PVC Cubical Quad for 10 Meters

Build this $30 plumber's special!

by Wayne Mishler KG5BI

The station calling "CQ" at 28.375 MHz from Yugoslavia was out in the open and coming in S-5. I keyed the mike and called him. There was a moment of silence. Then, in broken English, he said, "Q R Zed. Station calling. You are very weak. Please try again."

I complied. No response.

Then I heard another local ham call him, and the YU came back to that guy with a 5-9 report.

For a moment, I sat staring at my transmitter, wondering what was wrong. Then I heard my competition say that he was using a directional antenna. Mine was a dipole. I felt an antenna project coming on.

In the past, I had experimented with quad antennas for 2 meters. I still had the data for those antennas, which had produced considerable gain with good front-to-back ratio and workable standing wave ratio (SWR) at the feedpoint. So I put pencil to paper and came up with the dimensions for a monobander for 28 MHz.

Much of the data came from the *ARRL Antenna Book*, 14th edition, and the book *All About Cubical Quad Antennas*, coauthored by William Orr W6SAI and Stuart Cowan W2LX.

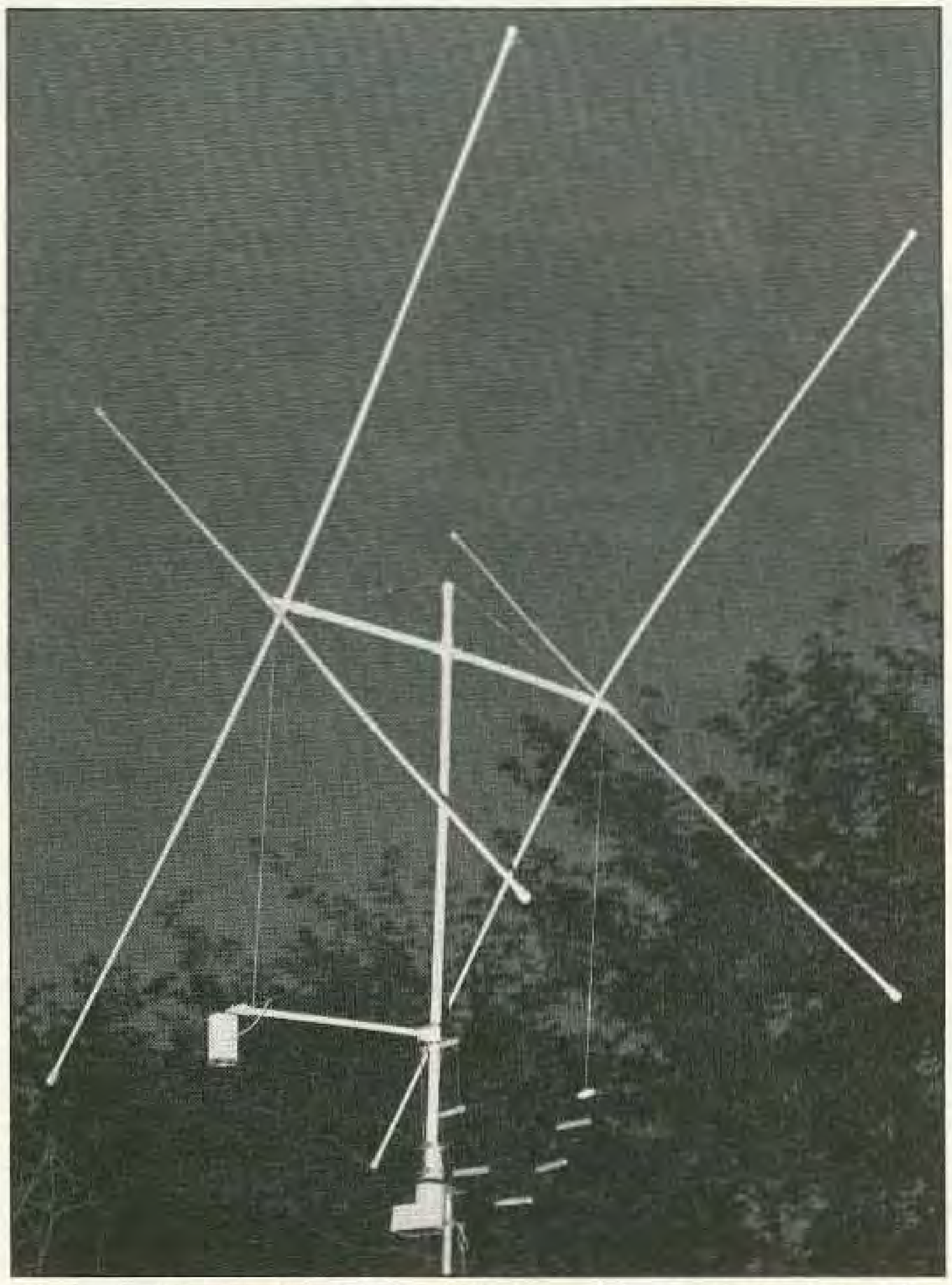

Photo A. The flexible PVC cubical quad has withstood thunderstorms and 60 mph winds.

Construction

For several reasons, I decided to use Schedule 40 PVC and wood dowels in constructing the antenna. These materials are readily available at hardware stores. They are transparent to RF, easy to work with, and resistant to weathering. (I gave the dowels that would be exposed to weather three coats of an oil-based enamel.) And the price was right. All of the materials, including antenna wire for the elements, cost about $30.

I made the boom and mast from a single 10-foot length of 1-inch PVC cut into three pieces (see Photo A and Figure 1): 1-foot, 3-feet, and 6-feet long. To make the boom, I cut the 3-foot piece in half. Using PVC cement, I glued the resulting two 18-inch pieces into opposite ends of a 1-inch PVC four-way cross fitting.

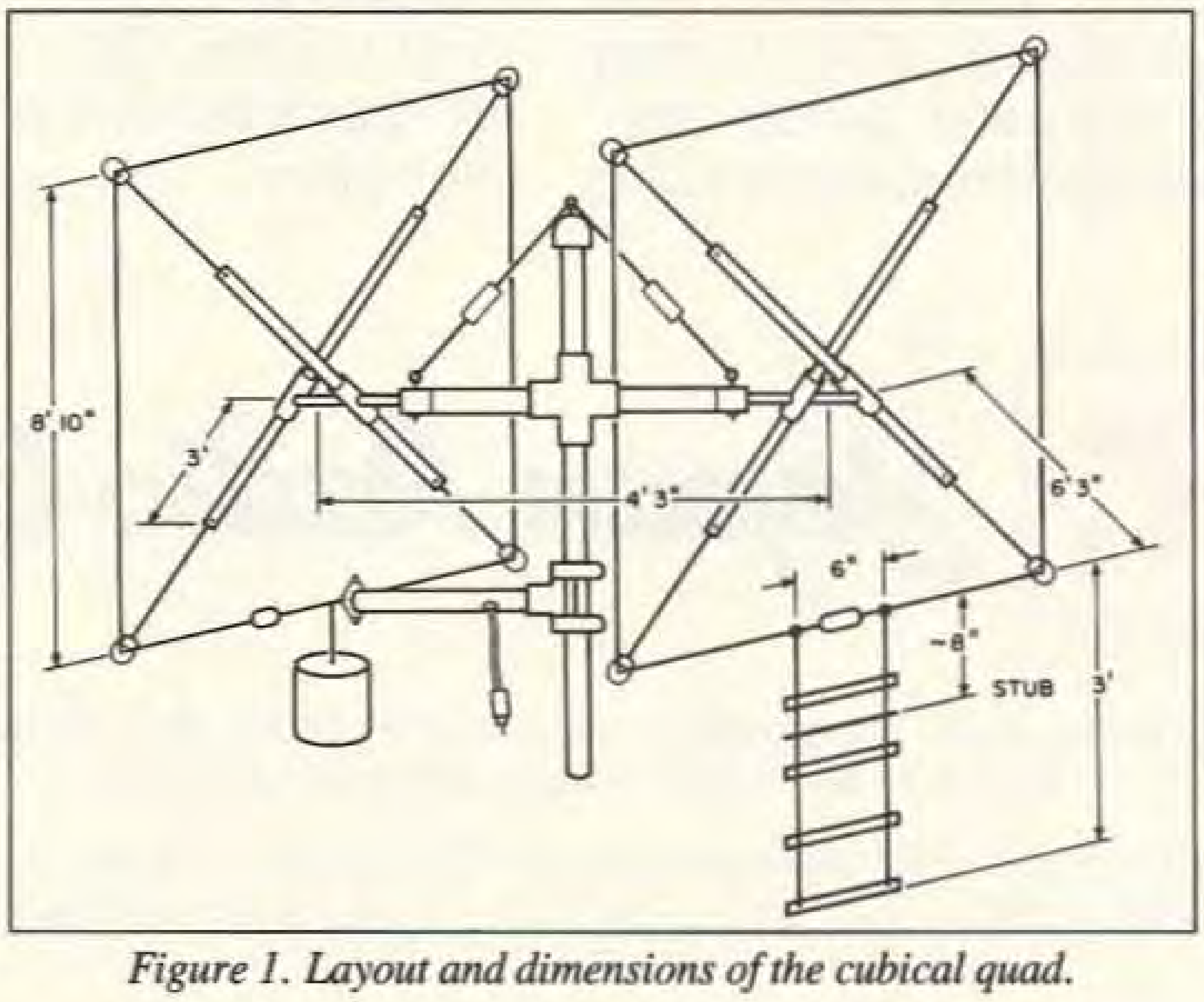

Figure 1. Layout and dimensions of the cubical quad.

I made the mast by gluing the 1-foot and 6-foot pieces into the remaining ends of the cross fitting. The purpose of the 1-foot length of PVC at the top of the mast is to provide support for the boom. Nylon string connected from the top of that piece to the spreaders helps keep the boom from bending downward.

To keep the bottom of the PVC mast from collapsing when clamped into a rotor, and to provide vertical rigidity for the mast, I inserted 1-inch dowels all the way through the mast, cross fitting, and top support piece.

At first, the dowels were slightly too big to go into the PVC. A power sander solved this problem.

Next, I drilled a hole in the center of the top of a 1-inch PVC cap fitting and installed a 3/16" x 2-1/2" eyebolt to serve as a tie-point for the nylon string that would support the ends of the boom. I then glued this cap onto the 1-foot support piece at the top of the mast.

Spreader Supports

PVC fittings hold the spreader arms (see Photo B). Both spreader supports are made the same way. Begin with a 1-inch PVC coupler fitting. Using PVC cement, glue a reduction adapter for 1/2-inch PVC pipe into the coupler. Then glue a short (1-1/2-inch) length of pipe into the adapter. Glue a cross fitting onto the exposed end of this pipe. Next, glue another short length of pipe into the opposite end of the cross fitting. Finally, glue the base of a "T" fitting onto the exposed end of this pipe and *immediately* rotate the "T" fitting until it is at right angles with the cross fitting when viewed from the end. With this last step, you'll have to work fast, because the glue sets up quick-

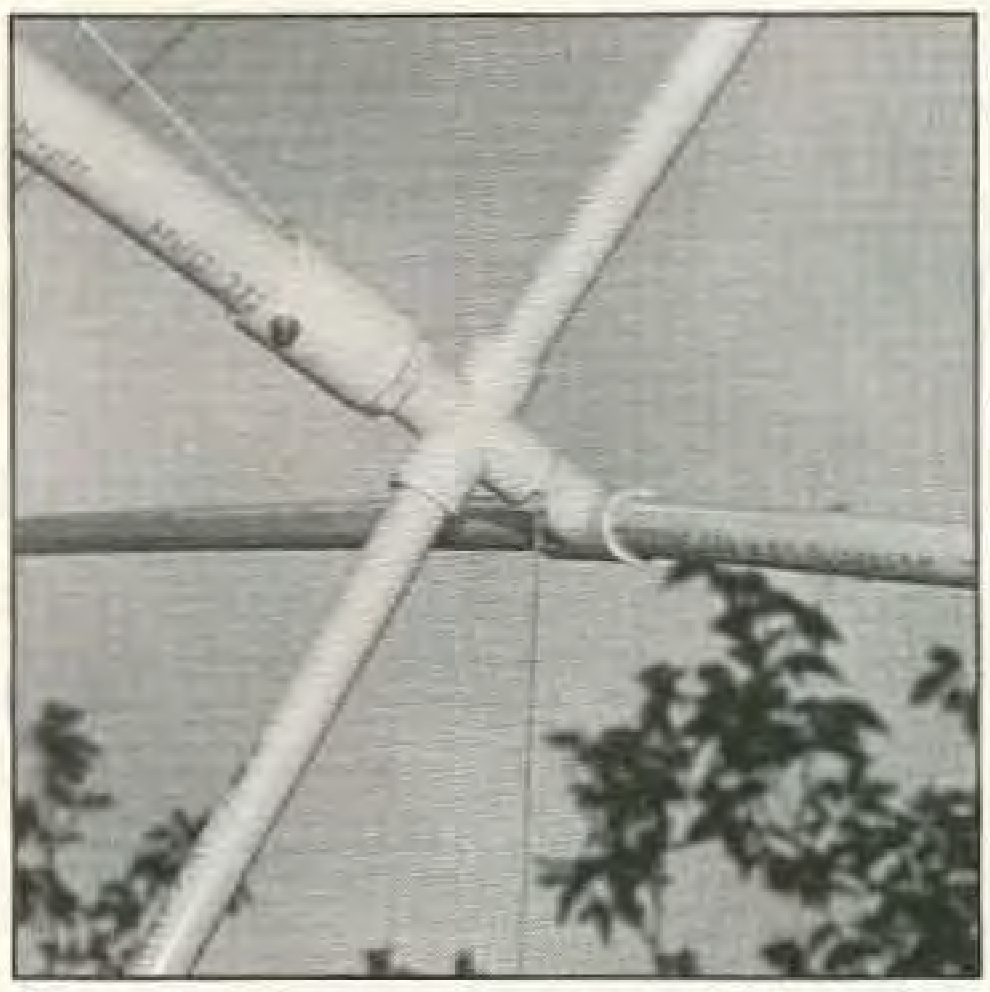

Photo B. The spreader arms, which are half PVC pipe and half wood dowels, fit into PVC fittings. The fittings are linked together with short lengths of 1/2-inch PVC pipe and glued with PVC cement. A "T" fitting is connected to a cross fitting which is connected to a 1-inch coupler fitting by way of a 1/2-inch adapter. The coupler fitting slips over the end of the boom, and is held in place with an eye bolt.

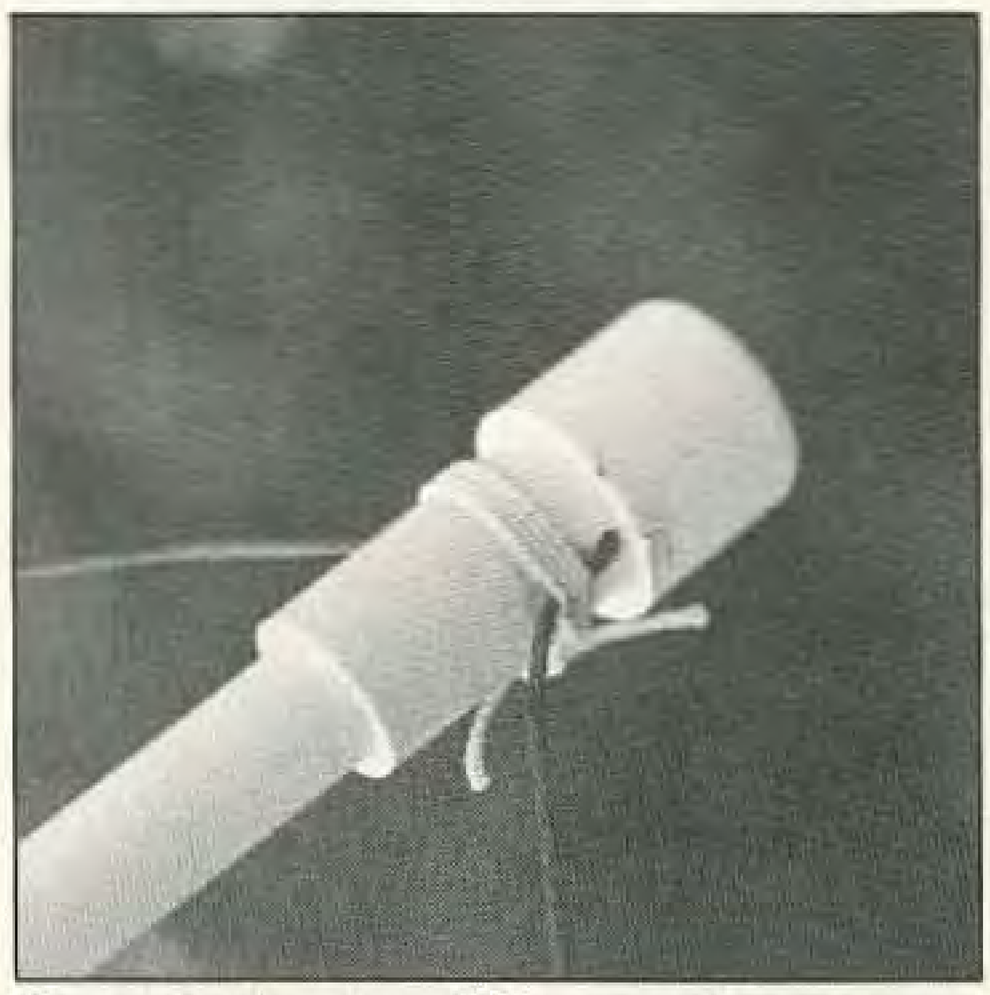

Photo C. The tips of the spreader arms are made of 1/2-inch PVC pipe, capped and drilled to accept the wire elements. The nylon string keeps the wire from slipping.

ly. Repeat the process to make the other support.

Adding Spreaders

To simplify construction, I made both elements the same size and lowered the frequency of the reflector with a tuning stub.

Begin by cutting eight 3-foot long pieces of 1/2-inch Schedule 40 PVC pipe. Insert and glue these into the fittings of the two spreader support assemblies, so they form an "X" when viewed from the end.

Select eight 4-feet long, 5/8-inch hardwood dowels, and paint them with a quality oil-base enamel. Give each dowel three coats, allowing each coat to dry at least overnight.

When the last coat of paint has dried, insert a dowel into one of the PVC spreaders until the total length, from the tip of the dowel to the center of the spreader support assembly (axis of the boom), measures exactly 6'3". Anchor the dowel to the PVC by drilling a 1/16-inch hole through the PVC into the wood, and screwing into this hole a #6 1/2-inch sheet metal screw. Repeat this process for the remaining seven spreaders.

To make tips for the spreaders, which hold the wire elements in place, cut eight pieces of 1/2-inch Schedule 40 PVC, each three inches long. Glue 1/2-inch PVC caps over one end of each piece. Next, using a 1/8-inch drill bit, drill at right angles through each pipe at the base of the cap.

Assembling the Elements

To assemble the reflector element, lay one of the completed spreader assemblies flat and place the tips on the ends of the dowels. Thread antenna wire through the holes in the tips. Each loop has a circumference of about 36 feet, so plan accordingly. After you have threaded the wire through all four tips, bring the wire together in the center of the bottom side of the loop, pull it snug, make sure that the spreaders are straight, and connect the two ends with an egg insulator. The ends of the reflector loop must be insulated from each other. Finally, wrap nylon string around the

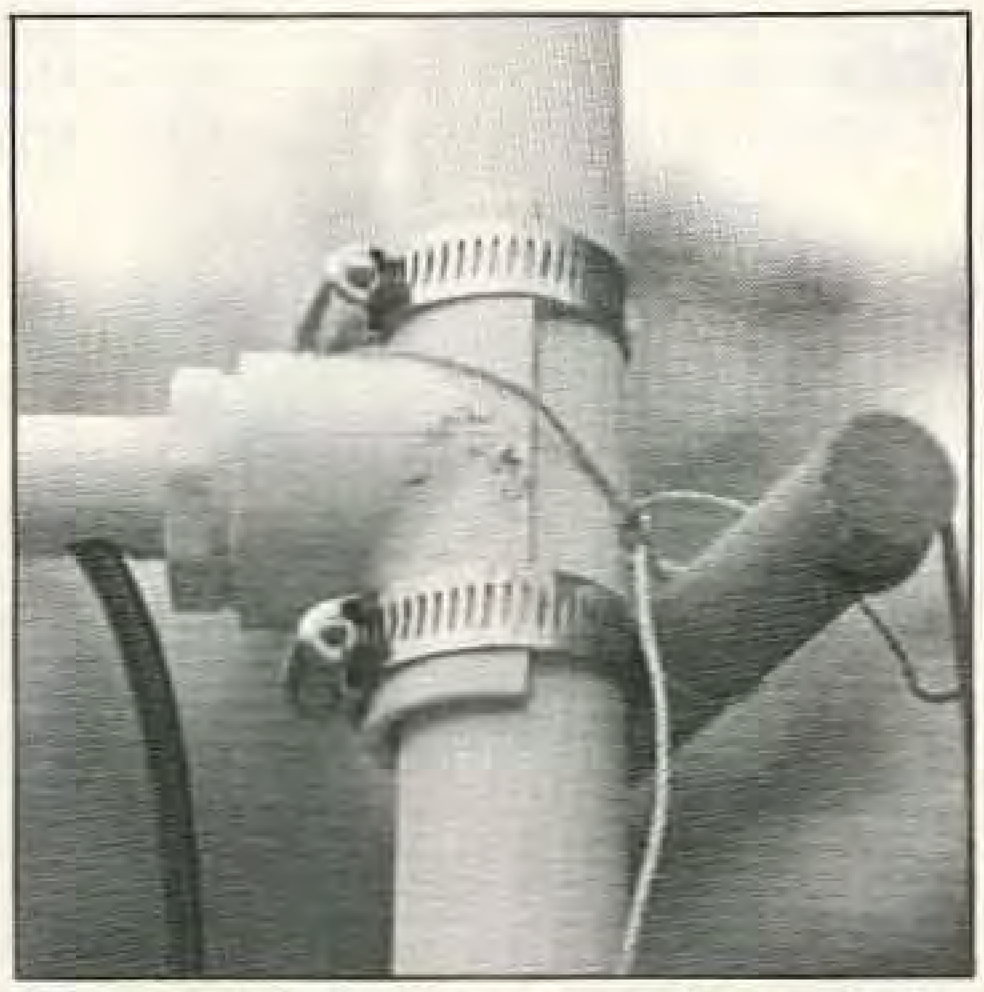

Photo D. The feedline support is attached to the antenna mast by a 1-inch "T" fitting. The top of the fitting has been hacksawed away to fit against the mast. Hose clamps hold the fitting in place. A reducing adapter glued into the base of the fitting accepts the 1/2-inch support pipe. The feedline enters the pipe through a hole in the bottom and screws to the SO-239 chassis connector at the other end of the pipe. The dowel at right is the end of the tuning stub, tied to the mast.

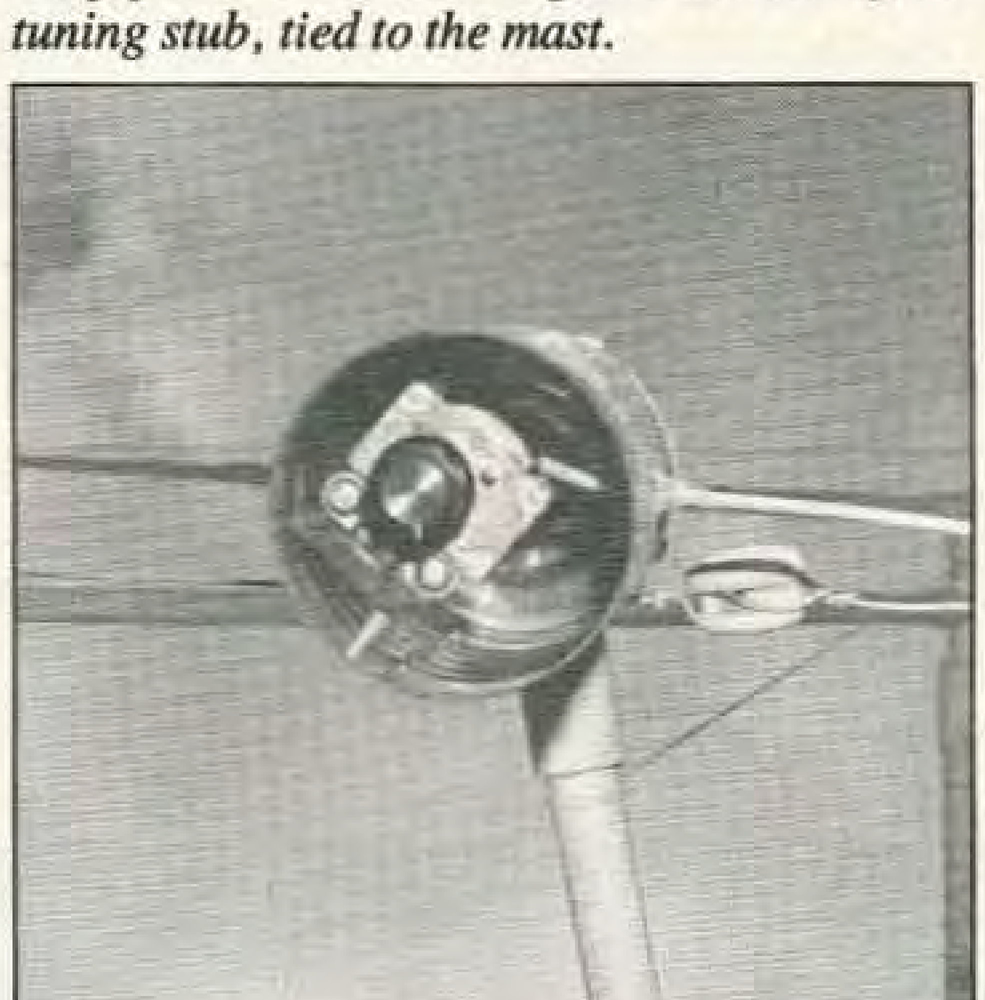

Photo E. A coffee can houses the matching capacitor. One side of the capacitor is electrically connected to the can; the other side to the driven element by an insulated wire through a grommeted hole in the can. A bare solid wire bolted to the top of the can is soldered to the center contact of an SO-239 chassis connector (out of view). A plastic lid that came with the can normally covers the opening, sealing out weather and insects.

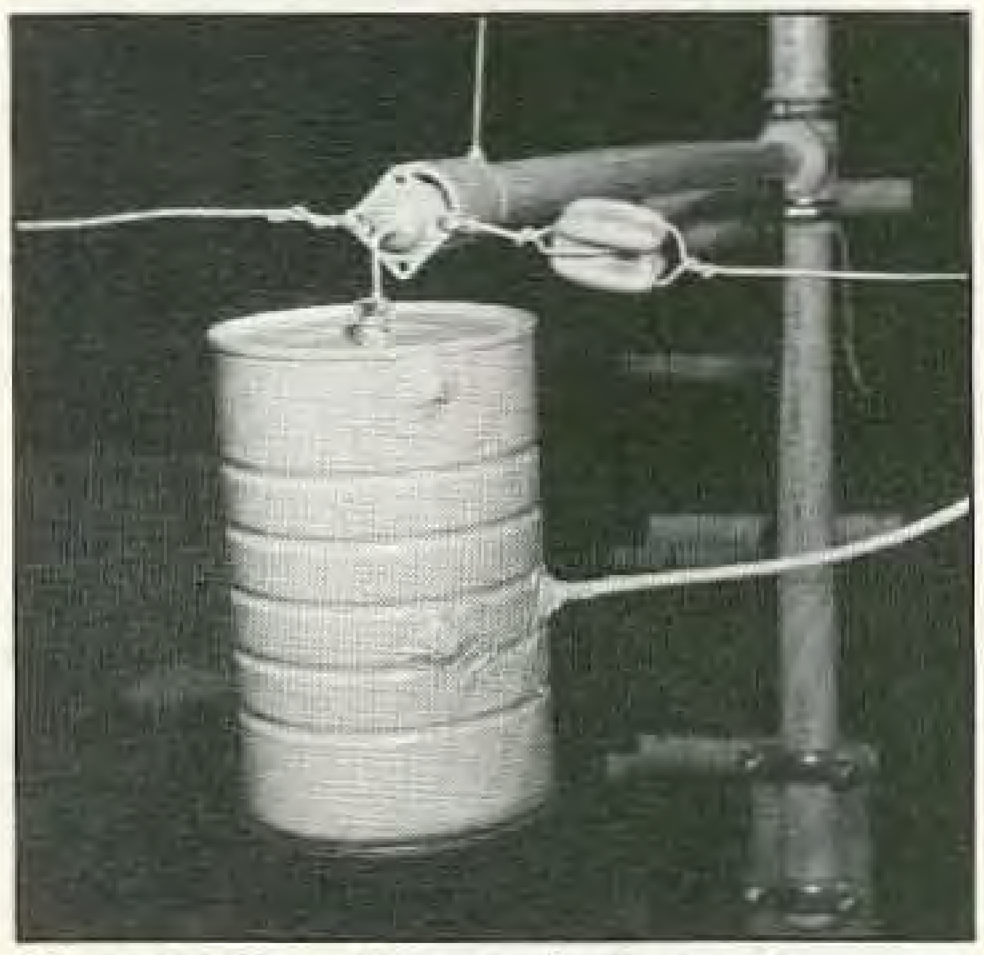

Photo F. The coffee can feedpoint is supported by a 1/2-inch PVC pipe through which passes the 50 ohm coax feedline. Note how the SO-239 chassis connector is rigged. One end of the driven loop is soldered to the left corner of the connector base. The other end of the loop is supported by, but insulated from, the opposite corner of the connector base. A wire bolted to the can is soldered to the center contact of the connector. The holes in the can have been sealed with silicon sealer, and the outside painted to prevent rust.

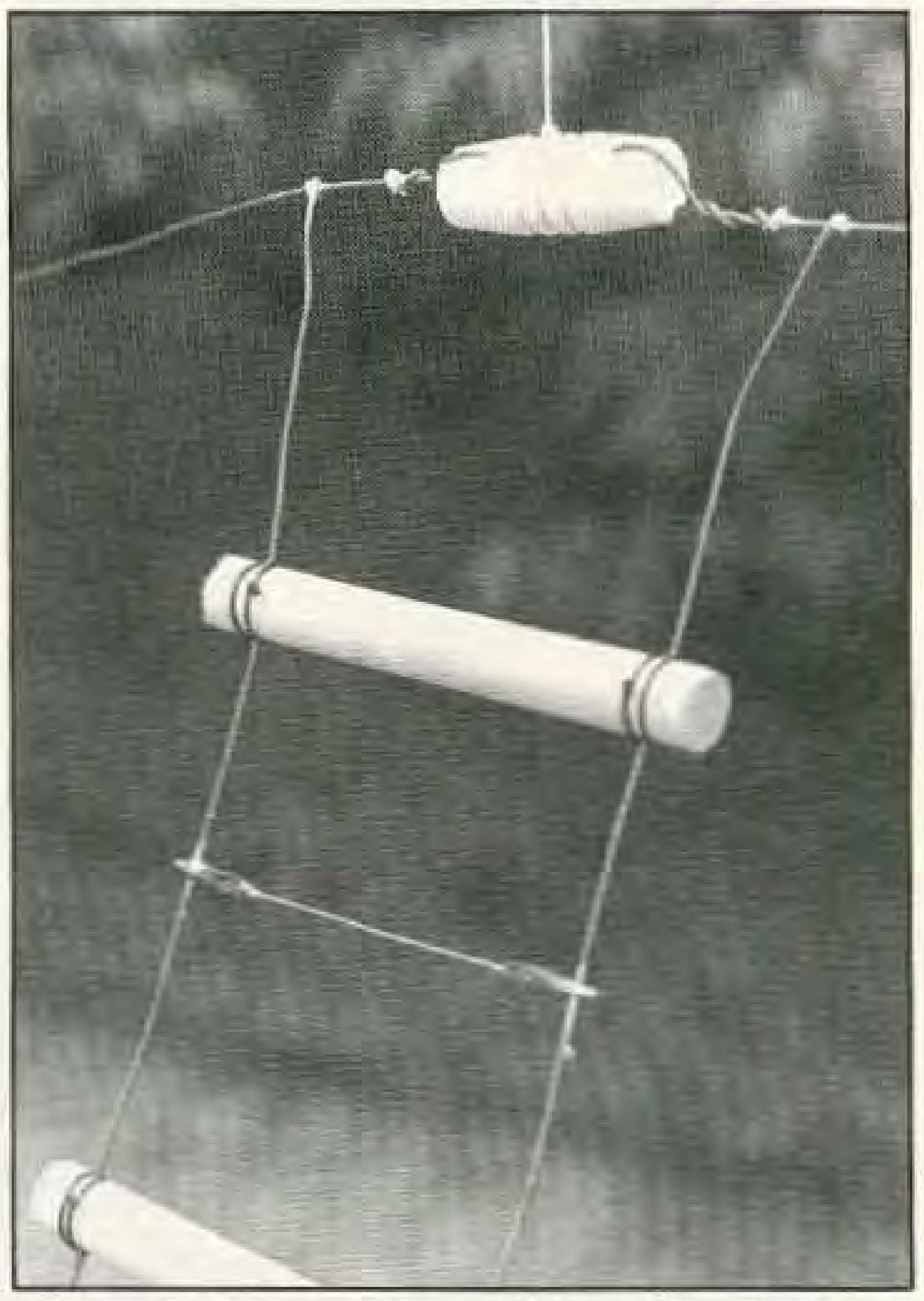

Photo G. The tuning stub is soldered across the insulator in the reflector loop. The wires of the stub are held 6 inches apart by wood dowels with holes drilled in the ends. The wires are tied to the stubs to keep them from slipping. Note the shorting bar, which is a length of solid wire with copper alligator clips soldered to the ends. After being adjusted, the bar is soldered to the stub wires. The string tied to the insulator keeps the bottom of the reflector loop from sagging.

tips of the spreaders and the wire, to keep the wire from slipping (see Photo C).

The completed element will seem floppy. Don't be concerned. Mine held its shape nicely after I raised the antenna to a vertical position.

The process for making the driven element is identical, except for the insulator. Instead of installing an egg insulator at the bottom of the loop, temporarily connect the ends of the wire together. You will add a feeder assembly at this point after erecting the antenna.

Final Assembly and Installation

Suggestion: Get a buddy to help you with this step. I didn't, and ended up doing a dance and balancing act that would have made an acrobat proud.

First, make sure that there are no power lines within reach! Place the elements on the boom. Adjust them until they are square with the mast, with the bottoms of the loops positioned so they will be toward the ground when the antenna is raised.

Fasten the elements to the boom with 3/16" x 2-1/2" eye bolts instead of glue (you may need to disassemble the elements later). Drill holes for the bolts through the coupler fittings and the boom. Install the bolts with the eyes at the top. They will serve as tie-points for the nylon string boom supports.

Rig two nylon strings from these eye bolts to the one in the top of the mast. Two small turnbuckles installed in the center of each string will make it easier to adjust the tension.

Prepare to mount the antenna in the rotor. Yes, you will need to rotate this antenna; it is very directional. I used a Radio Shack television rotor mounted on a section of steel television mast, because this is what I happened to have in the junk box.

Make sure the rotor is low enough for you to reach the bottoms of the element loops after the antenna is erected. Then, preferably with the help of a friend, hoist the antenna and clamp the base of the mast into the top of the rotor. Make sure everything is straight, and that the antenna is correctly oriented with the direction of the rotor at the time of installation. Tighten snugly.

Feeder Assembly

In order to achieve a workable SWR, you will need to feed the driven element through a capacitor. This is easy to do, using an air variable capacitor, a coffee can, and an SO-239 chassis connector.

First, make a support to attach the feeder assembly to the antenna mast. Start by cutting the top off a 1-inch PVC "T" fitting. Glue a 1/2-inch adapter into the base (uncut) end. Place the altered fitting on the mast, with the adapter pointing at the center of the bottom of the driven element loop, and fasten in place with hose clamps (see Photo D).

Cut a piece of 1/2-inch PVC pipe about 30 inches long, and glue one end into the fitting. Loosen the clamps and slide the fitting up or down so that the pipe touches the bottom of the loop at the center. Cut the pipe 1 inch short of where it touches the wire, and glue a 1/2-inch PVC coupler fitting over the cut end. Bore a 3/8-inch hole in the *bottom* of the pipe at the point where it enters the "T" fitting near the mast, to accommodate coax.

Next install an SO-239 *chassis connector* in the loop where the two ends of the wire come together. Cut both wires where they meet. Insert one of the wires through one of the holes in the base of the chassis connector (the ground part), and secure by twisting the wire around itself. Solder this connection. Connect an egg insulator to the opposite corner of the connector, then fasten the other end of the loop to this insulator. Thus, one end of the loop connects directly to the base of the chassis connector, the other to the insulator. The ends of the loop must be insulated from each other.

Cut a piece of 50 ohm coax 4 feet long and install an PL-259 plug to one end. Screw the installed plug onto the chassis connector. Thread the other end of the coax through the PVC pipe support and out of the hole near the mast. Install a PL-259 plug on this end of the coax.

Drill a hole for a 6-32 x 1/2" machine screw in the center of the bottom of a coffee can. Be sure to save the can's plastic cover. Using a lock washer, insert the screw from inside the can, so the threads protrude outward. Turn a nut onto the screw and tighten firmly.

Cut a piece of bare, solid 14-gauge copper wire 3 inches long. Form one end into a loop just big enough to slip over the screw. Bend the wire 90 degrees about 1 inch from the loop. Slip the loop over the screw. Place a washer and nut over the loop and tighten securely. Bend the opposite end of the wire 90 degrees, about 1 inch from the end.

Mount an air variable capacitor (use a capacitor with at least 1.16" plate spacing and a 100 to 400 pF maximum value) inside the can, with the rotor shaft pointing outward (so you can reach it). See Photo E for details. Make sure the rotor shaft and insulated knob are completely inside the can, so the plastic cover will not touch them. Set the capacitor in a fully meshed position (maximum capacitance). Electrically connect one side of the capacitor to the metal can. Solder an *insulated* wire 12 inches long to the other side of the capacitor. Pass this wire through a grommeted hole in the side of the can.

Solder the wire that is bolted to the top of

Table 1. SWR Curve

Frequency	SWR
28.0	2.0:1
28.1	1.6:1
28.2	1.3:1
28.3	1.3:1
28.4	1.6:1
28.5	1.8:1
28.6	2.1:1

Table 2. Parameters for the 10M PVC Cubical Quad

Operating frequency (in MHz)	28.40
Element spacing (in feet)	4.16
Circumference of element loops (in feet)	35.39
Dimension of one side of loop (in feet)	8.85
Length of one spreader arm from tip to boom axis (in feet)	6.26
Length of mast to boom axis (in feet)	6.00

Parts List

Quantity	Item	Source
1	1" x 10' PVC pipe	Hardware store
3	1/2" x 10' PVC pipe	Hardware store
1	1" PVC cross fitting	Hardware store
1	1" PVC "T" fitting	Hardware store
2	1" PVC coupler fitting	Hardware store
3	1" to 1/2" PVC adapter	Hardware store
1	1" PVC cap fitting	Hardware store
8	1/2" PVC cap fitting	Hardware store
2	1/2" PVC cross fitting	Hardware store
2	1/2" PVC "T" fitting	Hardware store
1	1" x 4' dowel	Hardware store
1	1" x 3' dowel	Hardware store
8	5/8" x 4' dowel	Hardware store
2	Small turnbuckles	Hardware store
8	#6 x 1/2" sheet metal screws	Hardware store
3	#6 x 1/2" machine screws	Hardware store
1	#6 lock washer	Hardware store
6	#6 washers	Hardware store
6	#6 nuts	Hardware store
3	3/16" x 2-1/2" eye bolts	Hardware store
1	Tube silicon sealant	Hardware store
1	Roll nylon string	Hardware store
1	Can spray paint	Hardware store
1	Can oil-base enamel	Hardware store
80'	Antenna wire	Radio Shack
2	Egg insulators	Radio Shack
1	SO-239 chassis socket	Radio Shack
2	PL-259 coax plugs	Radio Shack
4'	50 ohm coax	Radio Shack
1	Large air variable capacitor, 100 to 400 pF maximum.	Radiokit #21140 or 284130 are possible candidates.

Contact Radiokit at (603) 635-2235 or write P.O. Box 973, Pelham NH 03076.

the can to the center point of the chassis connector. Then solder the loose end of the insulated wire from the capacitor to the end of the driven element loop near the insulator. Put the plastic lid over the bottom of the can, seal all holes, and spray paint the outside of the can to prevent rust (see Photo F). *[Ed. Note: You can eliminate this capacitor feed arrangement and hook your coax directly to the driven element. However, if you are unable to obtain a very good SWR reading, you should use an antenna tuner in the shack or use the antenna mounted capacitor as described above]*

Tuning The Antenna

The tuning stub consists of two pieces of bare, solid 14-gauge copper wire 3 feet long, held 6 inches apart by dowel spacers (see Photo G). The shorting bar is a piece of bare solid wire with copper alligator clips soldered to the ends. Temporarily clip the bar to the stub about 6 inches from the reflector element.

Adjust the shorting bar on the tuning stub for maximum front-to-back ratio on receive, by moving it toward or away from the reflector element. Then adjust the capacitor for minimum SWR, using low power, with the SWR-meter placed at the input of the antenna. When finished tuning, solder the shorting bar in place.

My minimum SWR at maximum front-to-back ratio was 1.3:1 at 28.250 MHz. By moving the shorting bar closer to the reflector loop, I was able to achieve a 1:1 SWR, but with equal front-to-back signal strengths. I adjusted the stub for maximum difference between front and back, and then adjusted the capacitor for lowest SWR at the optimum stub setting. At this setting, the band width between SWR 2:1 was 600 kHz.

Operation

On the air, I couldn't believe my ears. I tuned in a California station calling "CQ." He was S-9 plus 10 off the front of my quad; only S-3 on my dipole. I gave him a call. He gave me an S-9 report. I rotated the antenna to the east. He dropped to S-5 and verified that my signal did likewise. I turned the antenna back to the west, and he went back to S-9 plus. When I switched to the dipole and transmitted, he could barely hear me.

But Will It Survive?

The next day, we had 45 mph winds. The flexible PVC bent and swayed, but did not break. There was no noticeable change of SWR in the wind. To date, the antenna has survived several thunderstorms and winds of 60 mph with no damage.

From my QTH in north Texas, the quad has enabled me to work with ease Australia, Columbia, Ireland, Hungary, Italy, Japan, Venezuela, Russia, Costa Rica, Argentina, and Germany. Since putting it on the air, I've yet to hear "Q R Zed" on 10 meters. But if I do, you can bet I'll be able to work him.

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