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MICROWAVE MEASUREMENTS OF THE INTENSITY DISTRIBUTION OF ECHELETTE DIFFRACTION GRATINGS

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SUMMARY AND CONCLUSIONS

Microwave measurements of the intensity distribution in the spectral orders of echelette diffraction gratings have been made for a set of gratings of blaze angles 25°, 35°, and 45° through the range of the ratio of wavelength to grating space of 0.5 to 1.5 and as a function of the angle of incidence of the beam of radiation onto the grating for both directions of polarization. The results show a manifold of strange effects and forcibly demonstrate the complexities of diffraction phenomena. The results can be of considerable value in selecting a grating for a spectrograph, predicting its performance for different wavelengths, and estimating the quality of an actual grating.

OUTLINE OF THE WORK

These measurements are an extension of the work covered in Report No. 2 of this project in which the energy distributions from a 15° and a 25° blaze-angle grating were reported. The idea behind the present program was to obtain a background of experimental data which could be used to predict the performance of echelette diffraction gratings. The following set of gratings was selected for this purpose, and are listed in the table below according to blaze angle and the ratio of the grating space to the wavelength [D/λ].

Blaze Angle

25°	35°	45°
.7	.7	.7
.94	.85	1.0
1.2	1.2	1.41
1.67	1.7	
2.4		

The apparatus, method of constructing the gratings, procedure in the measurements, etc. were the same as detailed in Report No. 2.

RESULTS

Graphs of the measurements are arranged as listed in the previous table, with the polarization having the electric field parallel to the grating grooves first, followed by the perpendicular component. Little can be said in general that cannot be gleaned from a cursory inspection of the curves. On the other hand, there is a wealth of details; as for example the anti-echelette action of the perpendicular component on a 35° grating at normal incidence [i = 0] in Fig. 18, or the symmetry of the curves for the parallel polarization for positive and negative angles of incidence when the grating space is small. Again in Fig. 16, the peaks in the 0^{th} order intensity correspond to the angle of disappearance of other spectral orders -- the condition for the "Wood Anomalies," and evidently an example of the same. And, as more general conclusions, the parallel polarization has its greatest concentration into a single order not at the blaze, but where the wavelength is such that the 1^{st} order spectrum occurs at a smaller angle than the blaze angle; also, efficiencies approach 100 percent for the perpendicular polarization at the blaze angle and larger angles.

These curves constitute a survey of the performance of echelette gratings and may be used as a guide to the selection of the most suitable grating for a spectrometer, or may serve to indicate how far any actual grating deviates from the behavior of a more or less perfect model.

% OF ENERGY IN SPECTRAL ORDERS

D= .7 λ　　BLAZE ∠ 25°

E ‖ TO GROOVES

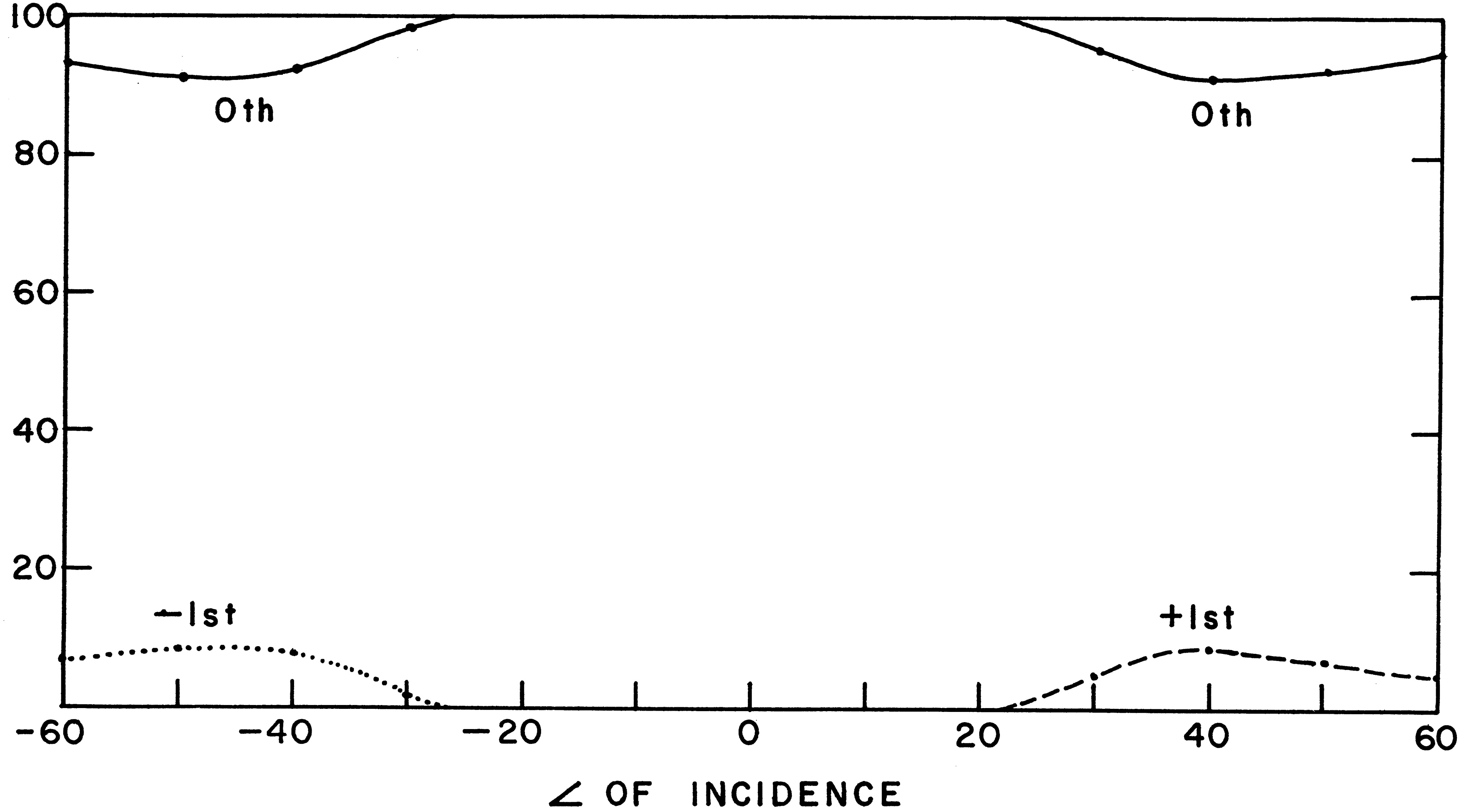


FIG. 1

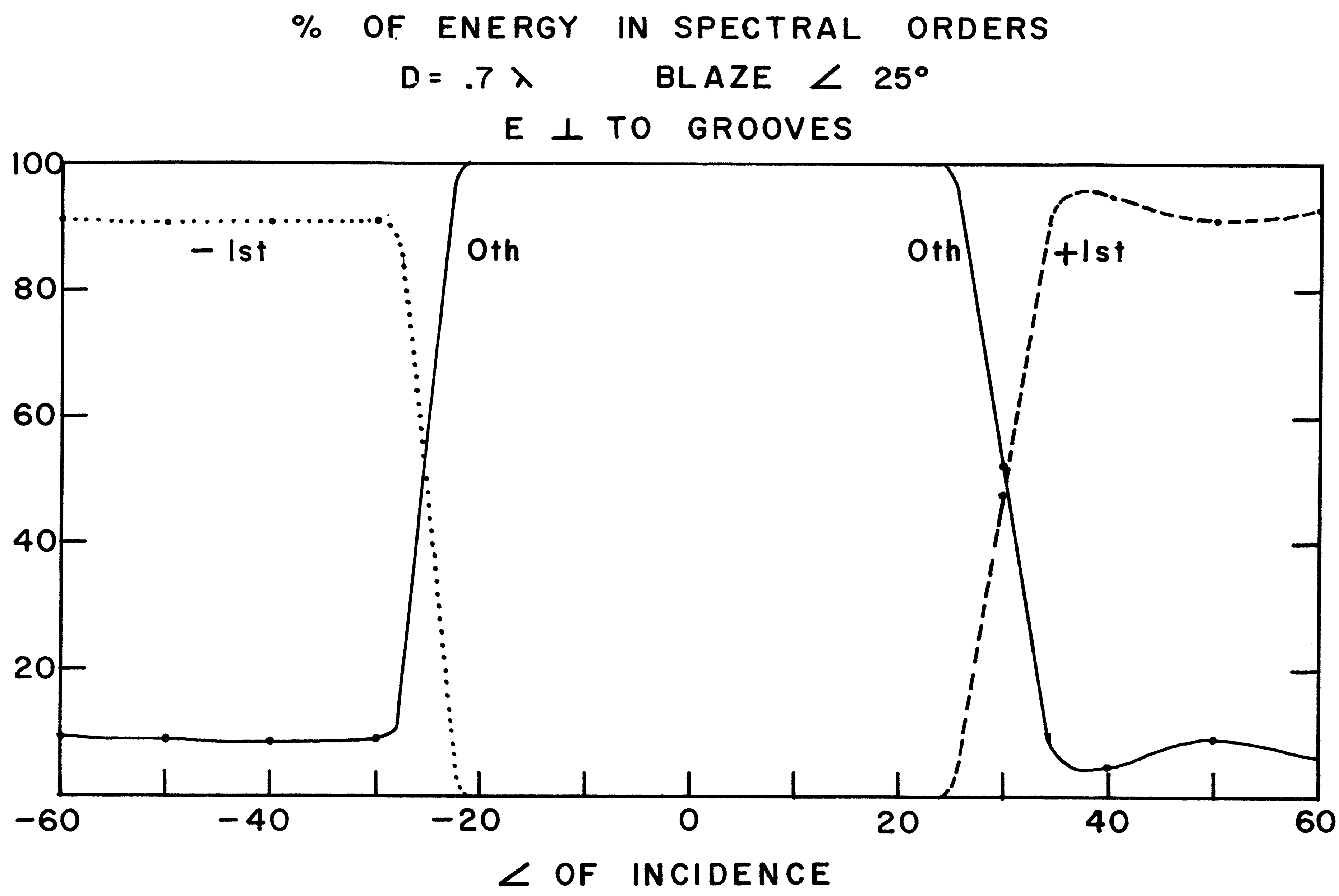

% OF ENERGY IN SPECTRAL ORDERS
D= .7 λ BLAZE ∠ 25°
E ⊥ TO GROOVES
100
80
60
40
20
−60
−40
−20
0
20
40
60
− Ist
0th
0th
+Ist
∠ OF INCIDENCE

FIG. 2

% OF ENERGY IN SPECTRAL ORDERS

D = .94 λ BLAZE ∠ 25°

E ॥ TO GROOVES

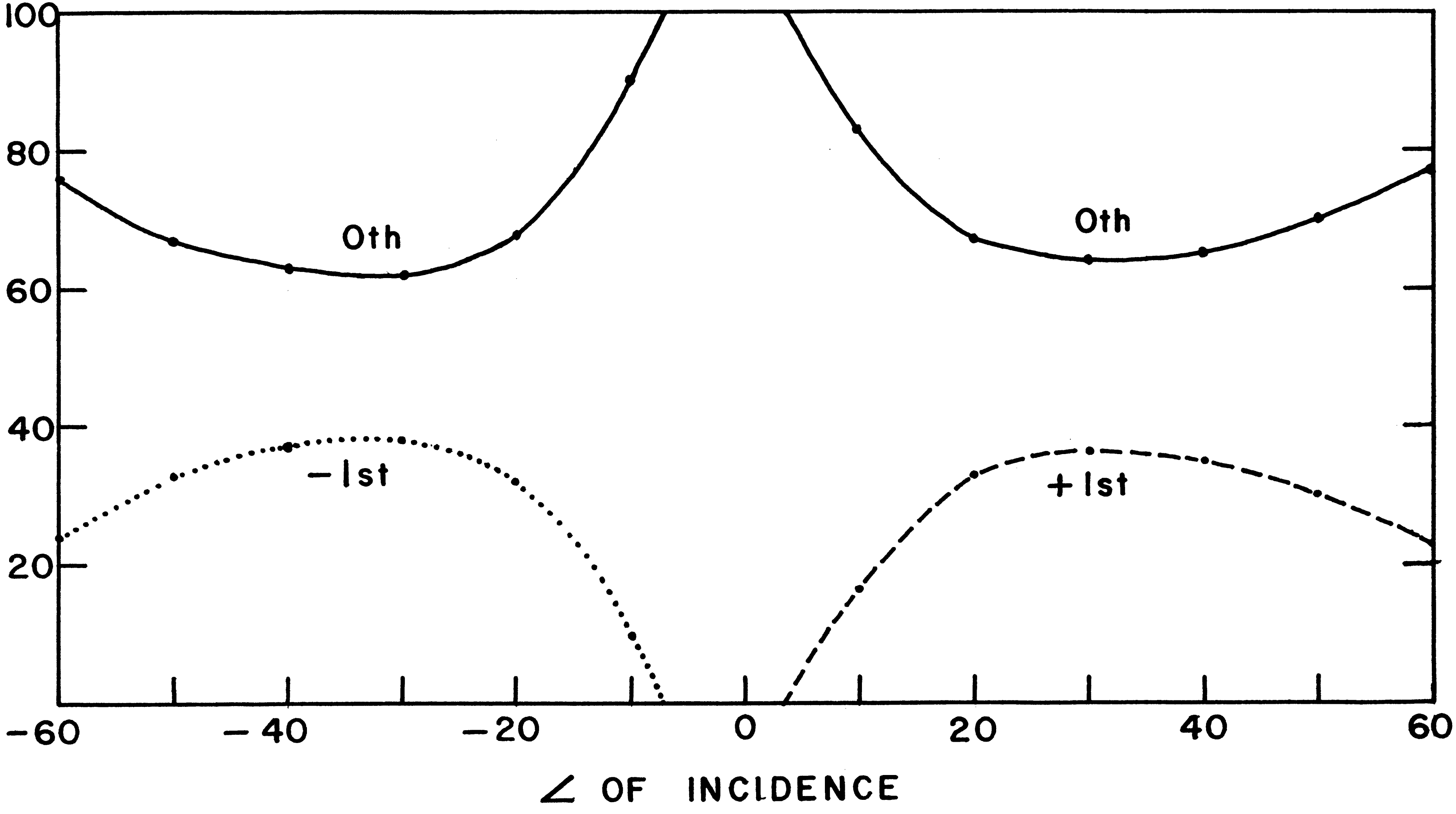


FIG. 3

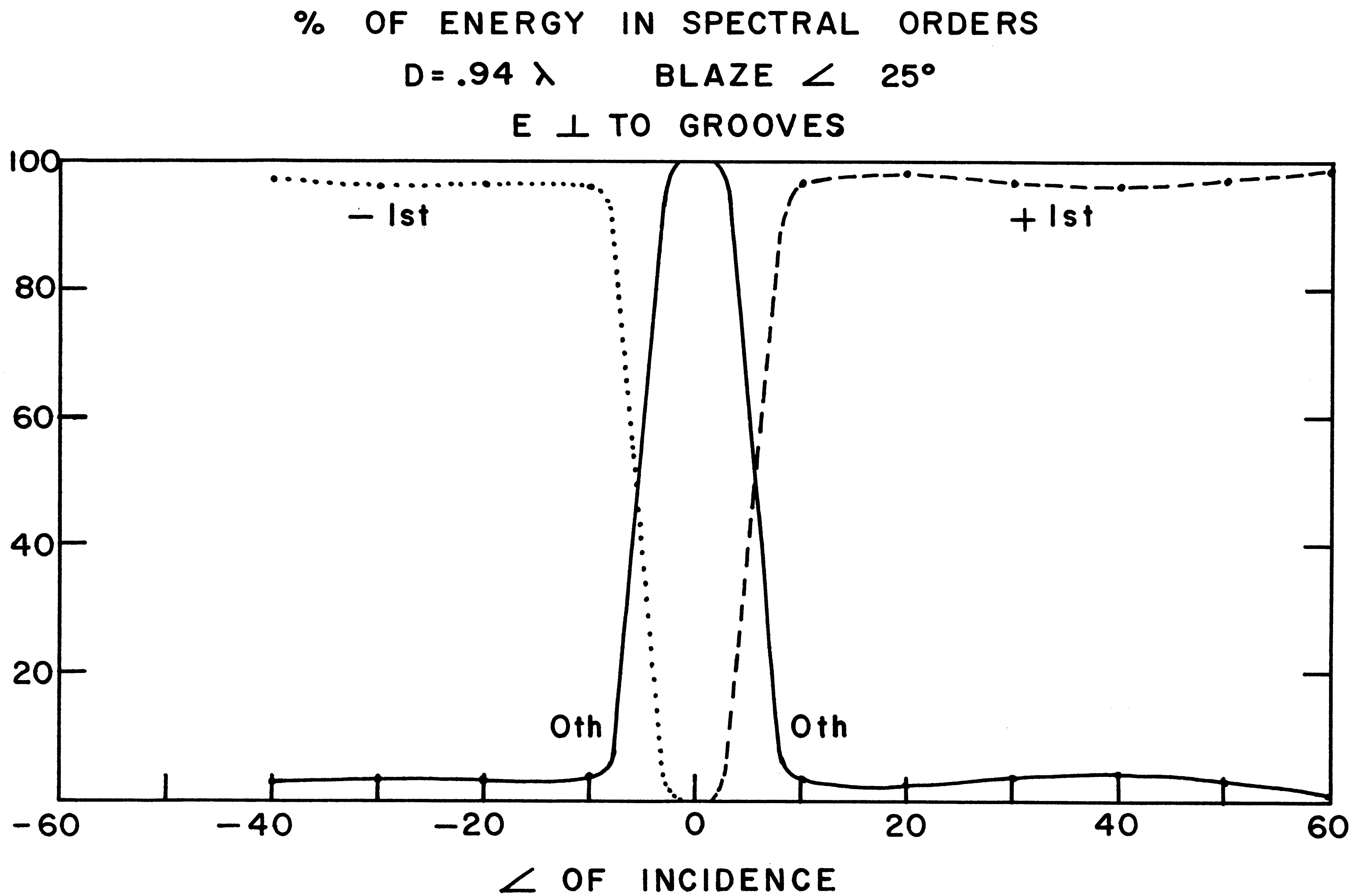

% OF ENERGY IN SPECTRAL ORDERS
D= .94 λ BLAZE ∠ 25°
E ⊥ TO GROOVES
100
80
60
40
20
− 1st
+ 1st
0th
0th
−60
−40
−20
0
20
40
60
∠ OF INCIDENCE

FIG. 4

% OF ENERGY IN SPECTRAL ORDERS

D= 1.2 λ BLAZE ∠ 25°

E ॥ TO GROOVES

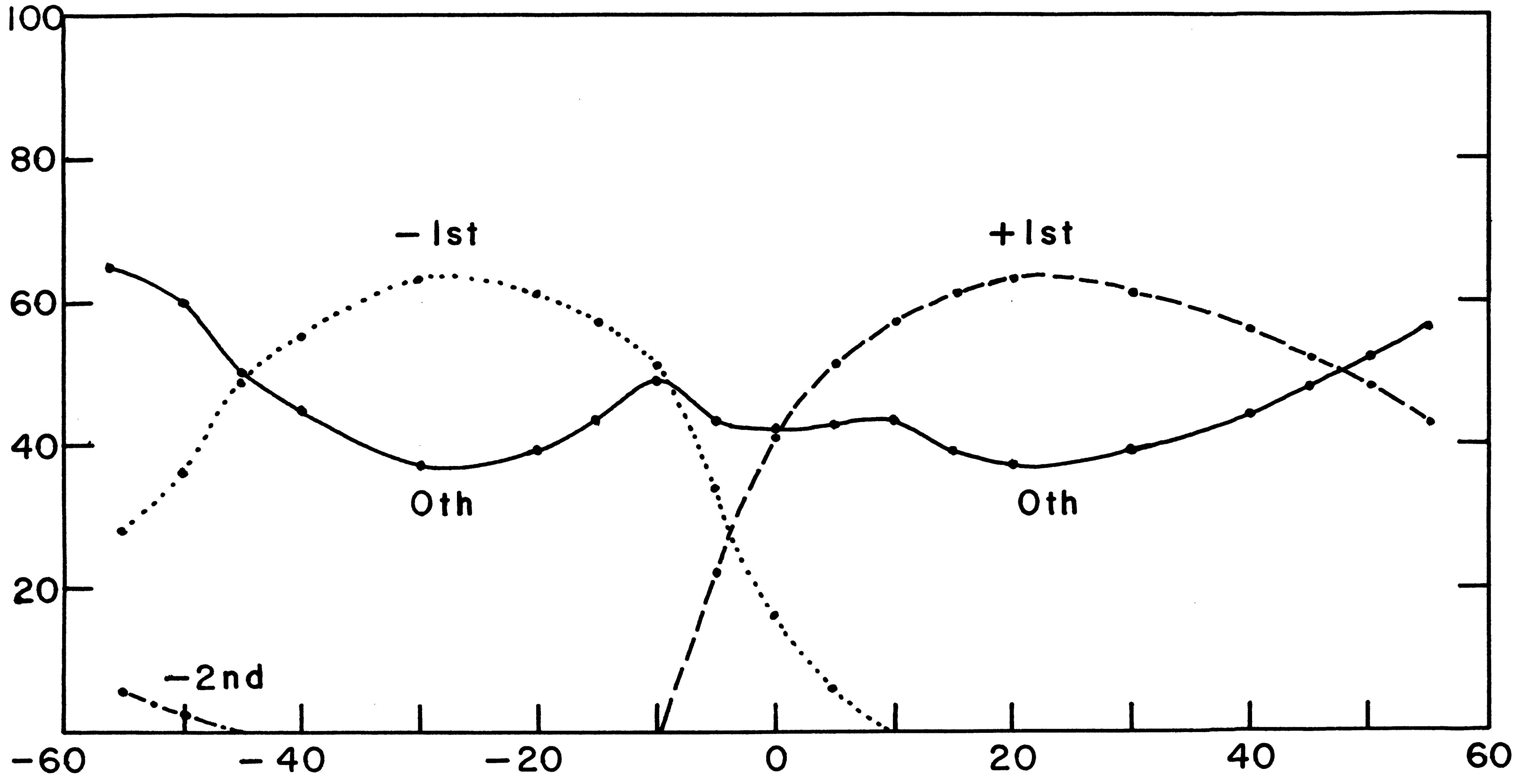
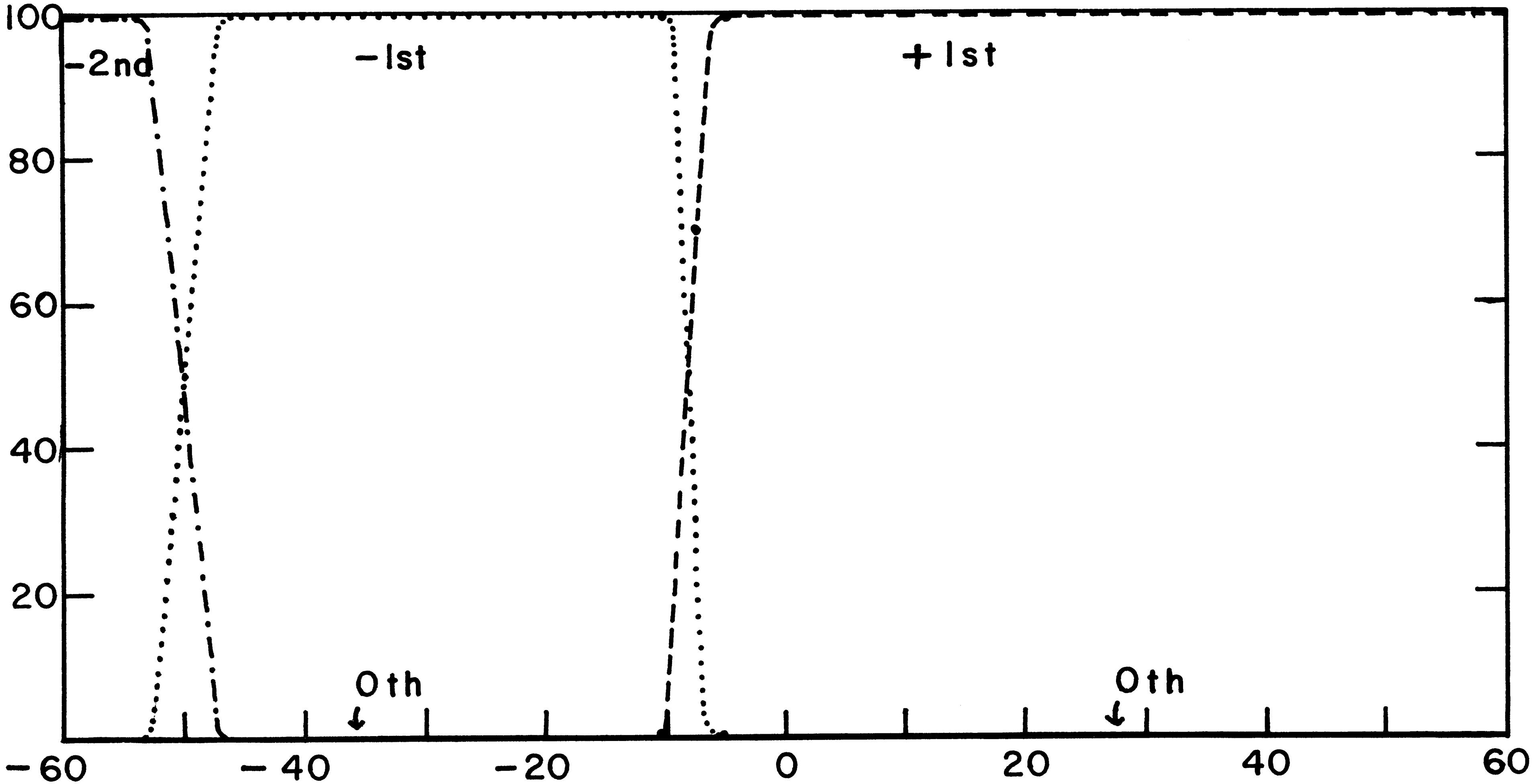


FIG. 5

% OF ENERGY IN SPECTRAL ORDERS

D= 1.2 λ BLAZE ∠ 25°

E ⊥ TO GROOVES



∠ OF INCIDENCE

FIG. 6

% OF ENERGY IN SPECTRAL ORDERS

D = 1.75 λ BLAZE ∠ 25°

E II TO GROOVES

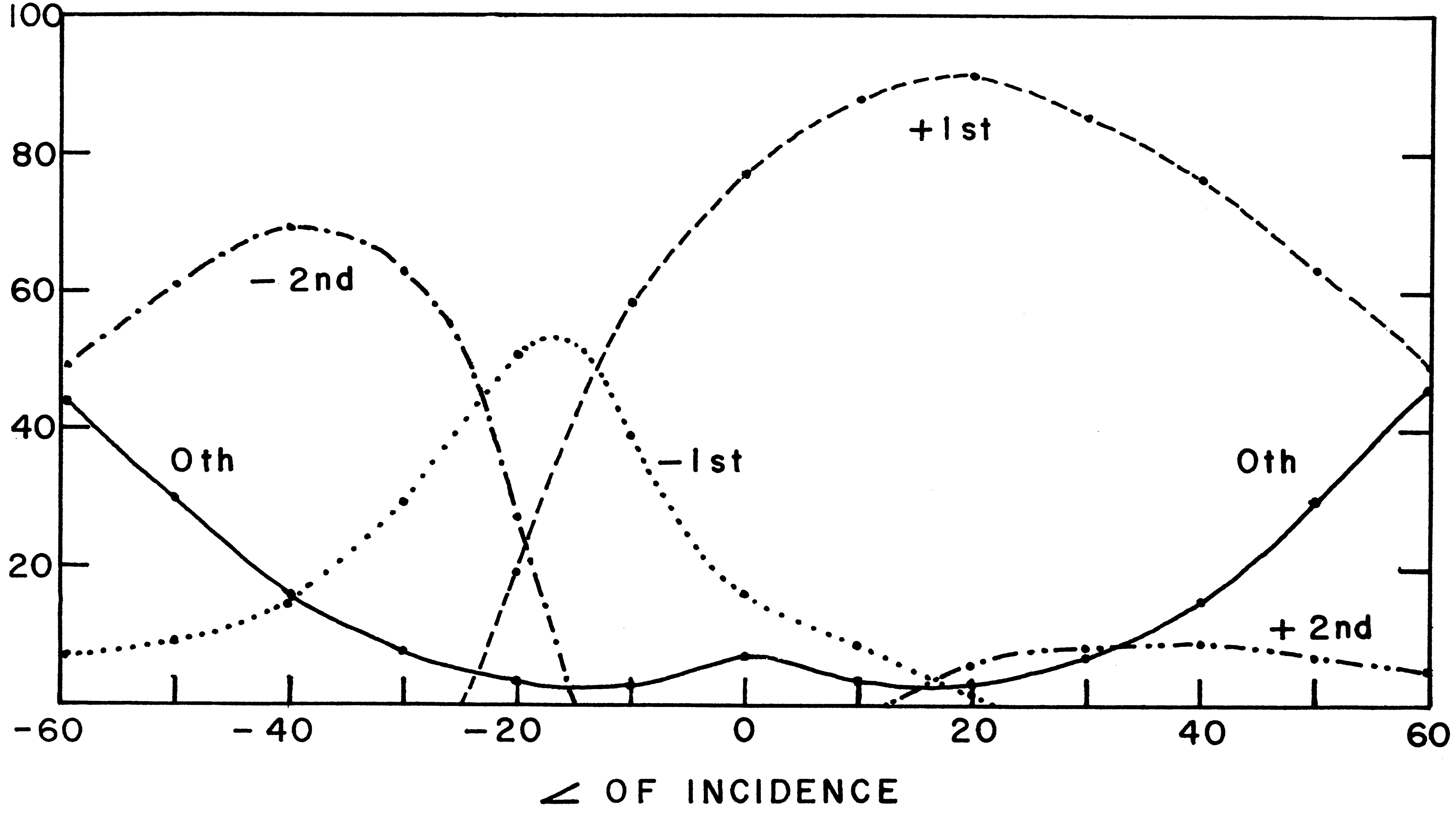


FIG. 7

% OF ENERGY IN SPECTRAL ORDERS

D = 1.75 λ BLAZE ∠ 25°

E ⊥ TO GROOVES

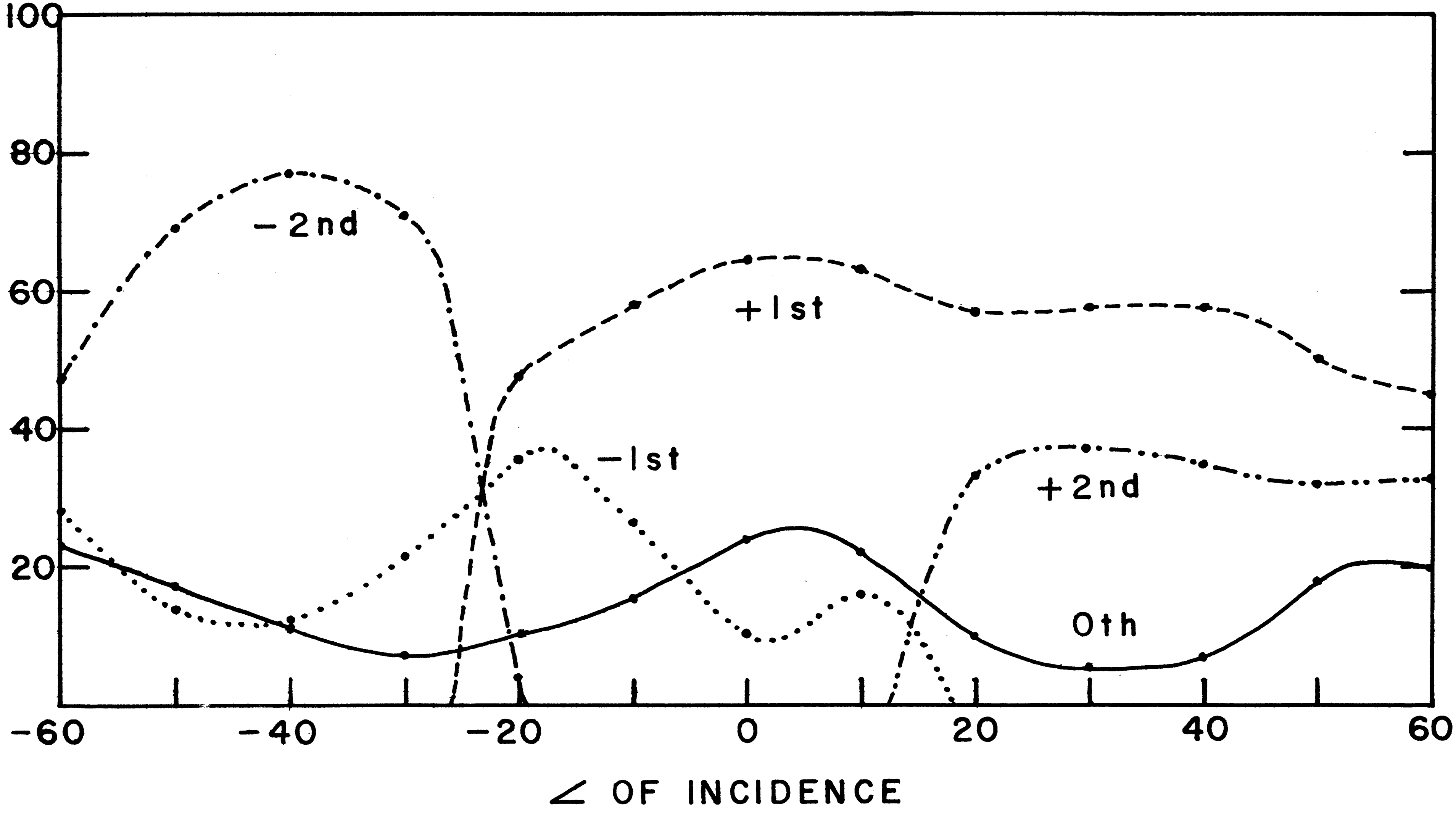
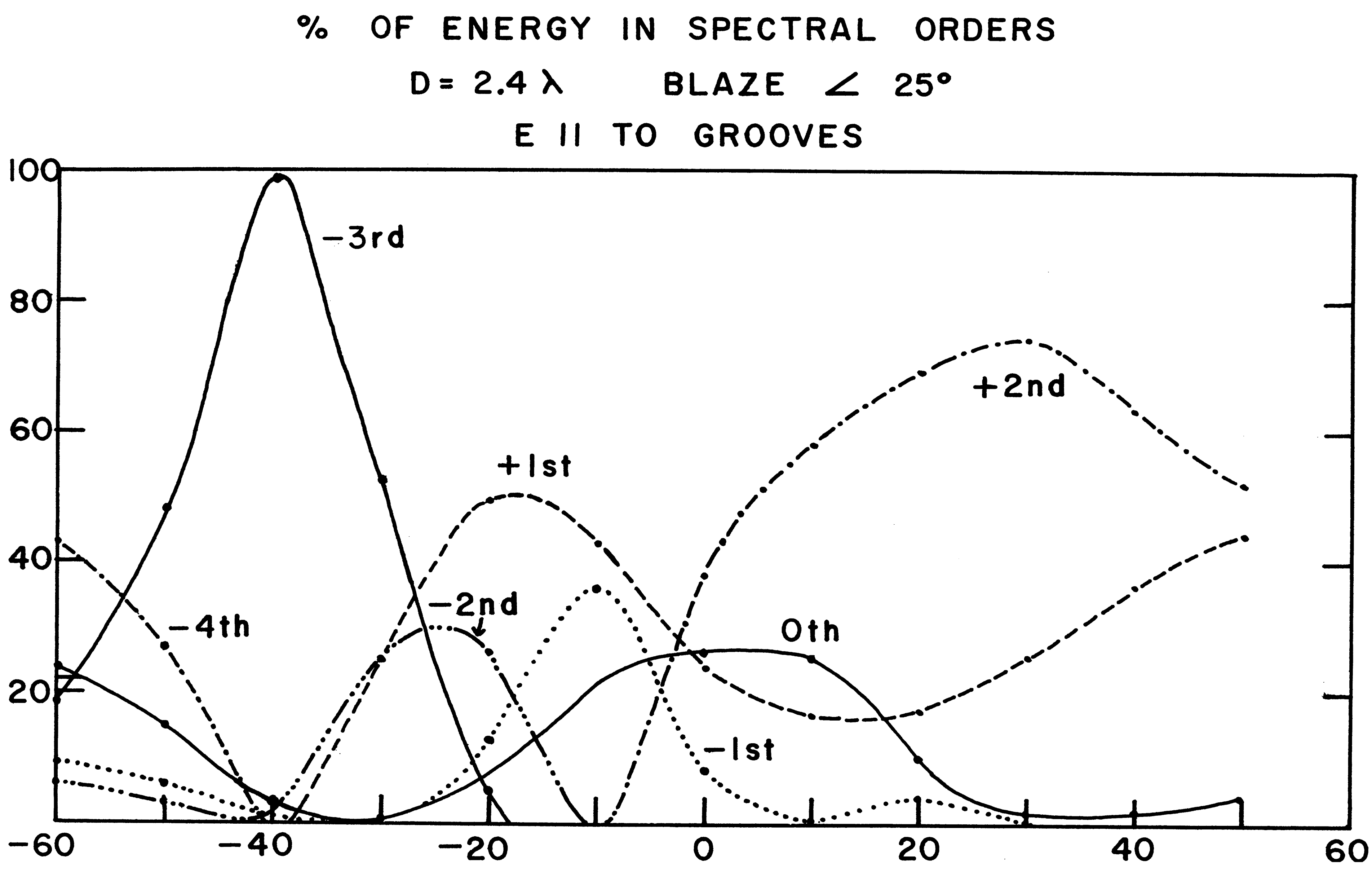


FIG. 8



% OF ENERGY IN SPECTRAL ORDERS
D= 2.4 λ BLAZE ∠ 25°
E II TO GROOVES
100
80
60
40
20
−3rd
+1st
+2nd
−2nd
−4th
0th
−1st
−60
−40
−20
0
20
40
60
∠ OF INCIDENCE

FIG. 9

% OF ENERGY IN SPECTRAL ORDERS

D = 2.4 λ BLAZE ∠ 25°

E ⊥ TO GROOVES

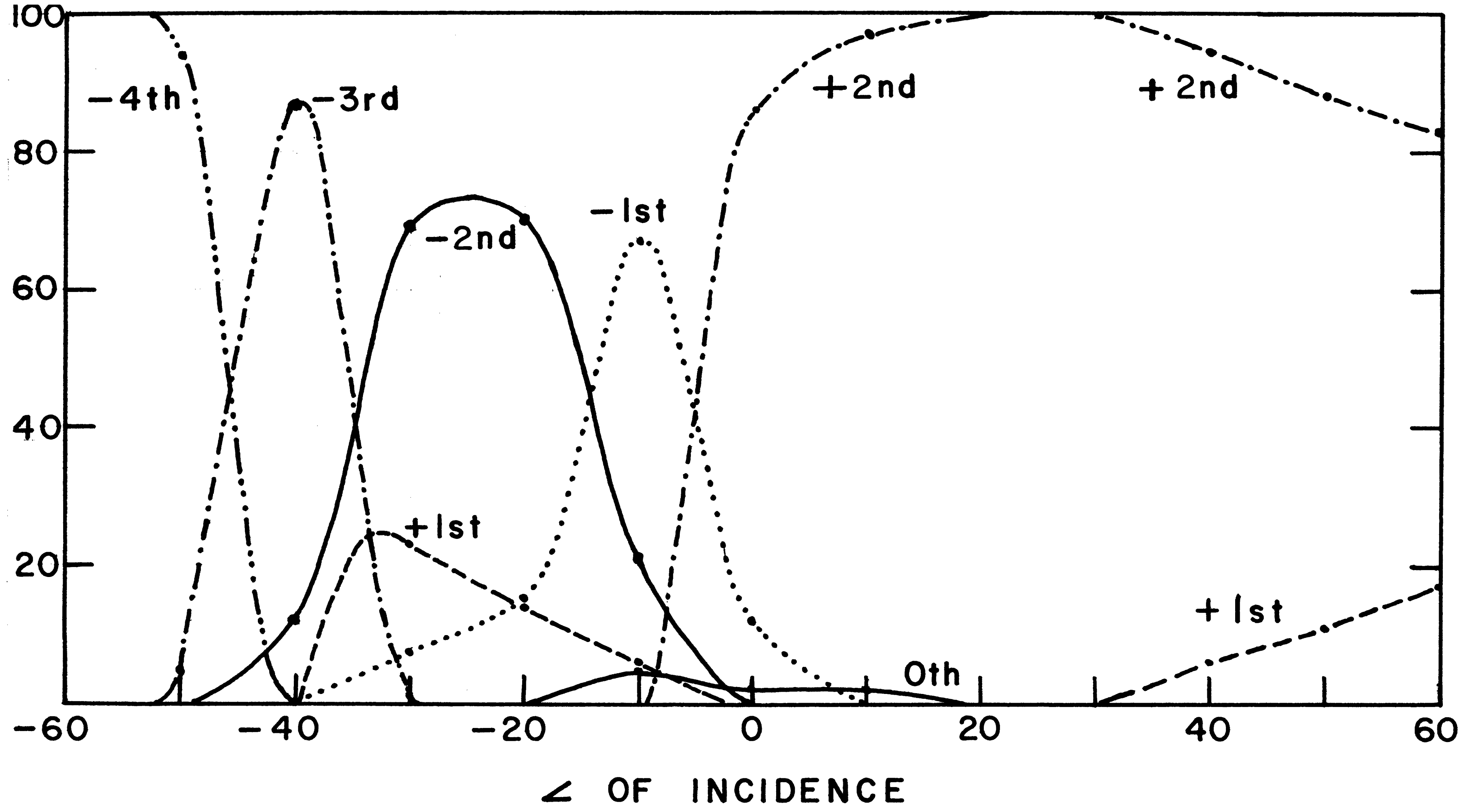


FIG. 10

% OF ENERGY IN SPECTRAL ORDERS

D = .7 λ BLAZE ∠ 35°

E ∥ TO GROOVES

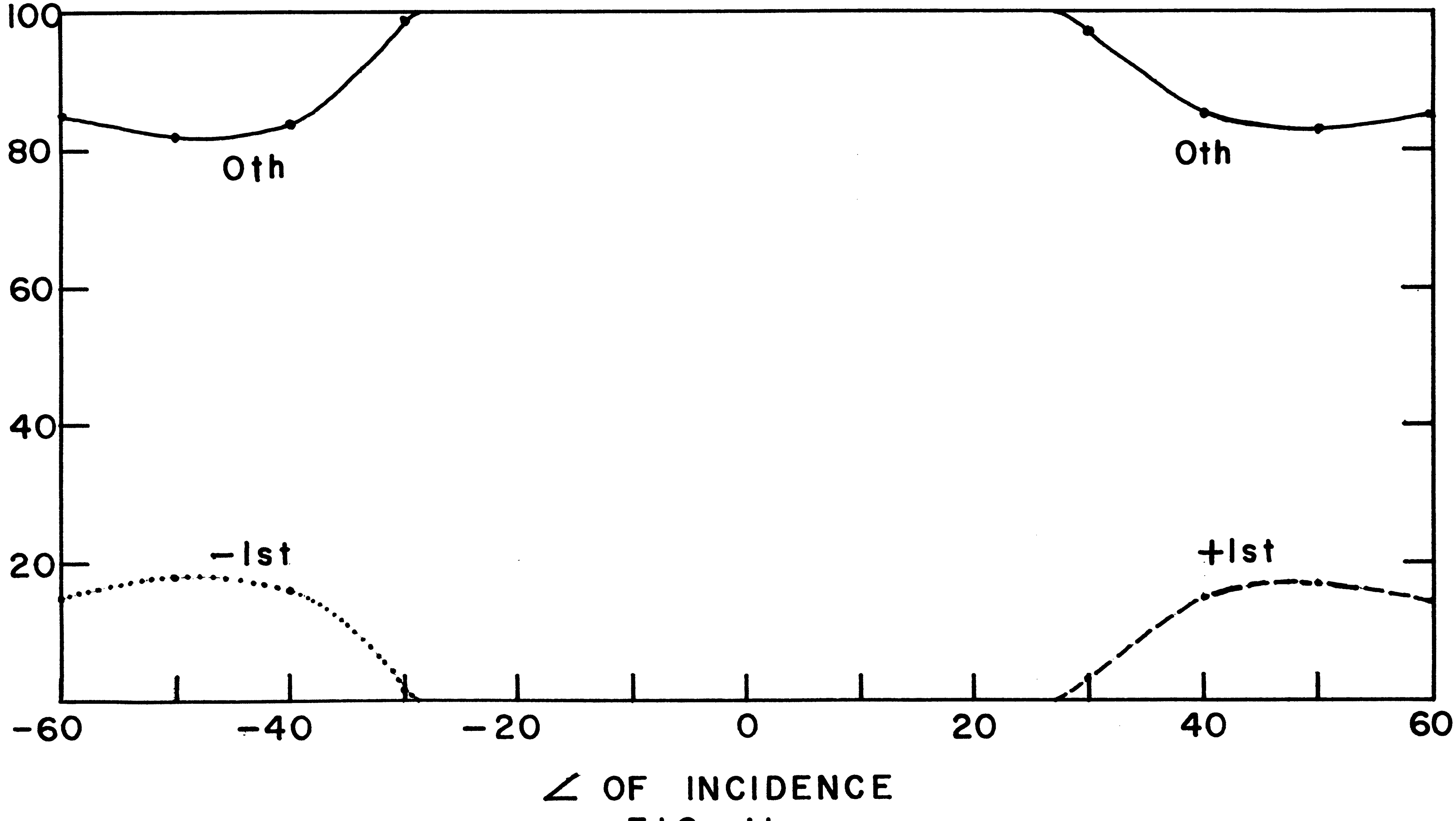
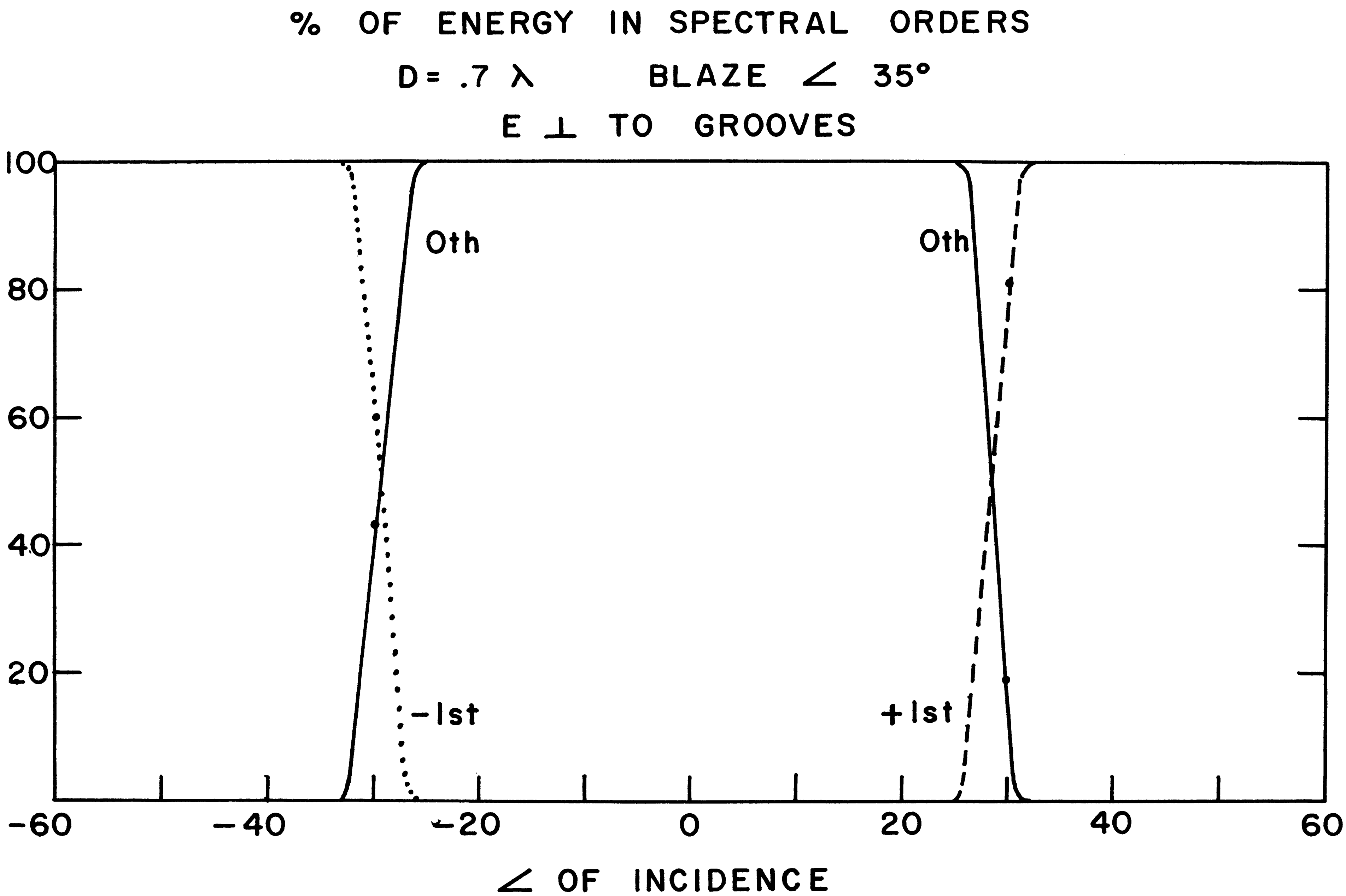


FIG. 11


% OF ENERGY IN SPECTRAL ORDERS
D= .7 λ BLAZE ∠ 35°
E ⊥ TO GROOVES
100
80
60
40
20
Oth
Oth
-1st
+1st
-60
-40
-20
0
20
40
60
∠ OF INCIDENCE
FIG. 12

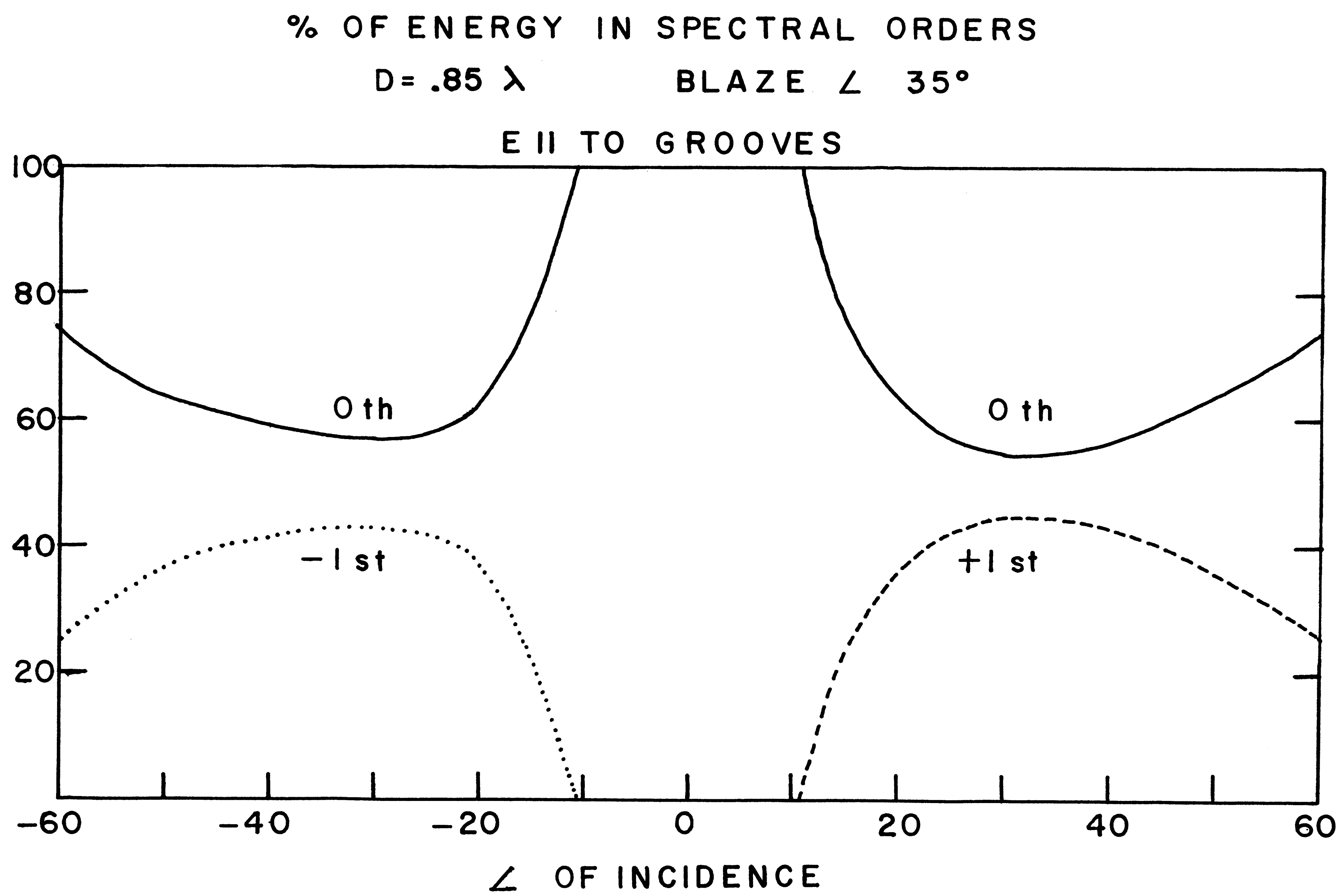
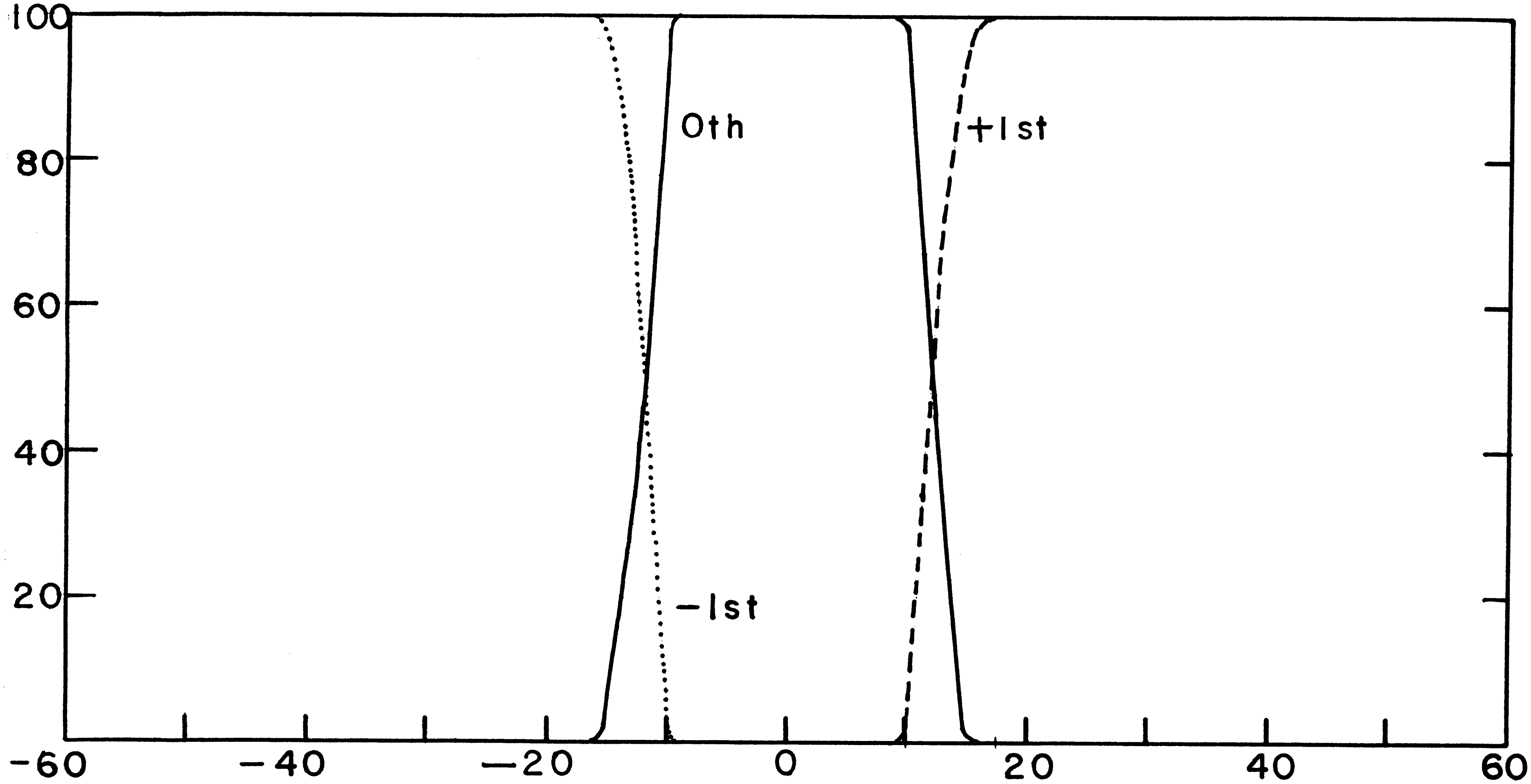

% OF ENERGY IN SPECTRAL ORDERS
D= .85 λ
BLAZE ∠ 35°
E ‖ TO GROOVES
100
80
60
40
20
0 th
0 th
−1 st
+1 st
−60
−40
−20
0
20
40
60
∠ OF INCIDENCE

FIG. 13

% OF ENERGY IN SPECTRAL ORDERS

D= .85 λ BLAZE ∠ 35°

E ⊥ TO GROOVES



∠ OF INCIDENCE

FIG. 14

% OF ENERGY IN SPECTRAL ORDERS

D= 1.2 λ BLAZE ∠ 35°

E ‖ TO GROOVES

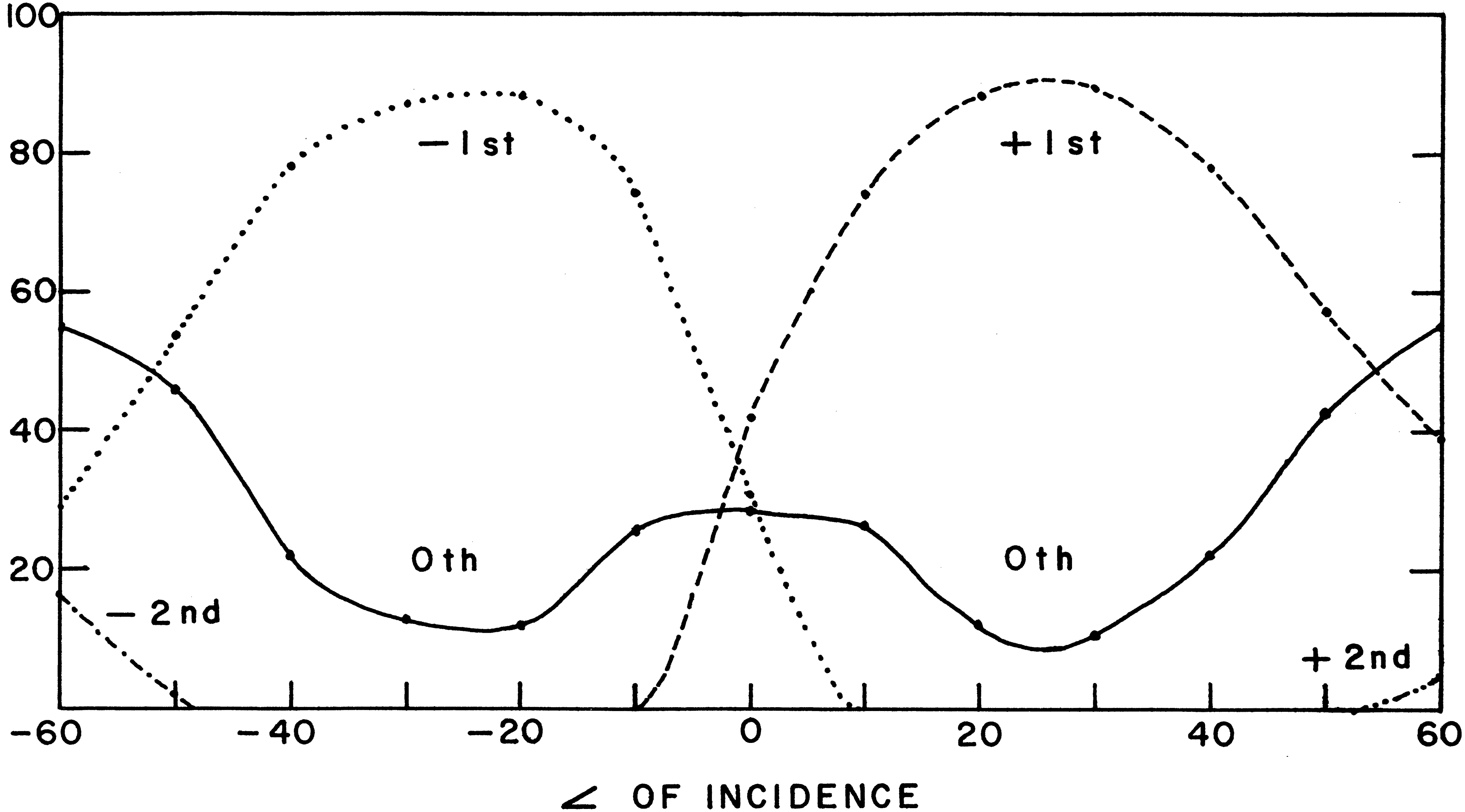


FIG. 15

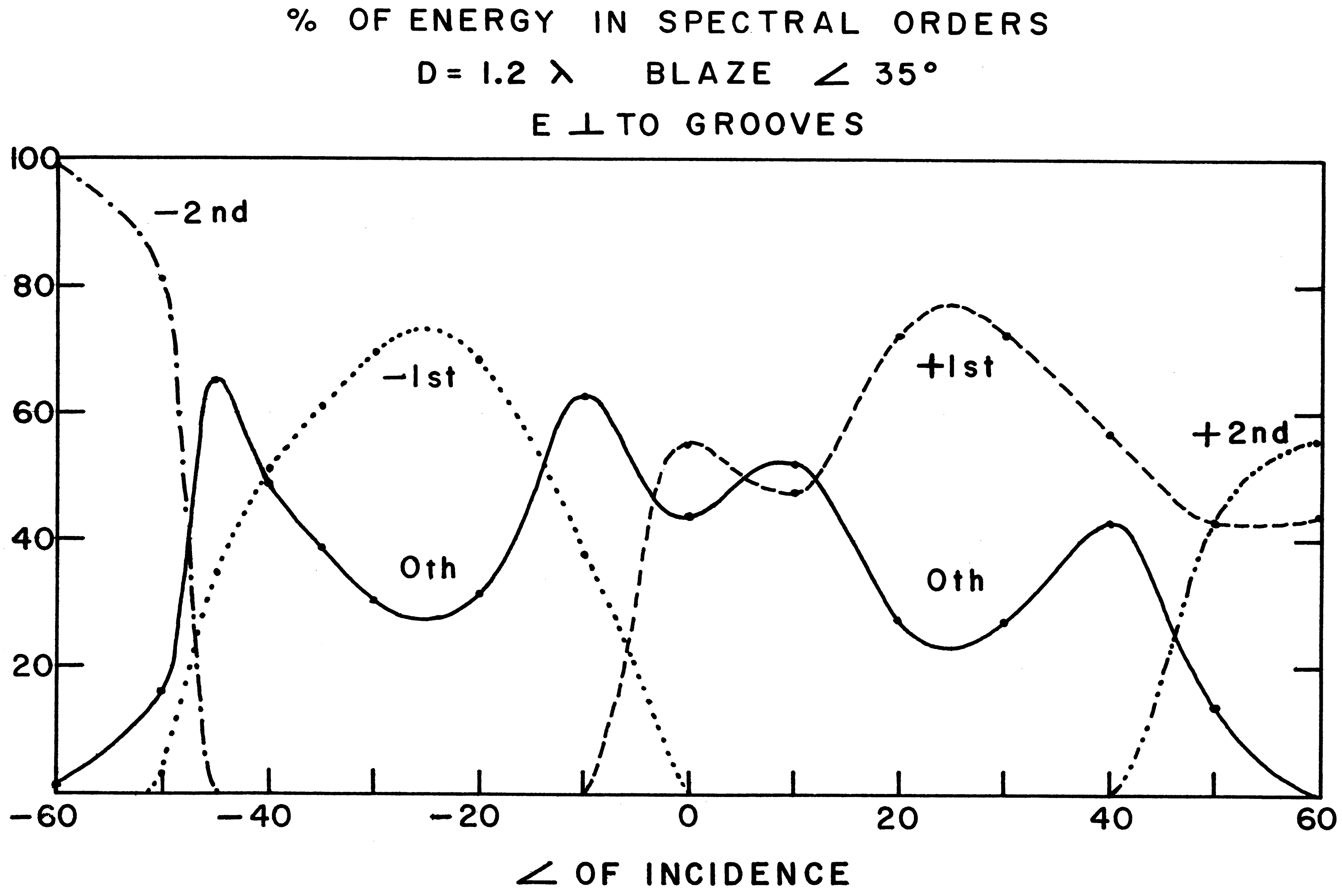

% OF ENERGY IN SPECTRAL ORDERS
D = 1.2 λ BLAZE ∠ 35°
E ⊥ TO GROOVES
100
80
60
40
20
-60
-40
-20
0
20
40
60
-2nd
-1st
0th
+1st
0th
+2nd
∠ OF INCIDENCE

FIG. 16

% OF ENERGY IN SPECTRAL ORDERS

D= 1.7 λ BLAZE ∠ 35°

E || TO GROOVES

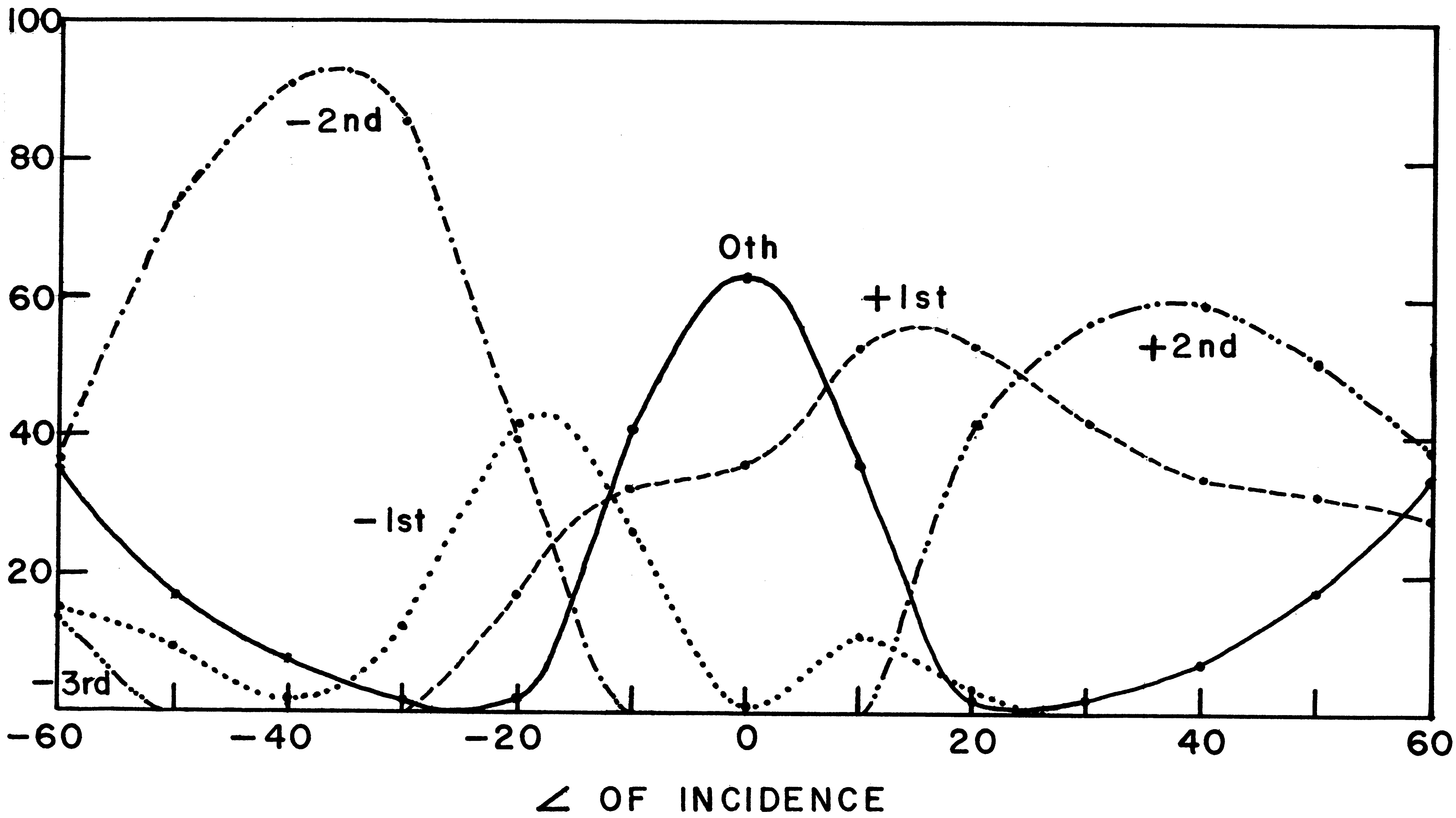


FIG. 17

% OF ENERGY IN SPECTRAL ORDERS

D= 1.7 λ   BLAZE ∠ 35°

E ⊥ TO GROOVES

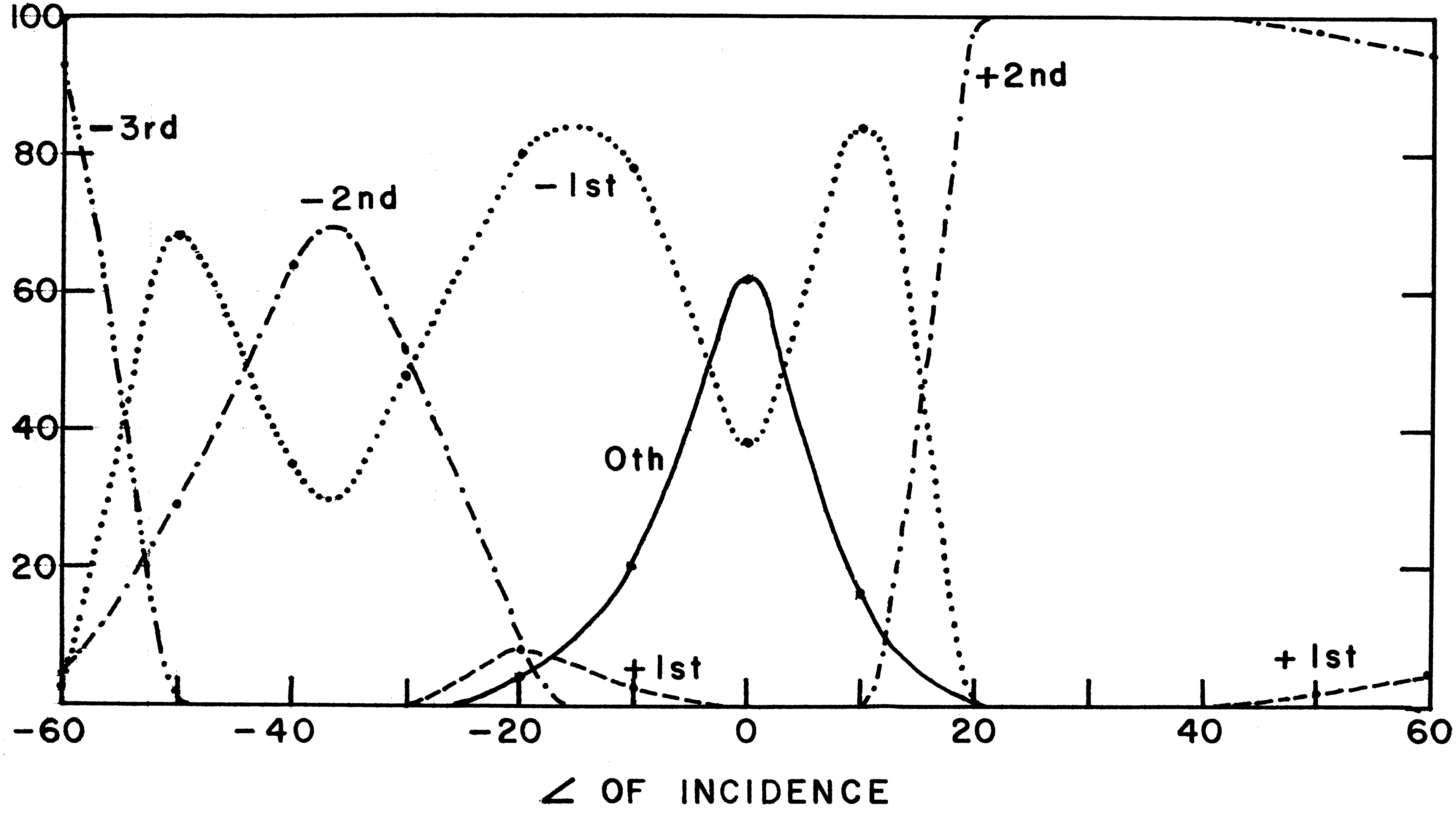


FIG. 18

% OF ENERGY IN SPECTRAL ORDERS

D = .7 λ BLAZE ∠ 45°

E ∥ TO GROOVES

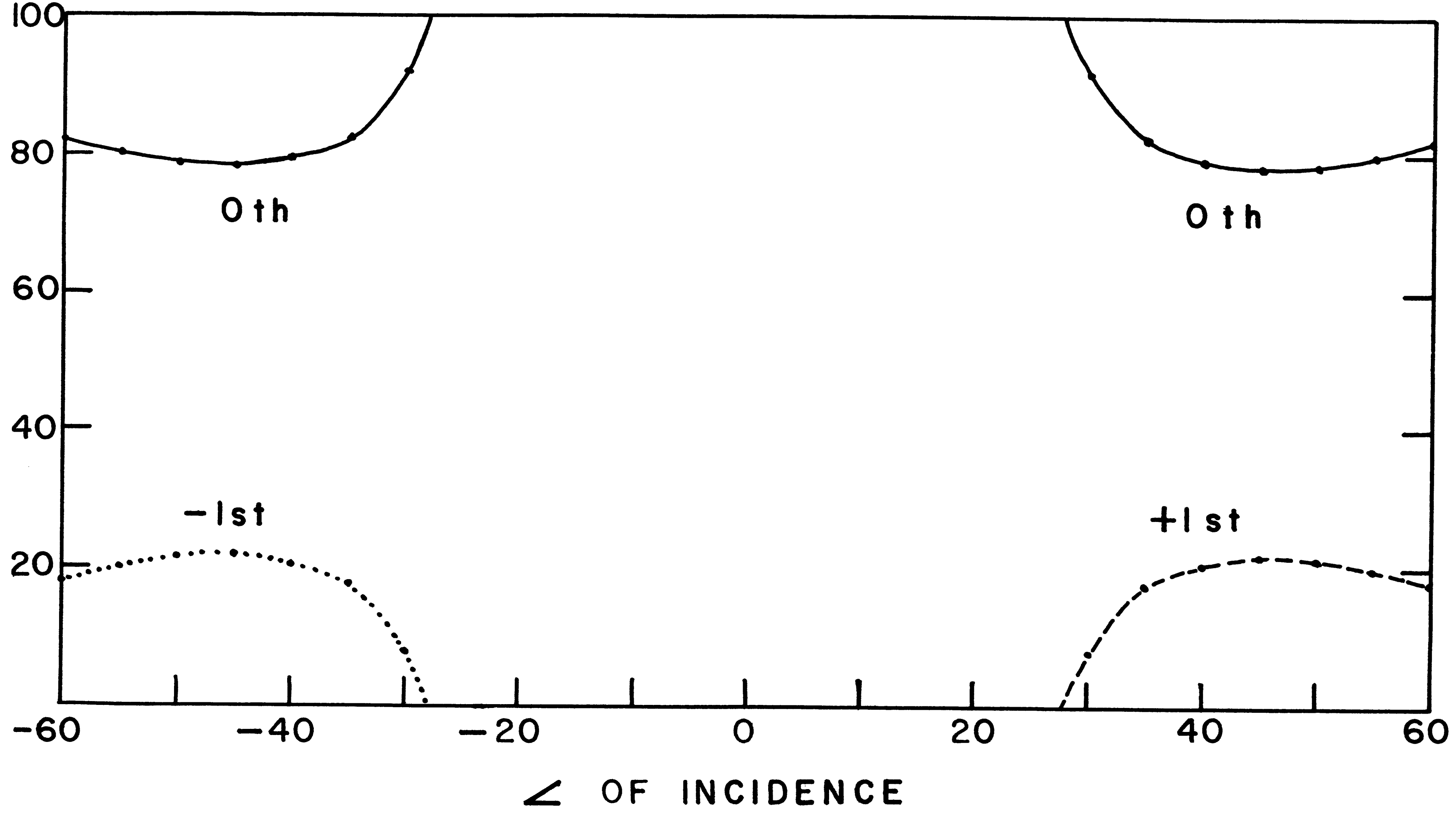


FIG. 19

% OF ENERGY IN SPECTRAL ORDERS

D=.7 λ BLAZE ∠ 45°

E ⊥ TO GROOVES

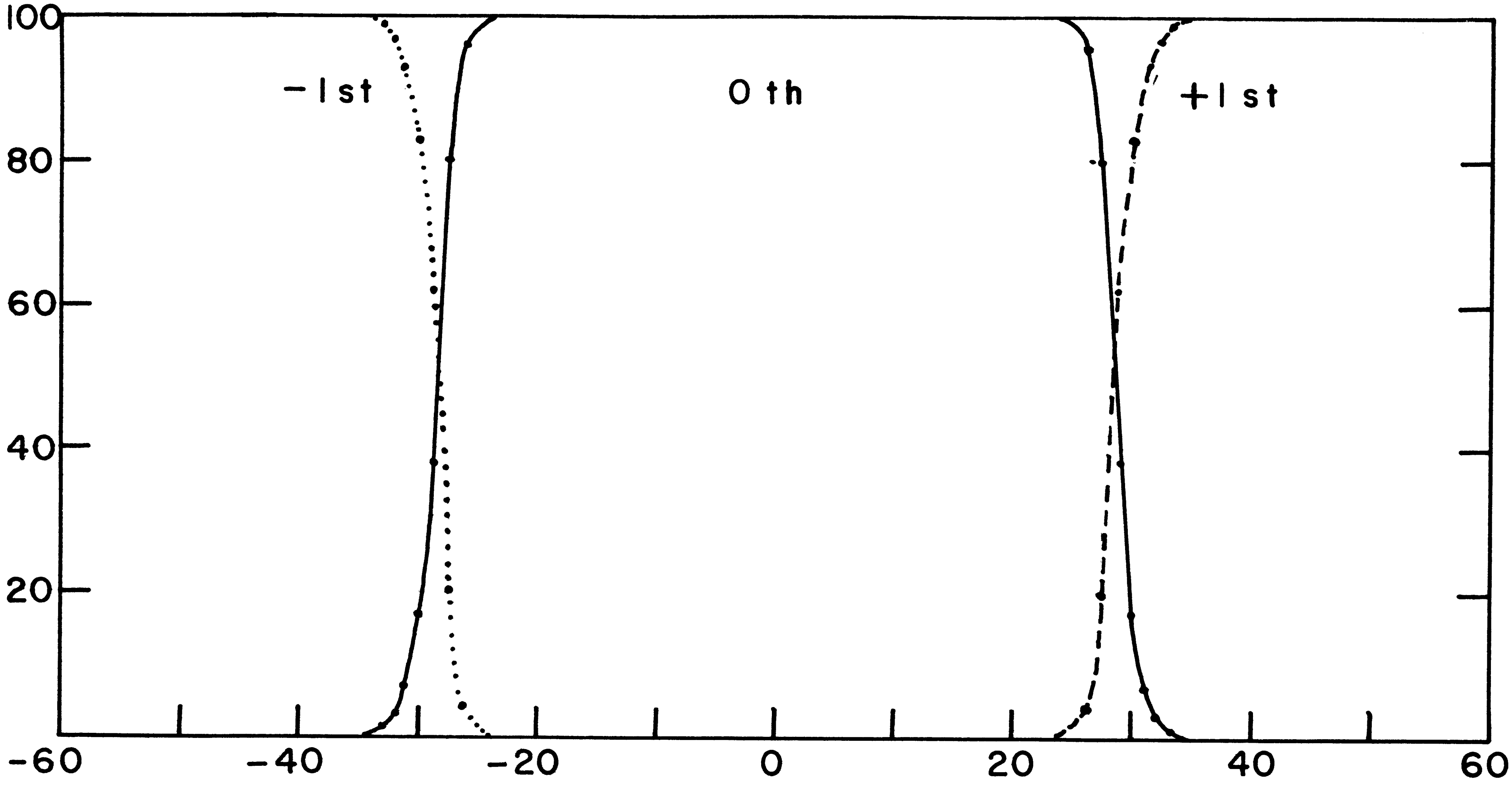


FIG. 20

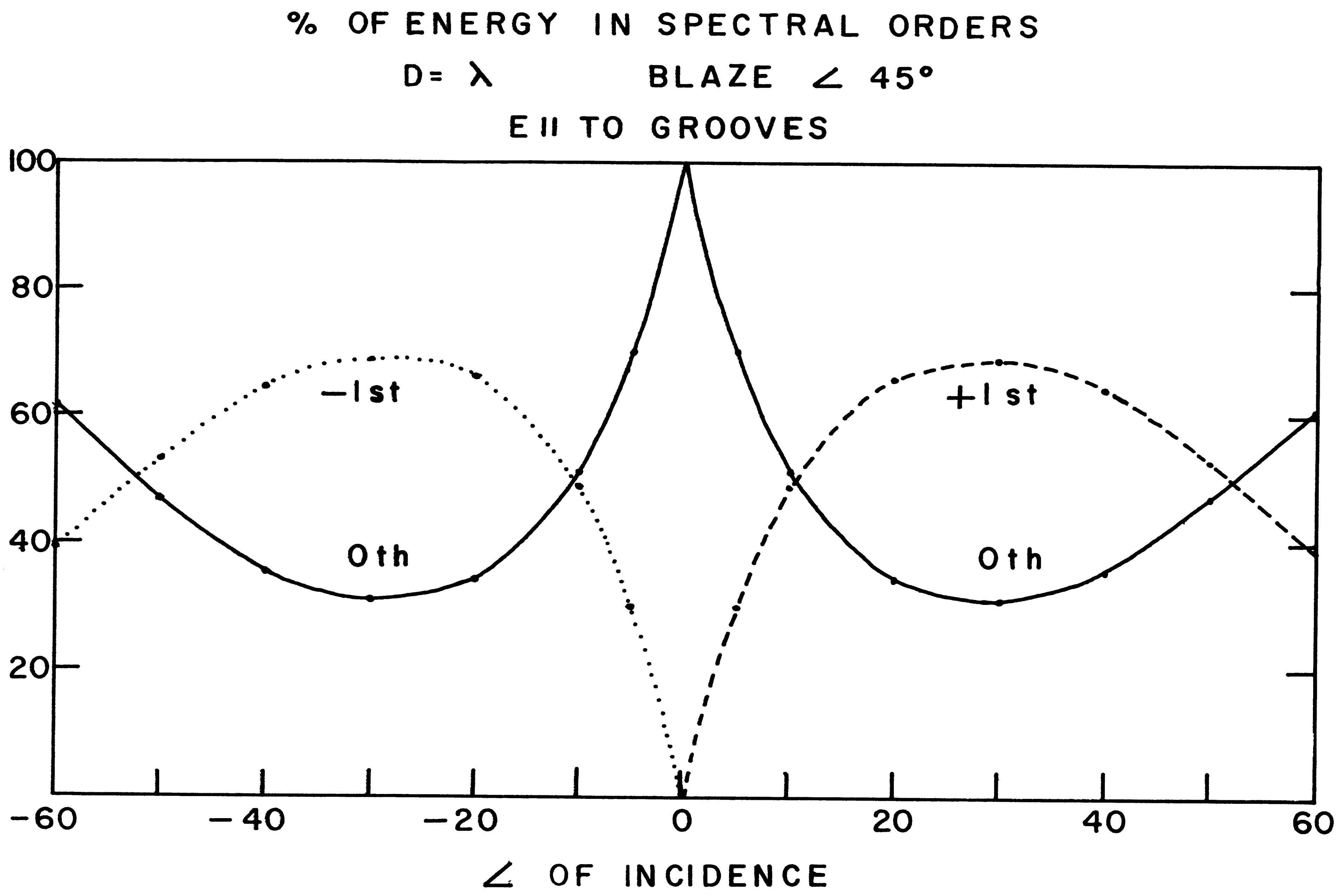

% OF ENERGY IN SPECTRAL ORDERS
D= λ BLAZE ∠ 45°
E ‖ TO GROOVES
100
80
60
40
20
−1st
+1st
0th
0th
−60
−40
−20
0
20
40
60
∠ OF INCIDENCE

FIG. 21

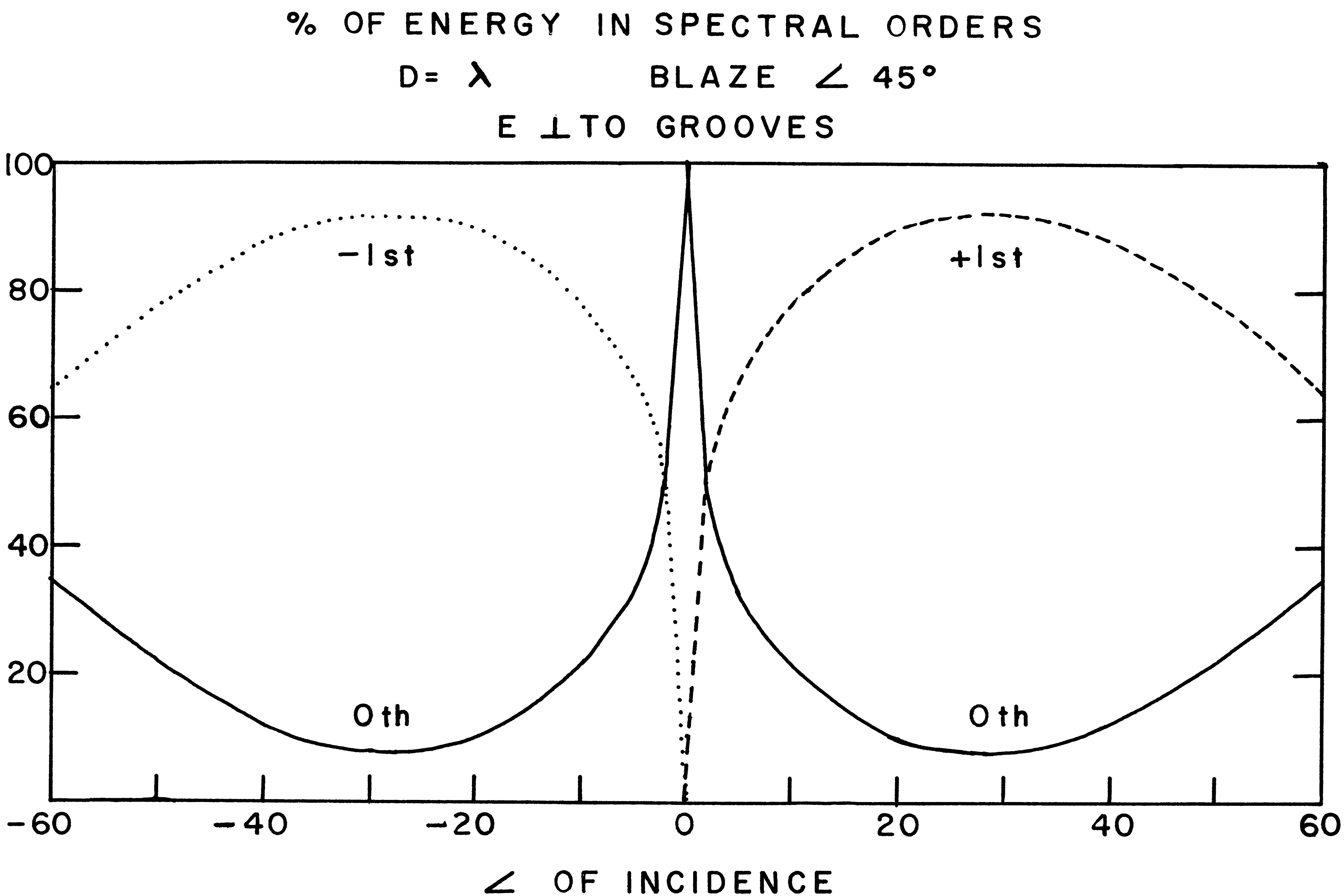

% OF ENERGY IN SPECTRAL ORDERS
D= λ BLAZE ∠ 45°
E ⊥ TO GROOVES
100
80
60
40
20
−1st
+1st
0th
0th
−60
−40
−20
0
20
40
60
∠ OF INCIDENCE

FIG. 22

% OF ENERGY IN SPECTRAL ORDERS

D= $\sqrt{2}$ λ BLAZE ∠ 45°

E ‖ TO GROOVES

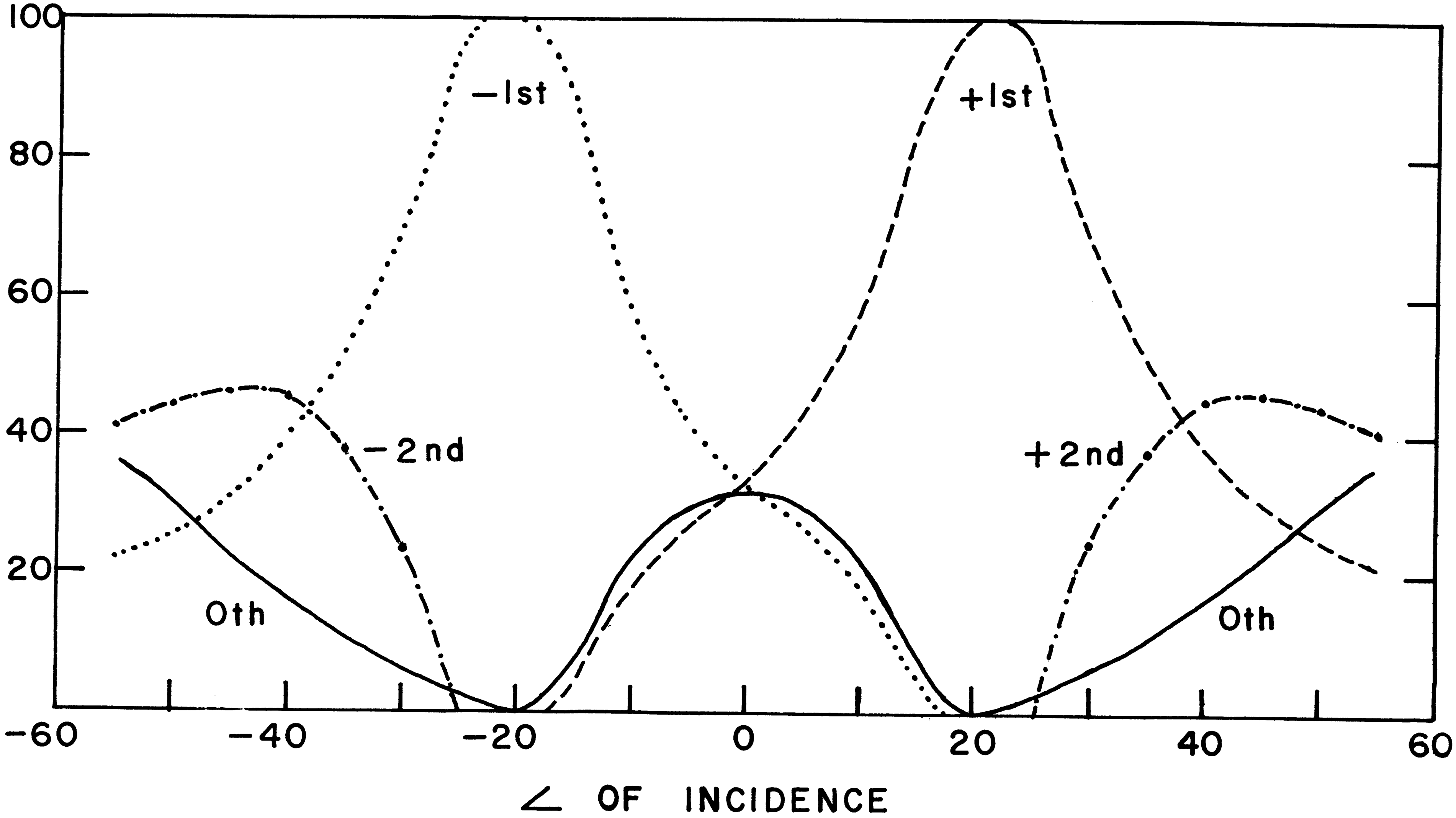
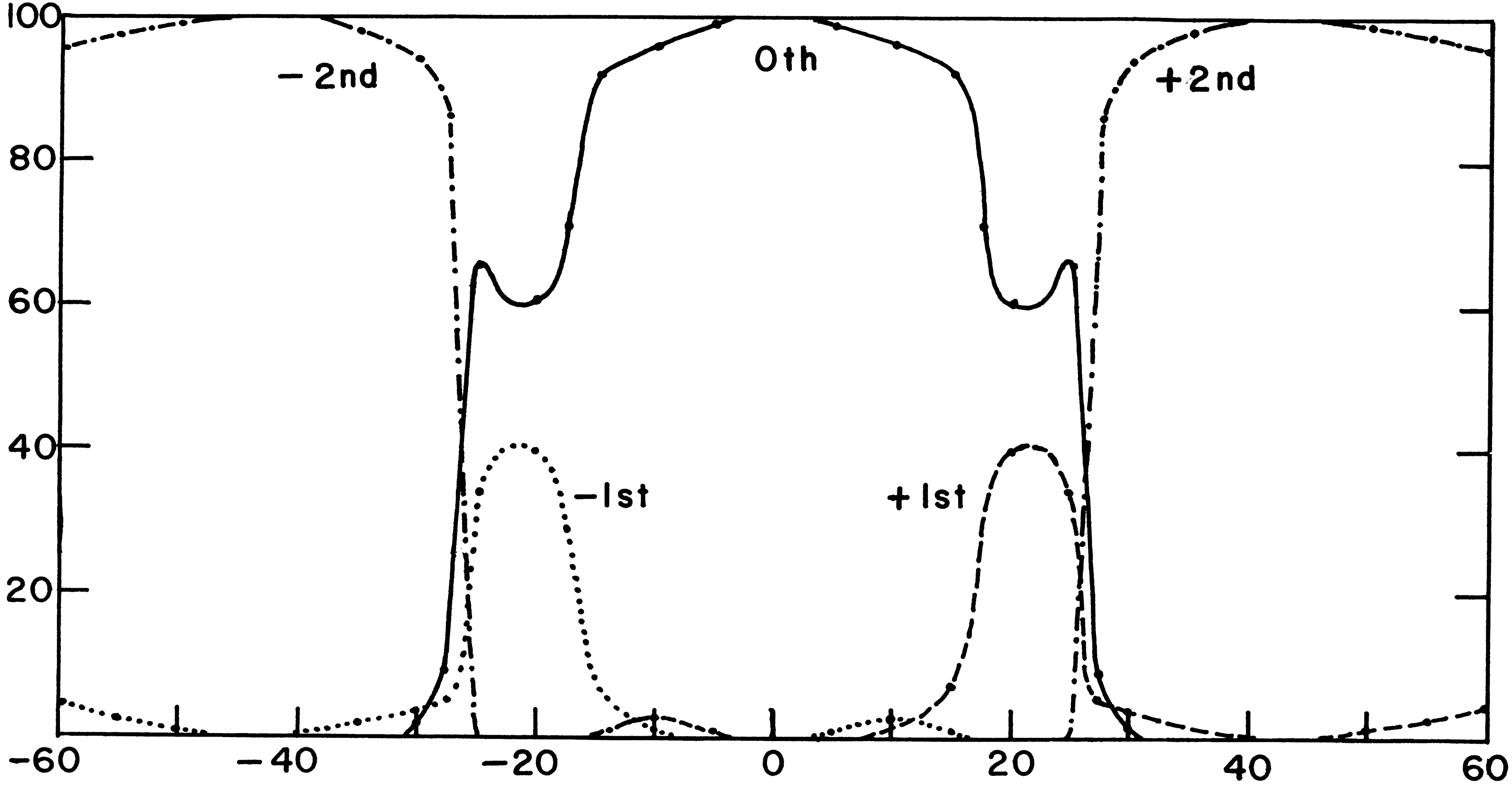


FIG. 23

% OF ENERGY IN SPECTRAL ORDERS

$D = \sqrt{2}\ \lambda$ BLAZE $\angle$ 45°

E $\perp$ TO GROOVES



$\angle$ OF INCIDENCE

FIG. 24