MORE ON ELECTRICAL SYSTEMS:

Presently I am in the process of wiring my Long EZ. I am quite fortunate to have the local assistance of good friend and fellow EZ builder/pilot, Ron White. (Cedar Rapids, Ia.) I also sent off a letter to Art Bianconi to get his thoughts on several issues. I am sure much of this will be of interest to you other builders and with Art's permission have included Art's letter in its entirety. (Thanks for your imput Art!!) Ed.

#39.5 ($.20)

Art Bianconi
99 Dover Green
Staten Island, NY
10312

March 3, 1986

Dear Arnie,

Got your letter on your Long-Eze circuits. I'll offer you some overviews and a few specifics.

First: it's bad practice to mix voltages on one panel and it has proven to be a source of damage in more than one instance. My experience has been that too many of these mixed voltage environments have been spawned by "fortuitous" gifts. ie: someone gives you a great deal on a 28 volt device, someone else gives you another great deal on a 14 volt device and you try to make both work together. The end result is always a hodgepodge of complex systems and inevitably winds up being torn out by most owners who usually end up opting for the 14 volt system. If you can economically convert all the devices to just one voltage the result will be something that is a: simpler and thus more reliable, b: easier to perform diognostics on and c: lighter.

While I have developed many electrical designs and panel layouts to enhance the Long's performance, I will get the plane flying first with the simplest of systems (Day, VFR). I know from past experience that flight testing a complex mechanism simply isn't fun. In addition, implimenting all those "good ideas" inevitably delays the first flight by many months and, often, years!Keep it simple, Arnie. Then, after you've flown off restrictions and debugged it, you can go back and fancy things up to suit your specific needs.

Ideally you should not have more than one device on any one fuse or circuit-breaker. This isn't always possible so I prioritize devices in terms of how vital they are to safe flight and then mix the low priority devices together. ie: the nav lights and the strobe lights are low priority so they could be fused together. The landing light(s) are low priority too however, they general draw more current than the others when they are used so it's best to isolate them to a dedicated circuit. Panel lights should have two different circuits, two sets of bulbs and two fuses and could be operated through a DPDT switch. This isolates the two circuits but activates both through one device. Or you can have red bulbs in one circuit and clear in the other and use separate switches. If you've ever had your panel go dark on the middle of a turbulent approach, at night, in the mountains, you'll immediately appreciate the importance of this kind of redundancy!

Overload protection is best done by examining the type of device being protected and it's best to remember here that what you wish to do is protect both the electrical consumer as well as the circuits around it. People often fail to recognize that when the insulation on a wire melts (as in a short circuit situation), that it usually takes the adjacent circuits with it too. (Which is another reason for not mixing voltages: if a 28 VDC circuit fries itself, the adjacent circuits are suddenly going to see 28 volts. If the device they feed is a 14 volt consumer, POOF!)

Avionics circuits should have a seperate fused circuit for each radio with the entire radio system operated through a master avionics switch. This is a throwback to the old dc/ac converter days and while we don't have such devices anymore, turning off all the radios from one switch is still a good feature to have. It enables or disables all the radios in one shot wothout your having to readjust all the volume levels to boot and it does protect the system from the severe voltage drops that occur when heavy consumers like a starter is used.

Motor driven consumers impose inductive loads and require substantially different fusing technology. For example: a 14 volt gear retraction motor might have a starting amperage of 25 amps but a running draw of only 10 amps. A fuse capable of staying intact during start up loads would NOT provide sufficient overload protection to the circuit. "Slow-blow" fuses are best for this type of situation. Non-inductive loads like lamps should be protected by regular fuses or c.b's at draw plus 30%. Devices like radios should be fused at 30% more than the current draw on "transmit" since this is the heaviest draw cycle; standby modes rarely draw as much current. Some radios like the Morrow II loran unit require cooling air. Bear this in mind when selecting avionics. A piece of 3/4" soft pvc tubing bonded to the top of the NG-25 nose gear blister will pickup enough dry pressurized air to cool the hot ones.

I personally prefer fuses over circuit breakers as the latter are notoriously inconsistent; the trip amperage changes from one trip to the next. Even the best C.B.'s will do this. Zink element fuses are consistent. One thing to keep in mind is that fuses, etc are temperature devices; essentially heat sinks and when the temperature of the zinc element reaches it's melting point, the fuse "blows". This is a thermal operation more so than an electrical one (that news seems to surprise many people) so be careful where you place the fuse clusters. If the fuse block is situated near a source of heat, the fuses will blow even with no overload present. I grease my fuses lightly with Vaseline before using them. It reduces the probability of junction resistance which can generate heat and cause premature blowing of the fuse.

The lighter gauge wiring promised by 28 volt systems rarely happens in real life even in production aircraft. You want extra circuits there in case you wish to add something later so you invariably wind up putting in a heavy gauge circuit "just in case....". Wire your bird with ribbon wire if possible like the kind you see inside computers. AMP Corporation makes them in high temp mil spec 18 gauge with about 3/8th inch separation with as many as 50 circuits per ribbon. Tracing these circuits is a snap and, if something does fry, it won't do a lot of damage. Furthermore, you can lay the harness up as a ply with 5 minute epoxy. It's neater, lighter and easy to test for continuity.

Use braided shielded wire for magneto kill switches. Ground both ends of the coax shield: one end at the magneto and the other at whatever ground plane or buss you've built into the panel. I suggest this for two reasons. A: it's good to have a redundant ground in this circuit. If the engine ground strap breaks you can still shut down the engine. B: the shielded braid tends to provide a more effective RF shielding (the magnetos do tend to clutter circuits with high voltage noise from time to time). Use switches that have illumination to indicate that the magnetos are hot or, again, use DPDT switches. Have one side of the switch control the magneto and the other side power bright LED's that glow red or green depending on status. Nice thing about this setup is that it's relatively easy to run an extra pair of wires to the aft most cooling baffle (the one that's visible from behind the plane) and wire an extra pair of LED's there too. Mine has an extra kill switch there for the mags too. This way you can tell at a glance weather the prop is likely to hurt you and you can ground the magnetos without having to walk around the wing to get at the switches, something people are usually too lazy to do.

Unless they are illuminated to indicate their status, rocker switches are hard to read. You're better off with toggle-type. Use short lever types where possible to minimize the chance of facial injuries. You can get illuminated DC rated switches in both rocker and toggle types from Radio Shack. While you're there, check out the headlight alert they sell for about 5 bucks. It's a natural for the canopy and gear warning and has both audible and visual clues.

Use braided wire out to the wing tip strobes from the amplifiers and although I know it contradicts the Eze weight distribution philosophy, put the amplifier as far away as you can from the avionics panel: behind the passenger seat near the center section spar. Better yet, get those compact, inexpensive strobes whose lamps and amplifiers are integrated and will fit into the lower section of the winglet. You can use a simple two wire system to activate them and you won't be introducing high voltage spikes in close proximity to the avionics panel. The light weight introduces insignificant moments so no loads are imposed to speak of and that section of the winglet can be hollowed out some without effecting strength. My installation will be like this with fresnel lens covers. The whole system will be flush as will be the nav light system. Zero drag with no additional weight penalty. (Eventually, I'd like to move the rudder horns inside the winglet away from the airstream.

My Long currently weighs 560 pounds WITH starter and alternator. I expect that I will pick up an additional 45 pounds before construction is complete. The possibility of the engine quitting in flight makes the starter desirable. Still, I feel certain that the starter and cabling will be pulled at the conclusion of flight testing. (I'm used to hand propping 200 horsepower Pitts; the Long-Eze's 115 Lycoming is a vacation by comparison!)

If you are determined to run a starter in your Long-Eze here's a suggestion: buy a ten foot coil of 5/8" o.d. soft copper plumbing (1/2" i.d.) Because it's flexible, the pipe can be hand bent to follow the contours of the fuselage floor. The pipe acts like an RF shield for any stray high voltage circuits within it and is a readily accessible ground plane sufficient to handle the heaviest consumer which in this case is the starter. Use a propane torch and a good grade of rosin core solder and sweat solder a heavy ground cable to the engine end of the pipe. The cable should be sufficient to reach either the motor mount bolts or the engine itself. Drill and tap the other end for several grounding tabs. Lay the pipe into the fuselage drilling appropriate holes though the bulkheads for the thru-ways. (PS: the 5/8 cutter used to drill the landing gear mounting tabs is perfect for this) If the fuselage outer skin isn't in place yet, cut a 5/8" channel along the outside, fit the pipe in there with flox and glass it in place with the outer skin. In any case trim the tubing so that it extends far enough forward to clear the rudder pedals when the aft end of the tube and the grounding strap are almost flush against the firewall. If you have a pipe flaring tool, this is a good time to use it as it helps minimize chaffing of the insulation. Now buy about ten feet of a good grade of heavy insulated high-voltage DC welding cable sufficient to handle the starter current draw for your particular installation (60 amps). Prepare one end for the battery terminal or master relay (if you have one) and slip it from front to back through the pipe. (you can also run sensor cables and other circuits along with it). The other end of the welding cable gets attached to the starter motor. The RAF manual fails to tell you how heavy a braided ground to use when completing the ground from engine to the mount. You'd better run a heavy one if you are using a starter! If you don't, I promise you the engine compartment will get hot in a hurry!

Nichrome type electric heaters are neither safe nor efficient. They require larger batteries, large alternators, heavy wiring, require separate air supplies to distribute heat effectively and with fuel lines, primers and tank valves in close proximity to your butt, the last thing you need is an ignition source. Besides, with so much free heat already available from the exhaust manifolding, creating another heat source is, in my opinion, a needless expense. You can easily and effectively harness the heat from the engine and distribute it through piping in the arm rests.

Make a conscious effort to position switches in a pattern that is logical. I know this may sound obvious but still people often forget how important this is. For example: the switch for the boost pump should be next to the fuel pressure gauge. I group my switches as follows:

1. Strobe Lights and Navigation lights.

2. Avionics Master, Alternator field and Master switch.

3. Landing Lights and Panel lights w panel rheostat and hi-low switch for landing light. (My landing light is a twin filament bulb with a wide low taxi beam and a narrow high beam for landing. It's a great unit.)

4. Magnetos switches (toggle type) and starter button.

By the way, I do NOT have the fuel valve or the lines inside the pilot compartment. I mounted the valve a la Vari-eze but turned it 90 degrees and it gets operated via a push-pull rod from both seats. The system is all on or off as this simplifies fuel management.

Keep your switches and fuse blocks spread out. I prefer two finger widths separation as it assures finding the right one in the dark if need be and makes operation easier with gloves on especially with the fuses. You get those guys too close together and the first time you need to replace a fuse, they'll hear the cussin' on the ground without a radio!

Use number tags and be generous with them in identifying circuits or, better yet, buy the appropriate gauge wires in as many different colors as possible. It's not a bad idea to get an EAA, IAC or other chapter to go along with you on this as it makes a broader selection of color codes possible and reduces the cost dramatically when you make a cooperative purchase. In fact, it might not be a bad idea to poll the current members of C.S. and see who needs to get what.

Use dual function gauges wherever possible. ie: EGT and CHT on one gauge. It saves weight and space on your panel. LCD readouts are extremely accurate and respond fairly quickly, however, remember that these devices use polarized light to display information. Because of this, the angle at which you can view them is rather narrow. Make sure you can read the gauge before you drill the panel hole to position it!

Back in the sixties I used to make up custom harnesses with special beeswax twine imported from Italy. It didn't stretch more than an 1/8th inch in 10 feet and was reasonably stable over a wide range of temperatures and humidity. After I wired the entire vehicle in twine, I'd wrap the bundle carefully every six inches then cut the ends away from all the consumers. I'd then carry it to the bench and copy and position each circuit from the twine to the real harness. The solderless connectors, firewall thru-ways, junction blocks were all installed on the bench then the entire assembly was placed in a special zip-lock envelope, holes pierced for each wire and the entire harness installed in the vehicle.

Let me know what your computer is. Maybe we can talk though floppies which might make your job easier. I'm on an IBM - XT with a Verticom CD-1 display driven by a Verticom M-256 graphics board. Full memory, etc. Also, feel free to copy anything here for use in the newsletter; all of it if it suits you.

I could go on for another ten pages but now's not the time. This should help. By the way, are you going to Oshkosh? If so: how, when and where are you staying? I figure on taking the Long but have alternate plans should the plane not be ready in time. It's probably too late for this year but perhaps we could orchestrate a 1987 C.S. party at the Oshkosh Convention or at Sun N' Fun

REGARDS