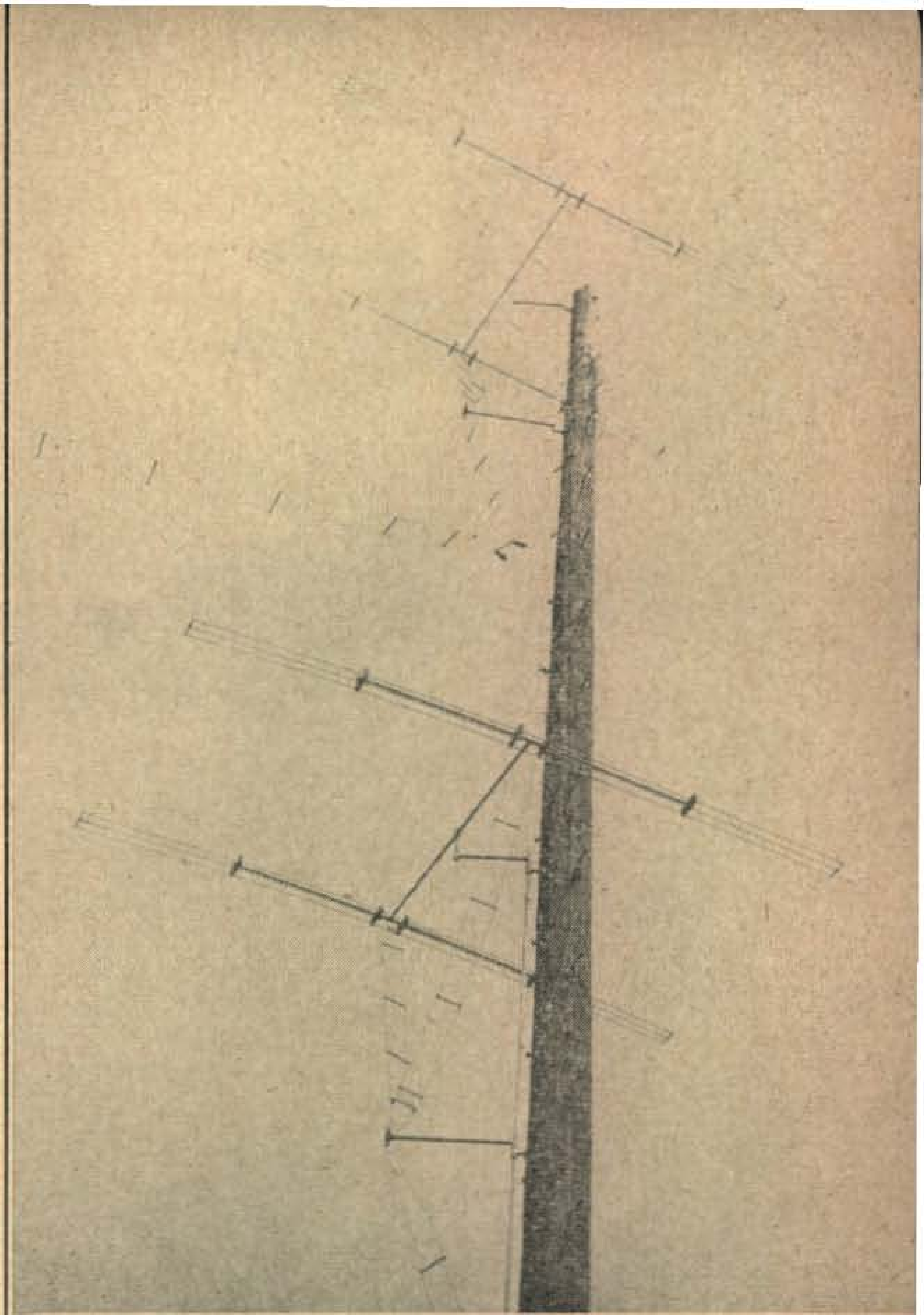
Fig. 1. This beam takes a big stick to support it. Spacing between sections on 28 mc is 25 feet.



The Improved Double Twin-3

HAROLD E. TAYLOR, W8RNC*

Further improvements and refinements of the popular Twin-3 beam give!ng greater gain and control of the vertical radiation pattern.

THE BASIC PRINCIPLES of the Single Twin-3 † and the Double Twin-3 ‡ have been known for the past few years. The original Twin-3 was developed by Dr. John D. Kraus, W8JK, of Ohio State University. The design is that of two half-waves spaced one-fifth wavelength apart and fed 180 degrees out of phase. Each 3-element doublet is constructed of 3 ultra close-spaced in-phase conductors with a spacing of 3 inches between centers. This has the effect of raising the feed-point impedance to match a 600-ohm open line.

The first Double Twin-3 built by the author was stacked at a distance of 0.45 wavelength.‡ Like all amateurs who are constantly looking for improvements, it was decided to increase this spacing to 0.75 wavelength. Theoretically, this would noticeably increase the power gain. An antenna of this spacing was built and is described here. The results obtained over a long period of 10-meter band operation have shown that the array does have more gain at this greater spacing. Quite possibly a still greater improvement might result if the spacing further approached 1.0 wavelength. In addition to this gain, a switching and phasing arrangement has been made where the operator may manually control the vertical radiation pattern.

*c/o Michigan Bell Telephone Co., 333 State St., Detroit 26, Mich.

†J. D. Kraus, "Twin-Three Flat-Top," *Radio*, Nov., 1939, P. 11.

‡H. E. Taylor and J. D. Kraus, "The Double Twin-3 Beam Antenna," *Radio*, Oct., 1940, p. 20.

Characteris ics of the Twin-

For those who may be unfamiliar with this antenna, the advantages of the improved Twin-3 rotary beam over the customary two, three, and four-element parasitic beams are quite pronounced. The Twin-3 is entirely pretuned, prespaced and prematched by direct physical measurements. There is no pruning or need for adjustments once the beam is up in the air. The radiation pattern of the antenna described is similar to that of the conventional horizontal doublet with a figure of 8 pattern. The beam width is 60 degrees between the half-power points. Although the gain of these arrays is difficult to compute the probable gain at the 10-degree vertical angle is about 12 db above that of an isotropic radiator in free space. The radiation resistance is very high, thus precluding wet weather effects. The match between the transmission lines and the elements is excellent, insuring a very low SWR, even when operated broad-band from 10 to 11 meters.

Mechanically, the improved Twin-3 need only rotate 90-degrees either side of the starting position. This greatly simplifies the construction problem. It can be built at a reasonable cost and is light in weight. The use of tubing for the elements provides sufficient strength so that they will not bend out of shape due to ice loads. A variety of feed systems may be employed to suit the individual requirements.

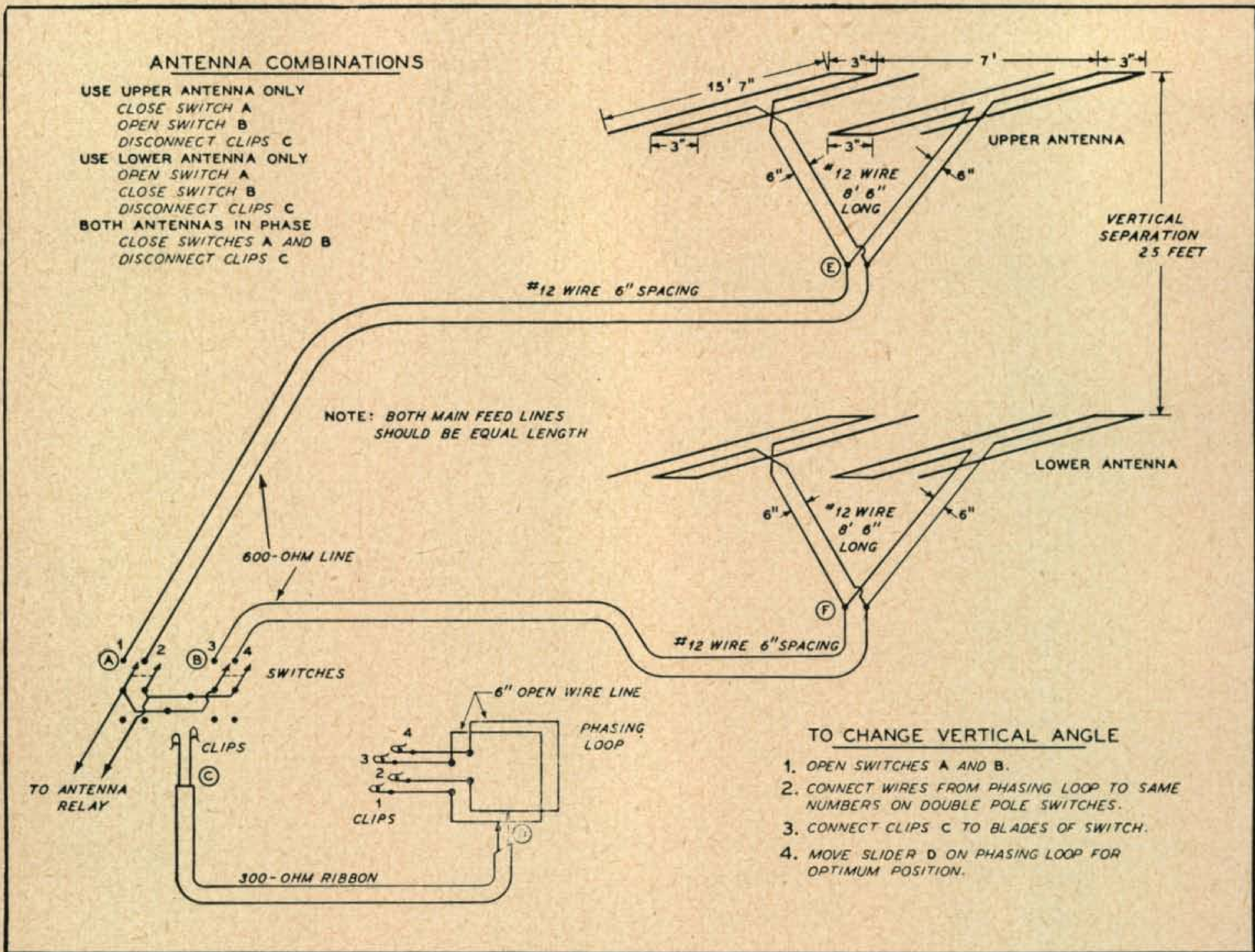


Fig. 2. Suggested method for mounting and switching the improved Double Twin-3.

Construction

The assembled beam is shown in *Fig. 1.* The array consists of two identical Twin-3 antennas spaced vertically 25 feet apart. Both antennas are supported from a ½-inch diameter vertical pipe running up the side of the telephone pole. This pipe is supported by five pipe flanges and five 2-inch long nipples. At the outer end of the nipples are ¾-inch tees. The vertical pipe is fed through the tees. This permits the pipe to be turned freely by the rotating mechanism.

Above ground on the main vertical pipe 24½ feet high is a tee fitting used to hold a short piece of ¾-inch water pipe about 20 inches long perpendicular from the telephone pole. This pipe guides the feed line that is connected to the bottom of the "V" section of the lower antenna. Ten feet from the top antenna, on the main vertical pipe, another tee fitting was used to serve the same purpose; i.e., to guide the feed line serving the upper antenna. Unlike the earlier Twin-3 models separate feed lines run from each antenna into the shack.

At a somewhat lower point each main feed line is fastened to the pole with insulators to relieve the strain on the guide arm. The top antenna in *Fig. 1* is 57 feet above ground and the lower antenna is 32 feet. When the array is turned both guide arms rotate to keep the feeders from becoming tangled. Any standard rotating device can be used for changing direction of the antenna.

A suggested method of mounting the radiators is shown in the photo. The cradle unit may be used as illustrated or the center crossarm fitting may be enlarged until the whole antenna is mounted on one vertical pole. The elements are 3/8 inch diameter aluminum tubing. The spacing between tubing is three inches center-to-center.

The *Q* sections and main feed lines are all made of No. 12 wire spaced 6 inches apart. It is not necessary to use high-cost insulators because the voltages are fairly low on the line. Wooden dowel rods, 6 inches long, well varnished, have been in use at W8RNC and have served very well. The two quarter-wave *Q* sections feeding the upper Twin-3 hang in the customary "V" as shown in *Fig. 2.* The same principle applies to the lower Twin-3 beam also. From the bottom of the "V" as shown in each antenna is a separate 600-onm line that connects to switches in the shack. Both lines were kept as far apart as possible outside the building to prevent mutual coupling.

In one of the *Q* section legs to each Twin-3 is an ordinary transposition block. The common 2-inch type has proven to be satisfactory. The fact that the line changes spacing for such a short distance is of no consequence as far as an impedance irregularity is concerned.

Dimensions

The Twin-3 described in this article was designed for operation at 28.7 mc. The radiator and *Q* section lengths may be scaled to any other frequency in the 10 and 11-meter band. The basic length of the radiator is 0.91 of the free space wavelength.

It would be customary to make both main feed lines equal in length. An alternate method would be to make one feed line a half-wavelength longer, but transposed at the point where the two feed lines join together at the station. This transposition would keep the two lines in-phase because of the difference in their lengths.

All linear dimensions were made on the tubing of the radiators before crimping the ends, used for holding the 3-inch tie pieces. Brass nuts and bolts should be used for fastening the tie pieces to the elements. The feed lines are also fastened to the radiators with small size brass nuts and bolts.

It is particularly important that the SWR be very near unity on both main transmission lines. If by some error in construction, the SWR is abnormal on either line it can be lowered by using a very short length matching stub.[1] The SWR, current or voltage, on each feed line tested separately should be less than 1.2:1. If the ratio exceeds this value there will be a noticeable change in the final tank plate current when using the phasing loop described below.

Phasing Feed Systems

There are two different practical methods by which it is possible to control the vertical angle of radiation. Both methods are in use at W8RNC. In the first method each feed line is terminated on a separate double-pole switch. The arrangement is shown in *Fig. 2*. The blades of both switches are tied together so that it is possible to shift from one antenna to the other; i.e., from the upper Twin-3 to the lower Twin-3.

If both switches are thrown in at the same time, the two beams, upper and lower, are driven in phase. The feed line from each antenna is poled properly at the switches. This can be readily detected by listening to signals on the receiver when poling first one lead and then the other. The poling giving the greatest S-point reading is the correct one to use.

Changes in the angle of radiation, of course, result from the difference in height above ground of the two antennas. There is no one best vertical angle suitable for all skip distances and hence no one best

1 H. E. Stewart, "Feeding the Beam," *CQ*, Mar., 1948, p. 42, Fig. 6.

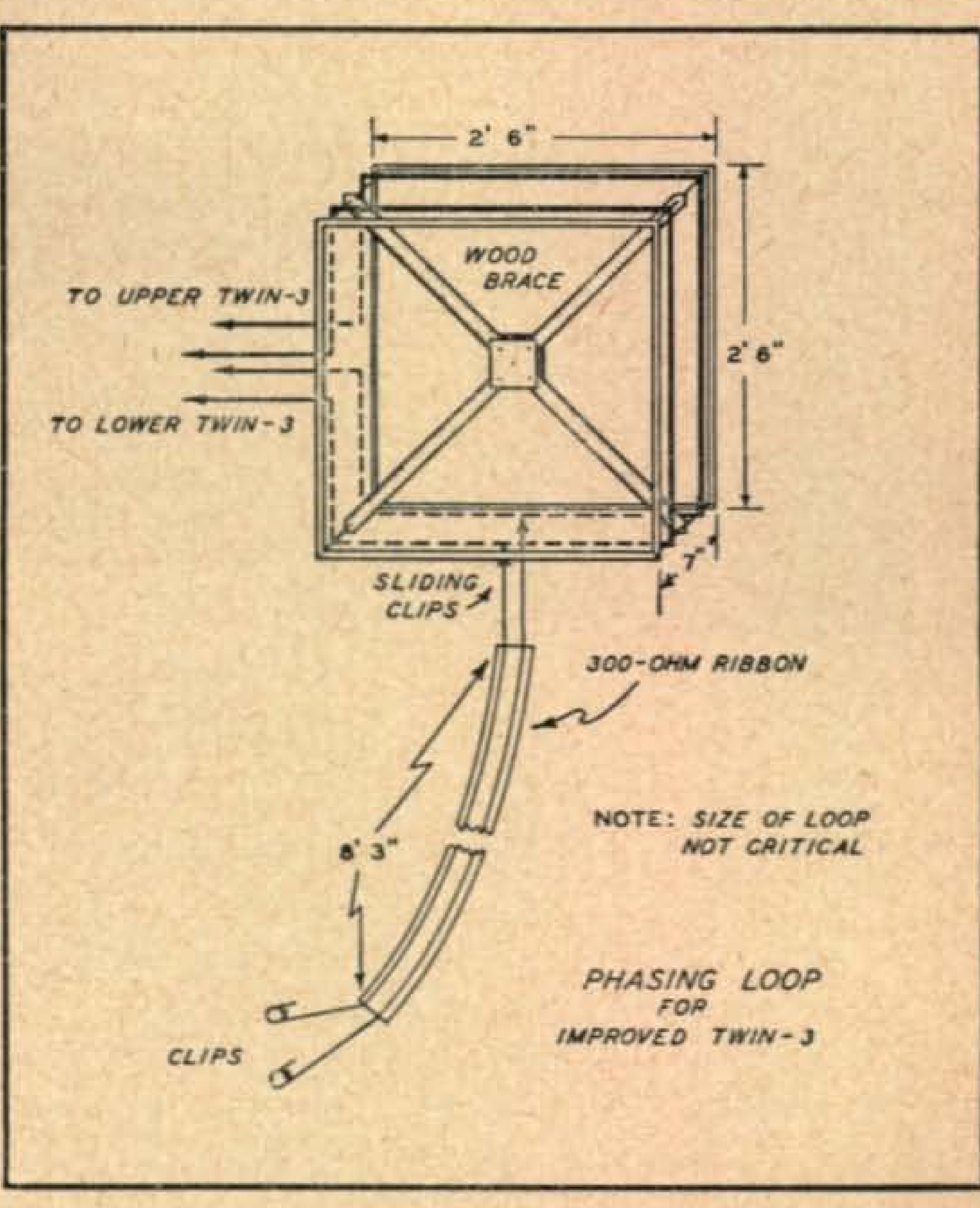


Fig. 3. Phasing loop, which in conjunction with feeder switches permits control of angle of radiation from operating position.

height for an antenna above ground. In theory, a good arrangement would be to put the antenna on some type of vertical lift or elevator and then adjust the height above ground to optimum for each contact. A much simpler and nearly equivalent arrangement is to have two antennas at different heights (ideally the vertical lobe pattern at one height should have maxima where the other has nulls, so that the combination of the two fills in at all vertical angles). Thus, by switching in one, or the other, or both together with the phasing loop, the best angle can be found for each contact.

The above assumes a good ground reflection factor which means little in the way of obstructions in the vicinity of the antenna. Gains of 6 db can be obtained when the direct and reflected waves add in phase. Therefore, phasing is an important point to consider in obtaining added signal strength.

The second method of controlling the angle of radiation employs the phasing principle. The phase

(*Continued on page 80*)

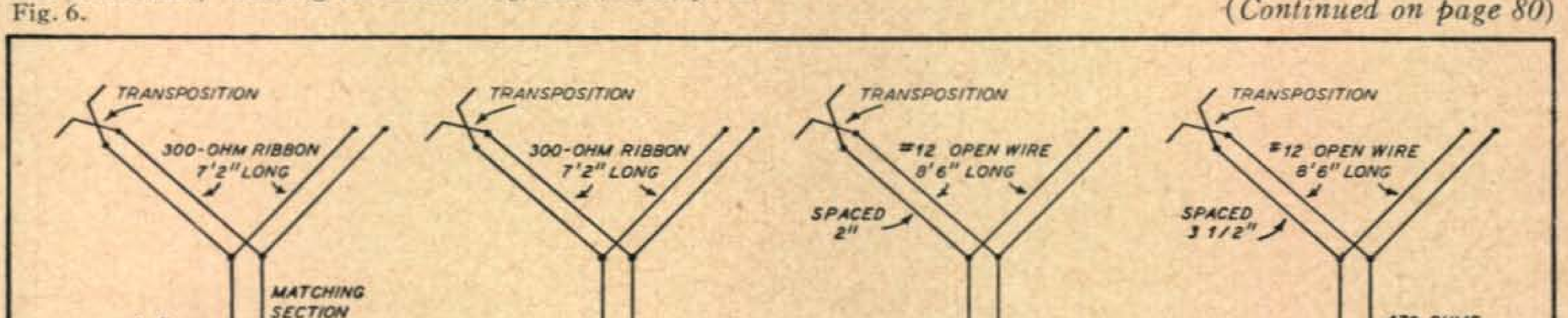


Fig. 4. Alternate feed systems for installations where standard 600-ohm line is impractical.

"Humm," I replied, as I drifted into the Land of Nod. I had won!

Not only had W3INL won; so had her OM, W3GHS. For between them they have worked a good deal of DX on 10-meter phone, with 115 countries to date, and have accomplished their heart's desire in making DXCC (how about W.A.Z. Jean?). Their rig consists of a pair of TZ40s in the final running 200 watts with a pair of TZ40s in the modulator. The antenna is a stacked 6-element affair, with the top section 45 feet above ground However, they have just completed a 50-ft wooden lattice tower, on top of which they will have their stacked 6-element rotatable beam, the top element being 70 ft. above ground. Above this they plan to have a stacked 6-element 2-meter beam, horizontally polarized. Jean happily comments: "With this 6-element beam, an ARC-5 transmitter and a 522 receiver I expect to, at long last after peddling W3GHS's a call on the air for so many years, get W3INL on the map!"

Jean adds: "In regard to my activities, I am raising a junior op, Richard, aged 7, seeing that 180 children get fed every day in a local school cafeteria, and I have many early morning hour contacts with locals on 10. It is not unusual for me to go to bed at 4, 4:30 or 5 a.m.—so you can see what my OM is up against—hi!"

BOOK REVIEWS

(from page 62)

data are available. This contrasts sharply with the lack of coverage of the problem of the angle of radiation, which is often the determining factor in the performance of an antenna.

Following this chapter there are sections on transmission lines and basic "sugar-coated" antenna theory. Both of these chapters are well handled and live up to their advance notices. The next several chapters deal directly with amateur antennas. The last chapters are devoted to coupling methods at the antenna and the receiver, television input circuits, measurements, navigational aids and duplexing. While the book is thoroughly readable it still falls short of the need for a comprehensive antenna handbook in the amateur field. —*O.P.F.*

DOUBLE TWIN-3

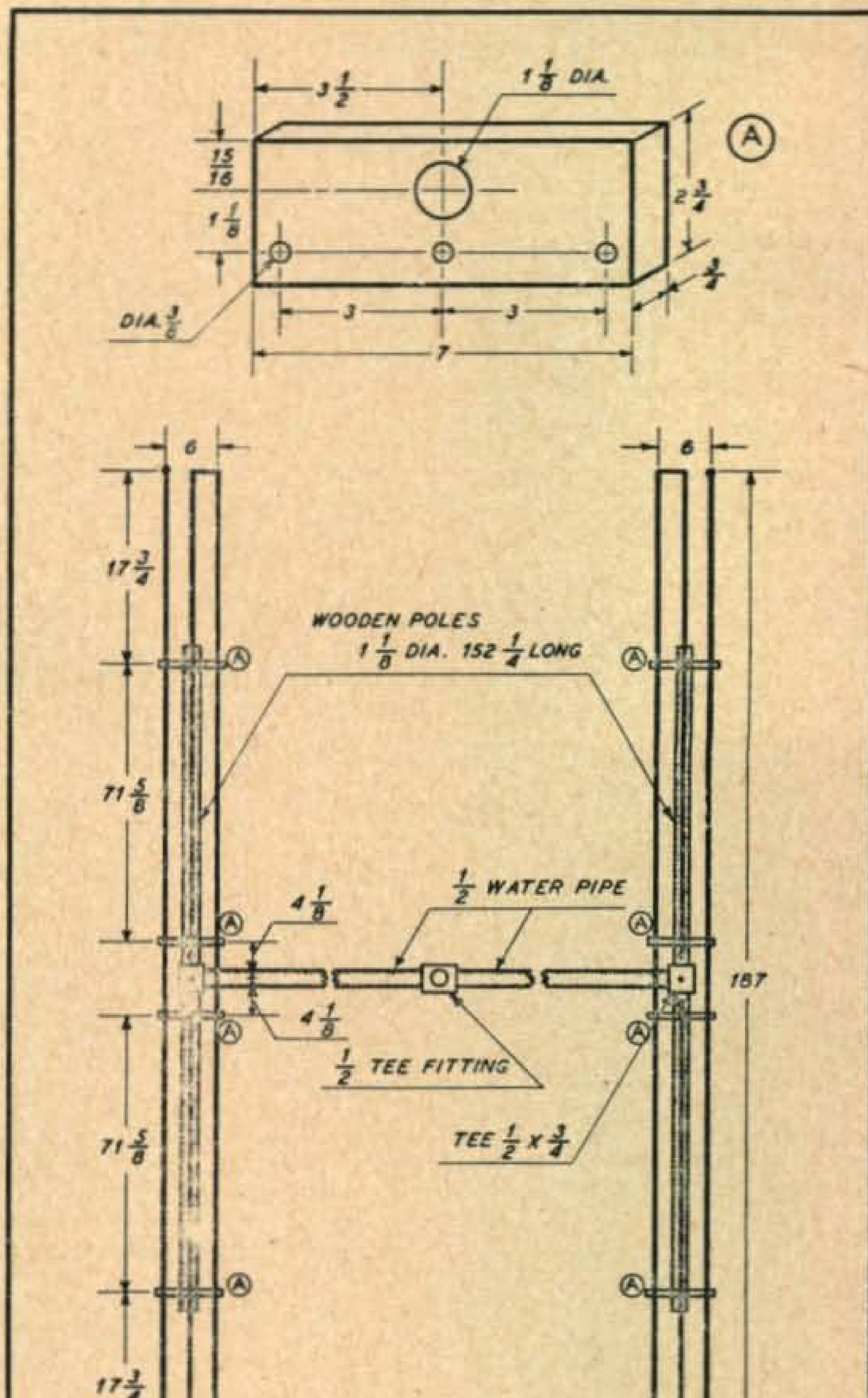
(from page 19)

relations desired in an antenna array are ordinarily obtained by use of transmission lines. It is a well known axiom that any line whose length is one electrical wavelength in free space, has a uniform phase shift of 360° per wavelength, 180° for a half-wavelength, and 90° for a quarter-wavelength. A change in phase between the two antennas of 0 to 90° is sufficient to control the vertical angle in 10-11 meter band operation.

To accomplish this a phasing loop was constructed as shown in *Fig. 4.* It uses a wooden frame 30 inches on a side and 7-inches deep. The frame is mounted on the wall of the shack near the entrance of the main transmission lines from the Twin-3 antennas. The line from the upper antenna is wound around the frame and joins the transmission line from the lower antenna at the bottom end of the frame. This places the two lines in series. Make sure that the two lines are properly poled.

The two antennas are then fed in parallel by taking a piece of 300-ohm Amphenol ribbon, 8′ 3″ long, attaching one end to the blades of the double-pole switches and the other end to two test clips which serve as sliders on the transmission line wound around the frame. The ribbon then feeds the two antennas at a joint impedance of about 300 ohms. As the clips slide along the phasing loop there is a change in the angle of radiation with the lowest possible angle from the combination resulting when the clips are at the end of the frame near the upper antenna termination (in-phase) and highest angle when near the lower antenna termination (out-of-phase).

An important point in using the phasing loop is to have the SWR very low. The degree of match



Constructional details for a single section of the Twin-3 resonant to 28.7 mc. All dimensions in inches. Notes: Obtain the materials as indicated above. Bore out the threads from the 3/4 inch sides of the 1/2 x 3/4 inch tee fitting. This will permit the 1 1/8 inch wood pole to make a snug fit. Drill one small hole in the side of 3/4 inch tee, fasten each pole with a wood screw passing through this hole. Drill out wooden blocks A and varnish. These are fastened to the wood pole with screws. Eight blocks are needed. The diameter of the radiating elements is 3/8 inch.

between the phasing loop and the short piece of 300-ohm ribbon may be checked best with a twin-lamp standing wave indicator.[4] The size of the coupling loop should be about 8 inches. If both main feed lines have a low SWR and are balanced the flash light bulb nearest the transmitter termination will be bright and the light nearest the clips to the loop will either be dark or burning very dimly. Should both lamps burn bright or have the same brilliancy, it is an indication that standing waves are present.

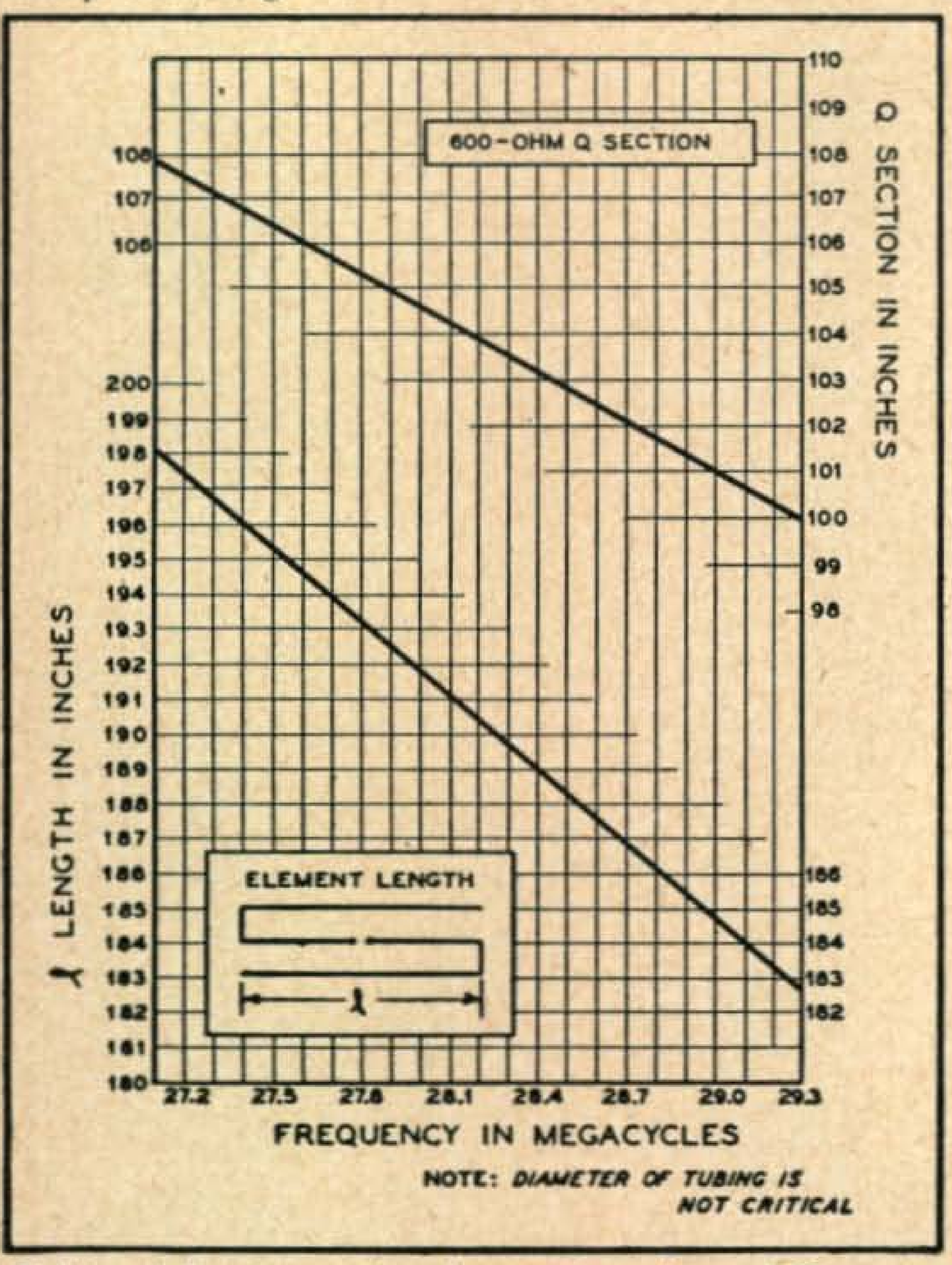


Table of dimensions for element lengths and Q section lengths.

Alternate Feed Systems

If mechanical conditions do not permit the use of the standard 600-ohm feed, as previously outlined, each single Twin-3 can be made to operate quite satisfactorily by any one of the four methods shown in *Fig. 4.* It should be remembered that the transmission line loss in types other than the open line is considerably greater, especially when the length is very long. Also, it naturally somewhat prohibits the use of the phasing loop to change the angle of radiation when ribbon type leads are employed.

The length of the 300-ohm ribbon for the *Q* sections is based on the formula

$$L_{ft} = \frac{205.5}{F_{mc}}$$

The improved Twin-3 of this type has been used on 10 meters at W8RNC for about eighteen months. The results have been excellent. During a ten-month period, over 600 DX phone contacts were made with most reports above S9. Although the antenna may seem complex, it has proved, without a doubt, to have been well worth the additional effort.

4 C. Wright, "The Twin-lamp," *QST*, Oct., 1947, p. 22.