AD NUMBER
ADC017574
CLASSIFICATION CHANGES
TO: unclassified
FROM: secret
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Distribution authorized to U.S. Gov't. agencies only; Proprietary Information; 01 FEB 1979. Other requests shall be referred to Commander, Naval Air Development Center, Warminster, PA 18974.
AUTHORITY
31 Dec 1989, per document marking; CNO/N772 ltr N772A/6U875630, 20 Jan 2006 & ONR ltr 31 Jan 2006

SECRET

VOLUME IB

AD C017574 L

SELF-TENSIONING ACOUSTICAL HORIZONTAL LINE ARRAY (SPRAY) DATA ANALYSIS (U)

FINAL REPORT OF BEARING STAKE TESTS
JANUARY THRU MARCH 1977

LEVEL III

JANUARY 1979

Prepared For
NAVAL AIR DEVELOPMENT CENTER
WARMINSTER, PENNSYLVANIA

UNDER CONTRACTS
N62269-77-C-0139
AND
N62269-78-M-6884

BY

SANDERS ASSOCIATES, INC.
95 CANAL STREET
NASHUA, NEW HAMPSHIRE 03061

DDC FILE COPY

NATIONAL SECURITY INFORMATION
UNAUTHORIZED DISCLOSURE SUBJECT TO CRIMINAL SANCTIONS

Classified by DD254 1 Dec 76
N62269-77-C-0139
Exempt from GDS of EO 11652
Exemption Category 3
Declassify on 31 Dec 1989

Classification Reviewed And
Approved by:
Ballard 2/21/79
Name Date

79 04 04 511

SECRET

ACCESSION for

NTIS White Section ☐
DDC Buff Section ☒
UNANNOUNCED ☐
JUSTIFICATION ....

BY
DISTRIBUTION/AVAILABILITY CODES

B

SECRET

VOLUME IB

SELF-TENSIONING ACOUSTICAL
HORIZONTAL LINE ARRAY
(SPRAY)
DATA ANALYSIS.

LEVEL III

FINAL REPORT OF BEARING STAKE TESTS
JANUARY THRU MARCH 1977.

JANUARY 1979

Distribution limited to U.S. Gov't. agen...
Proprietary Info.; Feb. 79. Other ...
for this document must be referred to

NAVAL AIR DEVELOPMENT CENTER
WARMINSTER, PENNSYLVANIA 18974

UNDER CONTRACTS
N62269-77-C-Ø139
AND
N62269-78-M-6884

BY

SANDERS ASSOCIATES, INC.
95 CANAL STREET
NASHUA, NEW HAMPSHIRE 03061

NATIONAL SECURITY INFORMATION
UNAUTHORIZED DISCLOSURE SUBJECT TO CRIMINAL SANCTIONS

Classified by DD254 1 Dec 76
N62269-77-C-0139
Exempt from GDS of EO 11652
Exemption Category 3
Declassify on 31 Dec 1989

Classification Reviewed And
Approved by:

Name Date

SAI DOCUMENT CONTROL #
1-10-602-0

SECRET

TABLE OF CONTENTS

VOLUME IB - DETAILED DESCRIPTION, TEST RESULTS

VOLUME	
IA	Overall Program Status and Test Results Summary
IB	Detailed Description, Test Results
II	Data Analysis Facility and Data Reduction Methodology
IIIA	Data Points 1, 2 and 3 Raw Data
IIIB	Data Points 4, 5 and 6 Raw Data
IVA	Data Points 7, 8 and 9 Raw Data
IVB	Data Points 10, 11 and 12 Raw Data

2.0 DETAILED DISCUSSION OF TEST RESULTS (U)

(U) The contents of this Volume discuss in more detail the measured vs expected results for each of the following:

- System FOM
- Array Gain and Signal Gain
- Beamwidth
- Bearing Accuracy
- Summary and Comparisons

2.1 SYSTEM FIGURE OF MERIT AND RANGE PREDICTIONS (U)

(U) System figure of merit (FOM) is defined as the total signal transmission loss that the system can tolerate and is expressed as

$$FOM = SL - NL + AG - DT \text{ (dB)} \quad (2.1)$$

where

SL = threat source level (dBμPA)

NL = local ambient noise spectral level (dBμPA^2/Hz)

AG = array gain (dB)

DT = detection threshold

(S) For the third generation threat, the detection threshold was computed for the 140 and 290 Hz lines as shown in Table 2-1 for a 1/32% analysis bandwidth (ABW). It is noted that in addition to a 1.3 dB mismatch loss, a processing loss of 2 dB was used to cover all other real processor degradations from ideal. A 5 minute integration time was assumed.

(S) Detection ranges for the third generation Soviet Nuclear Threat are estimated from the FACT-model-computed transmission loss (Volume IA, Figures 1-10, 1-11, 1-13, 1-14, 1-16, 1-17) based on FOM's computed from the measured data per equation (2.1).

TABLE 2-1

DETECTION THRESHOLD CALCULATION FOR 3RD GEN THREAT,
1/32% ANALYSIS BANDWIDTH (U)

Frequency (Hz)	Signal Line Width (Hz)	ABW (Hz)	N_s	DT Ideal (dB)	$-L_M$ (dB)	Processing Loss (dB)	Total DT Degradation (dB)	DT Actual (dB)
140	0.044	0.044	13	-12.2	1.3	2.0	3.3	-8.9
290	0.10	0.091	27	-11.0	1.4	2.0	3.4	-7.6

DT_{Ideal} = SNR (N_s) + 10 log ABW = Signal-to-noise in one Hz band required at processor input

SNR (N_s)[1] = Signal-to-noise required at the linear detector input for $P_D = 0.5$, $P_{FA} = 10^{-4}$, T = 300 sec integration time

N = Number of independent samples integrated

L_M = 10 log (1 - β/4) (dB) $0 \leq \beta \leq 2$ mismatch loss

β = $\frac{\text{Signal Line Width}}{\text{ABW}}$

DT_{actual} = $DT_I - L_M$ + Proc Loss (dB)

ABW = Analysis bandwidth of narrowband filter preceeding detector

(1) Obtain from Robertson's curves, G. H. Robertson, "Operating Characteristics for a Linear Detector of CW Signals in Narrowband Gaussian Noise", Bell Sys. Tech. J., April 1967.

(S) Table 2-2 contains the FOM and estimated range data for each data point in the three sites. Range zones (convergence zones) for greater than 50% detection probability are listed as well as the maximum 50% P_D range, which is averaged over the data points for each site (averages shown in last column). Data for 140 Hz as well as 290 Hz is provided. Note, however, that for a nominal λ/2 spacing, one would expect a nominal 3 dB gain improvement for the 140 Hz data, and thus expect range increases by approximately 1.5 to 2.0 times.

(S) The mean FOM for the 12 data points at 290 Hz is 89.8 dB; the greatest value is 92.9 for DP 9 in Site 4, and this corresponds to a continuous (no convergence zones) detection region out to 203 NM. Detection regions covered in the three sites are pictured in Volume IB, Figure 1-3, for the above conditions.

2.2 ARRAY GAIN AND SIGNAL GAIN (U)

(U) Measured array gain (SNR Gain) and signal gain are compared against theoretical reference curves vs number of elements in the aperture for all 12 data points in Figures 2-1 and 2-2. For comparison, the corresponding composite data for the deep MINYAKA site is contained in Figure 2-3. Individual data point presentation of gain data appear as Figures A-1 through A-24 in Appendix A.

(S) Measured signal gain clusters around the theoretical curve (20 log N) except for the Gulf of Oman (DP 1 and 2, Figure 2-1). This site might be expected to show somewhat poorer signal gain due to the large depth deficiency (see Section 1.2), and thus larger expected signal decorrelation resulting from greater signal acoustic interaction with the bottom and the surface. It is noted that the 140 Hz signal gain values (Figure 2-2) tend to be larger than the 290 Hz values. This also is expected since the sperture contains fewer wavelengths at 140 Hz and signal will, therefore, tend to be more correlated.

SECRET

(S) Table 2-2 FOM and Range Predictions Based on Measured Data. 3rd Gen Threat Line Levels and Line Widths: 290 Hz 135 dBμPa 0.091 Hz
140 Hz 135 dBμPa 0.044 Hz

Source Depth 60' Receiver Depth 100' FNWC Bottom Type 1

Site	DP	NL (dBμPa²/Hz)	AG	FOM	RANGE (NM) IN ZONES 1	2	3	4	5	Max R Range	R_{50} (NM) (1)	$\overline{P_{50}}$ (2)
		290 Hz DATA										
1A	1	65.7	10.0	86.9	0-45.9	55.8-64.3	72.7-85.7	96-97		85.7		98.3
	2	64.7	11.1	89.1	0-50.2	54.8-65.7	71.2-110.8			110.8		
	3	67.5	16.8	91.9	0-180					180.0		
	4	65.6	9.8	86.8	0-27.6	31.2-43.2	47.4-51.3	55.7-65.7	74.8-83.7	83.7		
3	5	68.4	11.7	85.9	0-27.2	32.4-42.8	47.8-50.9	56.3-65.	76.5-80.5	80.5		102.1
	6	68.9	12.6	86.3	0-27.4	31.9-43.	47.7-51.1	56.1-65.3	75.4-82.3	82.3		
	7	62.2	7.1	87.5	0-27.7	31.6-43.3	47.4-51.4			84.0		
	8	61.6	10.3	91.8	0-175					175.0		
	9	65.2	15.5	92.9	0-203					203.0		
4	10	64.6	12.6	90.6	0-138					138.0		150.7
	11	62.2	12.1	92.5	0-194					194.0		
	12	65.5	6.7	83.8	0-27.4	30-43.6				43.6		
		140 Hz DATA										
1A	1	140 Hz Not Projected in Site 1A										
	2											
	3	74.5	15.5	84.9	0-43.3	44.5-58.7	63.1-73.3			73.3		
	4	73.3	9.3	79.9	0-35.9					35.9		
3	5	76.6	14.9	82.2	0-38.1	48.6-53.6				53.6		54.2
	6	76.0	14.8	82.7	0-38.1	47.7-54.4				54.4		
	7	70.1	8.5	82.3	0-38.2	48.4-53.8				53.8		
	8	67.3	11.4	88.0	0-108					108.0		
	9	68.2	13.2	88.9	0-129					129.0		
4	10	74.2	10.5	80.2	0-22.5					22.5		60.8
	11	70.2	7.2	80.9	0-22.8					22.8		
	12	72.0	6.8	78.7	0-21.5					21.5		

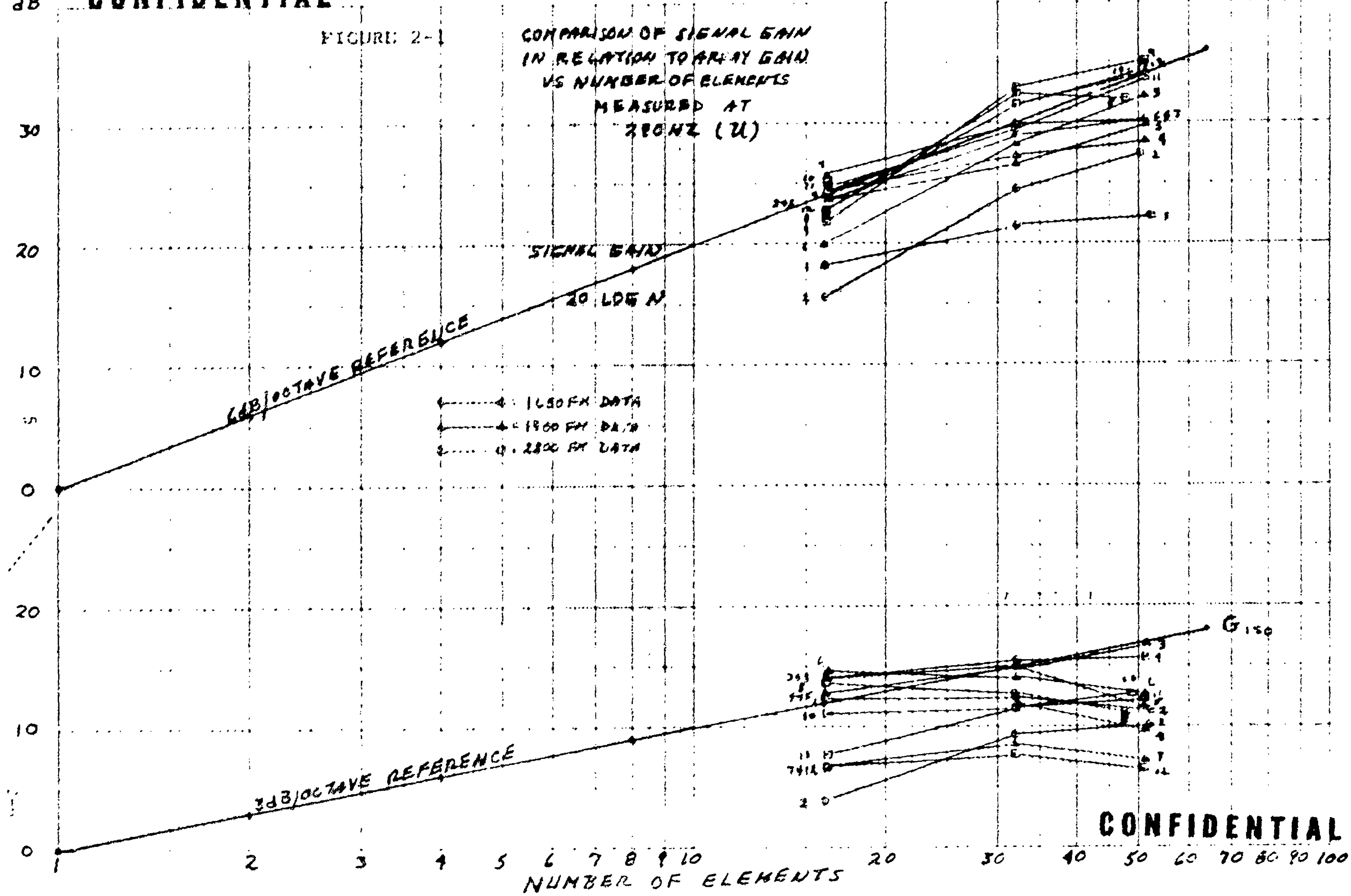
(1) R_{50} = Range in NM for 50% P_d

(2) $\overline{P_{50}}$ = Mean P_{50} for Site

SECRET

CONFIDENTIAL

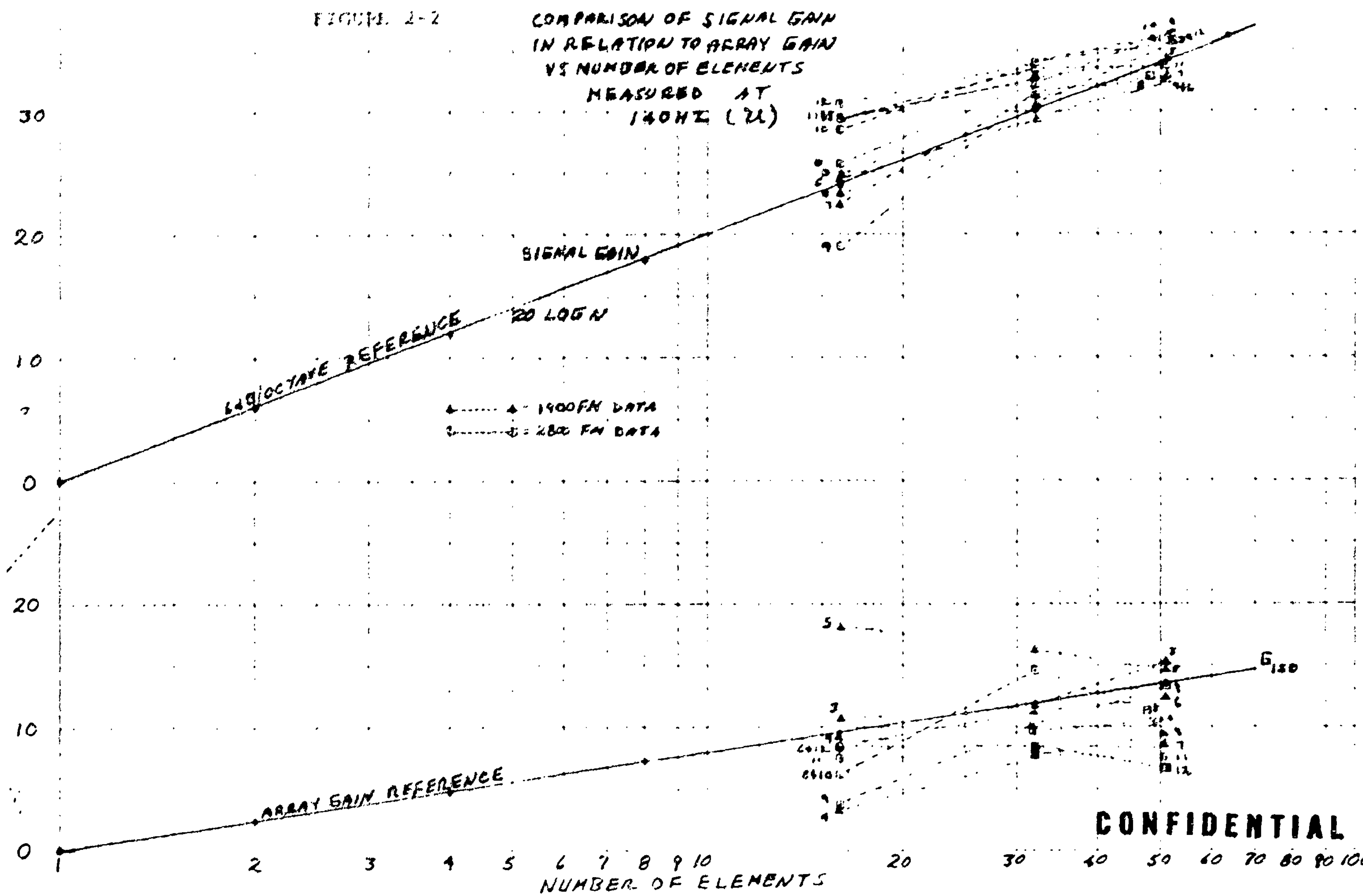
FIGURE 2-1



CONFIDENTIAL

CONFIDENTIAL

FIGURE 2-2



CONFIDENTIAL

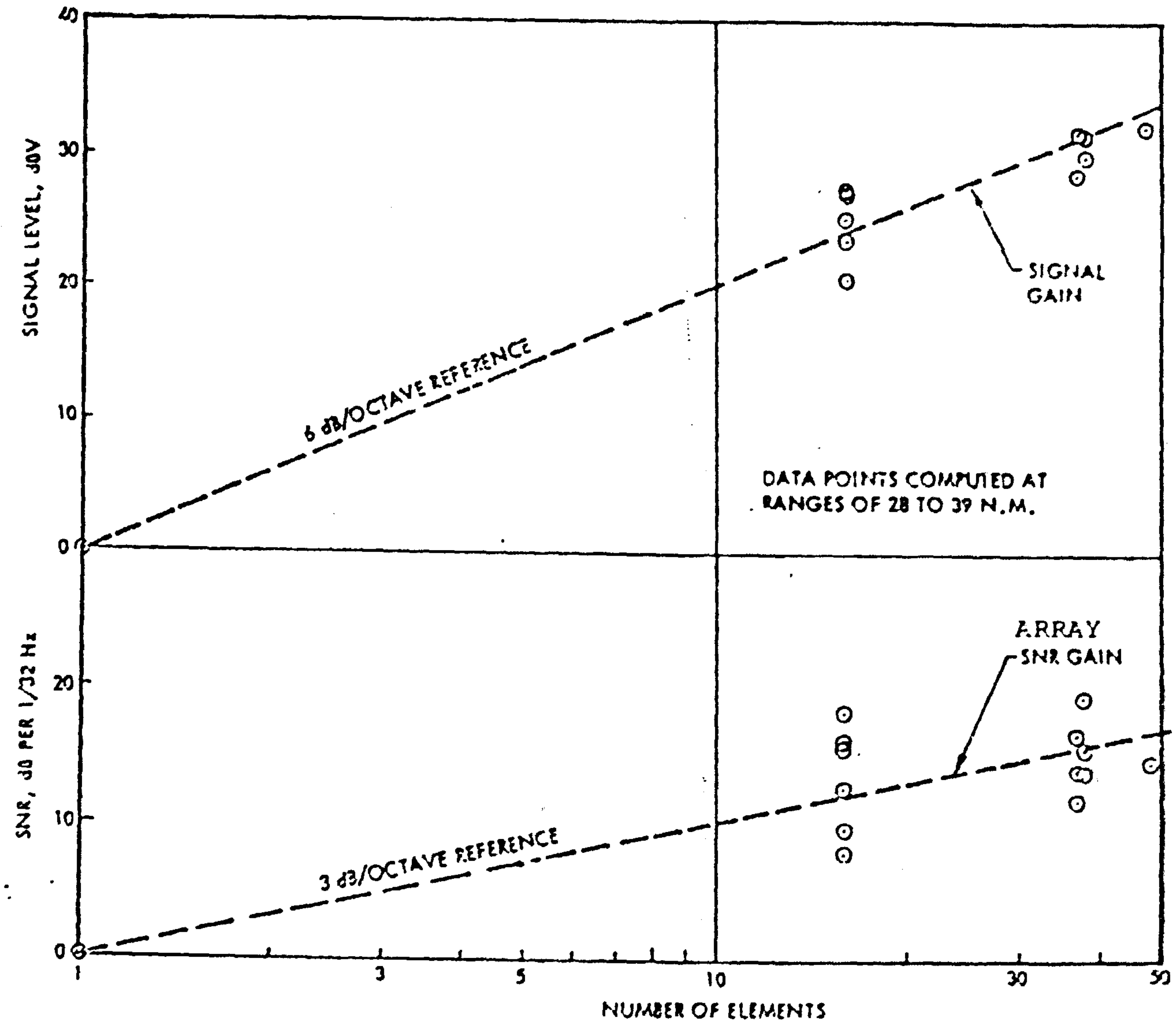


Figure 2-3 MINYAKA Data - Comparison of Signal Gain in Relation to SNR Gain vs. Number of Elements Measured at 295 Hz (U)

11488

(S) Also apparent is a characteristic droop in signal gain between half (32 elements) and full aperture, which becomes more significant at 290 Hz. The indication is that the plane-wavefront model used to process the data is becoming inadequate between 16 and 25 wavelengths, at least for the subject environmental conditions. Of course, uncompensated array deformation could also be at least partially at fault, but the progressively improved signal gain with improving acoustic conditions (going from Site 1A to Site 4) places greater credibility in the decorrelation argument. This indicates a need for more sophisticated array processing, especially in "shallow" water, for apertures approaching 25 wavelengths.

(C) The array (signal to noise) gain correlates reasonably well with signal gain according to the above referenced set of figures. One exception is site 1A where the signal gain is much farther below theoretical than array gain. Given the fact that array gain depends not only on coherently summing the signal, but also on rejecting noise (array gain (AG) = signal gain (GS) - noise gain (GN)), a lack of close correlation in array gain with signal gain is plausible. However, there appears to be an anomaly in the large discrepancy between signal gain and array gain for the Gulf of Oman. Noise anisotropy information is not contained in this report, but would be useful in relating signal gain and array gain.

(S) Of particular interest is the relatively constant level of measured array gain, independent of aperture (number of elements), unlike the deep water MINYAKA tests. This is especially evident for 290 Hz is given in Table 2-3 supporting this observation. Therefore, a strong indication is that in order to achieve the full potential of drift arrays in depth deficient water, the beamforming must accommodate a more complex model than a plane wave arrival; that is, it must include techniques to compensate for correlation losses.

Table 2-3 Array Gain Comparison for 290 Hz
vs. Number of Elements (C)

	Mean Array Gain (dB) for Number of Elements Shown, 290 Hz		
Site	16	32	max
1A	9.7	11.2	10.6
3	12.7	13.4	12.7
4	11.4	12.4	12.4
Overall Mean	11.8	12.7	12.3

2.3 BEAMWIDTH (U)

(C) Theoretical beam patterns for each frequency and aperture analyzed at each data point (which have random steer angles) were computed for comparison with MRA pattern response measurements. A typical pattern for the uniform-weighted* full aperture is shown in Figure 2-4 for DP 10 at 290 Hz. The rectangular pattern plot covers the full azimuth plane, and references azimuth angle from end fire, i.e., broadside on these plots appears at 90° and 270°. Thus the 151.5° horizontal steering corresponds to 61.5° off-broadwide steering in the context of the present report. Also provided in the hard copy computer display are the 3 dB beamwidth (4.12°) and array azimuth gain (15.0 dB). All other such plots generated are contained in Appendix B for reference. A brief discussion of the effect on theoretical beam pattern of elements missing from the aperture and quantizing lobes created by sampling data at a rate lower than that required for quantizing lobe suppression was given in Volume IA.

(U) Direct measurement of beamwidth in the normal sense during a sea test is not practical. Instead (of either rotating the array or maneuvering the projector ship on a circumferential course), an estimate of the beam characteristics is obtained by steering the beam over a relatively small azimuth region centered in the target direction. The estimate is good only in the main beam region; it is clear that the greater the beam is steered away from the target direction, the greater is the pattern error.

* Uniform weighting was used in beamforming for the entire data reduction. No sidelobe suppression was attempted.

CONFIDENTIAL

S106B SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 ONTLBF 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

DP 10
UNIFORM WEIGHTING.
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 49 ELEMENTS, -0.87 DB MAX., AC:S1362,SU:S1362,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
4.12 DEG. 3 DB BEAM, 15.00 DB AZ. GAIN, MAX. AT 208.5 DEG. HORIZ.

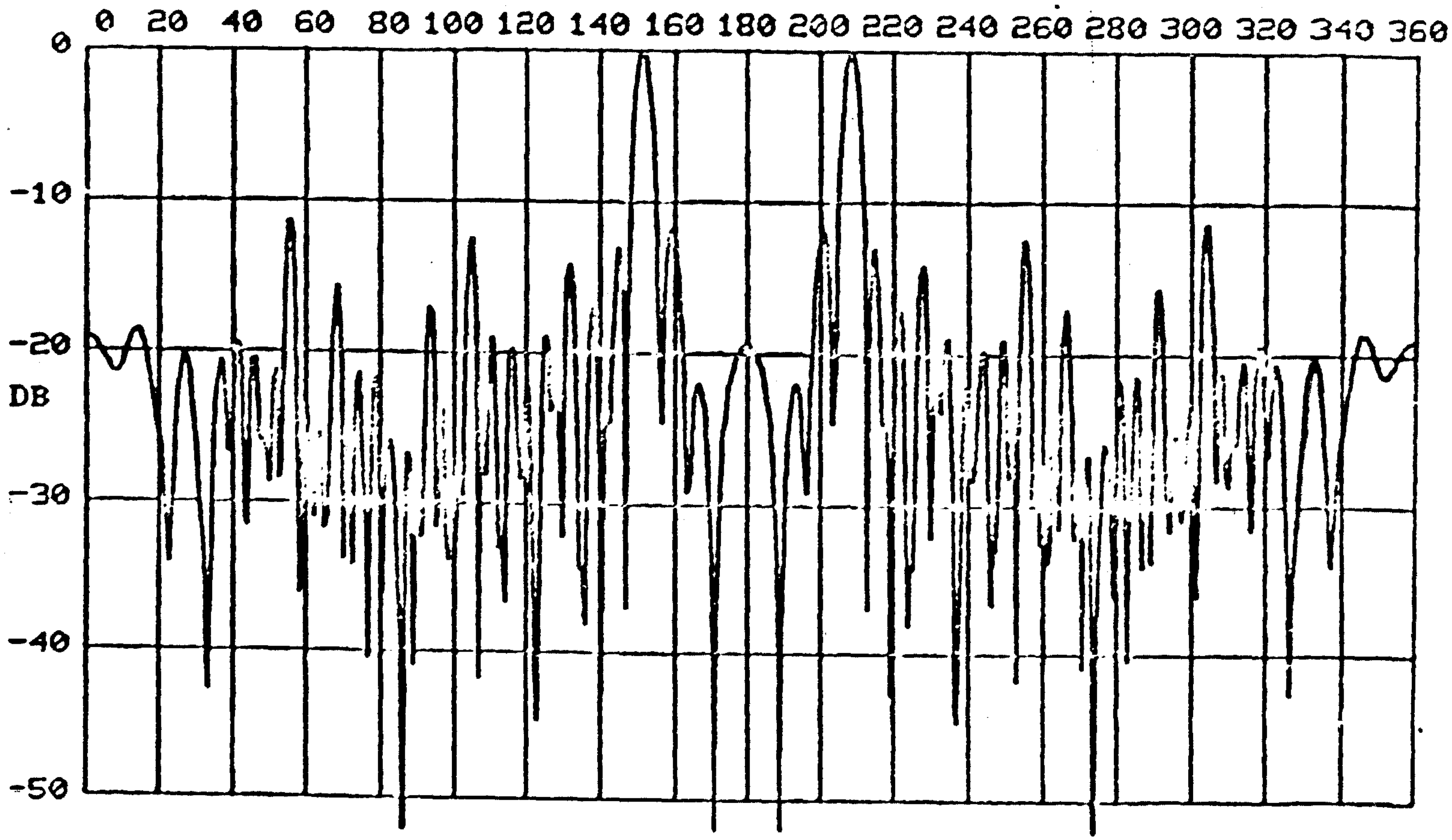


Figure 2-4 Theoretical Horizontal Plane Pattern for 49-Element Array @ 290 Hz for Data Point 10, 61.5° off Broadside Steering. Beamwidth 4.12°, Azimuth Gain 15.0 dB.

CONFIDENTIAL

(S) It is with this in mind that the "measured" pattern data should be viewed. Such a pattern appears in Figure 2-5 for DP 10 at 290 Hz, corresponding to the theoretical pattern of Figure 2-4. It represents one of the better examples of measured beam patterns, and is only 0.6° broader than theoretical. This corresponds to an array gain only 0.6 dB (10 log $(4.1^{\circ}/4.7^{\circ})$ = 0.6 dB)) below theoretical. Unfortunately, the measured array gain suffered an actual degradation of 2.4 dB for this data point when the data was properly reduced.

(C) It is also noted that the presence of interfering sources, particularly in the vicinity of the main beam (or its image), has a degrading effect on the measured pattern quality, as well as n both signal and array gain. Either discrete tonals radiated within an analysis bandwidth of the projector tone, or broadband noise radiated from such interference contaminates the data. Figure 2-6 is an example of a measured pattern at 290 Hz for full aperture in DP 7 where interference plays a significant, or probably a dominant role. The target (projector) was received on a beam steered to -22° (where the MRA occurs in the figure). However, at least 3 other smaller pattern peaks occur within 12°. It is felt these are associated with interfering sources in the near vicinity of the array emplantment.

(C) If one considers the 140 Hz data for this same data point (see Figure 2-7), the MRA has apparently shifted to -36° steering, indicating a possible array orientation change. But this is not possible because the same 5 minute segment of tape was analyzed for both 140 Hz and 290 Hz. The presence of at least one other source can, therefore, be deduced from this data comparison. The interfering source at -36° steering has a greater received energy at 140 Hz than is received from the projector.

CONFIDENTIAL

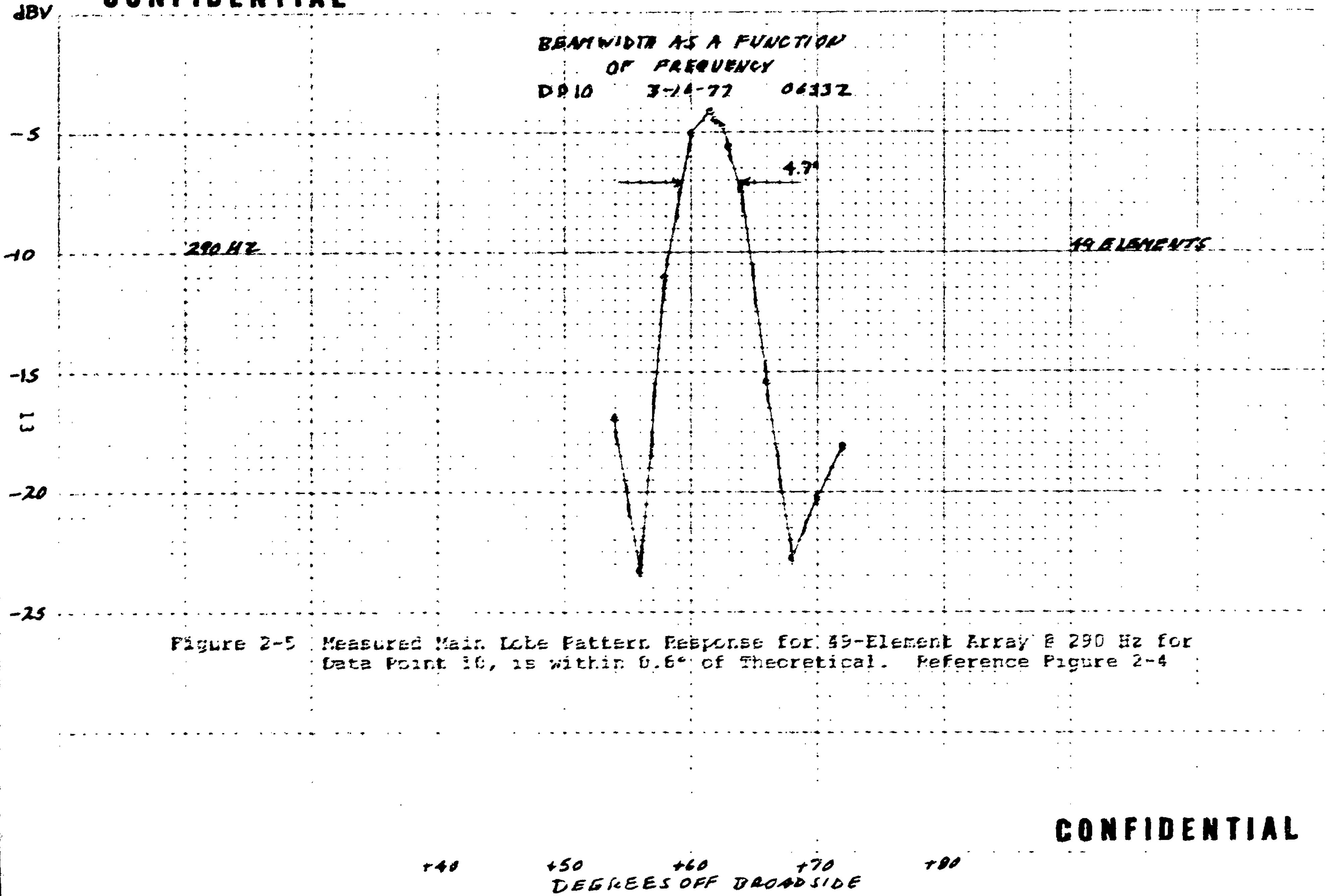


Figure 2-5 Measured Main Lobe Pattern Response for 49-Element Array @ 290 Hz for Data Point 10, is within 0.6° of Theoretical. Reference Figure 2-4

CONFIDENTIAL

CONFIDENTIAL

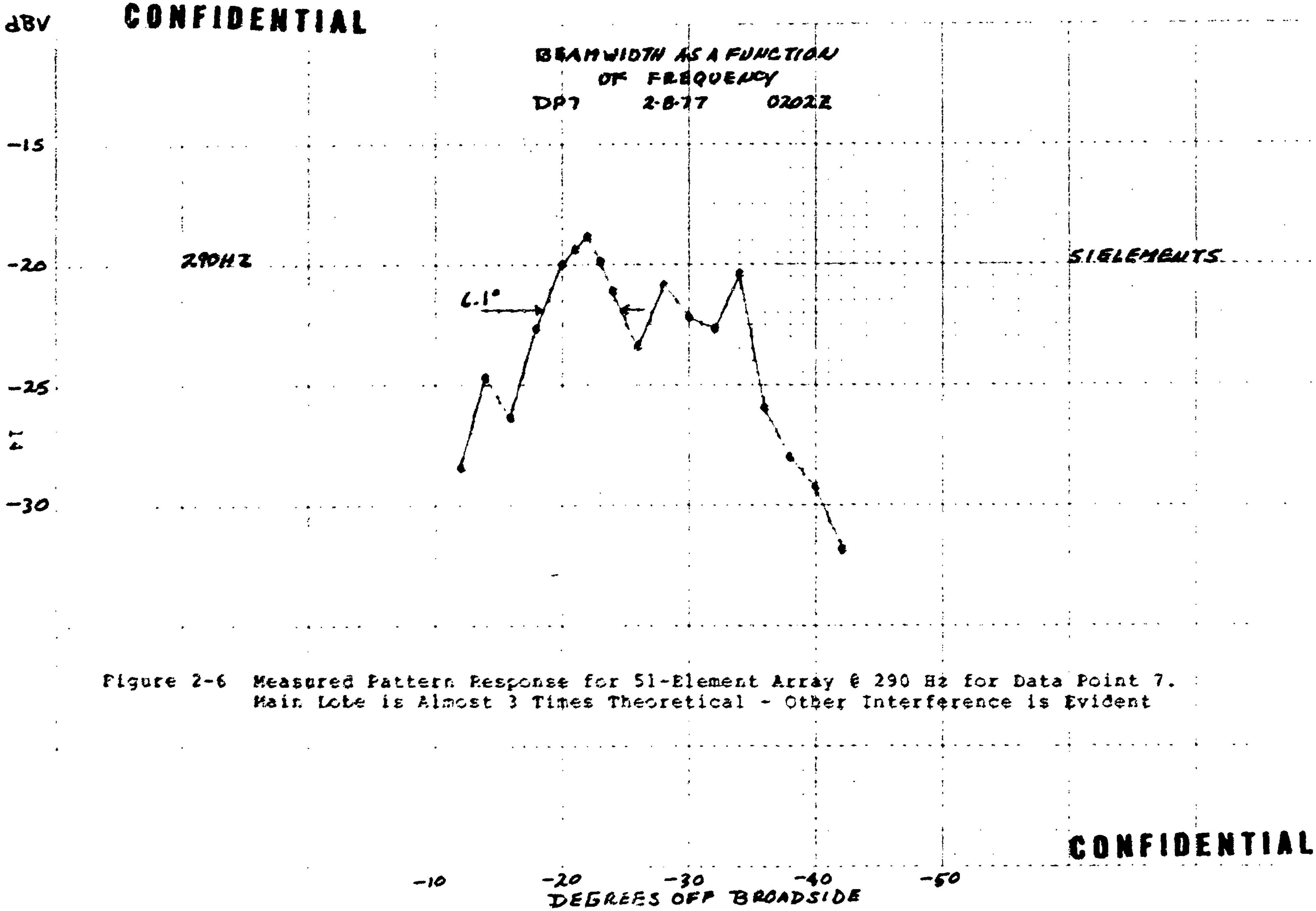


Figure 2-6 Measured Pattern Response for 51-Element Array @ 290 Hz for Data Point 7. Main Lobe is Almost 3 Times Theoretical - Other Interference is Evident

CONFIDENTIAL

CONFIDENTIAL

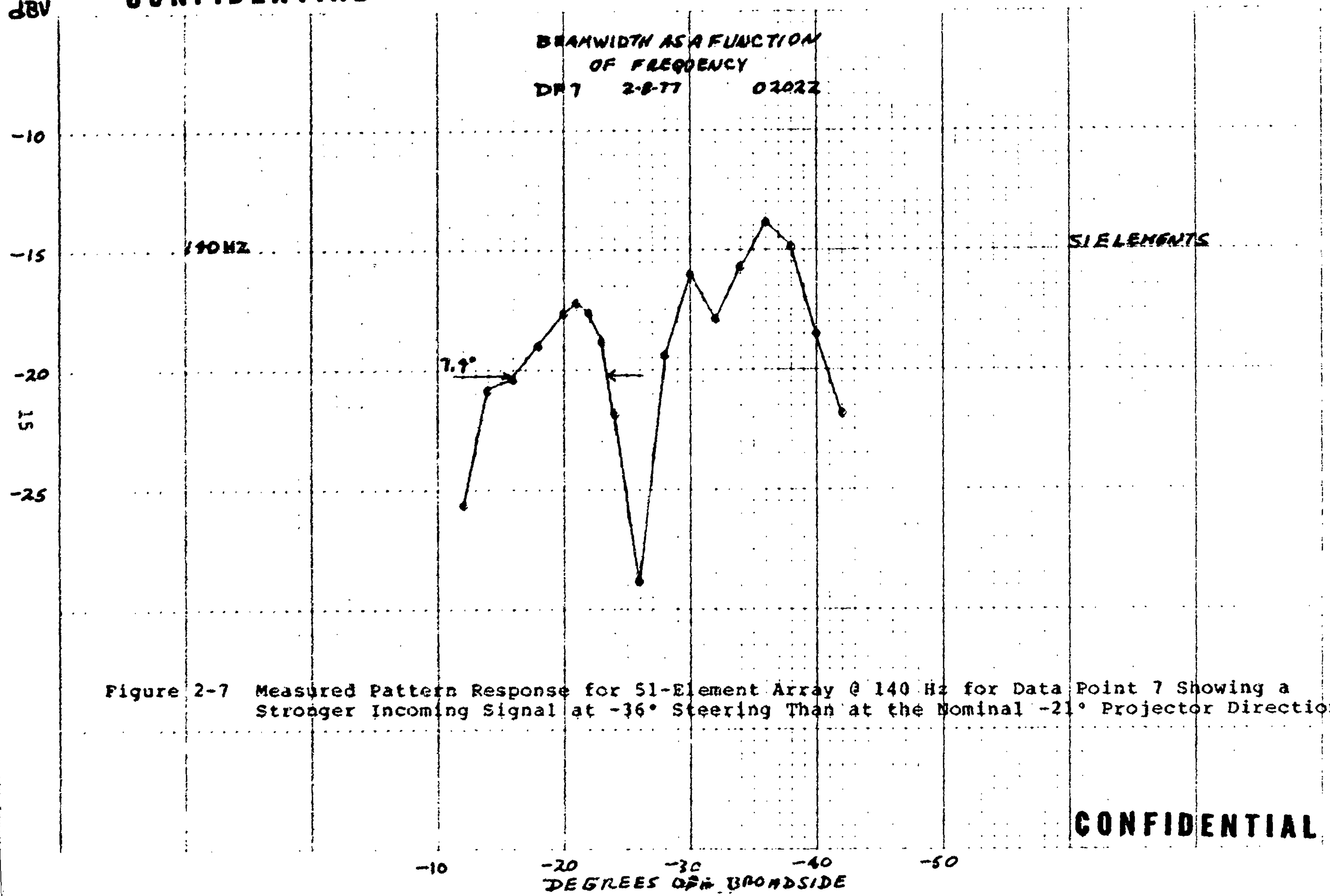


Figure 2-7 Measured Pattern Response for 51-Element Array @ 140 Hz for Data Point 7 Showing a Stronger Incoming Signal at -36° Steering Than at the Nominal -21° Projector Direction

CONFIDENTIAL

(S) On this assumption, it can be seen that the reported array gain of 8.5 dB (Ref Table 1-3, Vol Ia) at 140 Hz is pessimistic, and according to Figure 2-7, the measured gain should probably be stated as 11.9 dB based on considering the -36° steered "MRA" response.

(S) Observations of local interference in the Ship's log indicate the presence of six ships within a 10 NM radius of the array deployment including the monitoring ship (USNS Wilkes). Other traffic is included below:

True Bearing	Range	Vessel Description
158°	3 NM	Soviet Oceanographic Ship Soviet Tender
178°	28 NM	USNS Kingsport
182°	9 NM	Two other Soviet Vessels (Destroyers?)
183°	7 NM	US Minesweeper
	1 NM	USNS Wilkes

All of the "measured" beamwidth plots appear in Appendix C for reference.

2.4 BEARING ACCURACY - COMPARISON WITH NAVIGATION DATA (U)

(S) Array bearing accuracy measurements were made using the navigation data as a reference for data points 1 through 7 in Sites 1A and 3. In Site 4, the array compass data was noisy and could not be used to generate array target bearings. Bearing accuracy data, summarized in Figures 2-7A and 2-7B, shows extremely good accuracy. This is displayed as bearing error in Table 2-4. Excluding DP 6 and 7, the mean absolute deviation bearing error measured less than 5° and the rms less than 7°. Including these data points during which time the array underwent rapid rotation, as if due to an ocean eddy, the mean absolute deviation and rms bearing errors for Site 3 increased to 26.2° and 33°.

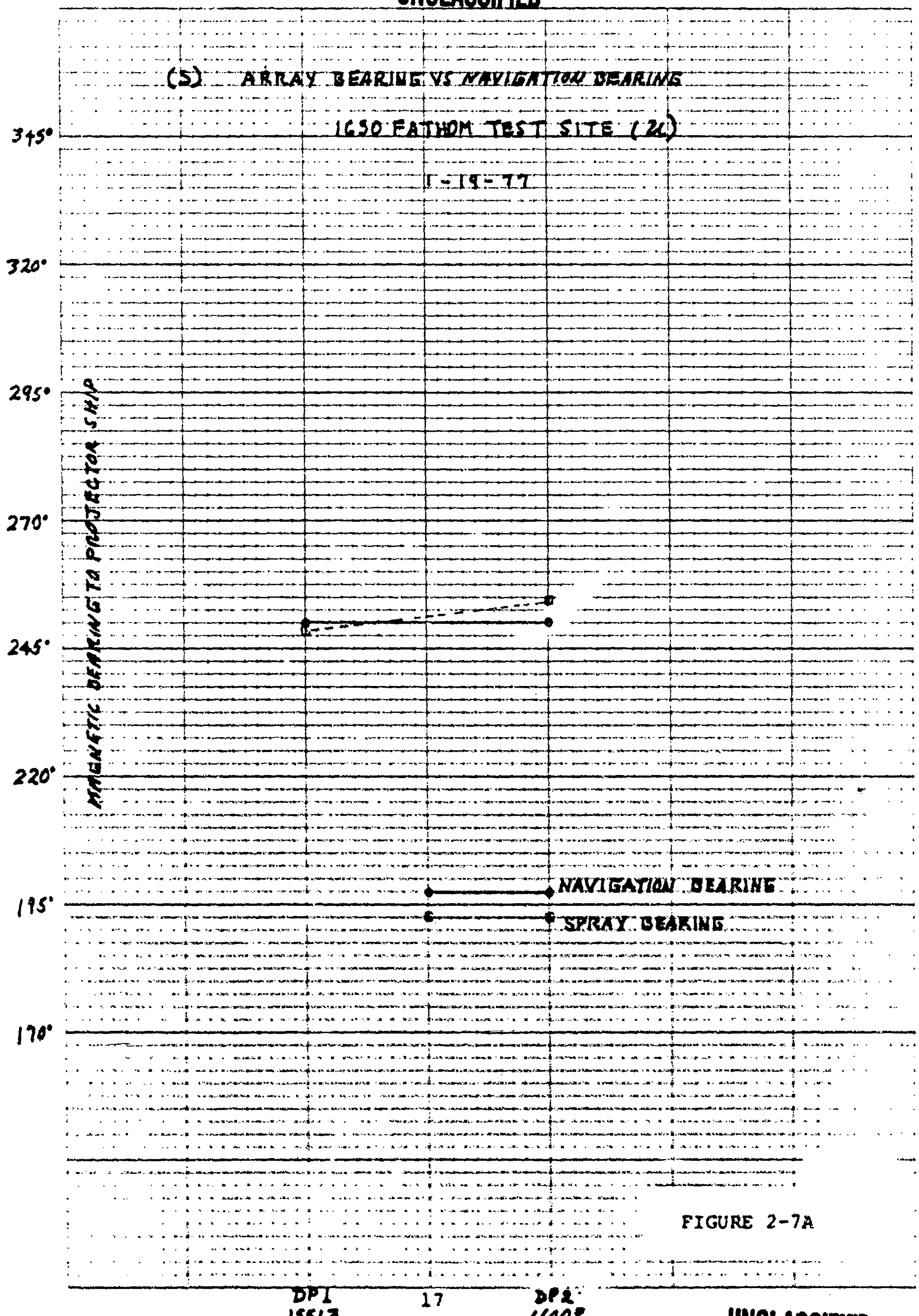

(S) ARRAY BEARING VS NAVIGATION BEARING
1650 FATHOM TEST SITE (U)
1-19-77
345°
320°
295°
270°
245°
220°
195°
170°
MAGNETIC BEARING TO PROJECTOR SHIP
NAVIGATION BEARING
SPRAY BEARING
DP1
1551Z
DP2
1600Z

FIGURE 2-7A

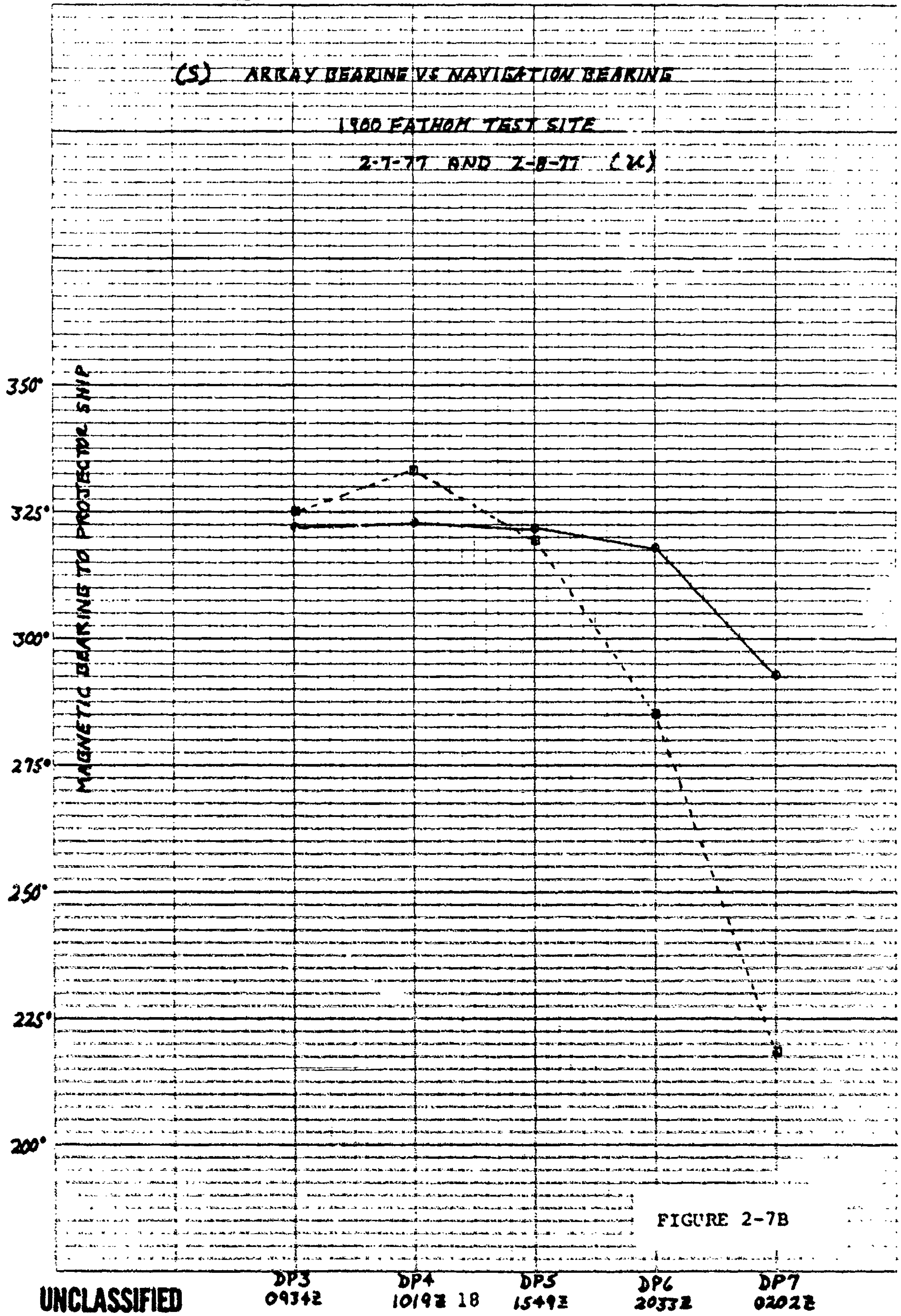

(S) ARRAY BEARING VS NAVIGATION BEARING
1900 FATHOM TEST SITE
2-7-77 AND 2-8-77 (U)
MAGNETIC BEARING TO PROJECTOR SHIP
350°
325°
300°
275°
250°
225°
200°
DP3 0934Z
DP4 1019Z
DP5 1549Z
DP6 2033Z
DP7 0202Z

FIGURE 2-7B

TABLE 2-4

BEARING ACCURACY SUMMARY (U)

Site	Data Point	Absolute Nav. Data Bearing	Array Bearing Error	Bearing Error MAE[2]	Bearing Error rms
1A	1	250°	-1.5°	5.3°	6.5°
	2	250°	+9°		
3	3	372°	+2.5°	-26.2°	33° (1)
	4	323°	+10°		
	5	322°	-3°		
	6	318°	-33°		
	7	393°	-65°		
4	Absolute bearing data available from array				

(1) Excluding DP 6 and 7, during which time a relatively rapid rotation of the array was occurring, we have for Site 3

$$MAE^2 = 4.6^\circ$$
$$rms = 6.1^\circ$$

(2) MAE = Mean Absolute Deviation

(S) Figures 2.8 through 2.14 are the actual work sheets used in determining bearing errors. Array heading, array broadside and computed (from compass and steering data) projector bearing are plotted along with the navigation data of the projector.

UNCLASSIFIED

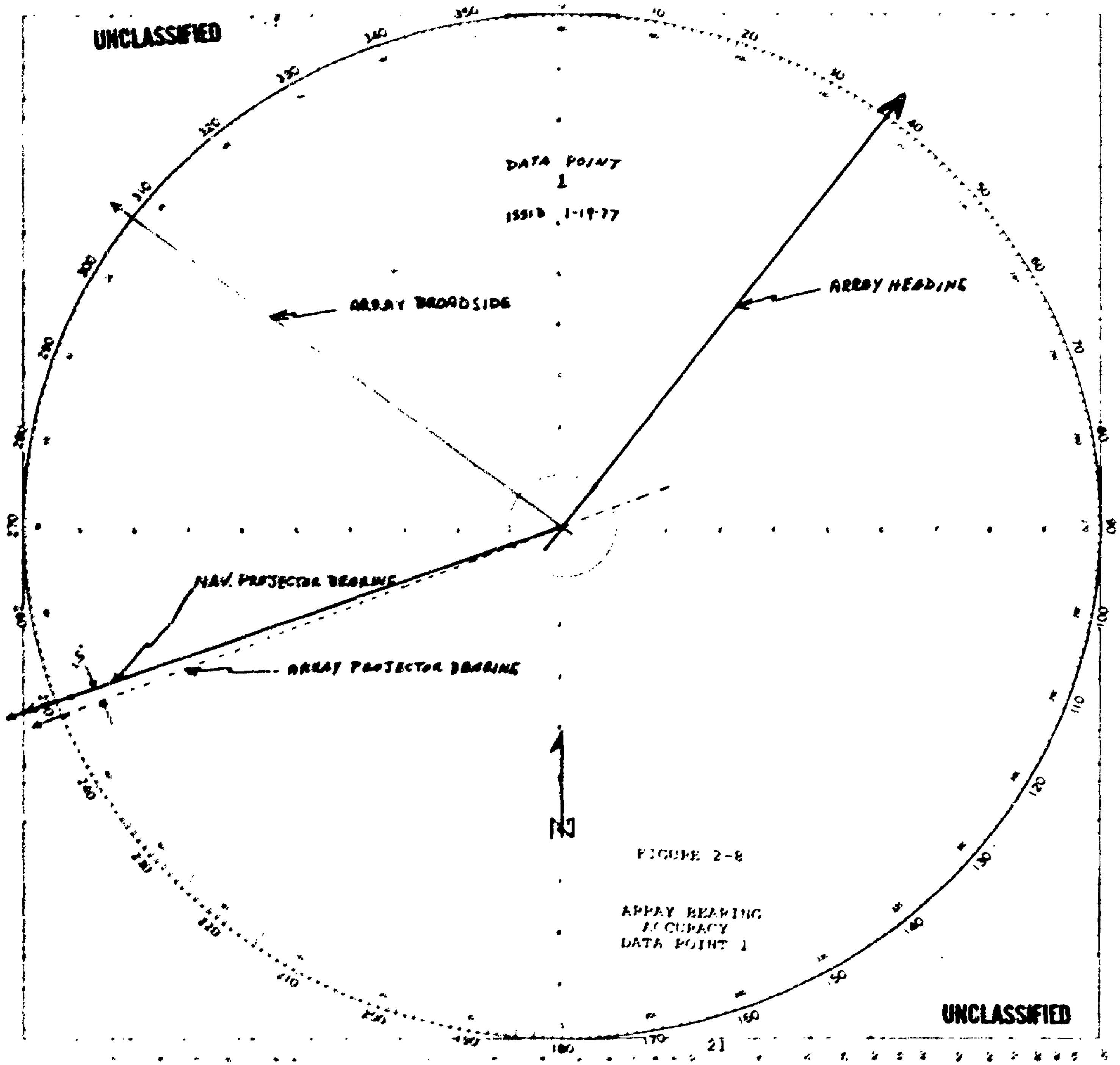


FIGURE 2-8

ARRAY BEARING
ACCURACY
DATA POINT 1

UNCLASSIFIED

UNCLASSIFIED

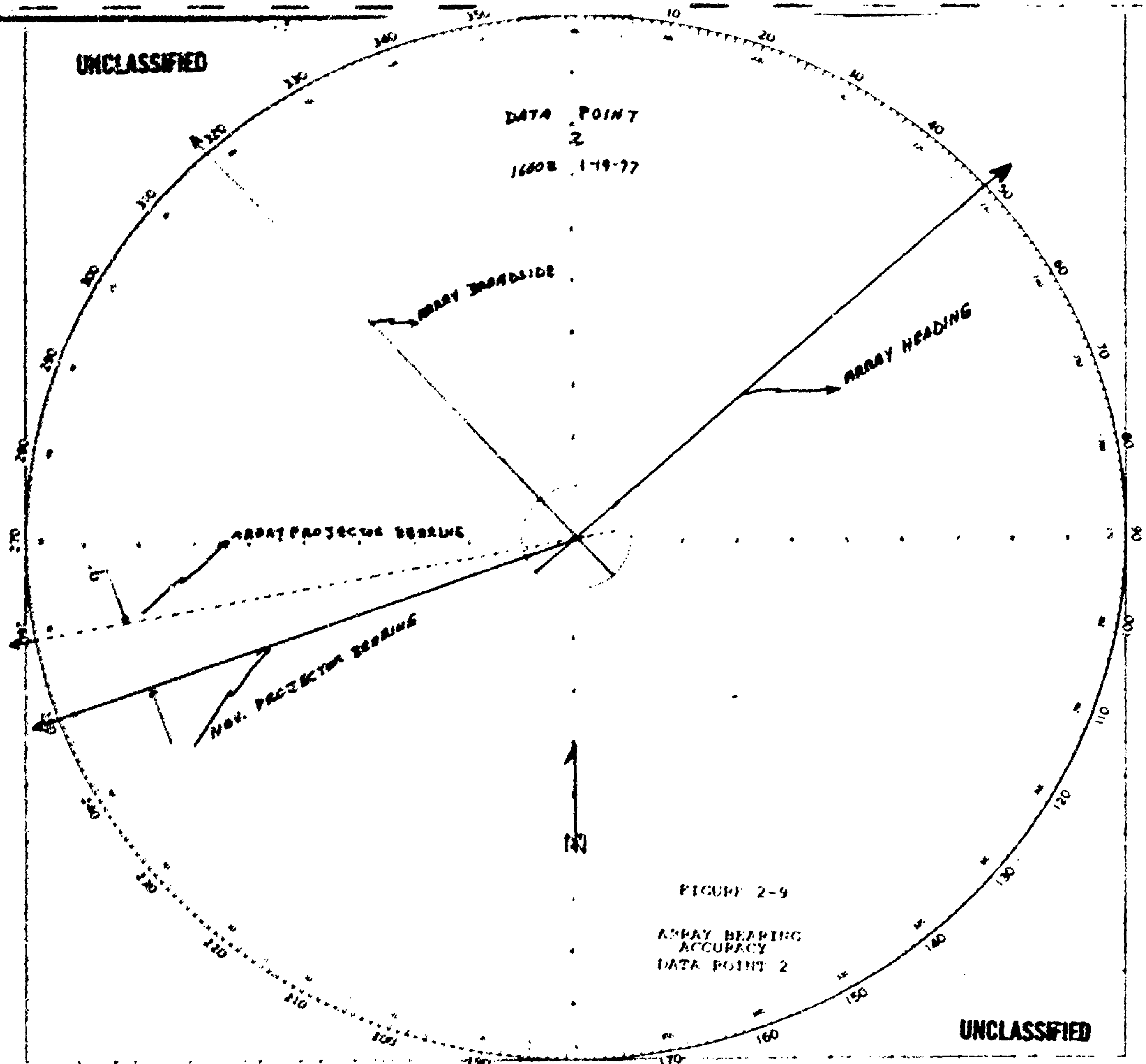
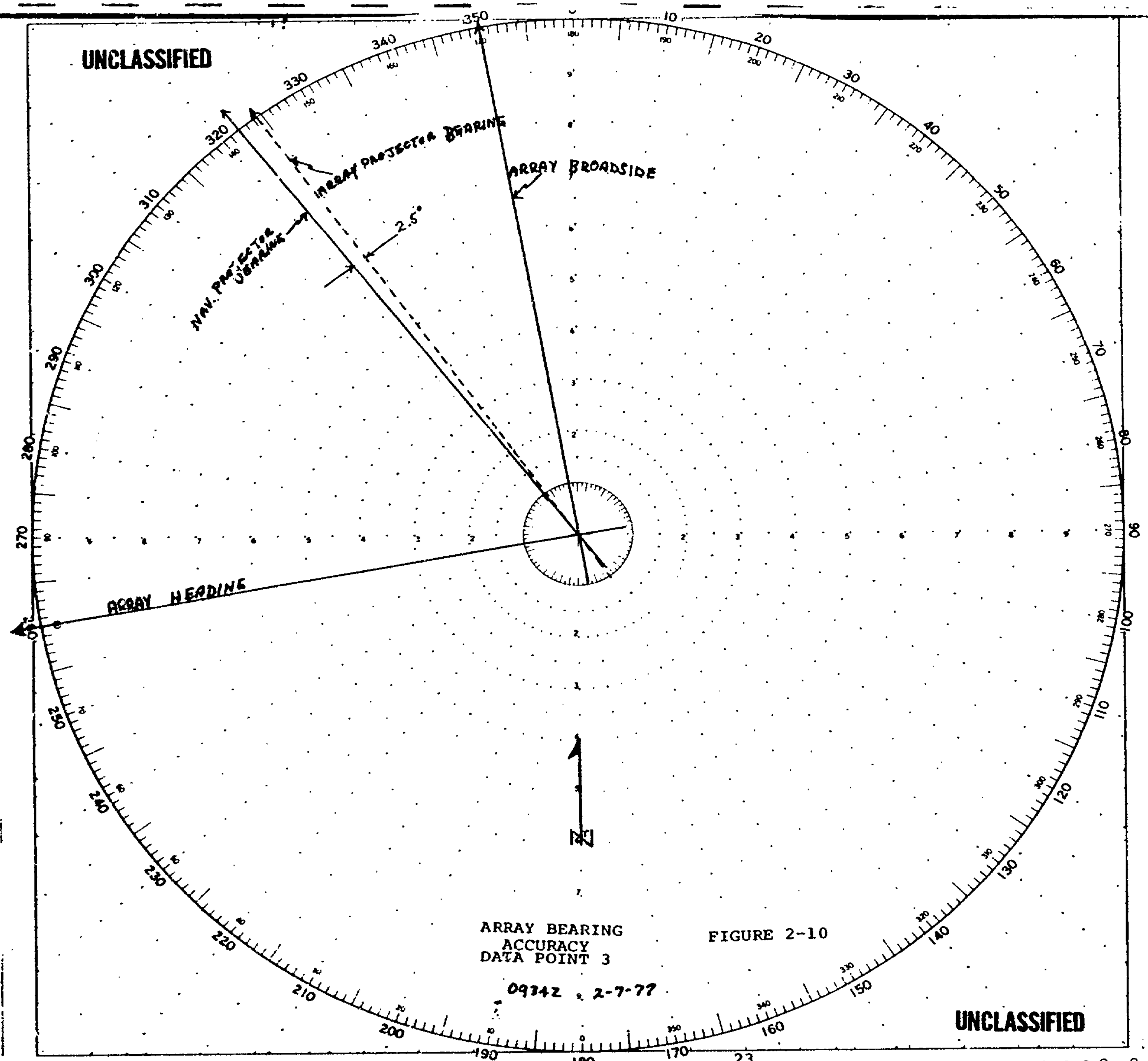


FIGURE 2-9

ARRAY BEARING ACCURACY
DATA POINT 2

UNCLASSIFIED

UNCLASSIFIED



ARRAY BEARING
ACCURACY
DATA POINT 3

FIGURE 2-10

UNCLASSIFIED

UNCLASSIFIED

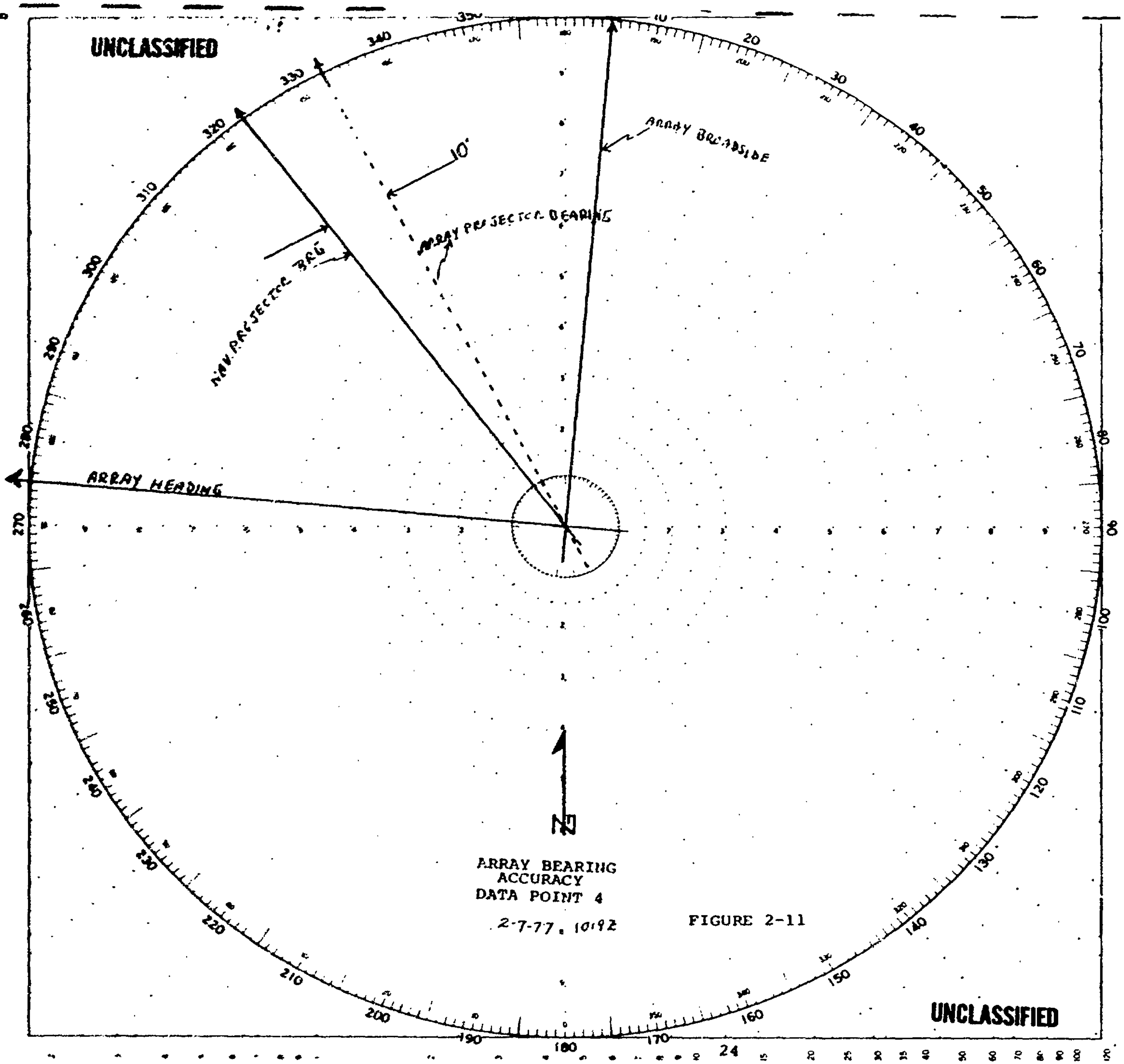
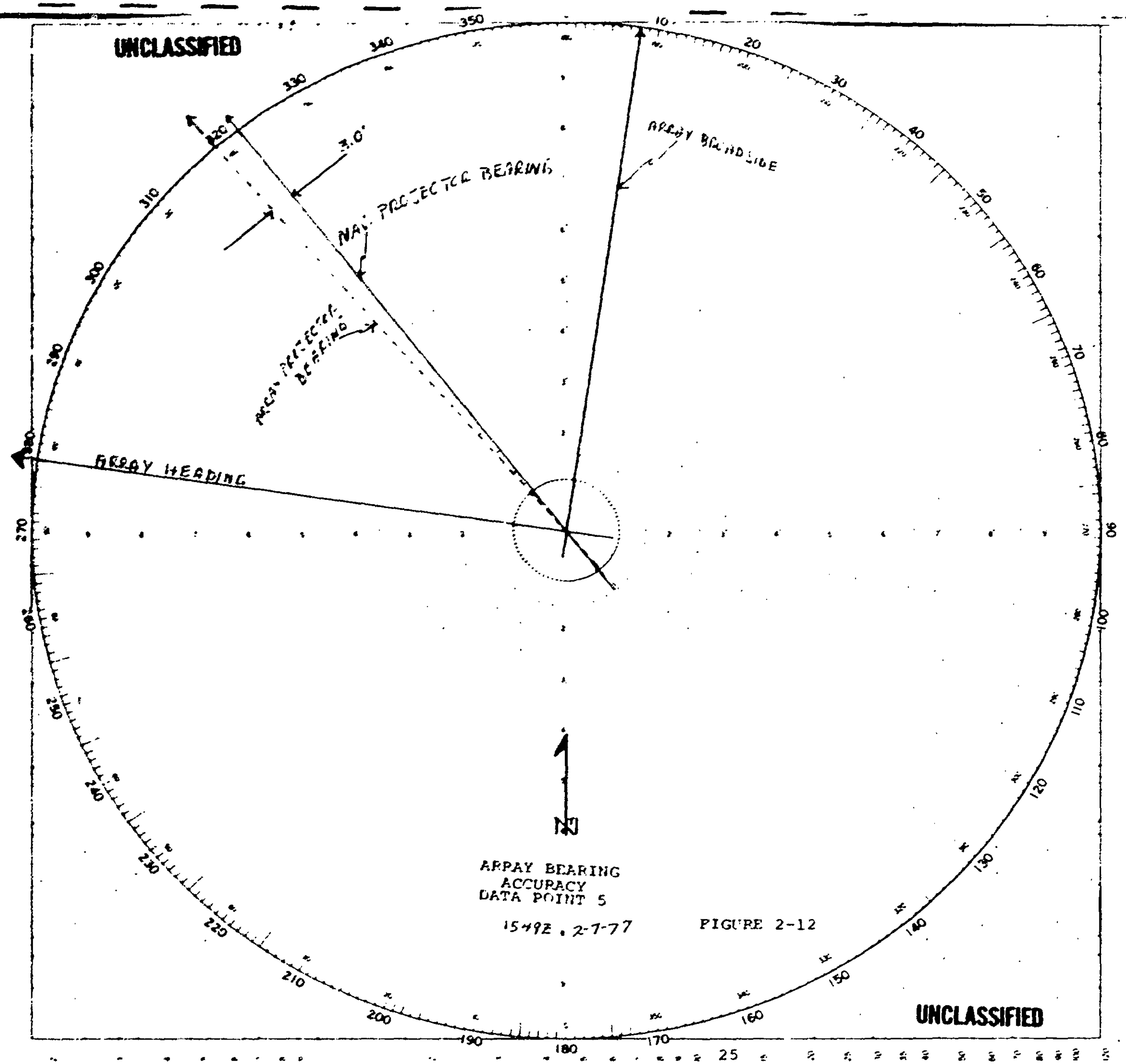


FIGURE 2-11

UNCLASSIFIED

UNCLASSIFIED

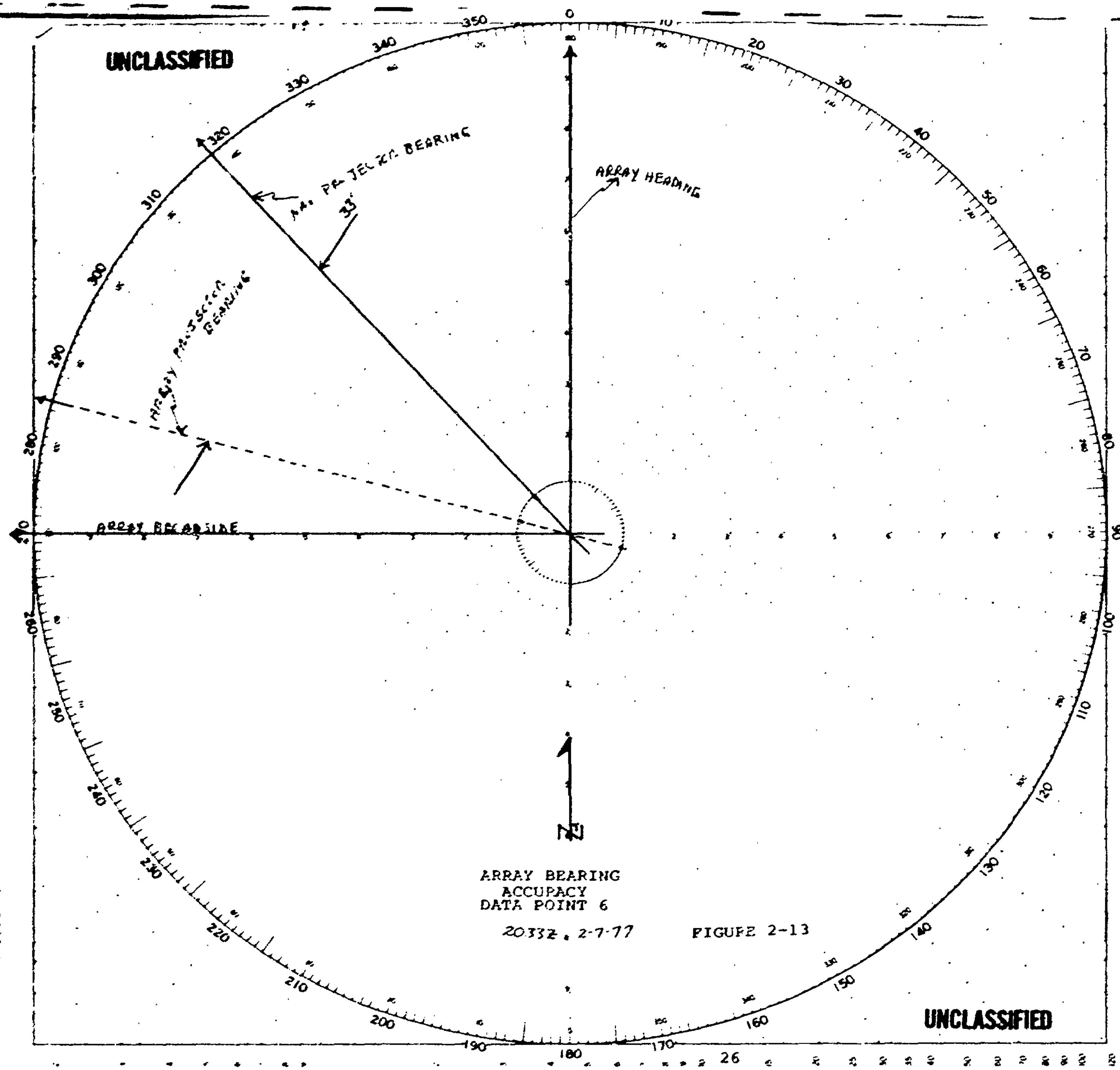


ARRAY BEARING
ACCURACY
DATA POINT 5

15492 . 2-7-77

FIGURE 2-12

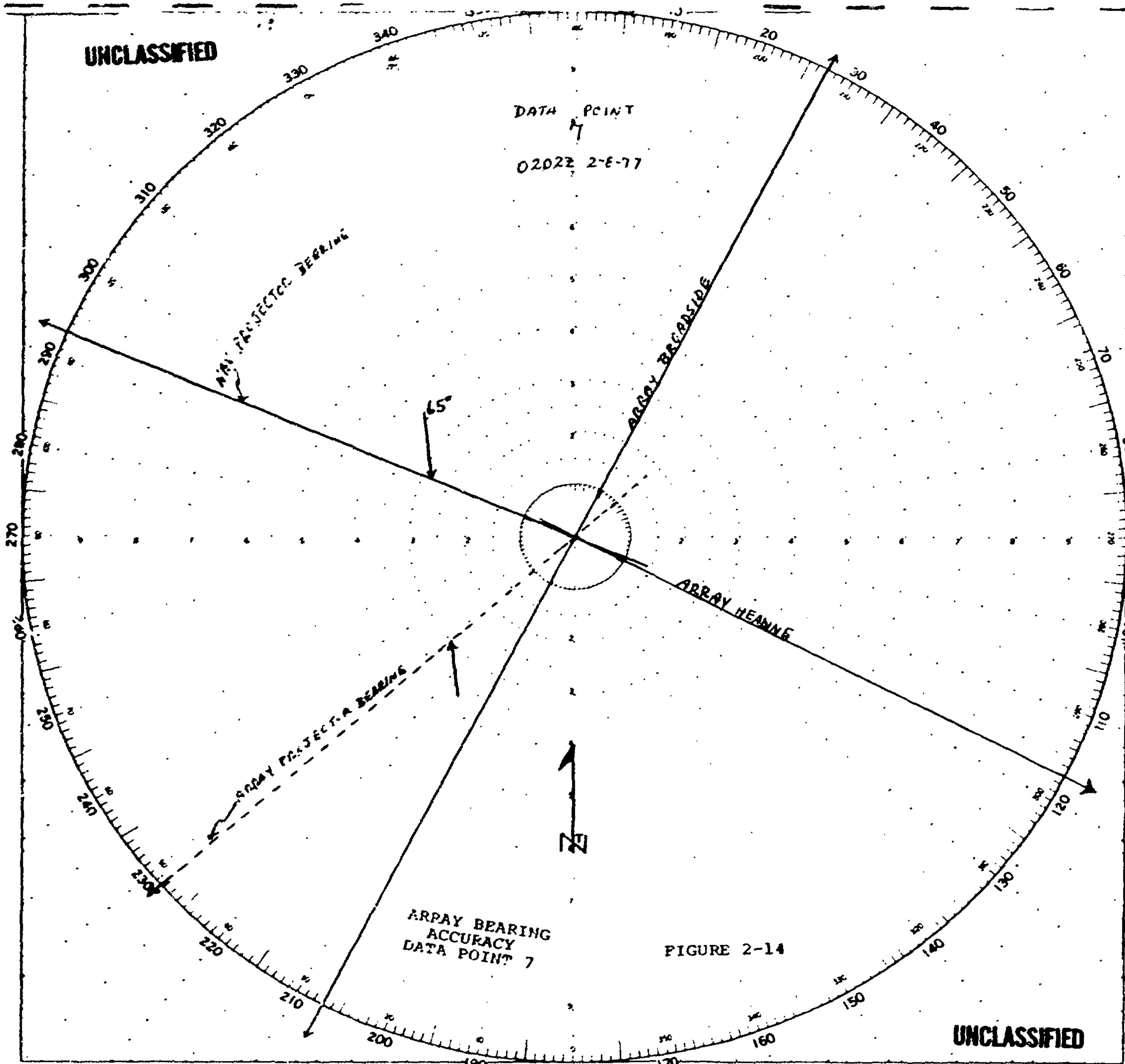
UNCLASSIFIED



ARRAY BEARING
ACCURACY
DATA POINT 6

2033Z, 2-7-77 FIGURE 2-13

UNCLASSIFIED



ARRAY BEARING
ACCURACY
DATA POINT 7

FIGURE 2-14

UNCLASSIFIED

2.5 SUMMARY AND COMPARISON OF ARRAY PERFORMANCE MEASURES (U)

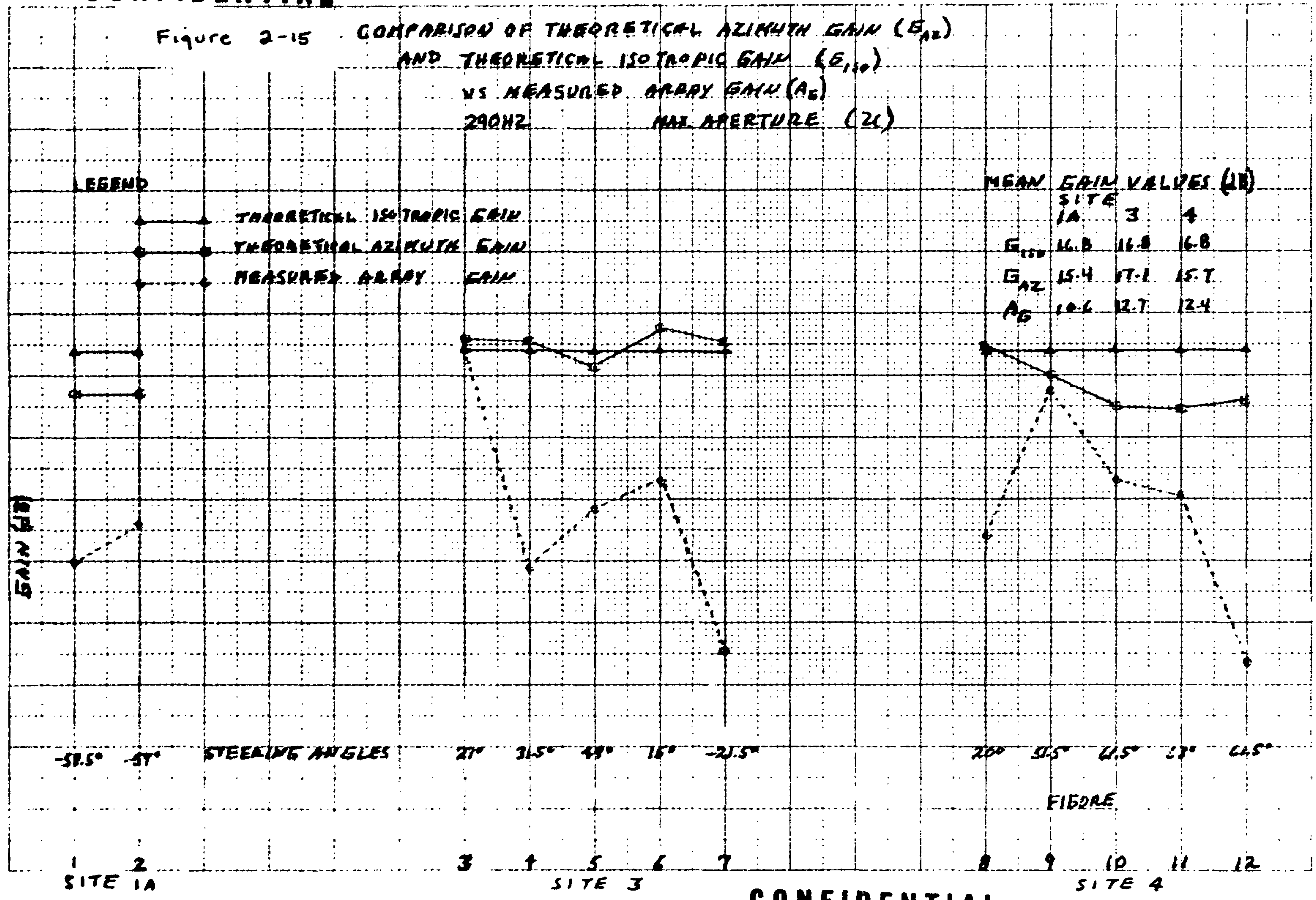
(U) The purpose of this section is to summarize and compare all of the measured array data with theoretical performance. Table 1-2 (Vol IB) compiles results of all the measured data with the exception of signal gain which has a theoretical value of 20 log (number of elements). Comparison of measured and theoretical signal gains are given in Figures 2-1 and 2-2, and on the figures in Appendix A, and will be summarized presently along with beamwidth and array gain data.

(U) Figures 2-15 through 2-23 compare measured array gain, AG, against two theoretical measures of array gain, G_{AZ} and G_{ISO}, under ideal conditions. The steps involved in the determination of measured array gain are discussed in detail in Volume II, Section 3 of this report.

(U) A brief description of the theoretical measures is in order. Azimuth gain, G_{AZ}, is the array gain that results when a two dimensional isotropic noise field (lying entirely in the azimuth plane) is considered. The entire signal is assumed incident on the array maximum response axis MRA, and thus, G_{AZ} is a measure of the array's noise discrimination in the horizontal plane. Isotropic (noise) gain, G_{ISO}, is just the familiar directivity index (DI) of the array, defined similar to azimuth gain except that a three dimensional, isotropic noise field is hypothesized. G_{ISO} is, therefore, a measure of the array's noise rejection characteristic over a three dimensional uniform noise field.

(U) Convenient approximate expressions for azimuth and isotropic gain for a line array of omni directional elements are given as follows:

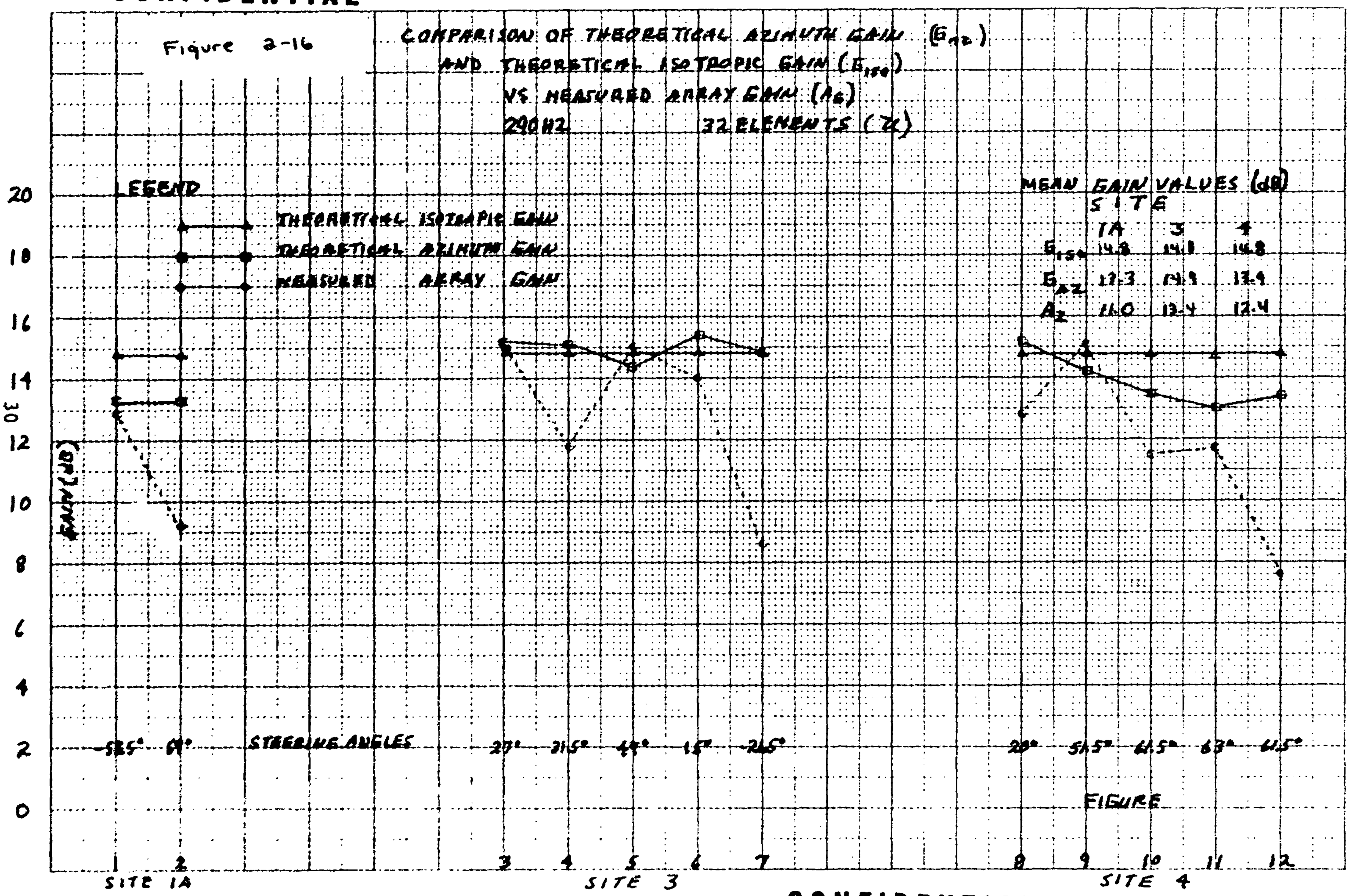
CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL

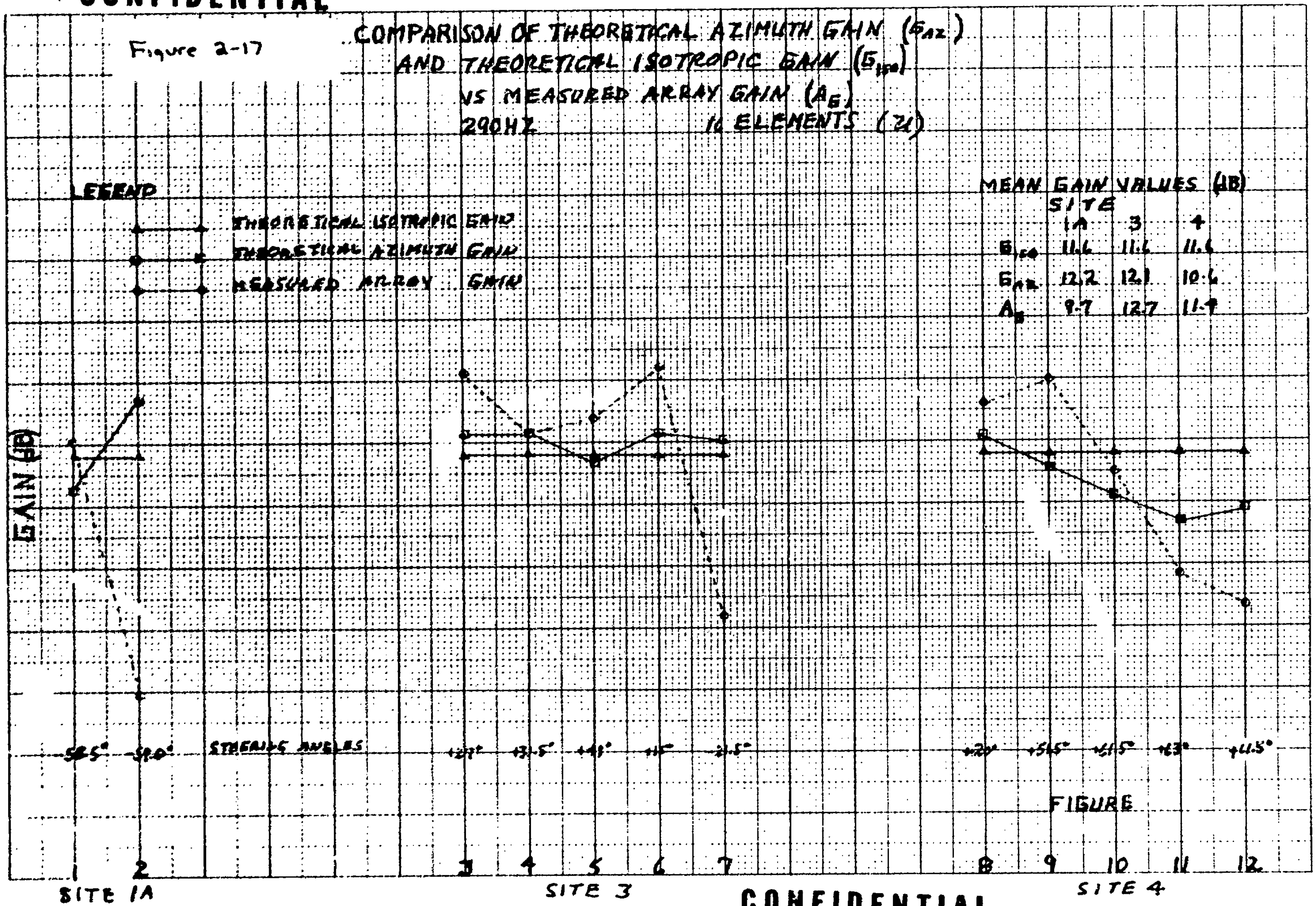
Figure 2-16



CONFIDENTIAL

CONFIDENTIAL

Figure 2-17



CONFIDENTIAL

CONFIDENTIAL

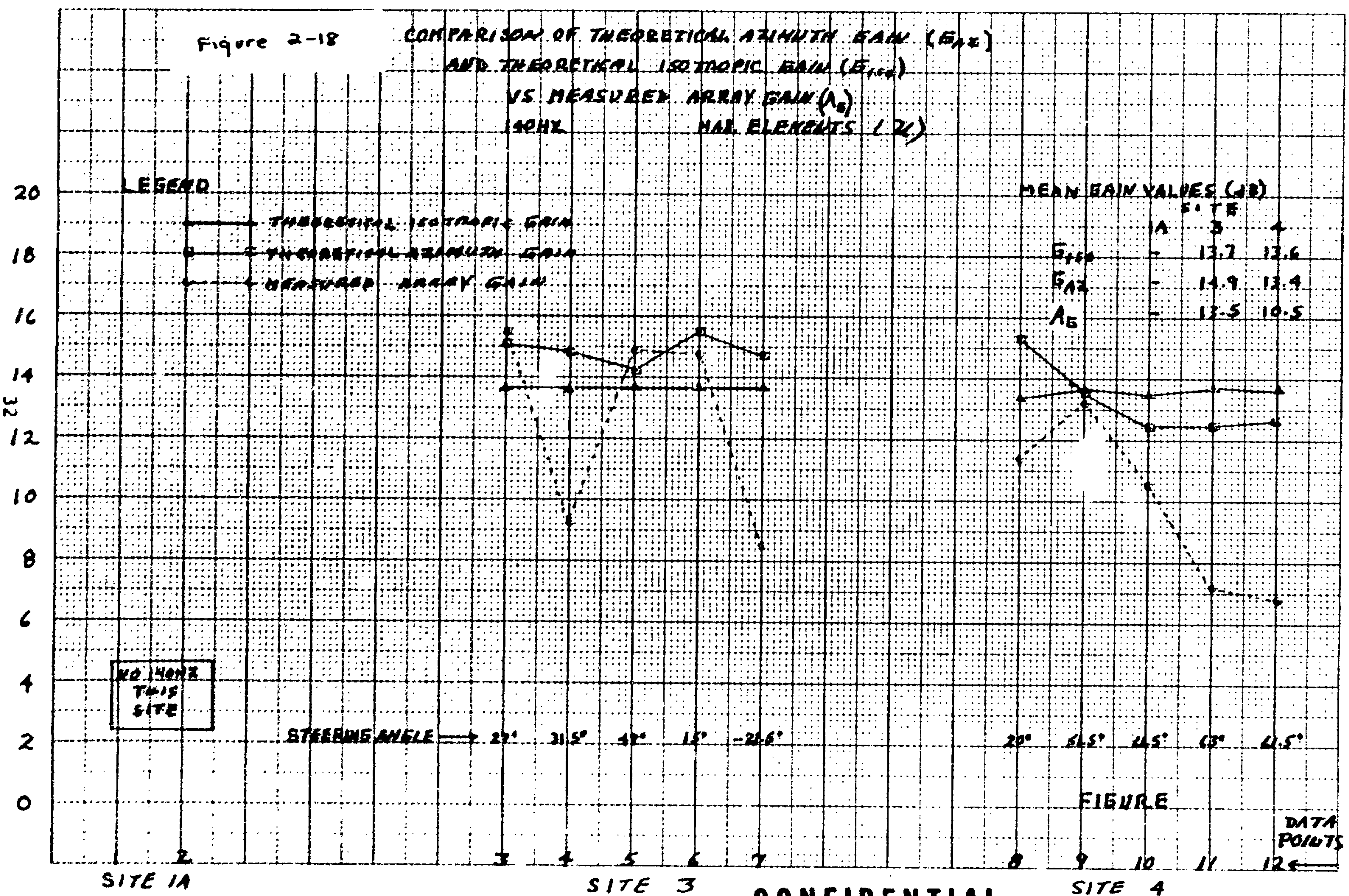
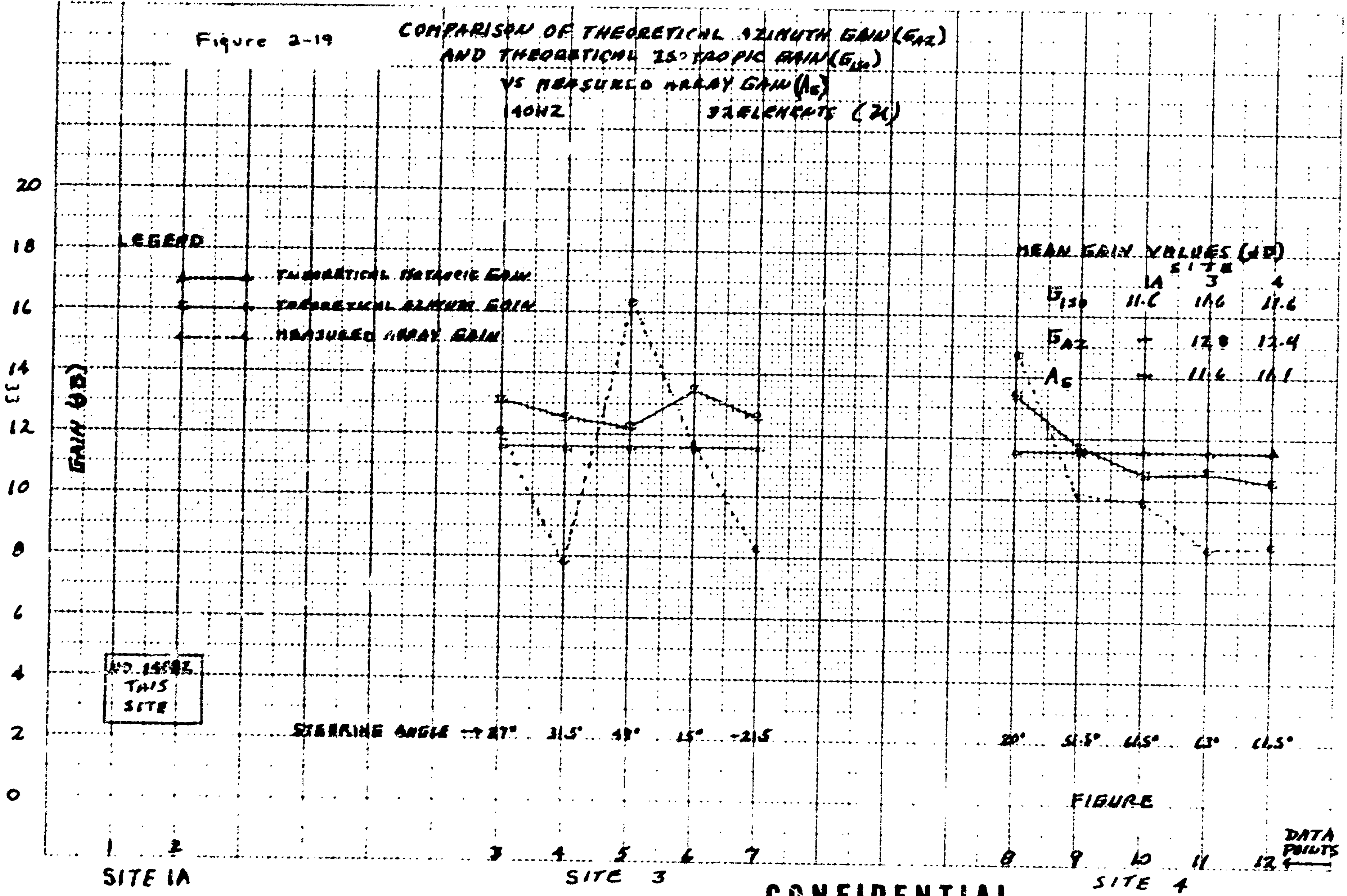


Figure 2-18 COMPARISON OF THEORETICAL AZIMUTH GAIN (G_{AZ}) AND THEORETICAL ISOTROPIC GAIN (G_{ISO}) VS MEASURED ARRAY GAIN (A_G) 140HZ MAX ELEMENTS (21)

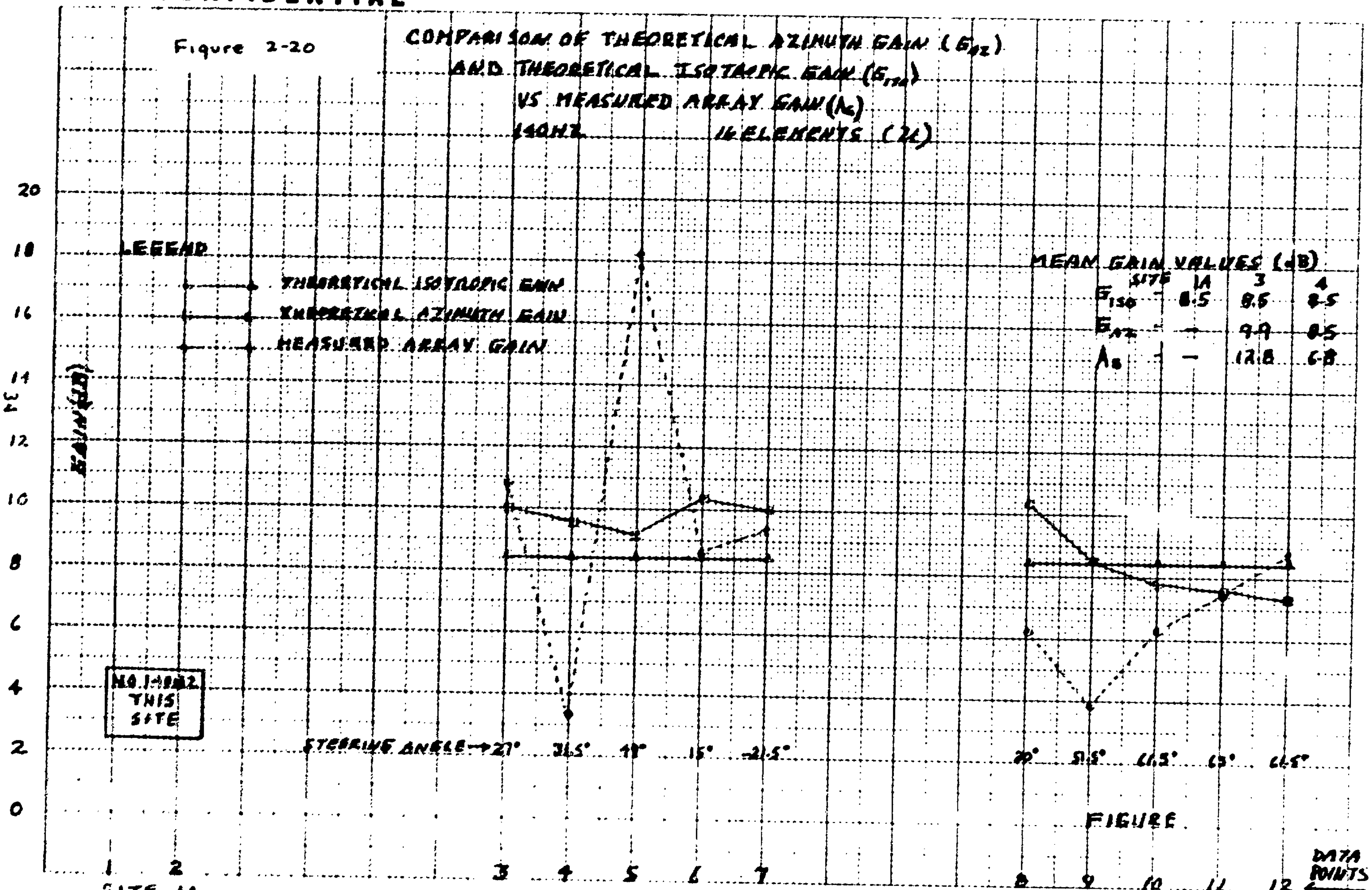
CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

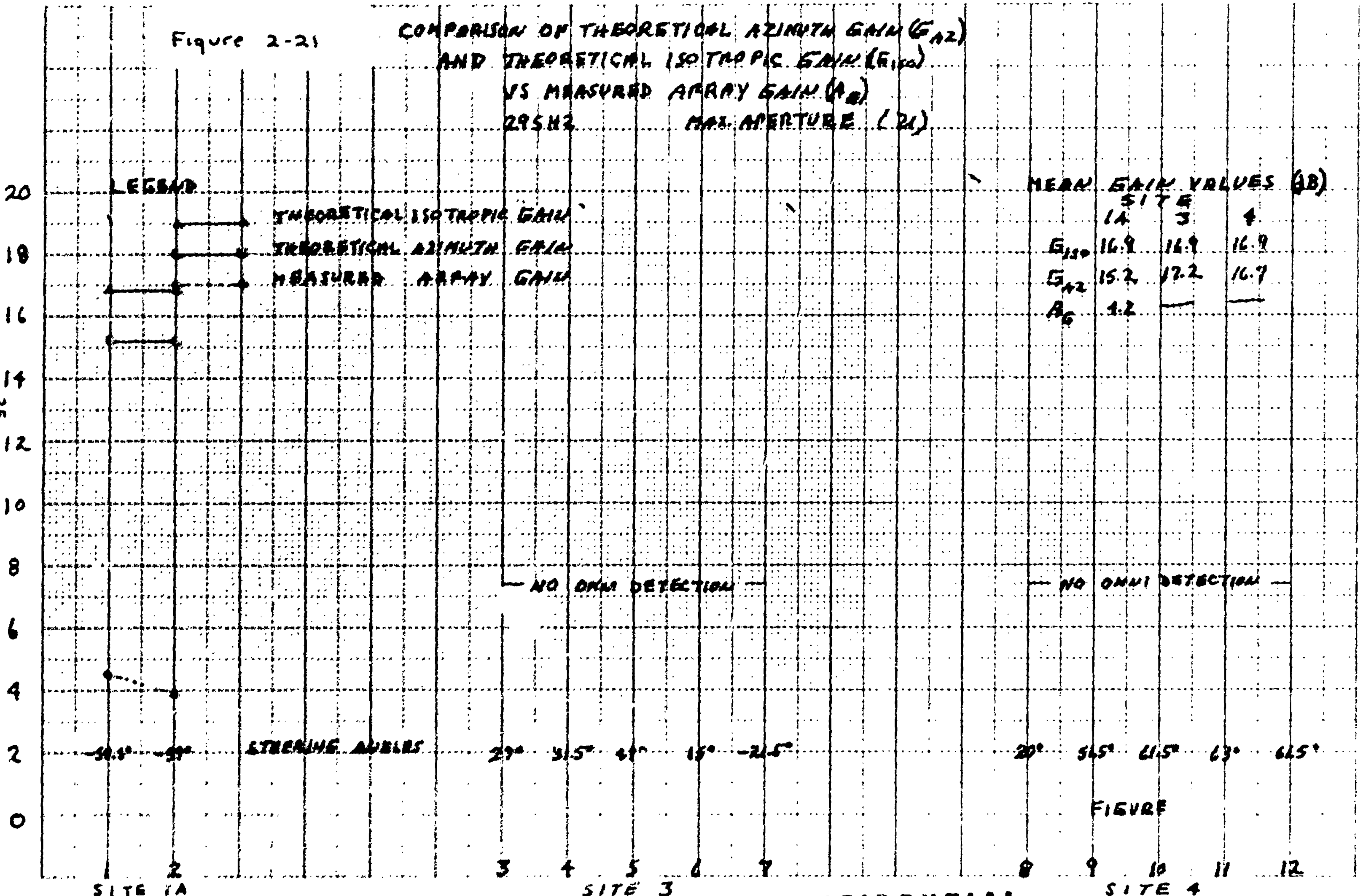
CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL

Figure 2-21



CONFIDENTIAL

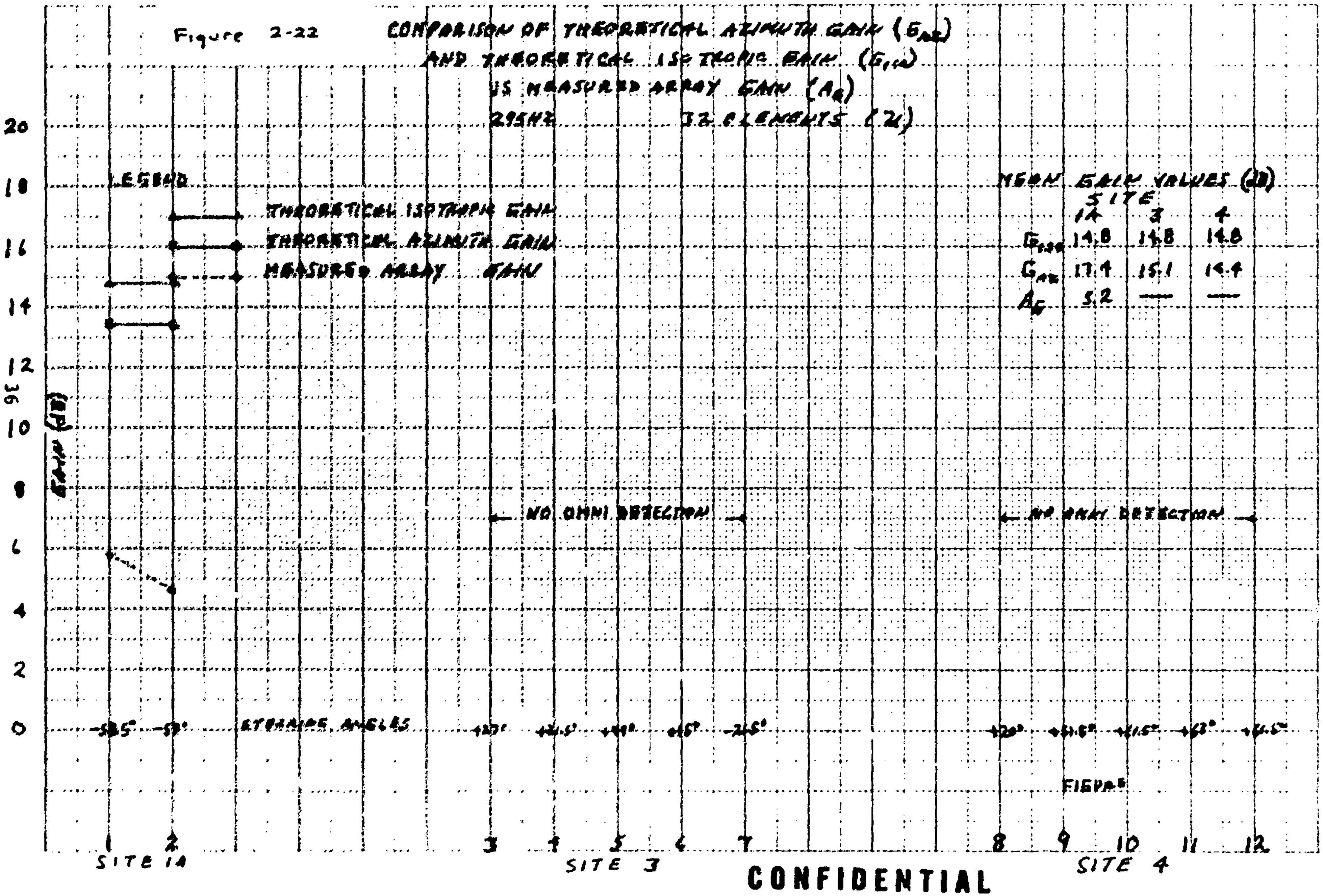
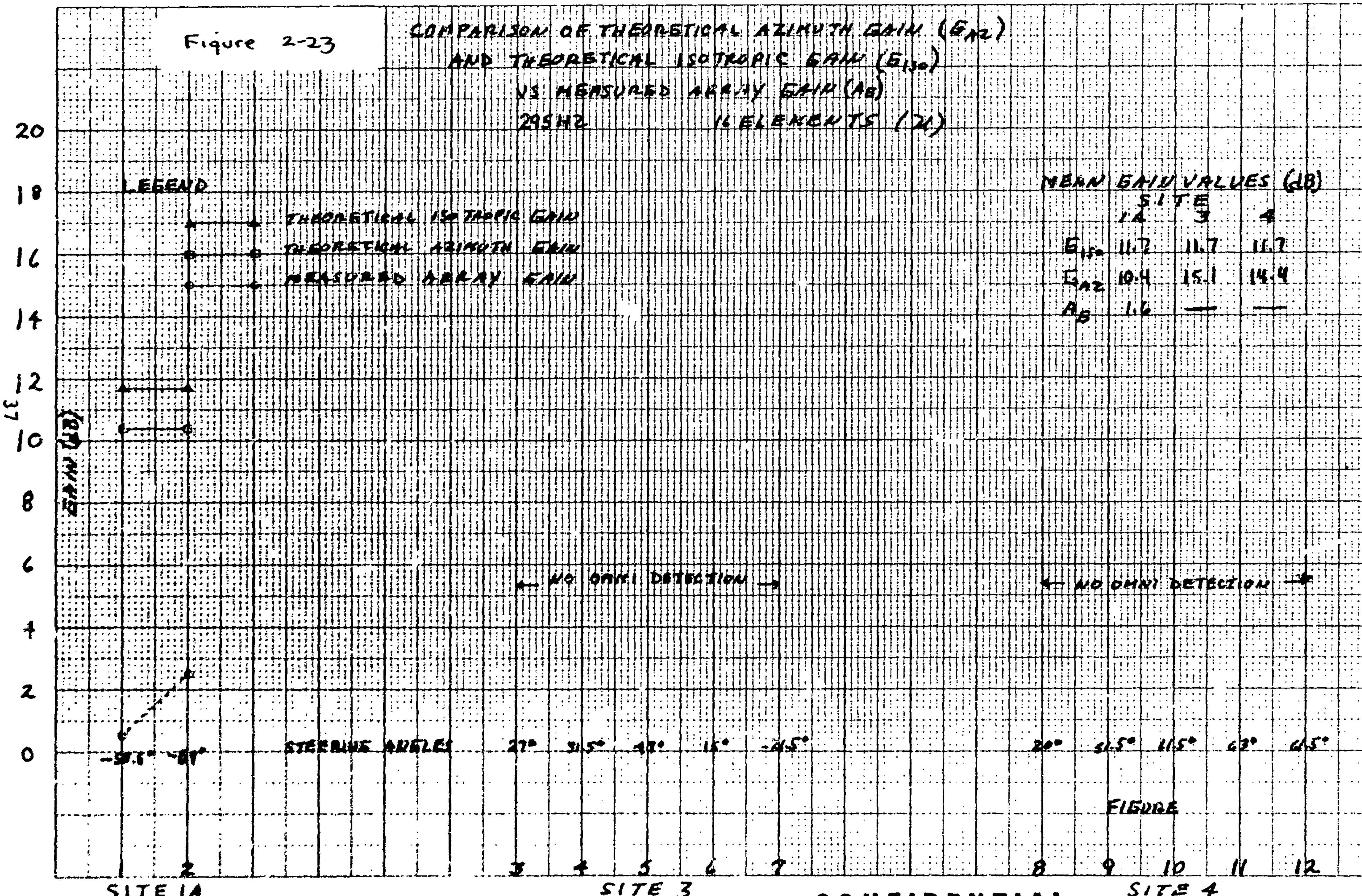


Figure 2-22 COMPARISON OF THEORETICAL AZIMUTH GAIN (G_{AZ}) AND THEORETICAL ISOTROPIC GAIN (G_{iso}) VS MEASURED ARRAY GAIN (A_G) 295HZ 32 ELEMENTS (2L)

K+E 10 X 10 TO ½ INCH KEUFFEL & ESSER CO. MADE IN U.S.A. 46 1323

CONFIDENTIAL

Figure 2-23



CONFIDENTIAL

$$G_{ISO} = 10 \log (2\ L/\lambda) = 10 \log (101.6^{\circ}/\theta_{3B}^{\circ})\ \text{dB} \qquad (2\text{-}2)$$

$$G_{AZ} = 10 \log \left[\pi (L/\lambda) \cos \theta_o\right] = 10 \log (159.6^{\circ}/\theta_3^{\circ})\ \text{dB} \qquad (2\text{-}3)$$

where

L = array length

λ = acoustic wavelength

θ_{3B}° = the 3 dB beamwidth in degrees when the array is steered to broadside

θ_3° = the 3 dB beamwidth in degrees independent of the steering imposed

and

θ_o is the beam steering angle off broadside.

(U) In addition to plotted gain, the summary figures contain mean theoretical and measured gain values for each site, and steering angles, which affect azimuth gain. These figures show that the measured array gain tends to correlate somewhat better with azimuth gain than isotropic gain (against which it was compared in Figures 2-1, 2-2 and the figures in Appendix A).

(U) In summarizing beamwidth measurements, it was found convenient to plot broadside equivalent beamwidth, obtained from measured values by adjusting for the steer angle:

$$\hat{\theta}_{3B} = \hat{\theta}_3 \cos \hat{\theta}_o, \qquad (2\text{-}4)$$

where

$\hat{\theta}_3$ = measured beamwidth at measured steer angle $\hat{\theta}_o$.

$\hat{\theta}_{3B}$ = broadside equivalent beamwidth.

This provides a better theoretical reference for visualization of deviations from theoretical, as shown in Figures 2-24 through 2-32.

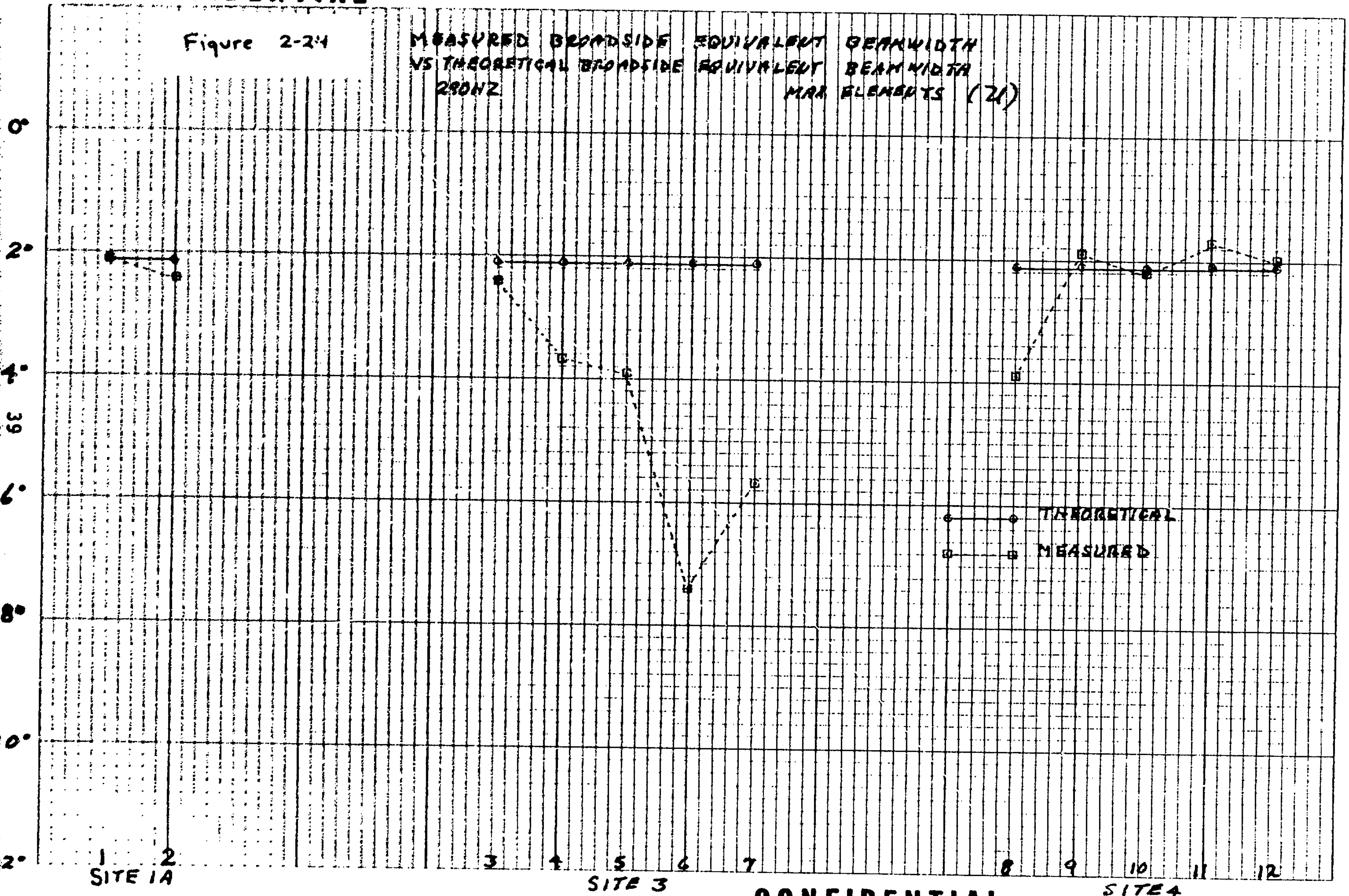

MEASURED BROADSIDE EQUIVALENT BEAMWIDTH
VS THEORETICAL BROADSIDE EQUIVALENT BEAMWIDTH
280HZ
MAX ELEMENTS (21)
0°
2°
4°
6°
8°
10°
12°
1
2
SITE 1A
3
4
5
6
7
SITE 3
8
9
10
11
12
SITE 4
THEORETICAL
MEASURED

Figure 2-24

CONFIDENTIAL

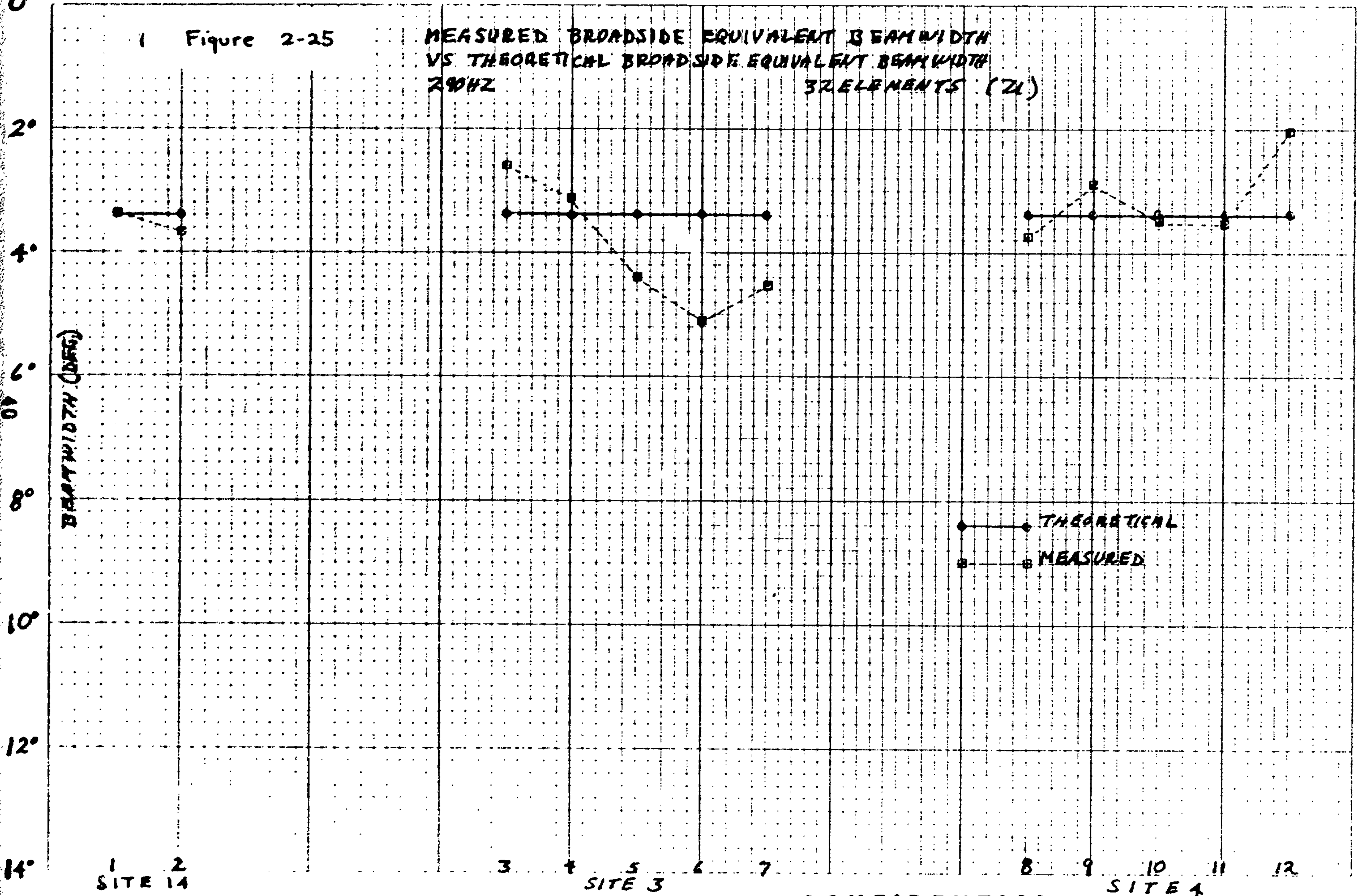
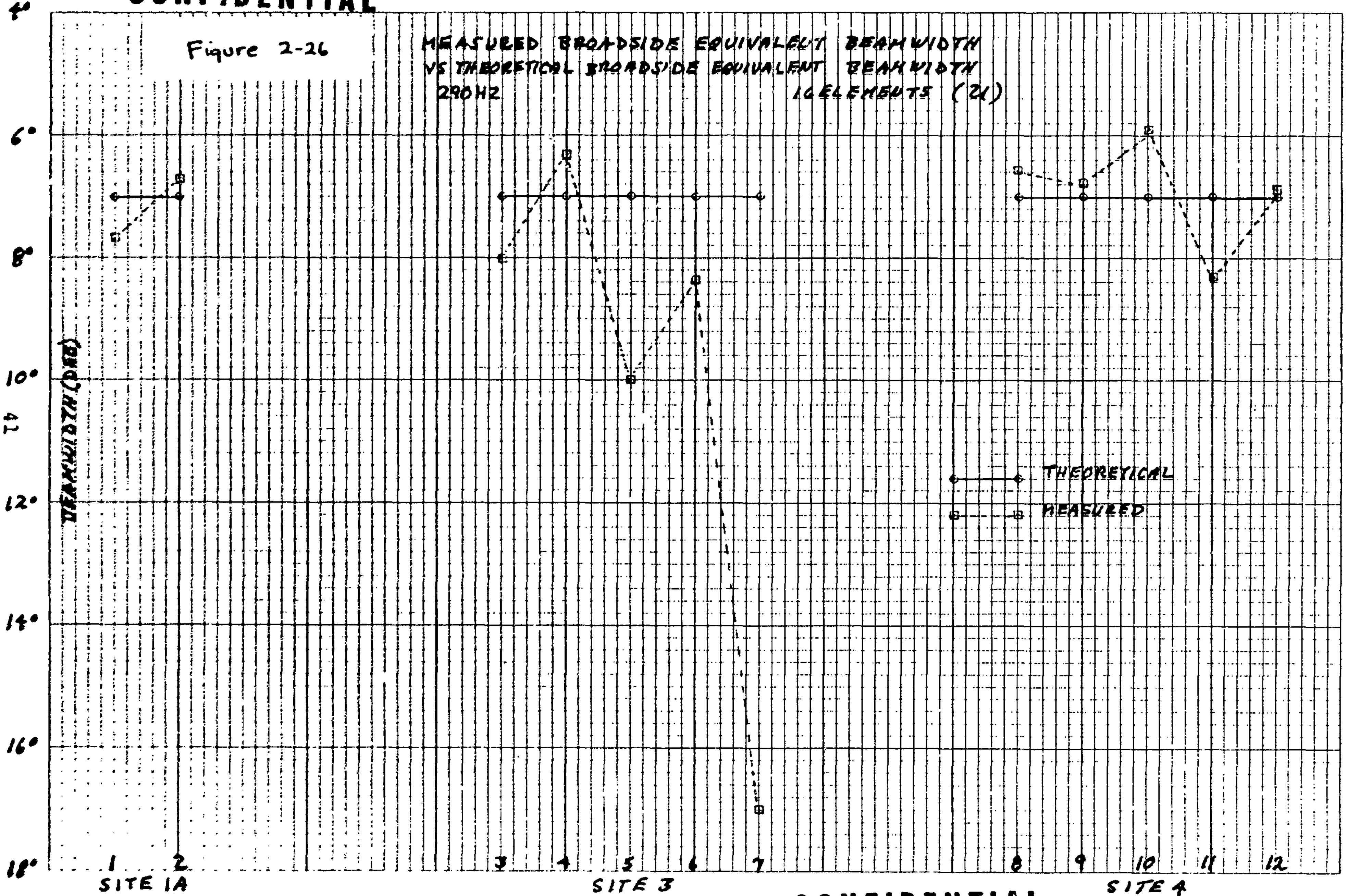


Figure 2-25 MEASURED BROADSIDE EQUIVALENT BEAMWIDTH VS THEORETICAL BROADSIDE EQUIVALENT BEAMWIDTH 28HZ 32 ELEMENTS (21)

CONFIDENTIAL

CONFIDENTIAL

Figure 2-26

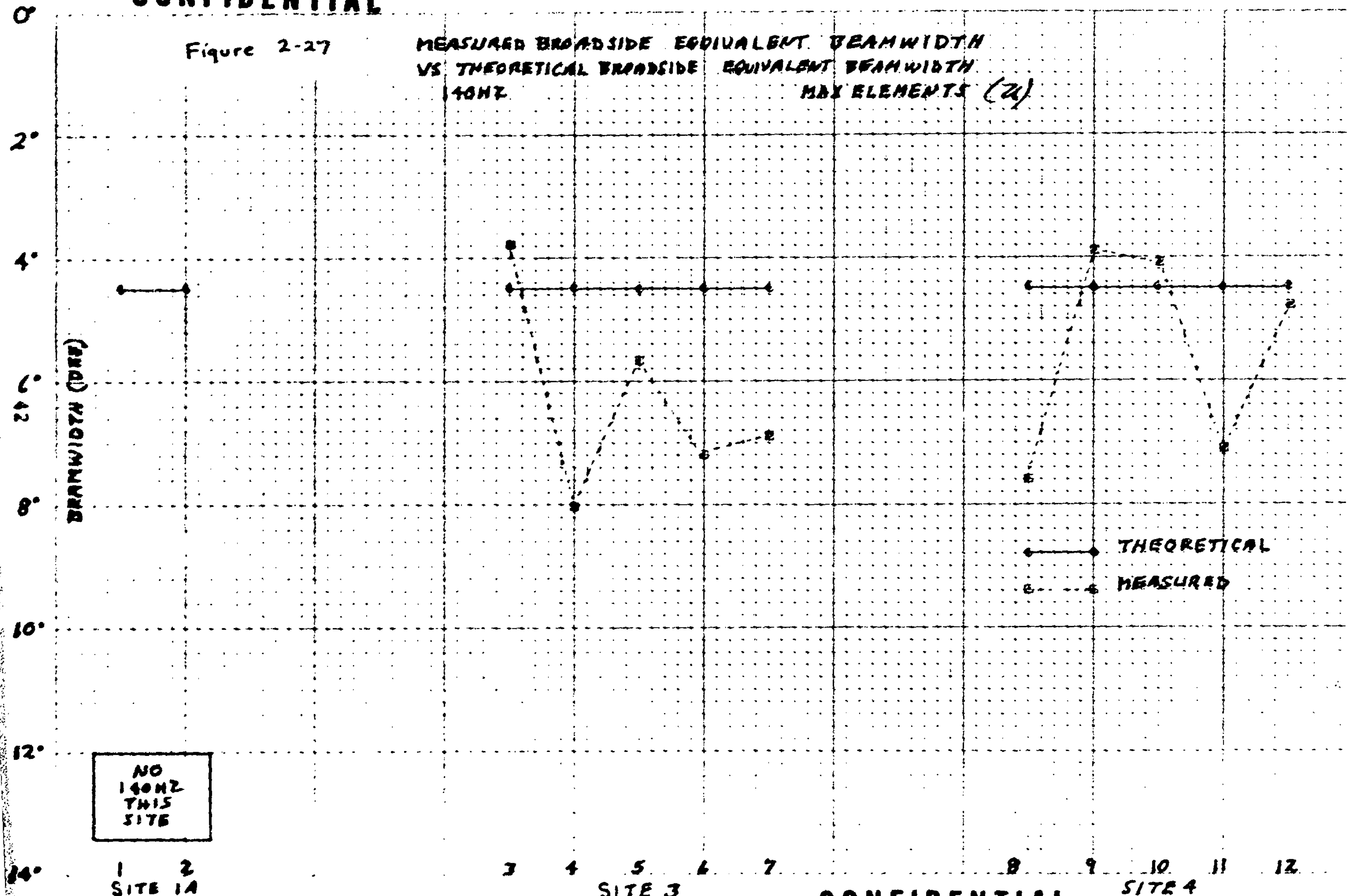


CONFIDENTIAL

46 0703

CONFIDENTIAL

Figure 2-27 MEASURED BROADSIDE EQUIVALENT BEAMWIDTH VS THEORETICAL BROADSIDE EQUIVALENT BEAMWIDTH 140HZ MAX ELEMENTS (U)

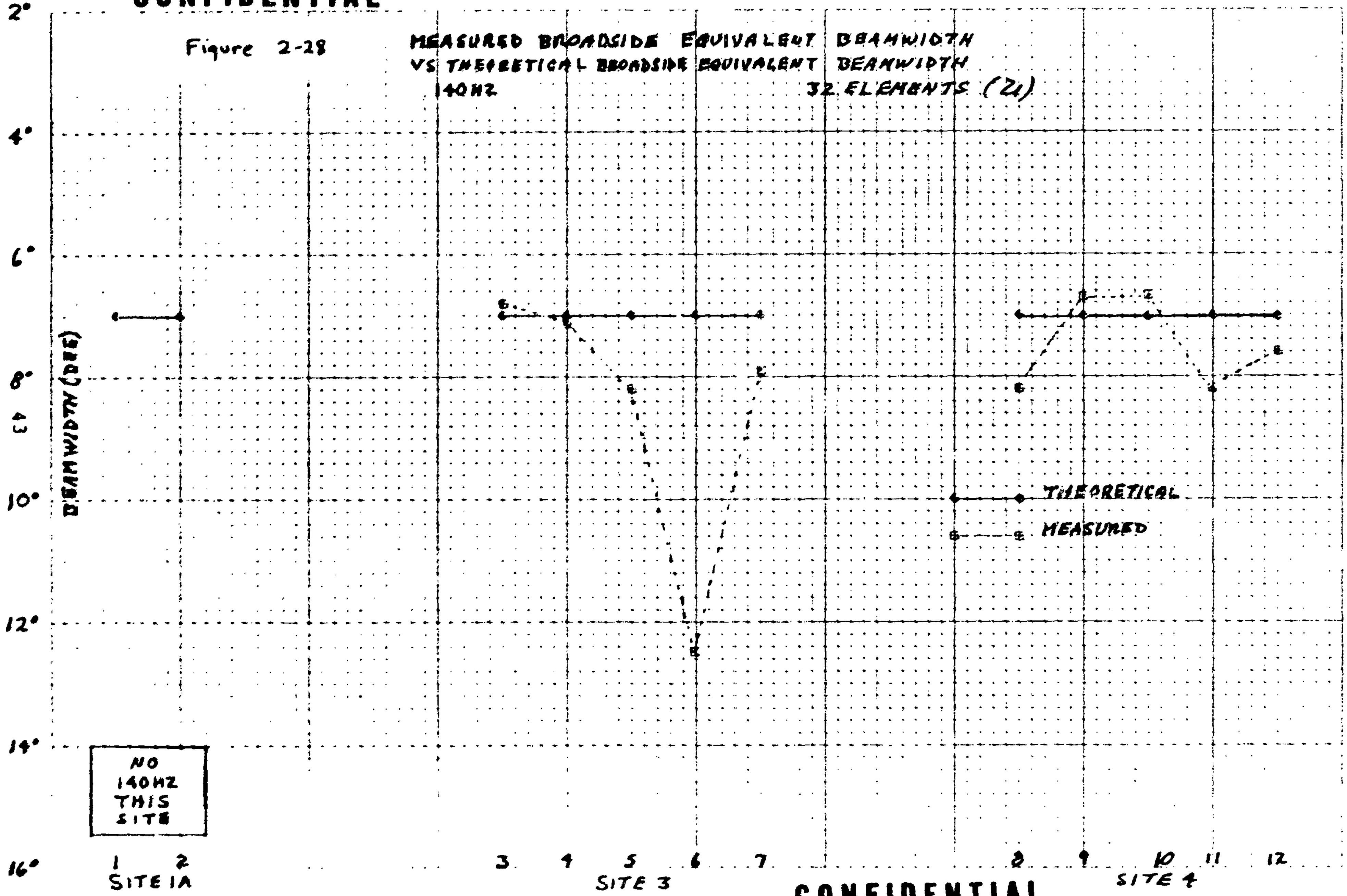


42

CONFIDENTIAL

CONFIDENTIAL

Figure 2-28



CONFIDENTIAL

K•E

46 0703

CONFIDENTIAL

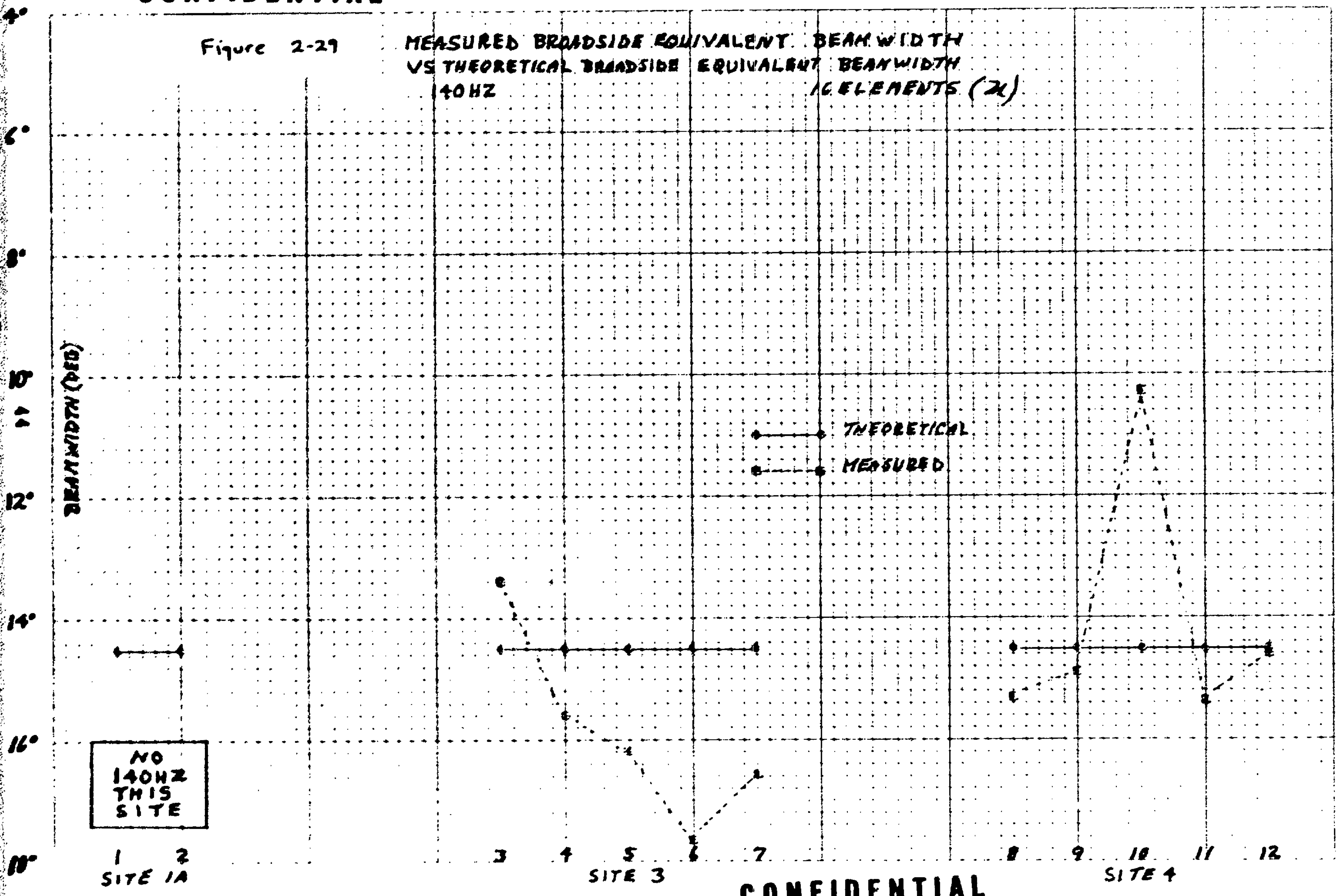


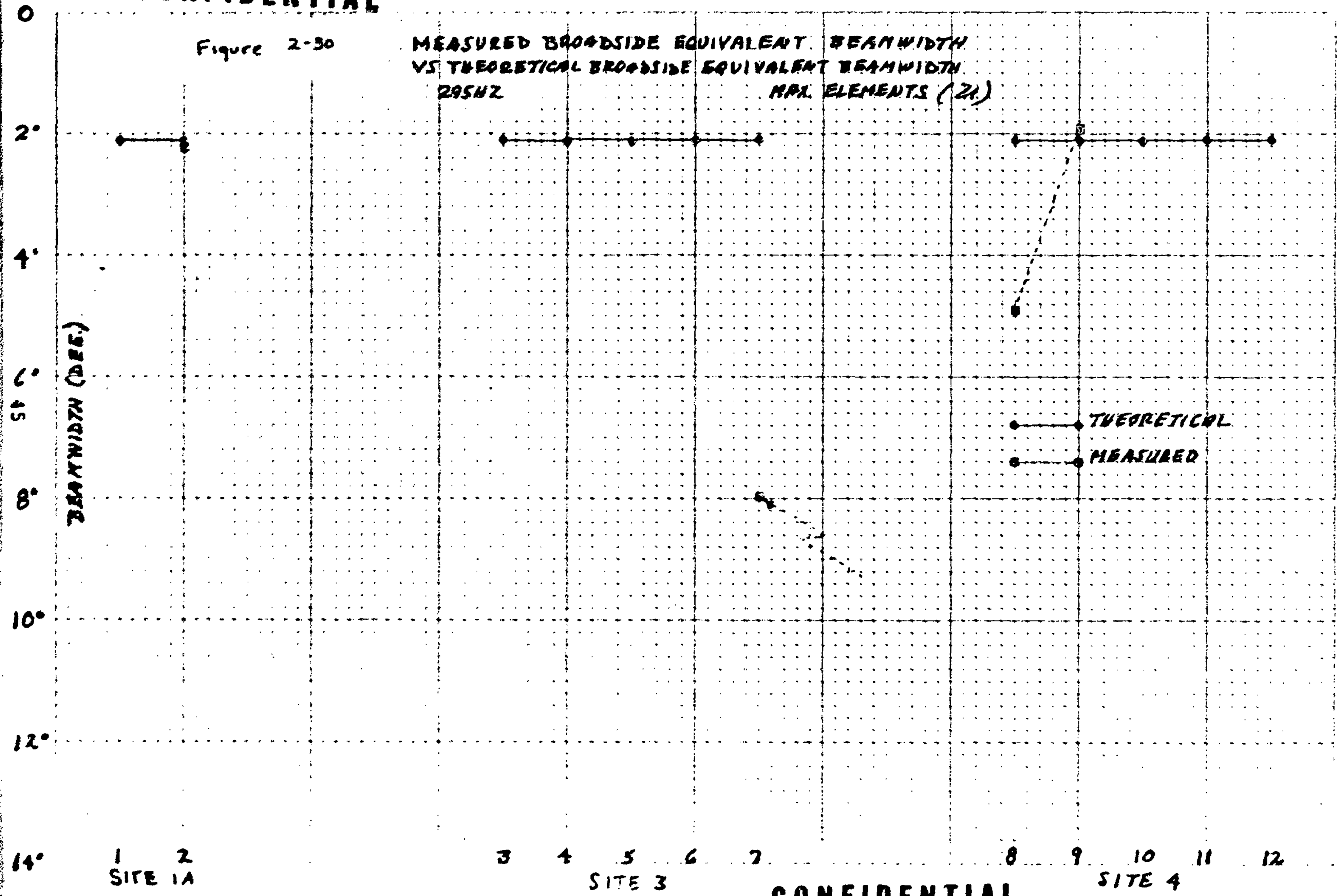
Figure 2-29 MEASURED BROADSIDE EQUIVALENT BEAMWIDTH VS THEORETICAL BROADSIDE EQUIVALENT BEAMWIDTH 140HZ 16 ELEMENTS (X)

44

CONFIDENTIAL

CONFIDENTIAL

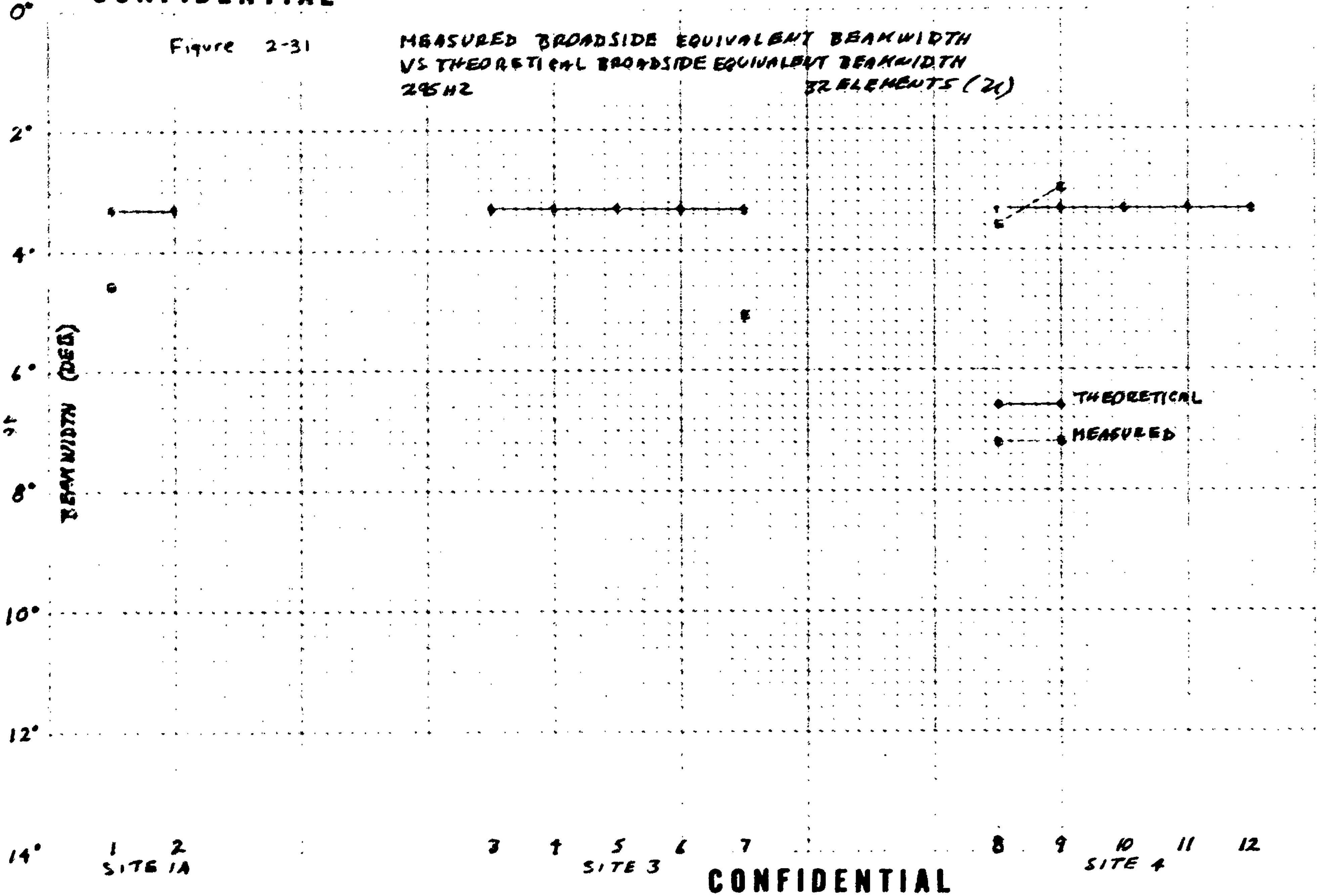
Figure 2-30 MEASURED BROADSIDE EQUIVALENT BEAMWIDTH VS THEORETICAL BROADSIDE EQUIVALENT BEAMWIDTH 29SHZ MAX. ELEMENTS (21)



CONFIDENTIAL

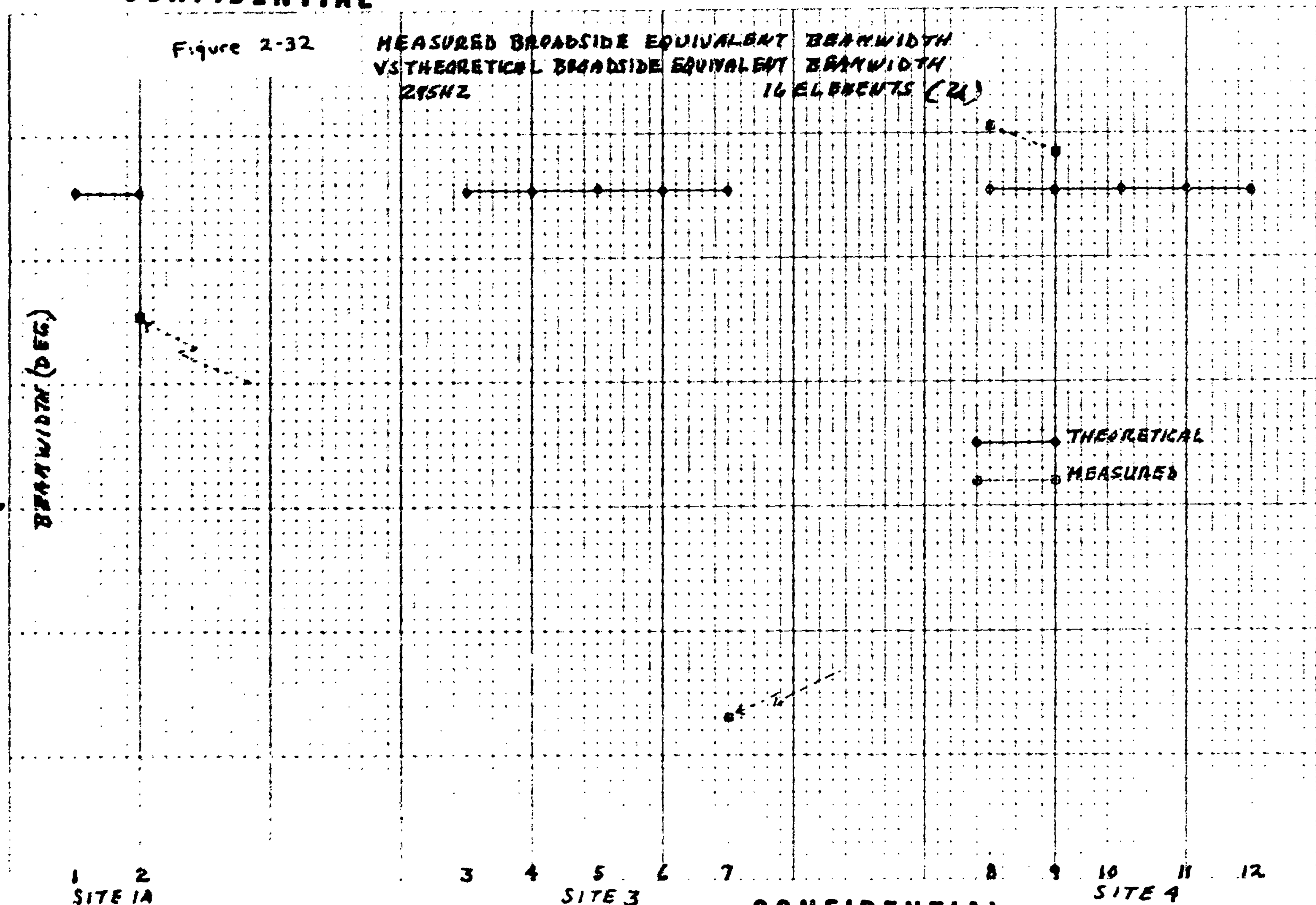
CONFIDENTIAL

Figure 2-31 MEASURED BROADSIDE EQUIVALENT BEAMWIDTH VS THEORETICAL BROADSIDE EQUIVALENT BEAMWIDTH 295 HZ 32 ELEMENTS (2L)



CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

(U) The overall array performance summary is presented in a series of tables which contain the differences in measured performance vs theoretical. Tables 2-5 through 2-7 show beam-width differences from theoretical, and indicate mean and rms differences as a function of site and aperture size. Tables 2-8 through 2-10 summarize signal gain differences from theoretical with mean differences noted. Tables 2-11 through 2-13 list array gain differences.

(U) These last nine tables are further compressed into three array performance summary tables which present ready visualization of the BEARING STAKE results. Tables 2-14, 2-15 and 2-16 correspond to frequencies 290, 140 and 295 Hz respectively.

(S) Table 2-5 Summary of Measured Beamwidth vs Theoretical (U)

Frequency = 290 Hz

		Beamwidth difference from theoretical for number of elements shown		
Site	DP#	16	32	MAX
1A	1	2.3°	0.7°	0.3°
	2	-0.4°	1.2°	0.9°
	Mean Error	0.95°	0.95°	0.6°
	rms Error	1.65°	1.0°	0.7°
3	3	1.7°	-0.6°	0.6°
	4	-0.7°	-0.1°	2.1°
	5	2.9°	2.0°	2.9°
	6	1.9°	2.1°	5.8°
	7	11.0°	1.4°	4.0°
	Mean Error	3.36°	1.0°	3.1°
	rms Error	5.22°	1.5°	3.5°
4	8	0°	0.7°	1.3°
	9	0.2°	-0.3°	-0.1°
	10	0.8°	1.2°	0.6°
	11	3.1°	0.9°	-0.5°
	12	0°	-2.2°	0.1°
	Mean Error	0.82°	0.1°	0.3°
	rms Error	1.43°	1.2°	0.7°

2.58° rms error for 36 points

2.1° rms error for full aperture (max.)

(S) Table 2-6 Summary of Measured Beamwidth vs Theoretical (U)

Frequency = 140 Hz

Site	DP#	16	32	MAX
		Beamwidth difference from theoretical for number of elements shown		
1A	1	140 Hz not projected in Site 1A		
Mean Error rms Error				
	3	-0.1°	0.3°	-0.3°
	4	1.0°	0.9°	5.1°
3	5	1.4°	2.2°	2.3°
	6	3.9°	6.1°	3.3°
	7	2.2°	0.4°	2.4°
Mean Error		1.68°	2.0°	2.6°
rms Error		2.15°	2.9°	3.1°
	8	2.2°	1.9°	3.9°
	9	1.8°	0.4°	-0.1°
4	10	-2.3°	1.5°	0.1°
	11	3.8°	3.1°	6.5°
	12	-5.8°	2.1°	1.5°
Mean Error		-0.1°	1.8°	2.4°
rms Error		3.5°	2.0°	3.5°

2.91° rms error for 30 points

3.28° rms error for full aperture (Max)

(S) Table 2-7 Summary of Measured Beamwidth vs Theoretical (U)

Frequency = 295 Hz

		Beamwidth difference for theoretical for number of elements shown		
Site	DP #	16	32	MAX
1A	1	-	3.0°	0.4°
	2	4.0°	-	-
Mean Error		4.0°	3.0°	0.4°
rms Error		4.0°	3.0°	0.4°
3	3	-	-	-
	4	-	-	-
	5	-	-	-
	6	-	-	-
	7	9.6°	2.2°	6.5°
Mean Error		9.6°	2.2°	6.5°
rms Error		9.6°	2.2°	6.5°
4	8	-0.3°	0.7°	3.2°
	9	-0.3°	-0.1°	0°
	10	-	-	-
	11	-	-	-
	12	-	-	-
Mean Error		-0.3°	0.3°	1.6°
rms Error		0.3°	0.5°	2.26°

3.82° rms error for 12 points

3.63° rms error for full aperture (MAX)

(S) Table 2-8 Summary of Measured Signal Gain vs Theoretical (U)

Frequency = 290 Hz

Site	DP#	16	32	MAX
		Signal gain difference from theoretical in dB for number of elements shown		
1A	1	-6.1	-8.7	-12.2
	2	-8.8	-5.5	- 6.6
Mean Differ.		-7.2	-6.8	- 8.5
3	3	-0.2	-1.9	-2.1
	4	+0.2	-3.0	-5.7
	5	-0.5	-3.4	-4.1
	6	-4.2	-1.5	-4.4
	7	+1.6	-0.3	-4.7
Mean Differ.		-0.2	-1.9	-4.0
4	8	-1.9	+2.2	-1.6
	9	-2.3	+2.8	+1.0
	10	+0.9	+1.0	+0.1
	11	+0.7	-1.1	-0.4
	12	+3.4	+1.6	+0.1
Mean Differ.		+0.7	+1.5	-0.1

(S) Table 2-9 Summary of Measured Signal Gain vs. Theoretical (U)

Frequency = 140 Hz

		Signal gain difference from theoretical in dB for number of elements shown		
Site	DP#	16	32	MAX
1A	1	140 Hz not projected in Site 1A		
	2			
Mean Differ.				
3	3	+0.4	0	+1.1
	4	-0.9	-0.9	-1.95
	5	+5.1	+2.8	-0.2
	6	+0.1	-1.0	-2.1
	7	+3.3	+1.0	-1.8
Mean Differ.		+2.2	+0.6	- .8
4	8	+1.4	+2.3	-1.0
	9	-5.1	+1.6	+1.9
	10	+4.6	+3.8	+2.1
	11	+5.1	+3.3	-0.6
	12	+6.2	+4.0	+1.3
Mean Differ.		+3.8	+3.1	+0.9

(S) Table 2-10 Summary of Measured Signal Gain vs. Theoretical (U)

Frequency = 295 Hz

		Signal gain difference from theoretical in dB for number of elements shown		
Site	DP#	16	32	Max
	1	-11.6	-13.	-17.3
1A	2	-10.7	-11.4	-14.2
Mean Differ.		-11.1	-12.1	-15.5
	3			
	4			
	5			
	6			
3	7			
Mean Differ.				
	8			
4	9			
	10			
	11			
	12			
mean difference				

(S) Table 2-11 Summary of Measured Array Gain vs. Theoretical (U)

Frequency = 290 Hz

		Array gain difference from theoretical azimuth gain (dB) for number of elements shown		
Site	DP#	16	32	Max
1A	1	+1.6	-1.1	-5.4
	2	-9.6	-3.4	-4.3
	Mean Differ.	-1.1	-2.1	-4.8
3	3	+1.9	-0.3	-0.4
	4	0	-3.2	-7.3
	5	+1.5	+0.6	-4.6
	6	+1.9	-1.3	-4.9
	7	-5.6	-6.1	-10.0
	Mean Differ.	0.6	-1.5	-4.3
4	8	+1.1	-2.4	-6.1
	9	+2.9	-0.9	-0.5
	10	+0.8	-1.9	-2.4
	11	-1.7	-1.3	-2.8
	12	-3.1	-5.8	-8.5
	mean difference	+0.5	-1.6	-3.2

(S) Table 2-12 Summary of Measured Array Gain vs. Theoretical (U)

Frequency = 140 Hz

Site	DP#	Array gain difference from theoretical azimuth gain (dB) for number of elements shown		
		16	32	Max
1A	1 2	140 Hz not projected in Site 1A		
Mean Differ.				
3	3 4 5 6 7	-10.8 -6.2 +9.0 -1.8 -0.[illegible]	-1.0 -4.8 +4.2 -2.0 -4.3	+0.4 -5.5 +0.7 -0.7 -6.2
Mean Differ.		+3.4	-0.2	-1.4
4	8 9 10 11 12	-4.1 -4.7 -1.5 -0.2 +1.3	+1.3 -1.5 -0.9 -2.5 -2.1	-3.9 -0.4 -1.9 -5.2 -5.8
mean difference		-1.3	-0.9	-3.0

(S) Table 2-13 Summary of Measured Array Gain vs Theoretical(U)

Frequency = 295 Hz

Site	DP#	16	32	Max.
		Array gain difference from theoretical azimuth gain (dB) for number of elements shown		
1A	1	-2.5	-5.1	-11.0
	2	-7.9	-8.8	-11.5
Mean Differ.		-4.4	-6.6	-11.2
3	3			
	4			
	5			
	6			
	7			
4	8			
	9			
	10			
	11			
	12			
mean difference				

TABLE 2-14 ARRAY PERFORMANCE SUMMARY, 290 Hz (U)

deg (dB)

SITE	MEAN BEAMWIDTH DIFFERENCE FROM THEOR		
	16 EL	32EL	MAX APER
1A	0.95° (-.3dB)	0.95° (-0.7dB)	0.6° (-0.6dB)
3	3.36° (-1.6dB)	1.0° (-1.0dB)	3.1° (-3.7dB)
4	0.82° (-0.3dB)	0.1° (-0.1dB)	0.3° (-0.3dB)

(dB)

SITE	MEAN SIGNAL GAIN DIFF. FROM THEOR. (dB)		
	16EL	32EL	MAX APER
1A	-7.2	-6.8	-8.5
3	-0.2	-1.9	-4.0
4	+0.7	+1.5	-0.1

(dB)

SITE	MEAN ARRAY GAIN DIFF FROM THEOR GAZ		
	16EL	32EL	MAX APER
1A	-1.1	-2.1	-4.8
3	+0.6	-1.5	-4.4
4	+0.5	-1.6	-3.2

TABLE 2-15 ARRAY PERFORMANCE SUMMARY, 140 Hz (U)

deg (dB)

	MEAN BEAMWIDTH DIFFERENCE FROM THEOR		
SITE	16EL	32EL	MAX APER
1A	-	-	-
3	1.68°(-0.4dB)	+2.0°(-1dB)	+2.6°(-1.9dB)
4	-0.1°(0dB)	+1.8°(-0.6dB)	_2.4°(-1.2dB)

(dB)

	MEAN SIGNAL GAIN DIFF. FROM THEOR (dB)		
SITE	16EL	32EL	MAX APER
1A	-	-	-
3	2.2	0.6	-0.8
4	3.8	3.1	0.9

(dB)

	MEAN ARRAY GAIN DIFF FROM THEOR GAZ		
SITE	16EL	32EL	MAX APER
1A	-	-	-
3	3.4	-0.2	-1.4
4	-1.3	-0.9	-3.0

TABLE 2-16 ARRAY PERFORMANCE SUMMARY, 295 Hz (U)

	MEAN BEAMWIDTH DIFFERENCE FROM THEOR		
SITE	16EL	32EL	MAX APER
1A	4.0°(-1.1dB)	3.0°(-1.8dB)	0.4°(-.5dB)
3			
4			

	SIGNAL GAIN DIFF. FROM THEOR (dB)		
SITE	16EL	32EL	MAX APER
1A	-11.1	-12.1	-15.5
3			
4			

	ARRAY GAIN DIFF. FROM THEOR GAZ		
SITE	16EL	32EL	MAX APER
1A	-4.4	-6.6	-11.2
3			
4			

2.6(C) <u>ARRAY PERFORMANCE AT 295 Hz</u> (U)

(C) Only a limited and somewhat dubious data base (2 data points) for array gain is reported for the 295 Hz line. (see Table 2-17) Because the low 295 Hz signal levels radiated were detected on omni channels only in Site 1A (DP 1 and 2), array gain is reported only for these data points. The beam-formed array output, however, indicated detections of the 295 Hz line in all three sites.

(C) Comparison of 290 and 295 Hz measured signal levels on omni channels (Table 2-17) show poor agreement with radiated levels. On the other hand, agreement of beamformed signal level is in good agreement (except for DP 2) with radiated levels. Further, one observes that measured SNR values for beamformed data are quite small (2.5 to 3.2 dB) in the analysis bandwidth for DP 1 and 2, making it implausible that the omni SNR's reported are accurate. The conclusion drawn is that measured omni signal levels are suspect, and the resulting SNR and AG values in Table 2-17, and in other data presented is questionable.

(C) It is noted from Table 2-17 that the AG for data points 8 and 9 must exceed 9.7 and 11.7 dB respectively, since presumably the omni SNR for these points is zero dB or less.

CONFIDENTIAL

TABLE 2-17

COMPARISON OF SIGNAL LEVELS, SNR AND AG FOR 295 HZ DATA (U)

Site	DP	Range	Proj Signal Level 290Hz	Proj Signal (dBμPa) 295Hz	Δ Sig Level (dB)	Meas Omni Sig Level 290Hz	Meas Omni (dBV) 295Hz	Omni Δ Sig Level (dB)	Meas BF Sig Level	Meas BF Sig (dBV)	BF Δ Sig Level (dB)		Meas SNR @ 295 Hz BF (dB)	Meas SNR @ 295 Hz Omni (dB)	AG @ 295 Hz (dB)
1A	1	91	155	145	-10	-49.7	-53.3	-3.6 (2)	-27.6	-36.3	-8.7 (1)		2.5	-2.0	4.5 } (3)
	2	91	155	140	-15	-51.5	-51.2	+0.2 (2)	-24.2	-31.4	-7.2 (2)		3.2	-0.7	3.9 } (3)
3	7	28	180	143	-37	-17.5	*	*	12.0	-24.2	-36.2	} (1)	3.3	*	*
	8	22	182	143	-39	-15.2	*	*	16.8	-19.2	-36.0	} (1)	9.7	*	*
	9	72	182	143	-39	-12.5	*	*	20.4	-17.8	-38.2	} (1)	11.7	*	*

(1) These are in good agreement with projected signal levels.

(2) These are in poor agreement with projected signal levels.

* Signal not detected on individual omni channels. Therefore, SNP and AG cannot be computed from measured data.

CONCLUSION: Omni measured signal levels and, therefore, SNR's are questionable and thus the very low measured array gain (AG) values reported (3) are unreliable.

CONFIDENTIAL

Appendix A

Comaprison of Signal Gain & Array Gain Vs. Number of Elements (U)

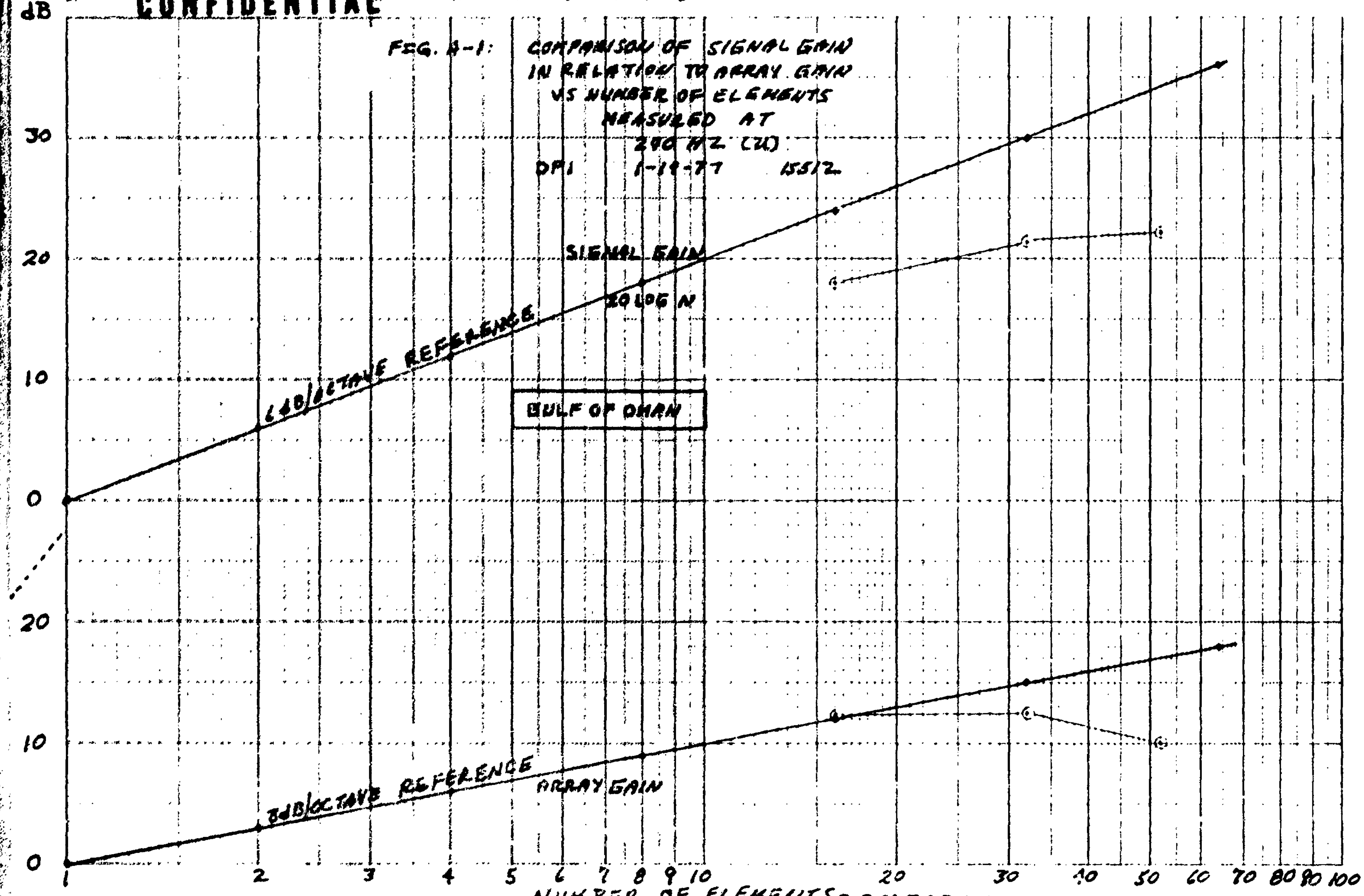
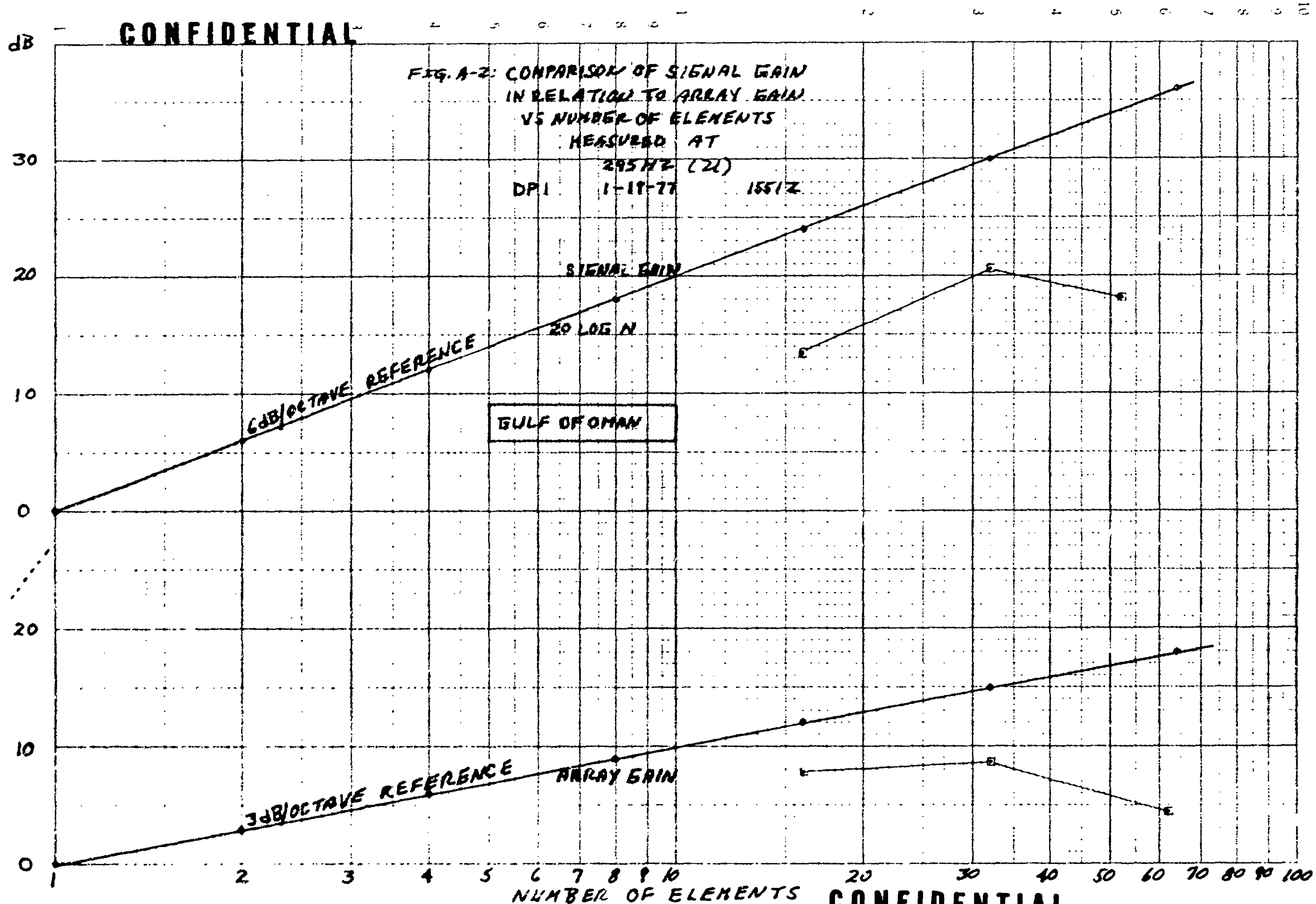


FIG. A-1: COMPARISON OF SIGNAL GAIN
IN RELATION TO ARRAY GAIN
VS NUMBER OF ELEMENTS
MEASURED AT
290 HZ (U)
DPI 1-19-77 15512
dB
30
20
10
0
20
10
0
SIGNAL GAIN
20 LOG N
6dB/OCTAVE REFERENCE
GULF OF OMAN
3dB/OCTAVE REFERENCE
ARRAY GAIN
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
NUMBER OF ELEMENTS

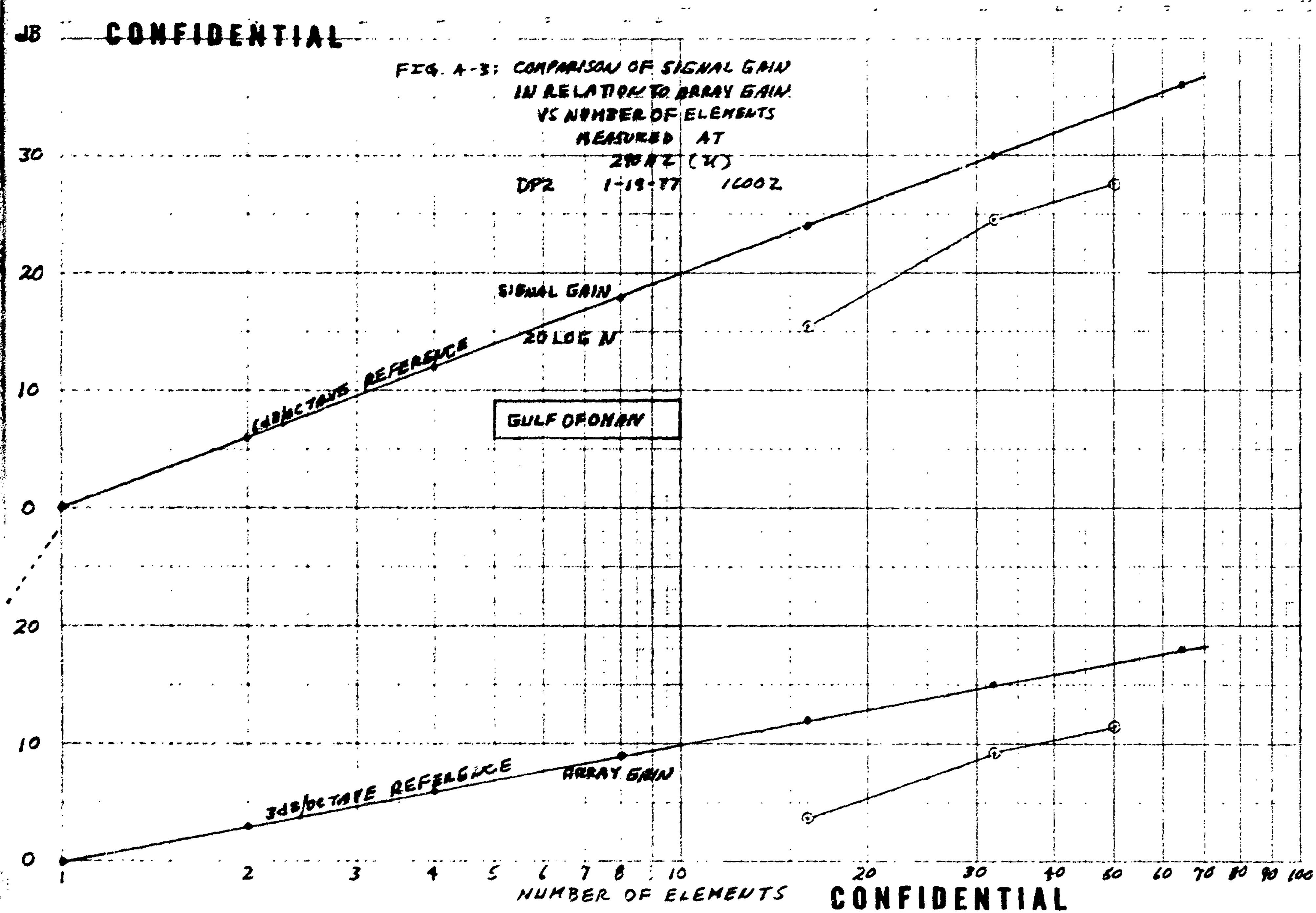
CONFIDENTIAL



CONFIDENTIAL

46 4973

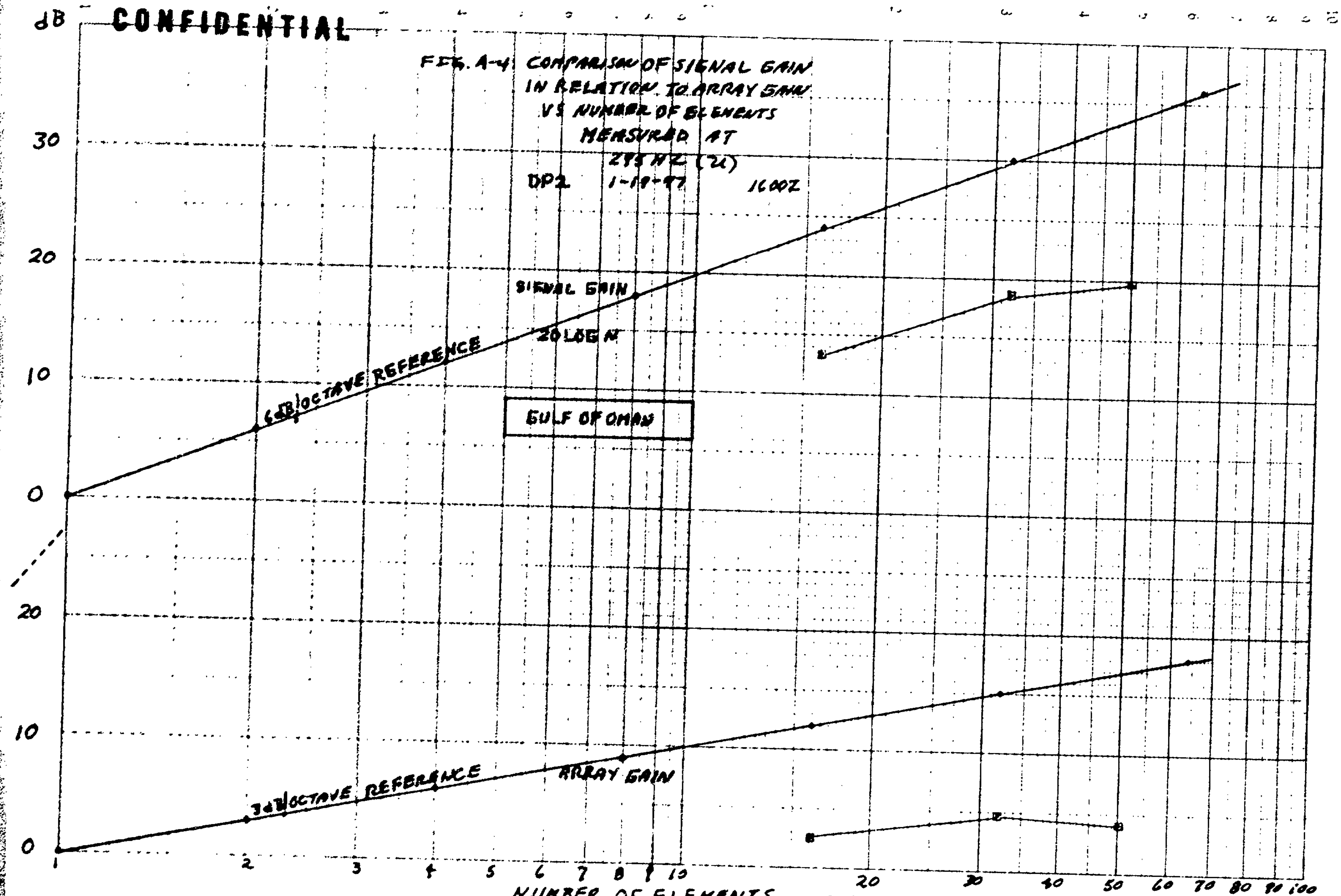
CONFIDENTIAL



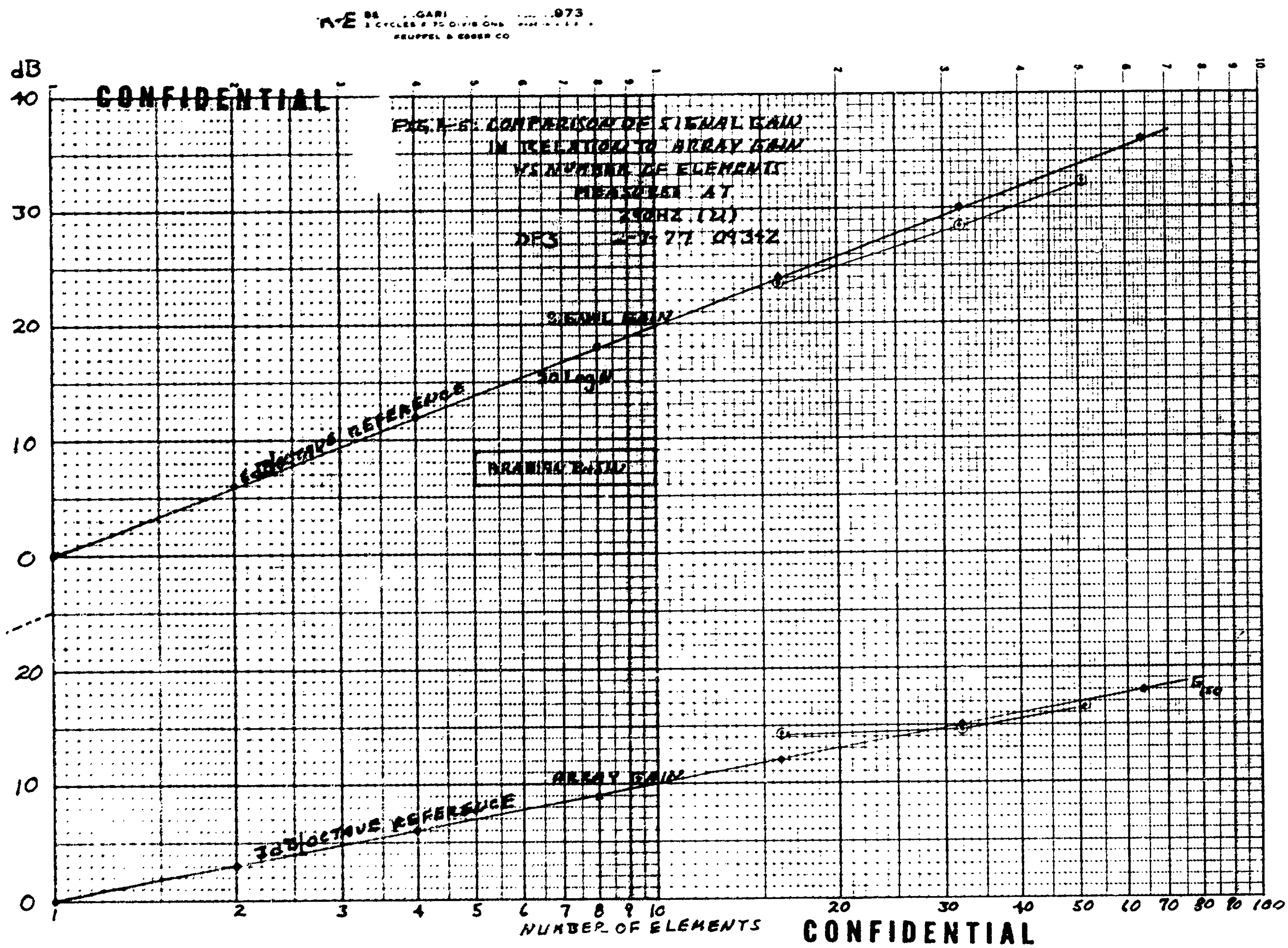
CONFIDENTIAL

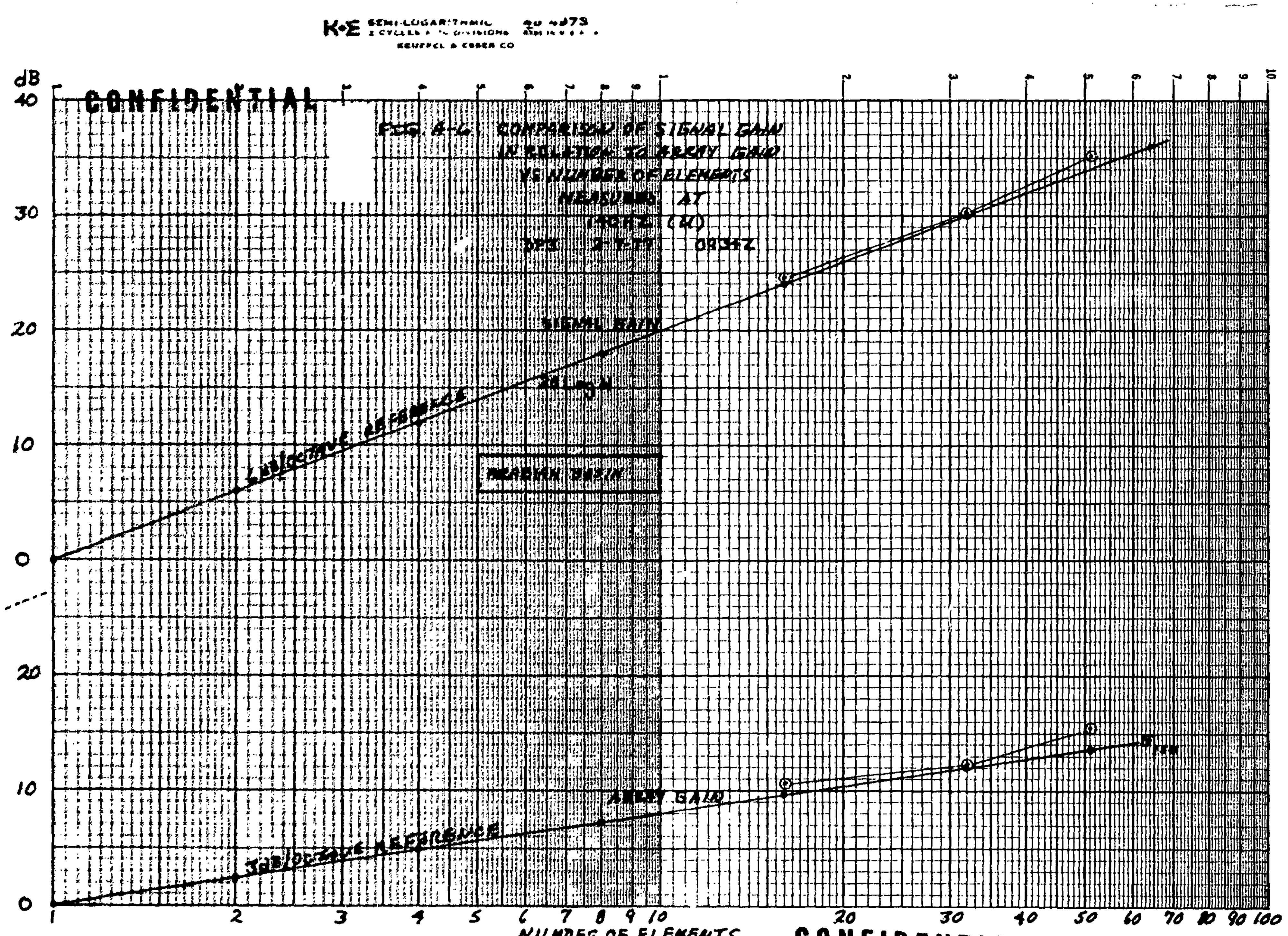
46 4973

CONFIDENTIAL



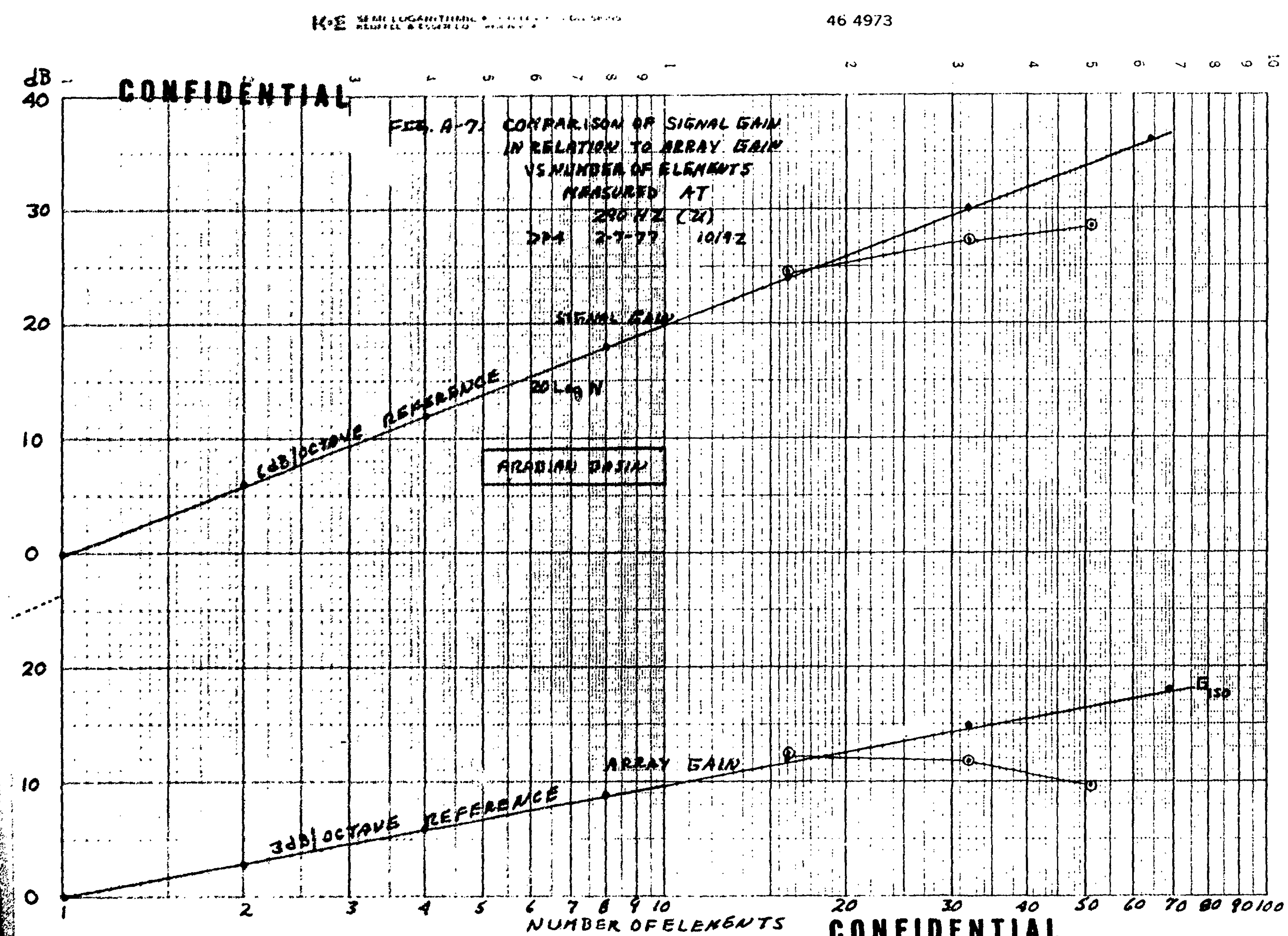
CONFIDENTIAL


CONFIDENTIAL
FIG. 1-6: COMPARISON OF SIGNAL GAIN
IN RELATION TO ARRAY GAIN
VS NUMBER OF ELEMENTS
MEASURED AT
250HZ (21)
DF3 2-7-77 0934Z
dB
40
30
20
10
0
20
10
0
SIGNAL GAIN
20 Log N
6dB/OCTAVE REFERENCE
ARRAY GAIN
3dB/OCTAVE REFERENCE
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
NUMBER OF ELEMENTS



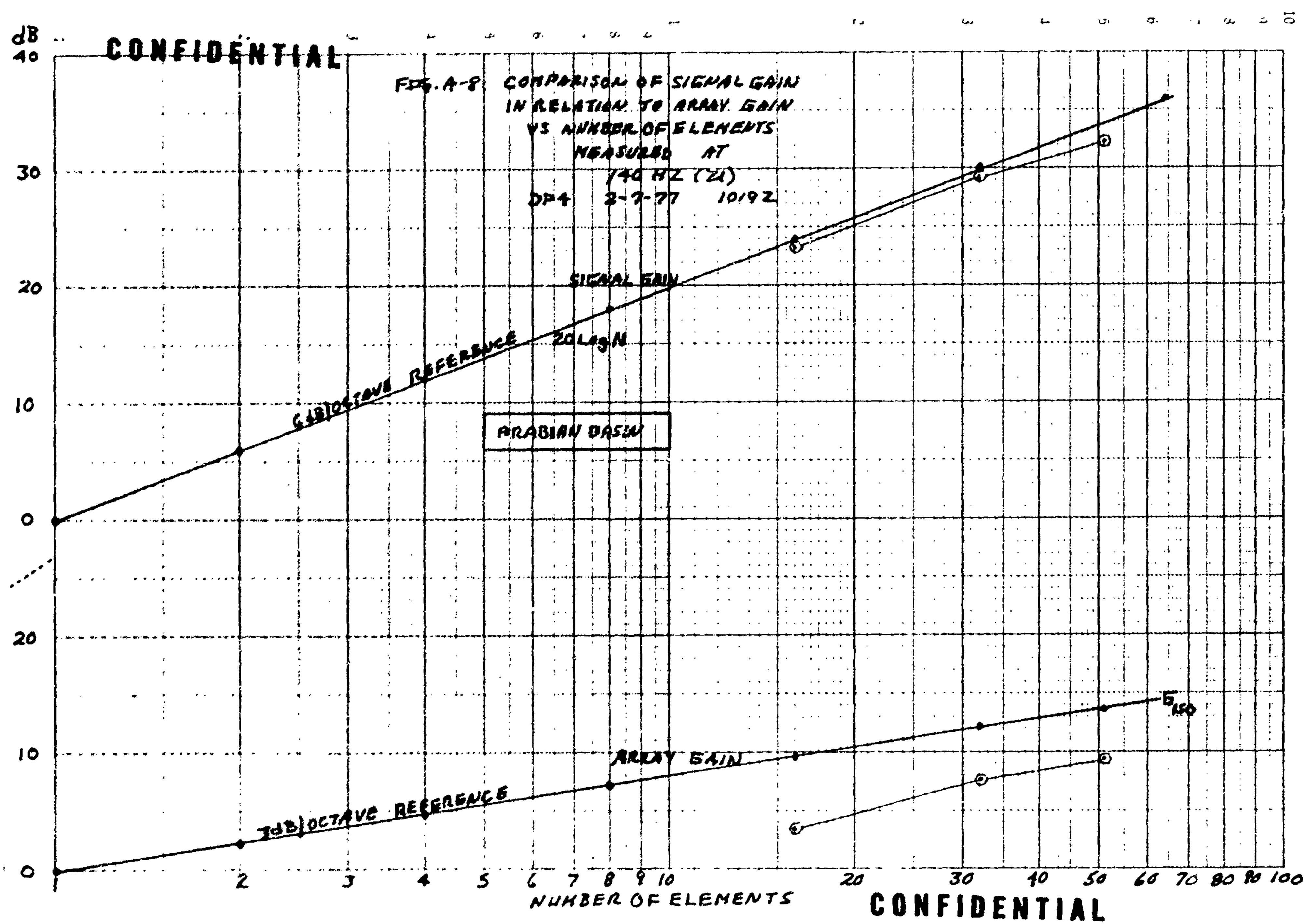
CONFIDENTIAL

CONFIDENTIAL



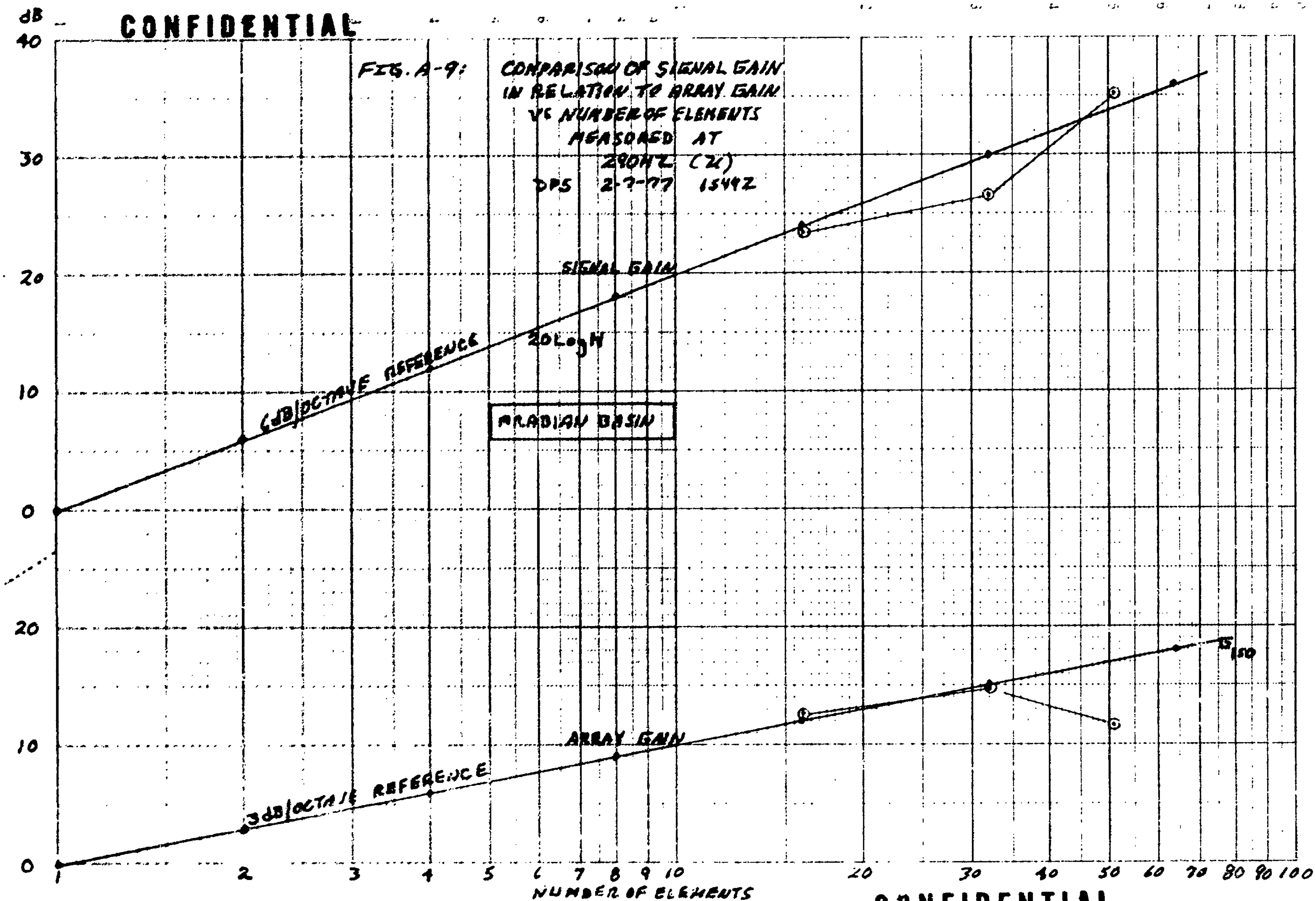
CONFIDENTIAL

CONFIDENTIAL



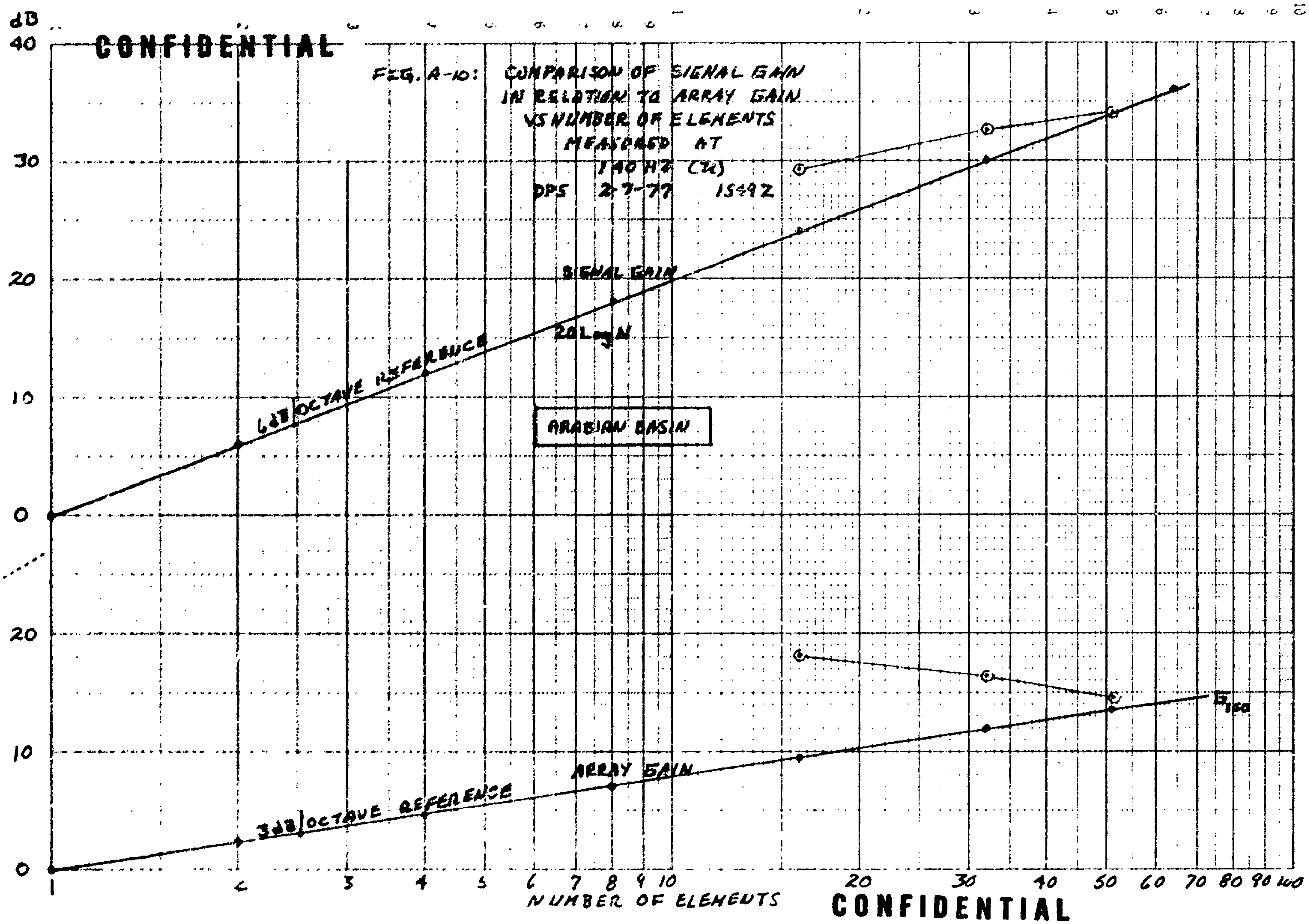
CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

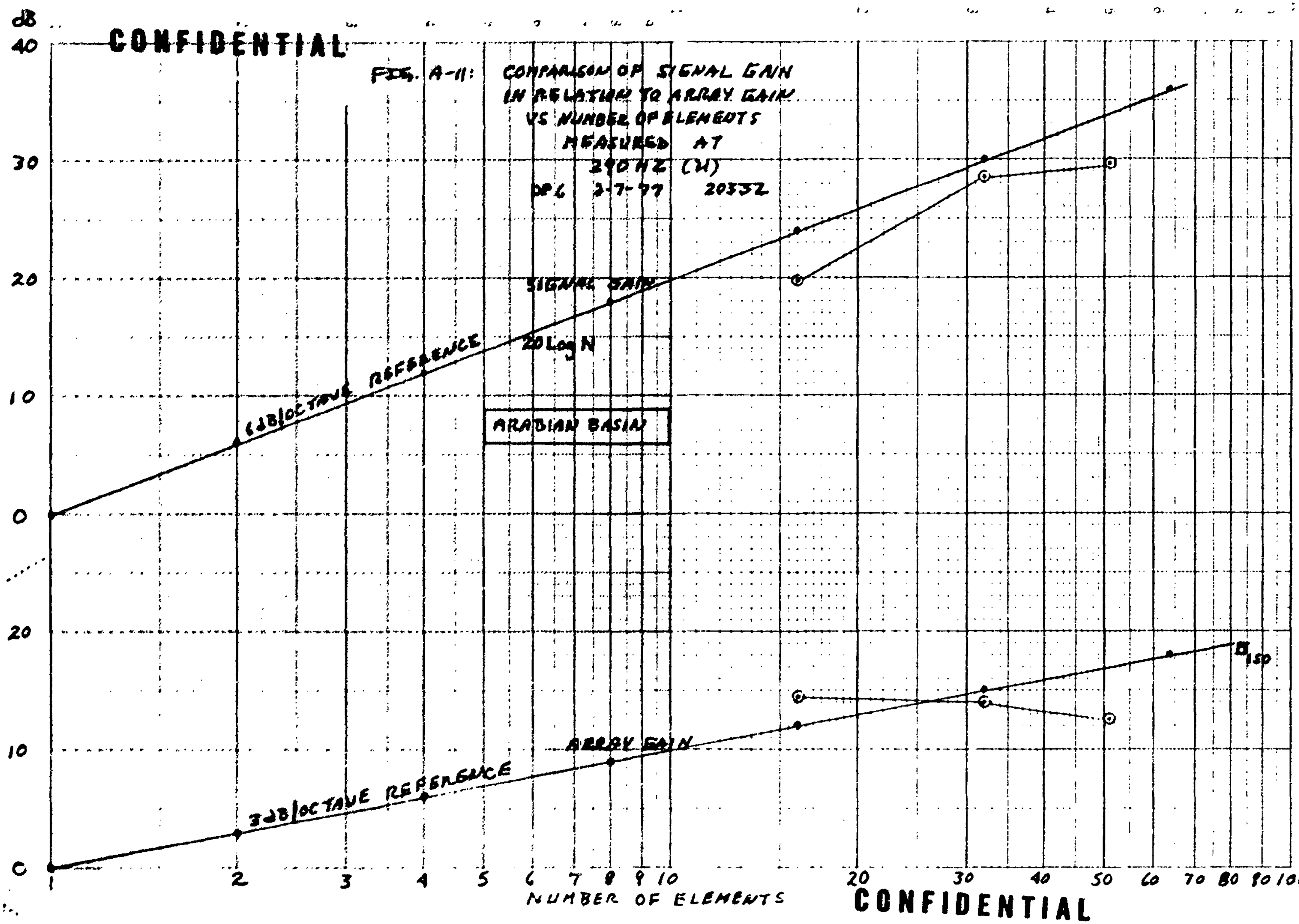
CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL

FIG. A-11: COMPARISON OF SIGNAL GAIN IN RELATION TO ARRAY GAIN VS NUMBER OF ELEMENTS MEASURED AT 290 HZ (U)



CONFIDENTIAL

CONFIDENTIAL

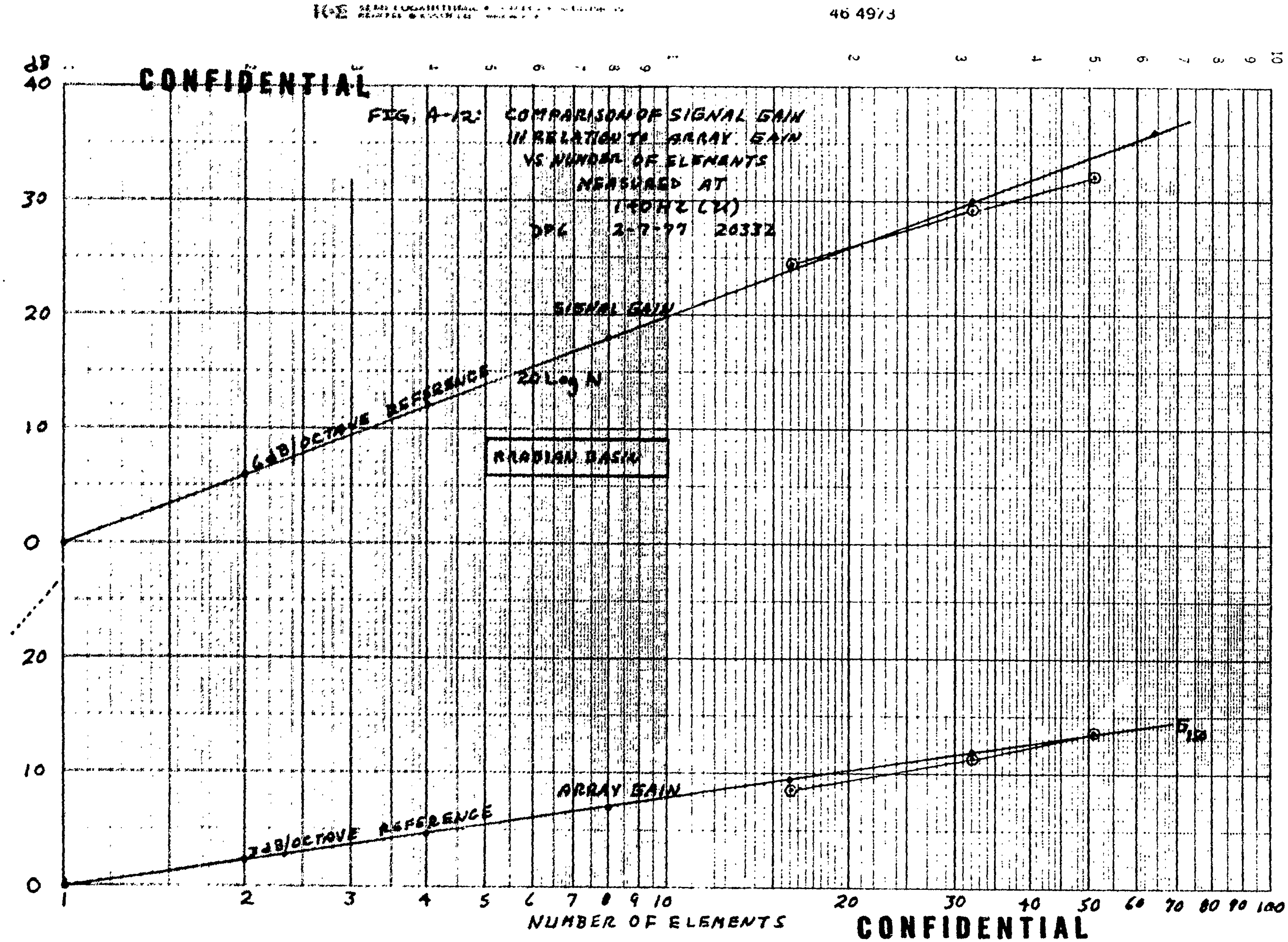
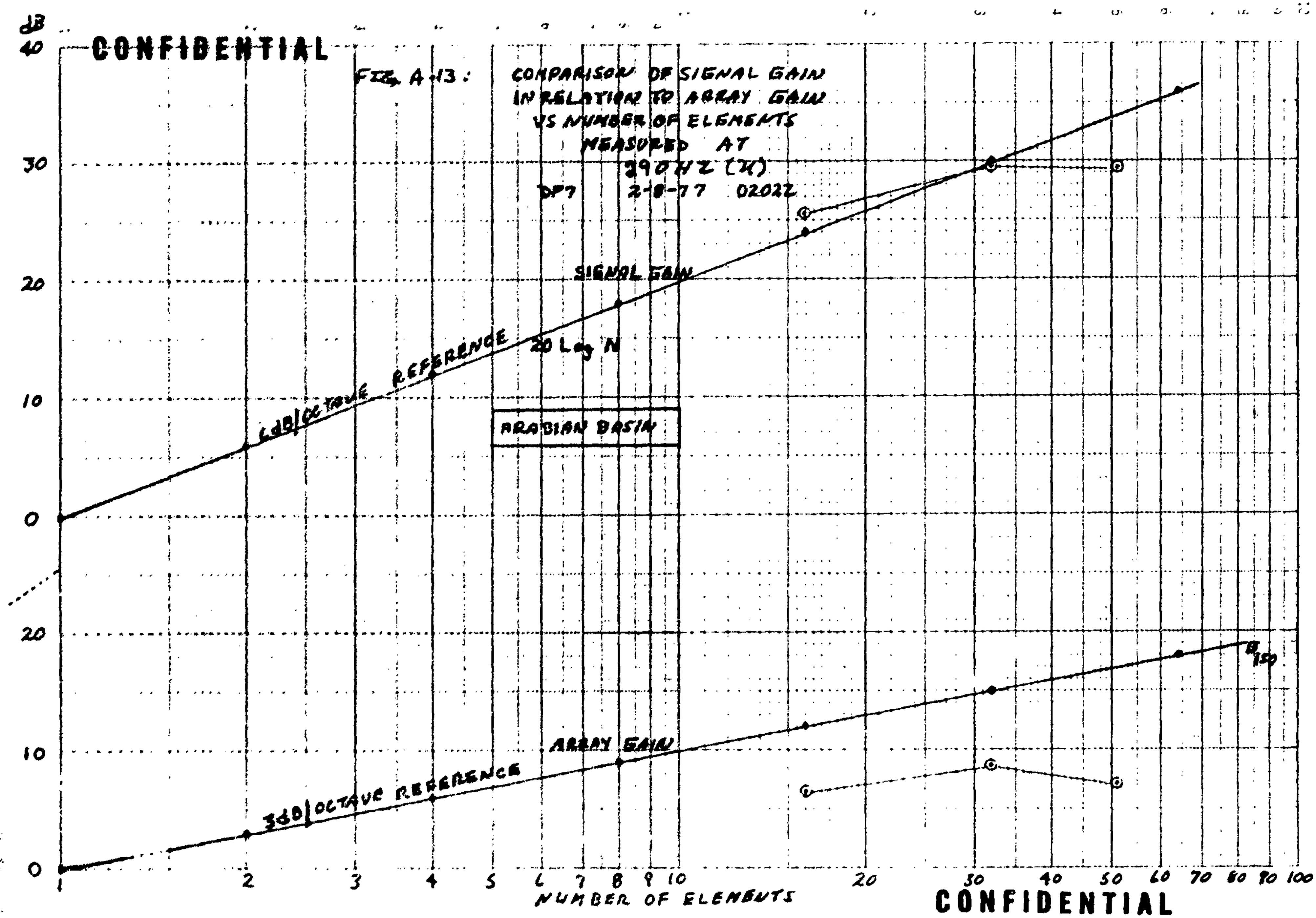
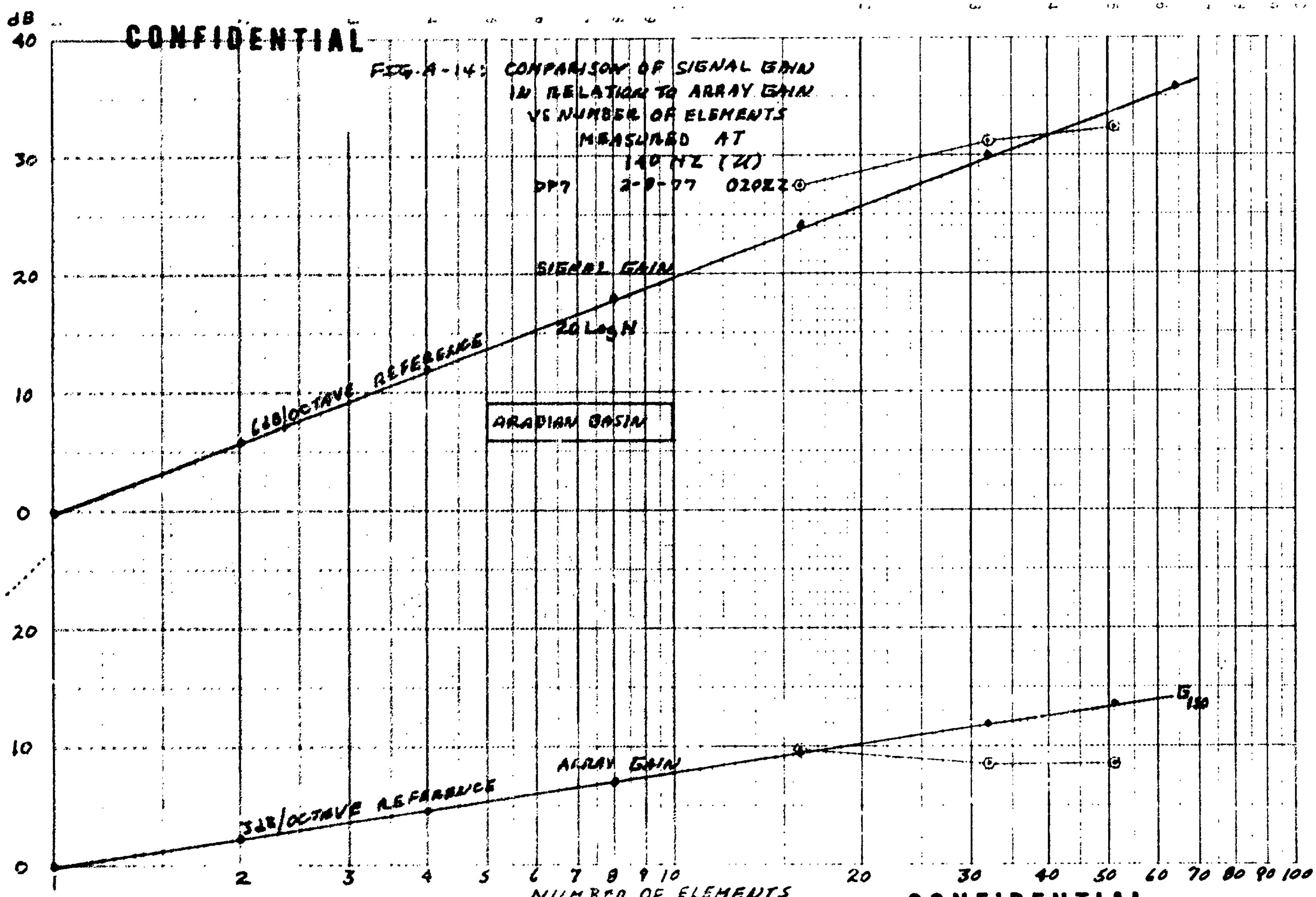


FIG. A-12: COMPARISON OF SIGNAL GAIN IN RELATION TO ARRAY GAIN VS NUMBER OF ELEMENTS MEASURED AT 140 HZ (U) DPG 2-7-77 20332

CONFIDENTIAL


CONFIDENTIAL
FIG. A-13:
COMPARISON OF SIGNAL GAIN
IN RELATION TO ARRAY GAIN
VS NUMBER OF ELEMENTS
MEASURED AT
290HZ (X)
DP7 2-8-77 02022
dB
40
30
20
10
0
20
10
0
SIGNAL GAIN
20 Log N
6dB/OCTAVE REFERENCE
ARABIAN BASIN
ARRAY GAIN
3dB/OCTAVE REFERENCE
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
NUMBER OF ELEMENTS
CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

40 4973

CONFIDENTIAL

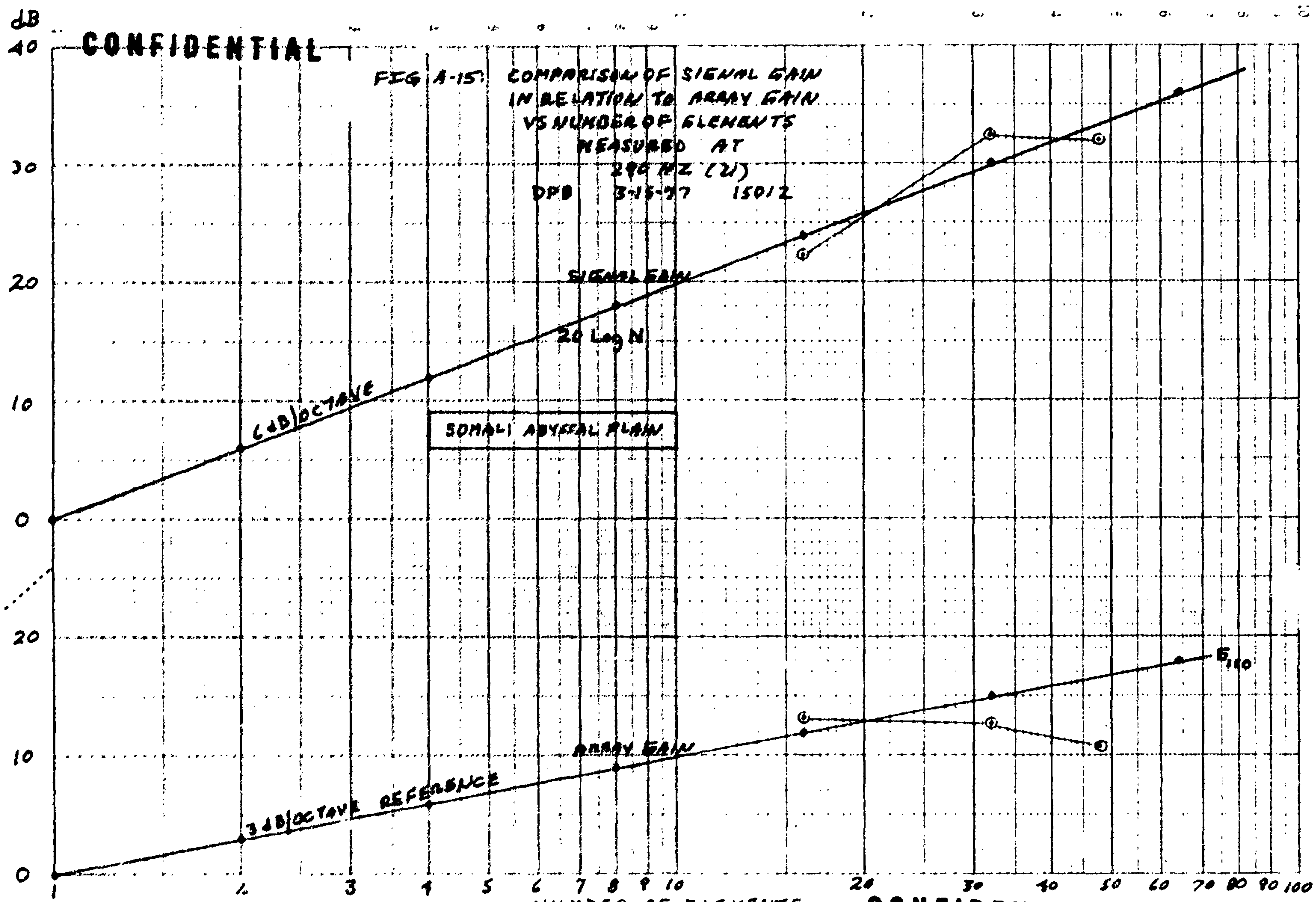


FIG A-15: COMPARISON OF SIGNAL GAIN IN RELATION TO ARRAY GAIN VS NUMBER OF ELEMENTS MEASURED AT 290 HZ (21)

DPB 3-15-77 1501Z

CONFIDENTIAL

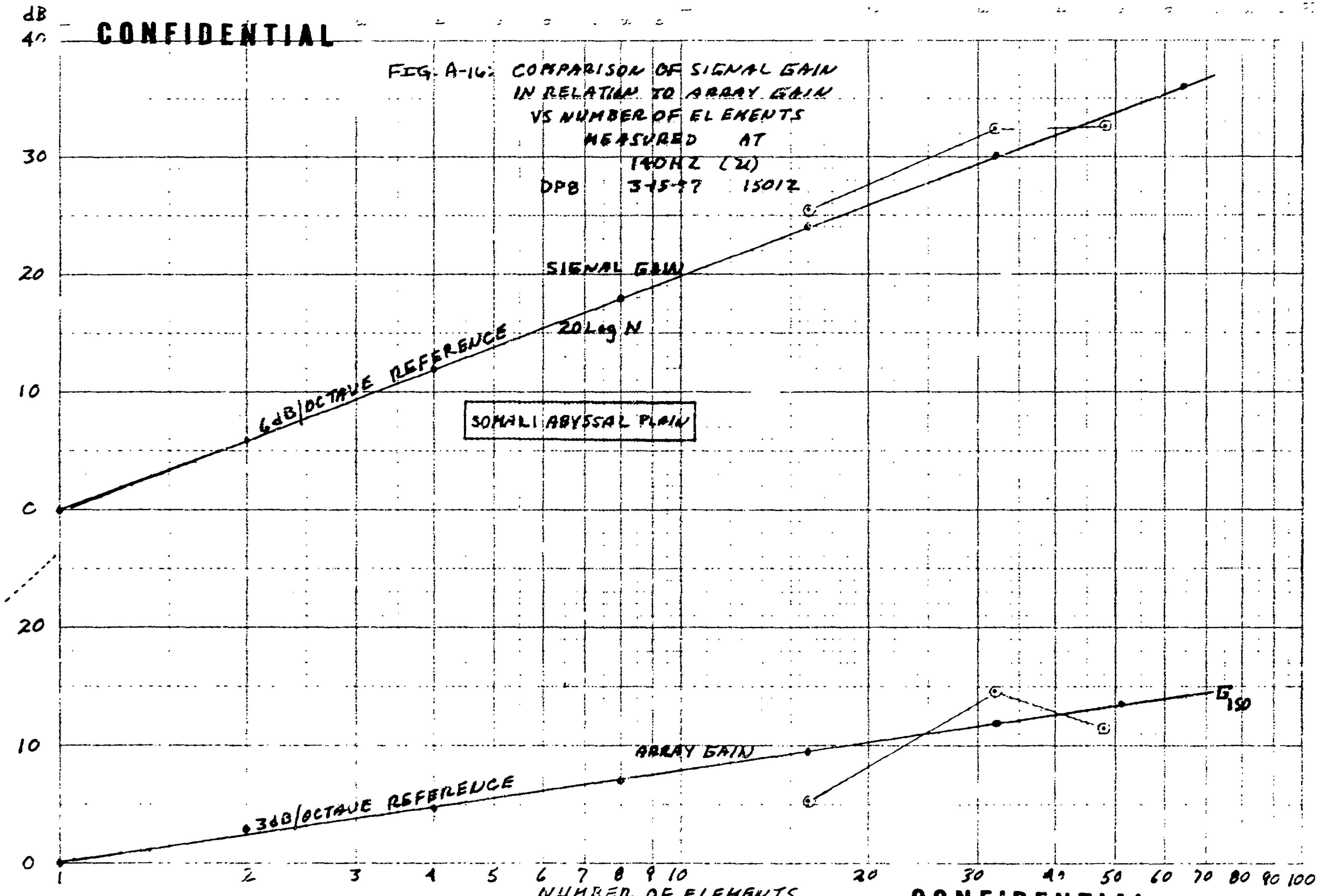
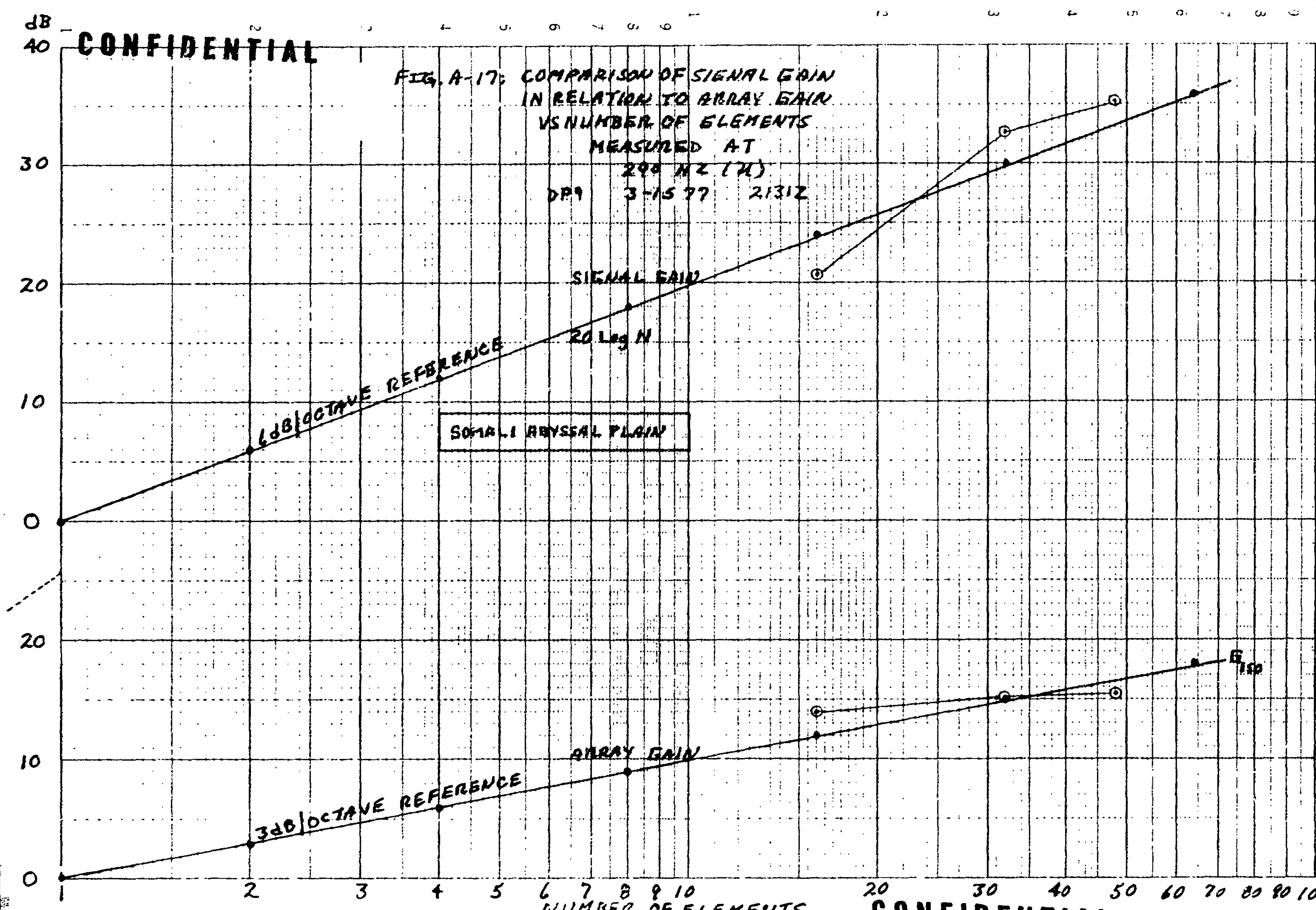


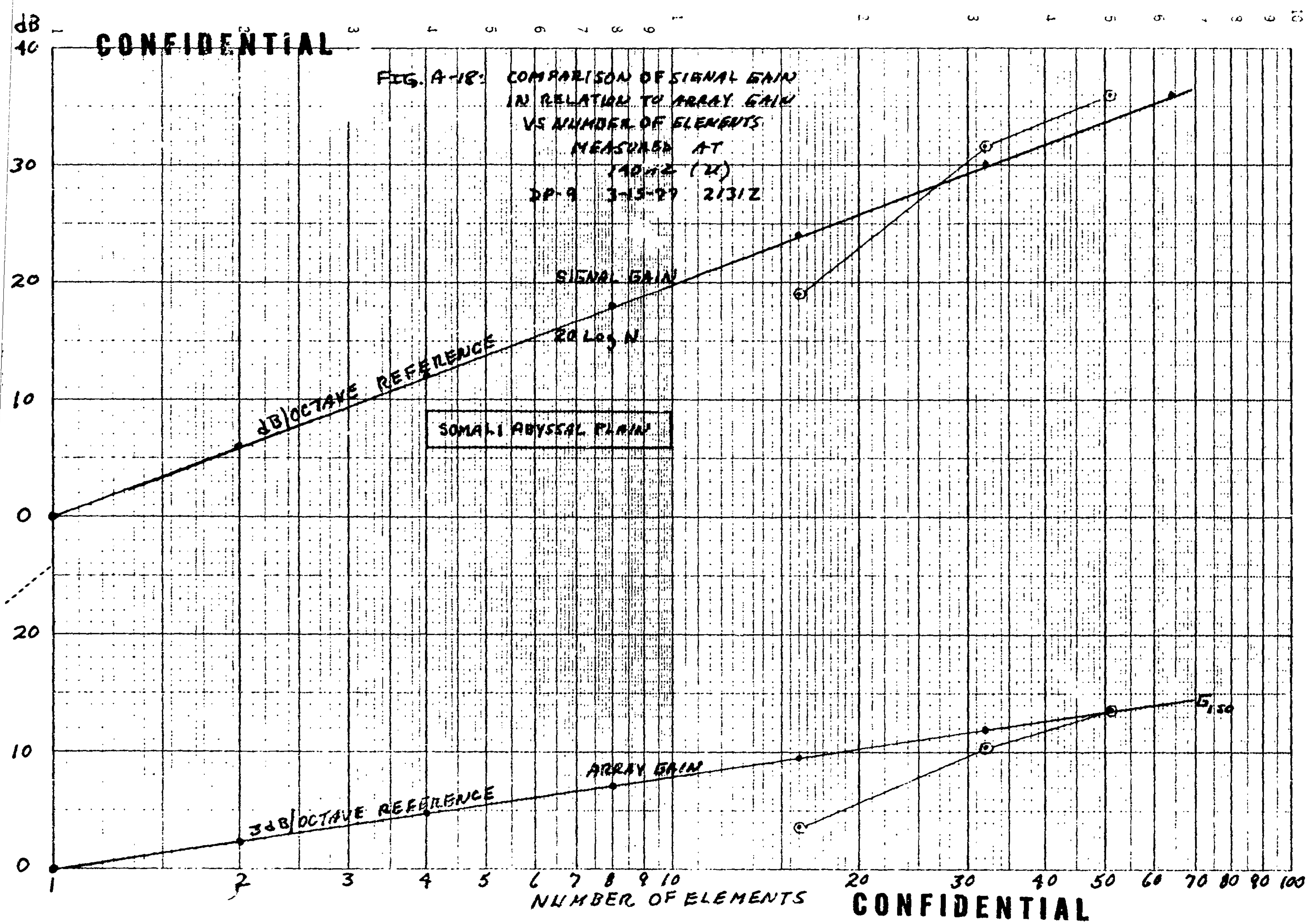
FIG. A-16: COMPARISON OF SIGNAL GAIN IN RELATION TO ARRAY GAIN VS NUMBER OF ELEMENTS MEASURED AT 140HZ (2L) DPB 3-15-77 1501Z

CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

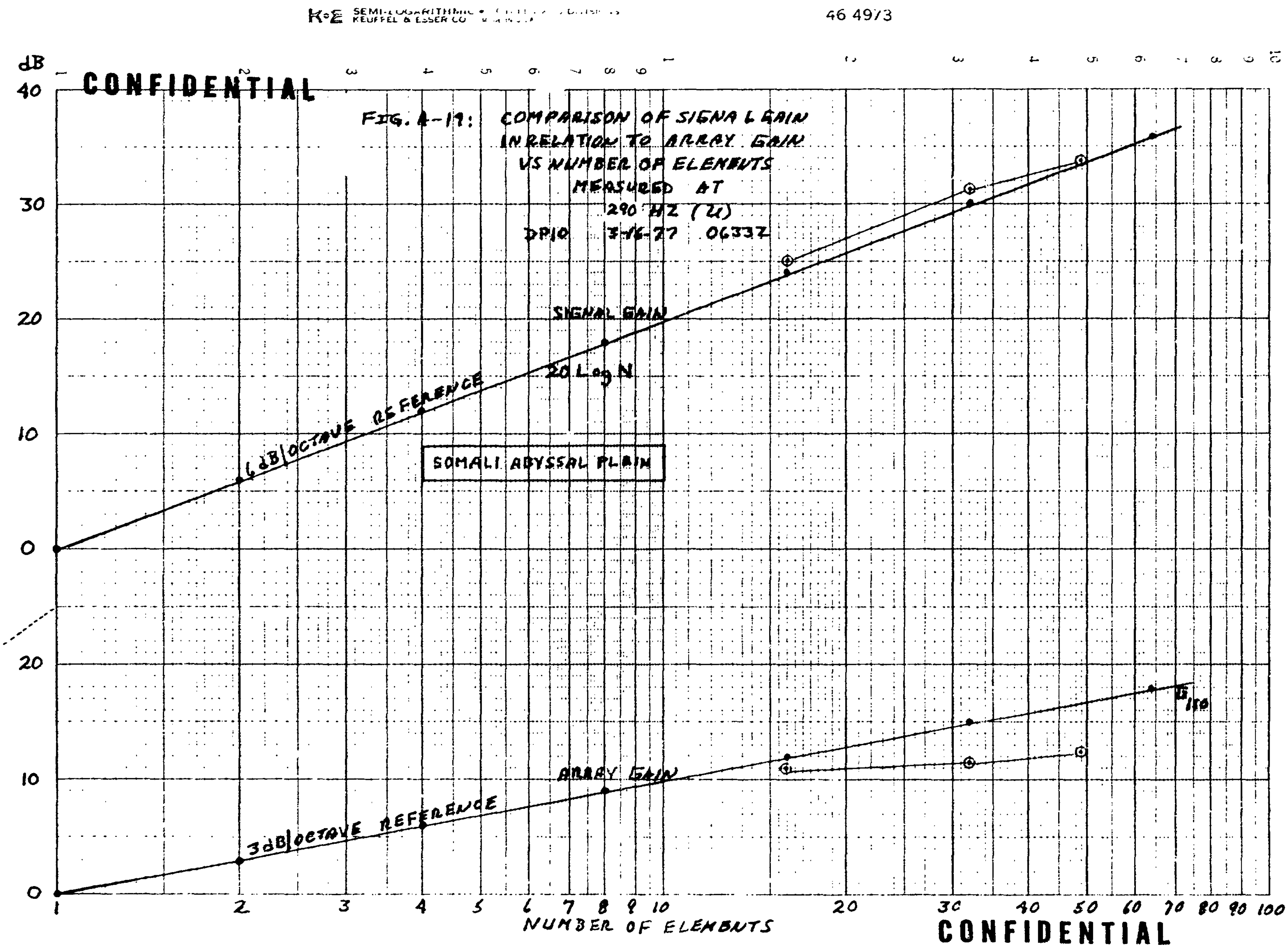
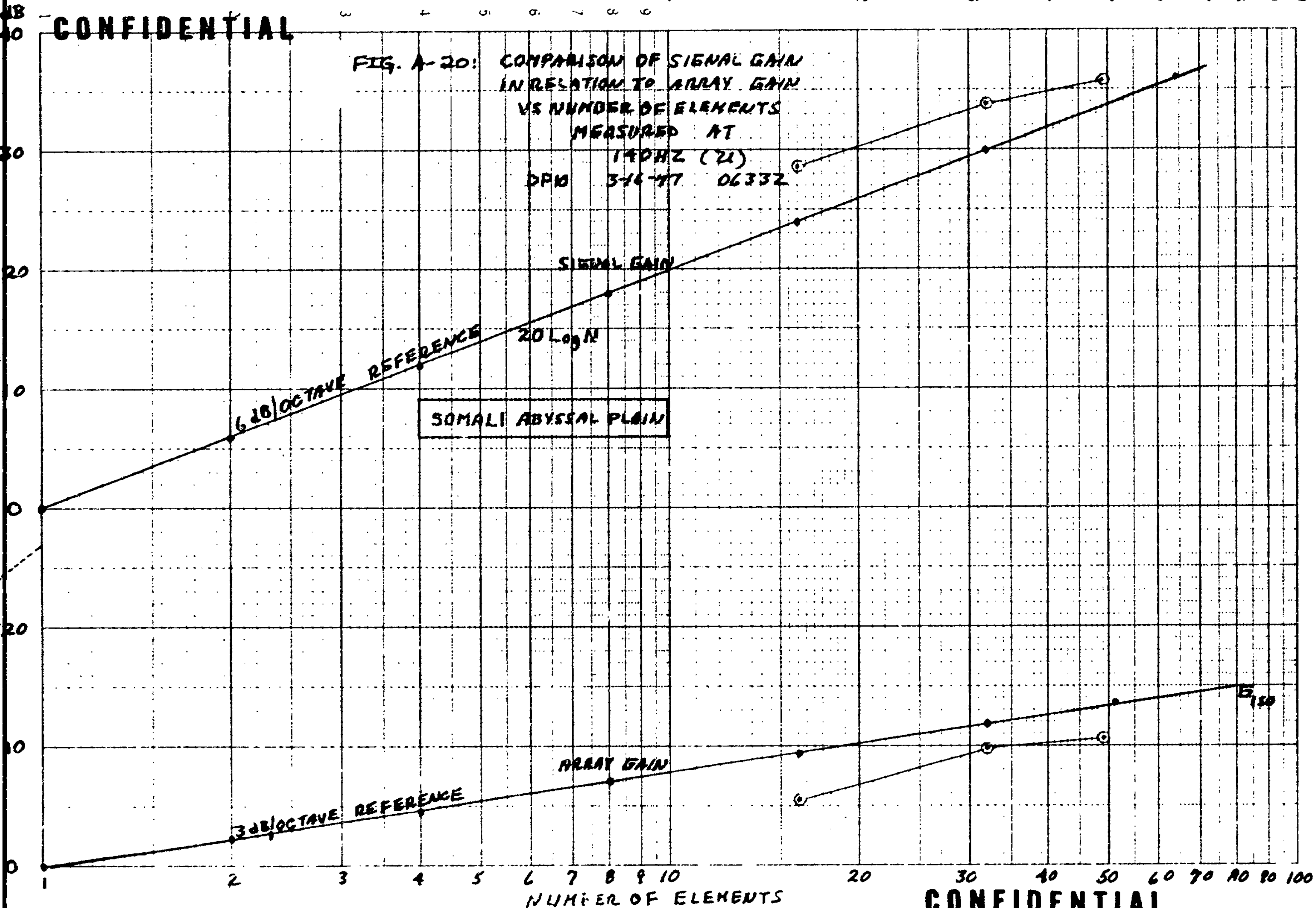


FIG. A-19: COMPARISON OF SIGNAL GAIN
IN RELATION TO ARRAY GAIN
VS NUMBER OF ELEMENTS
MEASURED AT
290 HZ (U)
DP10 3-16-77 0633Z
SOMALI ABYSSAL PLAIN
SIGNAL GAIN
20 Log N
6dB|OCTAVE REFERENCE
ARRAY GAIN
3dB|OCTAVE REFERENCE
dB
40
30
20
10
0
20
10
0
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
NUMBER OF ELEMENTS

K+E SEMI-LOGARITHMIC KEUFFEL & ESSER CO. 46 4973

CONFIDENTIAL



CONFIDENTIAL

K+E SEMI-LOGARITHMIC KEUFFEL & ESSER CO. 46 4973

CONFIDENTIAL

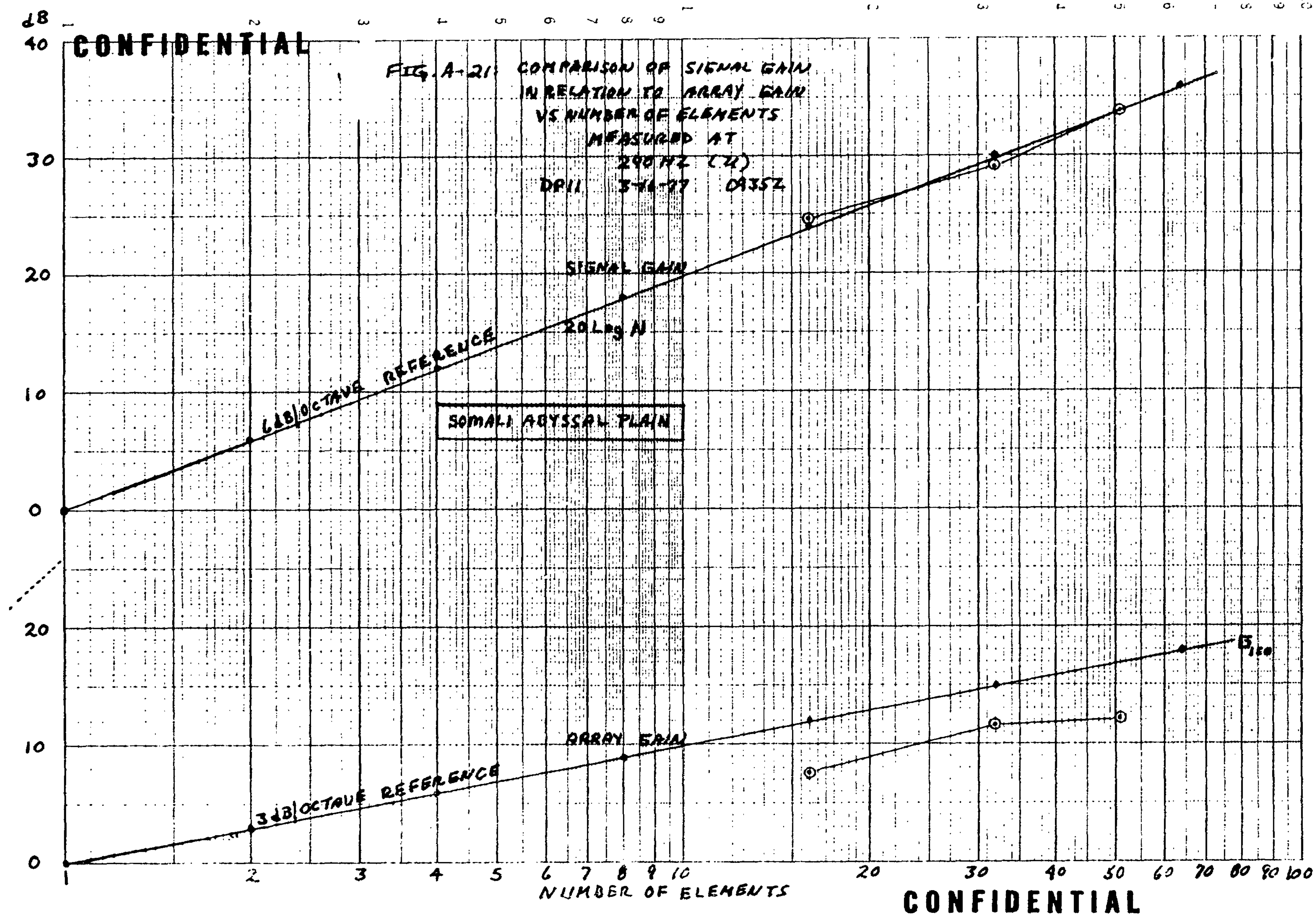
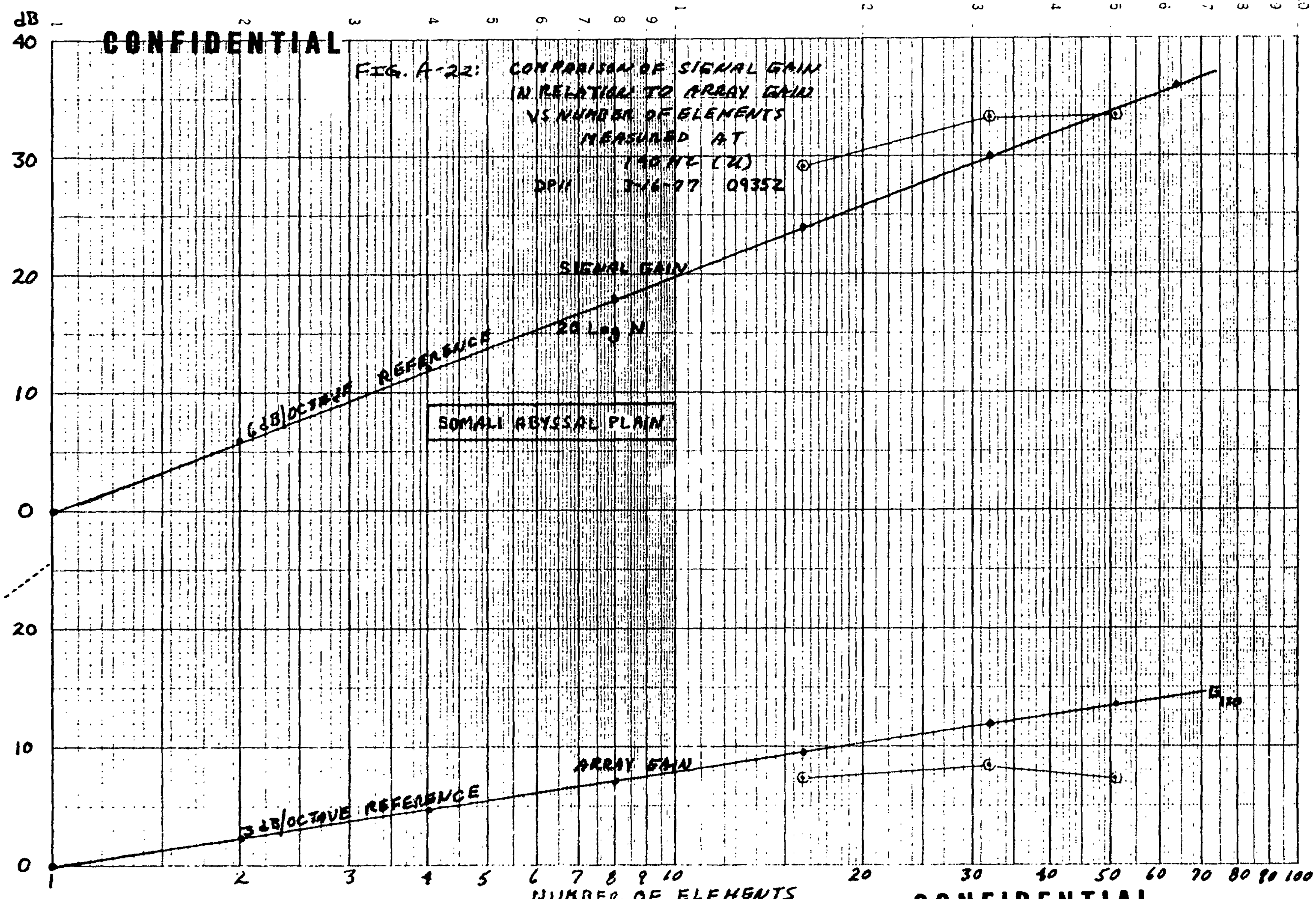


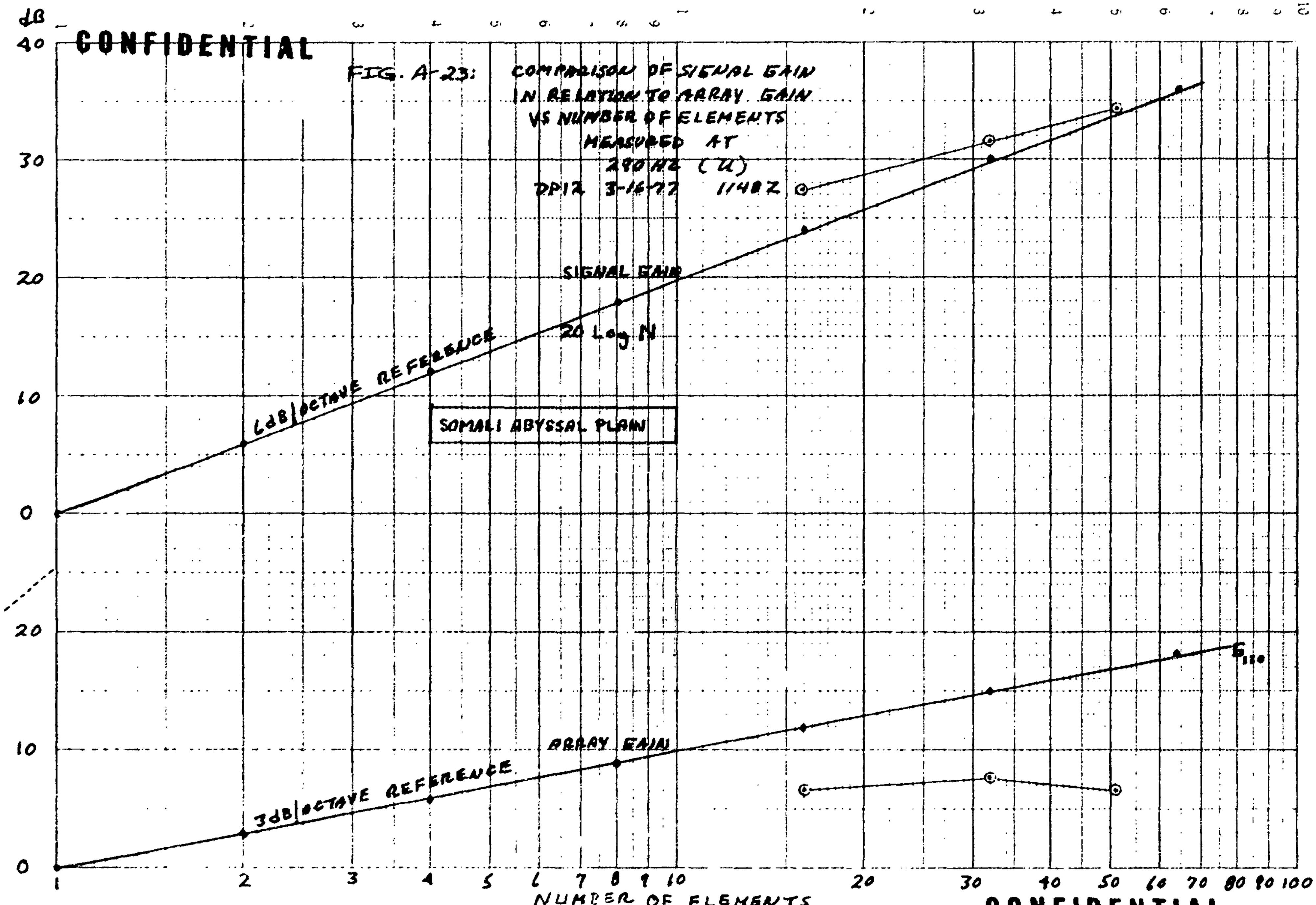
FIG. A-21: COMPARISON OF SIGNAL GAIN IN RELATION TO ARRAY GAIN VS NUMBER OF ELEMENTS MEASURED AT 290 HZ (2) DPII 3-16-77 0935Z

CONFIDENTIAL

FIG. A-22: COMPARISON OF SIGNAL GAIN IN RELATION TO ARRAY GAIN VS NUMBER OF ELEMENTS MEASURED AT 140 HZ (U) DP11 3-16-77 09352

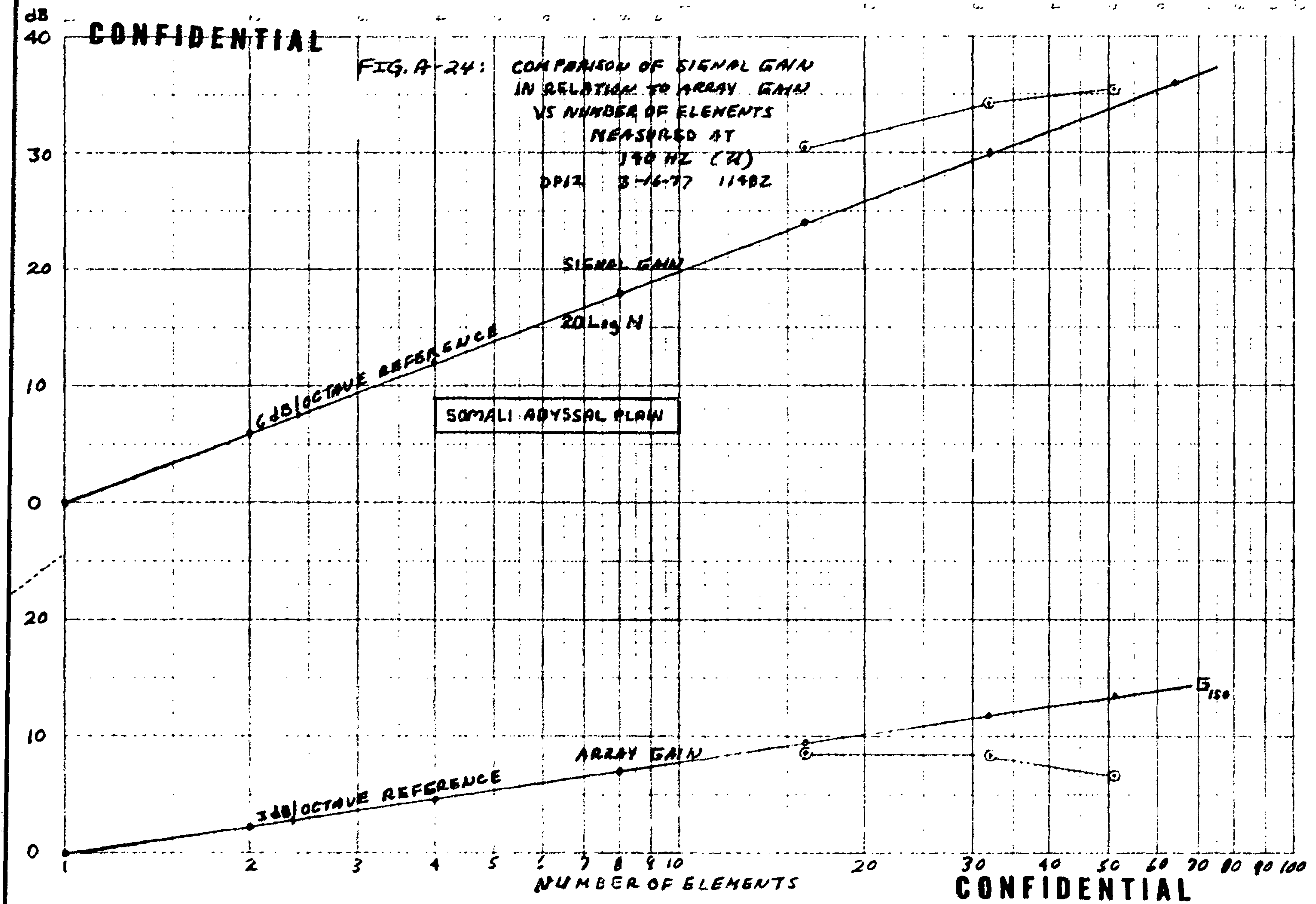


CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL



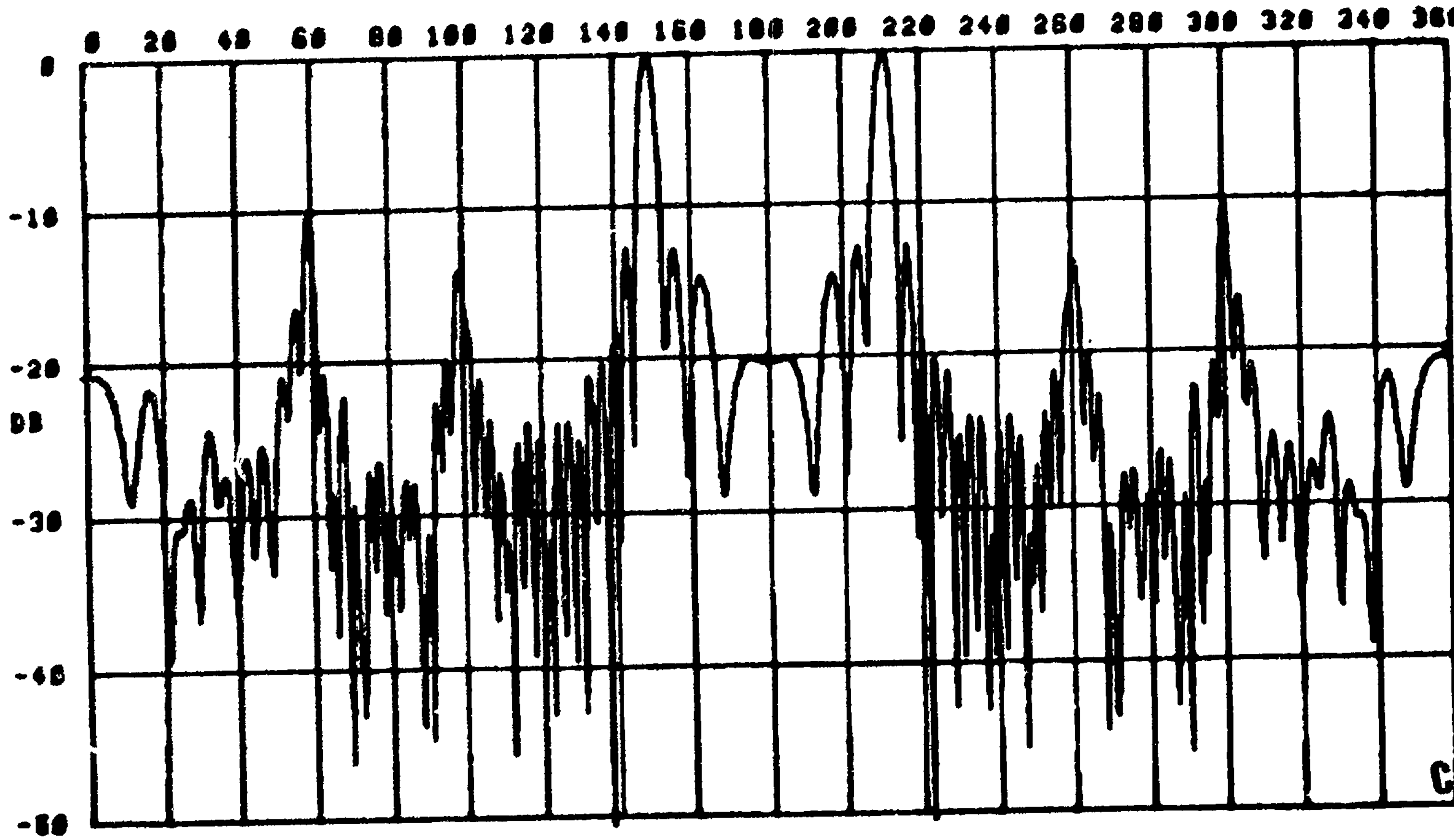
CONFIDENTIAL

APPENDIX B THEORETICAL BEAM PATTERN & ARRAY GAIN DATA (U)

S1237 SANDERS BEAM PATTERN PROGRAM (T.HOBAN) 24-Jan-78 ONTLBP 3.1
A: 53 ELEMENT SPRAY ARRAY SPACED 0.3333 FT.
ELEMENT 16 DELETED FROM APERTURE
S: SAME

CONFIDENTIAL

DATA POINT 1
1200 HZ. SAMPLING FREQ. DEGRADES PATTERN
290.0 HZ., 52 ELEMENTS, -0.03 DB MAX., AC:S1543,SU:S1543,WT:
90.0 DEG. VERT. RESP., 149.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
3.85 DEG. 3 DB BEAM, 15.41 DB AZ. GAIN, MAX. AT 149.0 DEG. HORIZ.



CONFIDENTIAL

Figure B-27 Theoretical Horizontal Plane Pattern for 52 Element Array @ 290 Hz for Data Point 1, 59° Off Broadside Steering. Beamwidth 3.85°, Azimuth Gain 15.4 dB.

CONFIDENTIAL

S1233 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 24-Jan-78 ANTLBP 3.1
A: 34 ELEMENT SPRAY ARRAY SPACED 0.3333 FT.
ELEMENTS 27 AND 28 DELETED FROM APERTURE.
B: SAME

DATA POINTS 1 & 2
1200 HZ. SAMPLING FREQ. DEGRADES PATTERN
290.0 HZ.. 32 ELEMENTS. -0.04 DB MAX.. AC:S1542.SU:S1542.WT:
90.0 DEG. VERT. RESP.. 149.0 DEG. HORIZ. STEER. 90.0 DEG. VERT STEER
5.83 DEG. 3 DB BEAM. 13.32 DB AZ. GAIN. MAX. AT 211.0 DEG. HORIZ.

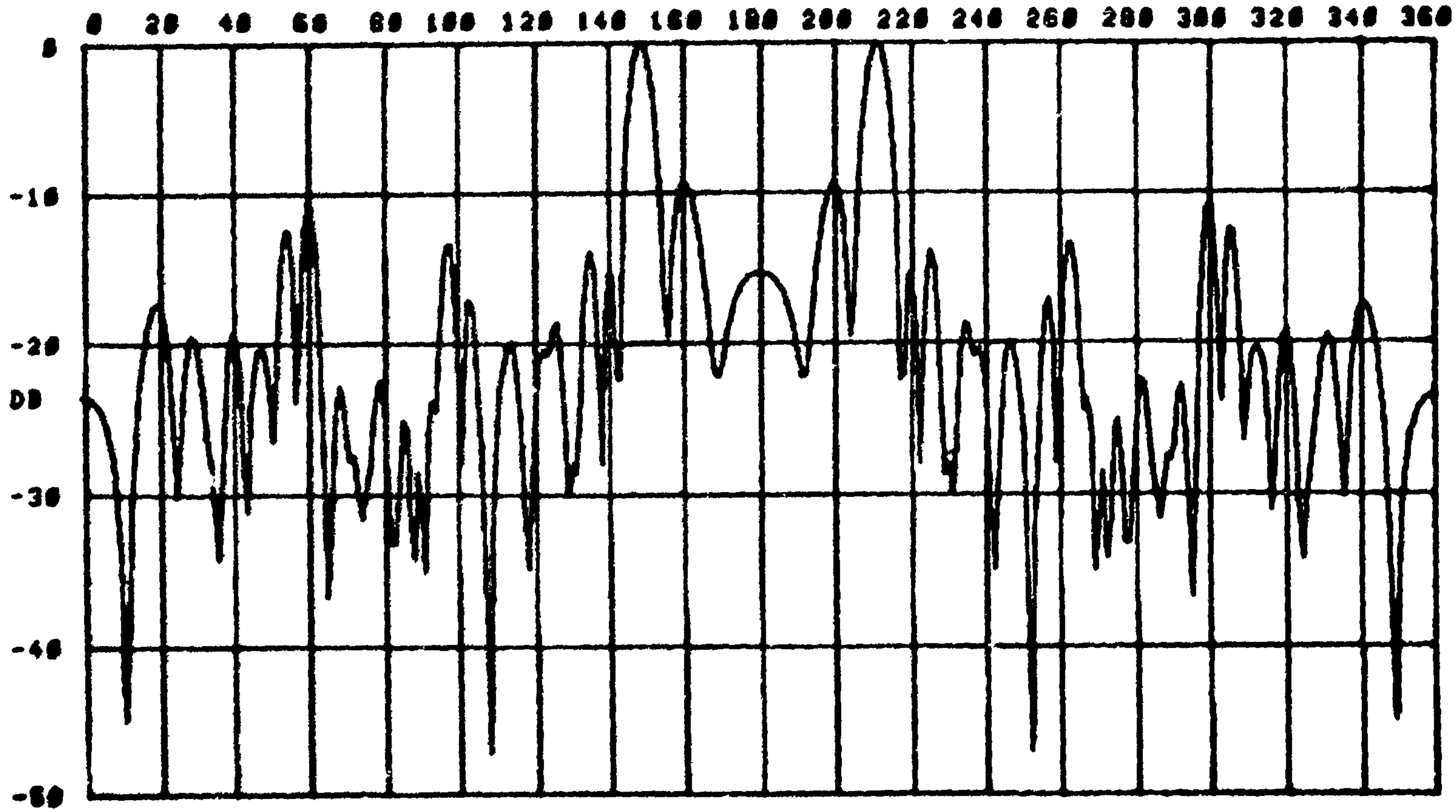


Figure B-28 Theoretical Horizontal Plane Pattern for 32 Element Array @ 290 Hz for Data Point 2, 59° Off Broadside Steering. Beamwidth 5.83°, Azimuth Gain 13.3dB.

CONFIDENTIAL

CONFIDENTIAL

S1231 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 24-Jan-78 ONTLDP 3.1
A: 16 ELEMENT SPRAY ARRAY. UNIFORMLY SPACED 6.33 FT.
NO ARRAY DEFORMATION
B: SAME

DATA POINT 1
1200 HZ. SAMPLING FREQ. DEGRADES PATTERN
290.0 HZ., 16 ELEMENTS, -0.70 DB MAX., AC:S1541,SU:S1541,WT:
90.0 DEG. VERT. RESP., 149.0 DEG. HORIZ. STEER. 90.0 DEG. VERT STEER
13.16 DEG. 3 DB BEAM, 10.46 DB AZ. GAIN, MAX. AT 150.0 DEG. HORIZ.

steer from B side

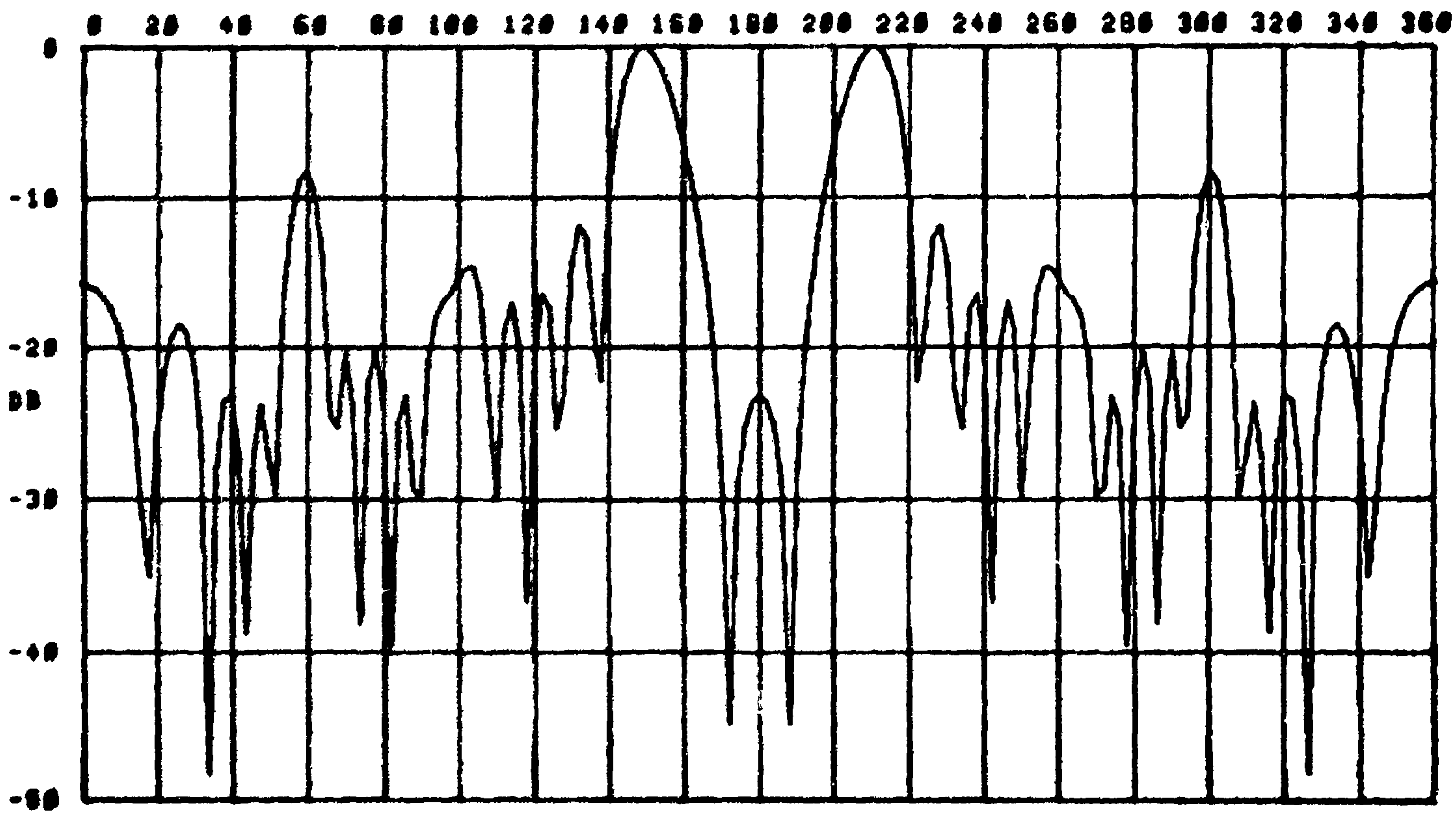


Figure B-29 Theoretical Horizontal Plane Pattern for 16 Element Array @ 290 Hz for Data Point 1, 59° Off Broadside Steering. Beamwidth 13.1°, Azimuth Gain 10.4 dB.

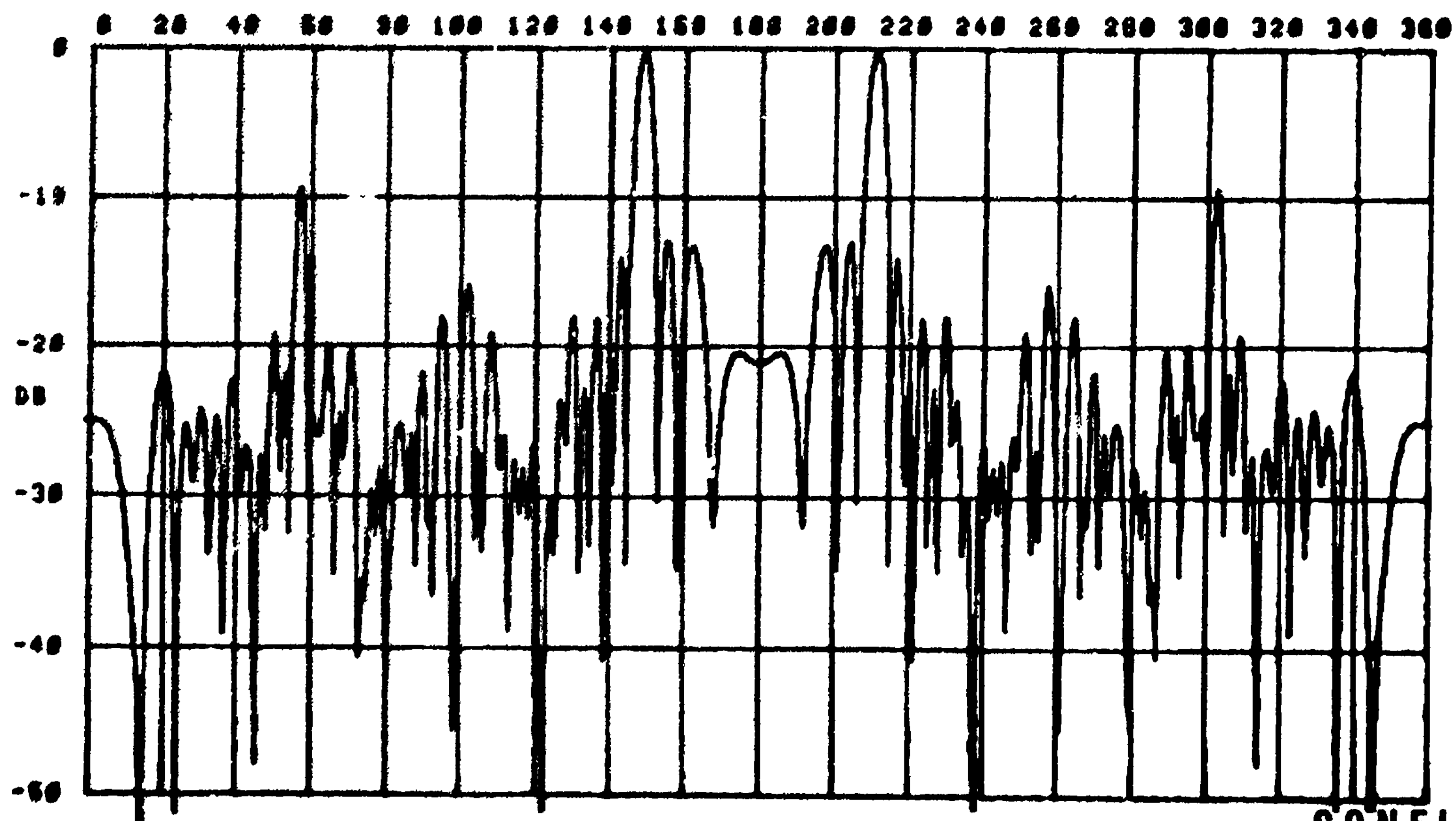
CONFIDENTIAL

Steering. Beamwidth 13.1°, Azimuth Gain 10.4 dB.

CONFIDENTIAL

```
   S1230  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)  24-Jan-78   ONTLBP 3.1
A: 53 ELEMENT SPRAY ARRAY SPACED 0.3333 FT.
   ELEMENT 16 DELETED FROM APERTURE
B: SAME

   DATA POINT 1
   1200 HZ. SAMPLING FREQ. DEGRADES PATTERN
   295.0 HZ.,  52 ELEMENTS, -0.84 DB MAX., AC:S1643,SU:S1643,WT:
    90.0 DEG. VERT. RESP., 149.0 DEG. HORIZ. STEER.  90.0 DEG. VERT STEER
    3.77 DEG. 3 DB BEAM,  15.50 DB AZ. GAIN, MAX. AT 149.0 DEG. HORIZ.
```



CONFIDENTIAL

Figure B-30 Theoretical Horizontal Plane Pattern for 52 Element Array @ 295 Hz for Data Point 1, 59° Off Broadside Steering. Beamwidth 3.77°, Azimuth Gain 15.5 dB.

CONFIDENTIAL

```
    61236  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)  24-Jan-78   BHTLBP 3.1
 A: 53 ELEMENT SPRAY ARRAY SPACED 0.3333 FT.
    ELEMENTS 16, 27 & 28 DELETED FROM APERTURE.
 S: SAME

    DATA POINTS 1 & 2
    1200 HZ. SAMPLING FREQ. DEGRADES PATTERN
    295.0 HZ.,  50 ELEMENTS, -0.83 DB MAX., AC:S1544,SU:S1544,WT:
     90.0 DEG. VERT. RESP., 149.0 DEG. HORIZ. STEER.  90.0 DEG. VERT STEER
     3.69 DEG. 3 DB BEAM,  15.38 DB AZ. GAIN, MAX. AT 211.0 DEG. HORIZ.
```

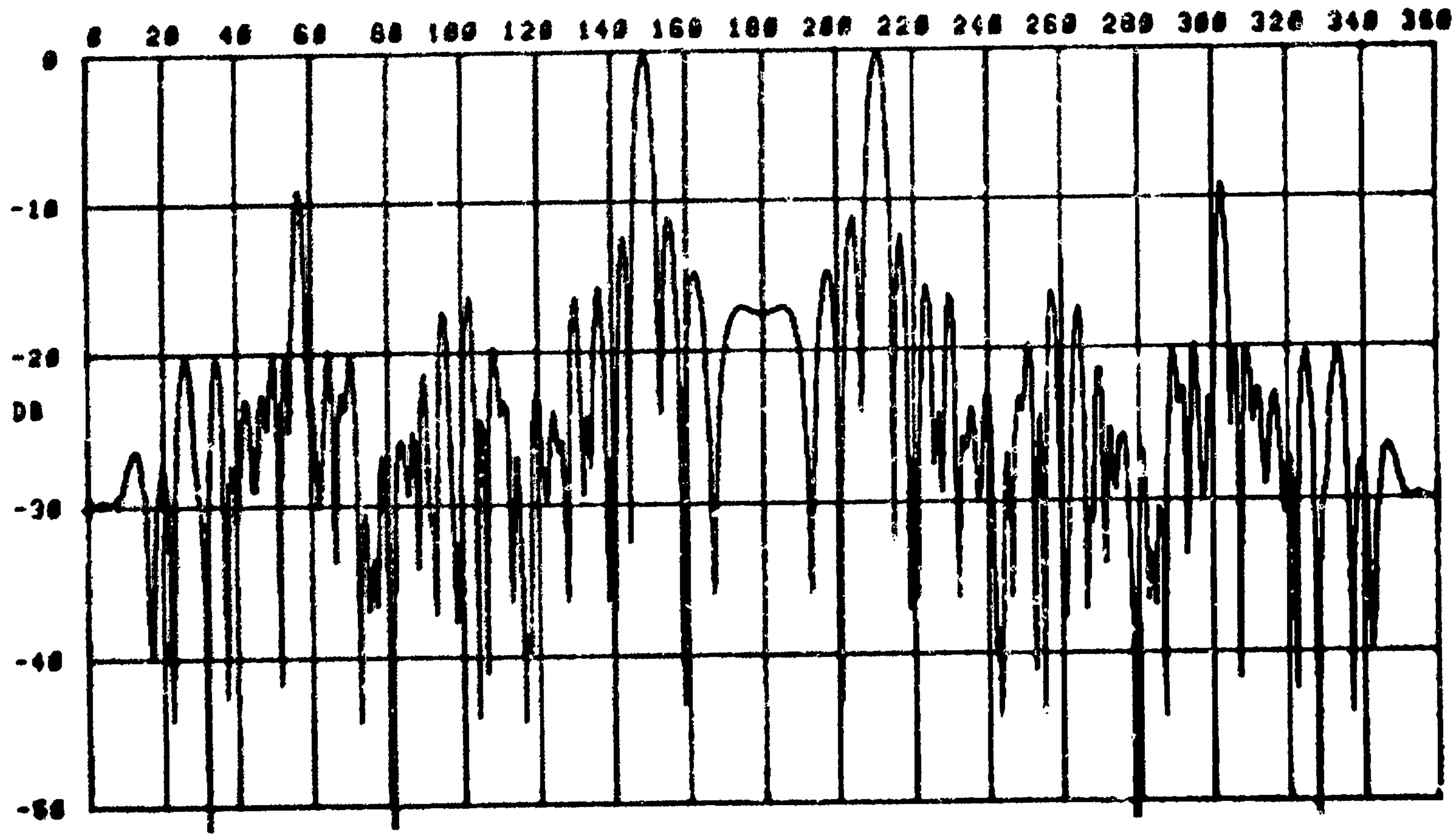


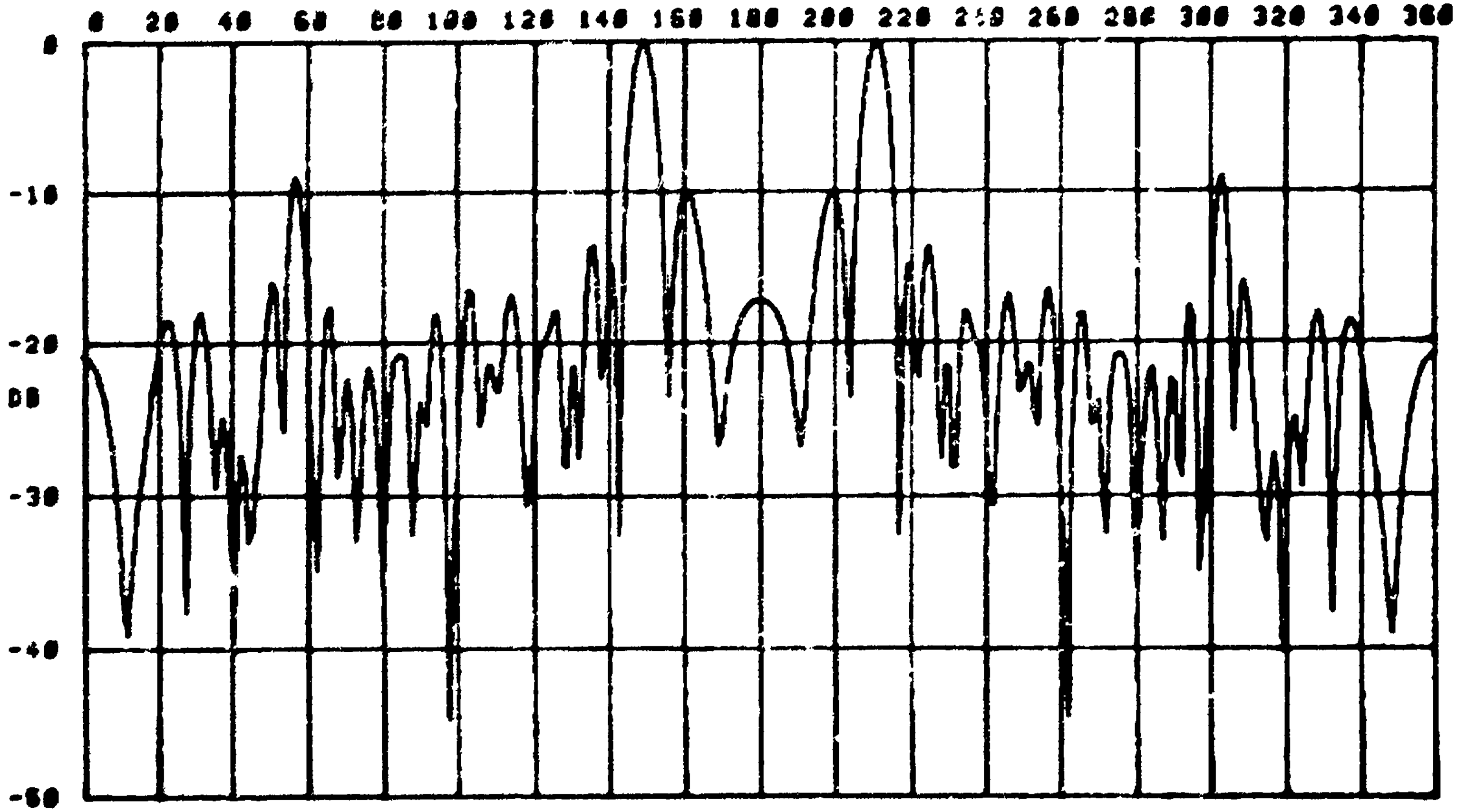
Figure B-31 Theoretical Horizontal Plane Pattern for 50 Element Array @ 295 Hz for Data Point 1-2, 59° Off Broadside Steering. Beamwidth 3.69°, Azimuth Gain 15.3 dB.

CONFIDENTIAL

CONFIDENTIAL

```
     S1234  SANBERS BEAM PATTERN PROGRAM (T.HOGAN)  24-Jan-70   OMTLBP 3.1
  A: 34 ELEMENT SPRAY ARRAY SPACED 8.3333 FT.
     ELEMENTS 27 AND 28 DELETED FROM APERTURE.
  S: SAME

     DATA POINTS 1 & 2
     1200 HZ. SAMPLING FREQ. DEGRADES PATTERN
     295.0 HZ.,  32 ELEMENTS, -0.02 DB MAX., AC:S1542,SU:S1542,WT:
      90.0 DEG. VERT. RESP., 149.0 DEG. HORIZ. STEER,  58.0 DEG. VERT STEER
      5.79 DEG. 3 DB BEAM,  13.44 DB AZ. GAIN, MAX. AT 149.0 DEG. HORIZ.
```



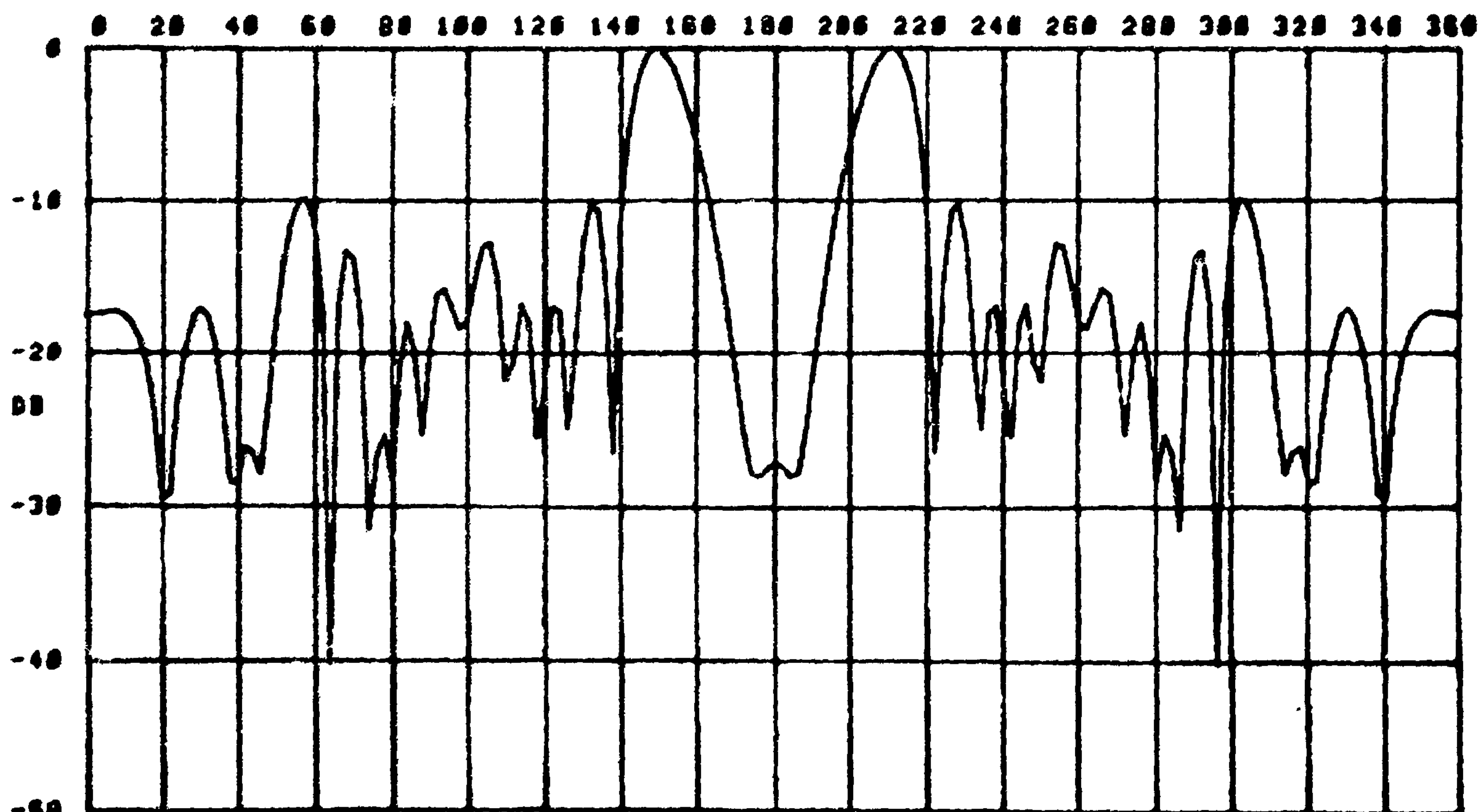
CONFIDENTIAL

Figure B-32 Theoretical Horizontal Plane Pattern for 32 Element Array @ 29– Hz for Data Point 1,2, 59° Off Broadside Steering. Beamwidth 5.79°, Azimuth Gain 13.4 dB.

CONFIDENTIAL

```
     S1232  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)  24-Jan-70   SNVLBF 3.1
  A: 16 ELEMENT SPRAY ARRAY.  UNIFORMLY SPACED 0.33 FT.
     NO ARRAY DEFORMATION
  B: SAME

     DATA POINT 1
     1200 HZ. SAMPLING FREQ. DEGRADES PATTERN
     295.0 HZ..  16 ELEMENTS. -0.90 DB MAX.. AC:S1541.SU:S1541.WT:
      90.0 DEG. VERT. RESP.. 149.0 DEG. HORIZ. STEER.  90.0 DEG. VERT STEER
     13.07 DEG. 3 DB BEAM.  10.33 DB AZ. GAIN. MAX. AT 150.0 DEG. HORIZ.
```



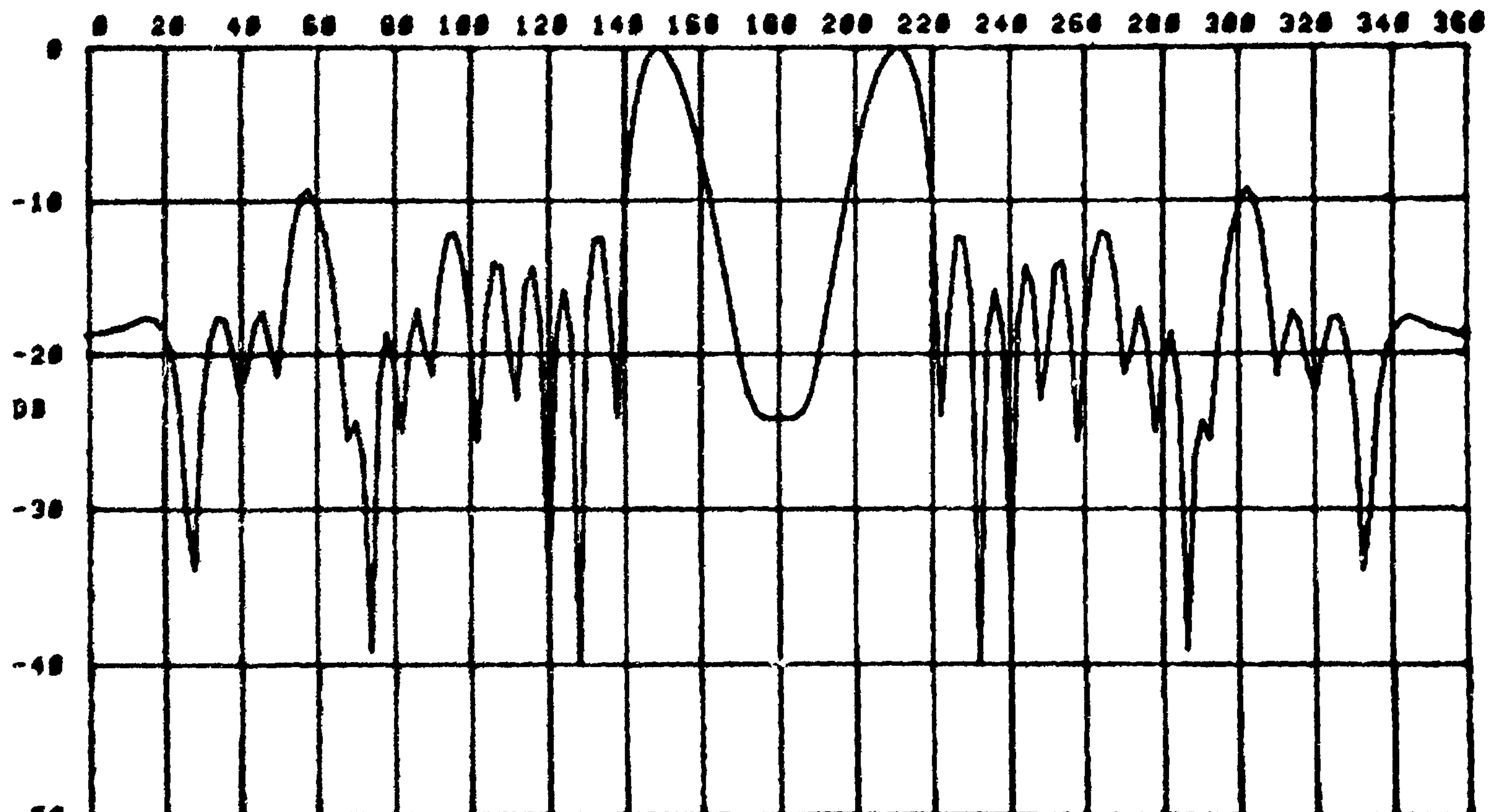
CONFIDENTIAL

Figure 3-33 Theoretical Horizontal Plane Pattern for 16 Element Array @ 295 Hz for Data Point 1, 59° Off Broadside Steering. Beamwidth 13.07°, Azimuth Gain 10.3 dB.

CONFIDENTIAL

```
   S1239  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)  24-Jan-78   ONTLSP 3.1
A: 63 ELEMENT SPRAY ARRAY SPACED 0.3333 FT.
   ELEMENT 15 DELETED FROM APERTURE
B: SAME

   DATA POINT 2
   1200 HZ. SAMPLING FREQ. DEGRADES PATTERN
   290.0 HZ.,  16 ELEMENTS, -0.07 DB MAX., AC:S1543,SU:S1543,WT:
    90.0 DEG. VERT. RESP., 149.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
   12.70 DEG. 3 DB BEAM,  10.37 DB AZ. GAIN, MAX. AT 212.0 DEG. HORIZ.
```



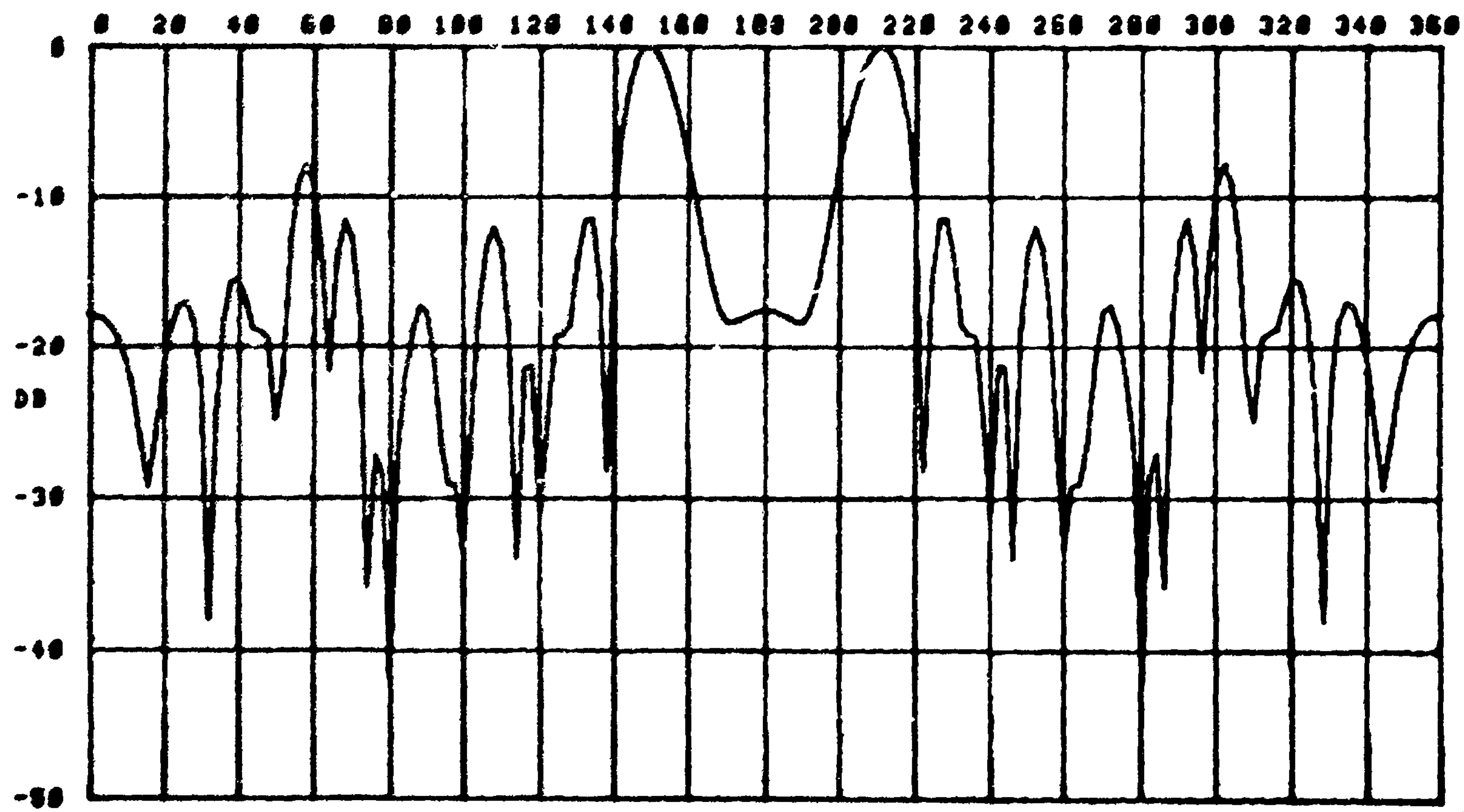
CONFIDENTIAL

Figure E-34 Theoretical Horizontal Plane Pattern for 16 Element Array @ 290 Hz for Data Point 2, 59° Off Broadside Steering. Beamwidth 12.7°, Azimuth Gain 10.3 dB.

CONFIDENTIAL

S123A SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 24-Jan-78 ONTLDP 3.1
A: 53 ELEMENT SPRAY ARRAY SPACED 0.3333 FT.
ELEMENT 15 DELETED FROM APERTURE
B: SAME

DATA POINT 2
1200 HZ. SAMPLING FREQ. DEGRADES PATTERN
295.0 HZ., 16 ELEMENTS, -0.06 DB MAX., AC:S1543,SU:S1543,WT:
90.9 DEG. VERT. RESP., 149.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
12.31 DEG. 3 DB BEAM, 10.44 DB AZ. GAIN, MAX. AT 212.0 DEG. HORIZ.



CONFIDENTIAL

Figure B-35 Theoretical Horizontal Plane Pattern for 16 Element Array @ 295 Hz for Data Point 2, 59° Off Broadside Steering. Beamwidth 12.31°, Azimuth Gain 10.4 dB.

CONFIDENTIAL

S6278 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 28-Feb-78 ONTLBP 3.1
4: SFRA) ARRAY TUNED TO 300 HZ.
6.3333 FT. UNIFORM SPACING.
5: SAME

DATA POINT 3
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 51 ELEMENTS, -0.02 DB MAX., AC:S2581.SU:S2581.WT:
90.0 DEG. VERT. RESP., 116.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
2.16 DEG. 3 DB BEAM, 17.24 DB AZ. GAIN, MAX. AT 116.0 DEG. HORIZ.

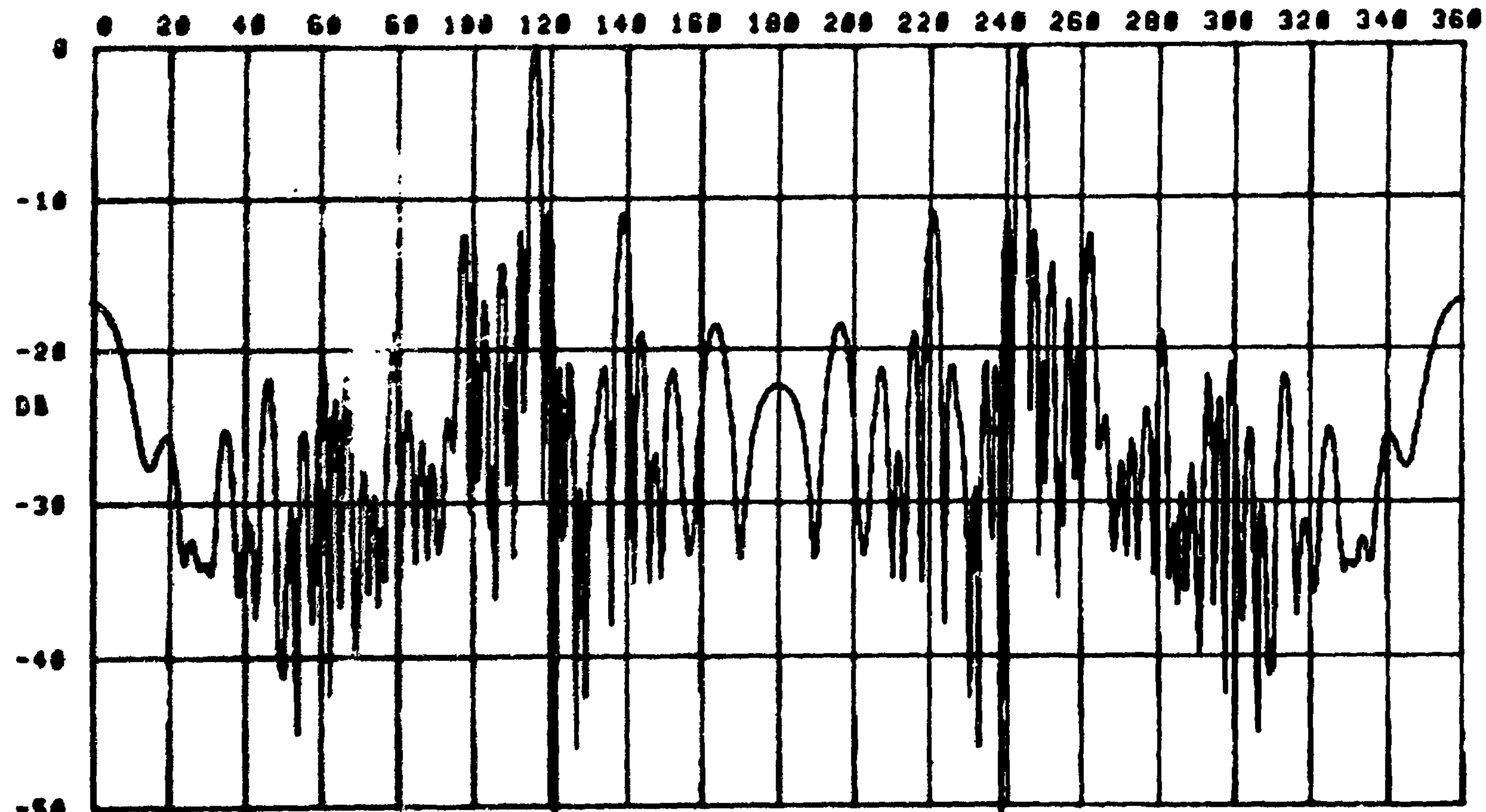


Figure B-36 Theoretical Horizontal Plane Pattern for 51 Element Array @ 290 Hz for Data Point 3, 26° Off Broadside Steering. Beamwidth 2.16°, Azimuth Gain 17.2 dB.

CONFIDENTIAL

CONFIDENTIAL

S2278 SAMBERG BEAM PATTERN PROGRAM (T.HOGAN) 20-Feb-78 ONTLBP 3.1
A: STEAT ARRAY TUNED TO 300 HZ.
6.3233 FT. UNIFORM SPACING.
S: SAME

DATA POINT 3
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 32 ELEMENTS, -0.02 DB MAX., AC:S2501,SU:S2501,WT:
90.0 DEG. VERT. RESP., 116.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
3.45 DEG. 3 DB BEAM, 15.20 DB AZ. GAIN, MAX. AT 116.0 DEG. HORIZ.

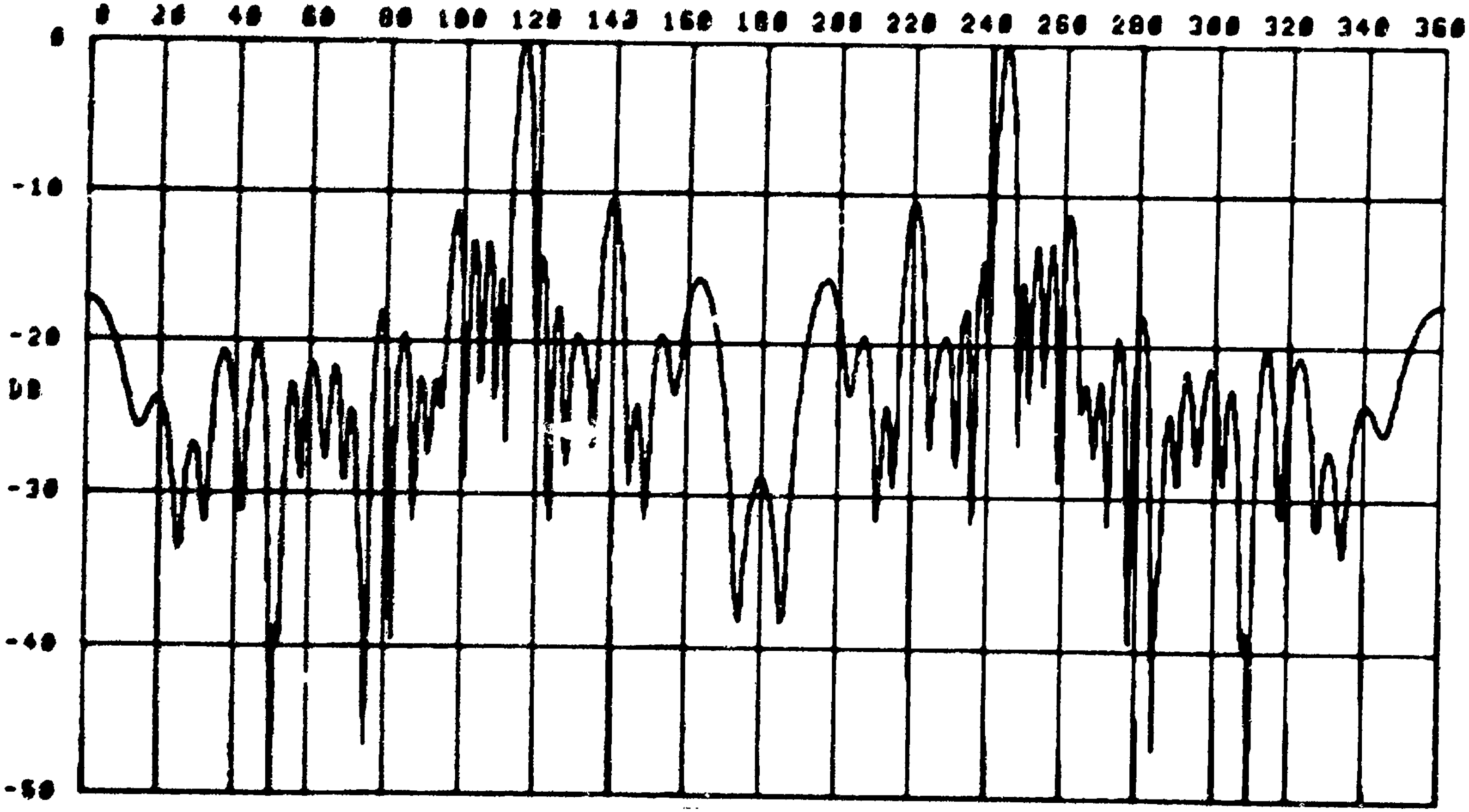


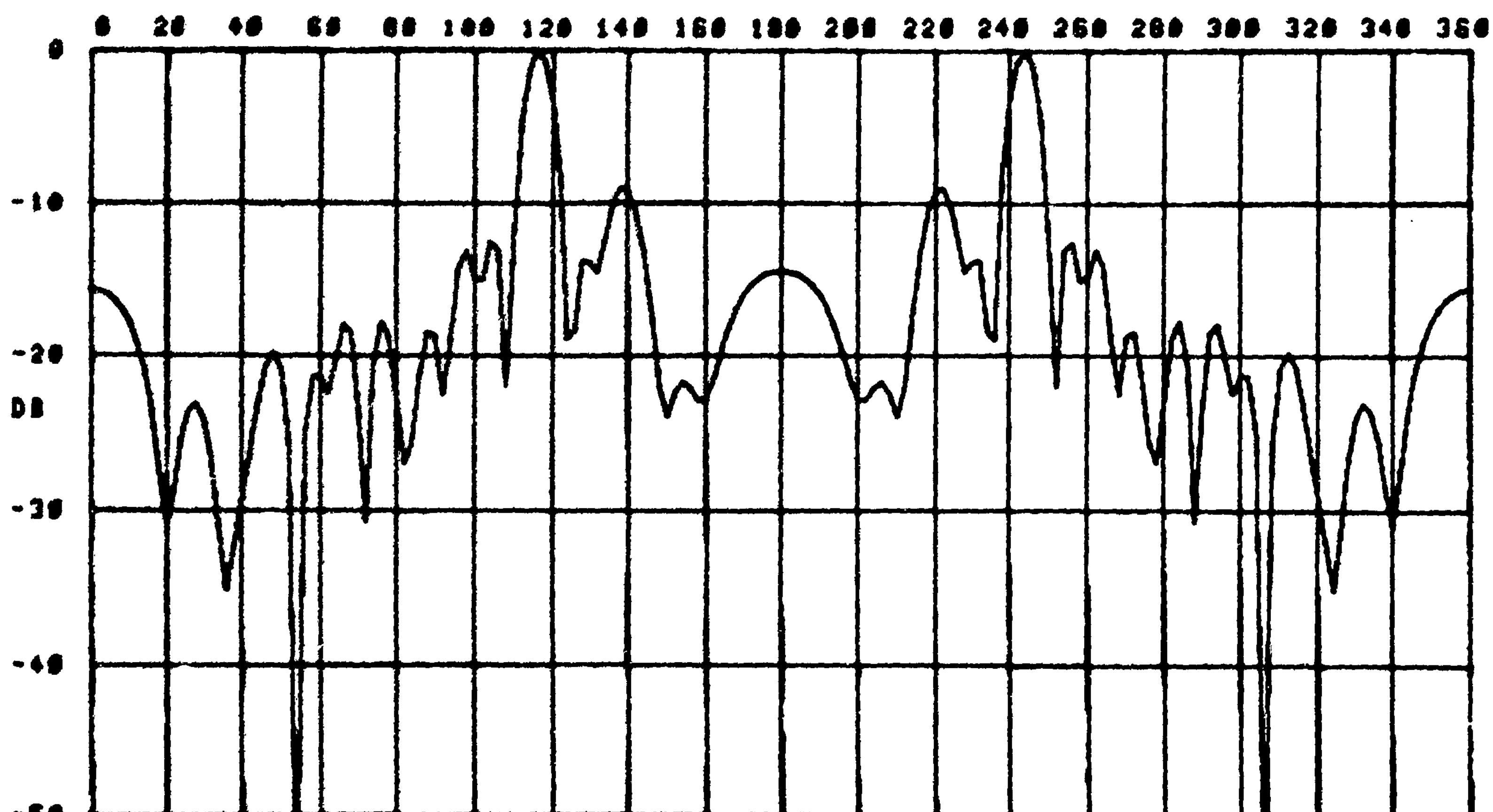
Figure 5-37 Theoretical Horizontal Plane Pattern for 32 Element Array @ 290 Hz for Data Point 3, 26° Off Broadside Steering. Beamwidth 3.45°, Azimuth Gain 15.2 dB.

CONFIDENTIAL

CONFIDENTIAL

```
     S2272  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)  20-Feb-78   QNTLBP 3.1
  A: SFEA) ARRAY TUNED TO 300 HZ.
     6.3333 FT. UNIFORM SPACING.
  B: SAME

     DATA POINT 3
     1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
     290.0 HZ.,  16 ELEMENTS, -0.76 DB MAX., AC:S2501.GU:S2501,WT:
      90.0 DEG. VERT. RESP., 116.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
      7.27 DEG. 3 DB BEAM,  12.26 DB AZ. GAIN, MAX. AT 116.0 DEG. HORIZ.
```



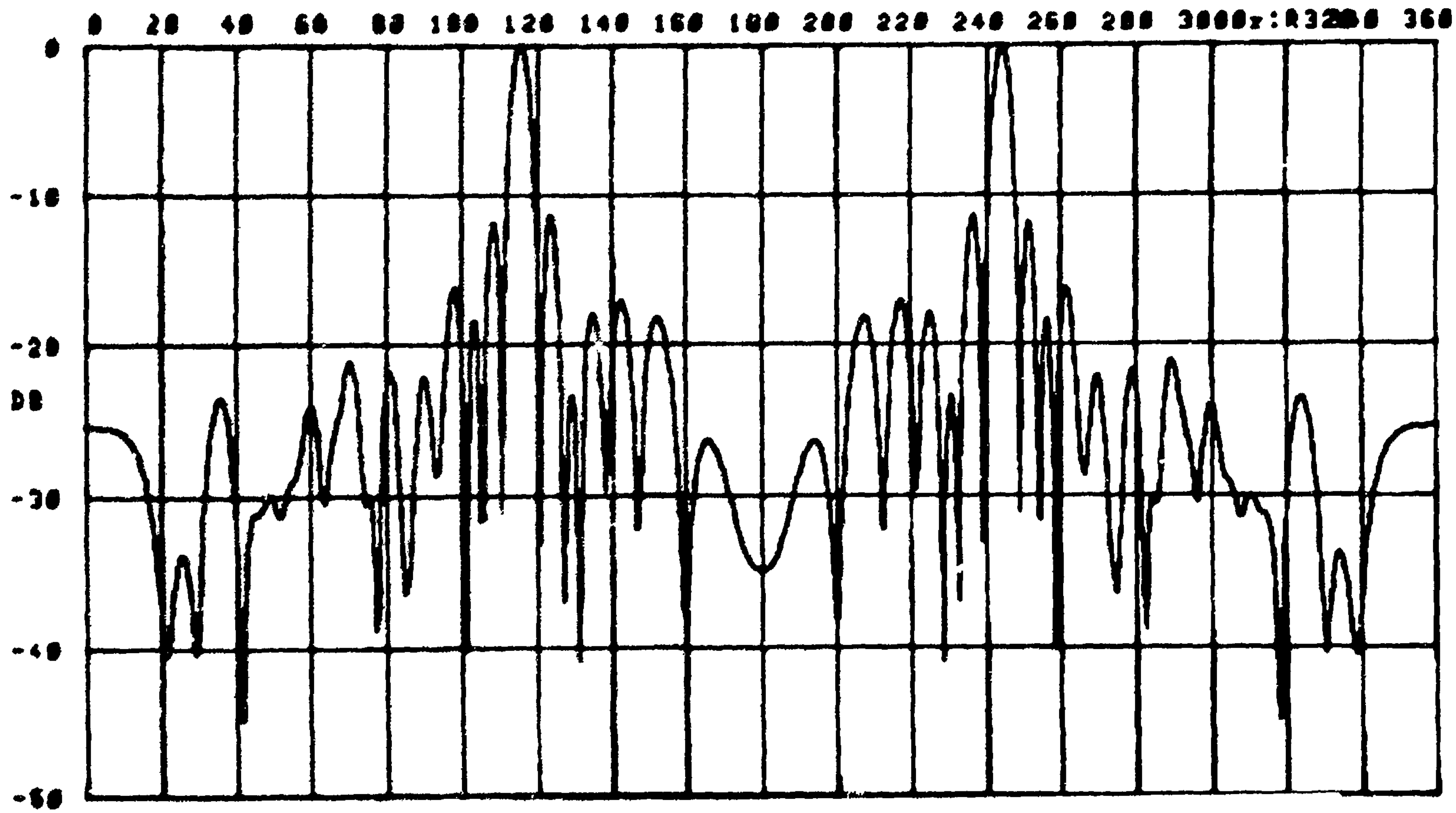
CONFIDENTIAL

Figure B-38 Theoretical Horizontal Plane Pattern for 16 Element Array @ 290 Hz for Data Point 3, 26° Off Broadside Steering. Beamwidth 7.27°, Azimuth Gain 12.2 dB.

CONFIDENTIAL

```
     S2277  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)  28-Feb-70   ONTLBP 3.1
A:   SFBA) ARRAY TUNED TO 300 HZ.
     6.3333 FT. UNIFORM SPACING.
S:   SAME

     DATA POINT 3
     1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
     140.0 HZ.,   51 ELEMENTS, -0.19 DB MAX., AC:S2581,SU:S2581,WT:
      90.0 DEG. VERT. RESP., 116.0 DEG. HORIZ. STEER.  90.0 DEG. VERT STEER
      4.47 DEG. 3 DB BEAM.  15.12 DB AZ. GAIN, MAX. AT 116.0 DEG. HORIZ.
```



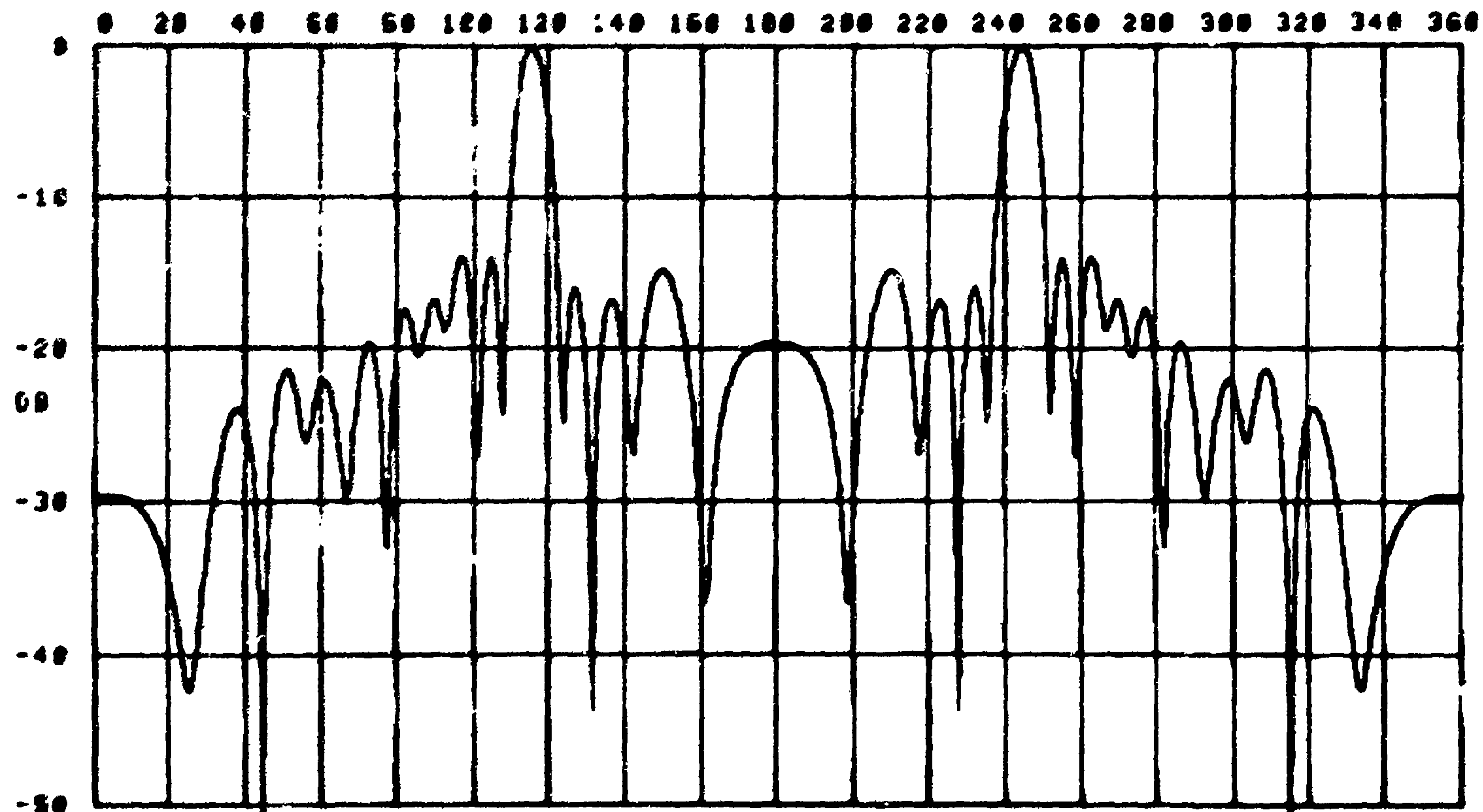
CONFIDENTIAL

Figure B-39 Theoretical Horizontal Plane Pattern for 51 Element Array @ 140 Hz for Data Point 3, 26° Off Broadside Steering. Beamwidth 4.47°, Azimuth Gain 15.1 dB.

CONFIDENTIAL

```
F2274  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)  28-Feb-78    ONTLBP 3 1
A: SPRAY ARRAY TUNED TO 300 HZ.
   6.3333 FT. UNIFORM SPACING.
B: SAME

   DATA POINT 3
   1200 HZ SAMPLING FREQUENCY DISTCRTS PATTERN.
   140.0 HZ.,  32 ELEMENTS, -0.10 DB MAX., AC:S2581,SU:S2581,WT:
    90.0 DEG. VERT. RESP., 116.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
    7.16 DEG. 3 DB BEAM,  13.13 DB AZ. GAIN, MAX. AT 115.6 DEG. HORIZ.
```



CONFIDENTIAL

Figure B-40 Theoretical Horizontal Plane Pattern for 32 Element Array @ 140 Hz for Data Point 3, 26° Off Broadside Steering. Beamwidth 7.16°, Azimuth Gain 13.1 dB.

CONFIDENTIAL

5AA71 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 20-Feb-78 ONTLBP 3.1
A: SFBA1 ARRAY TUNED TO 300 HZ.
6.3333 FT. UNIFORM SPACING.
B: SAME

DATA POINT 3
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 16 ELEMENTS, -0.16 DB MAX., AC:S2501,SU:S2601,WT:
50.0 DEG. VERT. RESP., 116.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
15.10 DEG. 3 DB BEAM. 10.01 DB AZ. GAIN, MAX. AT 116.0 DEG. HORIZ.

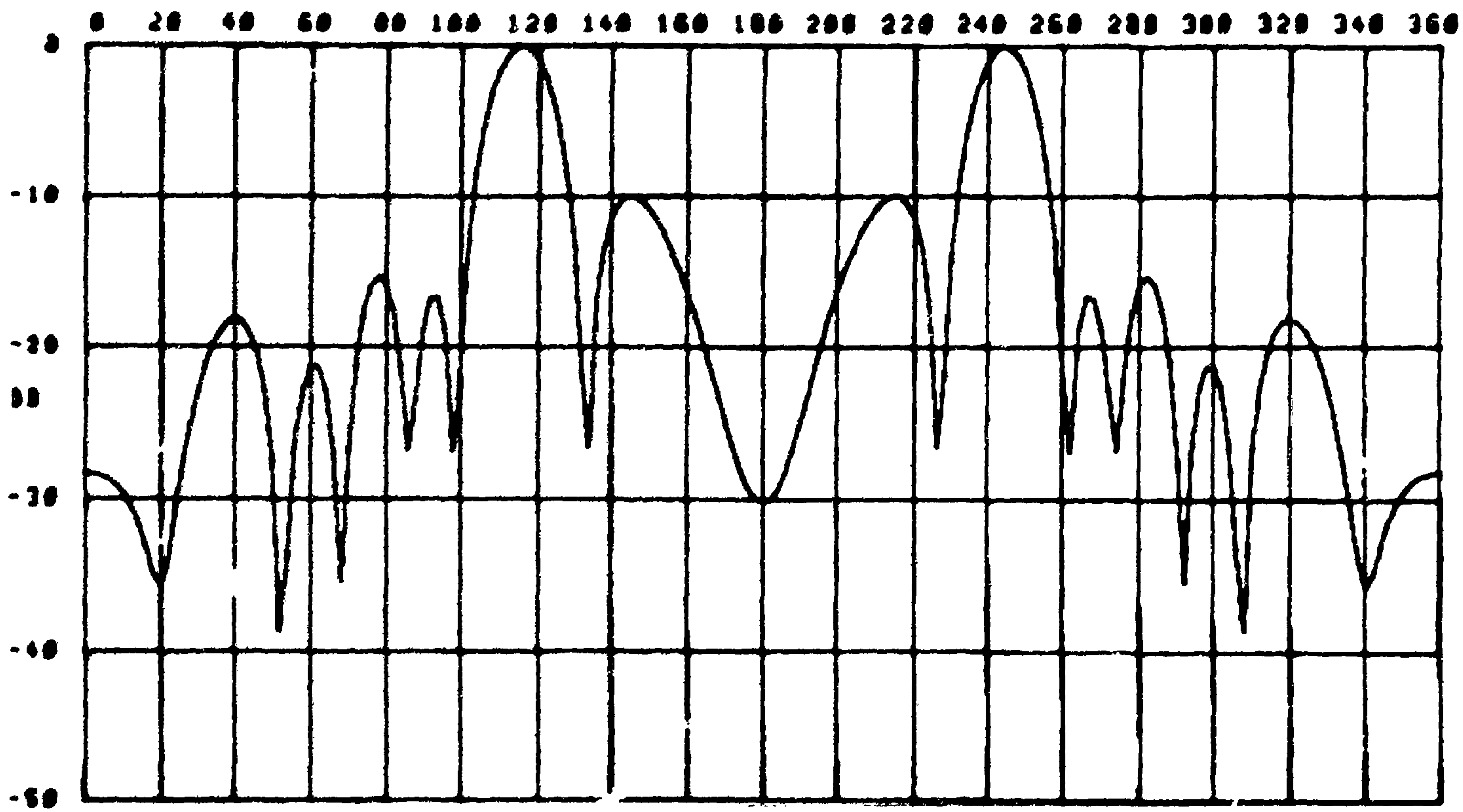


Figure B-41 Theoretical Horizontal Plane Pattern for 16 Element Array @ 140 Hz for Data Point 3, 26° Off Broadside Steering. Beamwidth 15.1°, Azimuth Gain 10.0dB.

CONFIDENTIAL

CONFIDENTIAL

S2279 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 28-Feb-78 ONTLBP 3.1
A: SFRAY ARRAY TUNED TO 300 HZ.
6.3333 FT. UNIFORM SPACING.
B: SAME

DATA POINT 3
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ.. 51 ELEMENTS, -0.01 DB MAX.. AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP.. 116.0 DEG. HORIZ. STEER. 90.0 DEG. VERT STEER
2.12 DEG. 3 DB BEAM, 17.35 DB AZ. GAIN, MAX. AT 116.0 DEG. HORIZ.

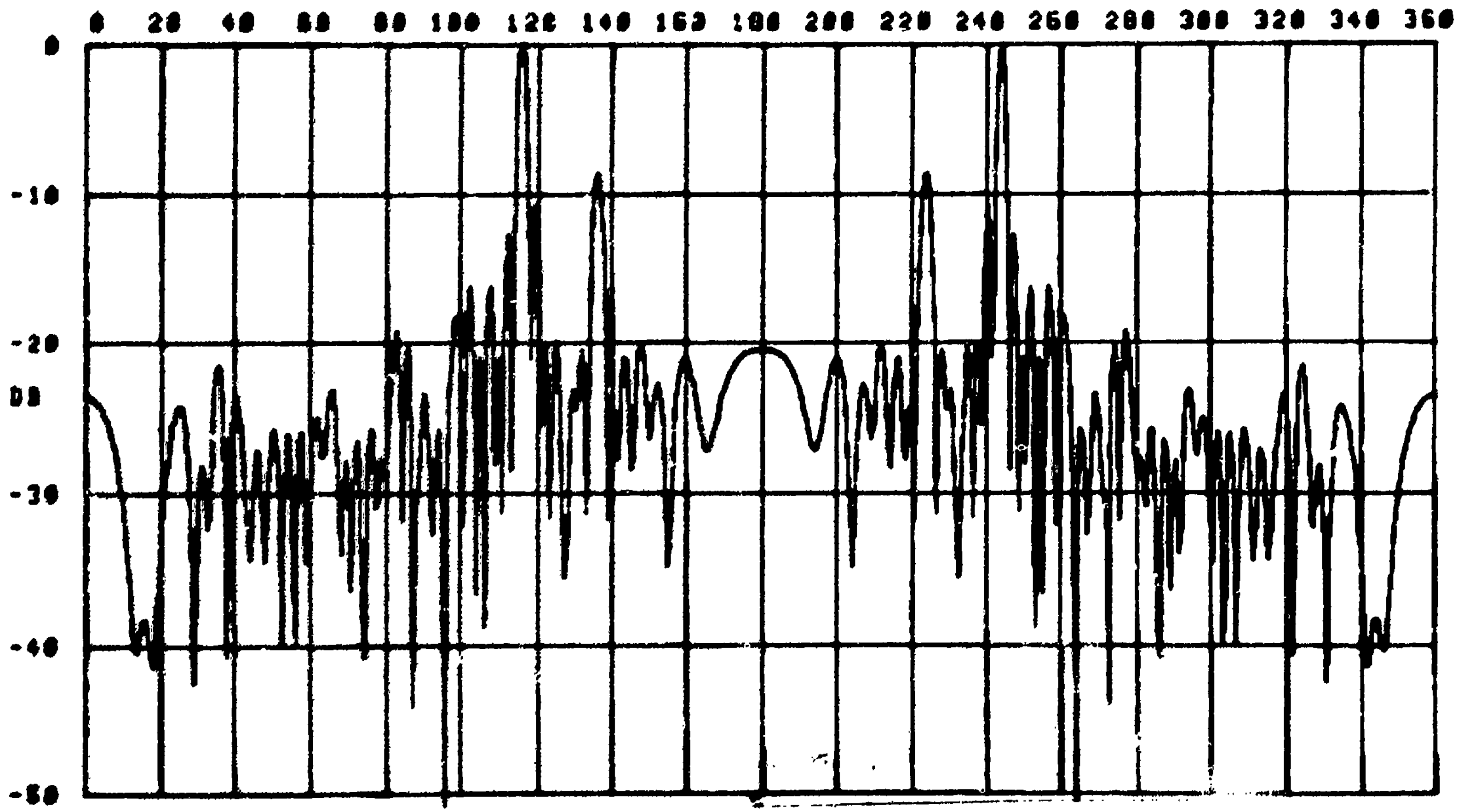


Figure B-42 Theoretical Horizontal Plane Pattern for 51 Element Array @ 295 Hz for Data Point 3, 26° Off Broadside Steering. Beamwidth 2.12°, Azimuth Gain 17.3 dB.

CONFIDENTIAL

CONFIDENTIAL

S2276 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 20-Feb-78 ONTLBP 3.1
A: SFRAY ARRAY TUNED TO 300 HZ.
6.3333 FT. UNIFORM SPACING.
S: SAME

DATA POINT 3
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ., 32 ELEMENTS, -0.82 DB MAX., AC:S2581,SU:S2581,HT:
90.0 DEG. VERT. RESP., 116.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
3.42 DEG. 3 DB BEAM, 15.29 DB AZ. GAIN, MAX. AT 116.0 DEG. HORIZ.

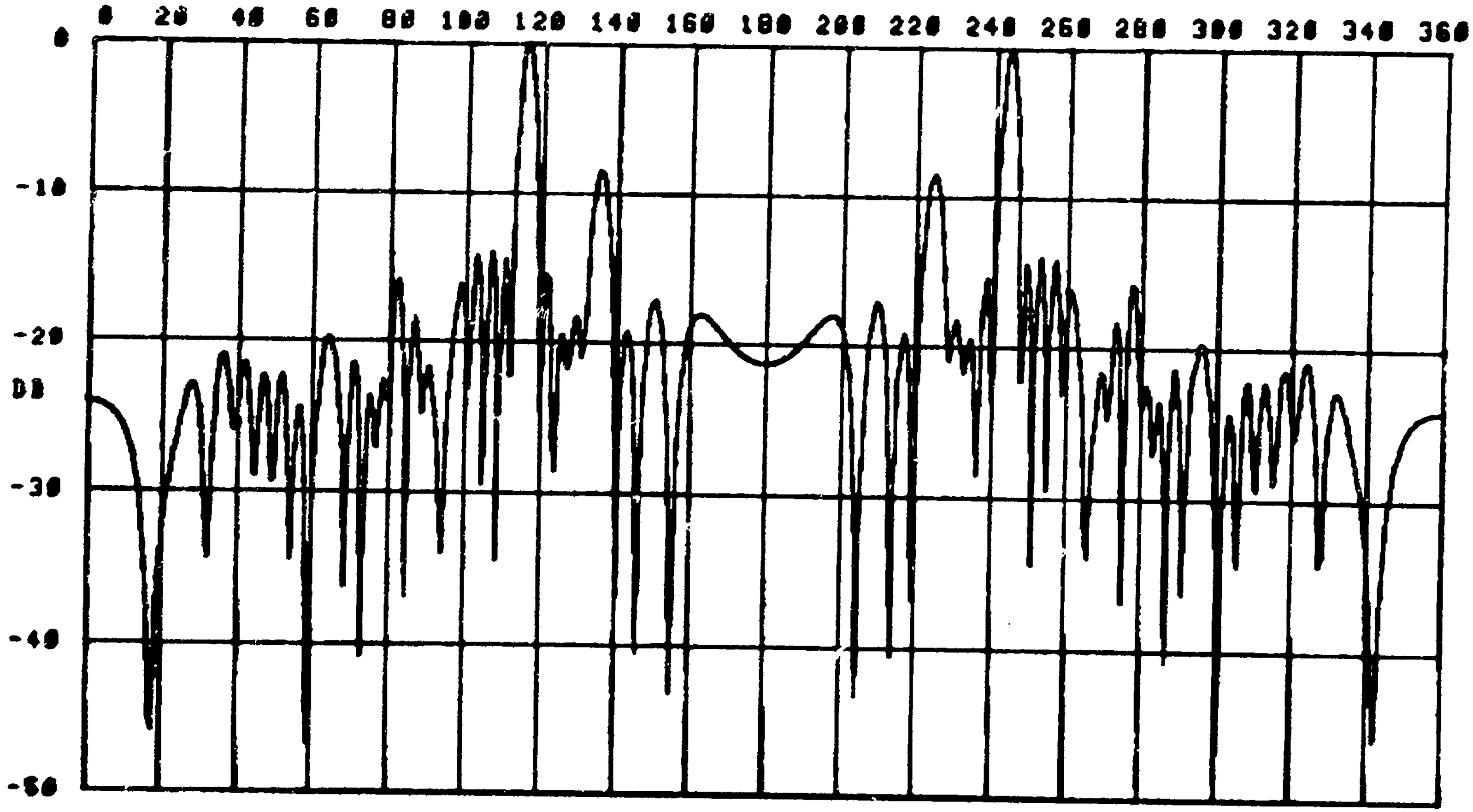


Figure B-43 Theoretical Horizontal Plane Pattern for 32 Element Array @ 295 Hz for Data Point 3, 26° Off Broadside Steering. Beamwidth 3.42°, Azimuth Gain 15.2 dB.

CONFIDENTIAL

CONFIDENTIAL

S2273 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 20-Feb-78 ONTLBP 3.1
A: SPRAY ARRAY TUNED TO 300 HZ.
0.3333 FT. UNIFORM SPACING.
S: SAME

DATA POINT 3
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ., 16 ELEMENTS, -0.77 DB MAX., AC:S2501,SU:S2501,WT:
50.0 DEG. VERT. RESP., 116.2 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
7.05 DEG. 3 DB BEAM, 12.39 DB AZ. GAIN, MAX AT 116.0 DEG. HORIZ.

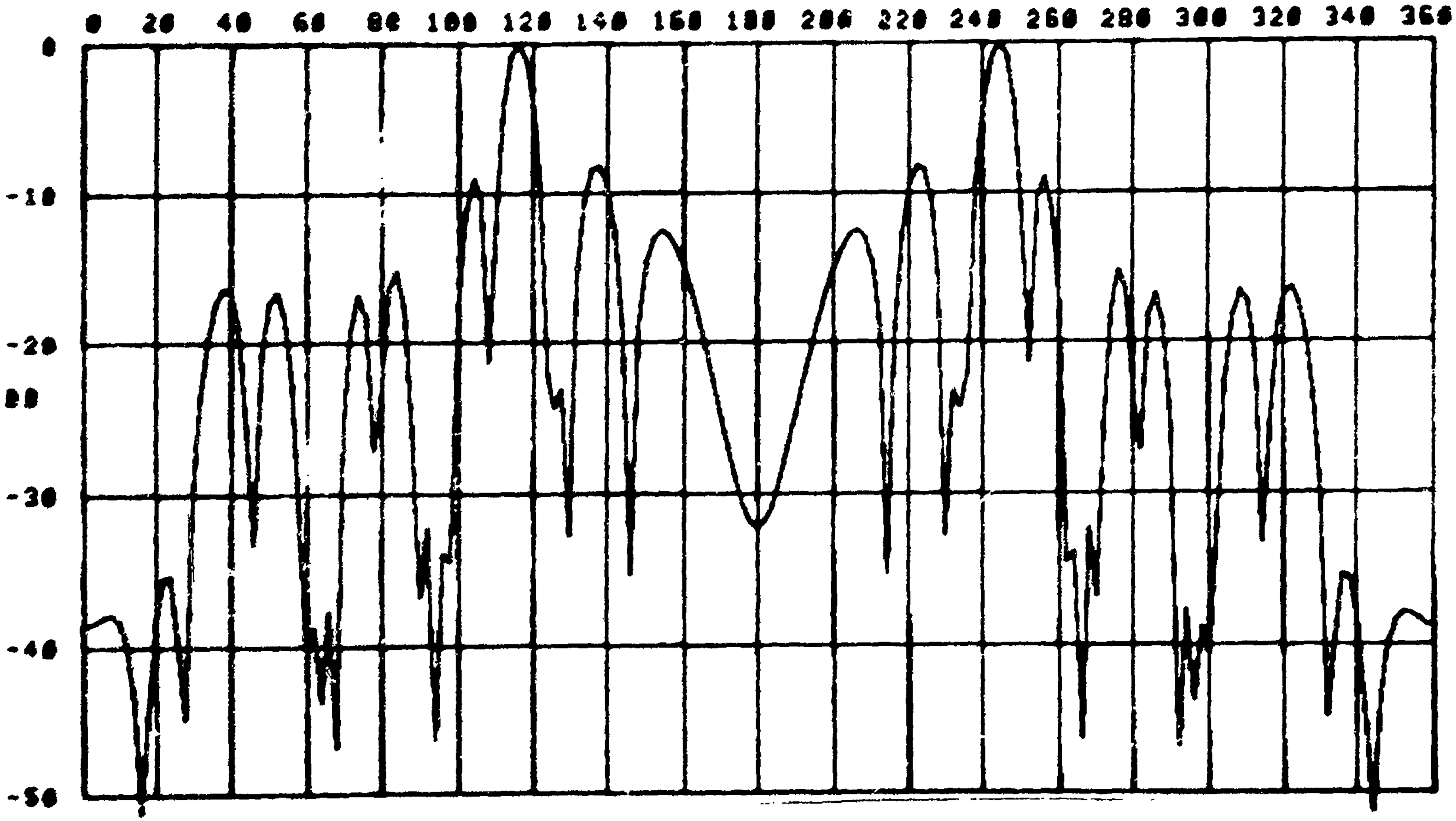


Figure B-44 Theoretical Horizontal Plane Pattern for 16 Element Array @ 295 Hz for Data Point 3, 26° Off Broadside Steering. Beamwidth 7.05°, Azimuth Gain 12.3 dB.

CONFIDENTIAL

CONFIDENTIAL

S227N SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 26-Feb-78 ANTLBP 3.1
A: SFRAY ARRAY TUNED TO 300 HZ.
6.3333 FT. UNIFORM SPACING.
S: SAME

34

DATA POINT 4
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 51 ELEMENTS, +0.79 DB MAX., AC:S2581,SU:S2581,WT:
50.0 DEG. VERT. RESP., 124.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
2.33 DEG. 3 DB BEAM, 17.15 DB AZ. GAIN, MAX. AT 236.0 DEG. HORIZ.

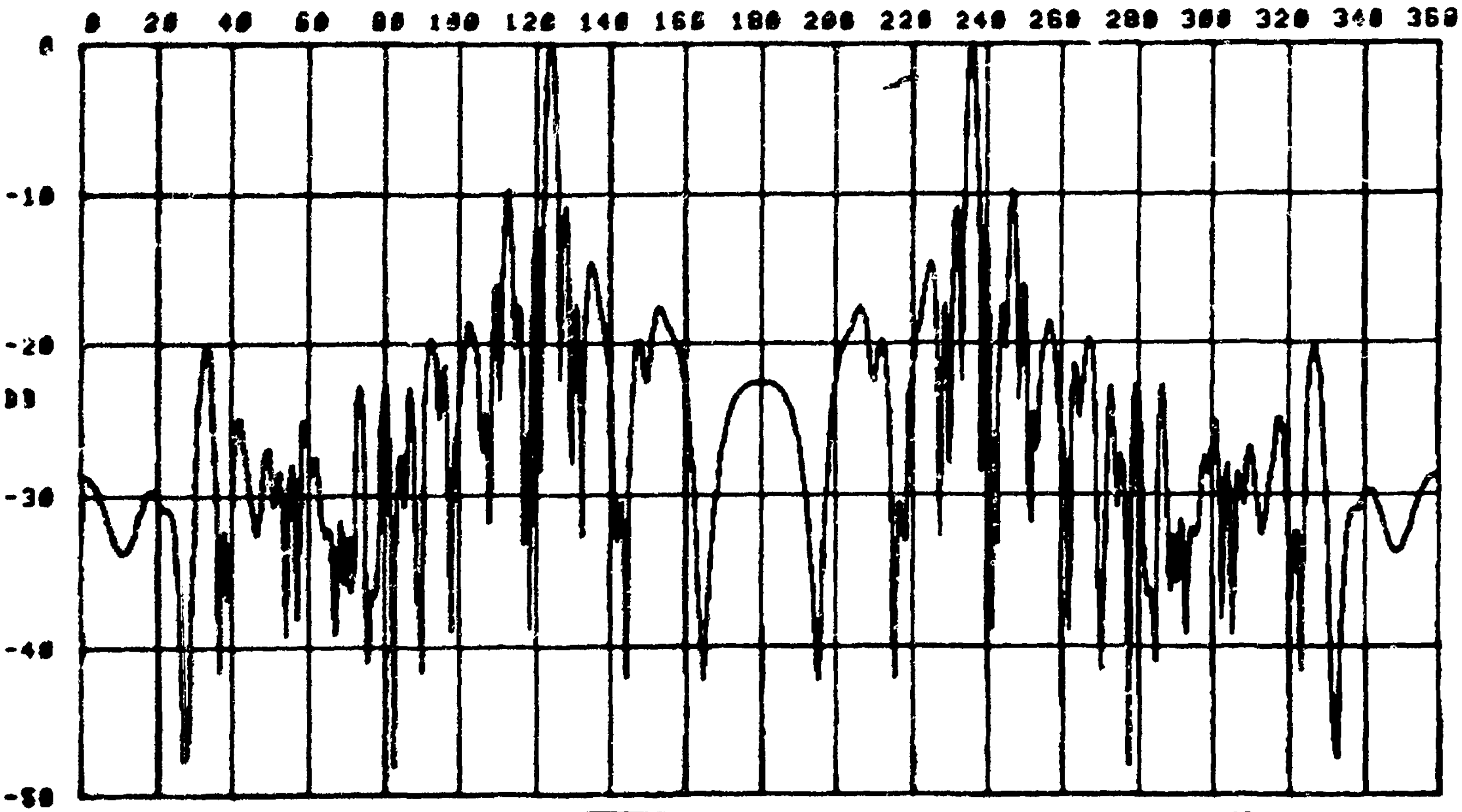


Figure B-45 Theoretical Horizontal Plane Pattern for 51 Element Array @ 290 Hz for Data Point 4, 34° Off Broadside Steering. Beamwidth 2.33°, Azimuth Gain 17.1 dB.

CONFIDENTIAL

CONFIDENTIAL

S2272 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 28-Feb-78 BMTLBP 3.1
A: SFRA1 AREA1 TUNED TO 300 HZ.
6.5333 FT. UNIFORM SPACING.
S: SAME

DATA POINT 4
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 32 ELEMENTS, -0.90 DB MAX., AC:52581,SU:52581,WT:
90.0 DEG. VERT. RESP., 124.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
3.80 DEG. 3 DB BEAM, 14.96 DB AZ. GAIN, MAX. AT 124.5 DEG. HORIZ.

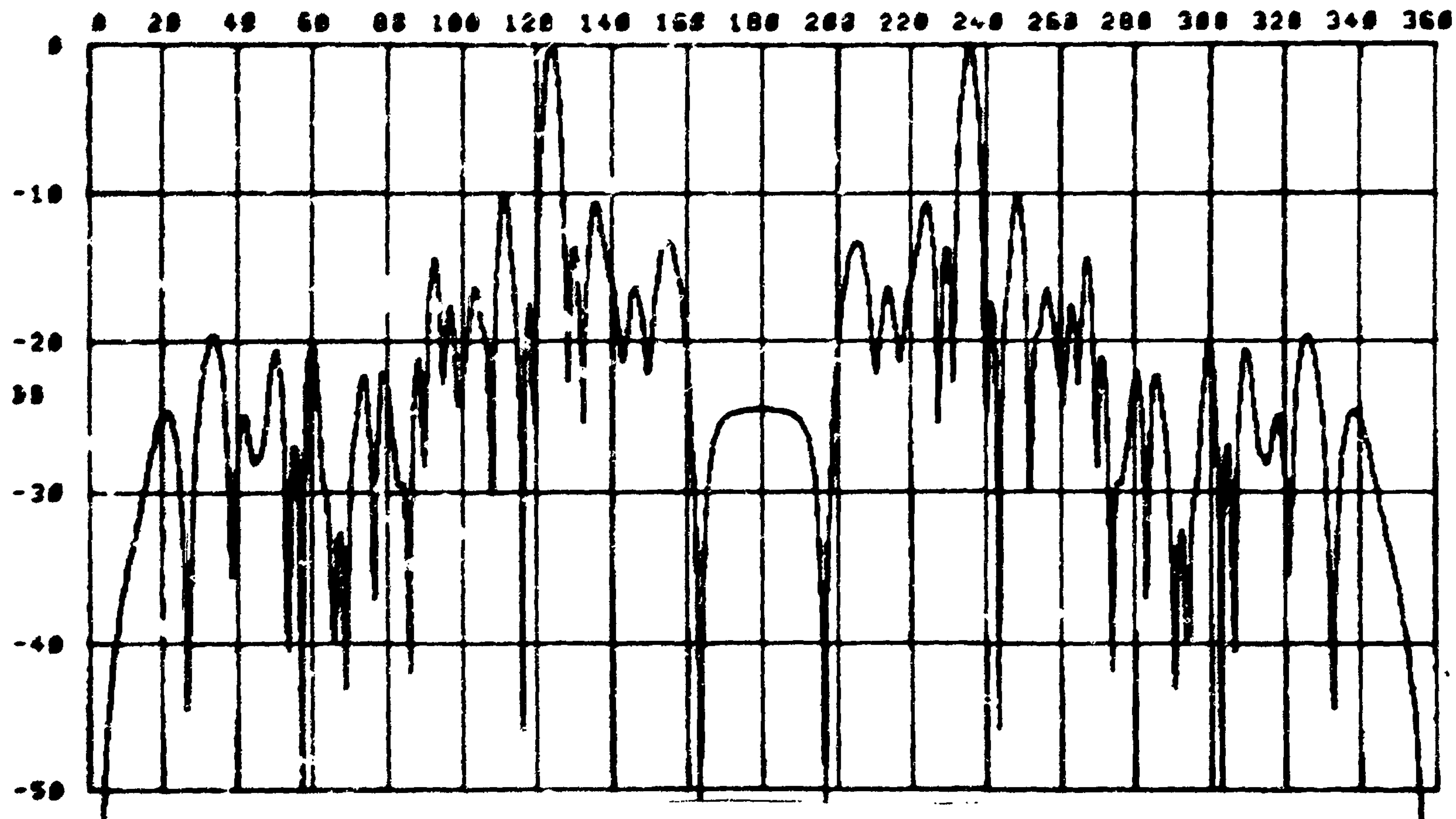


Figure B-46 Theoretical Horizontal Plane Pattern for 32 Element Array @ 290 Hz for Data Point 4, 34° Off Broadside Steering. Beamwidth 3.80°, Azimuth Gain 14.9 dB.

CONFIDENTIAL

CONFIDENTIAL

S2278 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 20-Feb-78 ONTLBP 3.1
A: SFRA) ARRAY TUNED TO 300 HZ.
6.3333 FT. UNIFORM SPACING.
B: SAME

DATA POINT 4
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 16 ELEMENTS, -6.65 DB MAX., AC:S2501,SU:S2501,WT:
90.0 DEG. VERT. RESP., 124.0 DEG. HORIZ. STEER. 90.0 DEG. VERT STEER
7.90 DEG. 3 DB BEAM. 12.26 DB AZ. GAIN, MAX. AT 236.0 DEG. HORIZ.

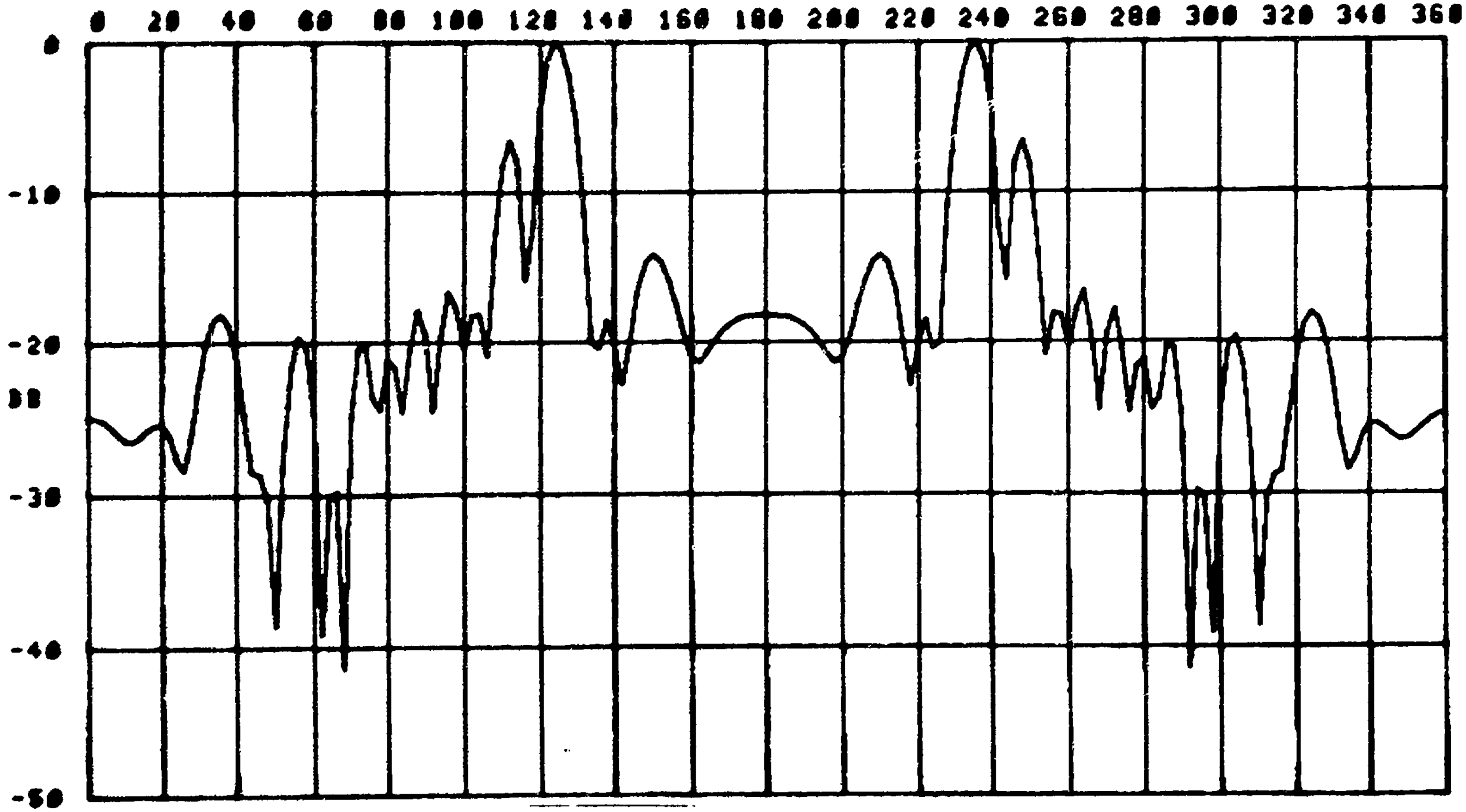


Figure B-47 Theoretical Horizontal Plane Pattern for 16 Element Array @ 290 Hz for Data Point 4, 34° Off Broadside Steering. Beamwidth 7.90°, Azimuth Gain 12.2 dB.

CONFIDENTIAL

CONFIDENTIAL

52276 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 28-Feb-78 GNTLBP 3.1
A: SFRAY ARRAY TUNED TO 300 HZ.
6.3333 FT. UNIFORM SPACING.
S: SAME

DATA POINT 4
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 51 ELEMENTS, -0.17 DB MAX., AC:S2581.SU:S2581,WT:
60.0 DEG. VERT. RESP., 124.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
4.84 DEG. 3 DB BEAM, 14.77 DB AZ. GAIN, MAX. AT 236.0 DEG. HORIZ.

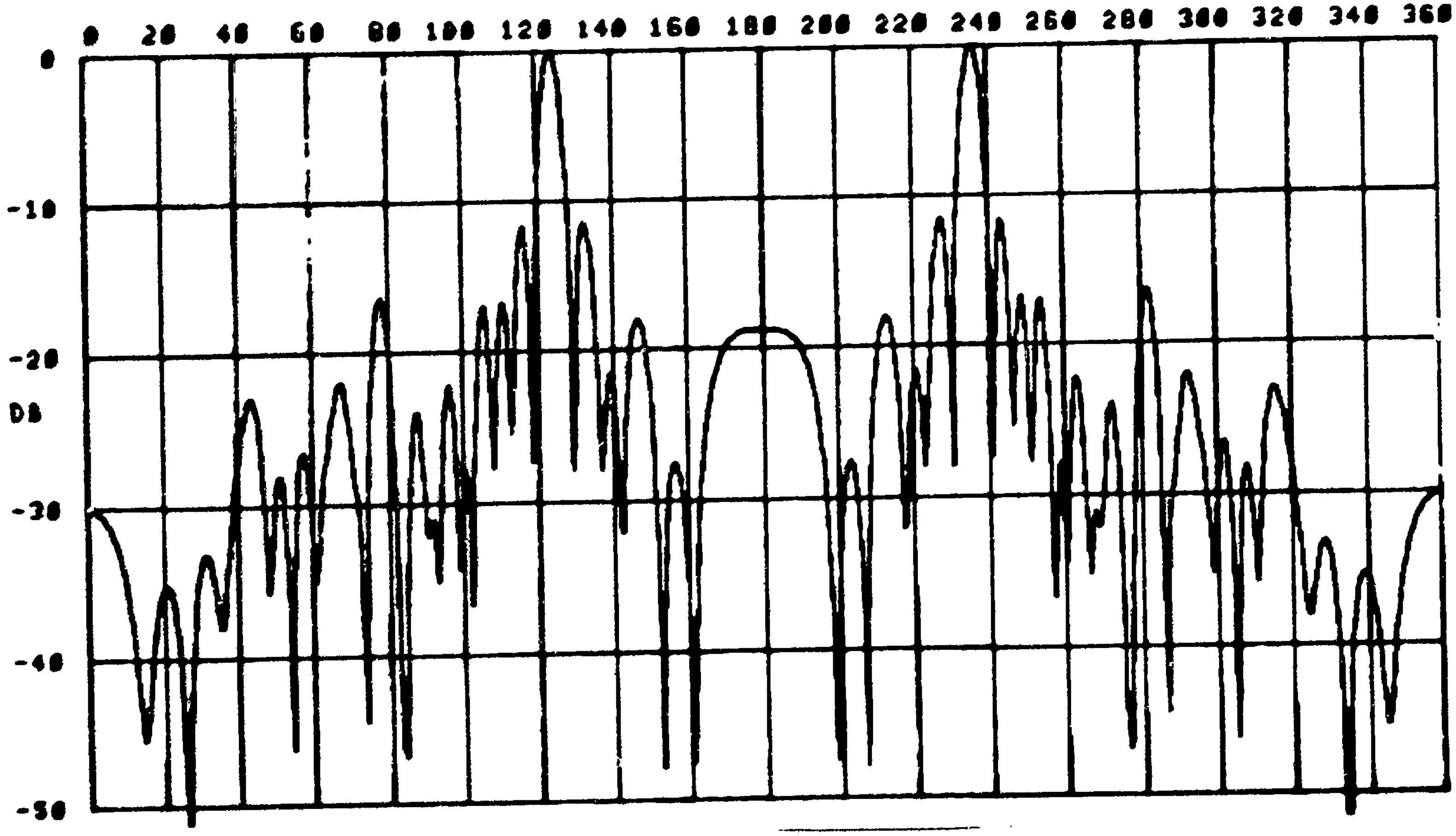


Figure B-48 Theoretical Horizontal Plane Pattern for 51 Element Array @ 140 Hz for Data Point 4, 34° Off Broadside Steering. Beamwidth 4.84°, Azimuth Gain 14.7 dB.

CONFIDENTIAL

CONFIDENTIAL

```
S2275  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)  20-Feb-78   ONTLBP 3.1
6: SPRAY ARRAY TUNED TO 300 HZ.
   6.3333 FT. UNIFORM SPACING.
5: SAME

   DATA POINT 4
   1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
   140.0 HZ.,  32 ELEMENTS, -0.10 DB MAX., AC:S2581,SU:S2681,WT:
    90.0 DEG. VERT. RESP., 124.0 DEG. HORIZ. STEER,  30.0 DEG. VERT STEER
    7.79 DEG. 3 DB BEAM,  12.57 DB AZ. GAIN, MAX. AT 236.0 DEG. HORIZ.
```

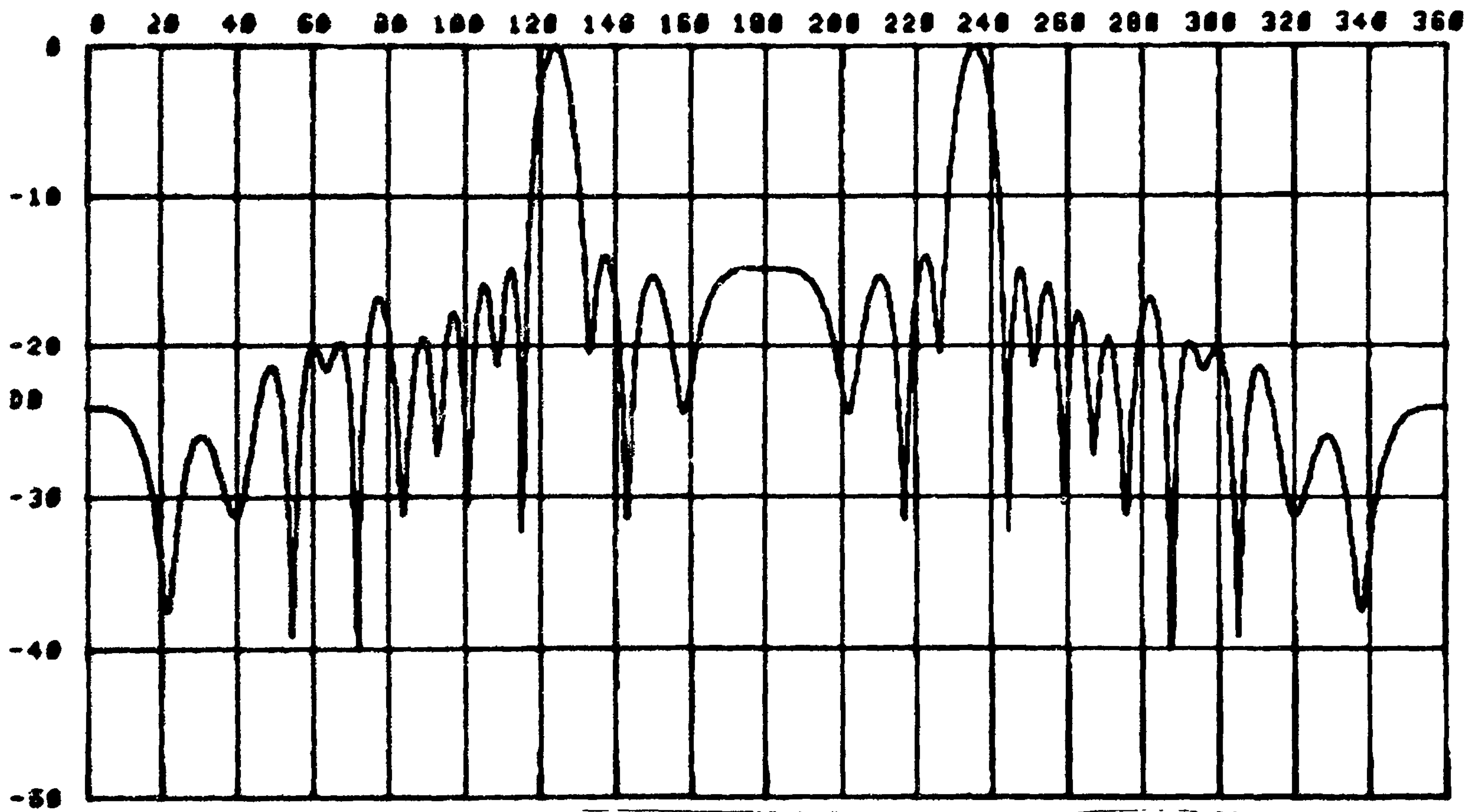


Figure B-49 Theoretical Horizontal Plane Pattern for 32 Element Array @ 140 Hz for Data Point 4, 34° Off Broadside Steering. Beamwidth 7.79°, Azimuth Gain 12.6 dB.

CONFIDENTIAL

CONFIDENTIAL

```
    S227A  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)  28-Feb-78   ONTLBP 3.1
6:  SPRAY ARRAY TUNED TO 300 HZ.
    6.3333 FT. UNIFORM SPACING.
5:  SAME

    DATA POINT 4
    1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
    140.0 HZ.,  16 ELEMENTS, -0.21 DB MAX., AC:S2501,SU:S2501,WT:
     90.0 DEG. VERT. RESP., 124.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
    16.76 DEG. 3 DB BEAM,   9.69 DB AZ. GAIN, MAX. AT 236.0 DEG. HORIZ.
```

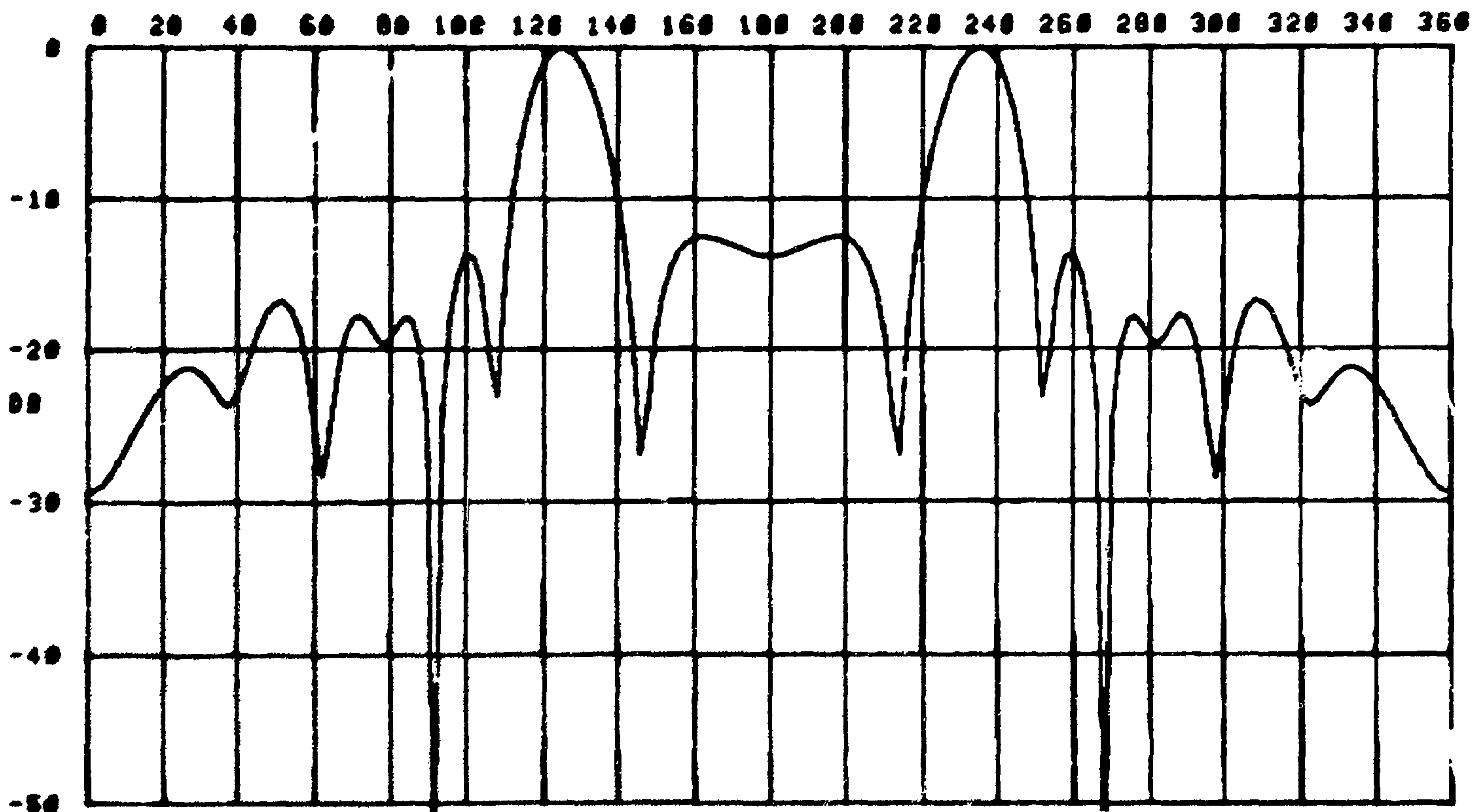


Figure B-50 Theoretical Horizontal Plane Pattern for 16 Element Array @ 140 Hz for Data Point 4, 34° Off Broadside Steering. Beamwidth 16.76°, Azimuth Gain 9.5 dB.

CONFIDENTIAL

CONFIDENTIAL

S&271 SANBERG BEAM PATTERN PROGRAM (T.HOGAN) 20-Feb-78 ONTLBP 3.1
6: SFRA) ARRAY TUNED TO 300 HZ.
6.3333 FT. UNIFORM SPACING.
5: SAME

DATA POINT 4
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ.. 51 ELEMENTS, -0.02 DB MAX., AC:S2581.SU:S2581.WT:
90.0 DEG. VERT. RESP., 124.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
2.30 DEG. 3 DB BEAM, 17.23 DB AZ. GAIN, MAX. AT 124.0 DEG. HORIZ.

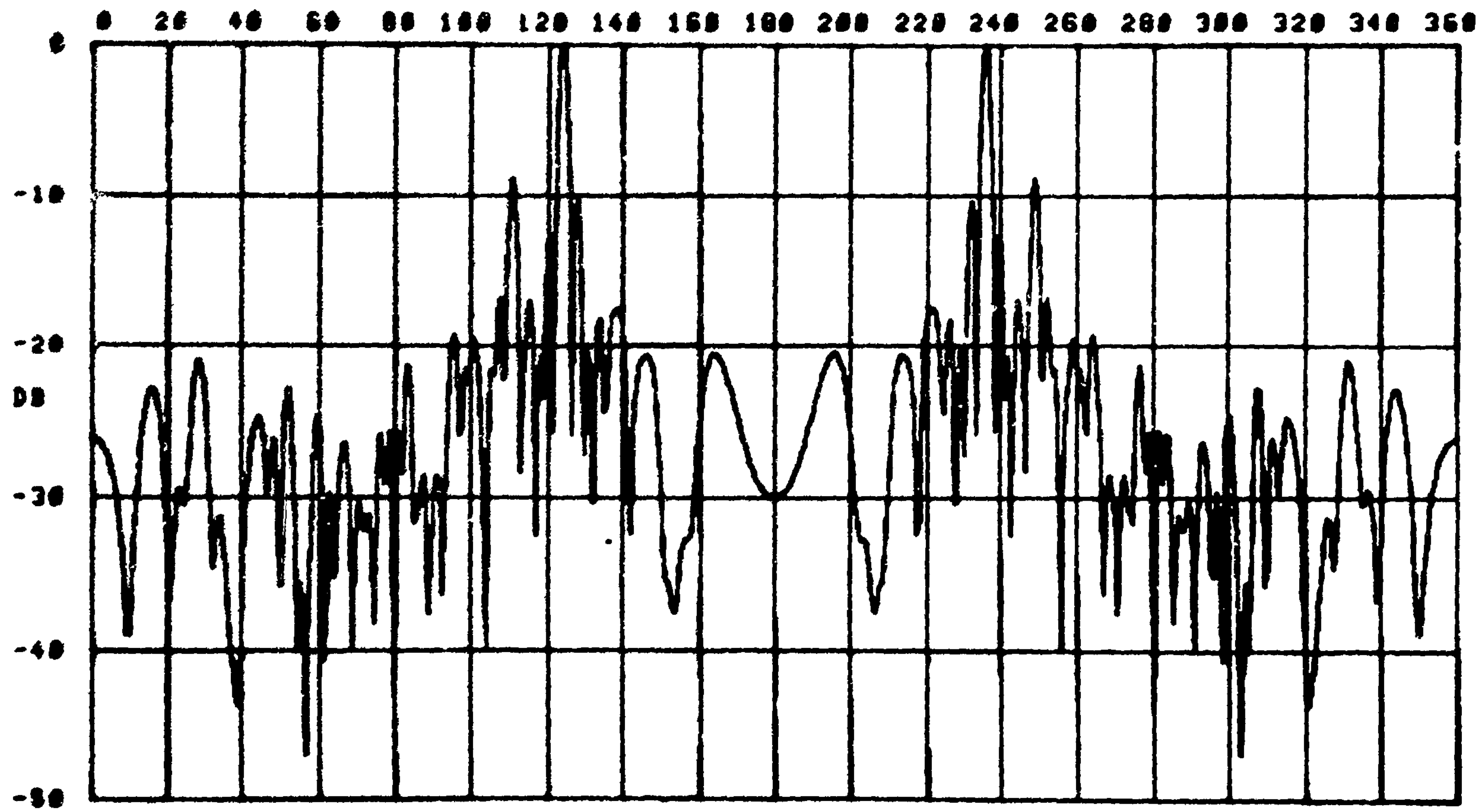


Figure B-51 Theoretical Horizontal Plane Pattern for 51 Element Array @ 295 Hz for Data Point 4, 34° Off Broadside Steering. Beamwidth 2.30°, Azimuth Gain 17.2 dB.

CONFIDENTIAL

CONFIDENTIAL

```
     S227F   SANDERS BEAM PATTERN PROGRAM (T.HOGAN)  28-Feb-78   ONTLBP 3.1
  A: SPRAY ARRAY TUNED TO 300 HZ.
     6.3333 FT. UNIFORM SPACING.
  B: SAME

     DATA POINT 4
     1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
     295.0 HZ.,  32 ELEMENTS, -0.77 DB MAX., AC:S2581,SU:S2581,WT:
      90.0 DEG. VERT. RESP., 124.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
      3.65 DEG. 3 DB BEAM,  15.19 DB AZ. GAIN, MAX. AT 124.0 DEG. HORIZ.
```

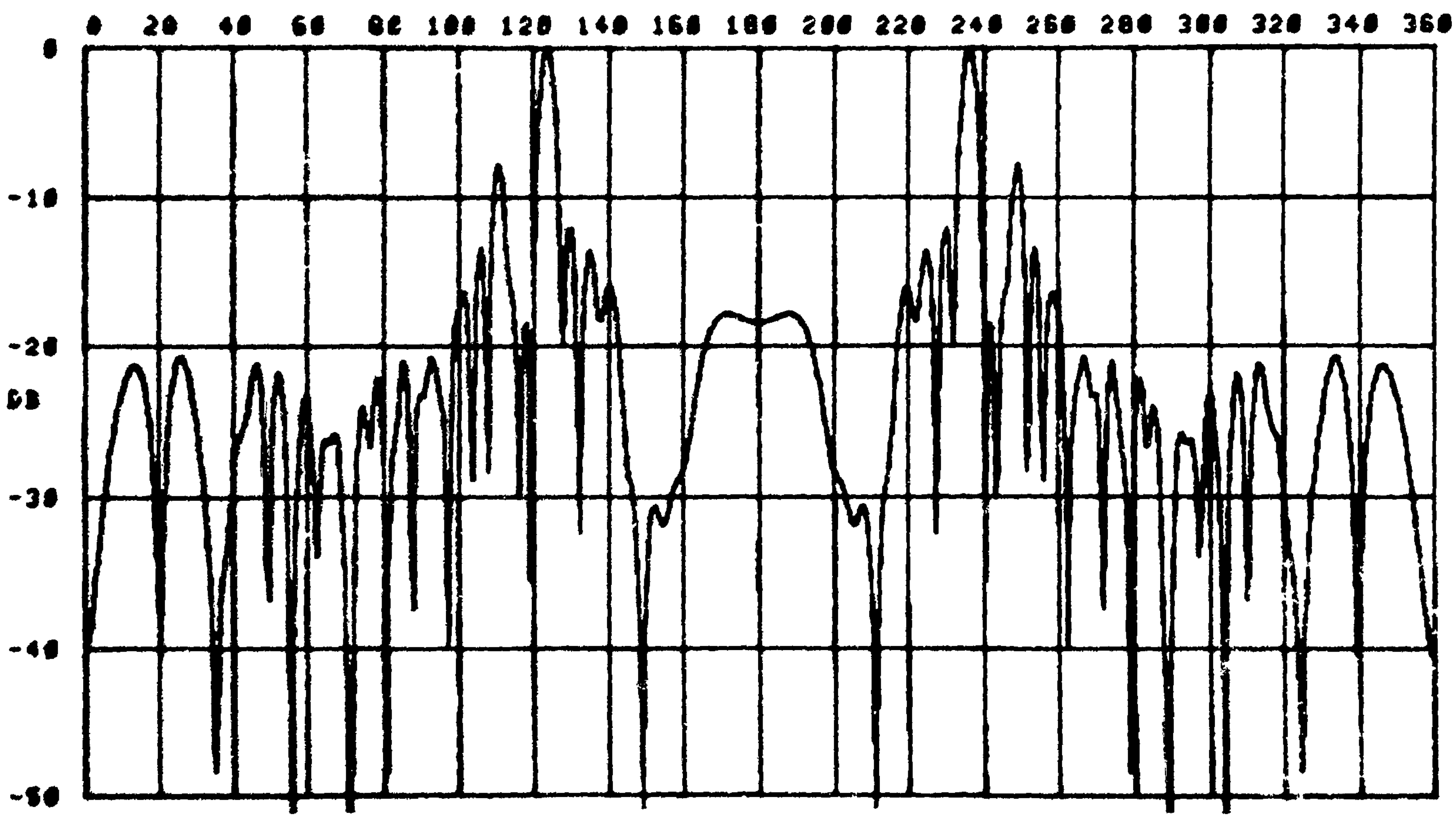


Figure B-52 Theoretical Horizontal Plane Pattern for 32 Element Array @ 295 Hz for Data Point 4, 34° Off Broadside Steering. Beamwidth 3.65°, Azimuth Gain 15.1 dB.

CONFIDENTIAL

CONFIDENTIAL

S227C SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 20-Feb-70 ONTLBP 3.1

A: SPEAT ARRAY TUNED TO 300 HZ.
6.3333 FT. UNIFORM SPACING.
B: SAME

DATA POINT 4
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ., 16 ELEMENTS, -0.89 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 124.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
7.83 DEG. 3 DB BEAM, 11.84 DB AZ. GAIN, MAX. AT 236.0 DEG. HORIZ.

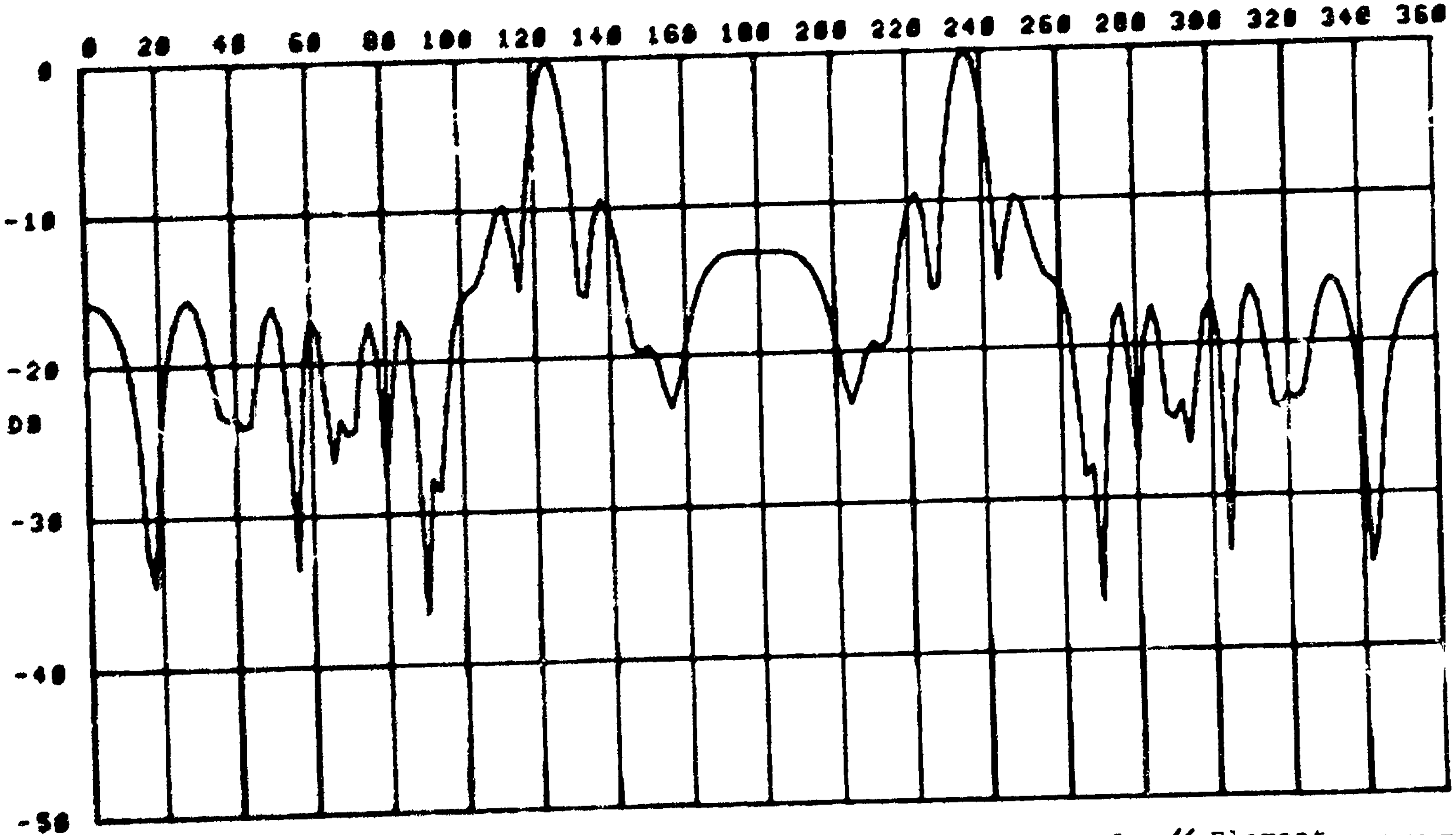


Figure B-53 Theoretical Horizontal Plane Pattern for 16 Element Array @ 295 Hz for Data Point 4, 34° Off Broadside Steering. Beamwidth 7.83°, Azimuth Gain 11.8 dB.

CONFIDENTIAL

S3156 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 15-Mar-78 ONTLBP 3.1
: ARRAY TUNED TO 300 HZ.
1.3323 FT. UNIFORM SPACING.
: SAME

DATA POINT 5
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 51 ELEMENTS, -0.81 DB MAX., AC:S3461, SU:S3461, WT:
90.0 DEG. VERT. RESP., 139.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
2.95 DEG. 3 DB BEAM, 16.32 DB AZ. GAIN, MAX. AT 139.0 DEG. HORIZ.

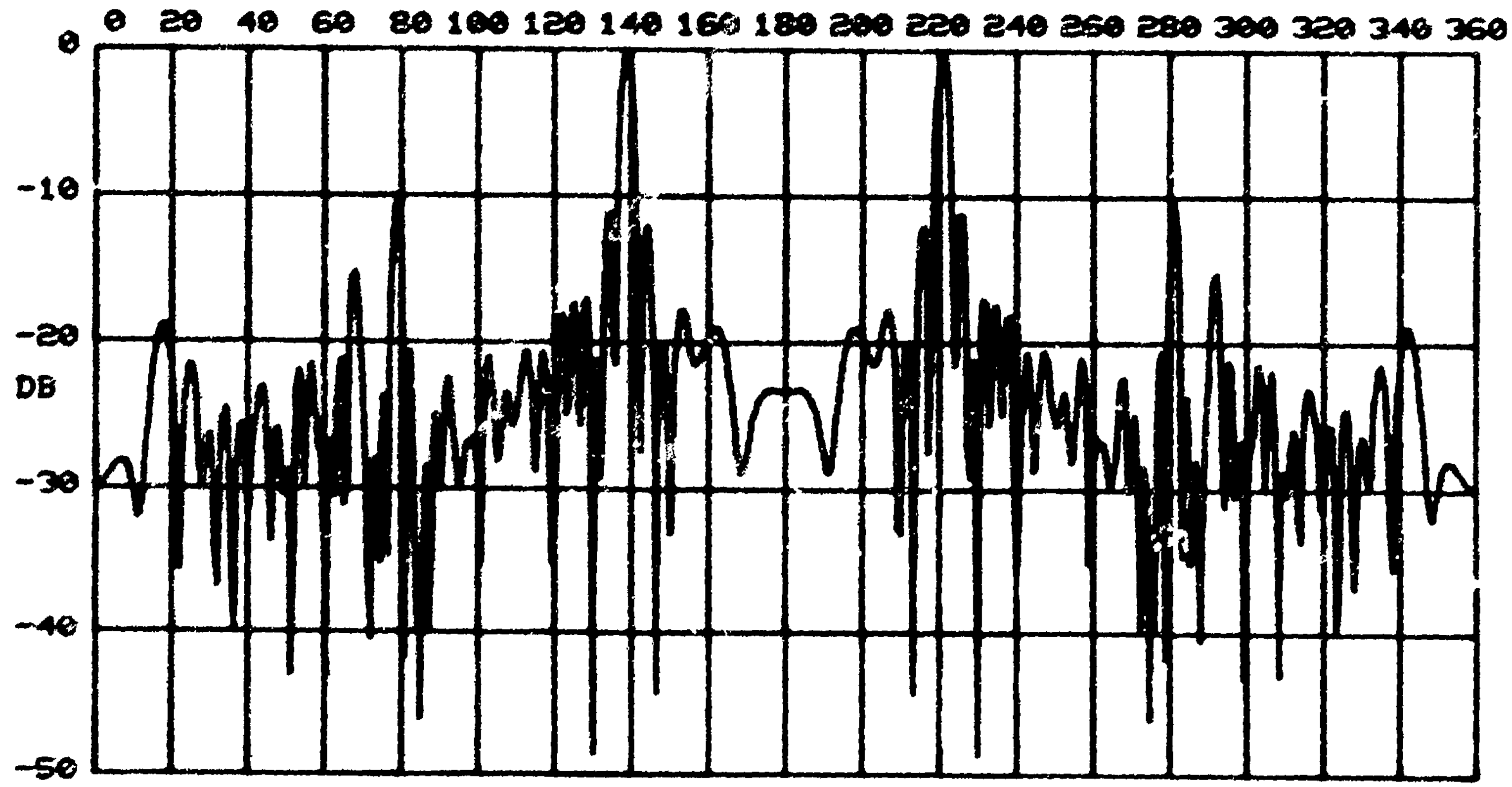
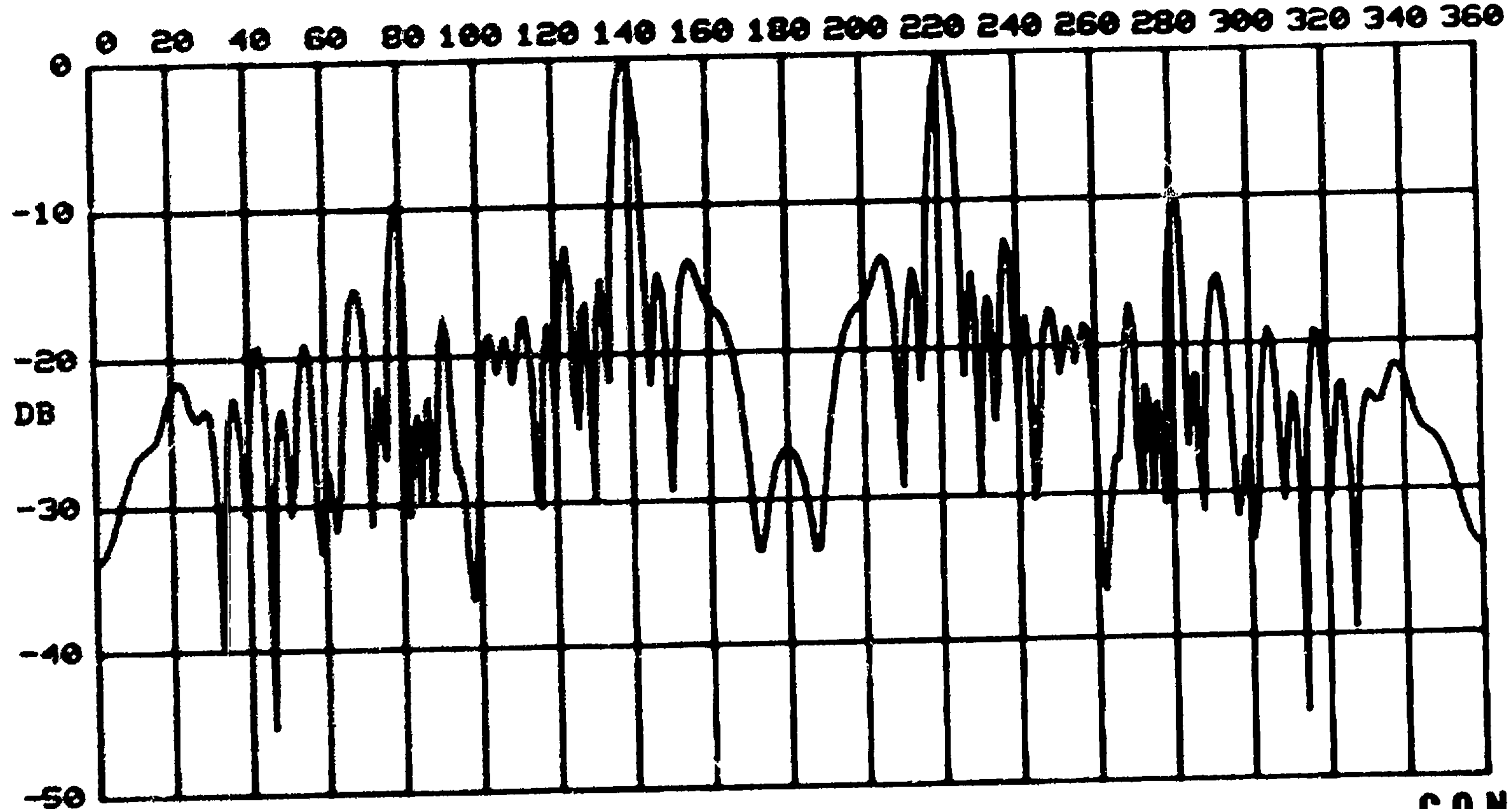


Figure 6-54 Theoretical Horizontal Plane Pattern for 57 Element Array @ 290 Hz for Data Point 5, 49° Off Broadside Steering. Beamwidth 2.95°, Azimuth Gain 16.3 dB.

CONFIDENTIAL

S3154 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 15-Mar-78 QNTLBP 3.1
A: ARRAY ARRAY TUNED TO 300 HZ.
8.3333 FT. UNIFORM SPACING.
S: SAME

DATA POINT 5
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 32 ELEMENTS, -0.81 DB MAX., AC:S3461,SU:S3461,WT:
90.0 DEG. VERT. RESP., 139.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
4.74 DEG. 3 DB BEAM, 14.37 DB AZ. GAIN, MAX. AT 139.0 DEG. HORIZ.



CONFIDENTIAL

Figure B-55 Theoretical Horizontal Plane Pattern for 32 Element Array @ 290 Hz for Data Point 5, 49° Off Broadside Steering. Beamwidth 4.74°, Azimuth Gain 14.3 dB.

CONFIDENTIAL

S3152 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 15-Mar-78 ONTLBP 3.1
A: SPRAY ARRAY TUNED TO 300 HZ.
2.3333 FT. UNIFORM SPACING.
B: SAME

DATA POINT 5
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 16 ELEMENTS, -0.89 DB MAX., AC:S3461,SU:S3461,WT:
90.0 DEG. VERT. RESP., 139.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
10.21 DEG. 3 DB BEAM, 11.28 DB AZ. GAIN, MAX. AT 138.0 DEG. HORIZ.

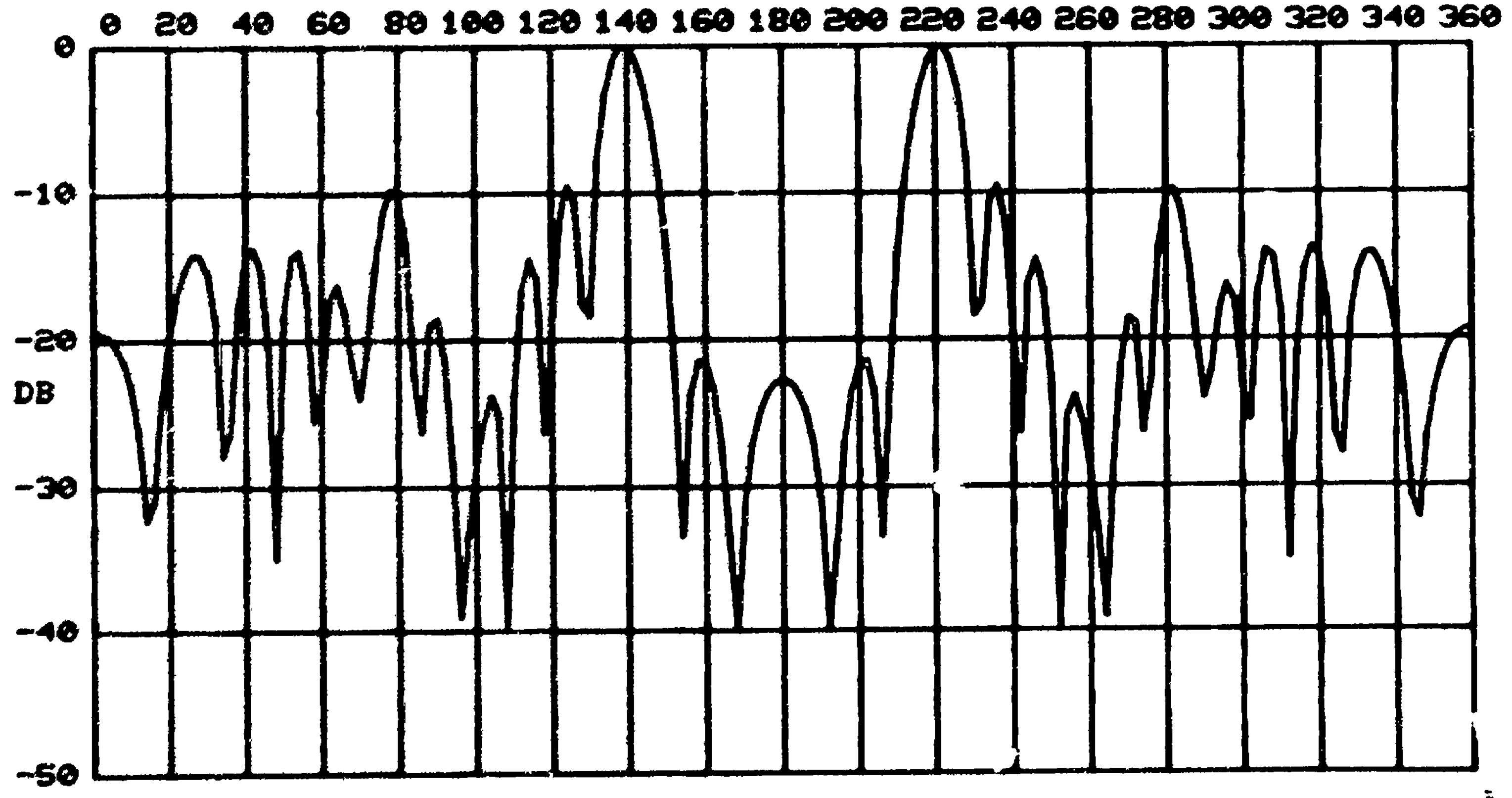


Figure B-56 Theoretical Horizontal Plane Pattern for 16 Element Array @ 290 Hz for Data Point 5, 49° Off Broadside Steering. Beamwidth 10.21°, Azimuth Gain 11.2 dB.

CONFIDENTIAL

```
S3155  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)  15-Mar-78   QNTLBP 3.1
A: SPRAY ARRAY TUNED TO 300 HZ.
   2.3333 FT. UNIFORM SPACING.
B: SAME

DATA POINT 5
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ.,   51 ELEMENTS, -0.18 DB MAX., AC:S3461,SU:S3461,WT:
 90.0 DEG. VERT. RESP., 134.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
 5.59 DEG. 3 DB BEAM,  14.21 DB AZ. GAIN, MAX. AT 134.0 DEG. HORIZ.
```

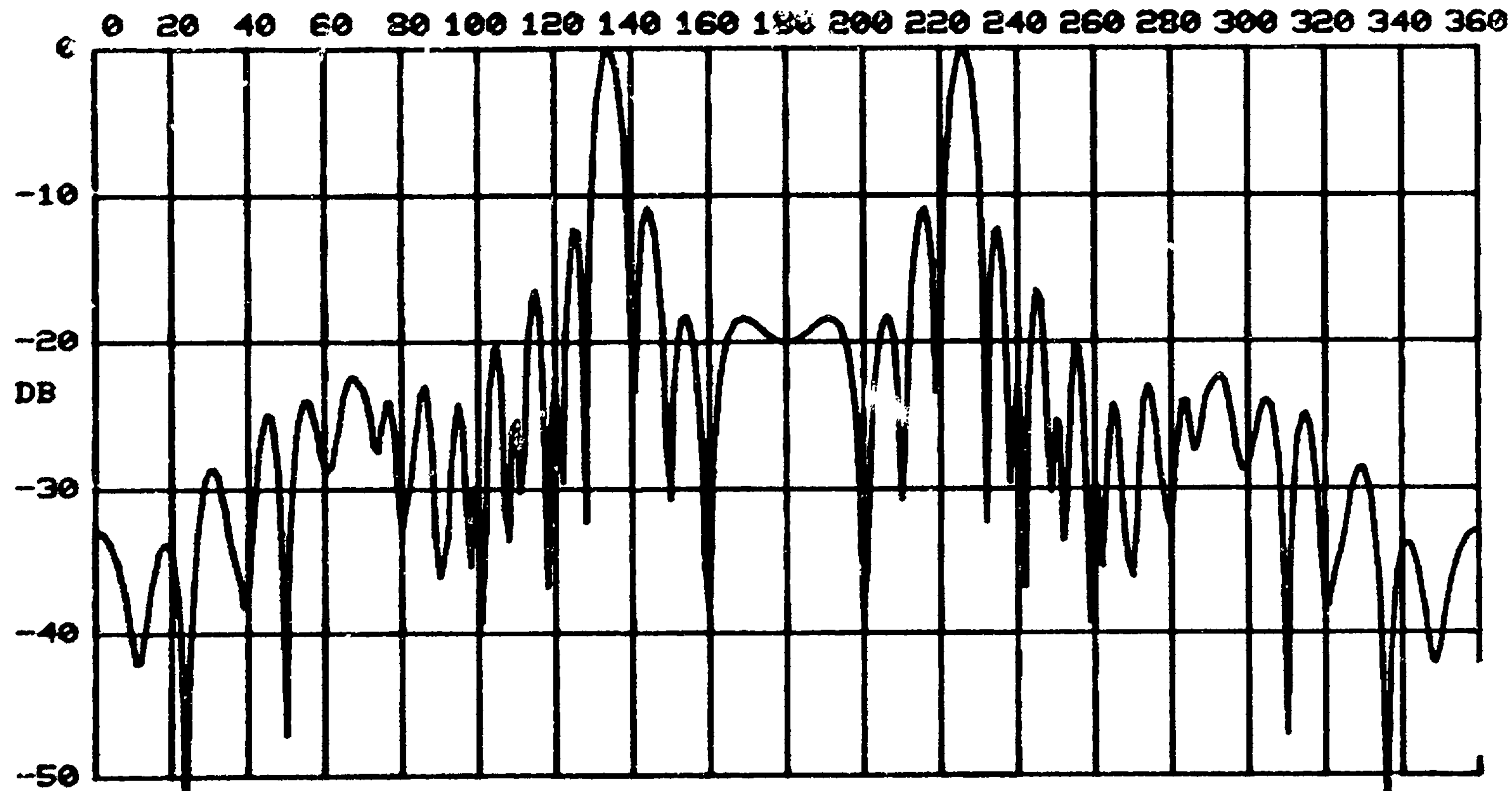
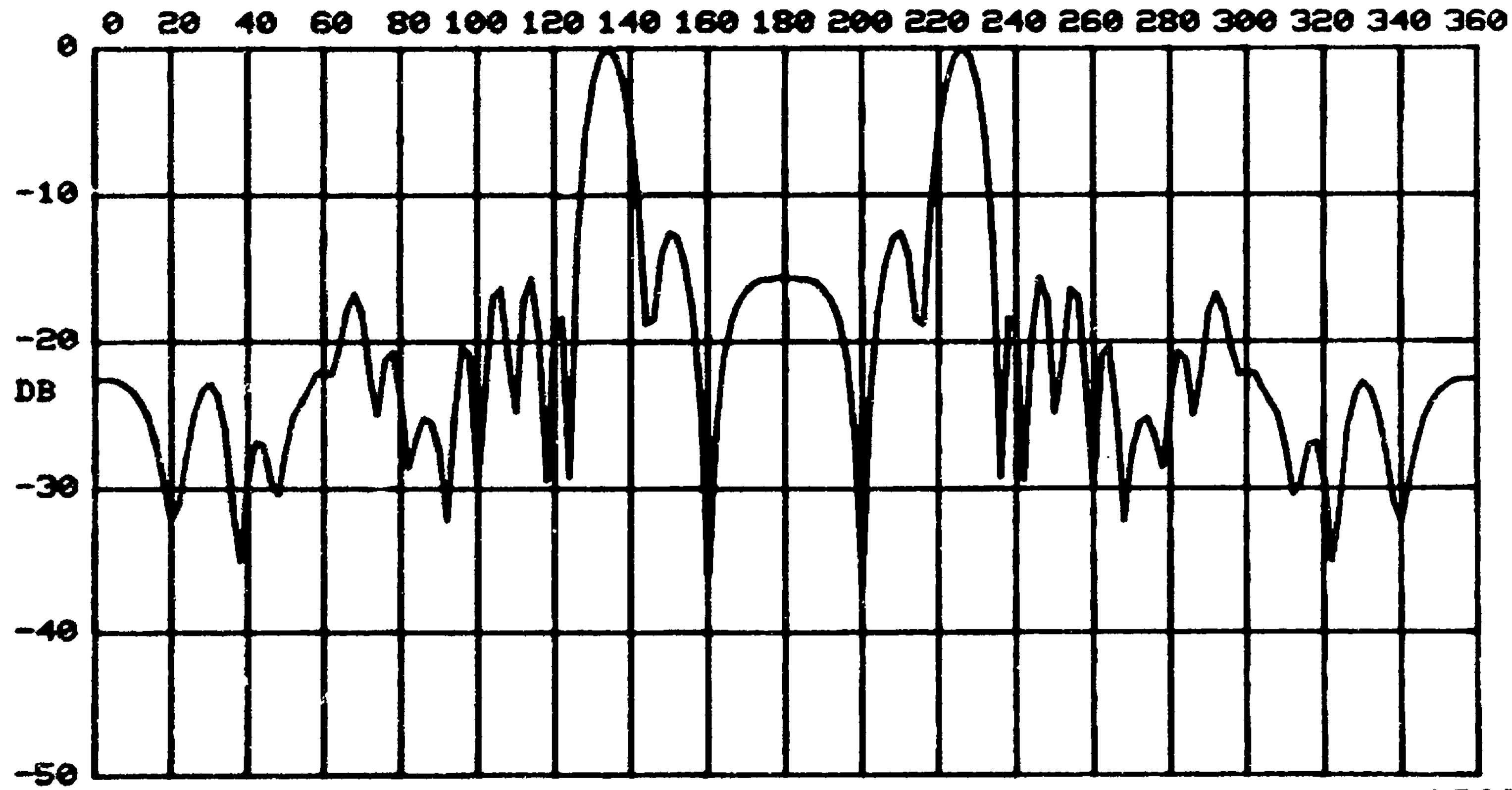


Figure B-57 Theoretical Horizontal Plane Pattern for 51 Element Array @ 140 Hz for Data Point 5, 49° Off Broadside Steering. Beamwidth 5.59°, Azimuth Gain 14.2 dB.

CONFIDENTIAL

S3153 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 15-Mar-78 QNTLBP 3.1
A: SPRAY ARRAY TUNED TO 300 HZ.
9.3333 FT. UNIFORM SPACING.
S: SAME

DATA POINT 5
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 32 ELEMENTS, -0.19 DB MAX., AC:S3461,SU:S3461,WT:
90.0 DEG. VERT. RESP., 134.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
9.01 DEG. 3 DB BEAM, 12.24 DB AZ. GAIN, MAX. AT 134.0 DEG. HORIZ.



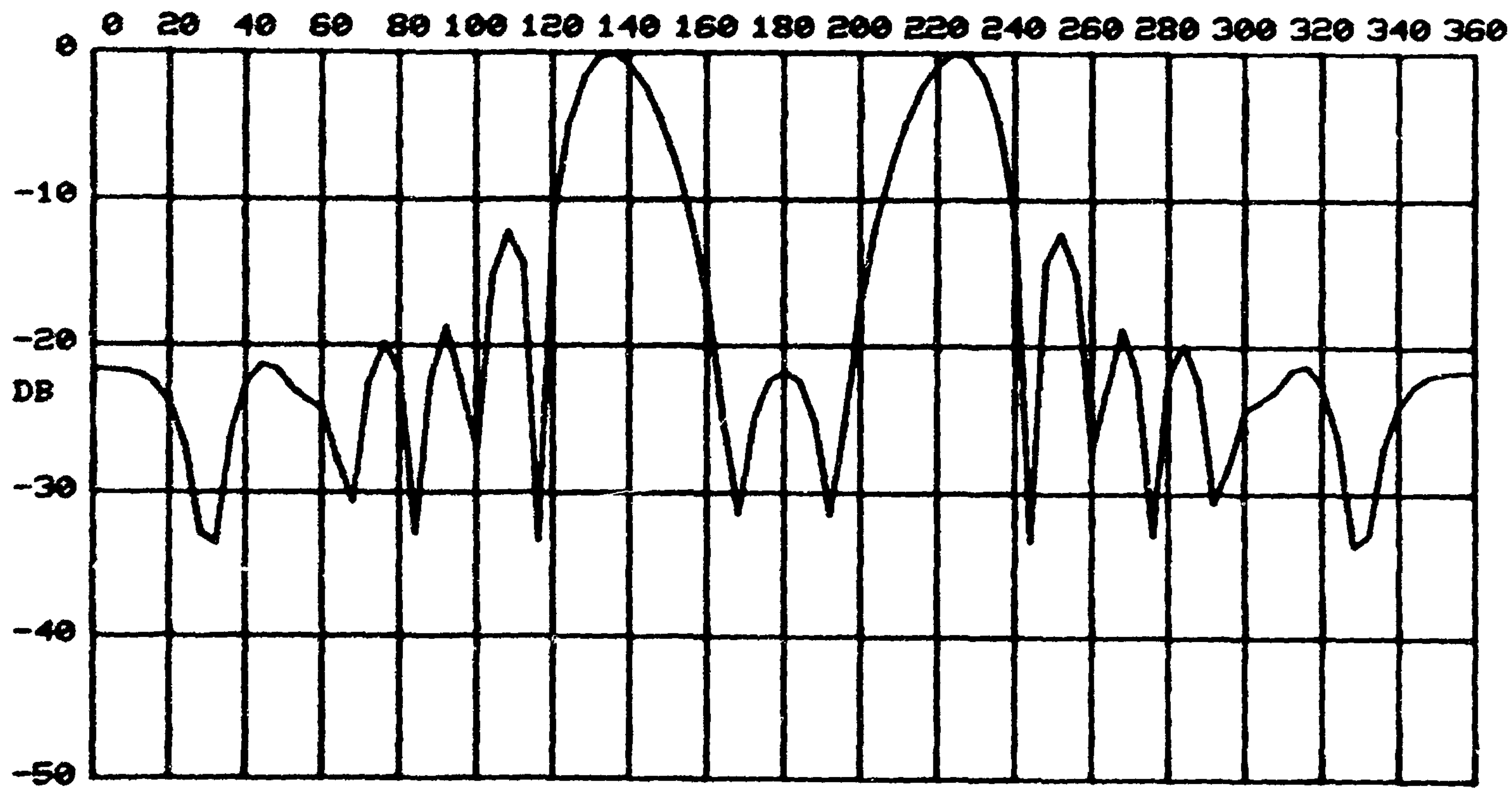
CONFIDENTIAL

Figure B-58 Theoretical Horizontal Plane Pattern for 32 Element Array @ 140 Hz for Data Point 5, 44° Off Broadside Steering. Beamwidth 9.01°, Azimuth Gain 12.2 dB.

CONFIDENTIAL

S3151 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 15-Mar-78 QNTLBP 3.1
[illegible]: [illegible] ARRAY TUNED TO 300 HZ.
[illegible].3333 FT. UNIFORM SPACING.
[illegible]: SAME

DATA POINT 5
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 16 ELEMENTS, -0.20 DB MAX., AC:S3461,SU:S3461,WT:
90.0 DEG. VERT. RESP., 134.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
19.76 DEG. 3 DB BEAM, 9.20 DB AZ. GAIN, MAX. AT 136.0 DEG. HORIZ.



CONFIDENTIAL

Figure B-59 Theoretical Horizontal Plane Pattern for 16 Element Array @ 140 Hz for Data Point 5, 44° Off Broadside Steering. Beamwidth 19.76°, Azimuth Gain 9.2 dB.

```
54026  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)    5-Apr-78    ONTLBP 3.1
       ARRAY TUNED TO 300 HZ.
2.1233 FT. UNIFORM SPACING.
SAME

DATA POINT 6
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ.,   51 ELEMENTS, -0.79 DB MAX., AC:S2581,SU:S2581,WT:
 90.0 DEG. VERT. RESP., 106.0 DEG. HORIZ. STEER,   90.0 DEG. VERT STEER
 2.01 DEG. 3 DB BEAM,   17.49 DB AZ. GAIN, MAX. AT 106.0 DEG. HORIZ.
```

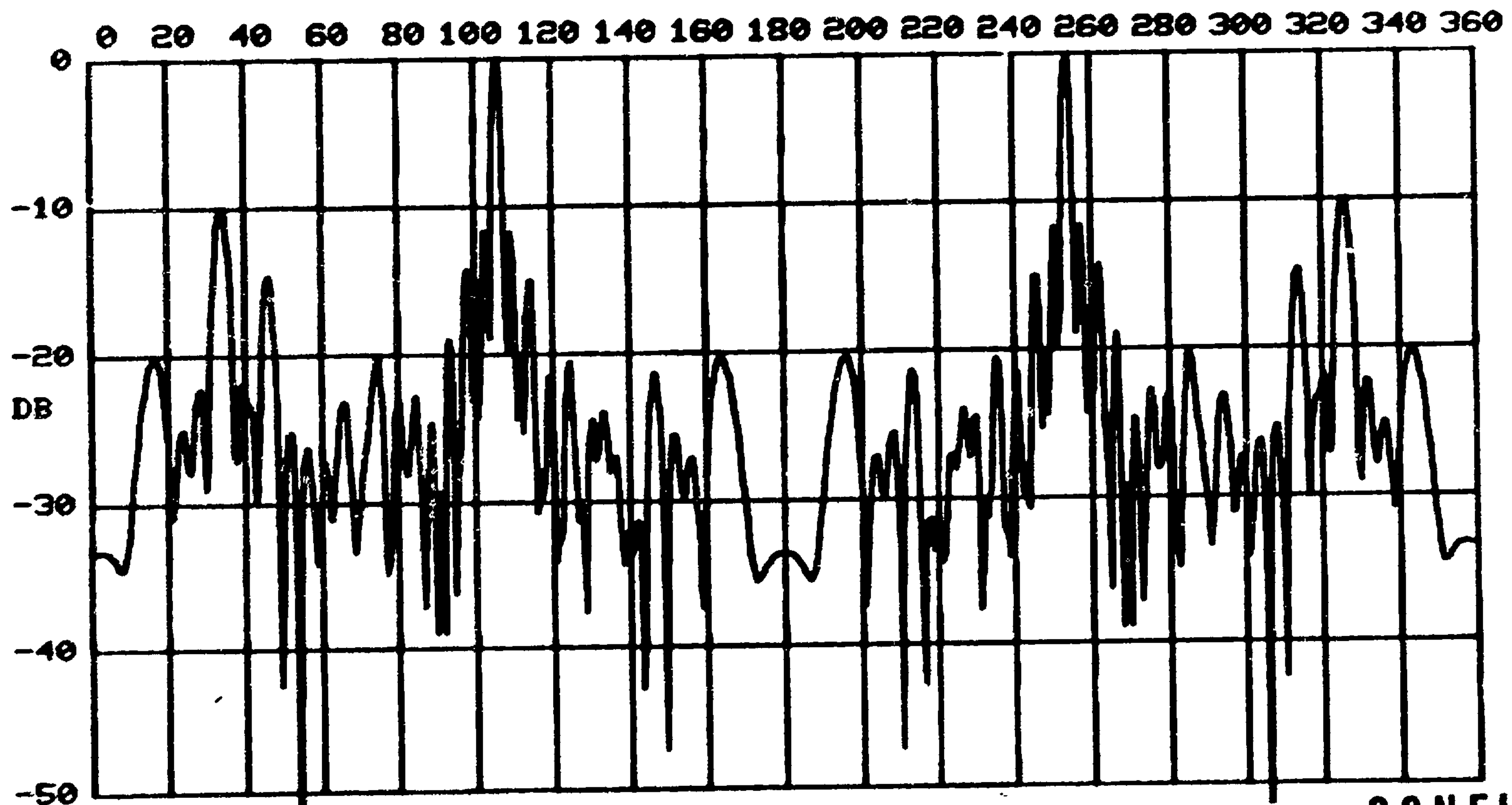
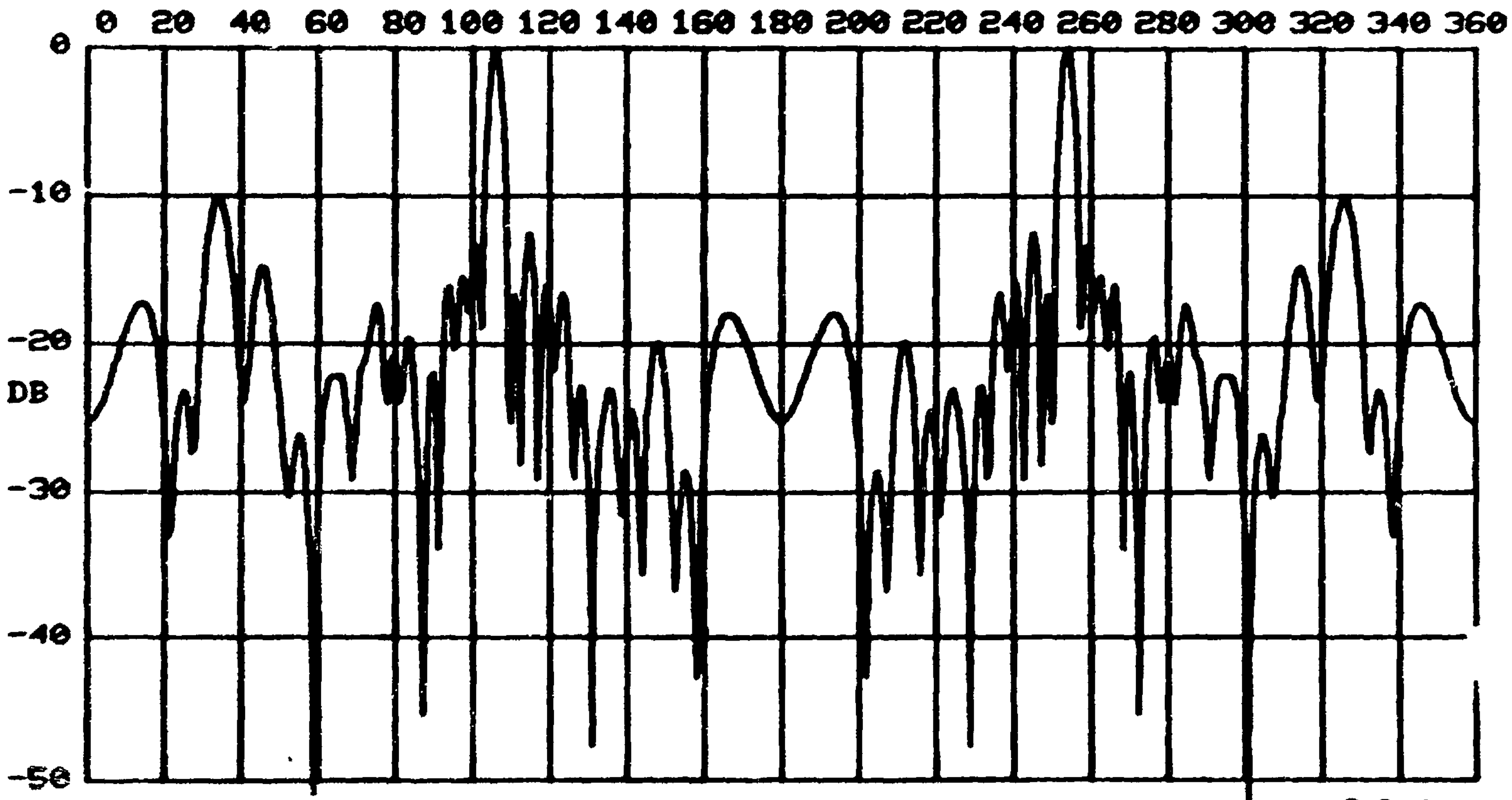


Figure B-60 Theoretical Horizontal Plane Pattern for 51 Element Array @290 Hz for Data Point 6, 16° Off Broadside Steering. Beamwidth 2.01°, Azimuth Gain 17.4 dB.

CONFIDENTIAL

```
34034   SANDERS BEAM PATTERN PROGRAM (T.HOGAN)    5-Apr-78    ONTLBP 3.1
        ARRAY TUNED TO 300 HZ.
        1.3323 FT. UNIFORM SPACING.
        SAME

DATA POINT 6
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ.,   32 ELEMENTS, -0.80 DB MAX., AC:S2581,SU:S2581,WT:
 90.0 DEG. VERT. RESP., 106.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
 3.24 DEG. 3 DB BEAM,  15.34 DB AZ. GAIN, MAX. AT 106.0 DEG. HORIZ.
```



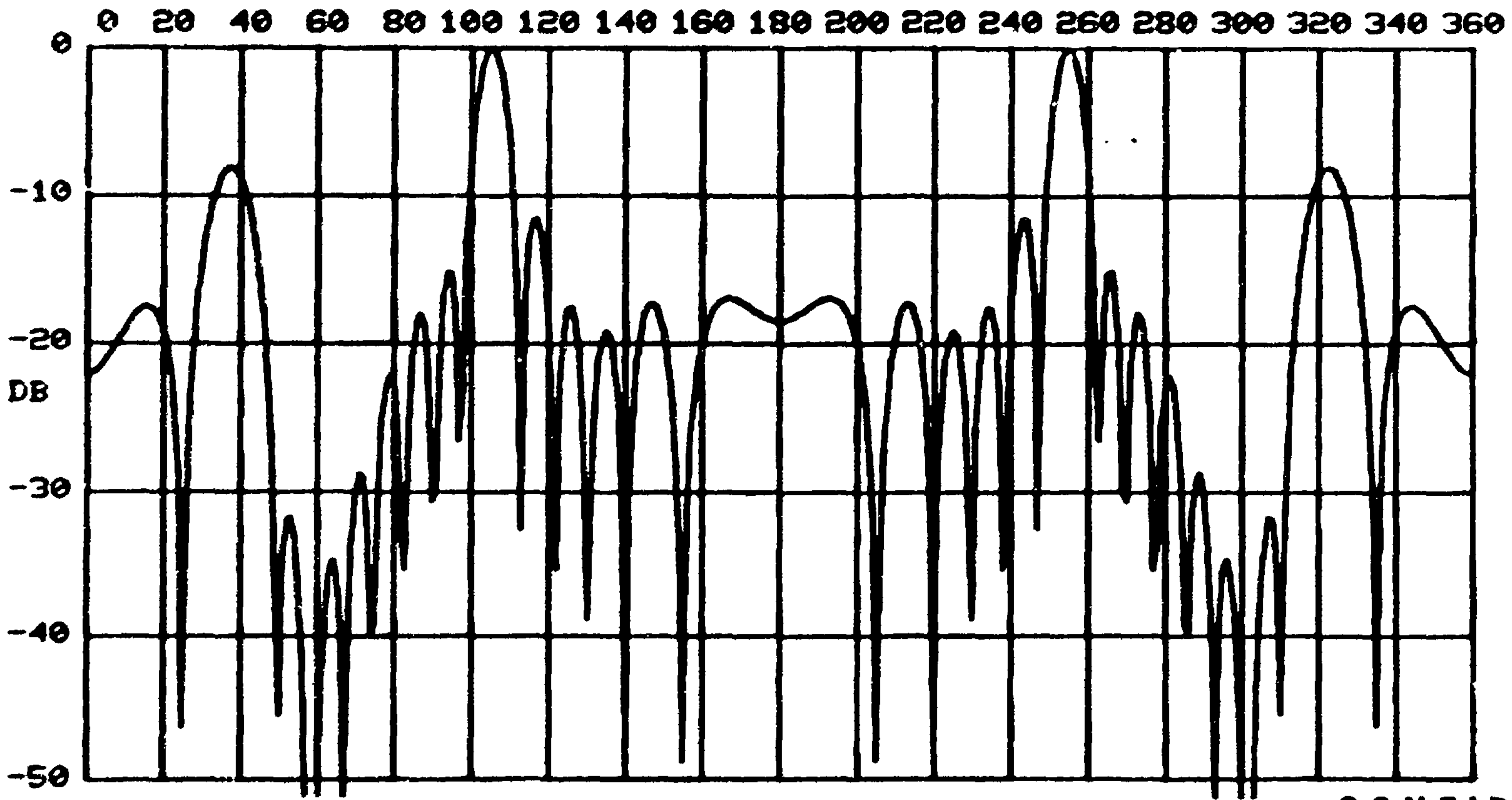
CONFIDENTIAL

Figure B-61 Theoretical Horizontal Plane Pattern for 32 Element Array @ 290 Hz for Data Point 6, 16° Off Broadside Steering. Beamwidth 3.24°, Azimuth Gain 15.3 dB.

CONFIDENTIAL

S4212 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-73 ONTLBP 3.1
ARRAY TUNED TO 300 HZ.
1.3333 FT. UNIFORM SPACING.
SAME

DATA POINT 6
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 16 ELEMENTS, -0.61 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 106.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
6.82 DEG. 3 DB BEAM, 12.53 DB AZ. GAIN, MAX. AT 105.0 DEG. HORIZ.



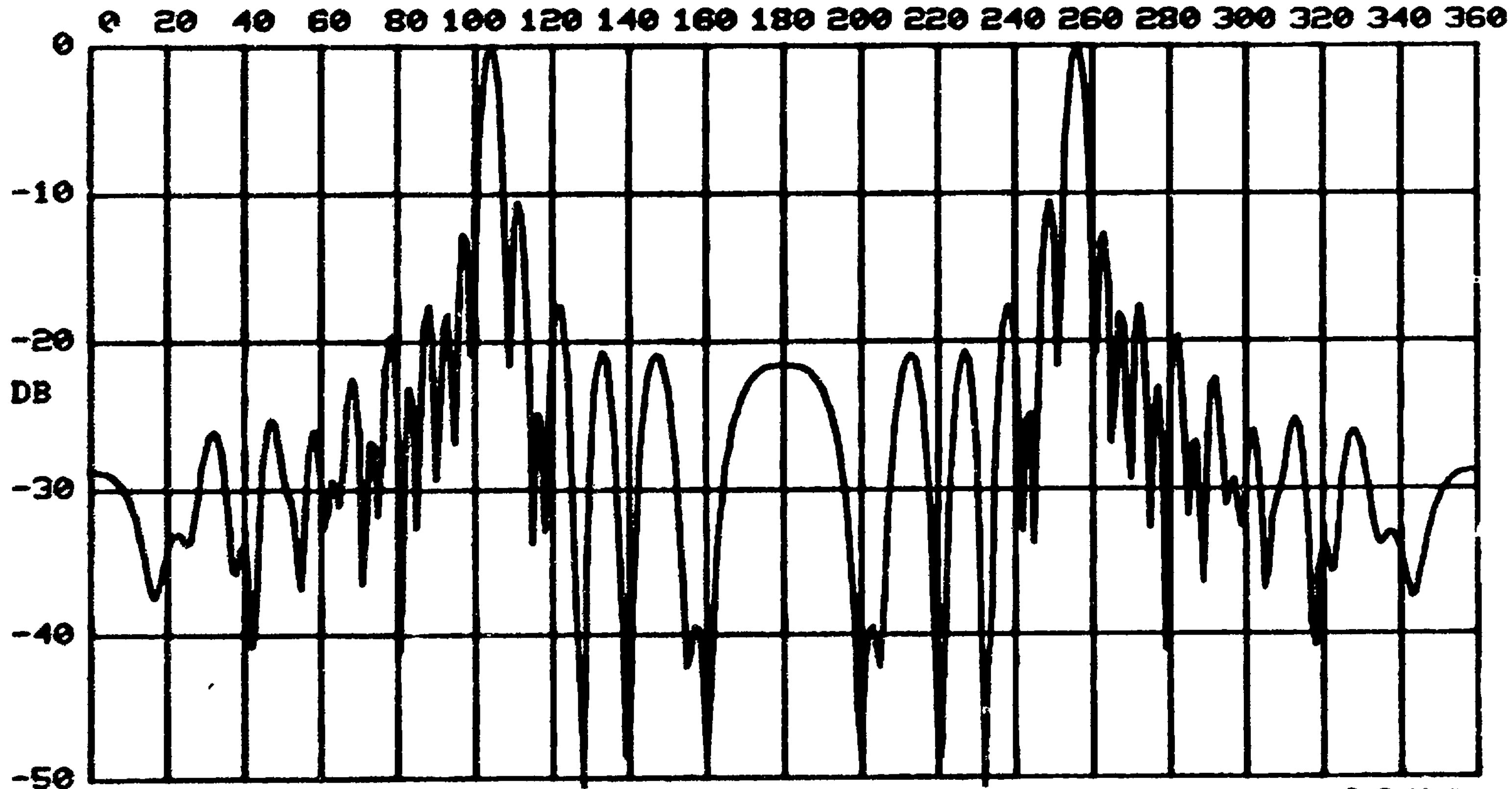
CONFIDENTIAL

Figure B-62 Theoretical Horizontal Plane Pattern for 16 Element Array @ 290 Hz for Data Point 6, 16° Off Broadside Steering. Beamwidth 6.82°, Azimuth Gain 12.5 dB.

CONFIDENTIAL

54035 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-78 QNTLBP 3.1
ARRAY TUNED TO 300 HZ.
2.3333 FT. UNIFORM SPACING.
SAME

DATA POINT 6
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 51 ELEMENTS, -0.19 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 104.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
4.16 DEG. 3 DB BEAM, 15.50 DB AZ. GAIN, MAX. AT 256.0 DEG. HORIZ.



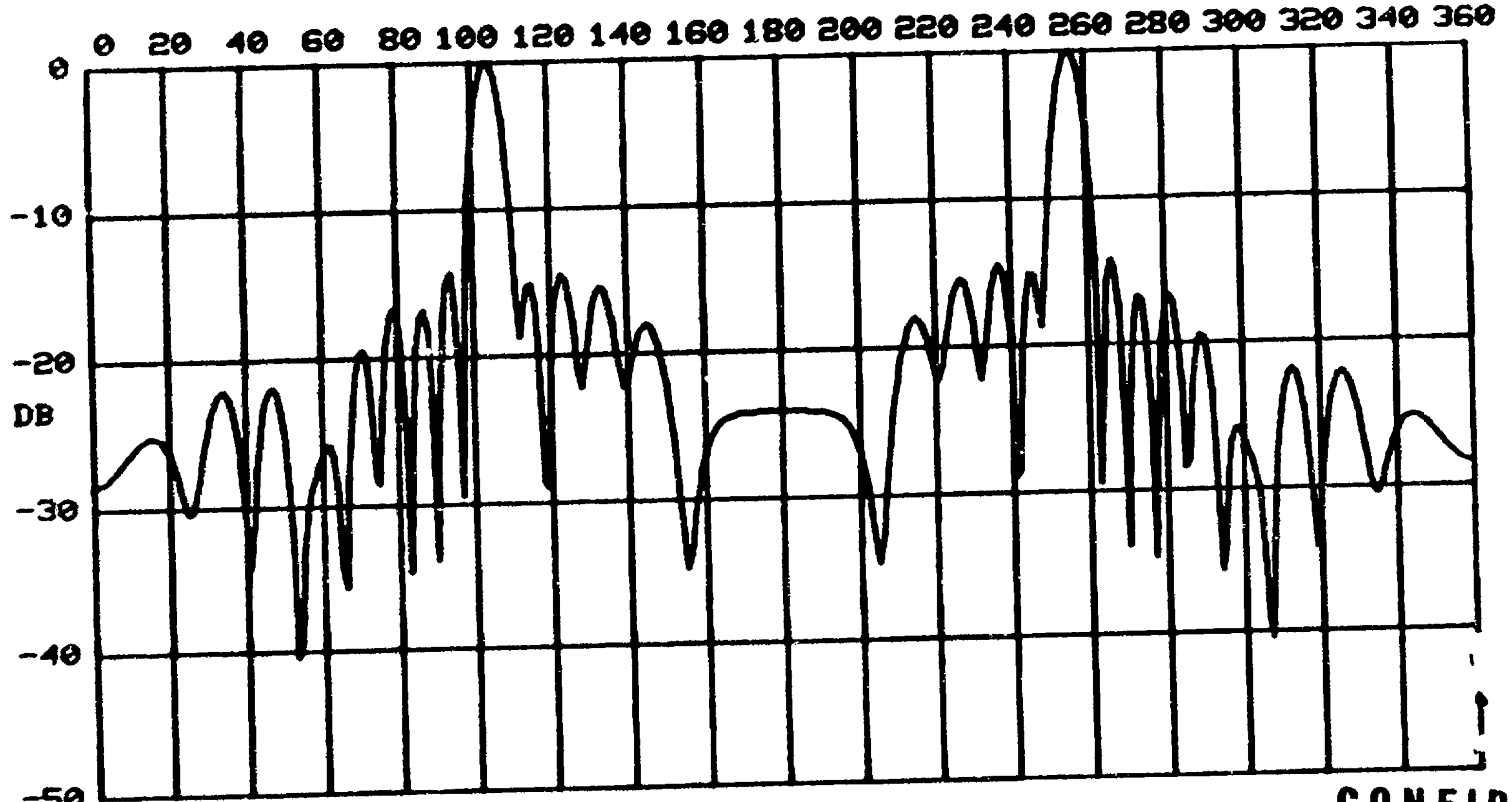
CONFIDENTIAL

Figure B-63 Theoretical Horizontal Plane Pattern for 51 Element Array @ 140 Hz for Data Point 6, 14° Off Broadside Steering. Beamwidth 4.16°, Azimuth Gain 15.5 dB.

CONFIDENTIAL

54033 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-78 QNTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING.
SAME

DATA POINT 6
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 32 ELEMENTS, -0.19 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 104.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
6.66 DEG. 3 DB BEAM, 13.49 DB AZ. GAIN, MAX. AT 256.0 DEG. HORIZ.



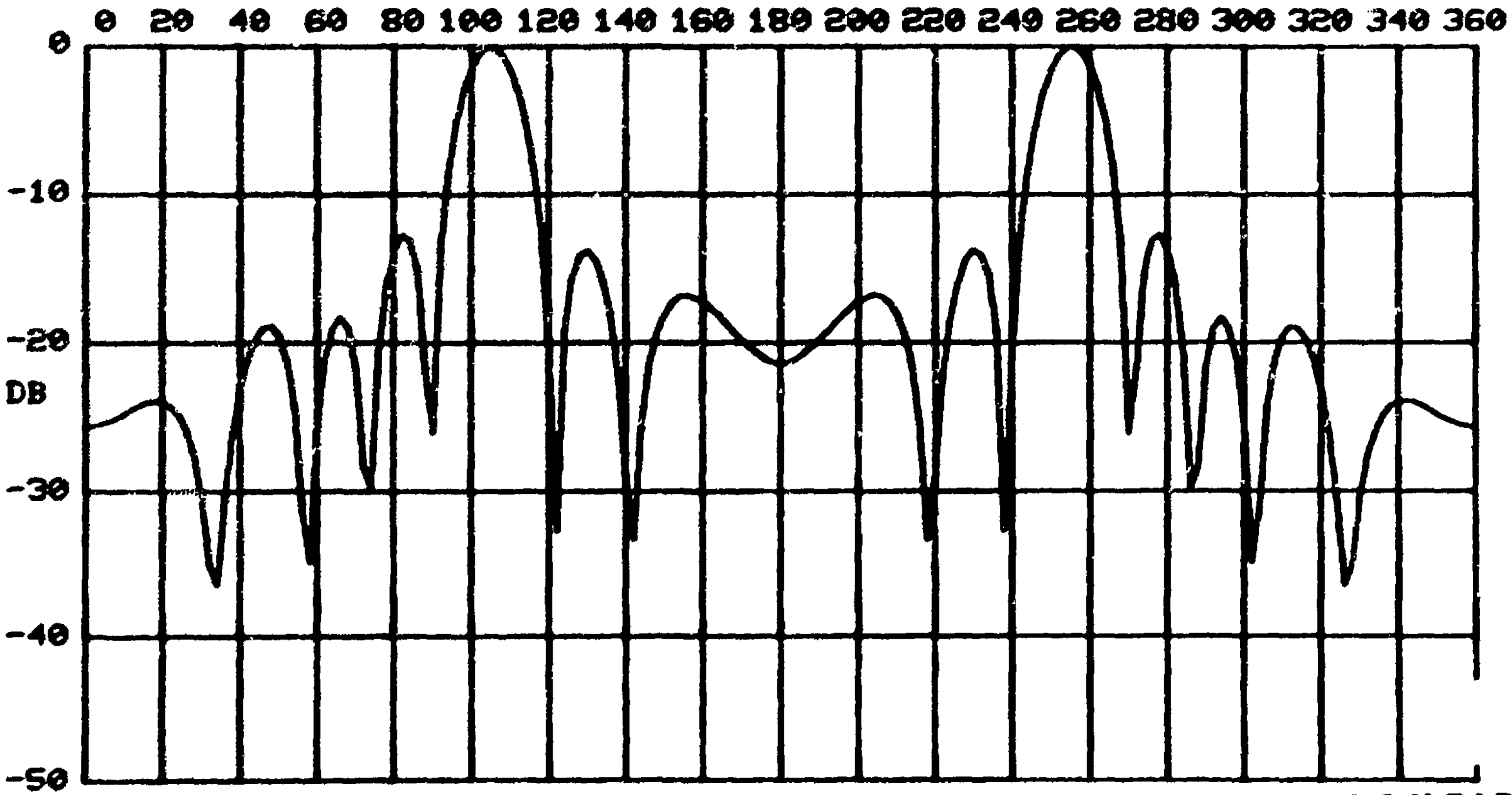
CONFIDENTIAL

Figure B-64 Theoretical Horizontal Plane Pattern for 32 Element Array @ 140 Hz for Data Point 6, 14° Off Broadside Steering. Beamwidth 6.66°, Azimuth Gain 13.4 dB.

CONFIDENTIAL

```
54021   SANDERS BEAM PATTERN PROGRAM (T.HOGAN)   5-Apr-78   ONTLBF 3.1
  SPRAY ARRAY TUNED TO 300 HZ.
  3.3333 FT. UNIFORM SPACING.
  SAME

DATA POINT 6
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ.,  16 ELEMENTS, -0.17 DB MAX., AC:S2581,SU:S2581,WT:
 90.0 DEG. VERT. RESP., 104.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
14.17 DEG. 3 DB BEAM,  10.45 DB AZ. GAIN, MAX. AT 256.0 DEG. HORIZ.
```



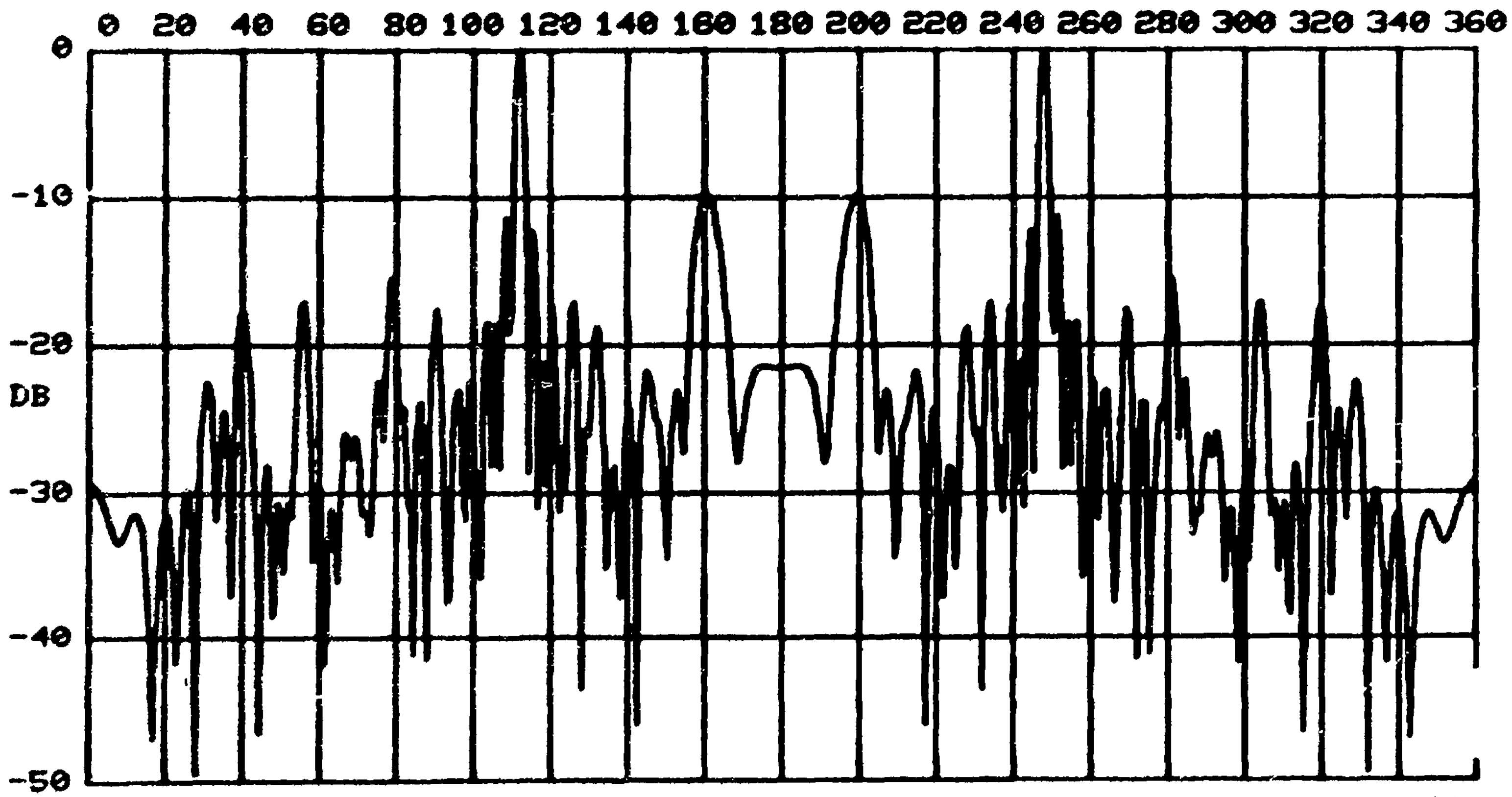
CONFIDENTIAL

Figure B-65 Theoretical Horizontal Plane Pattern for 16 Element Array @ 140 Hz for Data Point 6, 14° Off Broadside Steering. Beamwidth 14.17°, Azimuth Gain 10.4 dB.

CONFIDENTIAL

[illegible] SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-78 ONTLBP 3.1
[illegible] ARRAY TUNED TO 300 HZ.
[illegible] FT. UNIFORM SPACING.
[illegible]

DATA POINT 7
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 51 ELEMENTS, -0.79 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 112.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
2.10 DEG. 3 DB BEAM, 17.06 DB AZ. GAIN, MAX. AT 112.0 DEG. HORIZ.



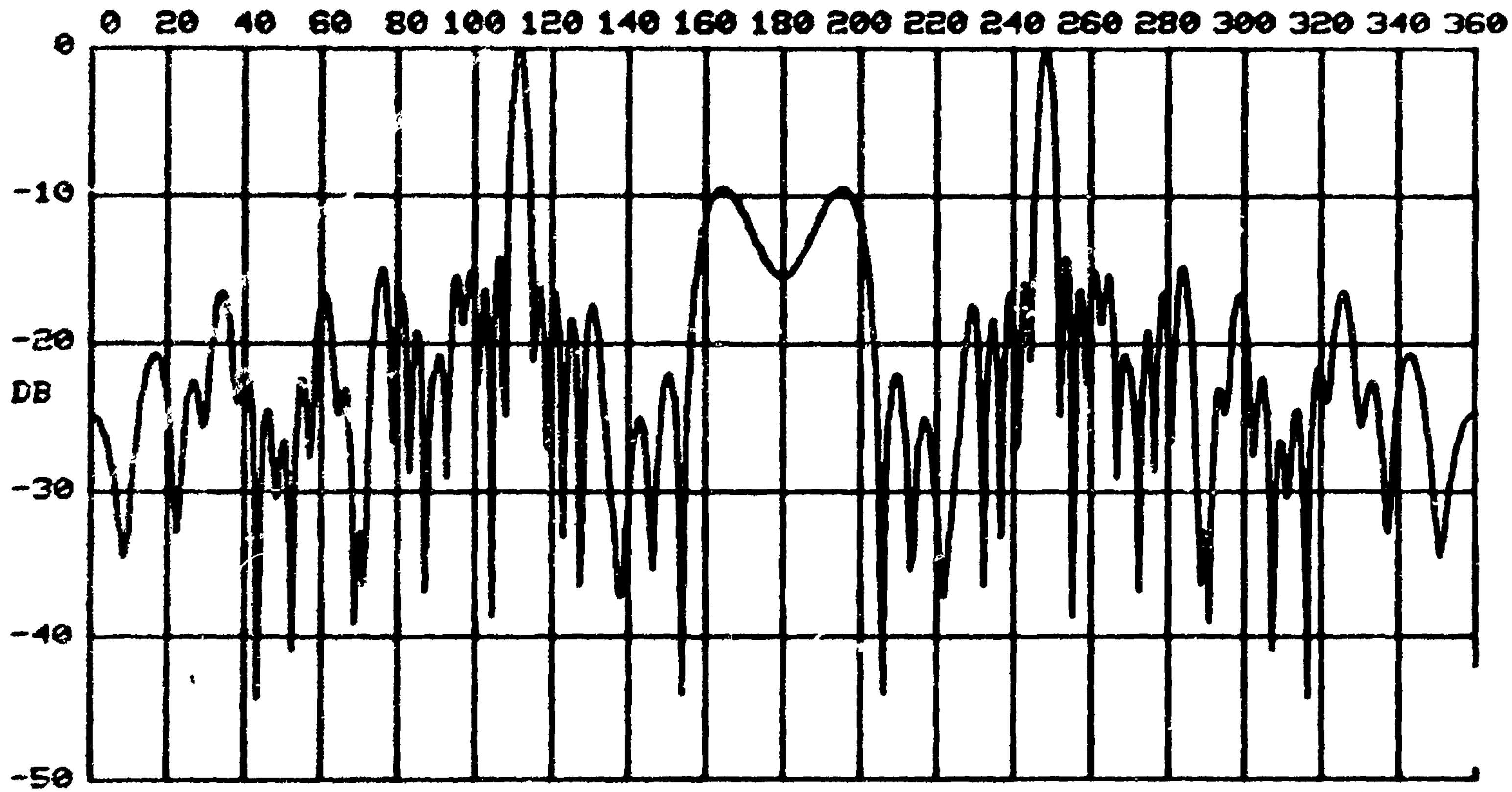
CONFIDENTIAL

Figure B-66 Theoretical Horizontal Plane Pattern for 51 Element Array @ 290 Hz for Data Point 7, 22° Off Broadside Steering. Beamwidth 2.10°, Azimuth Gain 17.0 dB.

CONFIDENTIAL

[illegible] SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-78 ONTLBP 3.1
[illegible] ARRAY TUNED TO 300 HZ.
[illegible] FT. UNIFORM SPACING.
[illegible]

DATA POINT 7
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 32 ELEMENTS, -0.81 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 111.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
3.36 DEG. 3 DB BEAM, 14.70 DB AZ. GAIN, MAX. AT 111.5 DEG. HORIZ.



CONFIDENTIAL

Figure B-67 Theoretical Horizontal Plane Pattern for 32 Element Array @ 290 Hz for Data Point 7, 21.5° Off Broadside Steering. Beamwidth 3.36°, Azimuth Gain 14.7 dB.

```
54?33  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)   5-Apr-73   QNTLBP 3.1
       ARRAY TUNED TO 300 HZ.
1.3333 FT. UNIFORM SPACING.
SAME

DATA POINT 7
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ.,  16 ELEMENTS, -0.84 DB MAX., AC:S2581,SU:S2581,WT:
 90.0 DEG. VERT. RESP., 109.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
 7.01 DEG. 3 DB BEAM,  12.04 DB AZ. GAIN, MAX. AT 109.0 DEG. HORIZ.
```

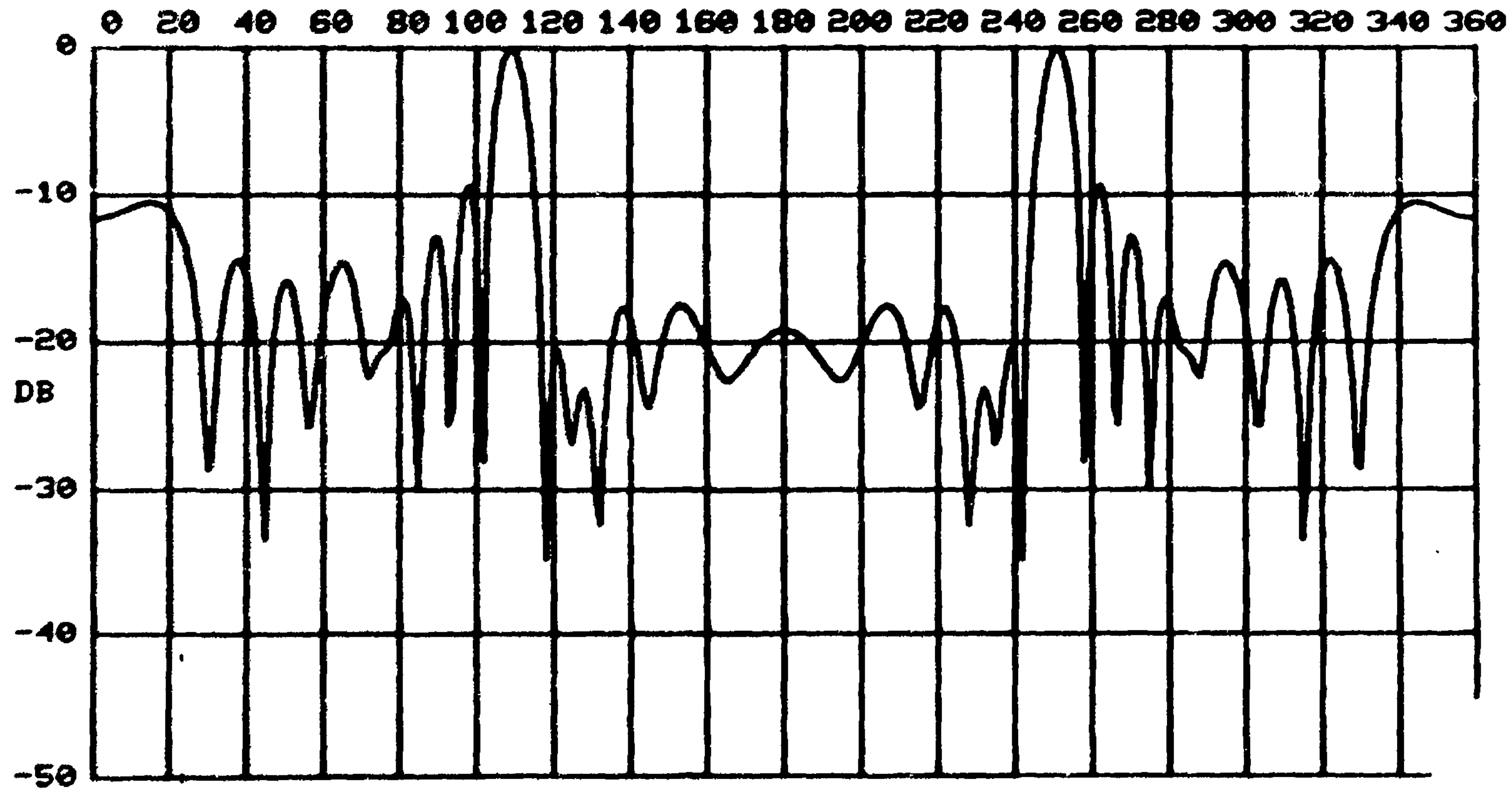
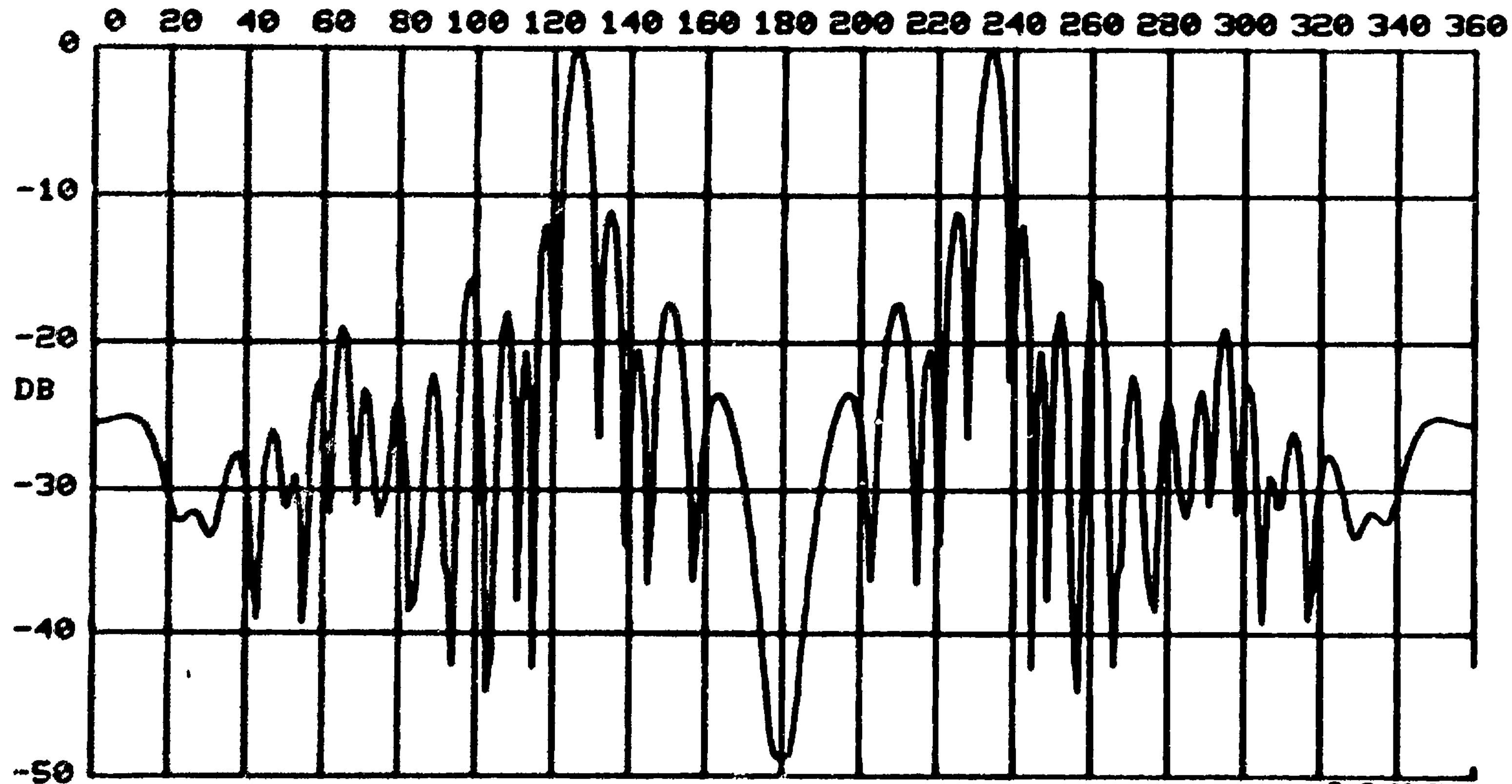


Figure B-68 Theoretical Horizontal Plane Pattern for 16 Element Array @ 290 Hz for Data Point 7, 19° Off Broadside Steering. Beamwidth 7.01°, Azimuth Gain 12.0 dB.

CONFIDENTIAL

S4??D SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-78 ONTLBF 3.1
[illegible] ARRAY TUNED TO 300 HZ.
?.???? FT. UNIFORM SPACING.
SAME

DATA POINT 7
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 51 ELEMENTS, -0.18 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 126.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
4.98 DEG. 3 DB BEAM, 14.73 DB AZ. GAIN, MAX. AT 126.0 DEG. HORIZ.



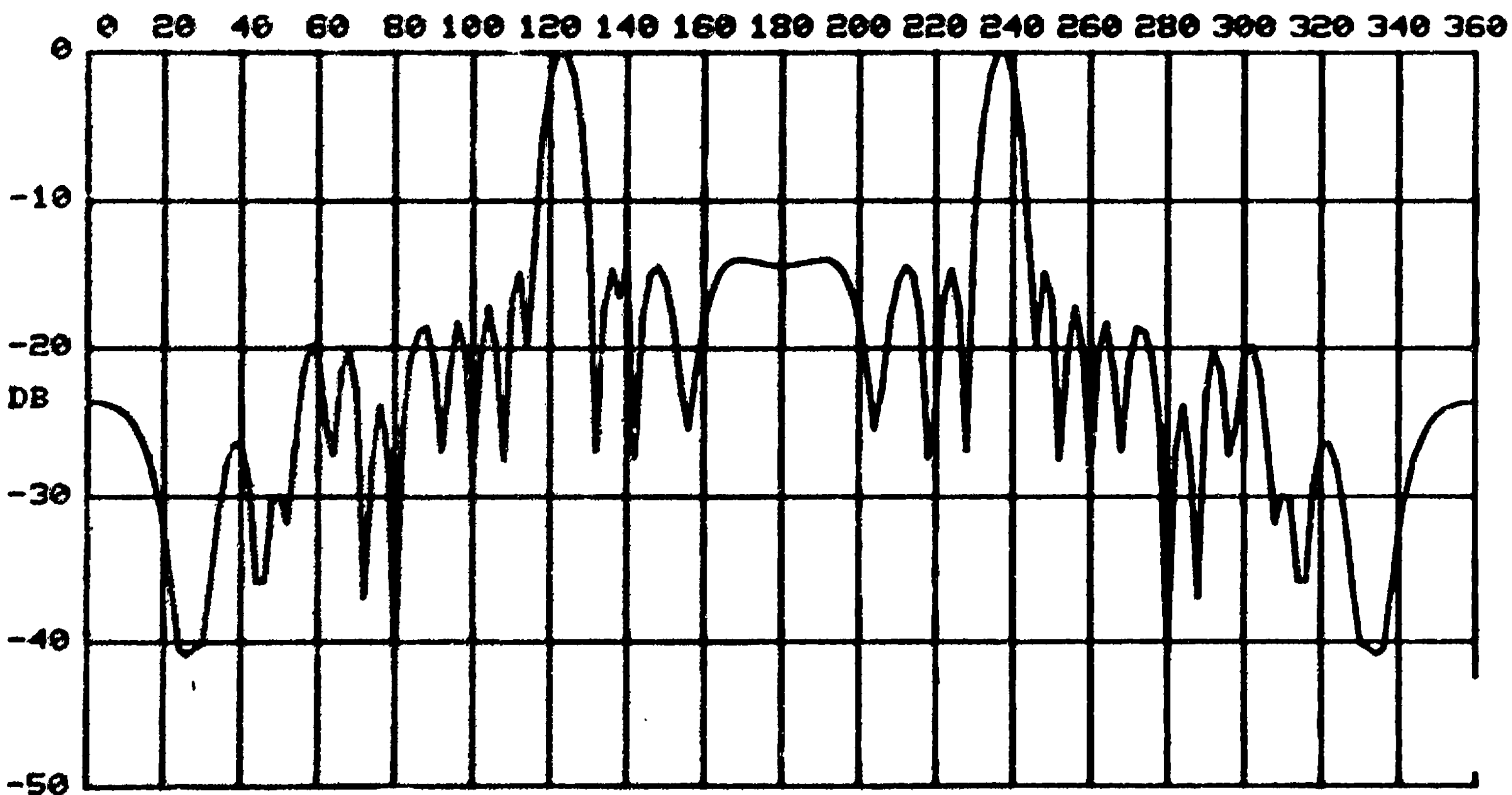
CONFIDENTIAL

Figure B-69 Theoretical Horizontal Plane Pattern for 51 Element Array @ 140 Hz for Data Point 7, 36° Off Broadside Steering. Beamwidth 4.98°, Azimuth Gain 14.7 dB.

CONFIDENTIAL

S402A SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-78 ONTLBP 3.1
[illegible] ARRAY TUNED TO 300 HZ.
3.2233 FT. UNIFORM SPACING.
[illegible]

DATA POINT 7
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 32 ELEMENTS, -0.35 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 123.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
7.99 DEG. 3 DB BEAM, 12.55 DB AZ. GAIN, MAX. AT 122.0 DEG. HORIZ.



CONFIDENTIAL

Figure B-70 Theoretical Horizontal Plane Pattern for 32 Element Array @ 140 Hz for Data Point 7, 33° Off Broadside Steering. Beamwidth 7.99°, Azimuth Gain 12.5 dB.

```
54027  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)   5-Apr-73   QNTLBP 3.1
A: ARRAY ARRAY TUNED TO 300 HZ.
   3.3333 FT. UNIFORM SPACING.
B: SAME

DATA POINT 7
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ.,  16 ELEMENTS, -0.17 DB MAX., AC:S2581,SU:S2581,WT:
 90.0 DEG. VERT. RESP., 118.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
15.98 DEG. 3 DB BEAM,  10.00 DB AZ. GAIN, MAX. AT 120.0 DEG. HORIZ.
```

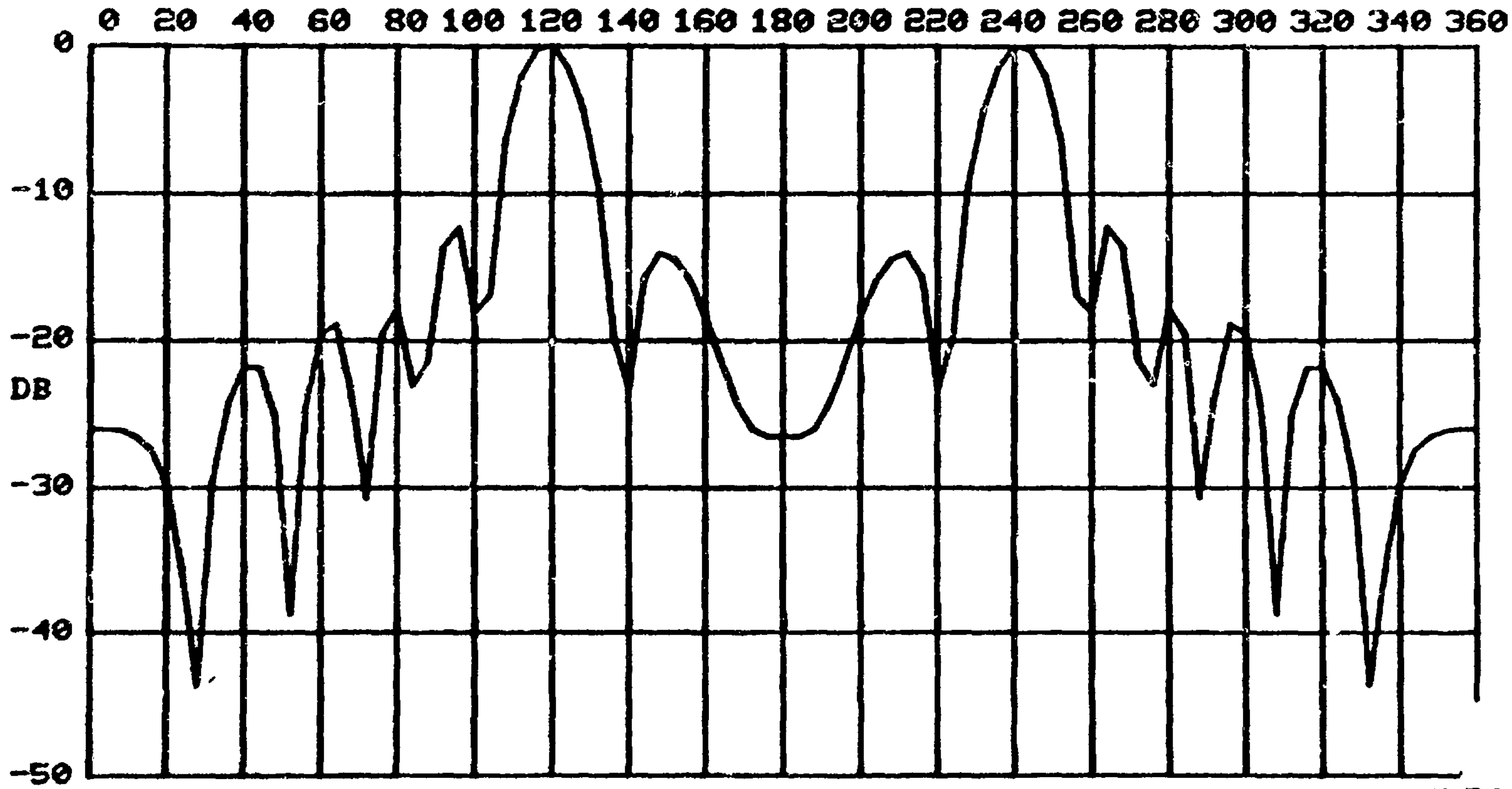
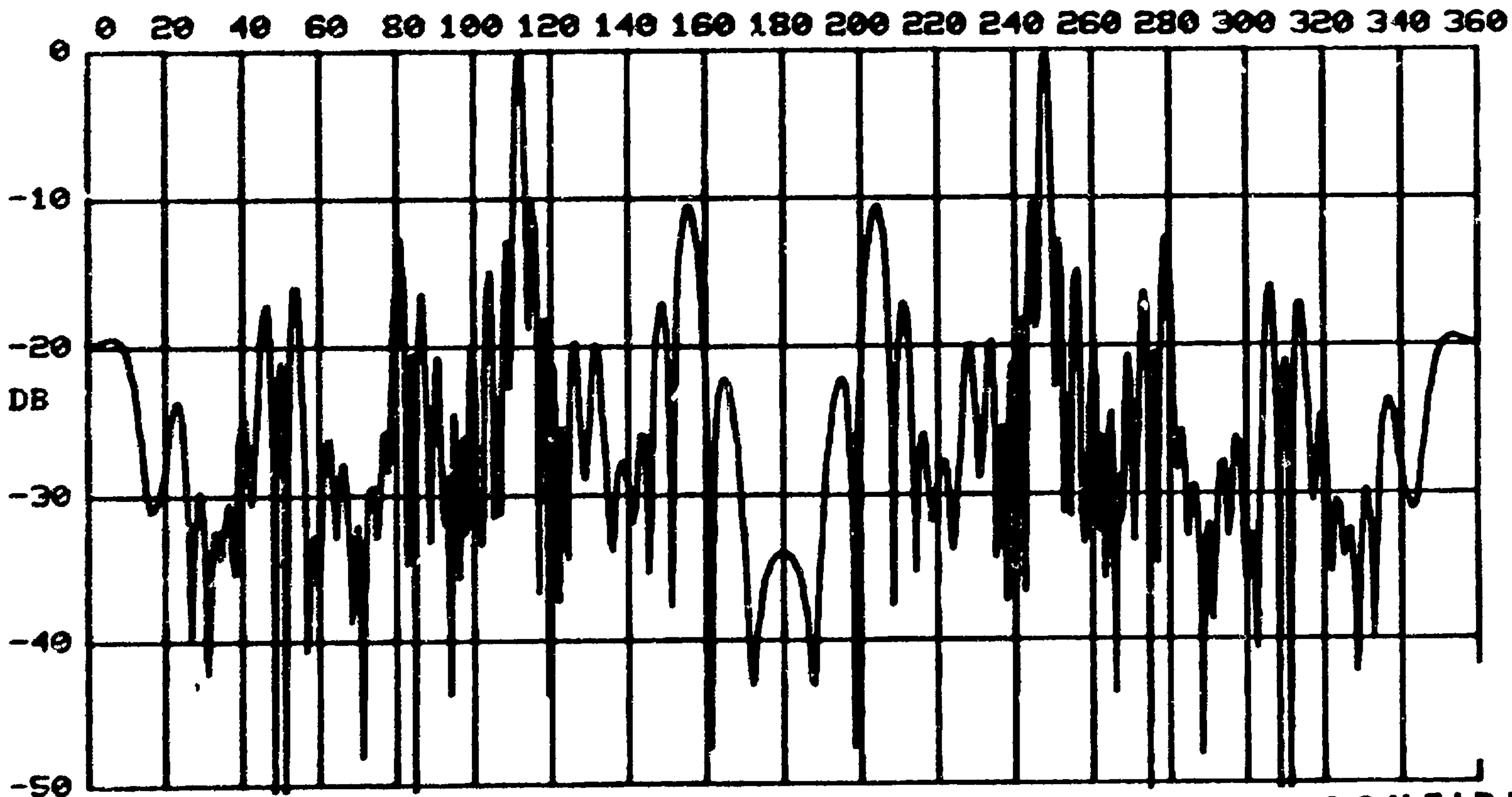


Figure B-71 Theoretical Horizontal Plane Pattern for 16 Element Array @ 140 Hz for Data Point 7, 28° Off Broadside Steering. Beamwidth 15.98°, Azimuth Gain 10.0 dB.

CONFIDENTIAL

SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-78 ONTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING.

DATA POINT 7
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ., 51 ELEMENTS, -0.89 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 112.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
2.06 DEG. 3 DB BEAM, 17.17 DB AZ. GAIN, MAX. AT 248.0 DEG. HORIZ.



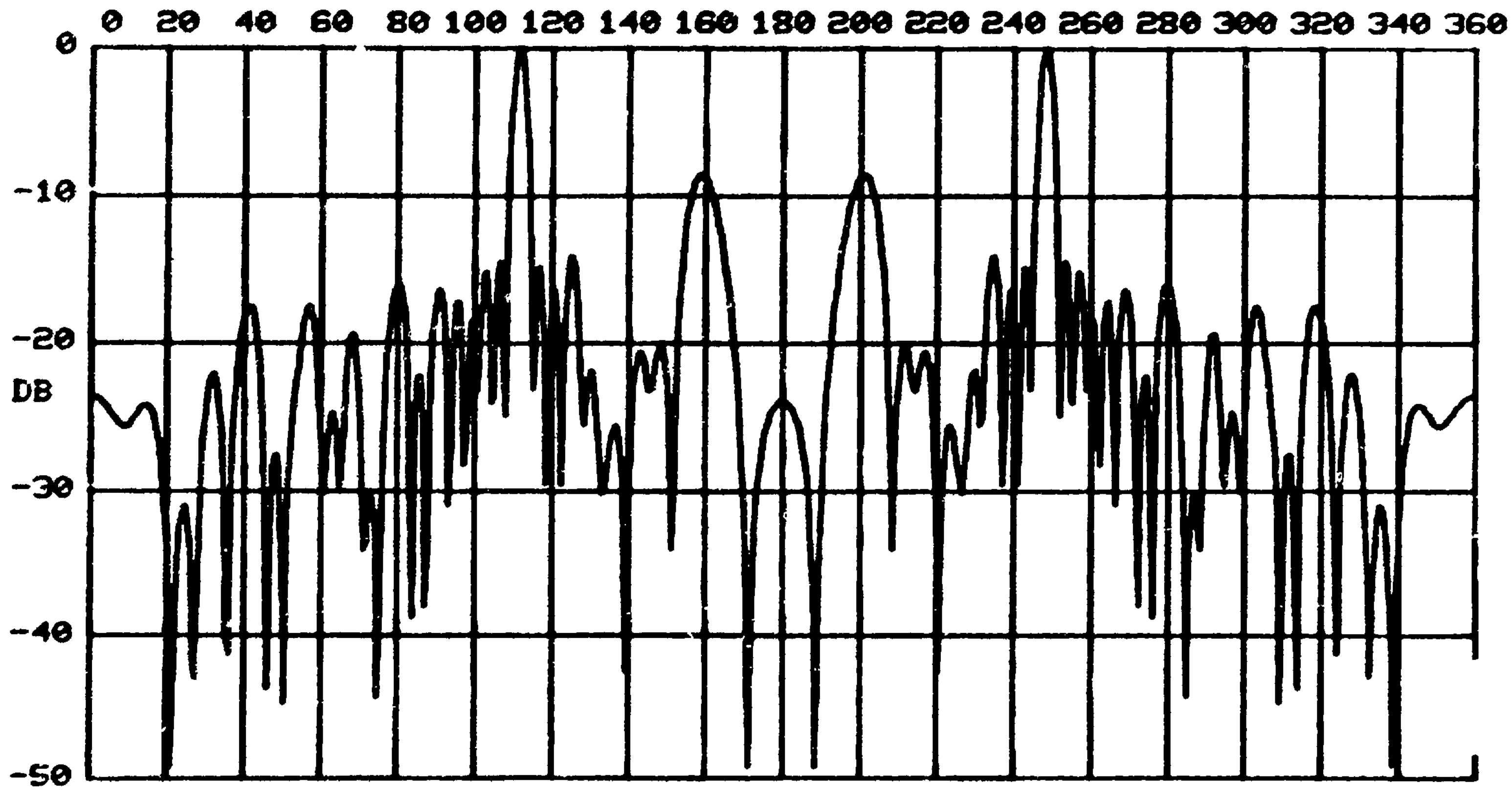
CONFIDENTIAL

Figure B-72 Theoretical Horizontal Plane Pattern for 51 Element Array @295 Hz for Data Point 7, 22° Off Broadside Steering. Beamwidth 2.06°, Azimuth Gain 17.1 dB.

CONFIDENTIAL

SANDERS BEAM PATTERN PROGRAM (T.HOGAN)   5-Apr-78   QNTLBP 3.1
ARRAY TUNED TO 300 HZ.
.3333 FT. UNIFORM SPACING.

DATA POINT 7
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ., 32 ELEMENTS, -0.78 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 111.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
3.27 DEG. 3 DB BEAM, 15.12 DB AZ. GAIN, MAX. AT 111.5 DEG. HORIZ.



CONFIDENTIAL

Figure E-73 Theoretical Horizontal Plane Pattern for 32 Element Array @ 295 Hz for Data Point 7, 21.5° Off Broadside Steering. Beamwidth 3.27°, Azimuth Gain 15.1 dB.

```
54??9  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)    5-Apr-78    QNTLBP 3.1
ARRAY TUNED TO 300 HZ.
?.???? FT. UNIFORM SPACING.
SAME

DATA POINT 7
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ.,  16 ELEMENTS, -0.85 DB MAX., AC:S2581,SU:S2581,WT:
 90.0 DEG. VERT. RESP., 109.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
 6.82 DEG. 3 DB BEAM,  11.73 DB AZ. GAIN, MAX. AT 109.0 DEG. HORIZ.
```

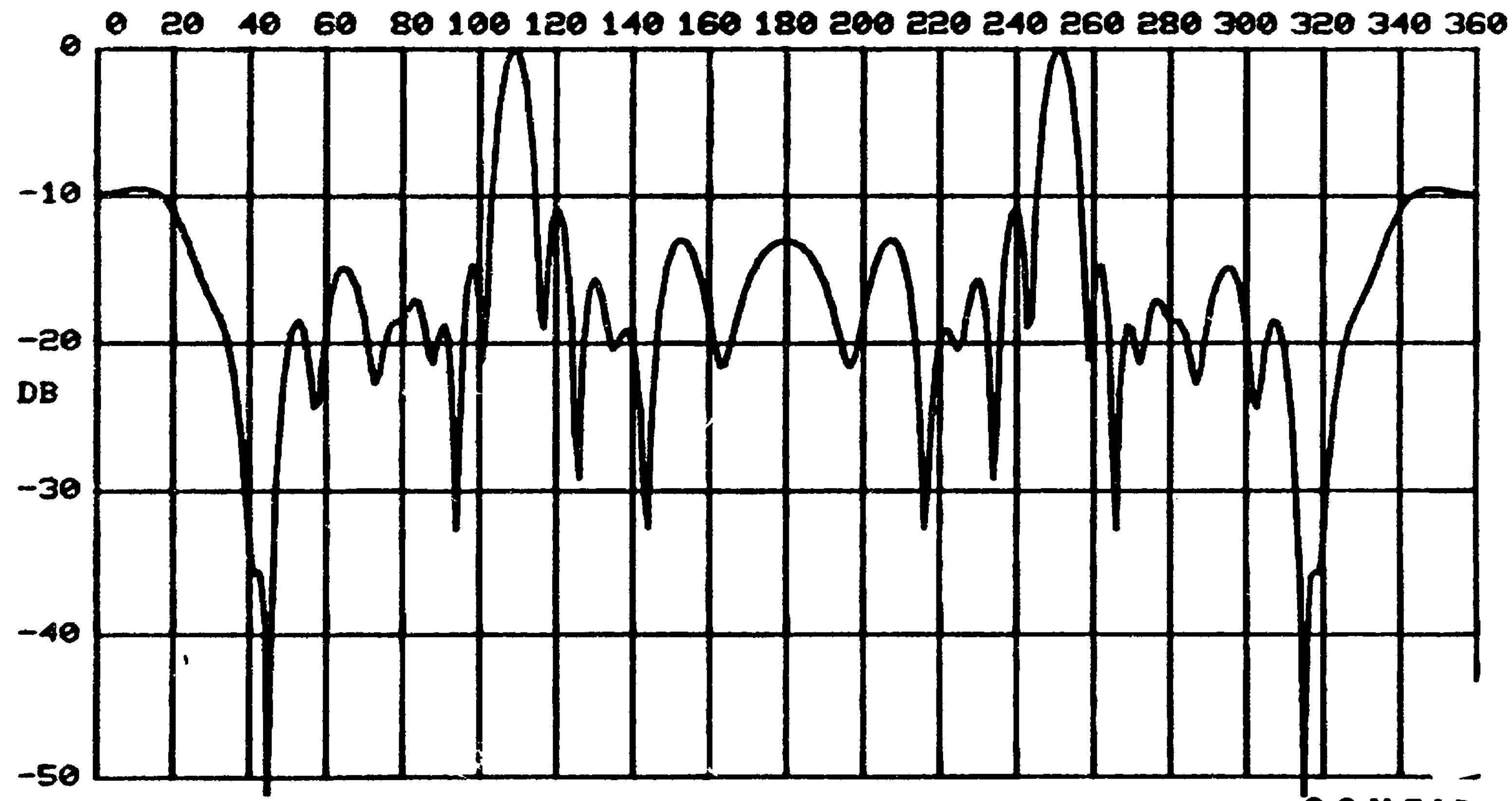
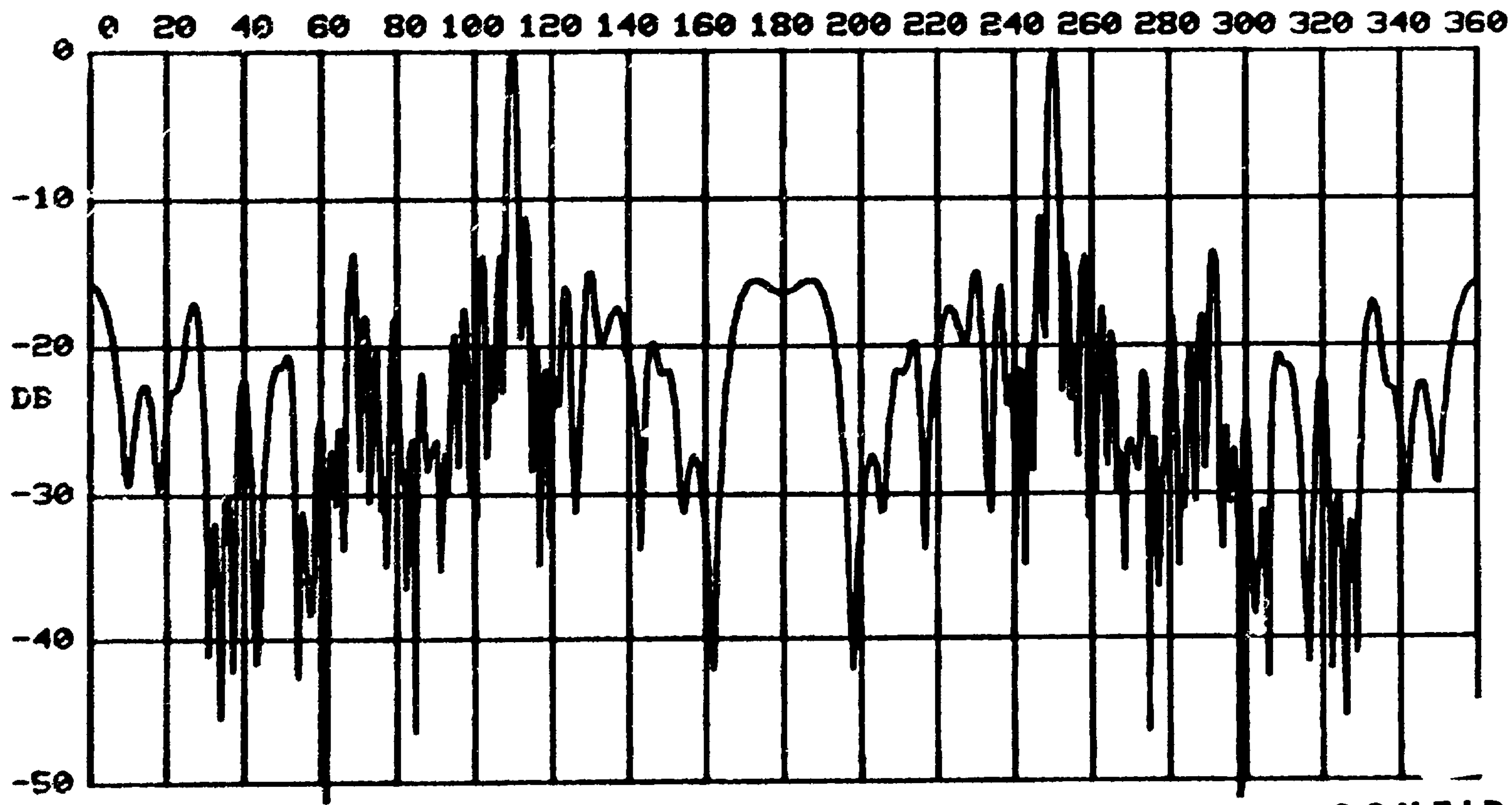


Figure B-74 Theoretical Horizontal Plane Pattern for 16 Element Array @ 295 Hz for Data Point 7, 19° Off Broadside Steering. Beamwidth 6.82°, Azimuth Gain 11.7 dB.

CONFIDENTIAL

DATA POINT 8
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 48 ELEMENTS, -0.86 DB MAX., AC:S4343,SU:S4343,WT:
90.0 DEG. VERT. RESP., 110.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
2.09 DEG. 3 DB BEAM, 16.92 DB AZ. GAIN, MAX. AT 110.0 DEG. HORIZ.



CONFIDENTIAL

Figure B-75 Theoretical Horizontal Plane Pattern for 48 Element Array @ 290 Hz for Data Point 8, 20° Off Broadside Steering. Beamwidth 2.09°, Azimuth Gain 16.9 dB.

SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-73 QNTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

DATA POINT 8
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 32 ELEMENTS, -0.86 DB MAX., AC:S4342,SU:S4342,WT:
90.0 DEG. VERT. RESP., 110.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
3.30 DEG. 3 DB BEAM, 15.22 DB AZ. GAIN, MAX. AT 110.0 DEG. HORIZ.

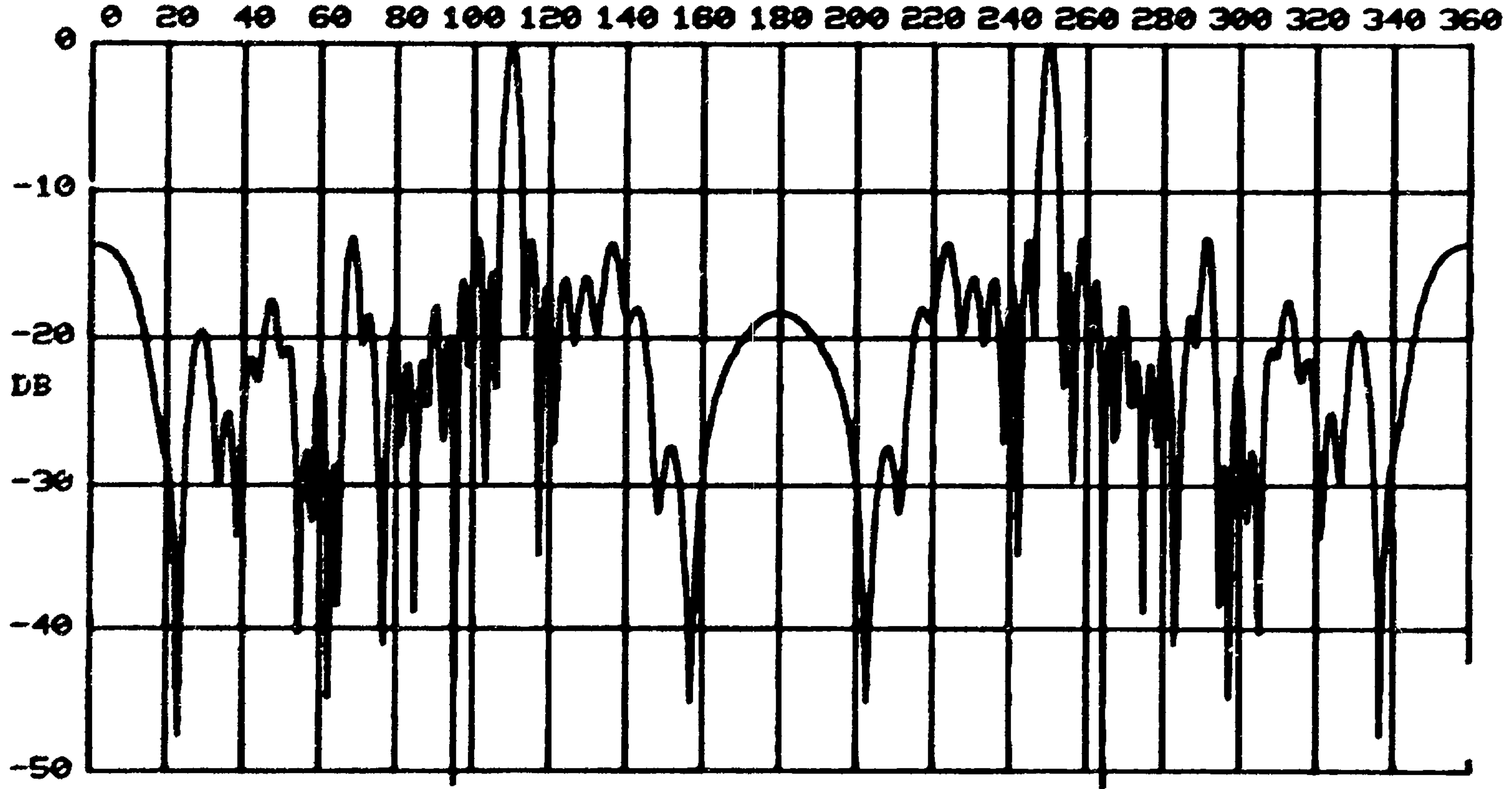
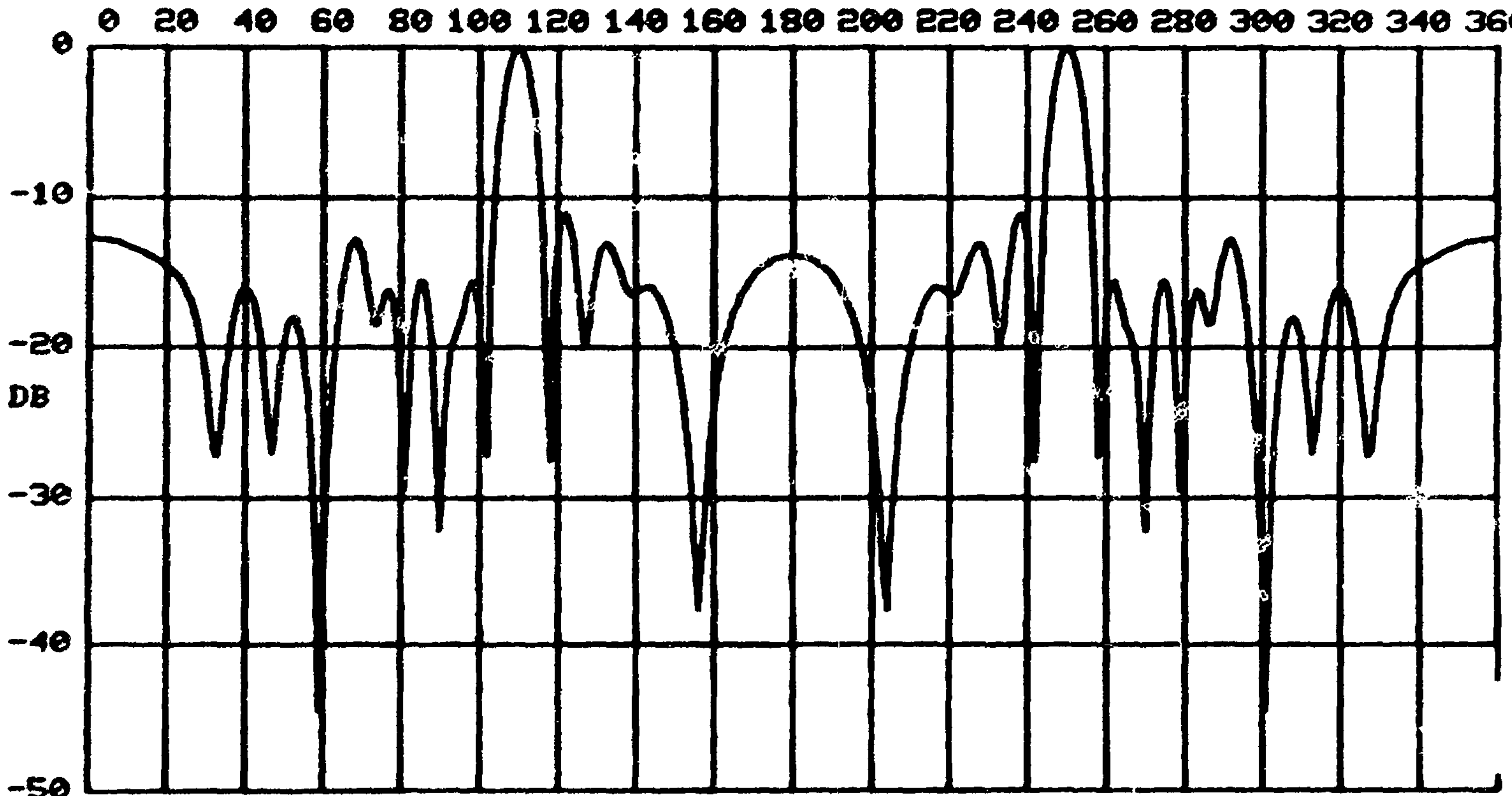


Figure 2-76 Theoretical Horizontal Plane Pattern for 32 Element Array @ 290 Hz for Data Point 8, 20° Off Broadside Steering. Beamwidth 3.30°, Azimuth Gain 15.2 dB.

CONFIDENTIAL

```
      SANDERS BEAM PATTERN PROGRAM (T.HOGAN)    5-Apr-78    ONTLBP 3.1
      ARRAY TUNED TO 300 HZ.
      FT. UNIFORM SPACING

DATA POINT 8
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ.,   16 ELEMENTS, -0.85 DB MAX., AC:S4341,SU:S4341,WT:
 90.0 DEG. VERT. RESP., 110.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
 7.06 DEG. 3 DB BEAM,  12.12 DB AZ. GAIN, MAX. AT 110.0 DEG. HORIZ.
```



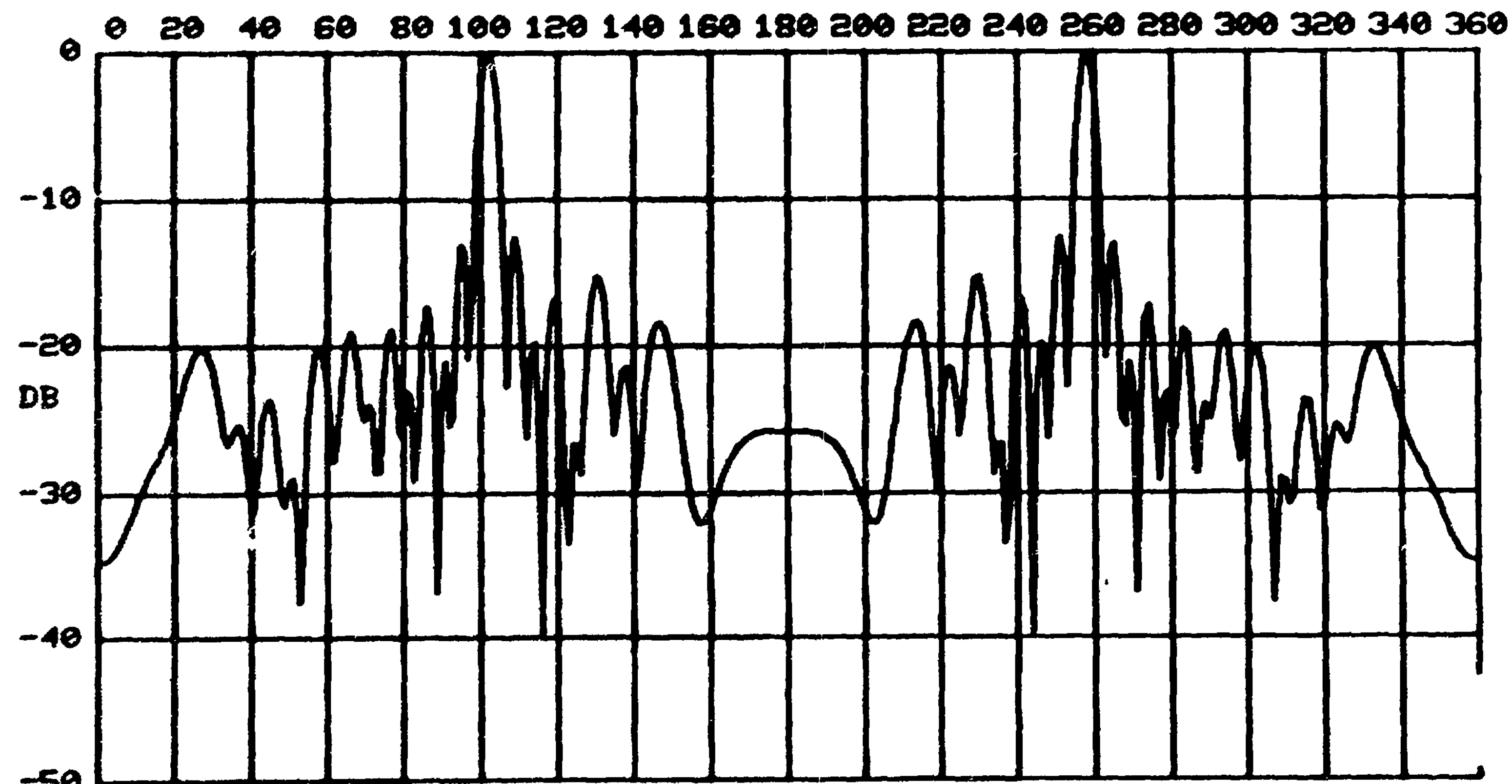
CONFIDENTIAL

Figure B-77 Theoretical Horizontal Plane Pattern for 16 Element Array @ 290 Hz for Data Point 8, 20° Off Broadside Steering. Beamwidth 7.06°, Azimuth Gain 12.1 dB.

CONFIDENTIAL

SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-73 ONTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

DATA POINT 8
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 48 ELEMENTS, -0.18 DB MAX., AC:S4343,SU:S4343,WT:
30.0 DEG. VERT. RESP., 102.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
4.16 DEG. 3 DB BEAM, 15.30 DB AZ. GAIN, MAX. AT 102.0 DEG. HORIZ.



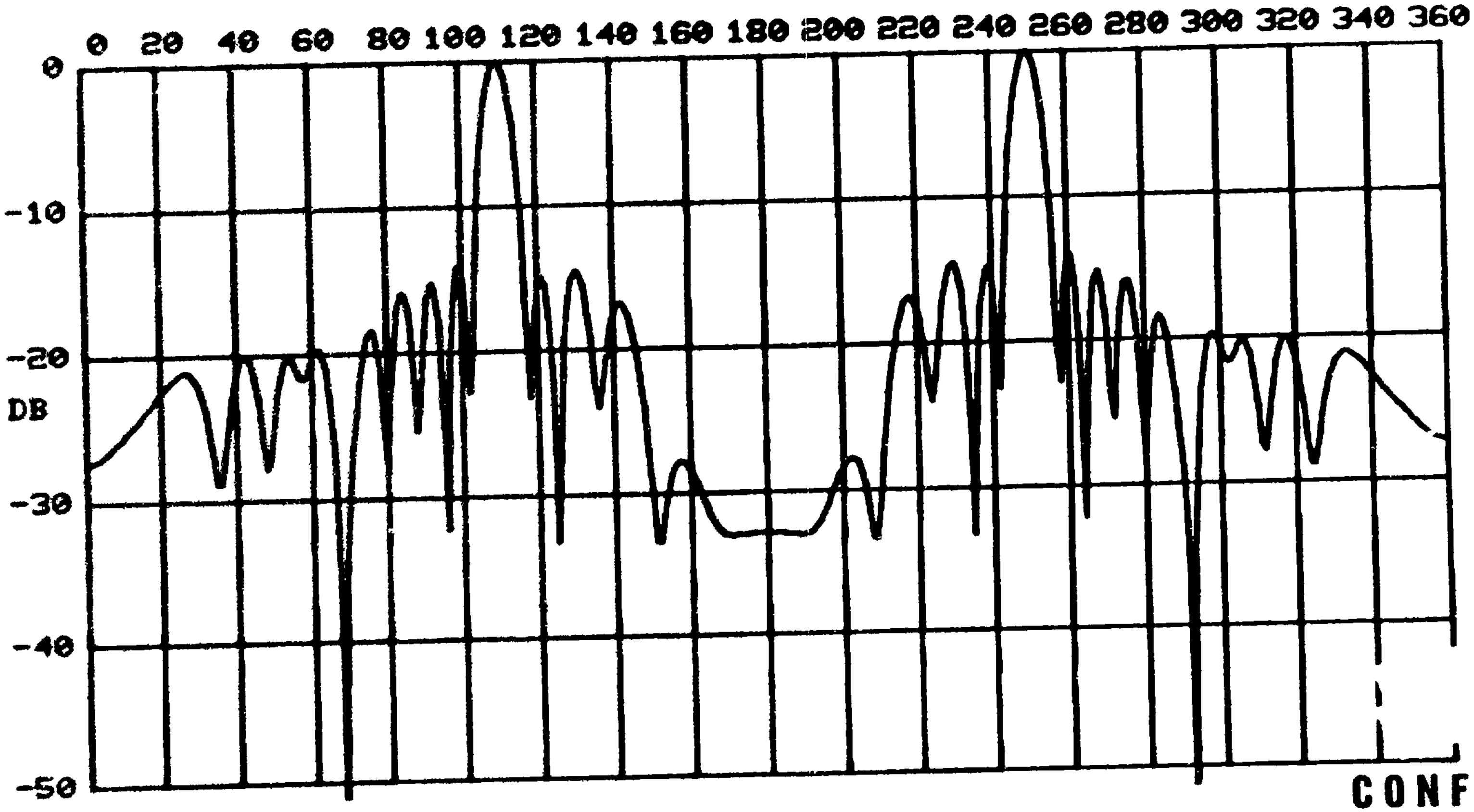
CONFIDENTIAL

Figure B-78 Theoretical Horizontal Plane Pattern for 48 Element Array @ 140 Hz for Data Point 8, 12° Off Broadside Steering. Beamwidth 4.16°, Azimuth Gain 15.3 dB.

CONFIDENTIAL

S4021 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-78 ONTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING
S4NE

DATA POINT 8
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 32 ELEMENTS, -0.18 DB MAX., AC:S4342,SU:S4342,WT:
90.0 DEG. VERT. RESP., 110.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
6.81 DEG. 3 DB BEAM, 13.36 DB AZ. GAIN, MAX. AT 110.0 DEG. HORIZ.



CONFIDENTIAL

Figure B-79 Theoretical Horizontal Plane Pattern for 32 Element Array @ 140 Hz for Data Point 8, 20° Off Broadside Steering. Beamwidth 6.81°, Azimuth Gain 13.3 dB.

S402G SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-78 ONTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

DATA POINT 8
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 16 ELEMENTS, -0.22 DB MAX., AC:S4341,SU:S4341,WT:
90.0 DEG. VERT. RESP., 103.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
14.07 DEG. 3 DB BEAM, 10.40 DB AZ. GAIN, MAX. AT 102.0 DEG. HORIZ.

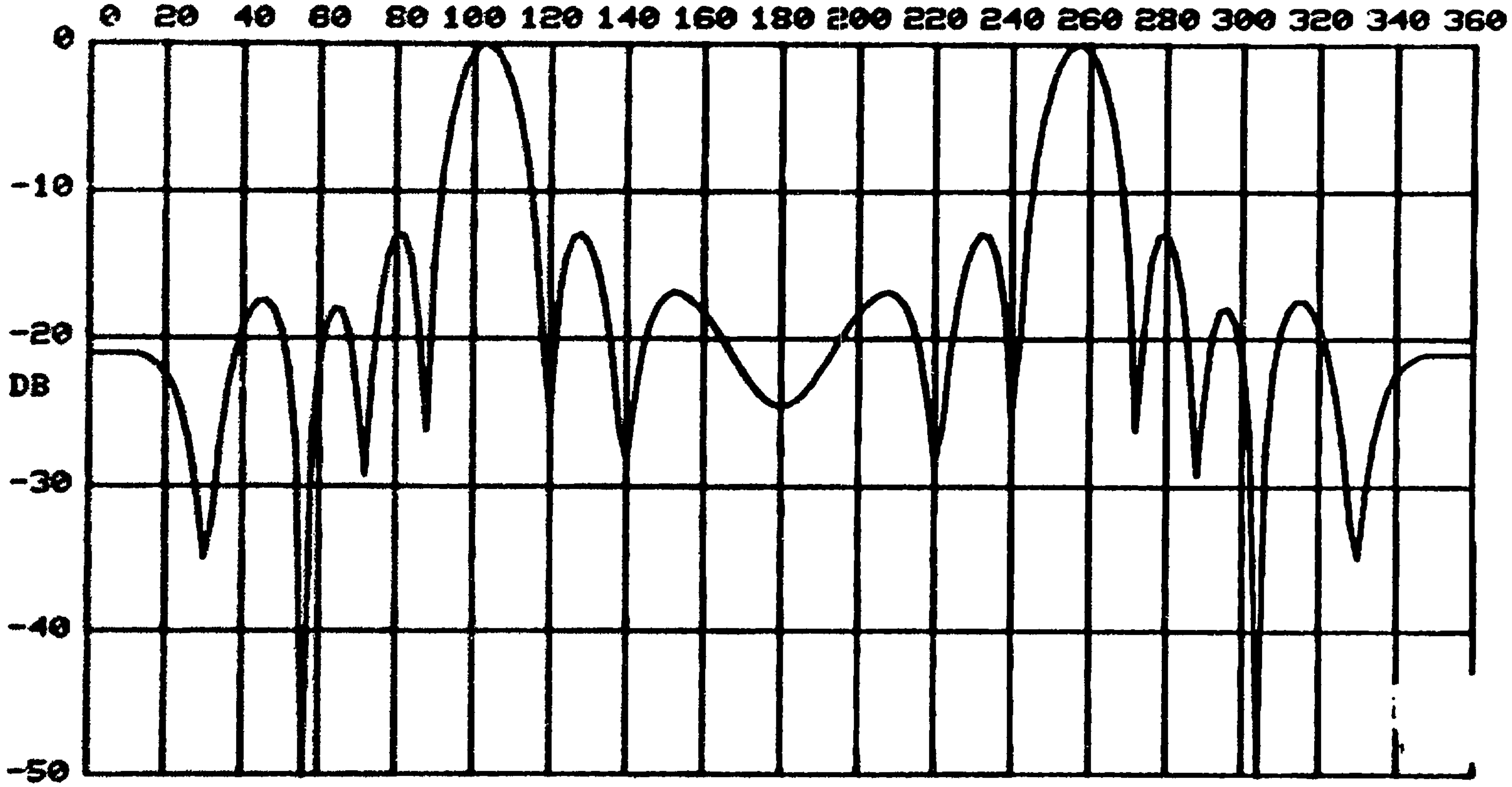
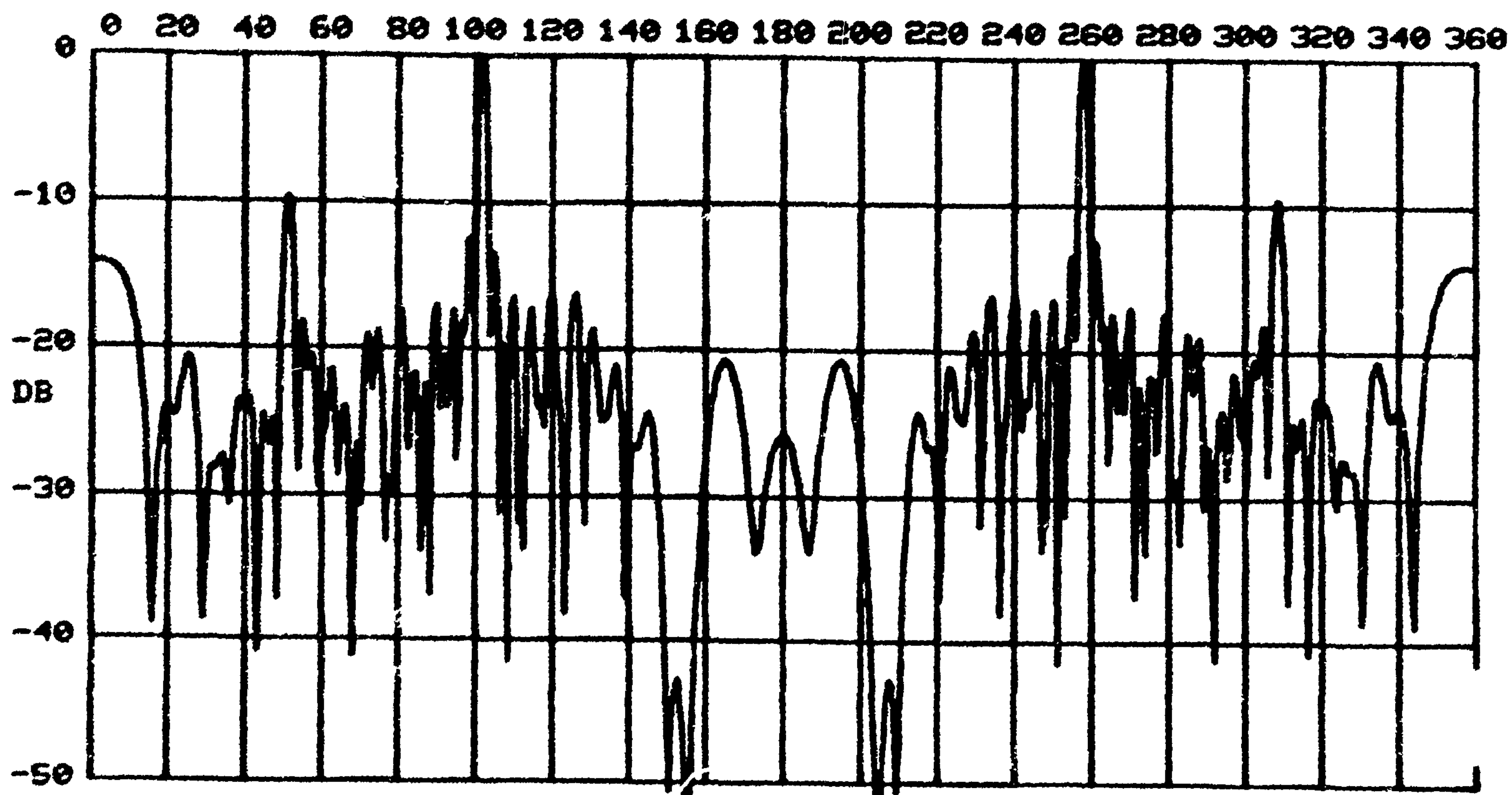


Figure B-80 Theoretical Horizontal Plane Pattern for 16 Element Array @ 140 Hz for Data Point 8, 13° Off Broadside Steering. Beamwidth 14.07°, Azimuth Gain 10.4 dB.

CONFIDENTIAL

SANDERS BEAM PATTERN PROGRAM (T.HOGAN)   5-Apr-78   QNTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

DATA POINT 8
1800 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ., 48 ELEMENTS, -0.85 DB MAX., AC:S4343,SU:S4343,WT:
90.0 DEG. VERT. RESP., 102.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
1.96 DEG. 3 DB BEAM, 17.04 DB AZ. GAIN, MAX. AT 102.0 DEG. HORIZ.



CONFIDENTIAL

Figure B-81 Theoretical Horizontal Plane Pattern for 48 Element Array @ 295 Hz for Data Point 8, 12° Off Broadside Steering. Beamwidth 1.96°, Azimuth Gain 17.0 dB.

S4..L SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-78 ONTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

DATA POINT 8
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ., 32 ELEMENTS, -0.84 DB MAX., AC:S4342,SU:S4342,WT:
90.0 DEG. VERT. RESP., 110.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
3.24 DEG. 3 DB BEAM, 14.68 DB AZ. GAIN, MAX. AT 250.0 DEG. HORIZ.

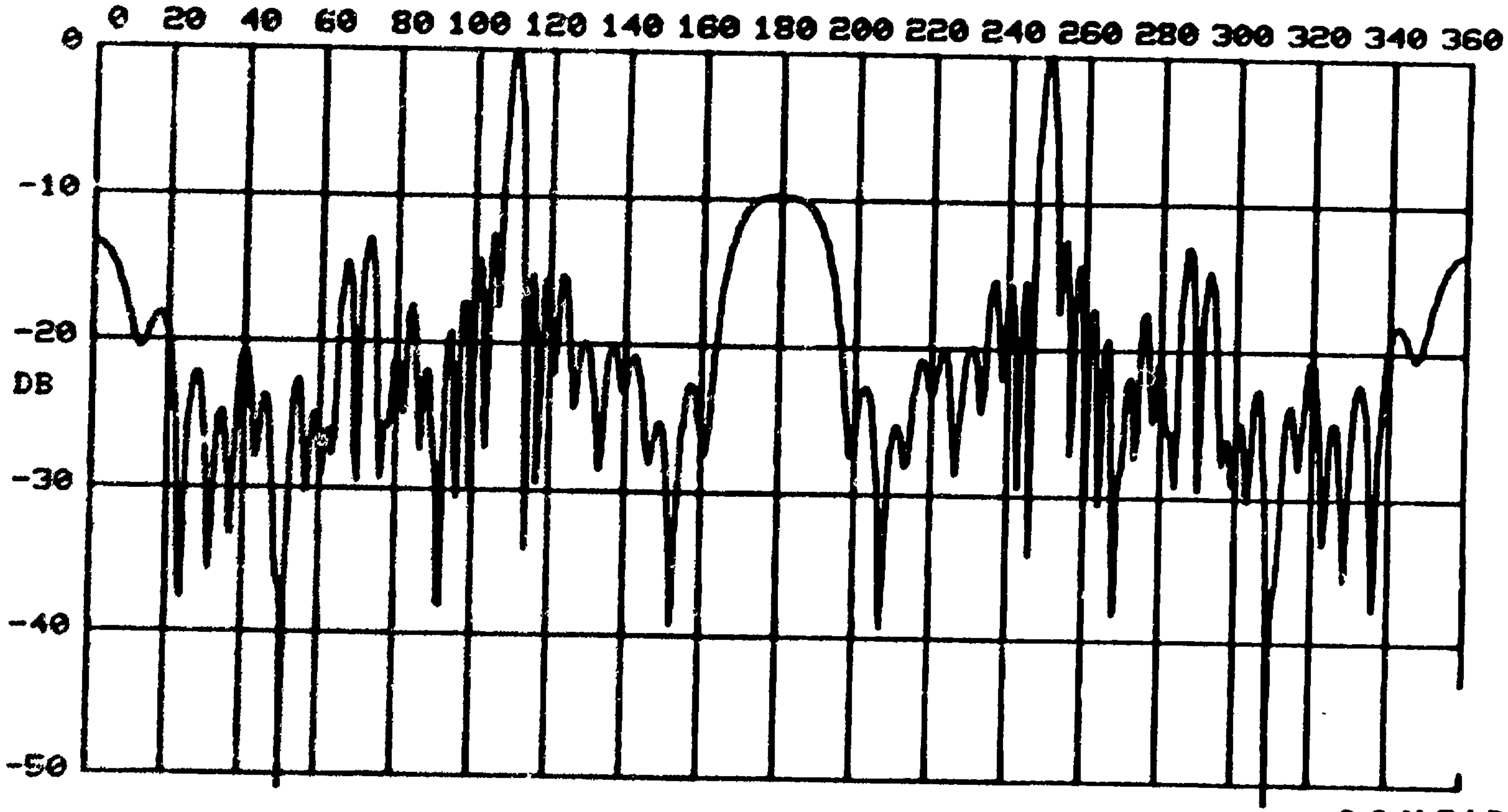
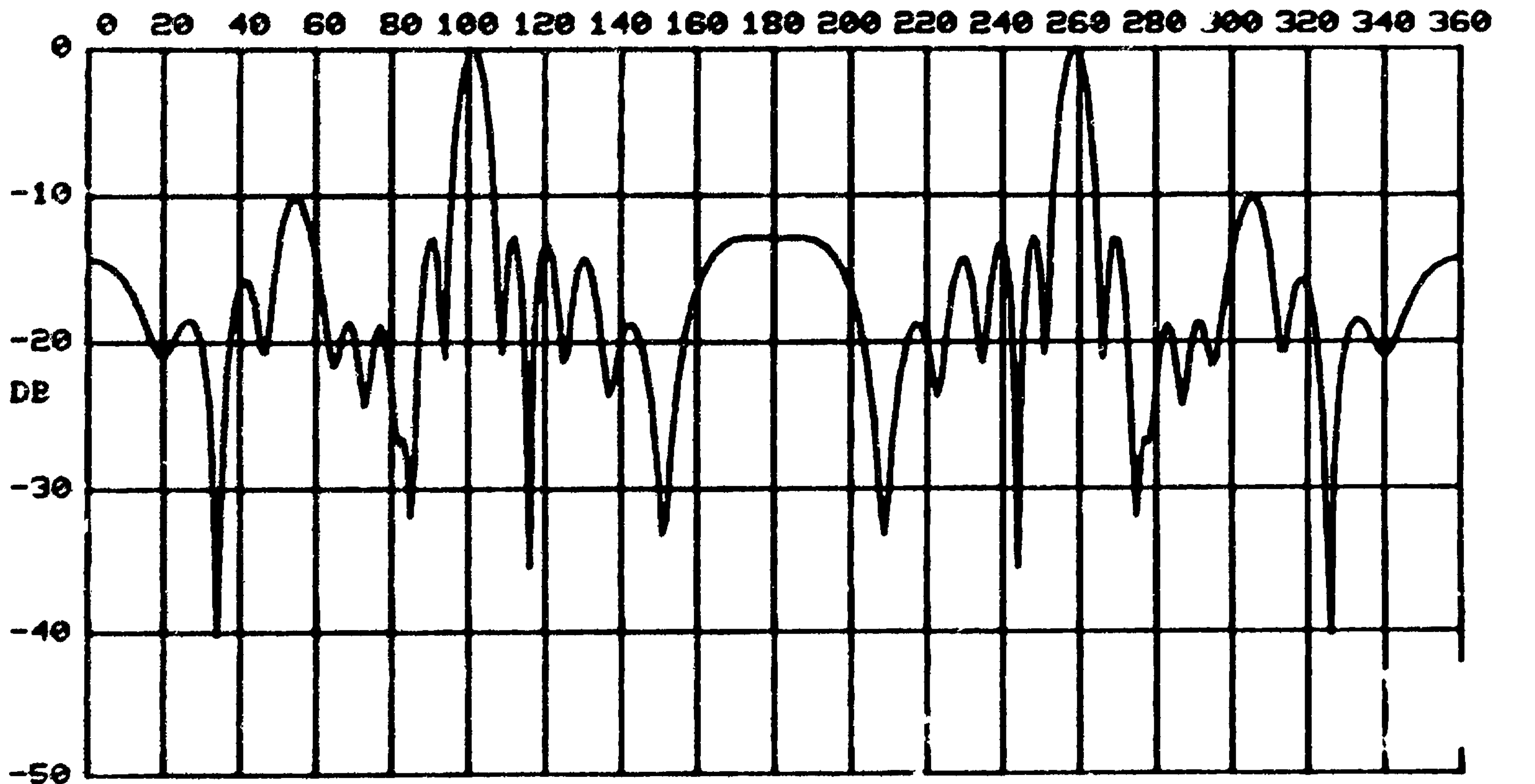


Figure B-12 Theoretical Horizontal Plane Pattern for 32 Element Array @ 295 Hz for Data Point 8, 20° Off Broadside Steering. Beamwidth 3.24°, Azimuth Gain 14.6 dB.

CONFIDENTIAL

```
[illegible]   SWIDERS BEAM PATTERN PROGRAM (T.HOGAN)    5-Apr-78    QNTLBP 3.1
[illegible] ARRAY TUNED TO 300 HZ.
[illegible] FT. UNIFORM SPACING
SAME

DATA POINT 8
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ.,   16 ELEMENTS, -0.87 DB MAX., AC:S4341,SU:S4341,WT:
 90.0 DEG. VERT. RESP., 101.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
 6.62 DEG. 3 DB BEAM,  12.28 DB AZ. GAIN, MAX. AT 101.0 DEG. HORIZ.
```



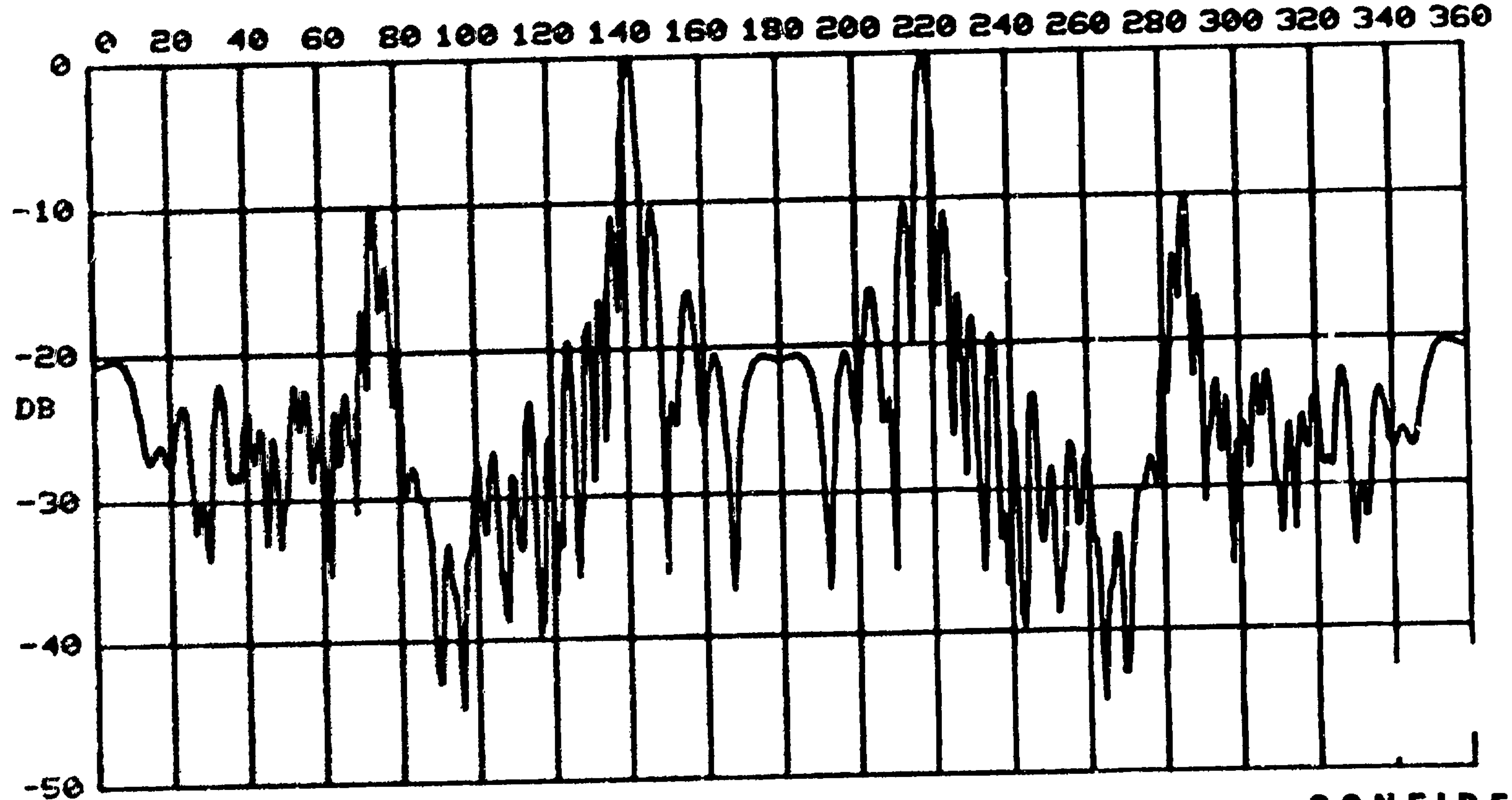
CONFIDENTIAL

Figure B-83 Theoretical Horizontal Plane Pattern for 16 Element Array @ 295 Hz for Data Point 8, 11° Off Broadside Steering. Beamwidth 6.62°, Azimuth Gain 12.2 dB.

CONFIDENTIAL

S105B SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 DNTLBF 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

UNIFORM WEIGHTING.
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 51 ELEMENTS, -0.80 DB MAX., AC:S1361,SU:S1361,WT:
90.0 DEG. VERT. RESP., 141.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
3.11 DEG. 3 DB BEAM, 16.04 DB AZ. GAIN, MAX. AT 141.5 DEG. HORIZ.



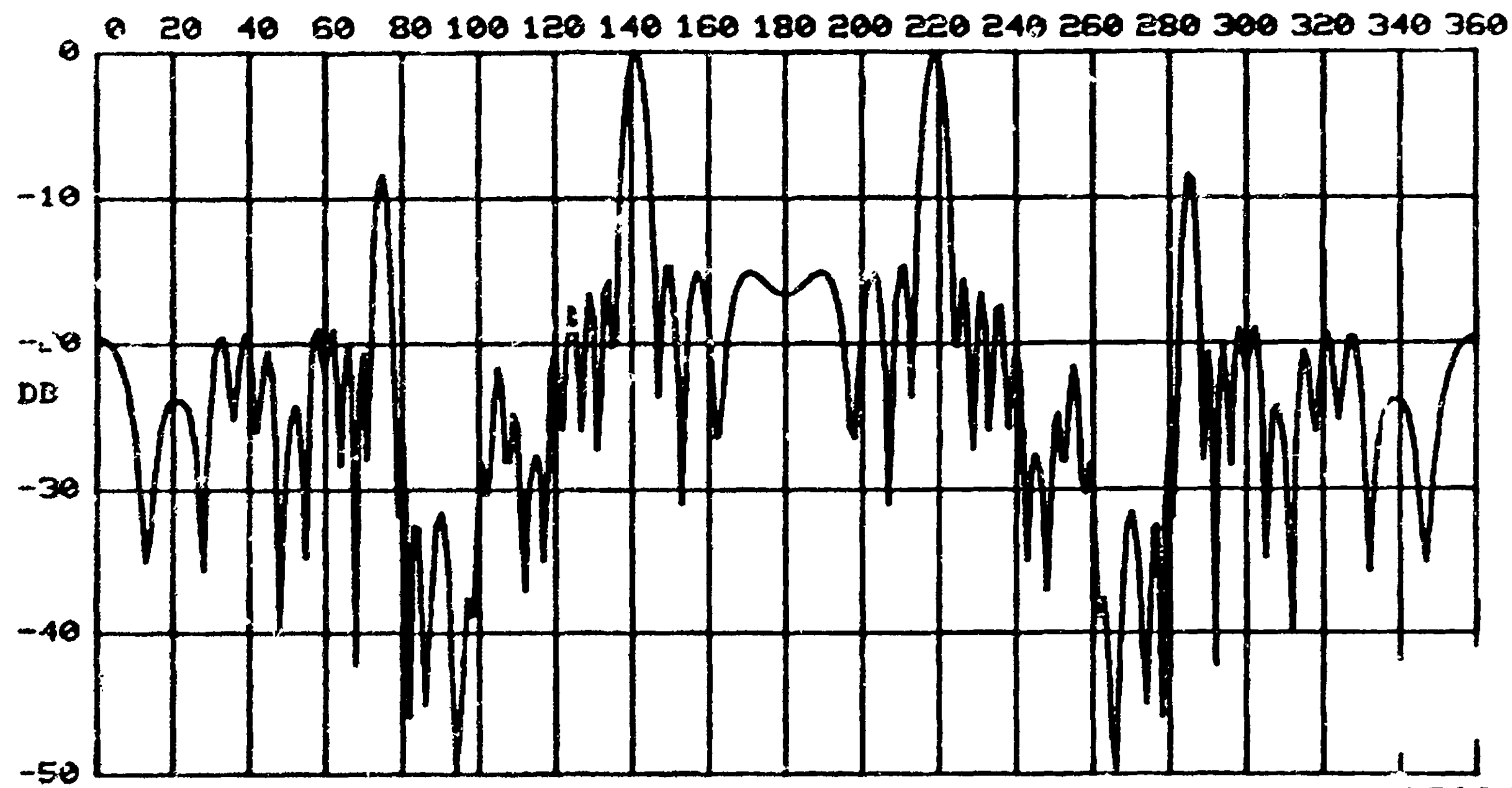
CONFIDENTIAL

Figure B-94 Theoretical Horizontal Plane Pattern for 51 Element Array @ 290 Hz for Data Point 9, 51° Off Broadside Steering. Beamwidth 3.11°, Azimuth Gain 16.0 dB.

CONFIDENTIAL

S1052 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 CNTLBF 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

UNIFORM WEIGHTING.
1800 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 32 ELEMENTS, -0.61 DB MAX., AC:S1361,SU:S1361,WT:
90.0 DEG. VERT. RESP., 141.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
4.95 DEG. 3 DB BEAM, 14.21 DB AZ. GAIN, MAX. AT 141.0 DEG. HORIZ.



CONFIDENTIAL

Figure B-85 Theoretical Horizontal Plane Pattern for 32 Element Array @ 290 Hz for Data Point 9, 51.5° Off Broadside Steering. Beamwidth 4.95°, Azimuth Gain 14.2 dB.

```
?1955   SANDERS BEAM PATTERN PROGRAM (T.HOGAN)   6-Jan-73   ONTLBF ?.1
        ARRAY TUNED TO 300 HZ.
        ... FT. UNIFORM SPACING

UNIFORM WEIGHTING.
1... HZ.   SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ.,  16 ELEMENTS, -0.60 DB MAX., AC:S1361,SU:S1361,WT:
 90.0 DEG. VERT. RESP., 141.5 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
10.56 DEG. 3 DB BEAM,  11.10 DB AZ. GAIN, MAX. AT 141.0 DEG. HORIZ.
```

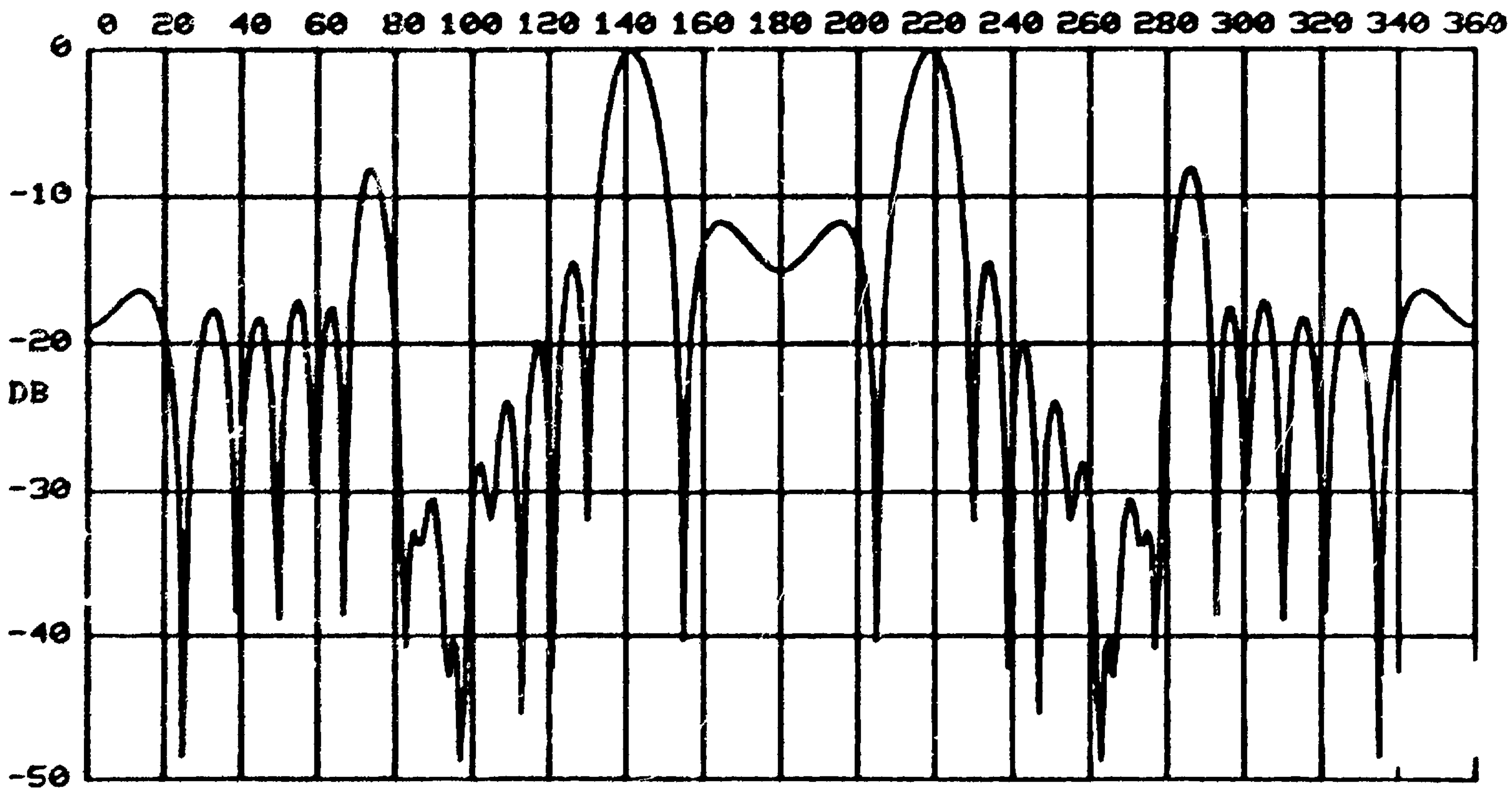
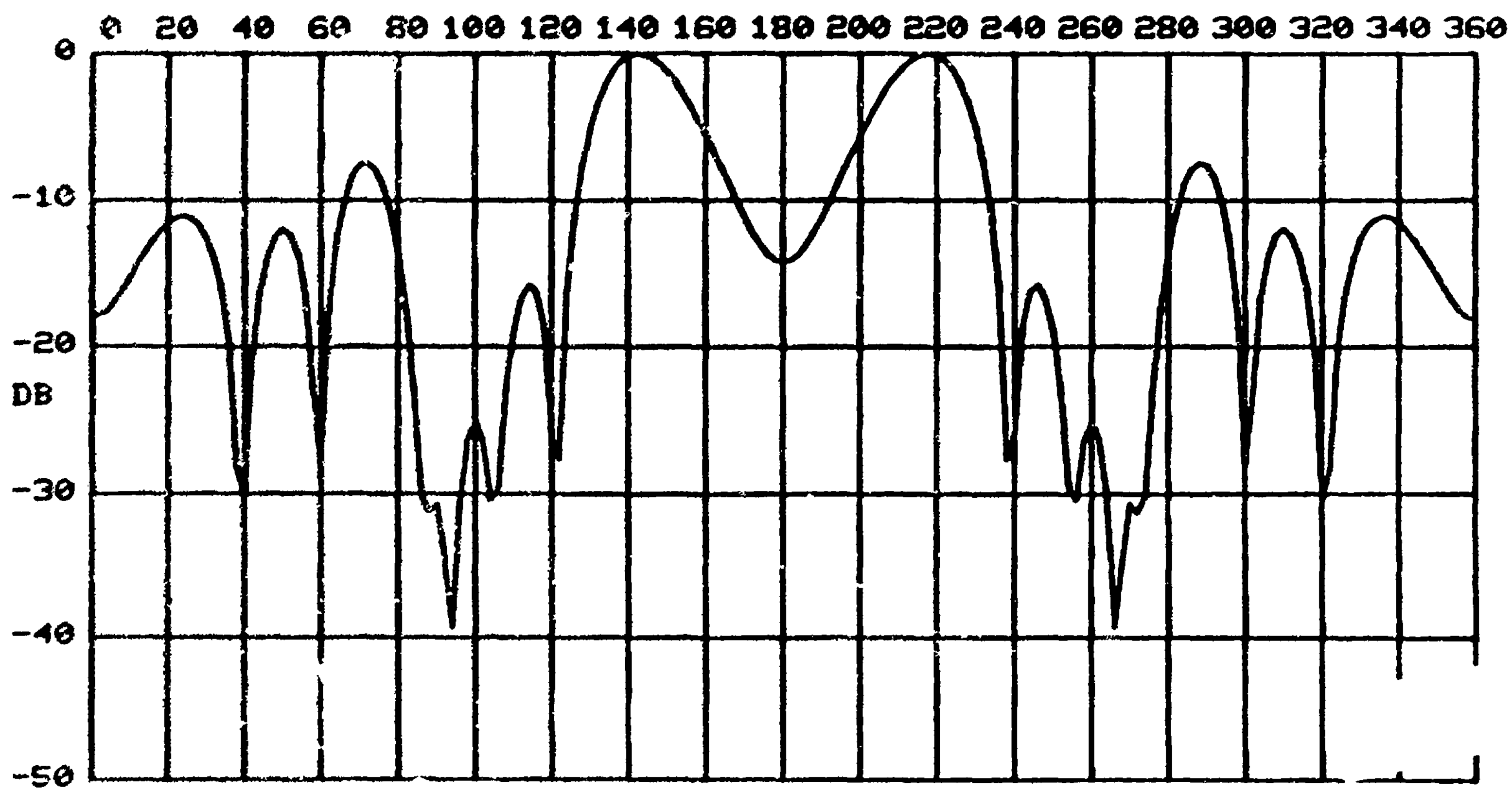


Figure B-86 Theoretical Horizontal Plane Pattern for 16 Element Array @ 290 Hz for Data Point 9, 57.5° Off Broadside Steering. Beamwidth 10.56°, Azimuth Gain 11.1 dB.

CONFIDENTIAL

?1.?52 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-78 ?NTLSP ?.1
?? ARRAY TUNED TO 300 HZ.
?.??3 FT. UNIFORM SPACING

UNIFORM W?GHTING.
1?0 HZ. S?MPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 8 ELEMENTS, -0.56 DB MAX., AC:S1361,SU:S1361,WT:
90.0 DEG. VERT. RESP., 141.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
22.39 DEG. 3 DB BEAM, 7.96 DB AZ. GAIN, MAX. AT 142.0 DEG. HORIZ.



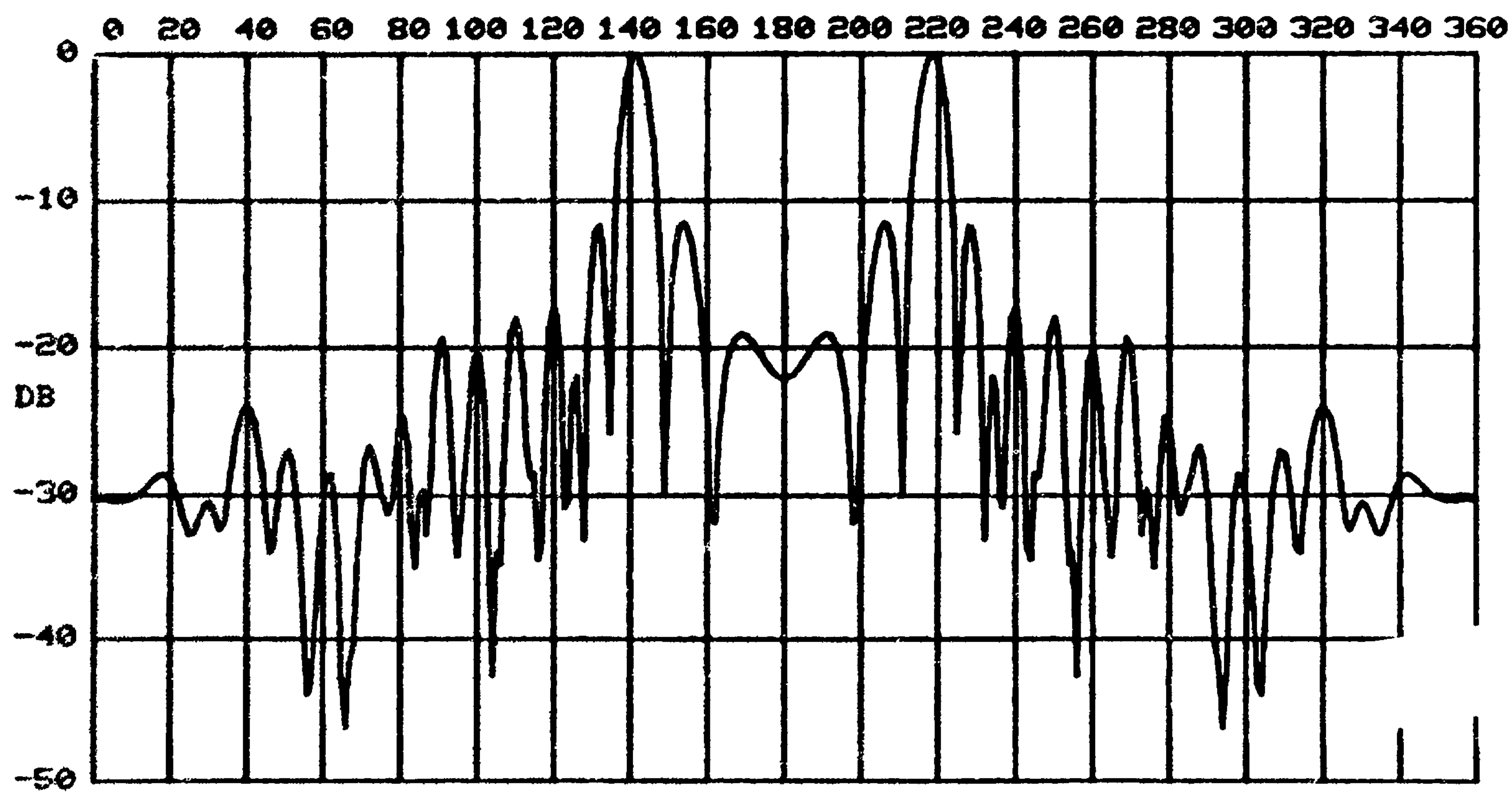
CONFIDENTIAL

Figure B-87 Theoretical Horizontal Plane Pattern for 8 Element Array @ 290 Hz for Data Point 9, 57.5° Off Broadside Steering. Beamwidth 22.39°, Azimuth Gain 7.9 dB.

CONFIDENTIAL

5105A SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 ONTLBP 3.1
[illegible] ARRAY TUNED TO 300 HZ.
[illegible] FT. UNIFORM SPACING
[illegible]

UNIFORM WEIGHTING.
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 51 ELEMENTS, -0.22 DB MAX., AC:S1361,SU:S1361,WT:
90.0 DEG. VERT. RESP., 141.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
6.50 DEG. 3 DB BEAM, 13.64 DB AZ. GAIN, MAX. AT 141.0 DEG. HORIZ.



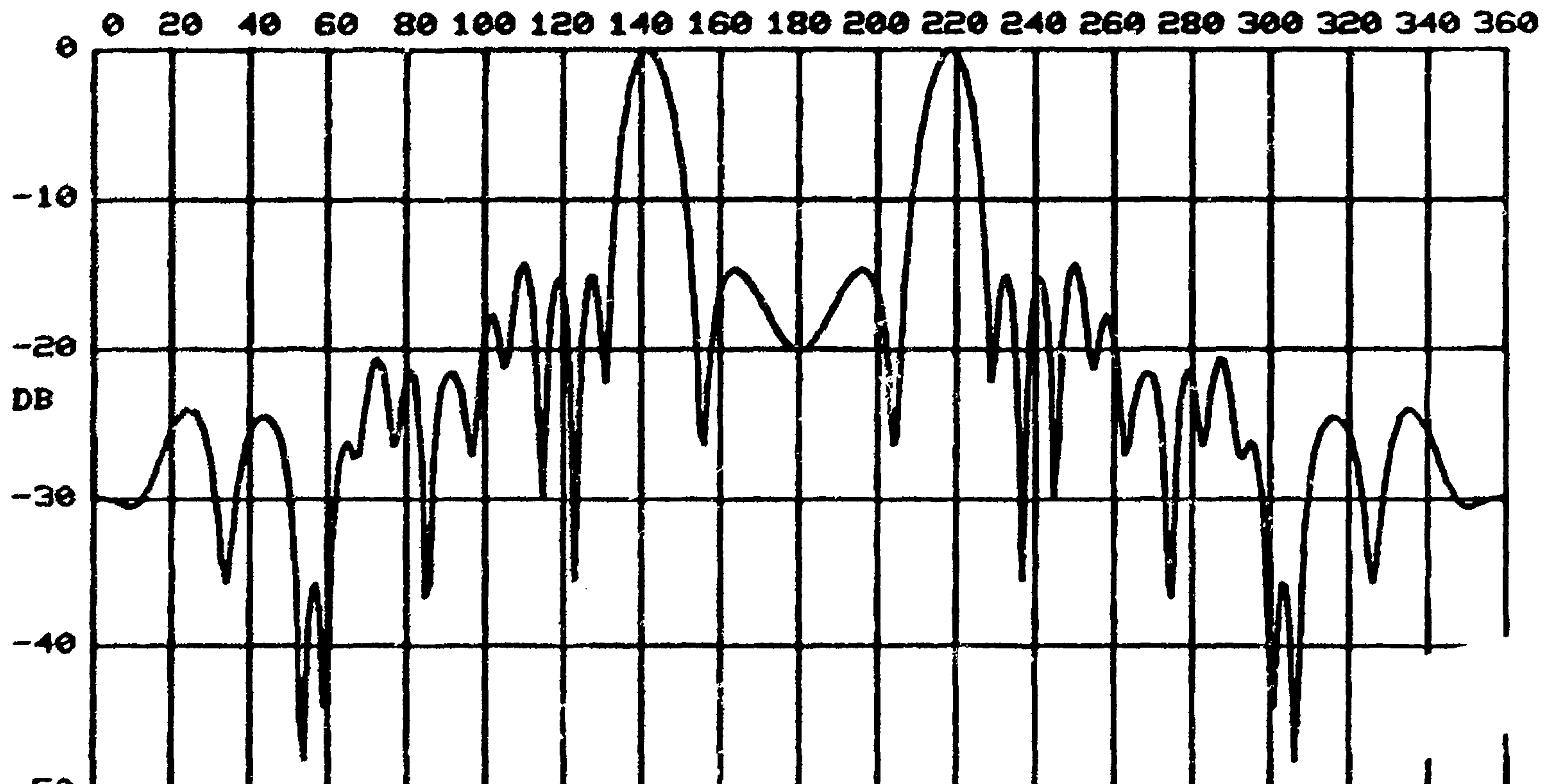
CONFIDENTIAL

Figure B-88 Theoretical Horizontal Plane Pattern for 51 Element Array @ 140 Hz for Data Point 9, 51.5° Off Broadside Steering. Beamwidth 6.50°, Azimuth Gain 13.6 dB.

CONFIDENTIAL

```
S1057   SANDERS BEAM PATTERN PROGRAM (T.HOGAN)    6-Jan-73    GNTLBP 3.1
  ARRAY TUNED TO 300 HZ.
  FT. UNIFORM SPACING

UNIFORM WEIGHTING.
1200 HZ.   SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ.,   32 ELEMENTS, -0.19 DB MAX., AC:S1361,SU:S1361,WT:
 90.0 DEG. VERT. RESP., 141.5 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
10.43 DEG. 3 DB BEAM,  11.74 DB AZ. GAIN, MAX. AT 141.0 DEG. HORIZ.
```



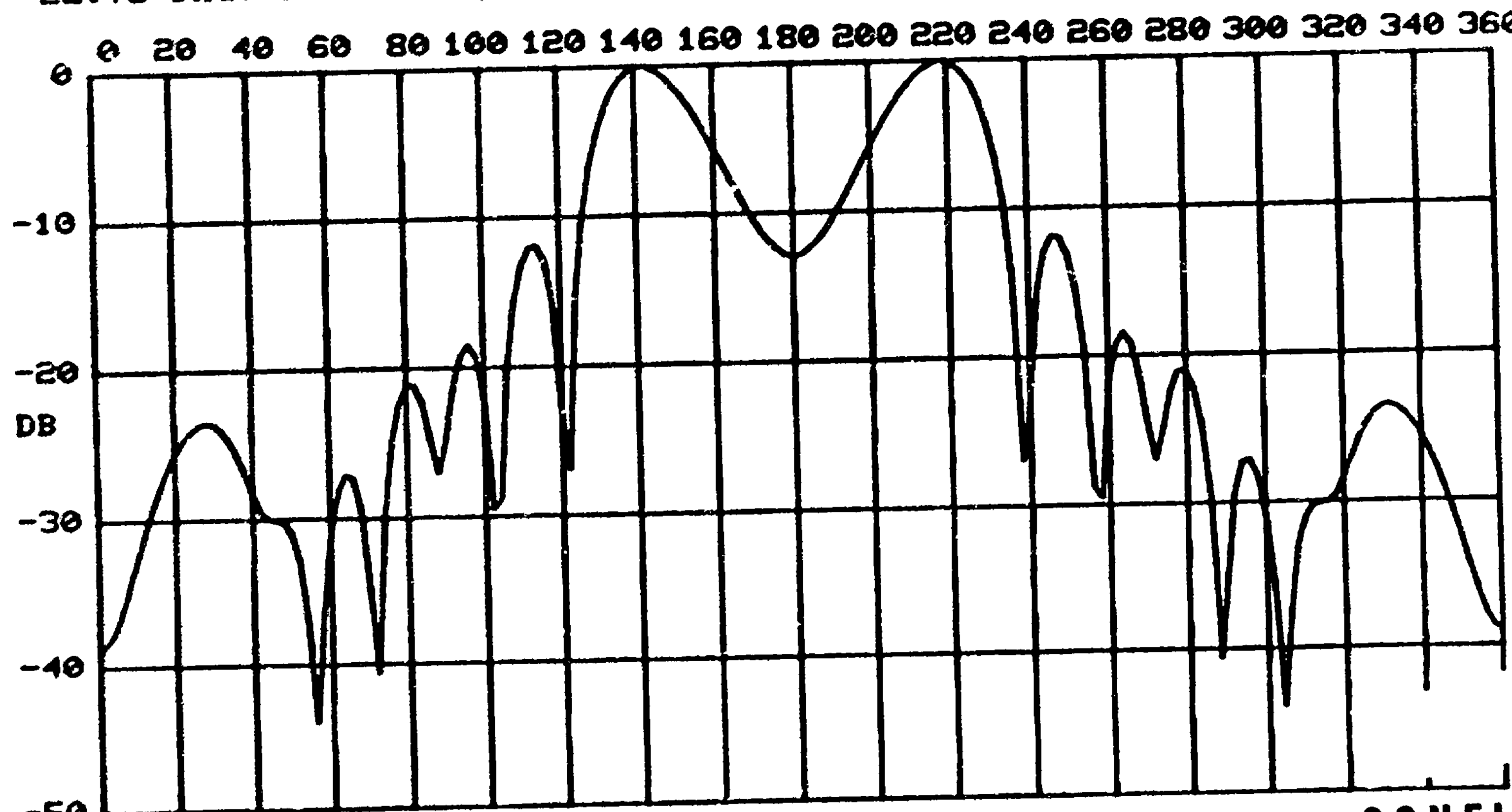
CONFIDENTIAL

Figure B-89 Theoretical Horizontal Plane Pattern for 32 Element Array @ 140 Hz for Data Point 9, 57.5° Off Broadside Steering. Beamwidth 10.43°, Azimuth Gain 11.7 dB.

CONFIDENTIAL

51354 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 GNTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

UNIFORM WEIGHTING.
HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 16 ELEMENTS, -0.16 DB MAX., AC:S1361,SU:S1361,WT:
90.0 DEG. VERT. RESP., 141.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
22.76 DEG. 3 DB BEAM, 8.48 DB AZ. GAIN, MAX. AT 142.0 DEG. HORIZ.

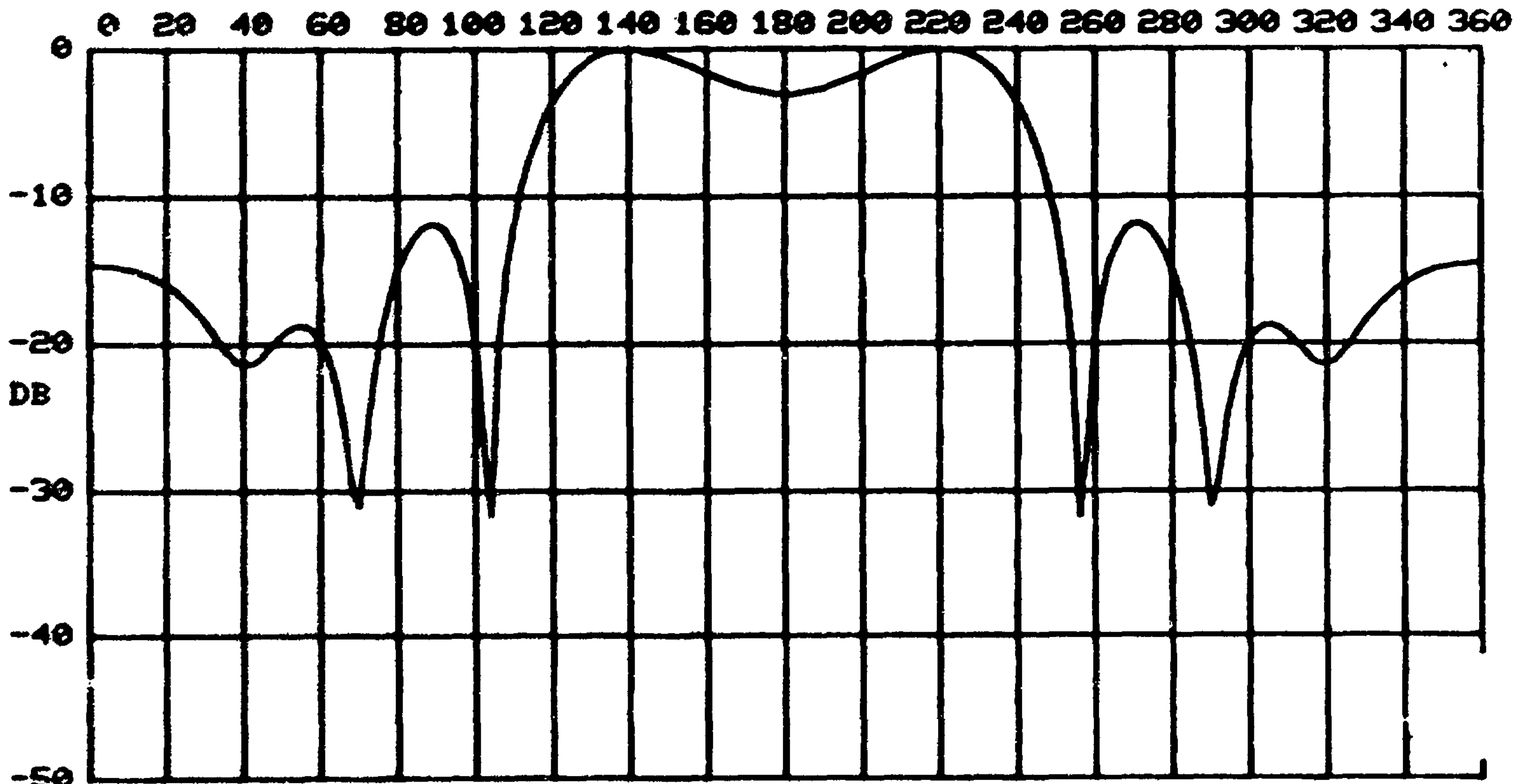


CONFIDENTIAL

Figure B-90 Theoretical Horizontal Plane Pattern for 16 Element Array @ 140 Hz for Data Point 8, 51.5° Off Broadside Steering. Beamwidth 22.76°, Azimuth Gain 8.4 dB.

CONFIDENTIAL

```
SANDERS BEAM PATTERN PROGRAM (T.HOGAN)   6-Jan-78   ONTLBP 3.1
... TUNED TO 300 HZ.
... FT. UNIFORM SPACING
...
UNIFORM WEIGHTING.
1... HZ.  SAMPLING FREQUENCY DISTORTS PATTERN.
140.. HZ.,   8 ELEMENTS, -0.14 DB MAX., AC:S1361,SU:S1361,WT:
 90.0 DEG. VERT. RESP., 141.5 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
55.78 DEG. 3 DB BEAM,   5.62 DB AZ. GAIN, MAX. AT 220.0 DEG. HORIZ.
```



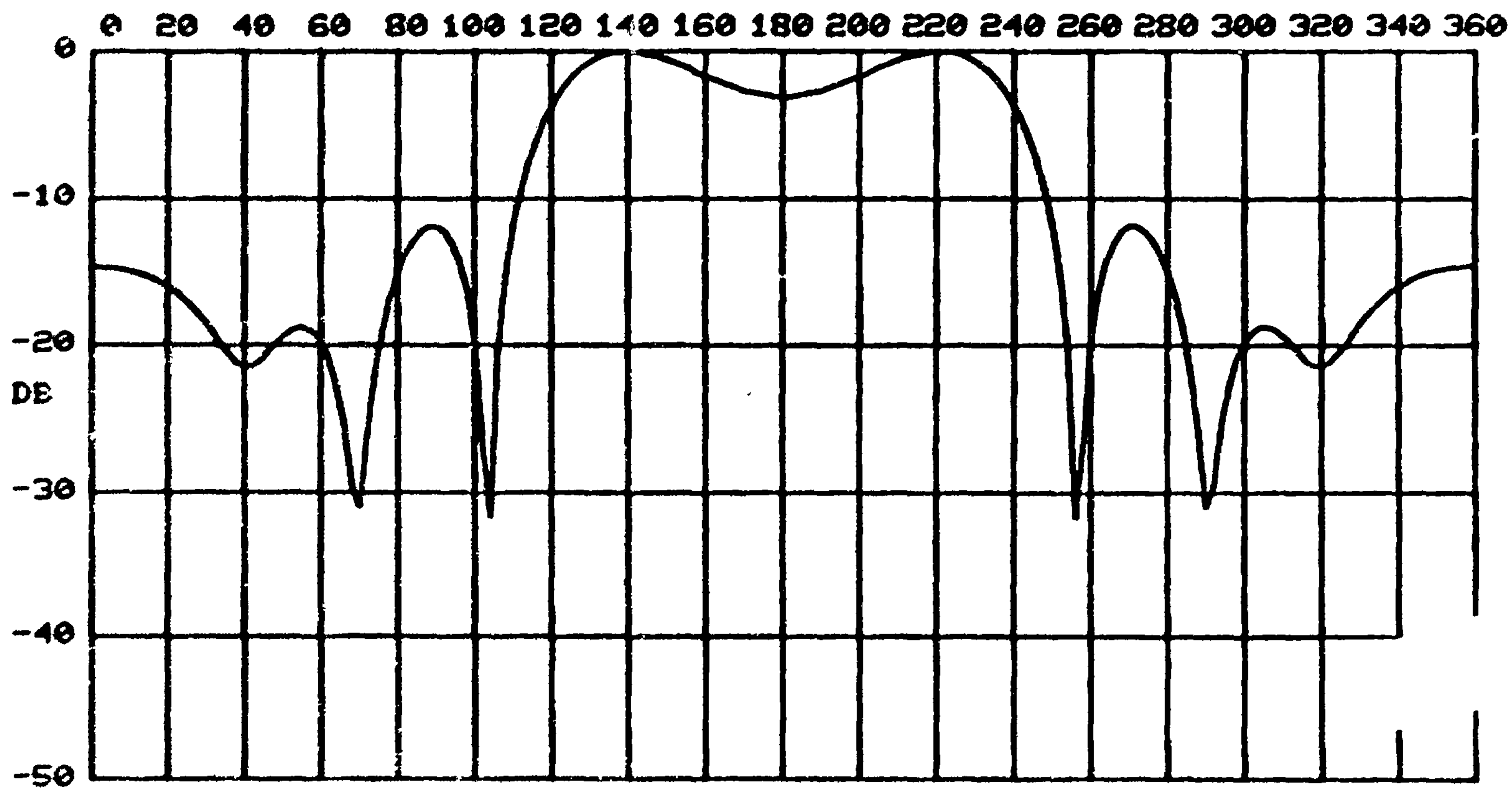
CONFIDENTIAL

Figure B-91 Theoretical Horizontal Plane Pattern for 8 Element Array @ 140 Hz for Data Point 9, 51.5° Off Broadside Steering. Beamwidth 55.78°, Azimuth Gain 5.6 dB.

CONFIDENTIAL

S1051 S-IDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-78 ONTLBP 3.1
TUNED TO 300 HZ.
FT. UNIFORM SPACING

UNIFORM WEIGHTING.
HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 8 ELEMENTS, -0.14 DB MAX., AC:S1361,SU:S1361,WT:
90.0 DEG. VERT. RESP., 141.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
55.78 DEG. 3 DB BEAM, 5.62 DB AZ. GAIN, MAX. AT 220.0 DEG. HORIZ.



CONFIDENTIAL

Figure B-92 Theoretical Horizontal Plane Pattern for 8 Element Array @ 140 Hz for Data Point 9, 515° Off Broadside Steering. Beamwidth 55.78°, Azimuth Gain 5.6 dB.

CONFIDENTIAL

S105C SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 ONTLEF 3.1

TUNED TO 300 HZ.

FT. UNIFORM SPACING

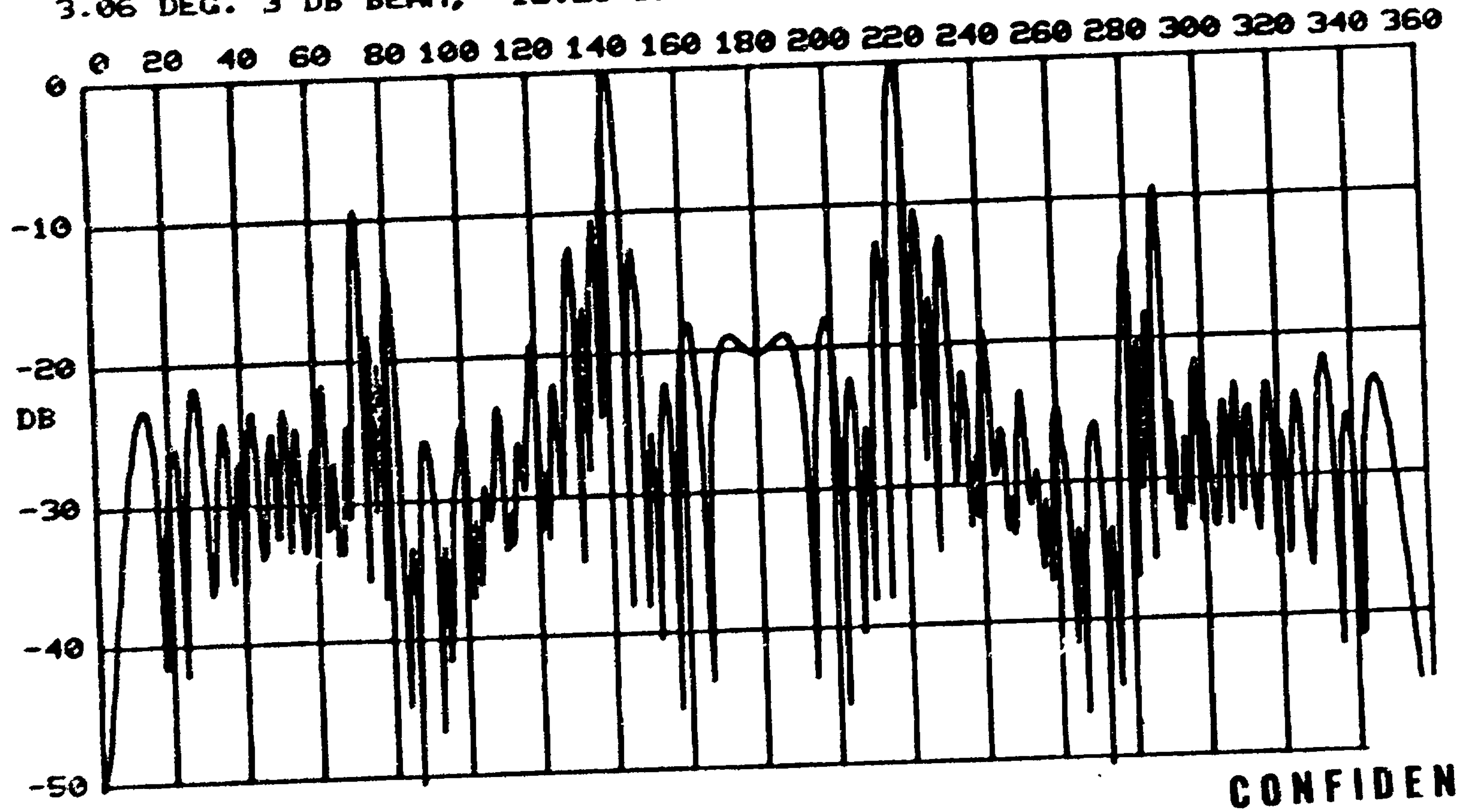
UNIFORM WEIGHTING.

1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.

295.0 HZ., 51 ELEMENTS, -0.81 DB MAX., AC:S1361,SU:S1361,WT:

90.0 DEG. VERT. RESP., 141.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER

3.06 DEG. 3 DB BEAM, 16.20 DB AZ. GAIN, MAX. AT 141.5 DEG. HORIZ.



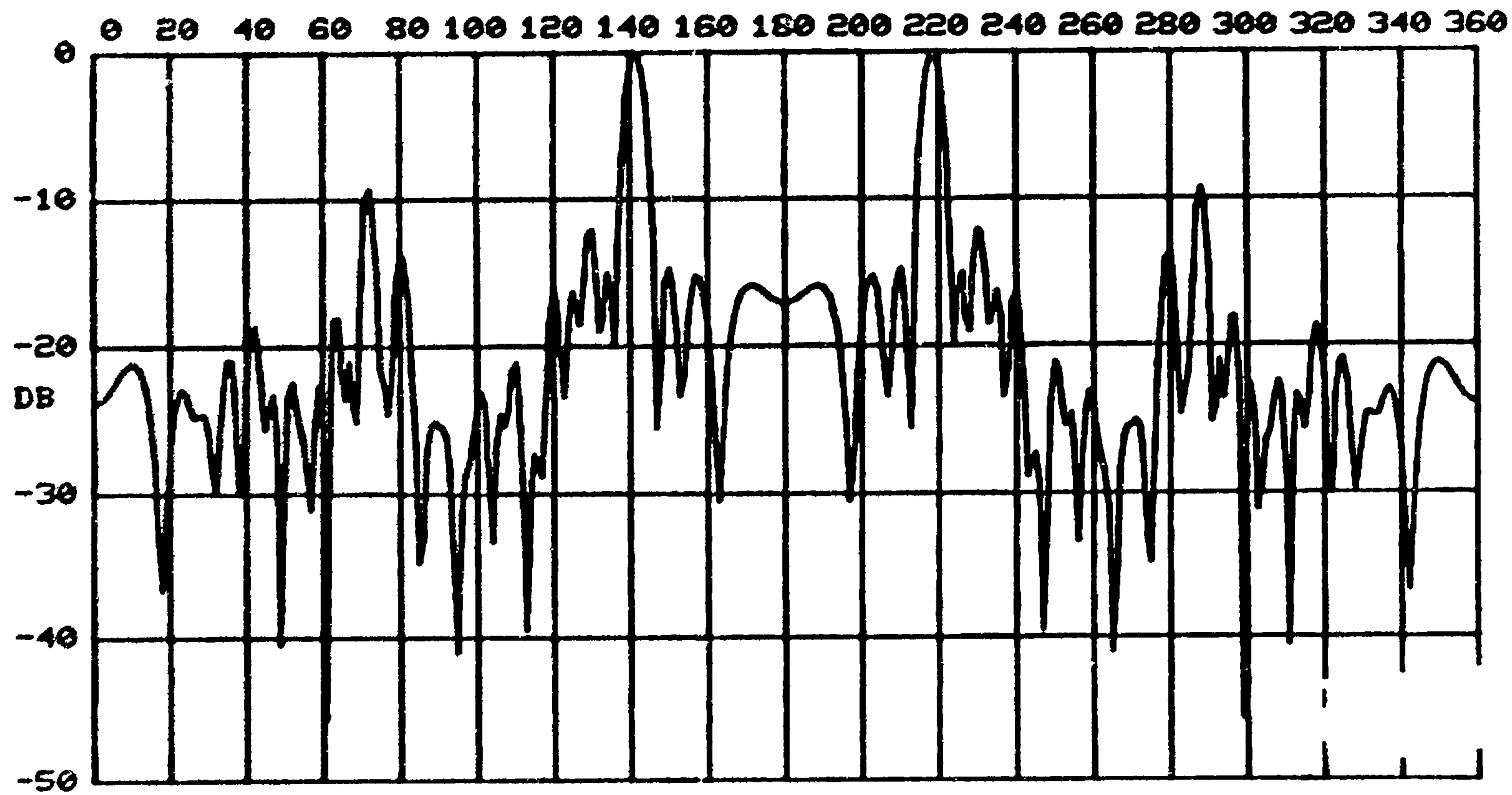
CONFIDENTIAL

Figure B-93 Theoretical Horizontal Plane Pattern for 51 Element Array @ 295 Hz for Data Point 9, 51.5° Off Broadside Steering. Beamwidth 3.06°, Azimuth Gain 16.2 dB.

CONFIDENTIAL

51059 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 ONTLBF 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

UNIFORM WEIGHTING.
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ., 32 ELEMENTS, -0.86 DB MAX., AC:S1361,SU:S1361,WT:
90.0 DEG. VERT. RESP., 141.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
4.93 DEG. 3 DB BEAM, 14.07 DB AZ. GAIN, MAX. AT 141.0 DEG. HORIZ.



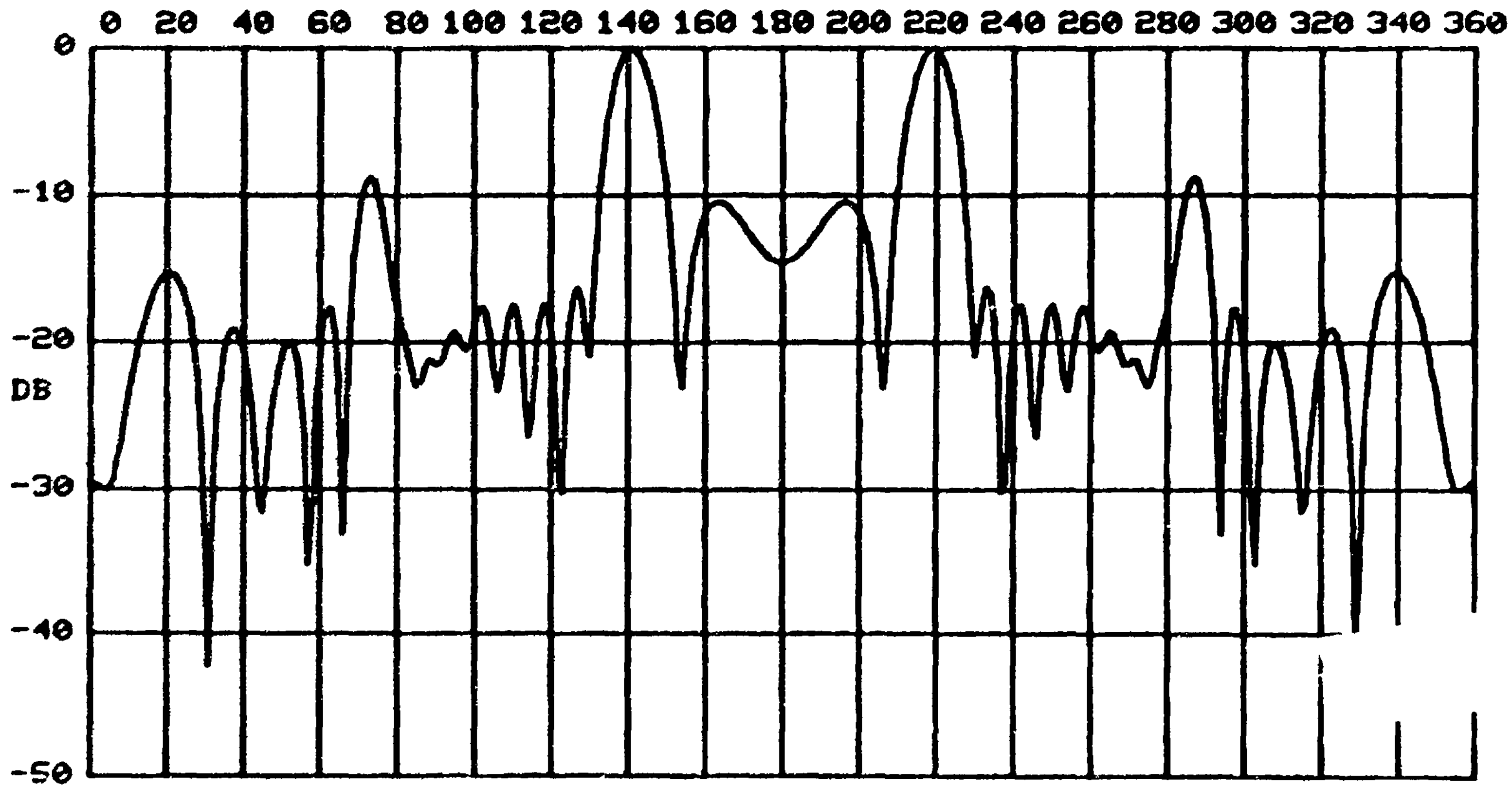
CONFIDENTIAL

Figure B-94 Theoretical Horizontal Plane Pattern for 32 Element Array @ 295 Hz for Data Point 9, 57.5° Off Broadside Steering. Beamwidth 4.93°, Azimuth Gain 14.0 dB.

CONFIDENTIAL

S1056 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 ONTLEP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

UNIFORM WEIGHTING.
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ., 16 ELEMENTS, -0.75 DB MAX., AC:S1361,SU:S1361,WT:
90.0 DEG. VERT. RESP., 141.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
10.30 DEG. 3 DB BEAM, 11.05 DB AZ. GAIN, MAX. AT 141.0 DEG. HORIZ.

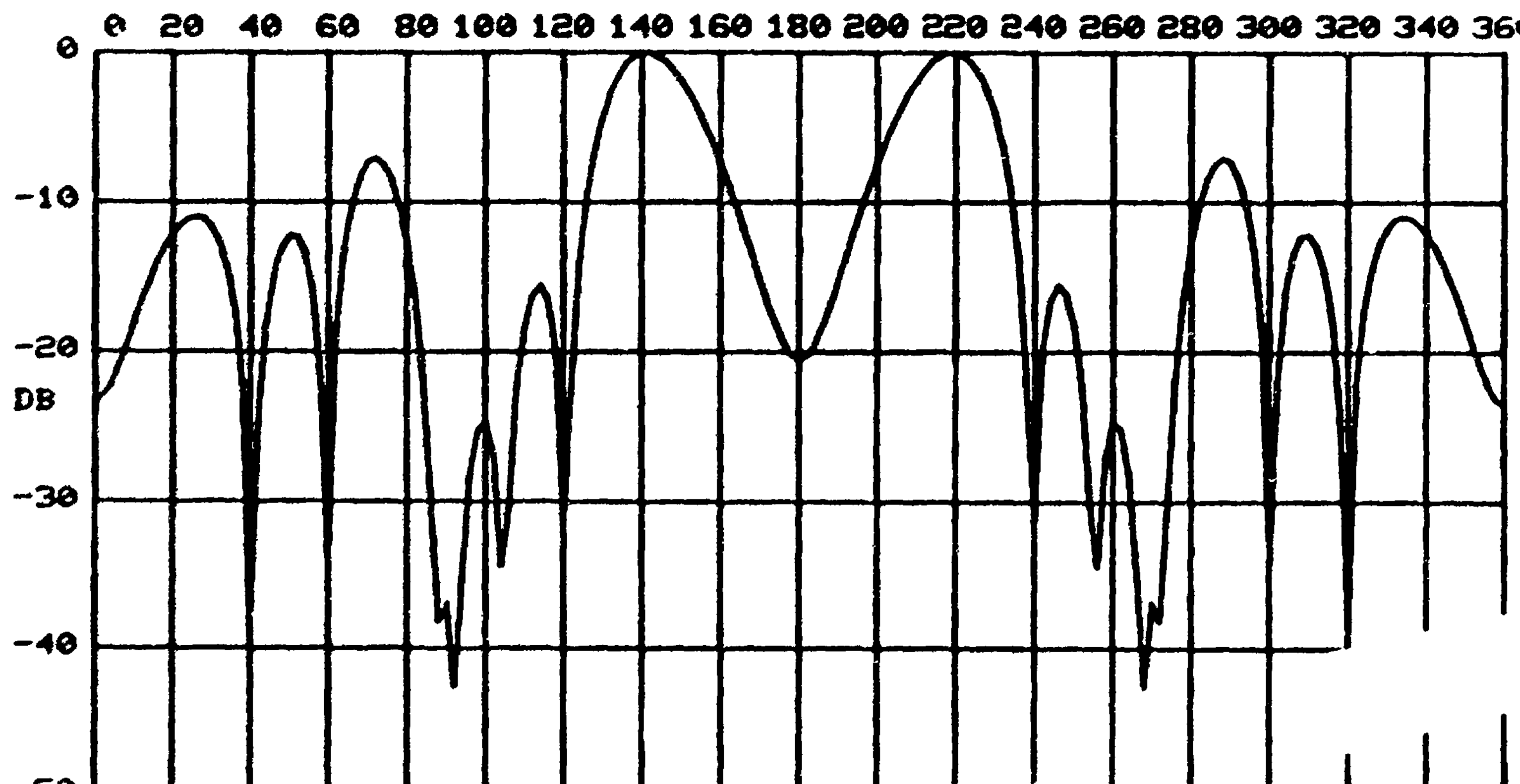


CONFIDENTIAL

Figure B-95 Theoretical Horizontal Plane Pattern for 16 Element Array @ 295 Hz for Data Point 9, 57.5° Off Broadside Steering. Beamwidth 10.30°, Azimuth Gain 11.0 dB.

CONFIDENTIAL

SANDERS BEAM PATTERN PROGRAM (T.HOGAN)   6-Jan-78   UNTLBP 3.1
ARRAY TUNED TO 300 HZ.
UNIFORM SPACING
UNIFORM WEIGHTING.
HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ., 8 ELEMENTS, -0.63 DB MAX., AC:S1361,SU:S1361,WT:
90.0 DEG. VERT. RESP., 141.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
21.25 DEG. 3 DB BEAM, 8.20 DB AZ. GAIN, MAX. AT 220.0 DEG. HORIZ.

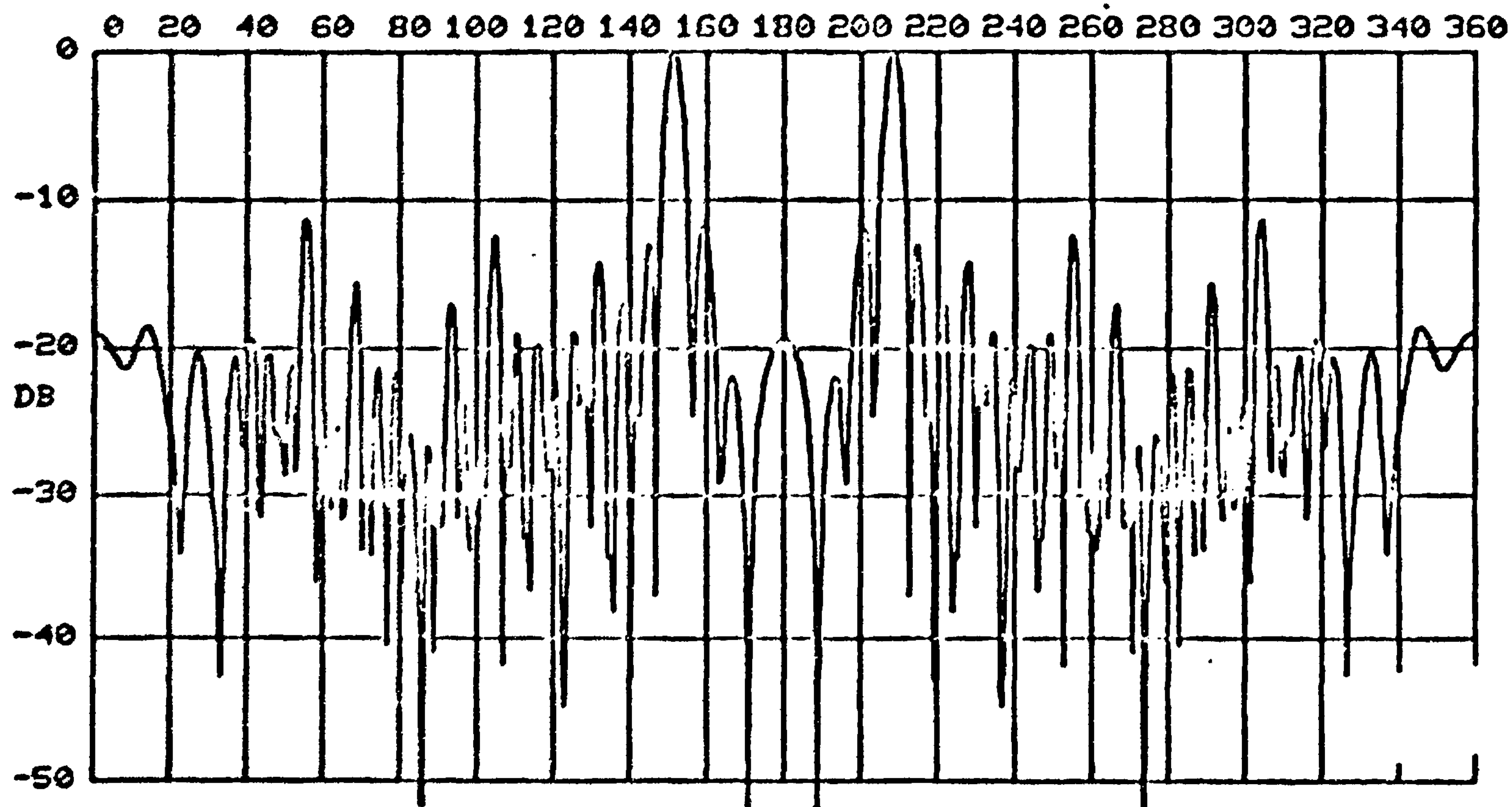


CONFIDENTIAL

Figure B-96 Theoretical Horizontal Plane Pattern for 8 Element Array @ 295 Hz for Data Point 9, 57.5° Off Broadside Steering. Beamwidth 21.25°, Azimuth Gain 8.2 dB.

CONFIDENTIAL

S106B SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 ONTLBF 3.1
[illegible] ARRAY TUNED TO 300 HZ.
[illegible] FT. UNIFORM SPACING
[illegible]
DP 10
UNIFORM WEIGHTING.
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 49 ELEMENTS, -0.87 DB MAX., AC:S1362,SU:S1362,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
4.12 DEG. 3 DB BEAM, 15.00 DB AZ. GAIN, MAX. AT 208.5 DEG. HORIZ.



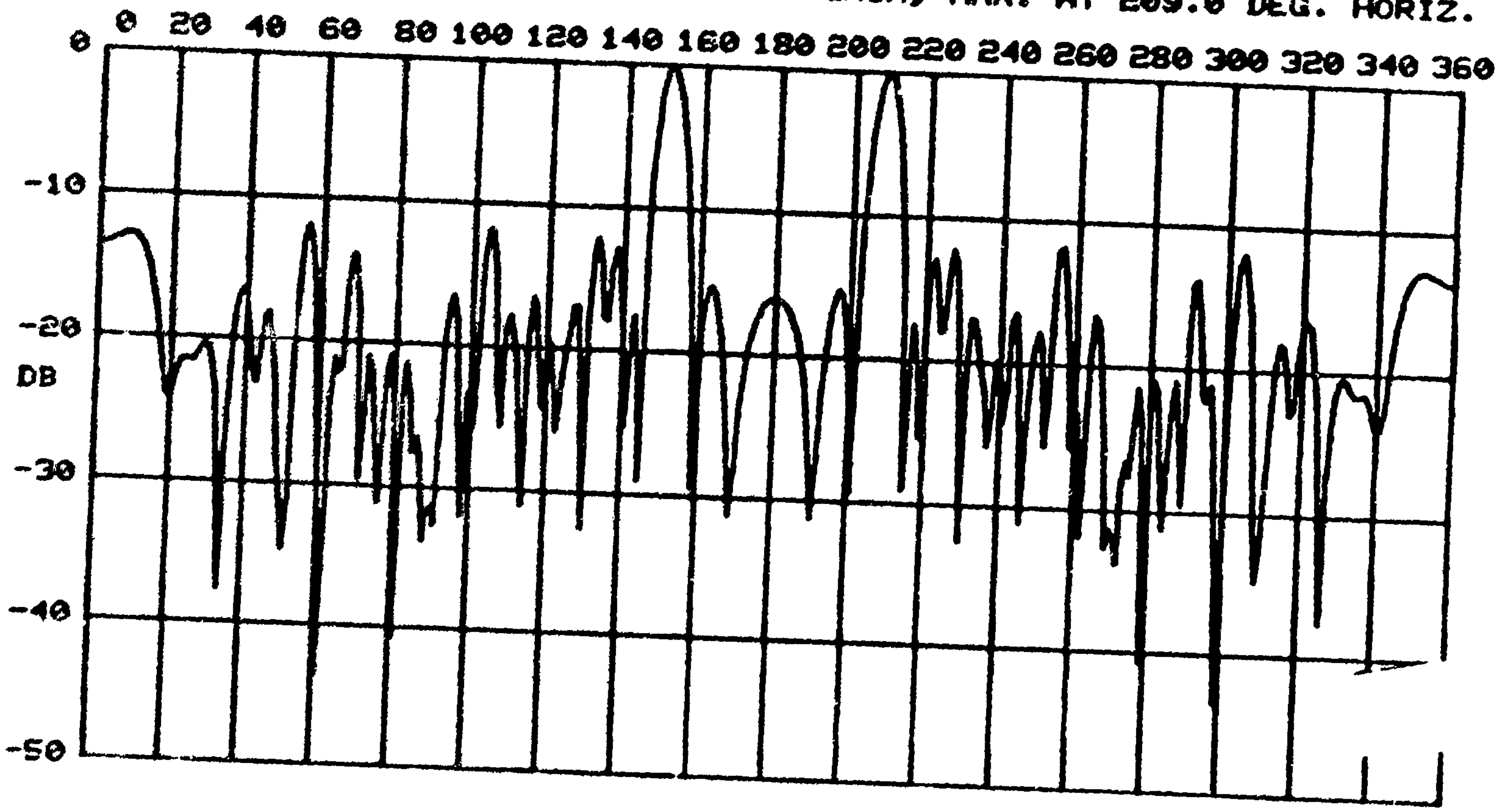
CONFIDENTIAL

Figure B-97 Theoretical Horizontal Plane Pattern for 49 Element Array @ 290 Hz for Data Point 10, 61.5° Off Broadside Steering. Beamwidth 4.12°, Azimuth Gain 15.0 dB.

CONFIDENTIAL

S1063 S-NDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 ONTLBP 3.1
... TUNED TO 300 HZ.
... UNIFORM SPACING

UNIFORM WEIGHTING.
1220 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 32 ELEMENTS, -0.89 DB MAX., AC:S1362,SU:S1362,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
6.08 DEG. 3 DB BEAM, 13.04 DB AZ. GAIN, MAX. AT 209.0 DEG. HORIZ.



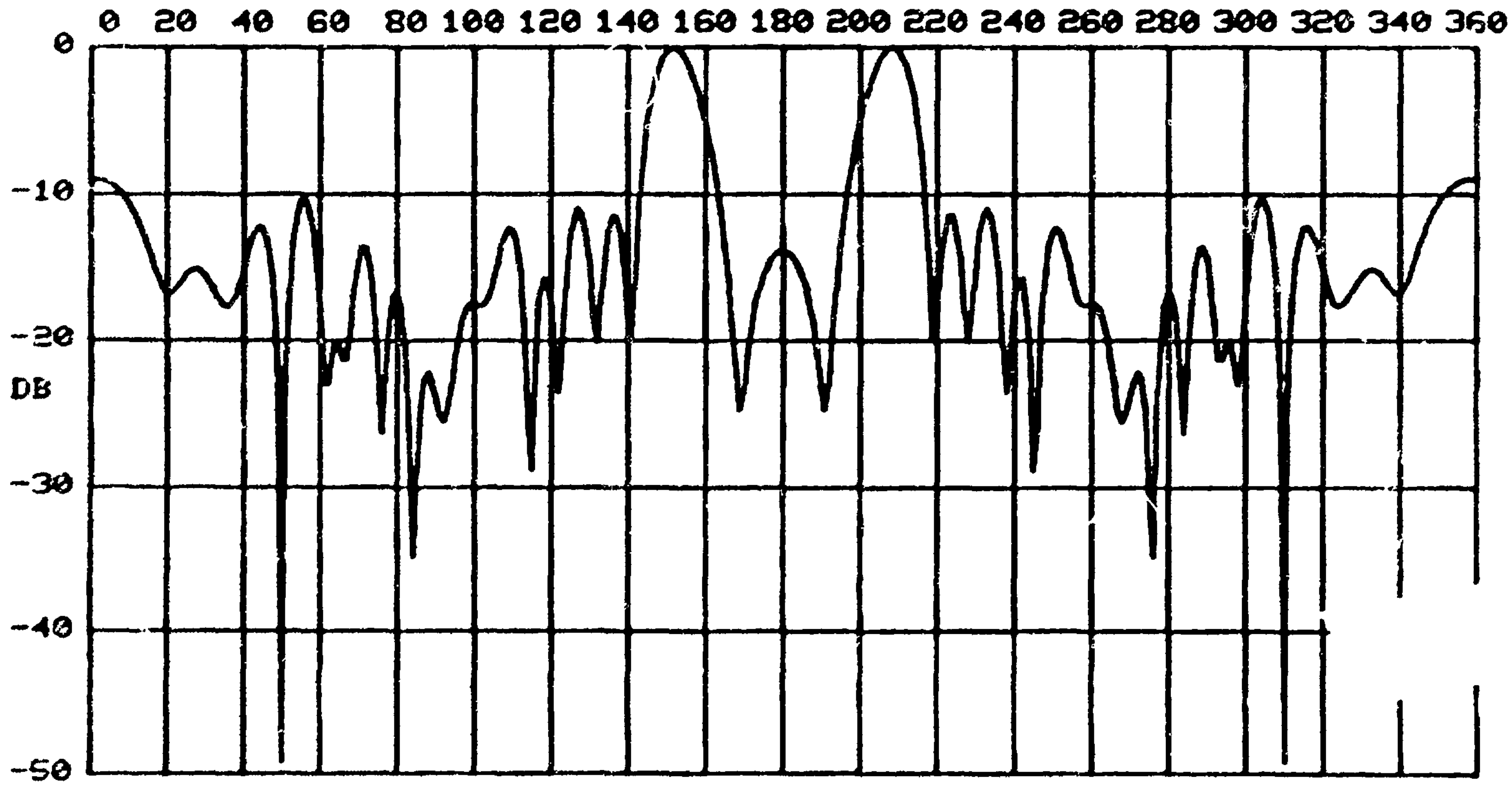
CONFIDENTIAL

Figure B-98 Theoretical Horizontal Plane Pattern for 32 Element Array @ 290 Hz for Data Point 10, 61.5° Off Broadside Steering. Beamwidth 6.08°, Azimuth Gain 13.0 dB.

CONFIDENTIAL

S1065 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 ONTLBF 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

UNIFORM WEIGHTING.
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 16 ELEMENTS, -0.79 DB MAX., AC:S1362,SU:S1362,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
11.76 DEG. 3 DB BEAM, 10.15 DB AZ. GAIN, MAX. AT 152.0 DEG. HORIZ.



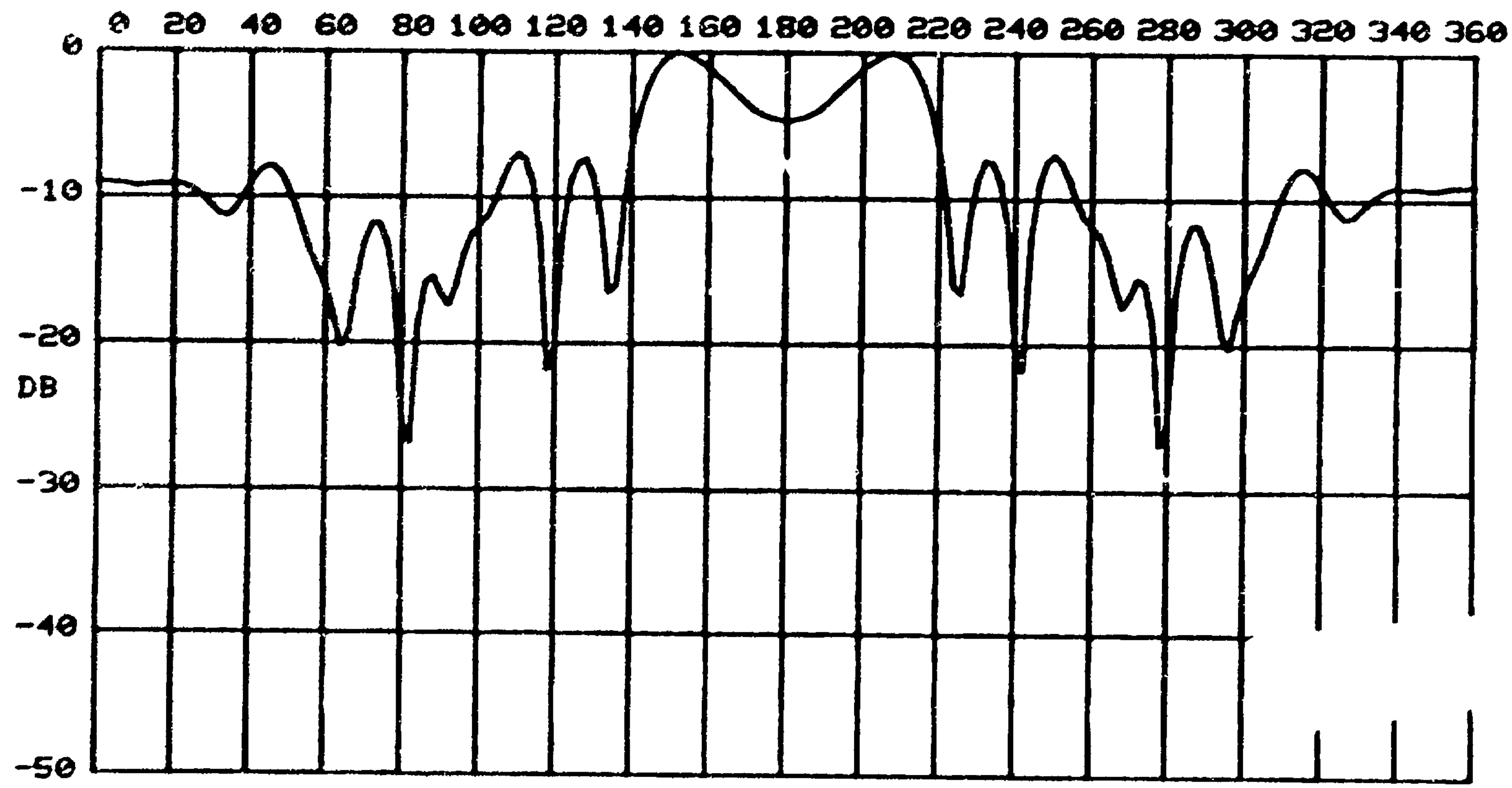
CONFIDENTIAL

Figure 5-99 Theoretical Horizontal Plane Pattern for 16 Element Array @ 290 Hz for Data Point 10, 6.5° Off Broadside Steering. Beamwidth 11.76°, Azimuth Gain 10.1 dB.

CONFIDENTIAL

S1062 S-NDERS FEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 ONTLBP 3.1
: [illegible] TUNED TO 300 HZ.
[illegible] FT. UNIFORM SPACING
: [illegible]

UNIFORM WEIGHTING.
1[illegible] HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 8 ELEMENTS, -0.86 DB MAX., AC:S1362,SU:S1362,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
24.63 DEG. 3 DB BEAM, 6.81 DB AZ. GAIN, MAX. AT 152.0 DEG. HORIZ.



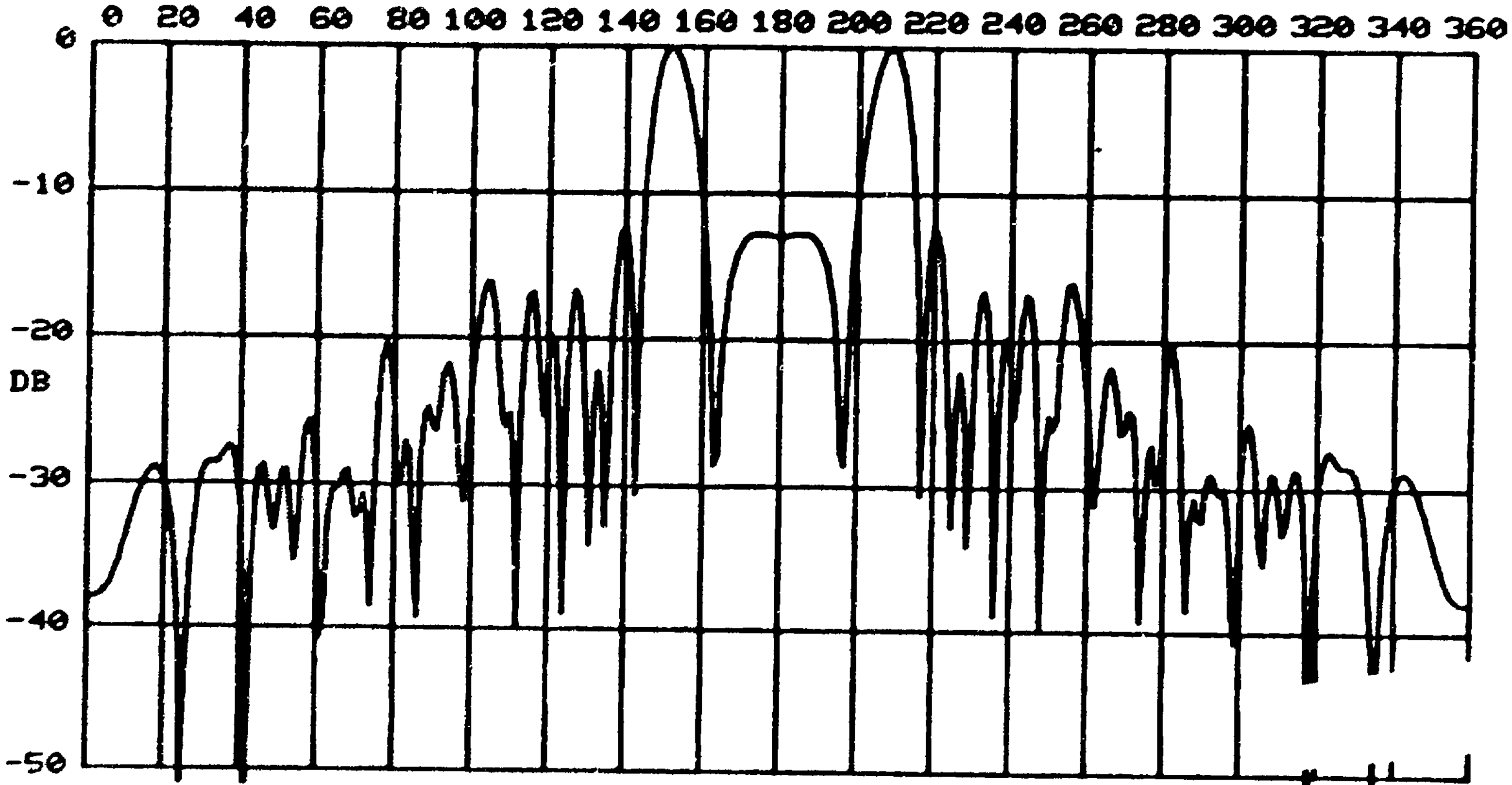
CONFIDENTIAL

Figure B-100 Theoretical Horizontal Plane Pattern for 8 Element Array @ 290 Hz for Data Point 10, 61.5° Off Broadside Steering. Beamwidth 24.68°, Azimuth Gain 6.8 dB.

CONFIDENTIAL

S1036 S-NDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 ONTLBF 3.1
TUNED TO 300 HZ.
FT. UNIFORM SPACING

UNIFORM WEIGHTING.
HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 49 ELEMENTS, -0.22 DB MAX.. AC:S1362,SU:S1362,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
2.63 DEG. 3 DB BEAM, 12.44 DB AZ. GAIN, MAX. AT 209.0 DEG. HORIZ.

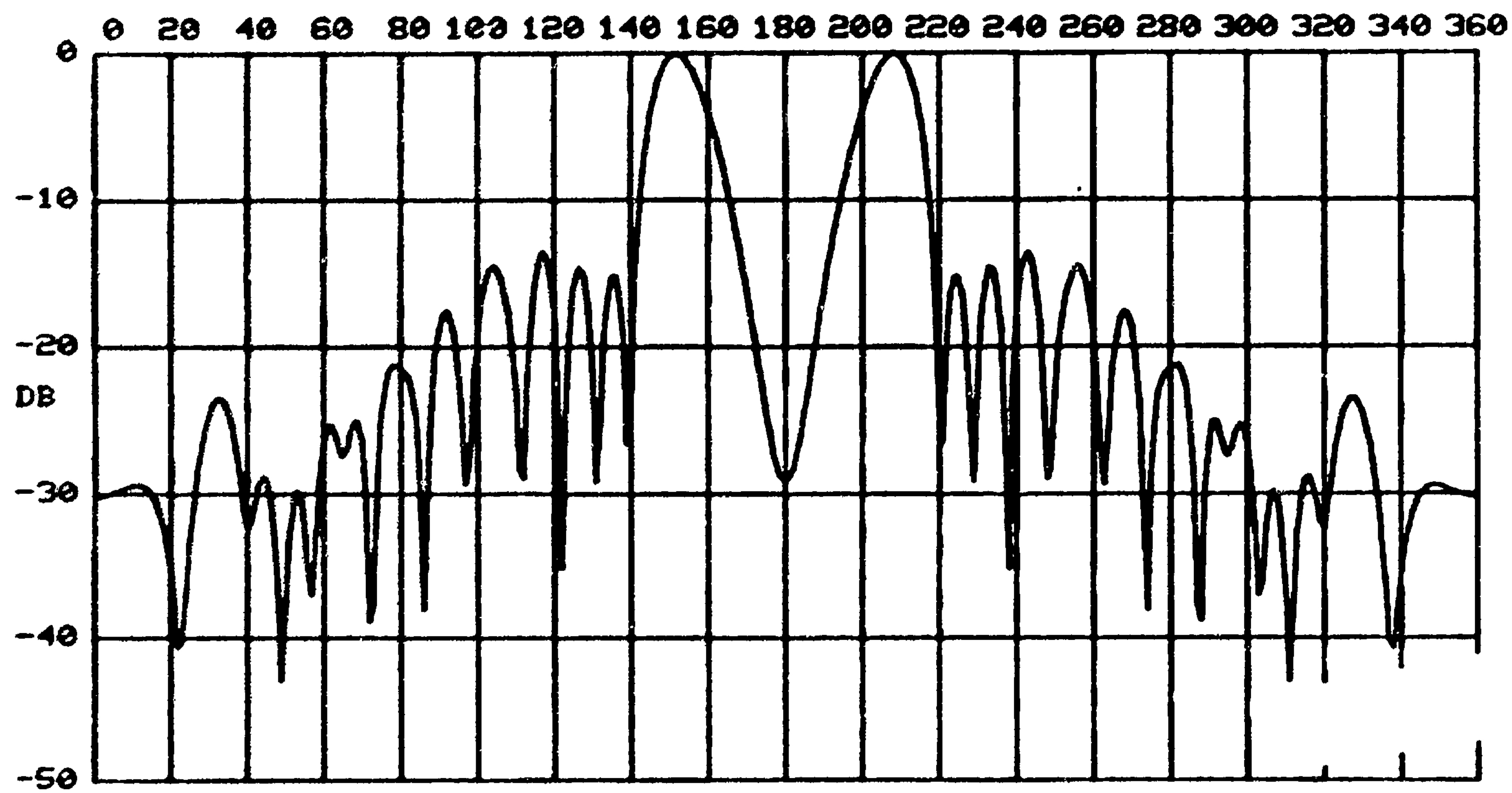


CONFIDENTIAL

Figure B-101 Theoretical Horizontal Plane Pattern for 49 Element Array @ 140 Hz for Data Point 10, 61.5° Off Broadside Steering. Beamwidth 8.63°, Azimuth Gain 12.4 dB.

CONFIDENTIAL

S1057 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 CNTLBP 3.1
[illegible] ARRAY TUNED TO 300 HZ.
[illegible] FT. UNIFORM SPACING
[illegible]
UNIFORM WEIGHTING.
1[illegible] HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 32 ELEMENTS, -0.20 DB MAX., AC:S1362,SU:S1362,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
13.05 DEG. 3 DB BEAM, 10.84 DB AZ. GAIN, MAX. AT 208.0 DEG. HORIZ.



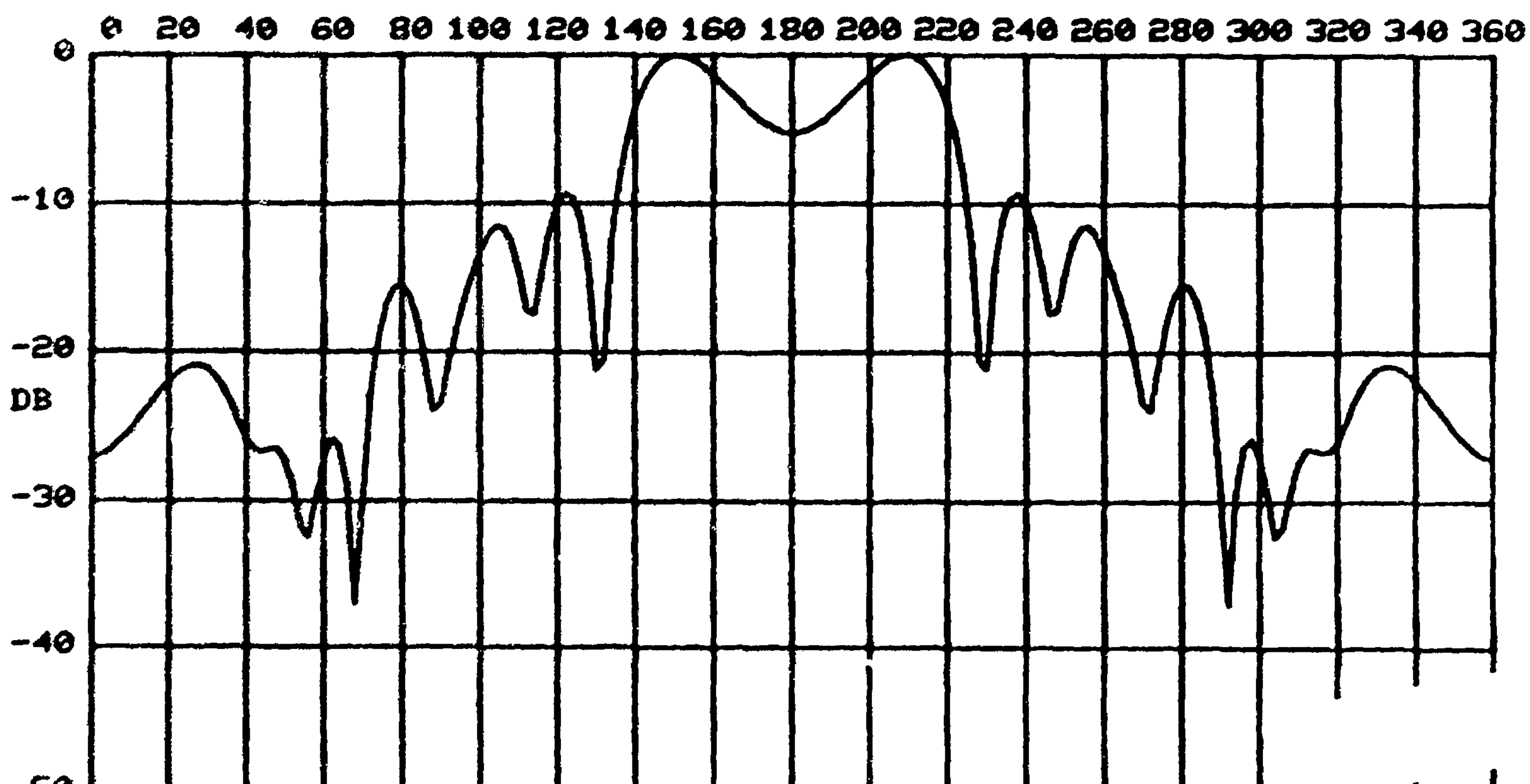
CONFIDENTIAL

Figure B-102 Theoretical Horizontal Plane Pattern for 32 Element Array @ 140 Hz for Data Point 10, 65° Off Broadside Steering. Beamwidth 13.05°, Azimuth Gain 10.8 dB.

CONFIDENTIAL

S1064 S-NDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 QNTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

UNIFORM WEIGHTING.
HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 16 ELEMENTS, -0.19 DB MAX., AC:S1362,SU:S1362,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
25.91 DEG. 3 DB BEAM, 7.77 DB AZ. GAIN, MAX. AT 150.0 DEG. HORIZ.

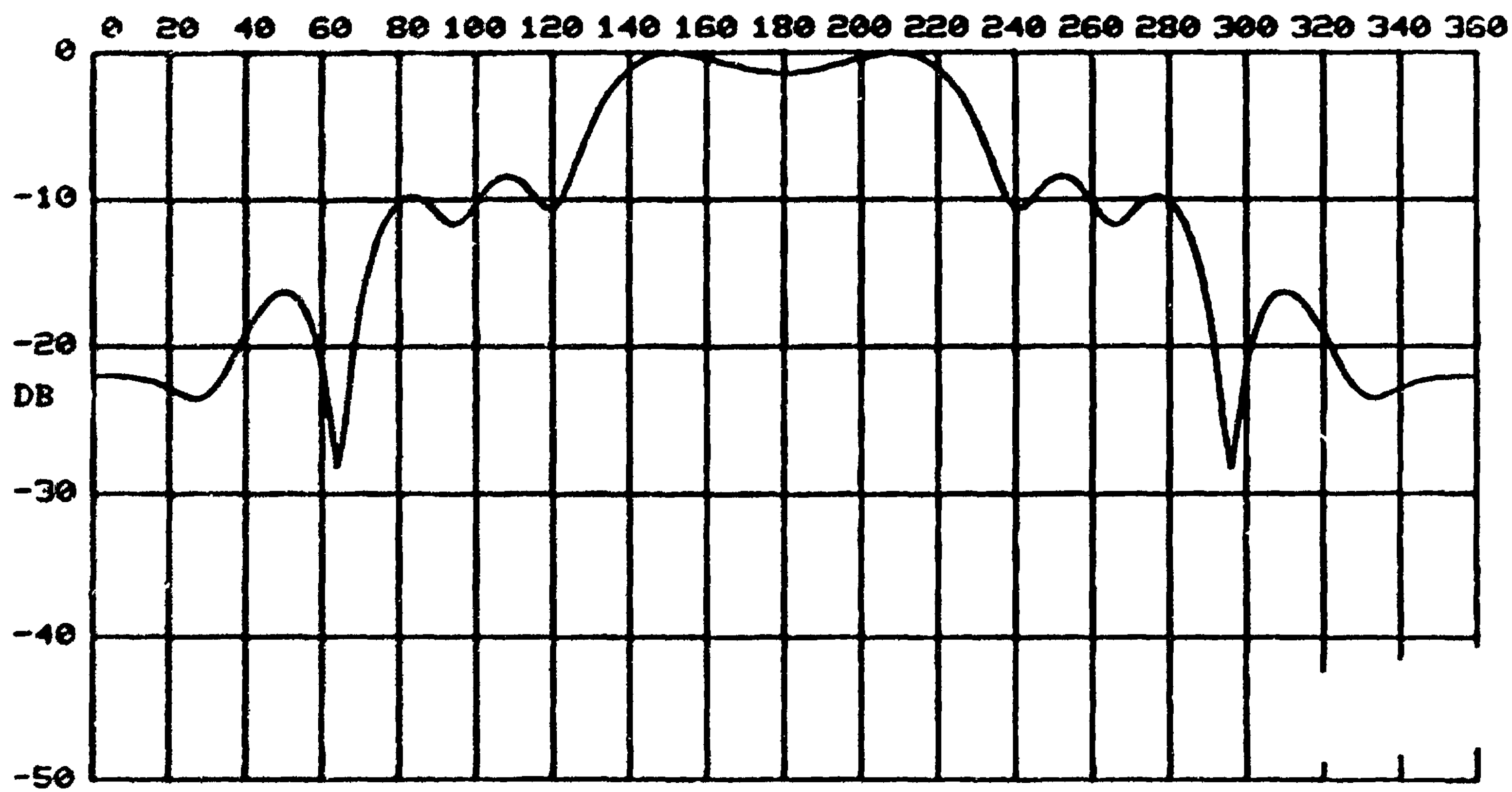


CONFIDENTIAL

Figure B-103 Theoretical Horizontal Plane Pattern for 16 Element Array @ 140 hz for Data Point 10, 61.5° Off Broadside Steering. Beamwidth 25.91°, Azimuth Gain 7.7 dB.

CONFIDENTIAL

S1061 SAUNDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 ONTLBP 3.1
... ARRAY TUNED TO 300 HZ.
... FT. UNIFORM SPACING
...
... 10
UNIFORM WEIGHTING.
1... HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ., 8 ELEMENTS, -0.20 DB MAX., AC:S1362,SU:S1362,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
92.49 DEG. 3 DB BEAM, 5.76 DB AZ. GAIN, MAX. AT 208.0 DEG. HORIZ.



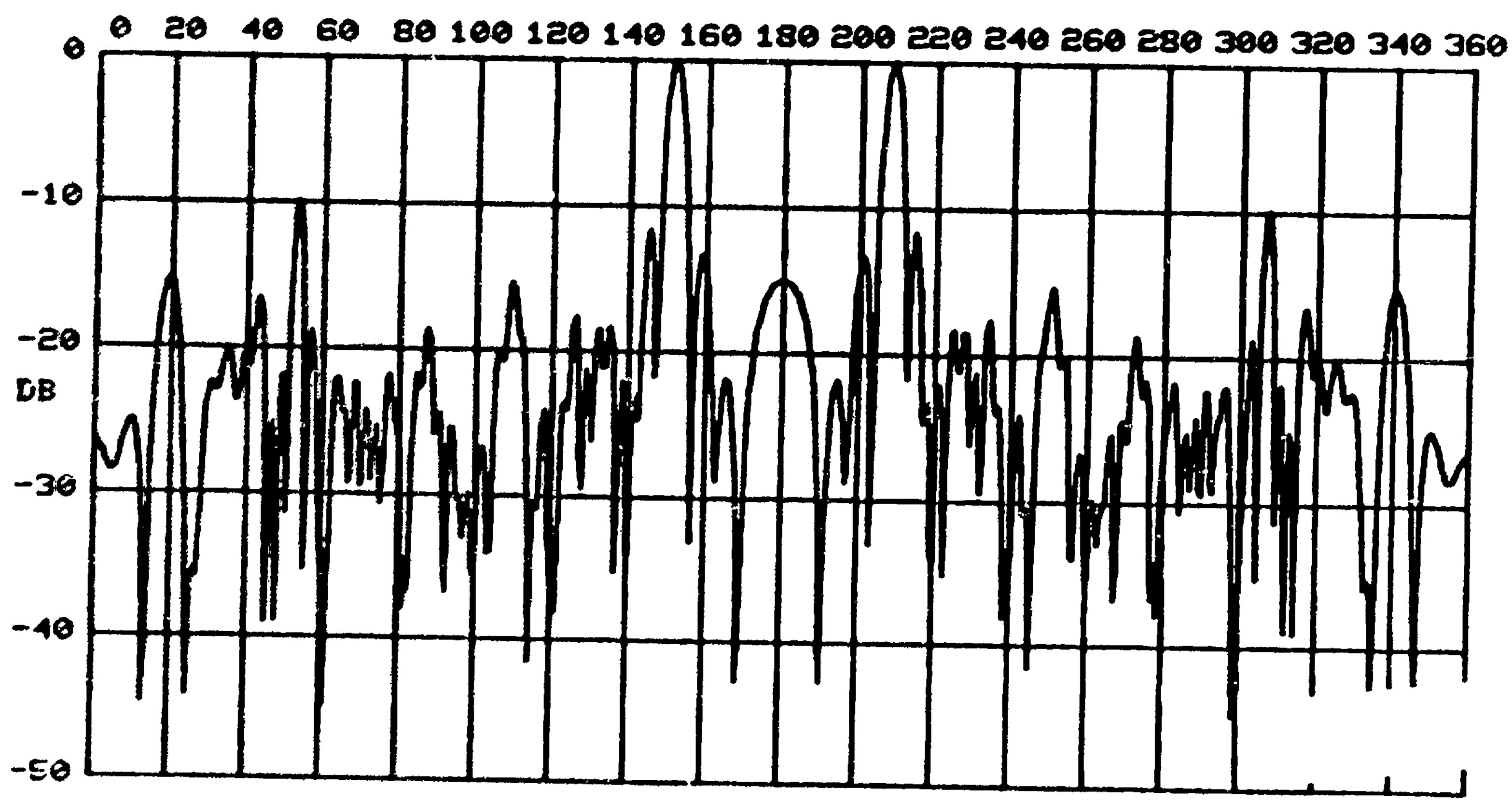
CONFIDENTIAL

Figure B-104 Theoretical Horizontal Plane Pattern for 8 Element Array @ 140 Hz for Data Point 10, 61.5° Off Broadside Steering. Beamwidth 92.49°, Azimuth Gain 5.7 dB.

CONFIDENTIAL

S103C SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 ONTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

UNIFORM WEIGHTING.
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ., 49 ELEMENTS, -0.85 DB MAX., AC:S1362,SU:S1362,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
4.04 DEG. 3 DB BEAM, 15.04 DB AZ. GAIN, MAX. AT 208.5 DEG. HORIZ.



CONFIDENTIAL

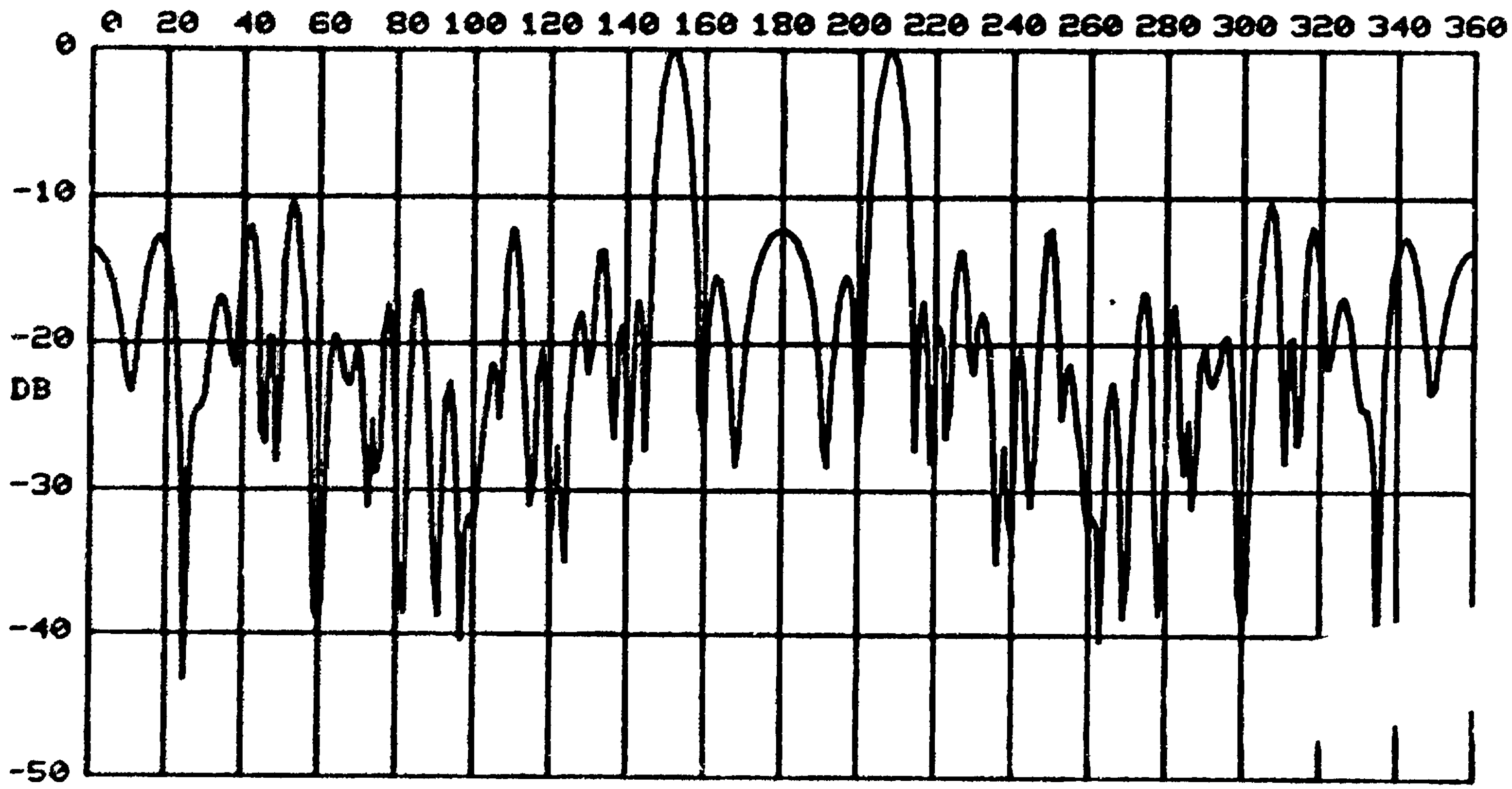
Figure B-105 Theoretical Horizontal Plane Pattern for 49 Element Array @ 295 Hz for Data Point 10, 61.5° Off Broadside Steering. Beamwidth 4.04°, Azimuth Gain 15.0 dB.

, Azimuth Gain 15.0 dB.

CONFIDENTIAL

S1059 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 CNTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

UNIFORM WEIGHTING.
HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ., 32 ELEMENTS, -0.92 DB MAX., AC:S1362,SU:S1362,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
6.08 DEG. 3 DB BEAM, 13.02 DB AZ. GAIN, MAX. AT 208.0 DEG. HORIZ.



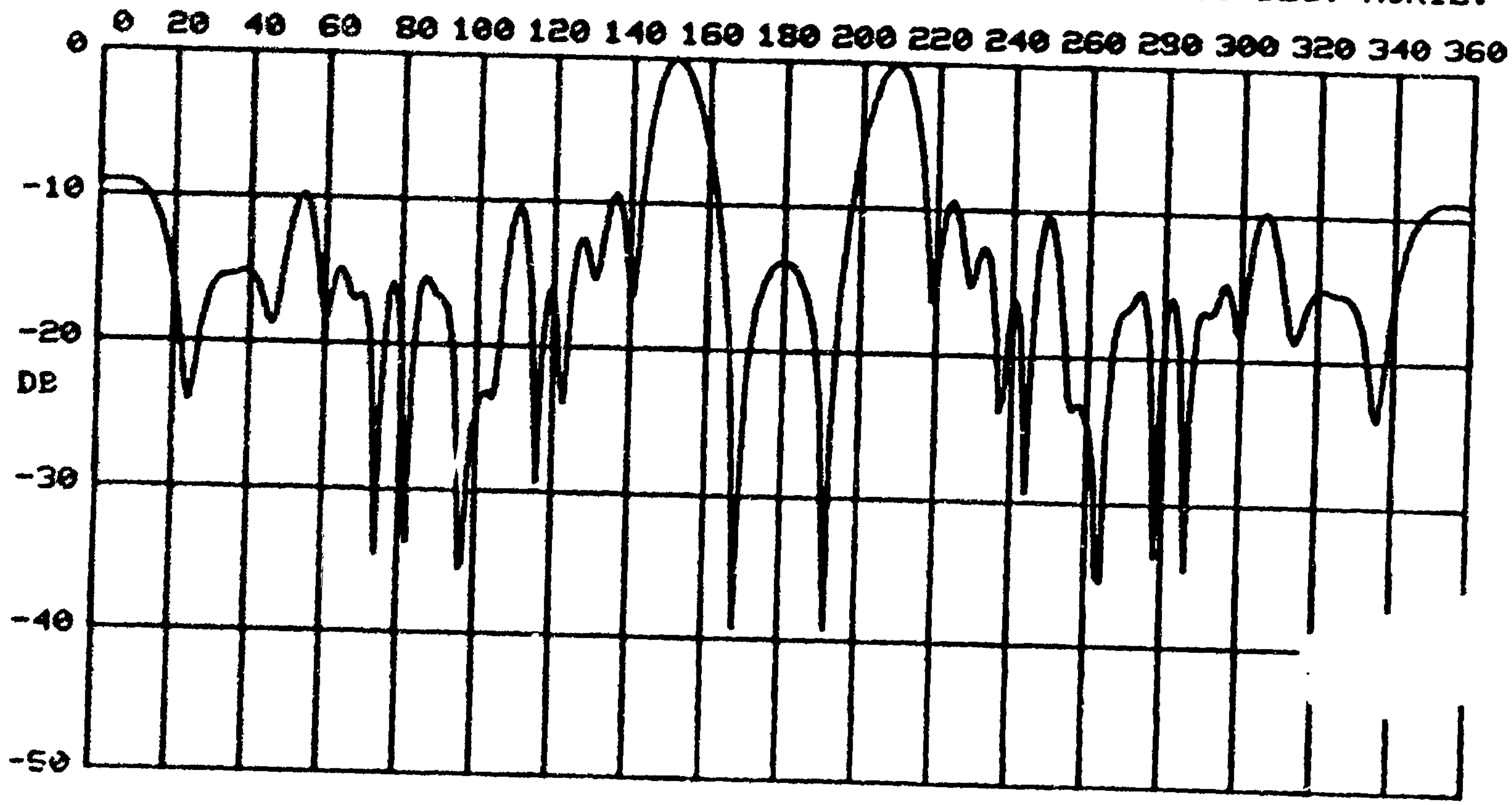
CONFIDENTIAL

Figure B-10b Theoretical Horizontal Plane Pattern for 32 Element Array @ 295 Hz for Data Point 10, 61.5° Off Broadside Steering. Beamwidth 6.08°, Azimuth Gain 13.0 dB.

CONFIDENTIAL

S1066 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-73 CNTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

UNIFORM WEIGHTING.
HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ., 16 ELEMENTS, -0.88 DB MAX., AC:S1362,SU:S1362,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
11.50 DEG. 3 DB BEAM, 10.04 DB AZ. GAIN, MAX. AT 151.0 DEG. HORIZ.



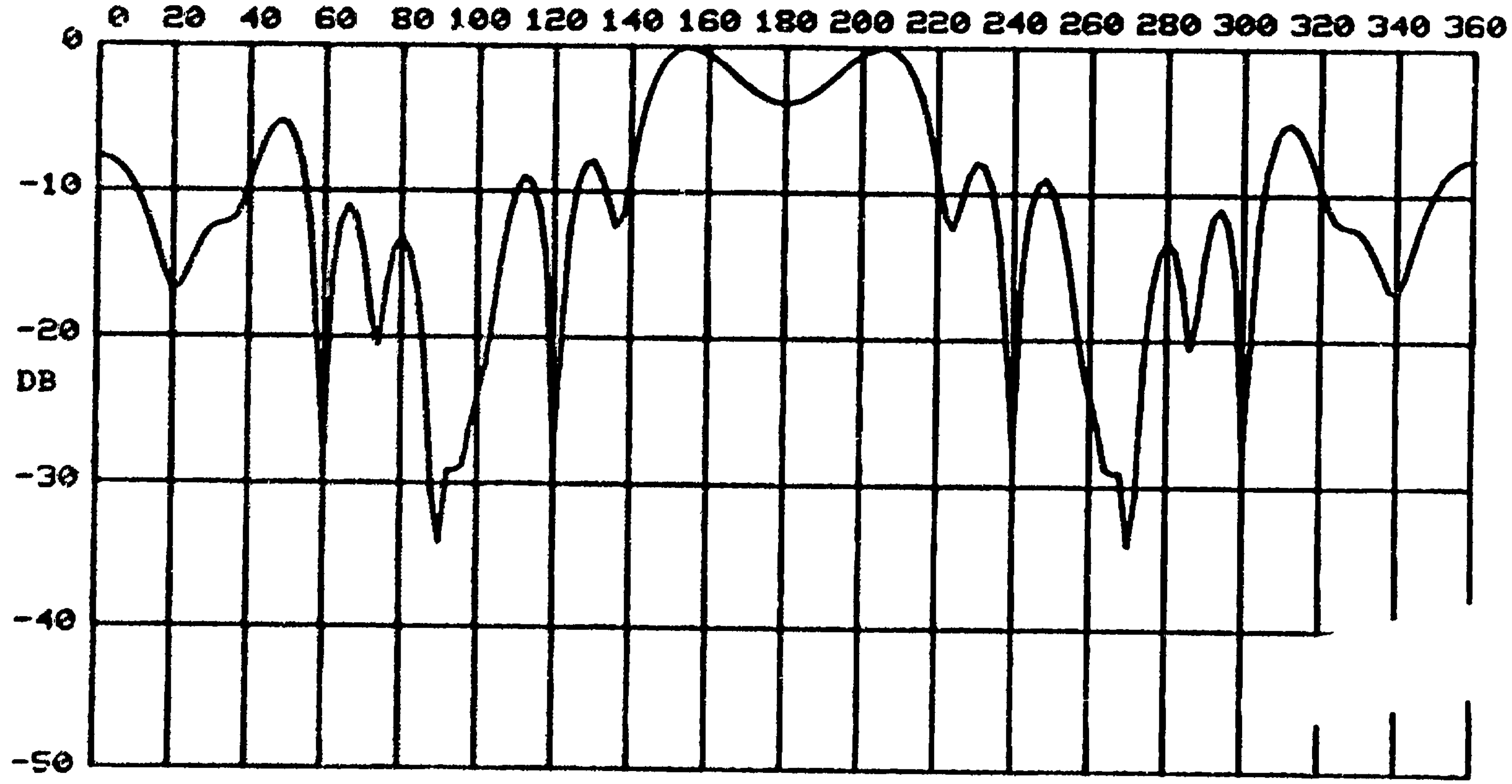
CONFIDENTIAL

Figure B-107 Theoretical Horizontal Plane Pattern for 16 Element Array @ 295 Hz for Data Point 10, 61.5° Off Broadside Steering. Beamwidth 11.50°, Azimuth Gain 10.0 dB.

CONFIDENTIAL

S1DE3 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 6-Jan-78 QNTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING

UNIFORM WEIGHTING.
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
295.0 HZ., 8 ELEMENTS, -0.57 DB MAX., AC:S1362,SU:S1362,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
26.95 DEG. 3 DB BEAM, 6.86 DB AZ. GAIN, MAX. AT 154.0 DEG. HORIZ.



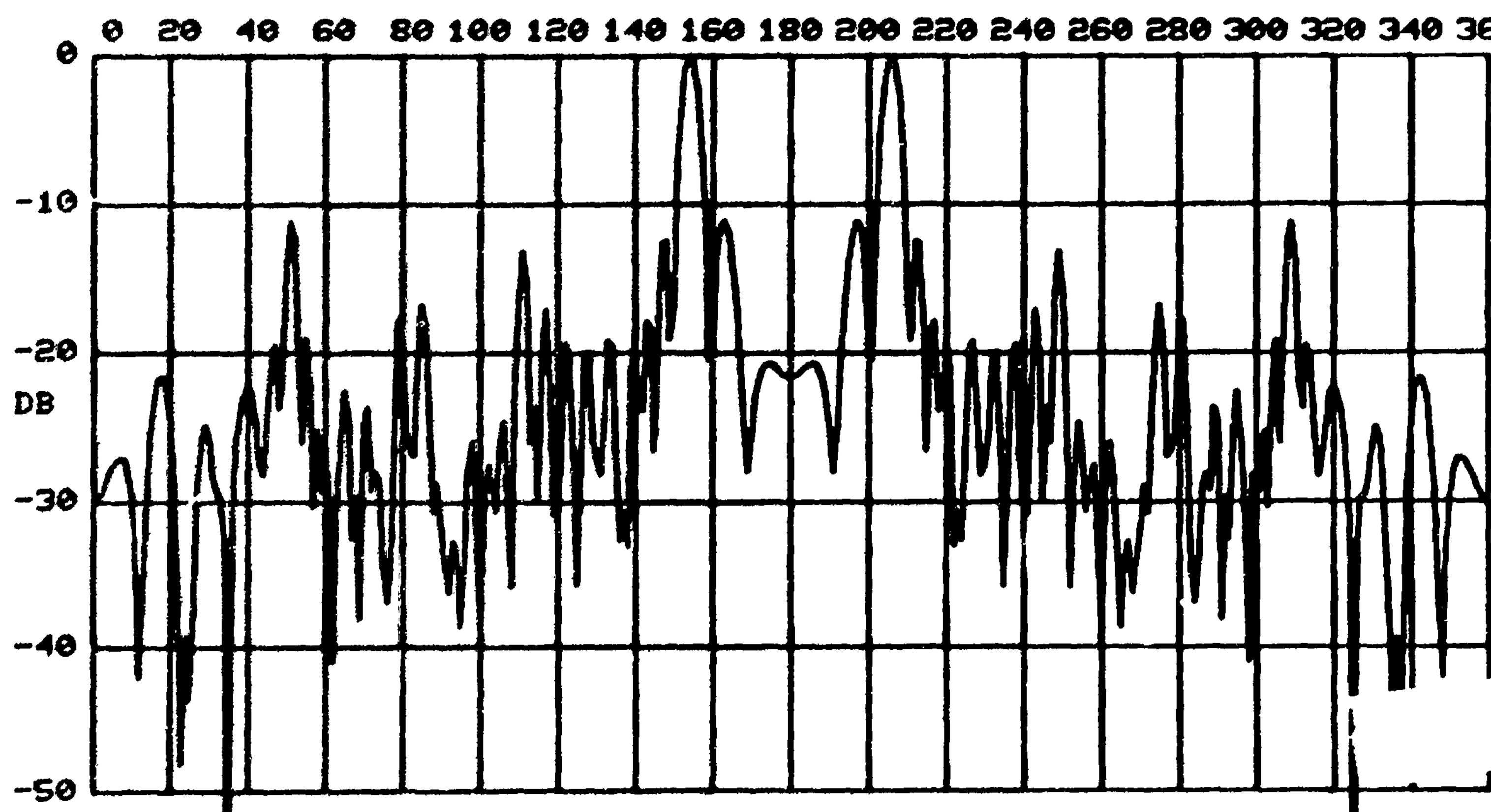
CONFIDENTIAL

Figure B-108 Theoretical Horizontal Plane Pattern for 8 Element Array @ 295 Hz for Data Point 10, 61.5° Off Broadside Steering. Beamwidth 26.95°, Azimuth Gain 6.8 dB.

CONFIDENTIAL

SANDEPS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-78 ONTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING.

DATA POINT 11
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 51 ELEMENTS, -0.83 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 154.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
4.46 DEG. 3 DB BEAM, 14.85 DB AZ. GAIN, MAX. AT 206.0 DEG. HORIZ.



CONFIDENTIAL

Figure B-109 Theoretical Horizontal Plane Pattern for 51 Element Array @ 290 Hz for Data Point 11, 64° Off Broadside Steering. Beamwidth 4.46°, Azimuth Gain 14.8 dB.

SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-73 QNTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING.

DATA POINT 11
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 32 ELEMENTS, -0.73 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 153.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
6.86 DEG. 3 DB BEAM, 13.01 DB AZ. GAIN, MAX. AT 153.0 DEG. HORIZ.

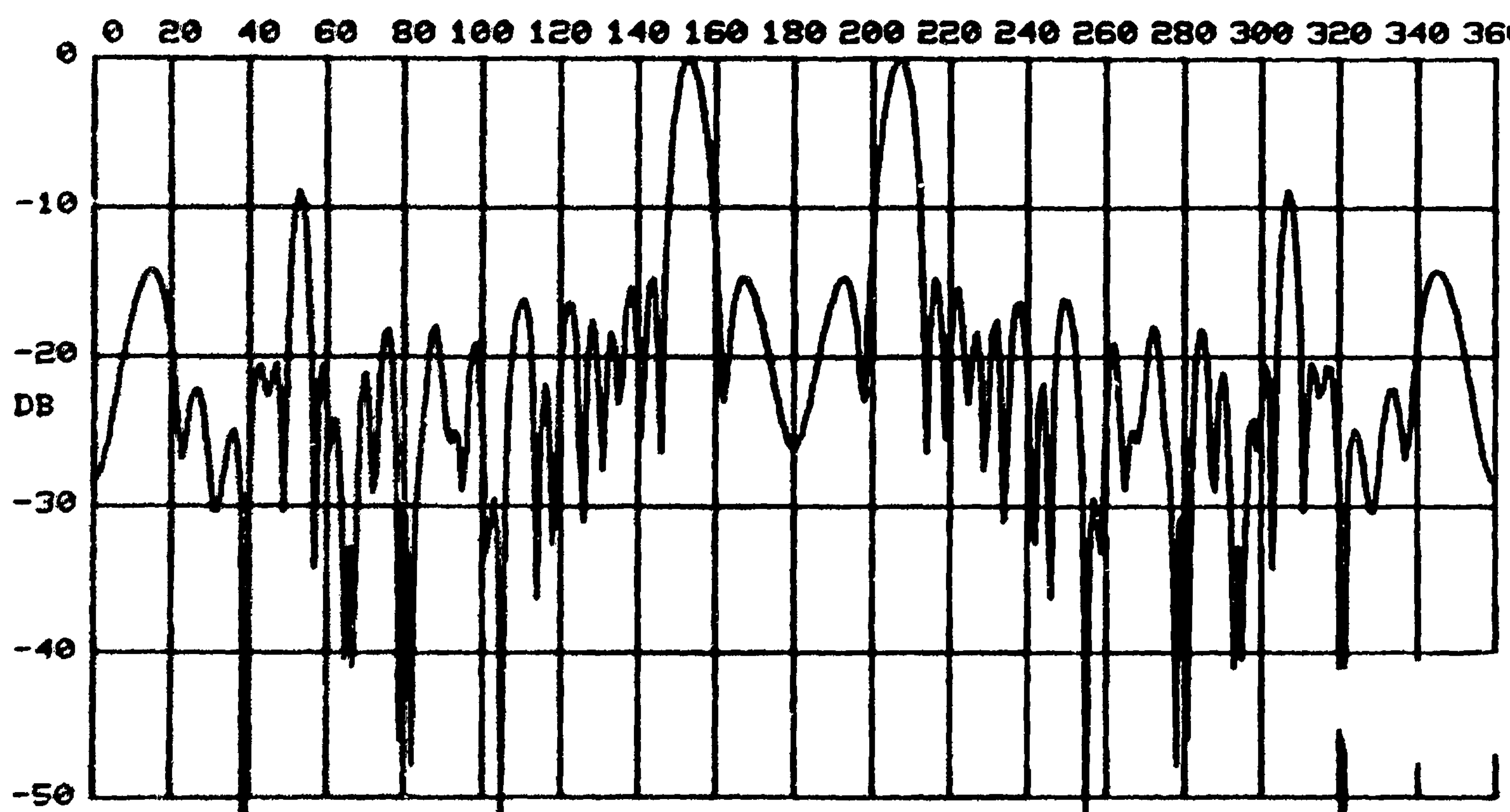
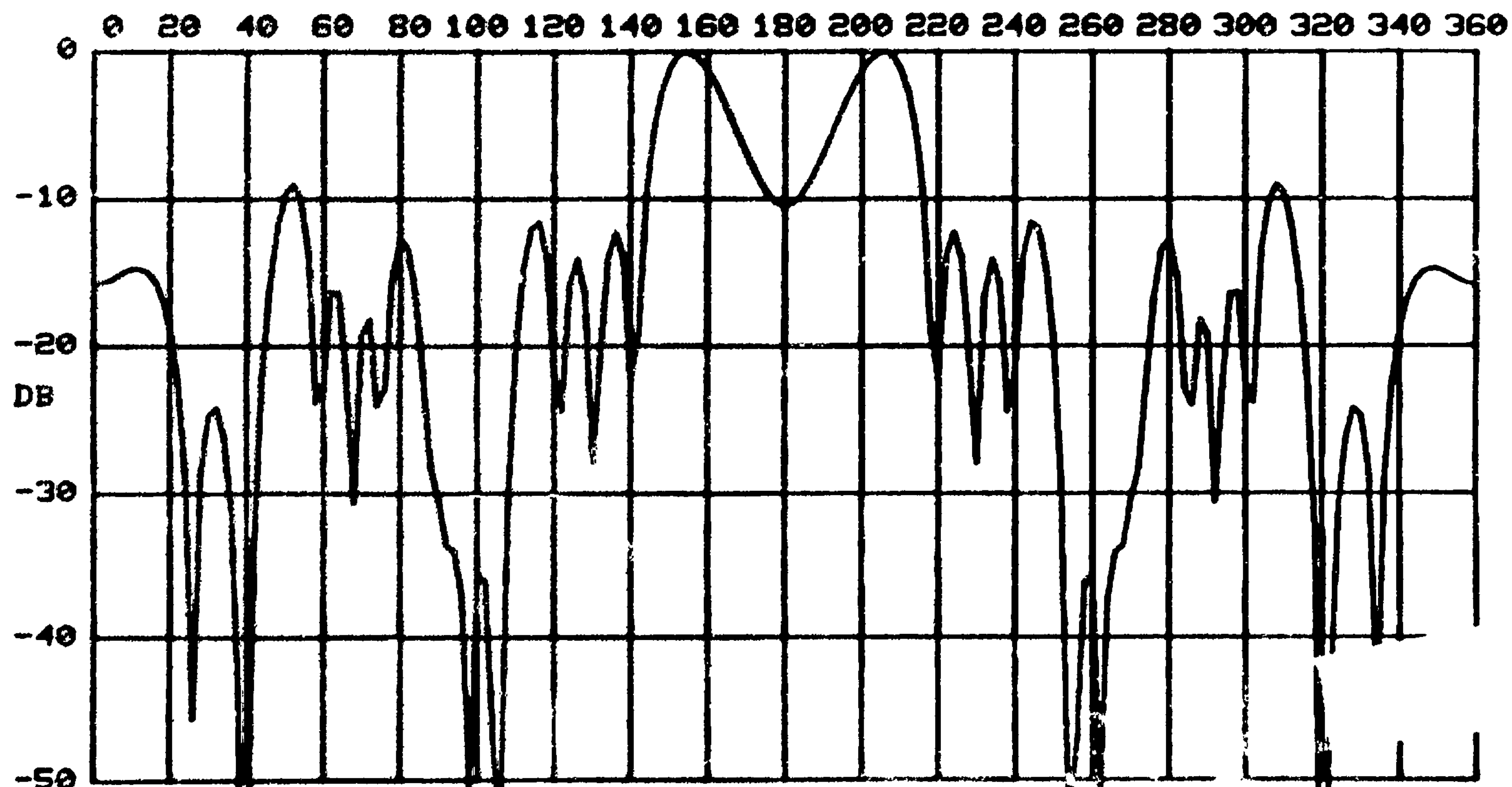


Figure B-110 Theoretical Horizontal Plane Pattern for 32 Element Array @ 290 Hz for Data Point 11, 63° Off Broadside Steering. Beamwidth 6.86°, Azimuth Gain 13.0 dB.

CONFIDENTIAL

54320 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 5-Apr-78 QNTLBP 3.1
ARRAY TUNED TO 300 HZ.
FT. UNIFORM SPACING.
SAME

DATA POINT 11
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
290.0 HZ., 16 ELEMENTS, -0.78 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 154.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
15.94 DEG. 3 DB BEAM, 9.43 DB AZ. GAIN, MAX. AT 206.0 DEG. HORIZ.



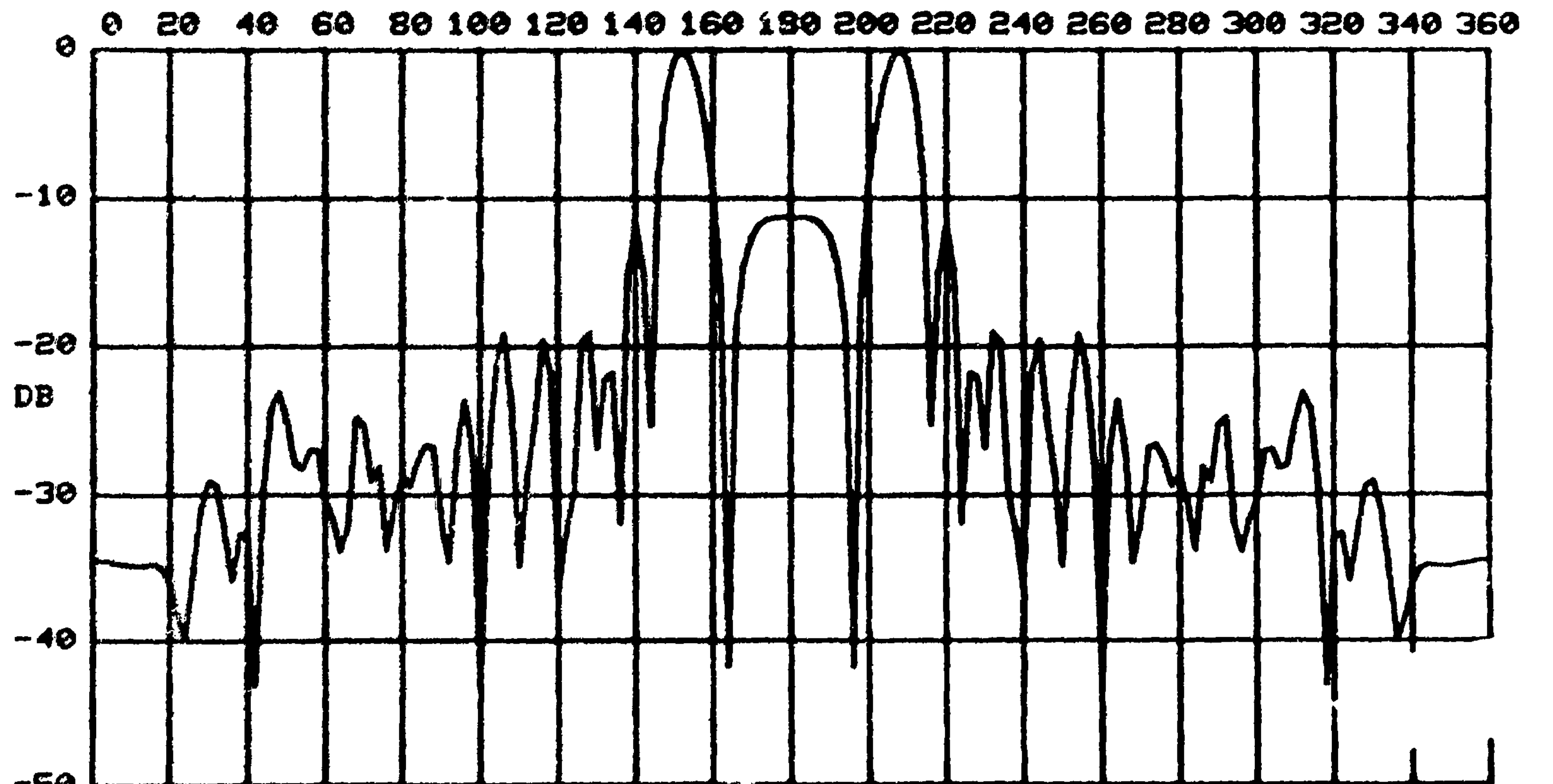
CONFIDENTIAL

Figure B-111 Theoretical Horizontal Plane Pattern for 16 Element Array @ 290 Hz for Data Point 11, 64° Off Broadside Steering. Beamwidth 15.94°, Azimuth Gain 9.4 dB.

CONFIDENTIAL

```
5402T   SANDERS BEAM PATTERN PROGRAM (T.HOGAN)    5-Apr-78    QNTLBP 3.1
[illegible] ARRAY TUNED TO 300 HZ.
[illegible] FT. UNIFORM SPACING.
[illegible]

DATA POINT 11
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ.,   51 ELEMENTS, -0.18 DB MAX., AC:S2581,SU:S2581,WT:
 90.0 DEG. VERT. RESP., 152.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
 8.69 DEG. 3 DB BEAM,  12.42 DB AZ. GAIN, MAX. AT 208.0 DEG. HORIZ.
```



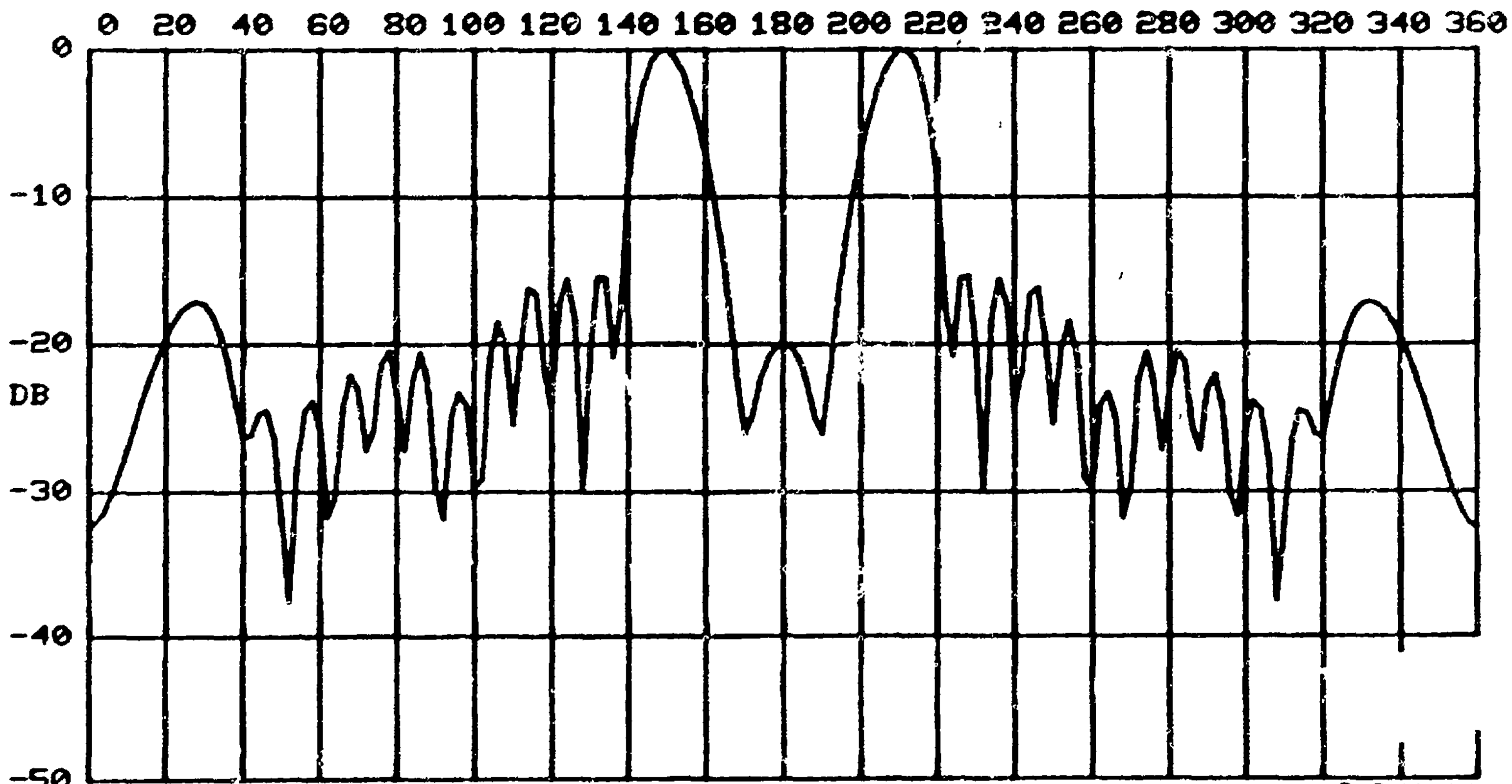
CONFIDENTIAL

Figure 8-112 Theoretical Horizontal Plane Pattern for 51 Element Array 3 140 Hz for Data Point 11, 62° Off Broadside Steering. Beamwidth 8.69°, Azimuth Gain 12.4 dB.

CONFIDENTIAL

```
S422R  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)   5-Apr-78   ONTLBP 3.1
 : ARRAY ARRAY TUNED TO 300 HZ.
   3.3333 FT. UNIFORM SPACING.
 : SAME

DATA POINT 11
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ.,   32 ELEMENTS, -0.31 DB MAX., AC:S2581,SU:S2581,WT:
 90.0 DEG. VERT. RESP., 149.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
12.90 DEG. 3 DB BEAM,  10.91 DB AZ. GAIN, MAX. AT 150.0 DEG. HORIZ.
```



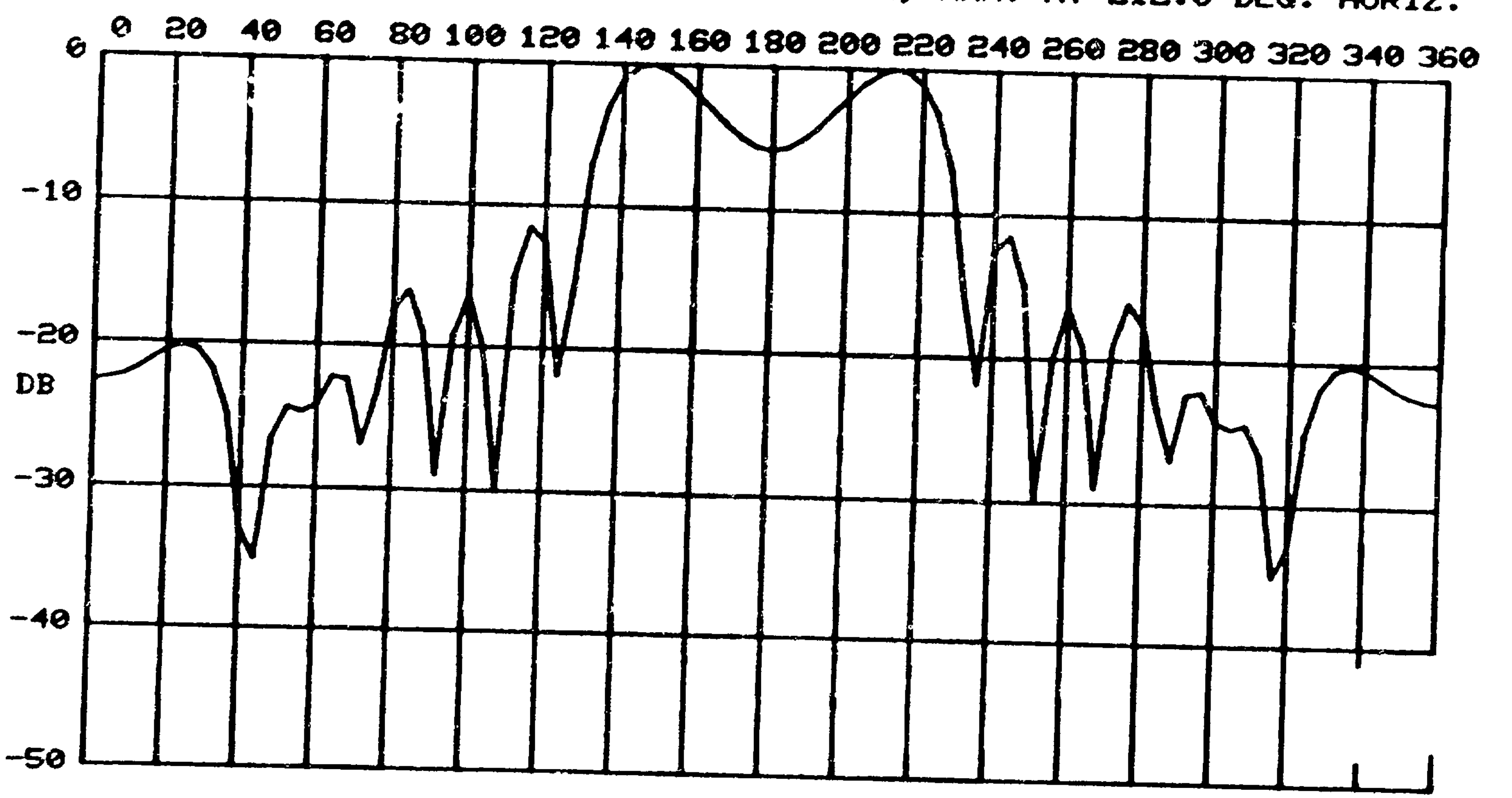
CONFIDENTIAL

Figure B-113 Theoretical Horizontal Plane Pattern for 32 Element Array @ 140 Hz for Data Point 11, 59° Off Broadside Steering. Beamwidth 12.90°, Azimuth Gain 10.9 dB.

CONFIDENTIAL

```
      SANDERS BEAM PATTERN PROGRAM (T.HOGAN)    5-Apr-78    ONTLBF 3.1
     ARRAY TUNED TO 300 HZ.
     FT. UNIFORM SPACING.
     SAME

DATA POINT 11
1200 HZ. SAMPLING FREQUENCY DISTORTS PATTERN.
140.0 HZ.,  16 ELEMENTS, -0.19 DB MAX., AC:S2581,SU:S2581,WT:
 90.0 DEG. VERT. RESP., 147.0 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
27.48 DEG. 3 DB BEAM,   7.63 DB AZ. GAIN, MAX. AT 212.0 DEG. HORIZ.
```



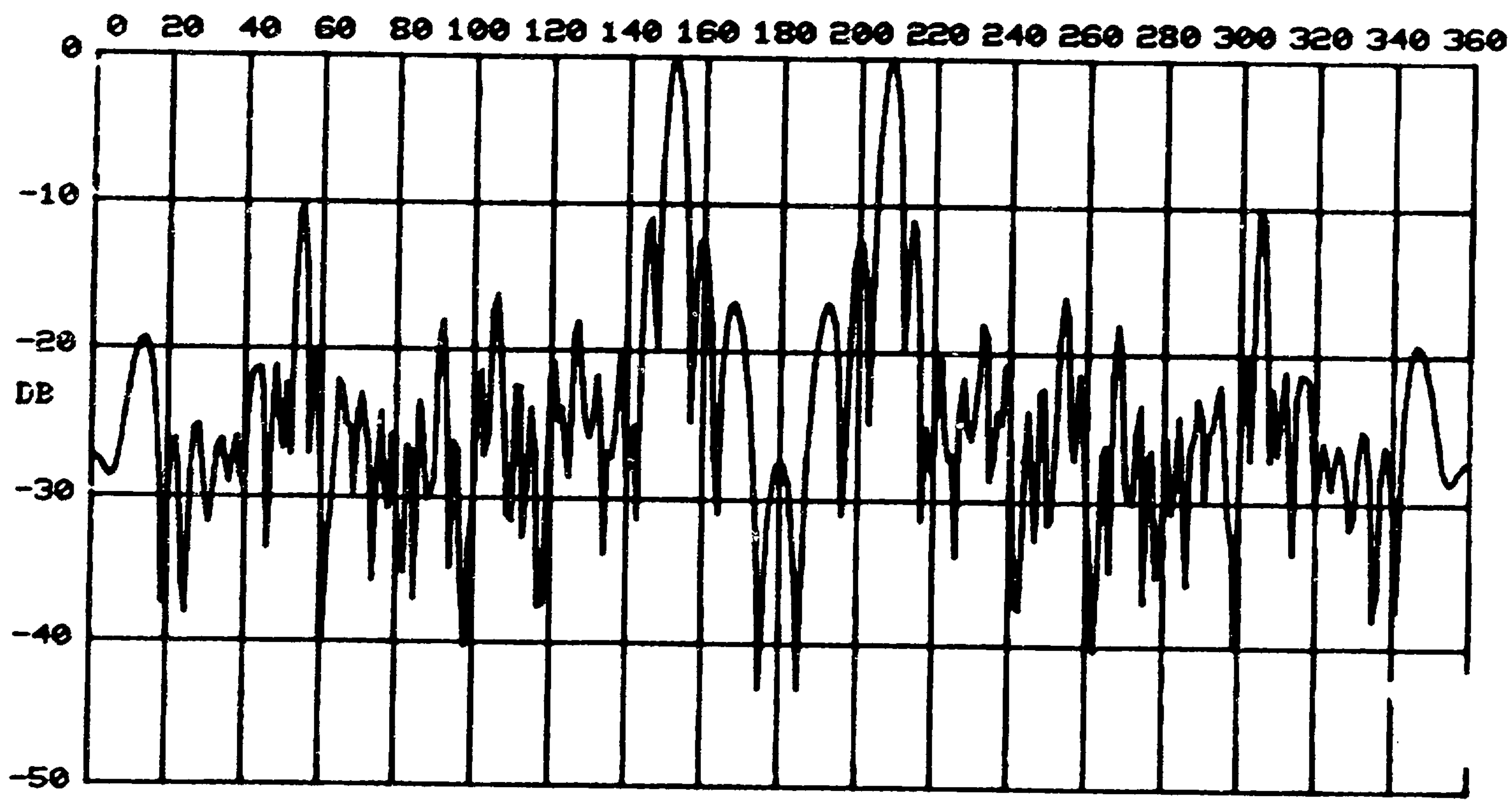
CONFIDENTIAL

Figure B-114 Theoretical Horizontal Plane Pattern for 16 Element Array @ 140 Hz for Data Point 11, 57° Off Broadside Steering. Beamwidth 27.48°, Azimuth Gain 7.6 dB.

CONFIDENTIAL

S?263 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 27-May-78 QNTLBP 3.1
A: SPRAY ARRAY TUNED TO 300 HZ.
8.3333 FT. UNIFORM SPACING.
S: SAME

DATA POINT 12
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN
290.0 HZ., 51 ELEMENTS, -0.81 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., ?2.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
4.14 DEG. 3 DB BEAM, 15.15 DB AZ. GAIN, MAX. AT 208.0 DEG. HORIZ.



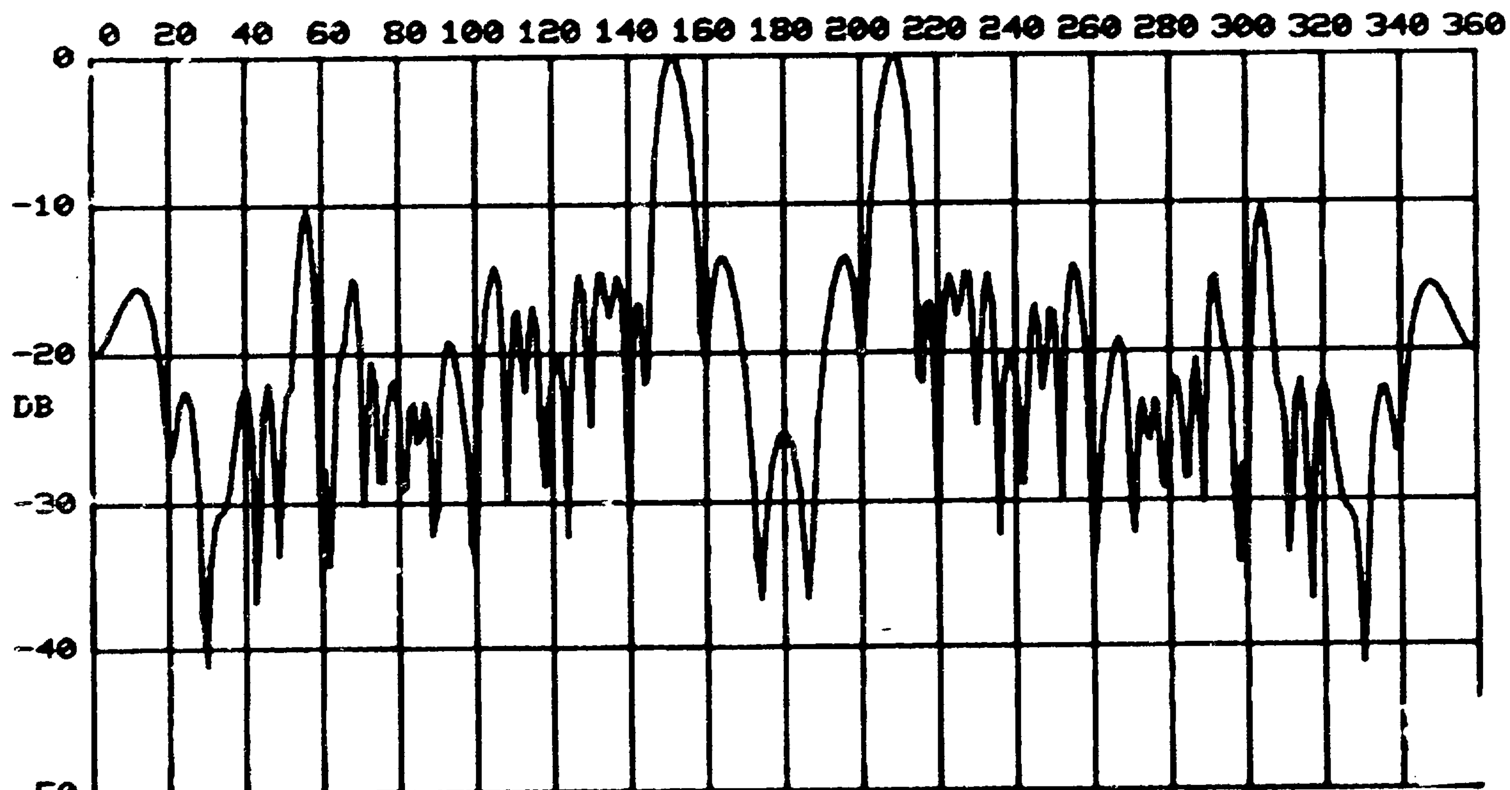
CONFIDENTIAL

Figure G-115 Theoretical Horizontal Plane Pattern for 51 Element Array @ 290 Hz for Data Point 12, 62° Off Broadside Steering. Beamwidth 4.14°, Azimuth Gain 15.1 dB.

CONFIDENTIAL

S5265 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 27-May-78 ONTLBP 3.1
A: SPRAY ARRAY TUNED TO 300 HZ.
8.3333 FT. UNIFORM SPACING.
S: SAME

DATA POINT 12
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN
290.0 HZ., 32 ELEMENTS, -0.85 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
6.50 DEG. 3 DB BEAM, 13.14 DB AZ. GAIN, MAX. AT 209.0 DEG. HORIZ.



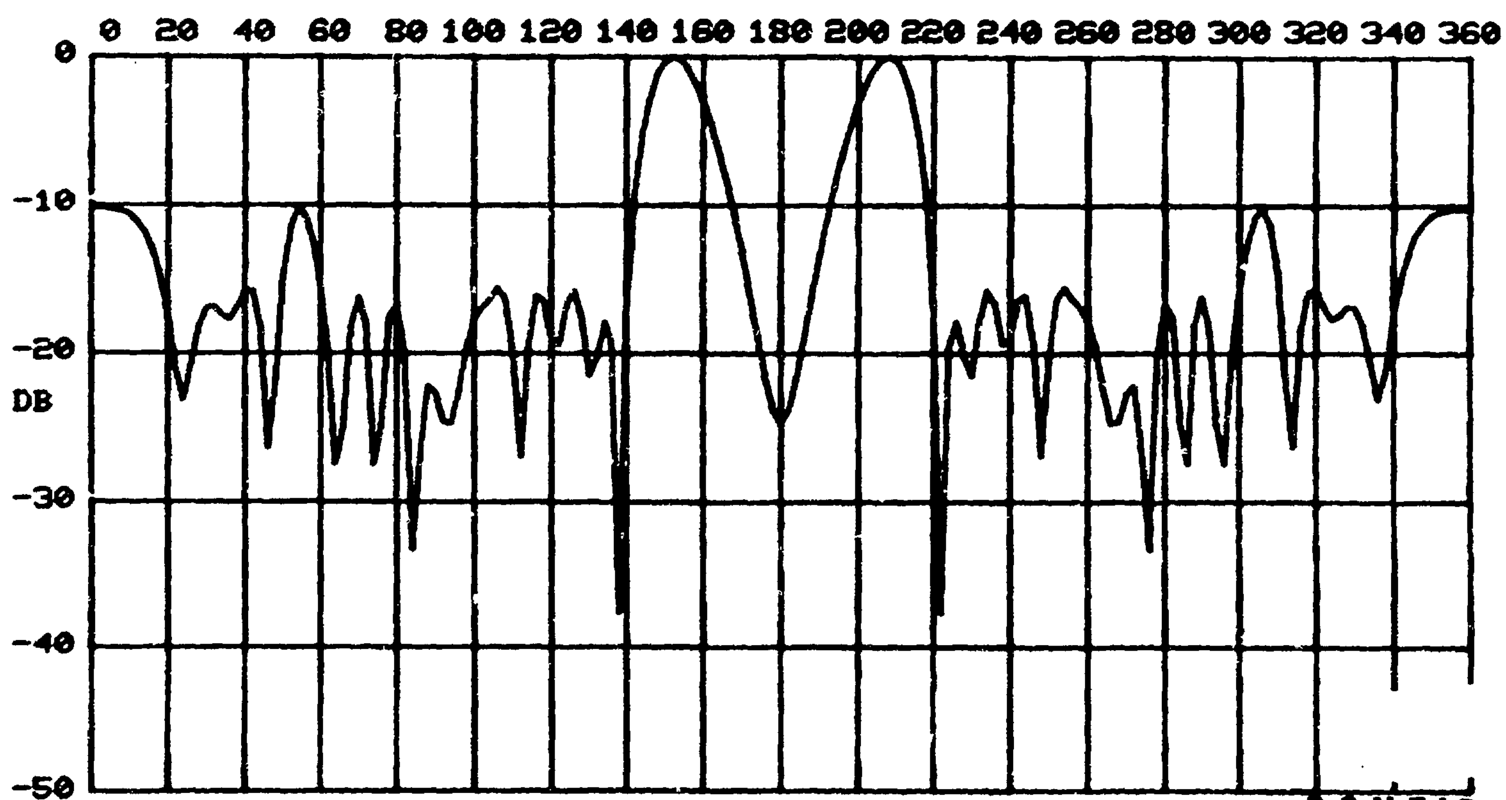
CONFIDENTIAL

Figure B-116 Theoretical Horizontal Plane Pattern for 32 Element Array @ 290 Hz for Data Point 12, 61.5° Off Broadside Steering. Beamwidth 6.50°, Azimuth Gain 13.1 dB.

CONFIDENTIAL

S5262 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 27-May-78 QNTLBP 3.1
A: SPRAY ARRAY TUNED TO 300 HZ.
8.3333 FT. UNIFORM SPACING.
S: SAME

DATA POINT 12
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN
290.0 HZ., 16 ELEMENTS, -0.76 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
14.38 DEG. 3 DB BEAM, 9.80 DB AZ. GAIN, MAX. AT 152.0 DEG. HORIZ.



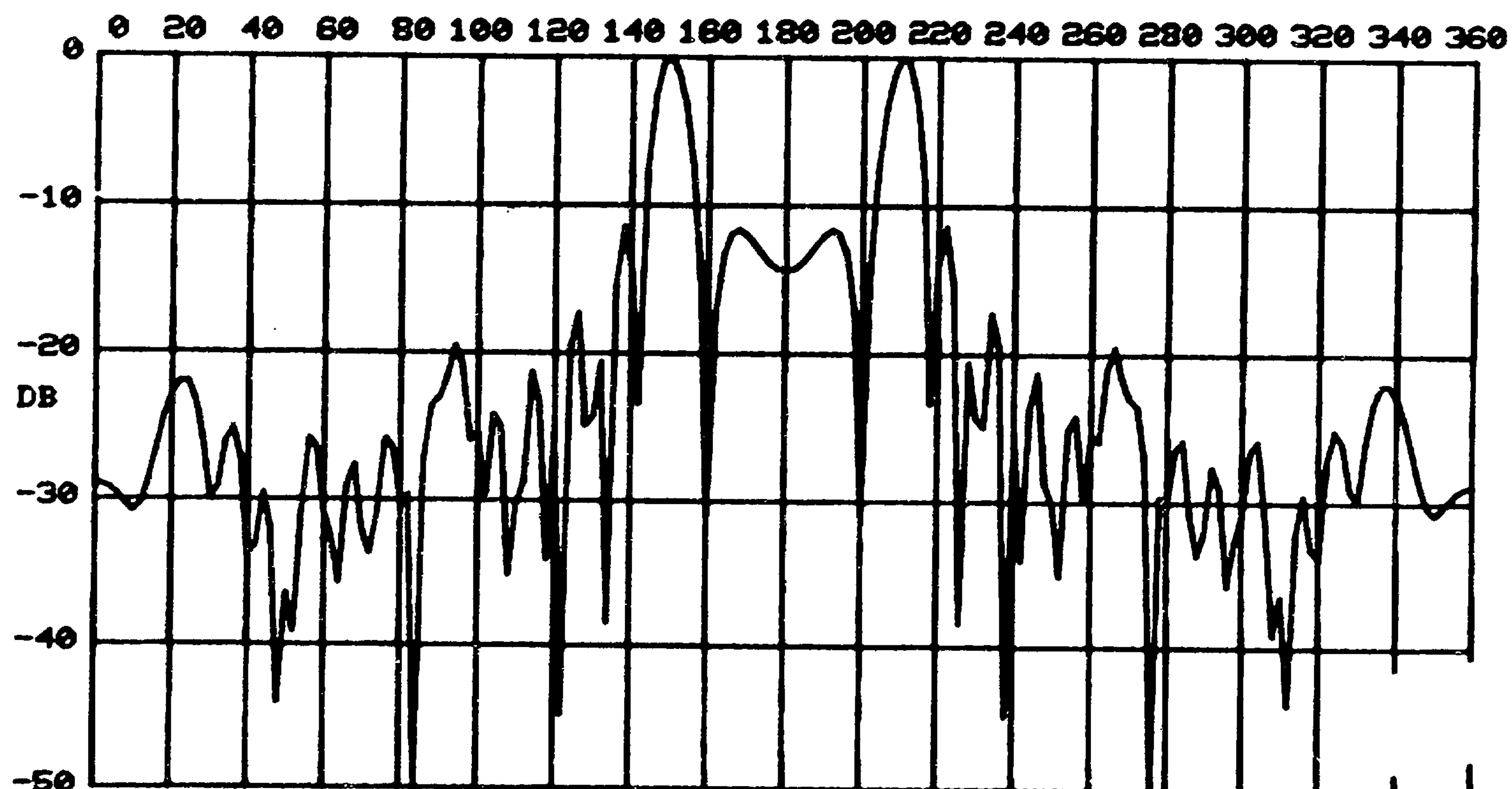
CONFIDENTIAL

Figure B-117 Theoretical Horizontal Plane Pattern for 16 Element Array @ 290 Hz for Data Point 12, 61.5° Off Broadside Steering. Beamwidth 14.38°, Azimuth Gain 9.8 dB.

CONFIDENTIAL

```
     S5267   SANDERS BEAM PATTERN PROGRAM (T.HOGAN)   27-May-78    QNTLBP 3.1
A:   SPPAY ARRAY TUNED TO 300 HZ.
     2.3333 FT. UNIFORM SPACING.
S:   SAME

     DATA POINT 12
     1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN
     140.0 HZ.,   51 ELEMENTS, -0.24 DB MAX., AC:S2581,SU:S2581,WT:
      90.0 DEG. VERT. RESP., 149.5 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
      8.05 DEG. 3 DB BEAM,  12.62 DB AZ. GAIN, MAX. AT 150.0 DEG. HORIZ.
```



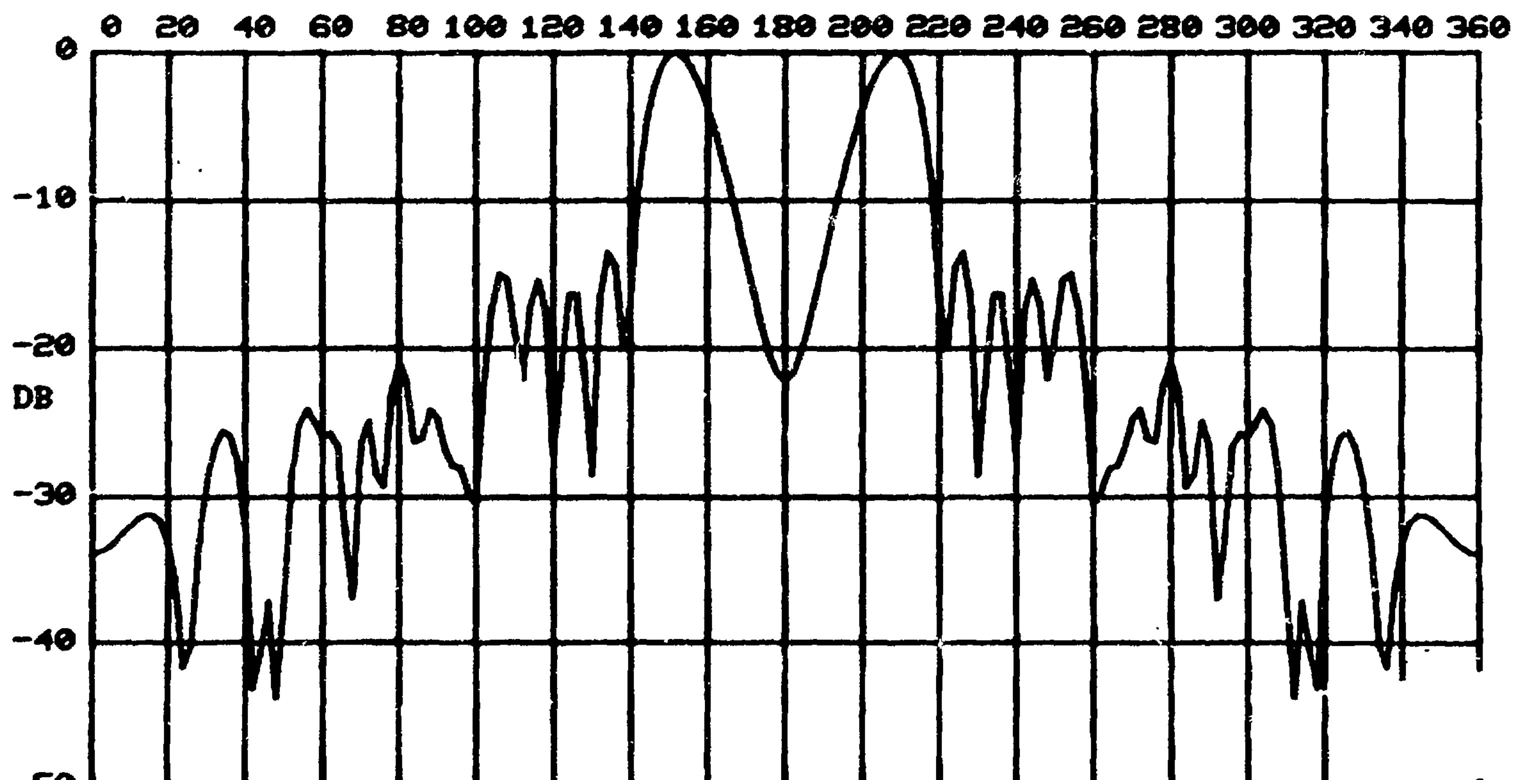
CONFIDENTIAL

Figure B-118 Theoretical Horizontal Plane Pattern for 51 Element Array @ 140 Hz for Data Point 12, 59.5° Off Broadside Steering. Beamwidth 8.05°, Azimuth Gain 12.6 dB.

CONFIDENTIAL

```
   S5264  SANDERS BEAM PATTERN PROGRAM (T.HOGAN)  27-May-78   QNTLBP 3.1
A: SPRAY ARRAY TUNED TO 300 HZ.
   8.3333 FT. UNIFORM SPACING.
S: SAME

   DATA POINT 12
   1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN
   140.0 HZ.,  32 ELEMENTS, -0.20 DB MAX., AC:S2581,SU:S2581,WT:
    90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
   13.89 DEG. 3 DB BEAM,  10.61 DB AZ. GAIN, MAX. AT 208.0 DEG. HORIZ.
```



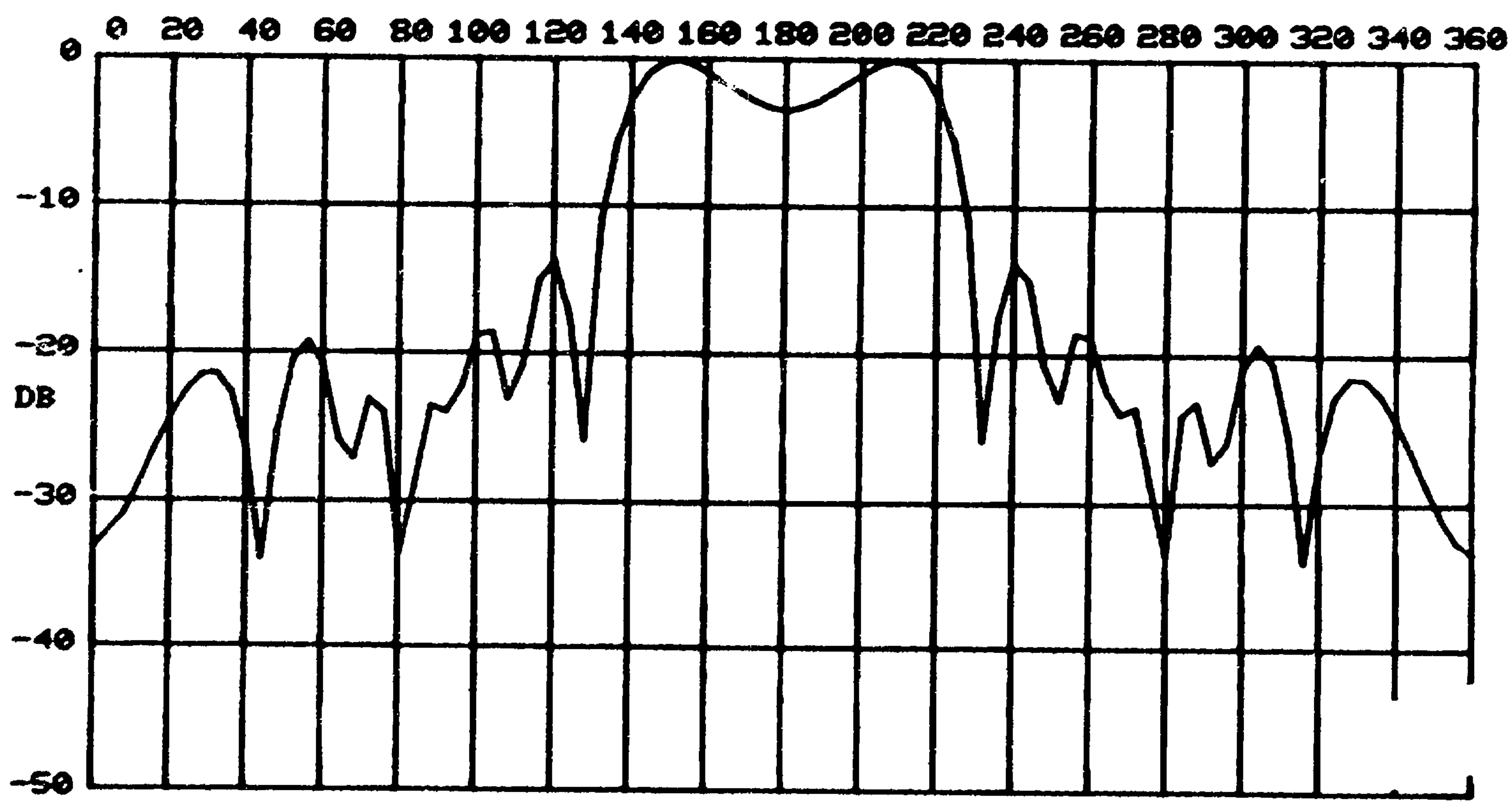
CONFIDENTIAL

Figure B-119 Theoretical Horizontal Plane Pattern for 32 Element Array @ 140 Hz for Data Point 12, 61.5° Off Broadside Steering. Beamwidth 13.89°, Azimuth Gain 10.6 dB.

CONFIDENTIAL

```
    S5261   SANDERS BEAM PATTERN PROGRAM (T.HOGAN)  27-May-78   QNTLBP 3.1
A:  SPRAY ARRAY TUNED TO 300 HZ.
    8.3333 FT. UNIFORM SPACING.
S:  SAME

    DATA POINT 12
    1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN
    140.0 HZ.,  16 ELEMENTS, -0.18 DB MAX., AC:S2581,SU:S2581,WT:
     90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
    34.91 DEG. 3 DB BEAM,    7.36 DB AZ. GAIN, MAX. AT 208.0 DEG. HORIZ.
```



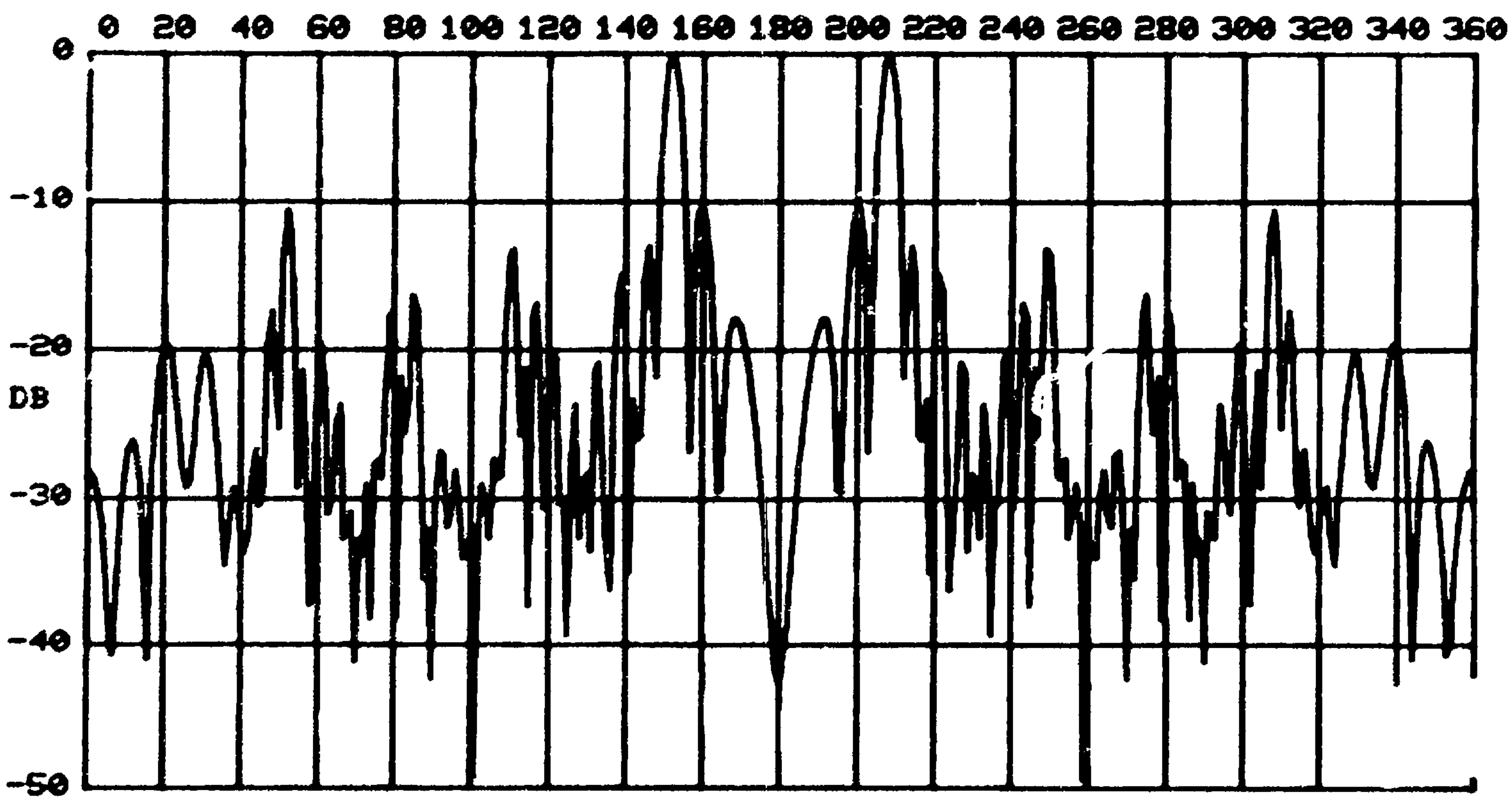
CONFIDENTIAL

Figure B-120 Theoretical Horizontal Plane Pattern for 16 Element Array @ 140 Hz for Data Point 12, 61.5° Off Broadside Steering. Beamwidth 34.91°, Azimuth Gain 7.3 dB.

CONFIDENTIAL

S5269 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 27-May-78 QNTLBP 3.1
A: SPRAY ARRAY TUNED TO 300 HZ.
3.3333 FT. UNIFORM SPACING.
S: SAME

DATA POINT 12
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN
295.0 HZ., 51 ELEMENTS, -0.89 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 152.0 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
4.06 DEG. 3 DB BEAM, 15.12 DB AZ. GAIN, MAX. AT 152.0 DEG. HORIZ.



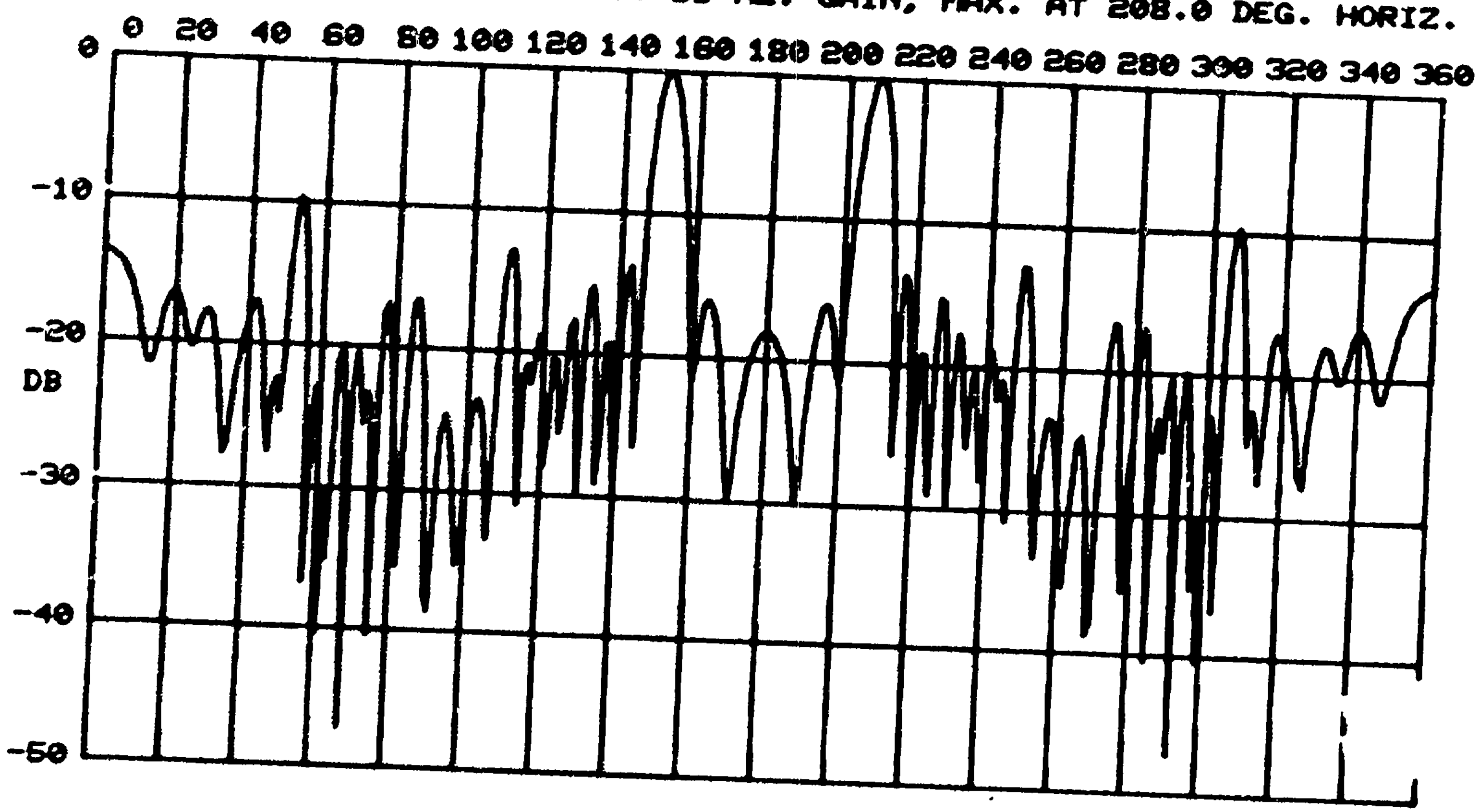
CONFIDENTIAL

Figure B-121 Theoretical Horizontal Plane Pattern for 51 Element Array @ 295 Hz for Data Point 12, 62° Off Broadside Steering. Beamwidth 4.06°, Azimuth Gain 15.1 dB.

CONFIDENTIAL

SE266 SANDERS BEAM PATTERN PROGRAM (T.HOGAN) 27-May-78 QNTLBP 3.1
A: SPRAY ARRAY TUNED TO 300 HZ.
8.3333 FT. UNIFORM SPACING.
S: SAME

DATA POINT 12
1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN
295.0 HZ., 32 ELEMENTS, -0.90 DB MAX., AC:S2581,SU:S2581,WT:
90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER, 90.0 DEG. VERT STEER
6.47 DEG. 3 DB BEAM, 13.07 DB AZ. GAIN, MAX. AT 208.0 DEG. HORIZ.



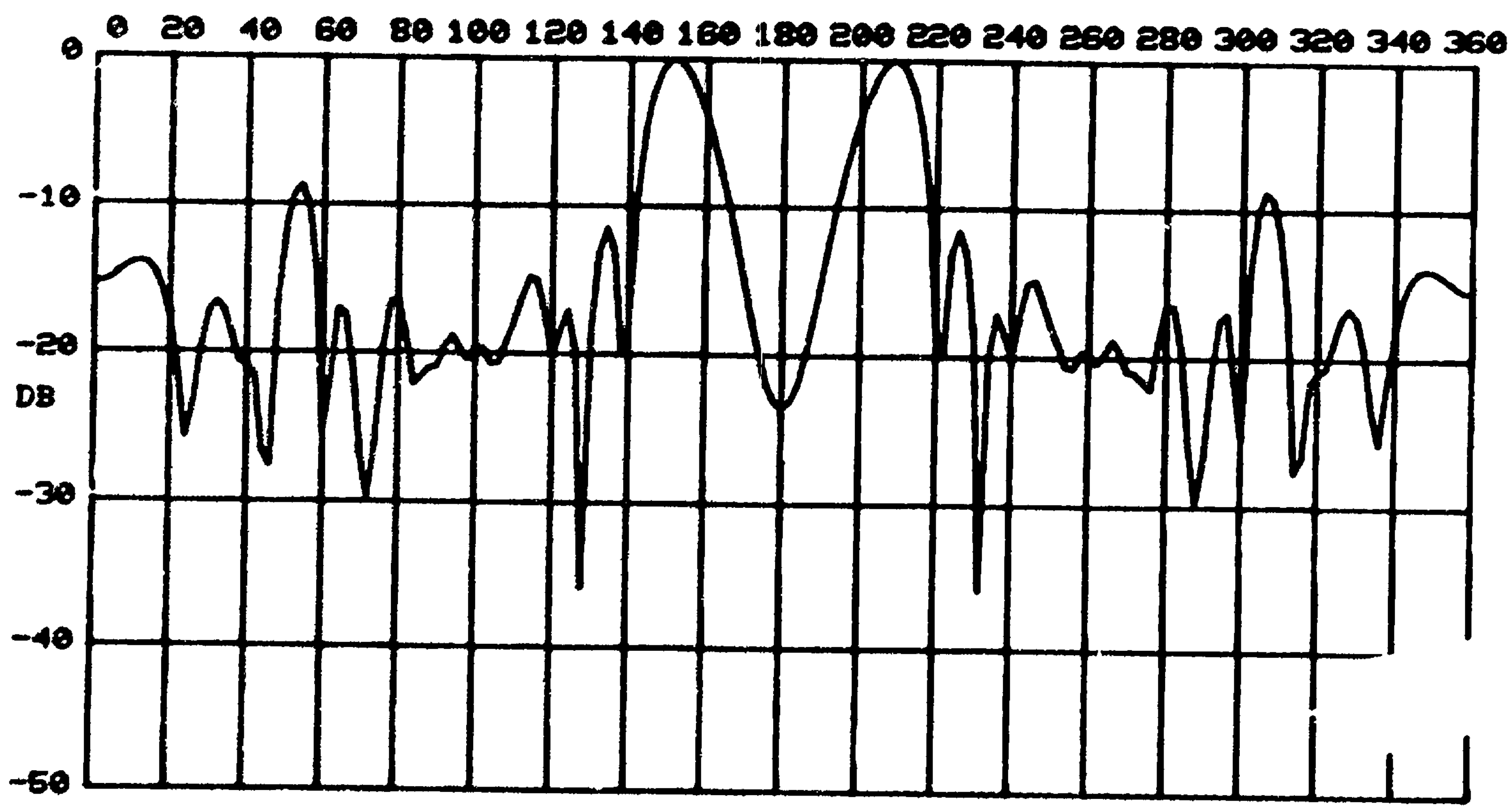
CONFIDENTIAL

Figure B-12 Theoretical Horizontal Plane Pattern for 32 Element Array @ 295 Hz for Data Point 12, 61.5° Off Broadside Steering. Beamwidth 6.47°, Azimuth Gain 13.0 dB.

CONFIDENTIAL

```
      55263   SANDERS BEAM PATTERN PROGRAM (T.HOGAN)  27-May-78   QNTLBP 3.1
A:  SPPAY ARRAY TUNED TO 300 HZ.
    8.3333 FT. UNIFORM SPACING.
S:  SAME

    DATA POINT 12
    1200 HZ SAMPLING FREQUENCY DISTORTS PATTERN
    295.0 HZ.,  16 ELEMENTS, -0.79 DB MAX., AC:S2581,SU:S2581,WT:
     90.0 DEG. VERT. RESP., 151.5 DEG. HORIZ. STEER,  90.0 DEG. VERT STEER
    13.79 DEG. 3 DB BEAM,  10.06 DB AZ. GAIN, MAX. AT 208.0 DEG. HORIZ.
```



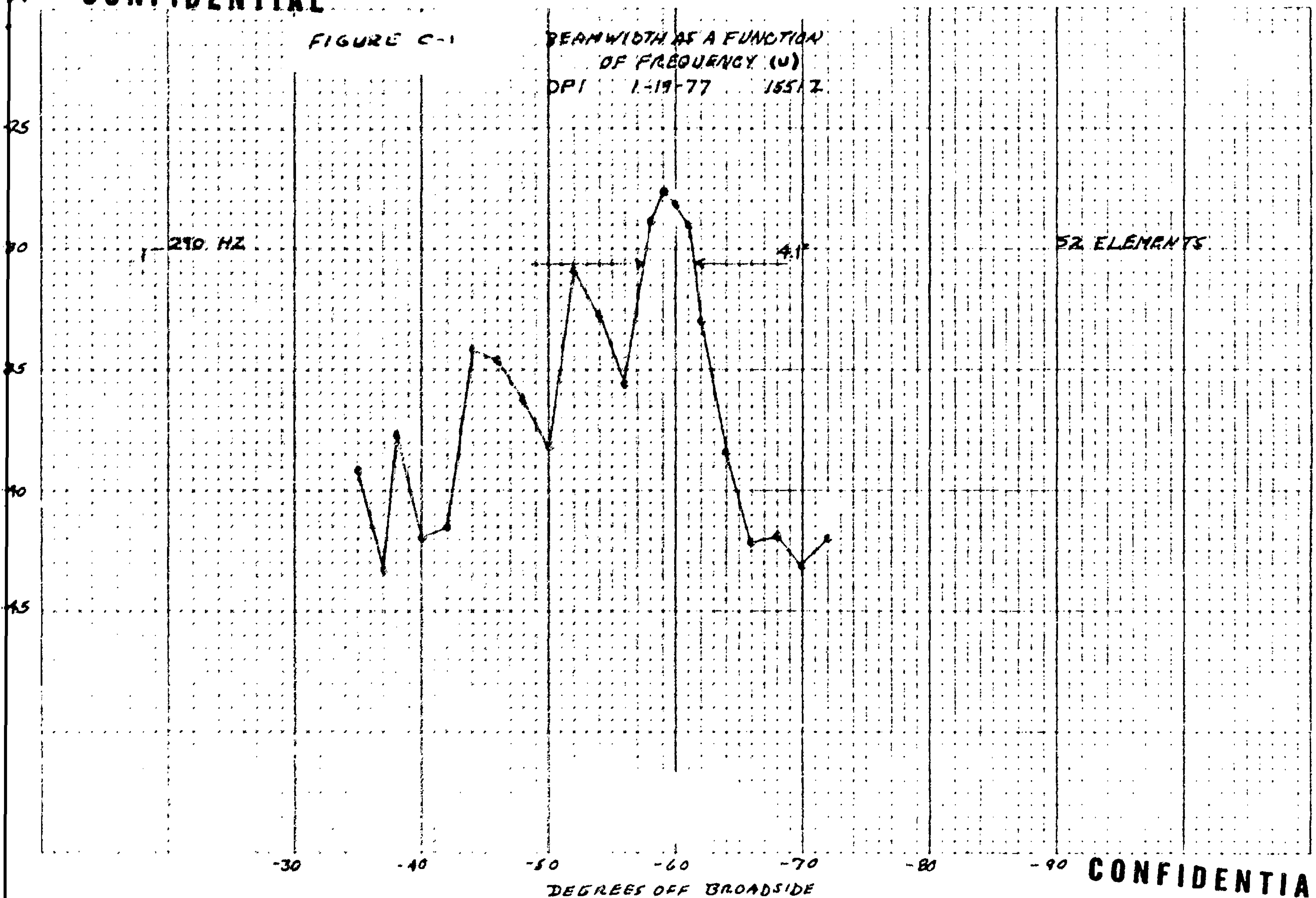
CONFIDENTIAL

Figure B-123 Theoretical Horizontal Plane Pattern for 16 Element Array @ 295 Hz for Data Point 12, 61.5° Off Broadside Steering. Beamwidth 13.79°, Azimuth Gain 10.0 dB.

APPENDIX C MEASURED BEAMWIDTH DATA (U)

CONFIDENTIAL

FIGURE C-1



CONFIDENTIAL

46 0705

CONFIDENTIAL

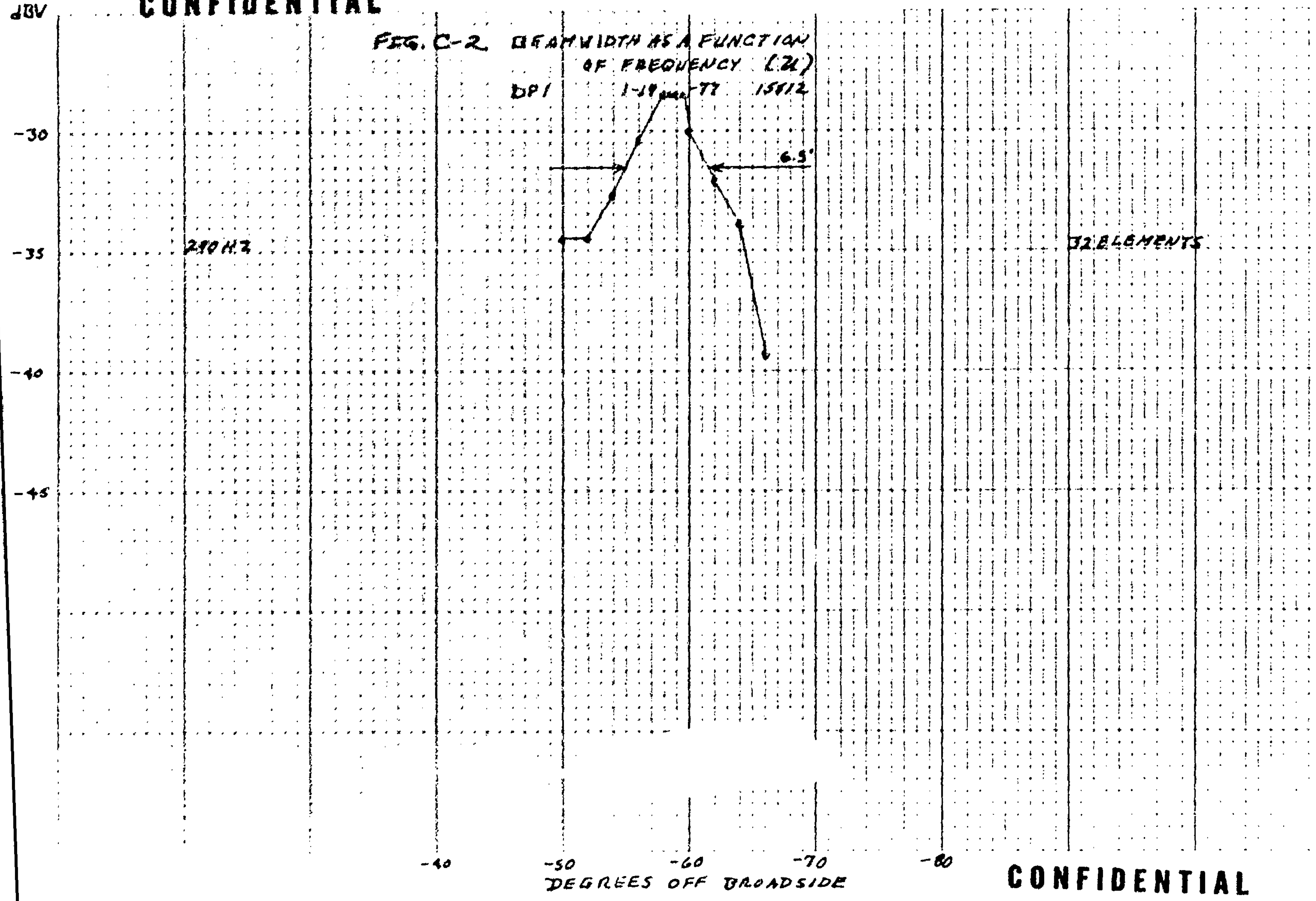
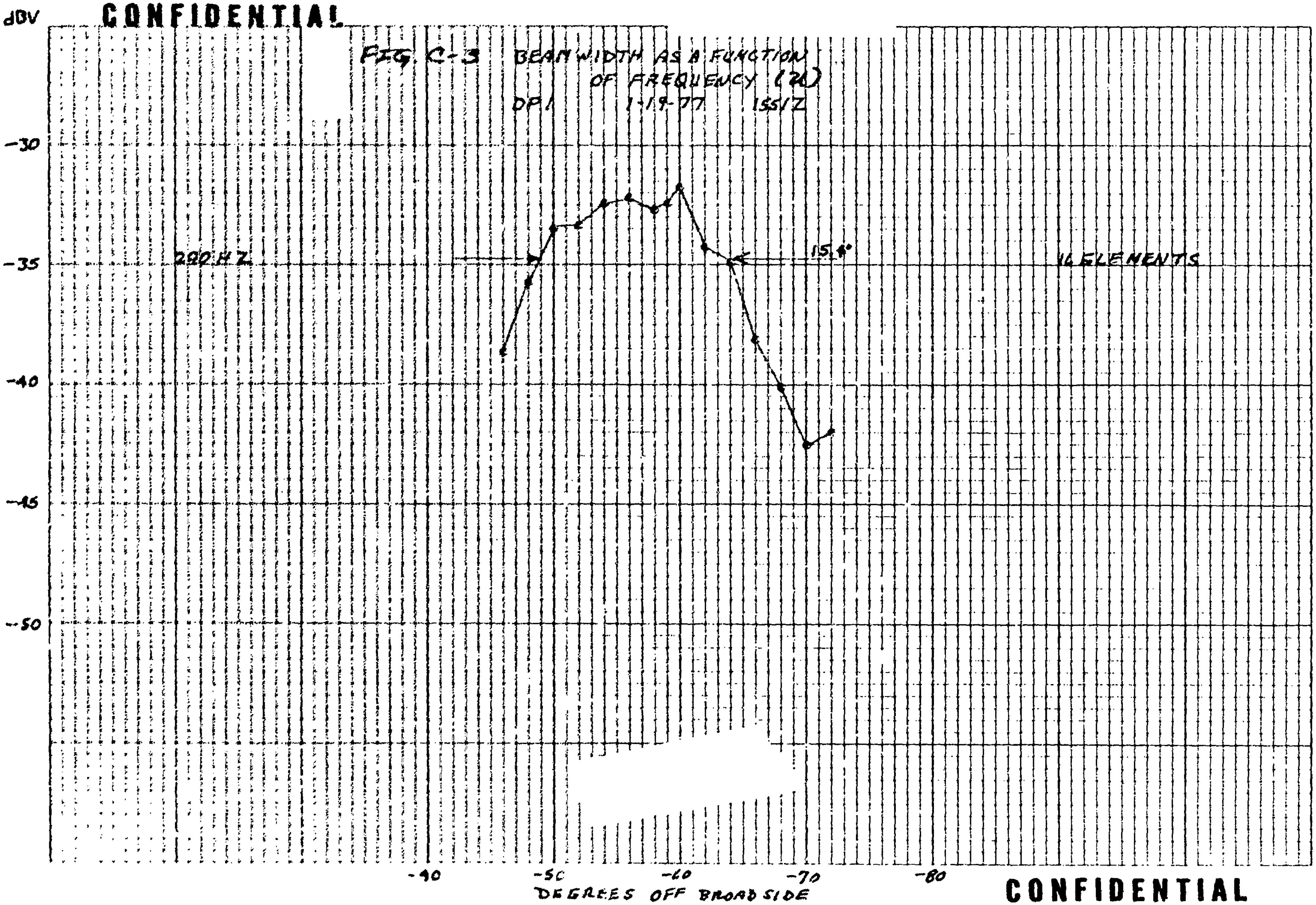


FIG. C-2 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2L)
DP1 1-19-77 15812

CONFIDENTIAL

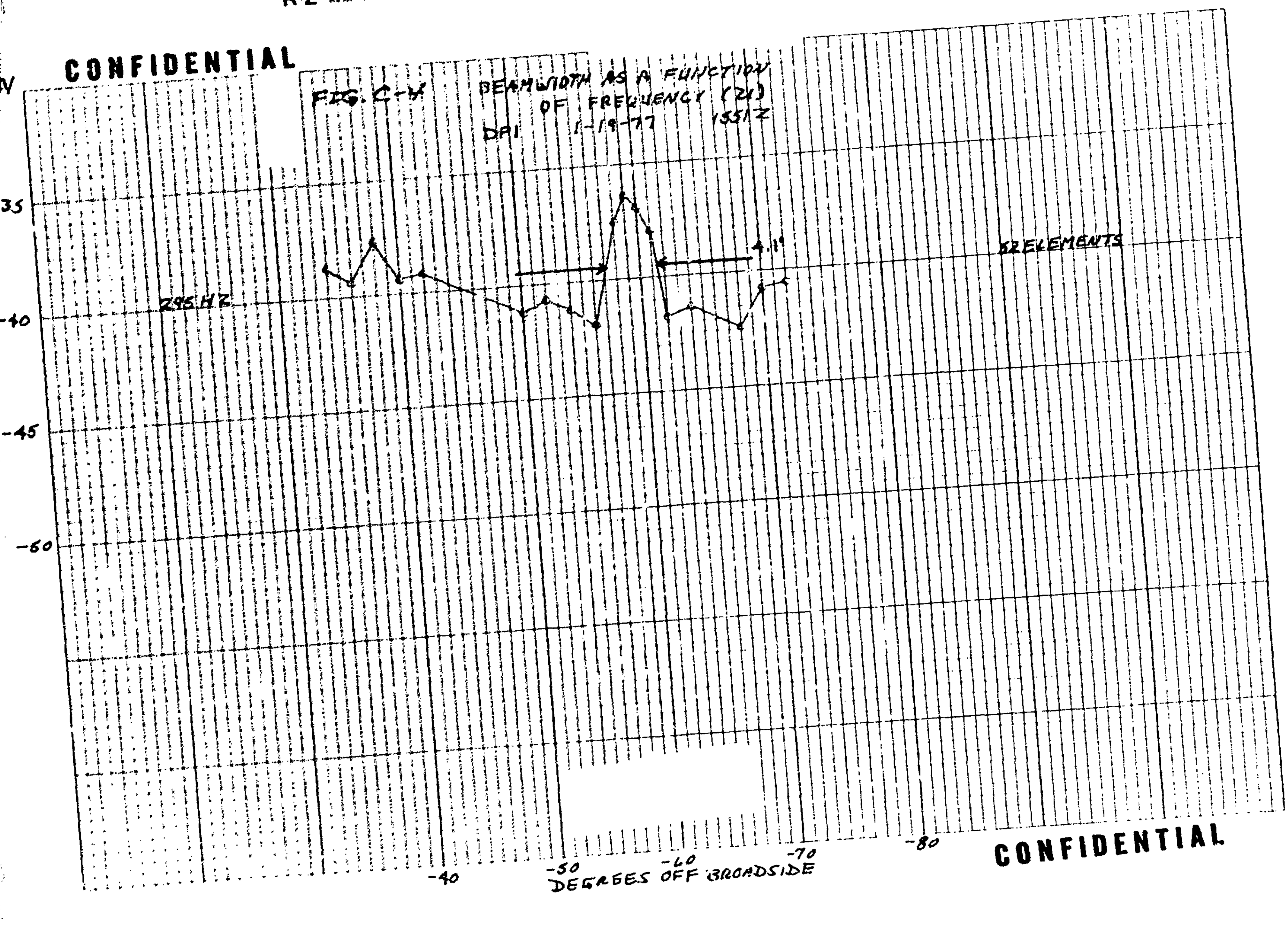
CONFIDENTIAL



CONFIDENTIAL

46 0703

CONFIDENTIAL



CONFIDENTIAL

46 0703

CONFIDENTIAL

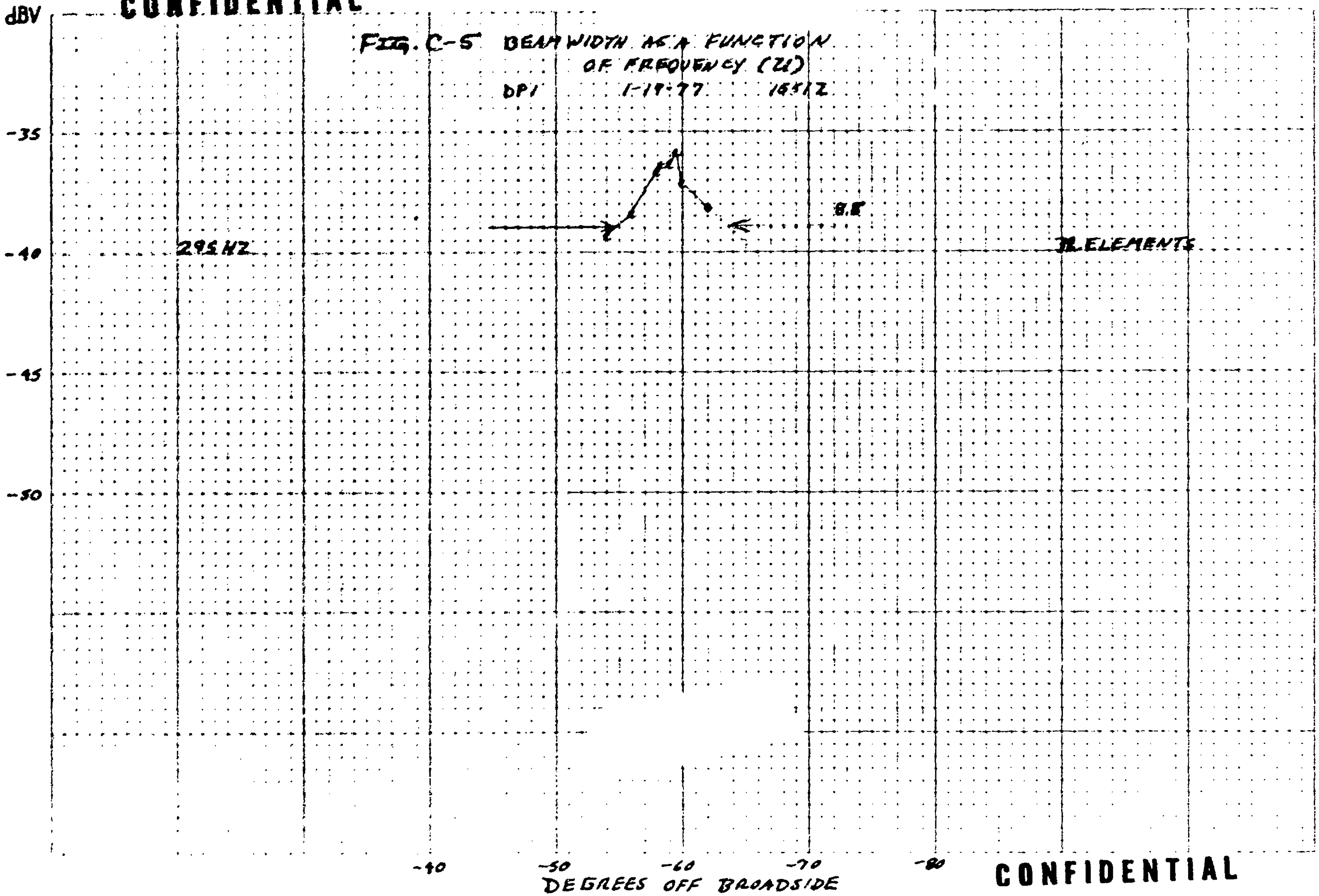


FIG. C-5 BEAMWIDTH AS A FUNCTION OF FREQUENCY (21)
DP1 1-19-77 1651Z

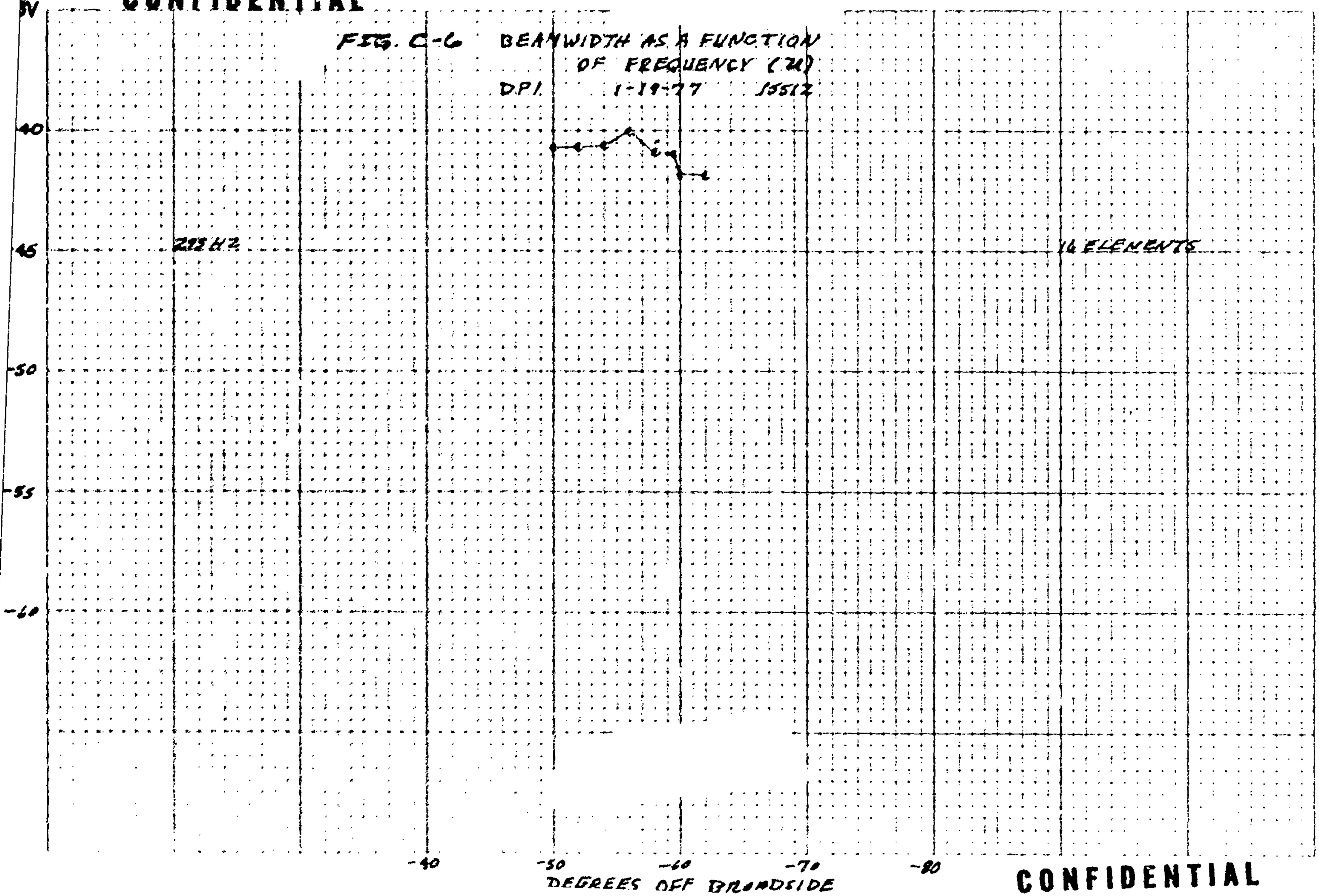
CONFIDENTIAL

K•E 46 0703

CONFIDENTIAL

FIG. C-6 BEAMWIDTH AS A FUNCTION OF FREQUENCY (H)

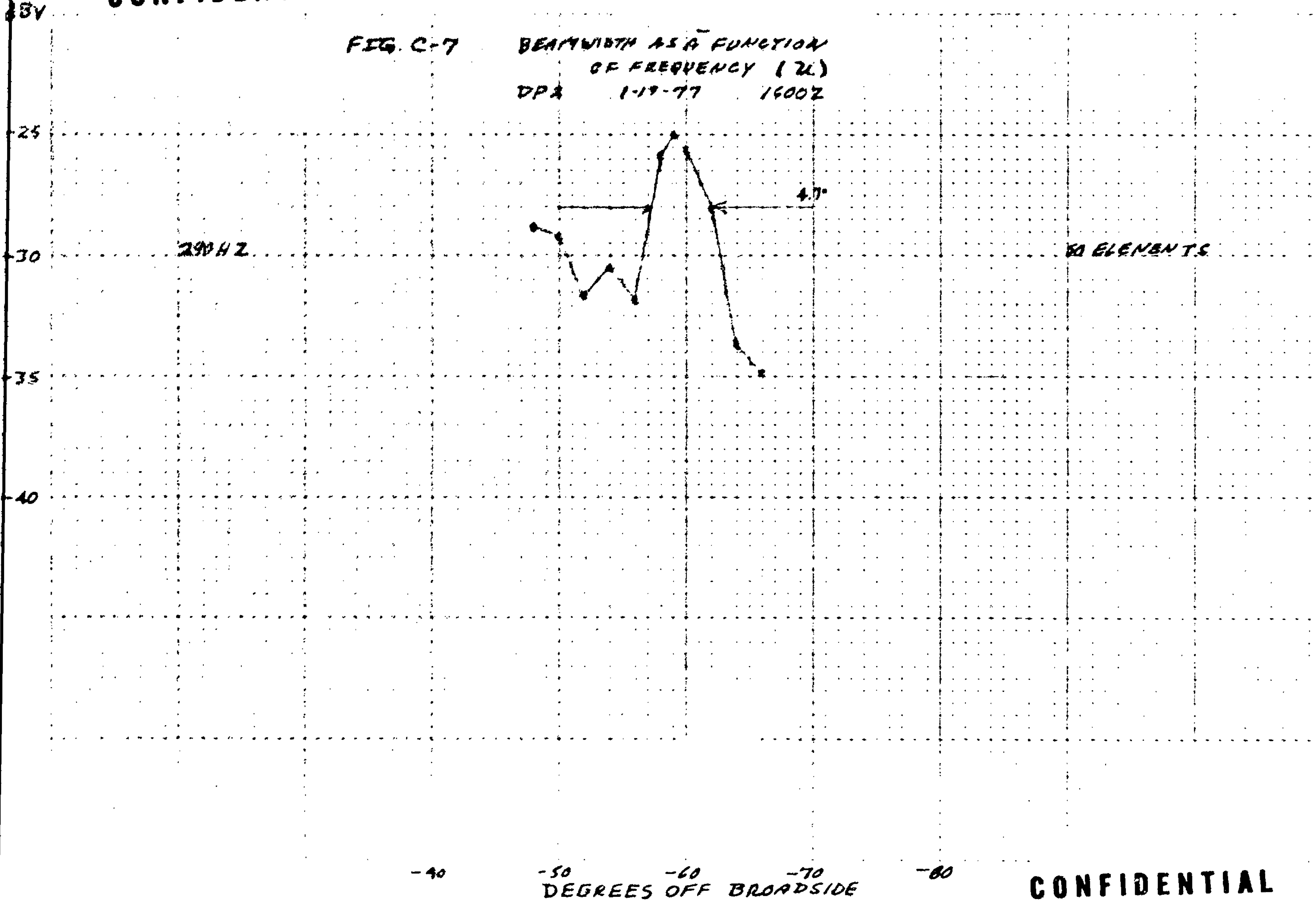
DPI 1-19-77 J5512



CONFIDENTIAL

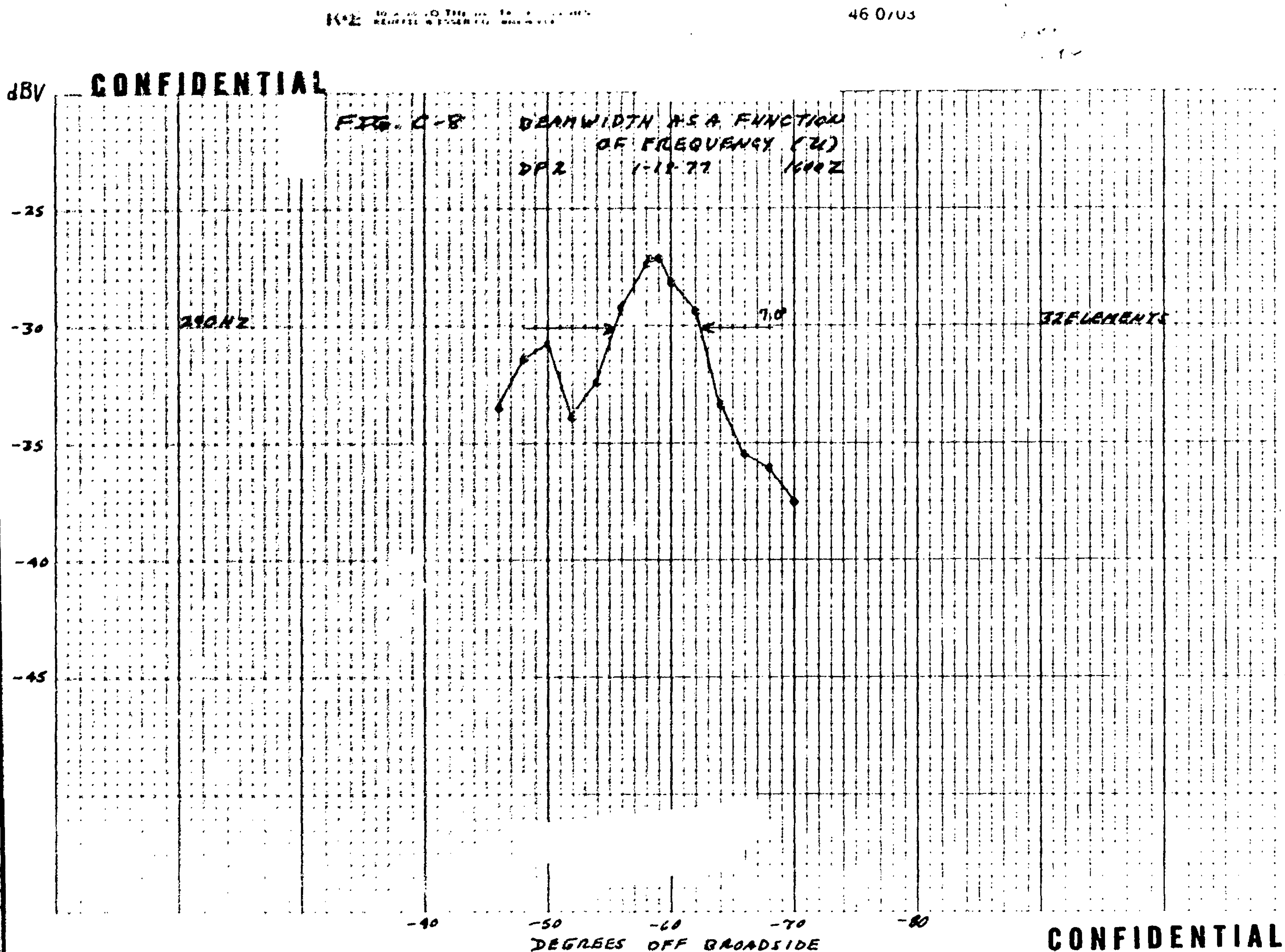
CONFIDENTIAL

FIG. C-7 BEAMWIDTH AS A FUNCTION OF FREQUENCY (U) DPA 1-19-77 1600Z

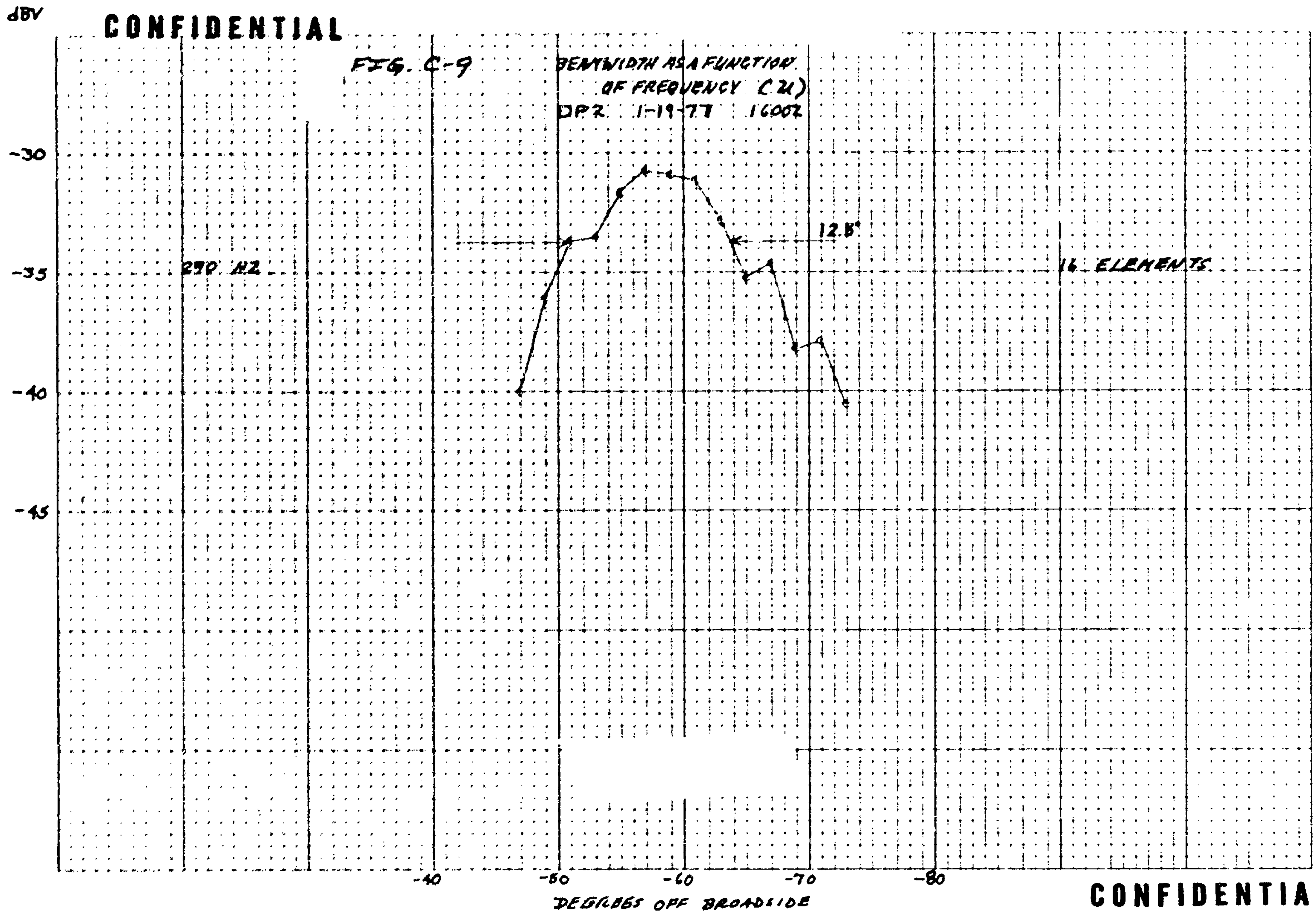


CONFIDENTIAL

CONFIDENTIAL



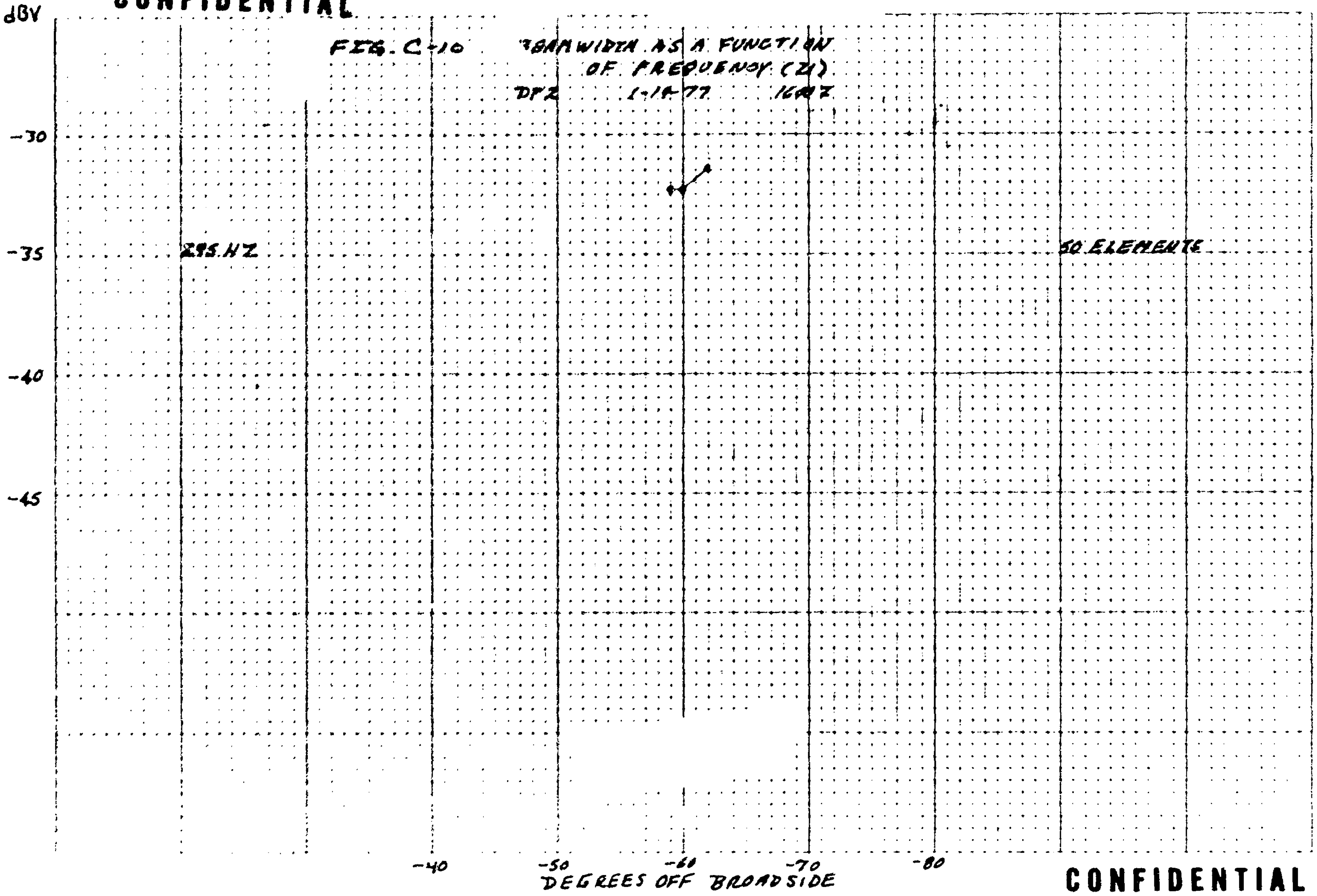
CONFIDENTIAL



CONFIDENTIAL

K•E 46 0703

CONFIDENTIAL

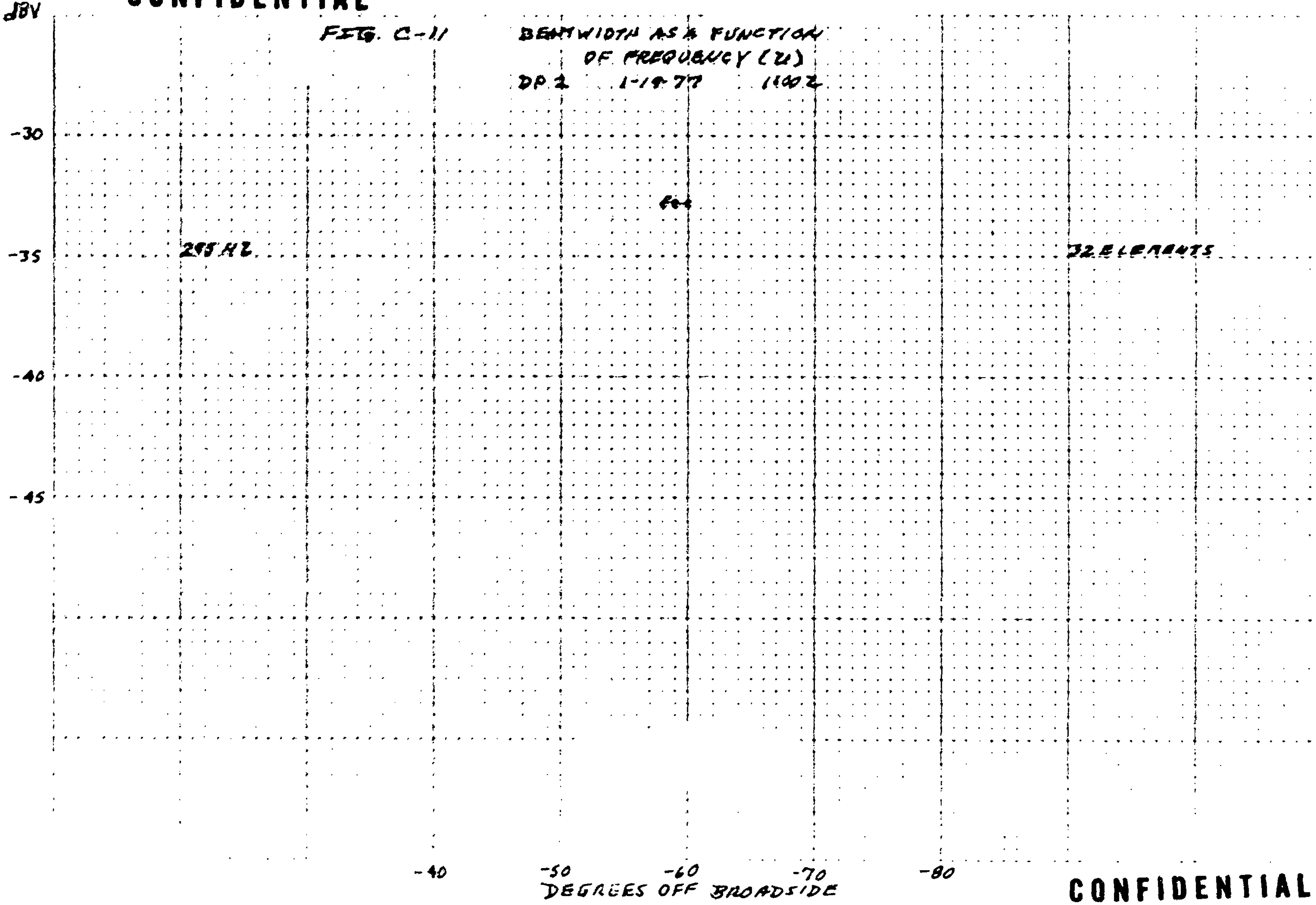


CONFIDENTIAL

K·E 46 0703

CONFIDENTIAL

FIG. C-11 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2) DP 2 1-19-77 1100Z

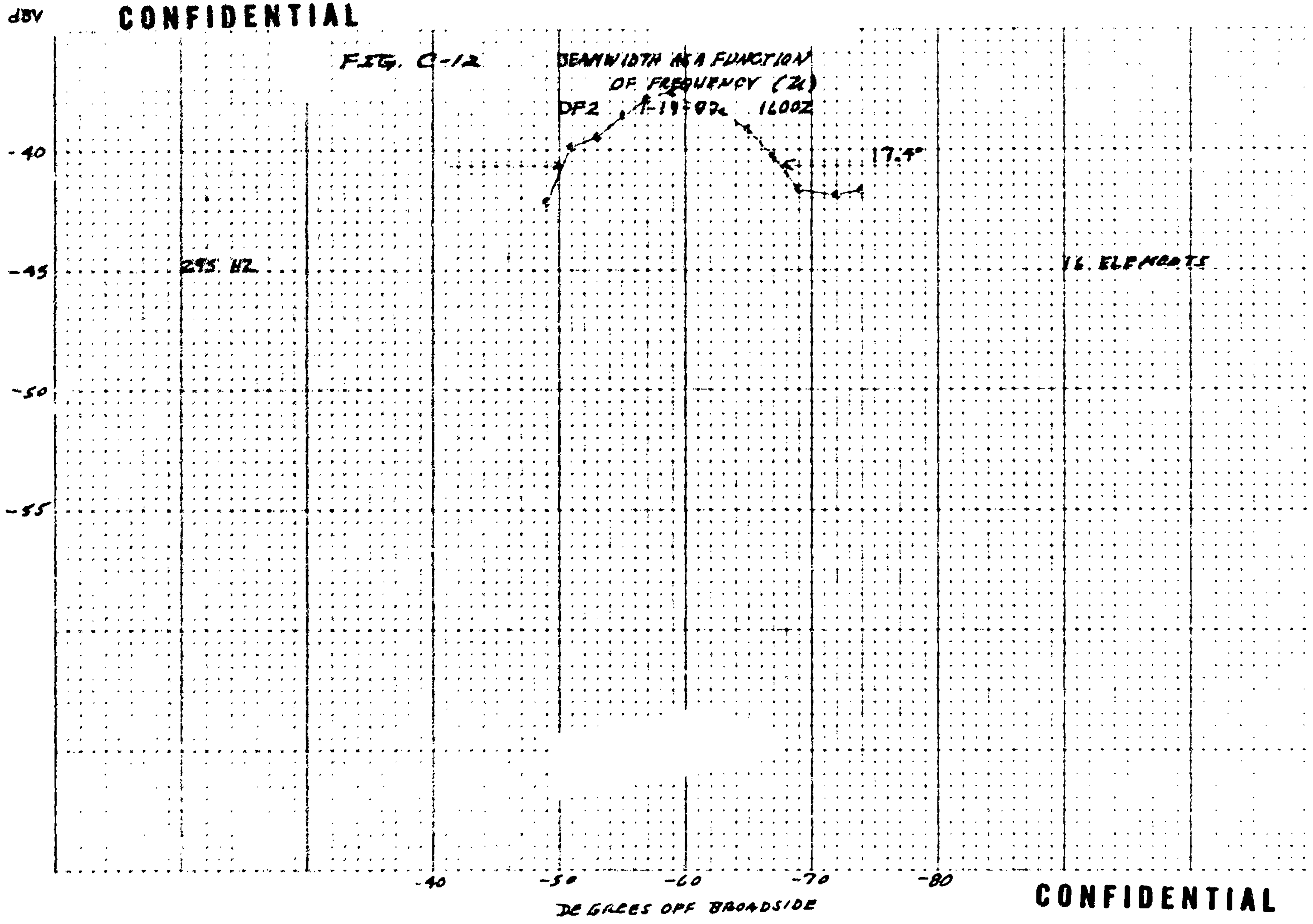


CONFIDENTIAL

46 0703

CONFIDENTIAL

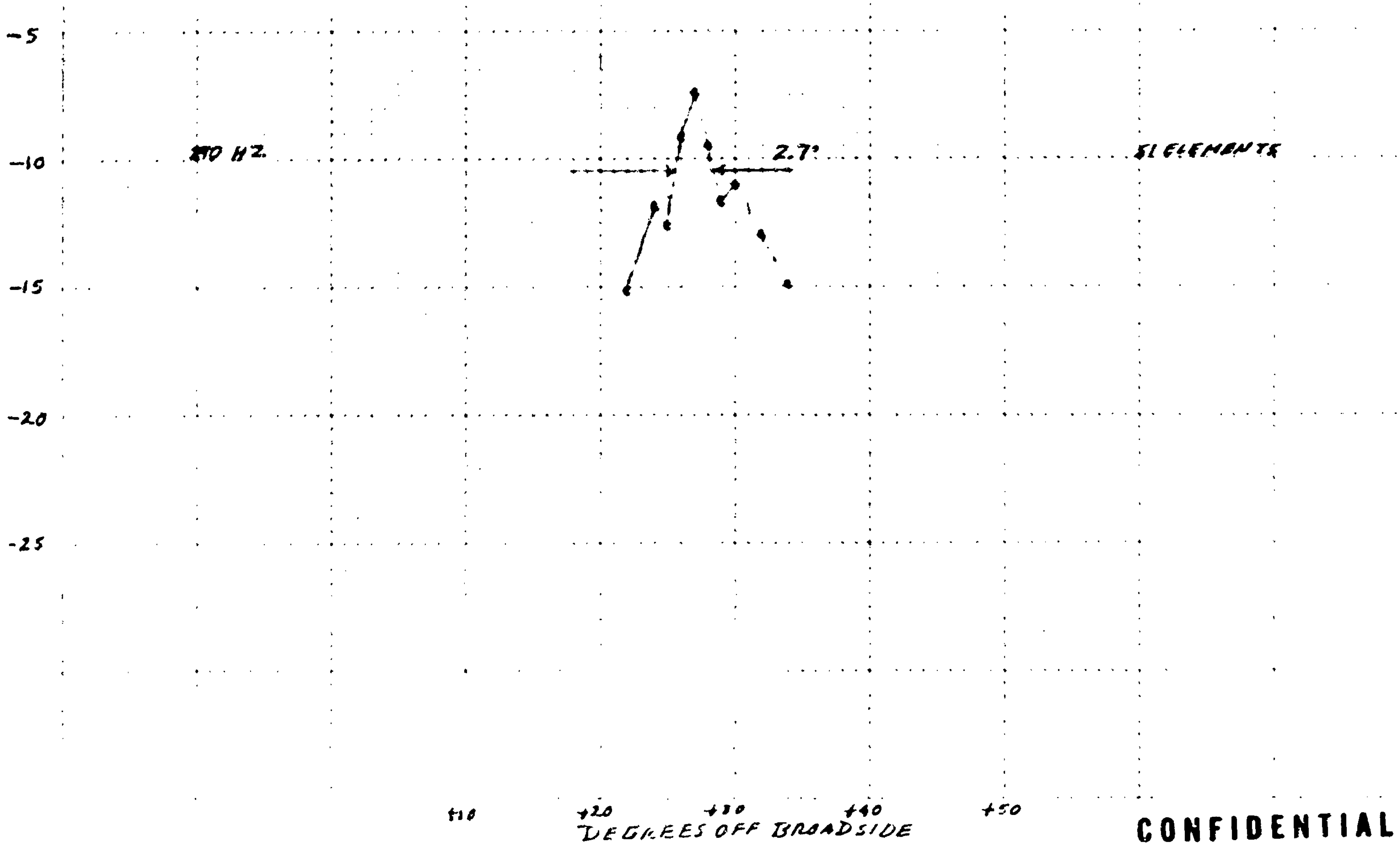
FIG. C-12



CONFIDENTIAL

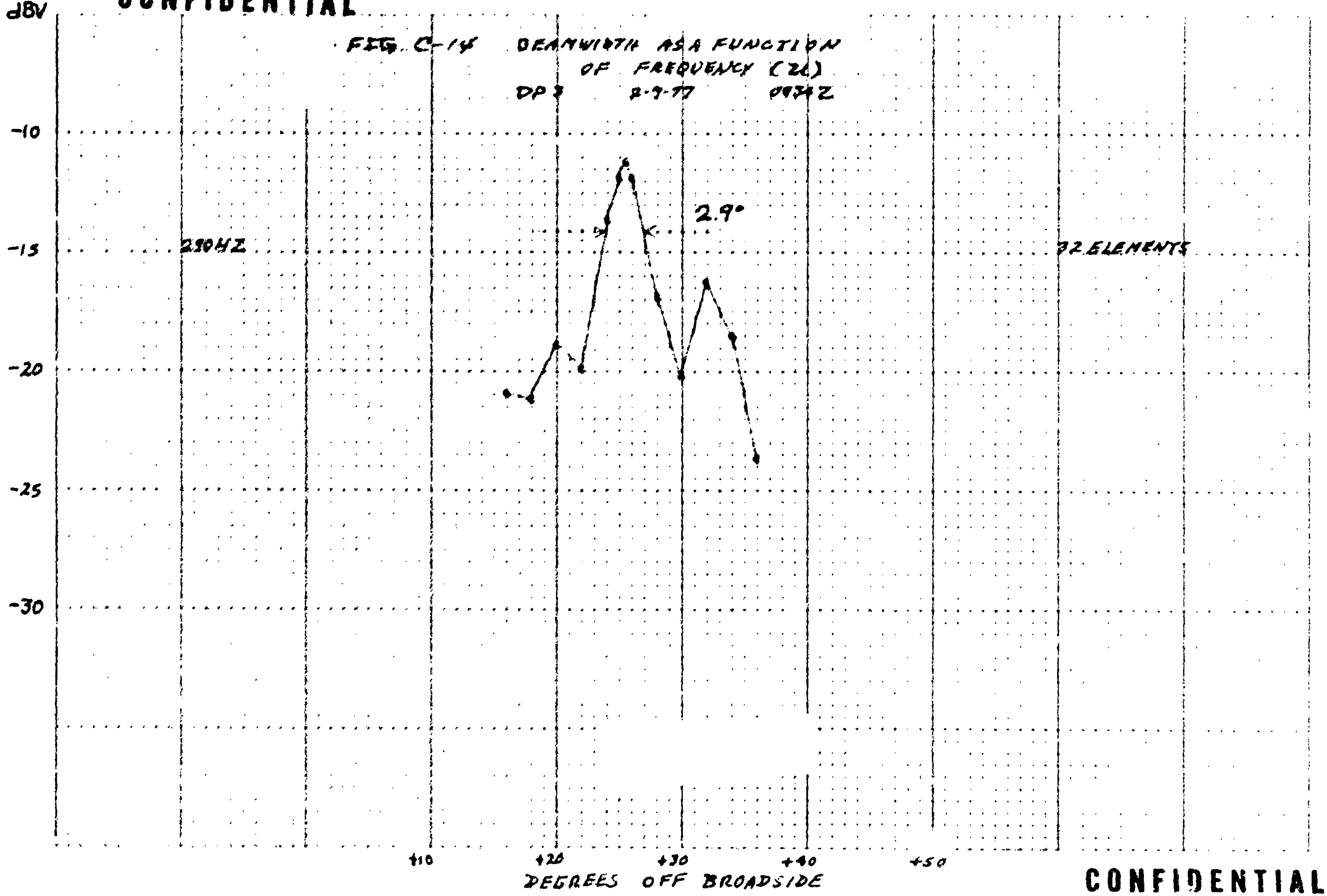
CONFIDENTIAL

FIG. C-13 BEAMWIDTH AS A FUNCTION OF FREQUENCY (H)
UPX 2.7.77 0934Z



CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

K+E 10 X 10 TO THE INCH KEUFFEL & ESSER CO. 46 0703

CONFIDENTIAL

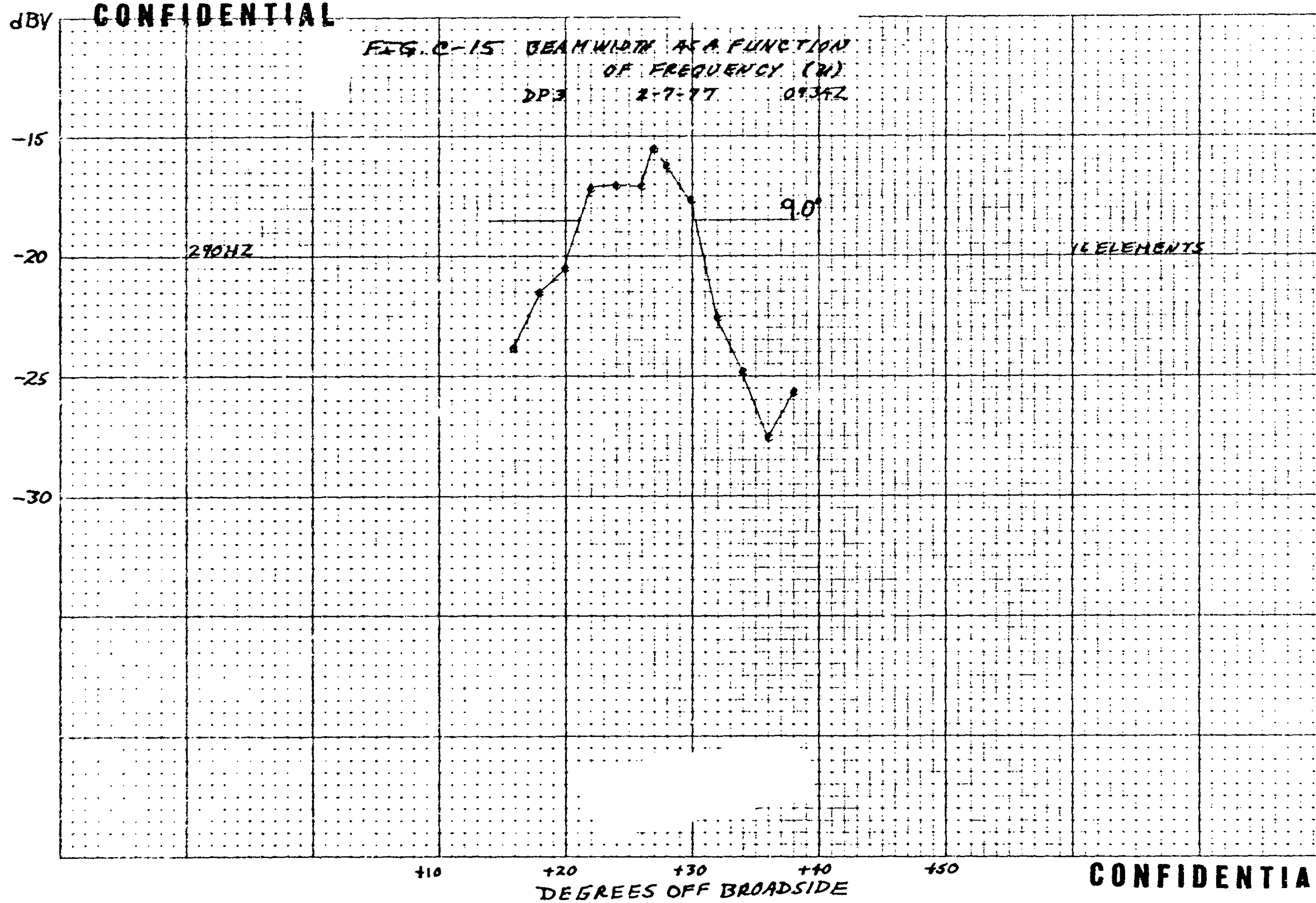
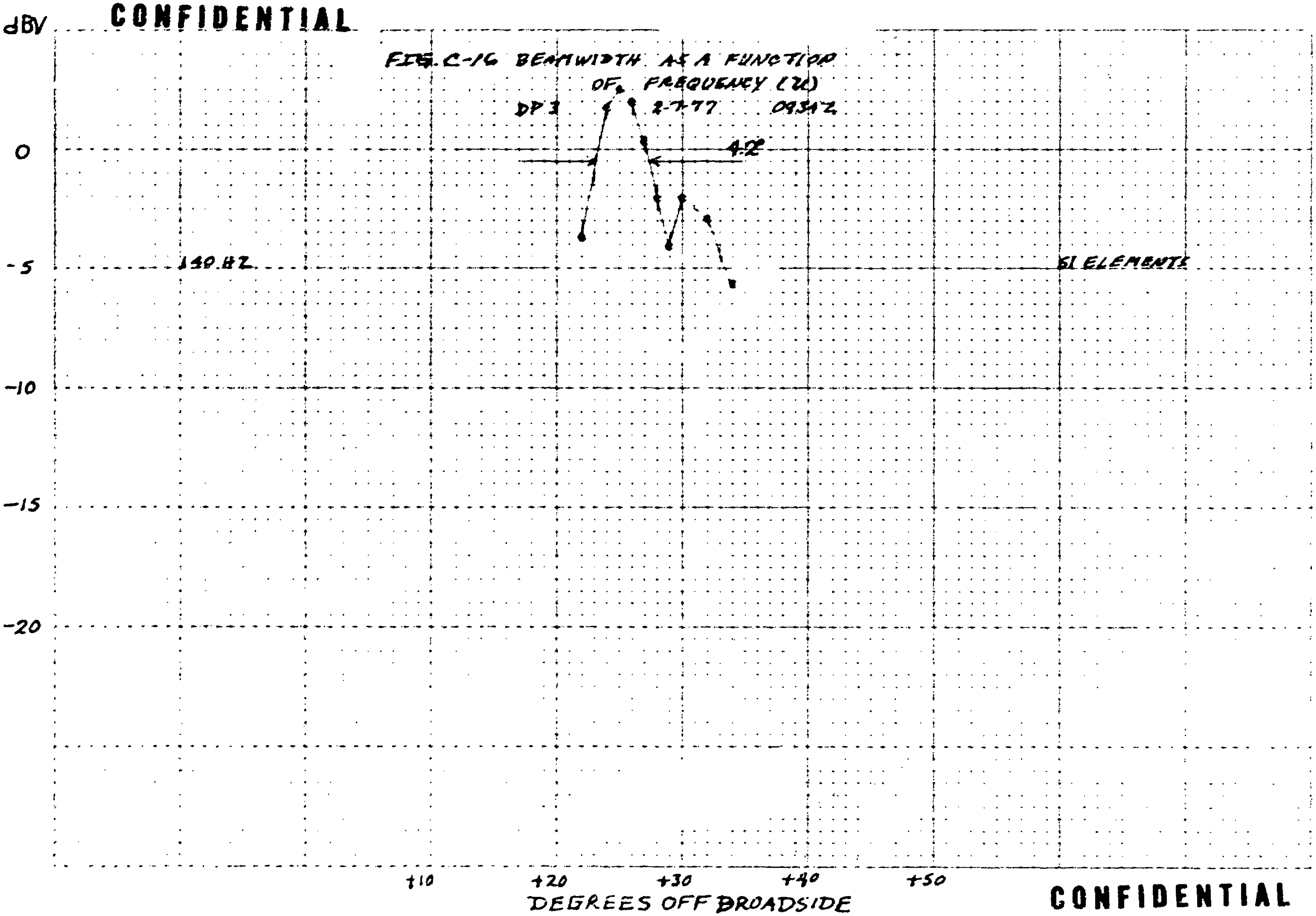


FIG. C-15 BEAMWIDTH AS A FUNCTION OF FREQUENCY (H)
DP3 2-7-77 0934Z

CONFIDENTIAL

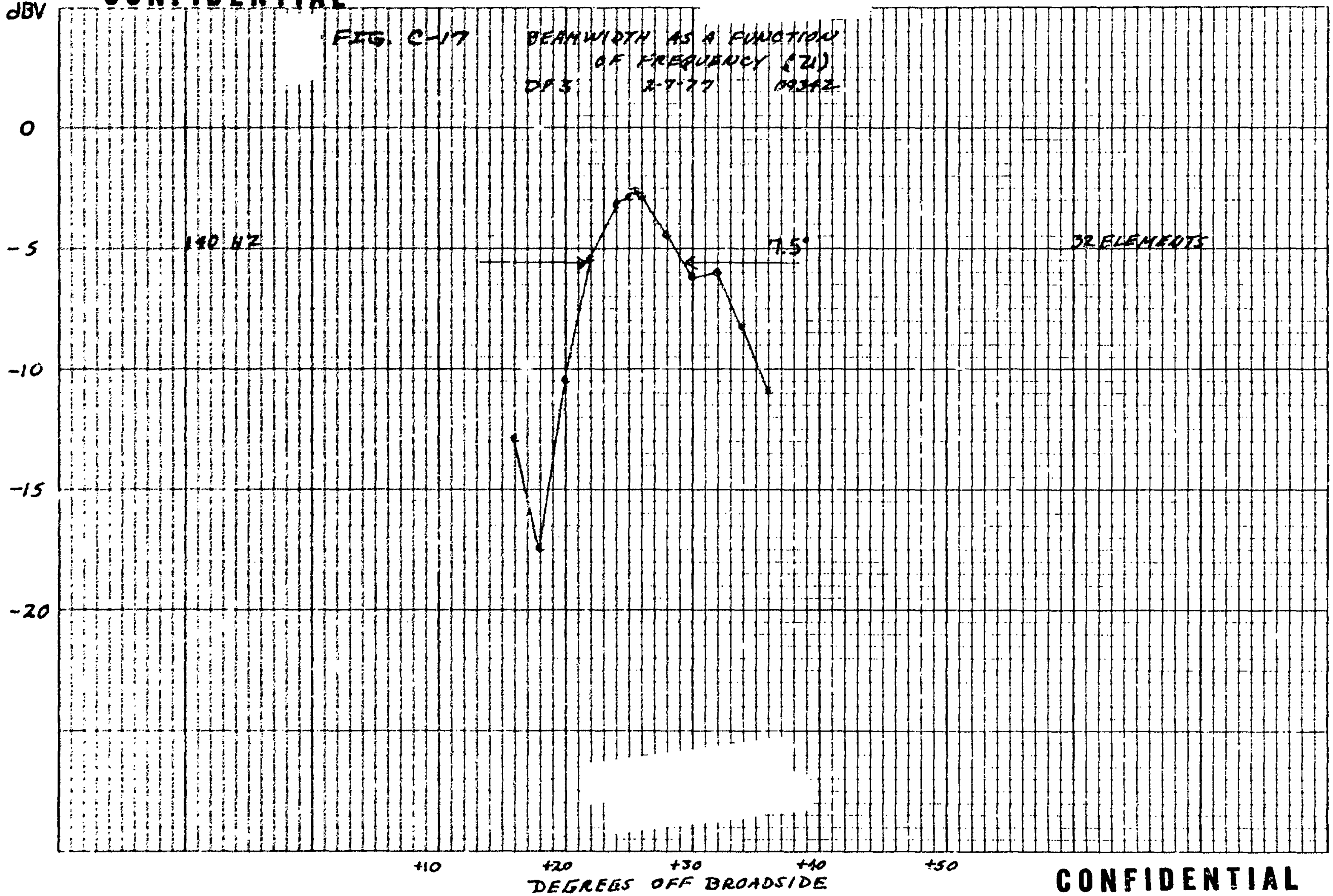
CONFIDENTIAL

FIG. C-16 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2U)



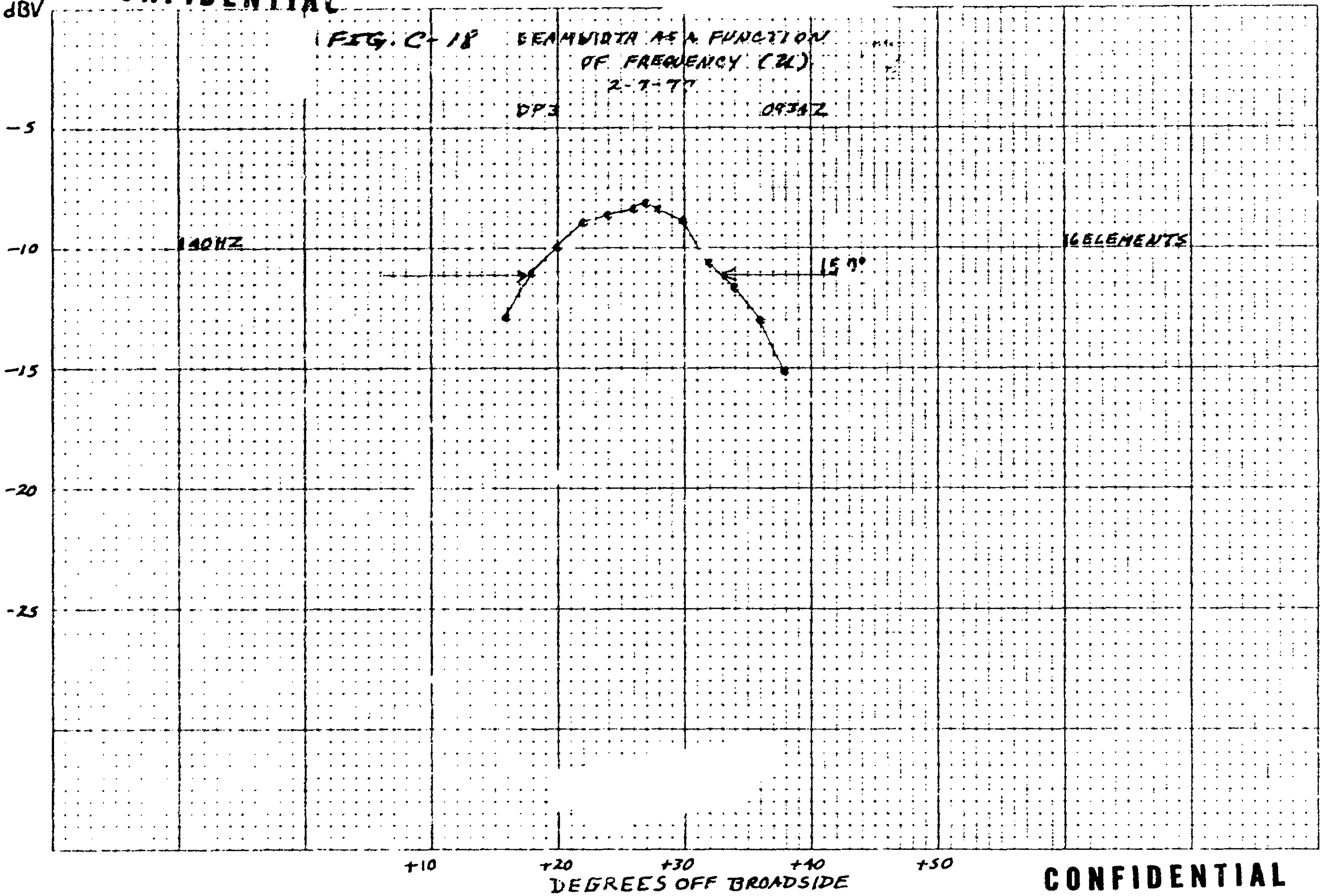
CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

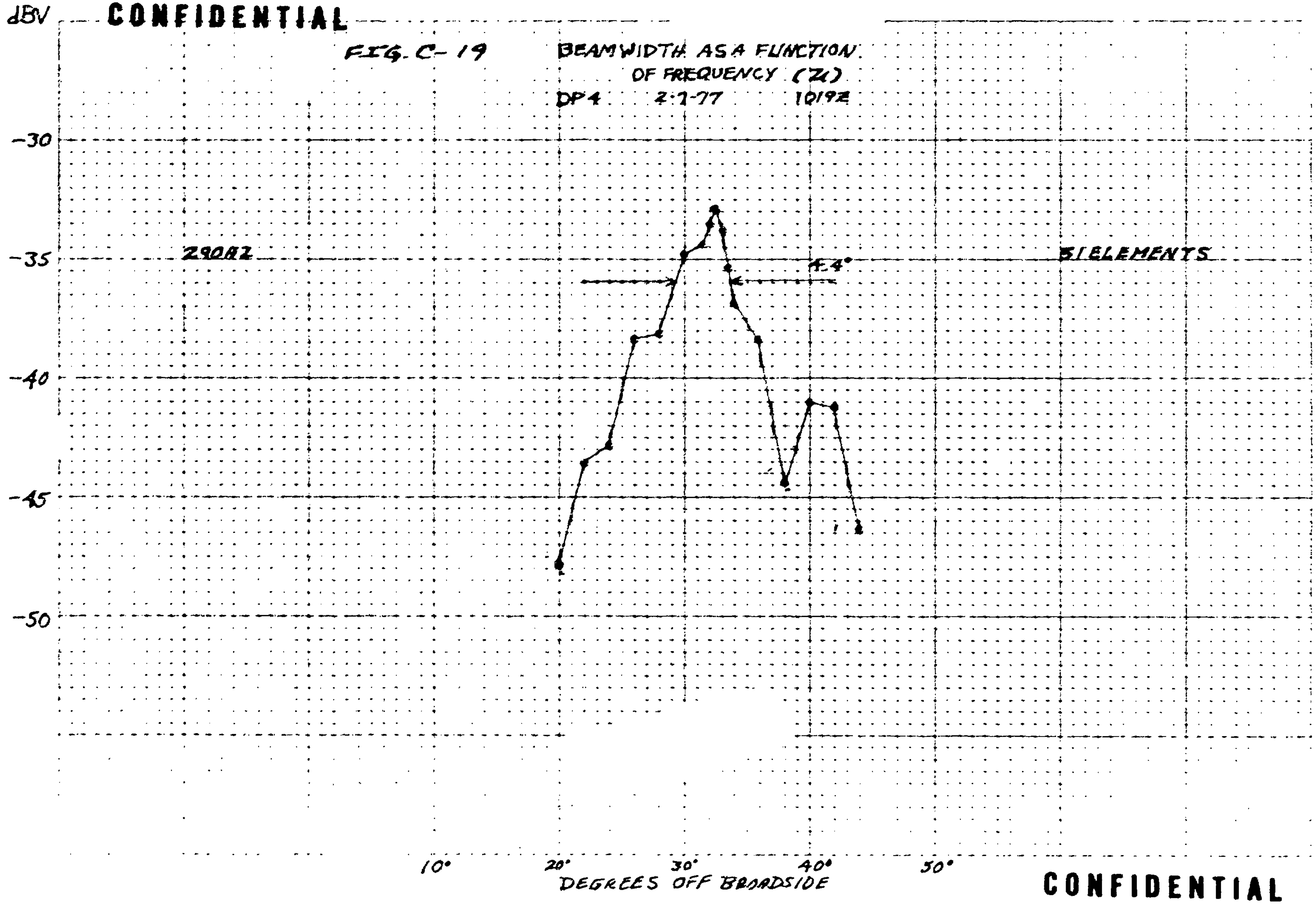
CONFIDENTIAL



CONFIDENTIAL

K+E 46 0703

CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL

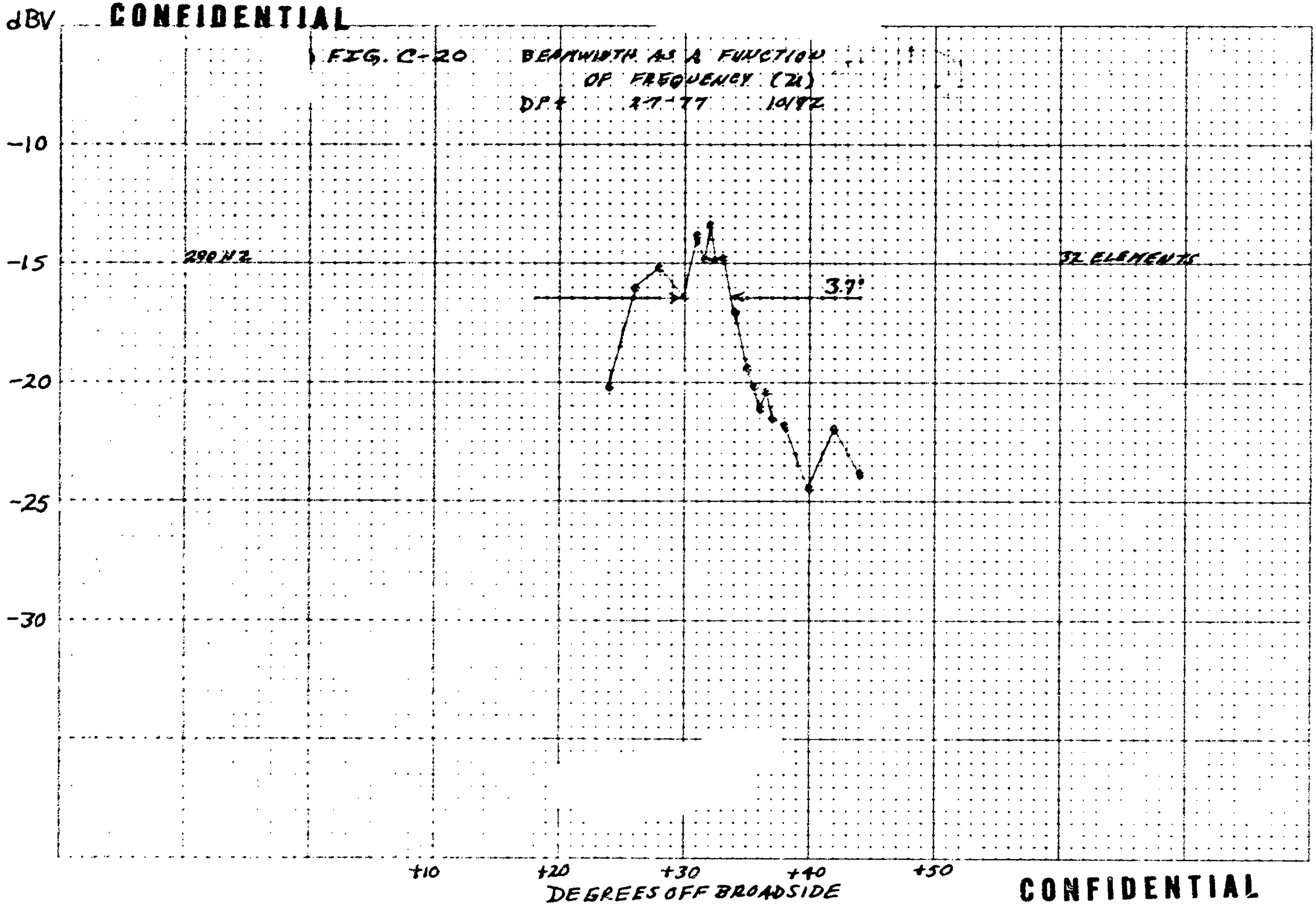
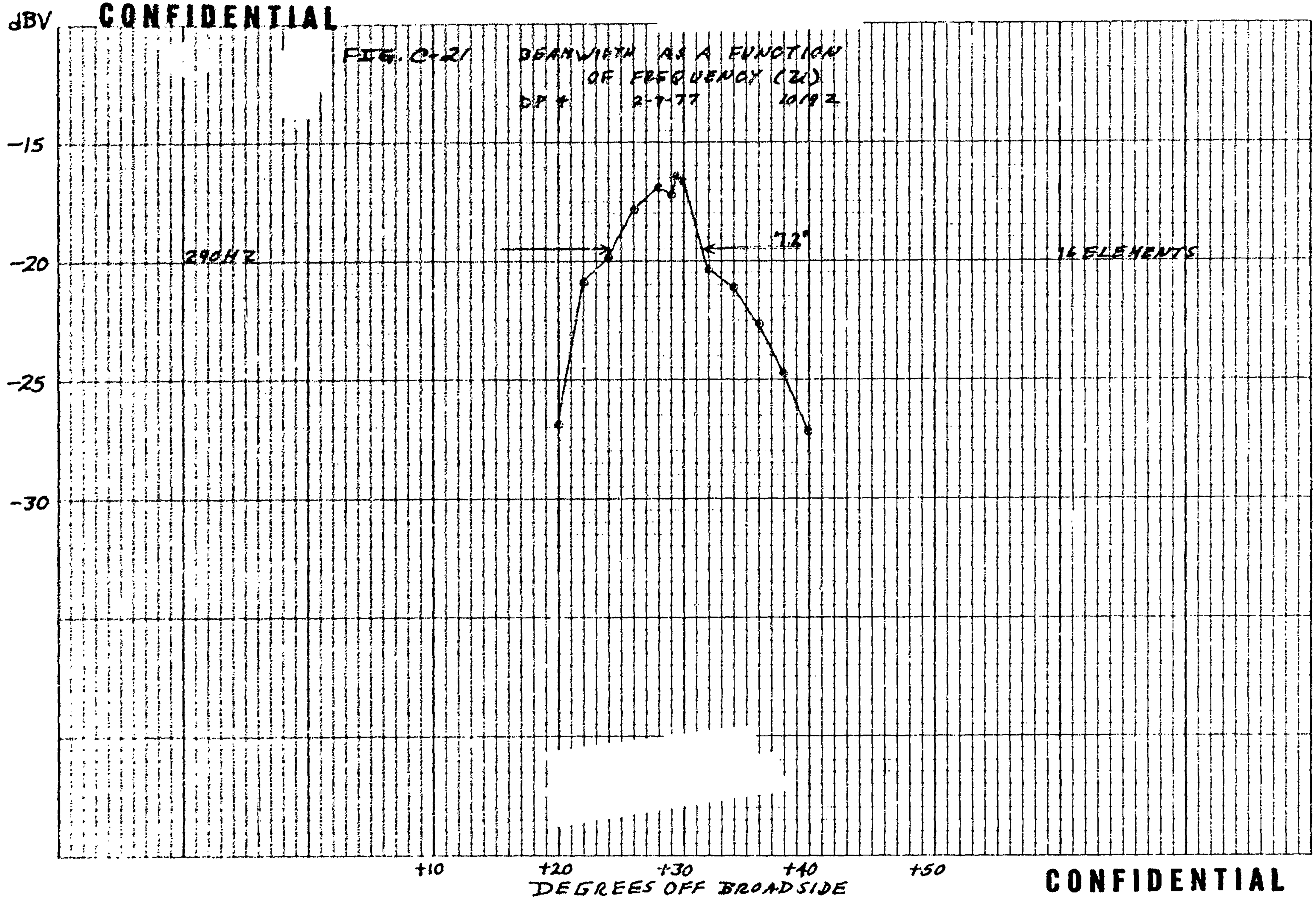


FIG. C-20 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2) DP# 2-7-77 10/82

CONFIDENTIAL

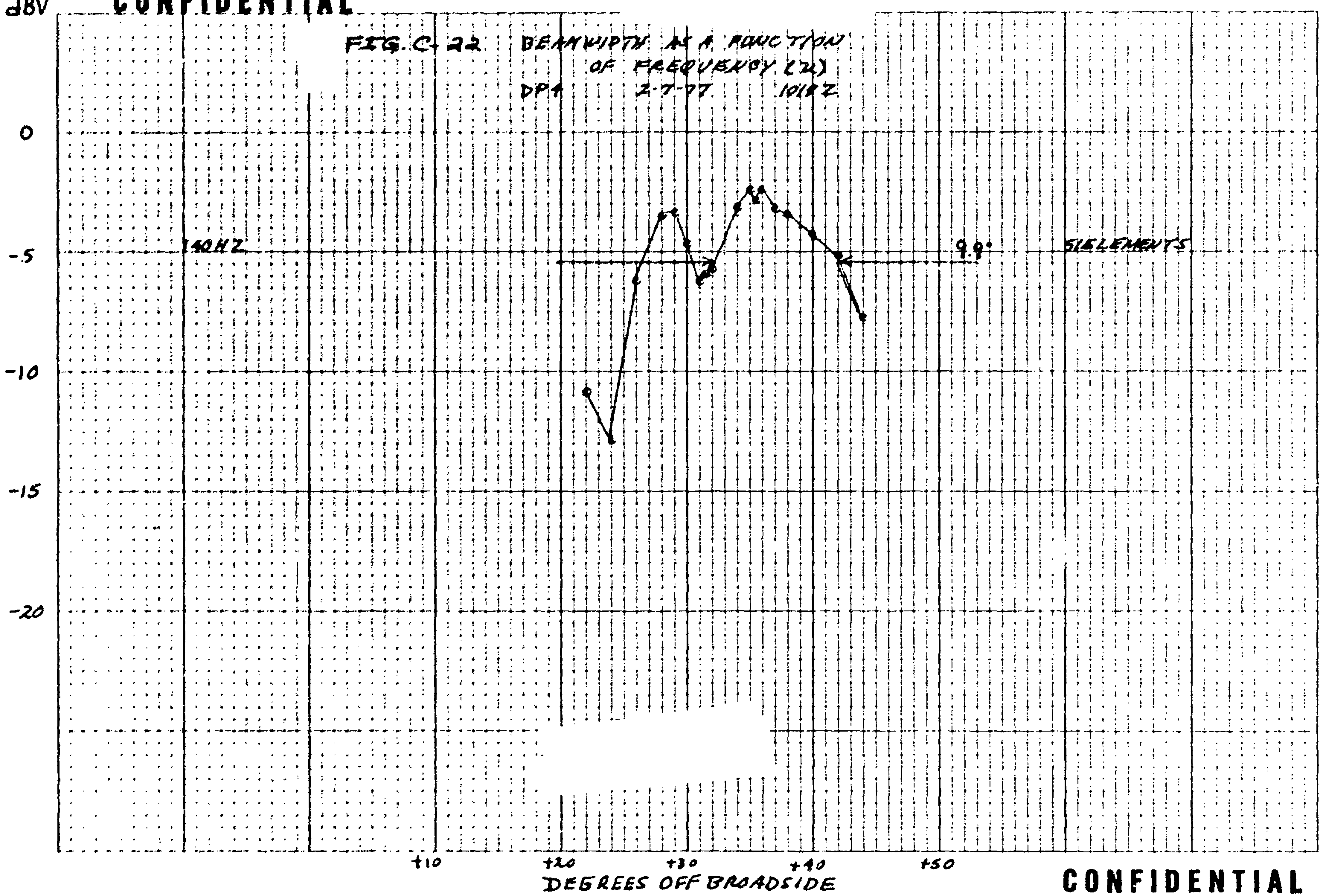
CONFIDENTIAL



CONFIDENTIAL

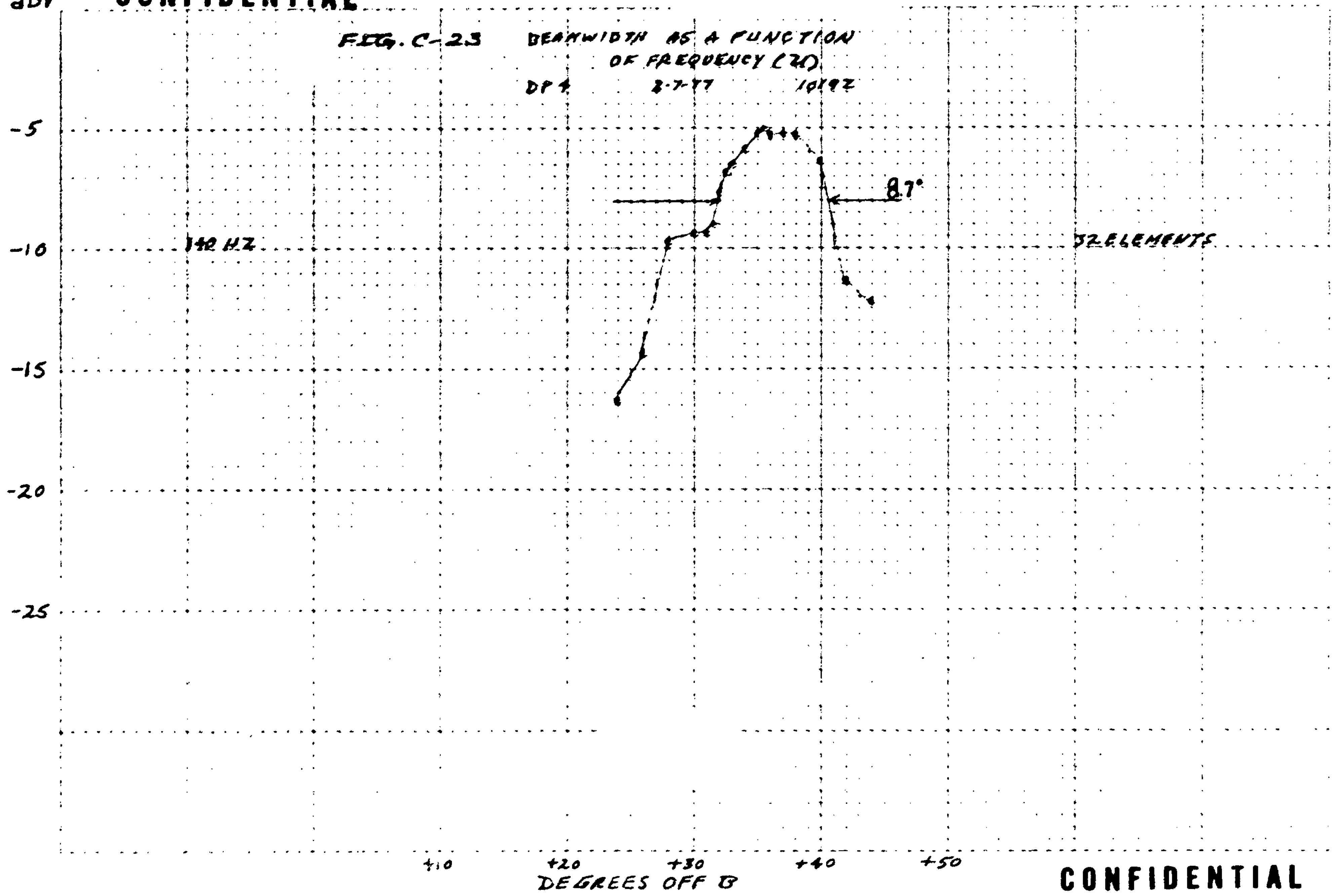
CONFIDENTIAL

FIG. C-22 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2) DP1 2-7-77 1018Z



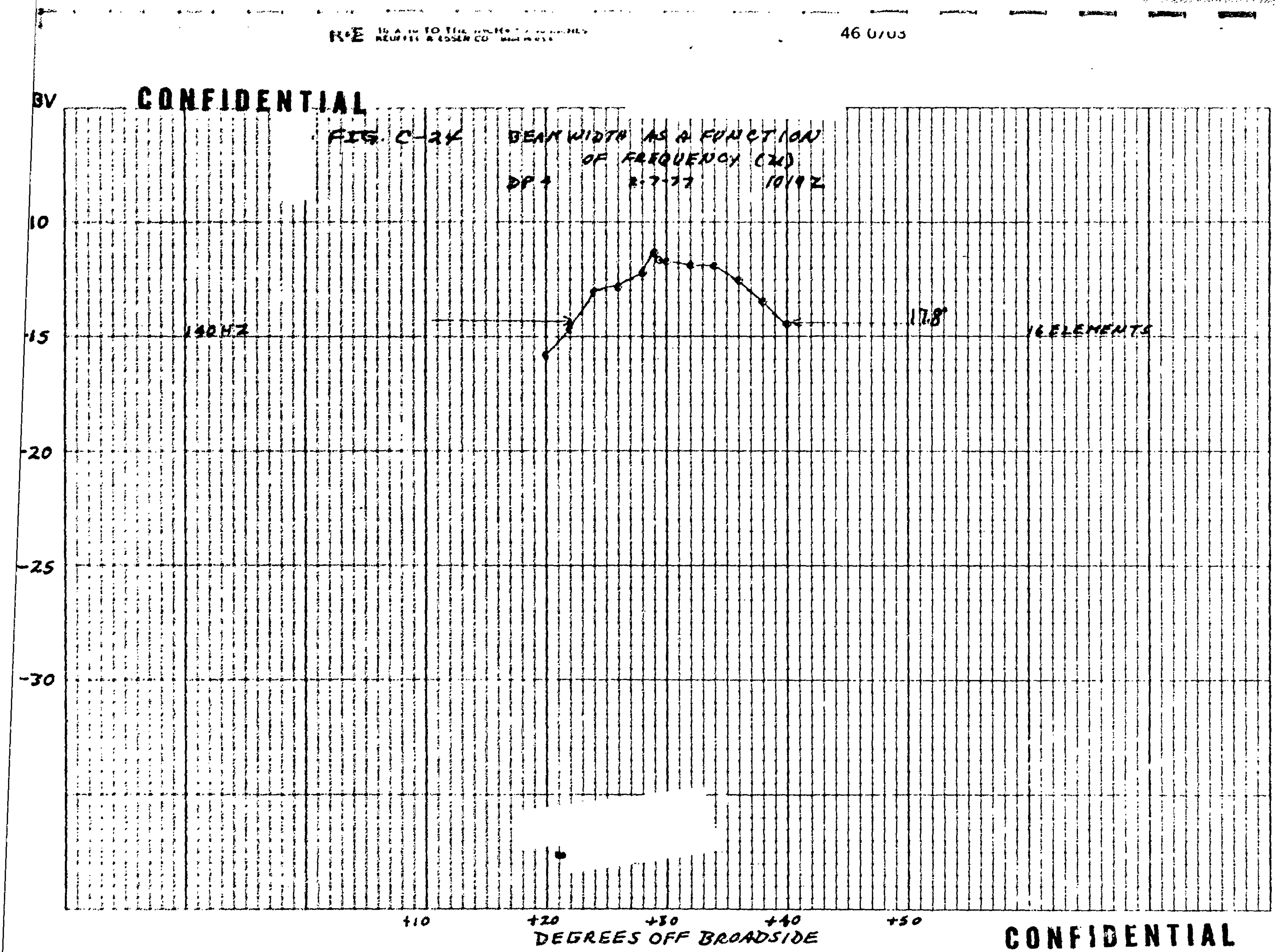
CONFIDENTIAL

CONFIDENTIAL



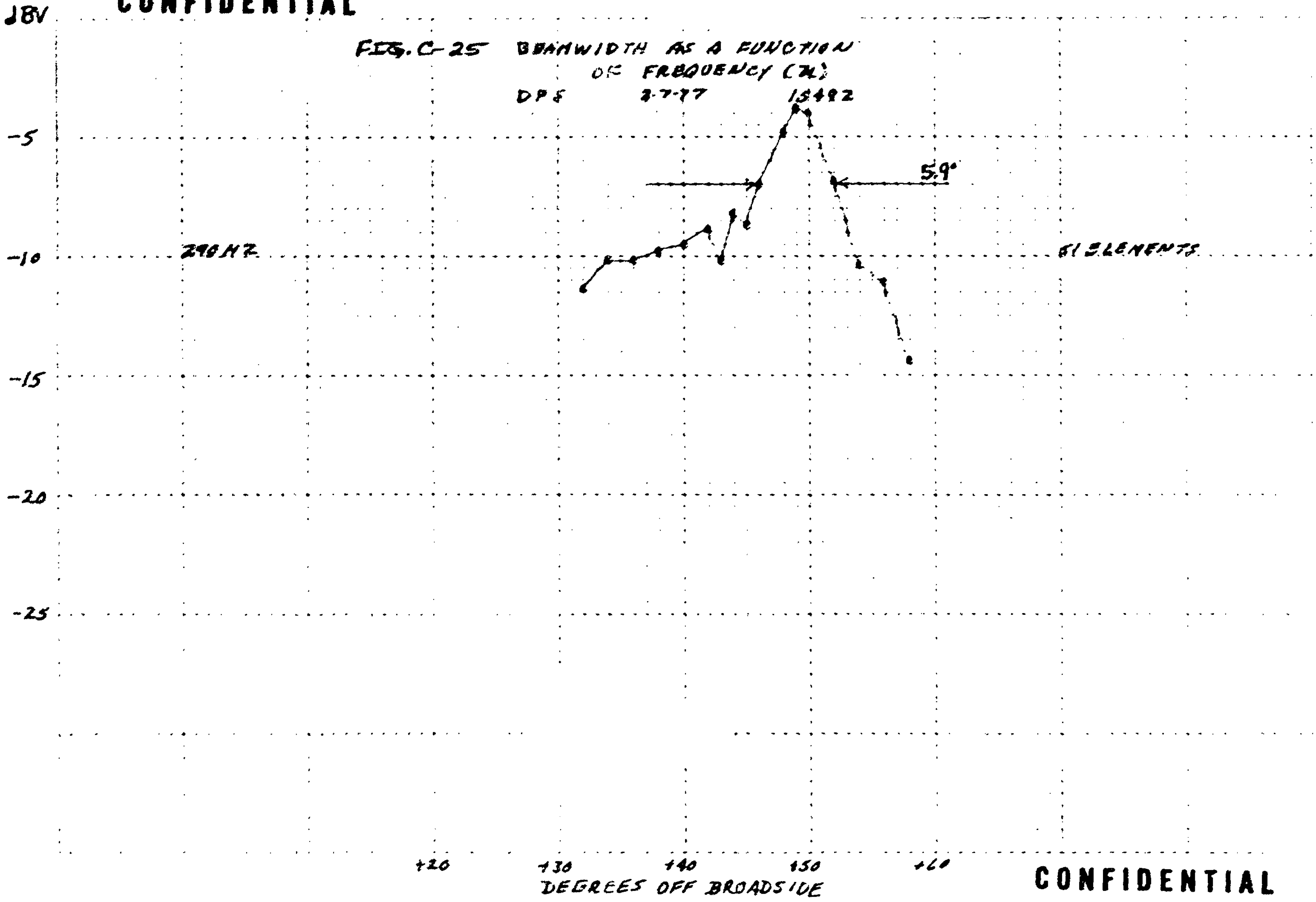
CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

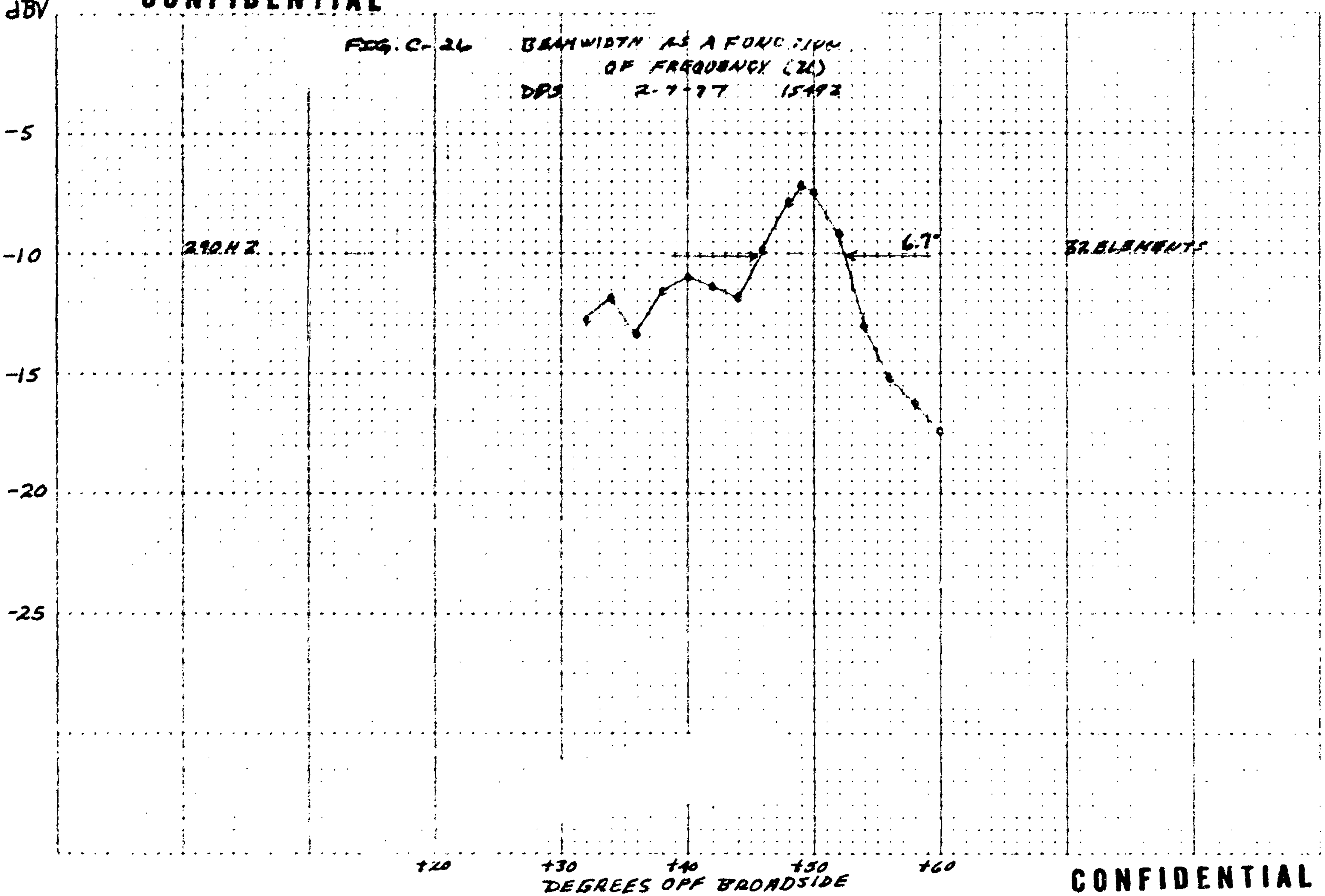
CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL

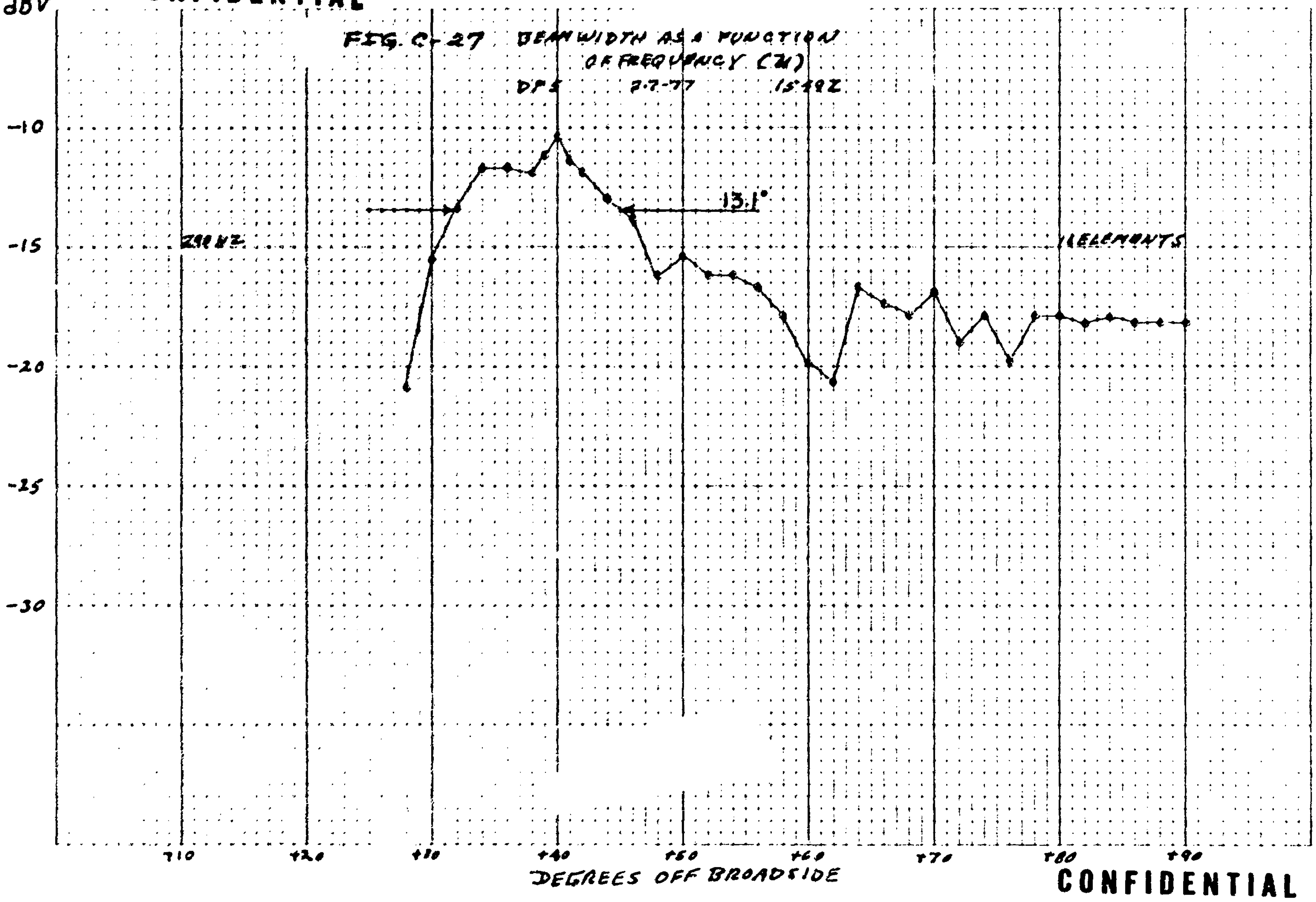
FIG. C-26 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2L)
DPS 2-7-77 1549Z



CONFIDENTIAL

K+E 46 0703

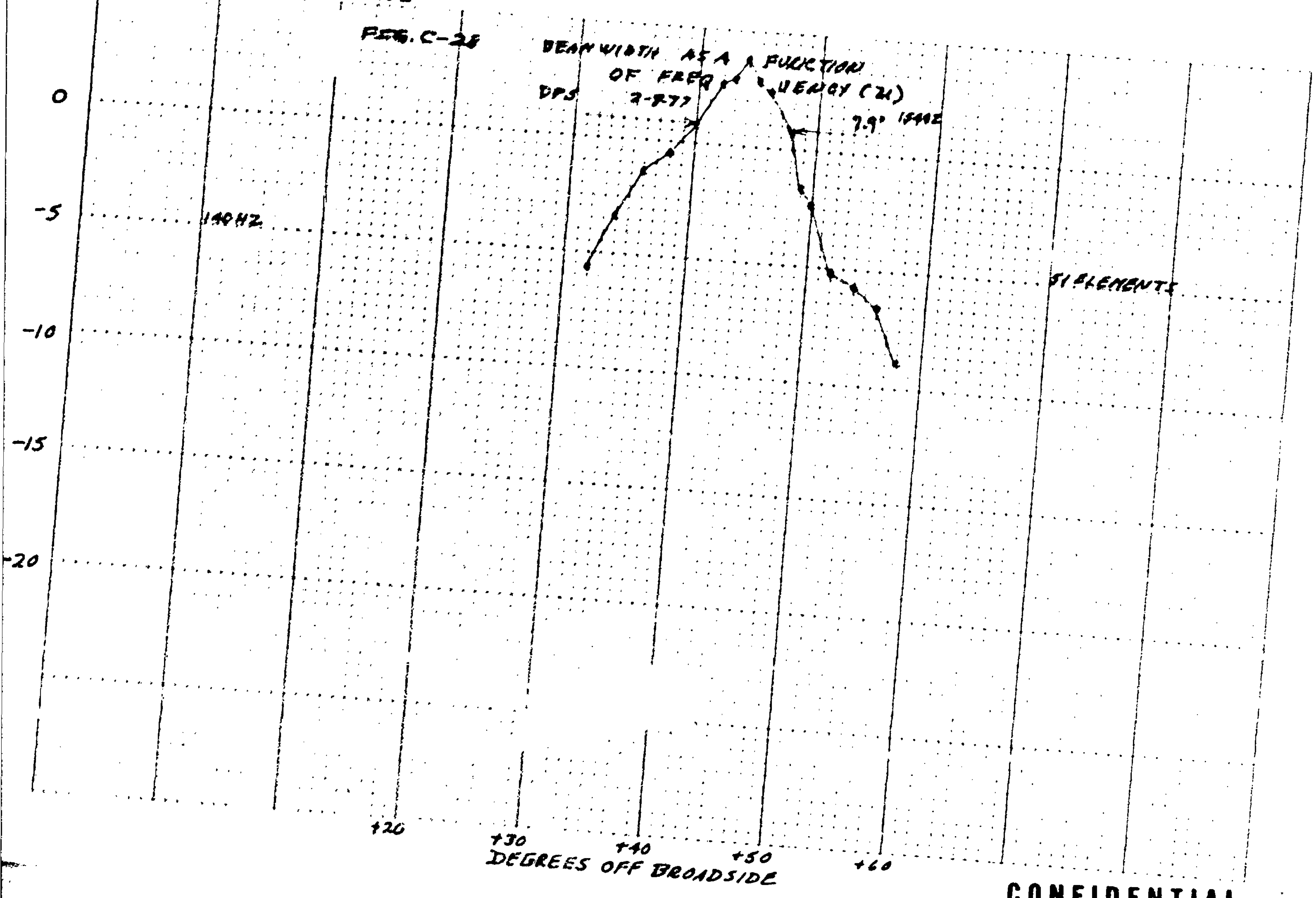
CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL

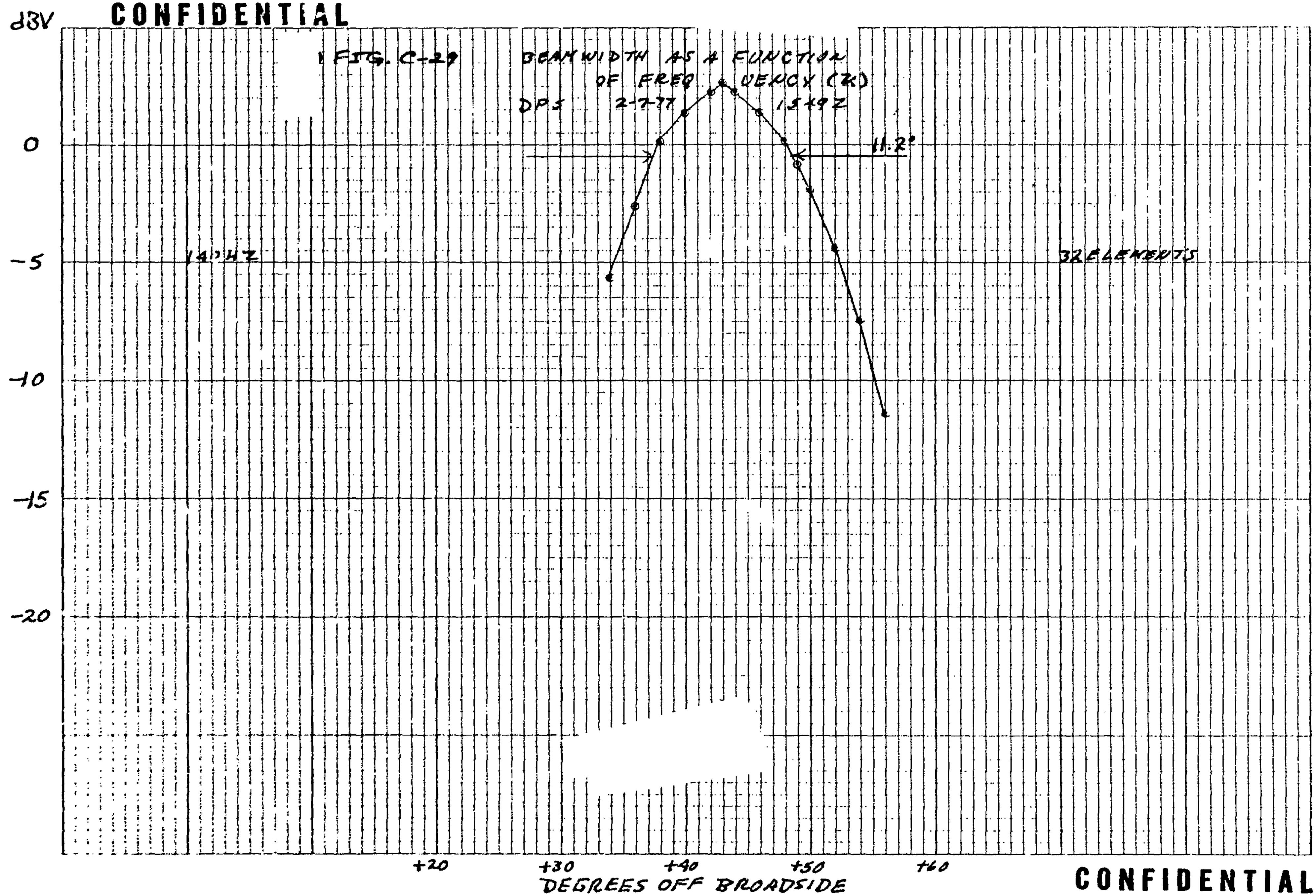
FIG. C-28



CONFIDENTIAL

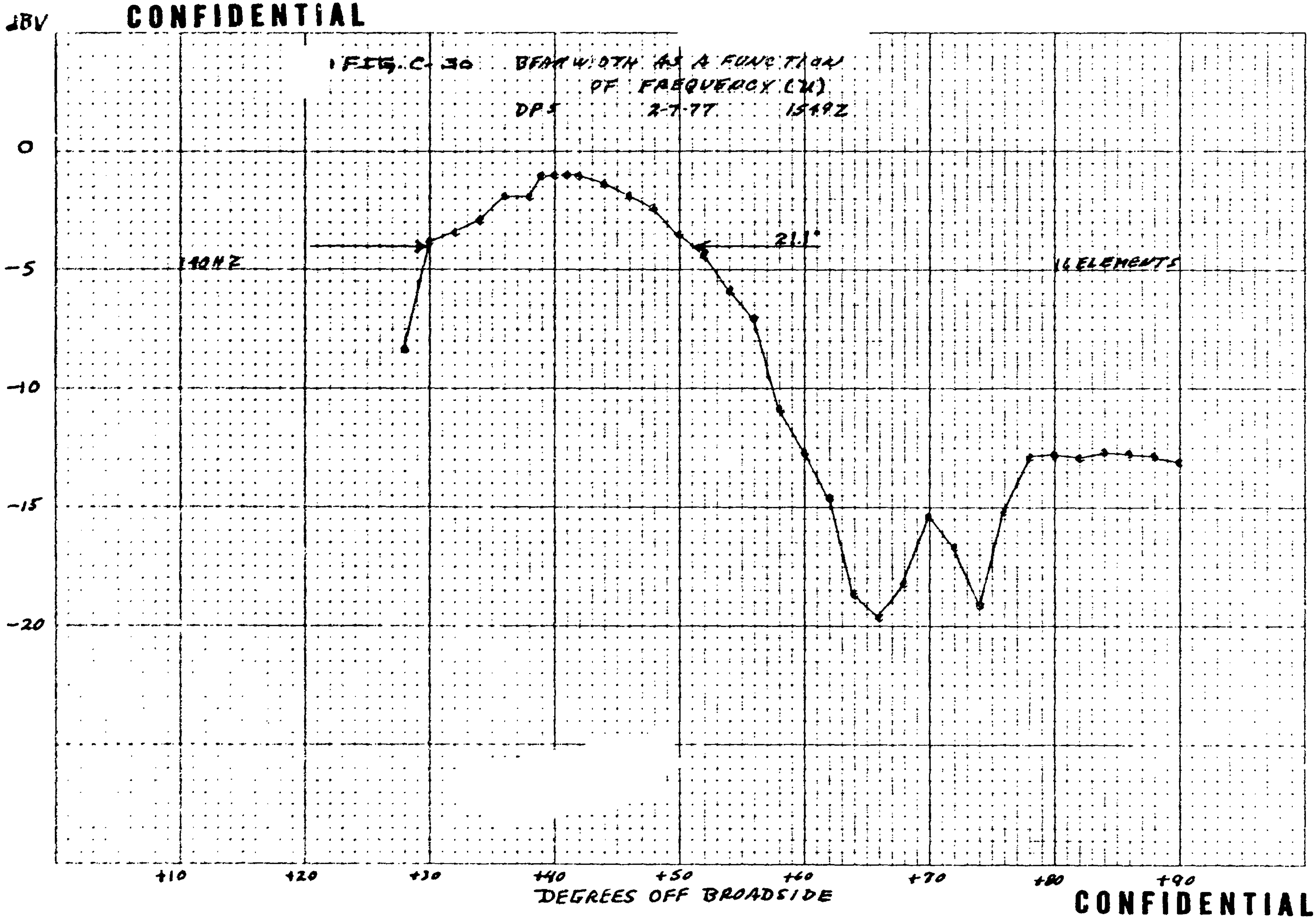
CONFIDENTIAL

FIG. C-29



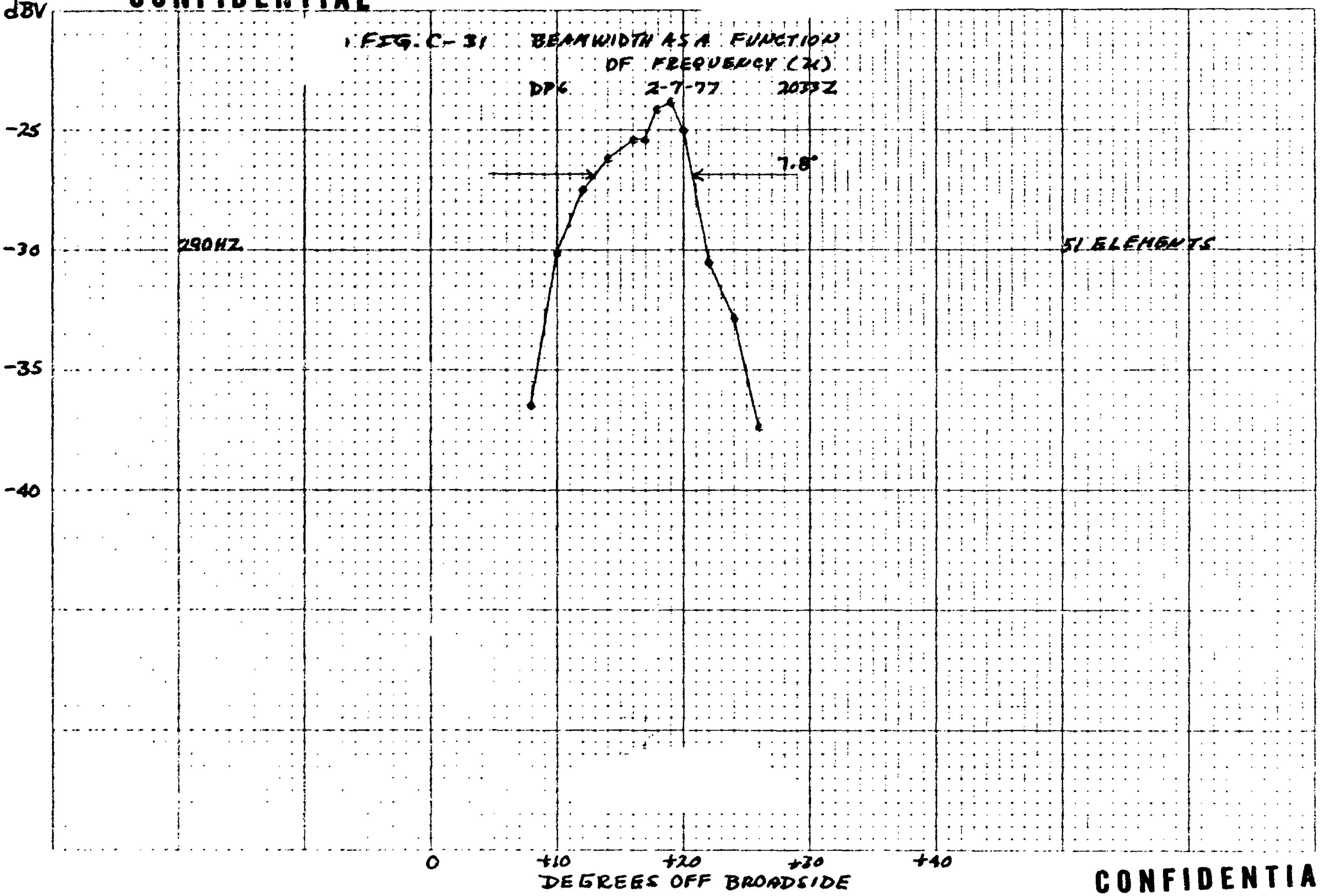
CONFIDENTIAL

CONFIDENTIAL



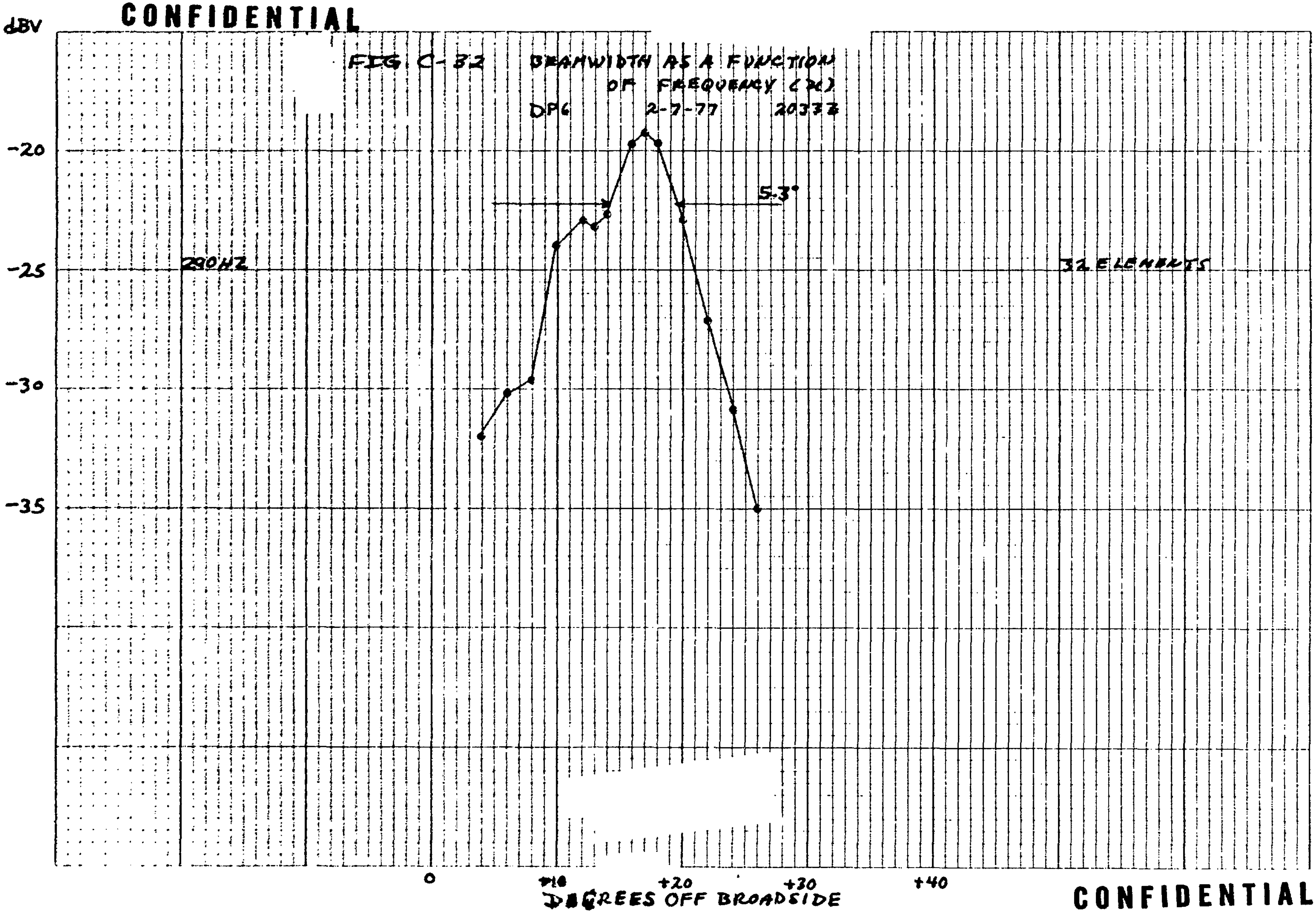
CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

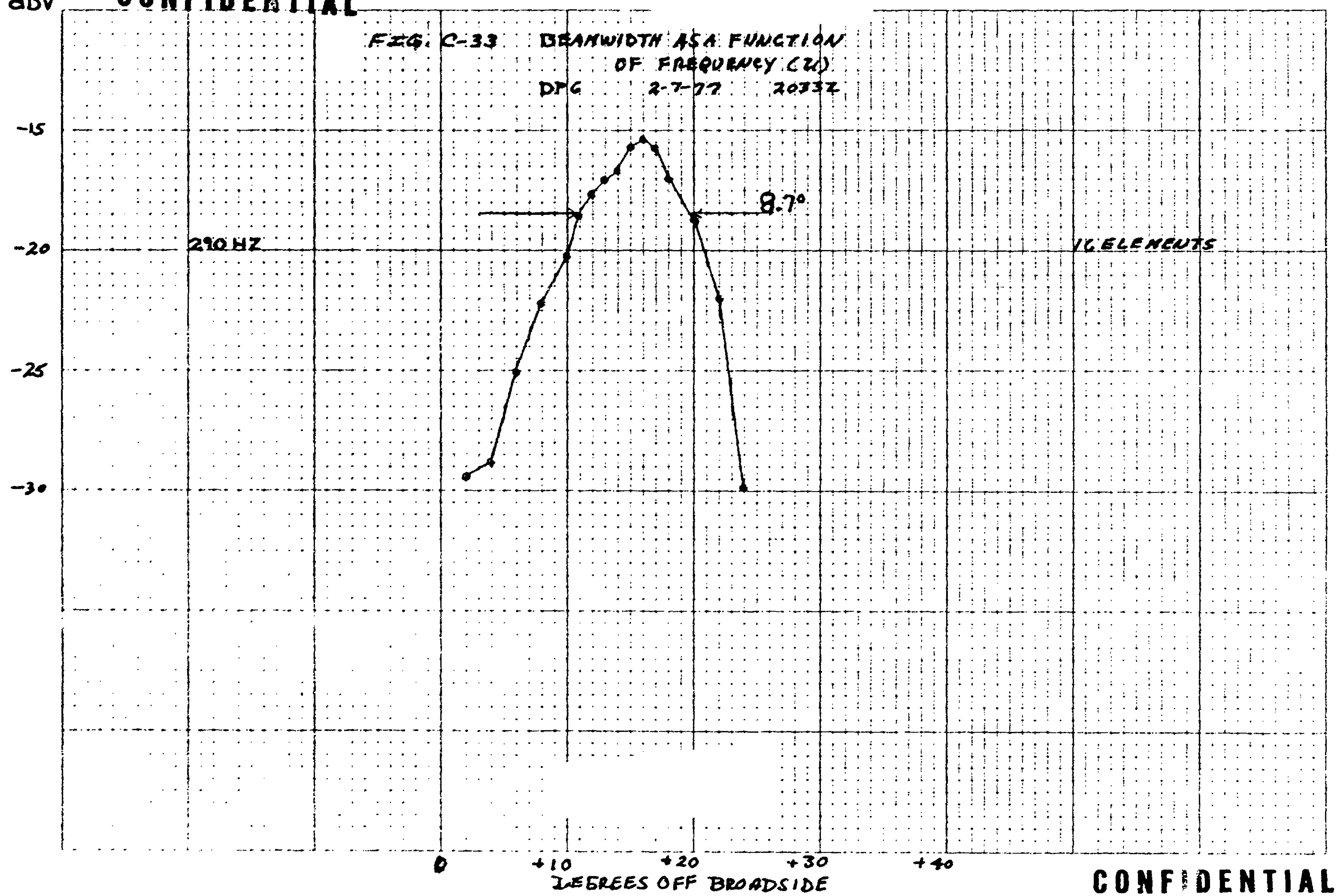
CONFIDENTIAL



CONFIDENTIAL

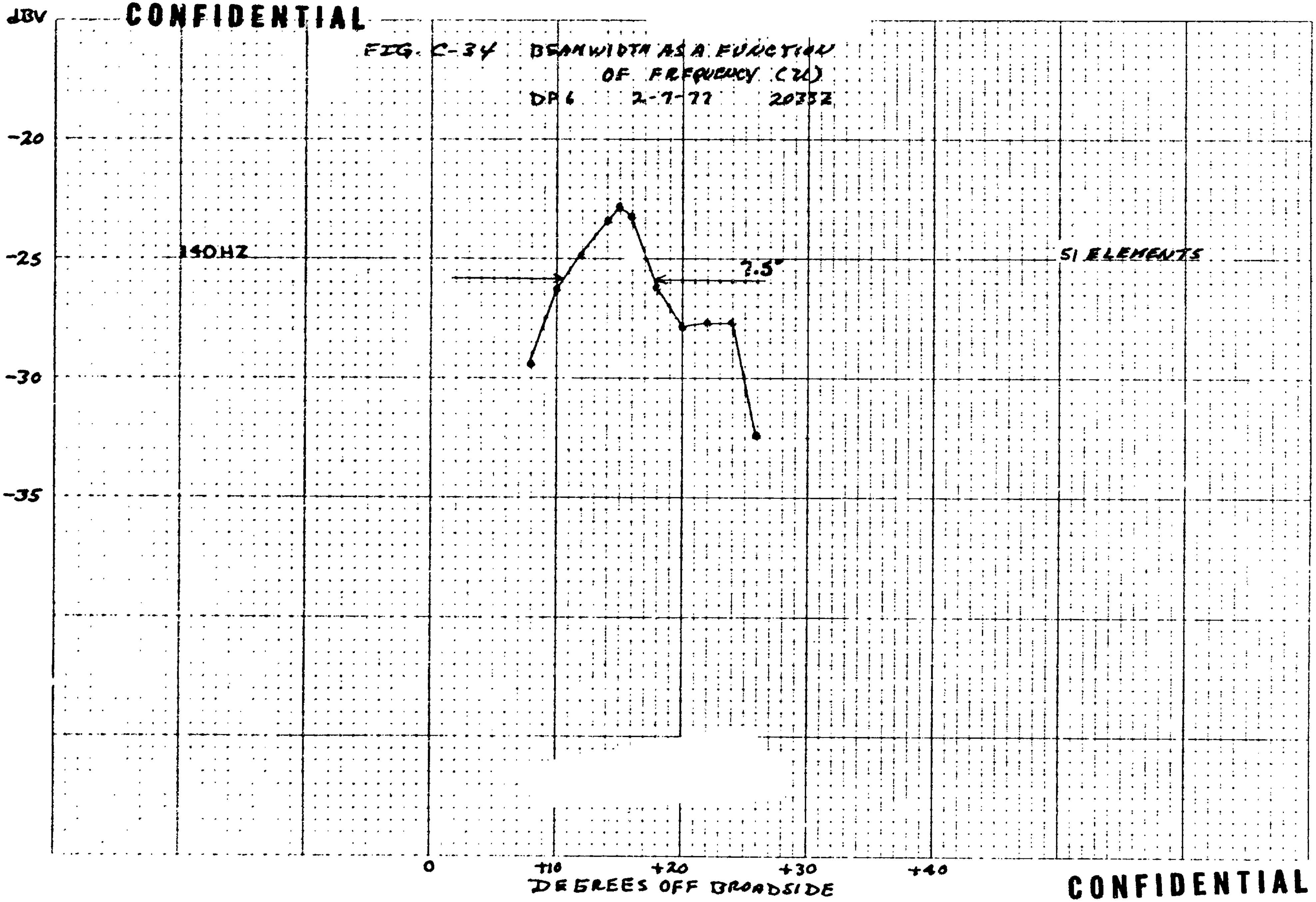
K•E 10 X 10 TO THE INCH KEUFFEL & ESSER CO. 46 0703

CONFIDENTIAL



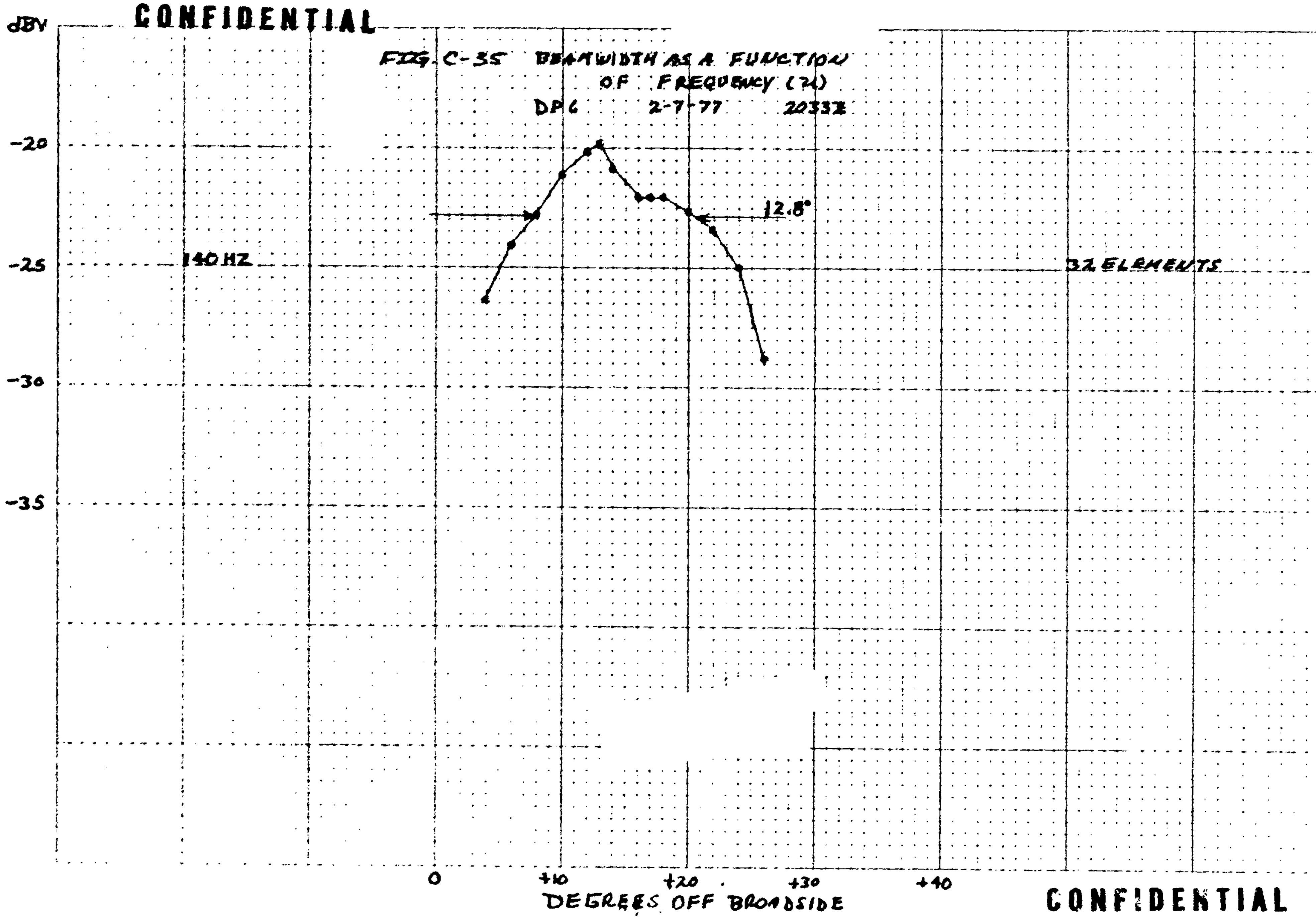
CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL

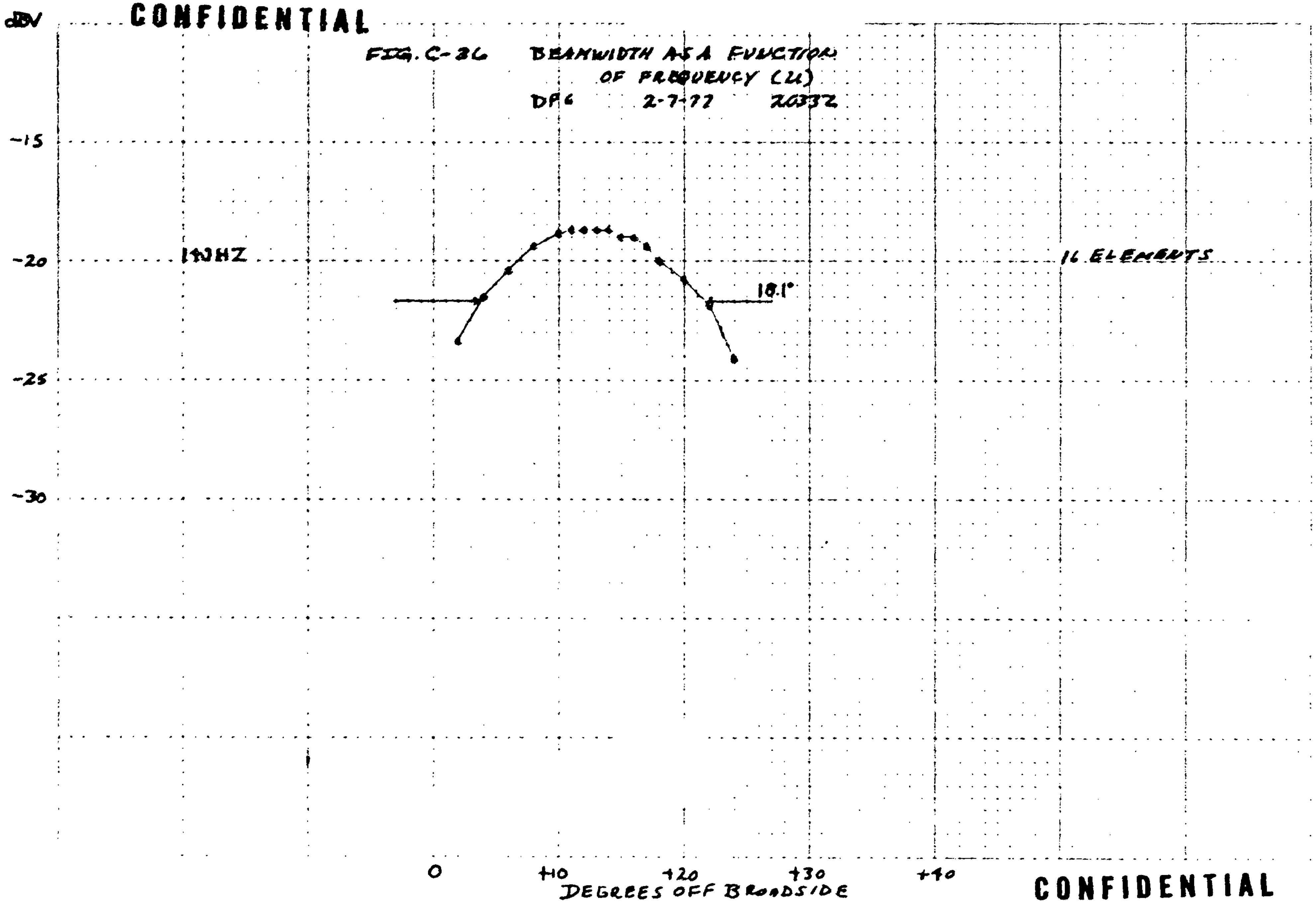


CONFIDENTIAL

CONFIDENTIAL

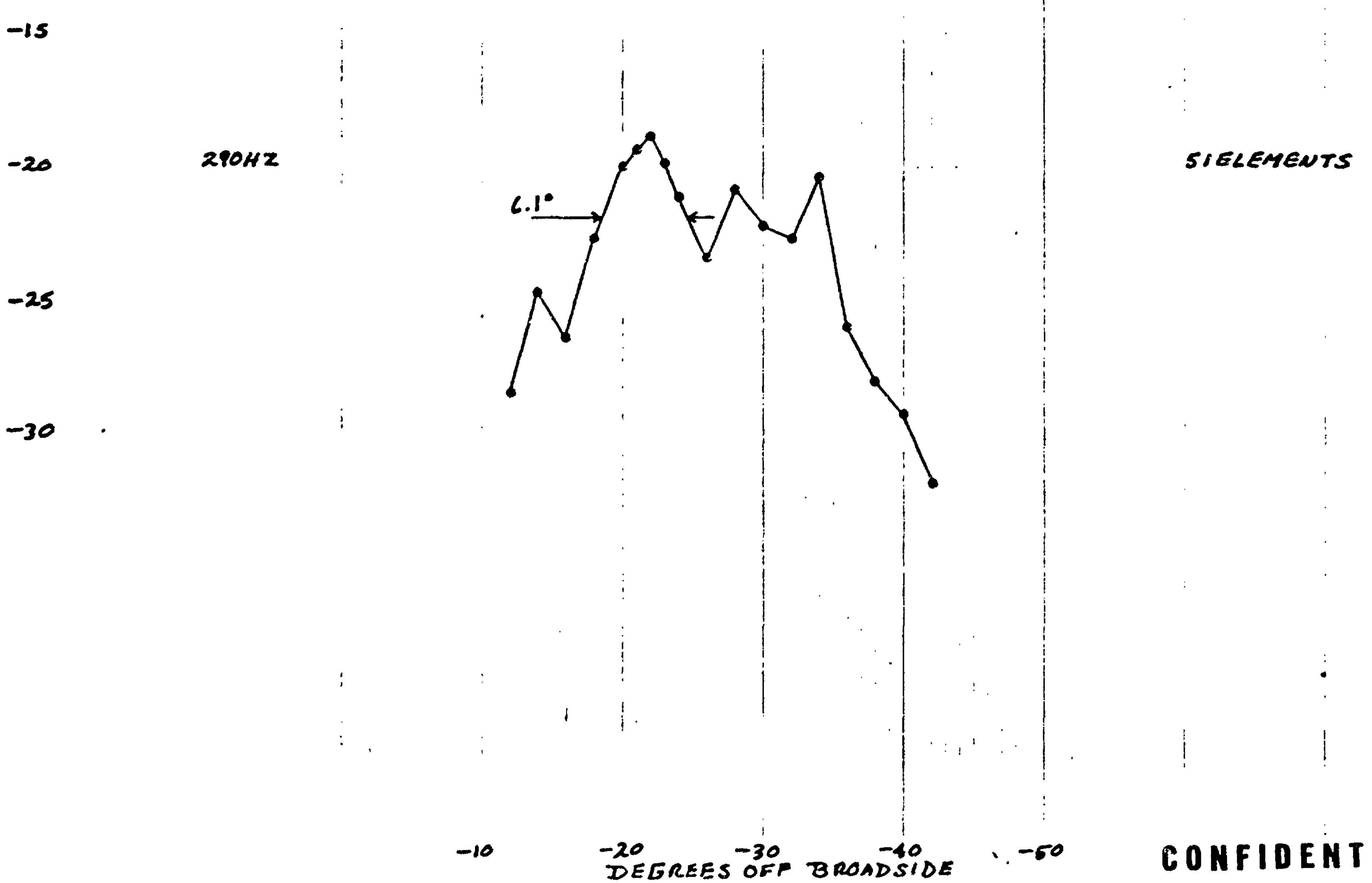
FIG. C-26 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2L)

DPG 2-7-77 20332



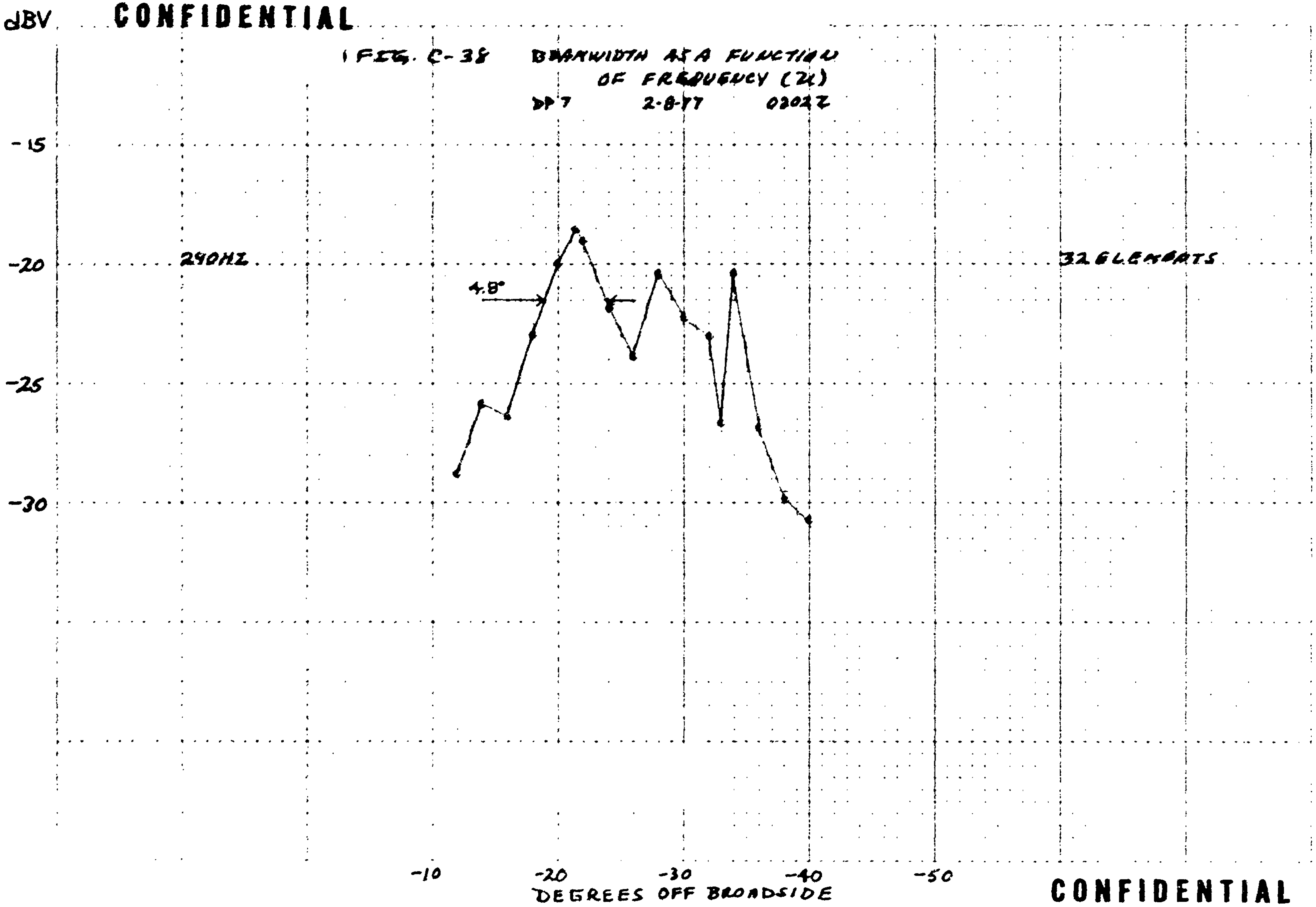
CONFIDENTIAL

FIG. C-37 BEAMWIDTH AS A FUNCTION OF FREQUENCY (Z)
DP7 2-8-77 0202Z



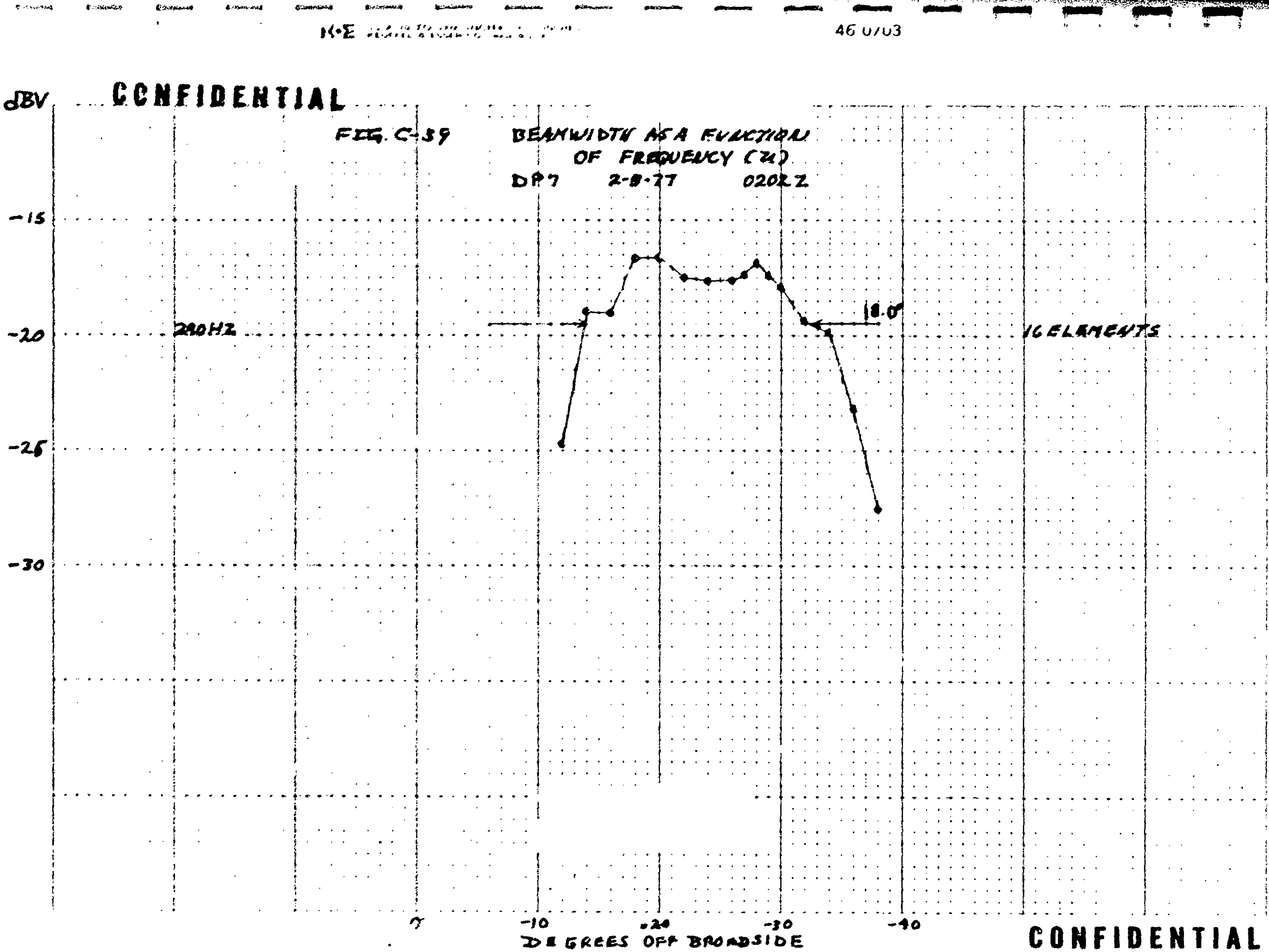
CONFIDENTIAL

FIG. C-38 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2L)
DP 7 2-8-77 0202Z



CONFIDENTIAL

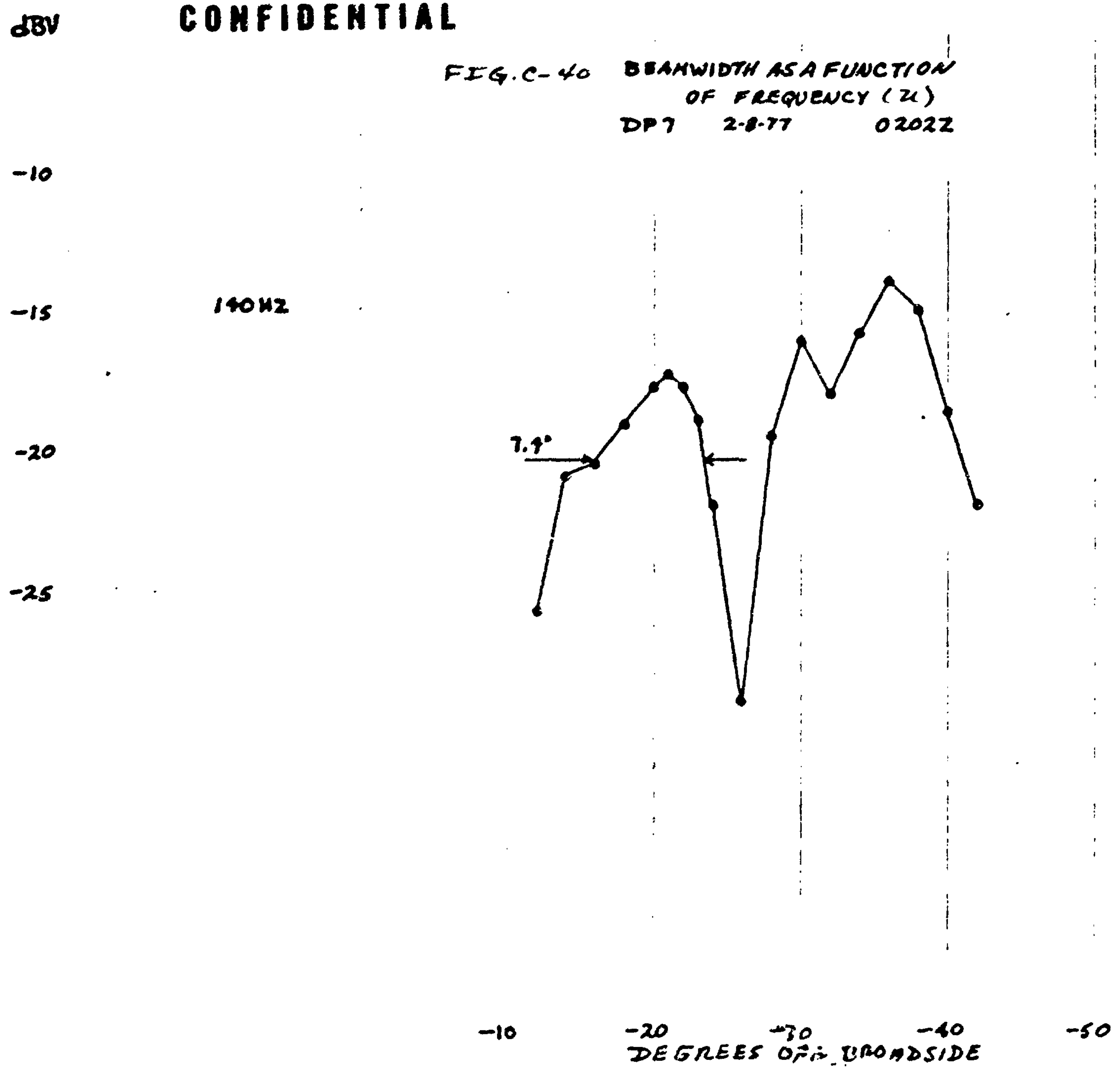
CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL

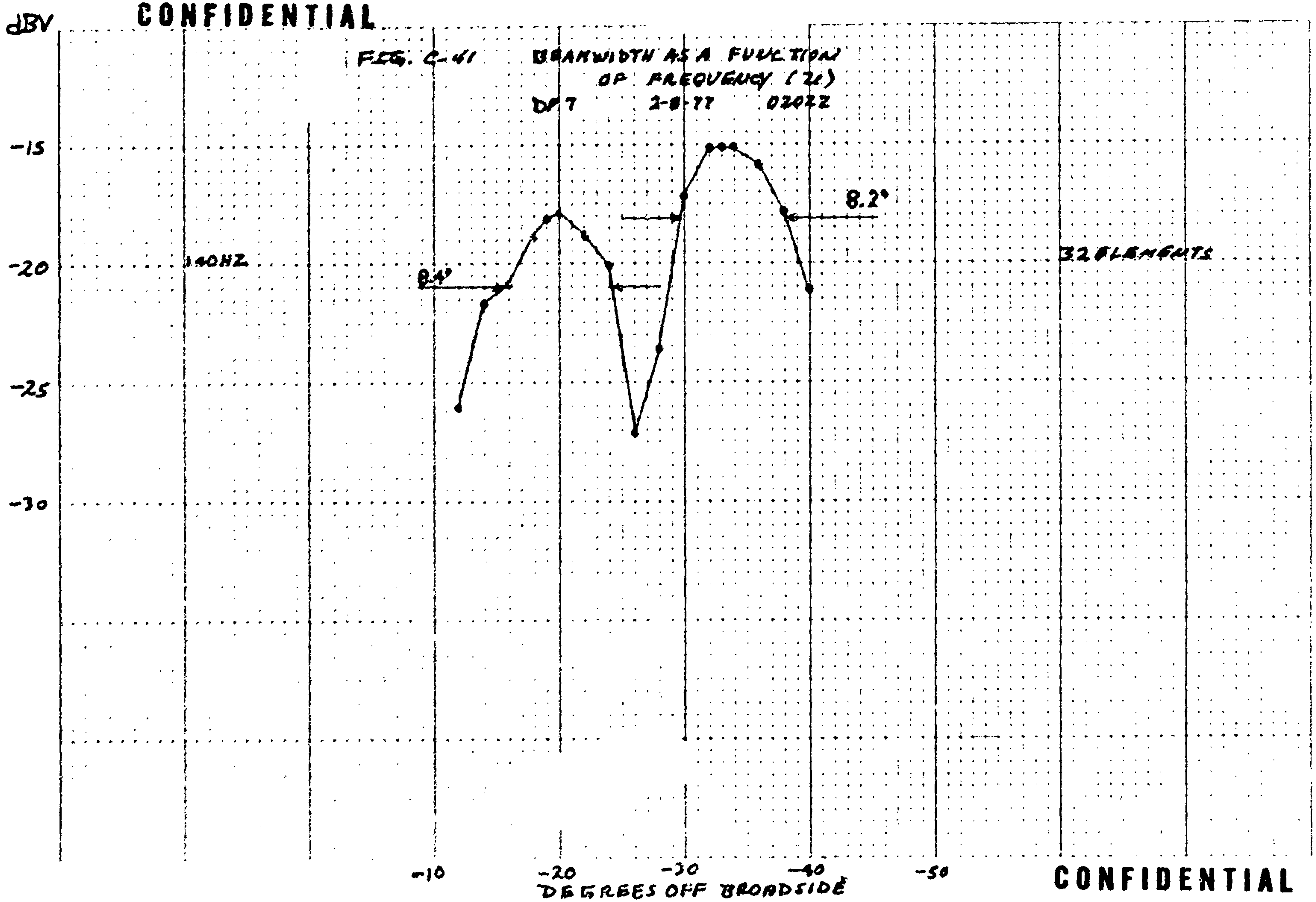
FIG. C-40 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2)
DP7 2-8-77 0202Z



CONFIDENTIAL

CONFIDENTIAL

FIG. C-41 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2L)
DF 7 2-8-77 0202Z

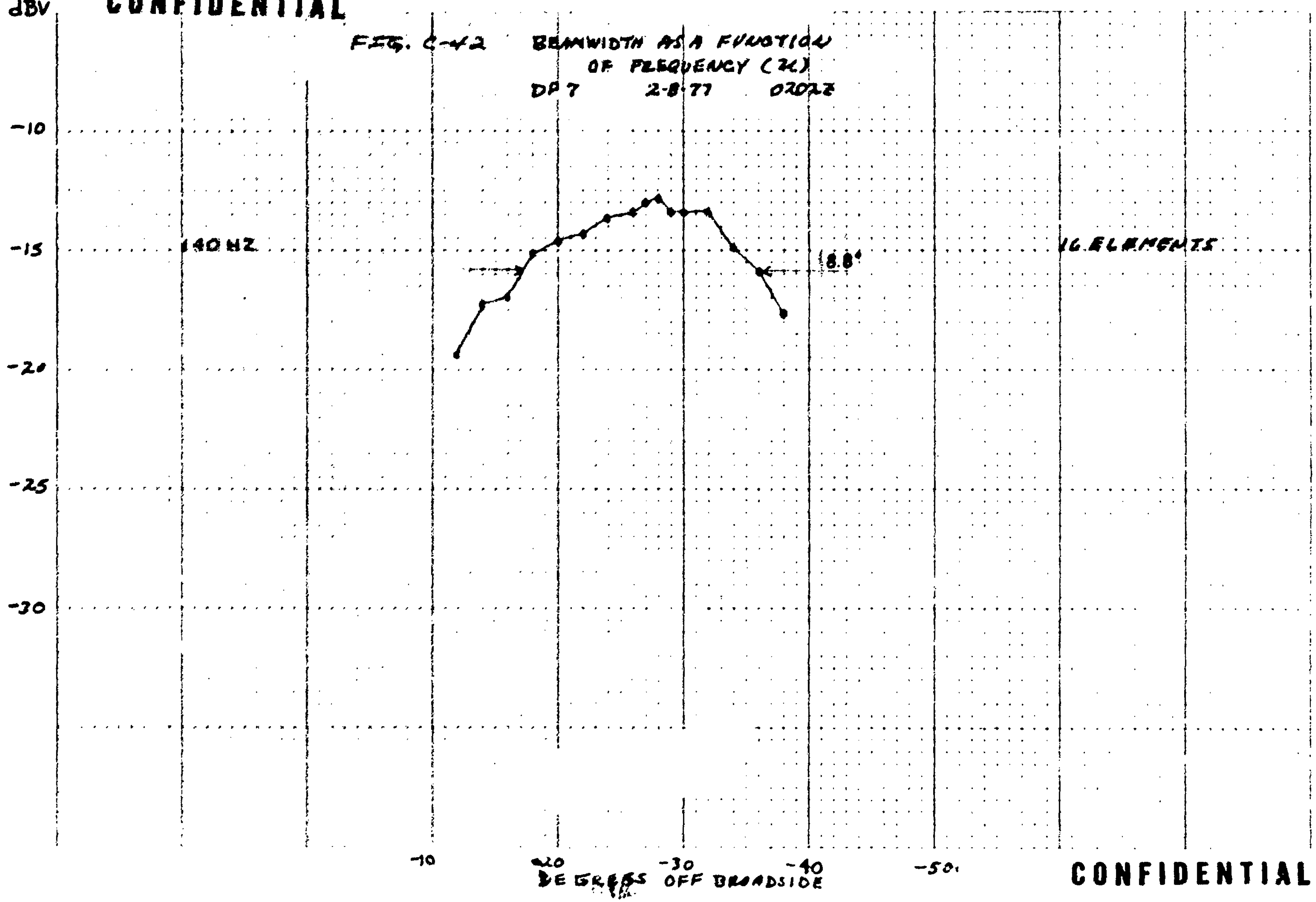


CONFIDENTIAL

K•E 46 0703

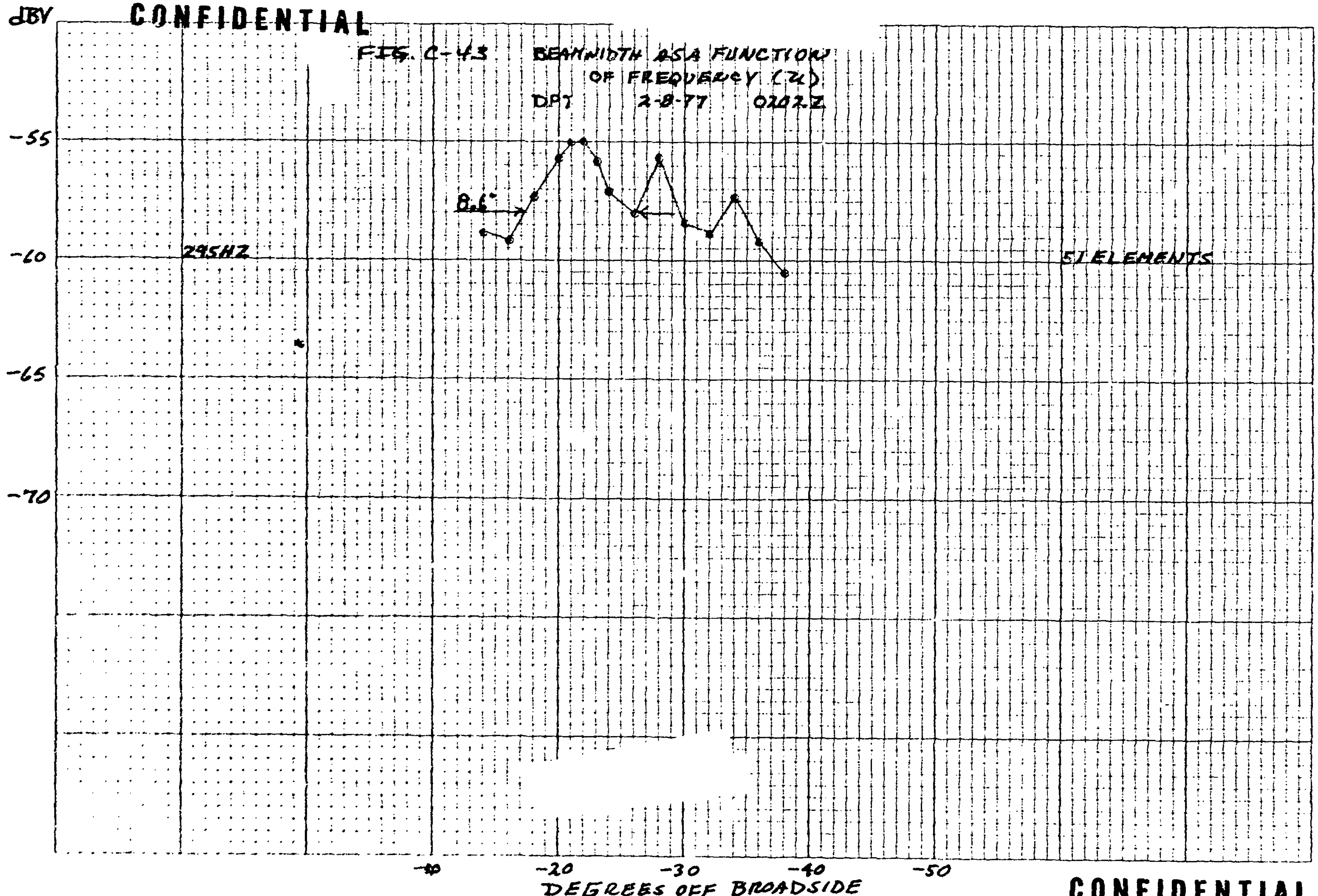
CONFIDENTIAL

FIG. C-42 BEAMWIDTH AS A FUNCTION OF FREQUENCY (Hz)
DP 7 2-8-77 0202Z



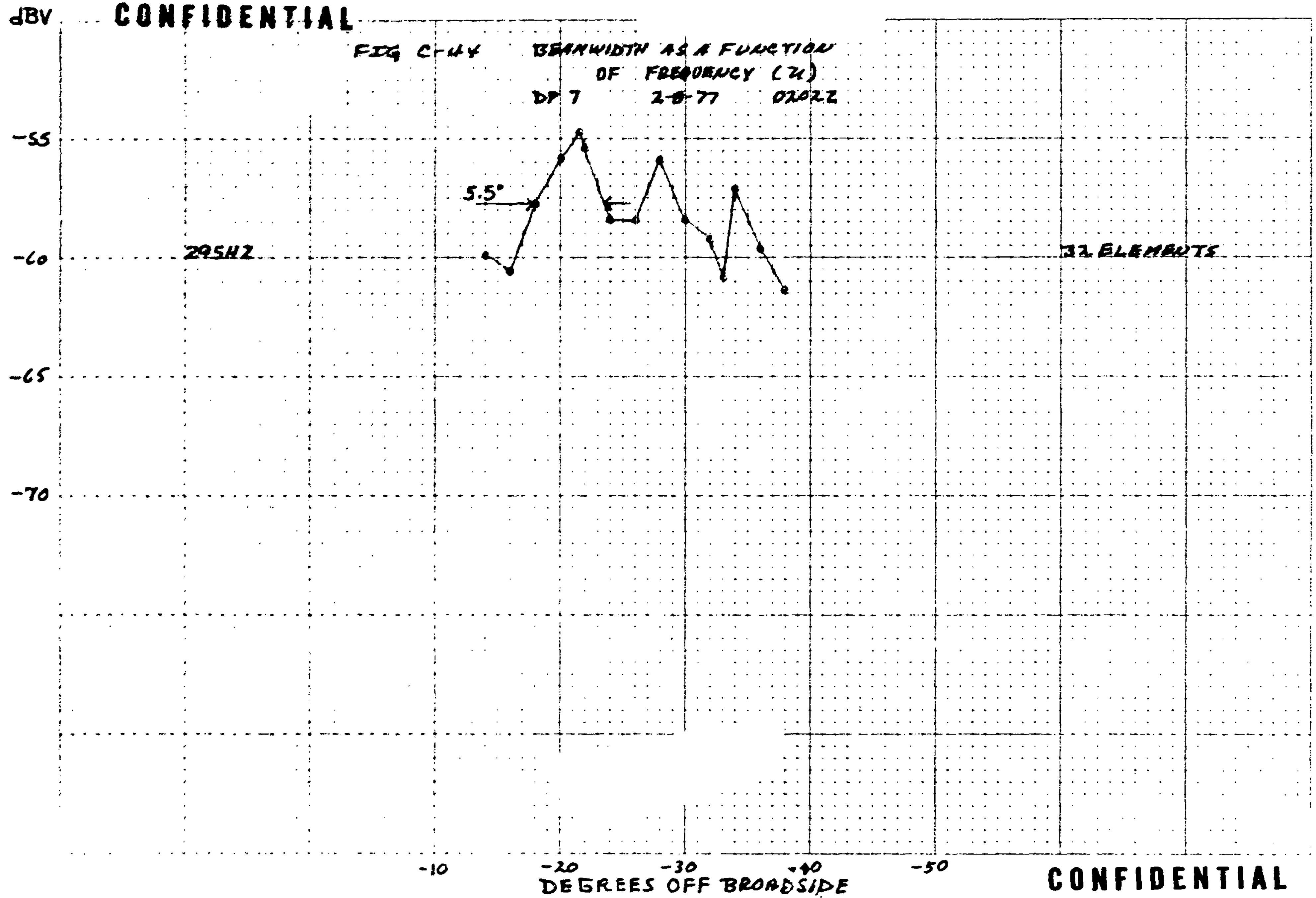
CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

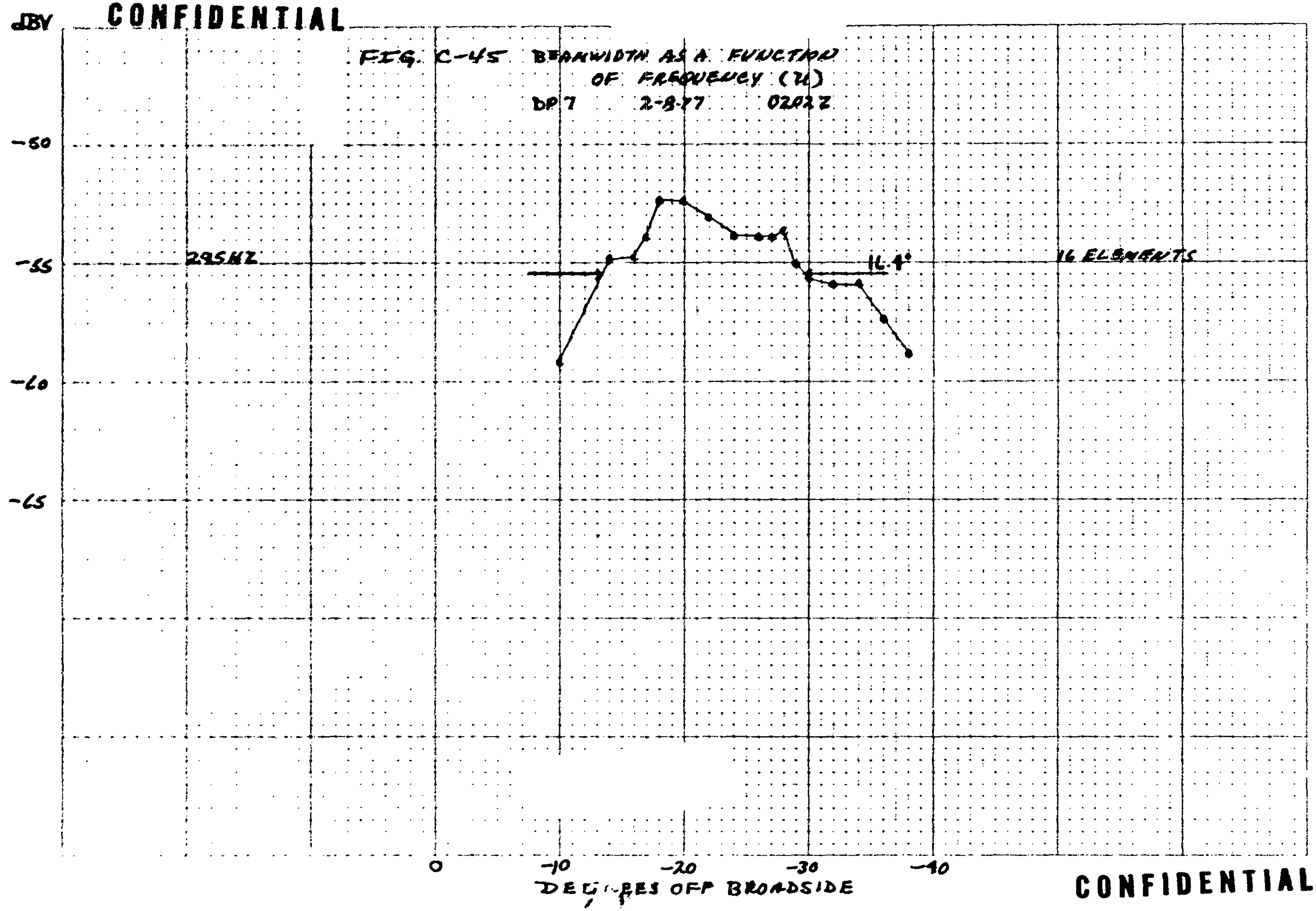
CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL

FIG. C-45 BEAMWIDTH AS A FUNCTION OF FREQUENCY (H)
DP 7 2-8-77 0202Z

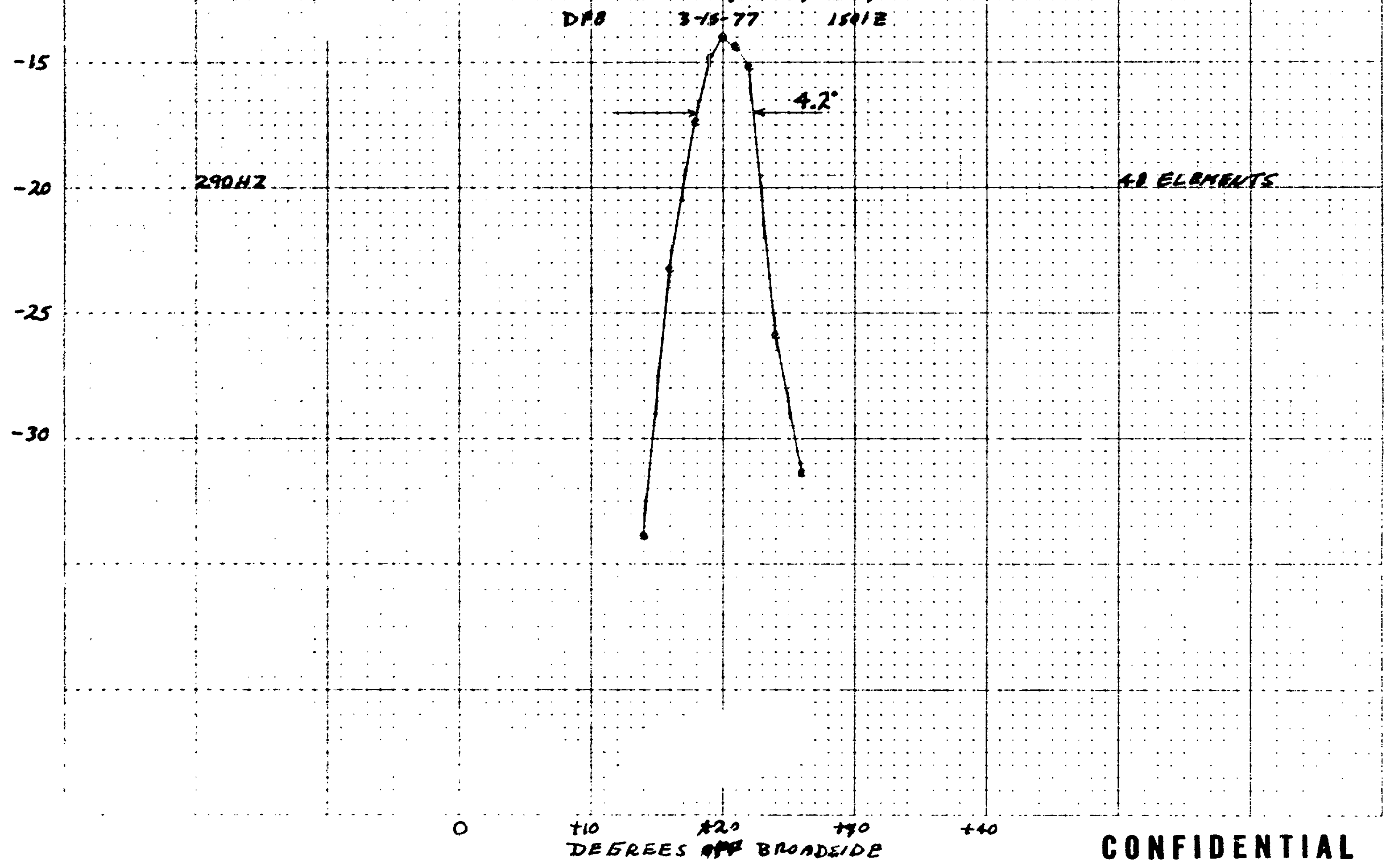


CONFIDENTIAL

K·E 10 X 10 TO THE INCH 46 0703

CONFIDENTIAL

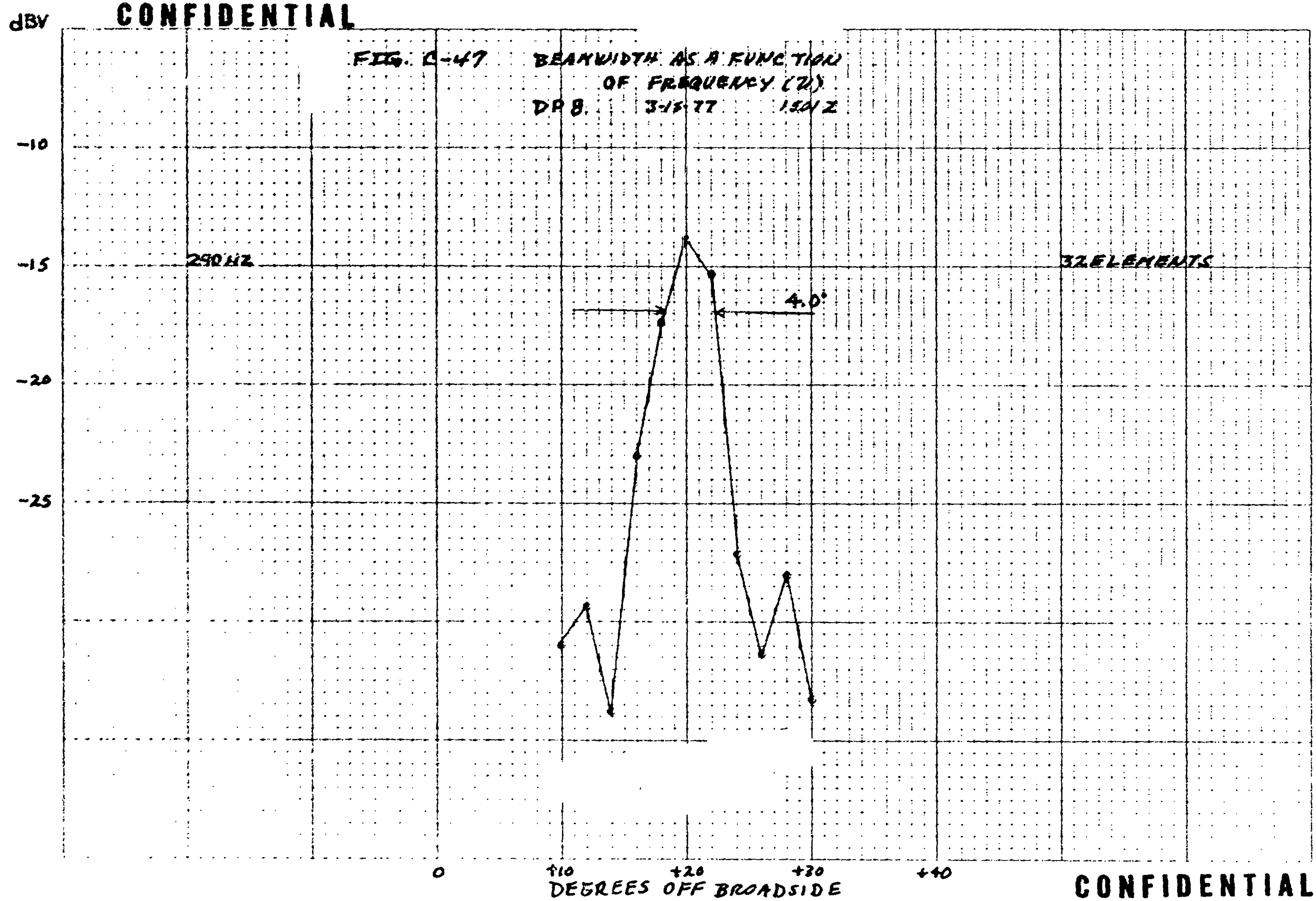
FIG. C-46 BEAMWIDTH AS A FUNCTION OF FREQUENCY (?)



CONFIDENTIAL

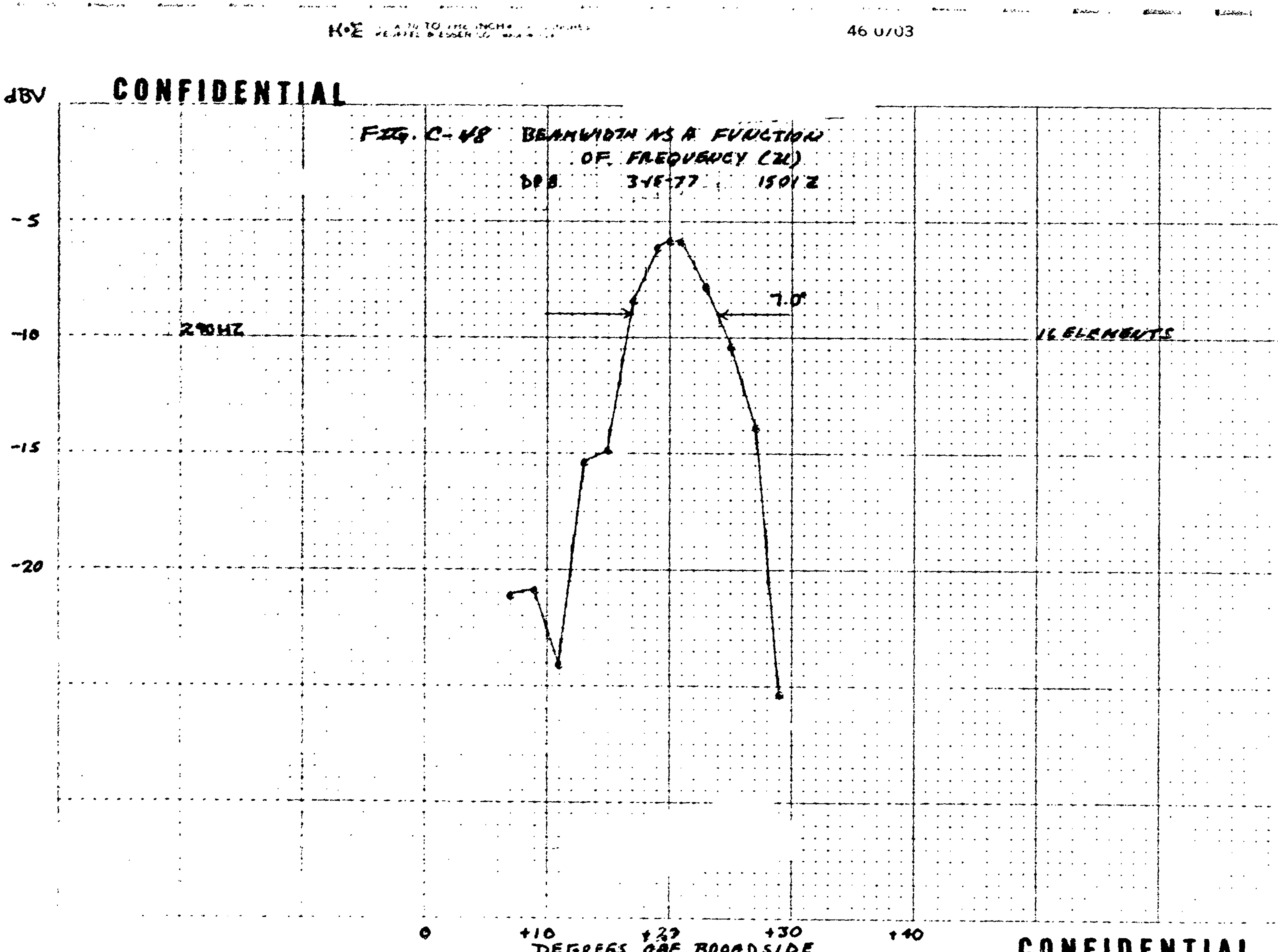
CONFIDENTIAL

FIG. C-47 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2)
DP 8. 3-15-77 150 HZ



CONFIDENTIAL

CONFIDENTIAL

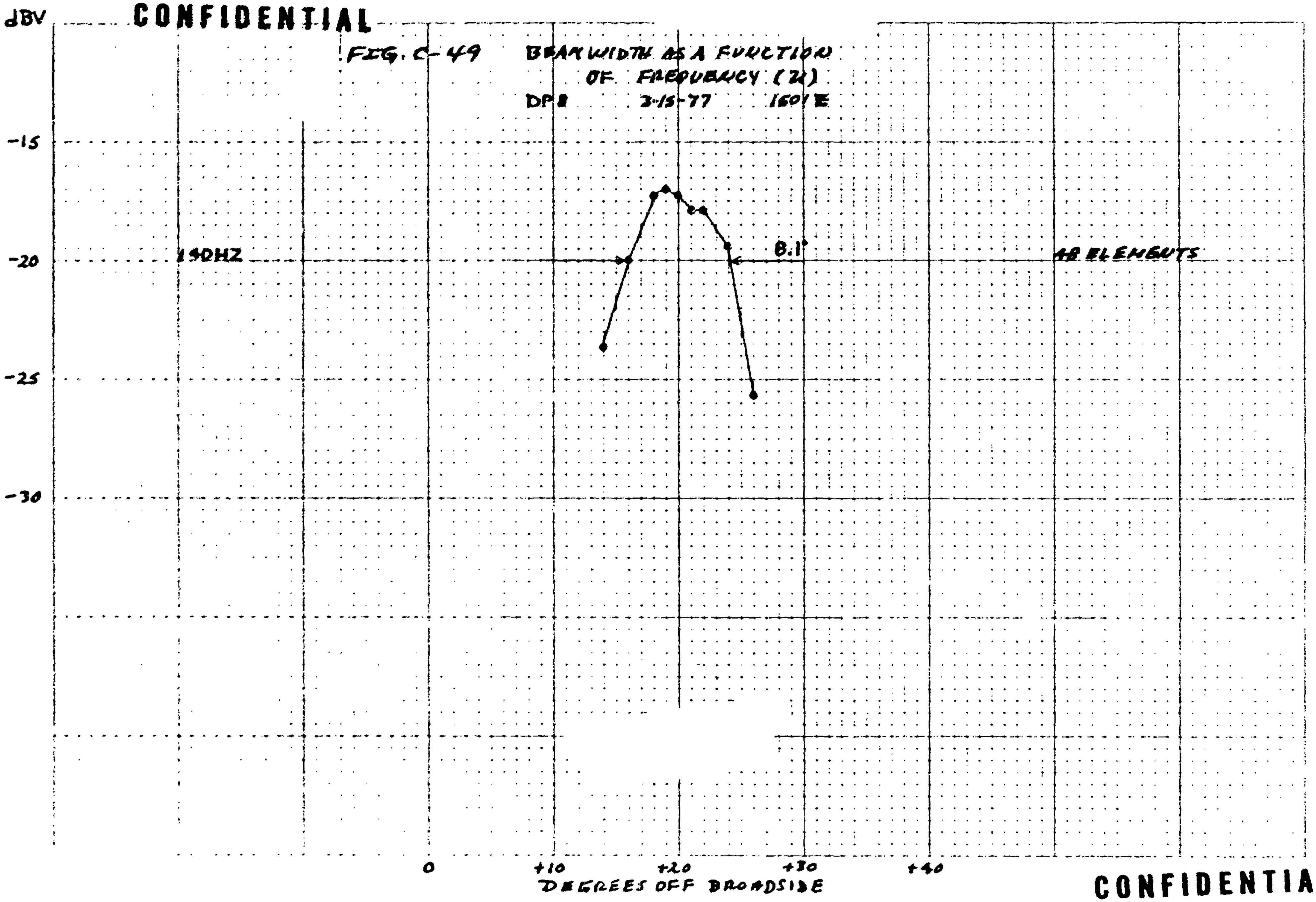


CONFIDENTIAL

CONFIDENTIAL

FIG. C-49 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2)

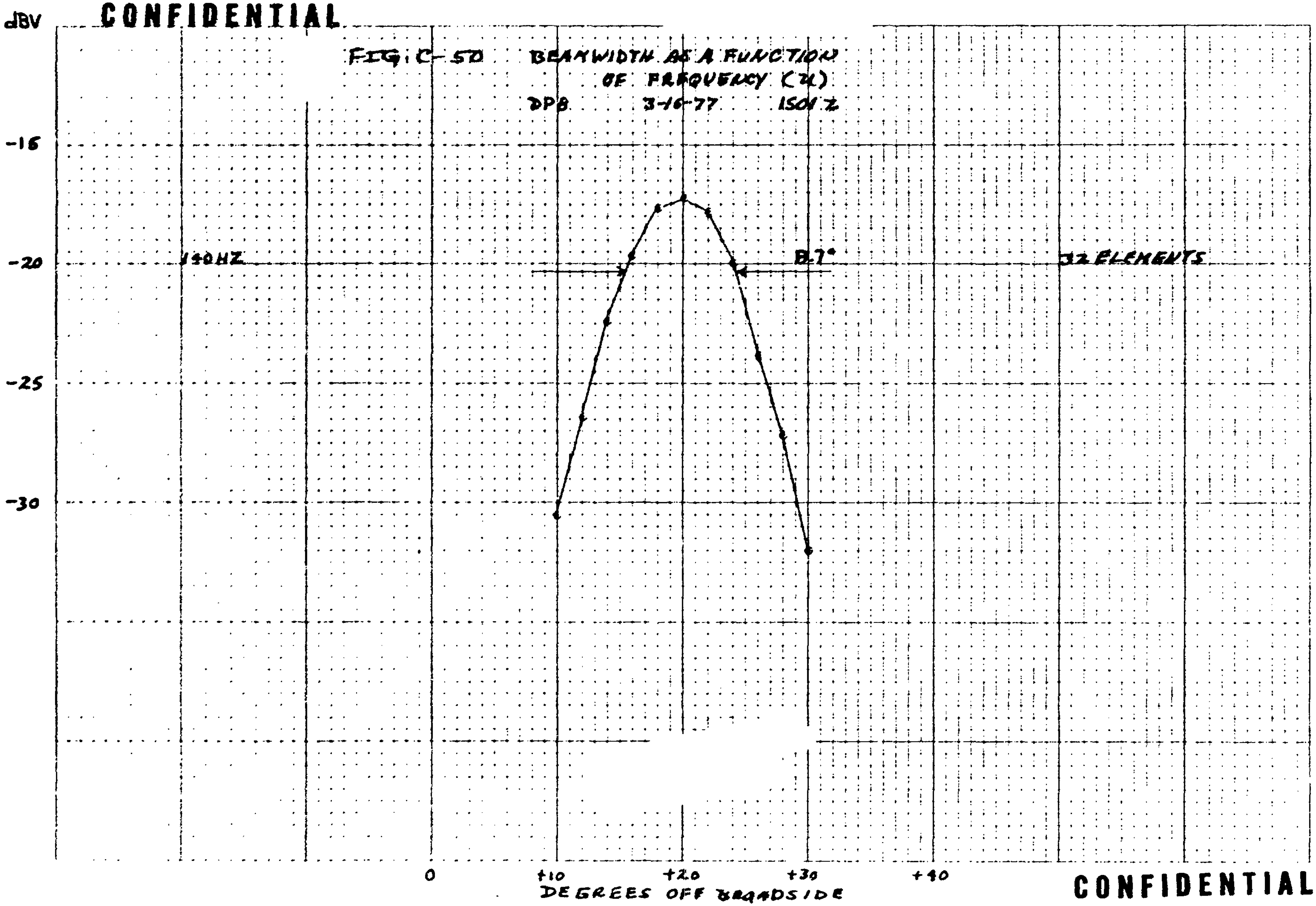
DP8 3-15-77 160°E



CONFIDENTIAL

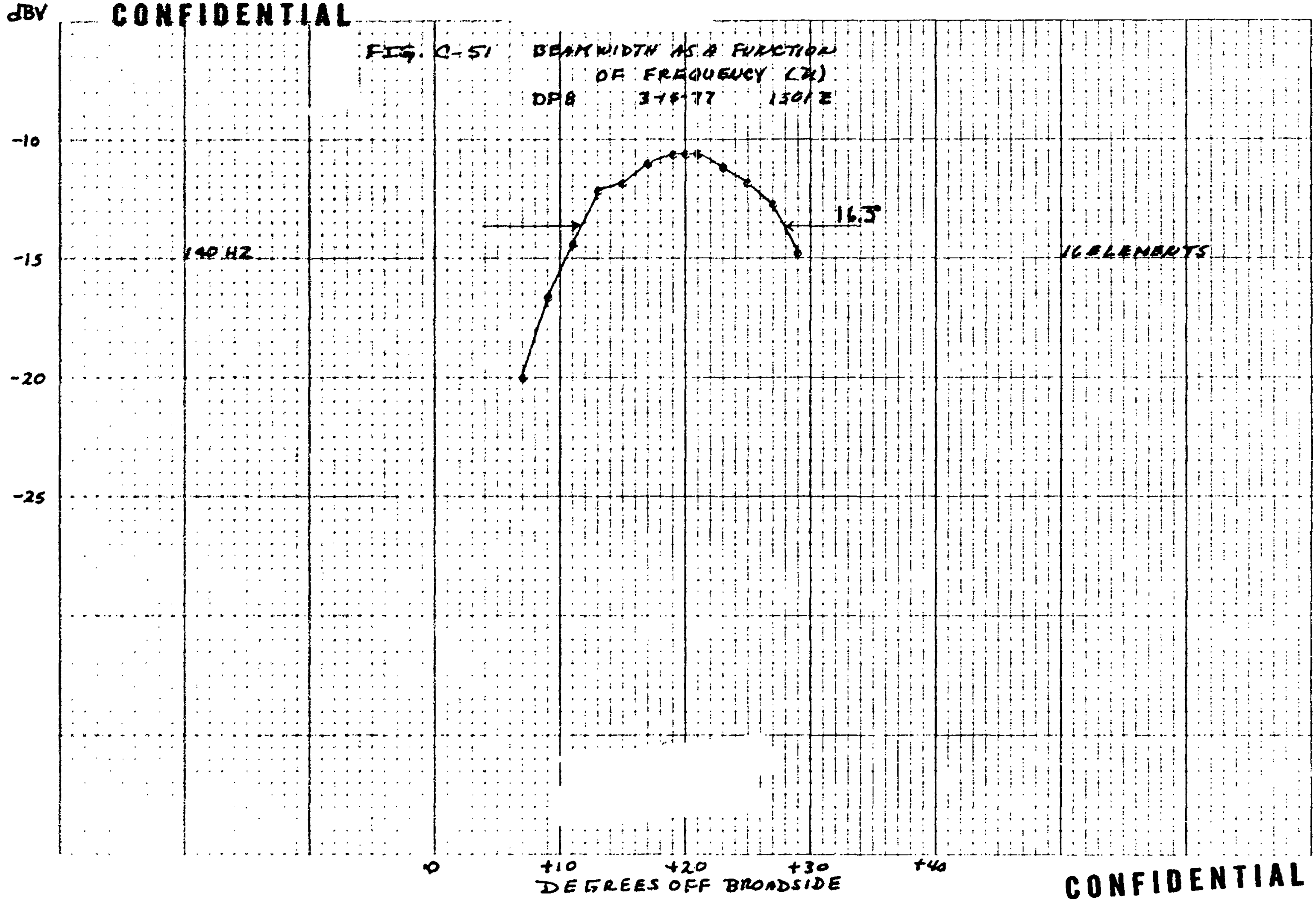
CONFIDENTIAL

FIG: C-50



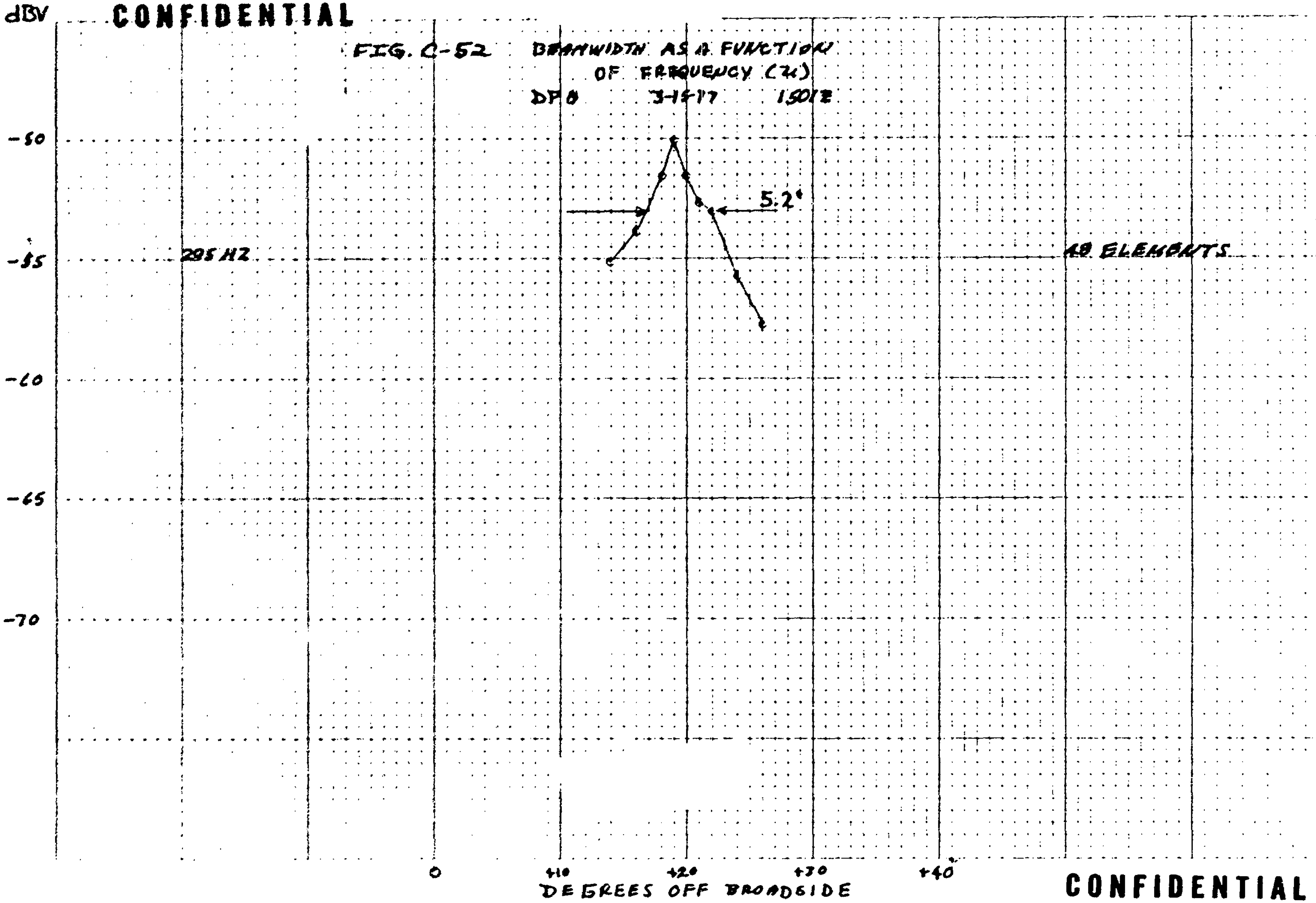
CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

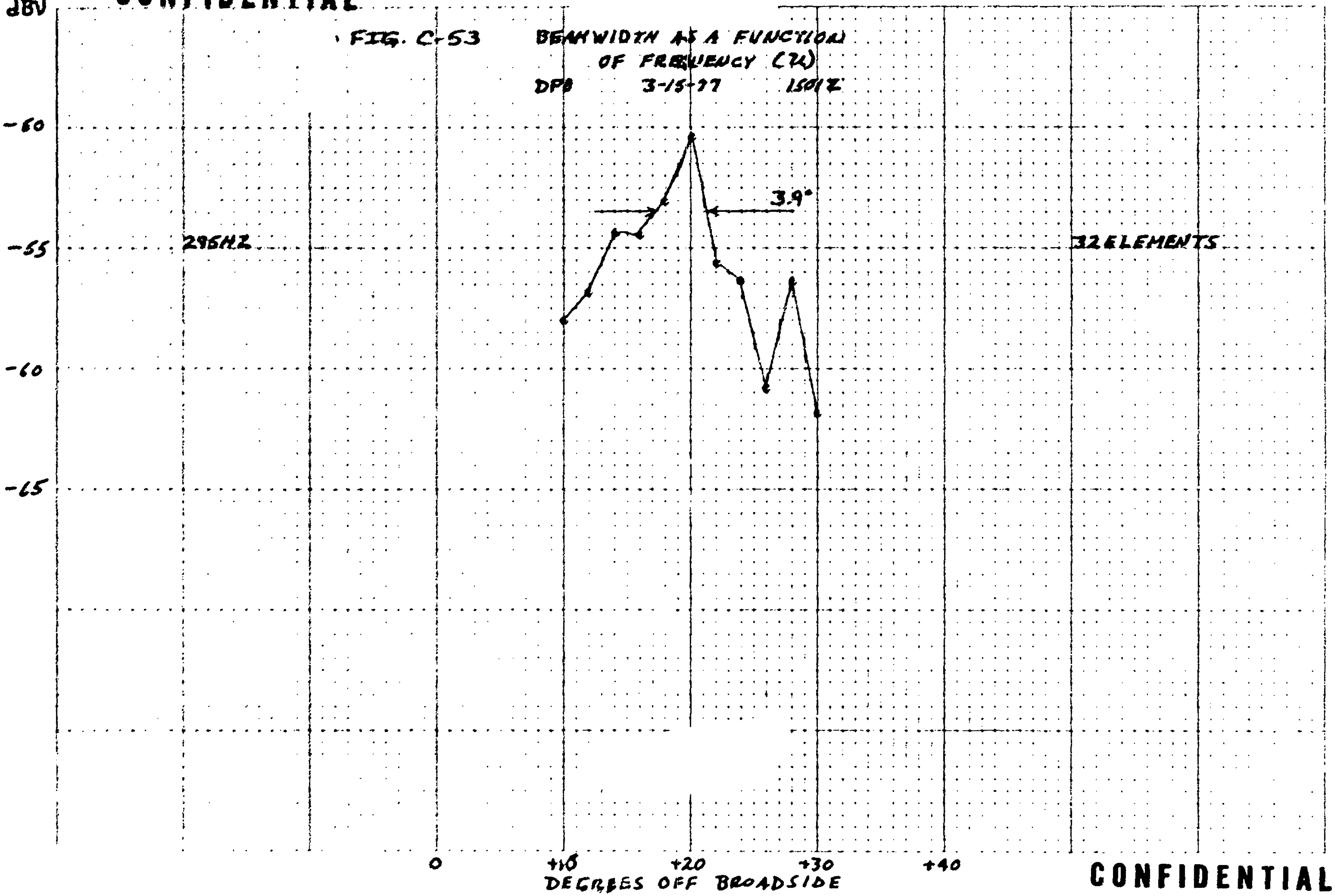
CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL

FIG. C-53 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2) DPB 3-15-77 1501Z

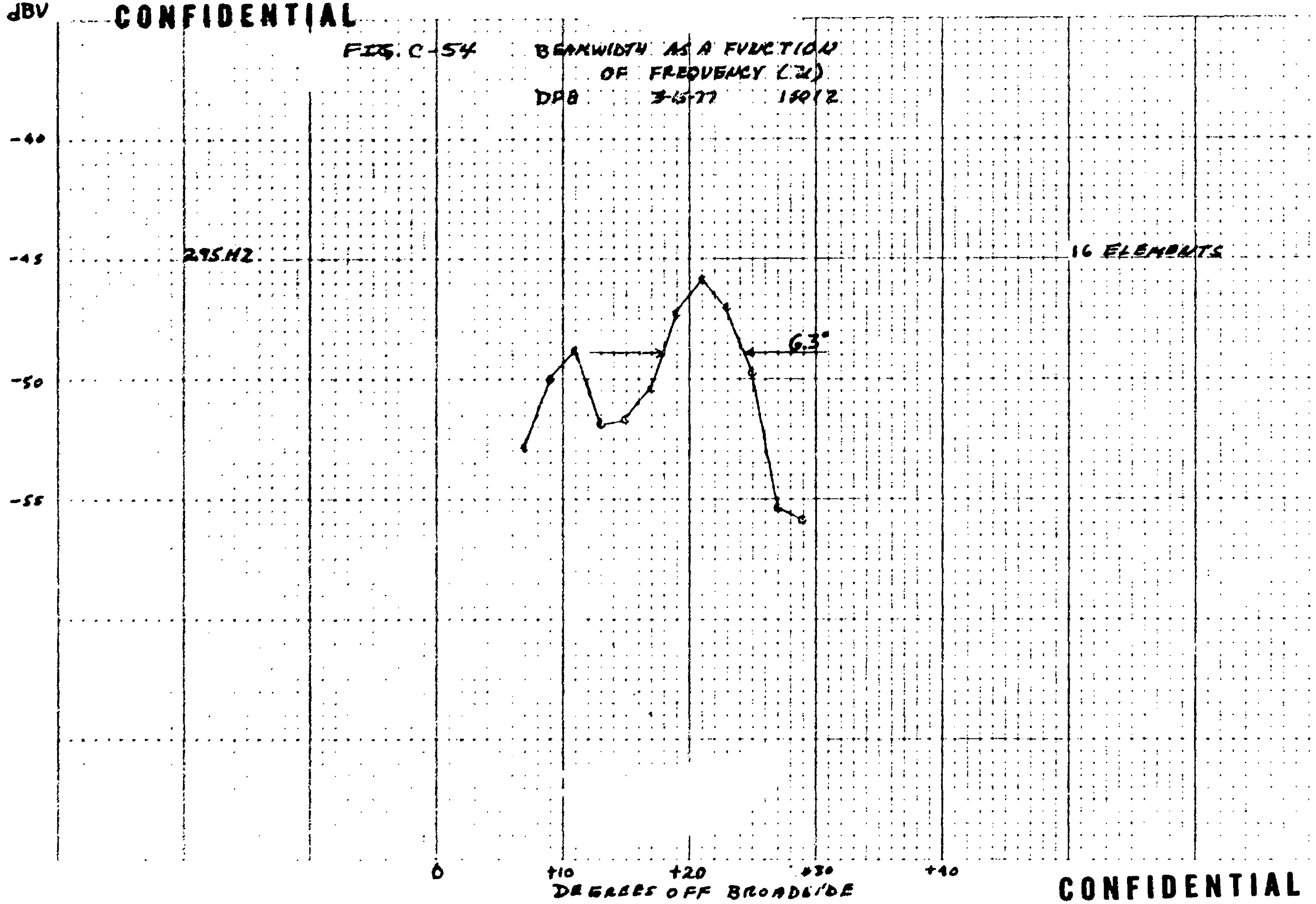


CONFIDENTIAL

CONFIDENTIAL

FIG. C-54 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2X)

DPB 3-15-77 1501Z

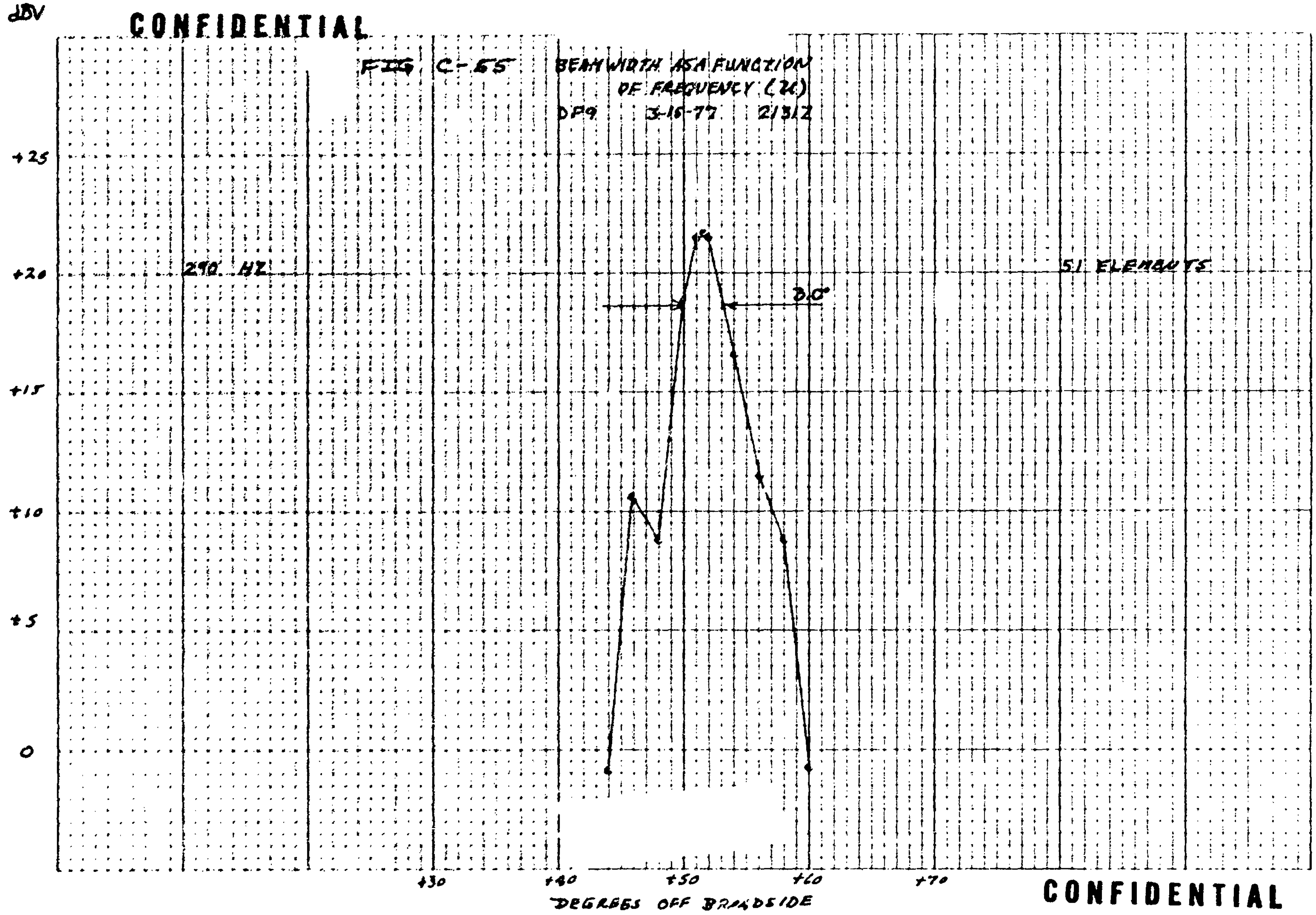


CONFIDENTIAL

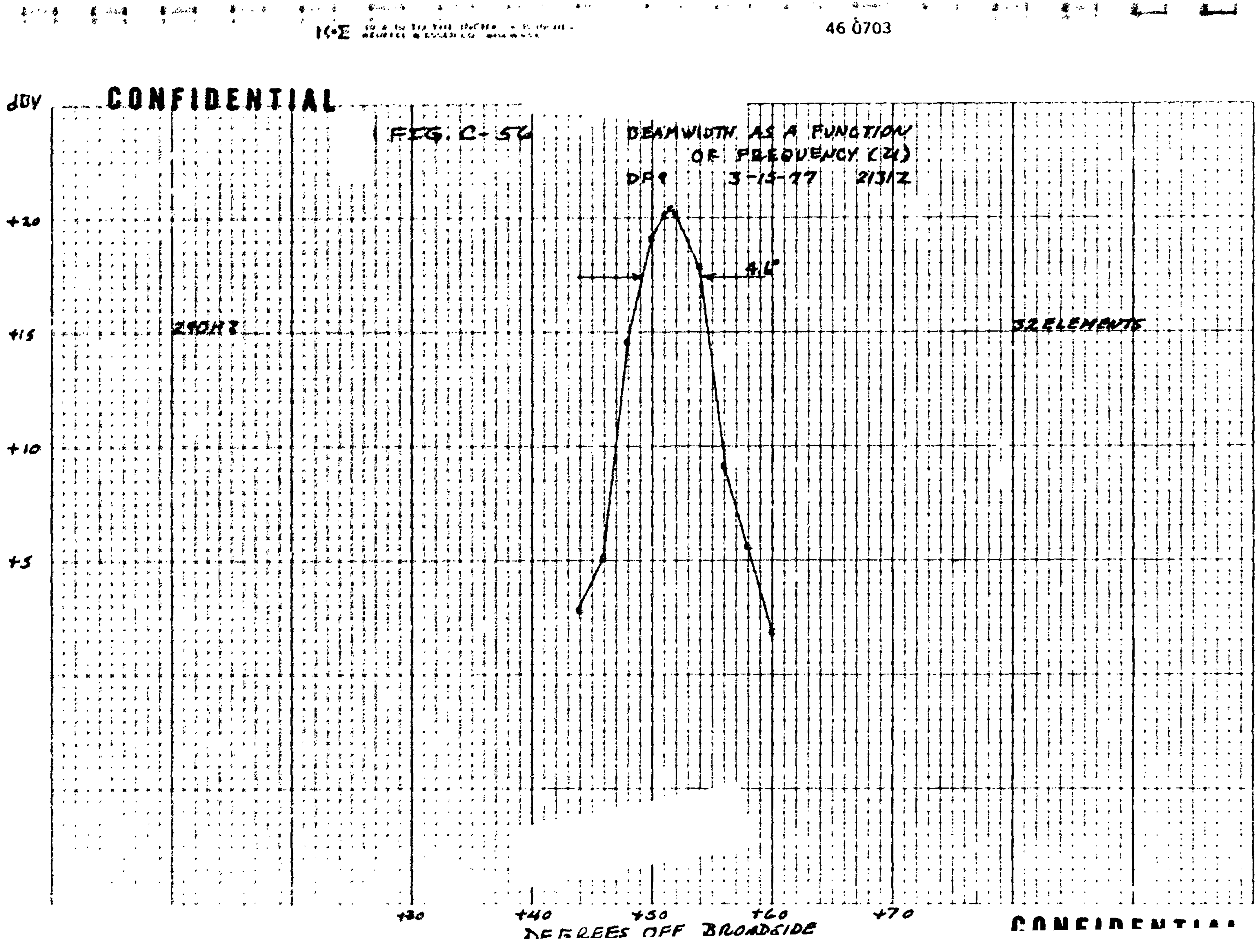
46 0703

CONFIDENTIAL

FIG C-65 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2C)
DP9 3-16-77 2131Z



CONFIDENTIAL

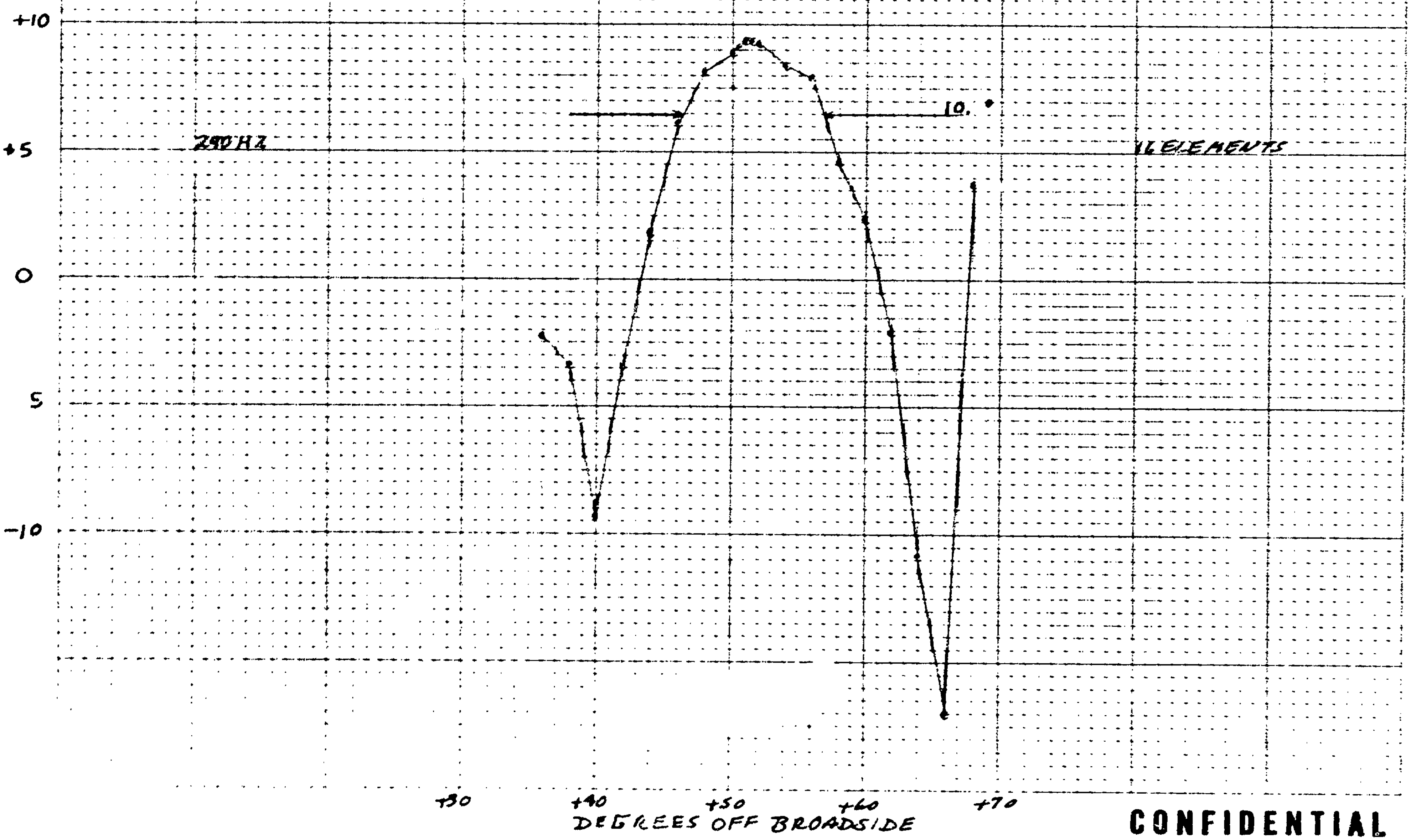


dBV
FIG. C-56
BEAMWIDTH AS A FUNCTION
OF FREQUENCY (24)
DP9 3-15-77 2131Z
+20
+15
+10
+5
290HZ
4.6°
32 ELEMENTS
+30
+40
+50
+60
+70
DEGREES OFF BROADSIDE

CONFIDENTIAL

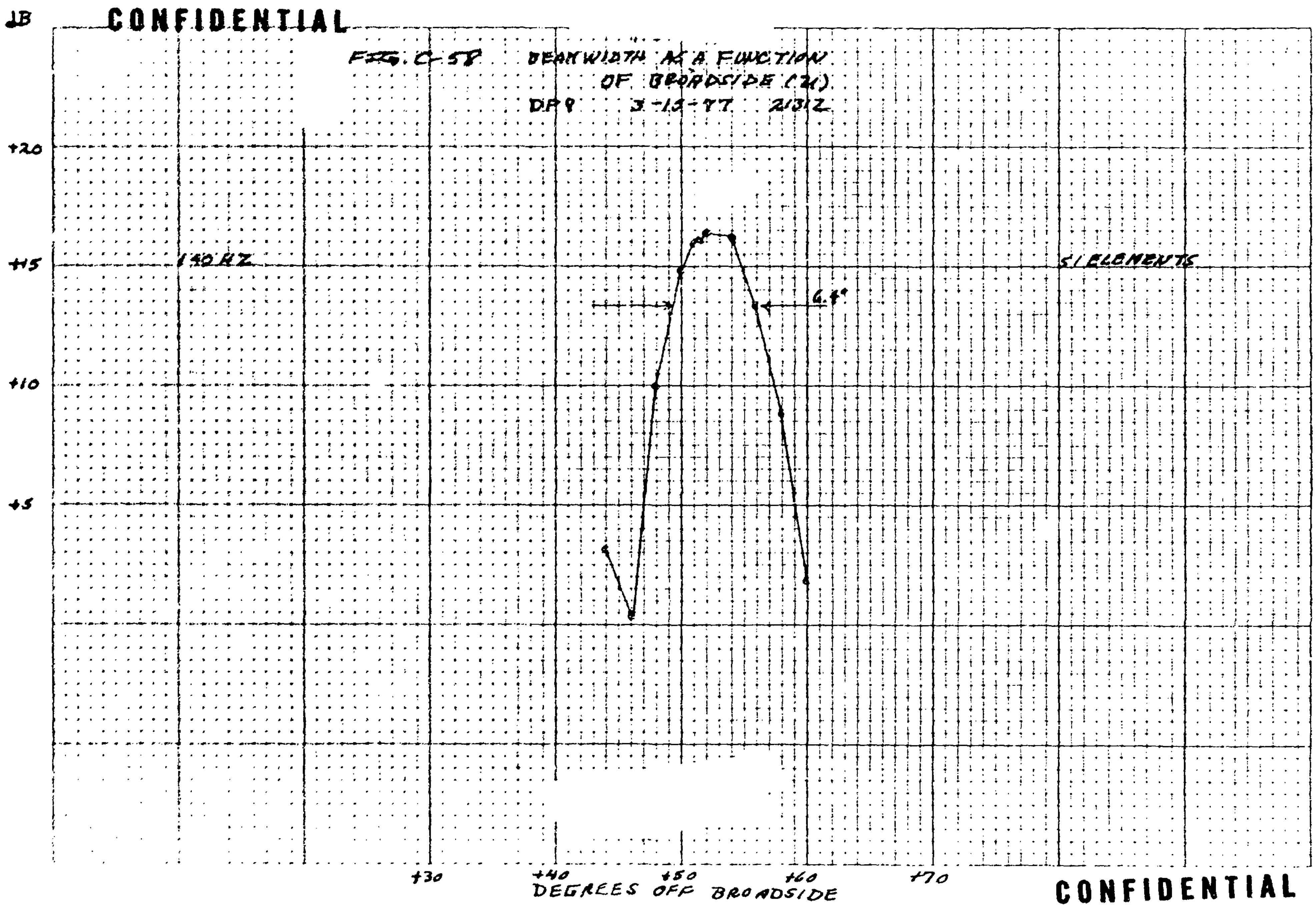
FIG. C-57 BEAMWIDTH AS A FUNCTION OF FREQUENCY (Z1)

DP9 3-16-77 2131Z



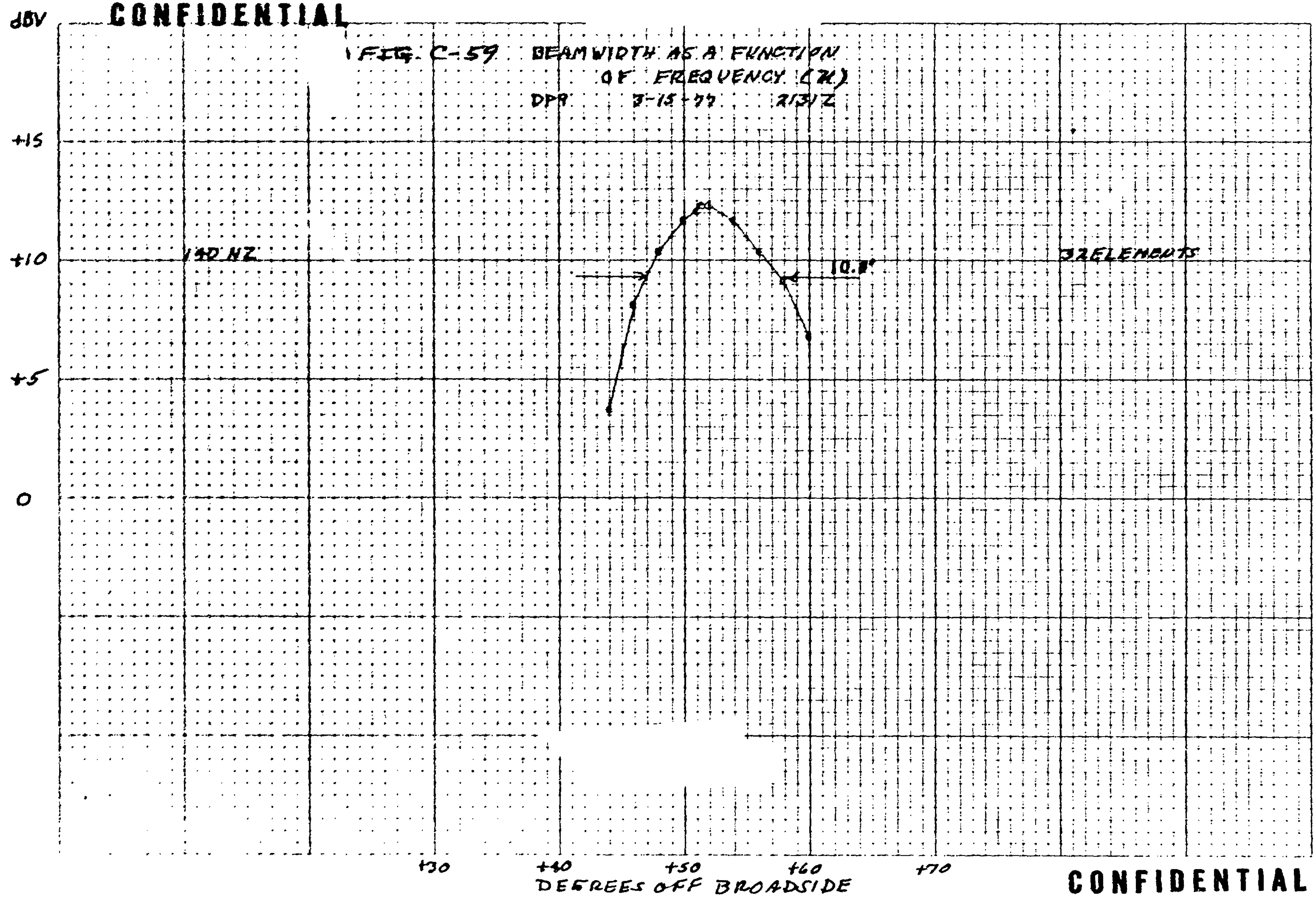
CONFIDENTIAL

CONFIDENTIAL



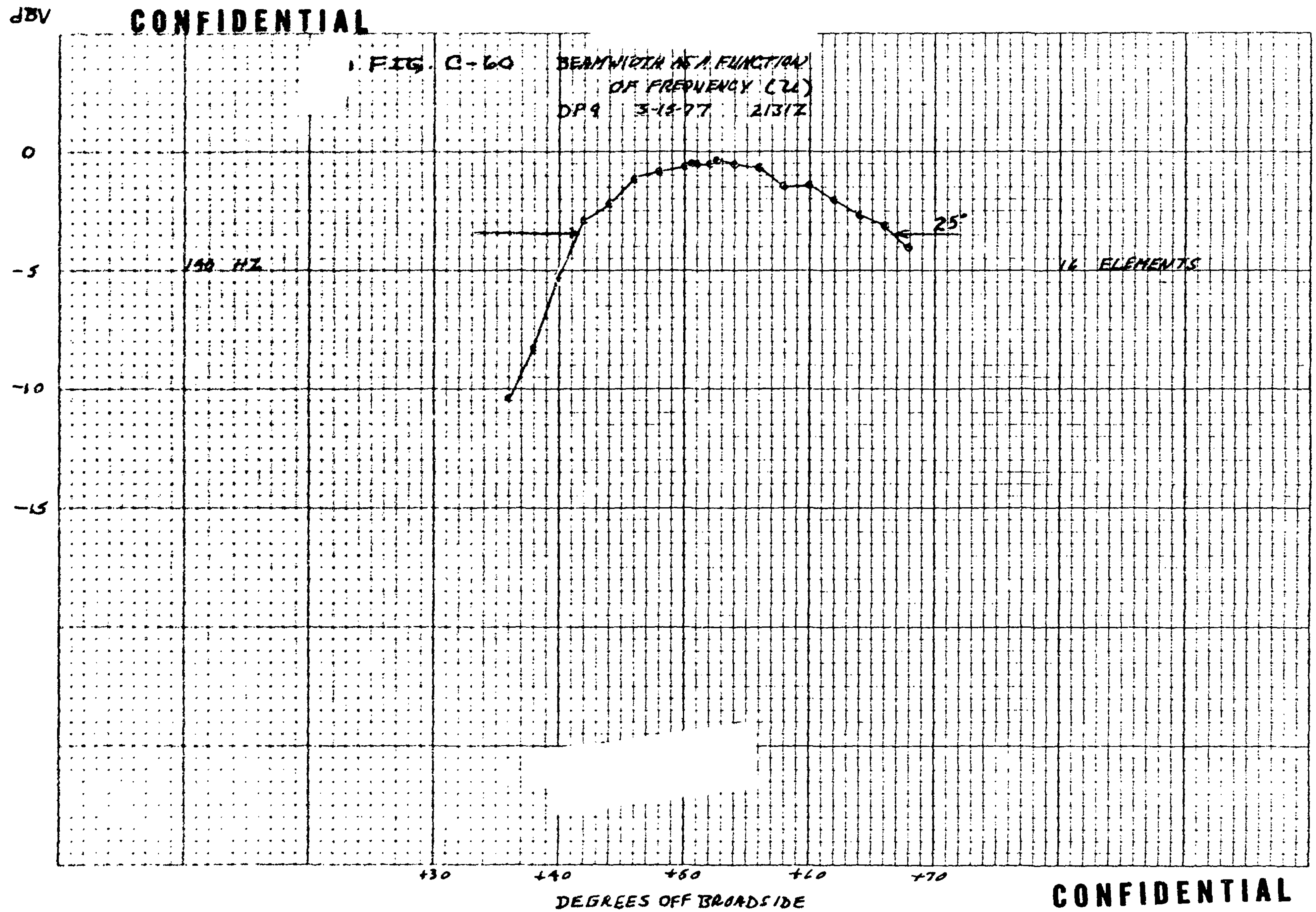
CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

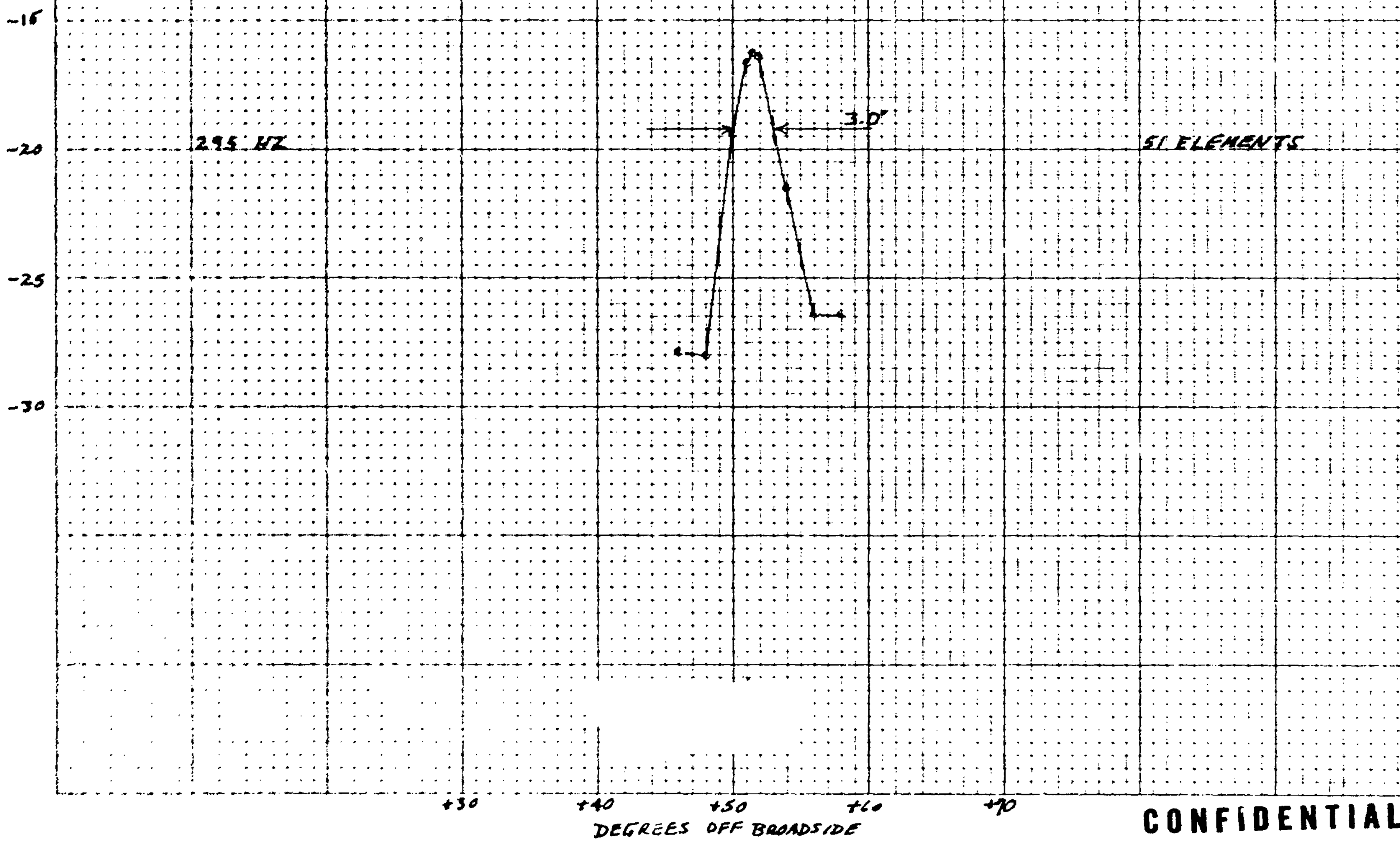
CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL

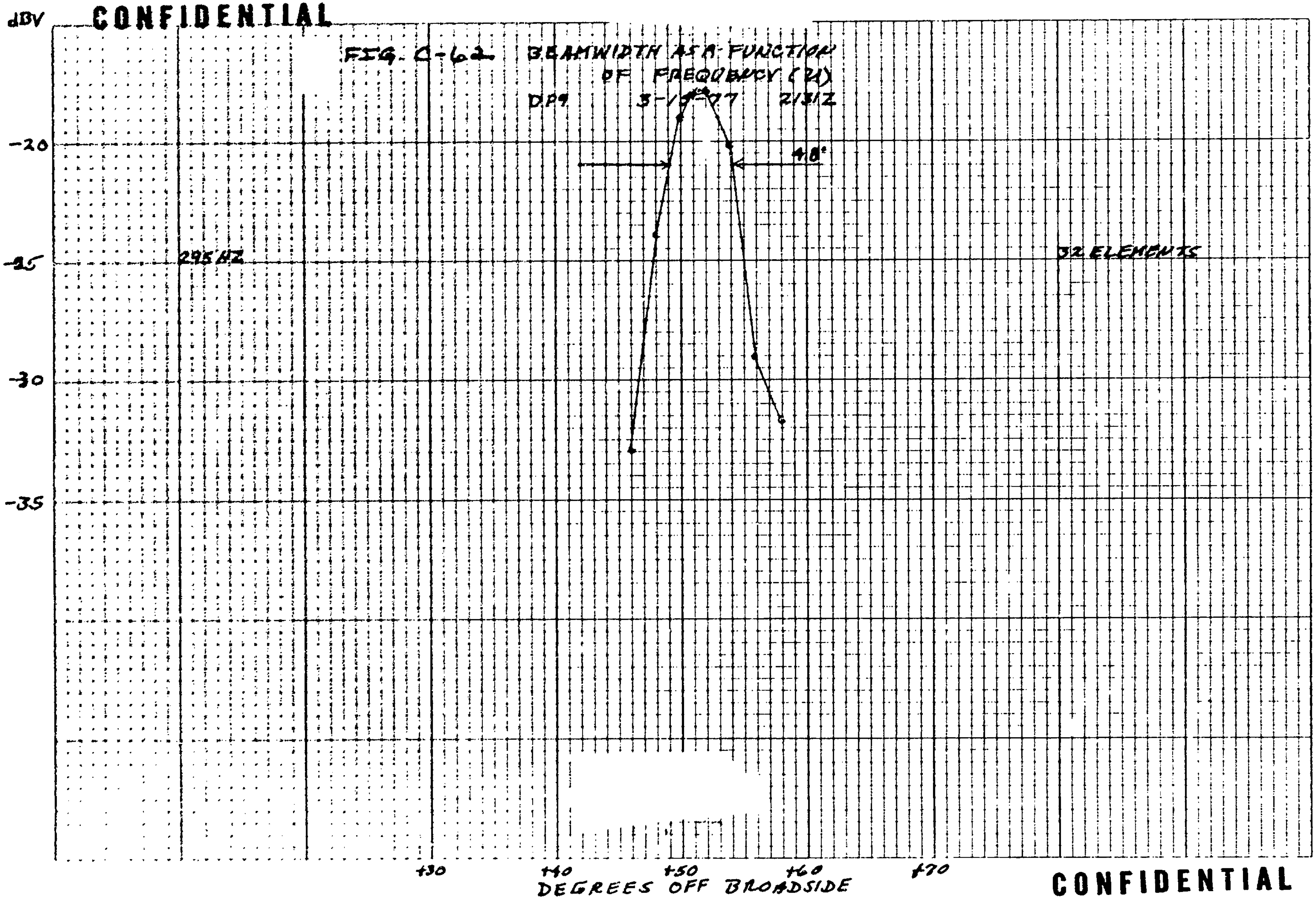
FIG. C-61 BEAMWIDTH AS A FUNCTION OF FREQUENCY (Z4)
DP9 3-15-77 2131Z



CONFIDENTIAL

CONFIDENTIAL

K+E 46 0703



CONFIDENTIAL

CONFIDENTIAL

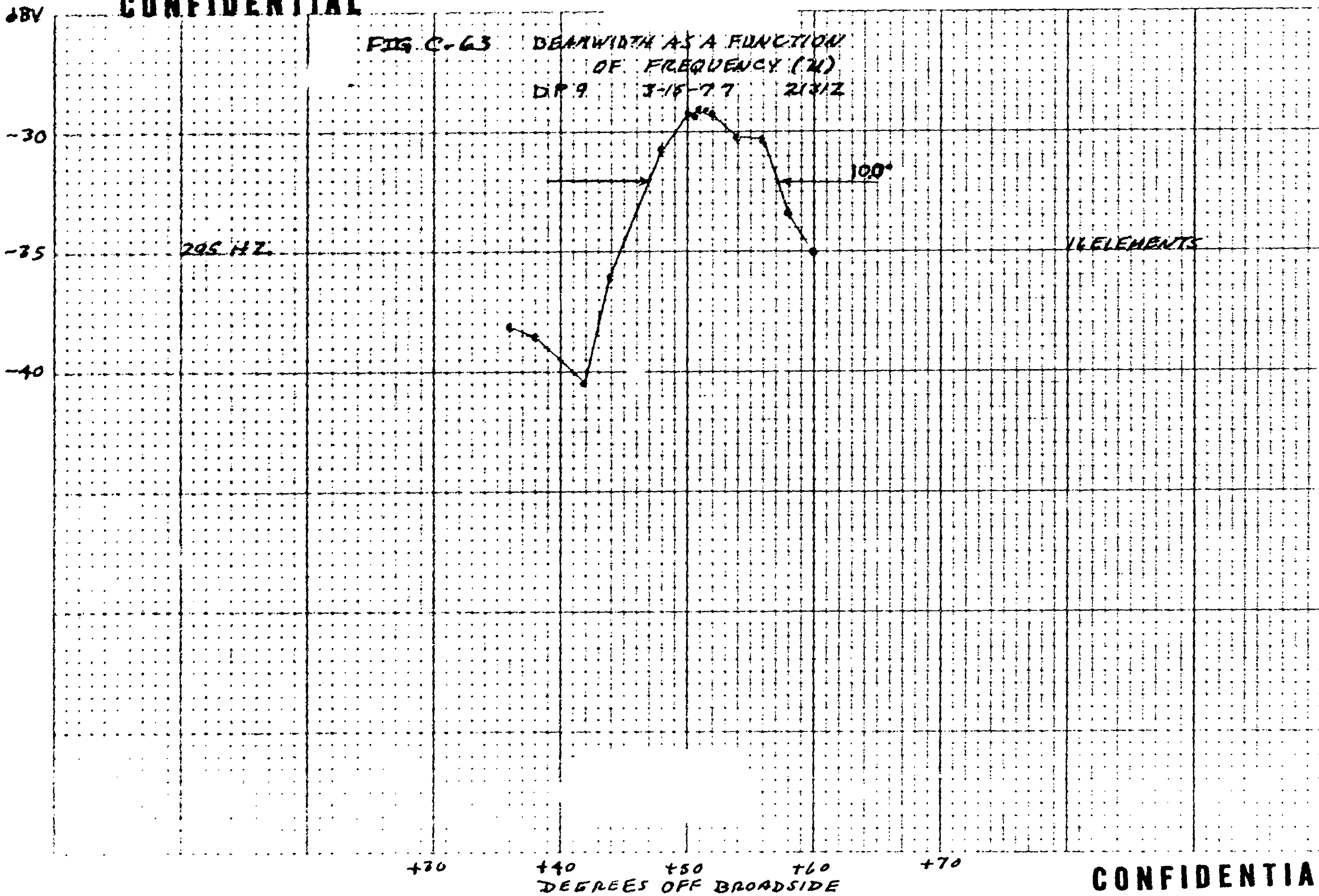
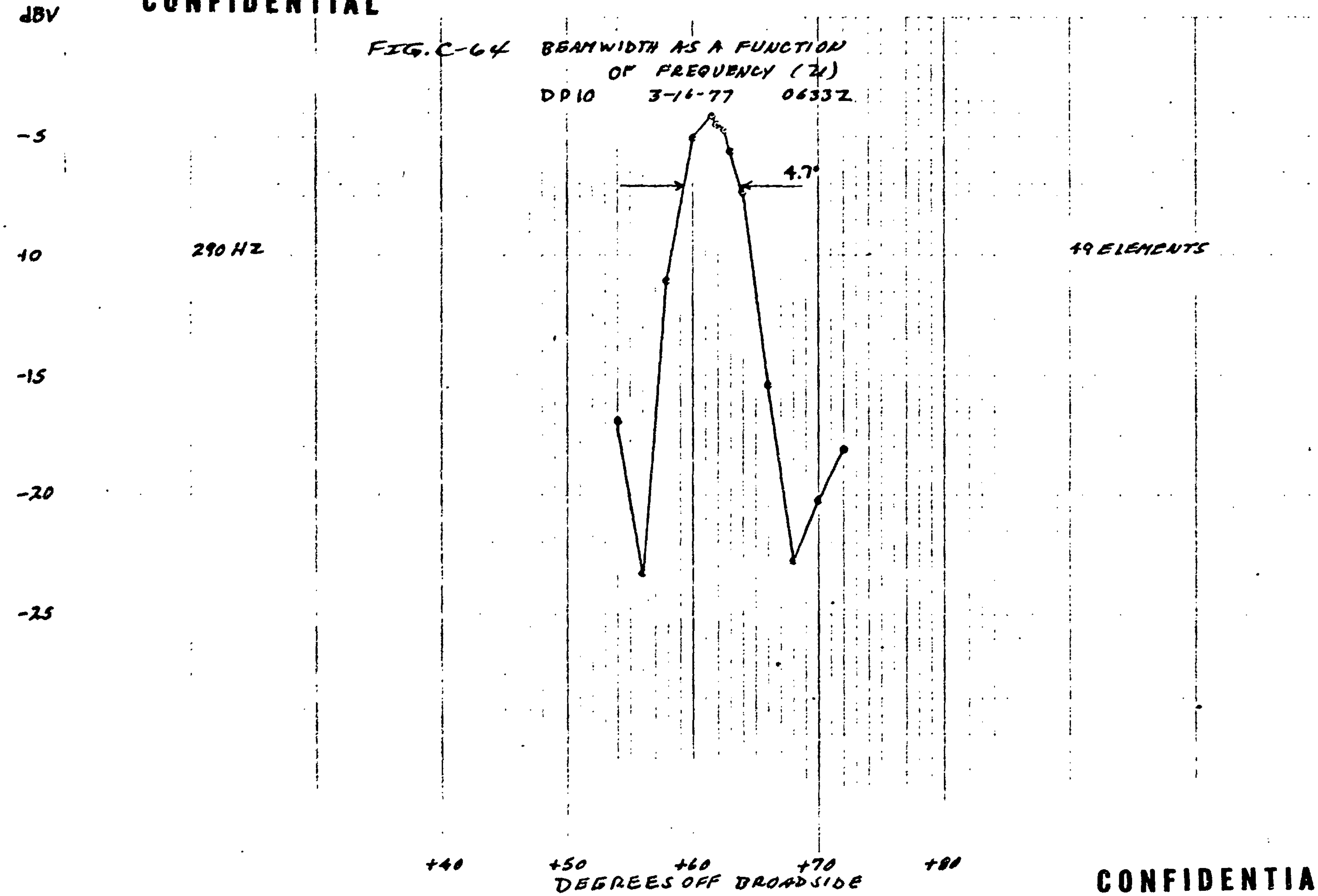


FIG. C-63 BEAMWIDTH AS A FUNCTION OF FREQUENCY (U)
DP 9 3-15-77 2131Z

CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL

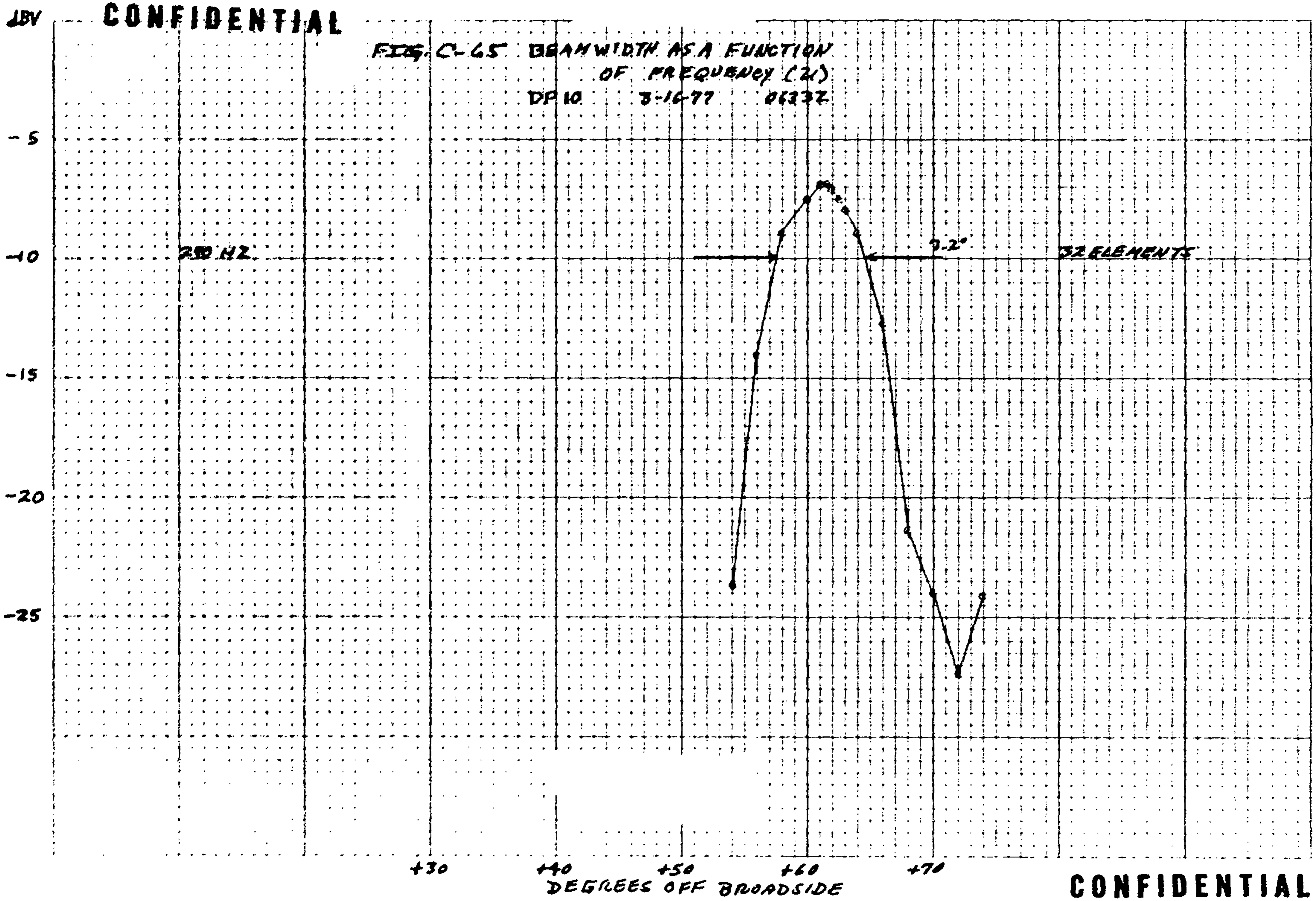


FIG. C-65 BEAMWIDTH AS A FUNCTION OF FREQUENCY (21)

DP 10 3-16-77 0633Z

CONFIDENTIAL

K+E 10 X 10 TO THE INCH 46 0703

CONFIDENTIAL

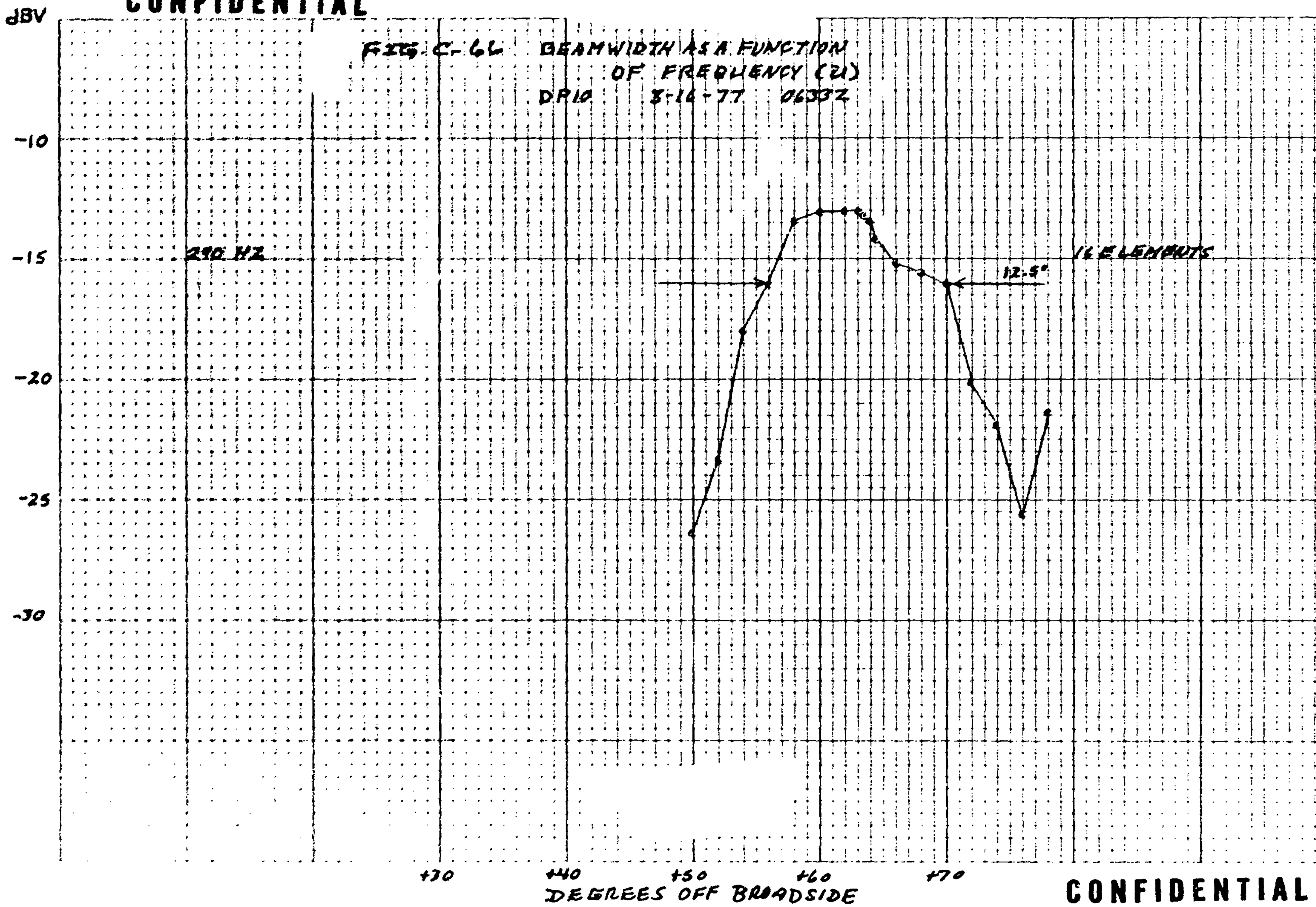
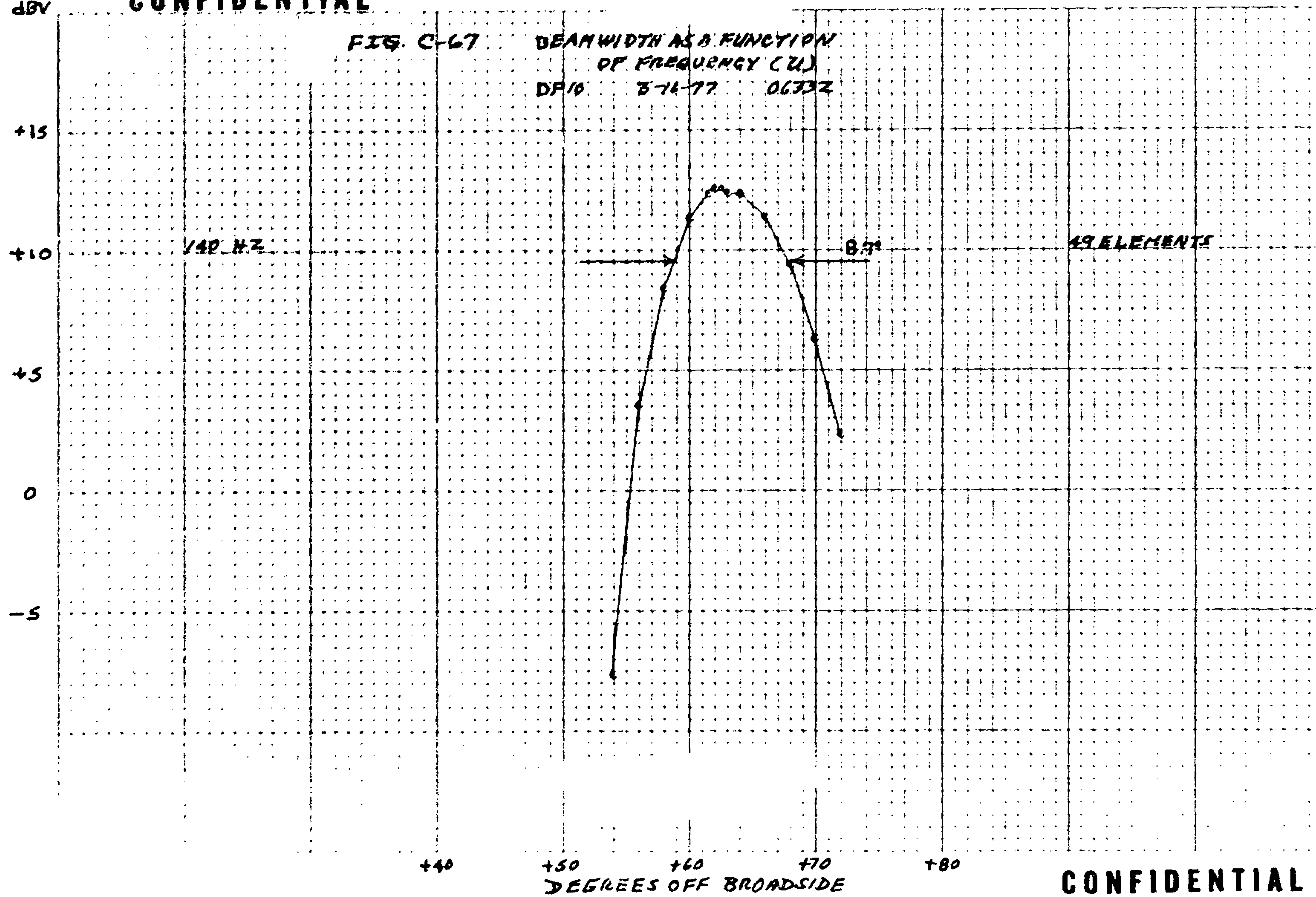


FIG. C-6L BEAMWIDTH AS A FUNCTION OF FREQUENCY (21)
DP10 3-16-77 0633Z

CONFIDENTIAL

CONFIDENTIAL

FIG. C-67 BEAMWIDTH AS A FUNCTION OF FREQUENCY (U)
DF10 8-16-77 0633Z



CONFIDENTIAL

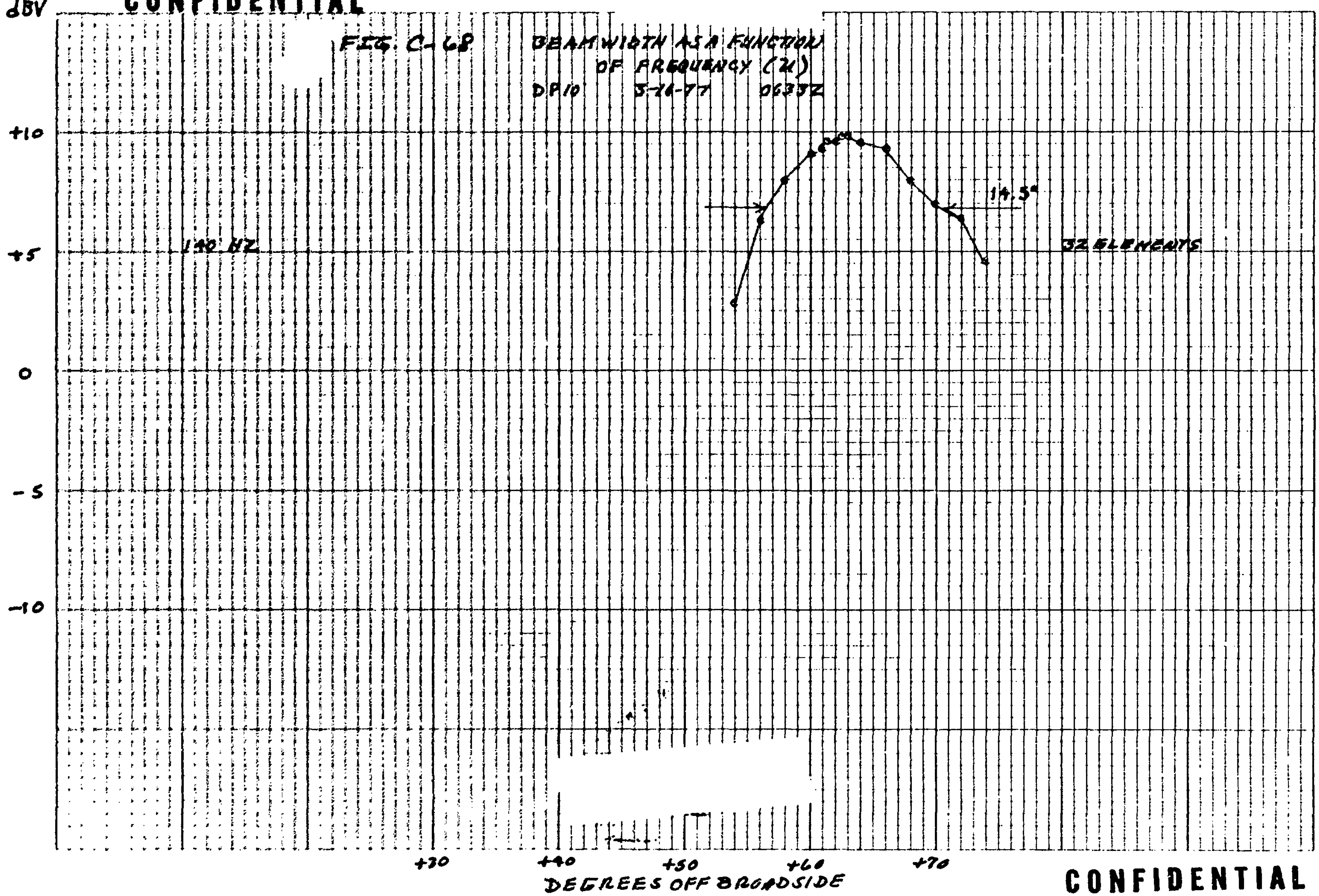
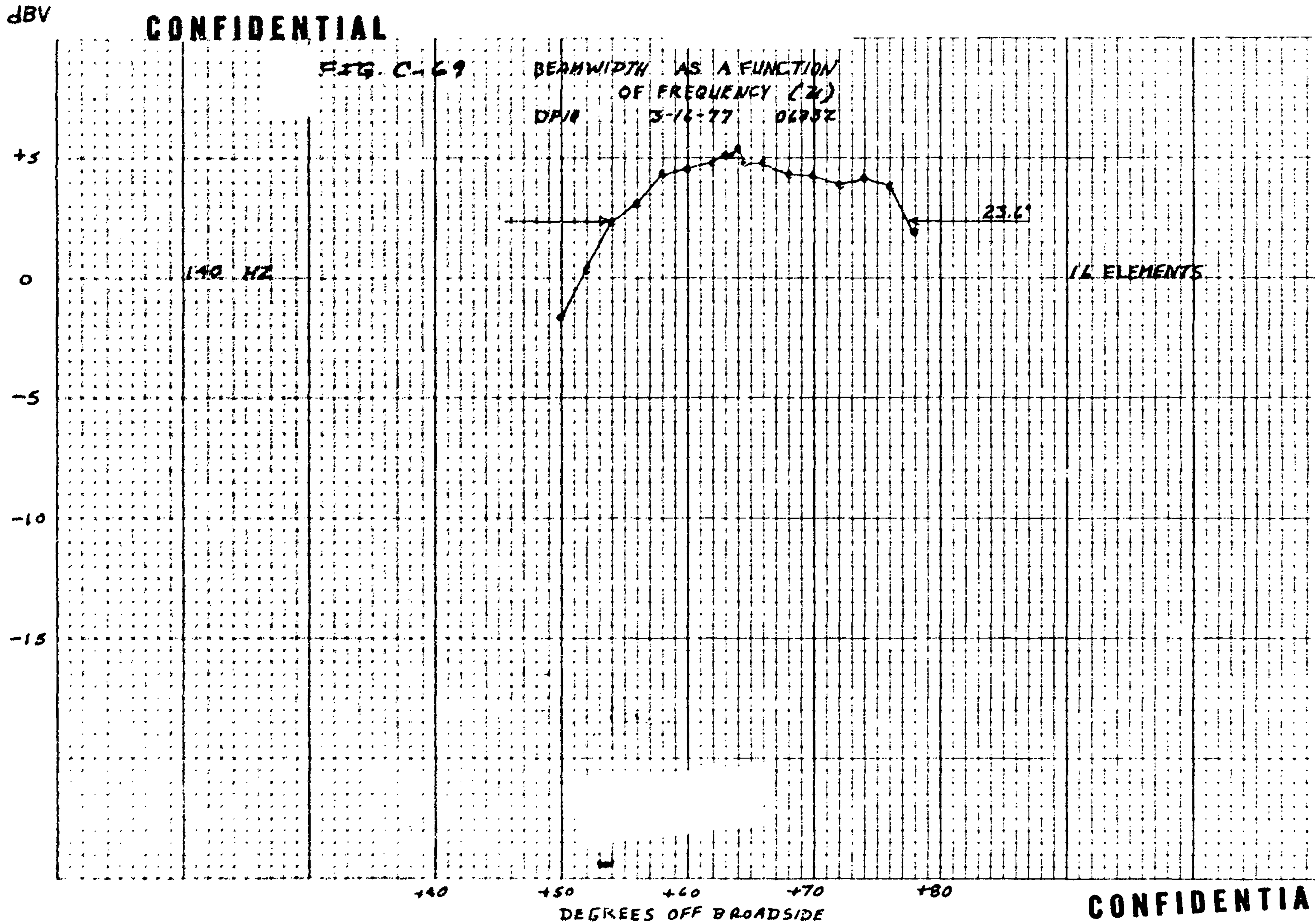
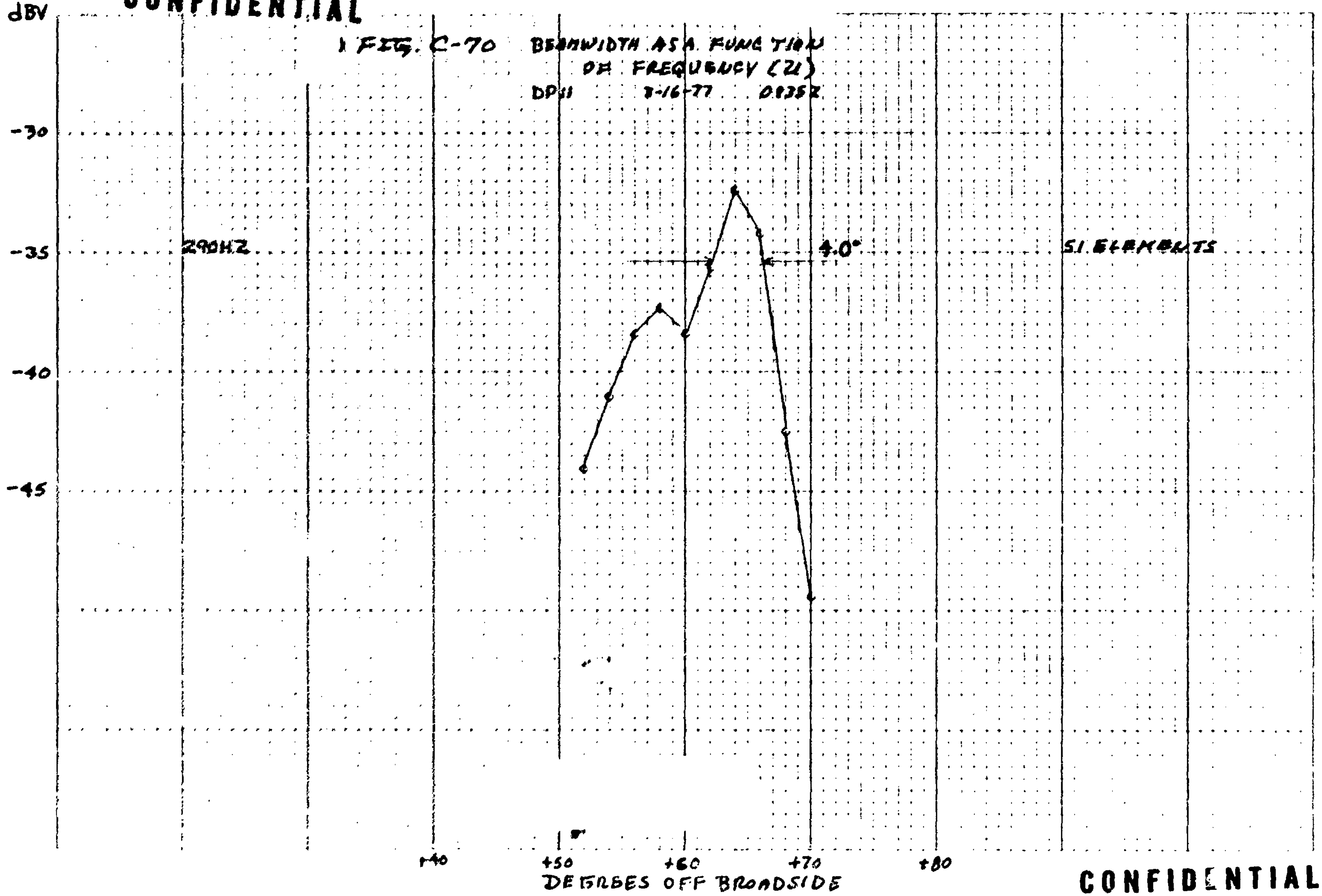


FIG. C-68
BEAMWIDTH AS A FUNCTION
OF FREQUENCY (2L)
DP10 5-26-77 0633Z
dBV
+10
+5
0
- 5
-10
140 HZ
14.5°
32 ELEMENTS
+30
+40
+50
+60
+70
DEGREES OFF BROADSIDE

CONFIDENTIAL

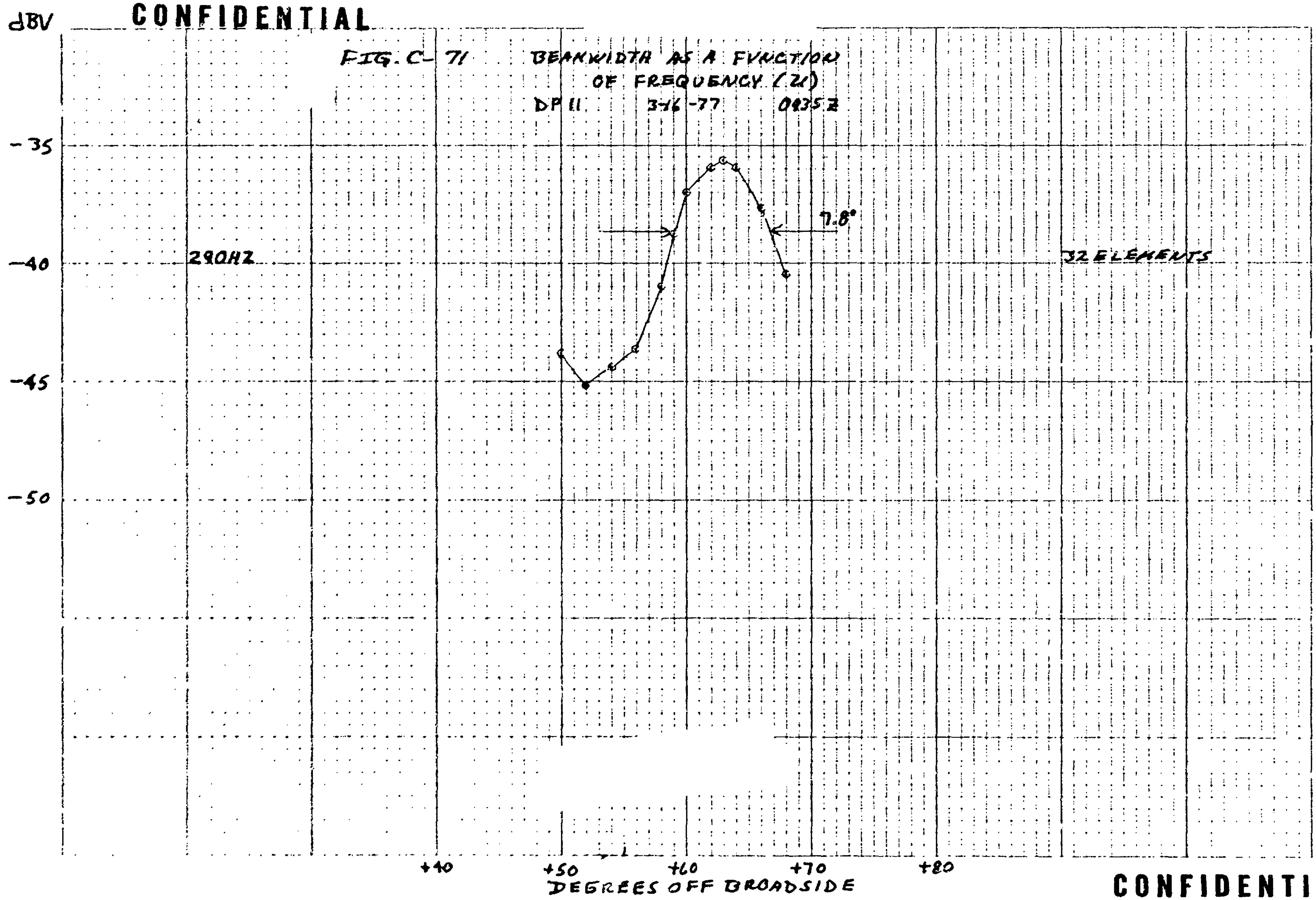


CONFIDENTIAL



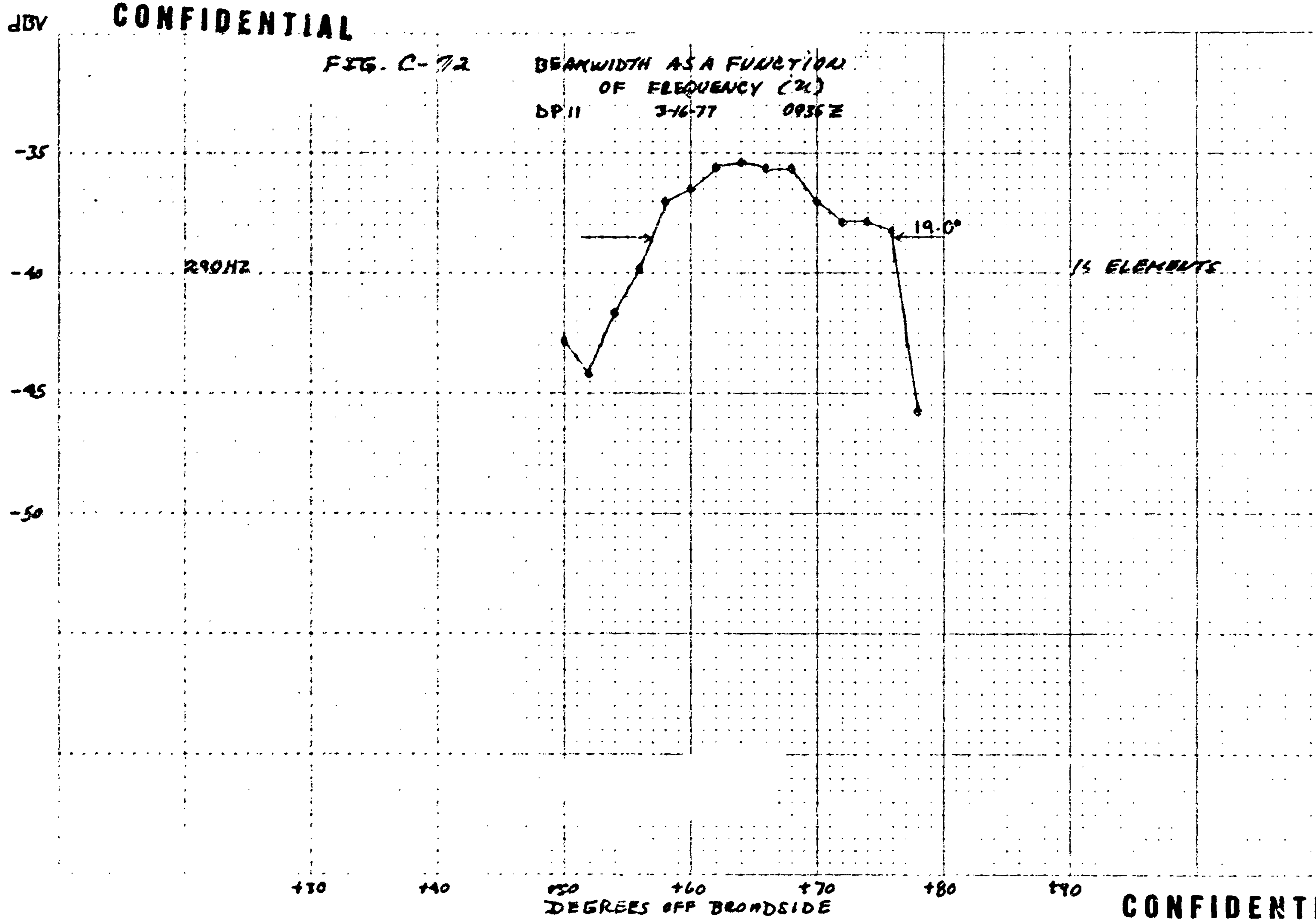
CONFIDENTIAL

FIG. C-71 BEAMWIDTH AS A FUNCTION OF FREQUENCY (21)
DP II 3-16-77 0835Z



CONFIDENTIAL

FIG. C-72


BEAMWIDTH AS A FUNCTION
OF FREQUENCY (2K)
DP11 3-16-77 0936Z
dBV
-35
-40
-45
-50
290HZ
19.0°
15 ELEMENTS
+30
+40
+50
+60
+70
+80
+90
DEGREES OFF BROADSIDE

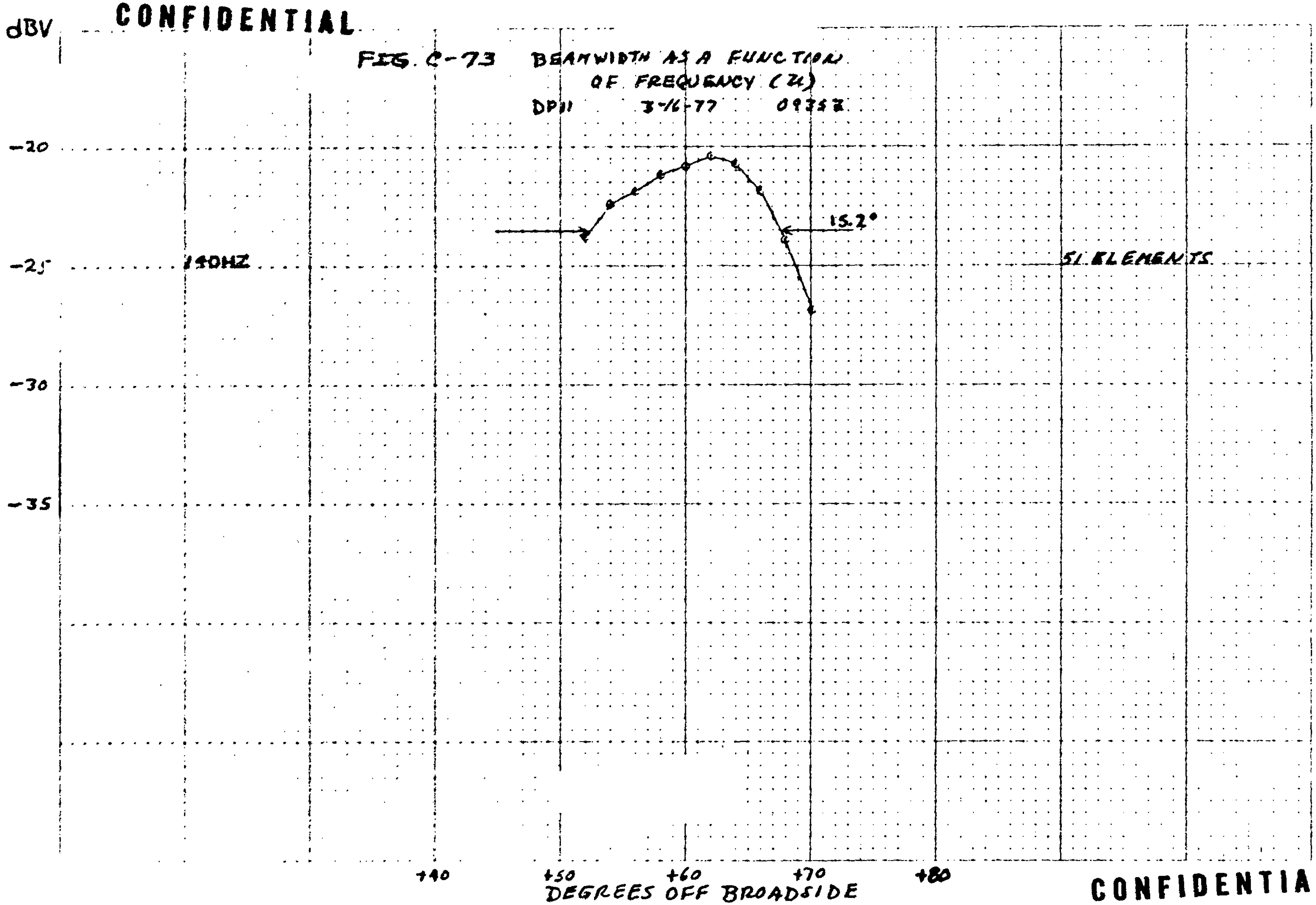
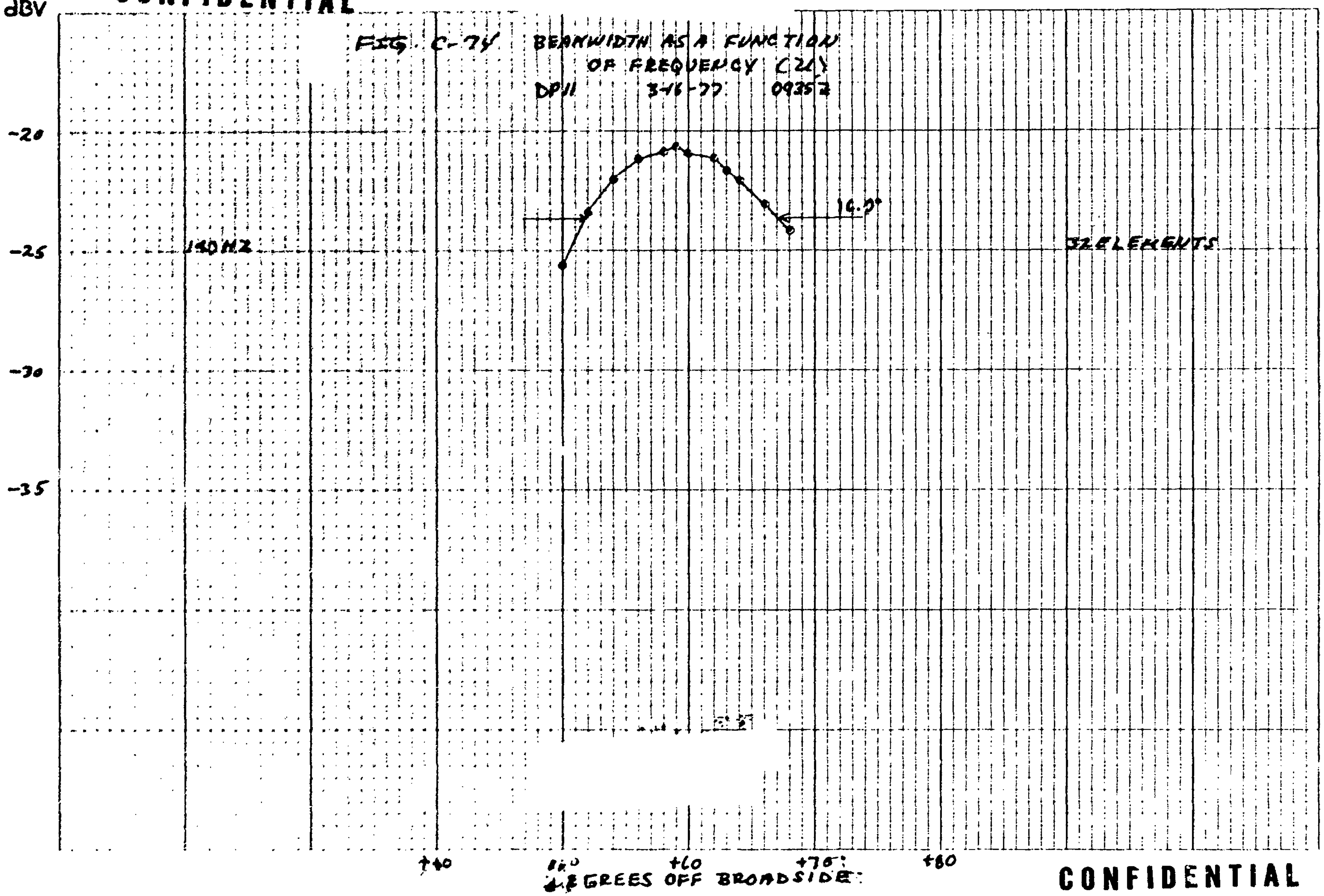


FIG. C-73 BEAMWIDTH AS A FUNCTION OF FREQUENCY (Z)
DP11 3-16-77 0935Z
dBV
-20
-25
-30
-35
140HZ
15.2°
51 ELEMENTS
+40
+50
+60
+70
+80
DEGREES OFF BROADSIDE

CONFIDENTIAL

FIG. C-74 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2L)
DP11 3-16-77 0935Z

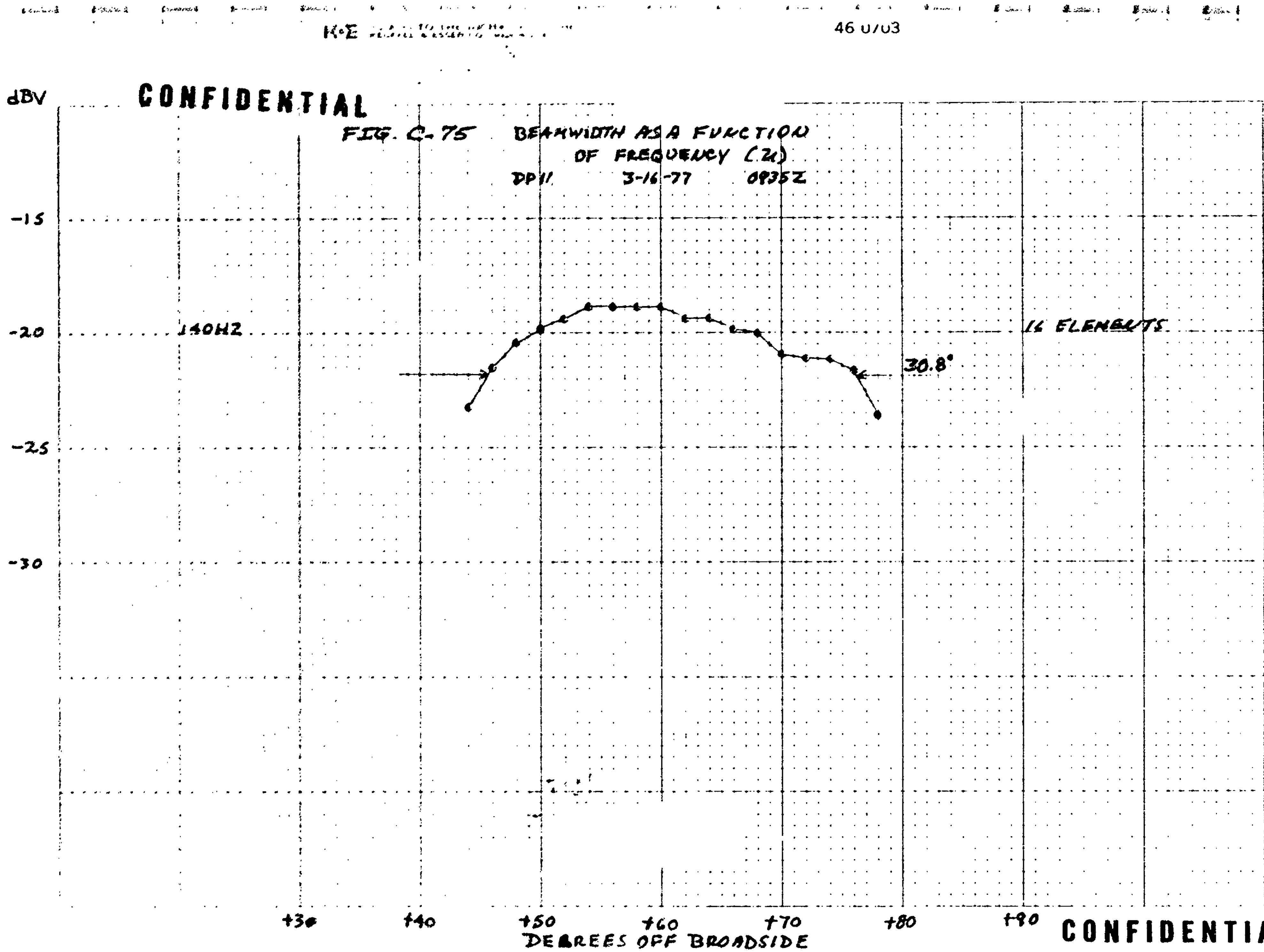


CONFIDENTIAL

CONFIDENTIAL

FIG. C-75 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2L)

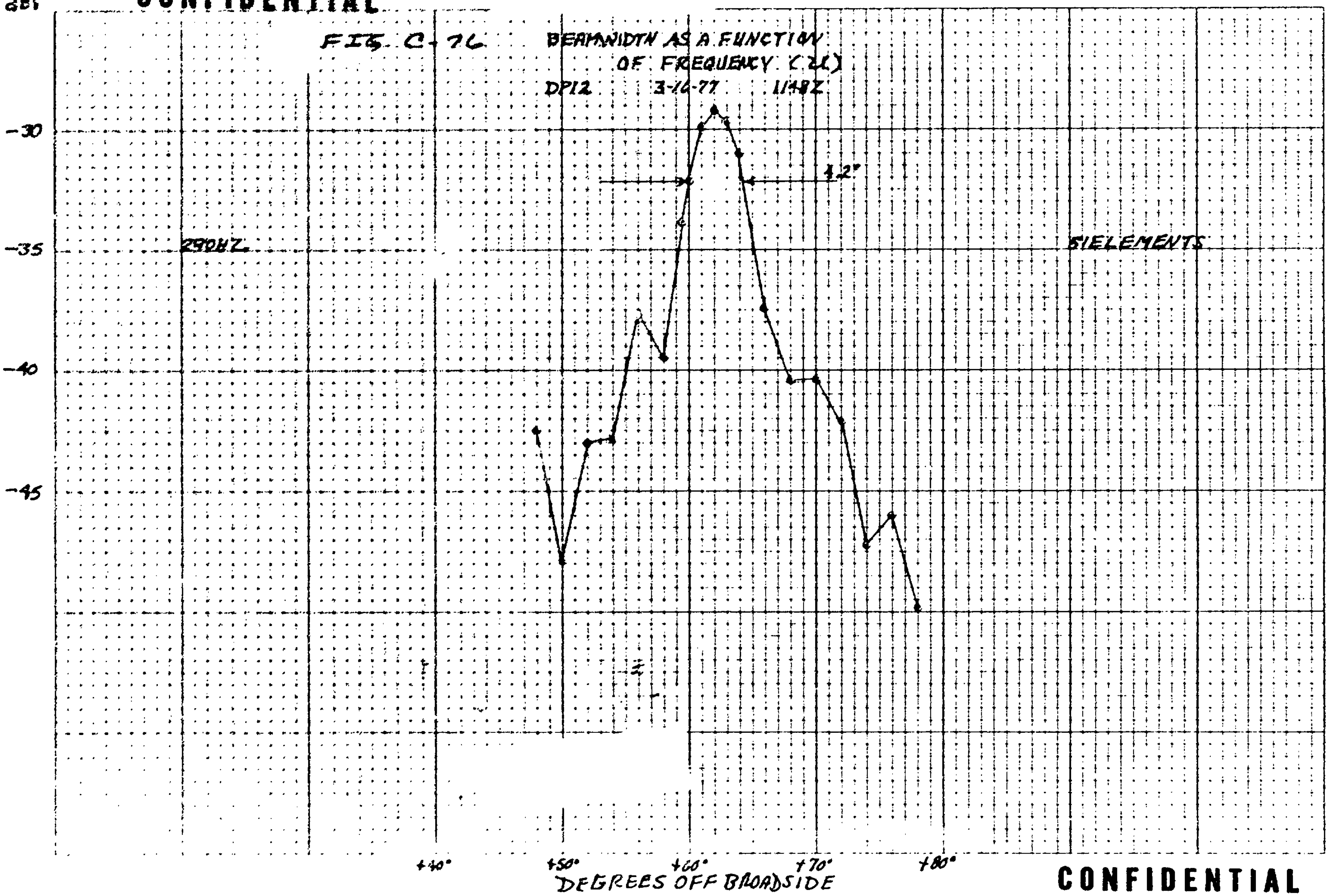
DP11 3-16-77 0935Z



CONFIDENTIAL

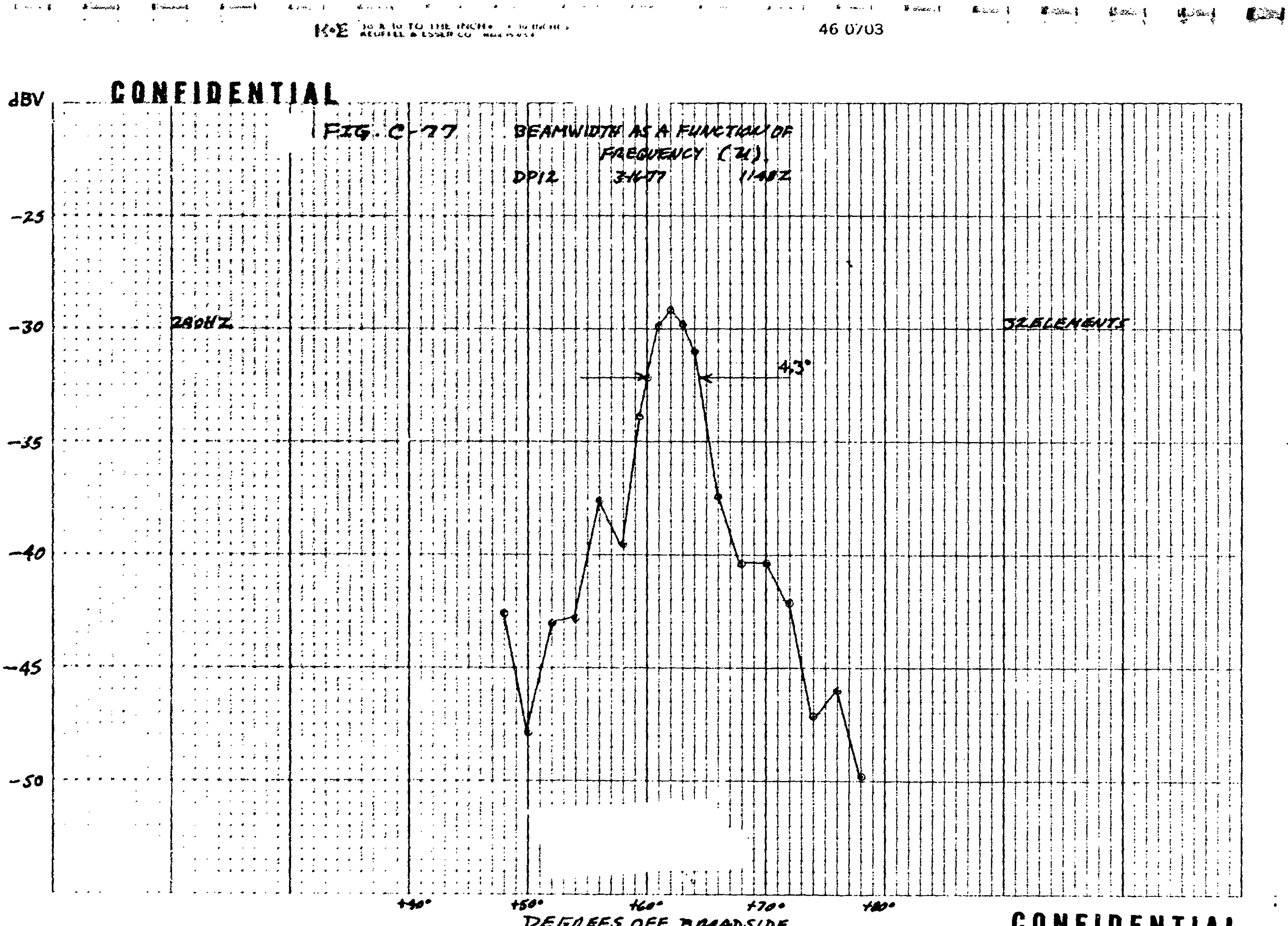
CONFIDENTIAL

FIG. C-76



CONFIDENTIAL

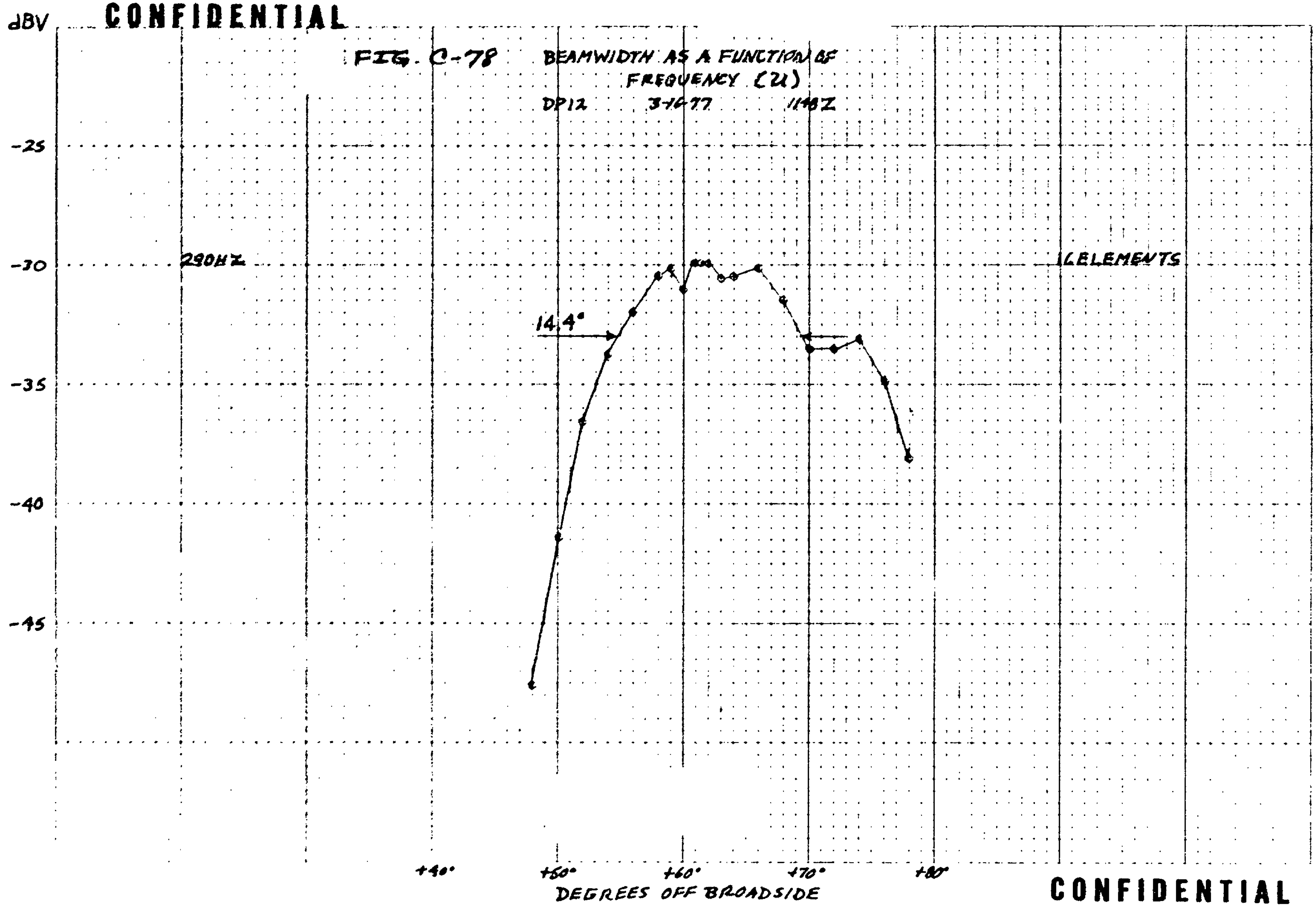
CONFIDENTIAL



CONFIDENTIAL

FIG. C-78 BEAMWIDTH AS A FUNCTION OF FREQUENCY (U)

DP12 3-16-77 1140Z



K•E 46 0703

CONFIDENTIAL

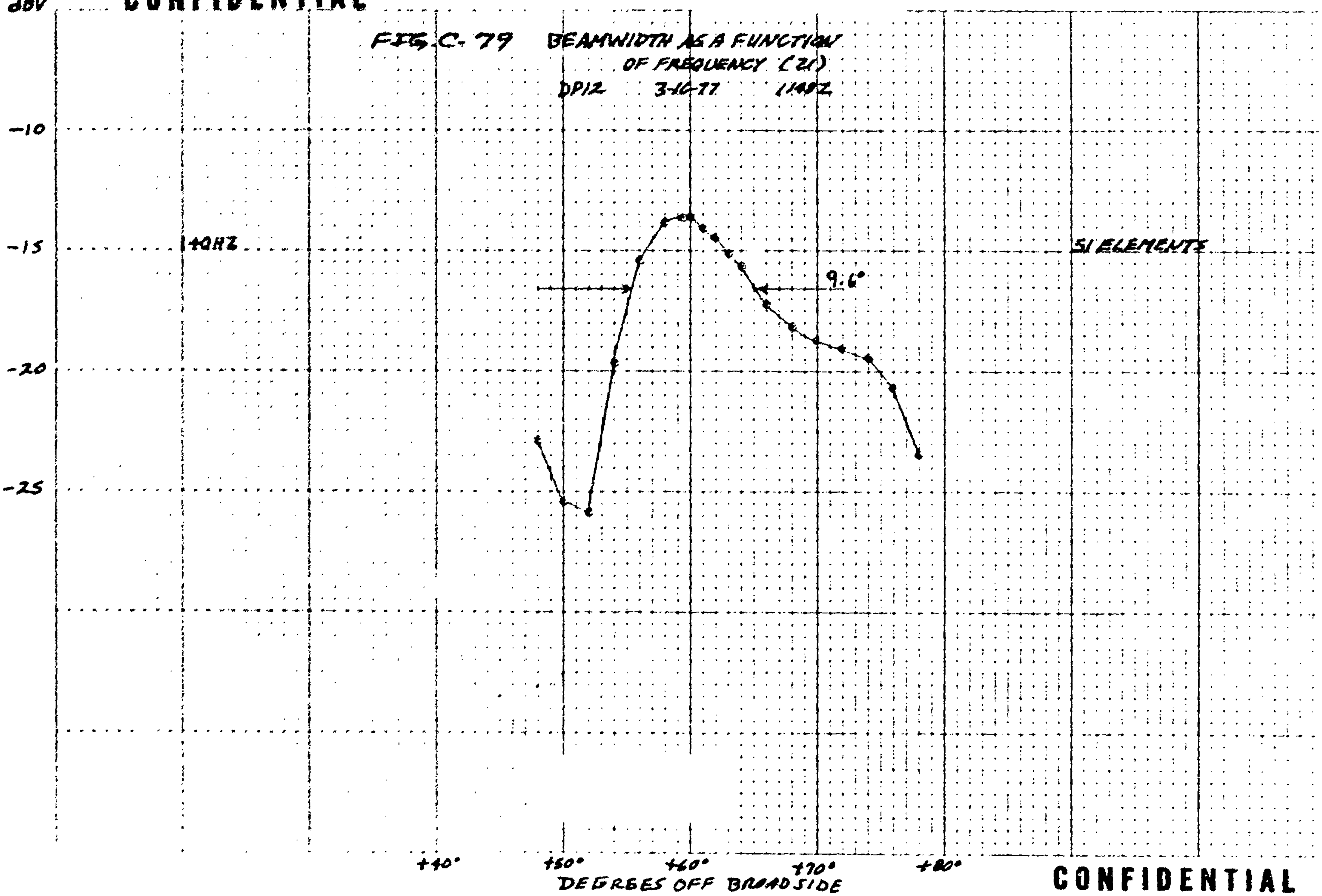
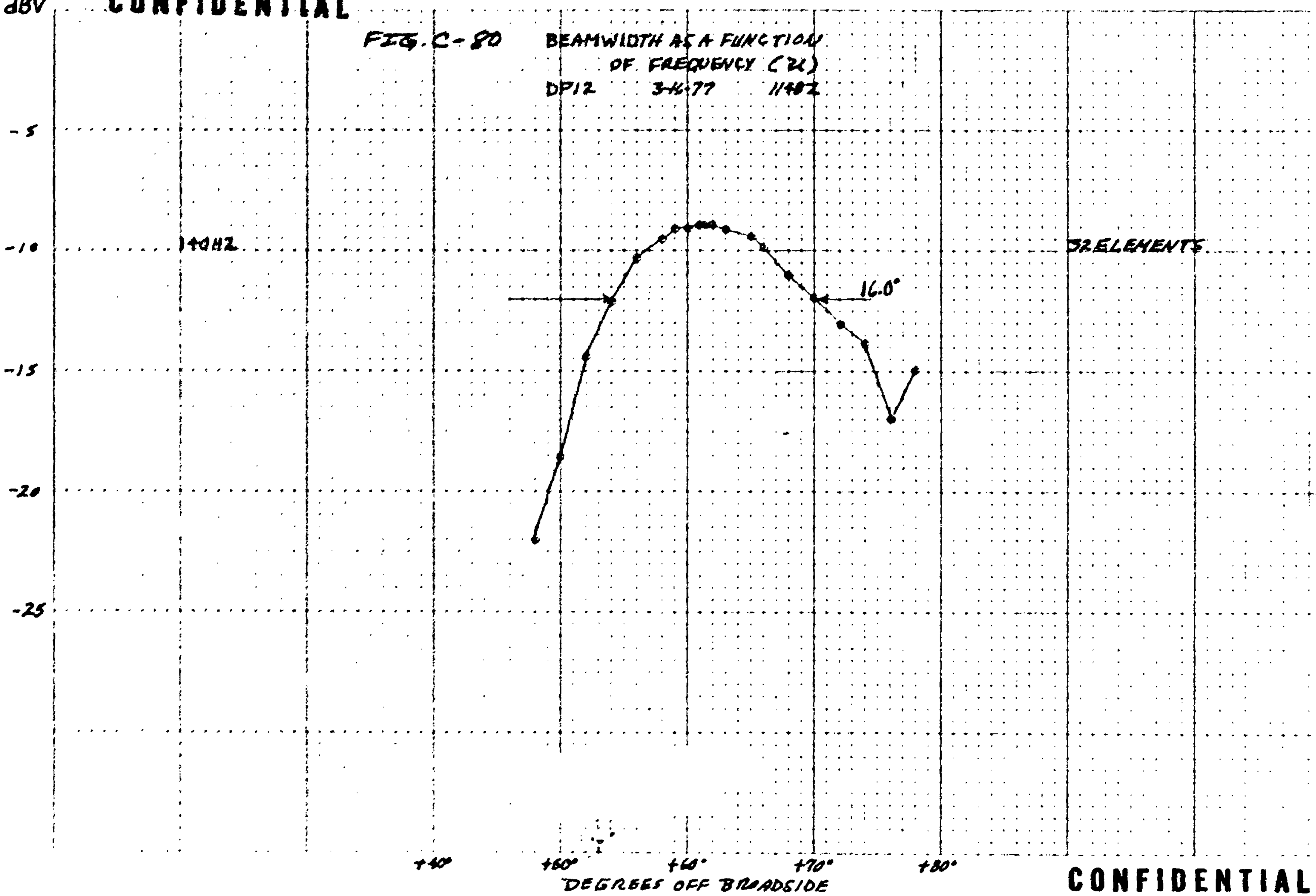


FIG. C-79 BEAMWIDTH AS A FUNCTION OF FREQUENCY (21)
DP12 3-16-77 114HZ

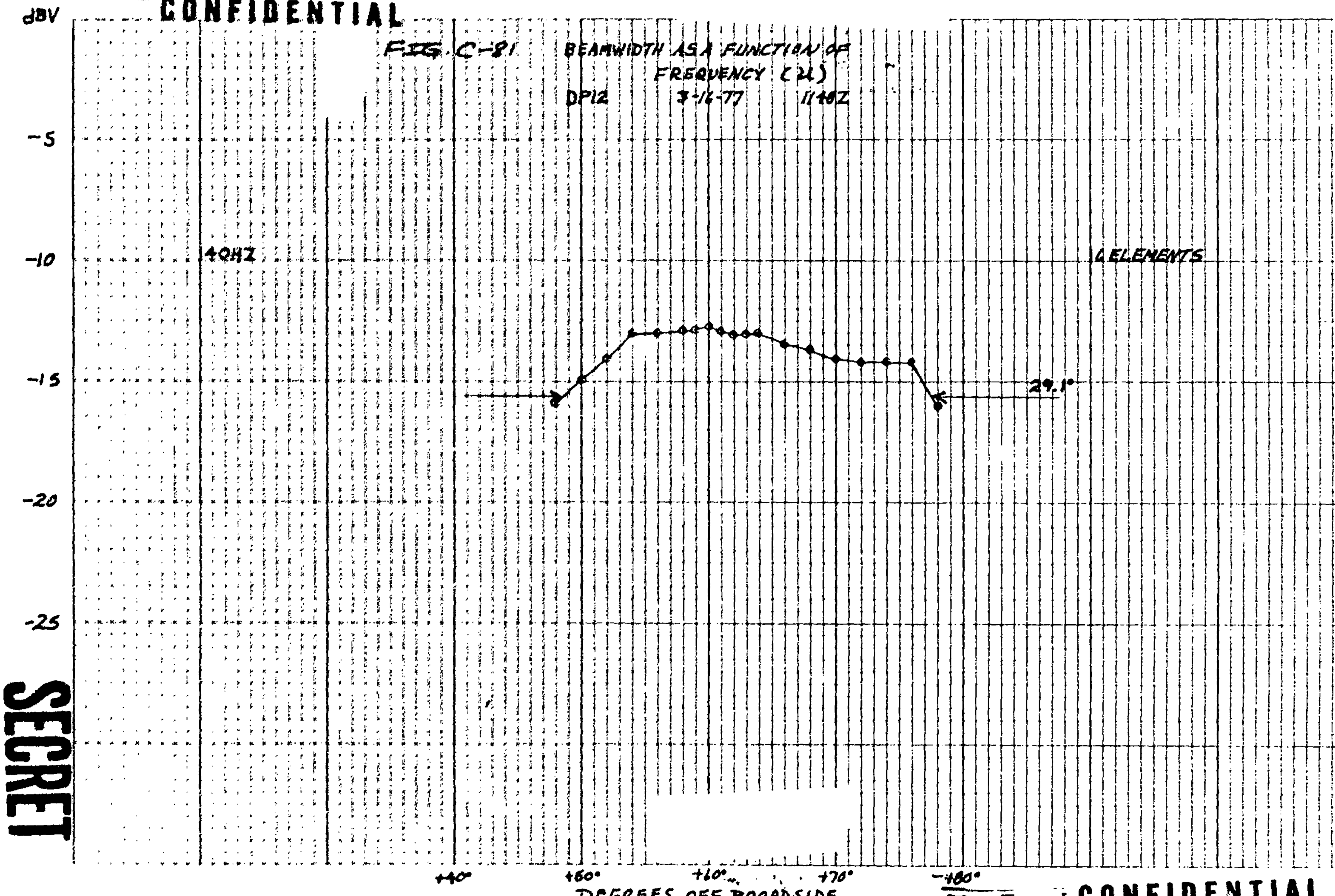
CONFIDENTIAL

FIG. C-80


BEAMWIDTH AS A FUNCTION
OF FREQUENCY (2L)
DP12 3-16-77 114HZ
dBV
-5
-10
-15
-20
-25
140HZ
32 ELEMENTS
16.0°
+40°
+60°
+70°
+80°
DEGREES OFF BROADSIDE

This page is CONFIDENTIAL

FIG. C-81 BEAMWIDTH AS A FUNCTION OF FREQUENCY (2L)



SECRET

This page is CONFIDENTIAL

SECRET

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
875 NORTH RANDOLPH STREET
SUITE 1425
ARLINGTON VA 22203-1995

IN REPLY REFER TO:

5510/1
Ser 321OA/011/06
31 Jan 06

MEMORANDUM FOR DISTRIBUTION LIST

Subj: DECLASSIFICATION OF LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP) DOCUMENTS

Ref: (a) SECNAVINST 5510.36

Encl: (1) List of DECLASSIFIED LRAPP Documents

1. In accordance with reference (a), a declassification review has been conducted on a number of classified LRAPP documents.

2. The LRAPP documents listed in enclosure (1) have been downgraded to UNCLASSIFIED and have been approved for public release. These documents should be remarked as follows:

   Classification changed to UNCLASSIFIED by authority of the Chief of Naval Operations (N772) letter N772A/6U875630, 20 January 2006.

   DISTRIBUTION STATEMENT A: Approved for Public Release; Distribution is unlimited.

3. Questions may be directed to the undersigned on (703) 696-4619, DSN 426-4619.

BRIAN LINK
By direction

Subj: DECLASSIFICATION OF LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP) DOCUMENTS

DISTRIBUTION LIST:

NAVOCEANO (Code N121LC – Jaime Ratliff)
NRL Washington (Code 5596.3 – Mary Templeman)
PEO LMW Det San Diego (PMS 181)
DTIC-OCQ (Larry Downing)
ARL, U of Texas
Blue Sea Corporation (Dr.Roy Gaul)
ONR 32B (CAPT Paul Stewart)
ONR 321OA (Dr. Ellen Livingston)
APL, U of Washington
APL, Johns Hopkins University
ARL, Penn State University
MPL of Scripps Institution of Oceanography
WHOI
NAVSEA
NAVAIR
NUWC
SAIC

Declassified LRAPP Documents

Report Number	Personal Author	Title	Publication Source (Originator)	Pub. Date	Current Availability	Class.
Unavailable	Bossard, David C.	ACOUSTIC ANALYSIS/ASEPS	Wagner Associates	780726	ADA076268	U
NRLMR3832	Heitmeyer, R., et al.	PRELIMINARY RESULTS OF AN ANALYSIS OF BEAM NOISE IN THE MEDITERRANEAN (U)	Naval Research Laboratory	780901	ND ADC016220	U
Unavailable	Watrous, B. A.	PARKA 1 OCEANOGRAPHIC DATA COMPENDIUM	Naval Ocean R&D Activity	781101	ADB115967	U
Unavailable	Dunbar, B., et al.	LAMBDA PROCESSING LABORATORY AND ENGINEERING SUPPORT, FINAL REPORT 1 JANUARY 1977 - 31 OCTOBER 1978	Texas Instruments, Inc.	781129	ND	U
Unavailable	Blumen, L. S., et al.	ASTRAL MODEL. VOLUME 2: SOFTWARE IMPLEMENTATION	Science Applications, Inc.	790101	ADA956122	U
Unavailable	Spofford, C. W.	ASTRAL MODEL. VOLUME 1: TECHNICAL DESCRIPTION	Science Applications, Inc.	790101	ADA956124	U
Unavailable	Townsend, R., et al.	SELF-TENSIONING ACOUSTICAL HORIZONTAL LINE ARRAY (SPRAY) DATA ANALYSIS. FINAL REPORT OF BEARING STAKE TESTS JANUARY THRU MARCH 1977. VOLUME IA. OVERALL PROGRAM PERFORMANCE RESULTS WITH TEST RESULTS SUMMARY	Sanders Associates, Inc.	790101	ADC017573	U
Unavailable	Unavailable	SELF-TENSIONING ACOUSTICAL HORIZONTAL LINE ARRAY (SPRAY) DATA ANALYSIS. FINAL REPORT OF BEARING STAKE TESTS JANUARY THRU MARCH 1977. VOLUME IB. DETAILED DESCRIPTION, TEST RESULTS	Sanders Associates, Inc.	790101	ADC017574	U
Unavailable	Unavailable	SELF-TENSIONING ACOUSTICAL HORIZONTAL LINE ARRAY (SPRAY) DATA ANALYSIS. FINAL REPORT OF BEARING STAKE TESTS JANUARY THRU MARCH 1977. VOLUME II. DATA ANALYSIS FACILITY AND DATA REDUCTION METHODOLOGY	Sanders Associates, Inc.	790109	ADC017575	U
Unavailable	Unavailable	SELF-TENSIONING ACOUSTICAL HORIZONTAL LINE ARRAY (SPRAY) DATA ANALYSIS. FINAL REPORT OF BEARING STAKE TESTS JANUARY THRU MARCH 1977. VOLUME IIIA. DATA POINTS 1, 2 AND 3 RAW DATA	Sanders Associates, Inc.	790109	ADC017576	U
Unavailable	Unavailable	SELF-TENSIONING ACOUSTICAL HORIZONTAL LINE ARRAY (SPRAY) DATA ANALYSIS. FINAL REPORT OF BEARING STAKE TESTS JANUARY THRU MARCH 1977. VOLUME IIIB. DATA POINTS 4, 5 AND 6 RAW DATA	Sanders Associates, Inc.	790109	ADC017577	U
Unavailable	Unavailable	SELF-TENSIONING ACOUSTICAL HORIZONTAL LINE ARRAY (SPRAY) DATA ANALYSIS. FINAL REPORT OF BEARING STAKE TESTS JANUARY THRU MARCH 1977. VOLUME IVA. DATA POINTS 7, 8 AND 9 RAW DATA	Sanders Associates, Inc.	790109	ADC017578	U