Tektronix®
COMMITTED TO EXCELLENCE

DESKTOP COMPUTER APPLICATIONS LIBRARY PROGRAM

TITLE

General Function Z=F(X,Y) Plot

ORIGINAL DATE

February, 1981

REVISION DATE

EQUIPMENT AND OPTIONS REQUIRED

32K

AUTHOR

Dony Robert Brussels, Belgium

PERIPHERALS

Optional - 4662 Plotter

ABSTRACT

Files: 1 ASCII Program

Statements: 452

This program draws two variable functions, z=f(x,y), with hidden lines removed. The draw is made in a rectangular region so that $X1 \leq X \leq X2$ and $Y1 \leq Y \leq Y2$.

The function may be drawn on a block representing axes parallel to the three real axes X,Y,Z as well as the study intervals.

The user writes the function to be studied, for instance in the form:

2500 Z=-8*EXP(-X*X-Y*Y)*(X+Y)

As soon as the user types RUN (RETURN), the program asks the inputs necessary to do the calculations and prompts for the following options.

1. Any seeing angle. The eye always looks at the origin of the axis. The azimuth angle 01 can vary from $Ø^{o}$ to $18Ø^{o}$, and from $Ø^{o}$ to $-18Ø^{o}$. The dip angle 02 can vary from $Ø^{o}$ to $9Ø^{o}$ and from $Ø^{o}$ to $-9Ø^{o}$.
2. The number of slices cutting the surface.
3. The number of joints on each slice.
4. The eventual file number to record the drawing in G.D.U.s that allows a fast redraw of the function later.
5. The true scale or a uniform scale.
6. One or two directions of cutting.
7. The drawing of the function with or without the axis block.

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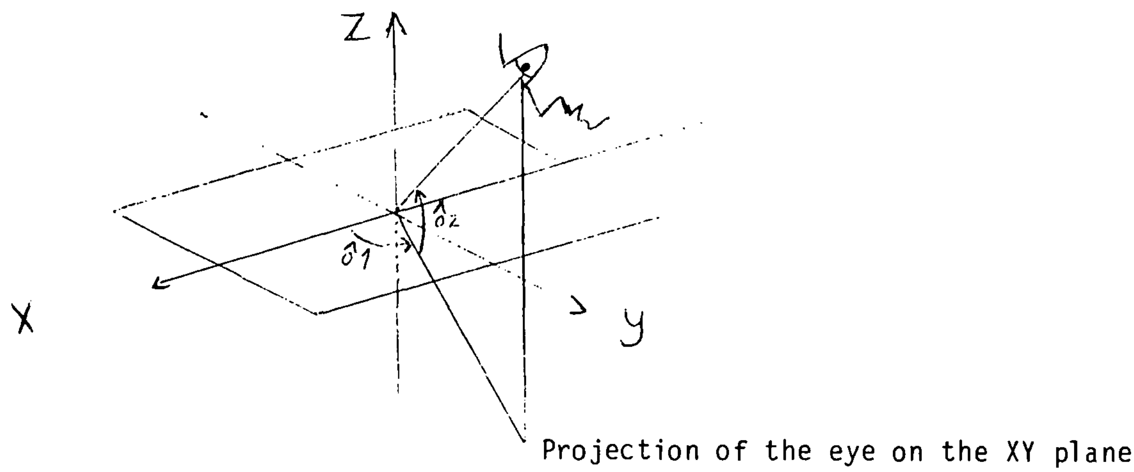
General Function Z=F(X,Y) Plot



OPERATING INSTRUCTIONS

Load the program into memory through the tape directory, or FIND33, and OLD. Change statement 2500 to the function of your choice, then RUN the program and respond to the prompts.

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COMMENTS

I have tried to scan always the screen always from right to left (climbing or descending). Points in the foreground are always drawn first. After the drawing of each line, the maximal and minimal crest lines are update. Any line situated inside these two crest lines is eliminated. Moreover the program also draws the edges of the surface when two directions are asked.
There are only 8 different cases according to the choice of the angles O1 and O2. They are called ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ . They are reduced to two cases only for each direction. The increments for the lines and the points are Y3 and X3.

G1 = 1 or 2 for the first direction
G1 = 3 or 4 for the second direction.

Let us examine two cases among the eight! See the following page 4 .

Case 1 : first direction G1=1 (index loop G=1)

- the fist line (FL1) is Y=Y2 and starts from X=X1
- the following lines are obtained by calculating Y=Y2-(U-1).Y3
- the following points on each line are calculated by X=X1+V.X3

second direction G1=3 (index loop G=2)

- the first line (FL2) is X=X2 and starts from y=Y2
- the following lines are obtained by calculating X=X2-(U-1).X3
- the following points on each line are calculated by Y=Y2-V.Y3

Case 8 : first direction G1=2 (index loop G=1)

- the first line (FL1) is Y=Y1 and starts from X=X2
- the following lines are obtained by calculating Y=Y1+(U-1).Y3
- the following points on each line are calculated by X=X2-V.X3

second direction G1=4 (index loop G=2)

- the first line (FL2) is X=X1 and starts from Y=Y1
- the following lines are obtained by calculated X=X1+(U-1).X3
- the following points on each line are calculated by Y=Y1+V.Y3

Reasoning in the same way for the other cases, we easily obtain the following flowchart.(page 5)

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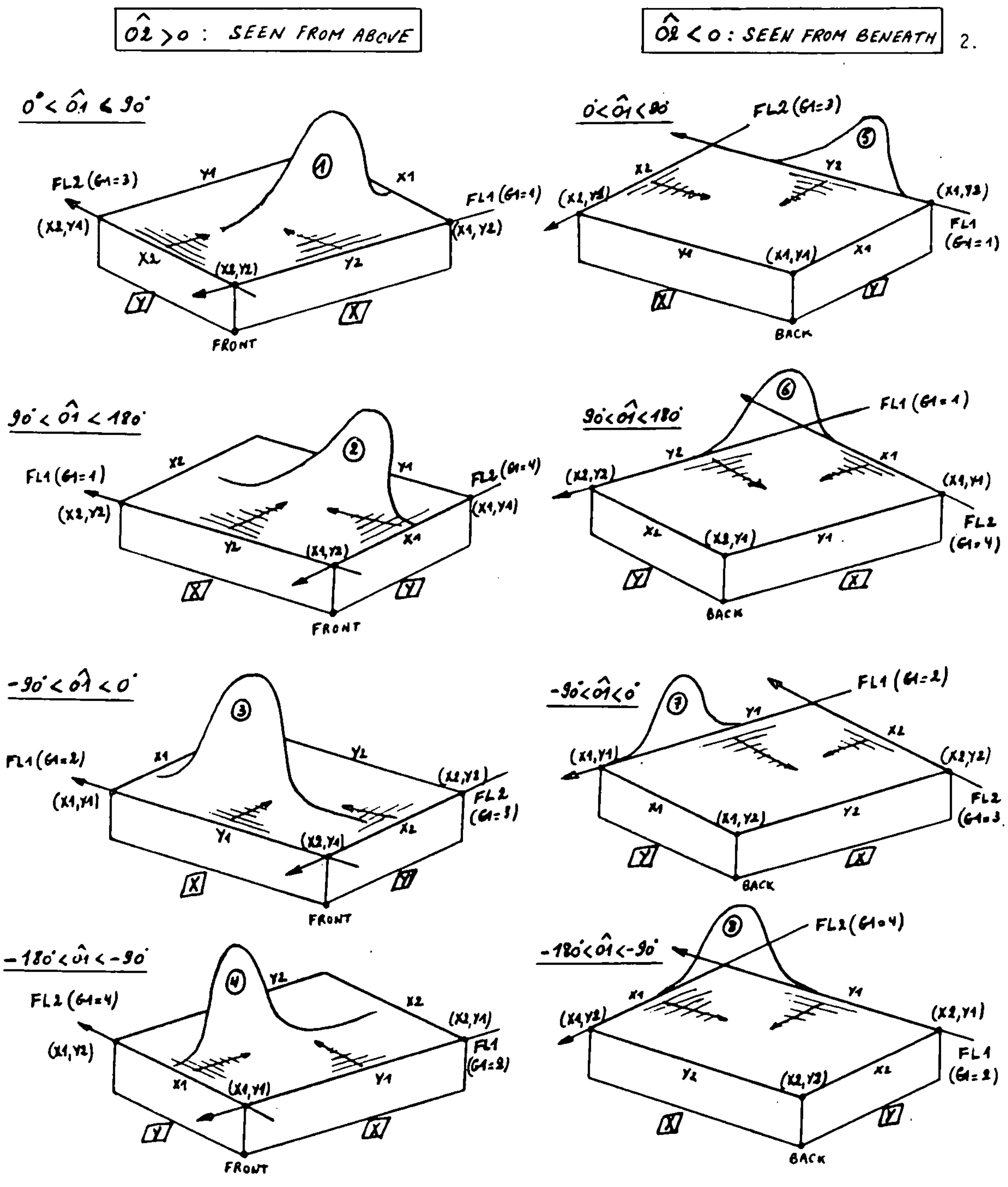

FL1 = FIRST LINE 1st DIRECTION

[X] // TO THE X AXIS

FL2 = FIRST LINE 2d DIRECTION

[Y] // TO THE Y AXIS

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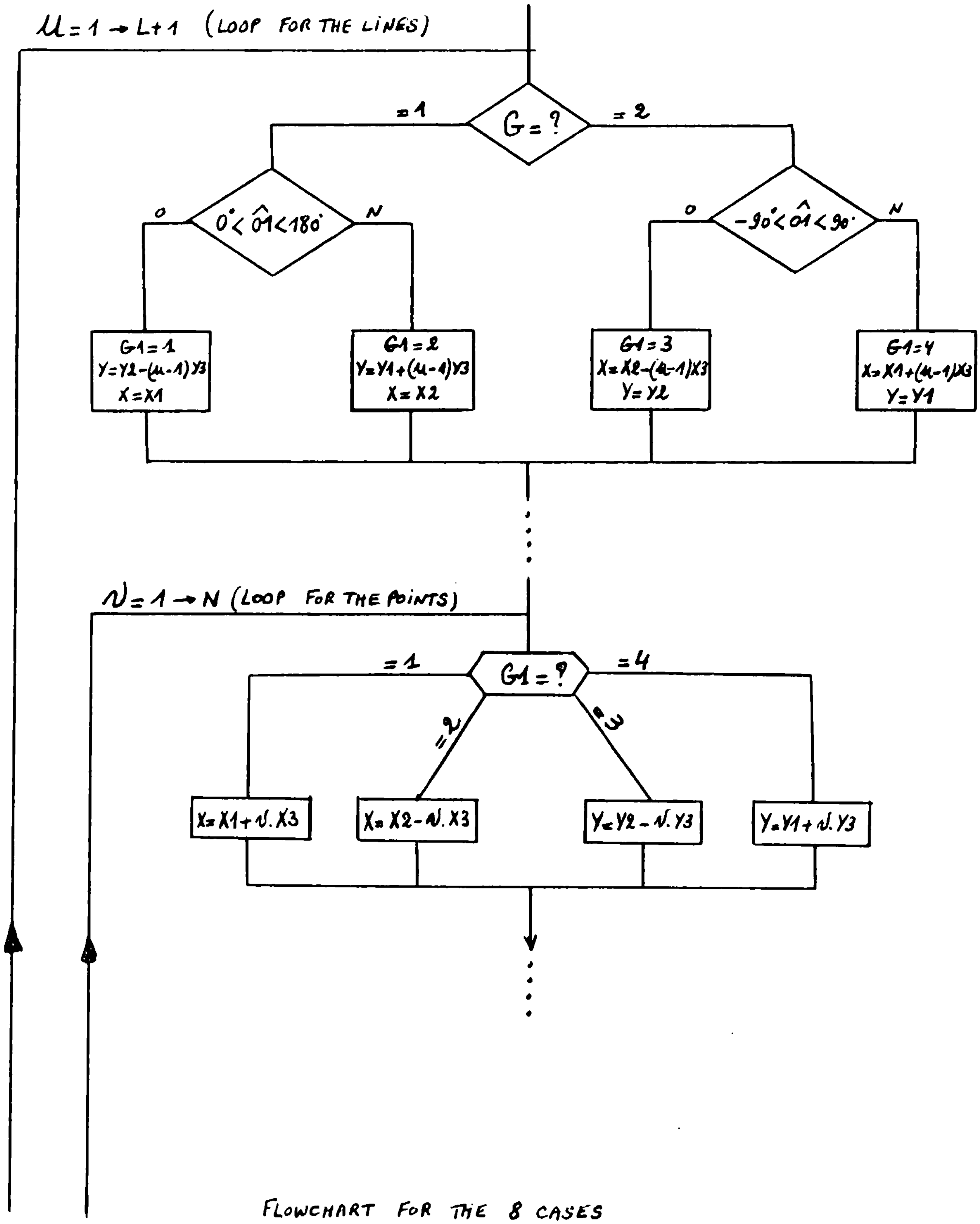
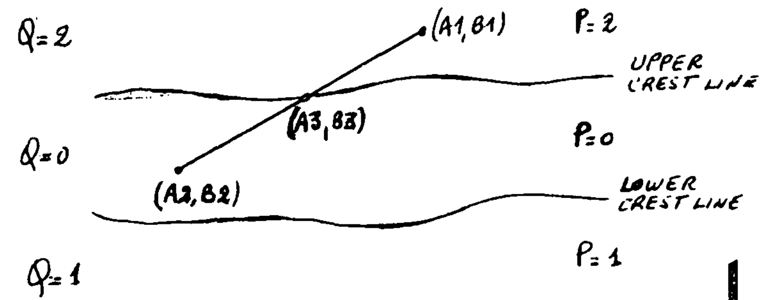


FLOWCHART FOR THE 8 CASES

THE HIDDEN LINE PROBLEM.

Let's take a point (A1,B1) which allows to determine P and the next point (A2,B2) which determine Q. We can have:

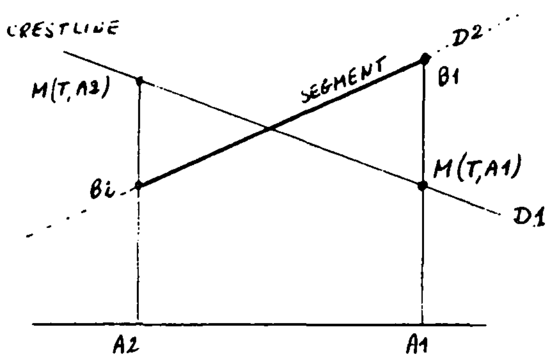


1) P=2 and Q=2 or P=1 and Q=1

   That means that the segment joining the two points is visible.

2) P=2 and Q=0 or P=1 and Q=0 or P=0 and Q=1 or P=0 and Q=2

   That means that the segment is partly hidden and cuts one of the crest lines. So the intersection point (A3,B3) is to be calculated. It is the variable T which allows to know which crest line is cut. To find (A3,B3), we only have to find the intersection of the two straight lines D1 and D2.



$$D1 \equiv \frac{y - M(T,A1)}{M(T,A2)-M(T,A1)} = \frac{x - A1}{A2 - A1}$$

$$D2 \equiv \frac{y - B1}{B2 - B1} = \frac{x - A1}{A2 - A1}$$

The solution of the system is

$$\begin{cases} A3 = \dfrac{B1.A2 - B2.A1 - M(T,A1).A2 + M(T,A2).A1}{D} \\ B3 = \dfrac{B1.M(T,A2) - B2.M(T,A1)}{D} \end{cases}$$

$$D = M(T,A2) - M(T,A1) - B2 + B1$$

Remark: If D=0, the segment is parallel to the crest line and must be drawn.

3) P=0 and Q=0

   Then the segment is completely hidden.

4) $P \neq Q \neq 0$

   Then the segment cuts the two crest lines simultaneously. So two intersections points (A3,B3) are to be found. It is the switch variable S which allows, after calculating the first intersection point, to calculate the second one.
   If P=1 then T=1 first then T=2.
   If P=2 then T=2 first then T=1.

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UPDATING THE CREST LINES MATRIX.

The linear interpolation is used therefore.

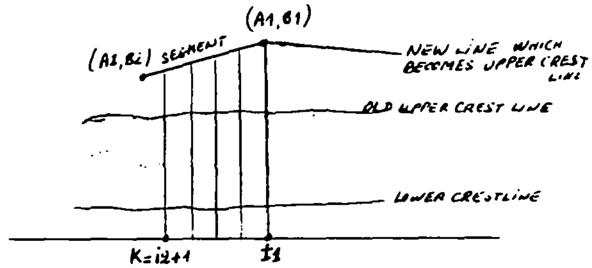
We have : $y = m.x + p$

At $(A1,B1) \rightarrow \begin{cases} B1 = m.A1 + p \\ B2 = m.A2 + p \end{cases}$
At $(A2,B2) \rightarrow$

The solution of that sysytem gives

$$m = \frac{B1 - B1}{A2 - A1}$$

$$p = \frac{B1.A2 - B2.A1}{A2 - A1}$$



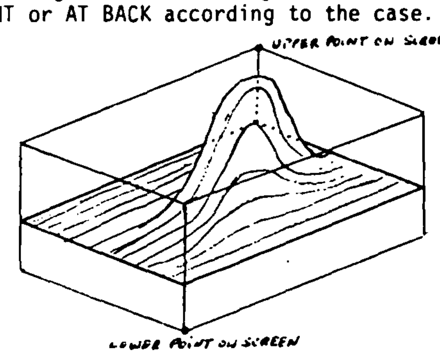
The variables I1 and I2 are the rounded values of A1 and A2.
In a loop with the index K varying from I2+1 to I1 by step 1, we can calculate the corresponding ordinates of the segment with the formula:

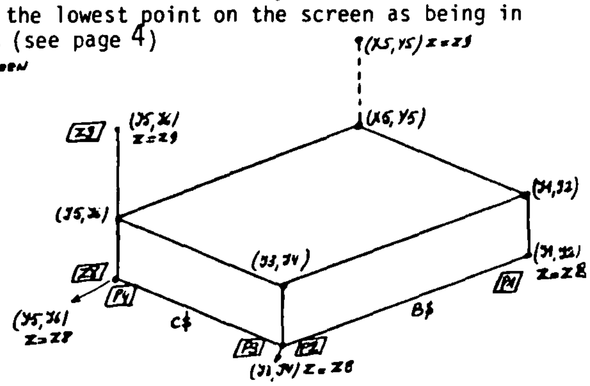
$$R = \frac{K.(B2 - B1) + A2.B1 - A1.B2}{A2 - A1}$$

where K is substitued for x and R for y.

DRAWING OF THE AXIS BLOCK.

We always try for the axis block never to come on the drawn surface except in some cases where it is impossible to avoid. For instance for the function Z=X.X+Y.Y where O1=45 and O2=30 . (see in the lot of drawing)
The representation of the axis block in the 8 cases will always be copied from the following scheme. You only have to see the lowest point on the screen as being in FRONT or AT BACK according to the case. (see page 4)





In order to have only one program for the eight cases, the axis block is drawn according to the following scheme with the indicated variables.

According to the case: J1, J3, J5 represent X1 or X2
J2, J4, J6 " Y1 or Y2
P1 P2 P3 P4 " X1, X2, Y1 or Y2 and are printed.
Z8 represents the minimum of the function and is printed.
Z9 " maximum " " " "
B$ and C$ represent X or Y

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If you imagine the surface in a box, you will note that the lowest point on the screen will always be (J3,J4) with Z=Z8 and that the highest point on the screen will always be (X5,Y5) with Z=Z9.
So, when drawing the axis block, you have to watch out for the minimum M3 and the maximum M4 of the function to be eventually corrected. That is why the coordinate of the lowest point (J3,J4) when z=Z8 is reevaluated. Then with the coordinate of the opposite point in relation to the axis center (X5,Y5) with Z=Z9, the maximum M4 is reevaluated.
That allows the scales H1 and H2 to be determined correctly before drawing the axis block.
A thorough examination of the eight possible cases gives the following flowchart. (see page 11).

RECORDING OF THE DRAWING ON THE MAGNETIC TAPE.

If F ≠ 0 then the drawing is recorded in binary DATA on the tape for a quick further use. Binary data are memorized in the matrix G3(). At the start of each line E1=0. In that case, we dimension G3 for N+1 points because we have to take into account that the edges of the surface are drawn. Varaible E is the points counter for matrix G3.
If E1≠0 then we check if the last memorized point in G3 is identical to the starting point (A1,B1) of the new segment to be drawn. Here is used the FUZZ function.

1) if YES then we memorize the arrival point (A2,B2) of the segment to be drawn in the matrix G3.

2) if NO then that means that hidden lines have been met. So we record the points already written in G3 then we resume to fill G3 with the last point.

Moreover, each time a line is finished, we have to record the matrix G3 (if F≠0)

In short we have the following flowchart (see page 12)

FASTER REDRAW OF THE FUNCTION.

Make sure to use an empty tape or file when you record the data of a drawing.
To read out the data in order to obtain a quick drawing, you only have to load the program in the computer and type RUN 5000 (RETURN).
The program asks for the number device and the number file to be read.
The device is the PLOTTER (number=1) or the screen (number=32).
The data are of course read exactly as they have been recorded, i.e in GDU.
(see the flowchart on page 12).

REMARKS: 1) It is obvious that the found minimum Z8 and maximum Z9 which are printed are not necessarely the true values. The more the number of slices L and the number of points N are great, the more Z8 and Z9 will be close to reality.
2) The axis block can also be recorded on tape. Personally I have not had enough memory to do so.

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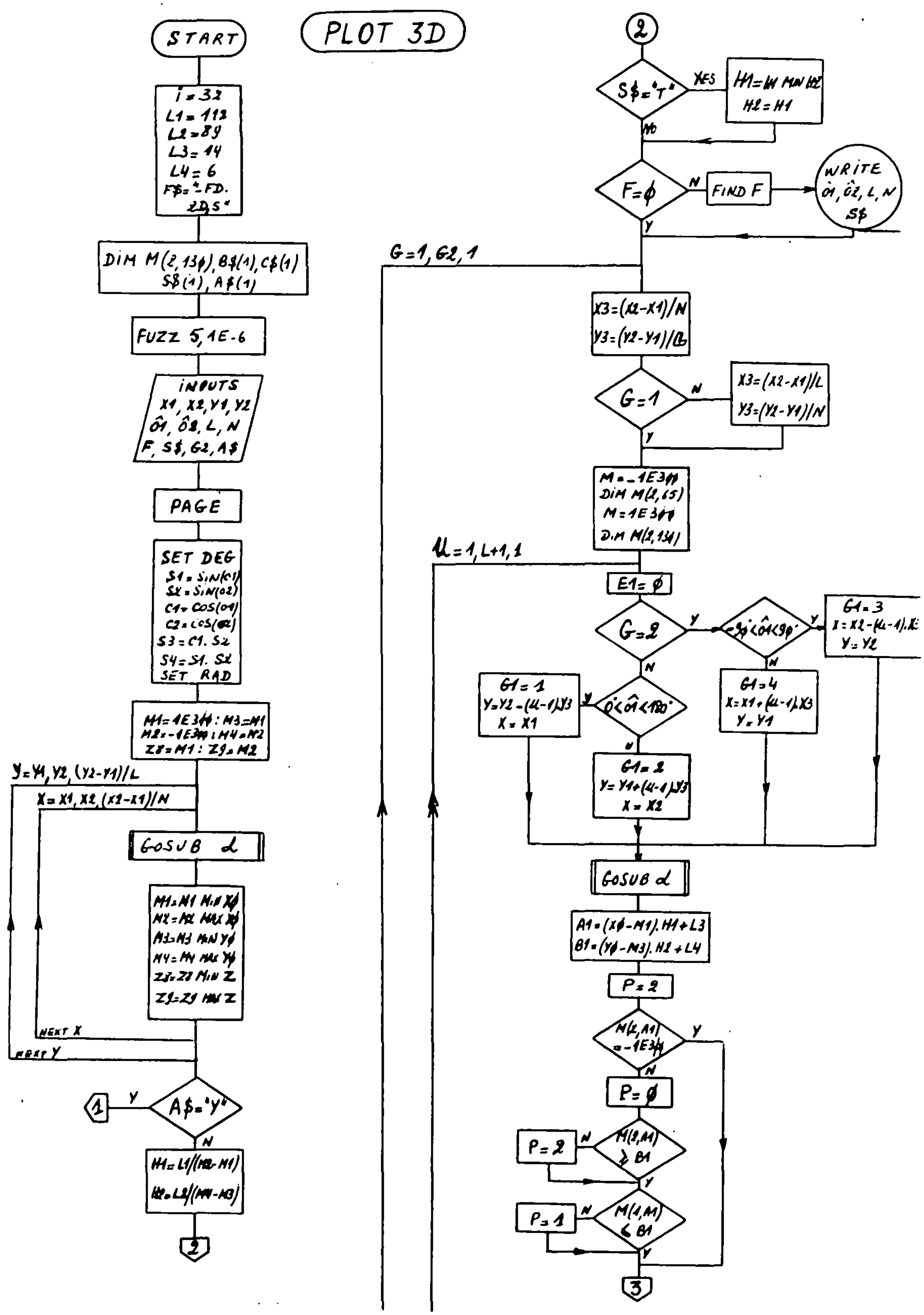
General Function Z=F(X,Y) Plot



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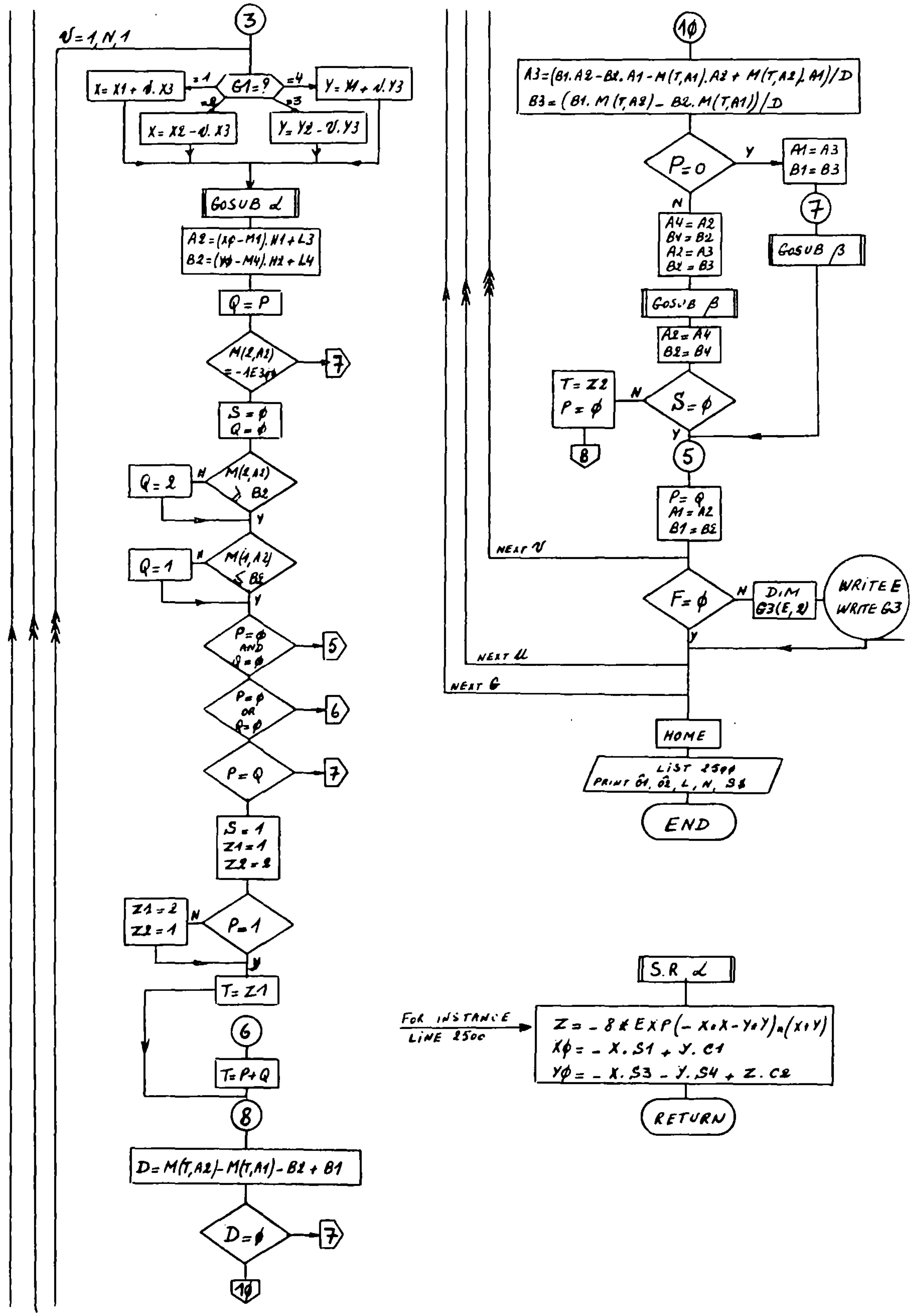

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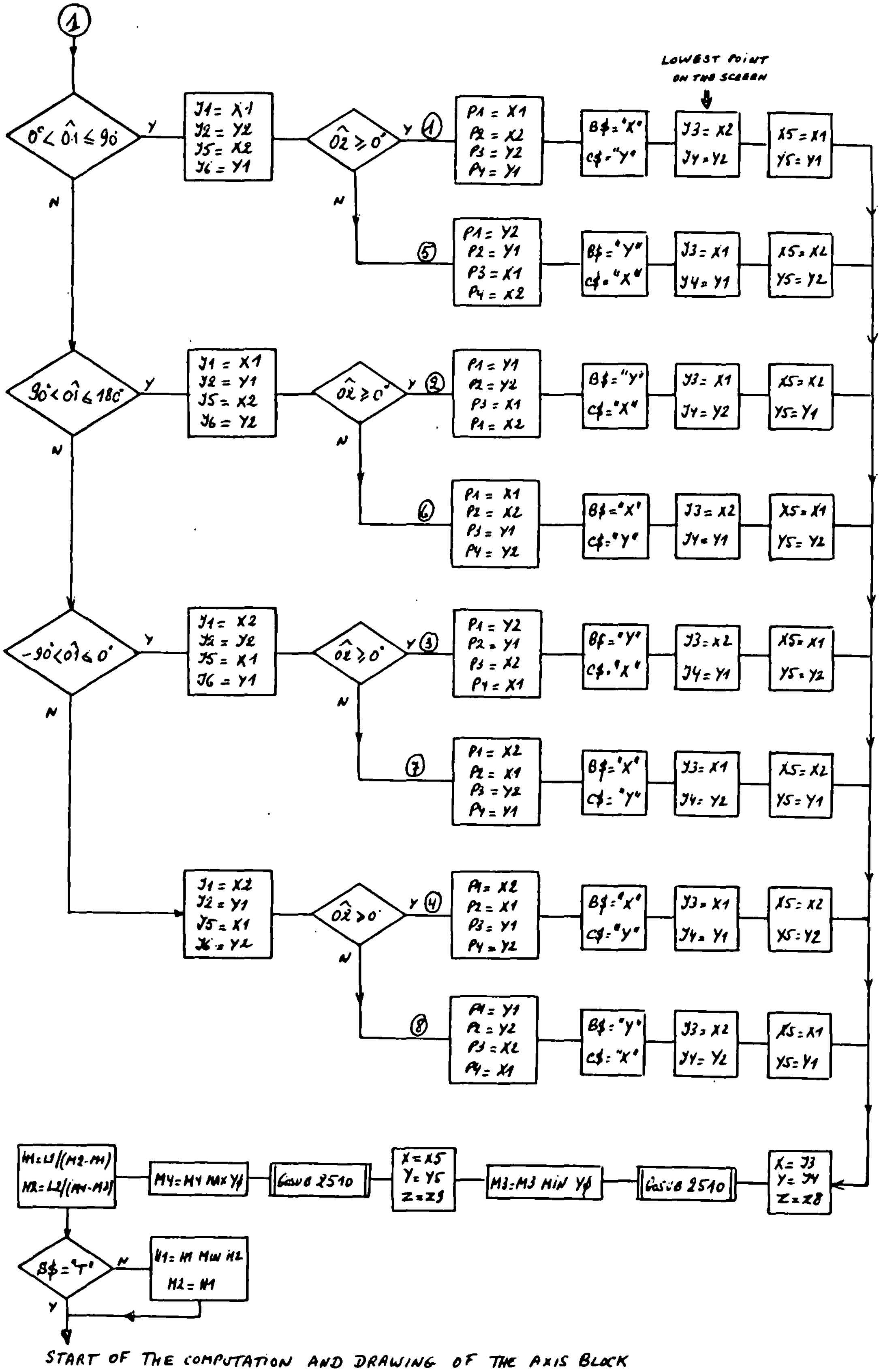
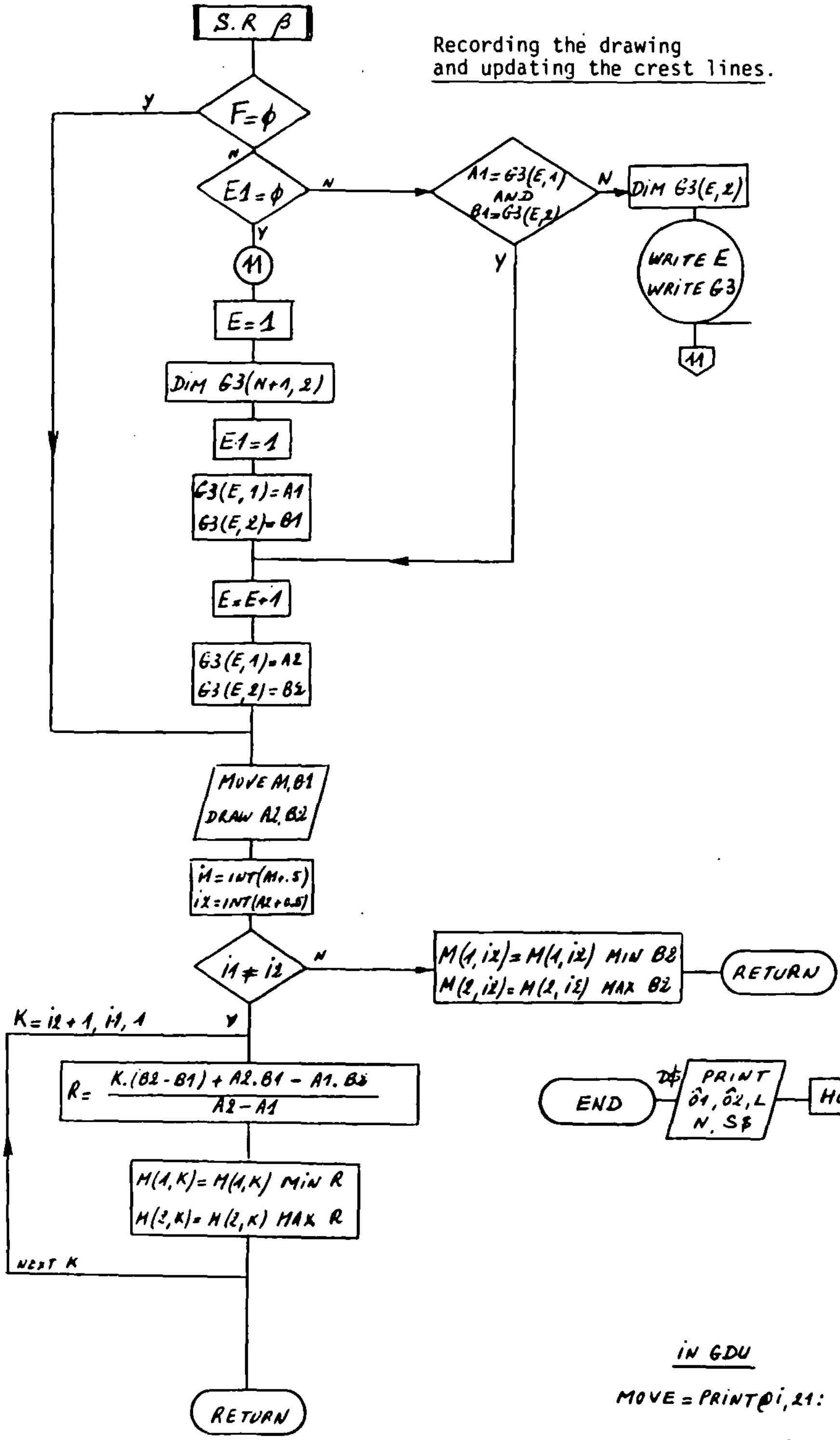


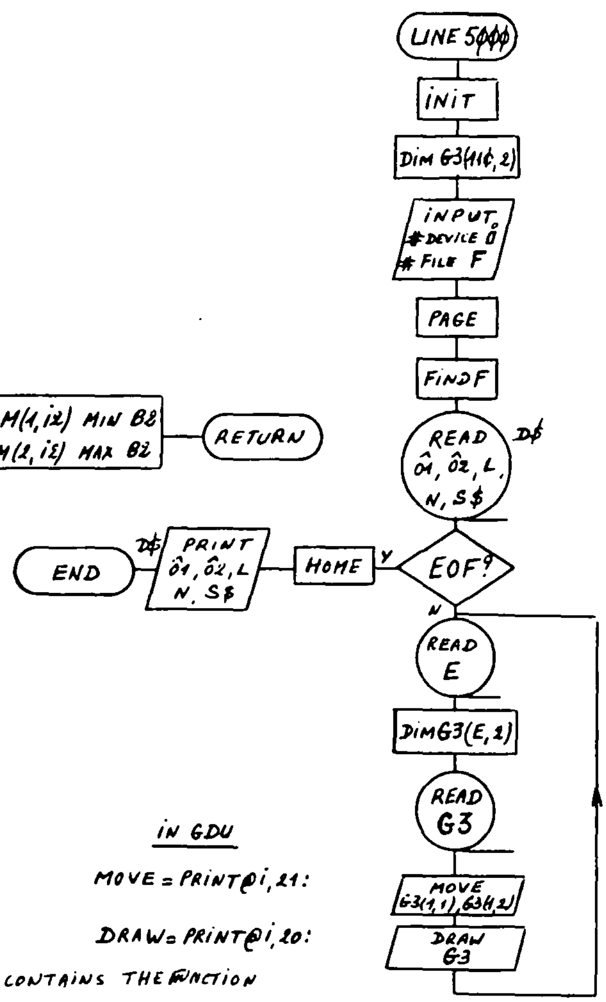
TITLE

General Function Z=F(X,Y) Plot

Recording the drawing
and updating the crest lines.



REDRAW THE FUNCTION



IN GDU

MOVE = PRINT@I,21:

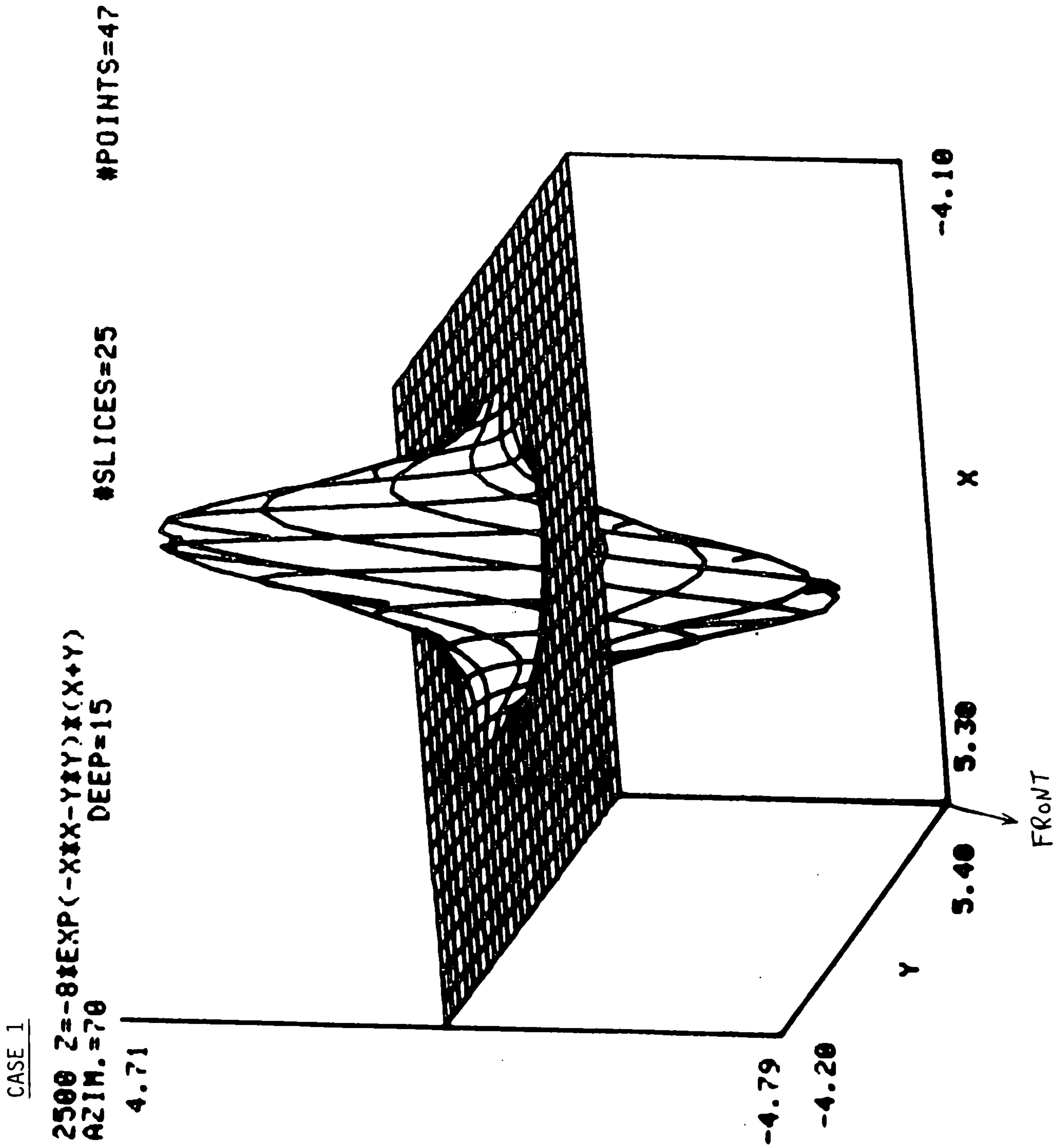
DRAW= PRINT@I,20:

D$ CONTAINS THE FUNCTION

TITLE

General Function Z=F(X,Y) Plot

TEST FOR THE 8 CASES



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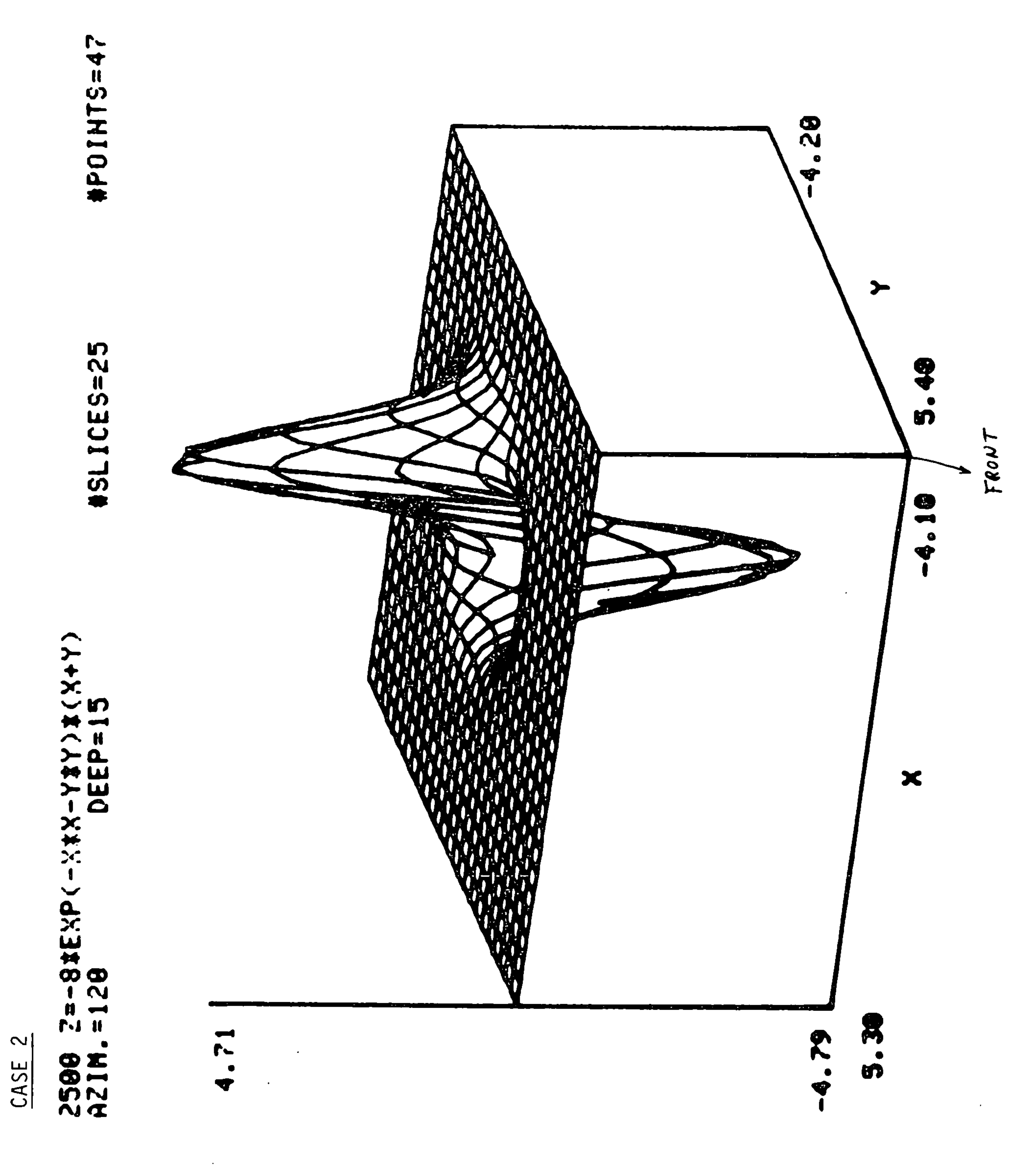

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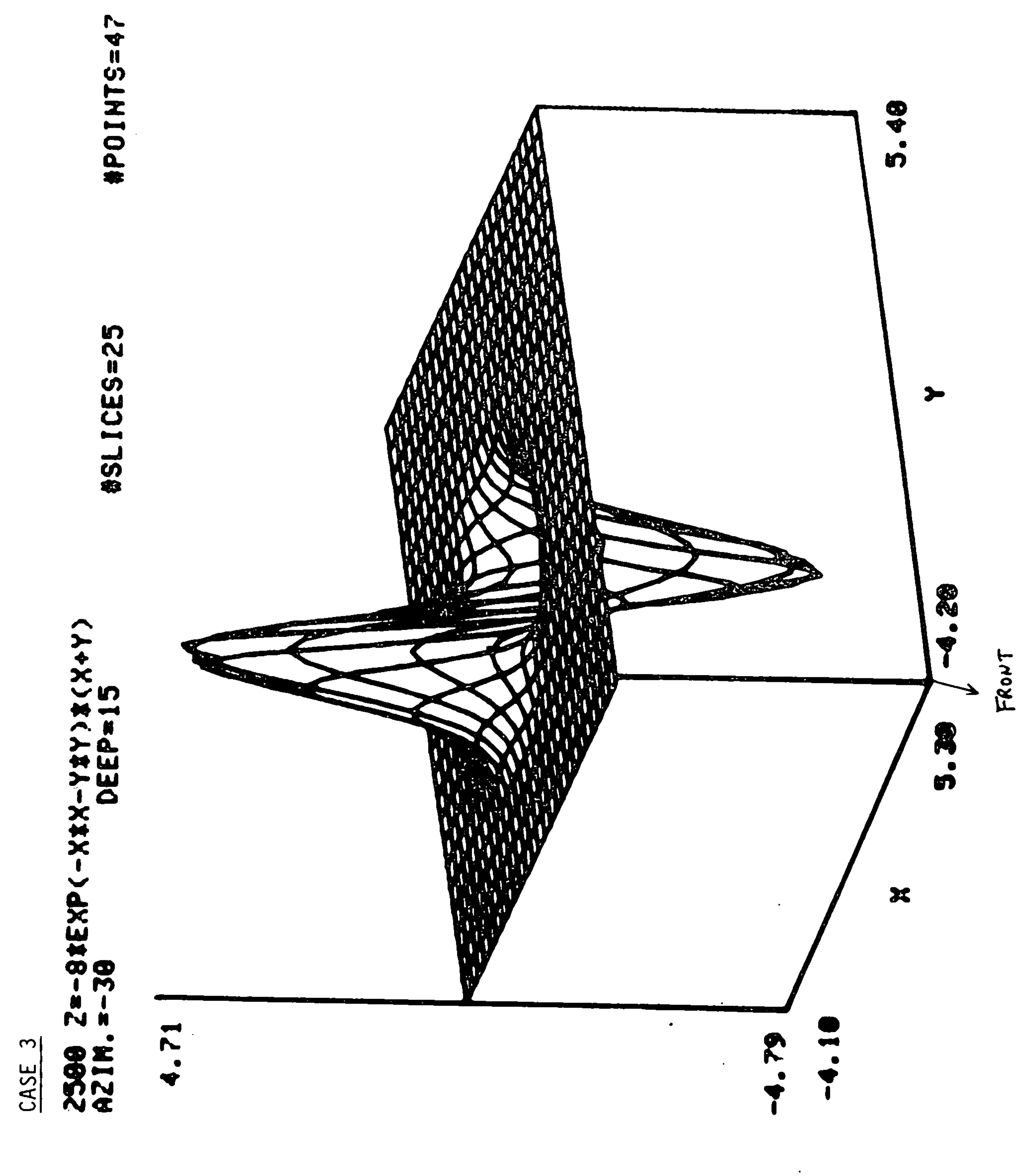

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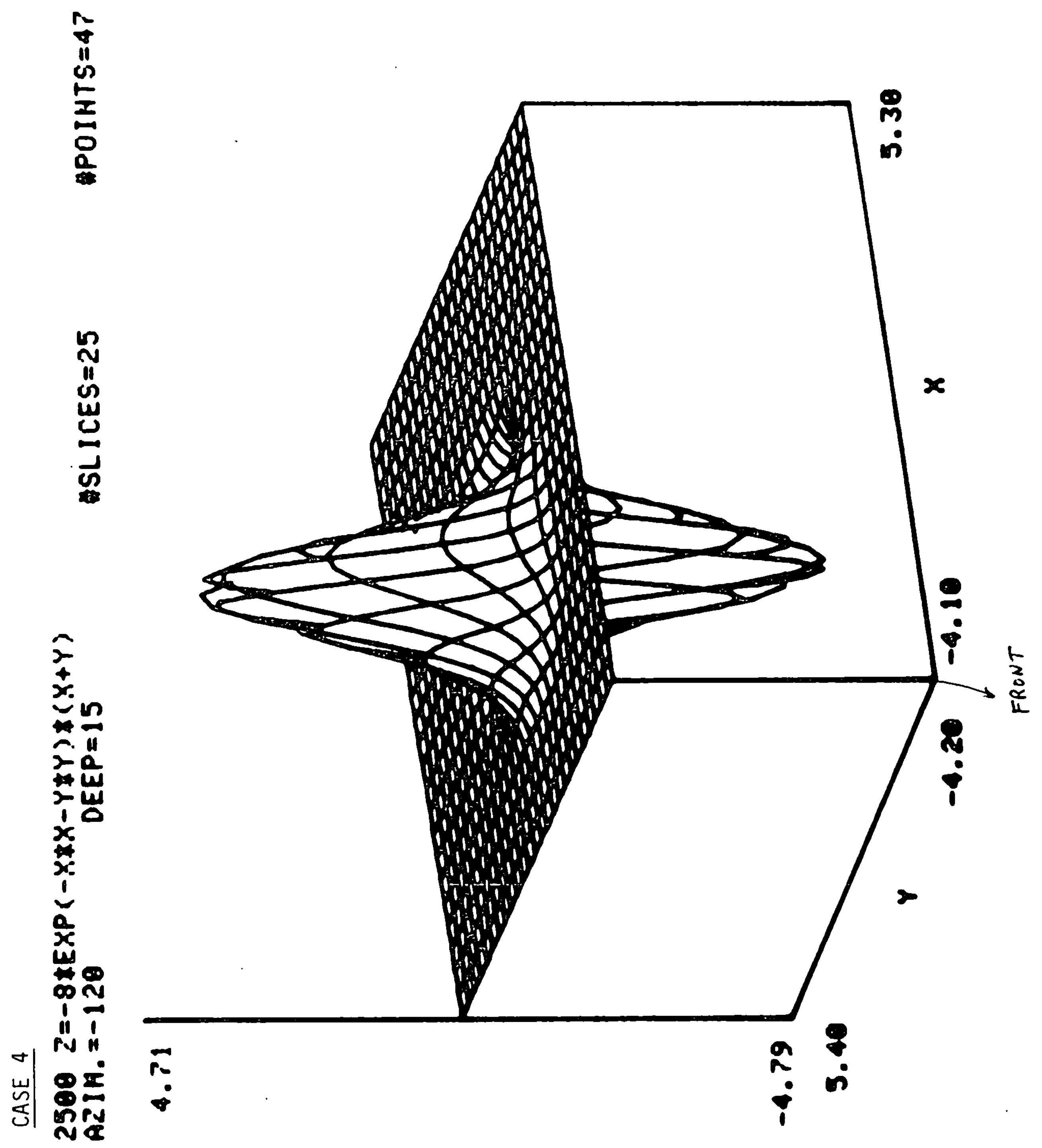

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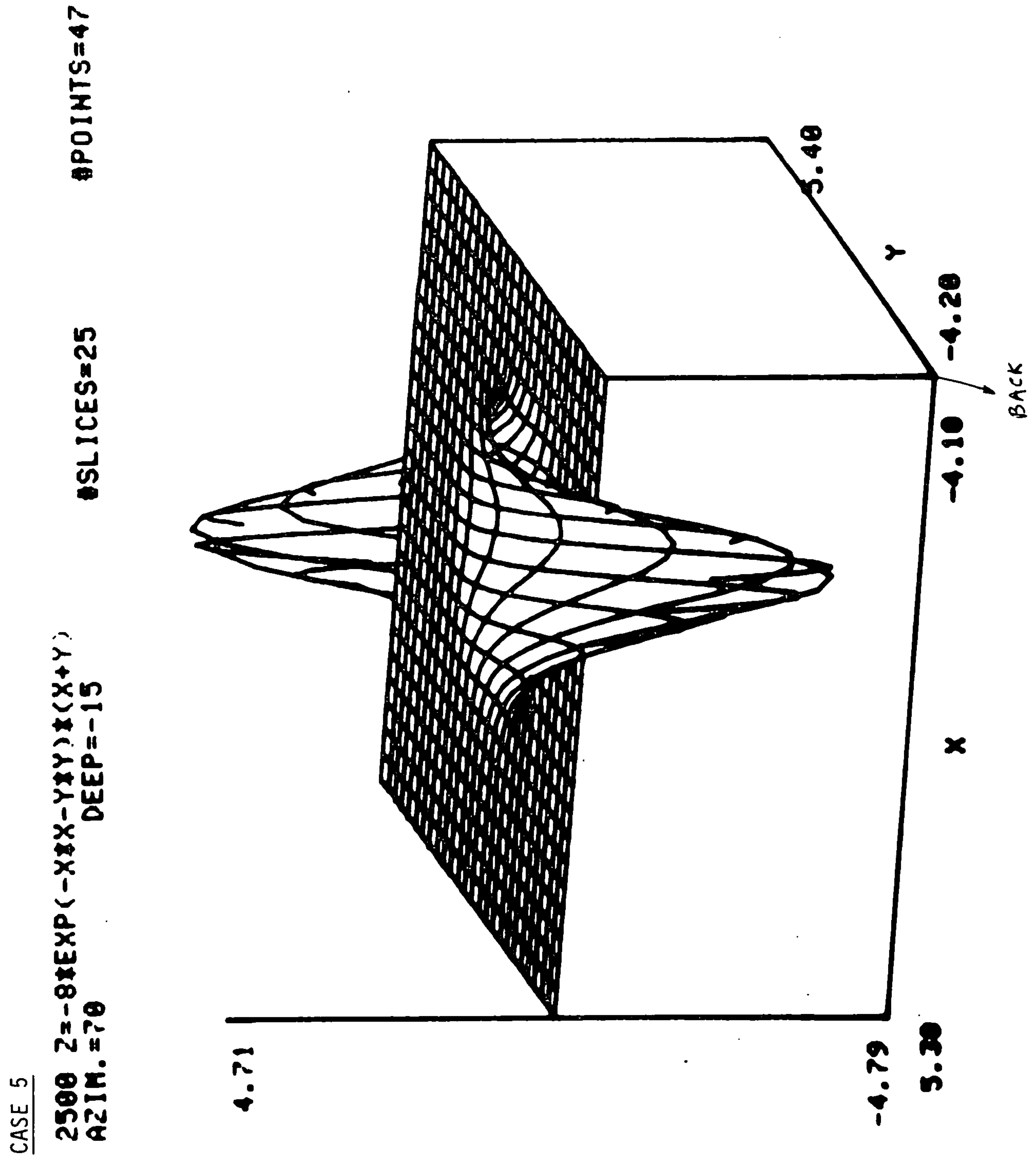

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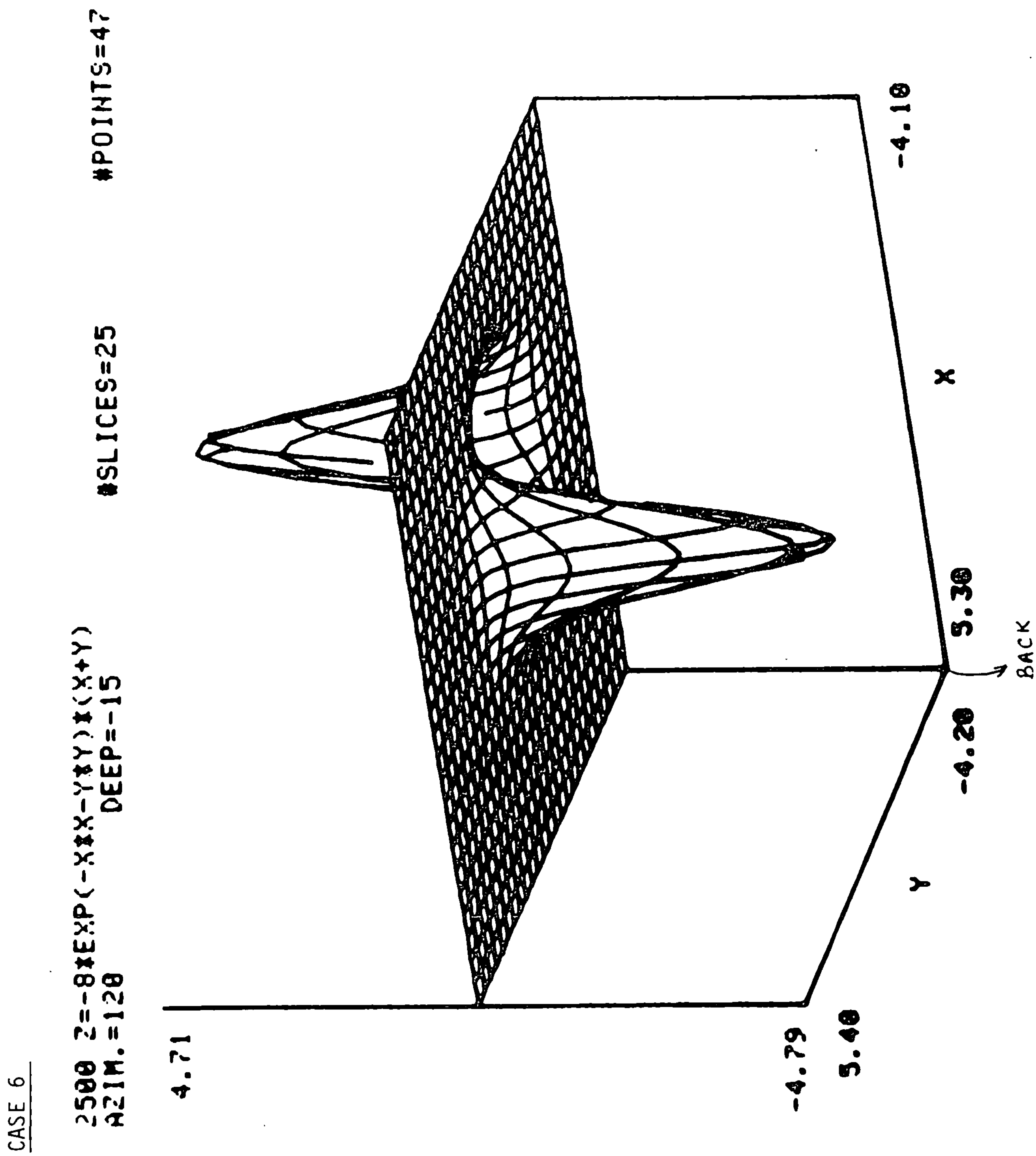

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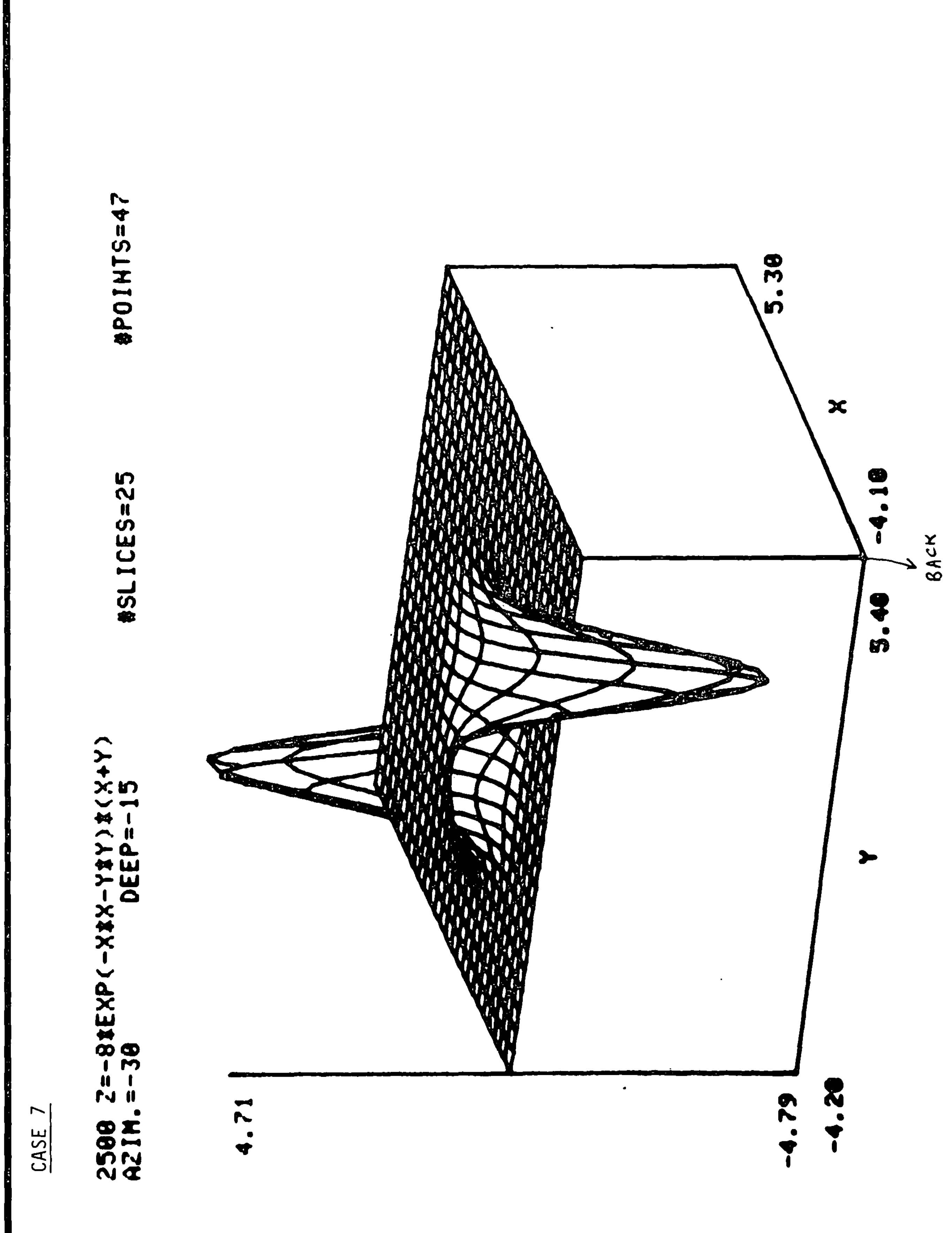

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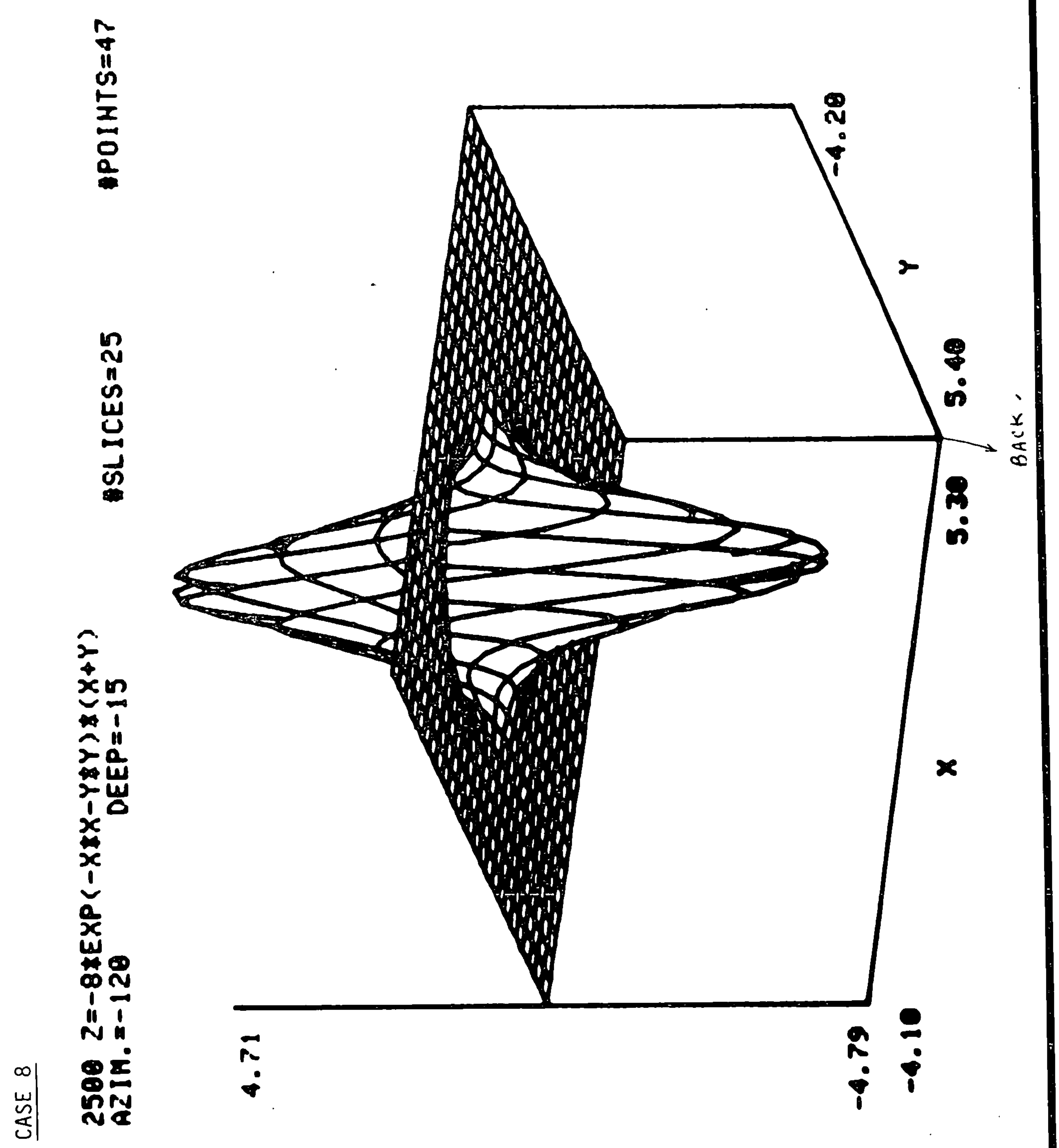

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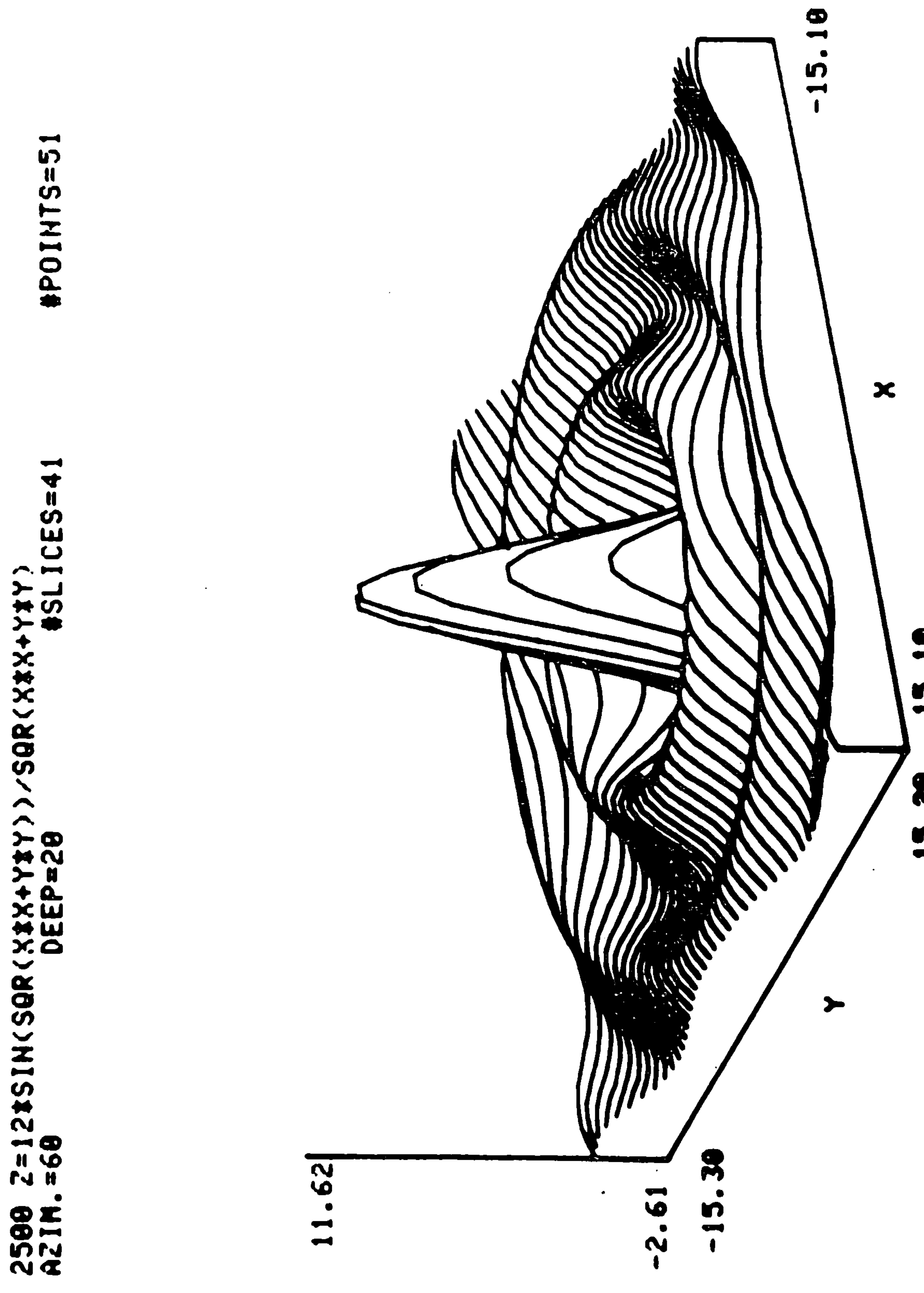

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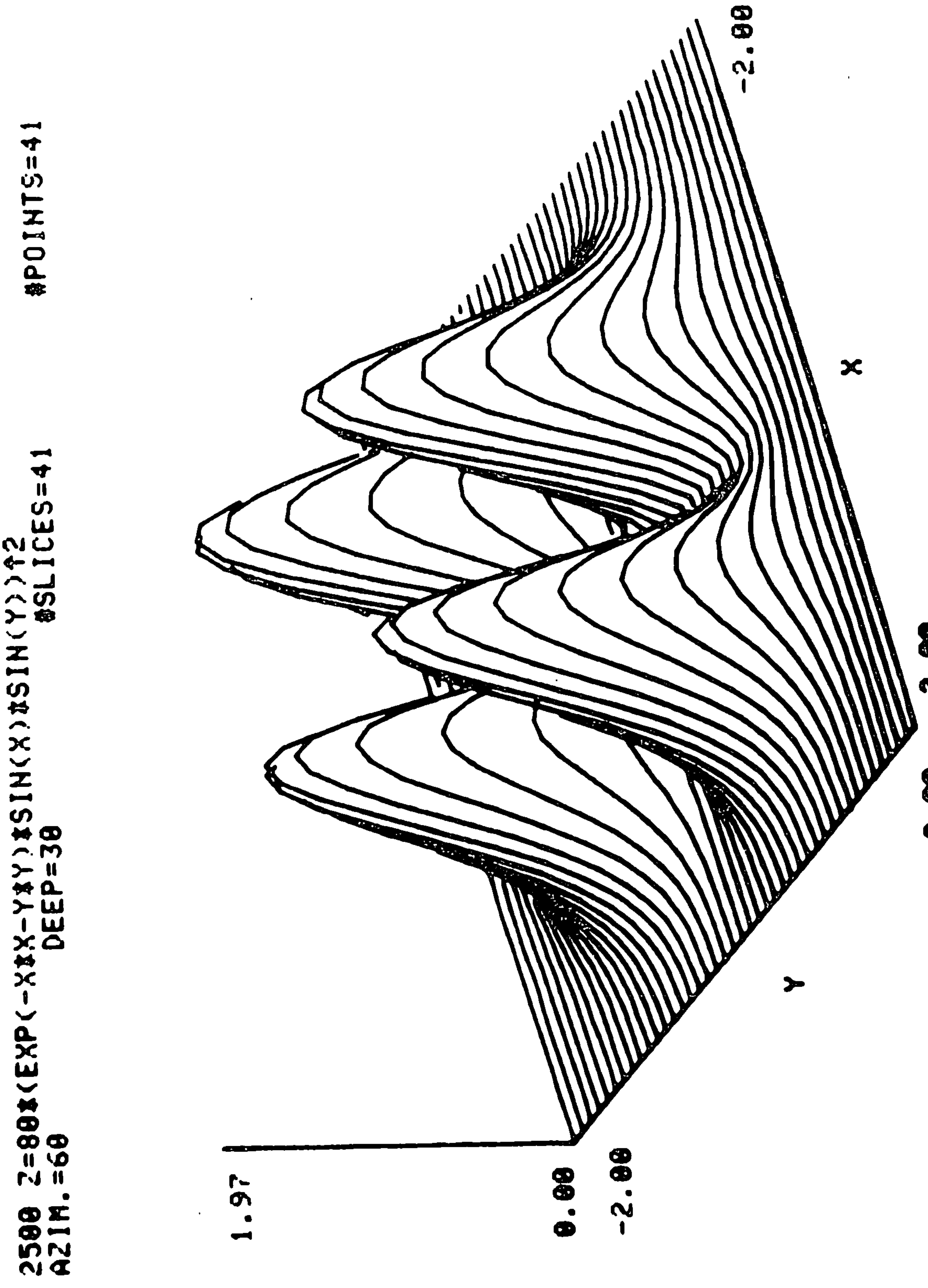
General Function Z=F(X,Y) Plot

EXAMPLES



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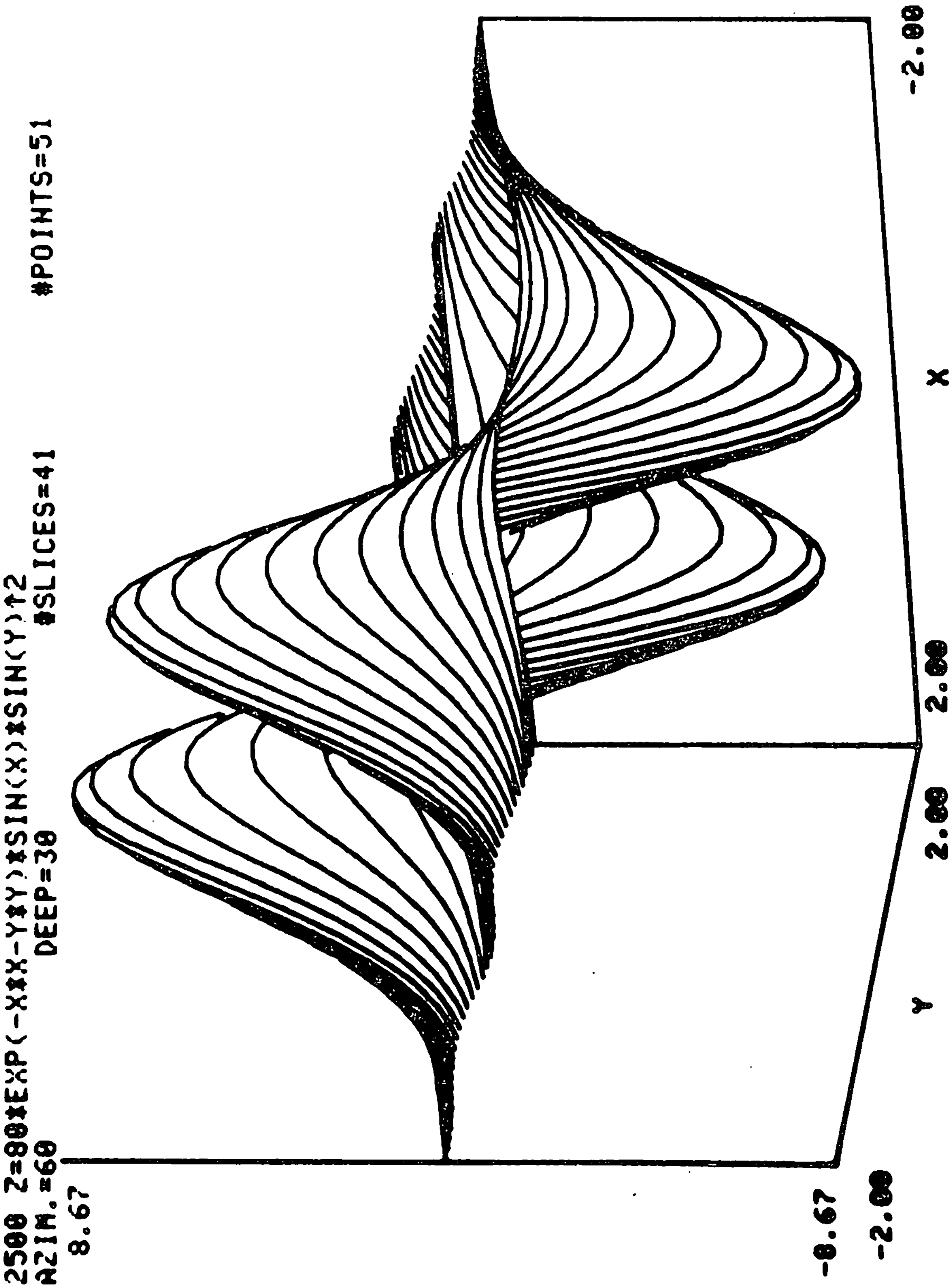

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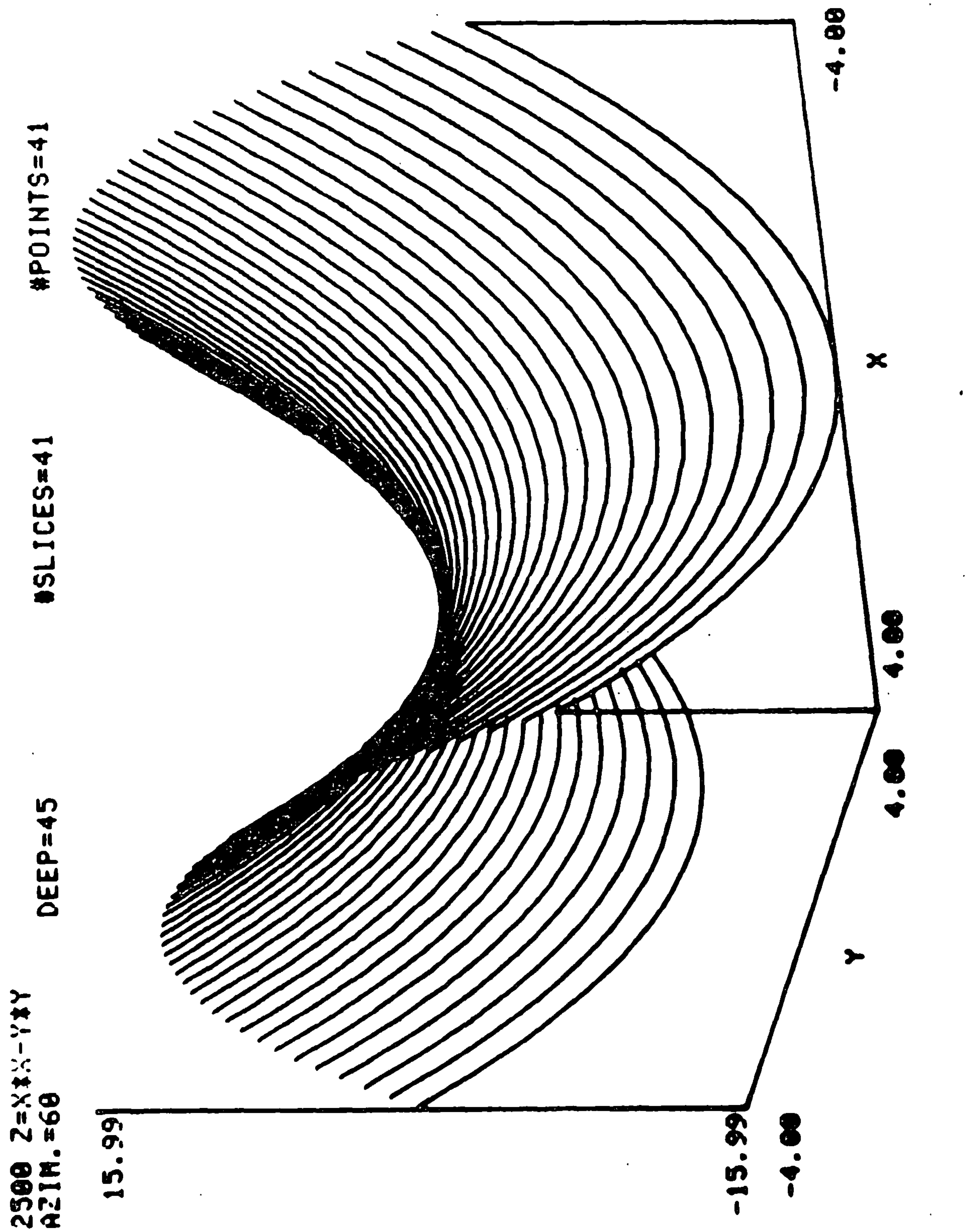

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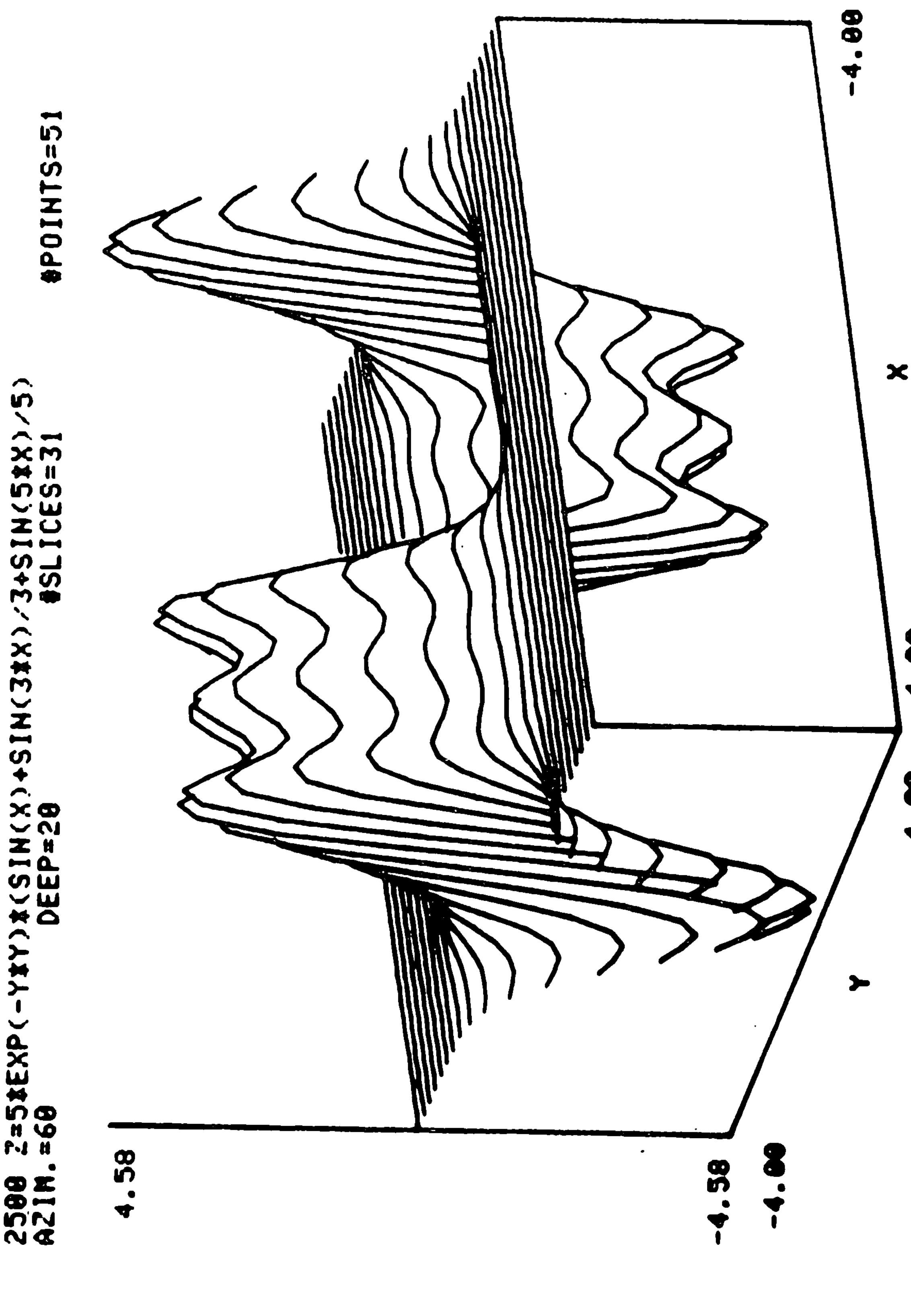

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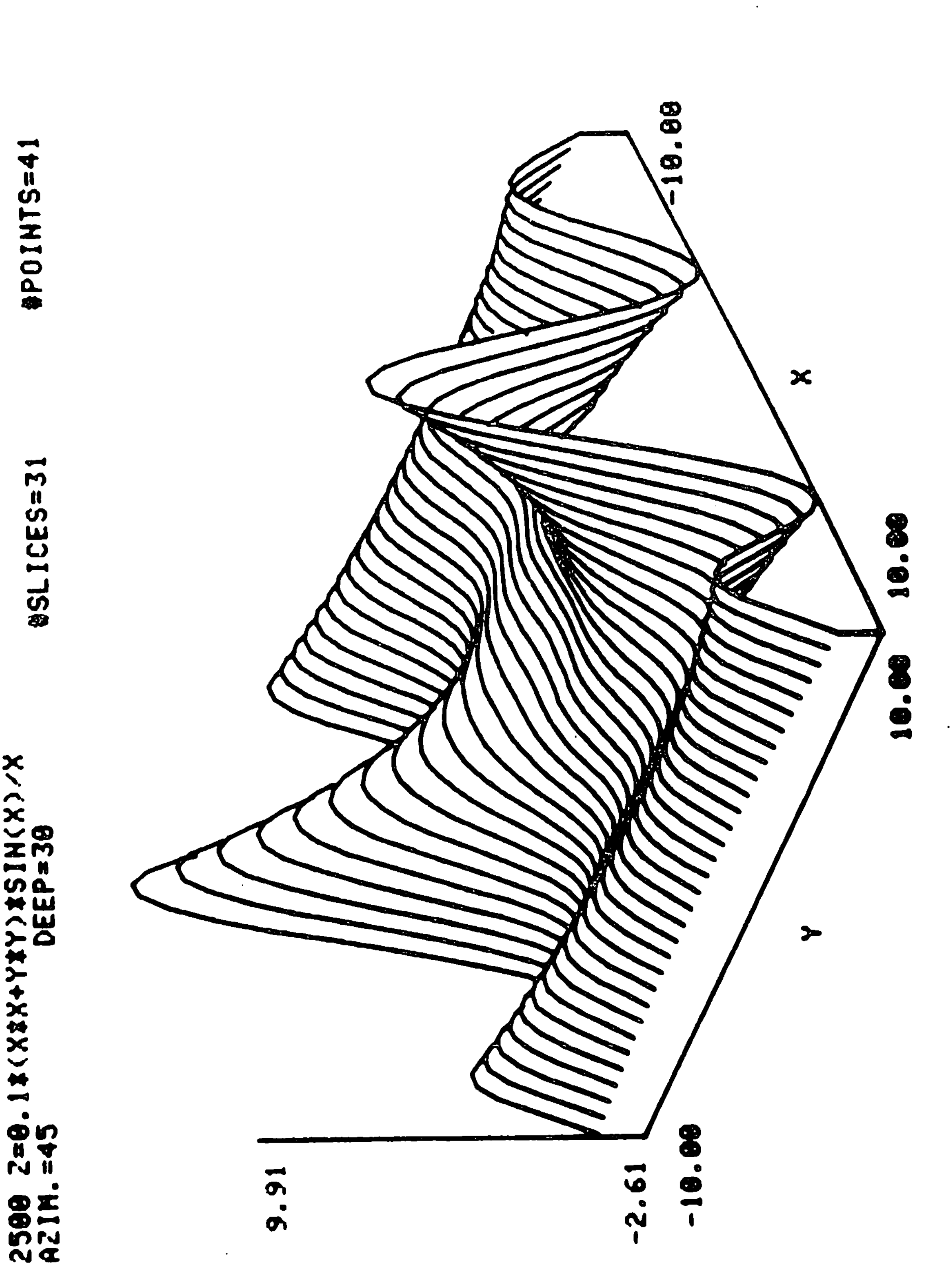

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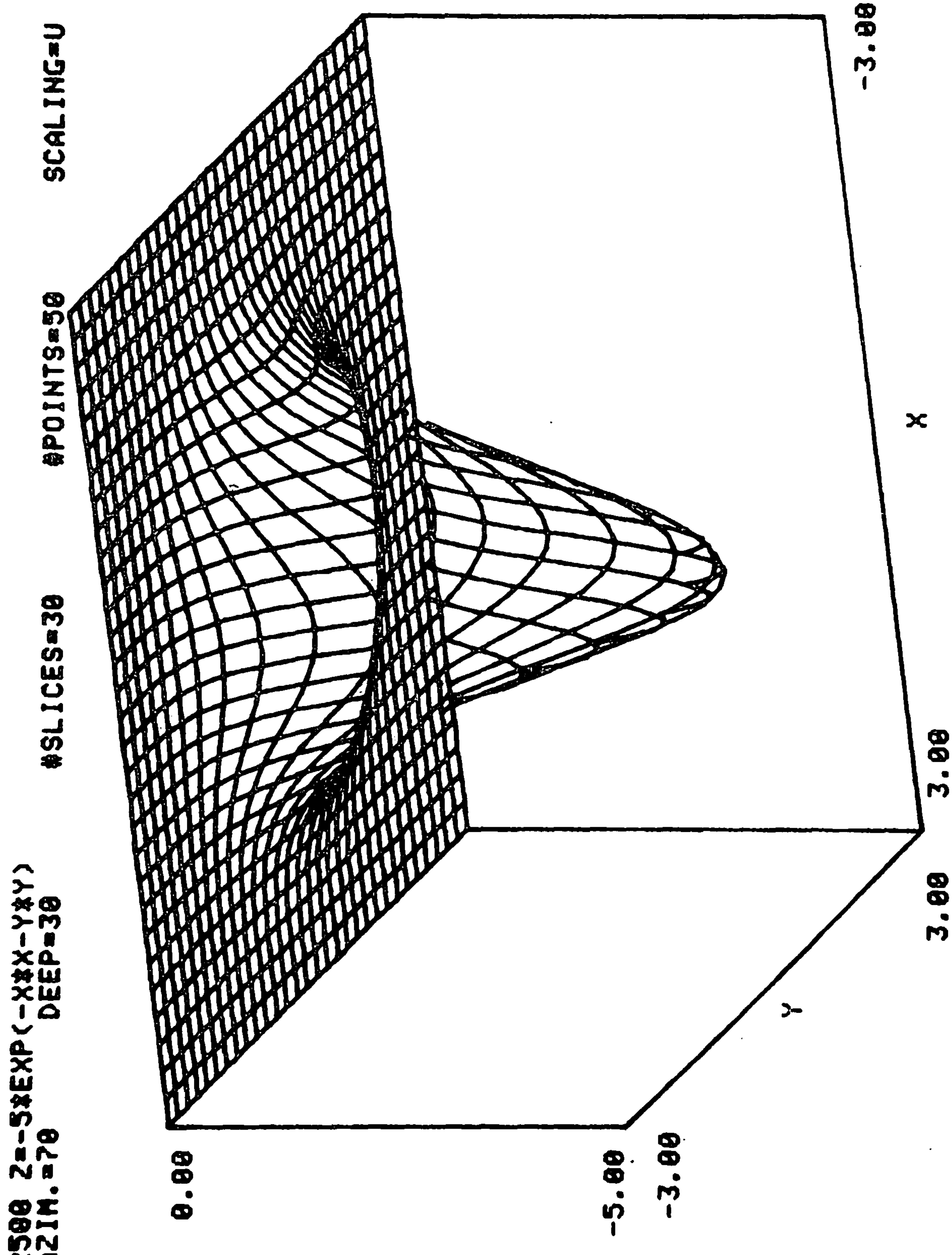

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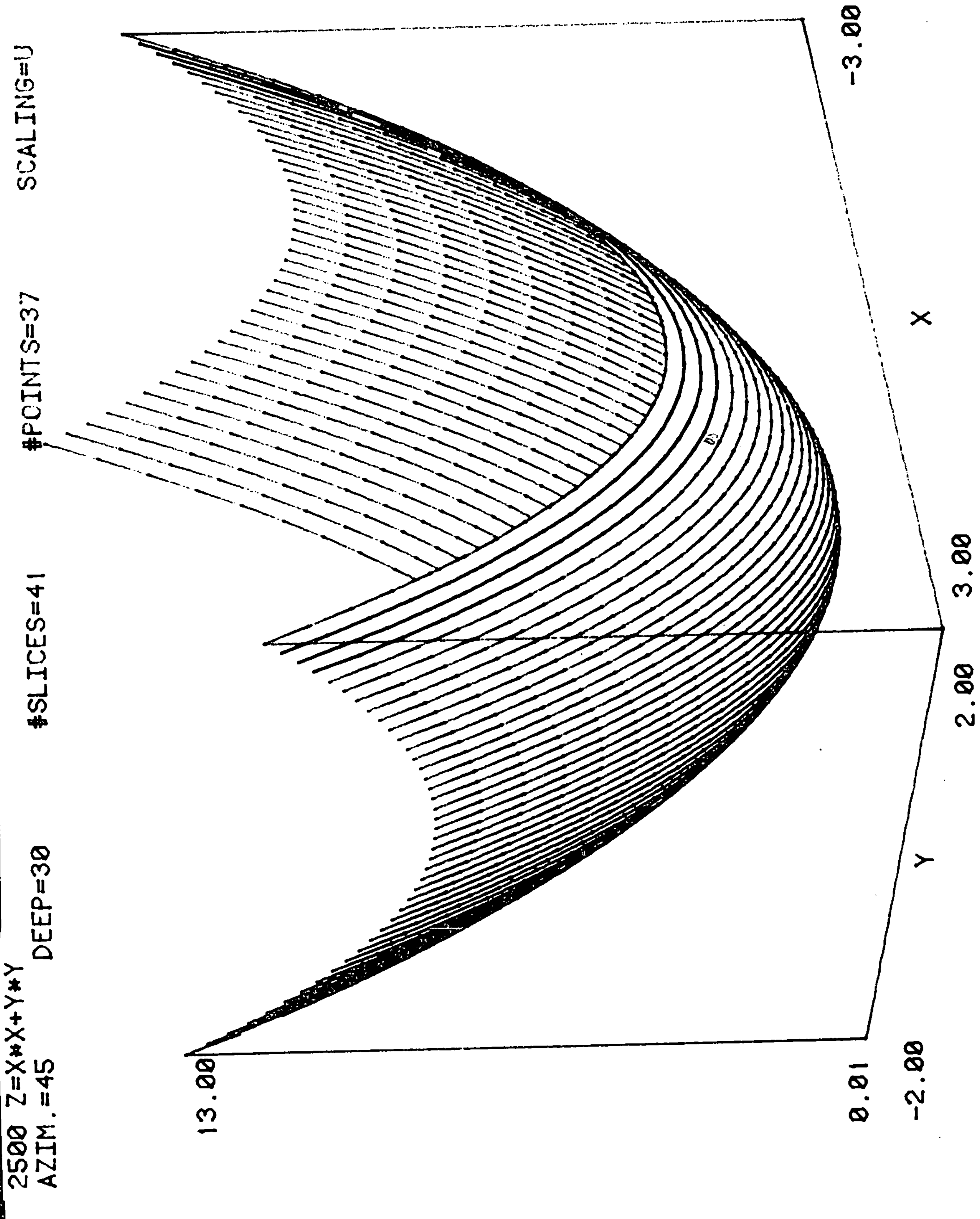

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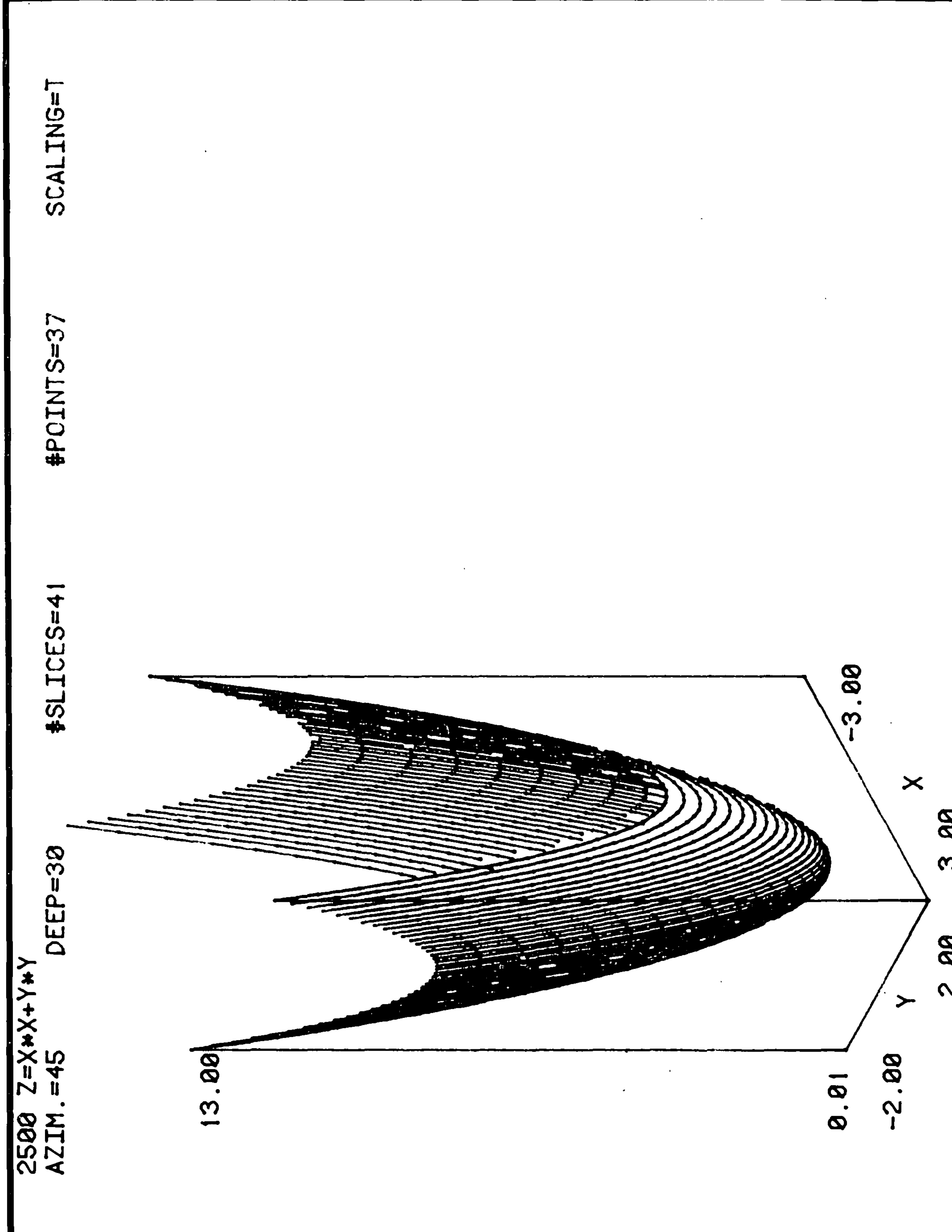

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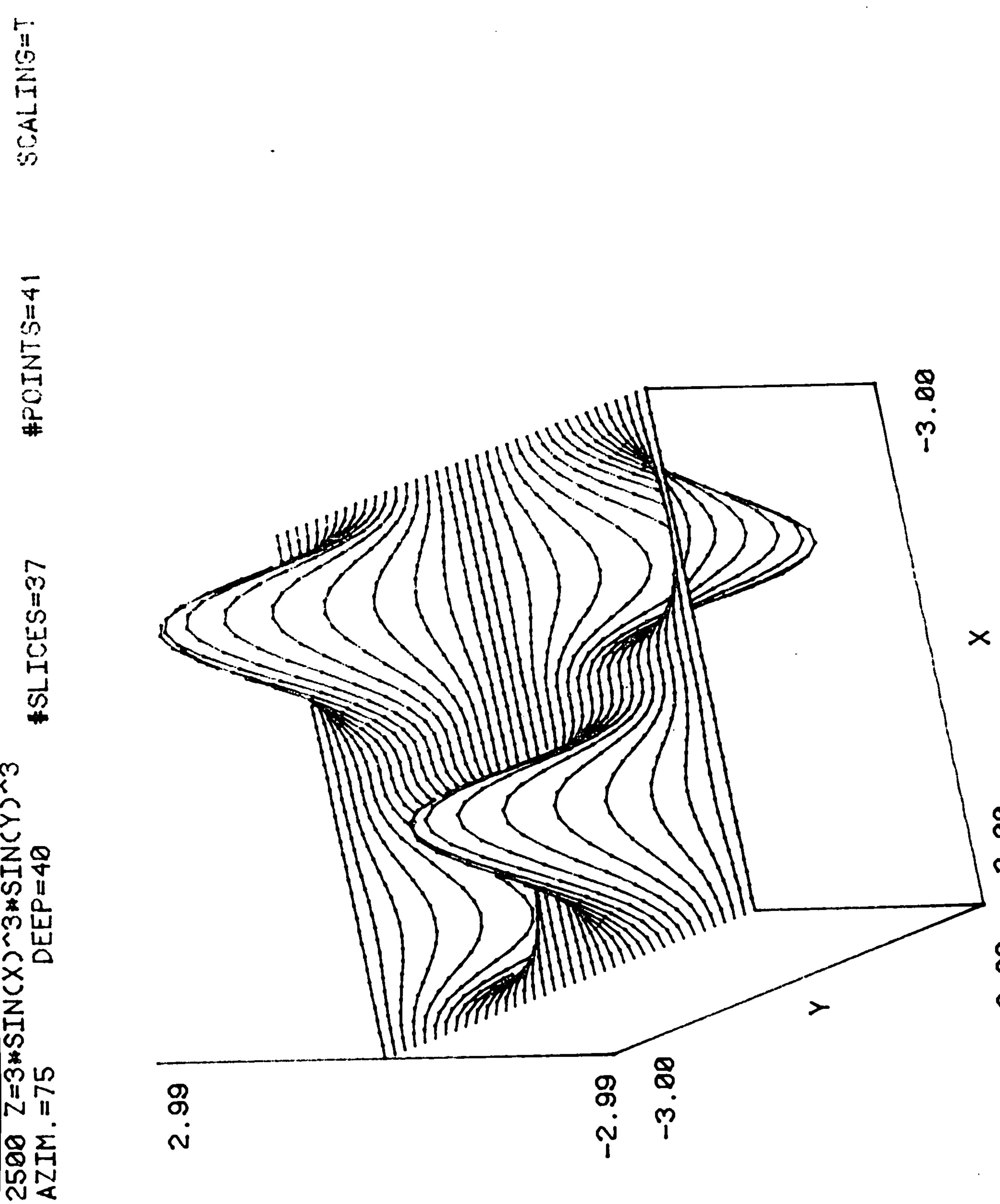

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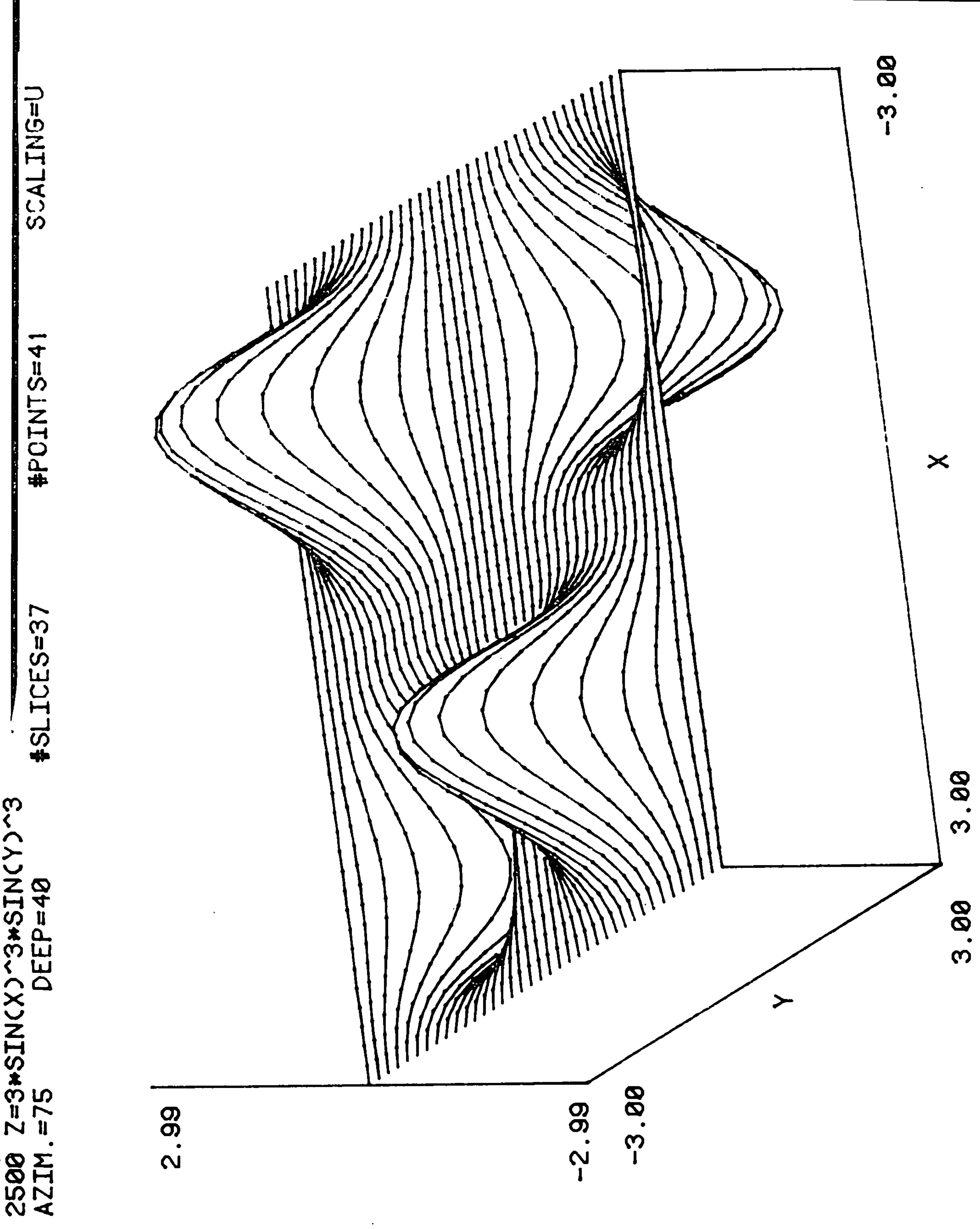

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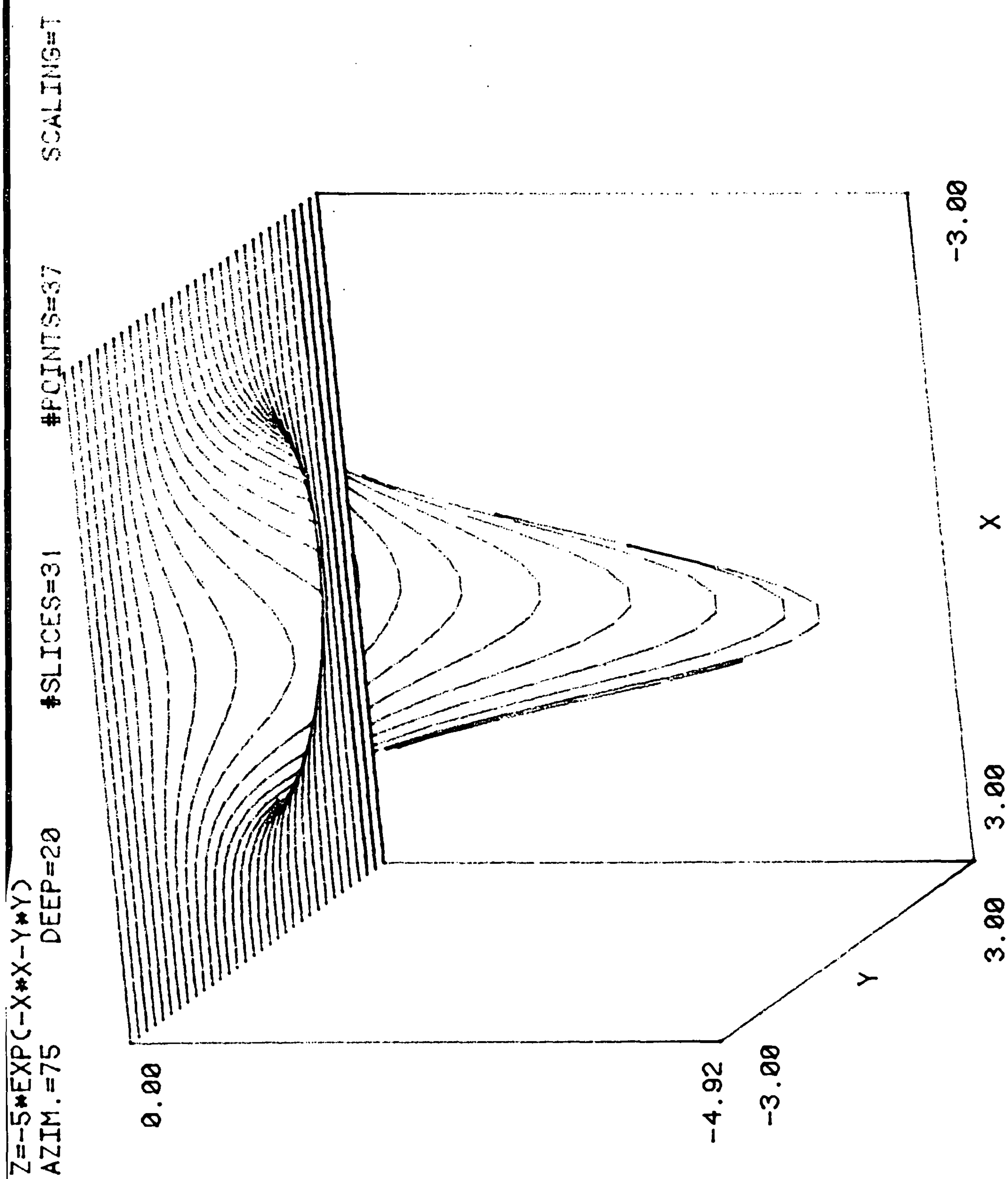

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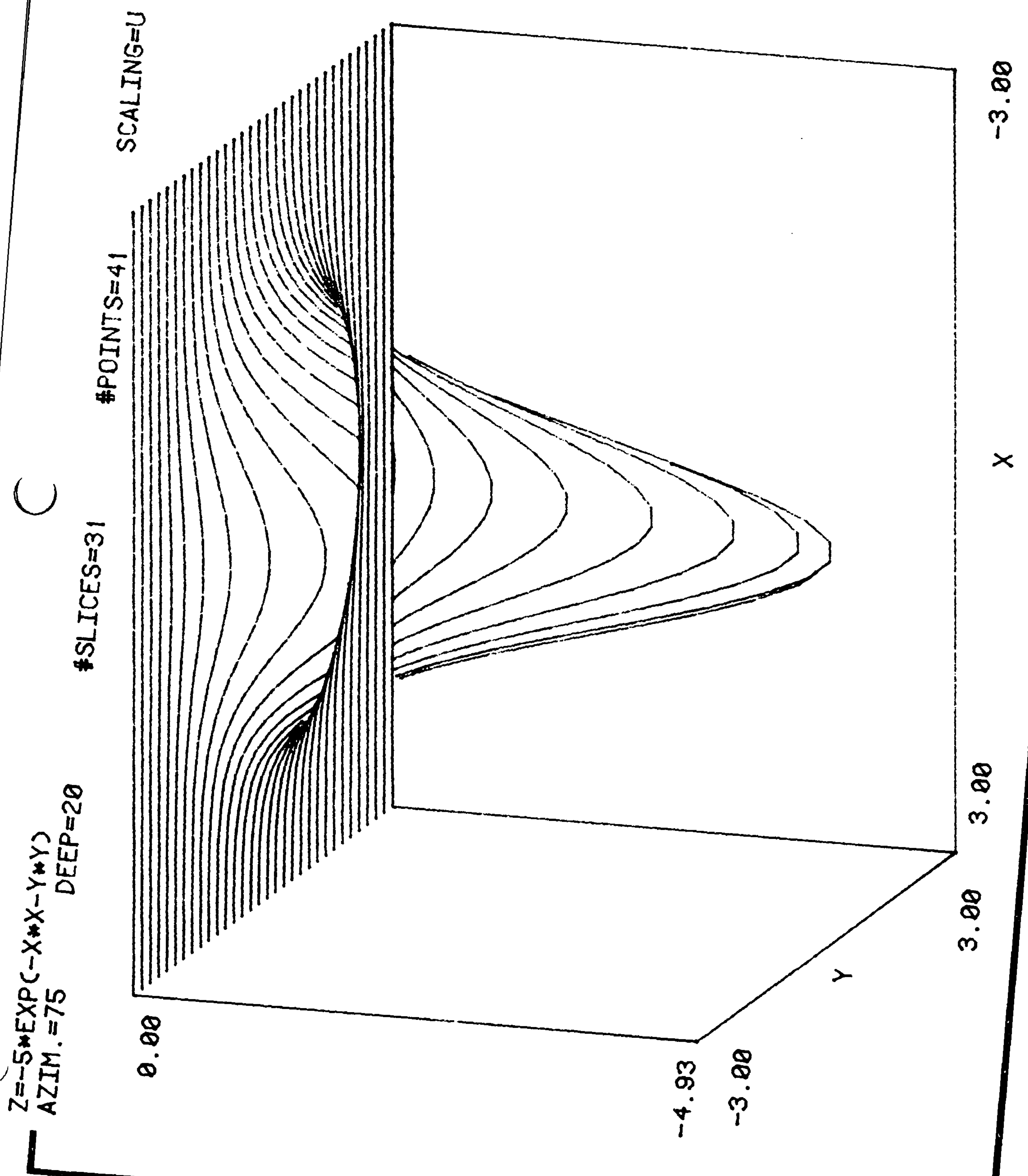

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