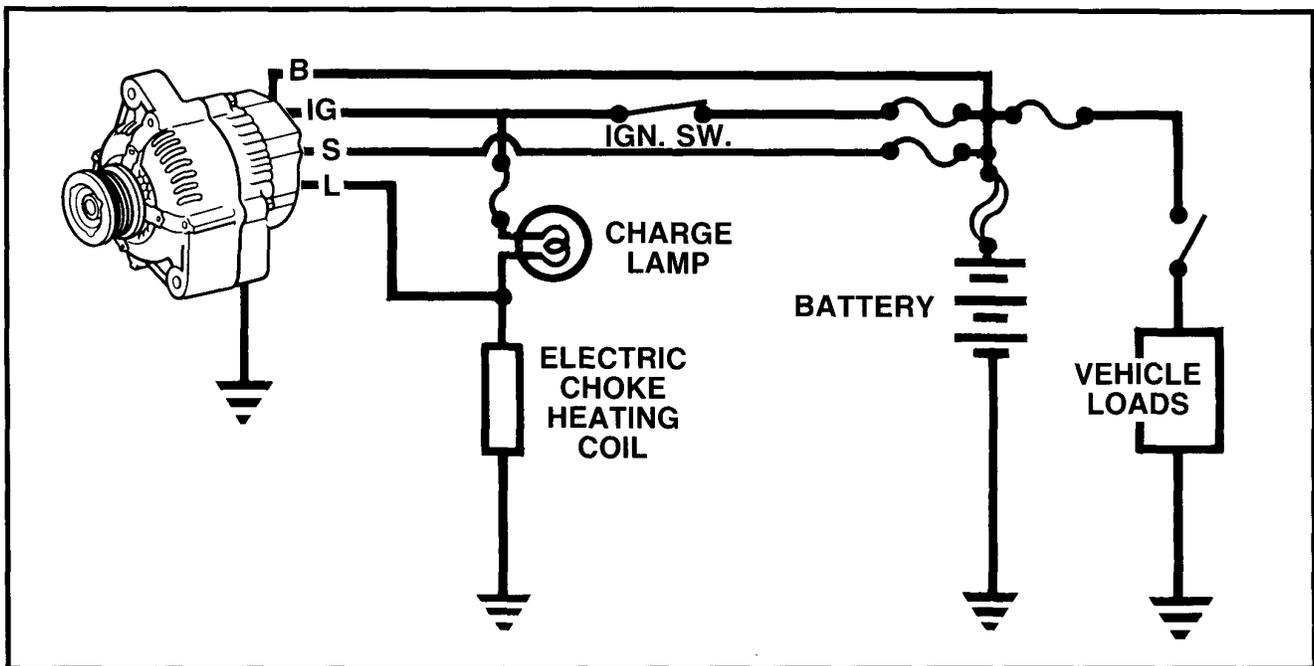


General

The charging system converts mechanical energy into electrical energy when the engine is running. This energy is needed to operate the loads in the vehicle's electrical system. When the charging system's output is greater than that needed by the vehicle, it sends current into the battery to maintain the battery's state of charge. Proper diagnosis of charging system problems requires a thorough understanding of the system components and their operation.

Operation

When the engine is running, battery power energizes the charging system and engine power drives it. The charging system then generates electricity for the vehicle's electrical systems. At low speeds with some electrical loads "on" (e.g., lights and window defogger), some battery current may still be needed. But, at high speeds, the charging system supplies all the current needed by the vehicle. Once those needs are taken care of, the charging system then sends current into the battery to restore its charge.



Toyota Charging Systems

Typical charging system components include:

IGNITION SWITCH

When the ignition switch is in the ON position, battery current energizes the alternator.

ALTERNATOR

Mechanical energy is transferred from the engine to the alternator by a grooved drive belt on a pulley arrangement. Through electromagnetic induction, the alternator changes this mechanical energy into electrical energy. The alternating current generated is converted into direct current by the rectifier, a set of diodes which allow current to pass in only one direction.

VOLTAGE REGULATOR

Without a regulator, the alternator will always operate at its highest output. This may damage certain components and overcharge the battery. The regulator controls the alternator output to prevent overcharging or undercharging. On older models, this is a separate electromechanical component which uses a coil and contact points to open and close the circuit to the alternator. On most models today, this is a built-in electronic device.

BATTERY

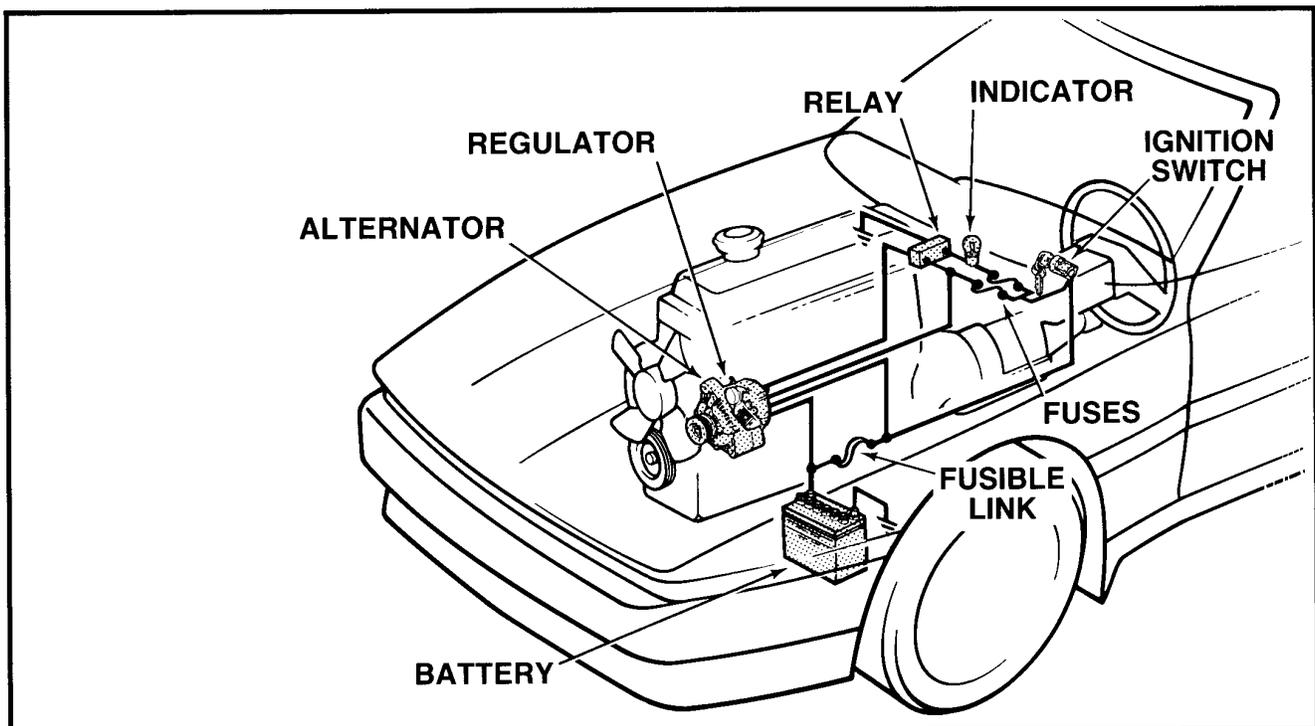
The battery supplies current to energize the alternator. During charging, the battery changes electrical energy from the alternator into chemical energy. The battery's active materials are restored. The battery also acts as a "shock absorber" or voltage stabilizer in the system to prevent damage to sensitive components in the vehicle's electrical system.

INDICATOR

The charging indicator device most commonly used on Toyotas is a simple ON/OFF warning lamp. It is normally off. It lights when the ignition is turned "on" for a check of the lamp circuit. And, it lights when the engine is running if the charging system is undercharging. A voltmeter is used on current Supra and Celica models to indicate system voltage ... it is connected in parallel with the battery. An ammeter in series with the battery was used on older Toyotas.

FUSING

A fusible link as well as separate fuses are used to protect circuits in the charging system.



Alternator Construction

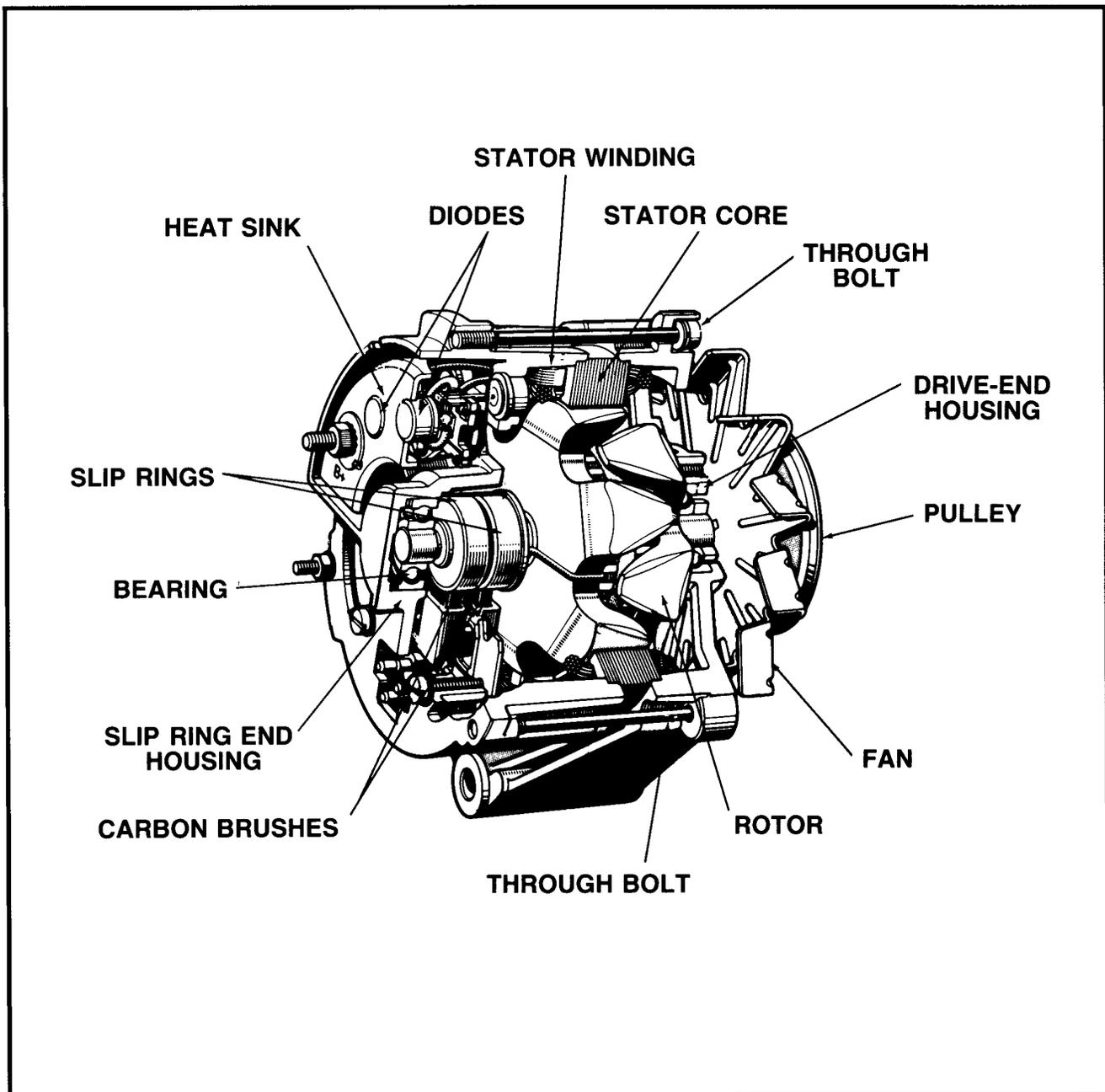
GENERAL

Two different types of alternators are used on Toyota vehicles. A conventional alternator and separate voltage regulator were used on all Toyotas prior to 1979. A new compact, high-speed alternator with a built-in IC regulator

is now used on most models. Both types of alternators are rated according to current output. Typical ratings range from 40 amps to 80 amps.

CONVENTIONAL ALTERNATOR

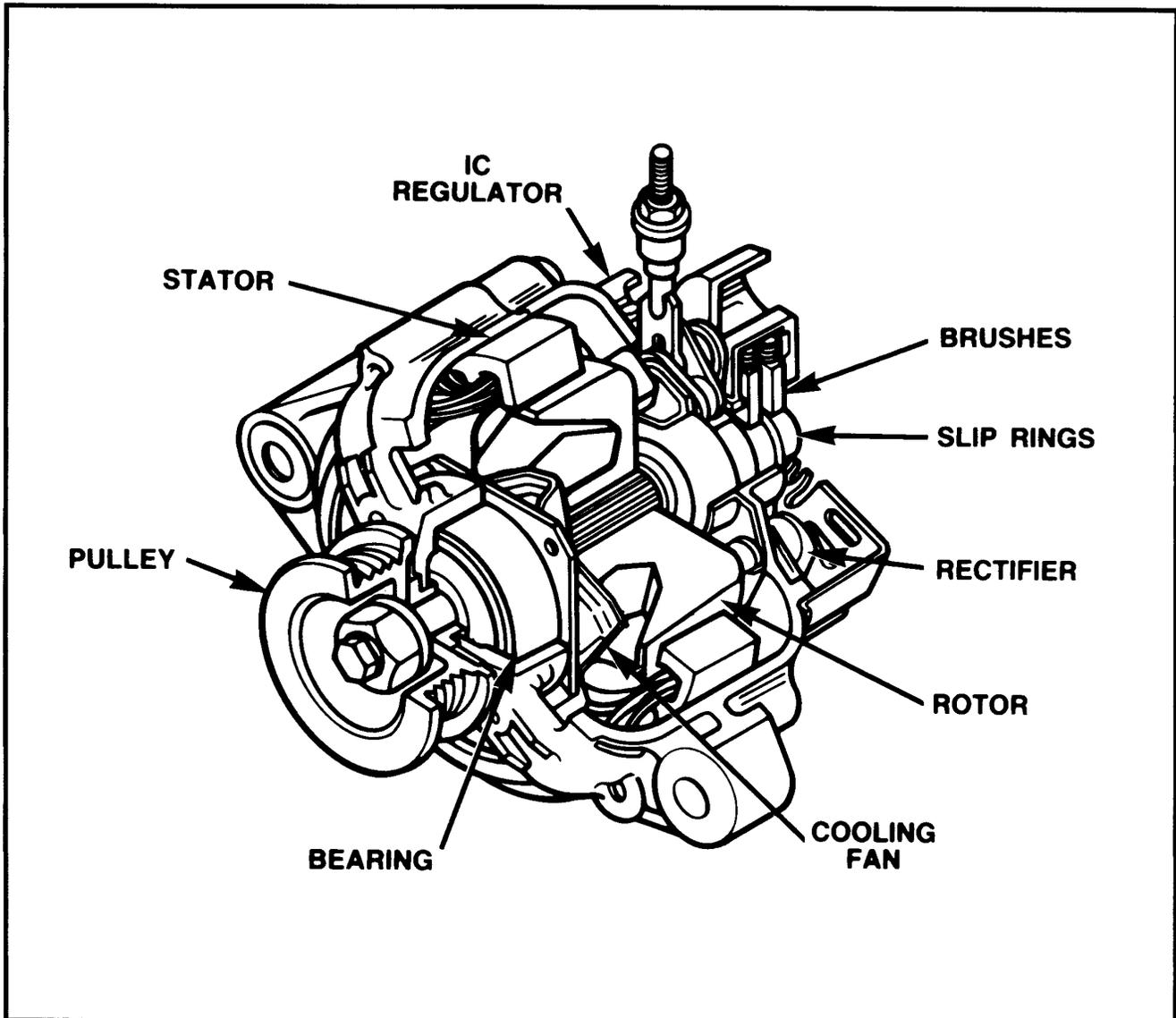
This type of alternator is currently used on some 1986 Tercel models, and all Toyotas prior to 1979.



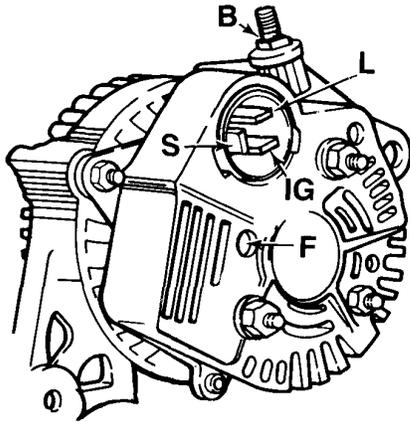
TOYOTA COMPACT, HIGH-SPEED ALTERNATOR

Beginning with the 1983 Camry, a compact, high-speed alternator with a built-in IC regulator is used on Toyota vehicles. Corolla models with the 4A-C engine use a different alternator with an integral IC regulator.

This new alternator is compact and lightweight. It provides better performance, as well as improved warning functions. If either the regulator sensor (terminal "S") or the alternator output (terminal "B") become disconnected, the warning lamp goes on. It also provides better serviceability. The rectifier, brush holder, and IC regulator are bolted onto the end frame.



ALTERNATOR TERMINALS

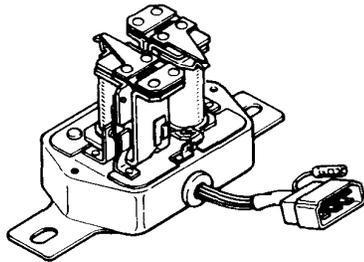


Alternator Terminals

Toyota's high-speed alternator has the following terminals: "B", "IG", "S", "U", and "17".

When the ignition switch is "on," battery current is supplied to the regulator through a wire connected between the switch and terminal "IG". When the alternator is charging, the charging current flows through a large wire connected between terminal "B" and the battery. At the same time, battery voltage is monitored for the MIC regulator through terminal "S". The regulator will increase or decrease rotor field strength as needed. The indicator lamp circuit is connected through terminal "U". If there is no output, the lamp will be lit. The rotor field coil is connected to terminal "P", which is accessible for testing purposes through a hole in the alternator end frame.

ELECTROMECHANICAL REGULATOR



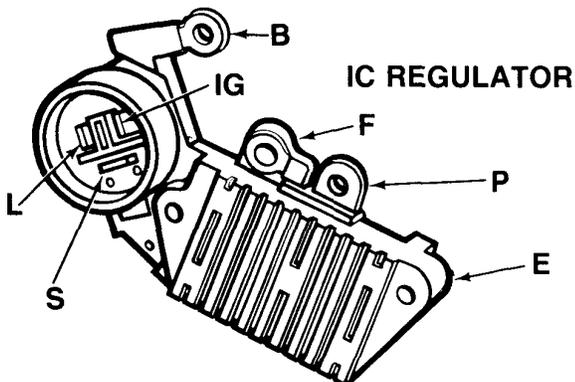
Regulator

While engine speeds and electrical loads change, the alternator's output must remain even - not too much, nor too little.

The regulator controls alternator output by increasing or decreasing the strength of the rotor's magnetic field. It does so, by controlling the amount of current from the battery to the rotor's field coil.

The electromechanical regulator does its job with a magnetic coil and set of contact points. The IC regulator does its job with diodes, transistors, and other electronic components.

IC REGULATOR

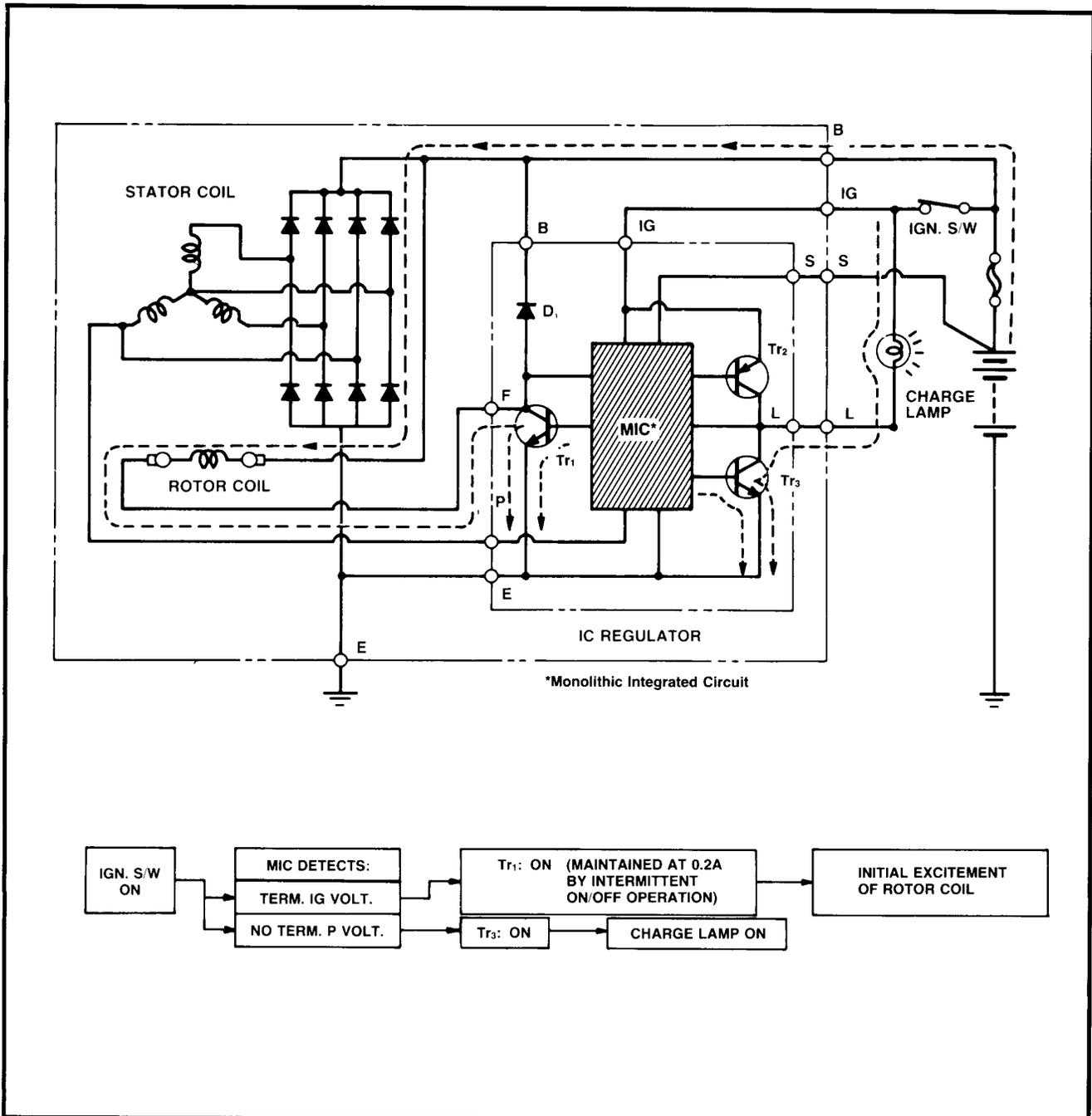


Alternator Operation

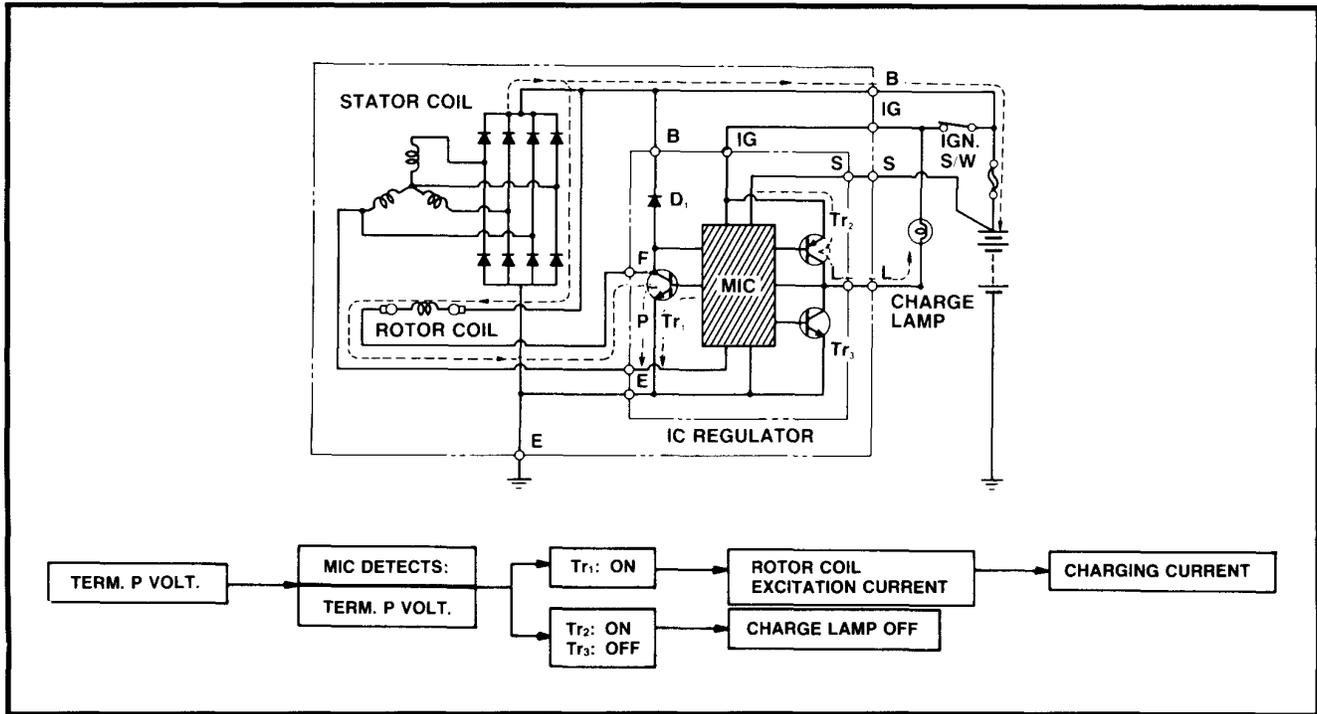
GENERAL

The operation of the Toyota compact, high-speed alternator is shown in the following circuit diagrams.

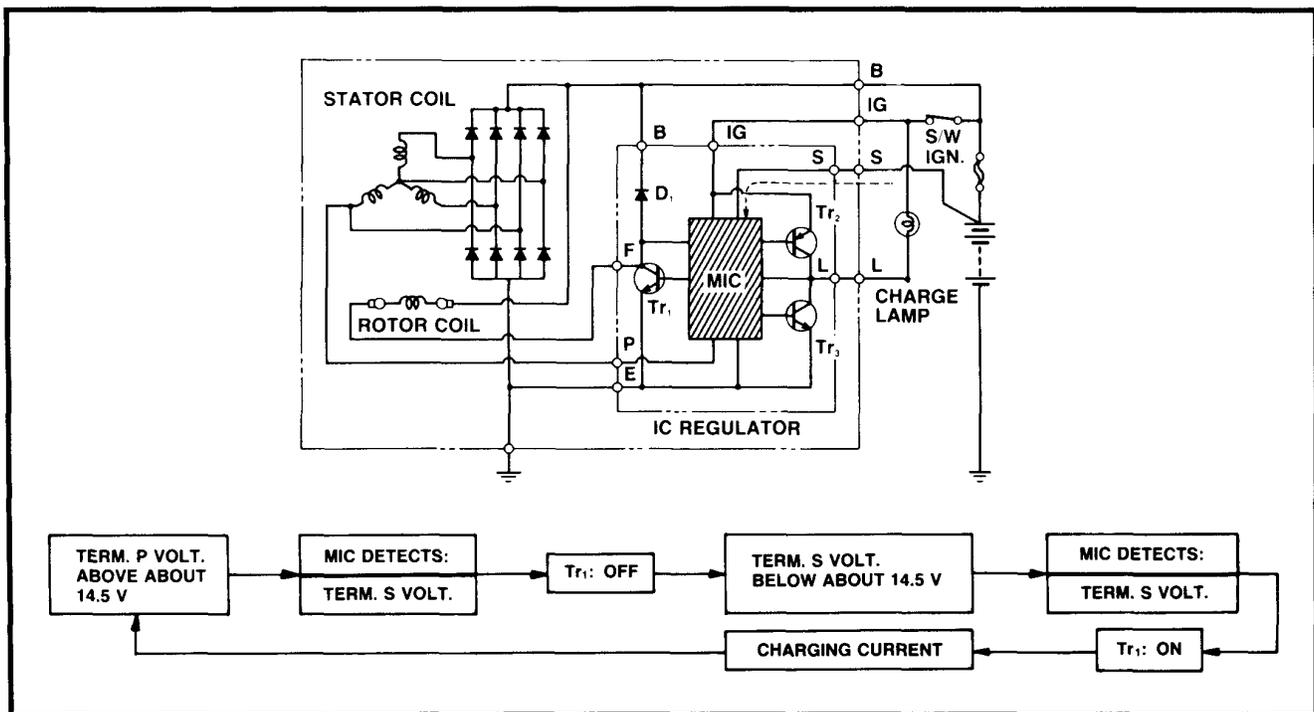
IGNITION ON, ENGINE STOPPED



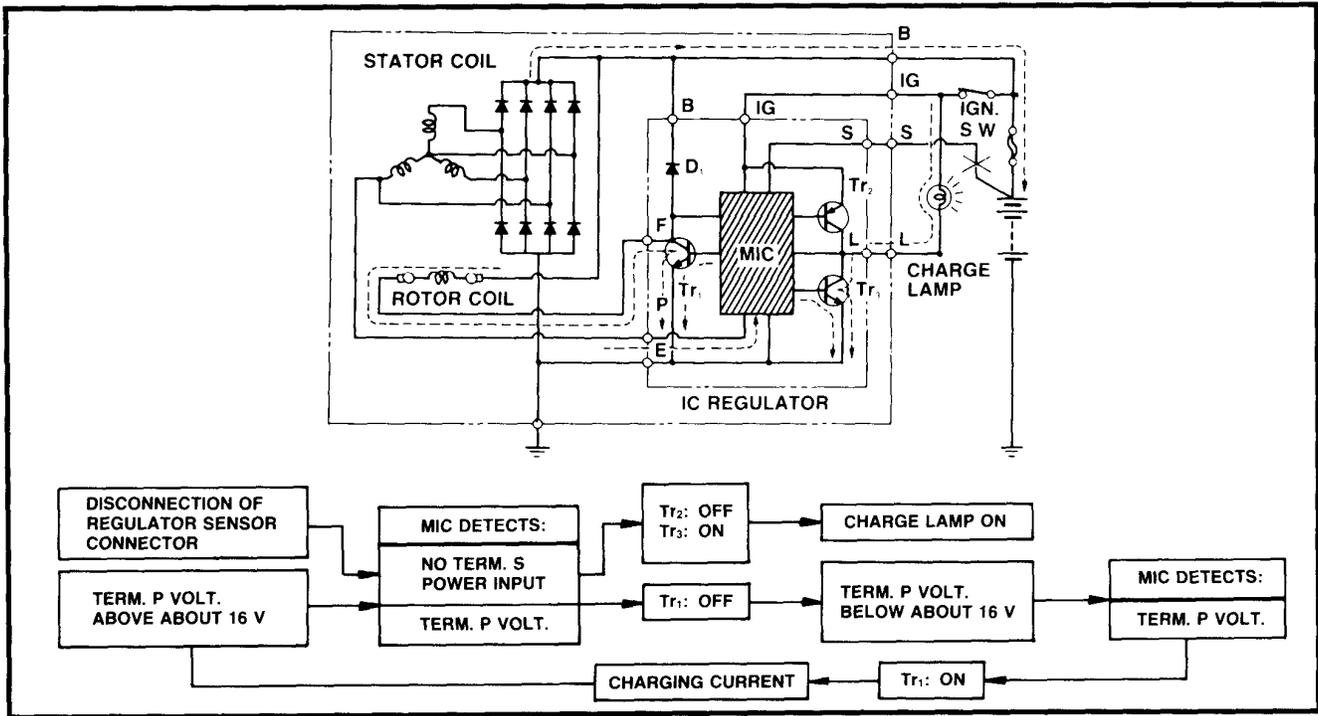
ALTERNATOR BEGINS OPERATING (Regulated voltage not achieved)



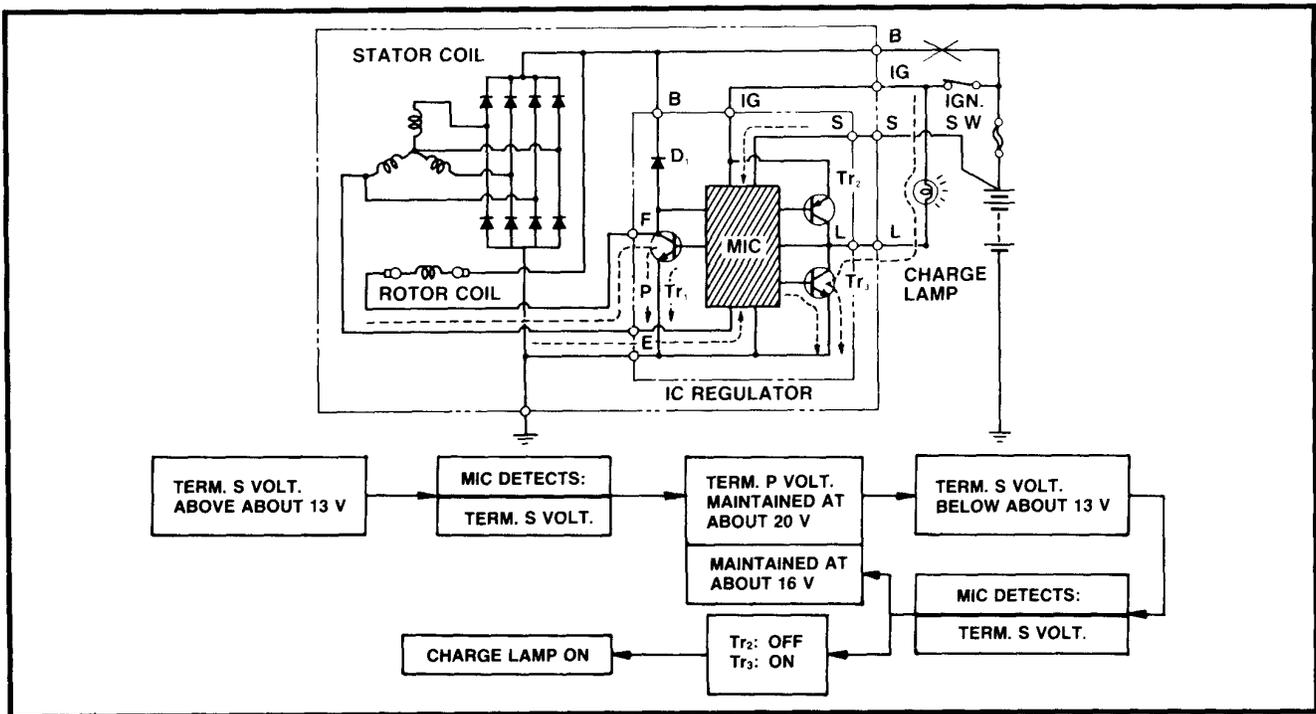
ALTERNATOR OPERATING (Regulated voltage exceeded)



TERMINAL "S" DISCONNECTED



TERMINAL "B" DISCONNECTED



Diagnosis and Testing

The charging system requires periodic inspection and service. Specific problem symptoms, their possible cause, and the service required are listed in the chart below. The service actions require a thorough **visual inspection**. Problems identified must be corrected before proceeding with electrical tests. These electrical tests include: an **alternator output test**, charging circuit **voltage-drop tests**, a voltage regulator (non-IC) test, charging circuit relay (lamp, ignition, engine) tests, and **alternator bench tests**.

PRECAUTIONS

- Make sure battery cables are connected to correct terminals.

- Always disconnect battery cables (negative first!) when the battery is given a quick charge.
- Never operate an alternator on an open circuit (battery cables disconnected).
- Always follow specs for engine speed when grounding terminal "F" to bypass the regulator. High speeds may cause excess output that could damage components.
- Never ground alternator output terminal "B." It has battery voltage present at all times, even with the engine off.
- Do not perform continuity tests with a high-voltage insulation resistance tester. This type of ohmmeter could damage the alternator diodes.

CHARGING SYSTEM TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	ACTION
Warning lamp does not light, with ignition ON and engine off	<ol style="list-style-type: none"> 1. Blown fuse 2. Lamp burned out 3. Wiring connections loose 4. Defective relay 5. Defective regulator 	<ol style="list-style-type: none"> 1. Check CHARGE, IGN, AND ENGINE fuses; replace as needed after correcting cause 2. Replace lamp 3. Check voltage drop in circuit, tighten loose connections 4. Check relays, if used, for continuity and proper operation 5. Check alternator output
Warning lamp does not go out with engine running; battery overcharged or undercharged	<ol style="list-style-type: none"> 1. Loose or worn drive belt 2. Defective battery or battery connections 3. Blown fuse or fusible link 4. Defective relay, regulator, or alternator 5. Defective wiring 	<ol style="list-style-type: none"> 1. Check drive belt; adjust or replace as needed after correcting cause 2. Check battery and its connections 3. Check fuse and fusible link; replace as needed 4. Check charging system output and component operation, as needed 5. Check voltage drop
Noise	<ol style="list-style-type: none"> 1. Loose or worn drive belt 2. Worn alternator bearings 3. Defective diode 	<ol style="list-style-type: none"> 1. Check drive belt; adjust or replace, as needed 2. Replace the alternator 3. Replace the alternator

VISUAL INSPECTION

A visual inspection should always be your first step in checking the charging system. A number of problems that would reduce charging performance can be identified and corrected.

CHECK THE BATTERY

- Check for proper electrolyte level and state of charge. When fully charged, **specific gravity should be between 1.25 and 1.27 at 80°F (26.7°C).**
- Check the battery terminals and cables. The terminals should be free of corrosion and the cable connections tight.

CHECK THE FUSES AND FUSIBLE LINK

- Check the fuses for continuity. These include the **Engine fuse (10A), Charge fuse (7.5A), and Ignition fuse (7.5A).**
- Check the fusible link for continuity.

INSPECT THE DRIVE BELT

- Check for belt separation, cracks, fraying, or glazing. If necessary, replace the drive belt.
- Check the drive belt tension using the proper tension gauge, Nippondenso BTG-20

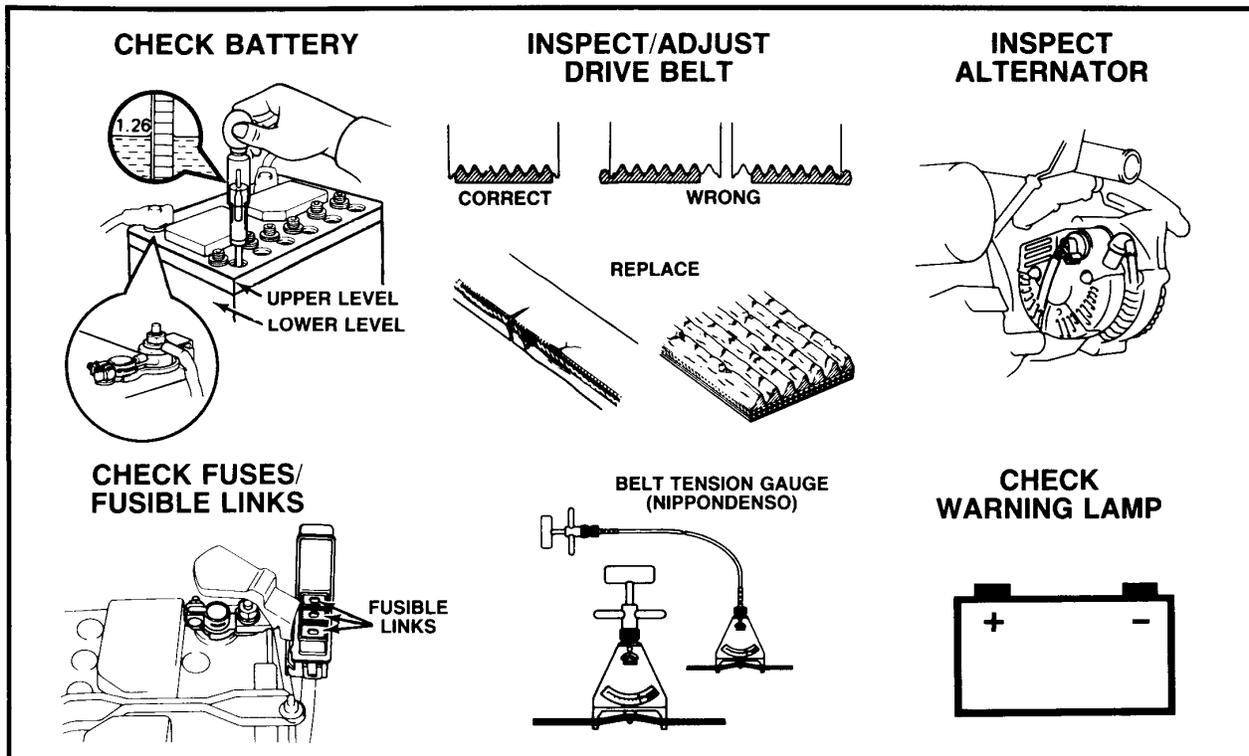
Refer to the appropriate repair manual for proper drive belt tension. "New" belts (used less than 5 minutes on a running engine) are installed with greater tension than "used" belts. Tension specs are different for different models.

INSPECT THE ALTERNATOR

- Check the wiring and connections. Replace any damaged wires, tighten any loose connections.
- Check for abnormal noises. Squealing may indicate drive belt or bearing problems. Defective diodes can produce a whine or hissing noise because of a pulsating magnetic field and vibration.

CHECK THE WARNING LAMP CIRCUIT

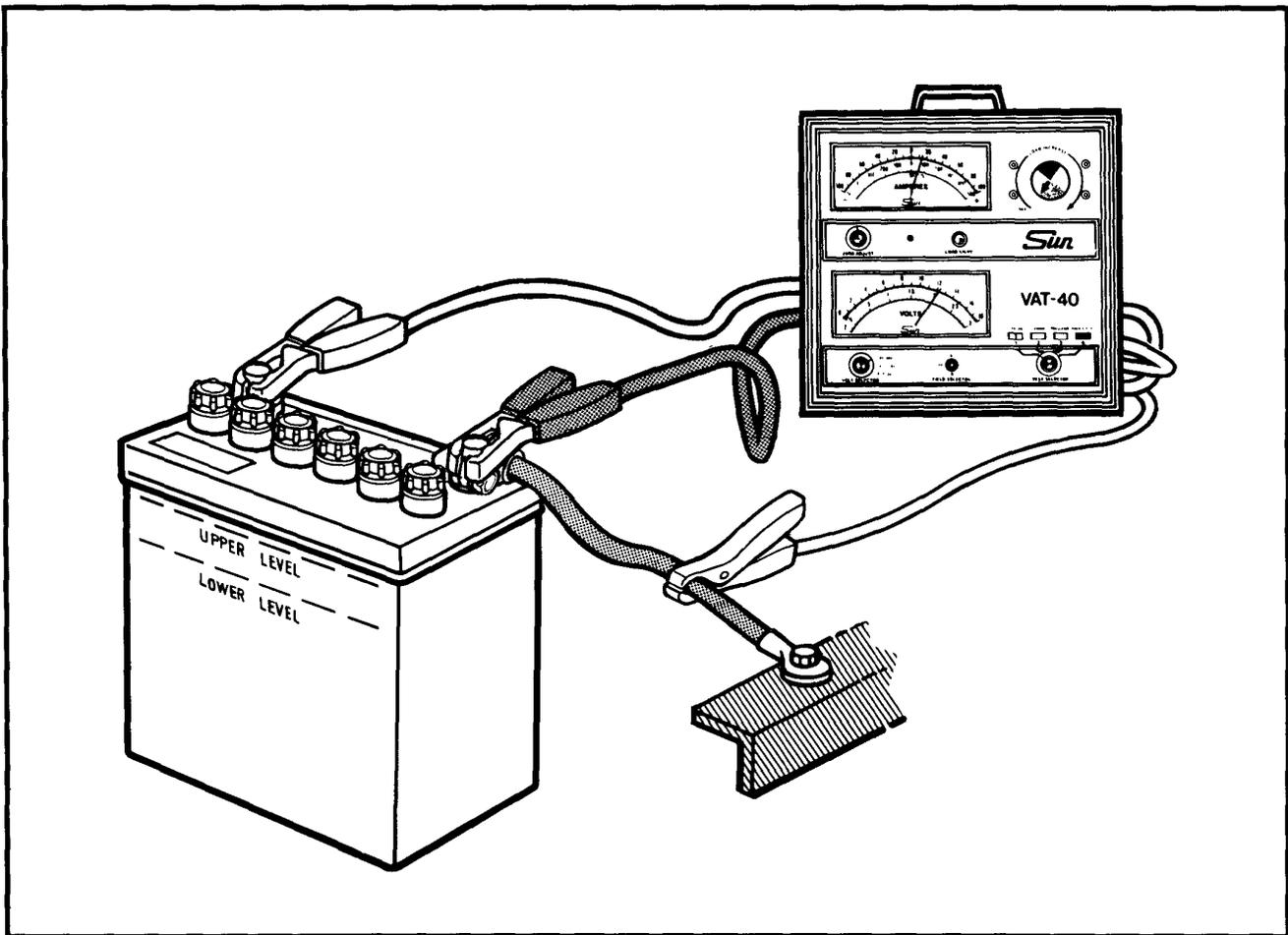
- With the engine warm and all accessories off, turn the ignition to ON. The warning lamp should light.
- With the engine started and the ignition in RUN, the warning lamp should be off.
- If the lamp does not operate as specified, check the bulb and check the lamp circuit.



ALTERNATOR OUTPUT TEST

The alternator output test checks the ability of the alternator to deliver its rated output of voltage and current. This test should be performed whenever an overcharging or undercharging problem is suspected. Output current and voltage should meet the specifications of the alternator. If not, the alternator or regulator (IC or external) may require replacement.

A Sun VAT-40 tester, similar testers, or a separate voltmeter and ammeter can be used. Toyota repair manuals detail the testing procedures with an ammeter and voltmeter. Follow the manufacturer's instructions when using special testers, although most are operated similarly. The following steps outline a typical procedure for performing the alternator output test using a Sun VAT-40:



Charging Without Load

1. Prepare the tester:

- Rotate the Load Increase control to OFF,
- Check each meter's mechanical zero. Adjust, if necessary.
- Connect the tester Load Leads to the battery terminals; RED to positive, BLACK to negative.
- Set Volt Selector to INT 18V.
- Set Test Selector to #2 CHARGING.
- Adjust ammeter to read ZERO using the electrical Zero Adjust control.
- Connect the clamp-on Amps Pickup around the battery ground (-) cables.

2. Turn the ignition switch to "ON" (engine not running) and read the amount of discharge on the ammeter. This is a base reading for current the alternator must supply for ignition and accessories **before** it can provide current to charge the battery.

NOTE: The reading should be about six amps.

3. Start the engine and adjust the speed to about 2000 rpm. Some models may require a different speed setting.

4. After about 3-4 minutes, read the ammeter and

voltmeter. Add this ammeter reading and the reading found in step 2 (engine not running).

NOTE: The total current should be less than 10 amps. If it is more, the alternator may still be charging the battery. Once the battery is fully charged, you should get specified results.

The voltage should be within the specs for the alternator. This is usually between 13 and 15 volts. Refer to the appropriate repair manual. If the voltage is more than specified, replace the regulator. If the voltage is less than specified, ground the alternator field terminal "F" and check the voltmeter reading. This bypasses the regulator, so do not exceed the specified test speed. If the reading is still less than specified, check the alternator.

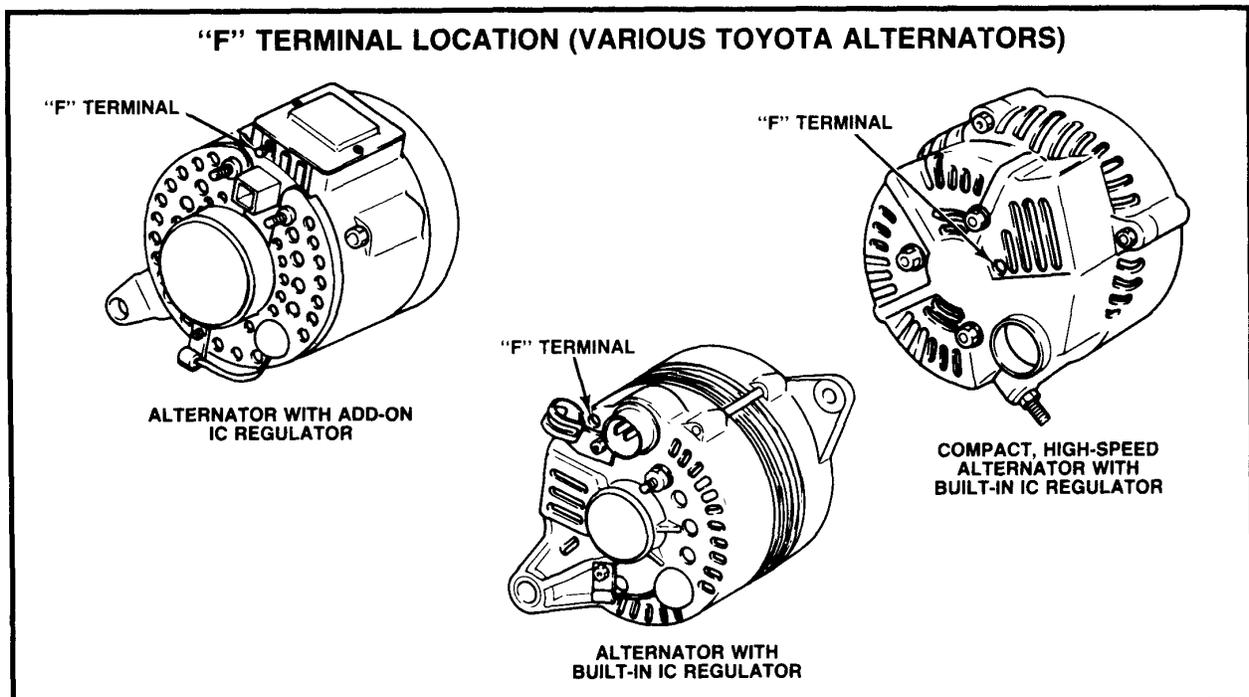
5. Remove ground from terminal "F."

Charging With Load

6. With the engine running at specified speed, adjust the Load Increase control to obtain the highest ammeter reading possible without causing the voltage to drop lower than 12 volts.

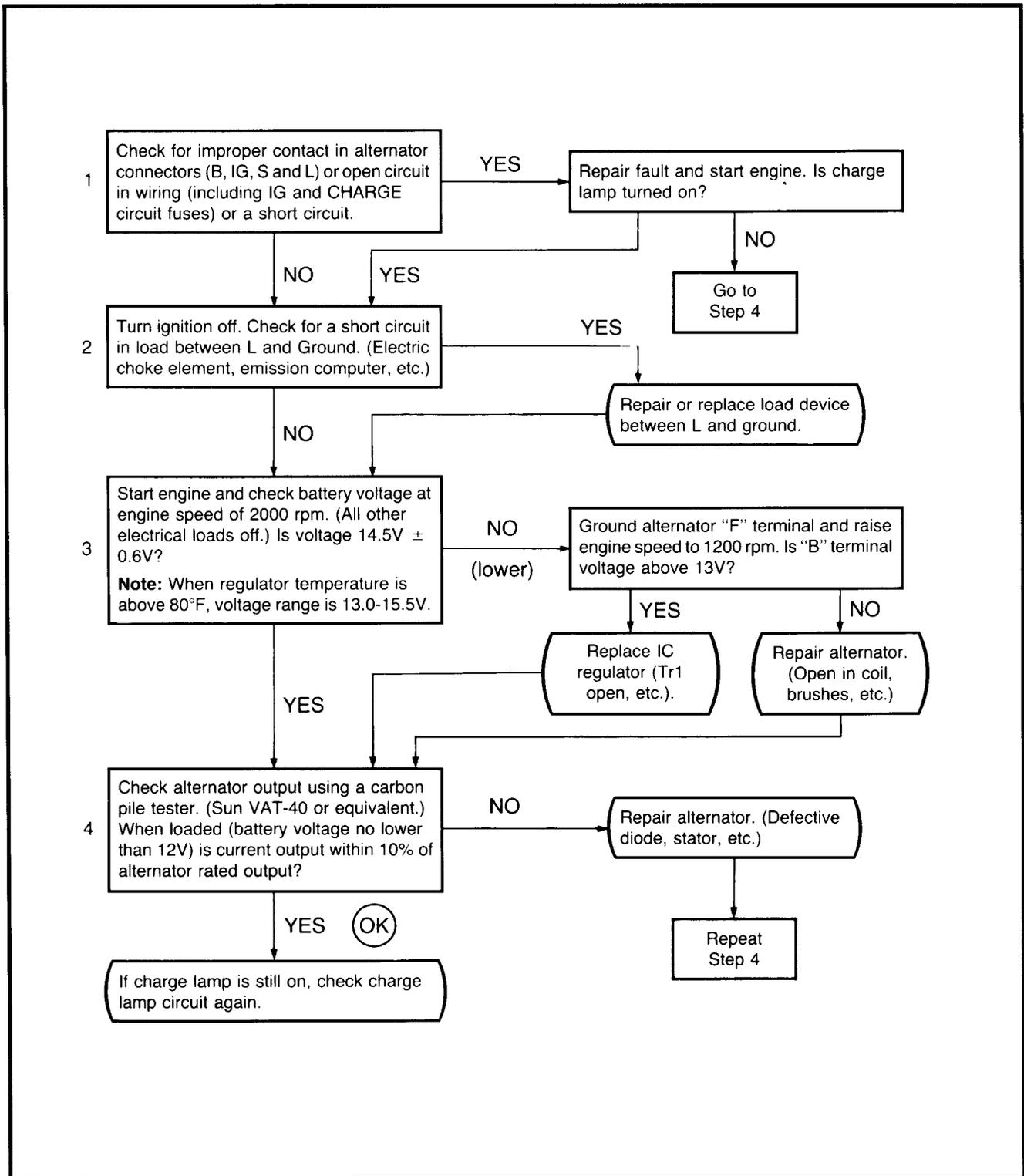
7. Read the ammeter.

NOTE: The reading should be within 10% of the alternator's rated output. If it is less, the alternator requires further testing or replacement.



TROUBLESHOOTING THE COMPACT, HIGH-SPEED ALTERNATOR.

Check Battery First!



VOLTAGE-DROP TESTS

Voltage-drop testing can detect excessive resistance in the charging system. These tests determine the voltage drop in the alternator output circuit. Both sides of the circuit should be checked ... insulated side as well as ground side. Excessive voltage drop caused by high resistance in either of these circuits will reduce the available charging current. Under heavy electrical loads, the battery will discharge.

A Sun VAT-40 tester or a separate voltmeter can be used. The following steps outline a typical procedure for performing voltage-drop tests using a voltmeter:

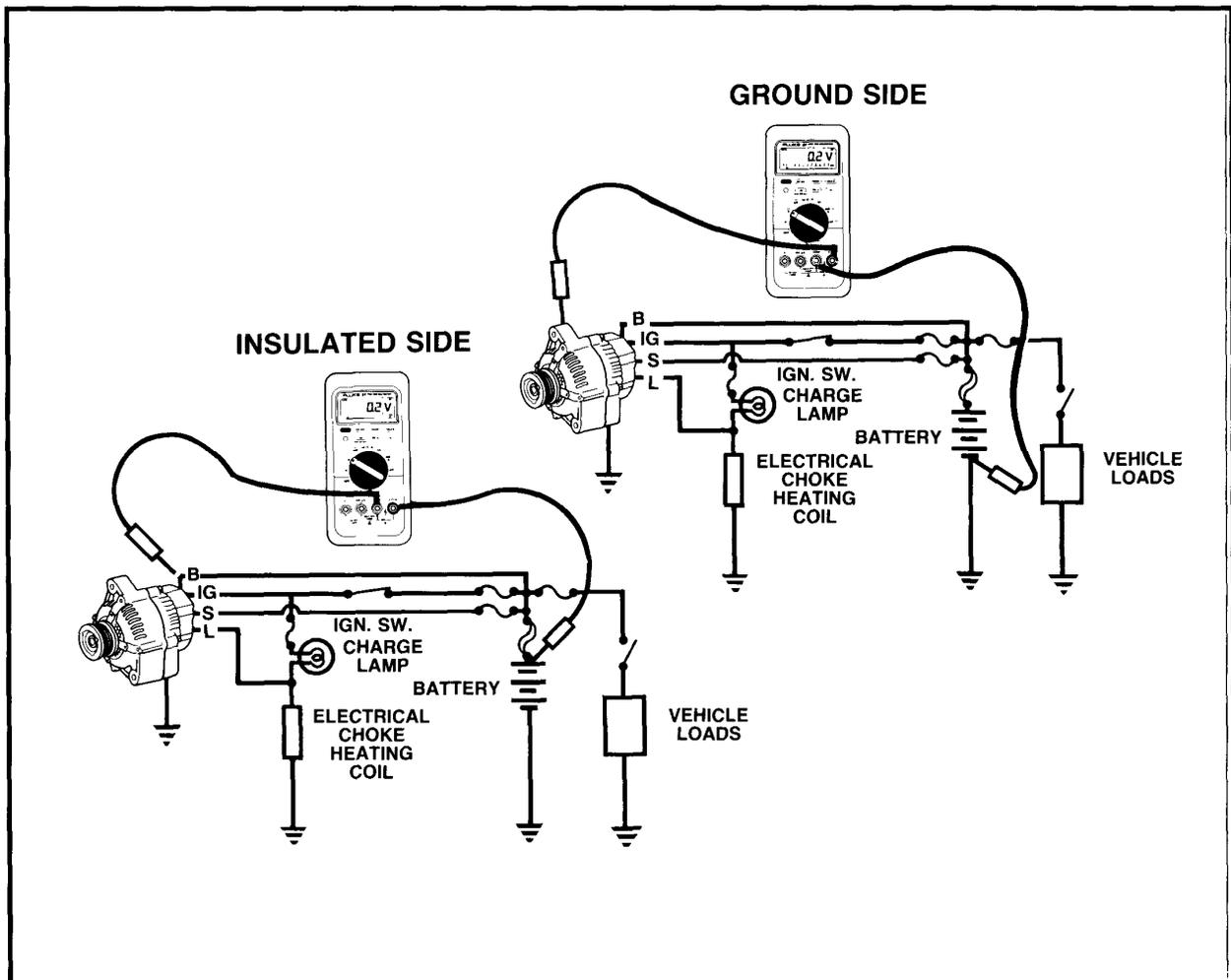
Output Circuit - Insulated Side

1. Connect the voltmeter positive lead to the alternator's output terminal "B" and the voltmeter's negative lead to the battery's positive (+) terminal.

2. Start the engine and adjust the speed to approximately 2000 rpm.
3. Read the voltmeter. The voltage drop should be less than 0.2 volt. If it is more, locate and correct the cause of the high resistance.

Output Circuit - Ground Side

1. Connect the voltmeter's negative lead to the alternator's frame and the voltmeter's positive lead to the battery's negative (-) terminal.
2. Start the engine and run at specified speed (about 2000 rpm).
3. Read the voltmeter. The voltage drop should be 0.2 volt or less. If it is more, locate and correct the cause of high resistance. Excessive resistance is most likely caused by loose or corroded connections.



CHARGING CIRCUIT RELAY TESTS

Various charging system layouts are used on Toyota vehicles. The indicator lamp circuit may or may not be controlled by a relay. Depending on the model, when a relay is used, it may be a separate lamp relay, the ignition main relay, or the engine main relay. Each is checked using an ohmmeter.

Charge Lamp Relay

When used, the charge lamp relay is located on the right cowl side of the vehicle. The following steps are used to check this relay:

1. Check relay continuity.

- Connect the ohmmeter positive (+) lead to terminal "4," the negative (-) lead to terminal "3." Continuity (no resistance) should be indicated.

- Reverse the polarity of the ohmmeter leads. No continuity (infinite resistance) should be indicated.

- Connect the ohmmeter leads between terminals 1 and "2." No continuity (infinite resistance) should be indicated.

If the relay continuity is not as specified, replace the relay.

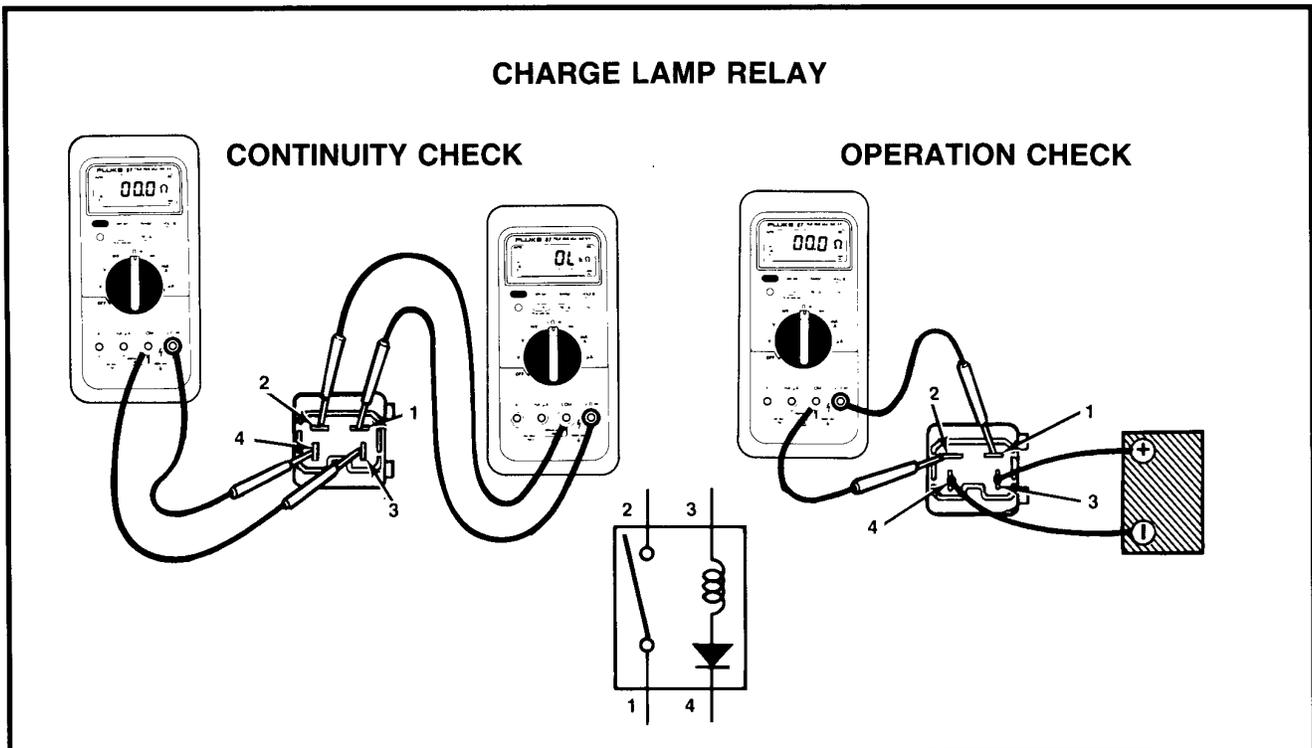
2. Check relay operation.

- Apply battery voltage across terminals "3" and "4."

NOTE: Make sure polarity is as shown.

- Connect the ohmmeter leads between terminals "1" and "2." Continuity (no resistance) should be indicated.

If relay operation is not as specified, replace the relay.



Ignition Main Relay

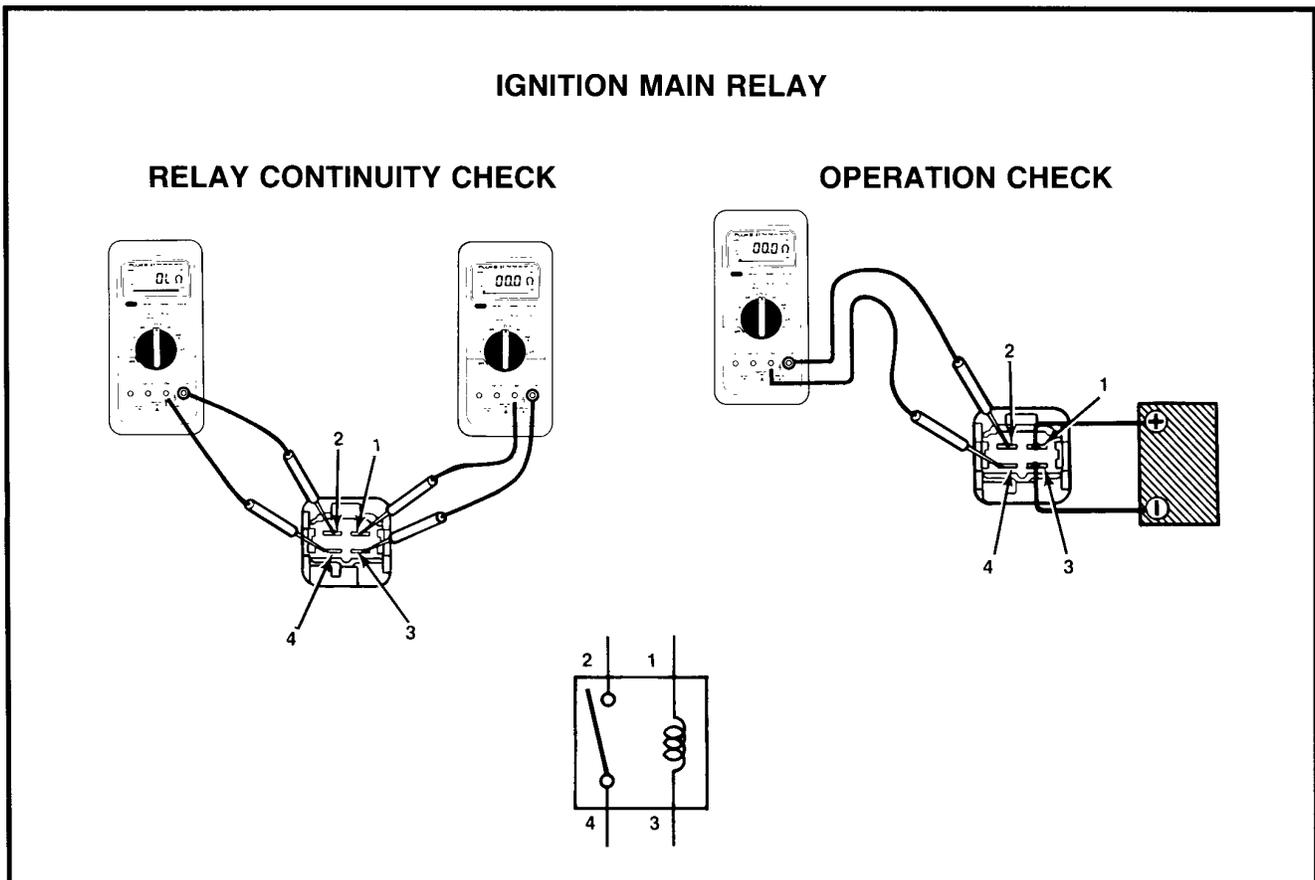
The ignition main relay is located in the relay box under the instrument panel. The following steps are used to check this relay:

1. Check relay continuity.
 - Connect the ohmmeter leads between terminals "1" and "3." Continuity (no resistance) should be indicated.
 - Connect the ohmmeter leads between terminals "2" and "4." No continuity (infinite resistance) should be indicated.

If relay continuity is not as specified, replace the relay.

2. Check relay operation.
 - Apply battery voltage across terminals "1" and "3."
 - Connect the ohmmeter leads between terminals "2" and "4." Continuity (no resistance) should be indicated.

If relay operation is not as specified, replace the relay.



ALTERNATOR BENCH TESTS

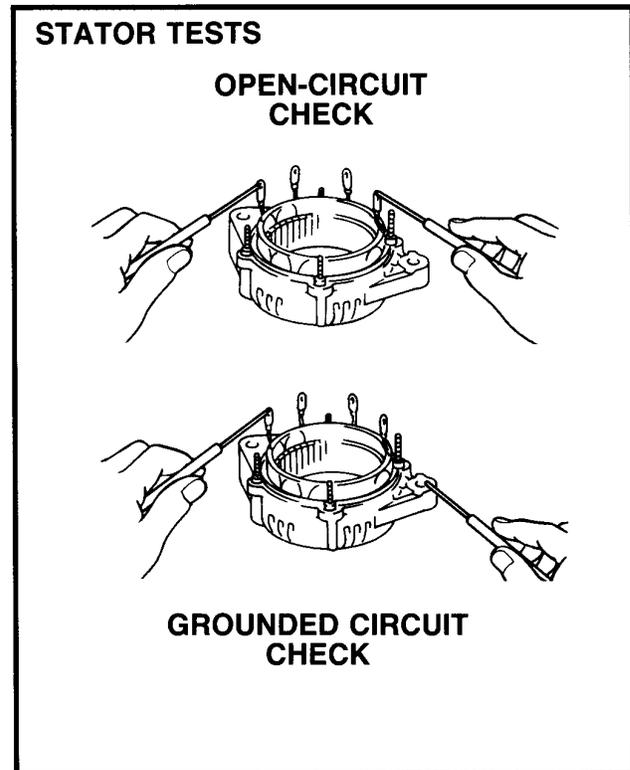
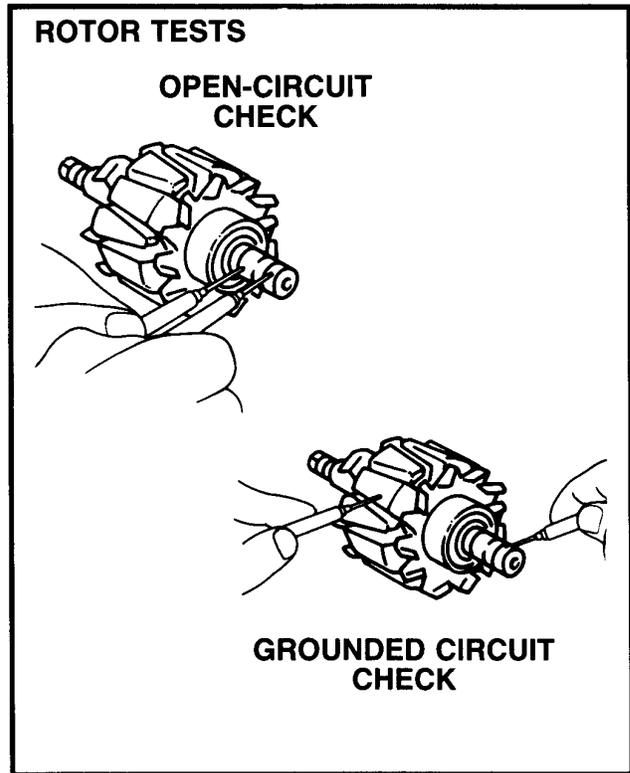
If the on-vehicle checks have indicated that the alternator is defective, it should be removed for bench testing and replacement. Specific procedures for removal, disassembly, inspection, and assembly are noted in the appropriate repair manuals. Only the electrical bench tests are covered here.

- Always disconnect the battery ground (-) cable before removing the alternator.
- Refer to the appropriate repair manual for test specifications.

An ohmmeter is used for electrical bench tests on the rotor, stator, and diode rectifier. The following steps are typical:

Rotor Tests

- Check the rotor for an open circuit by measuring for resistance between the slip rings. Some resistance (less than 5 ohms) indicates continuity. If there is no continuity (infinite resistance), replace the rotor.
- Check the rotor for grounded circuits by measuring for resistance between the rotor and slip ring. Any amount of resistance indicates a ground (continuity). The resistance should be infinite (0 ohms). If not, replace the rotor.

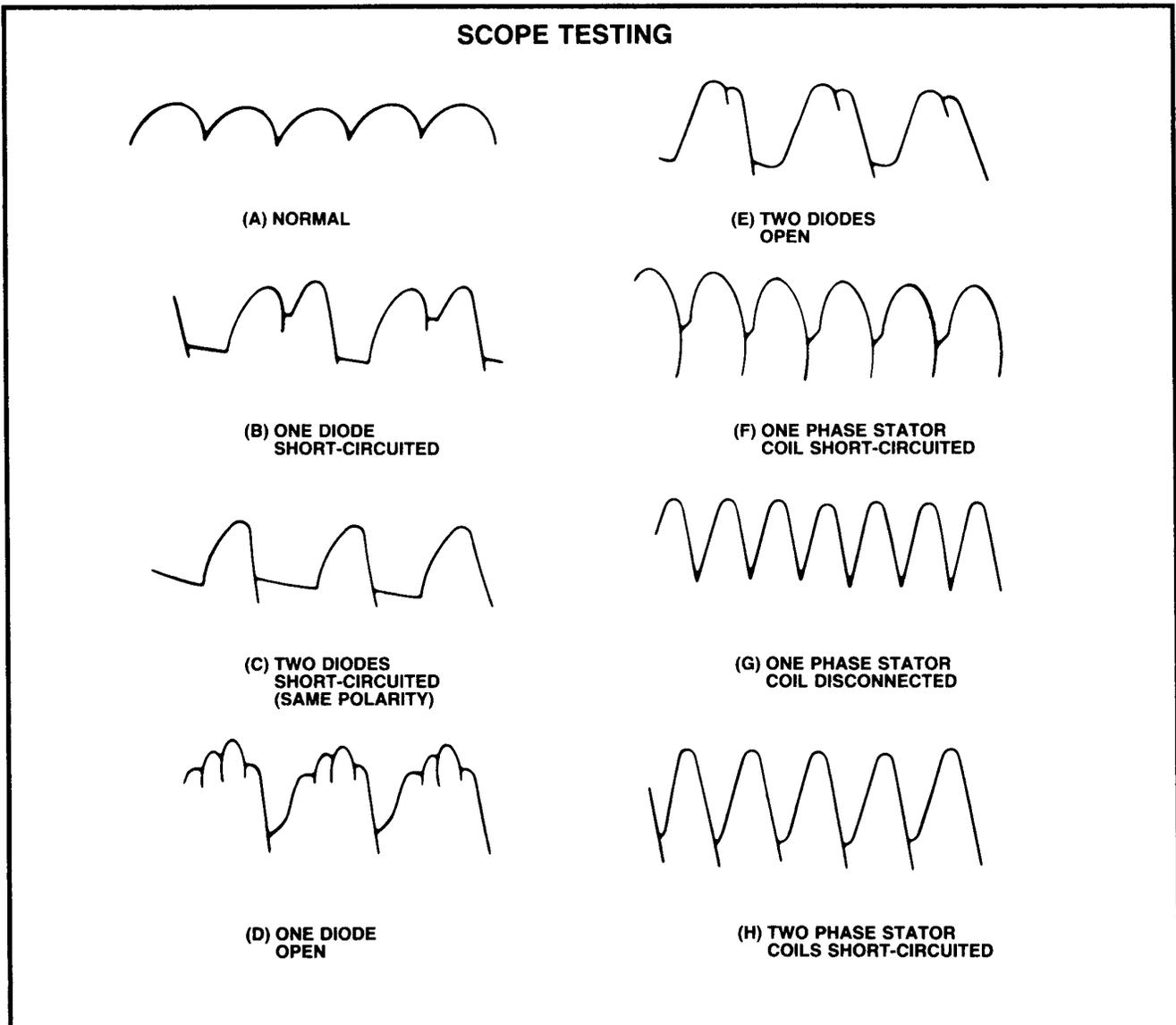


Diode Tests

Diodes can be checked with the alternator on the vehicle using a scope. Scope testing can identify open or shorted diodes, as well as problems in the stator coils.

The scope patterns shown below include:

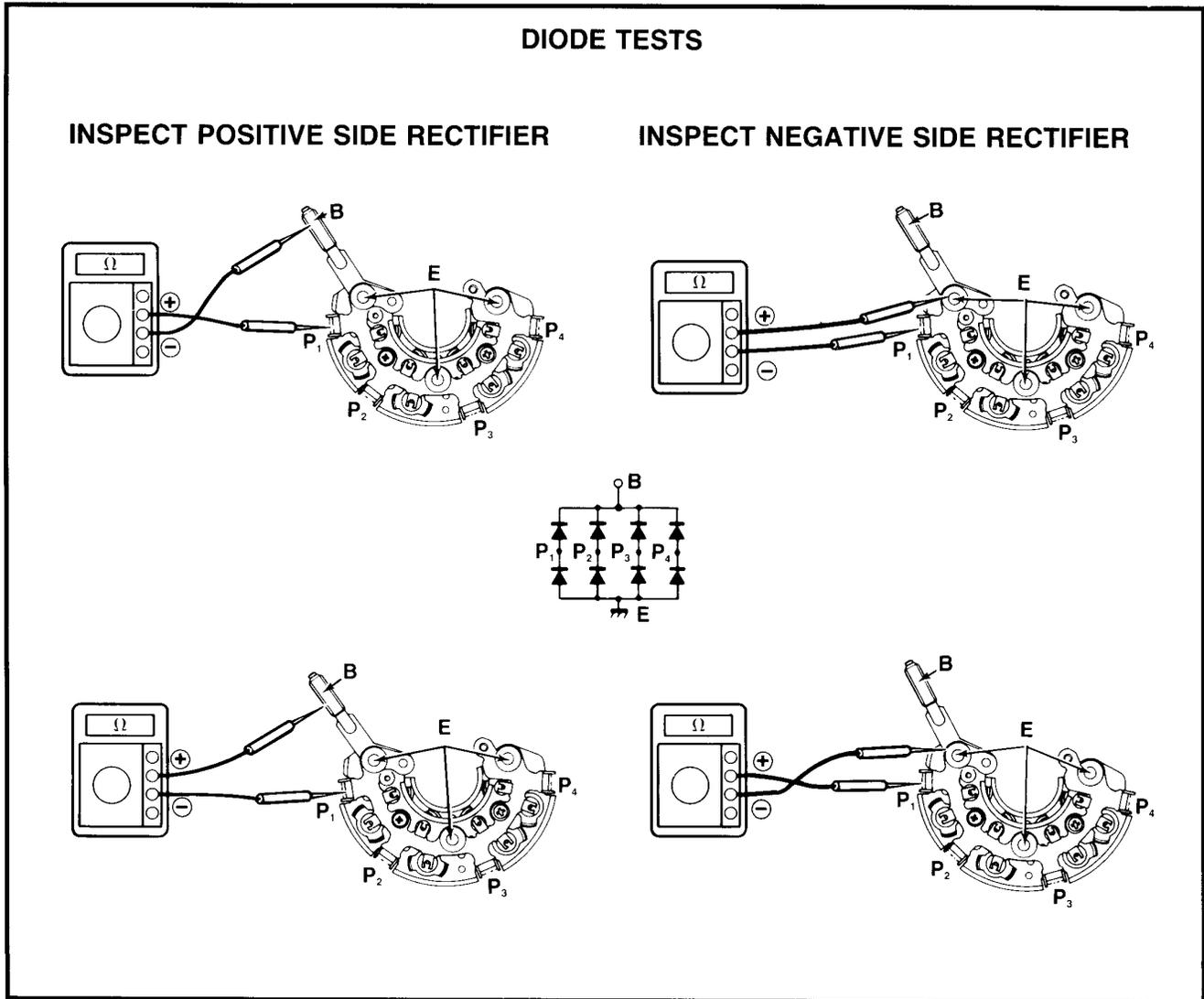
- a) Normal alternator output;
- b) one diode short-circuited;
- c) two diodes of the same polarity short-circuited;
- d) one diode open;
- e) two diodes open;
- f) one phase of the stator coil short-circuited;
- g) one phase of the stator coil disconnected;
- h) two phases of the stator coil short-circuited.



- Open and shorted diodes can also be located using an ohmmeter. Touch one ohmmeter lead to P₁ and the other lead to the "B" terminal (to check the positive diode) or to the "E" terminal (to check the negative diode). Then, reverse the leads. The meter should show no resistance in one direction, infinite resistance in the other. If no resistance is seen in both directions, the diode is

shorted. If infinite resistance is seen in both directions, the diode is open. Repeat the same test for P₂, P₃, and P₄.

NOTE: Most digital meters have a position marked "→|—" for diode testing. Refer to the meter instructions for specific readings.



This brief self-test will help you measure your understanding of The Charging System. The style is the same as that used for A.S.E. certification tests. Each incomplete statement or question is followed by four suggested completions or answers. In each case, select the one that best completes the sentence or answers the question.

1. A regulator controls alternator output voltage by regulating:
 - A. sine-wave voltage
 - B. battery voltage
 - C. field current
 - D. output current
2. In an alternator, alternating current is converted to direct current by the:
 - A. stator
 - B. brushes
 - C. rectifier
 - D. regulator
3. If the charging system indicator lamp goes on with the engine running, the cause may be loss of voltage at terminal:
 - A. "IG"
 - B. "S"
 - C. "L"
 - D. "F"
4. With the engine not running and the ignition ON, the charge lamp should light. If it doesn't, this may indicate a:
 - A. burned out bulb
 - B. grounded bulb
 - C. loose drive belt
 - D. overcharged battery
5. Which alternator terminal can be grounded for test purposes?
 - A. "B"
 - B. "IG"
 - C. "S"
 - D. "F"
6. When performing a visual inspection of the charging system, the alternator drive belt should be checked for proper tension.

Technician "A" says that new-belt tension specs are higher than those for used belts.

Technician "B" says that the belt tension is different for different Toyota models.

Who is right?

 - A. Only A
 - B. Only B
 - C. Both A and B
 - D. Neither A nor B
7. The amount of current the alternator must supply or ignition and accessories is about:
 - A. four amps
 - B. six amps
 - C. eight amps
 - D. ten amps
8. In an alternator output test under load, the output should be:
 - A. about 10 amps
 - B. about 30 amps
 - C. within 10% of rated output
 - D. within 20% of rated output
9. To check for excessive voltage drop on the insulated side of the alternator's output circuit, you would connect a voltmeter between the:
 - A. battery terminal and ignition switch
 - B. battery terminal and ground
 - C. battery terminal and alternator "S" terminal
 - D. battery terminal and alternator "B" terminal
10. High resistance in an alternator output circuit is often caused by:
 - A. a discharged battery
 - B. a shorted diode
 - C. loose or corroded connections
 - D. a bad regulator

SELF-TEST ANSWERS

For the preceding self-test on **The Charging System**, the following **best** complete the sentence or answer the question. In cases where you may disagree with the choice - or may simply want to reinforce your understanding - please review the appropriate workbook page or pages noted.

1. "C" - The regulator controls alternator output by increasing or decreasing the amount of current from the battery to the rotor field coil. (Page 5.)
2. "C" - The alternating current is changed into direct current by the rectifier, a set of diodes which allow current to pass in only one direction. (Page 2.)
3. "B" - If either the regulator sensor (terminal "S") or the alternator output (terminal "B") become disconnected, the warning lamp goes on. (Page 4.)
4. "A" - If the warning lamp does not light, with the ignition ON and the engine not running, the possible causes include a blown fuse, burned out lamp, loose connections, or faulty relay or regulator. (Page 9.)
5. "D" - Terminal "F" is the only terminal that can be grounded. Never ground alternator output terminal "B". It has battery voltage present at all times, even with the engine off. (Page 9.)
6. "C" - A "new belt" is one that has been used for less than 5 minutes. It is installed with more tension than a used belt, because it will stretch some during use. Methods of checking are different for different models. (Page 10.)
7. "B" - The reading should be about six amps. This is the amount of current the alternator must supply for ignition and accessories. (Page 12.)
8. "C" - With the alternator operating at maximum output, the reading should be within 10% of rated output. (Page 12.)
9. "ID" - To check for the insulated circuit voltage drop, connect the voltmeter leads to the battery's (+) terminal and the alternator output (B) terminal. (Page 14.)
10. "C" - Excessive resistance is most likely caused by loose or corroded connections. (Page 14.)

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