GAIN ANTENNA

for VHF/UHF REPEATERS

... Quadruples your repeater output power and will bring in solid those marginal mobiles in the fringe areas.

Ken W. Sessions, Jr. K6MVH

Probably the most popular antenna in the amateur repeater world is the omnidirectional collinear coaxial stack, although it is seldom called by that name. Versions of this antenna are manufactured by such companies as Prodelin, Phelps Dodge (Communications Products), and several other firms that build antennas specifically for the commercial bands.

Two of the reasons the collinear antenna is so popular are that it can be made to exhibit a great deal of omnidirectional gain at a very low angle of radiation and it takes up very little space. In its manufactured form, it resembles a long fishing pole with a pair of crossed fins at the base.

In spite of the fact that a great deal of painstaking effort is required to make the antenna and get it just right, the operation is surprisingly simple. And what makes it even more attractive to the amateur, it is remarkably inexpensive. About all you need is a good-sized hunk of 50Ω foam-dielectric coaxial cable and some polyvinyl-chloride (PVC) pipe. For 2 meters, the pipe should be between 20 and 21 ft in length; for 450 MHz, an 8 ft length will do fine. The total omnidirectional gain (as compared with a reference dipole) will be 6 dB (actually 5.8 dB, but who's counting?).

Building the Antenna

Ignoring the structural aspects, the antenna itself is nothing more than a series of precise lengths of coaxial cable soldered in an alternate phase-reversal configuration as shown in Fig. 1. A quarter-wave whip at the antenna's tip shorts the inner and outer conductors of the coax and becomes the terminal radiating element. At the lower end of the antenna, the last coax section

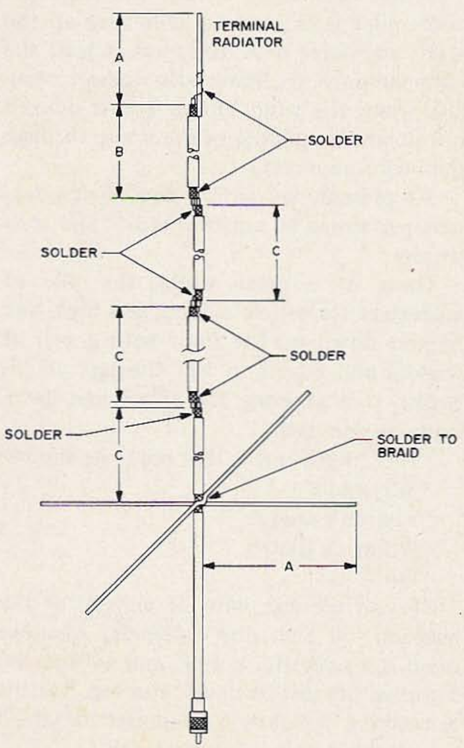

Fig. 1. The collinear gain antenna is made up of coaxial sections connected in a phase-reversal configuration. The bottom section (from the radials to the first joint) and the upper section (which joins the antenna to the shorted radiator) are half the size of all other sections.

actually becomes the feedline itself, whose length, incidentally, is not critical as long as the dimensions are followed with religious fanaticism.

A number of amateurs have managed to build antennas of this type, and diagrams have never been scarce. But few have handled the project successfully. Getting the antenna together is no big deal. The problems start to happen when it's time to turn the soldered-together pieces of coax into a structurally sound antenna. Applying wet epoxy, as in a fiber-glassing scheme, doesn't work out. I have yet to determine whether the problems are attributable to some chemical interaction between the wet epoxy and the coax dielectric (changing the dielectric constant of the line) or because the hardened epoxy doesn't allow any flexing of the coax braid. In any event, sealing the antenna with

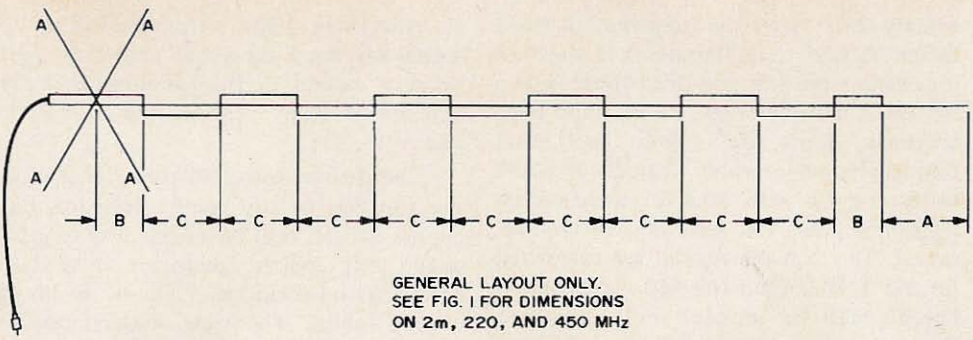

Fig. 2. Layout and dimensions of collinear gain antenna. The 2 meter dimensions are for a frequency of 147 MHz; the 450 MHz dimensions are for 442 MHz exactly. The 220 dimensions are for 220.5, just half the 450 frequency. The antenna is broadbanded enough to yield a low vswr on any frequency within a megahertz of that shown.

epoxy is ultrabad news. When the antenna is rigid and looks great, you'll measure a very disappointingly high standing wave ratio and you'll discover with much lament that your old groundplane worked better.

The commercial antenna people use fiber glass, but they do not use it to seal the antenna. Instead, they use an inert and flexible sealer, then encase the whole business within a preformed fiber-glass tubular envelope. At least one of the commercial suppliers uses beeswax as the inert sealer. Actually, there is no real need to immobilize the antenna once it has been placed inside the PVC pipe. The most important point in the construction process is to make the thing water-tight. Water drops inside a hunk of coax do bad things to antennas and feedlines; and once the water gets inside, you're better off changing antennas than trying to ignore the problems.

The dimensional details of the antenna are shown in Fig. 2. Lengths have been calculated in the decimal system to the nearest hundredth of an inch. Of course, you'll not be able to maintain this accuracy, but the system did simplify the computations. The 2 meter figures are based on an operating frequency of 147 MHz. The antenna is broadbanded enough to give an swr of close to unity regardless of the FM channel of operation. The 450 MHz frequency of operation is 441 MHz,

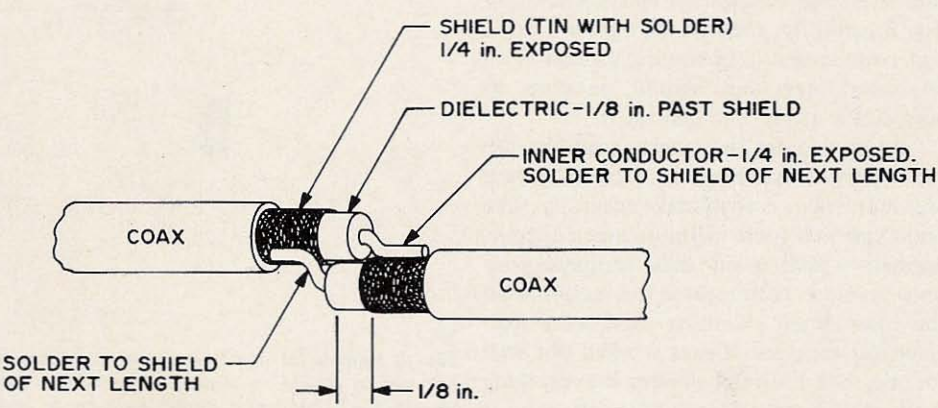

Fig. 3. The coaxial lengths should be soldered as shown. Keep the braid trimmed evenly all the way around and make sure the braid from one section doesn't make contact with the braid of the next section. If conductors are well tinned, problems will be minimized. Coax lengths are measured individually from braid end to braid end.

exactly three times the frequency of the 2 meter version. You'll note that the 450 dimensions are just one-third those shown for the 2 meter version. If you build both antennas, don't select those two exact frequencies for repeater channels or you'll likely end up with your 2 meter system triggering your 450 receiver – it *has* happened. The 220 dimensions are calculated for 220.5 MHz (half the 450 frequency). I haven't built the antenna for 220 because I've never had the occasion to use that band except when getting into W6ZJU's private repeater. But if 450 continues its trend of increasing population, there should be a general turning to 220 MHz for repeater control in the not-too-distant offing.

To begin construction, cut eight lengths of coax from the reel. Each piece should be cut about an inch oversize, then trimmed down later so that all pieces are of exactly the same length. The dimensions given are end-of-braid to end-of-braid for any given length. (See closeup detail in Fig. 3.) The braid-to-braid distance should be approximately the same as the distance between the inner and the outer conductor of the coax you're using, or approximately 1/8 in. This dimension is the only one that does not change with operating frequency or band.

When all the lengths have been cut and trimmed to the precise lengths, and you are sure they will fit together as shown, study Fig. 3 carefully, then tin all exposed braid and conductors. This tinning process is an important step and should be done as completely as you can manage it.

As you solder the lengths together, use care to avoid handling the soldered pieces any more than is absolutely necessary. The braid can pull loose without much encouragement – and when that happens your only recourse is to replace the section with the loose braid. Winding each joint with electrical tape has always worked out well for me, but I always wonder if everything is okay under that tape. Once the tape is applied, you'll just have to guess about the condition of the hidden joint. The best approach would probably be to make all joints first, then inspect the whole antenna. If everything looks shipshape, then go ahead and wrap the joints with tape. Just be very careful in the handling until the antenna is safely stuffed into its plastic pipe.

The quarter-wave radiator that goes at the top can be any good conductor, but copper is best. And the easiest way to get a good, stiff copper conductor is to buy some narrow-diameter (1/8 in. is ideal) copper tubing. The same material can be used for the radials at the base of the antenna. I *have* used type TW soft-drawn copper wire (10-gage), but it has proved too flexible for applications involving remote mounting – such as at distant repeater sites. The tubing offers a great deal better stability. If you have a heavy-wattage soldering iron or gun, you'll have excellent results soldering the tubing, too – even though you'll probably have to file or scrape the parts where solder is to be applied.

Ground Radials

There is nothing sacred about the manner in which the radials are attached to the antenna. Figure 4 shows the system I used, which worked but had a rather ugh look about it. K6VBT built one and used an arrangement of his own that looked

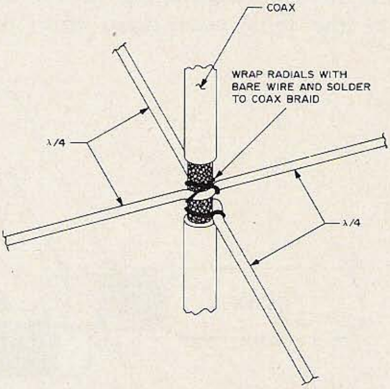

Fig. 4. Radials, of narrow-diameter copper tubing, should be cut to slightly longer than a half wavelength. The center should be bent to conform to the rounded shape of the coax braid so that on each radial a quarter-wave length extends outward from the coaxial braid. Tin the braid first. After wire-wrapping and soldering, wrap the joint well with electrical tape.

much more professional – but his required a lot more work and some rather precision drill work in the PVC pipe. The idea is to get four 19 in. radials extending equilaterally away from the antenna while maintaining some structural integrity. If the concept of Fig. 4 is adopted, the slot arrangement of Fig. 5 will hold things together satisfactorily.

The slots (Fig. 5) are cut lengthwise into the bottom of the PVC pipe so that the radials can be held in place when the PVC is inserted into the mounting pipe (made of heavy metal). The metal pipe is notched gently to seat the radials. Before inserting the PVC into the larger pipe, the slots on the PVC should be taped up (after the antenna is installed in the PVC sheath, of course).

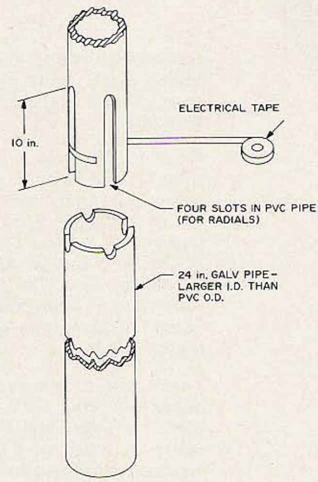

Fig. 5. Long slots in the PVC pipe will hold the radials in place with the antenna inserted. Wrap the bottom well with electrical tape after the antenna is installed in the fiber tube. Notch four matching places on a 2 ft length of galvanized pipe to seat, and try for a snug fit.

Building your own gain antenna *is* a lot of trouble, as you can readily see. But it looks pretty attractive when you start pricing the commercial equivalents. And there is an almost indescribable satisfaction that comes with putting out a good "commercial quality" signal from a homebrew antenna.

One Last Note

If your repeater doesn't give omnidirectional coverage, or if you'd rather have a definite preplanned radiation pattern, you can get considerably more gain than the 5.8 dB already promised by merely spacing the antenna a prescribed number of quarter wavelengths from the tower. Of course this means that your antenna will have to be side-mounted rather than top-mounted. If you space the antenna one quarter-wave from the tower, you'll get a major lobe in the same direction as the antenna is from the tower mass, as shown in Fig. 6A. Each additional quarter-wave essentially adds a lobe that exceeds the 5.8 dB omnidirectional reference point.

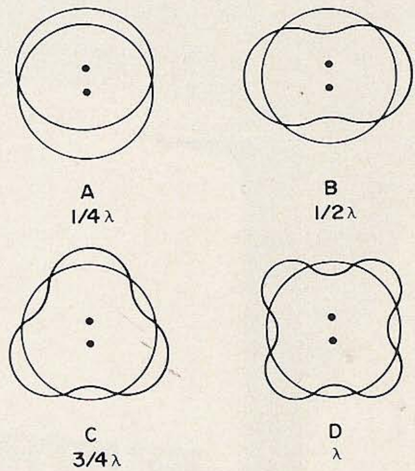

Fig. 6. By spacing the antenna the proper number of quarter wavelenghs, some interesting radiation patterns can be obtained. In the patterns shown, the circles represent the 5.8 dB omnidirectional gain achieved by top-mounting. The asymmetrical overlays represent the patterns obtained by side-mounting. Note that even though signal loss occurs in some directions, significant gain improvement is realized in other areas.

Playing around with antenna-to-tower spacing can help you spend a jolly afternoon at your repeater site – which can be great fun when compared with painting the fence or fixing the wife's vacuum cleaner. So grab yourself a hunk of coax or two and get started on the antenna. Then take a good look at a map of your area and see if you can't improve your repeater's efficiency by some selective mounting techniques.

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