Lightning Protection: Taming Thor's Thunder- On A Budget

Learn How To Affordably Safeguard Your Valuable Radio Equipment—And Maybe Something Far More Precious

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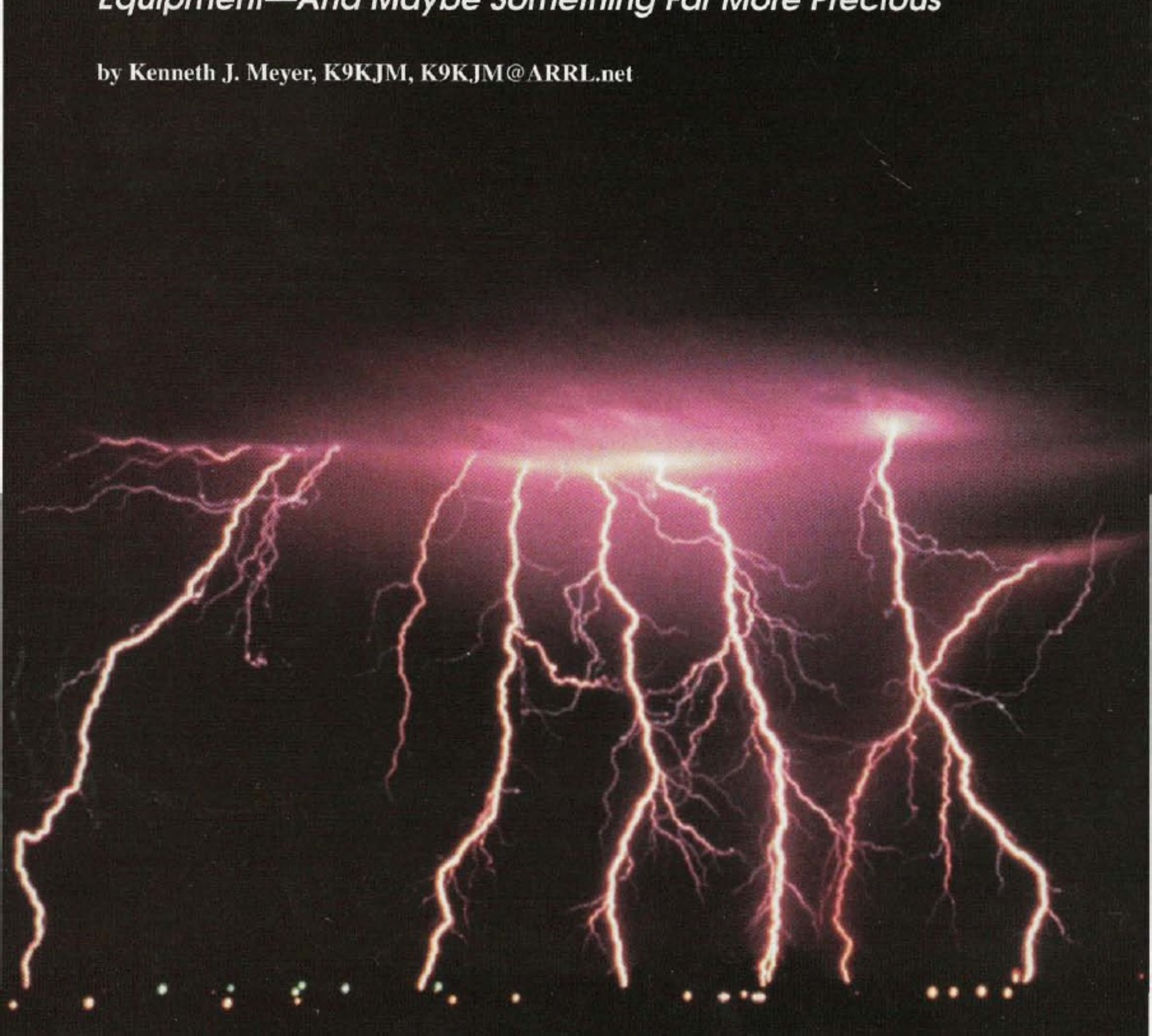


If you're a radio hobbyist, your radio equipment is extremely valuable to you. It's an investment, and like all investments it needs protection. One way to protect that investment is by making sure that you have adequate lightning protection in place. There are plenty of sources explaining how to protect your radio shack from lightning damage, but few people implement the proper protection because of the perceived high cost of (copper) supplies. While this article certainly isn't the "last word" on the subject, it will show you that you don't have to take an expensive approach and provide you with tips on how to properly protect your station—without breaking the bank.

First, let's dispel some old wives' tales regarding lightning. For starters, it is possible to take a direct lightning strike to your antenna mast, tower, or other support without your equipment suffering damage. Commercial, police, fire, and ambulance systems, cell phone towers, broadcast stations, etc. take direct lightning strikes during most large lightning storms, and when they're properly protected they don't suffer any damage. True, that equipment does have extensive ground systems and shiny copper straps that cost a lot of money to have installed, but it's possible to add protection on a budget. Don't listen to those misinformed folks who say "Nothing can protect from a direct lightning strike." Radio equipment survives lightning strikes all the time.

But wait, you say, doesn't a typical lightning bolt have millions of volts and many thousands of amps of power? Well, yes, they can. But lightning bolts, like lots of other things, come in all different sizes. While a large, powerful lightning strike of several "strokes" of longer than normal duration can have lots of power, even the largest strikes can be handled with large low-inductance conductors because of the very short duration of even the longest and largest strikes.

Indeed, part of the confusion over the years about lightning stems from the fact that lightning strikes can be large or small. So when someone tells you that his station was hit with a direct lightning strike and suffered no damage, despite having only minimal grounding with small-size conductors, that may be true—but he may have been extraordinarily lucky and taken only a minor hit.

Kenneth J. Meyer, K9KJM, is an extra class amateur radio operator who has actually used all of the cost-saving ideas in this article to install lightning protection systems on a low budget. He has supervised many commercial tower installations.

A worker "Cadwelding" (see text) #2 solid copper wire with 4-inch-wide flat copper strap. The dark material around the copper strap is Harger "ground enhancement."

In these tough economic times, why take chances with your valuable equipment, especially when it can be safeguarded inexpensively?

Proven Approaches For The Frugal Hobbyist

The first order of business for properly protecting a station—or home for that matter—is to make sure you bond (that is, electrically connect) all ground points together with a low-inductance conductor, such as a flat copper strap or a heavy gauge wire. This means that your electric power entrance ground, cable TV entrance, telephone landline entrance, hamshack ground, mast or tower ground, etc. all need to be bonded together.

Think of your equipment like a boat on a rough sea: When a large wave—a lightning strike, in our case—causes everything to move up and down together, the equipment is safe. Damage happens when there is a potential difference between ground paths; bonding eliminates that difference. Bonding is of extreme importance and we'll get back to it shortly.

The actual device used (lightning arrestor, grounding coax switch, etc.) is much less important than the proper bonding and grounding of coax shields before they enter the building. It's also important to understand that damage from lightning to most home stations comes in via surges to the electric AC power system, and not from direct antenna strikes, except in rare cases.

A VERY important step in protection is to install a "whole-house"-type of surge suppressor at your electrical power entrance panel. Such protectors are available from most electric shops, home supply stores, or companies specializing in these devices. A suitable device should cost between $50 and $100 or so retail, although I've found whole-house protectors (Delta LA 302-R) on eBay for only $35. Such protectors must be installed in the main breaker panel. If you are not comfortable working in this way, hire a professional electrician to install it.

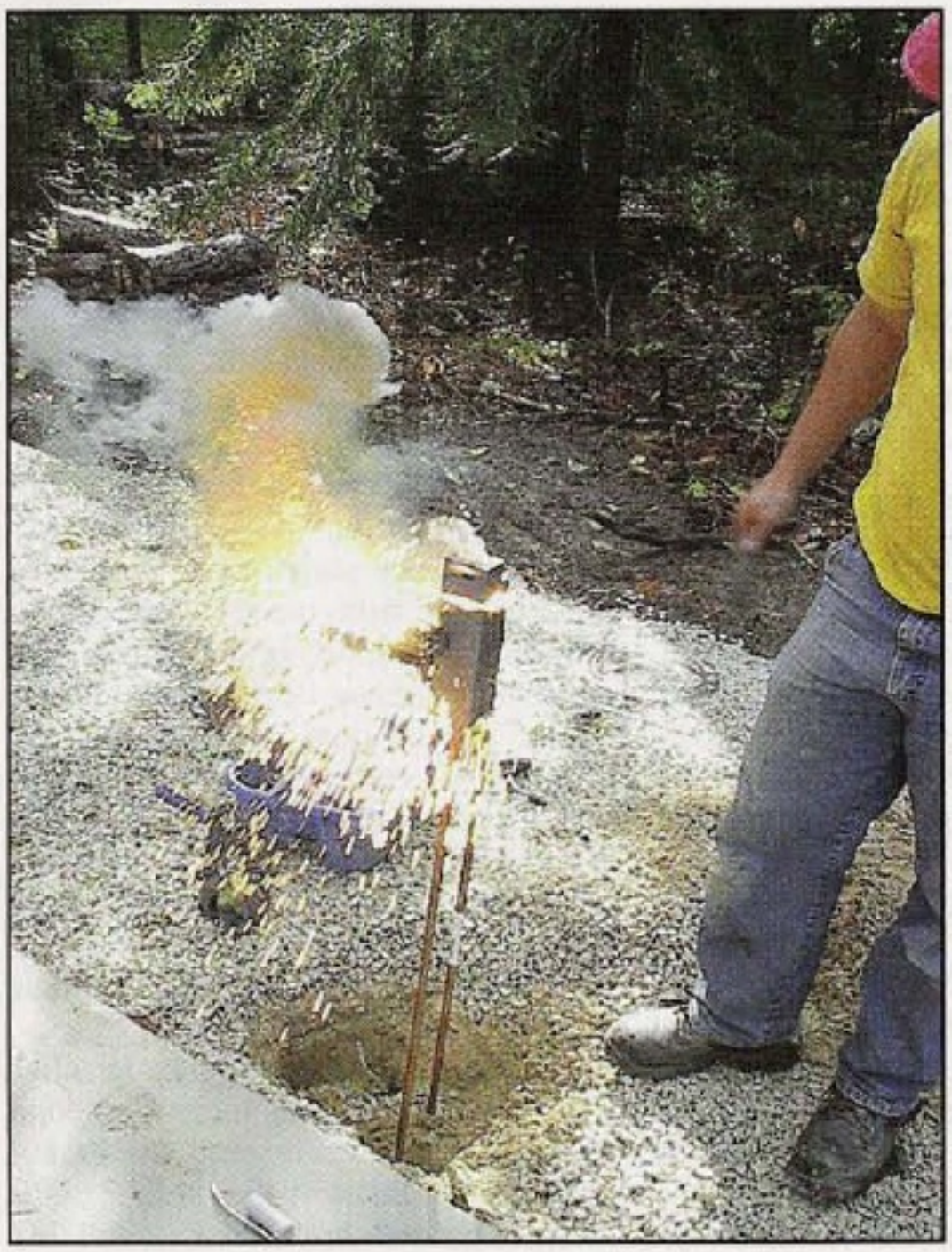
When lightning strikes the power line in your neighborhood, the power company arrestor on the pole (or underground pedestal) will divert much of the surge to ground, but there will still be a very large spike of energy entering your home. It's the job of this whole-house protector to dump much of that to ground right at the entrance panel. Then the familiar surge suppressor outlet-type

strips have a much better chance of getting the surge down to a level that won't damage your devices.

The Ties That Bond

Now let's get back to bonding your grounds together. Just hooking a light-gauge wire between the grounds is not enough. You need a low-resistance, low-inductance conductor (in this case, low inductance means having lots of surface area; see http://members.cox.net/pc-usa/station/inductance.htm for more). This is where many hobbyists throw up their hands in despair as they check out the prices of #2 stranded copper wire, or similar. Copper prices recently surpassed $4/pound, making it beyond the means of many of us. While prices have come down since, retail copper products remain fairly expensive, but a little legwork (or phone work) can pay off in a big way here.

A flat copper strap of between 2 to 6 inches wide by about .025 inch thick is the material of choice, but it can be quite steep if bought from a lightning protection company at full retail. In most cases, you can go right to your local home supply store and buy (or order) copper roof flashing for much less. An even better low-cost source could be an upscale roofer or roofing company that installs copper flashing. All will have "scraps" that can be purchased for just above scrap prices. The seamless roof gutter installation companies are another good source. They mostly use aluminum, but usually have copper available. (Note: Do make sure you watch out for the really paper-thin copper, which is nothing more than decorative. It looks and feels like copper "tin foil," and that material is much too thin for grounding. You want copper that is about .020 inch or so thick, or about the thickness of both sides of a paper matchbook cover).



A spectacular shower of sparks as the Cadweld exothermic material burns, producing the weld between a #2 copper wire and a 5/8-inch copper-clad ground rod. The black color graphite mold containing the molten weld metal is clearly seen.

Speaking of aluminum, it's usually not a good idea to use aluminum as a bonding conductor—at least outdoors and certainly not underground. Although aluminum is a great electrical conductor, there are serious corrosion problems associated with transitioning between copper and aluminum, and aluminum turns to a white powder in many soil types. Spend the extra effort to find copper.

If you have to run wire instead of flat copper strap because you were unable to obtain enough of a good wide strap, use the largest size wire you can get. Here again, old, used copper wire will work every bit as well as shiny new stuff, and outdoors or underground no one will know the difference! Check with local scrap yards for some nice heavy copper wire. Other sources include construction or wrecking companies that tear down buildings. Offer to pay more than they could get at the scrap yard for some of the heavy copper wire.

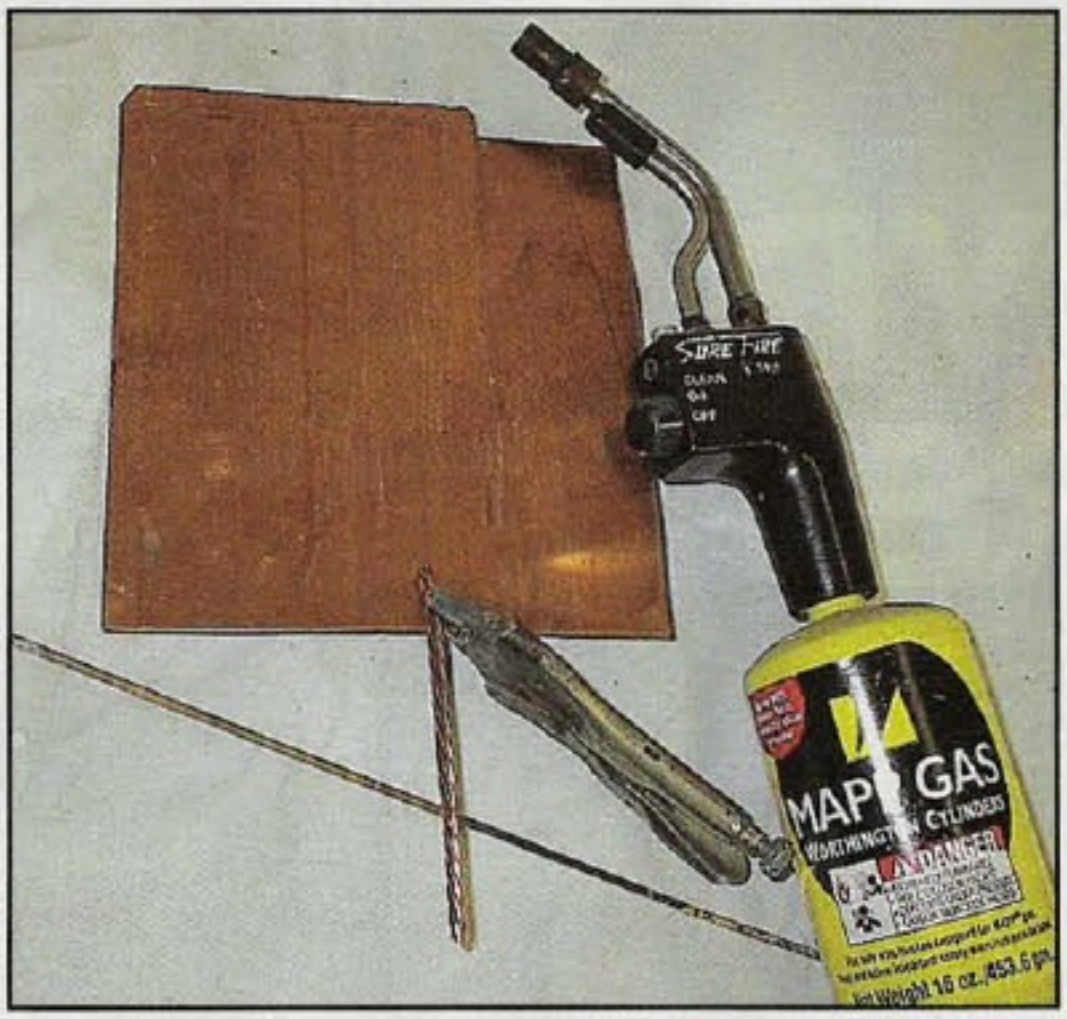
Even plain household copper wire can be used with a little planning. Common #12 or #14 gauge plastic insulated home wire can be stripped of its insulation easily with a knife. It's then an easy matter to attach a number of strands of that wire to an electric drill motor on one end and to a vise on the other and twist them into a larger size wire. Another possible low-cost conductor is flexible (soft) copper tube. A good size is 3/8 inch, and even new on sale this costs less than a dollar a foot. As an electrical conductor, tubing is almost as good as solid #2 copper wire.

It is important to keep a fairly large radius on all bends in the wire or strap (no sharp bends!). And try to keep your conductors always pointing downward—don't have them point down and then back up, then back down, etc.

Grounding Rods

Most hobbyists know that ground rods need to be driven for an effective ground system, but many don't know that those rods should be spaced about twice as far apart as their depth. For instance, you should space rods that are eight feet deep about 16 feet apart; if you space them closer, they lose effectiveness. Again, bond the rods together with copper wire or strap. Power company research has shown that #6 copper wire can handle approximately 96 percent of all direct lightning strikes without fusing open. (Research also found that it was much more economical for the power companies to just replace material damaged by those very rare "huge" lightning bolts that overwhelmed #6 wire rather than use heavier gauge wire at each power pole. Typically, only critical locations that simply cannot be allowed to fail, like tall tower sites or electric power substations, will use much larger diameter wire.) Nice, shiny new 5/8-inch heavy copper-clad steel rods sell for about $10 each in home supply stores.

Most installations should have at least six driven rods, depending on surrounding soil type. For instance, if you have wet, swampy soil you may get by with fewer ground rods than if you're on top of a sandy, dry soil hill. If deep rods can't be sunk, additional shorter rods, or a large radial wire system will work to provide a good ground. In extreme cases, where it's hard to drive in rods of any depth, a homebrewed ground enhanced rod can be made up of a section of used copper pipe that's drilled full of holes and filled with rock salt. Bury it as deep as you can, placed vertically, horizontally, or whatever.



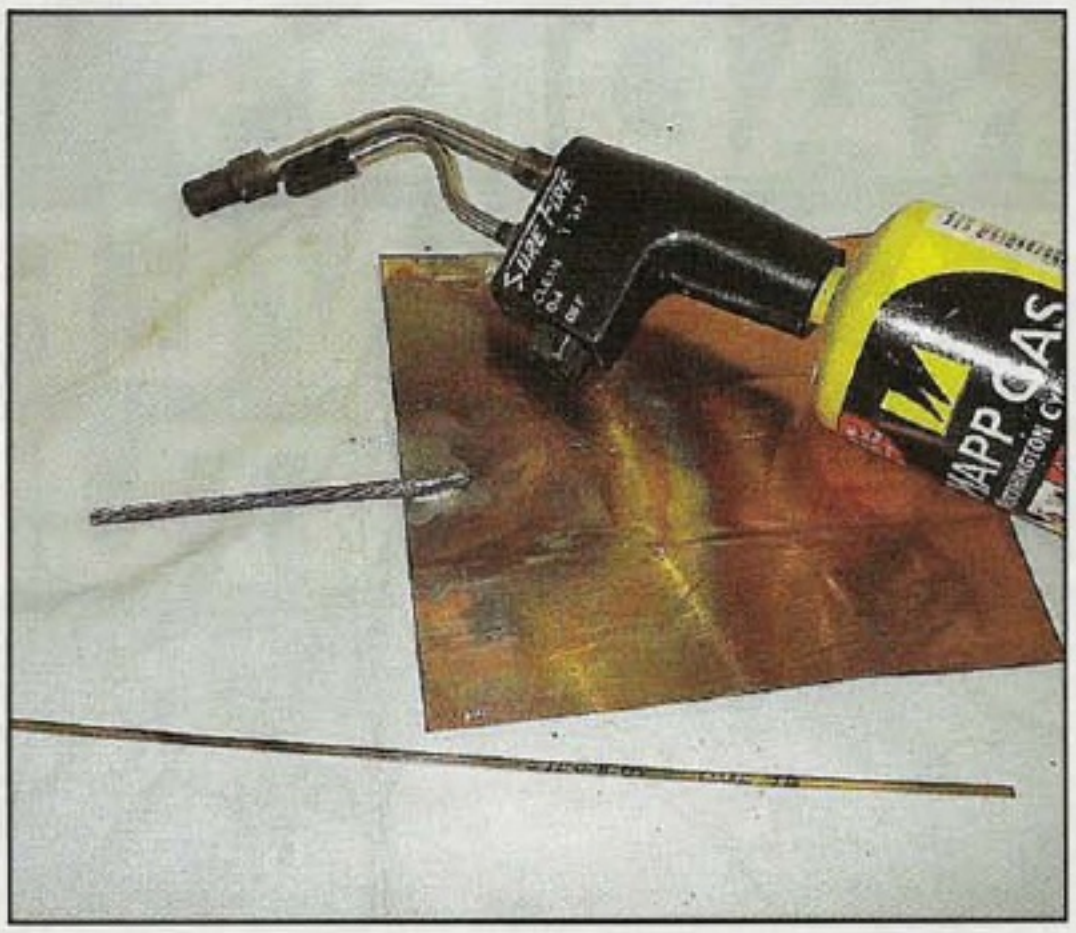
Ready to weld. A flat copper strap (scrap from a copper roof gutter installation that the author straightened out) with a stranded #6 copper ground wire. Locking-type pliers holding the wire in place, Silvaloy Excel 15 rod, and small handheld torch using MAPP gas are also shown.

A very low-cost source of high-quality ground rods can be as close as your local utility. Check with the power company or telco parts manager for used "pull out" ground rods. As these rods are just copper-clad steel, there's practically no scrap value to them. Often such old rods will be given to you, especially if you mention that you're a ham radio operator, member of ARES, REACT, or associated with any other type of emergency communications service. Yes, the rods will be bent up beyond recognition, but can be straightened between two trees. Or if they're bent too badly, cut them in half to make two good four-foot-deep rods. A bonus to using these old rods is that most of them will come complete with a commercial-quality wire clamp still attached to them, and hours soaking in some penetrating oil should make those old clamps function as good as new (and those clamps are expensive brand new!).

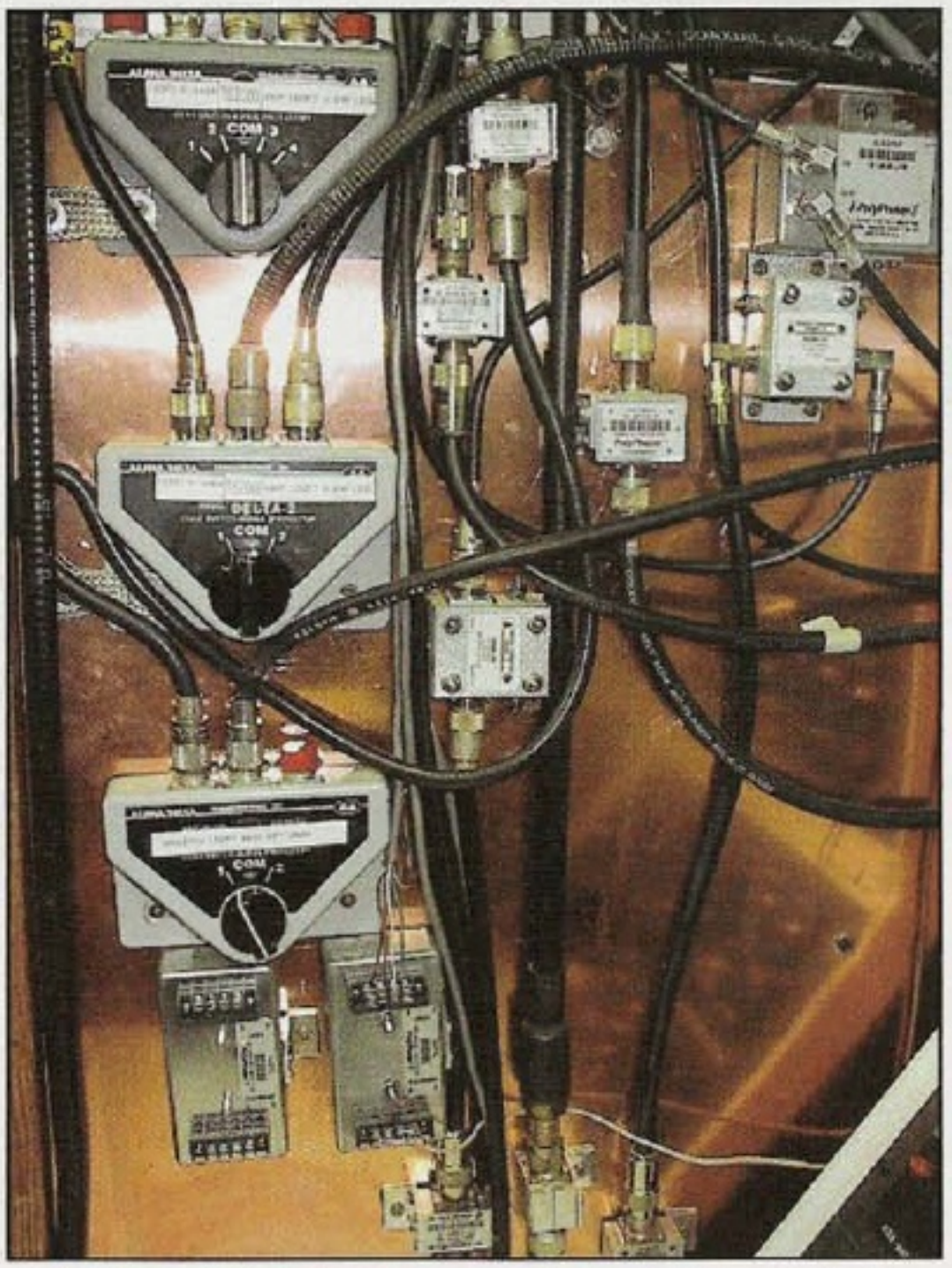
While you're talking to the person in charge of disposing of those old rods, it doesn't hurt to also ask if he can sell any used copper wire that would be suitable for grounding. Avoid the small 4 feet deep by 3/8 inch diameter "ground rods" sold in discount stores. This is not so much because of their size but because they're normally just copper plated, not heavily copper clad, and will turn to rust in a very short time.

Putting It All Together

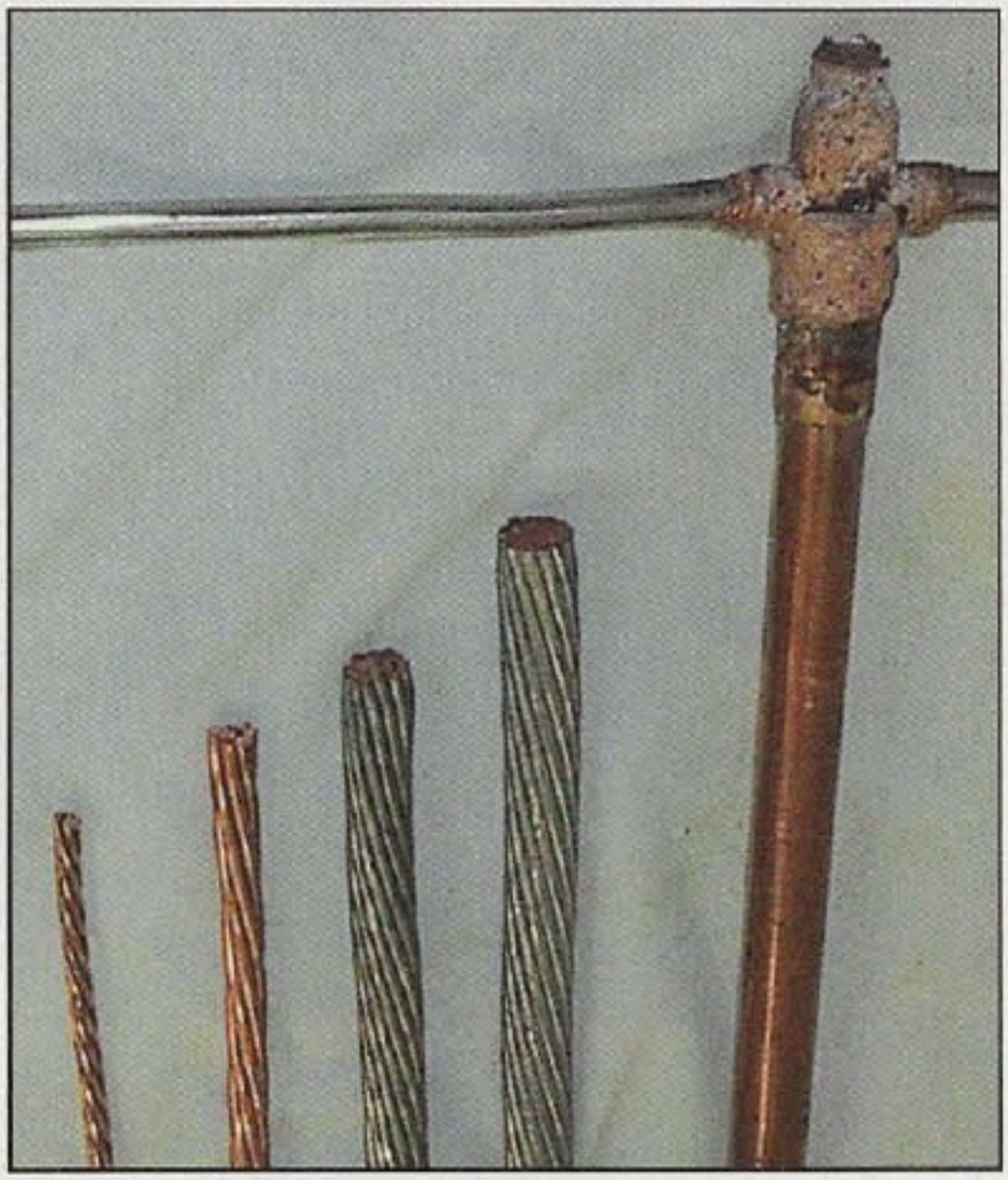
Now, how do you join all these parts together, or more properly, how do you actually join the copper strap and wire to the rods? Nowadays the "pros" mostly use exothermic welding, like Cadweld, to do the job. (Exothermic welding uses several chemicals that burn at a very high temperature to "weld" metals together.) While that type of bonding is very good, it's far from low cost. You either have to buy or have access to many molds of the various types, or buy the "one shot" weld kits, and both approaches are fairly costly. Good-quality mechanical clamps are also pretty expensive.



Completed weld. It took only a few drops of the welding rod to make a very secure weld. Note the change in color of the copper. To make the rod flow, the copper needs to be brought up to an almost red color.



This photo, taken in the author's hamshack, shows a "single point ground" panel with various coax switches that put unused antennas to ground, along with several brands of lightning arrestors. The copper sheet is "bonded" with the outdoor ground system with a 6 inch wide copper strap. The sheet is .022 inch thick copper screwed to a 3/4 inch thick plywood panel.



Close up of a completed "Cadweld" exothermic weld of a #2 solid copper wire to the top of a 5/8-inch-thick ground rod and examples of ground wire relative sizes. From left, #6 stranded copper ground wire, #2 copper wire, #2/0 wire, #1/0 wire, Cadwelded 5/8-inch ground rod.

A good low-cost approach to connecting all the elements is to obtain some of the welding "braze" rod used in the air conditioning trade, which goes by the name of Silfoss, Silvaloy, among others. These are "hard" braze rods with a silver/copper/nickel content. A small handheld propane torch will flow and weld them together under most conditions with light or fairly heavy gauge wire (the actual brazing process is very similar to plain old soft soldering; it just requires more heat to "flow" or melt the rod).

To do a good job in the real world with heavier gauge wires, you can use MAPP gas. This comes in a small container, just like propane, for a handheld torch but burns at a much higher temperature than propane and will work in flowing the weld in most cases. If you don't already own a small propane/MAPP gas handheld torch assembly, one can be purchased at a reasonable price from most home supply or hardware stores. They have many uses besides welding a ground system and would be a good investment. Or borrow one from a friend if your budget's really tight.

The hard silver solder sticks, or brazing rods, cost around $2 each, and one stick can make lots of connections. They can be purchased at most larger welding supply stores, and you can also check with your local air conditioner/refrigeration repairman. If some of your copper is really old and oxidized, a light sanding to clean it up will help the rod flow more easily. I use a small vise-grip-type pliers to hold conductors close while welding. DO NOT use any type of soft solder for these connections! This includes all types of lead/tin and the newer so-called plumbing "silver solder," which is still a very low temperature solder. Such solders will turn to a white powder underground in most soils and will blow apart if subjected to a direct lightning strike of any large magnitude.

Single Point Grounding

One of the most important concepts to remember is to have what is known as the "single point" ground, usually close to where all I/O (Input/Output) lines like coax, rotor wires, etc. enter the building. Commercial towers with a large bankroll to spend on lightning protection use a heavy copper plate, usually about 1/4 inch thick by 4 inches tall by 24 inches wide, to bolt all the lightning arrestors to. You can save lots of money and have just as effective a system by simply using some .025-inch-thick copper sheet, screwed to a piece of 3/4-inch-thick plywood.

Make this plate whatever size it takes to fit all of your coax switches (the ones that connect all unused antennas to your ground system) and attach whatever lightning arrestors you plan to use. Bond that panel to your outdoor ground system with as wide a copper strap as you can manage to get through your wall or window, and keep that interconnecting strap as short and as free from bends as possible.

Lastly, install the actual lightning arrestors themselves. Industrial Communications Engineers (I.C.E.) makes a good-quality one. Polyphaser also makes good arrestors, which are usually used at the public safety and commercial communication tower sites. I also like Alpha-Delta and similar constructed "strip line" grounding coax switches for VHF and UHF, and I use older ceramic rotary coax switches that ground unused ports for HF.

I personally run antennas that I have *no* intention of operating from during a thunderstorm to the grounding coax switch, and I run antennas that I *do* plan to use while a storm is raging overhead through a quality arrestor.

Now, Do Your Research

In well over 30 years of operation with my personal systems and also in overseeing commercial repeater tower sites with antennas at the very top of tall towers, I have NEVER had damage to radio equipment—and these antennas and towers *were* hit by direct lightning strikes numerous times, as measured by Polyphaser LSC-12 Strike counters.

While nothing in life is 100 percent certain, following the correct bonding and grounding procedures will go a long way toward protecting your station. Even if you can't follow through with all the recommendations, taking some of the steps along the proper path will reduce damage—and, more importantly, the odds of personal injury—over having nothing in place at all.

There is no cookie cutter formula for effective lightning protection. Each site and installation has enough variables to make it unique. Soil conditions, equipment layout, and other parameters combine to make all situations different. You need to do plenty of research (see some suggested resources below) before you can decide what's the best way to protect your station.

Again, this article was not intended as a definitive source on how to install an effective system, but to provide you with a good starting point on how to do a proper job on a low budget.

For additional information, I suggest visiting the following sites for starters:

ARRL: www.arrl.org/tis/info/pdf/0208053.pdf
Polyphaser: www.comm-omni.com/polyweb/appendixA1.htm
I.C.E.: www.iceradioproducts.com/
A good resource can also be found at
http://members.cox.net/pc-usa/station/ground0.htm. ■