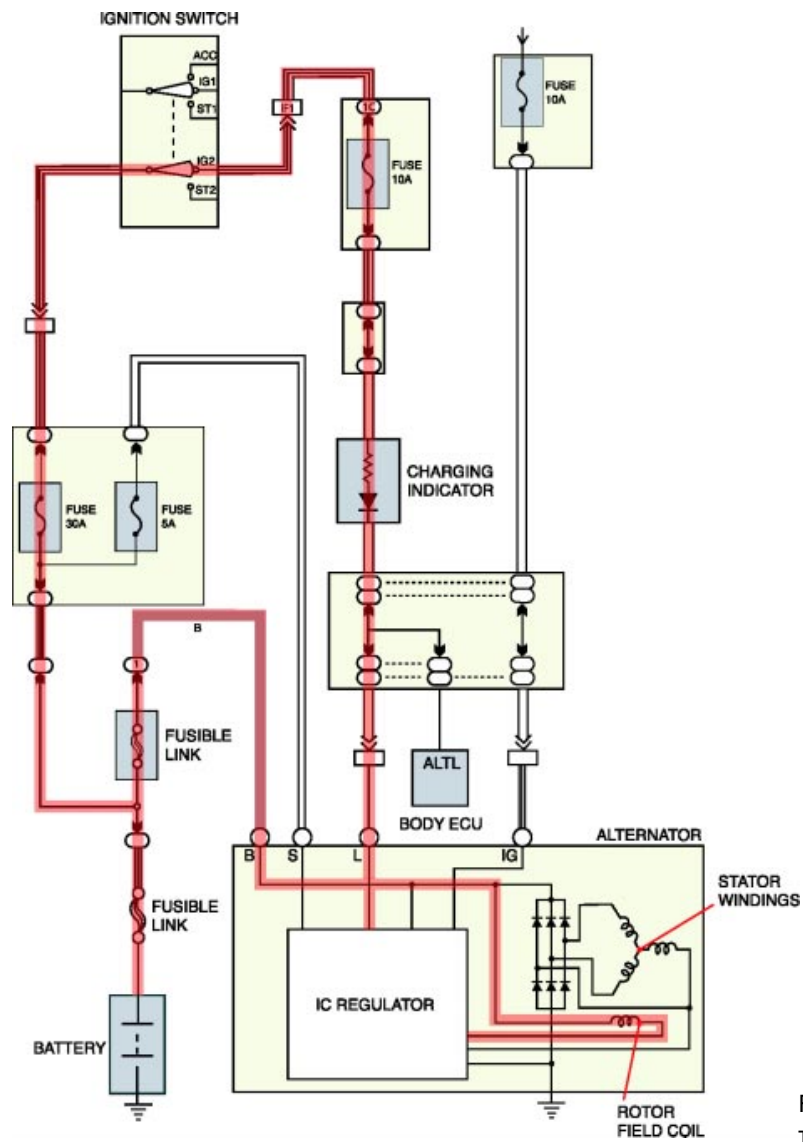


Fig. 5-07  
TL623f507c

**Ignition switch to ON - engine running, alternator output below desired voltage:**

- The windings in the stator generate a voltage any time the rotor is energized and spinning.
- Voltage generated in the stator is applied to the voltage regulator.
- If the alternator output voltage is below 14.5 volts, the voltage regulator responds by increasing current through the field coil of the rotor. This causes the voltage to increase.
- A charging current is sent to the battery.

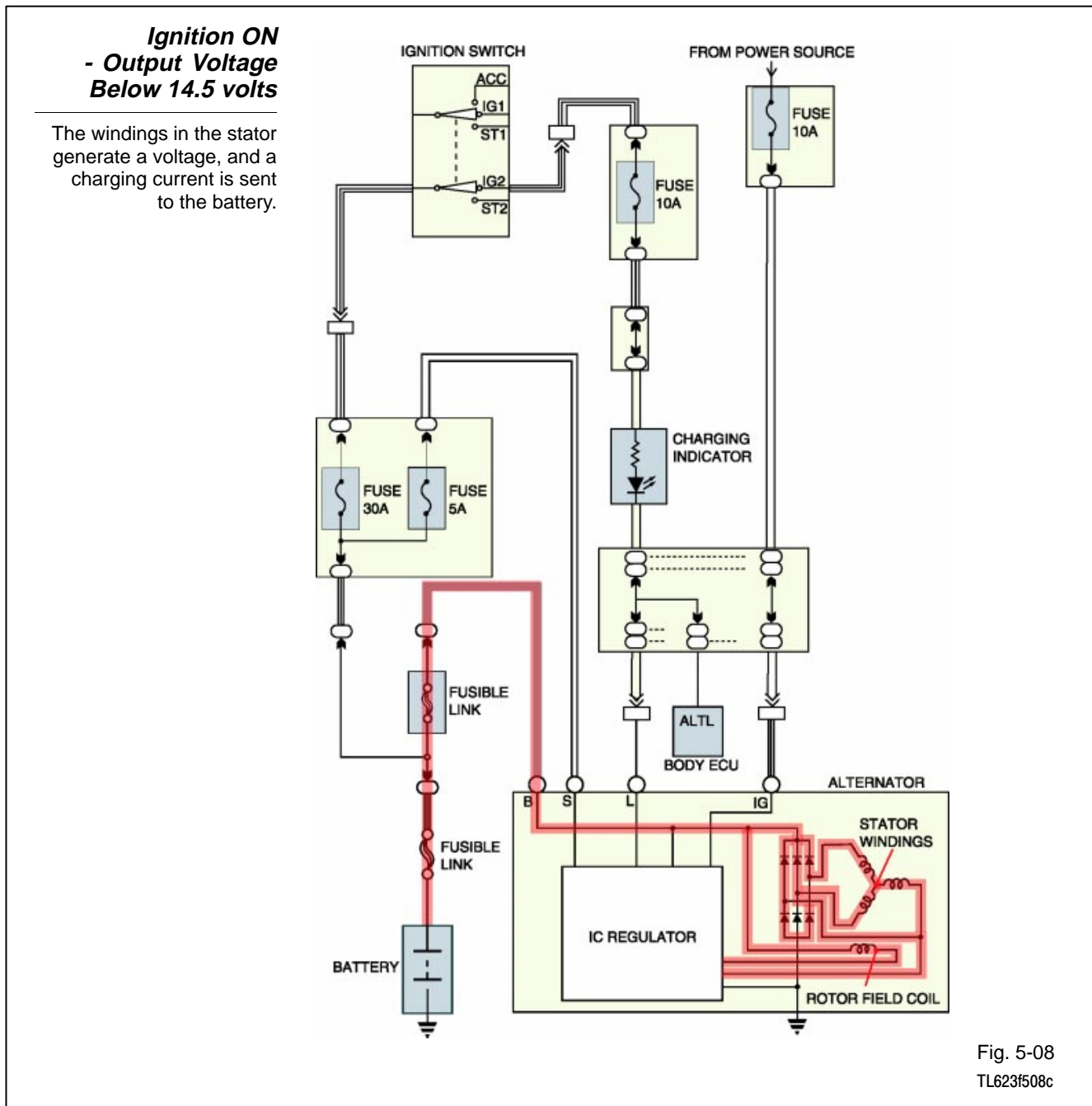


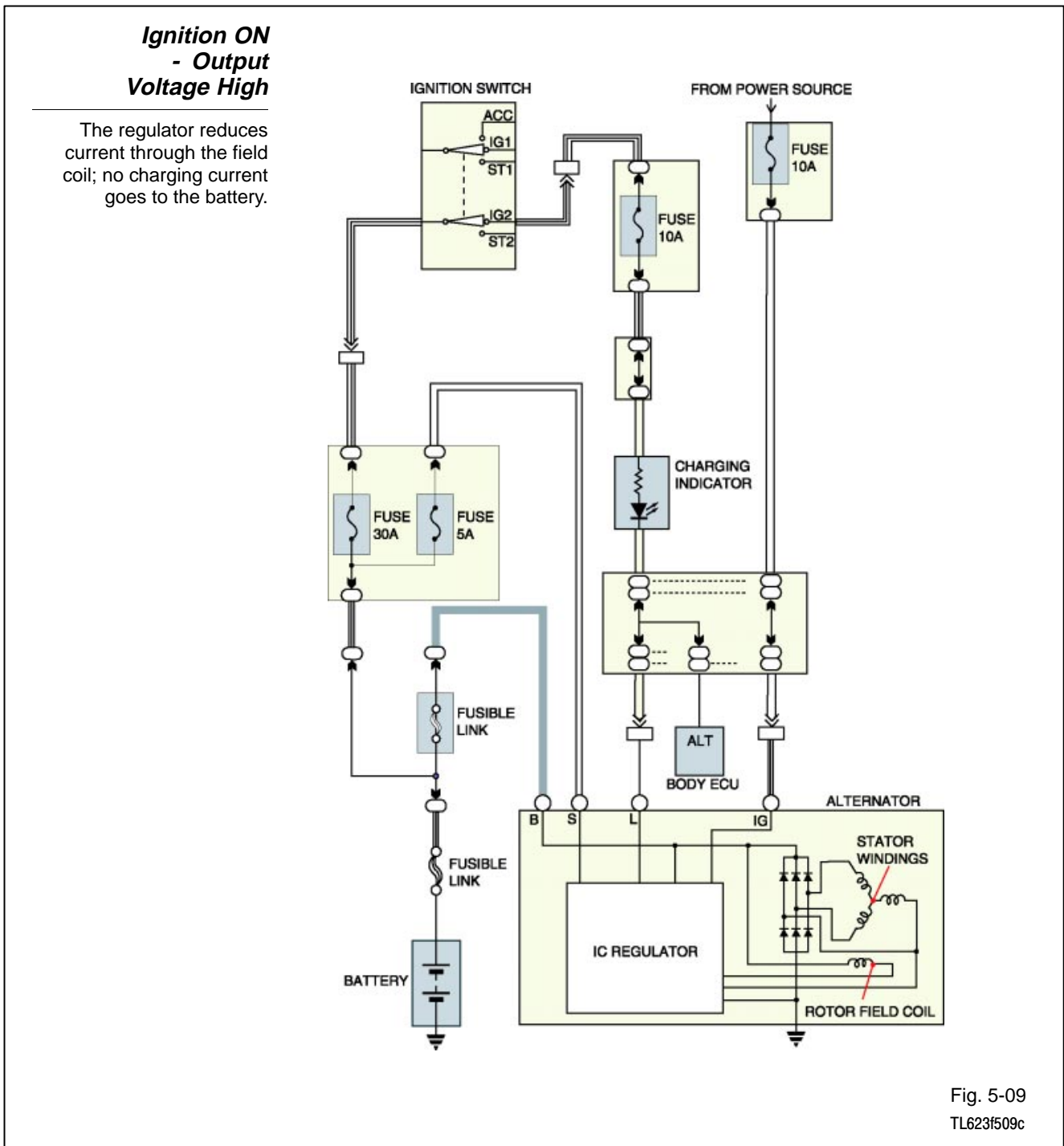
Fig. 5-08  
TL623f508c



**Ignition switch to ON - engine running alternator output above desired voltage:**

When the voltage regulator senses alternator output at or above 14.5 volts:

- It reduces current through the rotor field coil.
- This reduces alternator output voltage.
- No charging current goes to the battery.



Safeguards are built into the alternator in case the connection to Terminal B or Terminal S is lost:

- Terminal S is an input to the regulator to monitor voltage levels.
- Terminal B is alternator output.

**Terminal S disconnected:**

- The voltage regulator does not detect voltage.
- The voltage regulator regulates voltage at Terminal B to 16 volts and lights the Charging Indicator.

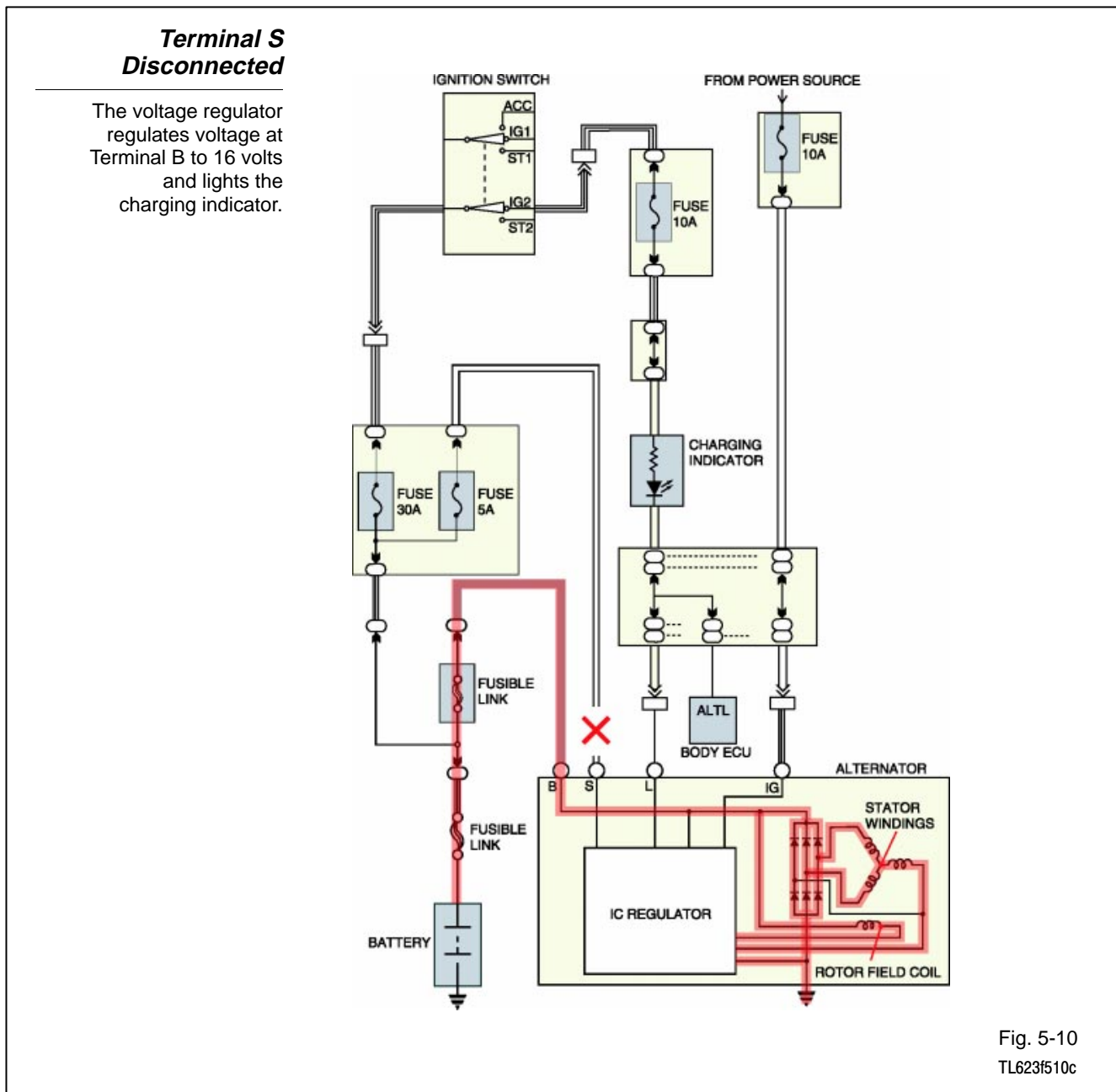


Fig. 5-10  
TL623f510c

**Terminal B disconnected:**

- No charging voltage available for battery.
- This condition could result in voltage regulator damage.

**Terminal B  
Disconnected**

An open circuit in the B terminal results in no charging output for the battery and could damage the voltage regulator.

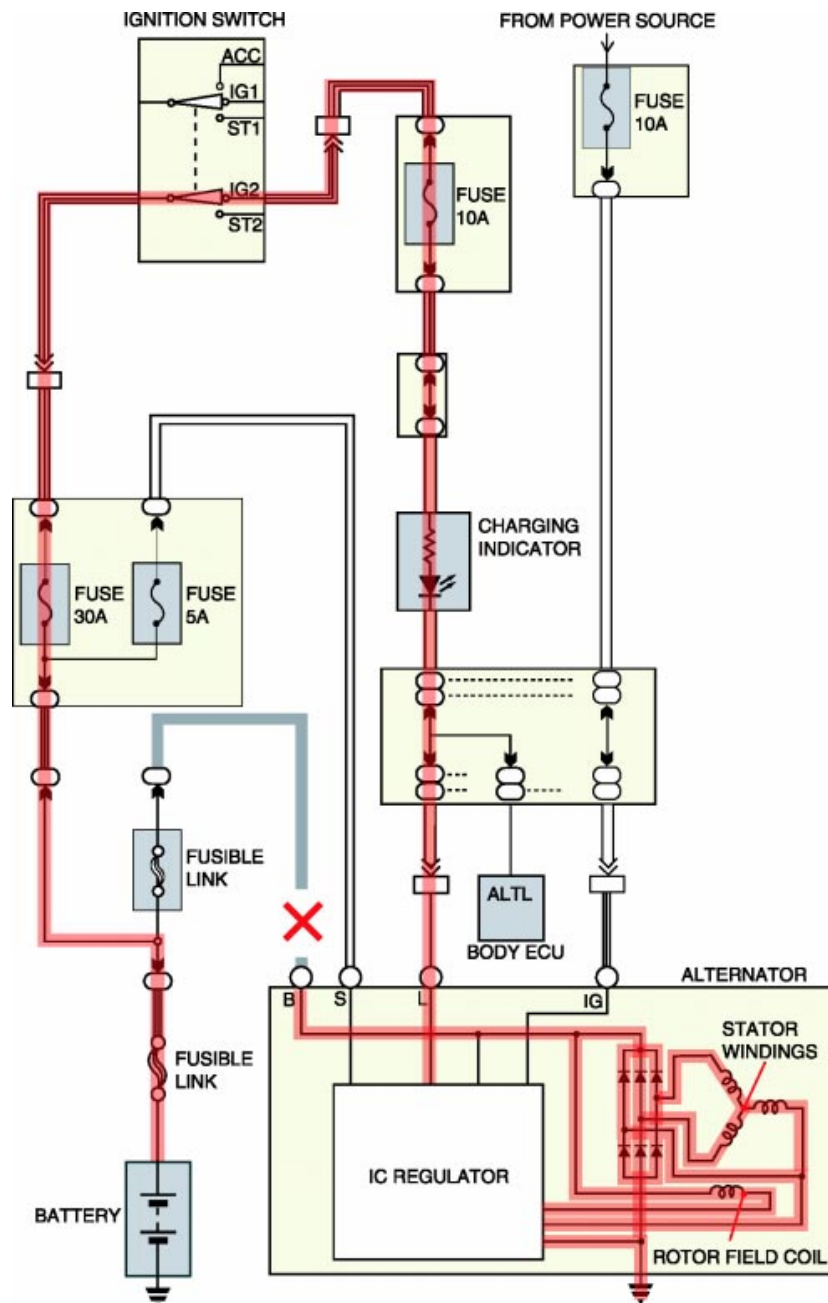


Fig. 5-11  
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**Diagnosis and Testing** The charging system requires little maintenance. The battery should be fully charged and connections kept clean and tight.

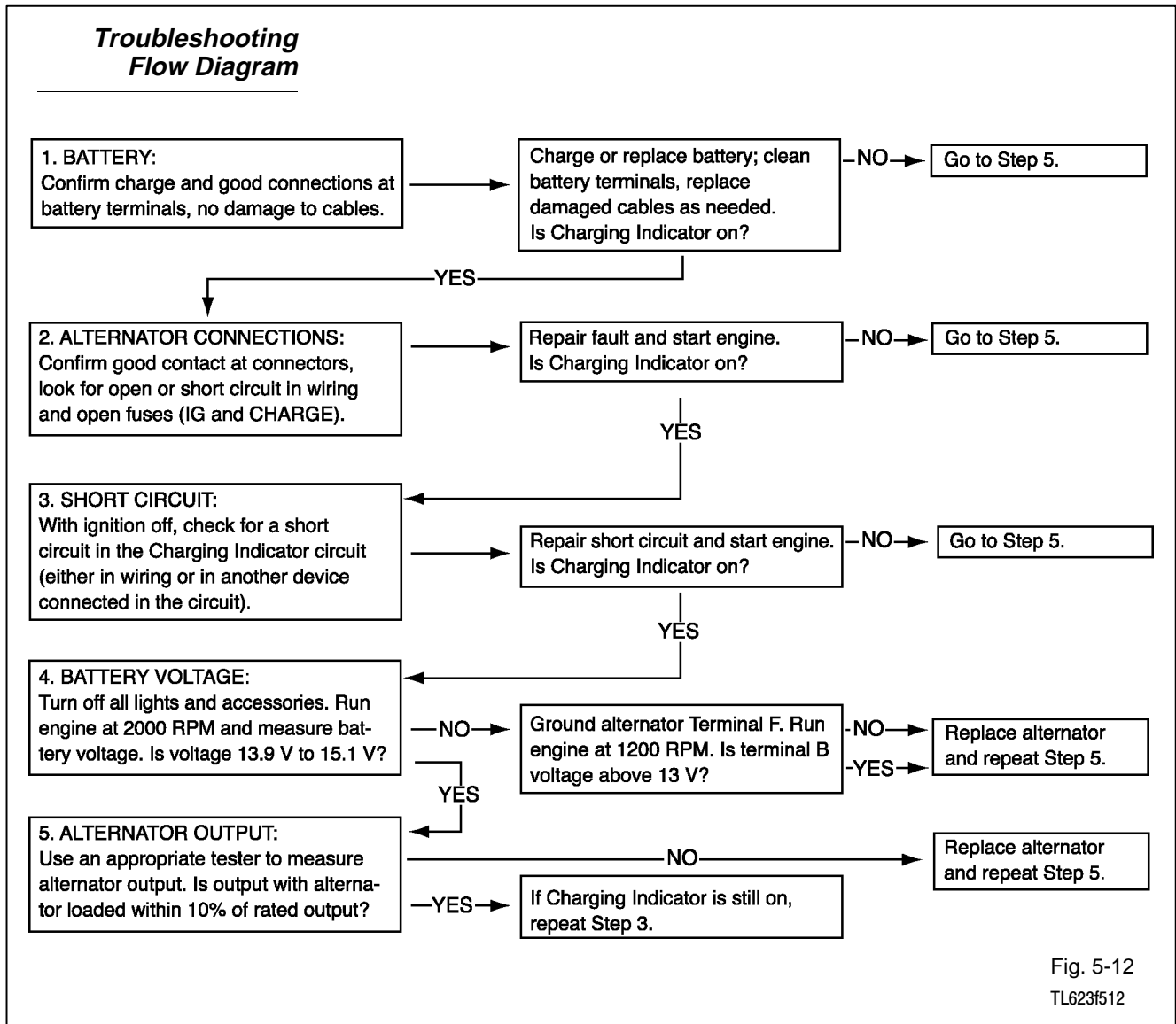
Diagnosis of charging system problems is typically straightforward. Problems may be electrical or mechanical.

The troubleshooting flow diagram on the next page lists the most common charging system problems, the possible cause, and recommended actions to resolve the problem.

Begin with a thorough visual inspection. If this fails to turn up the possible cause, several tests are available to help you find the problem:

- Alternator output test (no load)
- Alternator output test (with load)
- Voltage drop tests
- Charging current relay test
- Diode tests

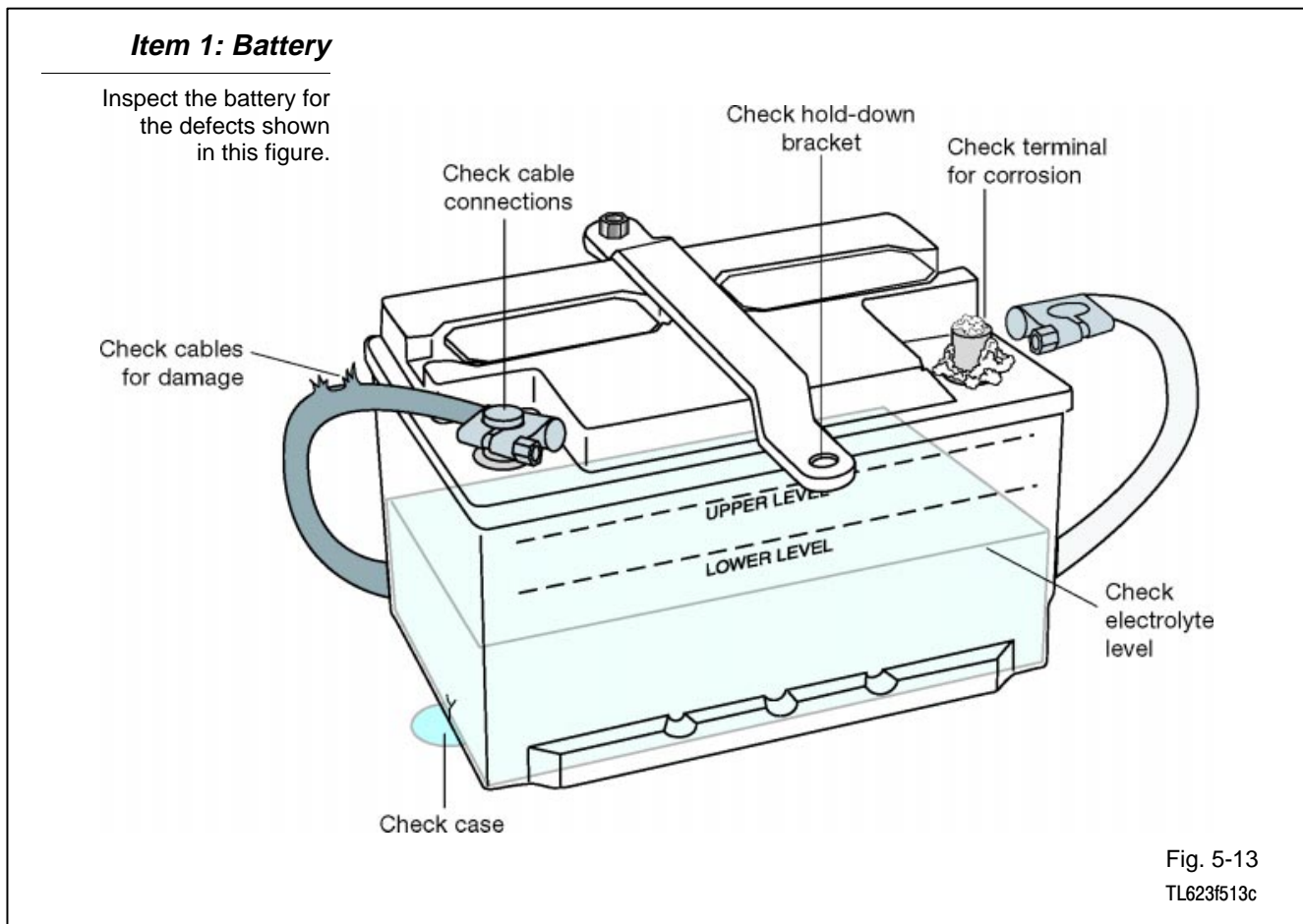
**Troubleshooting Flow Diagram** Use this flow diagram to troubleshoot charging systems with compact, high speed alternators.



**Charging System  
Visual Inspection**

Include the following items in a visual inspection of the charging system:

1. Battery
2. Fusing
3. Alternator Drive Belt
4. Alternator Wiring
5. Noise
6. Charging Indicator



## Other Battery Checks

**State of Charge** - Check the specific gravity of the electrolyte to determine the battery's state of charge.

- Specific gravity should be between 1.25 and 1.27 (at 80°F/26.7°C).

**Condition** - Check overall battery condition with a battery analyzer.

### **Other Battery Checks**

A hydrometer can tell you the battery's state of charge.

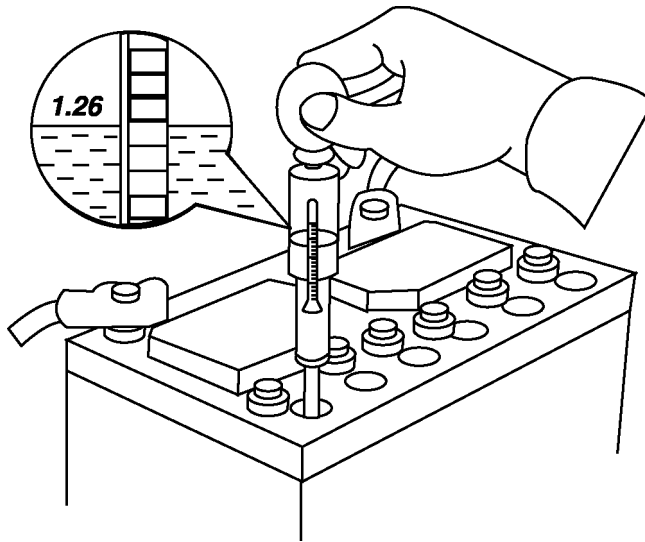


Fig. 5-14  
TL623f514

**Item 2: Fusing**

- Refer to the EWD to identify fuses and fusible links in the charging system for the vehicle under test.
- Check these components for continuity.

***Item 2: Fusing***

Fusible links must be part of the visual inspection of the charging system.

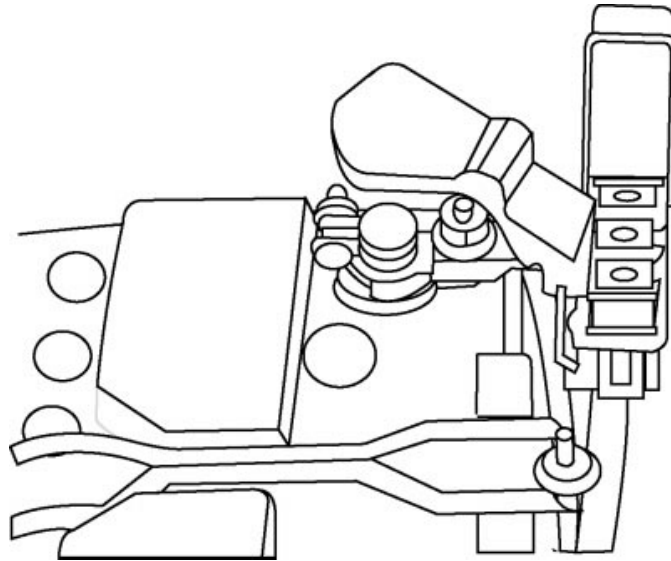


Fig. 5-15  
TL623F515



**Item 3: Alternator Drive Belt**

- Good condition
- Correct alignment
- Proper tension

***Item 3: Alternator Drive Belt***

Alternator drive belts must be in good condition and be properly aligned and tensioned.

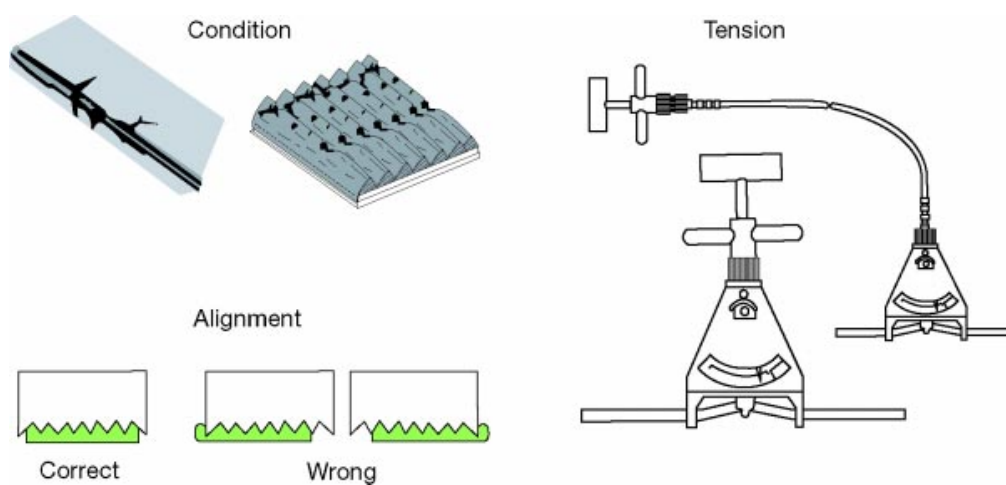


Fig. 5-16  
TL623f516c

### Item 4: Alternator Wiring

- Make sure all connections are clean and tight.
- Check wiring for frayed insulation and other physical damage.

#### **Item 4: Alternator Wiring**

Inspect wires and connections at the alternator.

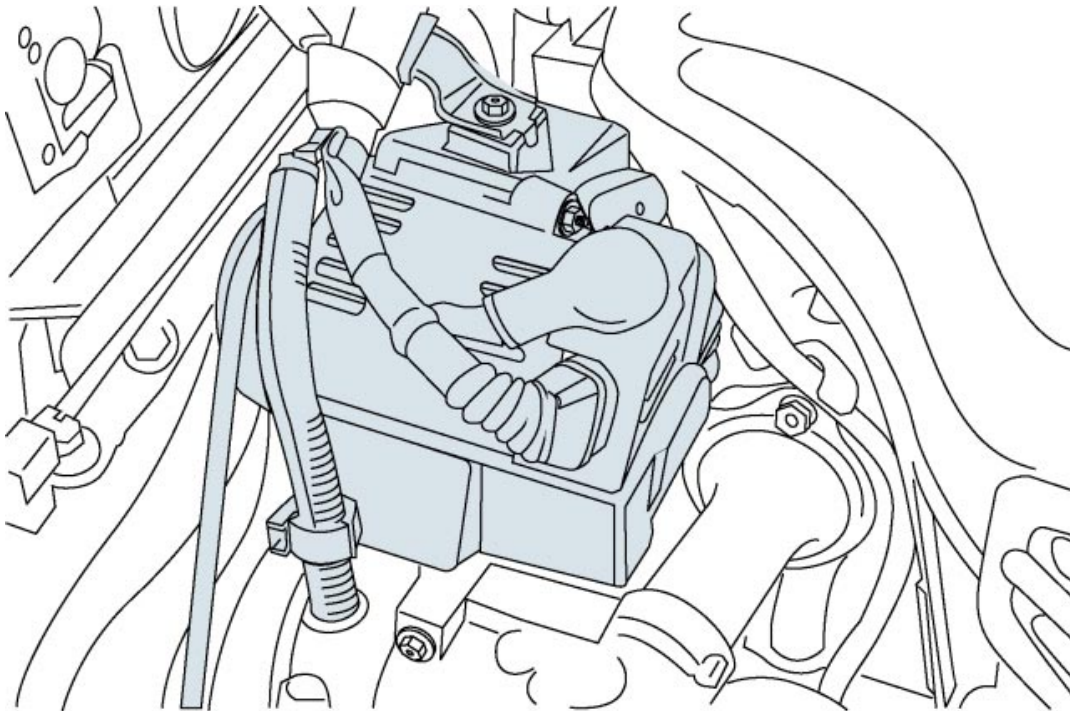


Fig. 5-17  
TL623F517

**Item 5: Alternator Noise**

Listen for any unusual noise while the alternator is operating:

- Squealing may indicate a bearing problem or a worn or improperly tensioned and adjusted drive belt.
- Hissing may be a sign that one or more of the diodes are defective, because of a pulsating magnetic field and vibration.

**Item 5:  
Alternator Noise**

Alternator noise may be important in diagnosing potential problems.

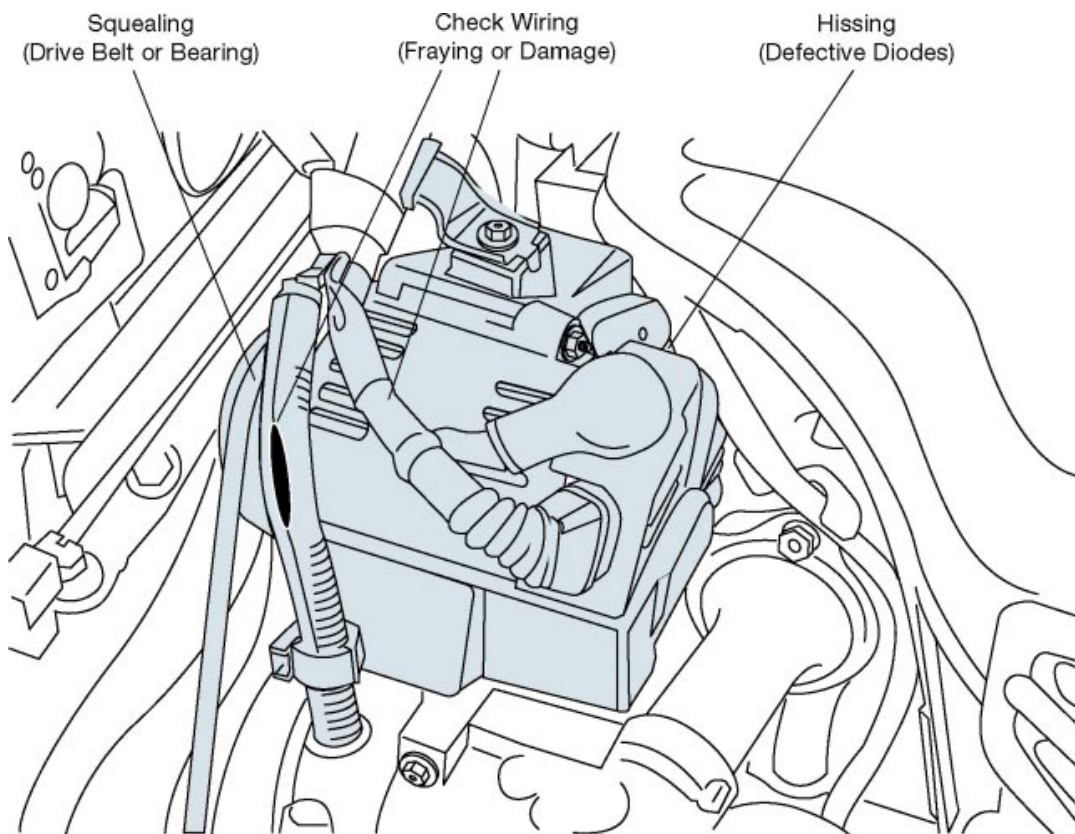


Fig. 5-18  
TL623f518

**Item 6: Charging Indicator**

- Indicator lights with ignition ON and engine not running.
- Indicator goes off with engine running.

If the indicator does not operate as described above, refer to the appropriate EWD and check the indicator circuit.

**Item 6:  
Charging  
Indicator**

The Charging indicator should be on with the ignition on and the engine not running and off with the engine running.

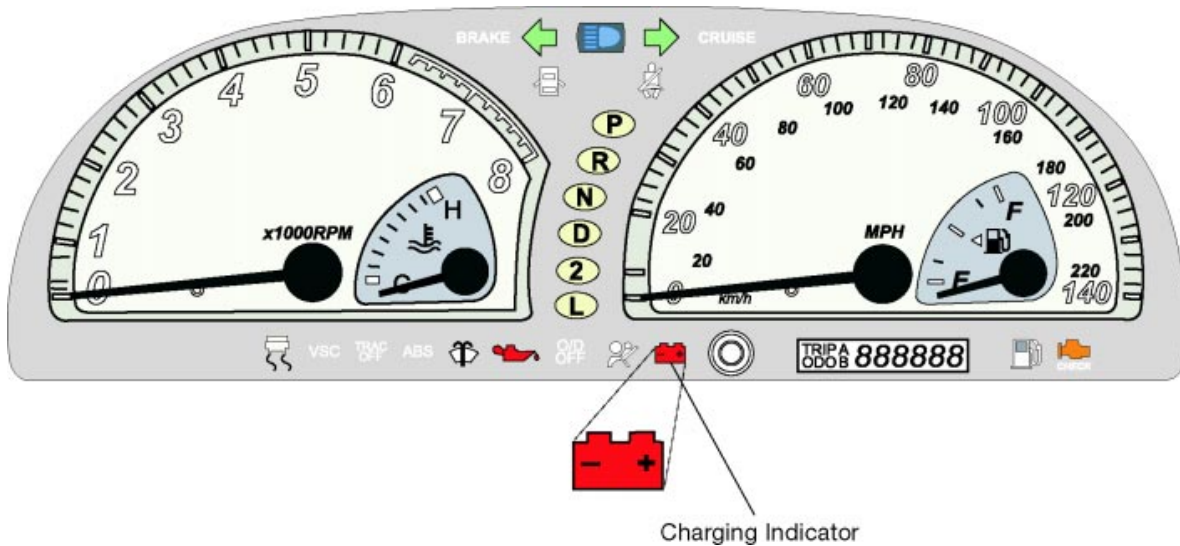


Fig. 5-19  
TL623f519c

**Alternator Output Test (No Load)** Use the following steps to perform the test with a Sun VAT-40 or VAT-60 tester:

1. Set the tester's Load control to OFF.
2. Connect the tester leads.
  - Red lead to positive terminal.
  - Black lead to negative terminal.
  - Clamp the ammeter clamp-on probe onto the battery's ground cable.
3. Set the tester's voltage range to the appropriate setting.
4. Zero both meters on the tester, if needed.
5. Turn the ignition switch to ON (do not start the engine).

**Alternator Output Test (No Load)**

A VAT-40 Battery Tester is connected for the no load output test.

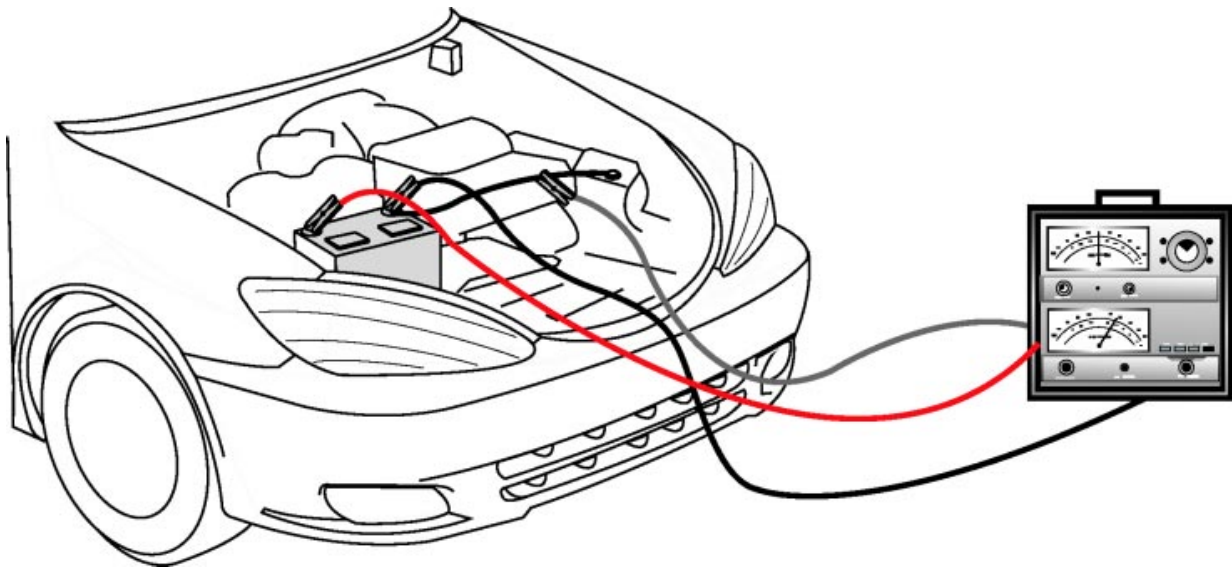


Fig. 5-20  
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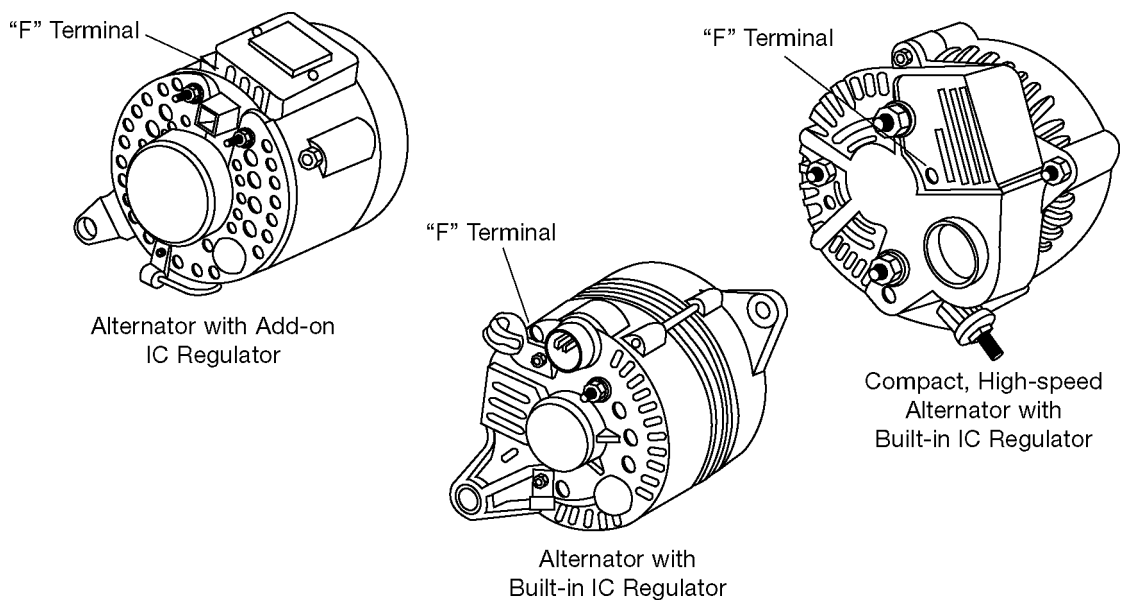
6. Record the ammeter reading.
  - This is the discharge current (typically about 6 amps).
  - Alternator must supply this amount of current before it can provide charging current to the battery.
7. Start the engine and adjust engine speed to about 2,000 RPM.
8. Allow engine to warm up for 3 to 4 minutes.
9. Record the ammeter reading.
  - Add the discharge current (from Step 4) to the reading now on the ammeter. The total should be less than 10 amps.
  - The battery may not have been fully charged if the total current is more than 10 amps. Monitor the ammeter; the reading should decrease as the battery charges.
10. Record the voltmeter reading.
  - The voltmeter reading should be within specification for the alternator during the entire test. This value is typically between 13 and 15 volts; refer to the appropriate service manual for the correct specification.
  - If the voltmeter reading is higher than specified, the voltage regulator is probably defective. Replace the regulator if possible or replace the alternator.
  - If the voltmeter reading is lower than specified, the cause could be a bad regulator or a fault in the alternator windings. Replace the alternator if it has an internal voltage regulator.
  - For alternators with externally mounted regulators, confirm the cause by grounding Terminal F on the alternator. This bypasses the regulator. If voltage increases, the voltage regulator is probably defective. If the voltage remains low, replace the alternator; there is a problem with the windings.
11. Remove ground from alternator Terminal F.

**Alternator Output Test (With Load)** Use the following steps to perform the test with a Sun VAT-40 or VAT-60 tester:

1. Keep the tester connections as for the alternator output test with no load.
2. Adjust engine speed to specified RPM (refer to the appropriate service manual).
3. Adjust the tester's load control to obtain the highest ammeter reading possible while keeping the voltage reading at or above 12 volts.
4. Record the highest ammeter reading.
  - The reading should be within 10% of the alternator's rated output.
  - Replace the alternator if the reading is more than 10% below the value specified.

### **Alternator Output Test (With Load)**

This figure shows the location of the "F" terminal for various alternator types.



Note: Current model alternators do not have an "F" Terminal.

Fig. 5-21  
TL623f521

**Voltage Drop Test** Voltage drop tests can isolate unwanted high resistance in the charging system. High resistance can cause these symptoms:

- Charging system cannot fully charge battery.
- Abnormally high current is drawn from battery under high load conditions.

**Use a DMM to perform a voltage drop test on the positive side of the battery as follows:**

1. Connect the red meter lead to Terminal B on the alternator.
2. Connect the black meter lead to the positive battery terminal.
3. Start the engine; adjust engine speed to 2,000 RPM.
4. Note the voltage reading.
  - The voltage drop should be less than 0.2 volts.
  - If the reading is higher, look for poor connections at the alternator and at the battery. Also, look for damaged wires or corroded wires.

**Test for voltage drop on the ground side of the battery as follows:**

5. Keep the engine running at 2,000 RPM.
6. Connect the red meter lead to the negative (ground) battery terminal.
7. Connect the black meter lead to the alternator frame.
8. Note the voltage reading.
  - The voltage drop should be less than 0.2 volts.
  - If the reading is higher, look for poor connections between the battery and ground and from the alternator frame to ground. Also, look for a damaged or corroded battery ground cable.



### Voltage Drop Test

Voltage drop tests can isolate high resistance in the charging system. Test voltage drop on the positive and the ground side of the battery.

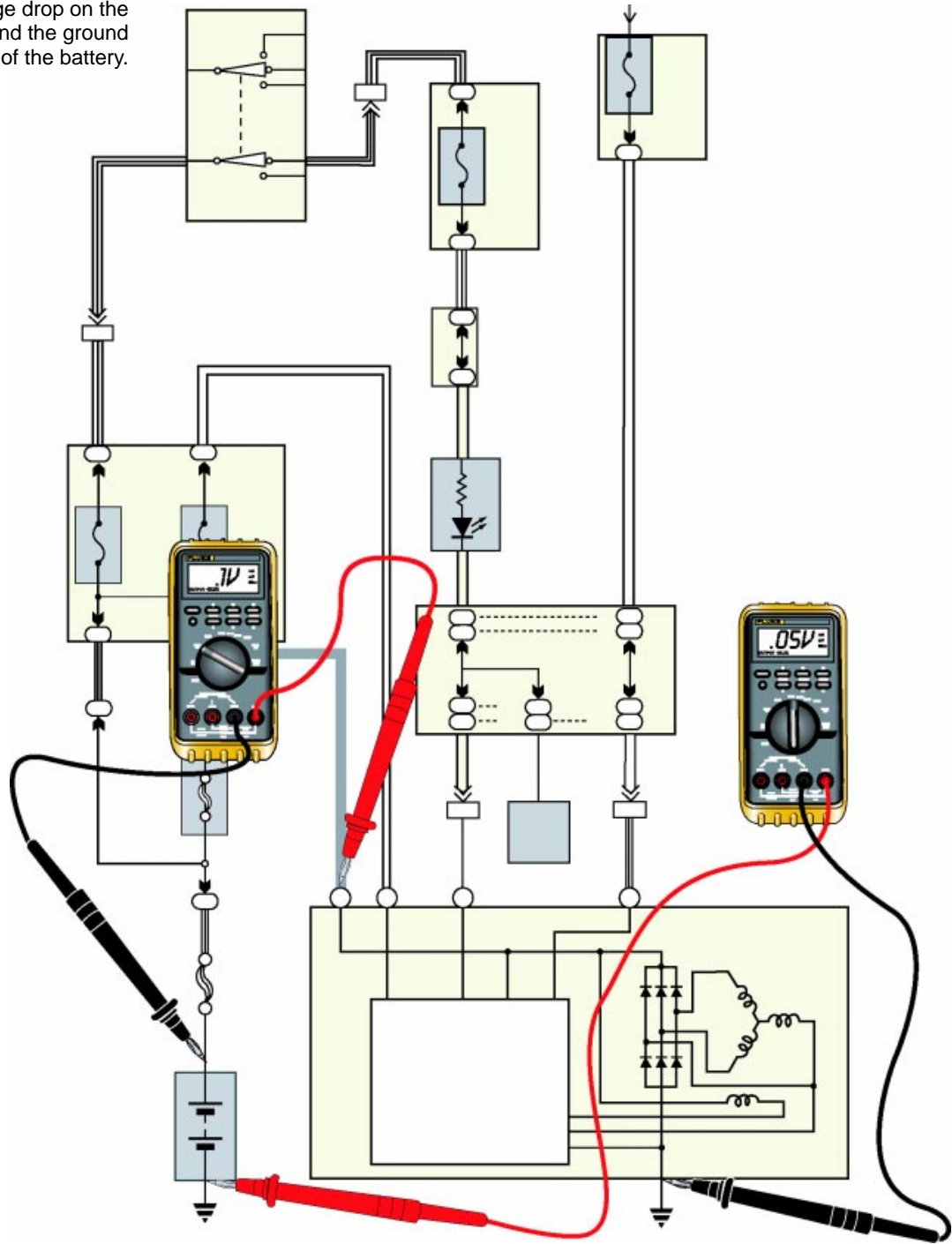


Fig. 5-22  
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**Notes**