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THE UNIVERSITY OF MICHIGAN

COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRICAL ENGINEERING

Radiation Laboratory

RADAR CROSS SECTION STUDIES OF A CONE-CYLINDER MODEL WITH AND WITHOUT FINS

August 1962

Final Report

Purchase Order DY-635706-00

Prepared by: R. E. Hiatt

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Contract With: Minneapolis-Honeywell Regulator Company
2600 Ridgway Road
Minneapolis 40, Minnesota

Administered through:

OFFICE OF RESEARCH ADMINISTRATION • ANN ARBOR

Radar Cross Section Studies of a Cone-Cylinder Model with and without Fins

Final Report

August 1962

Prepared by: R. E. Hiatt

The experimental work was performed under the direction of E. F. Knott, assisted by T. E. Hon, R. J. Pelkey, and R. L. Wolford.

The theoretical analysis was made by T. B. A. Senior

INTRODUCTION

At the request of Minneapolis-Honeywell and in accordance with the requirements of P.O. DY 635706, a limited study has been made of the cross section characteristics of a company-supplied model. The model is a cone-cylinder with detachable fins. It is approximately 12 feet long and the cylindrical portion is 13 inches in diameter. The cone section is 32 1/2 inches long, making a cone half-angle of about 11 1/2°. There are four fins, each 18 inches long; spaced 90° apart and extending 8.8 inches from the cylinder. The fins are curved in the radial direction, the radius of curvature being approximately equal to that of the cylindrical portion of the model. The fins are attached to a cylindrical sleeve 18 inches long which may be slipped on or off the base of the model. A sketch of the model is shown in Figure 1.

The study included measurements of radar scattering patterns at X- and S-band (9.3 and 2.87 gigacycles respectively). Measurements were made with the model in the horizontal flight condition and usually included the entire 360° azimuth coverage. Vertical and horizontal polarizations were used for each frequency and for each of these four frequency-polarization conditions, there were three fin conditions. The model was measured with 1) no fins, 2) fins in the vertical-horizontal condition (0° roll angle), and 3) fins at 45° to the vertical (45° roll angle).

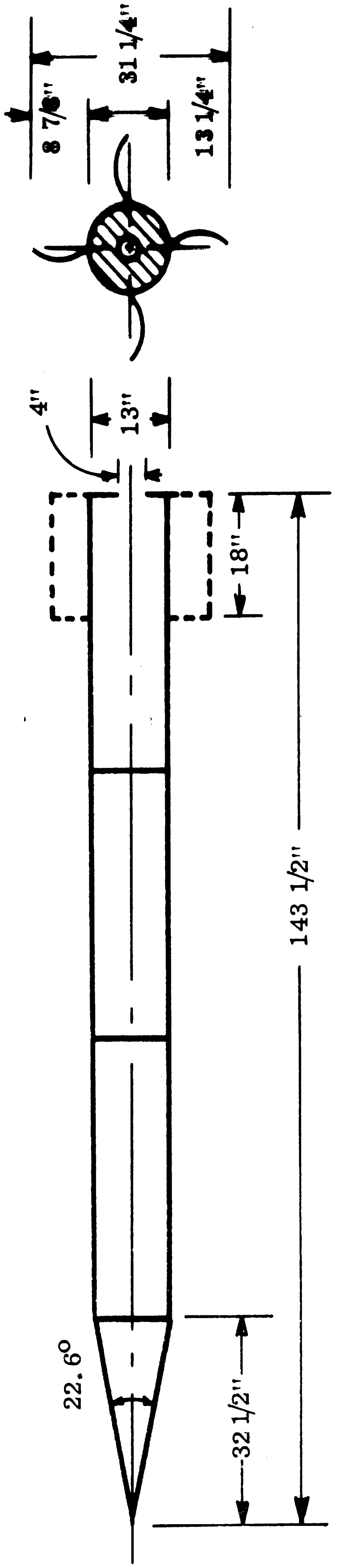

FIGURE 1: M-H CONE-CYLINDER MODEL

EXPERIMENTAL FACILITIES AND TECHNIQUES

The equipment used in the measurements is of the conventional cw type. A single antenna is used for both transmitting and receiving. The transmitted and received signals are separated by means of a waveguide hybrid tee acting as a balanced bridge. Since reflections from the load end of the bridge are being balanced against reflections both from the horn and from background scatterers hundreds of wavelengths beyond the horn aperture, one requires an oscillator which is very stable in frequency. At X-band, the required frequency stability is achieved by the use of cavity techniques. At S-band, the frequency stability is derived from a crystal oscillator. A frequency multiplier chain provides the crystal stability at the required microwave frequency.

The target under test is mounted on a styrofoam cylinder which rests on a pedestal placed at the desired range in front of the horn aperture. Prior to placing the model in position the bridge is balanced to minimize the signal to the receiver. When the target is in place, the reflected signal is fed to the super-heterodyne receiver and thence to the recorder. Chart movement in the recorder is synchronized with the rotation of the pedestal. Figure 2 shows a block diagram of the equipment.

The level of the scattered return is obtained by comparing it with the return from a calibrated corner reflector or sphere. The one square meter level thus obtained is indicated on each pattern.

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Measurements on the present model were made with the equipment inside the large open doors of a hangar, with the model and pedestal at a distance of 100 to 200 feet in front of the horn. Absorbing screens between the antenna and model served to minimize field variation at the model.

The measurement procedure was as follows. With no model present the receiver signal was minimized by the waveguide tuner adjustments. The model was then placed on the pedestal and its level checked by means of a theodolite. The 360^{0} azimuth pattern was then run and the model was removed. If the receiver balance was satisfactory, a standard scatter was used to calibrate the level of the return. Before a pattern was selected as satisfactory, the measurement was repeated until three patterns showed a good agreement. For the peak returns, agreement to within a db was usually achieved. For the lower, near nose-on aspects, more attention was paid to the average level. This was usually in agreement to within one or two db.

It should be noted that the above-mentioned ranges are insufficient to meet far field requirements for broadside aspects of a 12 foot model[+]. The ranges used (208 feet for most of the X-band work and 100 feet for S-band) were near the maximum possible compatible with the equipment sensitivity and the model scattering pattern. The ranges are considered adequate for all but near broadside aspects.

[+]Noted also in U of M Proposal ORA-62-1354-Bl, dated 26 June 1962.

The experimental return for the broadside aspect is expected to be less than the true value since the entire length of the model is not plane wave illuminated.

Another factor which served to decrease the experimental cross section for broadside and other aspects is the poor condition of the model. The model was fabricated from sheet aluminum, rolled into cylindrical or conical sections and welded. The ends of the three sections making up the cylinder were then welded together and this assembly was then welded to the cone. The resulting model differed from a true cone-cylinder quite considerably. Although the welded seams had been ground down, they still extended above the surrounding surface by more than 1/8 inch in many places. In other places, the aluminum surface was deformed so that it departed from a true cone or cylinder by as much as 1/4 inch. The flat sheet making up the base of the model was convex by about 1/4 inch. It is in order to mention these faults in the model since they would obviously produce an asymmetrical scattering pattern. In addition, the specular return from the cylinder, the side of the cone, and the base plate will tend to be lower, and the beamwidth of the scattered pattern broader, as a result of the above-mentioned deformities in the model.

RESULTS

1. X-band

The X-band scattering patterns are shown in Figures 3 through 13 and the S-band patterns in Figures 14 through 21. The insert in the lower center of each pattern indicates the no-fin case or horizontal-vertical fins, or fins at 45^o. Figure 3 is for the no-fin case with X-band vertical polarization. There are prominent lobes at about the 17 db > M^2 level for the tail and broadside aspects and lobes 10 db > M^2 are seen at about 77^o due to the specular return from the side of the cone. These lobes are characteristic of all the patterns for both frequencies and both polarizations. The broadside return is about 6 db below the theoretical value due to the near field illumination and the model defects. For a perfect model one would expect a single sharp lobe at 90^o with a 3 db beamwidth of about 0.3^o. In the present case and in several of the patterns that follow, the broadside lobe is composed of 2 or 3 peaks and the 3 db width is approximately 2^o. The lobed behaviour is to be expected from a cylinder whose surface is wavy or irregular in the axial direction. These defects and the limited measurement range both tend to increase the beamwidth.

The theoretical value for the tail-on aspect allowing for the 4" diameter hole in the center is about 18.5 db. The experimental values obtained are in good agreement with this allowing for some degradation due to the convex nature of the base plate. The theoretical value for the specular return from the side of the cone is about 10 db > M^2. The experimental values are generally a little below this due also, it is believed, to the deformations in the side of the cone.

The experimental return for near nose-on aspects for $0^{o} \pm 70^{o}$ is below the sensitivity of the system for the 200 foot range. Figure 3 shows that the level is at least 13 db < M^2. To determine the experimental level, additional X-band patterns were taken at a range of 100 feet for horizontal polarization. The results for the no-fin case (Figure 9) show the average return to be about 19 db < M^2. The calculated nose-on cross section, assuming a perfectly smooth cone-cylinder transition is 21 db < M^2 (independent of frequency). A projecting rim at the cone-cylinder transition will increase this return in proportion to the area of the projection. A projecting rim 0.1 λ wide would, for example, result in a nose-on cross section of 12 db < M^2.

Figures 4 and 5 show the patterns for vertical polarization with fins. In Figure 4 the roll angle is 0^{o} and in Figure 5 the roll angle is 45^{o} with the fins inclined at 45^{o} to the vertical. The major effect of the fins is to increase the return for the near nose-on aspects. A rough value for the average return for $0^{o} \pm 70^{o}$ aspects is about 10 db < M^2. Another effect of the fins is to increase the broadside return. In this case the increase is 3 or 4 db. In other cases it is less. Additional measurements, some of which are not presented, showed that the 90° return with fins in place was sensitive to small changes in roll angle. The calculated effect of the fins at broadside is to add or subtract 1.5 db to the broadside return of the cone-cylinder. This is believed to account for most of the variation in the broadside return observed in the with-fin patterns.

Figures 6, 7, and 8 are for X-band horizontal polarization in the no-fin, fins at 0°, and fins at 45° cases respectively. As would be expected, there are no major polarization effects. It is probable that most of the observed differences in the two sets of patterns are due to repeatability problems and model asymmetries.

Figures 9, 10, and 11 are repeats of the conditions of 6, 7, and 8 but with the measurement range decreased to 100 feet. This was done to raise the level of the near nose-on aspects so that a more accurate picture could be obtained for the behaviour at these aspects. These figures present nose-on data only, including aspects from - 72° to + 72°. The average return for the no-fin case is about -19 db while for the two cases with fins the average is about - 13 db with respect to M^2.

Figures 12 and 13 show scattering patterns for the fin section only for X-band horizontal polarization. In Figure 12 the axis of the fin section is horizontal and for Figure 13 the axis is vertical. The information contained in both of these patterns is of interest, but it should be noted that the patterns do not show the true return for the fins as an addition to the large model. The presence of the 18-inch long cylindrical section would be expected to affect the return for all aspects. It will increase the return for the end-on view and for the broadside aspect, its effect will be to increase or decrease the fin return depending on the relative phase of the contributors. The end-on return, Figure 12, is seen to be on the same order of magnitude as the return from the finned model for nose-on aspects. Figure 13 shows the pronounced oscillation that occurs as the roll angle is changed. A maximum return is obtained when the model is viewed normal to a plane containing two fins. This return may be considered to be the return from the sum of the two halves which in this case are in phase. With a 1^o or 2^o rotation, the phase centers of the two returns move enough to cause the two returns to be out of phase and a null results. As the pattern shows, this phenomena occurs to some extent over the entire 360^o.

2. S-band

Figures 14 through 21 show the S-band data. The major characteristics of the patterns are similar to those for X-band and has the same relative level of the main scattering peaks as would be expected. As would also be expected, the absolute level of the specular returns for tail, broadside and cone are lower for S-band.

Figure 14, 15, and 16 are for vertical polarization for the no-fin, fins at 0^o, and fins at 45^o cases. The corresponding patterns for horizontal polarization are given in Figures 17, 18, and 19. The experimental base return for the two no-fin patterns agrees well with theoretical predictions (8.5 db > M^2). The experimental broadside return for the no-fin case is again much less (7 or 8 db) than the theoretical estimate. The reasons for this are believed to be the same as those mentioned in the discussion of the X-band results; the near field effects and the imperfect model both tending to reduce the experimental broadside return. The specular return from the side of the cone agrees fairly well with the theoretical value (4.5 db > M^2).

Compared to the X-band results, the experimental S-band nose-on return (12 db < M^2) is somewhat higher than expected. It is equivalent to the return which would be obtained from a projecting rim $\lambda/100$ in depth at the cone-sphere junction.

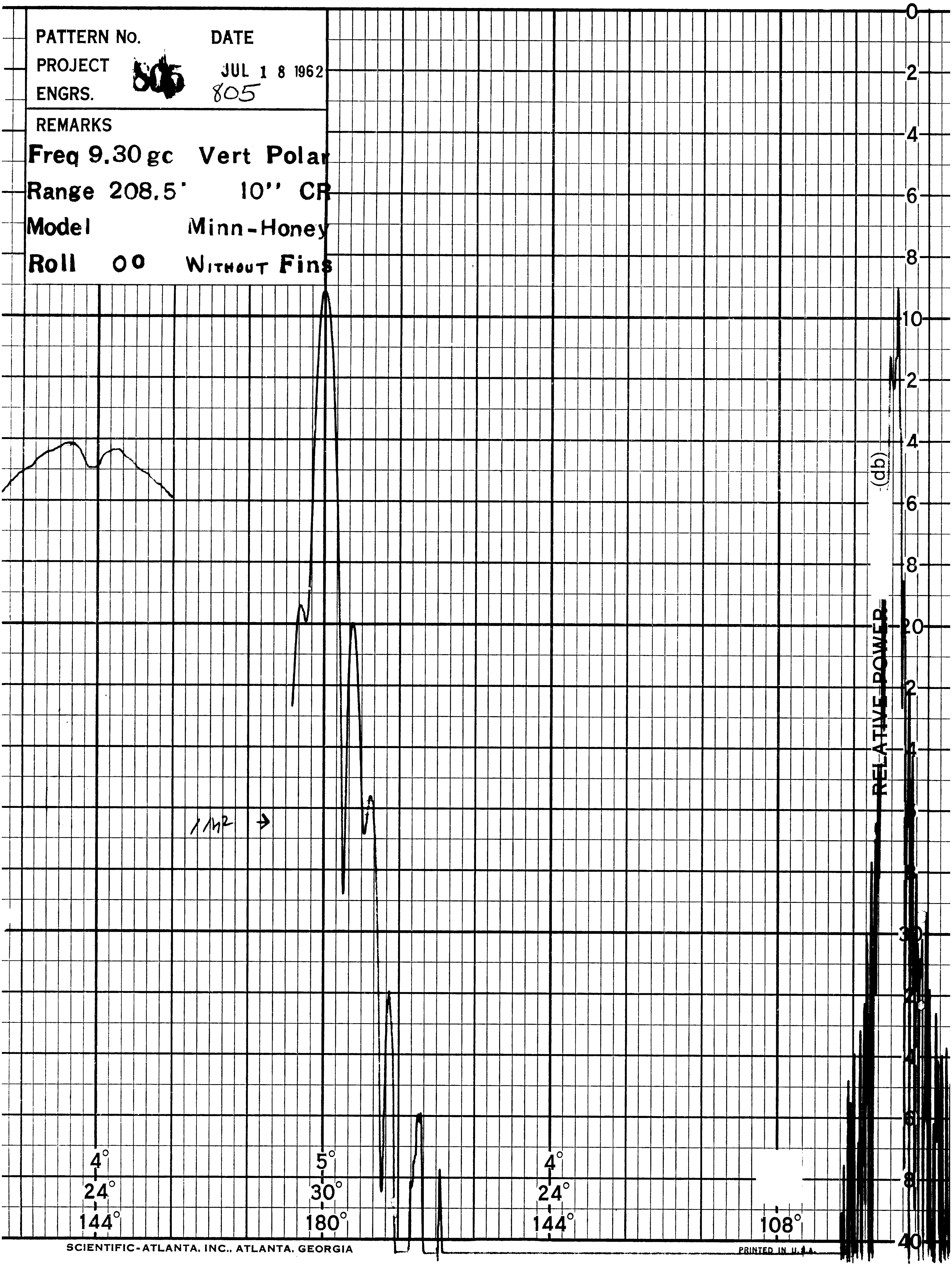
To provide additional information on the fin contribution, patterns for the fins only are shown in Figures 20 and 21. In Figure 20, the axis of the cylindrical shell is horizontal and the polarization is horizontal. In Figure 21, the axis of the cylinder and the polarization are both vertical, so that in each of the two patterns the polarization is parallel to the axis of the cylinder. As noted in the discussion of the X-band data, we do not obtain the true value of the fin return in these patterns since the cylinder makes a contribution nearly equal to that for the fins for broadside and probably for most other aspects. The effect of roll angle on the missile will not be as pronounced as that shown in Figure 21, since the fin contribution is small compared to the missile return at broadside aspects.

CONCLUSIONS

The experimental cross sections for the 12 foot cone-cylinder model for two polarizations, two frequencies, and 3 "fin conditions" have been presented in 19 patterns (Figures 3 - 21). Results of selected theoretical calculations are given in the following table in db > M^2.

Freq.	ASPECT				
	Tail-on	Broadside	Cone flash	Nose-on	
				no rim	λ/ 100 rim
9.3Gc	18.5	24	10	-21	-12
2.87Gc	8.5	18.9	4.8	-21	-12

Allowing for the condition of the model, the agreement between theory and experiment is good except for the broadside aspects. This disagreement was expected and is largely due to limited illumination resulting from the short measurement range.



PATTERN No.
DATE
PROJECT 805
JUL 1 8 1962
ENGRS.
805
REMARKS
Freq 9.30 gc Vert Polar
Range 208.5' 10" CR
Model Minn-Honey
Roll 00 Without Fins
1142 →
4° 24° 144°
5° 30° 180°
4° 24° 144°
108°
RELATIVE POWER (db)
0
2
4
6
8
10
2
4
6
8
20
2
30
40
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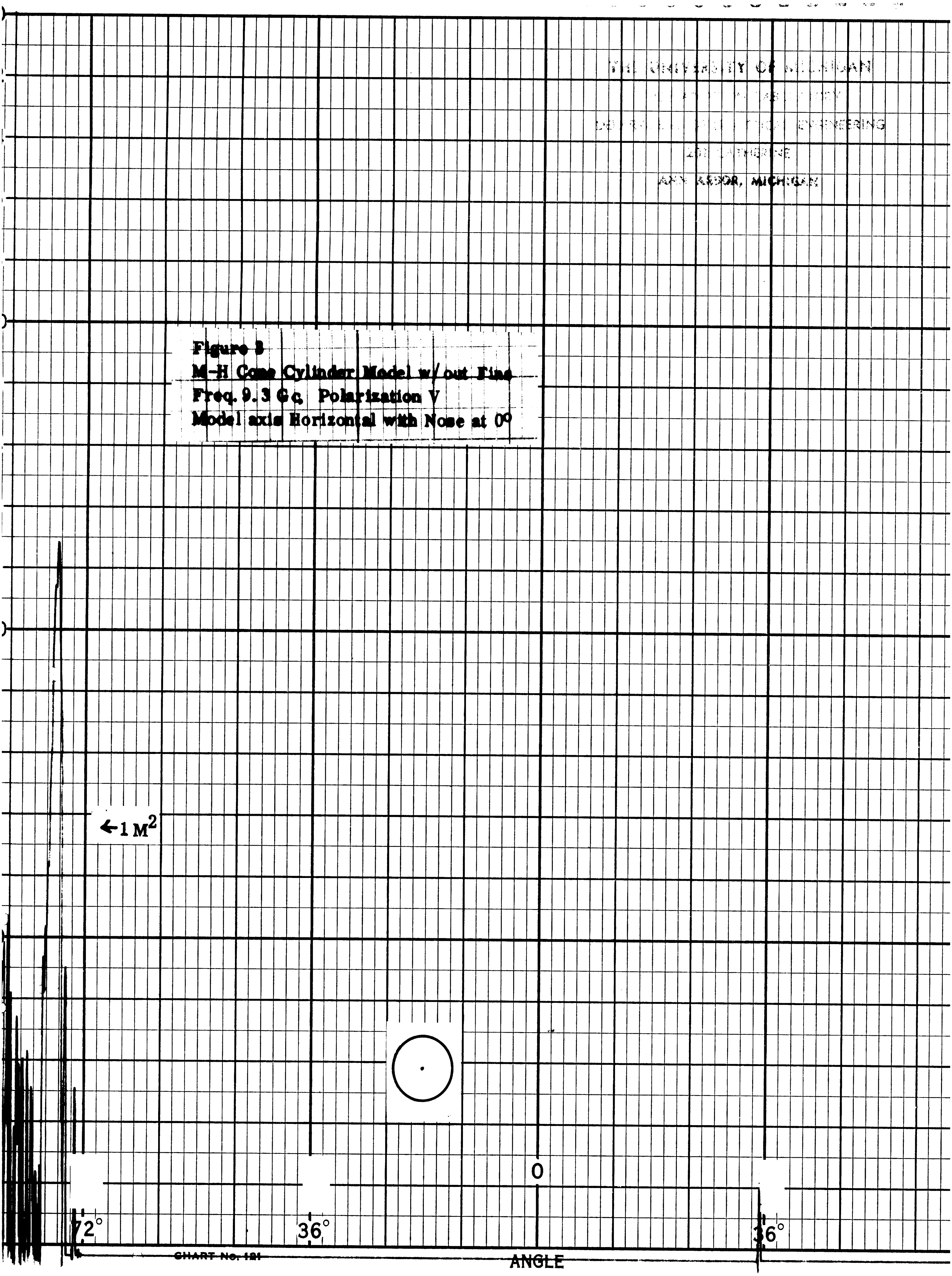
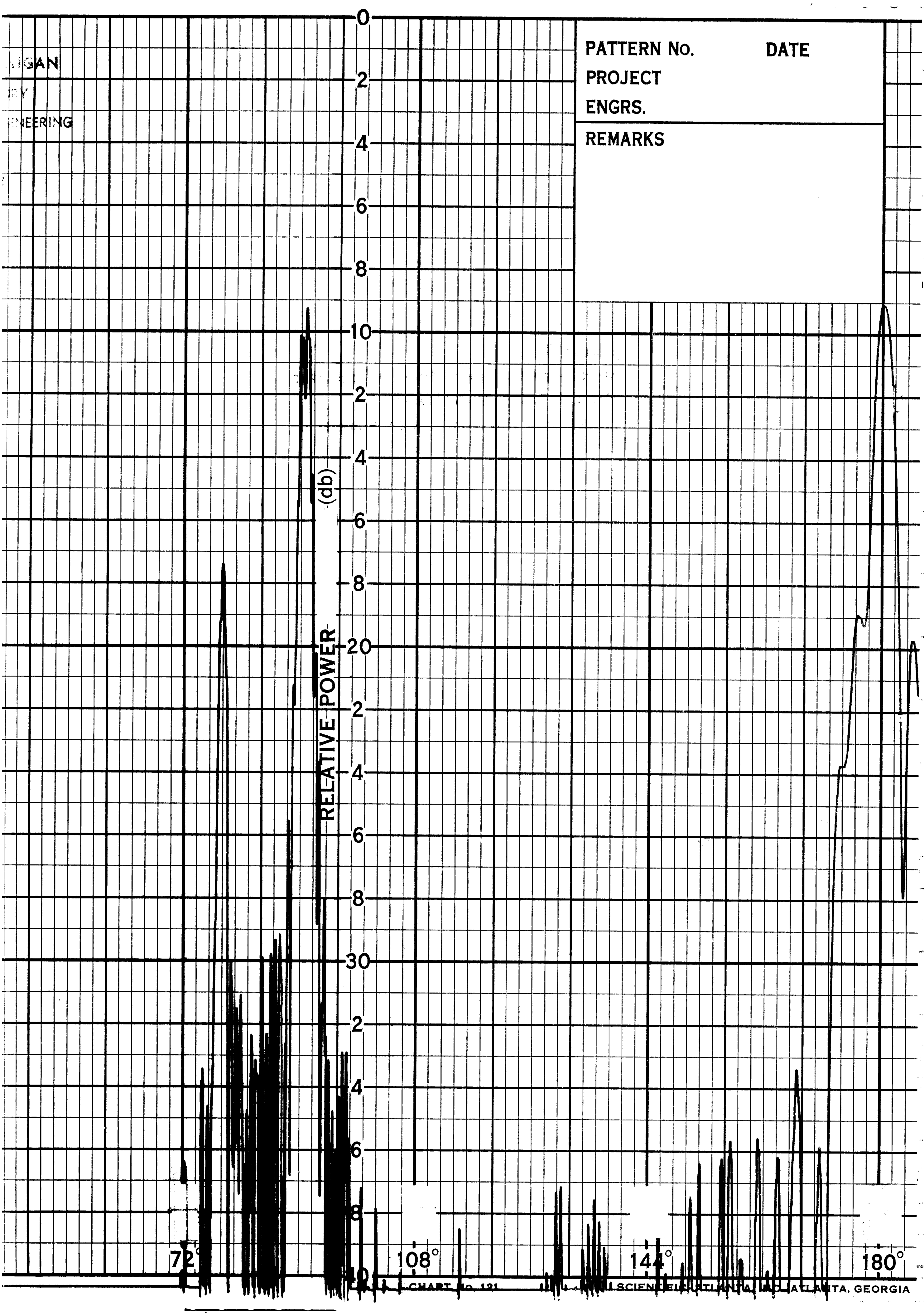
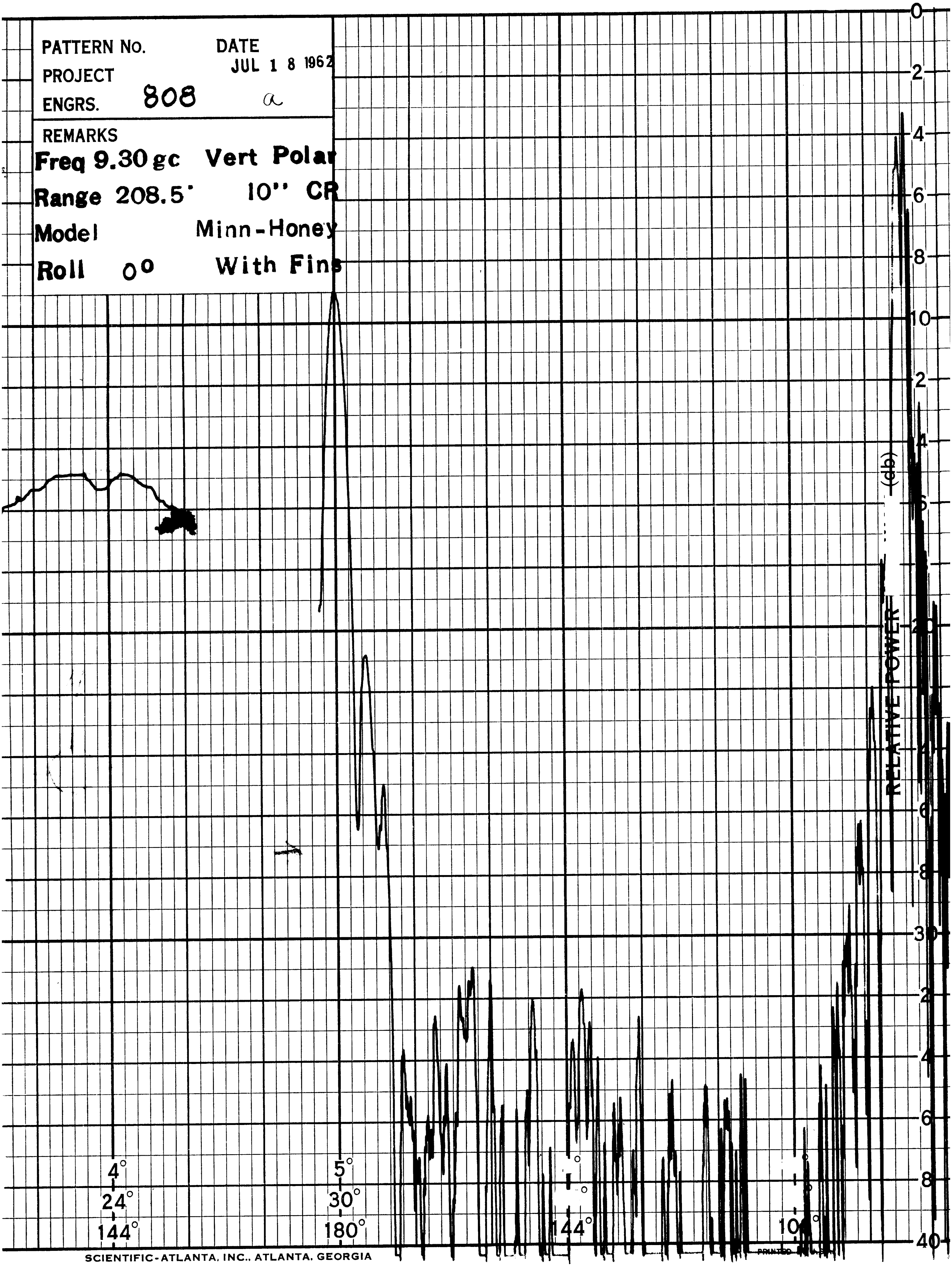


Figure 3
M-H Cone Cylinder Model w/out Fins
Freq. 9.3 Gc Polarization V
Model axis Horizontal with Nose at 0°


PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
RELATIVE POWER (db)
0
2
4
6
8
10
20
30
72°
108°
144°
180°
CHART No. 121
ATLANTA, GEORGIA



PATTERN No.
DATE
JUL 1 8 1962
PROJECT
ENGRS.
808
a
REMARKS
Freq 9.30 gc
Vert Polar
Range 208.5'
10'' CR
Model
Minn-Honey
Roll 0°
With Fins
RELATIVE POWER (db)
0
2
4
6
8
10
20
30
40
4°
24°
144°
5°
30°
180°
144°
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA

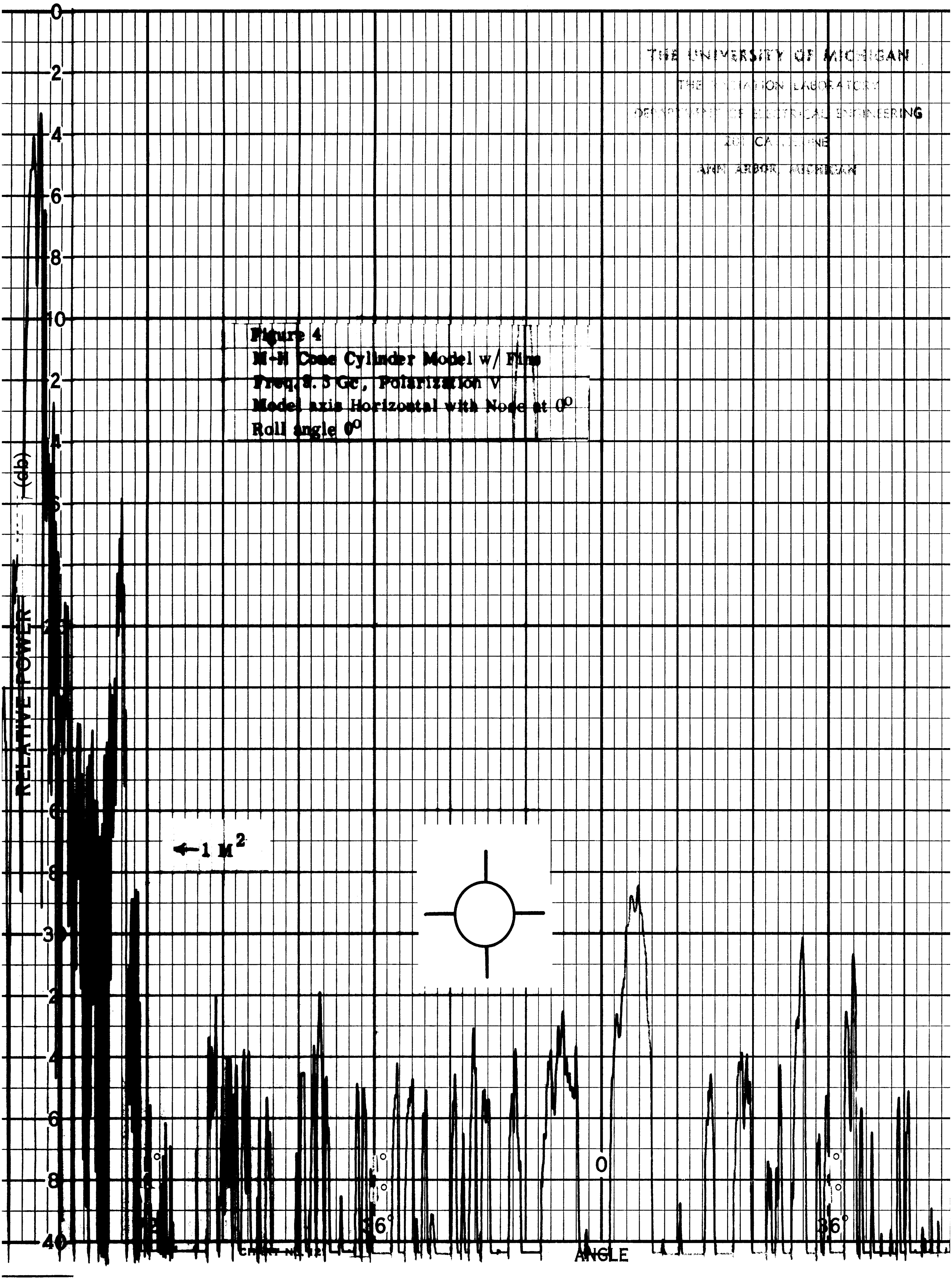
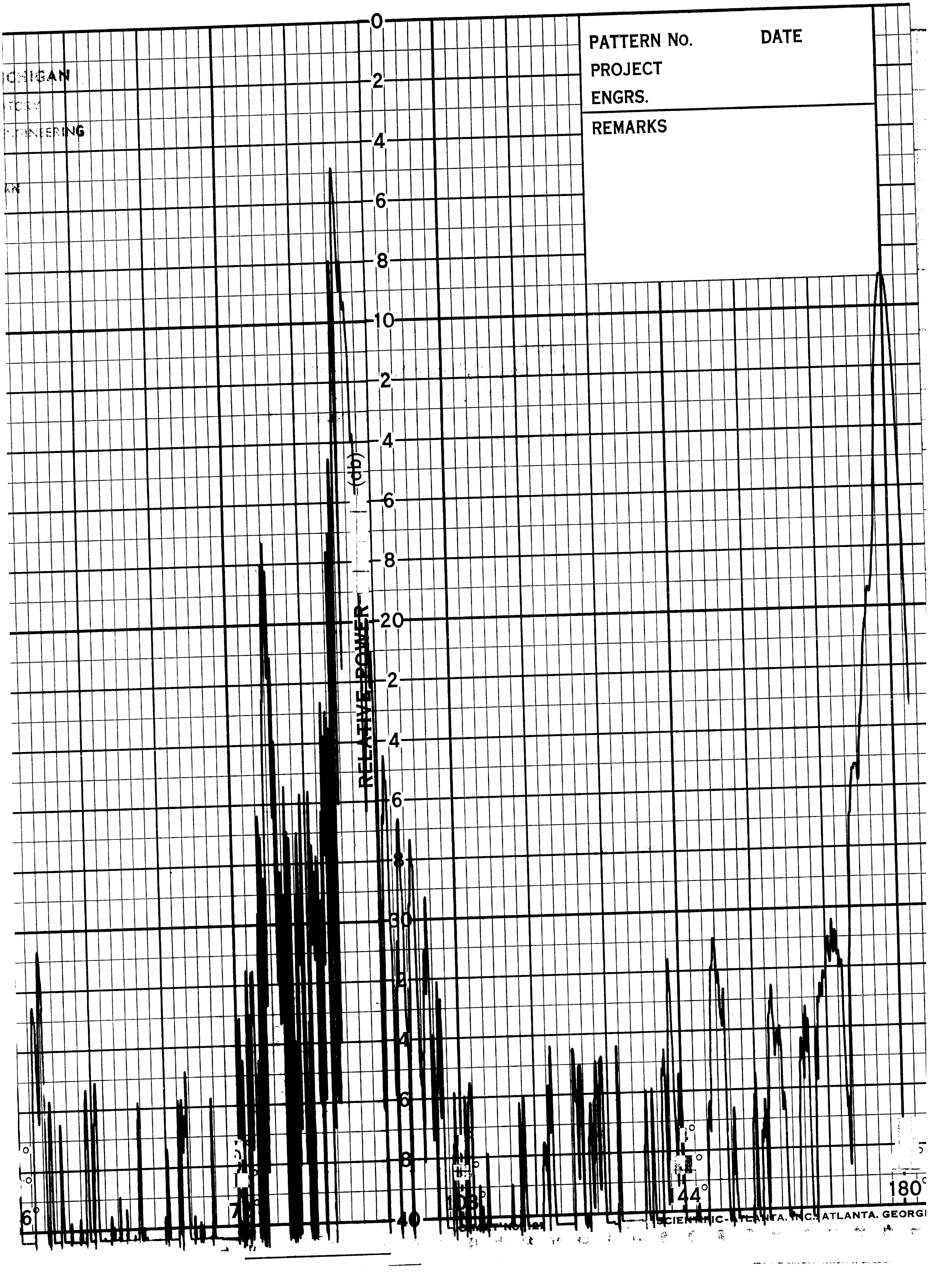
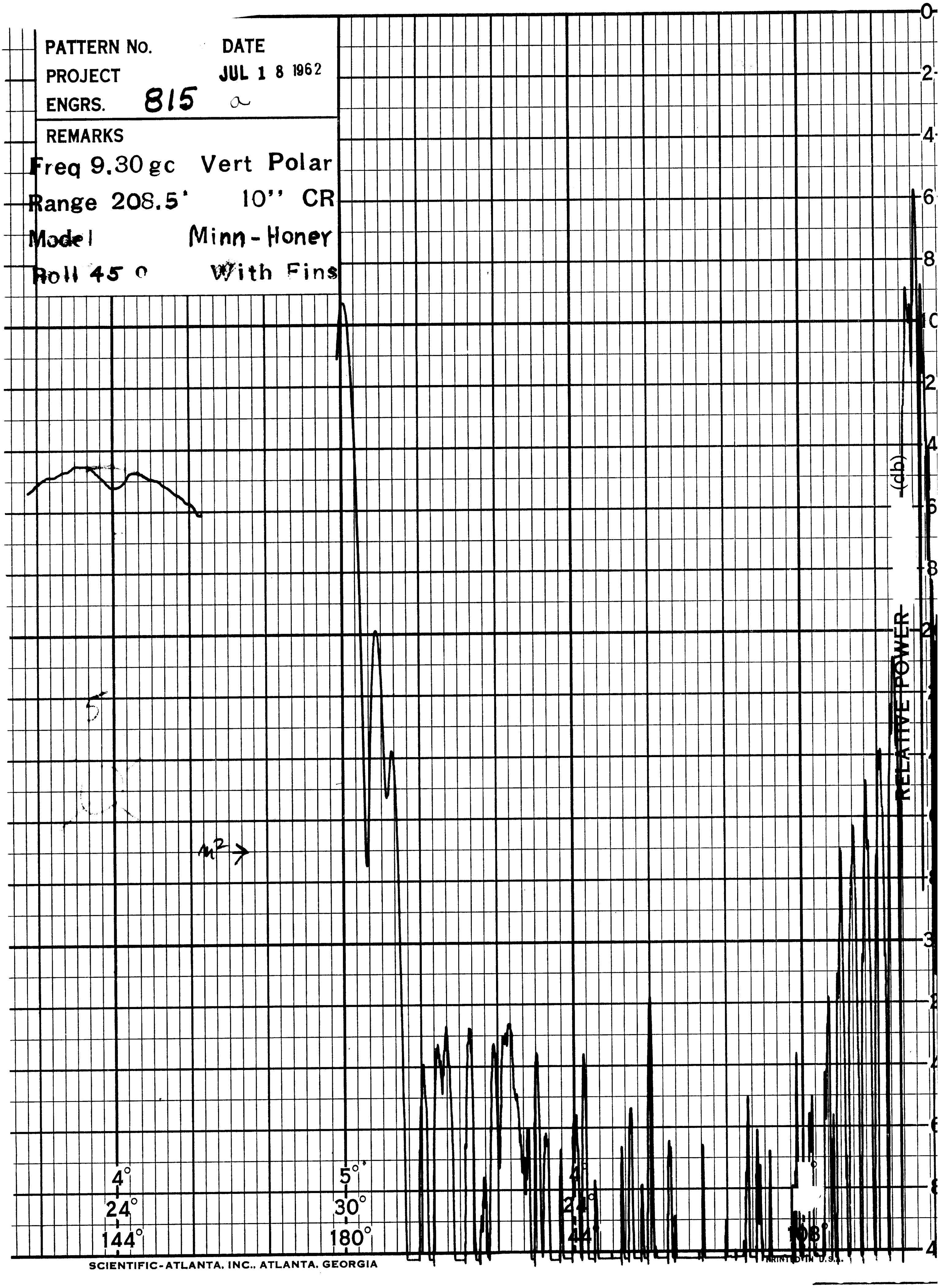


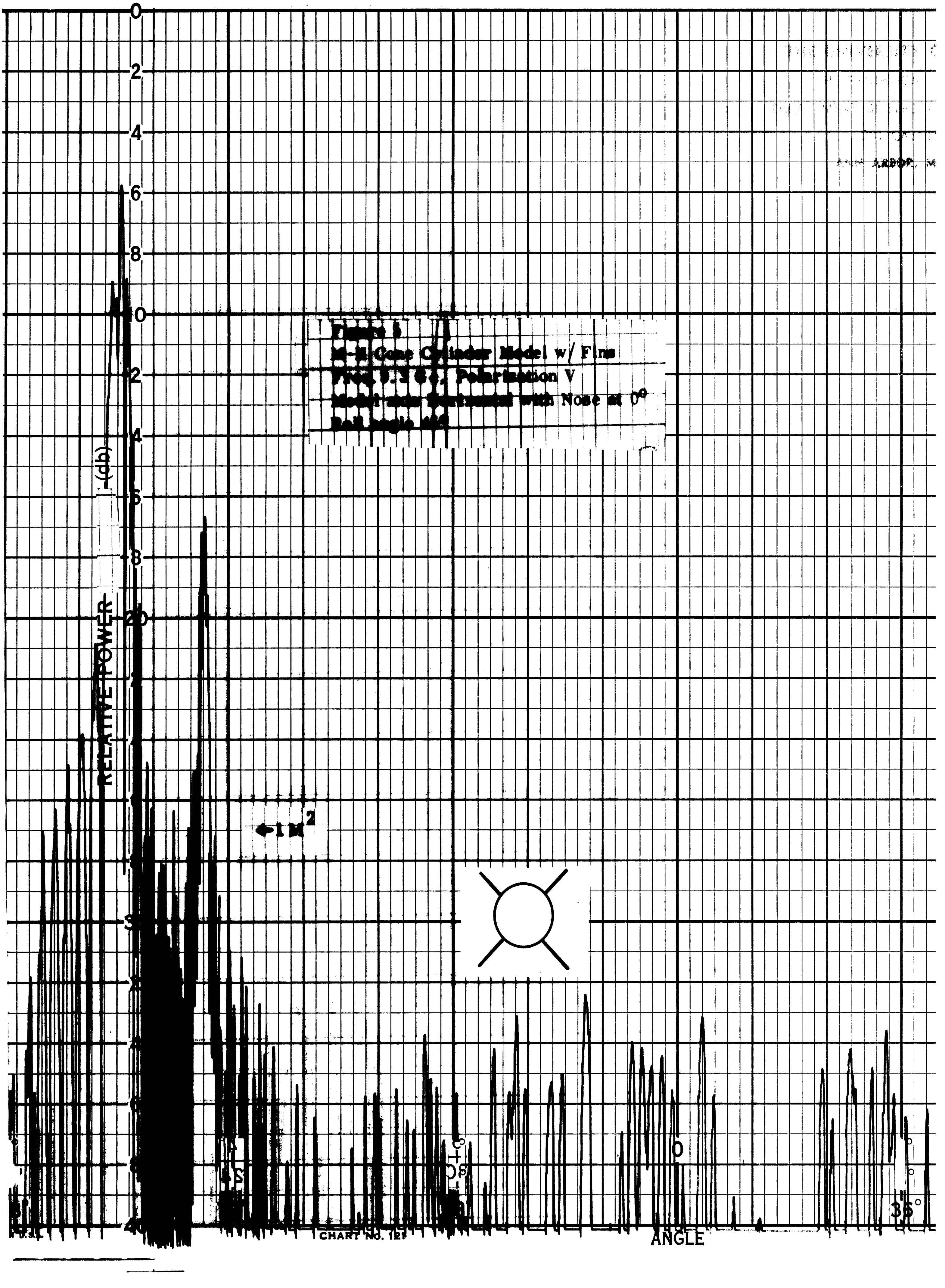
Figure 4
M-H Cone Cylinder Model w/ Fins
Freq. 8.5 Gc, Polarization V
Model axis Horizontal with Nose at 0°
Roll angle 0°



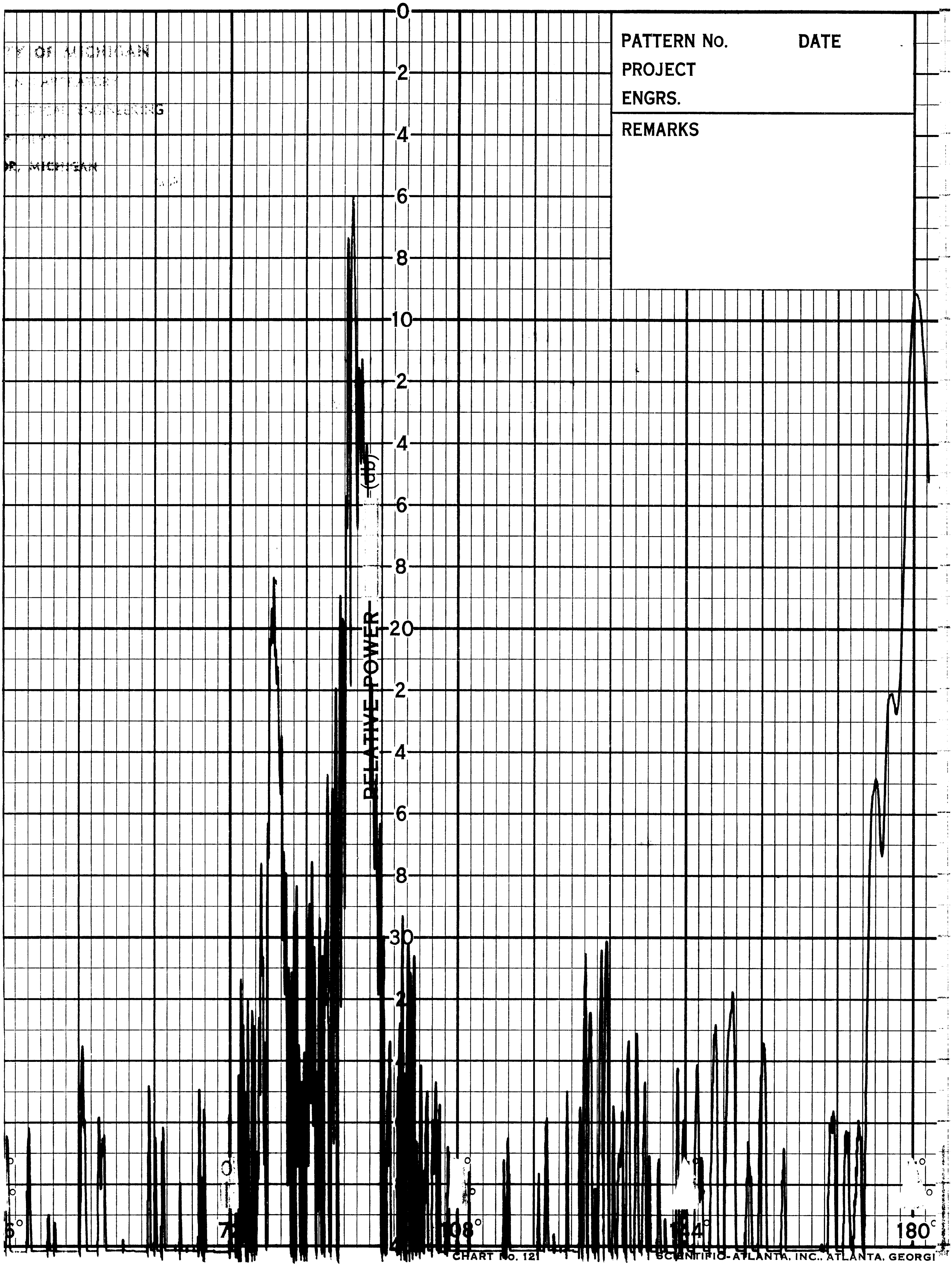
PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
RELATIVE POWER (db)
0
2
4
6
8
10
20
30
40
108°
144°
180°



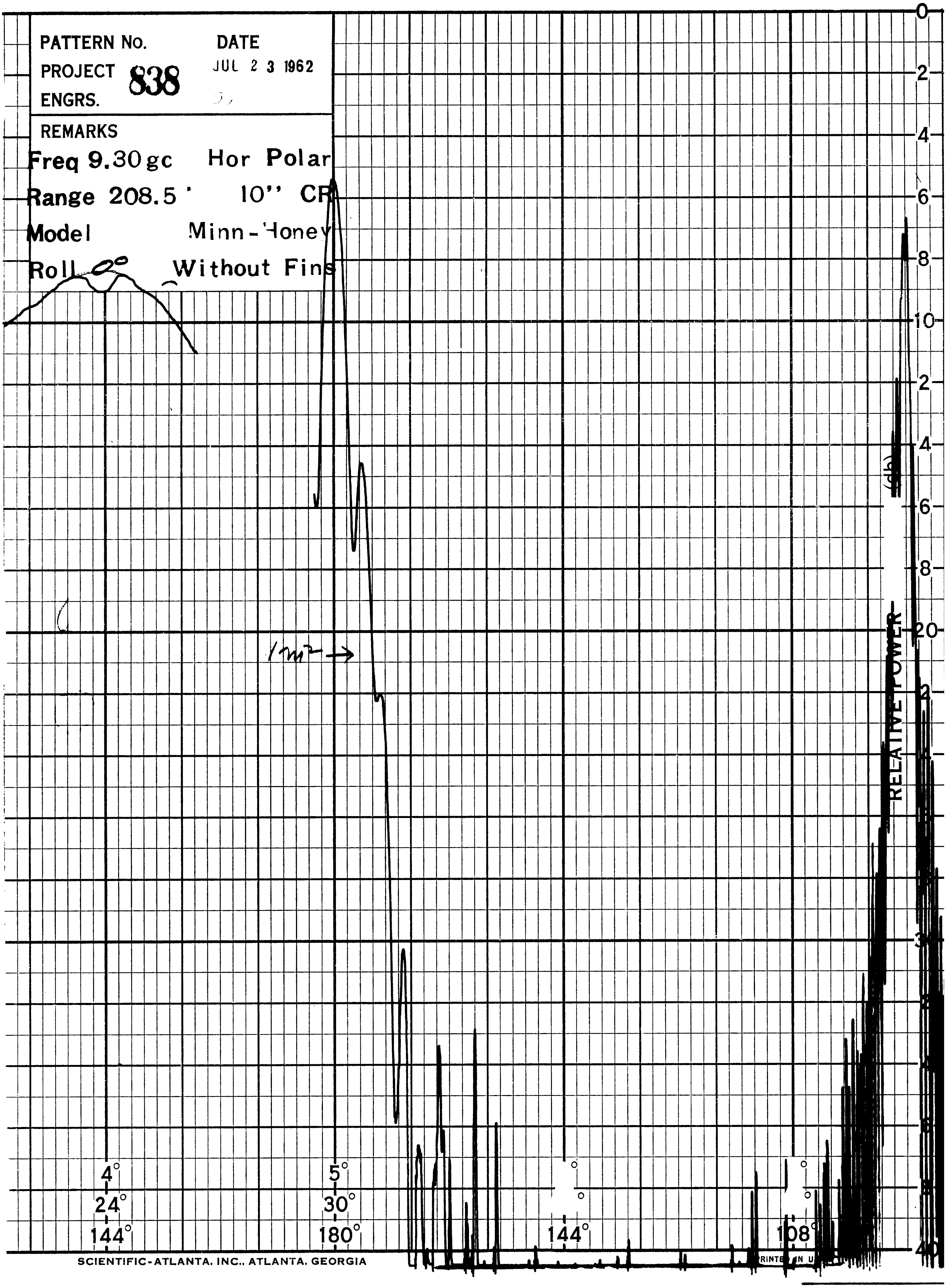
PATTERN No.
DATE
PROJECT
JUL 1 8 1962
ENGRS. 815
REMARKS
Freq 9.30 gc Vert Polar
Range 208.5' 10'' CR
Model Minn-Honey
Roll 45 0 With Fins
4°
24°
144°
5°
30°
180°
24°
44°
108°
RELATIVE POWER
(db)
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA



Cone Cylinder Model w/ Fins
Polarization V
with Nose at 0°
RELATIVE POWER
(db)
0
2
4
6
8
10
← 1 M²
ANGLE
CHART NO. 12



PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
RELATIVE POWER (db)
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
108°
180°
CHART No. 121
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGI


PATTERN No.
DATE
JUL 2 3 1962
PROJECT 838
ENGRS.
REMARKS
Freq 9.30 gc Hor Polar
Range 208.5' 10" CR
Model Minn-Honey
Roll 0° Without Fins
1m² →
0
2
4
6
8
10
2
4
6
8
20
RELATIVE POWER
(db)
4°
24°
144°
5°
30°
180°
144°
108°
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA

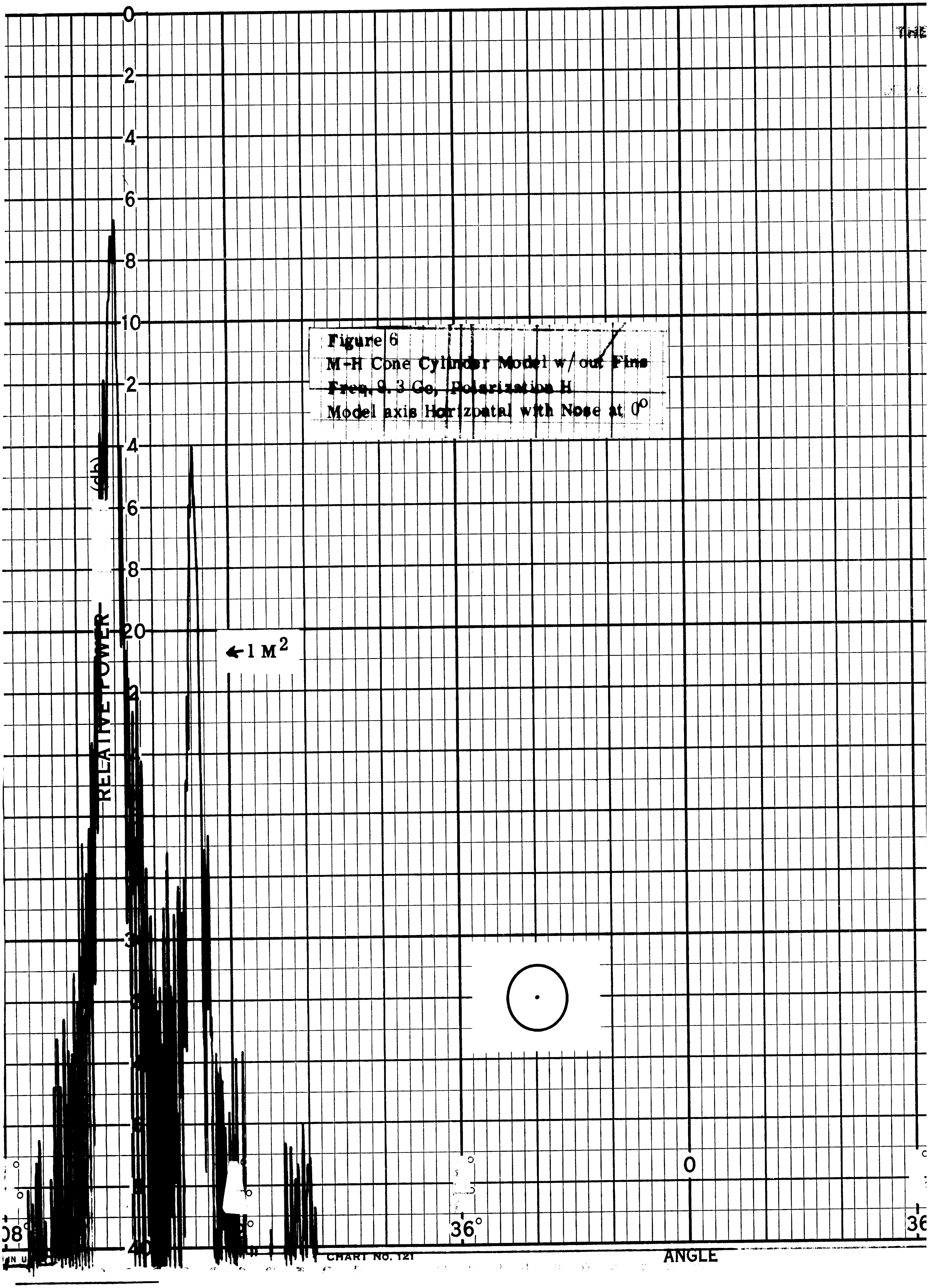
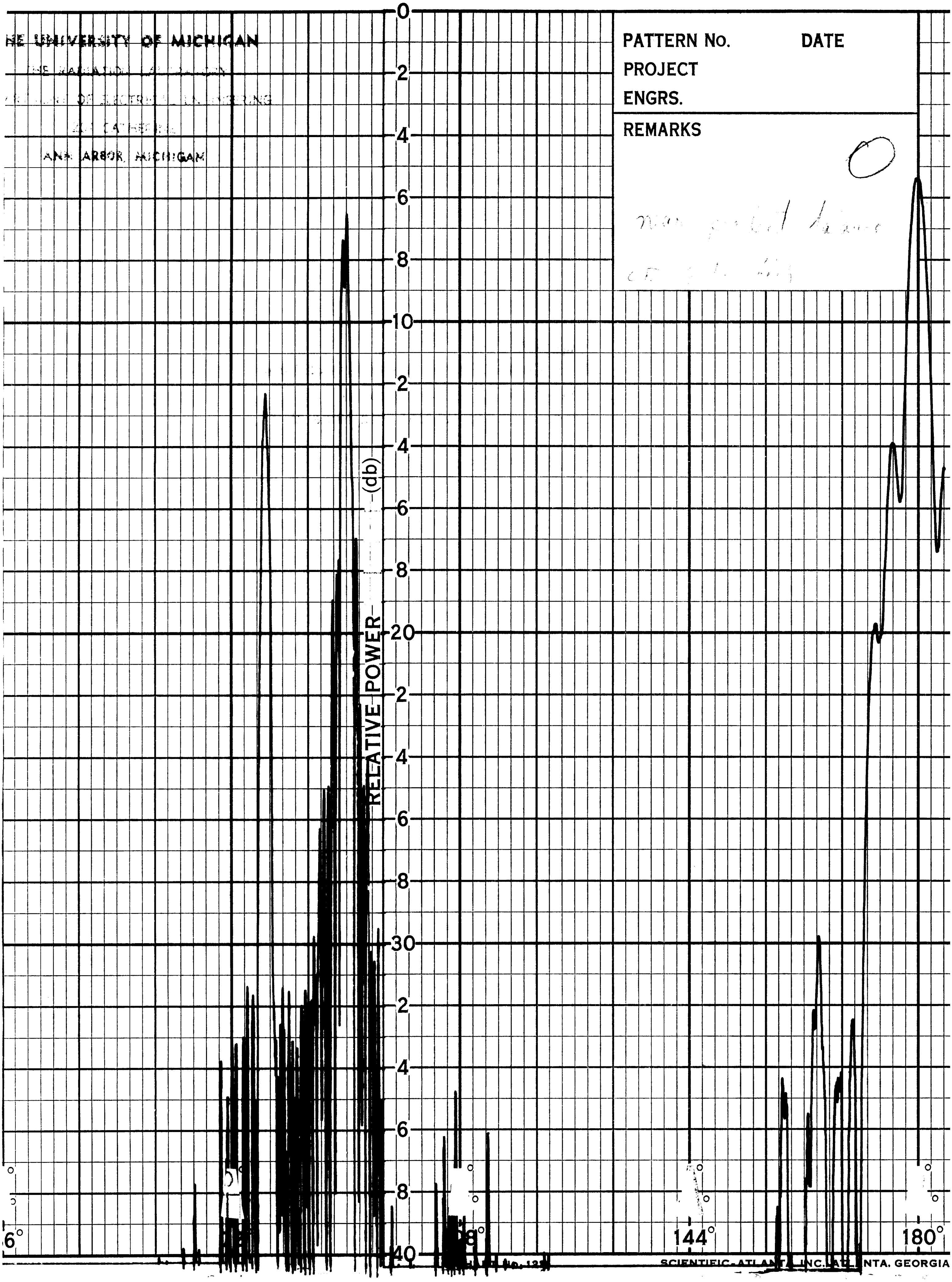
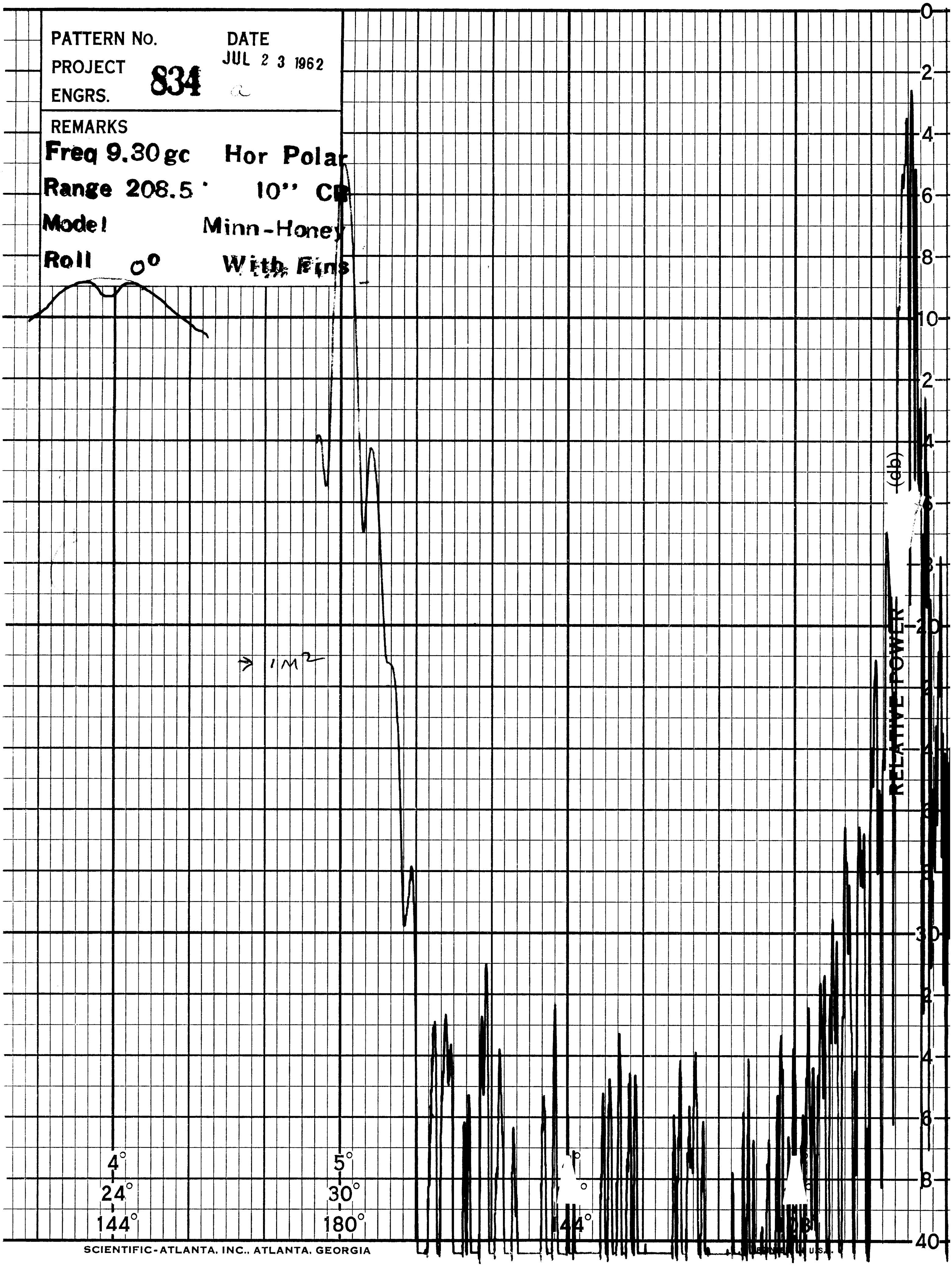


Figure 6
M-H Cone Cylinder Model w/out Fins
Freq. 9.3 Gc, Polarization H
Model axis Horizontal with Nose at 0°


THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN
PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
RELATIVE POWER (db)
0
2
4
6
8
10
20
30
40
144°
180°
SCIENTIFIC-ATLANTA, INC. ATLANTA, GEORGIA



SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA

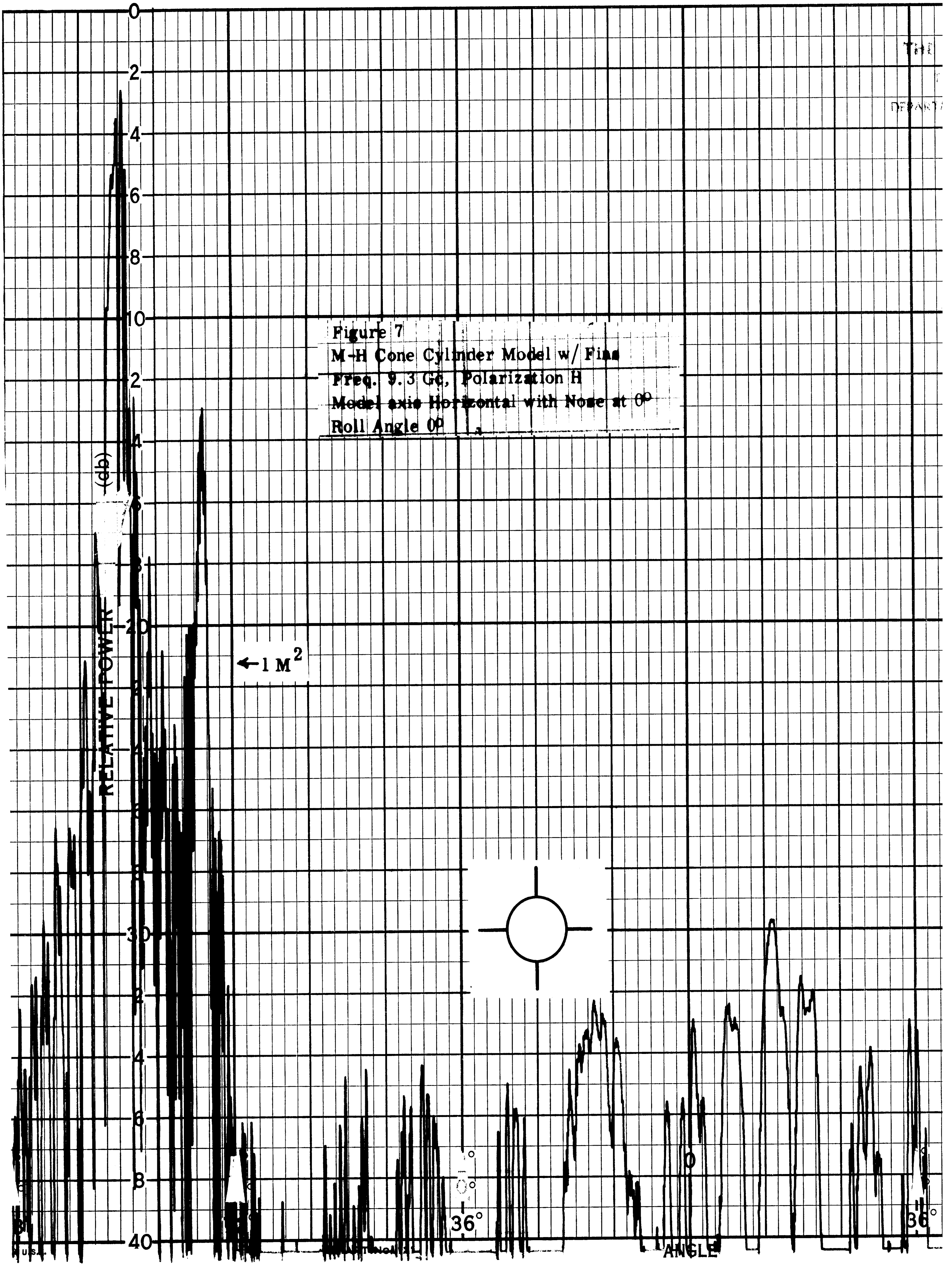
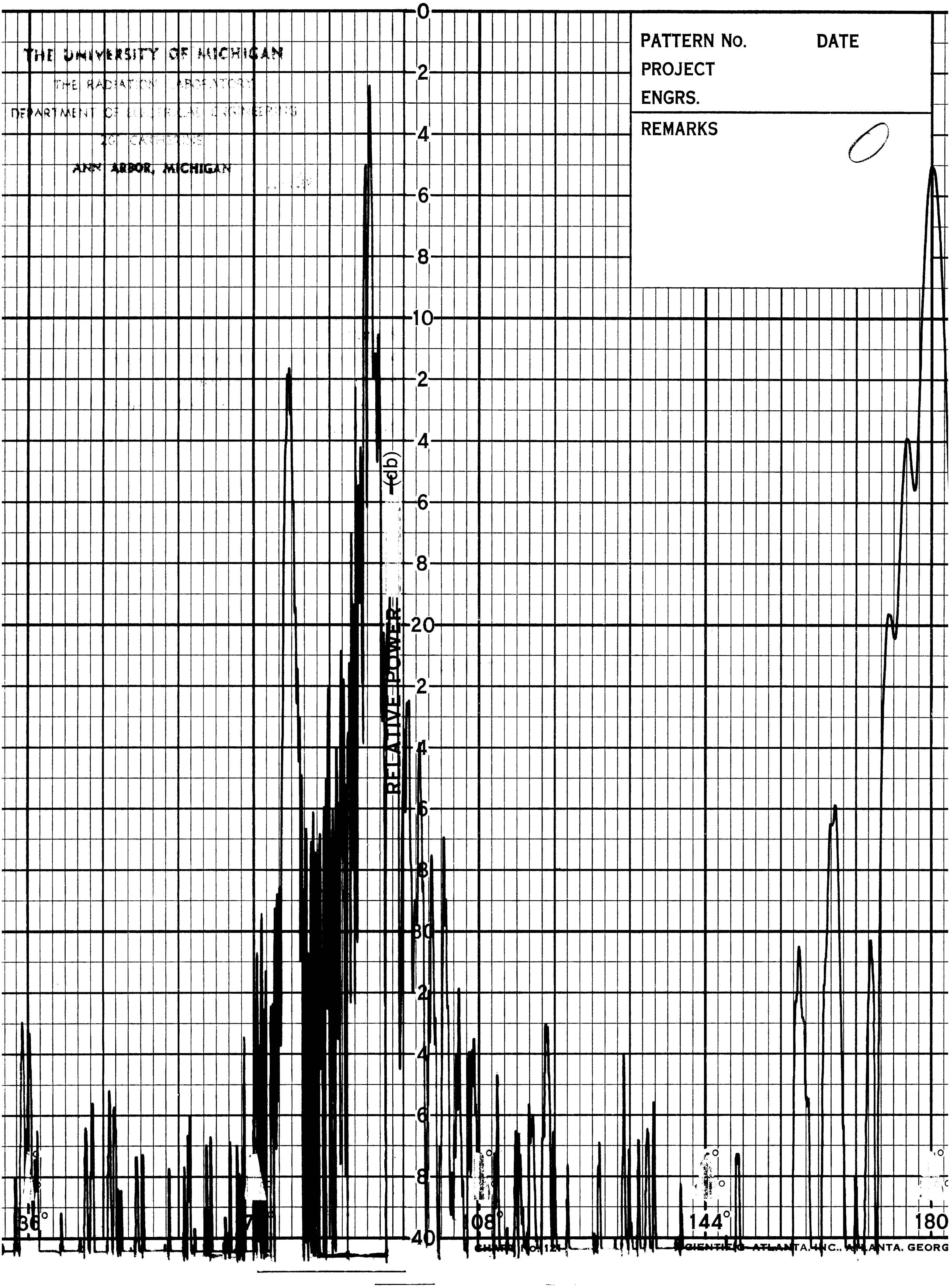
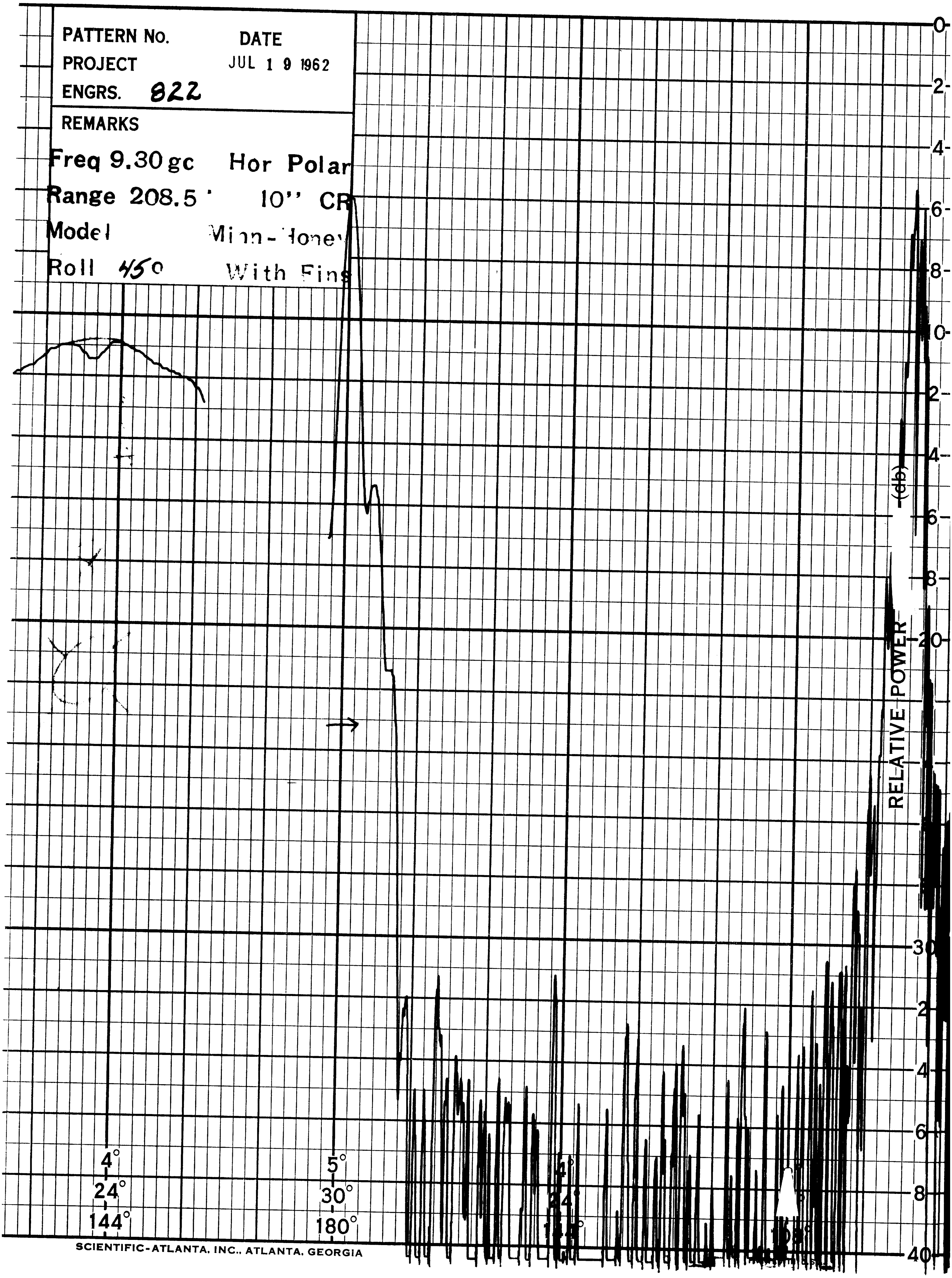


Figure 7
M-H Cone Cylinder Model w/ Fins
Freq. 9.3 Gc, Polarization H
Model axis Horizontal with Nose at 0°
Roll Angle 0°


THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN
PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
RELATIVE POWER (db)
0
2
4
6
8
10
20
40
108°
144°
180°


PATTERN No.
DATE
PROJECT
JUL 1 9 1962
ENGRS. 822
REMARKS
Freq 9.30 gc Hor Polar
Range 208.5 ' 10'' CR
Model Minn-Honey
Roll 45° With Fins
4° 24° 144°
5° 30° 180°
RELATIVE POWER (db)
0 2 4 6 8 10 2 4 6 8 20 2 4 6 8 30 2 4 6 8 40
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA

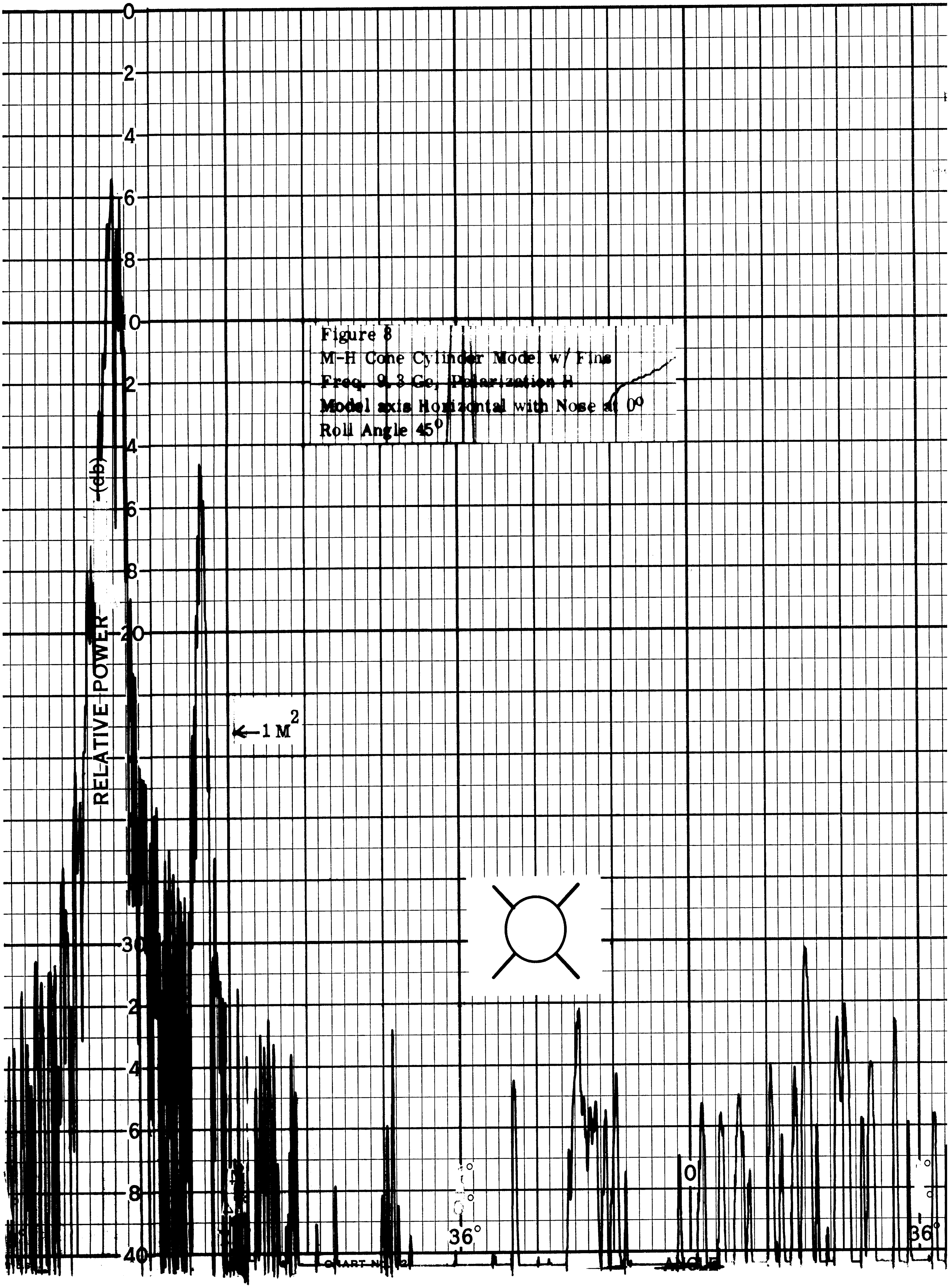
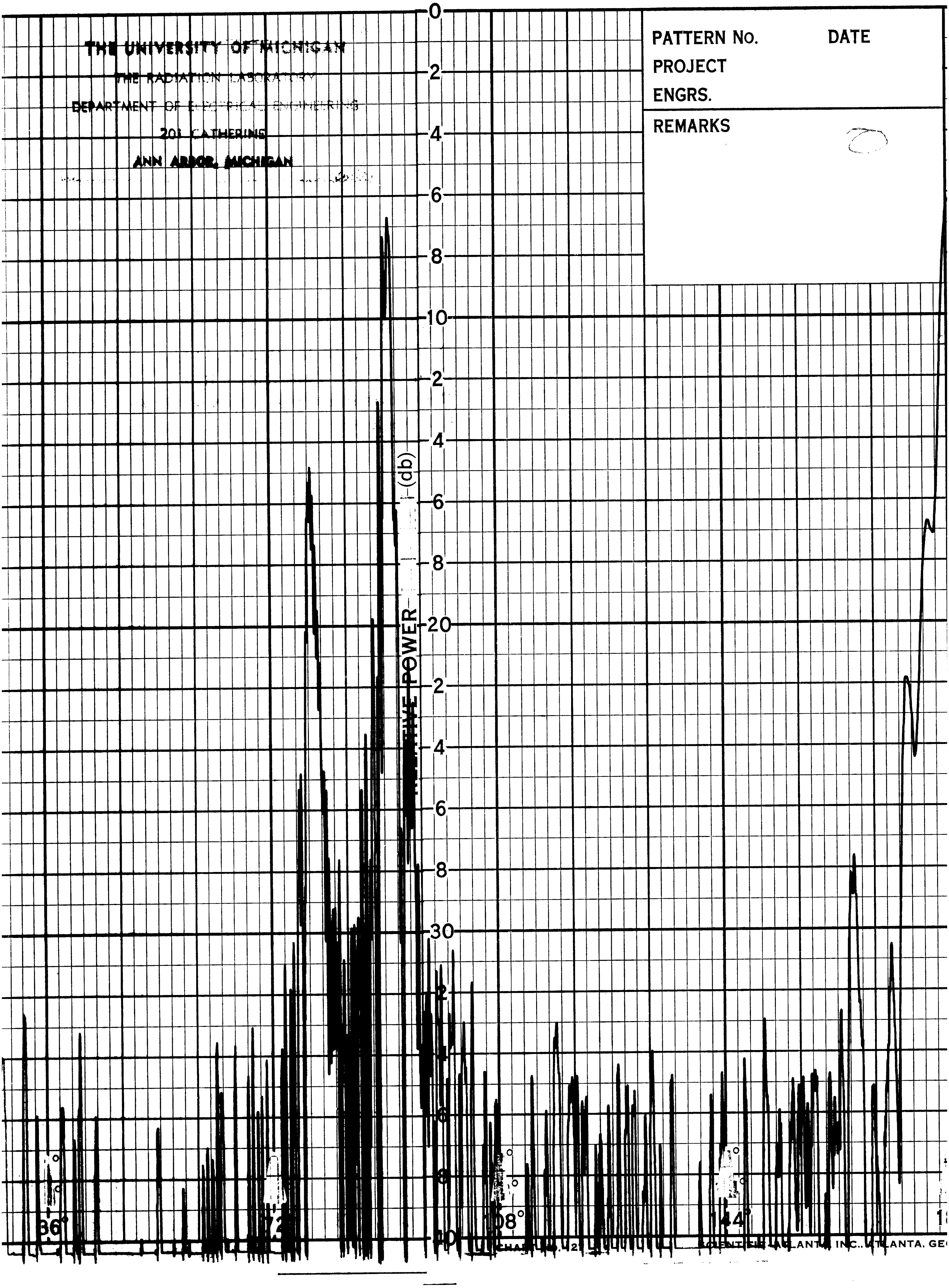


Figure 8
M-H Cone Cylinder Model w/ Fins
Freq. 9.3 Gc, Polarization H
Model axis Horizontal with Nose at 0°
Roll Angle 45°


THE UNIVERSITY OF MICHIGAN
THE RADIATION LABORATORY
DEPARTMENT OF ELECTRICAL ENGINEERING
201 CATHERINE
ANN ARBOR, MICHIGAN
PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
RELATIVE POWER (db)
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
36°
72°
108°
144°
SCIENTIFIC-ATLANTA, INC., ATLANTA, GE

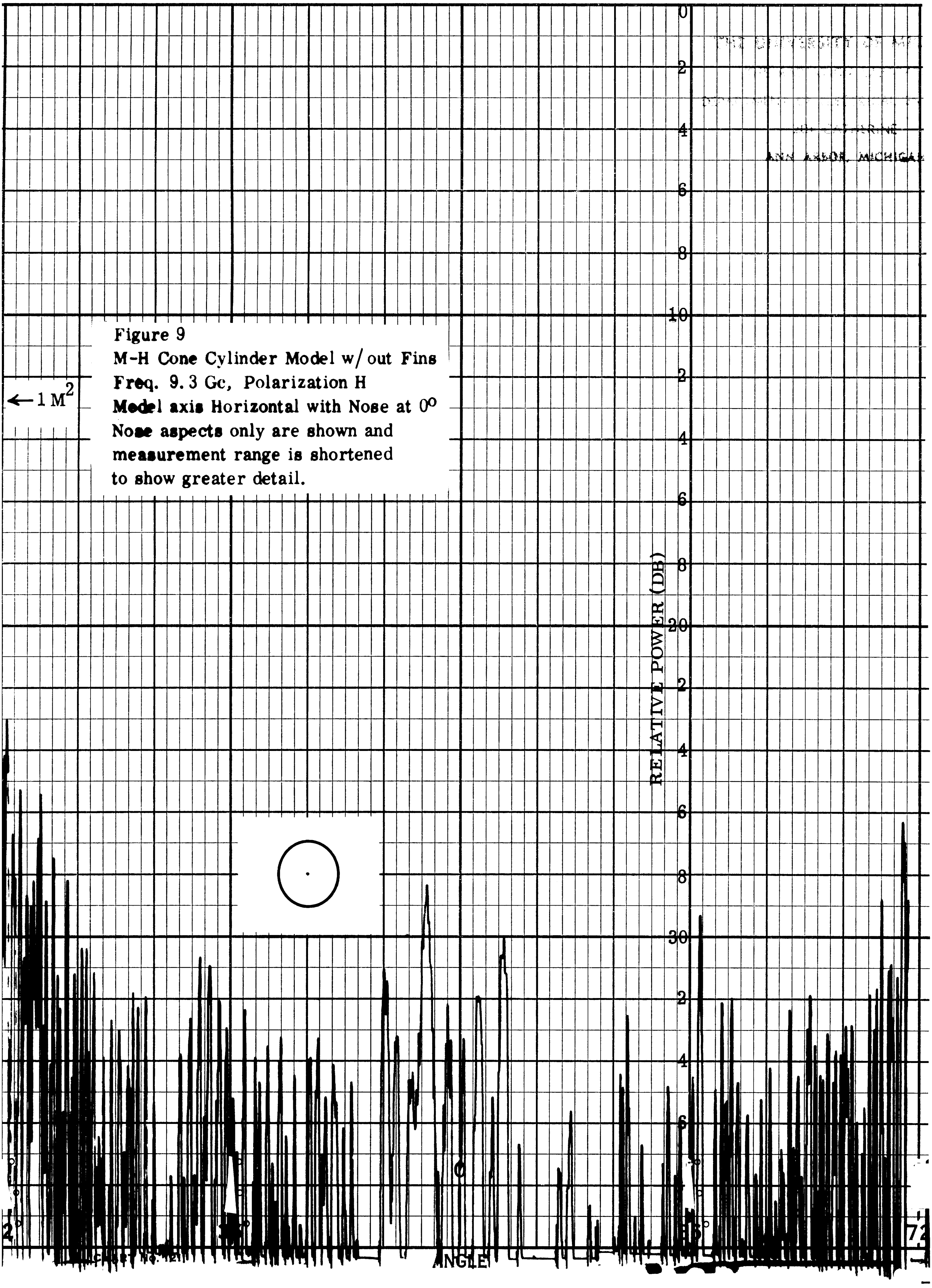


Figure 9
M-H Cone Cylinder Model w/ out Fins
Freq. 9. 3 Gc, Polarization H
Model axis Horizontal with Nose at 0^o
Nose aspects only are shown and
measurement range is shortened
to show greater detail.

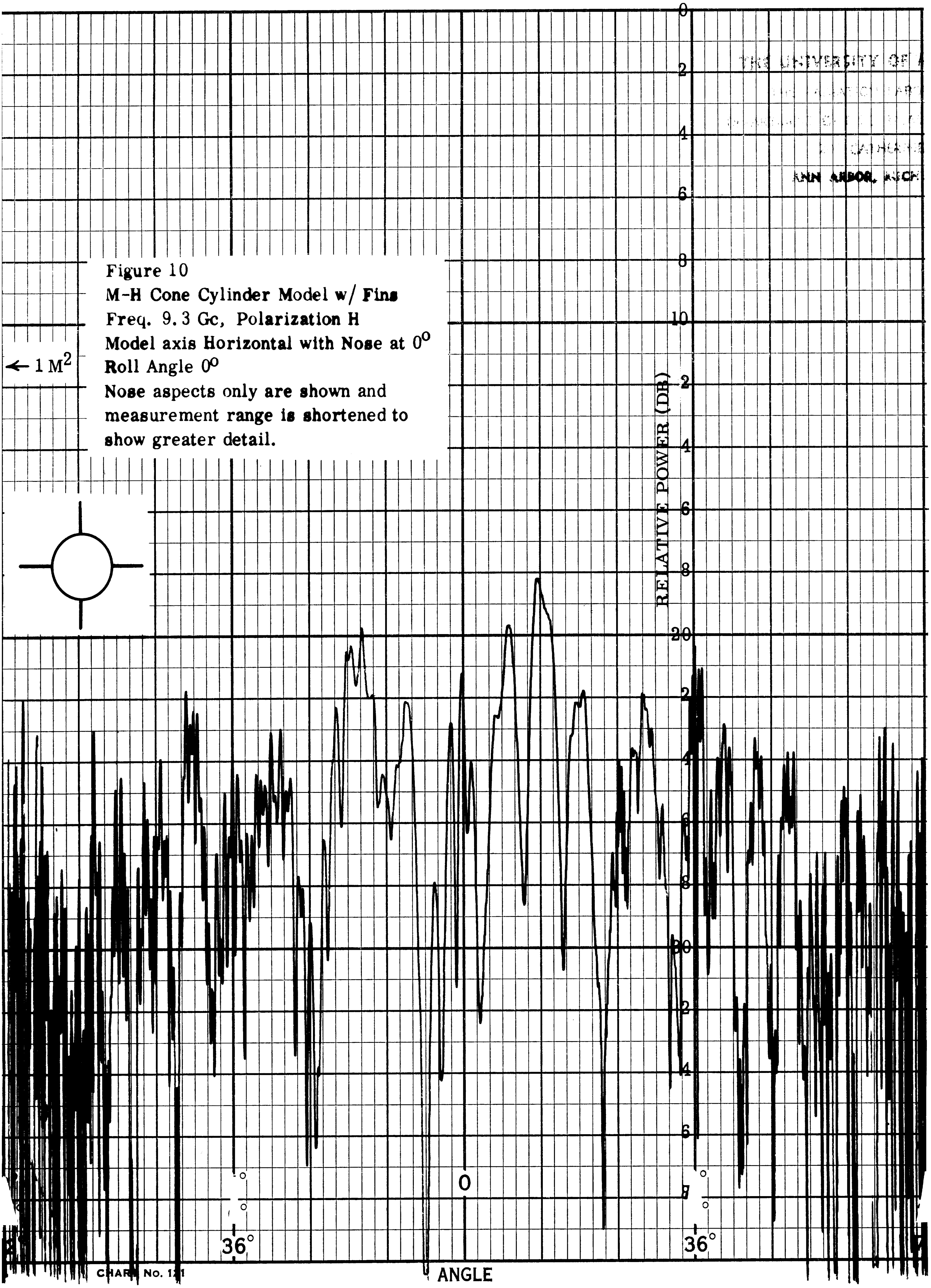


Figure 10
M-H Cone Cylinder Model w/ Fins
Freq. 9.3 Gc, Polarization H
Model axis Horizontal with Nose at 0°
Roll Angle 0°
Nose aspects only are shown and measurement range is shortened to show greater detail.

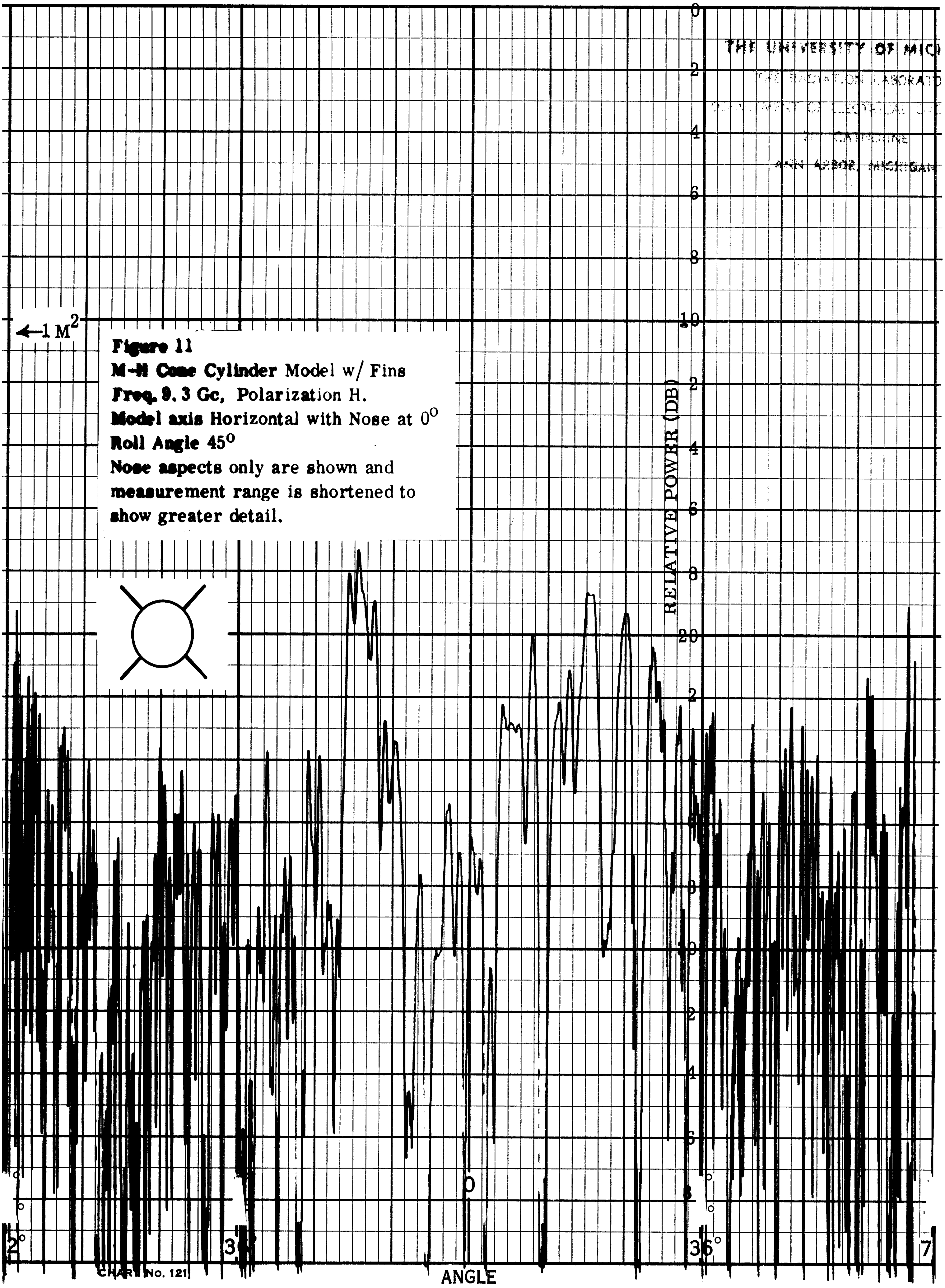
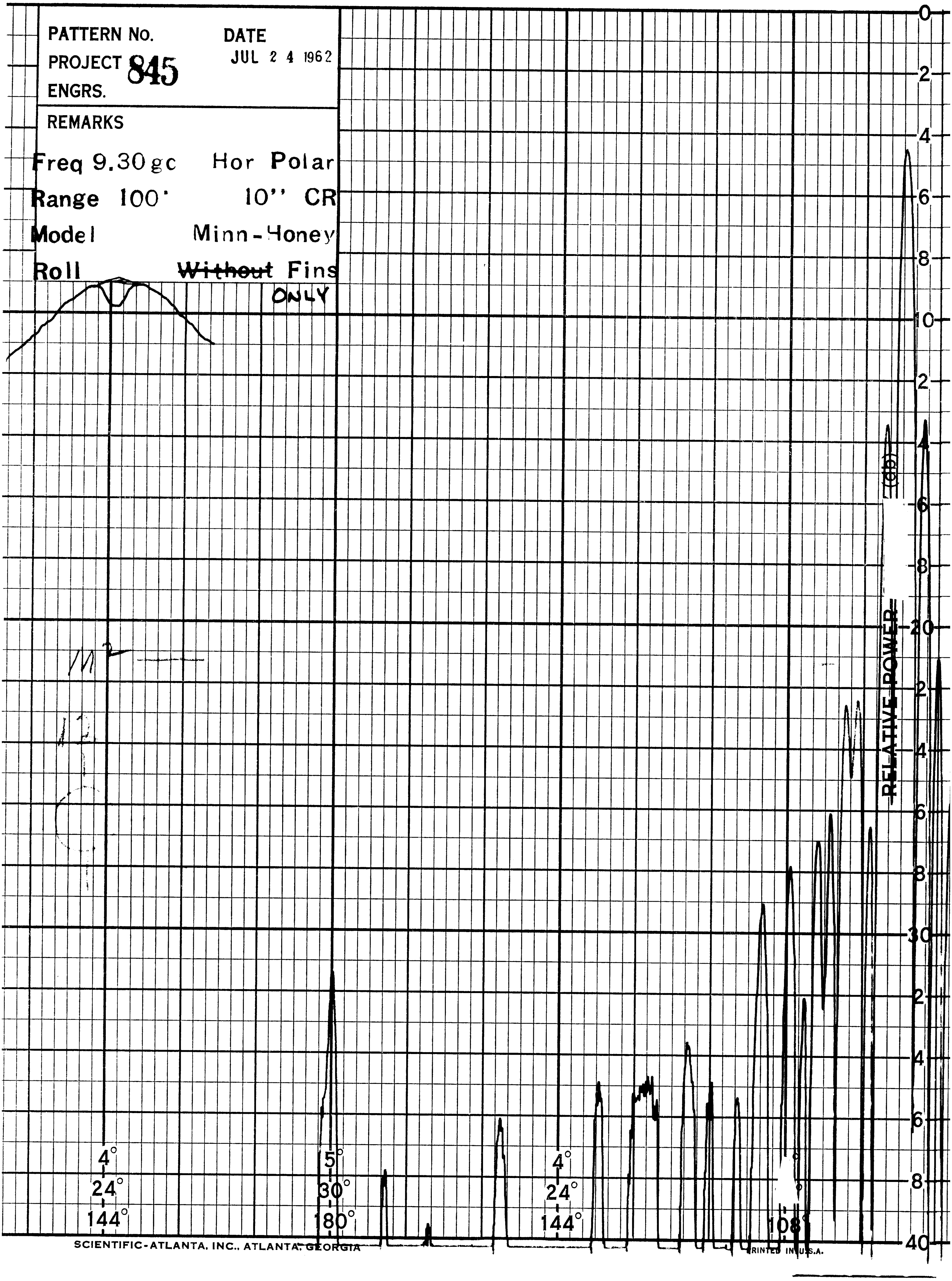


Figure 11
M-N Cone Cylinder Model w/ Fins
Freq. 9.3 Gc, Polarization H.
Model axis Horizontal with Nose at 0^{0}
Roll Angle 45^{0}
Nose aspects only are shown and **measurement range** is shortened to **show greater detail.**



PATTERN No.
PROJECT 845
ENGRS.
DATE
JUL 24 1962
REMARKS
Freq 9.30 gc Hor Polar
Range 100' 10'' CR
Model Minn-Honey
Roll Without Fins
ONLY
RELATIVE POWER (db)
0
2
4
6
8
10
20
30
40
4°
24°
144°
5°
30°
180°
108°
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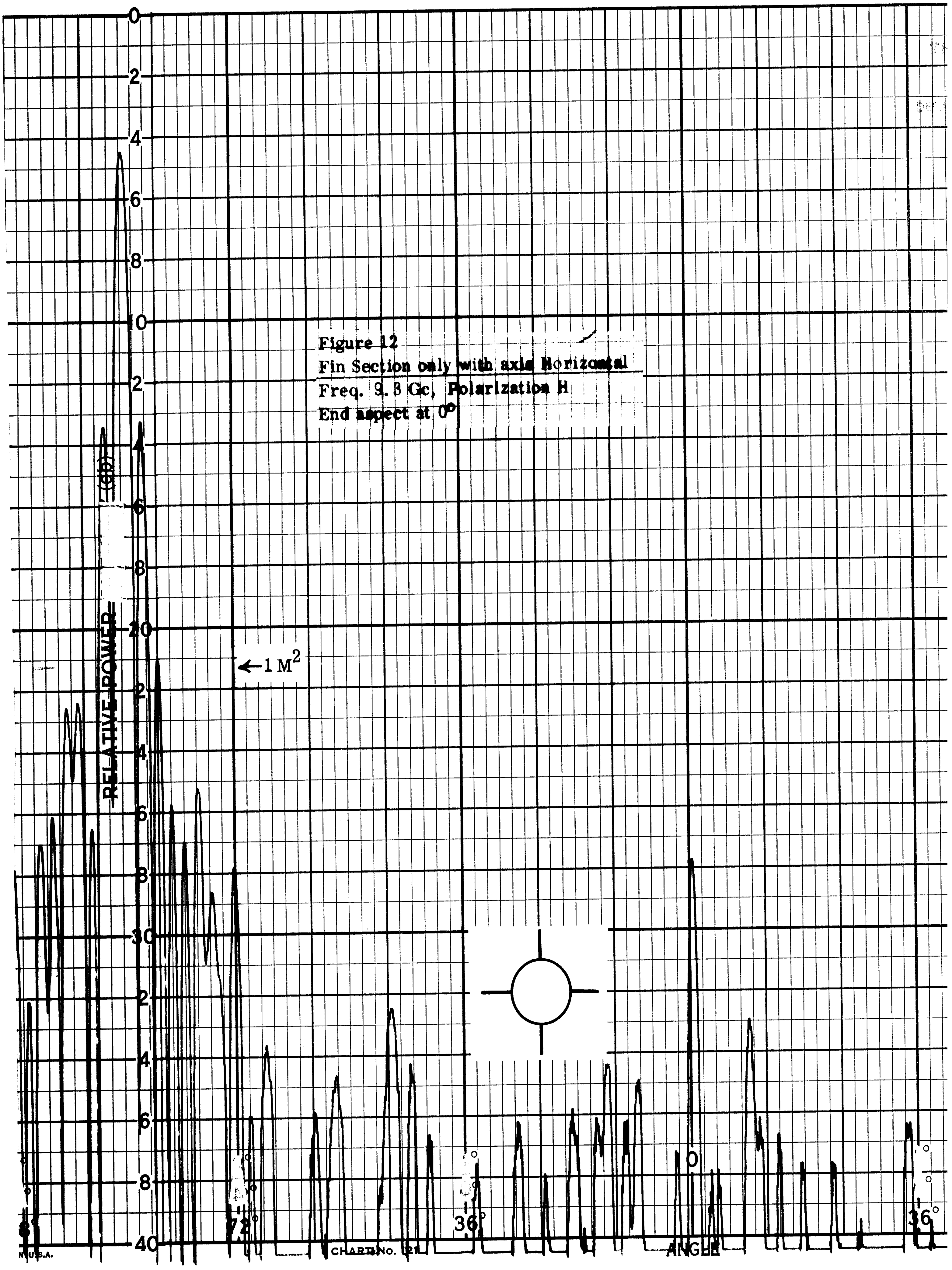
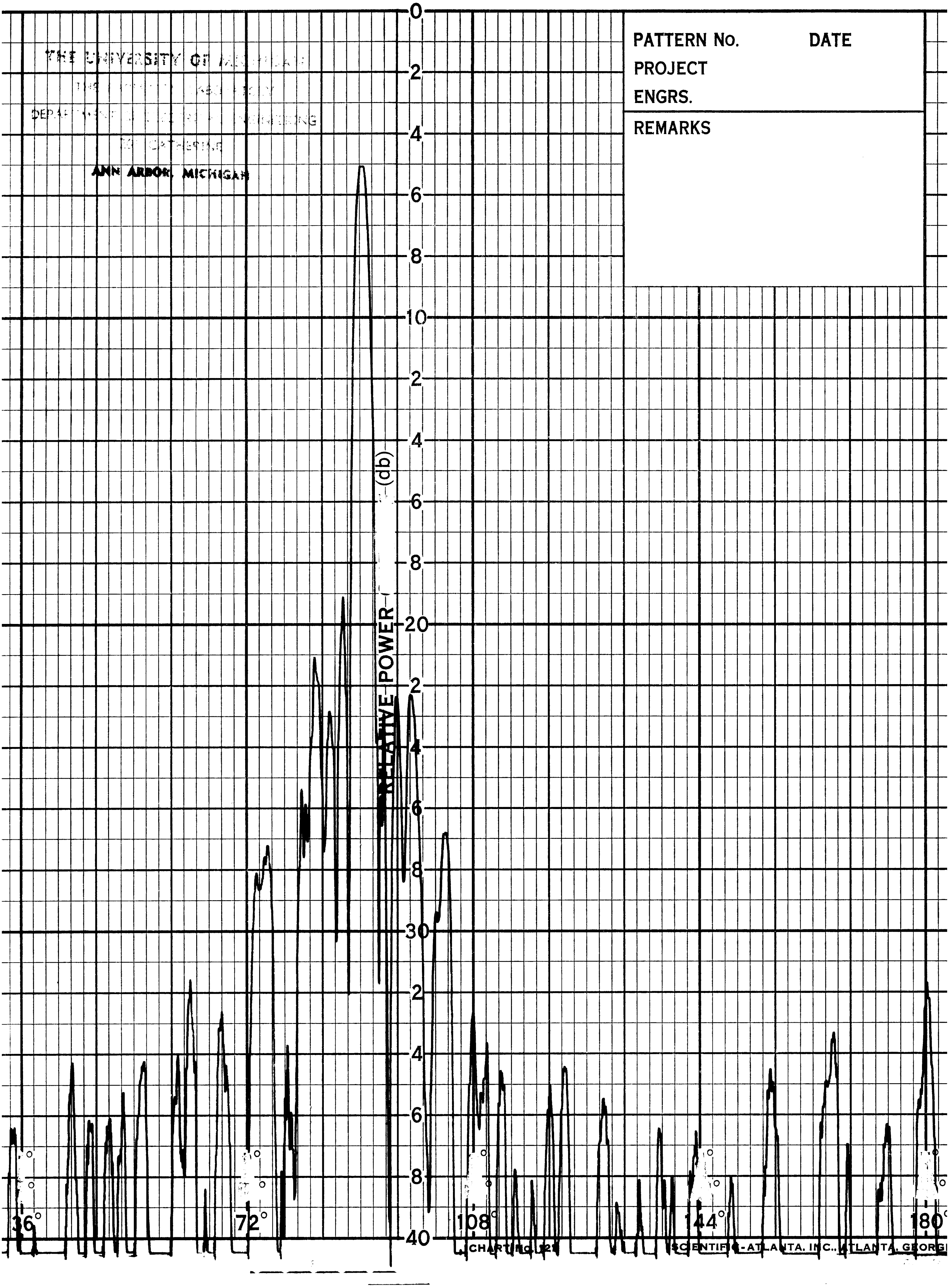
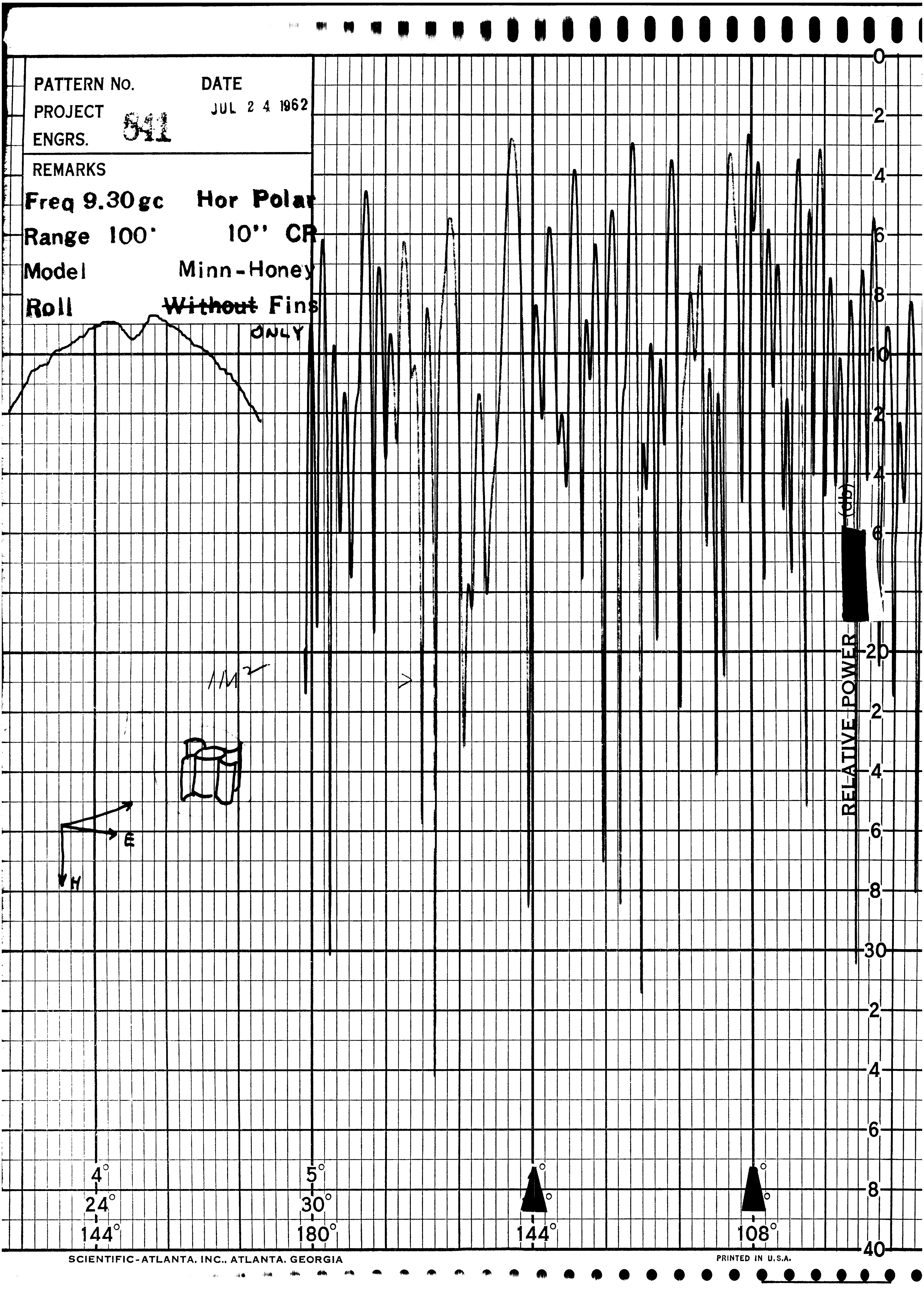
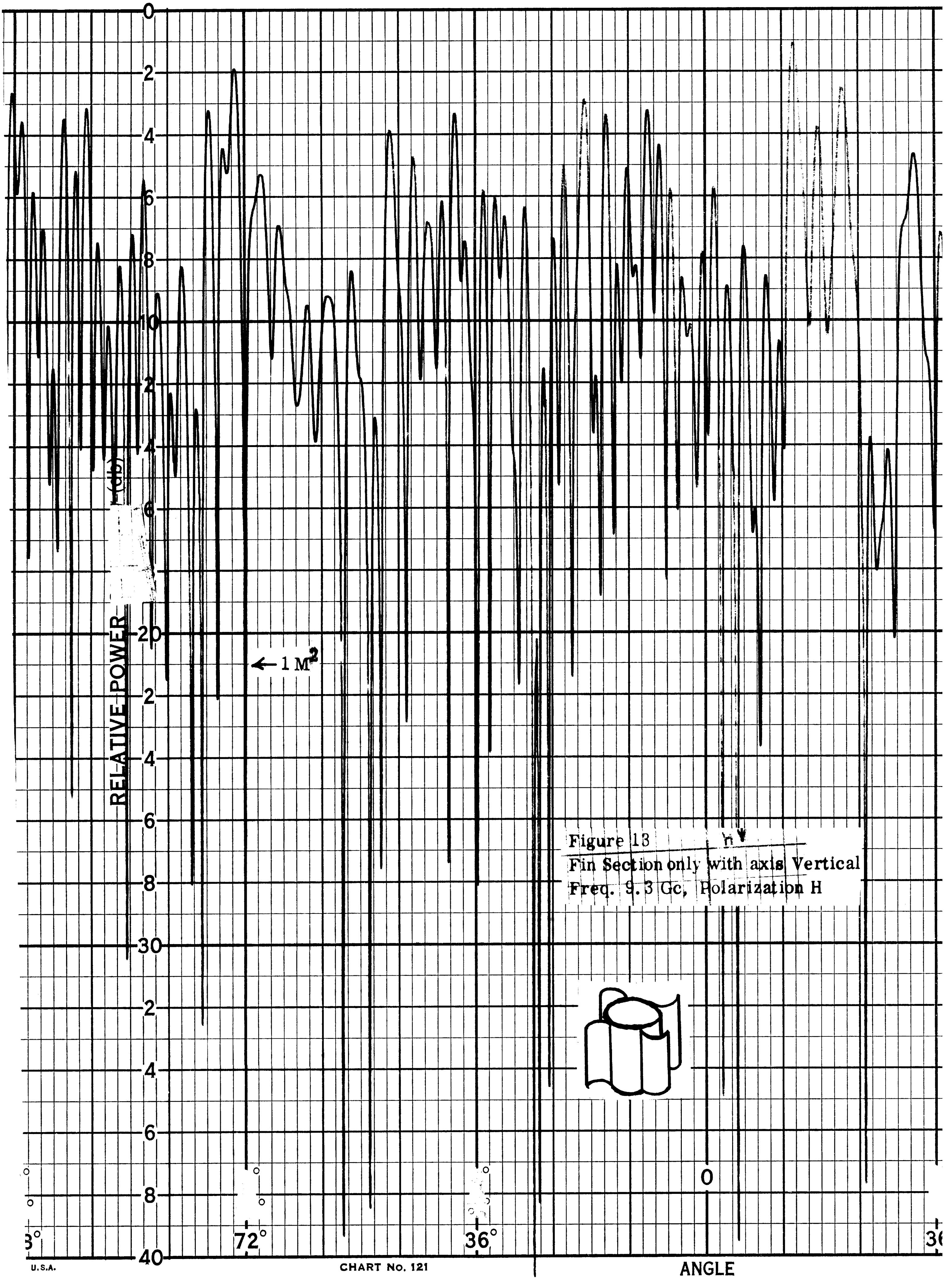


Figure 12
Fin Section only with axis Horizontal
Freq. 9.3 Gc, Polarization H
End aspect at 0°

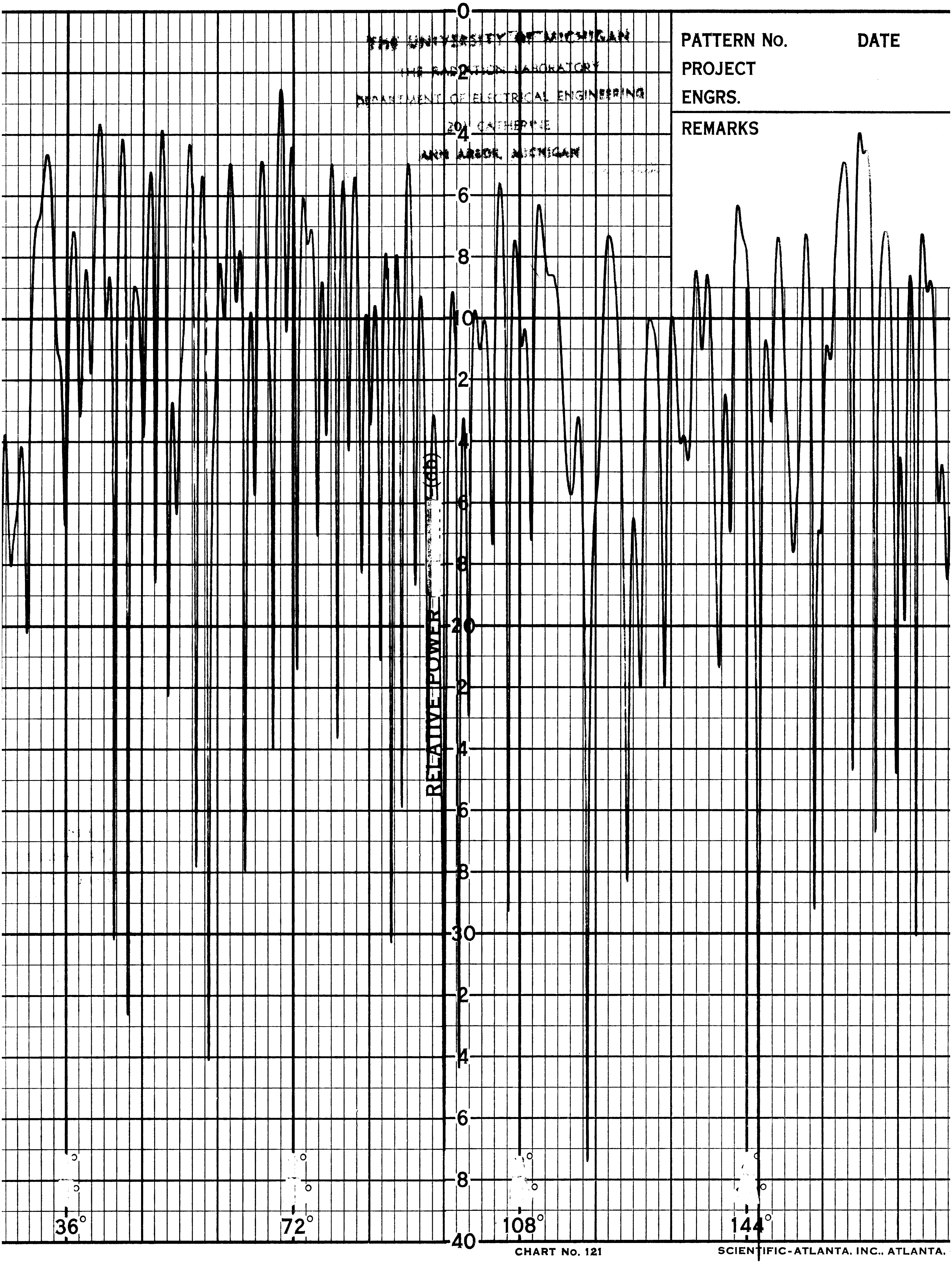


THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN
PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
RELATIVE POWER (db)
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
36°
72°
108°
144°
180°
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA

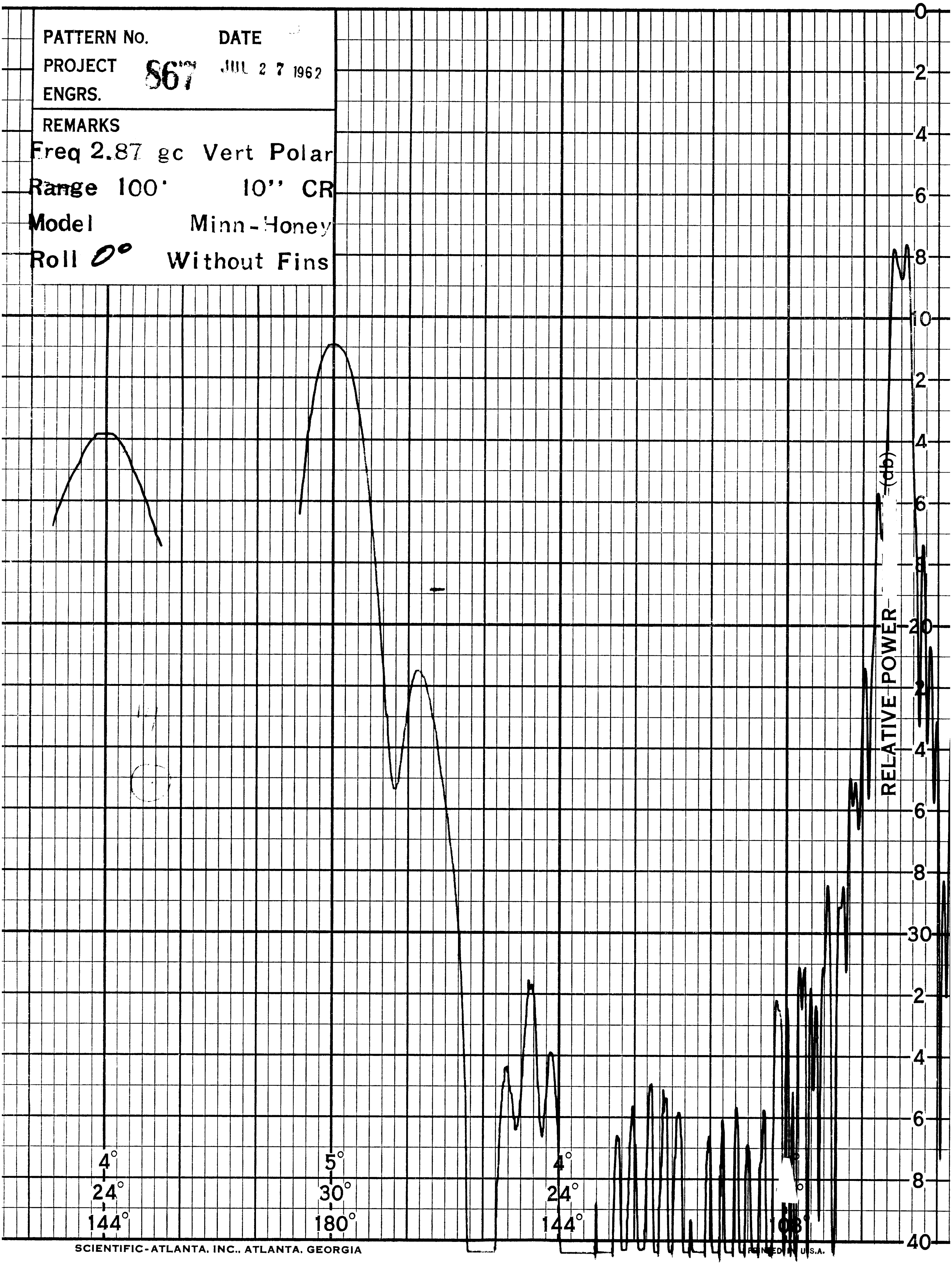

PATTERN No.
DATE
JUL 2 4 1962
PROJECT
ENGRS. 841
REMARKS
Freq 9.30 gc
Hor Polar
Range 100'
10'' CR
Model
Minn-Honey
Roll
~~Without~~ Fins ONLY
E
H
RELATIVE POWER (db)
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
4°
24°
144°
5°
30°
180°
144°
108°
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA
PRINTED IN U.S.A.



RELATIVE POWER (db)
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
← 1 M²
Figure 13
Fin Section only with axis Vertical
Freq. 9.3 Gc, Polarization H
72°
36°
0
U.S.A.
CHART No. 121
ANGLE



THE UNIVERSITY OF MICHIGAN
THE RADIATION LABORATORY
DEPARTMENT OF ELECTRICAL ENGINEERING
201 CATHERINE
ANN ARBOR, MICHIGAN
PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
RELATIVE POWER (db)
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
36°
72°
108°
144°
CHART No. 121
SCIENTIFIC-ATLANTA, INC., ATLANTA,


PATTERN No.
DATE
PROJECT 867
JUL 2 7 1962
ENGRS.
REMARKS
Freq 2.87 gc Vert Polar
Range 100' 10'' CR
Model Minn-Honey
Roll 0° Without Fins
RELATIVE POWER (db)
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
4° 24° 144°
5° 30° 180°
4° 24° 144°
108°
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA
PRINTED IN U.S.A.

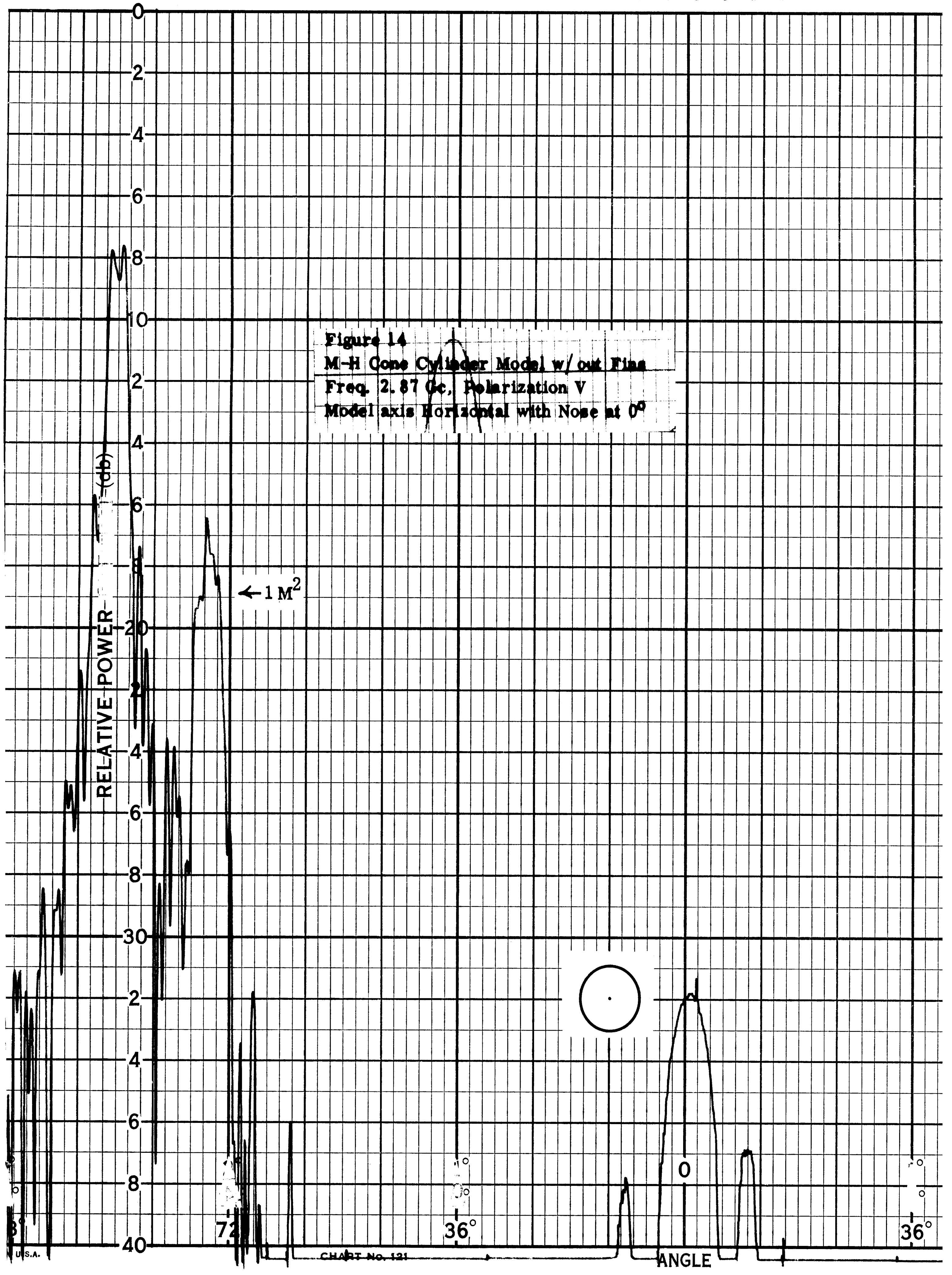
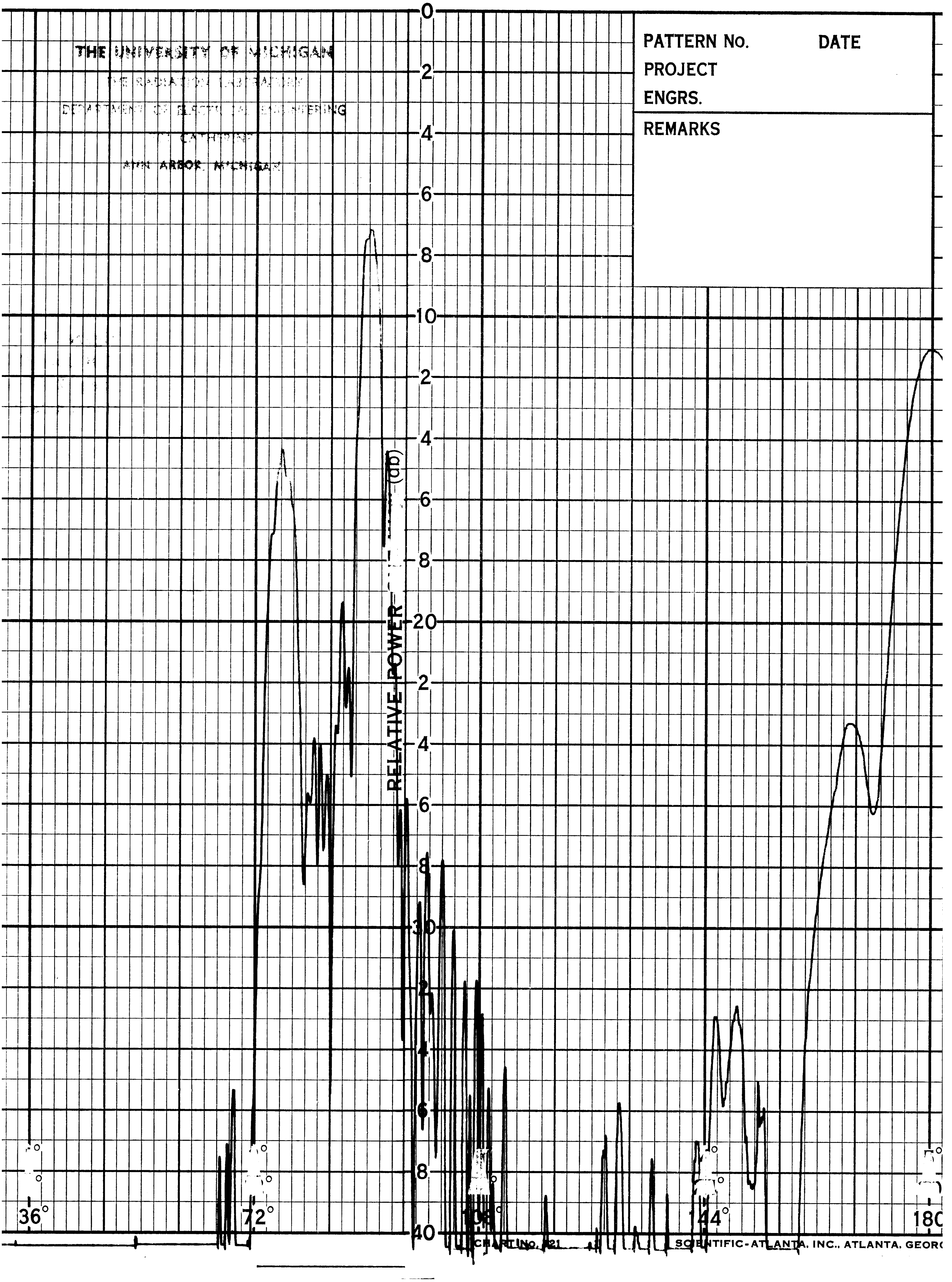
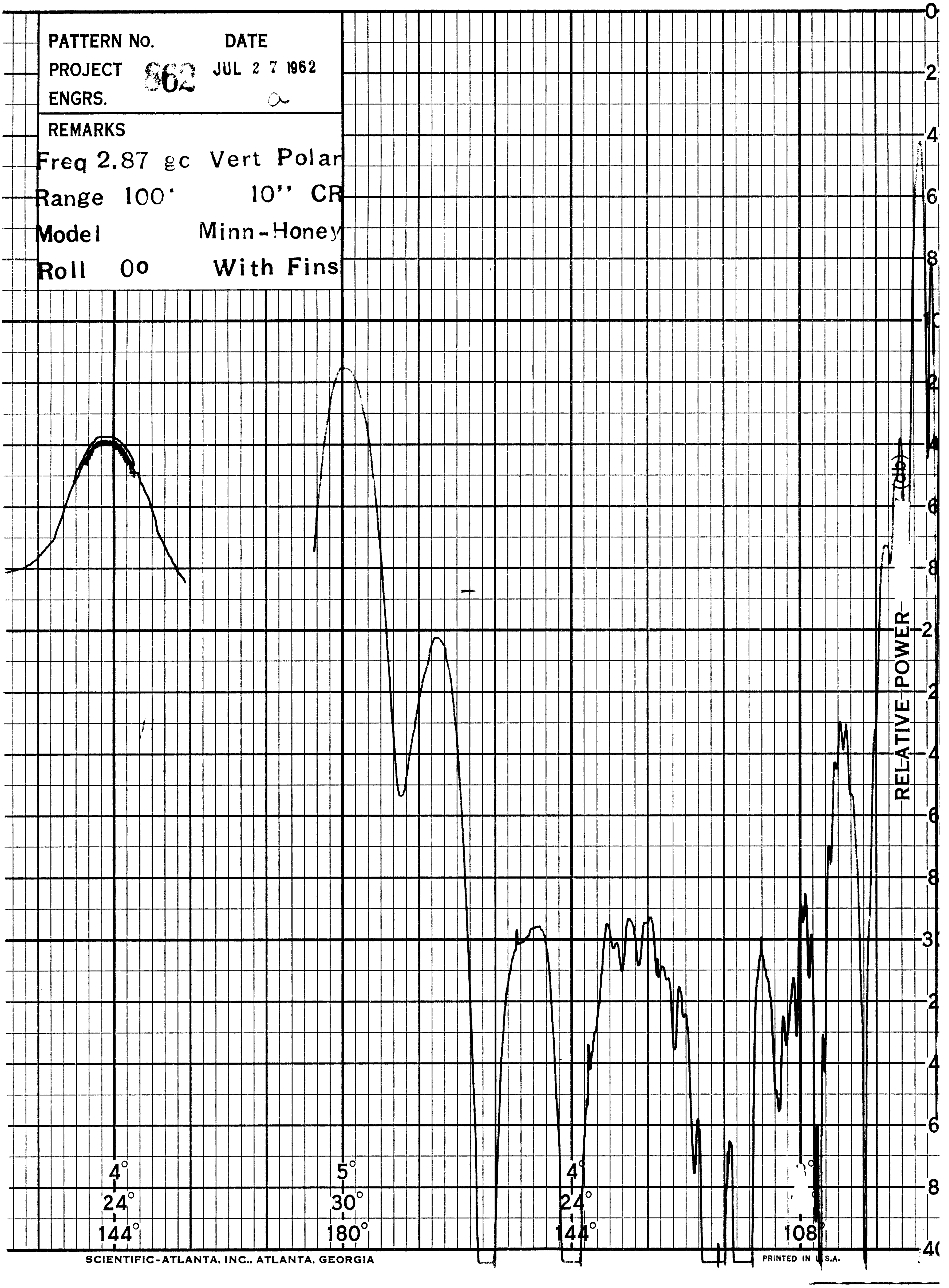


Figure 14
M-H Cone Cylinder Model w/ out Fins
Freq. 2.87 Gc, Polarization V
Model axis Horizontal with Nose at 0°
RELATIVE POWER (db)
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
← 1 M²
72°
36°
0
36°
ANGLE
CHART No. 121
U.S.A.


THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN
PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
RELATIVE POWER (db)
0
2
4
6
8
10
20
30
40
36°
72°
108°
144°
180°
CHART No. 21
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORG


PATTERN No.
DATE
PROJECT 862
JUL 27 1962
ENGRS.
REMARKS
Freq 2.87 gc Vert Polar
Range 100' 10" CR
Model Minn-Honey
Roll 0° With Fins
4°
24°
144°
5°
30°
180°
4°
24°
144°
108°
RELATIVE POWER (db)
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA
PRINTED IN U.S.A.

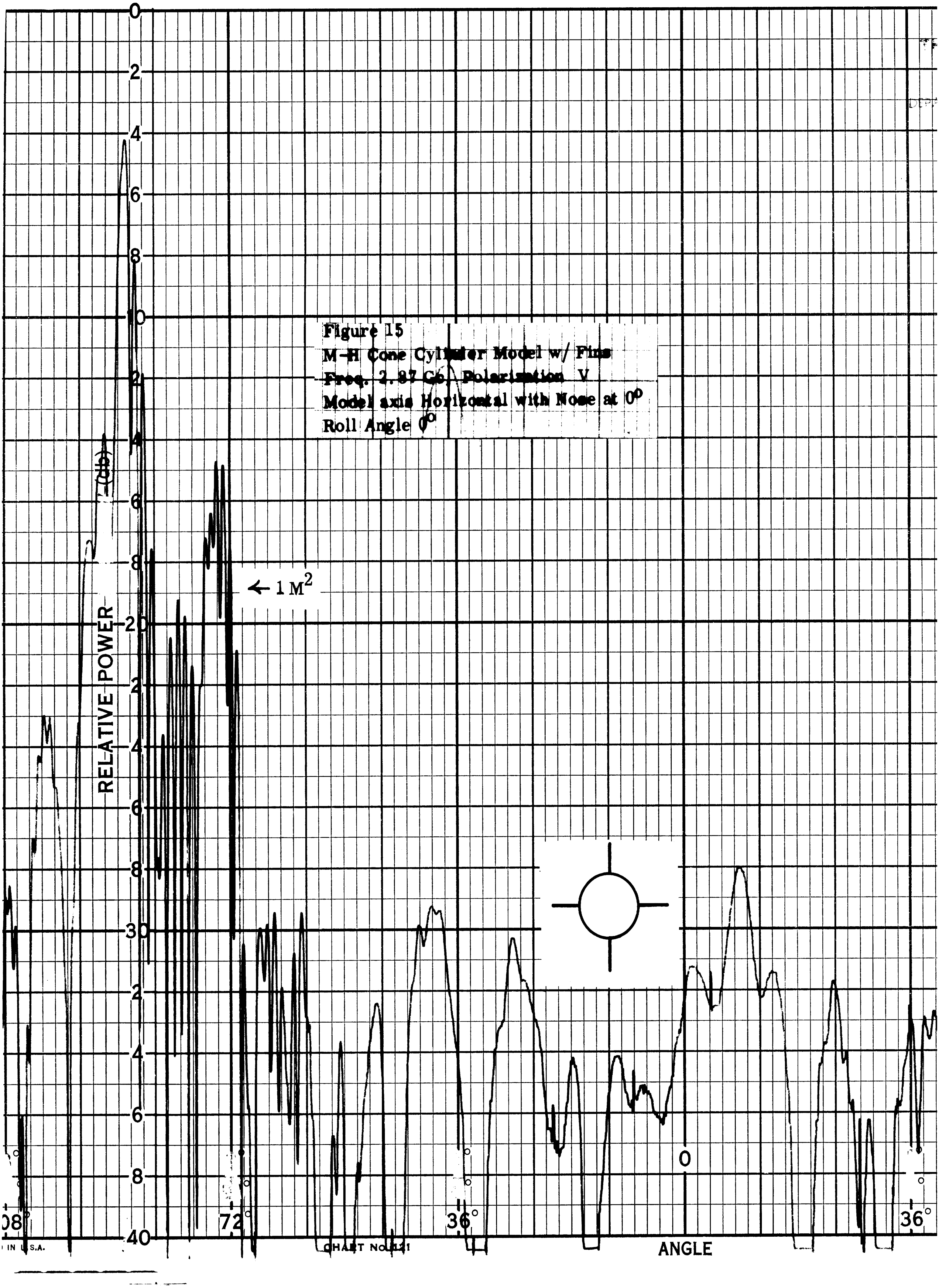
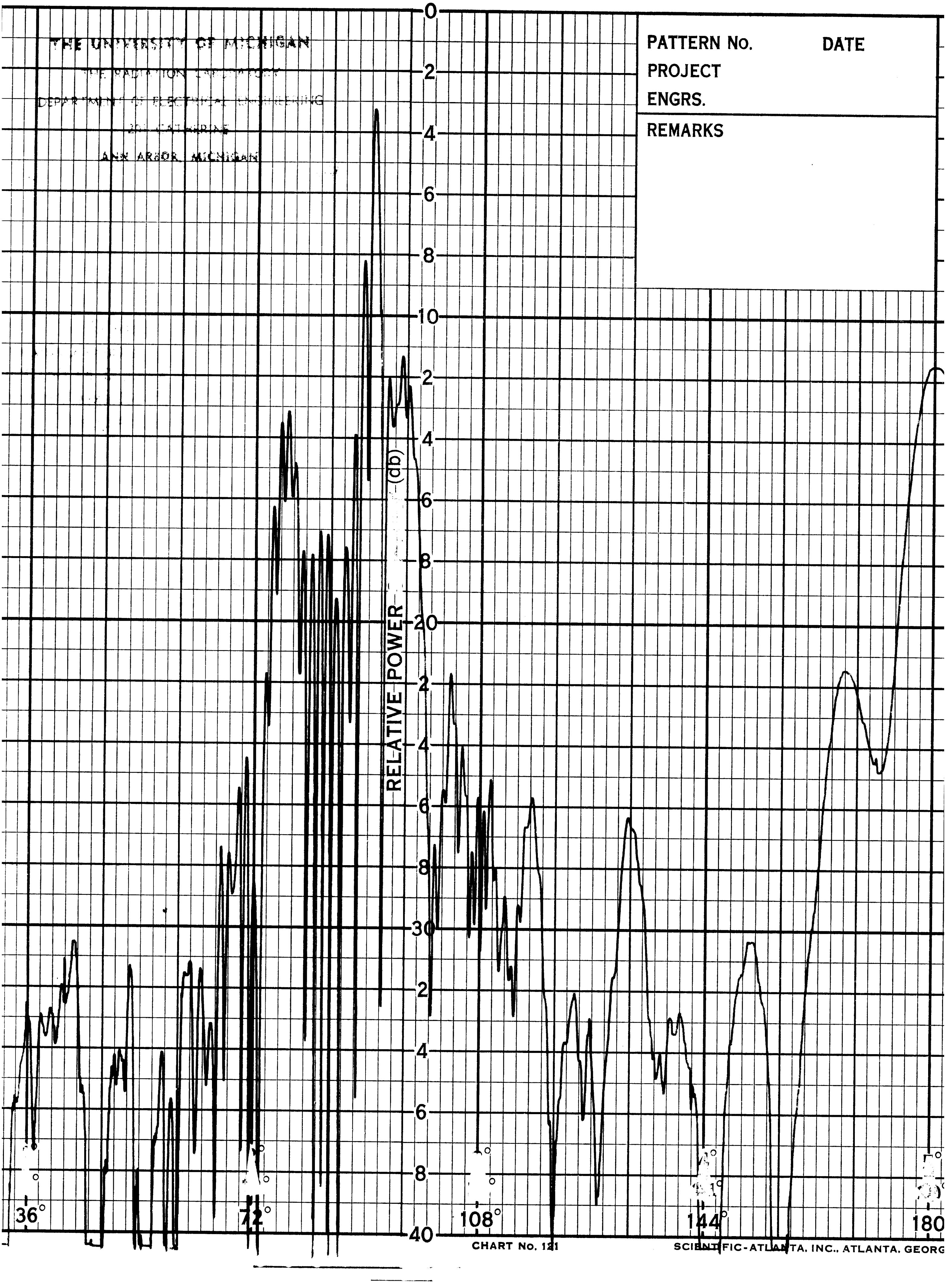
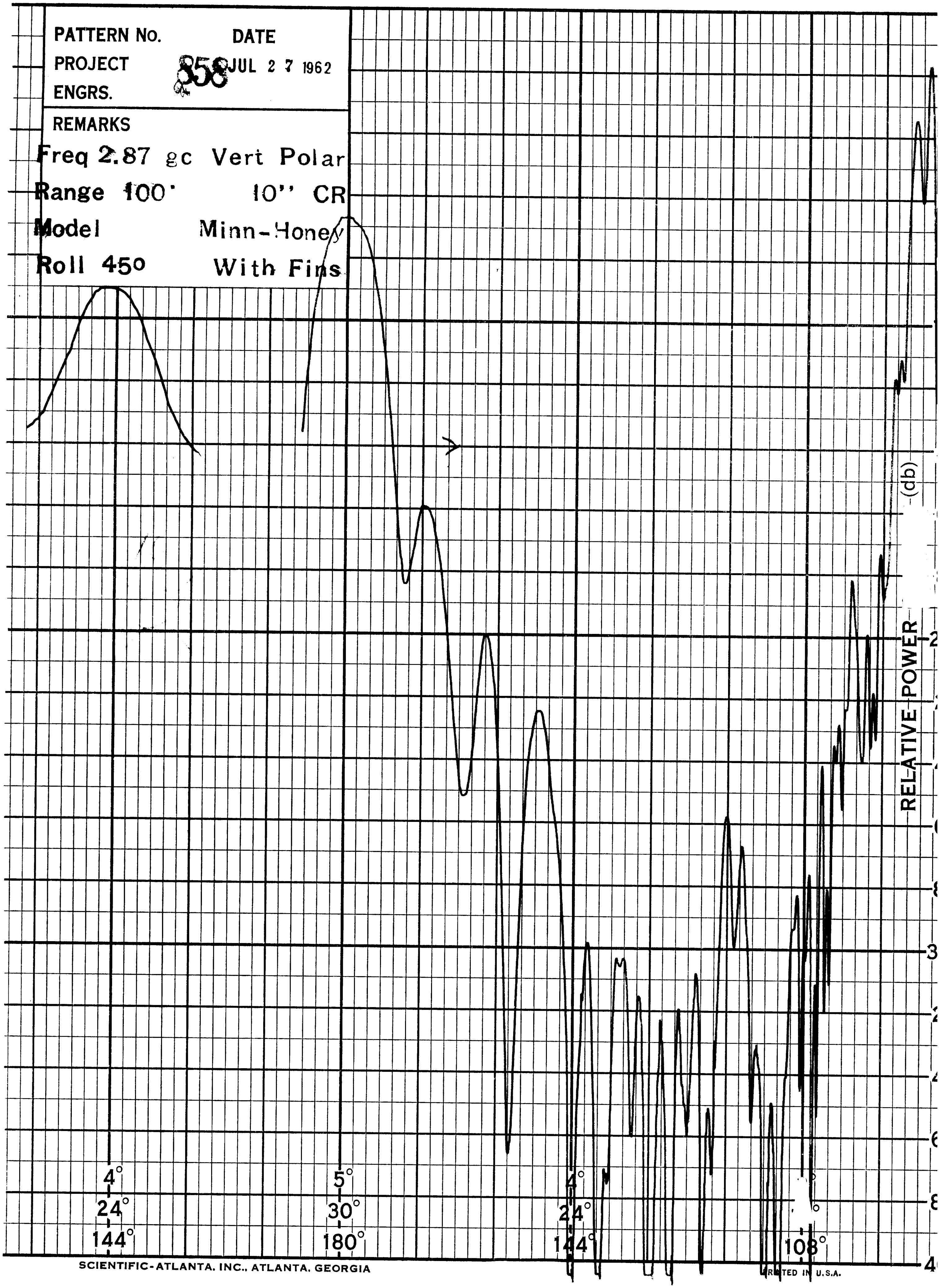


Figure 15
M-H Cone Cylinder Model w/ Fins
Freq. 2.87 Gc Polarization V
Model axis Horizontal with Nose at 0°
Roll Angle 0°


THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN
PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
RELATIVE POWER (db)
0
2
4
6
8
10
20
30
40
36°
72°
108°
144°
180
CHART No. 121
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORG



PATTERN No.
DATE
PROJECT
858
JUL 27 1962
ENGRS.
REMARKS
Freq 2.87 gc Vert Polar
Range 100' 10'' CR
Model Minn-Honey
Roll 45o With Fins
RELATIVE POWER (db)
4°
24°
144°
5°
30°
180°
4°
24°
144°
108°
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA
PRINTED IN U.S.A.

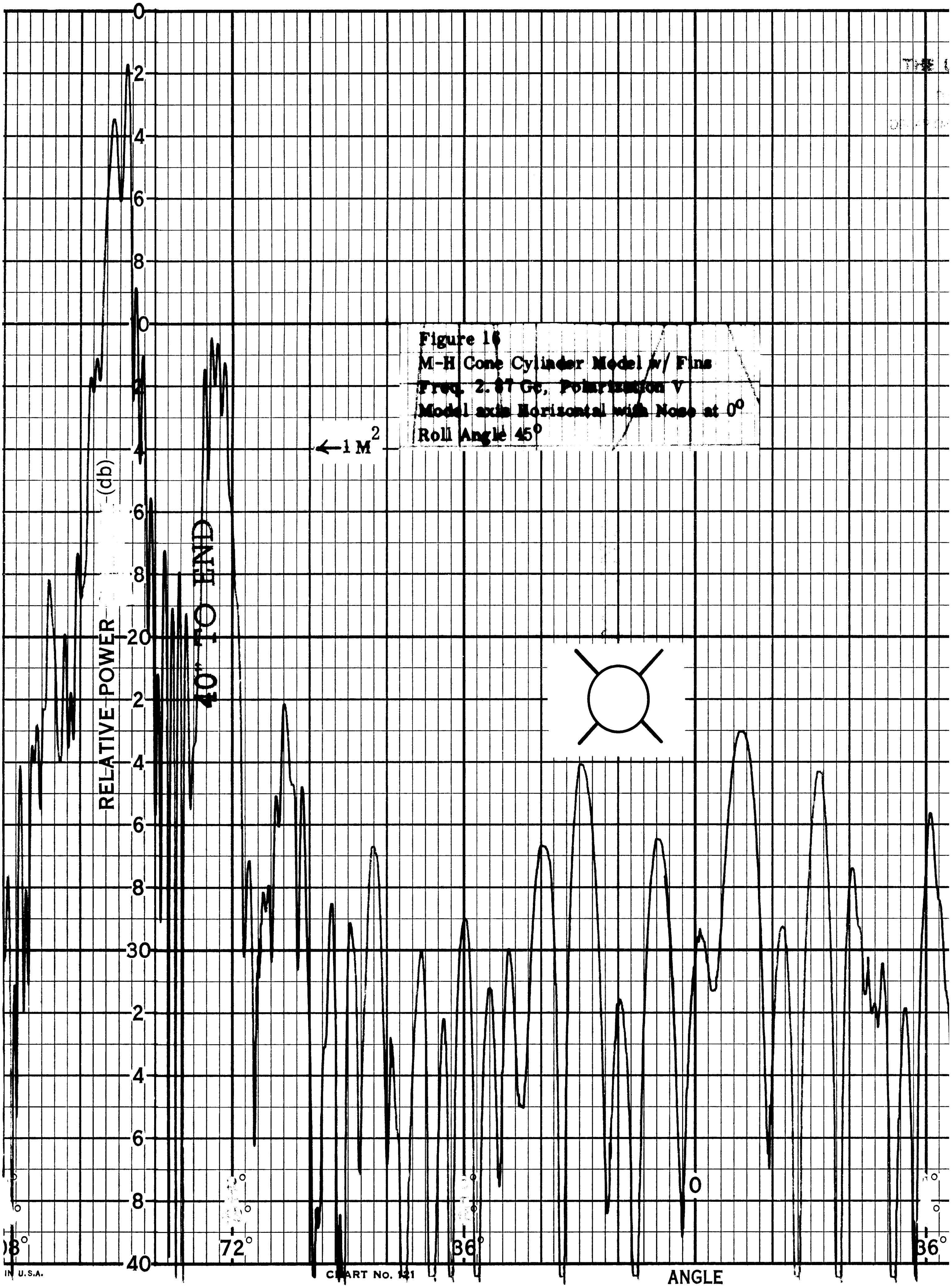
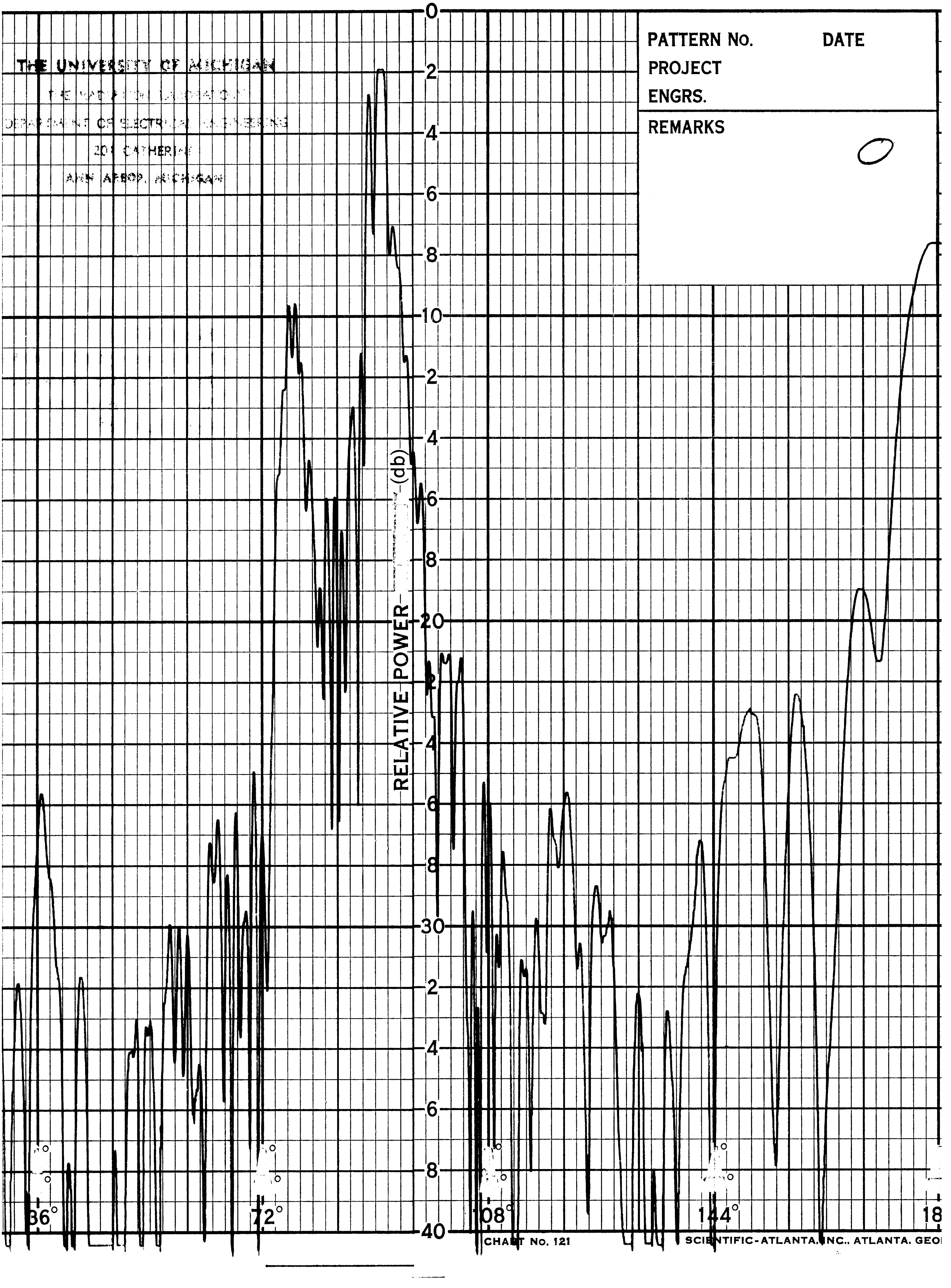
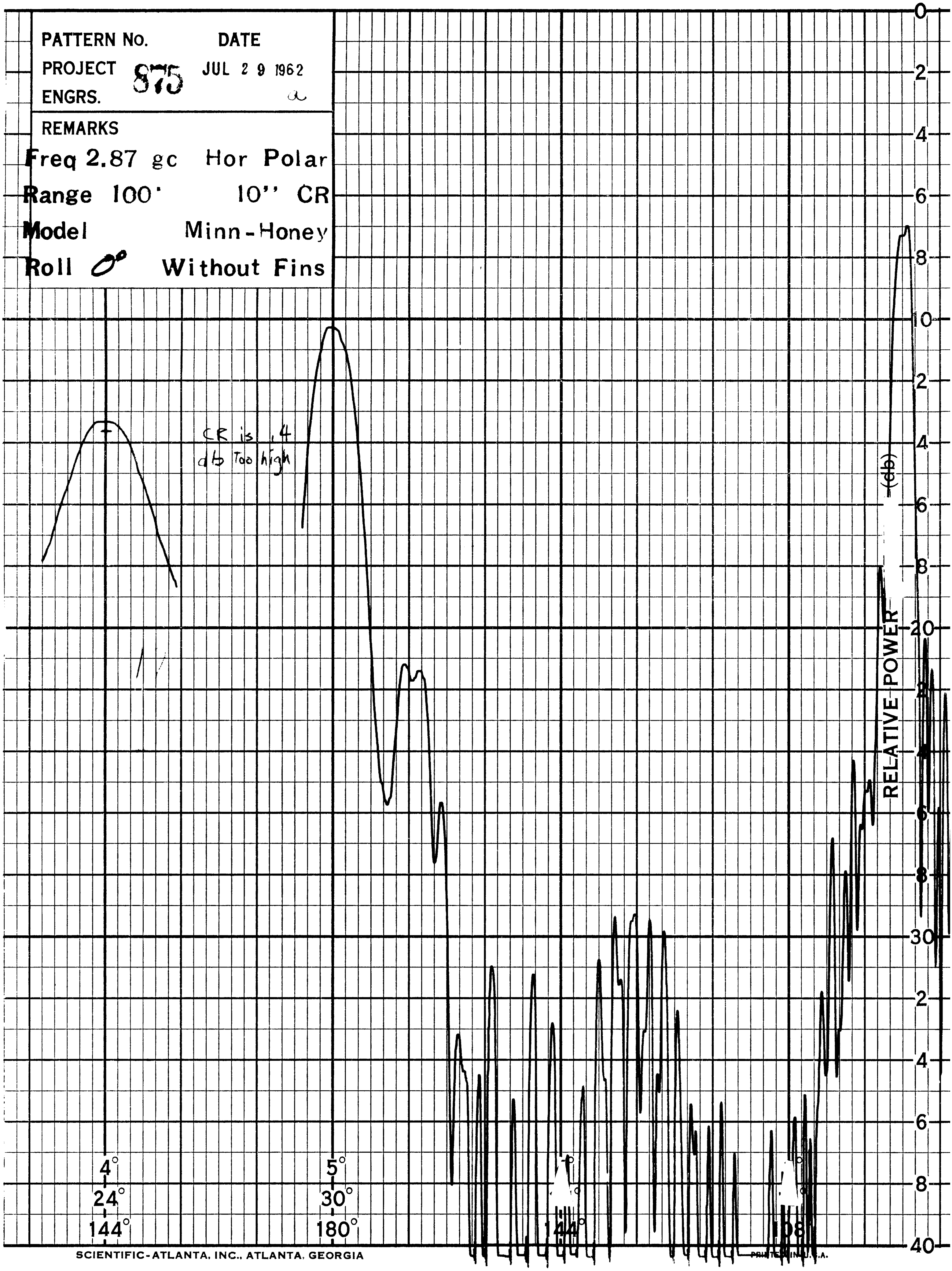


Figure 16
M-H Cone Cylinder Model w/ Fins
Freq. 2.87 Gc, Polarization V
Model axis Horizontal with Nose at 0°
Roll Angle 45°


THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN
PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
0
RELATIVE POWER (db)
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
36°
72°
108°
144°
CHART No. 121
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEO


PATTERN No.
DATE
PROJECT 875
JUL 2 9 1962
ENGRS.
REMARKS
Freq 2.87 gc Hor Polar
Range 100' 10'' CR
Model Minn-Honey
Roll 0° Without Fins
CR is .4
db Too high
4°
24°
144°
5°
30°
180°
144°
108°
RELATIVE POWER (db)
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA

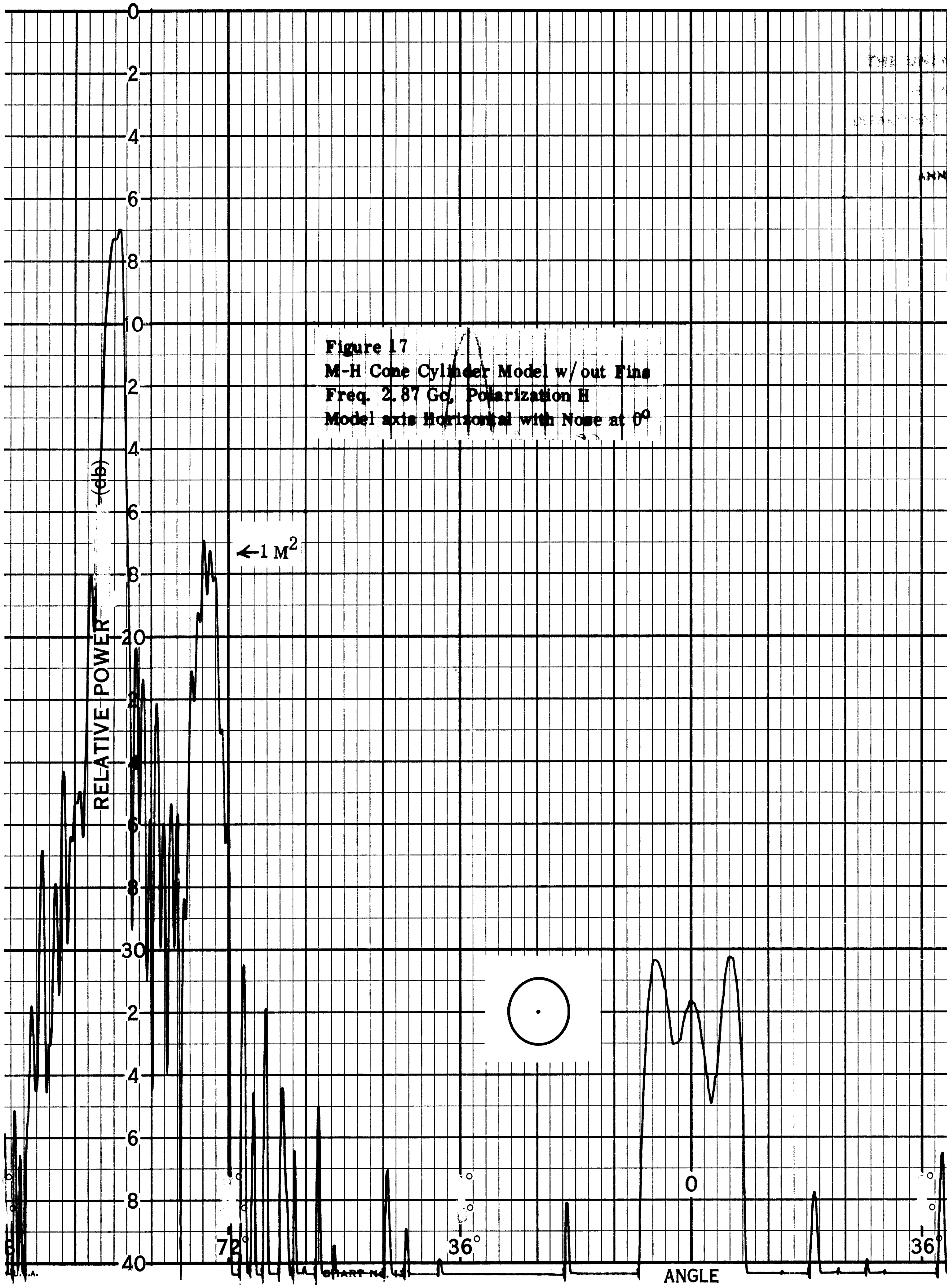
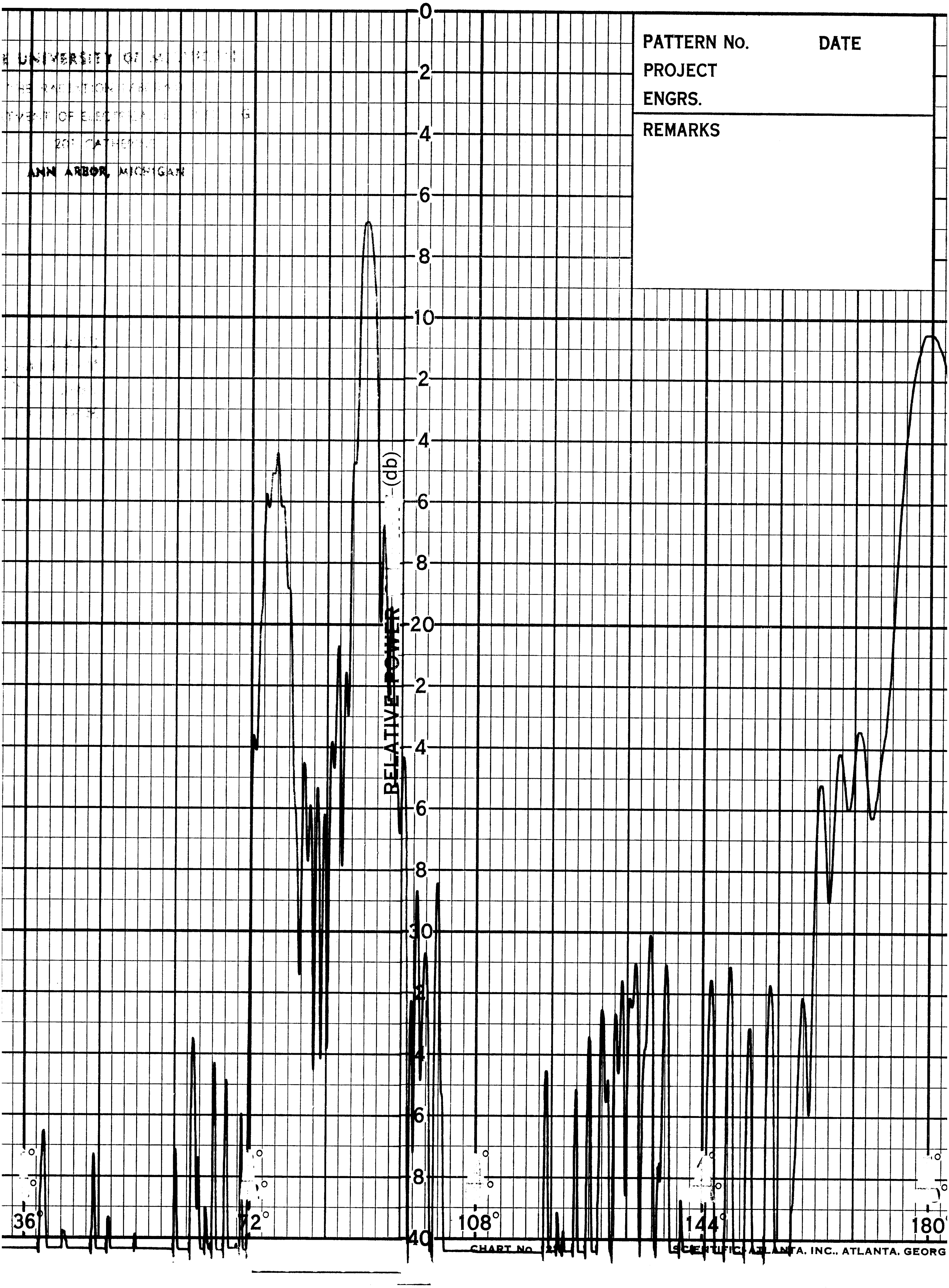
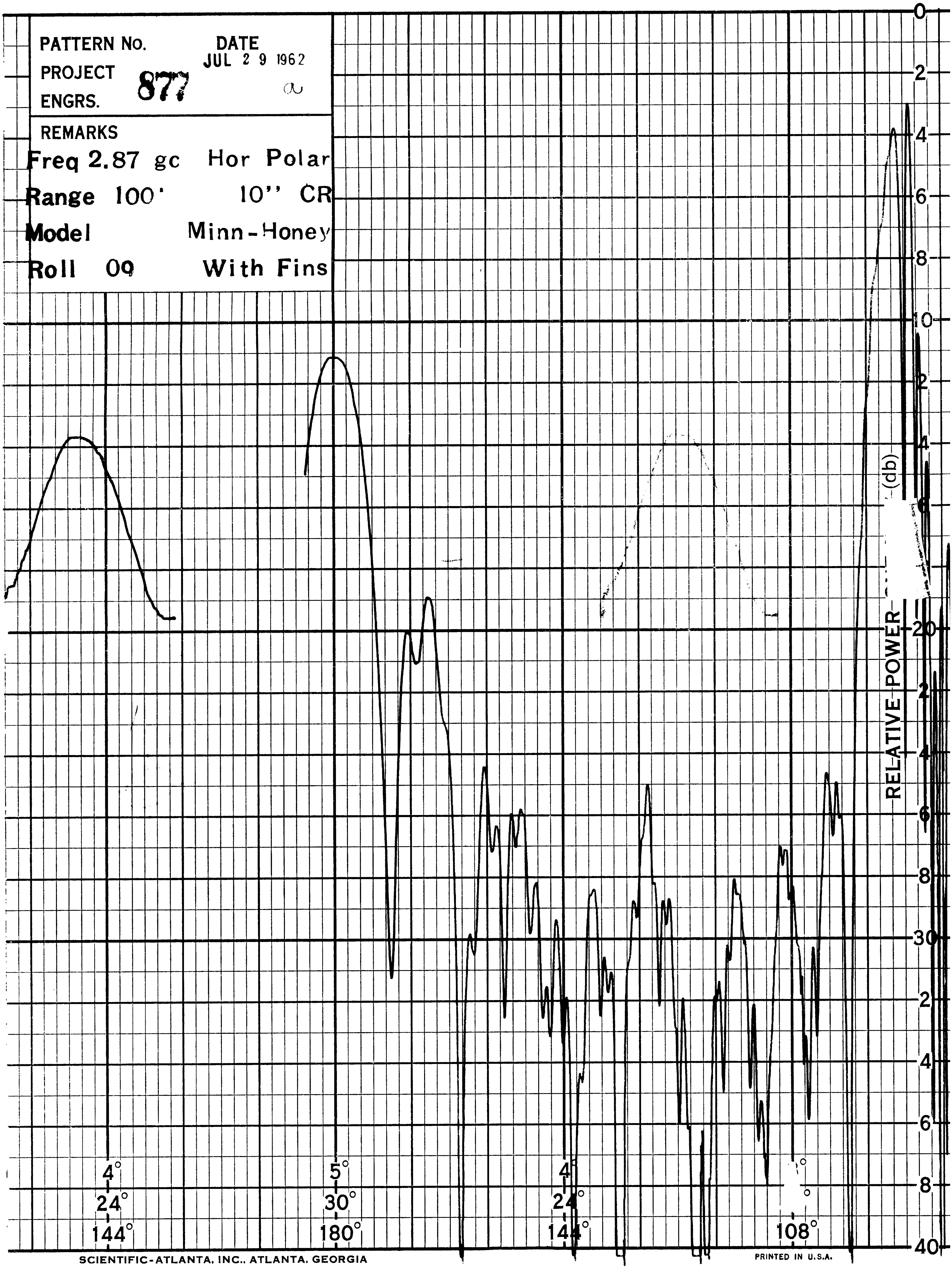


Figure 17
M-H Cone Cylinder Model w/ out Fins
Freq. 2.87 Gc, Polarization H
Model axis Horizontal with Nose at 0°



PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
ANN ARBOR, MICHIGAN
RELATIVE POWER (db)
0
2
4
6
8
10
20
30
40
36°
72°
108°
144°
180°
CHART No.
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORG



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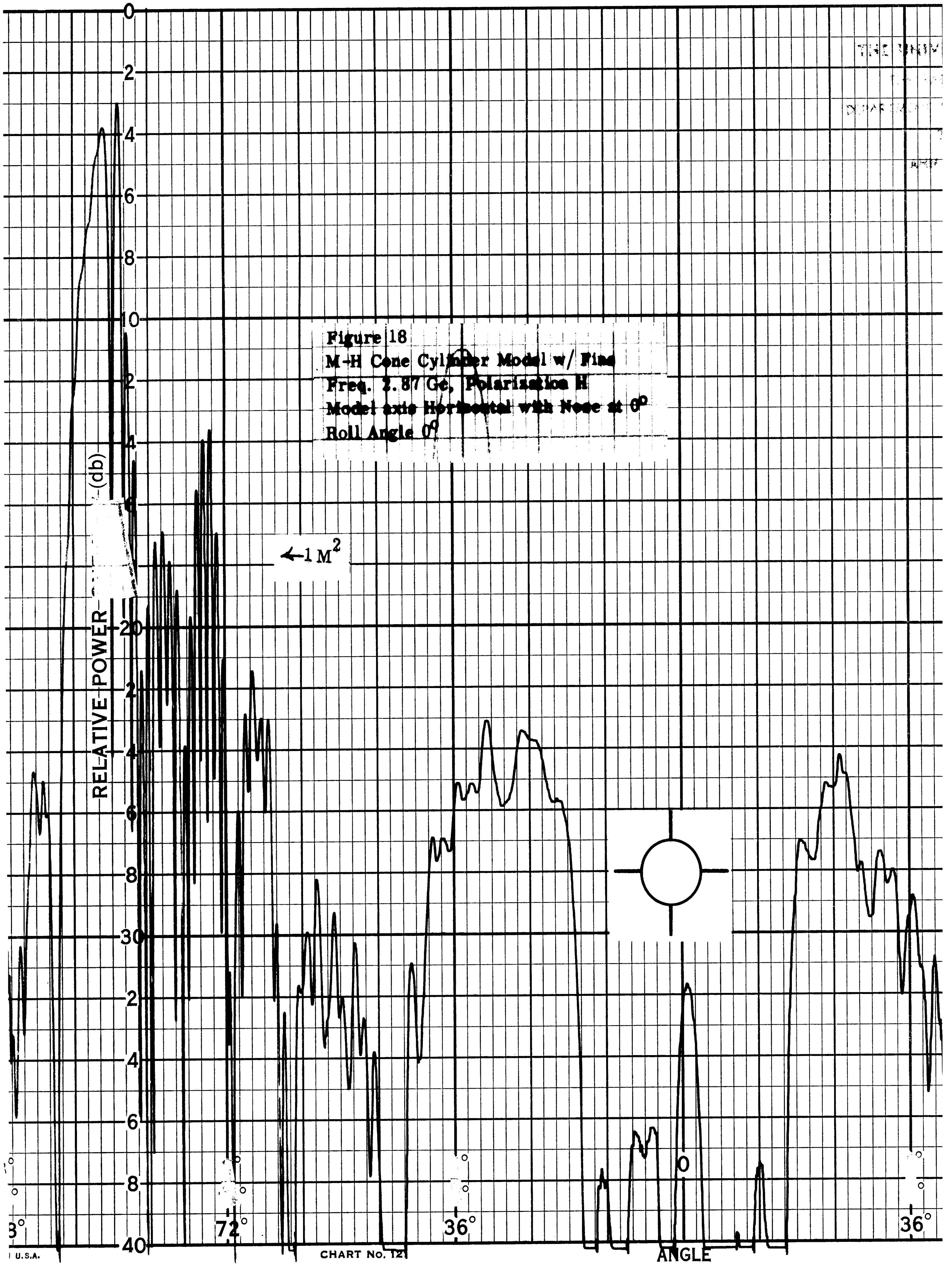
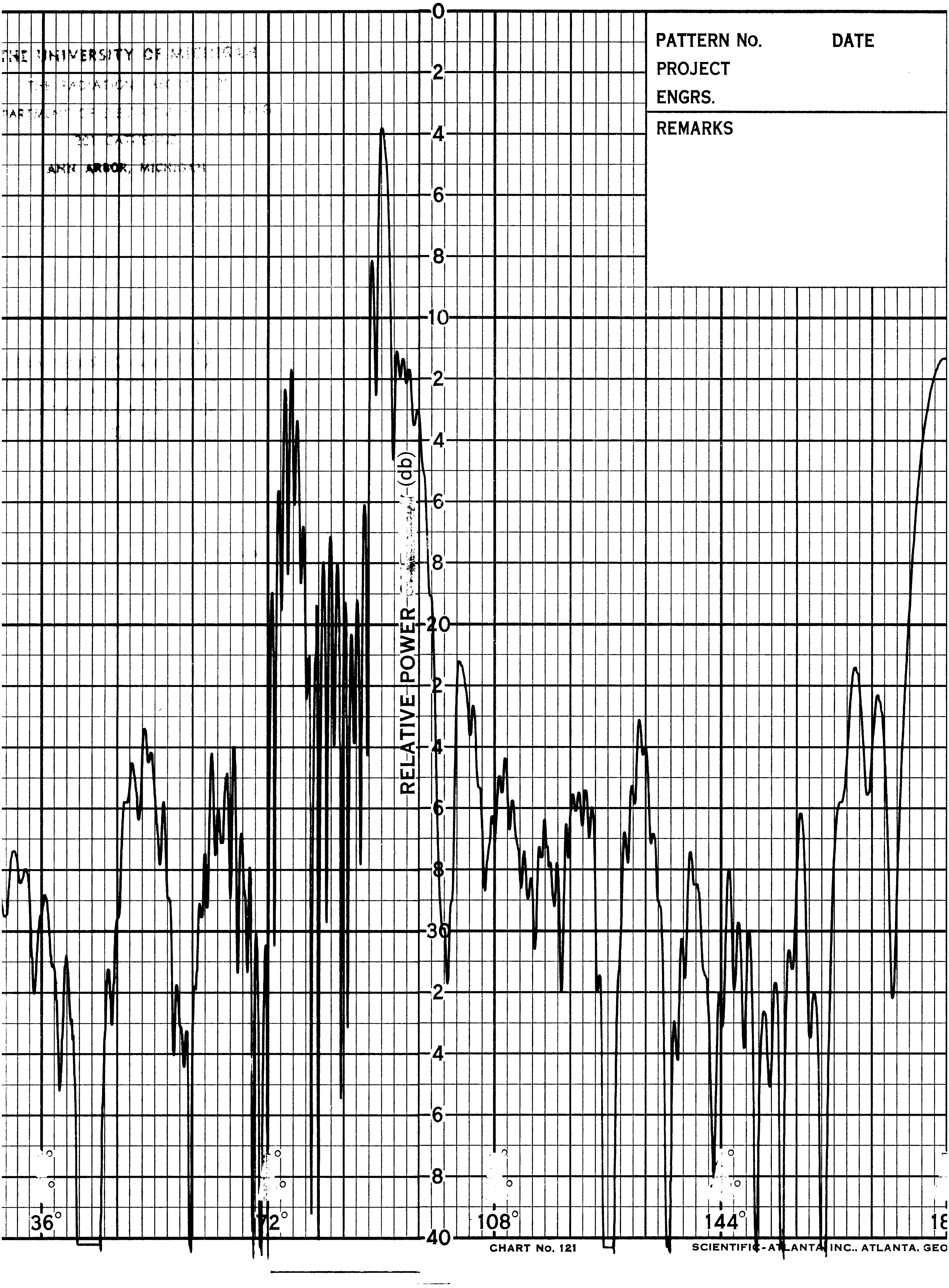
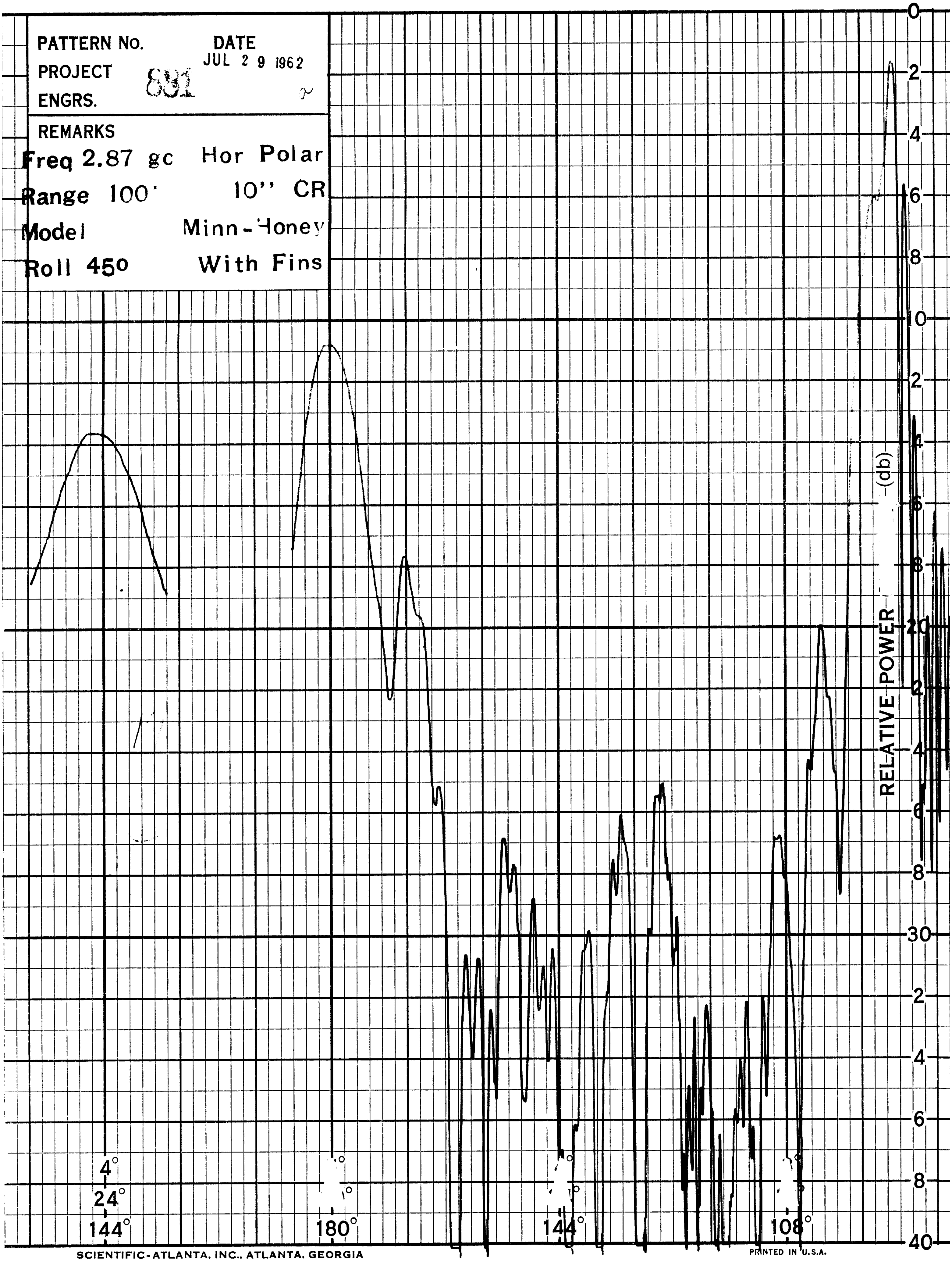


Figure 18
M-H Cone Cylinder Model w/ Fins
Freq. 2.87 Gc, Polarization H
Model axis Horizontal with Nose at 0°
Roll Angle 0°



PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
RELATIVE POWER (db)
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
36°
72°
108°
144°
CHART No. 121
SCIENTIFIC-ATLANTA INC., ATLANTA, GEO


PATTERN No.
DATE
JUL 2 9 1962
PROJECT
891
ENGRS.
REMARKS
Freq 2.87 gc Hor Polar
Range 100' 10'' CR
Model Minn-Honey
Roll 45° With Fins
RELATIVE POWER (db)
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
4°
24°
144°
180°
144°
108°
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA
PRINTED IN U.S.A.

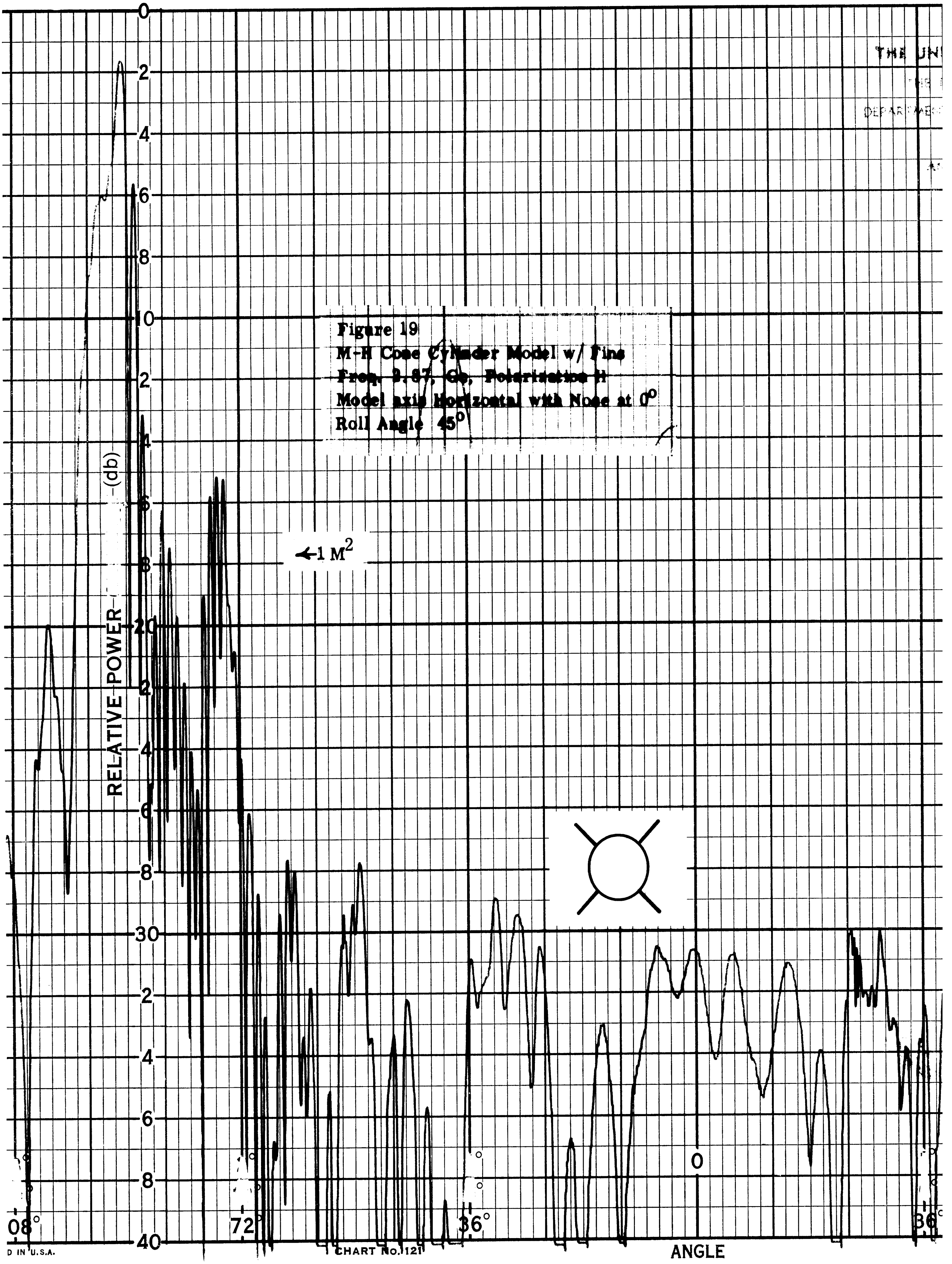
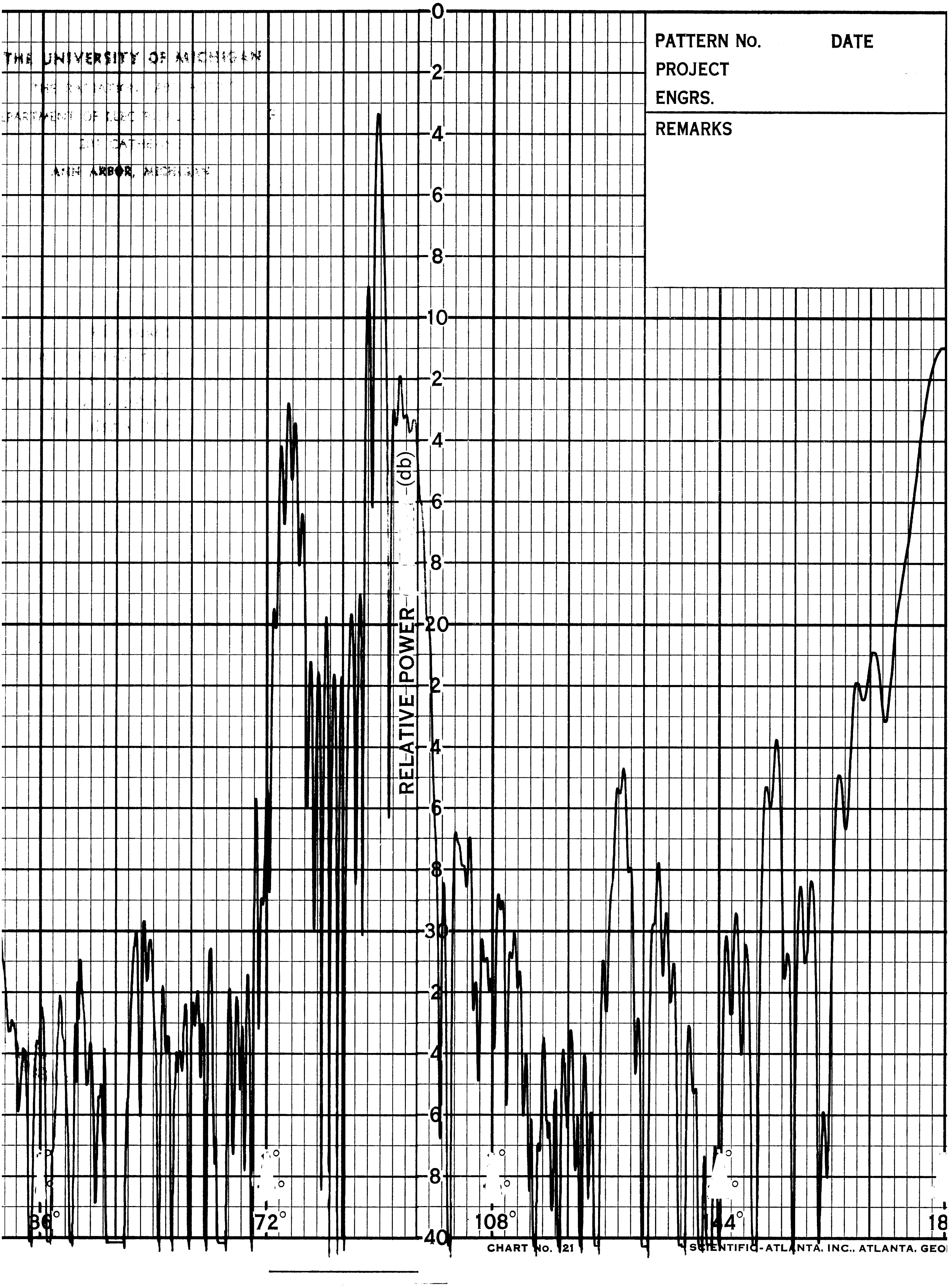
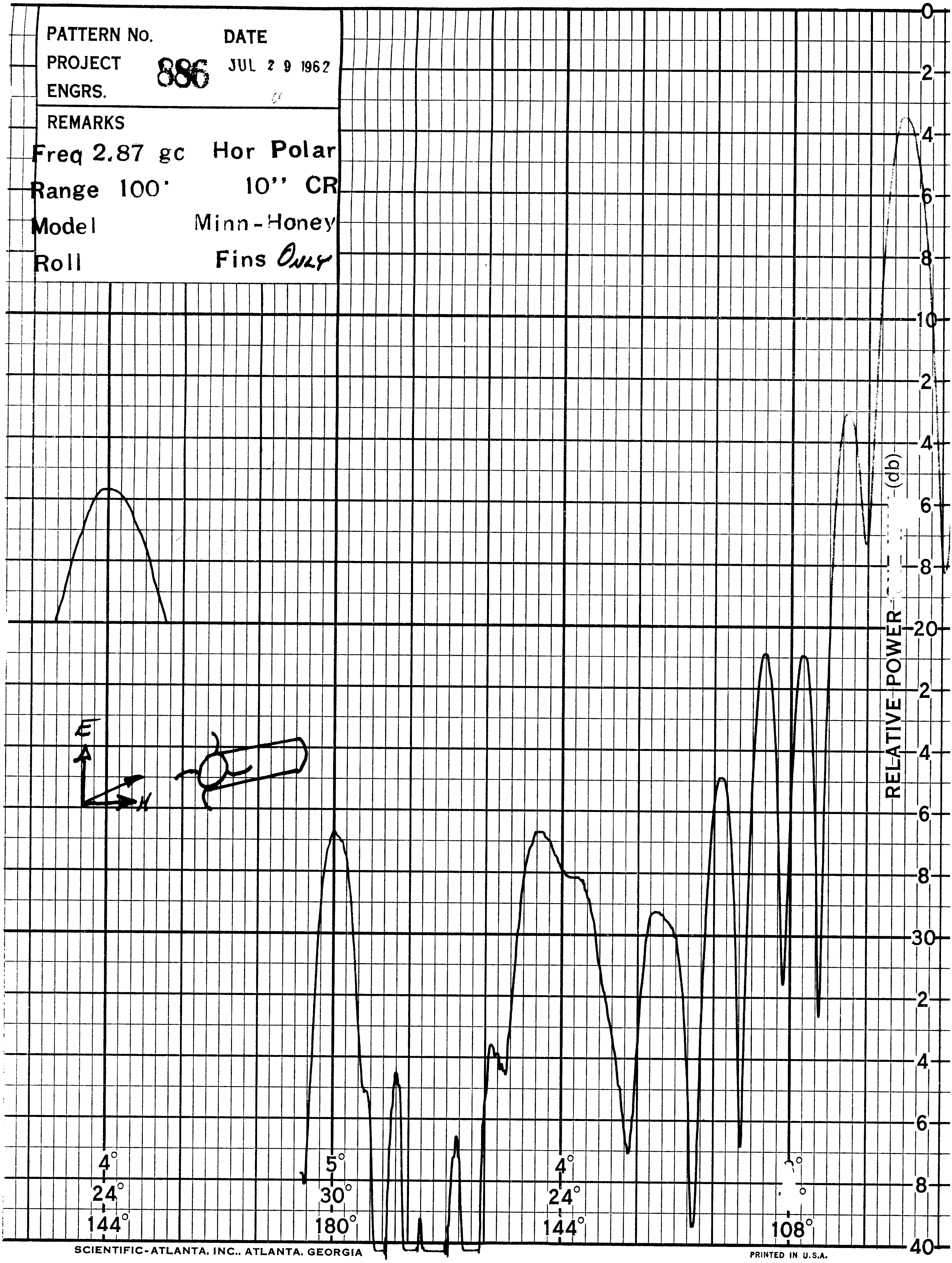


Figure 19
M-H Cone Cylinder Model w/ Fins
Freq. 3.87, Gc, Polarization H
Model axis Horizontal with Nose at 0°
Roll Angle 45°



PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
RELATIVE POWER (db)
0
2
4
6
8
10
2
4
6
8
20
2
4
6
8
30
2
4
6
8
40
36°
72°
108°
144°
18
CHART No. 121
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEO



SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA

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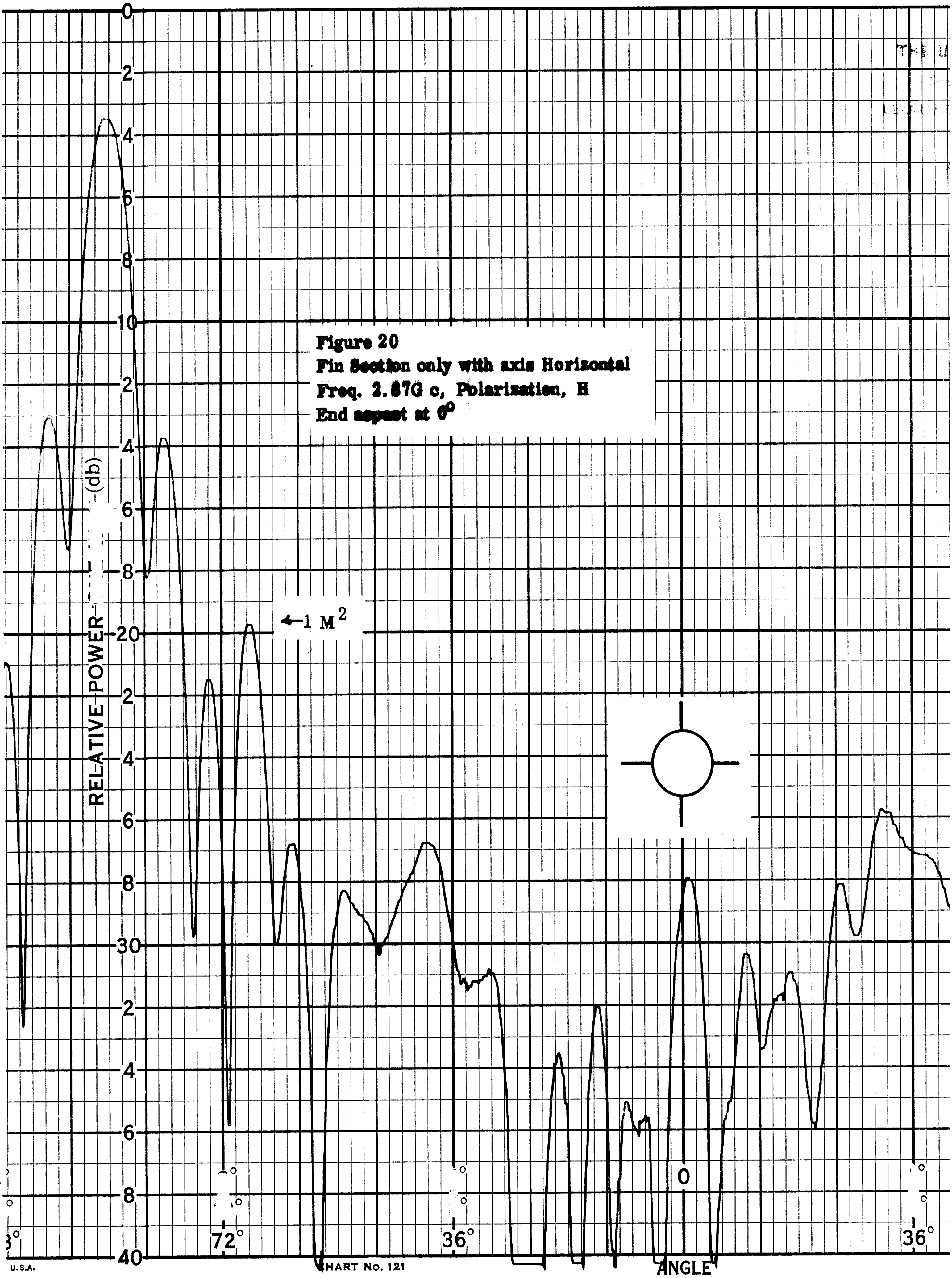
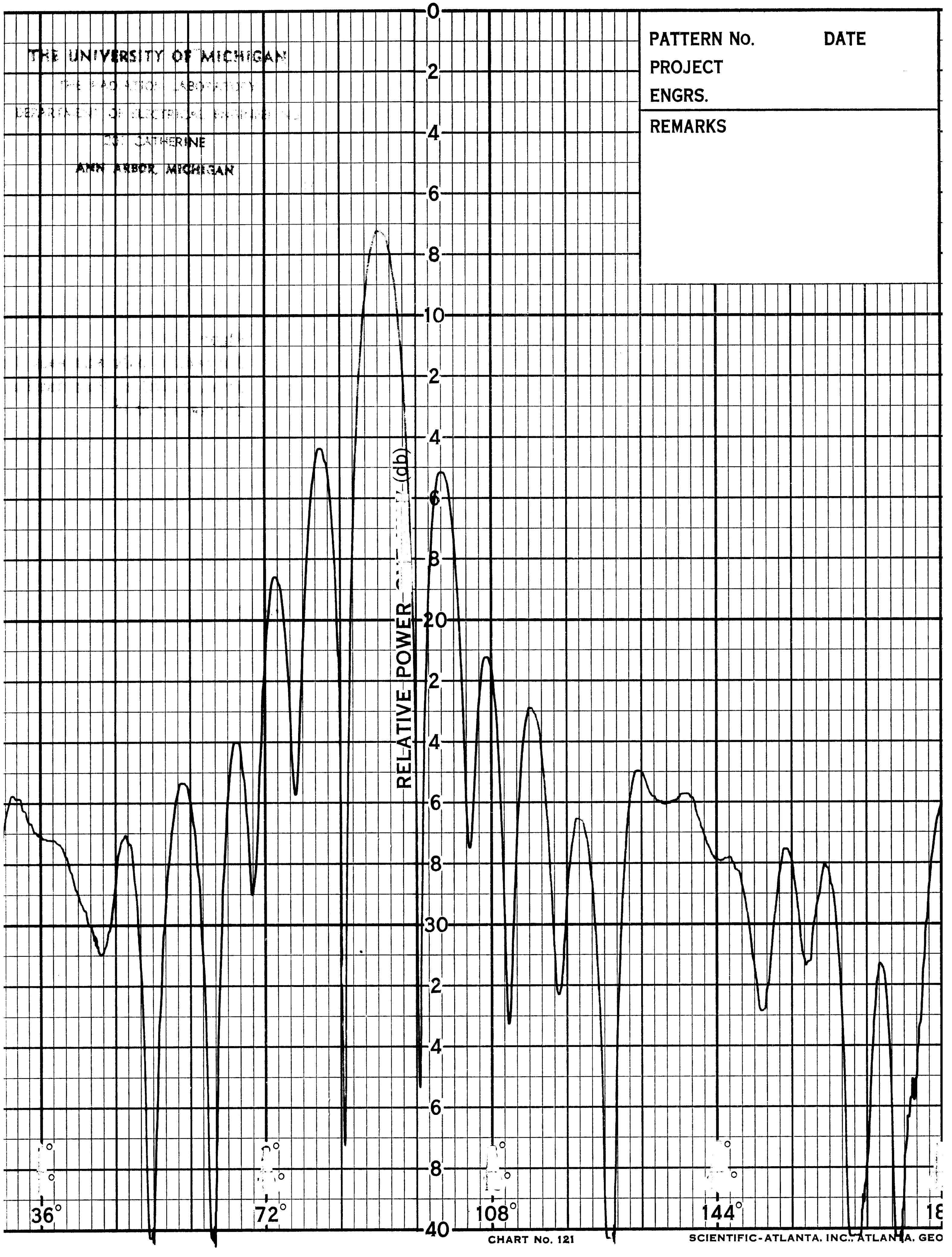


Figure 20
Fin Section only with axis Horizontal
Freq. 2.87G c, Polarization, H
End aspect at 0°


THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN
PATTERN No.
DATE
PROJECT
ENGRS.
REMARKS
0
2
4
6
8
10
20
30
40
RELATIVE POWER
(db)
36°
72°
108°
144°
CHART No. 121
SCIENTIFIC-ATLANTA, INC., ATLANTA, GEO

PATTERN No. DATE (a)

PROJECT 870 JUL 2 9 1962

ENGRS.

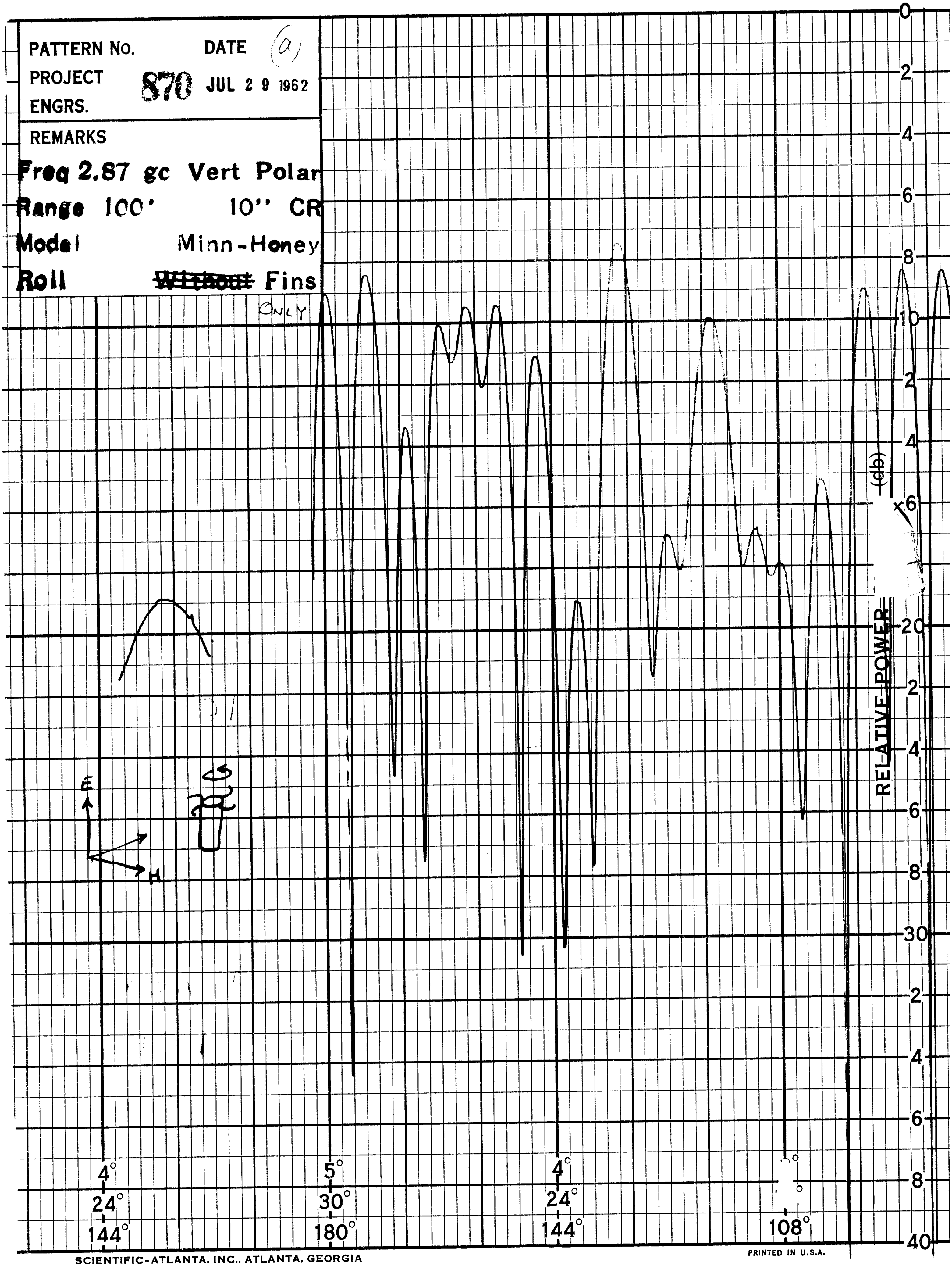
REMARKS

Freq 2.87 gc Vert Polar

Range 100' 10" CR

Model Minn-Honey

Roll ~~Without~~ Fins ONLY



SCIENTIFIC-ATLANTA, INC., ATLANTA, GEORGIA

PRINTED IN U.S.A.

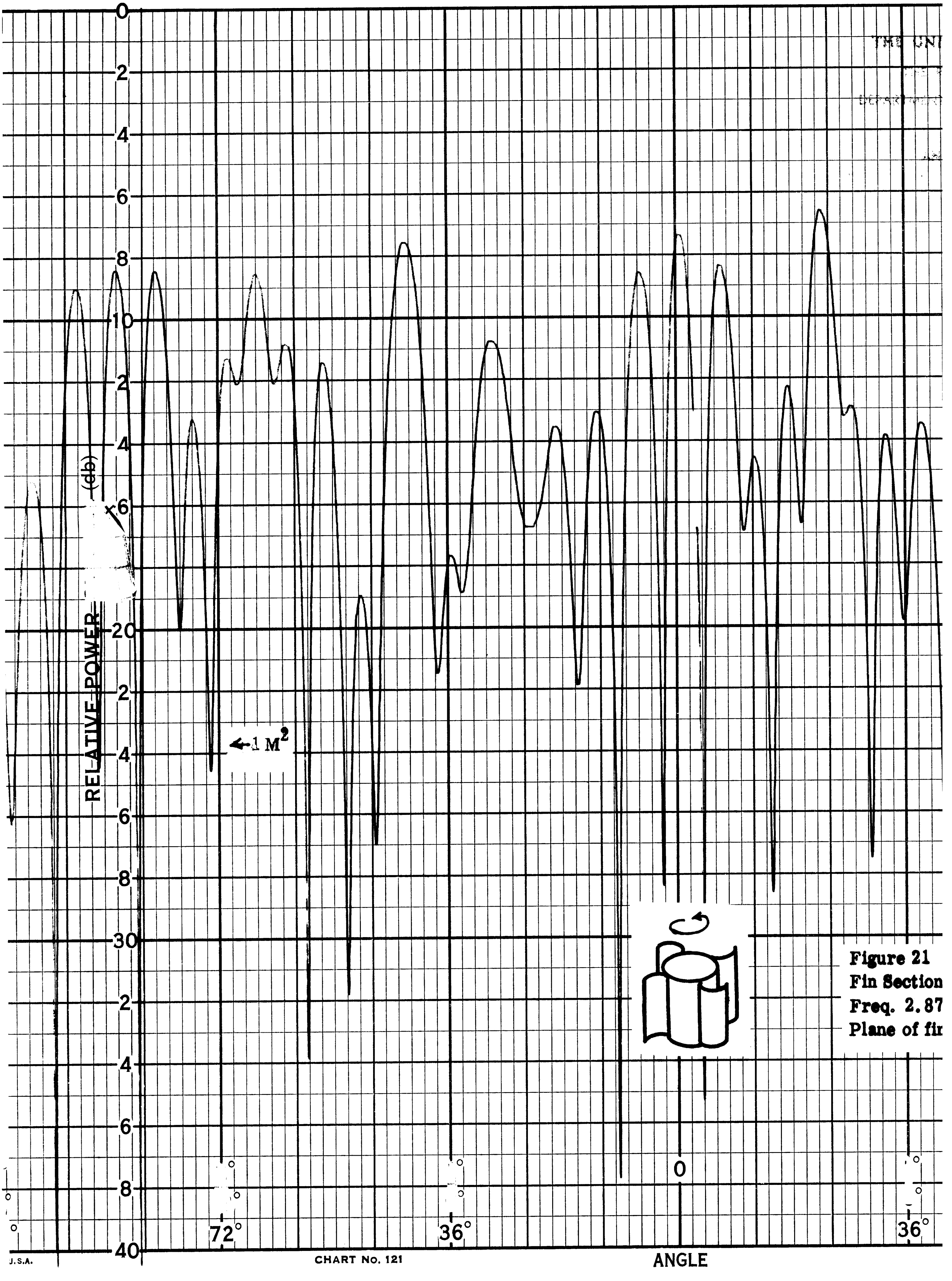


Figure 21
Fin Section
Freq. 2.87
Plane of fi

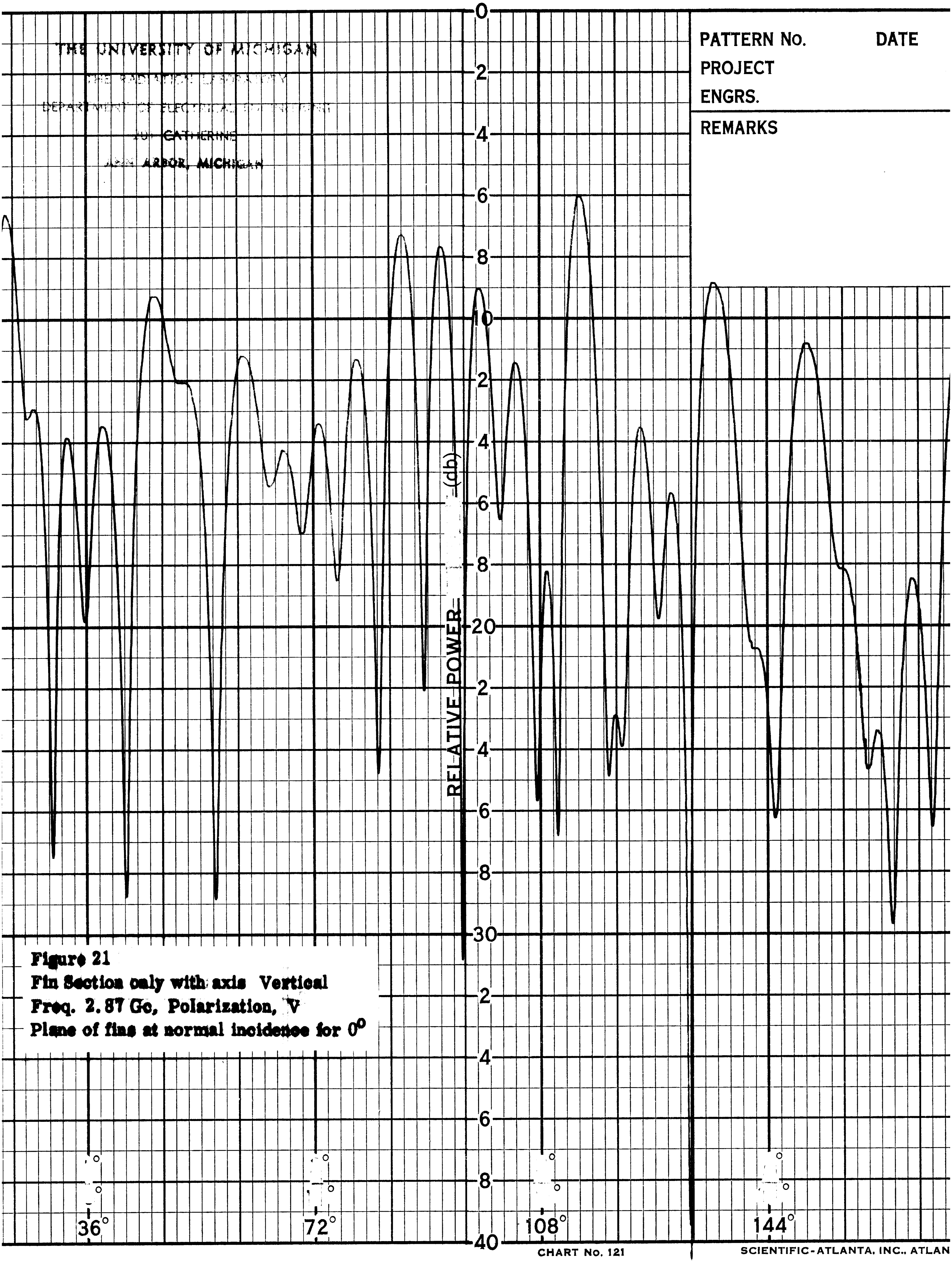


Figure 21
Fin Section only with axis Vertical
Freq. 2.87 Gc, Polarization, V
Plane of fins at normal incidence for 0°