Building the W8JK Beam

Dave Suggs, K4MJN

Employing a mechanical design using readily available materials, here's a classic beam with gain on six bands.

Homebrew antennas have been a special interest of mine over my 47 years of ham radio. It began with wire contrivances and feed lines that drove my parents batty during my pre-teen SWL days. Now my dear wife's mandate is "Paint the tower dark green and I don't want to see any antennas out any window. *Period*!"

With those parameters established, I've fashioned dipoles, V beams, loops, Zepps and other wire arrays over our small acreage in Blythewood, South Carolina, for over 31 years. They're always out of sight from the windows!

Antennas fed with open wire line and a tuner have been *de rigueur* for many years. You can load up most anything with a tuner, but getting a decent signal to radiate is something else. For design, I defer to the antenna experts. All of my antenna projects have, unabashedly, been based on articles by those amateurs whose knowledge of RF current, takeoff angles and patterns has been held in high esteem.

After acquiring a well-weathered 40 foot piece of tower, I decided to build a beam for the first time. I searched my collections of past *QST* magazines, old *ARRL Handbooks* and the League's antenna books. Anything needing coax, traps or heavy duty rotators lost my interest. I looked for something lightweight, with modest gain, multiband capability and a low radiation angle for DX. It also had to be forgiving if my measurements might be a bit off.

[1]Notes appear on page 35.

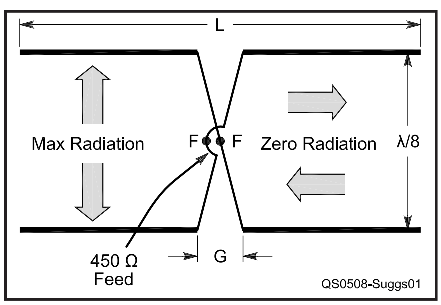

Figure 1—The classic W8JK antenna configuration uses two elements fed out of phase and spaced about 1/8 λ apart at the lowed frequency of operation. The 450 Ω twin lead feed connects in the center at FF.

The W8JK Antenna

Thumbing through my treasured 1948 *ARRL Handbook*, I became increasingly interested in the end-fire array designed by Dr John Kraus, W8JK, in 1937. The design was nearly as old as I and the fit was perfect! Searching more, I found his article in the July 1970 *QST*.[1] Then the June 1982 *QST* had an updated article.[2] It was definitive information I could digest.

Here was a simple, compact *six band* antenna that would cover 20 through 6 meters, including 17 and 12 meters, with one feed line, two elements and no traps or loading coils! Not only that, it didn't have to be too high, nicely fitting my 40 footer. The gain ranges from about 3.75 dBi on 20 meters to 6.75 dBi on 6 meters.[3] Not bad for a small multiband beam!

Figure 1 shows the antenna configuration described in W8JK's 1982 *QST* article. The W8JK beam consists of two dipoles spaced 1/8 λ apart at the lowest frequency used and fed 180º out of phase. The total length (L) of the dipoles can range from less than 1/2 λ to more than 3/2 λ. I was interested in using the antenna for 20 through 10 meters, so I followed the dimensions in the 1982 article. W8JK determined that if the L dimension is about 24 feet (somewhat less than 1/2 λ on 20 meters), the antenna can be used on all bands from 20 meters through 6 meters. This antenna has a clean bidirectional pattern over a 2:1 frequency range (14 to 28 MHz). Coverage can be stretched to 3:1 (14 to 50 MHz), but the

Title photo: Flying high and chasing DX! Topped with a 2 meter quad, this array was originally installed in 1985 and survived Hurricane Hugo in September 1989 with no damage. The flexibility of PVC construction and dacron guys on the elements seem to add longevity to this array in high winds—18 years of service with no problems.

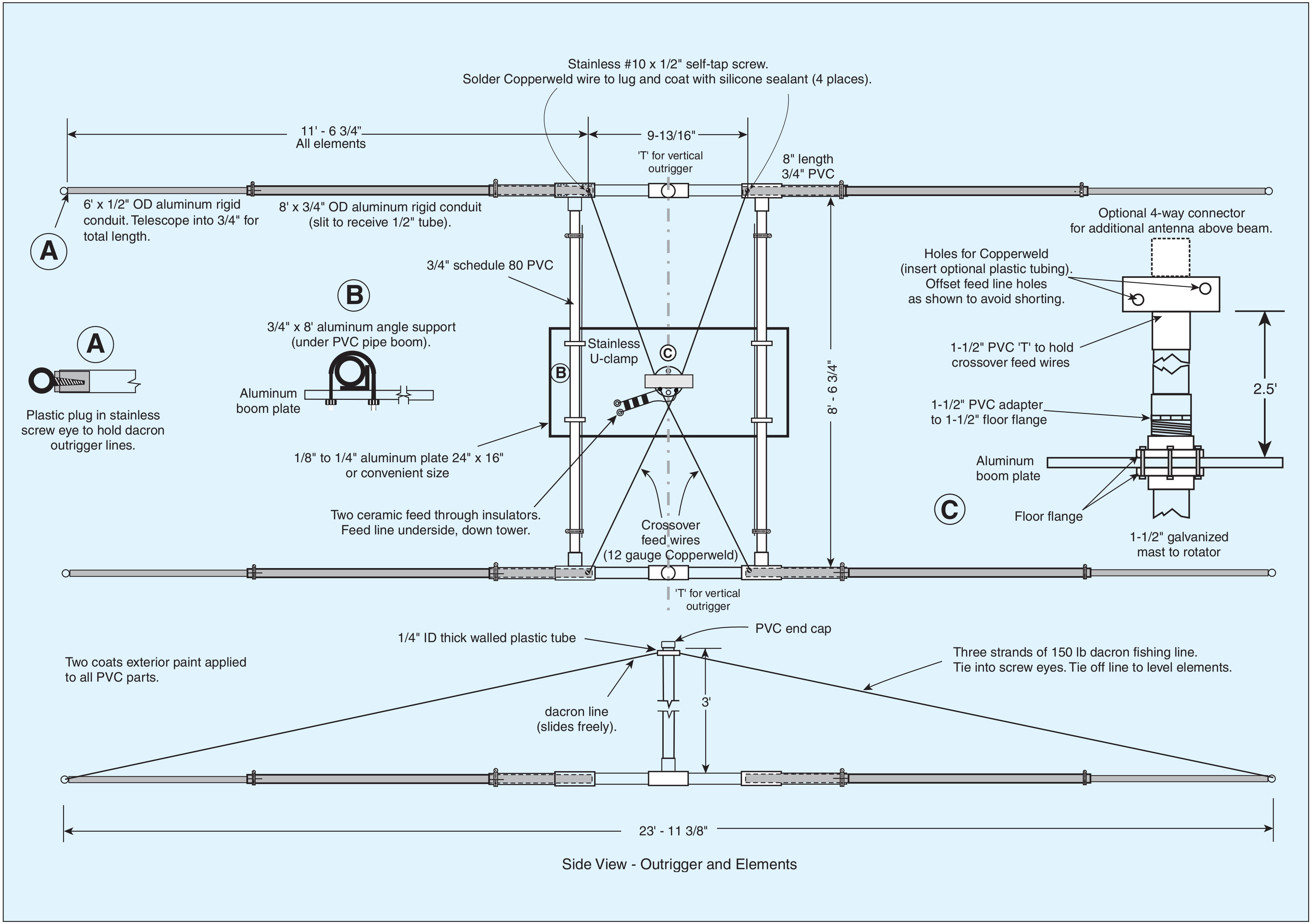

Figure 2—Construction details of the author's W8JK array. Inexpensive PVC and aluminum conduit make for an easy to build DX antenna from the early days of Amateur Radio.

pattern starts to deteriorate at the high end. The gap between element ends (G) isn't critical. I found I could reasonably construct a beam with roughly 24 foot overall elements and a 9 foot boom. The rotator could be lightweight and, with a thrust bearing, very manageable on the tower.

I decided to use standard PVC pipe and aluminum conduit readily available at most home centers and hardware stores for building the array. The PVC material on the first beam I constructed was schedule 40. My second version used schedule 80 pipe, which is a bit sturdier. Wherever possible, I used stainless hardware throughout the construction. Figure 2 shows the construction details.

Boom Construction

A single boom, even one made from large diameter PVC, seemed out of the question. What kind of boom-to-mast bracket could I fashion with 2 inch or larger PVC? Rigidity was required and there's too much wiggle and deflection with any length of PVC. I decided to use two 3/4 inch parallel PVC sticks that U clamped to an aluminum plate.

I had a plate in the junk box that was 24 × 16 inches, 1/8 inch thick, with a 1 inch, 90º lengthwise lip that added strength. It once served as a real estate sign. You can be flexible here by making it longer, wider or thicker. Quarter inch plate would be even better.

Two stainless steel U clamps secure each PVC boom pipe to the aluminum boom plate. As shown in detail C in Figure 2 and in Figure 3, two 1 1/2 inch galvanized floor flanges are centered on either side of the plate for mast attachments. I secured these flanges with stainless machine screws and lock washers. The bottom flange threads nicely into the 1 1/2 inch galvanized pipe mast, which mounts to the rotator through the thrust bearing. A 1 1/2 inch PVC adapter screwed into the top flange holds a vertical 1 1/2 inch PVC pipe 30 inches long to support the crossover wires and feed point.

I used 12 gauge Copperweld wire for the element's crossover feed. The crossover wires also serve as a guy wire structure, adding to boom rigidity. You could also use stranded wire here, but I like the Copperweld because it's strong and won't stretch over time. After some experimentation, I came up with the idea of clamping 3/4 inch aluminum angle underneath the PVC boom pieces for additional strength. The aluminum angles have no effect on antenna performance.

Next, use more 3/4 inch PVC pipe and T adapters to make the element mounts at the ends of the boom. These pieces also allow for element support outriggers and add rigidity to the boom structure. It's a good idea to get everything cut and lined up before using PVC cement to lock it all in place. Use a hacksaw to cut a slit at the end of each 8 inch PVC element mount and make sure the inside is smooth.

The Feed Point

The 30 inch PVC pipe glued into the adapter in the top flange is topped off with a PVC T or 4-way joint to support the crossover feed wires (Figure 4). I used a 4-way joint and added a short mast above it to support a small homebrew 2-meter quad. This arrangement will support any short, lightweight VHF/UHF antenna or vertical.

Place end caps on the T and drill 3/16 inch holes as shown. I inserted small poly tubing through the holes to help with abrasion from the crossover wires. It may be necessary to add a length of plexiglass or a PVC spreader here and there to keep the crossover wires from shorting together.

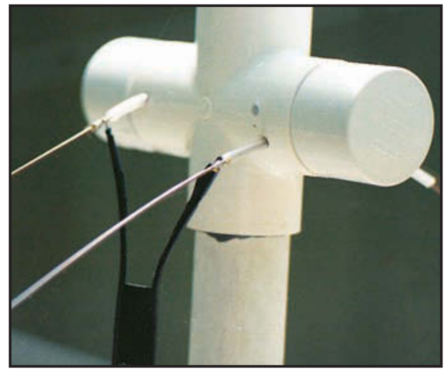

Figure 4—A PVC T or 4-way adapter supports two element crossover wires above the boom and provides a convenient attachment point for the 450 Ω feed line. The crossover wires are made from no. 12 Copperweld wire and double as guy wires for the twin boom.

Next drill two holes in the boom support plate and install a couple of ceramic feedthrough insulators. Location is not critical as long as you clear the mast. Once the elements are finished and everything is in place, you will solder a piece of 450 Ω ladder line at the midpoints of the crossover feed wires and feed the ladder line over to the feedthrough insulators on top. The other end of the feedthroughs will connect to the feed line to your station.

Building the Elements

The elements are made from 3/4 inch PVC pipe and 3/4 and 1/2 inch rigid aluminum conduit. You could use aluminum tubing here and save a little weight, but the conduit is easily available and has worked just fine for me.

As shown in Figure 2, carefully hacksaw a 1 inch slit at one end of an 8 foot piece of 3/4 inch conduit to receive the 1/2 inch element section. Good electrical contact between the two pieces of conduit is a must! Burnish the outside of the 1/2 inch piece to a high shine with 000 steel wool. Remove any rough edges and burnish the inside of the 3/4 inch piece as well. This removes any aluminum oxide that is present. A good conductive grease is appropriate here too. Slide the elements together to measure out to 11 feet, 6 3/4 inches as shown in Figure 2. Clamp the element joint securely with a stainless 3/4 inch hose clamp and check continuity with ohmmeter.

Lay the completed aluminum element sections alongside the slit 8 inch PVC element mounts and position them so they will end at the far side of the PVC T section on the boom. Mark each aluminum element at the slit end of the PVC and then slide the elements into the PVC section up to the mark. Hose clamp securely.

Figure 3—Galvanized pipe floor flanges are used top and bottom to connect the mast and crossover feed support. This is the top flange with a PVC adapter. The hole to the right of the flange is for a coaxial feed line for the 2-meter quad mounted above the W8JK array. Ceramic feedthrough insulators on left are for the 450 Ω ladder line feed.

Figure 5—The crossover feed wires are attached to the element ends with large solder lugs and stainless sheet metal screws. Weatherproof the connection with a blob of silicone sealant.

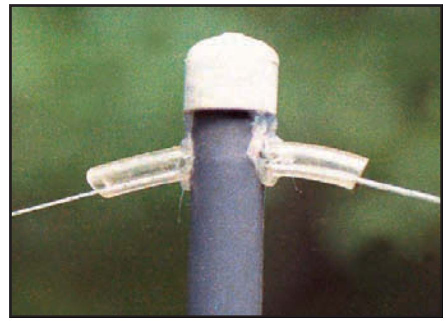

Figure 6—Detail of the outrigger support tube and dacron element guy lines. The plastic tubing reduces wear and allows the dacron to slip as needed when the elements flex in strong winds.

The crossover feed wires are connected to the elements with 1/2 inch long #10 stainless self-tapping sheet metal screws and heavy duty, ring-type solder lugs. Make sure the screws are long enough to pass through the lug and PVC and get a good bite in the conduit. Drill a hole smaller than the screw into both the PVC T and the element tubing (Figure 5). You want to make the contact right at the end of the element.

Feed the crossover wires through the holes in the T at the top of the mast and cut them a bit longer than needed to get to the element mounts. Attach solder lugs to the ends of each wire on one side of the boom and wrap a couple of turns for strength. Screw these lugs into the elements.

Pull the other ends of the wires until there is no slack. Then wire up the solder lugs and screw them to the elements. Keep the crossover feed wires taut and be sure to wire them up out-of-phase as shown in the drawings. If you encounter shorting of the crossover feed, add a dog bone insulator or suitable piece of PVC to separate them. Once everything is in place, solder the lugs. Solder the ladder line to the crossover wires as described earlier, check continuity again and cover all connections with clear silicone sealant.

Element Outriggers

The aluminum elements need support, as the PVC element holders are not strong enough by themselves. I used more PVC and some fishing line to make outriggers, as shown in Figures 2 and 6. Each element has a center support made from a 3 foot piece of 3/4 inch PVC, mounted vertically in the T section at the element center. I ran a support line from one element tip, through the center support, to the element tip at the other end. The support lines are made from four strands of 150 pound test dacron fishing line (dacron will weather better than monofilament).

The dacron lines are not tied to the center supports. I drilled a hole near the top of each support and inserted a piece of 1/4 inch poly tubing. The dacron line runs through the tubing and can slip back and forth in windy conditions. The ends of the dacron lines are tied to stainless screw eyes in plastic plugs inserted into the element ends. Caps seal the outrigger tops.

This completes the antenna assembly. Make sure that all PVC joints are glued and the hardware is tight. I applied two coats of dark green Rustoleum exterior paint to all of the PVC pieces to help retard the effects of sun and weather.

Tower Feed

Some care is required in feeding this antenna because of the very low radiation resistance. See the sidebar "Feeding the W8JK Beam" for more information on various approaches. For convenience, I opted to run 450 Ω ladder line from the antenna to my house. Then I put a 4:1 current balun on the outside wall and ran RG-8 coax into the shack to a tuner.

Ladder line *cannot* be cable-tied along a steel tower! I made standoffs from 3/4 inch PVC T adapters, with a pipe length that will hold the ladder line 3-4 feet away from the tower. See Figure 7. The 3/4 inch T sections are perfect for threading and holding 450 Ω ladder line. You may wish to add a black UV resistant cable tie and loop it through the T and a window in the ladder line to keep it from slipping through. I use the same system to bring the feed line along the house to the balun.

At the top of the tower, tie off a standoff long enough (at least 5 to 6 feet) to leave a sufficient loop of ladder line to allow element rotation of 180°. (The pattern is bi-directional, so you don't need 360° rotation like a conventional beam.) You don't want it wrapping around the mast, so allow plenty of slack to keep it away. Attach the feed line to the feedthrough insulators under the boom plate. I used ring lugs with lock washers soldered to the feed line on the feedthroughs. Coat both upper and lower connections with silicone sealant.

If you use another antenna with coax feed above the beam, build another long standoff at 90° to the ladder line standoff and allow

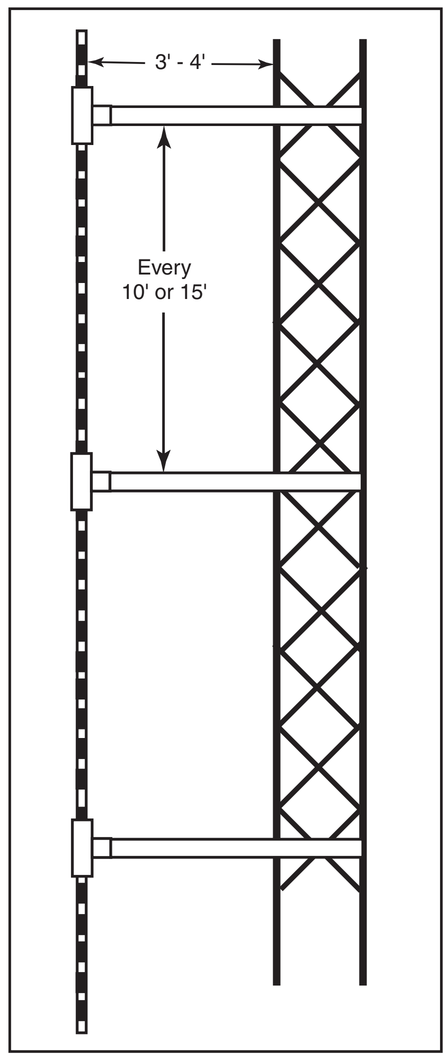

Figure 7—The 450 Ω ladder line runs through 3/4 inch PVC standoffs spaced down the tower. Attach the feed line to the standoffs with cable ties.

enough slack for rotation. Run the rotator several times to make sure you can turn at least 180°. This does limit a VHF/UHF quad. My "druthers" should have told me to use a VHF vertical on top rather than a quad. No more rotation problem!

On the Air!

After many summer weekends building (and often modifying midstream), the beam was ready to go up the tower (see Figure 8). The final mounted height of the antenna measured out at 47 feet (about $3/4\ \lambda$), so peak gain is at about 22° according to W8JK's article. The half-power beamwidth is 62°.

My antenna tuner matched the rig perfectly on all bands from 20 to 10 meters. Over the years, I've had lots of great US and DX contacts. Normally I run barefoot or an 800 W amplifier and can work anyone I can hear. I've found the W8JK to be a very effective DX contest antenna. I've not tried it on 6 meters, but it would be interesting to hear how it would work there.

The W8JK is bidirectional. This pattern has its pros and cons, but I've found it to be an asset. I've had numerous contacts on 15 meters with old friends, one in Boston and the other in the Virgin Islands. We would work each other on Sunday afternoon schedules with regularity and strong signals for all. On 20 meter nets, I've heard many a net control say he's turning the beam around to pick up someone on his backside. This bidirectional feature is a great antenna for a net control station, saving time for rotation.

Hope "you alls" like this "Bubba Engineering." I only regret I didn't find any use for duct tape in the construction. Build one and enjoy!

Feeding the W8JK Beam

The short elements and close spacing of this classic W8JK beam make it an attractive multiband antenna for low heights and limited space. The one drawback of the design is its very low radiation resistance—on the order of 2 Ω at 14 MHz. This makes feeding the antenna a bit more challenging than other designs, particularly on 20 meters.

In his 1982 article, John Kraus, W8JK, described a "trombone" matching system to short the feed line at a current maximum (any multiple of $1/2\ \lambda$ from the feed point) and couple a 50 Ω feed line to the shack at this point. The trombone is essentially a section of 300 Ω twin lead made from telescoping aluminum tubing. Its length can be adjusted to find the matching point for the various bands. Although this arrangement provides a good low-loss match to 50 Ω, you need to go outside and adjust the trombone section length to change bands.

Kraus also suggested that the antenna could be fed with twin lead, with tuning done at the station end. This approach makes for convenient band changes, but, as Kraus pointed out, brings high-voltage points on the feed line into the station. Also, because of the high SWR, losses in the tuner and feed line—even with low-loss twin lead—can negate any gain the antenna offers at the low end of its frequency range. For example, line loss with 100 feet of ladder line is about 3.6 dB at 14 MHz. Losses drop considerably as the SWR improves at the higher frequencies.

Initially, I decided to run ladder line all the way into my shack and use a tuner for quick band changes. I had some trouble with RF floating around the shack, so I brought the ladder line to the outside wall of the shack, fed it into a 4:1 current balun rated for 2 kW and ran about 15 feet of RG-8 coax to the tuner. I've been happy with this feed arrangement over the years and have had many enjoyable QSOs with the antenna. In preparing this article for publication, the ARRL technical folks pointed out that computer modeling shows that losses in the feed line (twin lead and coax), balun and tuner add up quickly to 8 or 9 dB on 20 meters. In addition, the high voltage present at some points on the feed line can stress a conventional 4:1 balun. The loss drops quickly on the higher bands and hasn't bothered me, as I operate mostly on 15 meters and like the convenience and other features of the antenna. If you decide to try one of these W8JK beams, you may want to consider a different feed arrangement.

Thanks to ARRL Technical Advisor John Stanley, K4ERO, and *QST* Assistant Technical Editor Joel Hallas, W1ZR, for modeling the antenna and feed options and providing information for this article.

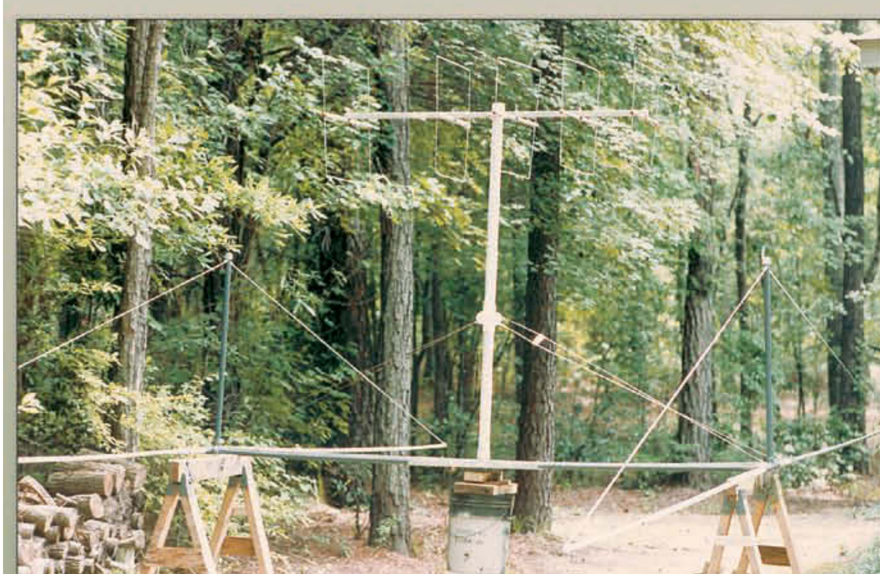

Figure 8—Here's the author's completed W8JK beam before painting the PVC with green paint for weather and sun protection. The green also helps the antenna blend in with the trees.

Notes

[1]J. Kraus, "W8JK 5-Band Rotary Beam Antenna," *QST*, Jul 1970, pp 11-14.

[2]J. Kraus, "The W8JK Antenna: Recap and Update," *QST*, Jun 1982, pp 11-14.

[3]John Kraus's 1982 *QST* article shows gain for this design ranging from 5.7 dBi on 20 meters to 8.2 dBi on 6 meters. Modeling with modern computer tools indicates that more realistic figures are 14 MHz, 3.75 dBi; 18 MHz, 4.3 dBi; 21 MHz, 4.5 dBi; 24 MHz, 4.6 dBi; 28 MHz, 4.9 dBi; and 50 MHz, 6.75 dBi. The computer model takes into account the very low radiation resistance of the design and real-world losses in the feed system and elements. Performance could be improved by lengthening the elements and optimizing the feed system.—*Ed.*

Dave Suggs was first licensed as K4MJN in 1958 and holds an Extra class license. He is a graduate of the US Air Force Radio Operator School and earned a BS degree from Clemson University. Dave has been self-employed as a graphic designer since 1966. You can reach him at 5501 Hardscrabble Rd, Blythewood, SC 29016 or by e-mail at **k4mjn@arrl.net**. QST