Tony Bingelis

DEVELOPING YOUR ELECTRICAL SYSTEM

Part 2
Wiring The Electric Power Systems

YOU HAVEN'T REALLY had a full measure of life's experiences until you have tried to explain to a desperate builder - in a hurry - how to wire his airplane . . . over the telephone.

The poor guy wanted to get his wiring completed before the airplane was covered (he had someone coming in to do that later in the week).

Heck, I've been messing with my own wiring for the RV-6 for over three weeks now, and there are still pesky little details that I am piddling with.

Anyhow, that gent seemed quite well informed because it only took him two long distance phone calls to completely grasp what he needed, and what he had to do. He already knew what he wanted to do.

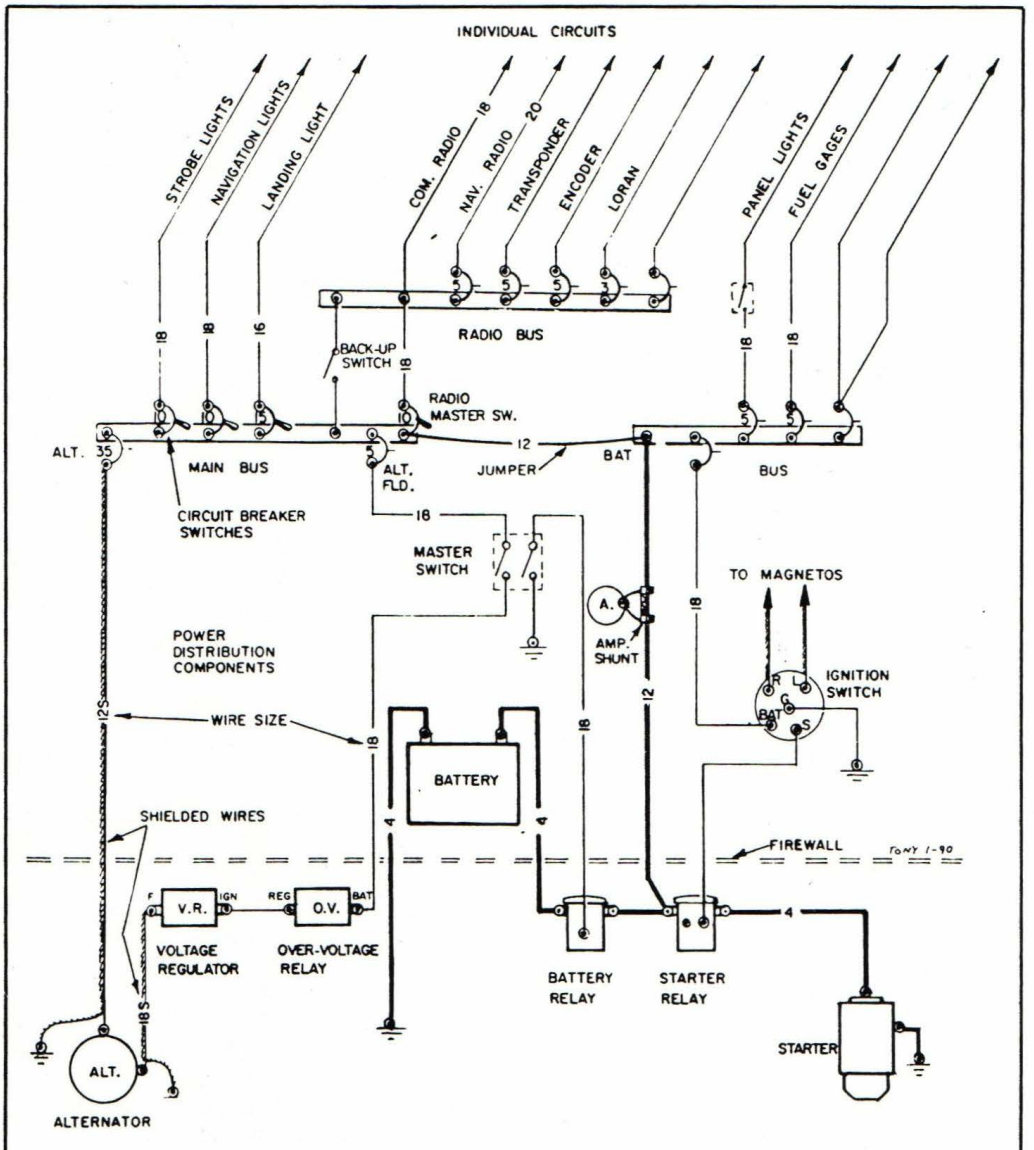
I wonder how he made out. I swear, he had more confidence in my ability to recall and convey all the wiring details over the phone than I had myself.

Let's hope that your own wiring job will not be that urgent and that you can take all the time you need to get it right the first time.

As I pointed out last month, both the alternator and the battery systems service a terminal strip called the "Main Bus".

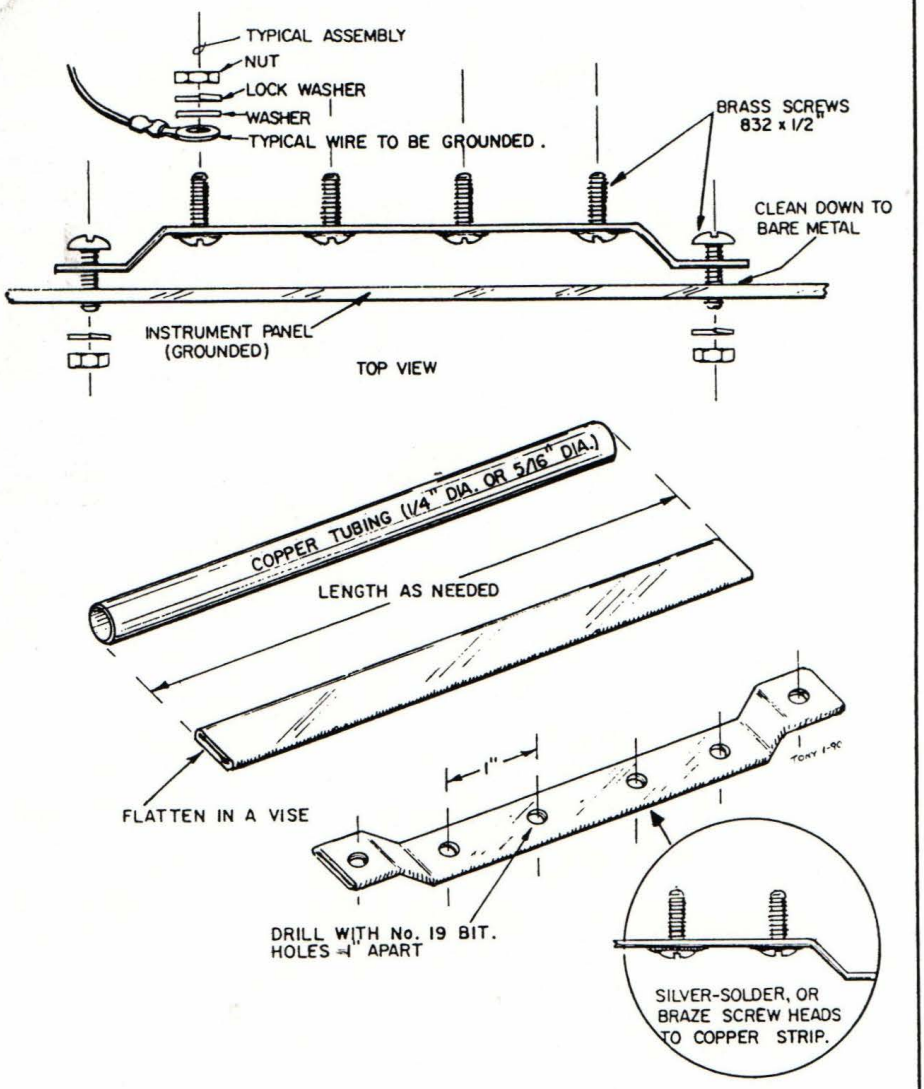
This terminal strip is really the heart of your aircraft's electric power system because all of the wiring branches out from this main bus to power all the many other electrical lights, bells, buzzers and gadgets most of us delight in installing.

Of the three basic electrical schematics illustrated last month, we'll use the most complex one as an example for



TYPICAL AIRCRAFT ELECTRICAL SYSTEM
(SCHEMATIC)

FIGURE 1.



GROUND TERMINAL BLOCK

FIGURE 2.

developing our wiring details. A slightly embellished version is illustrated for your convenience (see Figure 1).

First, let's try to establish a common understanding of how your aircraft's electric power system is expected to function.

THE BATTERY

As you know, your battery's main function is to supply the electrical power needed to start the engine. It can also provide a very limited electrical reserve you may have for use in the event of an inflight alternator failure.

The closer you locate the battery to the engine, the shorter the cables can be. Of course, locating the battery inside the engine compartment certainly shortens the cable lengths but it can also greatly shorten the battery life due to the heat that is always present.

Besides keeping your battery feeder cables as short as practical, install them so that they cannot be inadvertently reversed. You can do this by making each cable of a different length.

Many builders, at least those located south of the Mason/Dixon line, use the locally available No. 4 welding cable. However, anyone who expects to be operating in much colder climates would probably want to install the heavier No. 1 or No. 2 standard aircraft battery cables.

Protect the battery cable terminals by covering them with rubber booties (Electrical Terminal Nipples, that is) to prevent short circuits which might result from an accidental contact with foreign metallic objects like dropped tools, or maybe a screwdriver out of control.

The battery, in my estimation, when located inside the cockpit should be a gell cell type . . . even if the battery is to be housed there in a suitable well drained and well ventilated battery box.

The best thing about a gell cell battery is that it never has to be serviced. Servicing a conventional battery, especially in a hard to reach location, is not the easiest thing to do . . . battery water can splash and spill, you know.

THOSE GROUND CONNECTIONS

The most important ground connection is that one between the engine and the aircraft. Remember, the engine is insulated from the aircraft frame and engine mount by rubber shocks. Therefore, your grounding strap (or cable) must bridge across the shocks.

To simplify the installation of the rest of the electrical system, be sure to ground the instrument panel . . . especially if you are building a wood or composite aircraft.

Take great care to make the electrical ground connections correctly - that is, bare metal to bare metal. This means you must clean the surface under each grounding terminal of all paint, primer, glue, oil, etc.

It always surprises me to learn how many grounding terminals have to be established, even in an all-metal aircraft. An aircraft ground terminal can be as simple as a stud (bolt) specifically installed for that purpose, or as fancy as a terminal block that can handle multiple circuits (Figure 2).

Many electrical problems often originate in loose, poorly made ground connections. This sort of laxity results in increased resistance in the circuit and introduces unreliability in the system. Unfortunately, the problem created by a poor ground connection is generally very difficult to locate.

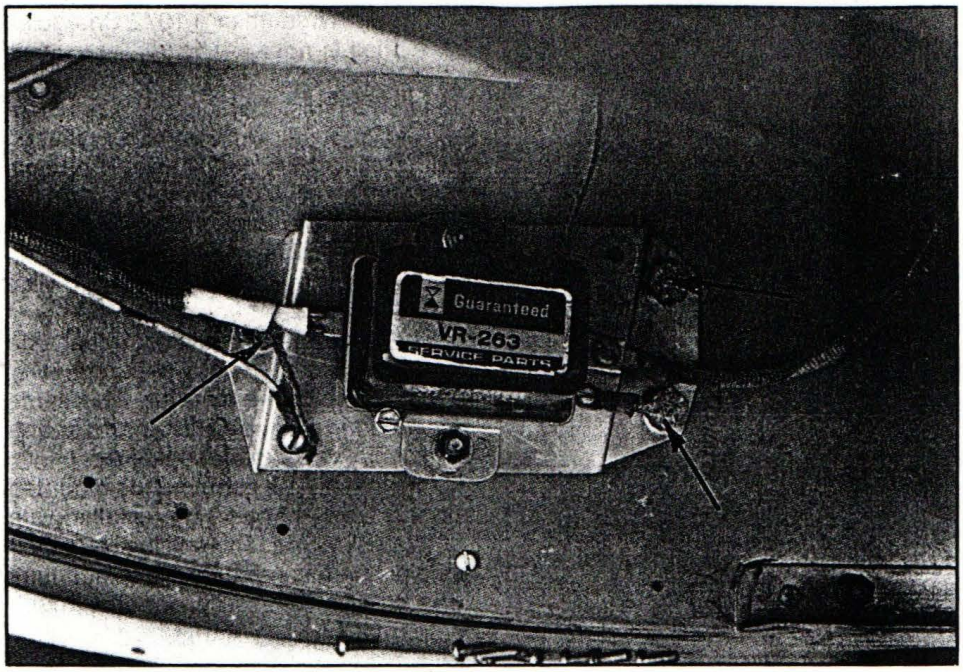
THE BUS BAR

The bus bar is not a bar nor is it a bus. Actually, it is a power (plus) terminal from which the wiring for most, if not all, your electrical wiring originates.

The main bus is usually a strip of copper to which one terminal of each circuit breaker, or fuse, is attached. The copper bus strip can be made to whatever length is needed to accommodate the circuit breakers, or fuses, that will be installed. For that matter, you can have two or three separate electrical buses and interconnect them with a jumper cable.

Typically, these extra buses include, in addition to the main bus, an avionics bus and an instrument lighting bus. Be careful when selecting a location for the buses because a sustained fault, like a short circuit, on the main bus can result in a fire hazard . . . or at the very least, the loss of the entire electrical system.

For this reason, keep the bus as small as practical and insulate it, or at



When attaching electrical components like relays, voltage regulators, etc., use nutplates behind the firewall to facilitate single handed removal and replacement of the unit in the future, if necessary.

least try to locate it where the terminal connectors would be protected from accidental contact with any adjacent metal structure.

It is also important that the bus, with its attached circuit breakers (or fuses), be located within reach of the pilot.

Trace the circuits shown in Figure 1 and you will see that the bus will receive its power from either the battery or the alternator (generator).

When the "generating system" is off, the bus and its attached wiring receive battery voltage only.

On the other hand, when the alternator (or generator) is running, the bus and equipment will be enjoying the increased voltage from the generating system.

Connect the alternator's "B" terminal to the main bus using a heavy shielded cable (wire). The shielding is essential to minimize the likelihood of radio interference.

A 60 amp alternator, for example, should be connected with a rather heavy, 10 gauge shielded cable. A smaller capacity, 12 gauge shielded cable may be adequate for serving a 35 amp alternator installation.

THE BATTERY CONTACTOR

For the cable from the main bus to the battery contactor, use an equally heavy wire and connect it through the ammeter shunt to the battery contactor. This cable, however, need not be shielded.

Note: Don't get confused by the different terms you may run into. A battery contactor, a master relay and a battery solenoid are merely different names for the same gadget. Most builders use the terms indiscriminately.

The battery solenoid (contactor) is connected directly to the battery by a heavy cable to reduce voltage drop to a minimum. Keep this cable short - under 2 feet if possible. This explains why you often see the battery solenoid mounted on the battery case.

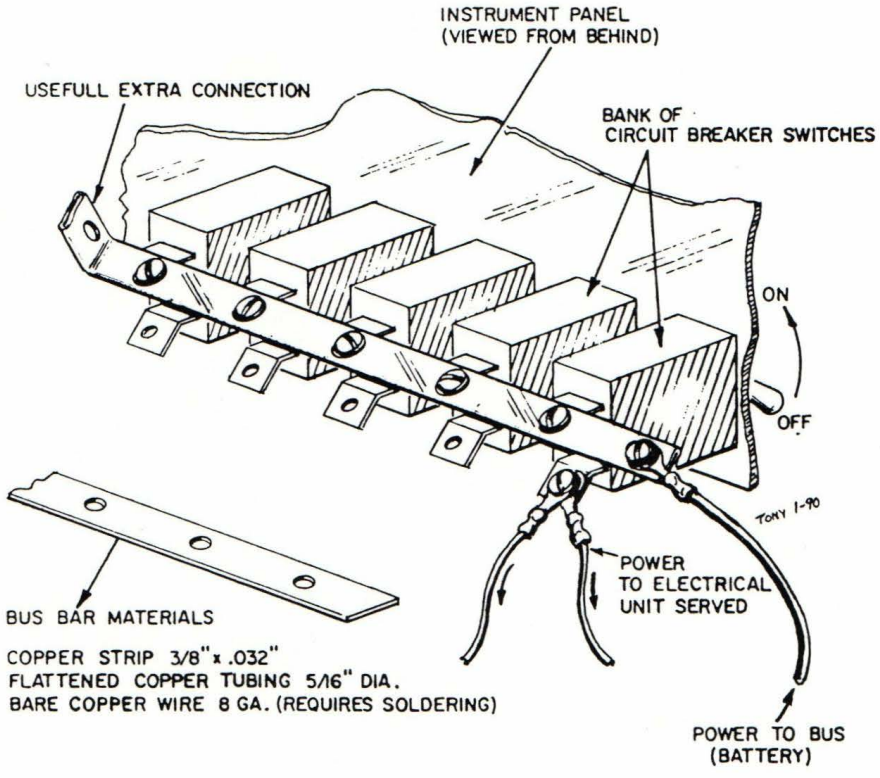
THE MASTER SWITCH

The master switch is a dual purpose switch in that it controls both the battery power circuit, and the alternator power circuit. The switch is usually a double pole, single throw (dpst) switch, although some homebuilders prefer to use two separate toggle switches mounted side by side.

A one-piece red rocker switch is commonly used for this purpose. However, I prefer to install a split rocker switch as a safety measure. The right half of this interlocking split rocker switch controls the battery circuit and the left side controls the alternator circuit by opening or closing the field circuit.

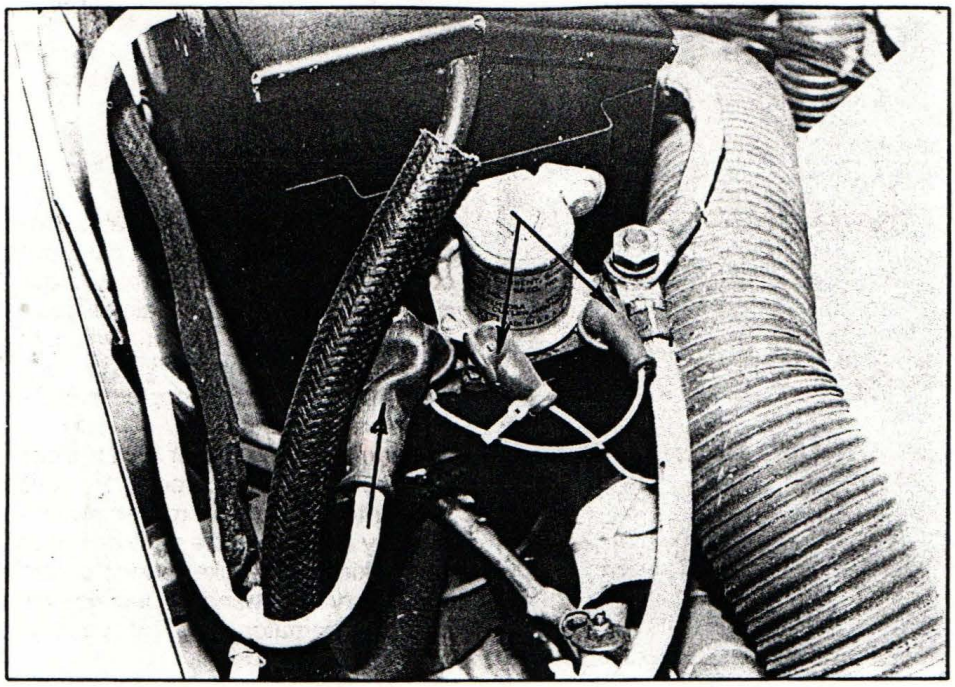
This type of switch allows the battery to be on the line without the alternator, however, operation of the alternator without the battery on the line is impossible.

The split master switch may or may not be labeled. When it is, it is labeled "BAT" on the right side, and "ALT" on



BUS BAR USING CIRCUIT BREAKER SWITCHES

FIGURE 3.



Protect your power cable terminals with rubber booties (electrical terminal nipples, that is) to prevent shorts caused by accidental contact with metal objects like screwdrivers and dropped hardware.

the left.

Note: As far as I know, Aircraft Spruce and Specialty Company is the only homebuilt supplier that carries the split master switches. In the past, I've had to salvage mine from old Cessna aircraft. Your nearest Cessna parts department might also be a source.

When you turn on the master switch, the battery solenoid will emit a very audible click. This sound is made by the battery solenoid as it, mechanically and electrically, connects the battery to the entire electrical system. If you don't hear the click, you most likely have a dead battery.

Not only does the master switch activate the electrical system, it also enables you to shut down the entire electrical system quickly by flipping the master switch "OFF". This control over the entire electrical system could be of vital importance in the event of an emergency.

THE STARTING SYSTEM

Study the schematic drawing (Figure 1) and you will notice that the starter system wiring is connected on the battery solenoid-side, instead of directly to the bus. This way, the extremely high starting current, required by the starter, will not pass through and damage the ammeter.

I assure you that the starting currents peak at a much higher amperage than the little ammeter is calibrated to handle. Besides, you don't want the resistance imposed by the ammeter to be adding to the voltage drop when the high starting currents are trying their best to crank that engine.

ALTERNATOR INSTALLATION

You should understand that the alternator depends on the aircraft battery as the source of power for excitation of the alternator. Without this initial excitation there will be no output by the alternator no matter how long you run the engine.

Because of the large vibration amplitudes present in the engine compartment, the alternator/generator terminals and wiring should be adequately supported and secured.

Take care when installing the cables that the terminal connectors are positioned so the possibility of short circuits between adjacent terminals is minimized. Be particularly careful to avoid creating an electrical short between the generator's positive terminal stud and the field terminal stud because an uncontrolled overvoltage will result.

Incidentally, protecting the alternator's terminal connections with rubber electrical terminal nipples is the wise thing to do.

THE VOLTAGE REGULATOR

When you get right down to it, the only purpose of the voltage regulator is to keep the battery voltage up. Because there are all kinds of voltage regulators on the market these days, it is obvious that you should try to obtain one that is known to be compatible with the particular alternator you have installed, be it a Toyota, Prestolite or whatever.

Most builders I know, myself included, have had very good service from inexpensive voltage regulators obtained from auto parts stores. You might check on a regulator for a pre-1969 Chrysler/Plymouth or a 1972 Chevrolet. The price is right.

Locate the voltage regulator as close to the main distribution bus as practicable to provide uniform load voltage under all loading conditions. The usual location, however, is somewhere on the upper firewall, but there is no law against mounting it inside the aircraft other than it might be too close to your radios or be less accessible.

The voltage regulator must be grounded locally with a separate wire, if necessary, to the airframe. This same precaution is advised for the over-voltage relay when one is installed.

Incidentally, all components mounted on the firewall should be installed with nutplates behind. This will facilitate their single handed removal if replacement or repair is necessary at some future date.

* * *

More wiring tips next month.

If you wish to contact the author of this column, **Sportplane Builder,** for additional information, please write to Tony Bingelis, 8509 Greenflint Lane, Austin, TX 78759.

BOOKS BY TONY

The following books by Tony Bingelis are available from the EAA Aviation Foundation, EAA Aviation Center, Oshkosh, WI 54903-3086, 1-800/843-3612, in WI 1-800/236-4800. Major credit cards accepted.

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