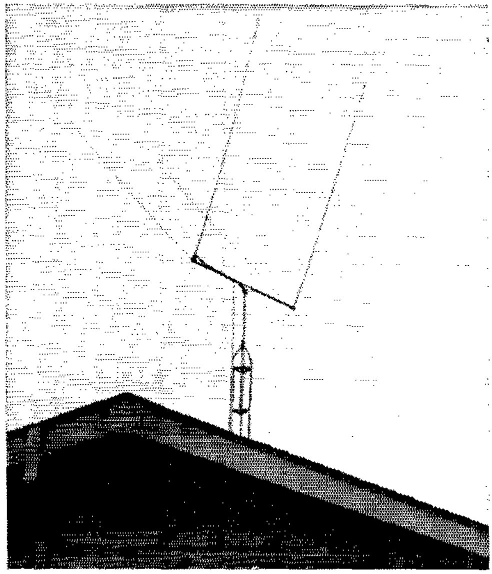
The HRH Delta-Loop Beam

A New Idea In Parasitic Beam Construction



This is a 10-meter, 2-element Delta Loop that is very similar in construction to the antenna described in the article.

BY HARRY R. HABIG,* K8ANV

The evolution and design of the antenna shown in the photographs came about primarily because of my lack of confidence in the mechanical durability of quads. Anyone who has ever built and used quads knows how difficult it is to keep them up in icing and high wind conditions.

Being an old-time mechanic, I felt there had to be a better design for an antenna that used full-wave elements in a parasitic array, so some years ago a start was made to find that better design. One thing that nearly all readers will agree is that Mother Nature is about the best designer there is. Along these lines, just observe the growth of branches on tree limbs. You'll find that many of the smaller branches will grow up in a semivertical pattern from the limb; see Fig. 1. It takes a considerable amount of icing and wind to break such branches, indicating the soundness of the design. This same idea should apply to elements mounted on a boom.

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Here's an antenna that should excite the interest of the amateur fraternity. The Delta-Loop beam has all the features of a quad without many of the disadvantages.

To test the idea, an element of aluminum tubing was mounted on a boom. The element was mounted as shown in Fig. 3. The boom was then secured to the family car with the element in a vertical position. The assembly was then tested at 65- to 75-m.p.h. Even though the element was only secured to the boom as shown in Fig. 3, there was no "set" or permanent bending. This test opened the door to several possibilities in beam design.

A loop aerial can take many shapes. Anyone who studies the history of the quad will find that many different configurations have been used. Why not use a triangle? [1] It should be possible to achieve a very good design using a vertical triangle. See Fig. 2. This shape appears ideal for a beam with full-wave elements, and has most of the advantages of the quad without many of the disadvantages. This led to the construction of several antennas of the type shown in the photographs, and some of these advantages become quickly apparent.

First, the entire antenna is *above* the boom. Second, the antenna is constructed primarily of aluminum tubing, which provides extra strength as compared with wire elements. Third, the antenna has Plumber's Delight type construc-

[1] A triangular loop configuration also was described in *QST* in April, 1968, "Technical Correspondence" by Norman Watson, W6DL, independently of K8ANV's design. Mr. Habig has been working for some years on this design and has a patent pending. — *Editor.*

tion, meaning that the antenna is at ground potential for lightning protection, plus the fact that this type construction lends itself to gamma matching of the feed point, eliminating the need for a balun. Last, but not least, we find the antenna is very attractive in its symmetry. Of course, the important point is how well does the antenna perform?

Several 10-meter models have been tested and the unit shown in the roof-mounted position is my present 20-meter Delta Loop. Using a gamma match with 50-ohm coaxial feed, a 10-meter model was matched at 28.8 MHz. The antenna consisted of a driven element plus reflector with the elements spaced 6½ feet apart, or approximately 0.2 wavelength. Surprisingly, the antenna was extremely flat across the entire 10-meter band, the worst mismatch being *less* than 1.2 to 1.[2]

I have no means of measuring gain or front-to-back ratios. However, with the spacing and element sizes the same as a quad, the gain should be the same, or at least so close the difference would be insignificant. On-the-air tests have shown the antenna to be as good as or better than quads I have had up. Front-to-back and front-to-side reports have been outstanding, both on ground wave and skip.

Element Lengths

Many tests have been made on driven elements to determine the effect of element lengths on s.w.r. It was found that the flattest curve was obtained with a formula of $\frac{1005}{f_{MHz}}$ (feet) for the driven element. The reflector should be about 3 percent longer, or $\frac{1030}{f_{MHz}}$ If directors are desired it would appear that a length three percent shorter than the driven element would be adequate.

[2] Editors note: A 10-meter model of the Delta Loop beam tested at A.R.R.L. Headquarters was matched at 28.8 MHz. and an s.w.r. curve was made using a Bird Wattmeter. The largest mismatch also was less than 1.2 to 1 MHz. (at 29.7 MHz.).

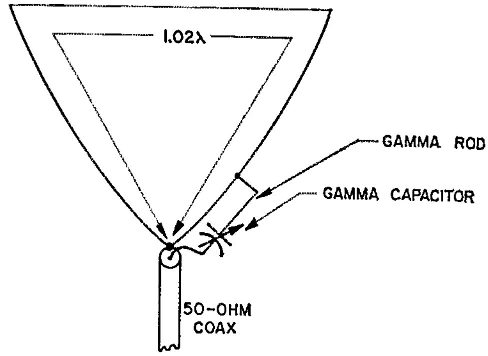


Fig. 2—This drawing shows the driven element and feed method of the Delta Loop. Tests have shown that the overall length of the antenna is slightly longer than a wavelength (1.02λ). Each side of the antenna is approximately ⅓ wavelength long. The top, or wire section, is made slightly shorter to put tension on the vertical members.

Bill of Materials

Tubing used is 6061 T6.

4 — 12-foot lengths of ¾-inch o.d., 0.035 wall (elements).

1 — 12-foot length 1¾-inch o.d., 0.065 wall (boom).

8 — ¾-inch diameter stainless steel hose clamps.

1 — 9-inch length of ⅜-inch o.d. by 5/16-inch i.d.

1 — 9-inch length of ½-inch o.d. to slide over ⅜-inch section.

25 feet of copper wire No. 12 or 14, or equivalent in stranded wire.

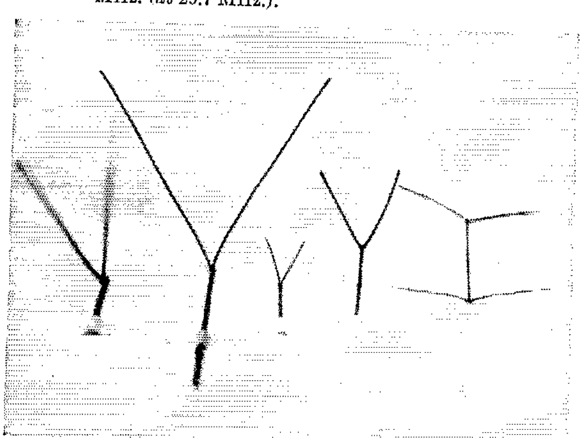


Fig. 1—The basic idea for the Delta Loop beam was conceived from the growth of tree limbs and branches. Here is just a few of nature's configurations that lend themselves to antenna design!

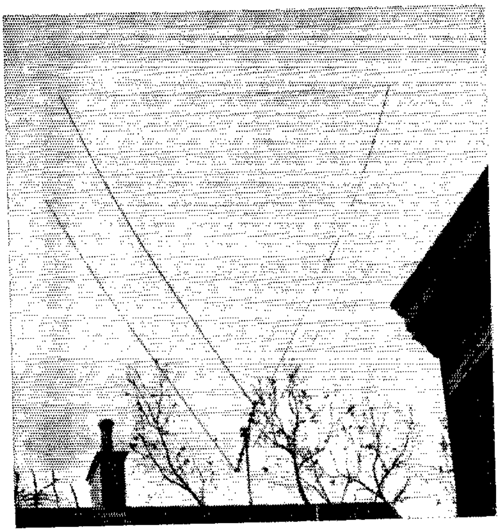
As to element spacing, I have long been an advocate of wide spacing (0.17 to 0.2 wavelength) whenever possible. In the 10-meter tests 0.2 wavelength spacing was used.

For those readers that are interested, I have included complete construction information on a 10-meter model, including list of the required tubing.

Construction Notes

Fig. 3 shows the method of mounting the element tubing to the boom. The angle between the semi-vertical elements is shown as 75 degrees but this can vary a few degrees either way without any appreciable effect on the performance of the array. It is difficult to drill and line up the element support holes in the boom and come out to *exactly* 75 degrees.

There are a couple of methods of making the holes in the boom to hold the elements. One of the simplest is to use a Greenlee-type chassis punch. This makes a clean hole in the boom.



Here is our roof mounted 20-meter Delta Loop beam that is now undergoing a series of tests.

Another method is to drill holes large enough to take the end of a 3/4-inch reamer and then ream out the holes to the necessary diameter.

One not accustomed to working with angles might find it difficult to drill holes at a 75-degree angle. A simple method is to first drill holes to take a single element. Next, make a jig from a piece of stiff cardboard or similiar material, using a protractor to get the 75-degree angle. Then insert the single element into the boom and lay the jig along the element; this will give you the correct alignment for the other element.

The elements are inserted through the boom just far enough to take a cotter pin on the underside of the boom. On the top side, a hose clamp is used to hold the element to the boom and prevent slippage. A length of copper wire can be wrapped around both elements just below the clamp to insure a good contact between the elements and the boom. Hose clamps are also used at the tops of the elements to hold the horizontal wire.

Fig. 4 shows the details of the gamma matching section. The gamma section is made up from the inner conductor of the coax, including its insulation, and two sections of telescoping aluminum tubing. The outer covering and braid is removed from a 52-inch length of RG-8/U coax. In Fig. 4, a male coax fitting is shown with a short length of braid, 2 inches long, which is grounded to the boom via a clamp and bracket. If desired, a chassis-type coax fitting, type SO-239, could be mounted on the boom with a small metal bracket. The capacitor section is made of two lengths of tubing, 3/8-inch, and 1/2-inch diameter, respectively, and both 9 inches long. The 3/8-inch tubing fits over the insulation around the coax inner conductor while the 1/2-inch tubing slides over the 3/8-inch material. The larger tube is drilled and tapped to take a locking screw. Spacing of the section from the element is 3 inches.

In adjusting the gamma, figures given in Fig. 4 can be used as a guide. In order to avoid matching errors, the gamma should be adjusted with the s.w.r. bridge right at the beam. Set the shorting bar to the dimension given in the diagram and slide the 1/2-inch tubing over the smaller tubing, looking for a setting that gives a match. If one cannot be obtained, move the shorting bar and sliding tubing assembly a short distance, say an inch, and then try different settings of the 1/2-inch tubing until you find a match. We found that the settings were not critical in getting a match. Once the beam is matched, the regular feed line to the station can be attached to the feed point. The connection should be taped to prevent moisture from getting into the fitting and coax.

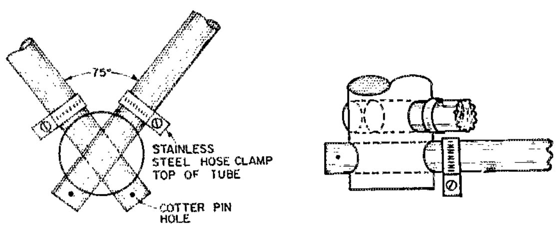


Fig. 3—This drawing shows the method of mounting the element to the boom. A cotter pin is used on the under side of the boom and a hose clamp on the top to hold the element securely to the boom.

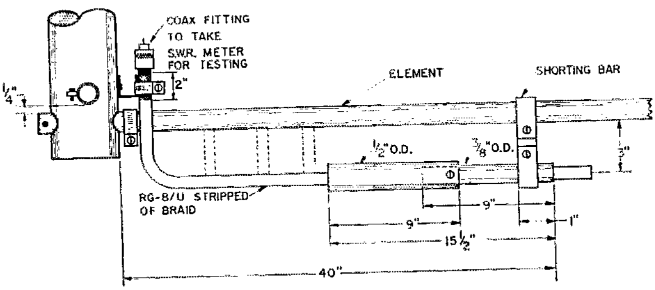


Fig. 4—Here are the details on the gamma-matching section. As mentioned in the text, the coax fitting can be a female type, SO-239, mounted on a small bracket which is mounted on the boom. Spacing insulators for spacing the gamma line from the element can be made up from pieces of Lucite or Plexiglass.

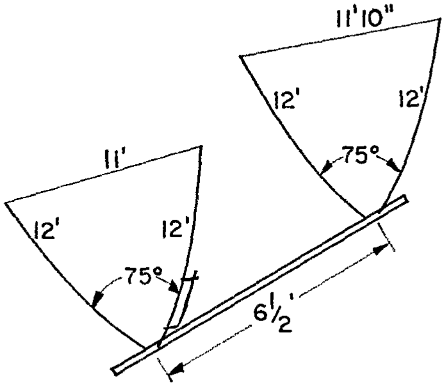


Fig. 5—For those interested in exact figures, this sketch provides the element and boom lengths for a Delta Loop beam for 28.8 MHz.

As stated earlier, the antenna is extremely flat across the entire 10-meter band. The present model was designed for 28.8 MHz. and matched at this frequency. The s.w.r. at the highest point, at 29.7 MHz., was about 1.2 to 1. This dropped to 1 to 1 at about 29 MHz. and stayed at 1 to 1 all the way down to 28 MHz. This feature of the antenna certainly is a help when using a transceiver designed for 50-ohm output. The beam has proved its ruggedness through winds and icing conditions. All in all, we think the Delta-Loop beam is one of best performers we have seen. QST

• *Beginner and Novice*

The Delta Loop Beam On 15

Constructional Information on A New Antenna

BY LEWIS G. McCOY,* W1ICP

THE Delta Loop beam described in the previous article appears to be ideal for the more ambitious Novice or General who is interested in 15-meter operation. Some of the features of the 15-meter beam described in this article include a very low s.w.r. across the entire band, use of readily available materials, "Plumber's Delight" type construction — which is always an appealing feature of any beam antenna — and last but not least, excellent performance. On the last point, the antenna shown in the photographs was tested during a DX contest with a transmitter input power of 100 watts. The boom of the antenna was mounted only eight feet above the ground, but in about five hours of contest operation 58 different countries were worked — and, believe it or not, the majority of the reports received were 5-9. Possibly conditions were above par, but even so the antenna shows it can do a real job under crowded band conditions.

As stated above, the beam uses Plumber's Delight type construction. For the newcomer's information, this type of construction has the antenna elements connected directly to the boom which in turn can be connected directly to earth ground without having any effect on the performance of the antenna. This is desirable because of the lightning protection offered by the system.

Fig. 1 is a drawing of the Delta Loop driven element. The overall length around the driven element is slightly over one wavelength. Each side is approximately 1/3 wavelength long. The reason we say "approximately" is that the top section of the antenna is made of wire and is slightly shorter than 1/3 wavelength in order to put tension on the wire. A gamma-match feed system is used, eliminating the need for a balun.

The formula used in figuring the driven element length is $\frac{1005}{f_{MHz.}}$, where f is the desired resonant frequency of the driven element. The answer will be in feet. The reflector length formula is $\frac{1030}{f_{MHz.}}$. For a frequency of 21.2 MHz. this figures

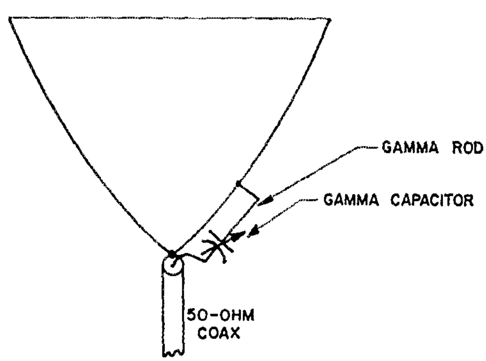
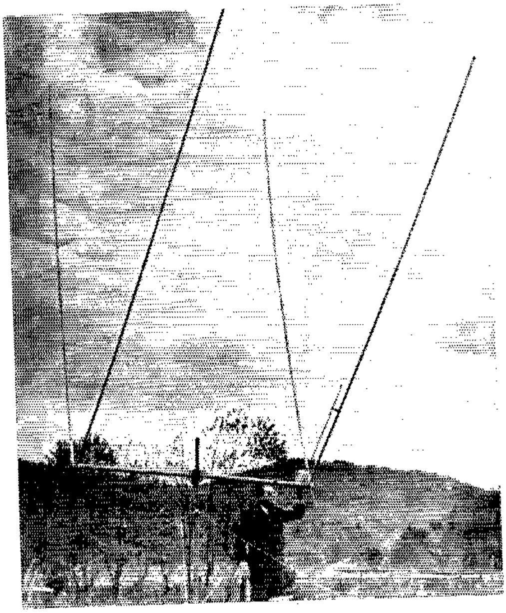


Fig. 1—Basic configuration of the Delta Loop driven element. Each side is approximately 1/3 wavelength long.

* Novice Editor



This view shows the completed antenna being matched.

out to a driven element 47 feet 5 inches long and a reflector that is 48 feet 7 inches long. Element spacing is approximately 0.2 wavelength or about 9 feet. Fig. 2 shows the two elements with the lengths of each segment.

Material Requirements

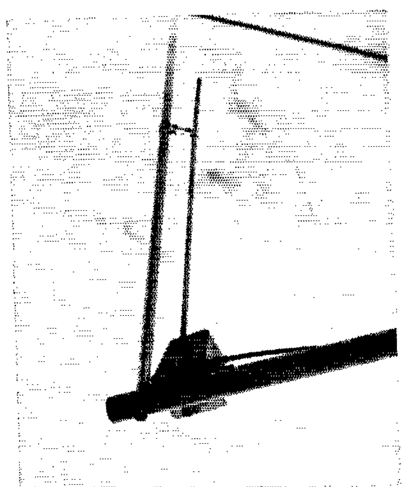
The beam elements were built primarily from Reynolds Do-It-Yourself aluminum tubing, which *should* be available from most hardware dealers. The reason we say "should" is because in some sections of the country hardware stores don't stock the tubing. However, most dealers will order the tubing for you. If you live in an area near or in a city of reasonable size, a look through the Yellow Pages will show any aluminum tubing dealers. The Reynolds Do-It-Yourself tubing comes in 8-foot lengths but most of the commercial tubing available from metal distributors comes in 12-foot lengths. If you obtain the 12-foot types, be sure to specify type 6061 (61S) alloy as this material affords excellent strength for antenna elements. The boom used in this antenna was made from this alloy and is 2 inches in diameter with a 0.065-inch wall. Another source of aluminum or steel tubing is electrical supply houses; although this type of aluminum is a little too soft for the elements it would be suitable for a boom. Also, electrician's thin-wall steel tubing is available in various sizes, including the 2-inch diameter, for a boom. In a pinch, the boom could be made of wood, such as a length of 2 × 4. In such a case, the bottoms of the elements could be connected together with a length of wire to maintain the Plumber's Delight feature. The shopping list included here should prove of help in purchasing the parts.

Construction

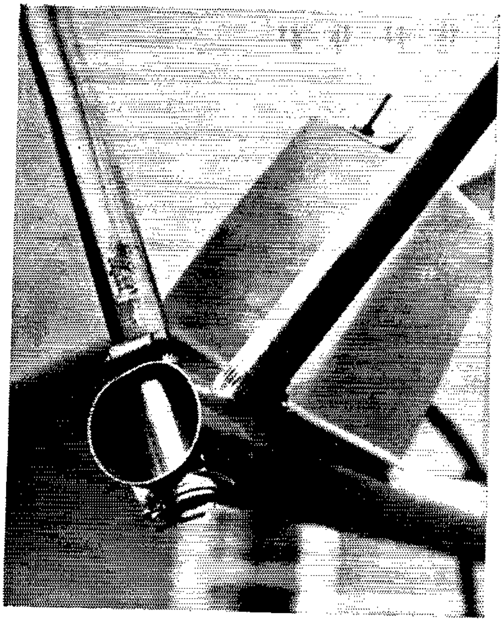
The first step in building the antenna is to make up the vertical elements. The description given here is based on using the Reynolds tubing. Using a hack saw, cut the ⅞-inch tubing into two-foot sections. This particular type is made by Reynolds for the purpose of telescoping the 1- and ¾-inch diameter sections together and comes in 6-foot lengths. After cutting off four 2-foot lengths you'll have one 4-foot piece remaining. Cut this into four 1-foot lengths and set these pieces aside for the time being.

Next, cut two lots, the thickness of the hacksaw blade, about 2 inches deep in one end of each of the 1-inch and ⅞-inch diameter lengths. Slide the ⅞-inch tubing inside the 1-inch diameter to a length of about six inches and then slip the hose clamps over the slots and tighten them. The ¾-inch tubing can then be inserted into the slotted ends of the ⅞-inch tubing and these sections clamped with hose clamps. Two of the elements should be adjusted to the proper length for the driven element and two for the reflector, as per Fig. 2 (or whatever length you wish from the formulas). Some amateurs may prefer to cut their antennas for the c.w. portion of the band and others for the phone section.

The next step is to cut the 1-inch holes in the boom to take the ends of the 1-inch diameter elements. We used a 1-inch chassis punch to make the holes, but a 1-inch metal reamer



The plastic freezer box is held in place by the small metal bracket which is attached to the boom with self-tapping screws. Also on the bracket is a coax fitting to take the RG-8/U coaxial feed line. The gamma rod is mounted on top of the box and is held to the element with the shorting clamp.



In this close-up view of the end of the boom the mounting of the element ends are clearly shown. Cotter pins are used on the bottom end of the element and hose clamps on the top side of the boom. This secures the elements to the boom. The plastic freezer box that houses the gamma capacitor is clearly visible behind the elements.

could also be used. The aluminum is easy to cut or punch so making the holes should be no problem. What *can* be a problem is lining up the holes so that the 75-degree angle between the elements is obtained. We made a jig from a piece of cardboard, using a protractor. Once one set of holes for the director and reflector were made the elements were temporarily mounted in the boom. The cardboard jig was laid on the elements and the 75-degree holes were marked off and drilled.

When the holes are all drilled, the boom can be laid on the ground and the element ends inserted into the boom holes. We allowed about ¼-inch extension of the base of the elements through the boom so as to allow space for cotter-pin holes. However, before drilling the cotter-pin holes, insert the four 1-foot lengths of the ⅞-inch tubing into the elements at the boom. This will serve to give added strength to the elements at the support point. Drill each of the four ends to take the cotter pins and install the pins. Tighten down the hose clamps on the top side of the boom to secure the elements in place.

Drill the tops of the elements to take the ¼- × 1-inch aluminum bolts and the top wires can then be installed.

The close-up view shows the gamma installation. The gamma capacitor is mounted inside a plastic freezer container which is held in place by a small metal L-shaped plate mounted on the box and the boom, using four self-tapping screws. This plate also holds an SO-239 coax chassis fitting to take the feed line. We like to install an s.w.r. bridge directly at the beam when making s.w.r. or matching tests to reduce matching errors, and having the fitting there simplifies the procedure. The gamma rod, made from a length of ⅜-inch aluminum tubing 36 inches long, is flattened at one end for a length of 1½ inches. The flatted portion is bent over at right angles and drilled to take one of the ¼- × 1¼-inch aluminum bolts, which is mounted through the top of the freezer box. The gamma rod is held in place by this bolt and by the shorting bar between the rod and the element. The shorting bar is made from a piece of aluminum, 1 inch wide and long enough to fit around the two pieces of tubing and provide a separation of 3 inches between the rod and the elements.

Shopping List

Quantity	*Length (ft.)*	*Diameter (in.)*	*Reynolds No.*
4	8	1	4242
4	8	¾	4222
2	6	⅞	4231
1	9	2	See Text.

3 feet of ⅜- or ½-inch diameter aluminum tubing.
12, one-inch diameter hose clamps, stainless steel.
35 feet of No. 12 or 14 copper wire, solid or stranded.
1 variable capacitor, 100 pf. maximum, 0.025 spacing or greater.
1 one-quart freezer container.
1 SO-239 Coax chassis connector.
5 ¼-inch diameter aluminum nuts and bolts, 1¼-inches long.

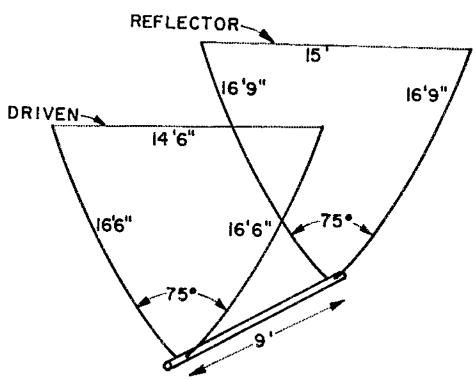


Fig. 2—This drawing shows the element dimensions and the boom length. All measurements on the elements are made from where the element enters the boom; the portion of the element extending through the boom is not counted.

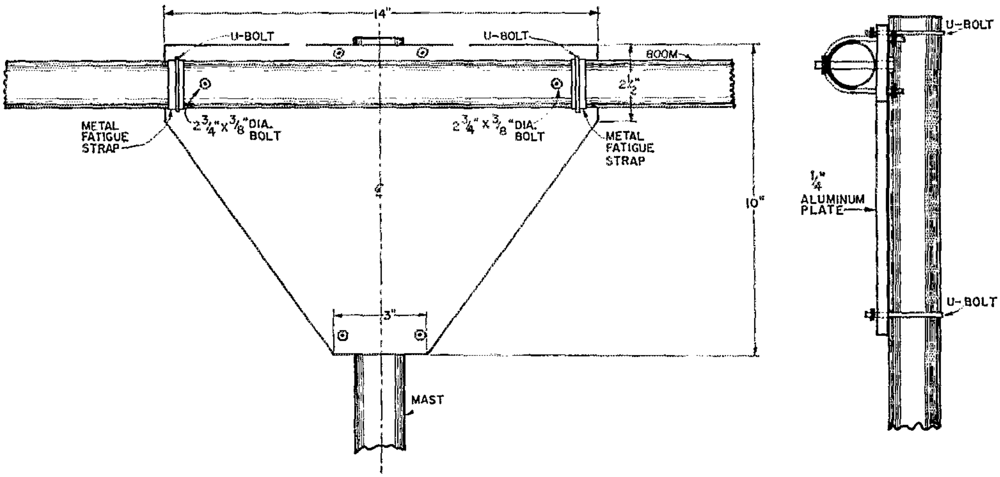


Fig. 3—Construction details for the boom-to-mast mounting bracket. The U bolts holding the boom are 2-inch type. Those holding the mast will depend on the mast diameter—we used 1½-inch U bolts for a 1½-inch diameter mast.

How you mount the antenna boom to the supporting mast will depend a great deal on what type of tower or supporting structure you have. The method shown in the photo is a fairly simple one, and easy to make up. Fig. 3 shows details of the construction of the mounting unit. The one shown in the photo supporting the beam was made from two pieces of 1/16-inch thick aluminum plate. However, we found that even with the double plate there was still too much "give" in the mounting setup, so a replacement was made from ¼-inch thick aluminum. This made the mount completely steady. Either a plate of ¼-inch aluminum or ⅛-inch steel should be adequate for the jobs. The 2-inch U bolts that hold the boom to the mounting plate were adequate, but just for added insurance, ⅜-inch, 2¾-inch long machine bolts (2 required) were installed through the boom and mounting plate for greater holding strength.

During our tests, a weather front moved through the area and we had wind gusts up to 40 m.p.h. plus icing and snow loading on the antenna. The antenna and elements showed very little movement in these winds, and the entire antenna appeared very strong.

Adjustments

Adjustment of the gamma section is quite simple. Install an s.w.r. bridge at the gamma feed point and tune up the rig on the desired frequency. Set the gamma shorting bar 24 inches from the base of the gamma rod and tighten the gamma-bar nuts and bolts just enough to make electrical contact. Set the s.w.r. bridge to read reflected power and adjust the gamma capacitor for a dip. The object is to find a setting of the capacitor and the gamma bar that gives a reading of zero in the reflected position. This may take a few tries, but you'll find the settings are not critical. If you adjust the antenna near the ground you may find it will require a new adjustment when it is up in its permanent location.

How you mount the antenna in its permanent location will depend on what you have to hold the antenna. If you use a boom mounting-plate-to-mast assembly such as already described, the U bolts holding the boom could be left slightly loose and the ⅜-inch bolts left out. The antenna could then be installed in an upside-down position and then rotated into place. Two men are better than one for this job, but one man *can* do the job. If a hole, say ½-inch diameter, is drilled through the boom a ½-inch rod could be slid through to serve as a lever to rotate the boom and antenna into an upright position and the U bolts and hardware could be then tightened down.

We think the Delta Loop beam is an excellent antenna and offers many possibilities. Certainly the results obtained to this point prove the antenna is real performer. Our tower is a crank-up job, making antenna testing a fairly simple project. The antenna was first matched at the 8-foot level (boom height) and at the cranked-up height, about 55 feet above ground. A very slight readjustment of the gamma capacitor was required at the greater height in order to get down to a 1-to-1 s.w.r. However, the change in s.w.r. from the 8-foot to 55-foot heights was very small. Also, the highest s.w.r. was at 21,450 kHz., the top end of the band, with a mismatch no worse than 1.2 to 1. At 21,300 kHz. the s.w.r. dropped to 1 to 1 and remained at that figure all the way to the lower band edge.

The entire antenna weighs about 15 pounds (using the aluminum boom) so the antenna could be rotated with a heavy-duty TV rotator. One last note: we sprayed the cotter pins and hose clamps with a clear acrylic spray to reduce corrosion. This simple precaution should be taken in all antenna construction to prevent or reduce rusting. QST