A V-H-F Helical Beam Antenna

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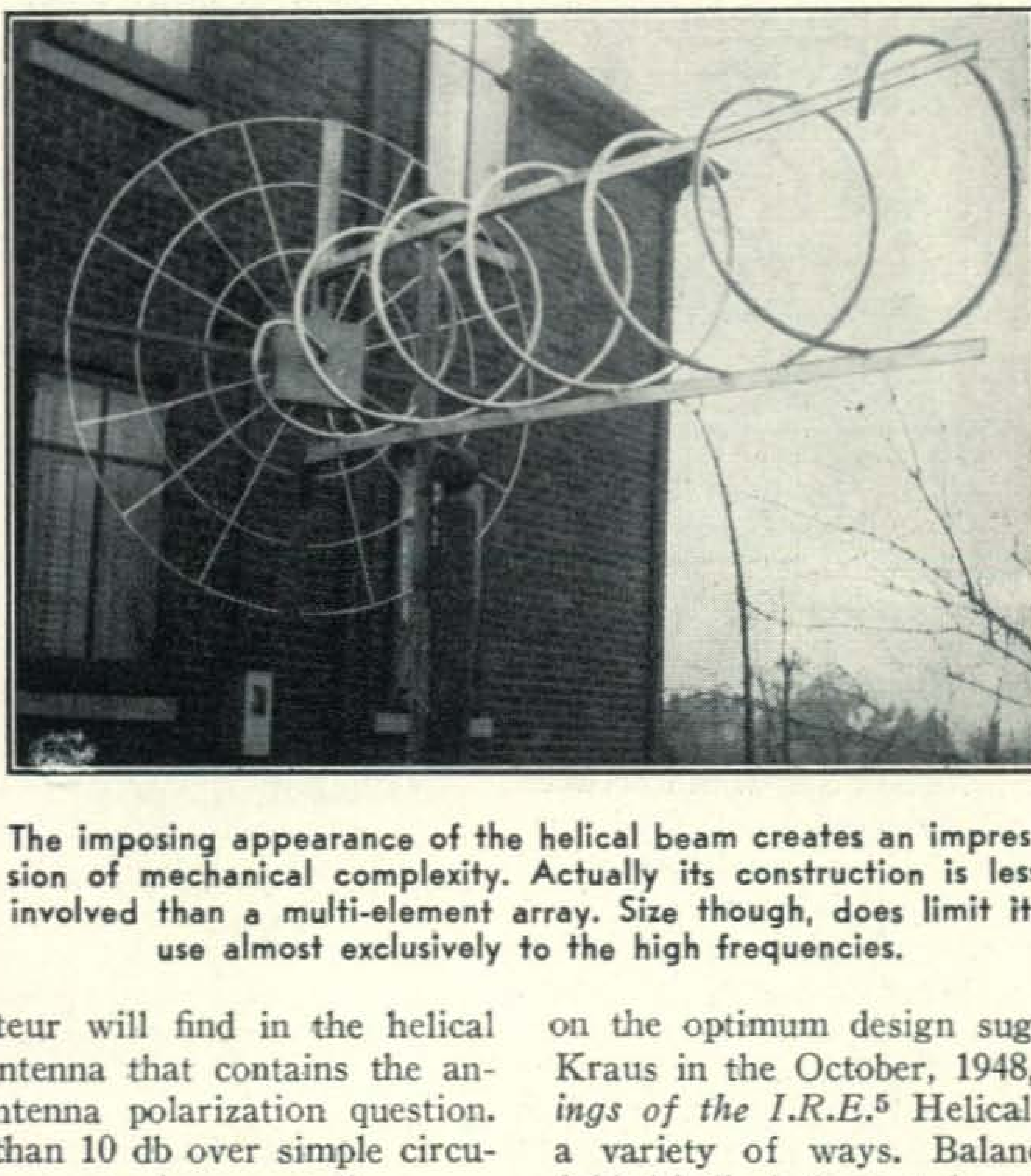
Circular polarization, with high gain, is the decisive settlement of the vertical vs. horizontal dispute.

THIS article describes a new mode of operation of the helical [1] type antenna. It has been found that the helical beam as developed by Dr. John Kraus, W8JK, has several advantages of great significance to amateur v-h-f practices.[2,3,4,5]

The helical beam is derived from the excitation of a helical conductor having the circumference of approximately one full wavelength. The generated lobe pattern of such an antenna shows that maximum power is radiated along the axis of the helix (*see Fig. 1*). The beam width — and to some extent the power gain — depend largely upon the number of turns in the helix. The radiation in this axial mode is substantially circularly polarized, i.e., the field intensity is nearly equal on both horizontal and vertical type receiving antennas. In addition, the terminal impedance characteristic is unusually uniform over a very wide frequency range. Thus, the radio amateur will find in the helical beam a broad-band antenna that contains the answer to the v-h-f antenna polarization question. Power gains greater than 10 db over simple circularly polarized sources are to be expected.

To understand the operation of the helical beam let us re-examine *Fig. 1*. Note that since one complete turn of the helix equals one wavelength it will be found that at any given instant the positive and negative charges appear near opposite ends of a bisecting diameter. Throughout one complete cycle of the radiated frequency these charges will revolve and the pattern perceived directly along the axis is one of revolving or circular polarization. This axial mode condition depends upon certain mathematical and physical relationships of the diameter of the helix (D) and the spacing between turns (S). The region of axial mode excitation is shown graphically in *Fig. 2*. Operating the helical antenna beyond the prescribed diameter spacing limits (i.e., too high or too low a frequen- diated pattern. Such cy) distorts the ra- antennas do not retain the axial mode pattern, but instead, may radiate a conical lobe pattern[3] or even if the frequency is too low, a normal mode pattern.[6]



The imposing appearance of the helical beam creates an impression of mechanical complexity. Actually its construction is less involved than a multi-element array. Size though, does limit its use almost exclusively to the high frequencies.

The antenna described in this article is based upon the optimum design suggetsions given by Dr. Kraus in the October, 1948, issue of the *Proceedings of the I.R.E.*[5] Helical beams may be fed in a variety of ways. Balanced, double layer and folded helical elements have been tested.[3] However, the most convenient uni-directional beam is built around a helix mounted normal to a small ground plane. The terminal impedance is then about 130 ohms affording a good match to the RG-63/U coax line having a characteristic impedance of 125 ohms.

The antenna shown in the photo and *Fig. 3* was built and tested by W8RNC and W8VRQ on the 2-meter band. Over the entire 144-148 mc range the helical antenna had a gain of 11.5 to 13 db over a non-directional circularly polarized antenna. The

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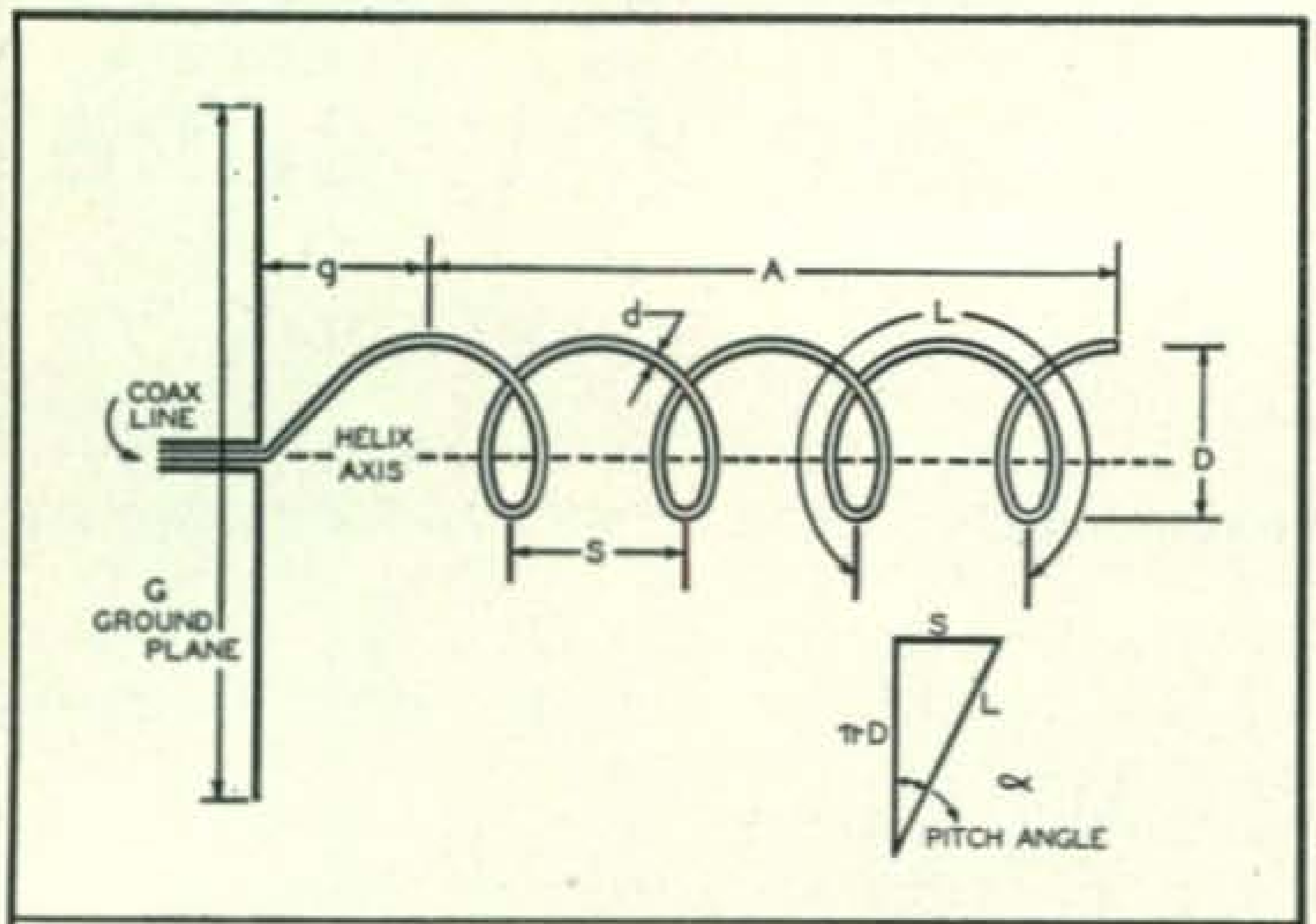
1 Helical: Of or pertaining to, or in the form of, a helix; spiral.. —Webster
2 J.D. Kraus, "Helical Beam Antenna," Electronics, vol. 20, April, 1947, page 109.
3 J.D. Kraus and J.C. Williamson, "Characteristics of Helical Antennas Radiating in the Axial Mode," Jour. Appl. Phys., vol. 19, Jan., 1948, page 87.
4 O.J. Glasser and J.D. Kraus, "Measured Impedances of Helical Beam Antennas," Jour. Appl. Phys., vol. 19, Feb., 1948, page 193.
5 J.D. Kraus, "Helical Beam Antennas for Wide-Band Applications," Proceedings I.R.E., vol. 36, Oct., 1948 page 1236.
6 H.A. Wheeler, "A Helical Antenna for Circular Polarization," Proceedings I.R.E., vol. 35, Dec., 1947 page 1484.



DESIGN DATA FOR 146.0 MC HELICAL BEAM

D -	DIAMETER OF HELIX	24"
S -	SPACING BETWEEN TURNS	19½"
L -	LENGTH OF ONE TURN	6' 9"
N -	NUMBER OF TURNS	6
A -	AXIAL LENGTH = NS	9' 8½"
∝ -	PITCH ANGLE	14°
d -	DIAMETER OF HELICAL CONDUCTOR	⅞"
g -	DISTANCE HELIX FROM GROUND PLANE	9¾"
G -	GROUND PLANE DIAMETER	66"

FOR OPTIMUM 14° PITCH ANGLE

$g=\frac{S}{2}$ $\quad A+g=S(N+\frac{1}{2})$ $\quad N=\frac{A+g}{S}-\frac{1}{2}$

IN WAVELENGTHS

WHERE:

$S = L \sin\alpha \qquad A = NS$

Fig. 1. A helical beam may be designed for another band if the dimension L is one wavelength in free space and the pitch angle maintained around 14°. Dimension g is not critical, although if the helix is too far from the ground plane, the feed impedance will be affected.

helix consists of 6 turns. The beam width between half-power points for the vertically polarized component was 56° and for the horizontally polarized component it was 52°. The six-turn helix is a compromise between power gain, terminal impedance, directivity, and constructional problems. It is possible to increase the power gain slightly by adding more turns to the helix. However, the mechanical difficulties would then probably offset the additional gain. Adding more turns would noticeably sharpen the radiated pattern, but would not appreciably change the feed point resistance of the antenna.

The helical antenna also will work well with a fewer number of turns and at some loss of power gain. The terminal impedance will remain fairly constant (about 130 ohms) with any helix of more than three turns. The six-turn helix will react in the axial mode over a frequency ratio of about 1.7:1 (about 110 to 180 mc). The SWR is well under 1.5:1.

Constructing the 2-meter Helical

The 144-mc helical beam consists of a 66-inch diameter ground plane and a 24-inch diameter helix. The ground plane is constructed of sixteen radials cut from ¼ inch soft drawn aluminum tubing. The helix is wound with ⅞ inch (O.D.) soft drawn aluminum tubing. The shield of the coax line is connected to the center of the ground plane and the center conductor to one end of the helix. The remaining helix end hangs free and is not electrically connected. Open-wire line cannot be used satisfactorily with this type of antenna.

The materials required to construct a 2-meter helical are as follows:

42 feet ⅞ inch O.D. aluminum tubing (soft)
78 feet ¼ inch aluminum tubing (soft)
One 12" x 12" aluminum plate
One 5-foot length 1" x 1" wood (ground-plane crossbrace)
Two 11-foot lengths 1" x 2" wood (helical supports)
One 66-inch length 1" x 3" wood (ground plane upright)
One 12" x 12" plywood ¾" thick
One support pole, misc. hardware, staples, coax cable, etc.

Ground Plane

Each of the sixteen radial elements is 30 inches long. These are spaced and supported in the ground plane by three concentric circles, also cut from the ¼-inch aluminum tubing stock. The first of these circles is wound from a piece 47 inches long, placing it about 15 inches from the center of the ground plane. The second circle is 151 inches long (concentric 24 inches from center) and the third is 207 inches long (concentric 33 inches from center). The ground plane tubing for each concentric circle was bent into partial shape by wrapping the tubing around the tub of a conventional washing machine.

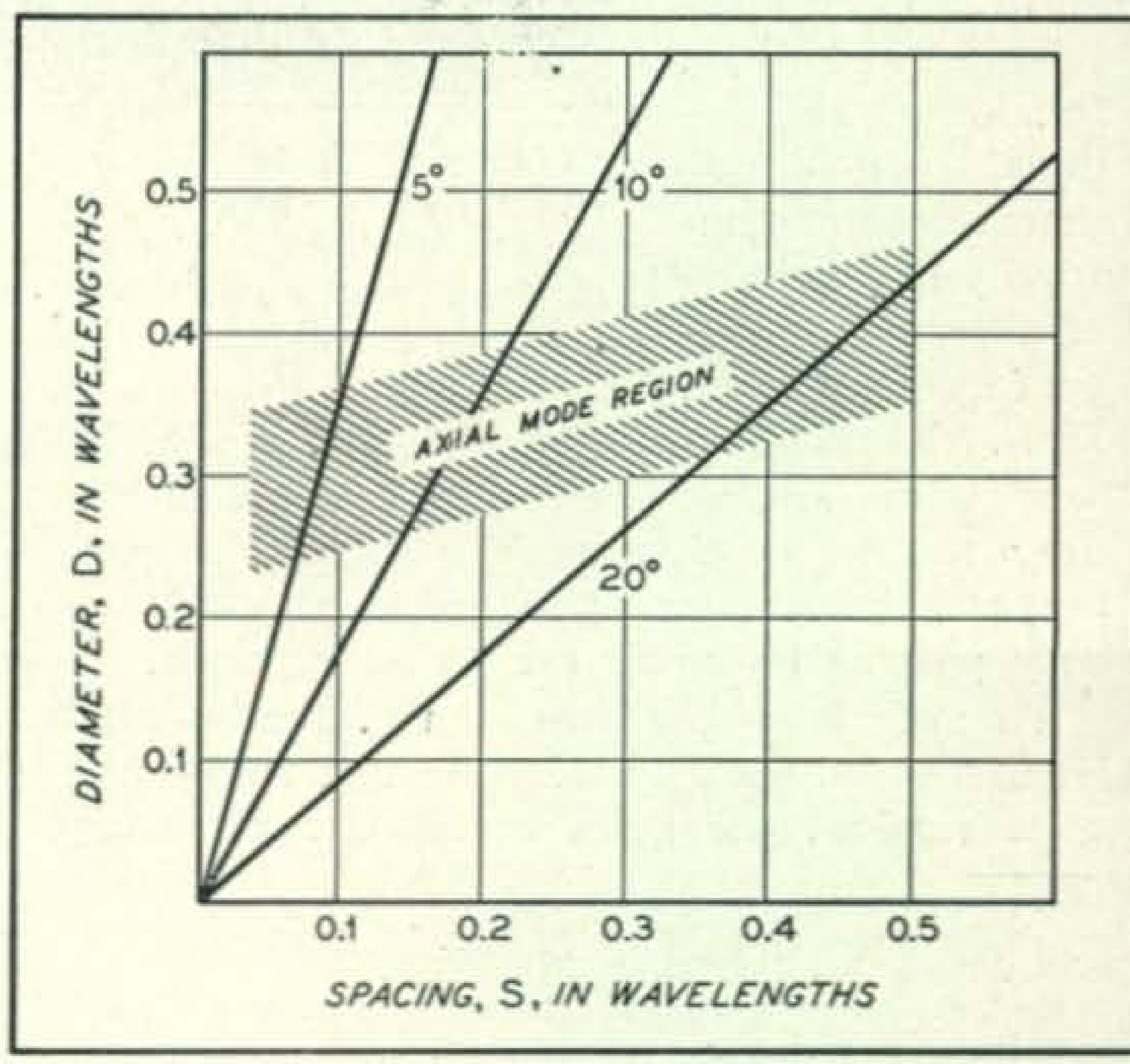


Fig. 2. The ratio of diameter to spacing of the helix will determine the mode of operation and the type of pattern radiated. Helical beams radiate in the axial mode. Parameters are pitch angles between adjacent turns. The frequency ratio corresponds to the length of the paramenters in the shaded area. For the 144-mc beam with an angle of 14° it extends from about 110 to 180 mc.

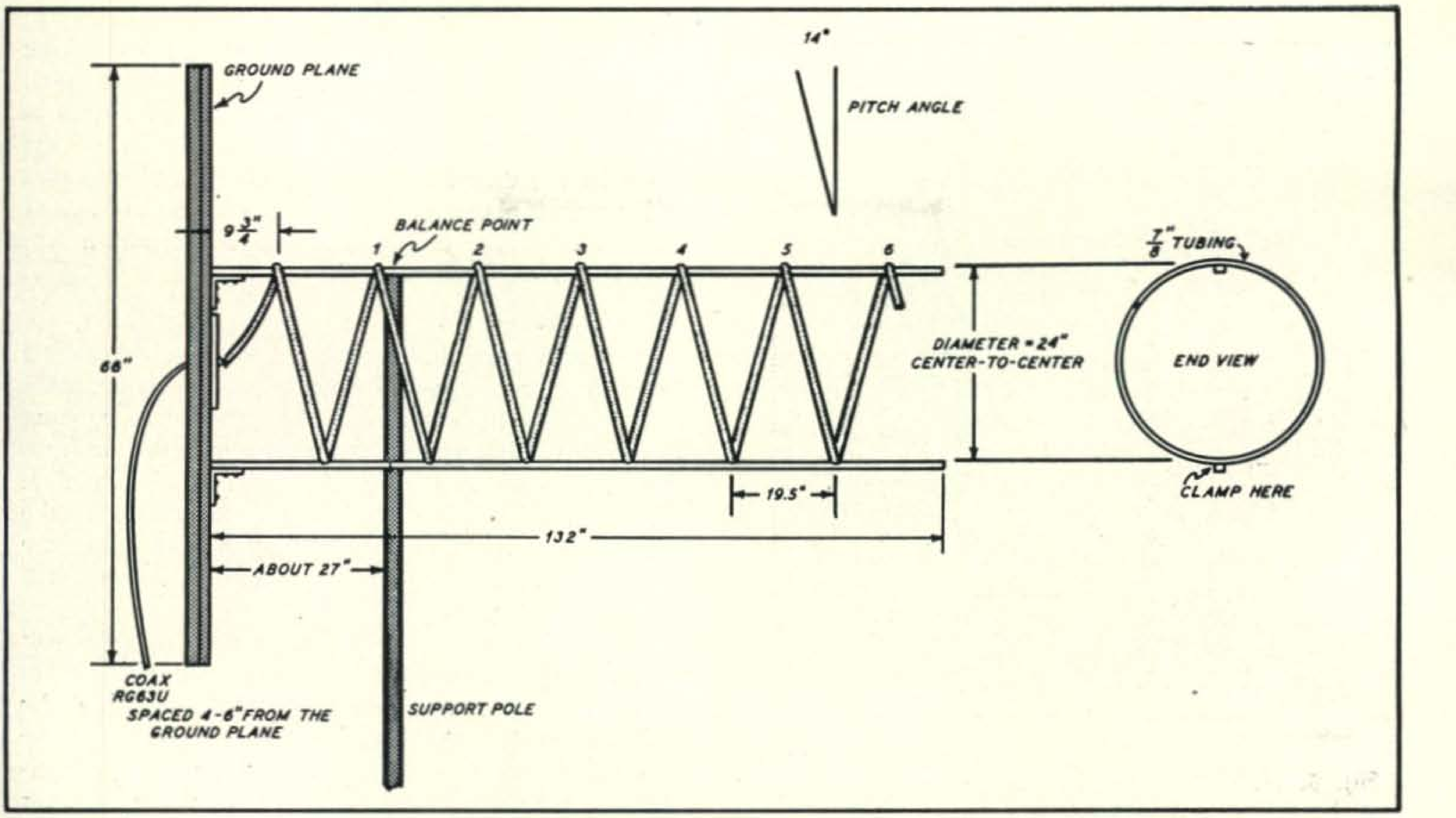


Fig. 3. Side constructional view of the 2-meter helical beam. The ground plane is attached to the helical supports by two 8-inch metal brackets. The array is held aloft on one pole located at the balance point.

Details of the ground plane construction are shown in *Fig. 4*. Each connection between the radials and the concentric circles is fastened with brass bolts. The center of the ground plane is an aluminum sheet about 12 inches square. A 6-inch diameter circle is scribed from the center of the aluminum. Each radial is cut off at this circumference line and is then hammered flat, so that the plywood and the aluminum sheet may be sandwiched together. Each radial is fastened to the plate with small nuts and bolts.

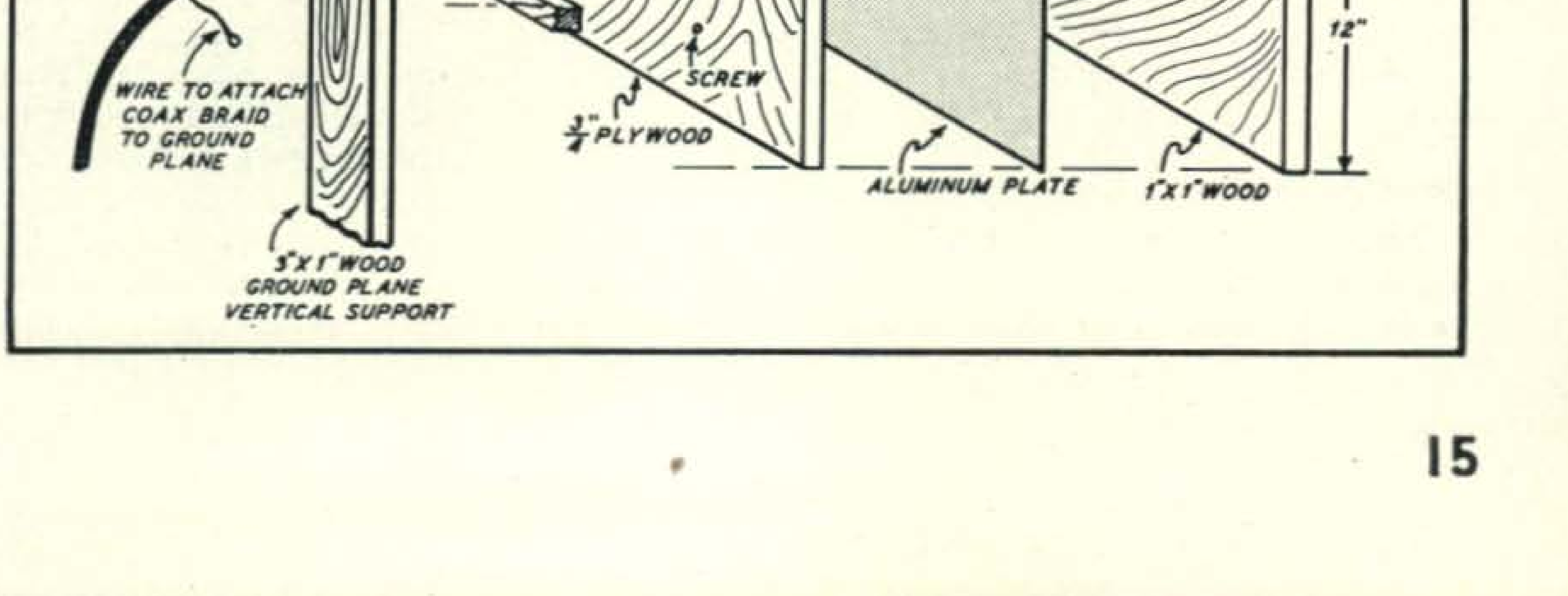
Once the ground plane has been assembled, a ½-inch hole is drilled through the support pole and the center plates. This is for the coax transmission line. The shield of the line is connected to the ground plane by inserting one or more metal screws through the wooden back plate to contact the aluminum sheet. A wire is brought over from each screw to the coax shield. These wires should be kept very short, about 1 inch long.

The ground plane tubing is clamped to the wooden supports with small saddle staples. Although the washing machine was not of the proper diameter for the concentric circles, it does, however, serve as a means to assist in shaping the tubing so that very little extra manipulation is required. Altogether, it takes two men about three hours to form, cut and assemble all the aluminum in the ground plane using a small electric power drill.

The Helix

The tubing for the helix is not a continuous length, but consists of five lengths of tubing joined together by small pieces of telescoping tubing and fastened in place with self-threading sheet metal screws. Each length is bent into shape before joining. The helix tubing is wrapped or bent around an oil drum having a diameter of 24 inches. When

Fig. 4. One suggested method for constructing the ground plane center. Radials are hammered flat at one end, then drilled and bolted in two places. A one-half inch hole is drilled through the supports and the ground plane center for the coax conductor which is attached to the end of the helix. Heavy aluminum material with radials directly supported and a coax connector for the feedline will also prove effective.



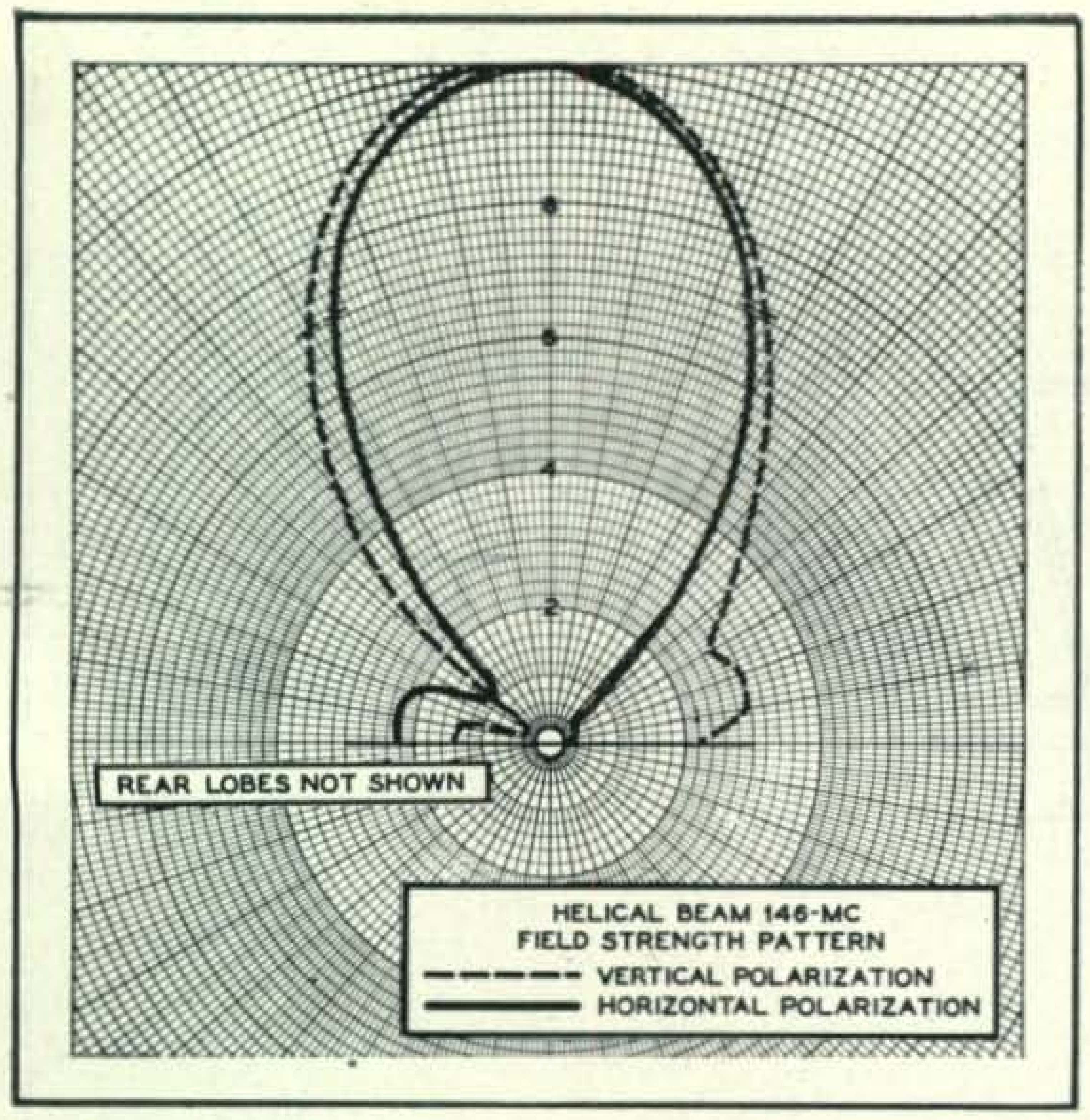


Fig. 5. Field strength patterns showing the similiarity in the vertical and horizontal polarizations as received and transmitted by the helical beam.

the tubing is removed from the oil drum a slight expansion takes place, so that if possible a slightly smaller diameter drum might be preferred. Some distortion can be tolerated in bending the tubing, although the same diameter tubing should be used throughout the entire length of the helix (except for the telescoping sections).

Each turn of the helix is fastened to the horizontal supporting member with small aluminum clamps. It is desirable that these wooden supports be varnished so that good insulation will be maintained in all types of weather. The helix supports are secured to the ground plane upright by two 6-inch kitchen shelf brackets. These are fastened to the vertical member of the ground plane with small bolts.

For ease of rotating and mounting the helical, the array is supported at the balance point. This is the point where the beam will hang horizontally. Using the materials described this will be between two and three feet from the ground plane along the helix supporting members. At the balance point only a vertical load is being exerted and, thus, a single vertical wood pole may be used to hold the beam in the clear. By rotating the pole, the helix and ground plane assembly can be turned in any direction. Additional details on construction are shown in *Fig. 3*.

Tests and Conclusions

The constructional tolerance of the helical is much greater than with other beams of comparable gain and dimensions. It may truly be cut according to physical dimensions, connected up and put into immediate operation with no further adjustments. The model just described was constructed in the basement of W8RNC's residence. By removing the ground plane, the helical was taken out doors without knocking down any walls.

Figure 5 shows the field strength pattern for both the horizontally and vertically polarized components. These tests were made by rotating the helical beam about a horizontal axis. During the time of these tests the helix became coated periodically with sleet, but no change in the 2-meter final amplifier loading could be detected. Some minor lobes are observed on the reversed side of the ground plane, These will be well down and are not shown in the field strength plots.

The diameter of the helix tubing is definitely a factor in the operation of the helical beam. It is recommended that tubing be used with a diameter of at least ¾ inch. If the 6-turn helix is inconveniently large, it can be reduced to 3 or 4 turns with a reduction of about 3 to 4 db in gain. Also, a ground plane consisting entirely of copper screen mesh might be constructed having the same area. A square ground plane having 66 to 70-inch sides also might be used.

The helical beam possesses the outstanding feature that it transmits and receives both horizontally and vertically polarized signals. Since the impedance is relatively constant over a very wide range this antenna might find useful applications in television fringe areas. For the amateur, however, it is the answer to a big problem.

Postscripts

Texas Hamfest

The South Plains Amateur Radio Club is sponsoring a hamfest in Lubbock, Texas, on April 23-24. It will coincide with the Electrical Engineering Show held at Texas Technological College and the hamfest will include a trip to the show. The Lubbock XYL Club will have a program for the XYLs. For reservations write Rogers Orr, W5NIC, 2501 23rd St., Lubbock, Texas.

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North Shore Radio Club Hamfest

The North Shore Radio Club of Long Island will hold its fourth postwar hamfest on Tuesday, April 19th, at Lost Battalion Hall, 9329 Queens Blvd., Elmhurst, L. I., at 8:30 p.m. The program will include speakers from ARRL, *CQ*, and FCC, with entertainment and prizes headed by a Collins 75 A-1 receiver. The Hall can be reached by the Independent subway to the Woodhaven Blvd. station. Tickets, available at New York equipment dealers, through the committee, or at the door, are $1.50.

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San Diego Hamfest

The Helix Amateur Radio Club is sponsoring a hamfest on Saturday, April 30th, at the Imig Manor Hotel, San Diego. The program will consist of technical talks, demonstrations and contests in the afternoon, followed by a banquet and entertainment in the evening. Main door prize will be a television receiver. For information and tickets ($4.25 per person) write E. Soltez, W6NQK, 350 Gavin St., San Diego 2, Calif.