Although parts of it resemble a strange blade for a food processor, it's actually a short tri-band antenna. N9AU takes us through his design considerations for this 12 foot roof-mounted antenna.

A 12 FOOT ROTATABLE ANTENNA FOR 20, 15, AND 10 METERS

BY RONALD J. GORSKI*, N9AU

For more than twenty years, I have been experimenting with antennas of all kinds, and I have formulated two very strong opinions:

1. It's not what you've got, but where you've got it.
2. Height above ground is not nearly as important as height above surrounding objects that can adversely affect performance.

Why Small Antennas?

A great many amateurs in this country live in urban areas that are unkind toward h.f. operation. City lots 30 feet wide are not conducive to 60 foot towers. Dipoles strung between the house and garage, parallel to utility lines, don't do the trick. Roof-top mounting of a yagi close to a building where there are gutters, wiring, aluminum siding, etc., causes performance to be marginal at best. Roof tower mounting is an expensive proposition, and the neighbors or XYL may not think highly of your house being dwarfed by a monster array. There are a couple of ways to deal with these problems: design an array that is small and light enough to be mounted at a substantial distance above roof-top level using TV-type hardware, or trade the h.f. equipment in for 2 meter gear. I chose the former.

Performance: Small vs. Large

A lot of information has been published on short antennas. Some of this information would lead one to believe that an antenna less than full size has serious shortcomings with respect to efficiency and bandwidth—*i.e.,* that you are sacrificing a great deal to get a small physical size. Let me say that the shortcomings are with the people who write these things. Efficiency is simply related to the loss resistance (R_L) of the inductive reactance necessary to resonate the short antenna. If this R_L can be made to go toward zero, the efficiency can be made to go toward 100%. If the coil is wound with small diameter wire on a lossy form, you're in trouble.

Bandwidth is a function of the reactance necessary to resonate the short antenna as compared to its radiation resistance. If only inductance is used to load the short antenna, the X_L will be high, the Q will be high, and the bandwidth will be small. On the other hand, if the antenna is totally end-loaded using large capacity hats, the necessary X_C will be small, the Q low, and the bandwidth large. It is that simple. For a very short dipole (0.17λ), the predominant use of capacity hats is not practical, as the size required would assume monstrous dimensions. The alternative is to use the largest practical-size capacity hats together with ultra-low-loss coils. Efficiency will be very near 100%, and the bandwidth will be more that enough to cover the amateur bands.

Initial Experiments

Initial experiments involved a short dipole helically wound with ½ inch wide copper tape with capacity hats at the ends. The test model was designed for 100 MHz and is fully described in a previous article.[1] Next, a 20 meter half-size dipole was built using fiberglass quad spreaders as the form for the copper tape winding with 18 inch diameter capacity hats at the tips. The efficiency was excellent, but the 18 inch hats were not large enough to secure a really good bandwidth. Radiation resistance was 18 ohms. It was felt that the fiberglass tubes could not support larger capacity hats in heavy ice. Also, some form of multi-banding was wanted, and it was thought that perhaps capacity hats, strategically placed along the helical winding, would have the effect of a parallel resonant decoupler. This proved only slightly productive in that adjusting resonance for one band affected resonance on other bands. The helical approach was abandoned.

Since larger capacity hats were needed for increased bandwidth, it was thought that a high-strength aluminum tube with lumped constants at the ends would be a better approach. Full end-loading yields a nearly constant current distribution, which will give the highest possible radiation resistance (R_r) for a given small physical size. The combination of large capacity hats and a larger R_r should give a much improved bandwidth. Perhaps some adaptation of the lumped constants could make multi-banding possible.

Design

Design criteria were set as follows:

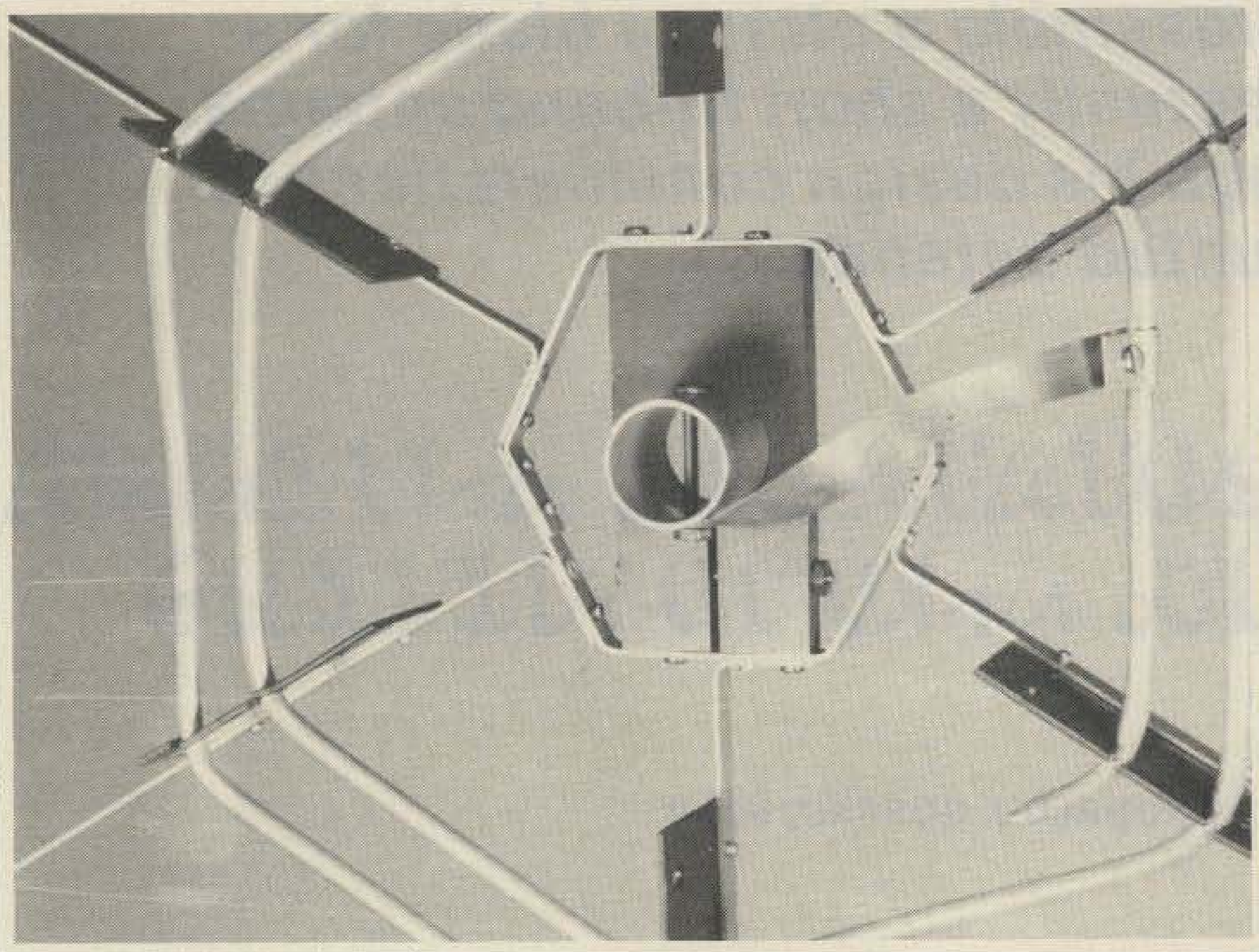
1. 12 foot length;
2. 20/15/10 meter operation;
3. Light enough so that TV-type masting could be used for support;
4. Sufficiently broad-banded so that v.s.w.r. would not exceed 2:1 over entire bands covered;
5. Use simple broad-band matching to 50 ohms.

---

*2330 West National Ave., Milwaukee, WI 53204

[1] *Ronald J. Gorski, W9KYZ, "Efficient Short Radiators,"* QST, *April 1977, p. 37.*

Fig. 1– Close-up of the resonator's center hub.



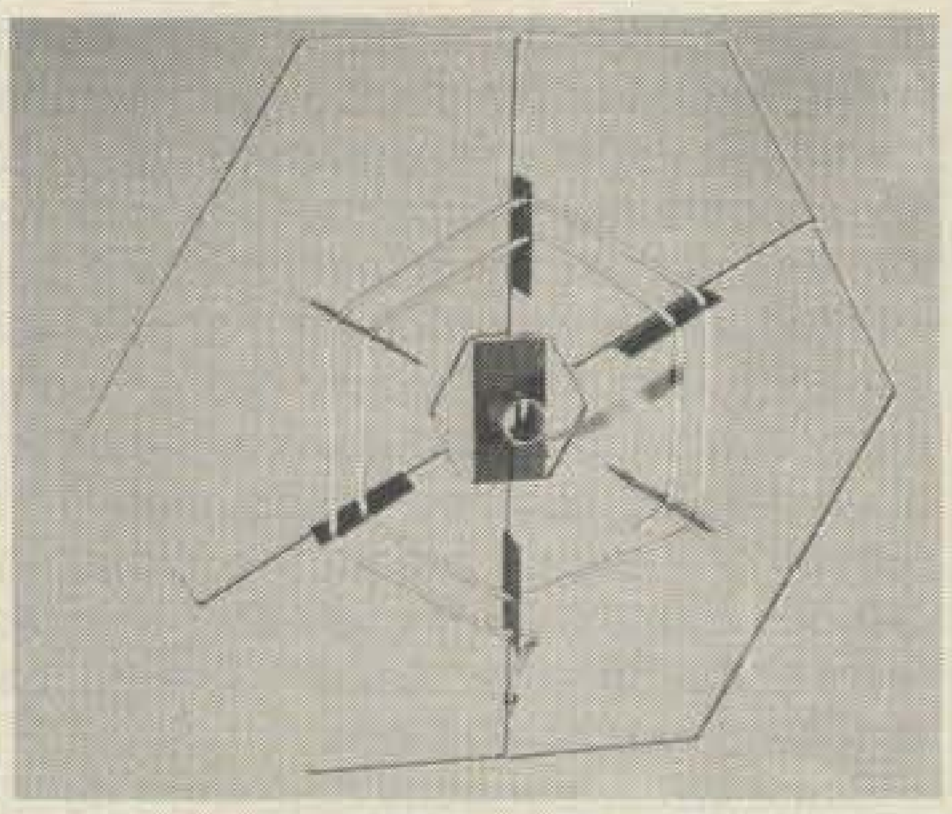


Fig. 2– The 15 meter resonator. The outside hex is 12 inches on a side. The hex-spiral coil consists of 1⅝ turns, the outer turn being 6 inches on a side and the inner turn being 5 inches on a side. The 10 meter dimensions are the same except that the coil has 1⅛ turns.

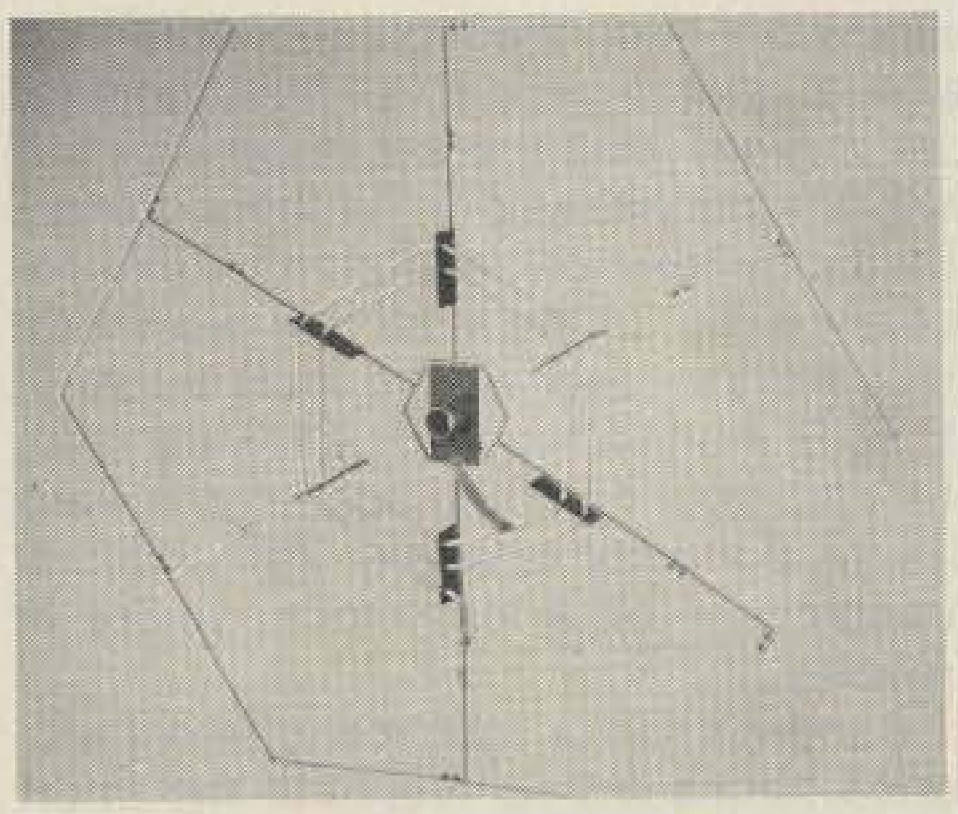


Fig. 3– The 20 meter resonator. The outside hex is 18 inches on a side. The hex-spiral coil consists of 2⅛ turns, the outermost turn being 7 inches on a side, the middle turn 6 inches on a side, and the inner turn 5 inches on a side.

A 12 foot long dipole was constructed using hex-shaped capacity hats, 18 inches on a side. That hats were insulated from the element. The 12 foot length was used because if a constant current distribution could be had, this length would yield a 25 ohm radiation resistance, which would be high enough to negate any coil losses and also high enough so that the dipole could be used for the driven element of a yagi. Also, 12 foot lengths of aluminum tubing are commercially available, and there would be no material waste.

At each capacity hat, a coil was connected between the insulated hat and the element. The inductance was adjusted for antenna resonance at 14.175 MHz using a dip meter. An "antenna-scope"[2] connected directly to the element center indicated a 25 ohm impedance. The height of the antenna was 35 feet.

Next, an attempt was made to secure resonance on 21 MHz using additional resonators. The 12 inch/side, hex-shaped, insulated capacity hats were installed at positions 4 feet either side of element center. As with the 20 meter resonators, coils were connected between the hat and the element. It was thought that since this coil inductance was much larger than the 4 foot element section, perhaps this lumped coil/capacity hat combination would effectively decouple the outer 2 foot element sections and the 20 meter resonators. The coils were adjusted for resonance at 21.2 MHz. Feed-point impedance was 25 ohms (same as 20 meters). The antenna-scope showed that indeed the 20 meter resonators had virtually no effect on 15 meter resonance. The initial theory, in fact, was proven: that a capacity hat/coil resonator can be placed on an element *(without breaking the element with an insulator)* and effectively decouple the remaining outside tip of the element.

This is the breakthrough that was being sought in multi-banding a short antenna. It is merely necessary to place a set of resonators, tuned to the appropriate frequency, at the proper position on an element for each band you want to operate. Positioning of resonators is determined by the length reduction desired and must be followed for each band. If a half-size antenna is built for 20 meters (16 feet), and 10 meter resonators are desired later, they must be placed 4 feet either side of center (8 feet overall) for proper operation. If this relationship is not adhered to, the feed-point impedance will be different on each band.

Construction

The element consists of two 6 foot lengths of 1⅛ O.D. × 0.058 inch 6061-T6 aluminum tubing, center spliced with a 9 inch length of 1 inch diameter fiberglass rod. The rod is inserted 3 inches into each tube and secured with 8-32 × 1¾ inch stainless hardware. Using 2 u-bolts, the rod is attached to a 2¼ × 4 × ¼ inch aluminum plate, which serves as an element-to-mast clamp.

The resonators consist of hex-shaped capacity hat-frames made from ⅜ × 0.063 inch 6061-T6 aluminum strips. The 10 and 15 meter hats are 12 inches on a side and the 20 meter hats are 18 inches on a side. A 2 × 4 × ⅜ inch gray PVC block supports a small inside hex, which in turn supports the larger outside hex through six spokes. A 1¼ inch hole is bored in the PVC block, and a saw-cut is made from this hole to one end. A 1¾ inch long piece of 1¼ O.D. × 0.058 inch aluminum tube is inserted into the plastic block, and the tube is secured with an 8-32 × 2¼ machine screw through a hole drilled edge-wise into the plastic block. Tightening this screw clamps the block onto the tube.

The plastic block is secured to the small hex with four #6 self-taping stainless screws (fig. 1). The outside hex and supporting spokes are made from six ⅜ inch wide strips which have been appropriately formed (see figs. 2 and 3). All joints are lapped 1 inch and are secured with two blind-rivets (aluminum). Prior to fastening the joints, each strip should be coated with some alum/alum anti-oxidizing compound.

The coil consists of hex spiral turns of ¼ inch aluminum tubing mounted to the spokes using pieces of black polypropylene sheet stock. Black poly is necessary, as it is least susceptible to damage from the sun's ultraviolet rays. Three ¼ inch

---

[2] *William I. Orr, W6SAI,* Radio Handbook, *21st ed., Editors and Engineers, Indianapolis, IN, p. 31.18.*

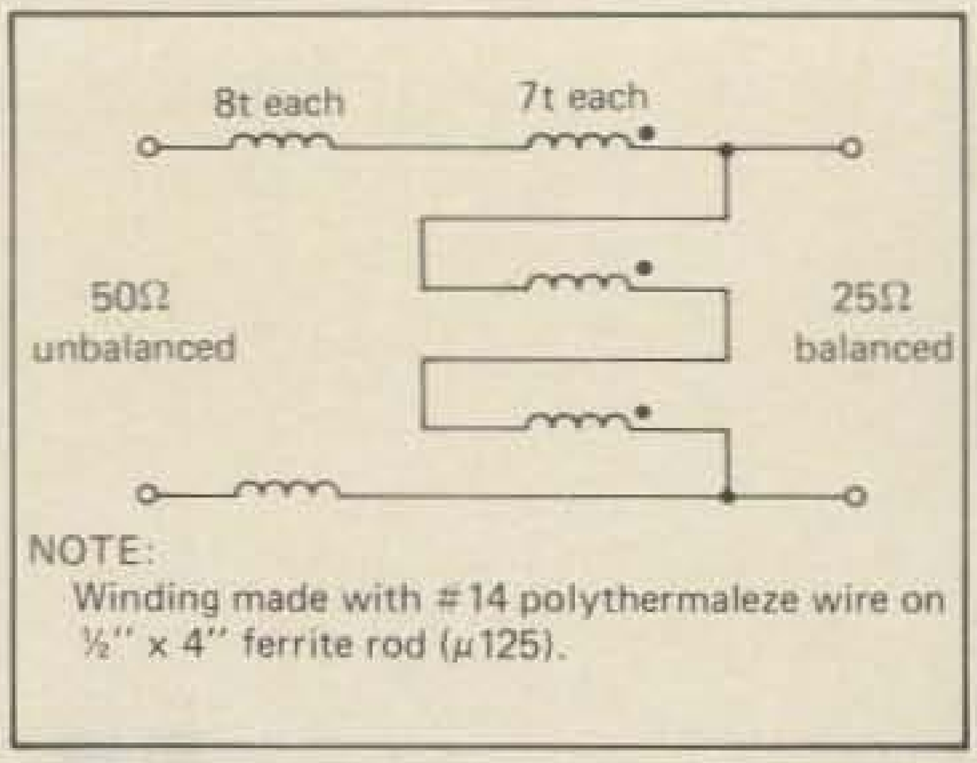


Fig. 4– The wiring diagram for the combination balun/2:1 transformer. Ferrite u = 125.

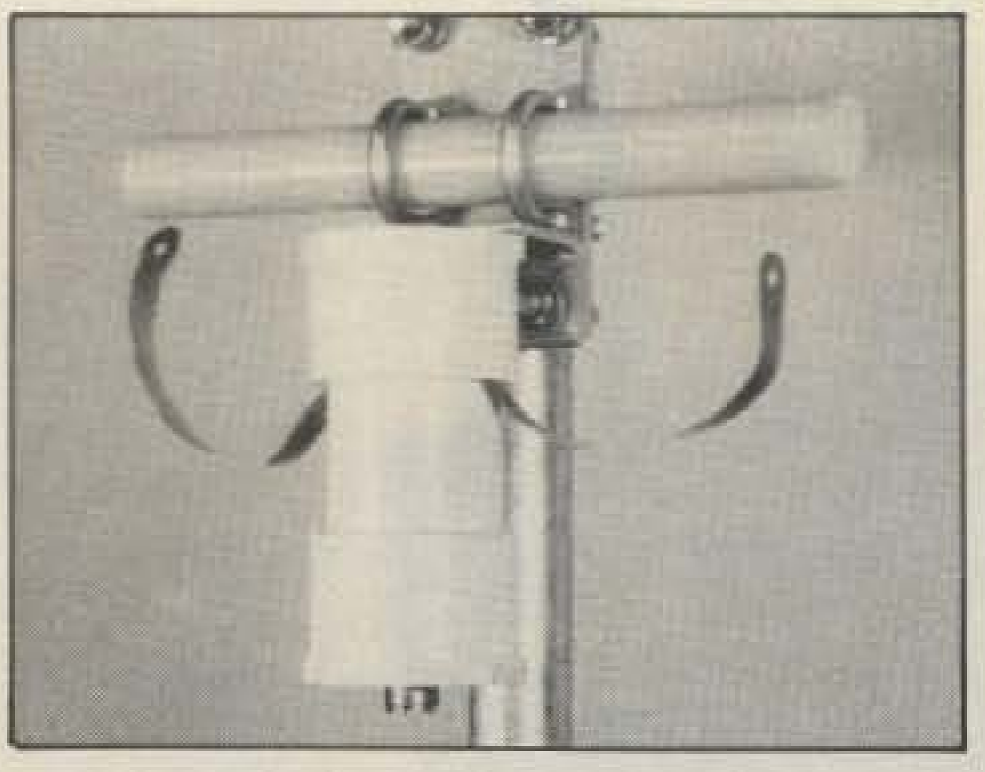


Fig. 5– The balun/2:1 transformer and center insulator as mounted on the element-to-mast clamp.

holes, spaced 1 inch apart, are punched in the plastic, and from each hole to the near edge the plastic is slit. The plastic spacers are riveted to the spokes. At each bend of the hex spiral coil, the ¼ inch aluminum tubing is inserted into these slit holes.

When completed, the assembly is rigid and lightweight. An adjustable strap connects between the coil and the inside 1¼ inch tube. The starting end of the coil (outside end) fastens to the adjacent spoke with 8-32 stainless hardware. The completed resonators are slipped over the 1⅛ inch O.D. element; the 10 meter resonators are positioned so that the outside edge of the center PVC block is 37½ inches from the center of the element. Drill a hole through the resonator's 1¼ inch tube and the element. Pass an 8-32 × 1½ inch stainless machine screw through the hole. Place the loose end of the coil strap over the screw and secure with a lock washer and nut. Likewise, mount the 15 meter resonators at 49½ inches from the center of the element and the 20 meter resonators so that the outside edge of the PVC block is flush with the end of the element.

The 25 ohm feedpoint impedance is matched to 50 ohms with a combination balun/2:1 transmission line transformer. This matching device is wound on a ½ × 4 inch ferrite rod (u = 125). The balun portion consists of eight bi-filar turns, close-spaced, and the 2:1 transformer consists of seven tri-filar turns, close spaced, all interconnected per fig. 4. The balun/transformer is housed in 1½ inch PVC tubing, and the completed model, together with the center insulator and element-to-mast plate, is shown in fig. 5. As a note of interest, two such transformers were connected in series, back to back, between a power amp and a 50 ohm dummy load. Efficiency was measured at 98%, and only a slight warming of the core was noticed after 5 minutes of 1200 watts RMS being applied at 28 MHz.

Tuning

While tuning of the resonators is best done with the dipole mounted in its final position, a good compromise can be had with it mounted at garage-roof level as long as the resonators are clear of power lines (important at all times), aluminum siding, etc. To initially adjust the resonators, it is best to couple a dip meter to a small coil across the center of the element with the transformer disconnected. Adjust the resonators for mid-band. Reconnect the transformer, feed a small amount of power to the antenna, and plot an s.w.r./frequency curve for each band. If resonance points need to be changed, move the appropriate coil tap strap—less coil to raise frequency and more coil to lower frequency. A strap movement of 1 inch is about equal to 100 kHz change in frequency. Mount the antenna in its final position and replot the s.w.r. If initially you kept clear of metal objects, the resonant frequencies should be very nearly the same, and the s.w.r. should be very close to 1:1. If the resonance points have changed much, the tuning will have to be repeated.

Installation

As I said in the introduction, it's not what you've got, but where you've got it. If the antenna is mounted close to house wiring, gutters, siding, etc., performance will be marginal. Every effort should be made to get this lightweight antenna up in the air where it will do some good. A typical installation is shown in fig. 6, where the dipole is mounted on a 30 foot TV push-up mast which has been lowered into a 10 foot tripod. The top of the tripod has been modified with a 1¾ inch bearing, and the entire mast rotates with the rotor being inside the tripod just above the roof. The mast is extended to 12 feet above the top of the tripod, and providing the tripod legs are *solidly* bolted into the roof, this installation should require no guy wires. Should you desire to mount the antenna in a different manner, stay away from metal guy lines.

Performance

With the 3 band dipole mounted 22 feet above roof-top level, performance has been excellent. The s.w.r. curves are plotted in fig. 7. Side nulls are in excess of 20 dB and front-rear lobes are broad, making only 180 degree rotation necessary. Virtually anything heard (pile-ups included) can be worked with 100 watts or less. The installation in fig. 6 has gone through 65 m.p.h. winds with no ill effects.

Fig. 6– The antenna is installed on a TV push-up mast mounted in a 10 foot tripod. the top of the tripod has been modified with a bearing and the entire mast rotates. The rotor is at roof-top level.

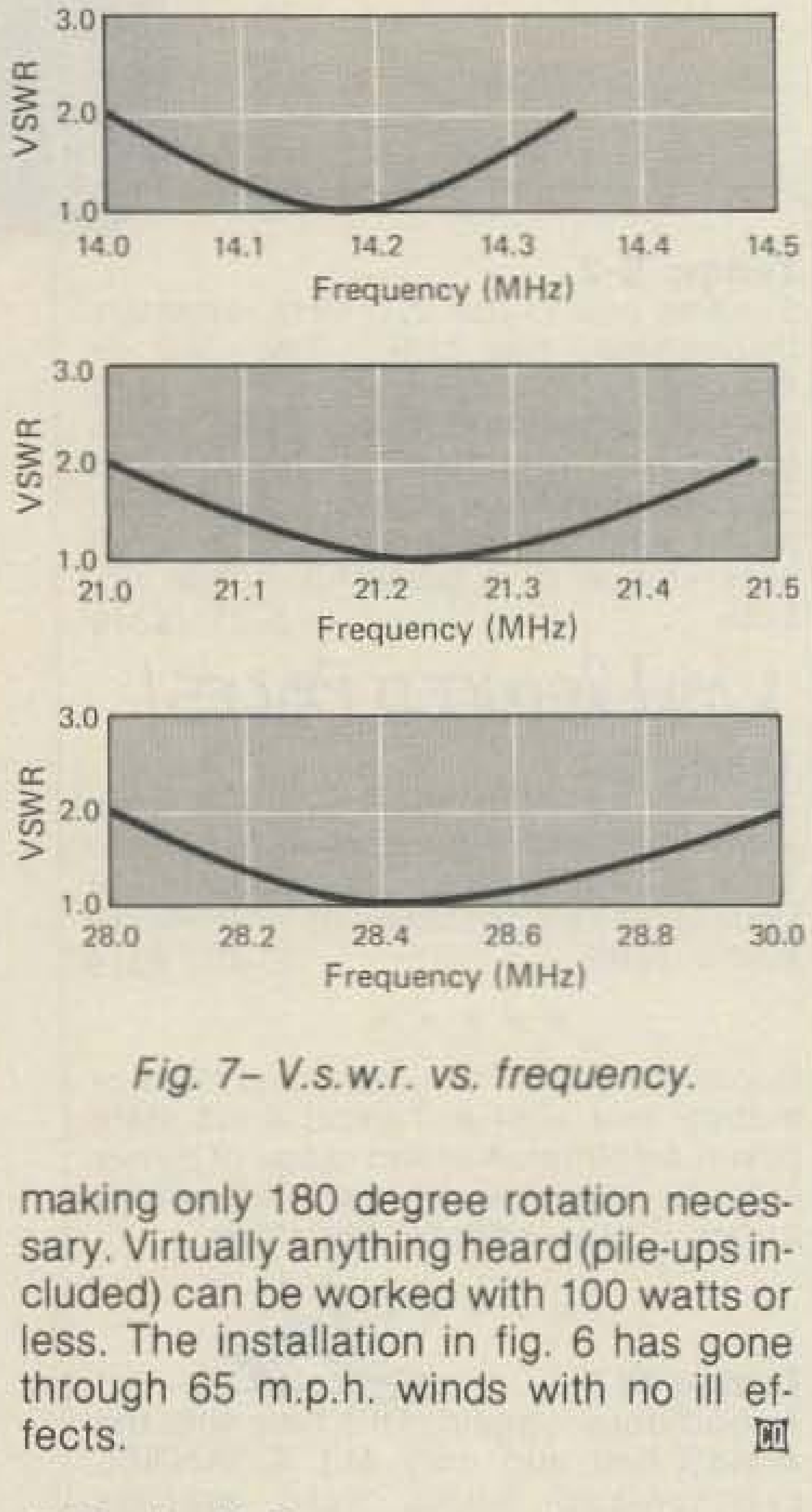


Fig. 7– V.s.w.r. vs. frequency.

Editor's Note

I met Ron Gorski, N9AU, at Radio Expo in Mundelein, Illinois, this past September where he was showing this antenna. I know he wasn't adverse to selling them, which he did. I was intrigued by the construction techniques and Ron's pitch *ergo* the article. If you want any more information you'll have to write to Ron.

—K2EEK