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2 m/70 cm Quad Revisited — Part 1

Try out this new, improved update to a CQ *article.*

The July 1999 issue of CQ Magazine *covered my original 2 m/70 cm quad project. This was my first attempt to build a dual-band quad antenna. Some shortcomings were present, including a bit of overconstruction, but who knew what the wind, cold, ice, and other elements were going to do to it. I know a lot more today!*

This new design using 3/4-inch PVC water pipe shows a little bit better performance and is much lighter in weight. In this version, I used AWG-12 bare copper wire fed through 1/4-inch agricultural PVA tubing. This looks better and the performance is better on 440 MHz. My use of a ferrite choke also enhanced the performance considerably: about 13 dBd over a dipole for under $20 (U.S.). The boom length is about 4 to 5 ft., and an old TV rotor does the rotating.

Part 2 of this article will explain the TV rotor part of the project.

Take a look at **Fig. 1** for the basic dimensions and layout of this PVC wonder. This modern-day "Plumber's Delight" is perfect for the 2 m/70 cm bands and in particular for satellite work. The system radiates both two-meter and 70-centimeter frequencies on the same elements with a boom length of under four feet (114 cm). The measured gain figures are about 11 dB over a dipole on two meters and 13 dB over a dipole on 70 cm. The additional

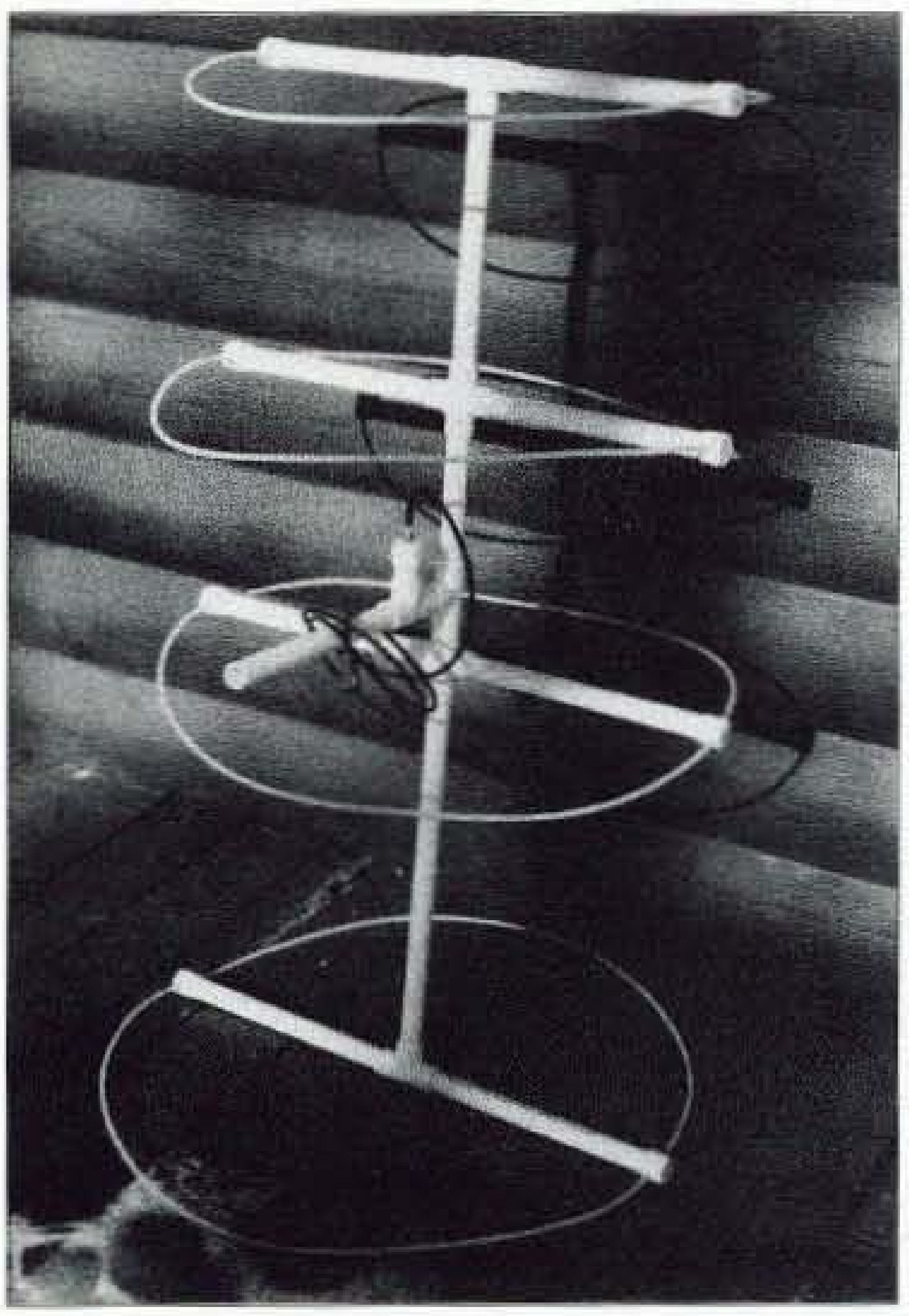

Photo A. *Quad antenna without wood dowel stiffeners.*

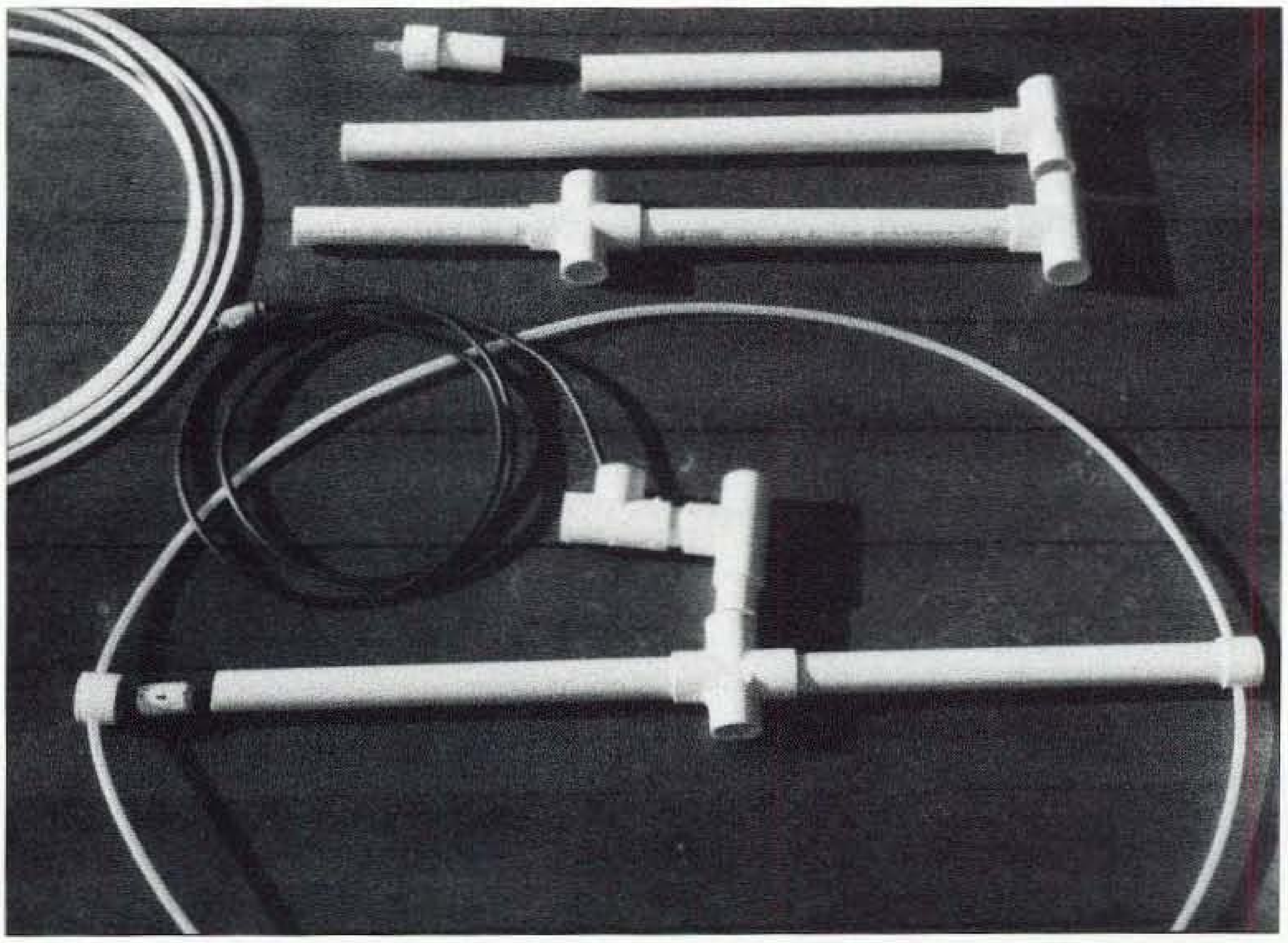

Photo B. *Element parts and pieces.*

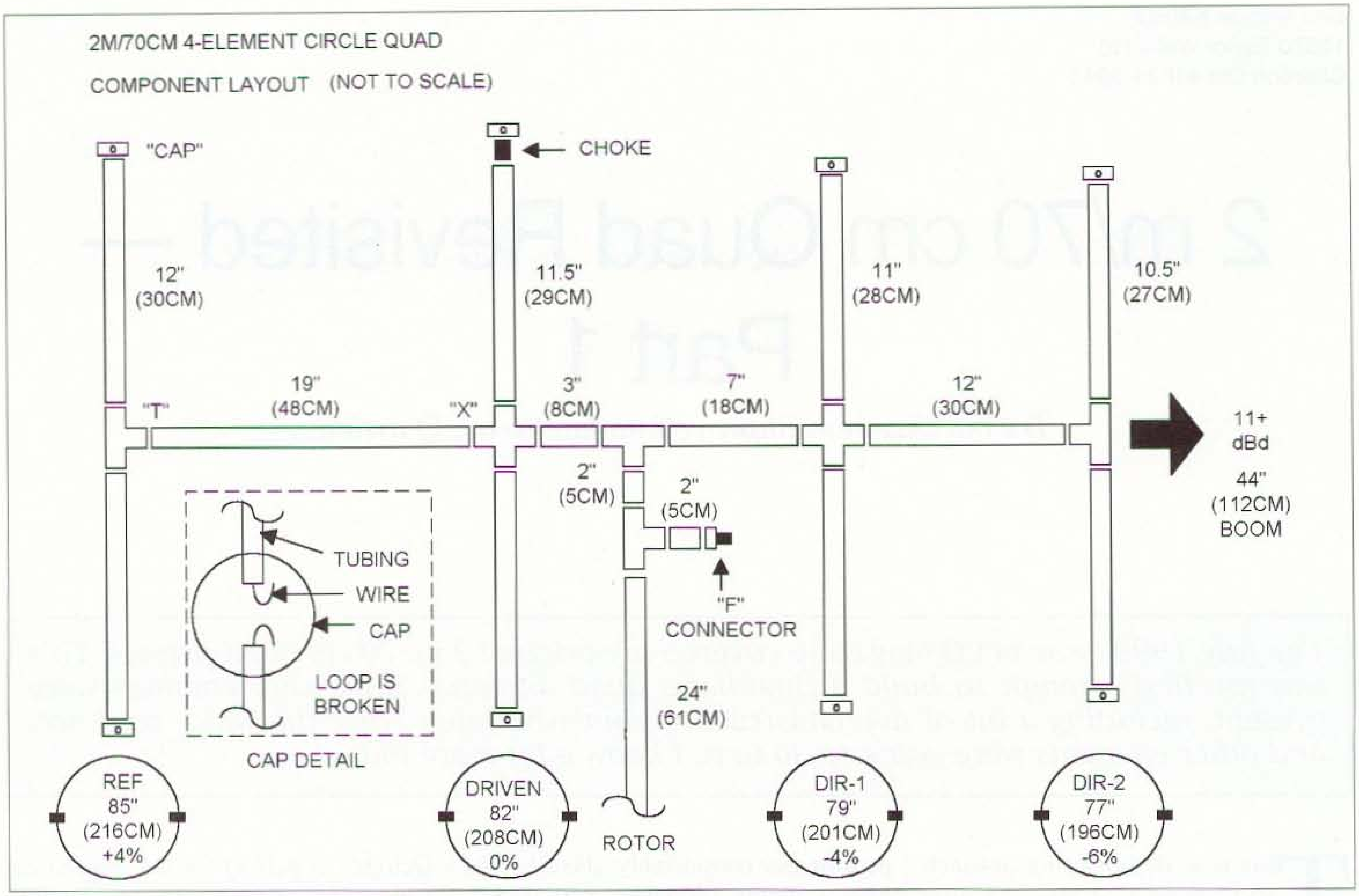

Fig. 1. Component layout for the 2 m/70 cm 4-element circle quad.

gain on 70 cm is due to the three wavelength elements. This is known as an "XL" element — that is, two or more wavelengths of the frequency being radiated. The noise figure, some times referred to as noise floor, is measured at about 3 dB below that of a four-element yagi. Some might consider that as gain also. The feedpoint is about 70 ohms, so a high-grade 75-ohm coax such as RG-6 can be used up to about 200 watts. The low-cost "F" connectors were also attractive at twenty-five cents each. There is no soldering involved since the center solid conductor makes the connection and the braid and foil shields are aluminum and cannot be soldered. After the connections are made, use black plastic PVC tape to weatherproof the connectors.

In regard to the gain figures, you will find **Fig. 2** is a circular plot of measured gains under actual conditions. The gain figure and pattern was obtained from a Kenwood TS-780S transceiver's "S"-meter and a magnetic compass. The repeater used was at 145 MHz and located about 50 miles away. The repeater is a 10-watt unit with an antenna system located on top of a 275-ft. tower.

Well, now let us look at how to put the thing together. The actual construction is very easy. The PVC water pipe can be cut with nearly any sharp object. A table saw is excellent, although a standard wood cutting saw or hack saw will also do the job. Round off the sharp edges prior to assembly to maximize the joint strength.

The end caps are drilled with a 0.125" drill bit to start pilot holes. Then follow up with a sharp 0.25" drill bit to finish the job. The PVA agriculture tubing is really a metric size, approximately 0.25" in diameter, and provides a very tight fit into a 0.25" hole. I use a little of the clear 100% silicone caulk on the outside just to be sure there is a good seal.

Just to make sure you understand: We are feeding on the side — that is, at the 90-degree point of the circle — so that the array is vertically polarized. Some testing has shown that a horizontal feedpoint at 180 degrees is acceptable also without any apparent difference in repeater work.

The circle element does some things very different from the square or triangle loops. The gamma and balun transformer matching devices were tried without success. When applying twenty watts of RF using these matching devices, the loop could be tuned to a 1:1 SWR without a problem. But, when receiving was tried, the signal strength was affected very negatively. The direct connection of the coax to the driven element proved to give the best results on both receive and transmit situations. If you make any of the parasitic loops, reflector, and directors a closed continuous loop you can expect to see degradation of the antenna system performance. The open loop results in a higher Q element then the low-Q continuous loop, which translates to more gain. The noise figure does not increase, since the small break provides a little bit of coupling capacitance and therefore aids in getting a high-Q circuit. This principle was used in the 1950s on the 6- and 2-

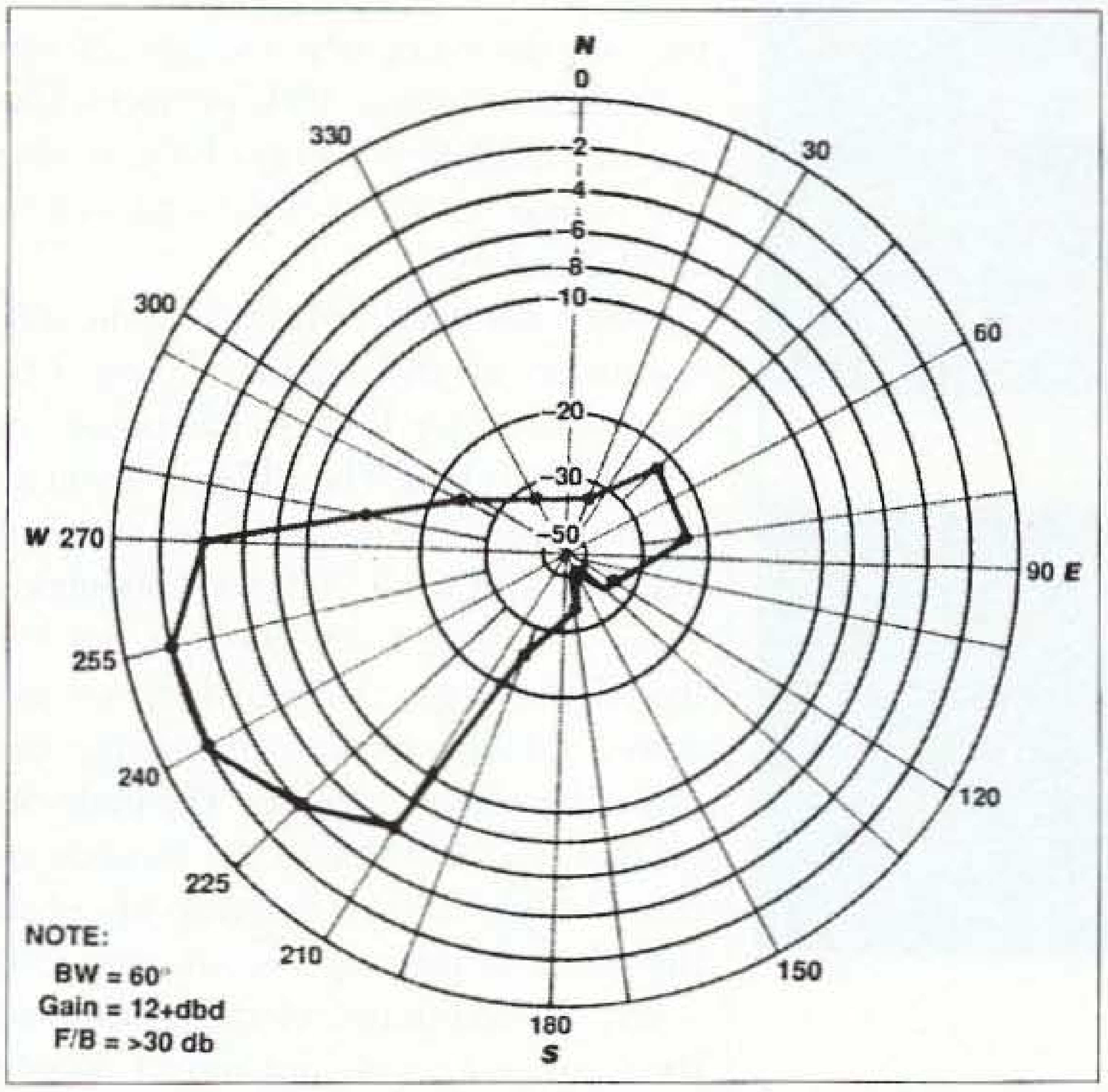

Fig. 2(a). The RF plot for the 4-element circular quad.

meter "Halo" loop mobile antennas. These were horizontal-mounted driven-element-only types which did very well for mobile installations.

No special tools or large efforts are needed to get this quality system. The element dimensions are not critical for good performance. The cost of materials amounts to about \$15.00 (U.S.). The stainless steel #4 sheet metal screws can be used to lock the PVC joints together, or you may use PVC glue. Either method has proven to be reliable. The PVC pipe and fittings are so tight that air and water leakage just does not seem to happen. The bandwidth is about what HF quads display and is in the area of ±2%. This is without tuning the antenna to the rig. At 145 MHz, this is about ±3 MHz, and at 435 MHz, ±9 MHz. Because there is always a

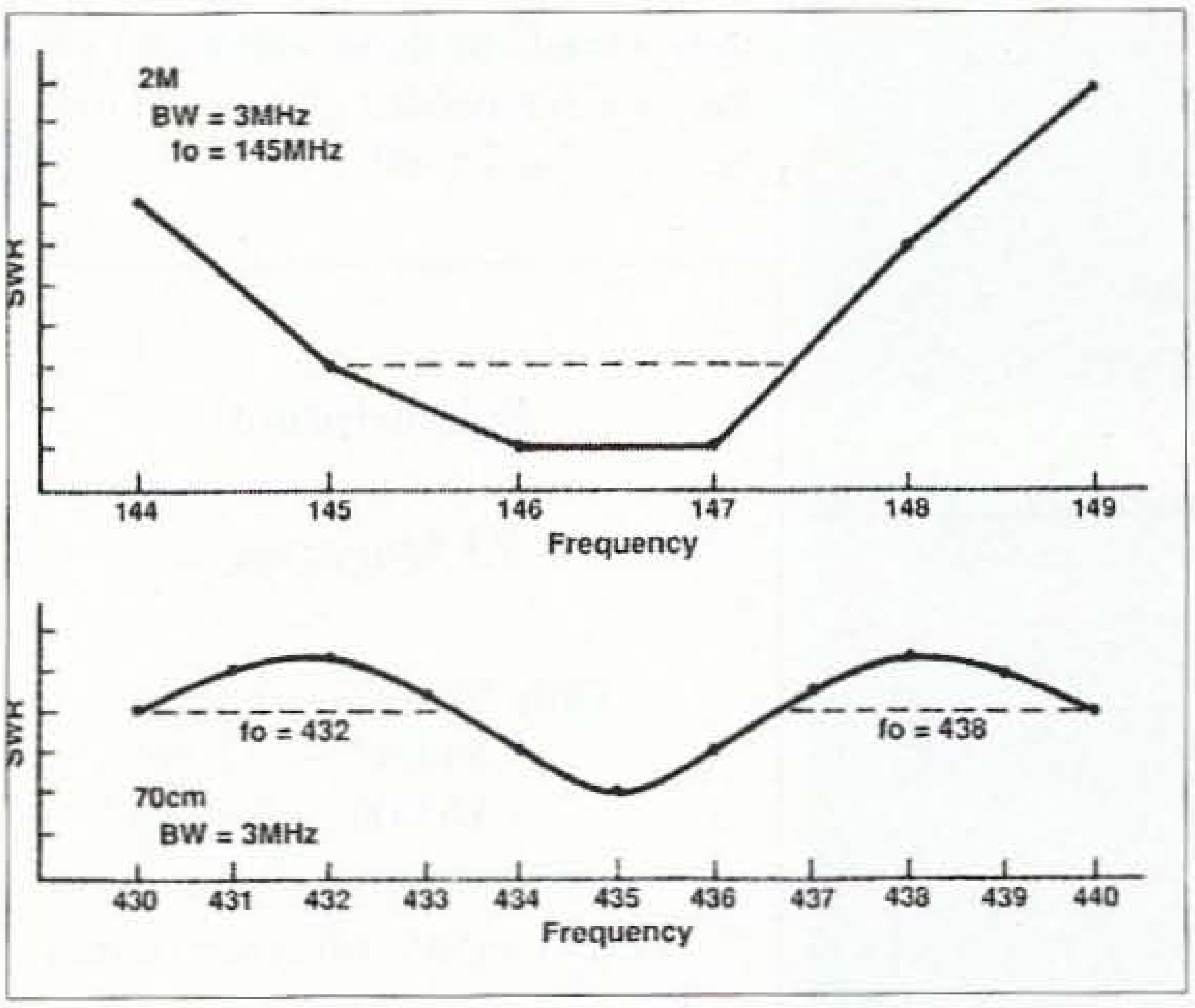

Fig. 2(b). The plot for SWR versus frequency, showing the usable bandwidth.

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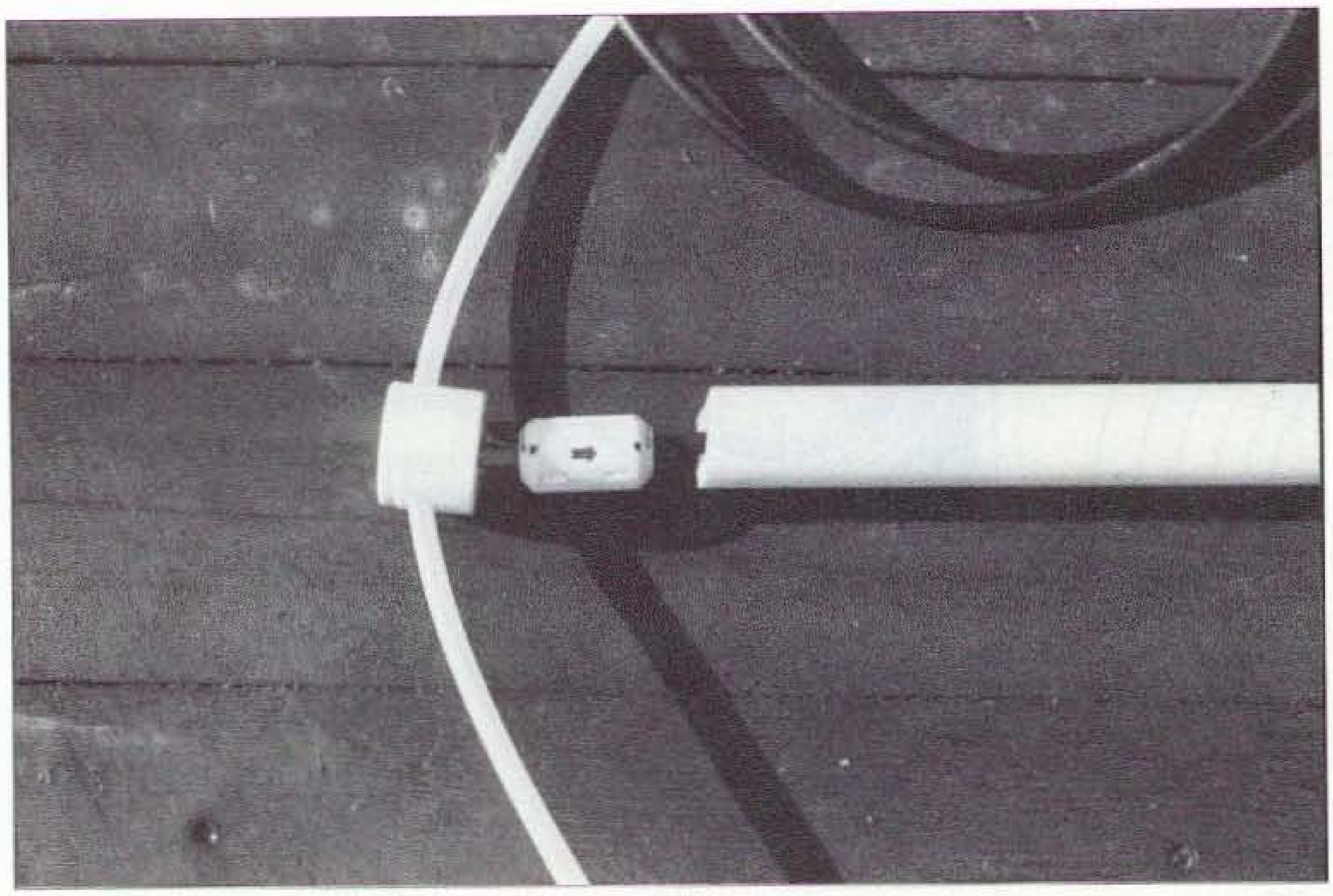

Photo C. *Close-up of ferrite RF choke assembly.*

mismatch between the antenna and rig in the VHF/UHF spectrum, primarily due to transmission line length, etc., an antenna tuner is very helpful. It is a good idea to cut the feedline to about 7-ft. multiples, which is any odd number of electrical one-half wavelengths. It just makes matching much easier.

Just a helpful note to those who are interested: A dual-band 2 m/70 cm antenna tuner, RF switch, SWR/PWR, DC power filter project will be coming out soon as a "Weekend Project." Most VHF/UHF satellite-capable rigs have separate outputs for the two bands. So a tuner for each output for antenna matching is almost always necessary. If 52-ohm feedline is used, make sure you use a one-quarter wavelength 2 m–75 Ω matching section of coax to change 52-ohm coax to 75 ohms, which the antenna-driven element is looking for. Remember that the name of the game at 2 m/70 cm is efficiency. You must get the RF power to the antenna!

Now let us get back to the antenna system. The antenna has been through 60+ MPH winds without any problem. Because it is so light and strong, even an occasional icing does not seem to bother it. The UV and heat buildup of the sun does not degrade any of my schedule-40 (white) PVC projects. The use of schedule-80 (gray) PVC is also acceptable if you prefer to pay extra for the materials.

I keep the length of the feedline to a minimum at my station. Every one knows the line loss of RF power at 430 MHz is bad. The RG-6 is about as good a coax as any, but keep in mind that the SWR = 1:1 200-watt continuous RF is the limit. If the SWR is not 1:1 then RF voltage will build up on the coax feed line thus again limiting the power handling capability. The trade-off on this type of cable is the breakdown due to high voltage building up when the SWR is up or power is over 200 watts. If additional elements beyond the four are contemplated, I would suggest that no real advantage was seen. If yagi one-half wavelength elements are placed as additional directors the noise would come up higher than the yagi director gains. Not a good idea! The advantage of a good quad antenna system is LOW NOISE with large bandwidth! This really comes into play on VHF/UHF bands.

In regard to the spreaders, I found that only two were needed to provide the loop support. If you are not happy with that or you live in an extreme weather area, you might want to consider extra top and bottom loop supports. I am including a very simple and inexpensive solution for that. I am including them in the article to show how it could be done, although I know they are not needed unless you expect heavy ice and wind. 73

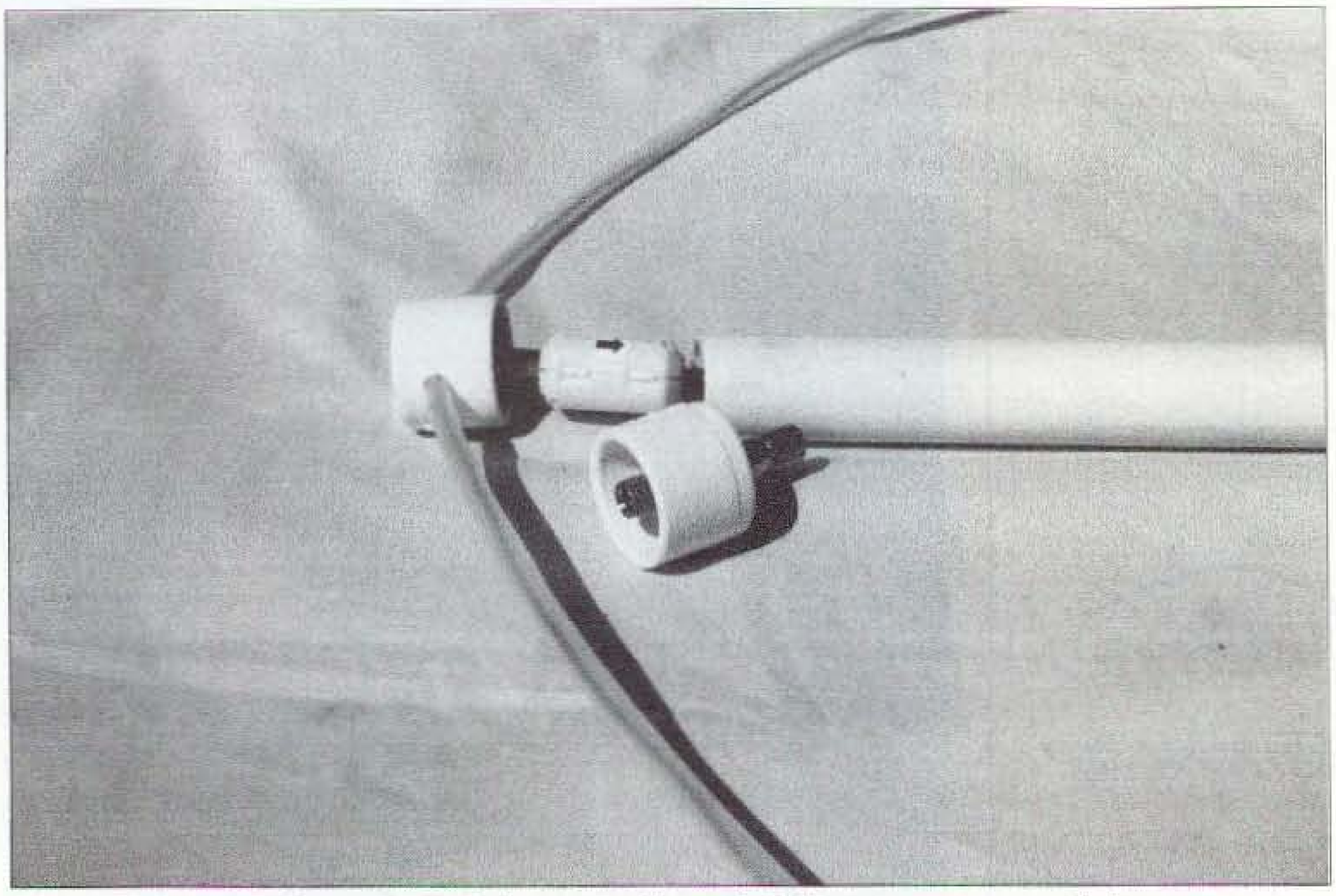

Photo D. *Driven element RF choke assembly and "F" connector coax fittings.*

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2 m/70 cm Quad Revisited — Part 2

Try out this new, improved update to a CQ *article (July 1999).*

Now that you have an excellent antenna, we need to move on to the feedline, rotor, and whatever else is needed to make a complete VHF/UHF antenna system.

Well, it is obvious that we do not need any $500 rotor system to turn this little light antenna. We have all seen those used — sometimes well-used Alliance Mfg. TV antenna rotors from the '50s and '60s era. The price is usually two to five dollars for the rotor section and about one or two dollars for the control units.

That might seem like an ideal solution for rotating our quad system, but first let us look at the biggest problem faced by the VHF/UHF folks: transmission power line loss. Coax feedline has many times more losses at 100 feet than, say, a good 300-ohm ladder line. However, the matching is much simpler. Yep! It is one of those trade-offs again. Nowadays, coax manufacturers make 1,000 MHz RG-6 75-ohm satellite receiver coax, which is about as good as it gets, and no problem at about fifteen cents per foot. So we can use up to about 100 feet without worry in the VHF/UHF range.

I am a believer that the antenna system should be located as close as possible to the ham shack to minimize the transmission line loss problems. I always use an odd multiple of one-half electrical line lengths, 7 feet in our case, to minimize the SWR problems. So you can see where 50-ft. and 100-ft. lengths look good! My Kenwood TS-780S puts out 20 watts RF when loading a 50-ohm resistive load. I have found that hybrid modules used in most transceivers can handle 75-ohm coax with very little SWR problem, and you still get full RF output. It is that stray inductance that the modules do not like! I have never been a believer in using two 100-watt "blocks" and a huge DC power supply to run them just to get 20 watts up at the antenna. The home-brew of a 4CX300 high voltage linear amplifier does not

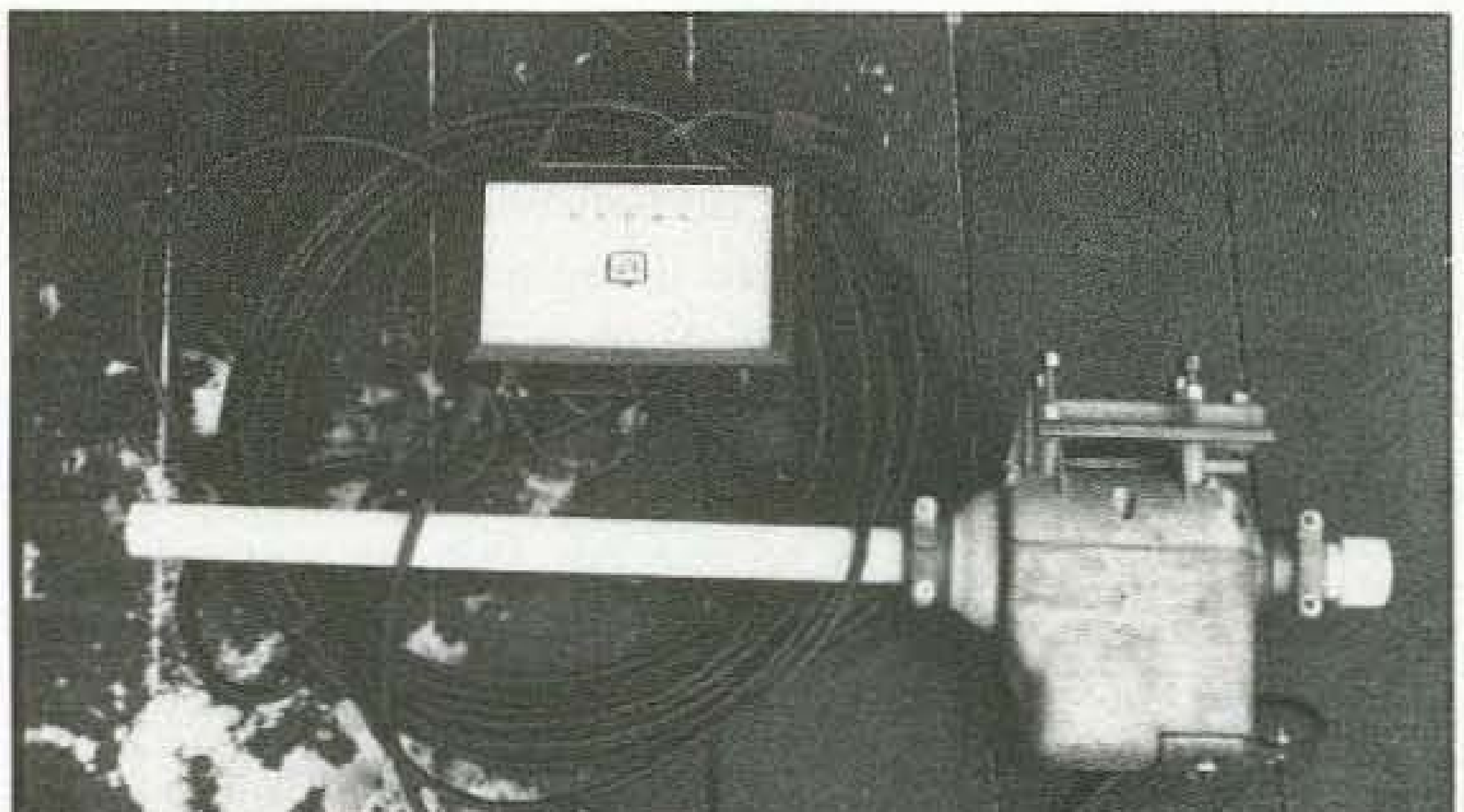

Photo A. *Rotor, cable, and control box assembly.*

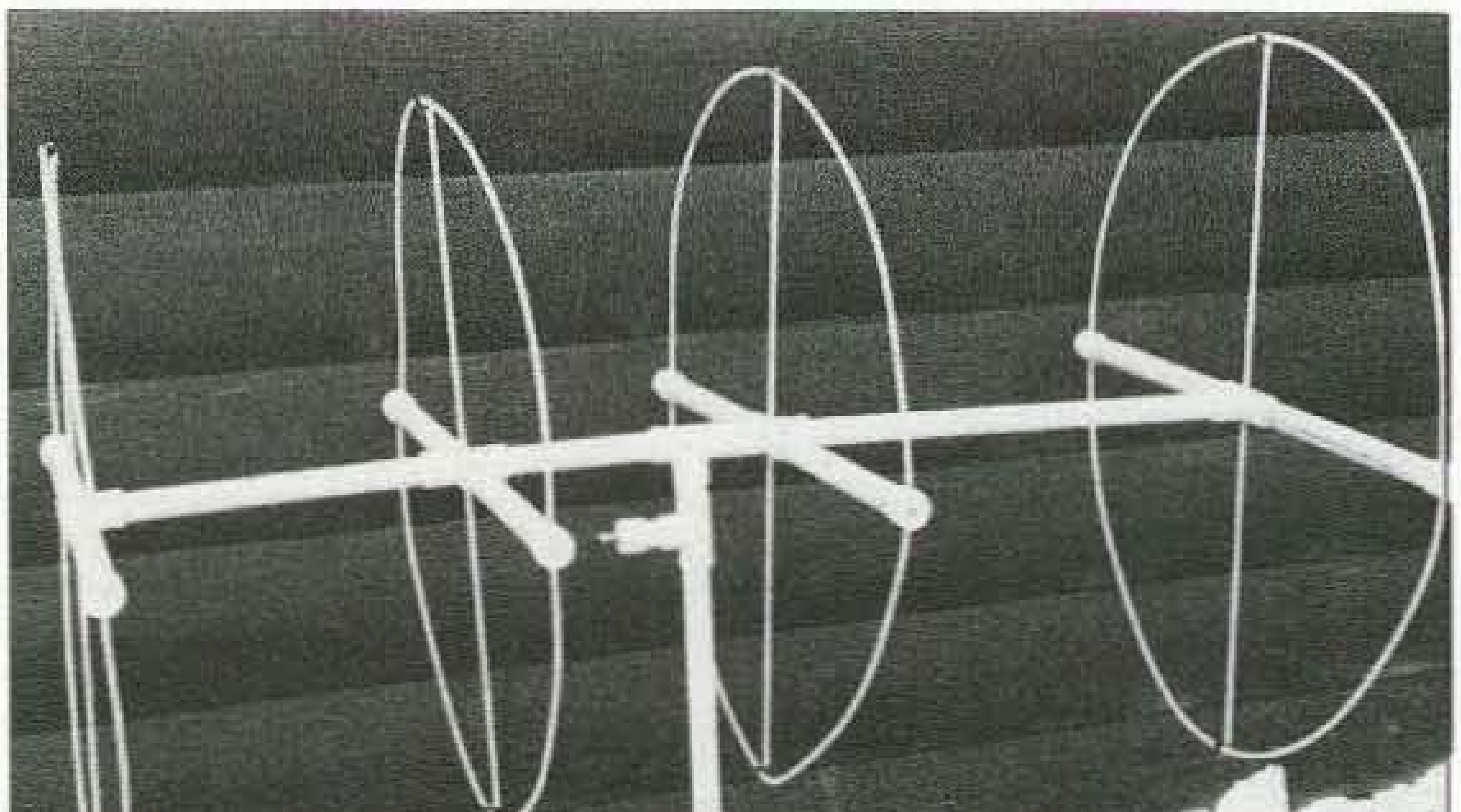

Photo B. *Another shot of the finished quad from Part 1.*

interest me much either! (I might try a project like that sometime in the future for those folks who think they really need one.)

I went to a couple of summertime ham flea market affairs and started looking for those crusty old TV rotors. They were there, and in big numbers. Seems like the new folks do not know what to do with them. Anyway, I started looking at rotors, since they are the hardest to find in good condition. I found a couple in the two- or three-dollar-each class, and purchased them. I then looked at the rotor case to check the stamped model number so that I could find the compatible control boxes. The control boxes are many, and usually run in the one- to two-dollar class. Purchase several just to make sure you have good parts if needed.

I found an old model T-45 rotor that was in like-new condition. I looked for the matching control box and found three of them for one dollar each. Such a deal! When I got them home and opened up the rotor, I was amazed. Almost like a mirror inside. I cleaned the insides of gear grease and checked everything out.

Take an old 24 VAC filament transformer and connect it to the motor wires to see if you hear a growl. Usually you will, since these motors are almost never bad. Then take one of the control boxes and check it out with a voltmeter. If everything looks good, plug it in to the 120 VAC power line. You should get 24 to 30 VAC when activated. Do the wire hookup to the rotor and see if you get action.

If the motor does not go with AC voltage on it, usually this means the start capacitor is bad. Among the two or three control units you purchased, you will have a good capacitor. It is the large white capacitor located in the control box, 100 µF, 30 VAC. Yes! I did say AC. If you had to, you could use a 100 VDC replacement capacitor. Once you have a working rotor system, you can swap parts off of the other controls to get the best-looking control. Sometimes the meters are bad, so make sure you have one that looks good and works. You do want to know what direction the antenna is in.

Open the rotor housing again. Purchase some electronic white grease or garage door opener white grease to lubricate the gears and slip bearings of the rotor. This is a light lubricant which has a low temperature rating and will not turn into cement on those cold nights. You might want to put a little zinc oxide primer paint, spray can of course, on the rotor housing, and finish with a coat of enamel paint. No rusting or oxidizing after that. I do recommend replacing the rotor screw terminal screws with #6-32 stainless steel machine screws. This will keep you out of trouble in the future. I have also used a male and female DIN-8 plug/socket system in-line so that I could have quick disconnect of the rotor line should I ever want to remove the antenna or rotor for repairs. PVC black tape weatherizes the connectors.

I recommend purchasing the eight-conductor light-duty black rotor cable. Anything beyond that is just a waste of money unless you have another suitable cable on hand. The cable has two AWG-18 conductors for the motor voltage and six AWG-22 conductors that provide the servo indicator job. This cable usually costs under twenty cents per foot when purchased new.

I have a roof mounting using two-inch PVC pipe and caps with stainless wood screws. I run the cable to the mounting using one-half-inch PVC (gray) pipe clamps and drywall screws. This system works for bringing the coax and rotor cables to the shack. Two couplings and a small piece of PVC pipe make a good wall entry for the cables. Use clear 100% silicone caulk to backfill and weatherize the entry.

Well, that is about it for this project. Remember, if using satellites you will need a second rotor system to elevate the antenna in the "Z" axis. You will need elevation to track those guys!

If there are any questions, I am available via USPS only, and only if I receive an SASE. Good luck! 73

Qty.	Item	Source	Cost
30 ft.	AWG-14 bare copper wire	Any	$1.20
1	Ferrite clamp-on RF choke	TDK via Hosfelt #80-287	$1.00
12 ft.	0.75 in. PVC water pipe	Any	$3.00
4	0.75 in. PVC "T" fitting	Any	$2.00
2	0.75 in. PVC cross fitting	Any	$2.00
8	0.75 in. PVC pipe caps	Any	$2.00
30 ft.	0.25 in. PVA agricultural clear tubing	Any	$3.00
2	Female type F coax connector	Hosfelt #60-342	$.50
1	Double female bulkhead type F	Hosfelt #FC-67	$.50
50 ft.	RG-6 Sat TV 75 ohm coax	Hosfelt #60-236	$7.50
Alt.	RG-59/U Alpha #1354 75 ohm coax	Hosfelt #60-506	—
Optional: 24	SS #4-025 sheet metal screws	—	—
Alt.	PVC glue and solvent/cleaner	—	—
Optional: 4	0.25 in. x 36 in. wood dowels	Local	$1.20
Optional: 8	#4 0.75 in SS panhead phillips sheet metal screws	—	—
Optional: 8	0.25 in. coax cable strips for stiffeners	—	—

Table 1. Parts list.