How about a quad that works seven bands (with full-size elements—no traps), uses a single feed line, has nothing to adjust at the antenna, and is inexpensive?! Sound incredible, but it is a fact. It works 2, 6, 10, 12, 15, 17, and 20 meters.

A Seven Band Boomless Quad

BY RICHARD E. JAMES, JR.*, W4DQU

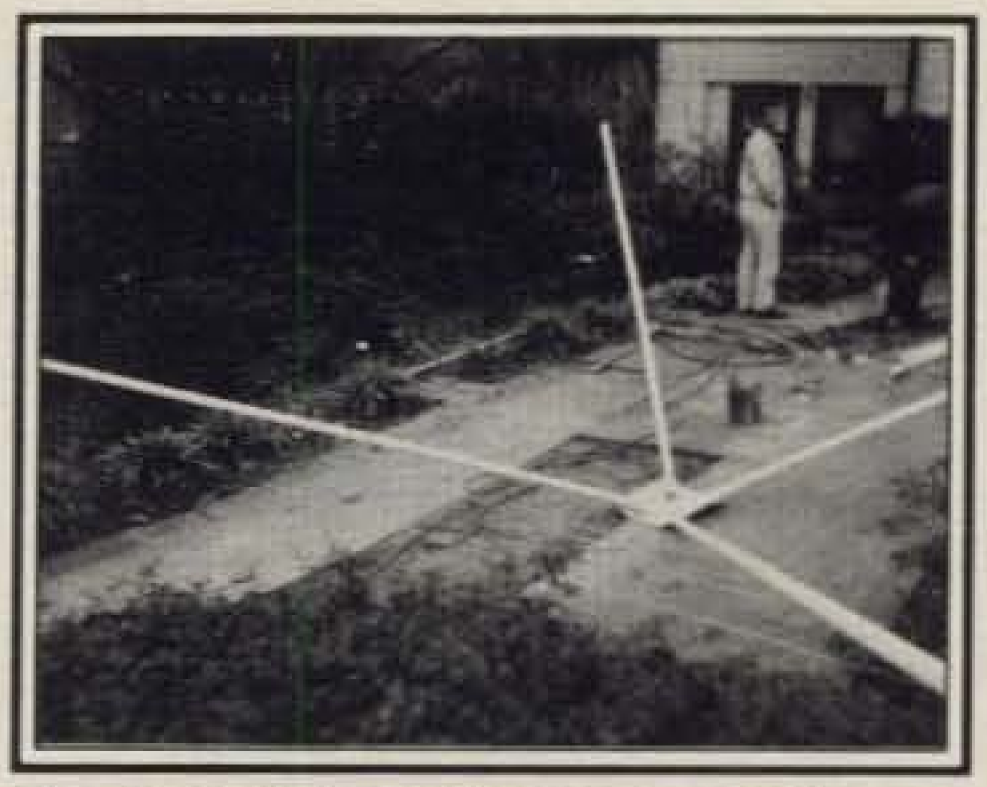
Here's a boomless quad built around a three-piece hub (manufactured by MFJ Enterprises) which makes it possible to do all the final assembly near the top of the tower (for those of us who can't afford a crank-over or lay-over tower). The MFJ hub is composed of the following:

1. A center piece made up of a piece of metal tubing about 18 inches long with two short pieces of angle iron attached to it with two bolts and a threaded rod.

2. Two aluminum plates, one for the driven element and one for the reflector.

Let me tell you why I think this quad is the best two element quad ever presented to the amateur fraternity.

About 1954 I became interested in quad antennas, and during the next fifteen years I built several utilizing the information available at the time. In 1969 I gathered together all the information I had been able to find and began a serious study, with the goal of trying to design a perfect two element quad. It soon became evident that such a quad would have to have:



The driven element after assembly, prior to installation.

1. A spacing between driven element and reflector of ⅛λ because this spacing gives the maximum gain. If elements for more than one band were to be put on one frame, a "boomless" quad would be called for in order to maintain ⅛λ spacing between driven element and reflector on each band. None of the boomless quads on the market met this requirement, then or now, because in order to do so an imaginary extension of the base of each pole must intersect its counterpart at the exact center of the hub. The boomless quad concept also has a side benefit of being much more rigid, thus holding its shape better than a boom-type quad.

2. Reflectors about 3% larger than their driven elements. The popular idea of using an adjustable reflector stub was discarded because it doesn't work well unless you use a stub in the top center as well as one in the bottom center. The reason for this is that a quad loop can be considered as a ½λ stacked over another ½λ with the ends bent towards each other. Just increasing the length of one of the two ½λ sections does not give the response one desires. Each of the ½λ sections needs to be increased in effective length. To get away from using two adjustable matching stubs, I decided to use reflectors that were larger than the driven elements. I found very little information on how much larger a quad reflector should be than a quad driven element.

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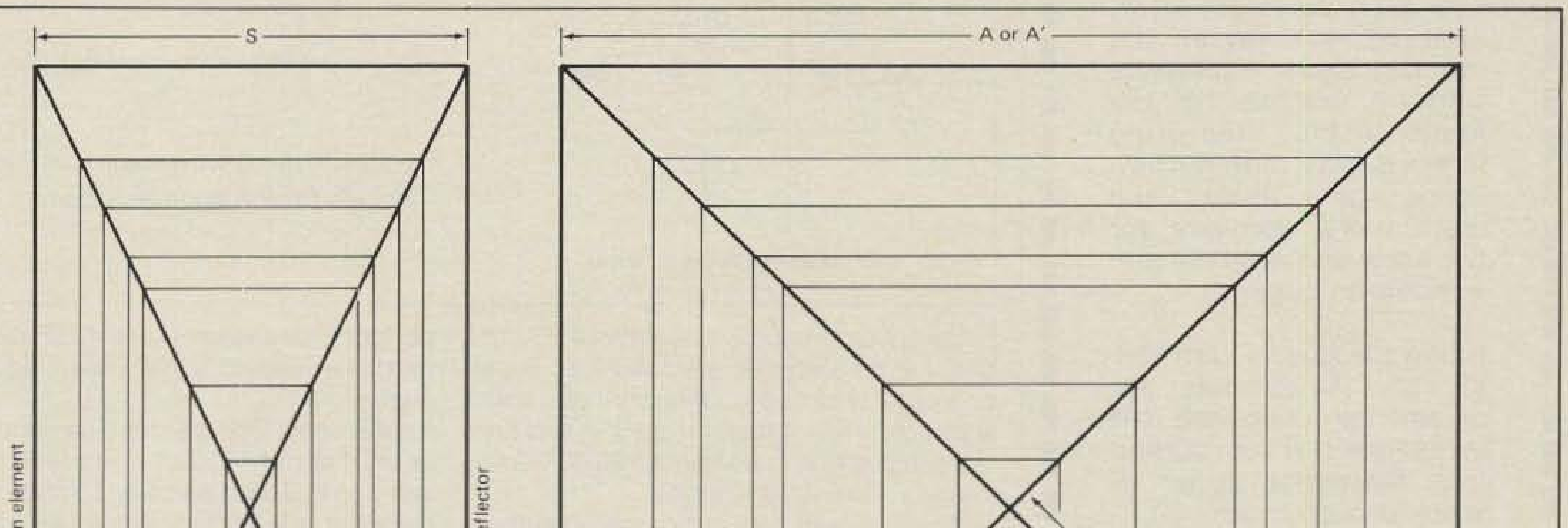


Fig. 1– A two-dimensional look at the boomless quad.

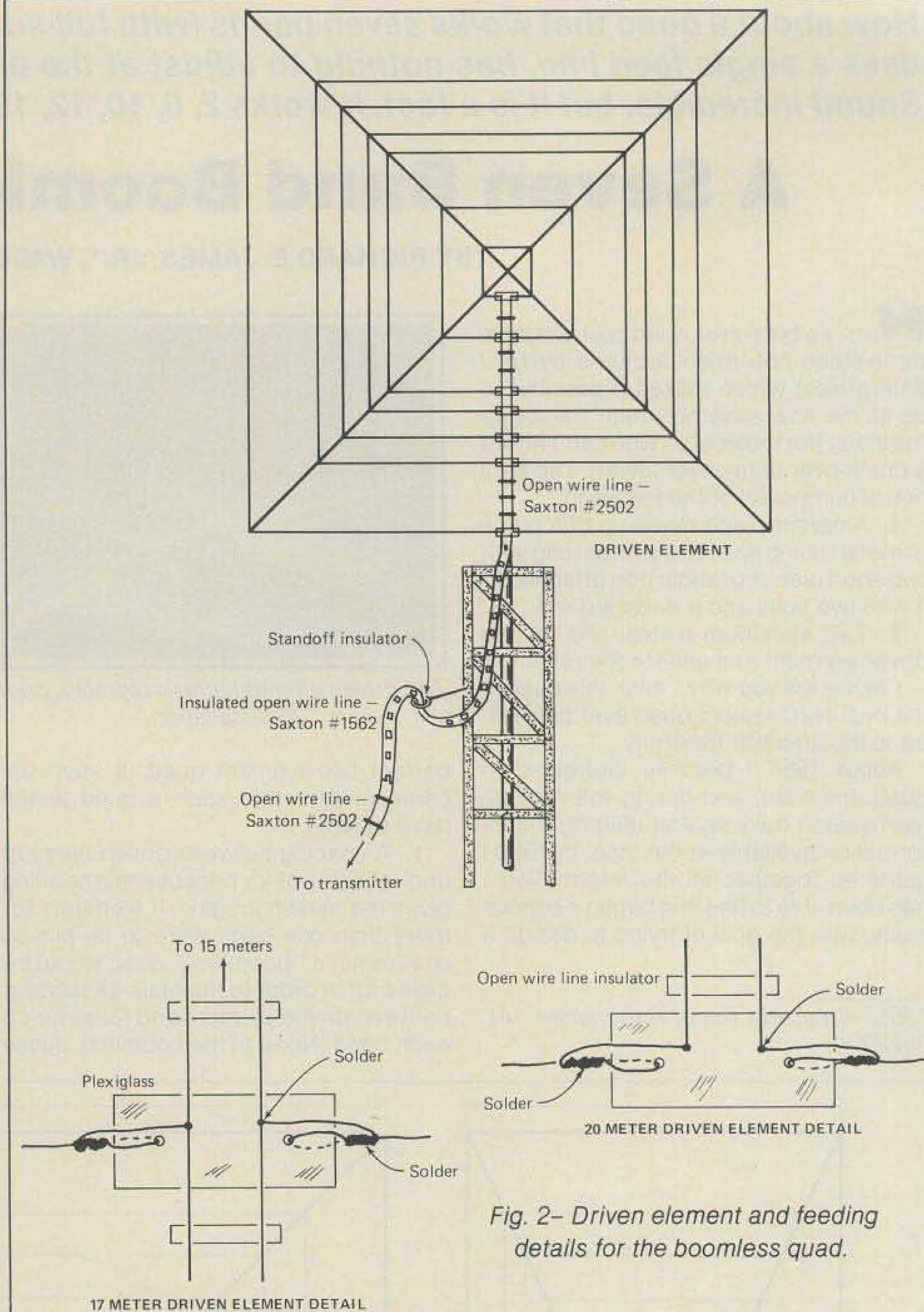


Fig. 2– Driven element and feeding details for the boomless quad.

Since a beam usually uses about 5% or 6%, I estimated that a closed loop such as a quad should probably work well with about one-half of that. I tried 3% and the front-to-back ratio was about 25 dB! (And there is nothing to adjust!)

3. Coax feed was out of the question. How could several driven elements be fed with one coaxial feed line? Also, I didn't want to use any heavy baluns on the driven elements. I had an inspiration: why not buy a roll of Belden #8210 (72Ω twin-lead), put a one-to-one ratio balun on the output of my linear, and tap each driven element into the feed line at the point where the feed line crosses each driven element (see drawings)? This feed system works perfectly. If, for example, a 15 meter signal goes up the feed line, it goes to the 15 meter driven element because the other driven elements offer more resistance to the 15 meter signal. The 72Ω twin lead matches each driven element perfectly because it is a 72Ω balanced feed line feeding a 72Ω balanced driven element.

Like coax, 72Ω twin lead has one drawback: it is rather lossy and I feel it is too lossy on 2, 6, and perhaps 10 meters. The reason it is lossy is that the two conductors are very close together (capacitive and inductive reactance losses), and they are separated by a dielectric material much less efficient than air. I have since used 300Ω open wire line (Saxton #2502) from an antenna tuner to a point near the antenna where I use a short length of Saxton #1562 "insulated open wire line" (about 10 or 15 feet) where the line must wrap and unwrap around the tower as the quad rotates. With this setup, if the insulated line touches the tower or rotator, it won't short out to ground because it is insulated.

If you do not wish to use an antenna tuner, you can still use the 300Ω line in the

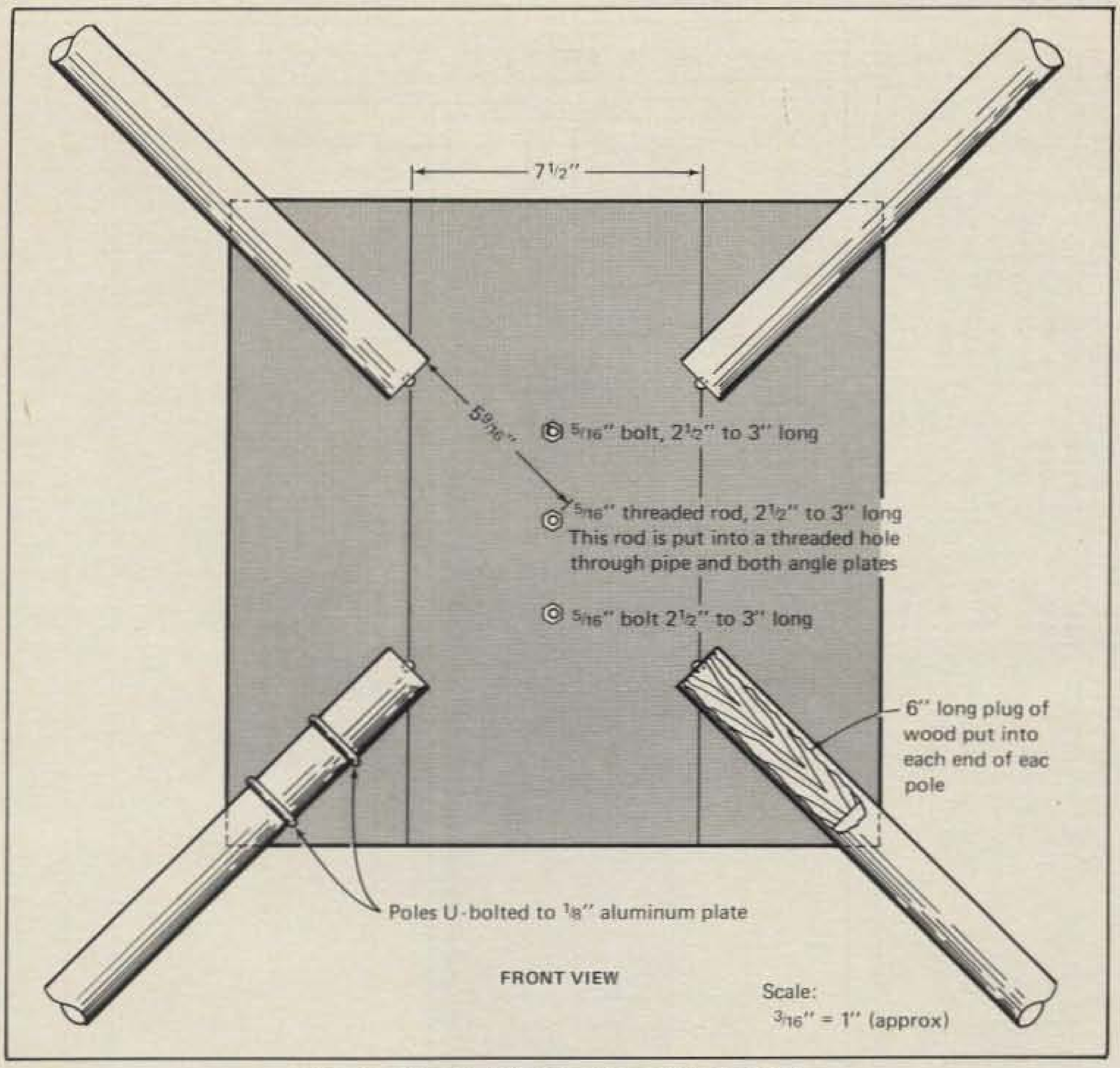


Fig. 3– Single hub construction details.

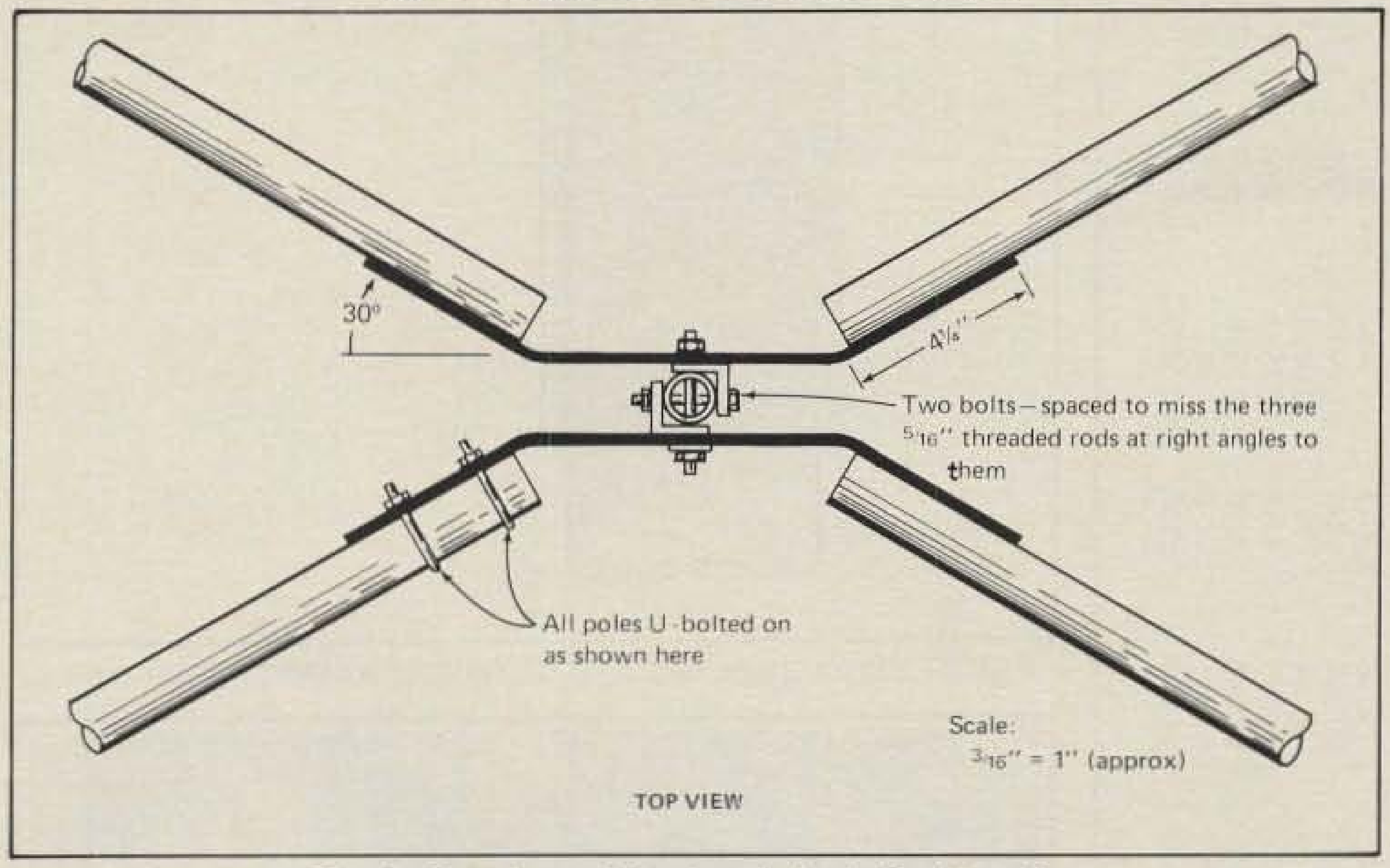


Fig. 4– Top view of the two hubs bolted together.

following manner: Put a 4:1 balun on the output of the linear (or output of the transceiver if you don't have a linear) and connect the 300Ω line to the antenna terminals of the 4:1 balun. Wrap a double loop for each driven element instead of a single loop and it will have a feed point impedance of about 300Ω.

If you use an antenna tuner, I don't see any need to wind double loop driven elements instead of single loops. A single loop driven element has a feed point impedance of about 72Ω, giving a 4:1 s.w.r. when a 300Ω feed line is used. A study of the feed line loss charts in the handbooks will show that the 300Ω feed line terminating with a 4:1 s.w.r. gives much less total loss than a 72Ω feed line with a 1:1 s.w.r.! (The 300Ω line terminating into 300Ω would have about 0.2 dB loss. The 72Ω twin lead terminating into 72Ω would have about 2 dB loss. The 300Ω line terminating into 72Ω [4:1 s.w.r.] would have 0.2 dB loss plus an additional loss of 0.2 dB because of s.w.r., making a total loss of 0.4 dB. Using a 300Ω line terminating into a 72Ω load would give 1.6 dB less loss or 45% more power into the antenna than a

Band Meters		Design Freq. MHz	Driven Ele. Side ¼λ Meters	Reflector Side ¼λ Meters	Spacing Between Ele. ⅛λ Meters	Distance—Center of Hub To Drilled Hole: Driven Ele. (Actual) Meters	Distance—Center of Hub To Drilled Hole: Ref. (Actual) Meters
(A) 20	Center of Each Band	14.175	5.2896	5.4483	2.6844	3.9672	4.0862
18		18.118	4.1384	4.2626	2.1002	3.1038	3.1969
15		21.225	3.5326	3.6386	1.7928	2.6494	2.7289
12		24.94	3.0064	3.0966	1.5257	2.2548	2.3224
10		28.85	2.5989	2.6769	1.3189	1.9492	2.0076
6		52.0	1.4419	1.4712	0.7317	1.0814	1.1138
2		146.0	0.5135	0.5289	0.2606	0.3851	0.3966
(B) 20	Middle of Bottom Half	14.0875	5.3225	5.4821	2.7011	3.9924	4.1122
18		18.0930	4.1464	4.2708	2.1043	3.1102	3.2035
15		21.1125	3.5514	3.6580	1.8023	2.6639	2.7439
12		24.9150	3.0094	3.0997	1.5272	2.2573	2.3251
10		28.4250	2.6378	2.7169	1.3386	1.9786	2.0380
6		51.0000	1.4702	1.5143	0.7461	1.1027	1.1358
2		145.0000	0.5171	0.5326	0.2624	0.3879	0.3995
(C) 20	Middle of Top Half	14.2625	5.2571	5.4148	2.6679	3.9434	4.0617
18		18.1430	4.1327	4.2567	2.0973	3.0999	3.1929
15		21.3375	3.5140	3.6194	1.7833	2.6358	2.7149
12		24.9650	3.0034	3.0935	1.5242	2.2527	2.3204
10		29.2750	2.5612	2.6381	1.2998	1.9212	1.9788
6		53.0000	1.4147	1.4571	0.7179	1.0611	1.0930
2		147.0000	0.5100	0.5253	0.2588	0.3826	0.3940

Band Meters	A Driven Ele. Side ¼λ	A′ Reflector Side ¼λ	S Spacing Between Ele. ⅛λ	Z Driven Element Actual	Z′ Reflector Actual	Distance from Butt of Poles to Drill Holes: D.E. Meters	Ref. Meters	D.E. Ft & In.	Ref. Ft. & In.
(A) 20	17′4¼″	17′10½″	8′9 11/16″	13′0 3/16″	13′4⅞″	3.8258	3.9448	12′6⅝″	12′11 5/16″
18	13′6 15/16″	13′11 13/16″	6′10 11/16″	10′2 3/16″	10′5⅞″	2.9624	3.0555	9′8⅝″	10′0 5/16″
15	11′7 7/16″	11′11¼″	5′10 9/16″	8′8 5/16″	8′11 7/16″	2.5080	2.5875	8′2¾″	8′6 5/16″
12	9′10⅜″	10′1 15/16″	5′0 1/16″	7′4¾″	7′7 7/16″	2.1134	2.1810	6′11 3/16″	7′2 5/16″
10	8′6 5/16″	8′9⅜″	4′3 15/16″	6′4¾″	6′7⅜″	1.8078	1.8662	5′11 3/16″	6′1 13/16″
6	4′8¾″	4′9 15/16″	2′4 13/16″	3′3 11/16″	3′7⅞″	0.9400	0.9724	2′11⅞″	3′1⅛″
2	1′8 3/16″	1′8 13/16″	10¼″	1′3 3/16″	1′3⅜″	0.2437	0.2552	9⅝″	10 1/16″
(B) 20	17′5 9/16″	18′0 1/16″	8′10 5/16″	13′1 3/16″	13′5⅞″	3.8510	3.9708	12′8⅝″	13′0 5/16″
18	13′7¼″	14′0⅛″	6′10⅞″	10′2 7/16″	10′6⅛″	2.9690	3.0621	9′8⅞″	10′0 9/16″
15	11′7 13/16″	12′0⅛″	5′10 15/16″	8′8⅞″	9′0″	2.5225	2.6025	8′3 5/16″	8′6 7/16″
12	9′10½″	10′2 1/16″	5′0⅛″	7′4⅞″	7′7 9/16″	2.1159	2.1837	6′11 5/16″	7′2″
10	8′7⅞″	8′10 15/16″	4′4 11/16″	6′5⅞″	6′8¼″	1.8372	1.8966	6′0 5/16″	6′2 11/16″
6	4′9⅞″	4′11⅝″	2′5⅜″	3′7 7/16″	3′8 11/16″	0.9613	0.9944	3′1⅞″	3′3⅛″
2	1′8⅜″	1′8 15/16″	10 5/16″	1′3¼″	1′3¾″	0.2465	0.2581	9 11/16″	10 3/16″
(C) 20	17′3″	17′9 3/16″	8′9 1/16″	12′11¼″	13′3 15/16″	3.8020	3.9203	12′5 11/16″	12′10⅜″
18	13′6 11/16″	13′11 9/16″	6′10 9/16″	10′2 1/16″	10′5 11/16″	2.9585	3.0515	9′8½″	10′0⅛″
15	11′6⅜″	11′10½″	5′10 3/16″	8′7¾″	8′10⅞″	2.4944	2.5735	8′2 3/16″	8′5 5/16″
12	9′10¼″	10′1 13/16″	5′0″	7′4 11/16″	7′7⅜″	2.1113	2.1790	6′11⅛″	7′1 13/16″
10	8′4 13/16″	8′7⅞″	4′3 3/16″	6′3⅝″	6′5⅞″	1.7798	1.8374	5′10 1/16″	6′0 5/16″
6	4′7 11/16″	4′9⅜″	2′4¼″	3′5¾″	3′7″	0.9197	0.9516	3′0 3/16″	3′1 7/16″
2	1′8 1/16″	1′8 11/16″	10 3/16″	1′3 1/16″	1′3½″	0.2412	0.2526	9½″	9 15/16″

Table I– Charts (A), (B), and (C) and dimensions for boomless quad. The charts represent various operating areas within each band.

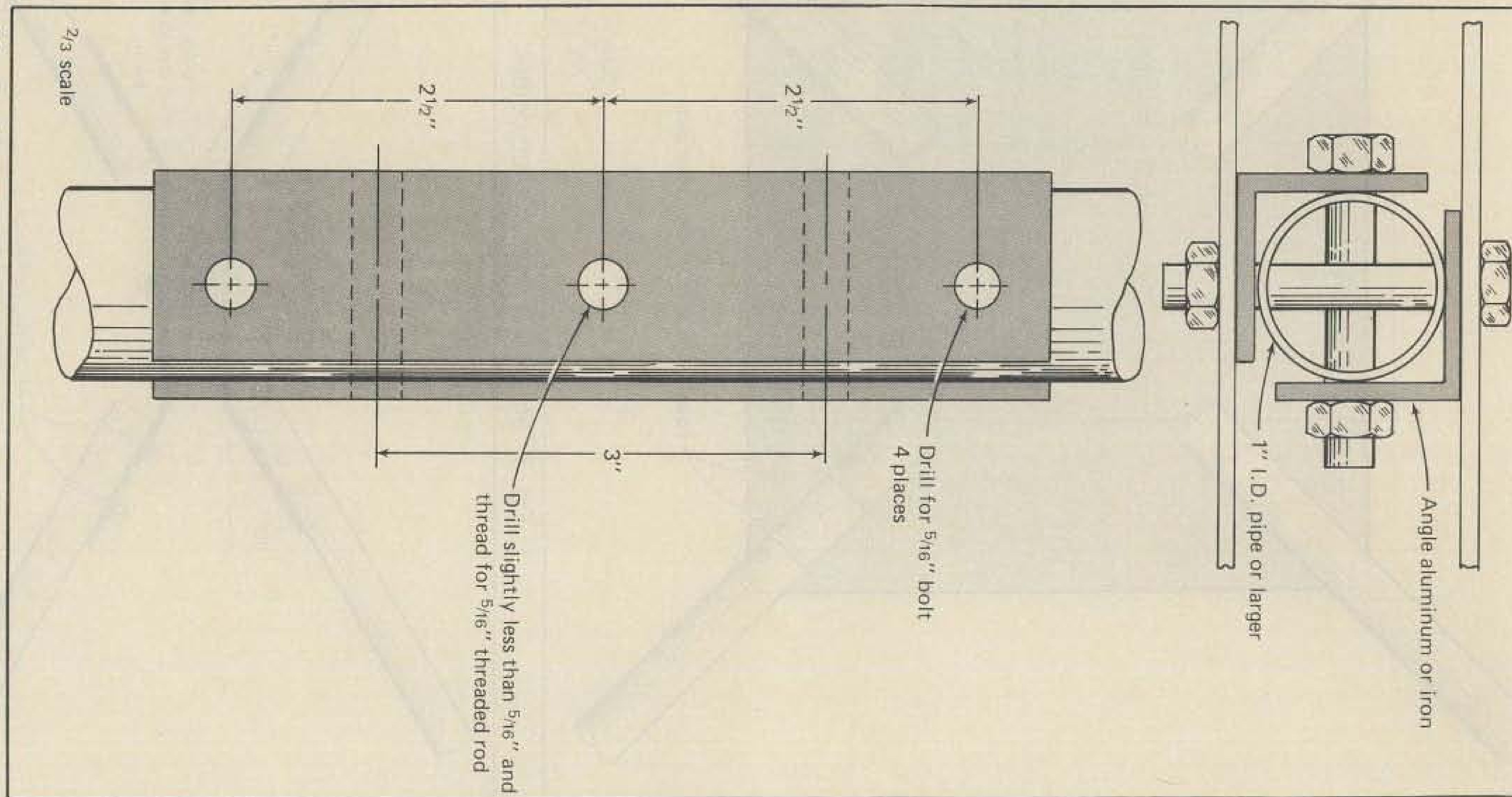


Fig. 5– Close-up mechanical of the hub-support center piece.

The reflector being assembled on the ground.

72Ω feed line terminating into a 72Ω load.)

Three kinds of poles can be used:

1. Fiberglass (best, but expensive);

2. Bamboo (cheap, but not durable like fiberglass or P.V.C.);

3. P.V.C. (use 200 PSI, not 160 PSI; 160 PSI is too light.)

The least expensive poles would be 1¼ inch nominal inside diameter P.V.C. plastic hot water pipe. It comes in 20 foot lengths which would be cut down to 13½ foot lengths. Eight poles would be needed and there would be 6½ feet wasted from each piece. Another way to do it would be to buy three 1¼ inch pipes and three 1 inch pipes. Then, using eight couplings and eight 1¼ inch to 1 inch pipe reducers, each pole could be built up as a "tapered" pole using:

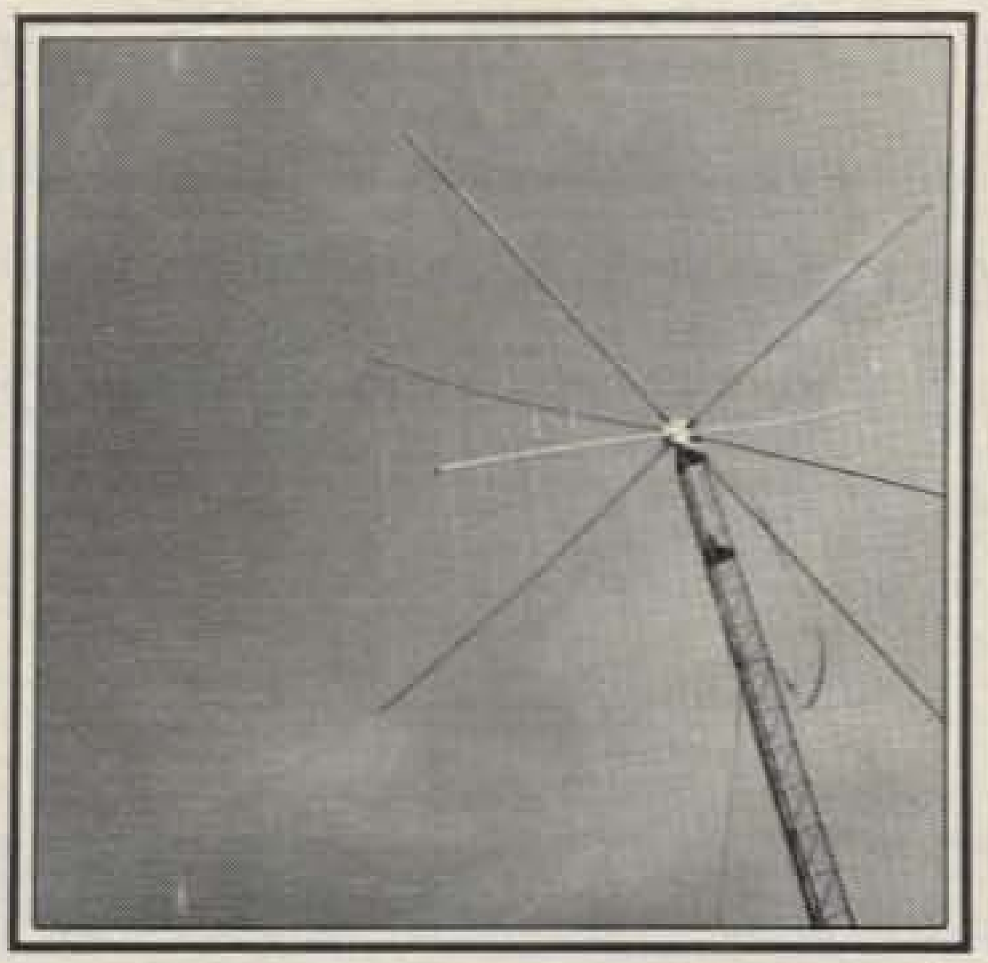
1 pipe 1¼" I.D. × 6′8"
1 coupling 1¼ inch to 1¼ inch
1 reducer for reducing from 1¼ inch pipe to 1 inch pipe
1 pipe 1" I.D. × 6′8"

Both methods have been tried, both work, and there is about the same expense for each method. The latter method uses six 10 foot pieces of pipe instead of eight, but you have the added expense of the couplings, reducers, and P.V.C. cement.

The holes for the wires (#18 or #16) are drilled directly through the pipes. The measurement of the distance (from the chart) is not from the base of each pipe, but from the center of the hub, which is 152mm or 6 inches from the base of each pole in the case of the MFJ hub. I find it easier to work with metric measurements; however, charts are given in feet and inches also.

Three charts are given under one heading, Table I. The first chart (A) gives the dimensions for the middle of each band. On any band except 10, 6, and 2 meters, a quad is "broad banded" enough so that the dimensions in Chart (A) are adequate for use anywhere in the band. The dimensions in Chart (B) are for the middle of the bottom half of each band and, if you are strictly a c.w. operator, you may use these dimensions. Chart (C) has dimensions for the middle of the top half of each band, and an amateur who works only in the upper half of each band may choose to use these dimensions. When you look at 10, 6, and 2 meters, it is definitely desirable to pick the dimensions for the part of each band in which you plan to operate most. The formulas for each column in the charts are given so that anyone desiring to make a quad for any frequency can calculate his own dimensions.

In any case, substract the 141mm or 5$\frac{9}{16}$ inches from the chart figures and measure from the bases of the poles. String the 20 meter wires and the 10 meter wires, carefully measuring the length of each of the four sides to make sure it is exactly right. Now, wrap and solder a "tie down" wire to each wire on each side of each pole at each of the four corners (both on the 20 meter and the 10 meter elements—reflector and driven elements, of course). Now string the wires for any other bands you wish. You won't have to measure the wire lengths carefully because the 20 and 10 meter windings have locked the poles into position. However, for rigidity and to keep wires from shifting, by all means wrap and solder corner wires on all elements just as you did on 20 and 10 meters.



The seven band boomless quad is up in the air. Sunlight reflects from the vertical wires of the quad. The driven element is in front. The section of open wire feed line can be seen draped in front.

Now solder the feed line to each driven element after putting an insulator in the center of the bottom of each driven element as illustrated. You can bring the feed line over from the back of the hub and feed the 2 meter element first and the 20 meter element last, or you can feed the 20 meter driven element first and terminate the feed line at the 2 meter element. It will work either way.

If you do not have a fold-over tower, you can still do the final assembly of the quad by climbing your tower. First mount your rotator on the tower. Then mount the quad hub on top of the rotator using a short piece of pipe or tubing about 18 inches long. Now the driven element plate with the four poles and driven elements can be lifted up to the center piece of the hub and mounted onto the center threaded rod and a nut put on loosely at this time. Carry the reflector elements up and mount on the other side of the threaded rod, securing it loosely with a nut also. At this time take up a measured corner spacing string of nylon line (about 150 to 210 lb test line) for one of the 20 meter corners and for one of the 10 meter corners. Rotate the driven element and the reflector element around until you can reach what is going to be the top left corner of the quad. Tie the 20 meter and the 10 meter strings. (The dimensions are given in the chart, but allow a few inches excess at each end for the knot.) Now rotate the two elements back 180 degrees the other way and tie the top right corner tie strings. At this time tie the spacing strings on the left and right bottom corners.

After finishing with the spacing strings (only the 20 meter and 10 meter strings are necessary), put the two lock bolts and nuts in the hub and tighten the nuts. Also tighten both nuts on the threaded rod.

To increase the rigidity and strength of this quad, particularly in windy areas, I recommend that four brace rods be substituted for the 10 meter tie strings. These rods are attached to clamps placed just below the 10 meter wires at 5 feet 8⅛ inches from the butt end of each pole. The clamps are made from pieces of pipe strapping about 7 inches long. Each of the eight straps is wrapped around its pole and bolted tight with a ¼" × 2" galvanized bolt. Each of the four rods is made of ½ inch 315PSI P.V.C. pipe 4 feet long with a ¼ inch hole drilled ⅝ inch from each end. When assembling the quad, and when you are ready for the tie strings, slip one of the rods in place first using a ¼ inch hex nut finger tight followed with a ¼ inch wing nut jammed down against it to keep it from working loose. All of this substitutes for a 10 meter tie string. Now proceed to put on a 20 meter tie string. This completes one of the four corners of the quad. Repeat this procedure at the other three corners as outlined above and in the article.

The quad is ready to use. It *is* beautiful and *performs* beautifully. Good DXing!

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