Top Ten

If you've been troubleshooting electrical problems on a hit-and-miss basis, the law of averages is not on your side.

We'd like to present our top ten list of ways you can use schematic wiring diagrams to turn more and more of those misses into solid gold "hits."

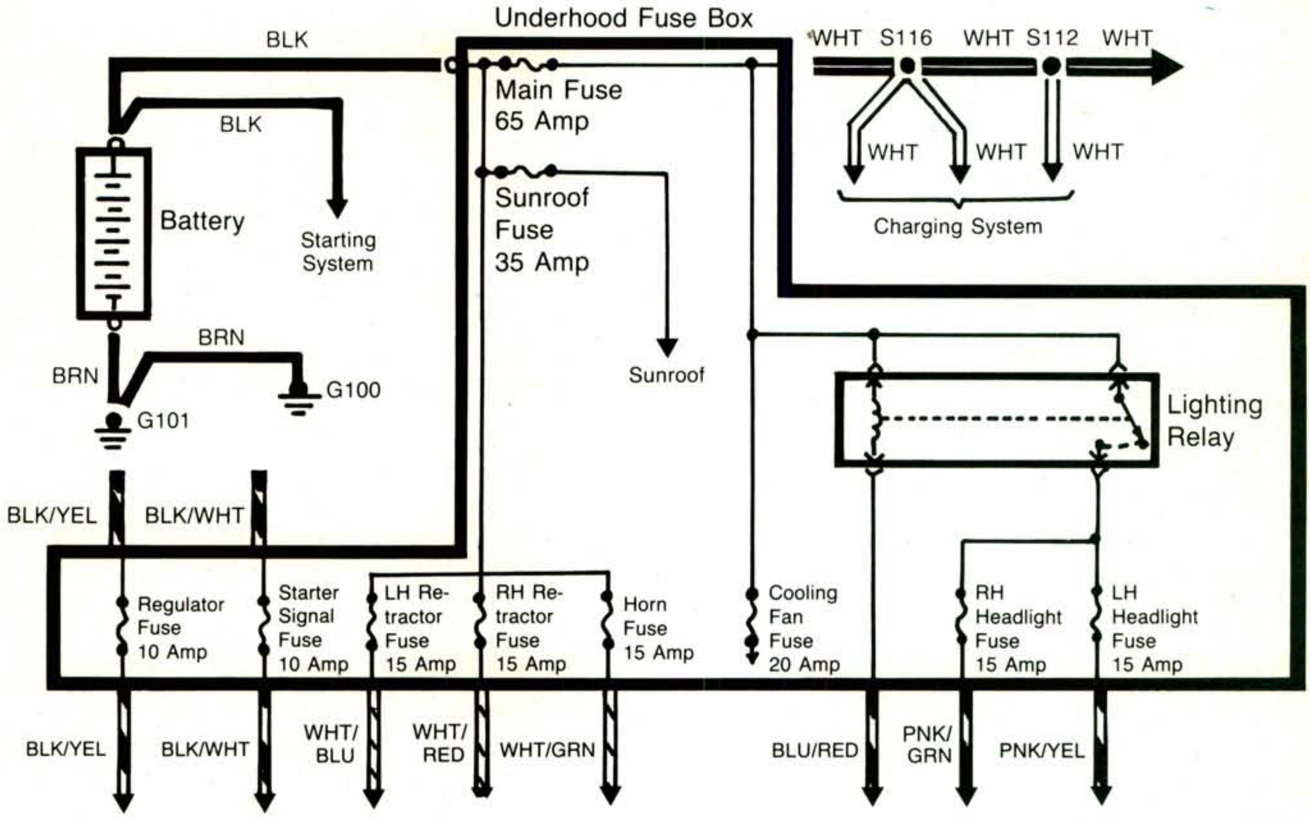
Schematic diagrams are a diagnostic tool, as valuable as any piece of test equipment. They contain vital information needed to troubleshoot vehicle electrical and electronic circuits.

Different vehicle manufacturers use a variety of symbols to illustrate similar circuits on cars. Once you learn each manufacturer's symbols (and arrangements for that matter), you can pay your quarter, push the button for your selection and sing along.

Our top ten really isn't arranged in any particular order. Whether or not any of these hits reaches number one depends on the problem confronting you. But each of these can be a troubleshooting favorite. So if you've just been humming the tune, maybe it's time you stopped and learned the words.

Figure 1

Power Distribution Schematic



1 YOU ARE MY POWER

BY VIC VOLTAGE

This little number has to do with the way the circuit gets its operating voltage. The main, or master power circuit is commonly referred to as the Power Distribution Schematic. It will usually include a schematic representation of the battery terminals themselves. We'll refer to the Power Distribution Circuit as the positive side of the circuit. See Figure 1.

The Power Distribution Schematic shows how each circuit is connected back to the positive terminal of the battery. In other words, it contains all the connections in the circuit required to complete the positive side of the circuit.

Identify the fuses used to make the positive voltage available to each circuit. Some fuses will power a single consumer or circuit. Other fuses will power more than one consumer or circuit.

In some cases, a schematic can help us check the condition of a fuse that feeds several circuits, even before we make our first voltage check. If one of the circuits powered by a fuse is working, but another circuit powered by the same fuse is dead, we know the fuse is good. We wouldn't know this as quickly without a working knowledge of how the power is distributed. The schematic will tell us this at a glance.

Some circuits are not protected by a fuse, but by a fusible link. The Power Distribution Schematic will show us the circuit or circuits protected by a fusible link. An open in the fusible link is the same as an open in a fuse. Fuses and fusible links can be hard to find, however. Engineers like to hide these circuit protectors in surprising places, just to make life interesting. The Power Distribution Schematic will quickly tell you if there is a fusible link in the circuit.

Checking for Power

When checking voltages in the positive side of the circuit, you can use your analog voltmeter just to see if voltage is present. (See *Import Service* June 1989, "Voltmeters, Testing Electrical Pressure".) If you want more accuracy, use your DVOM.

Expect to read about 12.6 volts with the key on, engine off (battery voltage), and about 14.5 volts with the engine running (charging voltage). The most common problems you'll see in the positive side of the circuit will be caused by voltage drops and open circuits. The schematic will send you to the proper test point so you can make your voltage drop measurements.

2 THE GROUND BENEATH MY FEET

BY EARTH

Next we have to determine how the circuit is grounded. The master ground circuit is similar in appearance to the Power Distribution Schematic, and not so surprisingly, it's called the Ground Distribution Schematic.

The Ground Distribution Schematic shows how a given circuit or circuits are connected back to the negative side of the battery. There can be separate ground schematics for each major system in the car.

The Ground Distribution Schematic should assign a number to each main ground connection for ease of reference. That way you can be sure you're checking the correct ground connection for the circuit being tested. Testing a ground for the wrong circuit is a real waste of time. The schematic also tells you if more than one circuit shares the same ground connection.

Figure 2 shows the ground schematic for the dash of a 1984 Honda Prelude. It shows all the dash circuits grounded at ground connection number G200.

Ground Distribution Dash Ground: G200

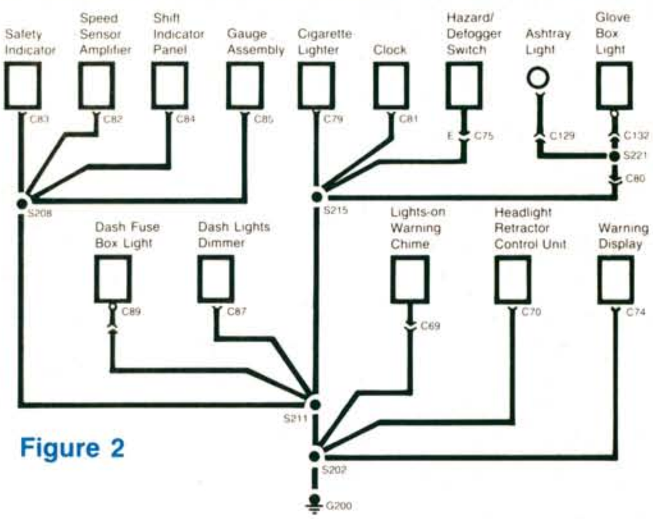


Figure 2

You'll notice all the connectors and splices in Figure 2. How many connectors do you count? How many splices? Any one of these connections could go bad and give us a voltage drop and a poor ground. The schematic tells us about the number of connections used, and their relative location in the circuit.

There are 15 connectors and 5 splices in this ground circuit. That means there are 20 separate potential problems waiting to happen. Try finding them without a schematic!

Can you identify which splice would affect all these circuits? That's right, S202.

Which splice would affect the cigarette lighter? Right again, S215. But notice that S215 also affects the clock, hazard/defogger switch, ashtray light, and glove box. The situation gets even more complicated when we notice that the ground provided by S215 to the ashtray light and glove box light is routed through an additional splice, numbered S221.

We need to be aware of these multiple connections before we start repairing circuits with bad connections. If we aren't aware of how these circuits are wired, we may perform repairs that can only be described as temporary and inefficient.

Let's say we want to fix a bad ground affecting the cigarette lighter. But if we aren't aware of the splice at S215, we may be tempted to run a separate ground to the lighter to get it working in a hurry.

Our repair was quick and the lighter works. But we've ignored the real cause of the problem, a bad connection at S215. This connection won't improve as time goes by, and we'll end up with problems in the rest of the circuit later, when the remaining consumers on that circuit start fighting for ground.

Remember, when you add a ground to repair a ground problem in one circuit coming from a multiple connection splice, you leave the rest of the consumers limping along on an already weak connection at the splice. Make sure that your ground circuit repair will provide a good ground to all the consumers on a given circuit. In this case, that means good connections all the way back to G200.

If you don't read the Ground Circuit Schematic, you won't know how many connections there are, and where they can be found in the circuit. You could start cutting away insulation and hunt through the entire cable harness to find them. But this is messy and time consuming. It doesn't make sense.

For instance, a bad ground at the speed sensor amplifier in this circuit could be caused by a bad connection at S208, S211, or S202, or even at the main ground connection G200.

Here are some diagrams that will show how important it is for you to locate the source of the problem and to properly repair the connection at that point.

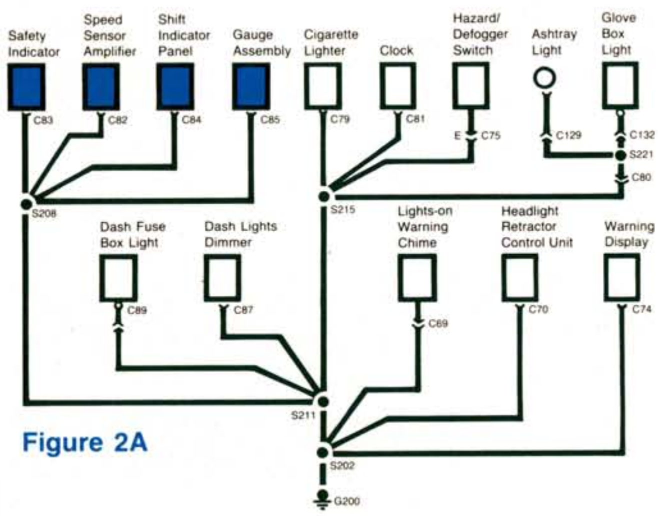


Figure 2A

A bad ground at S208 affects these circuits.

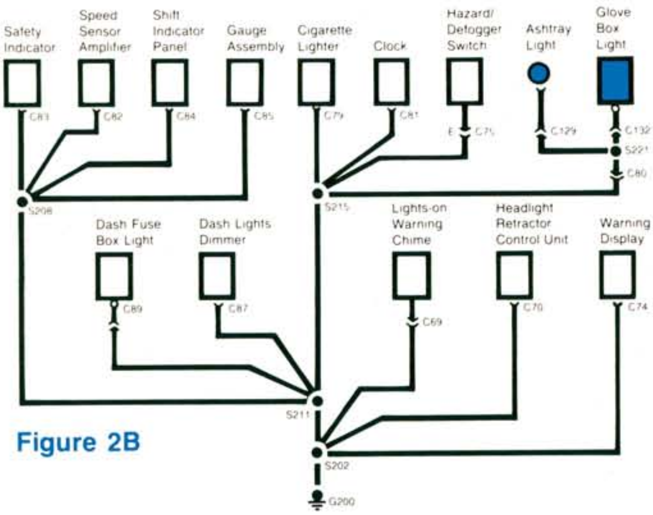


Figure 2B

A bad ground at S221 affects these circuits.

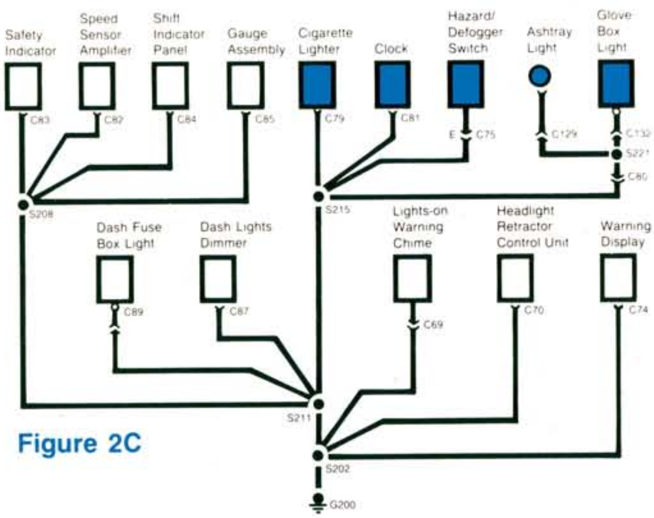


Figure 2C

A bad ground at S215 affects these circuits.

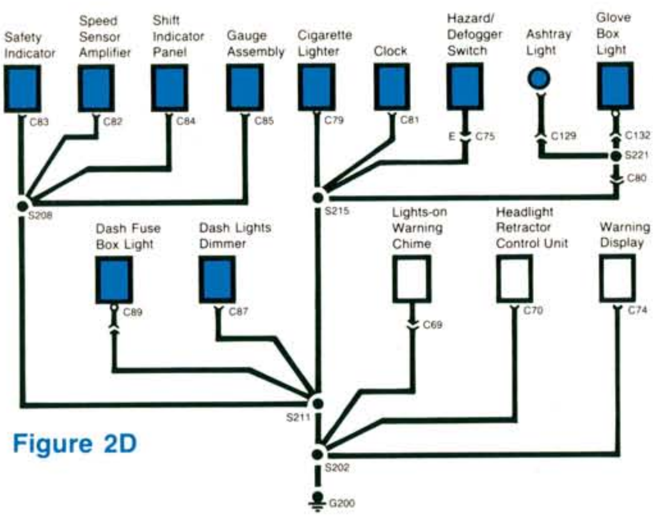


Figure 2D

A bad ground at S211 affects these circuits.

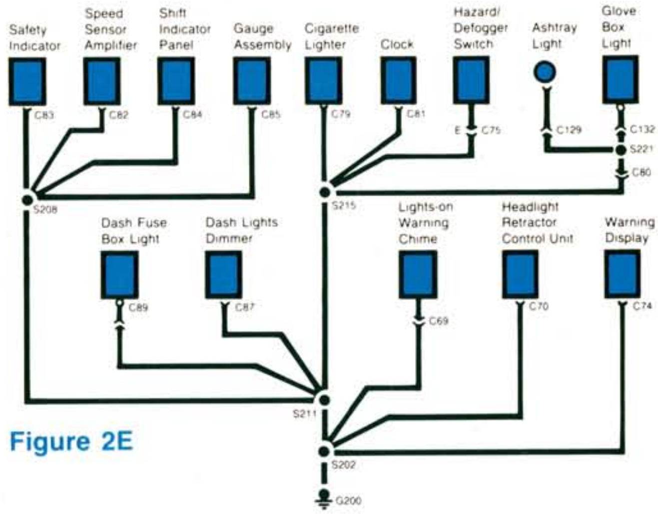


Figure 2E

A bad connection at S202 or at G200 affects all of the consumers on the G200 dash ground circuit. The closer the bad connection is to the main ground connection, G200, the more circuits are affected.

The closer the bad connection is to the main ground connection, the greater the number of circuits and components affected by that bad connection. The circuits and components farthest away from the main ground will be affected by any bad ground connection between those components and the main circuit ground.

3 MISSING YOU BY THE IGNORED COMPONENTS

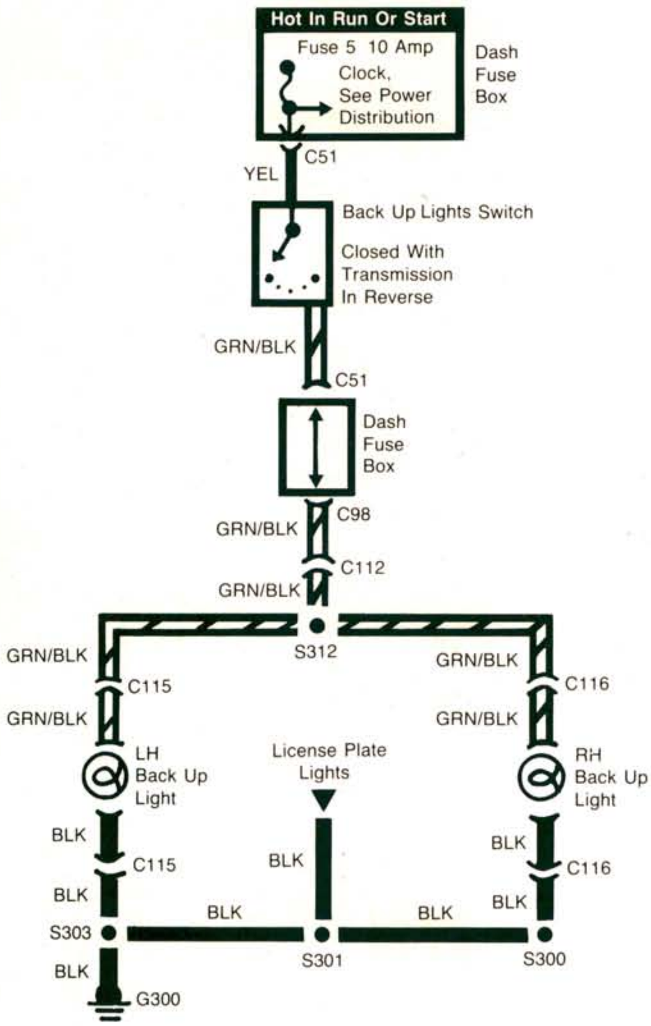
This one is a re-release of an old tune called Murphy's Law. If you forget to check a component because you don't even know it's there, or simply choose to ignore it, you can bet that that component will turn out to be the source of your problem.

If you haven't looked in the schematic and listed all the components and connections in that circuit, the ignored component will probably ambush you.

Look at all the connectors in the back up light circuit in Figure 3. If you forget to test just one of the connections in the circuit, you may pass right over the problem. You would never guess how many connectors are used in this circuit, let alone find them, unless you read the schematic. And this is a fairly simple circuit.

As the number of connections increases, so do the chances that one of these connections is bad, and one bad connection is all it takes to cause problems. Find and test these connections using voltage drop tests. Use your ohmmeter to check for opens between terminals.

Figure 3



4 HOW DO I GET TO YOU

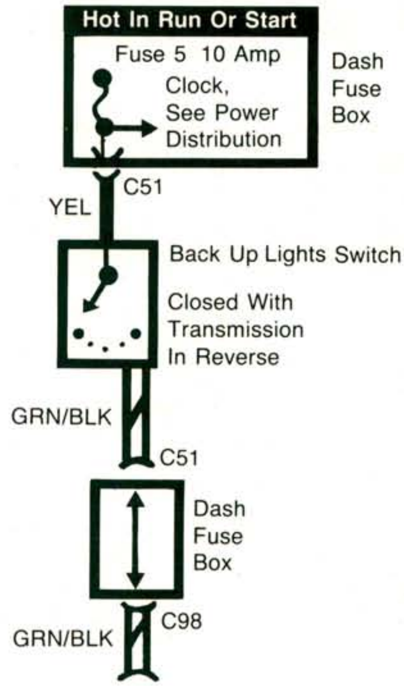
BY THE SERIES SINGERS

As always, the first step in troubleshooting a problem is understanding how the circuit is supposed to work in the first place. Once we've determined how current flows through the circuit, we can determine what the voltages should be at any point in that circuit.

Are the components connected in a series circuit? A parallel circuit? Or are they connected in a series-parallel circuit? It makes a difference.

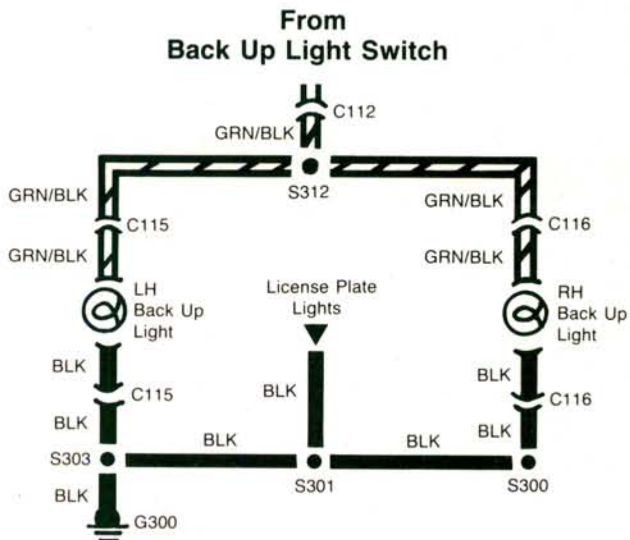
In a series circuit, the same current passes through all the components in series. Do you remember the old string of Christmas tree lights that went completely dead every time a bulb burned out? That's a series circuit. Voltage drops in a series circuit add up to the total voltage available.

This part of Figure 3 is a series circuit.



In a parallel circuit, total current divides among the branches of all circuits in parallel, (assuming that none of these paths is open). If one of the bulbs should burn out, the current flow to the other bulb will not be interrupted.

This part of Figure 3 shows the back up lights. These lights are a parallel circuit.



Even though current divides through the branches of a parallel circuit (in this case two license plate bulbs), each bulb will have the same operating voltage.

Knowing how current passes through the circuit and what the voltage readings should be before we start testing helps us understand how the circuit works. Reading the schematic is the quickest way to determine what's going on in the circuit, and whether it is a series or parallel circuit.

5 YOU TURN ME ON BY NORMALLY OPEN

Some automotive circuits are normally OFF. The circuit is completed when the switch is turned ON. Other automotive circuits are normally ON. The circuit is interrupted when the switch is turned OFF, causing an open circuit condition.

The schematic helps the technician identify the type of circuit being tested. It also helps him determine whether the circuit is controlled by a mechanical switch, or a semi-conductor controller (solid state).

Switches can be found in either the power supply or ground circuit. Here are the two types:

- **A Switch to Ground**. In this type of circuit, the consumer is permanently connected to operating voltage. The switch either opens or closes the path to ground to control that consumer. The interior light in figure 4 is switched to ground. One side of the bulb is always hot. When you open the door, a mechanical switch connects the other side of the bulb to ground, completing the circuit and turning on the light.
- **A Switch to Voltage**. In this type circuit, the consumer is permanently connected to ground. The switch closes the path from the voltage supply to the consumer. The brake lights in Figure 5 are switched to voltage.

Figure 4

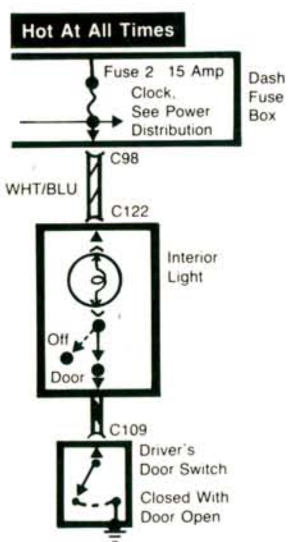
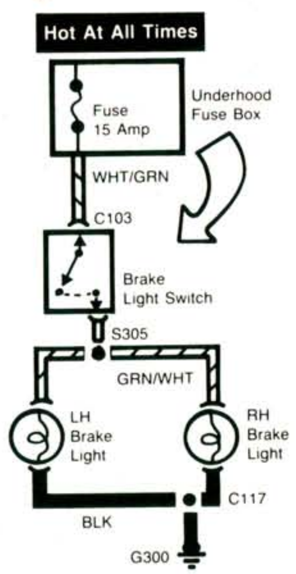
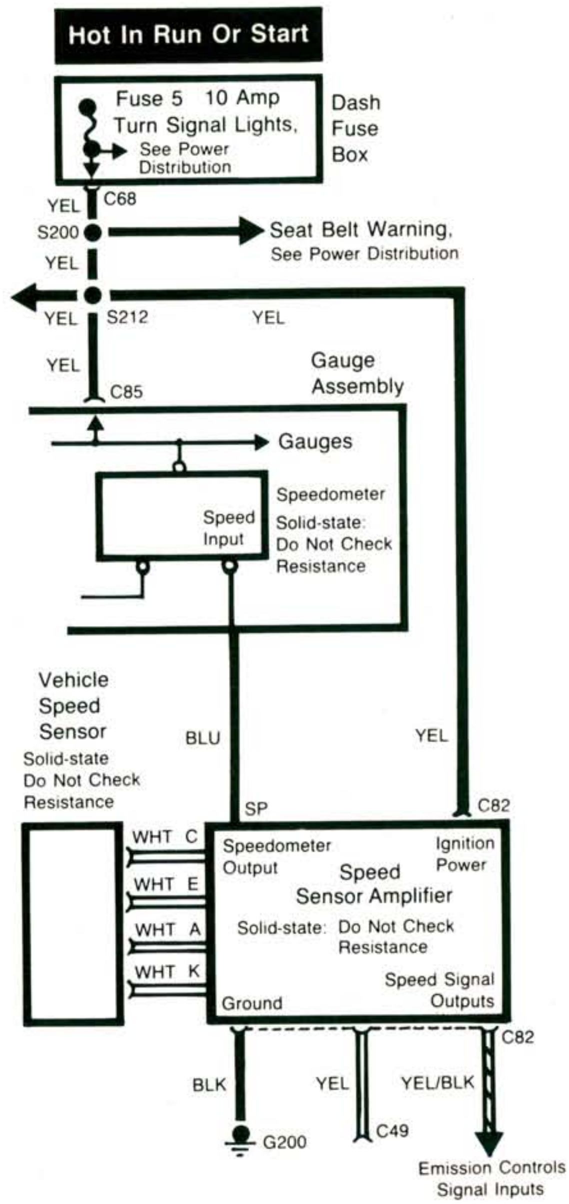


Figure 5



Mechanical switches are pretty simple to diagnose. But what about solid-state controls? These can be de-

Figure 6



scribed as electrical switches that are themselves controlled by electrical signals. They can be normally ON or normally OFF. They can switch to voltage or switch to ground. But before they can work, they need the proper electrical signals to do their job.

So what do we need? Right again. A schematic to tell us which electrical signals trigger our solid state component. Then we can test individual wires for input and output electrical signals, battery voltage, and of course, the ever important ground.

Input tests of solid state components become very important when we consider that test procedures and test values are not always available for solid state components. Diagnosis of that component then becomes a process of elimination.

If all our input values are correct at the speed sensor amplifier shown in Figure 6, and we still don't have a speed signal output at the yel/blk wire at connection C82 (bottom right hand corner of schematic), then it's time to visit the parts department.

But there's no sense plugging expensive components into the circuit when we have a bad ground connection (for example) at G200. We only waste time and money. We'll have to fix that bad ground connection one way or the other.

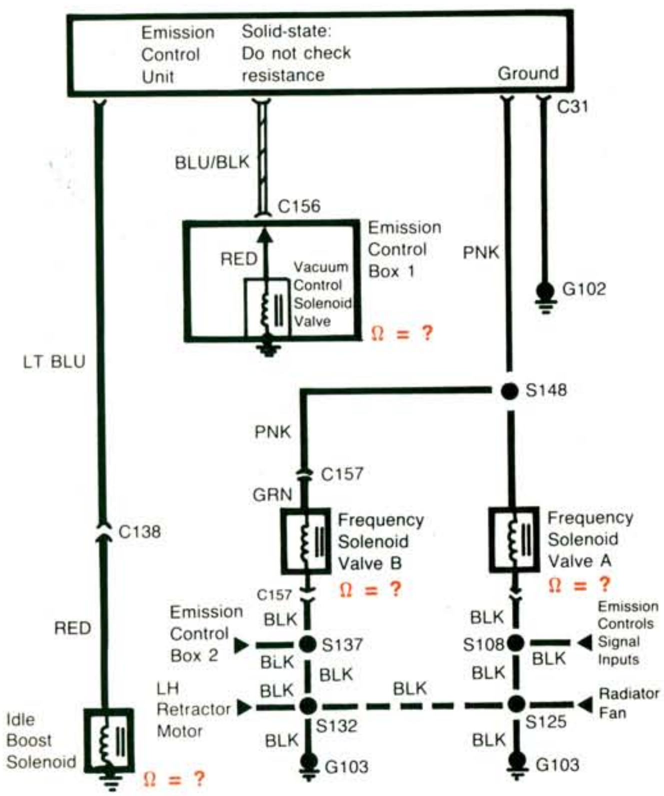
6 STOP RESISTING ME

BY THE LOAD

The purpose of a circuit is to control the load. But before we can determine whether or not the load is correct for any given circuit, we need to find out what the load is supposed to be in the first place.

Figure 7 shows an Emission Control Unit connected to four separate solenoids. Notice that frequency solenoid valves A and B are in parallel. If information about the resistance value for each solenoid is not

Figure 7



given by the manufacturer, you'll have to find the resistance of each solenoid by testing them individually. Use the correct ohmmeter for the job as outlined in the May 1989 issue of *Import Service*, and test each solenoid.

This next part is very important. As you test the resistance values for each solenoid, write your findings on the schematic. Place these numbers right next to the symbol for the component being tested. If you've ever been pulled away from a complicated test procedure to finish another job, you know how easy it is to lose your place when you return. This can mean starting all over again from scratch.

If any component is suspect, and resistance values for that component aren't given in the schematic, you may have no choice but to test a known good component to find out what normal resistance should be. I know we've all come to hate the words "known good components." But sometimes we need a starting point.

The point is, once the correct resistance reading is known, write it in the schematic next to the component symbol. If all the technicians in the shop get in the habit of writing correct test values in the schematic, it will save everyone a lot of time and effort. This becomes a valuable source of troubleshooting information.

You may even want to photocopy the schematic and jot down the initial test values. Then note the corrected values as you repair the circuit. Give this copy to the customer to show him all the work you did to fix his car properly. A picture is still worth a thousand words.

If load resistance disappears completely as it would with a shorted solenoid winding, a blown fuse or damaged ECU may result. The schematic will have the answer.

7 LOST WITHOUT YOU

BY THE LOCATORS

Any schematic worth the paper it's printed on will not only identify components and connectors, but will also help you find them. There are few things more annoying than a wiring diagram with no listing of component locations.

Take the time to familiarize yourself with the introductory material that comes with the diagrams. Usually, a good diagram will include a listing of the symbols used in the diagrams, plus some kind of locator chart. A few moments spent learning the symbols and the format of the diagram can keep you from getting lost, or misinterpreting the schematic.

Some diagrams will make a note next to the component giving its geographic location in the car. Others like this sample from a Volkswagen diagram, shown in Figure 8, list the numbered connectors and ground locations on a separate chart.

Figure 8

Wire Connectors	Ground Connections
T —junction box, by fuse/relay panel	1—from battery to trans. via body
T1a—single, left of battery	
T1b—single, behind instrument panel	4—rear panel
T1d—single, by brake master cylinder	6—on rear deck lid
T1f—single, engine compartment, left	
T2 —double, behind instrument panel by OXS control	7—on right door post
T2a—double, next to fuse/panel relay	8—on steering gear
T2b—double, by brake master cylinder	
T2e—double, behind instrument panel	10—on fuse/relay panel
T4 —radio connections	
T7 —7 point, short white housing, instrument cluster	13—on luggage comp., rear wheel housing
T7a—7 point, long black housing, instrument cluster	15—front wiring harness
T7b—7 point, long white housing, instrument cluster	16—in instrument panel wrapped in tape

8 OVERLOAD

BY THE SPIKE SUPPRESSORS

Does the circuit being tested have any spike suppression diodes connected across solenoid windings? These diodes should always be checked before any repaired circuit is powered up. If you don't replace a defective spike suppression diode, you may end up with a repeat failure of an Emission Control Unit.

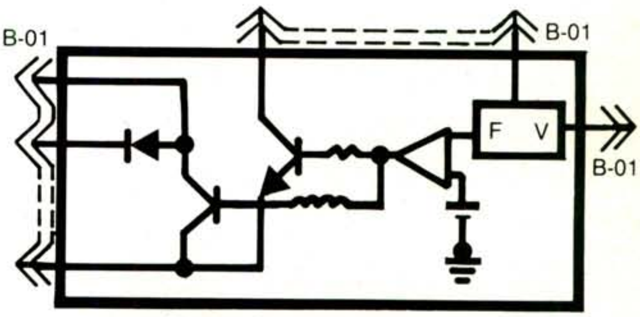
Spike suppression diodes are sometimes drawn on the schematic diagram to show you whether they are connected directly across a solenoid relay winding. If the diode is connected this way, then check it separately. (See *Import Service*, July 1988, "Voltage Suppression Diodes".)

If the diode is not shown in the diagram, then it is inside the solid-state Emission Control Unit, and will automatically be replaced when you replace the ECU.

In any event, use the schematic to locate spike suppression diodes. Then test diodes outside the ECU before powering up the circuit. See Figure 9.

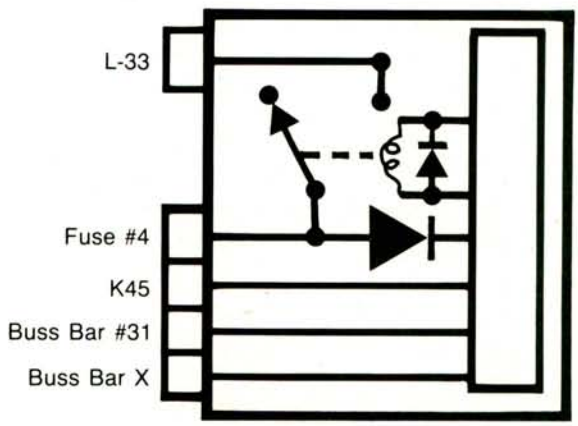
Figure 9

Diode In Control Unit



Engine Speed Control Unit

Diode In Relay



Window Ctrl Rly G7

9 COLOR ME LOST

BY FIND ME IF YOU CAN

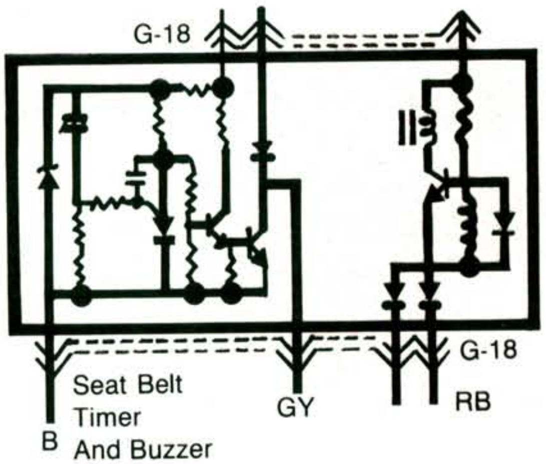
Let's hope that the wire sizes and wire colors used in the car are the same as the ones shown in the schematic. Good luck on this one—you'll need it. Sometimes you'll find that the wire you're looking for is a completely different color from the one shown in the schematic.

Fortunately, good schematics contain information about a given wire's location in a multiple connector.

Some diagrams will give you numbers that correspond to numbers on the connector body itself. Others, like our example in Figure 10, will show you a side view of the connector that corresponds to the wire colors in the main diagram.

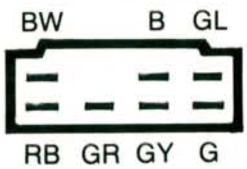
Figure 10

Component Symbol



Connector Symbol

G-18 Seat Belt Timer And Buzzer [SB]



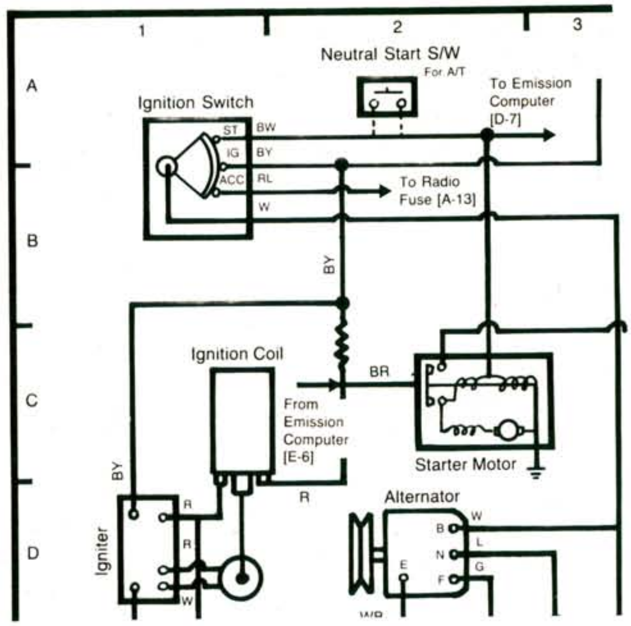
There is a better chance that pin connectors will be properly numbered, than there is that all the wire colors in the car will correspond to the colors shown in the schematic.

Tracing the wire to the correct pin in the multiple connector is a lot safer than relying on wire color alone.

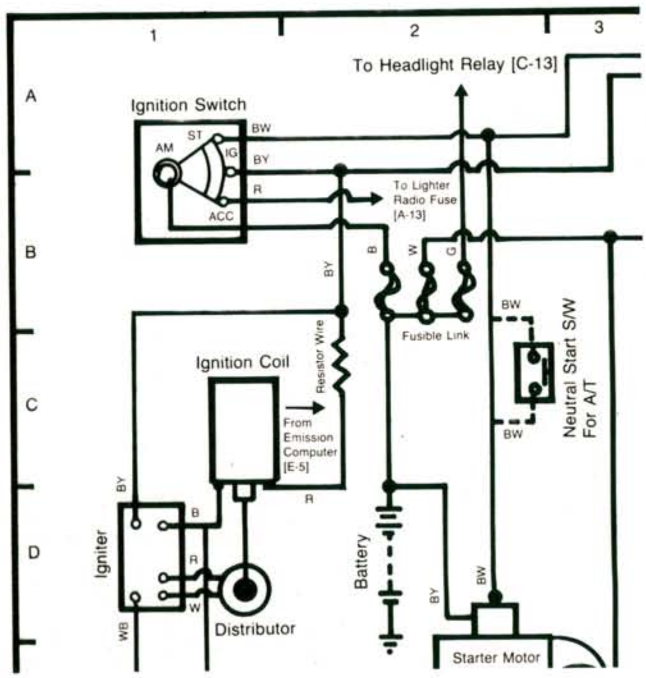
10 CHANGES BY THE ENGINEERS

Make sure the wiring diagram fits the car you're working on. If the wiring diagram in your hands is even one year off, you can get lost in a hurry. It's a little like trying to find your way around Chicago, using a map of Los Angeles.

These portions of two wiring diagrams are taken from the same corner of the main schematic. They apply to the same make and model car. But one applies to a 1978 model and the other to the same car one year later. As you can see, things change in a hurry.



Same Car—One Year Later



An Important Tool

A good wiring schematic in the hands of a competent technician is a valuable tool. It is every bit as important as an expensive piece of electrical test equipment. In addition to the obvious benefits listed above, it also helps you organize your thoughts, and plan your troubleshooting techniques. You end up with hits, not misses.

—By Vince Fischelli