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THE DESIGN OF A BROADBAND ROTATING FEED FOR A LOW NOISE TEMPERATURE ANTENNA WITH AUTO-TRACK CAPABILITY

June 1963

NASA CR71193

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Project Engineer	D. G. Henry

GPO PRICE $ ______

CFSTI PRICE(S) $ ______

Hard copy (HC) 4.00

Microfiche (MF) 1.00

ff 653 July 65

NAS 10-48

NEW MEXICO STATE UNIVERSITY
PHYSICAL SCIENCE LABORATORY
UNIVERSITY PARK, NEW MEXICO

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June 1963

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Approval:
Supervisor
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1.0 INTRODUCTION

The National Aeronautics and Space Administration Launch Operations Directorate of the George C. Marshall Space Flight Center has requested the Physical Science Laboratory of New Mexico State University to provide a nutating feed or feeds for a 19 foot parabolic reflector, which offers a low noise temperature auto-track capability.

2.0 ELECTRICAL PARAMETERS

2.1 Operating Frequencies

The operating frequencies of interest are 860, 900, 960, 1400, 1700, 2290 and 2800 Mc/sec. The frequency of highest interest is 2290 with 960 and 1700 next and 2800 of least importance.

2.2 Polarization

Polarization diversity is desirable, but not required. If a single polarization is to be provided, right circular polarization is required.

2.3 VSWR Limits

The VSWR must be 1.3:1 or better at the critical frequencies (2290, 1700 and 960).

2.4 Noise Temperature

The feed shall provide for maximum signal to noise ratio rather than maximum gain. The noise temperature of the preamplifier is assumed 75° K.

2.5 Tracking Modulation

The peak-to-peak tracking modulation in db shall not exceed 2.0 ± .5 db.

2.6 Modulation Rate

The modulation rate shall not be less than 20 cps.

2.7 Reference Signal

A reference signal coherent with the modulation voltage must be provided. The reference level shall be a nominal 10 volts at 600 ohms.

3.0 MECHANICAL PARAMETERS

The feed shall be rigidly connected to the reflector and be mechanically balanced to preclude vibration. The feed must also be capable of all-weather operation and be impervious to moisture, rain and salt spray, and blowing sand for a period of three years.

4.0 ANTENNA TYPES CONSIDERED FOR PRIMARY FEED

The 19 foot diameter parabolic reflector for which the feed is to be designed has a focal length to diameter ratio of 0.382. The reflector was furnished by the contractor.

The proper edge illumination of the reflector to give the optimum signal to noise ratio was determined theortically to be -20 db with respect to the center[1]. The antennas considered for the primary feed then had to be broadband as well as have a predetermined radiation pattern.

4.1 Crossed Valentines

The valentine antenna alone is broadband and has the desired radiation pattern. However, the valentine is linearly polarized. To obtain circular polarization, two valentines are mounted at right angles and properly phased. When this is done, the crossed valentines are not broadband due to the frequency dependent length of the phasing cable. For this reason, the crossed valentines and other antennas of the crossed type were not considered adequate for the Model 19NF feed.

4.2 Coaxial Helix

The helix is an antenna that depends upon its geometrical shape for circular polarization and not a phasing cable. However, a single helix is not broadband enough to obtain satisfactory radiation characteristics at all the desired frequencies. A coaxial helix was tried. The coaxial helix consists of two helices of different frequencies with the higher frequency antenna placed inside the lower frequency antenna coaxially. This antenna gave the desired pattern and impedance at the two extremes of the frequency range but the patterns at the center of the range (1400 and 1700 Mc/sec) were not usable.

4.3 Conical Helix

The next antenna to be considered was a conical helix (Fig. 1). This antenna seemed to fulfill the impedance requirements and the pattern requirements for a larger portion of the frequencies than any of the above.

However, at the upper frequencies (2290 and 2800 Mc/sec) the radiation patterns developed split lobes, high side lobes and excessive back radiation. Various angles of helices were tried along with various turn spacings. None of these efforts gave a usable pattern at the higher frequencies.

4.4 Conical Spiral

The conical log-spiral antenna is defined by a logrithmic equation. There are two arms to the spiral. The defining equation for the first arm is

$$\rho_1 = \rho_0 e^{b\phi} \qquad 4.1$$

where $b = \cot \beta \sin \alpha/2$ and ρ_0 is determined from truncation. β and α are the spiral rate and cone angle respectfully as shown in Fig. 2. The second arm is defined by

$$\rho_2 = \rho_1 e^{-b\pi} . \qquad 4.2$$

The diameters of the truncated portion of the cone and the base of the cone are determined by the extremes of frequency bandwidth desired. For this antenna, the diameter of the arms is a constant.

The first of this type of antenna tested had a spiral rate (β) of 73°, a cone angle (α) of 20°, a truncation diameter (d) of 0.592'', and a base diameter (D) of 4.92''. Since the antenna is a two armed structure and must be fed balanced, a broadband tapered balun[3] was constructed to excite and match the antenna. The antenna is shown in Fig. 3. The radiation patterns were smooth, had no back radiation above -20 db, and with the exception of 2800 Mc/sec were essentially the same. The patterns were a great deal too broad to give the desired illumination in the 19 foot parabolic reflector. A summary of the pattern characteristics is given in Table I.

A change of the spiral rate (β) from 73° to 83° with all other parameters remaining the same was next studied. This antenna was much more critical in its impedance matching. The same type of broadband balun, as previously noted, was used to feed this antenna. The radiation patterns of the conical spiral were quite good at all frequencies with the possible exception of 2800 Mc/sec, although 2800 is quite good except for the axial ratio. This antenna will give very close to the desired illumination when placed in the 19 foot diameter parabolic reflector. The antenna is shown in Fig. 4. Table II gives a summary of the patterns shown in Fig. 6 through Fig. 26. The antenna coordinate system is shown in Fig. 5.

This antenna was the model with which all tests of the 19 foot parabolic reflector were run.

5.0 PRIMARY FEED TESTS IN REFLECTOR

5.1 Radiation Pattern Test Setup

The 19 foot diameter parabolic reflector was mounted on an elevator on a 30 foot tower (Fig. 27). The 360° azimuth rotator is an integral part of this elevator. The 19 foot diameter parabolic reflector was used as a receiver in the radiation pattern measurement setup. The transmitter was located 3000 feet away (Fig. 28). A 10 foot diameter parabolic reflector with a linearly polarized feed, for the desired frequency, was used as a transmitting antenna.

The conical spiral antenna is shown mounted in the reflector for radiation pattern measurements in Fig. 29. The rf, a-c and modulation reference lines are run down the same tripod support leg.

5.2 Radiation Pattern Measurements

The conical spiral feed was mounted in the 19 foot diameter reflector with the axis of the cone coinciding with the axis of the reflector. The conical spiral was adjusted to give the best focus over the frequencies required. Radiation patterns at 960, 1700 and 2300 Mc/sec are shown in Figs. 31 to 36. These are the critical frequencies and also give a good representation of the entire group of operational frequencies. A coordinate system is shown in Fig. 30.

The average back radiation is down 47 to 50 db from the peak of the main lobe for all of the frequencies. The radiation patterns with the cone on axis were run so that a comparison of side lobe and back radiation could be made when the cone is tilted off axis to achieve the automatic track mode.

5.3 Modulation Level Tests

The conical spiral was tilted off axis a number of different ways to determine the optimum position for a constant power modulation. This power modulation is the difference between the peak of the main lobe and the point where the beam crosses the axis of rotation.

The cone base was kept on axis and the apex tipped off in the first series of tests. This configuration did not give a constant power modulation over the frequency range. The cone base was next moved off axis and the apex kept on axis. Various degrees of tilt were tried from 2.5° to 15°. The 15° tilt was found to give the most nearly constant power modulation level over the frequency range. The modulation level at each frequency is shown in Figs. 37 to 43. The amplitude of the patterns are not relative but are only to show modulation level and beamwidth. As seen on the figures, only the first ten db of the pattern is plotted.

Radiation patterns of the 19 foot diameter reflector with the conical spiral tilted at 15° are included in Figs. 44 to 99. These patterns are for the conical spiral when tilted to the left, right, above and below the axis of the dish. Both E_θ (horizontal) and E_ϕ (verticle) polarizations are run.

The patterns show only 0° to 180° since the patterns are symmetrical about this axis.

The front-to-back ratio when the feed is tilted does not differ appreciably from that when the feed is on axis. The first side lobe is slightly higher due to feed tilt. A summary of the pattern characteristics are given in Table III. The VSWR and axial ratio are also included in this table. The measured and calculated gain are also shown on this table.

6.0 NOISE TEMPERATURE

The noise temperature of the 19 foot diameter reflector was calculated from the equation

$$T_A = 1/4\pi \int_0^{2\pi} \int_0^{\pi} T_B(\theta,\phi)\ G(\theta,\phi) \sin\theta\ d\theta\ d\phi \qquad 6.1$$

where T_A - antenna noise temperature
$T_B(\theta,\phi)$ - background temperature distribution
$G(\theta,\phi)$ - radiation pattern of the antenna.

Using the measured radiation pattern of the antenna, the measured value of the cosmic noise[1], and assuming that the earth has a noise temperature of 290° K, a noise temperature was calculated for each frequency. The results of these calculations are given in Table IV. The upper frequencies give the best noise temperature and are within the 75° K specification while the lower frequencies are somewhat higher than the 75° K desired.

The noise temperature of the dish at the upper frequencies is not as low as was expected. This is probably due to the fact that the screen hole size is an appreciable portion of a wavelength and allows leakage through the screen. Also the reflector surface has perturbations which give rise to sidelobes which tend to increase the noise temperature. These perturbations also cause a loss in gain as seen in Table III by comparing the measured with the calculated gain.

7.0 MECHANICAL CONSTRUCTION

7.1 Rotator Assembly

7.1.1 Motor-Generator Mount

The motor and generator are mounted such that they form an integral part. (Fig. 100) Pulleys, belt and bearing are mounted directly to this housing. (Fig. 101) This complete unit can be removed from the tripod mounting plate.

7.1.2 Tripod Mounting Plate

The tripod mounting plate (Fig. 102) is used to support the motor-generator mount and feed antenna. Support studs are located at 120° on this plate. These studs are attached to the support arms attached to the dish. Next to one stud is located an rf connector, a-c plug and a reference generator output jack.

7.2 Tripod Assembly

7.2.1 Tripod Support Arms

The tripod support arms are made of fibercast pipe and are 10 feet long. (Fig. 103) The pipe is 2.375'' in diameter with a 0.210'' wall. The pipe is made by FIBERCAST of Sand Springs, Oklahoma.

7.2.2 Adjustable Mounting Studs

Adjustable mounting studs are located on the ends of the support rods attached to the dish. (Fig. 104) These studs can be adjusted a total of ± 1 '' linear travel. The studs will come marked for the proper position.

7.3 Radome

The radome (Fig. 105) is constructed of aluminum and is attached to the mounting plate by socket head cap screws from the reverse side of the plate. A stainless steel clamp is attached around the radome to help hold the o-ring in place. The radome is designed to be pressurized to 5 psi. The pressure is carried to the radome by means of 7/8'' heliax coaxial cable.

The radome is pressurized to protect the motor, generator and associated parts from condensation of moisture.

The radome should not be pressurized above the design pressure or serious damage could result.

7.4 Antenna Assembly

7.4.1 Counterweight and Ground Plane

The antenna has been dynamically balanced at 1200 rpm to minimize vibrations. The counterweight and ground plane have been bolted together to form a single unit. (Fig. 106) Screws and bolts should not be removed from this assembly or the balance will be destroyed.

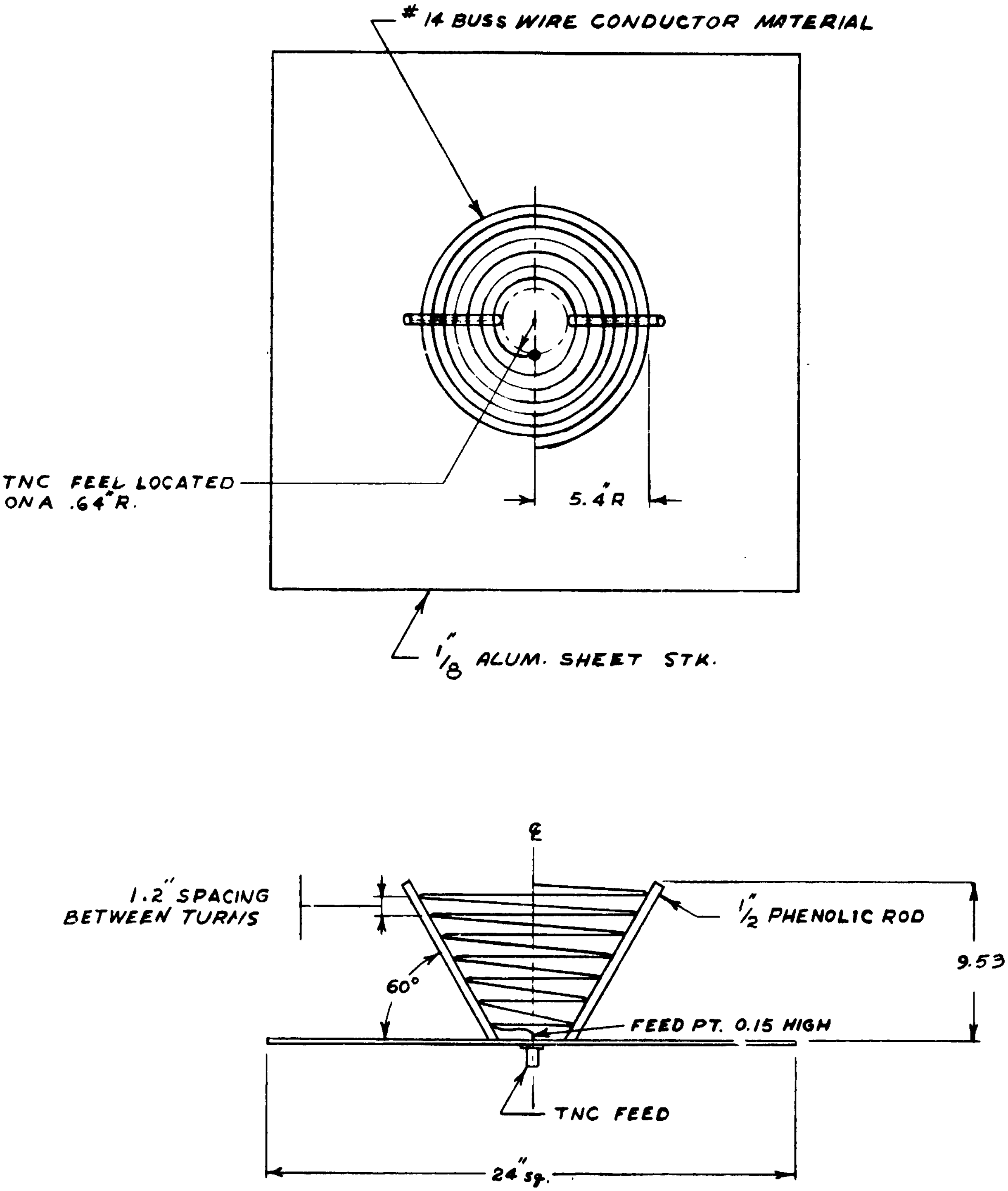
7.4.2 Conical Spiral Antenna

The conical spiral can be removed from the ground plane by removing the three (3) socket head cap screws on the underside of the ground plane. If this becomes necessary extreme care should be taken not to twist the rf connector at the base of the cone. The interior of the cone has been filled with a foam potting material and should not be disturbed. Failure to heed this warning can result in a destroyed balun and antenna.

7.4.3 Rotary Joint and RF Cable

The antenna counterweight and ground plane assembly can be removed by taking the rotary joint and rf connector off the end of the motor inside the radome. Set screws located at the base of the coupling shaft of the counterweight are then loosened and the entire assembly removed. Sealant and o-rings have been placed inside the motor shaft and should be removed with care.

The rotary joint is an RJ-3 (S/N 14) and is of advanced design as to long life at high speed and low noise. The rotary joint has been run a total of 10 hours and no noise has been detected.



7 1/2 TURN CONICAL HELIX FOR 960 & 2000MC

FIG. 1 - CONICAL HELIX

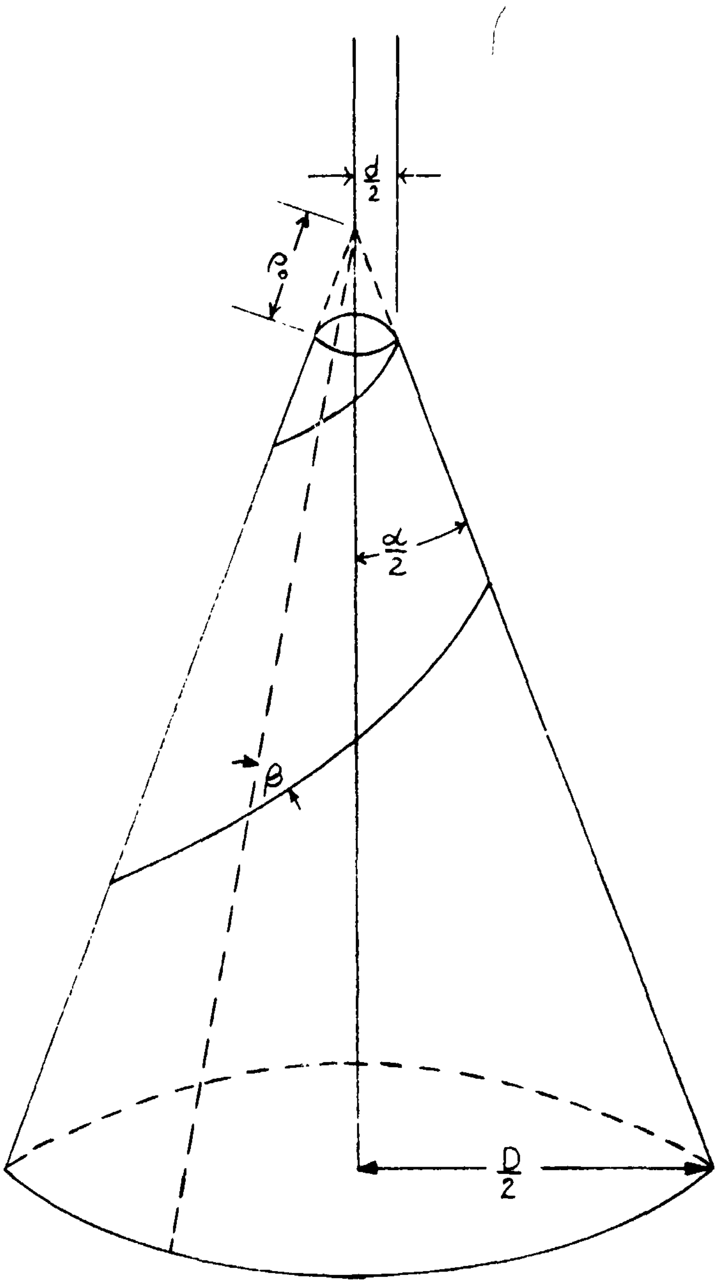


FIG. 2 - PARAMETERS OF THE CONICAL LOG-SPIRAL

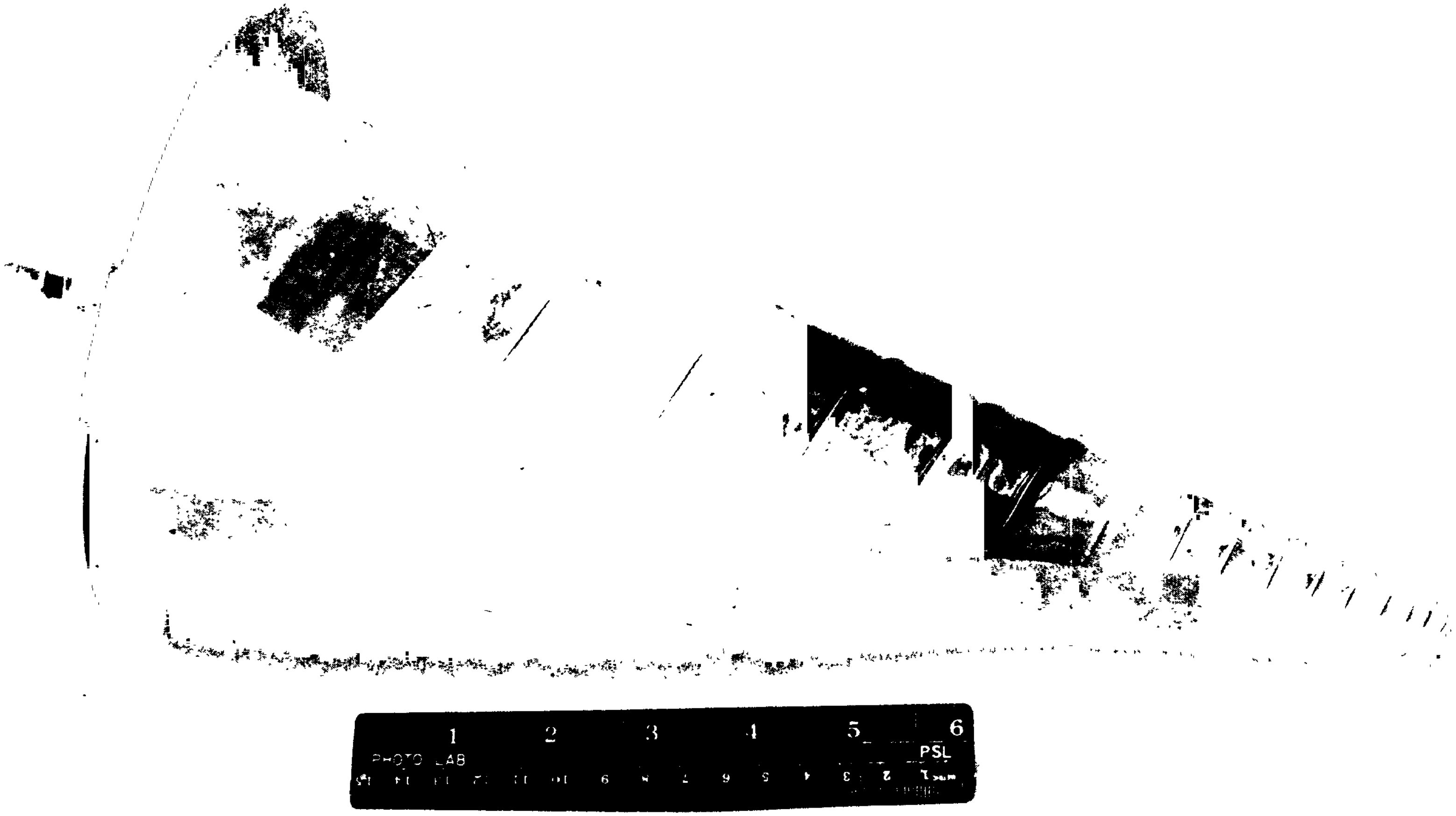


FIG. 3 - CONICAL SPIRAL, $\alpha = 20^\circ$, $\beta = 73^\circ$

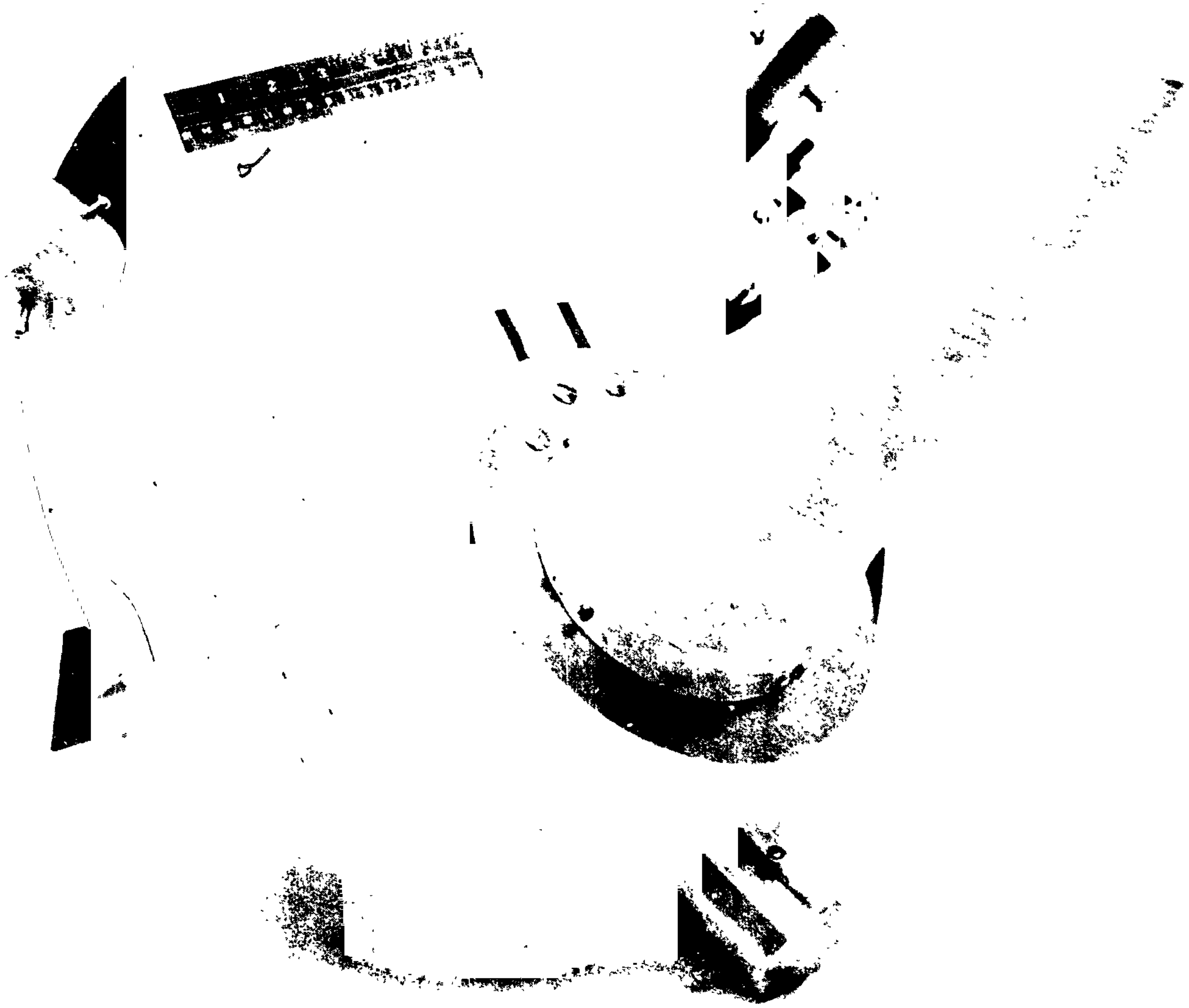


FIG. 4 - CONICAL SPIRAL, $\alpha = 20°$, $\beta = 83°$

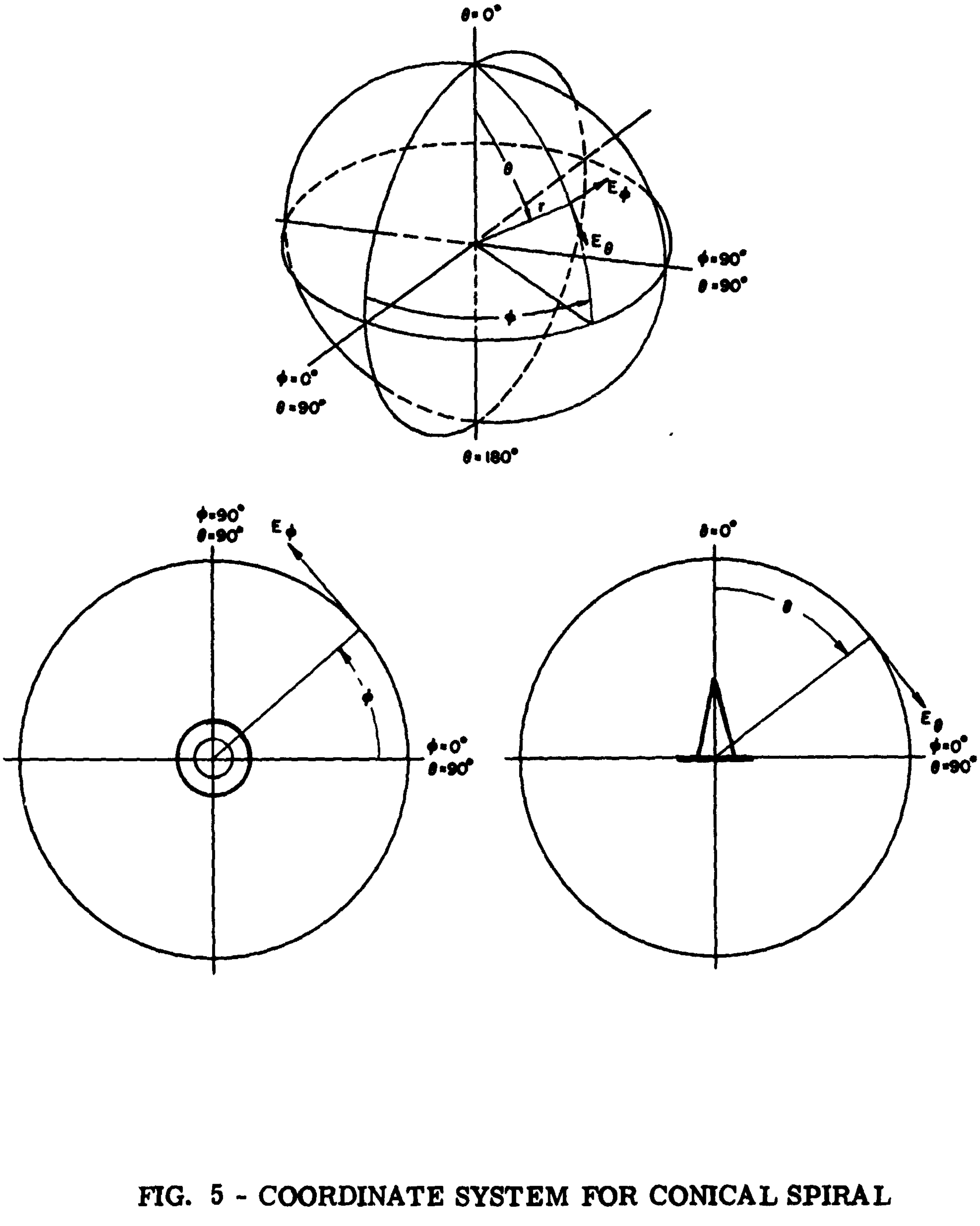


FIG. 5 - COORDINATE SYSTEM FOR CONICAL SPIRAL

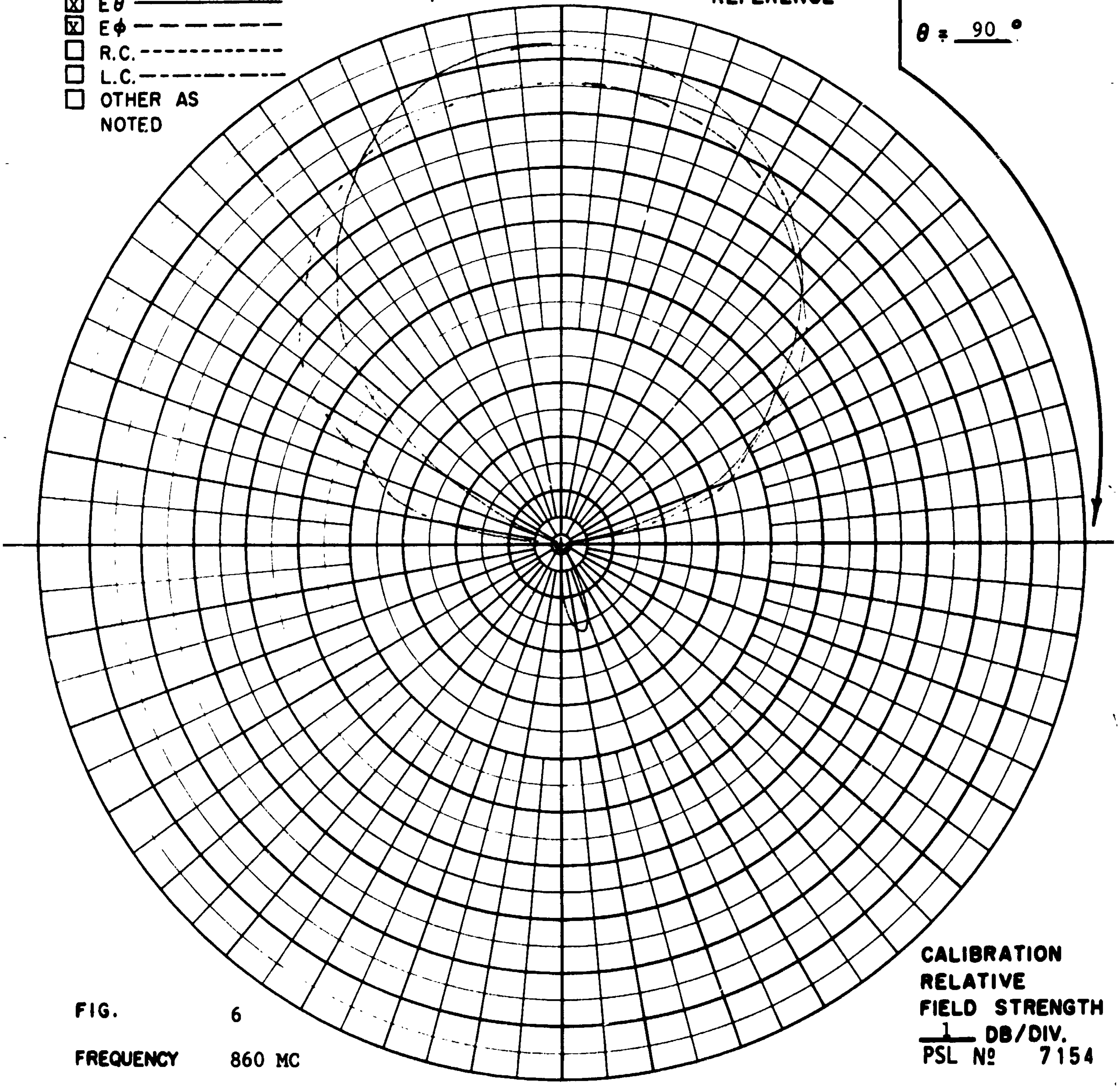
POLARIZATION

☐ GAIN REF -- -- --
☒ Eθ ————
☒ Eφ — — — — — —
☐ R.C.- - - - - - - - - - -
☐ L.C.— - — - — - —
☐ OTHER AS NOTED

φ = ____° θ = 0°

COORDINATE REFERENCE

φ = 0°
θ = 90°



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL Nº 7154

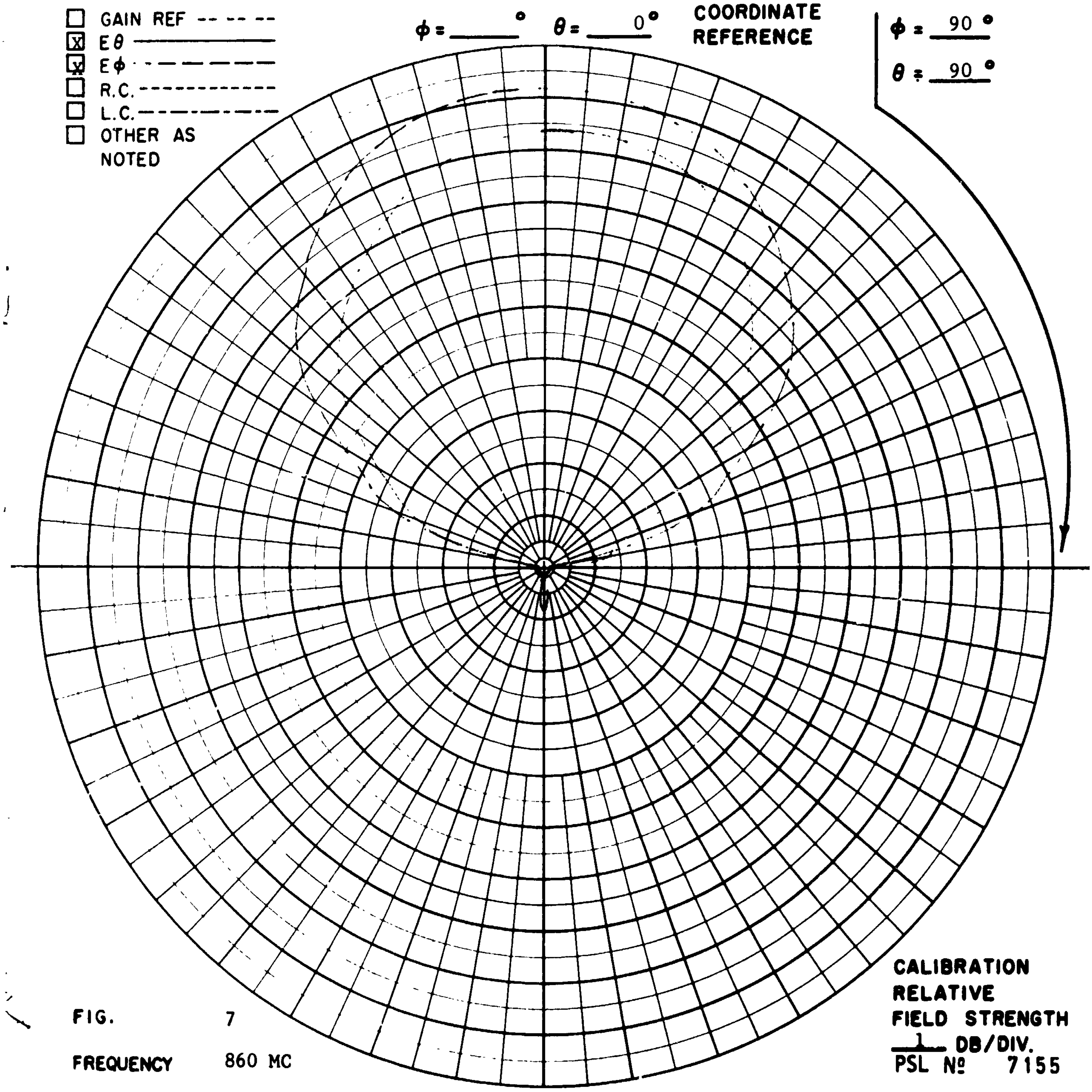
FIG.	6
FREQUENCY	860 MC
ANTENNA	CONICAL LOG-SPIRAL.
REMARKS	

POLARIZATION

☐ GAIN REF - - - - -
☒ Eθ ————
☒ Eφ - — - — - —
☐ R.C. - - - - - - - - - -
☐ L.C. — - — - — -
☐ OTHER AS NOTED

ϕ = ______° θ = 0° COORDINATE REFERENCE

ϕ = 90°
θ = 90°



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 7155

FIG. 7

FREQUENCY 860 MC

ANTENNA CONICAL LOG-SPIRAL.

REMARKS

POLARIZATION

☐ GAIN REF
☒ Eθ
☒ Eφ
☐ R.C.
☐ L.C.
☐ OTHER AS NOTED

φ = 90 ° θ = ____ ° COORDINATE REFERENCE

φ = 0 °
θ = ____ °

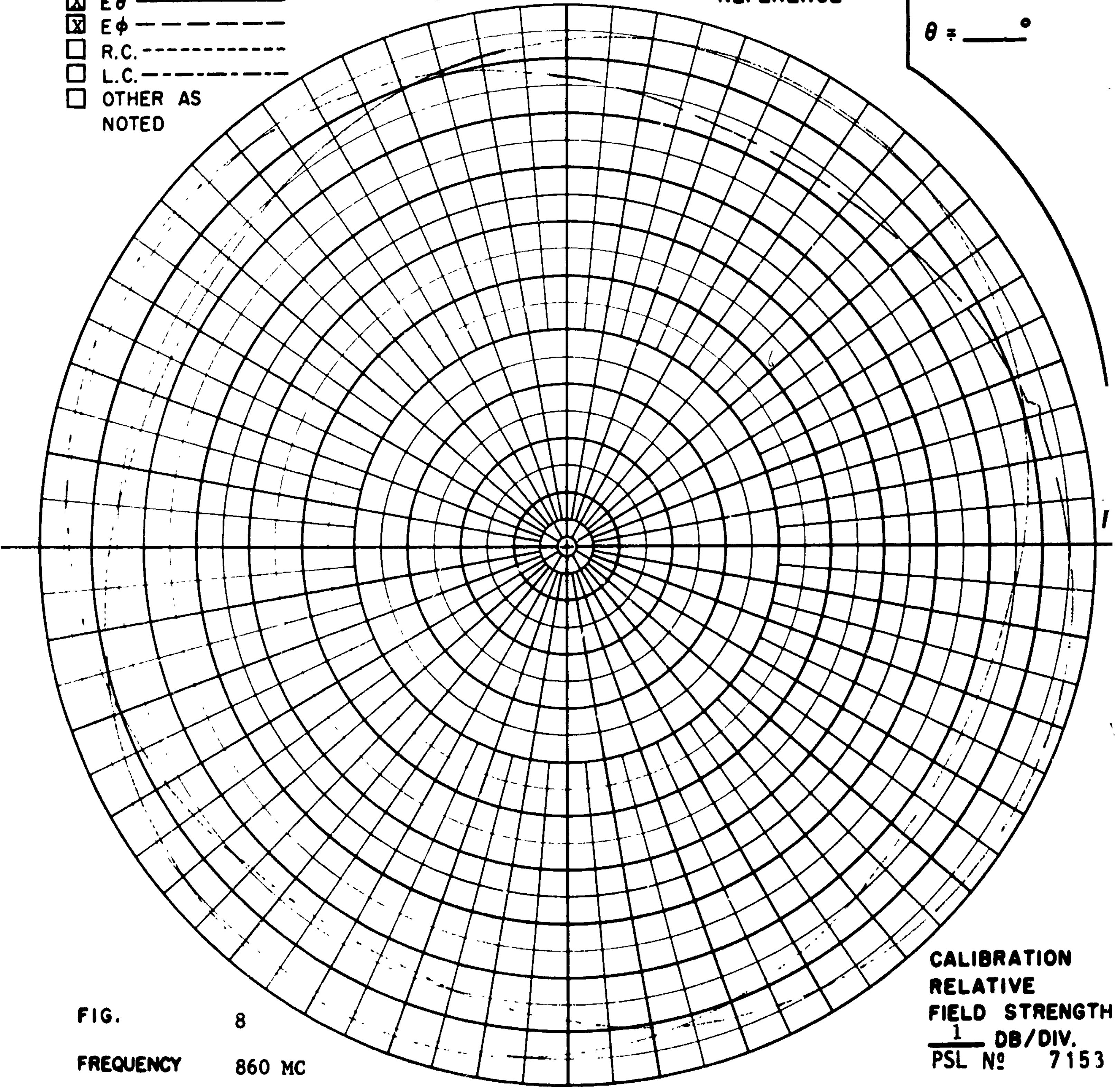


FIG. 8

FREQUENCY 860 MC

ANTENNA CONICAL LOG-SPIRAL.

REMARKS POLARIZATION ELLIPSE.

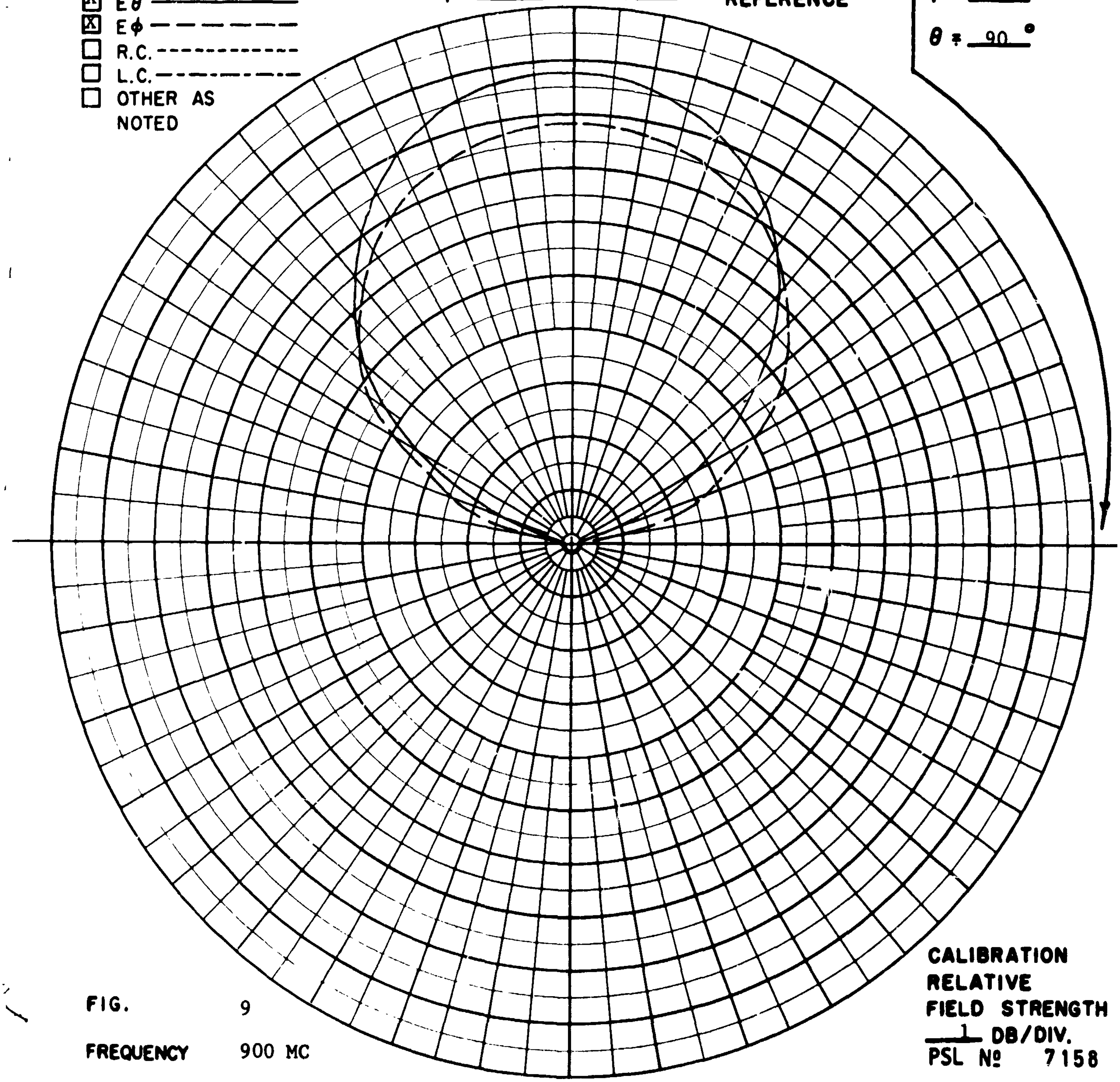
CALIBRATION
RELATIVE
FIELD STRENGTH
1 **DB/DIV.**
PSL № 7153

POLARIZATION

☐ GAIN REF -- -- -- --
☒ Eθ ————————
☒ Eφ — — — — — —
☐ R.C. ------------
☐ L.C. —-—-—-—-—
☐ OTHER AS NOTED

φ = ____° θ = 0° COORDINATE REFERENCE

φ = 0°
θ = 90°



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 7158

FIG. 9

FREQUENCY 900 MC

ANTENNA CONICAL LOG-SPIRAL.

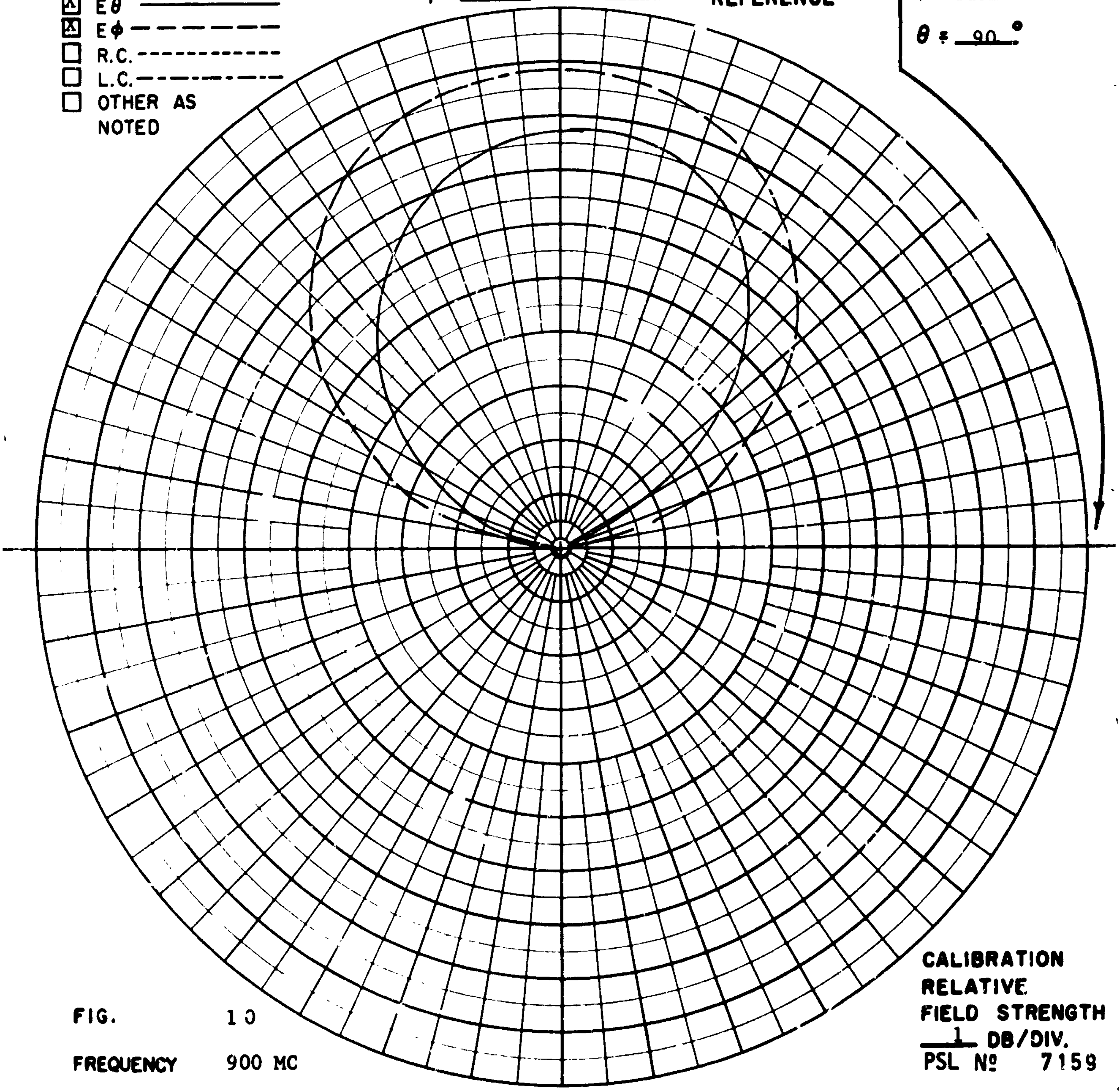
REMARKS

POLARIZATION

☐ GAIN REF
☒ Eθ
☒ Eφ
☐ R.C.
☐ L.C.
☐ OTHER AS NOTED

φ = ____° θ = 0° COORDINATE REFERENCE

φ = 90°
θ = 90°



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL No 7159

FIG. 10

FREQUENCY 900 MC

ANTENNA CONICAL LOG-SPIRAL.

REMARKS

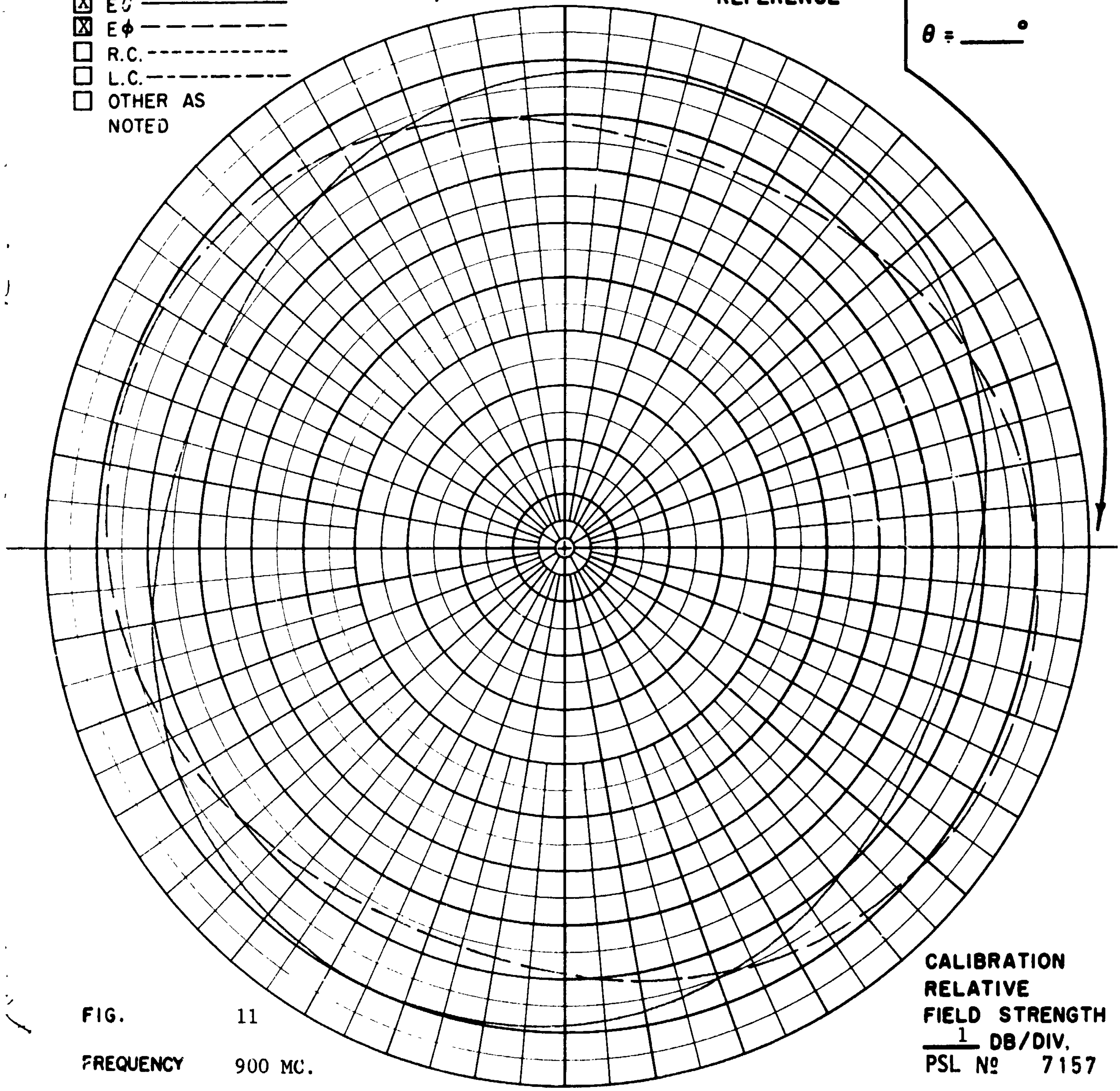
POLARIZATION

☐ GAIN REF - - - - -
☒ $E\theta$ ————
☒ $E\phi$ — — — — —
☐ R.C. - - - - - - - - - -
☐ L.C. —-—-—-—
☐ OTHER AS NOTED

$\phi =$ 90 ° $\theta =$ ____ ° COORDINATE REFERENCE

$\phi =$ 0 °

$\theta =$ ____ °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 7157

FIG. 11

FREQUENCY 900 MC.

ANTENNA CONICAL LOG-SPIRAL

REMARKS POLARIZATION ELLIPSE.

POLARIZATION

☐ GAIN REF -- -- --
☒ Eθ ————
☒ Eφ — — — —
☐ R.C.------------
☐ L.C.-·-·-·-·-
☐ OTHER AS NOTED

ϕ = ____° θ = 0° COORDINATE REFERENCE

ϕ = 0°
θ = 90°

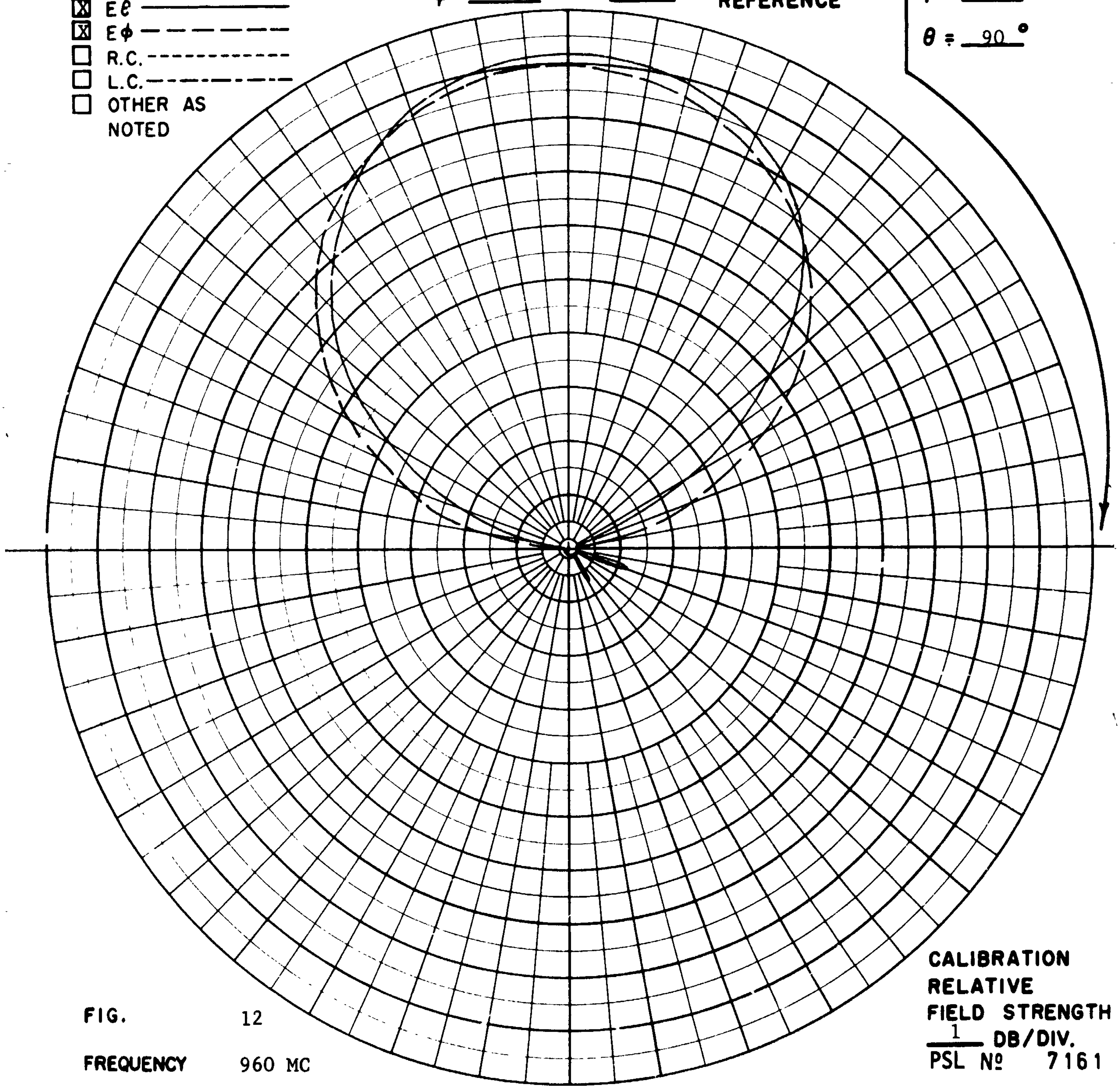


FIG. 12

FREQUENCY 960 MC

ANTENNA CONICAL LOG-SPIRAL.

REMARKS

CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 7161

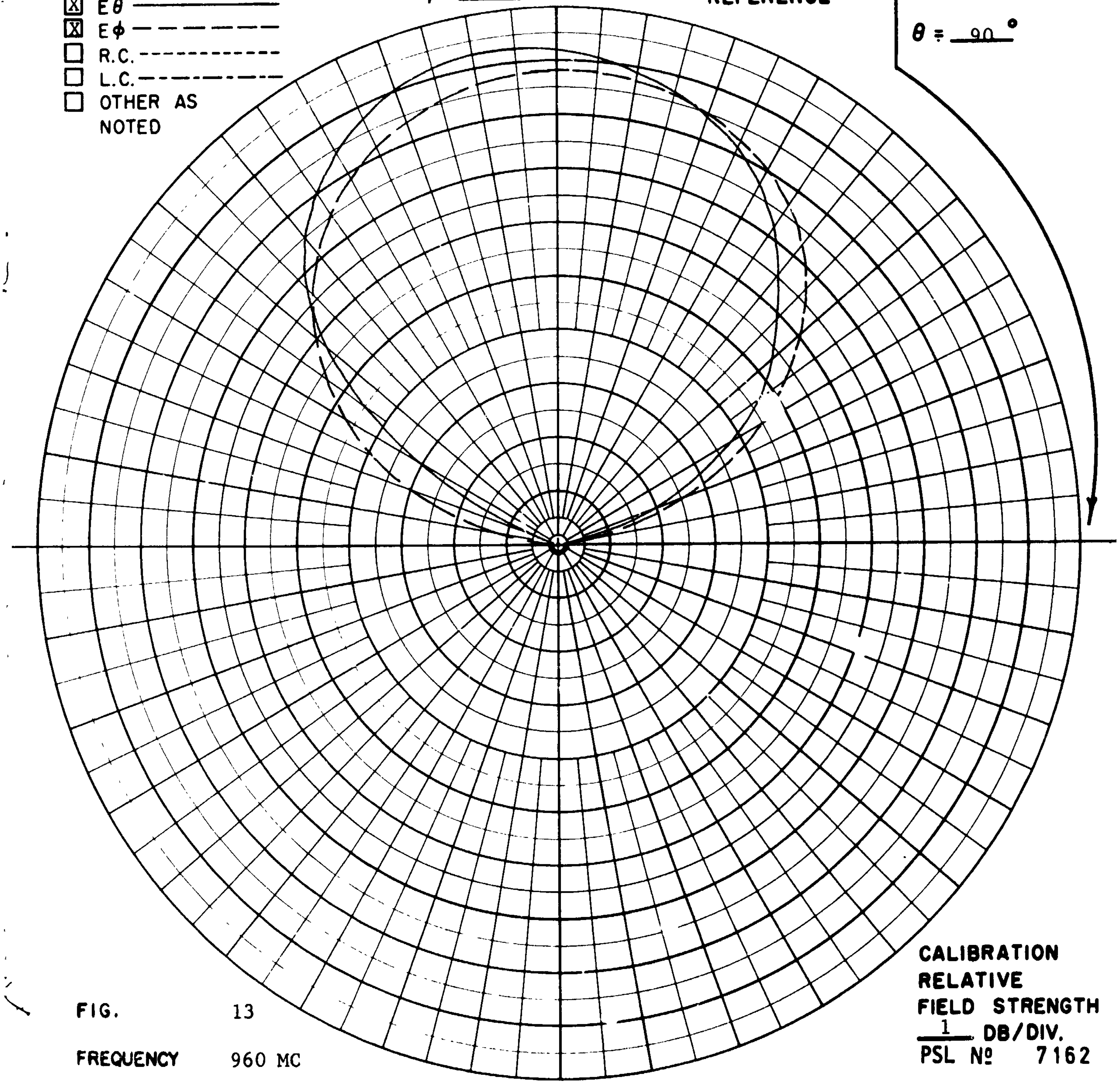
POLARIZATION

☐ GAIN REF -- -- --
☒ Eθ ————
☒ Eφ — — — — —
☐ R.C. ------------
☐ L.C. —·—·—·—
☐ OTHER AS NOTED

φ = _____° θ = 0°

COORDINATE REFERENCE

φ = 90°
θ = 90°



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 7162

FIG. 13

FREQUENCY 960 MC

ANTENNA CONICAL LOG-SPIRAL.

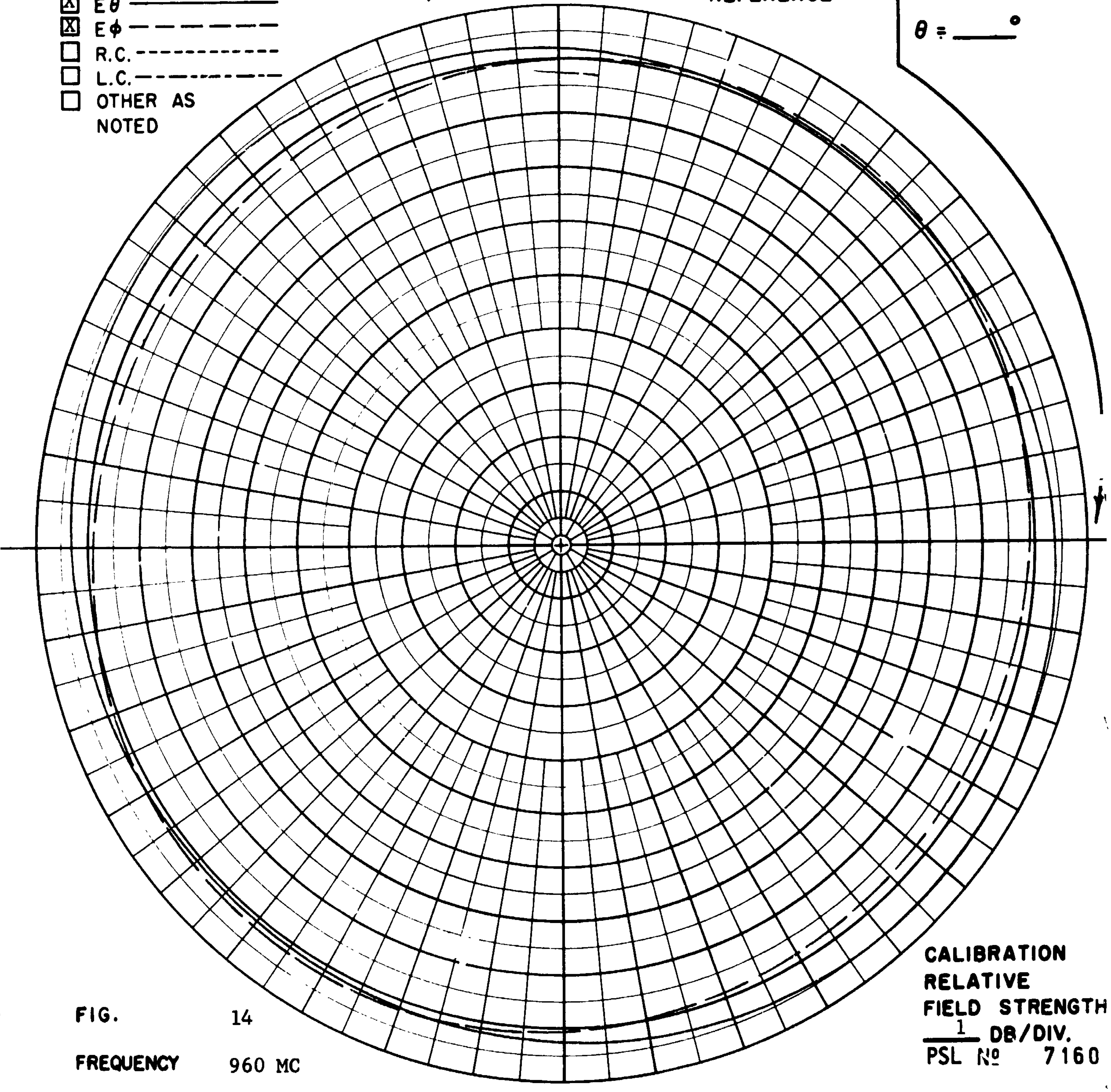
REMARKS

POLARIZATION

☐ GAIN REF -- -- --
☒ Eθ ————————
☒ Eφ — — — — — —
☐ R.C. ------------
☐ L.C. —-—-—-—
☐ OTHER AS NOTED

φ = 90 ° θ = ____ ° COORDINATE REFERENCE

φ = 0 °
θ = ____ °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 7160

FIG.	14
FREQUENCY	960 MC
ANTENNA	CONICAL LOG-SPIRAL
REMARKS	POLARIZATION ELLIPSE.

POLARIZATION

☐ GAIN REF -- -- --
☒ Eθ ———————
☒ Eφ — — — — — —
☐ R.C. ------------
☐ L.C. —-—-—-—-
☐ OTHER AS NOTED

ϕ = ° θ = 0° COORDINATE REFERENCE

ϕ = 0°
θ = 90°

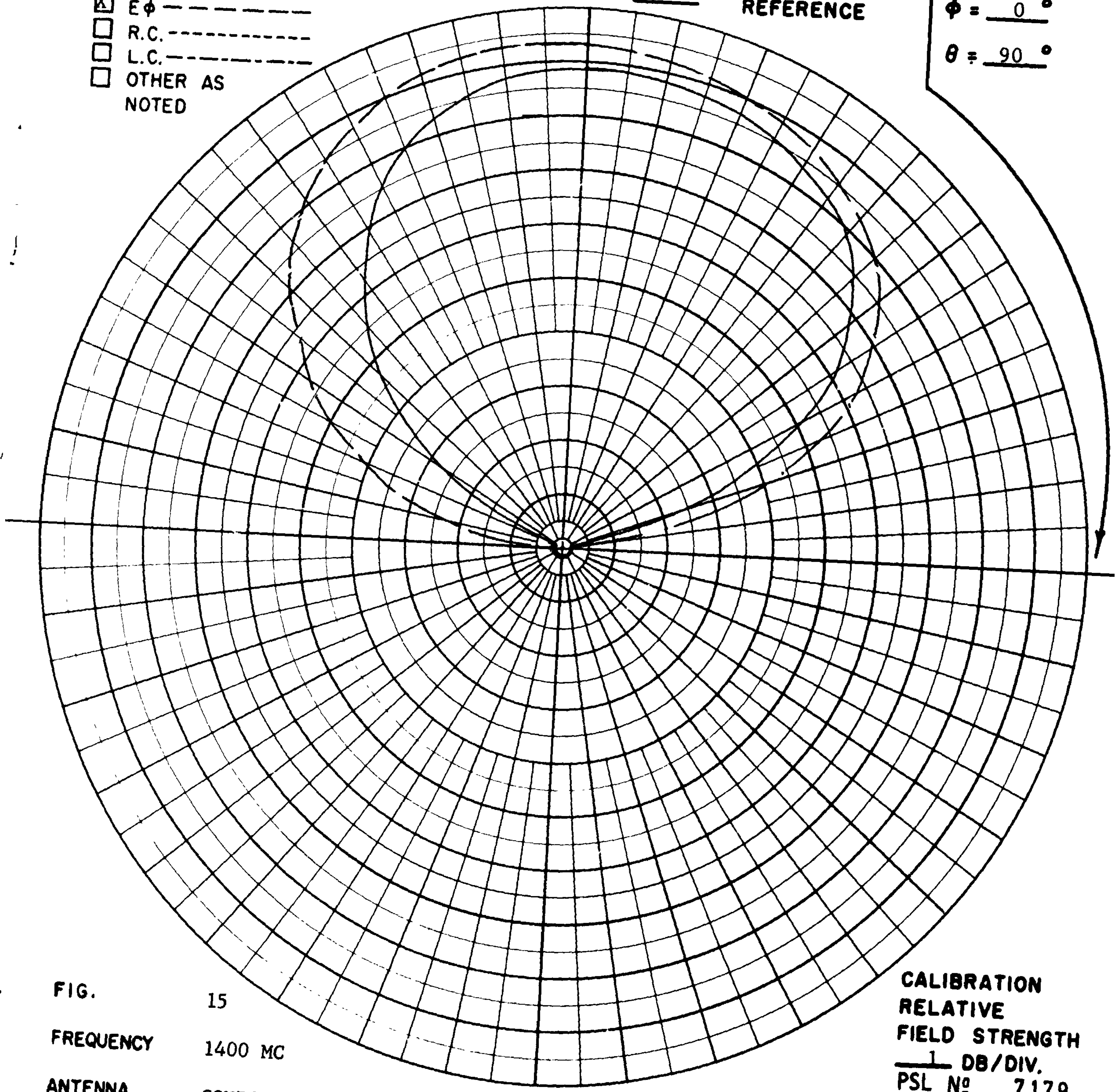


FIG. 15

FREQUENCY 1400 MC

ANTENNA CONICAL LOG-SPIRAL.

REMARKS

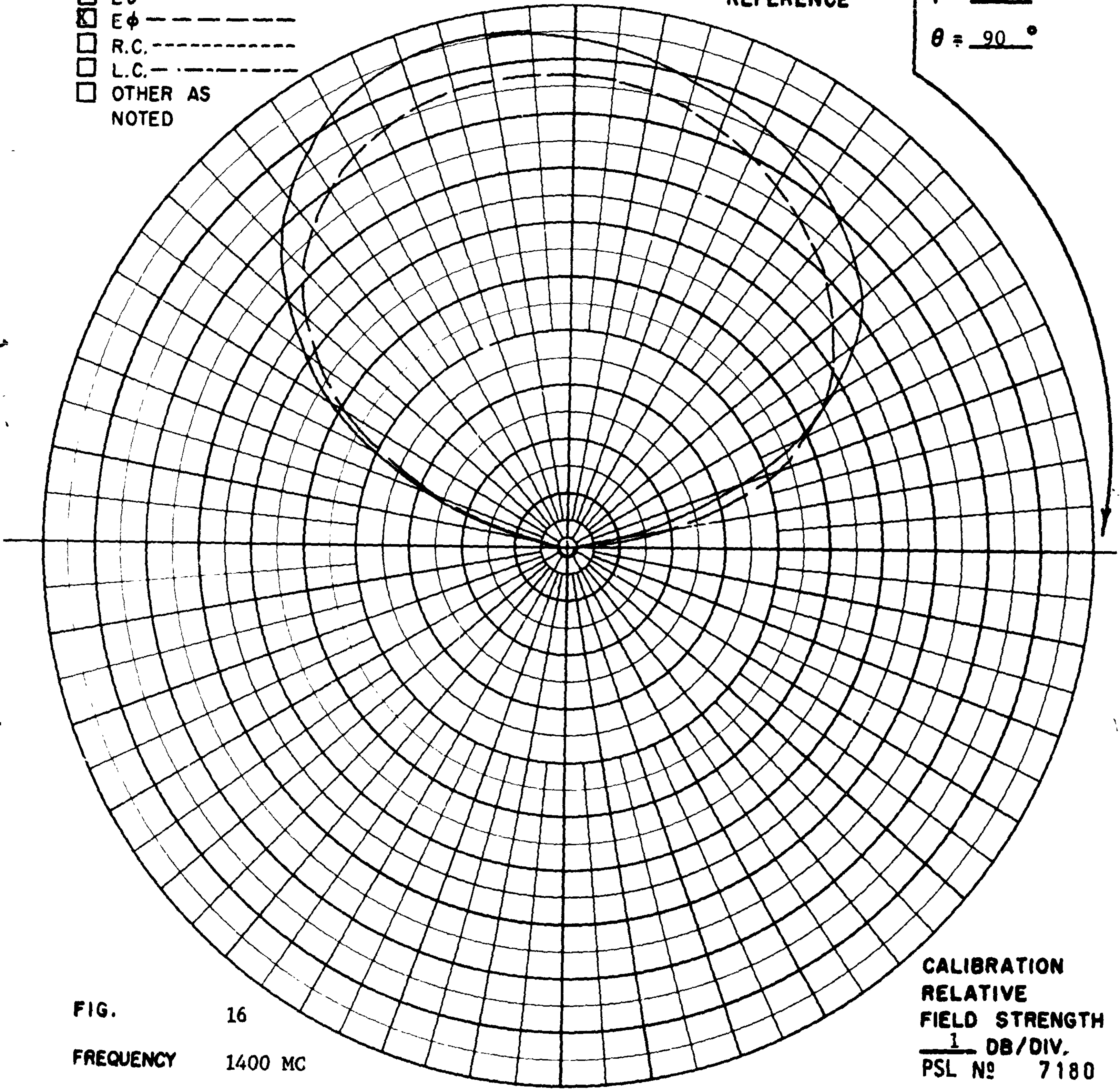
CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL No 7179

POLARIZATION

☐ GAIN REF -- -·- --
☒ Eθ ————
☒ Eφ — — — —
☐ R.C. ------------
☐ L.C. —·——·—
☐ OTHER AS NOTED

φ = ____° θ = 0° COORDINATE REFERENCE

φ = 90°
θ = 90°



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 7180

FIG. 16

FREQUENCY 1400 MC

ANTENNA CONICAL LOG-SPIRAL.

REMARKS

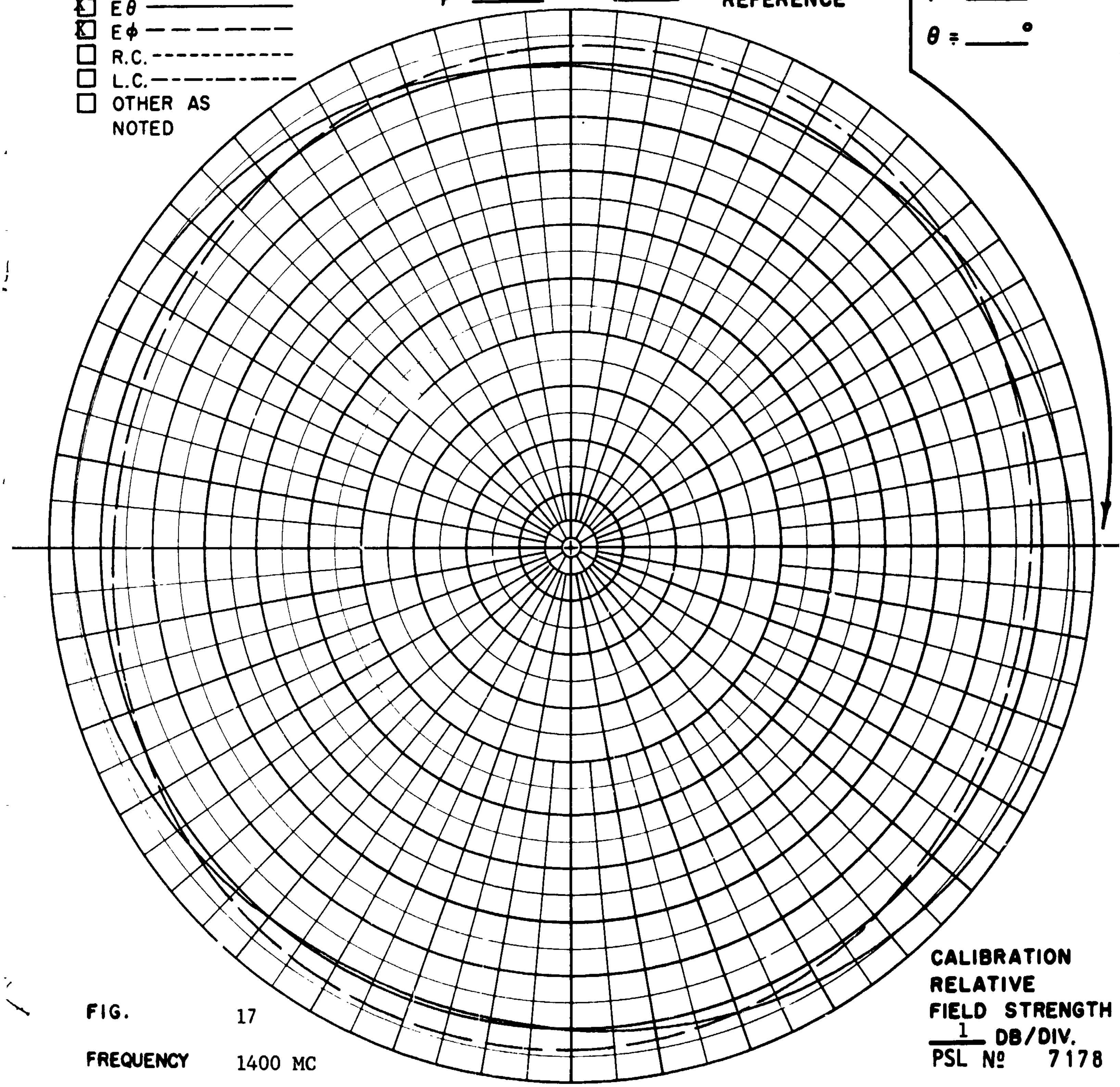
POLARIZATION

☐ GAIN REF
☒ Eθ
☒ Eφ
☐ R.C.
☐ L.C.
☐ OTHER AS NOTED

φ = 90 ° θ = ____ °

COORDINATE REFERENCE

φ = 0 °
θ = ____ °



CALIBRATION RELATIVE FIELD STRENGTH
1 DB/DIV.
PSL № 7178

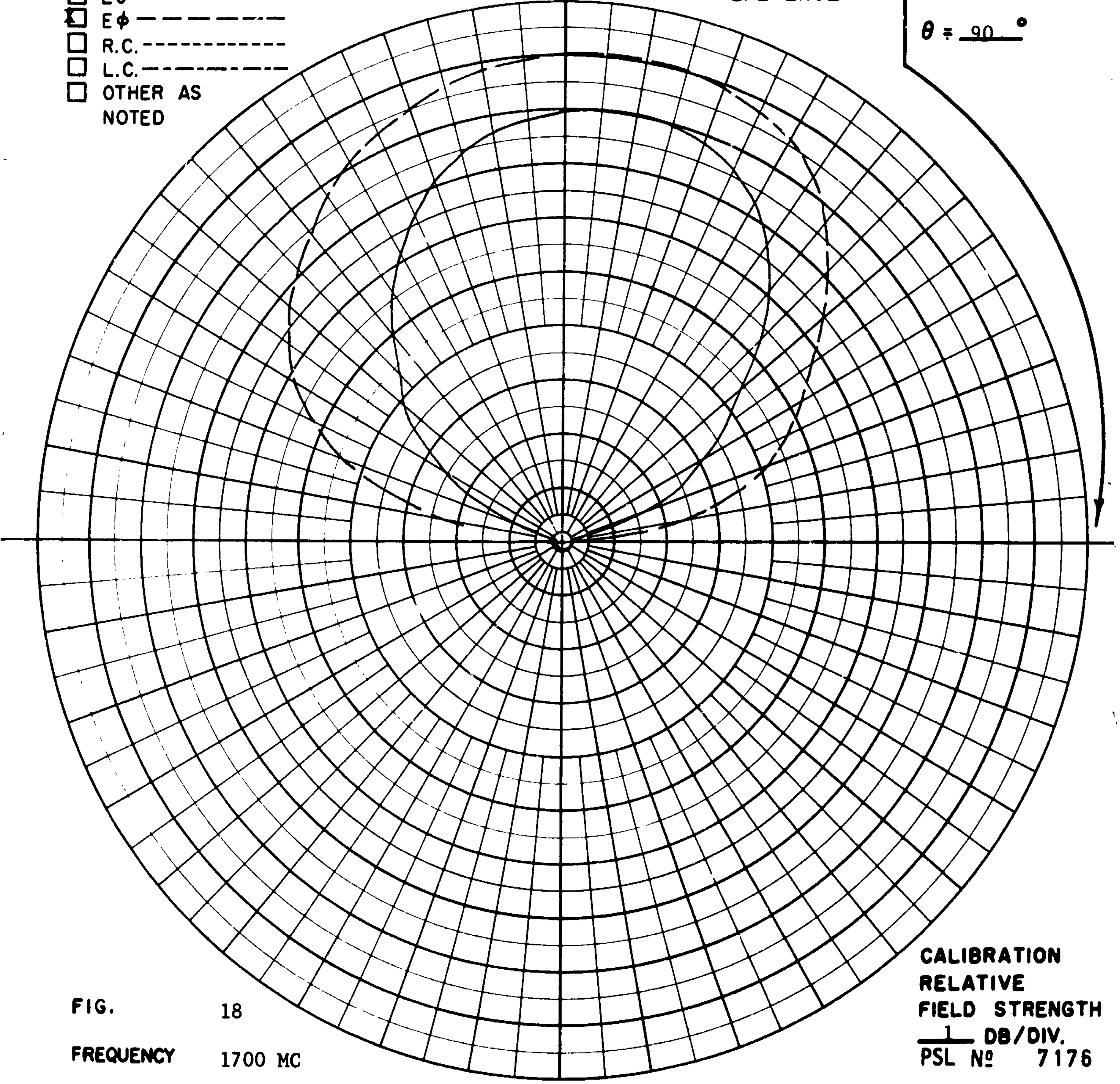
FIG.	17
FREQUENCY	1400 MC
ANTENNA	CONICAL LOG-SPIRAL
REMARKS	POLARIZATION ELLIPSE.

POLARIZATION

☐ GAIN REF -- -- --
☒ Eθ ————
☒ Eφ — — — — —
☐ R.C. ------------
☐ L.C. —-—-—-—-
☐ OTHER AS NOTED

φ = _____ ° θ = 0 ° COORDINATE REFERENCE

φ = 0 °
θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 7176

FIG. 18

FREQUENCY 1700 MC

ANTENNA CONICAL LOG-SPIRAL.

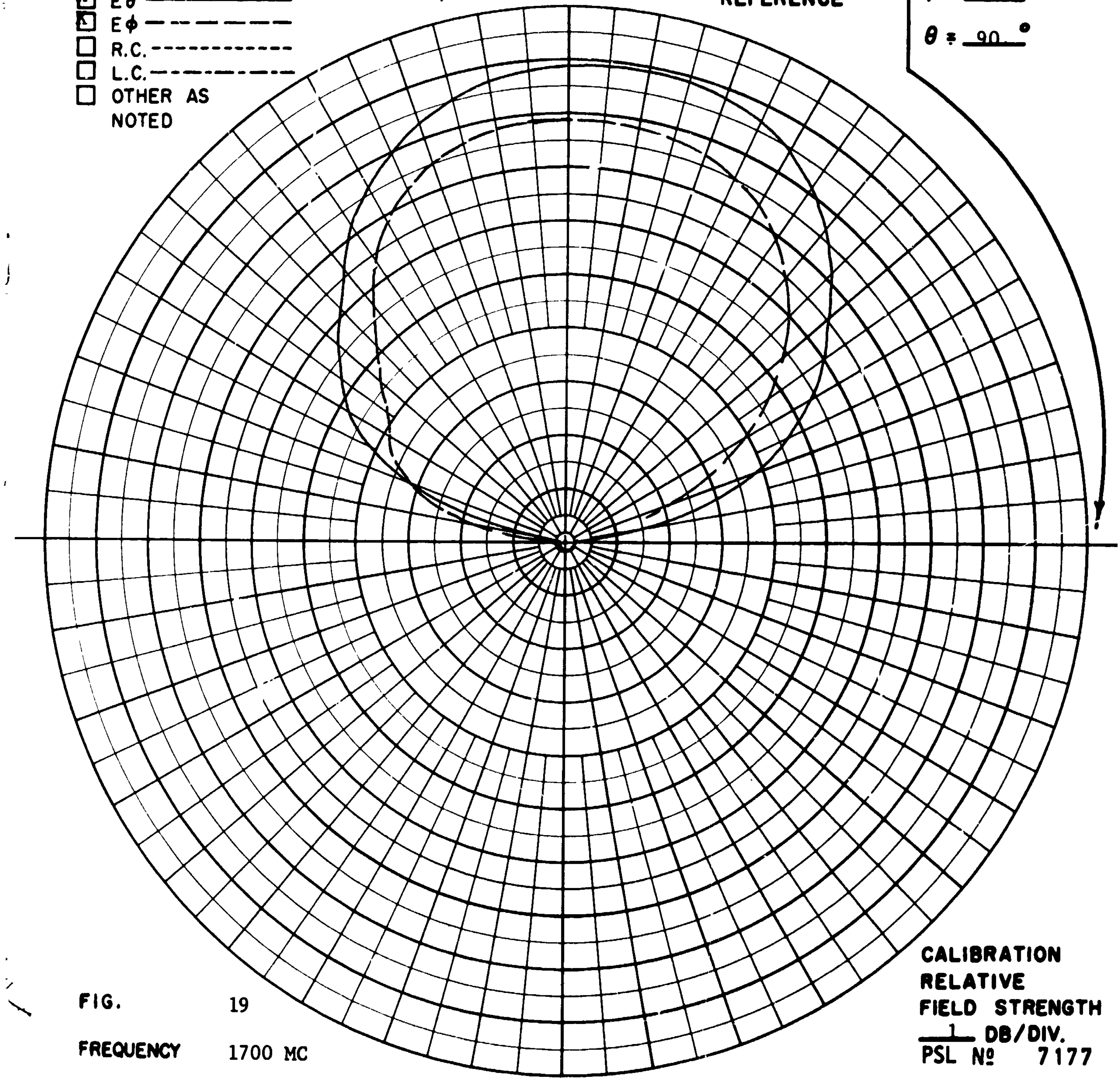
REMARKS

POLARIZATION

☐ GAIN REF -- -- --
☒ Eθ ————
☒ Eϕ — — — — —
☐ R.C. ------------
☐ L.C. —-—-—-—
☐ OTHER AS NOTED

ϕ = _____° θ = 0° COORDINATE REFERENCE

ϕ = 90°
θ = 90°



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 7177

FIG. 19

FREQUENCY 1700 MC

ANTENNA CONICAL LOG-SPIRAL.

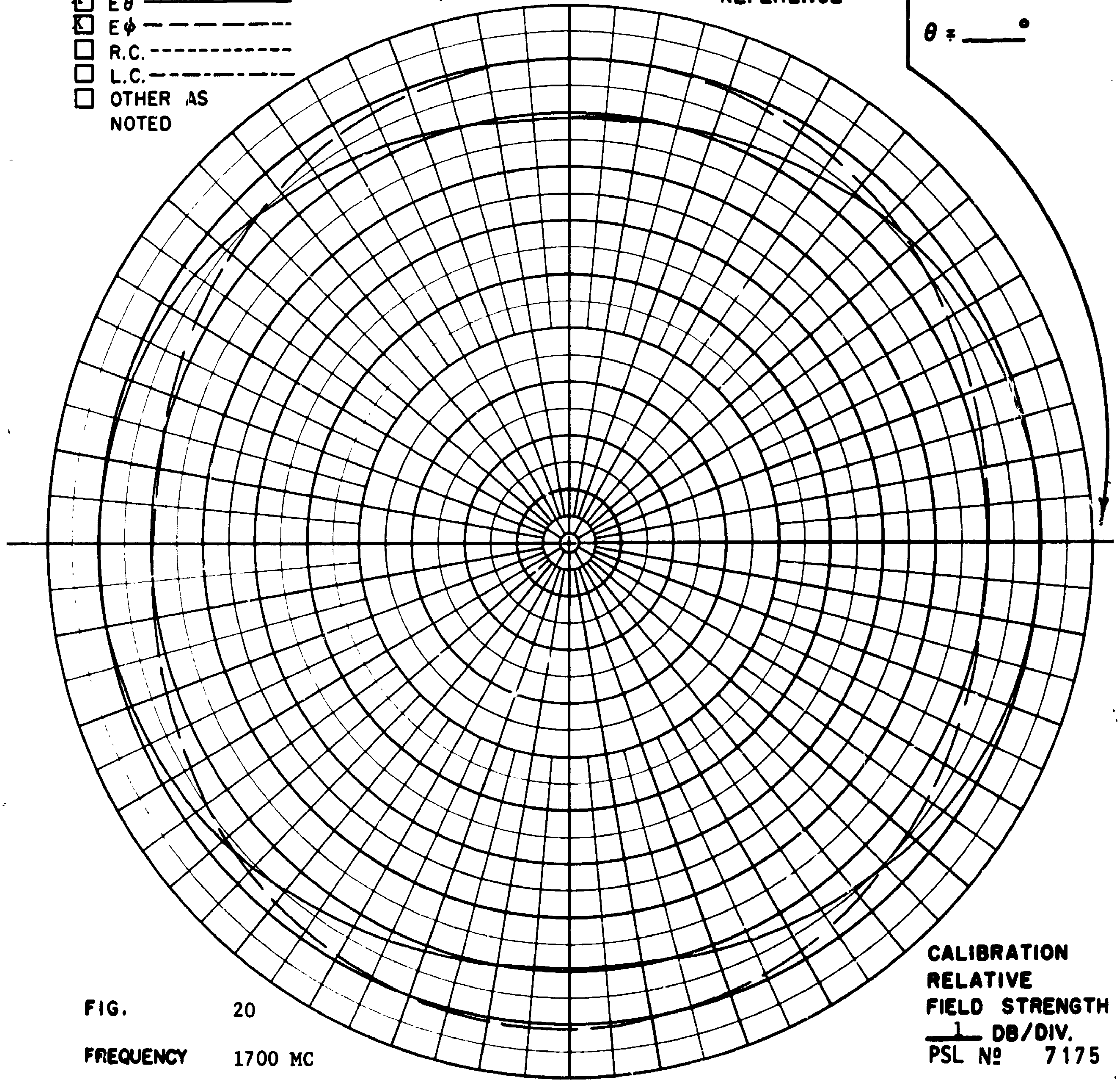
REMARKS

POLARIZATION

☐ GAIN REF -- -- --
☒ Eθ ————————
☒ Eφ — — — — — — —
☐ R.C. - - - - - - - - - - - -
☐ L.C. — - — - — - — -
☐ OTHER AS NOTED

φ = ____ ° θ = ____ ° COORDINATE REFERENCE

φ = ____ °
θ = ____ °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 7175

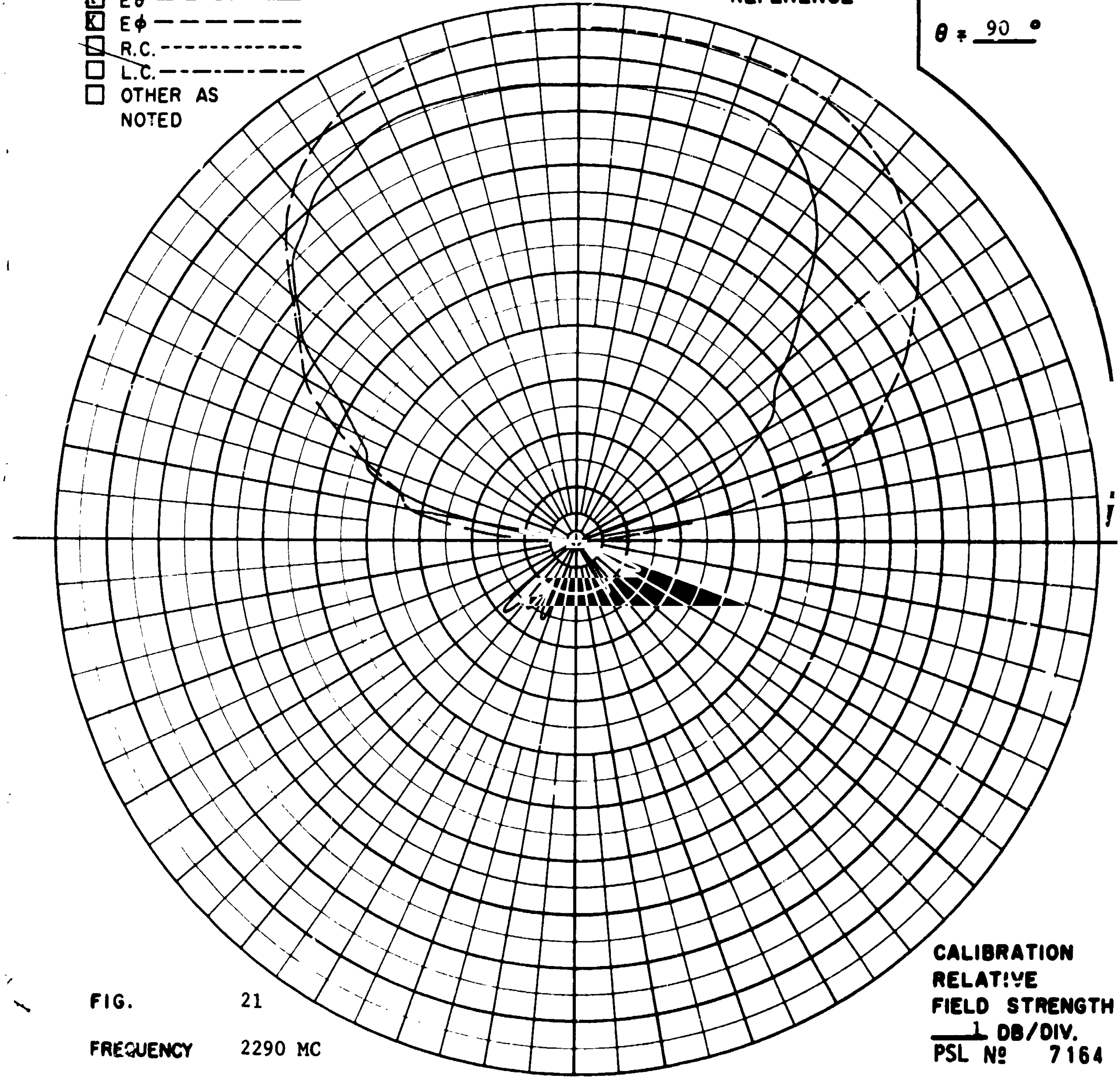
FIG.	20
FREQUENCY	1700 MC
ANTENNA	CONICAL LOG-SPIRAL.
REMARKS	POLARIZATION ELLIPSE.

POLARIZATION

☐ GAIN REF - - - - - -
☒ Eθ ————————
☒ Eφ — — — — — —
☐ R.C. - - - - - - - - - - - -
☐ L.C. —-—-—-—-
☐ OTHER AS NOTED

φ = ____ ° θ = 0 ° COORDINATE REFERENCE

φ = 0 °
θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL Nº 7164

FIG. 21

FREQUENCY 2290 MC

ANTENNA CONICAL LOG-SPIRAL.

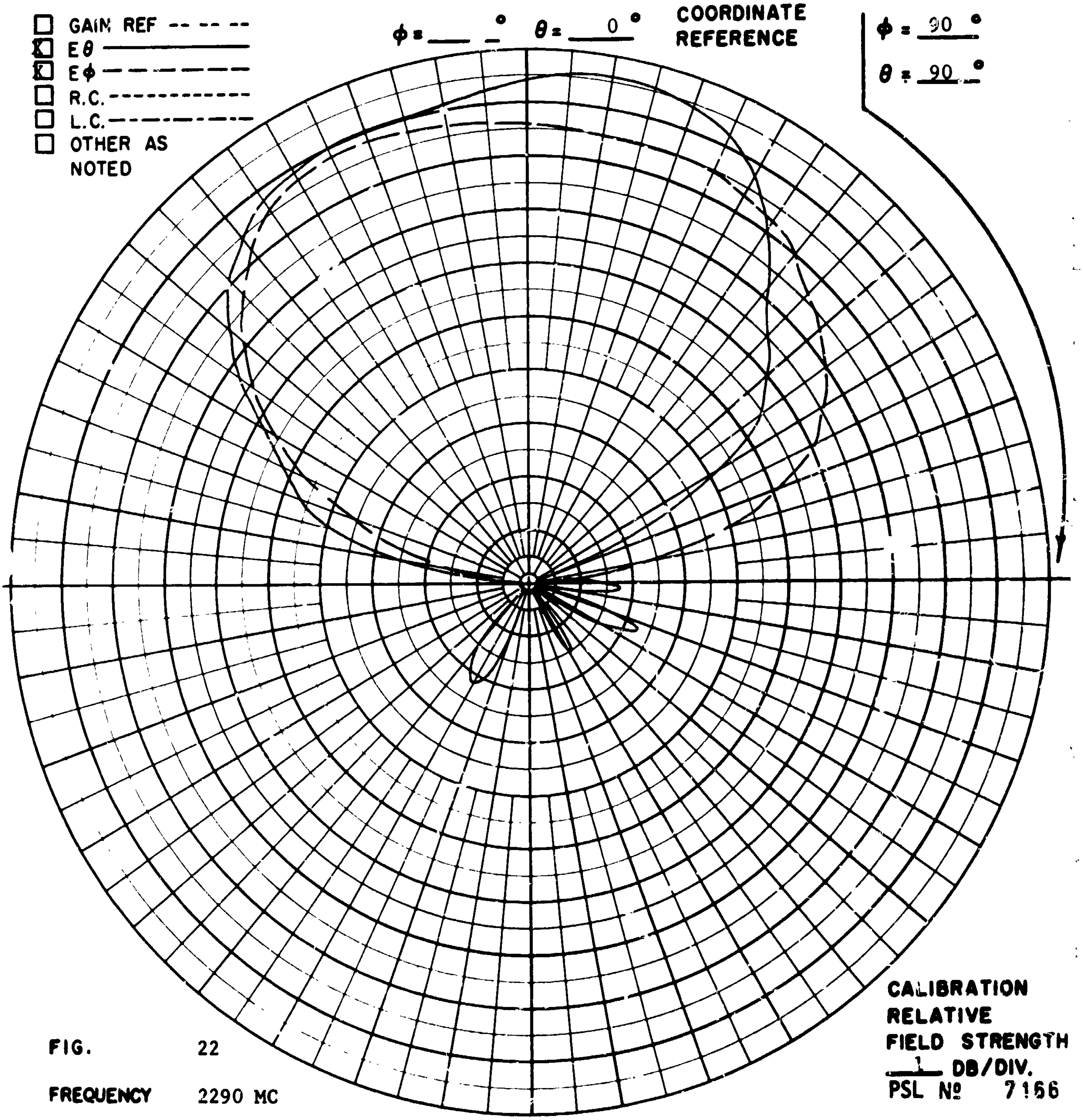
REMARKS

POLARIZATION

☐ GAIN REF -- -- --
☒ Eθ ————
☒ Eφ — — — —
☐ R.C. ------------
☐ L.C. —-—-—-—
☐ OTHER AS NOTED

φ = ____ ° θ = 0 ° COORDINATE REFERENCE

φ = 90 °
θ = 90 °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL Nº 7166

FIG. 22

FREQUENCY 2290 MC

ANTENNA CONICAL LOG-SPIRAL.

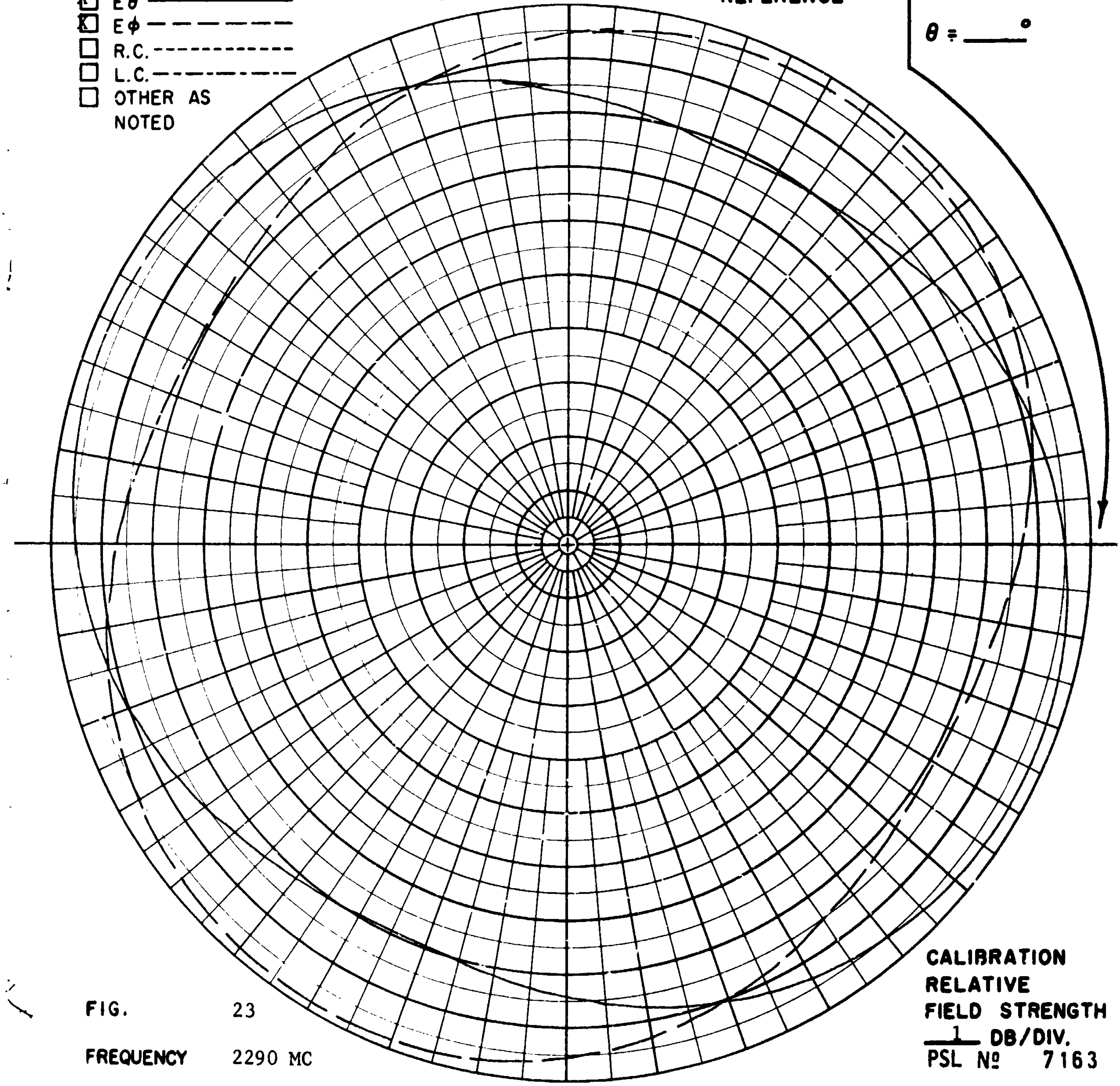
REMARKS

POLARIZATION

☐ GAIN REF -- -- --
☒ Eθ ————
☒ Eφ — — — — —
☐ R.C.-----------
☐ L.C.—-—-—-—-
☐ OTHER AS NOTED

φ = 90 ° θ = ____ ° COORDINATE REFERENCE

φ = 0 °
θ = ____ °



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 7163

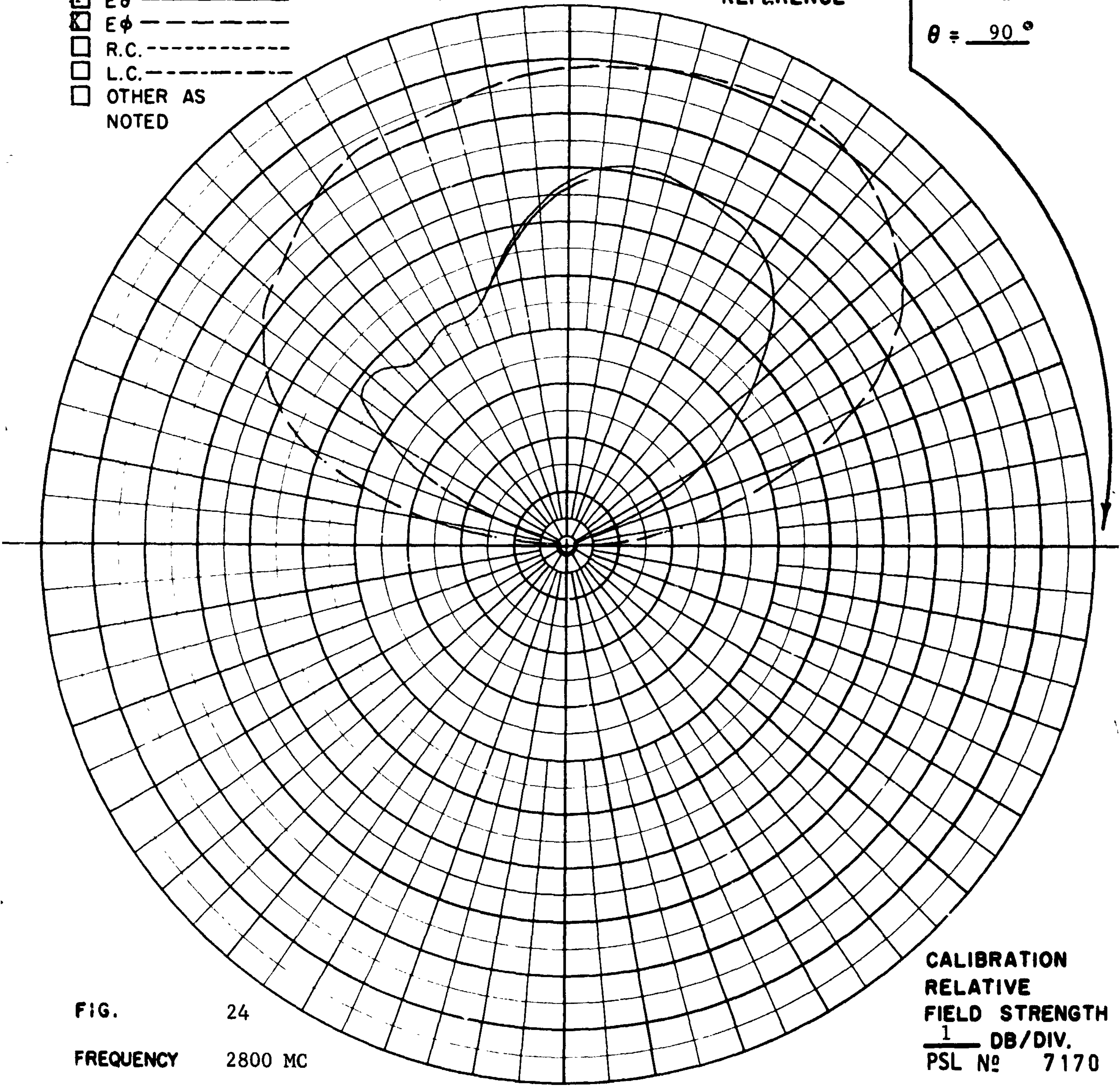
FIG.	23
FREQUENCY	2290 MC
ANTENNA	CONICAL LOG-SPIRAL.
REMARKS	POLARIZATION ELLIPSE.

POLARIZATION

☐ GAIN REF -- -- --
☒ Eθ ————————
☒ Eφ — — — — — —
☐ R.C. ------------
☐ L.C. ——-——-——-
☐ OTHER AS NOTED

φ = ______° θ = 0° COORDINATE REFERENCE

φ = 0°
θ = 90°



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 7170

FIG. 24

FREQUENCY 2800 MC

ANTENNA CONICAL LOG-SPIRAL.

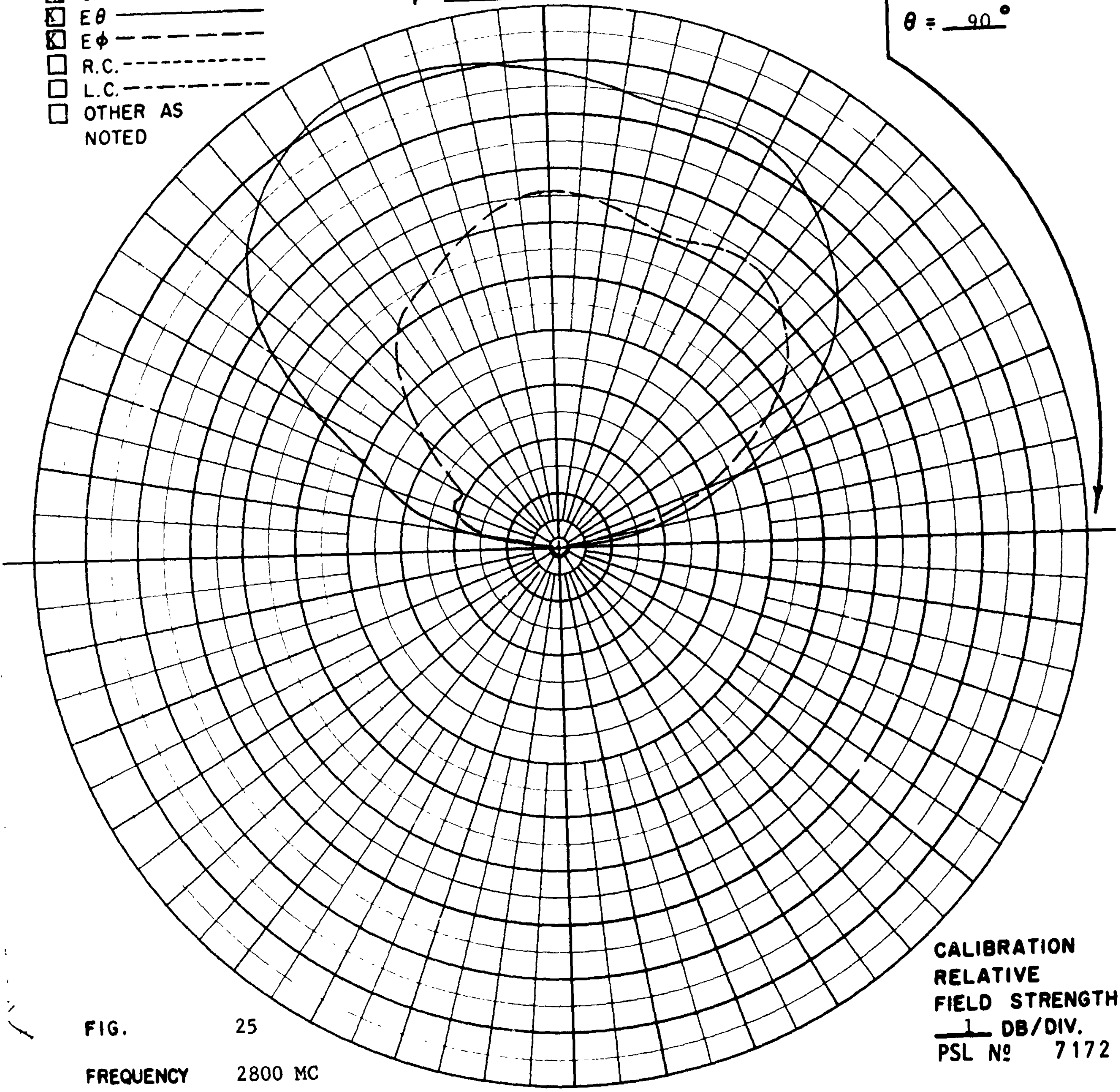
REMARKS

POLARIZATION

☐ GAIN REF -- -- --
☒ Eθ ————————
☒ Eφ — — — — — —
☐ R.C. ------------
☐ L.C. -·-·-·-·-·-
☐ OTHER AS NOTED

φ = ____° θ = 0° COORDINATE REFERENCE

φ = 90°
θ = 90°



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL Nº 7172

FIG. 25

FREQUENCY 2800 MC

ANTENNA CONICAL LOG-SPIRAL.

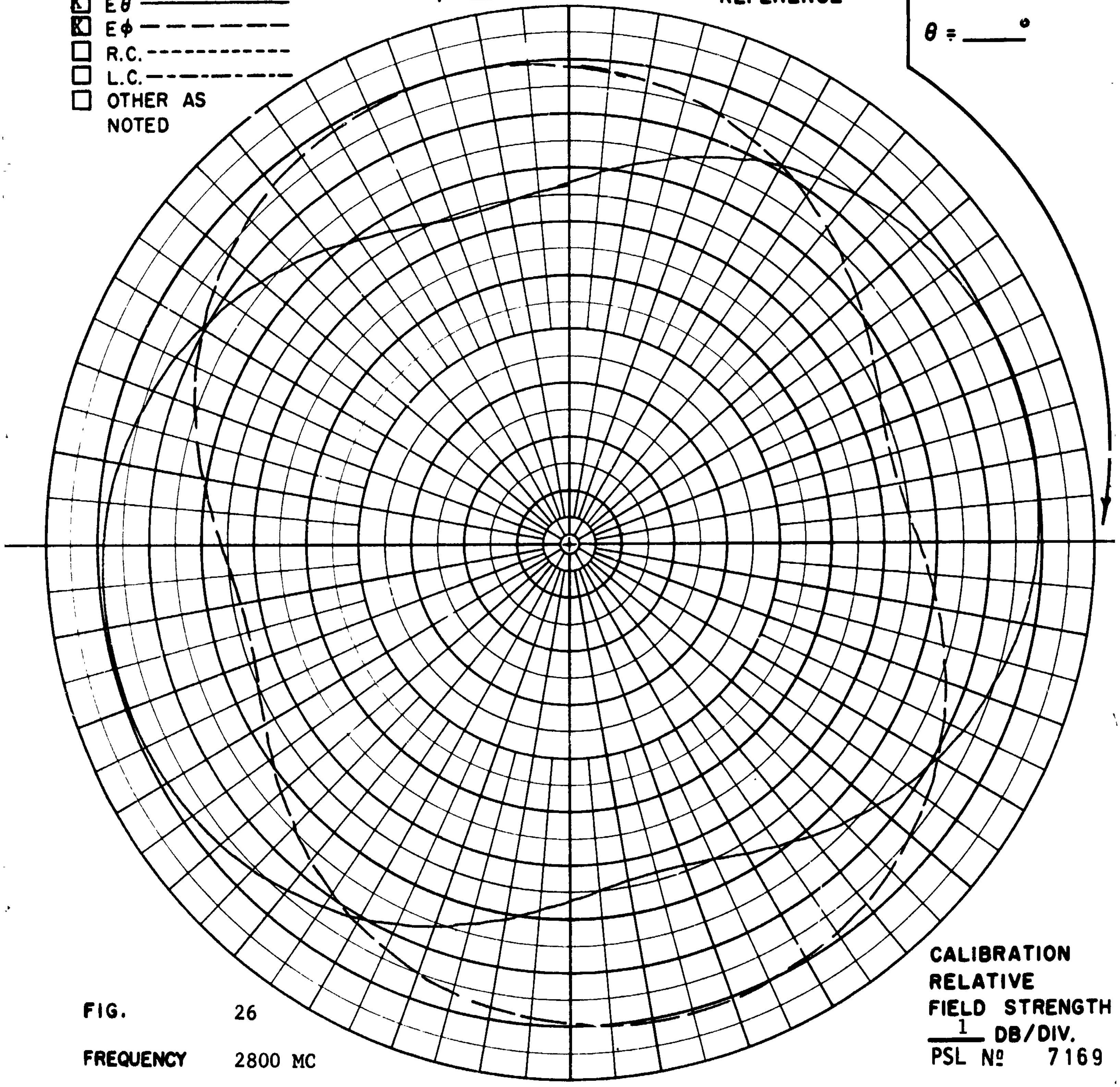
REMARKS

POLARIZATION

☐ GAIN REF -- -- --
☒ Eθ ————————
☒ Eφ — — — — — —
☐ R.C. ------------
☐ L.C. -·-·-·-·-·-
☐ OTHER AS NOTED

ϕ = 90° θ = ____° COORDINATE REFERENCE

ϕ = 0°
θ = ____°



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.
PSL № 7169

FIG.	26
FREQUENCY	2800 MC
ANTENNA	CONICAL LOG-SPIRAL.
REMARKS	POLARIZATION ELLIPSE.

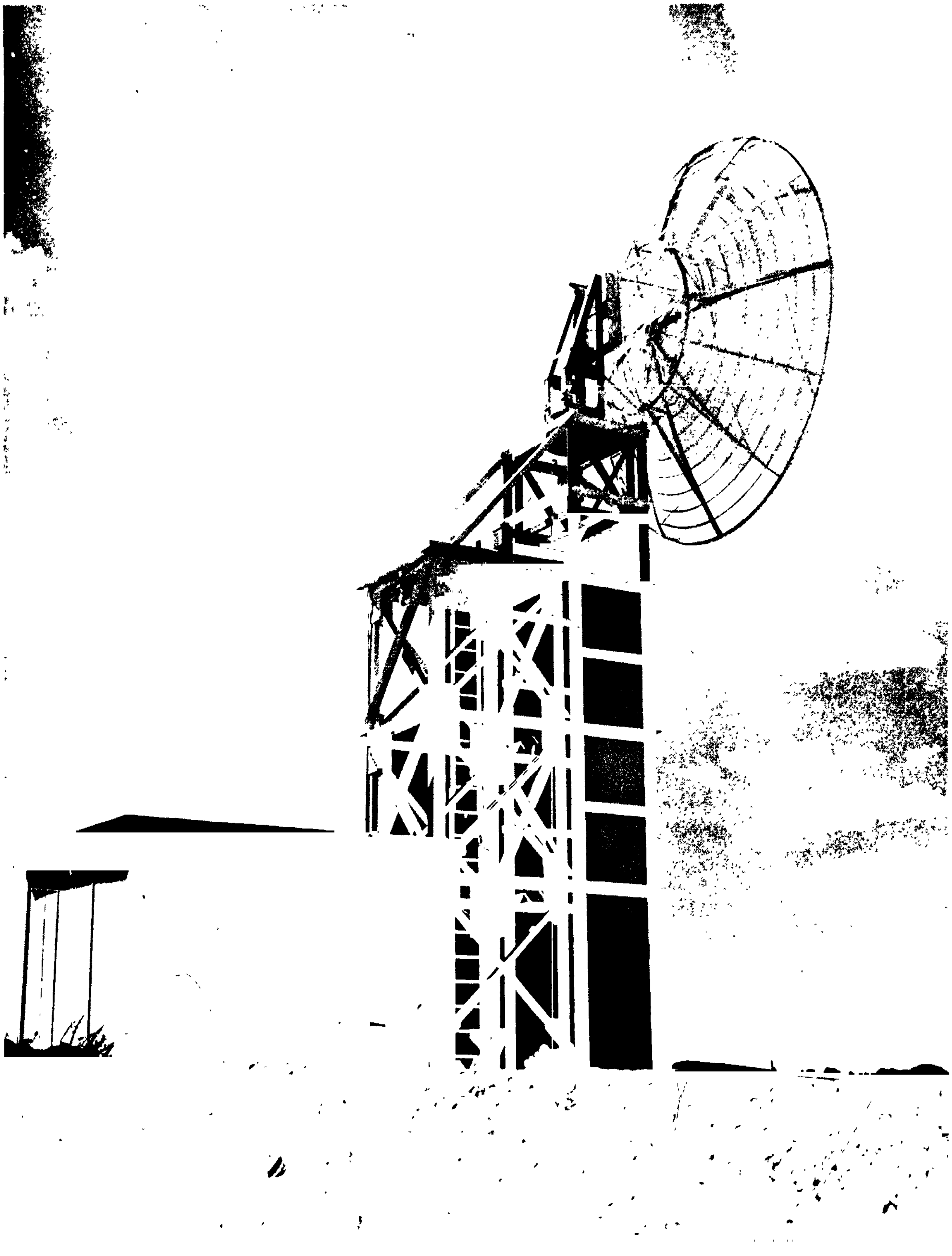


FIG. 27 - 19 FOOT PARABOLIC REFLECTOR ON ROTATOR

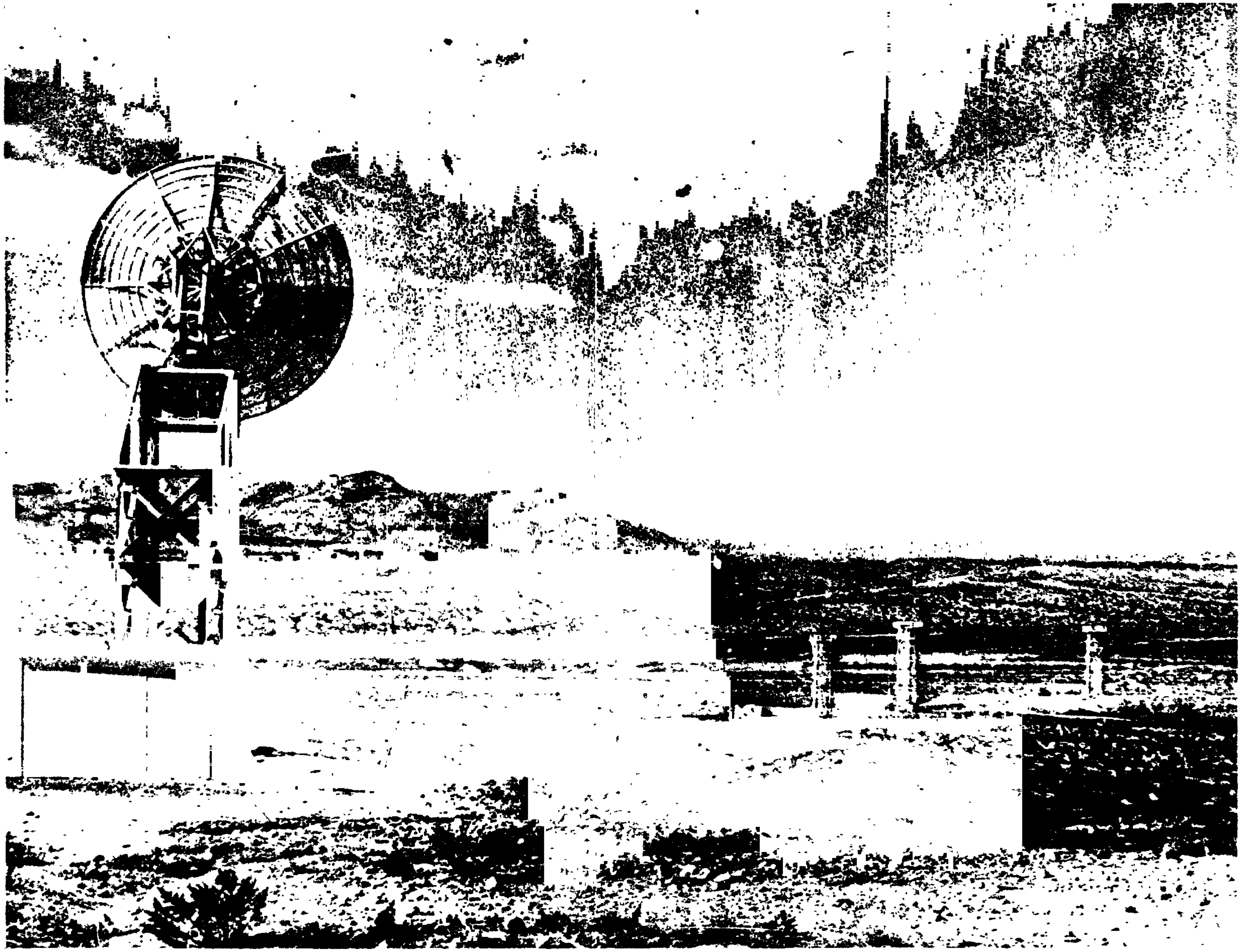


FIG. 28 - VIEW OF 3000 FOOT RANGE

FIG. 29 - CONICAL SPIRAL MOUNTED IN REFLECTOR

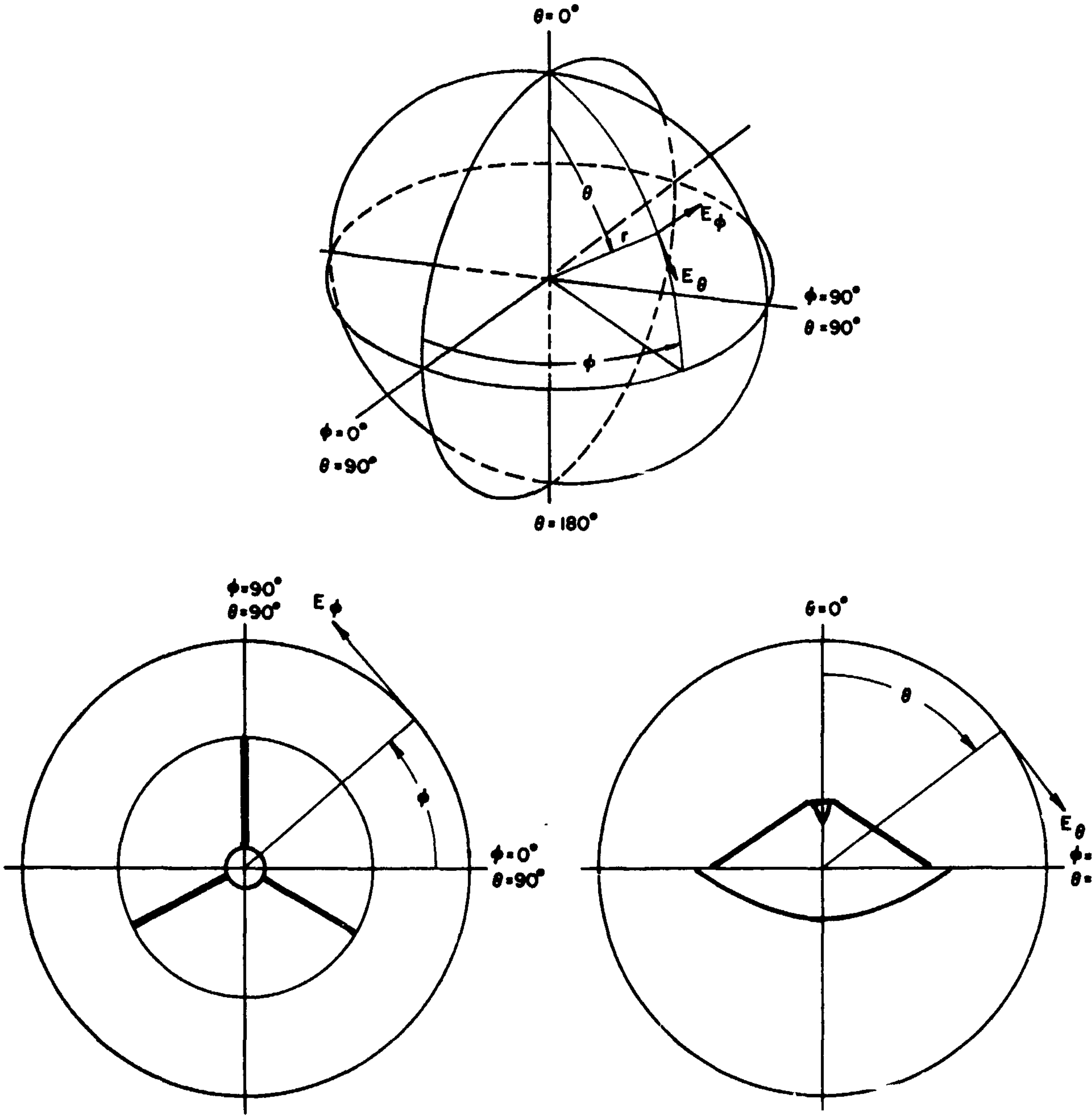


FIG. 30 - COORDINATE SYSTEM FOR 19 FOOT REFLECTOR

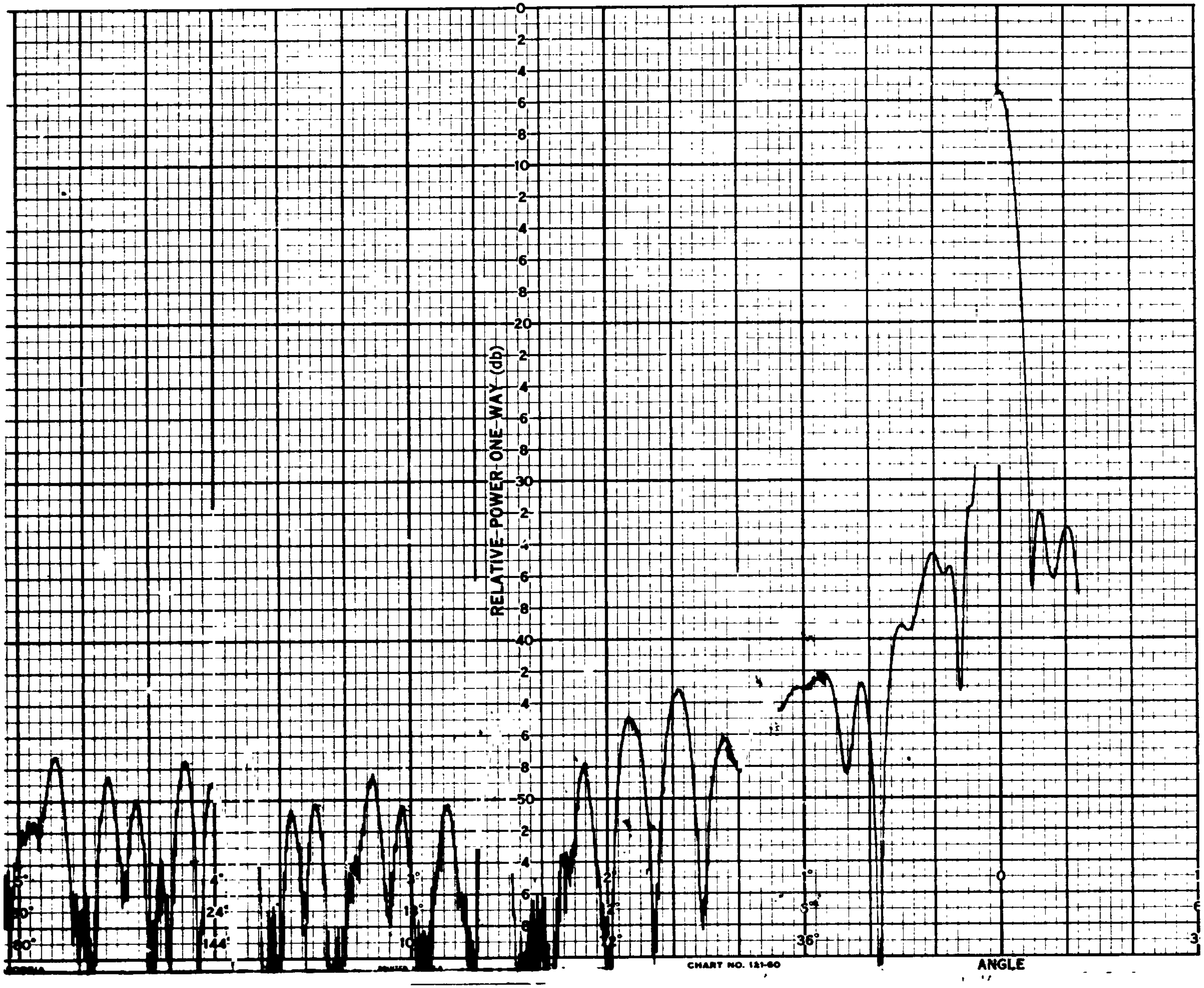


FIG. 31 - 960 MC, Eθ, FEED NOT TILTED

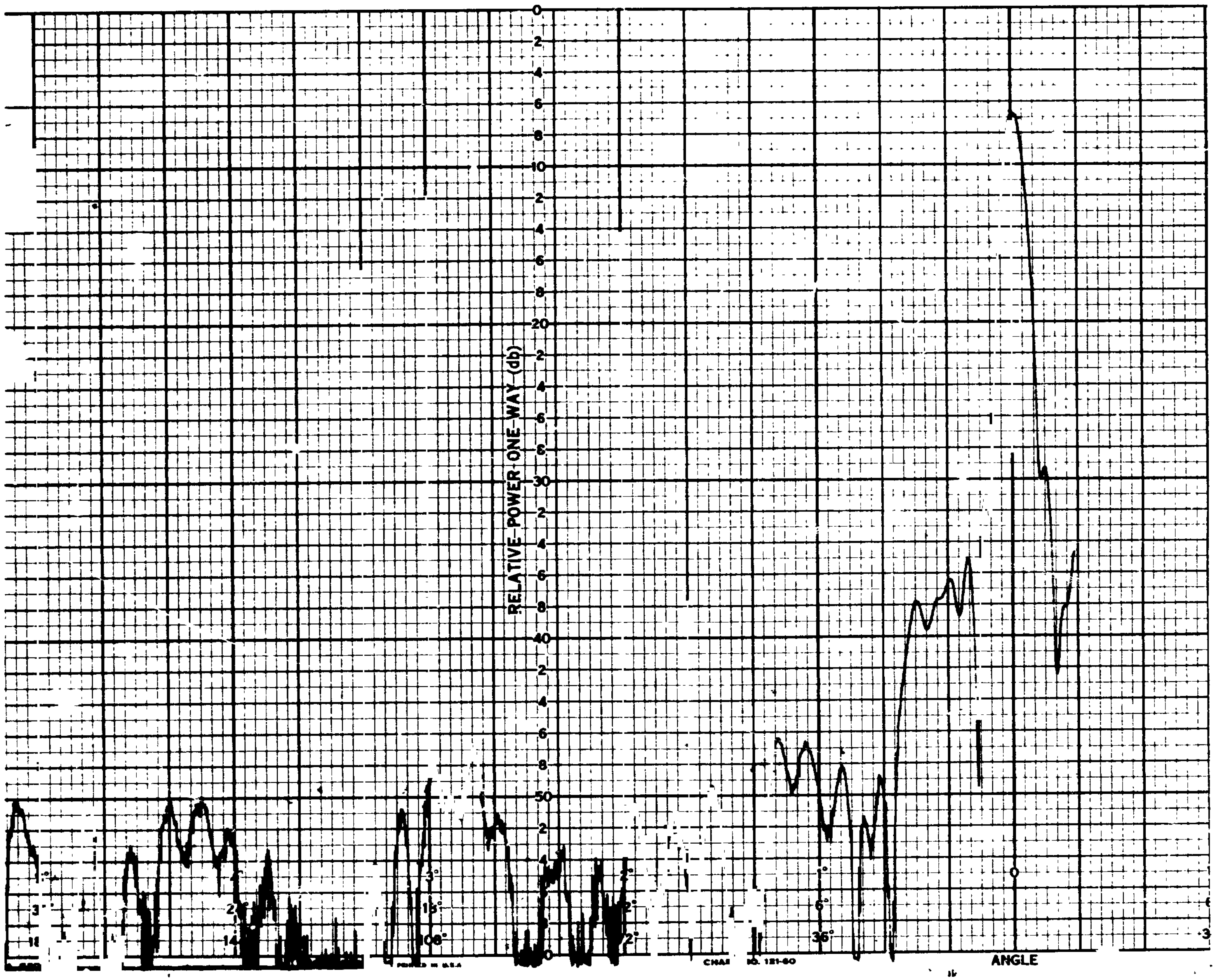


FIG. 32 - 960 MC, Eϕ, FEED NOT TILTED

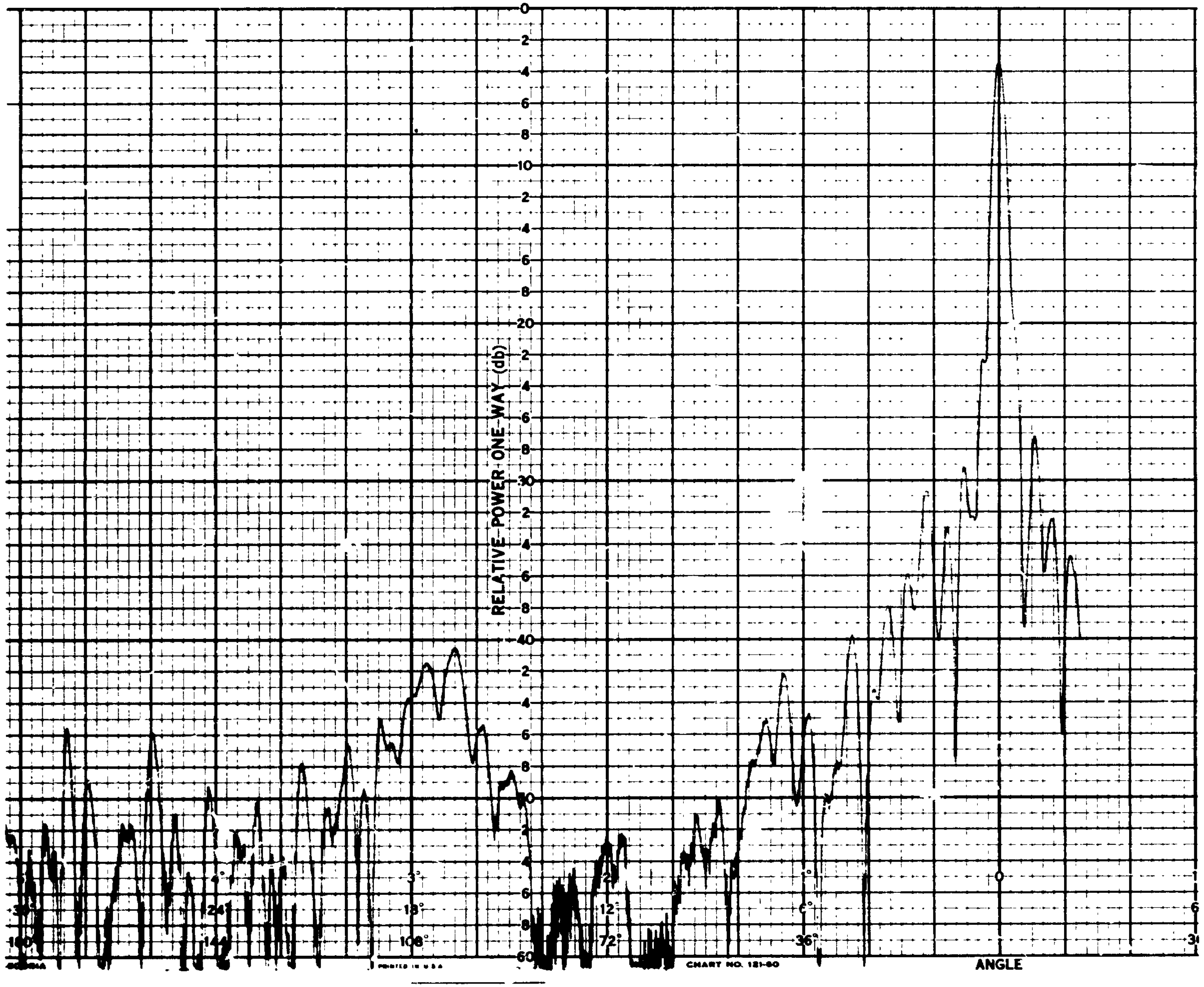


FIG. 33 - 1700 MC, Eθ, FEED NOT TILTED

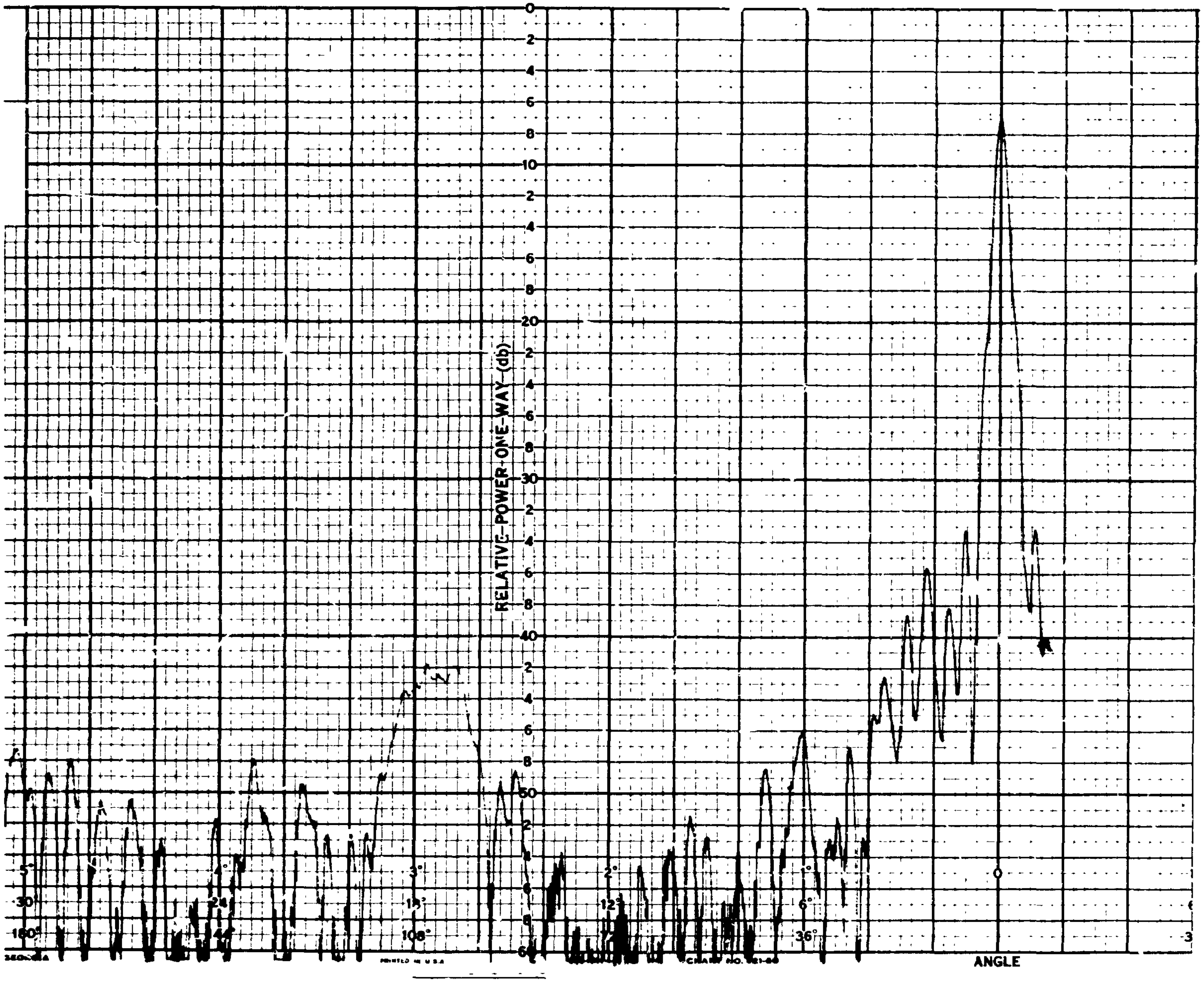


FIG. 34 - 1700 MC, Eϕ, FEED NOT TILTED

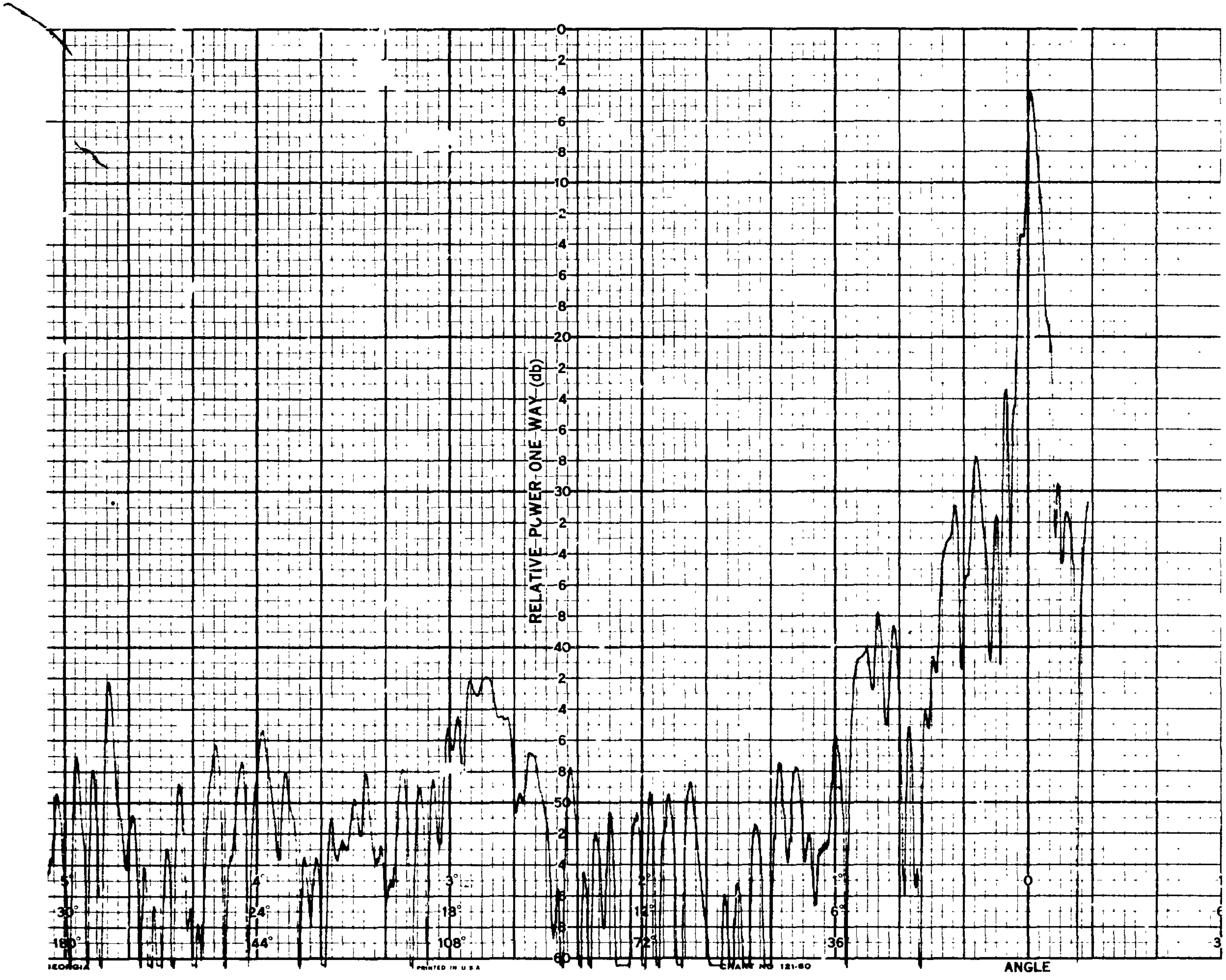


FIG. 35 - 2290 MC, Eθ, FEED NOT TILTED

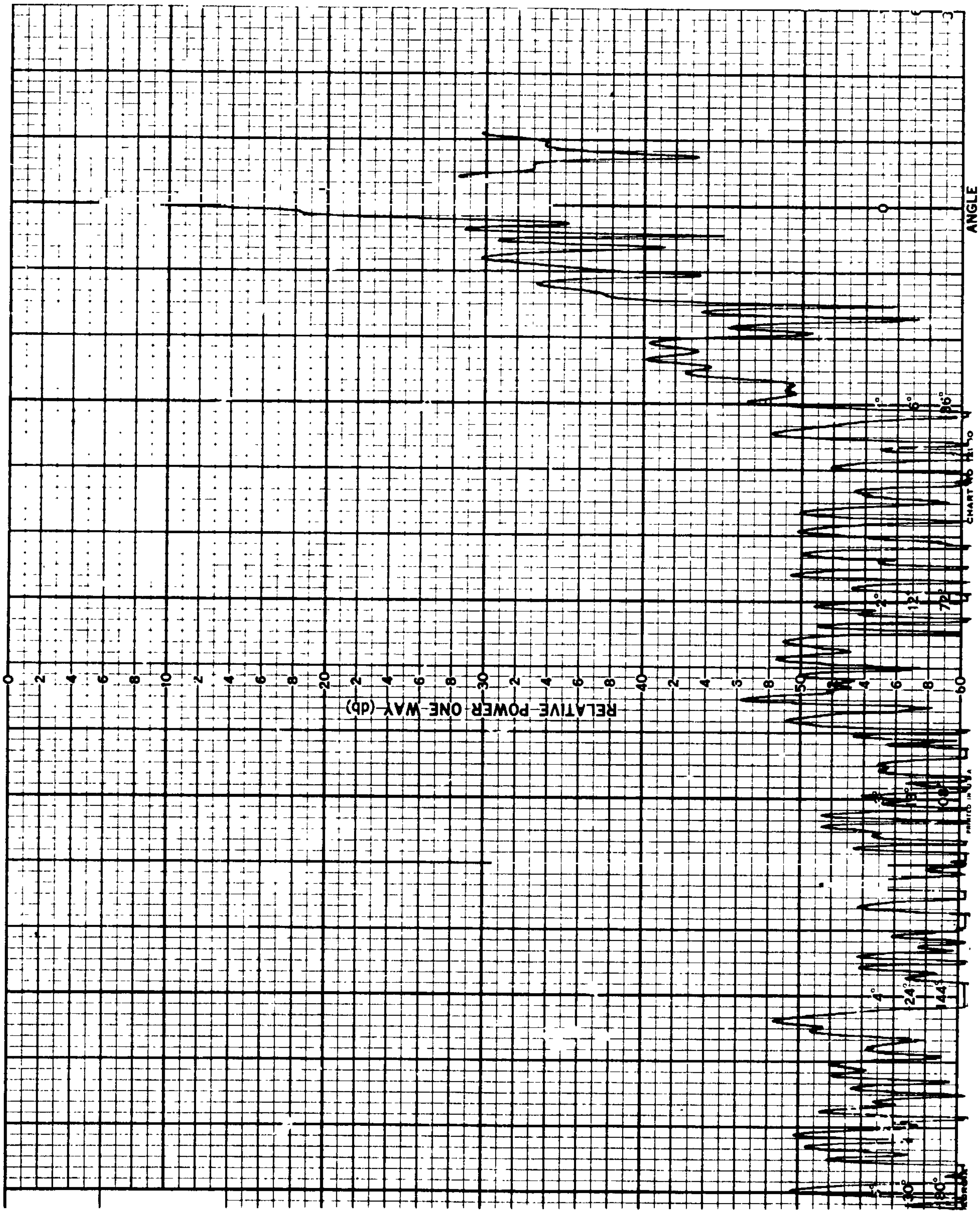


FIG. 36 - 2290 MC, EΦ, FEED NOT TILTED

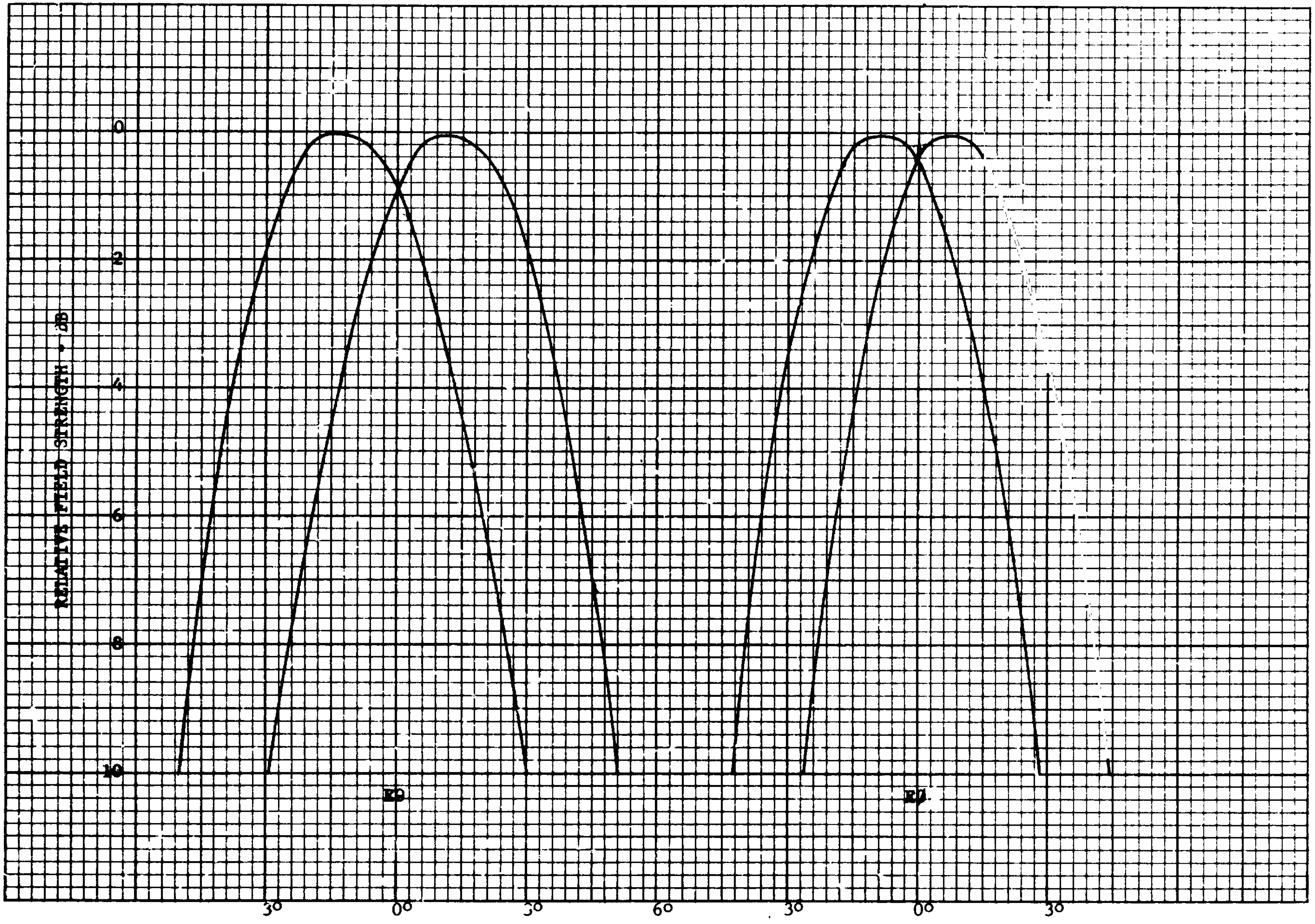


FIG. 37 - MODULATION LEVEL FOR 860 MC, 15° FEED TILT

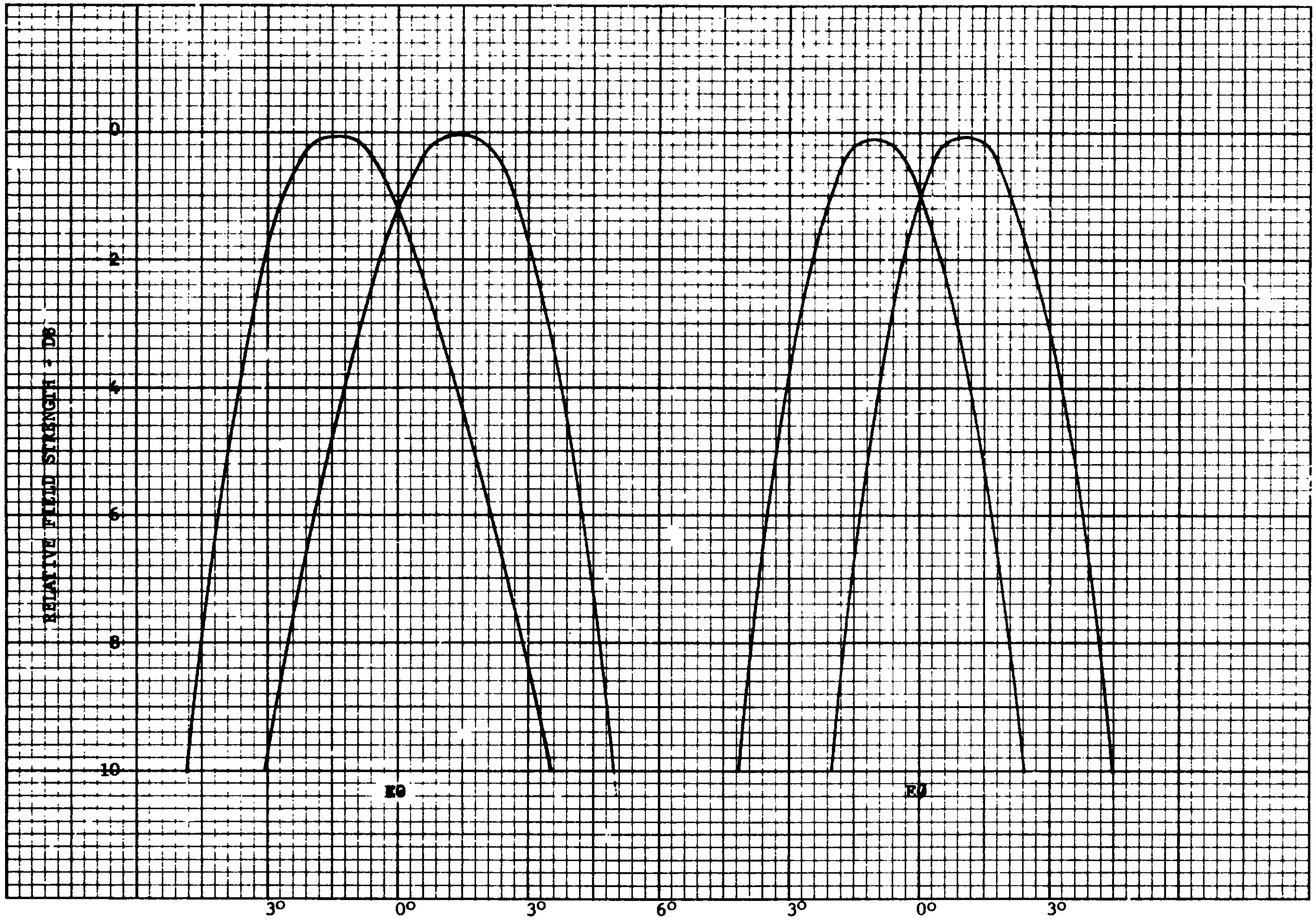


FIG. 38 - MODULATION LEVEL FOR 900 MC, 15° FEED TILT

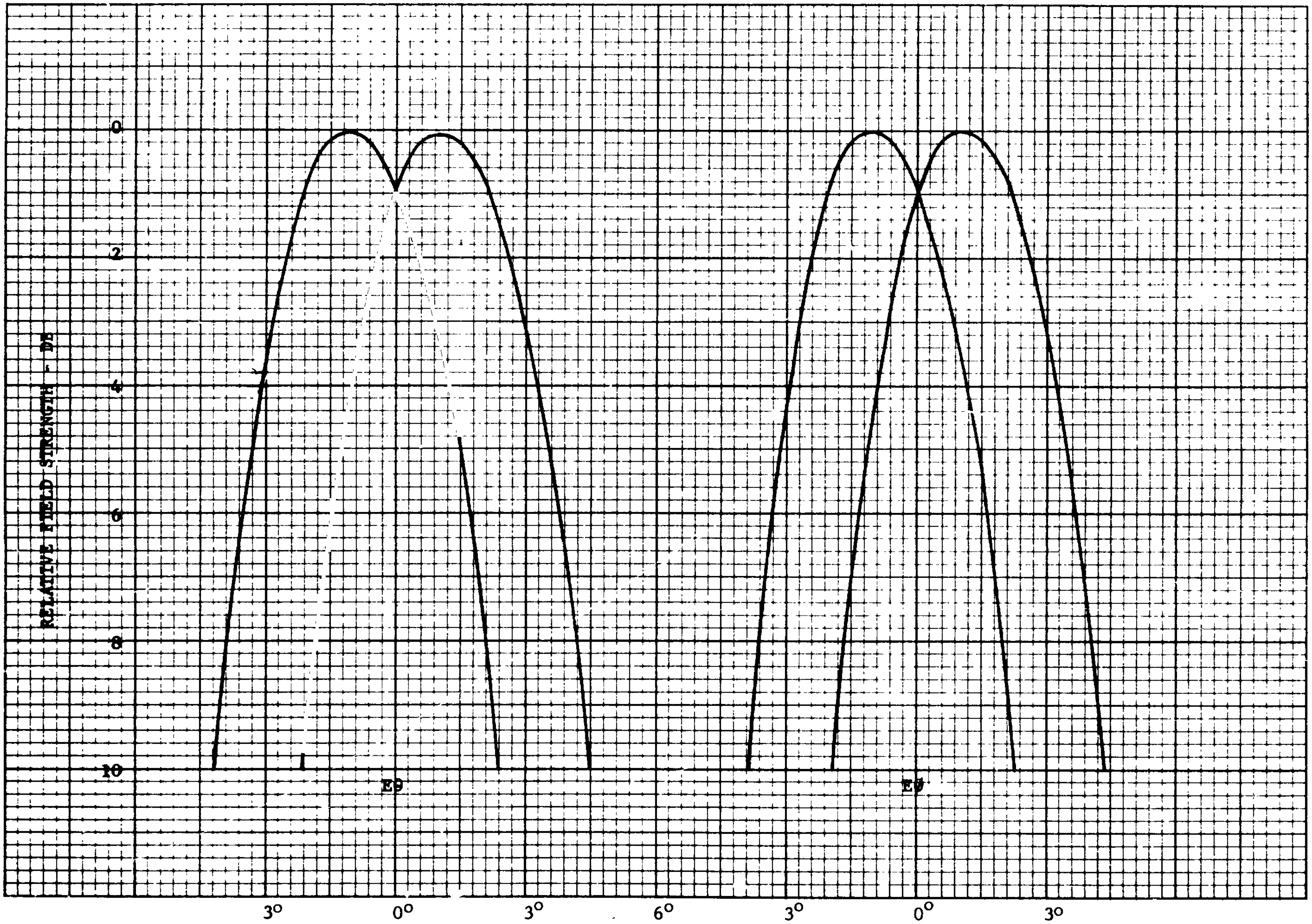


FIG. 39 - MODULATION LEVEL FOR 960 MC, 15° FEED TILT

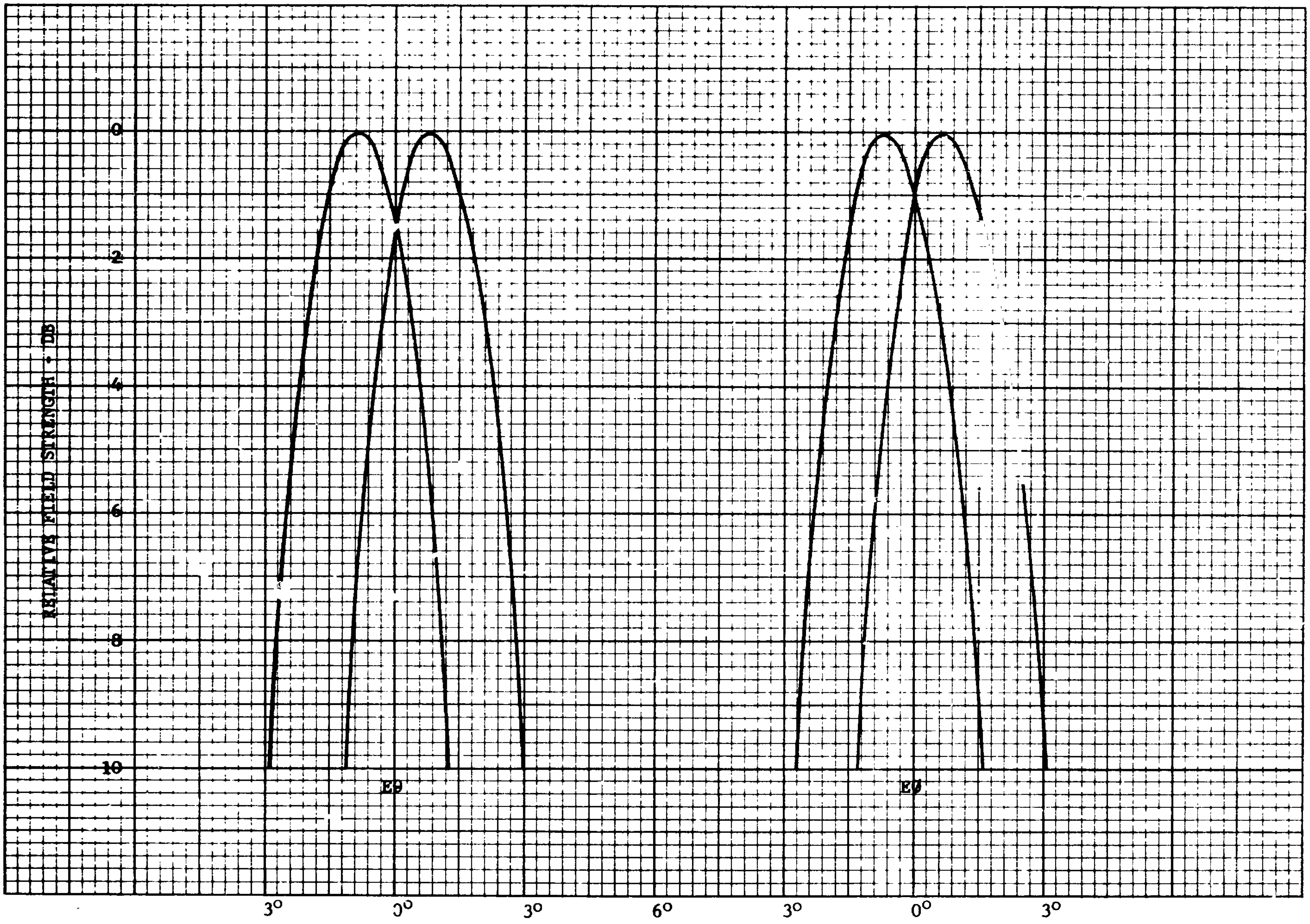


FIG. 40 - MODULATION LEVEL FOR 1400 MC, 15° FEED TILT

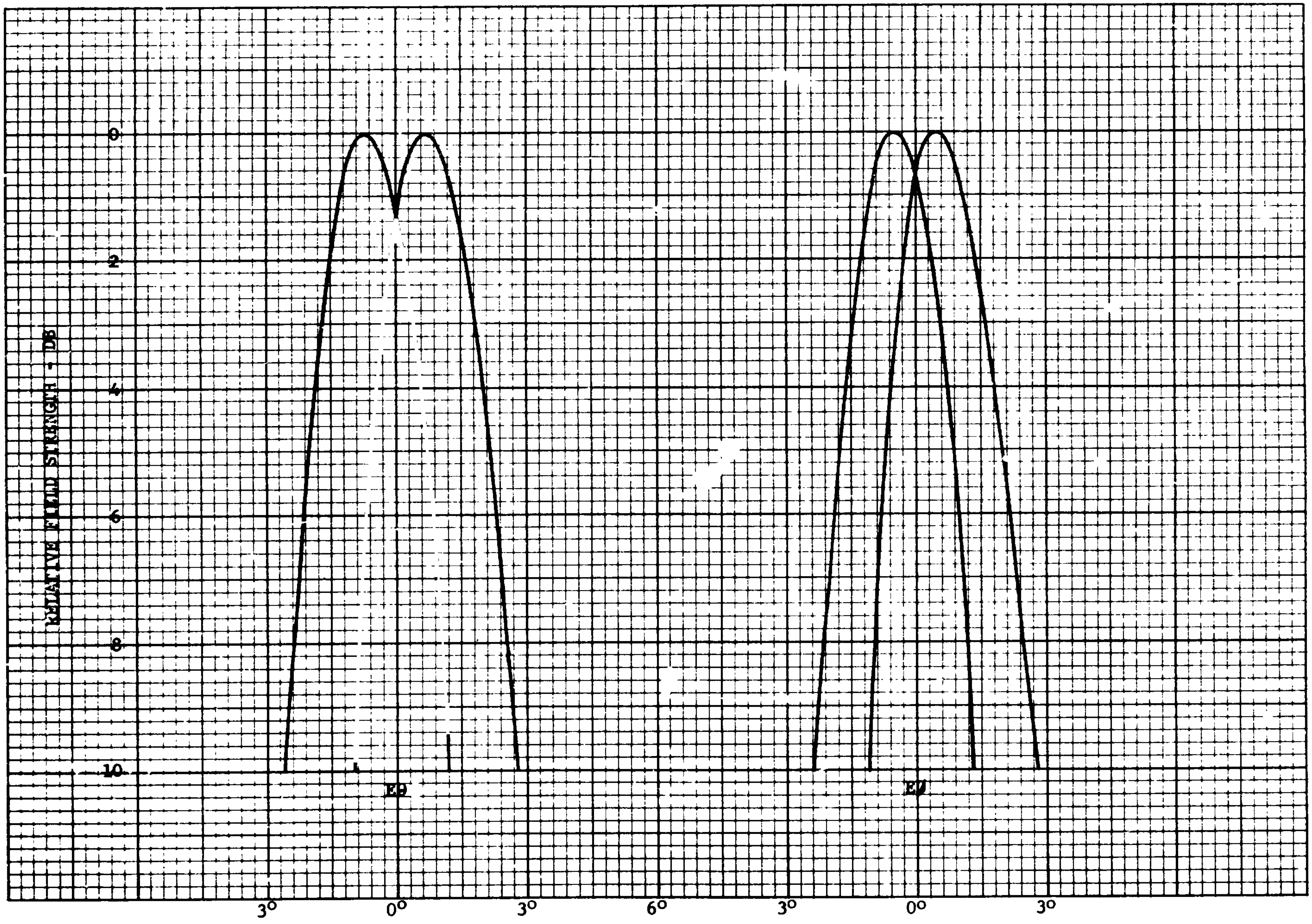


FIG. 41 - MODULATION LEVEL FOR 1700 MC, 15° FEED TILT

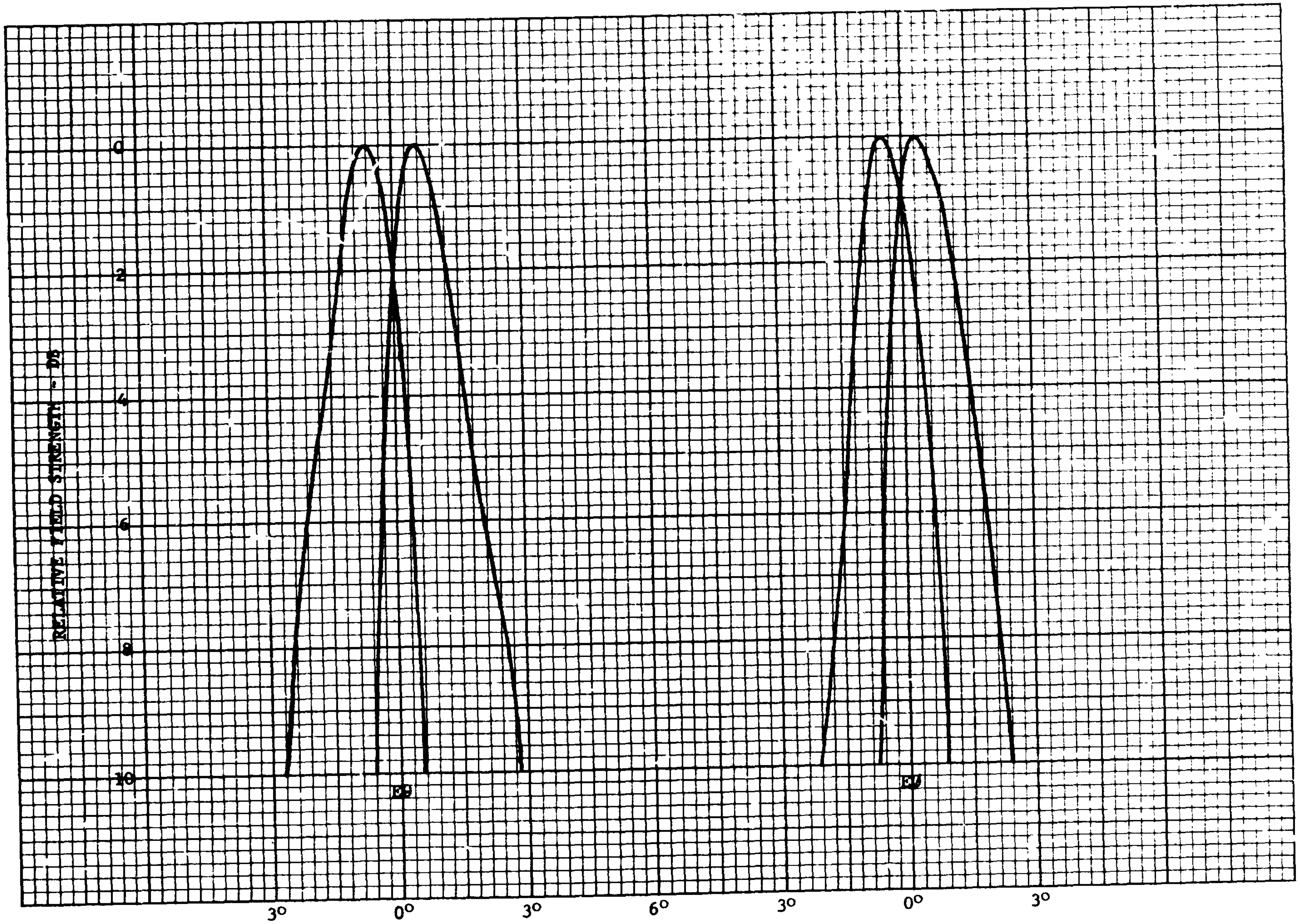


FIG. 42 - MODULATION LEVEL FOR 2290 MC, 15° FEED TILT

FIG. 43 - MODULATION LEVEL FOR 2800 MC, 15° FEED TILT

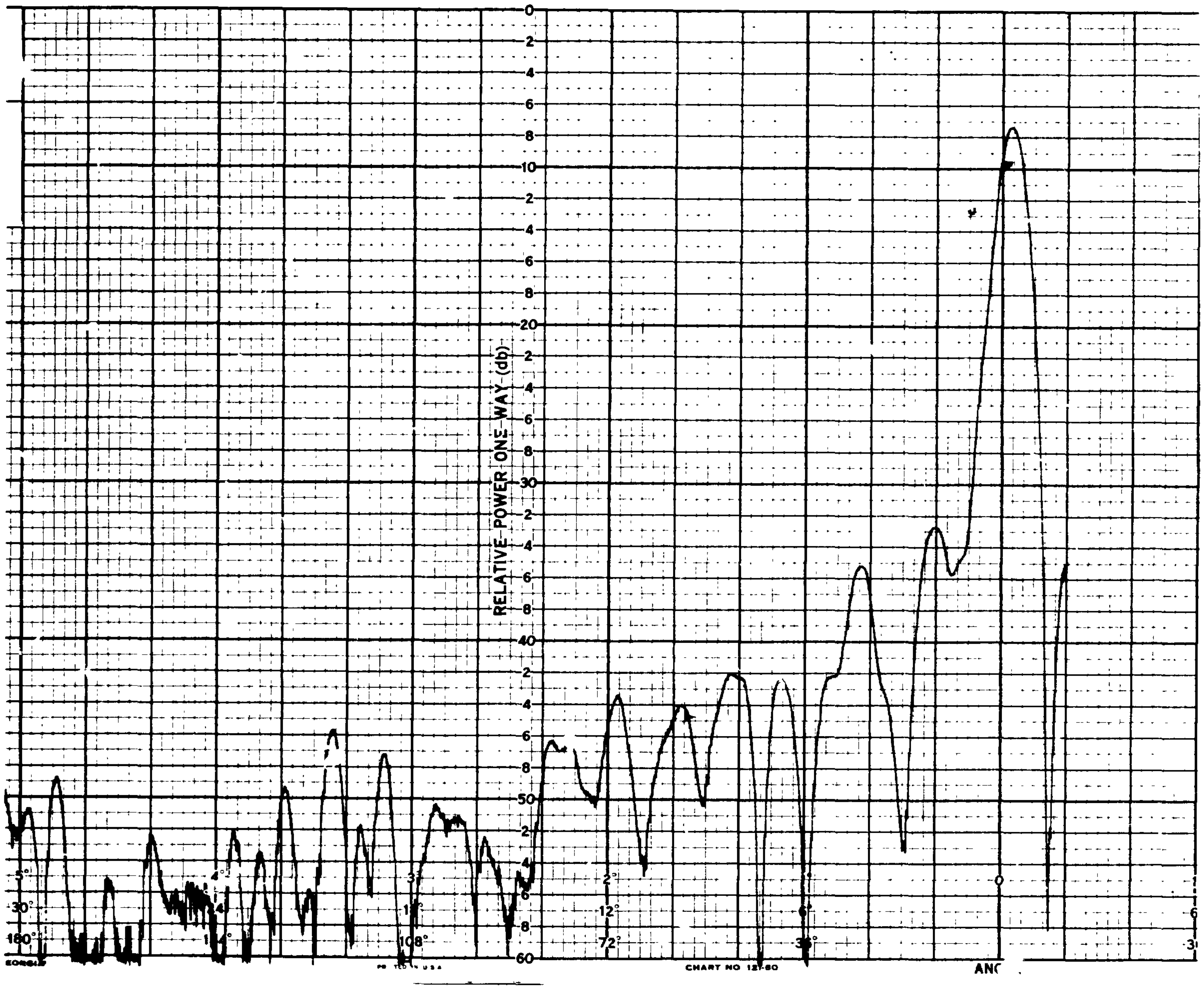


FIG. 44 - 860 MC, $E\theta$, FEED TILTED LEFT

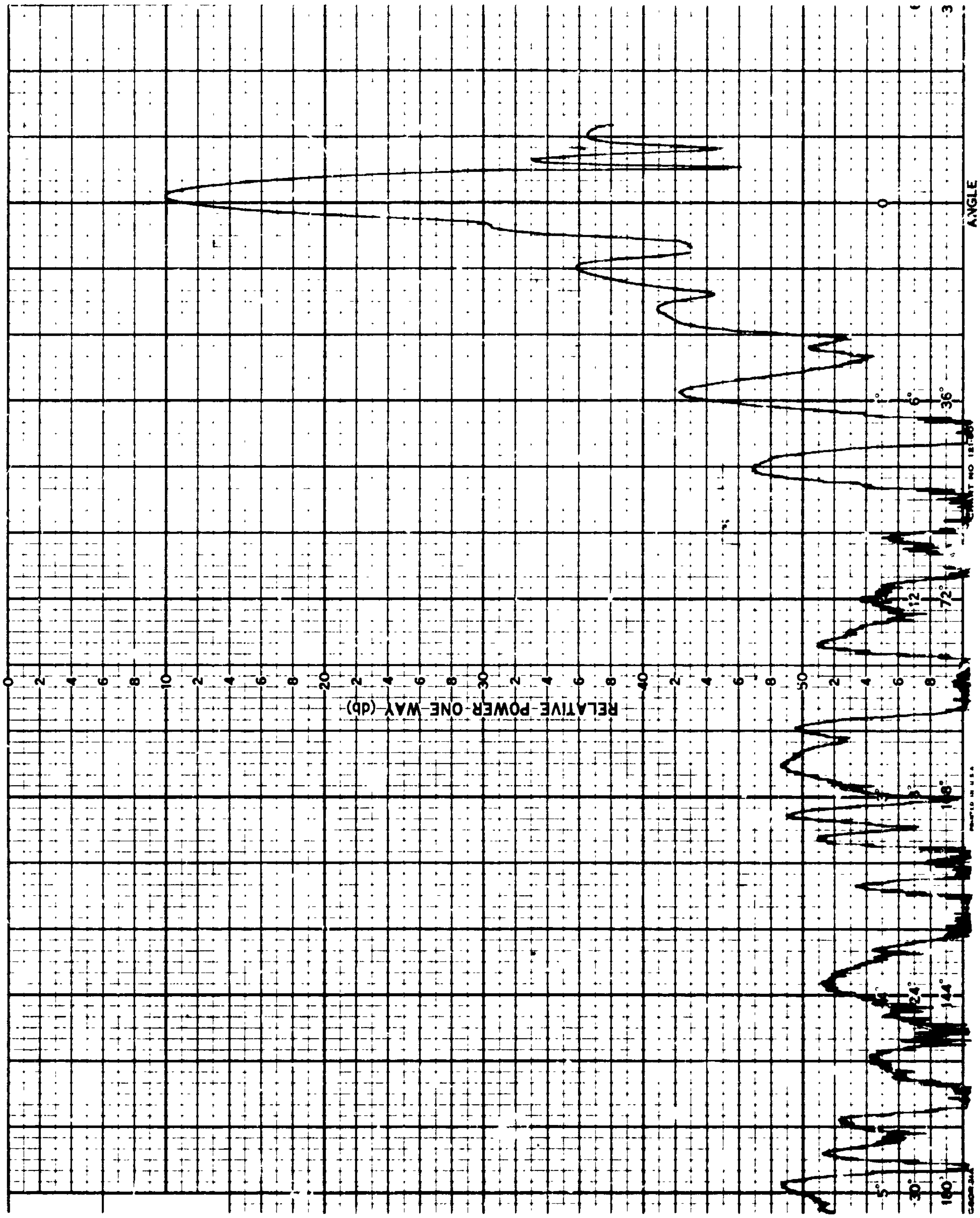


FIG 45 - 860 MC, Eφ, FEED TILTED LEFT

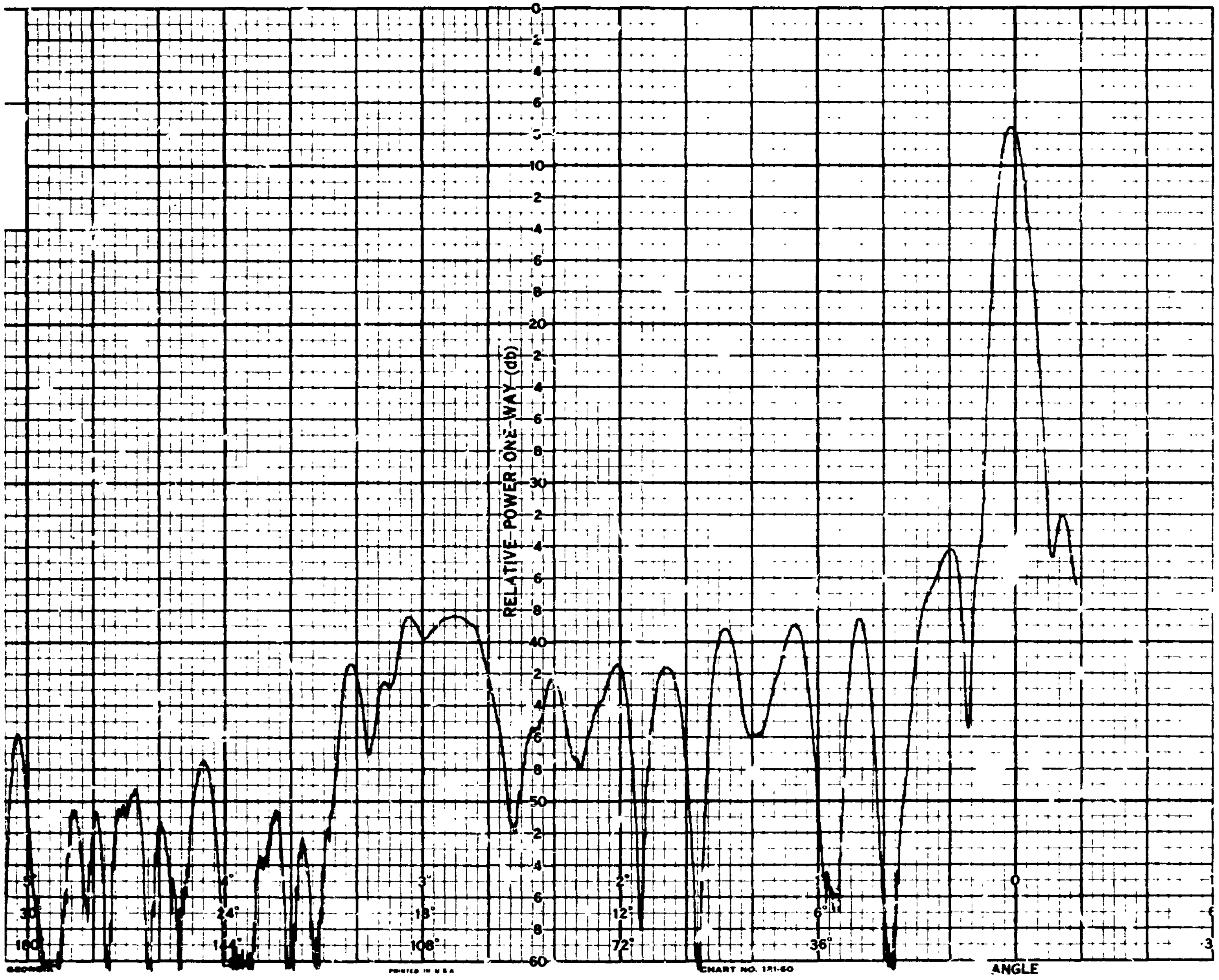


FIG. 46 - 860 MC, Eθ, FEED TILTED RIGHT

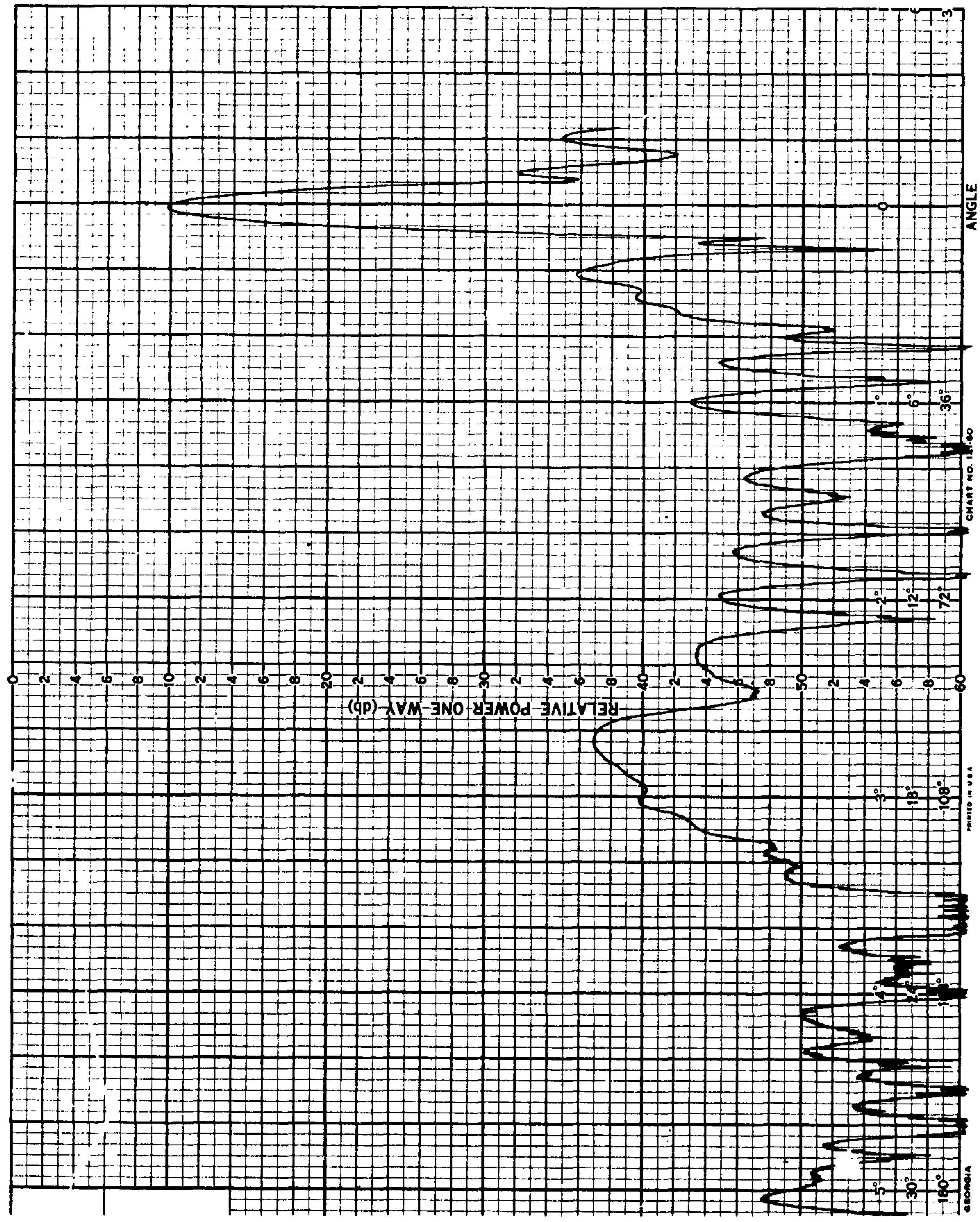


FIG. 47 - 860 MC, Eϕ, FEED TILTED RIGHT

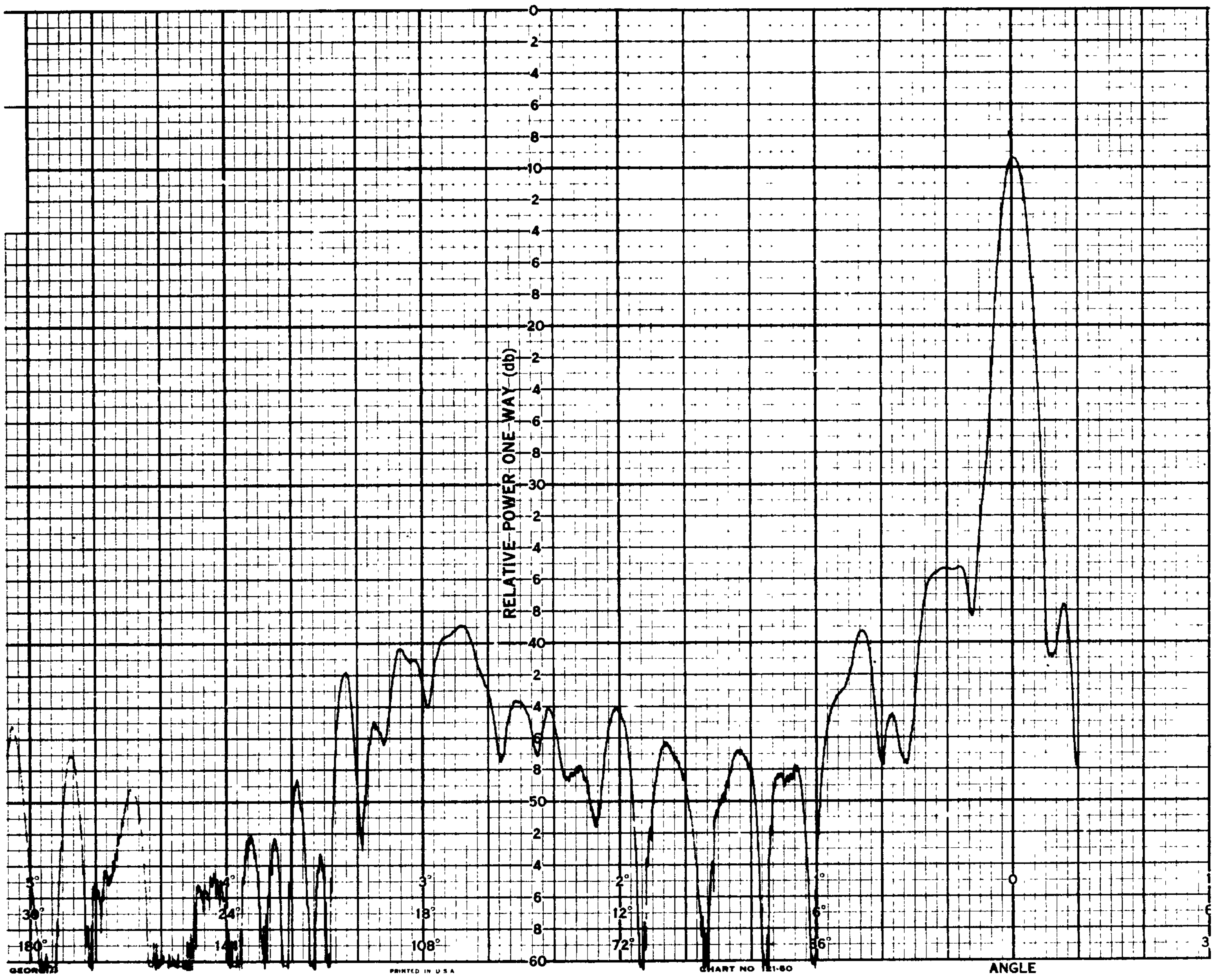


FIG. 48 - 860 MC, E_θ, FEED TILTED UP

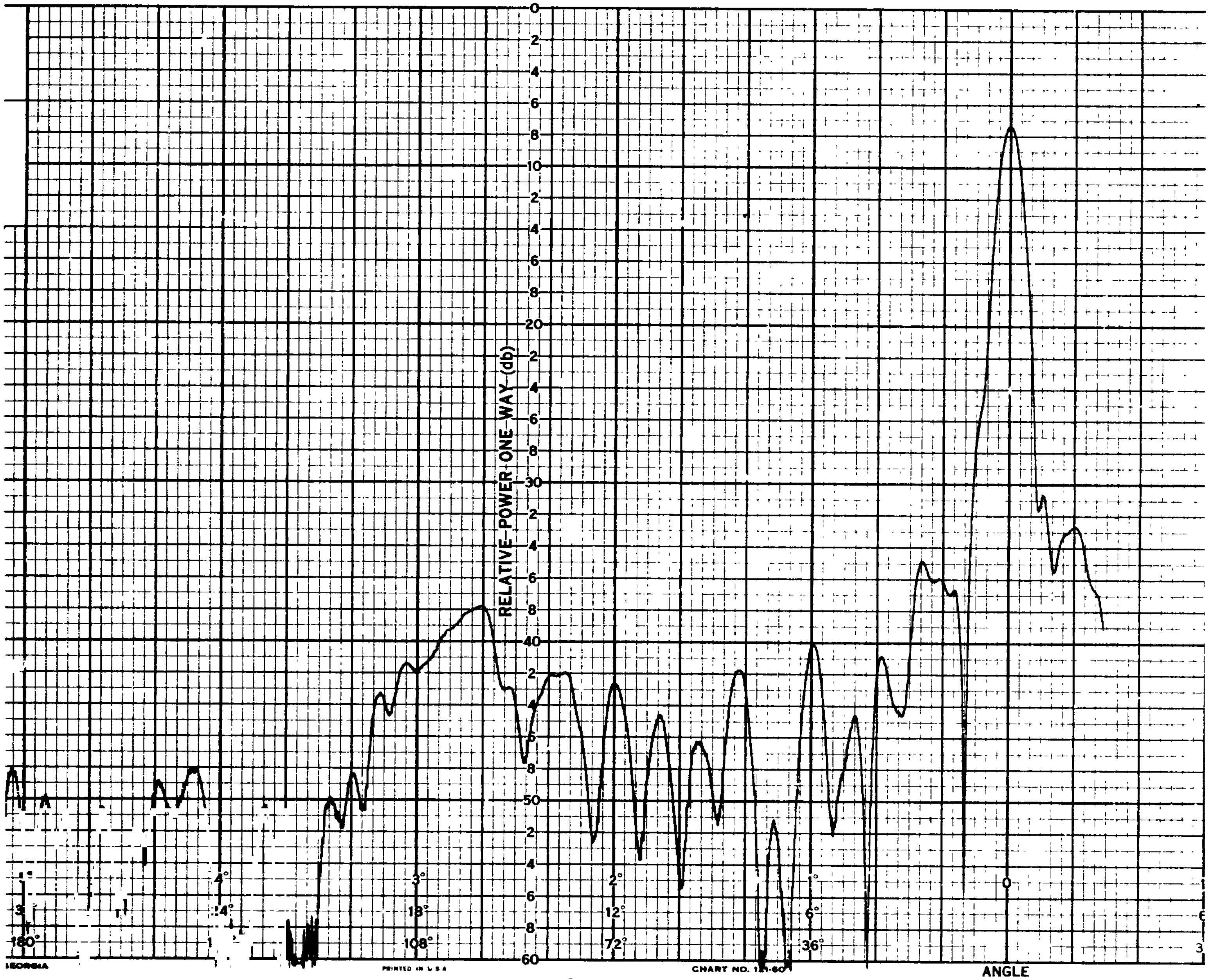


FIG. 49 - 860 MC, Eφ, FEED TILTED UP

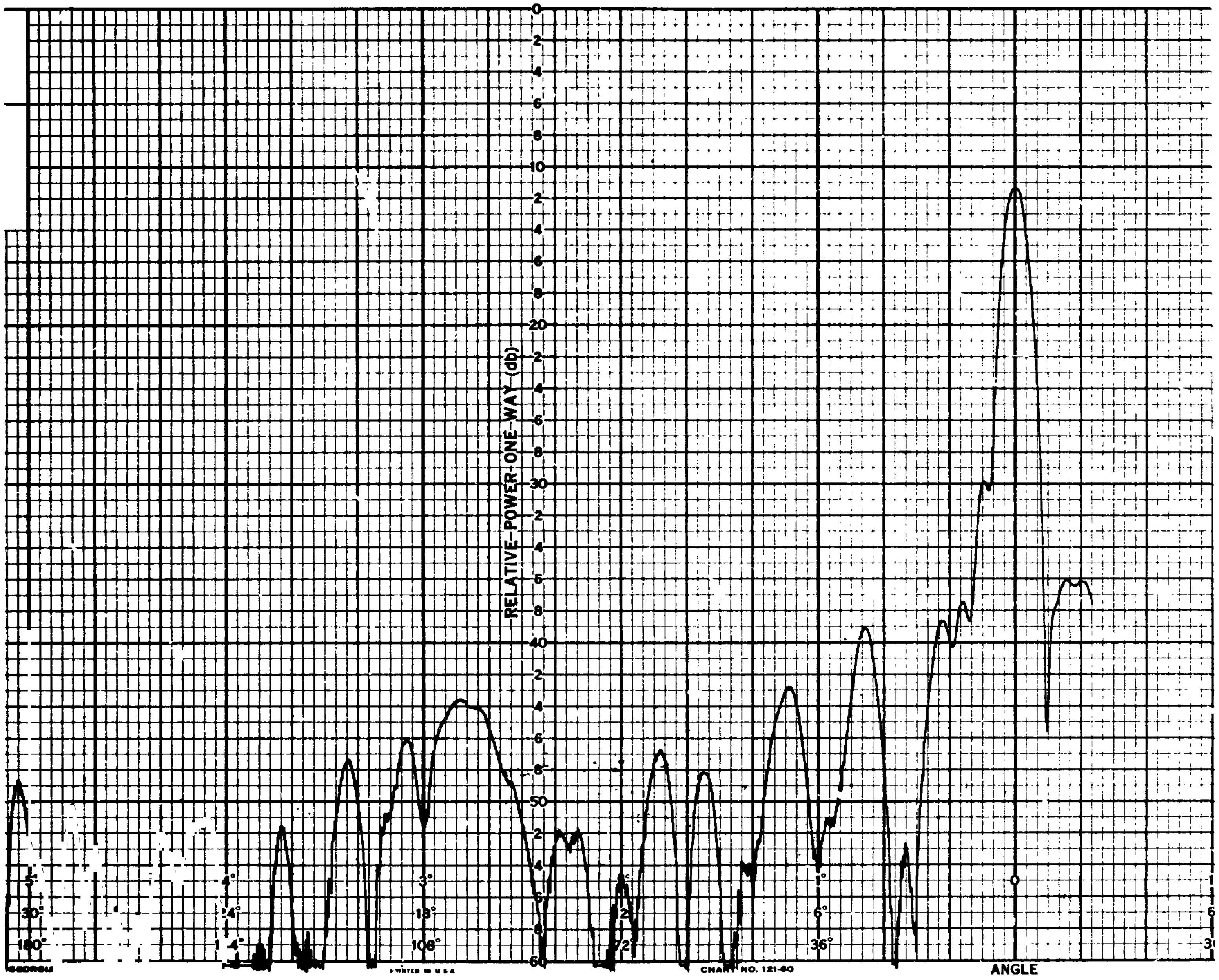


FIG. 50 - 860 MC, Eθ, FEED TILTED DOWN

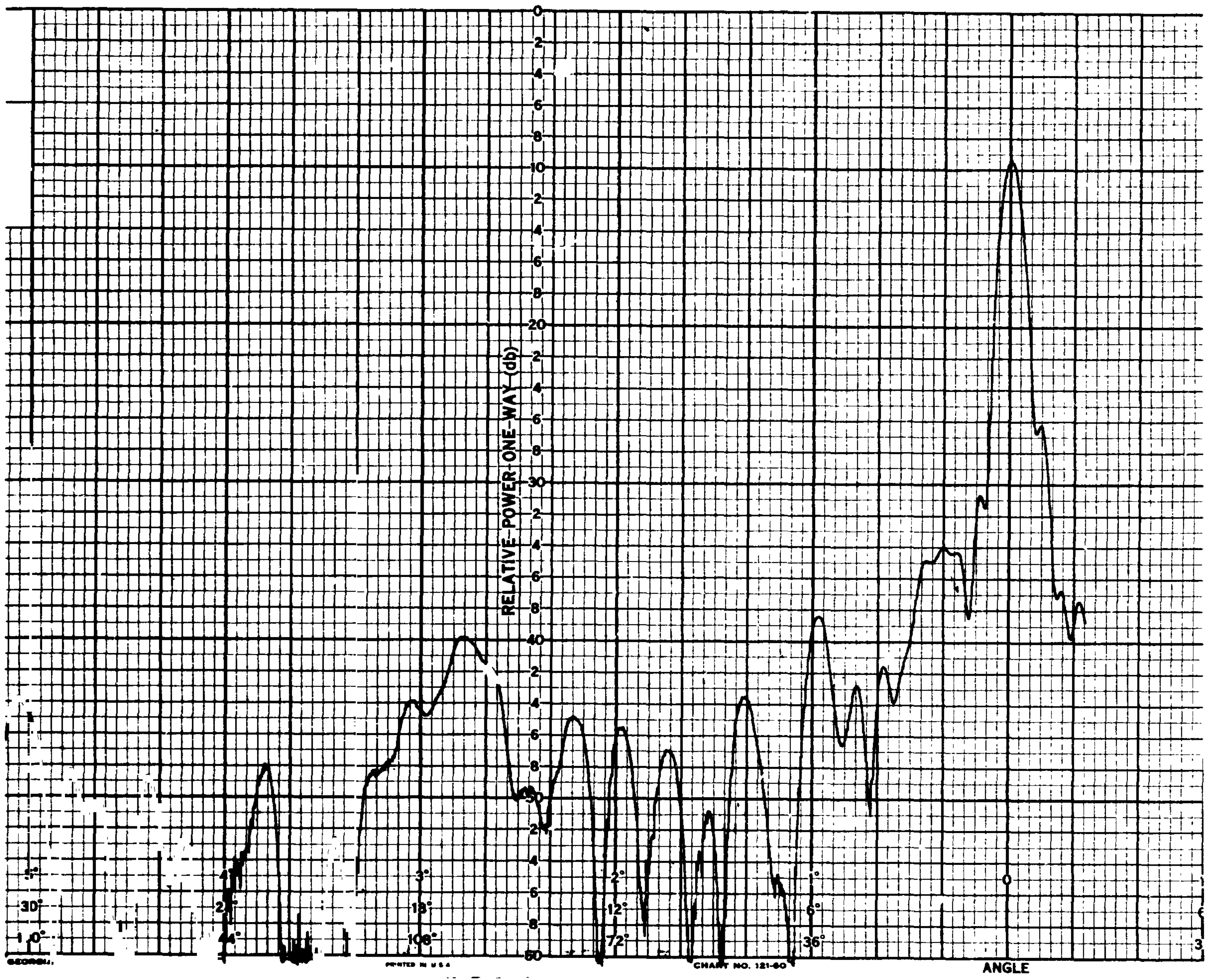


FIG. 51 - 860 MC, Eϕ, FEED TILTED DOWN

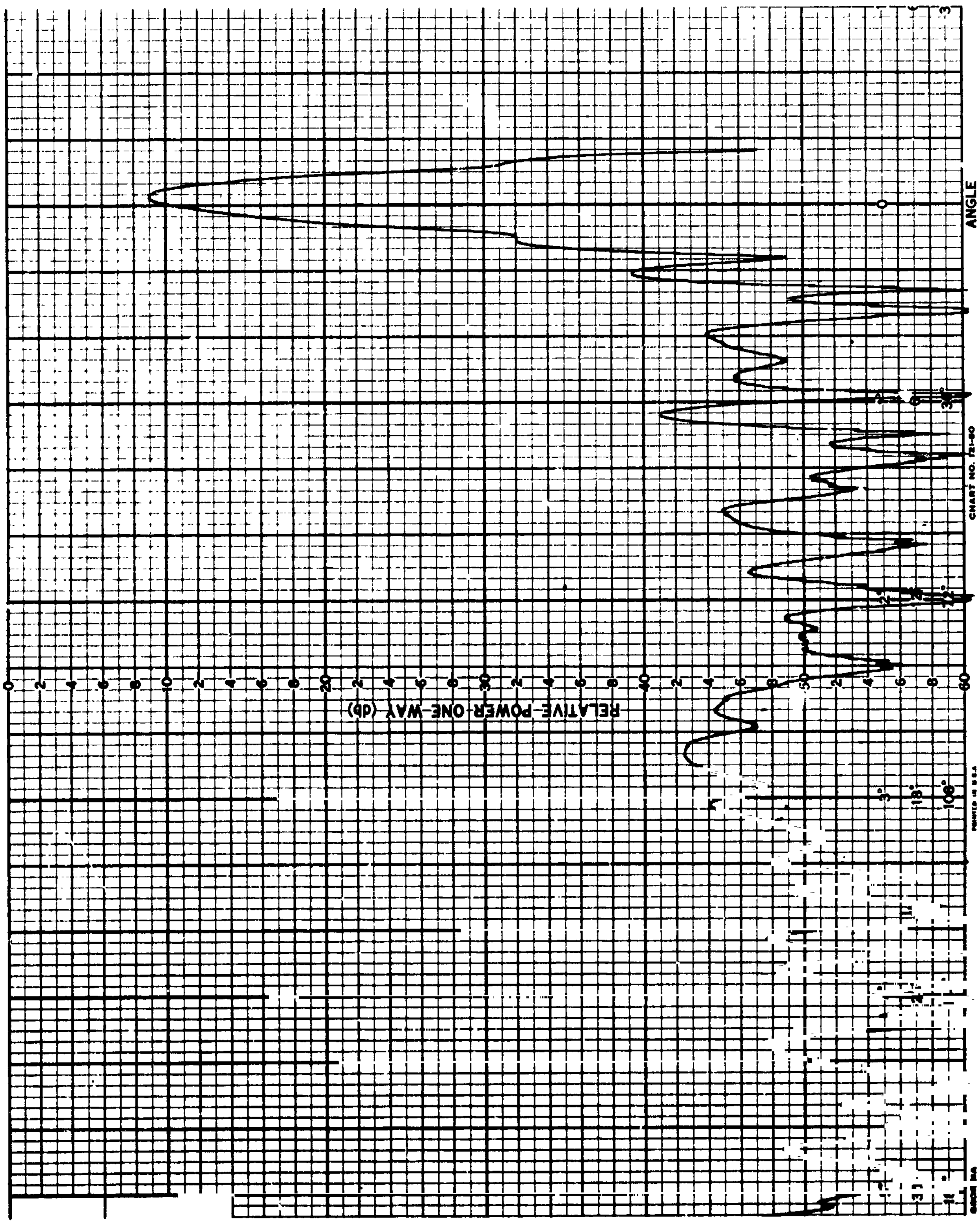


FIG. 52 - 900 MC, Eθ, FEED TILTED LEFT

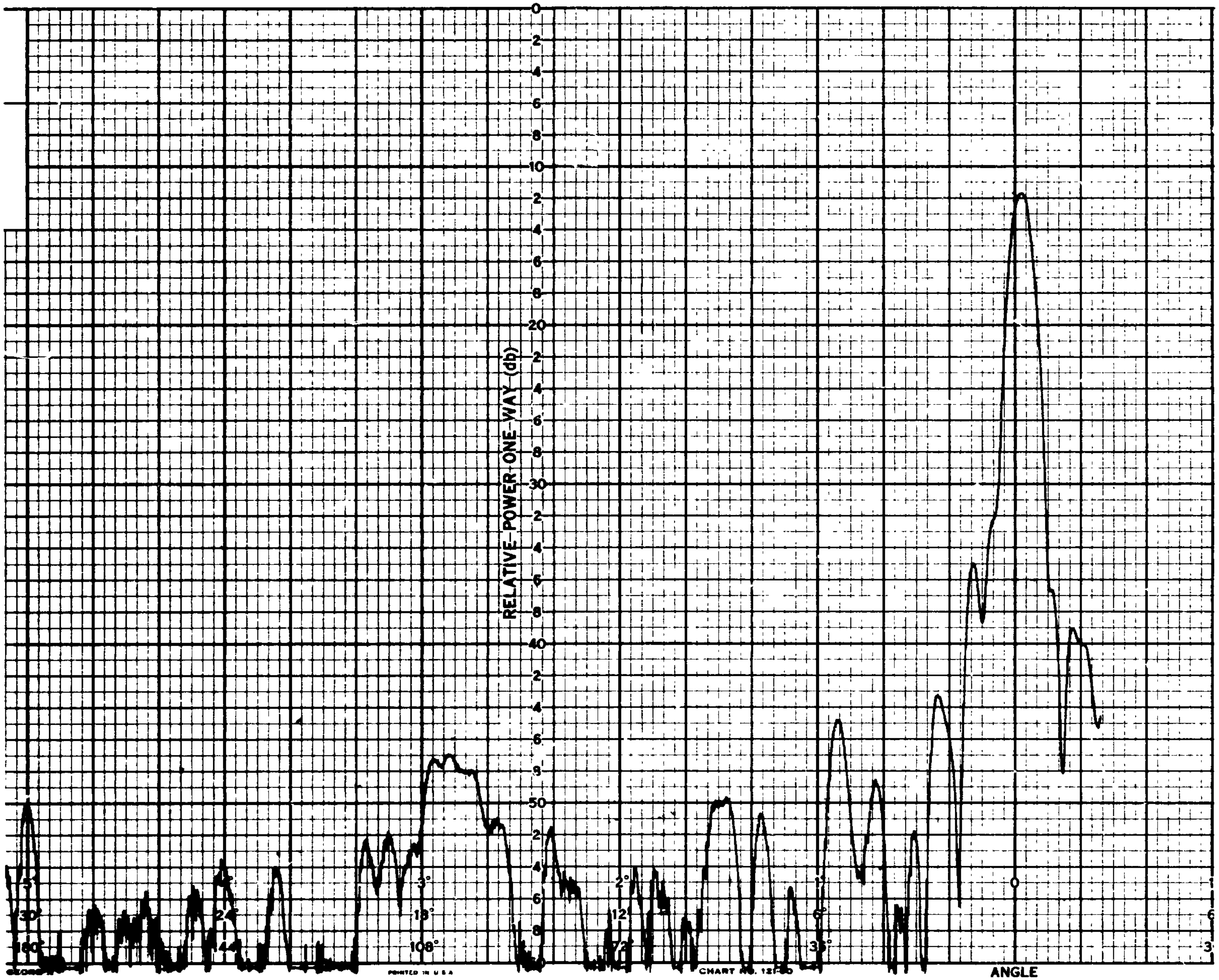


FIG. 53 - 900 MC, Eϕ, FEED TILTED LEFT

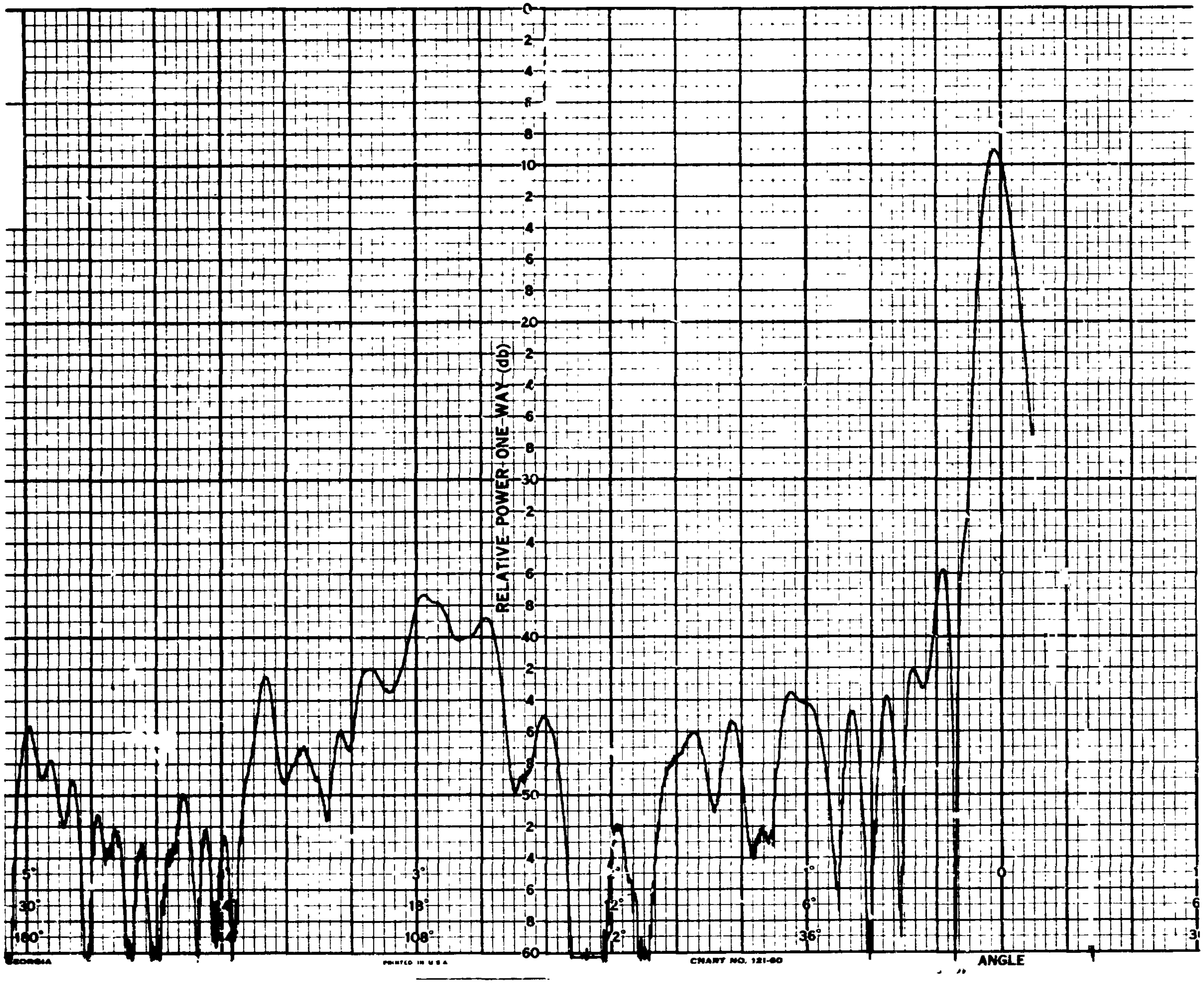


FIG. 54 - 900 MC, Eθ, FEED TILTED RIGHT

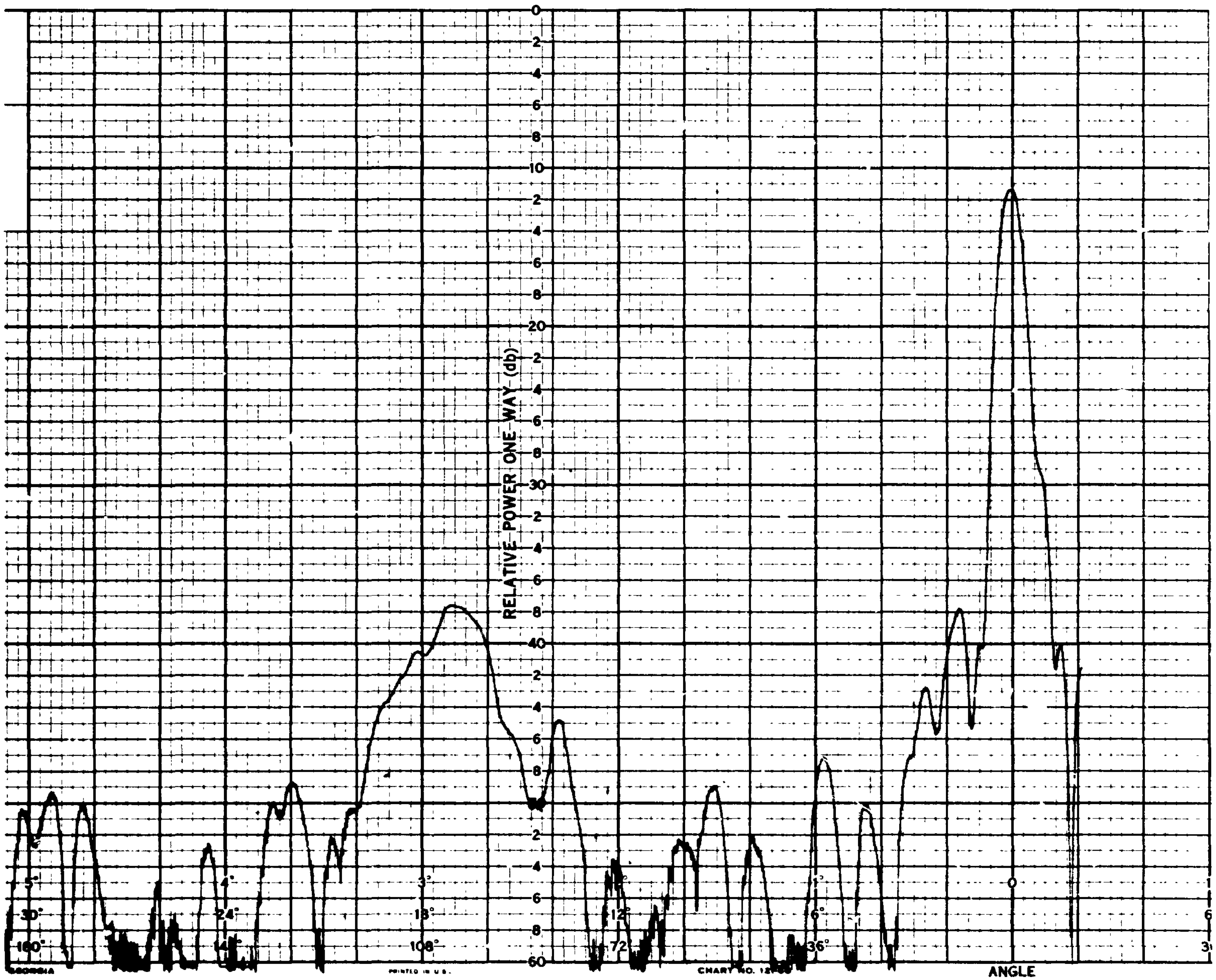


FIG. 55 - 900 MC, Eφ, FEED TILTED RIGHT

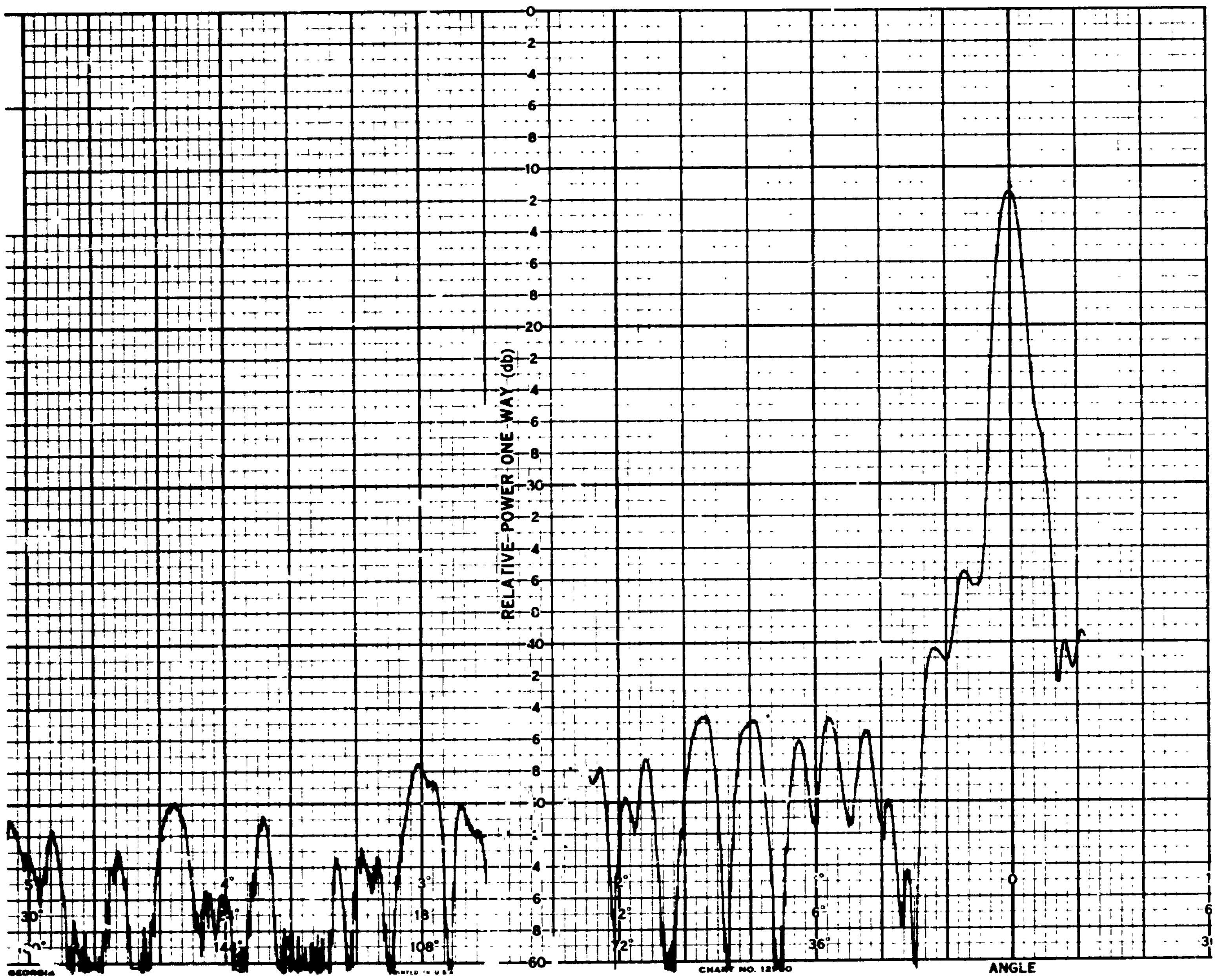


FIG. 56 - 900 MC, Eθ, FEED TILTED UP

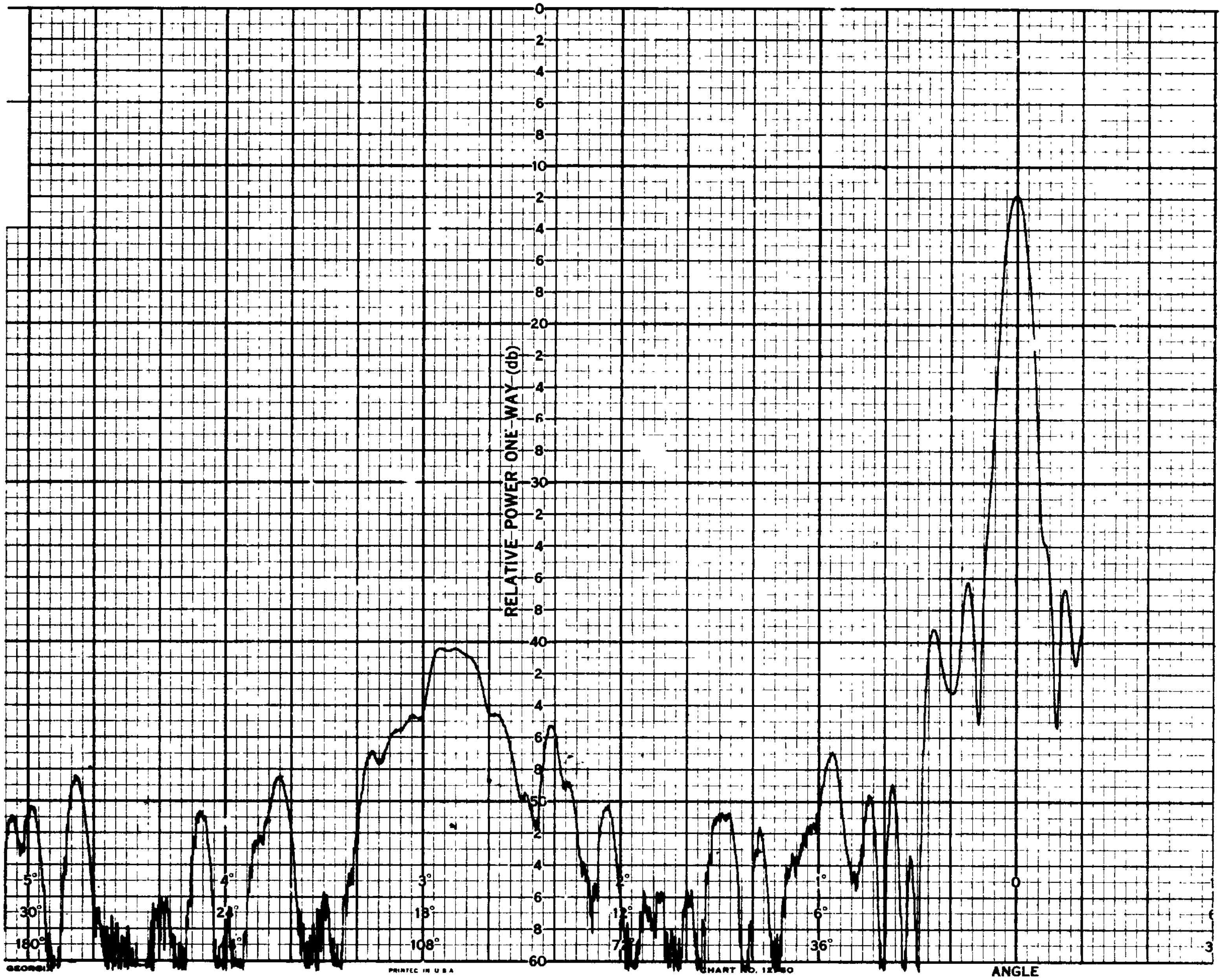


FIG. 57 - 900 MC, Eϕ, FEED TILTED UP

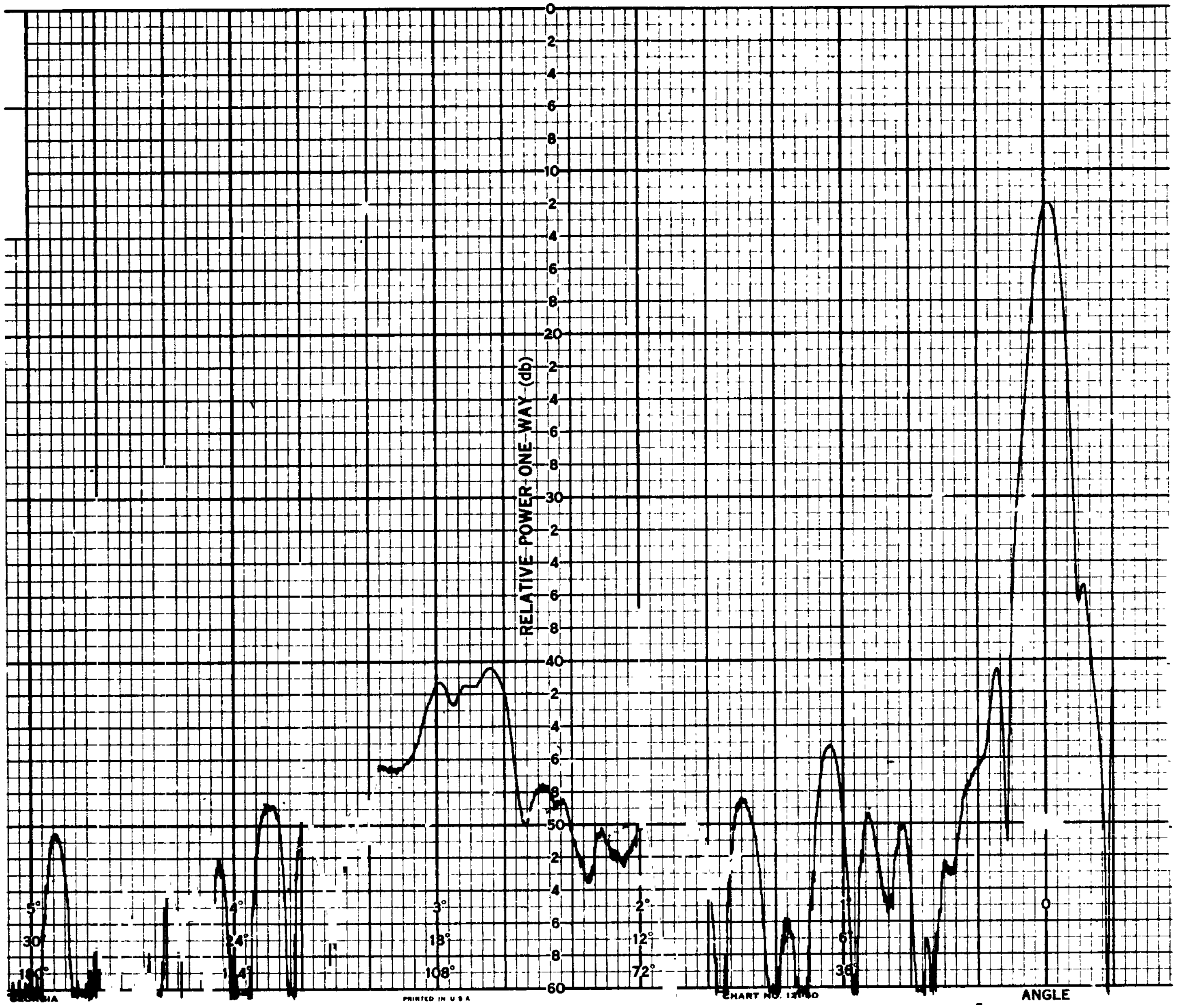


FIG. 58 - 900 MC, Eϑ, FEED TILTED DOWN

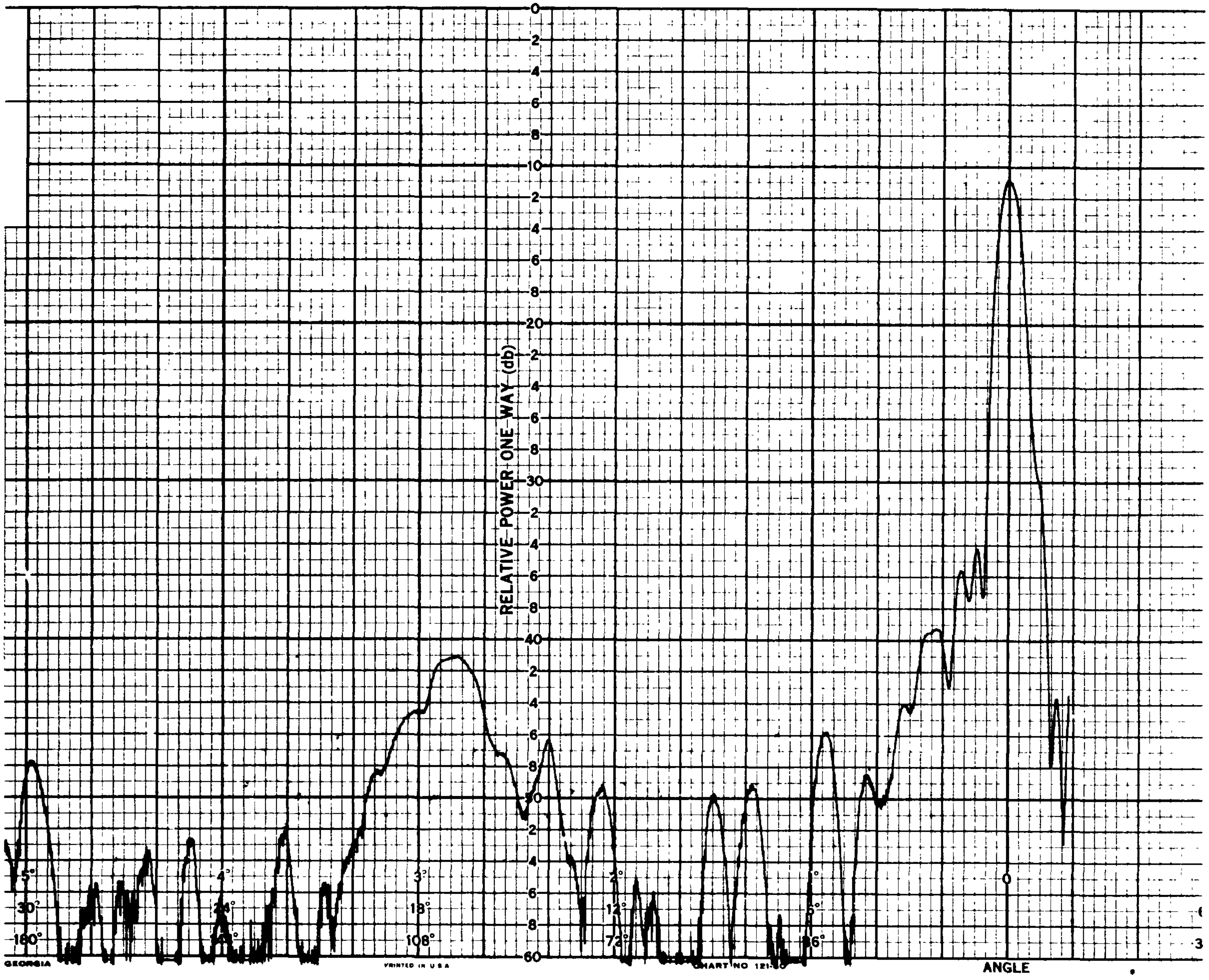


FIG. 59 - 900 MC, Eϕ, FEED TILTED DOWN

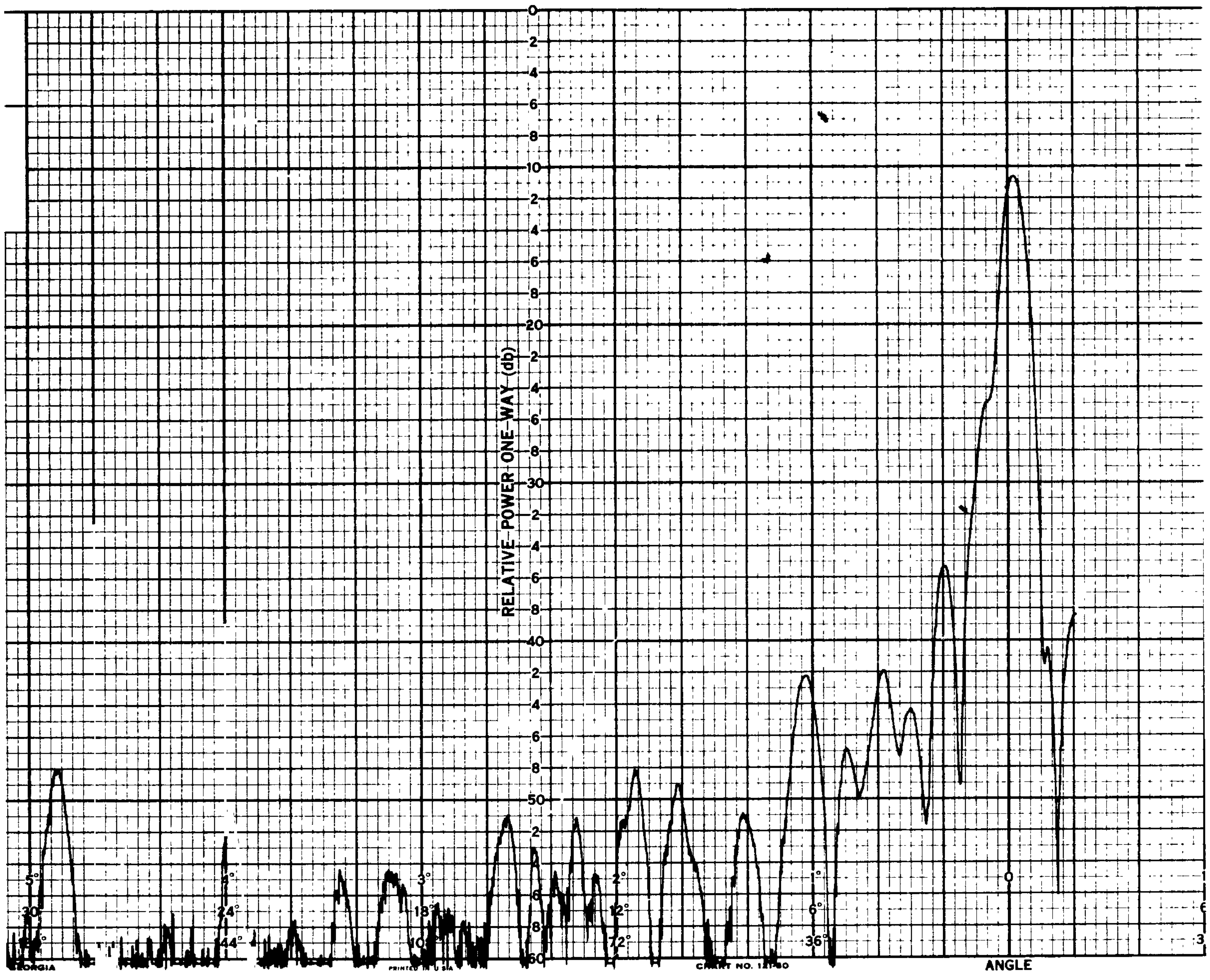


FIG. 60 - 960 MC, Eθ, FEED TILTED LEFT

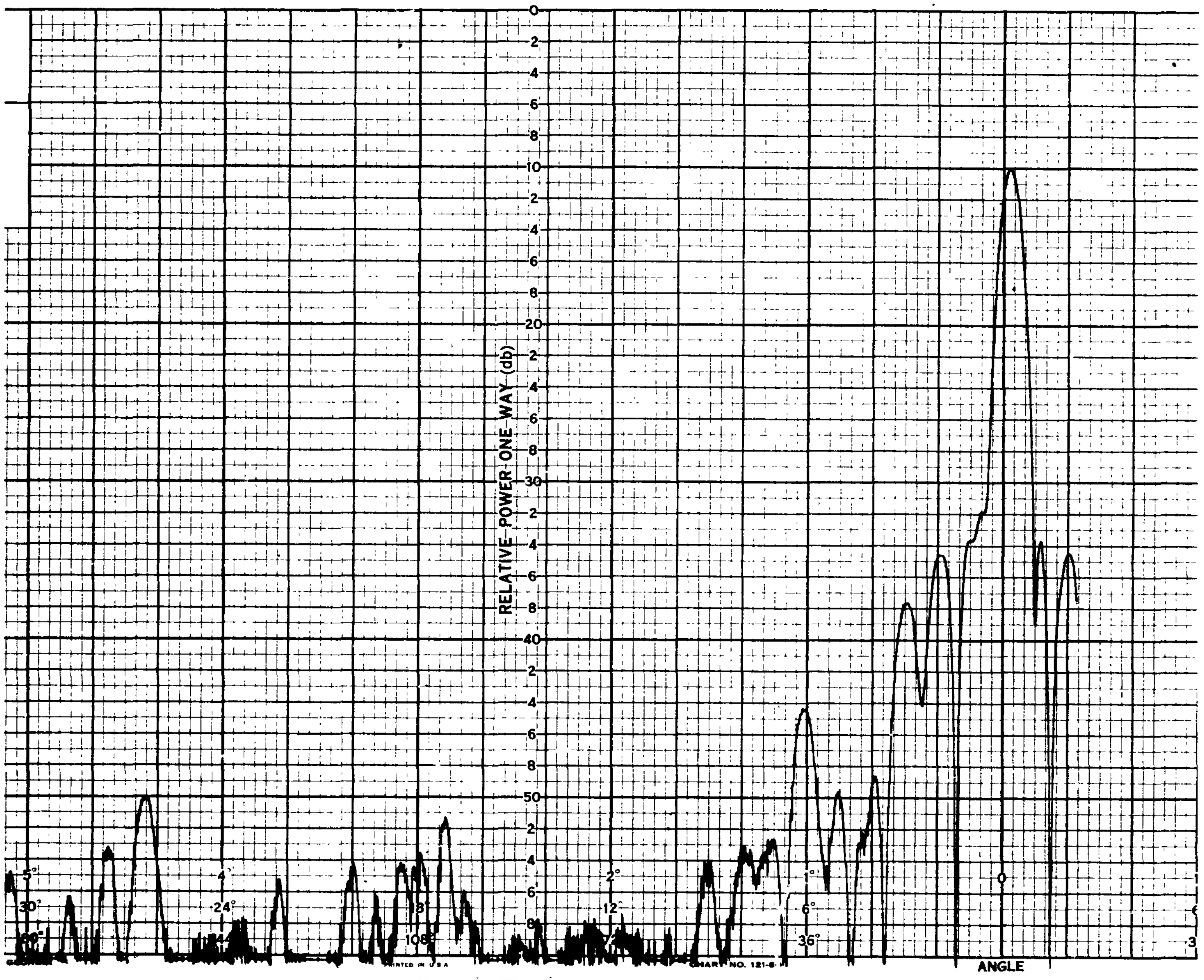


FIG. 61 - 960 MC, Eϕ, FEED TILTED LEFT

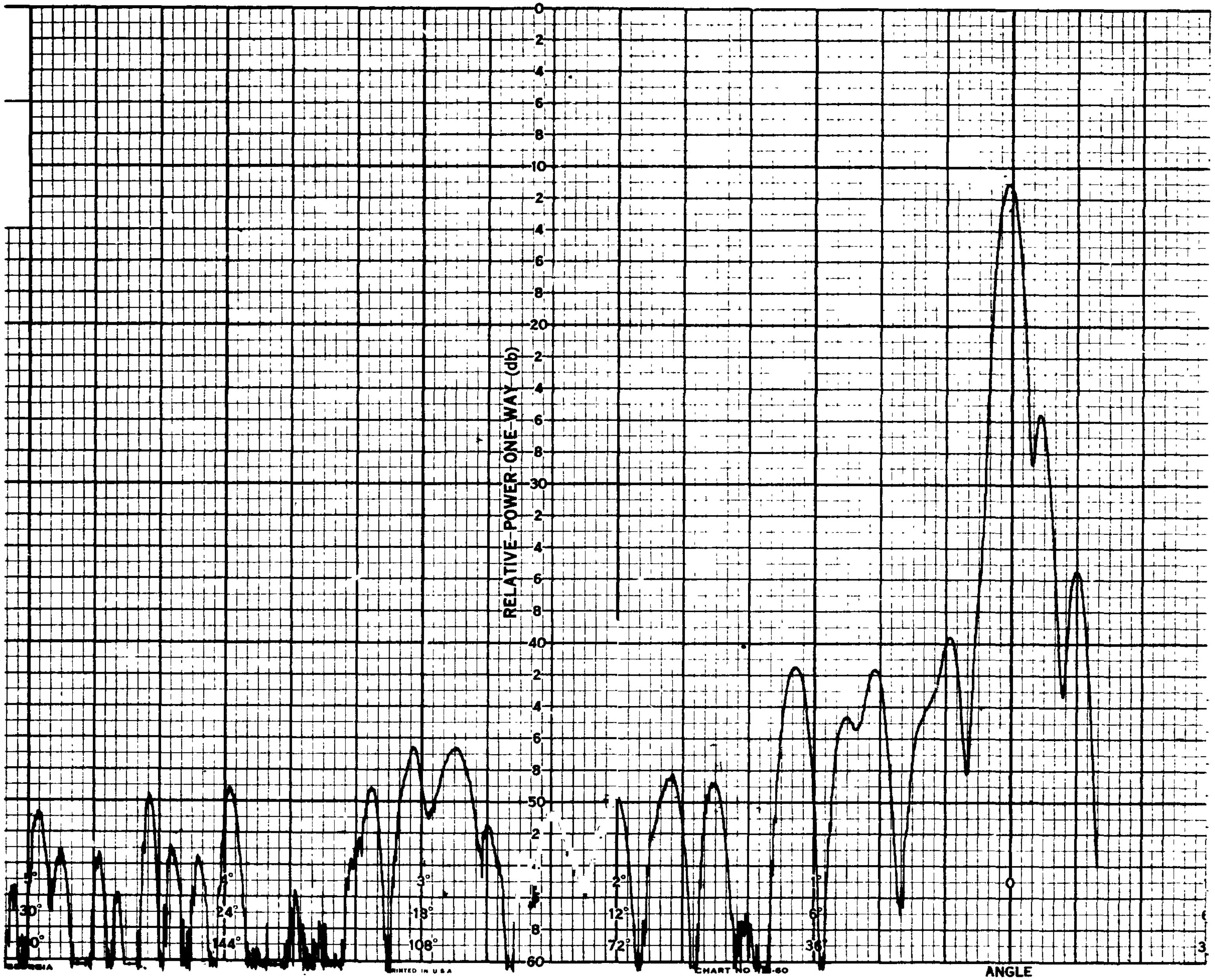


FIG. 62 - 960 MC, Eθ, FEED TILTED RIGHT

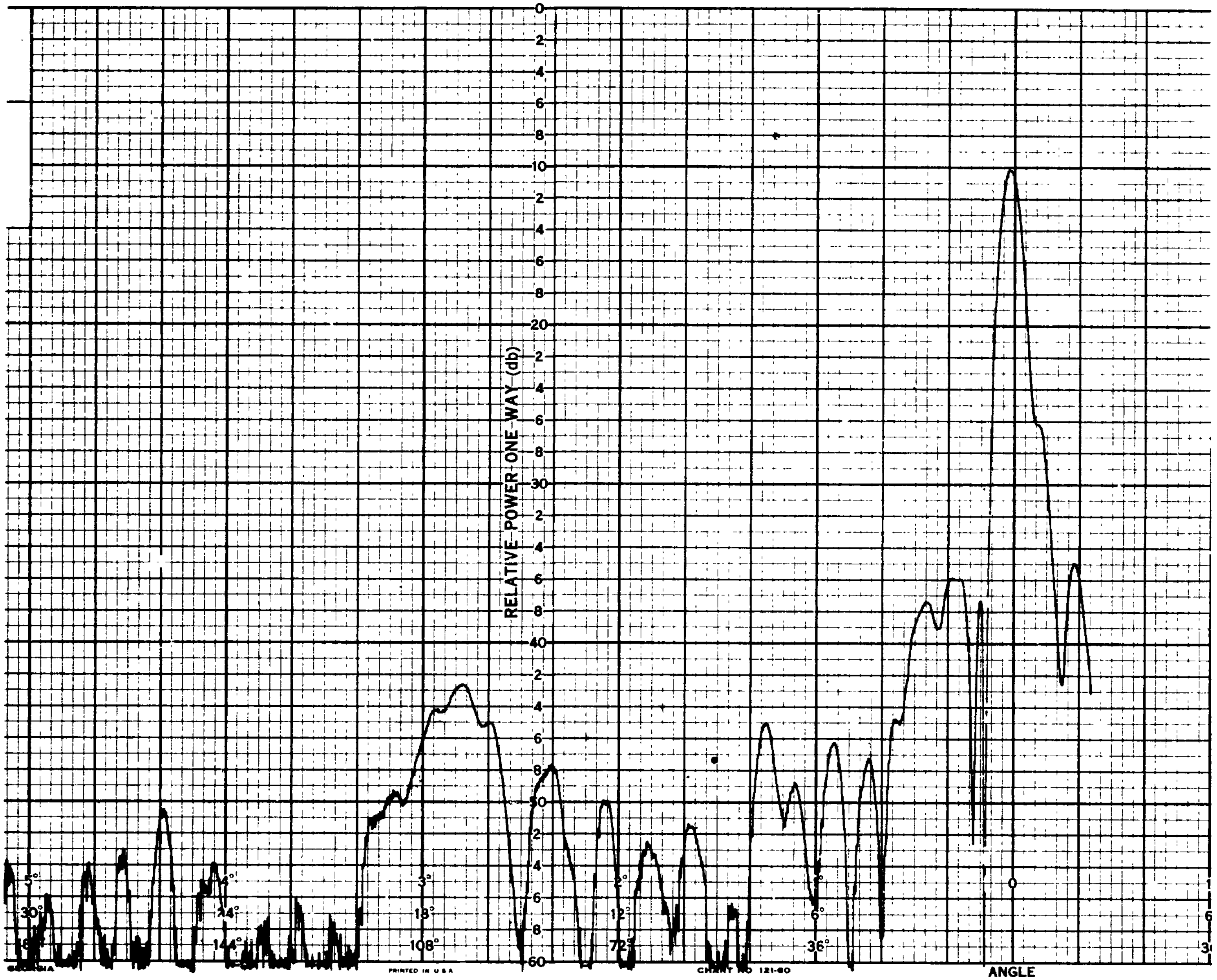


FIG. 63 - 960 MC, Eϕ, FEED TILTED RIGHT

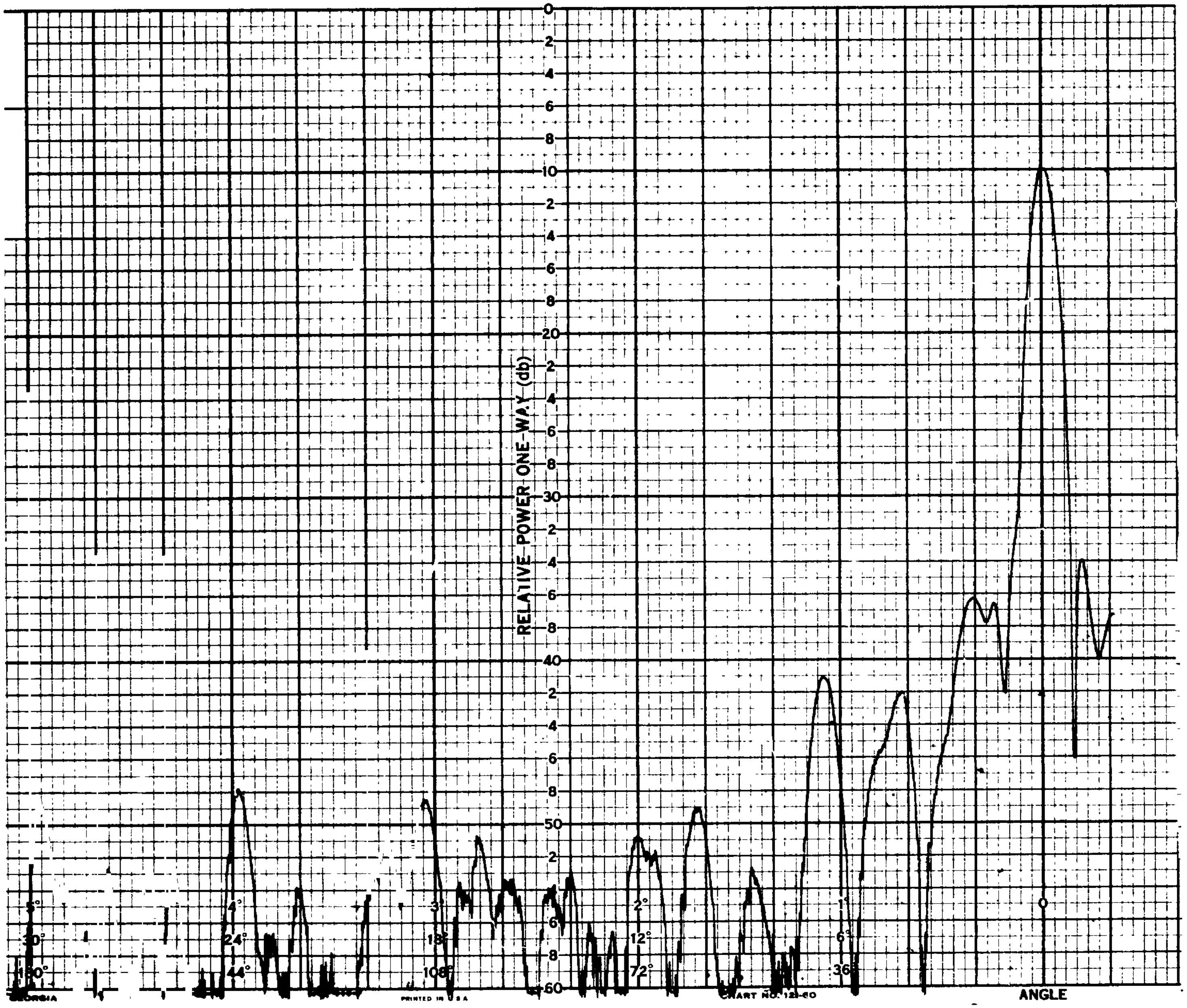


FIG. 64 - 960 MC, Eθ, FEED TILTED UP

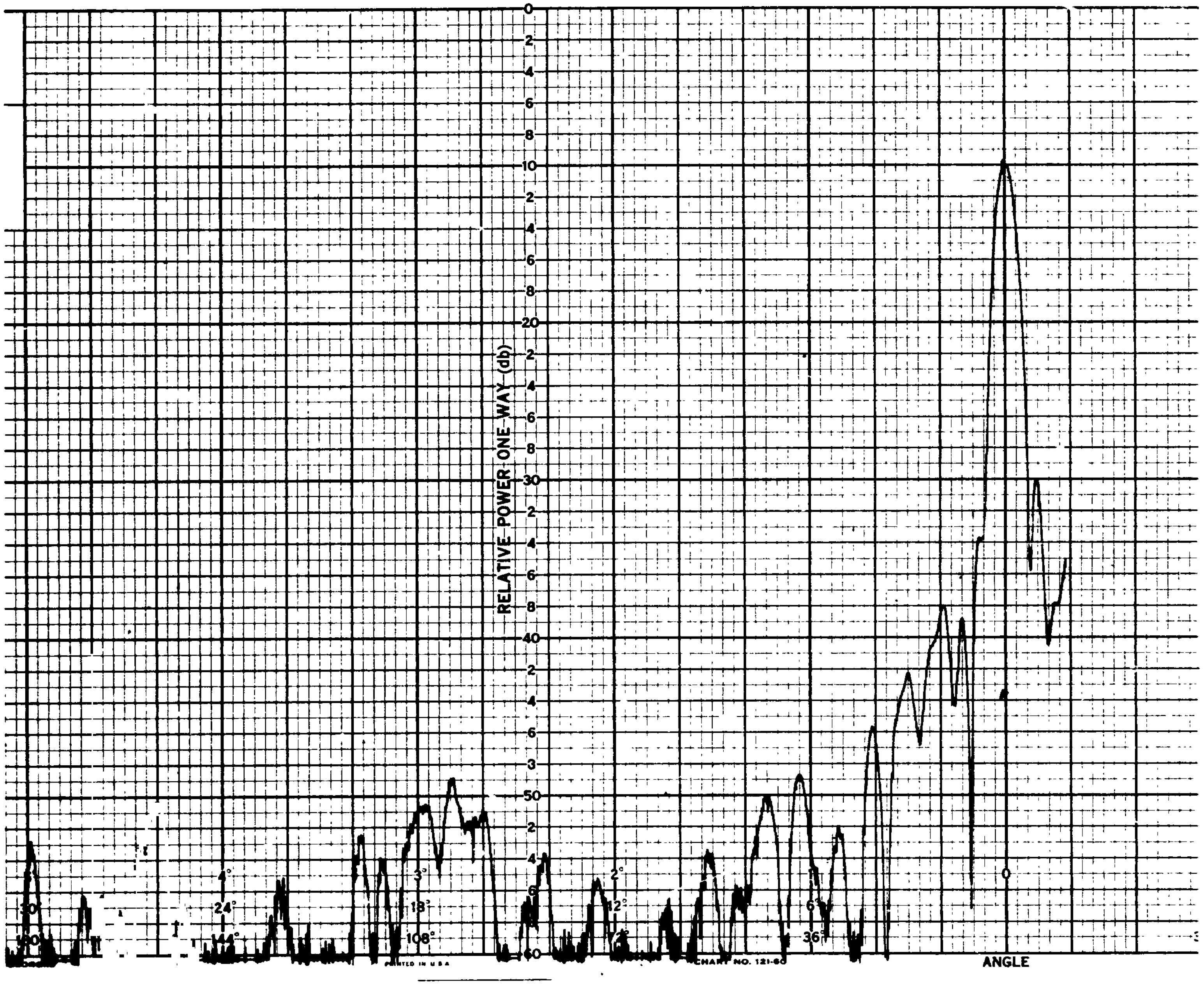


FIG. 65 - 960 MC, Eϕ, FEED TILTED UP

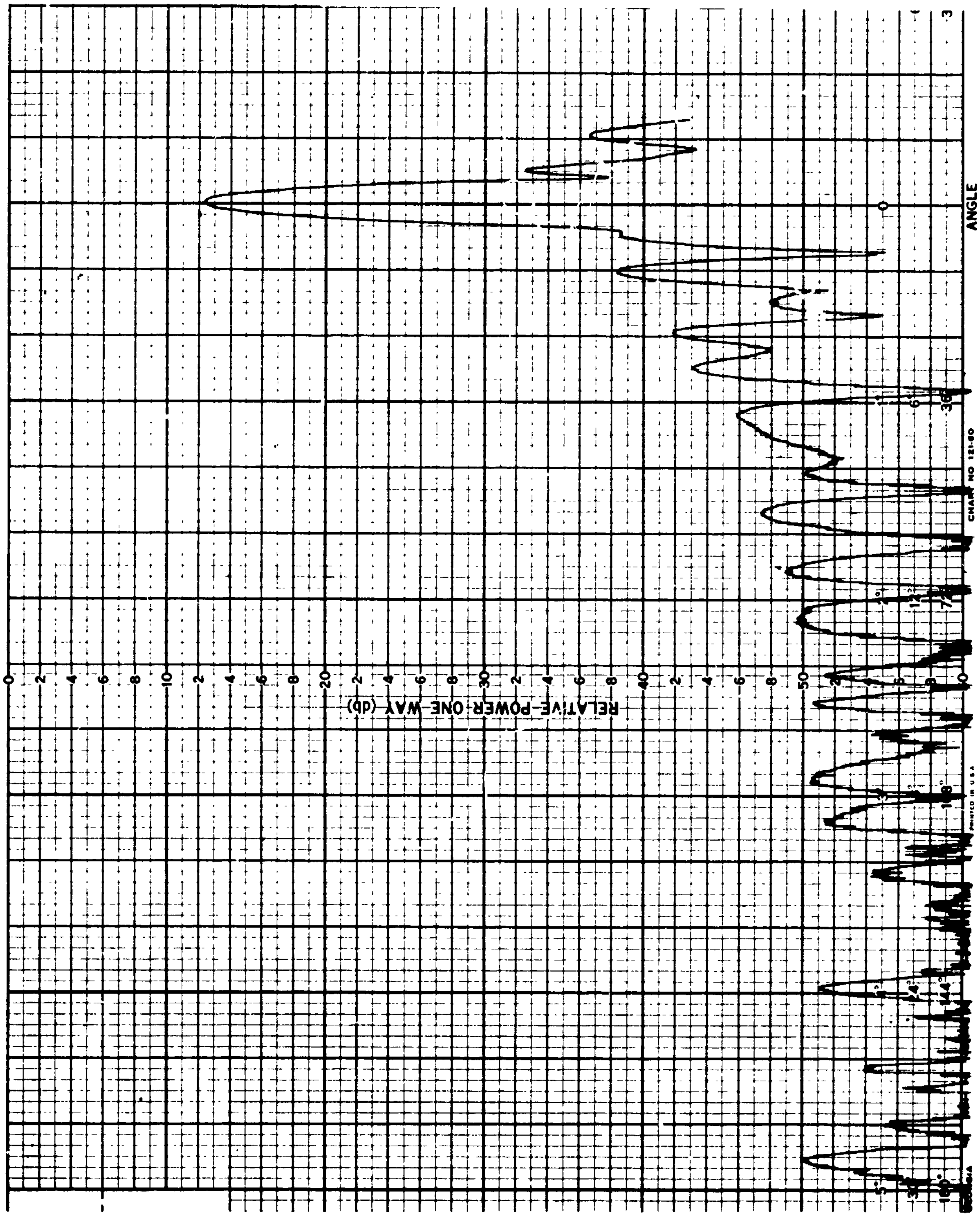


FIG. 66 - 960 MC, Eθ, FEED TILTED DOWN

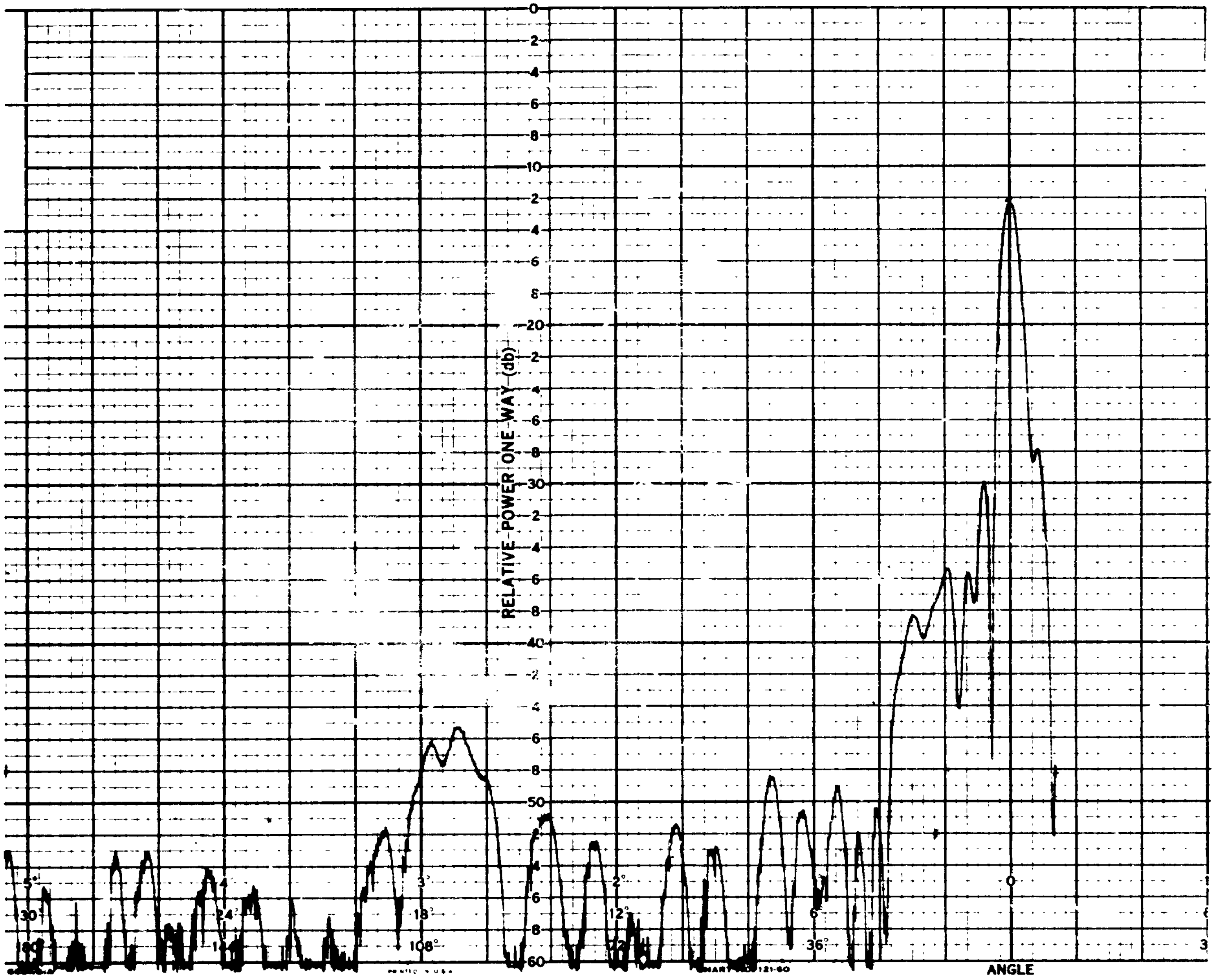


FIG. 67 - 960 MC, Eϕ, FEED TILTED DOWN

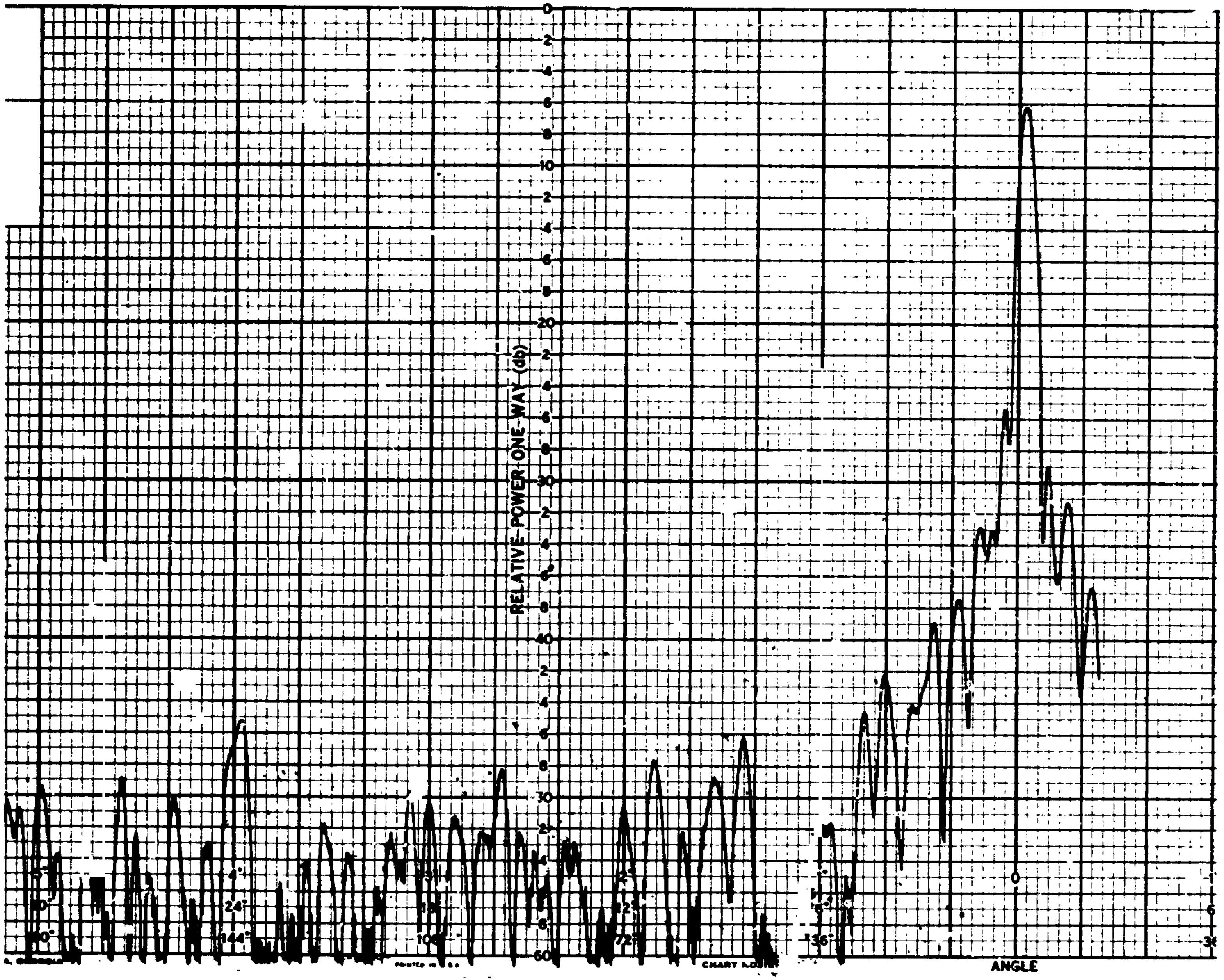


FIG. 68 - 1400 MC, Eθ, FEED TILTED LEFT

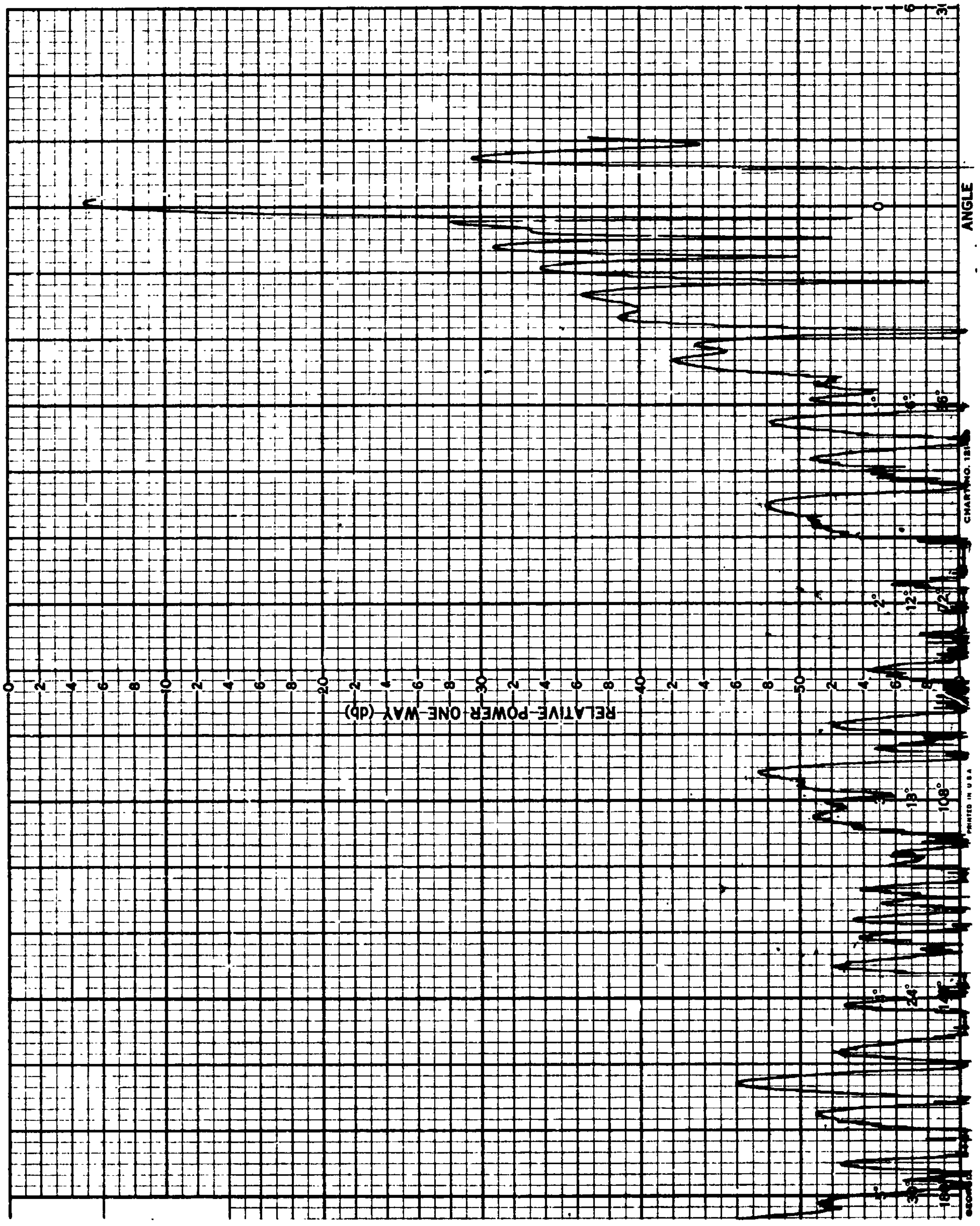


FIG. 69 - 1400 MC, Eφ, FEED TILTED LEFT

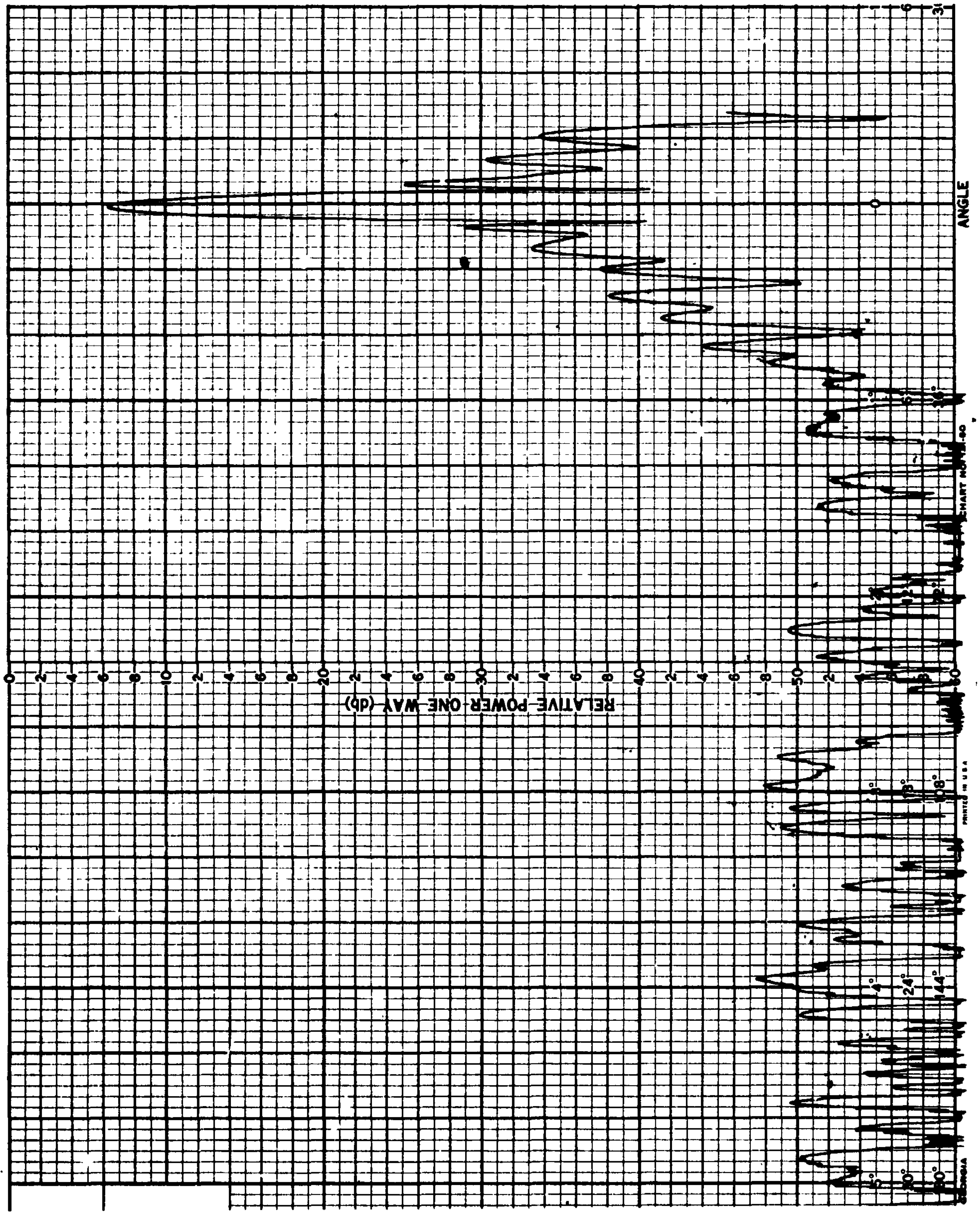


FIG. 70 - 1400 MC, Eθ, FEED TILTED RIGHT

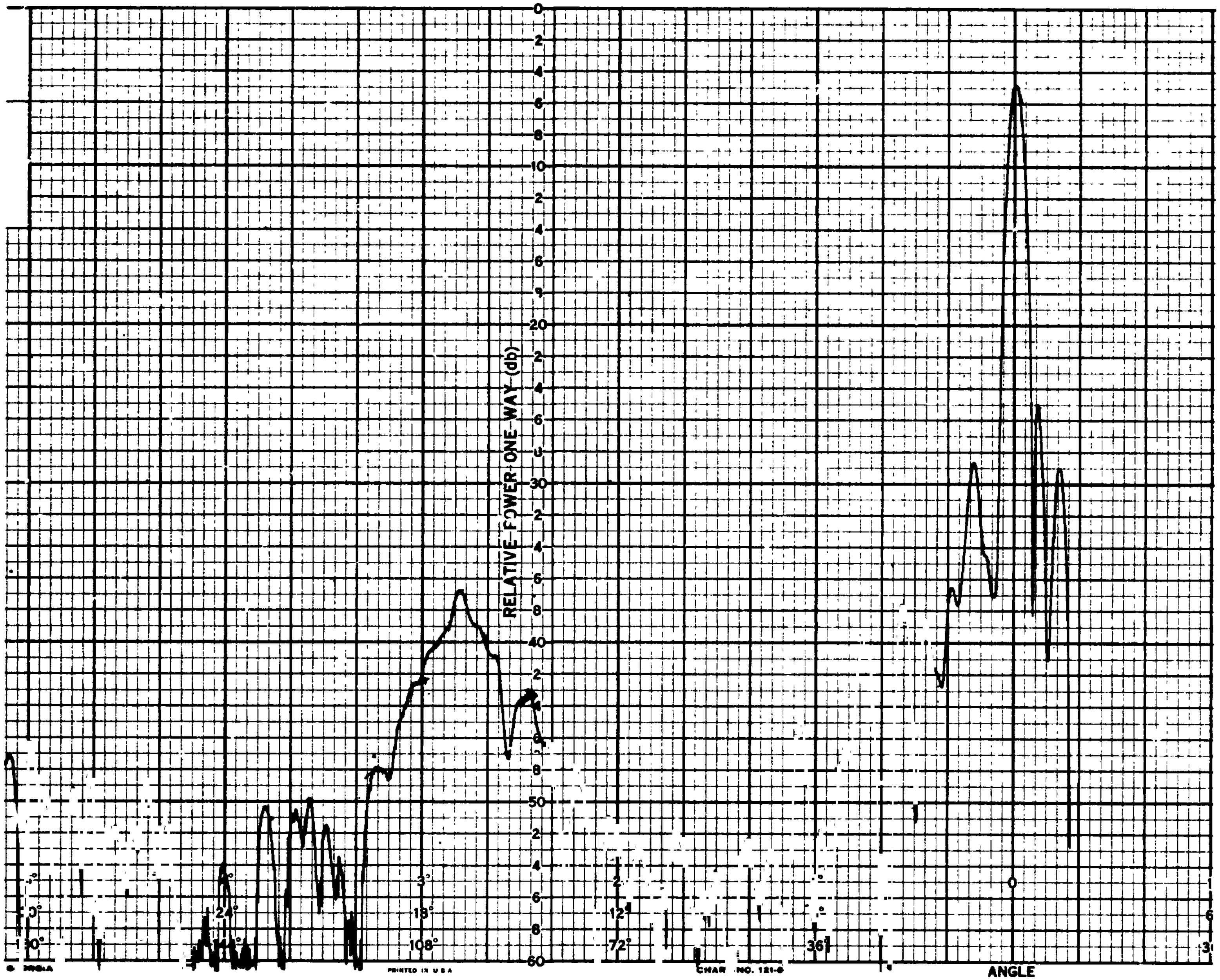


FIG. 71 - 1400 MC, Eϕ, FEED TILTED RIGHT

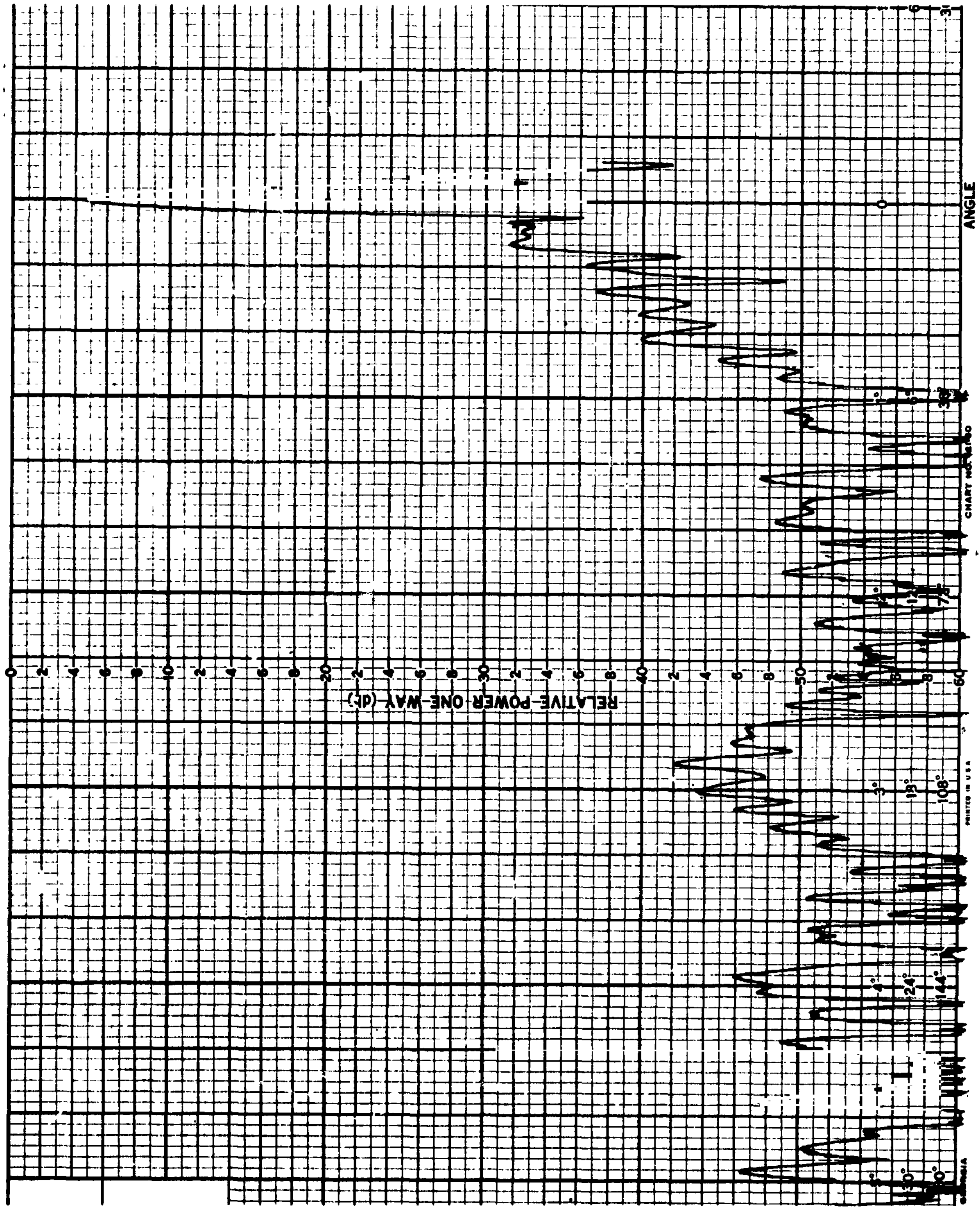


FIG. 72 - 1400 MC, Eθ, FEED TILTED UP

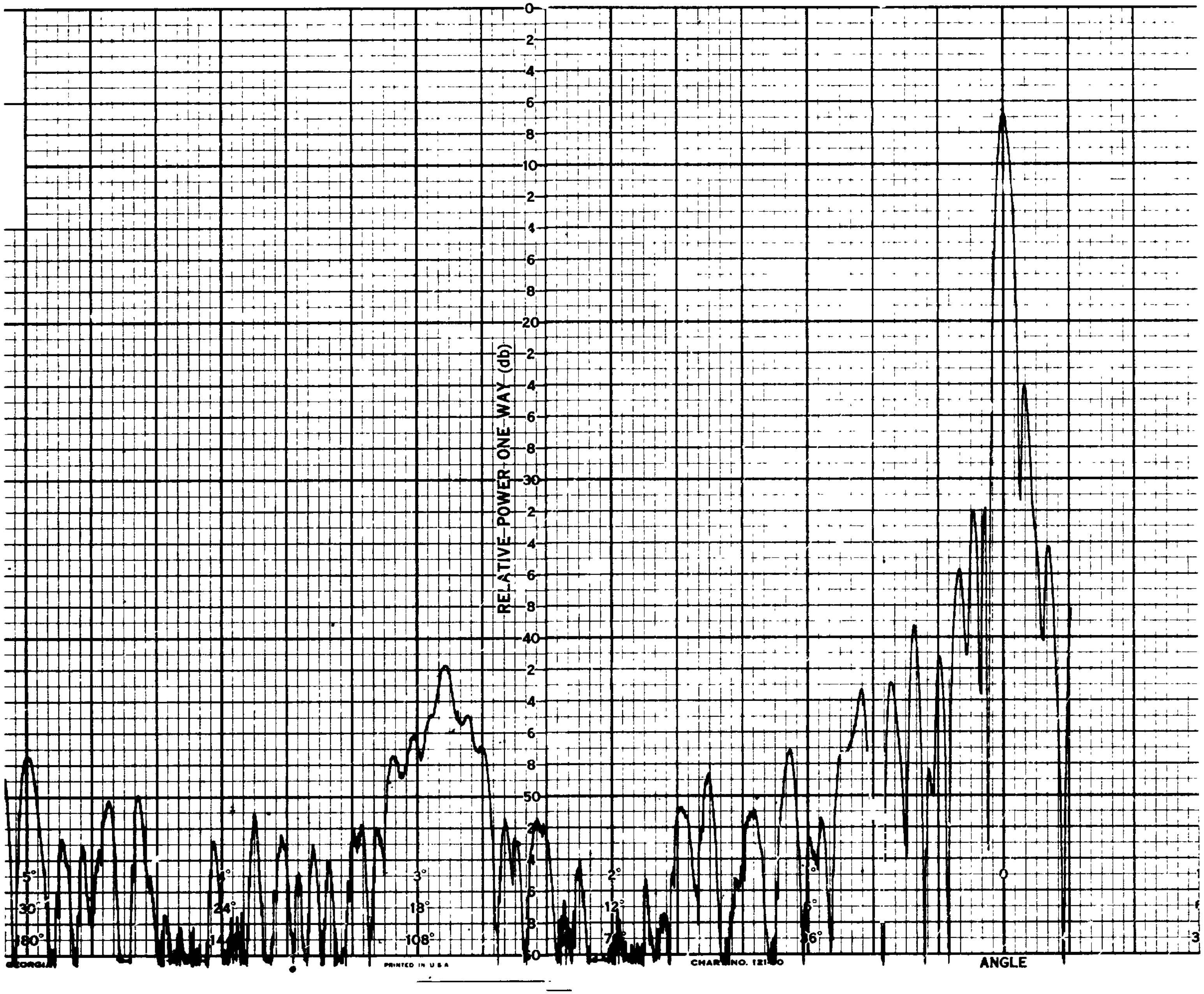


FIG. 73 - 1400 MC, Eϕ, FEED TILTED UP

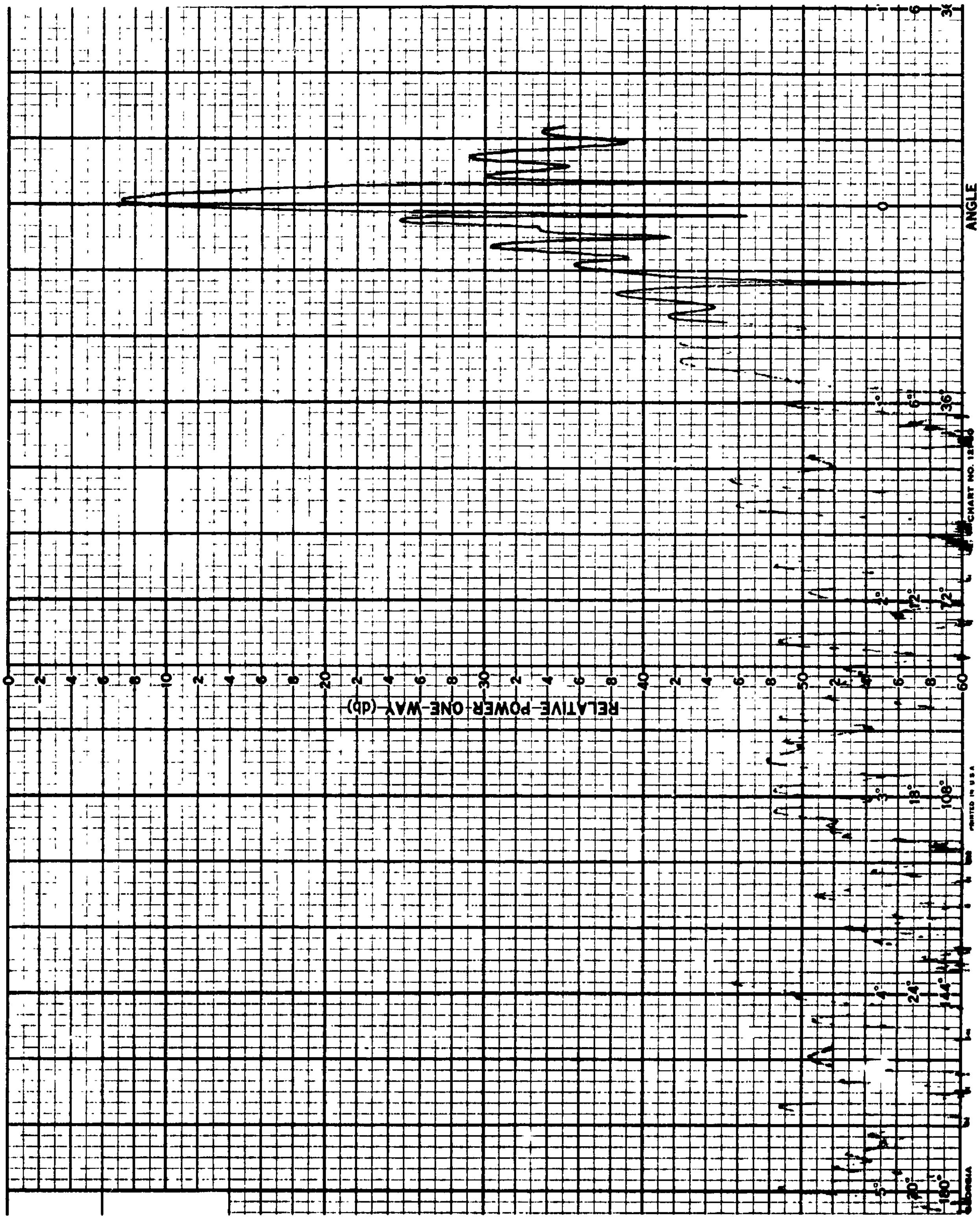


FIG. 74 - 1400 MC, Eθ, FEED TILTED DOWN

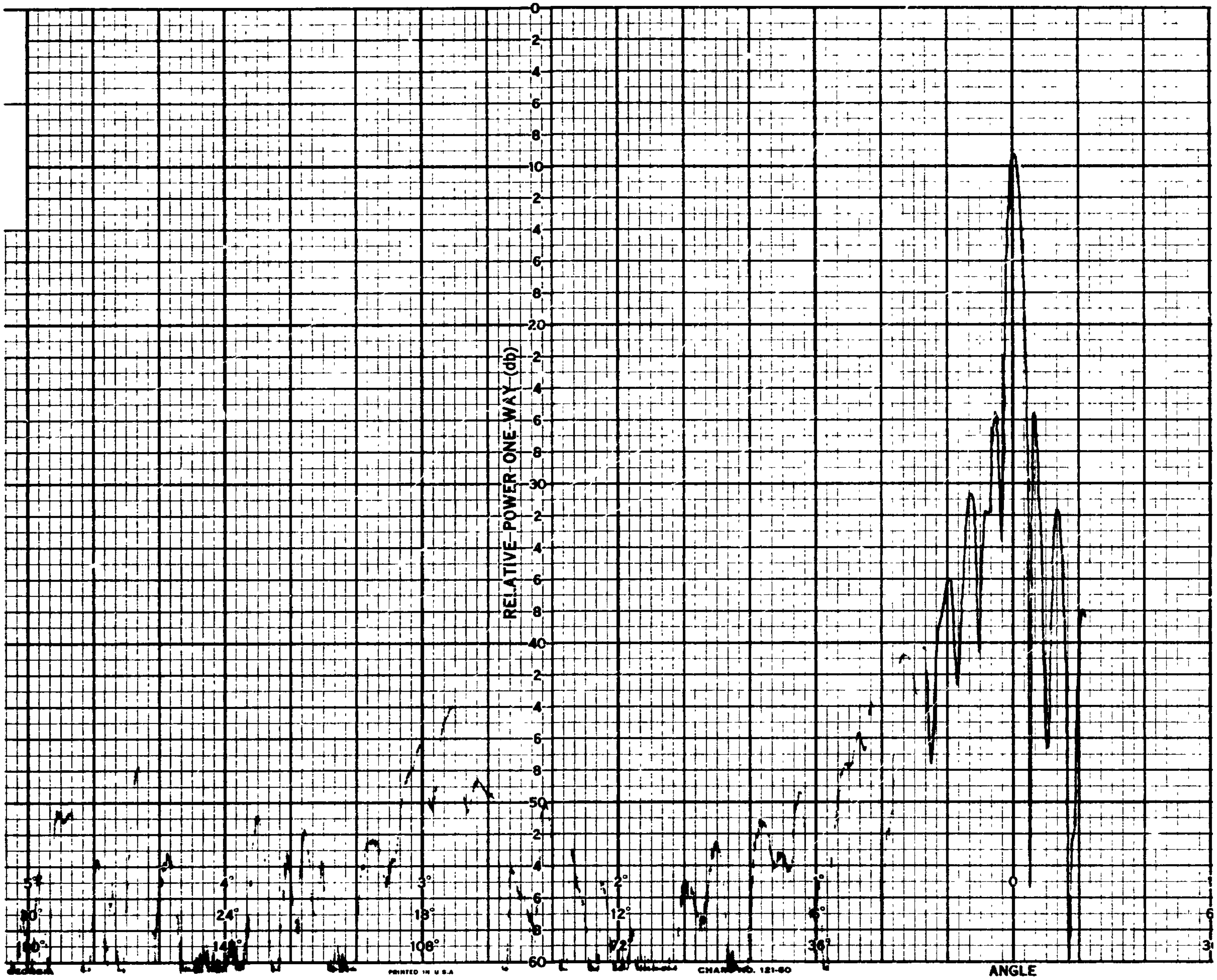


FIG. 75 - 1400 MC, Eϕ, FEED TILTED DOWN

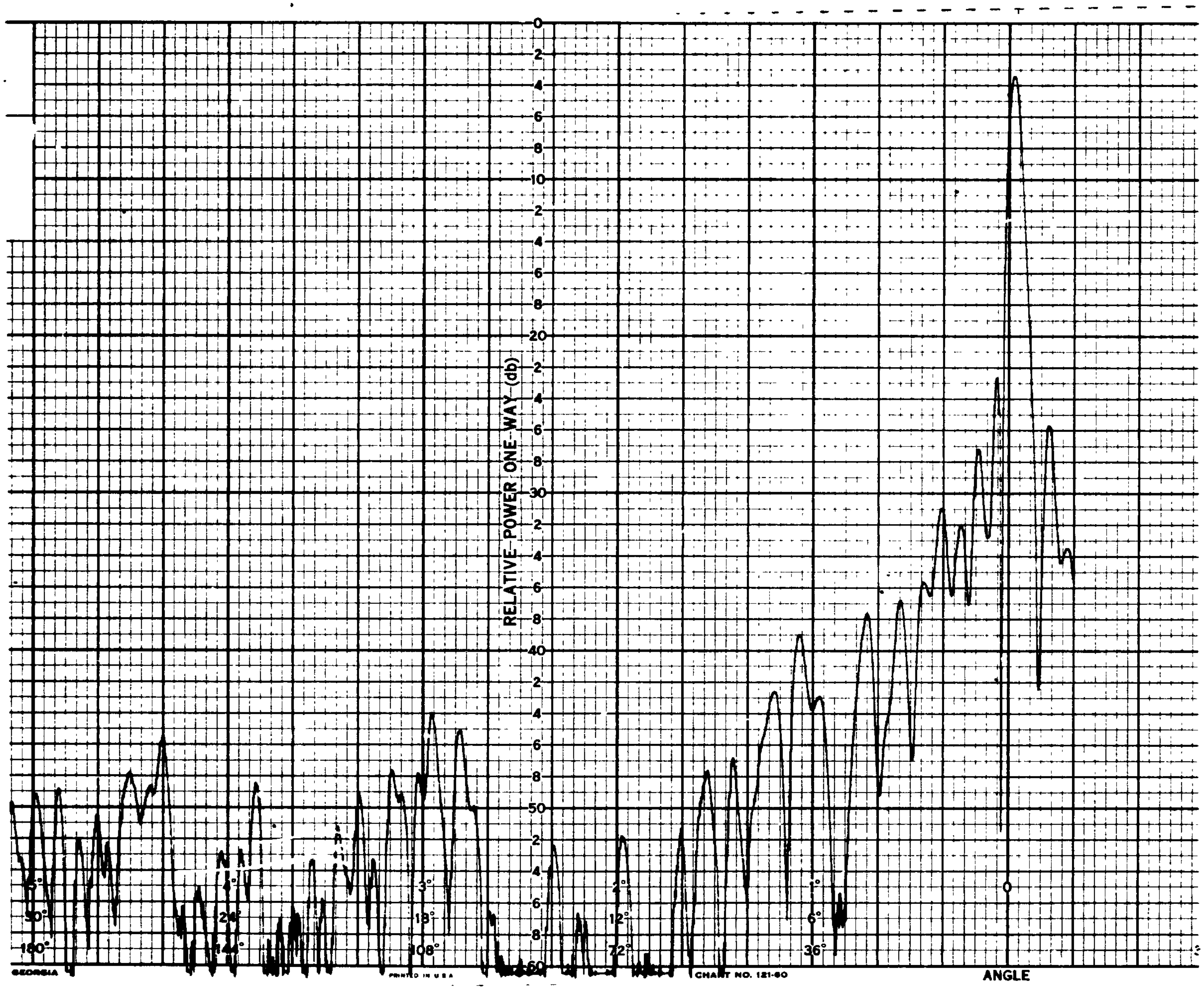


FIG. 76 - 1700 MC, Eθ, FEED TILTED LEFT

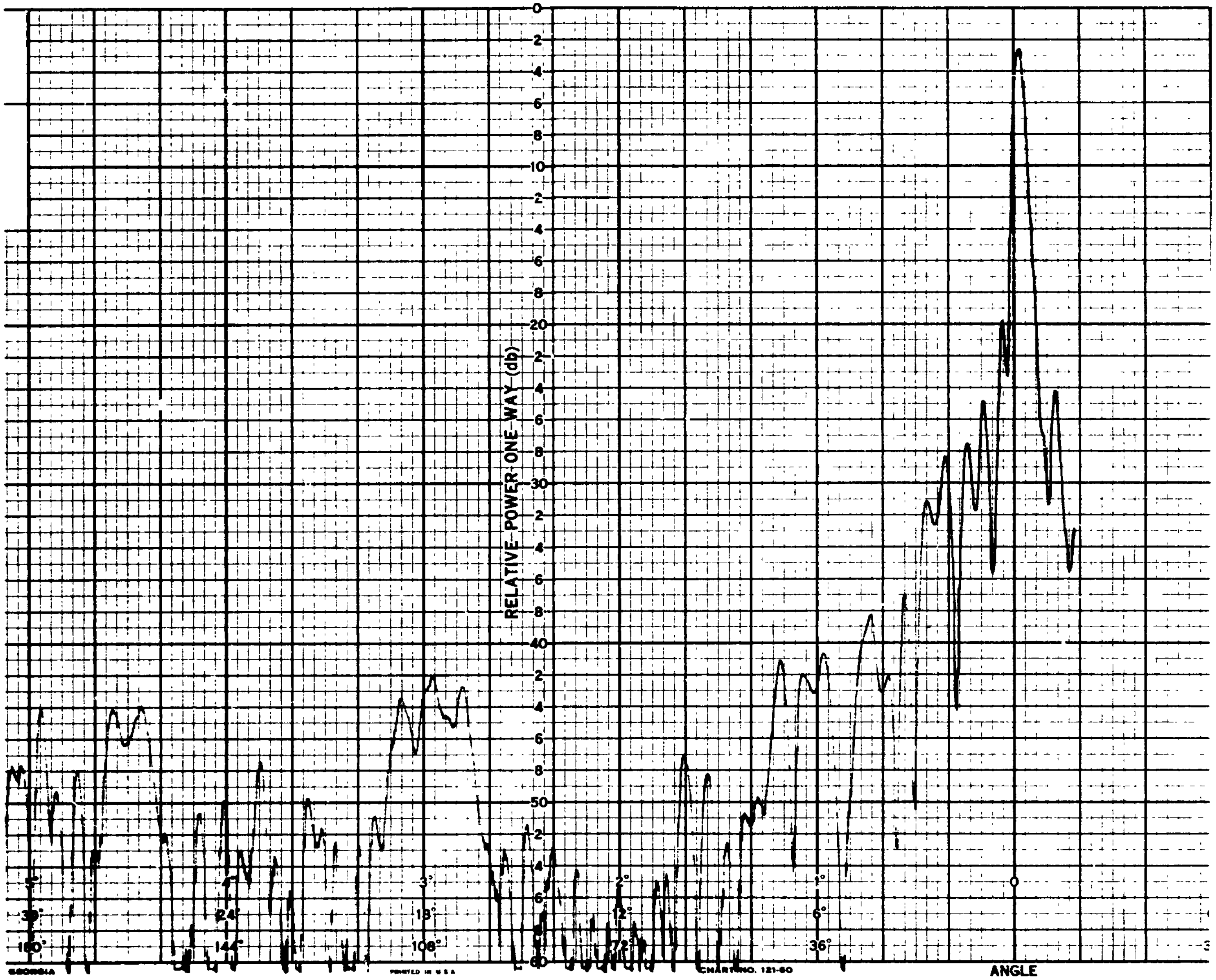


FIG. 77 - 1700 MC, Eϕ, FEED TILTED LEFT

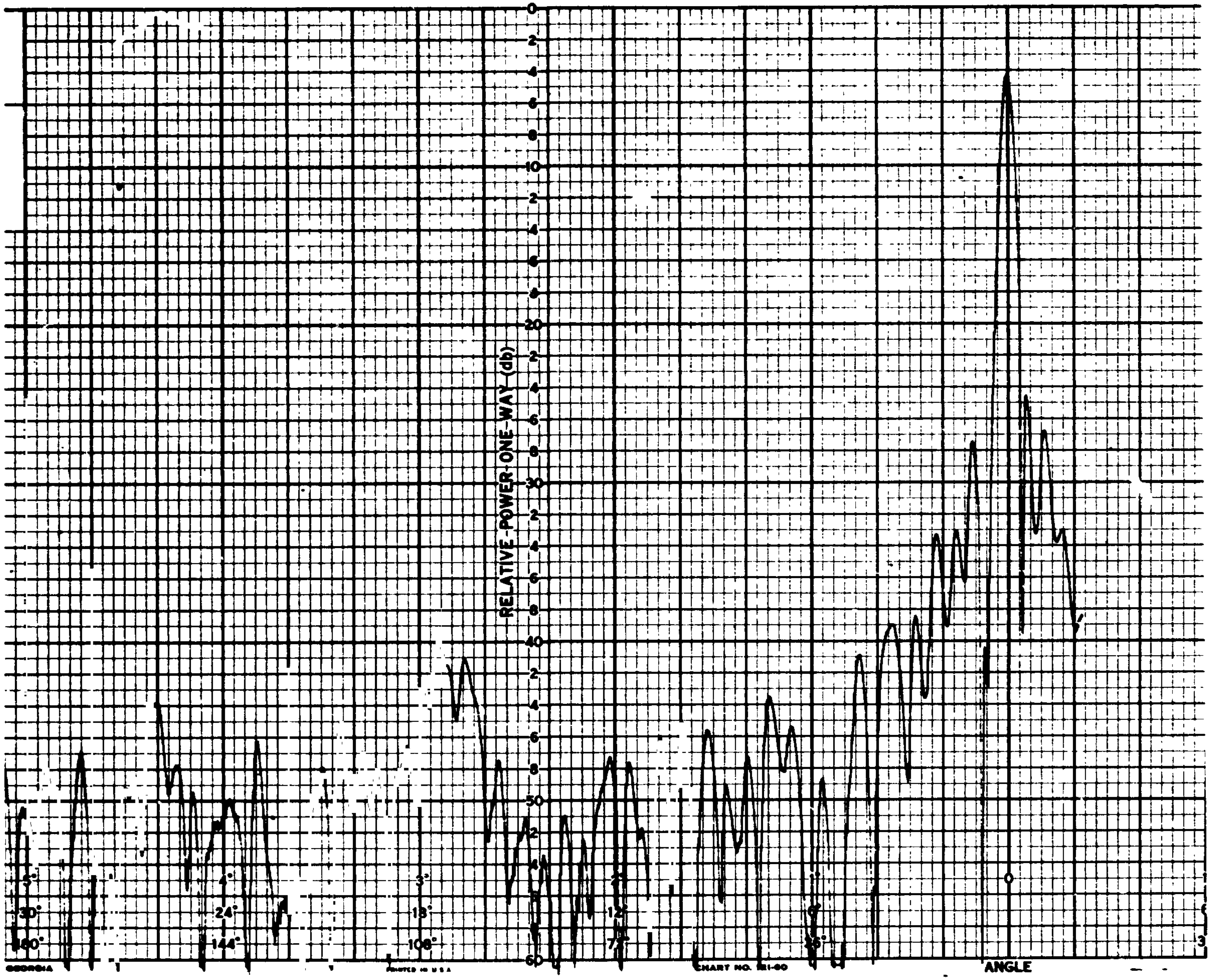


FIG. 78 - 1700 MC, Eθ, FEED TILTED RIGHT

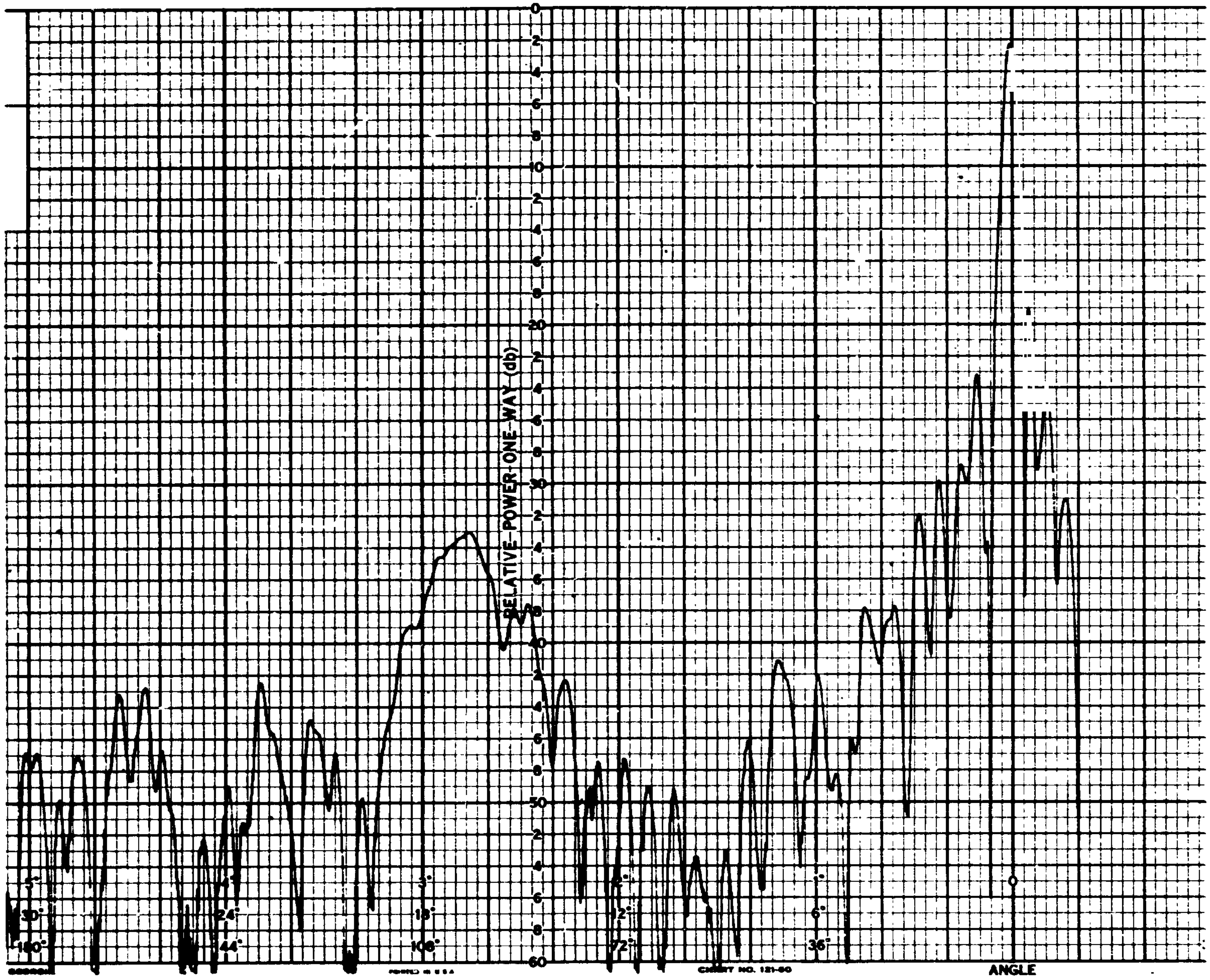


FIG. 79 - 1700 MC, Eφ, FEED TILTED RIGHT

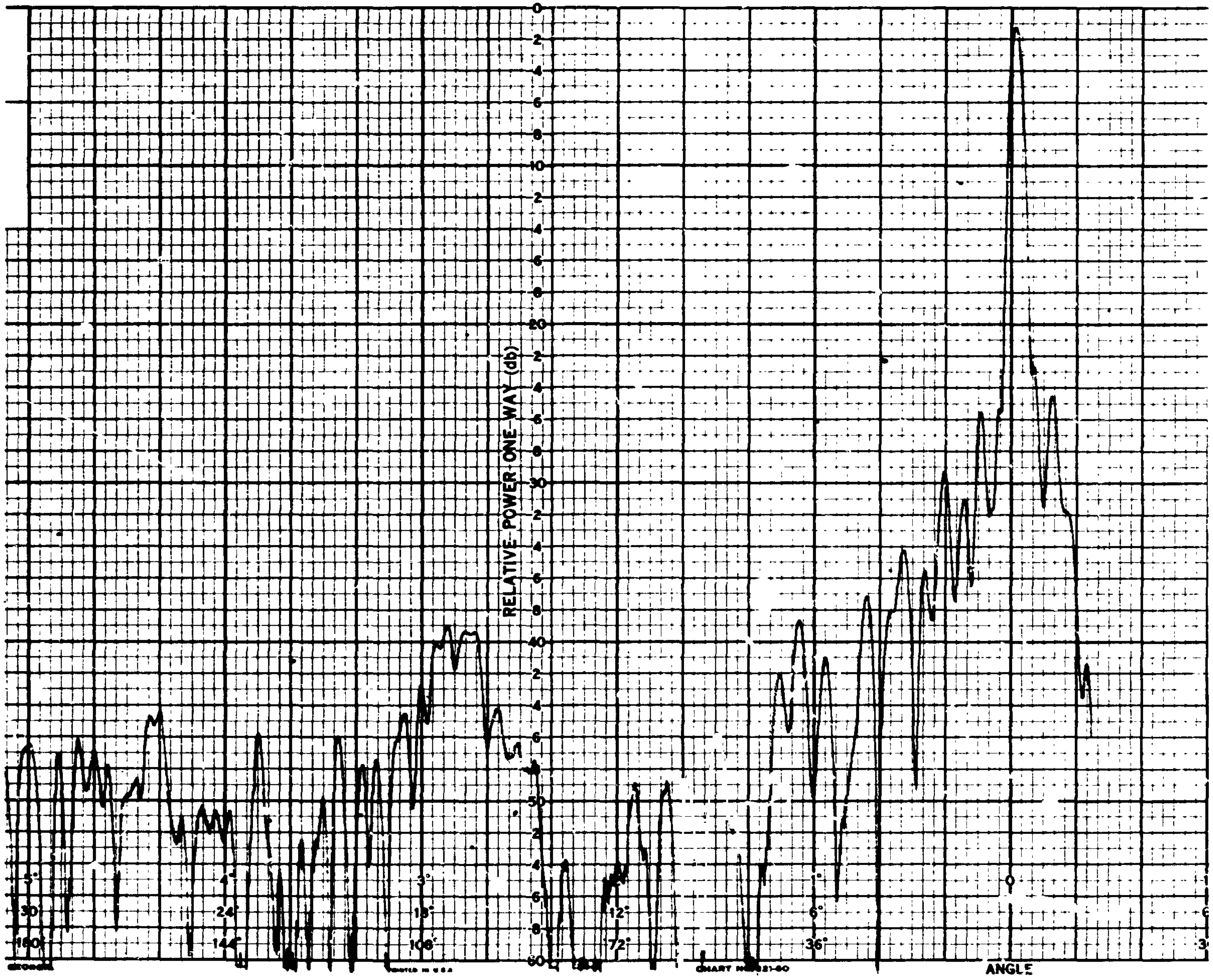


FIG. 80 - 1700 MC, $E\theta$, FEED TILTED UP

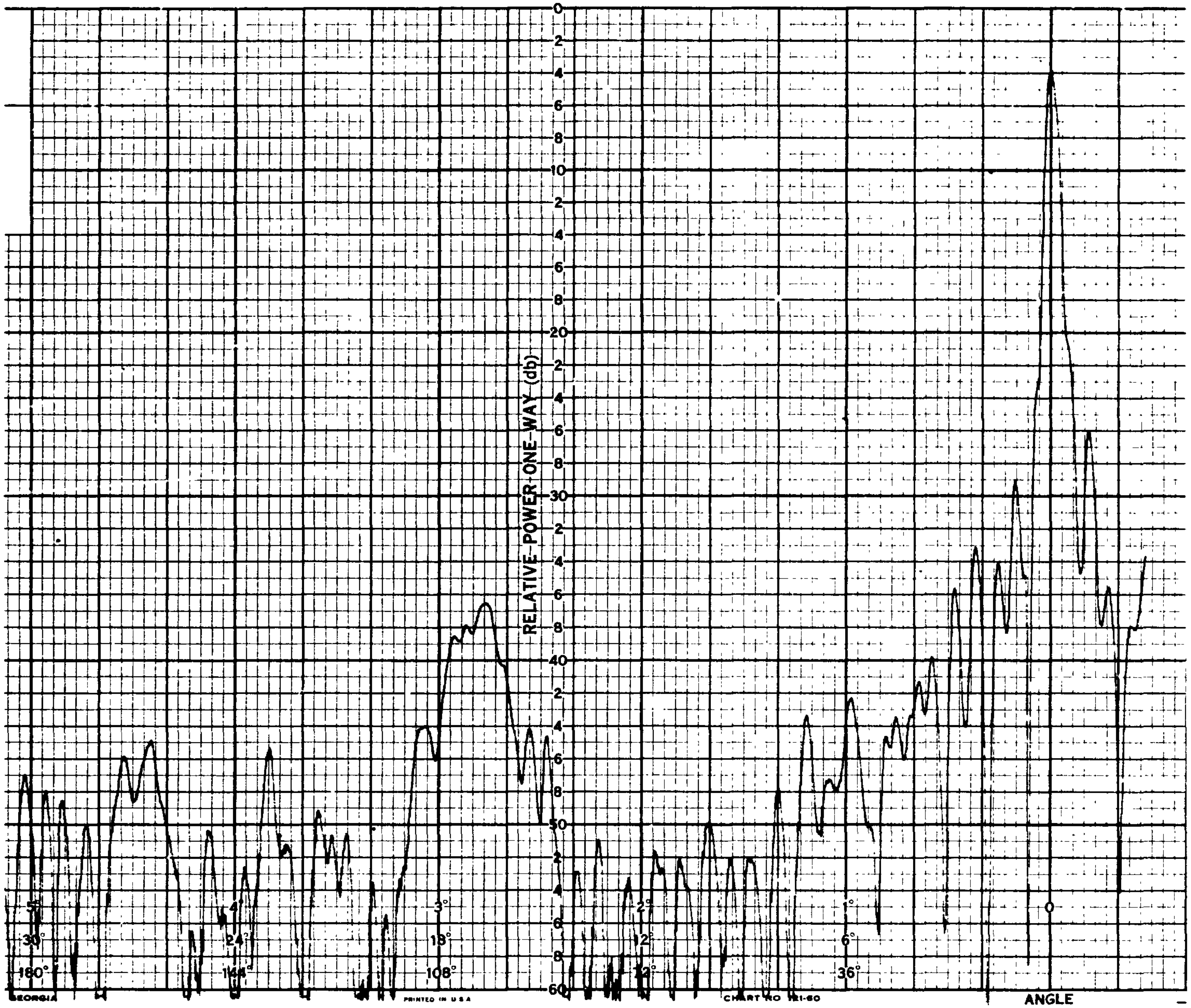


FIG. 81 - 1700 MC, Eϕ, FEED TILTED UP

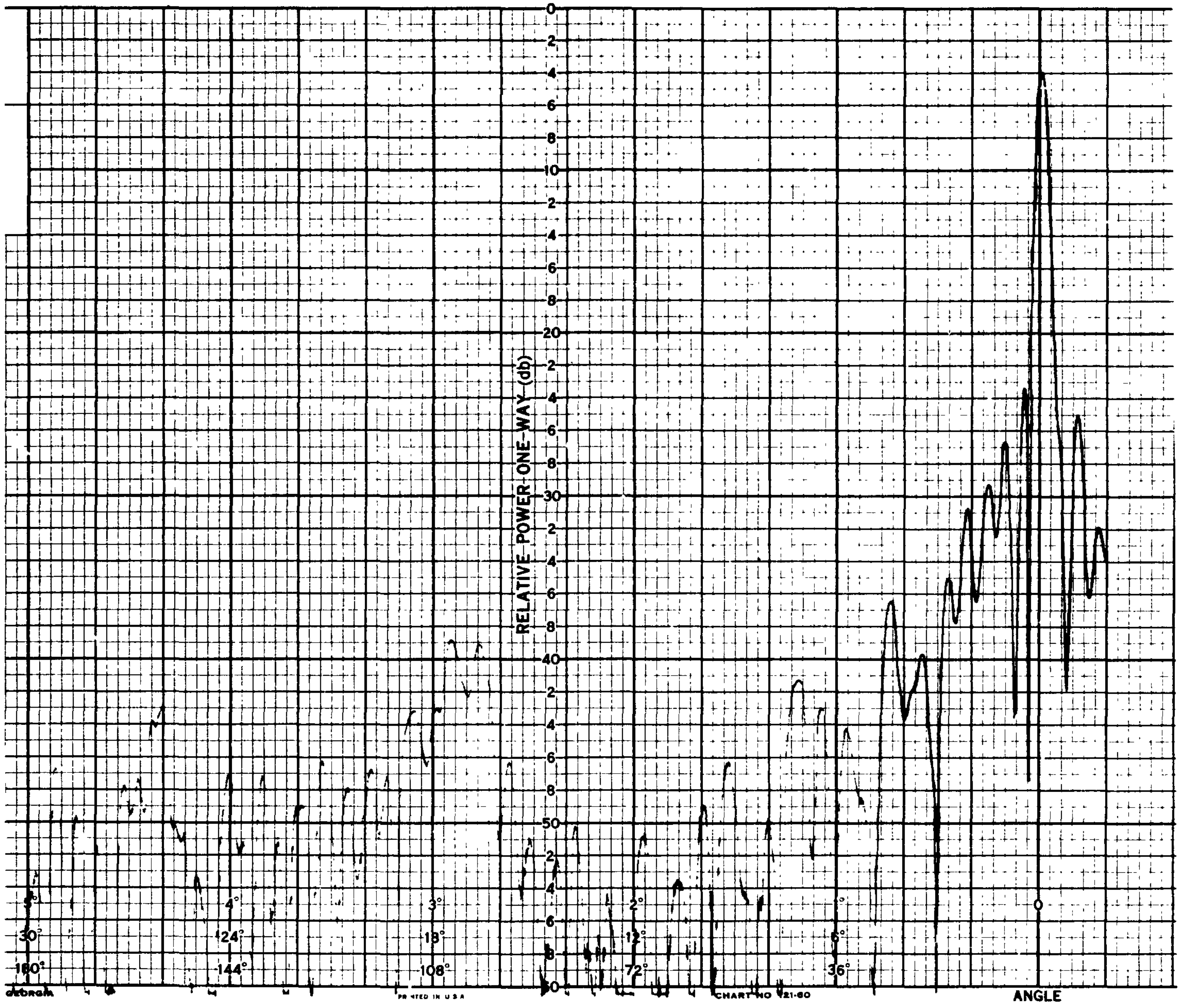


FIG. 82 - 1700 MC, Eθ, FEED TILTED DOWN

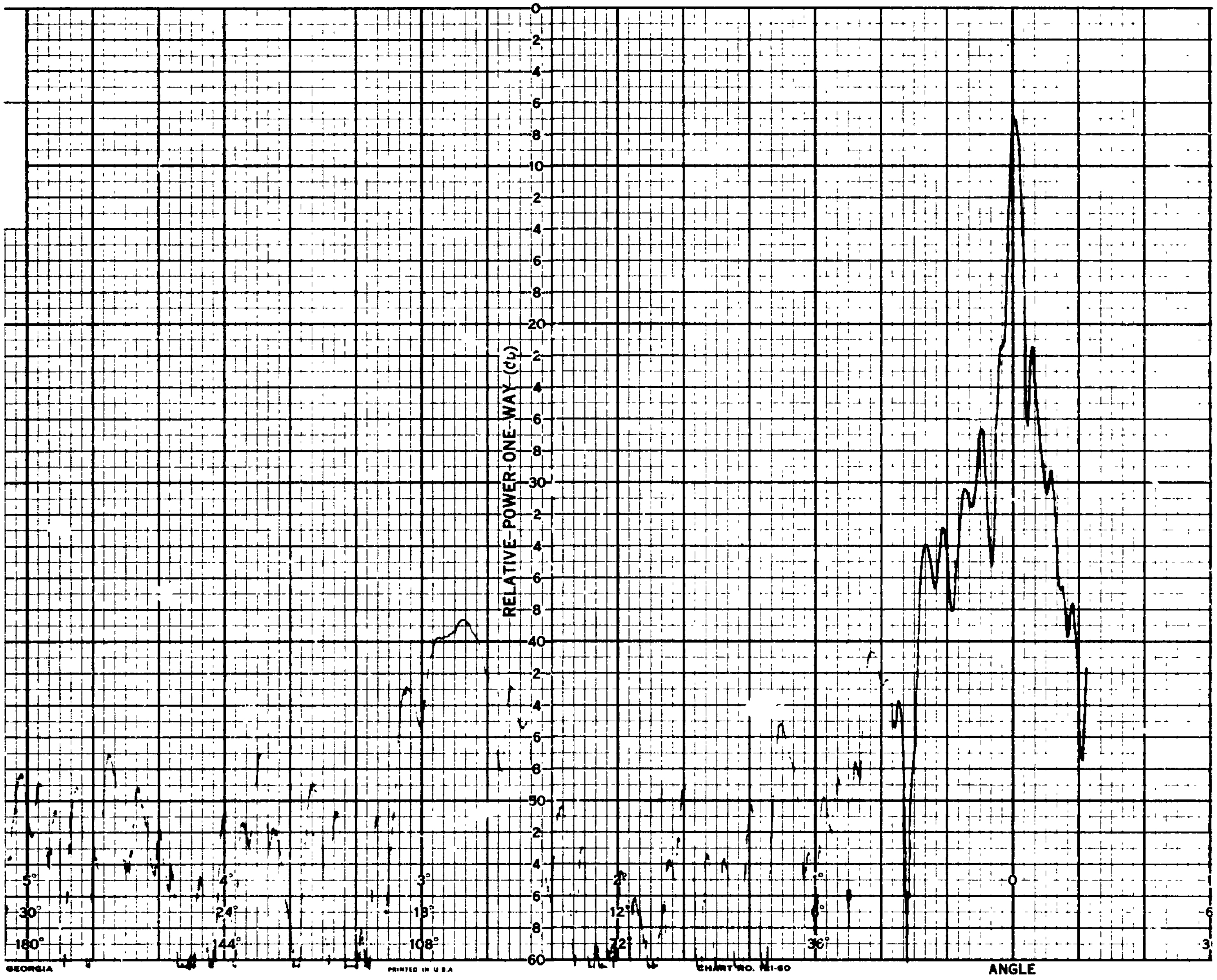


FIG. 83 - 1700 MC, Eϕ, FEED TILTED DOWN

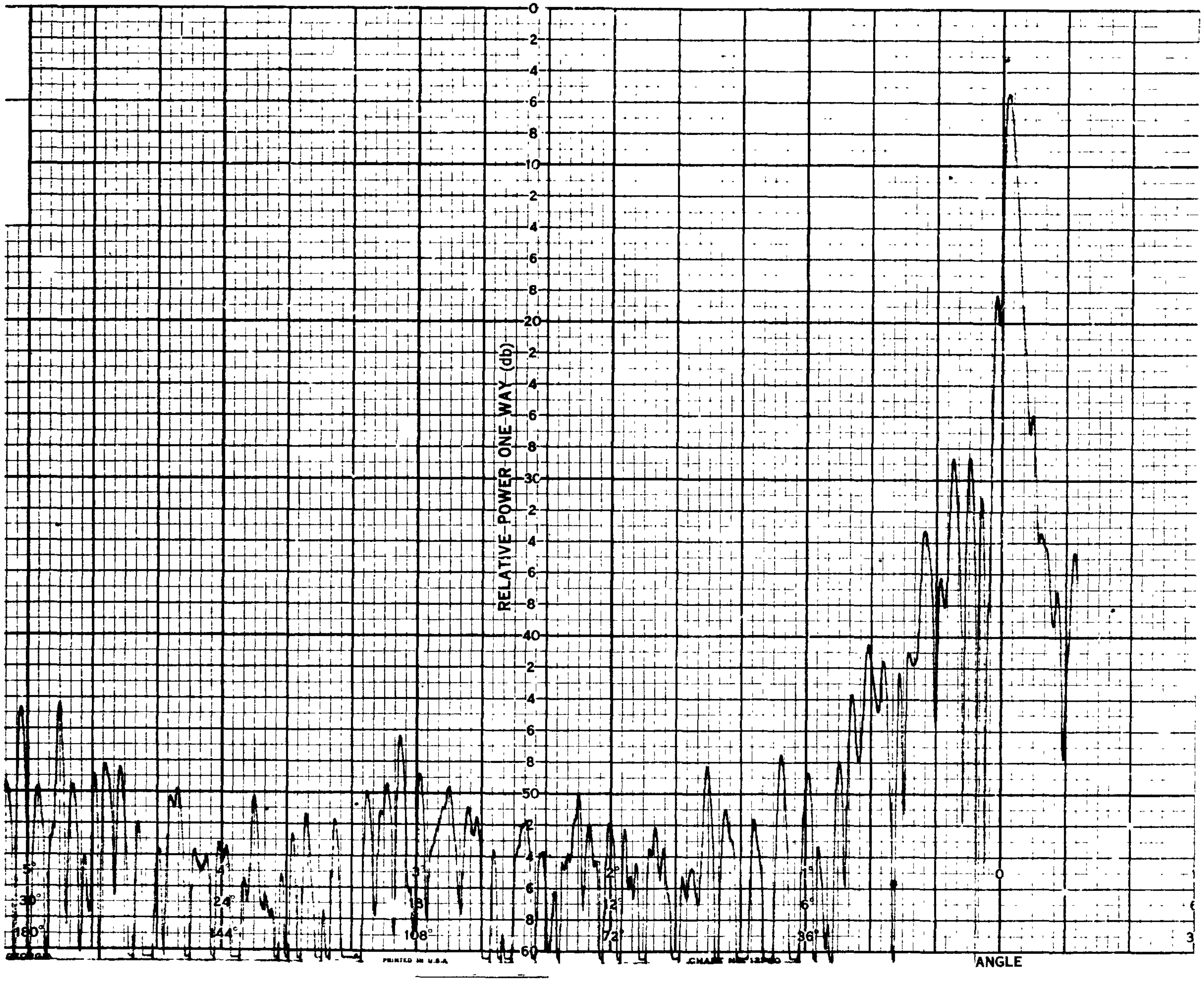


FIG. 84 - 2290 MC, Eθ, FEED TILTED LEFT

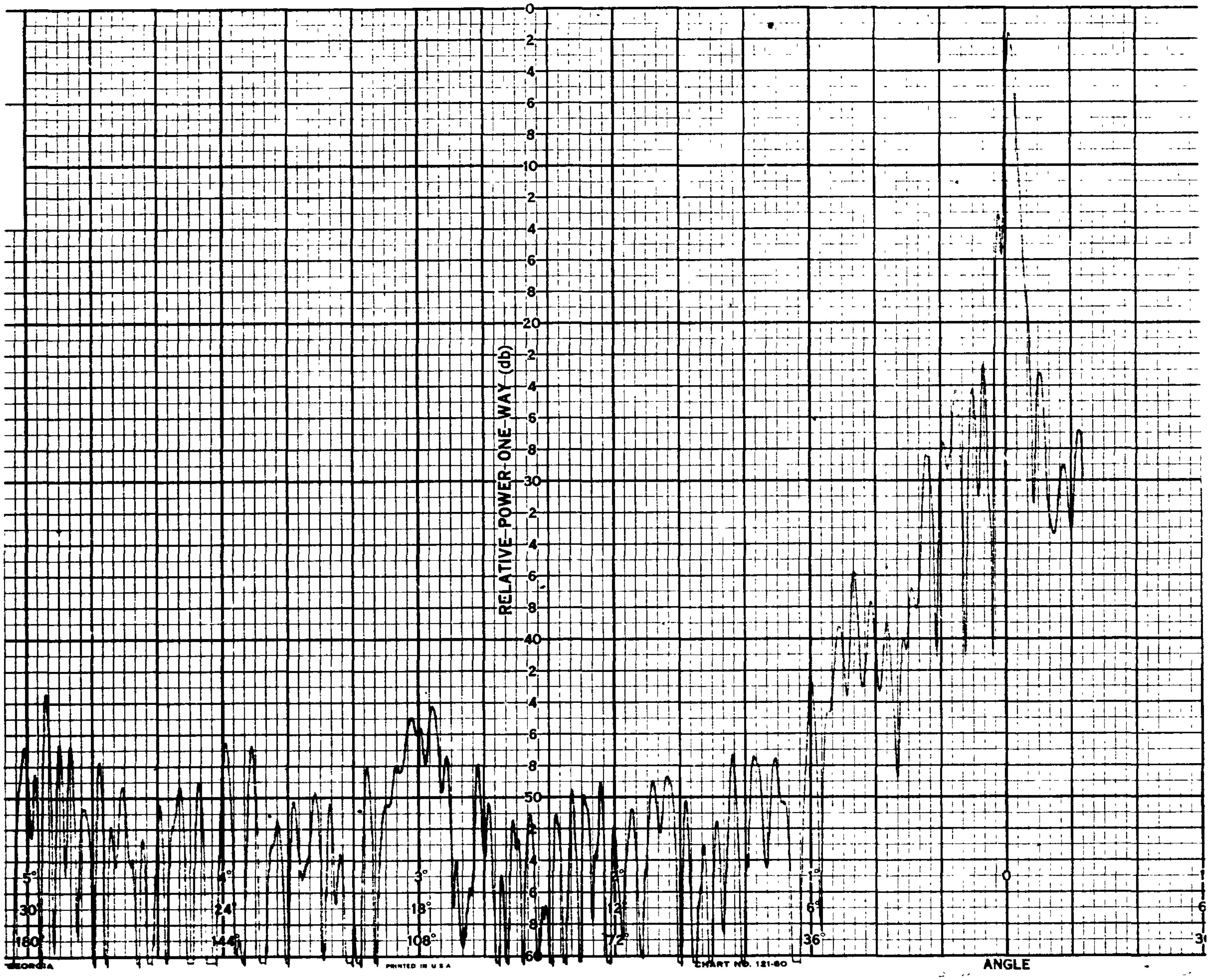


FIG. 85 - 2290 MC, Eϕ, FEED TILTED LEFT

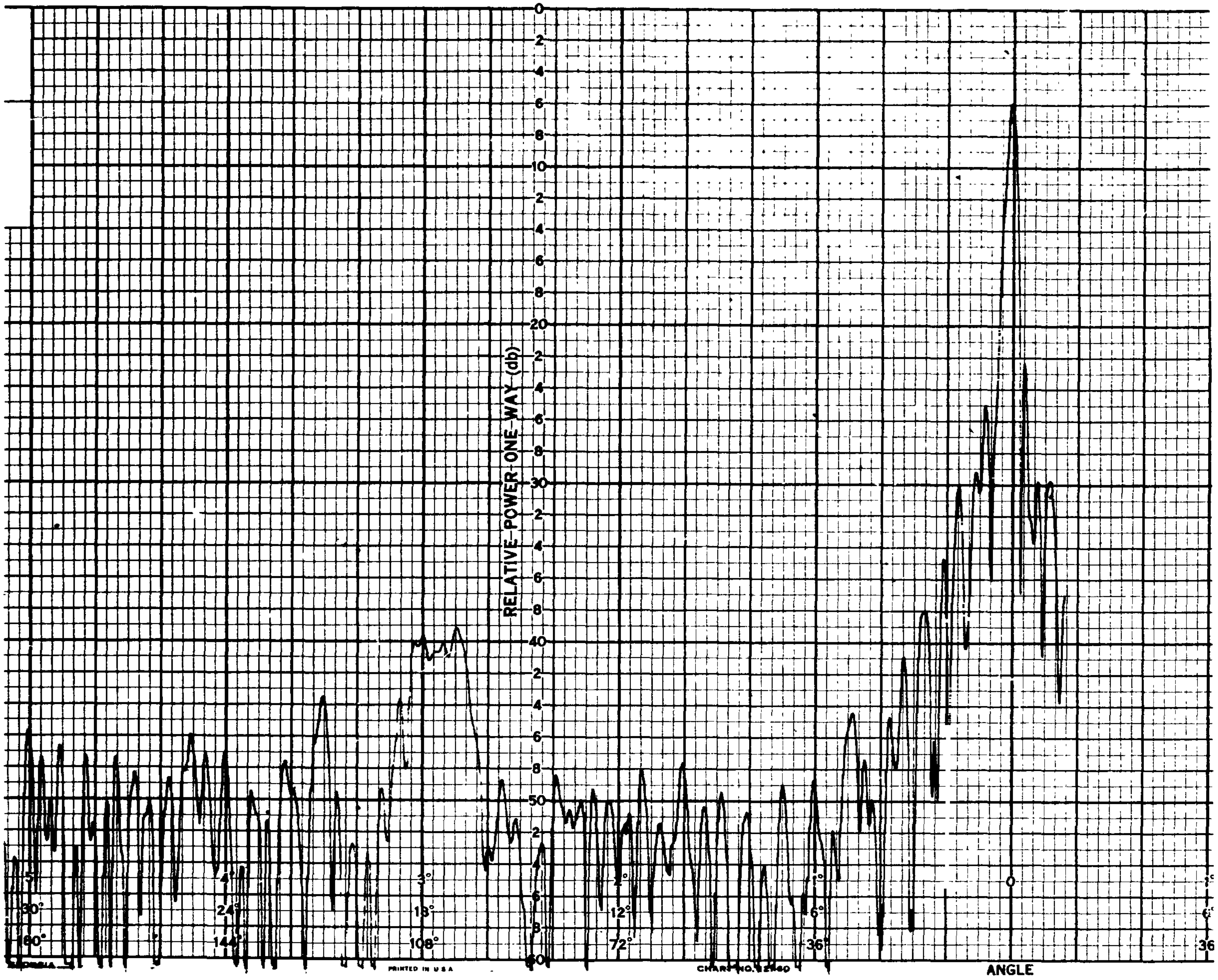


FIG. 86 - 2290 MC, Eθ, FEED TILTED RIGHT

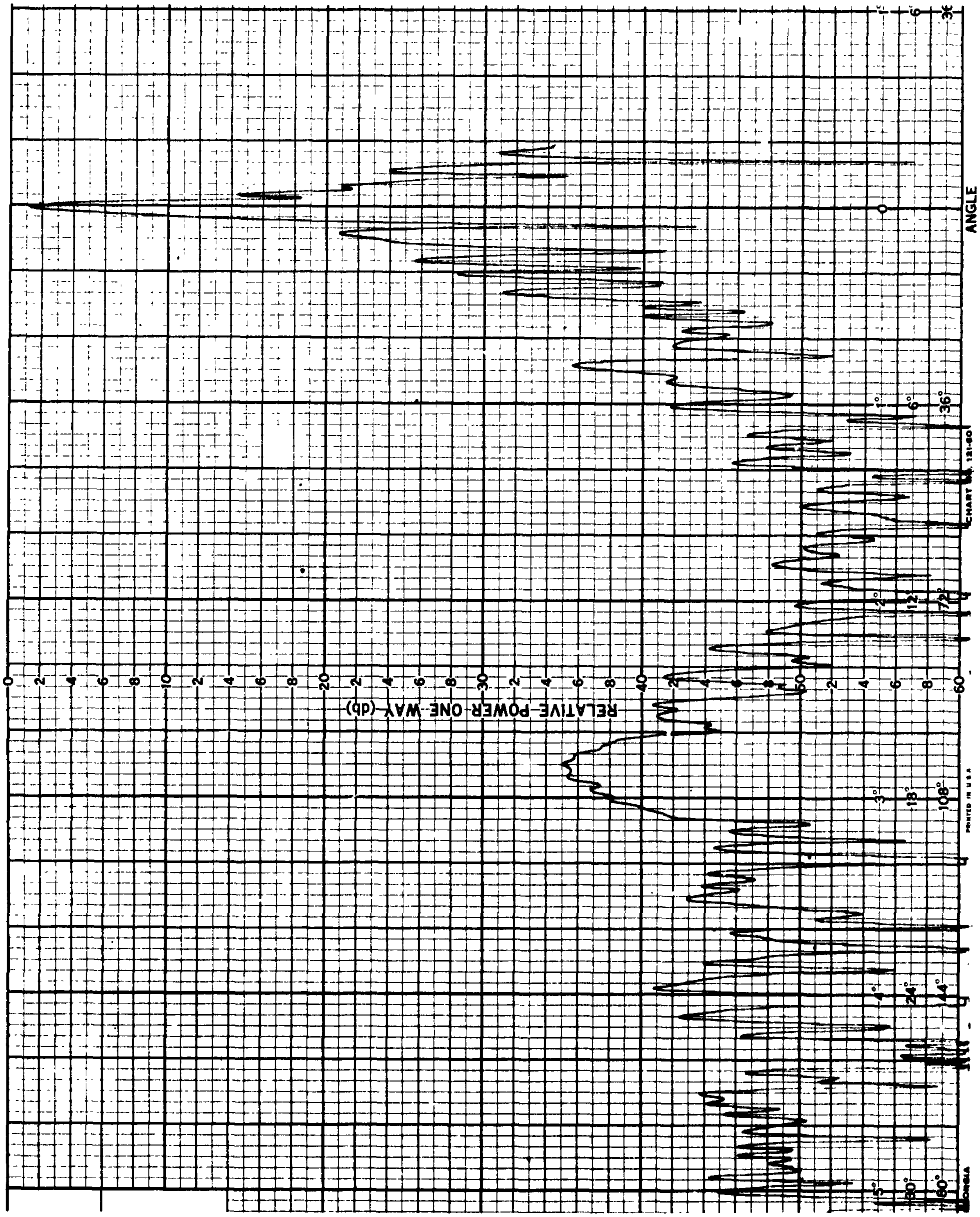


FIG. 87 - 2290 MC, Eφ, FEED TILTED RIGHT

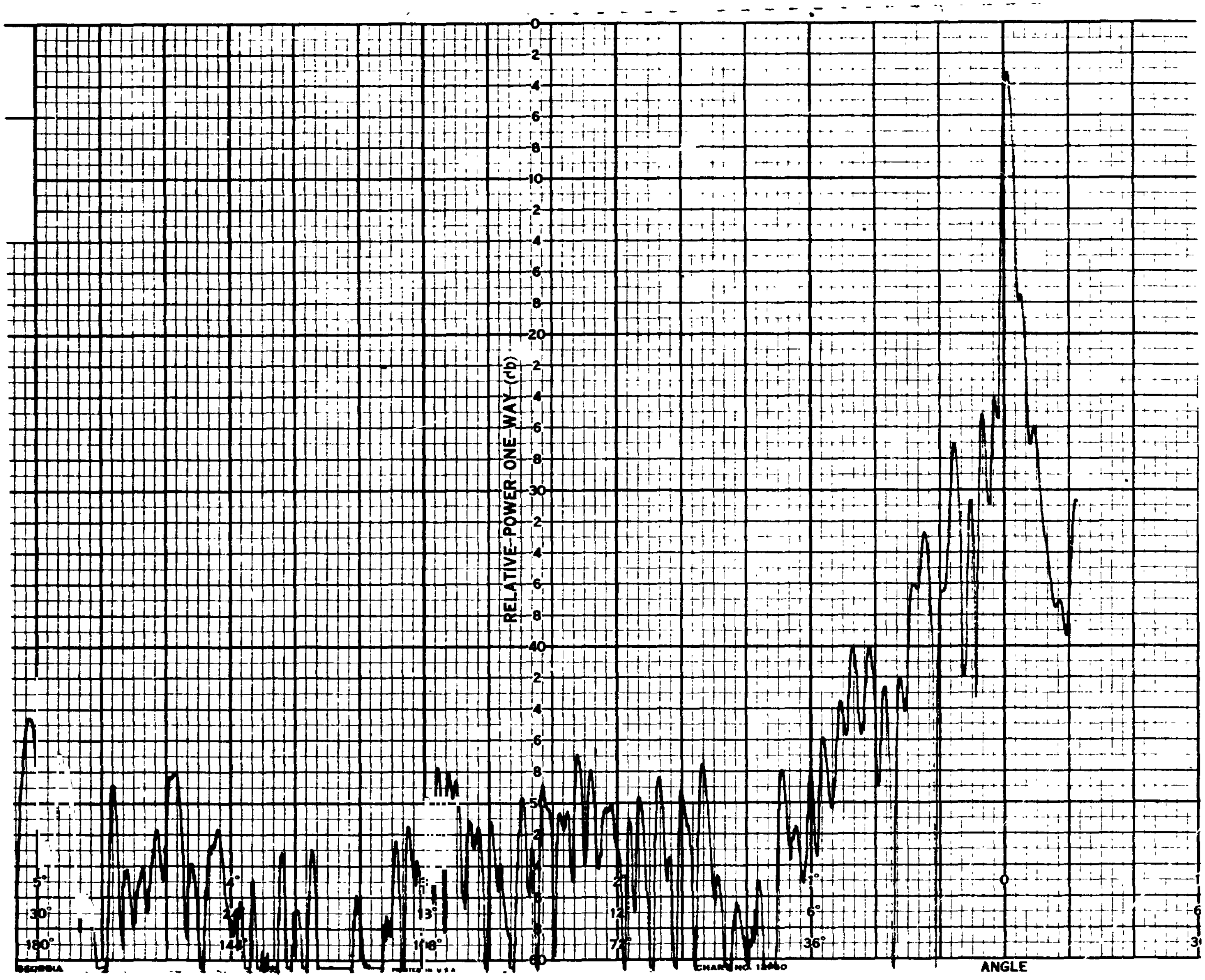


FIG. 88 - 2290 MC, Eθ, FEED TILTED UP

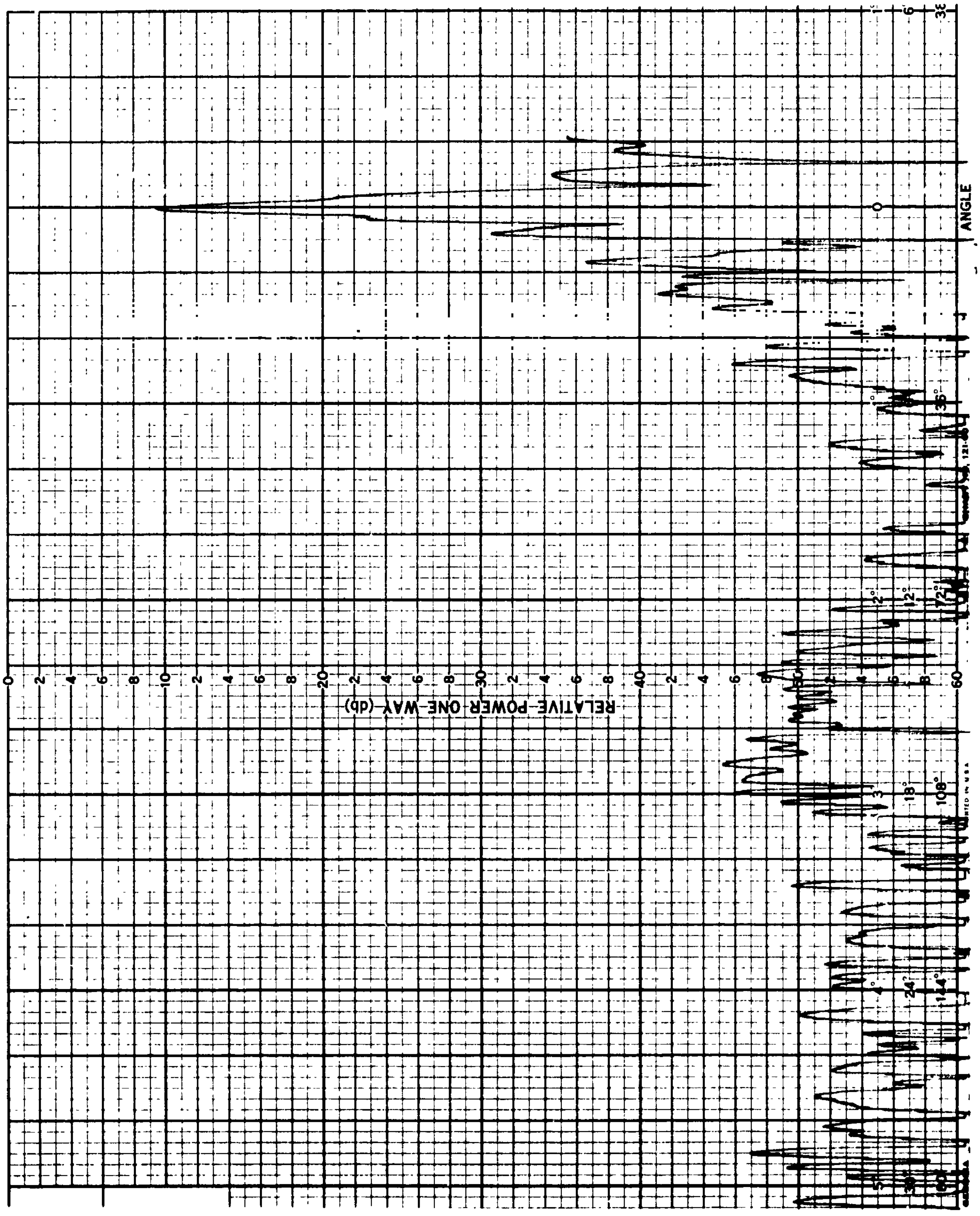


FIG. 89 - 2290 MC, Eφ, FEED TILTED UP

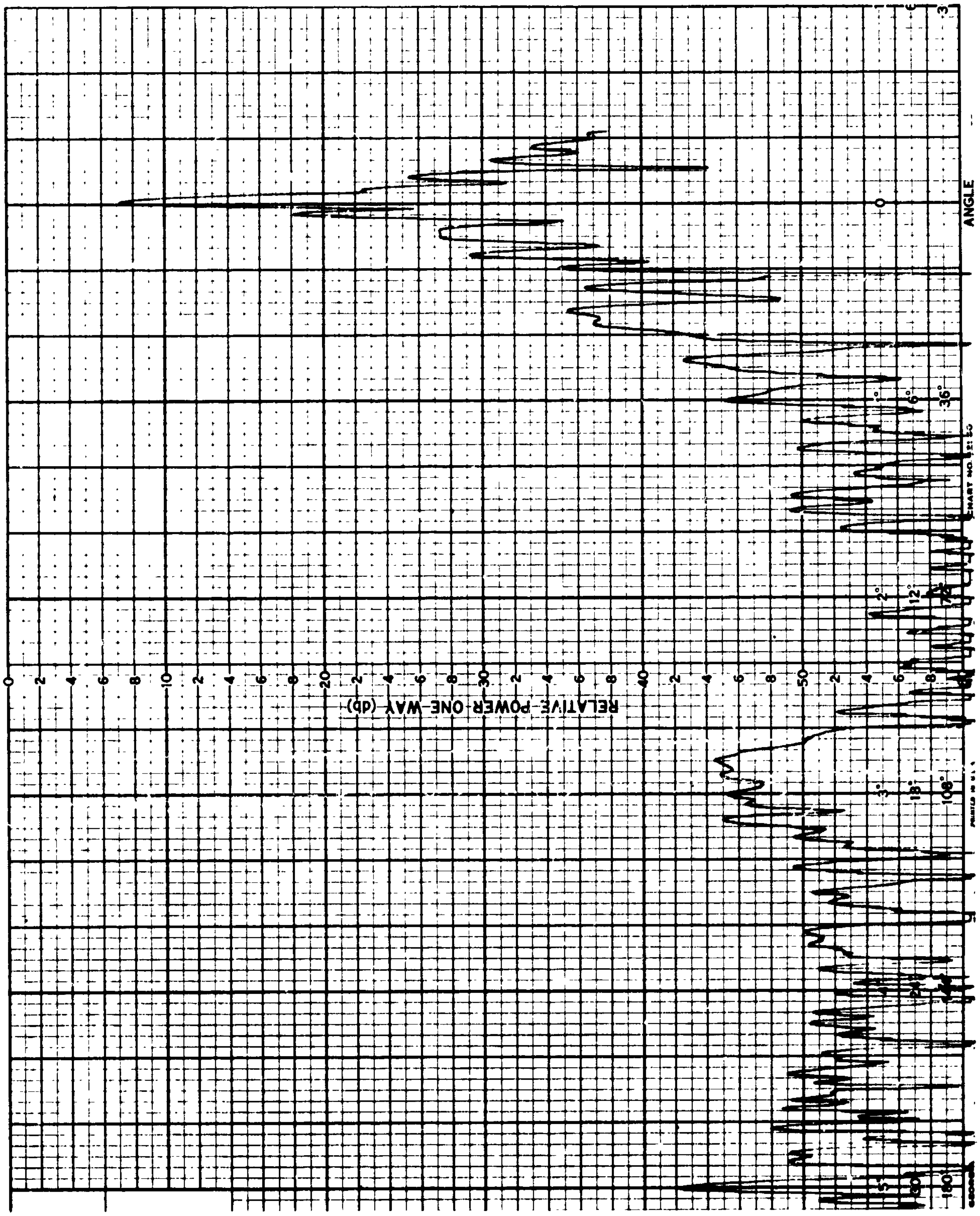


FIG. 90 - 2290 MC, Eθ, FEED TILTED DOWN

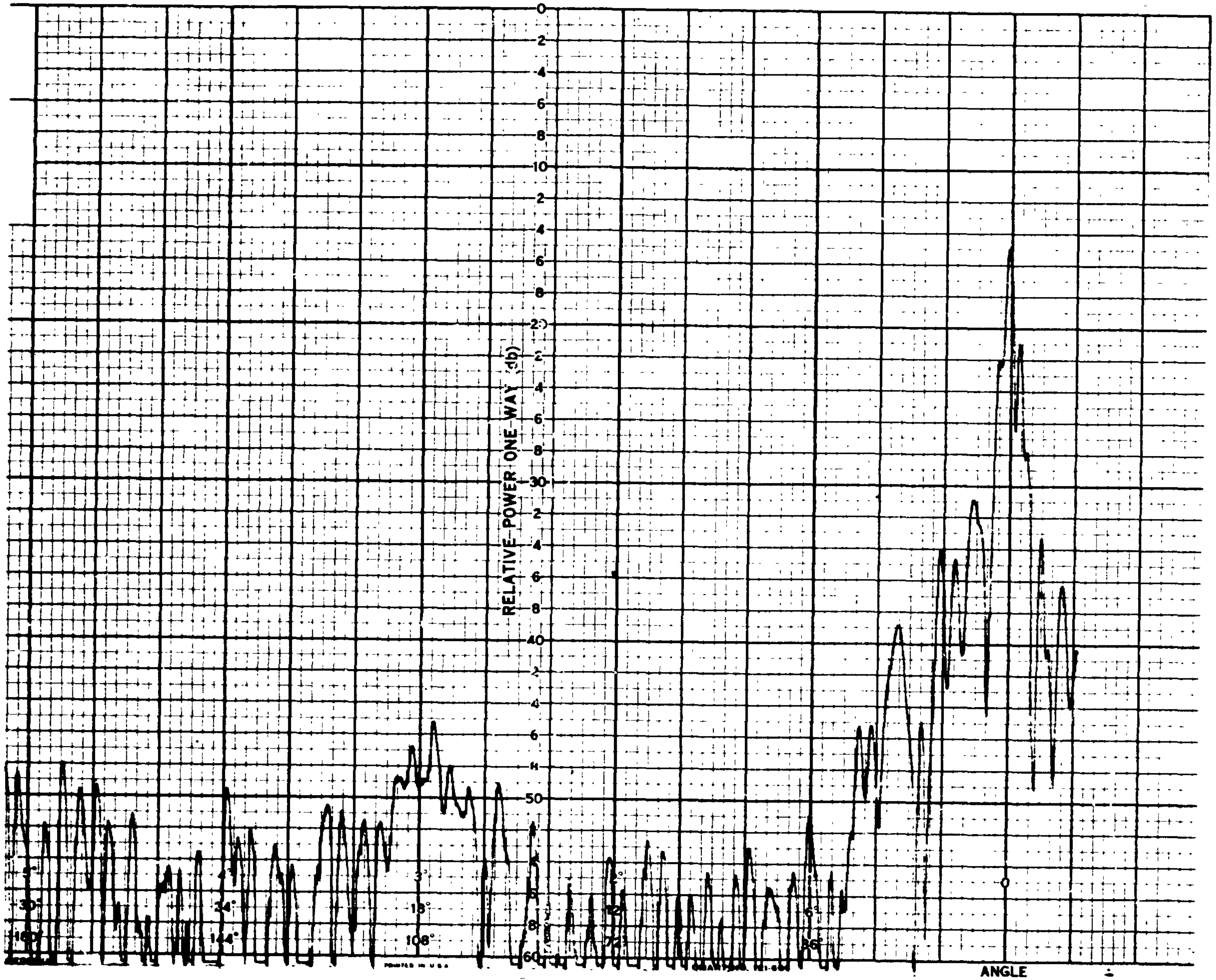


FIG. 91 - 2290 MC, Eϕ, FEED TILTED DOWN

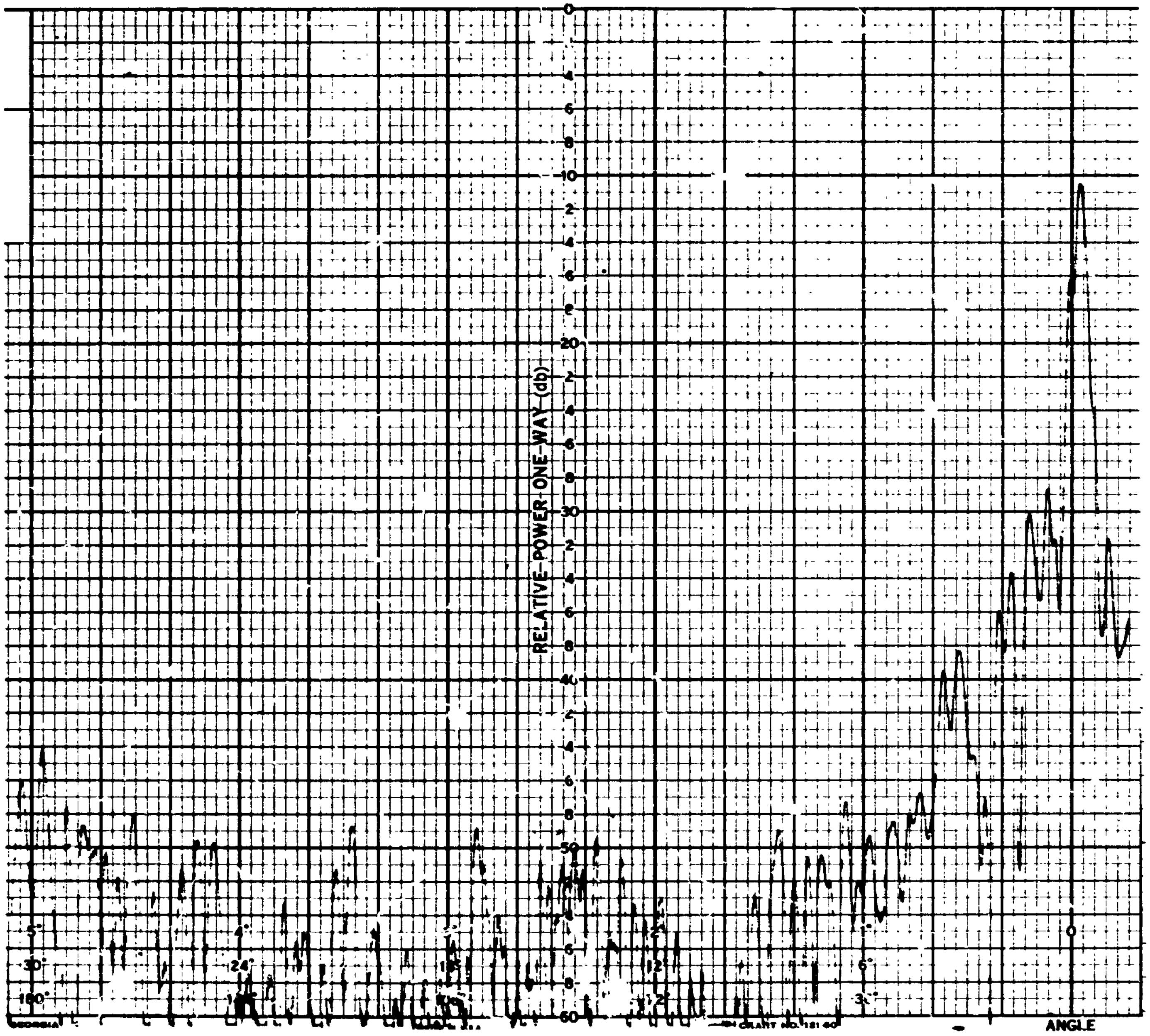


FIG. 92 - 2800 MC, Eθ, FEED TILTED LEFT

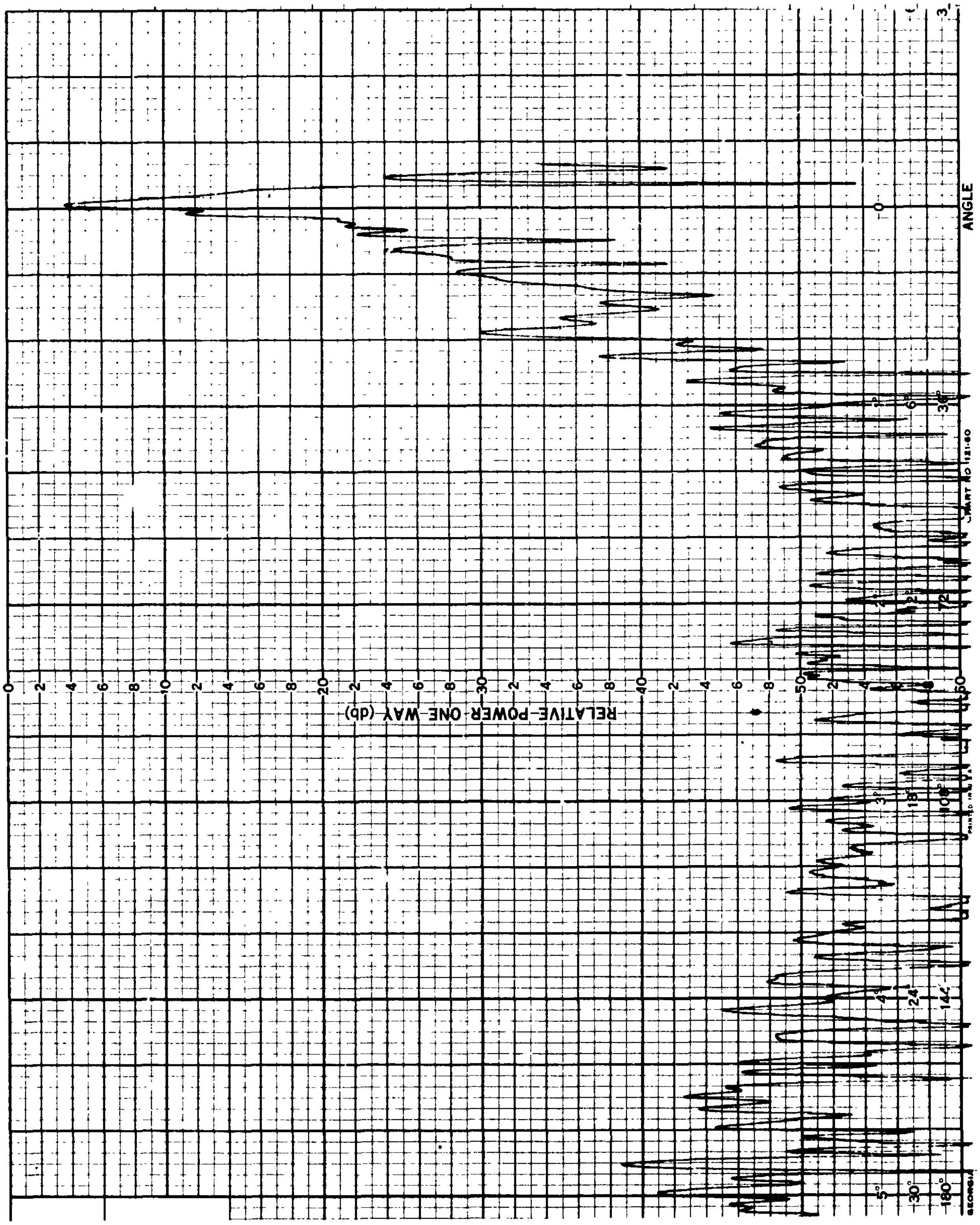


FIG. 93 - 2800 MC, Eφ, FEED TILTED LEFT

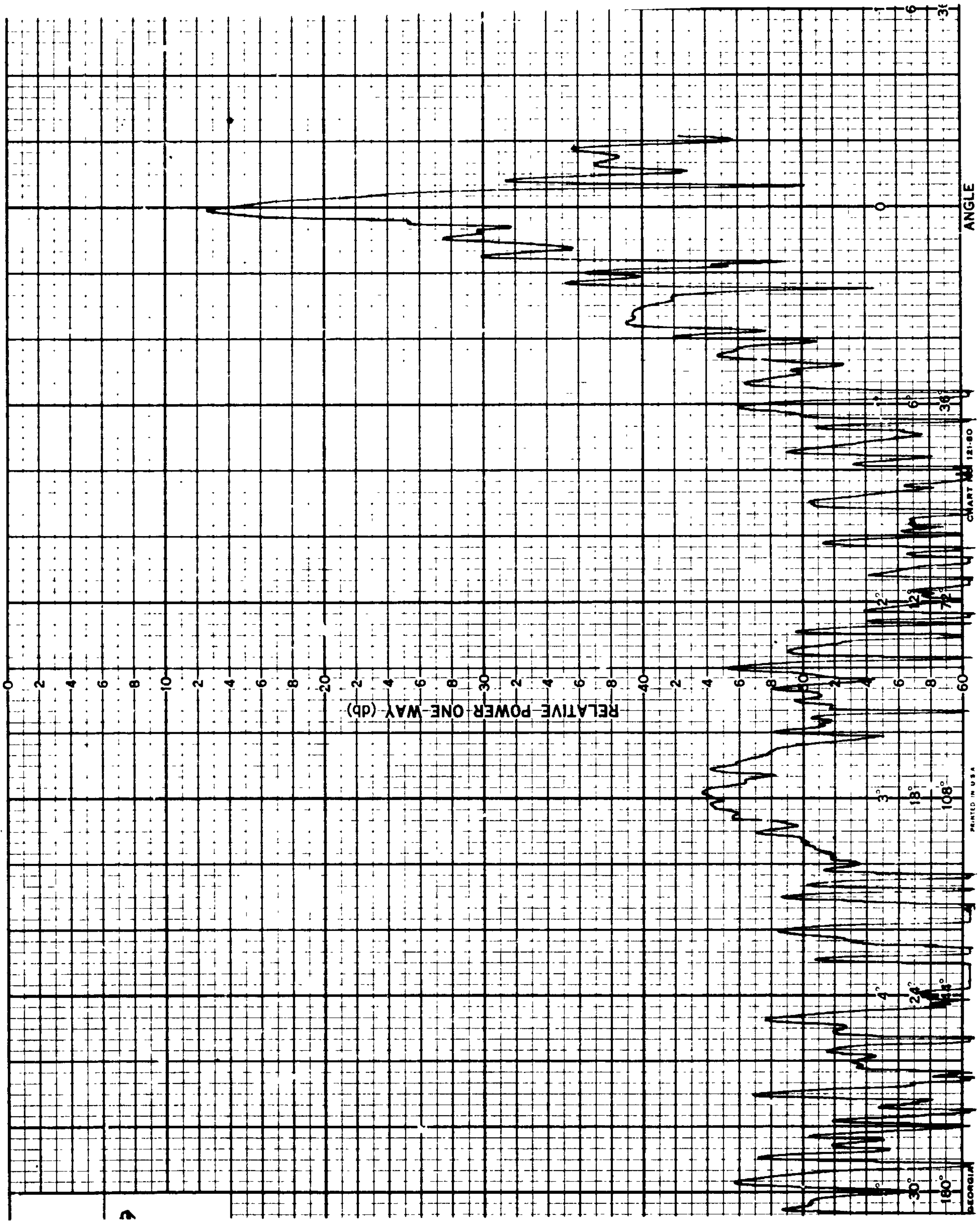


FIG. 94 - 2800 MC, Eθ, FEED TILTED RIGHT

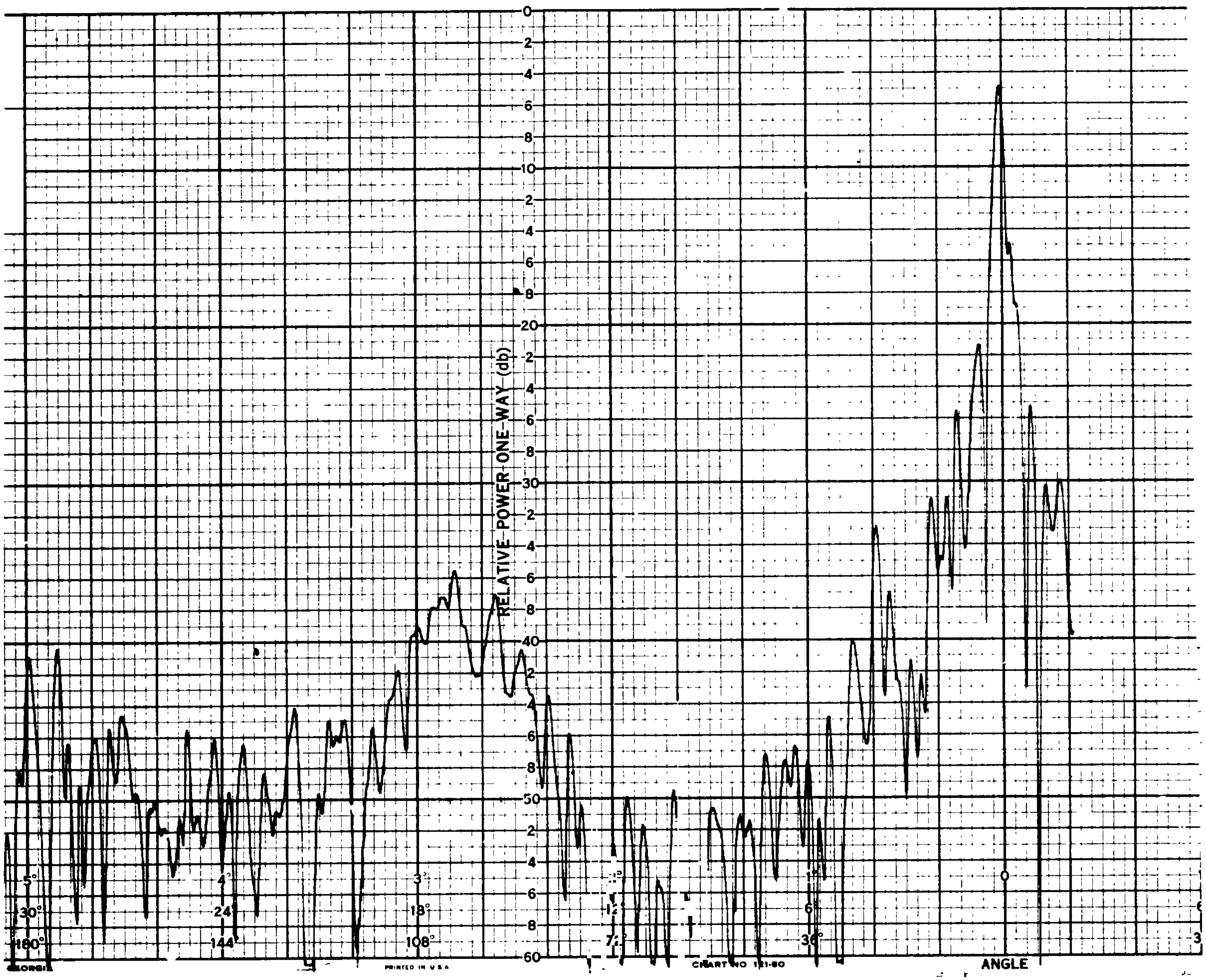


FIG. 95 - 2800 MC, Eφ, FEED TILTED RIGHT

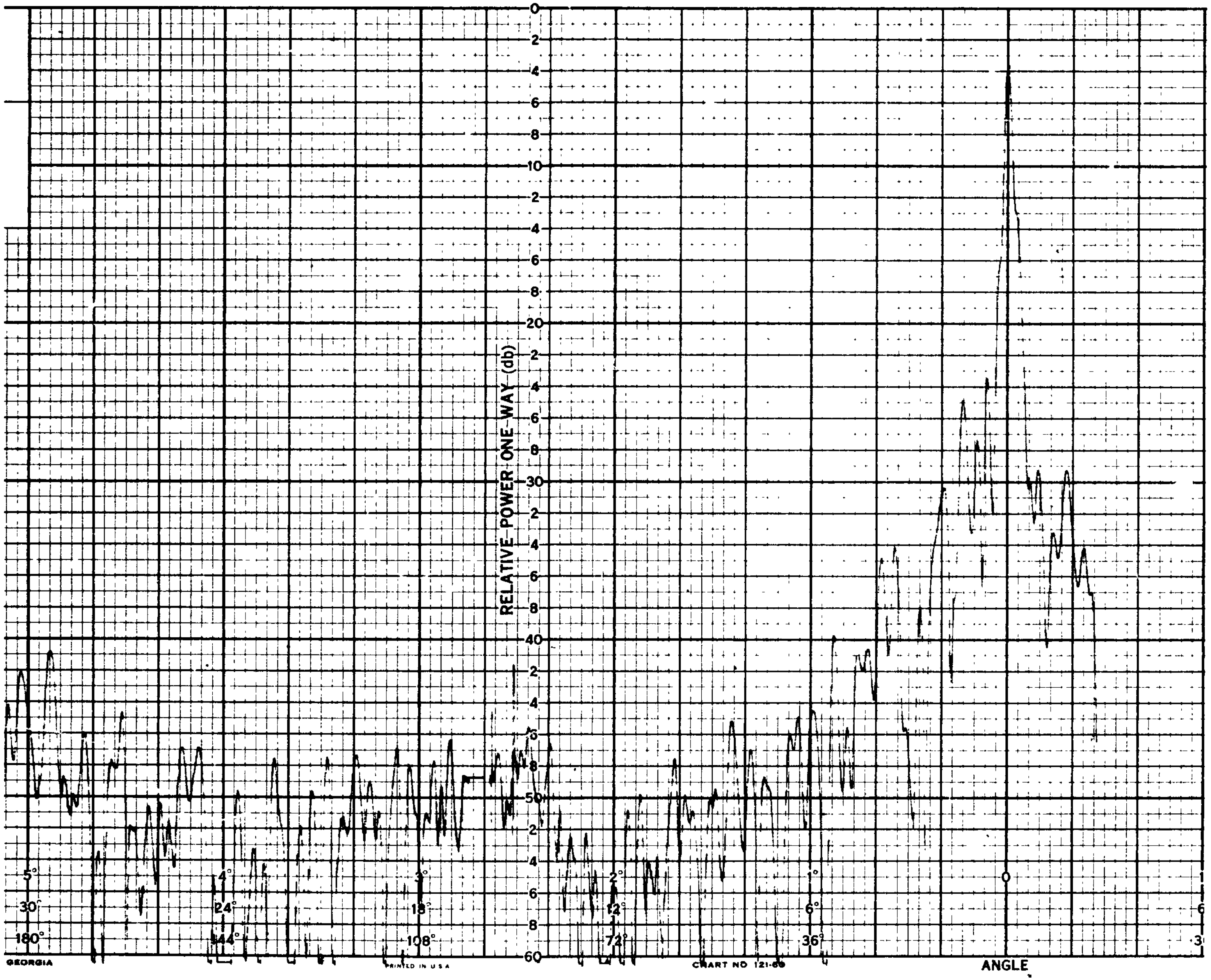


FIG. 96 - 2800 MC, Eθ, FEED TILTED UP

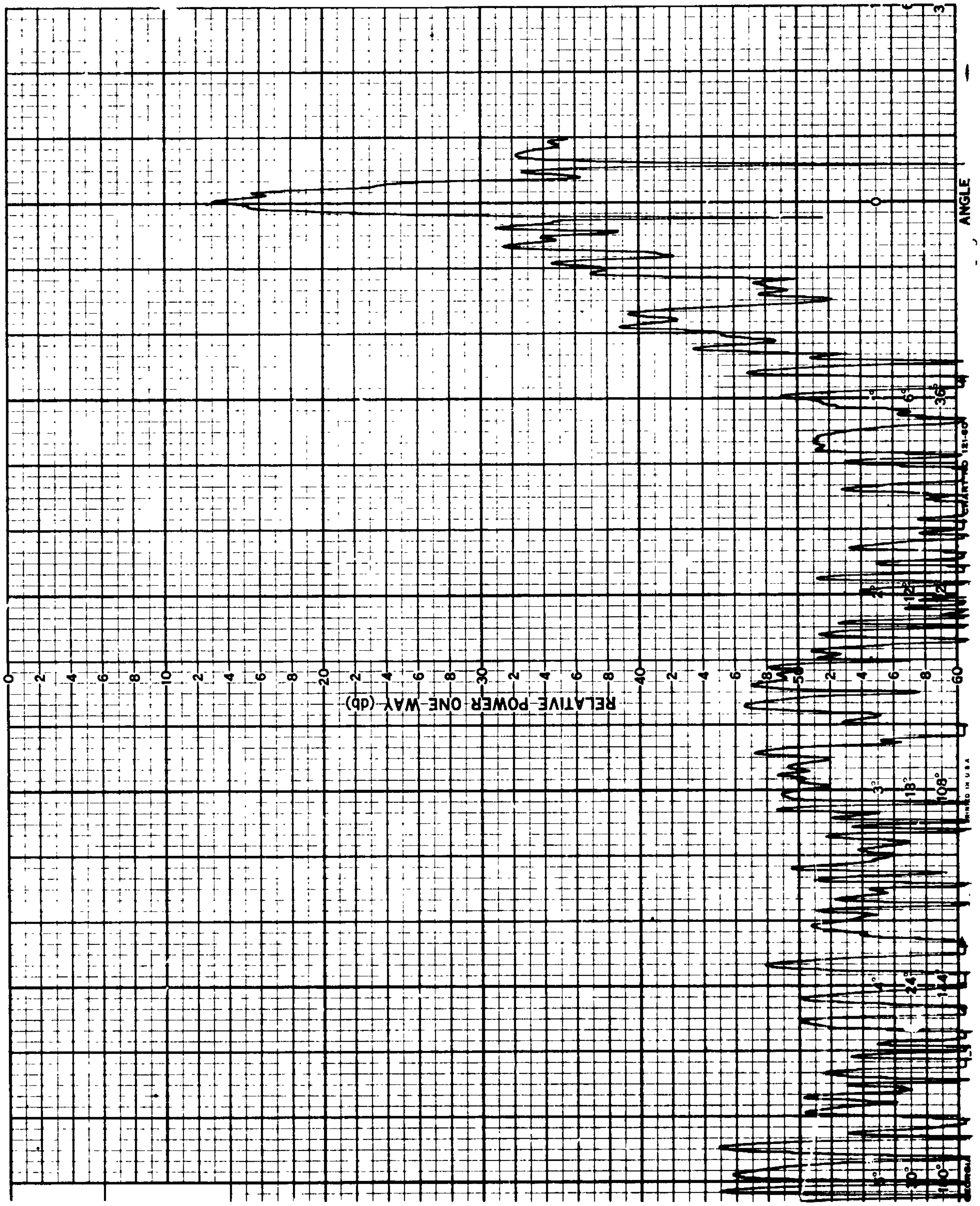


FIG. 97 - 2800 MC, Eϕ, FEED TILTED UP

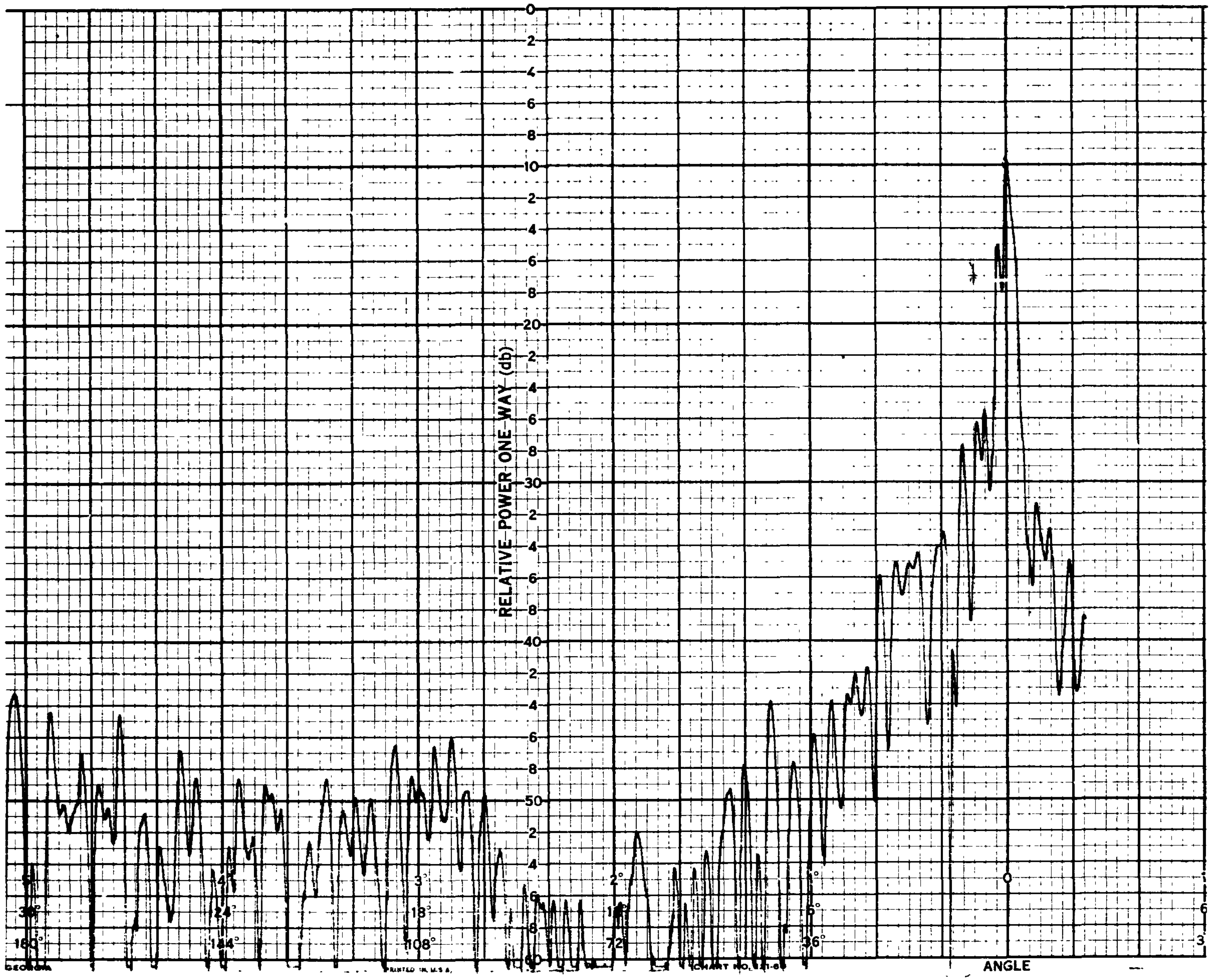


FIG. 98 - 2800 MC, Eθ, FEED TILTED DOWN

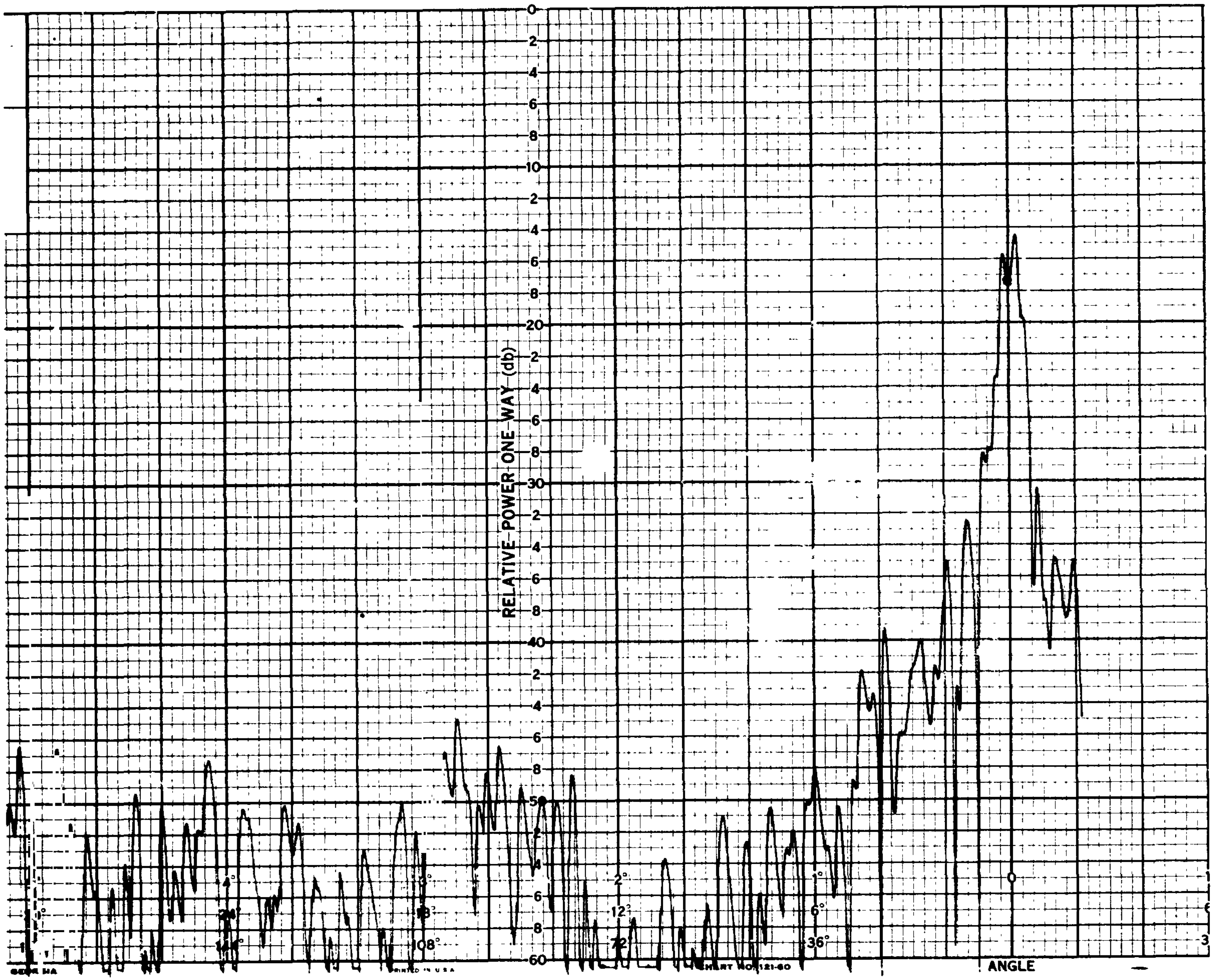


FIG. 99 - 2800 MC, Eϕ, FEED TILTED DOWN

FIG. 100 - MOTOR-GENERATOR MOUNT

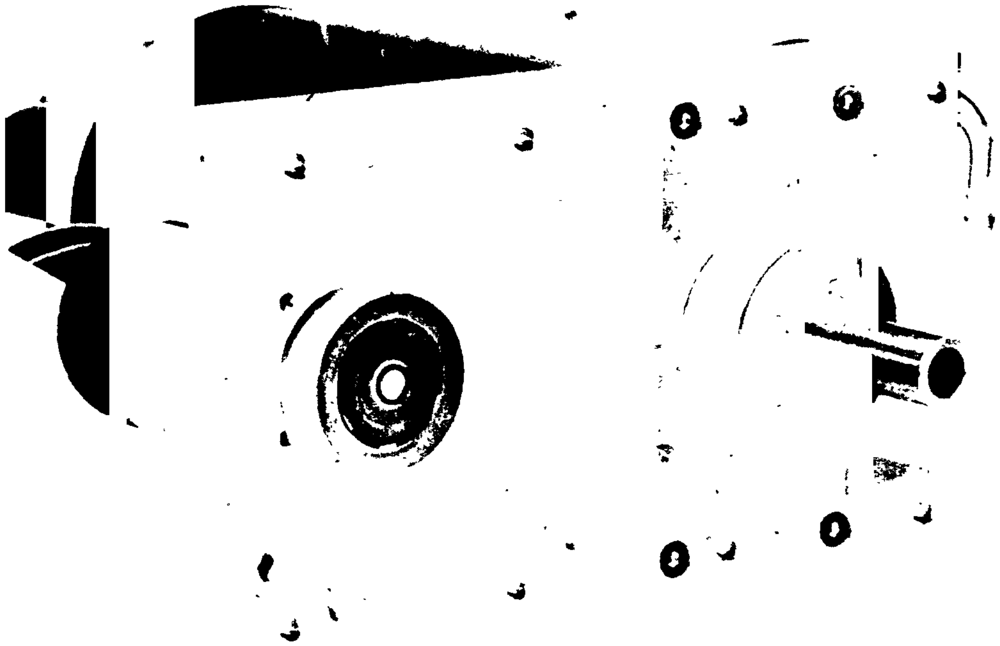


FIG. 101 - MOTOR-GENERATOR COUPLING

FIG. 102 - TRIPOD MOUNTING PLATE WITH MOTOR-GENERATOR IN PLACE

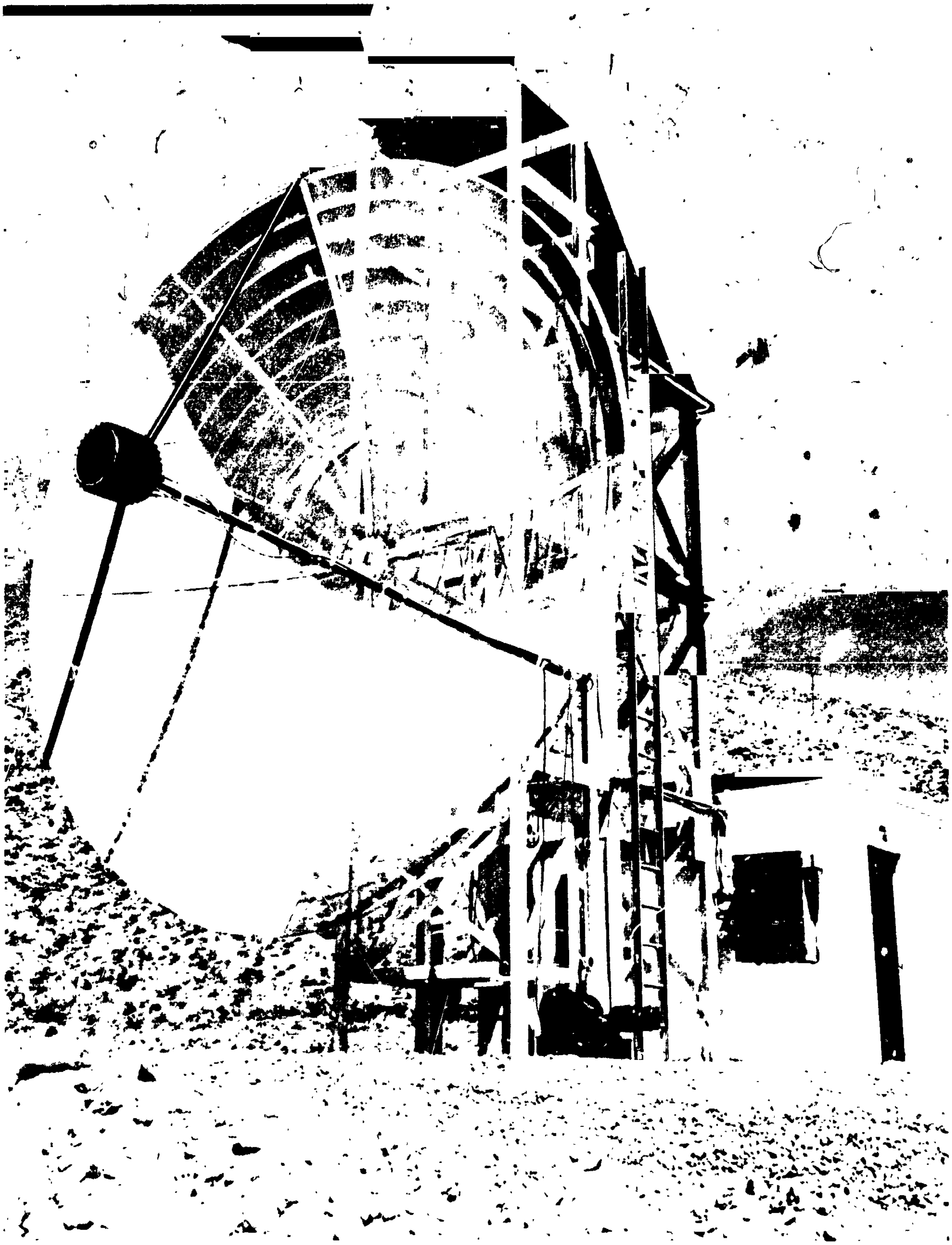


FIG. 103 - TRIPOD MOUNTED ON REFLECTOR

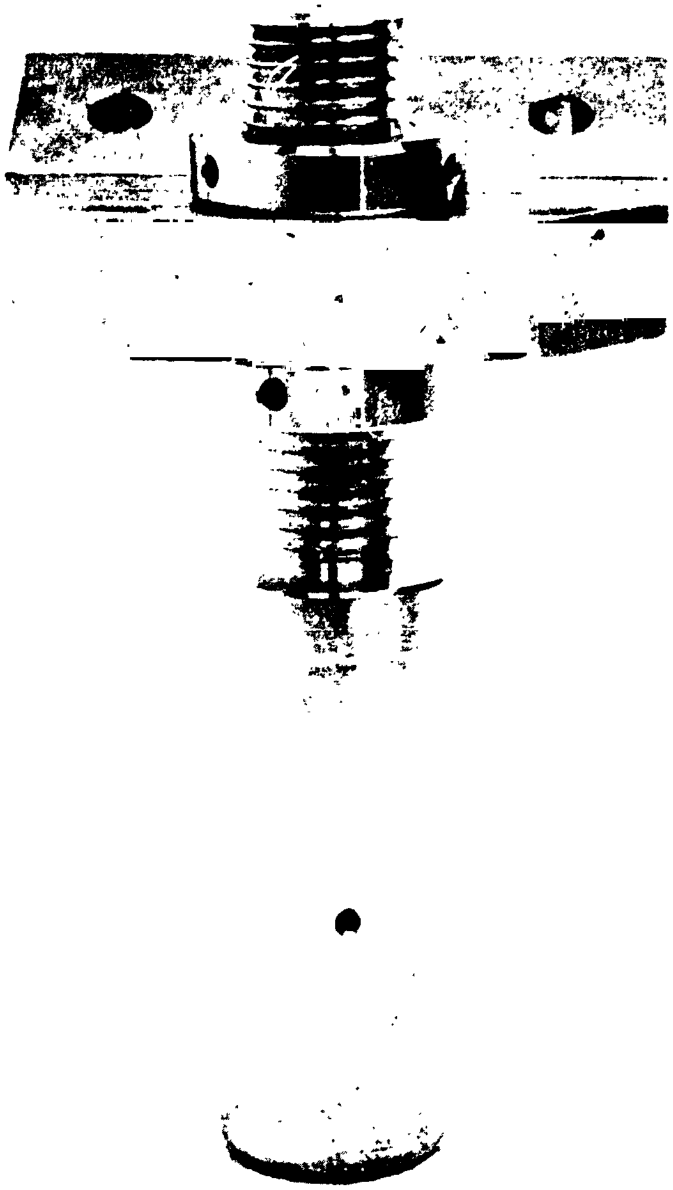


FIG. 104 - ADJUSTABLE TRIPOD MOUNTING STUDS

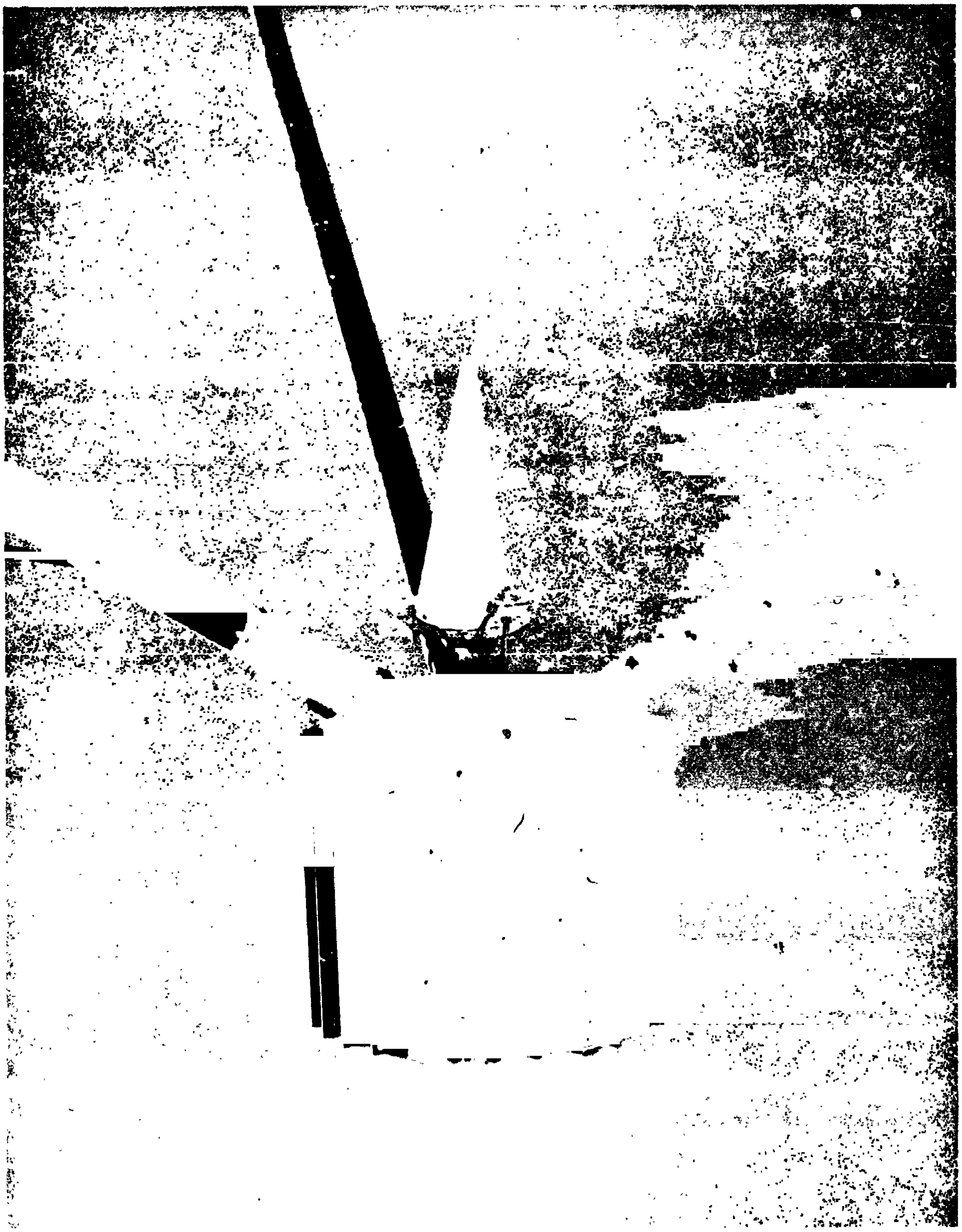


FIG. 105 - RADOME AND ANTENNA ON MOUNTING PLATE

FIG. 106 - ANTENNA AND COUNTERWEIGHT

TABLE I

RADIATION PATTERN CHARACTERISTICS FOR CONICAL LOG-SPIRAL WITH $\beta = 73°$ AND $\alpha = 20°$.

Frequency	Axial Ratio	Half-Power Beamwidth	Beamwidth to First Nulls	VSWR
900	3.5 db	83°	207°	1.22
960	3.0	86°	198°	1.24
1400	1.75	90°	210°	1.45
2290	4.5	99°	227°	1.18
2800	5.25	93°	196°	1.40

TABLE II

RADIATION PATTERN SUMMARY FOR CONICAL LOG-SPIRAL WITH β=83° AND α=20°. PATTERNS ARE SHOWN IN FIG. 5 THROUGH FIG. 25.

Frequency	Axial Ratio	Half-Power Beamwidth	Beamwidth to First Nulls	VSWR
860	2.75 db	62°	160°	1.64
900	2.80	63°	160°	1.70
960	0.75	68°	165°	1.05
1400	1.30	80°	170°	1.38
1700	2.10	79°	170°	1.32
2290	3.5	95°	175°	1.33
2800	5.0	97°	175°	1.32

TABLE III

CHARACTERISTICS OF 19 FOOT PARABOLIC REFLECTOR WHEN FED BY A CONICAL SPIRAL WITH 15° TILT TO THE AXIS.

Frequency Mc/sec	Half-Power Beamwidth		Modulation Level (db)		Front-to-Back Ratio (db)	Axial Ratio (db)	Gain with Respect to Isotropic (db)		VSWR
	Eθ	Eϕ	Eθ	Eϕ			Measured	Calculated	
860	4.4°	4.1°	0.9	0.5	40	4.5	33.6	34.4	1.43
900	4.3°	4.1°	1.1	0.9	41	1.5	33.8	34.8	1.70
960	3.7°	3.7°	1.0	1.0	46	1.75	34.6	35.3	1.083
1400	2.3°	2.5°	1.4	1.0	47	2.25	3.75	38.6	1.48
1700	2.1°	2.1°	1.2	0.8	48	2.5	39.0	40.3	1.35
2290	1.5°	1.55°	1.8	1.2	48	4.5	40.7	42.9	1.12
2800	1.5°	1.4°	1.9	1.5	46	7.25	41.2	44.6	1.30

TABLE IV

NOISE TEMPERATURE OF 19 FOOT PARABOLIC REFLECTOR

Frequency	Cosmic Noise Temperature (°K)	Ground Noise Temperature (°K)	Antenna Noise Temperature (°K)
860	60°	290°	132°
900	50°	290°	97°
960	45°	290°	90°
1400	20°	290°	47°
1700	12°	290°	50°
2290	6°	290°	37.5°
2800	4°	290°	42.1°

8.0 ACKNOWLEDGEMENT

The author wishes to acknowledge the help of L. D. Williams in the fabrication and tuning of the conical spiral antenna.

9.0 BIBLIOGRAPHY

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2. McClelland, O. L., "An Investigation of the Near Fields on the Conical Equiangular Spiral Antenna," Electrical Engineering Research Laboratory, University of Illinois, Contract AF 33(657)-8460, May 1962.

3. Duncan, J. W., Minerva, V. P., "100:1 Bandwidth Balun Transformer," Proceedings of the IRE, February, 1960.

10.0 PARTS LIST

	Parts:	Manufactures:
1.	Motor CM34H 79, 1200 rpm syn. (115 v 60 cps) 7/16'' I.D. Hole in shaft, Barden class 7 bearings, face mounting.	McLean Syntorque Corporation P. O. Box 100 West Hurley, New York
2.	AC Generator, 20 cps, 10 v output, Mod. 2A11	Indiana General Corporation Electro Mechanical Division 517 West Walnut Oglesby, Illinois
3.	Timing pulley, 22XL037, Standard stock bore	T. B. Wood and Son Chambersberg, Pennsylvania
4.	Timing belt, 130XL037, 3/8'' width	T. B. Wood and Son Chambersberg, Pennsylvania
5.	Bearing, ball, single row sealed 203PP	The Fafnir Bearing Company New Britain, Connecticut
6.	MS 3100E-12S-3P Wall Receptacle, environmental resistant.	Amphenol
7.	MS 3100E-10SL-4P Wall Receptacle, environmental resistant	Amphenol
8.	Capacitor, OV-3070 oval and mounting strap	Sprague Products Co. North Adams, Massachusetts
9.	Rotary Joint, RJ-3	Scientific-Atlanta