Dual Rhombic For VHF-UHF

-- work some DX!

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What single antenna can provide 26 dB of gain over a half wave dipole and also

(a) exhibit relatively low wind resistance;
(b) operate over a bandwidth approaching twice the design frequency;
(c) permit shared mast mounting with other antennas for ease of rotation;
(d) is easy and not overly time-consuming to construct; and
(e) is light of weight and inexpensive (under $20) too?

A parabolic dish cannot. The optimum spaced long yagi cannot. A collinear array cannot. Nor can the log periodic, corner reflector, helix, or any other antenna. The dual rhomboid *can!*

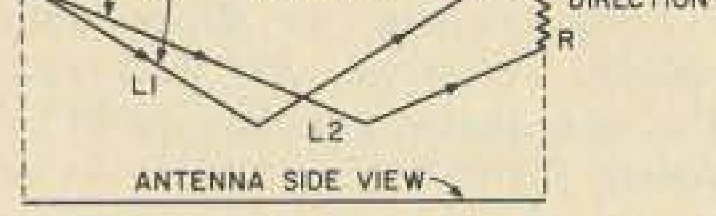


Fig. 1. Dual rhomboid antenna configuration.

The need for high antenna gain still exists. High gain antennas (in excess of 20 dB) are very directional antennas providing beamwidths between 5 and 10 degrees. Antenna gains greater than 30 dB produce half power beamwidths of less than 5 degrees and require very accurate pointing systems. Antennas with gain exceeding 20 dB are used on VHF, UHF, and higher. For best results at these frequencies, the antenna must be placed high and above the surrounding obstructions. Wind loading produced by such mast-mounted rotatable antennas at the top of the tower cannot be ignored if the antenna system is to survive.

Can you imagine a 21 foot diameter parabolic dish antenna[1] (required to produce 26 dB of gain) mast-mounted and rotatable on a 50 foot tower in a 50 mph wind? Even with the reflector constructed of 1 inch wire mesh? Over 750,000 foot-pounds of torque will be generated at the base of the tower. And that is without any additional antennas or any additional mast height. The dish antenna (excluding satellite work) to be effective requires a structure and platform to support it. Construction of the dish antenna is not the easiest of tasks.

The long yagi certainly has less wind resistance. An optimum spaced long yagi[2] requires a 100 foot boom to yield 26 dB of gain. It is easier to construct and could be made light in weight. But the 1 to 1.5 percent bandwidth of the operating frequency limits the usefulness, especially on the 420-450 MHz band. Stacking two 50 foot boom long yagis could be done with some ease. The stacking distance will require a mast extending out of the top of the tower in excess of 25 feet if the equivalent 26 dB of gain is to be realized. The torque loads created in starting and stopping a 100 foot boom represent an additional problem for the rotator mechanism. The swaying of a high gain long yagi antenna during gusty wind produces signal variations during both transmit and receive (similar to QSB created by atmospheric changes along the signal path).

Consider a 26 dB gain collinear array antenna. The array would have a lot less wind resistance than the dish antenna. It would also exhibit more bandwidth than the yagi. It would require, however, an array of 12 elements broadside (high) by 8 elements collinear (wide). It would take a total of 96 driven elements plus 96 reflector elements[3] to provide a gain of approximately 23 dB. To obtain the additional 3 dB for a 26 dB gain collinear array, the total array needed would contain 384 elements and a frame to support them. Even at 435 MHz, more than 384 feet of element material would be required. If the 192 reflectors were replaced with a screen mesh, more than 300 square feet would be required. Although a substantial improvement in bandwidth would be realized, a considerable increase in wind loading occurs.

The dual rhomboid antenna provides a gain of 26 dB (an effective radiated power increase of 400 times). It has relatively low wind resistance, wide operating bandwidth, consumes little mast height, is light of weight, easy and inexpensive to construct, and is rotatable.

The dual rhomboid is of the rhombic class, but with improvements. The double rhomboid antenna[4] configuration is shown in Fig. 1. Longwire antennas always radiate large numbers of side lobes that are distributed profusely. Judicious choice of the side length and apex angle selection of the rhomboids can cause destructive interference of the unwanted and wasteful side lobes. The dual rhomboid antenna designed for a high order of side lobe suppression at one frequency retains this characteristic very well over a substantial frequency range. This is not possible with a single rhombus.

The design principles involved are the same as for the "V" antenna and the rhombus antennas. The angles (referred to as tilt angles) were expressly selected for zero angle radiation from each rhomboid[5]. Since most antennas of the rhombus class operate against ground (heights of less than one to two wavelengths), zero angle radiation tilt angles are not normally selected. See Figs. 2 and 3.

The length of sides L_1 and L_2 specifically differ by a one-half wavelength factor. The array radiation pattern is the *product* of the patterns for the component sides at all points in space.

The only connection between the rhomboids is at the common feedpoints. The antenna consists of two rhomboid elements connected in parallel at their common apex where a balanced feedline connects[6]. One terminating resistor is required for each rhomboid. The terminating resistors should be of the noninductive variety and able to withstand the weather. Each terminating resistor should be capable at least of dissipating one-fourth of the input power to the antenna. Termination values of between 600 and 800 Ohms are recommended. For example, if 10 Watts is applied at the feedpoint, each resistor should be capable of 2.5 Watts dissipation.

The list of parameters for the dual rhomboid antenna shown in Table 1 is for a design frequency of 435 MHz.

The side lengths are calculated from the following formula:

$$L\ (\text{feet}) = \frac{984\ (N - 0.05)}{\text{Freq. (MHz)}}$$

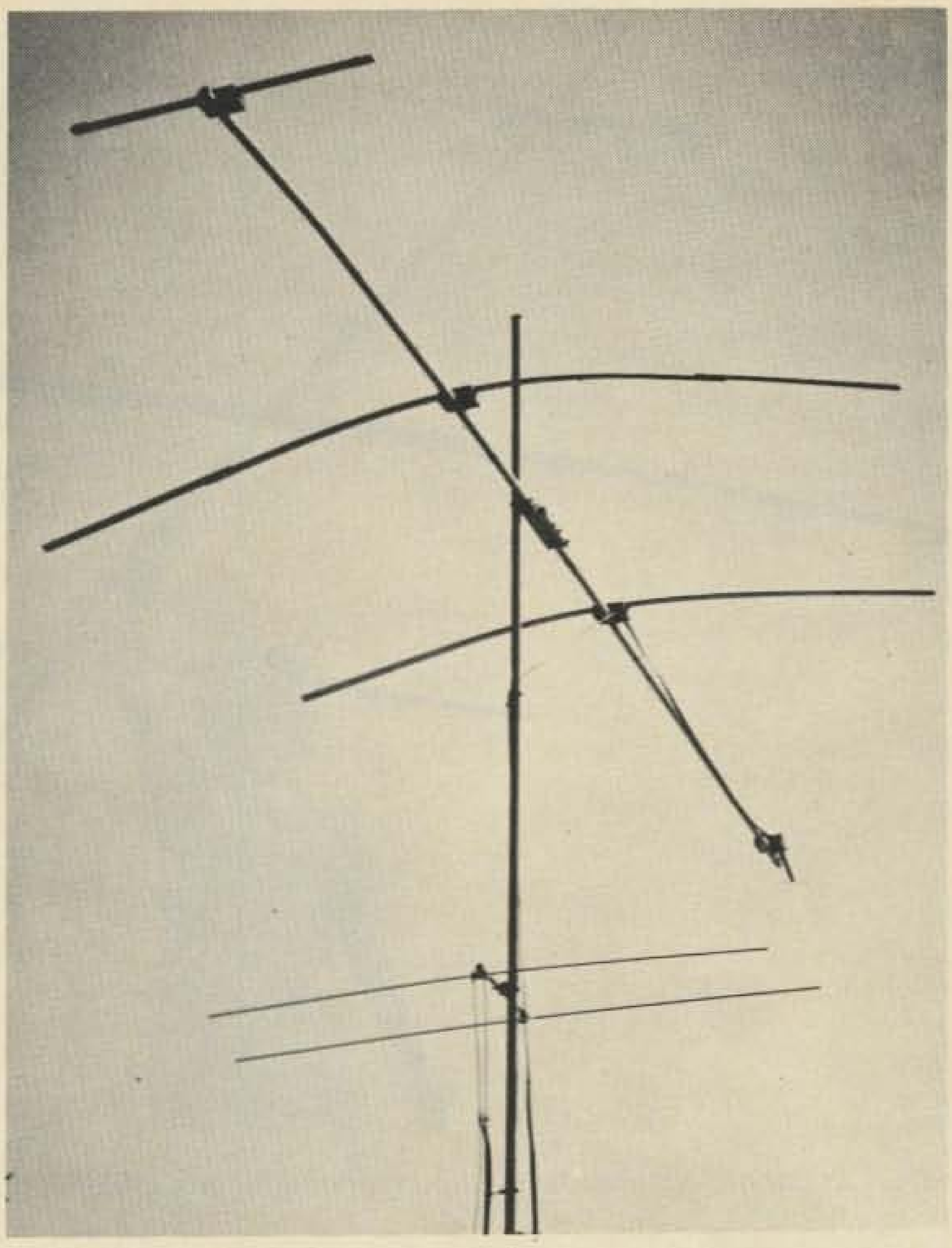
where N is the number of full waves. L_1 and L_2 for a design frequency of 435 MHz are 93.5 and 161.5 inches, respectively. The side lengths are needed to determine the boom length and the three crossarm lengths.

Apex angles α and β are derived by:

$$\alpha = 2(90 - \phi_2)$$
$$\beta = 2(90 - \phi_1)$$

and are 46 and 58 degrees, respectively. The tilt angles ϕ_1 and ϕ_2 were selected for side lengths of 3.5 and 6.0 wavelengths, as well as zero angles radiation.

The dimensions for boom, crossarms, and crossarm spacing are shown in Fig. 4.



Dual rhomboid antenna installation at WA8QQU, Reynoldsburg, Ohio.

The angle subtended between the diagonal of each rhomboid is equal to:

$$\frac{\beta - \alpha}{2} = \frac{58 - 46}{2} = 6\ \text{degrees}$$

An isosceles triangle is formed at the forward end of the beam by the rhomboids' crossover and the two terminators. Detailed specific dimensions for construction of the high gain dual rhomboid antenna whose bandwidth is essentially 420 to 890 MHz are shown in Fig. 4.

Construction

A metal boom that runs the full length of the dual rhomboid is not recommended. Excessive side lobes will be generated if this construction technique is em-

Design Center Frequency		435 MHz
Side length #	$L_1 = 3.5\lambda$	$L_2 = 6.0\lambda$
Tilt Angle	$\phi_1 = 61^\circ$	$\phi_2 = 67^\circ$
Apex Angle	$\alpha = 46^\circ$	$\beta = 58^\circ$
Beam Width *	$V = 5.8^\circ$	$H = 9.7^\circ$
Termination	R = 820 Ohms	R = 820 Ohms

*Half power level

#L_1 = 7.8 feet, L_2 = 13.46 feet

Table 1. List of parameters for dual rhomboid.

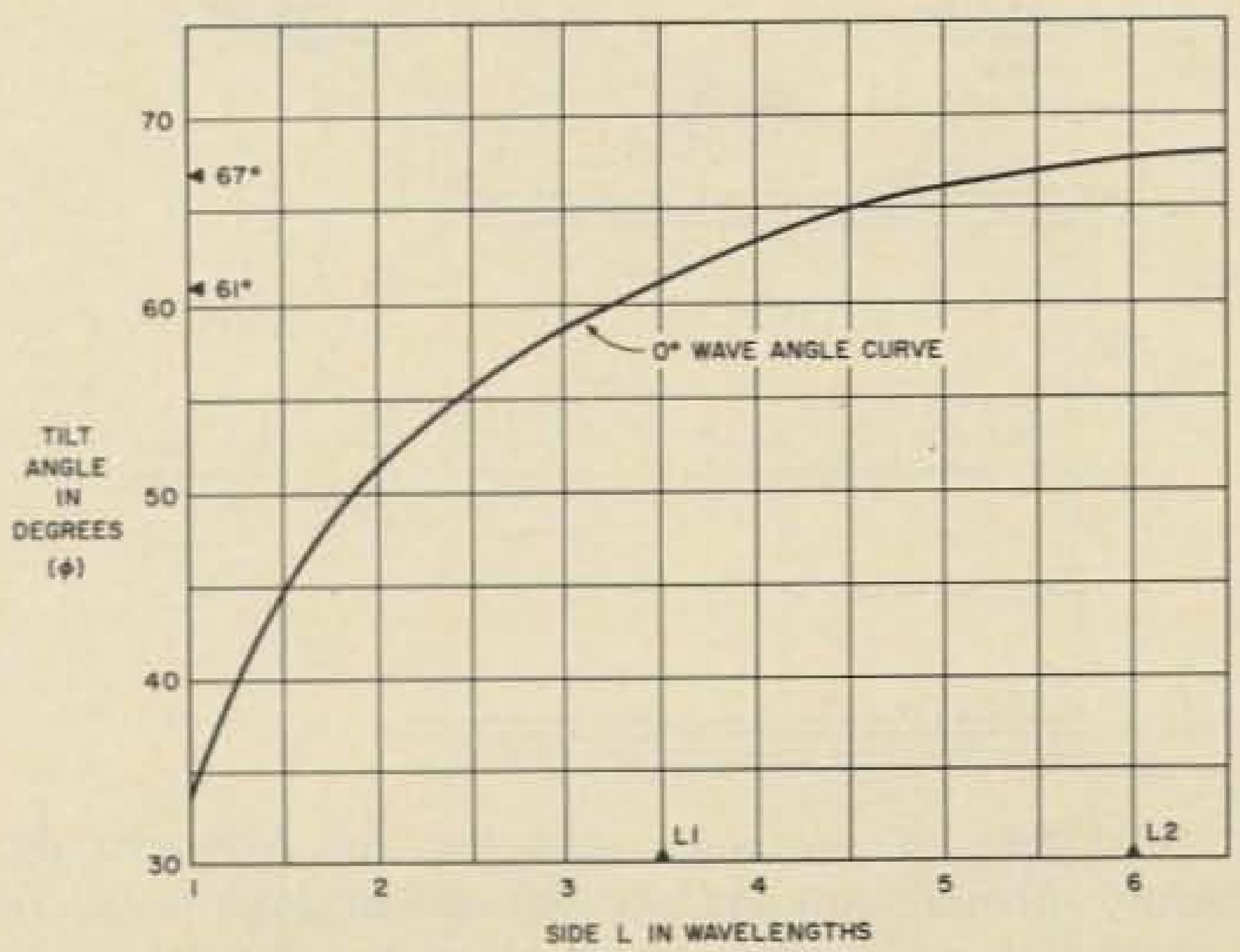


Fig. 2. Zero degree wave angle design chart.

Dual rhomboid antenna held with one hand by W8DMR's XYL. Total boom length is 20'6".

ployed. The center section of the boom should be made of metal or of material sufficiently rigid to support the nonmetallic crossarms. A total of about 86 feet of wire is required with each leg of the rhomboid being about 21½ feet long. The conductor size should be as large as the antenna frame can adequately support. Number 14 AWG solid copper, formvar coated was used in the author's dual rhomboid antenna. Even ¼ inch tubing is recommended. Although not recommended, a model used #24 AWG enameled single strand copper with some success.

The transmission line from the feedpoint to the mast should be foam 300 Ohm balanced nonshielded line. Open wire line or foam line works well. Once the feedline reaches the mast, a change to shielded 300 line or coaxial cable can be made. In the case of coaxial cable, a broad band balun should be used. If nonshielded 300 Ohm line is used, ABSOLUTELY DO NOT TAPE the feedline to any metal structure. This includes the metal section of the boom, the mast, the tower, other coaxial cables, downspouts, gutters, metal house siding, or metal sash windows. Never permit nonshielded 300 Ohm line to run along the ground or against masonry walls and floors, even if it is foam filled.

Operational Tests

The antenna has been used primarily to receive and transmit standard scan amateur TV signals. A secondary use has been to receive UHF commercial TV channels 14 through 83. The antenna has been used to receive channels 2 through 13, with less gain. The results have been excellent, with the exception that lobing was experienced on the higher UHF TV channels. The antenna has good front to back ratio. The antenna was rotated to vertical polarization to verify that the angle of radiation was truly zero. The antenna did not have a double (split) lobe in the vertical axis.

Additional Improvement

The dual rhomboid can be expanded such that it could be referred to as the quad rhomboid. This would be accomplished by adding two additional rhomboids, as in Fig. 5. There would be still a single feedpoint, but two additional terminators would

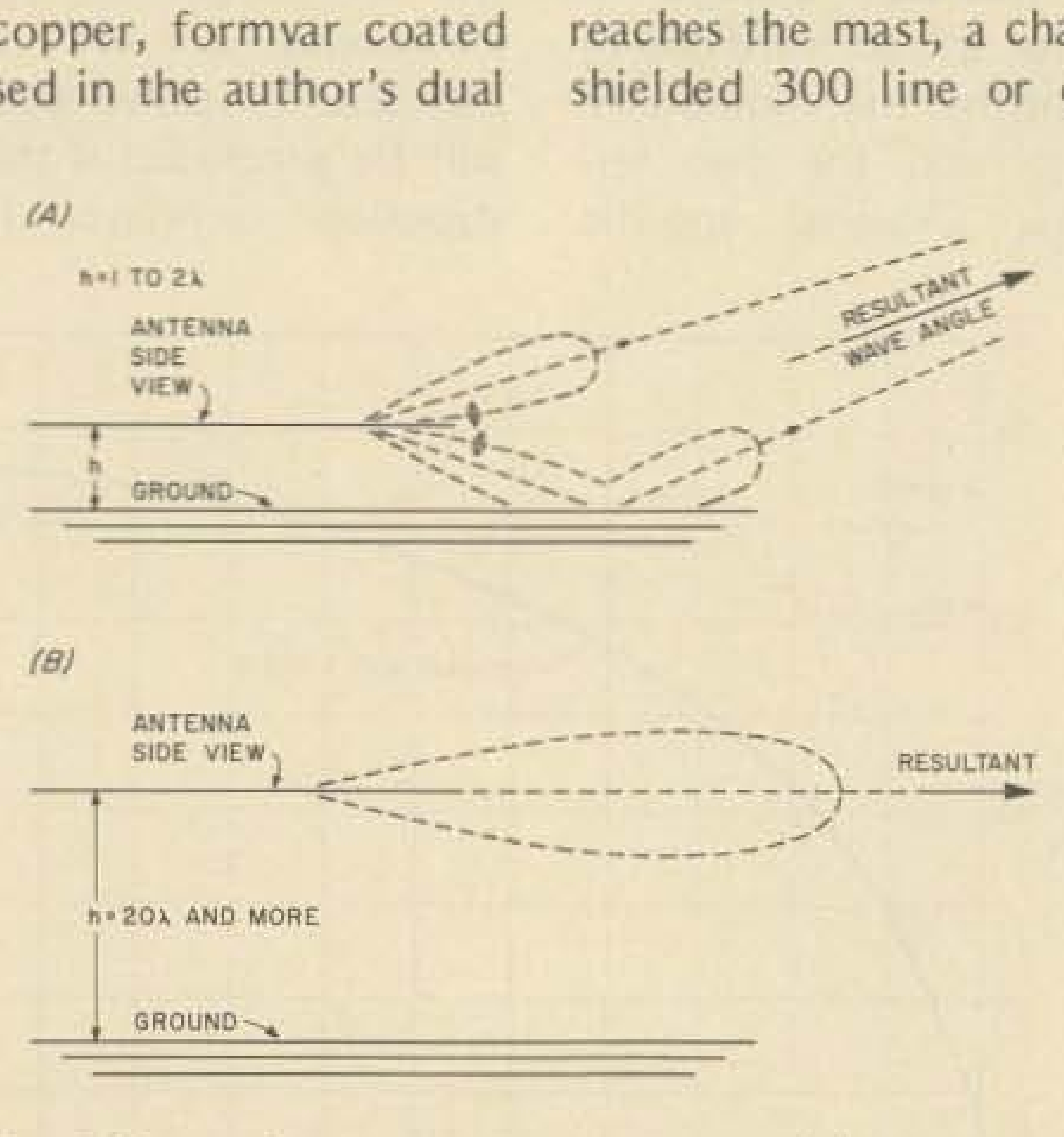


Fig. 3. Effect of tilt angle selection. (a) Non-zero angle radiation, rhombic antenna working against ground. (b) Zero angle radiation due to tilt angle selection. Note: *Tilt angle does not mean physically tilt the antenna. See Table 1.*

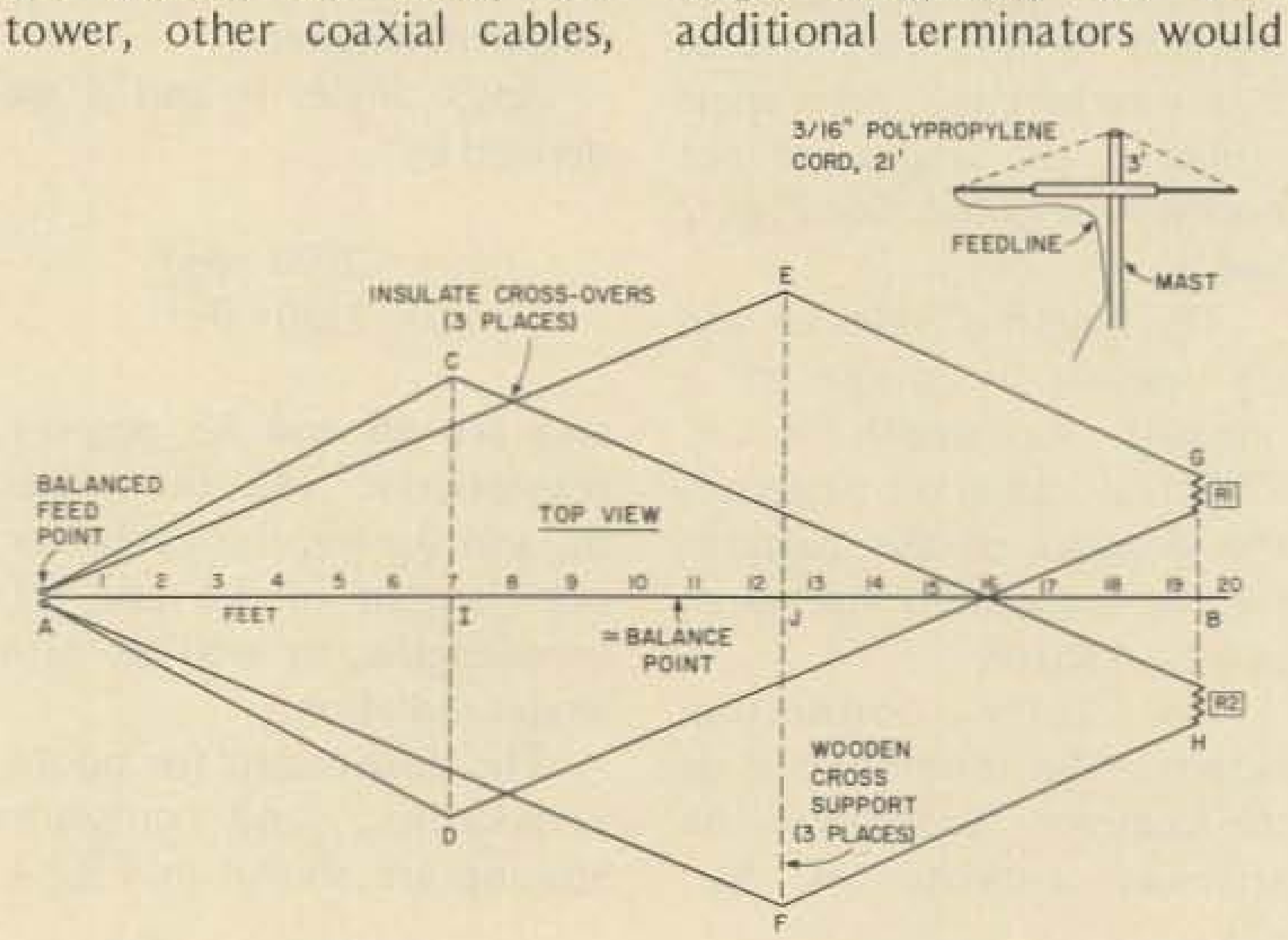


Fig. 4. Dual rhomboid antenna for 435-870 MHz. Beamwidth ≈ 10° H x 6° V. Gain over DP ≈ 26 dB. Boom length: AB = 19'6". Support spacing (see text): AI = 7'; IJ = 5'6"; JB = 7'. Support length: CD = 7'3"; EF = 10'3"; GH = 3'0". Rhomboid sides: AC, AD, EG, FH = 7'9.5"; AE, AF, CH, DG = 13'5.5". Feedline: see text. Wire needed: 14 AWG formvar, ≈ 86'0". Boom material: AI, JB = wood; IJ = metal. Cross support: CD, EF, GH = wood. Terminators: R1, R2 = 600 Ohms; Watts — see text.

be required. The feedpoint impedance would be lowered. The additional rhomboids should have different side lengths; as an example, L3 could be 2.5 wavelengths and L4 could be 7.0 wavelengths. The quad rhomboid would not require any additional mast space, as would be the case in stacking an additional dual rhomboid.

Acknowledgment

The contribution of Bob Dervin WA8QQU in field tests and experimental models is gratefully acknowledged. ■

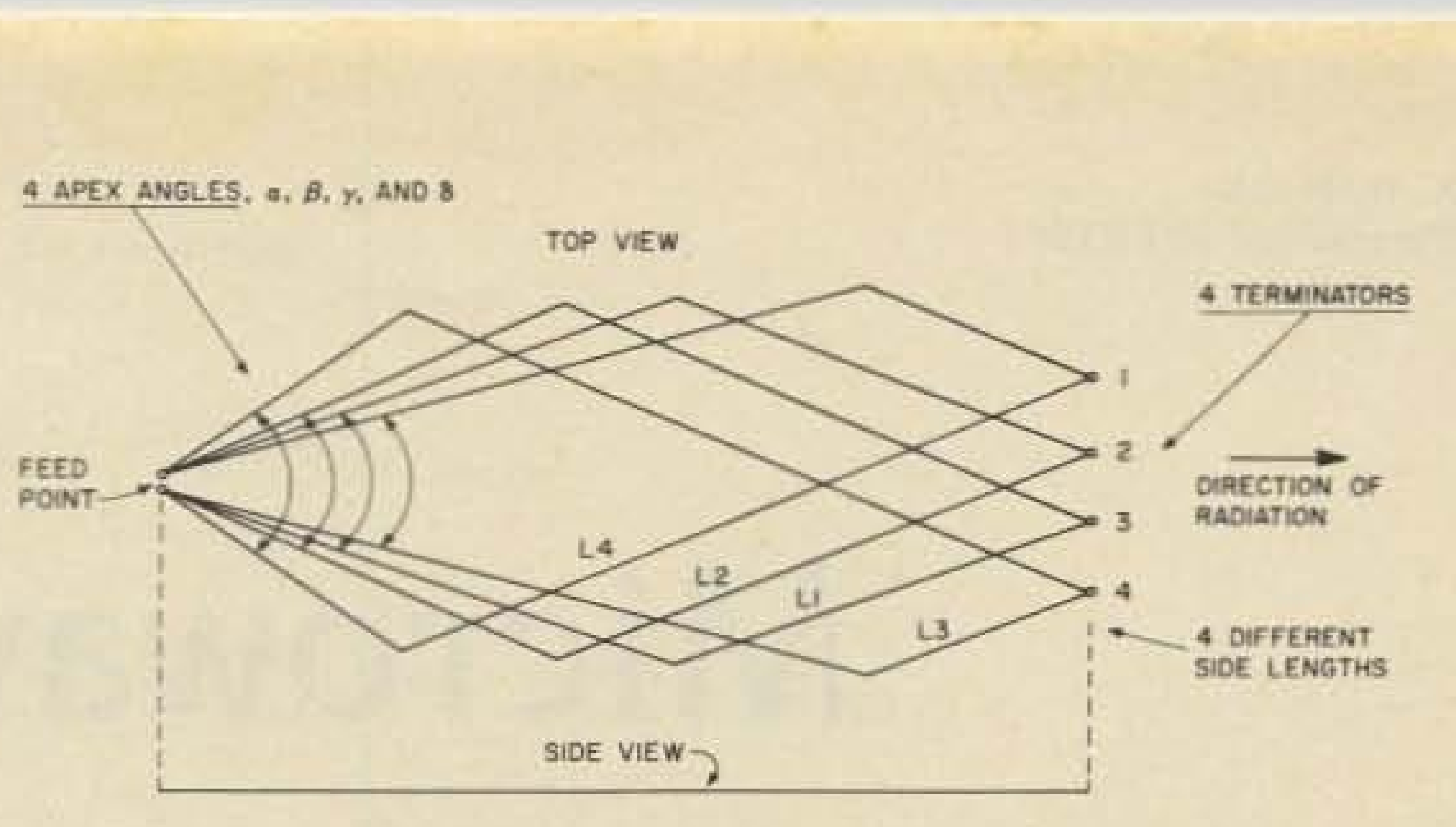


Fig. 5. Quad rhomboid antenna configuration.

References

[1] Parabolic Antenna Calculators, Gabriel Electronics Division, Needham Heights MA, 1959.

[2] "Yagi array length versus gain and bandwidth," *VHF Handbook*, 1956, page 104.

[3] "Collinear-broadside antenna combinations," *VHF Handbook*, 1956, page 105.

[4] "Improved Antennas of the Rhomboid Class," *RCA Review*, 1960, pages 117-119, Laport and Veldhuis.

[5] "Rhombic antenna design chart," *The ARRL Antenna Book*, 1956, page 168, 178.

[6] "VHF Rhombic Antennas," *Antenna Engineering Handbook*, N. Jasik, Editor, 1961, pages 4-30 to 4-33.

Corrections

Just a note to let you know that in the June *73* issue, on page 176 ("Current-Saver Counter Display," Fig. 4), there is an error in the circuit. The outputs of the two 7400 chips should be bussed before driving the 7447 decoder-driver. The existing schematic is incorrect in that the outputs of the "Latch No. 1" 7400 do not drive the decoder.

Doug Marquardt WB2AWG
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The article, "Aim Your Antenna With a Micro," in the June, 1977, issue of *73*, contains an unfortunate typographical error (of omission) and leaves implicit that which needs to be made explicit for some of us who not only cannot read "between the lines" but are having real difficulty with the lines themselves!

First, the omission. FORTRAN statement 290 correctly contains the minus sign (PL1 = -87.63*PIE/180) before the longitude. The corresponding BASIC statement number 170 omits this necessary minus sign.

Second, the implicit information which should have been quite explicit: The authors imply in the description of the FORTRAN program that the program contains the constants which represent the local latitude and longitude, as indeed it does. However, clarity of expression seems to dictate an *explicit* sentence or sentences such as the following:

> "It should be noted that FORTRAN statements 260 and 290 contain the latitude and longitude, respectively, of Chicago, as do the corresponding BASIC statements 140 and 170. For other 'local' locations, change 41.87 and -87.63 to the proper latitude and longitude."

A couple of sentences such as the above would have been most helpful, but then I would have been deprived of a little troubleshooting and the feeling of euphoria which I experienced when I finally found out where the "bugs" were. Other than the problems above, the article was excellent and now I can swing my hybrid-quad with arrogant precision. Those who are familiar with that miniaturized rf choke of an antenna may well ask, "Why bother?" Because it provides valuable practice and experience for the time when I will finally have an antenna with a decent front-to-back ratio and appreciable gain, that's why. So don't bother me while I aim my two element mini-antenna right down that Zed-El's throat. Who knows, maybe someday he'll come back to me and I can casually give him his correct beam bearing to several decimal places!

Ronald W. Evans K5MVR
Fort Worth TX

Please note a correction to my article, "Two Meter Scanner" (June, 1977):

The power input driving the LEDs through a 430 Ohm resistor is incorrectly marked "+5 V." This point should be marked "+12 V," as the display will not function correctly with a five volt supply.

Carl A. Kollar K3JML
Nanticoke PA

In my article, "Sending HI on the Hooter," in the May, 1977, issue of *73*, a few things were overlooked. The relays, RY1 and RY2, do have some limitations on their choice. RY1 is driven by a TTL output and should pull in at 5 volts and 16 mA maximum. RY2 should pull in at 5 volts and 80 mA maximum and also have a contact capable of switching ½ Amp of inductive load.

James F. Reid W8LWS
Ashley OH

I feel that your magazine is the tops. I really enjoyed the article "Superprobe," but found one error. The pulse LED would stay on all the time. Resistor R9 is drawn on the wrong place on the schematic; it should go from pin 4 of IC2 to ground, not from pin 3 of IC2 to ground. R1 can be increased to about 5-10k to increase input impedance.

Allan Armstrong
San Francisco CA

Oscar Orbits

Oscar 6 Orbital Information					Oscar 7 Orbital Information			
Orbit		Date (Aug)	Time (GMT)	Longitude of Eq. Crossing °W	Orbit	Date (Aug)	Time (GMT)	Longitude of Eq. Crossing °W
N	21919	1	0154:13	90.9	12394 A	1	0008:53	56.1
NA	21931 BTN	2	0054:09	75.9	12407 B	2	0103:10	69.7
NA	21944 BTN	3	0149:04	89.7	12419 AX	3	0002:31	54.5
N	21956	4	0049:00	74.7	12432 B	4	0056:48	68.1
NA	21969 BTN	5	0143:56	88.4	12445 A	5	0151:05	81.7
N	21981	6	0043:52	73.5	12457 B	6	0050:26	66.5
NA	21994 BTN	7	0138:48	87.2	12470 A	7	0144:43	80.1
N	22006	8	0038:44	72.2	12482 BQ	8	0044:04	65.0
NA	22019 BTN	9	0133:39	86.0	12495 A	9	0138:21	78.6
NA	22031 BTN	10	0033:35	71.0	12507 BX	10	0037:41	63.4
N	22044	11	0128:31	84.7	12520 A	11	0131:59	77.0
NA	22056 BTN	12	0028:27	69.7	12532 B	12	0031:19	61.8
N	22069	13	0123:23	83.5	12545 A	13	0125:36	75.4
NA	22081 BTN	14	0023:19	68.5	12577 B	14	0024:57	60.3
*	22094 L	15	0118:14	82.2	12570 BL	15	0119:14	73.8
*	22106 L	16	0018:10	67.2	12582 BL	16	0018:34	58.7
*	22119 L	17	0113:06	81.0	12595 BL	17	0112:52	72.3
N	22131	18	0013:02	66.0	12607 B	18	0012:12	57.1
NA	22144 BTN	19	0107:57	79.7	12620 A	19	0106:29	70.7
N	22156	20	0007:53	64.7	12632 B	20	0005:50	55.5
NA	22169 BTN	21	0102:49	78.5	12645 A	21	0100:07	69.1
N	22181	22	0002:45	63.5	12658 BQ	22	0154:24	82.7
NA	22194 BTN	23	0057:41	77.2	12670 A	23	0053:45	67.5
NA	22207 BTN	24	0152:36	91.0	12683 BX	24	0148:02	81.1
N	22219	25	0052:32	76.0	12695 A	25	0047:23	66.0
NA	22232 BTN	26	0147:28	89.7	12708 B	26	0141:40	79.6
N	22244	27	0047:24	74.7	12720 A	27	0041:00	64.4
NA	22257 BTN	28	0142:19	88.5	12733 B	28	0135:18	78.0
N	22269	29	0042:15	73.5	12745 A	29	0034:38	62.8
NA	22282 BTN	30	0137:11	87.3	12758 B	30	0128:55	76.4
NA	22294 BTN	31	0037:07	72.3	12770 AX	31	0028:16	61.3

The listed data tells you the time and place OSCAR crosses the equator in an ascending orbit for the first time each day. To calculate successive orbits, make a list of the first orbit number and the next twelve orbits for that day. List the time of the first orbit. Each successive orbit is 115 minutes later (two hours less five minutes). The chart gives the longitude of the first crossing. Add 29° for each succeeding orbit. When OSCAR is ascending on the other side of the world, it will descend over you. To find the equatorial descending longitude, subtract 166 degrees from the ascending longitude. To find the time it passes the north pole, add 29 minutes to the time it passes the equator. You should be able to hear OSCAR when it is within 45 degrees of you. The easiest way to do this is to take a globe and draw a circle with a radius of 2480 miles (4000 kilometers) from the home QTH. If it passes right overhead, you should be able to hear it for about 24 minutes total. OSCAR will pass an imaginary line drawn from San Francisco to Norfolk about 12 minutes after passing the equator. Add about a minute for each 200 miles that you live north of this line. If OSCAR passes 15 degrees from you, add another minute; at 30 degrees, three minutes; at 45 degrees, ten minutes.

OSCAR 6: Input 145.90-146.00 MHz; Output 29.45-29.55 MHz; Telemetry beacon at 29.45 MHz. OSCAR 7 Mode A: Input 145.85-145.95 MHz; Output 29.40-29.50 MHz. Mode B: Input 432.125-432.175 MHz; Output 145.925-145.975 MHz.

Orbits designated "X" are closed to general use. "ED" are for educational use. "BTN" orbits contain news bulletins. "Q" orbits have a ten Watt erp limit. "L" indicates link orbit. "N" or "S" indicates that Oscar 6 is available *only* on northbound or southbound passes. Satellites are not available to users on "NA" days. An asterisk (*) indicates AO-7B-6 intersatellite link.