

General

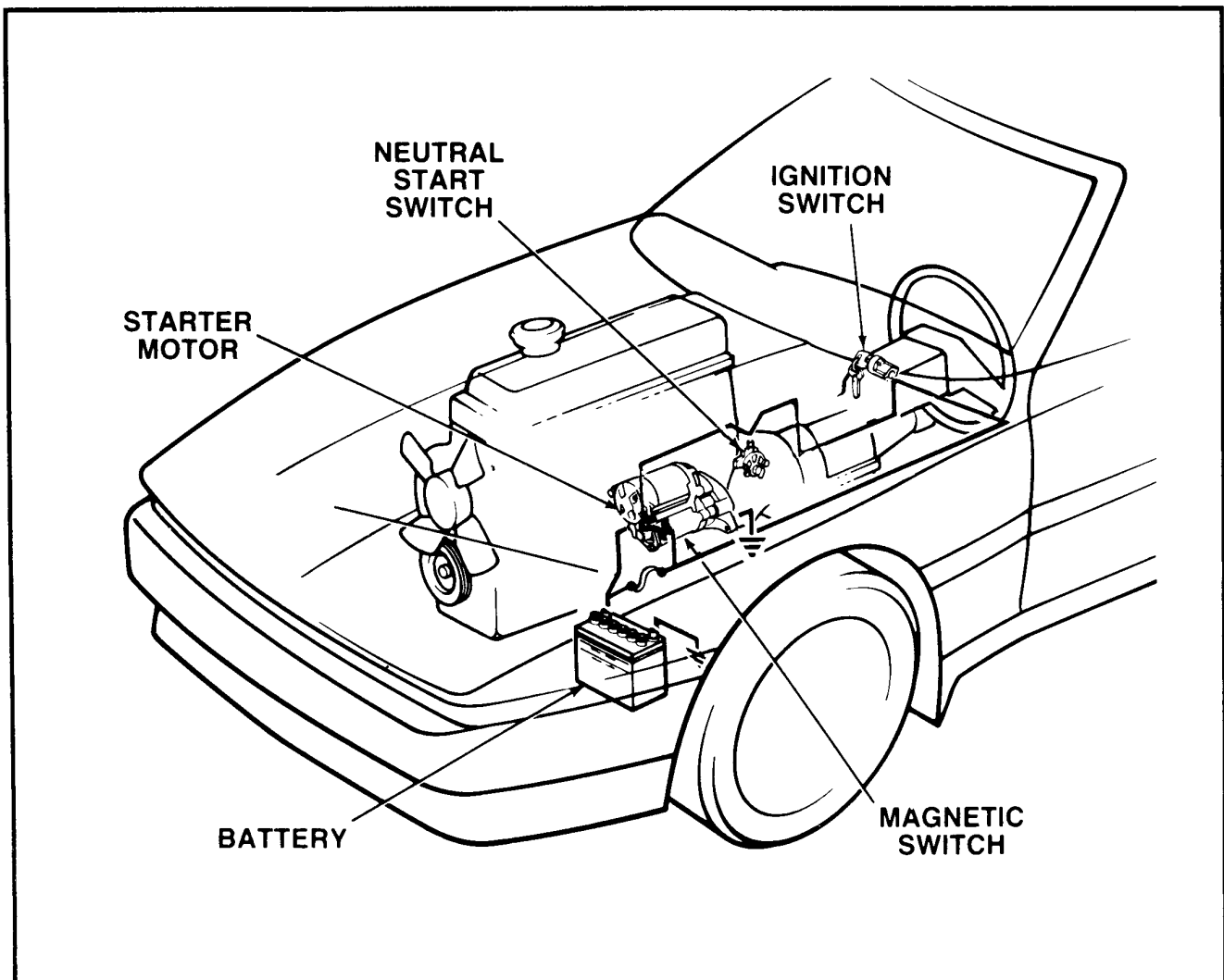
Starting the engine is possibly the most important function of the vehicle's electrical system. The starting system performs this function by changing electrical energy from the battery to mechanical energy in the starting motor. This motor then transfers the mechanical energy, through gears, to the flywheel on the engine's crankshaft. During cranking, the flywheel rotates and the air-fuel mixture is drawn into the cylinders, compressed, and ignited to start the engine. Most engines require a cranking speed of about 200 rpm.

Toyota Starting Systems

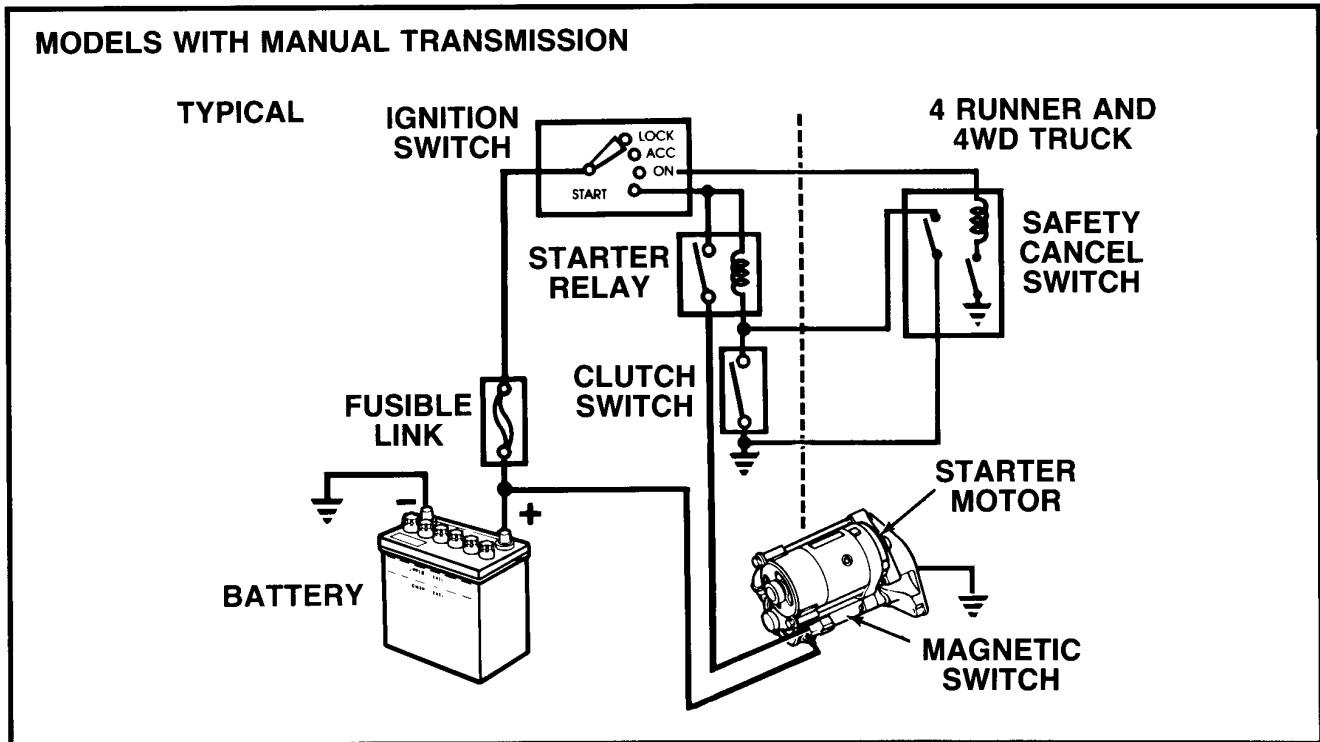
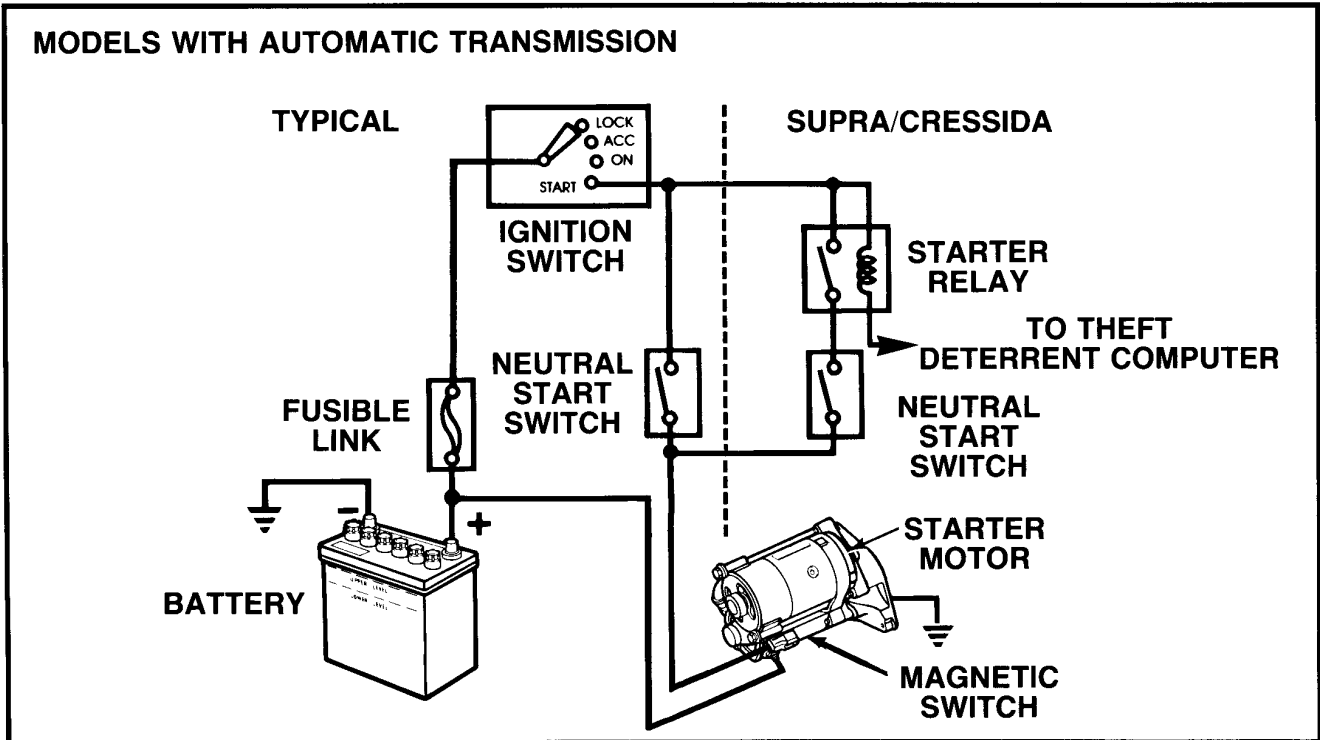
Two different starting systems are used on Toyota vehicles. Both systems have two separate electrical circuits ... a control circuit and a motor circuit. One has a **conventional starting motor**.

This system is used on most older-model Toyotas. The other has a **gear reduction starting motor**. This system is used on most current Toyotas. A heavy-duty **magnetic switch**, or solenoid, turns the motor on and off. It is part of both the motor circuit and the control circuit.

Both systems are controlled by the **ignition switch** and protected by a **fusable link**. On some models, a starter relay is used in the starter control circuit. On models with automatic transmission, a **neutral start switch** prevents starting with the transmission in gear. On models with manual transmission, a **clutch switch** prevents starting unless the clutch is fully depressed. On 4WD Truck and 4-Runner models, a **safety cancel switch** allows starting on hills without the clutch depressed. It does so by establishing an alternate path to ground.



Starting System Operation



Starting Motor Construction

GENERAL

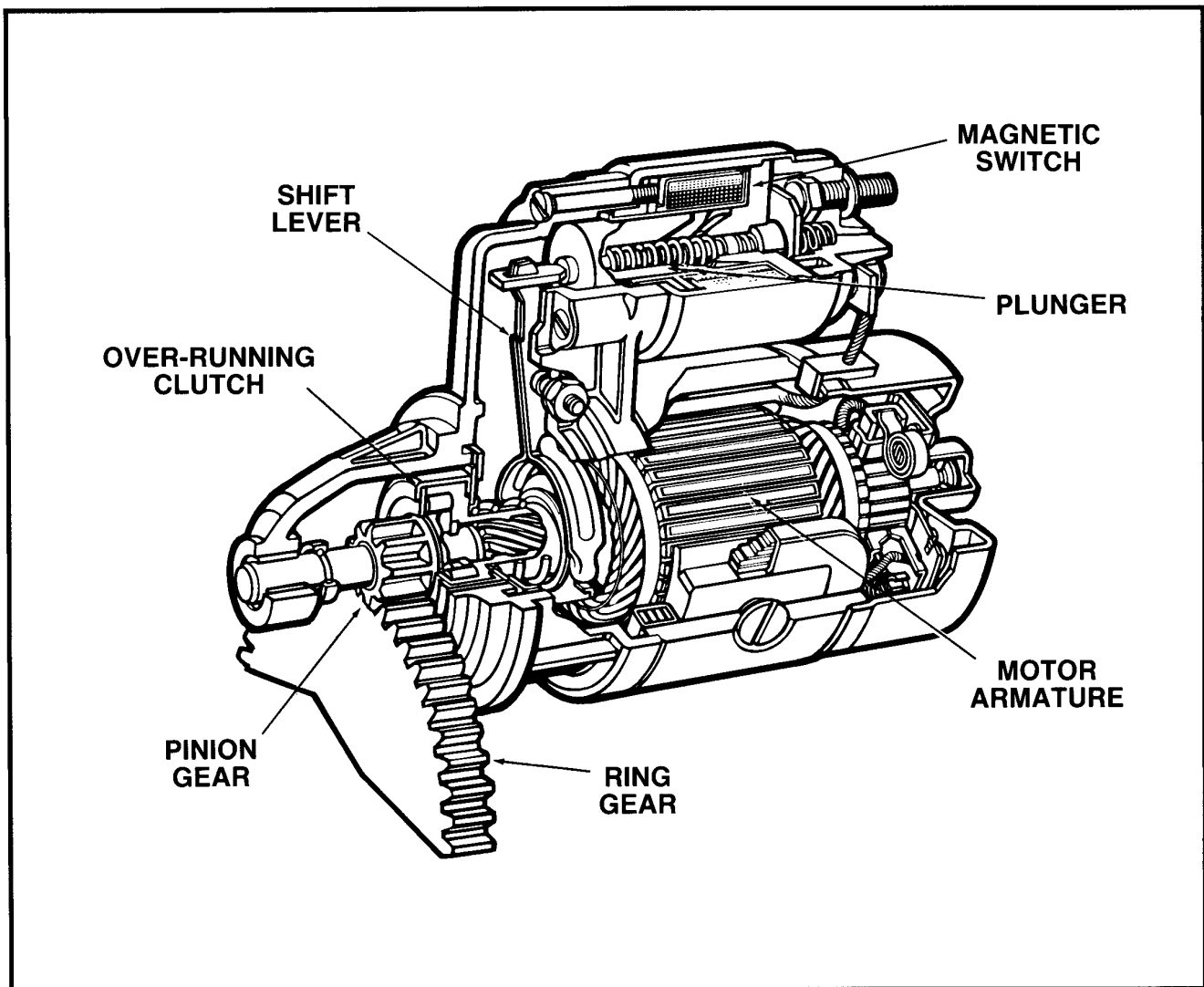
The starter motors used on Toyota vehicles have a magnetic switch that shifts a rotating gear (pinion gear) into and out of mesh with the ring gear on the engine flywheel. Two types of motors are used: conventional and gear reduction. Both are rated by power output in kilowatts (KW) ... the greater the output, the greater the cranking power.

CONVENTIONAL STARTER MOTOR

The conventional starter motor contains the components shown. The **pinion gear** is on the same shaft as the **motor armature** and rotates

at the same speed. A **plunger** in the **magnetic switch** (solenoid) is connected to a shift lever. When activated by the plunger, the **shift lever** pushes the pinion gear and causes it to mesh with the flywheel **ring gear**. When the engine starts, an **over-running clutch** disengages the pinion gear to prevent engine torque from ruining the starting motor.

This type of starter was used on most 1975 and older Toyota vehicles. It is currently used on certain Tercel models. Typical output ratings are 0.8, 0.9, and 1.0KW. In most cases, replacement starters for these older motors are gear-reduction motors.



GEAR-REDUCTION STARTER MOTOR

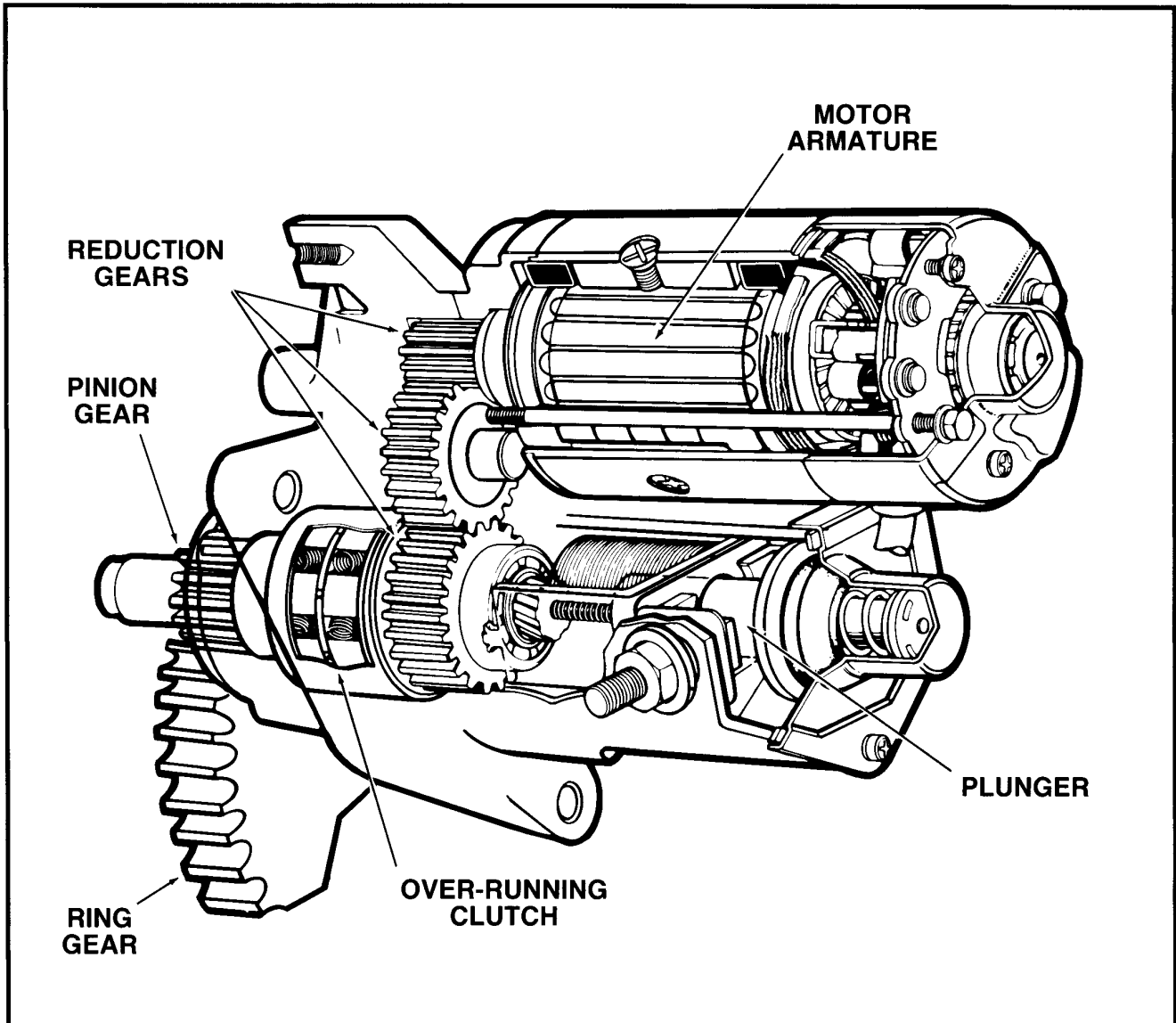
The gear-reduction starter motor contains the components shown. This type of starter has a compact, high-speed motor and a set of reduction gears. While the motor is smaller and weighs less than conventional starting motors, it operates at higher speed. The reduction gears transfer this torque to the pinion gear at 1/4 to 1/3 the motor speed. The pinion gear still rotates faster than the gear on a conventional starter **and** with much greater torque (cranking power).

The reduction gear is mounted on the same shaft as the pinion gear. And, unlike in the conventional

starter, the magnetic switch plunger acts directly on the pinion gear (not through a drive lever) to push the gear into mesh with the ring gear.

This type of starter was first used on the 1973 Corona MKII with the 4M, six cylinder engine. It is now used on most 1975 and newer Toyotas. Ratings range from 0.8KW on most Tercels and some older models to as high as 2.5KW on the diesel Corolla, Camry and Truck. The cold-weather package calls for a 1.4KW or 1.6KW starter, while a 1.0KW starter is common on other models.

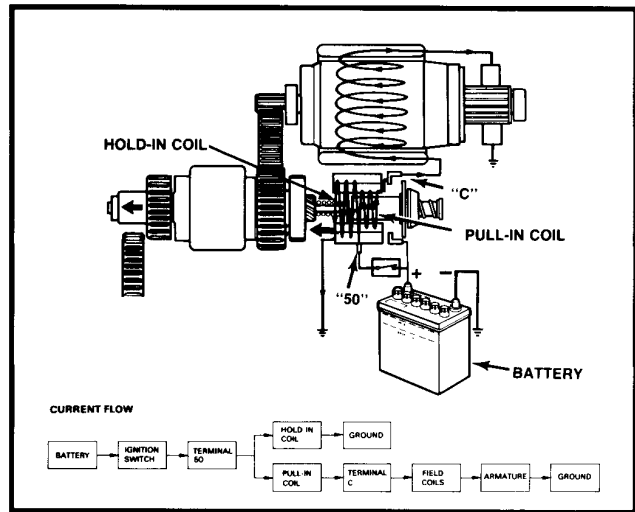
The gear-reduction starter is the replacement starter for most conventional starters.



GEAR-REDUCTION STARTER MOTOR

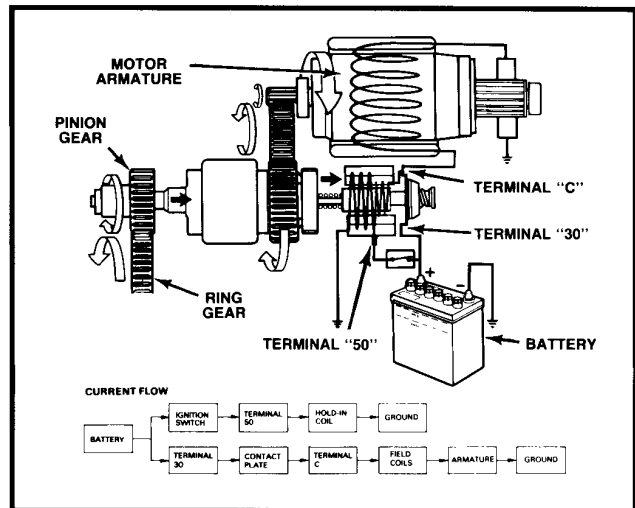
IGNITION SWITCH IN "ST"

- Current flows from the battery through terminal "50" to the hold-in and pull-in coils. Then, from the pull-in coil, current flows through terminal "C" to the field coils and armature coils.
- Voltage drop across the pull-in coil limits the current to the motor, keeping its speed low.
- The magnetic switch plunger pushes the pinion gear to mesh with the ring gear.
- The screw and low motor speed help the gears mesh smoothly.



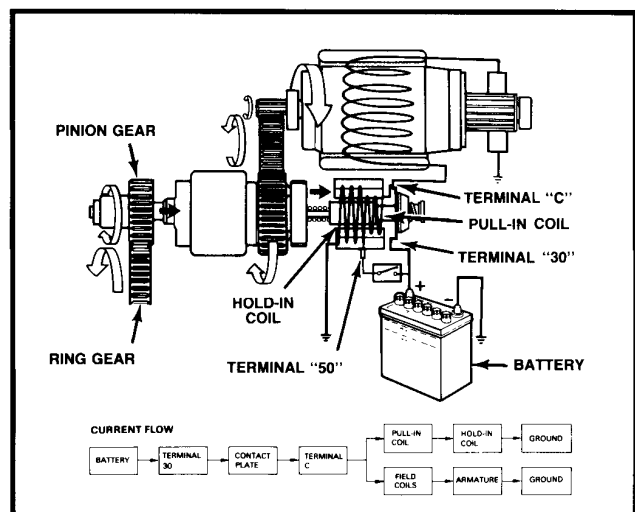
PINION AND RING GEARS ENGAGED

- When the gears are meshed, the contact plate on the plunger turns on the main switch by closing the connection between terminals "30" and "C."
- More current goes to the motor and it rotates with greater torque.
- Current no longer flows in the pull-in coil. The plunger is held in position by the hold-in coil's magnetic force.



IGNITION SWITCH IN "ON"

- Current no longer flows to terminal "50," but the main switch remains closed to allow current flow from terminal "C" through the pull-in coil to the hold-in coil.
- The magnetic fields in the two coils cancel each other, and the plunger is pulled back by the return spring.
- The high current to the motor is cut off and the pinion gear disengages from the ring gear.
- The armature has less inertia than the one in a conventional starter. Friction stops it, so a brake is not needed.

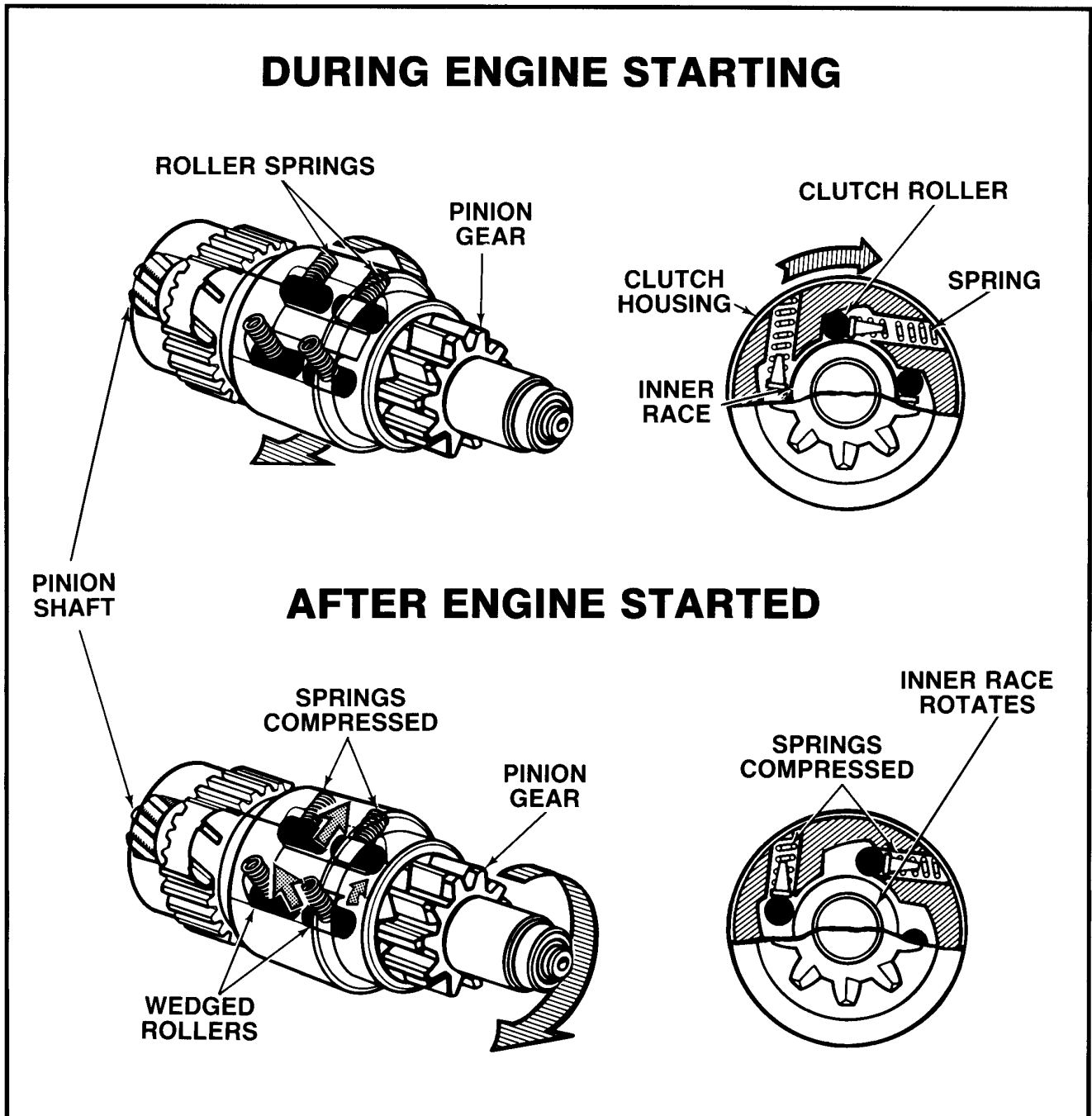


OVER-RUNNING CLUTCH

Both types of starter motors used on Toyota starting systems have a one-way clutch, or over-running clutch. This clutch prevents damage to the starter motor once the engine has been started. It does so, by disengaging its housing (which rotates with the motor armature) from an inner

race which is combined with the pinion gear. Spring loaded wedged rollers are used.

Without an over-running clutch, the starter motor would be quickly destroyed if engine torque was transferred through the pinion gear to the armature.



Diagnosis and Testing

The starting system requires little maintenance. Simply, keep the battery fully charged and all electrical connections clean and tight.

Diagnosis of starting system problems is relatively easy. The system combines electrical and mechanical components. The cause of a starting problem may be electrical (e.g., faulty switch) or mechanical (e.g., wrong engine oil or a faulty flywheel ring gear).

Specific symptoms of starting system problems include:

- The engine will not crank;

- The engine cranks slowly;
- The starter keeps running;
- The starter spins, but the engine will not crank; and,
- The starter does not engage or disengage properly.

For each of these problems, refer to the chart below for the possible causes and needed actions. Diagnosis starts with a thorough visual inspection. Testing includes: a starter motor current draw test, starter circuit voltage drop tests, operational and continuity checks of control components, and starter motor bench tests.

SYMPTOM	POSSIBLE CAUSE	ACTION NEEDED
Engine will not crank	<ul style="list-style-type: none"> ● Dead battery ● Melted fusible link ● Loose connections ● Faulty ignition switch ● Faulty magnetic switch, relay, neutral start switch or clutch switch ● Mechanical problem in engine ● Problem in theft deterrent system 	<ul style="list-style-type: none"> ● Check battery state-of-charge ● Replace fusible link ● Clean and tighten connections ● Check switch operation; replace as needed ● Check and replace as needed ● Check engine ● Check service manual for system tests
Engine cranks too slowly to start	<ul style="list-style-type: none"> ● Weak battery ● Loose or corroded connections ● Faulty starter motor ● Mechanical problems with engine or starter 	<ul style="list-style-type: none"> ● Check battery and charge as needed ● Clean and tighten connections ● Test starter ● Check engine and starter; replace worn out parts
Starter keeps running	<ul style="list-style-type: none"> ● Damaged pinion or ring gear ● Faulty plunger in magnetic switch ● Faulty ignition switch or control circuit ● Binding ignition key 	<ul style="list-style-type: none"> ● Check gears for wear or damage ● Test starter pull-in and hold-in coils ● Check switch and circuit components ● Check key for damage
Starter spins, but engine will not crank	<ul style="list-style-type: none"> ● Faulty over-running clutch ● Damaged or worn pinion gear or ring gear 	<ul style="list-style-type: none"> ● Check over-running clutch for proper operation ● Check gears for damage and wear; replace as needed
Starter does not engage/disengage properly	<ul style="list-style-type: none"> ● Faulty magnetic switch ● Damaged or worn pinion gear or ring gear 	<ul style="list-style-type: none"> ● Bench test starter ● Check gears for damage and wear; replace as needed

VISUAL INSPECTION

A visual inspection of the starting system can uncover a number of simple, easy-to-correct problems.

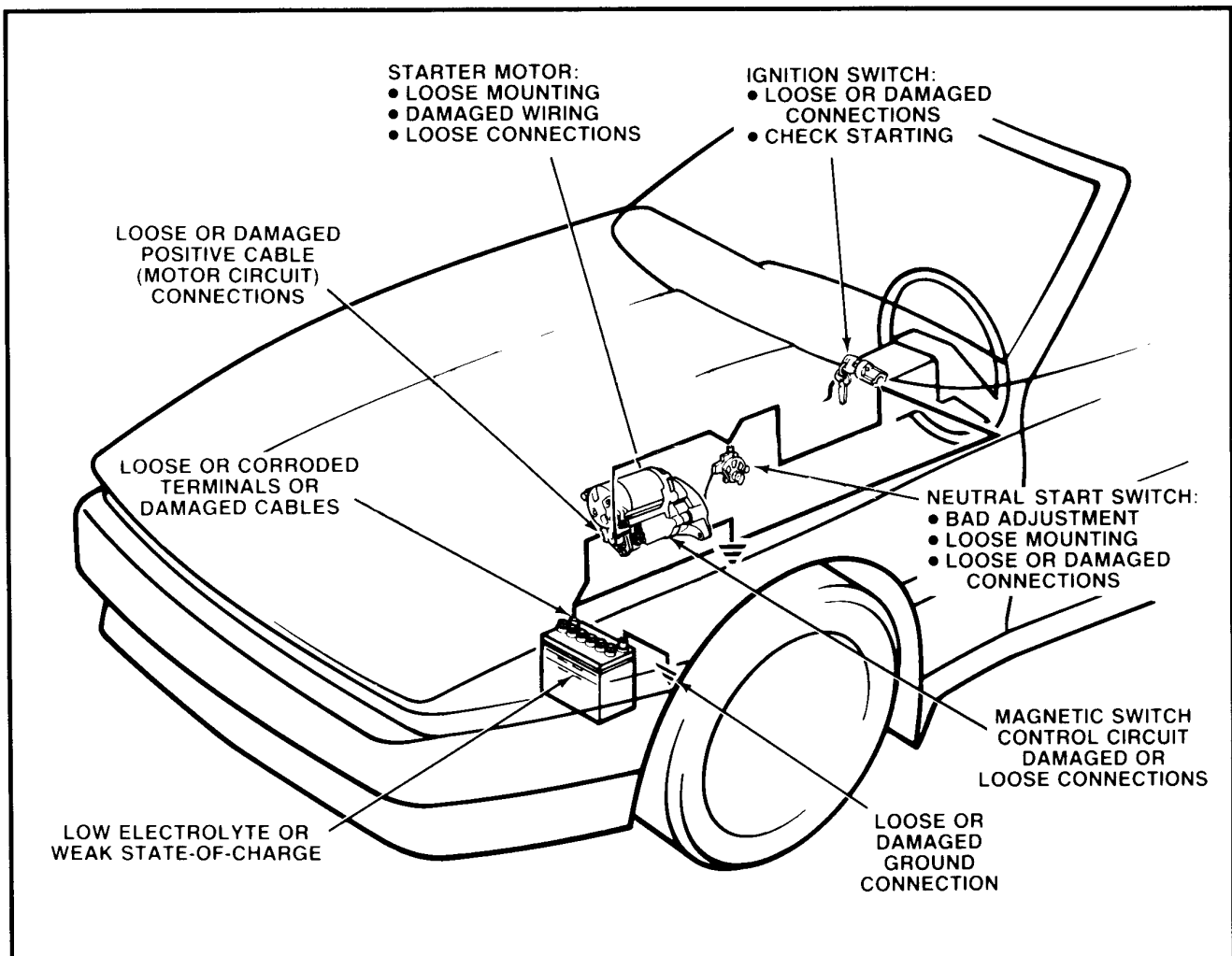
• **SAFETY FIRST:** The same safety considerations used in checking the battery apply here. Remove rings, wristwatch, other jewelry that might contact battery terminals. Wear safety glasses and protective clothing. Be careful not to spill electrolyte and know what to do if electrolyte gets in your eyes, on your skin or clothing, or on the car's finish. Write down programmed settings on electronic components. Avoid causing sparks.

• **STARTING PERFORMANCE:** Check the starting performance. Problem symptoms, possible causes, and needed actions are shown in the chart on the previous page.

• **BATTERY CHECKS:** Inspect the battery for corrosion, loose connections. Check the electrolyte level, condition of the plates and separators, and state of charge (specific gravity or open-circuit voltage). Load test the battery. It must be capable of providing at least 9.6 volts during cranking.

• **STARTER CABLES:** Check the cable condition and connections. Insulation should not be worn or damaged. Connections should be clean and tight.

• **STARTER CONTROL CIRCUIT:** Check the operation of the ignition switch. Current should be supplied to the magnetic switch when the ignition is "on" and the clutch switch or neutral start switch is closed. Faulty parts that prevent cranking can be located using a remote-control starter switch and a jumper wire. Use the "split half" diagnosis method. Ohmmeter checks can also identify component problems.



CURRENT DRAW TEST

A starter current draw test provides a quick check of the entire starting system. With the Sun VAT-40 tester, it also checks battery's cranking voltage. If another type of tester is used, follow the manufacturer's recommended procedure.

The starting current draw and cranking voltage should meet the specifications listed for the Toyota model being tested. Typical current draw specs are 130-150 amps for 4-cylinder models and 175 amps for 6-cylinder models. Cranking voltage specs range from 9.6 to 11 volts. Always refer to the correct repair manual. Only perform the test with the engine at operating temperature.

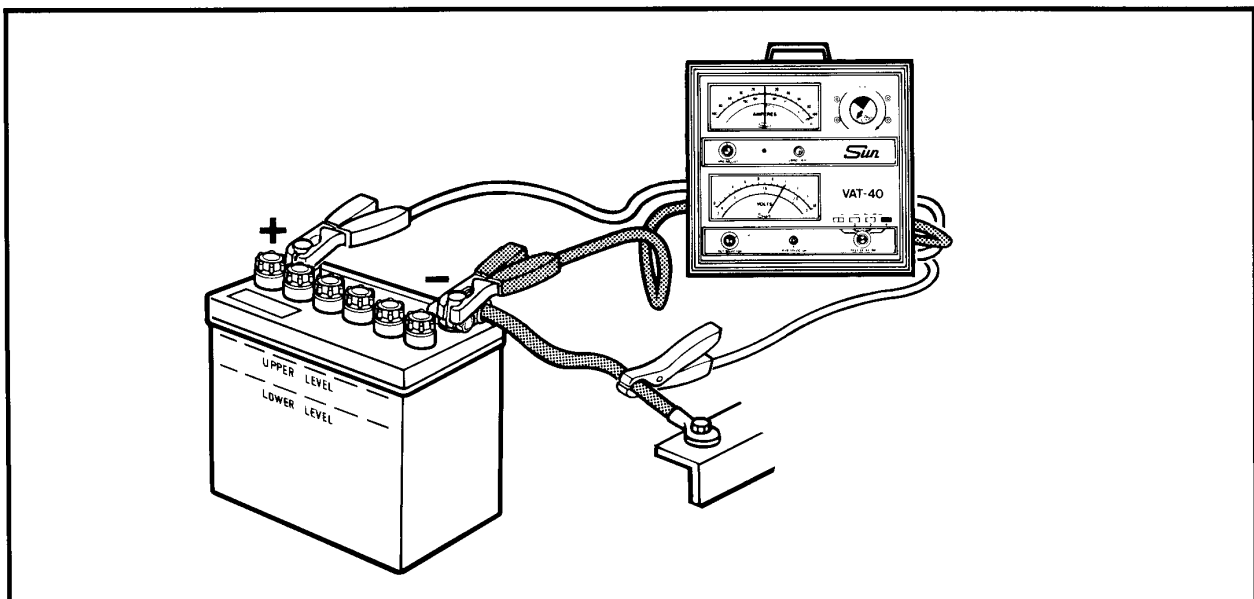
The following steps outline a typical procedure for performing a current draw test on a starting system:

1. This test should be made only with a serviceable battery. The specific gravity readings at 80°F should average at least 1.190 (50% charged). Charge the battery, if necessary.
2. 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.

NOTE: Battery open-circuit voltage should be at least 12.2 volts (50% charged). If not, the battery requires charging.

3. Connect the clamp-on Amps Pickup around the battery ground cable or cables.
4. Make sure all lights and accessories are off and vehicle doors are closed.
5. Set the Test Selector switch to #1 STARTING.
6. Disable the ignition so the engine does not start during testing.
7. Crank the engine, while observing the tester ammeter and voltmeter.
 - Cranking speed should be normal (200-250 rpm).
 - Current draw should not exceed the maximum specified.
 - Cranking voltage should be at or above the minimum specified.
8. Restore the engine to starting condition and remove tester leads.

TEST RESULTS: High current draw and low cranking speed usually indicate a faulty starter. High current draw may also be caused by engine problems. A low cranking speed with low current draw, but high cranking voltage, usually indicates excessive resistance in the starter circuit. Remember that the battery must be fully charged and its connections tight to insure accurate results.



VOLTAGE-DROP TESTS

Voltage-drop testing can detect excessive resistance in the starting system. High resistance in the starter motor circuit (power side or ground side) will reduce current to the starting motor. This can cause slow cranking speed and hard starting. High resistance in the starter control circuit will reduce current to the magnetic switch. This can cause improper operation or no operation at all.

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

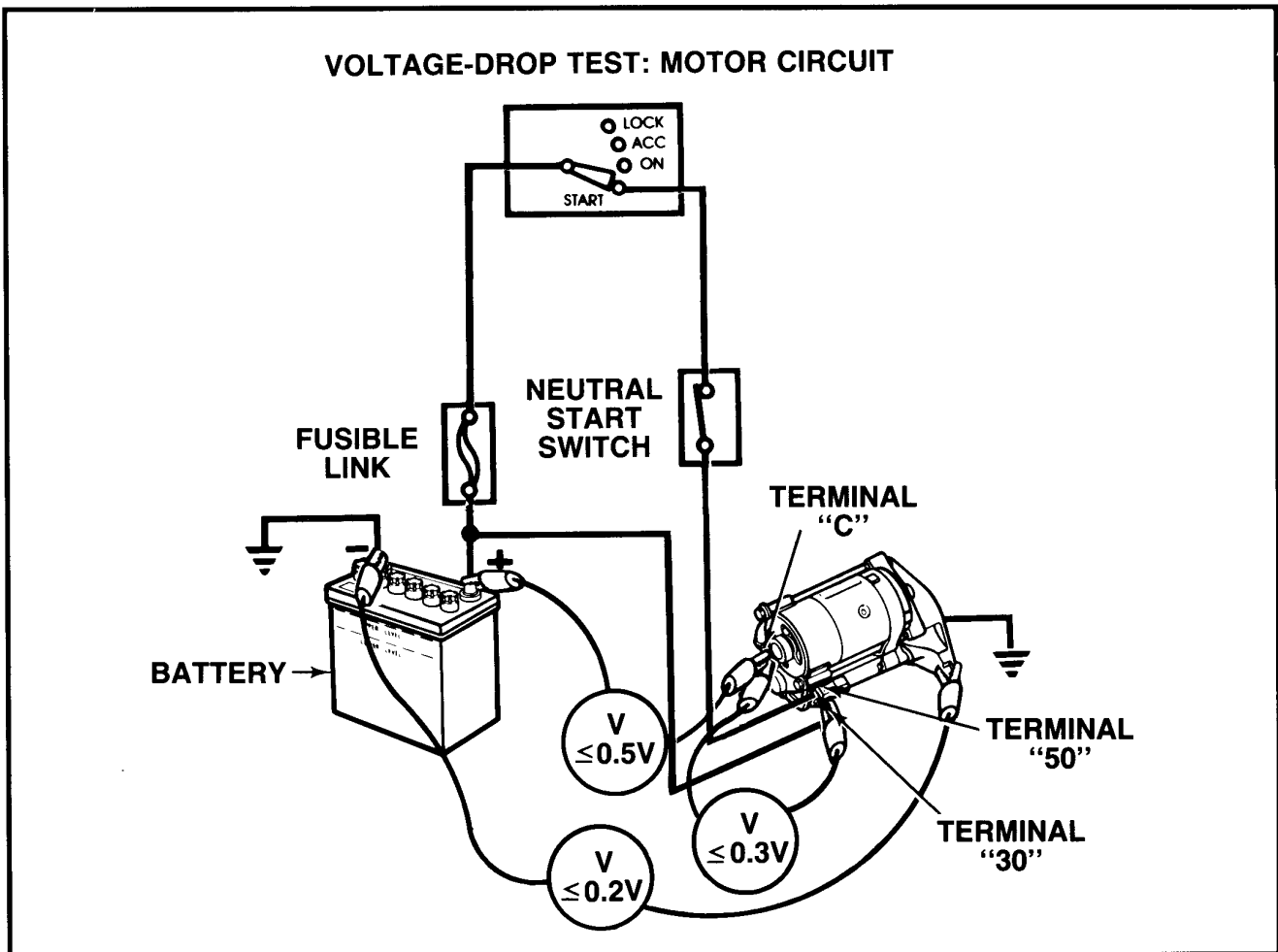
Motor Circuit (insulated Side)

1. If using the Sun VAT-40, set the Volt Selector to EXT 3V. For other voltmeters, use a low scale.
2. Connect the voltmeter leads ... RED to the battery positive (+) terminal, BLACK to terminal "C" on the starter motor magnetic switch.

3. Disable the ignition so the engine cannot start during testing.

NOTE: On models with the Integrated Ignition Assembly, disconnect the "IIA" plug. On others, disconnect the power plug to the remote igniter assembly (black-orange wire).

4. Crank the engine and observe the voltmeter. Less than 0.5 volt indicates acceptable resistance. More than 0.5 volt indicates excessive resistance. This could be caused by a damaged cable, poor connections, or a defective magnetic switch.
5. If excessive resistance is indicated, locate the cause. Acceptable voltage drops are 0.3 volt across the magnetic switch, 0.2 volts for the cable, and zero volts for the cable connection. Repair or replace components, as needed.



Motor Circuit (Ground Side)

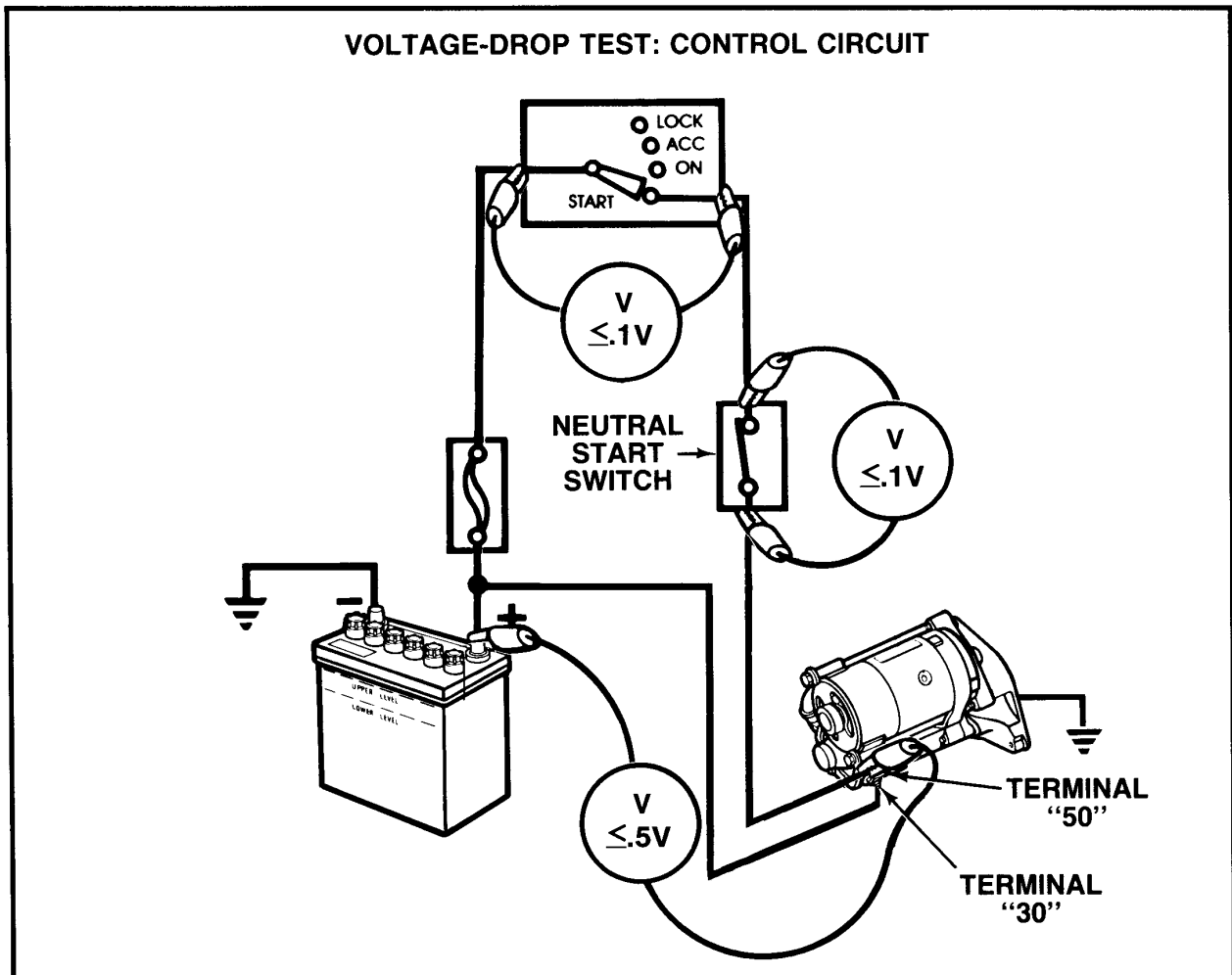
1. Connect the voltmeter leads ... RED to the starter motor housing, BLACK to the battery ground (-) terminal.
2. Crank the engine and observe the voltmeter. Less than 0.2 volt indicates acceptable resistance. More than 0.2 volt indicates excessive resistance. This could be caused by a loose motor mount, a bad battery ground, or a loose connection. Repair or replace components as necessary. Make sure engine-to-body ground straps are secure.

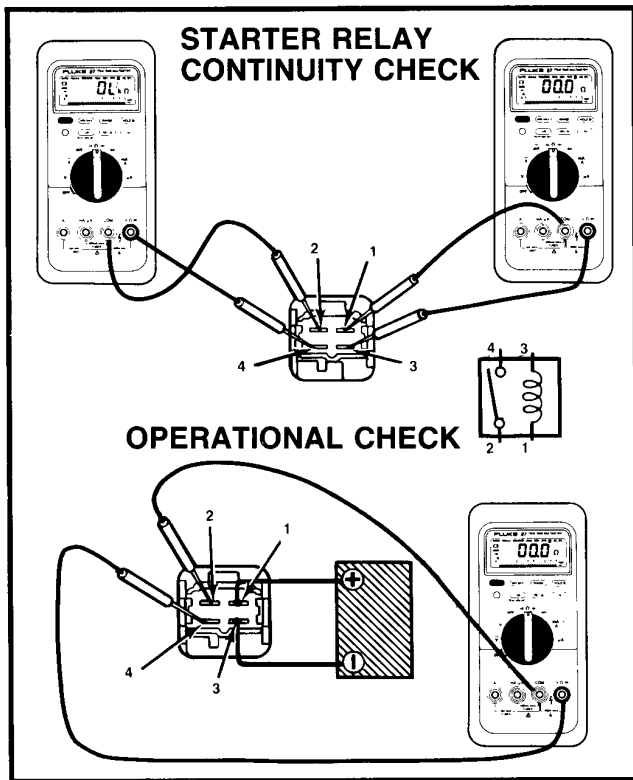
Control Circuit

1. Connect the voltmeter leads ... RED to the battery positive (+) terminal, BLACK to terminal "50" of the starting motor.
2. On vehicles with automatic transmission, place the lever in Park or Neutral. On vehicles with manual transmission, depress the clutch.

(NOTE: A jumper wire could be used to bypass either of these switches).

3. Crank the engine and observe the voltmeter. Less than .5 volt is acceptable. If the current draw was high or cranking speed slow, the starter motor is defective. More than .5 volt indicates excessive resistance. Isolate the trouble and correct the cause.
4. Check the neutral start switch or clutch switch for excessive voltage drop. Also check the ignition switch. Adjust or replace a defective switch, as necessary.
5. An alternate method to checking the voltage drop across each component is to leave the voltmeter connected to the battery (+) terminal and move the voltmeter negative lead back through the circuit toward the battery. The point of high resistance is found between the point where voltage drop fell within specs and the point last checked.





COMPONENT TESTS

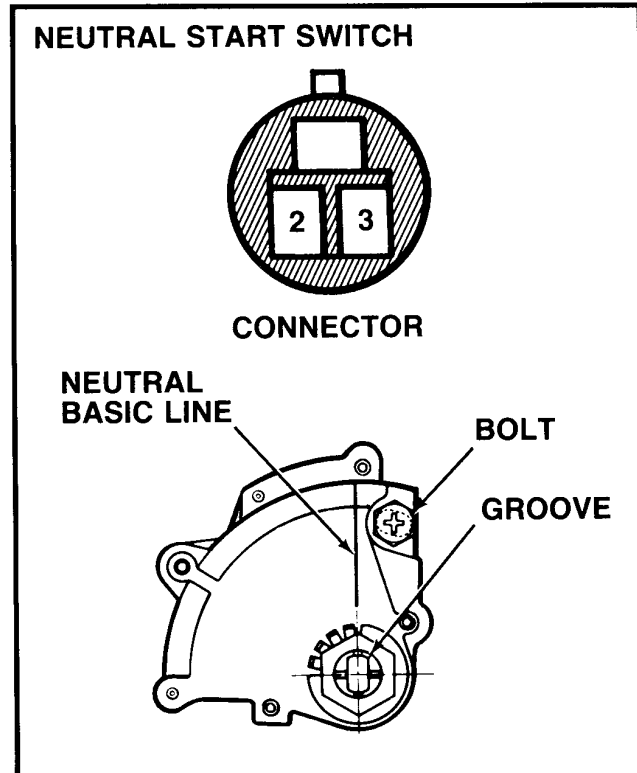
For the various tests on starting system components, refer to the appropriate Toyota repair manual for testing procedures and specifications.

Ignition Switch and Key

The ignition switch should be checked both mechanically as well as electrically. Make sure the switch turns smoothly, without binding. And, check the ignition key for wear or metal chips that might cause the switch to stick in the "start" position. Some duplicate keys have caused this problem. If an electrical problem is suspected, disconnect the battery and check the switch for proper operation and continuity using an ohmmeter.

Starter Relay

- Continuity Check: Using an ohmmeter, check for continuity between terminals 1 and 3, and, for no continuity, between terminals 2 and 4. Replace the relay if continuity is not as specified.
- Operational Check: Apply battery voltage across terminals 1 and 3 and check for continuity between terminals 2 and 4. Replace the relay if operation is not as specified.

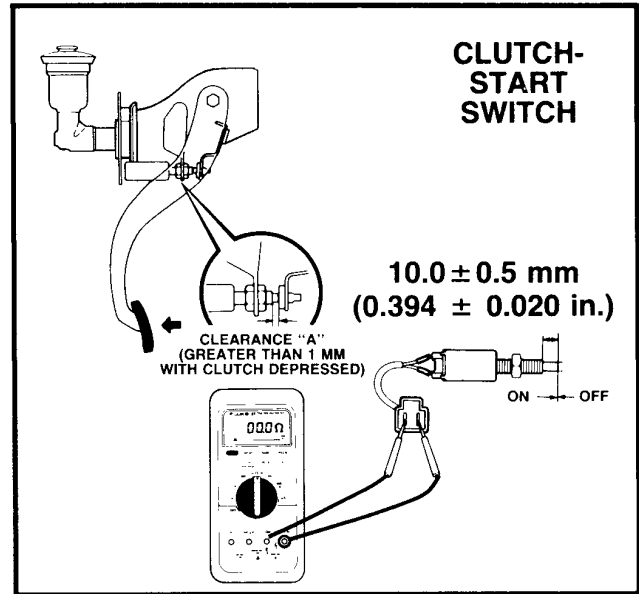


Neutral Start Switch

If the engine will start with the shift selector in any range other than "N" or "P," adjust the switch. First, loosen the switch bolt and set the selector to "N." Then, disconnect the switch connector and connect an ohmmeter between terminals 2 and 3. Adjust the switch until there is continuity. (Refer to appropriate Service Manual for specific vehicle procedures.)

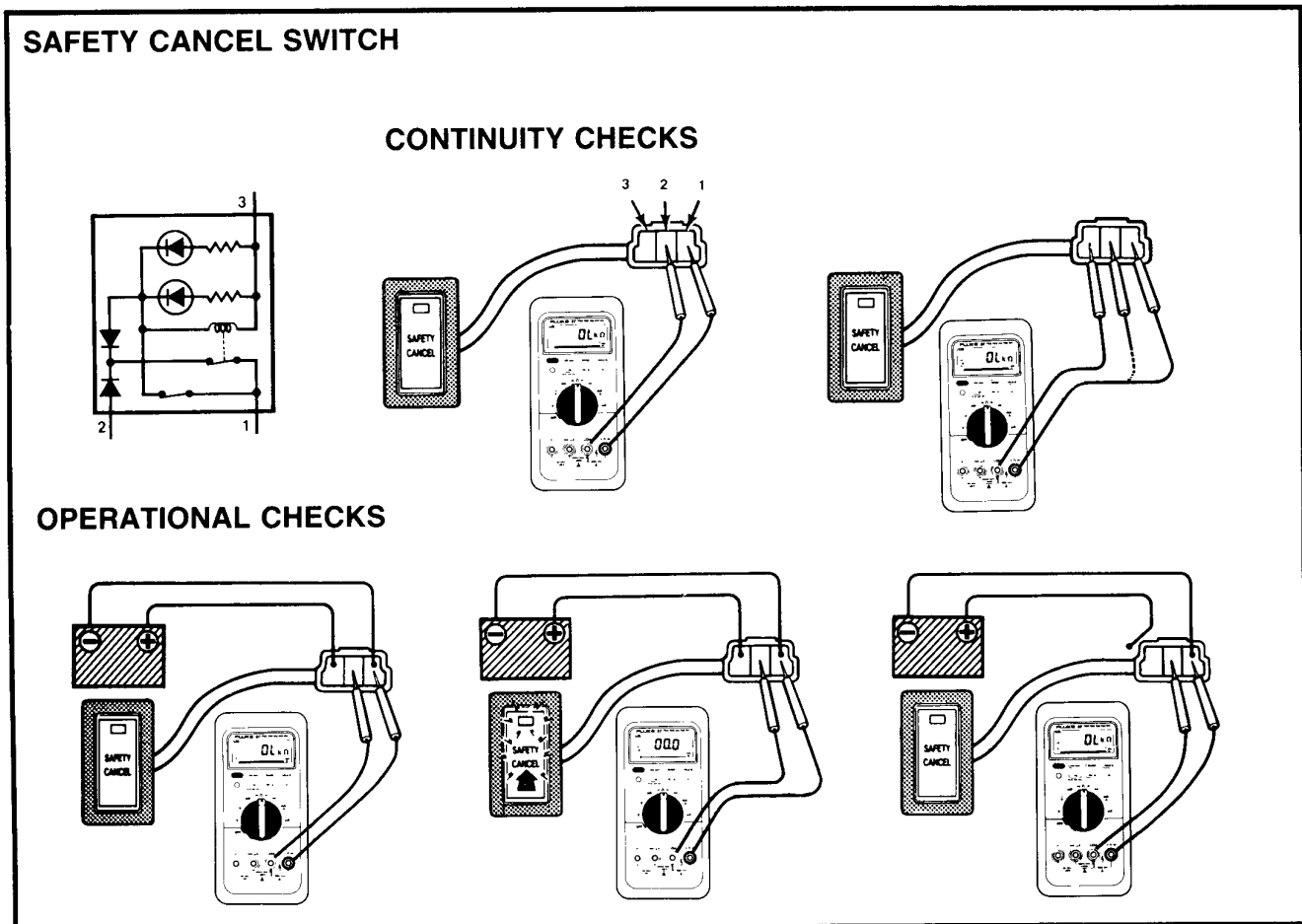
Clutch Start Switch

Follow the procedure given in Toyota repair manuals for checking pedal height and freeplay. Then, check the switch for proper operation and continuity. Using an ohmmeter on the switch connector, there should be continuity when the switch is ON (clutch depressed) and no continuity when the switch is OFF (clutch not depressed). If continuity is not as specified, replace the switch.



Safety Cancel Switch

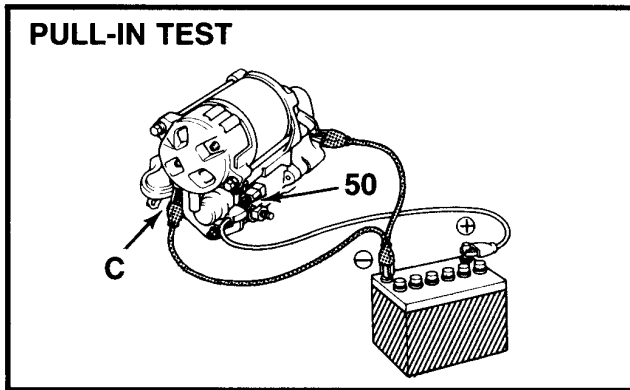
- **Continuity Checks:** Using an ohmmeter, there should be no continuity between terminals 2 and 1, 3 and 1, or 2 and 3. If there is continuity, replace the switch.
- **Operational Checks:** Connect a battery between terminals 3 and 1 as shown. No continuity should be seen between terminals 1 and 2. But, when the switch is pushed "on," there should be continuity. If operation is not as specified, replace the safety cancel switch.



MOTOR BENCH TESTS

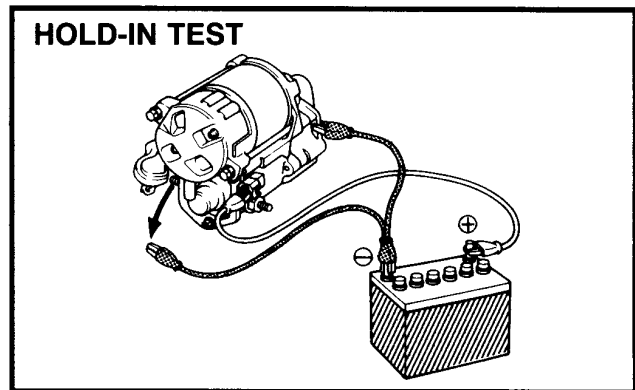
If the on-vehicle checks have indicated that the starter motor is faulty, it should be removed for bench testing and replacement.

- Always disconnect the battery ground (–) cable before removing the starting motor.
- **Complete each bench test within 3-5 seconds to avoid burning out the coil.**
- Refer to the appropriate repair manual for test specifications.



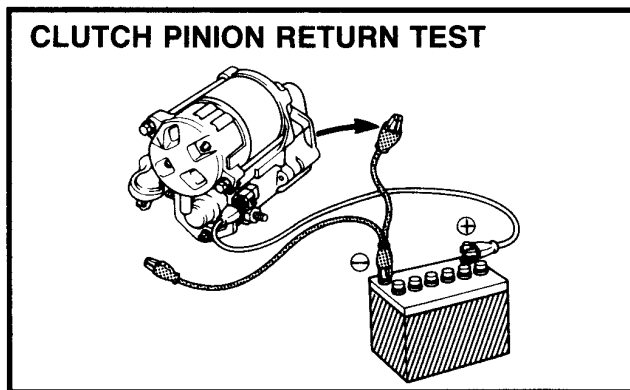
PULL-IN TEST

1. Disconnect the field coil lead from terminal "C."
2. Connect the battery to the magnetic switch ... positive (+) lead to terminal "50," negative (–) leads to the switch body and terminal "C."
3. The clutch pinion gear should move outward. If it doesn't, replace the magnetic switch.



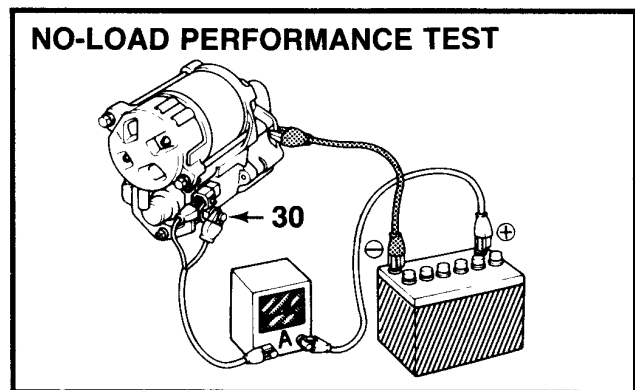
HOLD-IN TEST

1. With the clutch pinion gear out, disconnect the negative (–) lead from terminal "C."
2. The clutch pinion gear should remain out. If it returns inward, replace the magnetic switch.



CLUTCH PINION RETURN TEST

1. Disconnect the negative (–) lead from the switch body.
2. The clutch pinion gear should return inward. If it doesn't, replace the magnetic switch.



NO-LOAD PERFORMANCE TEST

1. Connect the battery negative (–) lead to the switch housing, the positive (+) lead to the ammeter.
2. Connect the ammeter negative (–) leads to terminal "30" and to terminal "50."
3. The starter should rotate smoothly with the pinion gear moving out. The ammeter should read specified current. (Refer to "Starter" section of Toyota repair manual.)

SELF TEST

This brief self-test will help you measure your understanding of The Starting System. The style is the same as that used for A.S.E. certification tests. The answers to this self test are shown on next page.

1. The starting system has two circuits. They are the:
 - A. motor circuit and ignition circuit
 - B. insulated circuit and power circuit
 - C. motor circuit and control circuit
 - D. ground circuit and control circuit
2. A basic starter control circuit energizes the magnetic switch through the ignition switch and the:
 - A. solenoid
 - B. neutral start switch
 - C. starter clutch
 - D. regulator
3. On a Toyota gear-reduction starter, the plunger in the magnetic switch:
 - A. pulls a drive lever to mesh the gears
 - B. pushes the pinion gear into mesh with the ring gear
 - C. is held in place by the pull-in coil
 - D. disengages the pinion gear from the starter armature
4. When an engine starts, the pinion gear is disconnected from the starter by the:
 - A. magnetic switch
 - B. plunger
 - C. over-running clutch
 - D. switch return spring
5. If the engine cranks too slow to start, the problem may be caused by:
 - A. engine problems
 - B. a faulty neutral start switch
 - C. an open relay in the control circuit
 - D. a damaged pinion gear
6. If a starter motor spins but does not engage and crank the engine, the problem is most likely caused by a bad:
 - A. magnetic switch
 - B. over-running clutch
 - C. positive battery cable
 - D. ignition switch
7. When performing a starter current draw test, low current draw usually indicates:
 - A. high resistance
 - B. a bad starter
 - C. a discharged battery
 - D. a short in the starter
8. When performing a starter current draw test, high current draw usually indicates:
 - A. a discharged battery
 - B. high resistance
 - C. battery terminal corrosion
 - D. engine problems or a bad starter
9. A test of a starting system reveals that the voltage drop between the battery positive (+) post and the starter motor terminal "C" is about one volt. The most probable cause is:
 - A. low resistance in the motor circuit
 - B. high resistance in the motor circuit
 - C. low resistance in the control circuit
 - D. high resistance in the control circuit
10. The voltage drop on the ground side of the starter motor circuit should be no more than:
 - A. battery voltage
 - B. 0.1 volt
 - C. 0.2 volt
 - D. 0.5 volt

SELF-TEST ANSWERS

For the preceding self-test on The Starting 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 starting system has two separate electrical circuits ... a control circuit and a motor circuit. (Page 1.)
2. "B" - If the transmission is in gear, the control circuit between the ignition switch and starter magnetic switch is interrupted by the neutral start switch. (Page 2.)
3. "B" - Unlike in the conventional starter, the magnetic switch plunger acts directly on the pinion gear (not through a drive lever) to push the gear into mesh with the ring gear. (Page 4.)
4. "C" - An over-running clutch disengages the pinion gear and prevents damage to the starter motor when the engine starts. (Page 7.)
5. "A" - If the engine cranks too slow to start, the cause may be a discharged battery, loose or corroded connections, a faulty starter, or engine problems such as the wrong oil. (Page 8.)
6. "B" - If the starter motor spins, but the engine will not crank, check the over-running clutch. (Page 8.)
7. "A" - Low current draw, with a low cranking speed and high cranking voltage, usually indicates excessive resistance in the starting circuit. (Page 10.)
8. "D" - High current draw, with a low cranking speed, usually indicates a faulty starter or engine problems such as the wrong oil or ignition timing. (Page 10.)

9. "B" - With the voltmeter leads connected between the battery (+) terminal and the motor "C" terminal, a reading of more than 0.5 volt indicates excessive resistance (in the motor circuit). (Page 11.)

10. "C" - With the voltmeter leads connected between the battery (-) terminal and the motor housing, a reading of more than 0.2 volt indicates excessive resistance (in the motor ground circuit). (Page 12.)

ASSIGNMENT

NAME: _____

1. List the two starting system circuits.
2. List the components that make up the “control circuit”.
3. List the components that make up the “motor circuit”.
4. Explain in detail how a “Conventional Starter” differs from that of a “Gear Reduction Starter”.
5. Explain why an “overrunning clutch” is needed and how it works.
6. Explain how the “starter drive pinion” engages (pushed out) with the ring gear when the ignition key is turned to the “Start” position.
7. List and describe the five items included in a “Visual Inspection”.
8. Explain in detail the steps taken in order to perform a “Current Draw Test”.
9. Explain the procedure and the need for a voltage drop test of the “Motor Circuit”