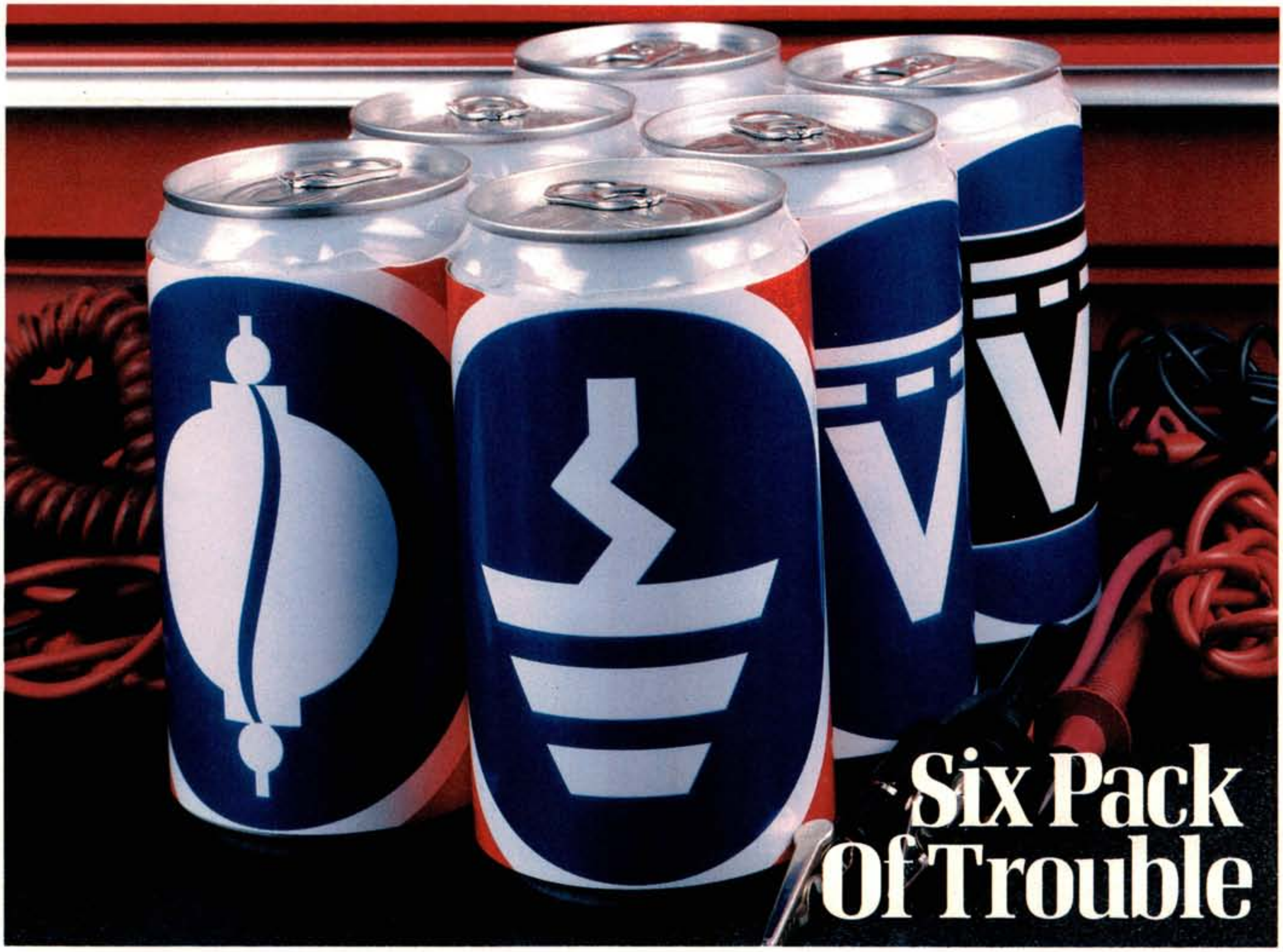


Six Pack Of Trouble

There are only six basic types of electrical problems which can affect automotive electrical circuits.

That's right — six.

No matter how complicated a circuit may be, electrical circuit problems can be classified by type. And as we said, there are only six to remember.

Now we all know that real problems in real cars can vary in appearance. Problems range from circuits which refuse to operate at all, to circuits which work poorly.

But below the surface, you'll always find that the cause of a problem falls into one of these six classifications. To keep things clear, we will illustrate each of the problems by using a simple series circuit.

This article is the first of a two-part series describing the six problem types, and show correct test procedures for each. Material for the articles comes from my Vehicle Electronics Troubleshooting Workshop conducted in Dallas, so you know that each diagnostic procedure has been tested in actual practice.

A Good Circuit

Let's start by examining a good circuit. Consider the following questions as we go along:

- What does a circuit do?
- What is a good circuit?
- What kinds of circuit problems do we need to deal with?
- How do we know when a good circuit goes bad?

These questions are easily answered when you first identify an automotive electrical problem by type, and then apply basic troubleshooting techniques.

A good circuit is one which delivers correct voltage and ground to a load. This allows electrical current to pass through the load so it can perform work. In fact, the load is the reason the circuit exists in the first place.

Without a load, you don't need a circuit. The load should become active as current passes through it. The load can be any electrical component such as a fan motor, a solenoid, a relay winding, a light bulb, a buzzer or warning device, or even an electronic component.

Let's look at a good circuit. **Figure 1** on the following page is a simple DC motor series circuit, and it satisfies all the requirements of a "good" circuit.

A source voltage of 14 volts is applied to the fuse through the closed contacts of the switch. Voltage passes through the fuse to pin 1 of the DC motor. The fuse is in series between the source of voltage and the motor.

In this example, the ground which completes our circuit is permanently connected to pin 2 of the motor.

Testing For a Good Circuit

Since current needs to pass through the load to perform work, we need to check both the voltage supply to the load and also check the ground before we know if the circuit is good.

Testing for source voltage is shown in **Figure 1.** The DVOM is indicating good source voltage (14 volts) at pin 1 of the motor. In most cases, our 14 volt reading tells us that the source side of the circuit is good.

Figure 2 shows a test of the ground side of the circuit. The DVOM reads 0.10 volt at pin 2 of the motor with the circuit loaded. In most cases, this indicates a good ground.

Why is this a good circuit?

- Source voltage is correct.
- The ground is complete—all the way back to the battery negative terminal.
- Current flow through the motor is within acceptable limits. If current flow were too high, the fuse would be blown.

Now that you understand the basic elements of a good electrical circuit, let's look at the first four cans in our six pack of electrical problem types.

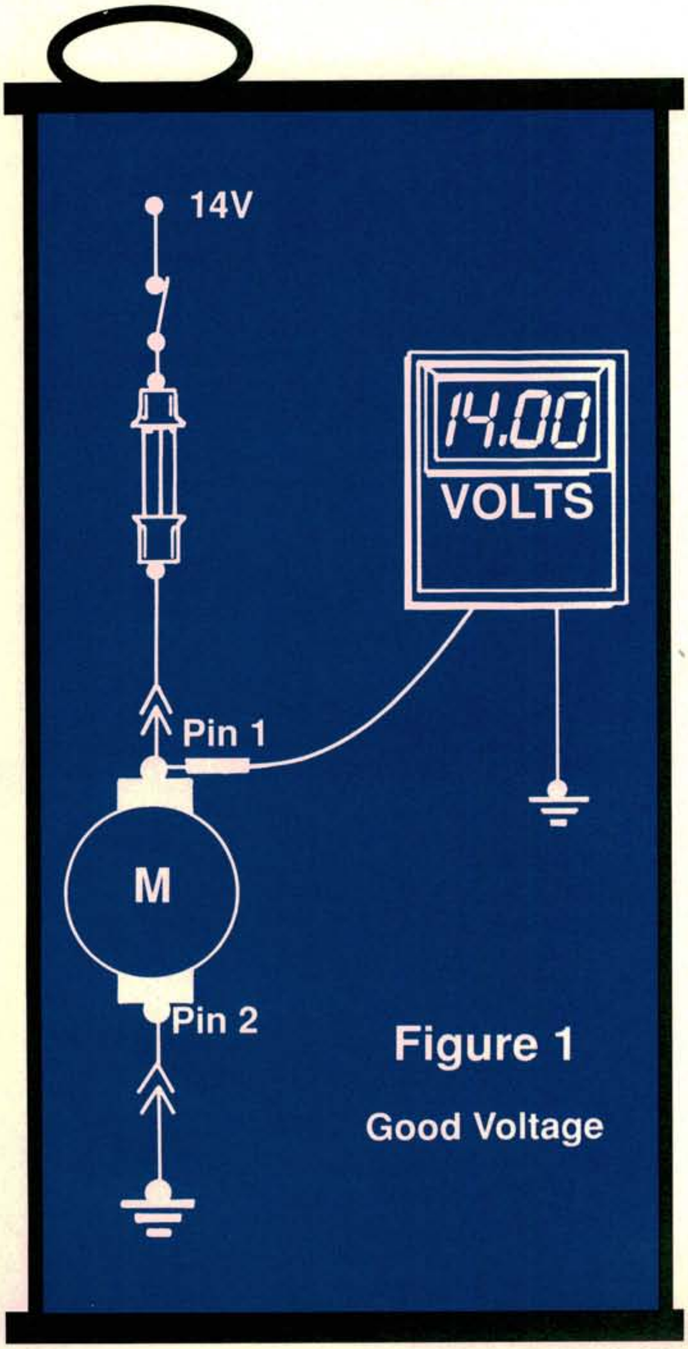


Figure 1
Good Voltage

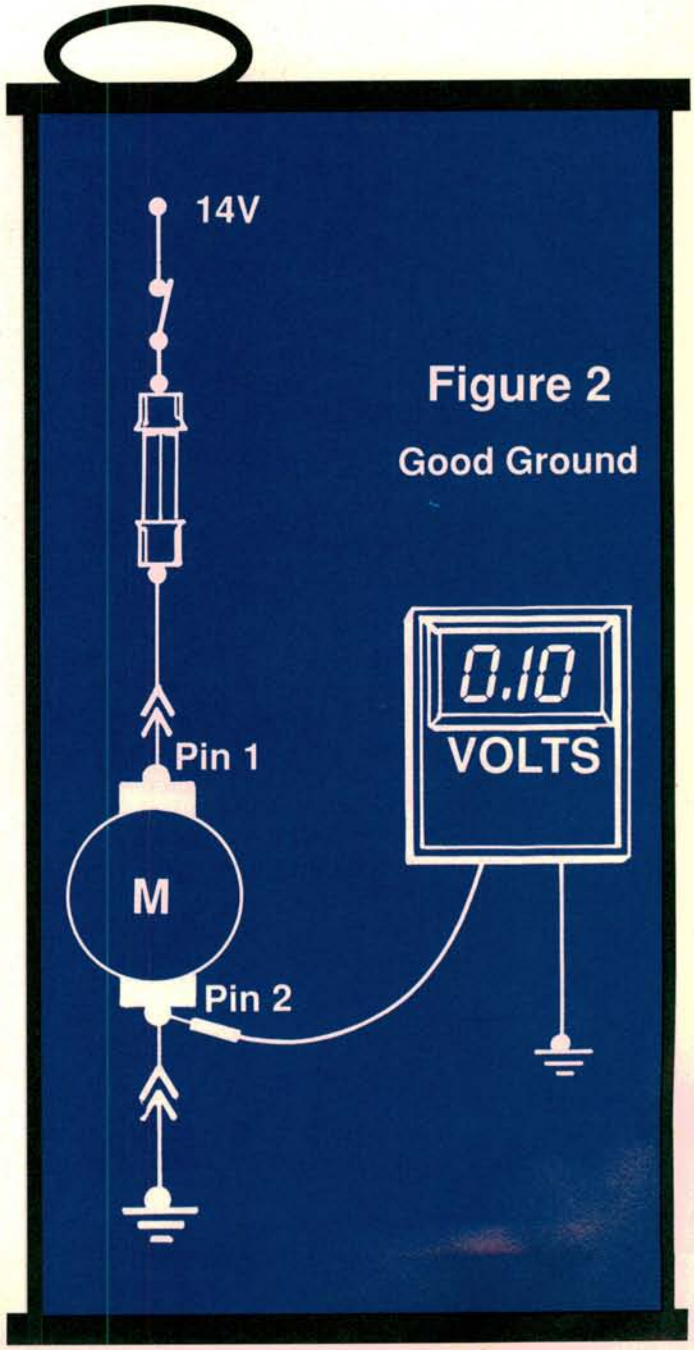


Figure 2
Good Ground

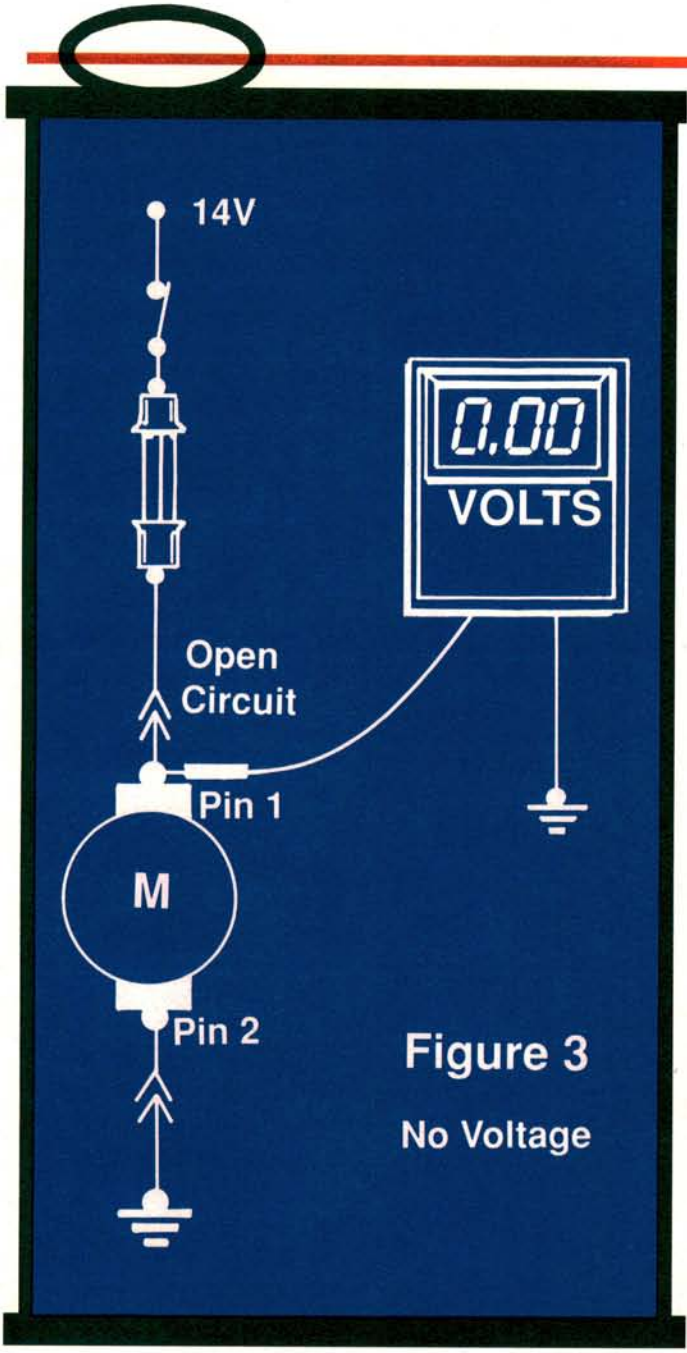


Figure 3
No Voltage

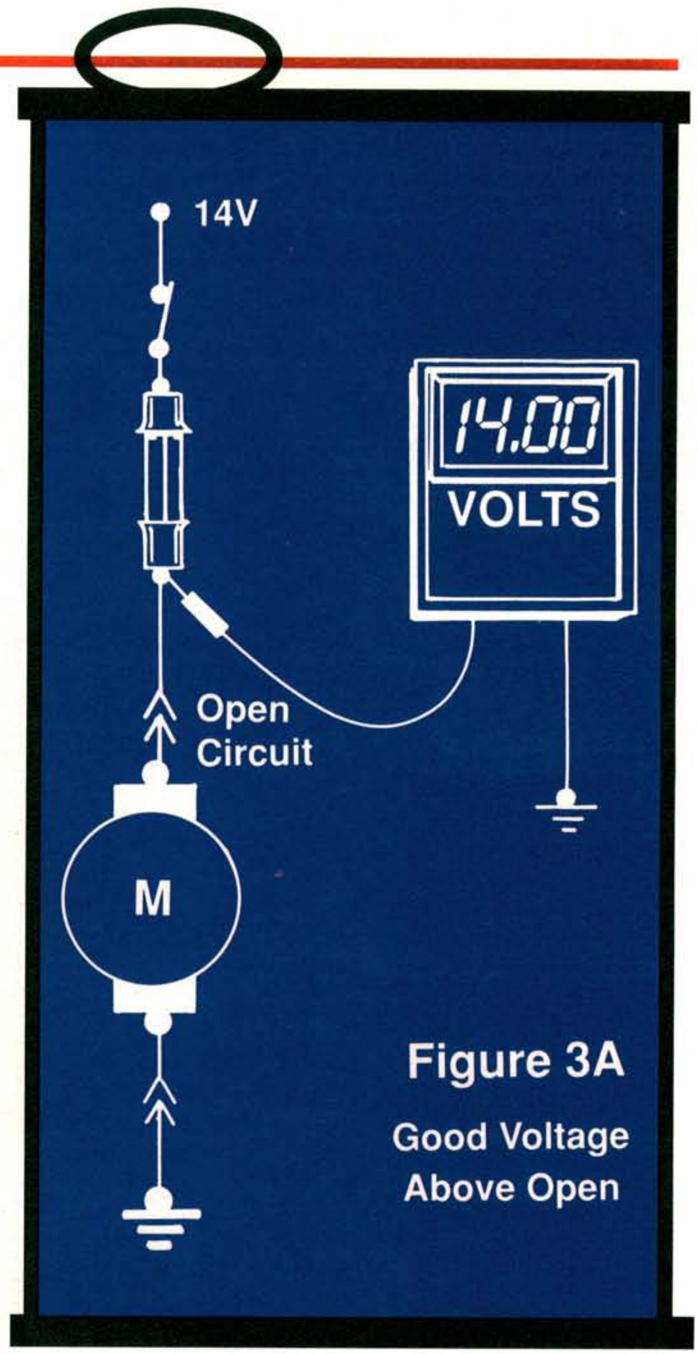


Figure 3A
Good Voltage Above Open

Can Number One—No Source Voltage

The motor circuit in **Figure 3** is dead. There is no voltage at pin 1 of the DC motor. Our DVOM reading of 0.00 volts tells us that there is no source voltage available at the load.

At this point, there's no sense in checking the ground at pin 2. With no source voltage applied to the load, the circuit isn't powered up. So a reading of zero volts between the negative battery terminal and pin 2 would be normal, even with a less than perfect ground.

What DOES make sense is backtracking through the voltage side of the circuit with our DVOM to find the point where the voltage is interrupted. We rediscover voltage at the motor side of the fuse (**Figure 3A**). That means that the fuse is good, and that our open lies somewhere between the motor side of the fuse and pin 1 at the motor.

A physical inspection of the connector is a good place to start. It may be loose or corroded or disconnected, preventing voltage from passing through. Or maybe a wire is broken somewhere in the circuit between the fuse and motor. Use the same DVOM tests to pinpoint the exact place where voltage in the circuit stops.

Once you've restored power to pin 1, complete your test of the circuit by checking the ground side of the circuit. Do this with the motor running (circuit loaded).

If you fail to check both the voltage and ground sides of the circuit, you may miss a border-line problem which will only get worse. That means another failure sometime in the distant future—or maybe an intermittent problem in the very near future.

Can Two—A Voltage Drop on the Source Voltage Side

In **Figure 4,** we see a more subtle problem. Our motor is running, but it runs slowly. This same type of problem may result in a dimly glowing bulb. Not enough voltage is reaching the load.

Our DVOM tells us that only nine volts is reaching pin 1 at the motor—not enough. Five volts are being consumed on their way to pin 1.

We can go ahead and do a quick check of the ground circuit since the circuit is at least partially powered up. A reading of zero volts at pin 2 will tell us that the ground is good enough to handle the nine volts currently reaching the motor. Later, when we restore full source voltage to pin 1, we'll double check the ground. The DVOM should still read zero volts at pin 2 when full source voltage is restored.

Start to backtrack the voltage source circuit with the DVOM. For the sake of argument, let's say that we find source voltage at the motor side of the fuse (**Figure 4A**). The connector becomes a likely suspect again. A voltmeter attached across the connector terminals shows us that this connector is dropping nearly five volts.

The connector is not open as it was in our first example. It's loose or corroded or both. And it's dropping five of the available 14 volts of source voltage before they can reach pin 1 at the motor.

Once the voltage drop is repaired and full source voltage is restored to pin 1 at the motor, load the circuit and double check the ground. Repeat the ground test from **Figure 2** and look for a reading of 0.10 volt or less as an indication that the ground is good when full source voltage is applied to the load.

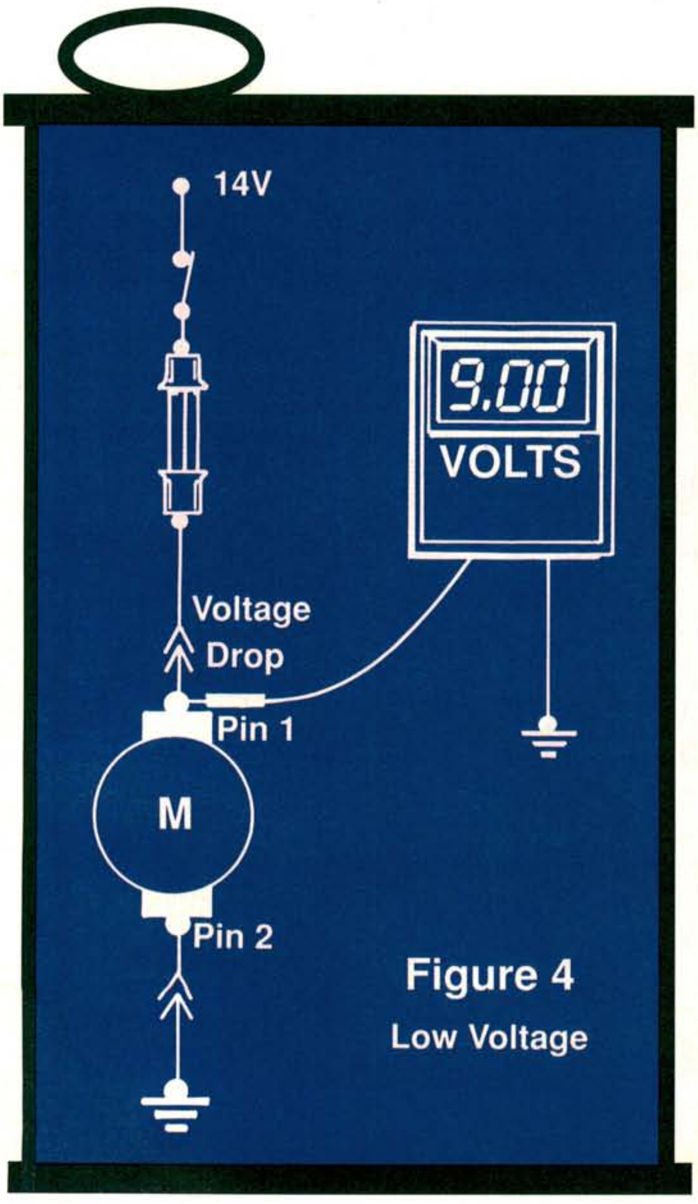


Figure 4
Low Voltage

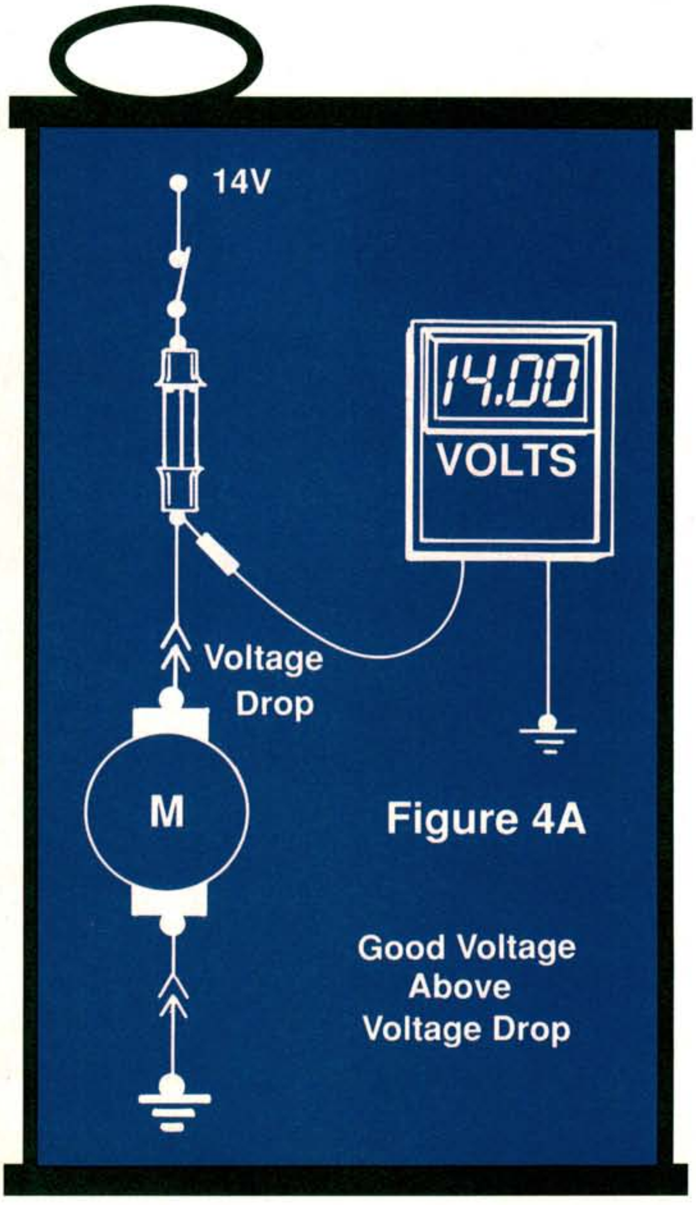
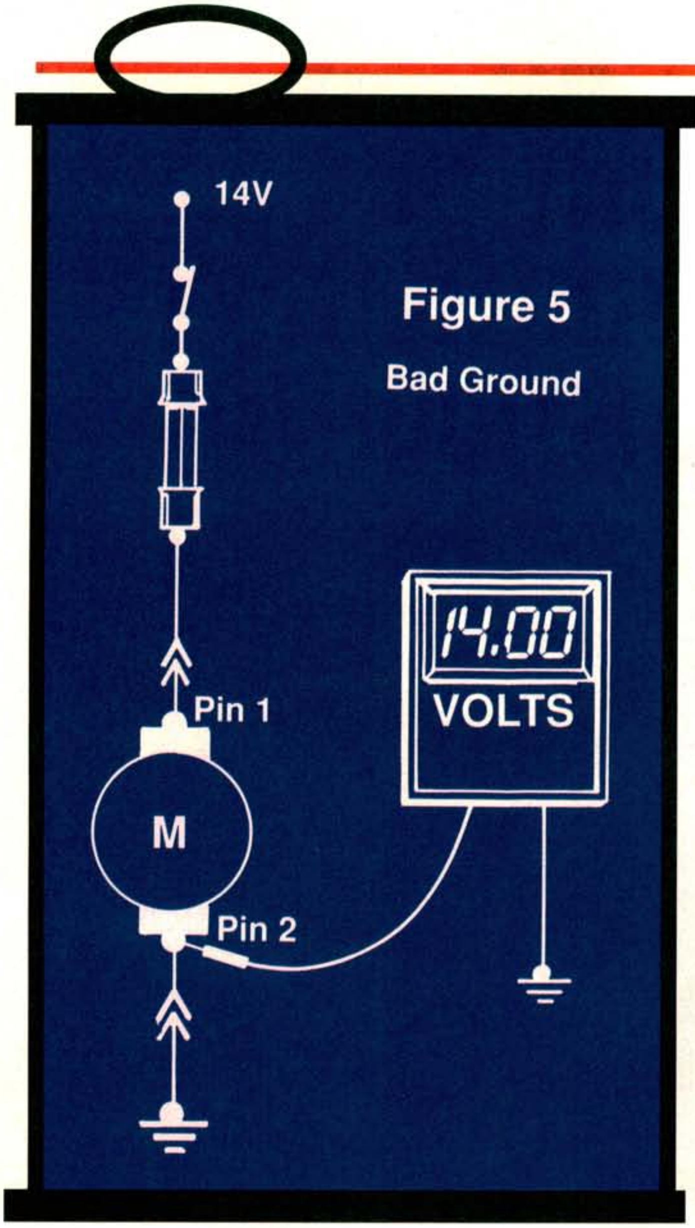
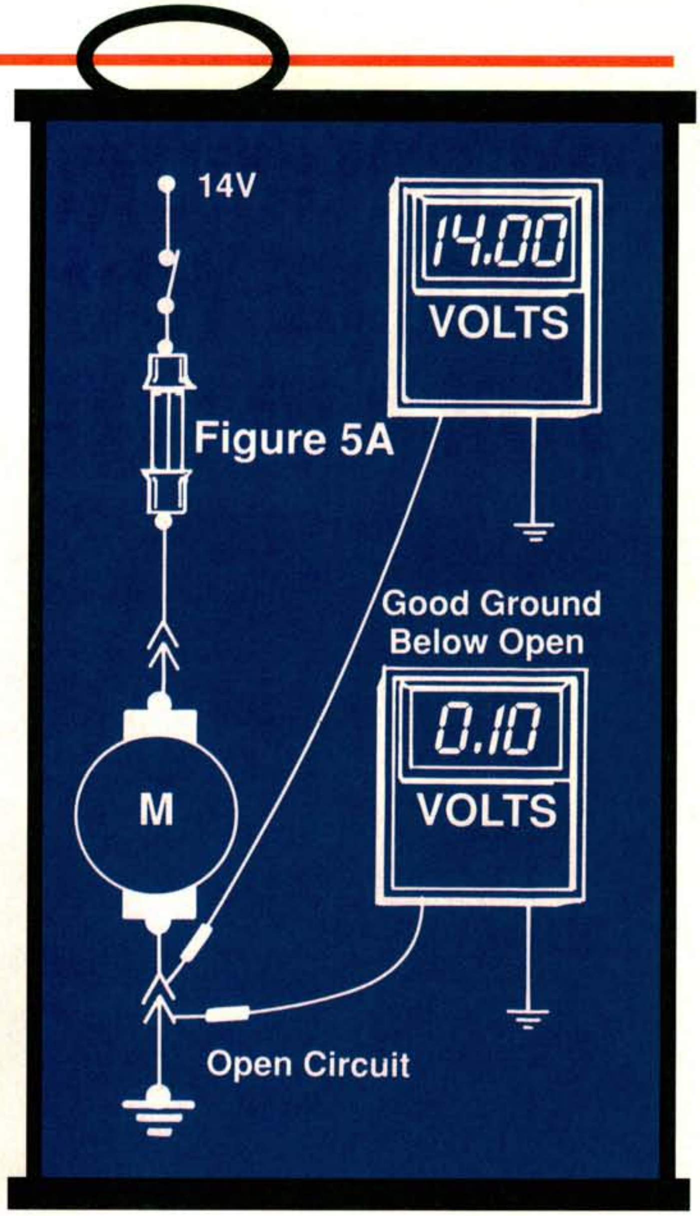


Figure 4A
Good Voltage Above Voltage Drop





Can Three—An Open Ground

The motor circuit in **Figure 5** is dead. This time there is an open circuit in the connection between pin 2 of the motor and the negative battery terminal.

If we start with a test of source voltage as we did with earlier tests, we close the switch and find source voltage is good (14 volts at pin 1). We leave the switch closed and move the DVOM test lead from pin 1 to pin 2. But our reading is still source voltage, 14 volts.

This tells us three things: 1) none of the source voltage is being dropped across the load, because no current is flowing through the load, 2) the motor itself is not open, and 3) the reason no voltage is being dropped across the motor is that there is no ground.

When we tested for the open circuit in the voltage side of the circuit, we worked back through the circuit toward the battery positive terminal. This time, we'll work our way in the other direction, towards the negative battery terminal. But this time, we're looking for the point at which we read NO voltage (0.10 volt or less).

This will tell us that we've reached ground.

In this example, we probe both sides of the connector. On the motor side of the connector, we are still reading a full 14 volts. But on the other side of the connector, the one nearer the negative battery terminal, we read 0.10 volt (**Figure 5A**).

Ground.

Now we know for sure that the connector is open. After repairing the connector and restoring ground, we'll load the circuit (run the motor) and double check source voltage at pin 1.

Remember, without a ground, the circuit was not loaded. Now that it is, we need to double check the source of voltage to be sure it can handle the normal circuit load.

Failure to check both sides of the circuit after a repair to either side may cause a second problem to go undetected.

Pay now or pay later.

Can Number Four—Voltage Drop on the Ground Side

The motor circuit in **Figure 6** is weak. The motor turns slowly. This problem is being caused by a voltage drop between pin 2 and the negative battery terminal.

Our source voltage reading at pin 1 is 14 volts with the circuit loaded. But moving our test lead to pin 2 gives us a reading of only seven volts.

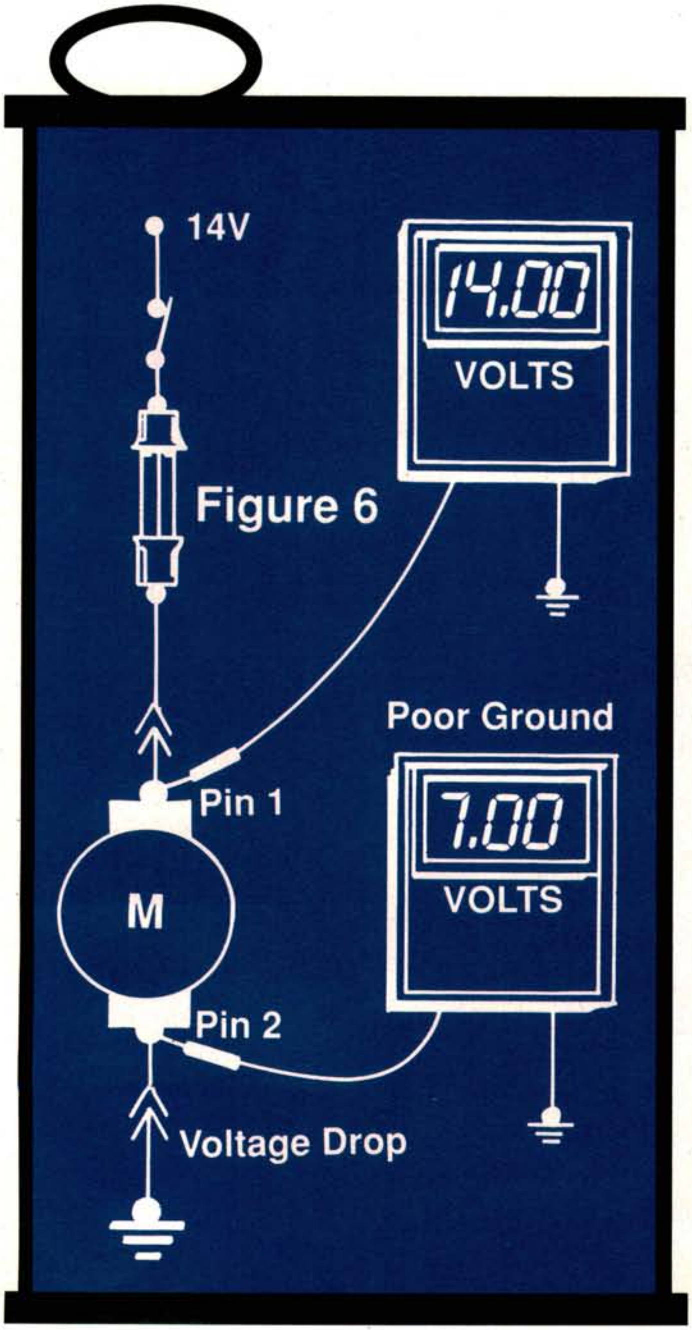
This tells us that while we have a full 14 volts at pin 1, only half that amount (seven volts) is actually available to power the motor. The other seven volts is being consumed at a bad ground connection.

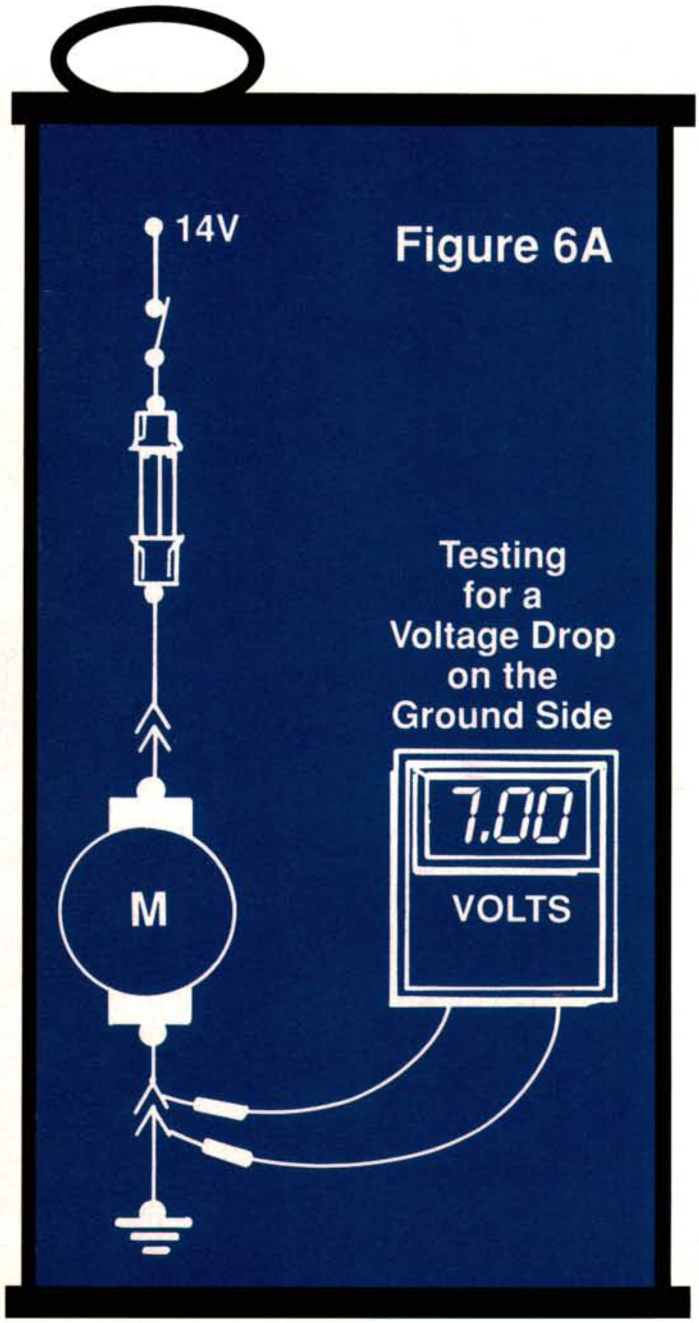
With only seven volts available to the motor, it's not surprising that the motor turns slowly.

Test for a bad voltage drop in the ground side as you tested for an open ground. Work toward the negative battery terminal, looking for a reading of 0.10 volt (or less). This will indicate ground.

You may find that the entire seven volts is being dropped at a single point (like our highlighted connector). If that's the case, a voltage drop test across the connector will show a reading of seven volts (**Figure 6A**).

Correct the bad connection, and check source voltage again with the motor running (load applied to the circuit).





Rules of Thumb

Here are a few rules of thumb to memorize. They'll speed your diagnosis of circuit problems.

1) **ALWAYS troubleshoot a circuit with the load connected.** You can't do a voltage drop test without first loading the circuit. Remember, there is no voltage drop until current is flowing.

2) **There is an OPEN in a series electrical circuit if the same voltage appears at both terminals of the load.**
- If both terminals read source voltage, the ground circuit is open.
- If both terminals read zero volts, the voltage or source side of the circuit is open. Both terminals read the same voltage when no voltage is dropped across the load.

3) **If the voltage dropped across the load is less than source voltage, there is a voltage drop in the circuit which must be found and eliminated.**

If the voltage drop in the circuit is on the source side of the load, voltage at the "hot" side of the load will be LOWER than source voltage.

If the voltage drop in the circuit is on the ground side of the load, voltage at the ground side of the load will be HIGHER than normal.

See you next month with Part Two. We still have two cans to open.

—By Vince Fischelli