

# ELECTRICITY AND WIRING

## ***A SHORT PRIMER***

(Sorry!)



\*This guide is not finished, but I've decided to release it as a work-in-progress because of its usefulness.

This troubleshooting guide was created exclusively for owners of E.R.A. cars. Any reproduction of this guide without permission of E.R.A. is strictly forbidden, and will be punished by the perpetrator being forced to work on a non-E.R.A. kit.

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## INTRODUCTION

Even without any electrical experience, you needn't be afraid of working on an E.R.A. kit. The basic concepts of electricity are relatively easy to understand, and this guide will make troubleshooting a straightforward and logical process. **Besides**, compared with the latest in production car circuitry, the **E.R.A. 427SC** and **GT** have very simple electrical systems.

E.R.A. built wiring harnesses have had very few functional flaws. We are unique in the industry in soldering all our connections to avoid the poor connections that inevitably result from water and salt. The majority of problems encountered by builders of our kit have been caused by faulty switches, wiper motors, or other peripheral components. (And even, on rare occasion, incorrect connections by the kit builder.) This mini-textbook will help you locate and eliminate most of the glitches that you might experience during your "Automotive Experience".

If you are electro-phobic or have limited knowledge of electricity, please read the **General Concepts** section. Even if you never have a problem with your car, acquiring a true understanding of what happens underneath the hood - or your roof - can be invaluable in real life. **Knowledge is power!**

Although help is always available from us, please read the following information first. If you must call, use this guide to gather as much information as possible before the phone call. This will make finding the answer to your problem much faster. **Thanks!**

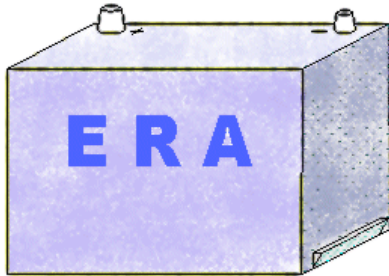
# The Shocking Truth! Everything You Ever Wanted To Know About Electricity, But Were Afraid To Ask

## BASIC CONCEPTS

### POWER, ENERGY, VOLTAGE, CURRENT (AMPERAGE)

**Power!** We have come to expect things to happen when the switch is turned on. Motors, solenoids, coils, radios, etc. are all our slaves. A little electricity is all that is necessary.

In automotive applications, electrical energy is carried by insulated copper wire to where it is needed. The source for this power is the battery an/or the alternator.



**Electric Current (I)** is essentially a flow of electrons within the wire. In most automotive applications, this current flows continuously in one direction within the wire "conduit" and is called direct current (DC).

Household current alternates direction 60 times a second (60 Hertz) in the USA, 50Hz most other places, and is called AC. (Strictly speaking, it should be called *alternating voltage*.)

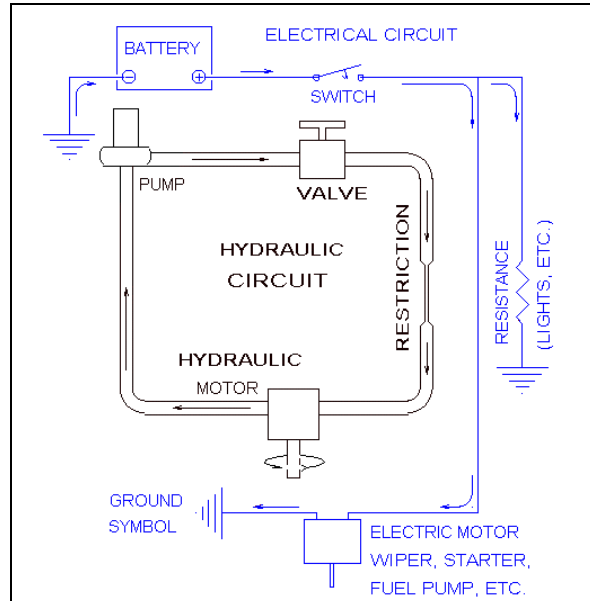
But everything that follows pertains only to DC current.

### Current flows from Positive $\Rightarrow$ Negative

By historical convention, current flows from positive to negative. Think of current (I) - i.e. amperage - as the rate of water flowing in a pipe, measured as gallons/hour.

*In reality, the electrons are flowing in the opposite direction, since their charge is negative.*

The analogous circuits of fluid and electricity are shown below. They each require a pump/generator or a energy storage source (battery/pressure accumulator). Both systems have energy draws in the circuit: Restrictions, motors, and storage areas.



**Resistance (R)** is the amount of hindrance to the current that a component creates. Every component in a circuit has resistance, although some have practically zero. **Impedance** is resistance associated with energy stored in a magnetic field - an alternator, coil or motor. It is the electrical equivalent of inertia and is proportional to the *rate of change* of current.

Notice that these are both circuits. The stuff going out must equal the stuff going in. The obvious difference is that automotive electrical circuits are typically completed through a **common ground** rather than a dedicated return line.

**Voltage (V)** is equivalent to the amount of pressure in the pipe at any given point, and resistance (R) is the amount of restriction to the flow within the pipe.

All the current that flows from the positive (+) sources must eventually go into the negative (-) sink which, in the case of a car, is called ground. Voltage is usually measured in relationship to ground, which is defined as being at 0 volts.

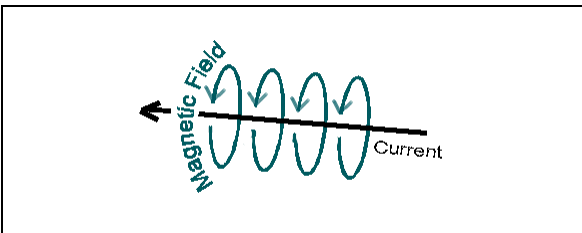
**Energy** (in the form of heat) is released when current passes through any resistance, and **Power** is the rate of Energy released per unit time. All wires have some resistance, superconductors notwithstanding, although the resistance is sometimes so low as generate negligible heat. The same thing happens when there is a restriction in a fluid carrying pipe. There is a voltage drop associated with this phenomenon:  $V=I \times R$ .

The **power** dissipated is  $= I^2 \times R = V \times I$  and is usually measured in watts (W).

Note! In AC circuits, since the voltage and current are changing continuously from positive to negative, companies have invented something called “peak power”. Since it’s calculated from the peak voltage, it inflates the amount of actual power absorbed over a full cycle.

Incandescent lights work because electrical energy is transformed into the heat necessary to make the filament glow brightly.

Any time there is a flow of electrons (current), a **magnetic field** is created surrounding the flow. **Mechanical energy** in the form of force and/or motion is released by the magnetic fields in electric motors and solenoids. Starter and wiper convert this energy into rotary motion. Solenoids convert the energy to a linear direction. Starter solenoids, relays and some electrically operated valves operate by this principal.



**Induction** is a phenomenon where energy is stored in a magnetic field generated by the current in a wire. The high voltage discharge of the ignition coil is an example of extracting large amounts of energy for a short duration using this method of storage of energy.

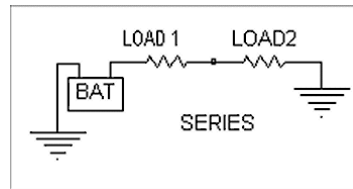
## ELECTRICAL CIRCUITS

All electrical components are in circuits, where all current flows from a source, through each component, into a sink.

There are several ways that components are integrated into these circuits:

### SERIES CONNECTIONS

All the current in a series connection must pass through all the loads in the series.



Consequently, there is a voltage drop across each load of  $\Delta V = I \times R$  where R is the resistance across the load. When more than one load exists in a parallel circuit, the total voltage drop still remains at battery voltage (assume 14 Volts for convenience here.)

$$\Delta V_{tot} = 14 \text{ Volts} = \Delta V_1 + \Delta V_2 + \dots$$

Since  $V = I \times R$

Each individual load has a voltage drop proportional to its resistance, but the current is decreased:  $I = \frac{14 \text{ volts}}{\text{(Sum of the Resistances)}}$

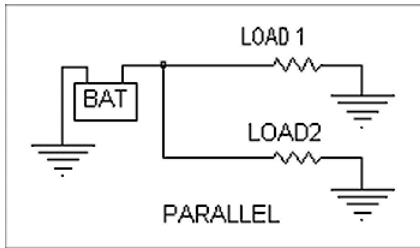
the sum of the individual voltage drops always adds up to 14.

#### What this means to you is...

If you have an extra resistance in a circuit, (perhaps in the form of a dirty connection or even an undersized wire) there will always be a voltage drop associated with that resistance.

Don't forget, **even copper wire has resistance**. If the current is too high there will be a high voltage drop along the wire. Try starting your car with an 18 gage wire from the battery to the starter! The wire will get very hot, and the starter will receive only 1 or 2 volts. Almost all the energy ( $V^2/R$ ) will be dissipated in the wire, not the starter. *Bad connections can frequently be found by feeling for warm spots along the circuit.* **Bad battery** connections can be found the same way.

## PARALLEL CONNECTIONS



Just about all circuits in an automobile are arranged in parallel. In theory each load sees the full 14 Volts supplied by the battery, and the total current draw is simply the sum of all the individual circuit currents.

In practice, there are always hidden resistances from non-ideal connections and even from the internal resistance of the battery itself. These extra resistances seldom create more than 1 or 2 Volts drop unless load conditions are very high.

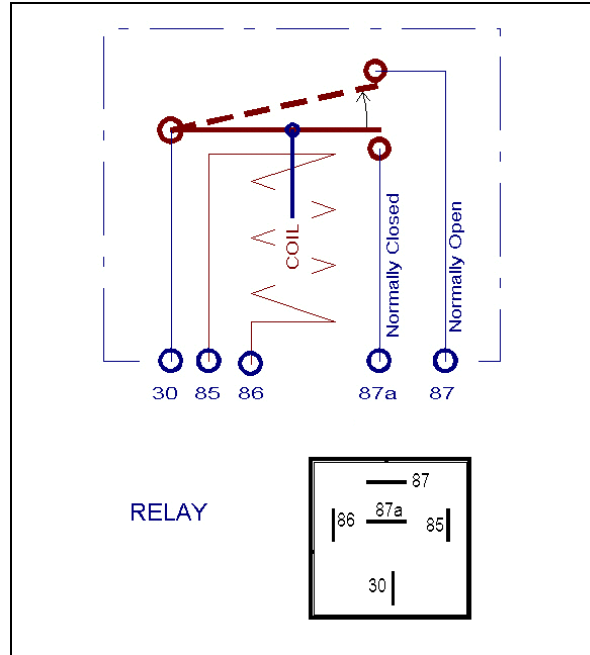
"**Ground**" is the electrical equivalent to zero energy level (zero pressure level). In an automobile, the chassis, engine and other passive surfaces usually act as ground. *All current from the battery and alternator ultimately ends up going to ground.* Sometimes current finds its way to ground through an unplanned path. This is what is known as a **short (circuit)**. See page 6.

The **switches** in any electrical system are simply valves which stop or selectively channel the current to appropriate places. Some switches are simply on or off. The light switch, for example, first opens the "valve" to the parking lights, and then to the headlights.

Other switches have variable internal resistance which is controlled by the knob. The rheostat for the dashboard lights is an example of this.

A **relay** is just a switch controlled by electricity instead of mechanical control. Relays are used when high current makes a standard switch impractical, or a simple action must start a complicated process.

Relays are frequently used in horn, lighting, charging, signal and fan circuits. There are many different internal configurations of relays, sometimes doing fairly complex tasks. Most of the relays that are used in E.R.A. cars have their circuit diagrams displayed on the casing as shown below. Numbers shown are ISO standard.



A **transistor** is a simple solid state relay that switches or regulates the current in a circuit. Transistors can act as a one-way valve (Diode), an amplifier, voltage regulator (Zener diode), or do much more complex functions when combined together in an *Integrated Circuit*. The CPU of a computer may have millions of transistors on a single chip. Most late model voltage regulators are solid state devices.

**Fuses** (or circuit breakers) are in most electrical circuits to prevent excessive current from overheating the wires in that circuit. Some fuses are fast acting - blowing almost instantly when their current limit is exceeded. Solid-state circuits need such fast protection. Some fuses are time-delayed in order to prevent momentary overloads from crashing the circuit. Electric motors, which usually require high starting current, usually use slow acting fuses.

Even copper wires have a small amount of resistance, and when very high current is present, the wires become like bulb filaments, burning off their insulation and possibly burning the rest of the car, too.

Fuses are usually rated at about twice the expected current in that particular circuit. Whenever a fuse blows it is an indication that there is a problem in the area serviced by the fuse.

Replacing the fuse with one of a higher rating risks overloading the wiring. The cause of the excessive current that caused the fuse to blow should always be found.

**Short circuits** (“a short”) are situations where there is a direct path (with minimal resistance) from the battery power (+) to ground, possibly through a switch. This is the primary cause of blown fuses. Wires connected to inappropriate terminals or insulation that chafes through on the chassis are examples of this.

**An open circuit** is one where no current flows. When a switch is off (open), it is appropriate. When a switch is on (closed contacts), and there is no current flowing, that is a problem. Open circuits are caused by broken wires, loose connections or bad switches.

## APPLYING THEORY TO THE AUTOMOBILE

### TROUBLESHOOTING

When troubleshooting, use the **E.R.A. wiring diagram** to trace the entire circuit. All connections are shown by small circles in the wire trace. Some wires may have several connections to other wires along its length. Voltage feedback may occur anywhere in *the Total Circuit*.

When **tracking a circuit**, check the connections on both sides of any **multi-plug connector**. Sometimes a terminal is incorrectly inserted into its terminal block so that it does not make contact with its proper mate in the other terminal block. On an ERA, wire(s) on one side of a junction will **always** mate with wire(s) of similar **color**.

The battery and alternator give a system voltage between approximately **12 and 15 volts**. This low voltage is not dangerous to touch. In fact, if you wet your fingers and short between the positive and negative terminals of the battery, you will barely feel it

Typically, batteries are rated at their cold-cranking amps (250-800 amps) and their ampere-hours (40-80). A big block starter may draw 400 amps on cranking so theoretically, you could crank an engine for 5+ minutes before the battery died (don't count on it). Especially since twenty seconds of continuous cranking is the maximum recommended without letting the starter cool down. Remember though – twenty seconds is a fairly long time.

Voltage in the **coil circuit**, however, may exceed **50,000 Volts**, but since the internal resistance is so high you don't get burned, just *Shocked!* Your heart doesn't like such disturbances much, either. It's triggered electrically, just like all your other muscles. Being careful around coils and spark plugs goes without saying

The basic **system** voltage (~14V) is exceeded significantly only when the voltage regulator malfunctions.

The battery has the ability to put out 12-13 volts until it is almost fully discharged, but the internal resistance of the battery makes the voltage appear lower when under very high current loading: The battery *runs down* during extensive cranking of the starter.

**Remember**, if you measure the voltage of a battery that has no load on it, (nothing drawing current) it will show 12 volts even when it is 95% discharged. Turn the lights on, and the voltage may drop several volts.

### TESTING EQUIPMENT

If you don't have one, invest about \$12 in a cheap **Volt-Ohmmeter (VOM)** from Radio Shack. With the VOM, you will be able to measure both voltage and electrical resistance. I like to sharpen the (red) positive probe so that I can puncture the insulation anywhere along the wire to test continuity. When checking resistance, always Zero the meter with the adjustment on the front.

**Voltage** can be measured from the power source to ground, or across a suspected voltage loss. **Resistance** is always measured **across** the component.

*When testing the **resistance** of a component, be careful that it is **electrically isolated** from the rest of the system.* It may be necessary to disconnect at least one side of its connections. Otherwise you may be measuring the voltage or resistance of other parts of the circuit. Also, if there is current flowing across the load, the VOM may be fried. That's why I don't buy the expensive ones!

If you are not sure whether the component is live, measure the voltage across it first, or disconnect the battery! Don't use the VOM on its Resistance Setting if you are not sure that the local voltage is zero. Check the VOM resistance calibration by touching the probes together. Use the Zero Ohm calibration to bring the needle to zero on the scale.

Check **fuses** with the VOM! Most components are protected by fuses or a circuit breaker. A fuse that looks good may not be. Remove the fuse and check the resistance across its ends with the VOM. It should be 0. Reinstall the fuse and check the voltage where the wires are connected at the block, at both sides of the fuse.

Subtle corrosion can prevent electrical continuity. **Don't forget to check at the wire, at the screw connecting the wire to the fuse block, and at the clip holding the fuse.** Have the switch for the (non-functioning) load on. If there is no current flowing, there might not be any voltage drop though the offending junction even though the connection is imperfect. A quick way to check (not necessarily definitive in high current situations) is to feel for increased temperature at the connections.

**Check the wiring diagram!** There are sometimes intermediate wiring connections that should be checked first. The ERA GT and 427SC have sub-assemblies with extra connections that may have been forgotten. Most of the multi-connector blocks are located under the dashboard. Make sure that the pin connectors in the blocks **are inserted all the way** and they make contact with their corresponding pin in the mating block.

**Check the battery voltage at the battery and the fuse box .** Low voltage results from a weak battery or bad connections. In the GT there is a circuit breaker in front of the dashboard. On the 427SC the circuit breaker is on the firewall, mounted next to the starter solenoid. The breaker should automatically reset after an overload, but if the overload persists, it will continue to break the power circuit.

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## ALTERNATOR AND VOLTAGE REGULATOR

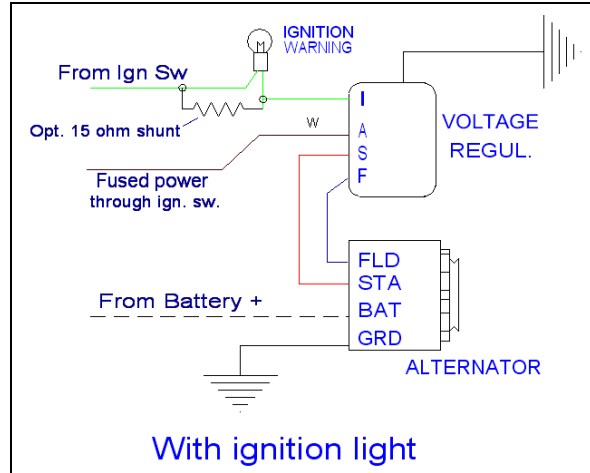
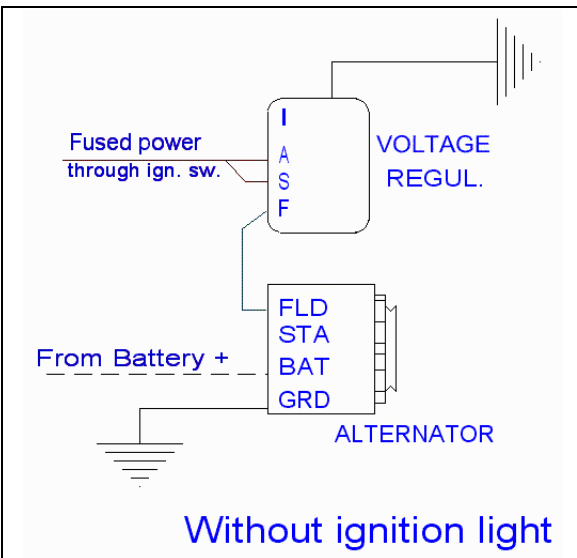
### OVERVIEW:

The **alternator** has a centrally rotating set of coils powered from the **field** terminal which create a magnetic field. As this rotor turns, it drags the field past the stationary coils that surround it.

This magnetic field generates **alternating current** within these stationary coils, which then passes through a grid of electrical one-way valves (**diodes**) to produce the DC current useful to automotive applications.

The voltage output is governed by the amount of current in the *field* circuit, and is controlled by the **Voltage Regulator**. Current is fed to the battery and other power absorbers through the large **Bat** terminal on the back of the alternator. A **ground** connection on the alternator case completes the electrical circuit. There is also a **Stator** terminal on the alternator, but it is not used on early ERA 427s without a dash warning light. You can recognize which style you have by the presence of a wire going into the stator terminal in the voltage regulator plug or the presence of four wires in the voltage regulator plug.

The main battery power comes from a connection on the starter solenoid.



Power flows from the **ignition switch**, through a fuse, to the voltage regulator. Voltage is measured from this source. Internal circuits take the power source and regulate it, sending it to the field terminal of the alternator so that the output voltage to the battery is correct.

### TESTING

**Note! A fully charged battery will also show no charge under many circumstances.**

If this is the first time the car has run, check the **polarity** of the ammeter by turning the lights on with the ignition switch off. If the ammeter moves to the positive side, switch the large wires on the back of the ammeter.

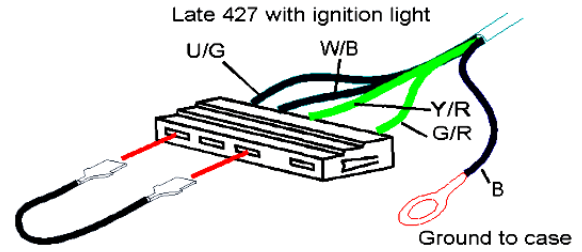
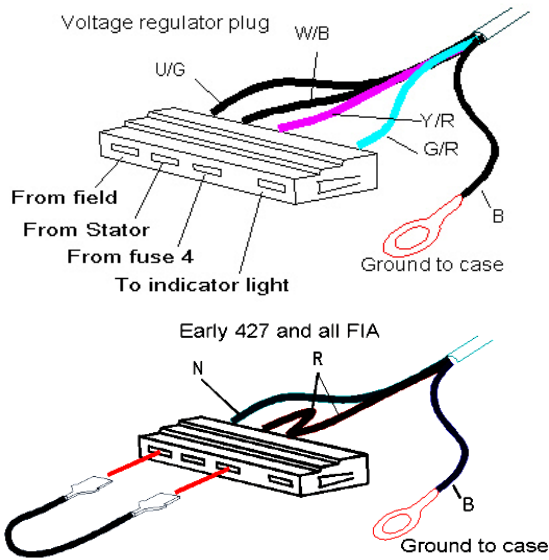
Check the system by turning the fan on with the engine running. You will normally see a discharge at idle, which changes to a charge condition above 1500 rpm.

See the wiring diagram for the appropriate **fuse** for the voltage regulator. Replace if necessary.

If you have a system that uses an ignition warning light, check that the dash light glows when the ignition is on but the engine is not running.

Check the voltage at the **Bat terminal** on the alternator. If the voltage is 13.5V or more with the engine running, there is a connection problem downstream. Follow wires and/or use the wiring diagram.

If the voltage is less than 13.5V: , remove the plug connector at the voltage regulator. With the ignition switch on, check that there is 11.5V minimum between the power wire and the black ground wire to the regulator case. If not, trace the power wire back to the fuse box, the black wire to its connection at a ground. Use a short wire to jump between the power and field wires on the plug.



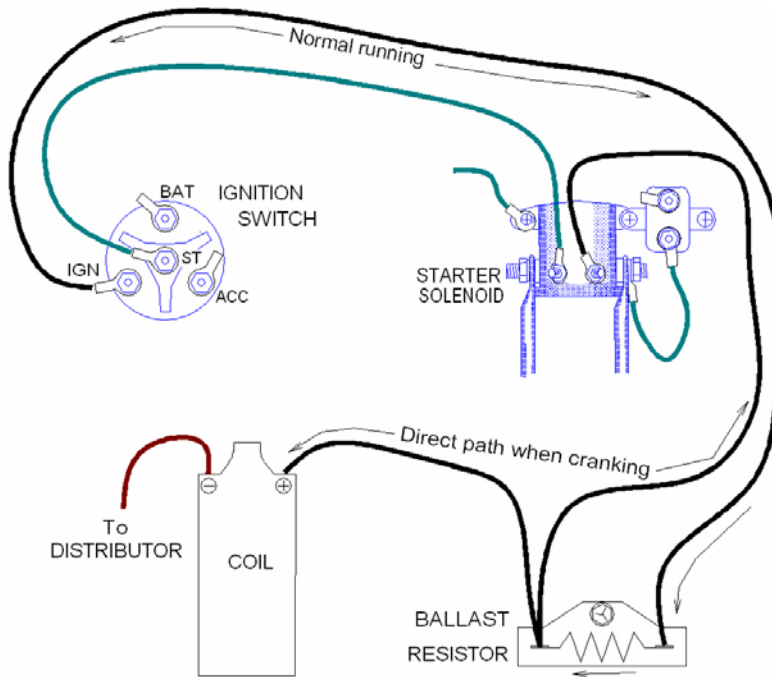
Start the engine and slowly raise the RPMs to 1500 MAXIMUM. If the ammeter shows a charge, the problem is in the regulator.

If there is no change, the problem is in the alternator. Replace it, or better yet, bring it to a testing facility.

**Sympton:** Battery slowly goes dead, but ammeter sometimes shows a positive charge.

This is usually a bad diode in the alternator, less often a bad regulator. There may also be a high current draw from some components, overwhelming the alternator capacity. With the ignition switch on but the engine off, turn things on, one at a time. Check the ammeter for an indication of excessive current draw

## IGNITION CIRCUIT



Sixties-vintage cars used a standard ignition circuit that incorporated a single or dual-point distributor with a ballast resistor. Most kits today will use an electronic distributor, and many use a multi-spark unit such as the MSD.

When you hook up your system, check whether the distributor requires a ballast resistor. Some – notably some of the Mallory units – will have considerably shortened life if run with the full system voltage.

The ballast resistor serves to reduce the voltage that the coil sees – typically to 8 or 9 volts. When the starter is cranking the engine, the ballast resistor is bypassed by a contact in the starter solenoid, thereby allowing full voltage to the coil. Because cranking load will lower the battery voltage, the coil will see a somewhat reduced voltage.

### TROUBLESHOOTING:

Symptom – Car starts but immediately dies when you release the key.

Disconnect the connections at the ballast resistor. Measure the voltage (or check with a test light) the voltage between the single wire and ground. If there is power there, the ballast resistor is likely bad. Reconnect the wires and measure the voltage at the positive side of the coil. If you see 8-13 volts, you may have a bad coil. If you measure less than 8 volts, replace the ballast resistor.

If there is no power at the single wire of the ballast resistor, check the voltage at the IGN terminal of the ignition switch. If there is no power there, replace the switch.

If there is power at the switch, check the multi-connectors between the dash harness and the front harness. It will be the same color as the single wire connection at the ballast resistor: a white, yellow, or green/violet wire, depending upon the vintage of your kit.

Symptom – No spark

With the engine off but the ignition on, check the voltage at the positive connection of the coil. You should see 8-13V, depending upon whether you've got points or an electronic ignition box.

## Headlight Malfunctions

If there are no headlights nor parking lights, follow the circuit of the power to the toggle switch. The power source on both the 427SC and the GT comes from the ignition switch. The high and low beams are fused separately after leaving the dimmer switch.

If both headlights are out, but the parking lights work, check the appropriate fuse. If it's good, check the connection at the light switch and the wire going to the dimmer relay (427SC/FIA with ERA column – see below) or the dimmer switch (GT and 427SC/FIA with Triumph column).

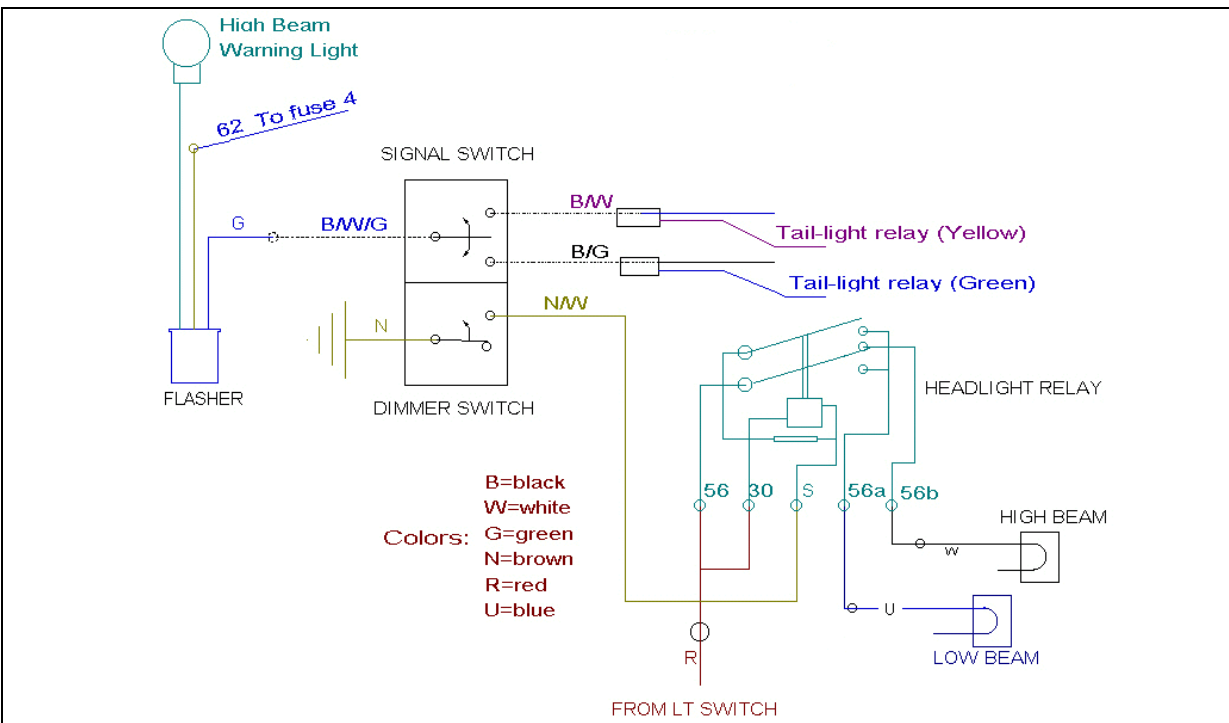
If you've got power going into the relay (or dimmer switch), check the power going out.

Check the connections at the headlight and/or the plug at the front body (ERA GT) or the bullet connections at the front spring perch (427 SC).

And finally, check the multi-plug connection under the dash.

If only one headlight is out, check the connections as described above and also see below.

Check the ground: The 427SC ground is at the right side of the X member, the ERA GT in the front bay top tube



If you have a VOM: Disconnect all 3 wires to the light, either at the plug on the light (GT) or the connections at the front crossmember (427SC). Check the resistance between the ground terminal and either of the others. If the resistance is infinite between the black wire connection and either one of the others, there is a bad filament in the bulb.

**High/Low beams exchanged.** The connections at the fuse box, dimmer switch, harness intermediate connections or at the headlight may be incorrect.

**Note:** On the 427SC, the Triumph column and the E.R.A. column have completely different switch circuits for dimming. See the diagrams in your wiring instructions and diagram.

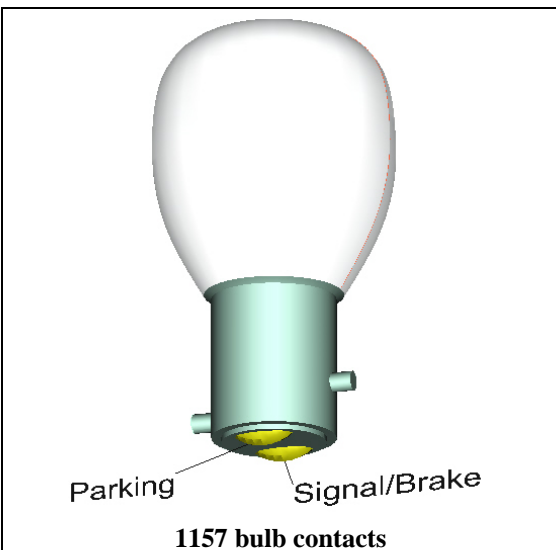
## Signal and Brake Lights

Note! **If a light seems to be on when it isn't supposed to, check the ground connection at the chassis. A common ground that isn't good will allow power feedback through other circuits.**

### 427 SC:

*ERA signal switch:* See the switch illustration on page 12.

Turn the parking lights on and make sure that each light is equally bright (side-to-side). The signal filament is brighter than the parking light filament, so if one light is extra bright the bulb may be inserted 180 degrees out in the socket, or the contact plate in the light may be reversed. If you have any doubt, check each light by disconnecting both park/signal wires, turning on the parking lights, touching the red harness wire to each light pigtail. The red pigtail should be the dimmer of the two. If it's not, reverse the contact plate in the socket (or reverse the wires if the contact plate has only one locating position).



Check fuse Use only a **Signal Stat** brand flasher, #180 (it comes with the kit). Some others don't consistently indicate flashing on the dashboard. You may not have a problem at all.

Some relays did not light the rear signals if the front signal lights were not working properly. Check the front lights if only the signal light(s) are not working.

A solid state relay is used for the rear lights, so that the same filament can be shared by the signals and brakes. Because of the internal circuitry of the relay, the **front signal lights must be connected for the rear signal lights to work**. Bench testing the relay is complicated. You must put a load on the un-used input wire for the output to function correctly.

If both signals on one side of the car are working and the other side is not, check the fuses under the steering column. Because of the sensitivity of the brake/signal relay to shorts, the fuses supplied by ERA are the quick-blow type.

If the fuse(s) are OK, exchange the connections at the 4-way connector near the steering column: The green/white wire and the green/red wire from the column switch on cars with the Triumph column, the black/white and black/green wires on the E.R.A. column. Try both signals (remembering that left is now right, of course). If the dead bulbs change from side to side, the problem will be in the switch or related wiring.

Check the appropriate fuses, and all the intermediate connections in the wiring harness. Note that the brake and signal functions are controlled by different fuses.

Make sure that the ground at the light is good by checking the resistance between the light and the chassis. It should be 0 ohms.

If there is some malfunction with the brake or signal lights, first check the connections and the voltage (with the signal or brakes on) at the 3 wire side of the relay.

If you are getting proper voltage into the relay, but none out, the relay is must be replaced (but remember the note about the front lights!) If the relay is good, check the voltage at the tail lights.

On early cars (> #600) the brake light safety warning light is controlled by twin switches at the master cylinders. See the diagram for the switches' function. Later cars used a single switch. The dash light became a charging warning light.

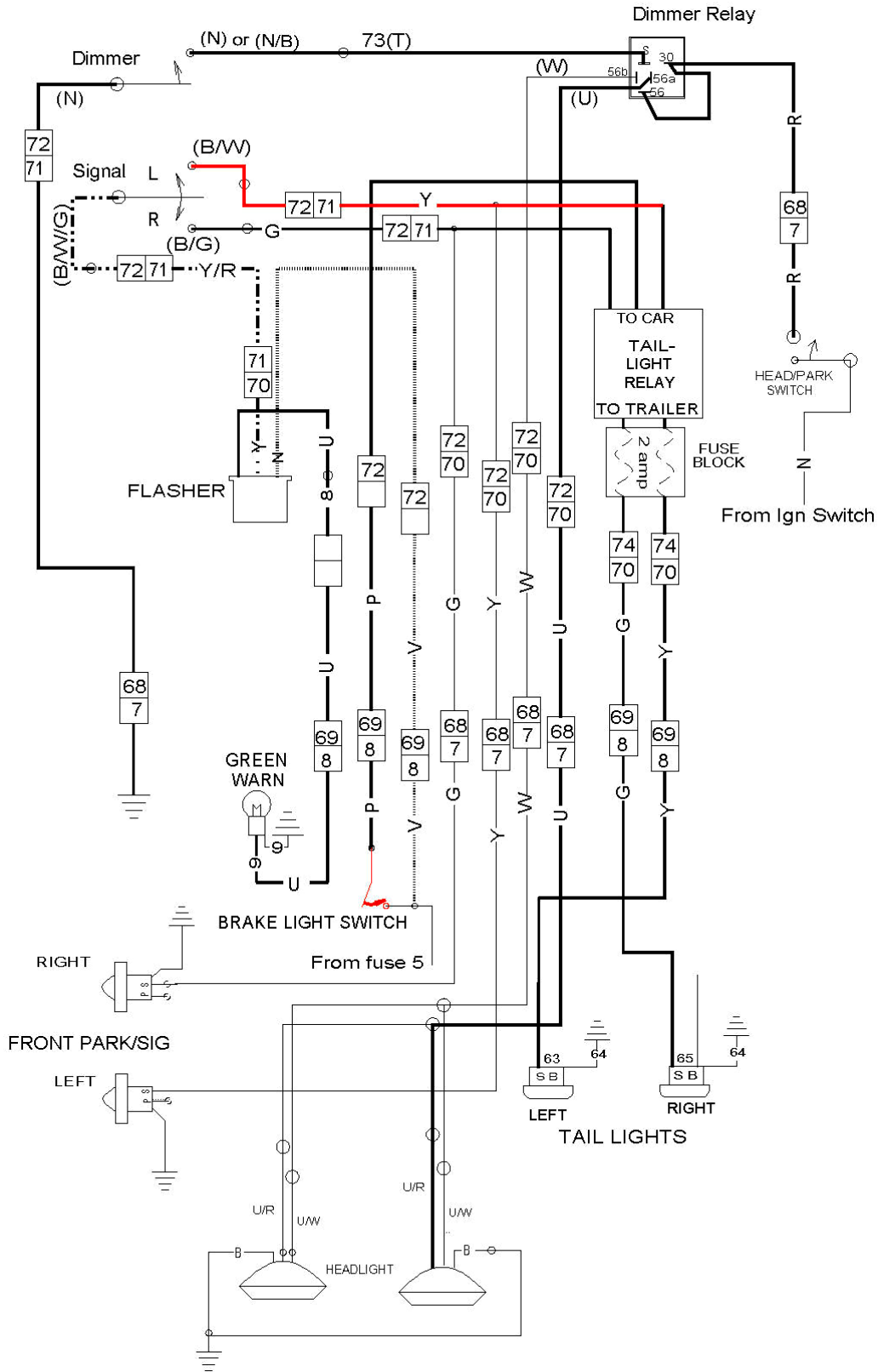
After some use, some switches may take excessive pressure to activate. If the brake lights don't go on except by hitting the brake very hard, use an ohmmeter to check the switches, and

replace if necessary. They are used on late VW Beetles and Rabbits.

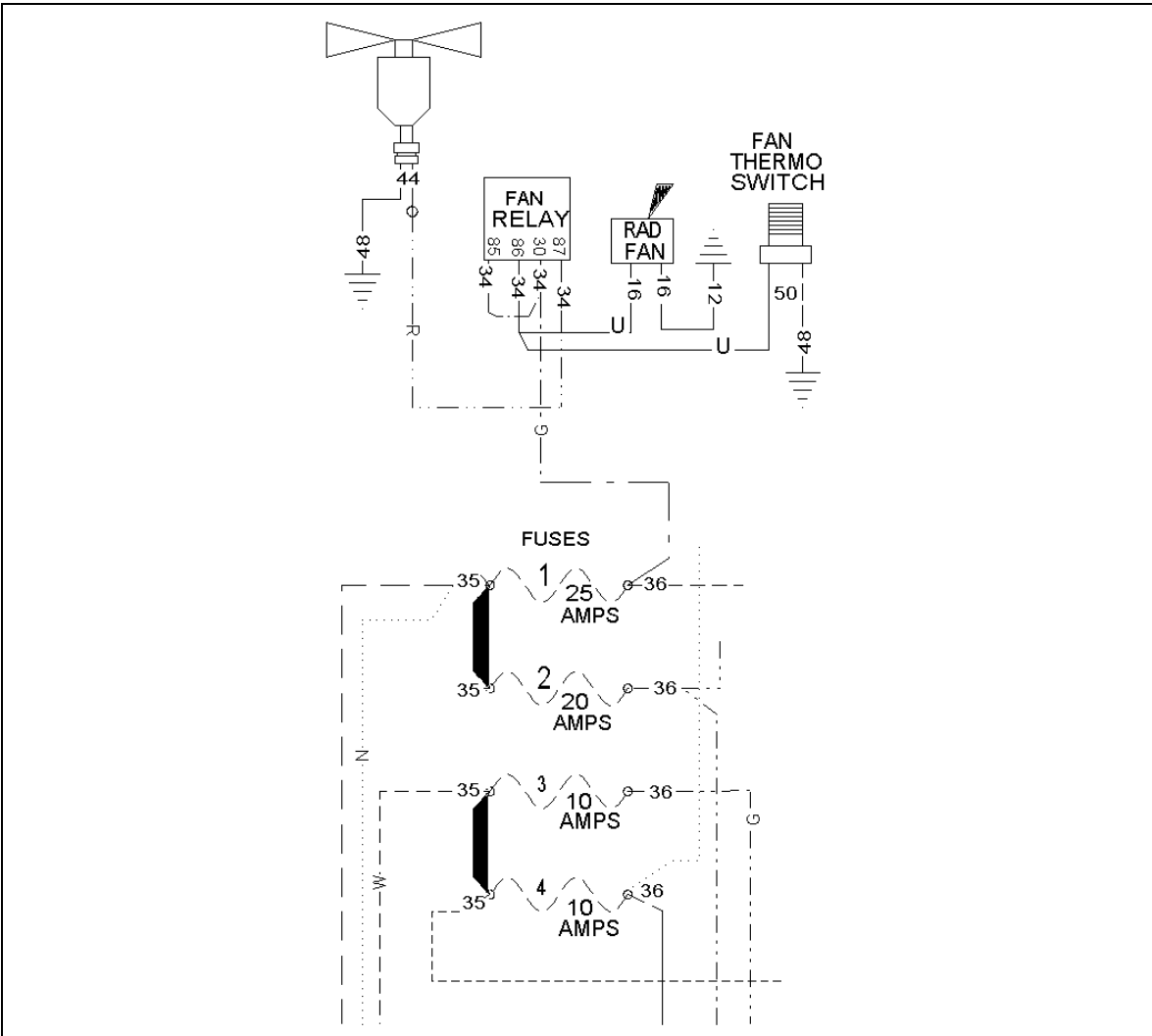
**Rear Signal and Brake Lights, ERA GT:**

Check the appropriate fuse, and all the intermediate connections in the wiring harness.

# Late 427 VW signal switch and headlight dimmer wiring



## RADIATOR FAN(S)



Shown above is the 427SC fan schematic, but the ERA GT is similar.

**Troubleshooting** – Assuming the fans don't work. The thermo-switch will activate only above 190F.

(A) If the fans won't automatically turn on, but work with the dash switch:

Check the thermo-switch connections at the connecting tube (427SC/FIA) or in the radiator (GT).

If the connections are OK, remove the wires from the thermo-switch and jump the wires together. If the fan(s) come on, the thermo-switch is defective.

If the fans still don't work, ground the non-black wire (with a jumper wire if necessary). If the fan works, the thermo-switch ground circuit is defective. Check the nearest ground connections.

If the fans won't work even with the dash switch:

Check the fan connections

With the dash switch on, check the voltage at the green or orange wire at the fan connection. If there is 12V between the wire and ground, check that the resistance between the black wire and ground is zero. If not, clean and check the nearest ground connection to the chassis.

If both the feed connections are OK, make sure that the pins between the fan and harness are mating properly.

Check Fuse connections – Go to (B).

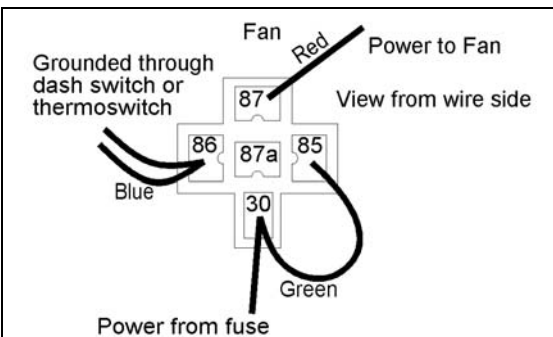
Check Relay – Go to (C).

**(B)** Check that there's at least 12V at both ends of fuse 1. If there isn't 12V on the right (green or orange wire) side, replace the fuse and check the wire connections. Some early fuse boxes tended to corrode because the fuse clamp was riveted to the tab where the wires attached. Later fuse boxes are one-piece. If the voltage is correct, go to **(C)**.

**(C)** Disconnect the relay wires and jump the wires that connect to terminals 30 and 87. If the fan works, go to **(D)** to check the relay and relay connections. If not, the connection from the relay to the fan is defective.

**(D)** Check that there's 12V at terminals 30 and 85 on the relay/connector. No voltage indicates a bad connection to the fuse box. . Not likely

Ground terminal 86. You should hear a click and the voltage at terminal 87 should be 12V. If not, the relay is bad.



With all connections remaining in place:

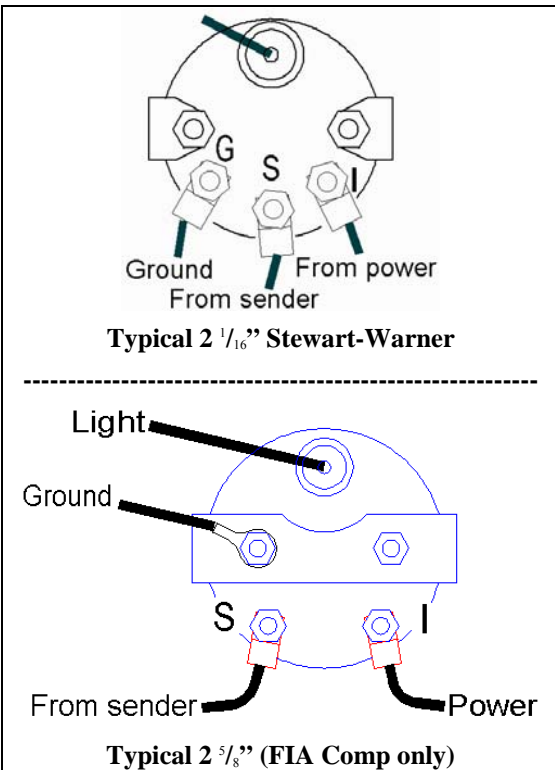
(E) Relay Ground

With the dash switch on, use a jumper wire to ground out terminal 86. If the relay clicks, the connection to the dash switch is faulty AND the thermo-switch is bad.

## FUEL GAGES

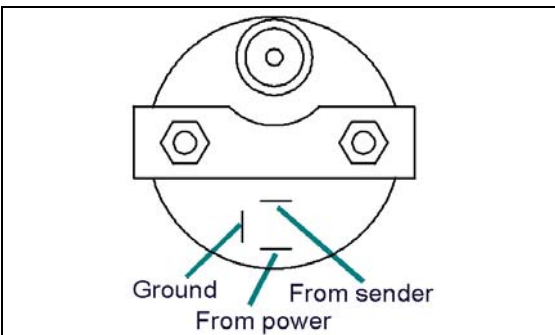
E.R.A. uses several combinations of gages and senders. Because of the shape of the tank, the gage will never be completely accurate over its entire range. Typically, the Stewart-Warner-sender equipped cars will show accurately at full and empty, but will be somewhat off at half-full. The Smith gage with electronic sender may be more accurate at half full but not at full.

## IDENTIFICATION

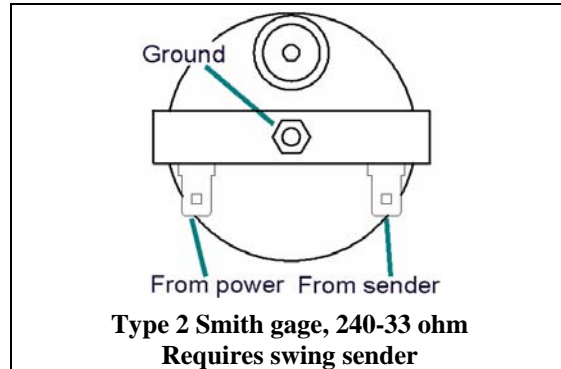


**Early Nisonger** and all **MOMA** gages require a Smith's sender with the following values:

Empty - 0 ohms  
Half - 40 ohms  
Full - 90 ohms

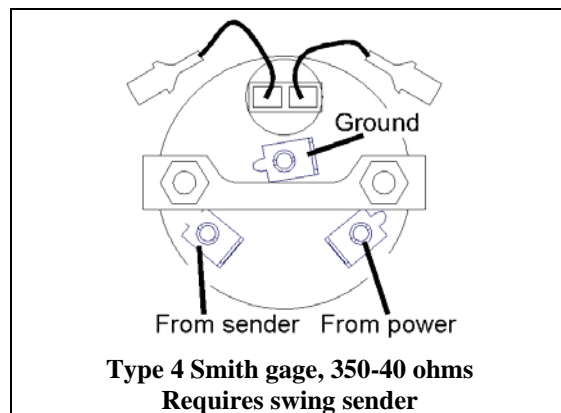
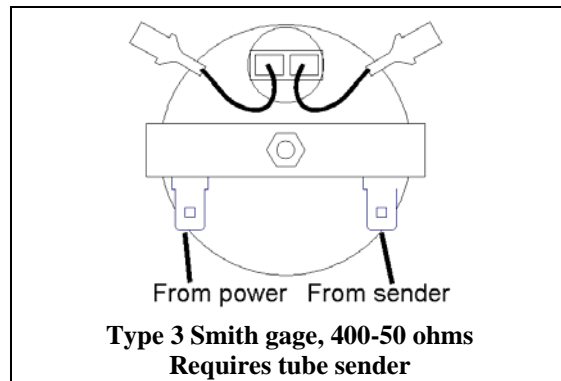


**Type 1 Smith gage, 0-90 ohm**  
**Requires tube or 6 hole sender**

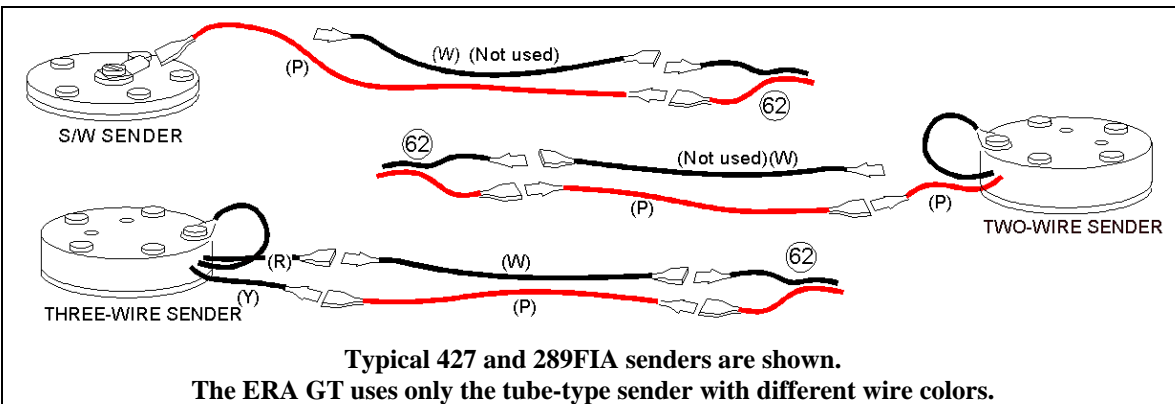


Later **Smith** (made by Caerbont) gages come in two visual variations, although their electrical function are similar. They may require a sender that has slightly different resistance requirements so we may use an electronic sender that is difficult to test with the specifications below.

Empty - 400 ohms  
Full - 50 ohms



## FUEL SENDER



### SENDER RANGES

All Stewart Warner and later Smith gages (427 after ~200) use the same range:

<b>Empty tank</b>	<b>240 ohms</b>
<b>Half full</b>	<b>140 ohms</b>
<b>Full</b>	<b>25 ohms</b>

Early Smith gages from MOMA use the original British range:

<b>Empty tank</b>	<b>0 ohms</b>
<b>Full</b>	<b>90 ohms</b>

### QUICK-TEST OF THE GAGE

Disconnect the wire(s) from the sender.

Touch the pink wire to ground (with the ignition switch on). The later-range gage (see above) will go from empty to full. The early gage will go from full to empty. If neither action happens, the gage is defective, there is a break in the circuit, or the fuse is blown.

### SWING-TYPE SENDER TESTING:

Measure the resistance of the sender with an ohmmeter. You can disconnect the sender wire at the gage or check directly at the sender connection. The sender **must be disconnected** from the gage for an accurate reading.

### TUBE-TYPE SENDER FROM CENTROID

Because of the solid-state circuitry, there is no easy way to test the sender short of an external bench setup.

### TROUBLESHOOTING

If your gage doesn't respond at all when the ignition switch is turned on, check the fuse for the instruments.

The (Type 4) 3-wire Smiths gage will go to full with no ground on the middle terminal, below zero with no sender connection or power.

The S/W gage will read below zero with no sender connection, maintain a reading with no power, and go to full with the sender terminal grounded.

### TESTING (FIA AND 427)

Check the connection at the left footbox.

Disconnect the rear main harness connection to the gage. The FIA has a plug inside the passenger's side wheel housing access panel. The 427 connection is at the left-front of the fuel tank.

**Stewart Warner:** With the ignition on, disconnect the white wire (or disconnect the plug on the FIA). The gage should drop to zero. If it does not, check the power to the gage.

If it does, jump the white wire to ground. The gage should move to full.

On the FIA, also check the ground inside the trunk at the top-left tube just behind the tank bulkhead.

If that fails, check the circuits from the gage to the rear. The FIA has a plug junction beneath the access plate inside the left rear wheel. The 427 connections are at left front of the fuel tank. Both harness continue to the front and connect at the left side of the driver's footbox with a 9-pin plug. Take special notice of the white wires' pin connections. If the circuit has complete continuity, the gage is defective. If the gage moves to full properly when the white wire is grounded, the sender is defective or the jumper from the sender to the harness is defective.

**Testing with a spare sender:** If you have a spare Stewart-Warner sender, you may check any gage and wiring in situ.

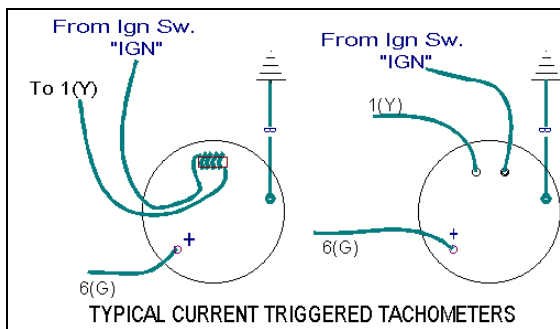
Disconnect the connections to the sender at the tank intermediate connection. The 427 connection is at the left front of the tank. The 289FIA is connected inside the access panel behind the left rear wheel. The GT connection is under the rocker access panel.

- Connect the harness sender wire to the center terminal of the S/W sender.
- Connect the S/W sender mounting plate to ground.
- With the ignition on, raise and lower the swing arm.

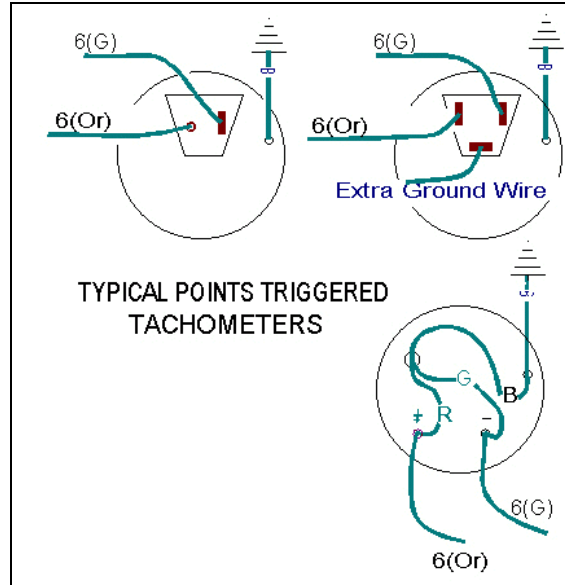
All gages (except for the early Smith, 90-0 ohm) should follow proportionally with the swing angle. The early Smith will show nearly empty with the swing arm up and full with the swing arm half-way down.

## TACHOMETER

There are many variations of tachometers – especially the “Smith” brand. The Nisonger and Moma current-triggered type look like this from the back:



The Nisonger and Moma points-triggered variations look like this:



The Caerbont points-triggered style looks like this:

## TROUBLESHOOTING

MSD with points-triggered tachometer

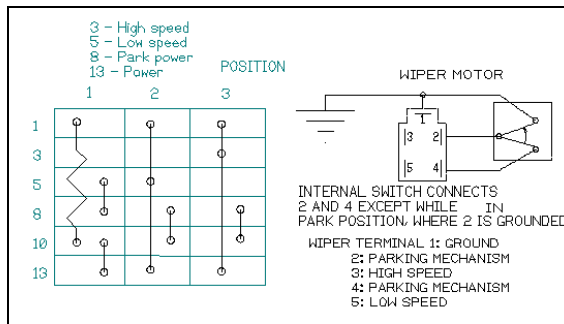
Check that all connections at the tachometer are OK, and that there is 12V at the appropriate terminal. Check that there is 1.0-1.5V at the MSD tachometer output. If not, the MSD is defective – even if the car runs OK.

## WIPER MOTOR AND SWITCH GT AND 427SC:

### SPECIAL NOTES:

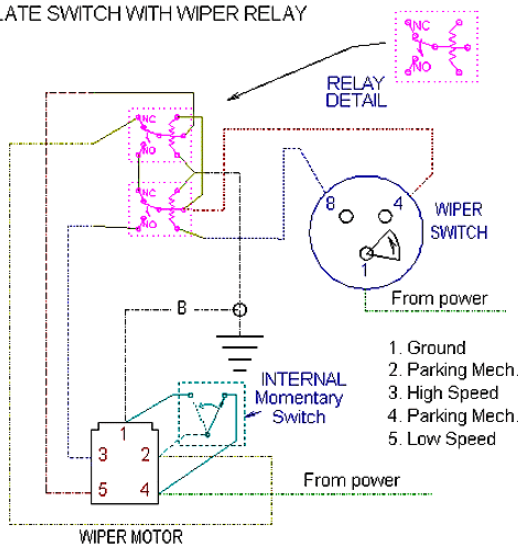
On chassis numbers before 227, the 427SC the motor connections #2 and #4 may be different than your original instructions. These new connections supersede the earlier ones.

From 427SC Chassis #227 and GT #2012, the wiper switch has been changed and a relay added to the wiper circuit. The relay parks the wipers when they reach the bottom of the windshield glass on the passenger's side by changing the connections to make the wiper motor into a generator for a short sweep period. The current created is shorted out, creating very high drag on the motor, stopping it quickly.



The original wiper switch did this operation internally (see above), but unfortunately is no longer readily available. E.R.A. now uses a more conventional switch and the relay board to do the same thing.

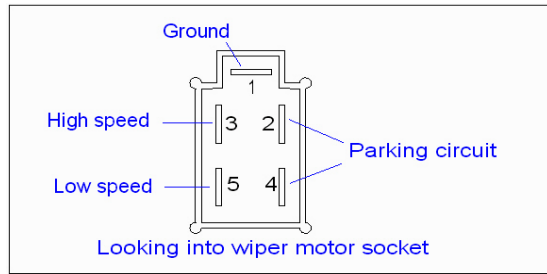
### LATE SWITCH WITH WIPER RELAY



## WIPER CHECKING AND TROUBLESHOOTING

### TESTING THE WIPER MOTOR

With a source of 12 volts, i.e. a jumper from the battery or fuse box: Ground terminal 1 of the wiper and connect 12 volts into terminal 3. The wiper should function at high speed. Switching power from terminal three to terminal 5 should result in the wiper running at low speed.



The automatic parking action of the wiper is controlled by terminals 2 and 4. These terminals will show a dead short between them for approximately 340 degrees of crankshaft rotation. The other 20 degrees will show an open circuit. While the motor is running on a test bench, connect an ohm-meter across 2 and 4. For every revolution of the crankshaft there will be a short duration perturbation from 0 ohms to open circuit. (This period is when the motor is supposed to stop when the switch is turned off.)

### SYMPTOM: NO ACTION AT ALL

#### CARS WITH RELAY BOARD:

This setup uses a simple switch with a special relay board to do the complex job of motor parking.

If the fuse has blown, turn the wiper switch off and replace the fuse with one of 20 ampere rating. If the new fuse blows immediately, check all the connections. Remove the switch from the dash panel if necessary. The numbers are difficult to see. If the connections are correct, go to (B).

**If the fuse has not blown**, check that there is 12 volts at the right side of the appropriate fuse. Occasionally, dirt or corrosion prevent proper contact. The ignition must be on for this test. Remove the wire from the motor terminal #5. With the ignition on and wiper switch at the middle position, the voltage should be 12V at the terminal. If not, go to (D). If yes, go to (C).

(A) For Cobra Only: Remove the wires at terminal 1 on the switch. This wire feeds power to the instruments. If a new fuse blows, the problem is in the wiring harness - very unlikely. If it doesn't blow, a wire is shorted at an instrument connection.

(B) Turn the switch to the middle position. If the motor runs for a second, then blows the fuse, go to (E), with special emphasis on #2 and #4 of the motor (see above italics). If the fuse blows immediately, without any motor action, go to (E) and then (F). If the connections seem to be correct, and you have a Cobra, go to (A). If you have a ERA GT, go to (E).

(C) Remove the wire at terminal #1 of the wiper. Use the VOM to measure the resistance between ground and the wire. If it is not 0, check the ground connections on the harness. If it is 0, go to (F).

(D) Check the voltage at terminal #1 of the switch. No voltage = harness problem. Go to (E). If there is voltage at #1, turn the switch to the first on position. If there is 12V at #5 on the switch, go to (E). If there is no voltage, the switch is bad, or the connections are misplaced.

(E) There is a discontinuity or an incorrect connection in the harness. Use the wiring diagram to trace the wire from source to load. Check any intermediate connections.

(F) You probably have a bad motor. Check the resistance between #1 and #3, and #1 and #5. The value should be very small for both. The usual problem is frozen or broken brushes within the motor. On some motors, there are wire connections from the back of the plug to the motor which may have come loose or broken.

#### **EARLY – WITHOUT WIPER RELAY BOARD:**

**If the fuse has blown**, replace it with one of 20 ampere rating. Turn the wiper switch off first. If the new fuse also blows, continue below.

The majority of non-functioning wipers are the result of incorrect connections at the switch, with fewer problems at the motor. Remove the switch from the dash panel to check the connections. The numbers are difficult to see.

Don't forget that the numbers are clockwise from each terminal. If the connections are correct, go to (B). There may also be an internal short in the motor. If the connections are correct at the switch and elsewhere use a jumper wire to go directly to terminal 5 on the wiper motor. If there is a spark with no motion of the wipers, the motor has an internal short. See also (F).

**If the fuse has not blown**, check that there is 12 volts at the right side of the appropriate fuse. Rarely, dirt or corrosion prevents proper contact. The ignition must be on for this test.

Remove the wire from the motor terminal #5. With the ignition on and wiper switch at the middle position, the voltage should be 12V at the terminal end of the wire. If not, go to (D). If yes, go to (C).

(A) For Cobra Only: Remove the wire at terminal 12 on the switch. This wire feeds power to the instruments. If a new fuse blows, the problem is in the circuits to the wipers: Either a wire is accidentally grounded or the wiring harness is defective - very unlikely. If it doesn't blow, a wire is shorted at an instrument connection.

(B) Turn the switch to the middle position. If the motor runs for a second, then blows the fuse, go to (E), with special emphasis on #2 and #4 of the motor (see above italics). If the fuse blows immediately, without any motor action, go to (E) and then (F). If the connections seem to be correct, and you have a Cobra, go to (A). If you have a ERA GT, go to (E).

(C) Remove the wire at terminal #1 of the wiper. Use the VOM to measure the resistance between ground and the wire. If it is not 0, check the ground connections on the harness. If it is 0, go to (F).

(D) Check the voltage at terminal #1 of the switch. No voltage = harness problem. Go to (E). If there is voltage at #1, turn the switch to the first on position. If there is 12V at #5 on the switch, go to (E). If there is no voltage, the switch is bad, or the connections are misplaced.

(E) There is a discontinuity or an incorrect connection in the harness. Use the wiring diagram to trace the wire from source to load. Check any intermediate connections.

(F) You probably have a bad motor. Check the resistance between #1 and #3, and #1 and #5. The value should be very small for both. The usual problem is frozen or broken brushes within the motor. On some motors, there are wire connections from the back of the plug to the motor which may have come loose or broken.

## **INSTALLING FOUR WAY EMERGENCY FLASHERS**

There are two methods to install emergency flashers on either car:

If you wish to keep the flasher in the car as a safety feature, follow method one.

If you are going to remove the switch after inspection, use method two for a simple installation.

**1: Standard 4-Way switch** going to each corner of the car. Purchase an aftermarket 4-way Emergency Flasher switch. Mount the switch under the dash as unobtrusively as possible. See the enclosed diagram for connections.

This system must include a second flasher dedicated to the emergency system. If a flasher doesn't come with the 4-way Flasher system, use a standard two wire flasher.

The connections intended for the signal lights can be made at the trailer relay mounted on the steering column.

### **2: Cheater (Quick and Dirty) bypass switch.**

This system will work for inspection but, since the ignition has to be on for it to function, it is not a good real world solution. It is, however very simple, requiring no permanent connections.

The dotted lines on the schematic represent this alternative. If you have any male bullet type connectors, you may connect the switch wires into the 4 way female connectors between the signal switch wires and the trailer relay.

To get all four lights to flash simultaneously, the ignition must be on. Turn the signal light switch either left or right (it doesn't matter which) and turn the new switch on. All four lights will flash.

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