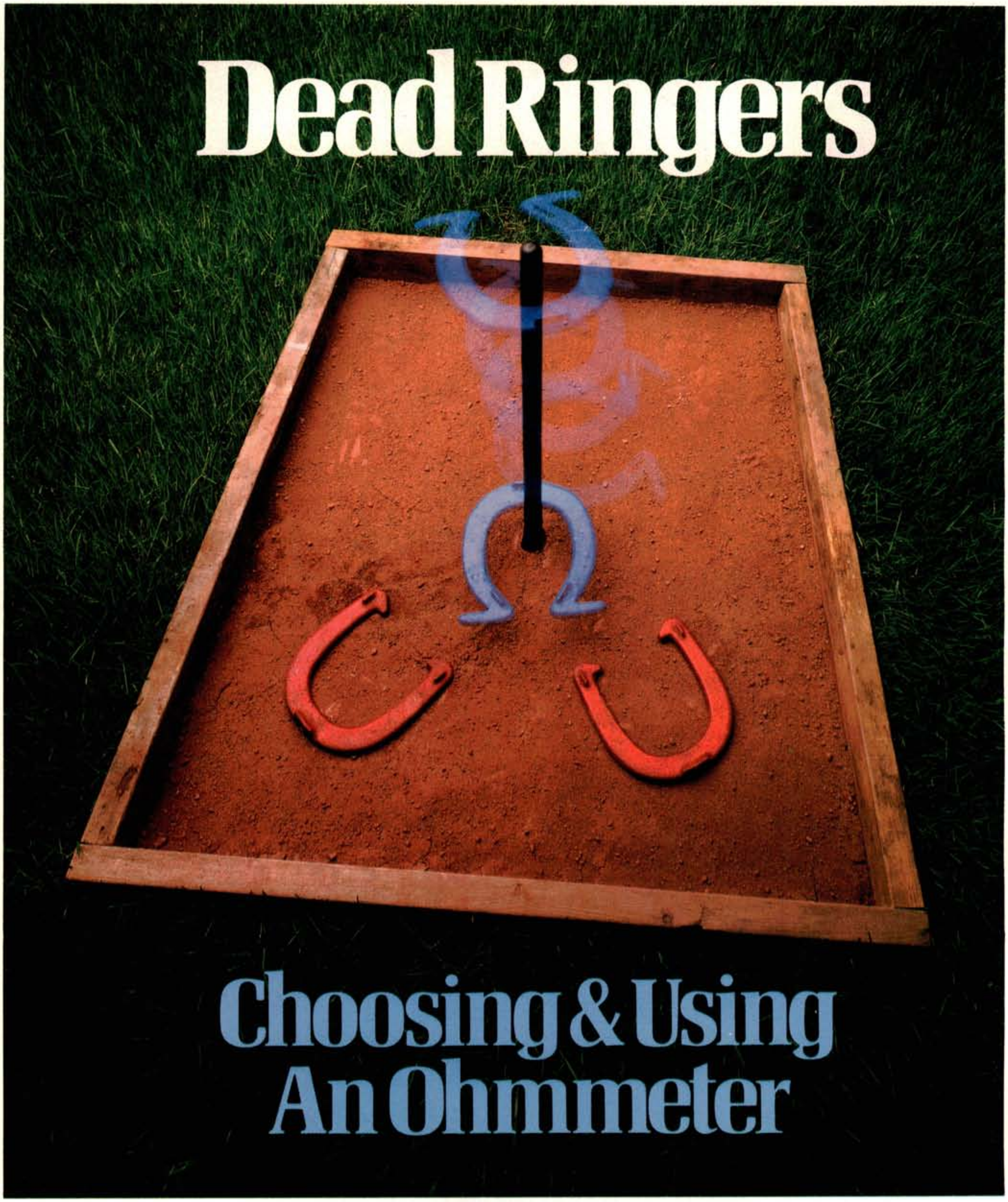

Oh! Those Ohmmeters

You've all seen those electrical trouble-trees in service manuals. They're the ones that take you step by step through a planned test sequence. They tell you to check the resistance between two points with an ohmmeter. Then the trouble-tree says that if you get a test reading of 40 ohms you should do such-and-such. Or if you get 10 ohms, to do something else.

But what happens when you get 15 ohms with your old ohmmeter? Usually you do what the trouble-tree says to do if you get the 10 ohm reading, just to play it safe. But it doesn't fix the problem.

And if you get a 30 ohm reading, you're tempted to do what the trouble-tree says to do if you get a reading of 40 ohms. That didn't fix the problem either? Hanged if you do. Hanged if you don't.

Dead Ringers

Ever been in this fix before? The problem is that electrical testing isn't a game of horseshoes. Close isn't good enough. If you keep ending up with close readings, but aren't getting that ringer that helps you solve the problem, maybe it's time to understand why ohmmeters can be so deceiving. You need to know how an ohmmeter works, and what it does. You also need to understand the differences between the three different types of ohmmeters.

What? Three different types of ohmmeters? You heard it here first in *Import Service*. All ohmmeters work on the same principle, but you can get three different resistance readings with the three different types of ohmmeters. This article will help you understand what the three kinds of ohmmeters have in common. It will also help you understand their differences.

What an Ohmmeter Does

Ohmmeters measure the resistance in a circuit, or the resistance of an individual component in that circuit. Resistance is the opposition that the circuit or component presents to the flow of current passing through it. Resistance is measured in units called ohms. If one volt of electrical pressure moves one ampere of current through a circuit, then the circuit has one ohm of resistance.

An ohmmeter reading of 20 with the ohmmeter set in the Rx1 scale would be expressed as 20 ohms. The symbol used to denote resistance is the Greek letter Omega, Ω. It even looks like a horseshoe. Whenever the Omega symbol is used, just use the word ohms in its place. So 20Ω is expressed as 20 ohms.

How A Basic Ohmmeter Works

All ohmmeters work on the same basic principle. We'll use an analog ohmmeter to describe how an ohmmeter works. At the same time, we'll look at what makes the analog ohmmeter different from the others. Later in this article, we'll look at the two remaining types of ohmmeters.

An ohmmeter has its own small voltage source. It's usually a battery (1.5 volts in VOMs) which induces a small ohmmeter test current into the circuit connected between the two test probes of the ohmmeter. This is shown in Figure 1.

In this figure, we see the ohmmeter measuring the resistance of a resistor. Our reading of 10 on the Rx1 scale indicates that a 10 ohm circuit is connected between the test leads.

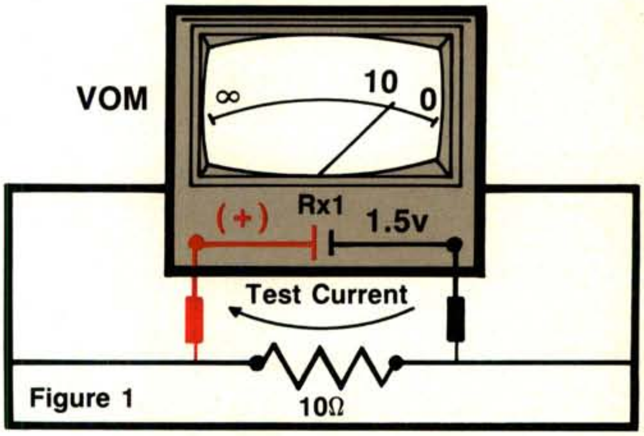

Figure 1

The single cell battery is shown on the front of the ohmmeter, just the way it's connected inside an ohmmeter. This will help you visualize what is happening. Also note that the ohmmeter test leads must connect to the circuit being tested. This makes a complete path for the ohmmeter test current to flow through.

The ohmmeter measures the amount of test current from its battery that can pass through the circuit. The needle on the meter moves according to the amount of current allowed to pass between the test probe tips. We interpret the movement of the needle by comparing it to the numbered scale on the ohmmeter dial, and say that we have so many ohms of resistance in the circuit.

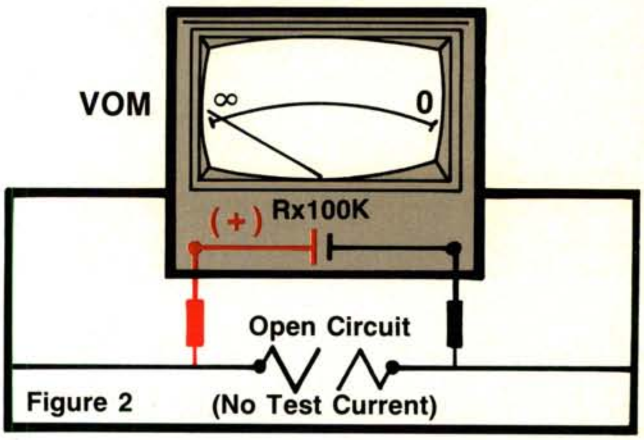

Figure 2

But what happens if we have an incomplete, or open circuit? The test current from the ohmmeter cannot flow through the open circuit. As a result, the ohmmeter shows maximum resistance, or an open circuit.

Be careful here, however. Make sure you switch to the highest scale on the ohmmeter dial. Then recheck the circuit to be sure that it's truly open, and not just a high resistance circuit. Whenever the needle on the ohmmeter is at either end of the dial, be suspicious. The circuit being tested may simply be out of the range of the scale you've selected.

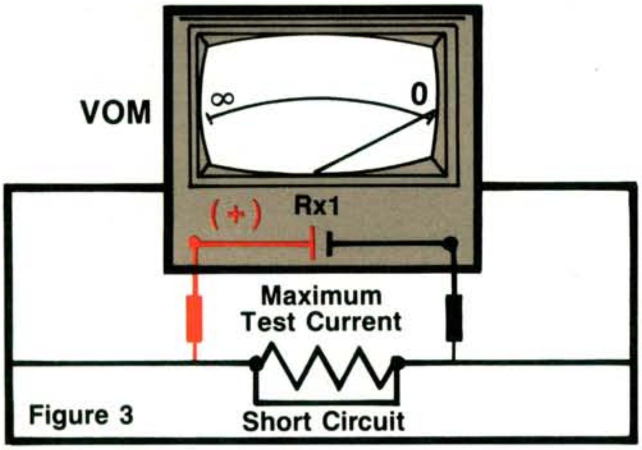

Figure 3

In Figure 3, we have a shorted circuit. There is a direct connection in the circuit. As a result, the maximum test current from the ohmmeter battery can flow between the test probe tips.

Be careful here too.

Make sure you switch to the lowest scale on the ohmmeter dial this time. Then recheck to be sure that the circuit is truly shorted, and not just a low resistance circuit.

In all of these figures, the positive terminal on the test battery inside the analog ohmmeter is connected to the red test lead. This makes the black test lead of the ohmmeter negative. It is important to know the polarity of the ohmmeter test battery when you test circuits with semiconductor components like diodes.

If you ignore polarity when you test these components, you may get the wrong reading. You might get lucky, but it's a coin toss at best. Ignore polarity, and you may not get that ringer.

In Figures 4a and 4b, you see that the battery might be installed either way by the manufacturer of the analog ohmmeter, and you won't know for sure until you check your particular ohmmeter's polarity with a Digital Volt-Ohmmeter, or DVOM.

Place a DVOM's voltmeter across the ohmmeter's test leads as shown and determine which ohmmeter test lead is the positive side of the ohmmeter's test battery. Since there's no standard rule about which way the battery is installed in the meter, you'll want to check your particular meter and remember its polarity.

Most analog ohmmeters have a zero-adjust. This is used to calibrate the meter for zero ohms. To adjust the meter for zero ohms on the scale you're using, simply touch the two leads of the ohmmeter together. Then turn the zero-adjust knob until the needle is on zero.

If you cannot adjust the needle to read zero ohms,

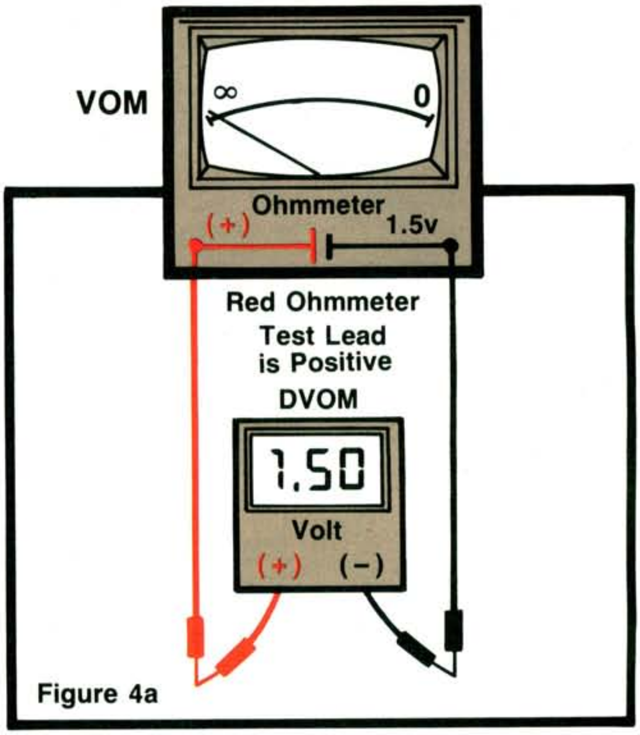

Figure 4a

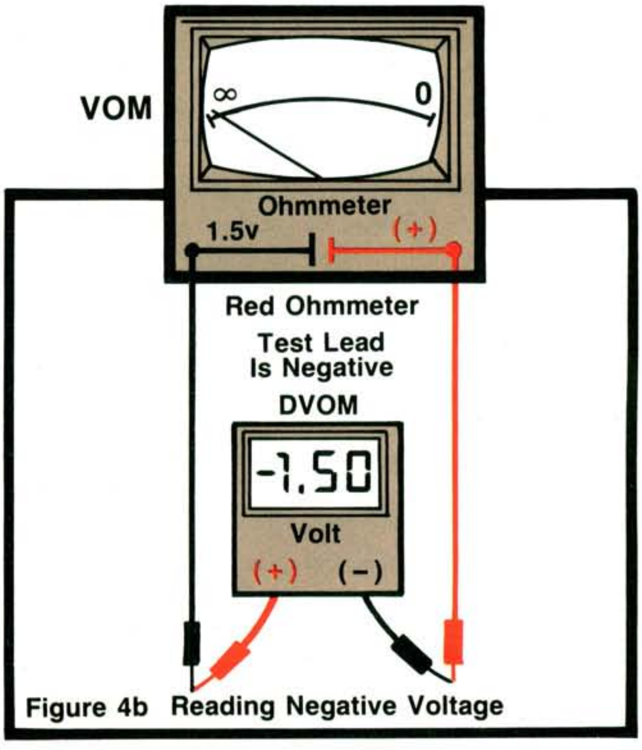

Figure 4b Reading Negative Voltage

the internal battery is weak and should be replaced. Remember to zero the analog ohmmeter each time you change ranges.

It's also important to remember that an analog ohmmeter is most accurate when it indicates a resistance reading at mid-scale. We repeat, if the meter reading is at either extreme of the scale, try switching to another scale to get the pointer to rest near the middle of the scale. The resistance reading will be more accurate. It will also be easier to interpret.

General Ohmmeter Tips

These two tips apply to any type of ohmmeter you use:

• First be sure the circuit is turned OFF before you connect the meter to the circuit. If there is voltage in the circuit being tested, that induced voltage will cause something called "ohmmeter smoke." This is very unhealthy, maybe deadly for the meter.

• Second, be sure there are no parallel paths for the ohmmeter test current to flow through around the circuit you're testing. The test current will flow through this parallel path and may give you a false resistance reading.

So far, we've covered the basics of ohmmeter operation and taken a look at the analog ohmmeter. Now let's move on to digital ohmmeters and something called the DIODE TEST feature. Once we look at these remaining two types of ohmmeters, we'll know about all three types of meter. Then we can look at some practical uses—and misuses of each.

Digital Ohmmeters

There are two types of digital ohmmeters. One is the standard digital ohmmeter found in a DVOM. The other is a separate DIODE TEST feature found in the DVOM.

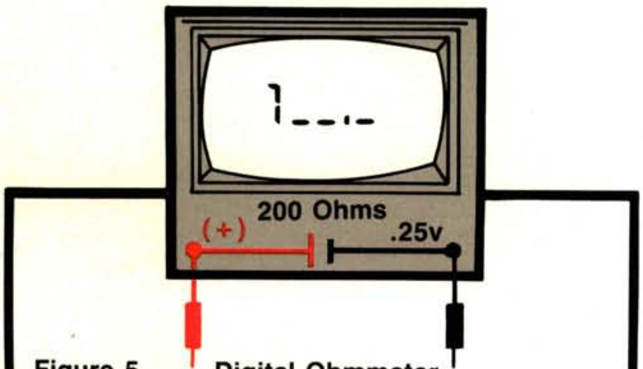

Figure 5 Digital Ohmmeter

Figure 5 shows a functional line drawing of a standard digital ohmmeter found in any DVOM. It looks the same as an analog ohmmeter except for the digital readout.

But look again. The digital ohmmeter test voltage is much lower than that of the analog meter.

This is done so that the resistance measurements can be made with safety in circuits containing semiconductor components.

You've probably noticed this note on many automotive electronic schematics: "Do not check resistance with an ohmmeter. Damage to sensitive electronic components could result." That's because the old analog ohmmeter has a test voltage high enough to fry some sensitive semiconductors (ICs) inside the electronic boxes. Digital ohmmeters with their lower test voltage are safer for measuring electronic circuits.

This also means that the standard digital ohmmeter ignores semiconductor components. It takes about 0.6 volts to turn on a typical semiconductor diode. But the digital ohmmeter's battery, at about 0.25 volts, is well below the 0.6 volts needed to turn the diode ON.

As a result, the standard digital ohmmeter sneaks in under the threshold voltage level needed to turn the semiconductor on. It takes its resistance reading, and sneaks out without so much as tickling the diode.

Re-Volting Developments

But wait a minute. This fast and dirty, in and out resistance measurement by the digital meter can also cause us problems. If the resistance check you're making needs to take into account the presence of a semiconductor device (like a spike suppression diode), the standard digital ohmmeter will simply overlook it.

Back in the July 1988 issue of *Import Service*, our "Voltage Suppression Diodes" article correctly instructed you to use an analog ohmmeter to test a spike suppression diode in parallel with a coil or relay winding. You need the higher test battery voltage of the analog meter to turn the diode ON so you can determine whether or not it's open.

Using a standard digital ohmmeter will not turn the diode ON. As a result, you won't know if the diode conducts (turns ON). The standard digital ohmmeter would indicate the resistance of the coil in parallel with the diode. But it would ignore the diode (unless the diode were shorted).

Catch-22

Looks like a problem. If you want to check the coil in the circuit by itself, you could use the standard digital ohmmeter and not harm the electronic circuit in the computer. But if you want to check the spike suppression diode, you need the additional test voltage supplied by the analog meter.

What if the diode is shorted? Then the standard digital ohmmeter will indicate the shorted diode and read 0.00 ohms.

But if the diode is open, a real possibility causing computer box failure, the standard digital ohmmeter won't be able to tell the difference between a good diode and an open one. It will indicate the resistance of the coil, regardless of polarity when you hook it up.

The open diode will not be detected by the standard digital ohmmeter, however.

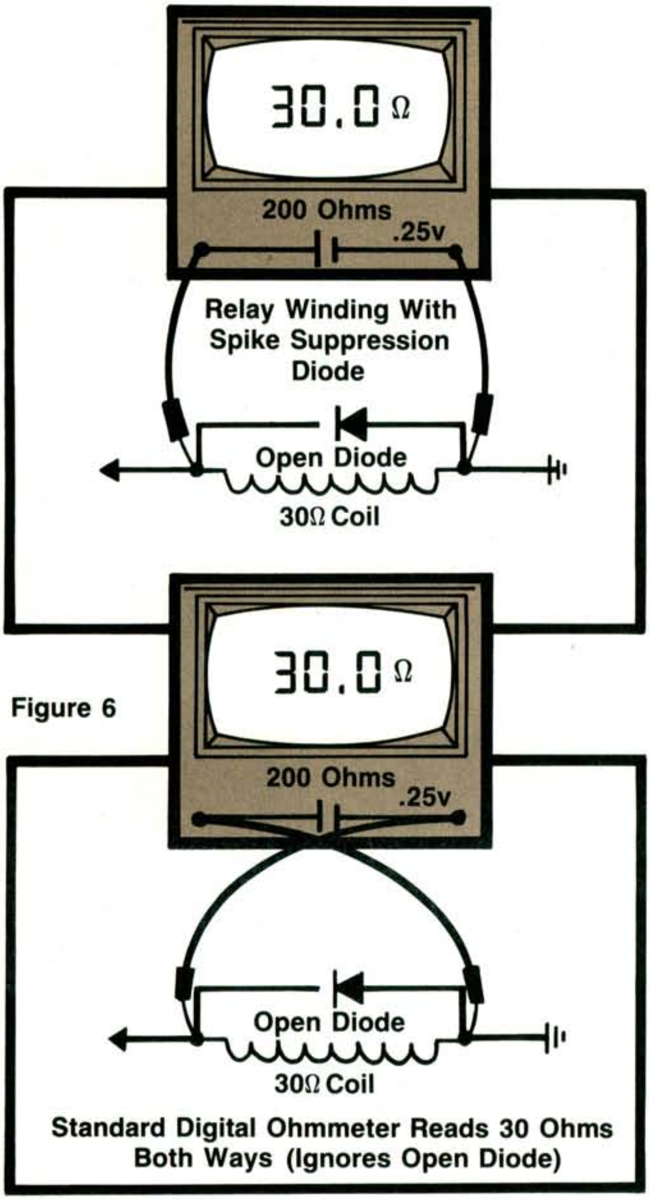

Figure 6

What Would The Analog Meter Read?

An analog meter showing 30 ohms regardless of the polarity of your connections would indicate an open diode. The analog ohmmeter should indicate about 7.5 ohms with the diode turned ON.

In this polarity, the test voltage of the analog meter forward biases the diode and turns it ON. The forward resistance of the diode would equal a total resistance of 7.5 ohms. We have 10 ohms in parallel with the 30 ohm resistance of the coil. Our equation reads:

$$\frac{30 \times 10 = 300}{30 + 10 = 40} = 7.5$$

Be careful here. If the test battery in the analog meter is weak, test voltage could drop so low that it won't turn the diode ON. You might mistakenly assume that the diode is open, when it's not. Stuff happens.

A Simple Ohmmeter Exercise

Just to illustrate how different meters can give you different readings, try this exercise. Start with your analog meter. Set it to the Rx1 scale and zero-adjust the needle. Now connect the two test leads to the lamp terminals of an ordinary 1893 lamp.

The pointer will first move to indicate about 8 ohms, but will climb quickly to a reading of about 12 ohms. Why did the resistance change? Because the lamp filament is a varying resistance. The filament read eight ohms when cold. But the ohmmeter test current excites the filament and it heats up.

Resistance increases to about 12 ohms as a result. The analog ohmmeter test voltage is about 1.5 volts and produces a change in the resistance of the filament. The meter is actually affecting our test results in this case.

Now do the same thing with a standard digital ohmmeter set to the 200 ohm range. First short the leads together to make sure the meter can read .000 ohms (a short). Then place the test leads across the lamp terminals. The 1893 lamp resistance measures about 4.2 ohms. Same lamp. Different readings. Why is this happening?

The answer is that the ohmmeter test voltage of the standard digital ohmmeter is much lower than the analog meter test voltage. The filament doesn't get as hot, and resistance in the filament is lower as a result.

Getting to Know the Digital Meter

The standard digital ohmmeter may take some getting used to if you're used to using nothing but an analog meter. Most digital meters indicate 1 __ __ . __ (on the 200 ohm range) with the dashes representing blank spaces in the readout. When a resistance measurement is made, the spaces fill in with digits to give you a reading. You can go as high as 200 on the 200 ohm range, for example.

The 1 __ __ . __ readout is also the indication for an open circuit or a resistance that is too high for the ohmmeter range you've selected. Some meters have a feature called autoranging that automatically selects the correct range for the resistance being measured. On a meter without this feature, you'll have to select the correct range manually.

If you're not sure what the display should look like for an open circuit, you can simulate an open very easily. Just turn the meter on and keep the probe tips apart. The ohmmeter will give the display for an open circuit since that's what it's seeing at the probe tips. Remember what the reading looks like so you can recognize it as an open circuit the next time it appears during a test.

Selecting the Correct Range

If the meter is not autoranging, you can fool yourself by selecting the wrong range for the circuit being tested. If you keep getting an open circuit reading when you test a circuit, switch to the highest range on the meter and retest. If the resistance in the circuit is too high for the range selected, you could mistakenly assume that the circuit is open.

Also be careful not to let your fingers touch the metal test lead probe tips. On high resistance readings, the ohmmeter will indicate the resistance through your body and give you a false reading.

This is just ohmmeter common sense, since most people have low enough body resistance to be read by the ohmmeter on high resistance ranges. (Don't confuse this with the story of the customer who had a short between his ears.)

Standard digital ohmmeter test battery polarity is not a problem for us like it was with the analog meter, since the voltage is not high enough to turn a semiconductor ON anyhow. Test battery polarity is only critical when battery voltage is high enough to turn a semiconductor ON.

The Diode Test

Some digital ohmmeters have both a standard digital ohmmeter and a separate Diode Test feature. We will classify this feature as a separate type of ohmmeter, our third type. You might think that this is stretching things a bit, but the Diode Test feature is still an ohmmeter.

The purpose of this Diode Test feature is to enable the standard digital ohmmeter to test semiconductor circuits. In the Diode Test mode, the standard digital ohmmeter test voltage rises slightly above 2.5 volts when the test leads are not connected. This is a low amperage test voltage and voltage can drop off quickly if the circuit being tested loads the battery down too far. This is enough voltage to turn the diode ON, however. But Diode Test checks diodes a little differently than reading the forward and reverse resistance of a diode as an analog meter would.

In Figure 7, a standard digital ohmmeter is checking a diode using Diode Test. It is indicating .600 volt. Notice that the polarity of the test battery turns the diode ON (DVOM Number 1). The reading shown is actually a voltage drop produced across the diode by the higher test battery voltage generated by the Diode Test mode.

When the diode turns ON, it loads down the ohmmeter test battery to .600 volt. The DVOM in Diode Test indicates this voltage drop to show the diode's condition. Silicon diodes, the most common in automotive circuits, have a black body and will indicate about .600 volt if they are good. This is the threshold voltage level

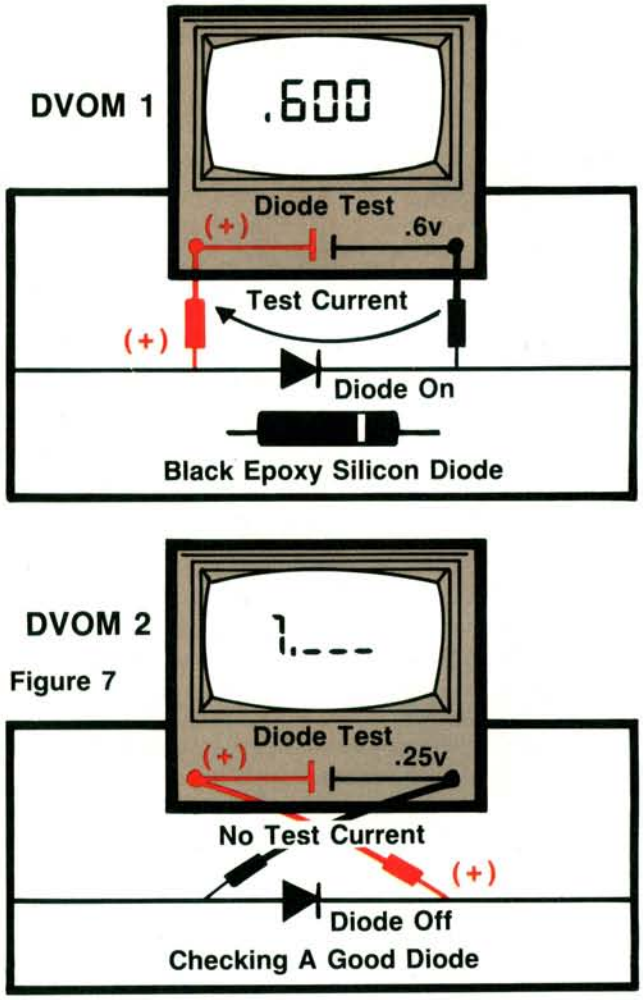

Figure 7

Checking A Good Diode

needed to turn these diodes ON.

Getting this reading informs you that the diode is turning ON and conducting. If it were shorted, the reading would be .000 volts. The meter would read 1 __ __ . __ if the diode were open.

Reversing the Leads

Now let's reverse the test leads as shown in Figure 7. This turns the diode OFF. Since there is no test current passing between the test probe tips, there is no load to measure. Our meter reading in this illustration also tells us that none of the 2.5 volts applied to the circuit by the test battery are leaking through the diode.

Our reading also tells us that the diode is not shorted (which would give us a reading of .000 volts); nor is it leaking current (which would give us any voltage reading other than open.)

Limitations of the Diode Test

Be careful when you use the Diode Test mode to check a spike suppression diode in parallel with a solenoid or relay winding.

In Figure 8, you see the ohmmeter test battery in the DVOM dropping to 0.3 volt because the coil is loading down the test battery below the voltage level (0.6 volt) needed to turn the diode ON. The Diode Test reading indicates .030 for the 30 ohms of the coil. This could lead you to incorrectly assume that the diode is open. Therefore, to use the Diode Test feature, one side of the diode must be disconnected from the circuit.

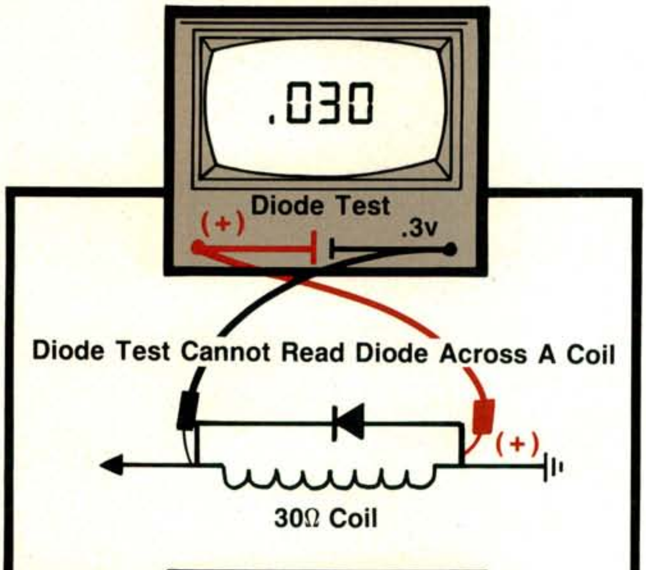

Figure 8

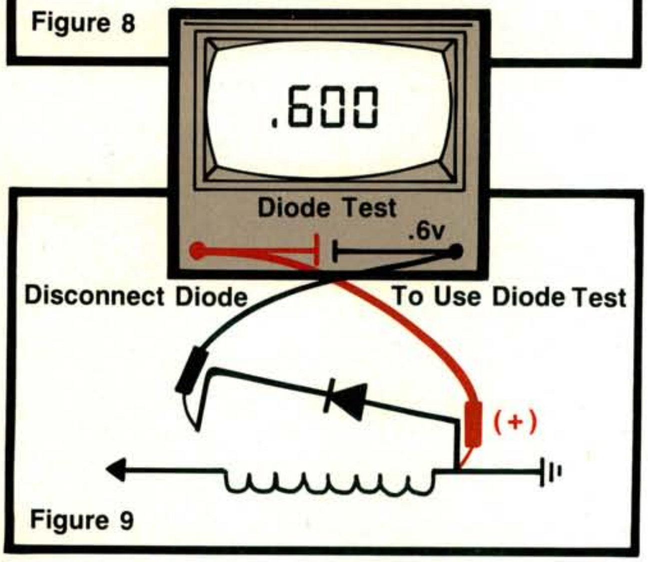

Figure 9

In Figure 9, one side of the diode is disconnected and the Diode Test indicates 0.6 volt to check the diode. Unfortunately, it takes time to disconnect the diode and you might break it in the process. So it's recommended that an analog ohmmeter be used in this instance. We can check the diode while it's still connected to the circuit using the analog meter. Now the analog meter's higher test voltage is an asset.

Most Diode Test features can be used as ohmmeters, and will measure as high as 2000 (readings will correspond to ohms), before indicating an open circuit. But we repeat, most Diode Test features can be loaded down in a hurry when resistance in a given circuit is too high. Never mind that it's a 2.5 volt circuit, it is still a low amperage circuit.

As a result, Diode Test is really best suited for use as a diode checker. Use it when checking a diode that's been disconnected from any parallel circuit. Other parts of the circuit may load the Diode Test battery to a point where it can no longer turn the diode in the circuit ON.

Summing Up

Let's look at the three types of ohmmeters one more time and review where they might best be put to use.

Use an analog ohmmeter to:

- Check spike suppression diodes across coils or relays.
- Check for clear-cut shorts to ground.
- Check the resistance of circuits.

Be careful with analog ohmmeters since they can:

- Damage sensitive auto electronic circuits.
- Turn ON semiconductors which may lower the total resistance in a circuit and change the total resistance reading.

Use a digital ohmmeter to:

- Check sensitive auto electronic circuits that might be damaged by the high test voltage of the analog meter.
- Check the "true" resistance in a circuit without turning ON semiconductors that could change the total resistance reading of the circuit.

Be careful with digital ohmmeters since they can:

- Ignore the presence of a semiconductor in a circuit.

Use the Diode Test feature to:

- Test diodes that have been disconnected from the circuit.

The Right Tool for the Right Job

You don't pound on things with an ohmmeter. You don't check electrical circuits with a hammer. There's a time and place for each tool. Having the right tools and knowing how to use them makes any job easier.

The point of this article is to let you know that the aging analog ohmmeter in your tool box still has a place there when it's properly used for the right job. But you need to be aware of the fact that it may not be doing all the things you need it to do. In fact, it may be causing you some problems you never anticipated.

It may be time for you to look at expanding your abilities and equipment to handle the ever increasing demands of the electrical systems you see. And once you've upgraded the quality and versatility of your test equipment, there's no substitute for hands-on practice with these tools until every throw of the Omega horseshoe is a ringer.

—By Vince Fischelli