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INTERACTIVE PLOTTING OF NASTRAN DATA ON MICROCOMPUTERS

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Summary

A microcomputer based program has been developed to aid in the development of NASTRAN models. The program reads in the complete NASTRAN data deck, produces a diagnostic print file, and then allows the user to view the model in an interactive mode. The program runs on a wide variety of hardware by making use of the Virtual Device Interface.

Introduction

When NASTRAN was introduced the most powerful computers available were required to run it. To even process the bulk data deck required a substantial computer. In the years since there has been enormous progress in computer hardware, providing substantial computing power for the desktop. While it is not yet possible to run NASTRAN on a personal computer it is now possible to do a significant amount of model development on a personal computer.

In addition to the great strides in computer hardware development, computer software has developed to the point that the phrase "user friendly" has become a cliche. Computer users now longer feel that they have to put up with obscure error messages and difficult interfaces with the computer. Instead they demand an interactive computing environment that allows for simple, intuitive commands.

In many facilities users now rely heavily on personal computers for word processing, spreadsheet manipulation, data preparation, and terminal emulation. Users in these facilities often make use of spreadsheet programs for bulk data preparation and data reduction of the NASTRAN output. In this way the central computer workload is reduced somewhat, and many users prefer the local control allowed by personal computers.

This paper presents research results carried out in part at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration (NASA).

This program consists of two major modules. The first module is used to process the entire NASTRAN deck and produce the files required for plotting. This module is essentially run in a batch mode, with little user interaction. The files produced consist of the location of grid points in the basic system and a file with the element information. The second module is the interactive graphics module. This second module reads the two files produced by the first module and provides a highly interactive environment for the user. As the plots are created they can also be sent to the hard copy device.

NASTRAN Reader

The NASTRAN deck must contain the BEGIN BULK card and the ENDDATA card (or its permutations ENDATA and END DATA). The executive and case control sections are optional, although the TITLE card information will be used if it is present. At this point the program will work with line elements (CBAR, CONROD and CROD) and the three or four node plate or membrane elements (CQDMEM, CQDMEM1, CQDMEM2, CQDPLT, CQUAD1, CQUAD2, CSHEAR, CTRBSC, CTRIA1, CTRIA2, CTRMEM, and CTRPLT). Solid elements could be added, but the complexity of typical solid element models is probably more than the typical user would care to endure on a personal computer.

The model geometry can be described with the usual coordinate system definition cards and the printed output will give a listing of all grid locations in the basic coordinate system. The free-field input capability of NASTRAN is also supported.

The user must first create the NASTRAN data deck with a text editor, word processor, spreadsheet, or other convenient means. After the data deck has been prepared the NASTRAN reader is run and asks the user for the file name, with an assumed extension of DAT. The user enters the base file name, and the output is send to file.PRT, file.ELE, and file.NOD. The printed output contains the grid point information in the basic coordinate system and element information. The other two files are used as input to the NASTRAN Plotter program.

NASTRAN Plotter

After the NASTRAN data has been read and the output files have been created the user may then run the second module to interactively plot the NASTRAN model. The user interface is modeled after some widely used microcomputer programs, providing a menu at the top of the screen. Just below the menu is an information line, giving a very brief description of the action that will taken if the currently highlighted selection is made. The cursor keys are used to move across the menu structure, with the selection made by pressing the down arrow key. Alternately the selection may be made by typing the capitalized letter of the command (usually the initial letter). The user can move to the main level in the menu structure by pressing the up arrow key or the escape key.

The main menu consists of three items: View selections, Scene selections, and Display options. The View selections allow the user to specify the mapping of the model axes onto the screen axes, rotate around the model or screen axes, translate on the screen, zoom

in a portion of the current display, clip the model fore and aft, and to reset the defaults. The Scene selections allow the user to display selected element types, specify hidden line elimination, shrink the elements, and to specify perspective plotting. The Display options allow the user to have the node and/or element labels shown on the plot and allow the user to add text at a user specified location on the screen.

In addition to the command line at the top of the screen, certain other commands are entered by using the first four of the function keys. F1 provides a context sensitive help screen, F2 exits the program, F3 plots the model using the current selections, and F4 makes a hard copy plot using the current selections.

The hidden line algorithm incorporates the Hedgley hidden line code (1). The Hedgley code processes only polygons, so the line elements are omitted if the hidden line option is selected.

Program Performance

Five typical NASTRAN models were used for Figures 1-6. These models were taken from some ongoing work and are typical of the range of model complexity suitable for this program. The characteristics of these models are tabulated in Table 1. The models range from 30 to 1216 nodes and from 30 to 1299 elements. The time required for the NASTRAN reader and for a screen image to be drawn are shown in Table 2. Also shown in Table 2 are the times for a popular commercial program to perform similar tasks on the same NASTRAN data decks. The commercial program was run on a VAX-11/780 with a typical afternoon workload. The microcomputer times are based on a 6 MHz IBM AT.

In reviewing Table 2 certain trends are evident. The relative performance of the microcomputer program vs. the commercial program on the VAX depends on the model size. The smallest deck is processed by the NASTRAN reader on the microcomputer faster than by the commercial program on the VAX. As the models get more complex the commercial program gets faster relative to the microcomputer. For moderate size problems this microcomputer program is adequately fast.

The microcomputer based program is consistently faster that the VAX based commercial program in screen drawing times when using the 1200 baud dial-up lines. Even when comparing the microcomputer performance with the VAX using a 9600 baud connection the times are generally comparable.

Examples

Figures 1 through 8 show examples of various program options with the sample NASTRAN decks listed in Table 1. Figure 1 shows a truss model plotted with moderate perspective. Figures 2 and 3 show a plate model with no perspective, first with node numbers, and then with the element numbers. Figure 4 shows the same model with the hidden lines removed. Figure 5 shows a plate model which used a cylindrical coordinate system for the grid point generation. Figures 6 and 7 show the same model, first with

element shrink enabled, and then with the hidden lines removed. Figure 8 is the most complex model and is shown with moderate perspective. The illustrations in this paper are reduced from their normal size to fit the manuscript requirements. Normally the plots take 8 × 9.8 inches on a 8.5 × 11 inch paper.

Programming Environment

Both modules of this program were written in FORTRAN. There are several popular FORTRAN compilers available for microcomputers now; this program was developed with Microsoft FORTRAN, version 3.31. The program should work with the other popular compilers as well.

A major problem area for developers of microcomputer programs that use a graphics interface is trying to address the wide variety of hardware available. There are three primary display devices available and a multitude of printers and plotters for the hard copy device. To address this problem, IBM has released a Virtual Device Interface system which allows the programmer to use a virtual screen to develop the graphics and let low level drivers convert the virtual screen to the specific hardware that the user has implemented. In addition to the drivers available from IBM the company that developed the VDI for IBM, Graphic Software Systems of Beaverton, Oregon, has released drivers for non-IBM hardware, such as the popular laser printer used to create the plots in this paper with 150 dots/in resolution.

Program Limitations

The NASTRAN reader program has a current limit of about 5000 nodes, and about 15,000 elements of any given type. The patience of the user would place a much lower limit on the practical size. The NASTRAN plotter program has a current limit of about 5000 nodes and an unlimited number of elements. The Hedgley algorithm has a limit of about 275 elements with the current memory allocation.

References

1. "A General Solution to the Hidden-Line Problem," David R. Hedgley, Jr., NASA Reference Publication 1085, 1982. Also available from COSMIC as M86-10038.

Table 1

Model Characteristics

Number	No. grids	No. elements	No. cards
1	30	82	199
2	46	30	117
3	104	148	122
4	1216	1299	2192

Table 2

Model Performance (times in seconds)

		Microcomputer		VAX	
Model	Hidden Line?	Bulk Data Reader	Screen Plot	Bulk Data Reader	Screen Plot 1200/9600 baud
1	no	42	2.8	97	14.6/2.7
2	no yes	26	3.0 14.2	50	12.5/2.8 14.2/7.2
3	no yes	91	7.6 86.7	54	27.9/4.5 27.8/21.6
4	no	826	35.9	245	162.4/24.1

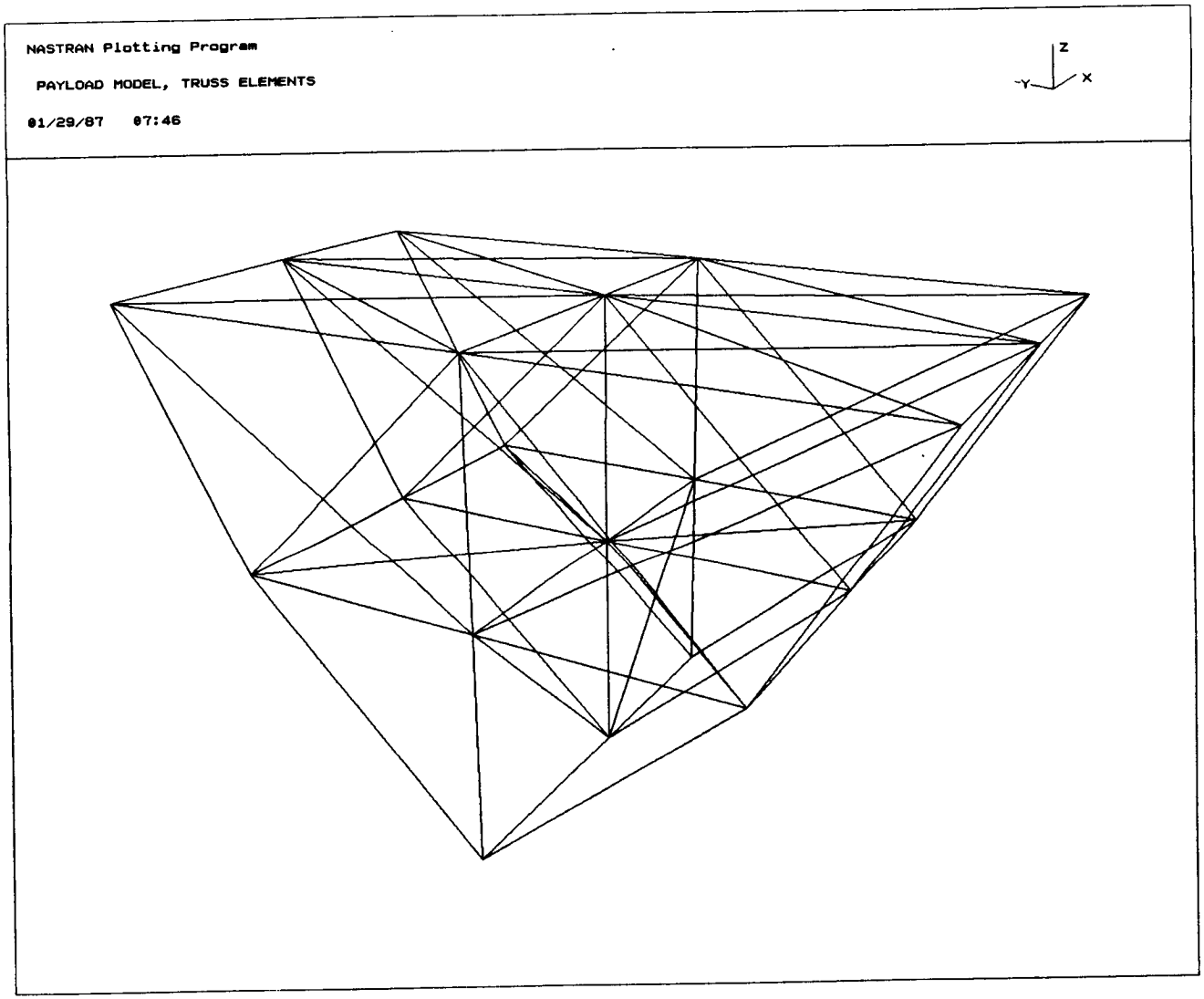

Figure 1. Truss Model with Perspective

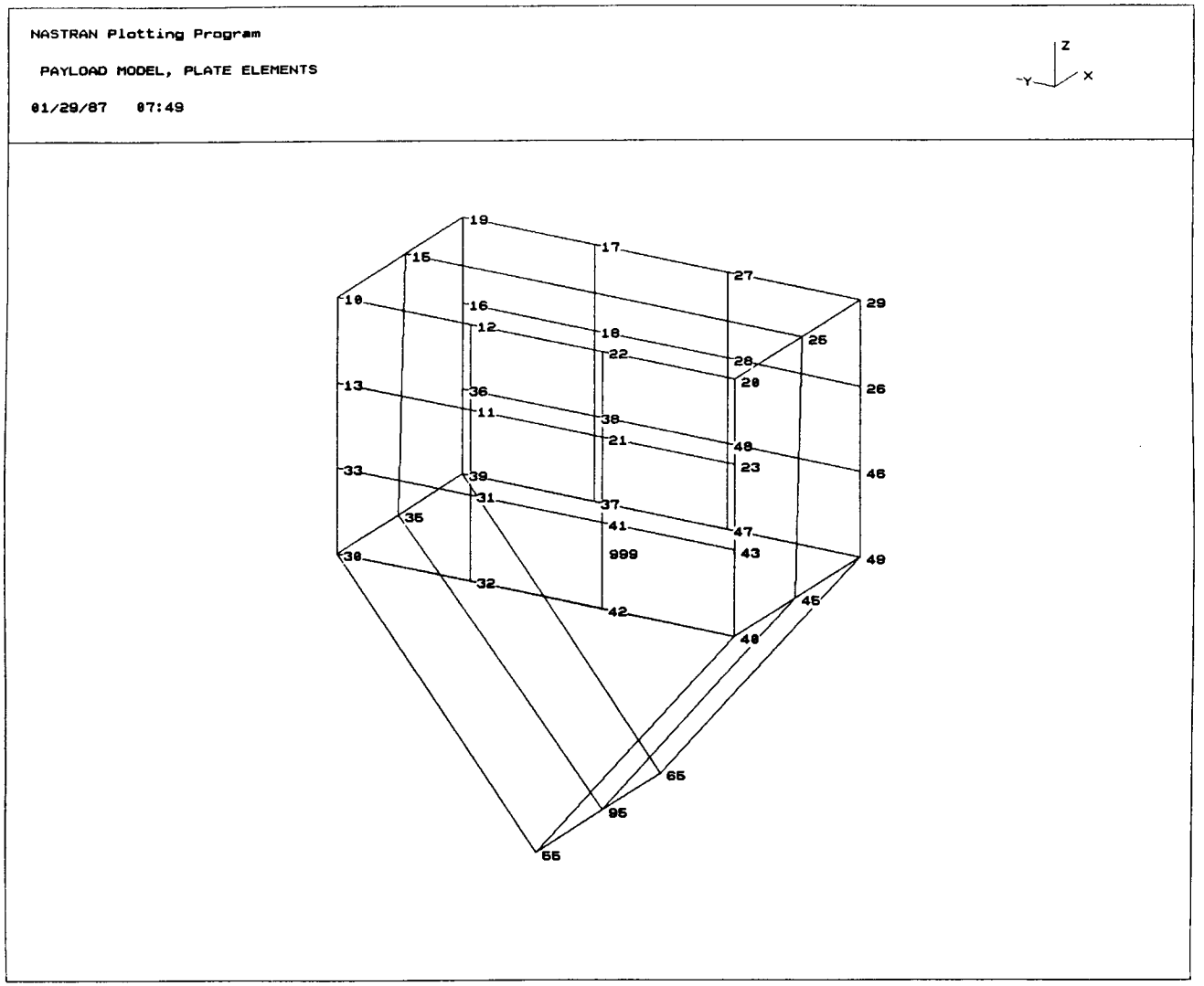

Figure 2. Plate Model with Node Numbers

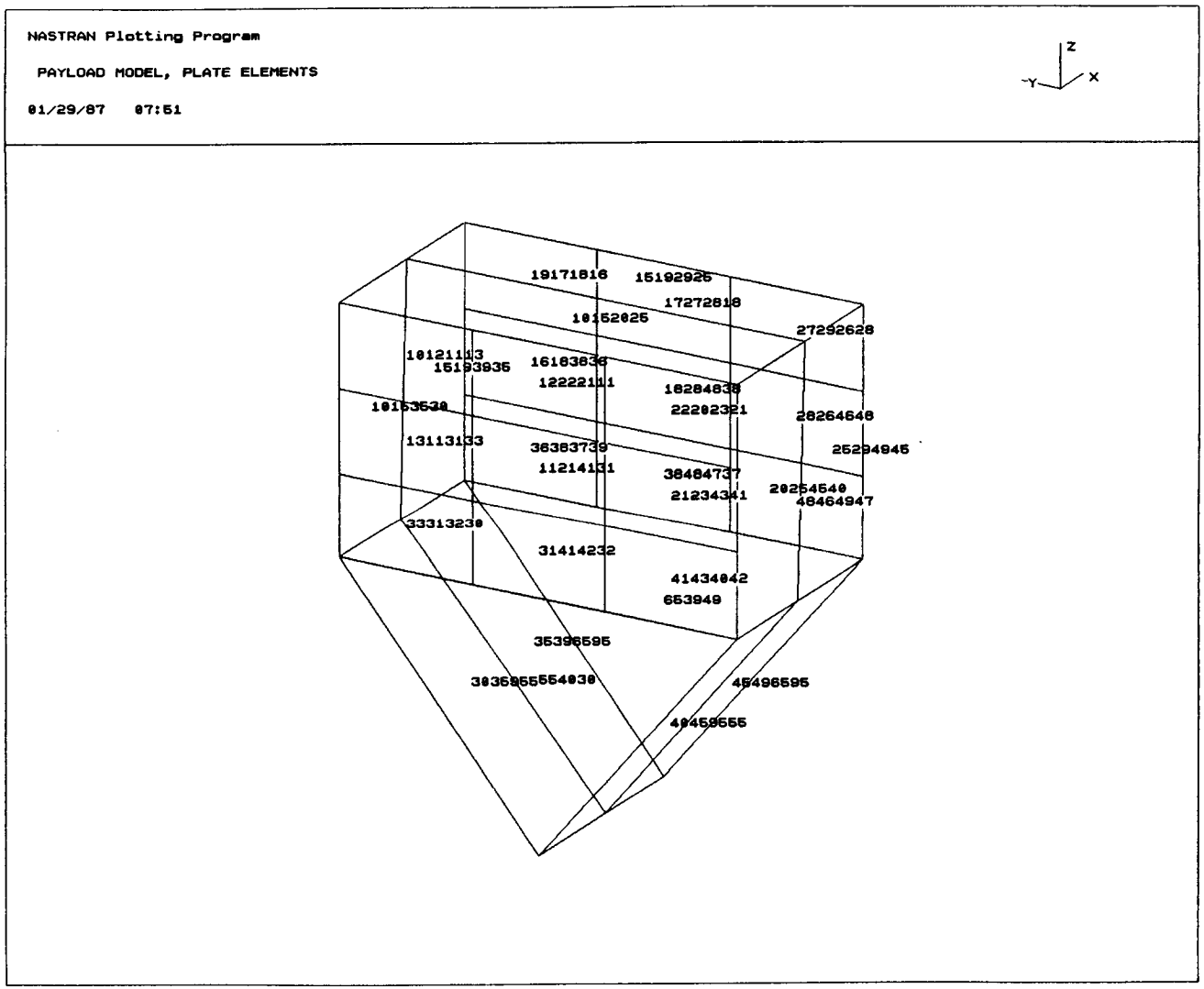

Figure 3. Plate Model with Element Numbers

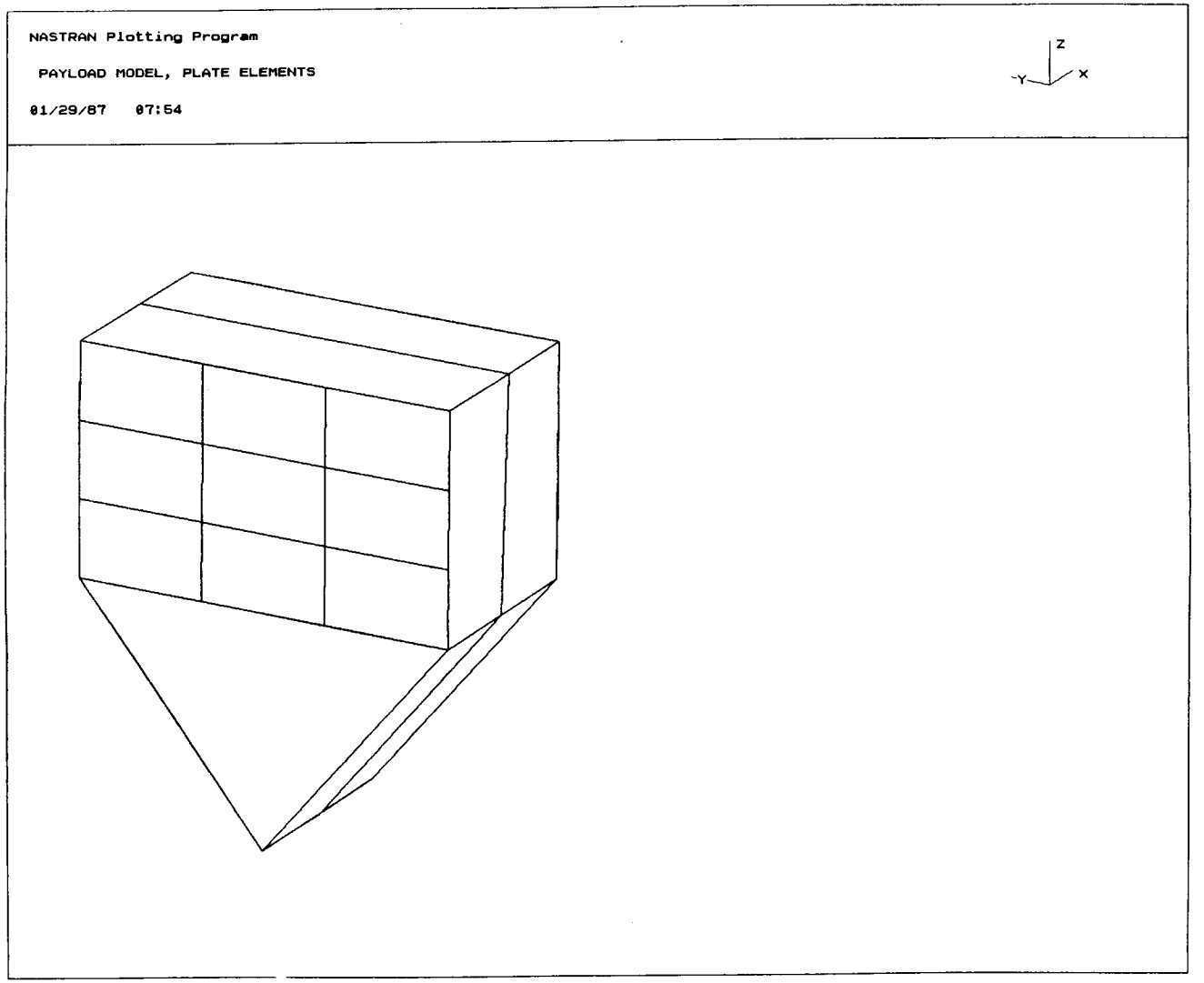

Figure 4. Plate Model with Hidden Lines Removed

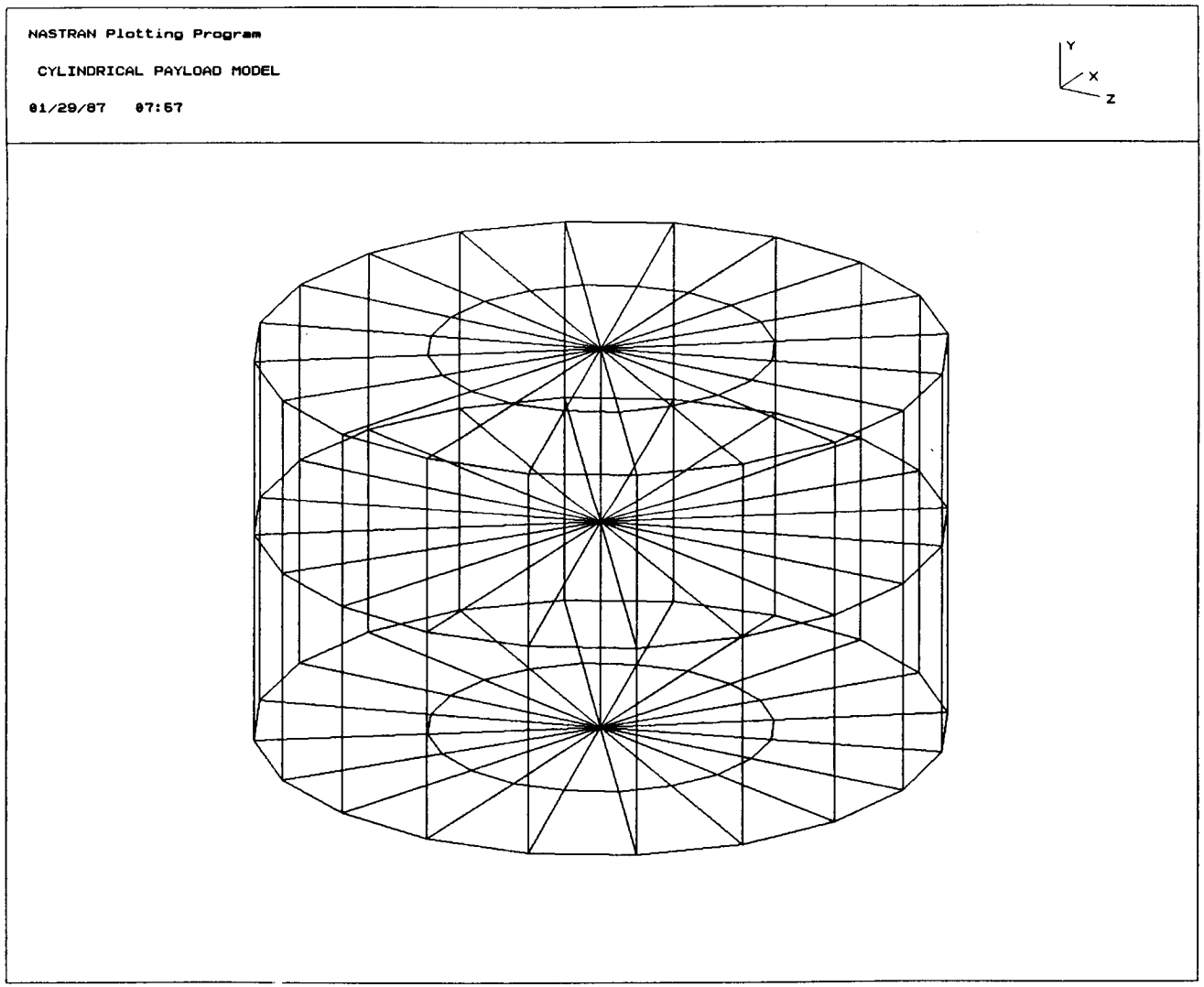

Figure 5. Cylindrical Model

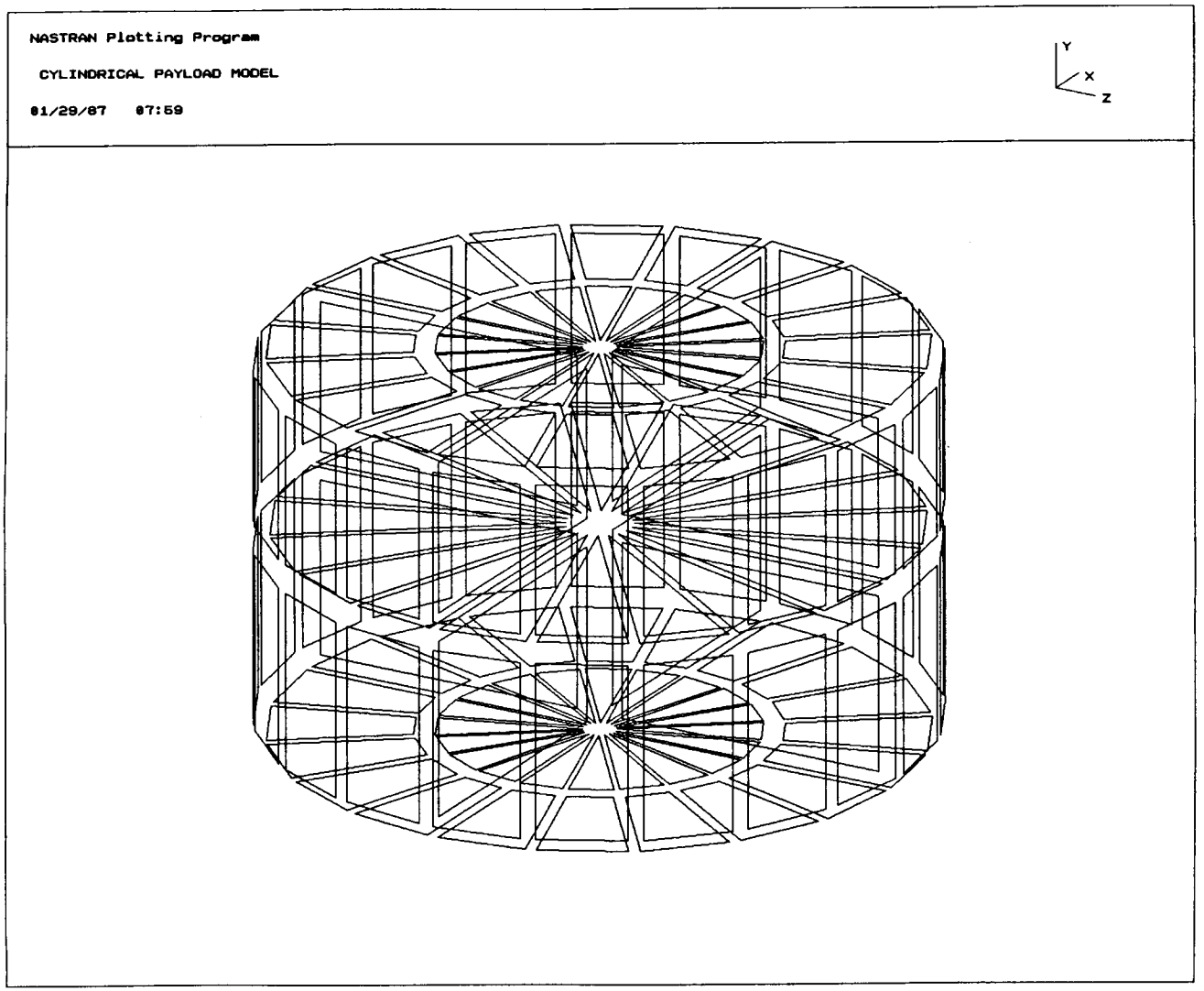

Figure 6. Cylindrical Model with Element Shrink

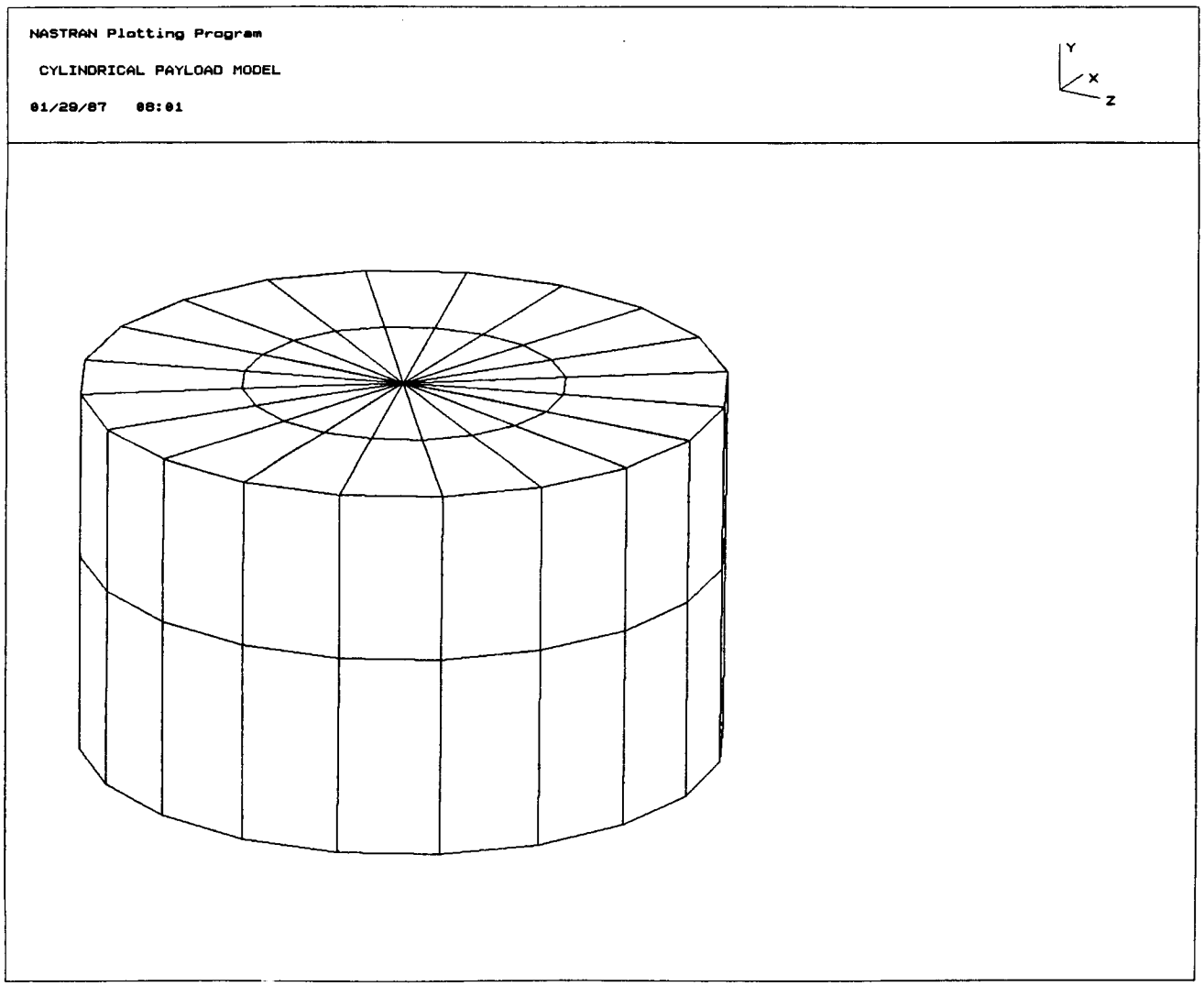

Figure 7. Cylindrical Model with Hidden Lines Removed

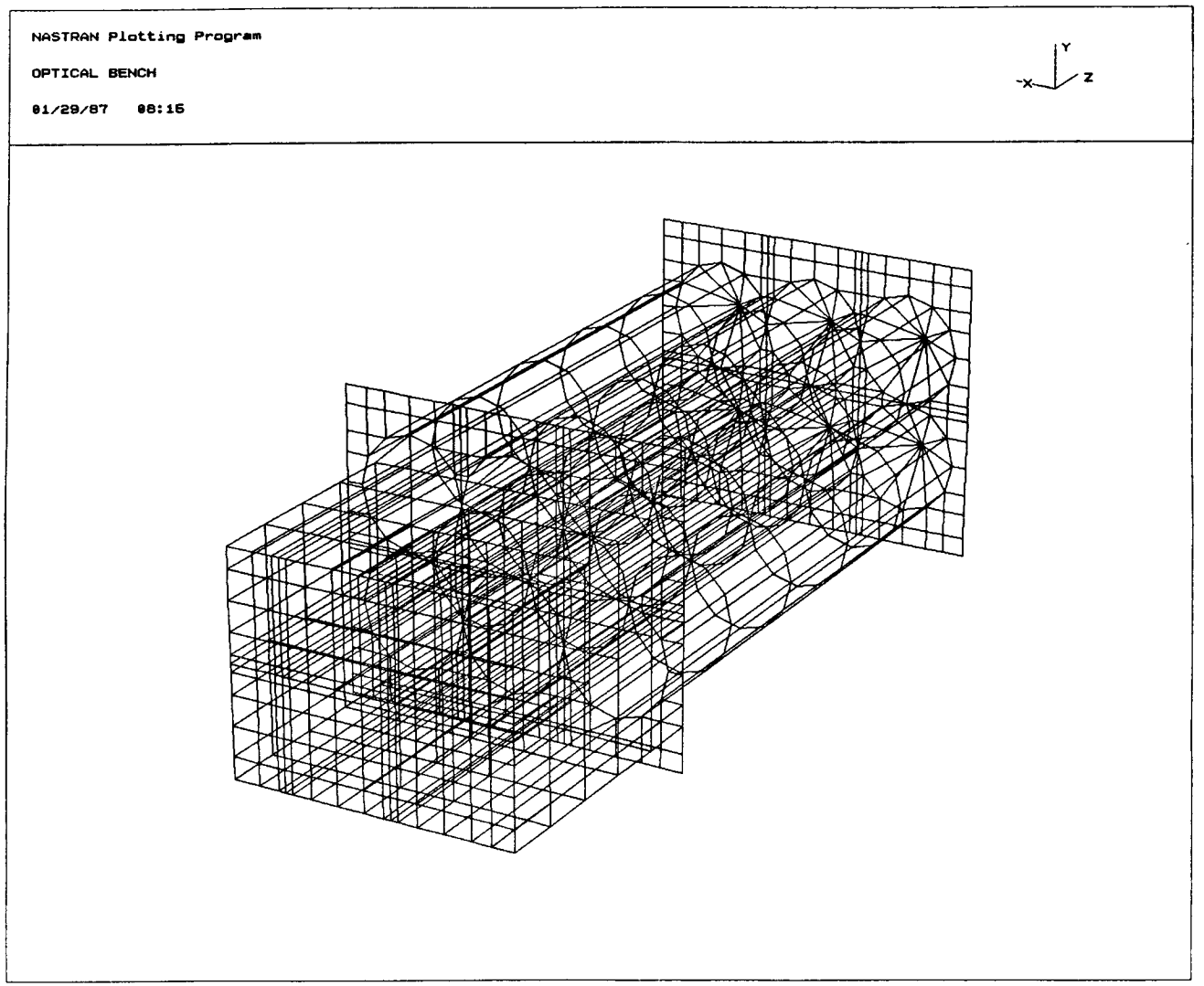

Figure 8. Optical Bench with Perspective