FINAL REPORT

PROTOTYPE HIGH-GAIN VEHICLE ANTENNA FOR MOBILE SATELLITE USE

in response to

DSS File No. 01SM.36001-2-2761

Q8301

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1. INTRODUCTION

This report describes the prototype high-gain vehicle antenna for mobile satellite use developed by Antech under DSS File No. 01SM.36001-2-2761.

This antenna, illustrated in Figure 1, operates with right-hand circular polarization in the frequency bands 821-825 MHz and 866-870 MHz. The radiation patterns are such as to cover a range of elevation angles suitable for communication with a geostationary satellite from locations in Canada while having the ability to scan in azimuth in order to track the satellite at any orientation of the vehicle.

The radiating part of the antenna is made up of three identical panels of twelve crossed dipole elements arranged on a square grid three elements high by four elements wide. Each element is fed from a microstrip hybrid coupler to provide the quadrature phase required for circular polarization. These hybrids are in turn fed from reactive power dividers (one for each vertical stack of three elements). These four stacks are connected to the outputs of a 4 by 4 Butler Matrix which provides the excitations to generate four beams (from each panel). Three additional beams are produced, by combining the patterns of two panels, for a total of 15 for the entire antenna. These beams are selected by coaxial relays driven by a microprocessor-based control circuit.

Chapter 2 of this report describes the signal-frequency components and Chapter 3 provides the results of testing of the complete antenna. The circuit details and operation of the beam selection controller board are included in Appendix A. Mechanical information may be obtained from Antech drawings 301-10000 "Antenna Assembly" (1 sheet), 301-20000 "Antenna Panel Assembly" (3 sheets) and unnumbered drawing "Case-MSat" (2 sheets).

2. COMPONENTS

2.1 Antenna Elements

Each element is a pair of crossed fan-shaped dipoles etched on 1/16 inch single-side copper-clad glass-fibre epoxy board. The dipole dimensions are shown in Figure 2. They are fed by two semi-rigid coaxial cables with the inner conductors crossed over in front of the elements. These cables pass through quarter-wavelength sleeve baluns which set the spacing of the elements from the ground plane.

2.2 Hybrid Couplers

Quadrature 3dB couplers are used both for generation of the equal-amplitude quadrature-phase excitations for the crossed dipoles and to divide power between two panels to form the three corner beams. These are made in microstrip form on 1/16 inch glass-fibre-teflon substrate with a dielectric constant of 2.33. A total of 39 two-branch branch-line couplers are used. Worst case measured performance data for a sample of twelve couplers are given in Table 1.

2.3 Butler Matrices

The microstrip Butler Matrix boards also use 1/16 inch glass-fibre-teflon substrate with a dielectric constant of 2.33. Crossovers are made from 0.141 inch 50 ohm semi-rigid coaxial cable. Also integrated on the same boards are three way reactive power dividers at the outputs of each Butler matrix. Therefore, (in the transmitting sense) there are four inputs and twelve outputs on each board. The layout of a Butler Matrix board is shown in Figure 3 and the worst-case measured R.F. performance is summarized in Table 2.

2.4 R.F. Cables

Semi-rigid 50 ohm coaxial cable (0.141 inch diameter) is used for all R.F. interconnections. SMA series connectors are used throughout. The cables between the Butler Matrix boards and the Hybrid boards are of appropriate lengths to form the elevation beam. The lengths of the cables between the switching box and the Butler Matrix 2L and 2R inputs are also critical as these provide the correct phasing for the corner beams.

2.5 R.F. Switching

Figure 4 shows in schematic form the positions of the fifteen beams with respect to the antenna, as viewed from above. The switching of power between the corresponding Butler Matrix ports is performed by ten SPDT and two SP6T coaxial relays with 12VDC coils. The interconnections between these relays are shown in Figure 5. Also included in this Figure are the 3 dB couplers used to produce the corner beams 4A, 8A and 12A by exciting two beam ports simultaneously. The SPDT switches are shown in the unpowered position. The locations of the switches inside the switching box are given in Figure 6.

Measured R.F. performance of the switching box (between the input connector and beam output connectors on the switches) is summarized in Table 3. Return loss measurements were made with 50 ohm terminations on the beam output ports.

3. TEST DATA

3.1 VSWR

Return Loss measurements were taken for each of the 15 beams over the frequency range of 800 MHz to 900 MHz. The results are recorded in Figures 7 through 21. Each plot contains three curves. The reference line (recorded with a short circuit termination on the directional coupler used to obtain the reflected signal) is a straight line except for amplitude marker dips at 821, 825, 866 and 870 MHz. The curve immediately above this was recorded with an open circuit termination and allows determination of calibration error. The third curve is the antenna return loss. These plots show Return Loss of better than 17 dB (VSWR ≤ 1.33) between 821 and 825 MHz and better than 12 dB (VSWR ≤ 1.67) between 866 and 870 MHz.

3.2 Feed Network Loss

An estimate of the loss incurred in the feed components for the array is given in Table 4. The components of this loss budget are based on typical results of tests of the individual parts of the network. In the case of cables, loss specifications published by the manufacturer were used. A typical value of 1.36 dB loss has been calculated.

3.3 Radiation Patterns

Radiation pattern measurements were made on an outdoor range 6m in length and elevated about 2.5m above ground as shown in Figure 22. Provision was made for tilting the antenna positioner in order to take conical cuts. These correspond to the azimuth patterns of the antenna in normal use with satellites at elevation angles of 15, 25 and 35 degrees above the horizon. To measure single-panel elevation patterns the positioner turntable was set parallel to the range axis and the antenna panel was tilted to align the desired beam with the source horn.

The azimuth patterns are given in Figures 23 to 58. Measurements were made for elevation angles of 15, 25 and 35 degrees at 823 and 868 MHz with horizontal and vertical polarization of the source horn. Each figure shows five beams, the four beams generated by a single panel plus one of the associated corner beams. The zero degree mark corresponds to an azimuth perpendicular to the panel face. The patterns for each panel are very similar with 1L and 1R beams near +/- 15° scan and 2L and 2R beams near +/- 45° The corner beams are, however, a few degrees offset from the nominal 60°. Sidelobe peak levels are typically 6 to 10 dB below main lobe gains.

Estimates of gain were made by comparison with a standard gain horn having a linearly polarized gain of 15.1 dBi at 823 MHz and 15.5 dBi at 868 MHz. The resulting calibration means that the 0 dB level on the patterns corresponds to a linearly polarized gain of 18.0 dBi at 823 MHz and 18.2 dBi at 868 MHz. To determine a value of circularly polarized gain from linearly polarized measurements it is necessary to make some assumptions. If the measured linearly polarized power gains G_H and G_V are assumed to correspond to the major and minor axes of the polarization ellipse and that the signals received from the two polarizations are at the correct phase to add in the 3 dB hybrid then the circularly polarized gain is

$$G_c = \frac{(\sqrt{G_H} + \sqrt{G_V})^2}{2}$$

An estimate for axial ratio may be obtained with the same assumptions as the ratio of the two measured gains G_H and G_V. The gain and axial ratio estimates for the azimuth peak of each beam are shown in Tables 5, 6 and 7 for 15, 25 and 35 degrees elevation. The maximum gain is 15.8 dBi and the minimum (on gain peak) is 8.0 dBi which occurs at 35 degrees elevation. The overall average axial ratio is 4.5 dB. The axial ratio shows best performance at low elevation and low scan angles; for example at 15 degrees elevation on 1L and 1R beams the average axial ratio is 0.6 dB increasing to 11.0 dB for corner beams at 35 degrees elevation.

The same technique has been used to estimate the gain at beam crossover points. Table 8 summarizes these estimates. While there are a few points at which the gain is less than 8 dBi these account for a very small part of the solid angle covered by the antenna.

In fact the average of all the crossover gains computed for all three elevation angles and both frequencies is 10.2 dBi.

Elevation patterns for a single panel (Panel 1) are shown in Figures 59 to 74. These patterns are taken through the azimuth peaks, for 823 and 868 MHz, vertically and horizontally polarized. No elevation patterns were recorded for corner beams because of the difficulty of mounting the complete antenna for these measurements. The characteristics of the elevation patterns are shown in Table 9. In this table the polarization column shows the orientation of the source horn during the tests. As the antenna panel was turned on its side for elevation measurements the "horizontal" and "vertical" directions with respect to the antenna under test are interchanged compared to normal antenna operation.

3.4 Weight

The weight of the antenna is 103 lb (47 kg) exclusive of any radome or external cables.

4. INTERFACE INFORMATION

A female SMA-series connector mounted on the switching box is provided for R.F. input. Refer to Appendix A for background information regarding the beam selection controller. A 10-pin connector, also on the switching box, is used for power and control connections. Pin assignment data is given in Table 10. Power supplies of 5 and 12 volts are required. The antenna control circuitry is isolated from the switching box so it may be used in either negative or positive ground configurations. The two supplies, however, must nevertheless share a common negative connection. The two alarm pins are at approximately +12V if off and 0.7V when on. Although the driver IC used for these alarm lines is nominally able to sink more than 1A, an LED in series with a resistor (connected to +12V) is recommended as an indicator which will result in minimal heating. The R.F. signal level input must be between zero and +5V with respect to the 0V line. The threshold is 2.6V. A power/control test cable (with connector) is supplied with the antenna. The colour code used is given in Table 10. The switch settings required to select each beam (in manual mode) are shown in Table 11.

TABLE 1. HYBRID COUPLER WORST CASE PERFORMANCE

Measurement	820-825 MHz	865-870 MHz
Input Return Loss (dB)	21.8	22.9
Output Return Loss (dB)	15.5	20.5
Isolation (dB)	19.2	23.5
Amplitude Unbalance (dB)	0.45	0.20
Phase Error (degrees)	1.5	1.5

TABLE 2. BUTLER MATRIX WORST CASE PERFORMANCE

Measurement	820-825 MHz	865-870 MHz
1L Input Return Loss (dB)	23.6	12.5
1R Input Return Loss (dB)	26.0	13.7
2L Input Return Loss (dB)	24.1	17.0
2R Input Return Loss (dB)	26.3	19.2
Single Output Port Insertion Loss (dB)	11.8 (1.0 dB excess)	11.9 (1.1 dB excess)
Output Amplitude Error (dB)	1.3	1.3
Output Phase Error (deg.)	6	10

TABLE 3. SWITCHING BOX R.F. PERFORMANCE

Measurement	820-825 MHz	865-870 MHz
Return Loss (dB)	≥20.5	≥17.4
VSWR	≤ 1.21	≤ 1.31
Insertion Loss (dB)		
Ordinary Beams	≤ 0.4	≤ 0.4
Corner Beams	≤ 0.5	≤ 0.6
Average	0.3	0.3

TABLE 4. ESTIMATED FEED NETWORK LOSS

Item	Condition	Loss (dB)
Element match	Typically 18 dB Return Loss	0.07
Balun Cables	5" at 0.1 dB/ft.	0.04
Hybrid Board Loss	Typical average, both bands	0.08
HB-BM Cables	Typically 1.5 ft. at 0.1dB/ft	0.15
Butler Matrix Loss	1L input, average of both bands	0.35
BM-SB Cables	Typically 2 ft at 0.1dB/ft	0.20
Switching Box Loss	Measured average, both bands	0.30
Input Match	Typically 14 dB Return Loss	0.17
	TOTAL	1.36 dB

TABLE 5. Gain and axial ratio at 15° elevation on azimuth peaks.

Beam	823 MHz			868 MHz		
	Az. Angle* (deg.)	RHCP Gain (dBi)	Axial Ratio (dB)	Az. Angle* (deg.)	RHCP Gain (dBi)	Axial Ratio (dB)
1	-45	11.1	3.7	-40	12.5	0.9
2	-14	14.2	0.5	-14	14.9	0.7
3	14	13.6	1.1	14	14.5	0.2
4	45	10.2	4.9	40	11.3	4.1
4A	60	9.9	7.9	60	13.0	1.4
5	-45	10.8	3.6	-40	12.6	1.5
6	-14	14.1	0.2	-14	15.2	0.5
7	14	13.5	1.4	14	14.7	0.1
8	45	10.1	5.4	40	11.5	4.3
8A	60	10.3	8.3	60	8.7	8.3
9	-45	11.0	4.4	-40	12.4	1.3
10	-14	14.1	0.1	-14	14.8	0.4
11	14	13.8	1.8	14	14.6	0.4
12	45	10.4	6.6	40	11.3	4.8
12A	60	9.4	8.0	70	10.0	6.6

*Measured from perpendicular to active panel.

Corner beams are grouped with preceeding beams (e.g. 4A with 1-4)

TABLE 6. Gain and axial ratio at 25° elevation on azimuth peaks.

Beam	823 MHz			868 MHz		
	Az. Angle* (deg.)	RHCP Gain (dBi)	Axial Ratio (dB)	Az. Angle* (deg.)	RHCP Gain (dBi)	Axial Ratio (dB)
1	-45	11.7	6.8	-45	12.6	3.5
2	-14	14.8	1.9	-14	15.4	1.2
3	14	15.1	0.7	14	15.8	0.1
4	45	10.4	3.5	45	11.9	3.9
4A	66	11.1	8.9	66	11.3	9.7
5	-45	11.5	5.4	-45	12.7	3.5
6	-14	14.8	2.2	-14	15.8	1.3
7	14	15.0	0.9	14	15.7	0.0
8	45	10.7	3.7	45	12.0	4.9
8A	65	11.4	8.2	68	11.2	10.0
9	-45	11.6	6.4	-45	12.6	3.6
10	-14	14.9	1.5	-14	15.6	0.9
11	14	15.2	1.0	14	15.8	0.0
12	45	10.6	4.6	45	11.9	4.9
12A	70	11.0	9.9	72	11.7	7.4

*Measured from perpendicular to active panel.

Corner beams are grouped with preceeding beams (e.g. 4A with 1-4)

TABLE 7. Gain and axial ratio at 35° elevation on azimuth peaks

Beam	823 MHz			868 MHz		
	Az. Angle* (deg.)	RHCP Gain (dBi)	Axial Ratio (dB)	Az. Angle* (deg.)	RHCP Gain (dBi)	Axial Ratio (dB)
1	-55	9.3	11.4	-54	9.0	10.2
2	-18	13.5	3.7	-14	13.1	1.6
3	14	14.2	0.0	14	13.7	0.5
4	53	7.6	5.1	48	10.3	4.4
4A	68	9.6	10.7	67	9.8	11.6
5	-56	8.9	12.9	-56	8.8	11.3
6	-16	13.2	4.3	-14	13.3	2.1
7	16	13.9	0.2	14	14.1	0.3
8	52	8.0	5.0	56	9.0	8.4
8A	68	9.7	9.8	68	9.6	12.6
9	-56	9.0	13.0	-54	8.9	9.4
10	-18	13.3	2.9	-14	11.3	1.2
11	16	14.0	0.8	14	14.3	0.3
12	54	8.1	5.0	57	9.2	8.4
12A	72	9.3	11.3	73	9.9	9.9

* Measured from perpendicular to active panel.

Corner beams are grouped with preceeding beams (e.g., 4A with 1-4)

TABLE 8. Summary of Gain at beam crossover points

Elevation Angle (deg.)	823 MHz Gain (dBi)		868 MHz Gain (dBi)	
	Minimum	Average	Minimum	Average
15	8.2	9.7	7.7	10.3
25	9.7	10.8	9.3	11.3
35	7.6	9.7	8.7	9.6

TABLE 9. Summary of measured elevation patterns

Frequency (MHz)	Beam	Polarization	Elevation of peak (deg.)	Beamwidth (-3dB)	Highest Sidelobe (dB wrt pk)	Sidelobe Elevation (deg.)
823	2L	H	26	30	- 7.8	-22
		V	22	28	- 5.2	-20
	1L	H	19	32	- 7.3	-26
		V	23	40	-12.0	-33
	1R	H	22	34	- 8.7	-28
		V	23	40	-12.0	-33
	2R	H	17	33	- 5.4	-27
		V	20	31	- 7.2	-26
868	2L	H	23	35	-16.0	-24, -44
		V	20	32	-13.7	-60
	1L	H	21	32	- 9.5	-23
		V	21	36	- 9.5	-31
	1R	H	22	32	- 9.5	-25
		V	23	36	-10.6	-29
	2R	H	21	30	- 7.2	-31
		V	22	29	- 3.9	-23

TABLE 10. POWER/CONTROL CONNECTOR PIN ASSIGNMENT

Pin	Test Cable Colour	Usage
A	Black	Spare, no connection
B	White	0V, common
C	Violet	+12V nominal, less than 1A
D	Orange	+5± 0.25V, less than 110 mA
E	Grey	Yellow alarm
F	Green	Red alarm
G	Brown	Spare, no connection
H	Blue	Spare, no connection
J	Red	RF level signal, 0 to +5V DC
K	Yellow	spare, no connection

TABLE 11. MANUAL BEAM SELECTION SWITCH CODING

Beam Number	Switch Settings* S1	S2	S3	S4
1	1	1	1	1
2	0	1	1	1
3	1	0	1	1
4	0	0	1	1
4A	1	1	0	1
5	0	1	0	1
6	1	0	0	1
7	0	0	0	1
8	1	1	1	0
8A	0	1	1	0
9	1	0	1	0
10	0	0	1	0
11	1	1	0	0
12	0	1	0	0
12A	1	0	0	0

* 0 defined as switch lever toward number; away from number is 1. S5 must be set to 0 for manual mode.

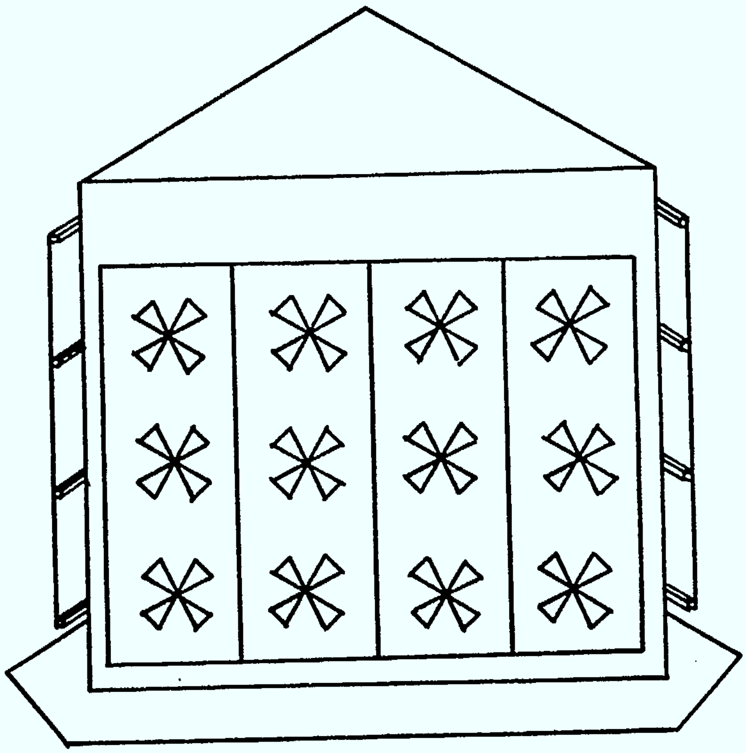


Figure 1 MSat Vehicle Antenna

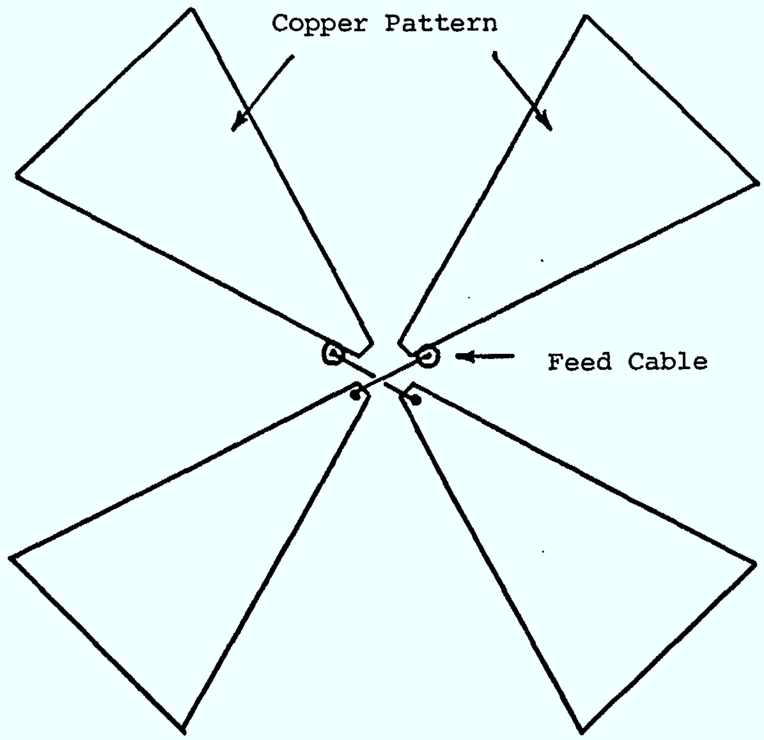
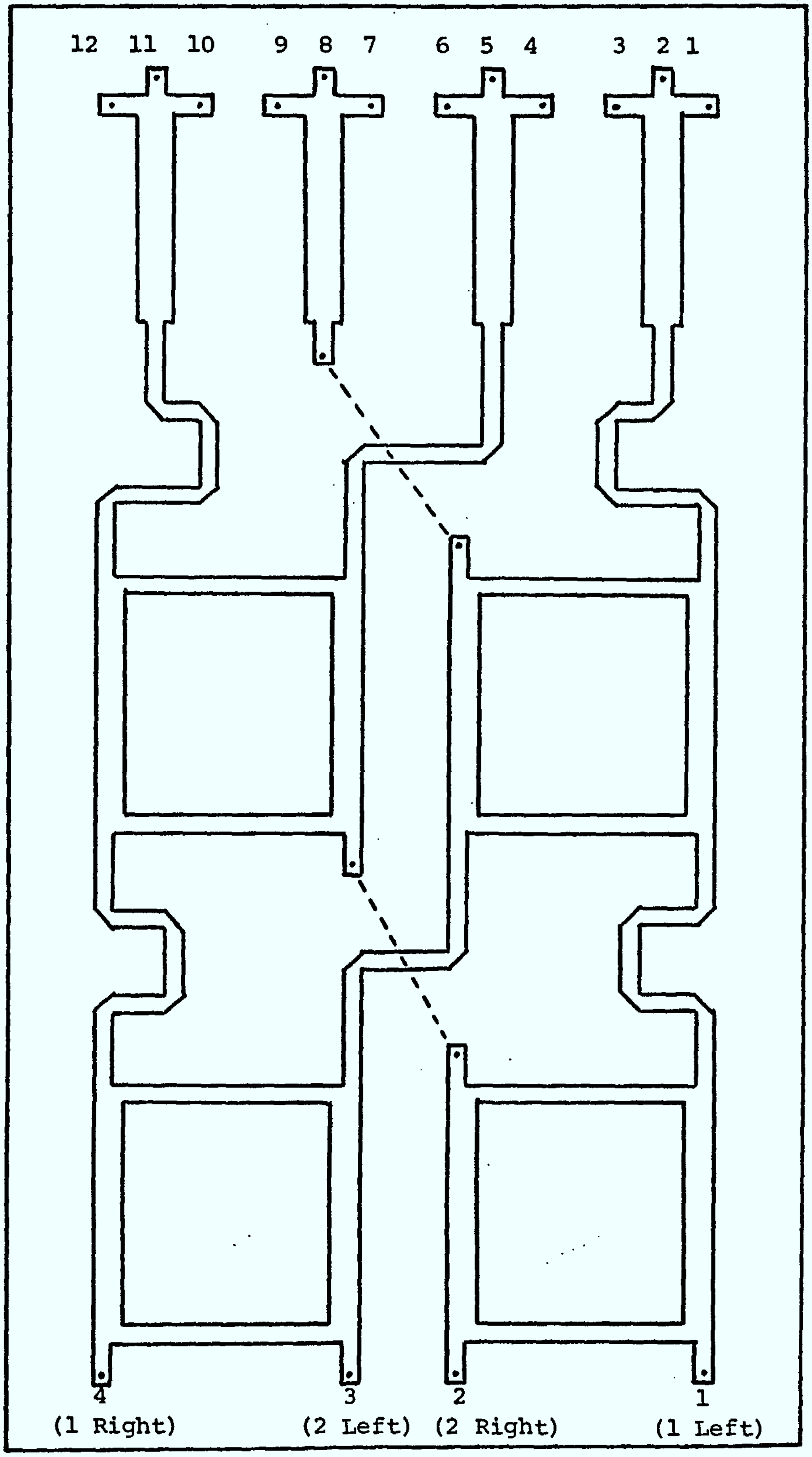


Figure 2 Crossed Dipole Element
(Full size)

OUTPUT PORTS



INPUT PORTS

Figure 3 Butler Matrix (seen from circuit side)

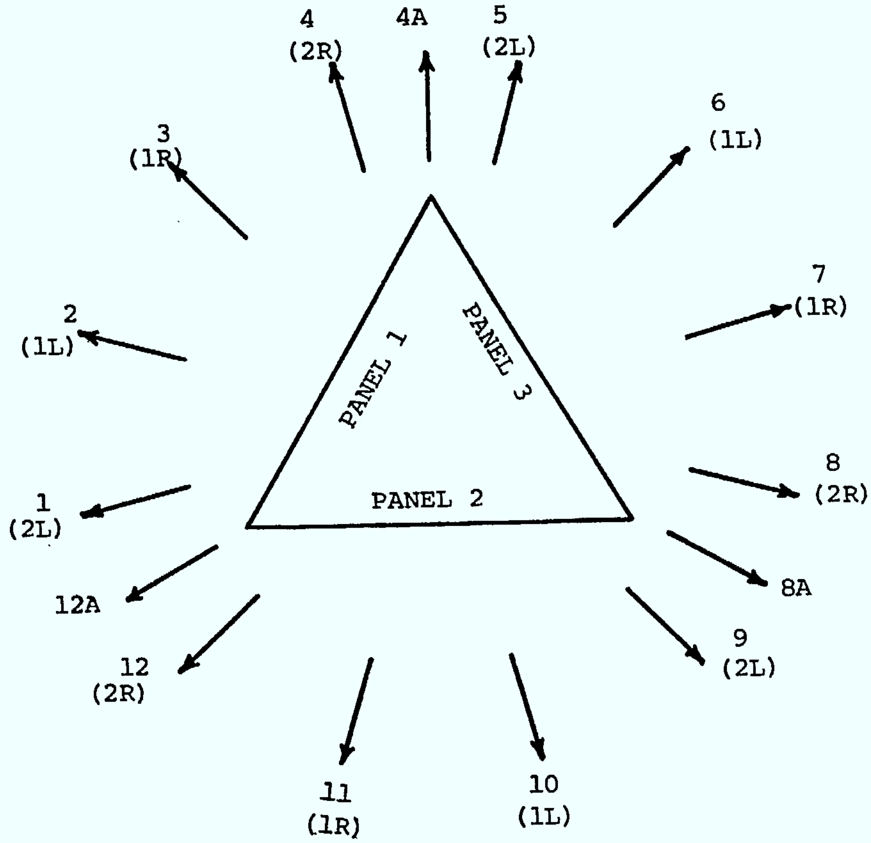


Figure 4 Beam Directions

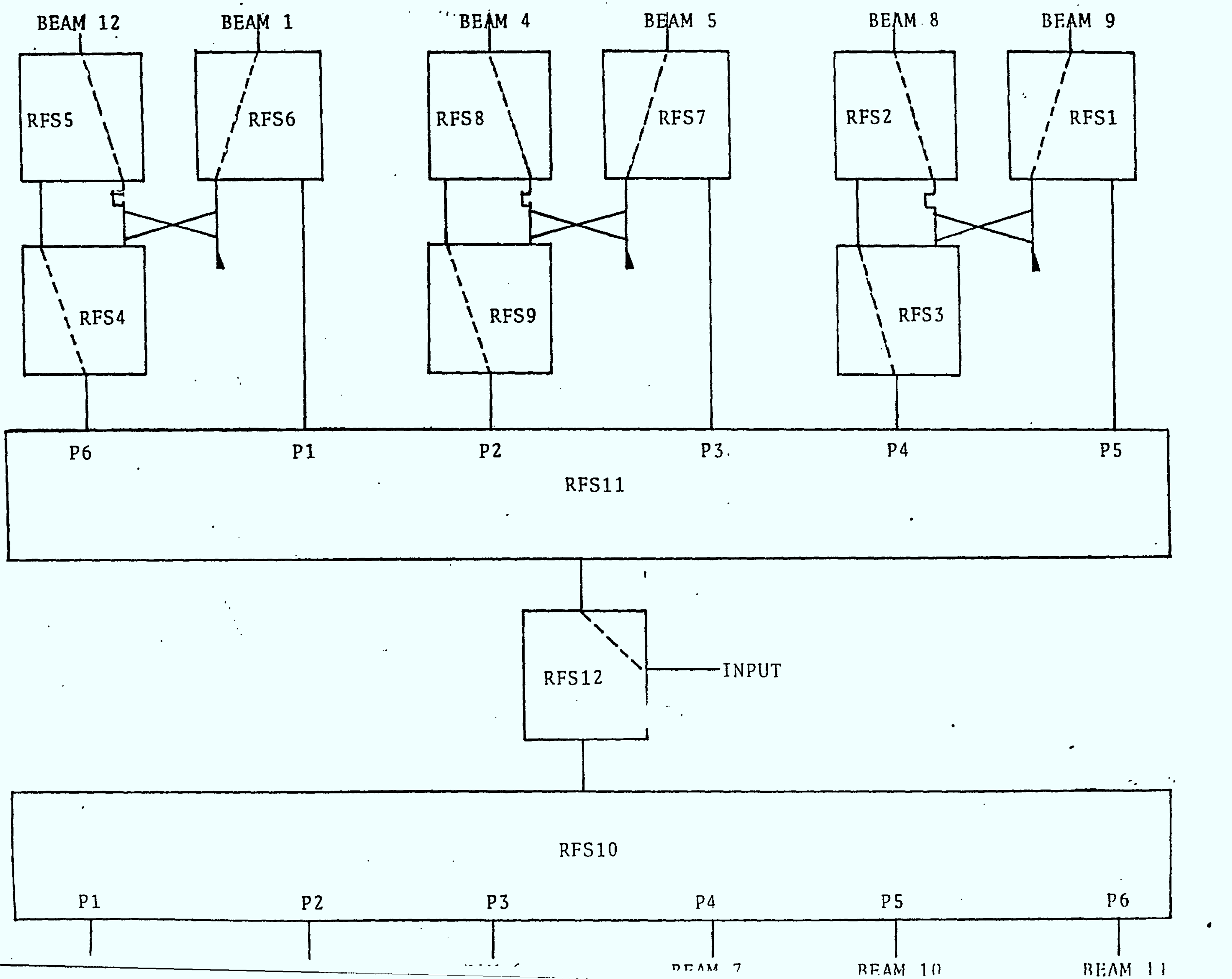


Figure 5. RF switch configuration

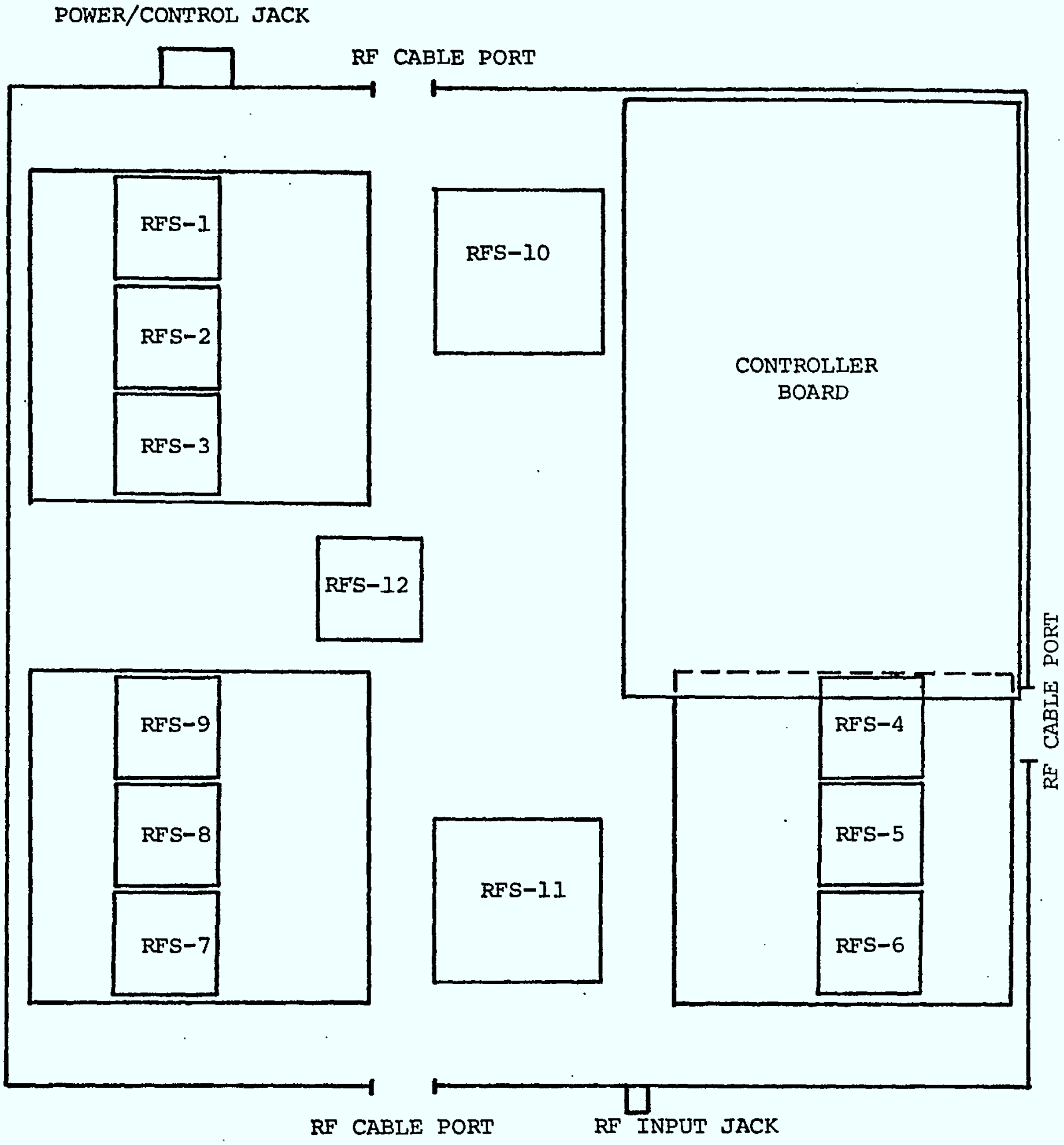


Figure 6. Switching Box Layout

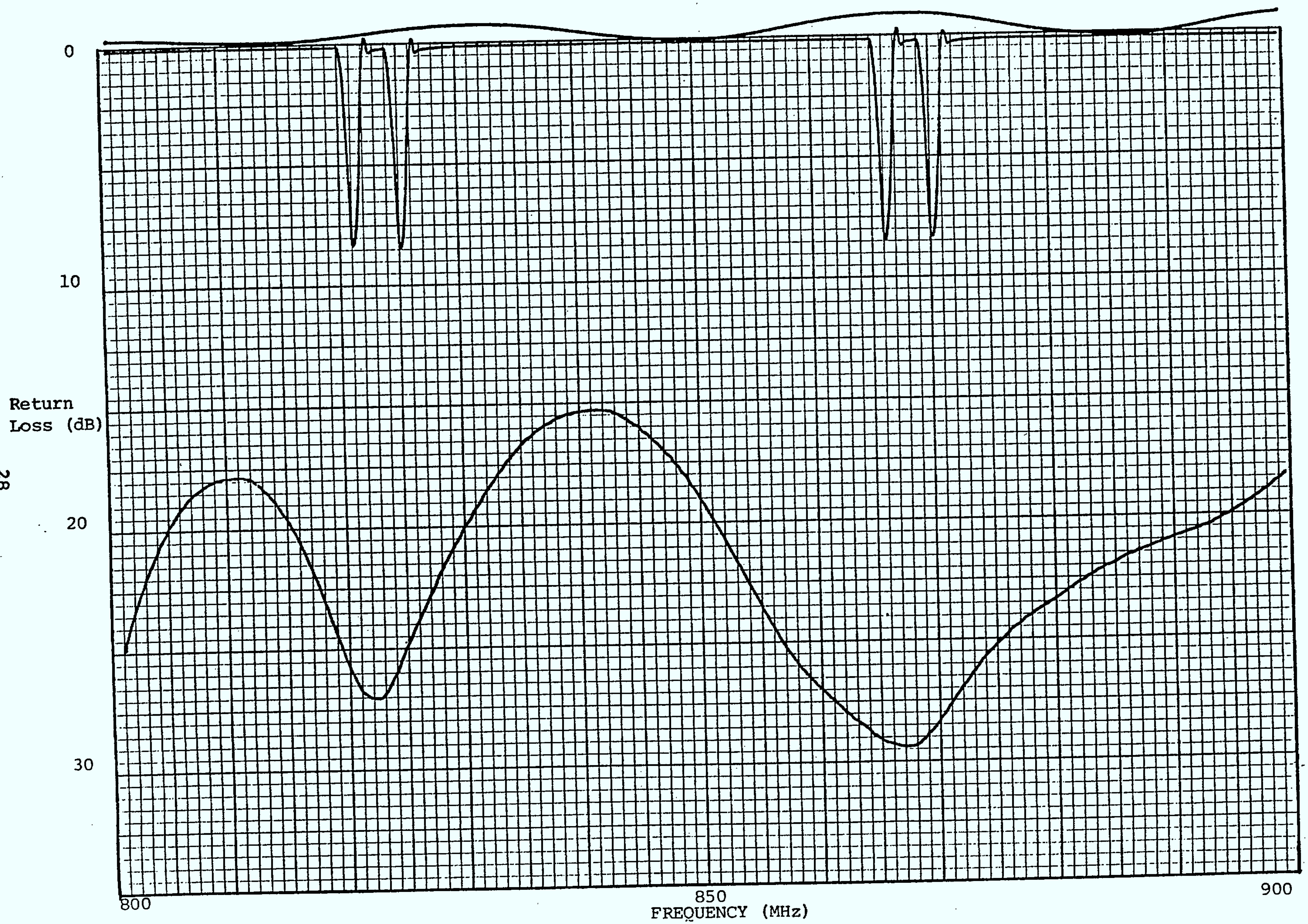


Figure 7. Beam 1 Return Loss

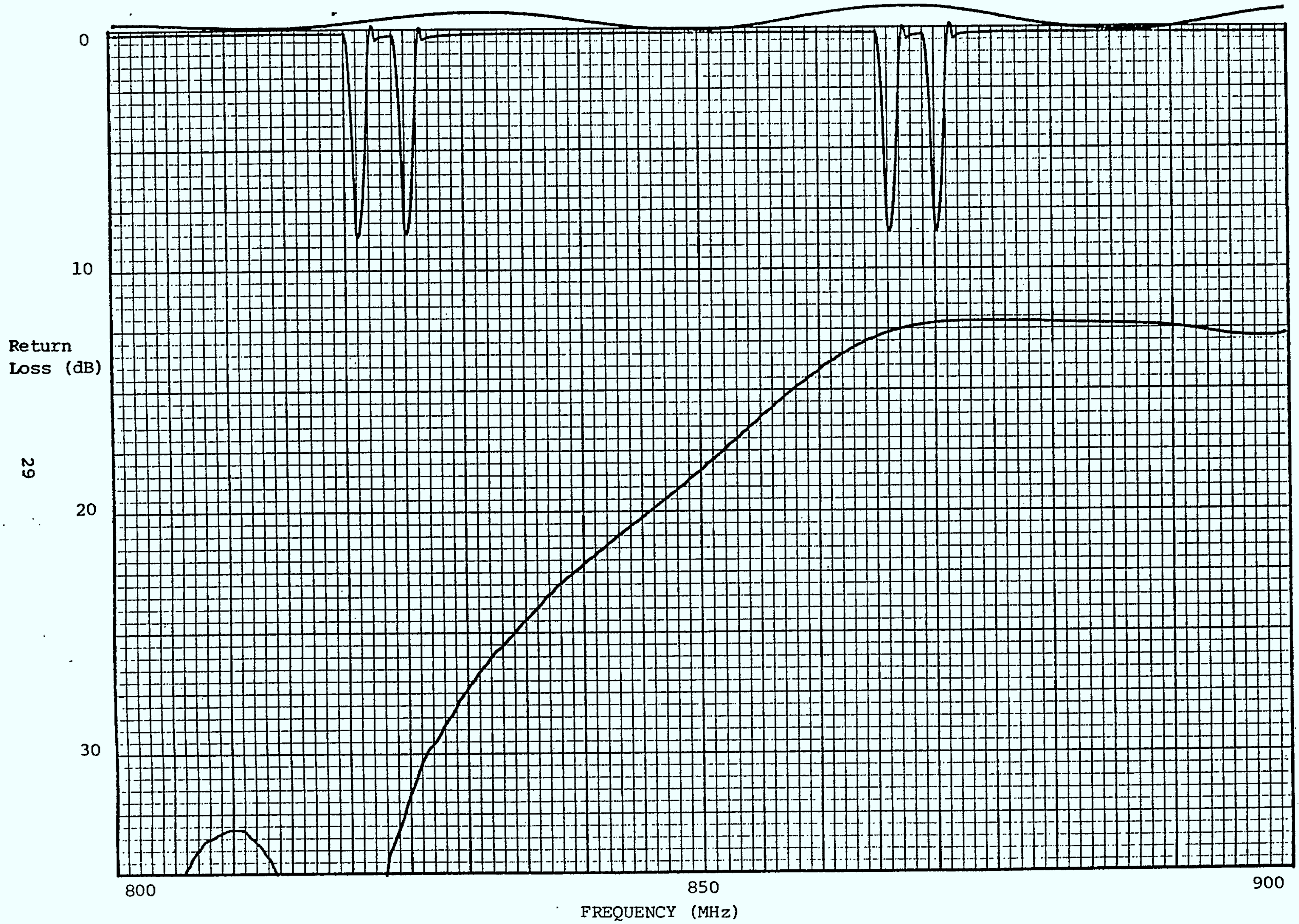


Figure 8. Beam 2 Return Loss

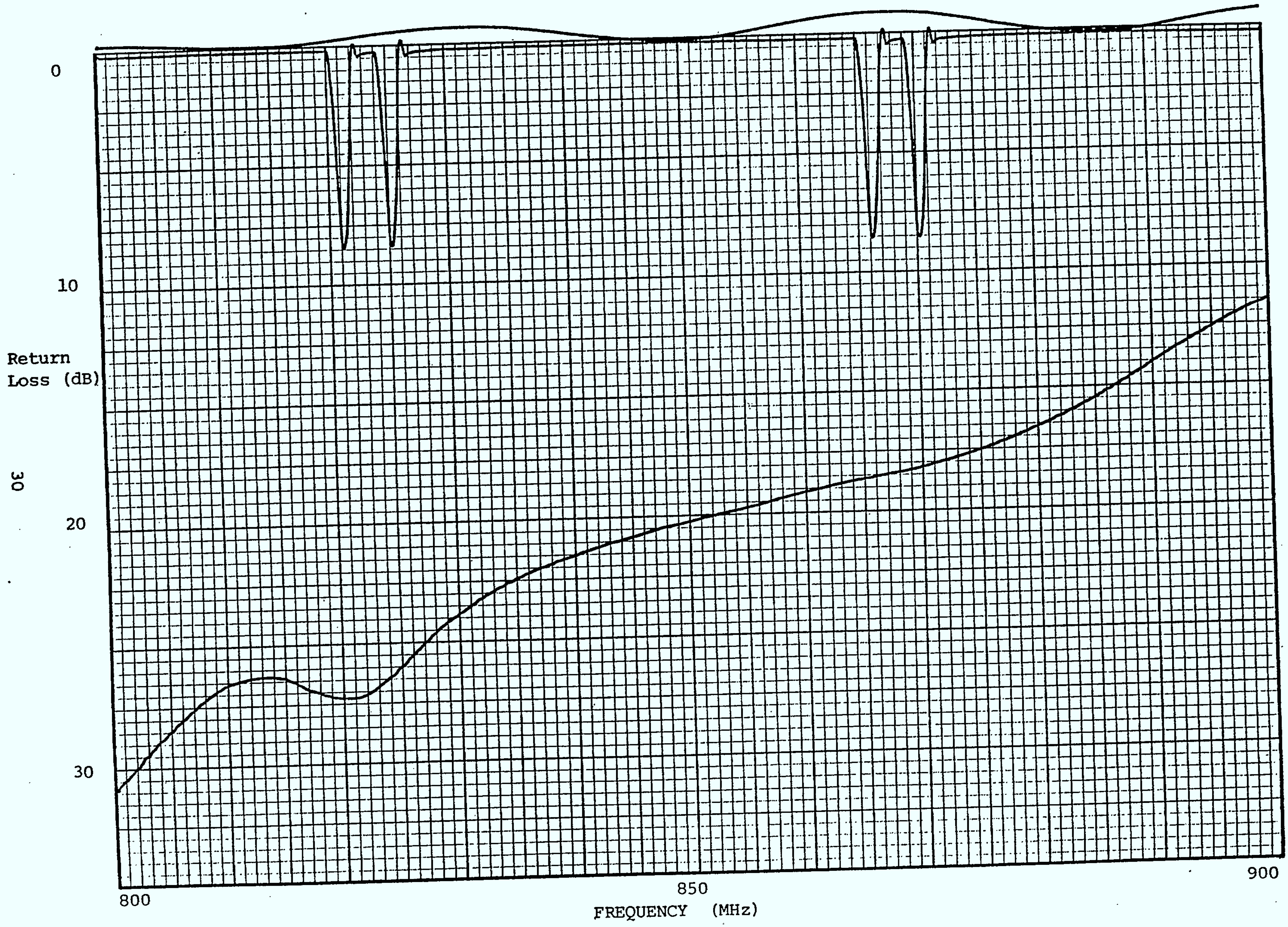


Figure 9. Beam 3 Return Loss

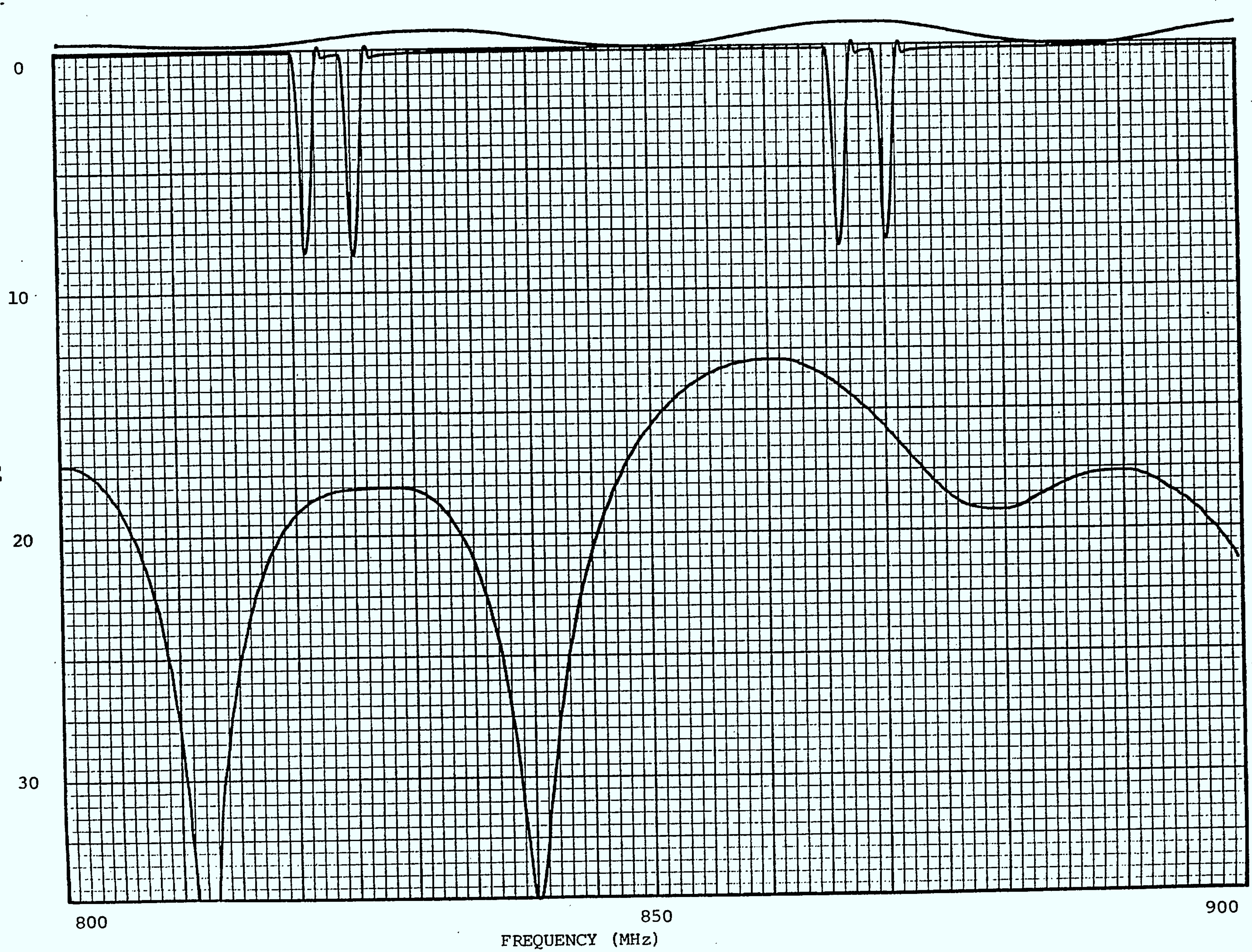


Figure 10. Beam 4 Return Loss

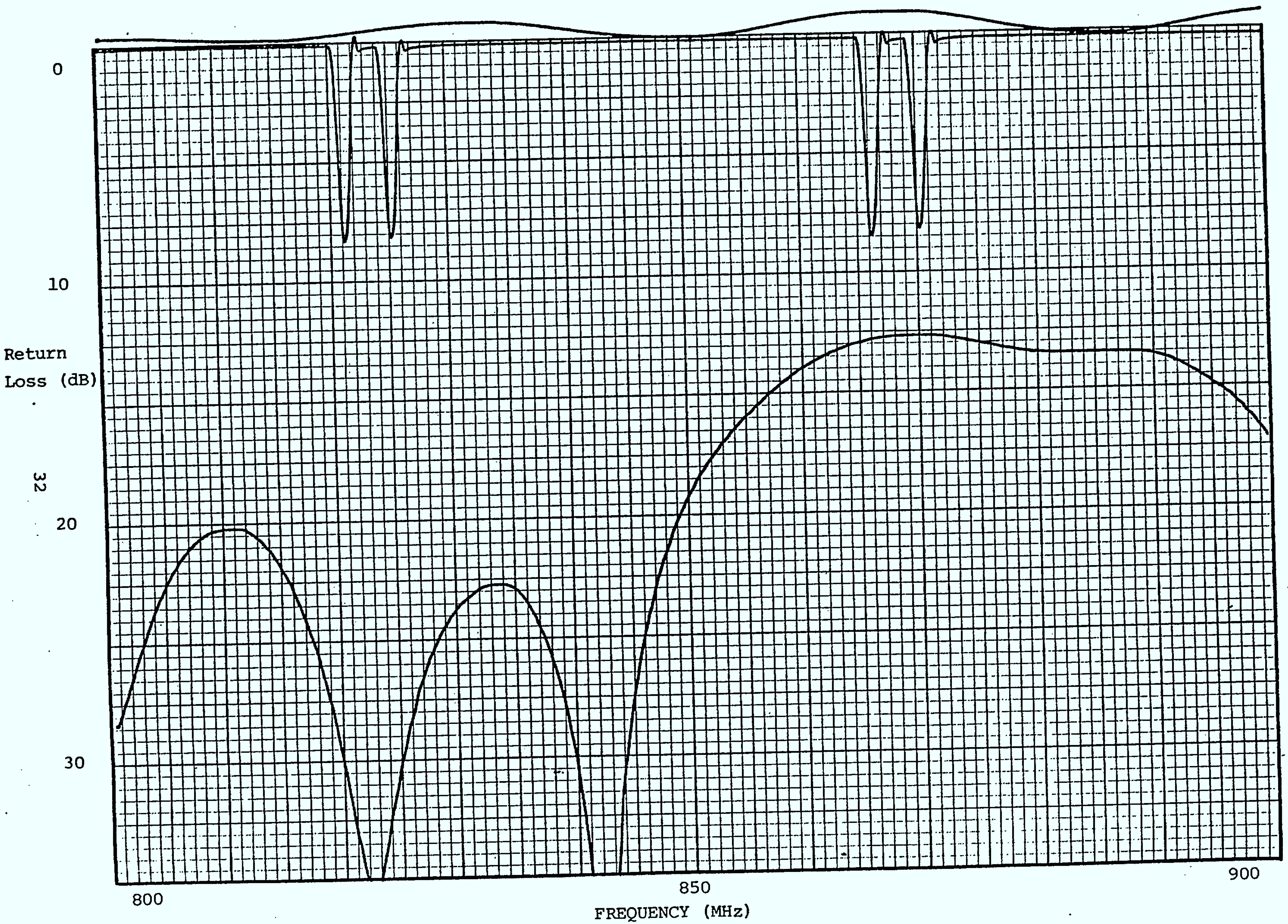
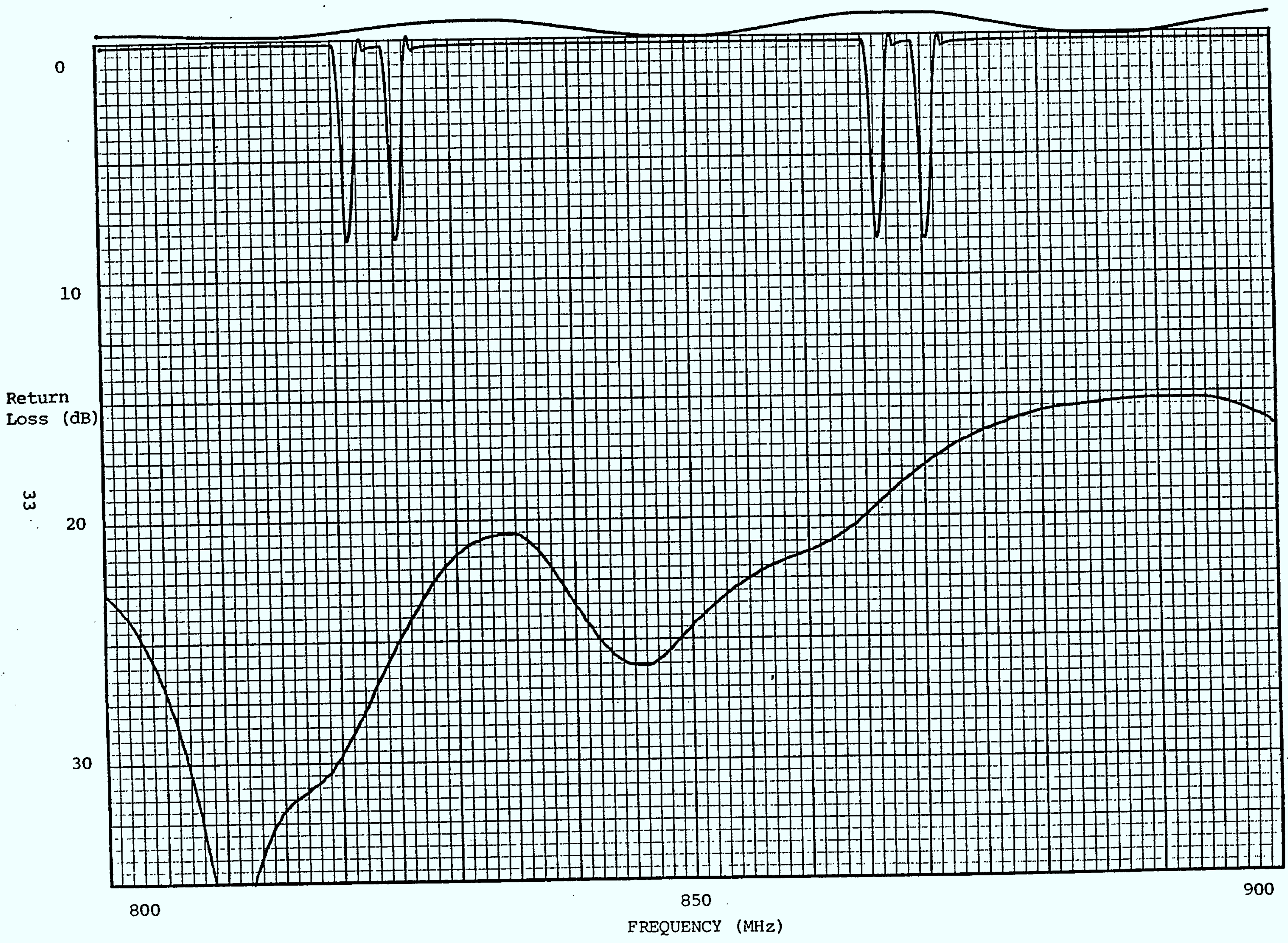


Figure 11 Beam 4A Return Loss



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13. Beam 6 Return Loss

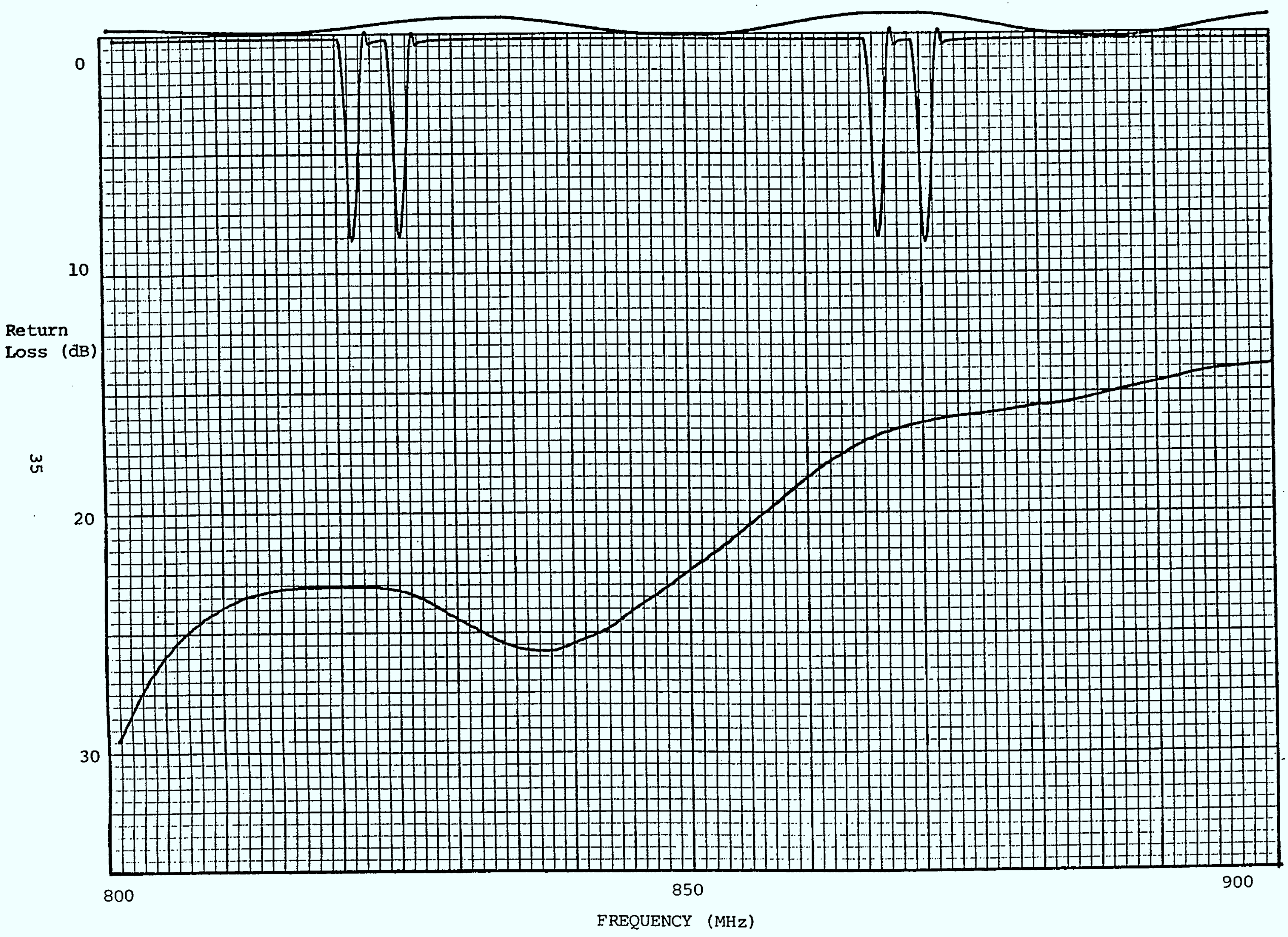

Figure 14 Beam 7 Return Loss

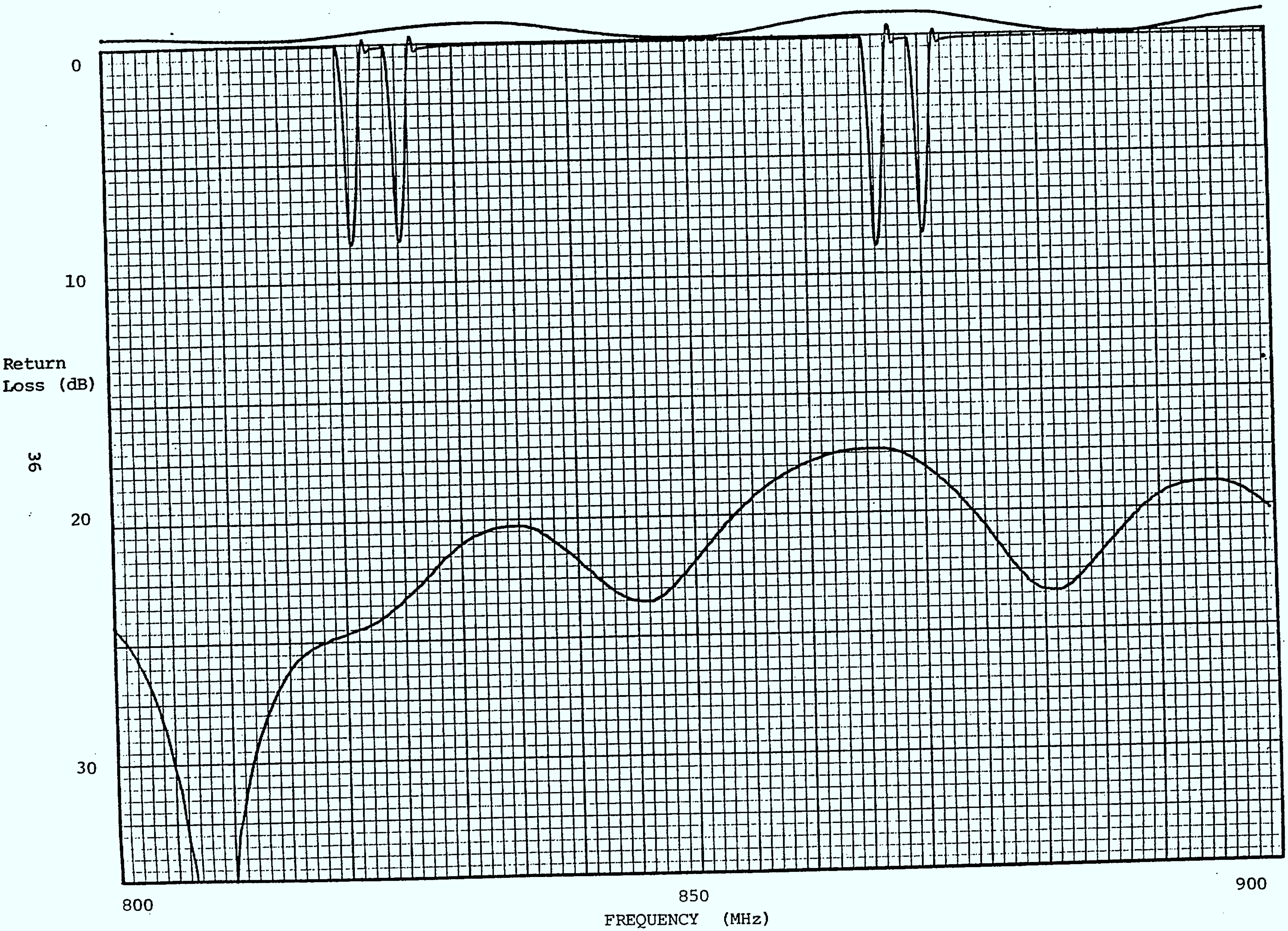

Figure 15. Beam 8 Return Loss

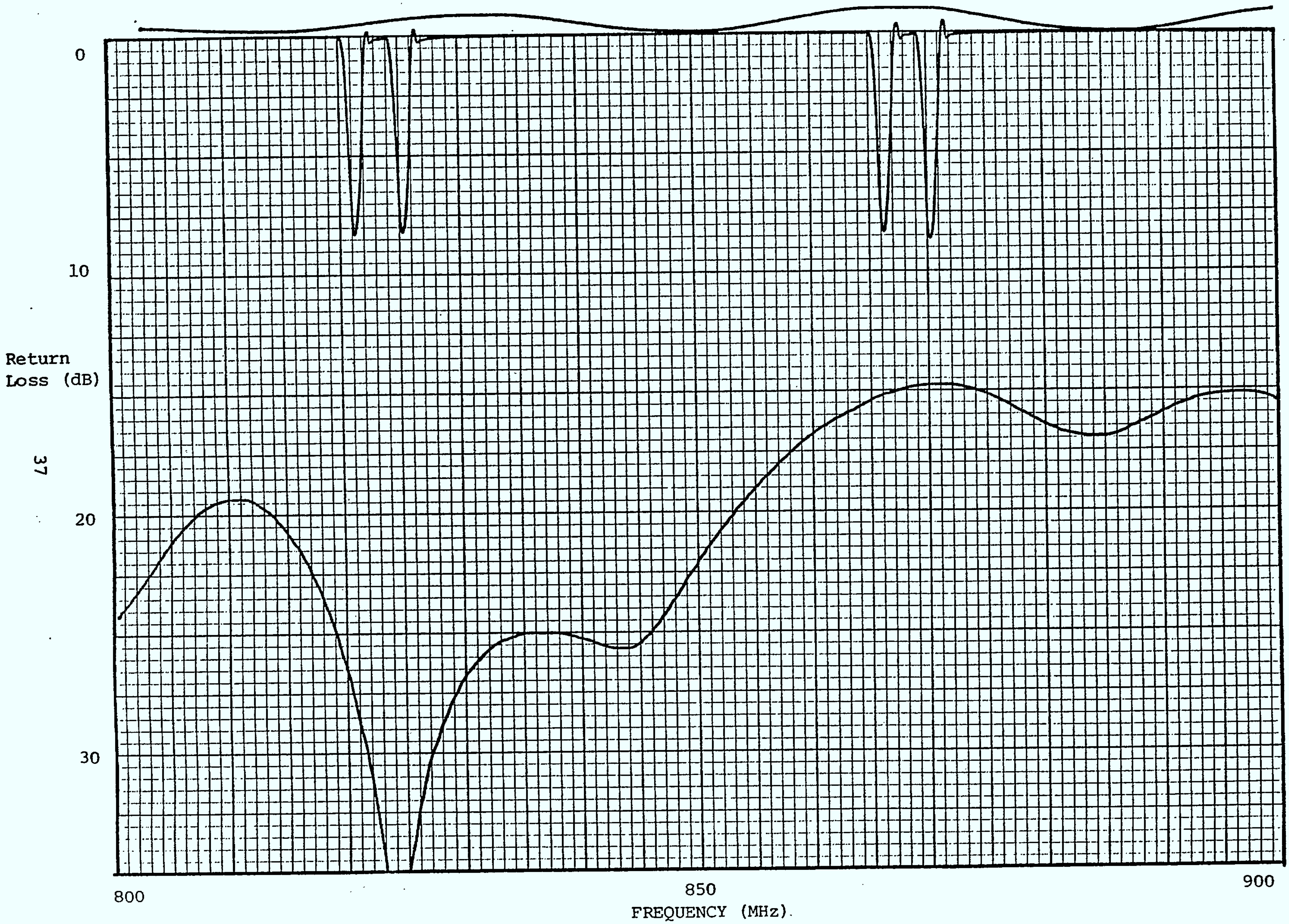

Figure 16. Beam 8A Return Loss

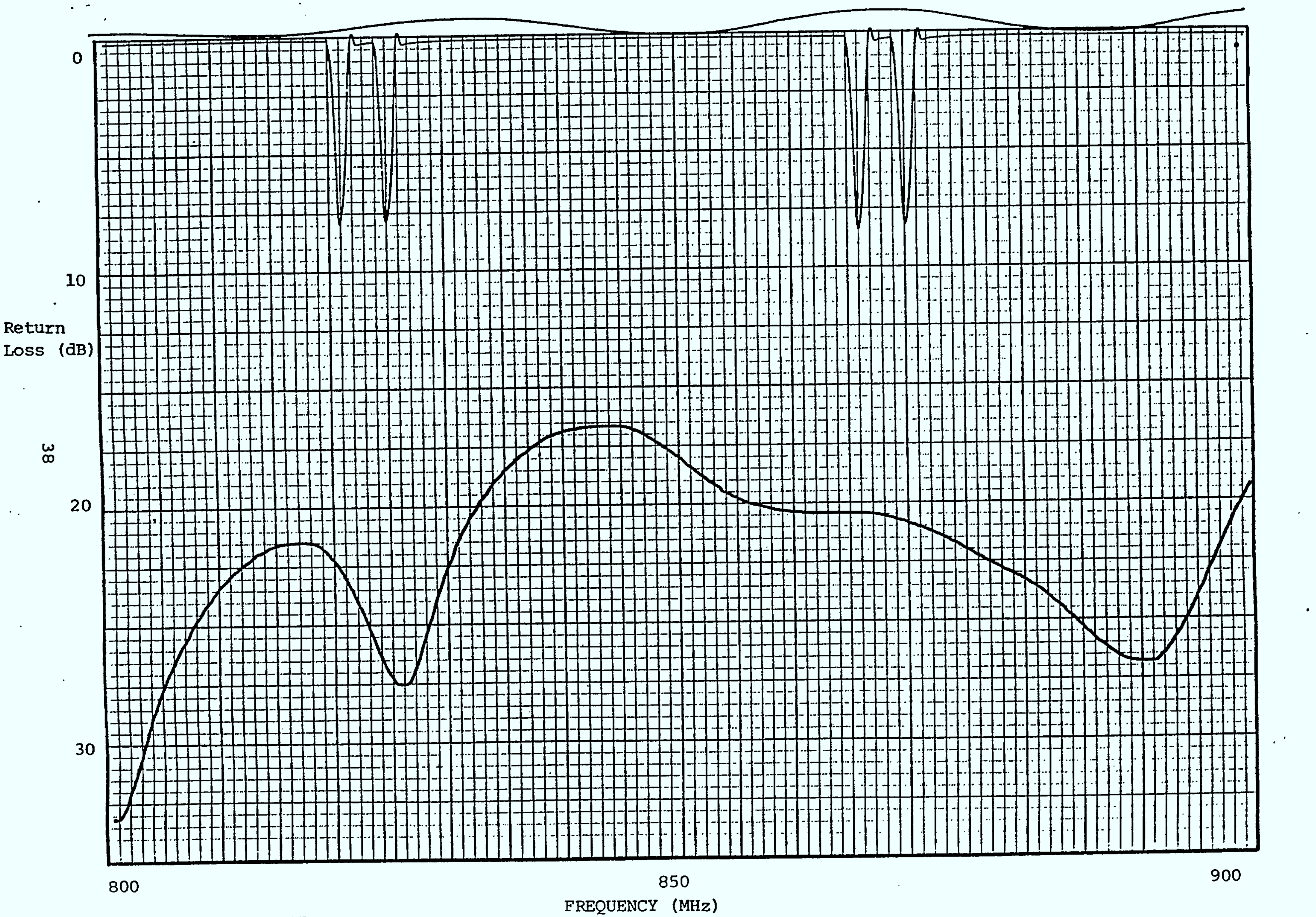

Figure 17. Beam 9 Return Loss

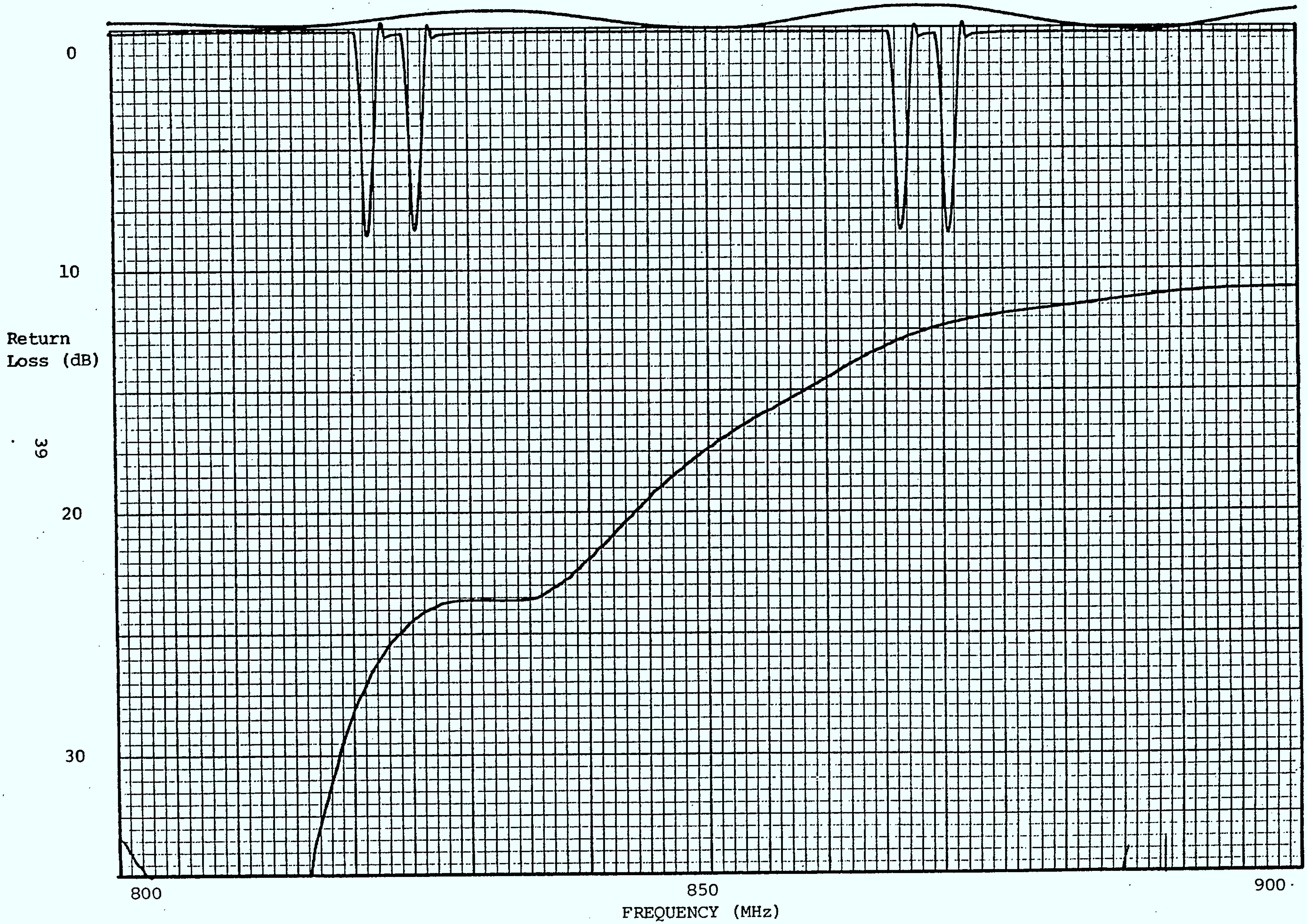

Figure 18. Beam 10 Return Loss

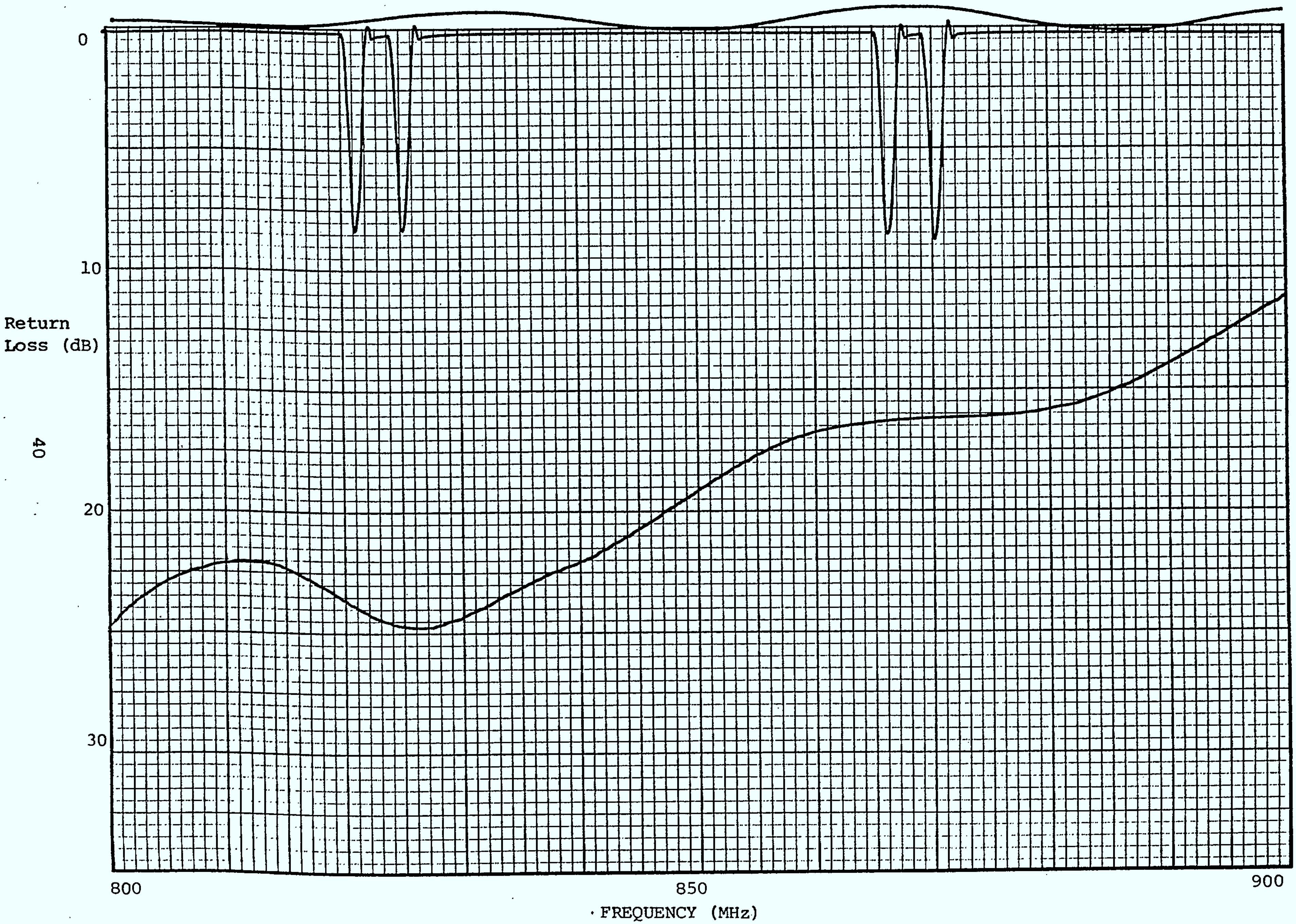

Figure 19. Beam 11 Return Loss

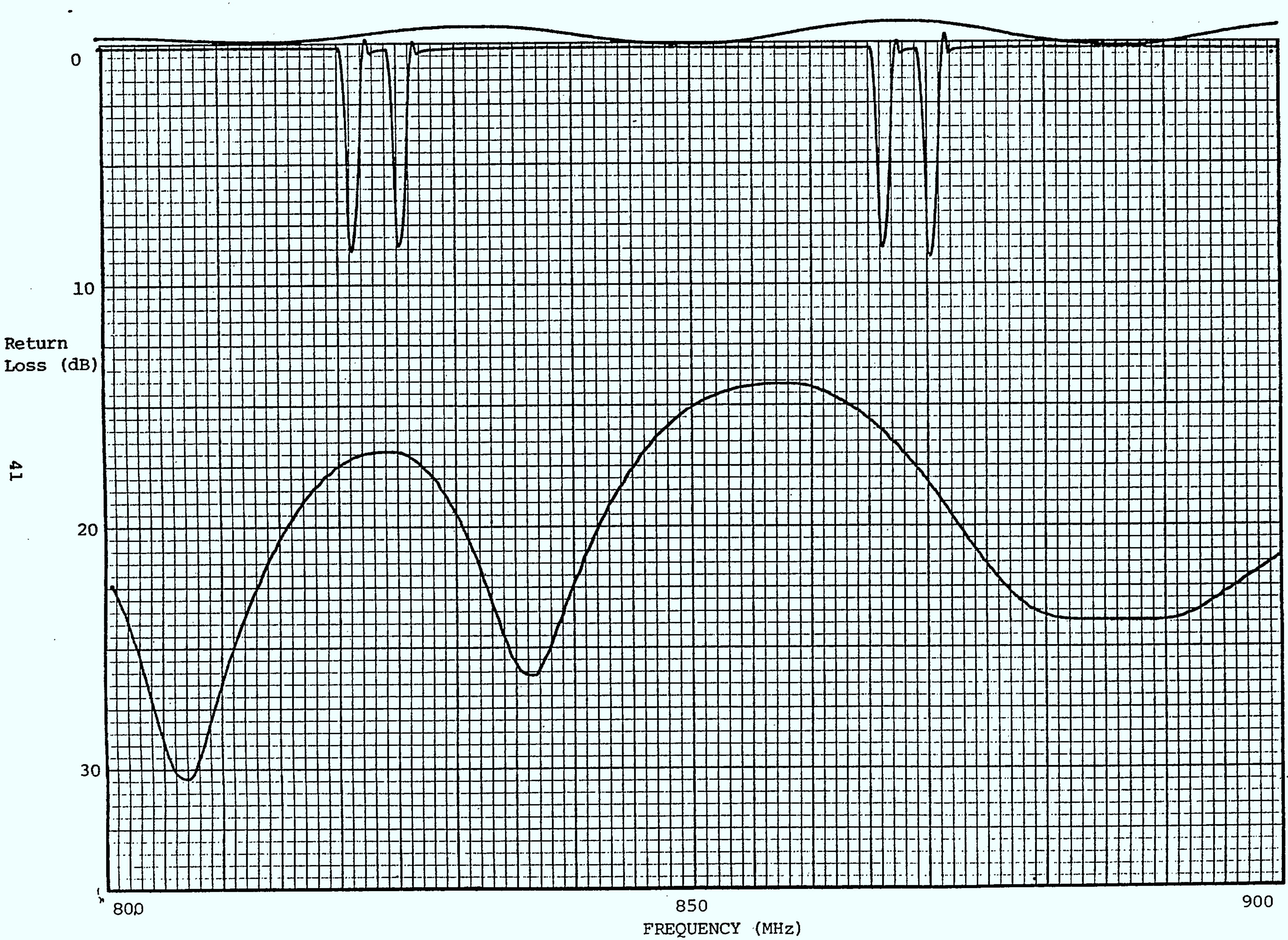

Figure 20. Beam 12 Return Loss

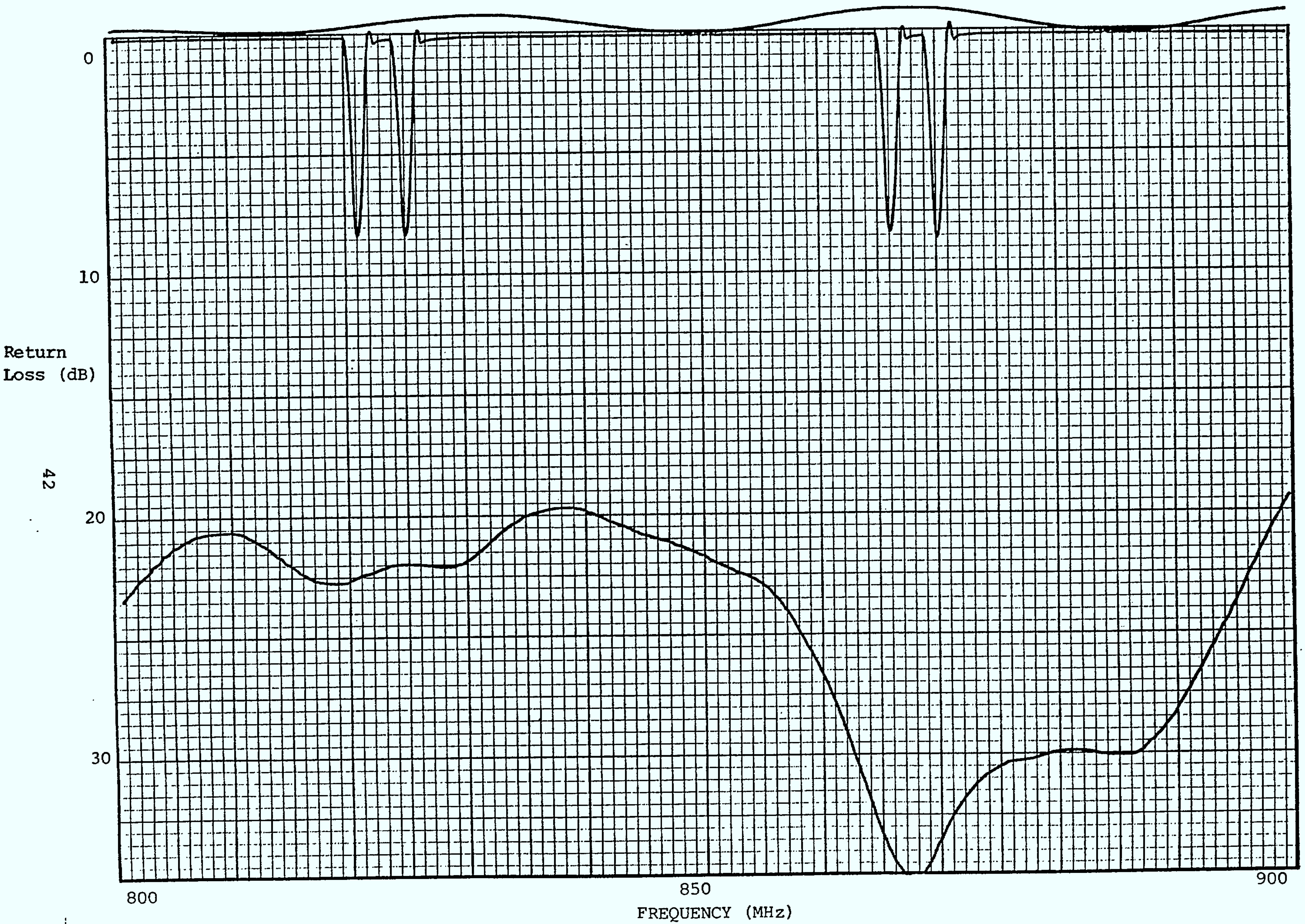

Figure 21. Beam 12A Return Loss

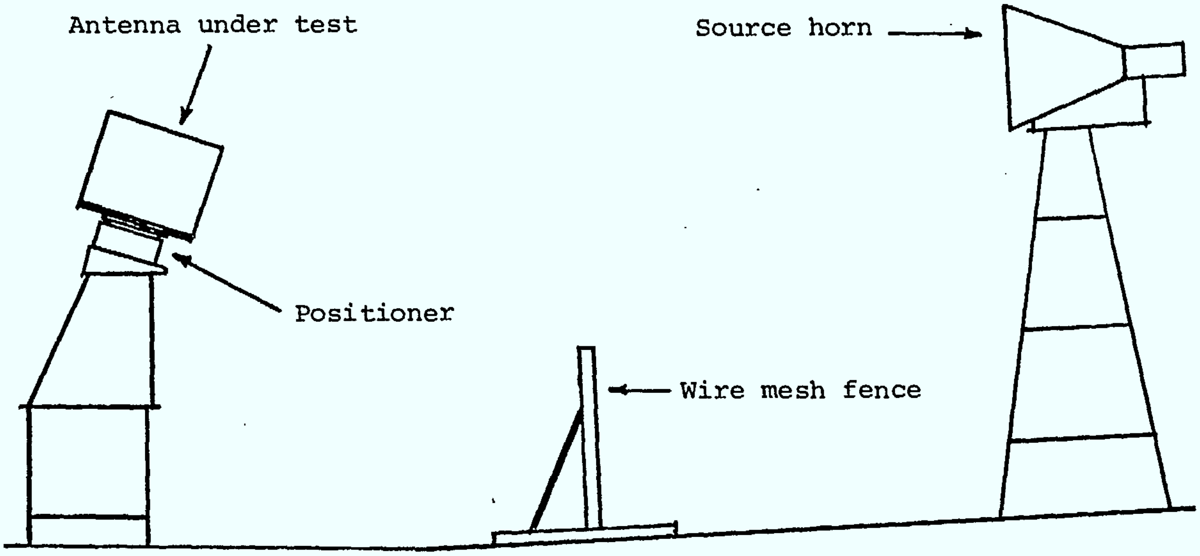

Figure 22. Antenna Test Range

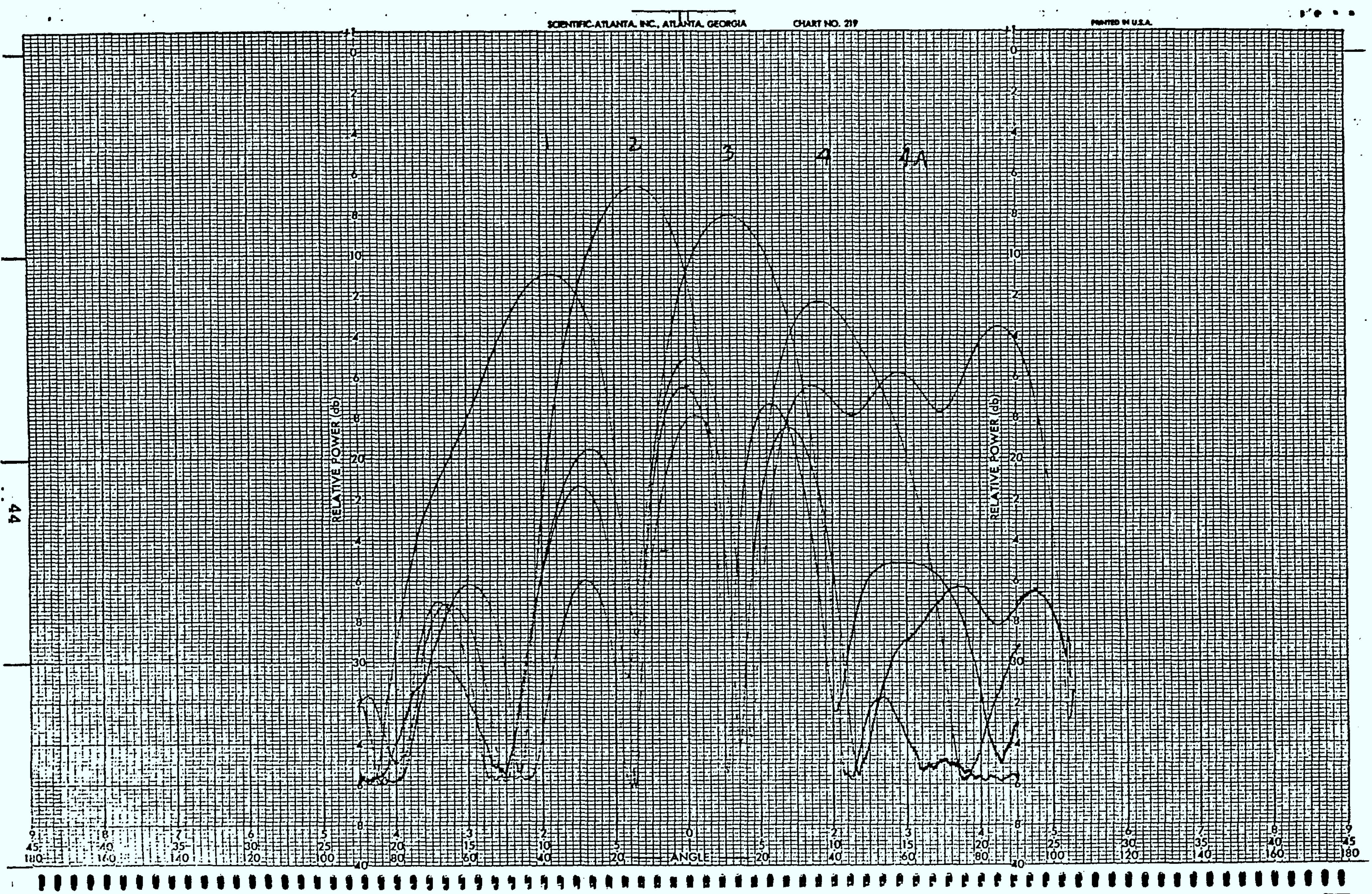

Figure 23. Azimuth patterns of beam 1-4A at 15° elevation, 823 MHz, Horizontal Polarization

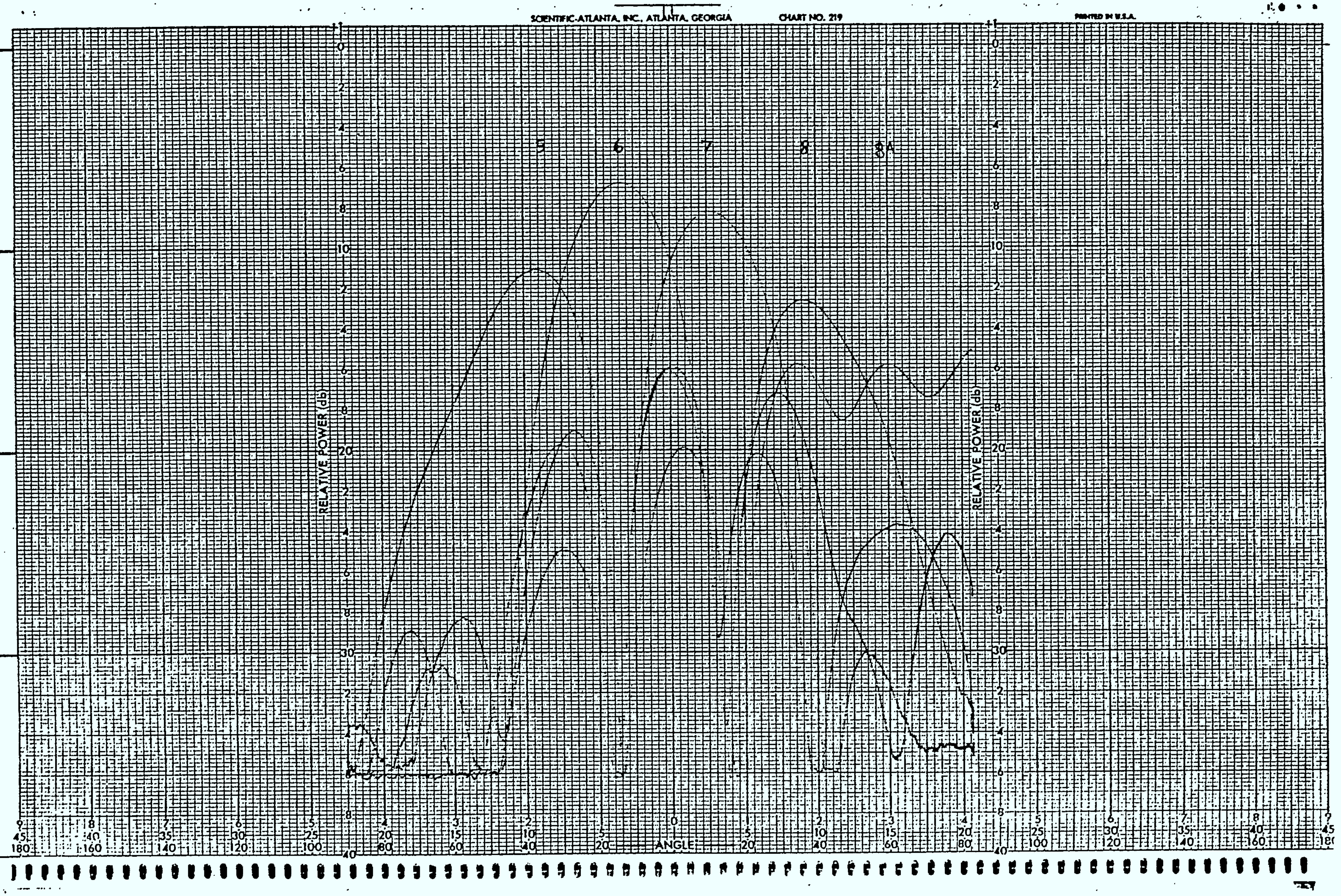

Figure 24. Azimuth patterns of beam 5-8A at 15° elevation, 823 MHz, Horizontal Polarization.

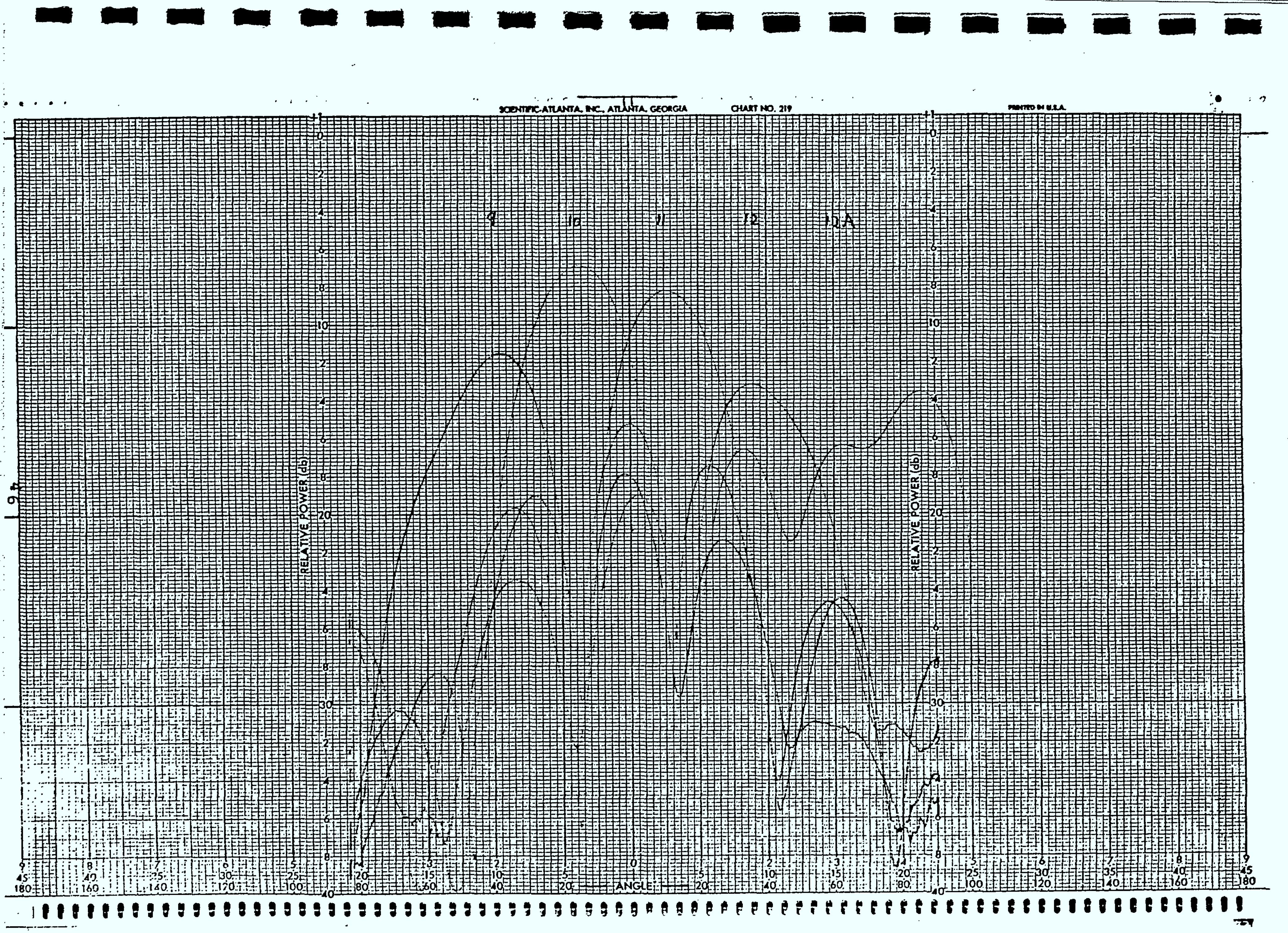

Figure 25. Azimuth patterns of beam 9-12A at 15° elevation, 823 MHz, Horizontal Polarization.

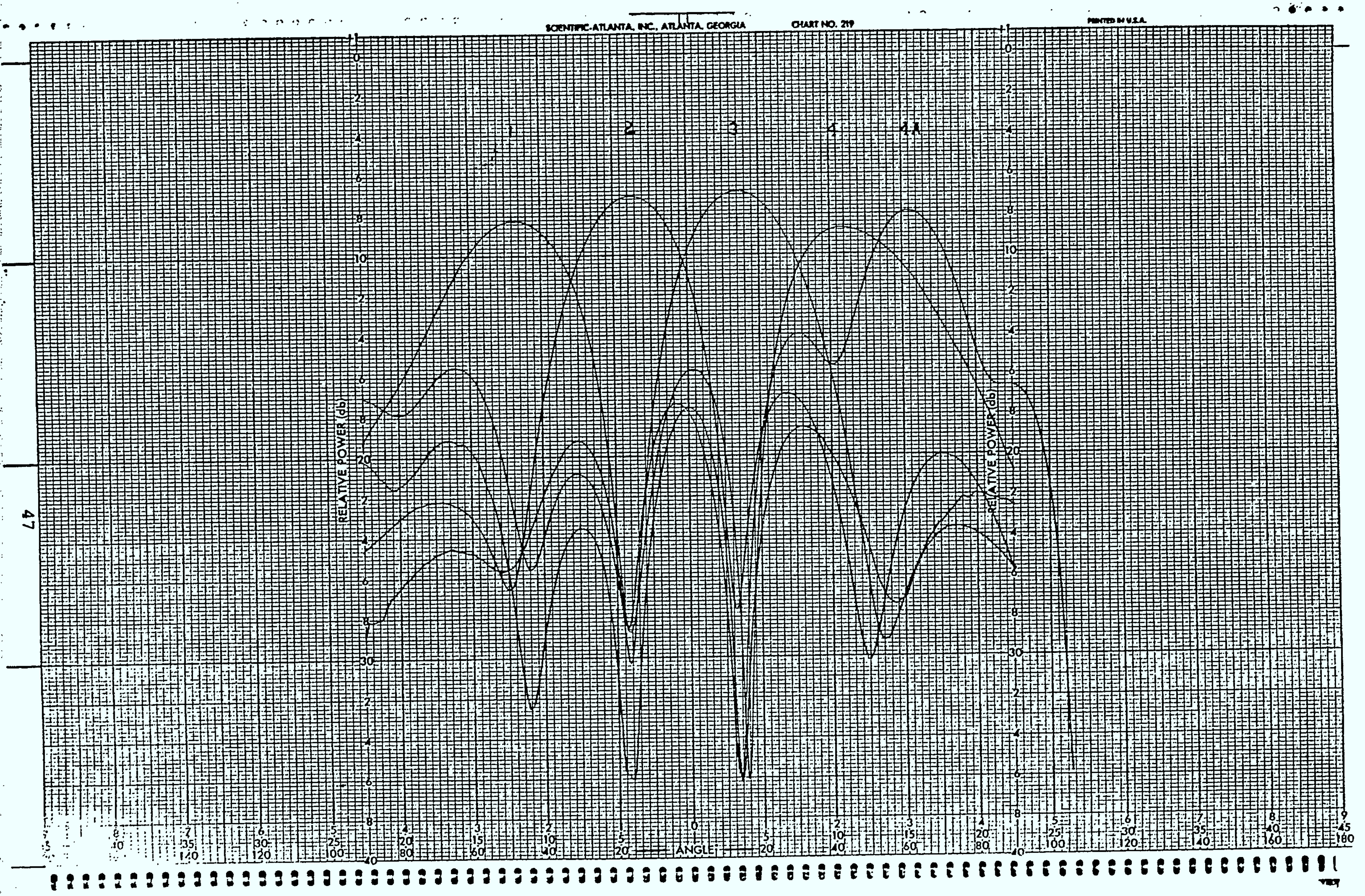

Figure 26. Azimuth patterns of beam 1-4A at 15° elevation, 823 MHz, Vertical Polarization.

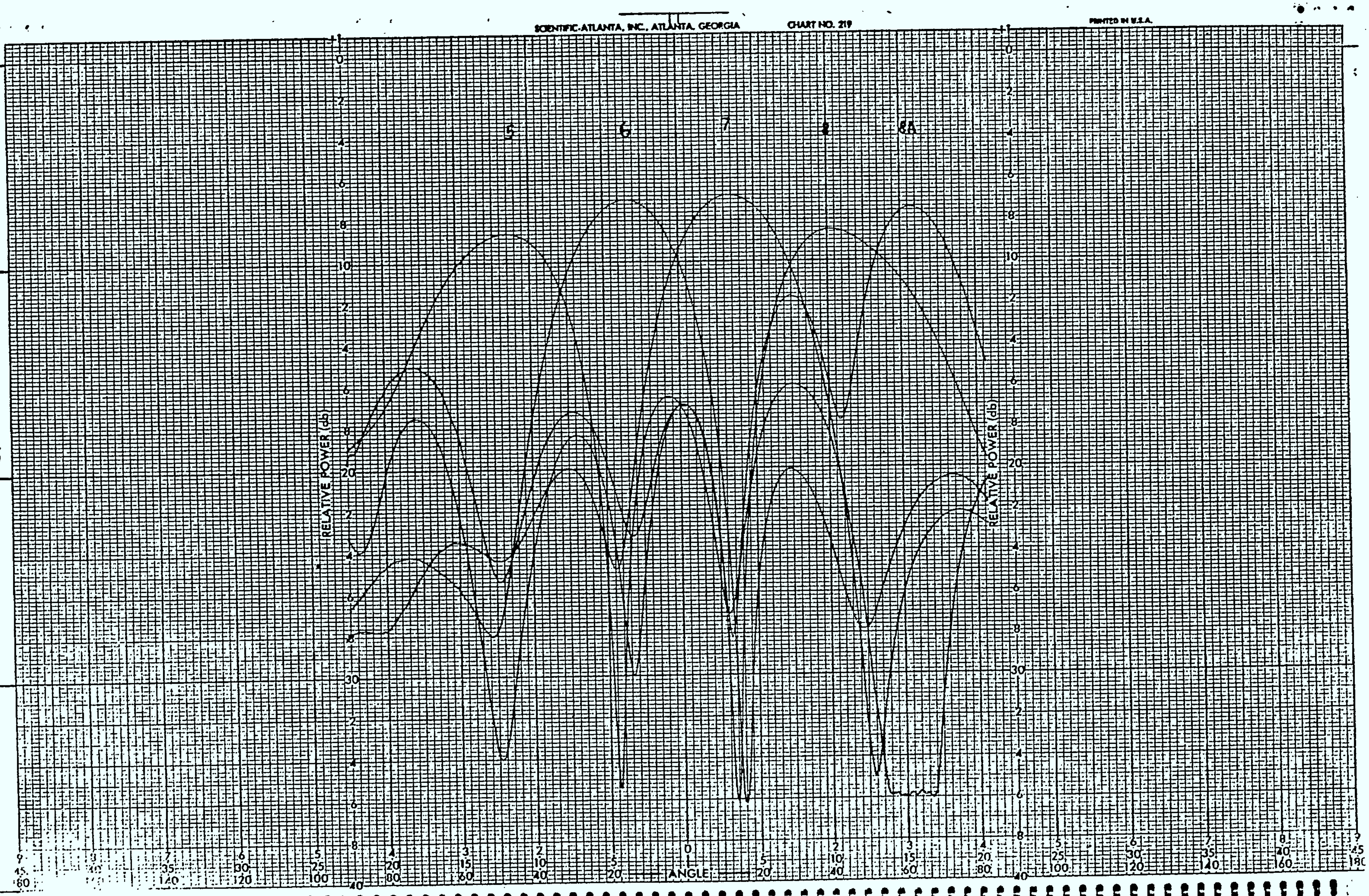

Figure 27. Azimuth patterns of beam 5-8A at 15° elevation, 823 MHz. Vertical Polarization

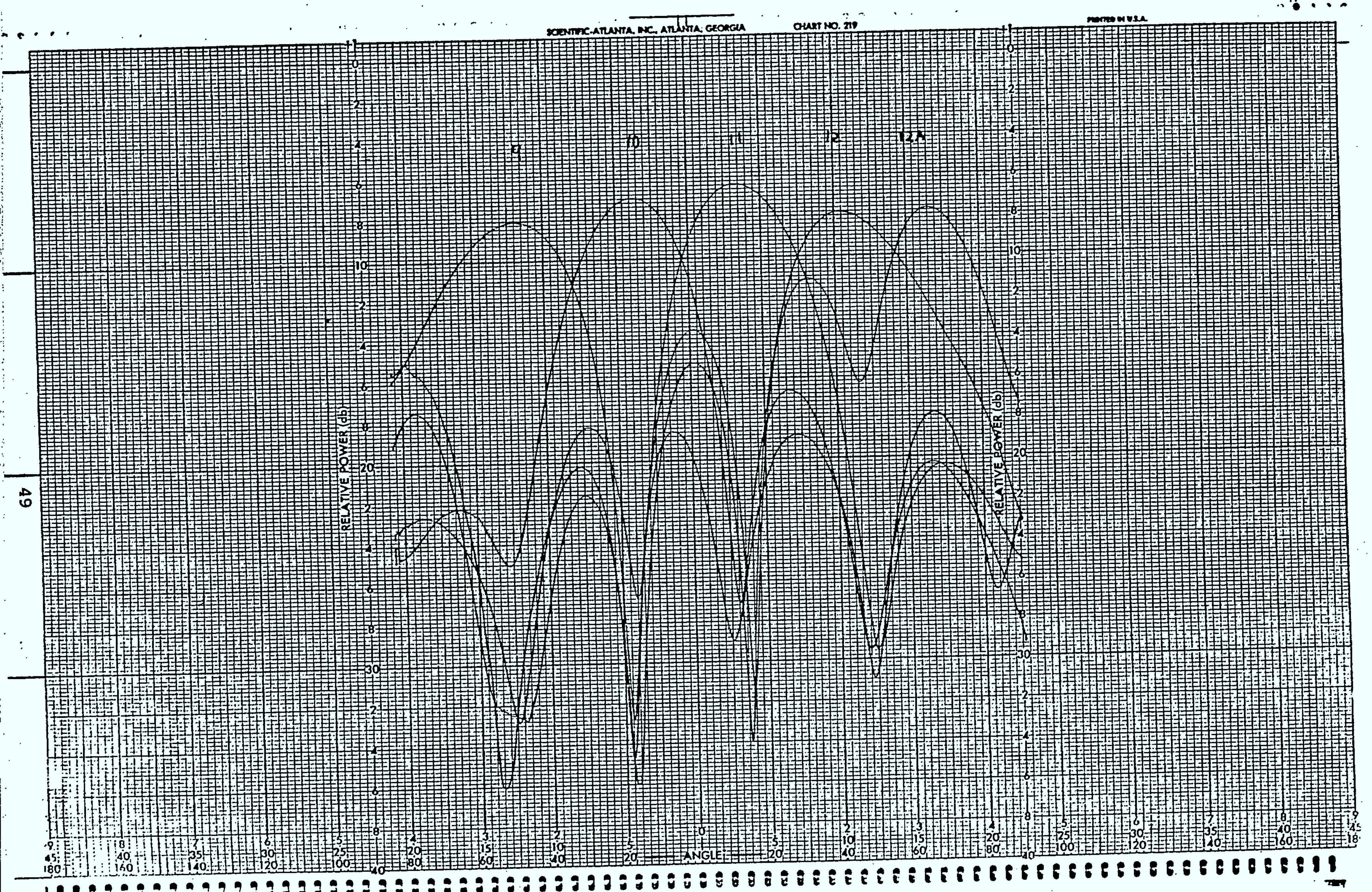

Figure 28. Azimuth patterns of beam 9-12A at 15° elevation, 823 MHz. Vertical Polarization.

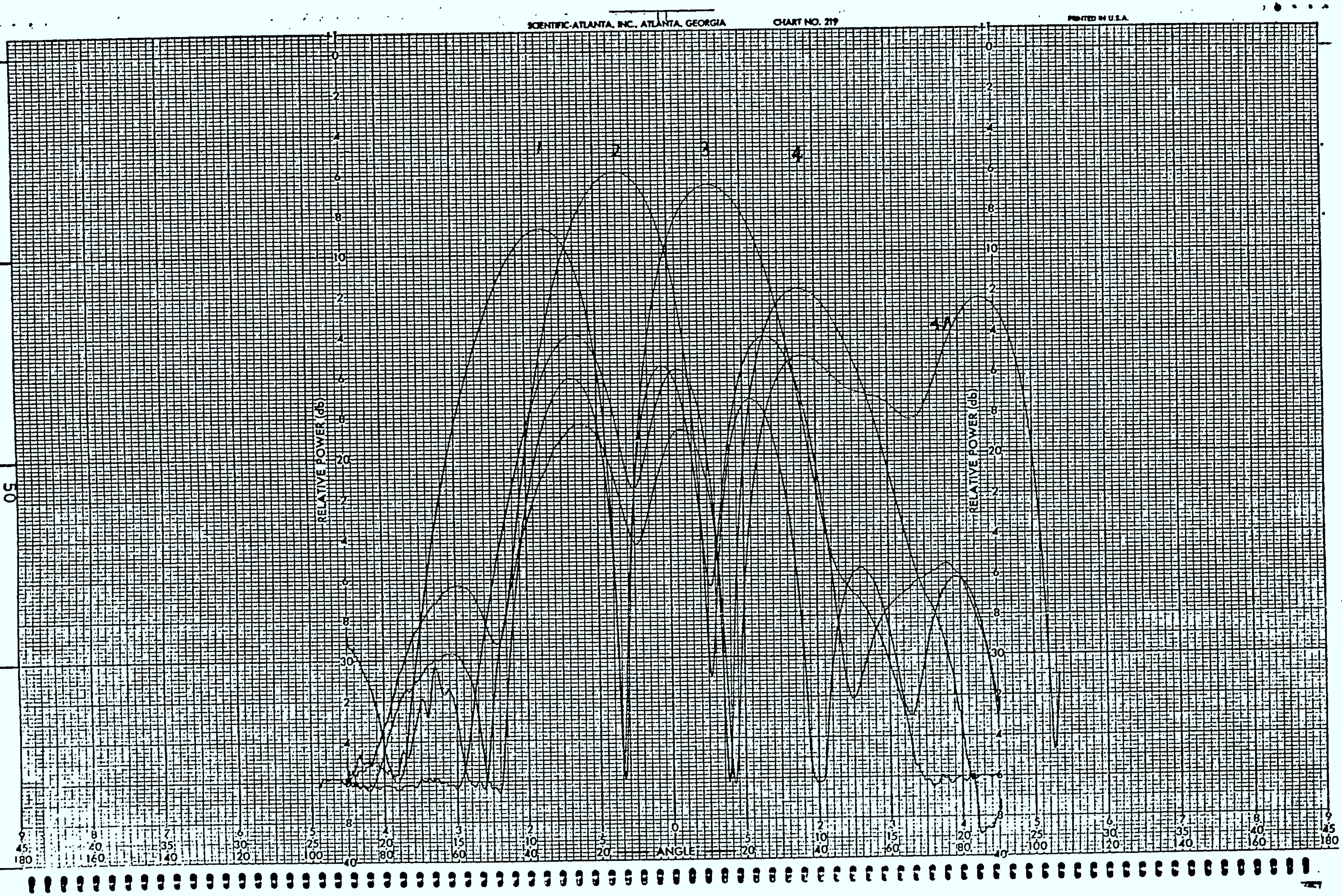

Figure 29. Azimuth patterns of beam 1-4A at 15° elevation, 268 MHz, Horizontal Polarization

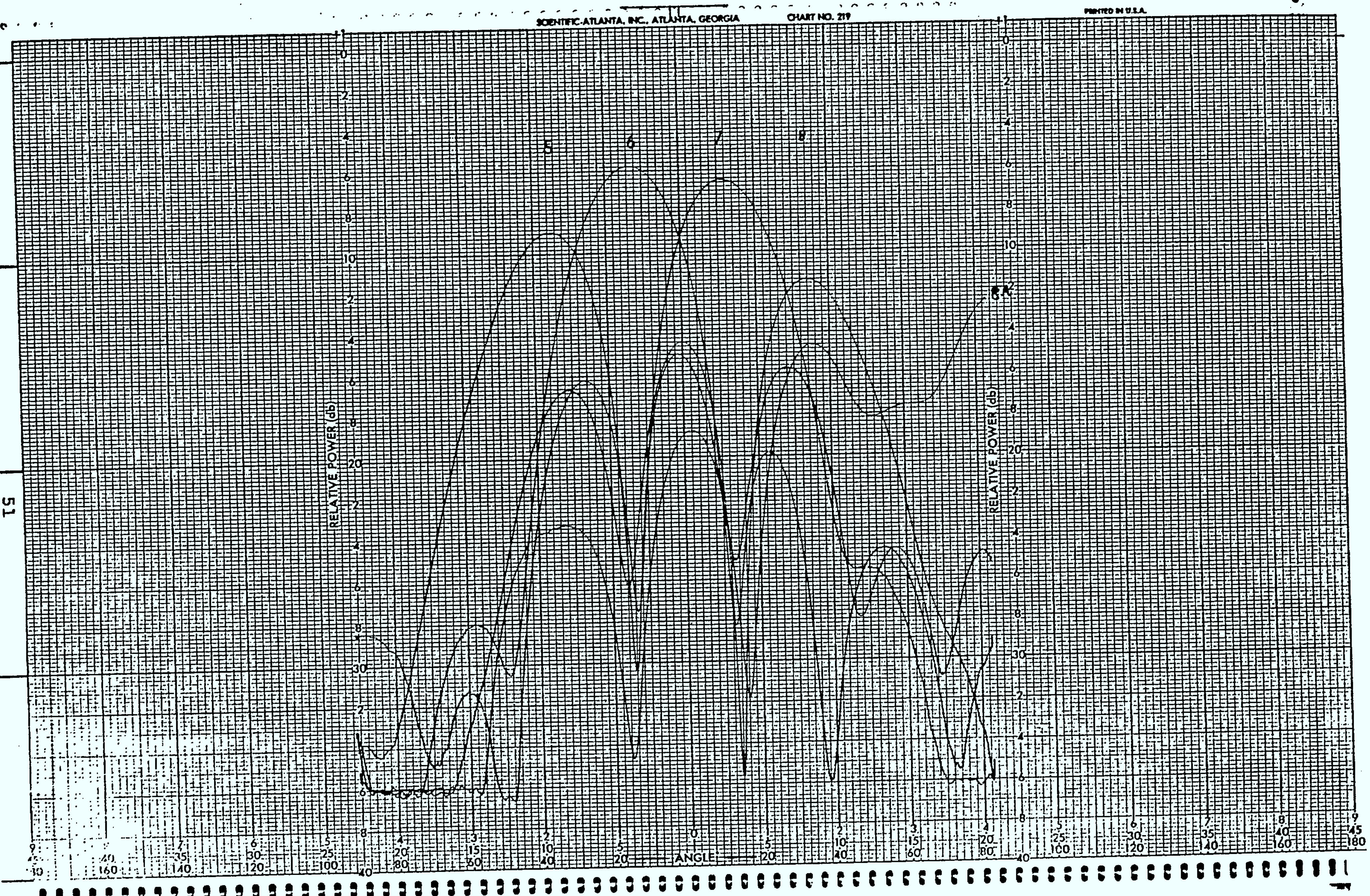

Figure 30. Azimuth patterns of beam 5-8A at 15° elevation, 868 MHz, Horizontal Polarization.

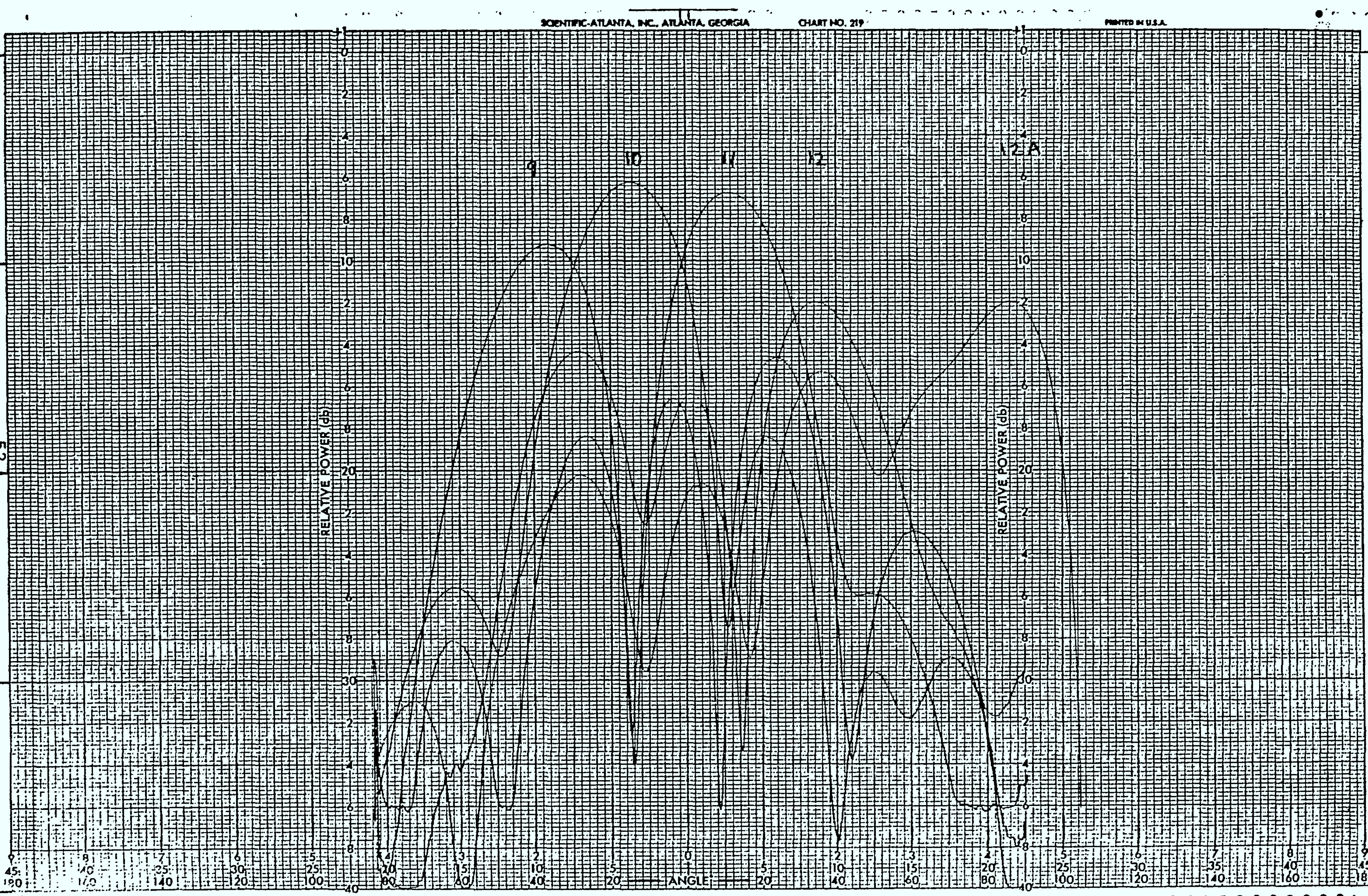

Figure 31. Azimuth patterns of beam 9-12A at 15° elevation, 868 MHz, Horizontal Polarization.

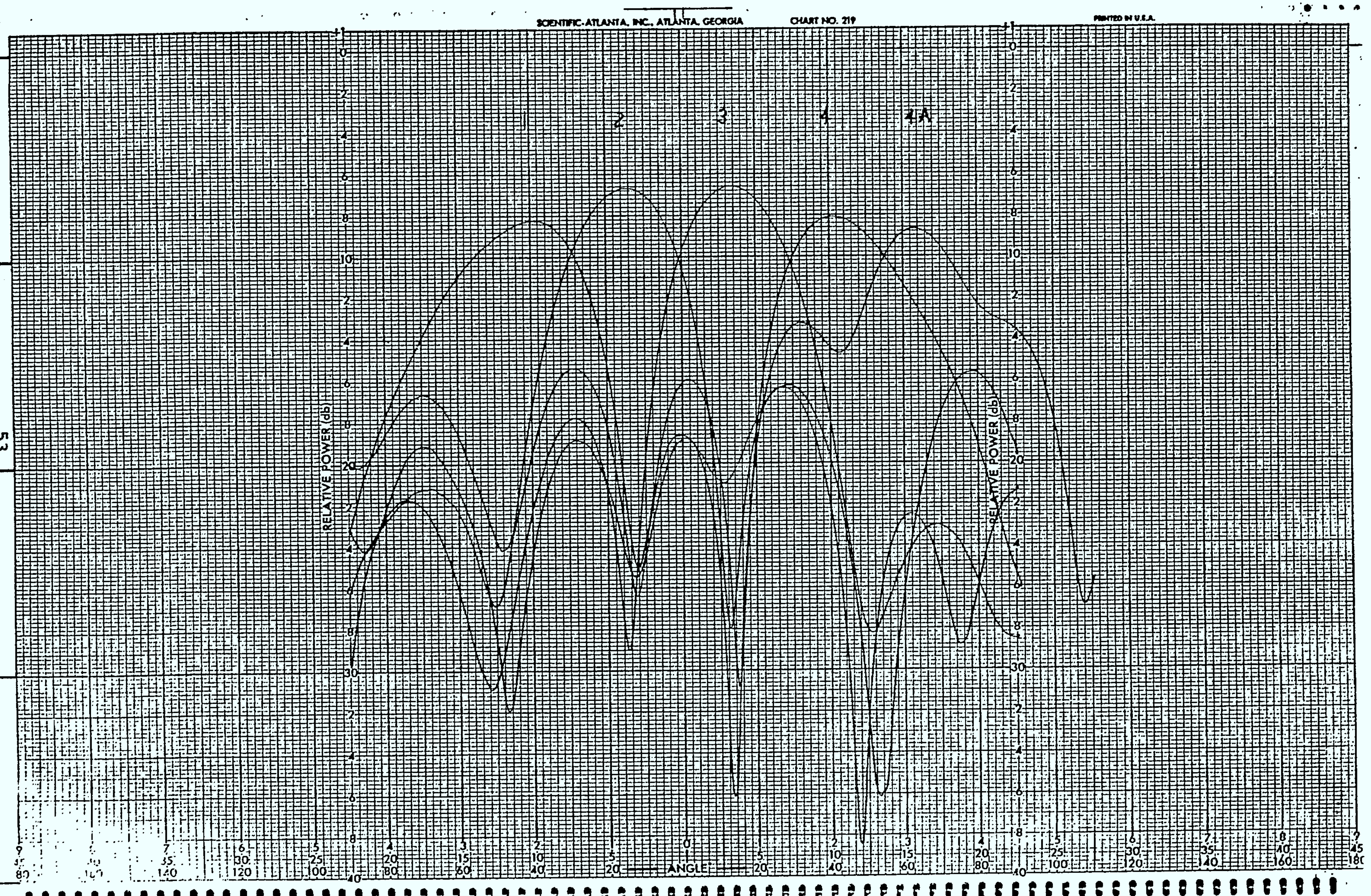

Figure 32. Azimuth patterns of beam 1-4A at 15^{o} elevation, 868 MHz, Vertical Polarization

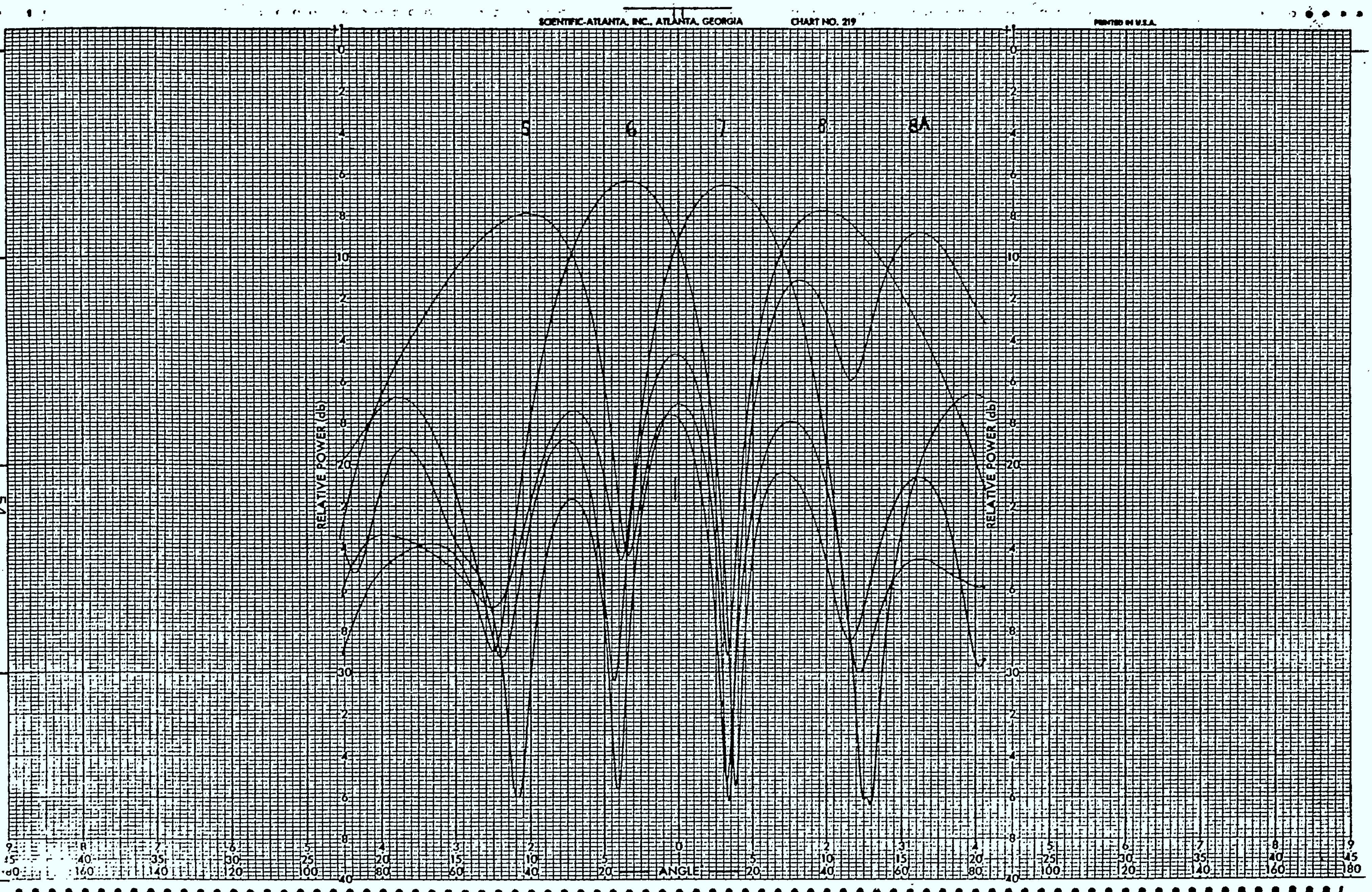

Figure 33. Azimuth patterns of beam 5-8A at 15° elevation, 868 MHz, Vertical Polarization.

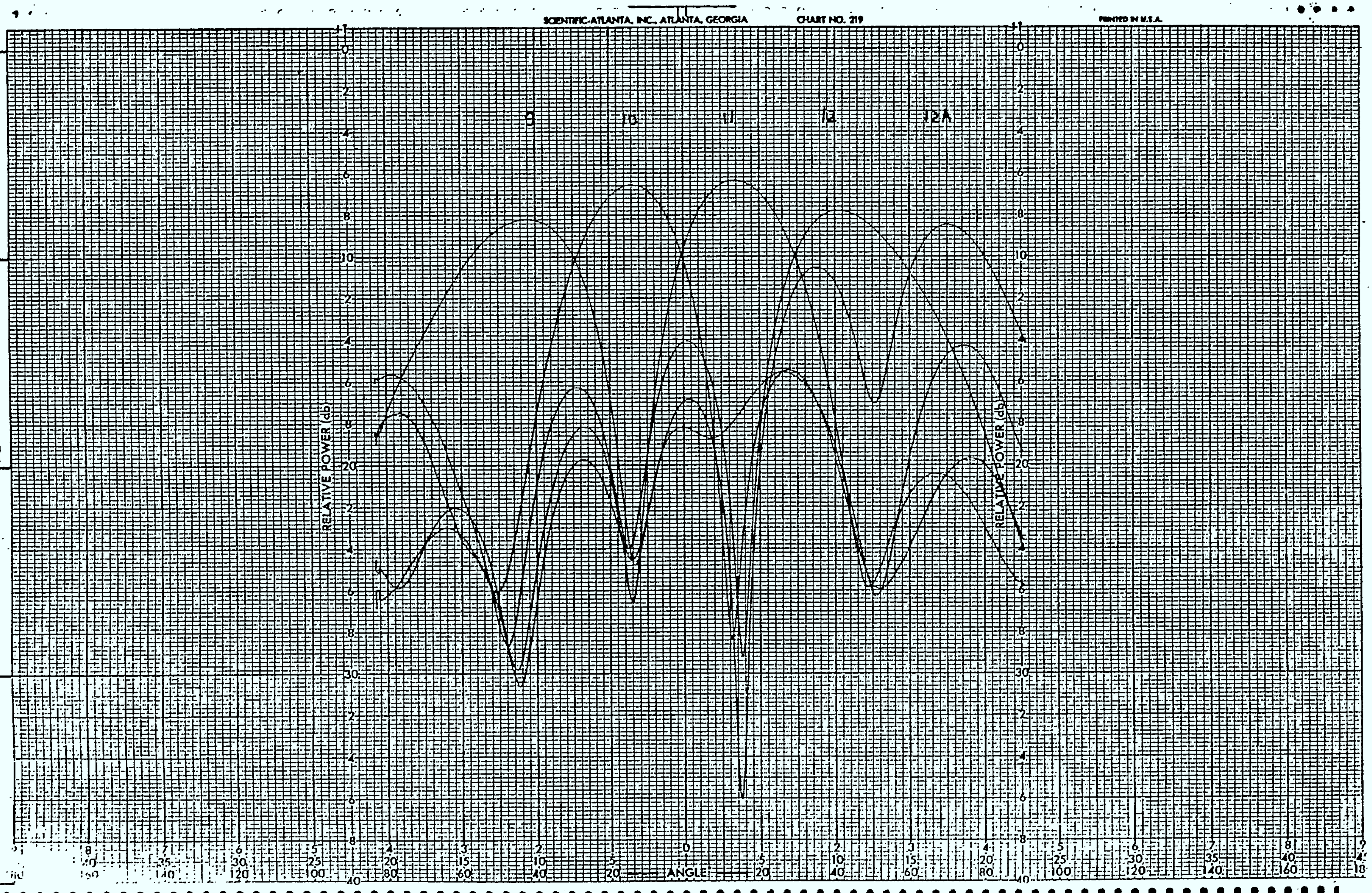

Figure 34. Azimuth patterns of beam 9-12A at 15° elevation, 868 MHz, Vertical Polarization.

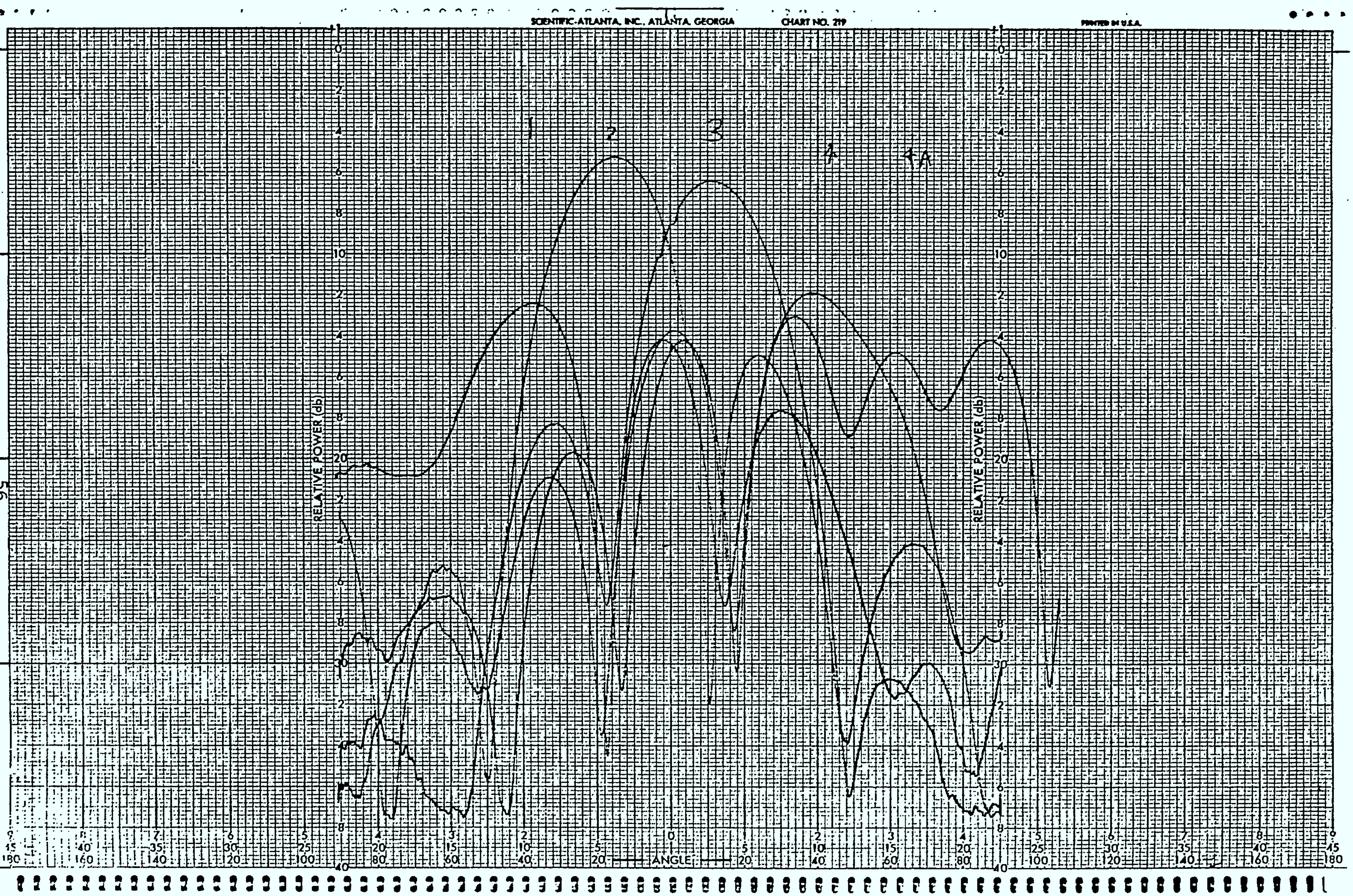

Figure 35. Azimuth patterns of beam 1-4A at 25° elevation, 823 MHz, Horizontal Polarization.

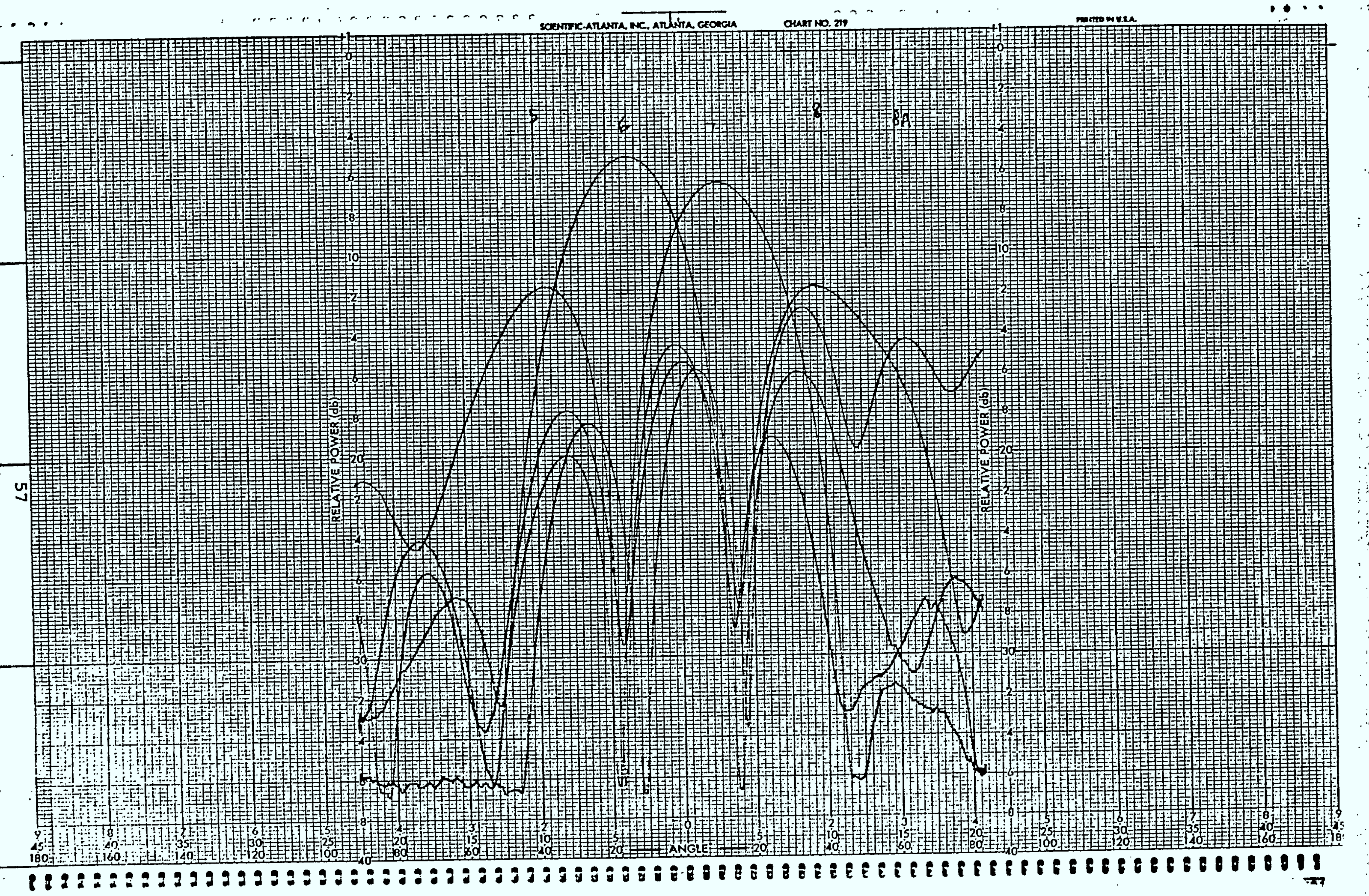

Figure 36. Azimuth patterns of beam 5-8A at 25^{O} elevation, 823 MHz, Horizontal Polarization.

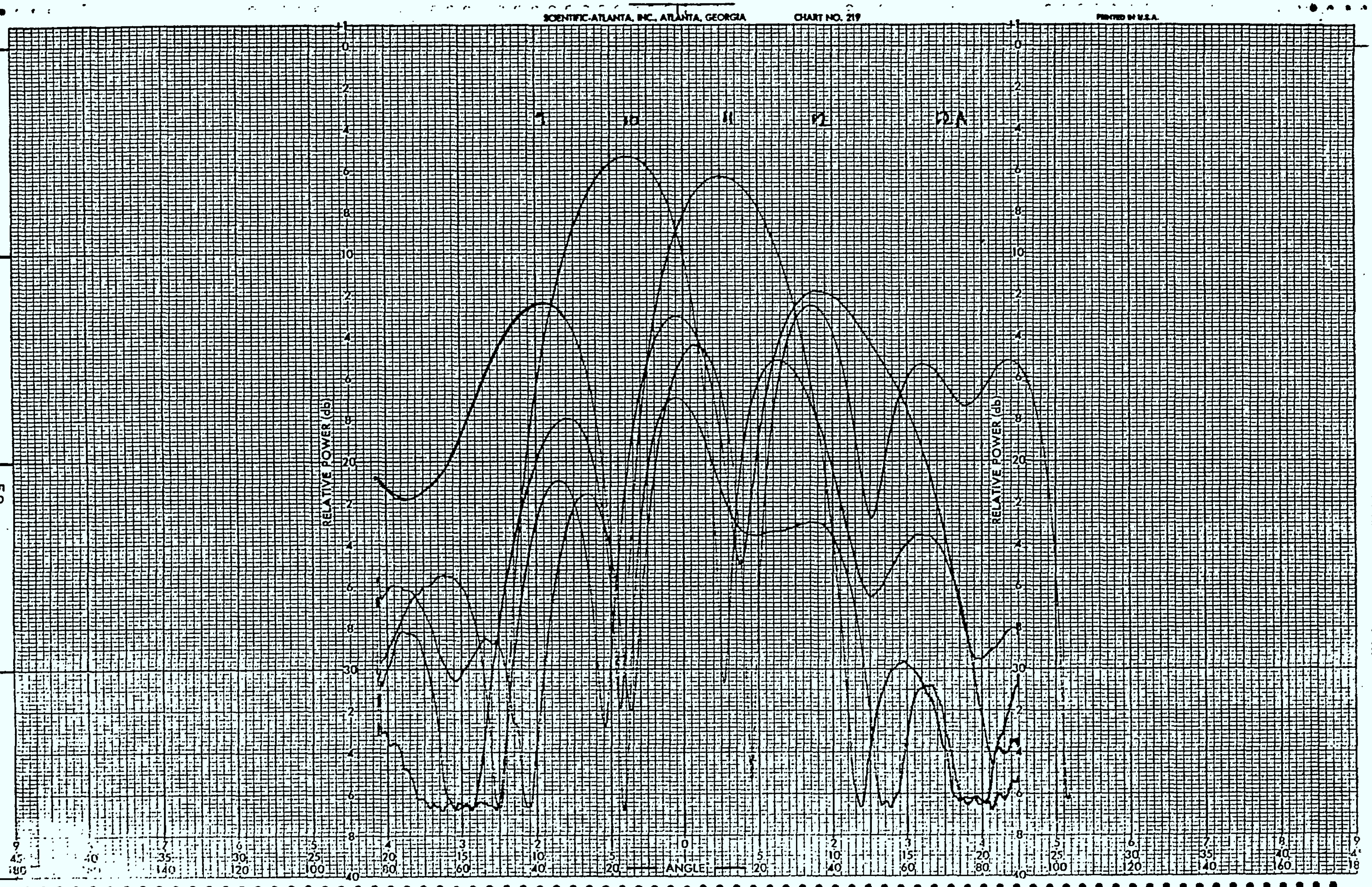

Figure 37. Azimuth patterns of beam 9-12A at 25° elevation, 823 MHz, Horizontal Polarization.

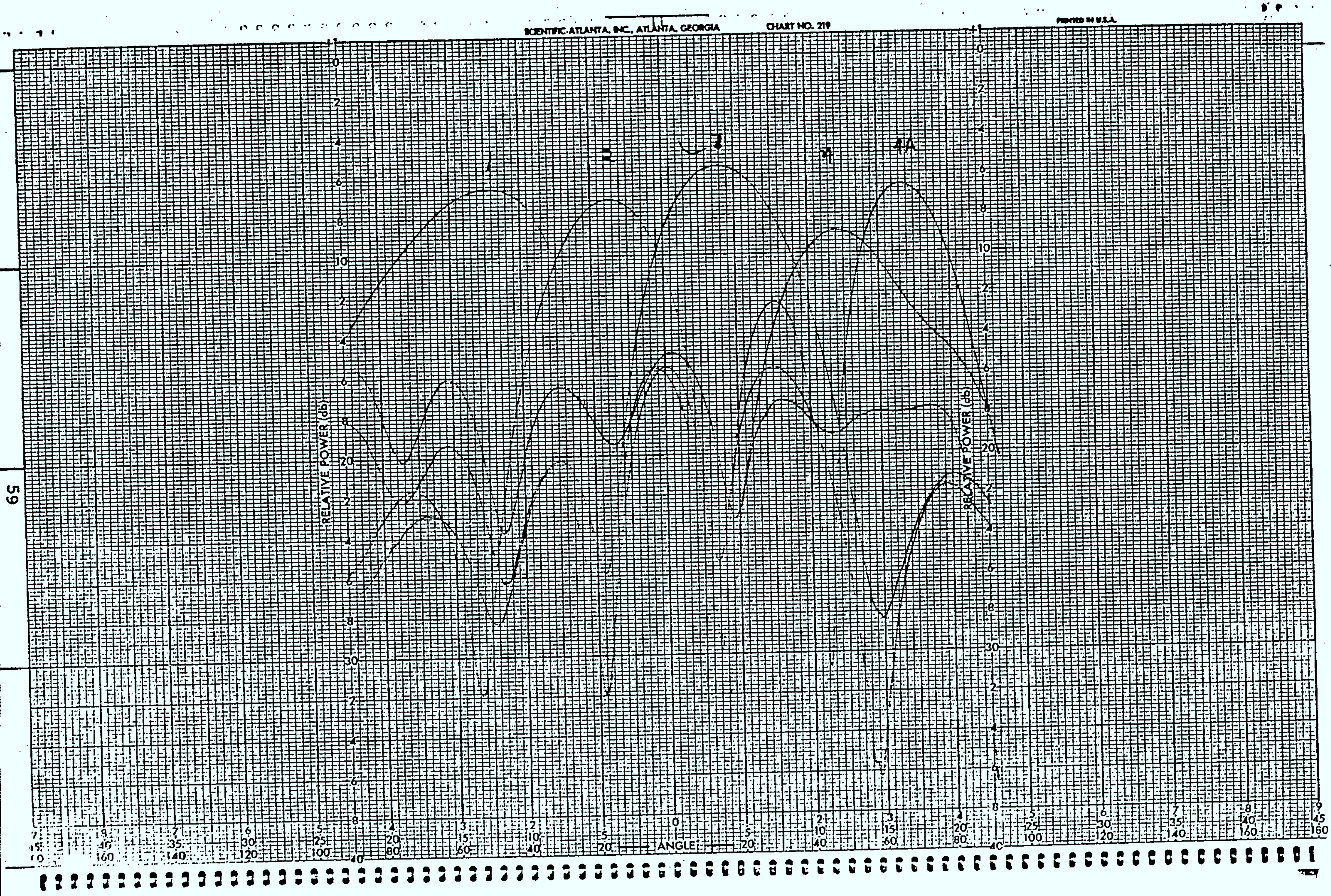

Figure 38. Azimuth patterns of beam 1-4A at 25° elevation, 823 MHz, Vertical Polarization.

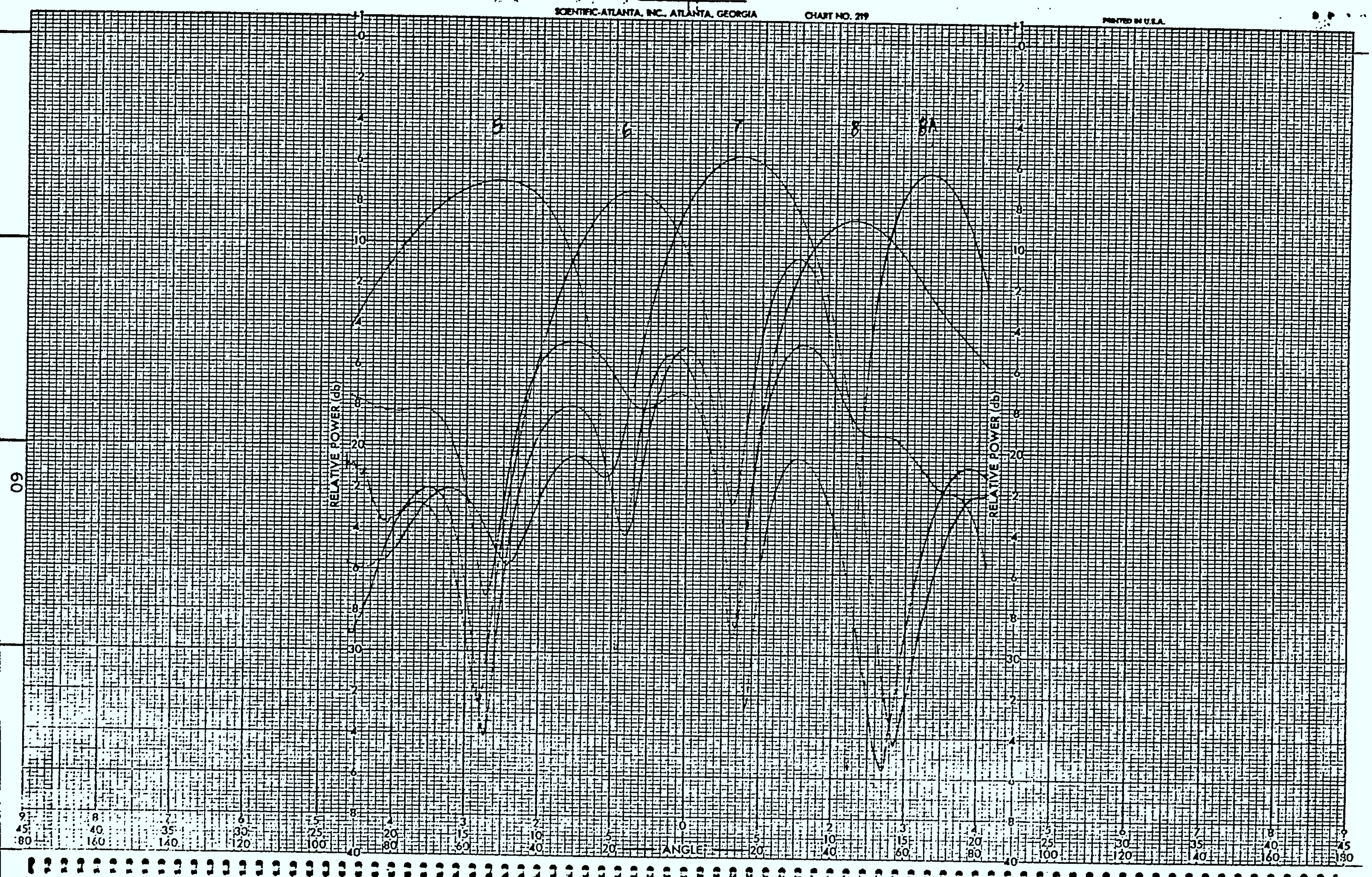

Figure 39. Azimuth patterns of beam 5-8A at 25° elevation, 823 MHz Vertical Polarization.

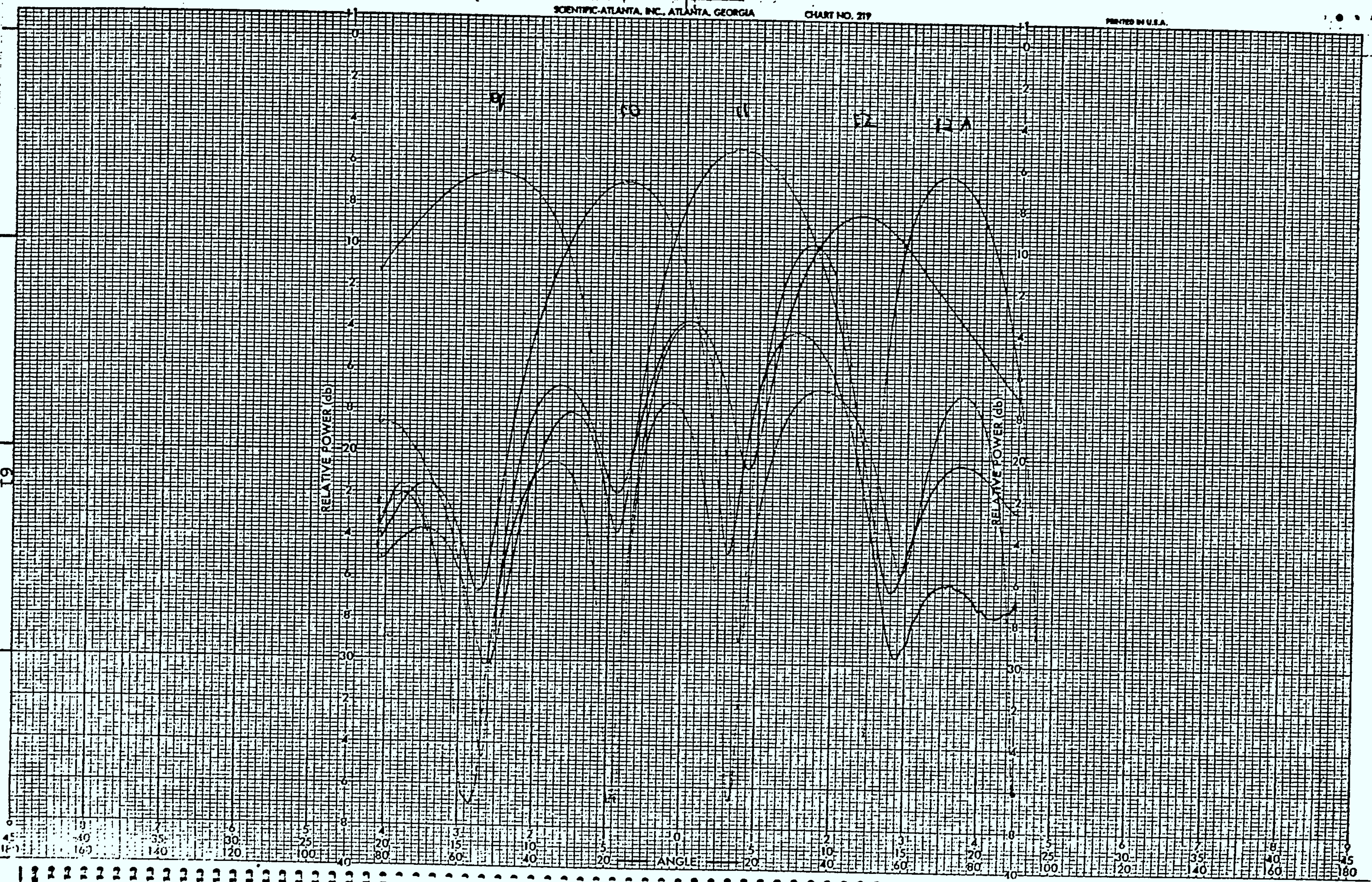

Figure 40. Azimuth patterns of beam 9-12A at 25^{o} elevation, 823 MHz, Vertical Polarization.

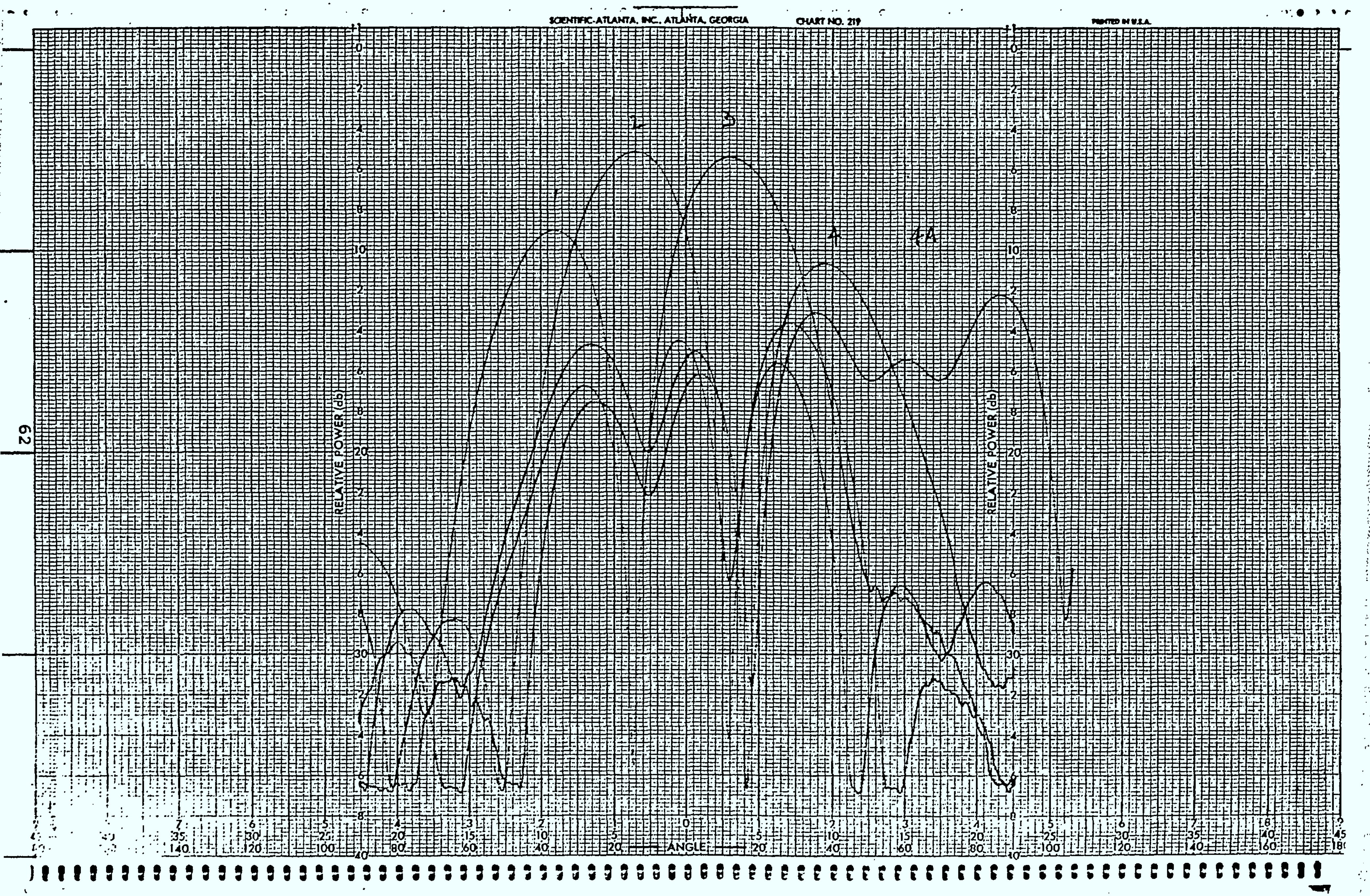

Figure 41. Azimuth patterns of beam 1-4A at 25° elevation, 868 MHz, Horizontal Polarization.

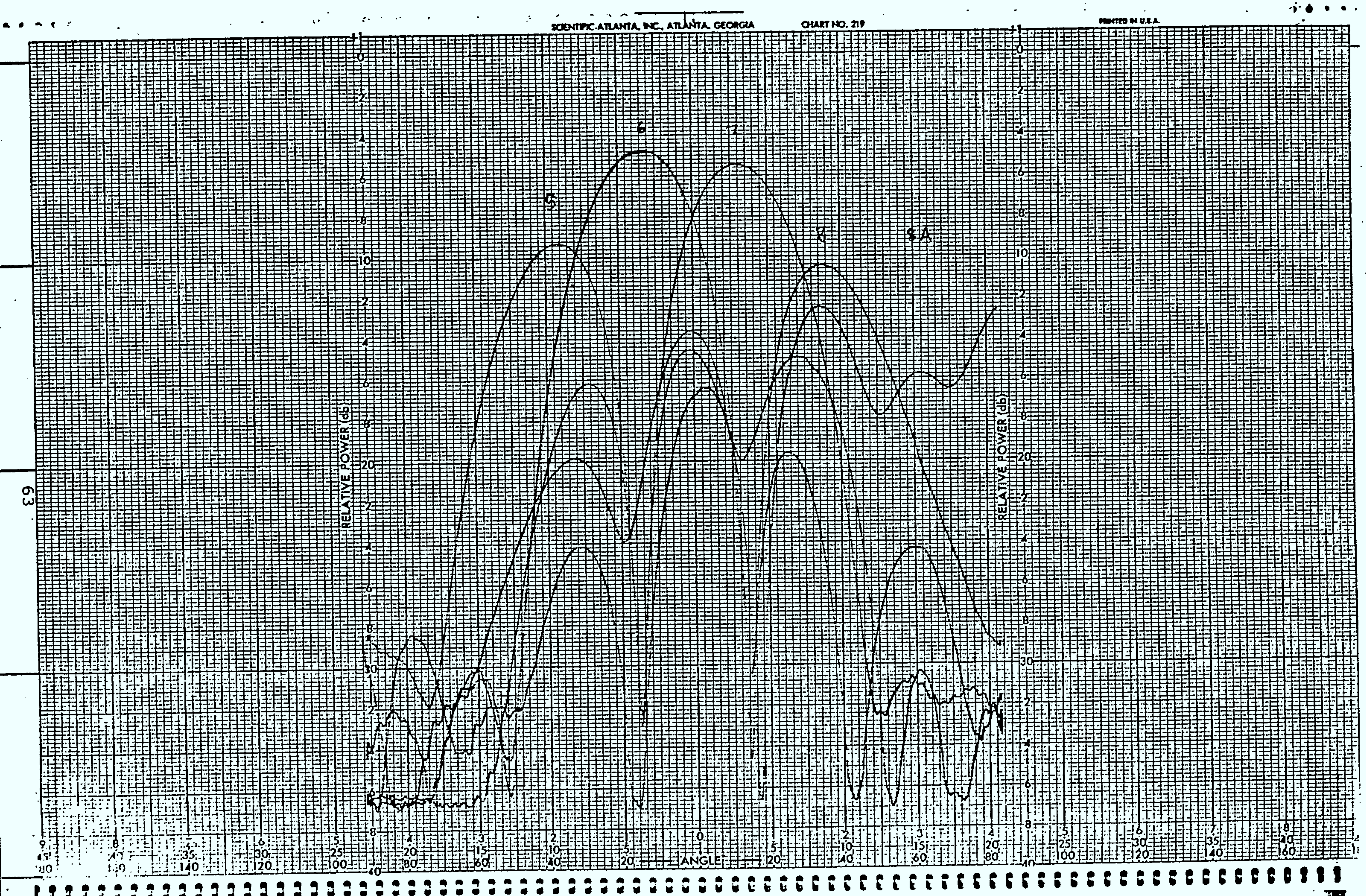

Figure 42. Azimuth patterns of beam 5-8A at 25° elevation, 868 MHz, Horizontal Polarization.

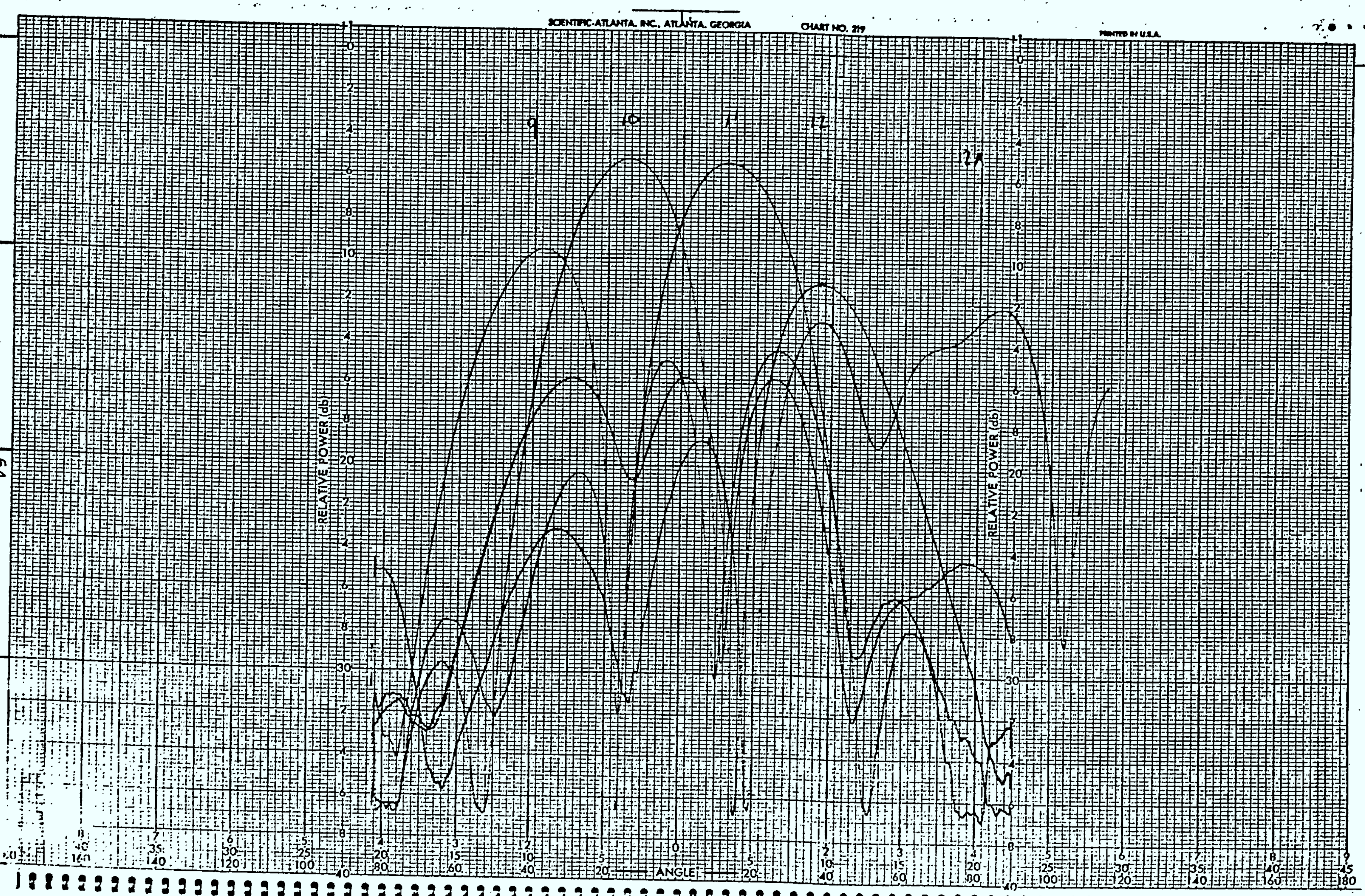

Figure 43. Azimuth patterns of beam 9-12A at 25° elevation, 868 MHz, Horizontal Polarization.

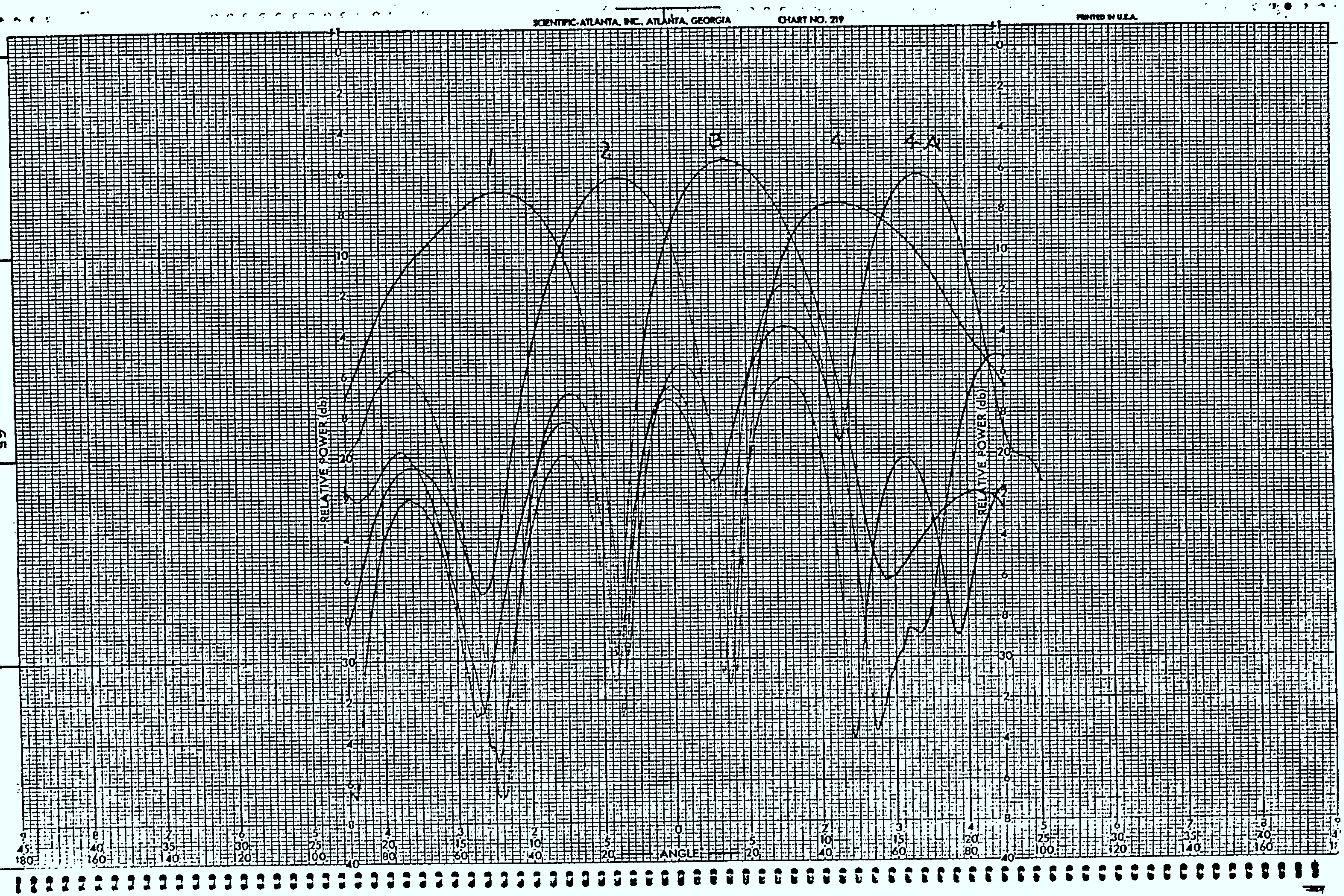

Figure 44. Azimuth patterns of beam 1-4A at 25° elevation, 868 MHz, Vertical Polarization.

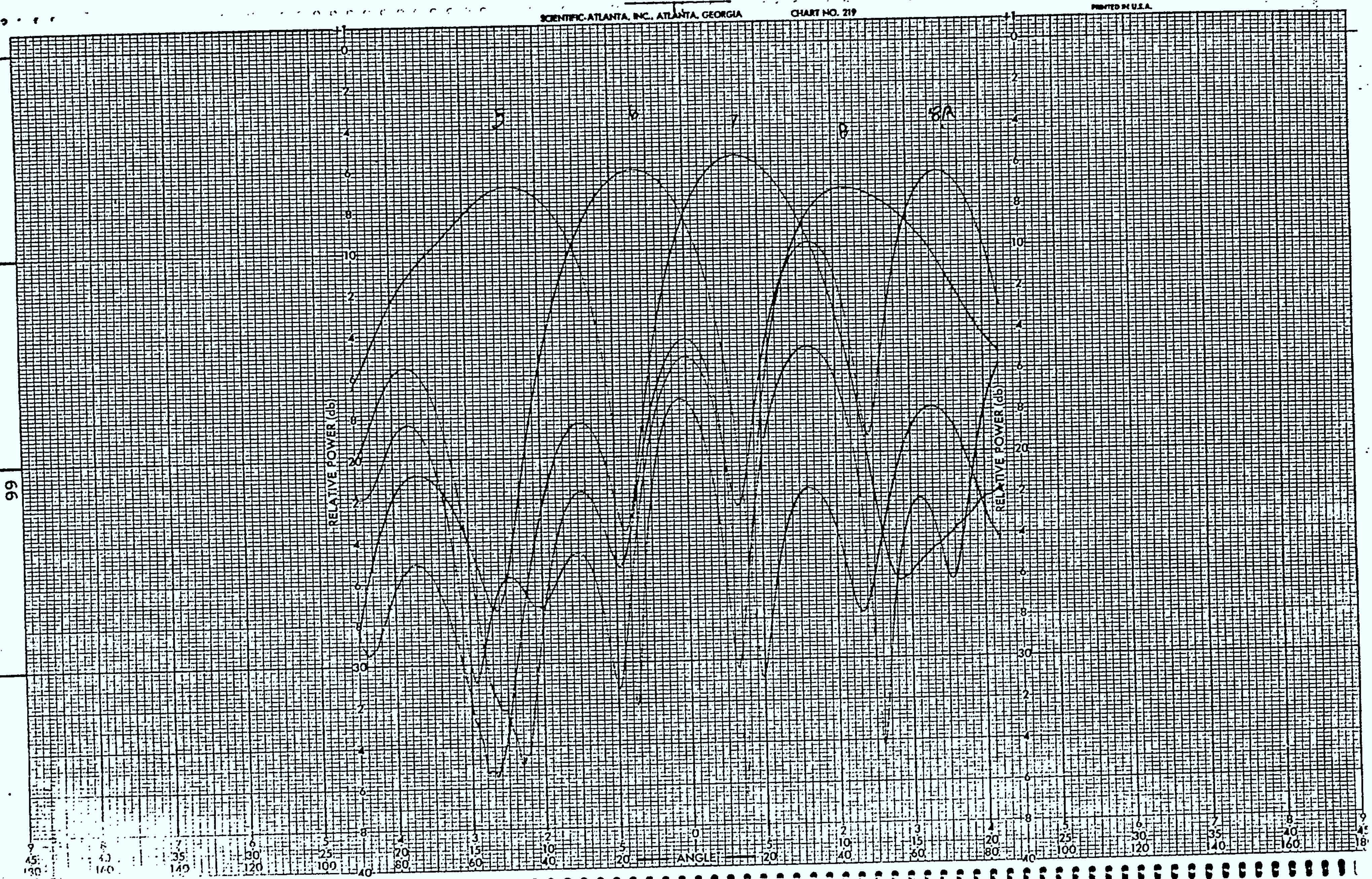

Figure 45. Azimuth patterns of beam 5-8A at 25° elevation, 868 MHz, Vertical Polarization.

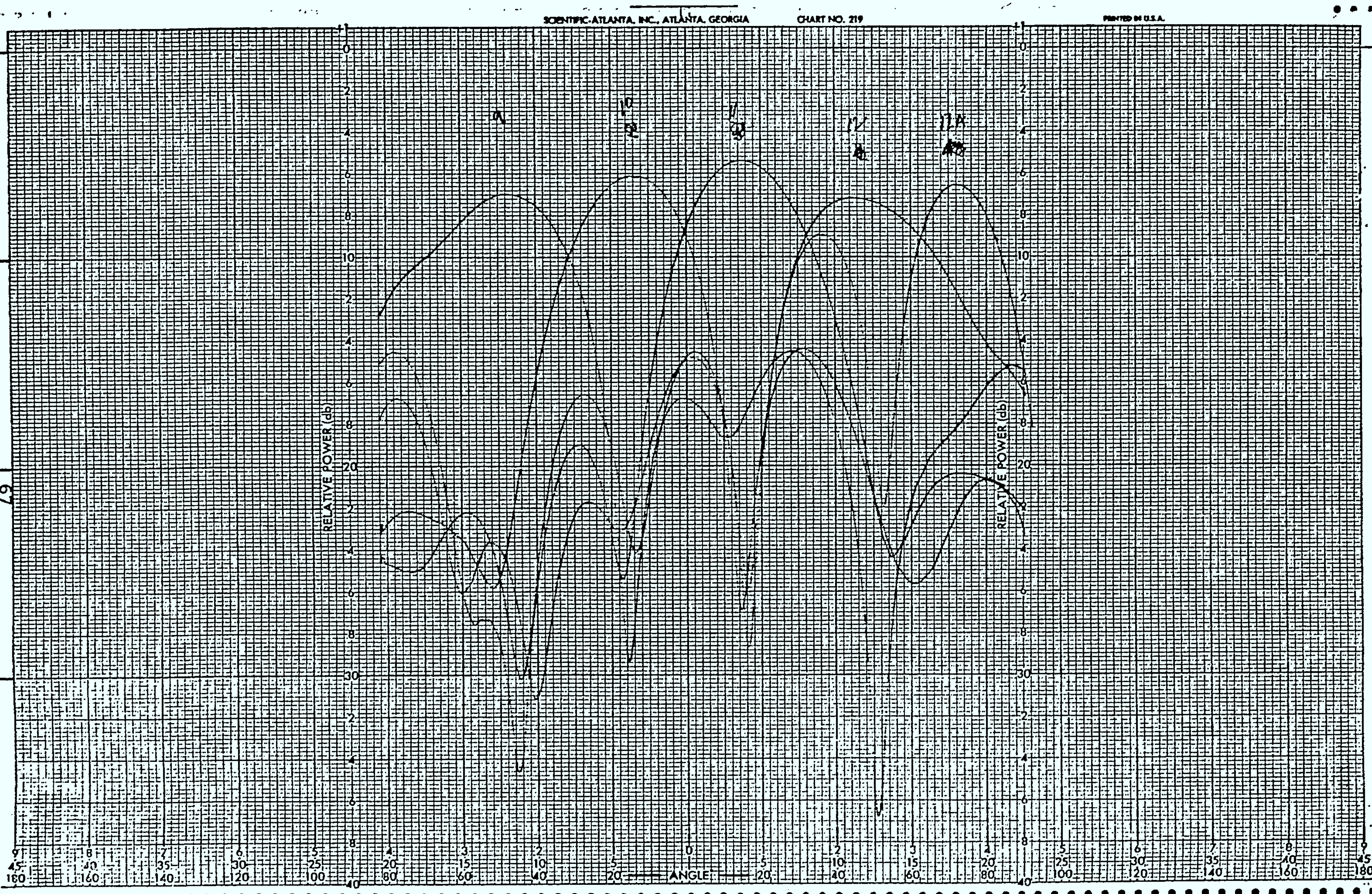

Figure 46. Azimuth patterns of beam 9-12A at 25° elevation, 868 MHz, Vertical Polarization.

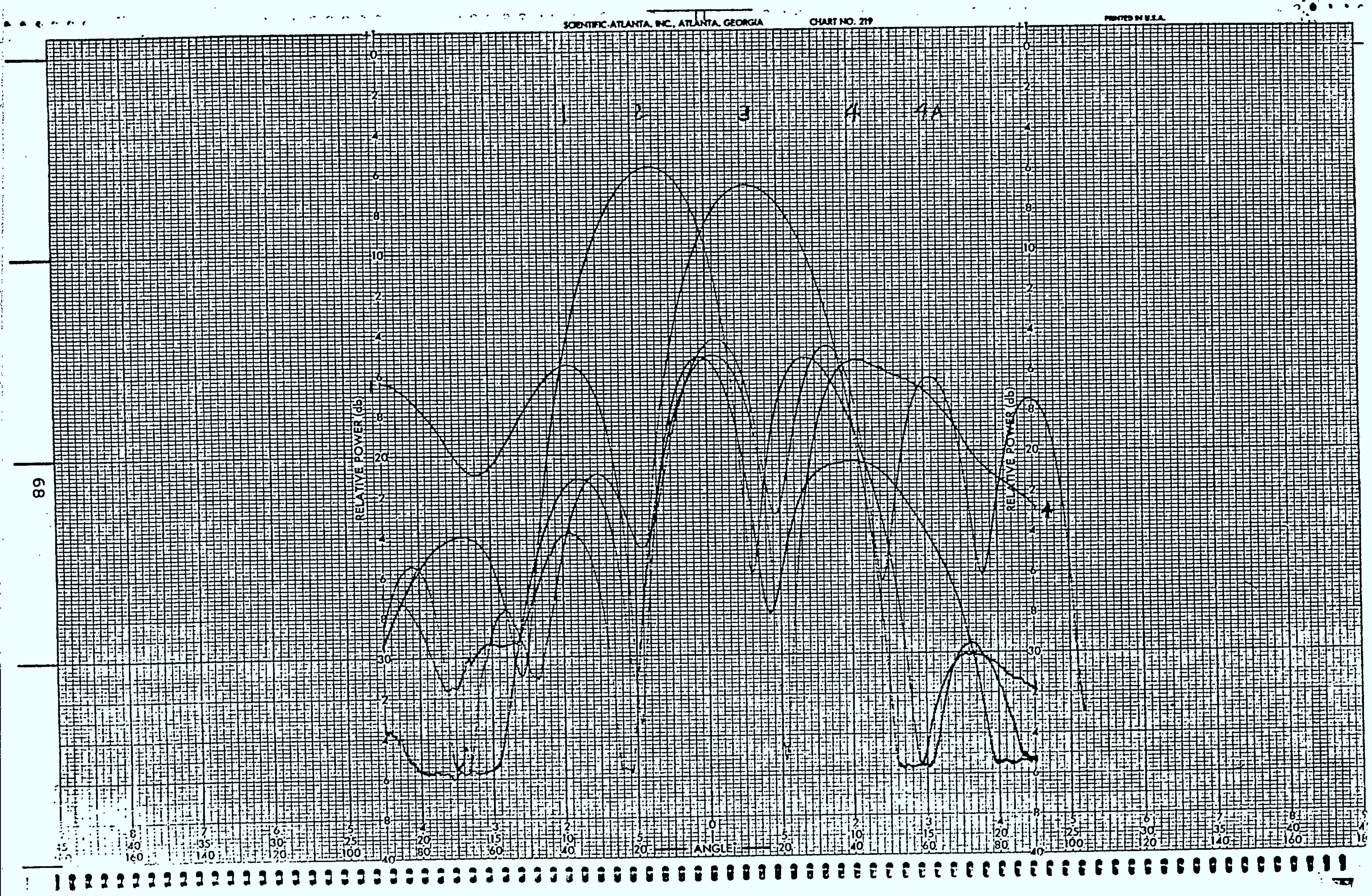

Figure 47. Azimuth patterns of beam 1-4A at 35° elevation, 823 MHz, Horizontal Polarization.

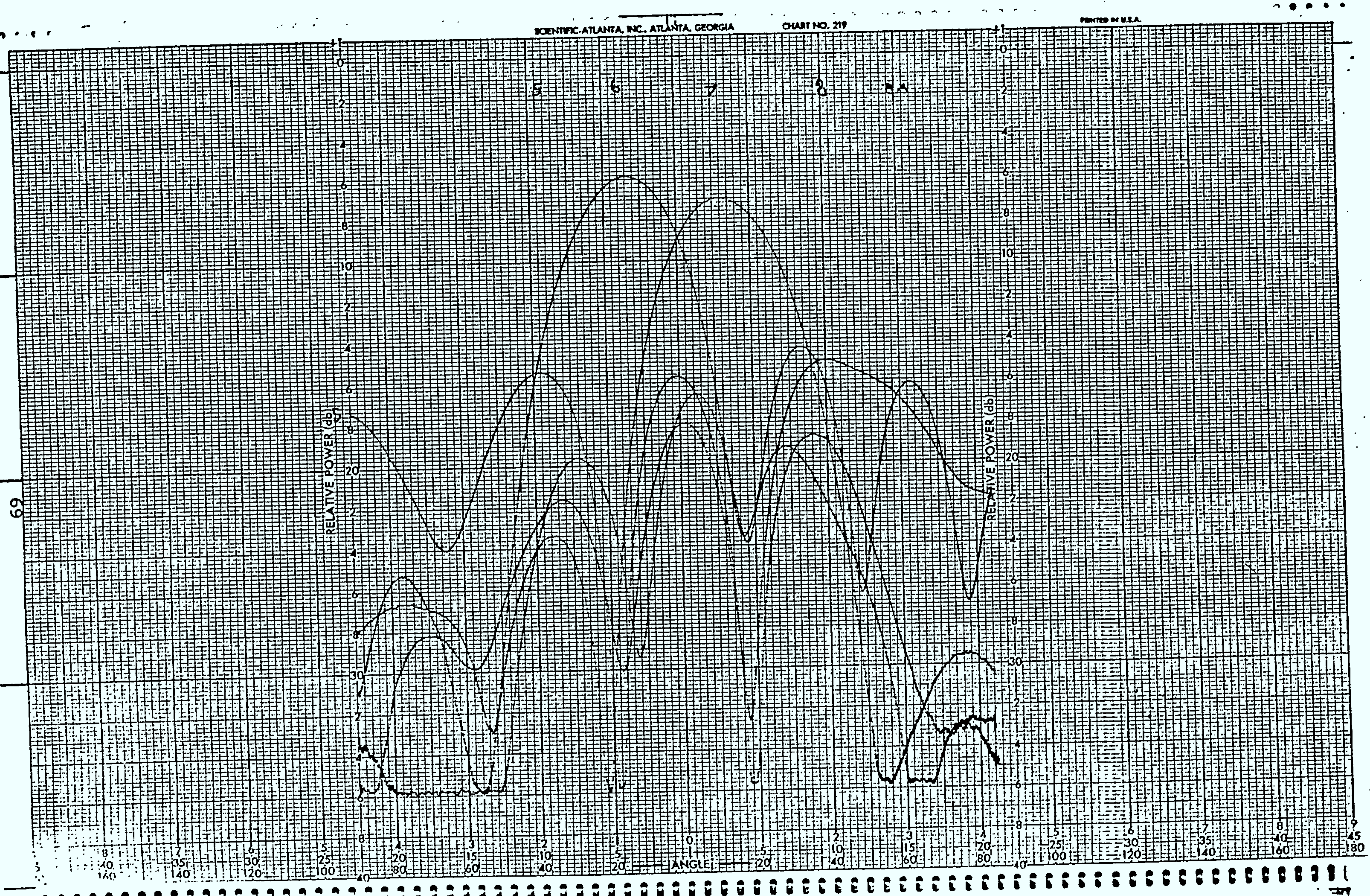

Figure 48. Azimuth patterns of beam 5-8A at 35° elevation,

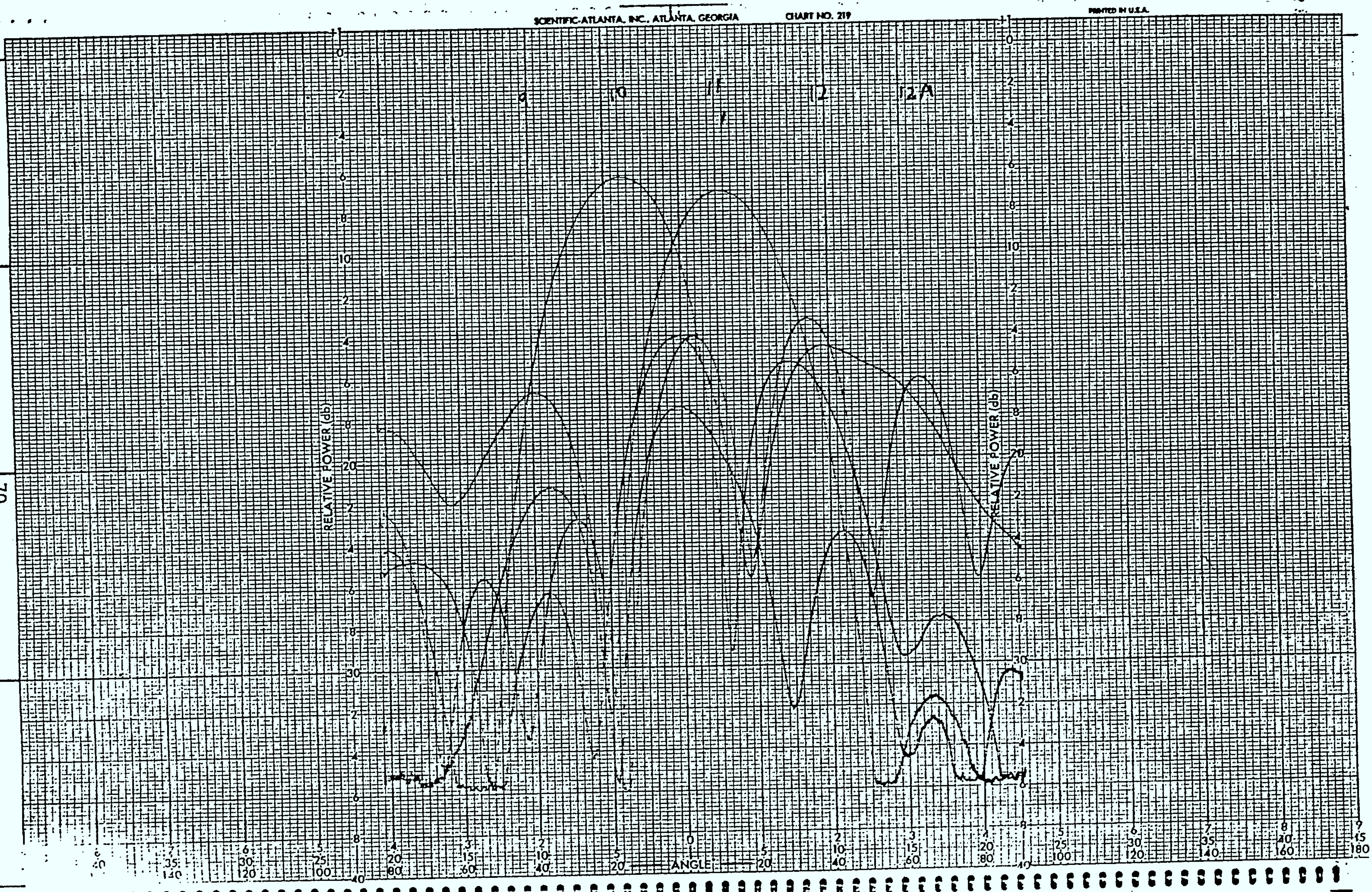

Figure 49. Azimuth patterns of beam 9-12A at 35° elevation,

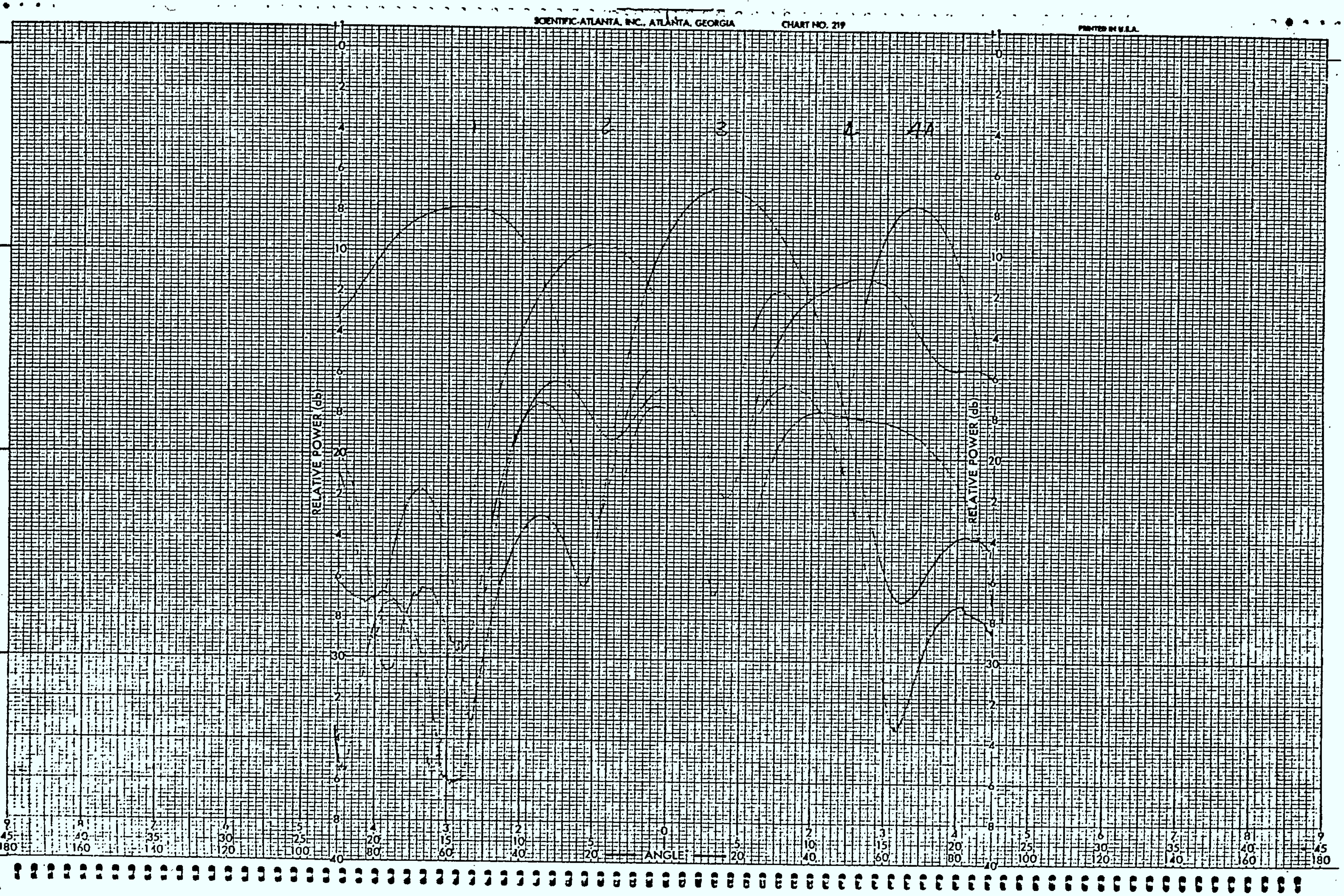

Figure 50. Azimuth patterns of beam 1-4A at 35° elevation, 823 MHz, Vertical Polarization.

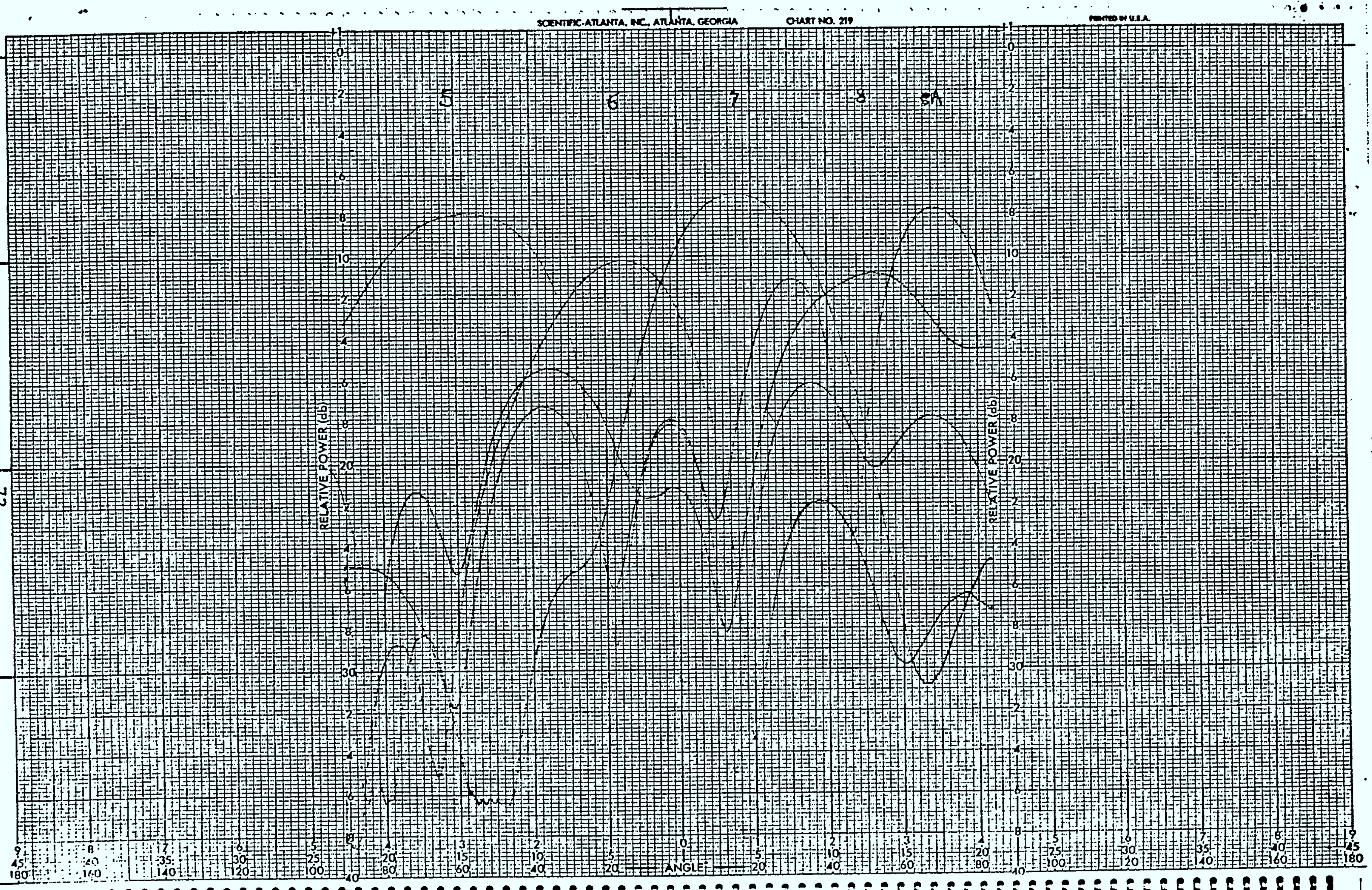

Figure 51. Azimuth patterns of beam 5-8A at 35° elevation, 823 MHz, Vertical Polarization

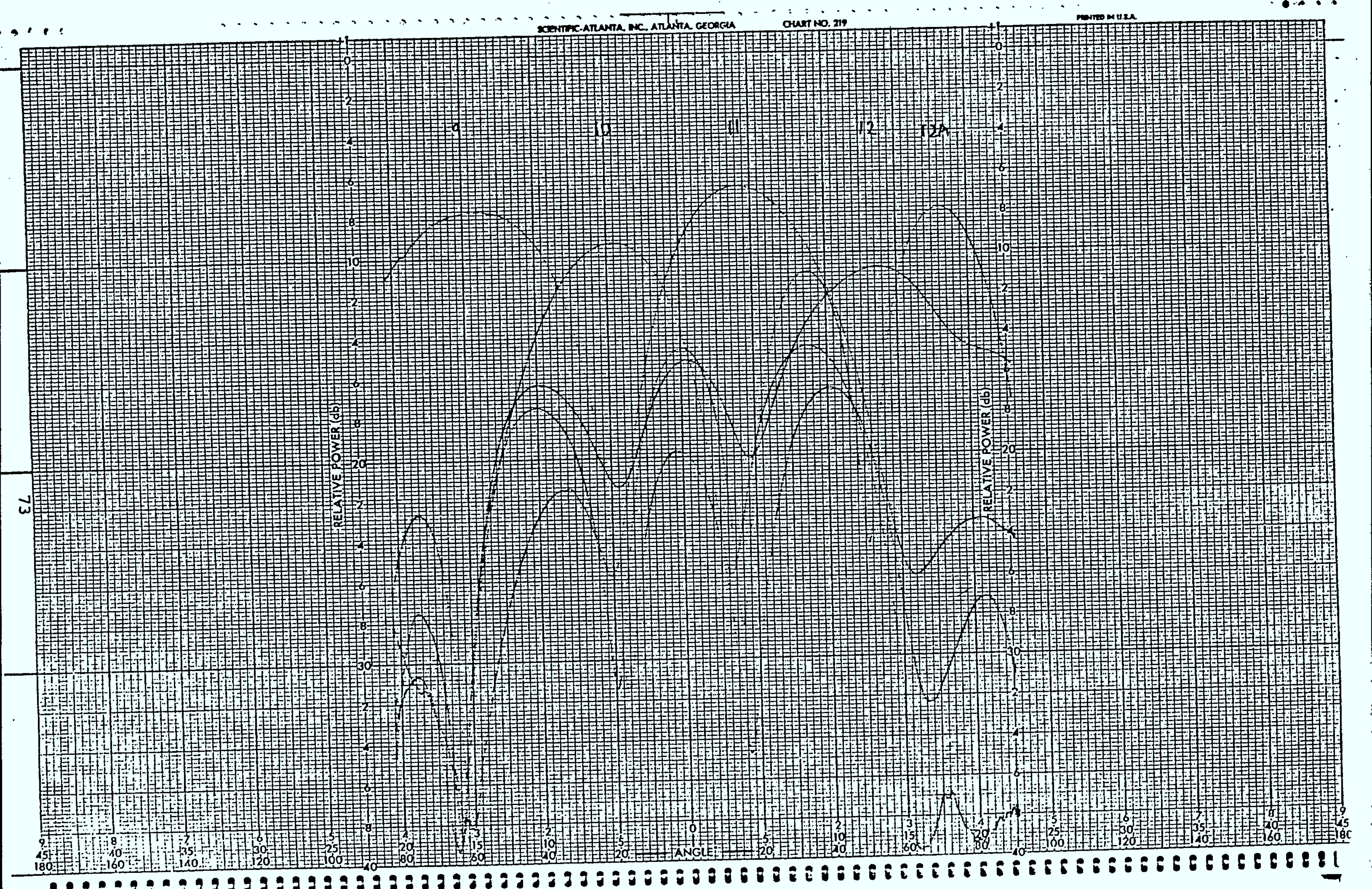

Figure 52. Azimuth patterns of beam 9-12A at 35° elevation,

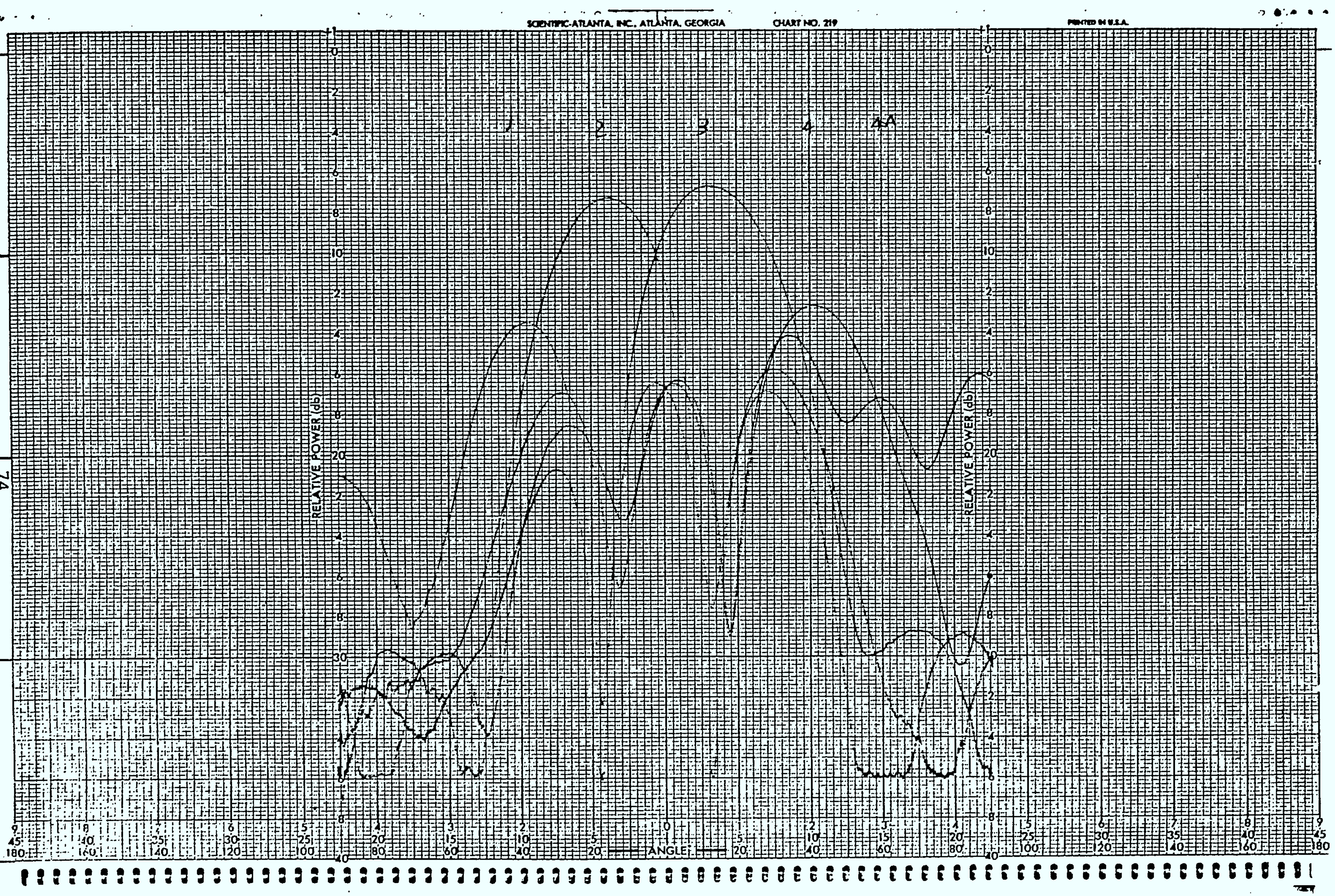

Figure 53. Azimuth patterns of beam 1-4A at 35° elevation, 868 MHz, Horizontal Polarization.

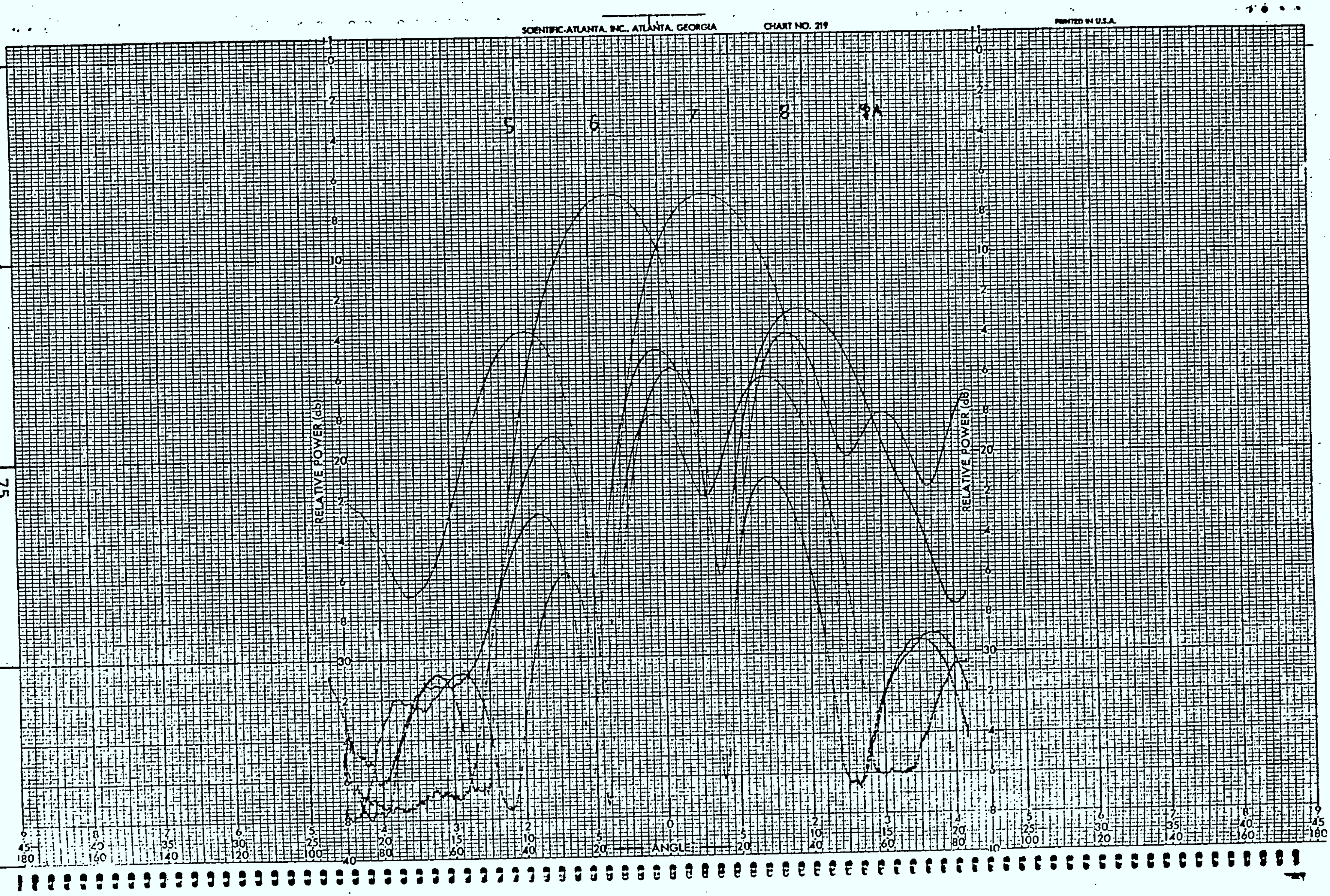

Figure 54. Azimuth patterns of beam 5-8A at 35° elevation,

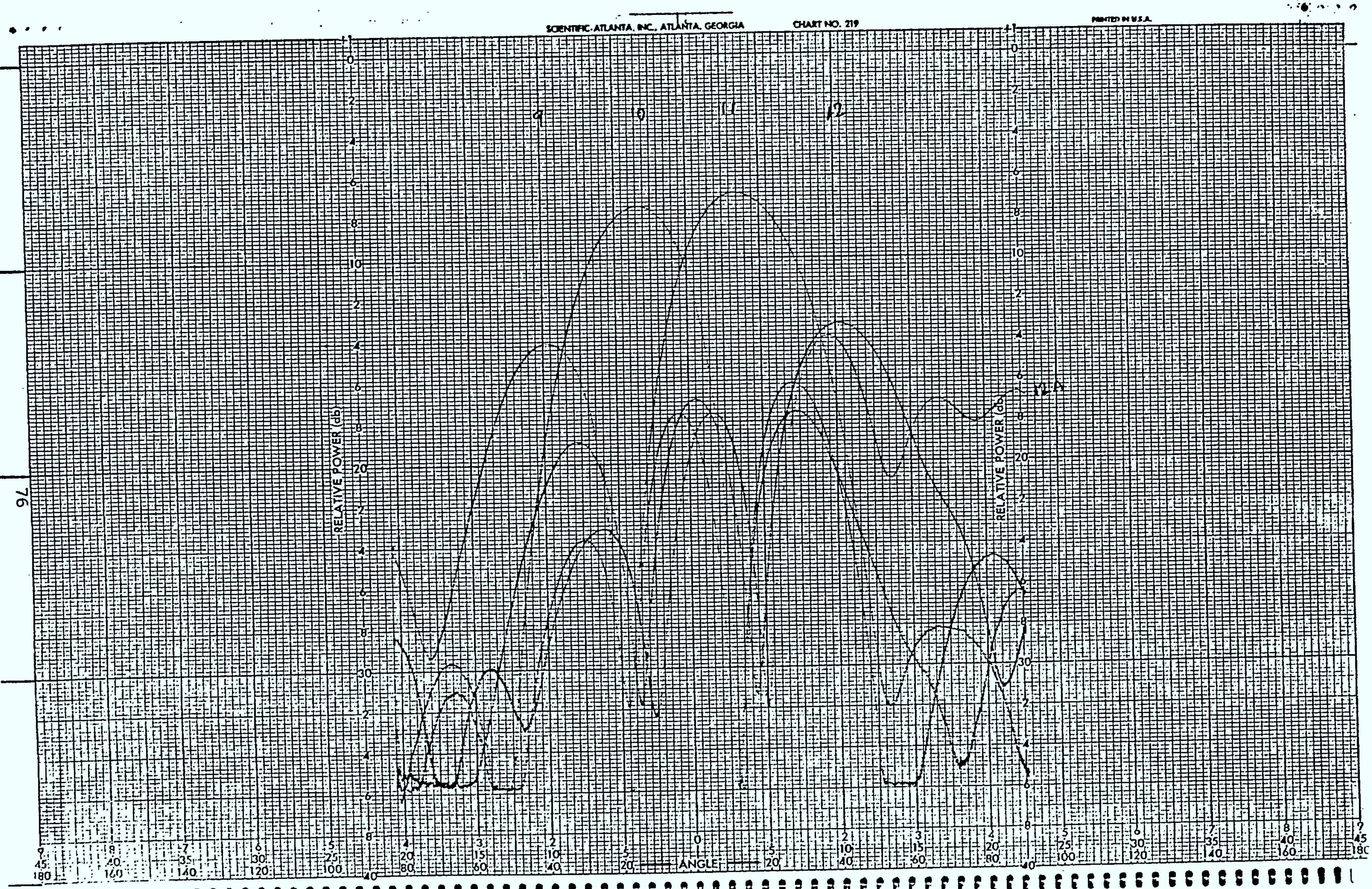

Figure 55. Azimuth patterns of beam 9-12A at 35^{o} elevation, 868 MHz Horizontal Polarization.

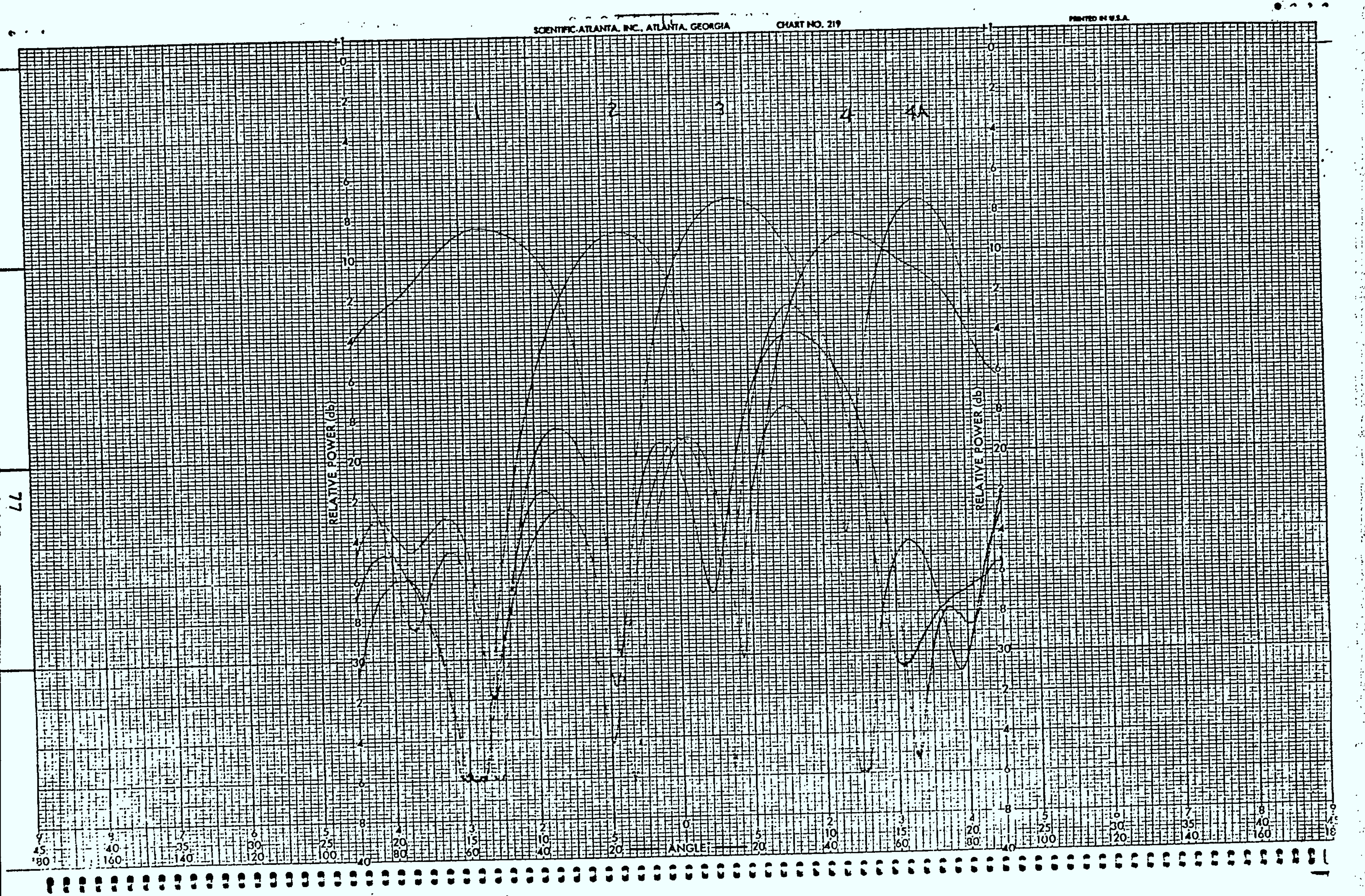

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Figure 56. Azimuth patterns of beam 1-4A at 35° elevation, 868 MHz. Vertical Polarization.

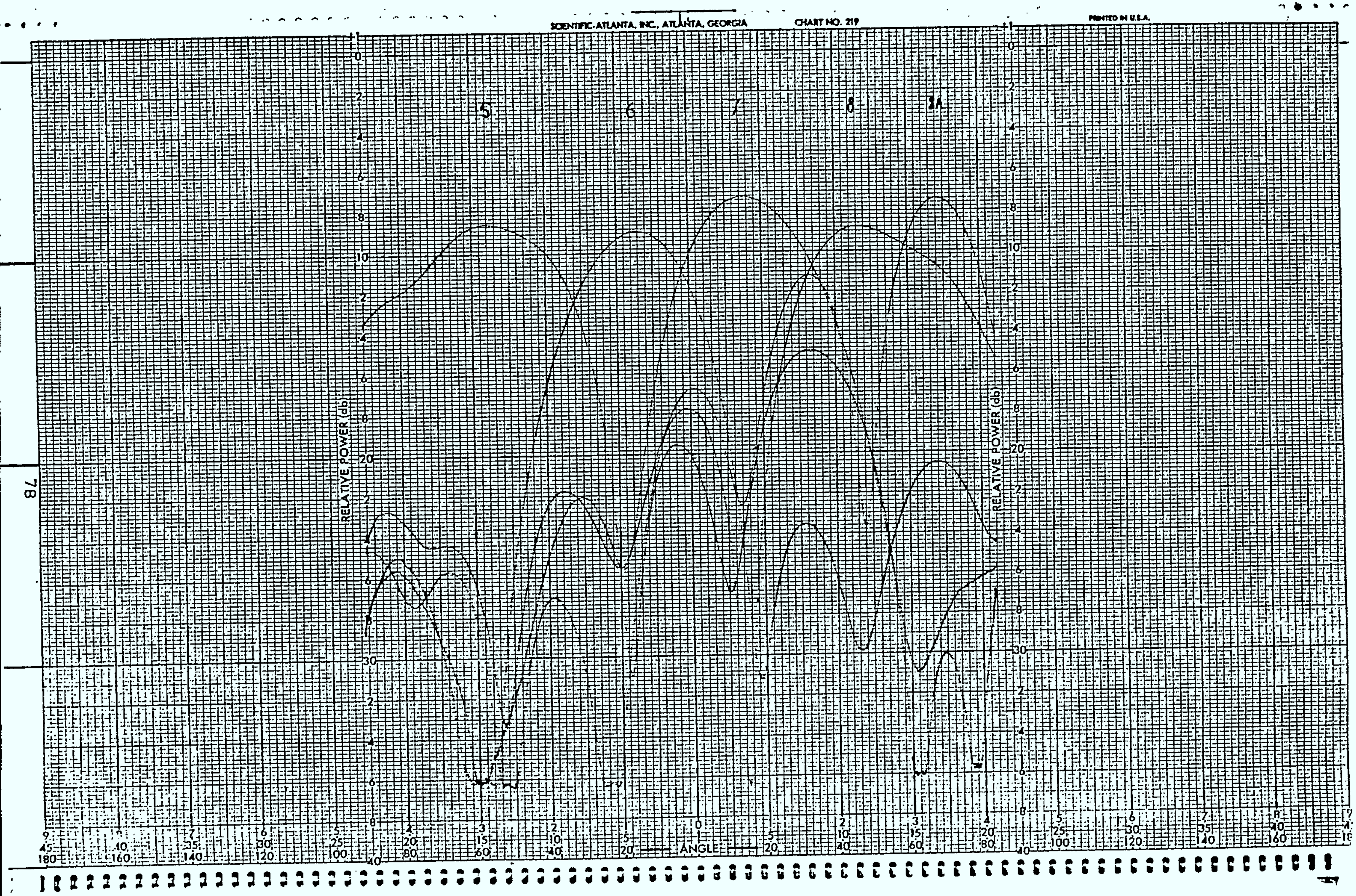

Figure 57. Azimuth patterns of beam 5-8A at 35° elevation, 868 MHz, Vertical Polarization.

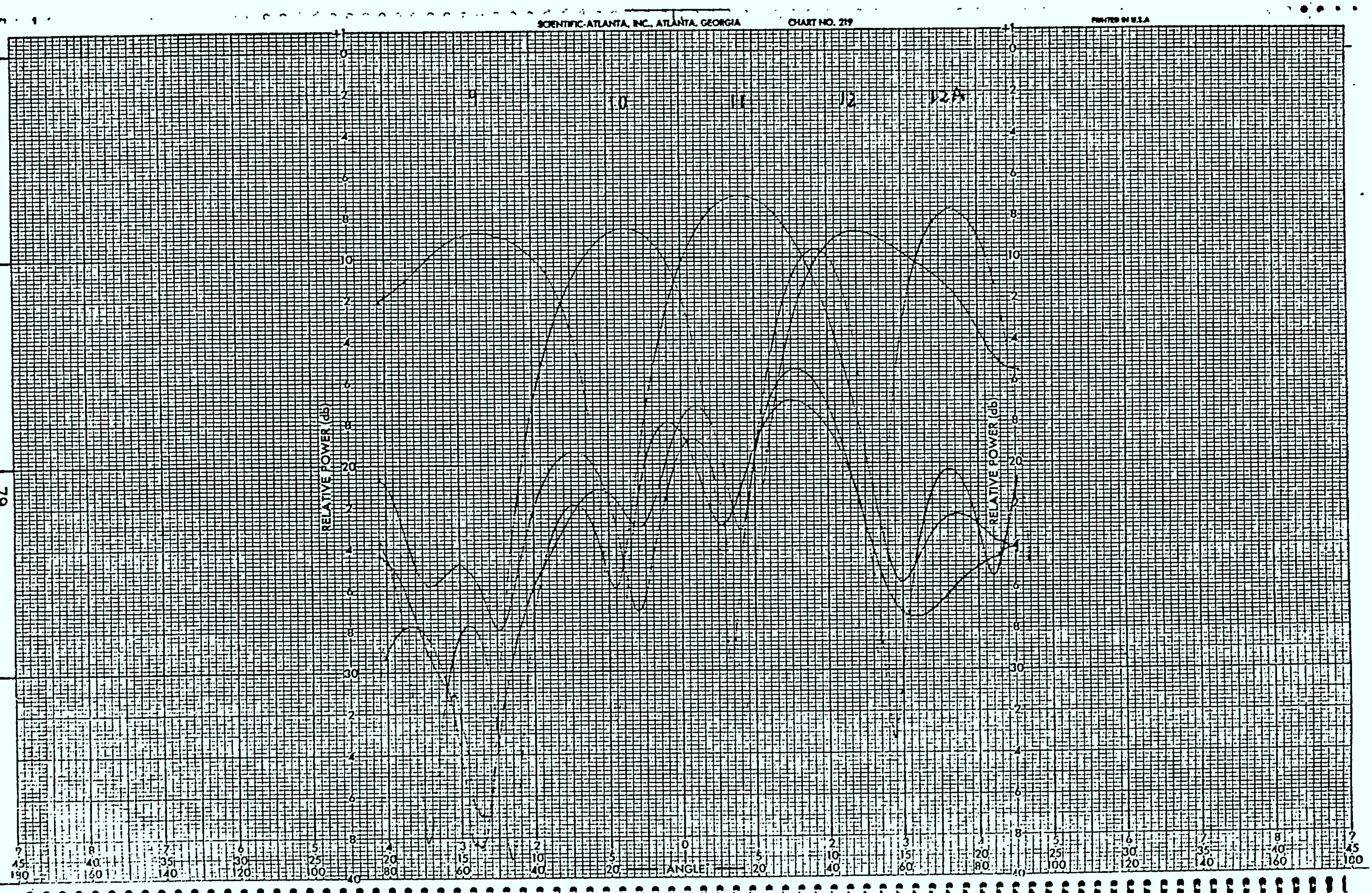

Figure 58. Azimuth patterns of beam 9-12A at 35° elevation, 868 MHz, Vertical Polarization.

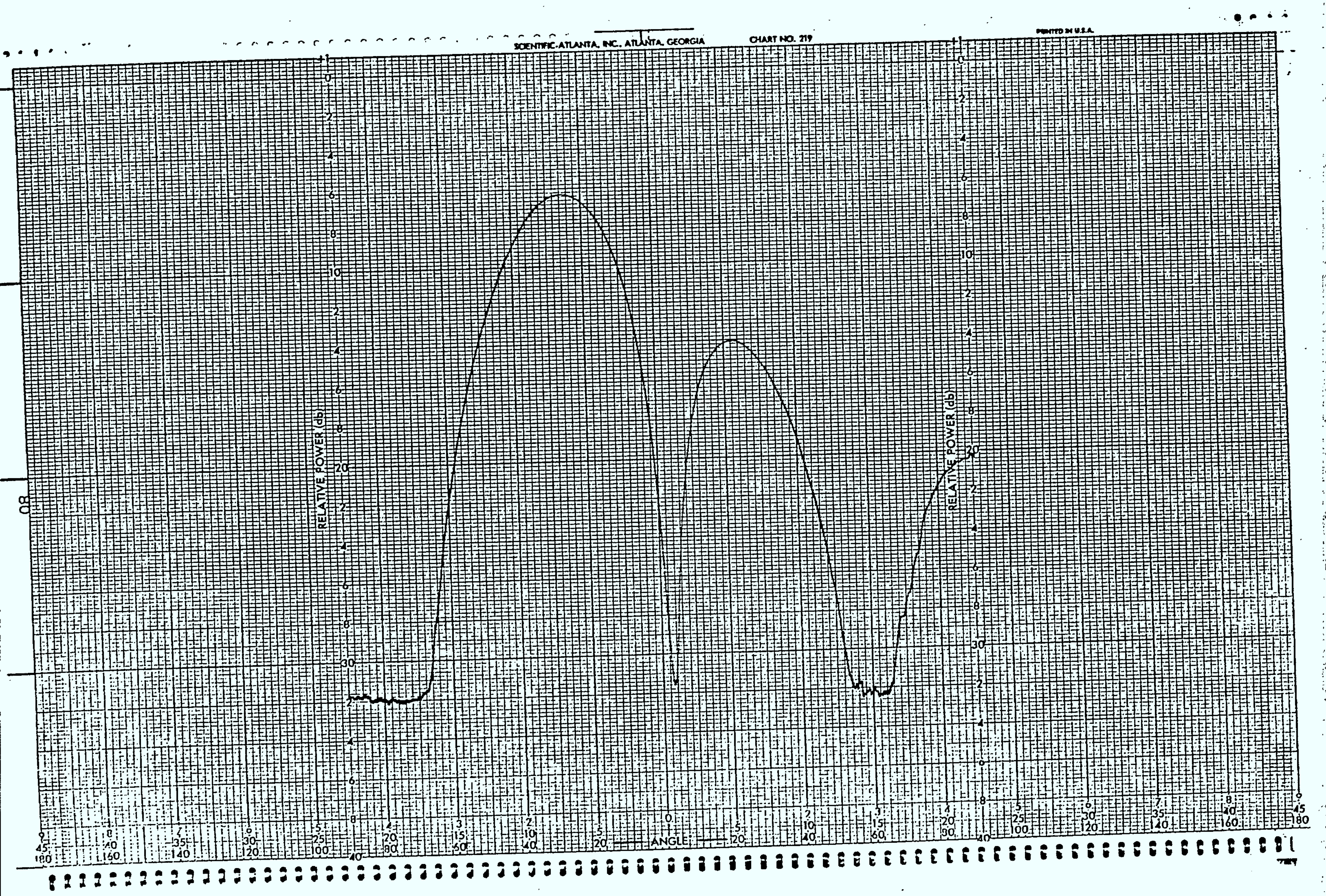

Figure 59. Elevation pattern of 2L beam, 823 MHz, Horizontal Polarization.

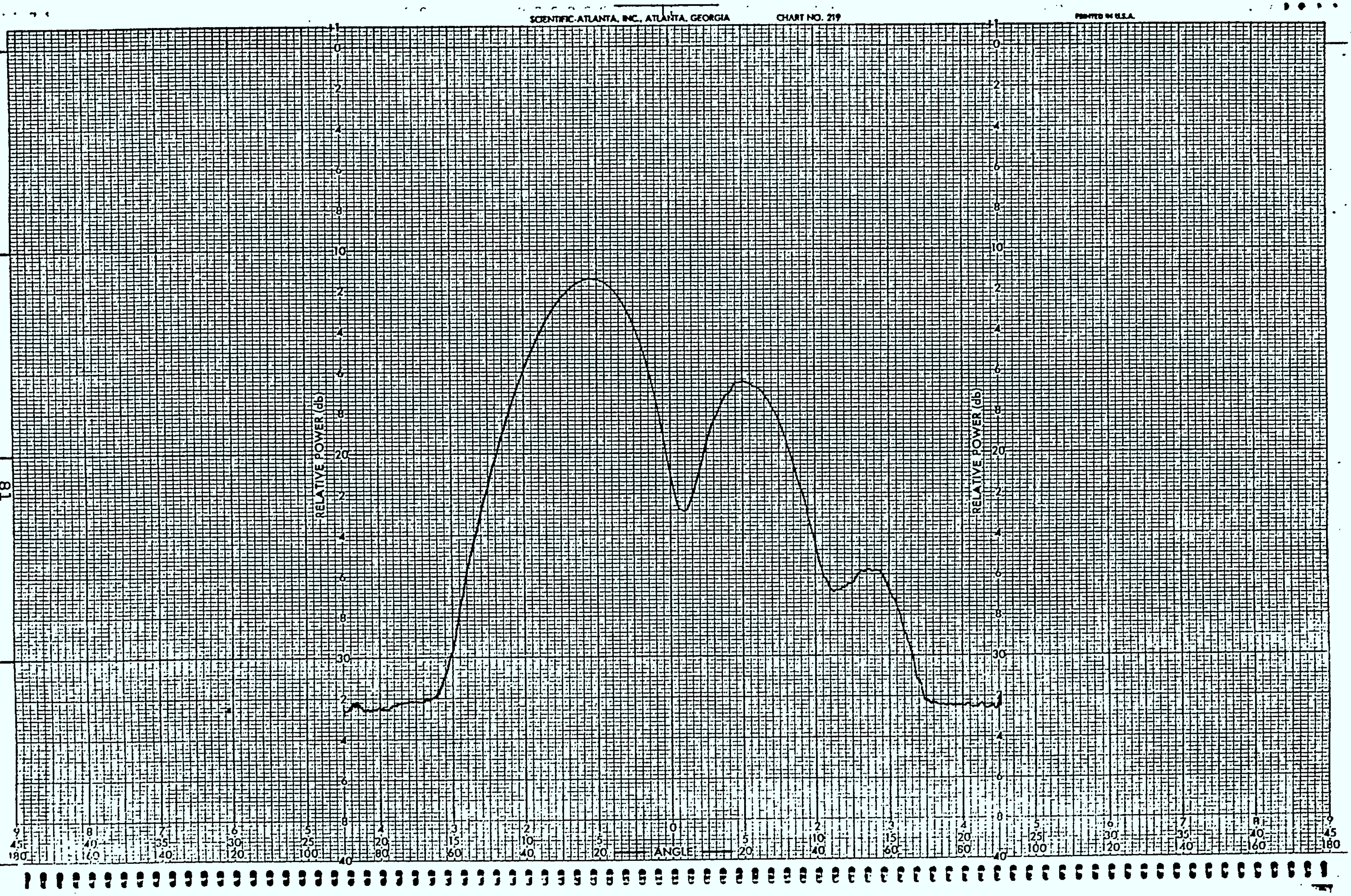

Figure 60. Elevation pattern of 2L beam, 823 MHz, Vertical Polarization.

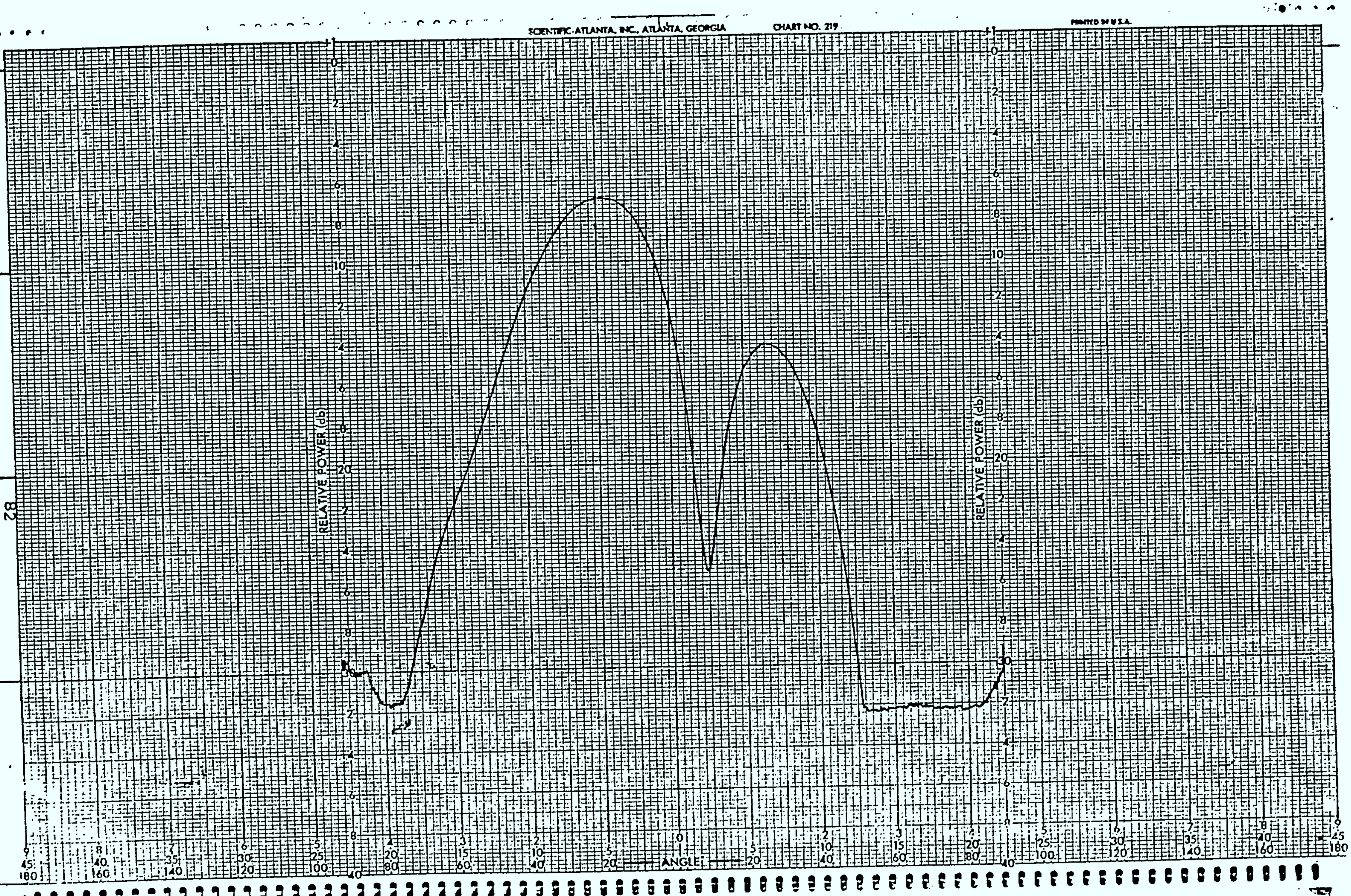

Figure 61. Elevation pattern of 1L beam, 823 MHz, Horizontal Polarization.

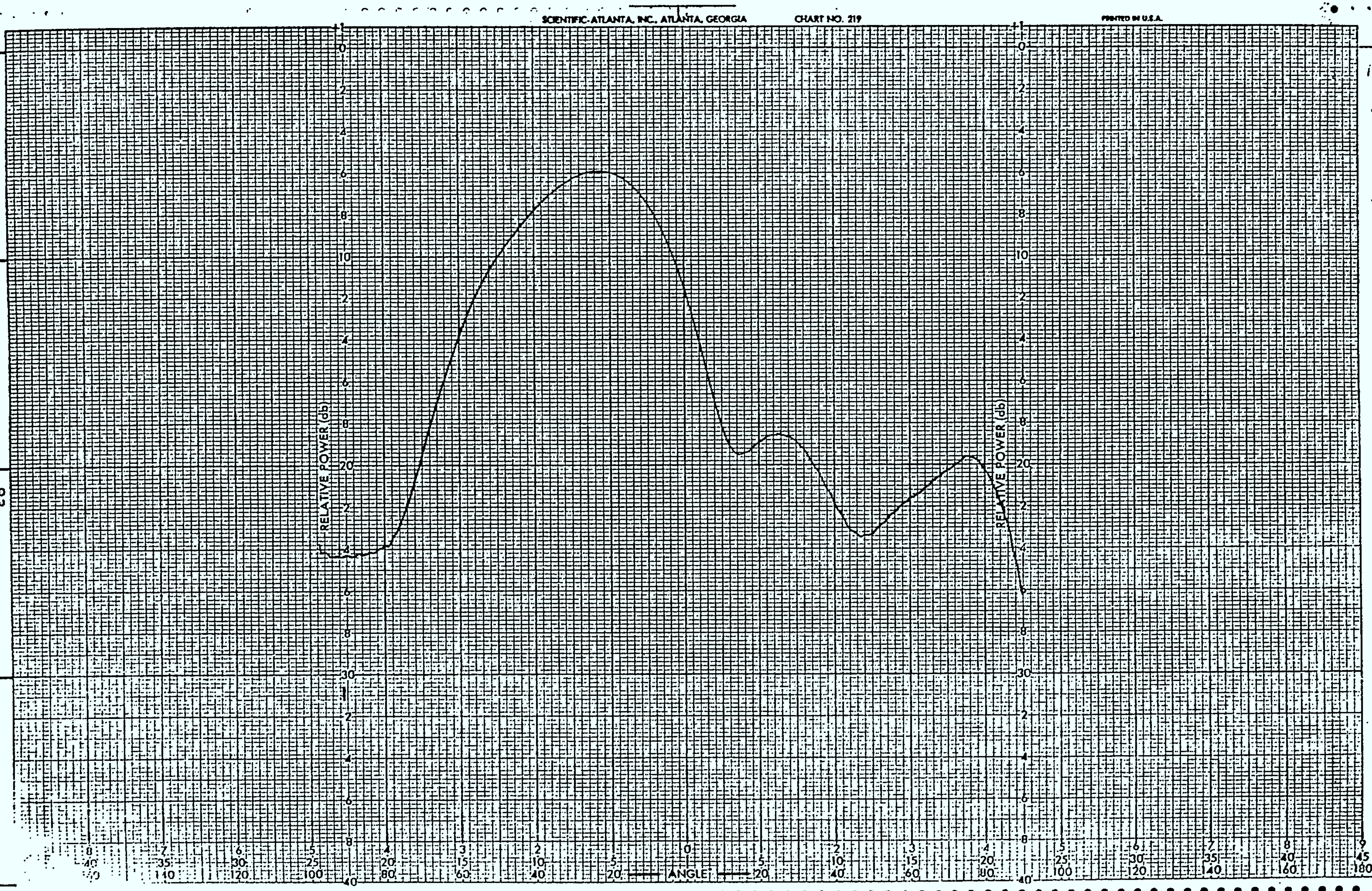

Figure 62. Elevation pattern of 1L beam, 823 MHz, Vertical Polarization.

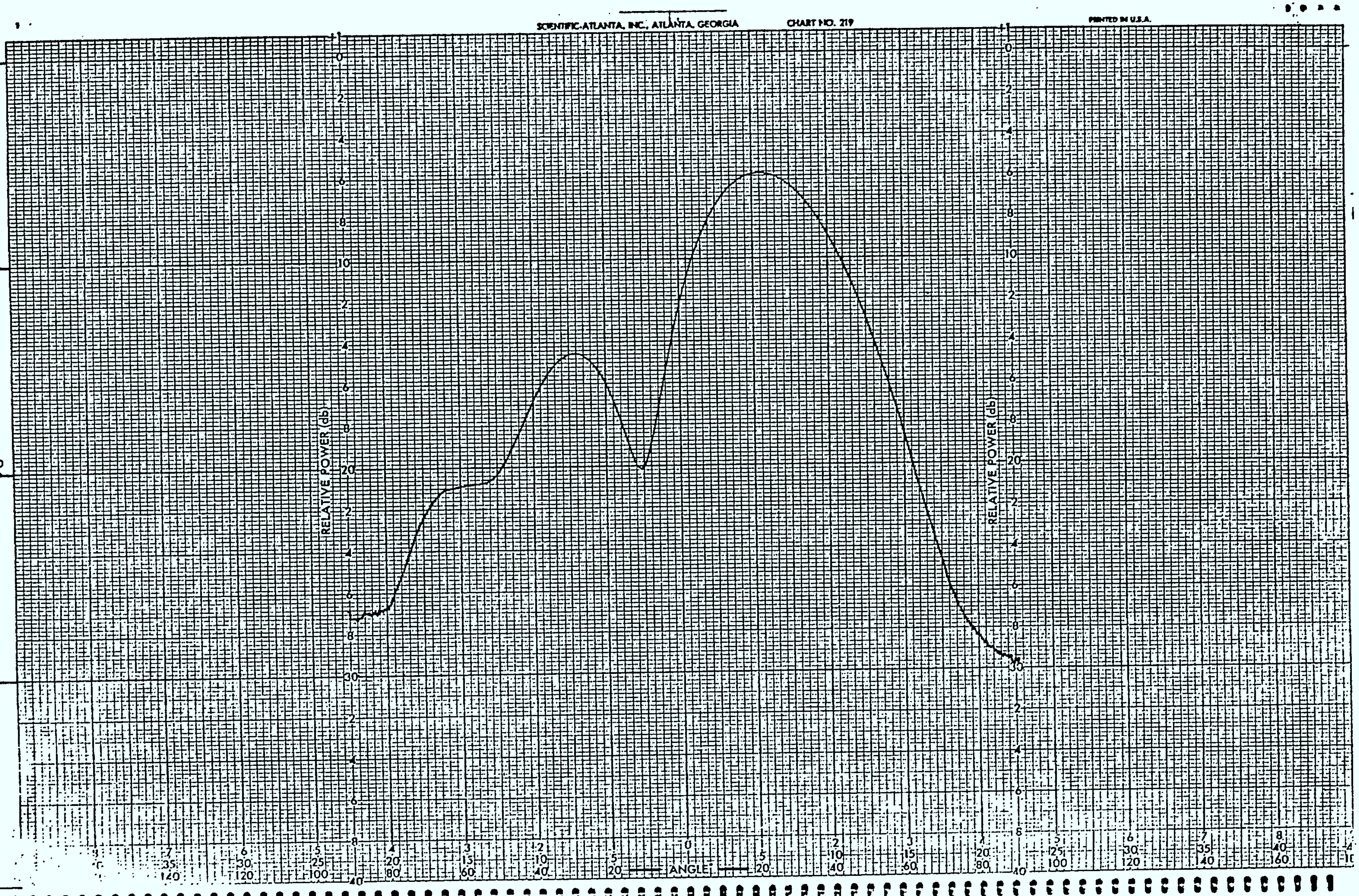

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Figure 63. Elevation pattern of 1R beam, 823 MHz, Horizontal Polarization.

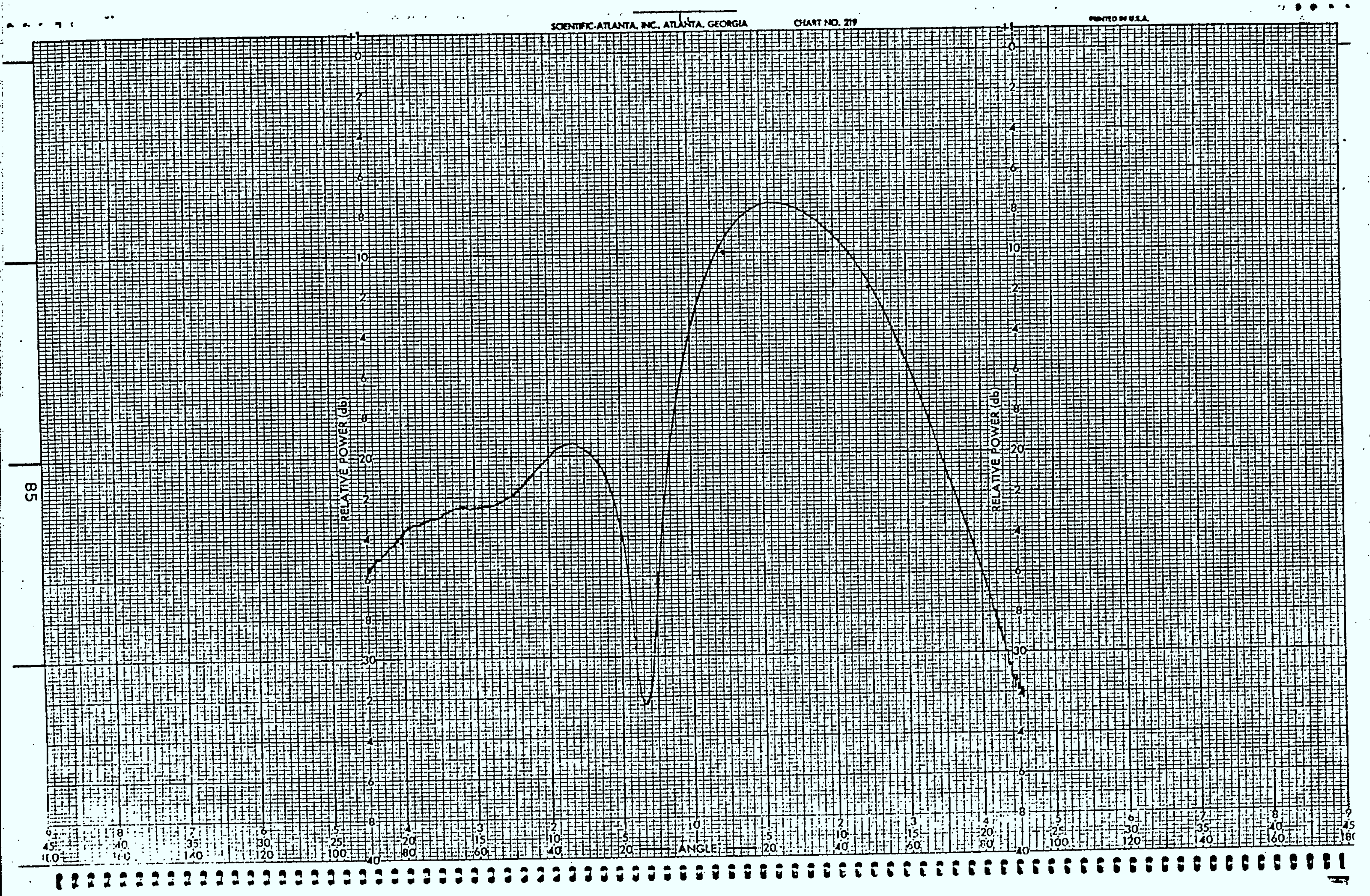


Figure 64. Elevation pattern of 1R beam, 823 MHz, Vertical Polarization.

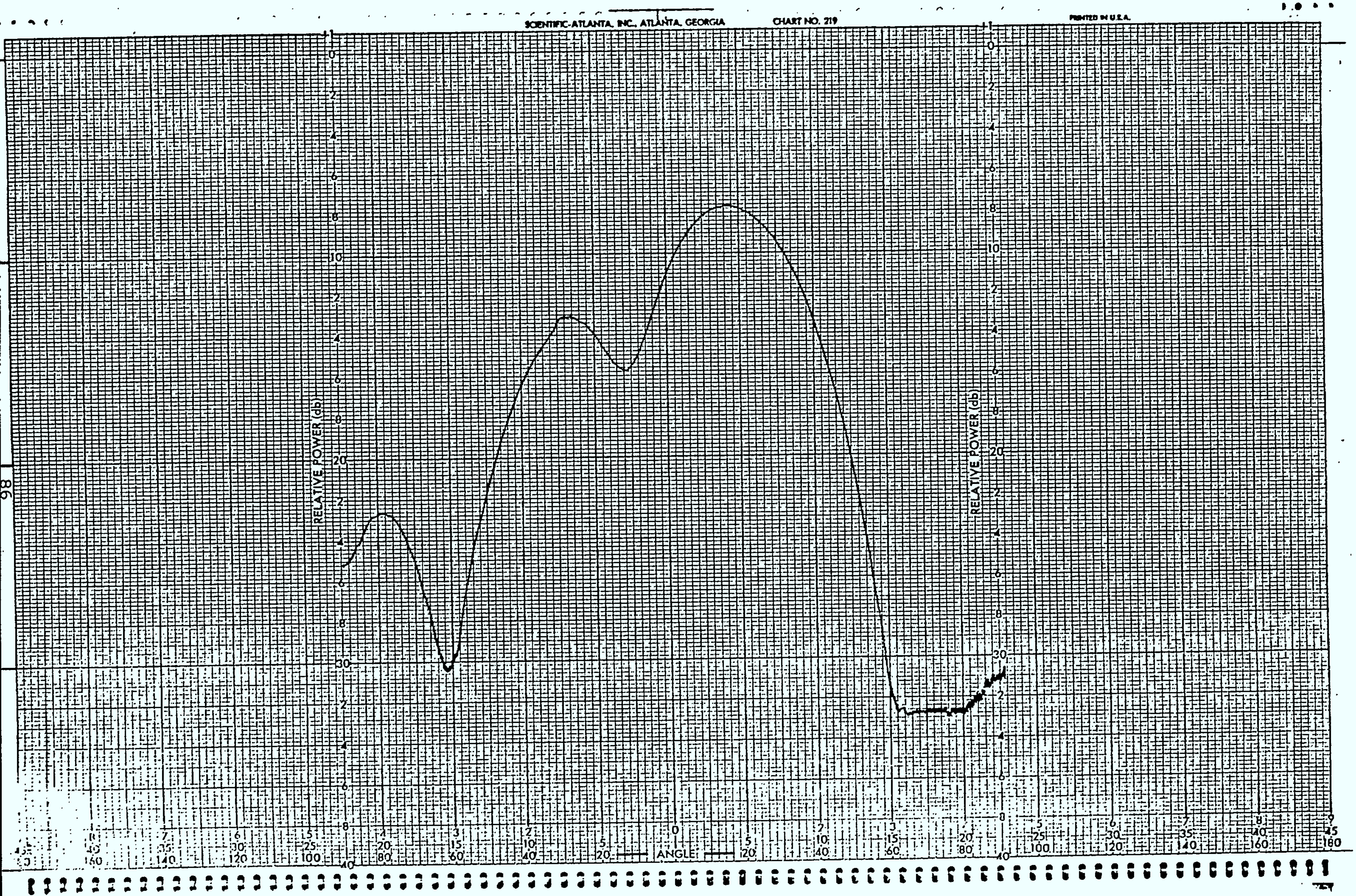


Figure 65. Elevation pattern of 2R beam, 823 MHz, Horizontal Polarization.

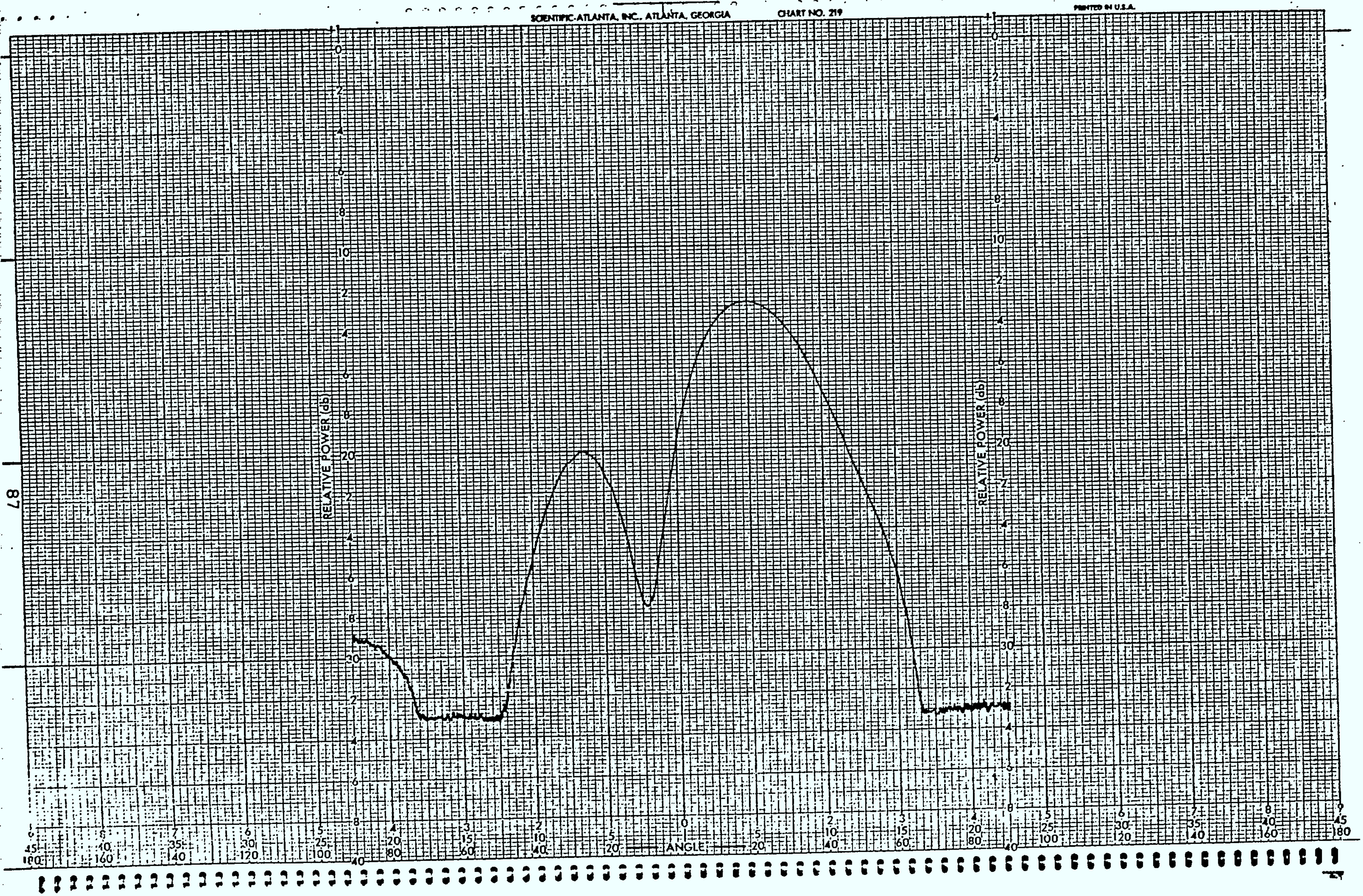


Figure 66. Elevation pattern of 2R beam, 823 MHz, Vertical Polarization.

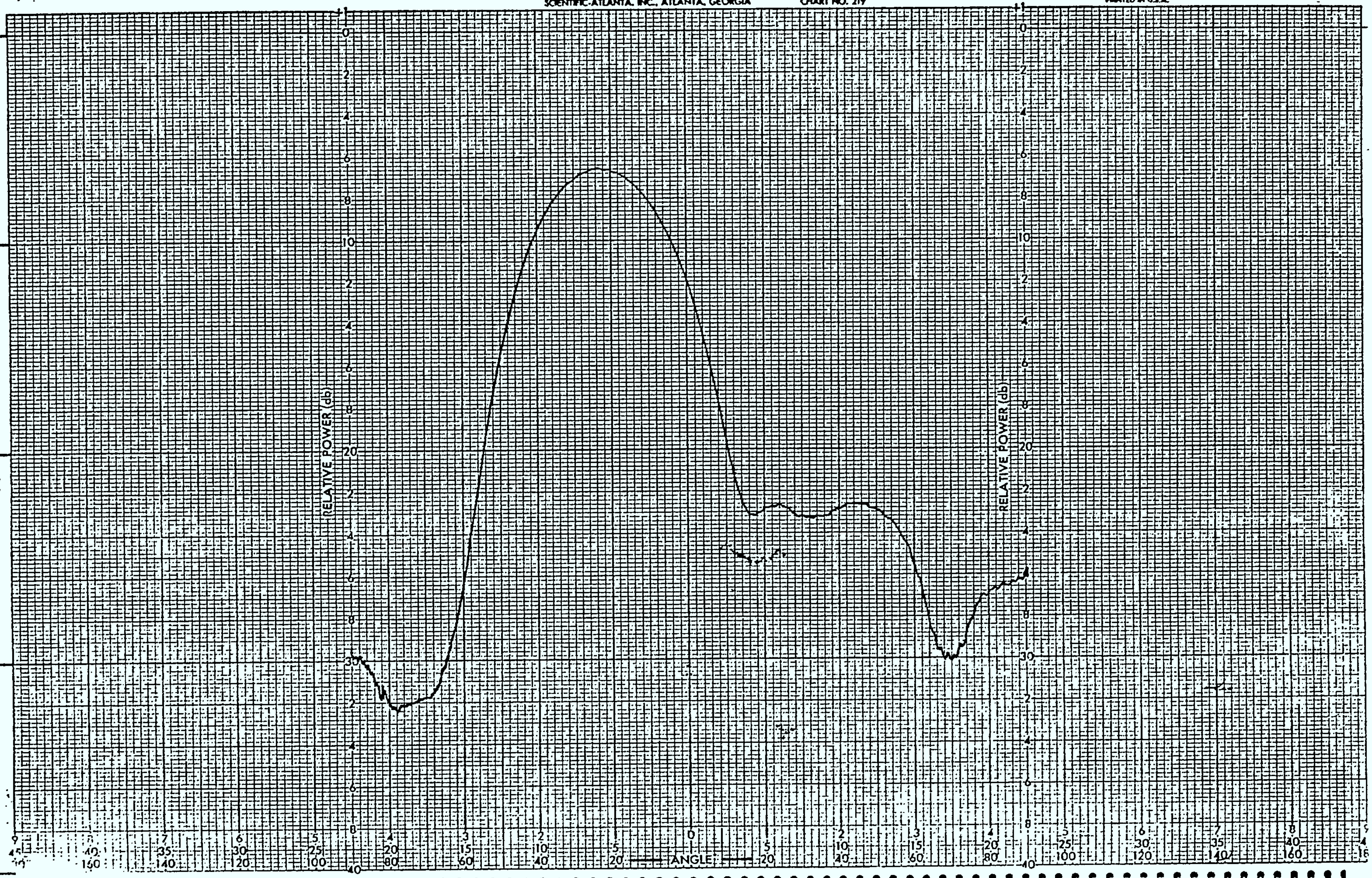
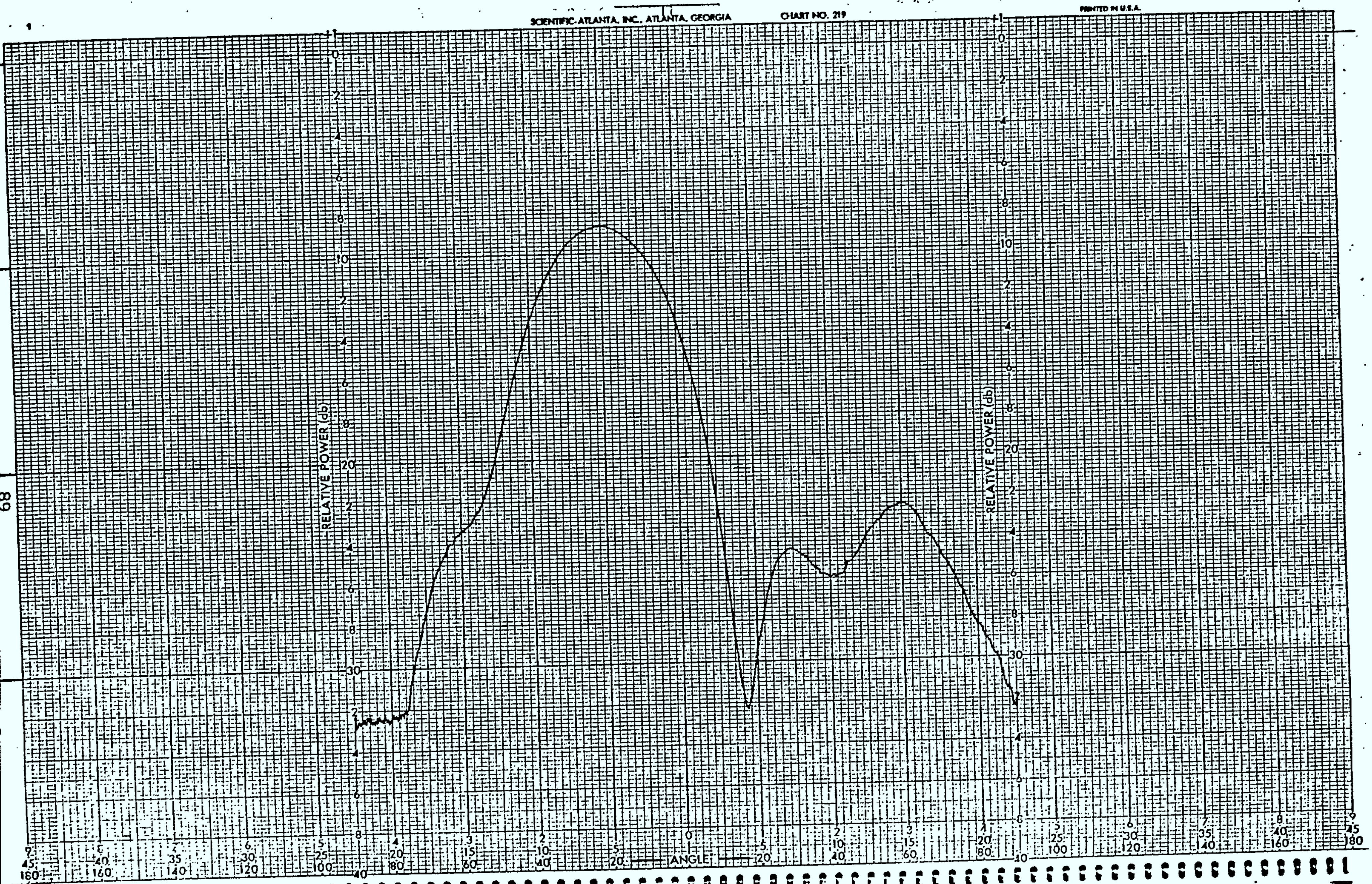


Figure 67. Elevation pattern of 2L beam, 868 MHz, Horizontal Polarization.



68. Elevation pattern of 2L beam, 868 MHz, Vertical Polarization.

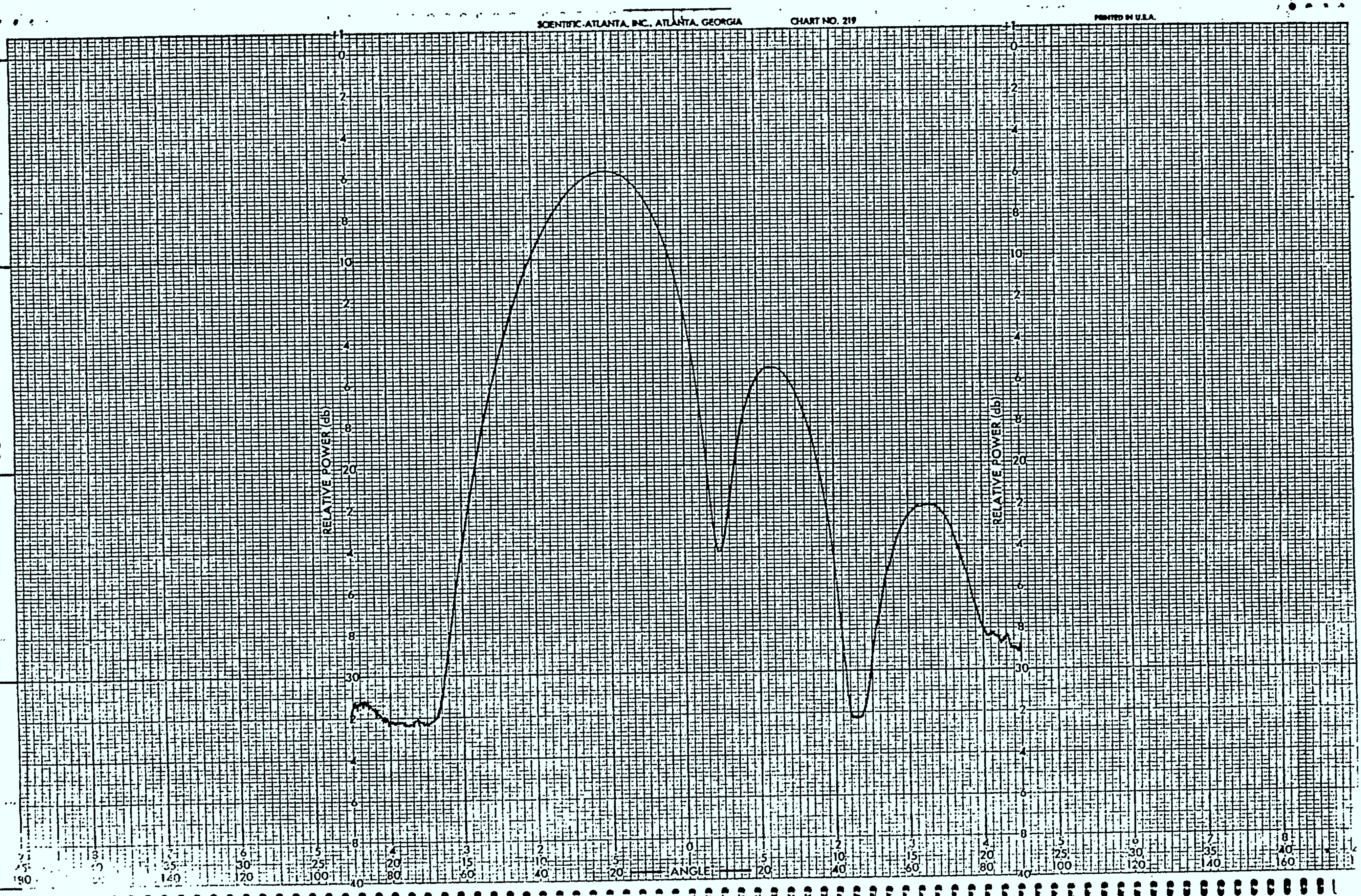


Figure 69. Elevation pattern of 1L beam, 868 MHz, Horizontal Polarization.

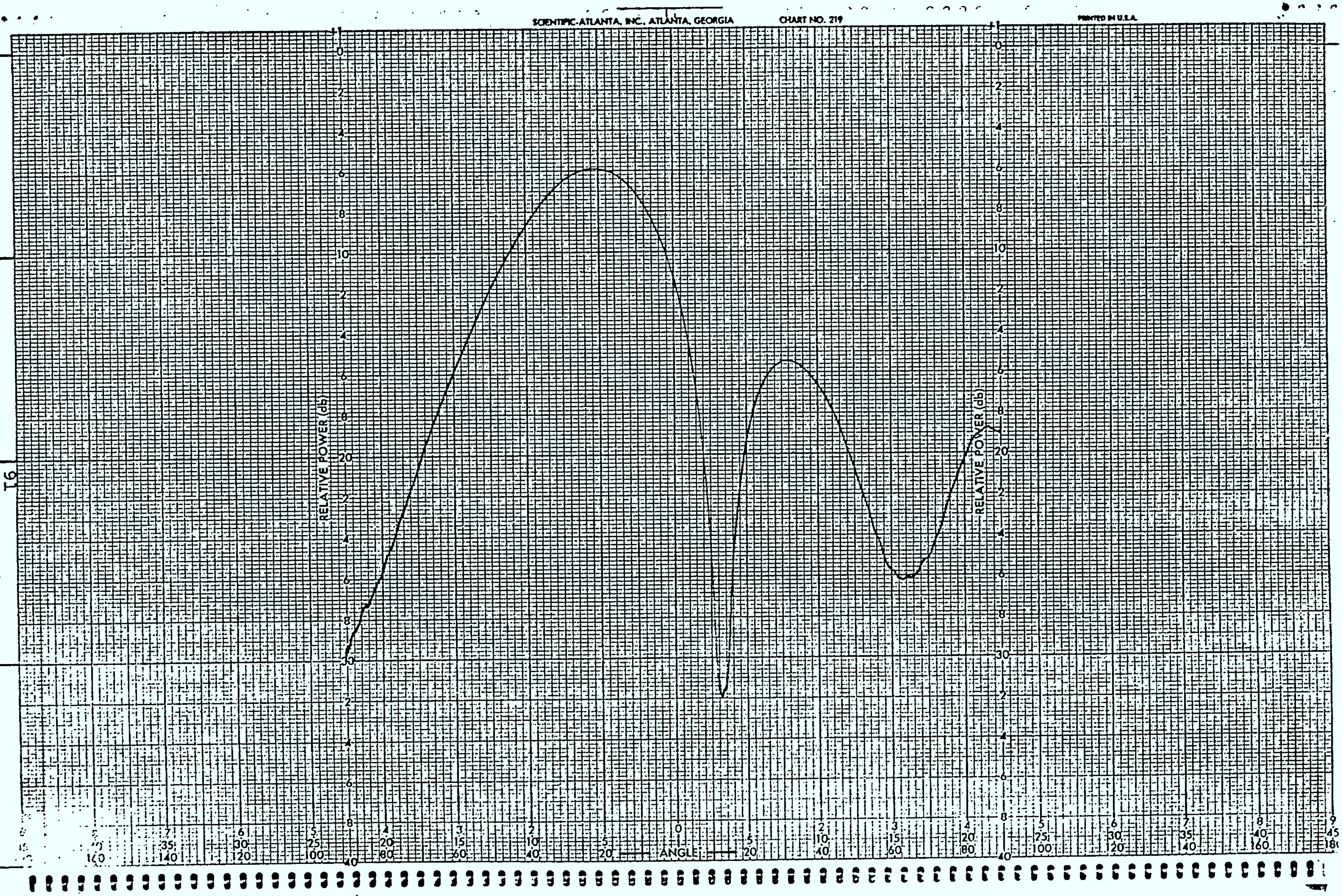


Figure 70. Elevation pattern of 1L beam, 868 MHz, Vertical Polarization.

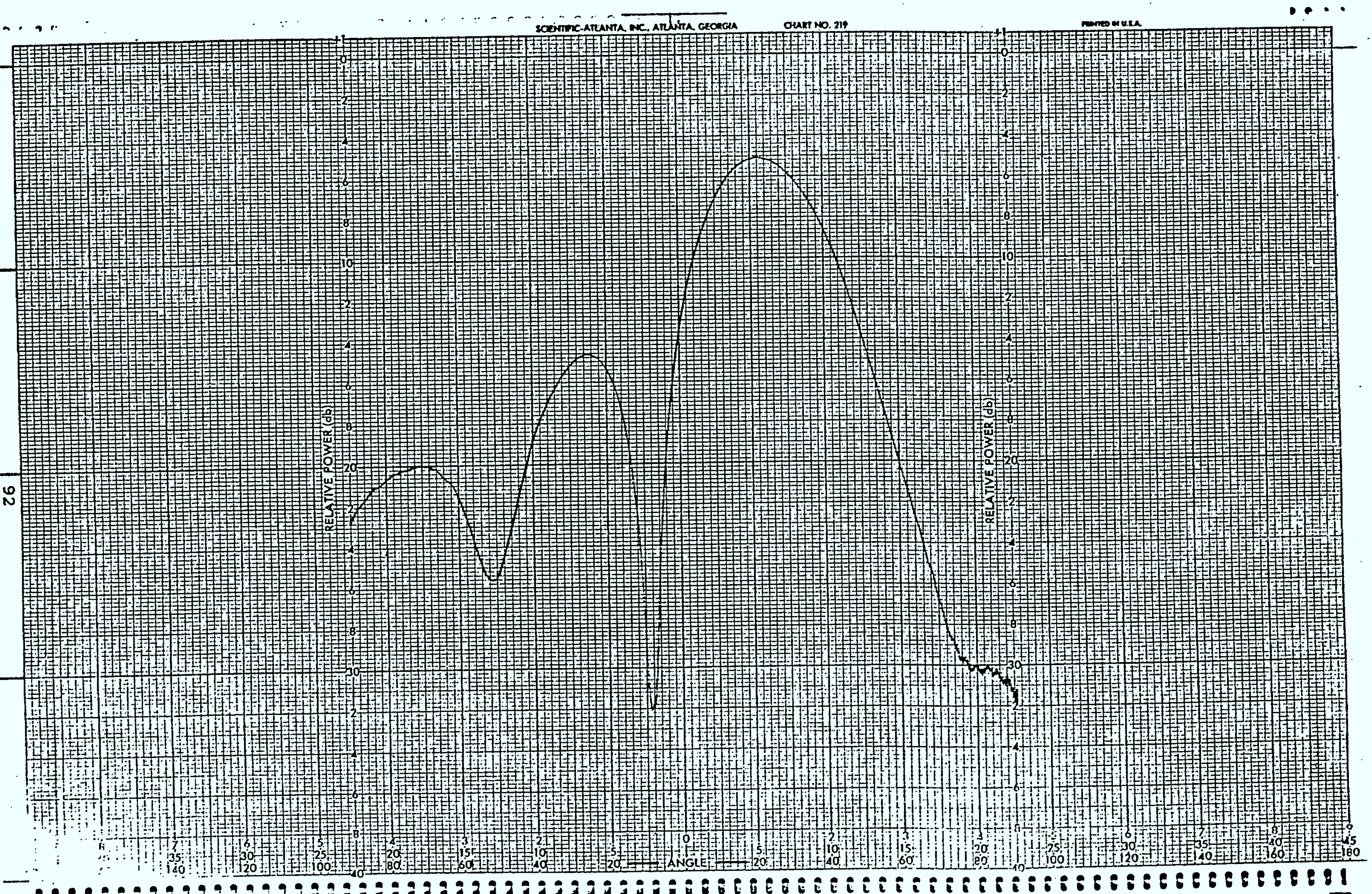


Figure 71. Elevation pattern of 1R beam, 868 MHz, Horizontal Polarization.

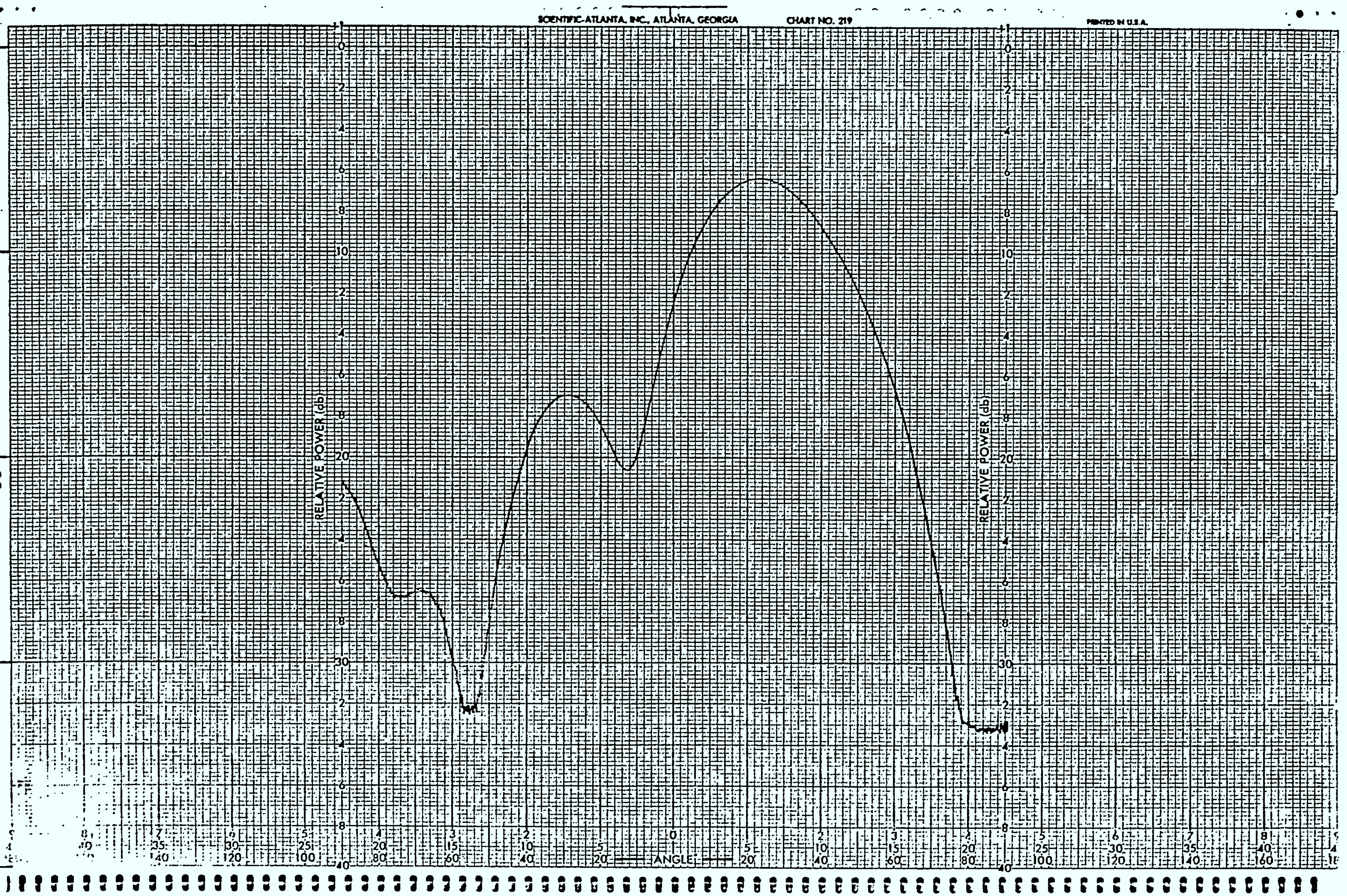


Figure 72. Elevation pattern of 1R beam, 868 MHz, Vertical Polarization.

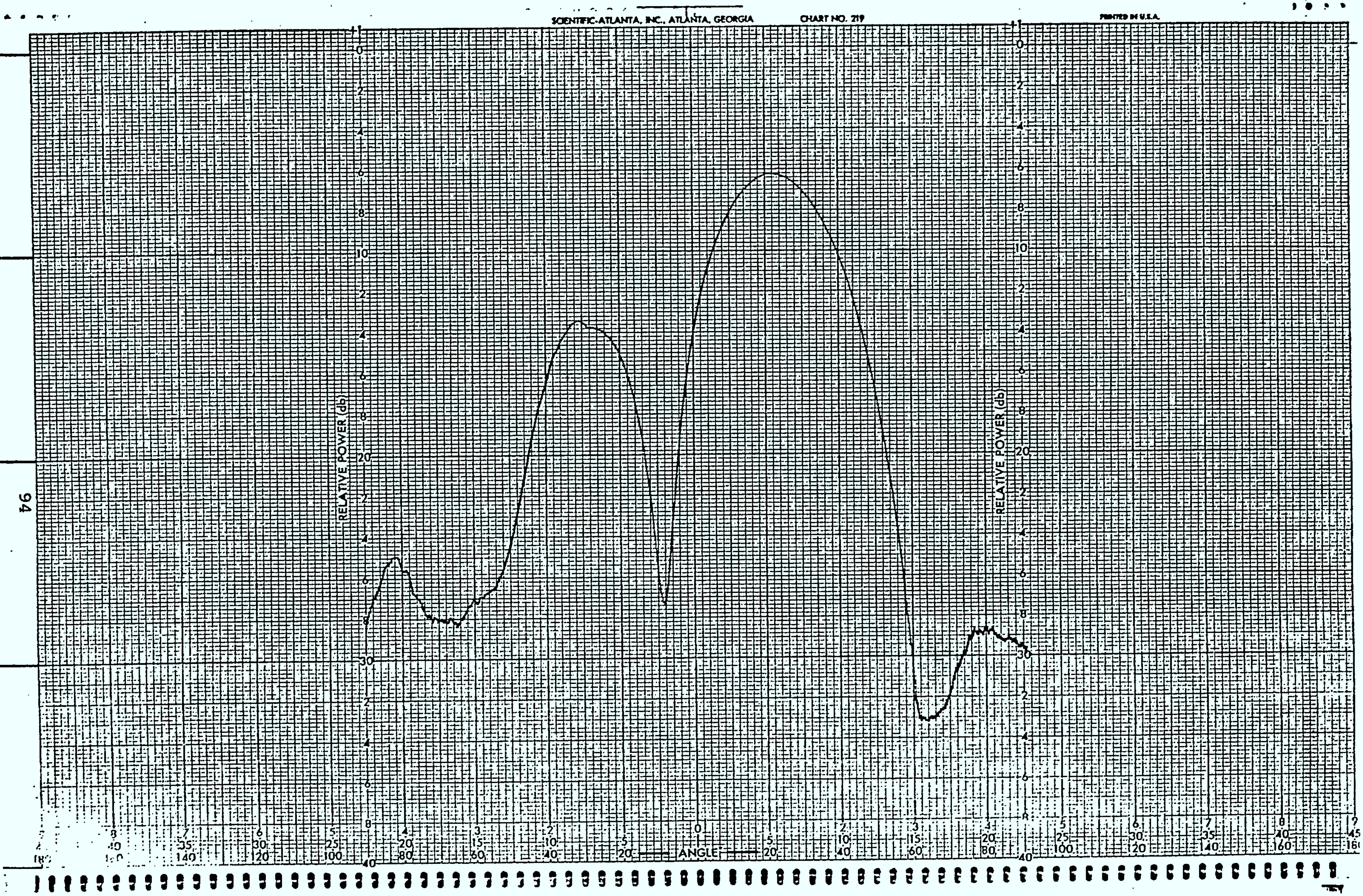


Figure 73. Elevation pattern of 2R beam, 868 HMz, Horizontal Polarization.

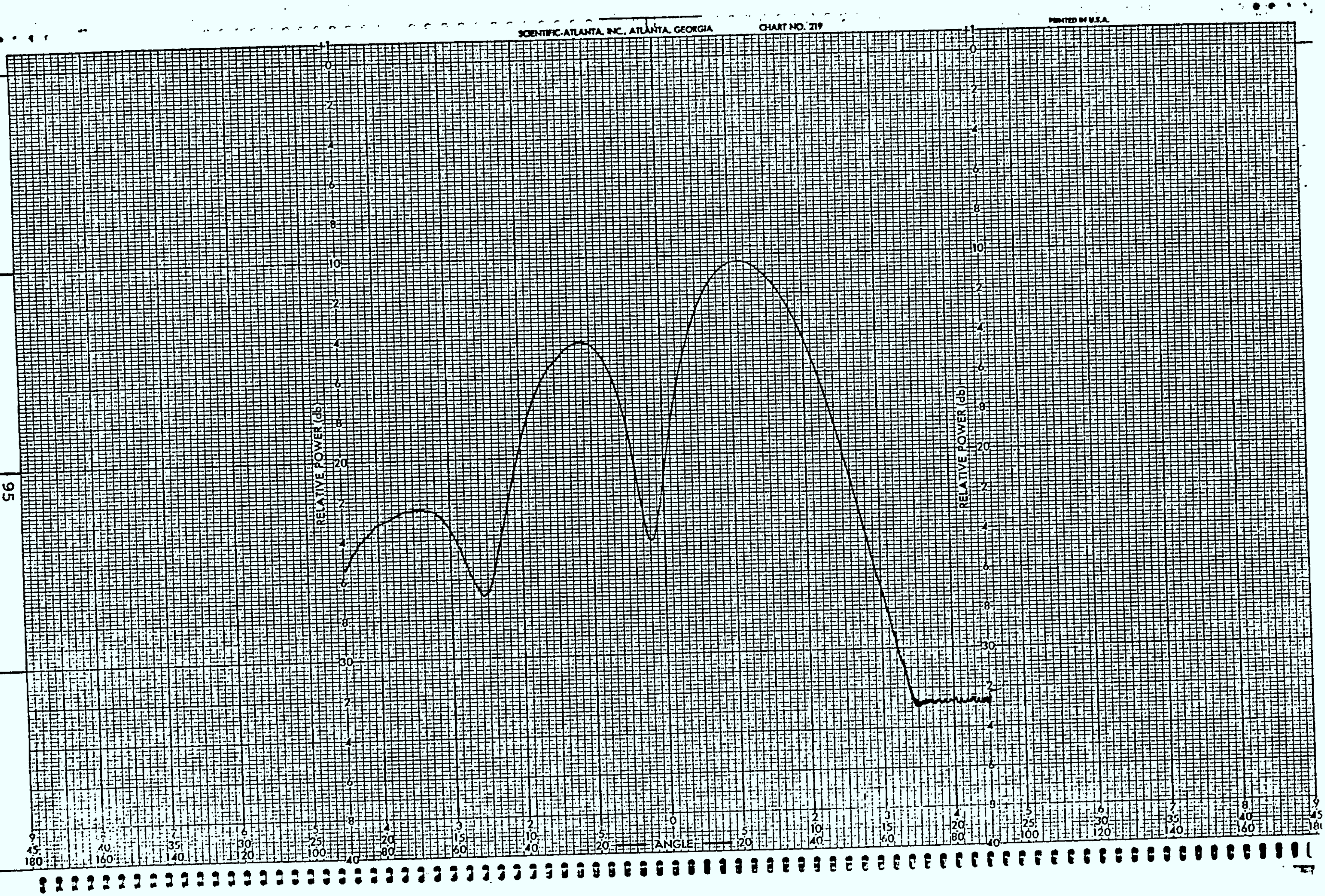


Figure 74. Elevation pattern of 2R beam, 868 MHz, Vertical Polarization.

APPENDIX A

BEAM SELECTION CONTROLLER

CONTENTS

BEAM SELECTION CONTROLLER

1. INTRODUCTION

The function of the Beam Selection Controller is to select from fifteen possible channels the one with the highest signal level. The choice is made by measuring the magnitude of a d.c. signal from the microwave receiver, the level of which is proportional to the received r.f. energy. The Controller selects each r.f. beam by setting the positions of two six way and ten SPDT miniature broadband coaxial switches.

2. CIRCUIT DESCRIPTION

The circuit schematic of the Beam Selection Controller is shown in Figure 1 with a Parts List in Table 1.

A single chip microcomputer, U11, with integral analog to digital converter, performs the following functions

1) Selection of the r.f. channel.
2) Quantisation of the input d.c. signal (indicating r.f. signal level).
3) Alarm indication. Activated on failure to acquire an adequate r.f. signal on any channel.
4) Automatic or Manual control.

Also shown in the schematic are interface drivers, U1 through U10, between the microcomputer and the actuating solenoids of the r.f. switches. The drivers are required to translate the 5v. level signals from the microcomputer to the 12v. levels required to operate the solenoids. Each output driver is equipped with a LED for ease of identification of the currently selected switches. The output drivers are capable of sinking up to 1.5A. and are protected with diodes to clamp induced reverse EMF from the solenoids and with 1000pF capacitors, C1 through C22, to limit the rate of rise of switching transients to prevent second breakdown of the output transistors.

Figure 2 shows the physical layout of the components on the circuit board while Figure 3 shows the connections to the r.f. switches which are shown in the unenergised position. The connection scheme is such that for any channel selected only two switch solenoids have to be energised and in addition each of the output driver chips, U1 through U6, carries only a single switch load at any time. Table 2 defines the assignment of the microcomputer ports to the r.f. switches.

Table 3 shows which r.f. switches are energised for each of the possible 15 beams.

3. OPERATION

Figure 4 shows an overall flow chart ot the operation of the Beam Selection Controller which, as shown, can operate in basically two modes: Manual and Automatic.

3.1 Automatic Mode.

The Automatic Mode is comprised of two major routines:

A) The Search Routine.
This routine controls the sequential switching of all 15 channels to determine which channel has the highest r.f. level. The Search routine also generates the Yellow Alarm signal whenever a search of all channels produces no signals above the threshold. Should a subsequent pre-determined number of searches (20 at present) continue to find no signals over the threshold the routine will activate the Red Alarm and reduce the search rate to once every two minutes. (This reduction in search rate is designed to prolong the life of the mechanical r.f. switches).
In normal operation the search routine will determine the channel with the highest r.f. level and thenhand control over to the Monitor Routine.

B) The Monitor Routine.
The input signal level of the optimum channel determine by the Search routine is continually monitored by this routine to ensure that it remains above the minimum threshold. Should the signal level fall below the threshold the Monitor routine verifies that adequate signal level is not available on adjacent channels befo returning control to the Search Routine.

Search Routine Operation.

A detailed flow chart of the Search Routine is shown in Figure 5. Four locations in memory are assigned as:

A) Flag store (used by the Monitor Routine)
B) Highest r.f. level channel address.
C) Magnitude of highest r.f. level.
D) Current channel address selected.

As is largely self-evident from the flow chart, the routin sequentially addresses each of the fifteen channels, testing each new input against a store of the highest level measured to that time. The highest channel store (address and level) is overwritten with the current channel address and level whenever the current level exceeds the stored level. When all fifteen channels have been measured the routine verifies that the highest level exceeds the minimum threshold and exits to the Monitor Routine. Failure to acquire a signal of adequate level causes the Yellow Alarm signal to be activated and a new search to be initiated. Should a subsequent secquence of searches continue to fail to find an acceptable signal the routine will activate the Red Alarm and drop the search rate to once every two minutes.

Monitor Routine Operation.

Figure 6 shows the flow chart for the Monitor Routine. The routine monitors the input signal level at 60mS intervals and verifies that the level is continuing above the threshold. Should the level drop below the threshold, and since at this stage the flag store is clear, the routine will initially decrement the channel address and set the decrement flag in the flag store. The signal level on this adjacent channel will then be compared with the threshold and, if satisfactory, the flag store will be cleared and the routine will revert to its monitoring role. If the signal level is still unsatisfactory however, the routine will check the flag store and seeing the decrement flag set will increment the channel address by two and set the increment flag.The signal level on this second adjacent channel will then be measured and compared with the threshold. As before, if the level is satisfactory the flag store is cleared and normal monitoring resumes. If the signal level is still unsatisfactory however, the routine on seeing the increment flag set in the flag store will return control to the Search Routine since neither the selected nor the immediately adjacent channels have adequate input signal levels.

At present the Monitor Routine has a maximum reaction time of approximately 60mS to loss of signal.

3.2 Manual Mode.

The flow chart for the Manual Mode is shown in Figure 7. The Manual Mode is entered when the Auto/Manual switch is in the Manual position. This causes an interrupt input to the microcomputer which will immediately suspend its current processing and begin to execute the Manual Routine. The routine causes the Manual Beam Selection Switches to be read and translated into drive signals to the appropriate r.f. switches. Having set up a specific beam the routine then causes the r.f. level to be measured and compared with the stored threshold level. Failure to equal or exceed the threshold will result in the activation of the Yellow Alarm

When the Auto/Manual switch is returned to the Auto position prior to relinquishing control to the Search routine the Manual routine will clear the Yellow Alarm(if set), reset the stack pointer and remove the interrupt mask. Note that since switching to the Manual Mode interrupts the microcomputer it may be used as a Reset switch by momentarily switching to the Manual mode and back to the Automatic.The microcomputer will clear all alarms and start a new search cycle.

3.3 Subroutines.

Two subroutines are used by all the control routines. These are the Delay Routine and the Output Routine.

Delay Routine.

The Delay Routine flow chart is shown in Figure 8. The routine translates the contents of RAM store locations 015 and 016 into a corresponding delay at the rate of 2.29mS per bit and 584mS per bit respectively. This allows delays to be created from 2.29mS to 149S.

Output Routine.

The Output Routine flow chart is shown in Figure 9. The routine translates the contents of RAM store location 013 (current channel address) and location 014 (Alarm status) into the necessary output patterns on the microcomputer ports A,B and C to drive the required r.f. switches and alarm signals. The appropriate output signals for each channel address are read by the routine from a look-up table in ROM locations 090 through 0BF. The Output routine also calls the Delay routine to insert a 60mS delay to allow switching transients to settle prior to returning control to the main program.

3.4 Power-up Routine

Figure 10 shows the flow chart for the Power-up Routine. This routine is only entered from a power-on reset and after clearing the Alarm store and enabling interrupts to the microcomputer hands over control to either the Search or Manual routines depending on the position of the Auto Manual switch.

4.1 RAM MAP

ADDRESS	DESCRIPTION
010	Flag Store. Bit 0 - Increment Flag. Bit 1 - Decrement Flag.
011	Highest r.f. level.
012	Highest r.f. level channel address.
013	Current channel selected.
014	Alarm status. Bit 0 - Yellow alarm. Bit 1 - Red alarm.
015	Delay Routine working store#1 (2.29mS per bit)
016	Delay Routine working store#2 (584mS per bit)
017	Search cycle count prior to Red Alarm.
018	Monitor Routine working store.

4.2 ROM MAP

ADDRESS	DATA	DESCRIPTION
080	7F	Threshold level for r.f. input.
081	1A	Switch delay, 60mS (26x2.29mS).
082	CD	Alarm delay, 2mins (205x0.584mS).
083	02	Test pause, 1S (2x0.584mS).
084	0E	Highest channel address minus one.
085	14	Number of searches prior to Red Alarm.
090	04	Port A Channel 1 output switch pattern
091	00	" 2 "
092	00	" 3 "
093	01	" 4 "
094	00	" 5 "
095	02	" 6 "
096	00	" 7 "
097	00	" 8 "
098	40	" 9 "
099	20	" 10 "
09A	80	" 11 "
09B	00	" 12 "
09C	00	" 13 "
09D	08	" 14 "
09E	10	" 15 "
09F	00	" Not assigned.
0A0	01	Port B Channel 1 output switch patter
0A1	40	" 2 "
0A2	20	" 3 "
0A3	00	" 4 "
0A4	80	" 5 "
0A5	00	" 6 "
0A6	10	" 7 "
0A7	08	" 8 "
0A8	00	" 9 "
0A9	00	" 10 "
0AA	00	" 11 "
0AB	04	" 12 "
0AC	02	" 13 "
0AD	00	" 14 "
0AE	00	" 15 "
0AF	00	" Not assigned.

ROM MAP (continued)

ADDRESS	DATA	DESCRIPTION
0B0	00	Port C Channel 1 output switch pattern.
0B1	04	" 2 "
0B2	04	" 3 "
0B3	80	" 4 "
0B4	80	" 5 "
0B5	40	" 6 "
0B6	04	" 7 "
0B7	04	" 8 "
0B8	20	" 9 "
0B9	20	" 10 "
0BA	10	" 11 "
0BB	04	" 12 "
0BC	04	" 13 "
0BD	08	" 14 "
0BE	08	" 15 "
0BF	00	" Not assigned.
F38	78	MOR Register.
FFA	03	INT Vector.
FFB	00	
FFE	04	Power Up Vector.
FFF	00	

4.3 DELAY ROUTINE

ADDRESS	INSTRUCTION		DESCRIPTION
0C0	TST 016	3D	Test 016 for zero.
0C1		16	
0C2	BEQ 06	27	Branch if 016 is zero.
0C3		06	
0C4	DEC 016	3A	Decrement 016.
0C5		16	
0C6	LDA FF	A6	Load A with FF.
0C7		FF	
0C8	STA 015	B7	Set 015 to FF.
0C9		15	
0CA	TST 015	3D	Test 015 for zero.
0CB		15	
0CC	BEQ 14	27	If zero exit since requested
0CD		0E	delay is zero.
0CE	LDX 015	BE	Load 015 to X.
0CF		15	
0D0	LDA FF	A6	Load A with FF.
0D1		FF	
0D2	DEC A	4A	Decrement A.
0D3	BNE -3	26	Branch when not zero.
0D4		FD	
0D5	DEC X	5A	Decrement X.
0D6	BNE -8	26	Branch when not zero.
0D7		F8	
0D8	TST 016	3D	Test 016 for zero.
0D9		16	
0DA	BNE -24	26	Branch when not zero.
0DB		E8	
0DC	RTS	81	Subroutine return.

4.4 OUTPUT ROUTINE

ADDRESS	INSTRUCTION		DESCRIPTION
0DF	LDX 013	BE	Load Current Channel address.
0E0		13	
0E1	LDA 090	E6	Load 90+X into A.
0E2		90	
0E3	STA 000	B7	Output to port A.
0E4		00	
0E5	LDA 0A0	E6	Load 0A0+X into A.
0E6		A0	
0E7	STA 001	B7	Output to port B.
0E8		01	
0E9	LDA 0B0	E6	Load 0B0+X into A.
0EA		B0	
0EB	ORA 014	BA	OR with Alarm status.
0EC		14	
0ED	STA 002	B7	Output to port C.
0EE		02	
0EF	LDA FF	A6	Set A to FF.
0F0		FF	
0F1	STA 004	B7	Set port A to Output.
0F2		04	
0F3	STA 005	B7	Set port B to Output.
0F4		05	
0F5	STA 006	B7	Set port C to Output.
0F6		06	
0F7	CLR 016	3F	Clear Delay store #2.
0F8		16	
0F9	LDA 081	B6	Load switch delay.
0FA		81	
0FB	STA 015	B7	Store Delay #1.
0FC		15	
0FD	JSR 0C0	BD	60mS switch delay.
0FE		C0	
0FF	RTS	81	Subroutine return.

4.5 SEARCH ROUTINE

ADDRESS	INSTRUCTION		DESCRIPTION
100	LDA 00	A6	Clear A
101		00	
102	STA 010	B7	Clear Flags.
103		10	
104	STA 011	B7	Clear highest r.f. level.
105		11	
106	STA 012	B7	Clear highest channel address.
107		12	
108	STA 013	B7	Set current channel to 1st(0).
109		13	
10A	JSR 0DF	BD	Call output routine.
10B		DF	
10C	CLR 00E	3F	Start A.D. conversion.
10D		0E	
10E	TST 00E	3D	Test for completion of A.D.
10F		0E	
110	BPL -4	2A	Branch if Bit 7 not set.
111		FC	
112	LDA 00F	B6	Load A.D. result into A.
113		0F	
114	CMP 011	B1	Compare A with highest r.f. level.
115		11	
116	BLS 06	23	Branch if A is smaller than M.
117		06	
118	STA 011	B7	Store highest r.f. level.
119		11	
11A	LDA 013	B6	Load current channel.
11B		13	
11C	STA 012	B7	Store highest level channel address.
11D		12	
11E	BRCLR7	0F	Test for Test Mode.
11F		03	
120		06	
121	LDA 083	B6	Load Test pause.
122		83	
123	STA 016	B7	Store for Delay Routine.
124		16	
125	JSR 0C0	BD	Call Delay Routine.
126		C0	
127	INC 013	3C	Set up next channel address.
128		13	
129	LDA 013	B6	Load next channel address.
12A		13	
12B	CMP 084	B1	Test for highest channel address.
12C		84	
12D	BLS -37	23	Re peat until all channels scanned.
12E		DB	
12F	LDA 011	B6	Load highest r.f. level.
130		11	
131	CMP 080	B1	Compare with threshold.
132		80	
133	BHS 32	24	Branch if above threshold.
134		20	

ADDRESS	INSTRUCTION		DESCRIPTION
135	BRCLR1	03	Test for RED ALARM.
136		14	
137		09	
138	LDA 082	B6	RED ALARM pause.
139		82	
13A	STA 016	B7	Alarm pause input to Delay
13B		16	Routine.
13C	JSR 0C0	BD	Call Delay Routine.
13D		C0	
13E	JMP 100	CC	Return to beginning of
13F		01	Search Routine.
140		00	
141	BRSET0	00	Test for YELLOW ALARM.
142		14	
143		06	
144	LDA 085	B6	Load maximum number of
145		85	searches prior to RED ALARM.
146	STA 017	B7	Store in Search Counter.
147		17	
148	BSET0	10	Set YELLOW ALARM on.
149		14	
14A	DEC 017	3A	Decrement Search Counter.
14B		17	
14C	BNE 04	26	Branch if Search Counter
14D		04	is not zero.
14E	BCLR0	11	Clear YELLOW ALARM.
14F		14	
150	BSET1	12	Set RED ALARM.
151		14	
152	JMP 100	CC	Return to beginning of
153		01	Search Routine.
154		00	
155	CLR 014	3F	Cancel Alarms.
156		14	
157	LDA 012	B6	Load highest level channel
158		12	address.
159	STA 013	B7	Store in current channel
15A		13	address.
15B	JMP 200	CC	Enter MONITOR ROUTINE.
15C		02	
15D		00	

4.6 MONITOR ROUTINE

ADDRESS	INSTRUCTION		DESCRIPTION
200	JSR 0DF	BD	Call OUTPUT ROUTINE.
201		DF	
202	CLR 00E	3F	Start A.D. conversion.
203		0E	
204	TST 00E	3D	Test for completion of A.D.
205		0E	
206	BPL -4	2A	Branch if Bit 7 not set.
207		FC	
208	LDA 00F	B6	Load A.D. result.
209		0F	
20A	CMP 080	B1	Compare with threshold.
20B		80	
20C	BLO 4	25	Branch if level below
20D		04	threshold.
20E	CLR 010	3F	Clear Flag Store.
20F		10	
210	BRA -18	20	Return to beginning of
211		EE	Monitor Routine.
212	BRCLR7	0F	Check for Test pause.
213		03	
214		06	
215	LDA 083	B6	Load Test pause.
216		83	
217	STA 016	B7	Store for Delay Routine.
218		16	
219	JSR 0C0	BD	Call Delay Routine.
21A		C0	
21B	BRSET0	00	Check for Increment Flag.
21C		10	
21D		25	
21E	BRSET1	02	Check for Decrement Flag.
21F		10	
220		10	
221	BSET1	12	Set Decrement Flag.
222		10	
223	LDA 013	B6	Load current address.
224		13	
225	STA 018	B7	Store current address.
226		18	
227	DEC 013	3A	Decrement current address.
228		13	
229	BPL -43	2A	Branch if positive to
22A		D5	beginning of Monitor Routine.
22B	LDA 084	B6	Load highest channel address.
22C		84	
22D	STA 013	B7	Store in Current address.
22E		13	
22F	BRA -49	20	Return to beginning of
230		CF	Monitor Routine.
231	BSET0	10	Set Increment Flag.
232		10	
233	LDA 018	B6	Restore current address.
234		18	

ADDRESS	INSTRUCTION		DESCRIPTION
235	STA 013	B7	Load restored address.
236		13	
237	INC 013	3C	Increment current address.
238		13	
239	LDA 084	B6	Load highest channel address.
23A		84	
23B	COMP 013	B1	Compare highest channel addres
23C		13	with current address.
23D	BHS -63	24	Branch if highest address is
23E		C1	greater than current.
23F	CLR 013	3F	Set current address to 0.
240		13	
241	BRA -67	20	Branch to beginning of
242		BD	MONITOR ROUTINE.
243	JMP 100	CC	Return to SEARCH ROUTINE.
244		01	
245		00	

4.7 MANUAL ROUTINE

ADDRESS	INSTRUCTION		DESCRIPTION
300	CLR 014	3F	Clear Alarms.
301		14	
302	LDA 0E	A6	Load Mask 00001110.
303		0E	
304	AND 03	B4	Extract D1,D2,D3.
305		03	
306	LSR	44	Shift right.
307	STA 013	B7	Store in current channel
308		13	address.
309	BRCLR6	0D	Test D6
30A		03	
30B		02	
30C	BSET3	16	Set Bit 3 in current channel
30D		13	address.
30E	JSR 0DF	BD	Call output routine.
30F		DF	
310	CLR 00E	3F	Start A.D. conversion.
311		0E	
312	TST 00E	3D	Test for completion of A.D.
313		0E	
314	BPL -4	2A	Branch if Bit 7 not set.
315		FC	
316	LDA 00F	B6	Load A.D. result into A.
317		0F	
318	CMP 080	B1	Compare with threshold.
319		80	
31A	BLO 4	25	Branch if level less than
31B		04	threshold.
31C	CLR 014	3F	Clear Alarm.
31D		14	
31E	BRA	20	Go to exit test.
31F		04	
320	LDA 01	A6	Load A with 01.
321		01	
322	STA 014	B7	Set YELLOW ALARM.
323		14	
324	BIL -36	2E	Check Interrupt Line.
325		DC	
326	RSP	9C	Reset Stack Pointer.
327	CLI	9A	Clear Interrupt Mask.
328	CLR	3F	Clear alarms.
329		14	
32A	JMP	CC	Jump to Search Routine.
32B		01	(Automatic Mode selected)
32C		00	

4.8 POWER-UP ROUTINE

ADDRESS	INSTRUCTION		DESCRIPTION
400	CLR 014	3F	Clear Alarms.
401		14	
402	CLI	9A	Clear Interrupt Mask.
403	BIL 3	2E	Test for Manual Mode.
404		03	
405	JMP 100	CC	Jump to SEARCH ROUTINE.
406		01	
407		00	
408	JMP 300	CC	Jump to MANUAL ROUTINE.
409		03	
40A		00	

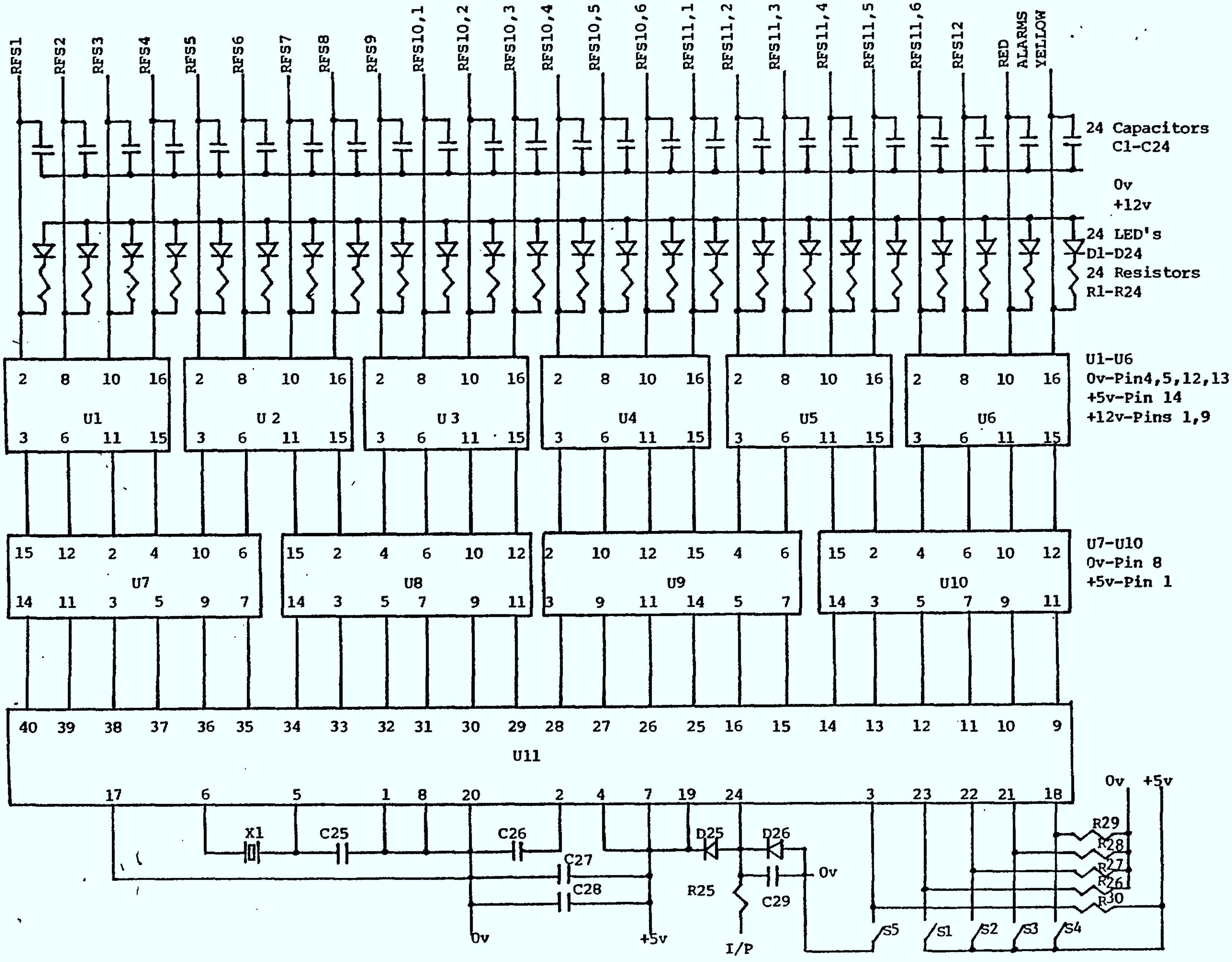
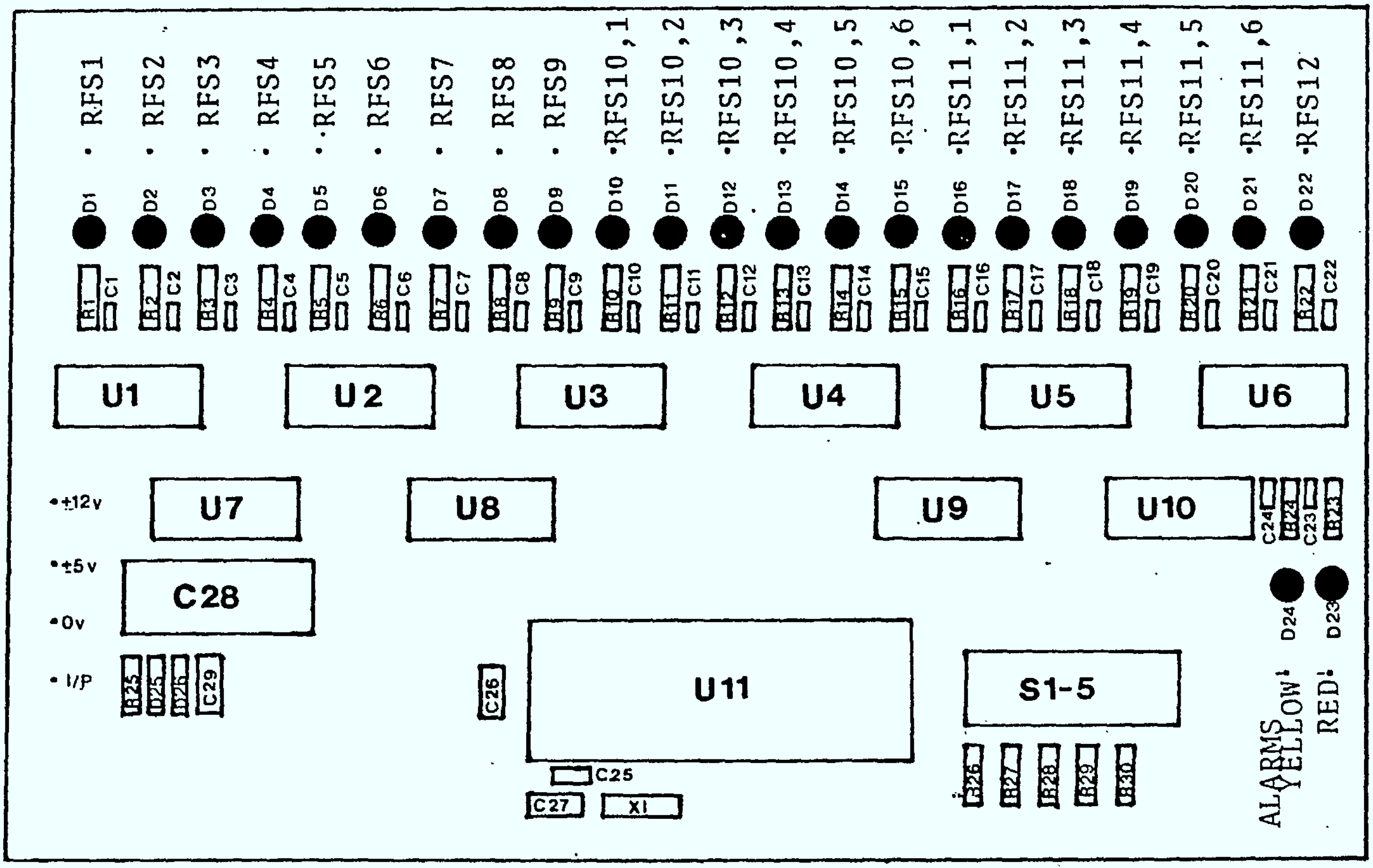


Figure 1 Schematic

FIGURE 2

CIRCUIT LAYOUT



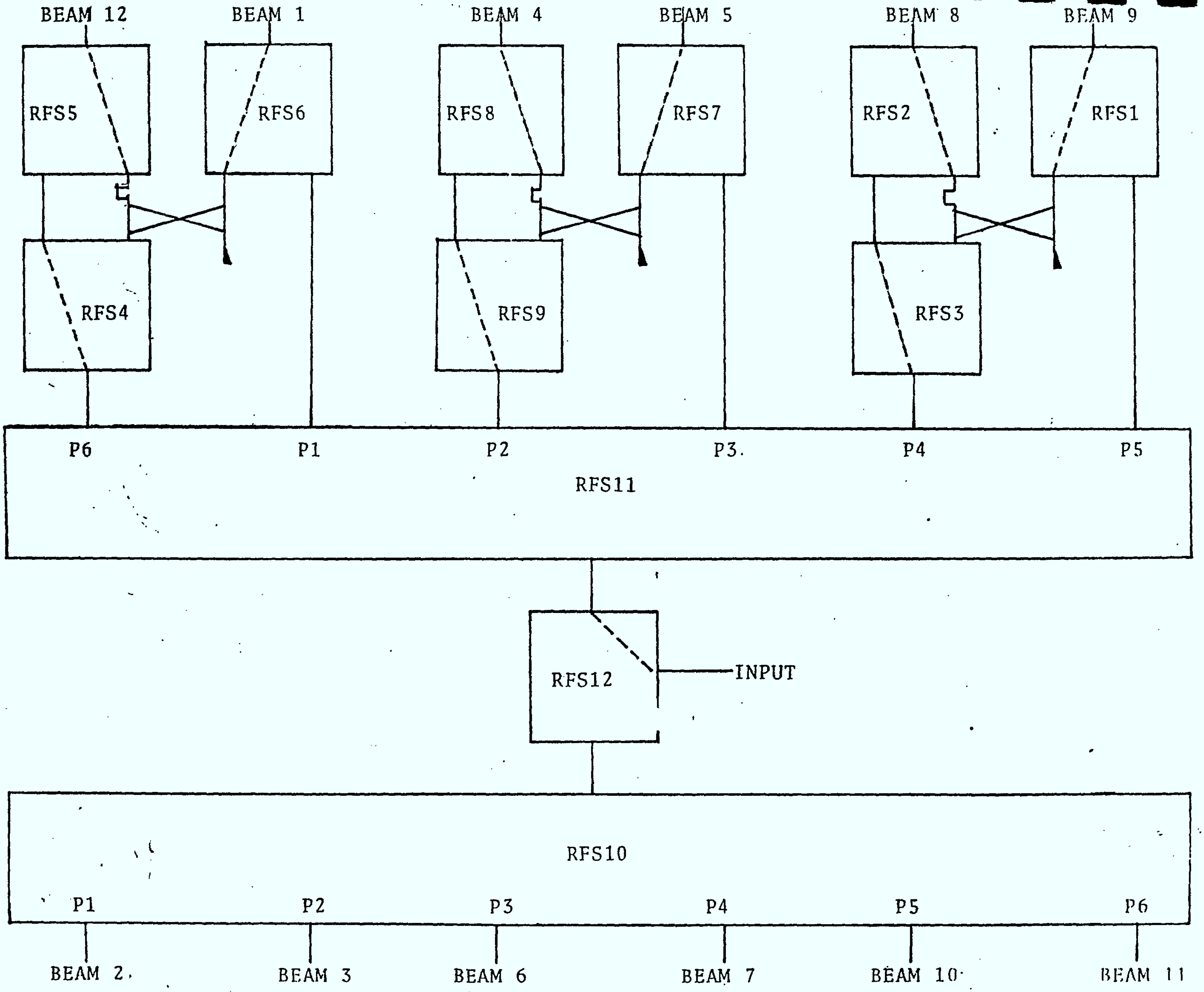


FIGURE 3
R.F. SWITCH CONFIGURATION

FIGURE 4

BEAM SELECTION CONTROLLER FLOW CHART

POWER-UP ROUTINE

AUTOMATIC MODE

SEARCH ROUTINE

SCAN ALL CHANNELS.

IF NO CHANNELS ABOVE THRESHOLD SET YELLOW ALARM.

IF 20 CONSECUTIVE SCANS WITH YELLOW ALARM ON THEN SET RED ALARM AND DROP SCAN RATE TO ONCE EVERY TWO MINUTES.

IF SIGNAL LEVEL ABOVE THRESHOLD FIND HIGHEST SIGNAL AND LOAD INTO CURRENT ADDRESS STORE.

EXIT TO MONITOR ROUTINE.

MONITOR ROUTINE

CHECK CURRENTLY ADDRESSED CHANNEL SIGNAL LEVEL REMAINS ABOVE THRESHOLD.

IF SIGNAL LEVEL LESS THAN THRESHOLD CHECK LEVEL OF ADJACENT CHANNELS.

RETURN TO SEARCH ROUTINE IF SIGNAL LEVEL ON ADJACENT CHANNELS ALSO LESS THAN THRESHOLD.

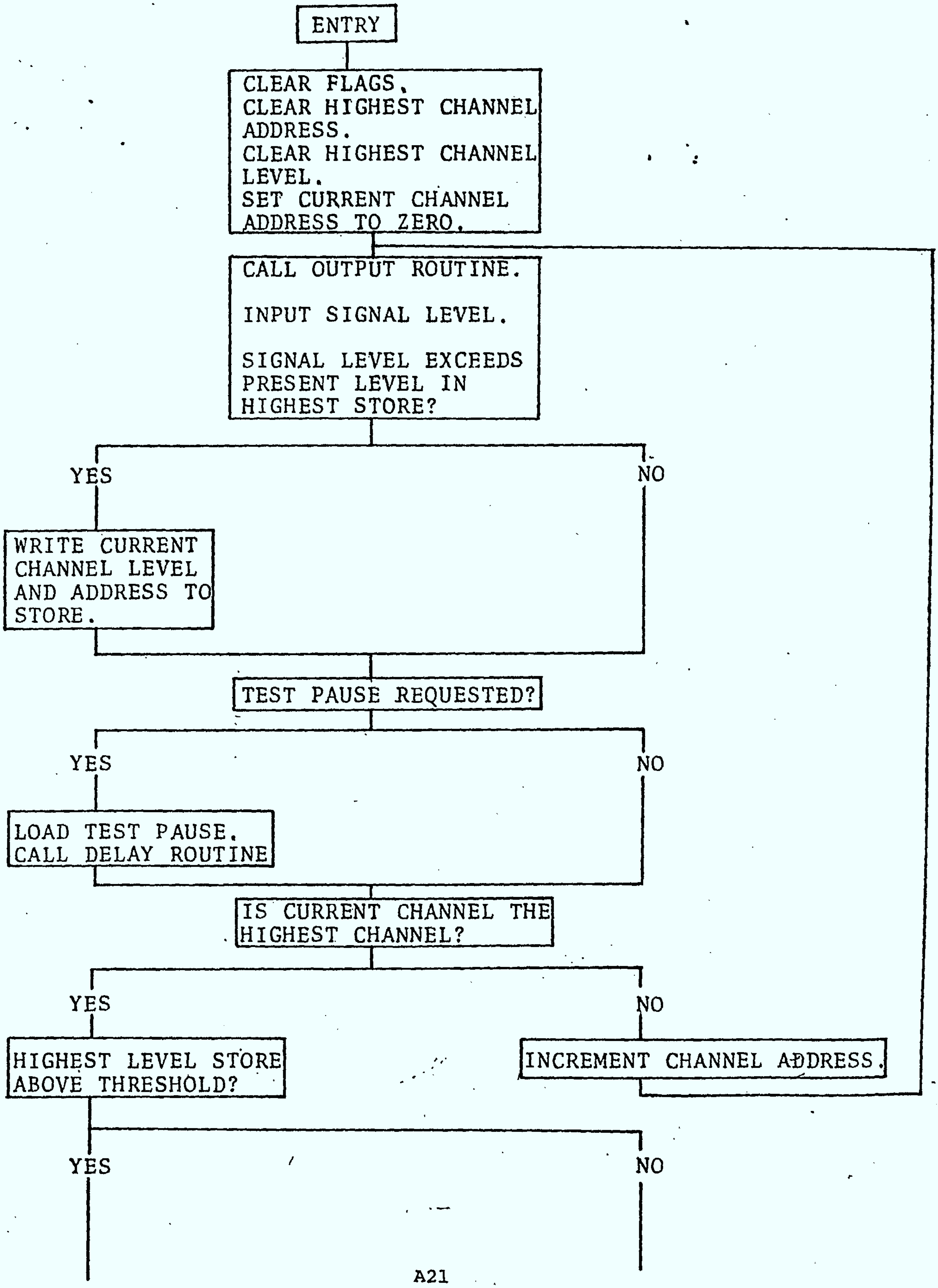
MANUAL MODE   INTERRUPT

MANUAL ROUTINE

BEAM SELECTION UNDER CONTROL OF MANUAL SWITCHES.

FIGURE 5

SEARCH ROUTINE FLOW CHART



SEARCH ROUTINE FLOW CHART (Continued)

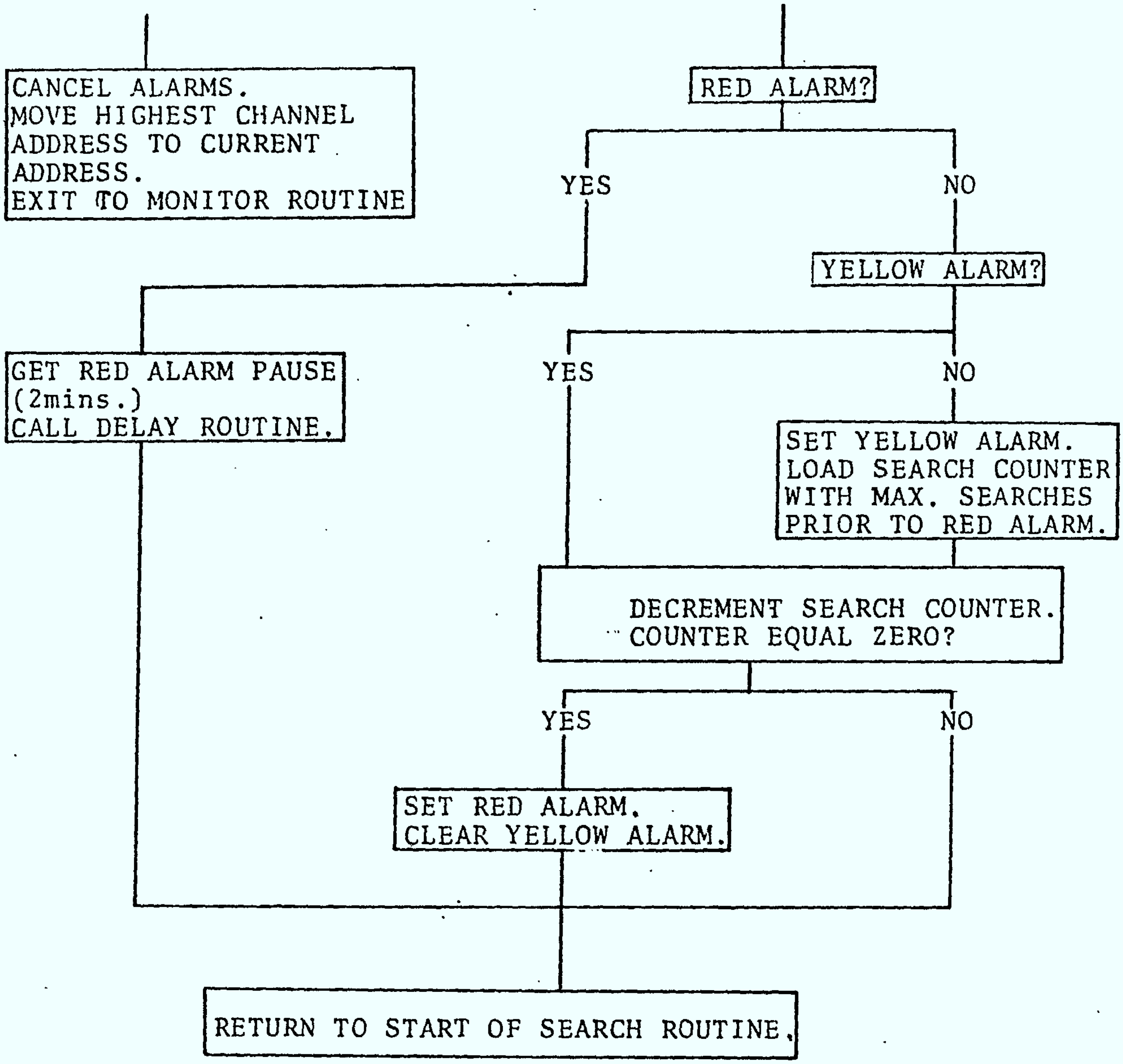


FIGURE 6

MONITOR ROUTINE FLOW CHART

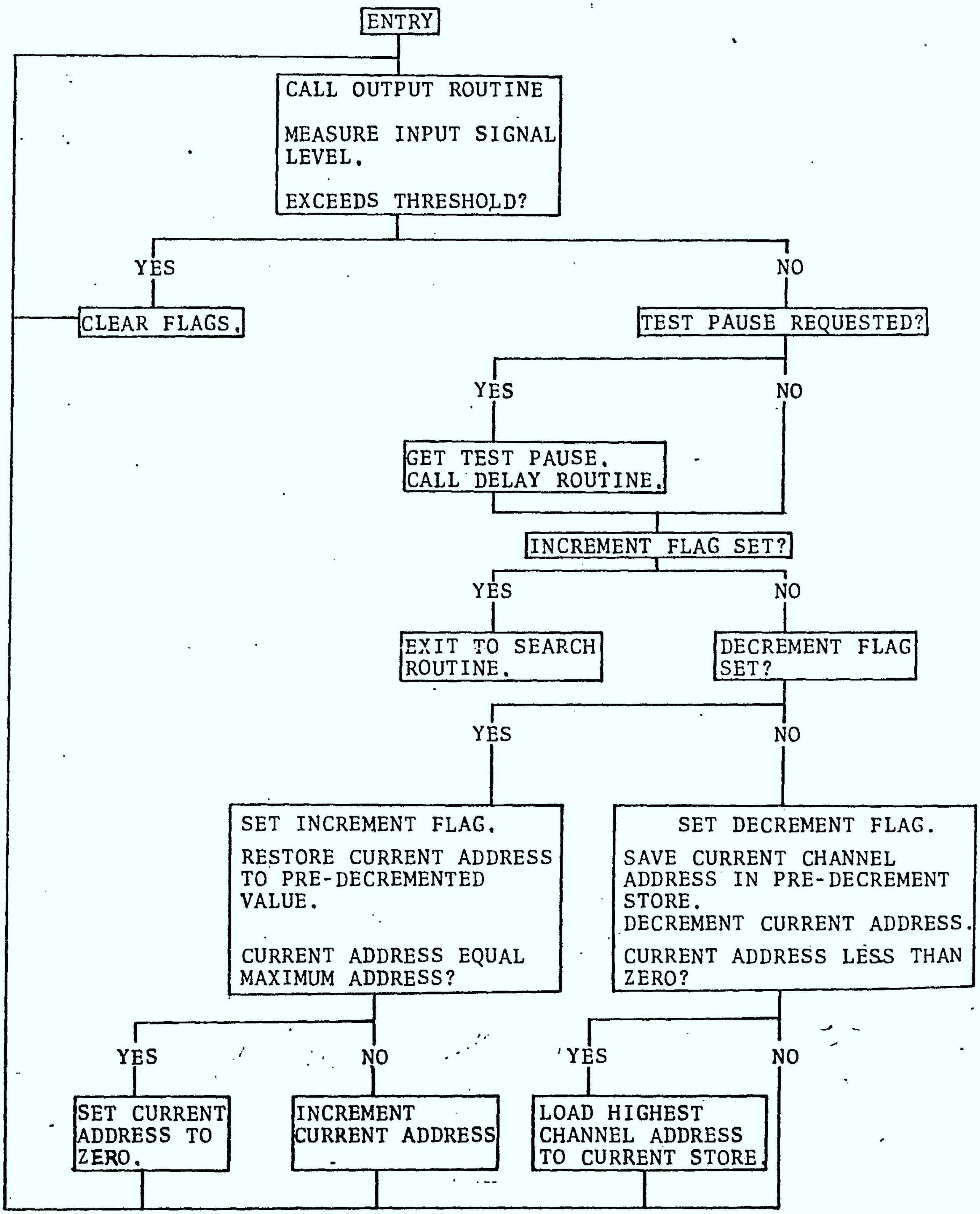


FIGURE 7

MANUAL ROUTINE FLOW CHART

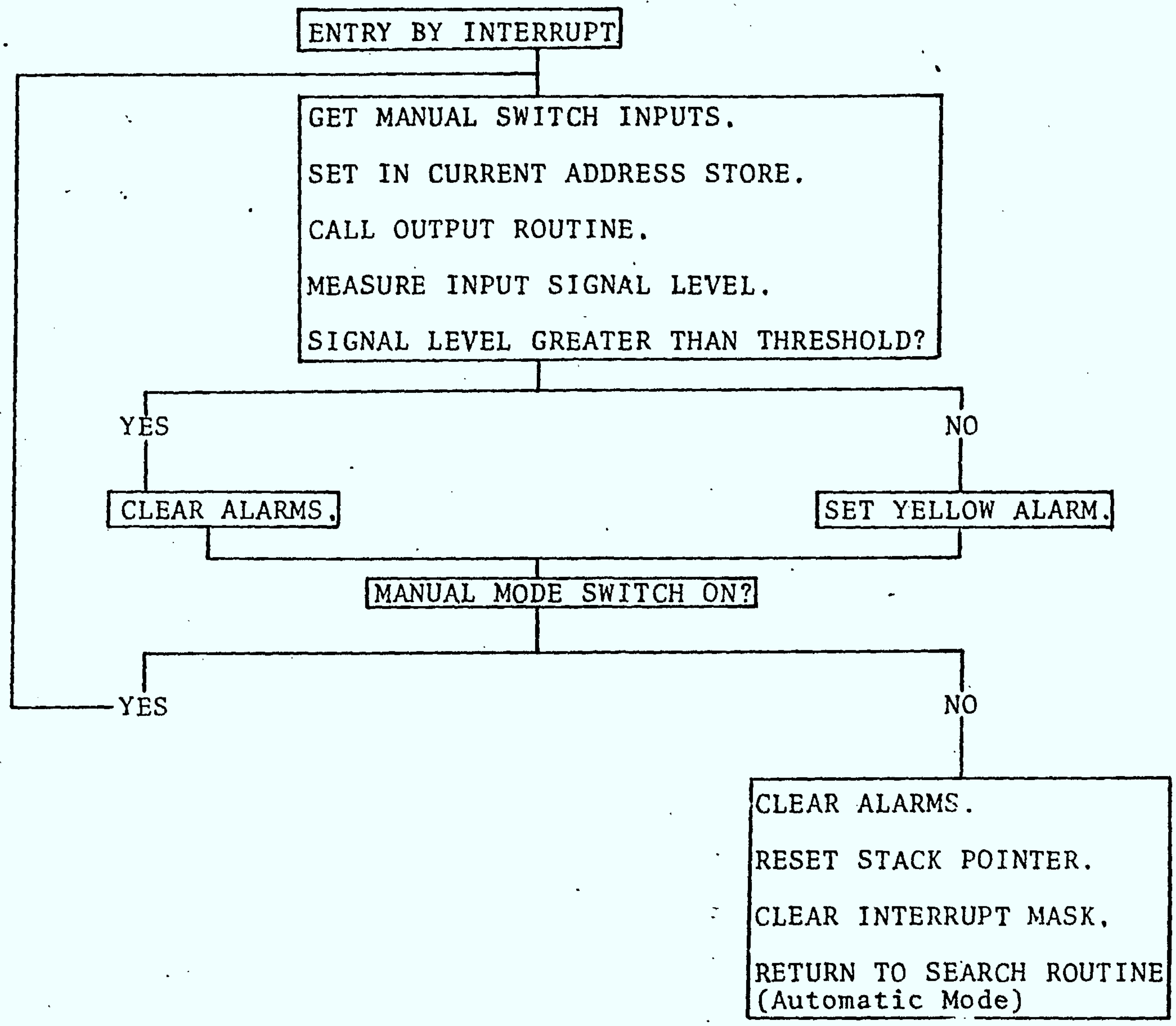


FIGURE 8

DELAY ROUTINE FLOW CHART

NOTE

The delay is set by two words. The Least Significant word has a value of 2.29mS per bit up to a maximum of 255x2.29mS i.e. 584mS.
The Most Significant word has a value of 584mS per bit up to a maximum of 255x584ms i.e. 149S.

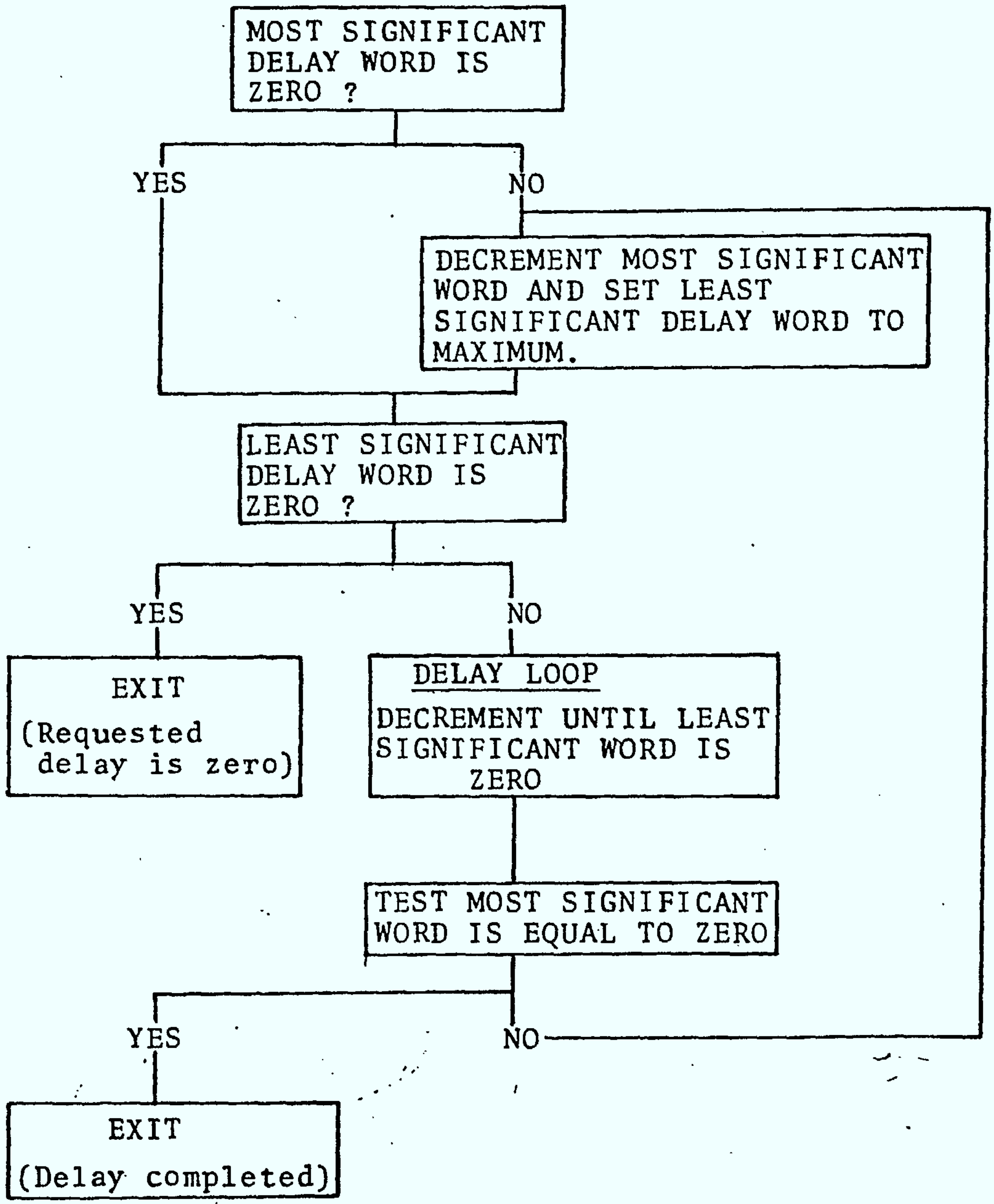


FIGURE 9

OUTPUT ROUTINE FLOW CHART

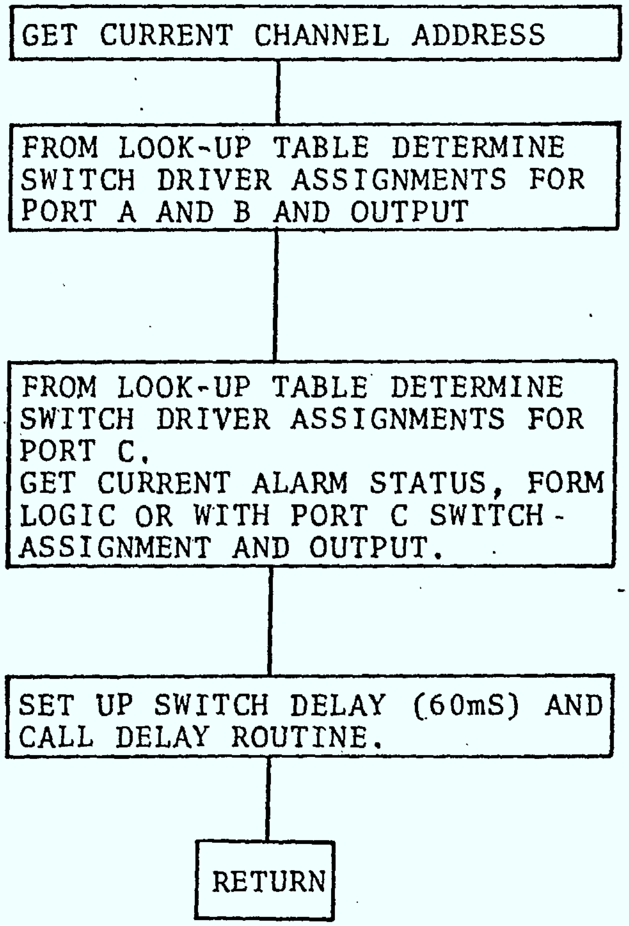


FIGURE 10

POWER-UP ROUTINE

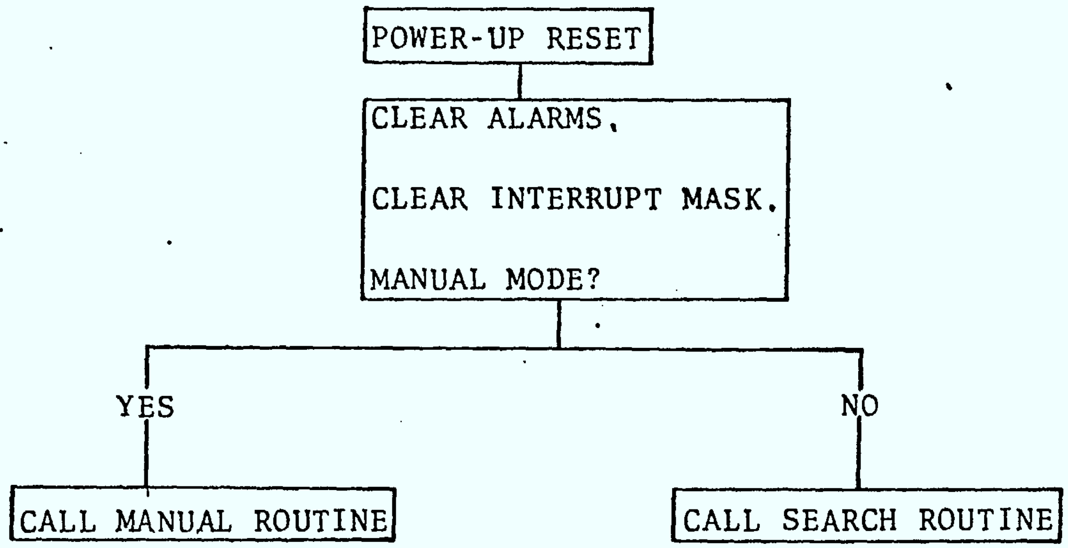


TABLE 1

PARTS LIST

CIRCUIT DESIGNATION	DESCRIPTION	QUANTITY
C1-C24	1000pf Capacitor	24
C25	27pf Capacitor	1
C26	0.01mfd Capacitor	1
C27,29	1mfd Capacitor	2
C28	47mfd Capacitor	1
D1-D23	MV5752 Red LED	23
D24	MV5352 Yellow LED	1
D25,26	1N4148 Diode	2
R1-25	1K, 0.25W Resistor	25
R26-30	22K, 0.25W Resistor	5
U1-6	SN75068 Integrated cct.	6
U7-10	CD4050B Integrated cct.	4
U11	MC68705R3 Integrated cct.	1
S1-5	SPST Switch	5
X1	3.579545 MHz Crystal	1

TABLE 2

MICROPROCESSOR PORT ASSIGNMENTS

PORT	ASSIGNMENT
7A	RFS1
6A	RFS2
5A	RFS3
4A	RFS4
3A	RFS5
2A	RFS6
1A	RFS7
0A	RFS8
7B	RFS9
6B	RFS10 P1
5B	RFS10 P2
4B	RFS10 P3
3B	RFS10 P4
2B	RFS10 P5
1B	RFS10 P6
0B	RFS11 P1
7C	RFS11 P2
6C	RFS11 P3
5C	RFS11 P4
4C	RFS11 P5
3C	RFS11 P6
2C	RFS12
1C	RED ALARM
0C	YELLOW ALARM

TABLE 2

MICROPROCESSOR PORT ASSIGNMENTS

PORT	ASSIGNMENT
7A	RFS1
6A	RFS2
5A	RFS3
4A	RFS4
3A	RFS5
2A	RFS6
1A	RFS7
0A	RFS8
7B	RFS9
6B	RFS10 P1
5B	RFS10 P2
4B	RFS10 P3
3B	RFS10 P4
2B	RFS10 P5
1B	RFS10 P6
0B	RFS11 P1
7C	RFS11 P2
6C	RFS11 P3
5C	RFS11 P4
4C	RFS11 P5
3C	RFS11 P6
2C	RFS12
1C	RED ALARM
0C	YELLOW ALARM

TABLE 3

R.F. SWITCH ASSIGNMENTS

BEAM #	R.F. SWITCHES ENERGISED	
1	RFS6	RFS11,1
2	RFS10,1	RFS12
3	RFS10,2	RFS12
4	RFS8	RFS11,2
4A	RFS9	RFS11,2
5	RFS7	RFS11,3
6	RFS10,3	RFS12
7	RFS10,4	RFS12
8	RFS2	RFS11,4
8A	RFS3	RFS11,4
9	RFS1	RFS11,5
10	RFS10,5	RFS12
11	RFS10,6	RFS12
12	RFS5	RFS11,6
12A	RFS4	RFS11,6

APPENDIX B. CHANGES TO DRAWINGS

1. 2.500 inch standoffs (301-20000-15) fabricated from 0.62 inch diameter round aluminum with two flats (½ inch A.F.) milled at one end.

2. Butler Matrix Board Support Angles installed inverted with 2.5 inch standoff flats at Butler matrix end for clearance.

3. Notches required in some Hybrid Board Support Channels to clear load resistor wires at one end of Hybrid Boards.

4. 96 10-32 x ½ inch long stainless steel socket head cap screws required to hold element board reinforcement strips.

5. 0.141 inch holes in Balun bases (301-20000-18B) enlarged to 0.144 inch.

6. 0.141 inch holes in Dielectric Spacers (301-20000-19) enlarged to 0.144 inch.

DATE DUE
