If you can remember where you put the propane torch kit—you know, the one you got in order to do the plumbing repair jobs around the house—dig it out as N7DF presents a project that is a lot more fun than plumbing repairs.

How To Build A Copper Yagi

BY LARRY STRAIN*, N7DF/NH2

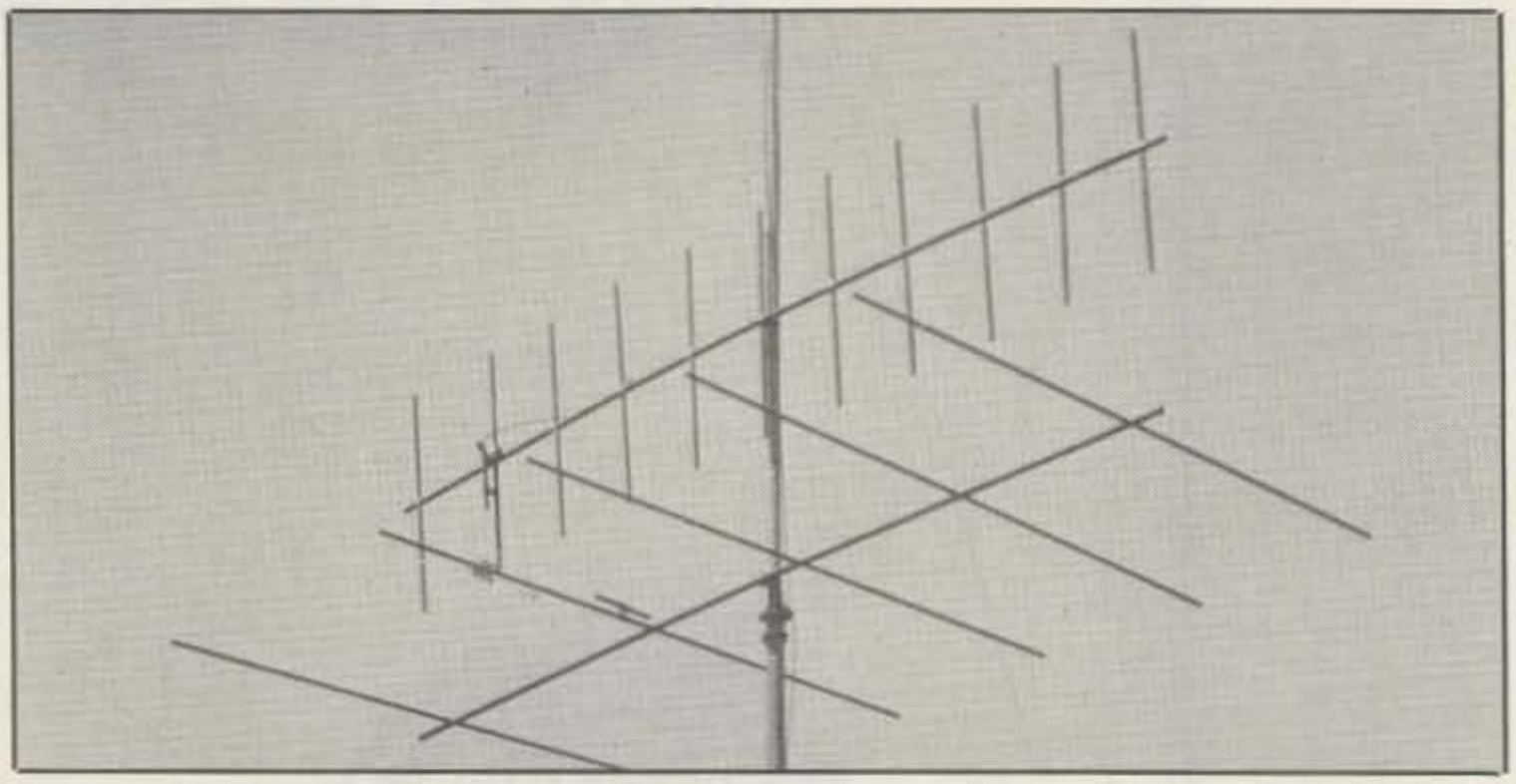
Building Yagi beams out of aluminum has become so routine that the thought of an alternative material for construction never enters one's mind.

The choice of aluminum has been based on its light weight, strength, and electrical conductivity. There are drawbacks to it, though. It is not always easy to get in small quantities in the various sizes and wall thicknesses needed for antennas. Also, it is difficult to fasten together, requiring elaborate clamping devices. Although self-protecting on exposed surfaces due to its oxidizing characteristics, it is subject to corrosion at points of contact due to electro-chemical reactions. Some of these drawbacks become very critical at VHF and UHF.

Fortunately, the size of antennas in the VHF/UHF range make weight considerations relatively unimportant. This allows the consideration of copper as a substitute building material for Yagis. Copper's advantages lie in better conductivity, ability to be soldered at joints, and ease of availability. Also, it can be surface-stabilized with common household chemicals.

Copper tubing comes in three grades: **K, L,** and **M**. These designate the wall thickness, with K having the greatest thickness. This is the type of pipe usually used for water pipes in houses. Type M is considerably thinner and lighter in weight. It is supposed to be used only in hot-water heating systems, but it is frequently used in cut-rate plumbing due to its low price. Fortunately, this has made it readily available. It is commonly referred to as "utility grade."

The common sizes of pipe available at nearly every hardware store and building-material supply house in the country are ½ and ¾ inch. Both K and M grades are usually stocked in straight lengths up to 10 feet. The diameter of copper pipe is actually the outside measurement. This makes it especially convenient for antenna construction as explained below.



Copper Yagis are not only easy to make, they look good, too!

For VHF beams at 6 meters and above, ¾ inch type K material can be used for the boom and ½ inch type M for the elements.

Construction is extremely simple. Holes for the elements are drilled through the boom with a ½ inch drill bit at the locations indicated by the antenna design. These holes must be carefully aligned to make sure that the elements are parallel. The use of a dowelling jig is the best way to assure this. These tools can be bought at most hardware stores or building material suppliers as well as through many mail-order sources.

Another way to get the holes straight is to clamp the pipe to a wooden 1 × 2 with hose clamps and drill it with a drill press or a hand drill, with the drill bit carefully aligned to the vertical (see fig. 1).

Since the pipe is normally sold in 10 foot lengths, a 5-element 6 meter beam or a 10-element 2 meter beam can be constructed with a single pipe for the boom. Using solder-on fittings will permit the extension of the boom, but much more than 3 or 4 feet on each end is not recommended because the copper will bend rather easily if you make the boom too long.

Elements can be cut to full length from ½ inch type M material (selected for its lightness). The center of each element must be marked and then a shallow groove filed ⅜ inch to either side of the center. These are required for centering the elements when they are inserted into the boom. Also, the grooves will remain visible after polishing the pipes before soldering.

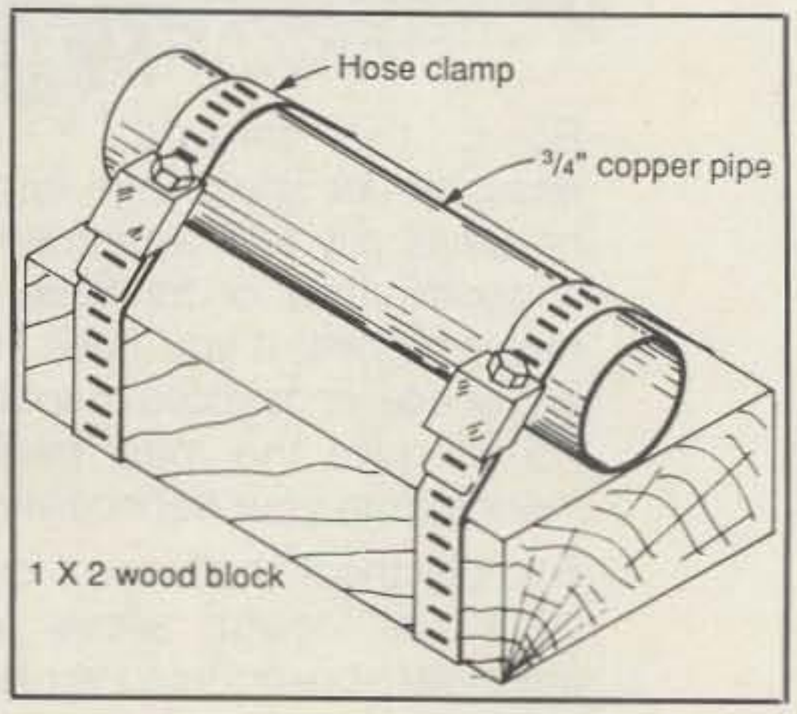
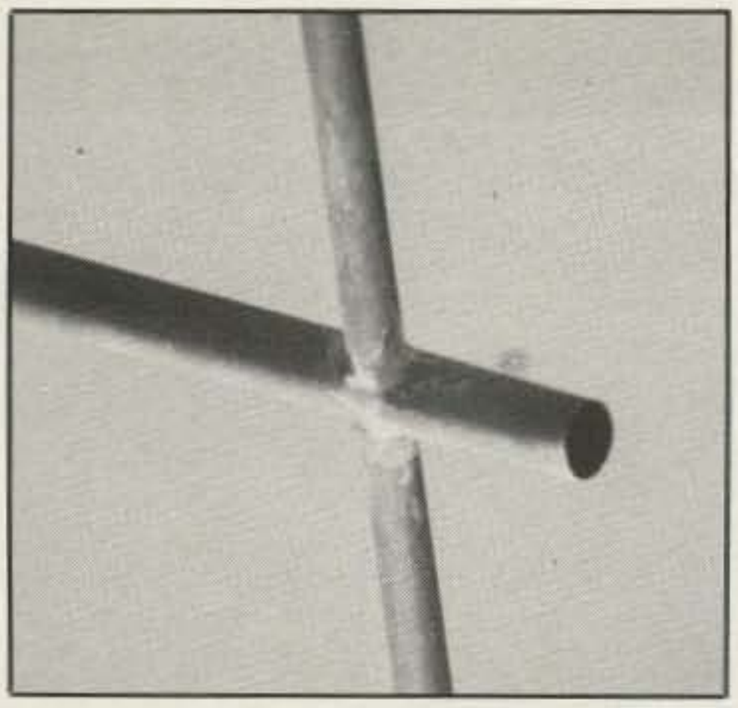


Fig. 1– The boom can be clamped to a wooden 1 × 2 to hold it for precise drilling.

*Box 25399, GMF, Guam 96921



The soldered element-to-boom connection is both mechanically and electrically better than a clamped aluminum joint.

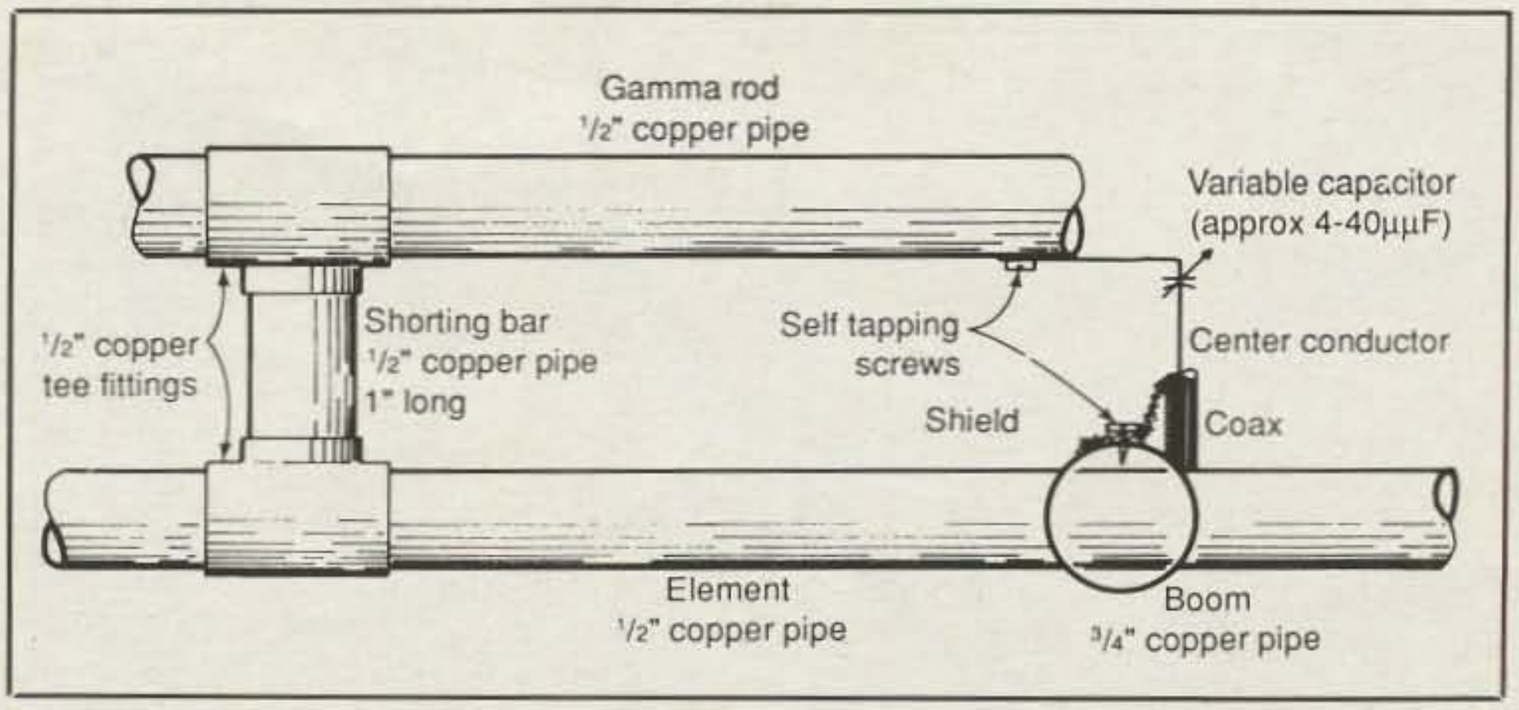


Fig. 3– The gamma match is assembled from copper TEE fittings and a short length of ½ inch pipe.

Each point on the boom where an element is to be inserted needs to be cleaned with a wire brush and/or steel wool until it is bright and shiny. This should extend for about 1 inch either side of the hole for the element. Likewise, the center of each element must be brushed clean for about an inch either side of the centerline.

With the boom lying on a hard, flat surface, insert and center each element. Slight filing or reaming of the holes in the boom may be necessary to get the element to slide through, but the fit should be as tight as possible.

Despite what your plumber wants you to believe, soldering copper pipe is quite easy. The only tool you need is a propane torch.

Non-acidic soldering paste or flux is used on copper pipe to prevent oxidation of the surface when it is heated. All of the polished area of the boom and the elements needs to be coated. Only the upper sides will be fluxed and soldered in the first step, and then the antenna will have to be turned over to get the other side. It will be necessary to rebrush the shiny places before fluxing, since the heat from soldering the top will have oxidized the metal slightly as will be evident from the change in color.

Common plumber's solder is quite good enough for this soldering. The electrical contacts of the joints are far better with this method than could ever be achieved with aluminum, so expensive silver solder is a waste of money for this purpose.

Soldering itself is accomplished as follows. Begin by heating the boom on either side of the element. Direct the flame as shown in fig. 2. Alternate between points A and B, slowly moving the flame towards the center for six or eight passes. This will require about one minute. Do the same for the element and then direct the flame to the boom over the joint and apply solder to the element where it enters the boom. If the solder does not immediately melt and flow into the joint, repeat the pre-heating step until it does. Be sparing with the solder. Use only enough to fill in the area between the boom hole and the element as needed.

Once both sides of the joint have been soldered, remove the heat and immediately wipe the joint with a clean, wet cotton cloth. Do not use anything but 100% cotton, as synthetics will melt and stick to the solder. This step should leave a nearly mirror-like finish on the solder. The solder will remain molten for a minute or more, so be careful not to move the antenna until it has fully hardened.

Continue soldering the elements until they have all been soldered on the top side. Then turn the entire antenna over and repeat the process on the other side. If after cooling there are cracks in the solder or it is not smooth, simply reheat and add more solder or wipe off the excess, as needed.

Probably some of the element will not line up perfectly. This can be corrected by gently twisting the offending elements

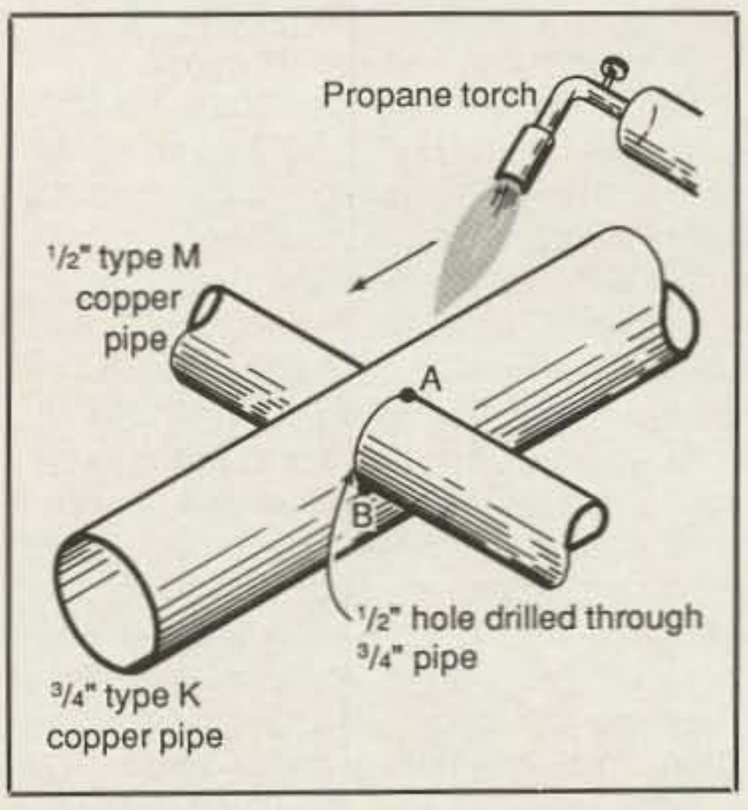
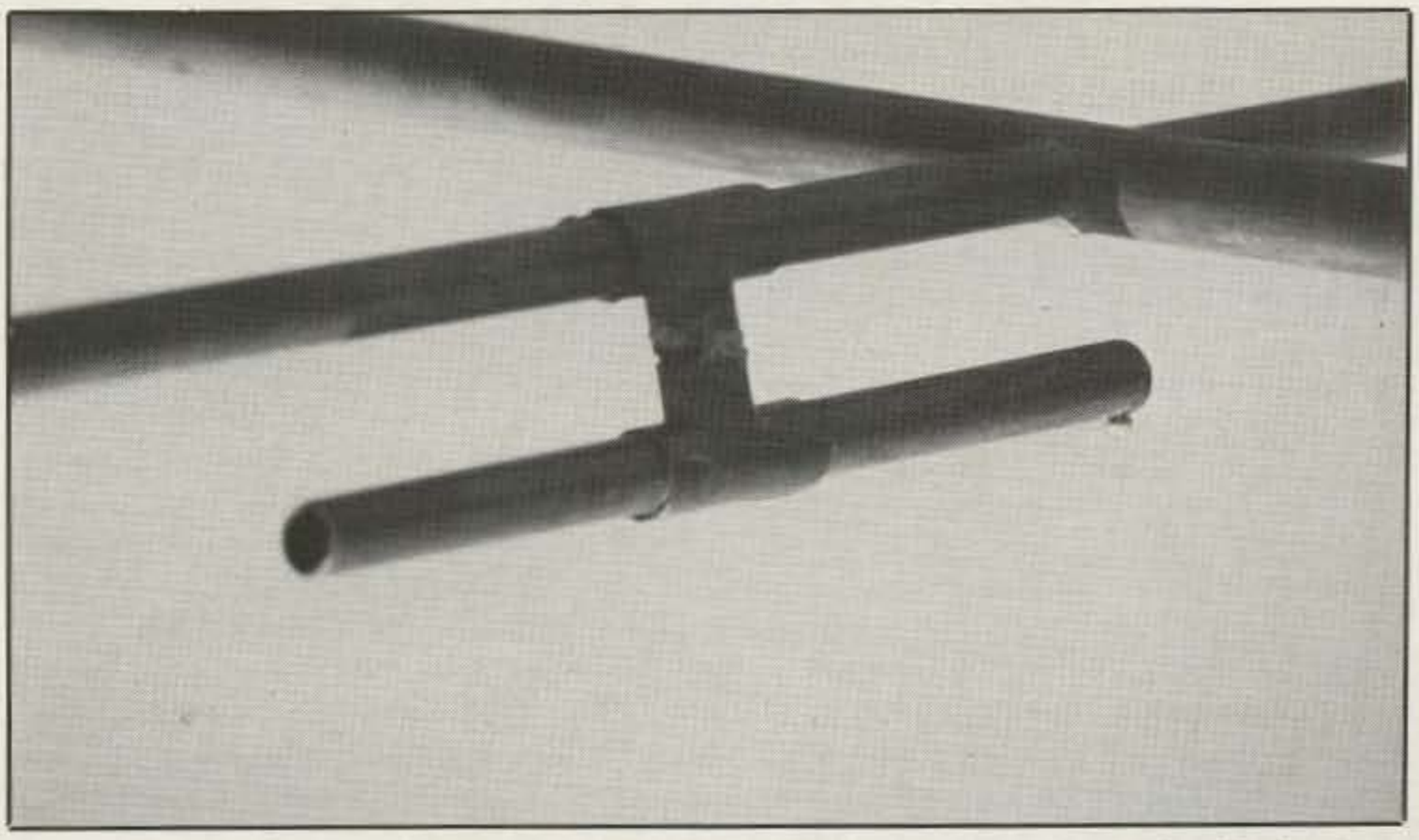
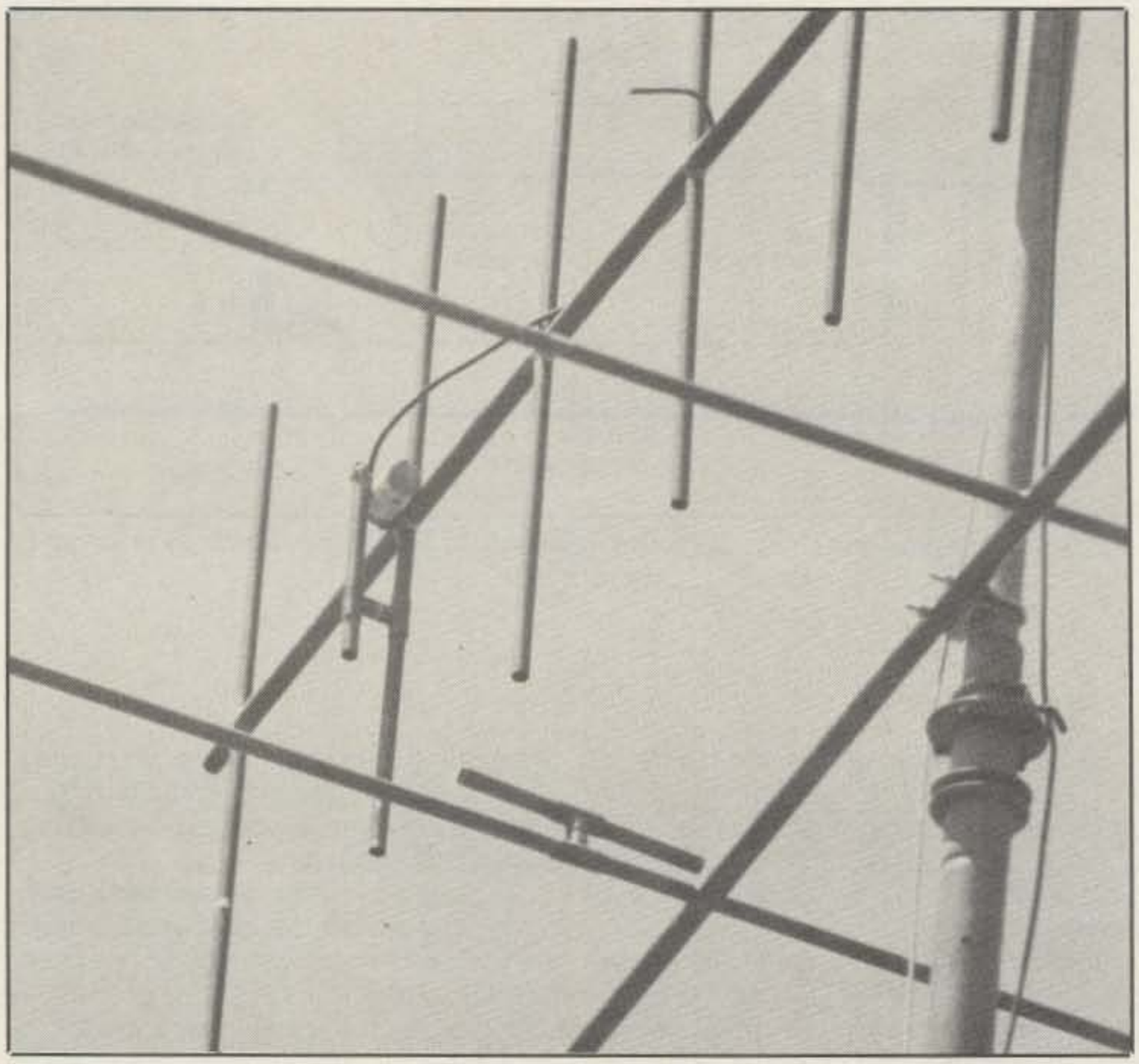


Fig. 2– Apply the heat to the boom and the element, moving it toward the joint from about 1 inch to either side.



The gamma match assembly is made with ½ inch fittings and soldered after final tuning.



A plastic pill bottle makes a convenient cover for the gamma-match capacitor.

around the boom until they are all nice and straight.

A gamma-match is the easiest match to use for this type of antenna, since it permits all joints to be fully conductive. Construction details are shown in fig. 3.

The two ½ inch copper "TEE" fittings are connected to each other by a short piece of ½ inch tubing. The TEEs must be split along their long side, and if there is an internal ridge molded into the fitting, it must be filed out. The modified fittings should be able to slide easily over the ½ inch driven element for tuning of the gamma match.

By adjusting the series capacitor and the shorting bar while monitoring the SWR, a match to either 50 or 72 ohm coax can easily be accomplished.

Once the proper location for the shorting bar has been determined, it can be soldered in place using a procedure similar to that used for the elements.

The lead from the gamma match capacitor should be soldered fast to the resonator bar, while the shield of the coax needs to be bonded to the boom at a point directly over the center of the element. A good contact can be made by fastening the conductors down with small self-tapping metal screws prior to soldering. Make sure the screw heads are fully encased in the solder to prevent corrosion.

At VHF, the capacitors are small enough to be comfortably housed in plastic pill bottles, which can be sealed shut with glue after final adjustments are made.

The boom can be mounted to the mast with a common TV antenna boom-to-mast bracket.

The final step is to chemically stabilize the surface of the copper boom and elements.

Wash the copper thoroughly with a "cloudy ammonia" solution (available in most supermarkets in the household cleaner section). The metal should turn a bright green except where it is covered by solder. Any places that remain brown should be wire brushed until bright and then washed with ammonia again.

Once the surface has dried, wash it again with petroleum distillate paint thinner. The metal should turn a dark bronze color. The antenna is now almost totally impervious to all environmental factors.

For UHF antennas the ½ inch pipe is obviously too large. There are smaller diameter rigid tubing sizes available on special order or you can straighten out rolled tubing. Large-diameter copper wire, brazing rods, and various other alternatives can be found. One possibility includes cutting the elements out of copper-clad printed circuit board, screwing them to the boom, and then soldering them. The possibilities are endless.

With the really bargain-basement prices that can be found on copper tubing, the total cost of building a 10-element 2 meter copper Yagi is less than $20! CQ