A Broadband Cubical Quad Antenna

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In recent years, the cubical quad antenna has gained widespread popularity as an efficient, high gain, rotary antenna. While contemplating a replacement for a TV antenna perched 50 feet up on our roof, I decided to construct a 10 meter quad. Its merits were many; high gain, simple construction, and inexpensive materials. Off to the drawing board!

Theory

A quad antenna is basically an extended dipole antenna (see fig. 1). Due to the relatively thin diameter of the wire used for a radiator, the antenna is usually quite critical as to its resonant frequency. The SWR rises quite sharply once you depart from the resonant frequency, making it useful over only about 300 *kc* of the 10 meter band. This is decidedly a disadvantage since the antenna would only be a compromise over the entire band.

The system of parallel dipoles provides a possible solution. If two parallel radiators could be used on the teen meter band, two separate resonant frequencies should also be found. This system was tried, using one radiator designed to resonate at 28.3 *mc* and one to resonate at 29.2 *mc,* fed with the same 75Ω feedline.

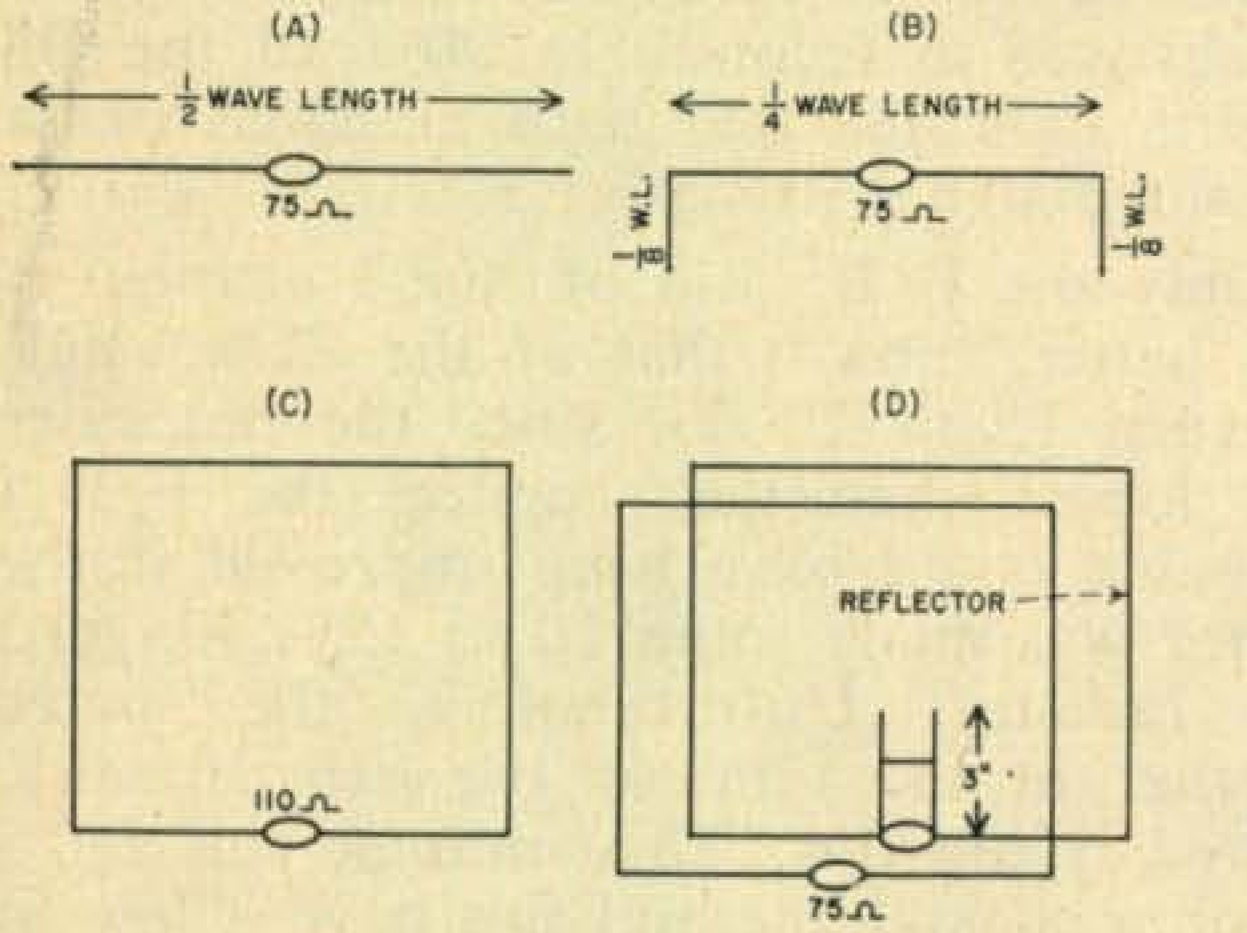

Fig. 1—Evolution of the quad radiator loop from a dipole antenna

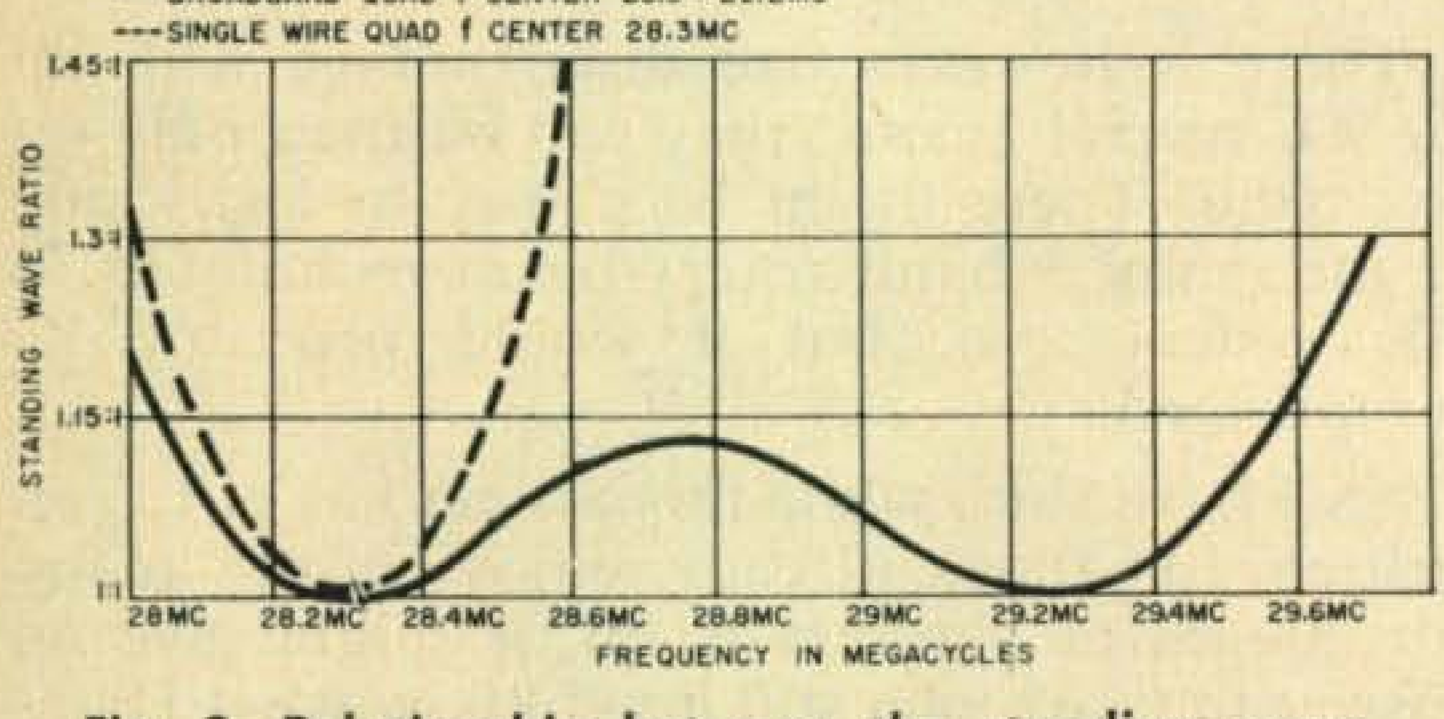

Fig. 2—Relationship between the standing wave ratio and the frequency for a broad band and single wire quad.

The results of this experiment proved amazingly successful. As was to be expected the antenna has an excellent 1:1 SWR at the two resonant frequencies, but on all frequencies between 28.3 *mc* and 29.2 *mc,* the SWR is below 1.15:1! By using these two radiators, an extremely broadband antenna is achieved, with outstanding performance over the entire 10 meter band. See fig. 2.

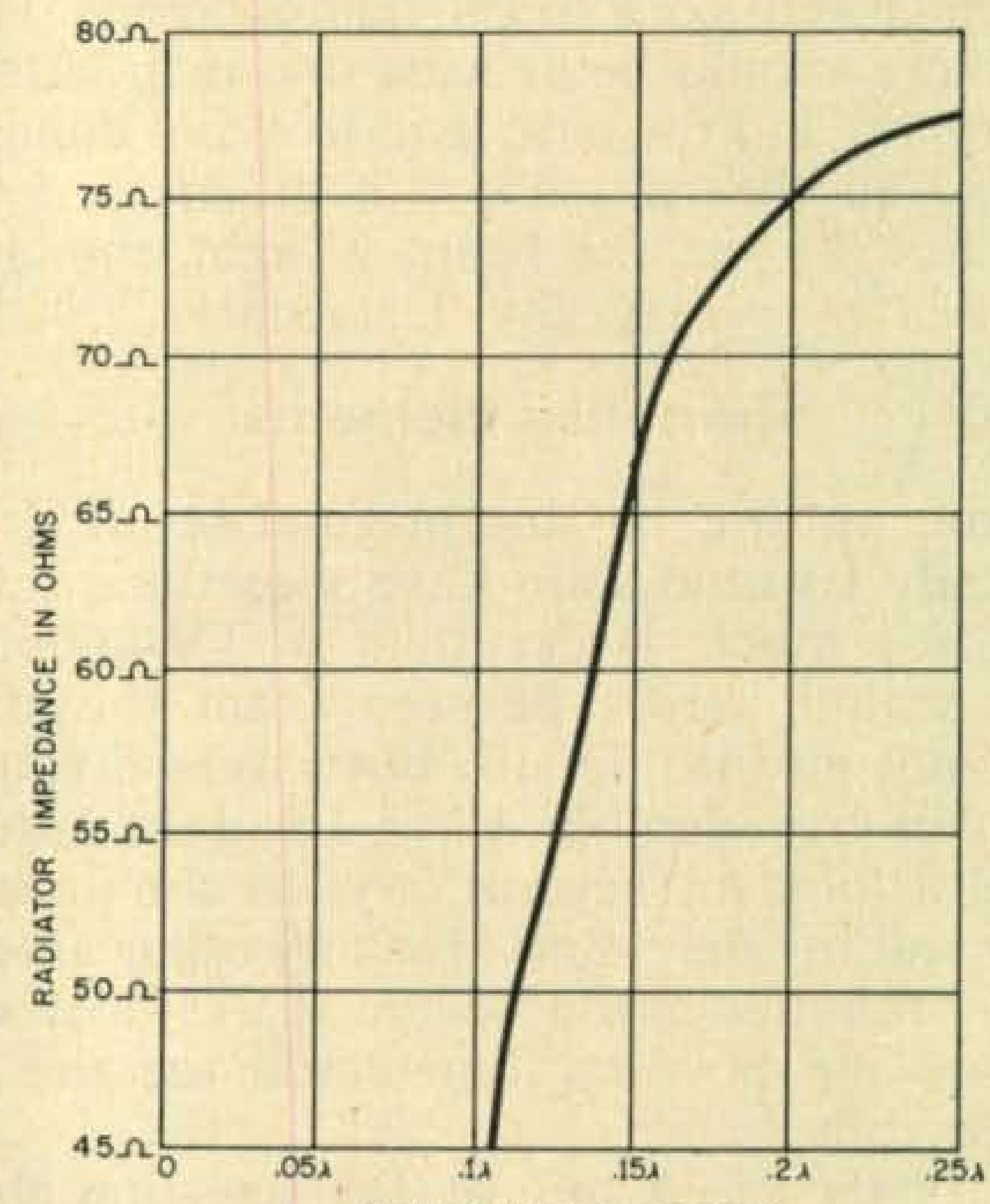

Fig. 3—Relationship between radiator impedance and spacing in a quad antenna.

The radiator of the quad antenna is a full wave extended dipole, therefore the length= some constant F. By experimentation using a fixed L and a variable F, I established a constant of 960 for this antenna.

$$L = \frac{960}{F}$$

where L = total length of radiator in feet
F = frequency in megacycles

This formula held true when the antenna was placed at multiples of ¼ wave lengths high, but varied slightly when the antenna was mounted at a different elevation.

Several methods have been developed to properly resonate the reflector of the quad antenna, such as adjustable tuning stubs, and remote tuning.[1] While these methods are satisfactory, the majority require a great deal of trial and error to obtain satisfactory forward gain. I found by experimenting that the reflector length for this antenna could be calculated in advance using the formula

$$L = \frac{990}{F}$$

Where L = total length in feet
F = operating frequency in *mc*

The use of this formula saves considerable trial and error in adjusting for maximum gain.

A short tuning stub (approximately 3 feet) should also be used in order to compensate for variations in height above ground. Details of adjustment are given later.

The optimum spacing between reflector and radiator has been the subject of considerable discussion, for it involves several related variables. As the graphs of fig. 3 and 4 show,

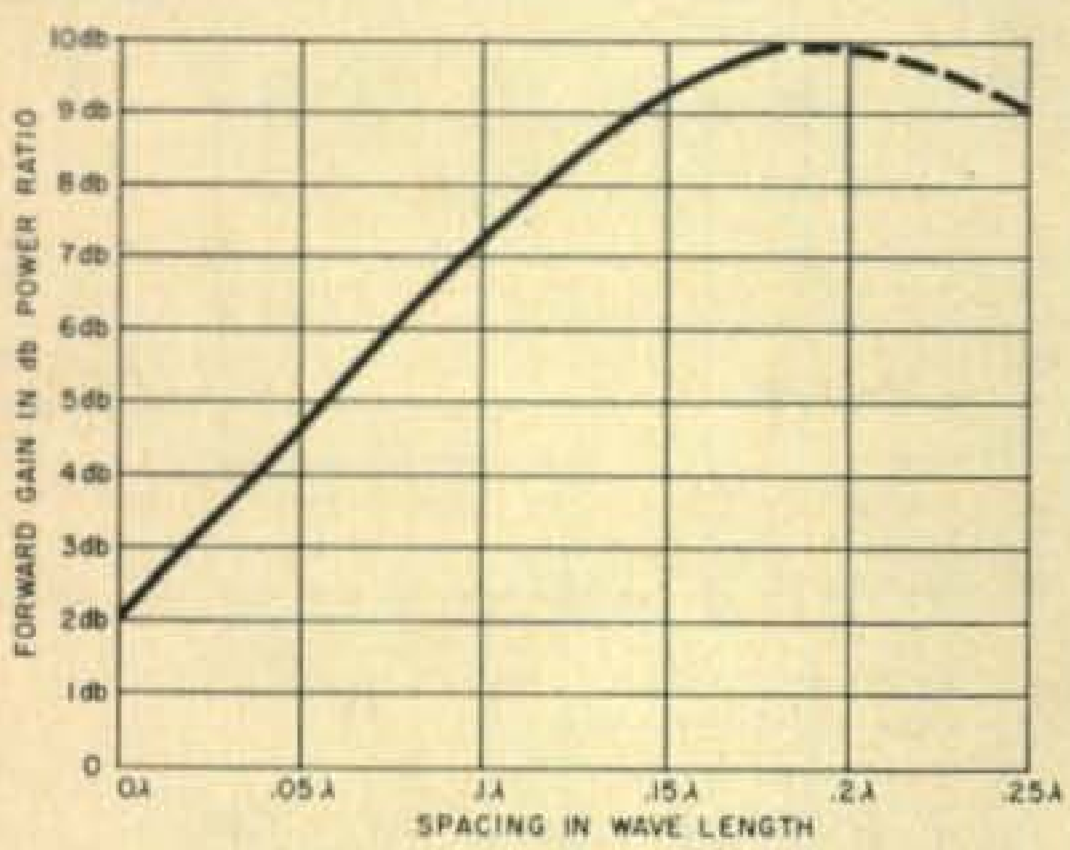

Fig. 4—Relationship between forward gain and spacing in a quad antenna.

both forward gain and impedance at the feedpoint of the radiator change as the spacing between radiator and reflector are changed. I found a .2 wavelength spacing as a good compromise for this antenna. The gain at this point is high (10 *db*) and the feedpoint impedance is low (75 ohms, providing an excellent match for RG-11 U coax cable). The adjustment of the reflector at this spacing changes the resonant frequency of the radiator very little. I highly recommended this spacing.

By combining the features of the parallel conductor radiator, pre-calculated reflector, and .2 wavelength spacing, a cubical quad can be built which will equal or surpass a good 3 or 4 element beam in performance, and cost considerably less in time as well as materials.

Construction

Once the antenna has been designed, the job of construction begins. The difference between a mediocre antenna which will last for a short time, and an antenna system to be proud of, requiring little maintainance for a considerable period of time, lies in the methods and the materials used in taking the antenna off the drawing board and putting it into the air.

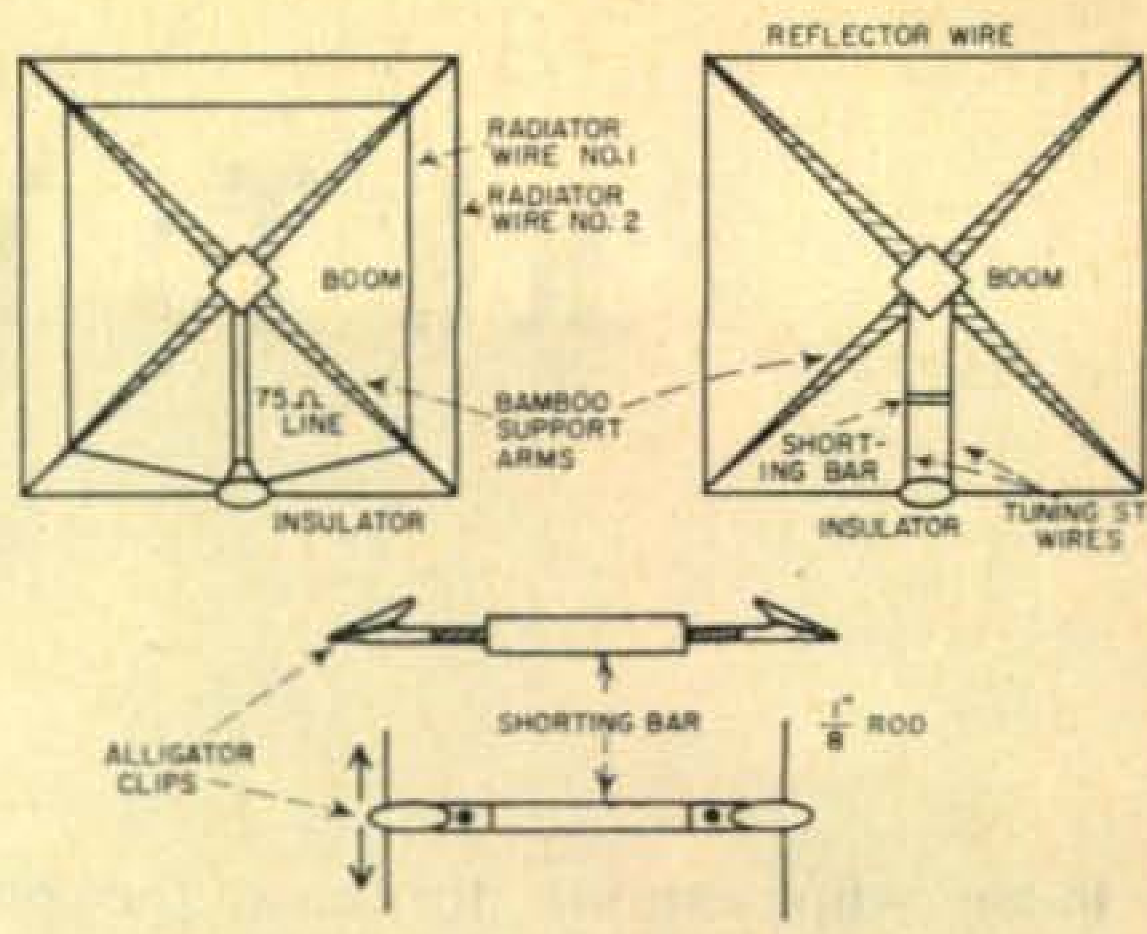

Fig. 5—Broad band Cubical Quad. See text for dimensions.

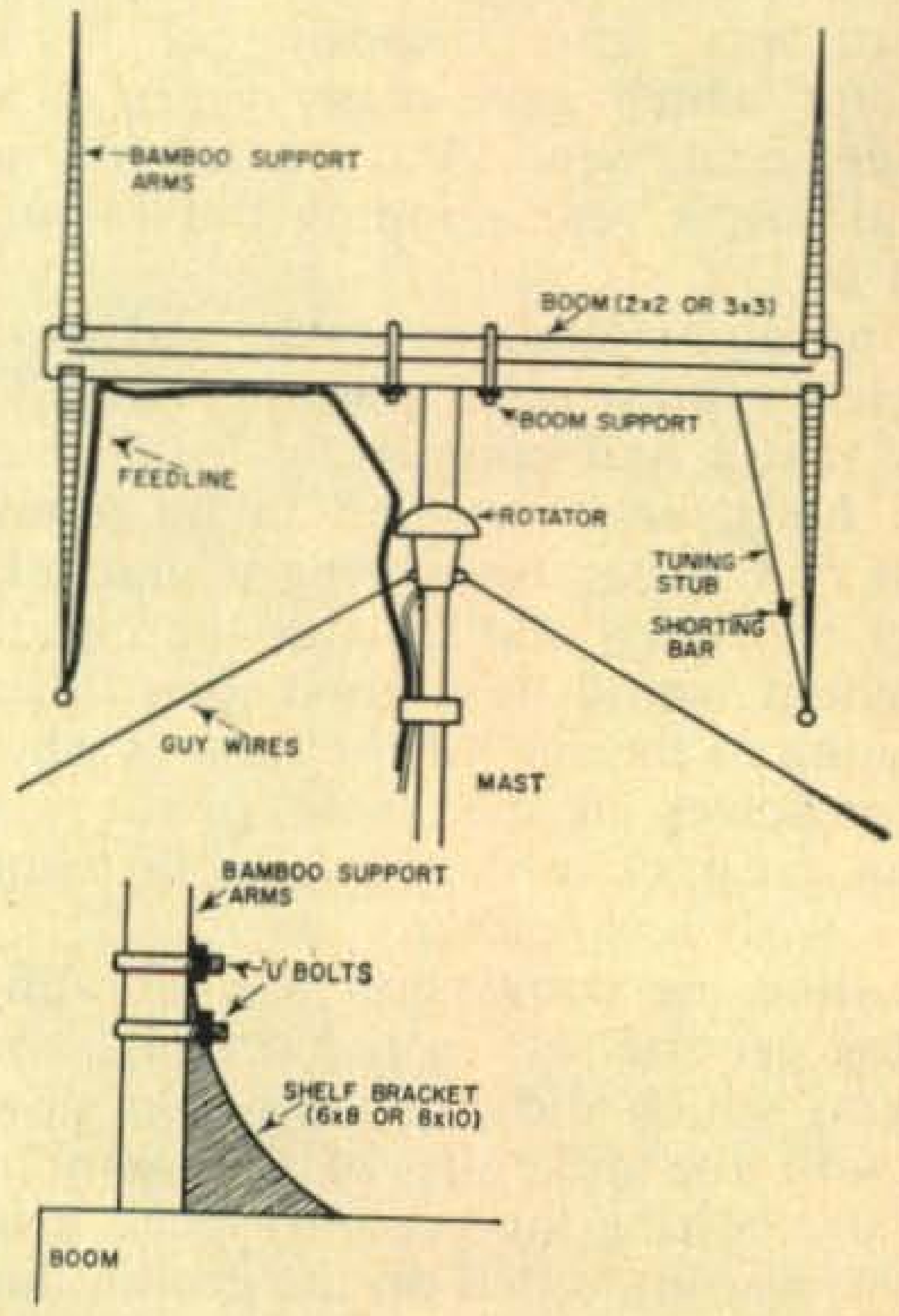

Fig. 6—Side view showing boom and details of attaching support arms to boom.

All of the weight of the antenna and strain from wind is concentrated at the mechanical connection between the boom and the mast. This is the critical part of the antenna, and should be properly made. This can be made by using a pipe flange and 2 "U" bolts, which can be purchased in a hardware store (See fig. 6).

Standard shelf brackets (6" x 8" or 8" x 10") make a simple and strong means of support for the arms of the quad (see fig. 6). These shelf brackets can be bolted or screwed to the boom and the arms fastened to the brackets with 2 small U bolts (¾").[2]

[*Continued on page 113*]

[1]Hagen, Hints & Kinks, QST Feb. 1958, p. 69.

[2] Hardware for connecting the boom to the mast is now being made by Cesco for $5.95 and heavy duty for $8.95. Quad mounts for the bamboo or fiberglass arms are $6.95 each in cast duraluminum. See ad in November 1958 CQ, page 20-21.

CUBICAL QUAD *[from page 45]*

An excellent material to use in the arms of the antenna are fiberglass fishing rod blanks. Although they are relatively more expensive in initial cost, they will outlast standard bamboo arms several times, and are impervious to moisture and heat. If fiberglass is too expensive for the antenna budget, the old standby, bamboo, will do a good job. If bamboo is used, several coats of weatherproofing compound should be used to protect the bamboo from the harsh effects of temperature and moisture.

After the antenna has been constructed on the ground, and the neighbors begin to question your sanity (the little girl next door asked if it was a big bird cage), give all the exposed metallic parts, except the radiator wire, two or three coats of aluminum paint (Rust-O-leum works well) to prevent rust and corrosion. install the feedline to the insulator in the radiator, and recruit your most trusted friends for an antenna raising party (emphasing the word "party").

Four persons held each of the four guy wires, while two people lifted the antenna and mast from the bottom and raised it to its resting place on the roof. The guy wires were then secured and adjusted to make the mast appear reasonably vertical. The situation was helped by the fact that the mast only weighed 8 pounds. Of course, as soon as we started raising the antenna, a brisk wind arose where there was previously none, complicating matters, and wires were swaying precariously all over the roof (it is a good thing our insurance agent didn't hear of this episode).

Adjustment

Adjustment of the antenna is not difficult if is undertaken properly. One of the easiest ways to accomplish this adjustment is to have one person at the base of the antenna with a long pole to move the slider on the reflector stub, one person operating the transmitter and receiver, and a distant local ham (1 to 10 miles) with an S=meter to serve as a guide to adjustment. Using voice break in, a smooth system was devised whereby the distant ham would call off the S=meter readings and I would shout these up to the man on the roof. The man on the roof just moves the slider for maximum S=meter readings, with the quad pointed at the distant ham, naturally. If the antenna was designed properly, the whole job of adjustment takes less than 10 minutes.

Performance

The most important characteristic of any antenna is its performance. The standing wave ratio of the broadband quad is much lower over the entire band than a single wire quad antenna (fig. 2), much greater freedom of

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frequency movement is available with the broadband quad. There is ample forward gain, averaging 10 *db* over the band, which represents an increase in radiated power of 10 times. A 30 watt transmitter with a quad will far outperform a 150 or 200 watt transmitter using a dipole. The directional characteristics of the antenna help considerably in reducing unwanted QRM.

The actual signal reports which I have received from foreign stations ranging in distance from 3,000 to 11,000 miles away have more than justified the construction of the antenna. These reports have ranged from 10 to 20 *db* better than a ground plane antenna previously in use at my station. DX becomes a pleasure rather than a rat race competition with the kilowatt stations.

I feel that this antenna is a worthwhile project for anyone interested in improving his signal on any high frequency.

I would like to thank Erwin Lodwig K2ODS, my father, for his cooperation in helping me prepare this article. ■

DIPOLE [*from page 41*]

Impedance matching is no problem because either 72 ohm coaxial cable or 72 ohm twin-lead line will do.

I tried various configurations of the dipoles (including those shown in amateur radio handbooks) and came up with the one shown in fig. 1. I found this configuration to give me the *best overall* on-the-air results. Reflectors were tried too but their construction was not worth the effort.

Referring to fig. 1, you will see that there is one dipole for each band except the 15 meter band. The antenna cut for 40 meters operates exceptionally well on 15. All dipoles (connected in parallel) are cut for mid-band operation and are ½ wavelength long.

Construction of the three insulator divider is not difficult. The insulators are arranged as shown using number 8 copper wire. The 40 and 80 meter dipoles are first attached to their insulators in the regular manner and then the separator wires are inserted. Solder is then poured into the insulator holes (with the bottoms blocked). The resultant connection is sturdy and electrically excellent. (Remember to tin all wires before pouring the solder into the holes!)

Coax cable connection is easily accomplished by using a medium to heavy piece of braid (shield) which is wrapped and soldered to the coaxial shield. The braid is then soldered to one side of the copper thru-wire. The center connection is simply brought up to the other side of the center separator and soldered. Plastic tape is used to seal off the end and to prevent moisture from accumulating between the coax shield and the center conductor.

The overall bandwidth of this antenna is