An Optium Performance Array for 160, 40 and 20 Meters

BY ADRIAN WEISS,* K8EEG/Ø

THE antenna described in this article represents one possible solution to the perennial problem of the city-dwelling amateur—limited space. After having enjoyed the advantages of various longwire antennas 1300-1900 feet long during the past several years, moving to a 40′ × 70′ city lot was a traumatic event in this ham's life, but the solution has made my particular brand of ham radio—QRPP, or under-five watt operation—as enjoyable as ever, with the added bonus of 160 meter operation thrown in for good measure.

The basic antenna is the familiar "8JK" endfire wire array that has been described in numerous places in the literature. It consists of two elements (at 7 mc, or half-wave frequency) or four elements (at 14 mc, or full-wave frequency) fed 180° out of phase, thereby resulting in a bi-directional pattern perpendicular to and in the plane of the elements. Under conditions of optimum spacing, the antenna described herein results in a theoretical gain of 4.7 db at 7 mc and 6.2 db at 14 mc. The spacing used in my version is a compromise between optimum spacing for these two bands—just under 1/8th wave on 7 mc and just over 1/8th wave on 14 mc. Since the array is fixed in an East-West pattern, the North-South direction is sacrificed, but when faced with the prospect of gaining the advantage in two directions that the antenna offers, it is not difficult to do without 360° coverage.

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Although a wire antenna is difficult to photograph, this photo shows the entire center boom mounted on a 10′ TV mast for added center height. Wires have been indicated by broken lines added by CQ artist. The 300 ohm open wire feedline is visible running off to the lower right of the photo.

One reason for choosing this type of array over other possibilities was the potential of the array as a top-loaded vertical radiator on 160 meters. There was no way of predicting the performance of the array beforehand on this band, but is was decided to take the chance on it—and it has turned out to be a fortunate choice. Judging from tests of the antenna as a top-loaded vertical on 160 meters, and from its DX performance during the 1971 *CQ* W.W. 160 DX Test, the antenna functions as a vertically polarized radiator on this band, resulting in excellent long-distance propagation.

At first glance, the mechanical requirements of such an array seemed a formidable obstacle. Usually this type of antenna is end-supported between two poles or trees or similar, with the result that the entire weight of the array (which is quite light due to its use of wire for the elements) depends for its stability upon the end-supports. With the 40 m.p.h. winds that characterize South Dakota weather, it seemed unlikely that the thing would stay up unless two telephone poles were planted—an impossibility. So, it was necessary to rethink the mechanical installation. It seemed logical to provide a stable support at the center of the array, the point of greatest stress, thereby eliminating the need for two stable end supports, and greatly increasing the durability of the whole affair. Coincidentally, the use of a single center support worked in perfectly with the apex of the roof of our two-story house—it was possible to achieve a center height of 40 feet with a single 10 foot TV aluminum mast, unguyed. Since the trees to be used for end-supports were very unstable at the 40 ft. level, it was decided to anchor the ends of the array at the 20 foot level where little movement occurred in even the highest winds. What resulted, thus, was an "8JK" array that looks like an inverted V. Judging from the performance of the array, the effects of bending the elements at the center as in an Inverted V seem to be the same broadening of the bi-directional pattern that is evidenced in the bending of a dipole at the center. No stations have been worked to the North or South, but the Southeast and Southwest have been worked consistently on 40 and 20 meters, but with appreciably lower signal strengths than the favored East-West pattern.

A quick appraisal of the materials needed will indicate that the outlay of cash for the array is quite low. At the most, $25.00 could be spent if #10 solid copper wire is used for the elements and feeders. This writer's array cost about $7.00 and one afternoon of time, excluding $3.50 for 100 feet of commercial 300 ohm open-wire feeders. The only problematic items are the bamboo poles used for the spacing booms. Usually these can be found in any sporting goods store that carries fishing equipment, and can be had for under $1.50 each, if thick 20 foot poles are used, and this is advisable.

The most difficult part of the mechanical setup is the "T" bracket used to secure the center boom to the TV mast, and even a Tenderfoot scout could handle this job. Figure 2 gives the details of the "T" bracket. In constructing the bracket, notches are first cut into the sides of the mounting pieces (1" × 3" and 1" × 2" pine or other suitable material) at the proper places for the insertion of the U-bolts which clamp the boom and mast to the "T" bracket. The horizontal and vertical mounting pieces are nailed together with 3 inch nails, which are then flattened on the underside for improved mechanical rigidity, Next, center of balance of the ten foot bamboo center boom is matched up with the vertical mounting piece of the "T" bracket and U-bolted to the horizontal piece with 1¼ inch U-bolts.

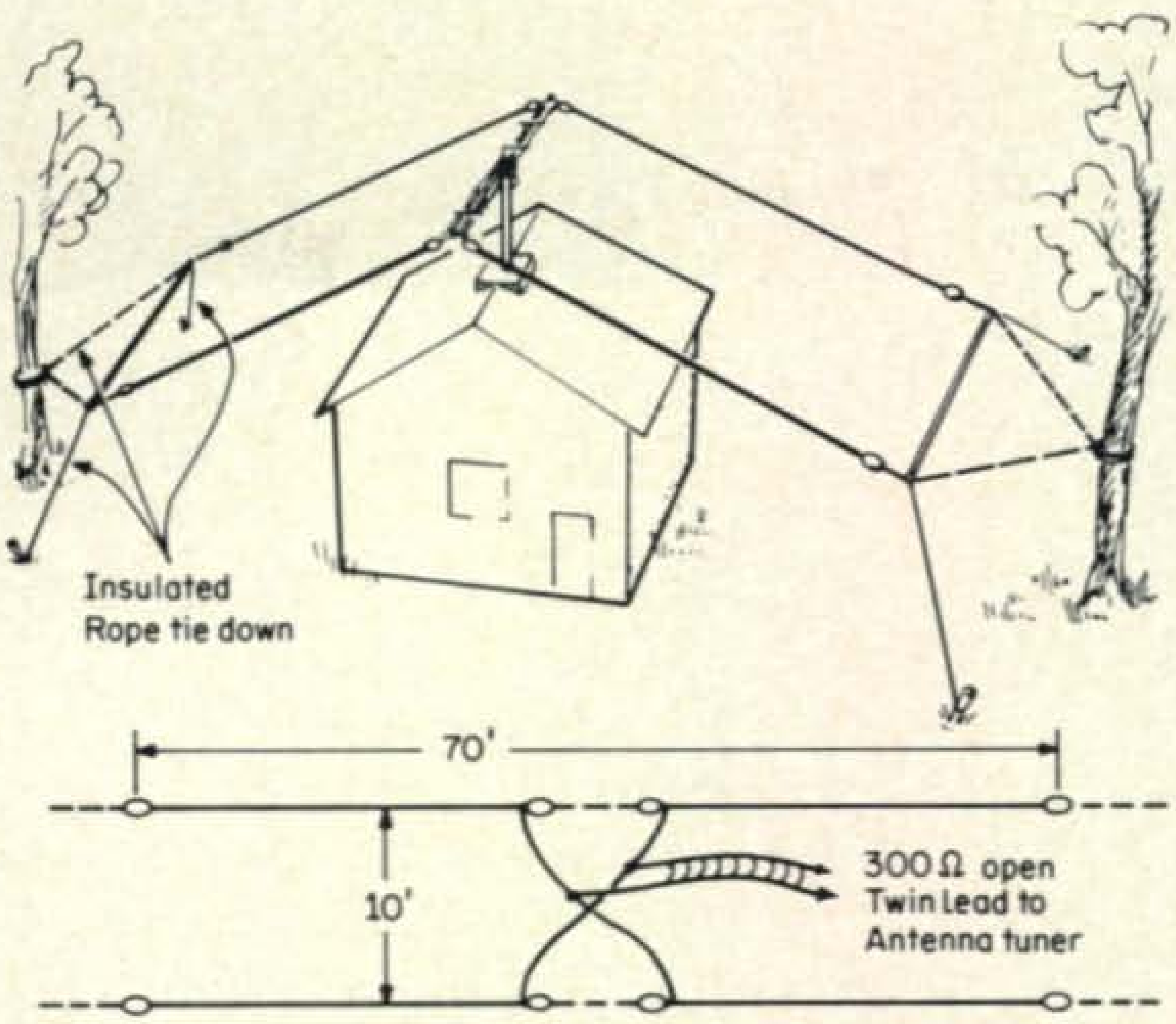


Fig. 1—Overall drawing of the optimum performance 160, 40 and 20 meter array showing positioning of the 10 foot bamboo poles used as booms for the wire elements. Also shown is the actual antenna configuration. Note the crossover of the elements at the center feedpoint. At each end of each element, heavy insulating cord is used to support the wire ends.

Six spacer arms six inches long are cut from 1/2" × 1" trim stock, and two small holes, 1/4" apart, are drilled in each end of the spacer arms. When securing the wire elements to the spacer arms, a small piece of bell-wire is looped through these holes and tightened to secure the elements in place. Finally, 1 foot lengths of heavy gauge wire —aluminum guy-wire is perfect—are connected to the ends of the boom (four required) for securing the insulators to which the elements are later connected. The "T" bracket can be varnished or painted, and is ready for the installation of the elements and for mounting.

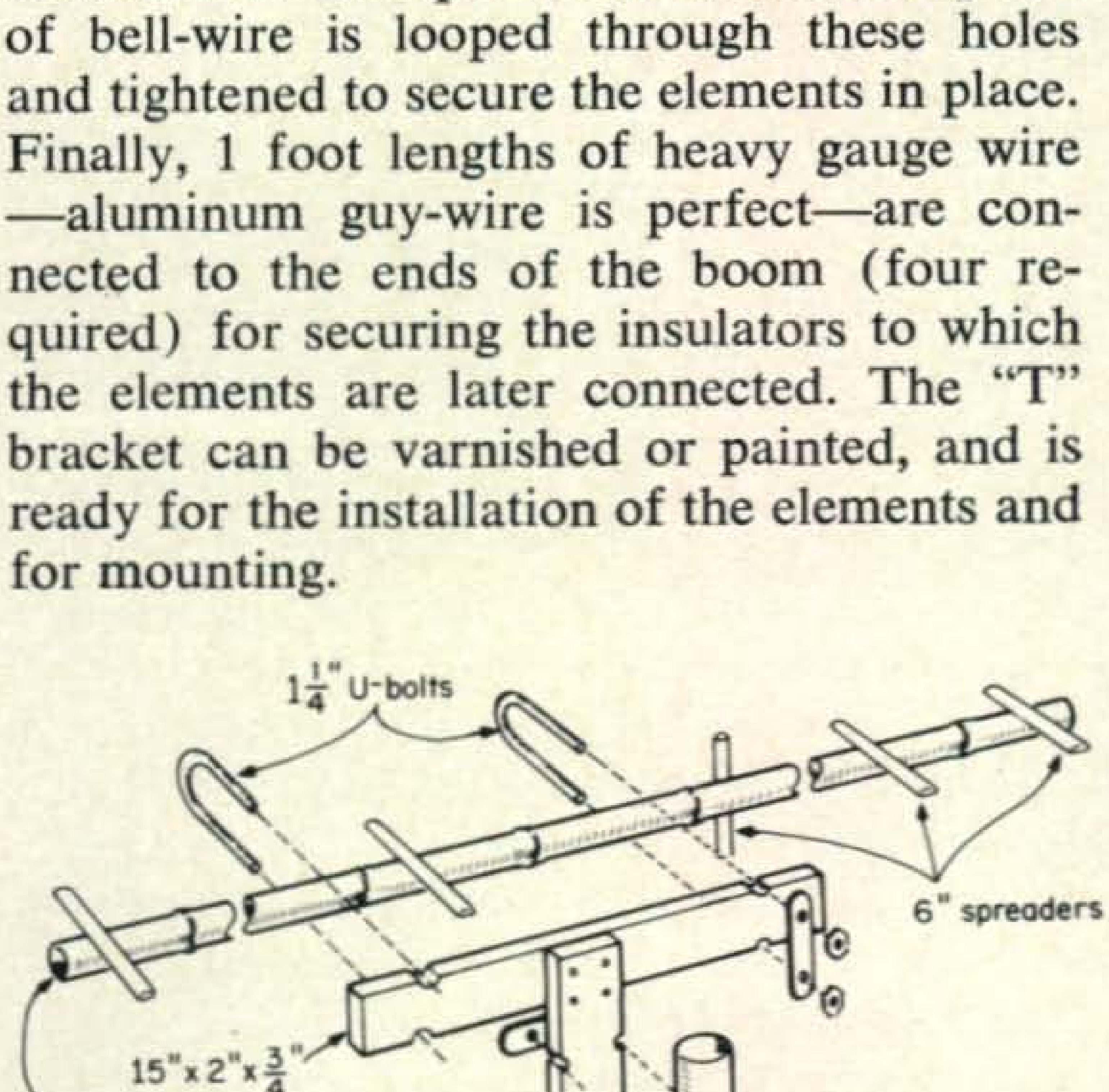


Fig. 2—Center boom construction. See text for detailed assembly instructions.

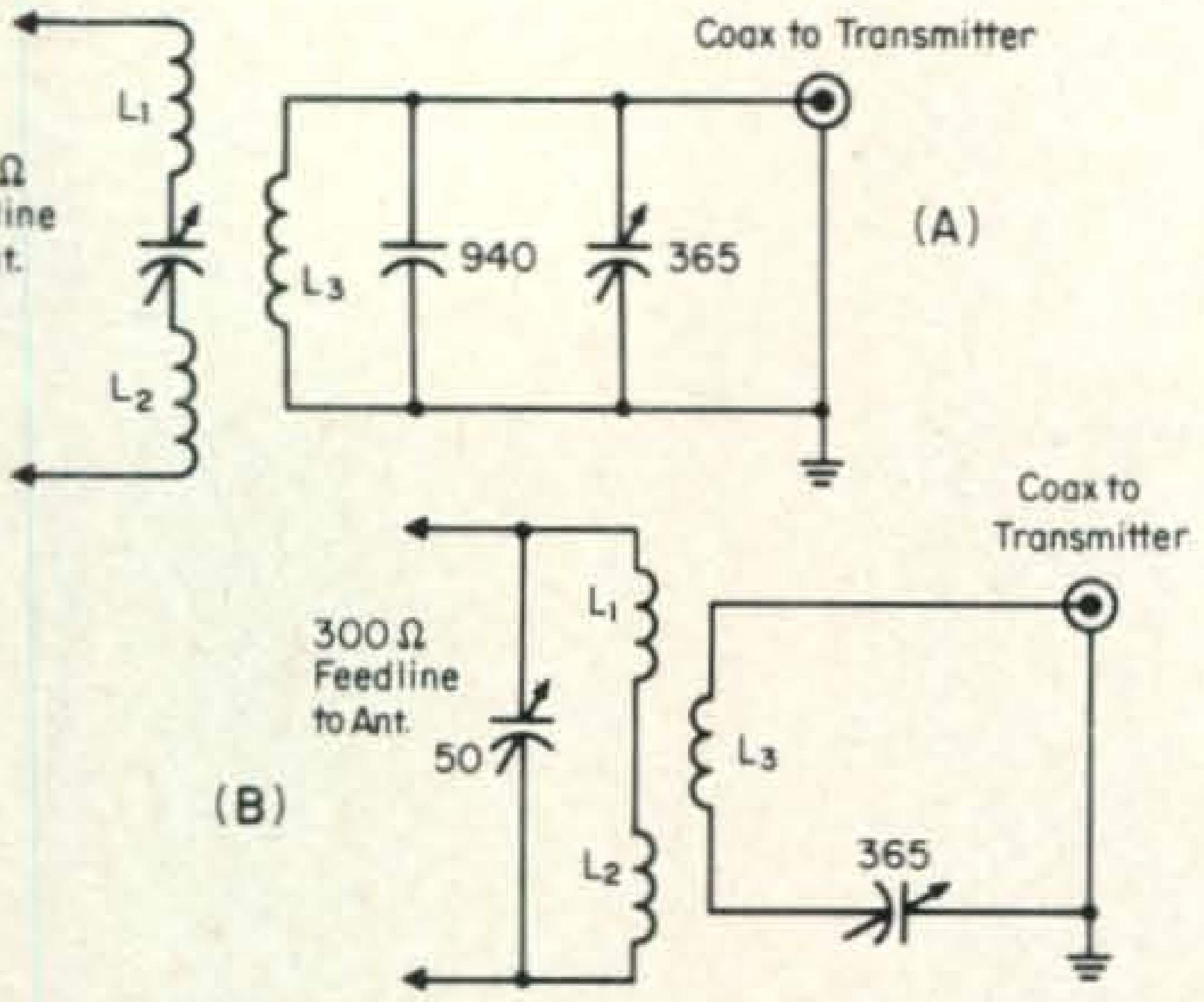


Fig. 3—(A) Antenna tuner for 7 mc. L_1 and L_2 are 26.1 μh total (20 t. #12, 3½" dia. close spaced). Separate L_1 from L_2 by width of L_3. L_3 is .82 μh (4t. #12 on same form as L_1 and L_2. Coupling can be made variable by using three forms. (B) 14 mc tuner. L_1 and L_2 are 2.5 μh total (10 t. #14, 1½" dia. close spaced). Separate by width of L_3. L_3 is 2 t. #12.

One beautiful aspect of this type of array is that the lengths of the wire elements are non-critical. The only requirement is that all elements be the exact same length to insure electrical balance. It is wise to use two continuous lengths of wire for the elements in order to keep actual ohmic resistance as low as possible by eliminating unnecessary soldering connections. Two lengths of from 70-85 feet can be laid out side-by-side, and folded in half to determine the exact center points where the feedline is to be attached. The easiest way of proceeding is to coil up the wire elements from the four ends to the centers before attaching them to the boom. Beginning at the center of the boom, the wire elements are attached to the spacer arms by looping a piece of bell-wire through the two holes at each end of the arms, and tightened by splicing. *Do not forget to cross-over the wire elements half-way between one end of the boom and the center—otherwise the antenna will not function properly.* The cross-over is aided greatly by mounting one spacer arm vertically and crossing at that arm.

The feed-line can then be soldered to the wire elements at the exact midpoint of the elements. It is important to insure a good connection at this point because of the electrical conditions which exist there. On 7 mc, for example, the radiation resistance of the array at the feedpoint is approximately 8 ohms, and the actual or ohmic resistance can be several times that amount—any lossy connections will hence result in wasted r.f. The best approach is to splice several inches of the feedline along the wire elment and solder liberally. I found it the easiest approach to unwind only a few feet of feedline so that the whole array can be mounted without difficulty.

The work on the center boom is completed, and the array can be swung aloft. Regular TV aluminum mast will carry the scant two pound weight of the entire assembly without any difficulty. U-bolts are used to secure the boom to the mast.

The end booms are then connected to the uncoiled wire elements at each end by means of insulators and heavy guage wire. Strong cord, such as bricklayer's twine, is entirely satisfactory for the halyards which secure the end-booms to their trees or poles. A continuous loop of cord, with its two ends tied to the ends of the boom, is used for the main connection; two single cords tied to each end of the boom are used to maintain horizontal attitude once the booms are raised aloft. After securing all points and adjusting for horizontal attitude, the array may be forgotten for several years, I suspect. The fiercest winds that the South Dakota plains can muster have failed to even sway this array, so its longevity seems hardly a matter for speculation.

On all three bands, antenna couplers are used to match the feedline to the transmitter. It is nigh impossible to get a good match between the feeder and the antenna, and the s.w.r. at the feedpoint can range as high as 30:1, but this does not affect the performance of the array. On 160 meters s.w.r. is no problem due to the electrical nature of the antenna on that band.

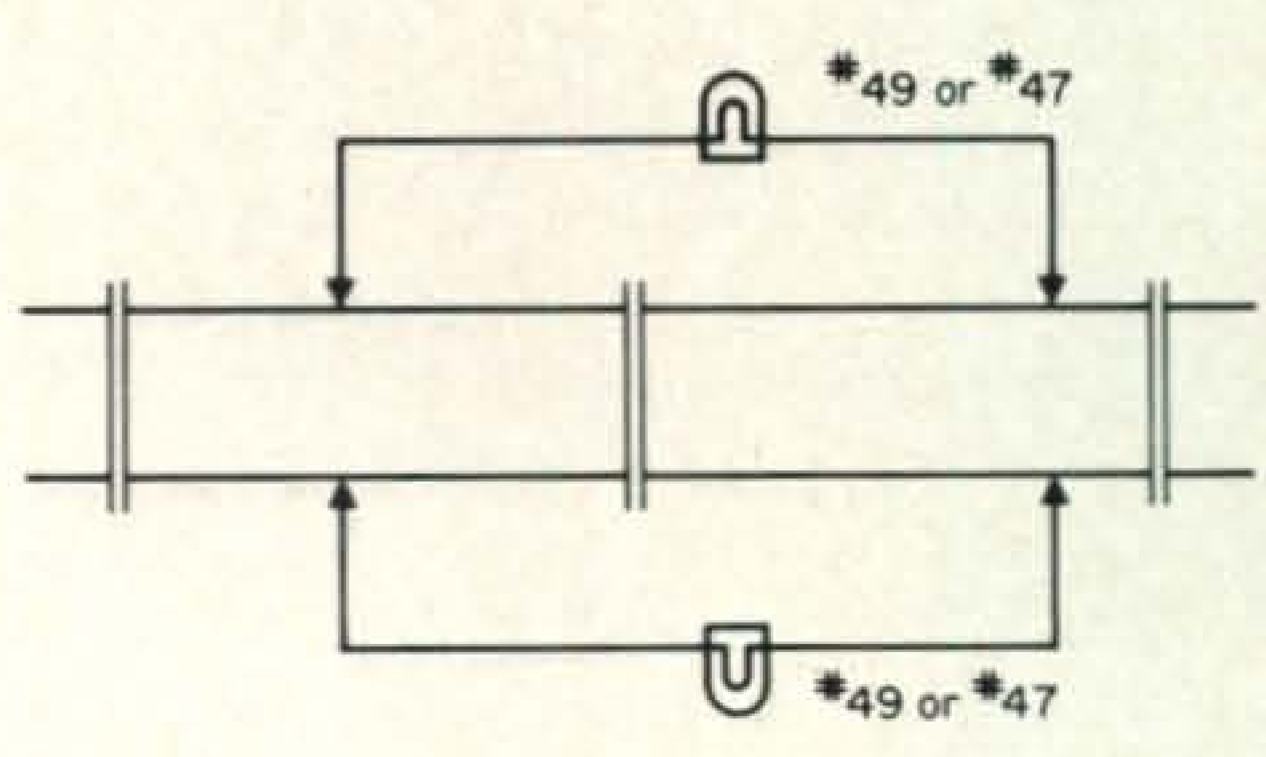


Fig. 4—Shunting #49 or #49 bulbs across 1"-6" of feedline will provide a handy current indicator for under-five-watt powers. Highest current indication is generally, but not always an indication of low s.w.r. Below 1 watt, bulb may have to be placed in series with feedline to get an indication, but in any case, they must be removed when tuning is completed.

Although any length of feedline can be used with a properly designed antenna coupler, it is wise to stick as close to the points of pure resistance on the feedline—or the electrical quarter-wave points—in choosing the length of the feedline. The *electrical* quarter wave-length of a feedline is computed from the following formula:

$$L\ (\text{ft}) = \frac{248}{f\ (\text{mc})} V \text{ (velocity factor of feedline)}$$

The velocity factor of your feedline may be determined from formulae found in the *ARRL Handbook* or *ARRL Antenna Book,* or from manufacturer's specifications. Any multiple of an *electrical* quarterwave for 7 mc suffices for both 40 and 20 meters. Capacitance and inductive reactance components will be at a minimum with such a length, thus making the design of an antenna coupler simpler.

Special care must be taken with the design and construction of antenna couplers to be used with this antenna on 40 and 20 meters. Although most handbooks and journals describe a variety of all-band antenna couplers involving tapped capacitances and inductances, a word of caution is in order. Even though these couplers will allow you to achieve a 1:1 s.w.r. between feedline and transmitter, any coupler which uses tapped inductances or capacitances (dual section capacitor with rotor tied to ground) is likely to be quite lossy. R.f. invariable seems to flow in the shorted-out portions of both components and is wasted internally, never reaching the feedline. For best efficiency, the feedline should be connected across a lumped inductance-capacitance—this assures that the coupler is canceling out only the capacitive/inductive reactances presented to it by the feedline—and not some internal components (see George Bonadio, W2WLR, "Antenna Tuner for Optimum Power Transfer," *ham*

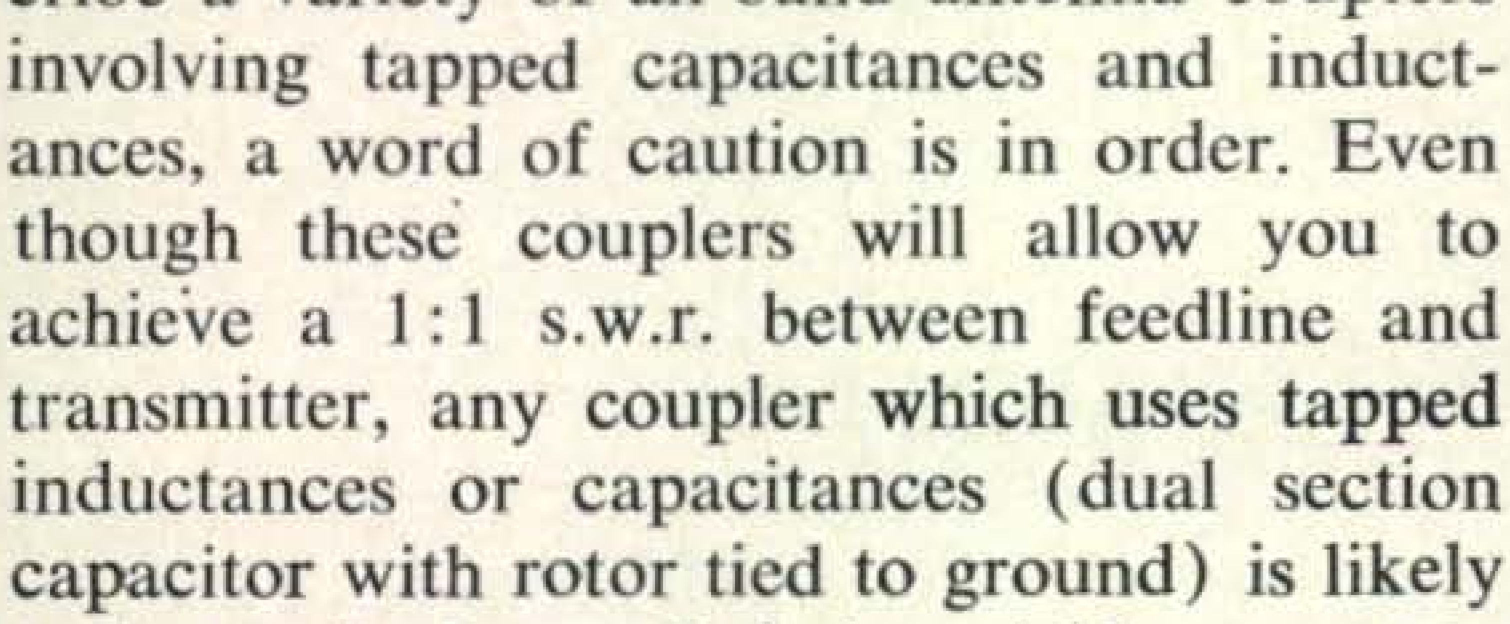
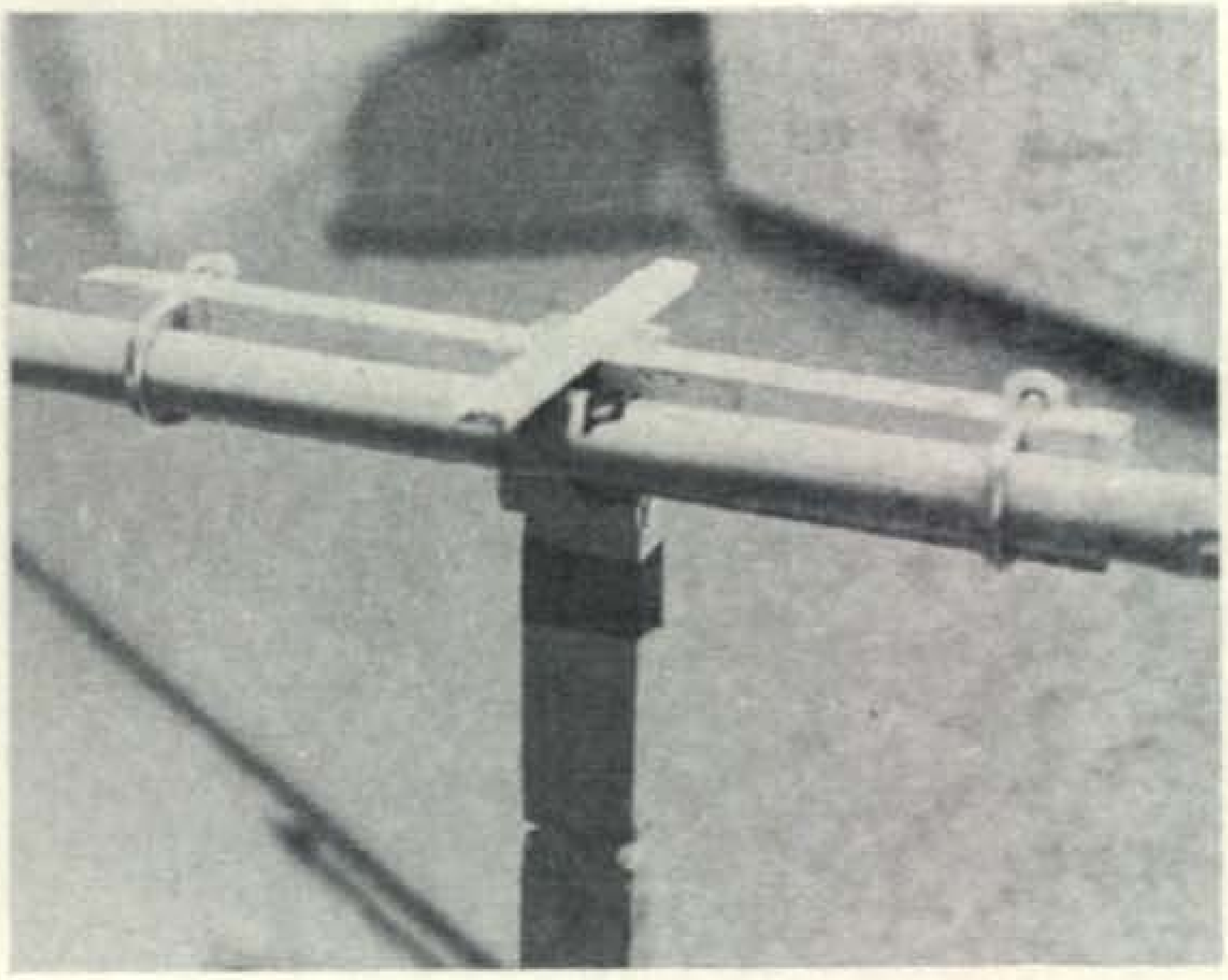


Fig. 5—Antenna tuner for 160 meters. *L* is approximately 47.4 mh for 1.8 mc, and 16.4 mh for 2.0 mc. Tap on L_1 must be determined by experiment, as must the value of C_2.



Closeup view of the "T" bracket used to join the bamboo center boom to the 10 foot TV-type mast on the roof of the house. Also shown is one of the six 6" long spreaders mounted atop the "T".

radio, May, 1970, 28-31, for discussion of this phenomenon). For example, I compared my "tried-n-true" all-band coupler with one designed especially for this antenna on 20 meters, and utilizing a lumped inductance-capacitance. The all-band coupler achieved a perfect 1:1 s.w.r. between transmitter and feedline, and *no* current flowed in the feedline! The compatible coupler achieved a 1:1 s.w.r. also· but the current flowing in the feedline from my 130 milliwatts output was sufficient to burn out a #49 bulb in three seconds! The difference, in short, was no less than between no current and high current! Similarly, on 40 meters, the old coupler, with the same output and a 1:1 s.w.r., showed only half the feeder current as did the properly designed unit. This should be convincing proof of the need for a "compatible" coupler employing simple lumped inductance-capacitance.

In my installation, a feedline slightly in excess of a half-wave was required—which resulted in a high degree of capacitive reactance presented by the feeders to the coupler. Correspondingly, a high amount of inductance was required in the coupler to cancel the reactive components involved. The circuits for couplers for 40 and 20 meters and proper values (for my set-up) are given in fig. 3. In regard to mechanical construction, it is wise to use the lowest loss components in any power-transfer circuit—this is especially true of operation at one-watt QRPP levels (see Bob Schoening, WØBE,

[*Continued on page 100*]

proposition that may not always work out and where it does so, it may be good over only a limited frequency range. Unless you're lucky, a different length may be required for each band. Nevertheless, where no other means is possible, this method would be worth a try.

Where the *line* s.w.r. is within 2.5:1, any loss due thereto usually will be relatively small. If the *line-input* s.w.r. can be handled by the transmitter (using the above means, if needed), you'll be in good shape as to power transferred to the anntenna and proper operation of the transmitter p.a. —W2AEF

Oscar Flyover [*from page 36*]

Jan, W3GEY, riding in the aircraft with the repeater at his side was able to check and observe its operation first-hand. While the repeater operated well during the test, some modifications will be made to improve its performance still further before it is launched into space.

Similar flyovers are planned for the remainder of 1971. Some may again involve the 2-to-10 meter repeater used on this flight, but others will probably take aloft a 432 mc-to-146 mc repeater being constructed by European radio amateurs or a 4-channel f.m. repeater being constructed in Australia.

Each successful flyover brings closer the day on which the next radio amateur satellite will be launched. According to AMSAT officials, that date is now tentatively set for early 1972. ■

Optimum Performance Array
[*from page 19*]

"Hunting for Losses," *The Milliwatt: National Journal of QRPP*, April, 1970, p. 5., for discussion). The 40 meter coupler was wound with #12 plastic covered house-wire on a 3.5 inch diameter plastic cleaning fluid container. The 20 meter coupler used #14 wire on a 1.5 inch diameter bullion cube container. If at all possible, use a wide-spaced capacitor with the feedline coil of the 40 meter coupler—this is a high-voltage point.

Tuning the coupler is the same as with any. With an s.w.r. meter between the coupler and transmitter, tune for lowest s.w.r. #49 and #47 bulbs provide handy feedline current indicators when shunted across the appropriate length of feedline. For under-five watt levels, #49 bulbs shunted across about 6 inches is adequate, but for greater power, shunt distance may be less than an inch. The lowest s.w.r. usually corresponds to the highest current, but not always—tune for highest indication of feedline current. See fig. 4 for connection of current indicators.

The circuit of the 160 meter coupler is shown in fig. 5. Again, low-loss parts are utilized. I found it best to connect the coupler to one side of the feedline and let the other side "float". Actually, little variation occurs between the two connections, but this seemed to work best. For efficient 160 meter operation, it is necessary to utilize several ground radials which are connected directly to the ground side of the coupler. In my installation, eight radials of random lengths were laid out along the curb of my street and another intersecting street. A few were run along neighbor's hedgelines. All were bent in several places, a matter of no consequence. Suffice it to note that the addition of the radials made a 3-6 db difference in signal level at the 1000 mile range! It may be further noted that said radials won't remain obscure during the summer, so they are pulled in until the fall when 160 opens up again. With a little ingenuity, adequate radial systems can be devised using small guage wire properly anchored to the ground and no one will know the difference. Be circumspect though!

Results

The performance of the array has been gratifying on all three bands. In some nine months of operation, my calls/QSO's rate has approximately doubled over previous antennas, and the stability of contact has increated considerably. On 40 meter, with an output of 800 milliwatts, I have managed to work 37 states, with KH6 twice! On 20 meters, with 130 milliwatts output, I have worked some 28 states and KH6. I rarely fail to raise a station on 20 meters even with such low power. With the addition of a transmitter capable of 900 milliwatts output on 20 meters, results are fantastic—fellows even call me now! The performance during the *CQ* WW 160 DX TEST was indeed amazing. Despite poor conditions, the array used as a top-loaded vertical was excellent on receiving—South Americans and KH6 were anywhere from S5-S9! Using about 75 watts output, I managed to work some 47 states, and 8 countries, including KH6, YV5, HKØ, VP9, VP2, KV4. According to later ragchews, it appears that my signal was the strongest reaching the East Coast from west of the Mississippi. In short, this old stand-by "8JK" has performed very well and made what once seemed a dead-end city lot a very rewarding experience. If you're in my predicament, this antenna could well be the answer to your problems. Give it a try. It costs little and requires little effort! ■

Half-Wave DDRR *[from page 22]*

DDRR antenna for v.h.f. use. Its dimensions for 6-meters probably make it somewhat impractical for most applications. However, for two meters on down it is particularly easy to construct for either fixed or mobile station use. The dimensions for bands other than two meters can be frequency scaled, as a first approximation, from the dimensions given for the 2-meter model. A model should be constructed for test purposes to determine the final dimensions. ■

75 M. WAS Antenna *[from page 28]*

The cost of the whole system including all the wire necessary to make both folded dipoles, is nominal. Refinements may be added, and these will certainly elevate the cost, but the basic antennas, lead-ins, and switches with a balun, should not cost in excess of $15-$20.

Nor is this system a particularly space consuming proposition. All of us know that a 75 meter antenna of any useful kind is not ideally suited to apartment dwelling—neither is this antenna. But if two such wires are put up at 70° angles to each other, (see fig. 2), the whole affair will go on a 100 × 65 foot lot, which is hardly in the estate category.

Result-wise, we completed our WAS in just over the month we had set as our goal. One or two of the "less difficult" states proved more of a problem than we had expected. We seldom had more than an hour of operating time per day, which didn't always come at the optimum propagation period, and this proved troublesome too. Depending upon whether you want to check into nets to get new states, on whether you want to make schedules on other bands for 75 meter contacts etc., you may expect to do better or worse than this. In any case, having two antennas oriented so that they cover all quadrants with major radiation lobes, will greatly help. Good luck. ■