three-element quad
for 15-20 meters which uses circular elements

Development of a circular-element quad beam from conception to final result — the *Dream Beam*

This project started in the winter of 1977-78 when I became active after having been off the air for over 40 years. I wanted a good antenna for 15 and 20 meters, but my location precluded a big beam. This article describes a quad antenna using circular elements rather than the usual square element configuration. Advantages of using circular rather than square elements are described together with construction details for building your own antenna. Development of the idea is discussed, beginning with a single-element circular antenna for 15 meters. The final version, a three-element circular quad, has given a good account of itself.

The idea was inspired by a bicycle wheel. Structural rigidity for the circular quad elements is provided by "spokes" radiating from the element hubs to the elements. Another bonus: the circular loop has a 0.9 dB gain over a square or diamond.[1]

May I now present the *Dream Beam*, its early development, model tests, construction, and performance.

early antennas

The first attempt was a very small model. The "bicycle" rim or tire (conductor) was made by springing a length of small-diameter stiff plastic tubing into a circle about two feet (0.6 meter) in diameter. The wheel hub was a 6-inch (153-mm) length of ¼-inch (6.5-mm) wood dowel with small plywood flanges on each end. Holes were drilled in the flanges all around, spaced at 45-degree intervals. Eight pairs of "spokes" were made from kite string connecting the "tire" in pairs to the holes in the hub flanges. Sure enough there was the wheel! It proved to be what I hoped for — very lightweight, surprisingly strong, resilient, simple, and a near perfect circle.

One-element circular quad loop for 15 meters. This work led to an attempt at a single-element, full-size antenna for 15 meters. The conductor for this antenna was 3/8-inch (9.5-mm) aluminum tubing lengths spliced together to a total length of about 46 feet (14 meters). This assembly was easily sprung into a circle, and the ends were attached to a feed-point insulator that included an SO-239 coax connector. The hub was a 30-inch (765 mm) length of 1-inch (26-mm) PVC plastic pipe to which some end flanges had been fitted.

Eight pairs of spokes were used, which were made from 40-pound (18-kg) test monofilament nylon fish line. It did indeed look like a big bicycle wheel! It was about 15 feet (5 meters) in diameter, and I wondered if I could ever get it up into the vertical position. I gingerly picked it up by the hub and, to my pleasant surprise, found it quite stable and easy to handle. The whole element weighed only about 2½ pounds (1 kg) — so light that I could carry it up a ladder to the roof alone using one hand for myself and one for

By J. W. Kennicott, W4OVO, 468 Colonial Drive, Lexington, Tennessee 38351

the antenna. The 15-meter antenna performed beautifully, and I used it for several months. It proved to my satisfaction that the construction principle was sound and would work.

One-element circular quad loop for 15-20 meters. A single-element 15 and 20 meter antenna was the next step. It was similar to the 15 meter version but quite a bit larger. About 70 feet (22 meters) of ½-inch (12.5-mm) aluminum tubing was sprung into a 22-foot (7-meter) diameter circle and connected with a similar feed point insulator. The hub was 4-foot-8-inch (1.4-meter) length of 1½-inch (38-mm) PVC pipe with flanges on each end. The number of spokes was increased to twelve pairs, and these were made from heavier 80 pound (36 kg) test monofilament nylon. The 15-meter element of no. 16 (1.3 mm) copper antenna wire was attached to the spokes in much the way a spider spins a web: rather than a true circle, it was a regular twelve-sided polygon. This antenna was a success and I worked much DX with it.

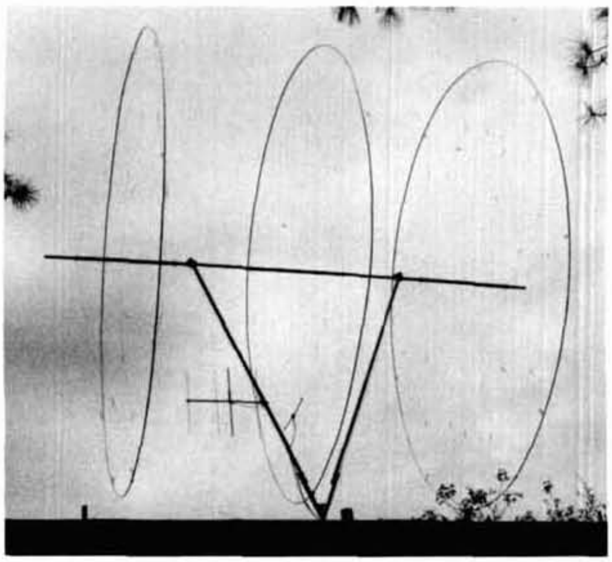
two-element beam for 15-20 meters

The two-element beam was a natural and easy development. Reflector elements were made just like the driven elements, except there were no feed-point insulators, of course. And did it work! I received excellent reports and many compliments on my signal from all over the world. I could usually contact any station I could hear. Europeans, ZLs, and VKs were worked with the greatest of ease and almost at will. It was a quiet receiving antenna and seemed to have excellent directional properties.

three-element beam for 15-20 meters

Then I began to think of installing a director. Would the antenna be further improved with a third element, a director? If so, could I get one up there? Yes, there might be a way, and I dreamed up the basics of the three-element version.

I was about to begin building when nagging doubts began to creep through my mind. The message said, "Look OM, you have a fine antenna now, but you really know very little about it. Do you know what the beamwidth is, what the pattern looks like, and whether you have the optimum reflector length and spacing? If you put up a director, what length will be best? What spacing will be optimum? What will the front-to-back ratio be? You really don't know these things. Enlarging the beam will take a lot of time and much work. You may fall flat on your face!" I had to agree. I decided to postpone the director and



The *Dream Beam* for 15 and 20 meters: like three giant bicycle wheels on one axle. The small 2-meter array (lower left center) gets a free ride.

embarked on a three-month period of model testing to find out where I was, where I wanted to go, and how I was going to get there.

model tests

In my backyard antenna range, a one-watt 2-meter carrier from a dipole illuminated the model antenna under test. Induced currents were observed and recorded and patterns plotted. After literally hundreds upon hundreds of patterns, I felt I had the answers to all the questions — plus much other valuable and interesting data.

One particularly interesting result concerns a very closely spaced two-element (driver and reflector) circular loop beam. If the reflector is made 1.018 times the length of the driven element and spaced at 0.065 wavelength, a very nice beam results. At 146 MHz this spacing is only about 5½ inches (140 mm). A beautiful 2-meter mobile beam antenna could be made using an aluminum loop driver. The reflector could be bracketed right to the driver with nonconducting material. You can't add a director to this arrangement; it will not work that way.

The model tests of the two-element configuration showed that I had been lucky. My earlier guesses at reflector length and spacing were reasonably close to optimum.

The bulk of the work was with the three-element configuration. Director and reflector lengths were varied, and the effects of various spacings investigated. The goal was to zero in on the optimum antenna. This was eventually done and the *Dream Beam* was made to the following dimensions:

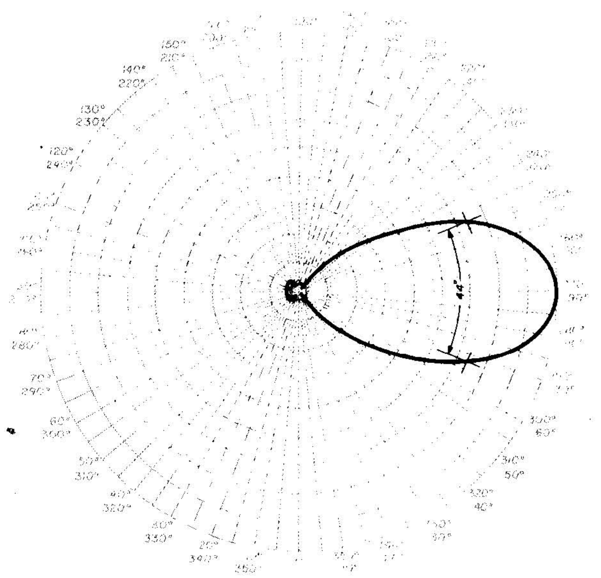


fig. 1. Horizontal radiation pattern of three-element, full-size circular loop beam at 145 MHz.

element lengths

14,275 kHz	**wavelength**	**feet**	**(meters)**
director element	0.977	67.34	(20.5)
director spacing	0.123	8.50	(2.6)
driven element	0.990	68.23	(21.0)
reflector spacing	0.123	8.50	(2.6)
reflector element	1.008	69.46	(21.2)
21,350 kHz			
director element	0.974	44.90	(14.0)
director spacing	0.141	6.50	(2.0)
driven element	0.987	45.50	(14.0)
reflector spacing	0.184	8.50	(2.6)
reflector element	1.005	46.30	(14.0)

You'll notice that the proportions of the 15-meter elements don't agree with those of the 20-meter elements. This comes about by mechanical considerations and the fact that it was necessary to tune the 15-meter element to resonance at 21,350 kHz. While the 15-meter array doesn't quite meet the optimum dimensions, only minimal harm comes from the dimensions used. The turning radius is only 14 feet (4 meters).

Fig. 1 is the horizontal pattern from model experiments. Numbers of vertical patterns were also made, and it always turned out that they were almost identical to the horizontal patterns.

impedance

The feedpoint impedance of a fullwave loop has been estimated to be in the range of 100-130 ohms. For the earlier one- and two-element antennas a very close match to 52-ohm coax was made with the use of quarter-wave matching sections of 75-ohm coax. In the three-element configuration the feed point impedance becomes much reduced. The impedance of the 20-meter driven element turned out to be about 20 ohms; the 15-meter element about 27 ohms. Excellent matches were made between the transmission lines and the antenna elements using matching stubs cut for these impedances.

circle versus rectangle

In general character there is much similarity between the *Dream Beam* and the familiar quad. Construction and configuration aside, there are some electrical differences. The resonant length of the circular configuration is somewhat less than that of the square or diamond. The resonant length of the circular loop is about $974/f$. The usual formula for the quad is $1005/f$. The parasitic element lengths are nearer to the length of the driven element in the case of circular loops. The director element is 1.3 per cent shorter; the reflector element is 1.7 per cent longer.

construction

To start at the bottom: A bearing and rotator are installed in the attic of my house. The installation is remarkably similar to the one described in detail by WØYBV.[2] He and I were perhaps cutting holes through our roofs at about the same time! The lower part of the Y-base (**fig. 2**) is a piece of 1½-inch (38-mm) steel pipe. To the top were welded two U-shaped steel members from a junk pile. They were just the right size and the V-struts were attached to them with U-bolts.

The V-struts are 12-foot (4-meter) lengths of 2-inch (51-mm) aluminum tubing. They are connected to the two 1½-inch (38-mm) diameter boom halves with U-bolts using tie plates cut from 1/8-inch (3-mm) aluminum sheet. This assembly must be carefully laid out so everything is in good alignment.

The 20-meter elements are made from lengths of 3/4-inch (9-mm) type 6061-T6 aluminum tubing. This tubing was flattened to make it something like an elliptical section about 15/16 inch (24 mm) wide and ½ inch (12.5 mm) thick. For the joints between sections, solid aluminum inserts were used. These inserts, 3/8 × ½ × 3 inches (9.5 × 12.5 × 77 mm), were fixed and connected by using no. 6 (M3.5) stainless steel machine screws. Spoke attach eyes are 3/32 × 1 inch (25 × 25.5 mm) stainless steel cotter pins in holes in the plane of the loops at proper intervals. Points are bent sharply back around the outside of the elements. The feedpoint insulator for the 20-meter driver is placed at the bottom. The SO-239 fitting mounted underneath was potted in silicone to make it watertight.

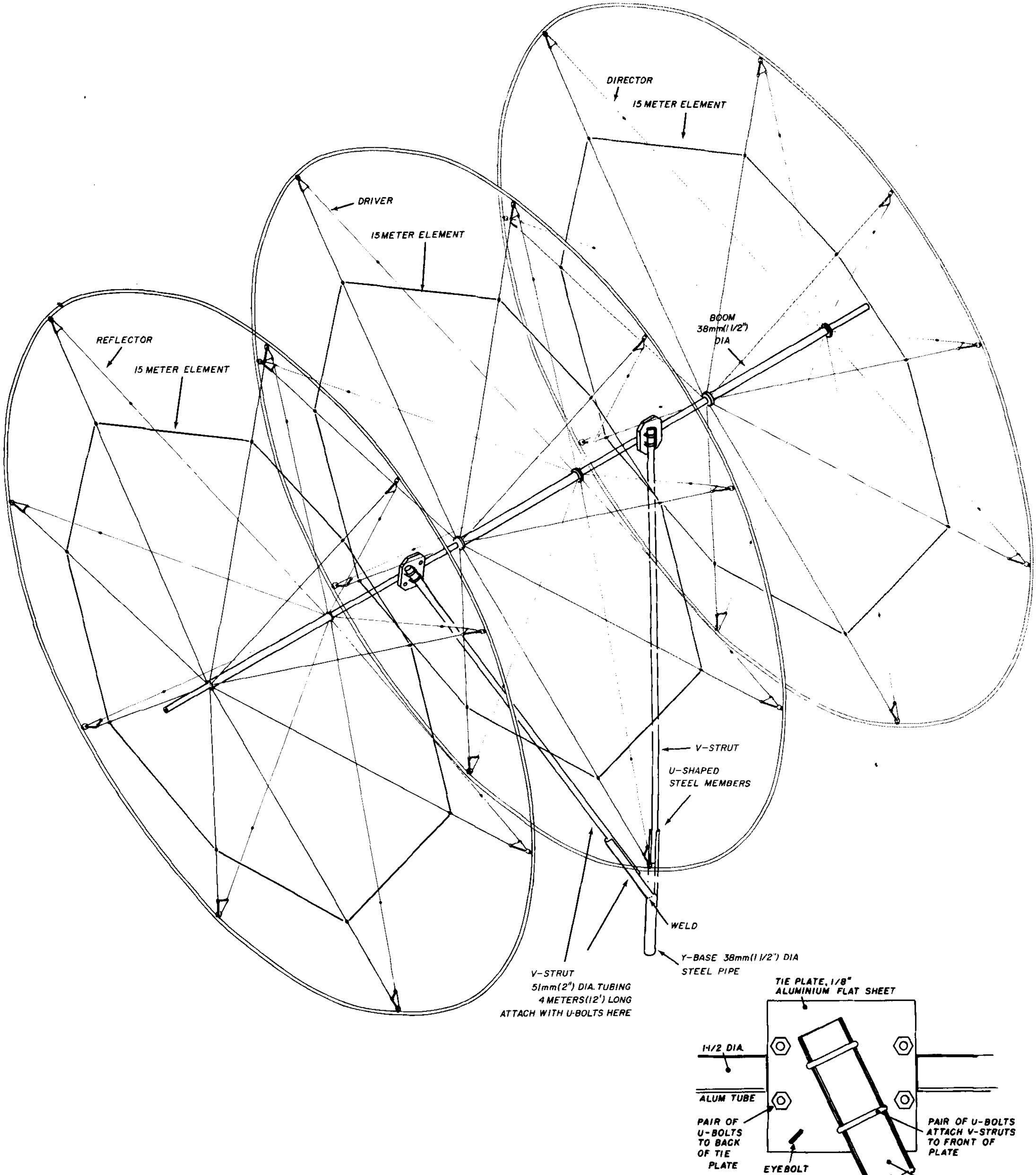


fig. 2. *Above*, the *Dream Beam*. Although this antenna is similar to the quad, there are some electrical differences because the resonant length of this circular configuration is somewhat less than that of a square or diamond: for a circular loop, it's about 974/f, as opposed to 1005/f for the quad. *Below*, details of the boom/V-strut mounting bracket.

The hubs are 6-foot (1.8-meter) lengths of 1½-inch (38-mm) schedule 40 PVC plastic pipe with spoke-attach flanges cemented on each end. Spoke-attach eyes are 1/8 × 1 inch (3 × 25.5 mm) stainless-steel cotter pins inserted in holes drilled through the flanges. Holes are parallel to the axis of the hub.

Nylon monofilament spokes in earlier antennas were not completely satisfactory. The *Dream Beam* elements have spokes of no. 20 (0.8 mm) stainless-steel wire. These are insulated, and nine pairs are spaced around at 40-degree intervals. Their lengths were calculated. They were made fairly accurately on a simple jig. This jig was a 12-foot (4-meter) length of 2 × 4 lumber with small finishing nails in it corresponding to the several points on the spokes. The element end of each pair of spokes is fitted with a 4-inch (102-mm) triangular insulator cut from a sheet of ¼-inch (6.5-mm) Lucite. The insulator is attached by a ¾-inch (19-mm) "key ring" to its spoke-attach eye. ("Key ring" is used for lack of knowing a better term. It consists of almost two turns of stiff, springy stainless wire and may be easily threaded onto and off of the attach eye. I got the key rings at a sailboat supply house, where they're called "cotter rings.")

In toward the hub another small plastic insulator is inserted in each spoke. These are ¼ × ½ × 4 inches (6.5 × 6.5 × 102 mm) long. There is a hole in each end to which the spoke is attached, and a hole in the center. The hole in the center is the eye through which the 15 meter element of no. 16 (1.3 mm) copper antenna wire is threaded. These elements become nine-sided regular polygons. These insulators must be accurately located (a nail in the jig) so that neat polygons of the correct perimeter result. The hub ends of the spokes are simply fixed to their attach eyes on the hubs. The flanges and hubs serve as insulation here.

handling

The elements may be assembled where there's sufficient room handy to the antenna location. Simply put them together. No jig or other special tooling is needed. They end up, completed, lying on the ground.

Handling and transport of the assembled elements at first appeared to present a tricky and complicated challenge. However, it turned out to be ridiculously simple, easy, and safe. A carrier was made like a grossly elongated T. The "up-and-down" portion is a 12-foot (4-meter) length of 1¼-inch (32-mm) light steel tubing. At the top, a 4-foot (1-meter) piece of tubing is attached across. Two clips were made from a piece of PVC pipe (somewhat larger then the hubs). The clips were cut so they could be snapped on and off the hubs with ease; they were bolted to the top of the T.

Simply clip the carrier onto the hub, pick up the element, and lift it to the vertical position. Superhuman strength and balance are not needed; after all, an element weighs only about 9 pounds (4 kg). I must admit to being a little frightened when I tried it for the first time. The 22-foot (7-meter) "wheel" looks gigantic when towering over your head! The purpose of the carrier, of course, is for transporting the element and slipping it onto the boom. The hub ID is about 3/32 inch (2.5 mm) greater than the 1½-inch (38-mm) boom, so it may be slipped on and off readily. When the hub is on the boom, give the carrier a downward jerk. The clips open and the carrier is separated. Elements went up and on, and off and down, many times during development for changes, adjustments, and pruning. Not the slightest difficulty was ever encountered.

assembly

Assembly of the entire array is really not so complex as it may at first seem. It was quite fun — a great satisfaction to see it up there, in place and "flying." I'm not exactly a spring chicken and don't claim the vision, balance, and agility of 30 or more years ago. The whole antenna was, however, assembled from the parts on the ground to their places in the rooftop array in about four hours. This work was done entirely alone with no assistance whatsoever.

Fig. 2 shows the various parts in relative positions. The key to the assembly of the structure is 20-foot (6-meter) length of 3/32-inch (2.5-mm) stainless-steel *flexible* cable. This is obtainable at most marine hardware dealers, particularly those handling sailboats and supplies. It is permanently attached to the *inside* of the left boom tube at the right end. Steps are as follows:

1. Position the steel **Y**-frame in the bearing and rotator.

2. Run a 25-foot (8-meter) messenger of stout cord or fish line through the eyebolt in the left tie plate (used later for the reflector preventer cord). Erect the left V-strut and boom half, securing it to the Y-frame with U-bolts.

3. Run a 25-foot (8-meter) messenger through the hub of the driven element. Bring the driven element into position, ready to slip onto the left boom half. Connect the flexible cable to this messenger and pull it through the hub of the driven element so it comes out on the right. Slip the driven element onto the left boom half.

4. Drill a 3/8-inch (9.5-mm) hole in the bottom of the right boom half near where it is attached to the V-strut. Run a 25-foot (8-meter) messenger (for the flexible cable) through this hole so that it comes out from this boom half on the left.

5. Run a 25-foot (8-meter) messenger through the eyebolt in the right tie plate (used later for the director preventer cord). Connect the flexible cable to its messenger. Pull the flexible cable into the right boom half so that it comes out through the 3/8-inch (9.5-mm) hole. Slip the right boom half into the driven-element hub and secure this V-strut to the Y-frame with U-bolts.

6. Pull the flexible cable tight and fasten it securely to the Y-frame. The structure is now erected. The hub of the driven element acts as a sleeve connecting the boom halves. The flexible cable holds them tightly together inside the hub.

7. Slip on the reflector element. Connect the preventer cord (1/8-inch or 3-mm high-grade nylon parachute cord) to its messenger and pull it through the eyebolt in the tie plate, securing it to the Y-frame. This preventer cord simply restrains the element from sliding off the boom.

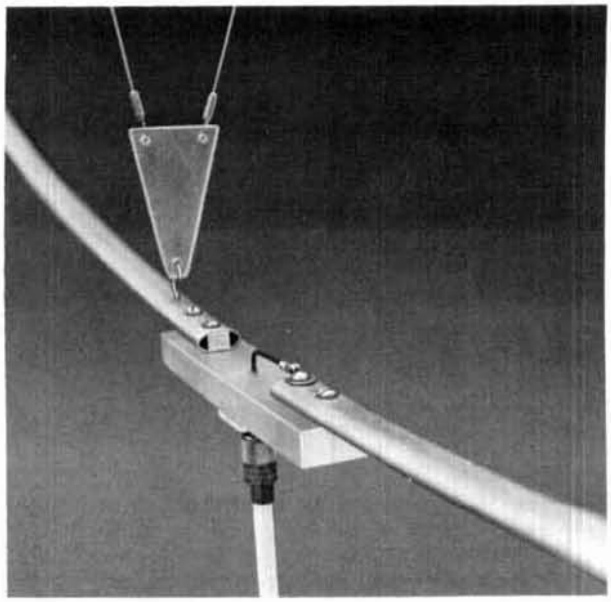
8. Slip the director element on in the same manner as the reflector.

disadvantages

The only disadvantage of this array is in the sheer size of the element assemblies. Once it's put together in your yard or patio, the only possible thing you can do with them is put them up where they belong. They are too large to ship by any means. They won't fit in your garage or basement, so they can't be stored away — unless you happen to have a vacant airplane hangar! They could be disassembled for shipping or storing, but not nearly so readily as with other beams.

serviceability

Only high-grade corrosion resistant materials were used. The PVC hubs were painted with polyurethane to avoid deterioration by sunlight. The antenna has satisfactorily survived two rather severe winter icings. Being somewhat resilient, the elements swing and sway in a gusty wind, but the array has withstood quite a number of very high winds in thunderstorms. As the array is mounted just above the rooftop, it's centered only about 30 feet (9 meters) above the ground. Some protection occurs from numerous tall trees in the area. I can't say how the array would do atop an 80-foot (24-meter) tower. The exposed area of each loop is 3 square feet (0.3 square meters). Further experience may show up weaknesses not anticipated.



How the feedpoint insulator is made and connected to the 20-meter driven element. The triangular-shaped insulator is between the circular conductor and the wire spokes. Portions of the Y-frame are visible, and the lower end of the V-strut can be seen.

performance

Evaluation of antenna performance is both difficult and perilous. The difficulty lies in the large number of uncontrollable variables, which render numerical comparisons very questionable. The peril is in one's ability to enforce strict self-discipline and maintain a truly objective viewpoint. It's easy and tempting to overrate something which is your own baby, your own creation.

In the past year every opportunity for evaluation and comparison has been seized; this process is still going on. Reports and results have been extremely encouraging, and I become more pleased and confident as the hard evidence comes in day by day and week by week. Much of the time I get reports such as: "You are very, very strong;" You have the strongest signal on the band;" and, "Your signal is 15 to 20 dB over S9." Some of the reports have been so good as to be not believable. I can't remember when another station couldn't read me if I could read him. Being picked out the first time in DX pileups has become fairly common. Though many long months in coming, the *Dream Beam* is now a reality.

reference

1. Frank Witt, W1DTV, "Simplified Antenna Gain Calculations," *ham radio*, May, 1978, pages 78-85.
2. Charles J. Ellis, WØYBV, "A Novel Way to Mount a Rotary-Beam Antenna," *QST*, May, 1979, pages 32-33.

ham radio