2
GENERAL PROCEDURE

ELECTRICAL TROUBLE SHOOTING PRACTICE

GENERAL CONCEPTS

Every electrical circuit in your car consists of five basic parts:

1. Source of electricity: battery or alternator.

2. Path for electricity from source to consumer: These are the wires, plugs, connectors, fuses, etc.

3. Control device: switches, such as turn signals, headlight switch, oil pressure switch, etc.

4. Consumer of electricity: Lights, horn, wiper motor, etc. - the reason for the circuit in the first place.

5. Return path for electricity from consumer back to source: this is the ground connection. In some cases, the device is connected directly to ground, such as the horns, and in other case, there is a separate wire for ground, such as the headlights.

Remove or disable any one of these five, and the circuit will not function. It follows, then, that if a circuit isn't functioning, one of these five items is the source of the trouble. To determine which of the five items is the problem, a systematic trouble shooting procedure is helpful.

TOOLS REQUIRED

Almost all electrical troubleshooting can be accomplished with only a very small set of tools. In addition to the normal assortment of screwdrivers, wrenches, etc, you should have the following:

<u>A cheap test lamp.</u> These can be bought for as little as $4.00, or for as much as $25.00. The $4.00 lamp is just as good as any. This lamp consists of a plastic holder for the bulb, with a sharp tip on it, and a long wire with an alligator clip on it. See **figure 2**. This is just about a mandatory tool to have, and is almost sufficient for all troubleshooting efforts

<u>Multi meter.</u> The next step up in the electrical tool department is a cheap VOM, commonly referred to as a multi meter. VOM stands for Volt Ohm Meter. Some of the better meters also have an ammeter as well. I don't recommend buying an expensive meter, as high quality isn't needed, and there is a very good chance that you will ruin it through misuse sooner or later. Ruining a cheap meter doesn't hurt as much as ruining an expensive meter.

<u>Buzzer.</u> A handy tool to have, especially if you work by yourself a lot. This you will have to make yourself, as they aren't readily available most places. It consists of nothing more than a 12-volt buzzer or chime module, with two long leads on it, both with alligator clamps. To use it, clip the negative lead to ground, for example, and the positive lead to the circuit you're trying to test. When you have power to the connection in question, the buzzer will sound, so you will know that you have succeeded in completing the circuit-much better than asking your SO to stand around and tell you if the meter is now reading 12 volts or not.

<u>Continuity tester.</u> A handy device, but very dangerous if you are not careful. Not dangerous in the sense that it will harm you or the car, but dangerous in that the indications can be very misleading. Exercise great care when interpreting continuity tester readings. More on this later. The tester itself is very simple, consisting of a plastic holder for a bulb and a battery, with a sharp tip on it and a long lead with an alligator clip. Some of these are nearly identical in appearance to the test lamp described above.

<u>Schematic.</u> Mandatory! Many electrical repair experts will tell you they don't need a schematic, but they are wrong. They may not need to have a printed schematic in front of them, but they MUST have a schematic in their head if they don't. I've worked with electrical problems on TR6s long enough that I can *almost* draw the schematic from memory, so I can do a lot of repair without a diagram in my hand. When working on my Toyota pickup, though, I must pull out the manual and review the schematic.

<u>Test leads.</u> A few short lengths of wire with alligator or crocodile clips on each end will be very helpful when trouble shooting. At least one of the leads should have an in-line fuse added.

<u>Soldering iron and solder</u>. A 100 watt or so soldering iron is best for this type of electrical work, but too big (within reason) is better than too small. If the iron is too small, it will take a long time for the wire to get hot enough to melt the solder, which will allow time for the heat to wick up the wire , and may damage the insulation. With a larger iron, you can get the wire hot enough before there is enough time for the wire to get hot beyond the area of the joint.

NEVER use acid core solder, as the acid will cause corrosion over time. Use a small diameter, low temperature solder, with a rosin core

Crimping tool. Don't skimp here. A poor quality crimping tool will make terminations that are prone to working loose with time.

Common sense and logic. It's amazing how much trouble shooting can be done without ever touching the car or a tool.

PROCEDURE

1. Source of electricity

The first thing we'll look at is item one of our list of basic circuit parts: source of electricity. The distribution of electricity in a British car can be divided up into four groups, distinguished by the main color of the wires used in each group. The four groups are:

BROWN: These wires are hot all the time, and are not fused.

WHITE: These wires are hot only when the ignition key is on, and are not fused.

PURPLE: These wires are hot all the time, and are fused.

GREEN: These wires are hot only when the ignition key is on, and are fused.

These four groups of wires and their colors need to be COMMITTED TO MEMORY. This bit of knowledge will be extremely valuable when trouble shooting electrical circuits.

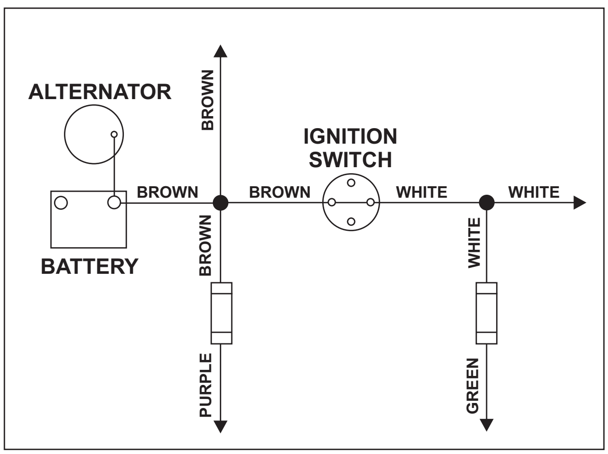

FIGURE 1

Refer to the **figure 1**, above. This is a very simplified diagram of the power feed/distribution scheme used in all TR6s, and in virtually every other British car of this era. The four groups of wires provide power to various loads as follows:

BROWN WIRES: starter, ignition switch, headlights, horns (if not fed by purple wires), and the fuse for the purple wires.

WHITE WIRES: ignition coil, electric fuel pumps, low oil pressure warning lamp, brake failure warning lamp, alternator warning light, and the fuse for the green wires.

PURPLE WIRES: horns (if not fed by brown wires), courtesy lamps, trunk lamp, glove box lamp, hazard flasher, and the high beam flasher (flash to pass).

GREEN WIRES: windshield wiper, windshield washer, brake lights, back-up lights, gauges, turn signals and the heater fan.

How's all this going to help us? Well, let's take a typical problem and see. Suppose you find that your brake lights don't work. Let's follow a logic path to a resolution. Remember, the brake lights get power from a green wire!

Does the engine turn over when you turn the key? If so, you know the battery is good, you have power on the brown wires, and you have power to the ignition switch, or else you wouldn't be able to get power to the starter.

If the engine doesn't turn over, then you know the battery is bad, or you have some bad connections somewhere in the main power circuit, so there's no need to waste time looking for the brake light problem till that problem is fixed.

Does the engine run? If so, you know you have power to the white wires, and you should have power to the fuse for the green wires.

If the engine doesn't run, you need to find out why. Maybe the white wires don't have power because the ignition switch is bad. If the white wires don't have power, it's for sure the green wires won't.

Do any of the other loads fed from the green wires work -- gauges, windshield wipers, turn signals, etc? If so, then you know you have power to the fuse, and you know that the fuse is good - otherwise, none of the other "green wire" loads would work.

If none of the other "green wire" loads work, it's a safe bet that either the fuse is blown, the fuse isn't getting power from the ignition switch, or there is a bad connection near the fuse.

By now, we've either found the source of our problem, determined that it is not a power problem, or we've narrowed the power problem down to particular area for further testing. We're left with two possibilities now - either we have power to the "green wire" or we don't

First, let's assume we don't have power to the green wire circuit, i.e., none of the green wire loads work. The first thing to check is the fuse itself. Most of the time, but not always, a blown fuse will be obvious from a visual examination. If this turns out to be the case, we are finished. If not, more work is needed.

The next step, then, is to look for power. The preferred approach to this is to start at a place where you know you have power and trace till you find a point where you don't, or, start with a place where you know you don't have power and trace till you reach a point where you do. In reality, though, it is often easier to pick a point that is easily accessible and work from there, moving in whichever direction is needed. If you find voltage at this point, move toward the load till you don't have voltage. If you don't have voltage at this point, move toward the battery till you find voltage.

In this case, the fuse is probably the easiest point to get to, so we will start there. With your test probe (or voltmeter), check for voltage on one side of the fuse or the other. Which side you start with doesn't matter. For the sake of argument, let's say you started with the white wire side of the fuse and found no voltage. As we have already established that we have voltage on the white wires (the engine runs), we can assume there is a break or bad connection in the white wire from the ignition switch to the "green" fuse, which will need to be fixed.

If we do find voltage on the white wire side of the fuse, then we know the fuse is bad, the fuse contacts are bad, or the connections/terminals for the green wires are bad.

2. Path for electricity

If we've determined that we have power (at the green wire), the next step is to verify a path for the power to get to the brake lights. How are we going to do this? Not with a continuity tester, as one might expect, but by looking for the presence or absence of voltage.

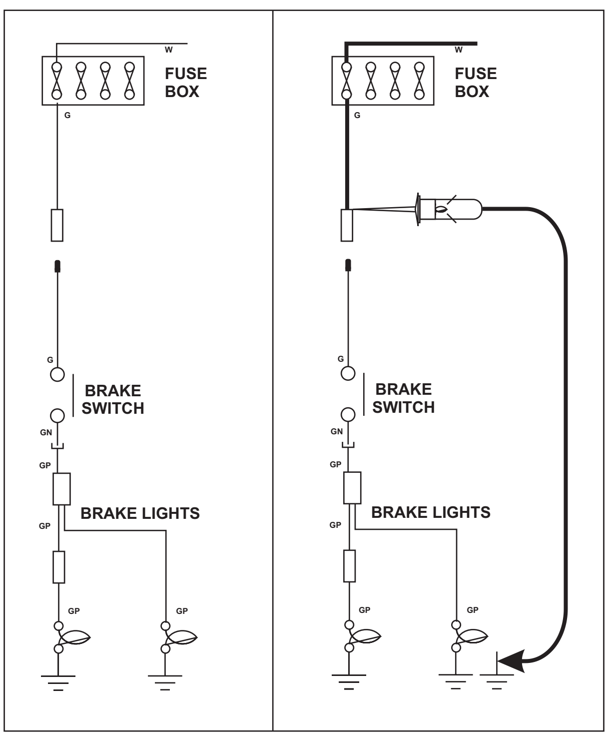

FIGURE 2

How does the presence of voltage verify continuity, when you can get a voltage reading on a battery that isn't even connected into the circuit? Refer to **figure 2**, below left.

On the left side of this figure, we see that one of the bullets has pulled loose from it's sleeve, interrupting the flow of electricity in the circuit. On the right side of the figure, we have connected our test light between the sleeve and ground. In order for the light to be lit, there must be voltage present at the bullet, and the test lamp provides the current path to ground through the light. If there isn't continuity, the test light will not illuminate. Continuity must exist from the battery, through the upper portion of the brake circuit, through the lamp, and through ground back to the battery; therefore, we have proven continuity through the brake circuit, at least up to the sleeve.

Suppose, though, that the bullet was not loose at this point, rather it was loose at the point shown on the left in **figure 3**. In this case, we would move our test lamp from the upper sleeve to the top of the brake switch. Finding voltage there, we would next move our probe to the lower side of the brake switch.

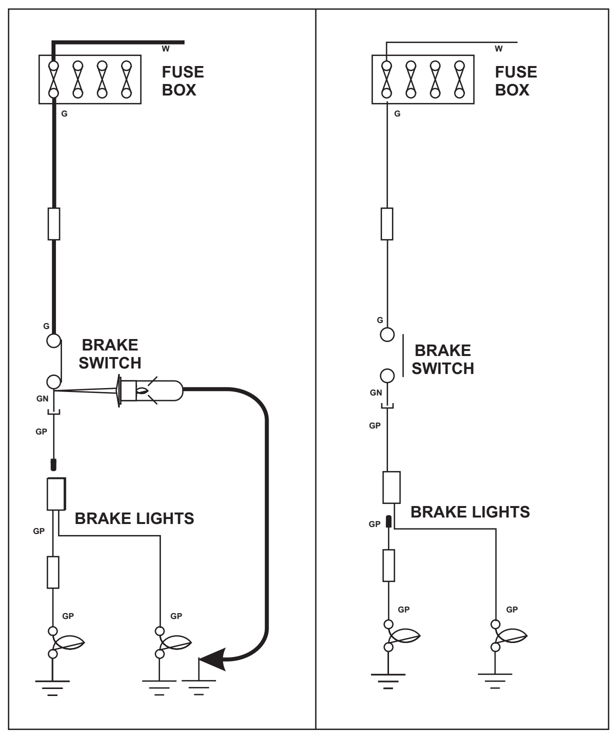

FIGURE 3

In order to check for circuit continuity here, the brake switch must be closed. If we have voltage here, we move our probe on down the circuit to the harness connector for the rear wiring harness (by the way, we have just proved our brake switch is OK, but more on that later). We continue moving our probe till we get to the top of the sleeve. At this point, we will find no voltage, so we know that the break is between the sleeve and the harness connector. A physical examination will be required to find the break. In this case, it was a loose connector, which will not be hard to find, but it might just as well been a break in the wire somewhere along the harness routing behind upholstery panels or carpet.

Suppose the break had been a loose connecter as shown on the right hand side of **figure 3**? If that were the case, we shouldn't have been going through all this testing in the first place. If the brake light on one side of the car is working, but not the other, we know the problem is somewhere in the circuit where the wiring for the two sides split. Our search would have been similar to the above, but confined to the wiring at the rear of the car, and we would not have been checking on the availability of power at all - if even one light works, we know there is power to the circuit.

That would be an example of how we can use common sense and logic to do a lot of our trouble shooting. A review of the wiring diagrams, a little process of elimination, and many problems can be solved without ever using a piece of test equipment.

3. Control device.

We've already seen, in our example above, one excellent way of testing control devices. If we have voltage on one side of a switch, but not on the other when the switch is in the on position, we know that the switch is bad. Having voltage on both sides of the switch is not, however, a guarantee that the switch is good. It is possible that there is so much internal resistance from contact corrosion that there will be an excessive voltage drop through the switch when an actual load is connected that the load won't work (refer to chapters 1 and 3 for more details on this).

The only way to be sure that the switch is good, other than actual operation in a circuit, is to use the ohms scale on a multimeter. The resistance from the input to the output of an ideal switch is zero. In practice, though, there will always be some resistance, but for a good switch, the resistance should be too low to read on any but a very precision ohmmeter. An internal resistance of just one tenth of an ohm in your headlight switch, as an example, will drop the voltage to the headlights by one volt or more - enough to cause a noticeable dimming of the headlights. An internal resistance of one ohm would drop the voltage to the headlights by 10 volts!

4. Consumer of electricity

Depending on the situation, it may be easier to check everything else first, and conclude that the device in concern is the problem, rather than just checking the device itself. In other cases, it may be easier to check the operation of the device first, before doing any other trouble shooting. An example of the former would the heater fan. This fan is ***VERY*** hard to get to for testing, so you would definitely want to try everything else first. The glove box lamp, on the other hand, is so easy to get to that it would be far easier to test it first.

In most cases, you will want to have the device you are testing out of the car, and on your work bench. To do this, you will need to have access to either a battery or a 12 volt power supply, and a set of test leads. In general, the test procedure involves connecting the device to the battery or power supply with the test leads, observing polarity if needed, and observing the operation of the device.

For the most part, polarity is not of concern, as most items on our Triumphs function perfectly well with either polarity. Off hand, I can't think of anything that came stock from the factory (alternator and radio excluded) that won't operate just as well with reverse polarity (although some of the motors will run backwards if the incorrect polarity is used). By the same token, it is just as easy to ensure correct polarity that you may as well do it and be on the safe side. Electric fuel pumps, as an example, are not in general polarity sensitive, but they may well have point protection diodes installed which will be destroyed by the application of reverse power polarity.

When testing light bulbs, a fused test lead is not really required, as light bulbs rarely, if ever, fail in the short circuit condition. For other devices, such as motors and fuel pumps, it is a good idea to use a fuse, as these can fail in a short circuit condition. If the power supply you are using isn't adequately fused, or if you are using a battery, you should use a fused test lead for motors (or any other device if you are not sure).

Most items on the car can be tested on the bench, with the exception of the ignition system. There are some tests you can make on the ignition coil and the condenser, but a thorough test will require testing in operation. Details for testing these items will be covered in chapter 20, Ignition Systems.

5. Return path (grounds)

Probably the most common, and most vexing, problems encountered with automotive electrical systems are faulty grounds. Perhaps the easiest way to locate ground problems is by the process of elimination - if everything else is OK, it must be a ground problem. There are, though, three tests you can make if you believe everything else is OK, and prefer to go directly to the ground problem:

a) Power bypass: if you know, or at least are reasonably sure, that the non-working device is good, you might try to bypass the rest of the circuit with a jumper directly from the battery. If the device is good, but still doesn't work, you can be pretty sure the ground connection is bad.

b) Ground bypass. In this test, just jumper from the ground terminal of the device directly to ground, using one of your test leads. If you have a good contact to the ground terminal of the device and to chassis ground, and the device then works, you can be sure your problem is a bad ground connection.

c) “Shotgun” approach: in this approach, just assume the ground connection is bad, and go ahead and fix it. Even if the ground connection is not bad, there is a good chance that it is going bad, and will cause problems later on anyway, so go ahead and clean all the contacts, terminals, etc, in the ground path as insurance. If this doesn’t fix the problem, you haven’t wasted your time, and you now know, at least, where the problem isn’t!

CAVEAT

In the tests above for a current path and for control devices, it was assumed that these would either be good, or they would be bad. In reality, it is not all that black and white. Most of the time, the real world condition will be somewhere in between these two extreme. You might find that one of your connectors, while still being functional and conducting current, has a very high resistance. In your testing, you might find that you do indeed have voltage throughout the circuit, and still have problems. This is covered in detail in chapter 3, Bad Grounds & Bad Connections.

SNEAK CIRCUITS

As you are doing your testing, particularly when using test leads to jumper directly from the battery to various points in the circuit, great care should be taken to avoid sneak circuits, or at least to be aware of them and know the potential problems they may cause. A “sneak” circuit is a circuit configuration that allows current to go where it isn’t wanted, usually an unexpected condition. Refer to **figure 4**, below left, for details.

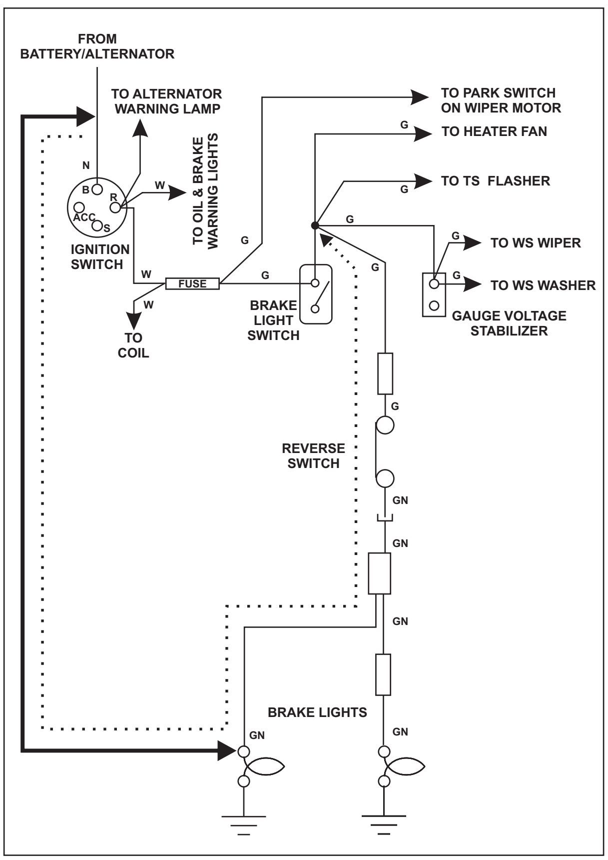

FIGURE 4

This figure shows the reverse light circuit and the power distribution portion of the “green” wire circuit in an early TR6. The heavy line to the left, with arrow heads on each end, represents a test lead used to jumper from the battery to one of the reverse lamps, as you might do for circuit testing. If the transmission should happen to be in reverse gear when you do this, you will create a potential circuit overload by the test lead. As shown by the dotted line, current will flow from the battery, through the test lead to the lamp, and from the lamp back up to the junction of the reverse lamp circuit to the rest of the green wire circuit. Any and all green wire loads that should happen to be on when you do this will now be powered through the test lead, including the ignition coil.

If your test lead is large enough to handle the current, there will be no problem with it, but you could get a nasty surprise if you should happen to have one of the other loads disconnected, and its power feed should be touching ground. In most cases, there will be no serious problem, but the potential exists for trouble, and it can often cause misleading results. Or, if a component should suddenly start working, you might be led to believe you have a short in the wiring somewhere. Electrical troubleshooting is confusing enough as it is, so review the schematics carefully before proceeding.

CONTINUITY TESTS

As mentioned earlier, continuity test can be very misleading. Refer to **figure 5** below for details.

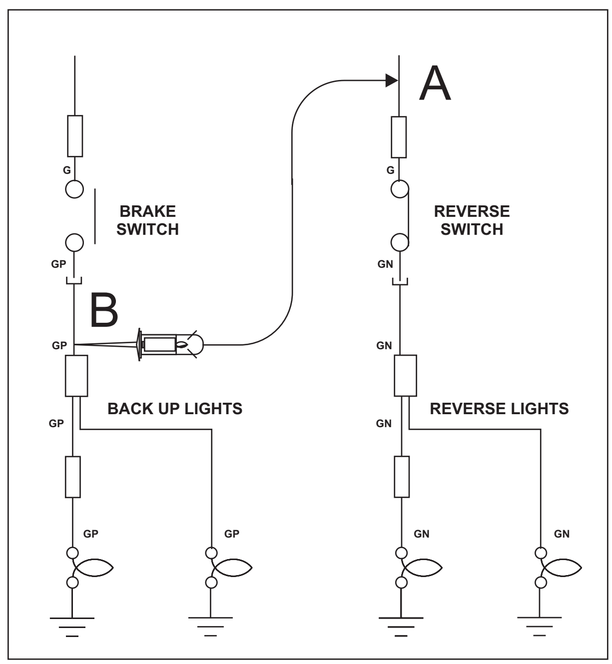

FIGURE 5

In this diagram, I have shown a battery operated continuity checker connected between points identifies as A and B. The two circuits, brake and reverse lamps, should be completely isolated from each other, and the continuity lamp should not light. However, because the lamp in the tester is a very small wattage (around ¼ W), much smaller than the other lamps (21W), there will be enough current flow in the circuit to cause the small test lamp to light, without the other bulbs being lit.

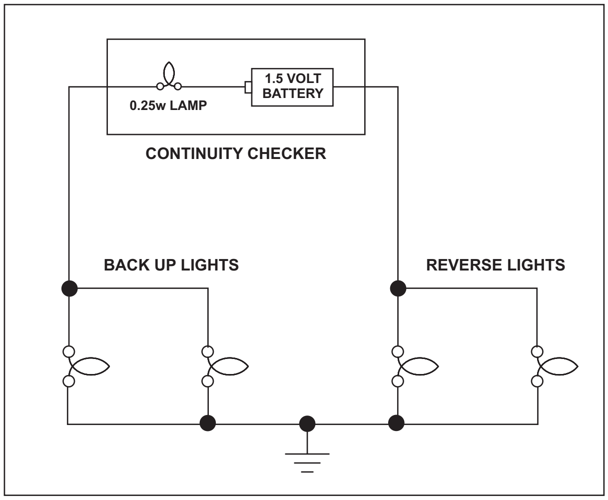

FIGURE 6

To illustrate this a little better, I have redrawn figure 5 as **figure 6**, above. If you do the numbers, using the formulas given in chapter 1, you will find that the current flow through the test lamp is about 0.10A, or about 60% of its rated current flow of 0.17A. This is enough to make the bulb glow, but not at full brilliance. Unless you are looking closely, you might not notice the difference. A current flow of 0.10A, split between the two bulbs in parallel in each circuit, 0.05A each, amounts to less than 2% of rated current for them, so they will not be lit at all.

In theory, that is. In reality, it's even worse. Using wattage and voltage to find the resistance of a bulb will give you the "hot" resistance value. When cold, a light bulb has much less resistance than when it is hot. In actuality, then, the test lamp might see as much as 80, 90 % or more of its rated current, as the brake and reverse lamps would not get hot enough to have more than a very small resistance. You would have to have pretty good eyes indeed to spot this small difference. Using the ohms scale on an in-expensive multi meter (and I recommend you use an inexpensive meter), the resistance of the lamps might not show up at all. The resistance of the bulbs might well be so small as to get lost in the inaccuracies of the meter. With many in-expensive meters, resistance values less than several ohms show up as zero, especially if the meter hasn't been re-calibrated recently for the ohms scale.

If you wish to make a continuity test, you must make sure that the circuit you are testing is ***completely*** isolated from other circuits. When done properly, these tests can be very valuable, but if improperly done, they can send you on a wild goose chase, looking for problems that don't exist. Goodness knows, there are enough real problems to attend to without any imagined problems.

GENERAL PRECAUTIONS

1. ALWAYS remove the negative lead from the battery when performing electrical work, unless the battery is needed for voltage or operational checks. Regardless of how careful you are, sooner or later you will create a short to ground, with a great potential for serious damage to the wiring. In fact, it is a good idea to remove the negative lead from the battery when doing ANY work under the hood, or any other work that might create a situation where your tools or equipment might accidently come into contact with a terminal or connector. The most common cause of fuses blowing is accidental contact with a tool, or with a part being removed or replaced.

2. When making voltage or operational tests that require the ignition key to be on for an extended length of time, it is a good idea to disconnect the white or the white/yellow wire from the ignition coil. If the points should just happen to be slightly open, there is a potential for damage from a mild arcing that can occur. Fully open or fully closed, no problem, but if just slightly open arcing can occur. In a short time, no damage will be done, but over a long time period, the points can pit. If the points are closed for a long time, the coil can overheat.

3. When making voltage checks, unless stated otherwise, there is no need to remove the wire from the terminal you are checking. When making temporary ground connections for testing, unless told otherwise, the existing ground wire can be left in place.

TROUBLESHOOTING PROCEDURES

In some of the following chapters, I have included detailed step-by-step procedures for troubleshooting various circuits, along with flow charts. Don't be dismayed if you get to the end of the procedure and the circuit still doesn't work - most likely, you had more than one problem. Just go back to step one and start over. Your procedure will follow a different path this time, but the path should lead to a satisfactory conclusion (unless of course, you had 3 problems!)