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TWO INTERACTIVE GRAPHICS POSTPROCESSORS FOR NASTRAN

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SUMMARY

Two new interactive computer graphics postprocessors, MAGGRAF and NASTEK, used for displaying NASTRAN-generated results are described. MAGGRAF is capable of displaying magnetic potentials or fields computed from results generated by a NASTRAN magnetostatic analysis. NASTEK is capable of displaying NASTRAN-generated PLT2 files on most Tektronix terminals. Exampl[illegible] the plotting capabilities for each of the programs will be presented [illegible] plots of the magnetic field around a ferromagnetic sphere and st[illegible] plots drawn with solid and dotted lines.

MAGGRAF

Introduction

MAGGRAF is an interactive computer graphics postprocessor used to display magnetic potentials, total fields, or field components computed from results generated by a NASTRAN magnetostatics analysis. This type of analysis computes magnetic potentials about ferromagnetic bodies due to source magnetic fields. MAGGRAF computes the magnetic fields or potentials from the prolate spheroidal harmonic expansion coefficients generated by NASTRAN. Magnetic fields or potentials can be displayed outside the prolate spheroidal surface at single points, along lines, or on planes in the form of X-Y graphs, two-dimensional (2D) contour plots, or three-dimensional (3D) surface plots.

Solving for the Magnetic Potential

The theory behind the governing equations for determining the magnetic potential around a ferromagnetic body is described in reference 1. Solving for the magnetic potential in MAGGRAF requires the solution of Laplace's equation in prolate spheroidal coordinates. The solution is given by

$$\phi(\xi,\eta,\theta) = \sum_{n=0}^{\infty} \sum_{m=0}^{n} \left[A_{mn} \cos (m\theta) + B_{mn} \sin (m\theta)\right] P_n^m(\eta) \left[\frac{Q_n^m(\xi)}{Q_n^m(\xi_o)}\right] \tag{1}$$

where

ϕ = reduced magnetic scalar potential

ξ, η, θ = prolate spheroidal coordinates

ξ_o = coordinate of the interior prolate spheroidal surface

P_n^m, Q_n^m = Legendre functions of the first and second kind, respectively

A_{mn}, B_{mn} = prolate spheroidal harmonic expansion coefficients

$$\left.\begin{matrix} A_{mn} \\ \\ B_{mn} \end{matrix}\right\} = \frac{\varepsilon_m}{4\pi} (2n+1) \frac{(n-m)!}{(n+m)!} \int_0^{2\pi} \begin{matrix} \cos \\ \sin \end{matrix} (m\theta) d\theta \int_{-1}^{+1} \phi_o(\eta, \theta) P_n^m (\eta)\, d\eta$$

$$\varepsilon_m = \begin{cases} 1, & m = 0 \\ 2, & m > 0 \end{cases}$$

$\phi_o(\eta, \theta)$ = distribution of potential ϕ on prolate spheroidal surface $\xi = \xi_o$

If the user has included in the finite element model a prolate spheroidal surface which encompasses all of the ferromagnetic material, then NASTRAN can compute the prolate spheroidal harmonic expansion coefficients and store them on a Fortran-readable file. MAGGRAF accesses these coefficients and solves equation (1) for any point outside the surface.

Input

Several quantities must be input to MAGGRAF before the program can compute the magnetic potential or field including the name of the file containing the prolate spheroidal harmonic expansion coefficients, a user-defined title, the type of graphic output to be generated, the component of the magnetic field strength or induction to be computed, and the output units. The type of graphic output selected determines the input, i.e., the coordinates of the points which define the X,Y,Z locations at which the magnetic field or potential is to be computed. For example, to define a set of points on a line, the Y and Z coordinates, the beginning and ending X coordinates, and the number of increments in X are input. To define a rectangular grid of points on a plane, the Y coordinate, the bounding X and Z coordinates of the plane, and the number of increments in X and Z are input. Linear combination factors are also input. These factors multiply the value of the source magnetic fields specified in subcases in the NASTRAN data deck to produce a total source magnetic field from various combinations of individual sources.

Output

All of the examples of output generated by MAGGRAF shown in figures 1-4 are of a component of the magnetic field strength or induction around a ferromagnetic sphere. An X-Y graph is shown in figure 1. A 2D contour plot is shown in figure 2. A 3D perspective surface plot is shown in figure 3. A 3D orthogonal surface plot with hidden lines removed is shown in figure 4.

To generate a 2D contour plot, contour lines are drawn in rectanglar regions formed by four adjacent points at which the magnetic field or potential was calculated. For each rectangle, a fifth point is interpolated in the center. The five points define four triangular subregions. Given the values of a contour line and of the magnetic field or potential at the five points, the coordinates of the points at which a contour line will cross the sides of the triangular subregions can be determined.

The elevation of a 3D surface corresponds to the values of the magnetic field or potential. To remove the hidden lines in the 3D surface plot, the surface is rotated such that points along a diagonal of the grid of points at which the magnetic field or potential was computed will appear along a vertical line on the plot (ref. 2). Then MAGGRAF can compute the points that are visible along any vertical line on the plot.

NASTEK

Introduction

NASTEK plots NASTRAN-generated PLT2 files on Tektronix 4010, 4050, 4100. and 4110 series terminals (ref. 3). Many options are available in NASTEK. Any frame in the PLT2 file can be plotted, or the entire file can be plotted automatically with a hardcopy made of each frame. Frames can be reduced or enlarged by setting a scale factor. Plots can be drawn with solid, dotted, dashed, or colored lines by using the PEN option on the PLOT card. Four styles of dotted or dashed lines are available. Eight different colored solid lines are available on the color Tektronix terminals.

Output

Figures 5-8 are examples of plots generated by NASTEK. Figure 5 is a plot of displacement contours. Figure 6 is an enlarged plot of the frequency deformation of a structure. Figure 7 is an enlarged plot of the undeformed shape of a structure. Figure 8 is an enlarged plot of the same structure as in figure 7, plotted with different types of dotted lines to differentiate parts of the structure. Colored lines could have been used instead of the dotted lines.

COMPUTER CODE

Both MAGGRAF and NASTEK are written in Fortran 77. MAGGRAF and NASTEK are approximately 4000 and 600 lines long, respectively. Currently, both programs are written with subroutines from the Tektronix TCS and Advanced Graphing II library of graphics subroutines. The future version of MAGGRAF will be rewritten with Metagek's TEMPLATE graphics software and will produce plots in color. The future version of NASTEK will be software independent.

REFERENCES

1. The NASTRAN User's Manual, NASA SP-222(06), September 1983.

2. Coleman, H. P.: A Fortran IV Plot Routine with Hidden Line Suppression for use with Small Computer Systems. Naval Research Laboratory Report NRL 4776, March 1982.

3. Lipman, R. R.: NASTEK - Interactive Display of NASTRAN-Generated Plots. David W. Taylor Naval Ship Research and Development Center Report DTNSRDC/CMLD-84/01, January 1984.

FERROMAGNETIC SPHERE
Z COMPONENT OF MAGNETIC FIELD INDUCTION VERSUS X COORDINATE POSITION

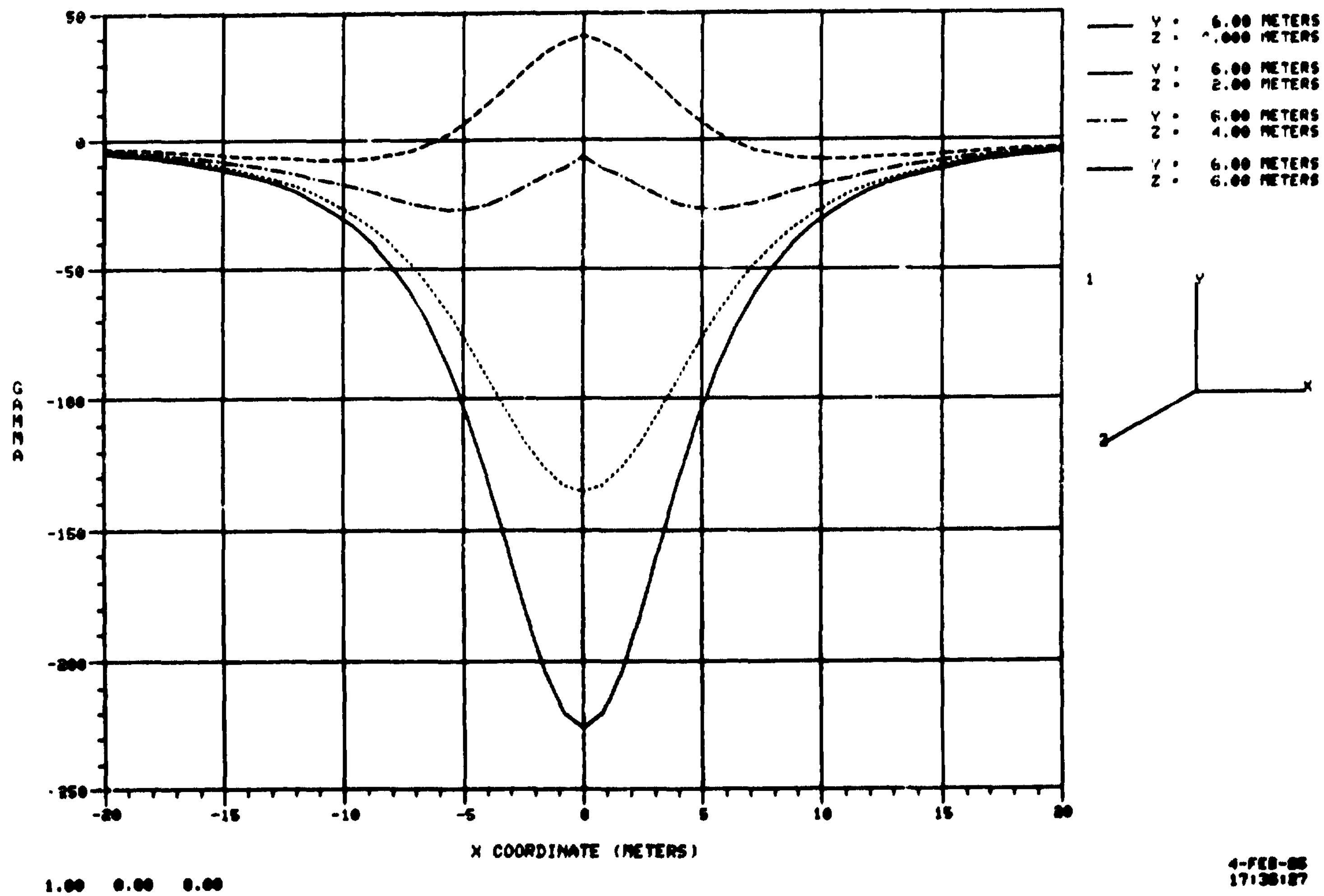

Figure 1 - X-Y graph

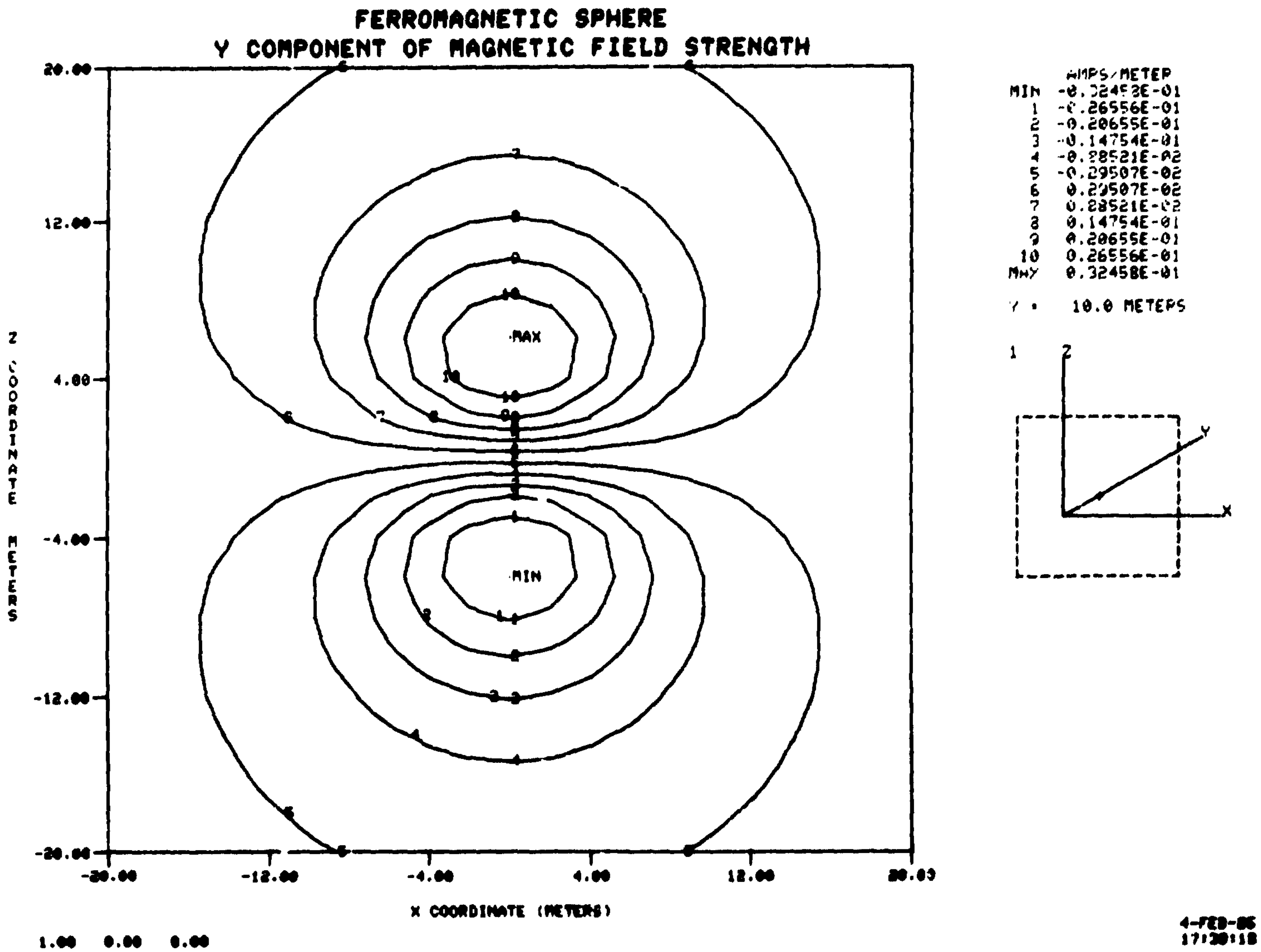

Figure 2 - 2D contour plot

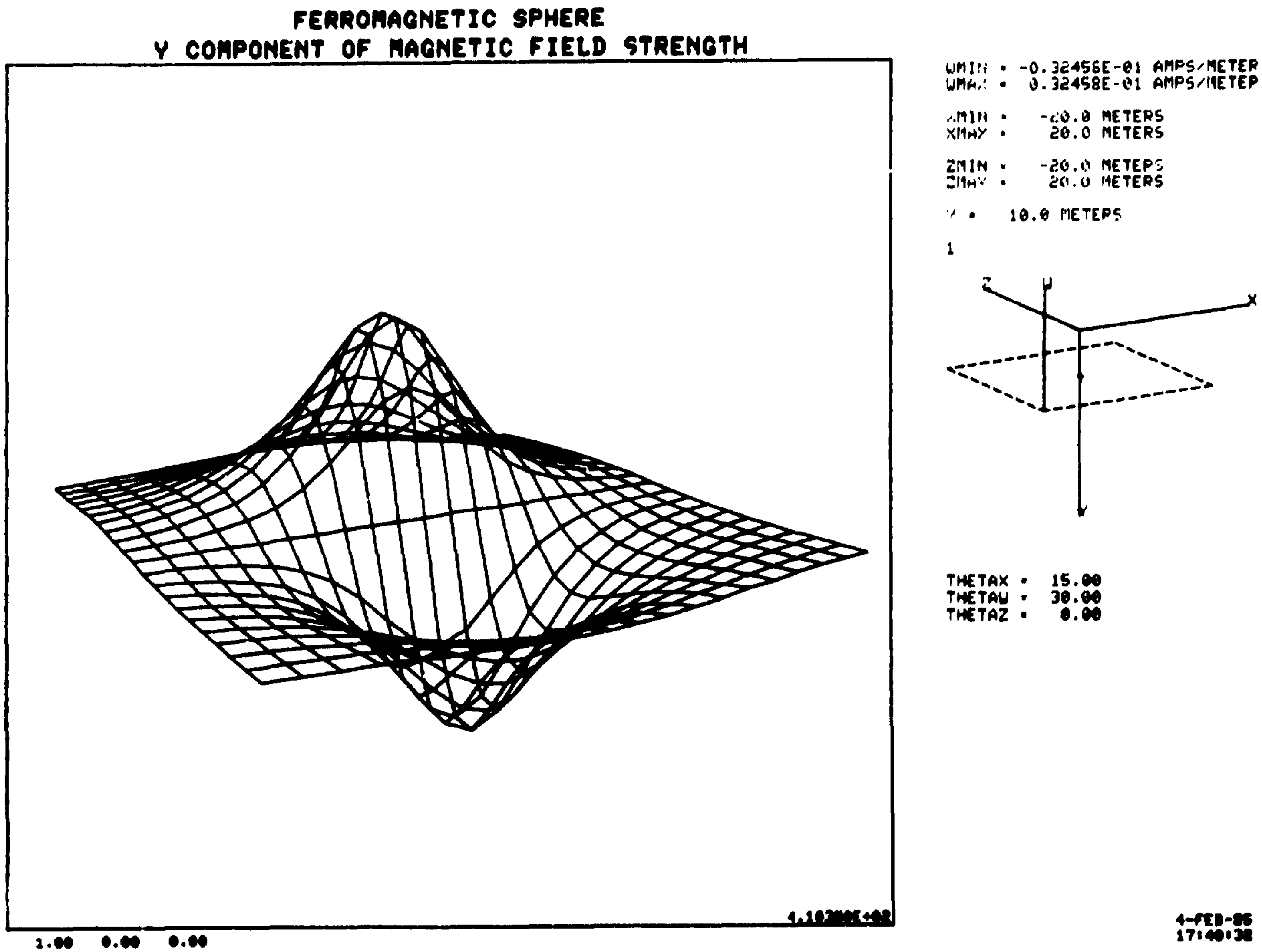

Figure 3 - 3D surface plot

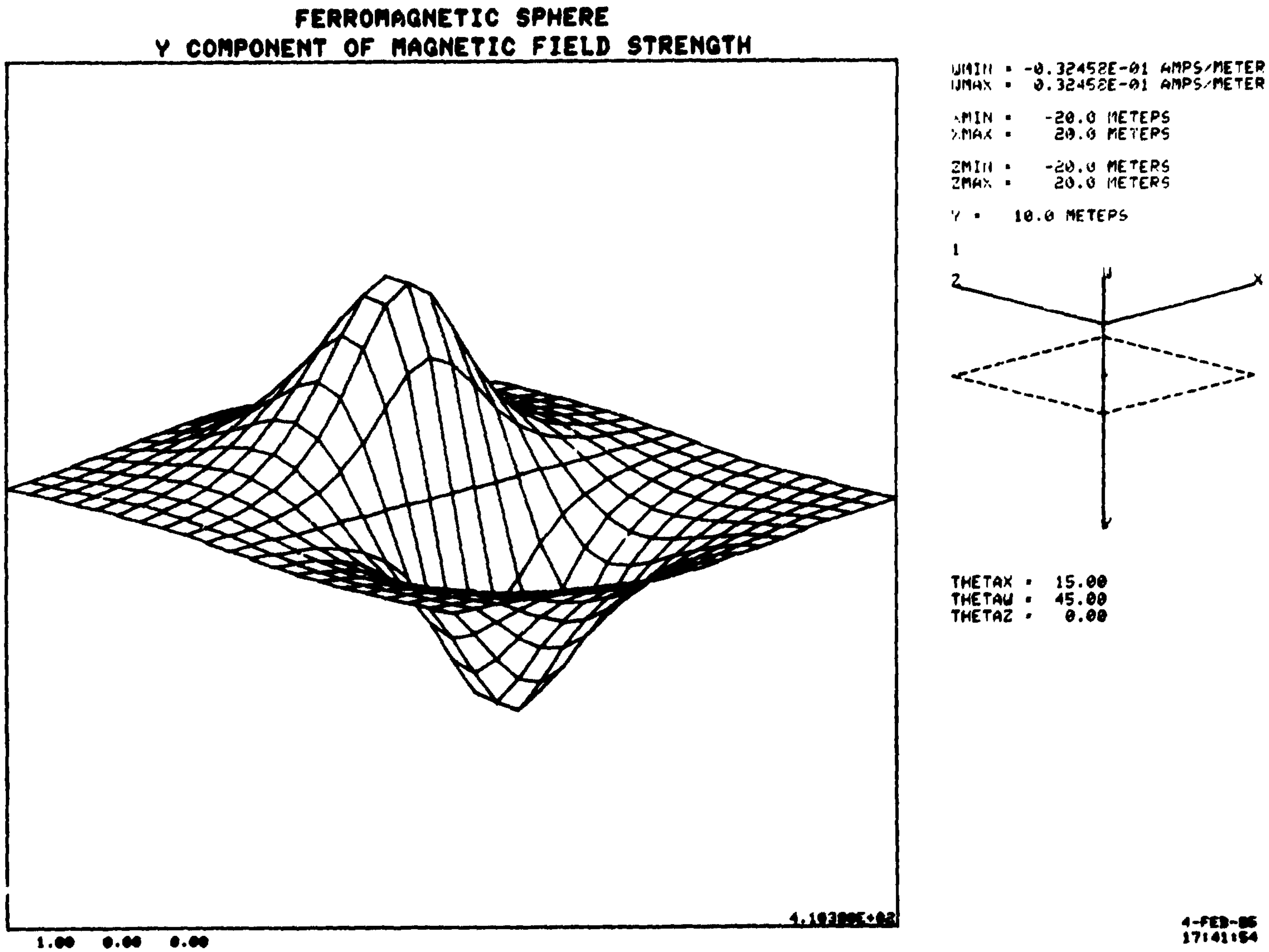

Figure 4 - 3D surface plot with hidden lines removed

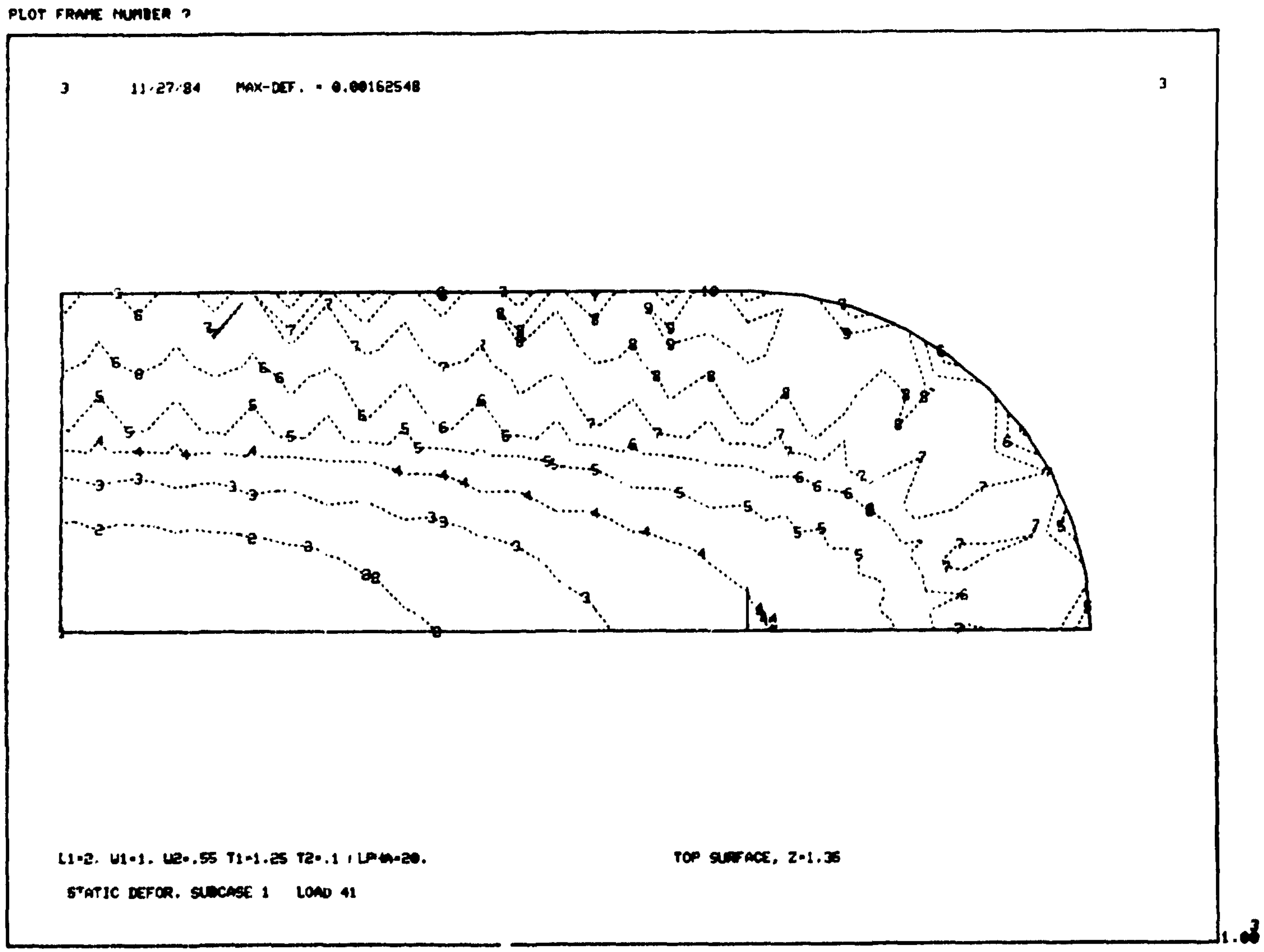

Figure 5 - Displacement contours

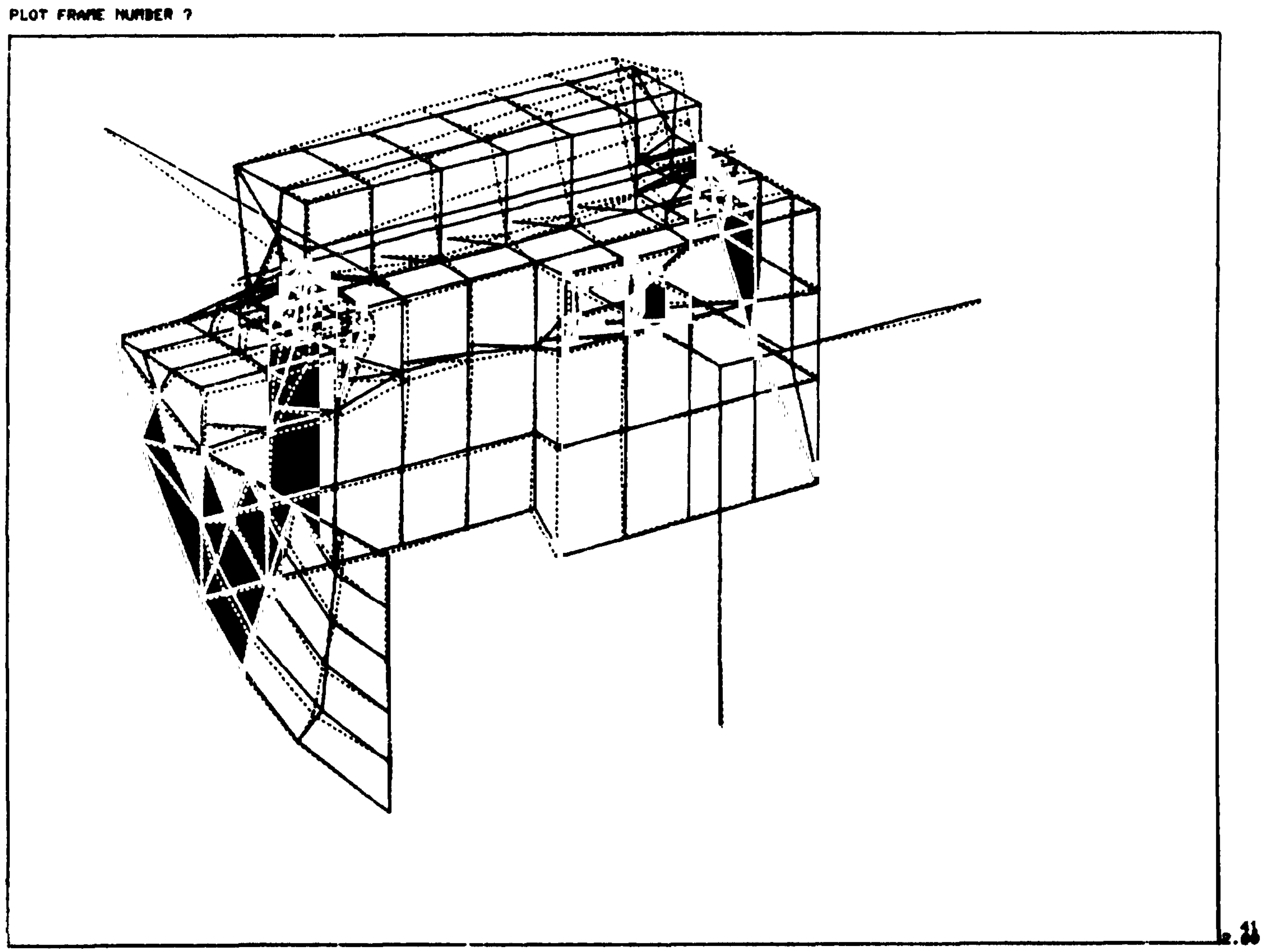

Figure 6 - Plot of frequency deformation

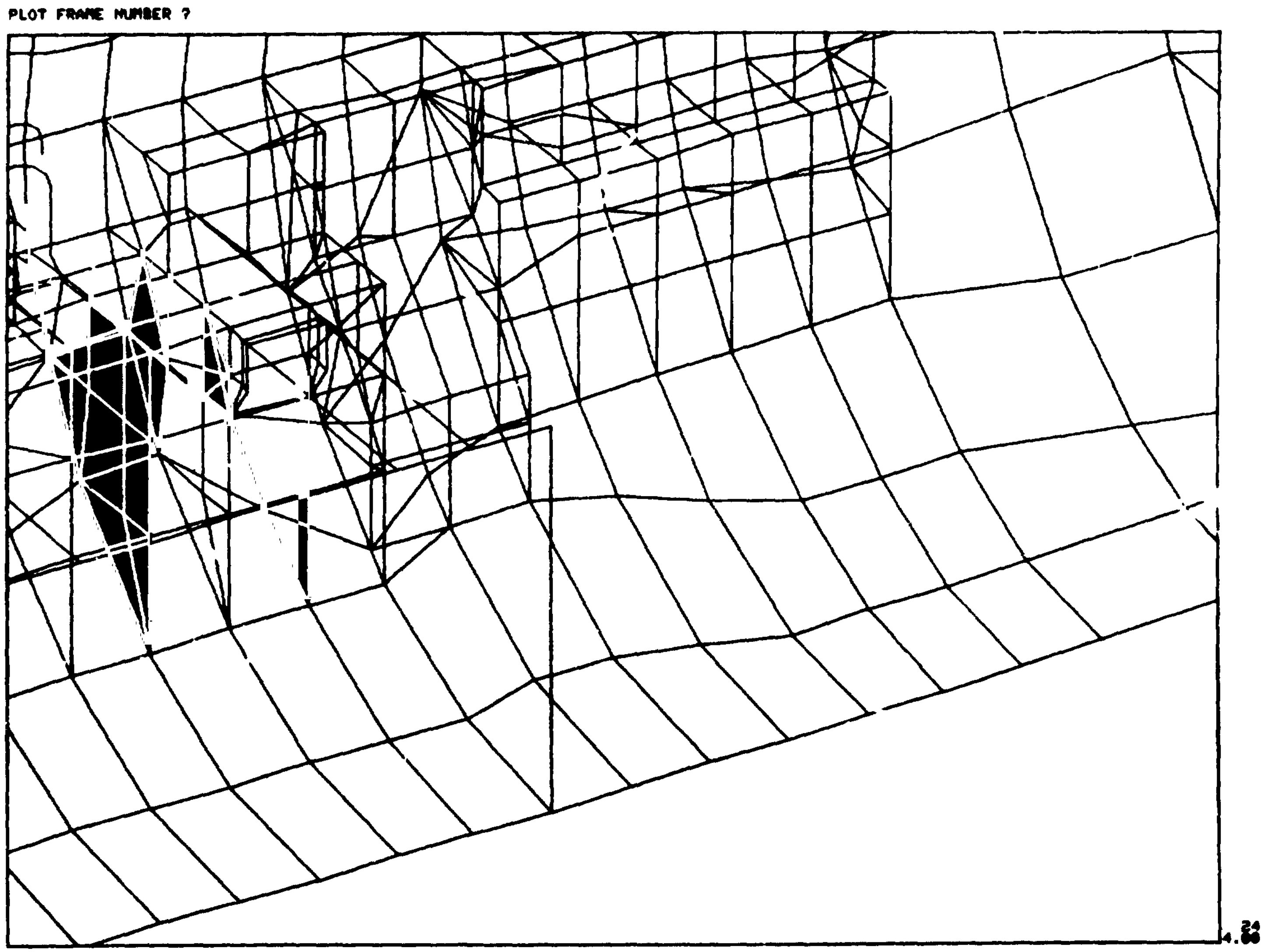

Figure 7 - Undeformed shape of a structure

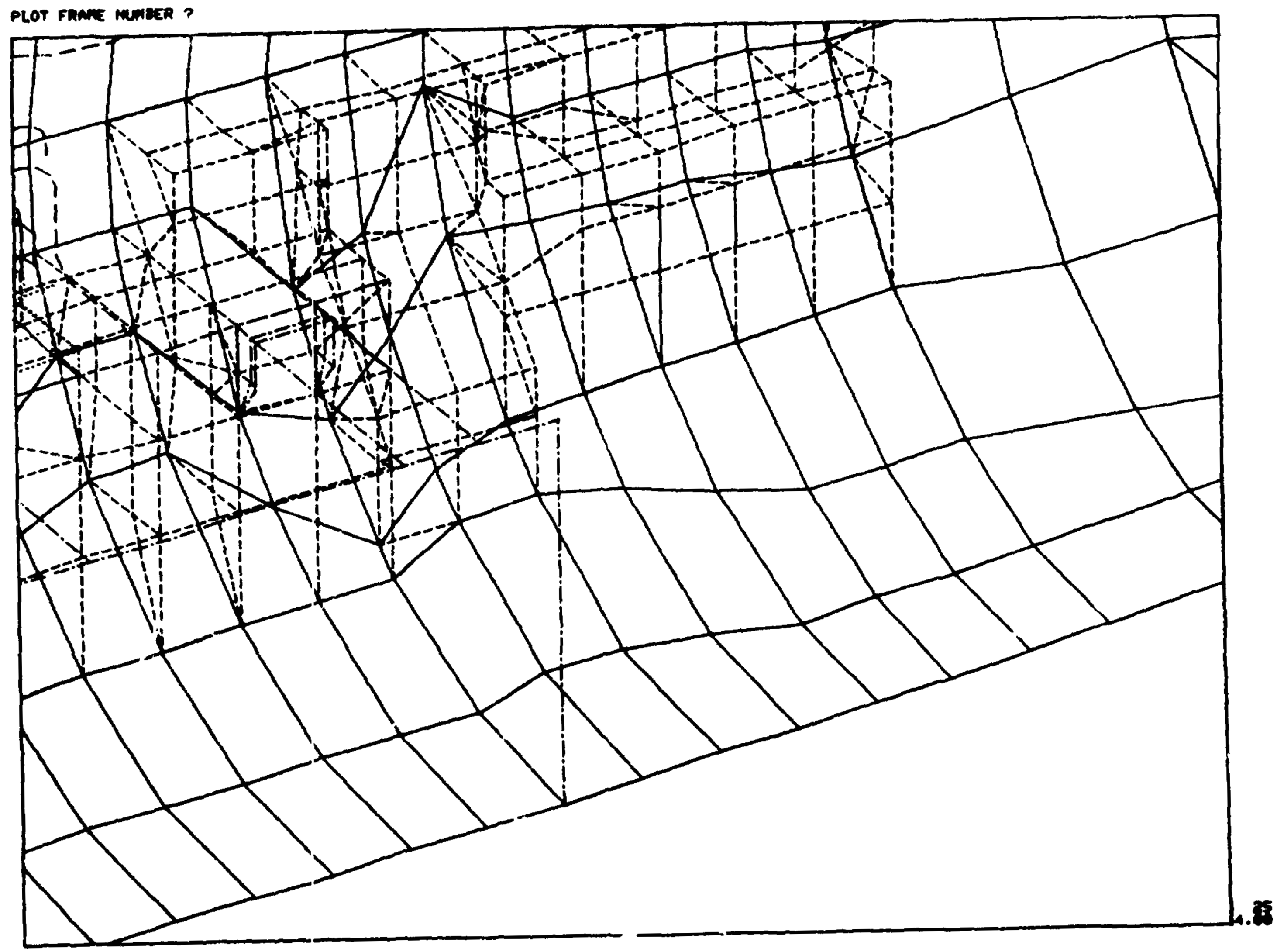

Figure 8 - Undeformed shape of structure plotted with dotted lines