8.15
#276

THE SPORTPLANE BUILDER

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THE ELECTRICAL BONDING OF AIRCRAFT

IT SEEMS THAT just about everyone who owns a homebuilt capable of extended cross-country flights is talking about aviation's latest fad, Long Range Navigation (LORAN). At any rate, a lot of spirited conversations have transpired hereabouts regarding the best way to install one of those super sensitive LORAN C units in a homebuilt that is currently flying. One major point dominating these discussions regards the obvious sensitivity of the LORAN C to electrical noises, particularly to disturbances like those emitted by a voltage regulator, magnetos, flow meter, clock, tachometer and other digital gadgets and instruments that we delight in installing. These electrical disturbances have to be nullified by the effective use of bonding and shielding.

If you are considering the installation of a LORAN C, you may be pleased to know that you probably already have many of the usual electrical disturbances under control. This would be especially true if your airplane is already equipped with a radio or radios as shielded ignition wiring and filter equipped magnetos are a must for most radio installations. But the chances are that your existing bonding and shielding are not adequate for a LORAN installation and really may only be marginal for your present needs.

On the other hand, you may not have a radio installed and have absolutely no bonding aboard. After all, most homebuilts are not electrically bonded . . . nor do they appear to really need it. Builders typically make a reasonable effort to install shielded wiring wherever they think it might be needed, but often not until after they have decided to install a radio. Bonding is another thing . . . an ignored thing.

Why Bonding Then?

I do not want to plant the impression that bonding is unimportant except when the installation of a LORAN C is contemplated. Not at all. Actually bonding could be very important for other more mundane reasons.

By the way, what do you think I mean when I refer to the term "bonding", or more correctly, "electrical bonding"?

When I make reference to the effect that an airplane is bonded, you could and would assume that its structure contains a metallic network (usually of braided wire) interconnecting all metal parts to form a continuous, low-resistance, electrical circuit terminating at the firewall or the engine. This bonding network is most extensive in wood and in composite type aircraft and almost non-existent in all-metal aircraft types.

An all-metal aircraft, for example, does not require as extensive a bonding network because its metal structure substitutes for the bonding strips that have to be strung throughout a non-conductor type of structure. In an all-metal aircraft, short bonding jumpers might have to be installed between control surface hinges and at other movable connections where a film of oil or grease could insulate the part electrically from the common ground return . . . but that's about the extent of the bonding requirement. Most equipment installed in an all-metal aircraft is automatically grounded by virtue of its physical contact with the metal structure. Of course, this is not so with a wood or composite structure.

In a wood or composite structure a separate ground return conductor has to be installed or the unit be tied into the bonding network with a jumper connection. Although the bonding strand network can take the place of some of the ground wires that would ordinarily have to be used, you should make sure that the bonding strand is large enough for the electrical load. For example, in bonding the engine/mount to the firewall a strap capable of handling 40 amps should be used. Actually, two separate ½" braided straps would be my preference.

Here's what bonding can do for you:

1. It can provide a low-resistance ground path for any equipment you may install and reduce the need for so many ground wires (wood/composite aircraft).

2. It permits the use of the aircraft's structure as a counterpoise ground for the radio circuitry.

3. It minimizes radio interference from electrical equipment disturbances.

4. It reduces the danger of lightning discharges . . . but don't take any bets on it.

5. It is very important in preventing the build-up of static charges between metal parts of the airplane. This, of course, eliminates a potentially dangerous fire hazard.

6. It makes the effective use of a LORAN C possible.

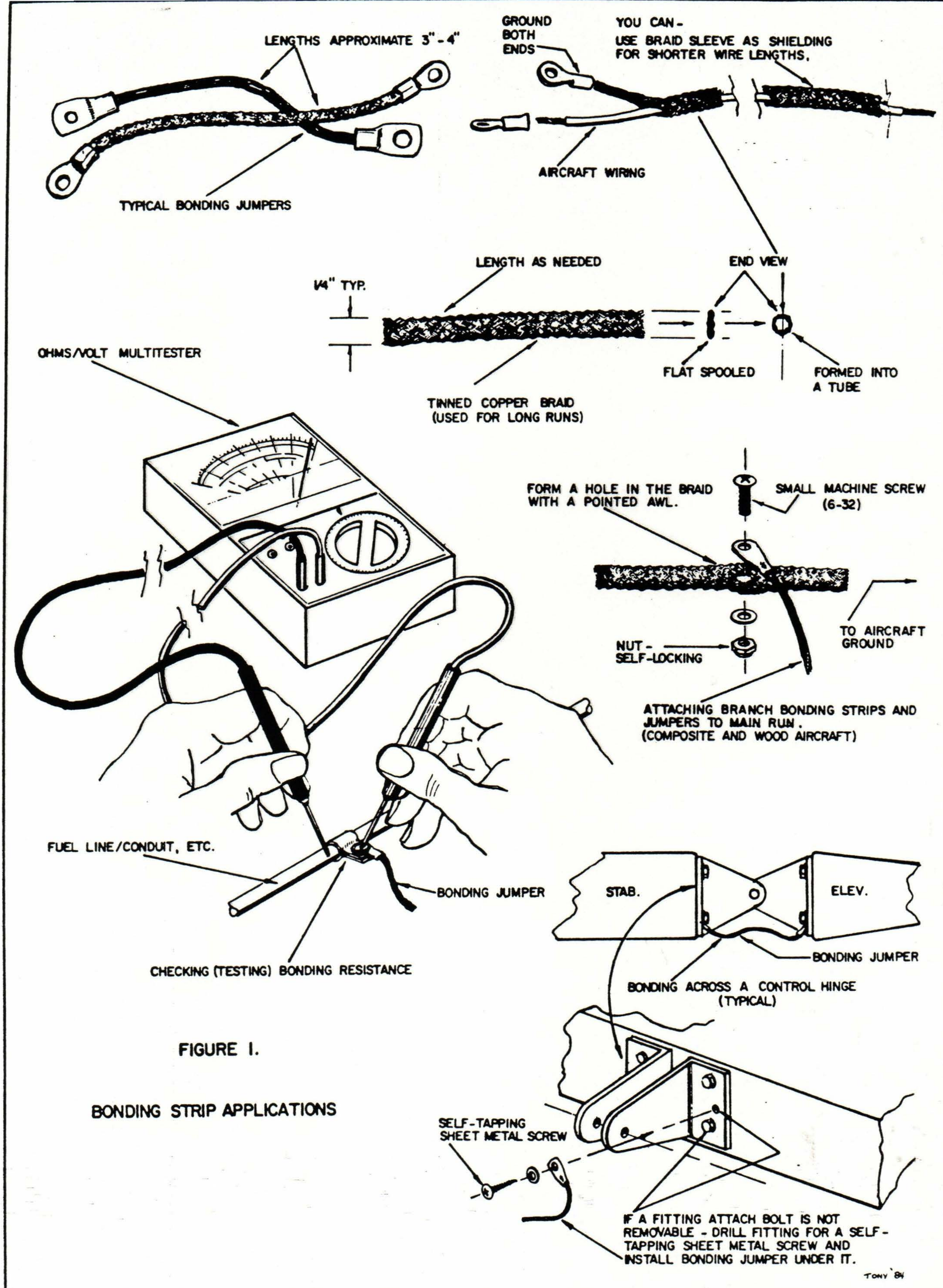


FIGURE I.

BONDING STRIP APPLICATIONS

Materials Required For Bonding

I suppose just about any kind of wire or metallic material that will work in a particular location for a particular part can be used to establish an adequate electrical bond between metal parts. There are, however, materials especially made for this purpose. For the long runs you would use an extra flexible tinned copper braid that comes in a roll from which you can cut whatever length of the braid you need. An average wood aircraft will take about 75 feet (plus jumpers) and a composite aircraft slightly less than that. The braid most frequently used is the ¼" wide stuff (32 amp current capacity) although a lighter ⅛" wide braid (16 amp current capacity) may be used if the installation is strictly for the reduction of radio interference and does not have the added requirement of serving as a ground return for electrical equipment.

Preformed bonding jumpers are commonly used to bridge control hinges and in making short branch connections. These are usually about 3" to 4" long.

About the only other items you might need are some small self-tapping sheet metal screws and a collection of small (6-32) machine screws with self locking nuts or plain nuts and lock washers of some sort.

Clamps and even metallic tape have useful functions in some locations.

Your most important bonding aid or tool will be an ohmmeter which you will need for checking the resistance at each connection (see Figure 1).

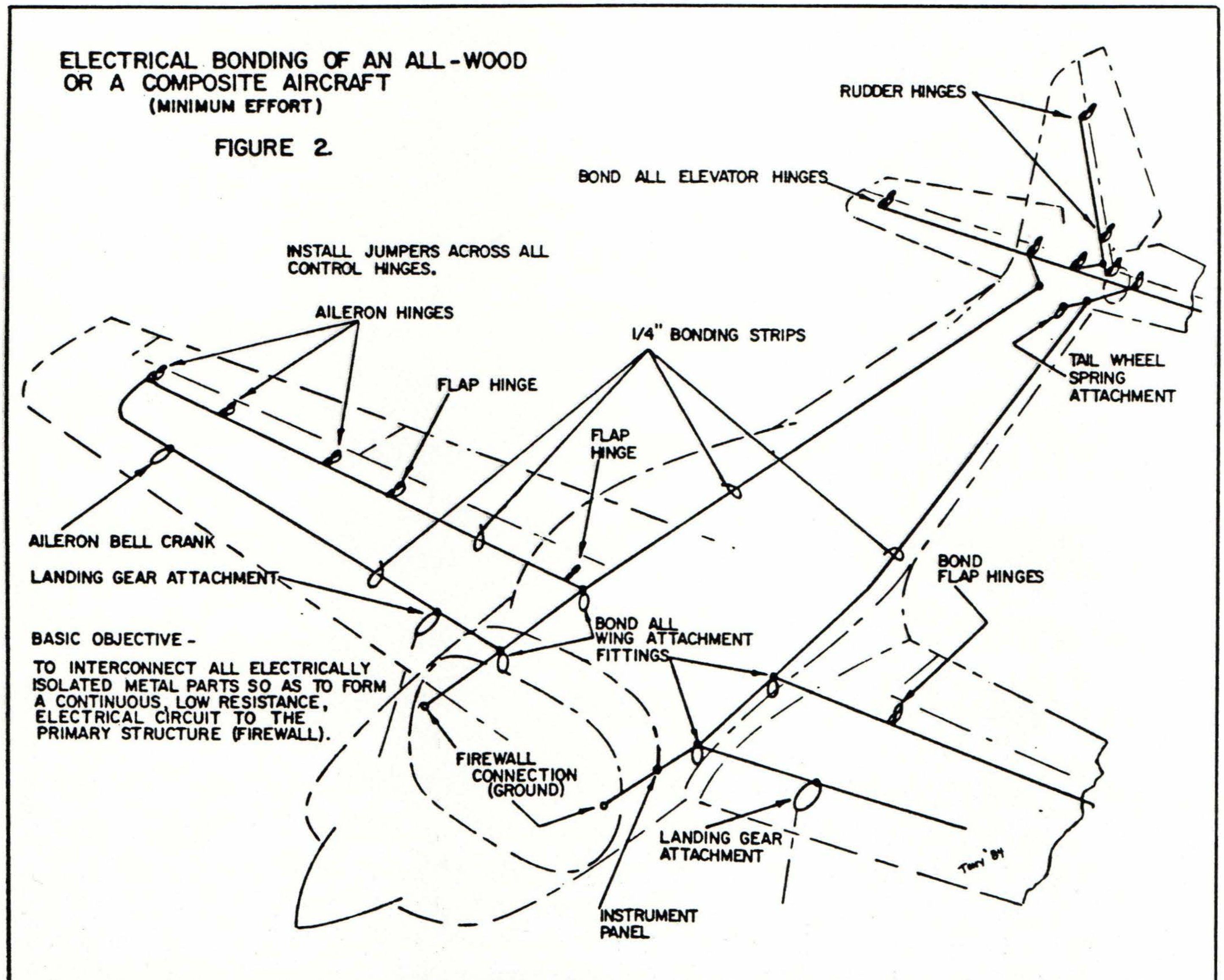
Bonding? To What Extent?

It is not until you actually start the bonding of the so-called isolated metal parts and equipment that you fully appreciate the large number of the items that really may have to be bonded. For most radio installations, the extent of bonding against electrical disturbances will probably not be more extensive than that illustrated in Figure 2. However, if a LORAN set is to be installed, you may have to go the extra mile and progressively keep adding to the bonded items until all of the electrical disturbances repugnant to the LORAN (as would be manifest by its continued disregard for operational decorum and accuracy) have been eliminated. A few other items might require bonding:

Inspection Plates	Piano Hinges
Fairing Gap Covers	Control Columns
Instrument Panel (of course)	Flap and Gear Motors
Canopy Frame/Rails	Rudder Pedals
Control Cables (all)	Miscellaneous (if you can find where it is)
Strobe Power Pack(s)	

The Way They Used To Do It

Wood fuselages were typically bonded by running at least one braided bonding strip from the engine, or firewall, along a longeron all the way back to the tail. Sometimes a bonding strip was affixed to each of the four longerons in larger aircraft. Then short branch bonding strips



were connected separately to each isolated metal part or unit along the route. Additional bonding strips were deployed along the front and rear spars, all the way out to the tips. From these trunk or primary bonding strips, short branch wires or jumpers were connected to the landing gear parts, water, fuel and oil line, rudder, elevator and aileron control hinges and also to the external wing brace wires . . . even to the internal wing drag wires and any other metal part that did not have a good, low-resistance electrical ground path to the engine.

What all this did, in effect, was to create an artificial circuitous aircraft ground network extending to all parts of the aircraft and terminating at the engine/firewall area.

More Bonding Details

To obtain a good, low-resistance connection between two metal parts, the mating surfaces must be clean bare metal and free of any kind of protective coating. This also applies to the anodic coating on anodized aluminum. It must be removed by sanding the connection area with a fine grit abrasive. Confine the spot cleaned for the connection to as small an area as possible. It should be only slightly larger than the bonding connector.

Note: Cadmium plated parts need not be sanded in order to obtain a good electrical connection.

After any bonding connection has been completed and checked with an ohmmeter, it should be given a protective finish. Polyurethane varnish is highly recommended for this purpose unless you want to use a matching paint. At any rate, it is highly important that moisture be kept out of all bonding connections, particularly if a bonding jumper or connector is made of a dissimilar metal.

Installing a copper jumper against an aluminum hinge fitting would be placing dissimilar metals in contact with each other. This practice invites the initiation of electrolytic action. This sort of activity is especially prevalent in the presence of moisture and results in the development of corrosion in the connection. You can recognize the corrosive presence of electrolytic action by the snow white coating or residue formed around and in the bonded connection. You can expect the corrosion to take place in the aluminum fitting and not in the copper jumper. For this reason, it is best to install an aluminum washer between the two metals. Then the corrosion, if it does occur, will attack the replaceable washer and not the essential part. For this reason, always try to use aluminum jumpers against aluminum parts.

For bonding most other parts made of cadmium-plated steel, copper, stainless steel, brass or bronze, the more commonly available tinned copper jumpers are recommended even though they are somewhat heavier.

Save weight by keeping your bonding jumpers as short as practical. Do not, however, make them so short as to restrict or interfere with the movement of control surfaces.

Don't try to attach jumpers by soldering them - makes the connection too brittle. Use self-tapping sheet metal screws or machine screws with self-locking nuts instead. If you must use plain nuts, add some sort of a lock washer for security.

If you cannot install a bonding jumper under one of the hinge bracket attachment bolts because there is no nut plate behind it to allow its removal, you will have to do something else. Try drilling a hole in the bracket for a small self-tapping sheet metal screw. Figure 1 illustrates such an arrangement.

To connect branch jumpers to the main bonding strip runs you will have to use a sharp pointed awl (ice pick) to spread a hole in the bonding braid. You will then be able to install a small 6-32 machine screw to complete the connection. Check the efficiency of the connection with an ohmmeter.

Testing Bonding Effectiveness

A number of references have already been made regarding the use of an ohmmeter to check the effectiveness of the bonding circuit and the individual connections as they are made. What does this mean and how do you do it?

The instrument you need is a simple inexpensive one similar to that illustrated in Figure 1 (Radio Shack, auto parts stores, etc.). Set it to read resistance measurements in accordance with the instructions that come with the unit. Place the probes as shown across the circuit or part to be tested and read the resistance on the appropriate scale. (Other types of testers equipped with a buzzer or light are also available.)

Naturally, you want to obtain the lowest possible resistance in each connection but how low must it be? Industry standards vary for various companies, and for parts tested, but for the most part resistances ranging up to 0.003 ohm are generally acceptable. The final test of the effectiveness of your bonding work, of course, is in the noise free operation of the radio equipment.

A Few Added Comments

When your aircraft is refueled at an airport from a fuel truck, the line boy (person?) pulls out a heavy cable with an alligator clamp on it and he clamps that to your aircraft to ground it. After all, static electricity can jump between the nozzle and the tank and ignite the fuel fumes. So where is the grounding clamp placed? On the landing gear axle? Is it grounded to the aircraft? Wouldn't a better place be on one of the exhaust stacks? But then how about your fuel tank? Is it grounded to the engine?

During the construction of a composite aircraft you should plan the layout for the bonding wire circuit and then bond the braid wire to the foam core before the glassing operations are undertaken. Naturally, you will remember to check the entire bonding circuit with an ohmmeter to assure yourself that it will provide the low resistance network you need to the firewall?

Just thought you might like to have something extra to think about.

WE SHALL REMEMBER THEM

FRANCIS E. YENNACO (EAA 68132), Woburn, Massachusetts. February 2, 1984. Former officer of EAA Chapter 136 and 106.

MAX O. STOCKING (EAA 132505), Arlington, Texas. February 13, 1984.

ERNEST W. OUZTS (EAA 103576), River Ridge, Louisiana. March 17, 1984.

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