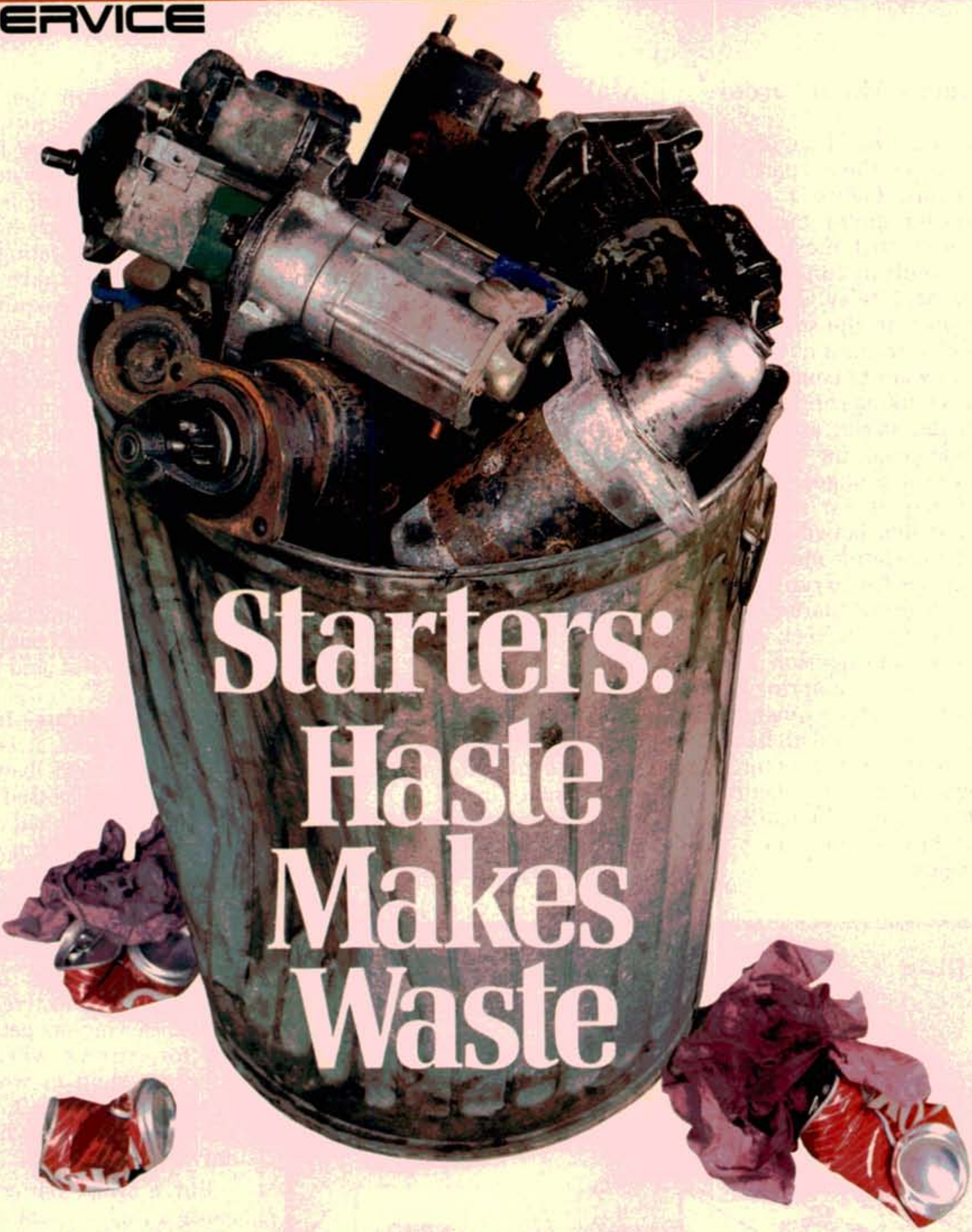
Starters: Haste Makes Waste



One bad apple may spoil the bunch, but we wonder how many good starters end up buried in the rebuilder's core barrel due to improper diagnosis of starter circuit problems. When we discuss starter system problems, we know that haste in diagnosing the cause of a starter circuit problem can indeed end up in a waste of time and money.

We're not going to discuss no-crank situations in this article. Instead we'll concentrate on the more annoying slow-cranking starter syndrome. No-crankers are a different story altogether, and are usually easier to diagnose than a slow-cranker.

Slow-crankers are tough because they may be the result of more than one problem. Is the battery weak? Is the starter motor dragging? Is there a mechanical problem with the engine?

To make things even tougher, the owner of the slow-cranker usually shows up on the first day of his vacation. That puts you on the spot since the car is sure to be loaded to the roof with camping equipment and an assortment of screaming children. Each and every one of the little ones has ants in his pants and mischief in his eyes.

You don't want any lost motion. A thorough, efficient diagnosis becomes a must. Besides, five minutes after they arrive, you'll probably find one of the kids out in the bays trying to spin balance his unsuspecting younger brother.

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The Starter Motor Circuit

In the interest of saving time, we'll keep the theory part of our article short. **Figure 1** shows a basic starter motor circuit. We should note that most solenoid circuits include one or more switches or a relay. But an unwanted open in the solenoid circuit usually means a no-crank. As noted, we want to concentrate on the slow-cranking car.

When the starter solenoid circuit is energized, the starter solenoid pulls a plunger. Once the plunger moves far enough, it closes a switch between the battery and the starter motor. When the engine begins to run, the one-way clutch in the starter drive is overrun by the flywheel. As soon as you back the ignition key off the start position, a spring in the solenoid pushes the plunger back, opening the current path between the battery and starter motor.

Enough theory, we'd better get on with the job. It looks like the younger brother needed a two ounce weight.

Make a Plan

A good troubleshooting plan eliminates wasted motion, and prevents replacement of the wrong parts. Random parts replacement leaves the local parts store with a core barrel containing many falsely accused starters. A hit and miss approach has always been the worst way to attack a problem of this sort. And installing a new battery on a trial basis is a bad way to instill customer confidence—especially when you don't guess right the first time.

Let's write out a good plan for diagnosing the slow-cranking vehicle.

Step 1: Do a thorough visual inspection.

Look around. Don't jump to conclusions. Are there any visibly bad connections at the battery terminals, starter solenoid, or at the starter motor itself?

How about the condition of the battery cables? Are the cables bloated from a wad of corrosion hiding beneath the insulation? Are the cable ends clean and tight? Is the battery filled to the proper level with water? Is the alternator belt loose? Is the battery the wrong battery for the car? Check the CCA rating of the battery and compare it to the manufacturer's requirements for this particular vehicle.

Finally, look for signs that someone else has already tried (unsuccessfully) to fix the problem. As mentioned in last month's electrical article, the best place to start looking for your problem is often the last place someone else was working.

You might be tempted to start your tests by doing a starter draw test. This is a mistake. A starter draw test is not conclusive without a battery test, and here's why:

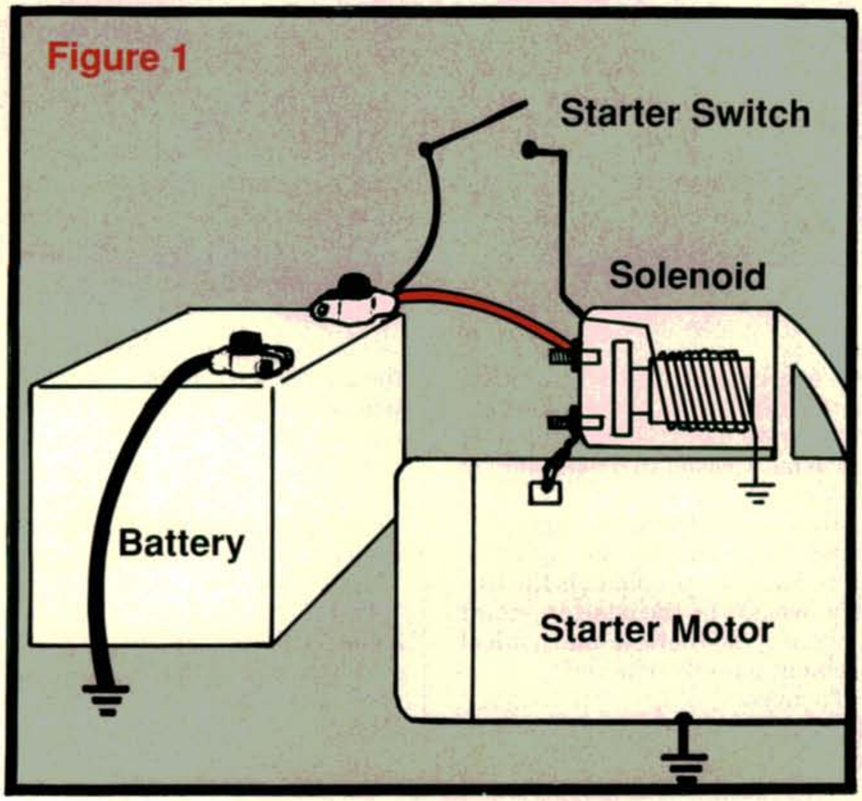
Low Starter Draw—If the starter draw is too low, it could be the result of a weak battery. But it could also be caused by a weak starter motor, a bad connection, or a weak cable. You won't know for sure which component is bad based on a low starter draw.

High Starter Draw—If the starter draw is too high, it could be caused by a defective starter motor. Starter motors get a real hunger for current when armature windings short or worn bearings cause the armature to drag. Slow starter RPM equals high current draw.

But a weak battery can also cause a high current draw. That's right, a weak battery can cause either a low current draw, or a high current draw, depending on circumstances. In some cases, a weak battery can't develop enough counter-electromotive force (C-emf, the DC motor resistance when turning) to limit the starter current draw to the correct level.

It only seems logical then to test the battery first. We need to eliminate a few of the unknowns in our puzzle, and the battery is the place to begin.

Figure 1



Step 2: Eliminate the Battery

The battery must be eliminated as the problem since it provides the voltage needed to force current through the starter motor. Without sufficient voltage, especially under load, all other tests become a waste of time.

Look for a Bad Cell—Batteries With Removable Caps:

If any cell "boils" when you crank the starter, you're done—and so is the battery. Please, please protect your skin and eyes when working around any battery, especially one with removable caps. And remember, no smoking. Even the most experienced among us can get careless when those visiting kids mistake the engine analyzer for the pop machine.

Removable cap batteries allow you to check for weak cells with a hydrometer. Uniformly low readings may simply mean the battery is discharged through no fault of its own. If specific gravity is lower than 1.225 on all cells (75 percent of full charge), the battery needs to be recharged before further testing. It's too weak to crank the starter at the proper speed.

Specific gravity readings above 1.225 in all cells mean it's okay to load test the battery (we'll get to load testing procedures in a moment).

If one cell in the battery is 50 points lower than its neighbors, that cell is bad—in fact that battery is bad. Even if the battery isn't the only problem, you can replace it with confidence and try the starter again. If the car is still a slow-cranker, the battery was only part of the problem. But at least you can explain with authority, that you proved the old battery was bad.

What if the battery doesn't have removable caps?

If the battery has removable caps, check the specific gravity of all cells using a hydrometer. Look for minimum readings of 1.225. All readings should be within 50 points of one another.

How to Determine State of Charge in Sealed-Top Batteries

We need an accurate DVOM to check state of charge in sealed-top batteries. Measure no-load voltage across the battery posts with your DVOM. If the reading is lower than 12.45 volts (75 percent of full charge), the battery must be recharged before testing.

No-load voltage of 12.45 volts or higher, measured across the posts, means the battery is strong enough to load test.

Tempting—Tempting!

If the battery is uniformly discharged, both you and the customer may be tempted to slap a new battery in the tray and go for it. Neither of you wants to wait around for the old battery to charge. The dead end kids are dismantling everything in sight, and there's a chance that the old battery might still flunk under pressure even when the specific gravity gets high enough for a load test.

What you don't know at this point is why the battery is discharged. If it's just plain tired, and that's the only problem, the new battery is certainly a part of the fix you're looking for.

But if the old battery passes the load test after a recharge, then the charging system that couldn't keep the old battery fully charged may not do a bit better with a new battery.

Step 3: Remove the Surface Charge

If the battery was recharged in the previous step, remove the surface charge before load testing by applying a 150 amp load to the battery for 10-15 seconds. You can do this by turning on the head lamps for two to three minutes. Use the longer times for tests of newer batteries, the shorter times for older batteries.

Step 4: Load Test the Battery

Connect a variable resistance carbon pile and an accurate DVOM across the battery terminals. Set the DVOM scale to the 20 volt scale. Don't just rely on the analog voltmeter on your load tester to measure battery voltage. Your DVOM is more accurate.

You can use the analog ammeter on the load tester to measure current draw. The numbers are higher, so the ammeter is accurate enough for this test.

To load test, adjust the carbon pile until the ammeter shows a battery drain equal to one half the battery's CCA rating. Keep the drain constant for 15 seconds, and note the DVOM reading at that time. Turn off the load.

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Battery Flunks If—The battery flunks the load test if the DVOM reads less than 9.6 volts on a 12 volt system or 4.8 volts on a 6 volt system with the electrolyte at 70 degrees Fahrenheit. Changes in temperature of the electrolyte will affect acceptable voltage levels. A good rule of thumb is to deduct 0.1 volt for every 10 degree F decrease in the temperature of the electrolyte.

For instance, at 40 degrees F, the DVOM can read 9.3 volts after the load test and still be okay. If the temperature is above 70 degrees F, add 0.1 volt for each 10 degrees F to your anticipated readings.

On sealed top batteries, use an accurate DVOM to measure no-load voltage across the battery terminals. Make sure the battery has 12.45 volts across the posts before load testing.

Battery Passes If—If the battery voltage reading on the DVOM is at least 9.6 volts at 70 degrees F (etc. etc.), then the battery is good. If the cranking speed is good, the discharged battery was the starter circuit culprit.

The 9.6 volt spec is a minimum. What you and the customer would both like at this point in time is a little extra breathing room provided by a reading of 10.0 to 10.5 volts.

If the battery passed with room to spare, don't send the troops off to fun in the sun just yet. The starter circuit may be working properly now, but the charging system ought to be checked. (There is always a possibility that the kids played the car radio for 10 straight hours yesterday, with the doors open and the courtesy lights on, but why take the chance?)

Starter Motor Current Draw Test

If the recharged battery doesn't fix the slow-cranking problem, we can proceed with the rest of our starter system tests. The starter motor current draw test is next on our list, and all you need is an inexpensive hand held inductive ammeter to do it.

Place the ammeter on the battery cable as described by the manufacturer of your meter. Be sure the cable is straight and has no bends or kinks in the area of the cable where you place the meter. Kinks and bends can affect your readings. Disable the ignition and turn off all accessories.

Crank the engine and note the current draw of the starter. Crank long enough to get a stable reading. Be careful not to crank so long that you overheat the starter motor.

Not all manufacturers give accurate specifications for acceptable starter draw. The sidebar below is a list of sample draws on real cars. We opened most of the hoods in our parking lot (and several others) and checked starter draw on good cranking cars. These figures are not absolutes, but should give you a sampling of representative draws on specific cars. You should keep a log of your own, recording readings from good-cranking cars passing through your shop.

A simple inductive ammeter can be used to check starter draw. These are inexpensive, and every shop should have at least one.

Starter Draw Readings

In many articles over the years, we've suggested that you test known good cars, and then keep a record of your findings as a reference. This time, we thought we'd get you started by actually doing a sampling of real starter draws on several imports. All tests were done with the cars at normal operating temperature. All test cars had good batteries, ran well, and had no slow-cranking problems.

These are not absolutes! Lower ambient temperatures and cold engines will give us different readings. But these readings should give you a reference for typical good-cranking current draws on a few common imports.

• BMW 535	126 Amps
• BMW 320 i	126 Amps
• Honda Accord	143 Amps
• Mazda GLC	130 Amps
• Mazda 12A Rotary	130 Amps
• Mercedes Benz 5-Cylinder Diesel	170 Amps
• Nissan 200 SX	170 Amps
• Saab 900	115 Amps
• Subaru 1.8 L Four Cylinder OHC	125 Amps
• Toyota Cressida Twin Cam Six	83 Amps
• Volkswagen Rabbit 1.8	95 Amps
• Volvo 2.3 L Four Cylinder	123 Amps

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What If The Draw Is Too High?

Remember this: High mechanical resistance or low electrical resistance mean high current draw.

High *mechanical* resistance can be caused by anything which makes the starter motor work harder than it should. The starter itself may have dry or binding armature bushings or bearings. Or the engine may have high turning friction caused by a mechanical problem. Hard engine turning may also be caused by things as simple as improper ignition timing or the wrong weight (or badly sludged) engine oil.

Low *electrical* resistance can occur when the starter motor armature rubs on the field coils inside the starter. The starter can't turn fast enough to develop its C-emf. Current runs wild with no resistance.

What If the Draw Is Too Low?

Low current draw means that there's a roadblock in the path the current takes from the battery, through the starter, and back to the battery.

Low current draw problems fall into two categories: Bad Connections or Bad Cables.

We can sum up the test procedure for low current draw in two words: Voltage Drop.

If You Have a Bad Voltage Drop During Cranking:

A reading of more than 0.5 volt during cranking tells us that we have too much resistance in the voltage side of the starter circuit. Actually, the reading may be 1-2 volts or more on cars with cranking problems. The higher the voltage drop, the slower the cranking. When we get a voltage drop in the 11-12 volt range, there's no cranking at all.

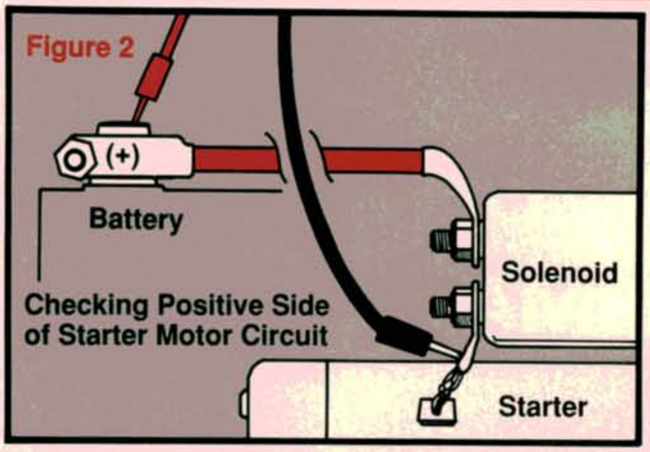
Readings of 0.3-0.5 volt (or less) indicate a good circuit. There is no excessive voltage drop during cranking on the voltage side of the starter.

Step 6: Isolate the Voltage Drop

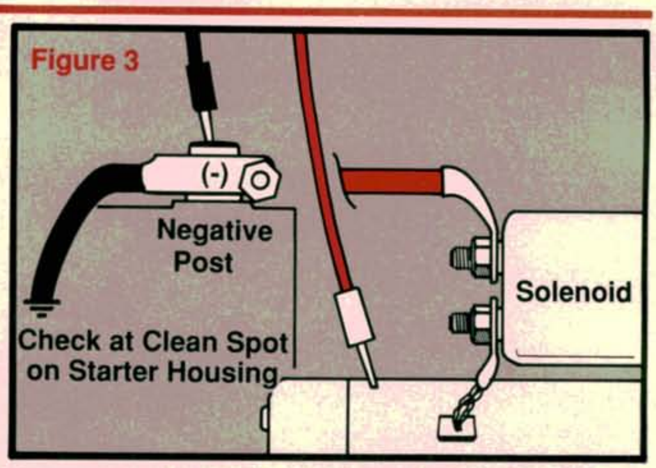
We need to divide and conquer when we look for the cause (or causes) of the voltage drop (or drops). Checking the voltage drop of each part of the circuit tells us where the resistance occurs. Each separate DVOM placement checks the voltage drop of a small portion of the circuit.

Don't forget the ground side of the circuit. A reading of 0.1 volt or less is good.

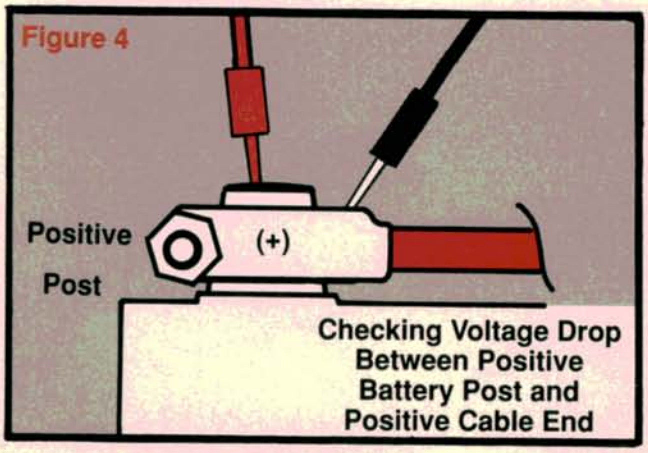
Let's walk through a set of voltage drop tests for a slow cranking starter system.



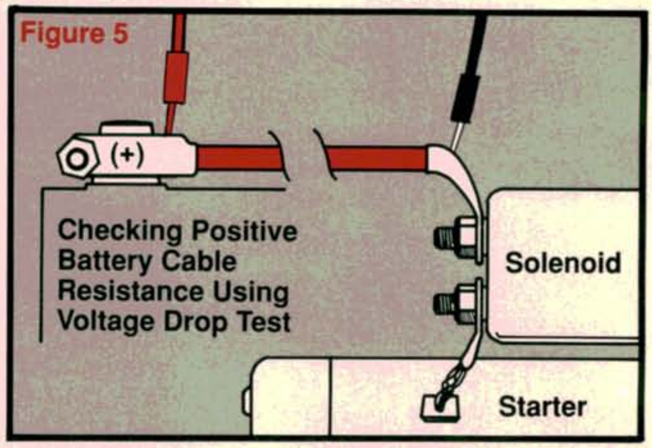
Connecting our DVOM between the battery positive post and the main positive connection to the starter, we find that we have a 2.0 volt drop during cranking on the voltage side of the starter circuit. What about the ground side?



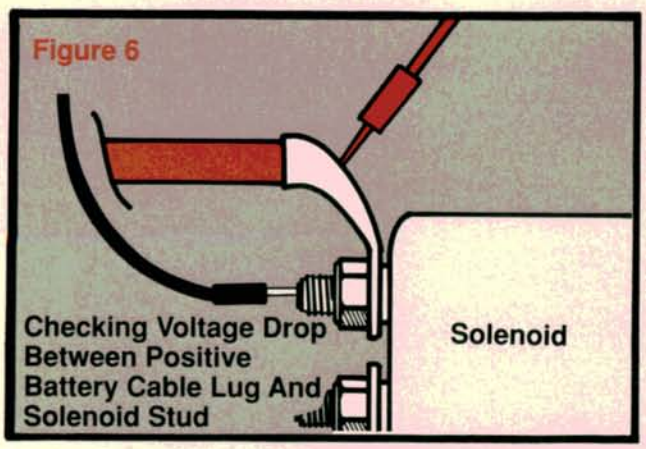
Connecting our DVOM between the battery negative post and a clean spot on the starter motor housing shows us a 0.01 voltage drop on the ground side during cranking. (0.1 volt is the maximum allowable ground side drop). Our voltage drop on the positive side of the circuit is the problem.



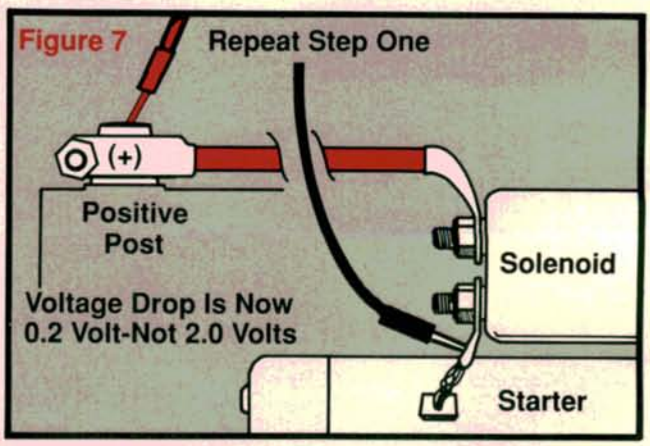
Connecting our DVOM leads as shown, test the connection between the battery positive post and battery positive cable terminal end. When cranking, we have a voltage drop of 0.5 volt. But we still have an additional 1.5 volt drop somewhere in the voltage side of the starter motor circuit.



Next we test the positive battery cable voltage drop. We connect our DVOM as shown, and get a reading across the cable of 0.01 during cranking. The main battery positive cable is not our problem.



Moving down the line, we check the connection between the battery positive cable and the solenoid. This time, our voltage drop is over 1.3 volts during cranking. We clean and tighten the cable connections at the battery post and solenoid.



We recheck the drop between the battery positive post and the main positive connection at the starter. This time, the starter cranks at normal speed, and our total voltage drop for the positive side of the starter motor circuit is about 0.2 volt. We're done.

— By Vince Fischelli