The Zig-Zag Array

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A compact sixteen-element, vertically-polarized beam, with a gain of over 11 db, which you can build for about seven dollars.

It is particularly true in the antenna field that you never get "something for nothing." Gain, bandwidth, and physical size are closely related, and any change in one must be at the expense of one or both of the others. In spite of the somewhat unusual appearance of the antenna to be described, it is no exception to the above, and the measured gain proves to be almost exactly that derived from the aperture area. It does, however, offer maximum performance within its size with definite advantages of simplicity of construction and adjustment.

Theory of Operation

This antenna is fundamentally a condensed version of the Chireix-Mesney, French array, which dates back a good many years, and was used in large curtains at high frequencies. The actual operation of the array can, perhaps, be most easily seen from *Fig.* 2. Starting with the two-wavelength open ended transmission line of *Fig.* 2A, with the current flow in each half-wave section being indicated by the arrows for excitation at either end or any high voltage point, the basic radiating section of the antenna can be formed by assuming the transmission line to be pulled into the shape of *Fig.* 2B by pulling out the X-marked points and holding the original spacing at the Y-marked points. It will be seen that the vertical components of the current flow in each half-wave section are all in the same direction, while the horizontal components all oppose each other—thus effectively cancelling the horizontally-polarized radiation. The vertical in-phase components form, in effect, a broadside array of eight elements fed in phase. A similar explanation of the operation may be arrived at by considering the upper and lower halves as being long-wire antennas folded to keep the vertical current components in phase.

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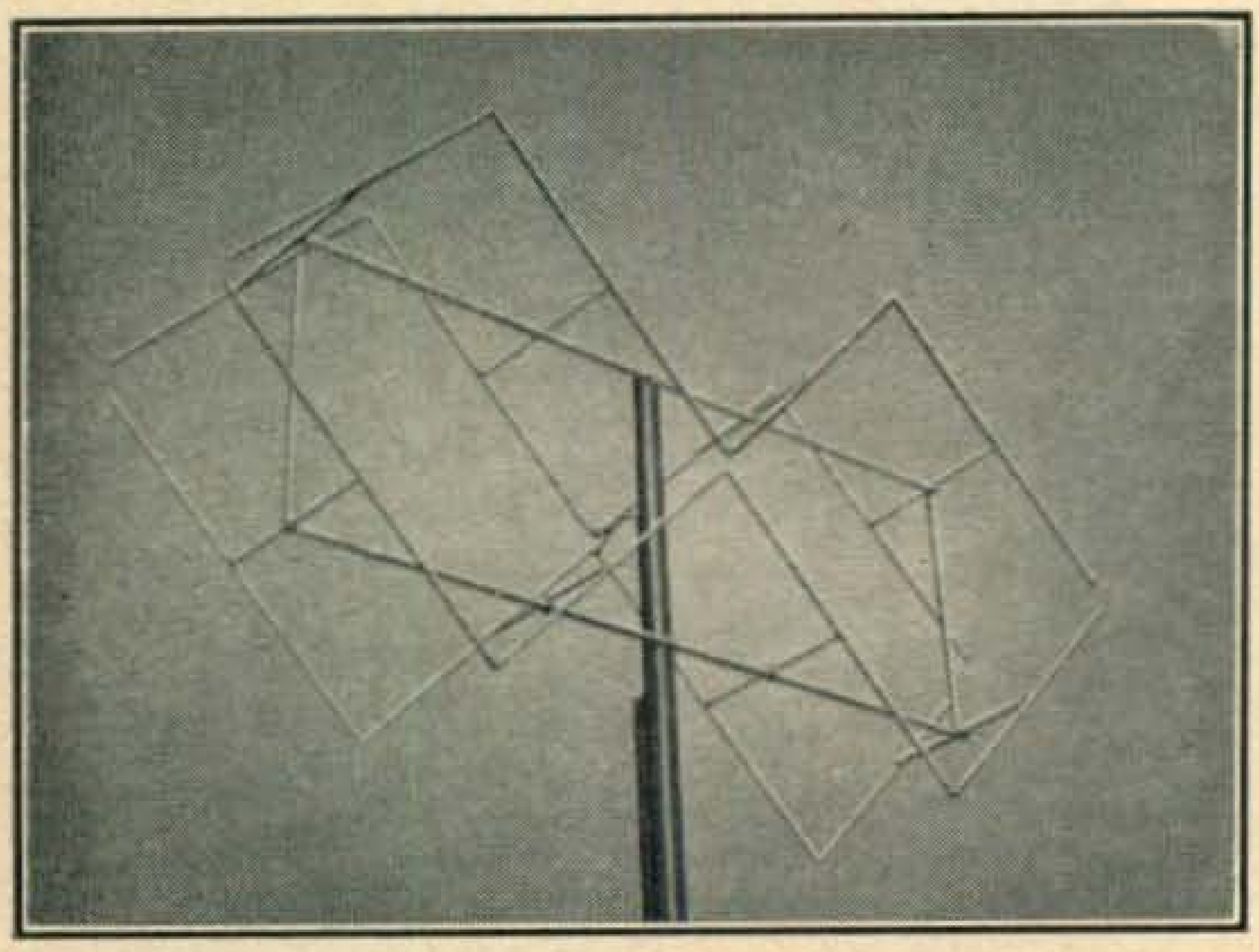

Fig. 1. Here's how she looks when completed and mounted atop your tower.

The operation of the parasitic reflector is conventional, and the reflector is an electrical and mechanical duplicate of the radiating section, spaced a quarter wavelength behind the driven half. The antenna can be fed at either end or at the center, but, to maintain exact symmetry, it is highly desirable to feed the antenna at the center point. The impedance at this point for the full array is from 600 to 900 ohms, depending upon the size of elements used.

The resulting complete array is a compact sixteen-element, vertically-polarized beam requiring no phasing lines, and with a gain of approximately

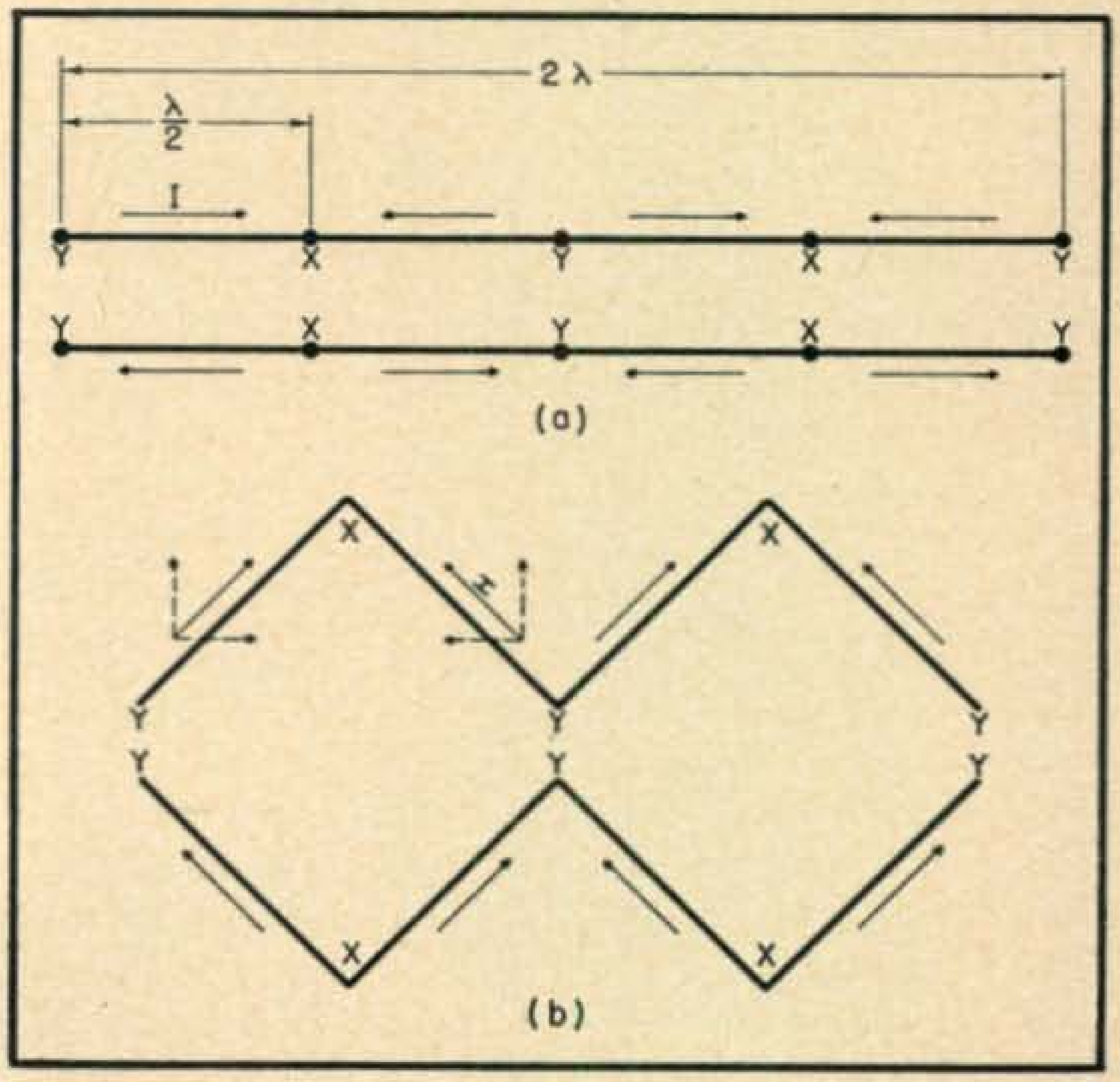

Fig. 2. The development of the Zig-Zag array, illustrating a two-wavelength transmission line (a), and its transformation into a hot antenna (b).

11.5 db. The measured vertical and horizontal patterns are shown in *Figs.* 3 and 5. The horizontally-polarized radiation is too weak to be indicated on the same pattern scale with the vertical pattern. The antenna can, of course, be used on horizontal polarization by rotating the mounting 90°.

Constructional Details

The antenna illustrated in *Fig.* 4 was constructed in a matter of a few hours at a cost of approximately $7.00 for the aluminum involved. Each of the four main element sections is a continuous piece of one-quarter inch soft drawn aluminum tubing. The horizontal spacers are quarter-wave sections of $\frac{5}{16}$-inch hard drawn tubing. These spacers are slotted at the ends with a rat-tail file, slipped over the quarter-inch element sections at the center of each half-wave section, and crimped around the quarter-inch tubing with gas pliers. The supports for the upper and lower halves of the antenna are

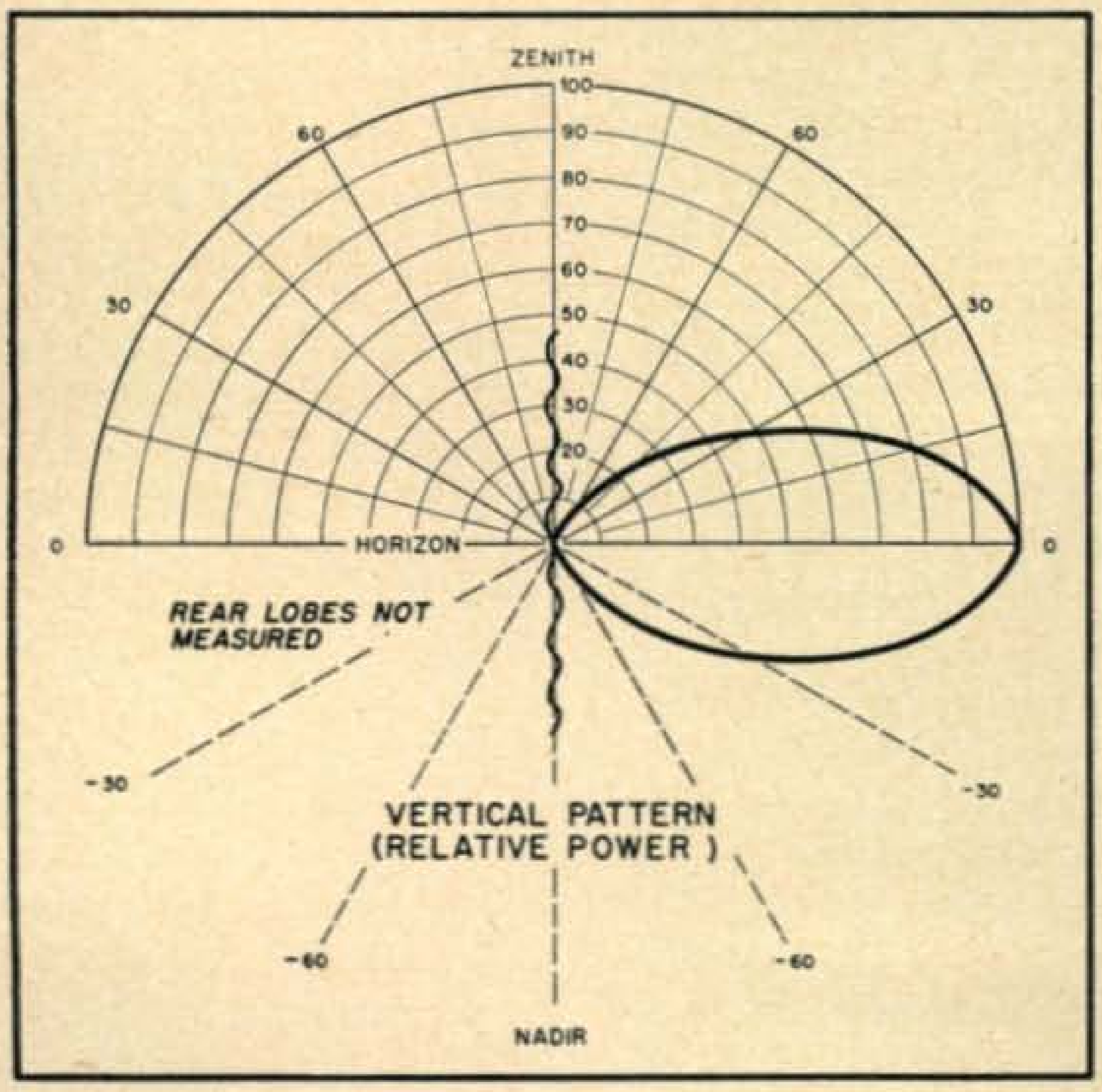

Fig. 3. The radiation pattern in a vertical plane, illustrating the low angle of radiation attainable with the Zig-Zag array.

two pieces of $\frac{7}{8}$-inch, 0.065-inch wall thickness, hard drawn aluminum tubing which was notched with a hack saw to receive the $\frac{5}{16}$-inch spacers, and then secured to the spacers with a single 6-32 bolt at the center of each spacer. It will be noted that in the antenna in *Fig.* 1 there are two extra

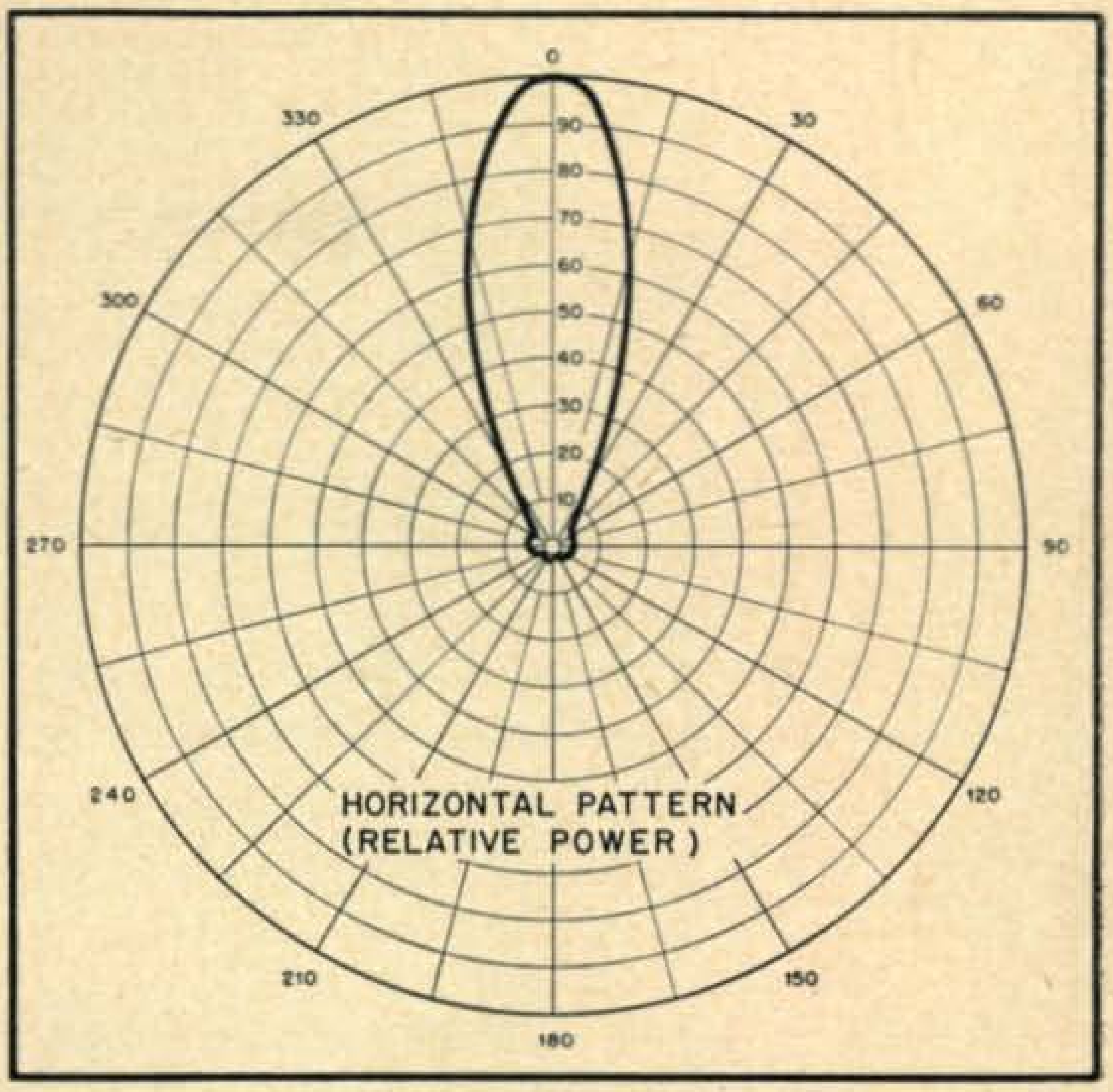

Fig. 5. The radiation pattern in the horizontal plane is sharp enough to please the most rabid beam enthusiast.

vertical struts between the spacers at each end. They were added to this particular antenna because of the twisting in the U-channel used as the vertical support, and would not be necessary if a stiffer support were used. The feed line is attached across the center of the driven section with element clamps made from pairs of small cable clamps.

The construction described can be modified or varied to meet the desires of the individual constructor. Any combination of horizontal or vertical members may be placed between the centers of the half-wave elements, as these points are zero current points and the vertical members less than the resonant length.

The antenna shown is fed directly with 300-ohm twin-lead, since the resulting 2.5 to 1 standing wave

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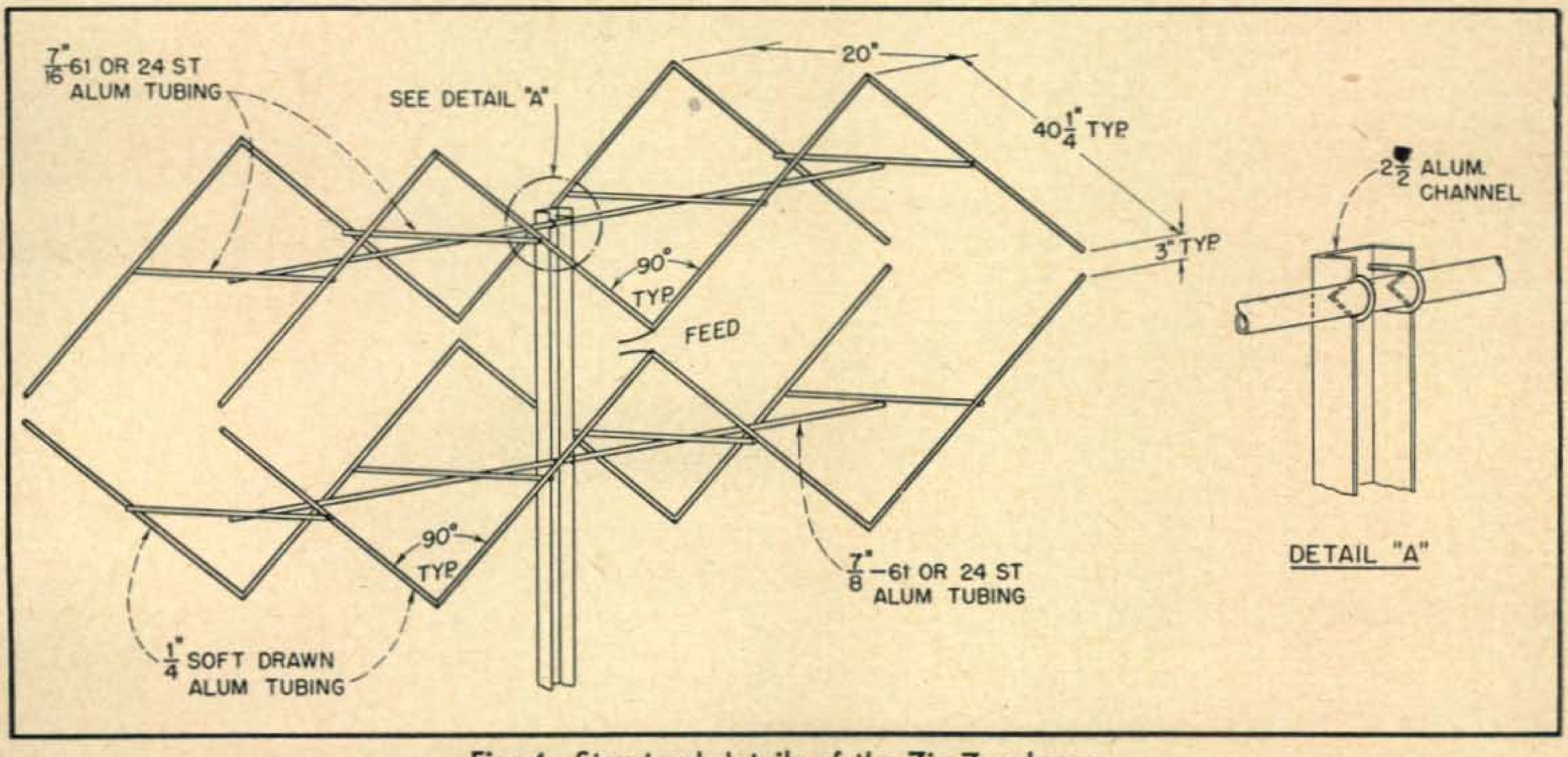

Fig. 4. Structural details of the Zig-Zag beam.

ZIG-ZAG BEAM

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ratio was not considered objectionable for the 15-foot total length of the line in use. If long transmission line runs are necessary, it would be desirable to improve the match at the antenna with either a quarter-wave matching transformer or a section of tapered line. The antenna may be fed with 50- or 70-ohm coax through a matching section and balun. This method of feeding was used in the original test.

The initial tests of this antenna were made at 1/10 scale at 1450 megacycles with the test antenna constructed of bus bar. The patterns were measured on automatic recording equipment synchronized with the supporting mast, which was motor driven to rotate on two axes. The ease and speed of making measurements on the model gave the opportunity to investigate various feed points, the effect of changing supporting members and bandwidth, and correct element length. As a matter of note, the bandwidth for the antenna described with quarter-inch elements is approximately 10 percent, or 14 megacycles at 140 megacycles. The element lengths, as might be expected, agree quite closely with the value computed by the standard long-wire formulas for each of the four two-wavelength sections. With the bandwidth involved, however, the element lengths are not critical and are roughly the same as free-space lengths. No pruning or adjustment should be required.

The performance of this antenna in the nine months of its operation has been extremely good. Although the gain is theoretically about two db below that of a full 16 element beam, the ease of construction, lack of insulators and phasing lines, light weight, and simplicity far outweighed the small difference in gain for the writer.