A Low Cost 40 Meter Vertical

BY REV. DRAYTON COOPER*, K4KSY

Outlined below is a simple 40 meter vertical antenna using a 40 foot telescoping TV mast mounted in a wooden cradle. The base insulator used is a scrounged telephone pole insulator. The antenna is practically flat from 7200 to 7300 kc with an s.w.r. of unity at 7250 kc and 1.3:1 at the band edges. Total cost — $14.75.

Let's face it: some hams like verticals, some don't. If you're one of the ones who do, or one of the ones who think you might, read on. If you have a closed mind about this type of antenna, and are already prejudiced to the point you believe that they're good for long-haul QSOs, but sorry for the average stuff, then kindly turn the page to the next article.

After spending some years in the broadcast business, it appeared to me that evidently the vertical is pretty good, or else it wouldn't be so universally accepted and required in that field. But true to form, I erected one horizontal after another, going along with the crowd. Then I started doing some 160 meter work, and heard the booming signal that W2FYT and others put in with their shortened verticals. Says I, "If a loaded mast will do that, what would a regular quarter-wave vertical put out?" And then the wheels started turning. Primary considerations here were low overall cost, availability of materials, simplicity of erection and efficiency.

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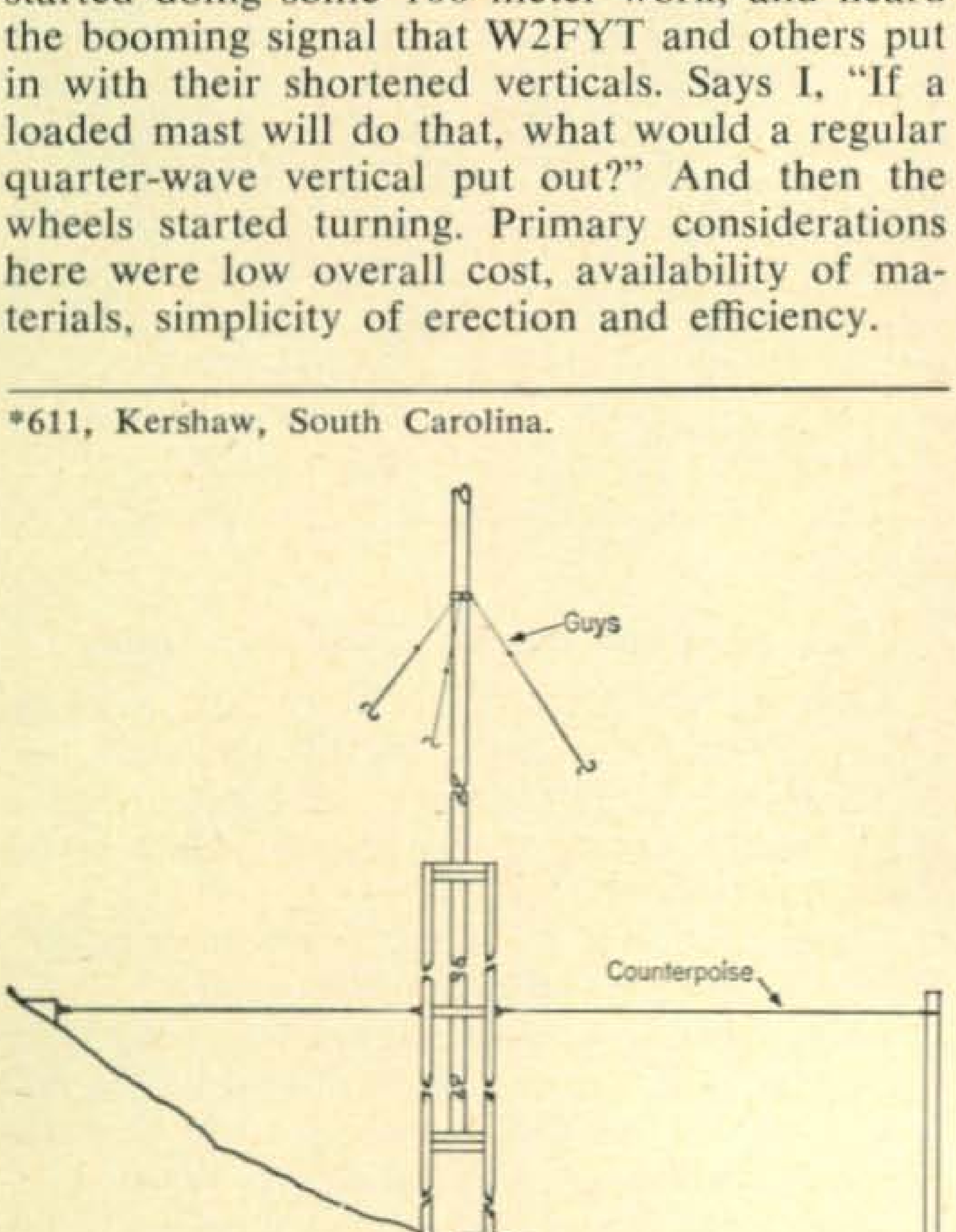


Fig. 1—Side view shows how the counterpoise for the 40 meter vertical is staked out on a slope so that the lines remain level.

Since the vast majority of K4KSY's operation is on 40, it was decided that this would be the band to try a vertical on; this frequency also lends itself to a full-sized vertical because a quarter-wavelength is only 30 odd feet. A 40 meter antenna will also work passably on 15 meters, the only other band which is utilized here to any great extent.

Beer-can type verticals were discarded as being impractical, and commercially-available loaded, or trapped, verticals were discounted because of their inherently lower efficiency as compared to a non-compromise quarter-wave.

This meant finding something that could project itself 35 feet in the air, and yet be strong and broadbanded. The choice boiled down between irrigation pipe and telescoping TV mast. The latter was chosen because it is universally available, was obtainable immediately at a TV repair shop in this small town, and could be lowered in the event of high winds.

When the clerk in the TV shop realized that his crew was not going to have to install the mast, he let it go for a paltry $11.00. This was for a 40 foot telescoping mast, complete with hardware and 250 feet of guy wire.[1]

Mounting The Cradle

With this problem solved, the next hurdle was mounting the stick. A roof-mount was definitely out of consideration, and a ground-mount presented insulation problems. Of course, it could always be shunt-fed, but this, too, seemed to be disadvantageous. Therefore, a wooden cradle was constructed, especially designed to support the base of the mast. This cradle stands six feet tall before placing it in position. It has four legs, although a three-legged variety could be used as well.

Basically, it consists of four 2"×2"×6' strips braced at three vertical points into a 6" square. One wooden plate, ¾"×6"×6" was cut, and then a 2" diameter hole was cut in the center of the plate. Another plate, exactly like this first one, was fashioned, and a third identical *except* for the hole, was made. Finally, 12 pieces of

[1] Allied Radio, Telescoping TV Antenna Mast, 40', #92 CZ 103, $9.75.

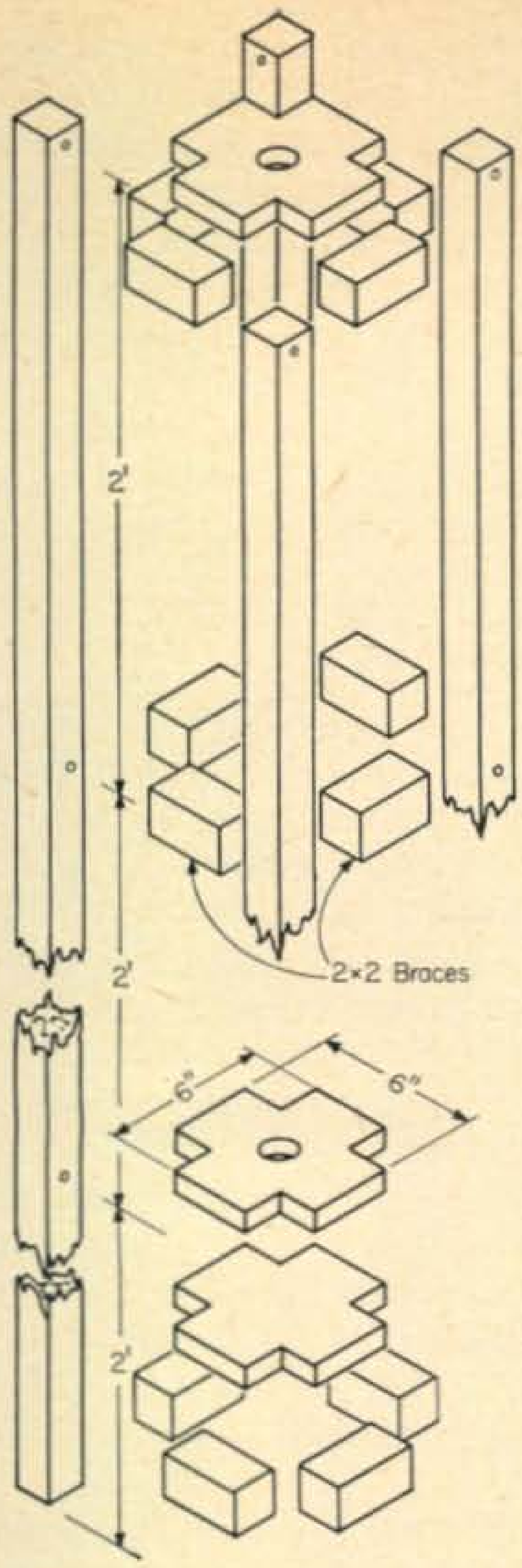


Fig. 2—Sketch shows the dimensions of the 40 meter vertical support cradle. The uprights and cross supports are made of 2" × 2" stock and the three plates of ¾" stock. The bottom 2 feet of the uprights are given a coat of creosote before the cradle is secured in the ground.

2"×2" stock were cut, four inches long each.

Assembly is a snap, and cost of the materials was less than $1.00 at a local woodworking shop. Each of the plates is notched on the corners to receive the 2"×2"×6' strip. Then one of the plates with a hole is screwed (after being glued) to the solid plate. This forms the bottom of the cradle, and supports the weight of the antenna.

Two feet from the bottom of the strips, this plate is mounted. Screw the legs (strips) into the plate. Two feet above this bottom plate, the four short pieces of 2"×2" stock are fastened into place between the uprights by securing with screws. Then, at the very top the remaining plate, one with the hole in it, is mounted. Both the upper and lower plates are further supported by the 4" 2×2 stock as shown in the photos.

When your cradle is completed, a good coat of creosote on the bottom 2 foot section of each of the legs is advised, and a heavy coating of deck enamel over the whole business is preferable. This will slow down the effects of the weather.

Naturally, the best possible lumber should be used as this cradle will be exposed to all sorts of temperature extremes, snow, rain, sleet, and what-have-you. I was fortunate in being able to get heart-pine, a variety of wood that is extremely tough.

Installation

Next in the process, dig a two-foot hole in the ground at the place where you intend to erect your mast. Set the feet of the cradle in it, tamp the earth down tightly, and let sit for a day or so (and hope it doesn't rain in the meantime).

Now then, to the antenna itself. Figure from the formula the length needed at the chosen frequency ($L=F(mc)/234$). If you plan to use metal guy wires as I did, you will find that because of the reactance from the guys, your calculated length will be six inches or so too long. But this is a minor discrepancy, and can be taken care of later.

Placing the collapsed mast on a level surface such as the ground, extend each section to its extreme length. Measure what you have; you'll find a 40-foot mast is actually closer to 37 feet long) and then adjust to the desired length. Then be sure you mark each section at its joint after it has been set for proper length. This will save you from a terrible headache later on.

Most masts have a little cloth sack thrown in them, fastened by a thin wire in the top section. If you'll open this little sack, you'll find a convenient chart telling you exactly how long the guy wires have to be, and the best places to secure them. Cut the guy wires, spacing them every three or four feet with egg insulators, and attach them to the guy rings before goings any further. When this is through, you're ready to go up with the mast.

Having already visited the local telephone company warehouse, I had a three-inch glass pole insulator handy. If you don't have one, make friends with a phone company lineman and chances are you'll be able to get this insulator free. Place it in the bottom plate of the cradle. It will fit snugly into the hole there, and needs to be secured no further.

Now get a buddy to help you do the rest. By all means do this, or be sure your hospitalization insurance is paid up. Raising a mast while standing on the top rung of a stepladder, without assistance, is pretty tricky. But if you're the chancy type, go ahead and play the odds by yourself.

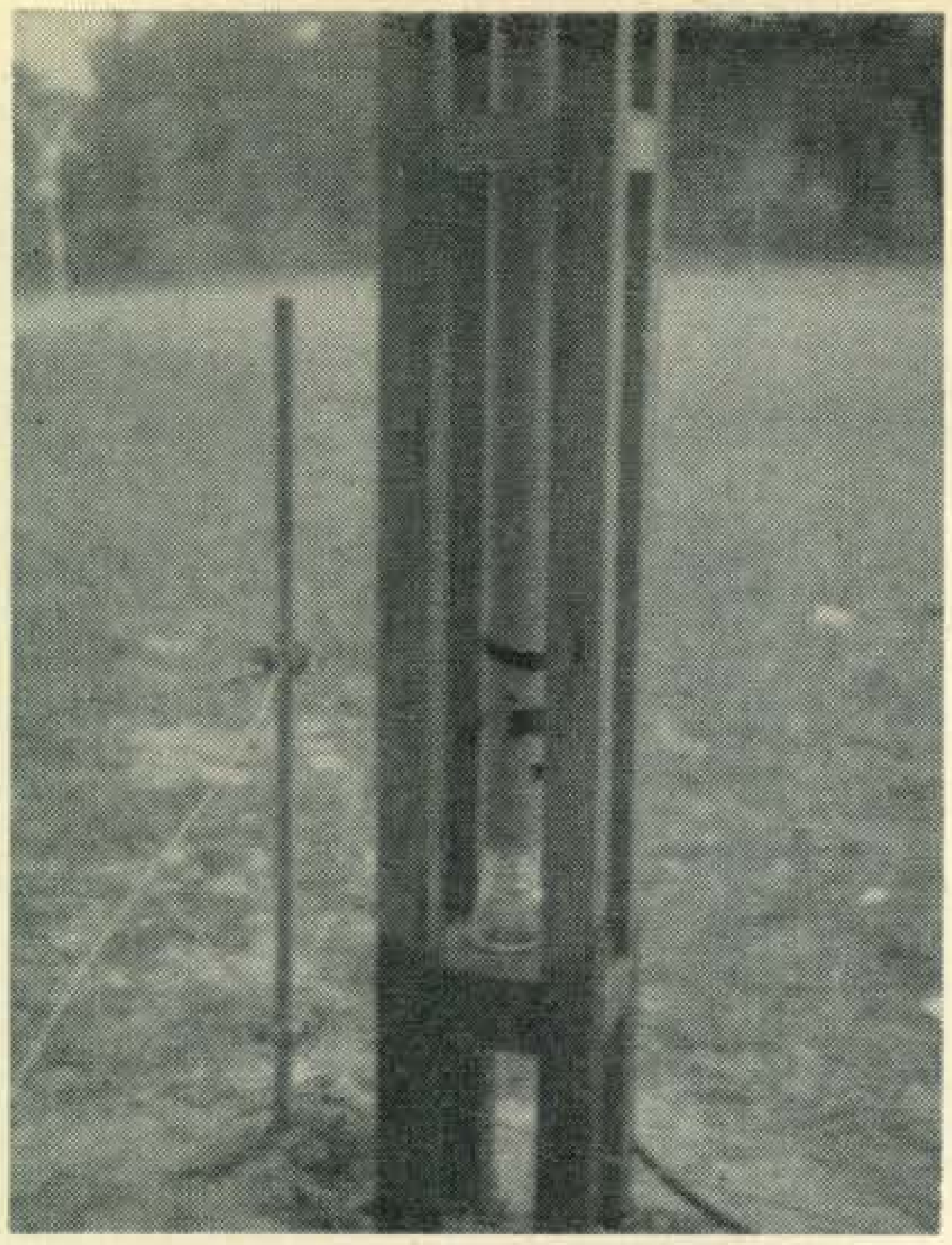
With the mast collapsed, slip it through the top plate of the cradle while your buddy helps you. Then one of you hold the base insulator in place, while the other lets the mast slowly settle down on it.

After this is accomplished, raise the mast, section by section, to the previously marked points, and tighten down on the set screws. When this is finished, you're practically through.

Secure the guy wires to the anchors which you have already set out at the proper places. I was fortunate in having large trees which could serve as anchors, but I did put in one "dead-man". Tighten up on the guys (I hope you remembered the turnbuckles!) and then step off and admire your beauty! Nice, isn't it?

Radial System

No quarter-wave vertical will work unless it has a good ground to be loaded against. A simple rod driven into the ground at the base will not be enough unless you happen to live in a salt-marsh. Either a set of buried radials, or a counterpoise, will have to be used. We chose the



A closeup view of the 40 meter vertical base support shows the mast resting on the telephone insulator. Note the 2 × 2 supports for the base plate supporting the insulator and weight of the vertical. The ground rod is clearly visible on the left.

latter because our lot happens to be on a hill, and burying radials would cause the tower to be higher above ground on one side than the other.

Ready-made radial kits are available, but we "rolled our own" by using left-over wire from some horizontal antennas we had taken down. Beginning with a ground rod at the base of the mast, we laid out six radials, 40 feet long each. These were in a fan configuration. They were all soldered to a clamp on the rod.

The dimensions of the radials are not actually critical. A lot of hams putting up this type of antenna simply use what wire they happen to have, and let the measurements fall where they may. Ideally, though, radials should be as near the length of the antenna as possible, or multiples of that length. However, one old saw is wise to remember here, "The more the merrier." Put down as many as you can, and make them as long as you can, and you won't have any trouble getting it to work.

With the counterpoise, the object is to get the radials above the ground. This saves a lot of digging, and it also will quickly discourage anyone from snooping around your mast in the dark. The real reason, of course, is to give you a stable and uniform ground. In our QTH, the earth is a pretty poor mixture of sand, clay and rocks, with an extremely poor conductivity rating.[2]

Stakes for the counterpoise were driven in the ground where the extremes of the radials would be placed. Since the lot here slopes from north to south, the stakes on the northern side of the mast are only six inches tall, whereas the southern stakes are approximately 10 inches high.

After running the radials out and fastening them to the stakes, a perimeter wire was run from radial to radial, joining them all at the far end. Again, these connections were soldered.

The feedline is, at last, connected to the antenna. Use 50 or 52 ohm coaxial cable. The inherent impedance of a grounded quarter-wave is in the neighborhood of 50 ohms; however, because of differences in ground conductivity and other variables, this figure may be somewhat off. But 50-52 ohm cable will match closely enough. If you're a nut for perfection, you can build up a coupling unit yourself.

Loading

The loading here is practically flat from 7200 through 7300 kilocycles. Only minor touching up of the final is necessary in a rapid QSY from 7203 to 7296. An s.w.r. bridge showed a 1.6:1 reading at band edges, and 1.3:1 at resonant frequency (7250). We adjusted the height downward a few inches, and the ratio dropped to unity at 7250, and less than 1.3:1 at band edges.

This antenna was designed particularly for 40 meters. With a little playing around with loading coils, it could be made to work pretty well on 75 meters, and also on 160. Any antenna will load on any band if you will take the time to work on a coupling network. A bit of coil stock, and some patience and the old "tap and try" method, and you'll have yourself a vertical for 160, 80 and 40, plus 15.

Another strong point in the favor of a quarter-wave vertical is the fact that a second one can be put up, and the two of them phased into a vertical array.[3] Or, for that matter, put up two more and phase the three of them, and you'll have an endless number of possible patterns you can devise with a good phasing network. And don't kid yourself, a vertical array will squirt a signal a long way!

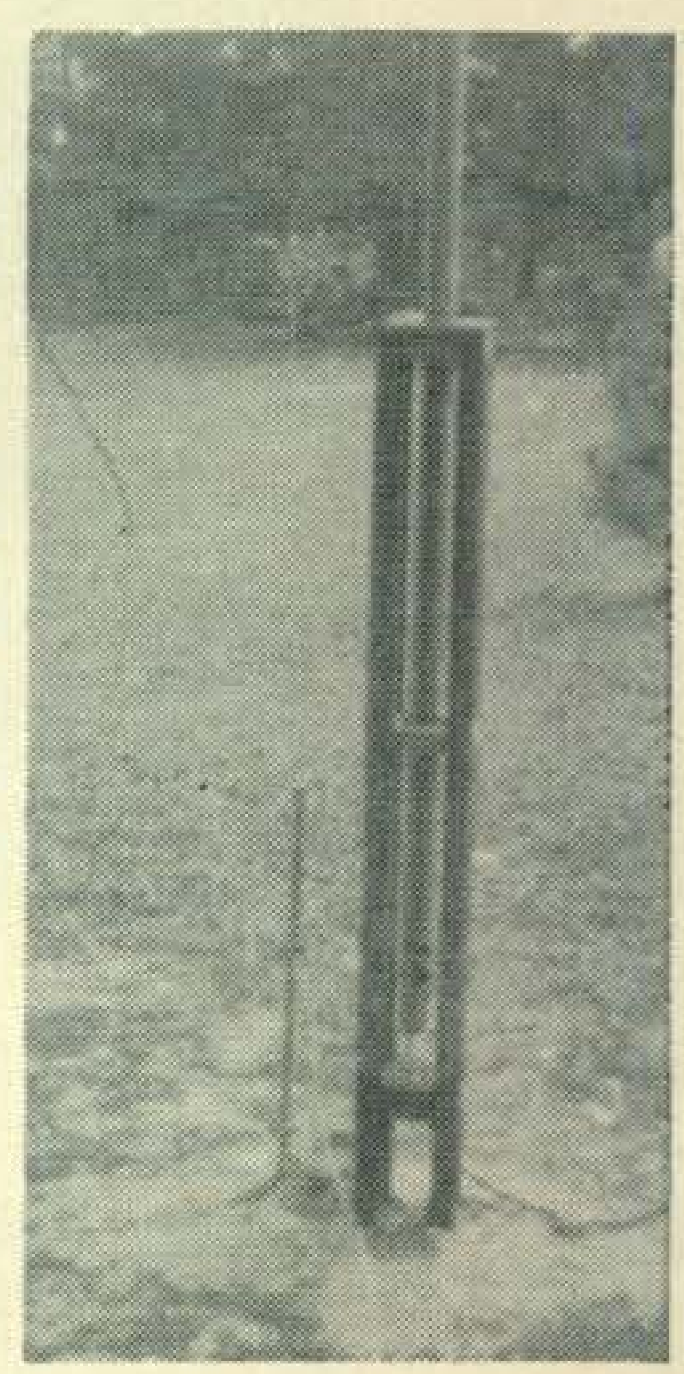
Results

We hams are a pragmatic bunch, and the proof of any system is in whether or not it will work

[*Continued on page 96*]

[2]The local broadcasting station frequently can provide data on ground conductivity. If the conductivity is good, radials may be used. If it is poor, use the counterpoise.

[3]Dixon, R. S., "A Forty Meter Vertical Beam," *CQ*, July 1962, page 52.



Overall view of the 40 meter vertical base shows the feed line running off to the right and the ground rod on the left of the support. One of the stakes supporting the counterpoise system can be seen in the background.

limitations. The input impedance of the load being altered must be of *positive reactance at the lower frequency,* and of *negative reactance at the higher frequency,* like that in curve *B* of fig. 1. The differential series network which folds up the curve over itself can only be applied if such is the case. (A network of series X_L and X_C always looks more capacitive as frequency is lowered, and more inductive as frequency is raised.) If the load impedance is not as stated above, it must first be reversed in sign by a suitable transformation network before the series differential reactances can be applied.

A rectangular plot of s.w.r. versus frequency for the modified Mark III 80 meter feed is shown in fig. 6. At no time is the s.w.r. exactly 1:1, although it approaches it closely at several frequencies.

Inasmuch as the Mark III is already sufficiently broadened on 7 and 14 mc, even enough to permit MARS operation on frequencies at some distance outside the bands, no changes have been made in the feed for those two bands. The only other change in the Mark III since the original article has been the removal of the 21 mc feed. The vertical pattern was not good for DX on that band. Removal of the 21 mc feed caused the feed point for 14 mc to move down the mast about 3 feet. This is the only change. The antenna has performed well for 20 months as of the date of writing, and no further changes are contemplated. ■

40 M. Vertical [*from page 40*]

out. One week after loading ours up for the first time, we had worked 12 countries and numerous stateside QSOs on 40 meters. A check of the reports given by all contacts since the vertical went into operation shows an average signal strength of 8-plus. Unimpressed? Well, maximum power here is 135 watts p.e.p.

Perhaps the greatest satisfaction has arisen from saying "Antenna here is a quarter-wave vertical with a counterpoise ground system, all home-brew, OM." To which the guy will reply, "Tell me more, Dave, it sounds interesting." And you've got a good QSO sewed-up. Total cost here, $14.75. How can you miss? ■

Class C Linear [*from page 35*]

a strictly linear exciter—no compression, clipping, or a.l.c.[6] *etc.* More than half the time, not counting pauses, such an envelope has a peak to r.m.s. power ratio 8 db or greater. Since 8 db is about a 2.5 amplitude ratio, if the peak is at the p.e.p. (*i.e.,* no flat-topping), the same r.m.s. value is produced by a constant signal of 1/2.5 of the peak amplitude where the efficiency is also 1/2.5 or 40% of the p.e.p. efficiency. For these very unfavorable conditions (existing most of the time) this amounts to average efficiencies of approximately 40% of 30% (p.e.p. eff.) or 12% for Class A, 40% of 60% or 24% for Class B, and 40% of 80% or 32% for a Class C linear. It's been said many times before but bears repeating—i.e. by comparison, a two-tone signal, which has a 3 db peak r.m.s. ratio, would show 21% for Class A, 42% for Class B, and 56% Class C average efficiencies which look (and are) *lots* higher than voice signals! A.l.c. and/or audio compression will help keep the peaks up at the p.e.p. level, but they can't beat the 8 db Peak/Ave. ratio down because they can't change short interval envelope shapes. A good clipper is the most immediate, practical way to reduce the peak to average envelope ratio, and a good one improves *both* intelligibility and efficiency. The efficiency pay-off for clipping & a.l.c. is greatest of course in the Class C case due to the higher p.e.p. efficiency.

An alternate form for the Clamp tube of fig. 1 is shown in the circuit of fig. 4. A similar version of this was also in the *CQ Sideband Handbook* section (page 154). The 6BL7, V_2, is a dual triode with the first half as a d.c. amplifier, the second as a cathode follower d.c. screen driver or modulator. W6EDD has recently developed this circuit to drive a pair of 4W300B's in a Class C Linear. Its use solves an objection to the circuit of fig. 1 by eliminating R_4 because it has to be a rather husky resistor since the current is high under static conditions. A second problem solved is that if the filament should burn out in the fig. 1 case, or V_2 inadvertently left out of the socket, full screen voltage is applied to the amplifier tube which would certainly be rough! Still another advantage is that the cathode follower of fig. 4, being a low impedance device, will give better assurance of linearity against any non-linear screen grid loading.

Part II of this article will cover the construction and adjustment of a Class C linear amplifier.

[*To be continued*]

[6] A.l.c. does not normally affect envelope shape (linearity) providing the time constant is greater than 50 ms.

The Dow ECO [*from page 37*]

20 may endanger the crystal. Find out from either a smart old-timer or a smart newcomer what tubes this applies to. Also, operate the screen of electron-coupled crystal oscillators at a maximum of 100 to 150 volts unless special precautions have been taken in the design.

Check the oscillator against a stable standard, such as a continuously-running crystal oscillator or the b.f.o. of a stable receiver. If it is good, use it and enjoy it. Yet, in honesty, remember that much of what you have done was pioneered by Lieutenant Jennings B. Dow, USN, ex-W3TL.

Postscript

Experimenting with oscillators is a most rewarding experience. Comparisons are easy to make between one test and the next.

The principle is basically understood, yet there is much in the subject of oscillators for the ham to improve and invent—for instance a good *and exact* mathematics of how those blinking things work in Class C.