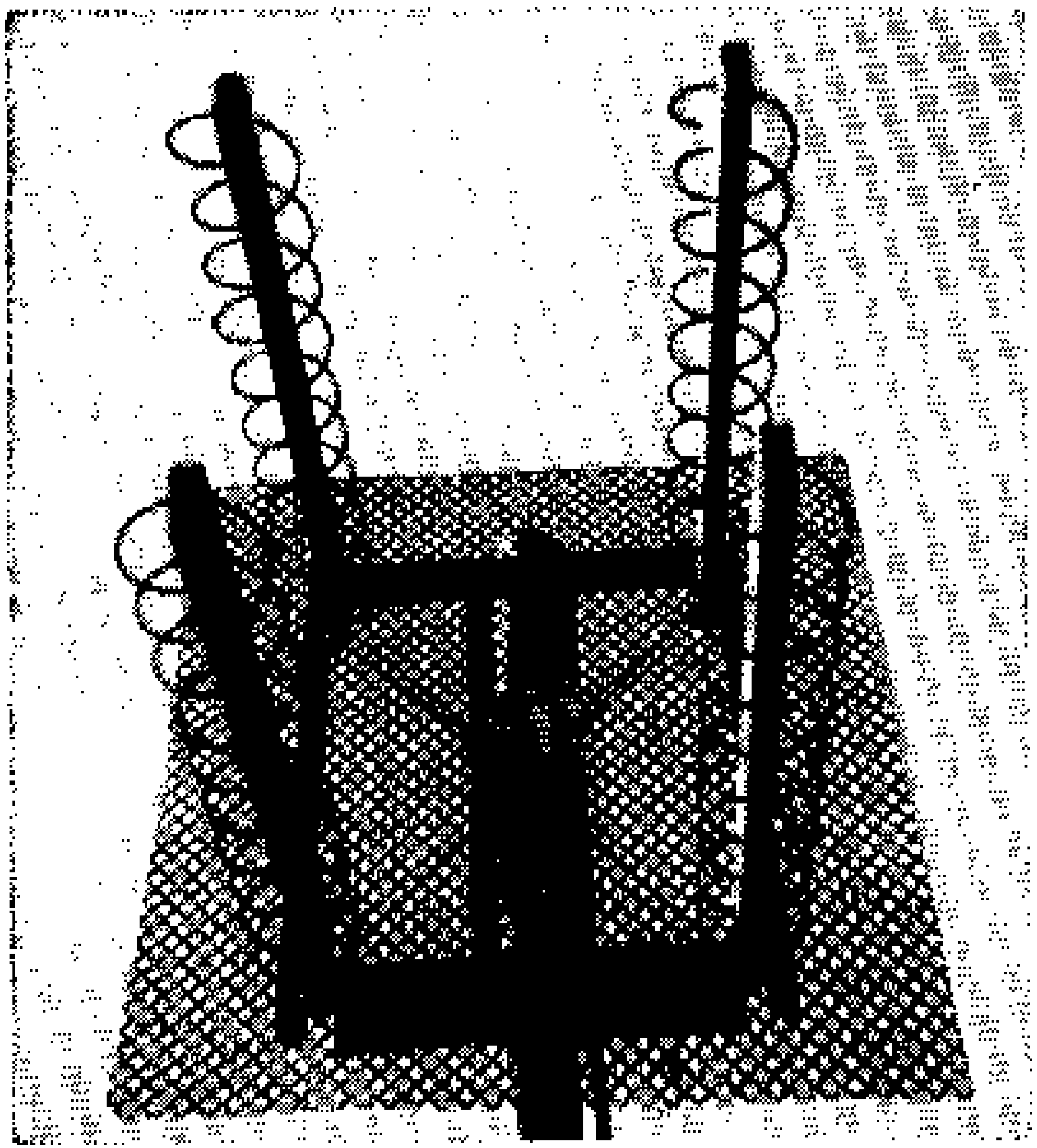
A Quadhelix Antenna for the 1215-Mc. Band



High Gain and Simple Matching

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Front view of the 4-helix array for 1215 Mc. The coils are terminated at a common junction at the center of the array. The slope of the terminating wires with respect to the ground plane determines the feed impedance. This makes possible the matching of four helices without the use of a coaxial transformer.

In recent years, it would seem that much of the use of the 1215-Mc. band has been carried out with accurate and stable receivers and transmitters, and 10- to 30-foot dishes on alt-azimuth mounts, for moonbounce work. Certainly this is an exciting activity. However, for those who do not have these tools of the trade, a return to earth may be in order. Many readers may be aware of the amazing ranges achieved by L-band radars during certain tropospheric conditions, that permit these radars to "paint" targets to well over 2000 miles. The author submits that these tropospheric conditions exist quite frequently. With these conditions, a parametric amplifier,[1] a good crystal converter,[2] and an antenna of the type to be described should provide many firsts and much excitement, even with moderate transmitter power.

General

The helical antenna has suffered in popularity (but not in performance) because it is not generally well understood. That crazy corkscrew is capable of generating linear, elliptical, or circular polarization, but perhaps because of its attendant problem of matching an odd-ball feed impedance to a standard transmission line, it seems to find little acceptance in amateur circles. It is common in communication with missiles and satellites, however. Since this article is primarily concerned with a method of building a quadhelix, the author refers the technical reader to the source book, *Antennas*, by Dr. J. D. Kraus (W8JK), McGraw-Hill Book Co., Inc., New York, 1950.

The helical antenna represents the transition point between linear-element antennas and the loop antenna. It has several modes of operation which are controlled strictly by its geometry. It can radiate in an axial mode, along the axis of the helix, or in a broadside mode, perpendicular to the helix axis. Since the axial mode is of concern in this article, only that mode will be discussed. Once the basic geometry is established for axial-mode radiation, we find that other changes in the geometry can create either of the two linear polarizations, horizontal or vertical. Elliptical polarization, or the case in this article, circular polarization, can also be generated. To make the subject even more interesting, we can also generate either right-hand or left-hand circularity. The u.h.f. men can now spend many pleasant ragchewing hours over the relative merits of right-hand *vs.* left-hand circularity. In fact, some of the subtleties in simply understanding the definition of right- or left-hand circularity could provoke excellent occupancy of the 1215-Mc. band, just to get in on the battles — er — discussions. As a standard to take off from, the author suggests winding the helix turns clockwise. Opposite circularity will result in working only those signals which bounce from perfect reflectors.

The helix is inherently a broadband antenna, which eliminates s.w.r. problems over an amateur u.h.f. band. Bandwidth is on the order of 1.7 to 1 in frequency. Expressed in terms of the helix circumference wavelength, this represents a range of from approximately 0.73 to 1.22 wavelengths. Over this range, the v.s.w.r. varies very little, remaining in the order of 1.15 to 1. Also over this range, the input impedance can be seen to vary on a Smith chart in tight curls from about 120 to 160 ohms, thus the generally

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[1] Troetschel and Heuer, "A Parametric Amplifier for 1296 Mc.," *QST*, January, 1961.

[2] Meyer, "A Crystal-Controlled 1296-Mc. Converter," *QST*, September, 1962.

quoted figure of 140 ohms. The pattern of the antenna is a well-defined lobe in both the vertical and horizontal planes over the antenna bandwidth, with pattern breakup occurring at the limits. There is a definite sharpening of the antenna pattern when the helix is used near its upper frequency limit, and this characteristic was utilized to some extent in the design of the quadhelix in this article.

The only difficult part of the helical antenna is the problem of matching the feedline to the impedance of the helix. Several articles have described one- to three-helix arrays,[3] and have described how to build the coaxial matching section required to match the array. There is nothing wrong with the theory, but coaxial sections are tedious to build, they do fill up with moisture, and it takes considerable faith to be sure that the matching section you build is really ¼ or ¾ wavelength, or some other needed value, at these frequencies. The quad described gets around this problem by using simple tapered lines as the matching sections. (See Fig. 1.) Further, if one helix is good, two — properly matched and phased — are approximately 3 db. better. Four helices are another 3 db. better yet — and easy to match by the method described.

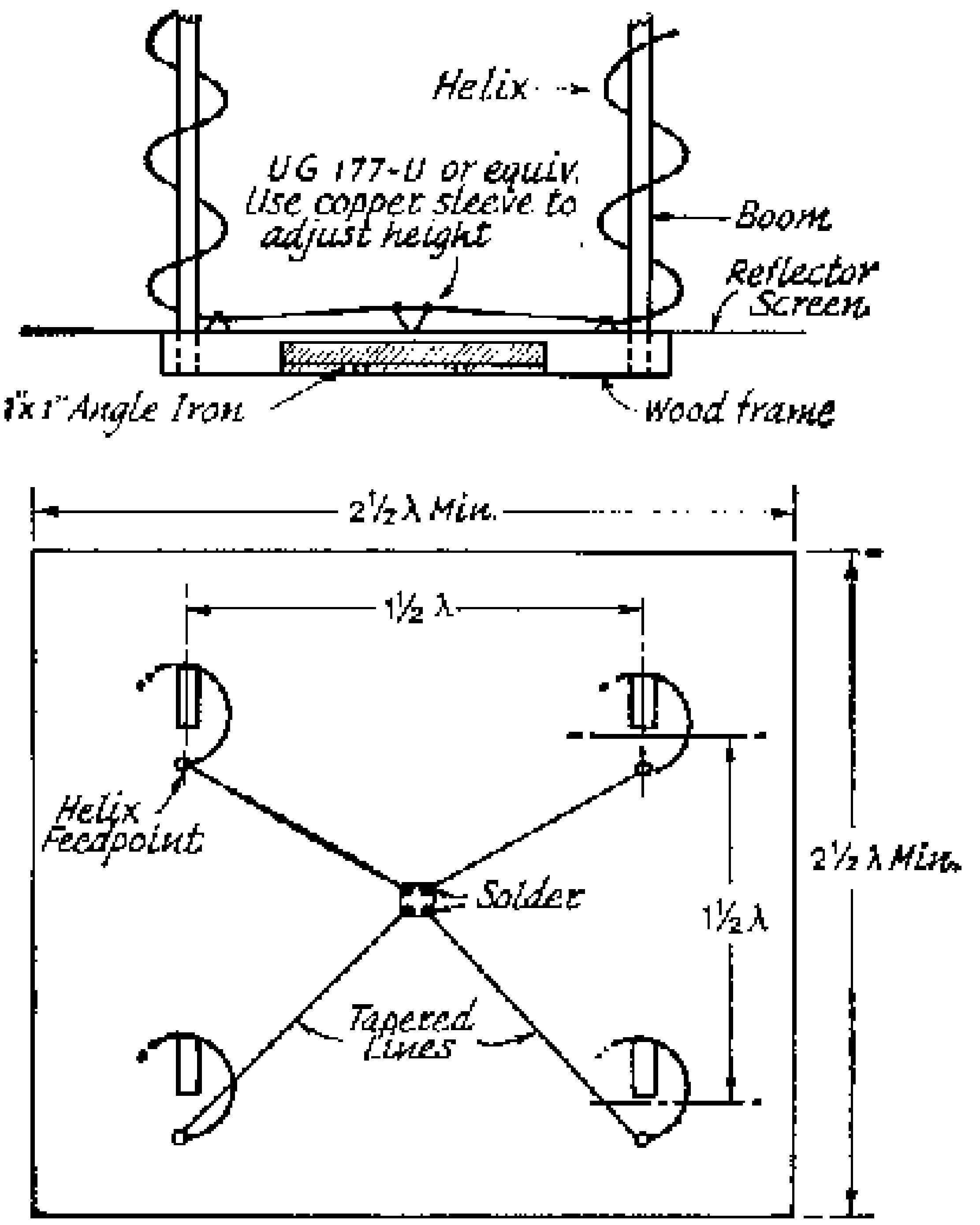


Fig. 1—Top and front views of the quadhelix array. The termination at the center is a UG-177/U coax hood. This connects to the center pin of an N-type coaxial fitting which projects through the ground plane to provide a point of connection for the transmission line. Height of the junction may be varied to achieve an impedance match.

Construction

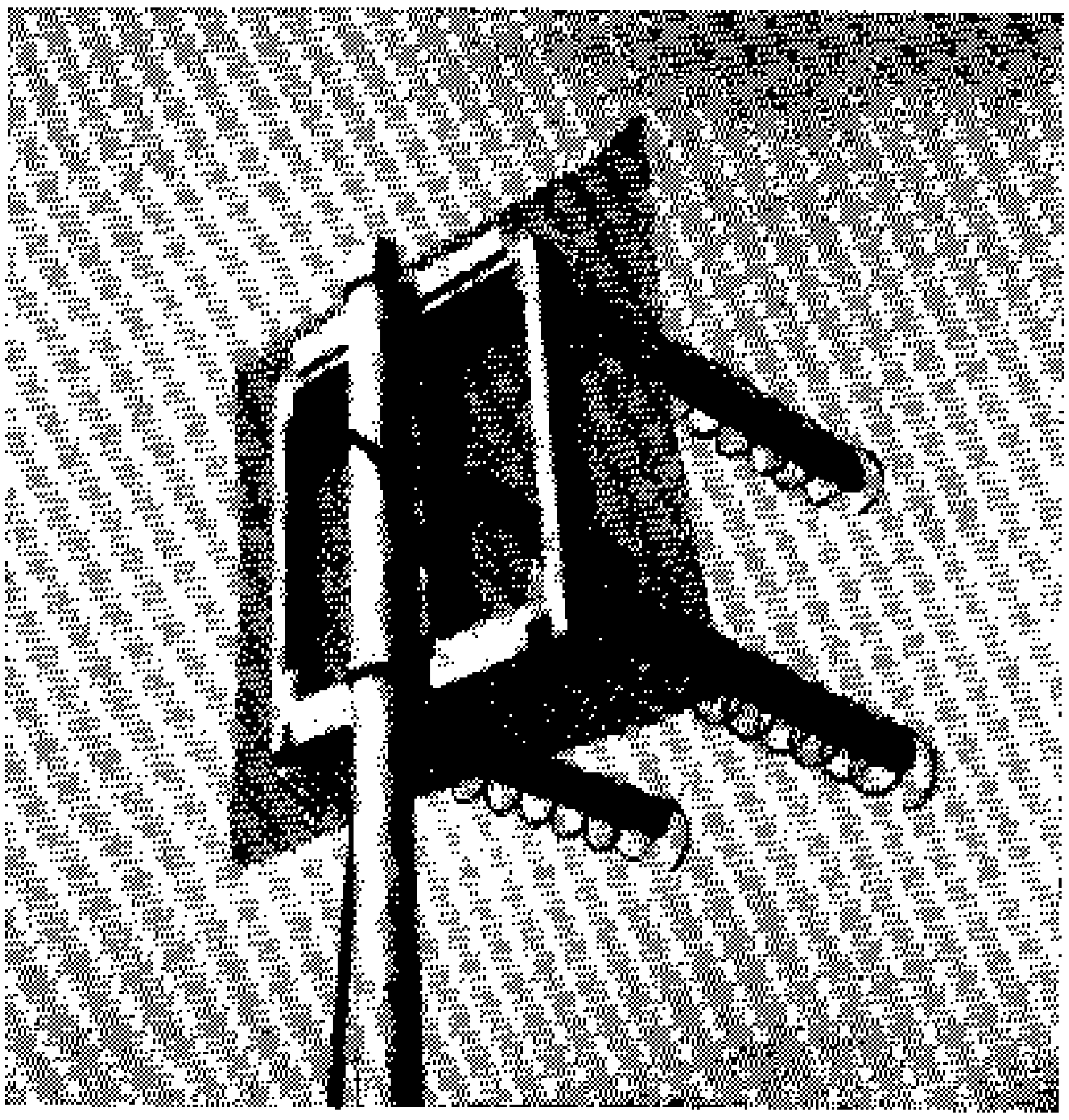
The quadhelix consists of four ten-turn helices formed from No. 10 AWG copper house wire from which the insulation has been stripped. The helices are mounted on booms made from 1 × 2-inch smooth lumber. These booms are attached by wood screws and wood glue to a frame made from the same size lumber. The wooden portion should be painted or stained as a weather preservative. Fastened to the top and bottom of the frame are two 8-inch pieces of 1 × 1 inch angle iron from your favorite hardware store. These angle-iron pieces are drilled to accommodate the U bolts, which will fasten this antenna to the mast.

The sheet reflector is made from perforated aluminum. This also forms the ground plane for the matching lines. From the photograph it can be seen that a small piece of sheet aluminum was used to stiffen the ground plane at its center, where the coax connector is attached. Mounted on the antenna side of the ground plane are tapered lines, which make up the matching section. These lines connect together at the coax feed point, and the other ends provide the feed to the individual helices. The tapered lines are of such a geometry as to transfer the approximately 140-ohm impedance of the helices to a 200-ohm point at the coaxial fitting. Strapping all four of the 200-ohm points together provides the 50-ohm feed point required for RG-8, -9, -14, or -17 coaxial cable. The tapered lines are also made from No. 10 AWG wire.

If you desire to vary the impedance ratios because of a different feed-line impedance, the following calculation is typical: For a single wire near a ground:

$$Z_0 = 138 \log_{10} \frac{4h}{d}$$

Where h is the height to the conductor center, and d is the wire diameter.



Rear view of the helical array at K6UQH, showing the wooden frame and angle irons used for mounting the frame to the vertical support.

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[3] Scott and Banta. "Using the Helical antenna at 1215 Mc.," *QST*, July, 1962.

In order to reduce any interaction of the fields between the helices and the tapered phasing lines, it is important to keep the tapered lines as close to the ground plane as practical. This condition can be met by using No. 10 wire for the tapered lines. The diameter of this size wire is 0.1019 inch. Then, assuming that the impedance at a helix feed point is 138 ohms,

$$\log_{10}\frac{4h}{d} = \frac{138}{138} = 1$$

$$\frac{4h}{d} = 10$$

$$h = \frac{10 \times 0.1019}{4} = 0.254 \text{ in.}$$

This is the height at the feed-point end of each helix. At the coax end where the four tapered lines join,

$$\log_{10}\frac{4h}{d} = \frac{200}{138} = 1.45$$

$$\frac{4h}{d} = 28.2$$

$$h = \frac{10 \times 0.1019}{4} = 0.717 \text{ in.}$$

Slight discrepancies here are nearly meaningless as the v.s.w.r. is between the four tapered lines in parallel and the 52-ohm coax line. For other conditions, just plug in the appropriate numbers. The important point is to keep the matching lines as close to the ground plane as possible.

The helices are mounted (center to center) on a square whose sides are 1.5 wavelength, or 13.7 inches. The tapered lines will then be approximately one wavelength long. In any case, keep the tapered line lengths equal. The aluminum reflector screen should be 2.5 wavelengths (minimum) on a side. The antenna described has a reflector screen which is 2 by 2 feet. The details of the individual helices are shown in Fig. 2. The over-all layout can be seen in the photographs. Mounting of the helix turns on the wooden booms was accomplished by using small metal horseshoe brads. A more elegant method would be to mount the turns on small standoff insulators. Care should be taken when adjusting the position of the helix coils on the boom to assure that the pitch angle (spacing between the turns) is the same for each turn of the helix. You should visually check to be sure that the helix circumference remains constant along the helix axis.

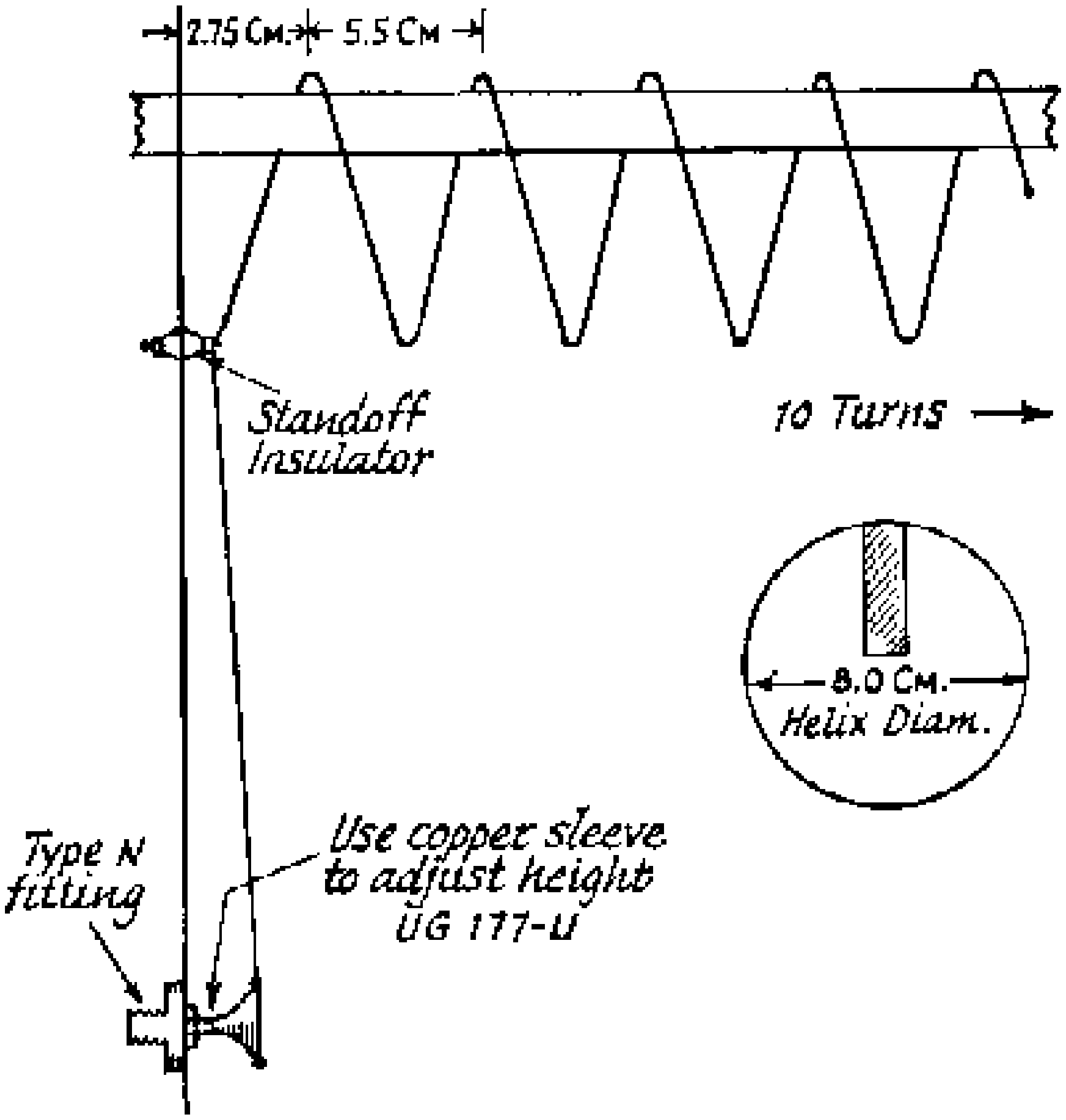

Fig. 2—Principal details of the individual helices and the termination.

Conclusions

Use of the quadhelix in the San Francisco Bay Area on various 1296-Mc. signals such as the gang up at Eimac and WA6JZN has thoroughly demonstrated its "searchlight" capability. It has a sharp beam pattern, and requires careful pointing. This antenna has a conservative 20-db. gain capability, and as such is not too far from a moonbounce antenna by itself. Several of these quads could be stacked for additional gain.

One caution: When this antenna is mounted on your mast, park your car in the driveway, not in the street. This corkscrew has a dangerous fascination for passing hams. Several near misses between parked cars and passing hams are on record near my home location!