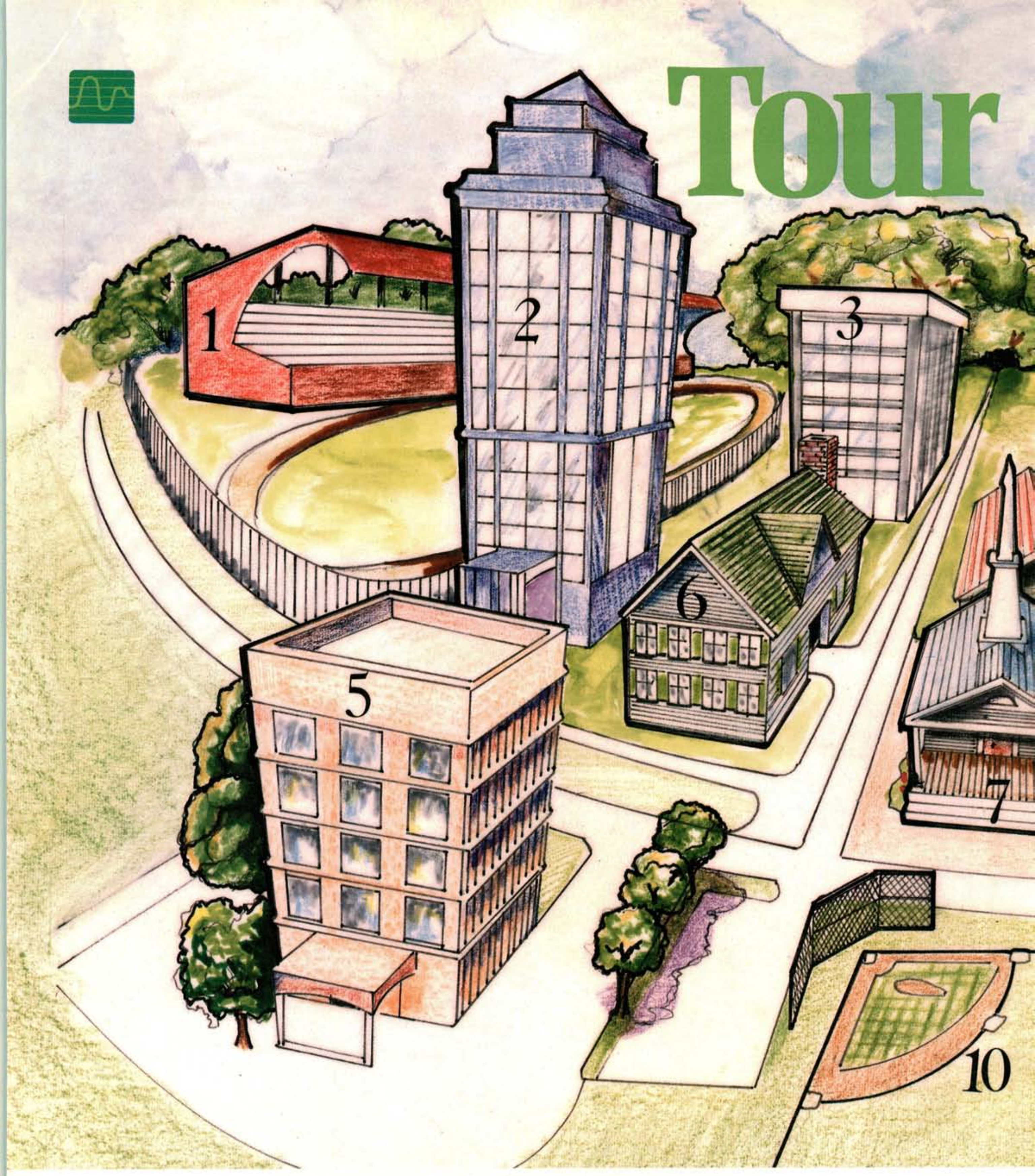


Electrical Schematics

You wouldn't leave for a summer vacation without taking a road map. Driving around aimlessly can make the wife and kids crazy. So why wander into an unknown electrical problem without an electrical schematic diagram? Think of a schematic as a tour guide which will deliver you to a successful repair with as little lost motion as possible.

Wiring diagrams will show you all the main highways used by power and ground circuits,

Guide

and point out some secondary roads you might miss otherwise. In fact, wiring diagrams contain far more information than you might think.

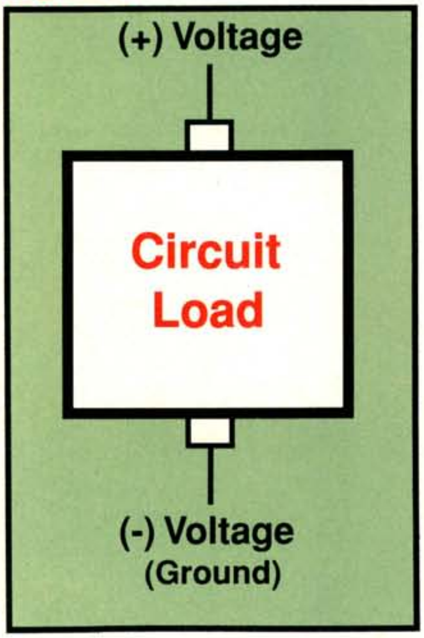
In this article, we'll look at electrical system wiring diagrams and learn how they can be useful as a tour guide which will show us the shortest route to our destination—repair of a faulty electrical circuit. (There are also electronic and vacuum schematic diagrams, but those are stories for another day. Electrical schematics will keep us busy enough for the time being.)

What Is An Electrical Circuit?

An electrical circuit is considered to be a circuit which needs only voltage and ground to work. It contains no semiconductor components.

Figure 1 shows a simple block diagram of an electrical circuit. Most electrical circuits are fairly simple. They show how a circuit gets power (+) and ground (-).

Figure 1



What Is An Electrical Schematic Diagram?

An electrical schematic diagram is a drawing of an electrical circuit where components are represented as symbols. The symbols are connected by lines which represent wires (or sometimes the metal chassis/ground circuit).

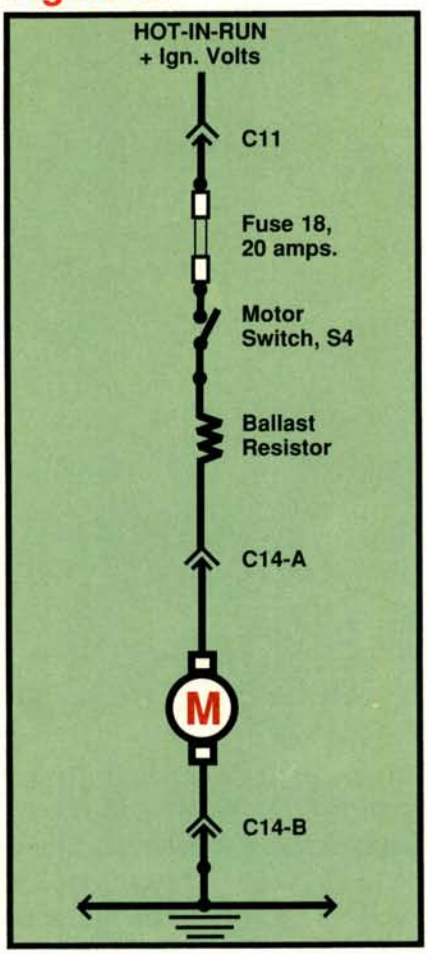
These wires are the roads leading between individual components, and they are a high accident area for electrons. **Figure 2** shows a typical electrical schematic of a DC motor circuit.

Our definition of an electrical schematic implies that you need to know what each symbol stands for. Unfortunately, different manufacturers may use slightly different symbols to represent the same components. That's where a thing called the *legend* comes in. Like the legend on a map, it helps you identify what a particular symbol represents.

Once you know what components the symbols stand for, and recognize that the lines are paths between the components, the only other tool you'll need is your finger. That way you can trace along a path between components and troubleshoot a circuit before you ever touch the car. An experienced technician with a good electrical or electronics background will always plan his repair with the help of the correct schematic.

We'll give you a real example of troubleshooting on paper a little later.

Figure 2



What Is The Purpose Of An Electrical Schematic?

The purpose of an electrical schematic is to tell you what components are involved in a particular circuit, and how they are connected together.

A really outstanding schematic will give you both Static and Dynamic values for a circuit.

- **Static Data** includes voltage and resistance values when the circuit is OFF.
- **Dynamic Data** gives you current and voltage information as well as signal patterns for the circuit when it's turned ON. Dynamic Data is very useful as a troubleshooting tool.

Unfortunately, there aren't too many outstanding schematics to choose from. Most provide only Static values.

Getting Started—What To Look For First

Even if you're fairly familiar with a circuit on a given car, a wiring diagram is still a very useful tool. It'll help you find the correct location of a ground terminal for a given circuit, or help you identify a specific pin number in a connector.

Let's face it, even if you were born in Boston, Bismark, or Baton Rouge, you probably don't know all the street names in your own hometown by heart.

For our purposes, this article will assume that you know nothing, *zilch*, about a car or a given circuit. You're not in your hometown, and don't know any street names. We'll assume that this is the very first time you've been forced to deal with this circuit.

Identify the Load

The first thing we need to identify is the Load (or Loads) in a circuit.

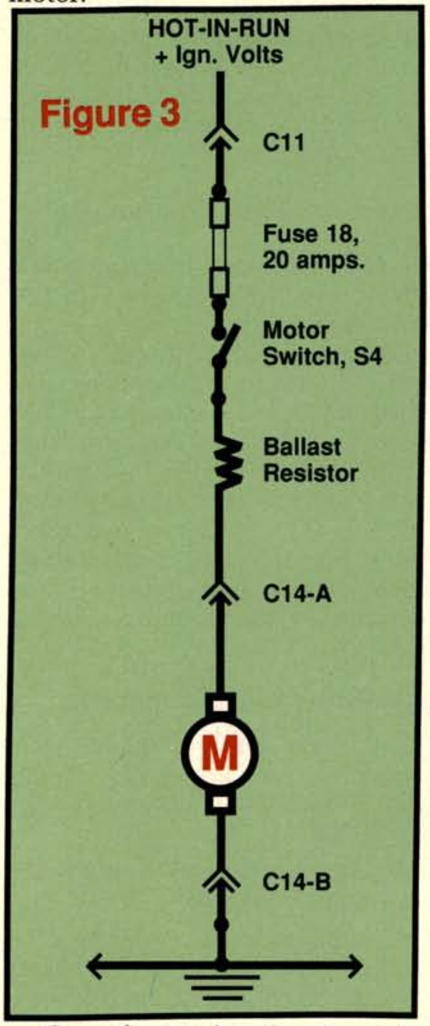
The Load is the heart of a cir-

cuit. It is the reason the circuit exists. The Load is what the circuit will power.

Examples of Loads:

- The Load of the blower motor circuit is the blower's motor.
- The Load of the power window circuit is the motor in the door which drives the window up and down.
- The Load of the headlight circuit is the headlamp itself.

It's easy to identify the Load. In **Figure 3** the Load is the DC motor, marked with a big "M." This is a fairly universal symbol for a DC motor.



Once the Load in the circuit is identified, the schematic tells you how the positive voltage gets to the voltage feed terminal of the Load. It also tells you how the negative voltage (we'll call it ground) gets to the Load.

In **Figure 3**, positive voltage is in connector C14-A. Negative voltage is in C14-B.

The Load needs both voltage and ground. The schematic tells you where they come from, and where they need to go to reach the Load terminals. It also tells you which switching devices are used to control the ON or OFF state of the circuit.

A Real Example

A customer comes to you with his car problem. "When I push the button, my gizmohickey doesn't work." You look at the gizmohickey and sure enough, it doesn't work when you push the button.

This time, the customer is actually right.

At this juncture of the troubleshooting process, some techs bolt in a new gizmohickey, especially if there's a new one handy, and the gizmohickey is easy to replace. Maybe the new one works, and maybe it doesn't.

Let's say it doesn't. If you've already glanced at the schematic, you'll know the path taken by the voltage and ground to get to the Load.

If voltage or ground (or both in some cases) are missing at the Load connection, the new gizmohickey won't work any better than the old one did.

At this point we need to know if positive voltage is lower than normal, or if negative voltage (ground terminal voltage) is higher than normal.

Let's start with the voltage supply in **Figure 3A**

Trace the Voltage Side of the Load Circuit

Start at the voltage side of the Load. Trace back along the line representing the voltage supply. Note all the common places where an open circuit can occur: connectors, switches, fuses, and the ballast resistor. Think to yourself as you go. Is the fuse blown? Are the contacts on the switch dirty? Or is the ballast resistor open? Is connector C11 open?

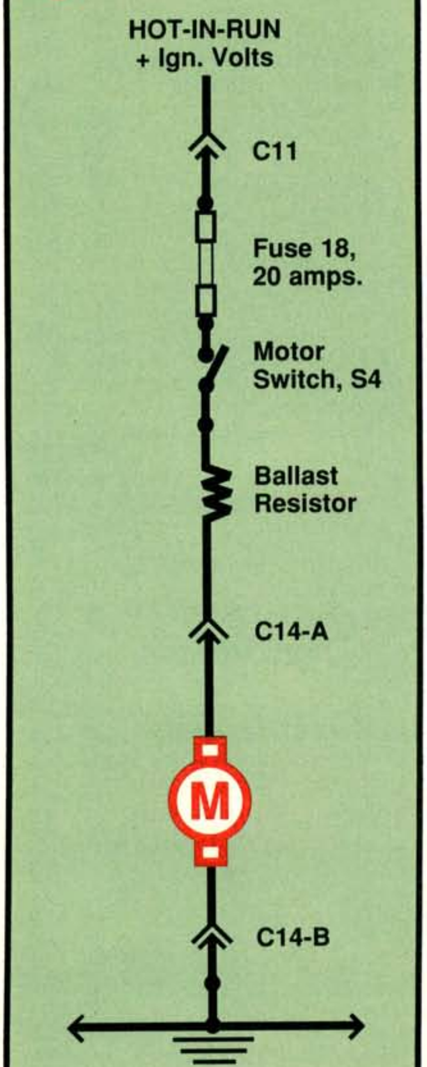
This is called troubleshooting on paper. It's fast, easy, and folks, it's clean! You are making a list of possible reasons why there may not be any voltage at the Load. And you're also making mental notes on the locations of these connections as you go.

Once you've identified all the components which make up the voltage supply side of the Load circuit, you're ready to move from troubleshooting on paper to the real thing. Now you have a plan, and you won't make the mistake of forgetting to check any key component which might cause a LOW or NO voltage condition at the Load.

You may start by checking the fuse, since it's usually easy to reach. You'll check for voltage into and out of the fuse. If the fuse is good, you can start at the other end, working back from the Load toward the fuse. Your voltage tests at the starter show no voltage. But you work your way upstream. At one point, voltage will reappear.

When voltage is found, you've reached the area of the circuit where the problem is located. No voltage at one point, voltage at the next point. The problem is between those two points. Clean the connections or replace a defective switch to restore continuity. The schematic diagram has shown you the path to take when troubleshooting.

Figure 3A



Trace the Ground Side of the Load Circuit

Start at the ground terminal of the Load, and trace the wire on the schematic to the ground connection. Note the ground circuit number. Look to see if any other Loads share the same ground. If the ground connection is bad, expect other Loads sharing the same ground to also be affected.

If you notice that other circuit Loads sharing the same ground are also working improperly, you have identified a bad ground circuit as the cause of your problem.

Correct the bad connection (or connections) in the ground circuit until you get a voltage drop reading of 0.1 volt or less on the ground side of the Load.

Start with the Schematic

By tracing the circuit on paper before troubleshooting, we do two important things:

- We get a mental picture of the entire circuit. We understand HOW the components line up to provide voltage to the Load. We also have an idea where they're located.
- We won't forget to check a critical part of the circuit we wouldn't know was there without the schematic. Maybe connector C11 is hidden in the dash behind an air duct.

Important Things to Look for in a Schematic

As you go through the schematic, do the following:

1) Note how voltage gets to the Load.
2) Note how ground gets to the Load.
3) Note the number and location of connections and components in the voltage side of the Load.
4) Note the number and location of connections and components in the ground side of the Load.
5) Note the number of circuits which share a ground circuit.
6) Note the path of current through the circuit.

7) Identify the type of switch which is used to turn the circuit ON and OFF. It may be a simple ON/OFF switch or may be a relay.

8) Be sure you understand what the circuit is supposed to do when powered up.

9) Note the presence of a resistor (like a ballast resistor) which will drop some of the voltage.

10) Note the location of all connectors. Connectors are a notorious cause of low or no-voltage, both positive and negative.

11) Note the color or pin terminal numbers of important wires. Pin numbers may be more accurate in some cases. Some manufacturers won't stop the manufacturing process when they run out of red wire!

12) When you determine circuit voltage or resistance in a working circuit, jot down the correct values on your schematic for future reference.

Now Let's Do It

The schematic diagram shown in **Figure 4** is a Datsun starter circuit. Yes, Datsun, just before they decided to change it to Nissan. It is a representative starting circuit which illustrates the need for a schematic diagram.

The schematic shows the circuit for a diesel engine. Lines labeled M are for a manual transmission equipped car. Lines marked A are for automatics. Lines marked AS are for cars with automatic transmissions with speed control. This is the type of information normally supplied in the legend at the bottom of the schematic.

Our car has a manual transmission which won't crank, so we'll use the lines marked with an M. The blue line highlighting the circuit shows the path of voltage to the Load with the ignition key in the START position.

Let's follow our own advice:

First, we'll identify the Load(s). In this case, the first Load we encounter is the starter motor, shown in the lower left corner of our schematic. It is permanently grounded. That tells us that we need to get voltage to the positive side of the Load (starter).

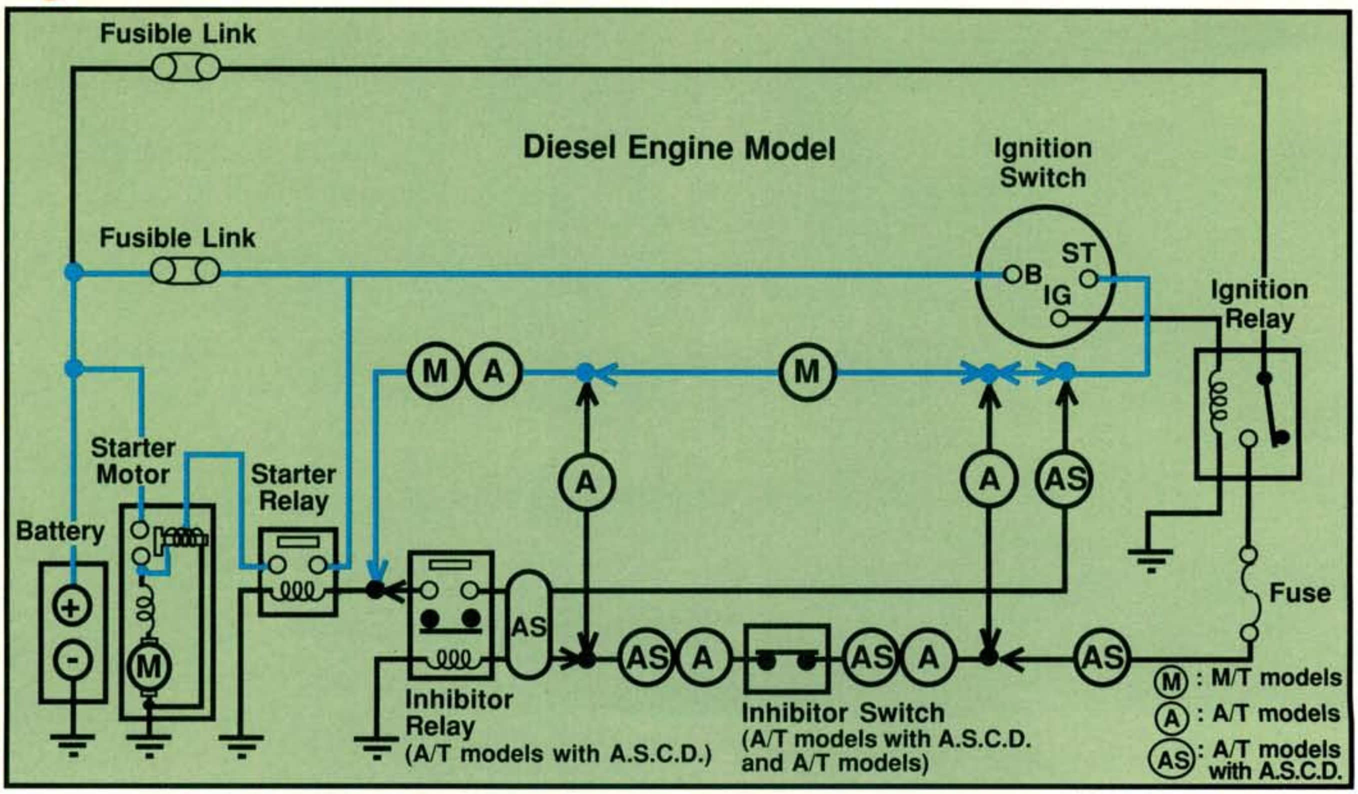
Put your finger on the Starter. Then move it up to the starter solenoid contacts. This identifies a second Load, the windings in the solenoid. The solenoid is also permanently grounded. The solenoid windings must be powered up to close the solenoid's switch contacts.

Now move your finger to the next step, the starter relay. Its windings must also be powered up to close its internal switch.

We have now identified three Loads in the same circuit: the starter motor, the starter solenoid, and the starter relay. Each has a permanent ground (one end of each winding is always grounded). That means each must be switched to voltage to do its job of providing cranking voltage.

(Try to imagine tracing even this simple circuit without a schematic. It would be a nightmare trying to track this through the wiring harness.)

Figure 4



Follow the Trail

Let's follow the voltage through the schematic diagram to see how the voltage ultimately reaches the starter motor. It should be easy now. We've already identified all the Loads.

1) The ignition switch is turned to the Start (ST) position. This provides voltage to the starter relay winding. Trace from the ST terminal on the ignition switch to the voltage side of the starter relay. When the ignition switch moves to the ST position, it supplies voltage to the relay which energizes. This closes the relay switch contact. Load #1 is doing its job.

2) Battery voltage now flows through a fusible link and through the relay switch contacts to the voltage side of the solenoid.

3) The starter solenoid winding energizes the plunger in the solenoid (Load #2). This closes the switch contacts in the solenoid. Battery voltage passes through the switch to the starter.

4) Battery voltage supplied to the voltage side of the starter energizes the starter motor (Load #3).

Without our schematic tour guide, we might not even be aware that there is a starter relay in the circuit. If you don't know it's there, and it's hidden out of sight, you may not test it at all. (See the May 1992 issue of *Import Service* for more information about troubleshooting relays.)

Better Schematics

Once you start using schematics, two things will probably happen:

- Your efficiency rating on electrical problems will improve, and you'll wonder how you ever did without them.
- You'll start criticizing many of the poorer diagrams for not including enough information. Here are a few suggestions we'd like to make for improving schematics:

1) Give us recommended voltage readings at different points in the circuit.

2) Give us resistance values of critical components so we can check them with an ohmmeter.

3) Give us recommended current readings for critical circuits. That way we can tell when circuit current is too high or too low.

4) Give us signal wave form patterns in electronic circuits so we can tell when an electronic circuit has a problem not related to voltage.

Is anybody listening?

—By Vince Fischelli