

STARTER	
Free Speed	3000 RPM (min.) @ 11.5 V
Free Current	90 amp (max.) @ 11.5 V
Stall Current	400 amp (max.) @ 2.4 V
Stall Torque	8 ft-lbs (11 Nm) (min.) @ 2.4 V

SERVICE WEAR LIMITS	IN.	MM
Brush Length (minimum)	0.433	11.0
Commutator Diameter (minimum)	1.141	28.981

TORQUE VALUES

ITEM	TORQUE		NOTES
Battery Terminal Hardware	60-96 in-lbs	7-11 Nm	page 5-18
Starter Battery Positive Cable Nut	60-85 in-lbs	7-10 Nm	metric, page 5-18
Starter Mounting Bolts	13-20 ft-lbs	18-27 Nm	page 5-18

GENERAL

The starter is made up of an armature, field winding assembly, solenoid, drive assembly, idler gear and drive housing.

The starter motor torque is increased through gear reduction. The gear reduction consists of the drive pinion on the armature, an idler gear and a clutch gear in the drive housing. The idler gear is supported by rollers. The clutch gear is part of the overrunning clutch/drive assembly.

The overrunning clutch is the part which engages and drives the clutch ring gear. It also prevents the starter from overrunning. The field windings are connected in series with the armature through brushes and commutator segments.

Wiring Diagrams

For additional information concerning the starting system circuit, see the wiring diagram at the end of Section 7, ELECTRICAL.

Starter Relay

The starter relay is not repairable. Replace the unit if it fails.

Starter Interlock

See [7.5 STARTER INTERLOCK](#) for operation and troubleshooting information.

OPERATION

See [Figure 5-1](#). When the starter switch is pushed, the starter relay is activated and battery current flows into the pull-in winding (10) and the hold-in winding (11), to ground.

The magnetic forces of the pull-in and hold-in windings in the solenoid push the plunger (7) causing it to shift to the left. This action engages the pinion gear (1) with the clutch ring gear (13). At the same time, the main solenoid contacts (8) are closed, so battery current flows directly through the field windings (3) to the armature (4) and to ground. Simultaneously, the pull-in winding (10) is shorted.

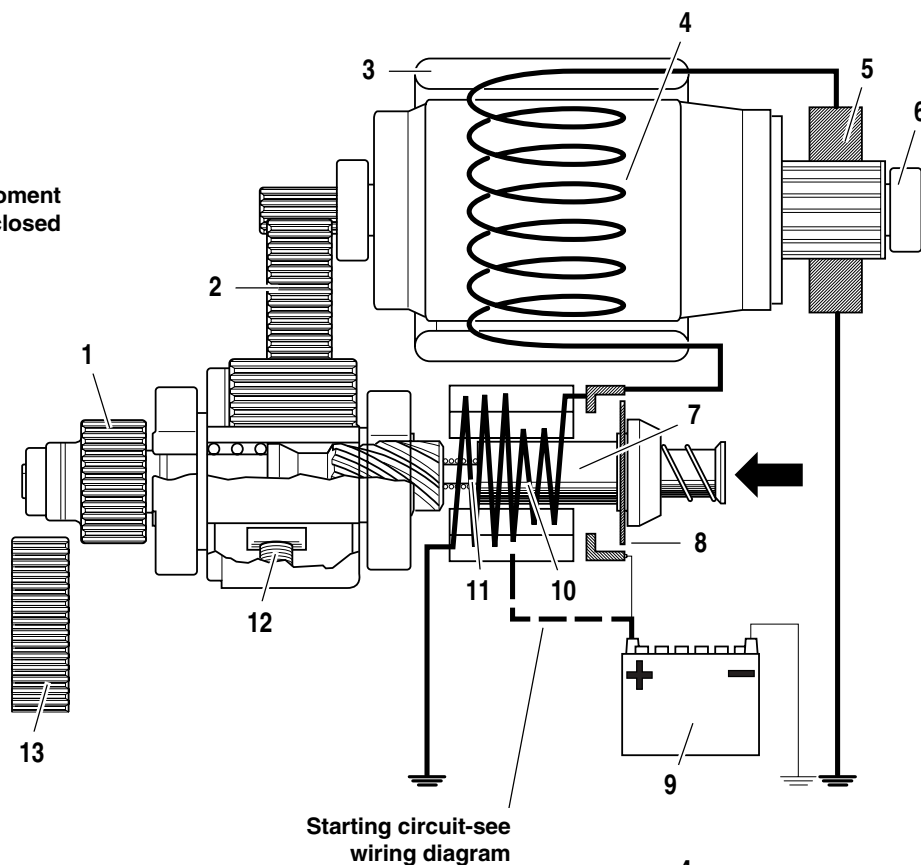
The current continues flowing through the hold-in winding (11) keeping the main solenoid contacts (8) closed. At this point, the starter begins to crank the engine.

After the engine has started, the pinion gear (1) turns freely on the pinion shaft through the action of the overrunning clutch (12). The overrunning clutch prevents the clutch ring gear (13) (which is now rotating under power from the engine) from turning the armature (4) too fast.

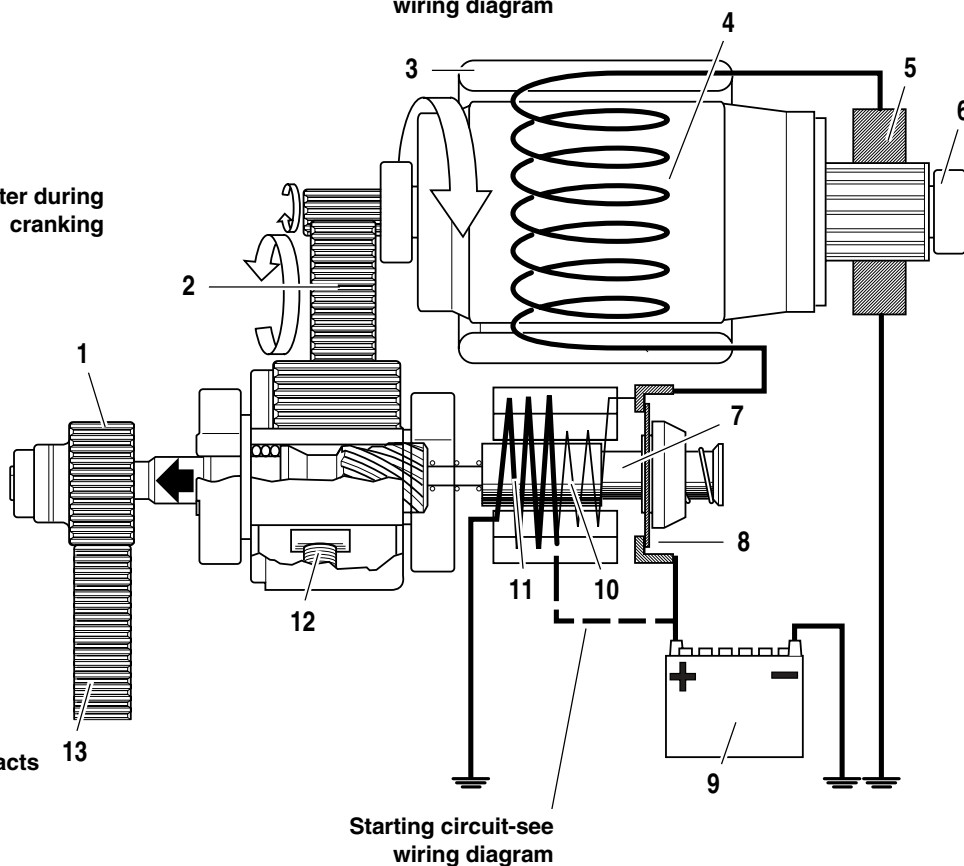
When the starter switch is released, the current of the hold-in winding (11) is fed through the main solenoid contacts (8) and the direction of the current in the pull-in winding (10) is reversed. The solenoid plunger (7) is returned to its original position by the return spring, which causes the pinion gear (1) to disengage from the clutch ring gear (13).

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Starter at moment
starter switch is closed



Starter during
cranking



1. Pinion Gear
2. Idler Gear
3. Field Winding
4. Armature
5. Brush
6. Ball Bearing
7. Solenoid Plunger
8. Main Solenoid Contacts
9. Battery
10. Pull-in Winding
11. Hold-in Winding
12. Overrunning Clutch
13. Clutch Ring Gear

Figure 5-1. Starter Operation

Table 5-1. Troubleshooting

PROBLEM	SOURCE OF PROBLEM	PROBABLE CAUSE	SOLUTION
1. Starter does not run or runs at very low speeds.	Battery.	Voltage drop due to discharged battery. Short-circuited or open between electrodes. Poor contact condition of battery terminal(s).	Charge battery. Replace battery. Clean and retighten.
	Wiring.	Disconnection between starter switch and solenoid terminal. Malfunction in starter interlock system.	Repair or replace wire. See 7.5 STARTER INTERLOCK .
	Starting switch or starter relay.	Poor contact condition or poor connection.	Replace.
	Solenoid.	Poor contact condition caused by burnt contact. Contact plate removed. Pull-in winding open or short-circuited. Hold-in winding open.	Polish contact surface or replace solenoid assembly. Repair. Replace solenoid assembly. Replace solenoid assembly.
	Starting motor.	Poor contact condition of brushes. Commutator burnt. Commutator high mica. Field winding grounded. Armature winding grounded or short-circuited. Reduction gears damaged. Insufficient brush spring tension. Disconnected lead wire between solenoid and field windings. Ball bearing sticks.	Check brush spring tension. Correct on lathe or replace. Correct by undercutting. Replace. Replace. Replace. Replace. Repair or replace lead wire. Replace bearing.
2. Pinion does not engage with ring gear while starter is running or engine cannot be cranked.	Battery.	Voltage drop due to discharged battery. Short-circuited or open between electrodes. Poor contact condition of battery terminal(s).	Charge battery. Replace battery. Clean and retighten.
	Wiring.	Disconnection between starter switch and solenoid terminal.	Repair or replace wire.
	Overrunning clutch.	Overrunning clutch malfunction (rollers or compression spring). Pinion teeth worn out. Pinion does not run in overrunning direction. Poor sliding condition of spline teeth. Reduction gears damaged.	Replace overrunning clutch. Replace overrunning clutch. Replace overrunning clutch. Remove foreign materials, dirt, or replace overrunning clutch. Replace overrunning clutch and idler gear.
	Ring gear.	Excessively worn teeth.	Replace ring gear.
3. Starter does not stop running.	Solenoid.	Return spring worn. Coil layer shorted. Contact plate melted and stuck.	Replace solenoid. Replace solenoid. Replace solenoid.
	Starting switch or starter relay.	Unopened contacts. Poor returning.	Replace starting switch or starter relay. Replace starting switch or starter relay.

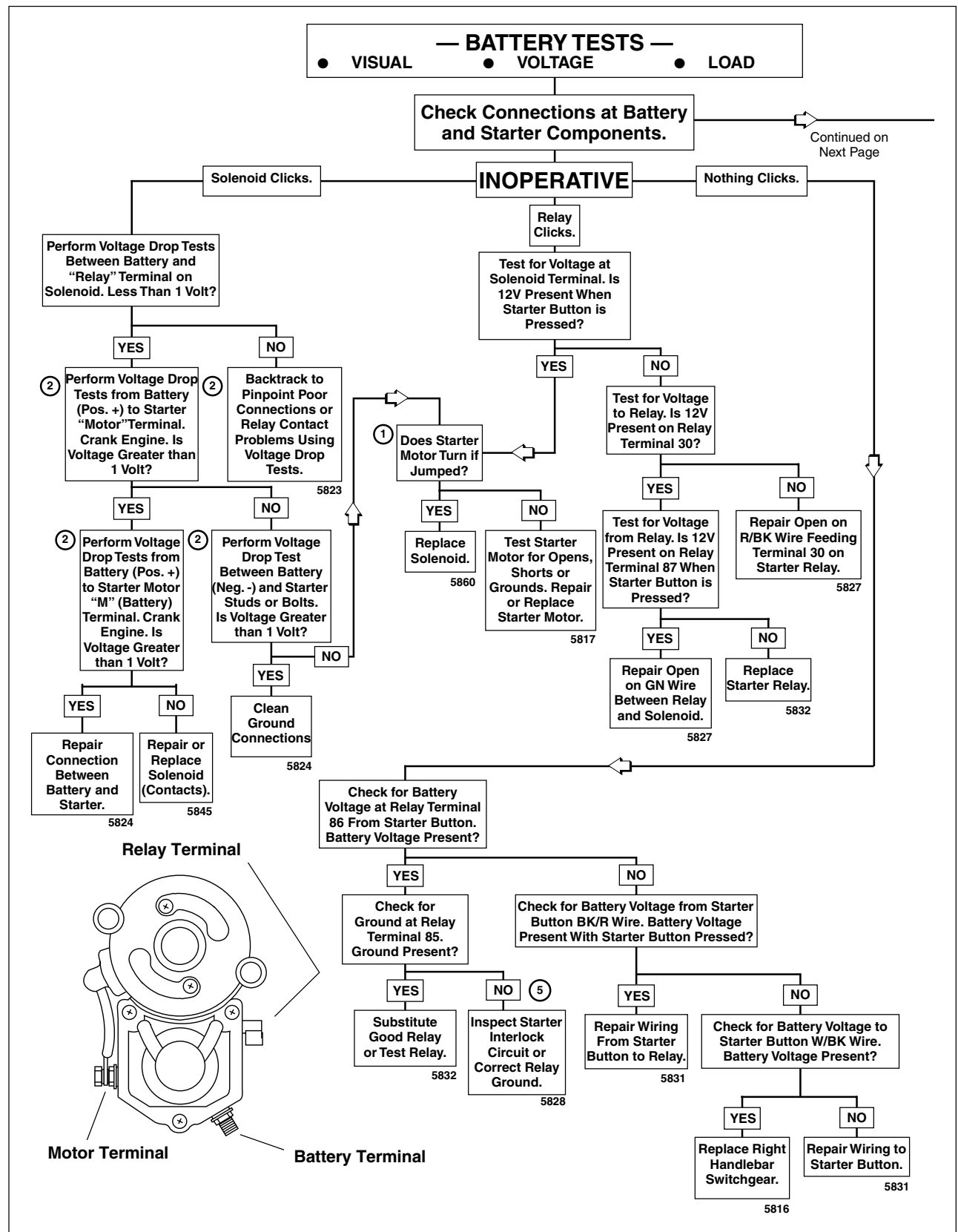


Figure 5-2. Starting System Diagnosis, Part 1

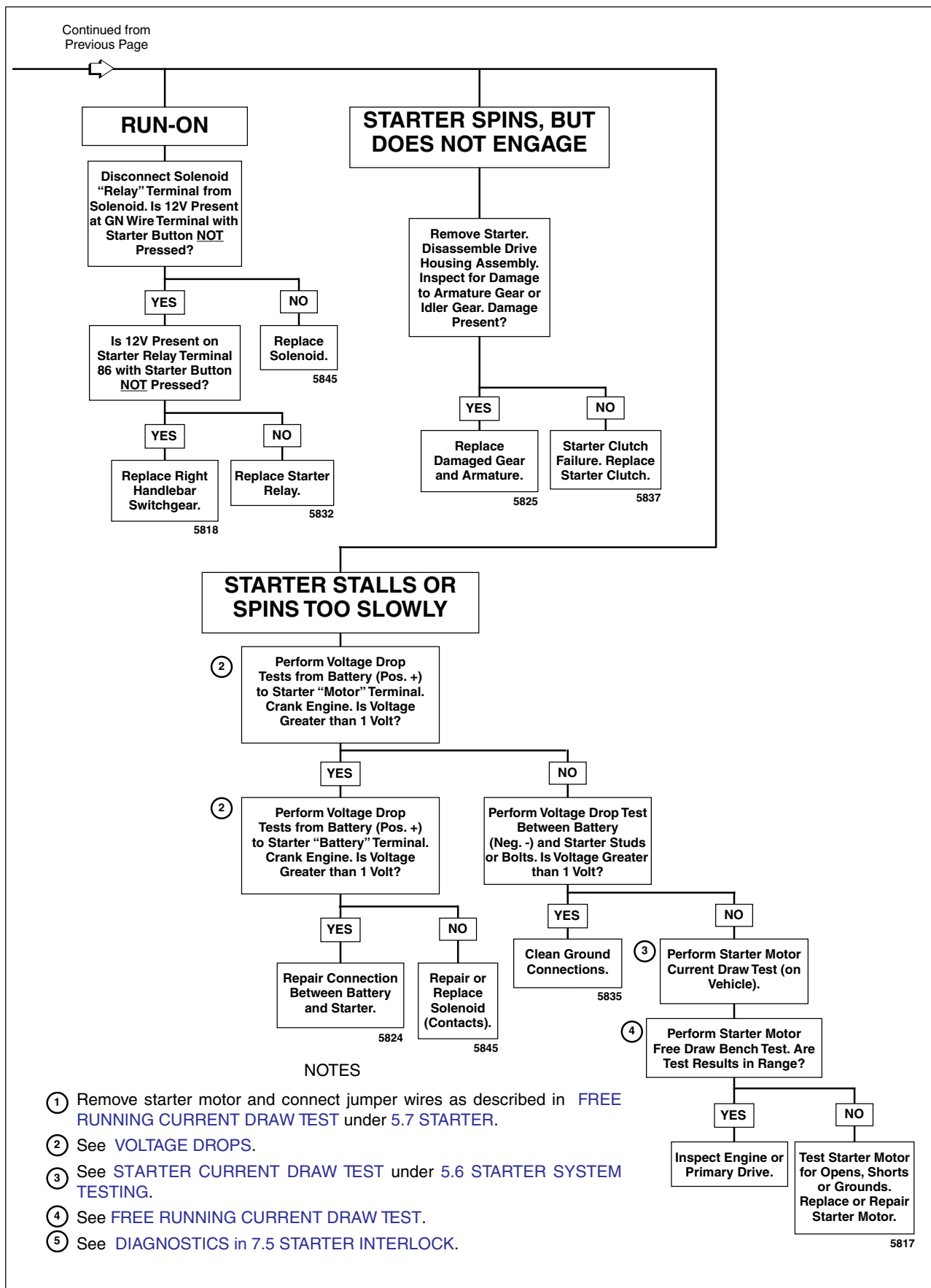


Figure 5-3. Starting System Diagnosis, Part 2

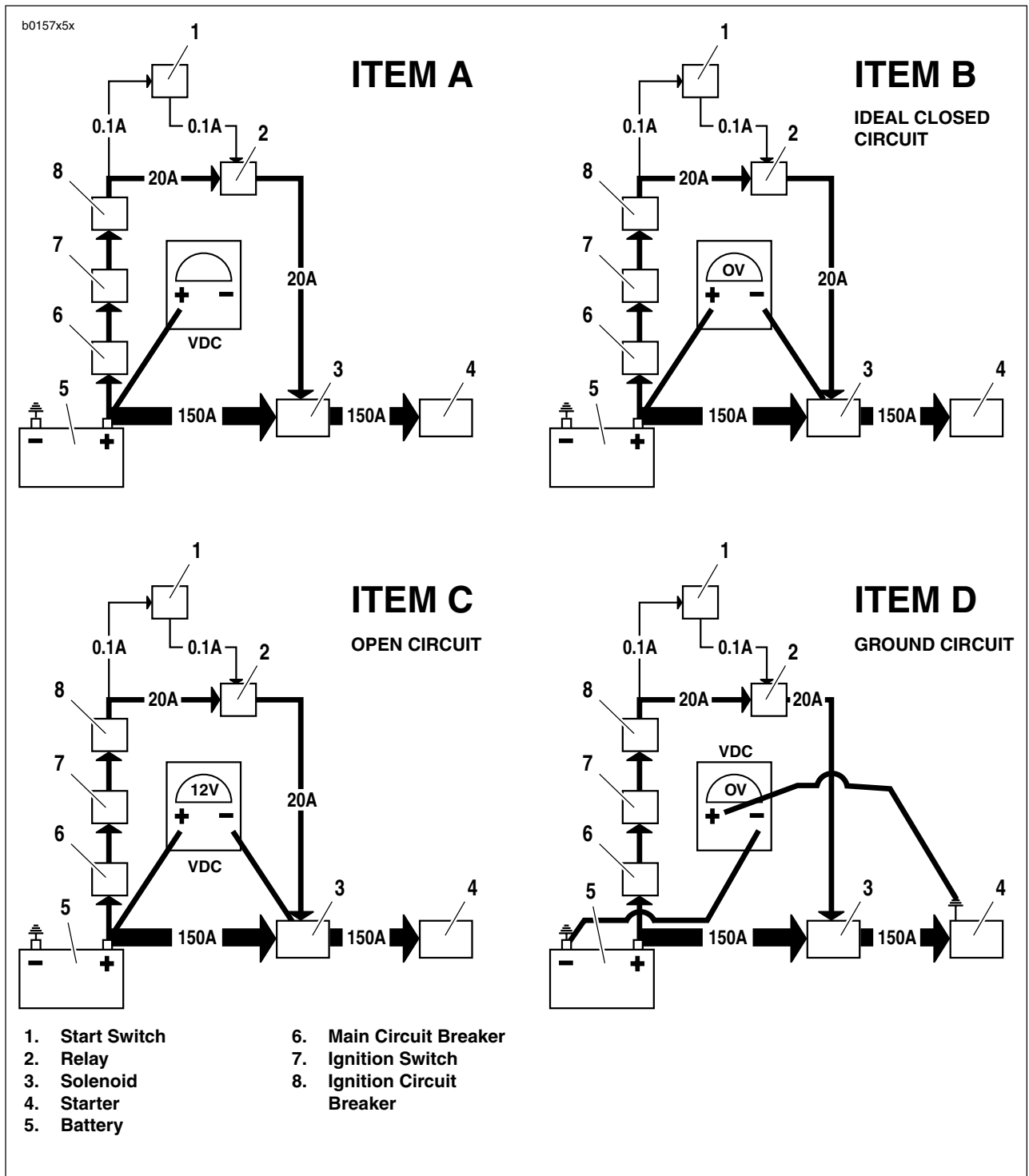


Figure 5-4. Typical Circuitry. Refer to wiring diagrams for more information.

GENERAL

The troubleshooting table beginning on [page 5-4](#) contains detailed procedures to solve and correct problems. Follow the [5.3 STARTING SYSTEM DIAGNOSIS](#) diagram to diagnose starting system problems. The [VOLTAGE DROPS](#) procedure below will help you to locate poor connections or components with excessive voltage drops.

VOLTAGE DROPS

Check the integrity of all wiring, switches, circuit breakers and connectors between the source and destination.

The voltage drop test measures the difference in potential or the actual voltage dropped between the source and destination.

1. See [ITEM A](#) in [Figure 5-4](#). Attach your red meter lead to the most positive part of the circuit, which in this case would be the positive post of the battery (5).
2. See [ITEM B](#) in [Figure 5-4](#). Attach the black meter lead to the final destination or component in the circuit (solenoid terminal from relay).
3. Activate the starter and observe the meter reading. The meter will read the voltage dropped or the difference in potential between the source and destination.
4. An ideal circuit's voltage drop would be 0 volts or no voltage dropped, meaning no difference in potential.
5. See [ITEM C](#) in [Figure 5-4](#). An open circuit should read 12 volts, displaying all the voltage dropped, and the entire difference in potential displayed on the meter.
6. Typically, a good circuit will drop less than 1 volt.
7. If the voltage drop is greater, back track through the connections until the source of the potential difference is found. The benefit of doing it this way is speed.
 - a. Readings aren't as sensitive to real battery voltage.
 - b. Readings show the actual voltage dropped, not just the presence of voltage.
 - c. This tests the system as it is actually being used. It is more accurate and will display hard to find poor connections.
 - d. This approach can be used on lighting circuits, ignition circuits, etc. Start from most positive and go to most negative (the destination or component).
8. See [ITEM D](#) in [Figure 5-4](#). The negative or ground circuit can be checked as well.
 - a. Place the negative lead on the most negative part of the circuit (or the negative battery post). Remember, there is nothing more negative than the negative post of the battery.
 - b. Place the positive lead to the ground you wish to check.
 - c. Activate the circuit. This will allow you to read the potential difference or voltage dropped on the negative or ground circuit. This technique is very effective for identifying poor grounds due to powdered paint. Even the slightest connection may cause an ohm-meter to give a good reading. However, when sufficient current is passed through, the resistance caused by the powdered paint will cause a voltage drop or potential difference in the ground circuit.

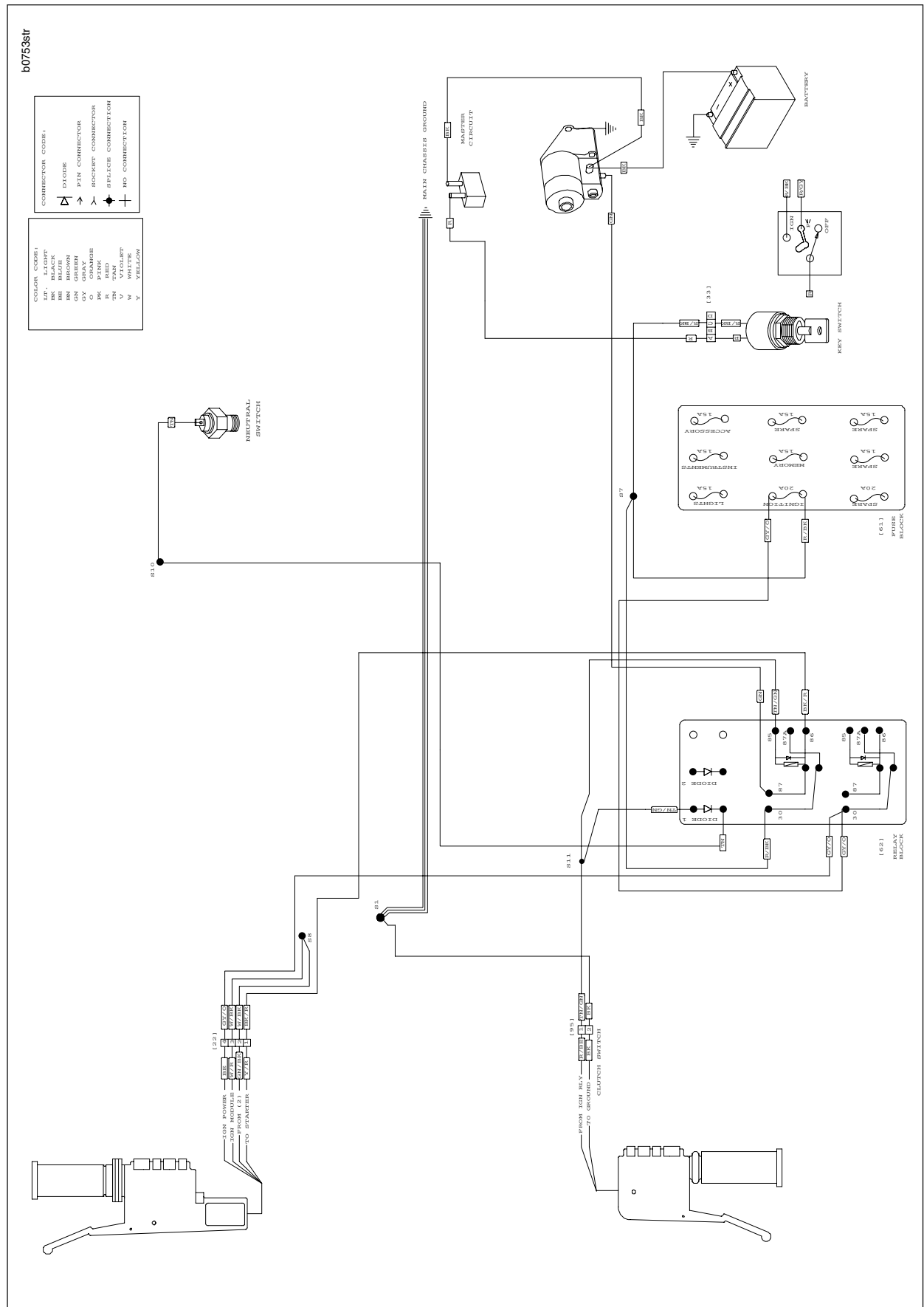


Figure 5-5. Electric Starting System Circuit

NOTES
