Looking for a good weekend project that will come in handy? Looking for an excuse to tour your local Home Depot and pick up a lot of great stuff? K8IHQ gives us the opportunity to do both, plus end up with a really neat dual-band antenna.

How To Build A 2 meter/70 cm Circular Quad

A Weekender's Plumber's Delight

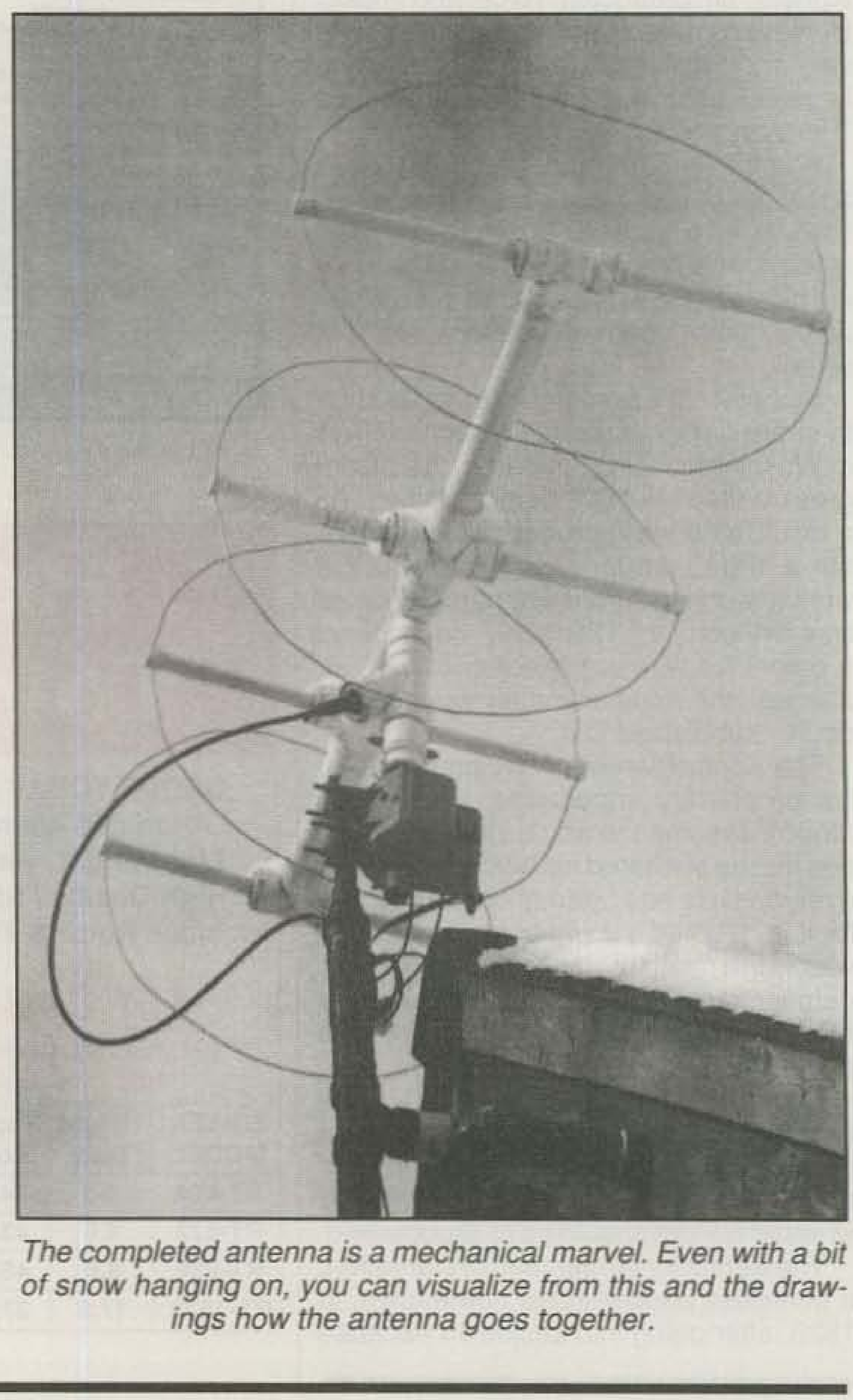
BY CARL MARKLE*, K8IHQ

With a little effort, this project can be fun and result in an antenna system for 145 MHz as well as 435 MHz without tricks, switches, or other bank-busting expenditures. Let's look at what can be done to solve the VHF/UHF wideband, low-Q, short-boom, rugged, and low-cost system we might put together in a weekend or less.

Now, you may say, you do not have the expertise, sources, and general wherewithal to do something like this yourself. Well, contrary to your belief, almost anyone can accomplish this project regardless of age or lack of background. This antenna system is excellent for VHF/UHF DXing and without equal for FM repeaters within a 50 mile radius of a QTH if elevated about 25 feet in the air. My QTH is a cedar-log home with 25 foot above-ground gable ends, making it ideal for short-run coax length, and adequate height above ground. I use an old Alliance TV antenna rotor system, the mechanical type. However, any light-duty rotor will work fine. Your local RadioShack store still offers one at about $70.

Let's first look at the feed-line situation at your particular location. Since I use a Kenwood TS-780 2m/70cm transceiver with only 10 watts output on these two bands, it is especially important that I get the maximum power to the radiator—i.e., antenna system. Since I am using under 100 watts output, I have found that good RG6 satellite TV cable is excellent and inexpensive to purchase from your local electrical supply house at a price under 12 cents per foot. I chose to use PL259 and SO239 male/female coax connectors for this project, although type N military connectors could be used. By using a UG176 reducer for the PL259 male termination, a good weather-tight connection can be made without a problem. You must, however, grip down on the threaded end with a set of vice-grip pliers and drill out the hole dimension ever so slightly so as to accommodate coax cables such as RG8X and RG6. An alternative using type F connectors is outlined in fig. 3.

The length of coax at these frequencies is very important if adequate SWR control is expected from a no-tune solid-state transceiver. A 1.5:1 or less ratio is very important if adequate power is



The completed antenna is a mechanical marvel. Even with a bit of snow hanging on, you can visualize from this and the drawings how the antenna goes together.

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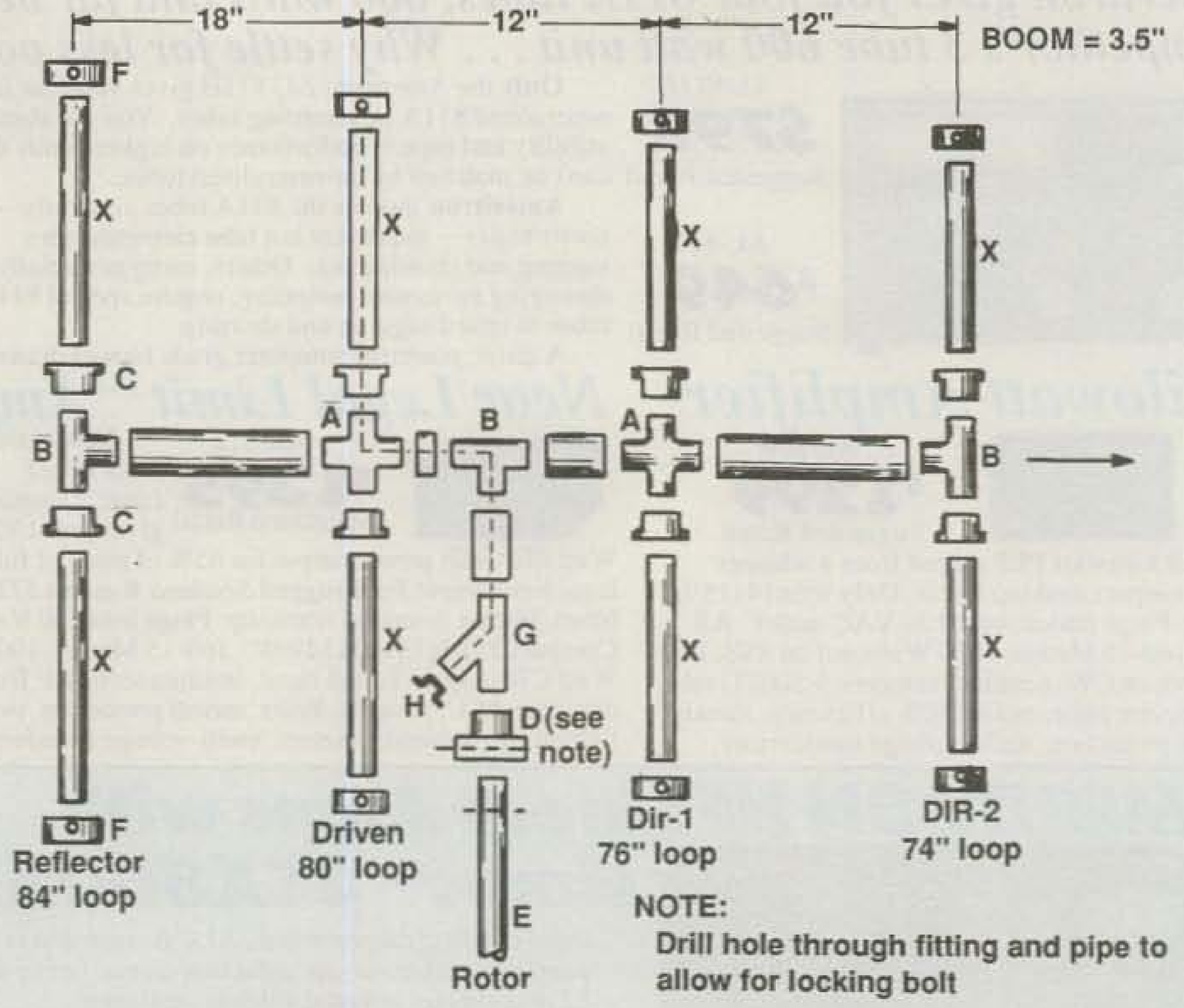

Bill of Materials

30 ft.	#14 AWG copper wire	$2.50
30 ft.	0.25 inch dia. milk white polyethylene	$2.50
10 ft.	1.5 inch dia. PVC-DWV pipe	$2.00
10 ft.	0.75 inch dia. PVC-DWV pipe	$2.00
A	(2) 1.5 × 1.5 inch PVC-DWV cross fittings	$4.00
B	(3) 1.5 × 1.5 inch PVC-DWV tee fittings	$1.50
C	(8) 1.5 × 0.75 inch reducer fittings	$4.00
D	(1) 1.5 inch PVC-DWV dishwasher coupling	$1.00
E	(1) 1 inch steel EMT electrical pipe (2 ft.)	$2.00
F	(8) 0.75 inch PVC cap fittings	$2.50
G	(1) 1.5 inch PVC-DWV "Y" fitting	$2.00
H	(1) 1.5 inch test plug	$.25
	(1) SO-239 (UHF) coax receptical	$1.00
Total		**less than $30.00**

Fig. 1– The overall mechanical assembly diagram for the dual-band circular quad. Dimensions shown as X are 3/4 inch PVC pipe, the length of which is determined by the loop diameter.

expected to reach the antenna system. The length of the coax must be determined as follows.

Use the formula as given:

$$L(\text{feet}) = 492/F\ (\text{MHz}) \times VF$$

Using this formula, you will be able to determine the correct electrical one-half wavelength long piece of cable. It will always be shorter than the free-air antenna element length. In the case of RG6 coax cable, the VF (velocity factor) is about 70%, so the one-half electrical length of coax at 145 MHz works out to be about 33 inches. Now that we know the length, we can use any odd multiple of that length for our transmission line—that is, one half, three halves, five halves, seven halves, etc. In my case, it worked out to be about 15 halves, or 40+ feet.

Now attach a PL259/UG176 connector to each end of the coax and check with an ohmmeter for continuity, center pin to center pin, and shield to shield. Then check from center pin to shield to ensure no shorting has taken place in the coax or connectors. Do not just assume everything is okay.

Next connect the coax between the transceiver and a 50 ohm dummy load to check the SWR. This match between the 50 ohm transceiver and 75 ohm coax and back again to a 50 ohm dummy load

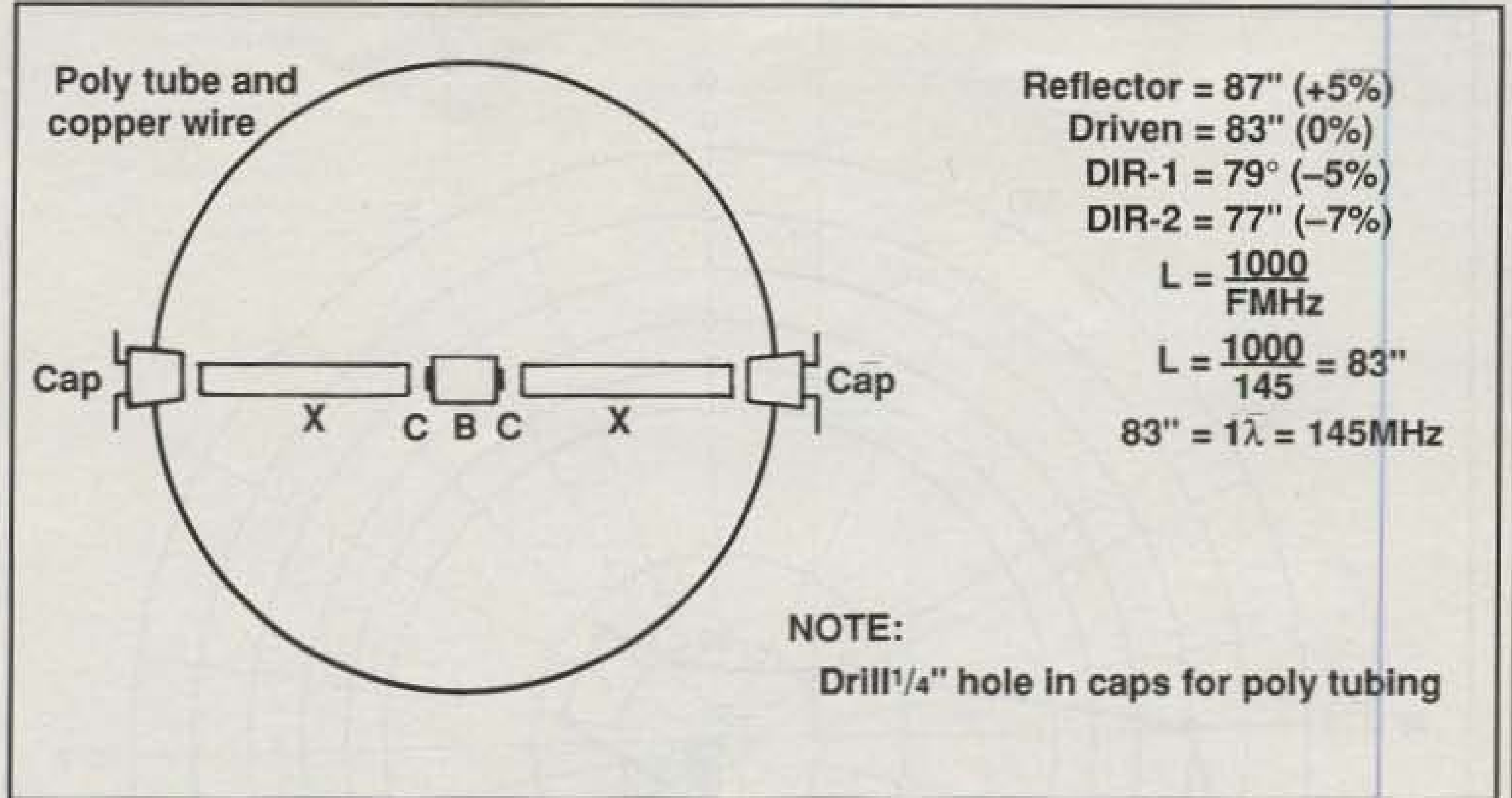

Fig. 2– Details of the loop construction.

should result in about a 1.5:1 SWR reading. This is adequate for the mismatch between 50 and 75 ohms. If you have a 75 ohm carbon resistor to use for a dummy load, use it for this check. Look at the power input and ensure it is below 10 watts. If you have a 2 meter SWR meter, the exact ratio will appear, as will the power level. Some folks do not have a 2m/70cm SWR meter. For the purists involved here, no attempt is being made to have exact matching. A note worthy of mention here is that if you choose to use 50 ohm cable versus the RG6, be aware of the loss of power at 435 MHz as well as the velocity factor involved.

Now quickly test the power output with the SWR/PWR meter between the transceiver and coax using a dummy load at the other end of the coax and record the power level. Place the SWR/PWR meter between the coax and dummy load and record the power. This will give you a true indication of power losses on the cable due to everything. Yes, it will reflect how efficient your transmission line is.

The next step is the installation of the 39 inch piece of RG59 used between the SO239 connector and the driven element. Run the cable through the PVC tubing when assembling the unit. Be sure to make a small loop of three or four turns at the element end, which will tend to act as an RF choke and tend to subdue RF radiation from the outer shield of the coax. I recommend the use of stainless steel screws in the mounting of the SO239 connector to the PVC test plug so as to resist rust. No sealant is to be used on the PVC system, since we want air to flow and condensation to drip out of the system. An air hole might be drilled on the lower lip of the test plug to allow any accumulated moisture to escape around the SO239 area. (See fig. 3.)

The theory of the system is that circular one wavelength elements provide more gain and lower noise figures than a Yagi one-half wavelength element would. It also provides for more overall gain with a shorter boom. And, the most important factor is the quad is low Q and therefore

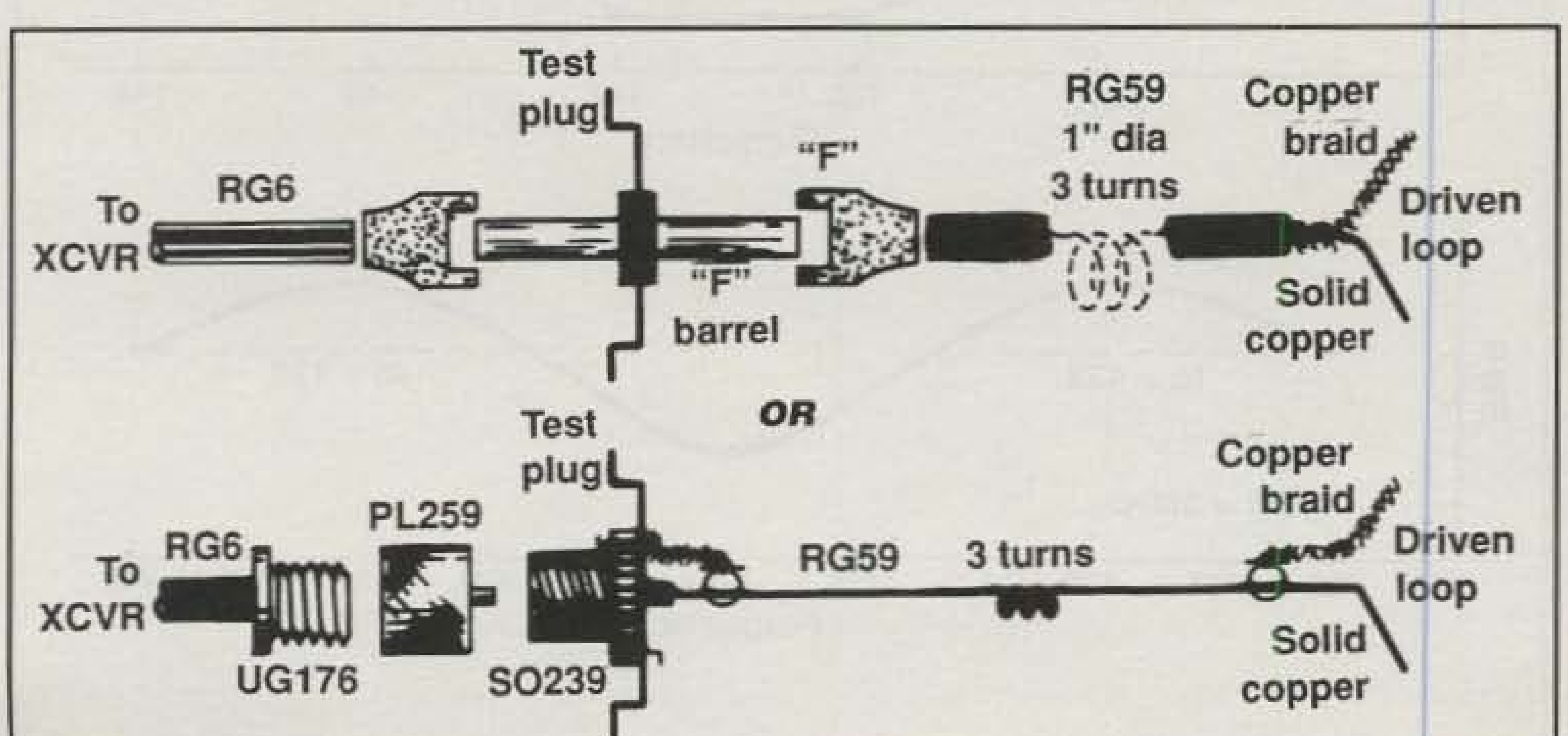

Fig. 3– Two methods for constructing the coaxial cable assembly.

inherently has a wider usable bandwidth and a lower noise figure than a Yagi. This is important when operating on the 2m/70 cm bands. The space between elements is optimized for the 2 meter band and works out to be a very nice wide-spaced ratio on the 70 cm band. The elements are one wavelength on 2 meters and three wavelengths on the 70 cm band. The three wavelength size gives additional gain on 70 cm, but no attention was given to this. Both of the bands receive a nominal 11 to 12 dBd gain figure. This is quite impressive for a 3.5 foot boom.

When assembling this system, make sure you dry fit the PVC fittings and test before final assembly. When positive results are achieved, mark each connection and one at a time pull apart, clean, and cement each connection. Marking these connections makes sure that proper assembly will take place. After the quarter inch holes have been drilled for the element, insert the milk-white poly tubing through the cap holes and position. Friction will hold the elements in their place. (You can also use clear silicon caulk on the outside of the tubing; this will ensure that the tubing will remain secure during bad weather and strong wind conditions.) Be sure that you feed the proper length of 14 AWG copper wire inside the tubebefore assembly. Do not solder the ends of the loop wires together. Leave the wire

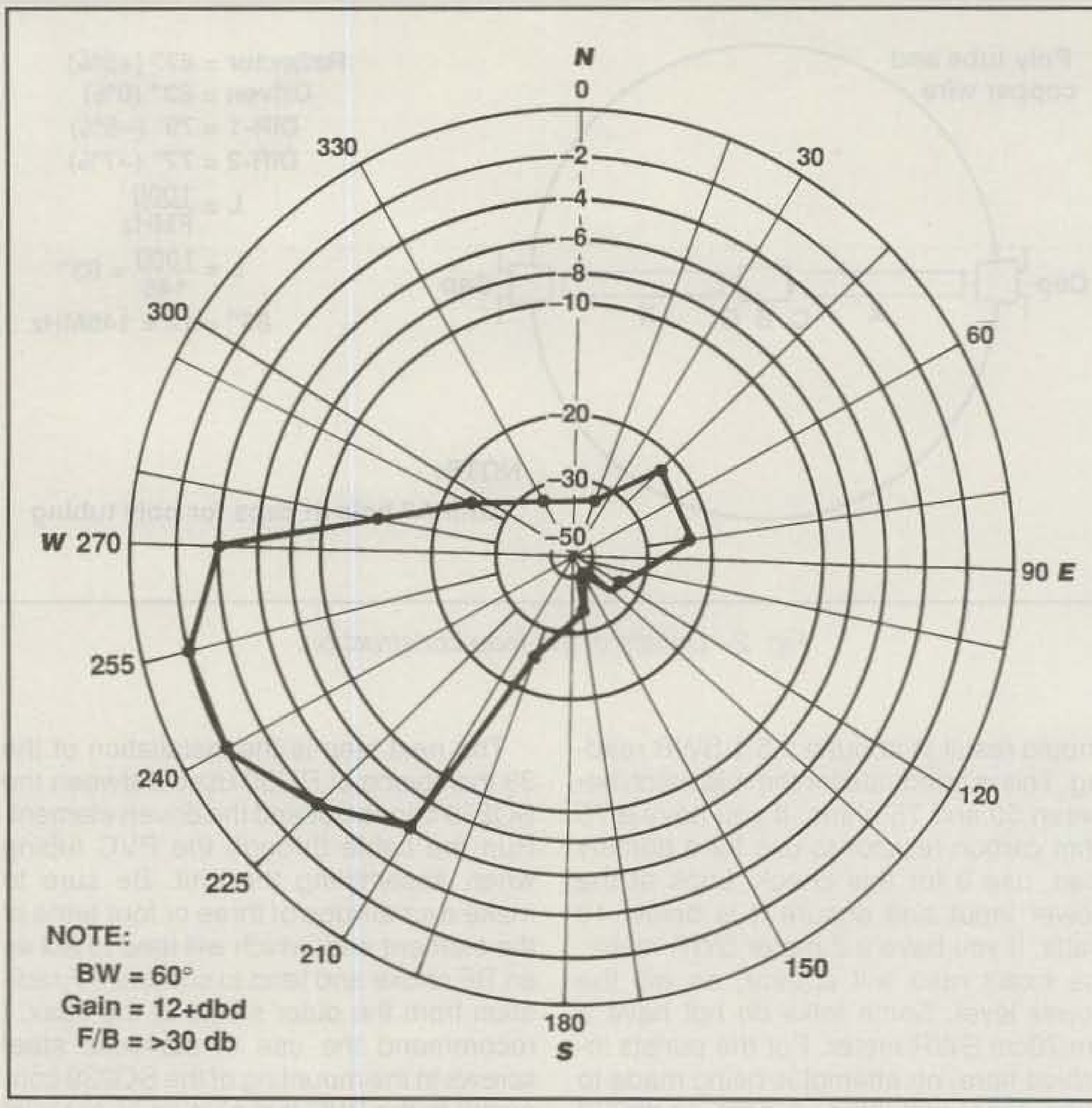

Fig. 4– The RF plot for the 4-element circular quad.

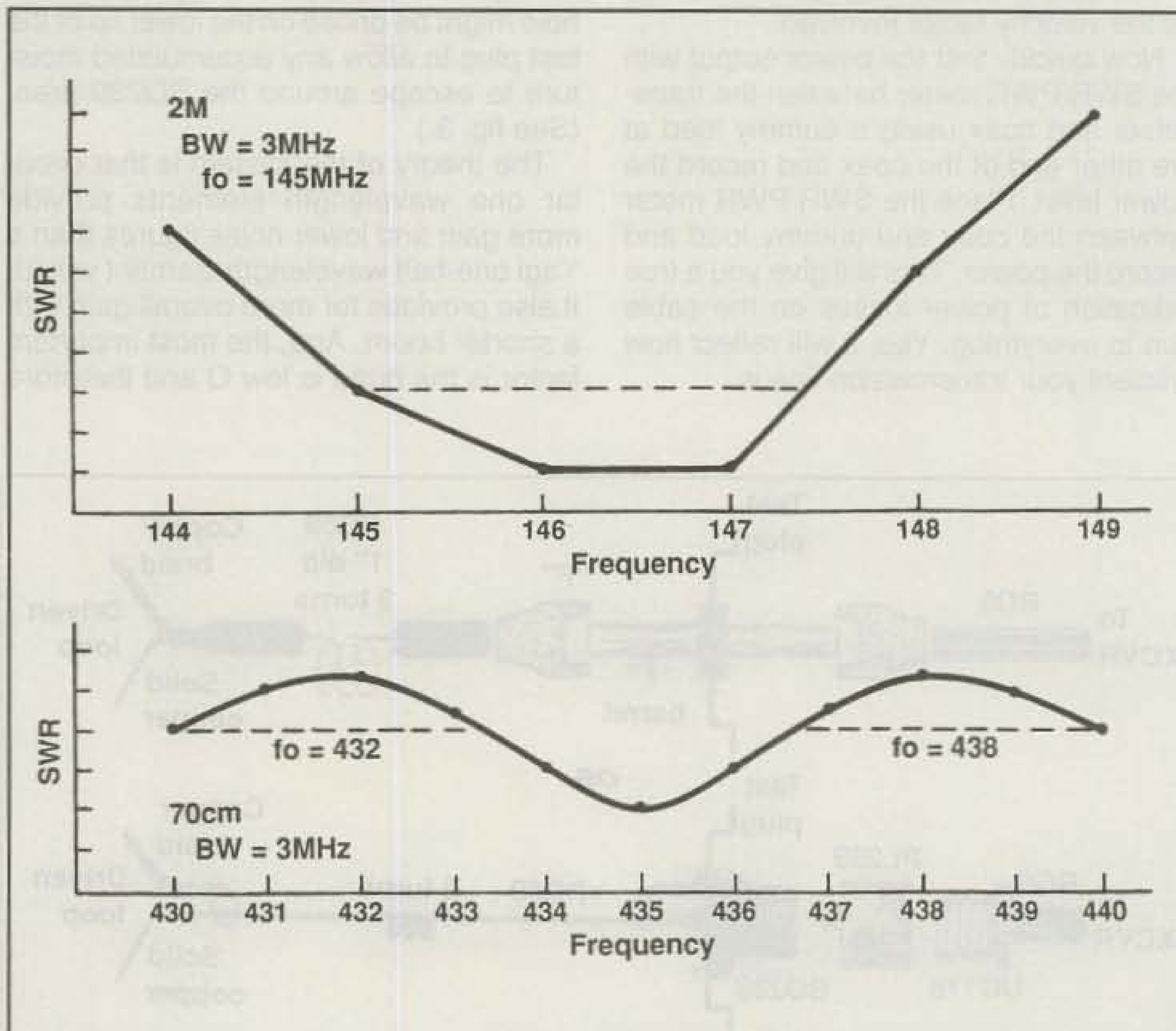

Fig. 5– The plot for SWR versus frequency showing the usable bandwidth.

ends protruding outside of the PVC caps. Bend the ends of the wire to secure. Solder the driven element to the coax directly. No matching or balancing is required, since it was found that any type of matching device resulted in high SWR or loss of received signal. Let's do what works! Attach the test plug into the Y PVC fitting using clear silicon caulk.

Element spacing is approximately 0.1 lambda between the driven element and the director elements at 145 MHz. The space is 0.15 lambda between the driven and reflector elements because it is where the best results were obtained and for no other reason. Again, no attempt was made to satisfy the critics or purists.

Refer to the fig. 1 assembly detail drawing to review the components and dimensions. Use good-quality components such as NIBCO® PVC and Oatley® primer and glue products. Do not paint these PVC parts; the sun's heat will destroy them due to thermal build up during the hot summer.

The proof of the pudding is in the test results. Once the one inch EMT electrical pipe has been installed and locked into position by a screw or bolt to the PVC antenna system and rotor system, the tests can begin. Pick a distant and relatively unused repeater on the 2 meter band or perhaps do your testing after midnight when the repeater is not being used. Rotate the antenna through the points of the compass every 10 degrees—that is to say, N, NE, E, SE, S and so forth. Record the transceiver S-meter strengths to determine the approximate front to back gains as well as front to side. The forward gain should be at least 11 dB, the front to back 30 dB, and the front to side over 40 dB. Ensure that this measurement is from a repeater located at least 30 miles away or more. Key it up and take a reading. Do not cause problems! If someone is using the repeater, that's even better. Just take readings at the compass points as mentioned above.

The dimensions for the copper wire elements are given in fig. 2. These lengths were used to optimize performance whether they meet a theoretical best length or not. Again, do what works!

The performance of the system at this QTH is given in fig. 4, the polar gain chart, and is the actual plot and signal strength given by the Kenwood TS-780 transceiver on its S-meter. SWR/PWR readings at this location are also given by the meter system on the TS-780 and are matched with a Heathkit HM-2102 SWR/PWR meter (2 meters) calibrated with a commercial-grade Bird® wattmeter and a dummy load.

All of the system components and their local prices are listed in the "Bill of Materials" list. The overall cost should not exceed $30—quite a bargain at today's inflated prices. Good luck, and good DX.■