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THINGS TO LEARN, PROJECTS TO BUILD, AND GEAR TO USE

A Compact 2-Element Yagi For 10 Meters

Ten meters has come out of the summer doldrums. A lot of newly-licensed amateurs are joining the old timers on this exciting band. That's good! They are having a lot of fun making new friends and working DX. Many of them start out with a dipole or ground-plane antenna, but the urge to work bigger and better DX compels the new amateur to think about a rotary beam.

There are plenty of good Yagi beams on the market, but it's possible to build one at home from scratch. The amateur with a lean purse will be interested in the simple beam described here. It is a 2-element design built on a boom that is only a little over 4 feet long! That means a low-profile installation that will not unduly excite the neighbors! The design is derived from the ON4UN Yagi Design computer program. If you have a Novice friend, you might join him in this antenna project. Since much of the assembly information is described in various handbooks, only general information is given here.

The compact beam is shown in fig. 1. The design frequency is 28.4 MHz. The little antenna compares favorably with a conventional 3-element beam on a much longer boom. Power gain is about 4.2 dBd and the front-to-back ratio is about 11 dB. Those are very impressive figures for a beam of this size. The beam is light enough so that it may be mounted above an existing beam. About 8 feet of separation between the arrays is recommended.

Beam Construction

The beam is built on a 4 foot 6 inch length of 2 inch OD aluminum tubing. The elements are composed of 12 foot center sections made of 1 inch aluminum tubing having a .058 inch wall. Tip sections of ⅞ inch diameter tubing slip nicely inside the center sections, which are slotted at each end. Hose clamps are used to make a good mechanical joint. Anti-oxidizing compound ("Penetrox," or the equivalent) is coated over the overlapping section of the tips before the joint is clamped. The elements are mounted to the boom by means of aluminum plates measuring 8 inches by 2½ inches. Galvanized U-bolts mount the elements to the plate and the plate to the boom. This type of construction is described in detail in the *Beam Antenna Handbook.*[1]

The overall length of the elements is affected by element taper and mounting hardware. The elements must be lengthened about 1 inch to compensate for this. The final dimensions are shown in the drawing.

The Feed System

A gamma match system is used which permits the driven element to be grounded to the boom. Details of the match are shown in fig. 2. This is a coaxial design, the .375 inch diameter gamma rod serving as the outer conductor of a capacitor made up of a length of RG-8A/U or RG-213/U coax. The outer jacket and braid are removed from the coax and the insulated inner conductor is slipped within the aluminum tubing. Adjustment of the overlap determines the value of series capacitance required by the match. In this case, the capacitance is about 48 pF. High-quality coax runs about 29.5 pF per foot, so the overlap comes to about 20 inches. In order to make the match work properly, the driven element must be shorter than resonance, as shown in fig. 1.

Antenna Adjustment

Using the dimensions given, the antenna is very close to optimum. It may be necessary to touch up the gamma match a bit to obtain the lowest value of SWR at the design frequency. This can be done atop the tower, or the antenna can be temporarily placed atop a high stepladder. The beam should be tilted so that it points up at about 45 degrees to lessen the effect of the ground (driven element higher than the reflector). The length of the gamma rod and overlap of the coax capacitor are adjusted for lowest SWR when low power is applied to the antenna. If an acceptable

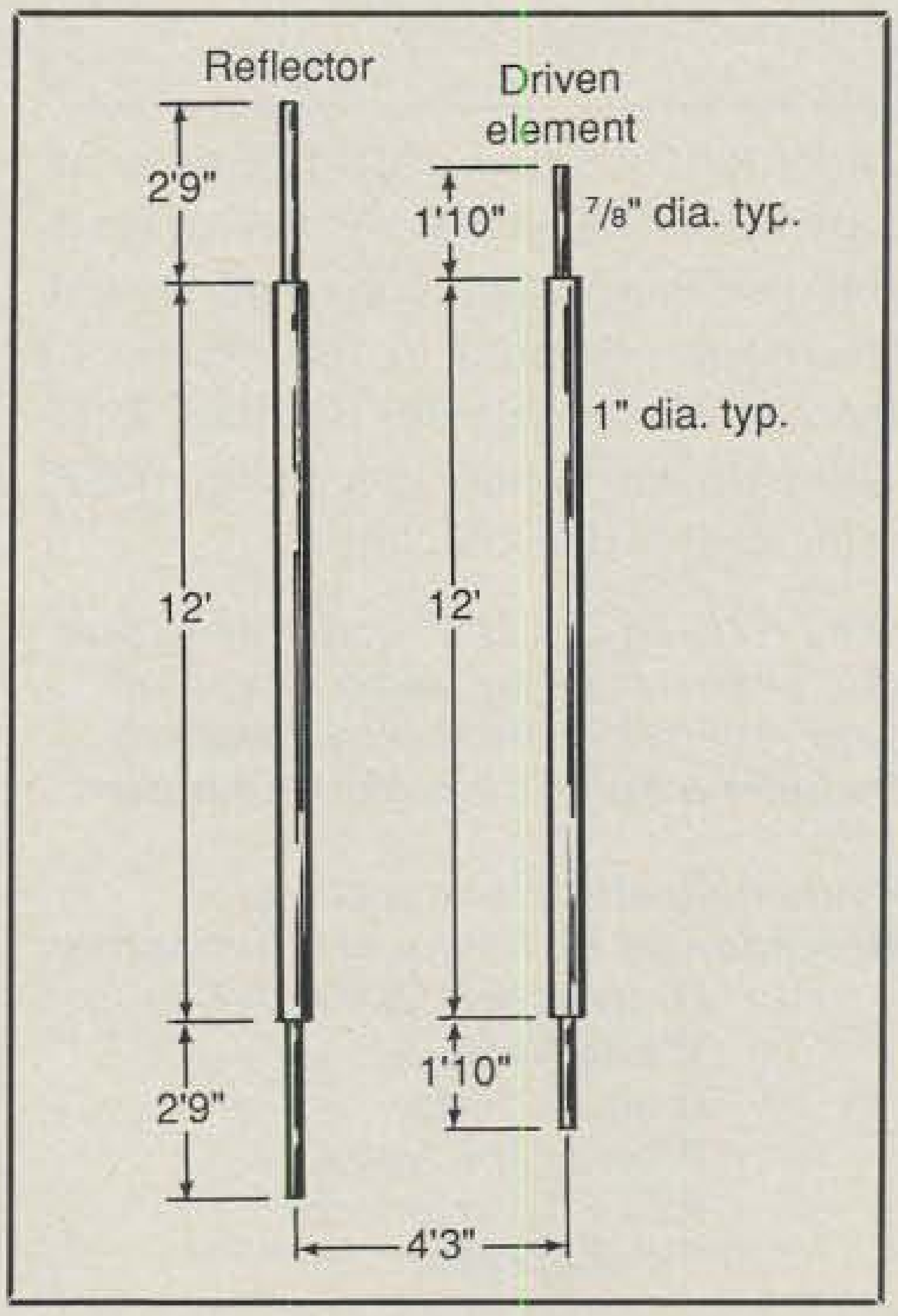

Fig. 1– Dimensions of the 10 meter Yagi.

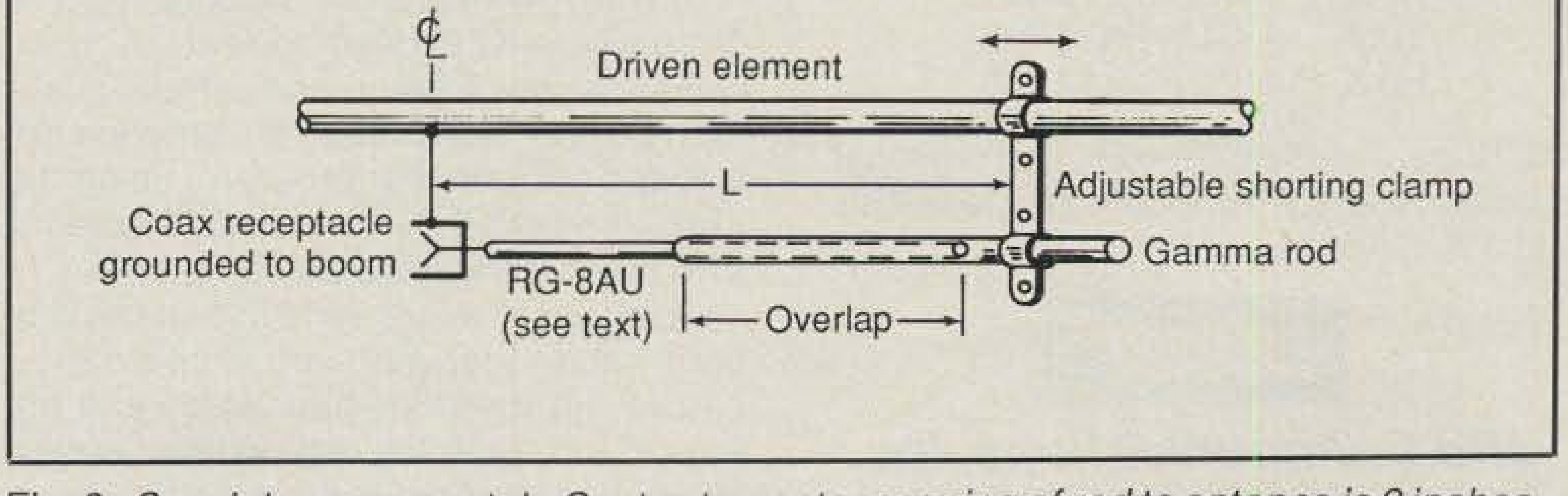

Fig. 2– Coaxial gamma match. Center-to-center spacing of rod to antenna is 2 inches. Length L is about 23 inches. Seal ends of gamma rod against moisture.

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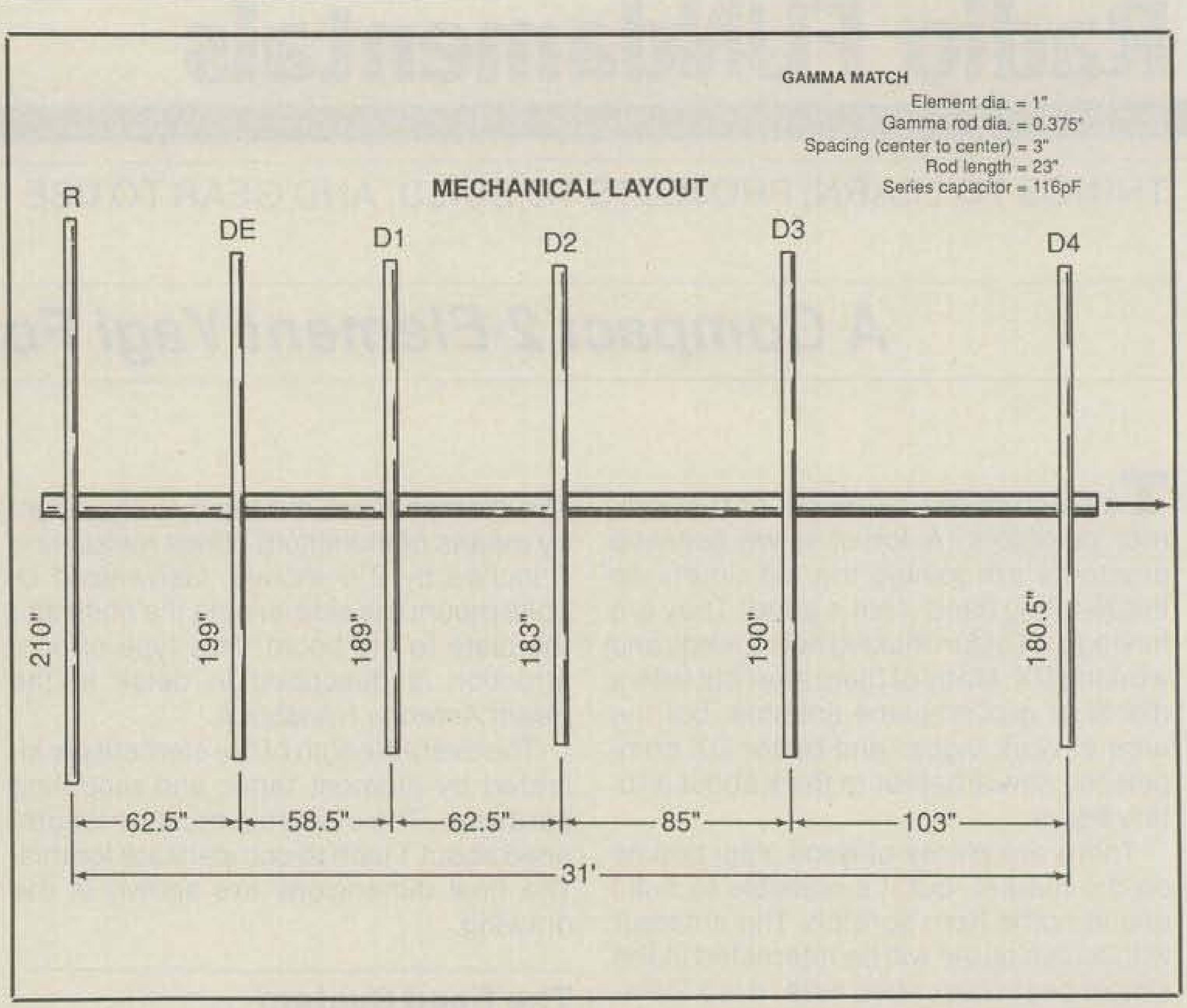

Fig. 3– Assembly of "big gun" Yagi. See fig. 1 for element assembly. Feedpoint resistance is about 30 ohms.

minimum value of SWR is not attained, the length of the driven element is adjusted slightly. A change in length is applied equally to each tip. The interlocking adjustments are element length, gamma rod length, and gamma capacitance. You'll find out that the antenna is probably on-the-nose and requires little, if any, tuning to achieve a good value of SWR at the design frequency.

A "Big Gun" Yagi For 10 Meters

So much for the little array. How about a big-gun design that will really bore a hole through a pile-up? Since the Yagi computer-modeling programs became readily available, it is possible to model antenna designs to fit the application. Trade-offs between gain, front-to-back ratio, operating bandwidth, and input impedance are easily and quickly accomplished.

The best-known antenna modeling program is MININEC, developed at the Naval Ocean Systems Command at Point Loma (San Diego), California. This antenna design is based on that program, using the K6STI and ON4UN versions suitable for IBM PC clone-type home computers.

Contrary to a long-held belief, the programs show that improved results can be had in the areas of bandwidth and improved front-to-back ratio without suffering a loss of gain when staggered director elements are used. That is to say, the director lengths are not constant, nor do the lengths decrease in an orderly manner with respect to distance from the driven element.

Characteristics of the Antenna

This beam provides a power gain of 9 dBd (11.14 dBdi) over a dipole with a front-to-back ratio of 23 dB at the design frequency. SWR is less than 2-to-1 over the range of 28.0 to 28.8 MHz. Gain remains within 0.1 dB of the maximum figure over the operating range. For simplicity, the antenna is fed with a gamma matching system so that all elements can be grounded to the boom.

The "big gun" is shown in fig. 3. Note that directors 1 and 3 are longer than directors 2 and 4. Boom length of the array is 31 feet, and the elements are mounted on small plates above the boom. The center sections of the elements are 1 inch aluminum tubing having a .058 inch wall. The tip sections are ⅞ inch tubing with a .049 wall. This combination makes a light, rigid element.

The boom is made of 2½ inch diameter tubing having a .083 wall. Sections of tubing are spliced together and supported by a top strut and bracing guys run to the boom tips. Each guy has a turnbuckle in it and is broken up at two points by strain insulators. The turnbuckles place the boom under slight tension, which helps to keep the array from weaving around in a heavy wind.

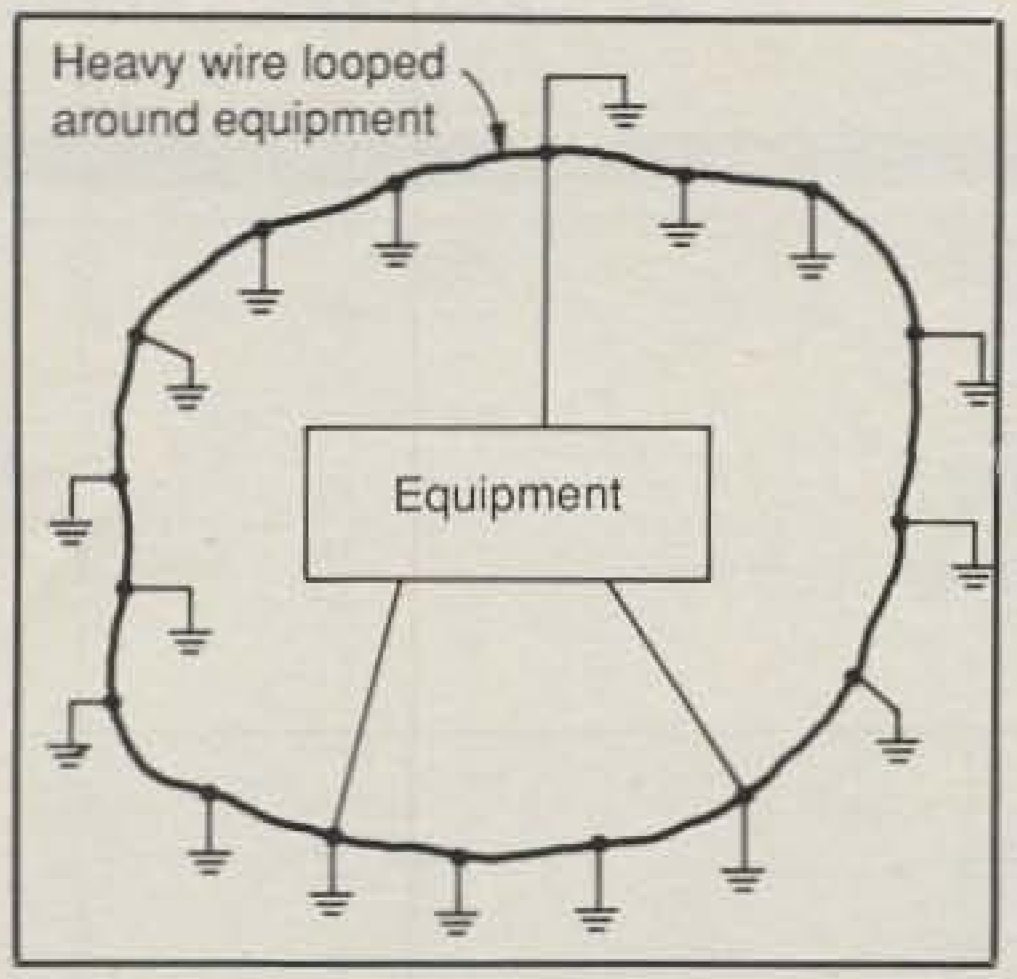

Fig. 4– SWG wire is looped around equipment and grounded at 15 to 18 points.

For the gamma match to function properly, the driven element must be shorter than resonance. Element taper requires that all elements be about 1 inch longer than a constant-diameter element; the driven element must be shortened as shown in the drawing.

It is difficult to adjust the gamma match when the beam is atop the tower. A close adjustment can be made when the beam is atop a temporary support, with the boom elevated at a 45 degree angle to the ground (reflector closest to the ground). If you can place the beam on a 20 foot high support in this fashion, you can adjust the gamma match at your leisure. A little effort in this adjustment will pay big dividends in operational bandwidth of the array.

Improved Grounding Techniques

George Riddle, W6FMZ, brought to my attention an article in the March 1988 issue of *Signal* magazine. It concerns ground measurements conducted by the Army Material Systems Analysis Activity, Aberdeen Proving Ground, Maryland.[2]

Ground resistance measurements using a 6 foot ground rod were taken in a number of locations. The military has used such ground rods for the past 50 years. Ground resistance measurements for a single rod ranged from 13 ohms in moist soil at Fort Story, Virginia to over 7,000 ohms at Fort Lewis, Washington (10 ohms is considered the upper limit of acceptability).

Continued testing on various grounding schemes led to the surface-wire-ground (SWG) technique. The early SWG consisted of a number of 6 inch long stakes used to secure a 100 foot long, ⅛ inch diameter cable to the earth in a straight line.

In the final design the wire length is reduced to 70 feet, the wire being grounded along its length by 15 stakes, each 10 inches long. The wire is looped around the equipment, and three heavy connecting wires ground the equipment to the SWG (fig. 4).

The SWG has been tested against a conventional 6 foot ground rod in a number of locations in the continental United States, Alaska, and Germany. In all cases the SWG offered improved performance, with values ranging from 2:1 to 10:1 better than the ground rod.

The short ground stake is a tapered, star-shaped design (shown in fig. 5) that provides enhanced soil contact and can easily be inserted into or removed from the ground.

Now here's an interesting idea that 160 meter enthusiasts using an end-fed Marconi antenna should investigate! Ground loss plays a big role on this band, and anything that can be done to decrease it should be a great help!

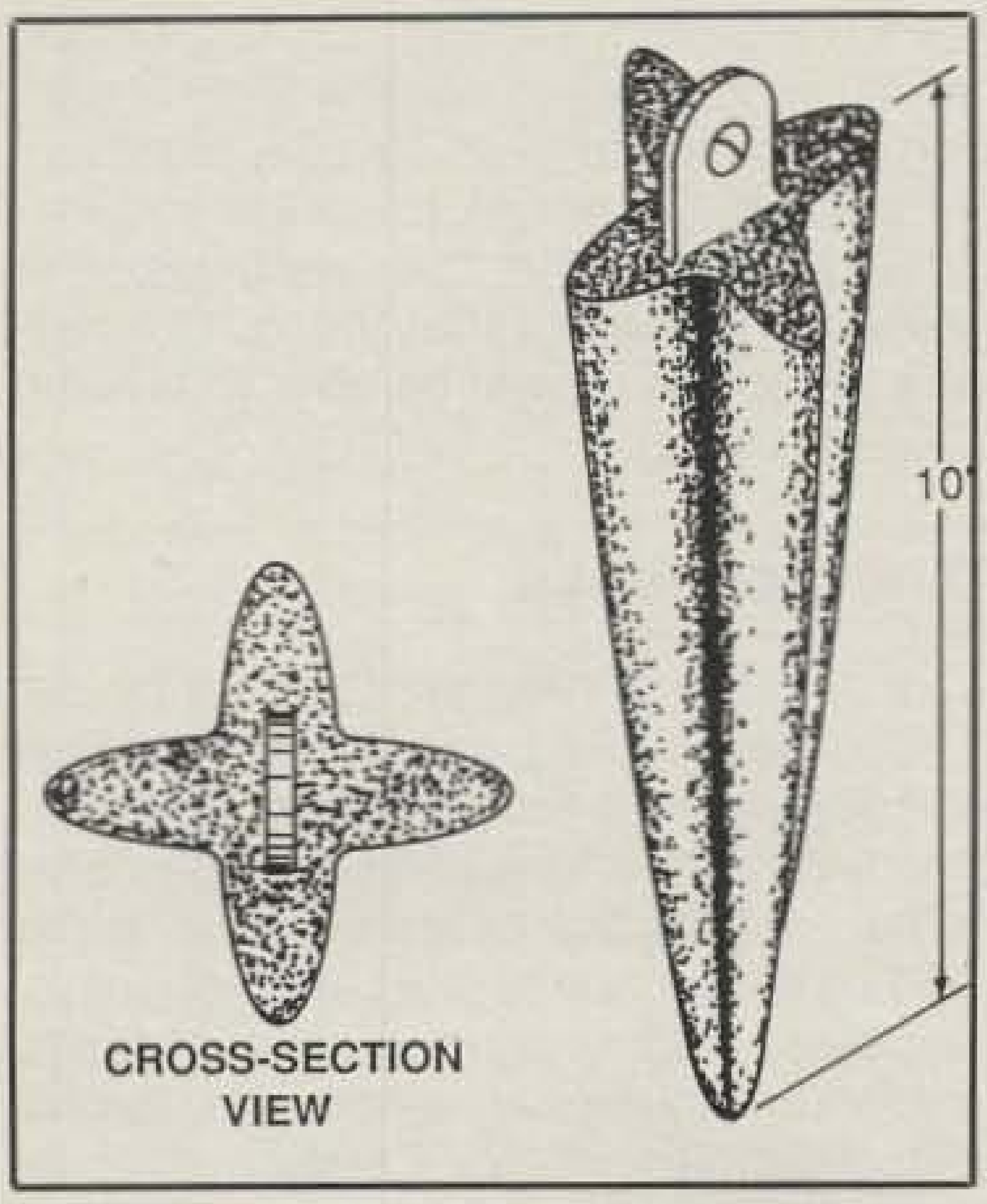

Fig. 5– Ground stake is cruciform (star-shaped) with connecting bolt at top.

The Dead Band Quiz

This little brain teaser is an easy one. The reader who sends me correct identification of the three missing words, identification of the quote, and the best background review concerning it will receive an autographed copy of the new second edition of the *Beam Antenna Handbook*. Hint: The quote is extracted from a manuscript dated 1742:

"I counsel you by way of caution to forbear from _________ _________ _________ in those dark hours when the powers of evil are exhalted."

Footnotes

1. *Beam Antenna Handbook* is available from *CQ*'s Book Shop.
2. This system was briefly mentioned in "Technical Correspondence," by Dave Talley, W2PF," *QST*, January 1989, page 41.