15
GAUGES

GAUGE OPERATION

Of the six gauges found in a TR250 or a TR6, three are electrically operated (water temperature, fuel level, and ammeter or voltmeter) while the remaining three (speedometer, tachometer, and oil pressure) are mechanically operated. This being an electrical repair manual, the mechanical gauges will not be addressed. The TR250 through the '72 TR6 models had an ammeter, while the '73 through '76 TR6 models came equipped with a voltmeter. All models covered had electrical fuel level and water temperature gauges.

Unlike the gauges used in earlier Triumphs, the voltmeter, fuel, and water gauges are of the bimetal, or thermal, type. **Photo 1**, below, shows the internals of a thermal meter. The ammeter is of an entirely different type, and will be discussed later. Within the body of a thermal meter is a bimetal strip, a pair of dissimilar metal strips bonded tightly togther. Surrounding these strips is a coil of resistance, or heater, wire. As electrical current flows through the coil, it heats up, just as the coils in a space heater do (although obviously not as hot). Because the two strips are of dissimilar material, they expand at a different rate in response to temperature changes. As one piece gets longer than the other, they must bend to compensate, the piece on the outside of the curve being longer than the piece on the inside.

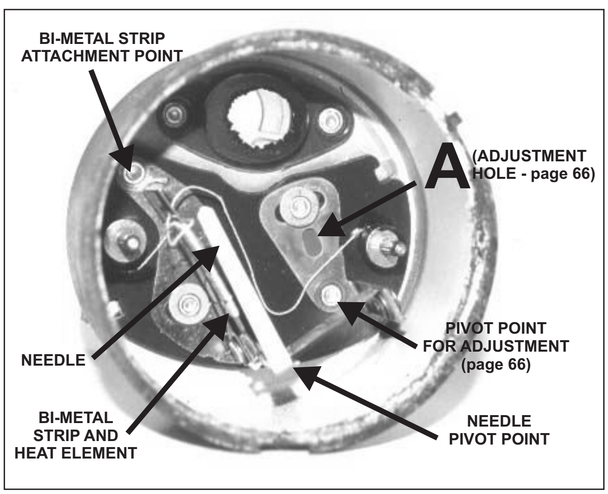

PHOTO 1

One end of the bimetal strip is permanently attached to the meter housing, while the other end is free to move. The meter needle is mechanically connected, through a series of levers and pivots, to the free end of the strip in such an arrangement that the motion of the needle indicates the amount of movement. As the amount of movement is dependent upon the temperature of the wire coil, and the temperature of the wire coil is dependent upon the current flow, the needle, in effect, is reading the amount of current flowing through the meter.

If a way can be found to relate the current flow to a physical parameter, such as water temperature, the needle movement will then correspond to the value of the parameter. And, of course, there is a way, as illustrated in **figure 1**, below. The resistance of the fuel sender varies as the fuel level varies, and the resistance of the temperature sender also varies as the water temperature varies. As current is equal to voltage divided by resistance, if we can keep the voltage constant, and let the resistance in the circuit vary according to temperature or fuel level, the current will then be a function of temperature or fuel level.

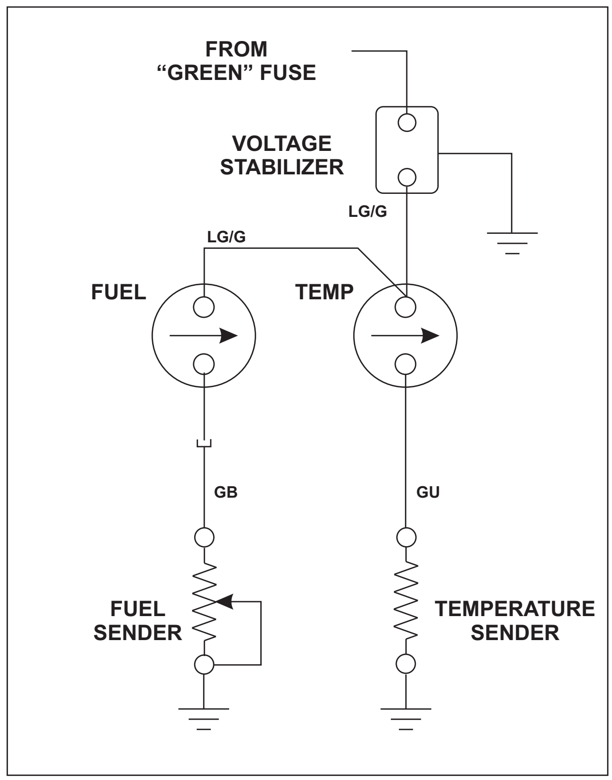

FIGURE 1

If the voltage isn't kept constant, the gauge readings will also vary with voltage, depending on the engine rpm, battery condition, electrical loads, etc. To ensure a constant voltage, a voltage stabilizer is used. Similar to the gauges, the voltage stabilizer also has a bimetal strip, but this strip is connected to one of a pair of electrical contacts, the other contact being fixed. When the strip is cold, it is straight, and the two contacts touch, creating a path for current flow. As the strip is heated by the flow of current, it bends, separating the contacts and cutting off the current flow. The contacts stay apart until the strip cools, at which time it straightens out, and the contacts touch again, starting the cycle all over. **Photo 2** below shows the internals of a voltage stabilizer, and **figure 2** below shows a schematic diagram for it.

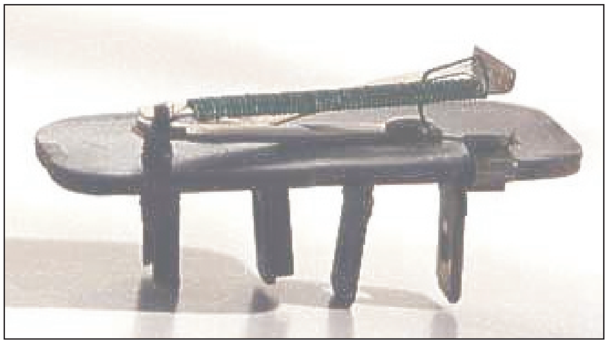

PHOTO 2

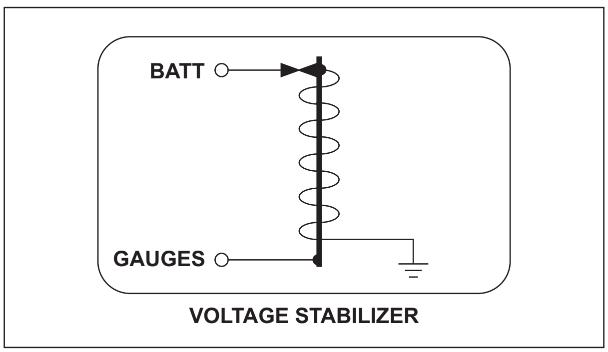

FIGURE 2

Notice in **figure 2** that the coil is connected between ground and the battery when the contacts are closed, but the gauges are connected directly to the battery terminal. With the arrangement, the gauges receive full battery voltage with the contacts closed, and zero voltage when the contacts are open. The voltage seen by the gauges, then, consists of a series of ON-OFF operations, swinging from 12 volts to zero volts and back again, as shown in **figure 3**, above right. The average voltage seen by the gauges depends on the relative amount of time the contacts are closed as compared to the time they are open. If the two times are equal, the average voltage seen by the gauges is 50 % of battery voltage. If the contacts are open one half as long as they are closed, the average voltage will be 66.7%, and so on. With a battery voltage of 14.6 volts, and a 68.5% on-off ratio, the average voltage seen by the gauges will be about 10 volts, which is the correct value for a TR250 or a TR6.

But what if the battery voltage isn't 14.6, but a lower value, such as 12.6? In this case, the current through the heat element will be less, and it will take the element longer to heat the bi-metal strip to its opening temperature. As the bi-metal strip opens at the same temperature, regardless of current, it will still take the same amount of time to cool off enough to re-close the contacts. Thus, the on time will increase compared to the off time, so the gauges will see a higher percentage of the battery voltage - ideally, the same 10 volts as before, or 79.4% of battery voltage. In the same manner, if the battery voltage increases, the strip will heat up faster, reducing the on to off ratio.

The ON-OFF ratio is, however, not adjustable, so if it is off, the stabilizer will have to be replaced. Unfortunately, unless you have some specialized equipment, or know how to rig up a special test set-up, you can't measure the average voltage - your meter needle will just swing from one extreme to the other. The only way to know that the stabilizer voltage is off is if both the fuel meter and the temperature meter are showing the same error, high or low.

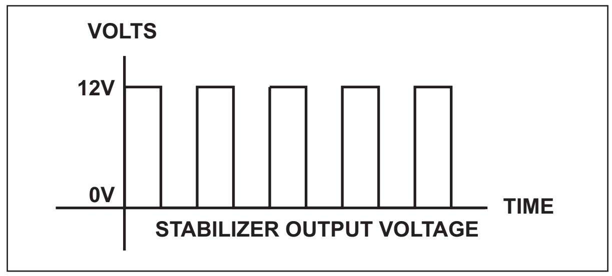

FIGURE 3

In **photo 3** below, I have shown the interior of a fuel sender. As the fuel level rises and falls, the lever attached to the float rotates around the pivot point, moving a wiper across the resistance wire. When the fuel tank is near empty, the float is near the bottom, and the wiper is near the end of the resistance wire. The entire length of the wire is now in the circuit, and the sender resistance is maximum. As the fuel level rises, the float also rise, moving the wiper to the beginning of the wire, offering the minimum resistance to the circuit.

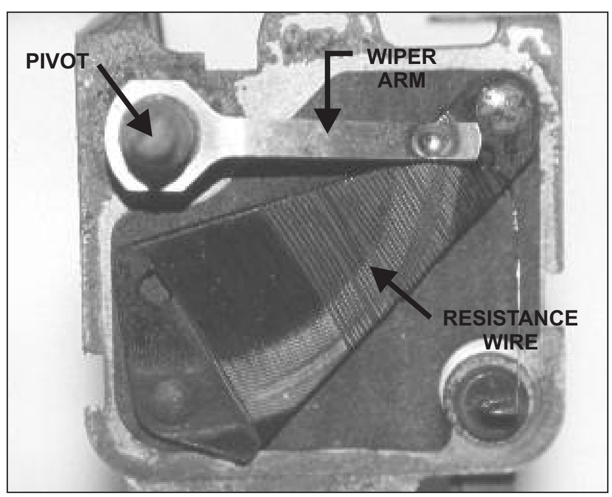

PHOTO 3

Internally, a voltmeter is constructed the same as the fuel level and water temperature gauges (isn't it interesting that we call those indicators "gauges," but we call a voltage indicator a "meter!"), but it has a higher resistance heater coil, and is designed to connect directly between a full 12 volt source and ground. Obviously, the voltmeter isn't connected to the voltage stabilizer, for the exact opposite reason we connect the other meters to it. We don't want voltage variations to alter the fuel level reading, for example, but voltage variations are exactly what we want to see on the voltmeter. Figure 4 below illustrates the voltmeter connections as used in the '73 - '76 model TR6. Also illustrated in **figure 4** is an ammeter

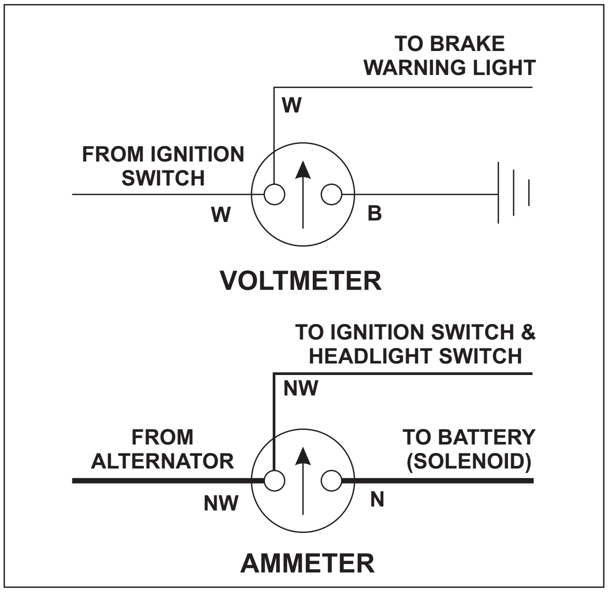

FIGURE 4

circuit. An ammeter operates on a different principle than the other meters discussed above. As shown in **photo 4** below, current is passed through a loop of wire, (**A**), inside the meter. Current flow through a loop of wire creates a magnetic field around the wire. This magnetic field interacts with an iron pole piece, (**B**), which is coupled to the needle. The iron pole piece rotates in response to the magnetic field. The direction of rotation is determined by the direction of the current, and the amount of rotation is determined by the strength of the current.

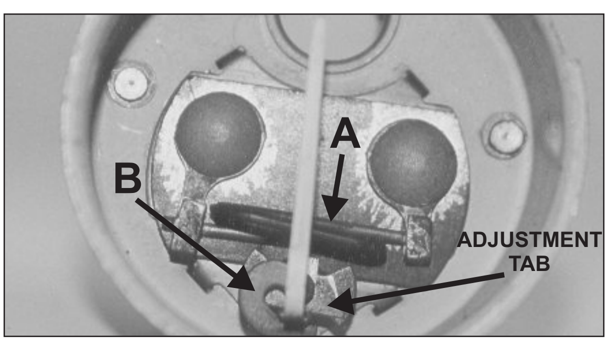

PHOTO 4

The response time for the ammeter to react to a change in current is virtually instantaneous, while the thermal type gauges are quite sluggish in their response to a change in resistance. There is no particular advantage to a quick response time for any of the gauges, but a slow response time is an advantage for the fuel gauge. Under no reasonable condition will the engine coolant temperature change rapidly, and sudden changes in charge/discharge current, such as when turning on or off electrical loads, are little concern as compared to long term discharge indications. A rapidly responding fuel gauge would be a real nuisance, in any car, but especially so in a sports car. Fuel sloshing around in the tank when the car is cornering or bouncing over bumps would cause the needle in the fuel gauge to bounce all over the dial, making it difficult, if not impossible, to get a good indication of the actual fuel level.

AMMETER OPERATION

The operation of the gauges described above, voltmeter, fuel gauge, and water temperature gauge, is pretty straight forward and simple. At first glance, the ammeter operation appears to be just a simple and straight forward, but it is just a bit more complicated than it seems. **figure 5** below depicts the operation of the ammeter under normal operating conditions, with the battery fully charged, the alternator working as it should, and the electrical load within the capacity of the alternator. ***ALL*** of the electrical load is being supplied by the alternator, and it is also supplying a small charge current to the battery to maintain its charge. The battery is not supplying any current at all.

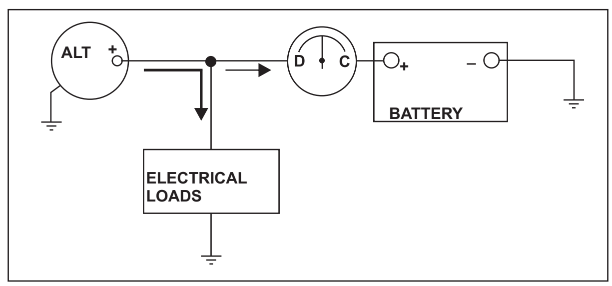

FIGURE 5

Figure 6 shows the same conditions, except the battery has been discharged quite a bit by starting the car, and the alternator is now having to supply the full electrical load ***and*** provide a fairly large current to recharge the battery.

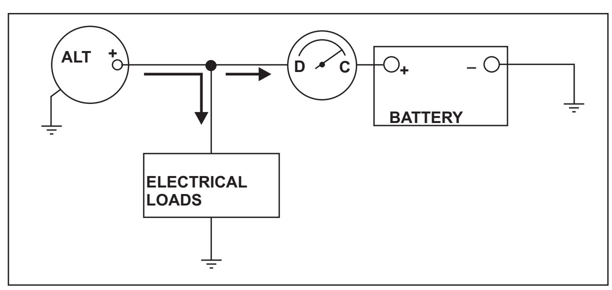

FIGURE 6

In this situation, the capacity of the alternator must be equal to the electrical load AND the recharging current. If not, you will see a noticeable dimming of your lights. In this case, the ammeter will show a fairly large charge current.

In **figure 7**, the electrical load exceeds the capacity of the alternator, and the battery is making up the difference. The ammeter will show a discharge. Typically, this is a small discharge, but if the electrical load is very excessive, the discharge current can be quite large.

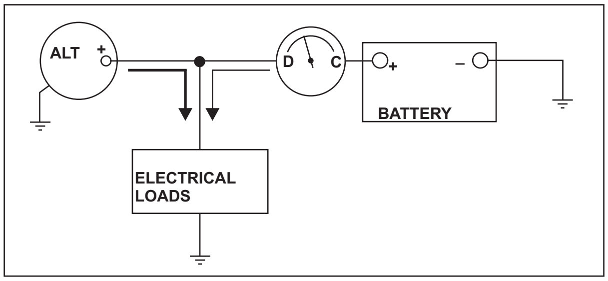

FIGURE 7

In **figure 8**, the alternator has completely failed (or the engine is not running). The total electrical load is now supplied by the battery, and the ammeter reads a heavy discharge current.

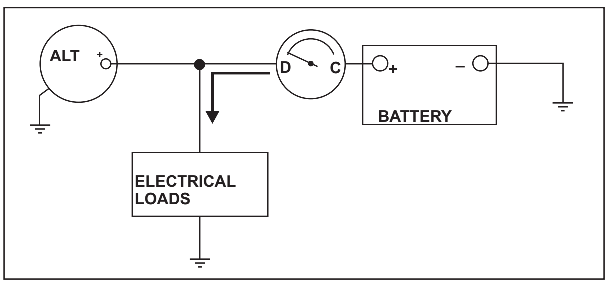

FIGURE 8

Figure 9 represents a more realistic configuration, and one that is seen in the TR250 and the ‘69 - ‘73 TR6 range. Some of the electrical loads have been connected on the battery side of the ammeter, rather than on the alternator side. These loads are non-metered, and will not show on the ammeter. If everything is working as it should, and the

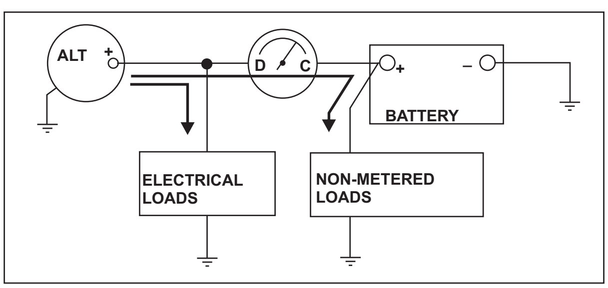

FIGURE 9

alternator is supplying the full metered load, operating any of the non-metered loads will cause the ammeter to show a *charge* current. In the TR250/TR6, the horns and the high beam “flash to pass” function are non-metered. If you blow the horn or flash your headlights, the ammeter will show a charge reading.

Figure 10 illustrates what happens if you should upgrade your alternator with a more powerful unit, one whose output can exceed the range of the ammeter, and the ammeter has been bypassed with a larger wire directly to the battery. As you can see, every metered load in the car will show as a discharge current, and you will have no indication at all as to any charging current that may be going into the battery.

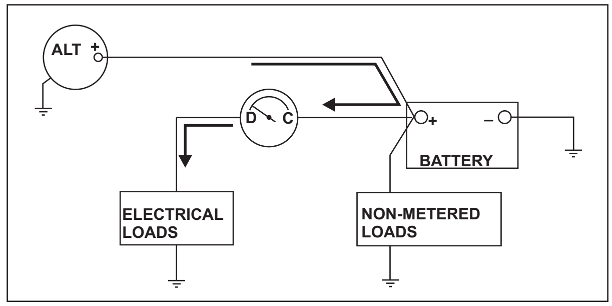

FIGURE 10

TROUBLESHOOTING

Fuel level and water temperature gauges

As both gauges receive power from the stabilizer, and the stabilizer receives power from the “green” fuse, the first step is to determine if there is power at this fuse. The windshield wipers, windshield washer, turn signals, brake and backup lights, and heater fan all receive power from this fuse, so if ***ANY*** of these items work, then you have power at the fuse. If ***NONE*** of these items work, then you need to go to chapter 23, Power Distribution, and resolve the power issue before proceeding. If you have power, then you can proceed with the troubleshooting steps.

Step 1. What are the symptoms?

a) Both gauges are operable, but read incorrectly by about the same amount? The only commonality the two gauges have that would produce this symptom is the voltage stabilizer, which will need to be replaced.

b) Both gauges read zero - no movement at all from the rest position? Go to step 2.

c) Each gauge has a different symptom?

i) gauge reads zero? Go to step 5.

ii) gauge reading is erroneous? Go to step 5.

iii) gauge is pegged at high end? Go to step 7

Step 2). With a voltmeter or a test lamp, check for voltage at the light green/green wire on the stabilizer terminal marked "I." You should see an ON- OFF indication here if the stabilizer is working properly. The lamp should flash roughly once per second, more or less, or the meter needle should swing from zero to 12 volts at the same rate. If not, go to step 3. If so, go to step 4.

Step 3). Check for voltage on the green wire on terminal "B" of the stabilizer. If you have voltage here, the stabilizer is bad and must be replaced. If you don't have voltage, there is a break or a bad connection in the green wire from the fuse, which will need to be fixed.

Step 4). Check for the presence of the pulsating voltage at the gauges, on the light green/green wires. You should see the voltage swinging from zero to 12 volts, at the rate of one cycle per second. If you don't have the pulsating voltage here, there is a break in the LG/G wires between the stabilizer and the gauges, which must be repaired. If you do have the voltage, go to step 5.

Step 5). Go to your local Radio Shack, or equivalent, and purchase two 100 ohm resisters. I recommend buying ½ watt resisters, but you can get by with ¼ watt if you wish, but they will get quite hot if you leave the circuit connected for an appreciable length of time. Lift the lead from the meter to the sender, at the sender, and connect one of the 100 ohm resisters between this lead and ground. Turn the key on and watch the meter, which should go to ***approximatel*y** mid scale. If you previously had no reading at all, and you now have a reading, your sender is bad, and must be repaired or replaced. If you still have no reading, go to step 6.

If you previously had an erroneous reading, repeat the above test, using two 100 ohm resisters in series. You should now see a reading of ***approximately*** ¼ scale. Repeat the test again, using the two resisters in parallel. You should see a reading of ***approximately*** full scale. If you get readings close to the above values, your sending unit is the problem. If not, your meter is out of whack, and should be replaced, repaired, or adjusted. See the adjustment section later in this chapter.

Step 6). If you did not get a response with the resisters at the sender end of the meter lead, lift the lead from the meter and try again, connecting the meter terminal to ground through the resister. If your meter now reads properly, there is a break in the lead from the meter to the sender which will need to be repaired. If you don't get a reading, the meter is bad and will need to be repaired, or replaced.

Step 7). If your meter is pegged on the high end of the scale all the time, key on or off, your meter is defective. If it is pegged on high only when the key on, you have a short to ground somewhere. Go to the appropriate sender and remove the lead to the meter. If the meter now reads zero, the sender is faulty, and must be repaired or replaced. If not, proceed to step 8.

Step 8). Replace the lead to the sender and move to the meter itself. At the meter, lift the sender lead and watch the gauge. If it returns to normal, there is a short in the lead to the sender which must be fixed. If not, the short is in the meter itself, and the meter must be repaired or replaced.

VOLTMETER

Troubleshooting the voltmeter is a much simpler process than the previous meters, as there is no sending unit or voltage stabilizer involved. If you are getting erroneous readings, the only thing that can be wrong is the meter, which will have to be repaired, replaced, or adjusted.

If it doesn't read at all, there are a couple of tests to make.

Step 1). Is the meter getting voltage? The voltmeter receives power from the white wire coming from the ignition switch, the same wire that feeds the ignition system and the "green" fuse. If you are getting power to the loads fed from either of these, you should be getting power to the voltmeter. Using your voltmeter or test lamp, look for voltage on the meter terminal with the white wire. If you don't have power here, there is a break or a bad connection in the white wire circuit. If you do have voltage, go to step 2.

Step 2). With a short piece of wire, momentarily short the ground lead of the voltmeter to a known good ground point. If the meter now works, you have a bad ground connection. If not, the meter is bad, and will need to be repaired or replaced.

AMMETER

As can be seen in **photo 4**, the ammeter is a very simple device - for all practical purposes, nothing more than a piece of wire. As long as the wire inside the meter is intact, the meter will conduct current, whether it gives an indication or not. If the wire breaks, you will not have to look too hard for an indication, as nothing in the car will work if the engine isn't running, except the "always powered" loads fed from the "purple" fuse (horns, the headlight flash-to-pass feature, courtesy lights, and the hazard flasher), and, if the ammeter is an open circuit, you can't operate the starter to get the engine to run. Refer to **figures 10, 11,** and **12**, next page, for details. These figures depict the circuits as if the ammeter were an open circuit. An open circuit in the ammeter is the same as if the ammeter were simply removed from the circuit.

If the ammeter is still functional as far as passing current, but just isn't working, there isn't much you can do except repair or replace it. There is no adjustment for accuracy in the ammeter, but there is an adjustment you can make to center the needle if it is off center with zero current. You can see the adjustment tab in **photo 4**, or if this tab is frozen or too tight to allow adjustment without fear of damage to the meter, you can just bend the needle very carefully. Confine the bending to the horizontal portion of the needle, at the back of the case, and your adjustments won't be seen from the front of the meter.

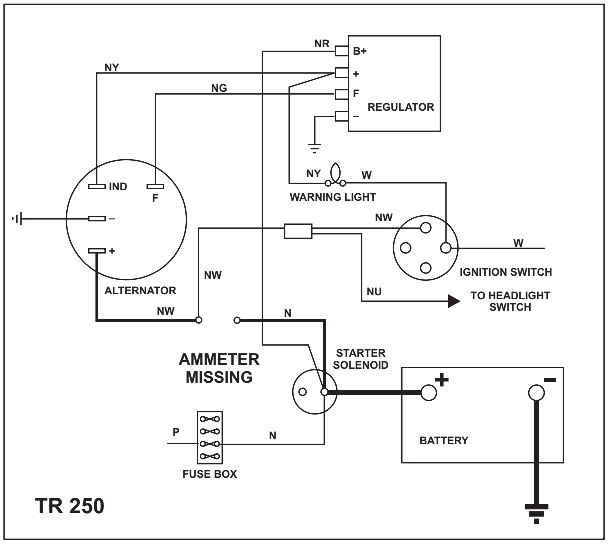

FIGURE 10

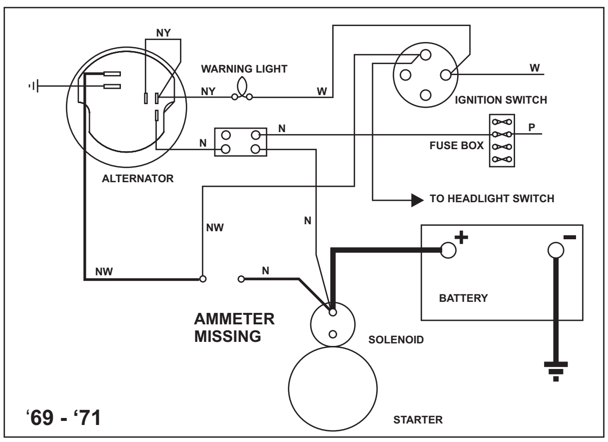

FIGURE 11

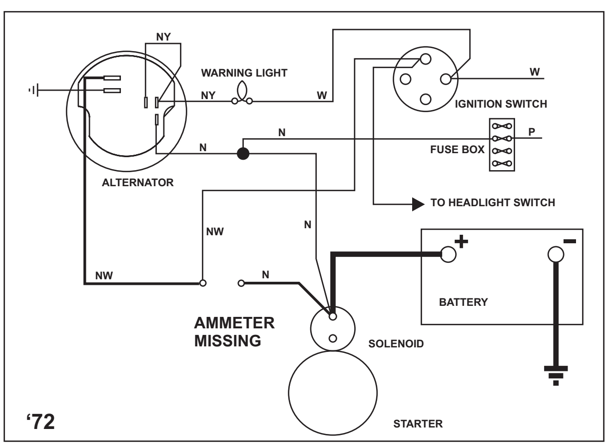

FIGURE 12

POLARITY CONCERNS

Being thermal devices, neither the voltmeter, fuel level gauge, nor the water temperature gauges are polarity sensitive. That is, you can connect them up either way and they will still work just fine. The heat elements get just as warm with current flow in either direction. However, it may be helpful to wire them in a certain way to ease the routing of the existing wiring harness, as one of the wires to the meter may be a bit longer than the other, or otherwise be routed such that it will only reach one terminal but not the other.

The ammeter, of course, ***is*** polarity sensitive. Its purpose is to tell you how much current is flowing, ***and*** which way it is flowing. For some strange reason, though, the gauge maker did not see fit to mark the terminals, so I have included the "original" connections in **figure 13** below.

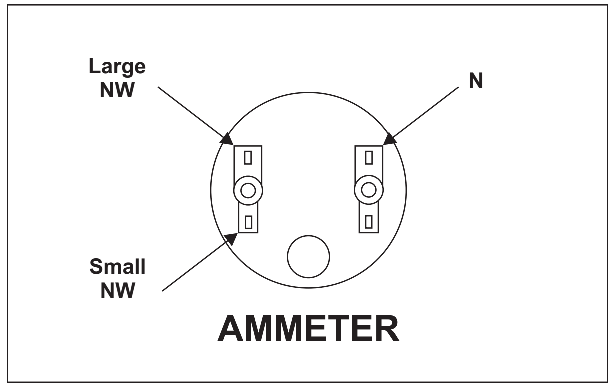

FIGURE 13

ADJUSTMENTS

If your gauges are reading inaccurately, it may be possible to adjust them for improved accuracy. In Photo 5 below, you can see two small holes in the back of the meter case. In the holes, you can see small slots in pieces of metal inside the case. One of the slots has been labeled "**A**", and this slot corresponds to the slot marked "**A**" in photo 1, page 61. As you can see, this slot is in a small, triangular shaped piece. The small end of this piece of metal is pinned to the case, and has a bracket to hold part of the meter mechanism. The large end is also pinned to the case, but there is a slot to allow this end of the piece to pivot. The remainder of the meter mechanism is also mounted to a piece of metal, which is also pinned at both ends, and has a slot on one end for adjustment. If the meter isn't too badly corroded, you can use a small screwdriver or other tool, inserted into the slots from the rear, to move the metal pieces. By adjusting these two pieces, interactively, you can re-calibrate the gauge.

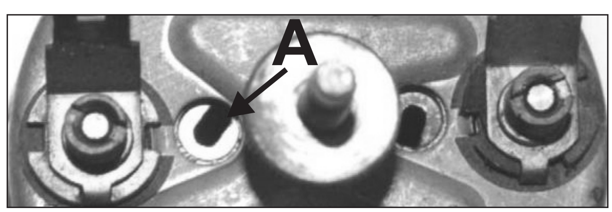

PHOTO 5

AMMETERS VERSUS VOLTMETERS

Which one is best? Which one gives the most accurate picture of your car's charging system? The ***ammeter***, without a doubt. If it's wired properly, an ammeter will tell you exactly how much current is going into your battery if it's being charged, or how much is going out if it's being discharged. A voltmeter, on the other hand, only tells you that the ***capability*** to charge your battery is available. Compare **figures 14** and **15**, right, to figure 5, page 63.

Figure 14 shows the proper connections for a voltmeter, and **figure 15** show a not uncommon condition in an old MGB with the batteries mounted in cages under the floor board. These cages can rust out with time, and the batteries can fall out and bury themselves in the side of the road. A voltmeter would still say everything is OK! Under these conditions, an ammeter would show a zero reading, which is correct.

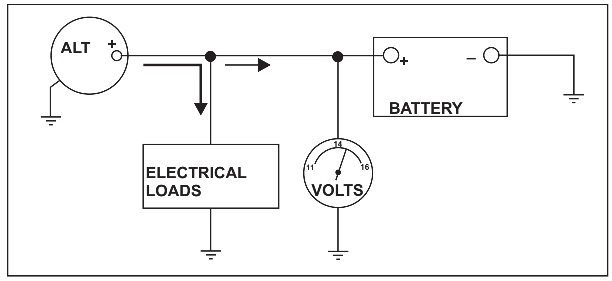

FIGURE 14

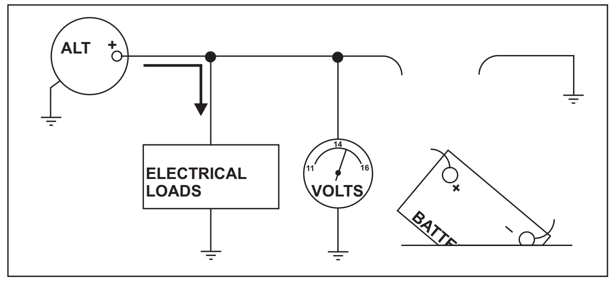

FIGURE 15

A ludicrous comparison, to be sure, but very illustrative of the differences nevertheless. The bottom line is, either one will work quite well, provided you know and understand what each is telling you. The following sections provide guidance on what to look for when reading the two different meter types.

AMMETER:

When you first turn on the ignition, the ammeter should show a discharge, as the battery is supplying ***all*** of the current to the car. How much discharge will depend on how many items you have on. On an ammeter equipped TR, none of the "purple" loads are run through the ammeter, so they won't show up as a discharge, and you will normally not have any of the "green" loads on when you are trying to start the car, so the discharge reading should be rather small. Whatever the reading, it should be compared to an expected reading for the loads you do have on. If the reading doesn't correspond to what is expected, something is amiss, and bears investigating.

As you crank the engine, the battery will experience a discharge, which can be quite substantial if the car takes a lot of cranking to start. After the engine is running and the alternator takes over the chore of supplying power to the car, the ammeter should show a slight to moderate charge current as the battery is being recharged to replace the energy used for cranking. The ammeter should gradually return to a near zero reading as the battery reaches full charge. The more cranking that was required, the more charge current required, and the longer it takes to replenish the battery. If the ammeter doesn't return to near zero in a reasonable amount of driving, something is amiss. You should be observing your ammeter on a regular basis so you will be aware of what is normal and what is an indication of a problem.

After the battery is fully charged, the ammeter should show only a very small charge current, quite often so small that it is not noticeable on the meter. If you continue to get a discharge reading, the alternator is not doing its job. If you get a high charge reading, either the alternator regulator is faulty, causing the alternator to produce an over voltage, or the battery is not accepting a charge. If it's the former, action should be taken fairly quickly, as damage to your battery could result, perhaps even causing it to boil over and severely damaging your under hood paint. If its the latter, be aware that you may not have enough battery left to re-start your car should you need to stop the engine.

VOLTMETER:

When you start your car, if you're like most of us, you turn the key past the run position immediately to the start position. The voltmeter, being a thermal device, will not have time to give an accurate reading of the battery condition if you do this. You really should get in the habit of delaying the start just long enough to monitor your battery. A good battery, in a full state of charge, should read 12.6 volts, but you should check your meter when you know the battery is good, so you can compensate for meter inaccuracies. A completely flat battery will only produce 11.64 volts. Naturally, if your battery is dead, you will know it soon enough as you try to start the engine, but if the reading is lower than it should be, yet the battery is strong enough to start the car, you will know that trouble is brewing. You can then take corrective action at your convenience, rather than while you are away from home n a vacation.

After the engine is running, the alternator should raise the system voltage to 14.6 volts. If it doesn't, the alternator is bad, and should be fixed soon, before you have a chance to be stranded with a dead battery.

TROUBLESHOOTING FLOW DIAGRAM