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September 1979
NSRP 0006

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Proceedings of the REAPS Technical Symposium

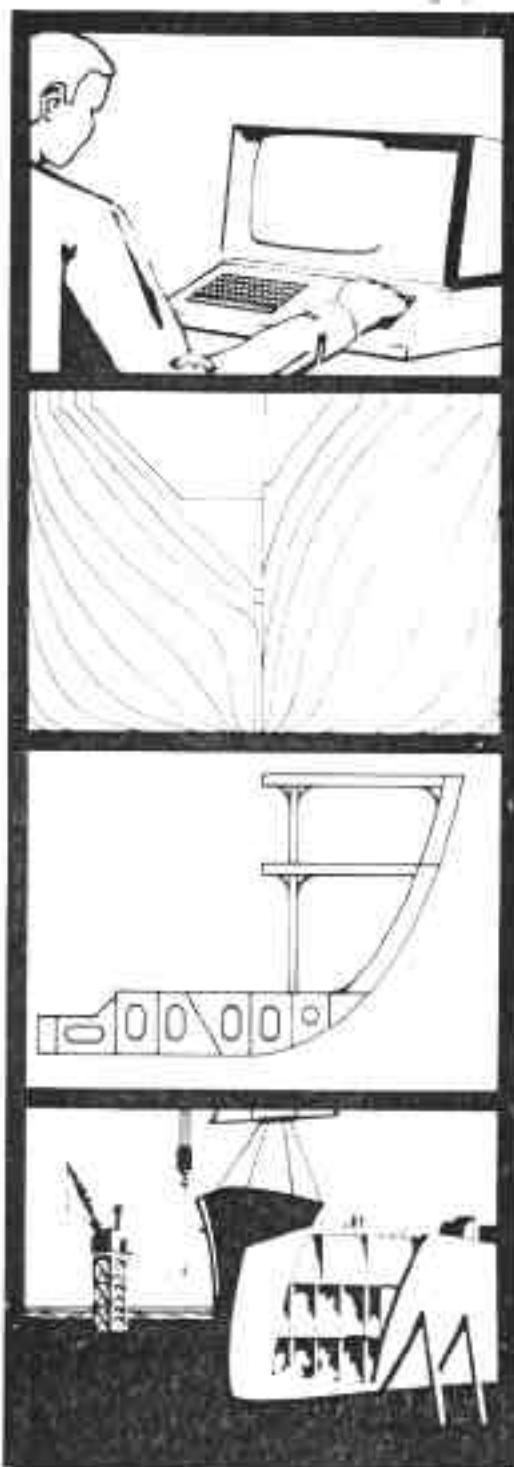
Paper No. 20: Application of the GIFTS-5 Minibased Graphics System for Ship Design and Analysis

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE SEP 1979		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE The National Shipbuilding Research Program Proceedings of the REAPS Technical Symposium Paper No. 20: Application of the GIFTS-5 Minibased Graphics System for Ship Design and Analysis				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Surface Warfare Center CD Code 2230 - Design Integration Tools Building 192 Room 128 9500 MacArthur Blvd Bethesda, MD 20817-5700				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 28	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

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Proceedings of the
REAPS Technical Symposium
 September 11-13, 1979
 San Diego, California

**APPLICATION OF THE GIFTS-5 MINIBASED GRAPHICS SYSTEM
FOR SHIP DESIGN AND ANALYSIS**

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APPLICATION OF THE GIFTS-5 MINI-BASED GRAPHICS SYSTEM FOR SHIP DESIGN AND ANALYSIS

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INTRODUCTION

The GIFTS finite element structural analysis system has been developed with the support of the Office of Naval Research, the U.S. Coast Guard, and members of the GIFTS Users Group (GUG). It is a graphics-oriented collection of programs, which operate on a standardized data base. The system is designed to fit in a relatively small core area, and is specifically suited to time sharing and mini-computer systems. It may be used as a stand-alone finite element package or as a pre- and postprocessor for other systems.

CAPABILITIES OF GIFTS 5

- A. Model Generation. Automatic model generation and interactive model editor. Generation of parametric lines with equally, or unequally spaced points, generation of three- and four-sided surface patches, covered with triangular or quadrilateral elements of arbitrary order. Generation of line structural elements of arbitrary order, including a sophisticated library of beam elements. Generation of six-sided and five-sided solid regions, filled with first order solid elements.
- B. Model Display. Display of model outlines or detailed element plots. Choice of absolute viewing direction or incremental rotations. Labelling by user of system point number, element number, element type, material or thickness number. Introduction of perspective. Selected display by boxing parallel to model or display axes. Selective elimination of surface patches. Selective plotting of point or element slices in solid regions.

- c. Generation and Display of Load and Boundary Conditions. GIFTS is capable of load and boundary condition generation on surface patches, lines or points, as well as inertial loading due to translational acceleration or angular velocity. The user may obtain plots of loads and moments applied to the model, in the form of arrows, whose scale may be influenced by the user. The model freedoms may be displayed in the form of vectors, superimposed on the model. Prescribed displacements and freedom-to-freedom constraints may be introduced by the use of Lagrange constraints.
- D. Displacement and Stress Display. A plot of the deformed model, with automatically scaled displacement, may be produced once the deflections have been computed. All model plotting options are applicable. In addition, the user may change the displacement scale, or create composite loading cases by linearly combining a number of loading cases. Labelled stress contours may be plotted within the area being viewed. Principal stresses may be displayed as vectors showing direction and magnitude. Symbols denoting stress level may also be used. For beam elements applied forces and resultant shear and moments diagrams over the length of the beam element are displayed. A detailed plot showing normal stress and shear stress distributions over the cross-section may be produced at any point along the beam's length.
- E. Static Analysis. The GIFTS 5 analysis package supports a library of basic first order elements encompassing a rod element, a general purpose beam element, triangular and quadrilateral membrane elements, triangular and quadrilateral axisymmetric elements, triangular and quadrilateral bending elements and constrained substructures as well as second order rod, triangular and quadrilateral membrane and triangular and quadrilateral axisymmetric elements. Matrix partitioning is utilized to set up and solve the equations. Several nodes are lumped together in each partition to increase solution efficiency. A band-width optimization program is included, although the program is not band width limited.

- F. Substructuring. The program has substructuring and constrained substructuring capabilities. The substructure boundaries may be kinematically constrained using rigid linear or cubic constraint functions.. Substructures and/or constrained substructures may be assembled, together with ordinary finite elements to form a model. After model analysis,- it is possible to request a local analysis of any individual substructure.
- G. Vibrational Mode Analysis. GIFTS 5 uses the subspace iteration method to obtain a number of the lowest vibrational frequencies and modes of an arbitrary structure. Stresses may also be computed.
- H. Transient Response Analysis. It is possible to apply a time varying load to a structure, and compute the deflection and stress histories. GIFTS uses the Houbolt scheme (third order backward difference).
- I. Axisymmetric Solids. GIFTS 5 is capable of solving axisymmetric models under either axisymmetric loads, or non-axisymmetric loads broken down into a Fourier series.
- J. Thermal Stress. A temperature field may be defined for any structure being, analyzed, and GIFTS 5 will compute the resulting thermal stresses. It does not, however, have heat flow analysis capability.
- K. Retrieval of Numerical Information. Apart from graphic display, GIFTS may be used to extract practically any subset of information from the data base and print it in an organized manner on the screen, or on a line printer.
- L. Error Detection. Extensive checks are performed throughout the system to protect the user against his own mistakes. User oriented error and warning messages are printed out wherever appropriate.

MACHINE INDEPENDENCE

GIFTS 5 is written exclusively in FORTRAN IV. A computer word length of 16 bits or more is assumed. No more than four alphanumeric characters are stored in one word. Hollerith constants appear only in DATA statements. All real variables are single precision and no complex variables are used. Disk

files are either sequential or index sequential. In an index sequential file it is assumed that any record may be read or written at random. Most files are blocked for I/O efficiency. Core buffers may contain more than one block. Plotting commands to the terminal are "graphics primitives," and can be easily interfaced to any existing graphics package or, better still, implemented directly. GIFTS-5 includes its own special purpose FORTRAN written Tektronix terminal driver. GIFTS-5 versions are available for the Data General ECLIPSE-S/230, the DEC-10 and DEC-20, the PDP-11 and the PRIME family of computers. Versions are under preparation for the CDC 6000 series, the IBM-370 series, UNIVAC and VAX-11/780 computers.

DOCUMENTATION

The program/listings contain extensive commenting, which makes GIFTS 5 essentially self-documenting. In addition, however, the following manuals are available:

GIFTS PRIMER -- Contains an introduction to the finite element method and the GIFTS system. The text is illustrated by a number of solved simple examples.

USER'S REFERENCE MANUAL -- A document describing the program operation, instruction set, conventions used and so on.

THEORETICAL MANUAL -- Contains element formulation, and a description of all numerical procedures used in the various solution modules.

SYSTEMS MANUAL -- Contains a detailed description of the Unified Data Base, and key information to the system design.

MODELLING GUIDE -- A discussion of modelling efficiency, supported by many examples and comparison with classical solutions.

INTERFACING GIFTS TO OTHER PROGRAMS

It is a relatively easy task to interface GIFTS to any other finite element programs. After the pre-processing is complete, a program has to be written to extract the relevant data from the GIFTS data base, create an input file for the FEM program, and initiate its execution. It is assumed that the program will place results on an output tape. This output tape can then be read by another interface program, which then feeds the data back into the GIFTS Data Base for further processing and display. Interfaces exist for SAP-IV and ANSYS. Others are being prepared for NASTRAN, STAGS, DAISY and SAP-V.

DISTRIBUTION OF GIFTS 5

GIFTS 5 has been supported by the Office of Naval Research and the United States Coast Guard. It is in the public domain and may be obtained from the University of Arizona for a reasonable charge. Users Groups exist both in the United States (UGUG) and in Europe (EGUG).

POTENTIAL IN SHIP ANALYSIS AND DESIGN

Although the program is being applied regularly to practical ship structure analysis by many organizations, it is somewhat difficult to produce realistic examples of its use in a university environment. Nevertheless, a set of examples are included, which clearly demonstrate the suitability of the program for typical ship structure analysis efforts. These examples span the spectrum from simple beam idealization of a complete tanker hull, to a detailed analysis of a full ship using substructures.

Analysis of a Stiffened Bulkhead.

Figure 1 shows a three-dimensional view of one half of a vertically stiffened bulkhead of, say, an oil tanker. Only one half is modeled because of symmetry. The problem was generated and solved using GIFTS-5 on an ECLIPSE-S/230 minicomputer, running in a time-sharing mode. The model has a total of 195 nodes and 322 elements, 154 of which are beam stiffeners and 168 quadrilateral shell elements. The problem has a total of 839 active degrees of freedom, with a maximum half band width of 106, and a computational (r.m.s) half band width of 76.

Figure 2 shows the commands necessary to generate the model, and apply boundary conditions and loads to it. These commands may be entered either interactively or via a file. The loads produced by the second set of commands are displayed in figure 3, and represent hydrostatic pressures from a partially filled center tank, and a full wing tank. The translational degrees of freedom, showing both symmetry conditions and support from the deck, bottom, side-shell and longitudinal bulkhead appears in figure 4.

The deflections of the bulkhead are shown in figure 5. Stress contours are displayed in figure 6. Load, shear force bending moment and torque diagrams can be displayed for any stiffener element (see figure 7), and detailed stress distribution at any position along the element may be shown (see figure 8).

The analysis, on the time shared minicomputer, cost approximately 40 dollars, based on a standard charging algorithm. The computer time requirements are given below:

Stiffness computation	608	CPU seconds
Decomposition	394	CPU seconds
Deflection computation	101	CPU seconds
Stress computation	62	CPU seconds
Total residence time	41 minutes	wall clock time (other jobs running simultaneously)

Two Dimensional Membrane Analysis of Webframe.

Figure 9 shows the subdivision of a webframe structure into grids, in preparation for the mesh generation procedure. Figure 10 gives the resulting stress contours. Such an analysis is typical of day to day applications. The mesn generator provides a basic arrangement of nodes and elements, which may be then edited using the GIFTS editing module, to introduce local changes, such as stiffeners.

Analysis of an Idealized Bulk Carrier Using Substructuring.

This analysis was conducted as a term project by two students at the university. A typical bay of the ship was modeled using substructures, each involving up to 700 degrees of freedom, see figure 11. These substructures are then repeated over the parallel midside portion of the ship, and the fore and aft portions were completed using ordinary shell finite elements to give the complete structure, see figure 12. The problem was run on the PDP-15 minicomputer using the GIFTS-3 package. Results included overall behavior of the model as well as detailed, stress and deflection results in the individual substructures. Results are not shown here due to space considerations.

Analysis of Tubular Joints

Tubular joints are of importance, particularly in the case of offshore structures. The constrained substructure technique is used here to provide both overall behaviour and detailed stress distributions at the joints. In this case a two-dimensional tubular frame was modeled using beam elements, except at the joints, where a more detailed substructure was employed, see figures 13 and 14. Constraint conditions were applied at the substructure/beam interface to ensure compatibility. The results show the deflections of the frame under load, see figure 13, as well as the stress distribution in the joint, see figure 15.

CONCLUSIONS

A general purpose interactive, graphics oriented, finite element program has been described, which has applications in ship structure analysis, both static and dynamic, as well as in preliminary ship design. Its suitability for minicomputer application, as well as its dual role as a pre- and postprocessing and an analysis tool, give it a certain uniqueness in today's increasingly minicomputer dependent engineering environment.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the support of the Office of Naval Research under contract no. N00014-75-C-0837, the United States Coast Guard under contract no. DOT-CG-43565-A and the Gifts Users Group members for the support leading to this paper.

Special thanks are also due to Michael W. McCabe and Richard M. Osgood for their technical support, and to Ms. Maria D. Pinedo for help in preparing the manuscript.

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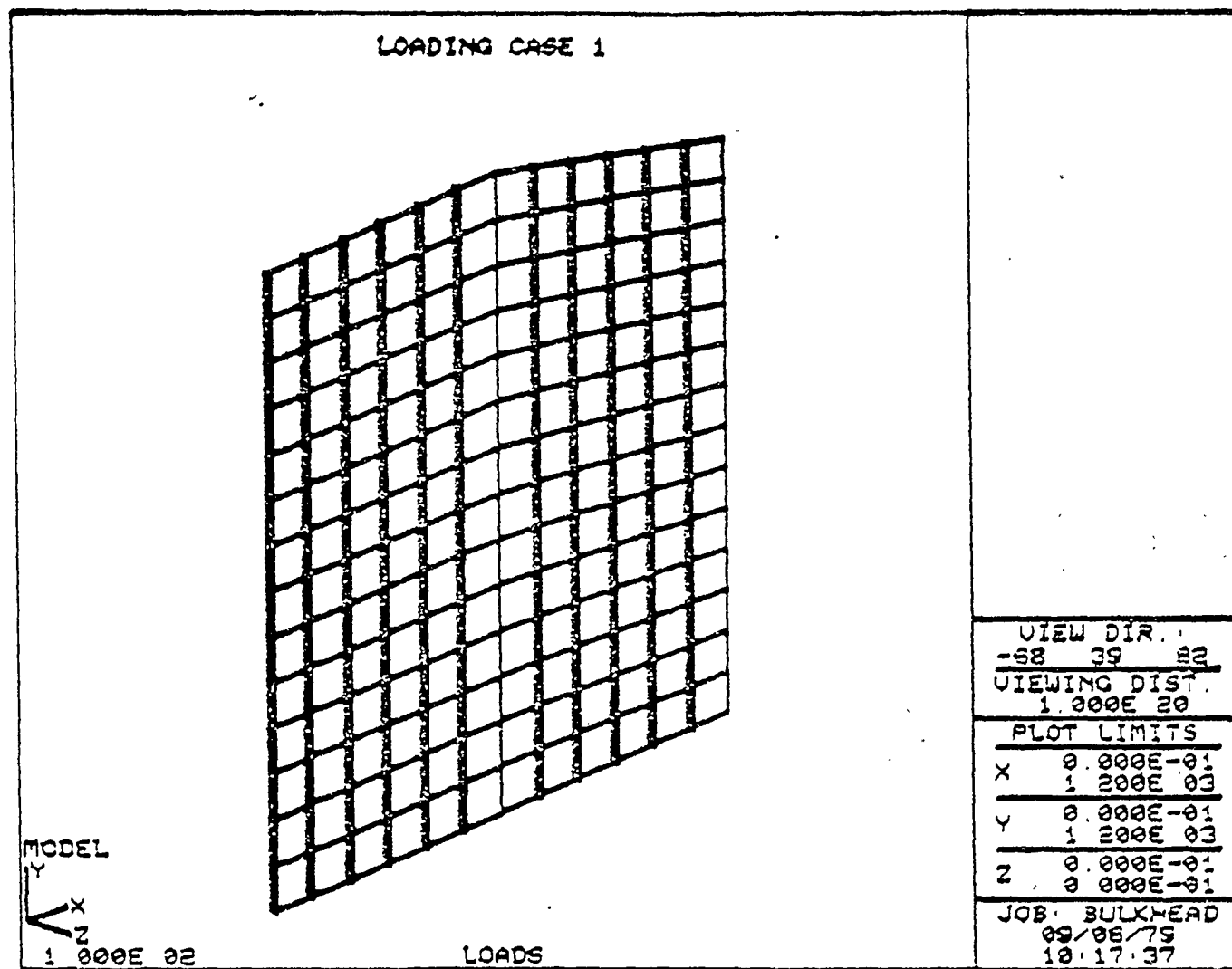


Figure 1. Finite Element Model of a Stiffened Bulkhead

```

MSTEEL/1/0
ETH,1/1/0.8,/0
TBEAM,10/2/30,20/0.7,0.9/0,0/0
KPOINT/1/,,/2/600,,/3/1200,,/4/0,1200/5/600,1200/6/1200,1080/0
LETY/BEAM2/1,2
SLINE/L12/1,2,7/L23/2,3,7/L45/4,5,7/L56/5,6,7
L25/2,5,15/L36/3,6,15/ /
SLINE,1/L14/1,4,15/5/ /
GETY/QB4/1,1
GRID4,2/G1/L12,L25,L45,L14/G2/L23,L36,L56,L25/ /
END

```

Commands to Generate Structural Model

```

SUPG,6/G1/G2/ /
SUPL,1/L14/L45/L56/L12/L23/
SUPL,2/L25/L36/
SUPL,3/L12/L23/L36/L45/L56/L25/
SUPL,5/L14/
LDCASE/1
HEADG,2/G1/0.,0.8/800.,0./G1/0.,-0.6/600.,0./ /
LDCASE/2
HEADG,2/G2/0.,0.6/600.,0.,-0.8/800.,0./ /
LDCASE/3
HEADG,2/G1/0.,0.8/800.,0./G1/0.,-0.6/600.,0./ /
HEADG,2/G2/0.,0.6/600.,0./G2/0.,-0.8/800.,0./ /
END

```

Commands to Apply Boundary Conditions and Loads To Bulkhead

Figure 2. Commands for Model, Boundary Condition and Load Generation for Stiffened Bulkhead

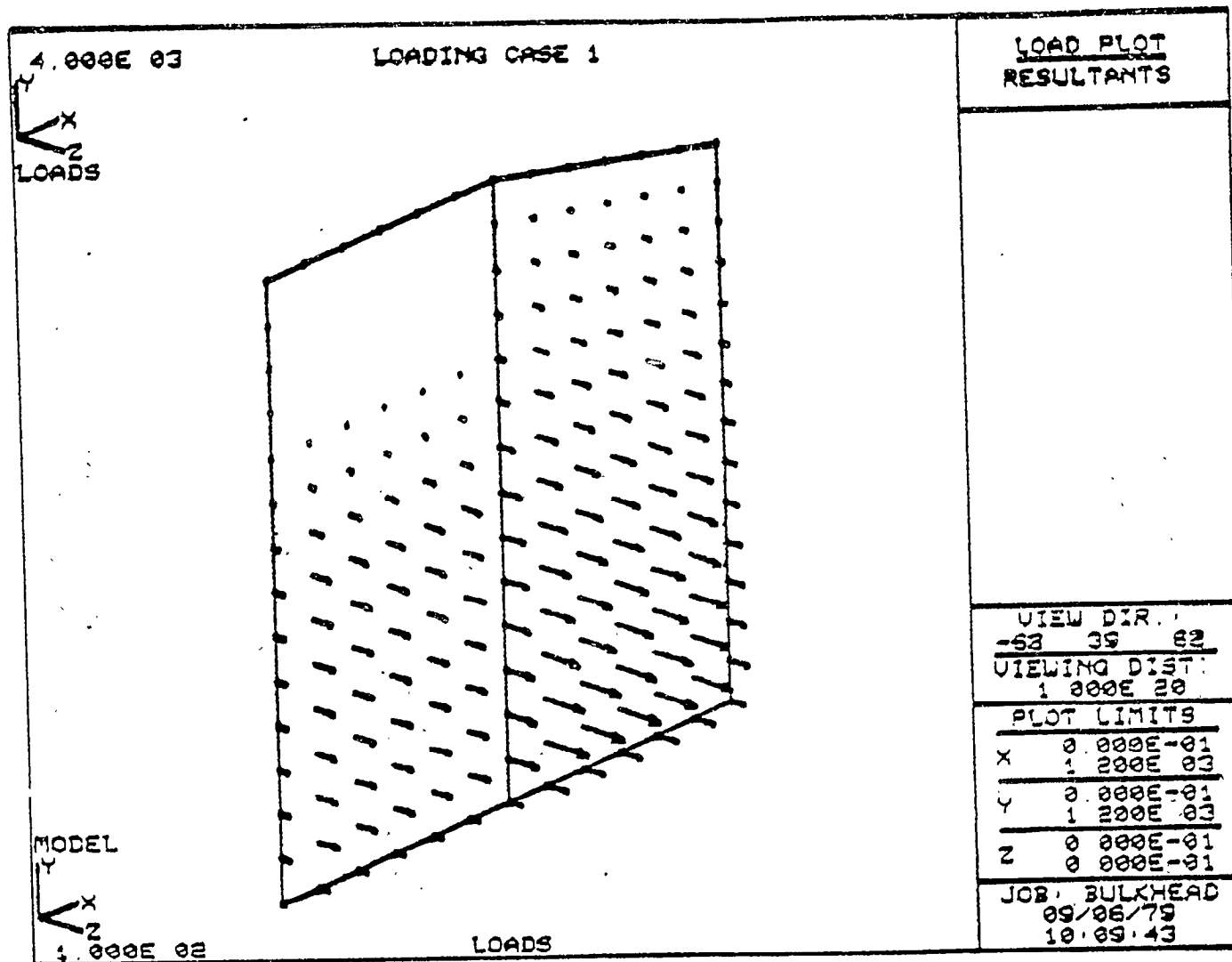


Figure 3. Hydrostatic Pressure Loading on Transverse Bulkhead

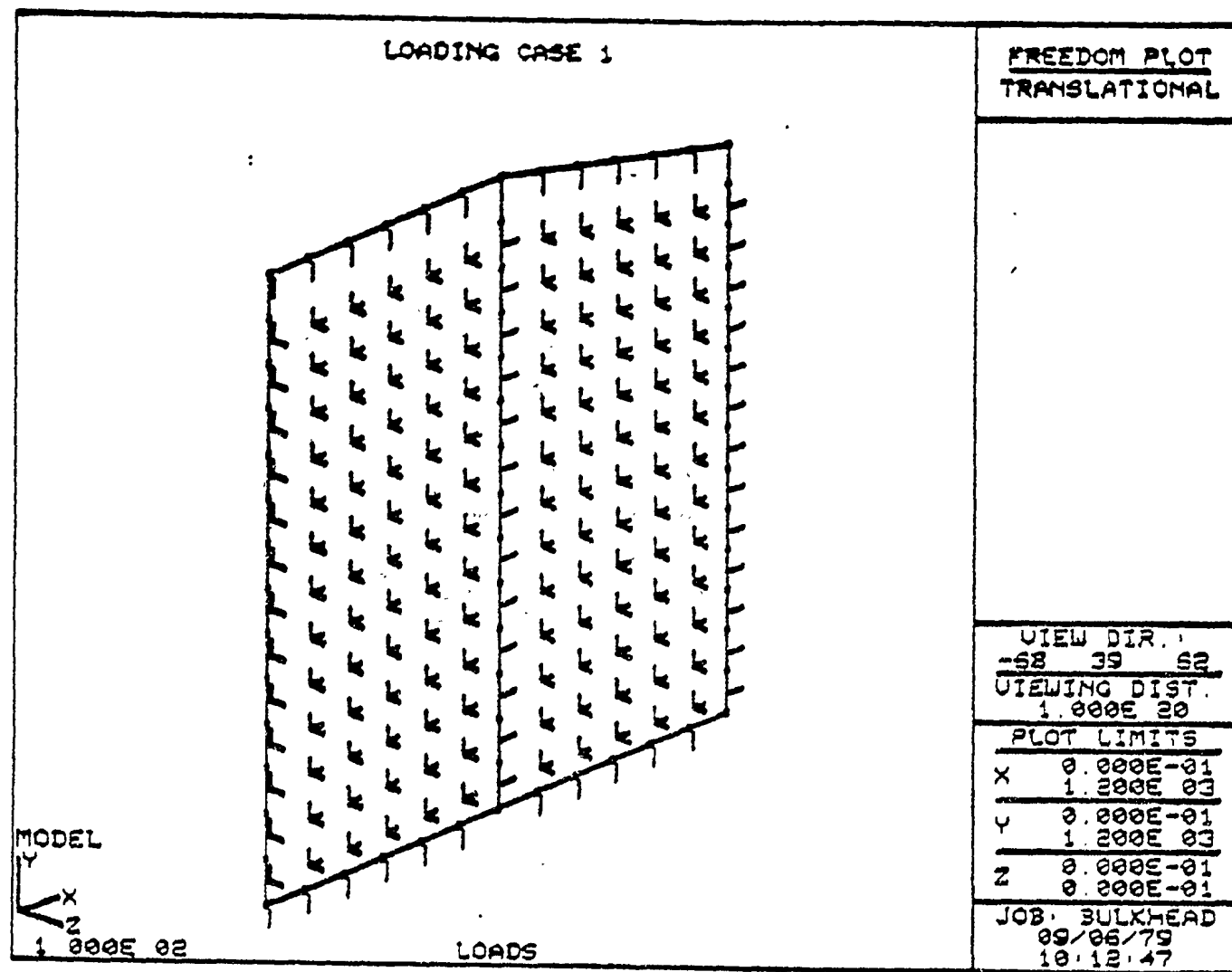


Figure 4. Translational Freedom Pattern for Bulkhead Model

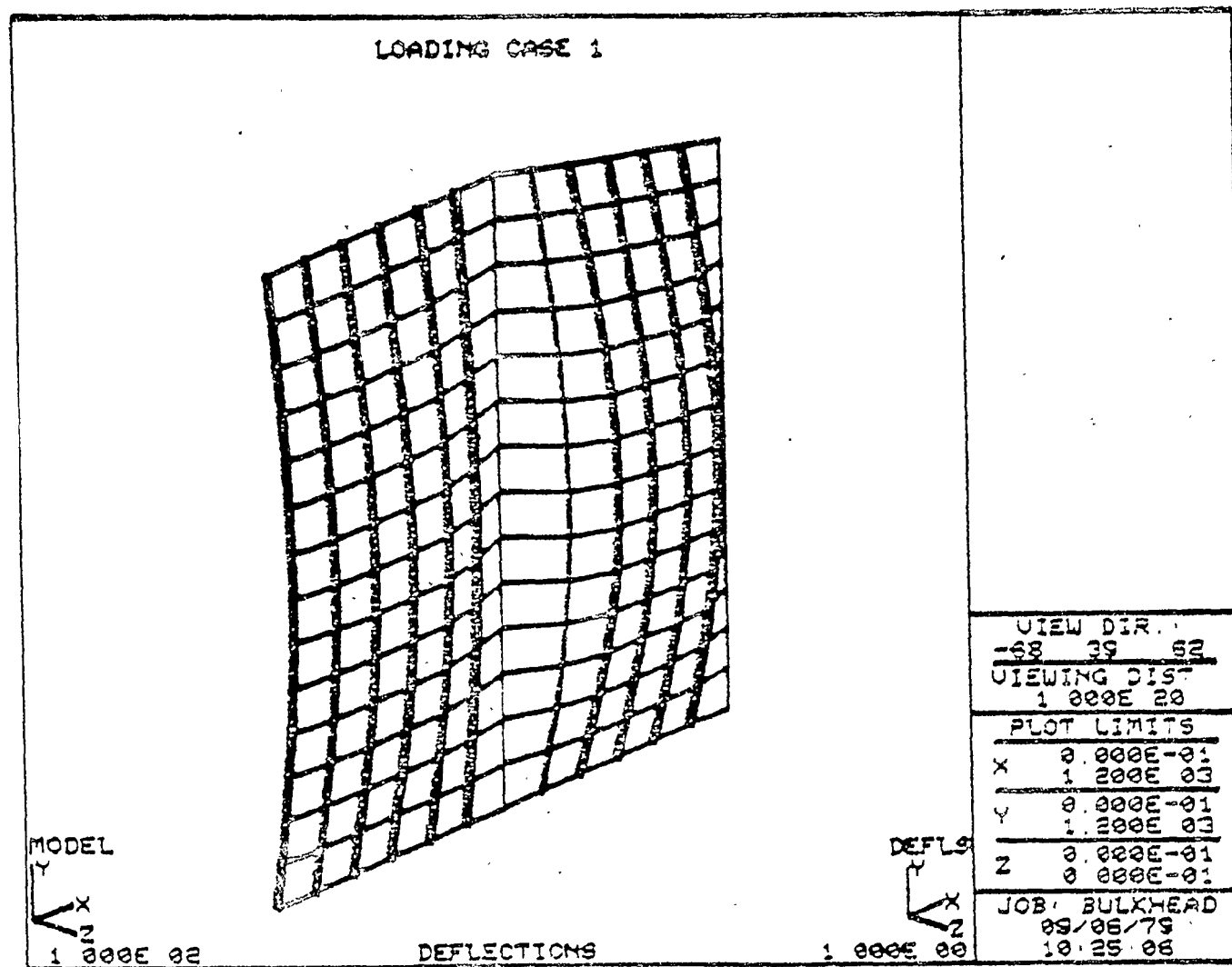


Figure 5. Deflections of Bulkhead under Hydrostatic Pressure

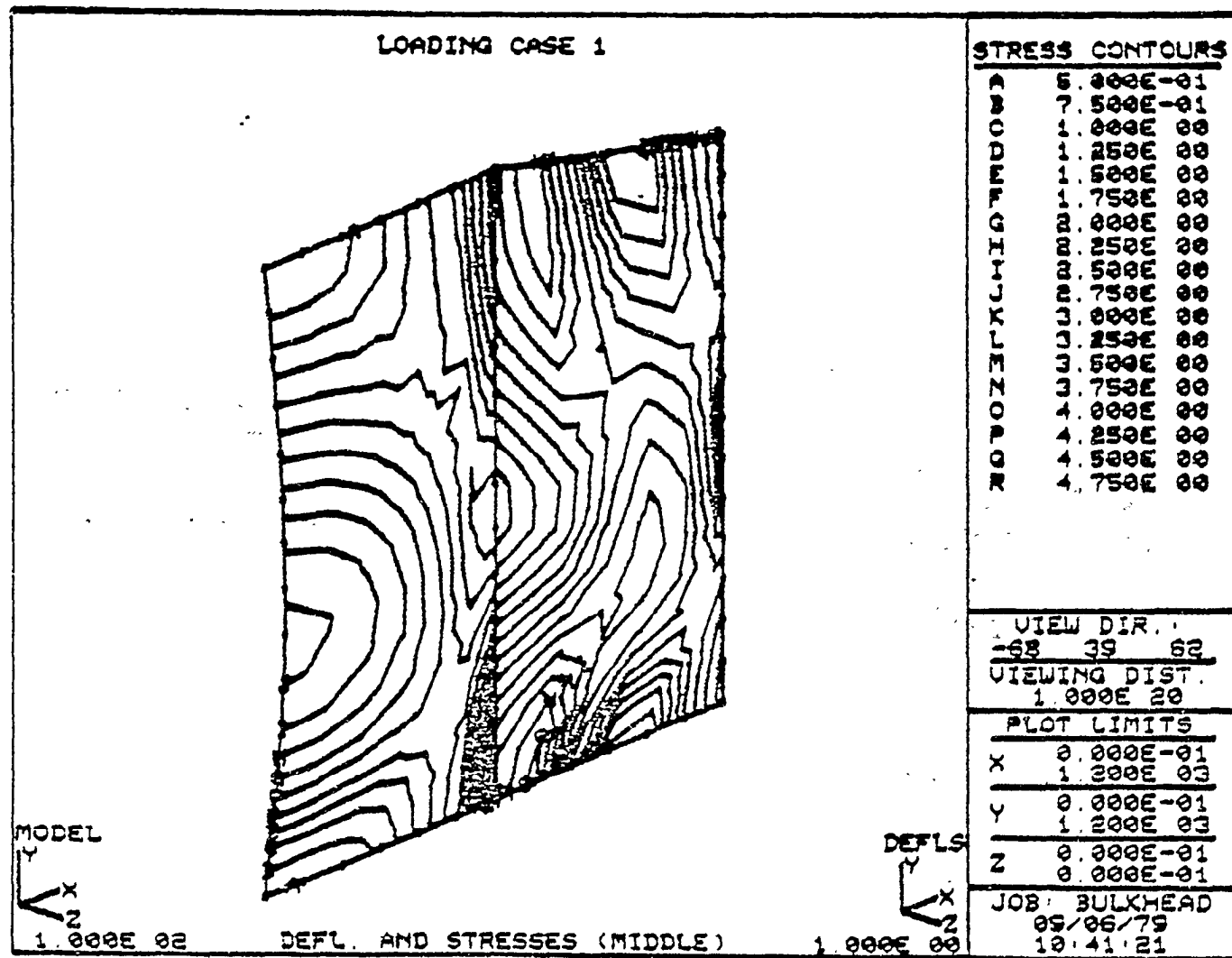


Figure 6. Von-Mises Stress Contours in Bulkhead Plating

APPLIED LOADS		RESULTANT FORCES		BEAM PROPERTIES	
QX	0.000E-01	N	1.210E 05	A	3.870E 01
QY	0.000E-01	LY	2.100E 03	AG	1.780E 01
QZ	0.000E-01	UZ	-1.670E 03	AP	1.584E 01
GMX	0.000E-01	MX	-2.192E 02	IP	3.740E 03
ELEMENT NO. 243		BY	-7.040E 04	IQ	8.010E 02
LOADING CASE 1.		BZ	7.201E 05	J	8.240E 00
				ZO	0.000E-01
				YO	2.150E 01
				ZO	0.000E-01
				YO	3.000E 01
				AL	0.000E-01
				YIELD STRESS	
				0.000E-01	
				BEAM FORCES	
				N	1.210E 05
				LY	2.100E 03
				UZ	-1.670E 03
				MX	-2.192E 02
				BY	-7.040E 04
				BZ	7.201E 05
				JOB: BULKHEAD	
				09/06/79	
				10.31.18	

Figure 7. Load, Shear Force and Moment Diagrams for Typical Stiffener Element

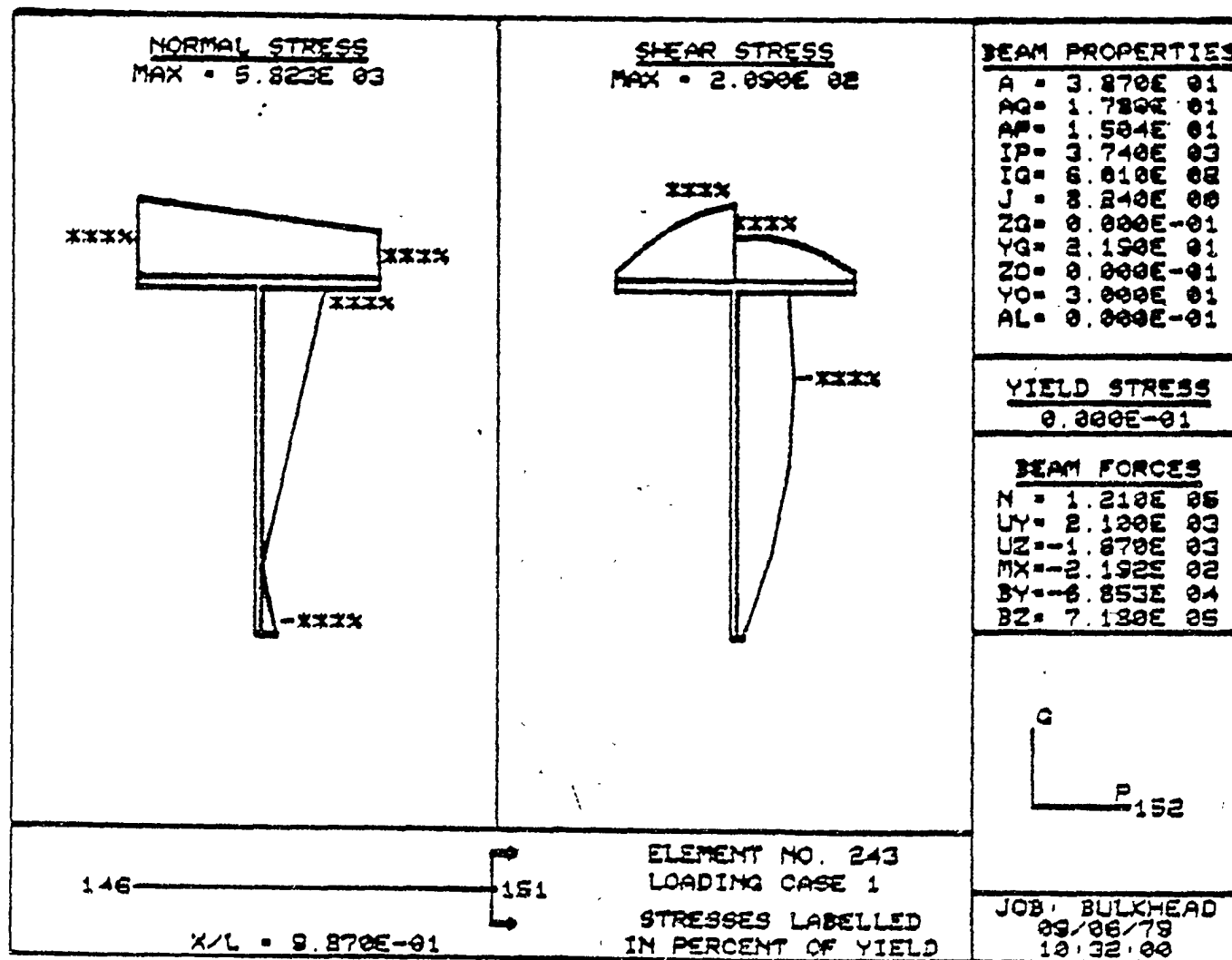


Figure 8. 'Detailed Stress Distribution on Beam Cross-section

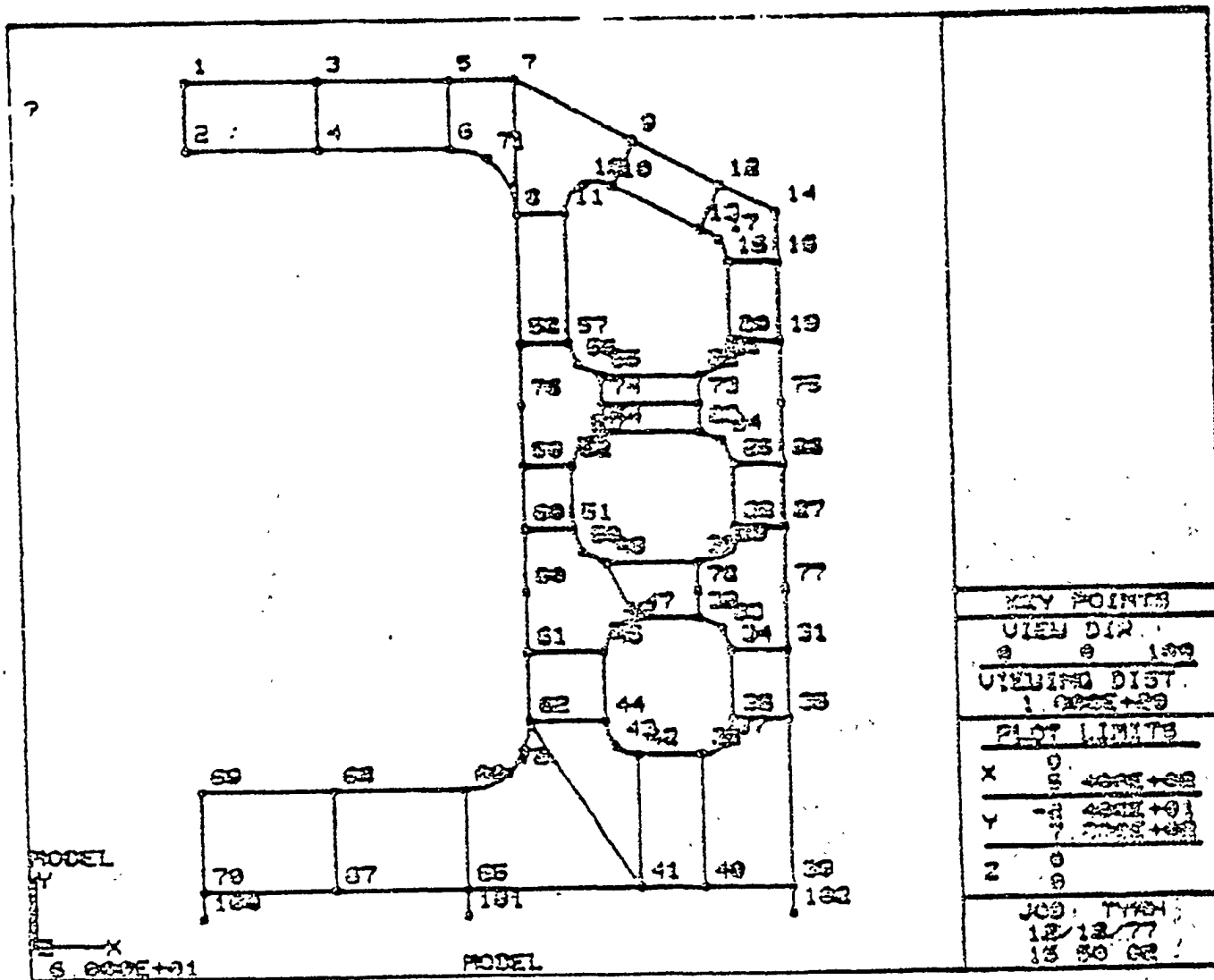


Figure 9. Subdivision of Webframe into Grids

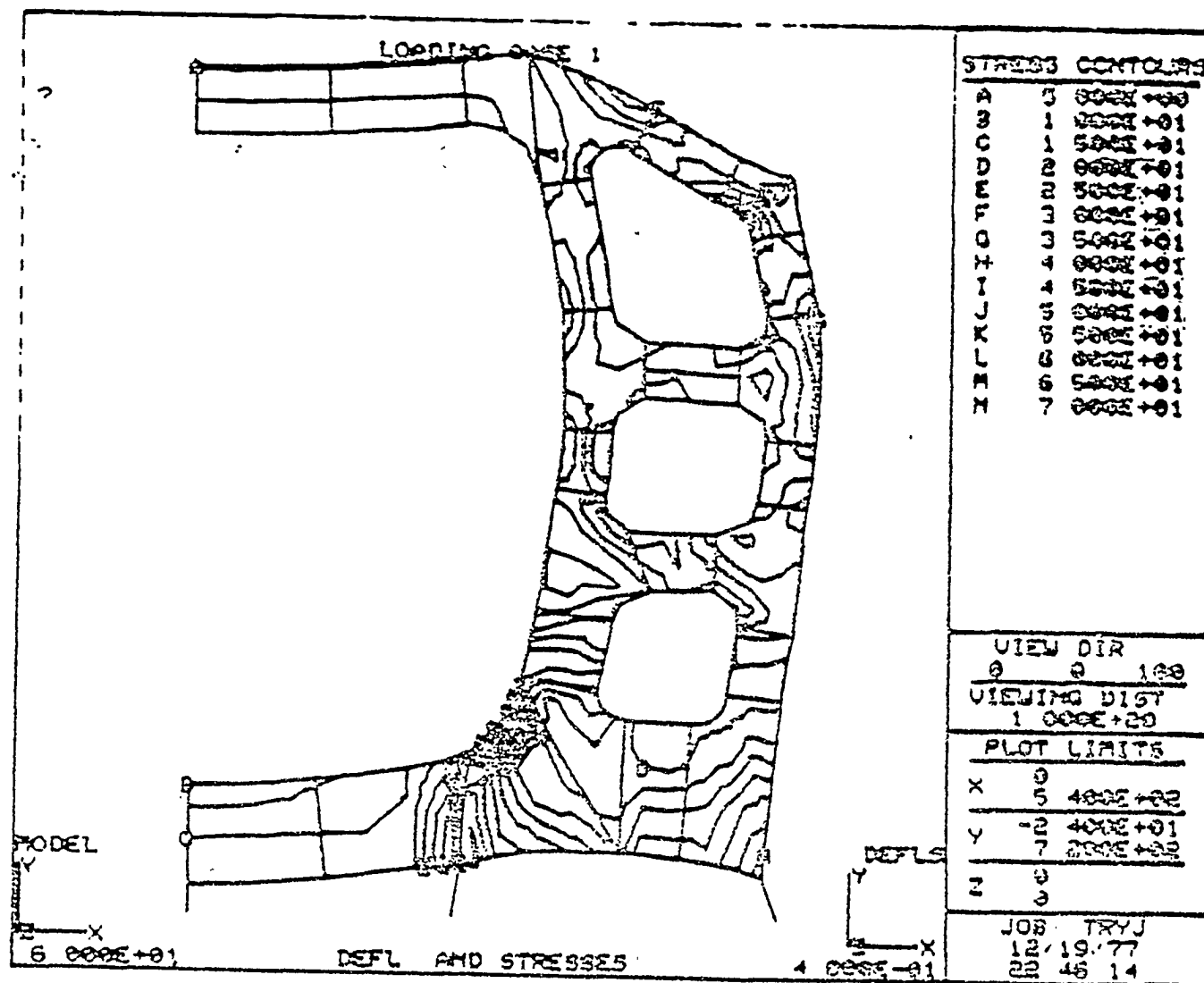


Figure 10. Stress Contours in Webframe Structure

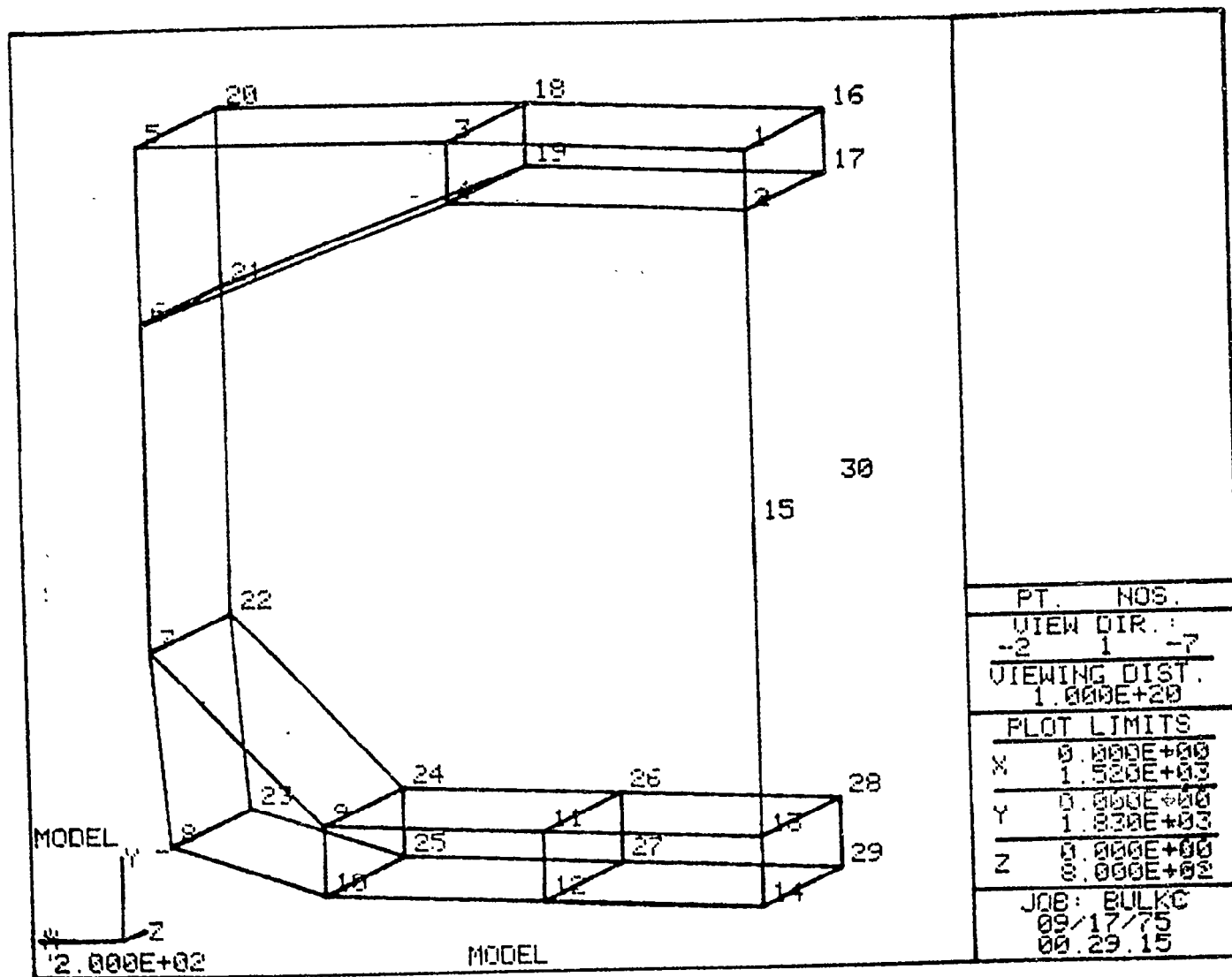


Figure 11. Subdivision of Bulk Carrier Bay into Substructures

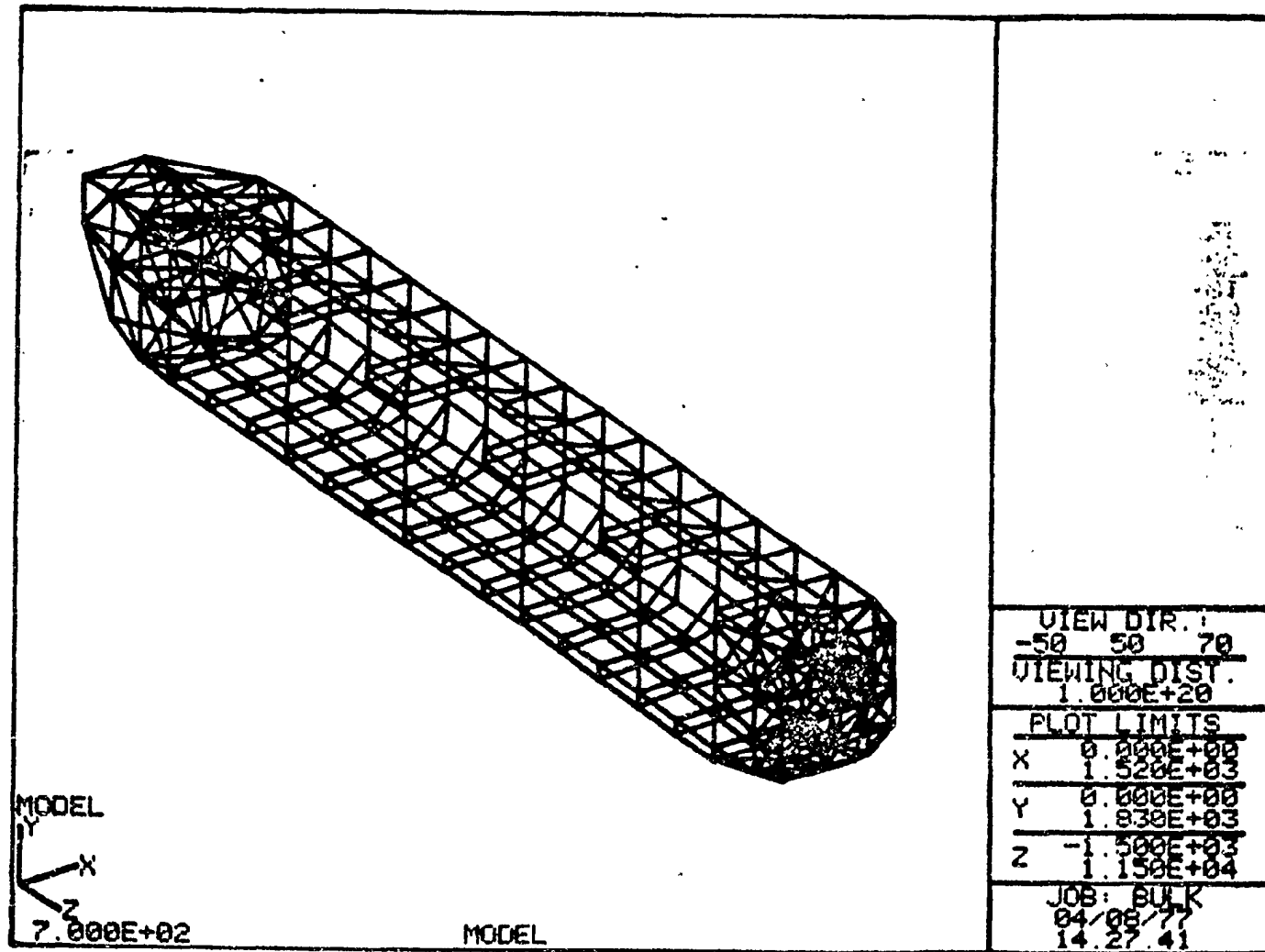


Figure 12. Complete Bulk Carrier Model

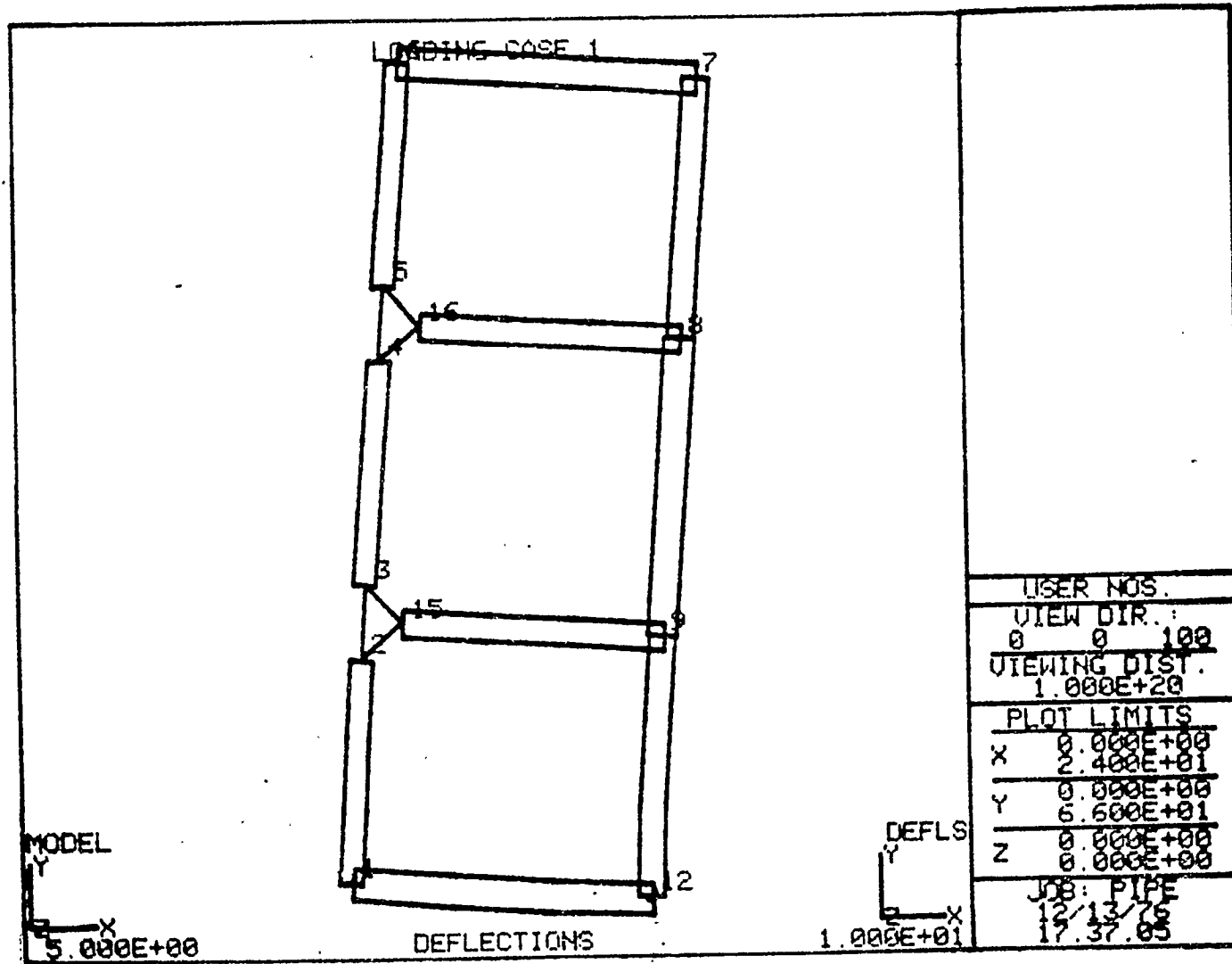


Figure 13. Two-Dimensional Tubular Frame Modeled Combining Beam Elements and Constrained Substructures

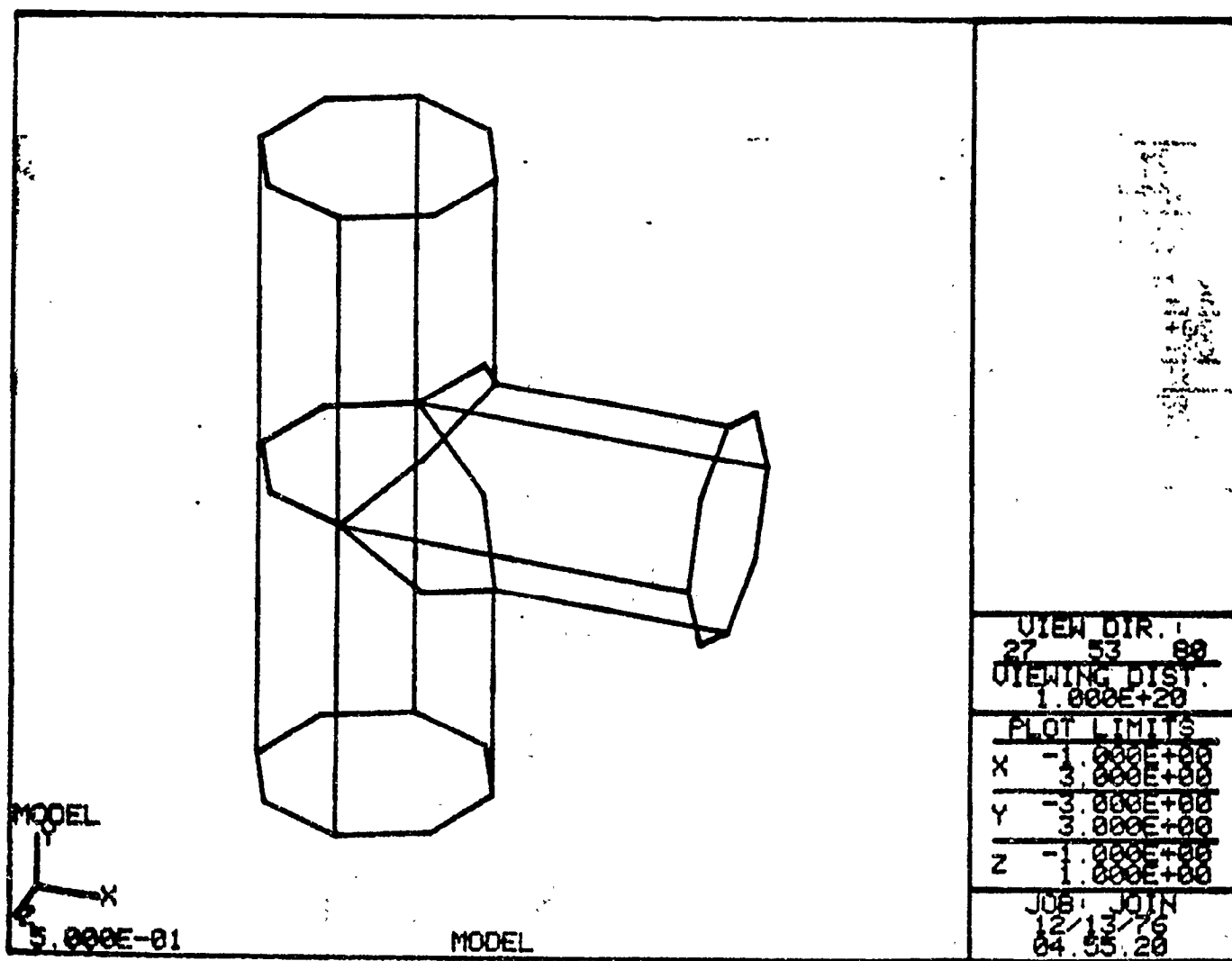


Figure 14. Outline of Grids Used to Model Tubular Joint

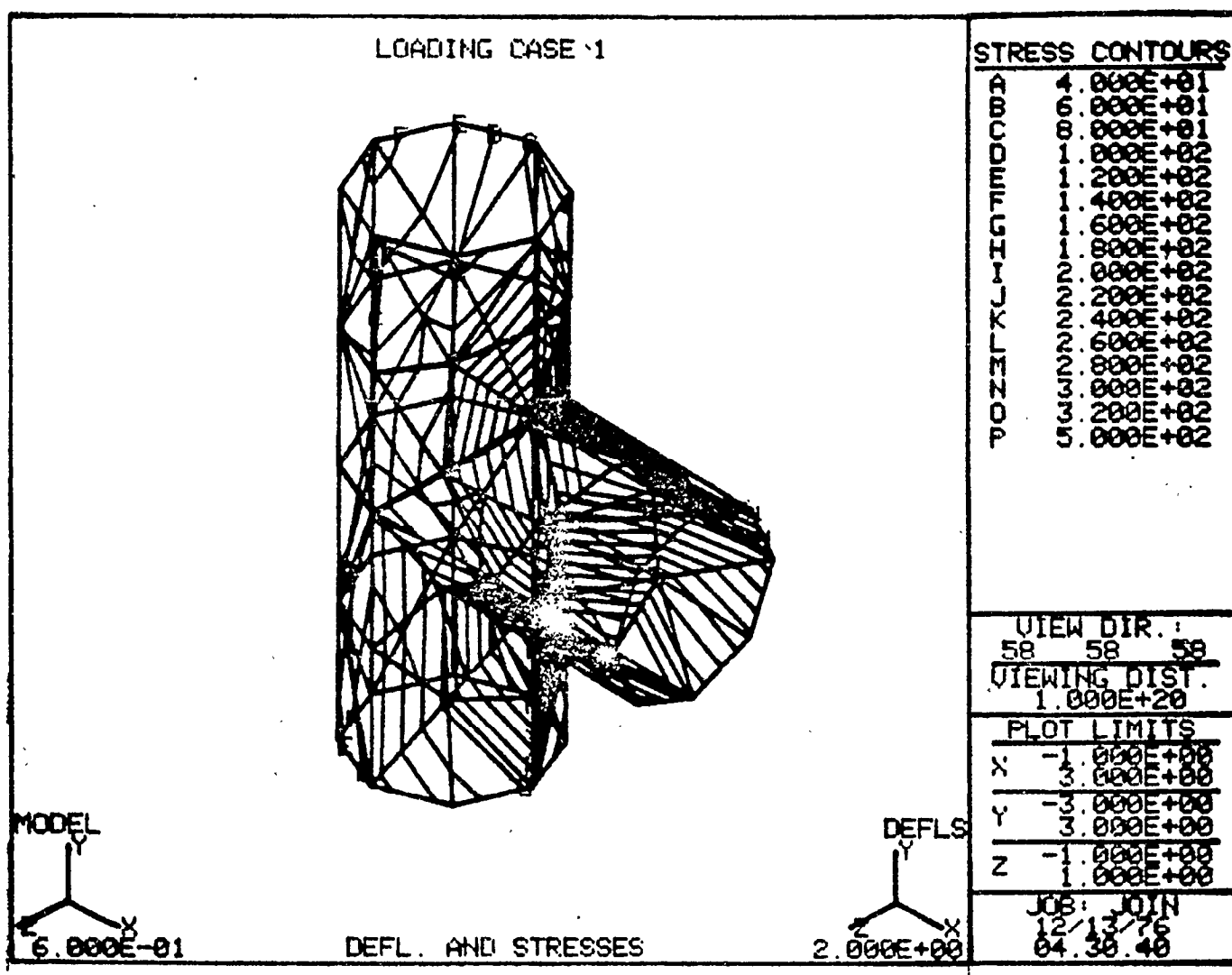


Figure 15. Detailed Stress Distribution in Tubular Joint

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