By Al Alvareztorres, AA1DO

Two on 10

Hankerin' for more performance on 10 meters? Wanna greet the upcoming sunspot peak with gusto? This home-brew two-element beam is the perfect introduction to rolling your own gain antenna.

Living in a condo has many advantages, none of which is being able to mount a tribander on a 60-foot tower. So I make do with a long, thin random wire that works nicely as long as the New England wind, snow and ice don't conspire to give my hamming a holiday (which happens more often than I'd like). And although it's somewhat directional on the higher bands, I haven't figured out how to rotate 200 feet of wire without the neighbors becoming suspicious. One answer is to operate mobile. A bumper-mounted vertical is fine for casual operation, but it leaves a lot to be desired when mountaintopping for rare DX. With the solar maximum just around the corner, I decided that a portable 10-meter beam was necessary.

The beam had to fit in the trunk of my Subaru (limiting the largest component to about four feet in length) and had to be easy to assemble and erect on site by one person. In this article I'll describe the antenna and provide some construction tips that may help you avoid some pitfalls if you take on this worthwhile project.

The Boom

From past experience I know that TV masts make good booms for smaller antennas. They're lightweight, strong and readily available at most RadioShack and home stores. The light-duty stuff is plenty strong and comes in five-foot lengths. That was my starting point.

At 28.4 MHz, for an antenna made of tubing and not supported at the ends, a half wavelength is 491.8 divided by 28.4 MHz, or 17.3 feet. To accommodate my "Subaru factor," four feet divided by 17.3 feet produces a boom length of 0.116 wavelength, a size that gives a nice gain and a feed-point impedance that can be easily matched to your coax line.

The TV mast (with the crimped end lopped off) fits in my trunk and allows two elements to be mounted 4 feet apart and fed with RG-58 coax. So far so good. I would be building a two-element beam.

Now, how to mount the elements to the boom and the boom to the mast (another 5-foot TV mast section)? In the past I had used a U-bolt and clamp arrangement, but this technique requires care in keeping the elements parallel to each other and to the ground. This is fine for permanent installations, but not something to be bothered with while operating portable.

I decided on right-angle pieces permanently mounted to the boom (see Figure 1). I used 1/2-inch 1 × 2 aluminum angle scrap because it "looked about right." Your local hardware store has aluminum angle in various dimensions and lengths. I cut six, 3-inch pieces of angle to make the U-bolt mounting brackets—two to hold each element and two to hold the mast.

Drilling the two holes in the angle's smaller dimension—the part that attaches them to the boom—isn't critical as long as you drill the holes on the boom the same distance apart. The angles will be permanently mounted to the boom using 2-inch bolts, nuts and lock washers. When you mount them, be careful not to crush the tubing. It's not terribly strong, but it *is* lightweight. We're going for portability here!

The holes in the larger dimensions should be tailored to allow the mounting of the 1 1/4-inch U-bolts for the elements and the 1 3/4-inch U-bolts for the mast. Because the element mounts must be as parallel as possible and the boom mount must be at right angles to them for maximum efficiency (and so your antenna doesn't look like it's under the influence), make the boom holes with a drill press if possible.

Now for the Elements

Most beam antennas are made with aluminum tubing because it's strong, lightweight and available in sizes that "telescope" into each other. The telescoping feature is important. It helps in transportation and makes tuning the antenna a snap.

The beam's driven element should be 17.3 feet. The length of a reflector for a two-element Yagi with 0.116-wavelength element spacing should be 18 feet 1/2-inches.

I needed 35 feet of tubing (plus some to fit inside each telescoping joint for support). Because the tubing comes in 8-foot lengths, this worked out to five lengths of assorted sizes. The three telescoping sizes available at my local hardware store were 1 inch, 7/8 inch and 3/4 inch—perfect! Because the 1-inch section was going to be the center part of the two elements, I picked up U-bolts and nuts while I was there. You'll also need eight hose clamps sized to fit your tubing.

This is how the material was cut up. One 1-inch tube was cut in half, yielding two four-foot lengths. The two 7/8-inch tubes

Figure 1—Two pieces of angle aluminum are attached to the boom with two nuts, bolts and lock washers. Your drilling must be accurate, so use a drill press if possible. In addition to drilling the boom holes, you'll need to drill four holes in each angle piece: two for accepting the boom-mounting nuts and two for the U bolts that will hold the element.

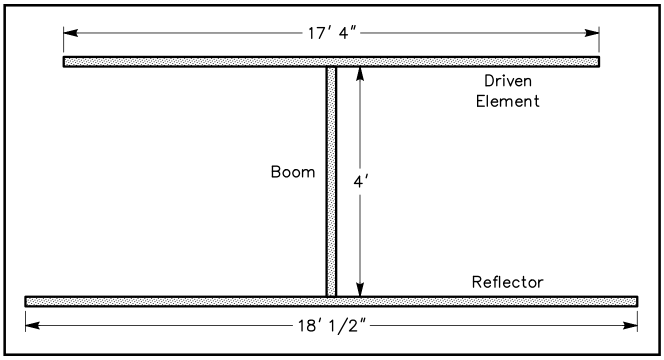


Figure 2—Dimensions and mounting configurations for the boom, driven element and reflector element.

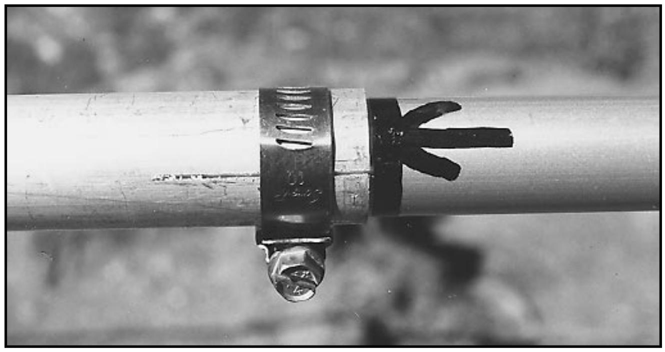


Figure 3—Use hose clamps to compress the slotted ends of the telescoping elements and keep everything in place. Marking the exact positions of the sliding tubes makes it much easier to assemble the antenna in the field.

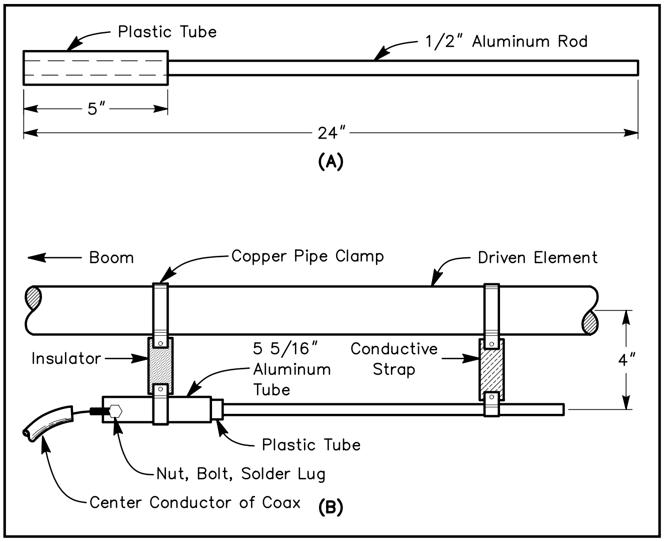


Figure 4—Making your own gamma match is easier than you think. Construct the variable capacitor element by sliding a 5-inch piece of $^{1}/_{2}$-inch diameter plastic tubing over a 24-inch piece of $^{1}/_{2}$-inch diameter aluminum rod (A). Then, slide the plastic-sleeved end of the rod into a $5^{5}/_{16}$-inch long, $^{3}/_{4}$-inch diameter aluminum tube and attach the entire assembly to the driven element (near the boom) using one plastic insulator and one conductive strap as shown (B). Note that the assembly must be separated from the driven element by 4 inches, center-to-center.

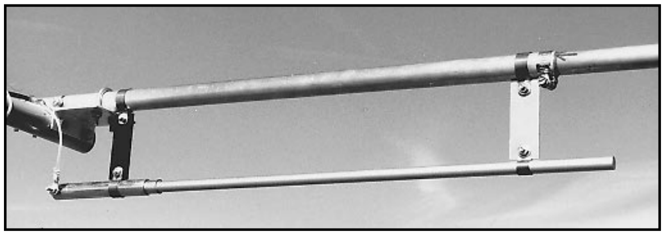


Figure 5—The finished gamma match mounted and ready for action.

were cut in half to yield four four-foot lengths. One $^{3}/_{4}$-inch tube was cut in half to yield two four-foot lengths. From the remaining $^{3}/_{4}$-inch tube I cut off an 8-inch piece (for later use in the gamma match) and cut the remaining length in half to yield two lengths a little over 3.5 feet each. I then took the 1-inch tube and cut a slot in each end to a length of about $1^{1}/_{2}$ inches. Pushing the tube endwise into a band saw makes a really nice double-slot arrangement. I did the same at one end of each $^{7}/_{8}$-inch tube. When the elements are assembled, hose clamps will pinch the slots closed and keep the element sections in place (see Figure 3).

Slappin' Together Time

In the garage I erected a 3-foot tripod. I then cut a small piece off the un-swaged end of the second five-foot TV mast (so it would fit in the trunk) and installed it into the tripod. I mounted the boom on the mast with **U**-bolts and clamps and attached the two 1-inch tube sections to each end of the boom with **U**-bolts and centered them for balance. I then slid the unslotted ends of the four $^{7}/_{8}$-inch tubes into the ends of the 1-inch tubes, holding them in place with hose clamps. I inserted unslotted ends of the four remaining tube sections in place (using the two shorter $^{3}/_{4}$-inch tubes on the driven element). You won't believe how big a 10-meter beam seems when it's inside a garage!

Some Last Element Details

I drilled a hole at the center of the driven element and installed a bolt to attach the shield of the coax. I drew a ring around both 1-inch tubes with permanent markers to show the exact center for easy assembly. I used black when marking the driven element and red on the reflector. That way, in the field I wouldn't have to stop to figure out what was what (that's also why I cut slots into only one end of some of the element sections).

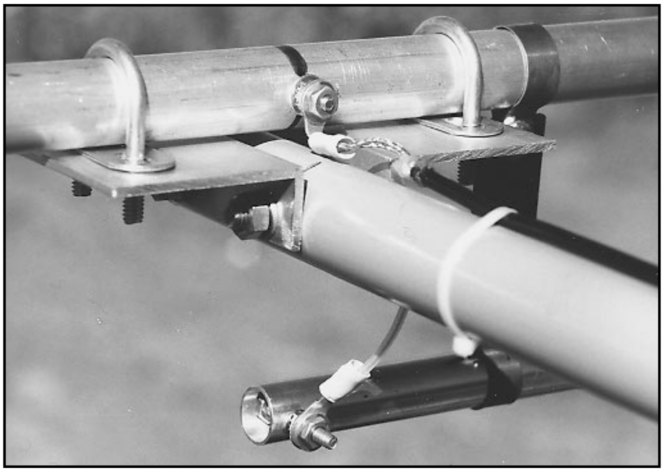
Feeding the Antenna

As you may have noticed, this antenna uses "plumber's delight" construction. The driven element isn't split into two legs like a conventional dipole. In this case, the driven element is one piece, and everything is shorted to the boom, to the mast and to ground. To top it off, the whole mess is fed with unbalanced coax. So, how does it work? Like magic! And the magic words are *gamma match*. There are actually several ways to feed a plumber's delight antenna, but the gamma match is probably the simplest.

How a gamma match works is beyond the scope of this article. In short, the braid of the coax is connected to the center of the driven element (since this is where the voltage null occurs in a half-wave conductor). The center conductor of the coax is connected to the same driven element through a capacitor some distance away from the center. In the old days we used tuning capacitors from discarded AM radios. Tuning caps are as scarce as hen's teeth nowadays, so I decided to try a technique I'd come across in the 1974 *ARRL Antenna Book*—incorporating the capacitor into the structure of the gamma match.

Building the Gamma Match

I took the 8-inch piece of $^{3}/_{4}$-inch tubing that I had set aside before and cut it to $5^{5}/_{16}$ inches. I cut a piece of $^{5}/_{8}$-inch plastic



The shield braid of your coaxial cable attaches to the driven element using a nut, bolt and solder lug. The center conductor, however, must attach to the end of the gamma match capacitor, as shown here.

Bill of Materials

(2) 5-foot light-duty TV mast
(1) 1-inch x 8-foot aluminum tube
(2) $^{7}/_{8}$-inch x 8-foot aluminum tube
(2) $^{3}/_{4}$-inch x 8-foot aluminum tube
(1) $^{1}/_{2}$-inch x 4-foot aluminum rod
(1) 1-foot section of clear vinyl tubing
(1) 2-foot aluminum angle
(2) $1^{3}/_{4}$-inch U-bolts
(4) $1^{1}/_{4}$-inch U-bolts
(8) Hose clamps to fit on 1-inch tubing
(6) 2-inch bolts & hardware
(2) $1^{1}/_{2}$-inch bolts & hardware
(4) $^{1}/_{2}$-inch bolts & hardware
(1) 3-foot tripod
(3) 1-foot metal tent pegs

tubing to a length of 5 inches and cut a $^{1}/_{2}$-inch aluminum rod (tubing will work) to 24 inches. Sliding the plastic tubing onto the $^{1}/_{2}$-inch rod until their ends were flush, I now slid this assembly into the $5^{5}/_{16}$-inch tube until $^{1}/_{2}$ inch of the plastic tube was left exposed (see Figures 4 and 5). I now had a capacitor!

I drilled a hole near the end of the $5^{5}/_{16}$-inch tube and installed a small bolt for the center conductor of the coax. This assembly was mounted to the driven element so that the larger end (the one with the bolt) was directly under the center of the element and the two tubes were four inches apart center-to-center.

The gamma match is held on by an insulated strap at the end closer to the center of the driven element and by a conductive aluminum strap at the other end. The locations of the straps aren't critical at this point. The straps themselves can be made of any sturdy insulating and conducting materials. I used flat plastic stock and flat aluminum stock (1 inch by $^{1}/_{16}$ inch worked fine) held in place by copper clamps (designed to hold copper pipes to a wall). These clamps come in all sizes, are easily bent to the proper size, already have holes in them for attaching to the straps and are inexpensive. Mechanically, everything looked good! But would it work?

Tuning the Antenna

I was fortunate that it was a beautiful summer day and that I had my wife, Donna, AA1DQ, to help me. I disassembled the monster in the garage and reassembled it on the lawn. Everything went together nicely in about 15 minutes. I attached the braid of the coax to the driven element and the center conductor to the gamma match. The fact that it was only four feet off the ground would have little effect on the tuning, although the overall performance would be affected by the high angle of radiation. Leaving the hose clamps over the element slots loose, I adjusted the driven element length to about 17 feet and the reflector to about 18 feet $^{1}/_{2}$ inch.

I would make the adjustments while Donna, visible through the shack window, keyed the transmitter and recorded the SWR readings. It goes without saying that visual (or some other positive) contact is imperative for safety. She could see that I was clear of the antenna before keying the transmitter.

I find that it's best to keep a written record when tuning an antenna (even if it's only a dipole) so that I know where I am and which way I'm going. I make a chart with frequency on the Y axis and antenna length on the X axis. I then enter the lowest SWR point (resonance) at the appropriate X-Y position. As I change the length I can easily see what's happening.

If you find that the SWR at your chosen frequency is unacceptable, begin adjusting the gamma match by sliding the center bar in or out. If you can't achieve a match, slide the entire matching section toward or away from the center of the driven element. As a last resort, adjust the driven element length. This will also have an effect. Remember to keep records. Otherwise you may get your adjustments all out of whack and won't know where you are. When you're done, tighten the hardware on the gamma match, as it will not be moved again.

I was lucky. After only a few adjustments I obtained a 1:1 match at any chosen frequency (28.0 to 28.5 MHz). A match of 1.3:1 was attainable beyond these frequencies (up to 28.6 MHz). Your mileage may vary.

I was overjoyed. The beam showed very good side rejection and a respectable front-to-back ratio. I marked the element sections at their contact points with a ring using the same permanent markers. When erecting the system I could simply slide the sections to the rings and tighten the hose clamps. There was nothing left to do but try it out on Beseck Mountain. Along the way I got some foot-long metal tent pegs to hold the tripod steady.

The Verdict

The antenna has been used several times mountaintopping and contesting. It performs well and can be erected by one person in about 15 minutes. It was well worth the effort. I have since gotten another section of mast and, with two people, it can easily be put up at 10 feet.

I haven't experimented with the reflector length yet to see the effect on the gain and the front-to-back ratio. As they say, "If it ain't broke, don't fix it!"

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