# The Mark III DX Antenna

BY COMMANDER PAUL H. LEE*, W3JHR

*Here is a vertical antenna, 50 feet tall and self supporting, for the 80, 40, 20 and 15 meter bands. Its low angle of radiation makes it ideal for DX operation.*

THIS antenna has proven itself with such success that it seems worth passing on to those who would like to build a colinear vertical. The antenna was originally intended for use only on 14, 7, and 3.9 mc, but I have found that it can be successfully used on 21 mc as well. I do not as yet know what its vertical pattern is on 21 mc, nor do I know what its current distribution is.

## Antenna Operation

### 14 MC Operation

The Mark III antenna is 50 feet tall, and is grounded at its base. It would have been impractical to make this taller and heavier mast self-supporting and still insulated at the base like the Mark II, so I decided to ground it and shunt feed it with several feed rods. Basically it is one half of a three-element center-feed colinear on 14 mc, as can be seen in fig. 1. (The mirror image below ground is the other half.) A three-element colinear has a gain of 3.2 db over a dipole. Replacing the bottom half with a ground plane and putting all the power into the upper half gives an additional 3 db gain. The current distribution on this antenna is as shown in fig. 1. The phase reversal at the point a quarter-wave above ground can be accomplished in several ways, by a shorted quarter-wave stub, a tuned circuit, or a quarter-wave coaxial sleeve. The latter is shown in fig. 2. This design is used quite commonly at v.h.f. and u.h.f., where size permits several elements with coaxial sleeves to be stacked vertically. The phase reversal occurs at the open or bottom end of the coaxial sleeve. Inasmuch as the current loop in the bottom portion of the mast occurs at ground level, the bottom end can be grounded and fed with a shunt or "gamma" type of feed, as shown in fig. 2. The vertical pattern over ground of average conductivity at 14 mc is also shown in fig. 2. Note that the pattern is "squashed" down, with most of the power going out at angles from about 3 to 22 degrees. This is ideal for DX work because it places the first reflection zone out at a distance of from 1100 to 2100 miles.

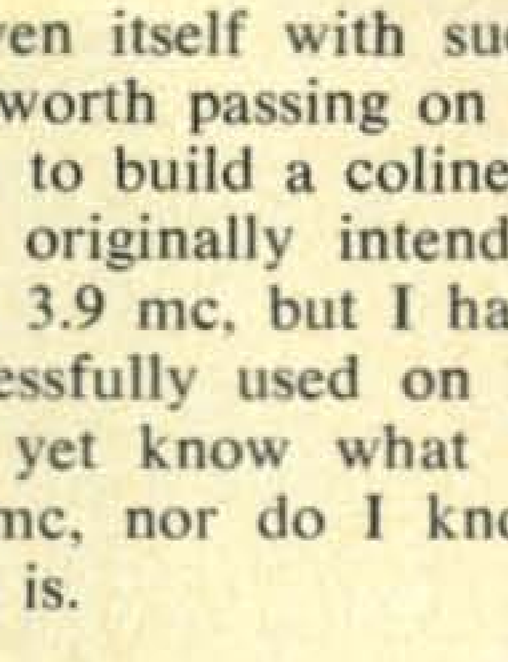

Fig. 1—on 14 mc, the antenna operates as one half of a 3 element center fed colinear. Also shown is the current distribution. The mirror image below ground constitutes the second half of the antenna.

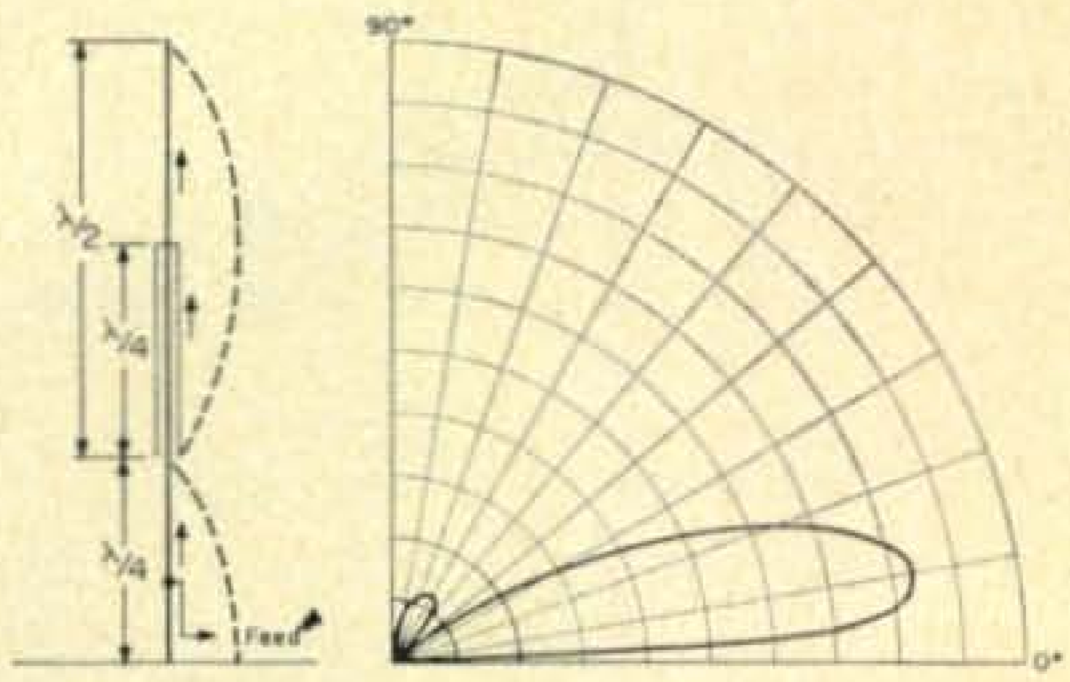

Fig. 2—Phase reversal is accomplished by the use of a coaxial sleeve rather than the stub shown in fig. 1. The resulting vertical radiation pattern is shown.

### 7 MC Operation

On 7 mc the coaxial stub is too short to

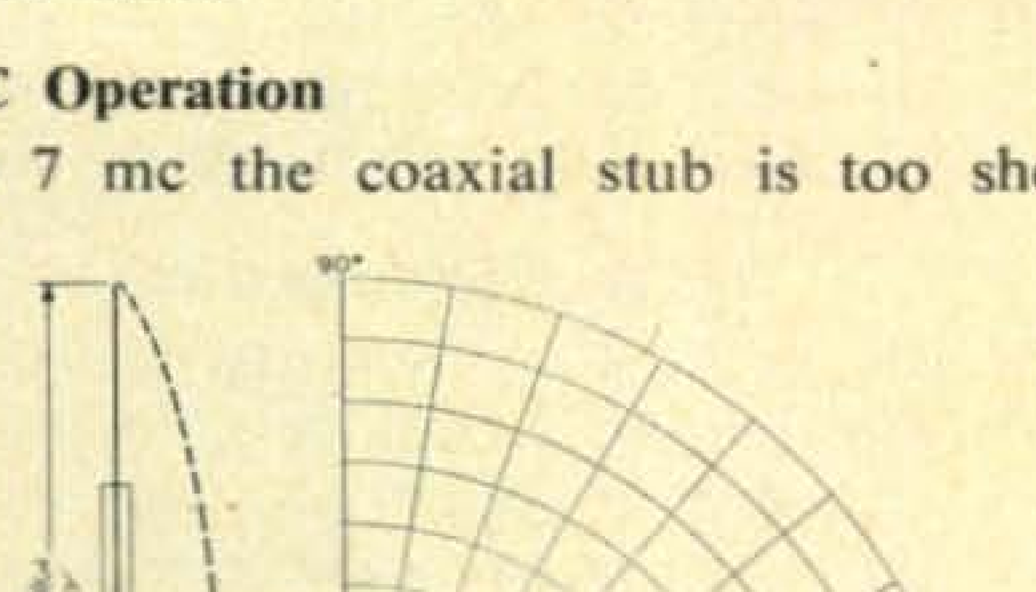

Fig. 3—Since the coaxial stub will not resonate at 7 mc the antenna behaves as ⅜ wave vertical and presents the radiation pattern shown above.

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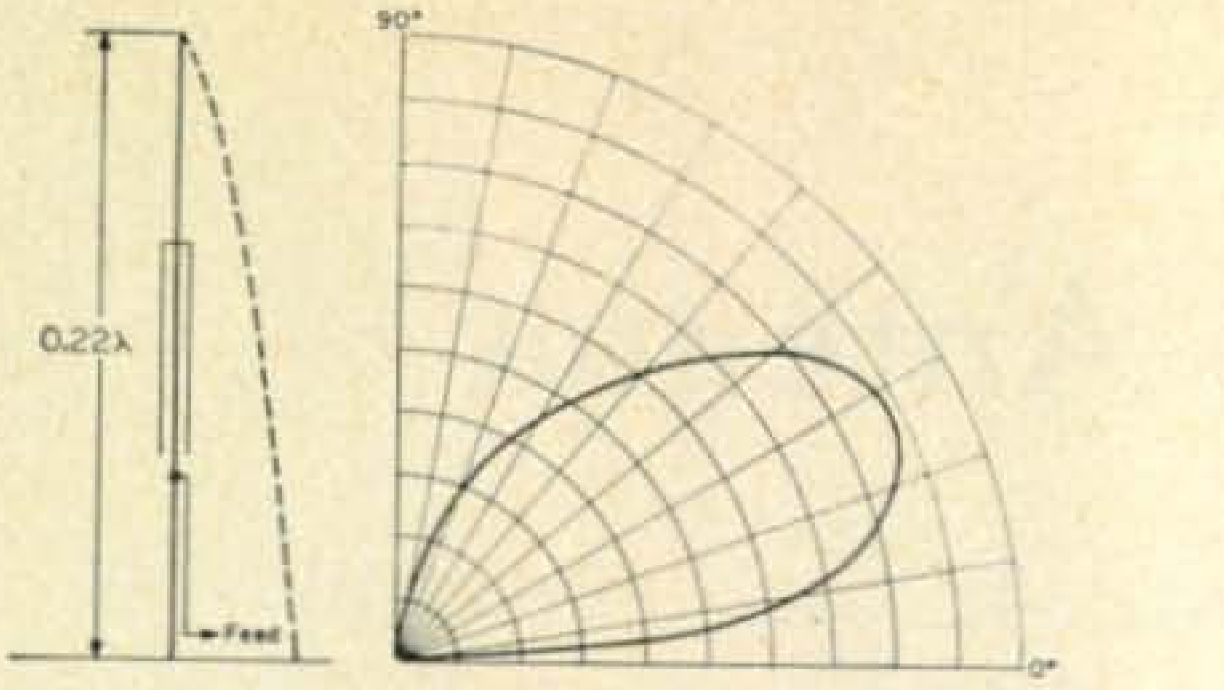


Fig. 4—The coaxial stub has no effect on 3.9 mc operation and the antenna acts as 0.22 wavelength unit with the vertical radiation pattern shown.

resonate, and it has little if any effect on the current distribution or the vertical pattern. The antenna behaves as a ⅜ wave vertical, whose vertical pattern over average earth at 7 mc is shown in fig. 3. Here again we can feed this antenna with a shunt or "gamma" feed, as shown. Note that this antenna's pattern is useful for angles of about 5 to 45 degrees, which is good for medium and long distance work on 7 mc.

### 3.9 MC Operation

On 3.9 mc the stub again has no effect, and the current distribution is shown in fig. 4. At this frequency the antenna is 0.22 wavelengths tall. The vertical pattern is also shown. Useful power is radiated over vertical angles from 8 to 60 degrees, making this antenna good for short, medium, and long distance work on 3.9 mc. Here again the mast can be fed against ground with a "gamma" type feed rod. There is only one problem at 3.9 mc, and that is the "Q" of the antenna. It is slightly too short to be self-resonant (not quite a quarter-wave), and therefor the impedance looking into the bottom of the feed rod is in the order of 9 + j110 ohms. This is with the feed rod connected at the highest possible place on the bottom of the mast, just below the open end of the stub. The "Q" is about 12. With the matching network (to be described later) adjusted to give a v.s.w.r. of 1 at 3.9 mc, the v.s.w.r. rises to about 1.7 at 3.8 and 4.0 mc. This is not too bad, however, and can be easily compensated for in the output pi-network of the transmitter. On 7, 14, and 21 mc, however, the v.s.w.r. is a flat 1 over the whole band.

## Mast Construction

The dimensions of the mast are shown in fig. 5. The bottom section is a 20 foot length of 4" aluminum irrigation pipe, of which four feet is set in the ground. The next section is a 20 foot length of 3" irrigation pipe, with 30" of this telescoped into the top of the bottom section. The third piece is 10 feet of 2" irrigation pipe, with 18" telescoped into the top of the 3" piece. The top section is a 9 foot length of 1½" tubing, which is telescoped 12" into the top of the 2" piece.

The telescoped junctions are made as shown

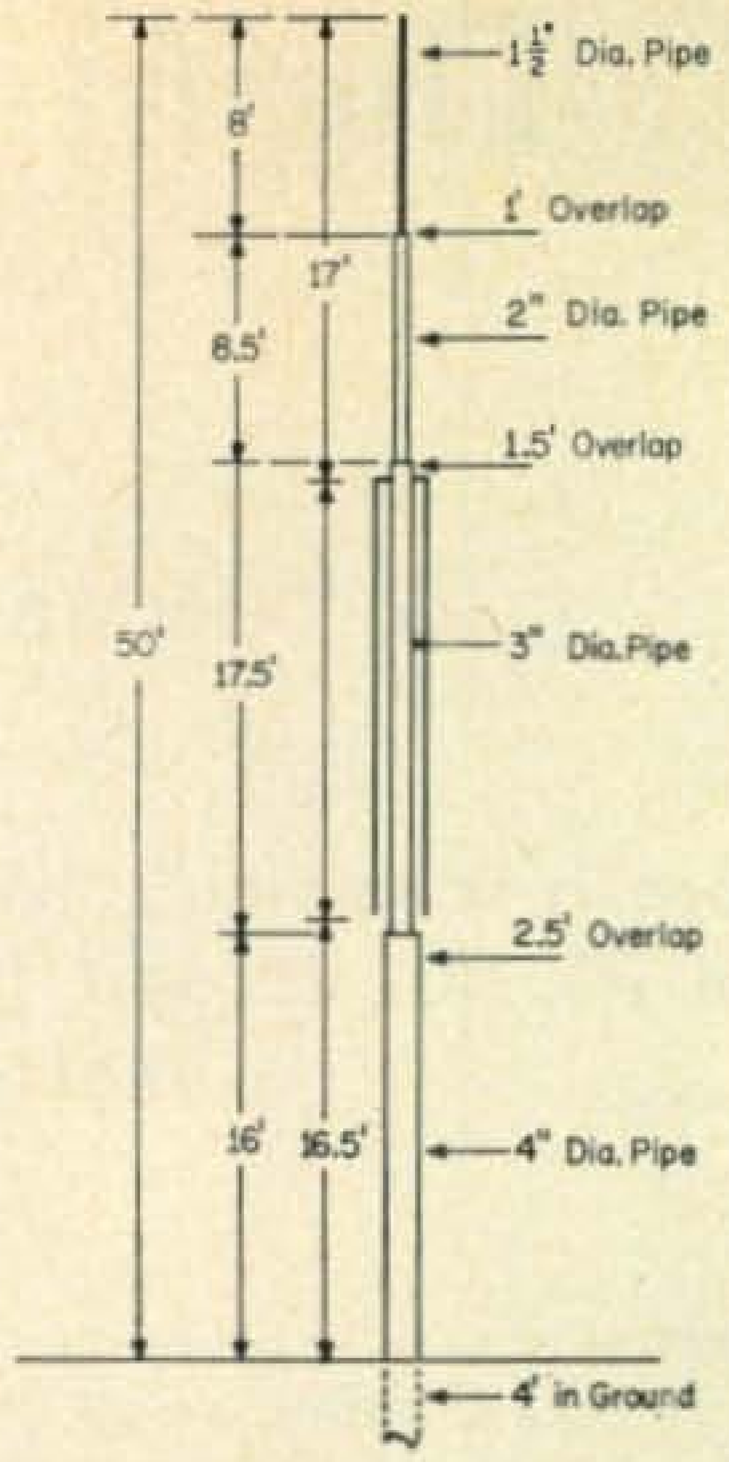


Fig. 5—Dimensions of the antenna sections showing lengths, overlaps and location of the coaxial sleeve.

in fig. 6, by using some hardwood shims which are planed down to the proper shape, wrapped with thin sheet aluminum, and are held in place by four large bolts which pass through the junction (two bolts at right angles to the other two). Bolt sizes are shown in the table in fig. 6.

The coaxial sleeve is hung around the 3" section. It is 16.5 feet in length, and is shorted to the mast at its top and is open at its bottom. Feed rod dimensions are shown in fig. 7. The 3.9 mc feed rod, which is connected to the mast at a point just below the open end of the sleeve, is also used for the 7 mc feed by switching matching networks. The 14 mc feed rod is connected to the mast about 8 feet from the ground. The connecting point for the 21 mc feed rod was found by experimentation to be about 4.5 feet from ground. The three feed rods are made of 1" aluminum tubing, and are connected to the mast by brackets of aluminum strap at their upper ends, and are held by standoff insulators

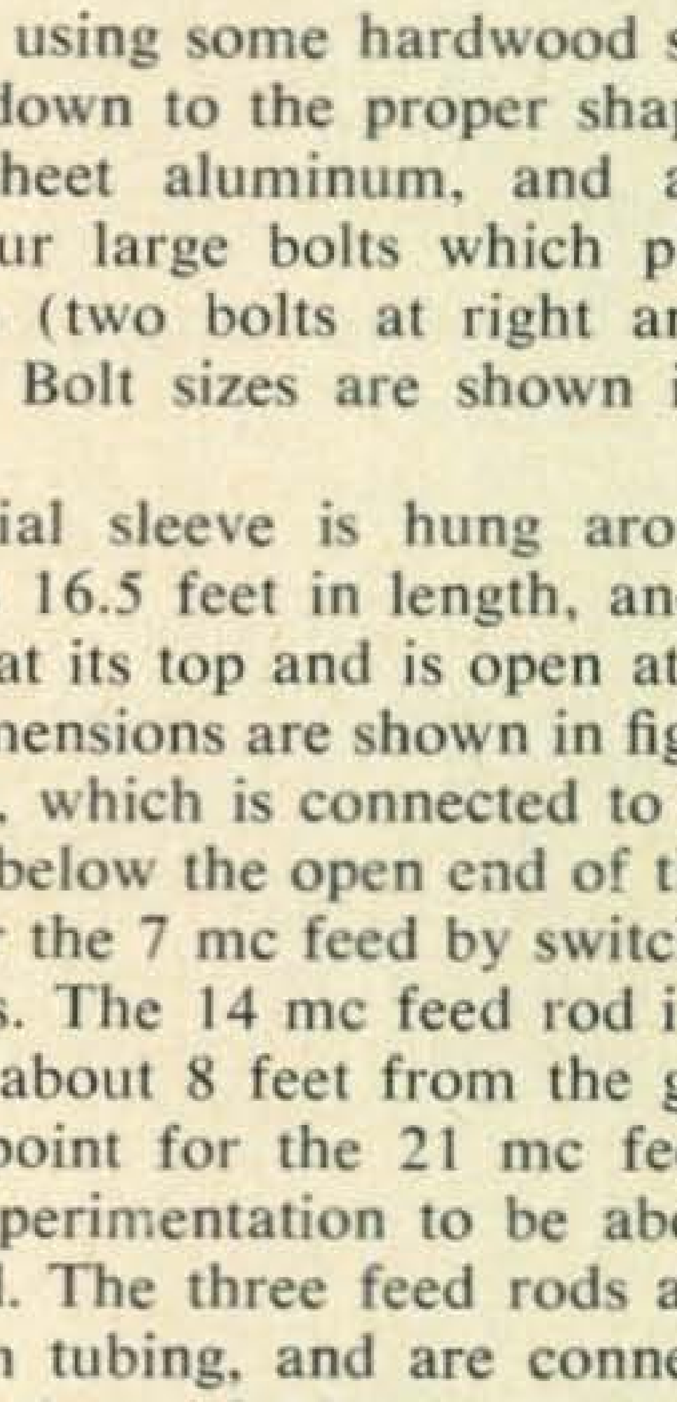

Fig. 6—Cross section of the junctions showing construction and positions of the hardwood spacers. The hardwood blocks are wrapped with thin sheet aluminum. Bolt sizes for each junction are as follows:

| *Junction* | *Bolt Size* | |
|---|---|---|
| 4" to 3" | (3) ½" × 7" | (1) ½" × 12" |
| 3" to 2" | (3) ⅜" × 5" | (1) ½" × 12" |
| 2" to 1½" | (2) ¼" × 4" | |

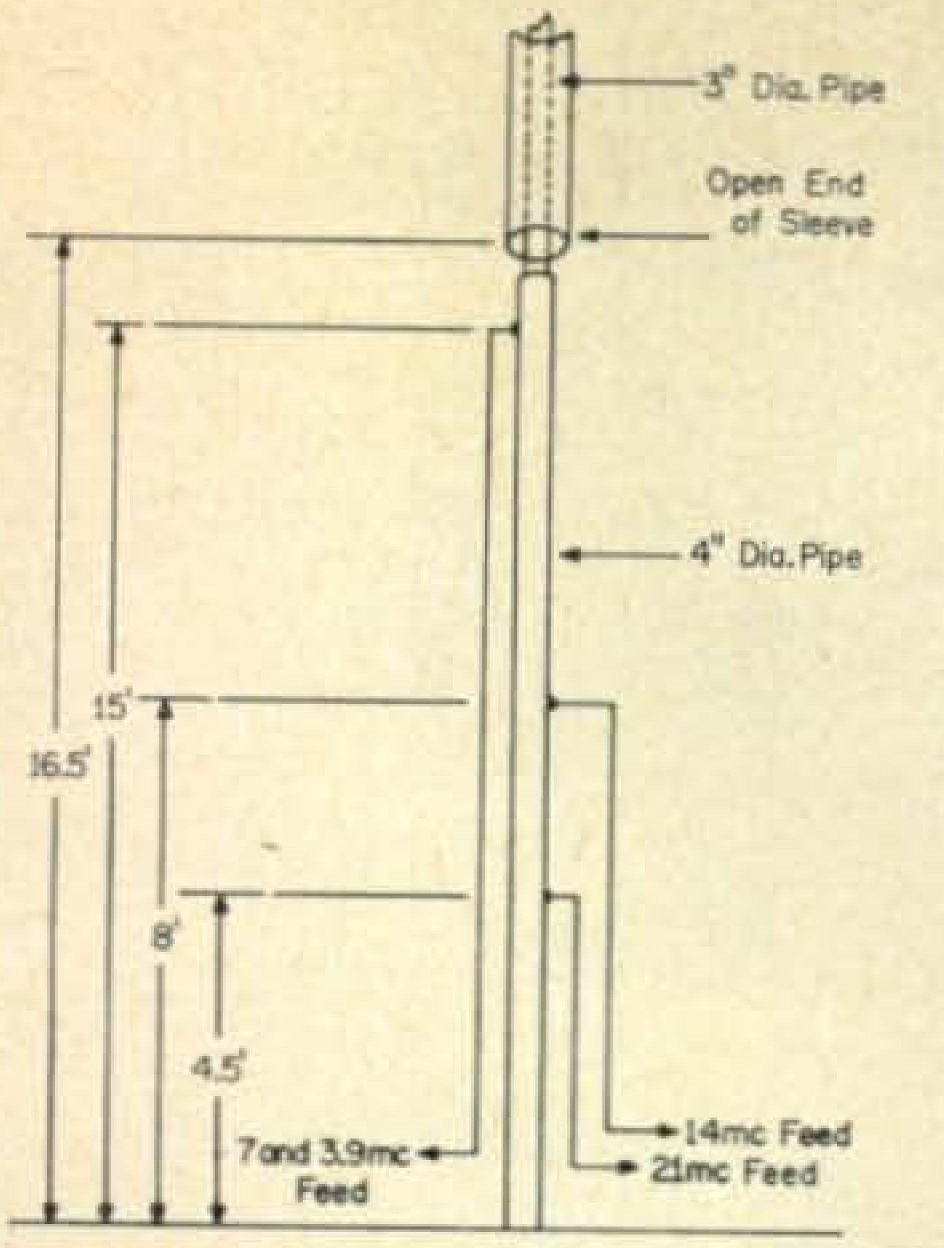


Fig. 7—Location of the feed lines for each band.

at their bottom ends. Details of these fittings follow in a later paragraph. Switching between feed rods to change bands is done in the tuning unit at the base of the mast. Those who read the articles on the Mark II antenna will recognize this tuning unit box and its wood post, which has been cut off short.

### Coaxial Sleeve Construction

Now let us see how the coaxial sleeve is made. It is a simulated coax, or cage, with six peripherial wires as shown in fig. 8. It has a 9½" diameter. The no. 9 aluminum clothesline wires are strung taut, with four spreader rings made of aluminum strap. The top and bottom rings are made of ¼ × 1" strap, and the two middle rings are made of ⅛ × ¾" strap. This material is of the Reynolds "do-it-yourself" variety available in many hardware stores, in 6 or 8 foot lengths. The brass ¼-20 nuts and bolts are also easily obtainable. A little trick is used in securing the wire under the nuts. Instead of turning the loop in the wire clockwise around the bolt under the nut, the loop is turned counter-clockwise. This brings the wire out on the right hand side of the bolt, and when tension is put on the wire it tends to turn the nut clockwise and tighten it. This prevents the nuts from working loose. The open end of the sleeve is pulled off by means of a pair of heavy springs and turnbuckles, with an E. F. Johnson type 136-112 12" strain insulator in series with each. The top ring of the sleeve is held securely in place by double nuts on the 12" long ½" bolt which passes through the mast joint. The turnbuckles at the bottom are similarly fastened to the 12" long ½" bolt which passes through the lower mast junction. This is shown very clearly in the accompanying photograph. The sleeve is kept under considerable tension by means of the heavy springs, with the turnbuckles turned down to their limits.

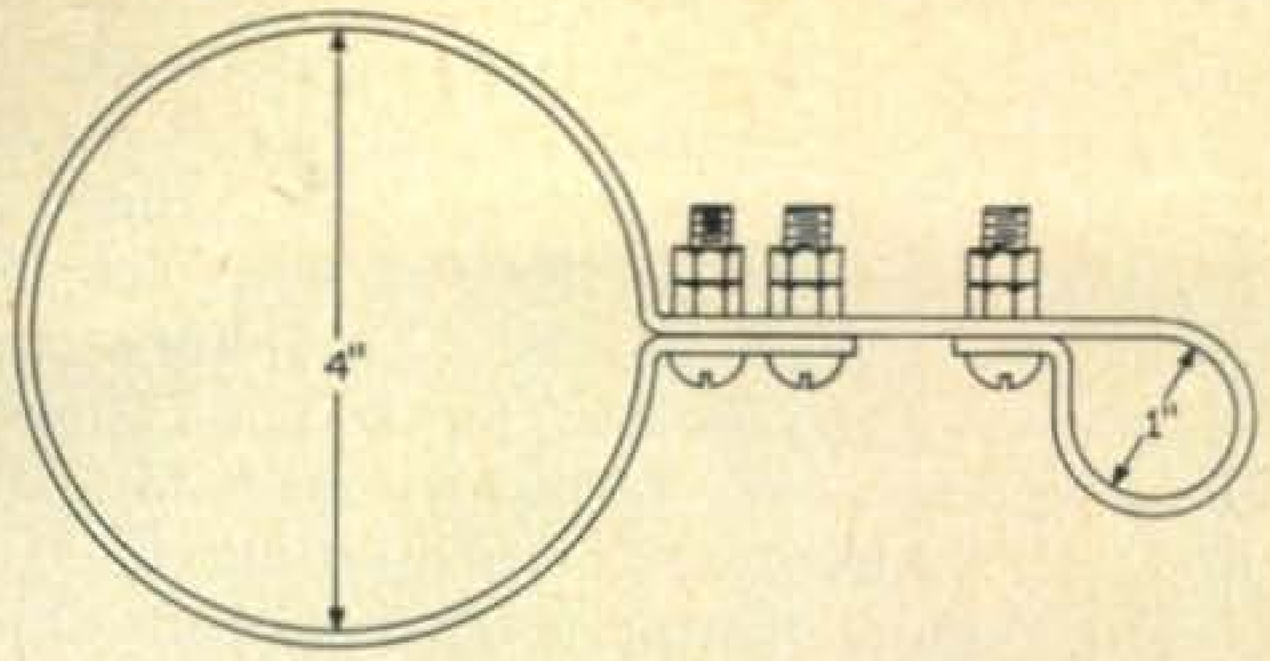


Fig. 9—Construction details for the upper connecting clamps for the feedlines. They are fabricated from ⅛" × ¾" aluminum strap and held together by ¼-20 × 1" brass screws. Three straps are required.

### Feed Line Construction

The connecting clamps for the upper ends of the feed rods are shown in fig. 9. There are three of these, made from ⅛ × ¾" aluminum strap, with ¼-20 brass hardware. After the final adjustment, double nuts are used to prevent the bolts from working loose. Figure 10 shows the design of the mounting ring for the bottom insulators of the feed rods. This ring fits on the mast about 18" above ground level.

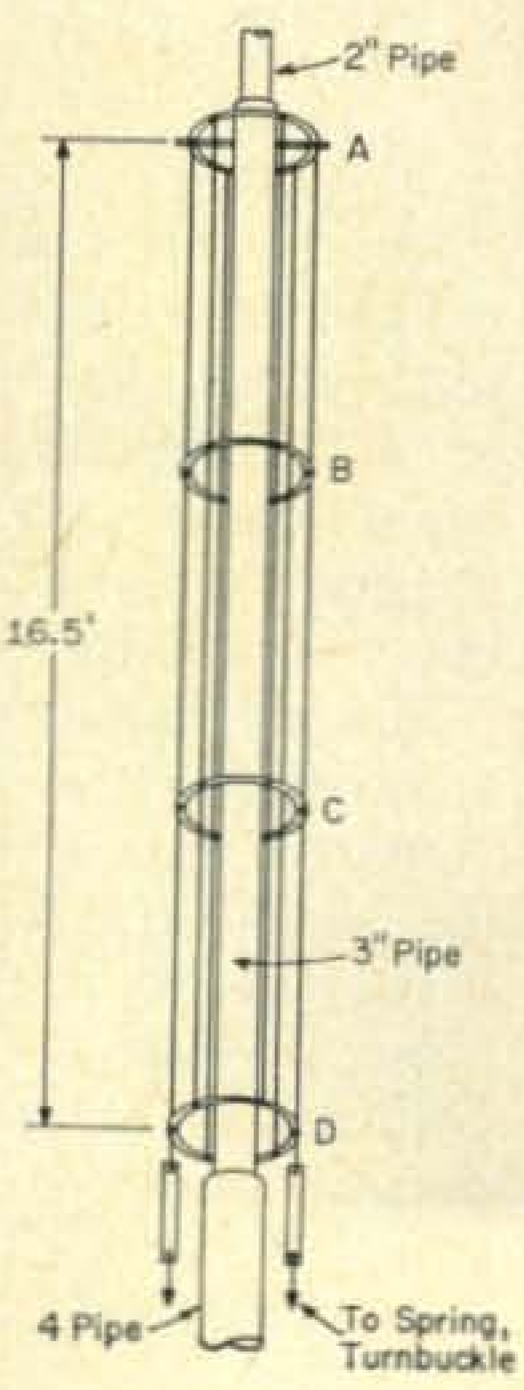


Fig. 8—Construction details for the coaxial sleeve. Six lengths of #9 aluminum wire form the cage and are held in place on the aluminum rings by ¼-20 × ¾" brass screws and nuts. Rings A and D are made from ¼" × 1" aluminum with a 9" i.d. Rings B and C are made from ⅛ × ¾ aluminum with a 9¼" i.d. The two bottom brass bolts to which the 12" Johnson insulators (#136-112) are attached, measure ¼-20 × 1¼".

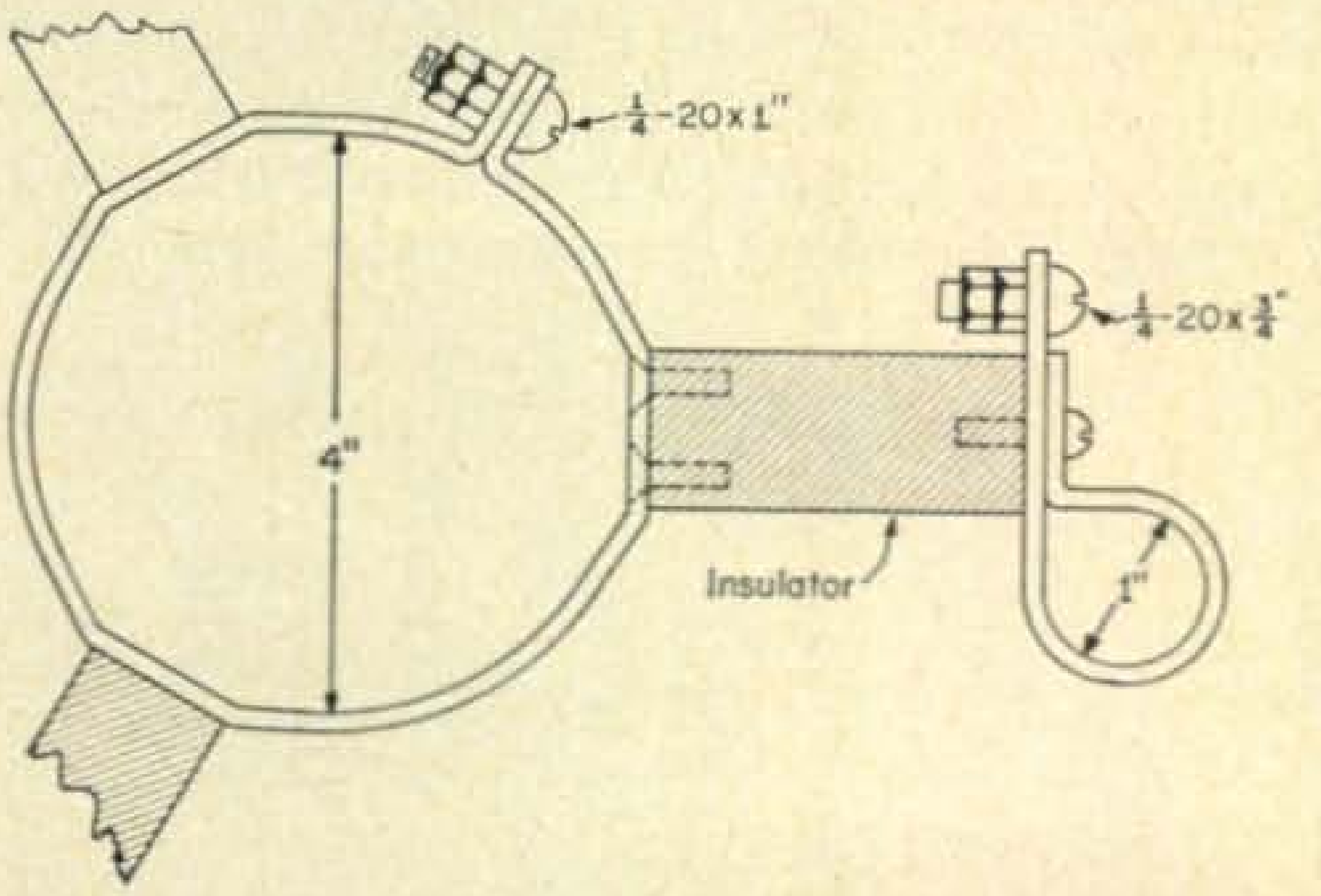


Fig. 10—Base mounting ring for the 3 feed lines. It is constructed from ⅛ × ¾" aluminum strap. The area beneath the 1⅛" × 1⅛" × 2½" insulators are flat for solid support. The tubing clamps (3) are also fabricated from ⅛ × ¾" stock. The hardware is brass of the dimensions shown.

The insulators are of a surplus type, square in cross-section and 2½" long. I obtained them as part of some large s.p.d.t. knife switches which I bought from Barry Electronics, 512 Broadway, New York City at 80¢ each. Each switch has three of these insulators, and I bought enough to give me a good stock of these handy items. Insulators made by Millen or E. F. Johnson could be substituted.

The aluminum strap is flattened beneath each insulator, as shown in fig. 10, to give a smooth bearing surface for the insulator. There is a similar strap, made to mount only one insulator, which is used to brace the middle of the 13 foot 7/3.9 mc feed rod to keep it from vibrating in a wind.

Figure 11 shows the detail of the heavy ground clamp used at the base of the mast. It is made of the ¼ × 1" strap, and is held tightly around the 4" mast by means of the ¼-20 bolts with double nuts. It is placed about 4" below ground level, and is used as the tie point for a piece of the ¼ × 1" strap which serves as the ground bus to the tuning unit and as the connecting point for the twelve buried ground radials. The 12 radials are of the No. 9 aluminum wire and are pushed into slots in the sod to a depth of about 3". Two of them are over 60 feet long and the others vary in length from 35 to 50 feet, fitting within the limits of the property. The coaxial feed cable and the relay control cable are buried from the house to the mast. The coaxial line is RG-8/U, and the control cable is plastic-covered electrical cable designed for direct burial. As much of the original Mark II setup as possible was used without change.

### Assembly

This antenna mast was put together on the ground, the sleeve was fastened in place, all bolts tightened, and then it was raised easily by three people, and set in a 5" post hole drilled with a post hole borer. It was a bit awkward to handle because of its 50 foot length, but was not heavy, weighing no more than 30 to 35 pounds. It is quite strong in spite of its 50 foot height. During the 50 knot wind experienced shortly after its erection, the top of the mast bent over about 8 feet out of

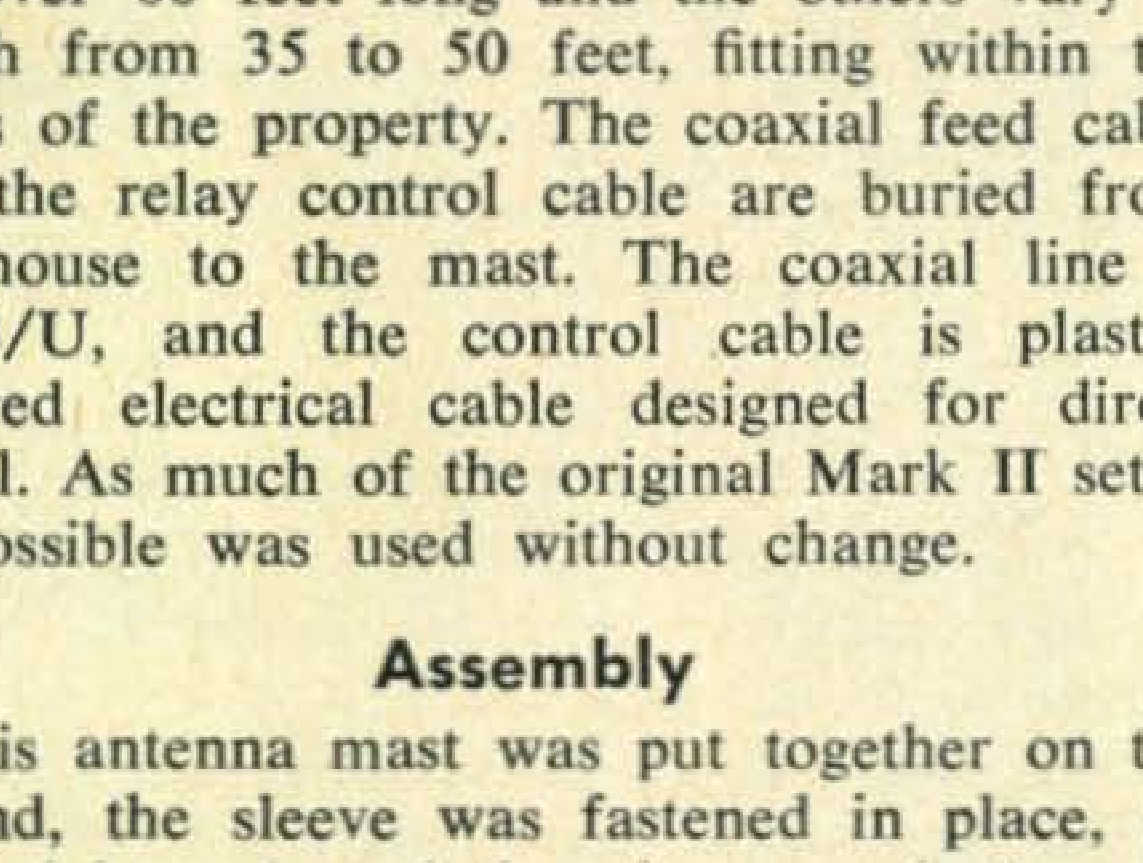


**Fig. 11—Ground clamp details used to connect to the radials and the tuning unit. It is made from ¼ × 1" aluminum stock and furnished with brass hardware.**

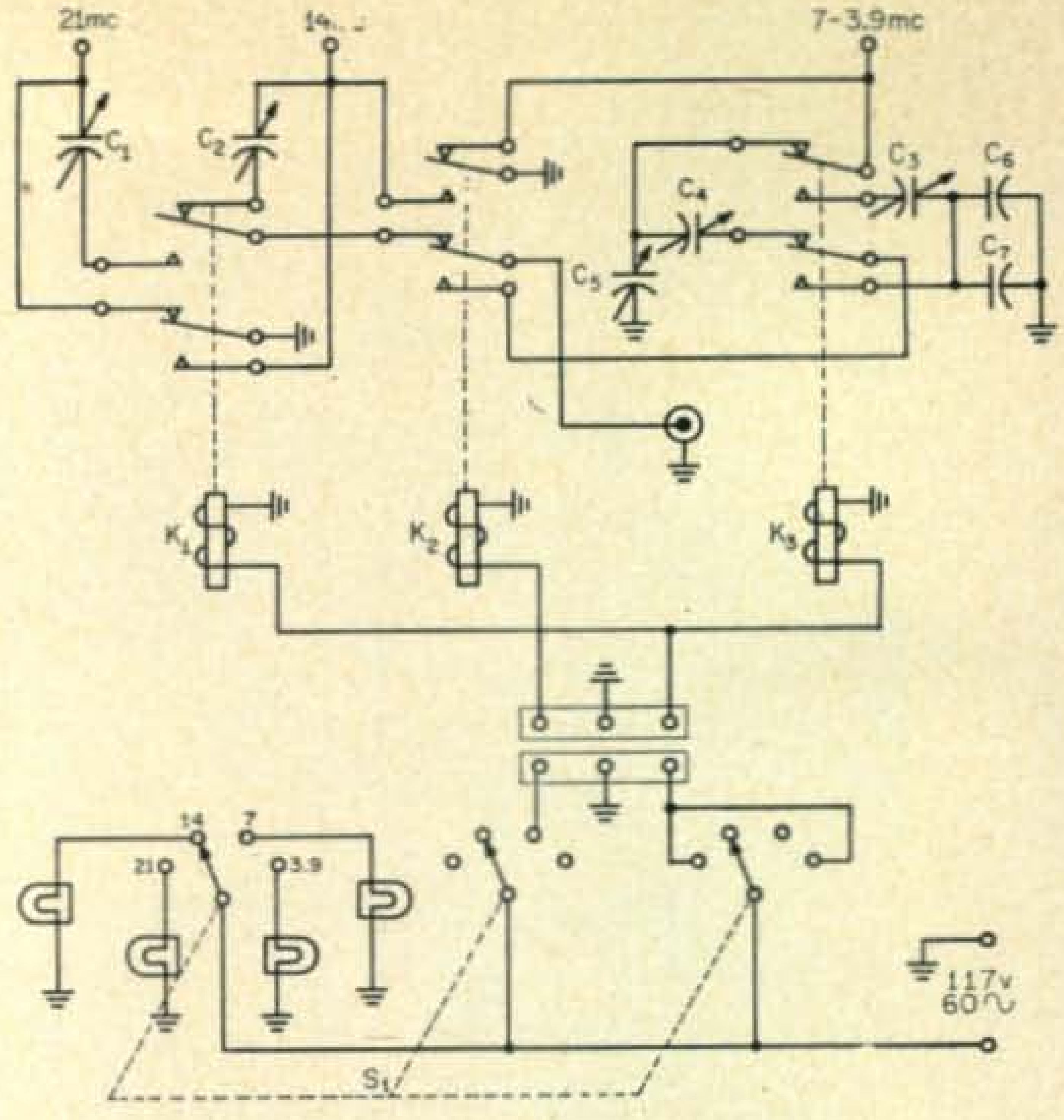

**Fig. 12—Circuit of the tuning unit used to feed the Mark III Colinear vertical. The control circuit is connected to the remote tuning unit by underground plastic cable.**

**$C_1$, $C_2$, $C_4$—110 mmf vacuum variable.**
**$C_3$—750 mmf vacuum variable.**
**$C_5$—150 mmf Air variable.**
**$C_6$, $C_7$—0.0011 mf 5 kv micas. Sangamo type F-2 or equiv.**
**$K_1$, $K_2$, $K_3$—D.p.d.t. relay 117 v.a.c. coil. Ameco type 51 or equiv.**

plumb, but when the wind died there was the mast, as straight as before. The movement of the sleeve in normal winds has no effect on loading.

### Tuning Unit Adjustments

The operating sequence of the tuning unit relays is as follows:

| *Freq.* | $K_1$ | $K_2$ | $K_3$ |
|---|---|---|---|
| 21 mc | on | off | on |
| 14 mc | off | off | off |
| 7 mc | off | on | off |
| 3.9 mc | on | on | on |

On 3.9 mc I am using a simple "L" network, with 03 in series with the + j110 ohms feed point reactance, adjusted to leave about + j20 ohms of $X_1$ in the series arm of the "L", with fixed capacitors $C_6$ and $C_7$ as the shunt arm. The input impedance is 51 + j0 ohms at the connection to the coaxial line. On 7 mc the relays cut in an "Omega" match, consisting of two variable capacitors, $C_4$ and $C_5$. $C_5$ is the shunt arm of the "Omega" from feedpoint to ground, and $C_4$ is the series arm leading to the coaxial line. On 7 mc the input impedance of the feed point is more favorable. Again, the input impedance is adjusted to 51 and j0 ohms. On 14 mc, the connection point of that feed rod to the mast was adjusted, and $C_2$ was tuned to give an input impedance of 51 + j0.

ohms. On 21 mc the same thing was done using the length of the 21 mc feed rod and capacitor $C_1$ to obtain 51 plus j0 ohms. Relay control is by means of switch $S_1$ on the operating desk, as described in the January 1961 article. Back contacts on the relays are used to ground unused feed rods. This was especially necessary in the case of the 7/3.9 mc feed rod, as a match could not be obtained on either 14 or 21 mc with it floating.

One might get the impression from the preceding paragraph that a General Radio R. F. Bridge is necessary for tuning up. It certainly is a very handy tool, because it enables one to read accurately both the magnitude and sign of reactance and the magnitude of resistance, for each change in tuning. However, it is not an absolute necessity. One may use an s.w.r. meter, inserted in the coaxial line right at the input to the tuning unit. This must be an s.w.r. meter which will handle power, however, as adjustment of the variable capacitors is done with the transmitter on and feeding r.f. power to the antenna. This is really a two-man job, with one person at the transmitter to turn it on and off for stub adjustments. He must also see that adjustments being made at the tuning unit do not cause overload at the final amplifier. In my own case, I did not care whether the 4-1000A, running at low voltage and about 100 watts input, went out of tune or not, as long as I was able to get enough output for s.w.r. meter readings. The 4-1000A could not be hurt at all under such conditions. However, the proud owner of a sensitive pair of 6146's would not be so fortunate, and should have someone standing by the transmitter to retune the final tank if required!

An appropriate type of s.w.r. meter is the "Beercan S.W.R. Indicator" described on page 96 of November 1957 *CQ*. There is also a good one on page 736 of the *Radio Handbook*, 15th Edition. These two are designed to read s.w.r. under power.

Using the s.w.r. meter, adjustment will take longer than with an r.f. bridge, because it is more of a cut-and-try operation. At high values of s.w.r. it is quite difficult to detect the results of changes in tuning. For example, a reactance change from +j175 to +j150, while appreciable and in a favorable direction, would show very little change on the s.w.r. meter. Or, a change from +j50 to –j50 in reactance, with the *R* term remaining about the same, would not show up on the s.w.r. meter as a change unless one passed through the j0 point slowly in the tuning process. However, don't give up hope at this point. The job can be done with an s.w.r. meter and some patience and care.

In fact, the next tuning unit I build will contain a built-in s.w.r. meter as a permanent fixture, with provision for shorting out the sensitive microammeter for its protection when not in use.

## Performance

The Mark III has provided many excellent DX contacts on 14 mc, which it was designed to do, and it has outperformed nearby Yagis in laying down strong signals in overseas places like Europe and Australia. On 7 mc it gives very strong signals over the whole of the United States and Canada, depending on skip conditions, and has provided many excellent DX contacts at night. It is useful on 3.9 mc for short-range daytime contacts out to 500 or 750 miles, and at night it reaches out to the West Coast and Europe with no trouble at all. Being able to use it on 21 mc was an unexpected bonus. I had not originally so intended, and I have no idea of the current distribution nor vertical pattern shape on the 21 mc band. However I plan to make an actual vertical pattern measurement on all bands at an early date. This is not hard to do with the antenna in place and connected normally.

For those of you who care to write for further information, please enclose a stamped envelope. ■

# NEW YORK GETS CALL PLATES


Left to right, W2AAO, K2SJO and Gov. Rockefeller.

HOWARD MAGUIRE, W2AAO, (left) who for almost ten years pioneered the adoption of call-letter license plates for New York State amateurs is shown receiving his personal plate from Governor Nelson Rockefeller during the Hudson Amateur Radio Council's Convention held at the Statler Hilton Hotel in N. Y. C. on October 13th. Through Howard's extensive efforts, N. Y. amateurs will display plates for the coming year. Stan Zak, K2SJO, HARC Convention Chairman seems quite pleased with the goings on. Kentucky, Massachusetts and New Jersey remain to be convinced.