TECHNICAL NOTE NO. 20

IMPEDANCE DATA ON OBLIQUE INCIDENCE ANTENNA LOCATED AT LUBBOCK, TEXAS

by

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ILLUSTRATIONS

A NOTE ON THE PERFORMANCE OF GRANGER ASSOCIATE'S 726 2.5/32-2A ANTENNA

1. Introduction

This technical note gives the results of a series of performance measurements made by the author on a Granger Associates type 726-2.5/32-2A antenna. This antenna was purchased by the Radiolocation Research Laboratory of the University of Illinois and installed on the campus of the Texas Technological College, Lubbock, Texas. The antenna is to be used in conjunction with ionospheric sounding equipment located at Texas Technological College, and operated under the supervision of the Radiolocation Research Laboratory of the University of Illinois.

Given in this technical note are (1) a brief description of the antenna, (2) the result of impedance measurements made on the full scale structure, and (3) the results of pattern measurements made on scale models of a single element of the array and of the array.

2. Description of the Antenna

This antenna is a frequency-independent array of two log-periodic, triangular tooth, unidirectional elements. The frequency range of the structure is approximately 2.5 to 32 Mc. The design parameters as measured by the author from the full scale model are $\alpha = 30^{\circ}$, $\tau = .683$, $\xi = 3.5^{\circ}$ (see Figure 1.) The nine triangular shaped teeth of each element are hung from a fiberglass catenary supported at the back of the element by a 140 foot steel tower and at the front of the element by a 24 foot wooden pole. Since the vertices of the two elements of the array meet at the front of the array, a single wooden pole serves as a common support for both catenaries. The angle between the two elements of the array is 40°. The two elements of the array are fed in parallel to give an H-plane (azimuthal) sum pattern. The teeth of each element are capacitively shunt fed from a form of open wire transmission line common to this type of Granger Associate's antenna.

A ground screen system consisting of #10 copper wire is arranged under each of the elements and extends to approximately 100 feet in front of the array. The junctions of the wire of this ground screen are silver soldered to give a good electrical and mechanical connection.

All the hardware of the structure appears to be weather resistant consisting of aluminum, stainless steel, and galvanized steel.

In general the structure appears to be well built with good engineering practices being used throughout.

3. Impedance Measurements of the Full Scale Antenna

Figure 2 shows the block diagram of the impedance measuring set-up used by the author. The impedance was measured through 346 feet of RG 17/u coaxial cable terminated in the transmitter building located back of the array. This is the actual cable to be used with the antenna under operating conditions.

Table 1 gives the data as recorded from the bridge readings, and that same data corrected for cable losses and cable length. Columns labelled R_o and X_o are respectively the real and imaginary components of the impedance seen looking into the cable from the transmitter building. Columns labelled R_R and X_R are respectively the real and imaginary components of the impedance at the feed point of the antenna, normalized to 50 ohms. Figures 3 and 4 are graphs used to correct the data for cable loss.

Figure 5 is the Smith Chart plot of the normalized feedpoint impedance plotted from columns labelled R_R and X_R of Table 1.

As can be seen from this Smith Chart plot the feedpoint VSWR of the array is 2:1 or less from slightly above 2.5 to 31 Mc. This is approximately the impedance performance claimed by Granger Associates.

Table 2 is the measured impedance data furnished by Granger Associates for this antenna, and Figure 6 is the Smith Chart plot of the Granger data.

Comparing the Granger data plot (Figure 6) with the plot of the data taken by the author, (Figure 5) one sees that the agreement between the two plots is in general reasonably good. The rotational discrepancy at the high frequency end of the band could possibly be explained by a difference in the definition of the actual feed point of the array. For the data taken by the author, the feed point of the array was defined at the dielectric surface of the LC connector on the impedance transformer located at the front of the antenna. The feed point as defined by the Granger representative who measured the antenna impedance is unknown.

4. Single Element Model Pattern Measurements

Using the measured design parameters of the full scale antenna as stated in the antenna description above, that is, $\alpha = 30$, $\tau = .683$ and $\xi = 3.5^{o}$, a scaled model was constructed of one of the elements of the array. The scale factor was such that the longest tooth of the model was approximately $\lambda/4$ in length at 475 Mc. (since the longest tooth of the full scale antenna is approximately $\lambda/4$ at 2.7 Mc the approximate scale factor is 175:1). The triangular teeth of the element were made of #20 tinned copper wire and soldered to a brass plate (see Figure 7). A brass rod of the proper length was located at the back of the element as shown to represent the tower of the full scale model. The feed line of the model was made from 75 ohm twin lead transmission lines. This transmission line was fed from a chassis type, BNC coaxial connector through the brass plate as shown. Elevation and azimuthal patterns of the model were measured on a ground screen pattern range.

The resulting H-plane (azimuthal) patterns of this single element are shown in Figures 8, 9, 10 and 11. The E-plane (elevation) patterns are shown in Figures 12 and 13. These patterns were taken over the 450-2070 Mc frequency range.

The average measured azimuthal half-power beamwidth was found to be approximately 118 degrees. The average measured elevation half-powered beam width over perfect ground was approximately 34 degrees.

5. Two Element Array, Model Pattern Measurements

A two element array was constructed using two elements as nearly as possible identical to the single element described in the preceeding section. These two elements were soldered to a brass plate with their vertices at a common point and with an angle of 40 degrees between the planes containing the teeth of the elements, see Figure 14.

Figures 15, 16, 17 and 18 show representative H-plane (aximuthal) patterns of the two element array from 450 to 2070 Mc, and Figure 19 shows the representative E-plane (elevation) patterns over the same frequency range. Again, these patterns were measured on a ground screen pattern range.

The average measured azimuthal half-power beamwidth of the array was approximately 77 degrees. The average measured elevation half-power beamwidth over perfect ground was approximately 32 degrees. The average front-to-back ratio as calculated from the H-plane patterns was approximately 15 db.

Freq (Mc)	λ (ft)	525/λ	R_o (From Bridge)	X_p (From Bridge)	$X_o = X_p/fMc$	Normalized $R_o/50$	Normalized $X_o/50$	in db Total Cable Loss	Loss Corrected R_c	Loss Corrected X_c	Rotated R_R	Rotated X_R
1.9	518	1.012	46	200 90	-58	.92	-1.16	.311	.87	-1.24	1.07	-1.38
2.0	492	1.07	20	200 165	-17.5	.40	- .35	.325	.36	- .37	.62	- .89
2.1	468.6	1.12	24.9	200 239	18.65	.50	.373	.337	.45	.39	.42	- .28
2.3	427.9	1.275	71.5	200 92	-47	1.43	- .94	.35	1.42	- .93	.55	.47
2.5	393.7	1.335	24.5	200 206	2.4	.49	.048	.37	.46	.05	1.21	.85
2.7	364.5	1.44	74.8	200 259	21.8	1.5	.436	.381	1.55	.53	1.78	- .21
2.9	339.4	1.548	52	200 173	- 9.32	1.04	- .186	.398	1.05	- .20	1.15	- .125
3.1	317.5	1.653	46	200 206	1.93	.92	.0386	.411	0.92	.038	0.98	- .09
3.3	298.3	1.76	68	200 185	- 4.54	1.36	- .091	.428	1.37	- .095	.725	.02
3.5	281.2	1.867	38	200 177	- 6.58	.76	- .132	.443	.72	- .140	.82	.26
3.7	266	1.975	59	200 293	25.1	1.18	.502	.457	1.20	.60	1.44	.53
3.9	252.4	2.08	57	200 80	-30.8	1.14	- .616	.468	1.12	- .71	1.95	- .10
4.1	240	2.188	32	200 208	1.95	.64	.039	.478	.60	.04	1.23	- .53
4.5	219	2.40	57	200 132	-15.1	1.14	- .302	.502	1.15	- .37	.76	- .202
4.9	201	2.61	55	200 221	4.29	1.10	.086	.530	1.12	.10	.93	.130
5.3	186	2.82	41.5	200 182	- 3.4	.83	- .068	.554	.79	- .095	1.04	.260
5.7	173	3.04	69	200 109	-16	1.38	- .32	.571	1.45	- .43	1.64	- .07
6.1	161	3.26	44	200 271	11.6	.88	.232	.592	.86	.26	1.10	- .33
6.5	152	3.45	52	200 130	-10.8	1.04	- .216	.615	1.04	- .25	.90	- .22
8.0	123	4.26	52	200 130	- 8.75	1.04	- .175	.692	1.04	- .22	.90	.19
10.0	98.5	5.34	58	200 200	0	1.16	0	.780	1.19	0	.91	- .16
12.0	82.1	6.39	47.5	200 120	- 6.67	.95	- .134	.865	.92	- .175	.82	.02
14.0	70.4	7.46	54	200 99	- 7.21	1.08	- .144	.934	1.10	- .195	1.00	- .20
16.0	61.5	8.54	59	200 70	- 8.13	1.18	- .163	1.01	1.22	- .23	1.34	- .08
18.0	54.7	9.60	48.5	200 110	- 5.0	.97	- .10	1.07	.95	- .15	1.13	- .09
20.0	49.2	10.7	48.5	300 90	-10.5	.97	- .21	1.13	.95	- .28	1.15	.28
22.0	44.8	11.7	54	200 21	- 8.14	1.08	- .163	1.20	1.10	- .25	1.01	.25
24.0	41.0	12.8	37.5	200 219	.792	.75	.0158	1.25	.67	.035	1.35	.31
26.0	37.9	13.9	59.0	100 450	13.5	1.18	.26	1.31	1.28	.40	1.40	- .30
28.0	35.2	14.9	63.0	500 253	- 8.82	1.26	- .176	1.37	1.36	- .275	.86	- .33
30.0	32.8	16.0	35.5	500 83	-13.9	.71	- .278	1.42	.60	- .35	.60	- .35
31.0	31.8	16.5	32.5	100 108	.258	.65	.0516	1.45	.52	.07	.52	.07

Physical Length of Cable = 346 ft. or 346/.659 = 525 ft. = Electrical Length of Cable where 65.9 is V.P.% for RG 17/U

$X_p = X_1 - X_2$ = Reading - initial setting

Loss of Cable = 3.46 x loss/100 ft. db. Data Taken: 11 Apr 1963

TABLE 1

IMPEDANCE DATA TAKEN ON GRANGER ASSOCIATES MODEL 726-2.5/32-A

LOG PERIODIC ANTENNA LOCATED ON CAMPUS OF TEXAS TECH, LUBBOCK, TEXAS

Freq. (Mc)	R	Xf	R_k	$R_k/50$	X/50	Rotated $R_k/50$	Rotated X/50
2	25	-75	25	.5	-.75	.57	-.85
2.5	94	70	94	1.88	.56	1.63	.65
3	43	-31	43	.86	-.21	.89	-.24
4	54	-141	54	1 08	-.71	1.30	-.71
5	49	52	49	.98	.21	.94	.20
6	53	-142	53.1	1.06	-.47	1.23	-.45
7	44	-15	44.2	.88	-.04	.91	-.10
8	61	45	61.3	1.23	.11	1.15	.21
9	45	-110	45.5	.91	-.24	1.05	-.27
10	49	-50	49.5	.99	-.10	.99	-.01
11	43	-1	43.1	.86	0	.88	-.075
12	58	39	58.8	1.18	.07	1.08	.185
13	49	-120	50.0	1.0	-.18	1.14	-.125
14	48	-25	50.0	1.0	-.04	1.03	-.04
15	50	-148	51.3	1.03	-.20	1.19	-.09
16	40	-105	41 2	.82	-.13	.99	-.24
17	43	40	44.5	.89	.05	.90	-.07
18	49	- 25	50.9	1.02	-.026	1.28	-.08
19	43	- 30	44.9	.90	-.03	.99	-.10
20	47	90	49.4	.99	.09	.92	.03
21	56	- 50	59.1	1.18	-.05	1.08	.185
22	48	-280	50 9	1.02	-.25	1 30	.01
23	37	-188	39.9	.79	-.16	1 15	-.27
24	34	20	36.4	.73	02	.915	-.29
25	37	153	39.8	80	.12	.85	-.175
26	43	290	46.4	.93	.21	.80	-.045
27	45	290	48 8	.98	20	.82	-.02
28	48	310	52.2	1 05	22	.80	.04
29	54	480	59.4	1 19	.30	.74	.11
30	74	100	82 0	1.64	.67	.55	.26

REMARK

This is a copy of the impedance data taken on Granger Associates Model 726-2.5/32-2A Log Periodic Antenna by a representative of Granger Associates dated 31 Jan 1963. See Smith Chart Plot of Rotated Impedance (Figure 6).

Apparently this impedance was measured through a short length of cable (estimated length given below). This cable length was estimated from data and Smith Cha Plot supplied by Granger Associat

Pts. rotated through ≈ 4.981 ft (Electrical Length)

TABLE 2

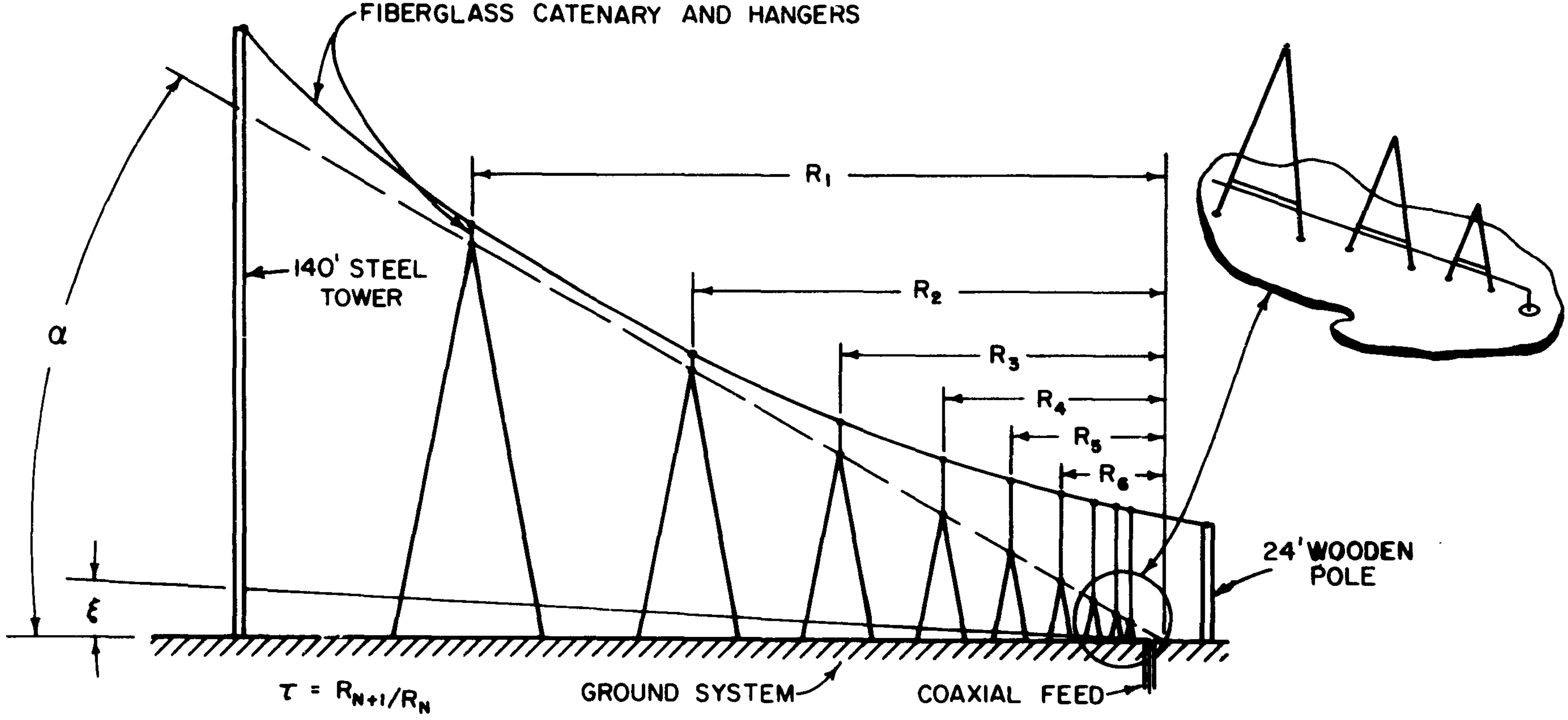

Figure 1. Sketch of an element of Granger Associates 726-2.5/32-2A log periodic two element array showing the design parameters

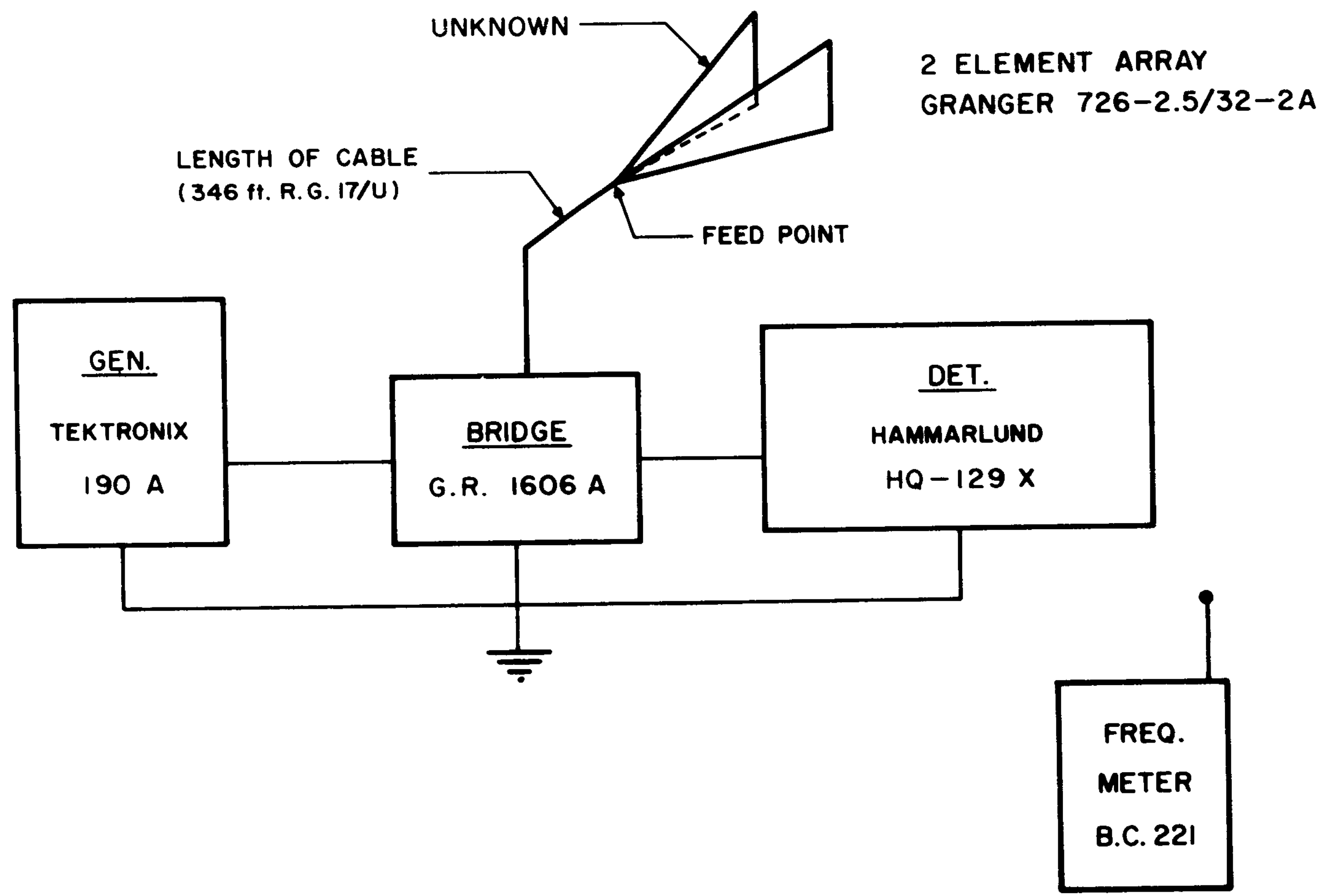

Figure 2. Block diagram of the impedance measuring setup

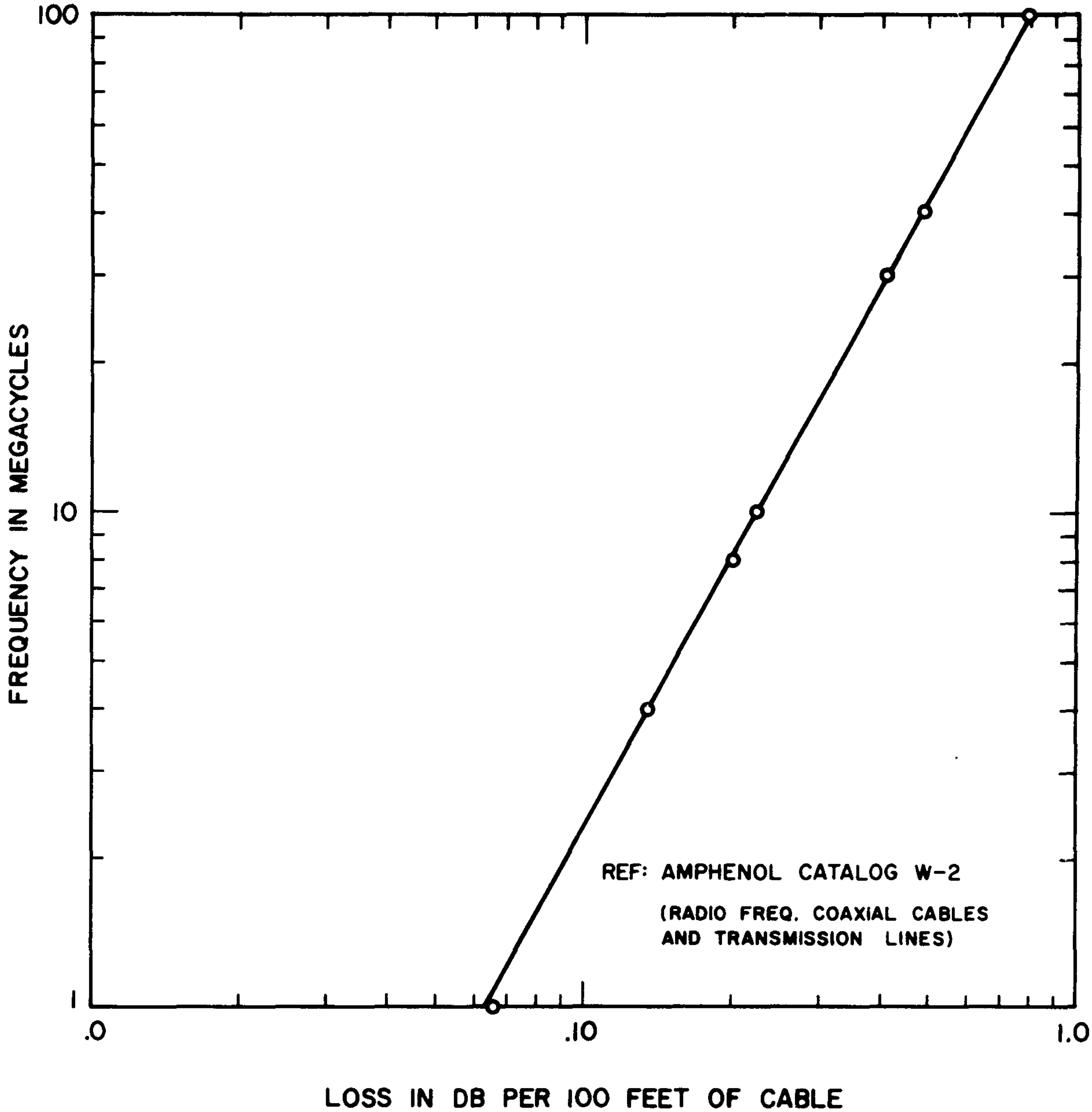

Figure 3. Loss in DB per 100 feet of RG 17/U cable as a function of frequency in megacycles

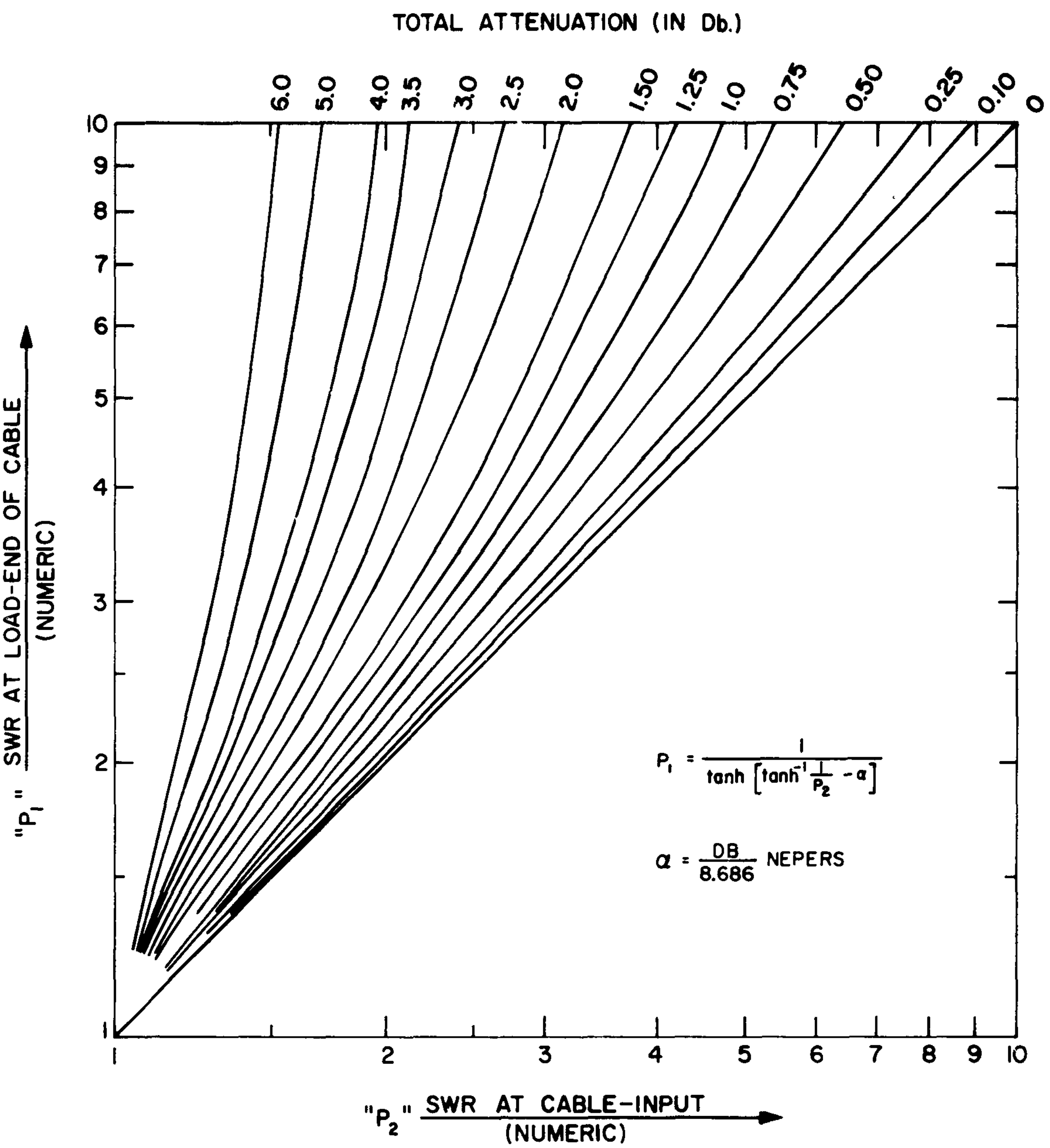

Figure 4. A graph used to correct measured VSWR for cable losses

NAME F.R. ORE	TITLE G.A. 726-2.5/32-A	DWG. NO.
SMITH CHART FORM 5301-7560-N	GENERAL RADIO COMPANY, WEST CONCORD, MASSACHUSETTS	DATE 4-11-63.

IMPEDANCE OR ADMITTANCE COORDINATES

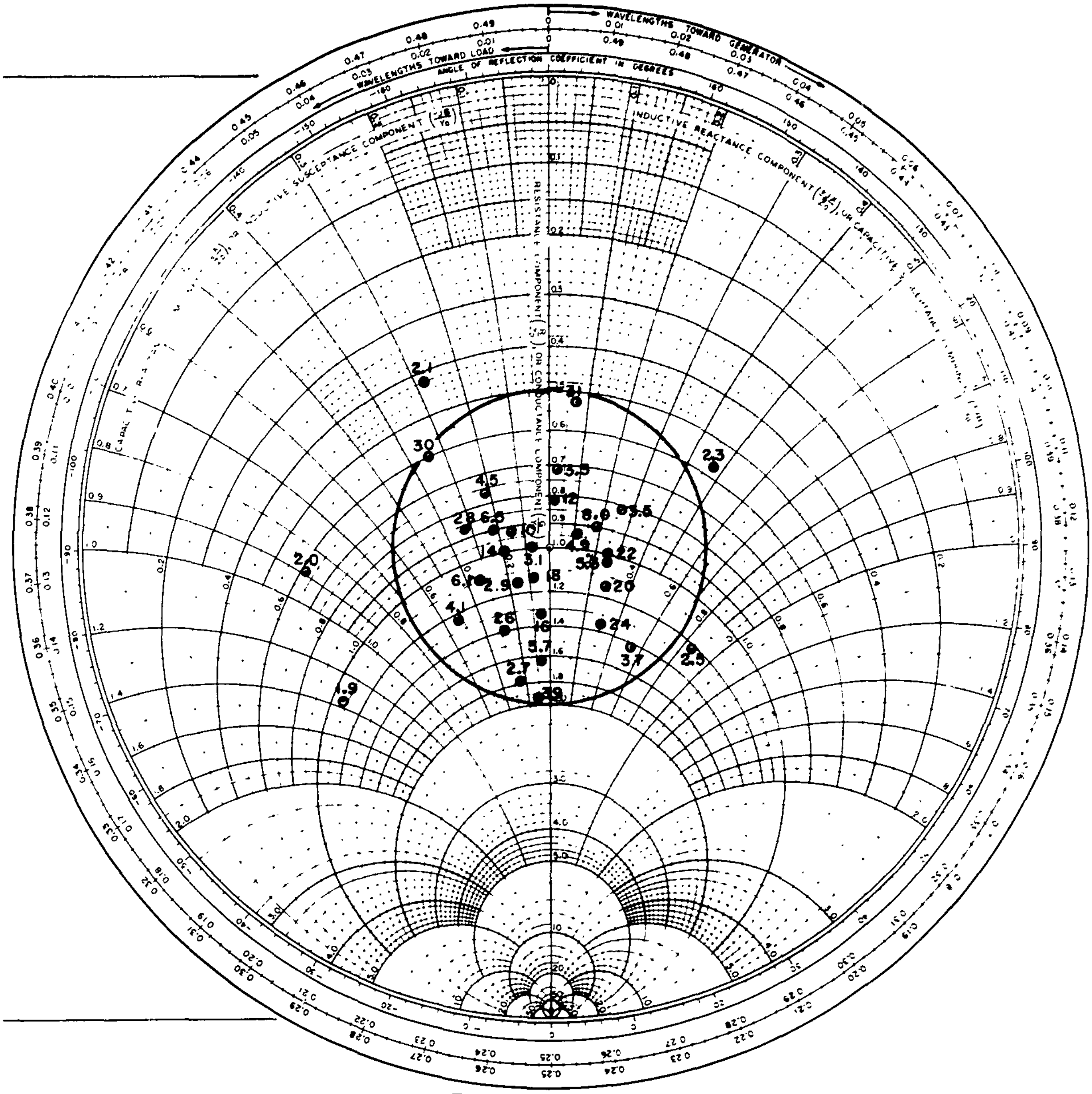

Figure 5

NAME HOCHMAN	TITLE G.A. 726-2.5/32-A	DWG. NO.
SMITH CHART FORM 5301-7560-N	GENERAL RADIO COMPANY, WEST CONCORD, MASSACHUSETTS	DATE 1-31-63.

IMPEDANCE OR ADMITTANCE COORDINATES

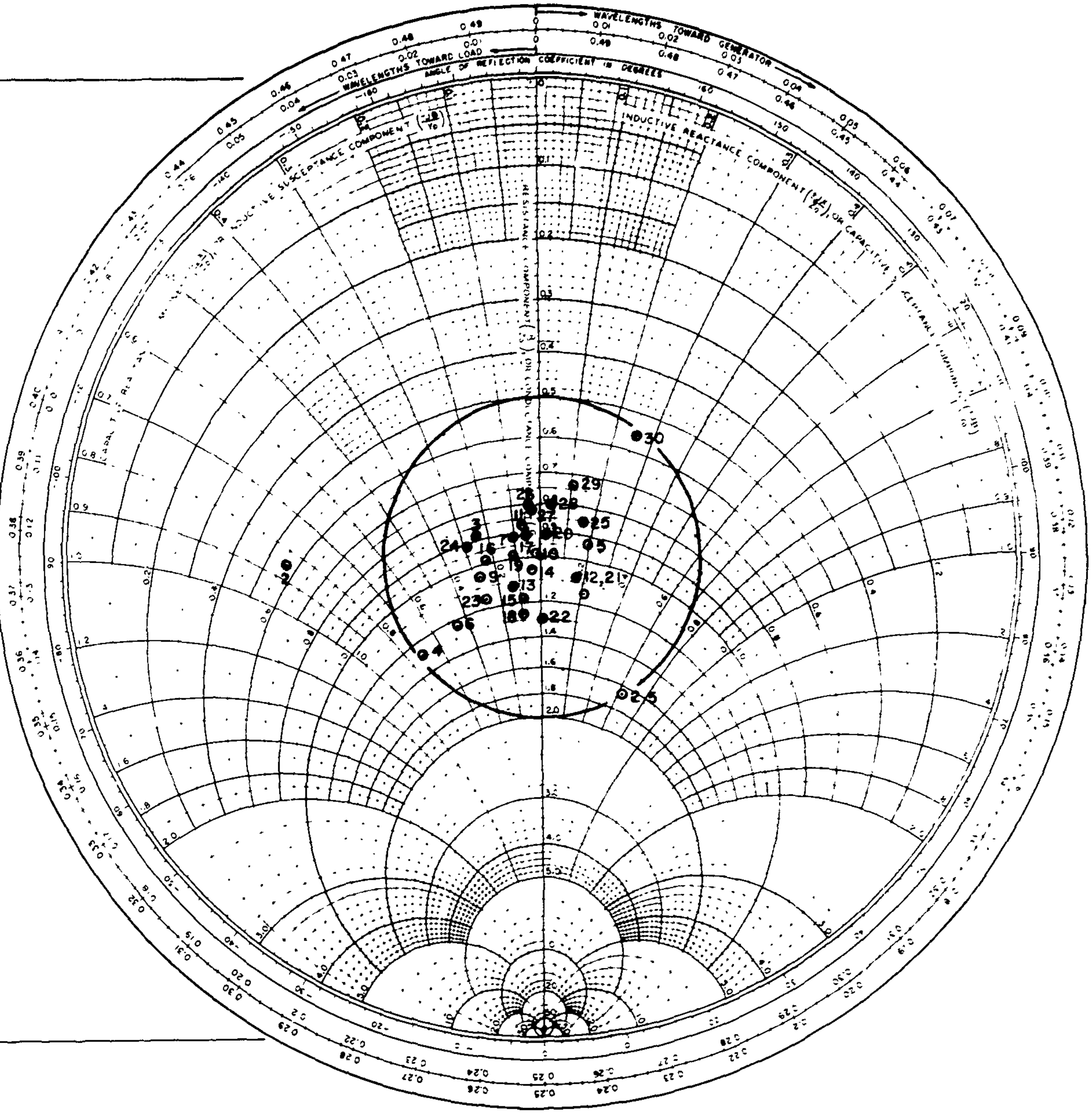

Figure 6

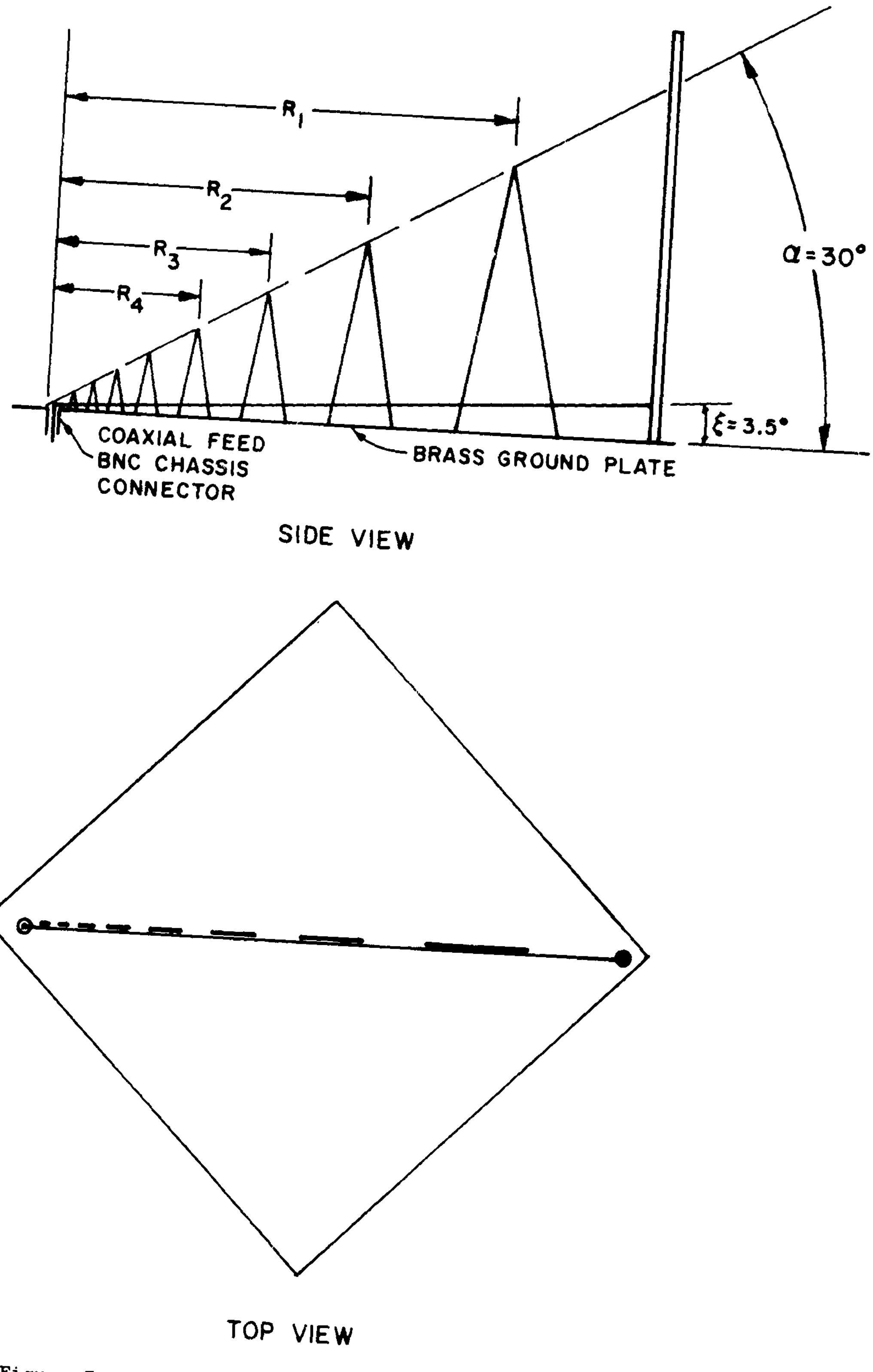

Figure 7. Single element model

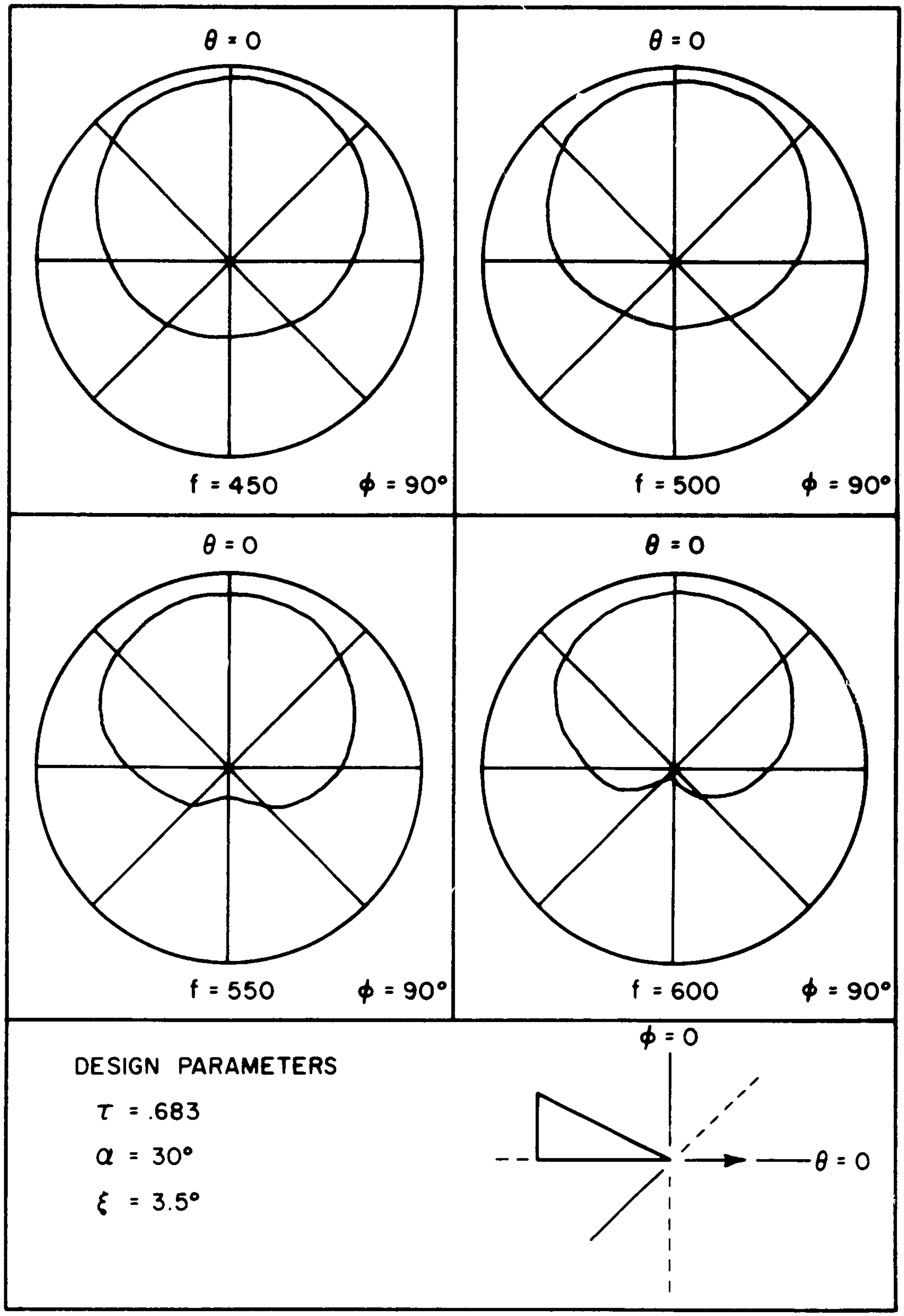

Figure 8. Measured, single element, azimuthal patterns

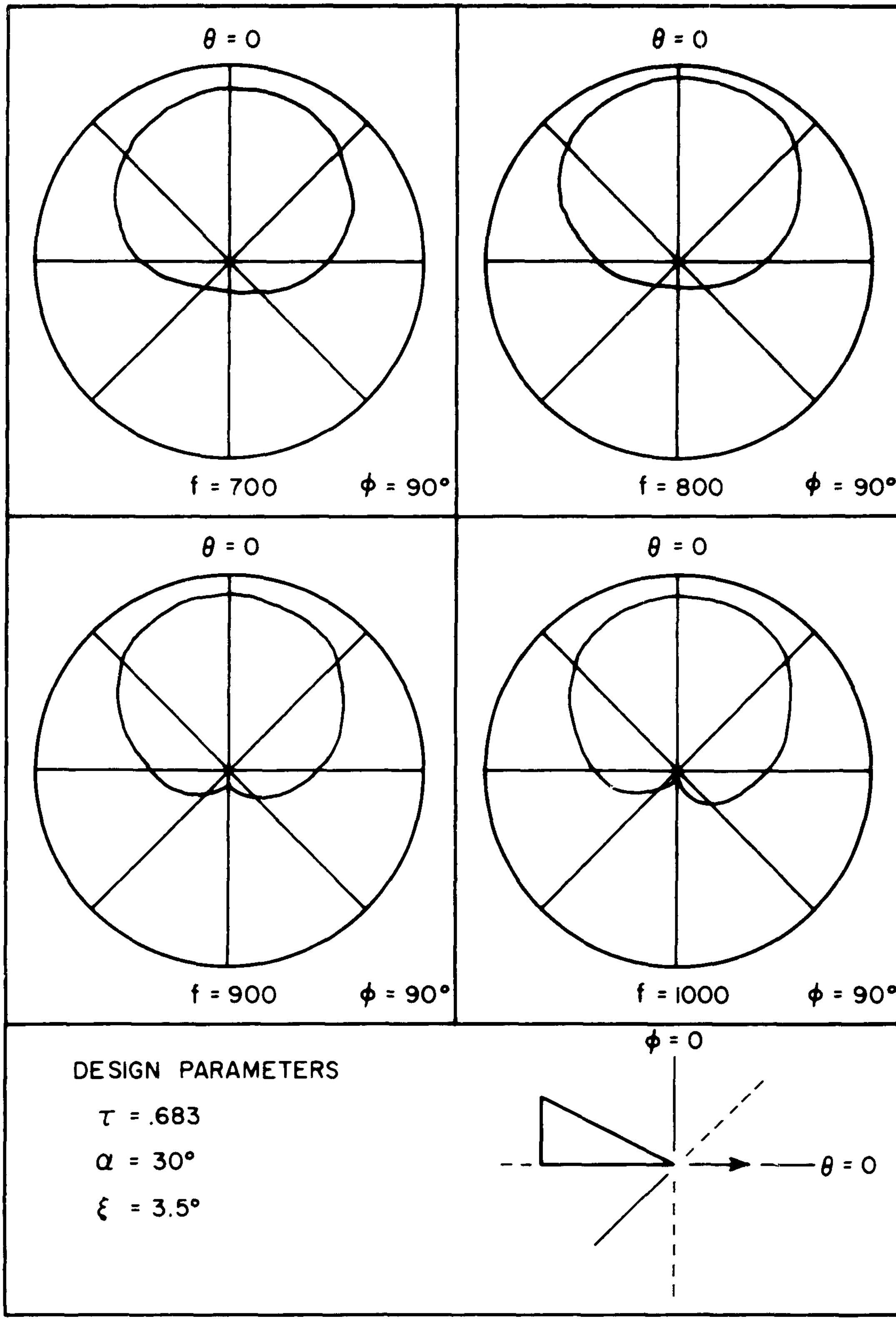

Figure 9. Measured, single element, azimuthal patterns

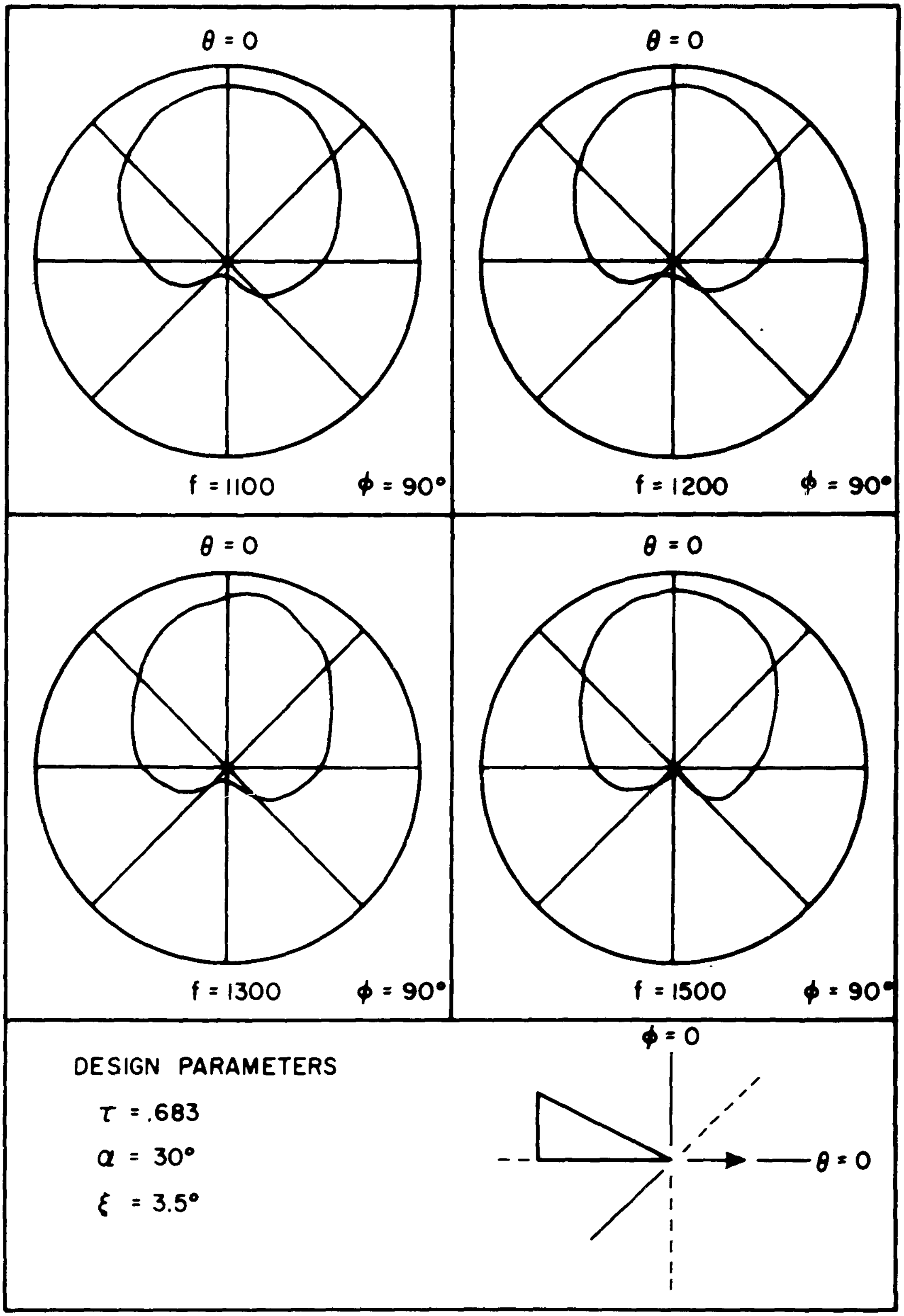

Figure 10. Measured, single element, azimuthal patterns

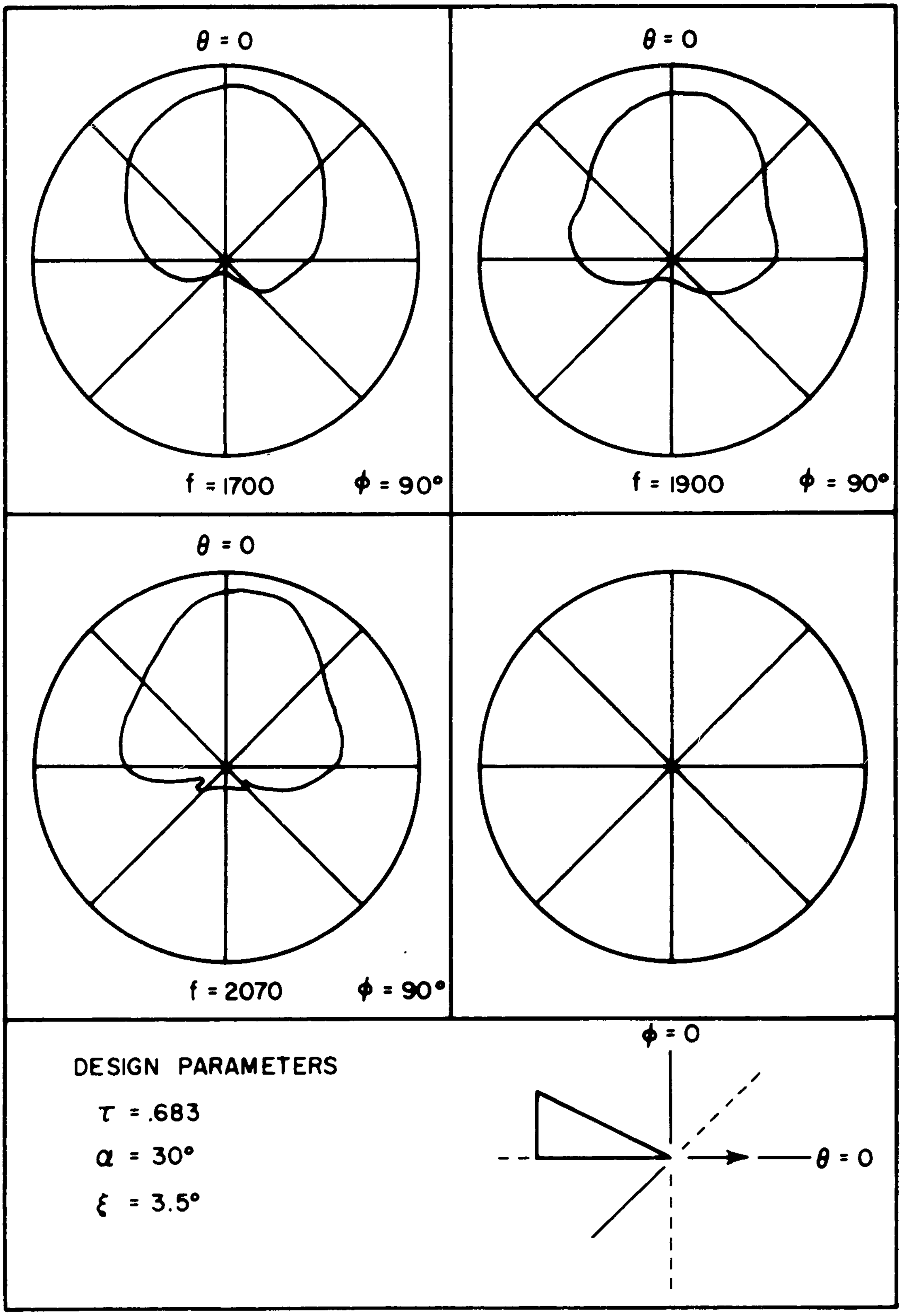

Figure 11. Measured, single element, azimuthal patterns

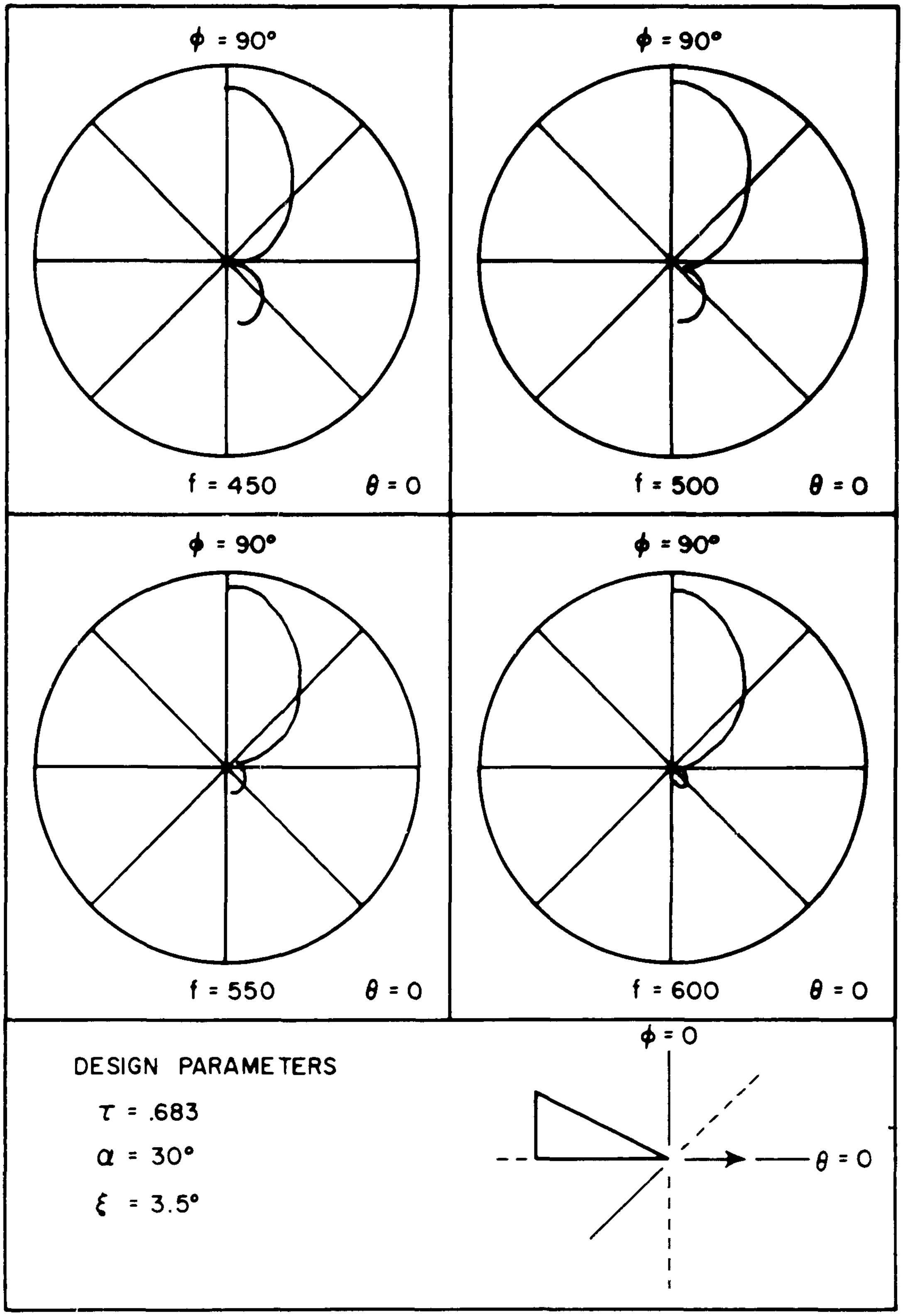

Figure 12. Measured, single element, elevation patterns

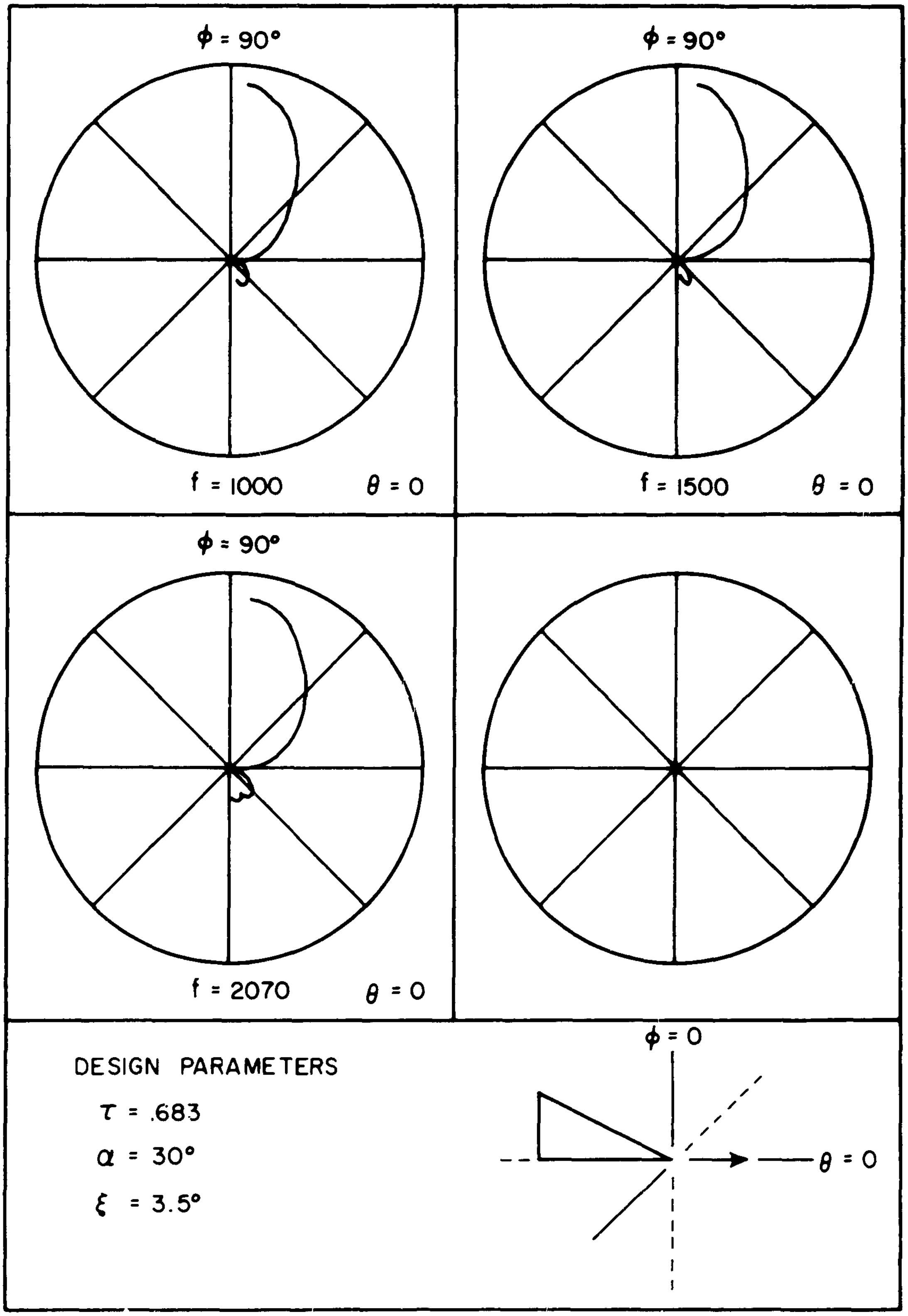

Figure 13. Measured, single element, elevation patterns

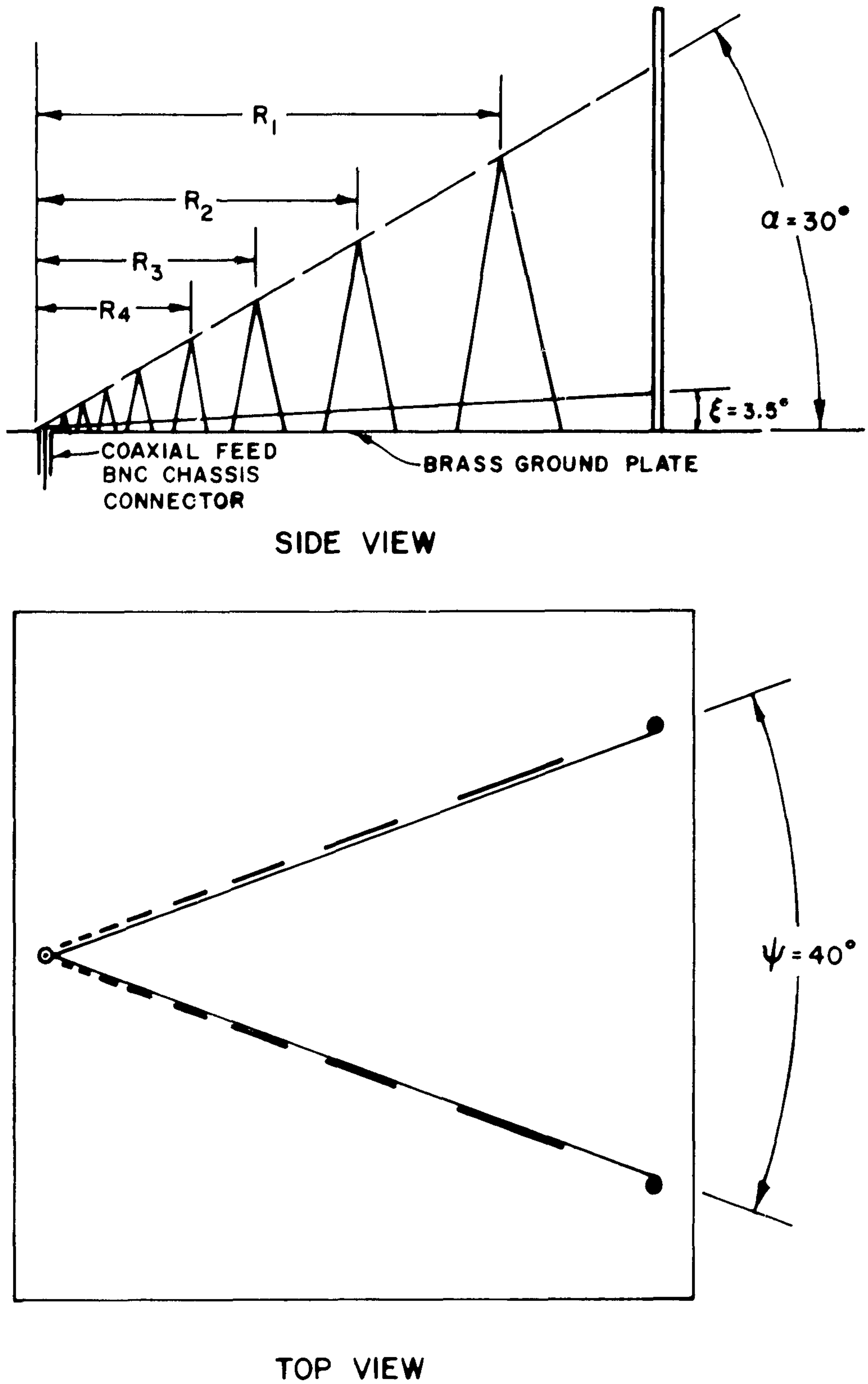

Figure 14. Two element array model

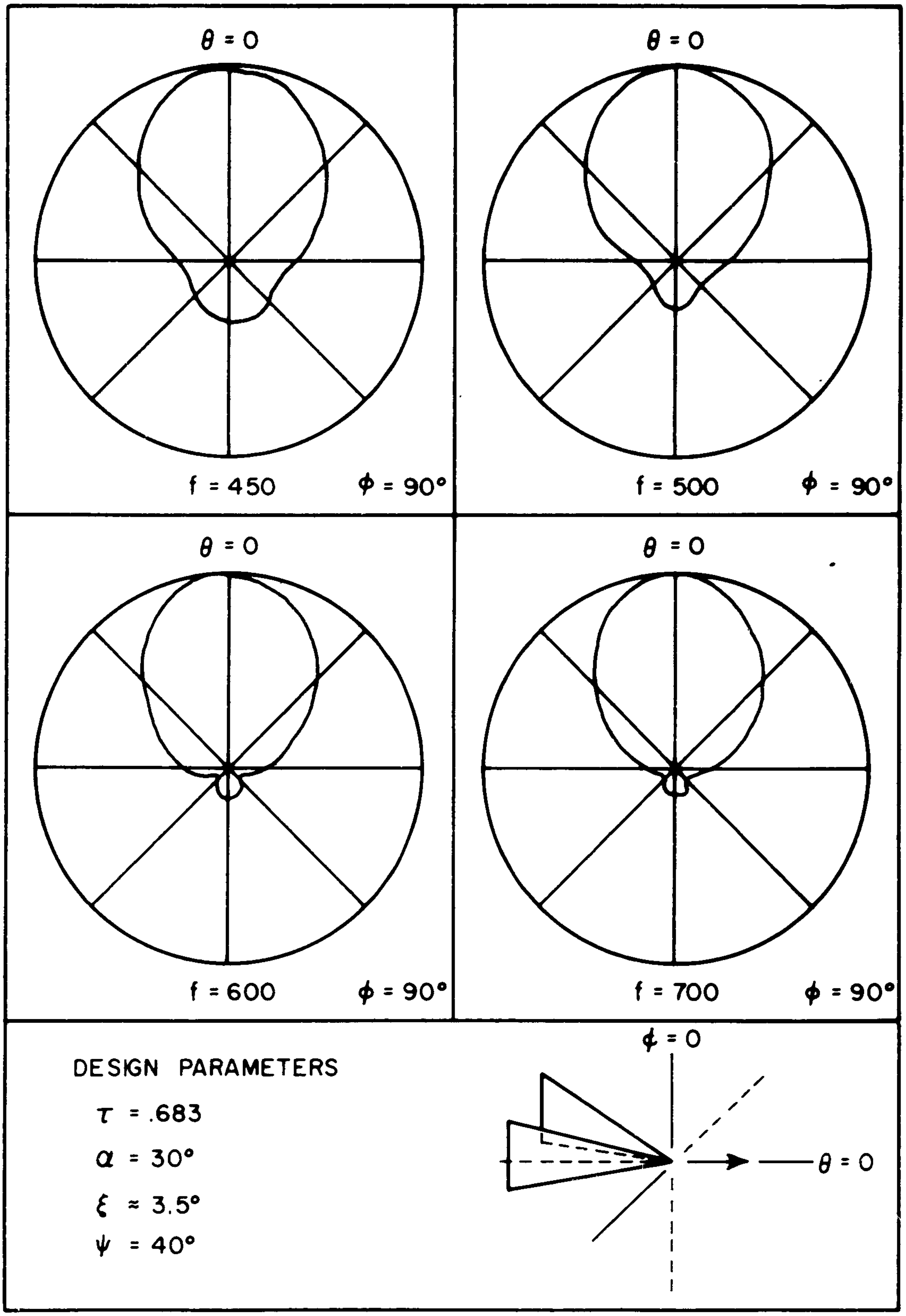

Figure 15. Measured, two element array, azimuthal patterns

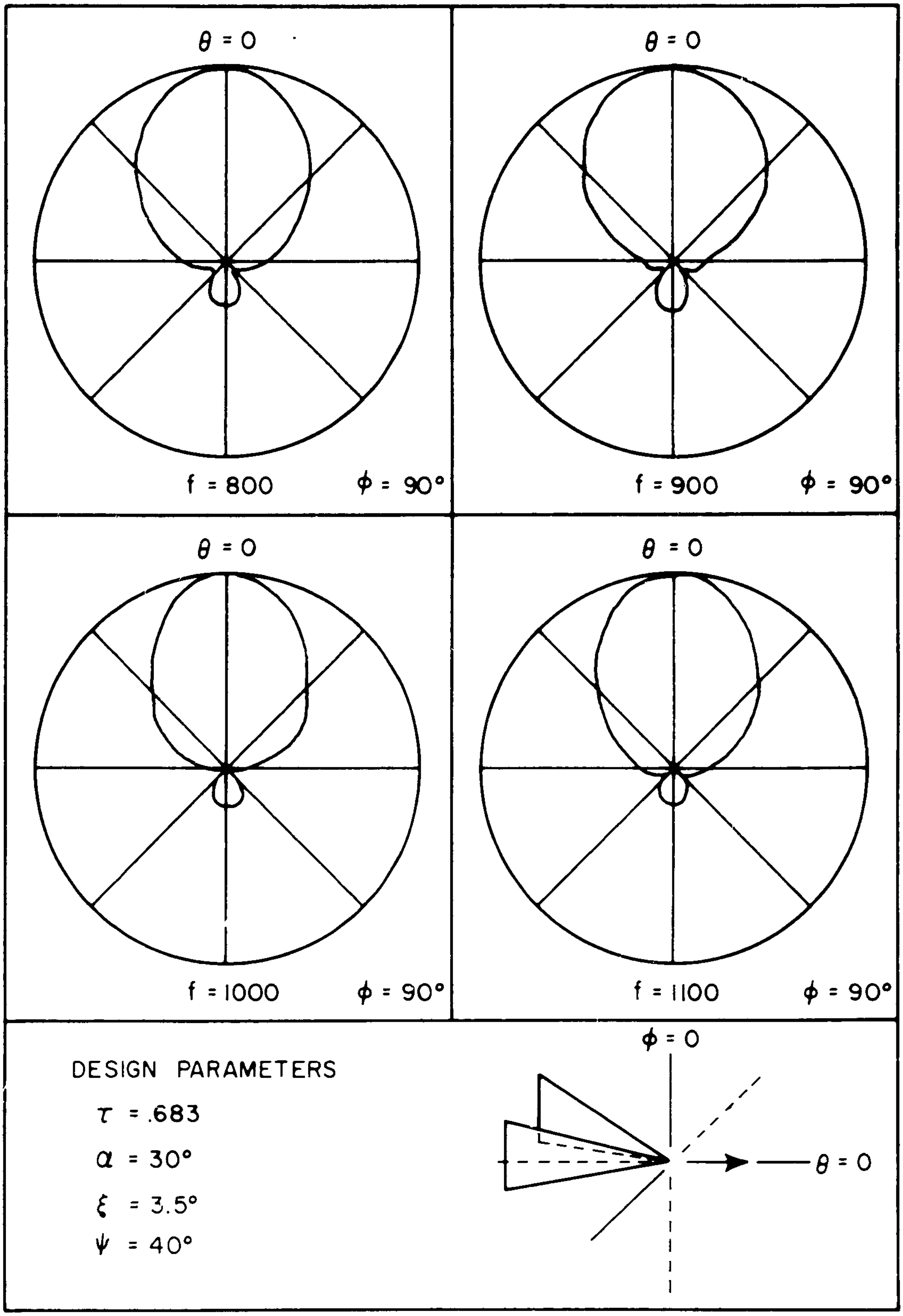

Figure 16. Measured, two element array, azimuthal patterns

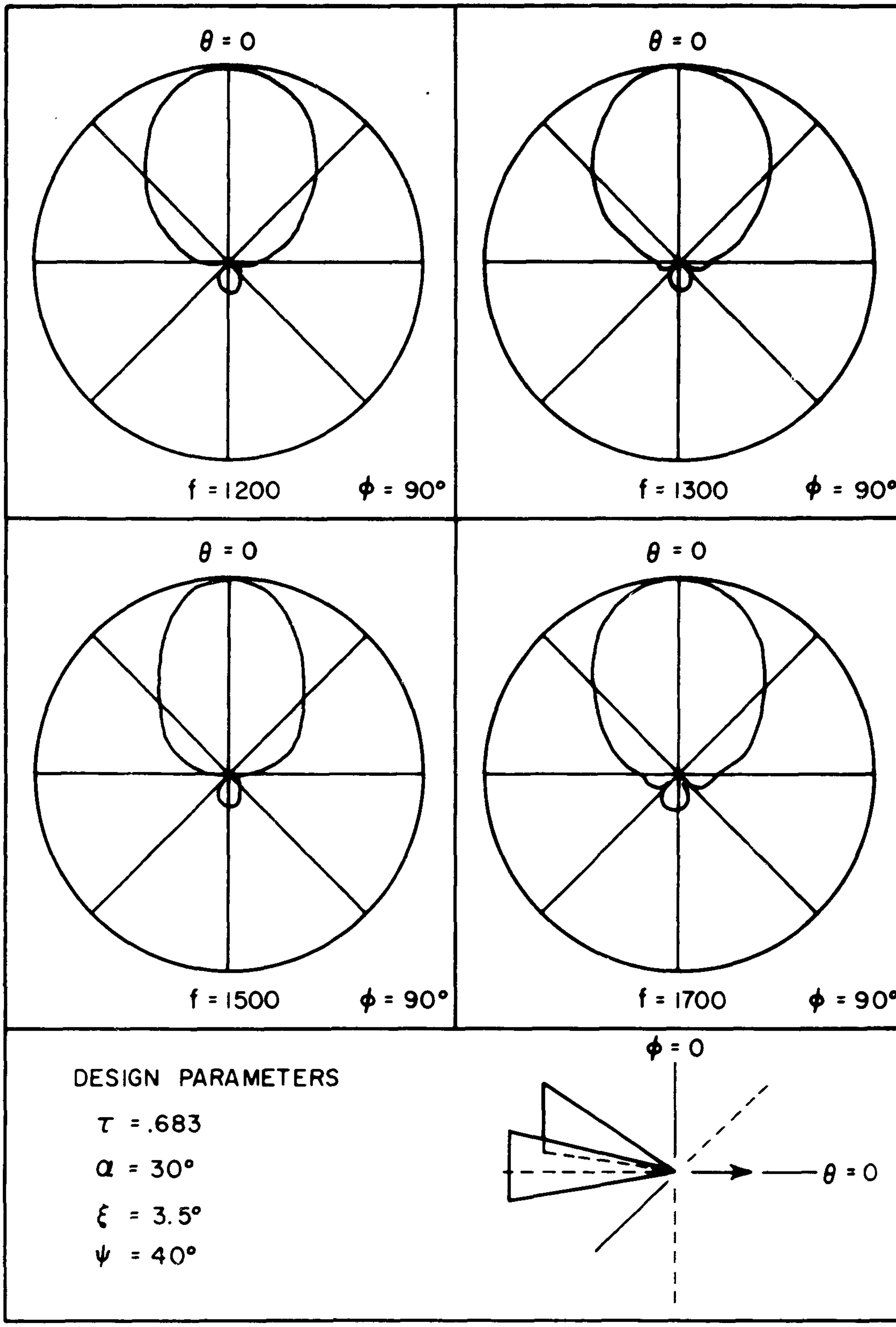

Figure 17. Measured, two element array, azimuthal patterns

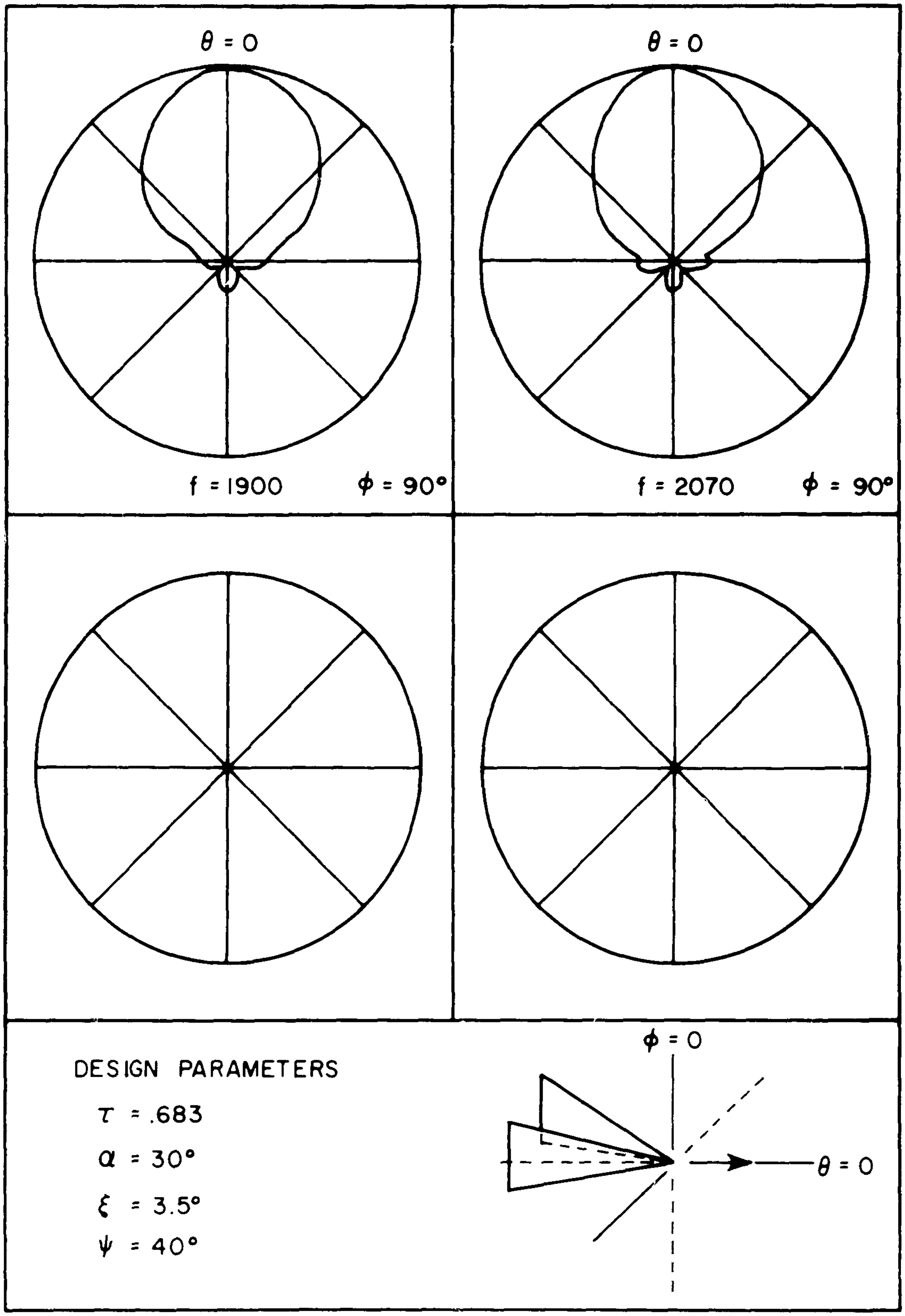

Figure 18. Measured, two element array, azimuthal patterns

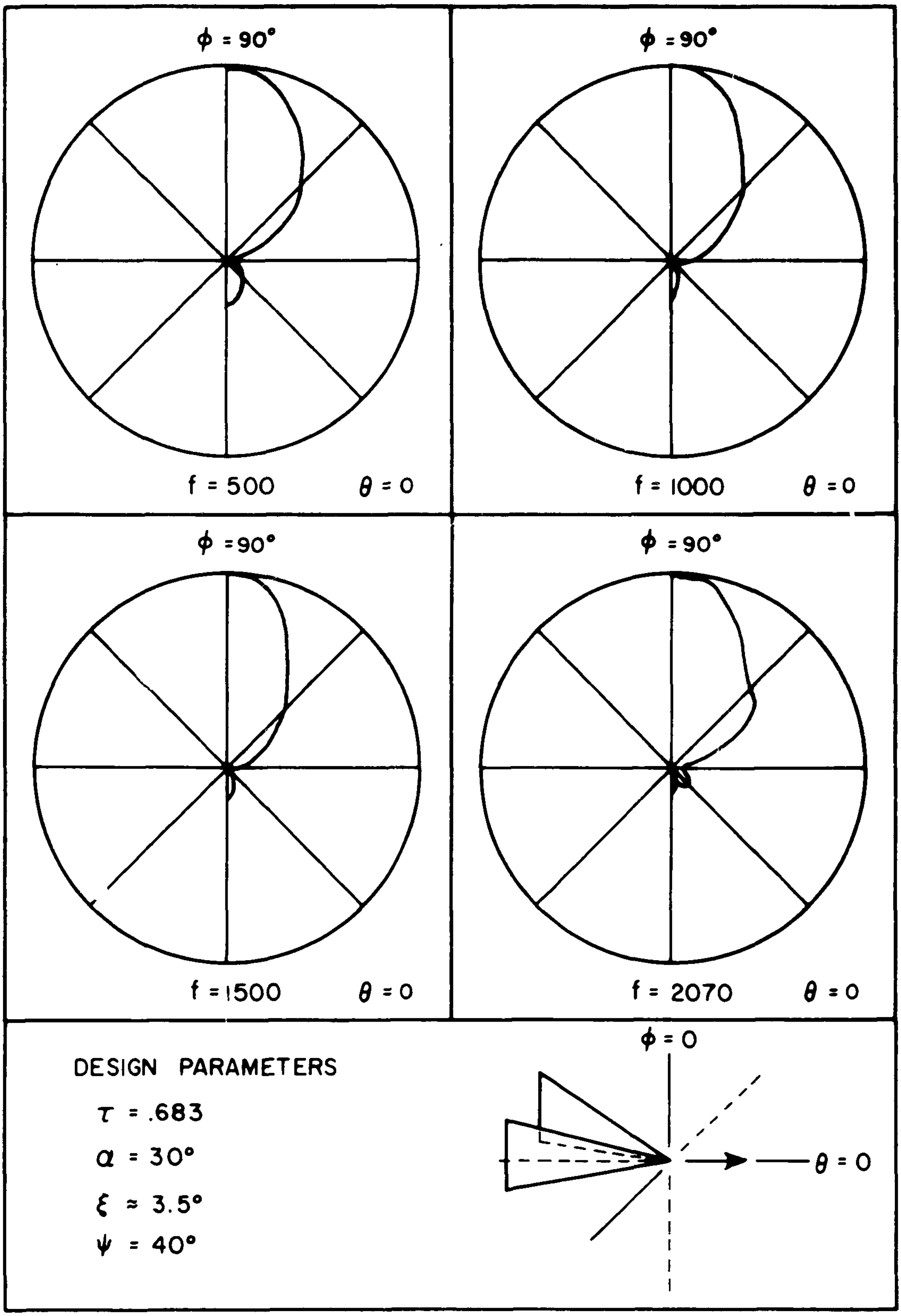

Figure 19. Measured, two element array, elevation patterns

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