Engineering Systems

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Managing Distributed Power on an APOLLO SYSTEM

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ABSTRACT

An earlier MSC/NASTRAN User's Conference paper described Apollo MSC/NASTRAN use on a minimum-investment, single-node DN420. This paper describes a multi-node, state-of-the-art network of Apollo microcomputers, printers, color plotters, auxiliary storage disks, and tape drive. Modern finite element pre- and post-processing software for magnetic, structural, thermal, and CAD applications is described.

INTRODUCTION

A. O. SMITH Data System Inc.'s Engineering Systems has been providing its customers with software and consulting solutions since the early 1970s. Over those years, computing requirements have included the application of both mainframe and microcomputers. The mainframe being used primarily for MSC/NASTRAN consulting analysis, electromagnetic analysis, and software development programming, with pre- and post-processing being performed on both the micros and the mainframe.

Two years ago, in the Reference 1 paper, A. O. SMITH'S experience with their first Apollo unit was related by Dr. Vern Overbye. That first installation consisted of a DN420 with 1Mb of memory, a 167Mb Winchester disk, a floppy disk drive, and a floating point processor. CPU times for runs performed on this machine ranged upwards of forty times that of the IBM 3033. However, due to the multi-user environment of the IBM, the Apollo jobs showed an elapsed time of just over three times that of the IBM.

Approximately one year ago, all consulting and software development were consolidated on an expanded Apollo Domain network. This paper outlines the management of that network of microcomputers to satisfy the computational requirements of sophisticated finite element analysis and related activities.

HARDWARE CONFIGURATION AND USAGE

PRIMARY NODES

The Apollo network used by Engineering Systems consists of a total of twelve individual nodes, each connected to one another by a ring of communication. Six of these nodes have color monitors, three DN660s and three DN550s. The other nodes on the network are two DN330s, two DN300s, and the original DN420, all of which are monochrome, and a DSP90, which is a monitor-less fileserver (see Figure 1 and Table 1). The two DN660s that are licensed to perform MSC/NASTRAN have been upgraded from 2Mb to 4Mb in an effort to improve their interactive performance, particularly when a batch job is running in the background. All three of the DN550s are currently being upgraded to DN560s by increasing their memory from 1.5Mb to 3Mb, also in an effort to improve their interactive response time.

DISK STORAGE

Disk space on the entire network totals 1651Mb of on-line storage (see Table 1). A 500Mb Winchester drive serves one of the 4Mb DN660s to provide for large data bases, scratch files, and output files created by large MSC/NASTRAN runs. Of the twelve nodes on the network, half of them are diskless (two DN550s, two DN330s, and two DN300s), requiring them to be booted off of a node with a disk. This dependence tends to accentuate any maintenance-related down time by taking multiple nodes out of service at once. Twin 300Mb CDC storage modules provide additional on-line disk space through the fileserver.

AUXILIARY EQUIPMENT

In addition to controlling the twin 300Mb CDC drives, the fileserver controls a 6250 bpi 9-track tape drive and a Versatek V-80 printer. The tape drive is essential for both routine back-up procedures, as well as permanent archiving of data sets that need to be saved for possible future use. The Versatek printer is used to print data files and to secure hard copy output of screen graphics.

A second color monitor, a Tektronix 4109, is attached to one of the DN660s, to accommodate a second user. It is through this Tek 4109 that a color hard copy can be obtained on the Tek 4692 hard copy unit.

Floppy disk drives are integral to one of the DN660s and the DN420. These floppy drives are used primarily for back-up of small datasets. Also integral to one of the DN550s is a 1/4-inch streamer tape drive, capable of capturing 45Mb of data. This provides a good intermediate alternative between the relatively slow, small capacity floppy disk, and the fast, high density 9-track tape drive, which is typically operated only by the system administrator. This medium is utilized quite frequently for personal back-up tapes.

Communication with outside computer facilities is provided by means of a KMW Series II Protocol Converter. The KMW has provided the ability to log onto other computers at remote sites and transfer data to and from that location. The HASP/RJE connection reduces the need for time-consuming tape transfers.

CONSULTING SOFTWARE

GENERAL PURPOSE

General purpose software that is utilized for consulting activities on the Apollo system by Engineering Systems can be divided into three categories: 1) Pre- and Post Processors, 2) Structural Finite Element Codes, and 3) Electromagnetic Finite Element Codes.

While a small portion of pre-processing is done with a Graytech 3-D CAD package to establish geometric line data, by far the bulk of pre-processing and all of the post-processing is performed by PDA's

Patran, which is resident on all six color nodes. Patran provides the analyst with the capability to interactively construct geometric points, lines, arcs, splines, surfaces (patches), and volumes (hyperpatches). Solid modeling has recently been enhanced by the addition of primitives to the available set of options. Once the geometry is established, a finite element mesh can then be mapped onto that outline with the required degree of refinement. After the addition of properties, loads and boundary conditions, the model is then ready to be translated to the appropriate finite element code as input bulk data.

The two structural finite element codes available to A. O. SMITH consulting engineers are MacNeal-Schwendler's MCS/NASTRAN and Hibbitt, Karlsson, and Sorensen's ABAQUS, with MSC/NASTRAN performing the bulk of the work. Our own two proprietary magnetic finite element codes also reside on the Apollo system, AOS/MAGNETIC™ and AOS/MAGNUM™. AOS/MAGNETIC calculates magnetic fields and performance of a wide variety of magnetic and electrical devices. It utilizes the finite element method to study performance parameters such as forces, torques, power losses, and impedances in an effort to maximize the electrical efficiency and minimize materials, a process previously possible only through prototype testing. AOS/MAGNUM extends this capability to three dimensional electromagnetic solutions. Devices that have had this method applied to them are AC, DC and permanent magnet motors, transformers, solenoids, switches, relays, loudspeakers, and alternators. Results from MSC/NASTRAN and AOS/MAGNUM are then post-processed by Patran with the help of color contour and color fringe plots.

The greatest asset of the distributed power concept of the Apollo system is that it eliminates the need for time-consuming file transfers to and from a mainframe. In fact, the total elapsed time for successive iterations conducted on the Apollo is often shorter than when performed on a mainframe many times faster. This is primarily because the Apollo is a single user system and time for sending data files to and receiving results files from the mainframe is eliminated.

SPECIALITY

A number of specialty software programs have been written over the past year to enhance the simultaneous use of Patran and MSC/NASTRAN on the Apollo system. One that is extremely useful is QNAST. It was determined that a MSC/NASTRAN job running on one of the DN660s degraded the interactive use of that node. It was also noticed that given the freedom allowed by the system, more than one MSC/NASTRAN job could be initiated simultaneously. If the node running the job was left unattended, someone could accidentally log off the person who was running MSC/NASTRAN, and kill the job.

For these reasons, a MSC/NASTRAN queuing program was developed to accomodate runs with CPU times in excess of one hour. With this program, a user can submit a MSC/NASTRAN run to the queue from anywhere on the network for execution on the MSC/NASTRAN nodes at a later time. The jobs are executed in the order in which they appear in the queue, with the first job starting at a specific time, say 5PM, and no job starting after 8AM the next day (except weekends). When QNAST is called, a menu allows the user to: select the node on which to run, then either add a job, insert a job, remove a job from the queue, kill a job that is running, display the queue, display release time for the first job, or change the release time (see Figure 2). The important fact to note about this program is that it "manages" the MSC/NASTRAN jobs running by communicating with two background processes that run constantly on the MSC/NASTRAN nodes. These two processes, Nastran_Server and Nastran_Cruncher run constantly along with a window called Nastran_Job_Window (see Figure 3), which displays the MSC/NASTRAN link information and start and finish times. This allows users to log in and out as they please, and provides information about the queue on demand, which previously was difficult with the multiple windowing features of the Apollo.

CONSULTING EXAMPLES

PATRAN

A consulting engagement at its inception requires that geometric data be provided to describe the object to be analyzed. That data may come from one of many sources: engineering drawings, hand sketches, prototype or production parts, or CAD-generated line data. Whether the line data is produced by the analyst or transferred from a CAD package, this is the starting point for a Patran model. Figure 4 shows a wire frame representation of basic CAD geometry. Surfaces and volumes (if solid geometry) are then created to assemble these lines into a model (see Figure 5) closely representing the actual part. This geometry is then meshed by dividing it into an appropriate number of elements (see Figure 6). Loads, boundary conditions, and material properties (see Figure 7) are then applied before translating the model to the appropriate analysis code.

Once the analysis is complete, results are translated back to Patran, viewed by the analyst, and captured for report or presentation by the Versatek printer, the Tek color hard copy unit, a 35mm camera, or in some instances when animation is necessary, a VCR camera. Patran offers a wide variety of post-processing options: simple deflected shapes (see Figure 8), animation of those deflections, stress contours (see Figure 9), fringe plots, and combinations of each.

MSC/NASTRAN

MSC/NASTRAN Version 64 was installed on two of the Apollo DN660s in early 1985. Since that time, many sizes of analyses and many of the solution sequences have been satisfactorily performed. Run statistics for three of those analyses are recorded in Table 2. CPU times for these three runs range from a moderately sized job of just over two hours to a relatively large job that consumed 18 1/2 hours. The first of these examples, an exhaust manifold (Figure 10), was also run on a 3084 IBM mainframe. The ratio of the run times show a factor of approximately 19 times for the Apollo. With more than 10,000 DOF and a grid bandwidth of almost 40, this 1804 grid plate model would most likely be run at an overnight priority.

The other two runs, the head of an engine (Figure 11), with 11,675 DOF, nearly 4000 grids and a 183 grid bandwidth, and the engine block (Figure 12), with 11,386 DOF, 3871 grids, and a grid bandwidth of 165, are both solid element models. These two solution 24 runs would be performed at night or on the weekend. Models larger than the block would be subdivided into superelements and run as separate solutions.

AOS/MAGNETIC

An example of the utilization of AOS/MAGNETIC to determine the magnetic flux pattern in an automotive horn is shown in Figure 13. Part (a) of the figure describes the various components of the horn, part (b) shows the axisymmetric model that was utilized to solve the problem, and part (c) shows the resulting magnetic flux lines. Those regions of high field are saturated, indicating a possible need for more material, whereas the regions of lower density indicate material could be eliminated. In addition to the magnetic field, AOS/MAGNETIC also calculates the magnetic force and inductance in the horn.

Figure 14 shows one half of a permanent magnet DC brush-type motor used in the blower mechanism of an automotive heating and cooling system. The components of the motor and the 2D finite element model are shown in parts (a) and (b). Part (c) depicts the resultant nonlinear magnetic flux pattern. The program also calculates the torque generated by the motor as a function of current.

AOS/MAGNUM

A typical example of the use of AOS/MAGNUM is represented by the model of one-twelfth of an automotive alternator shown in Figure 15. This three-dimensional technique provides the capability of modeling parts that do not possess a constant cross section like that of the previous examples. Contours of constant magnitude of potential A are shown in part (c) for the rotor and stator.

FUTURE CONSIDERATIONS

What does the future hold for our usage of the Apollo system as a consulting tool? As is generally the case with any computer system, it needs to be faster, with greater disk capacity, and more workstations. The speed factor will most likely be addressed within the near future by the addition of a large number cruncher to handle the growing demand of ever larger MSC/NASTRAN and AOS/MAGNUM runs. Secondly, disk space continues to be a problem, because the more you have, the more you utilize. Also, as our consulting and software business expands, the number of workstations will undoubtedly grow, having grown already from the initial nine to the current twelve nodes.

REFERENCES

1. Overbye, V.D., "Apollo MSC/NASTRAN: A User's Experience," MSC/NASTRAN User's Conference Proceedings, Pasadena, CA, March 22-23, 1984.

2. Brauer, J.R., "Automotive Electrical Components Analyzed by Magnetic Finite Elements," International Congress & Exposition, Detroit, MI, February, 1985.

3. Brauer, J.R., "Automotive Alternator Electromagnetic Calculations Using Three Dimensional Finite Elements," COMPUMAG Conference, Fort Collins, CO, June, 1985.

TABLE 1 HARDWARE

Primary Nodes

3	Apollo DN660 Nodes (4Mb,4Mb,2Mb)
3	Apollo DN550 Nodes (1.5Mb each)
2	Apollo DN330 Nodes (2Mb each)
2	Apollo Dn300 Nodes (1Mb each)
1	Apollo DN420 Node (1Mb)
1	Apollo DSP90 Fileserver (2Mb)
12	Apollo Nodes Total

Disk Storage

500Mb	Winchester
167Mb	Winchester
167Mb	Winchester
167Mb	Winchester
50Mb	Winchester
300Mb	CDC 9766 Storage Module
300Mb	CDC 9766 Storage Module
1651Mb	Total Storage

Auxiliary

1	Tektronix 4109 Color Monitor
1	Tektronix 4692 Color Hard Copy Unit
1	Versatek V-80 Printer
1	KMW Series II Hasp/RJE Protocol Converter
1	Apollo 1600/6250 BPI Mag Tape Drive
1	Apollo 45Mb 1/4-inch Streamer Tape Drive
2	Floppy Disk Drives

TABLE 2 MSC/NASTRAN RUN STATISTICS

	Apollo CPU	IBM 3084 CPU
Exhaust Manifold	127.6 Min.	6.7 Min.
Grids------1804		
DOF---------10,488		
RMS BW-----39.6 (Grids)		
Engine Head (Highcore=100000)	12.6 Hrs.	-------
Grids------3892		
DOF---------11,675		
RMS BW-----183 (Grids)		
Engine Block (Highcore=400000)	18.5 Hrs.	0.892 Hrs.
Grids------3871		
DOF---------11,436		
RMS BW-----173.3 (Grids)		

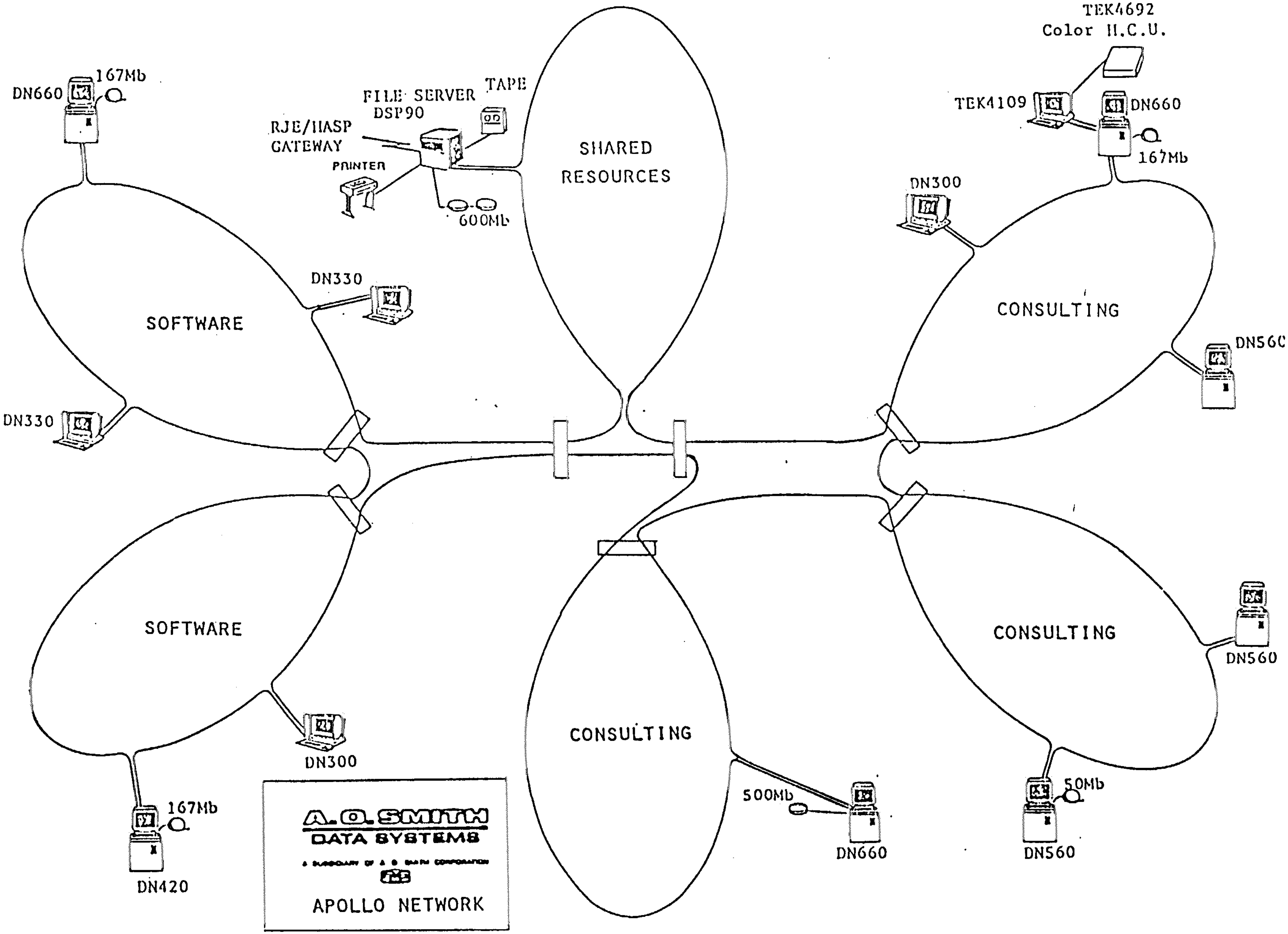
TEK4692
Color H.C.U.
DN660
167Mb
FILE SERVER
DSP90
TAPE
RJE/HASP
GATEWAY
PRINTER
600Mb
SHARED
RESOURCES
TEK4109
DN660
167Mb
DN300
SOFTWARE
DN330
DN330
CONSULTING
DN56C
SOFTWARE
CONSULTING
DN560
CONSULTING
DN300
DN420
167Mb
A. O. SMITH
DATA SYSTEMS
A SUBSIDIARY OF A. O. SMITH CORPORATION
APOLLO NETWORK
500Mb
DN660
50Mb
DN560

FIGURE 1.

```
$ QNAST
 --------- welcome to the nastran queue system -------

          1. access nastran queue on node_2edf
          2. access nastran queue on node_415e
          3. exit

enter choice >2

          1. append a nastran run to the queue
          2. insert a nastran run at the top of queue
          3. remove a nastran run from the queue
          4. kill the currently running nastran job
          5. display current queue
          6. display current queue release time
          7. change queue release time
          8. exit this menu

enter choice >
```

FIGURE 2. QNAST Menu

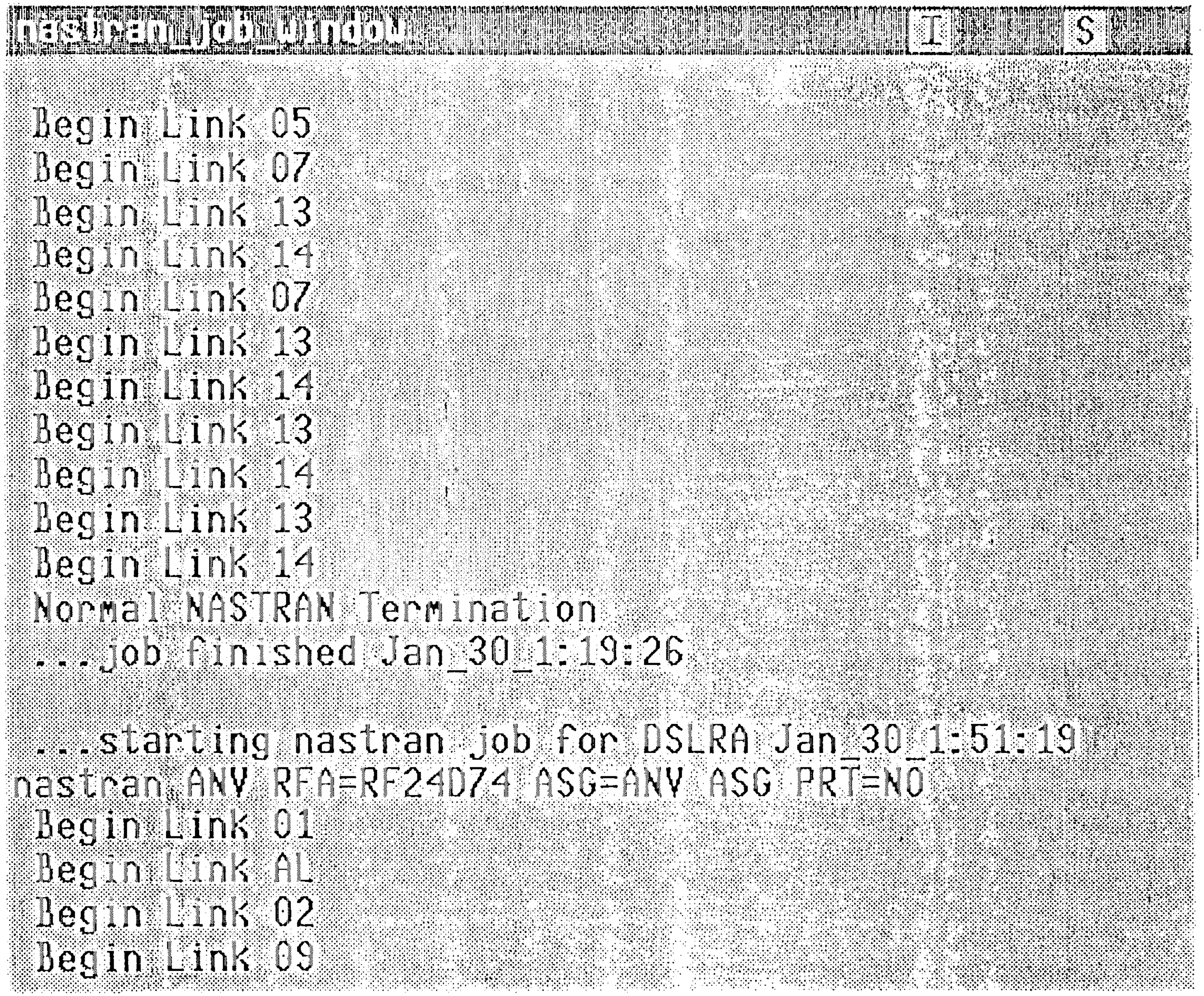

FIGURE 3. NASTRAN_JOB_WINDOW

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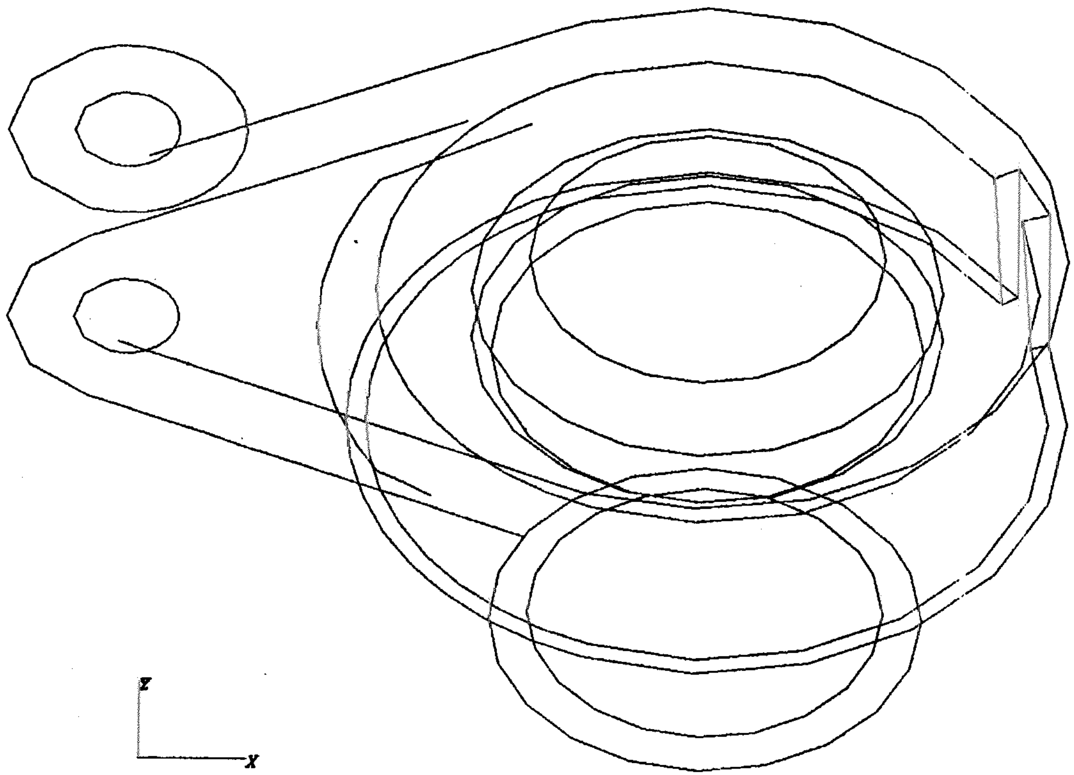

FIGURE 4. CAD Wireframe

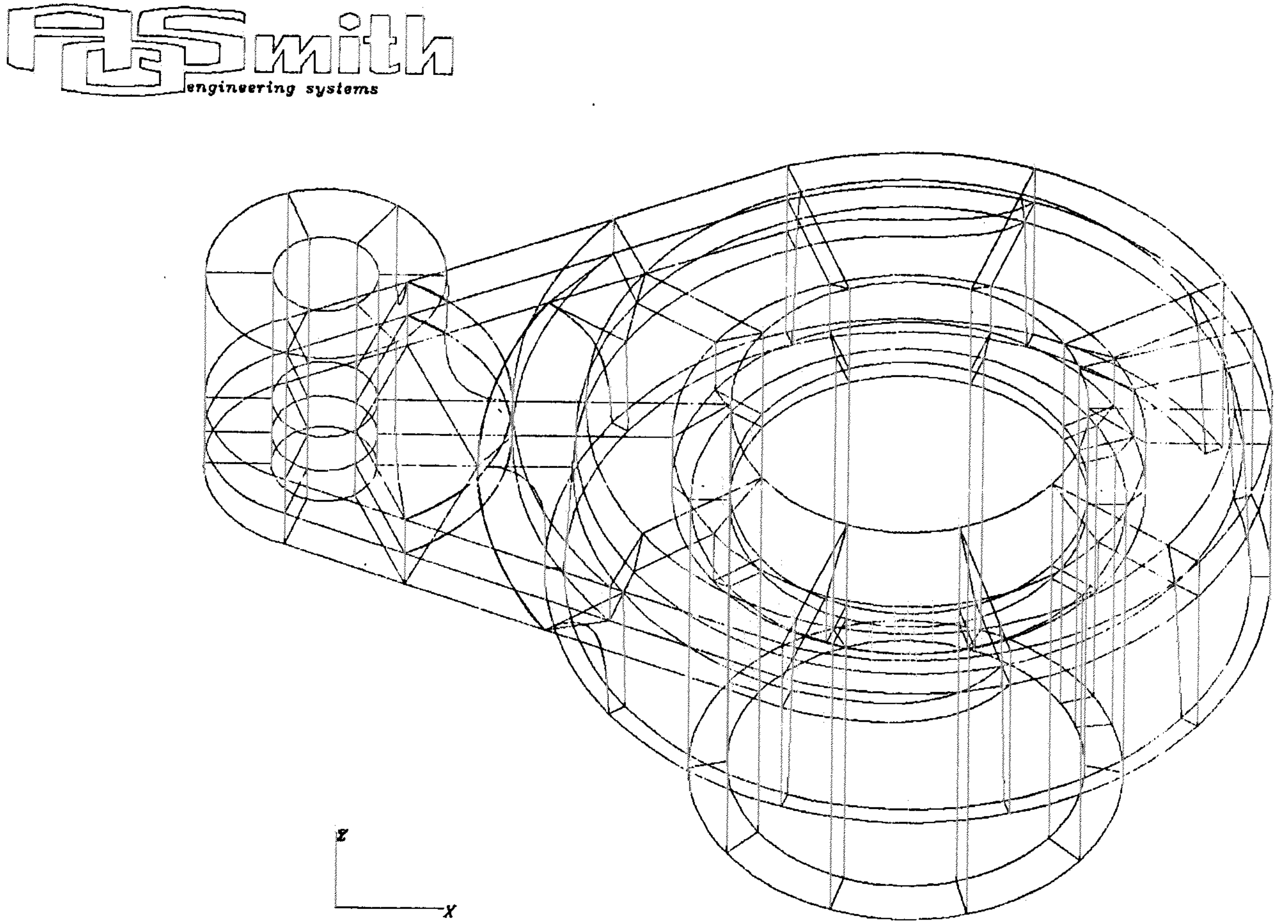

FIGURE 5. Volume representation

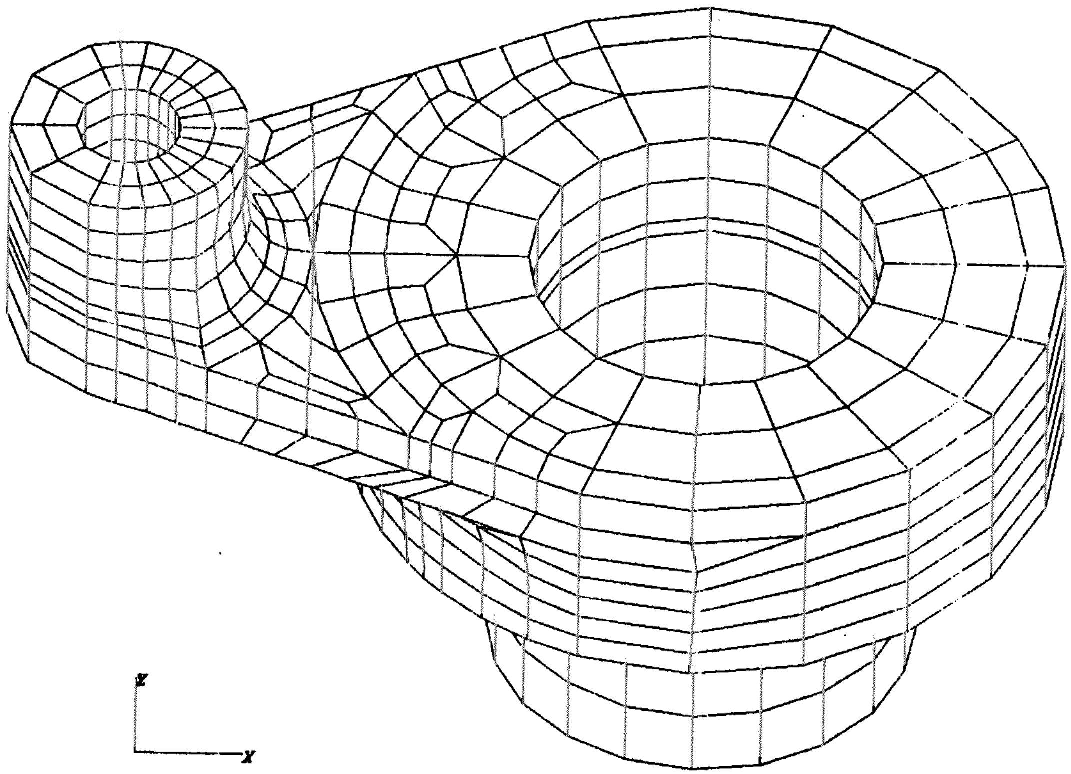

FIGURE 6. Finite Element Model

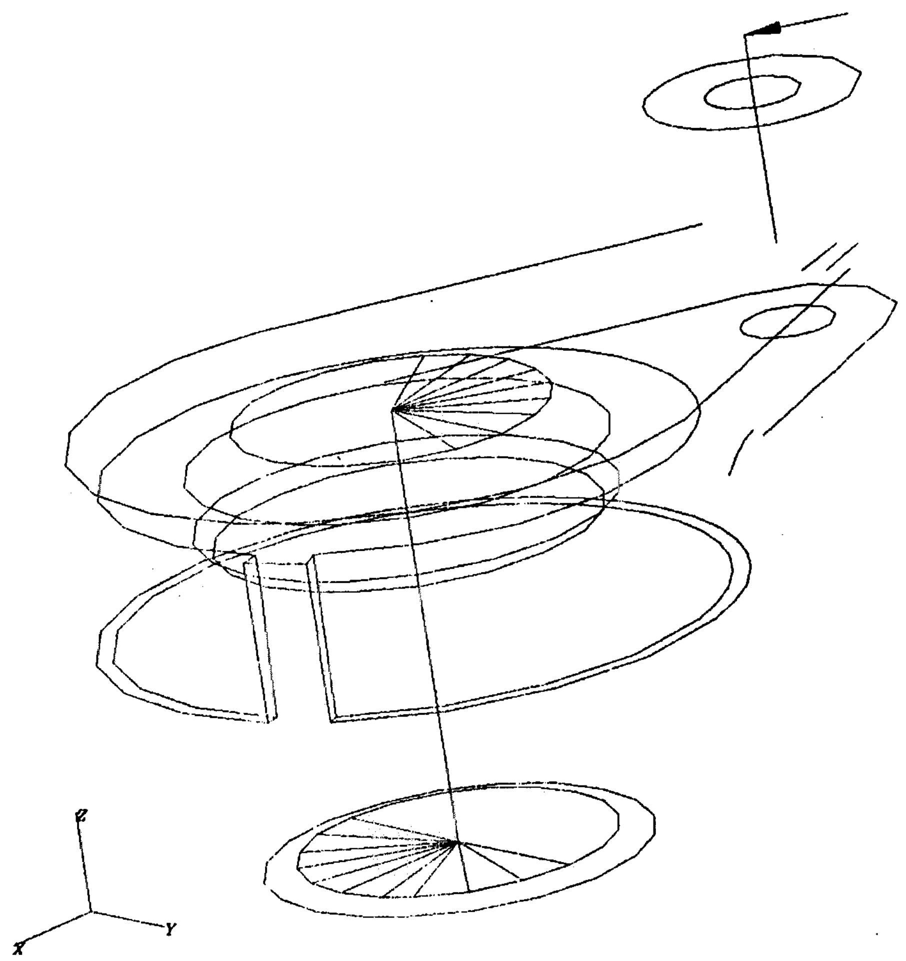

FIGURE 7. Loading and constraints

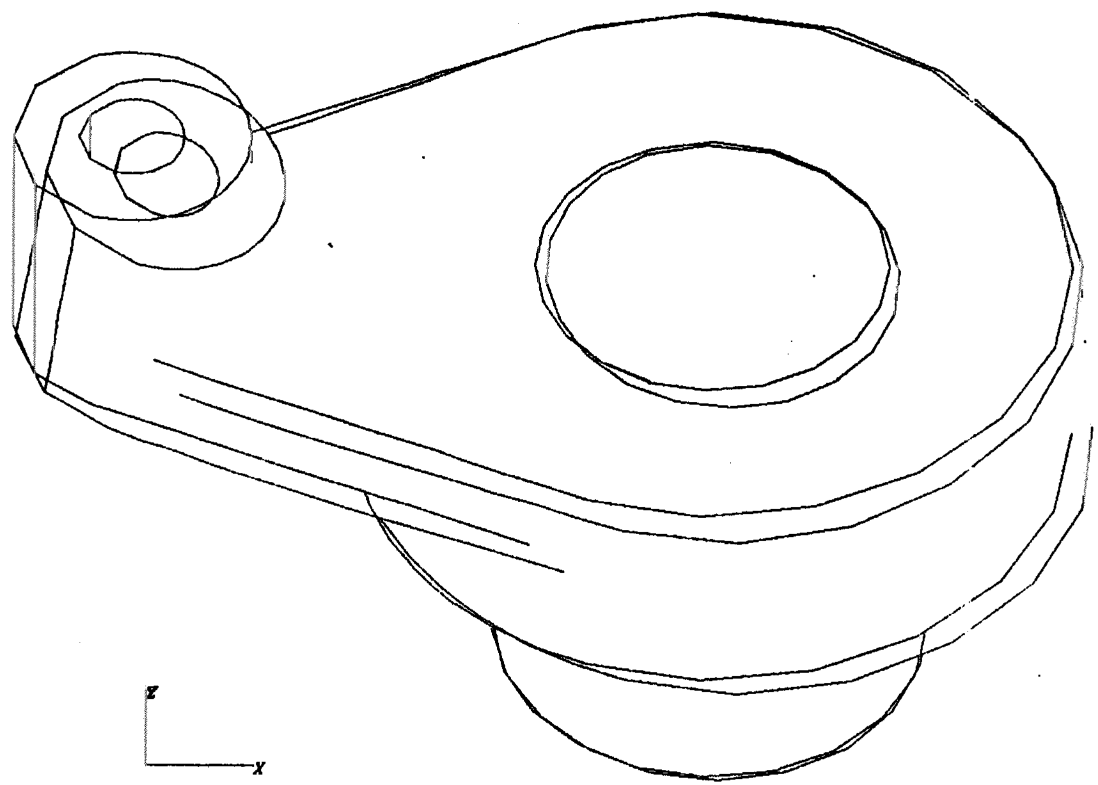

FIGURE 8. Deflected shape

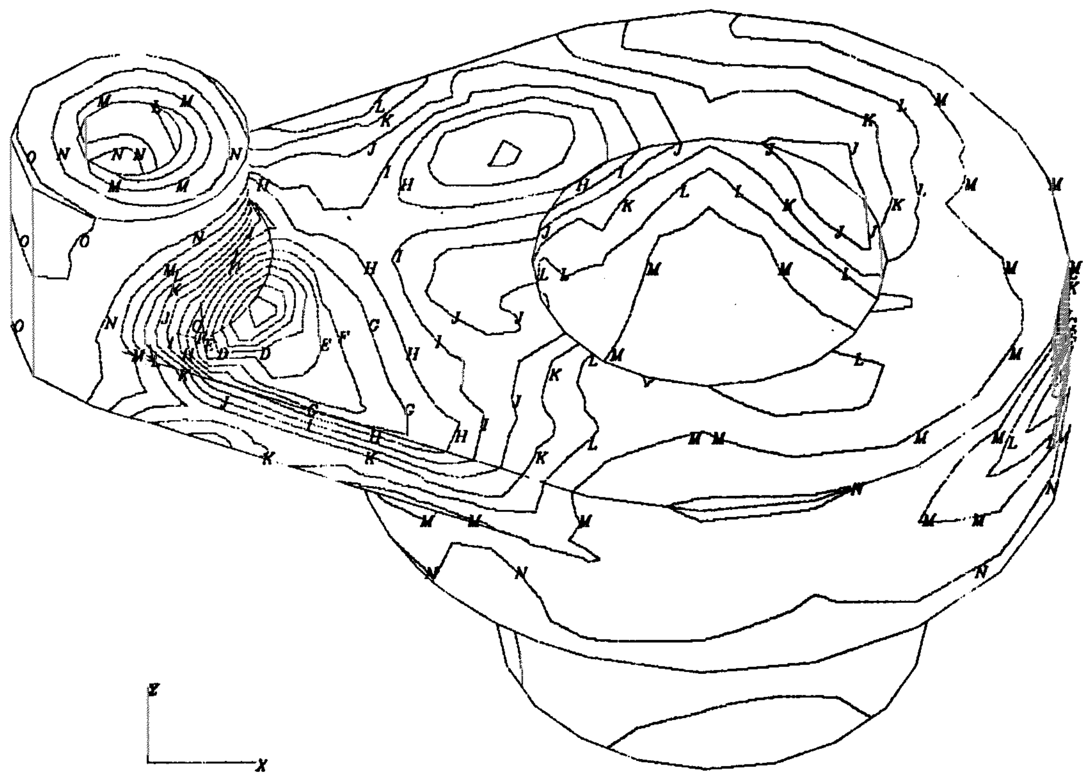

FIGURE 9. Stress contour plot

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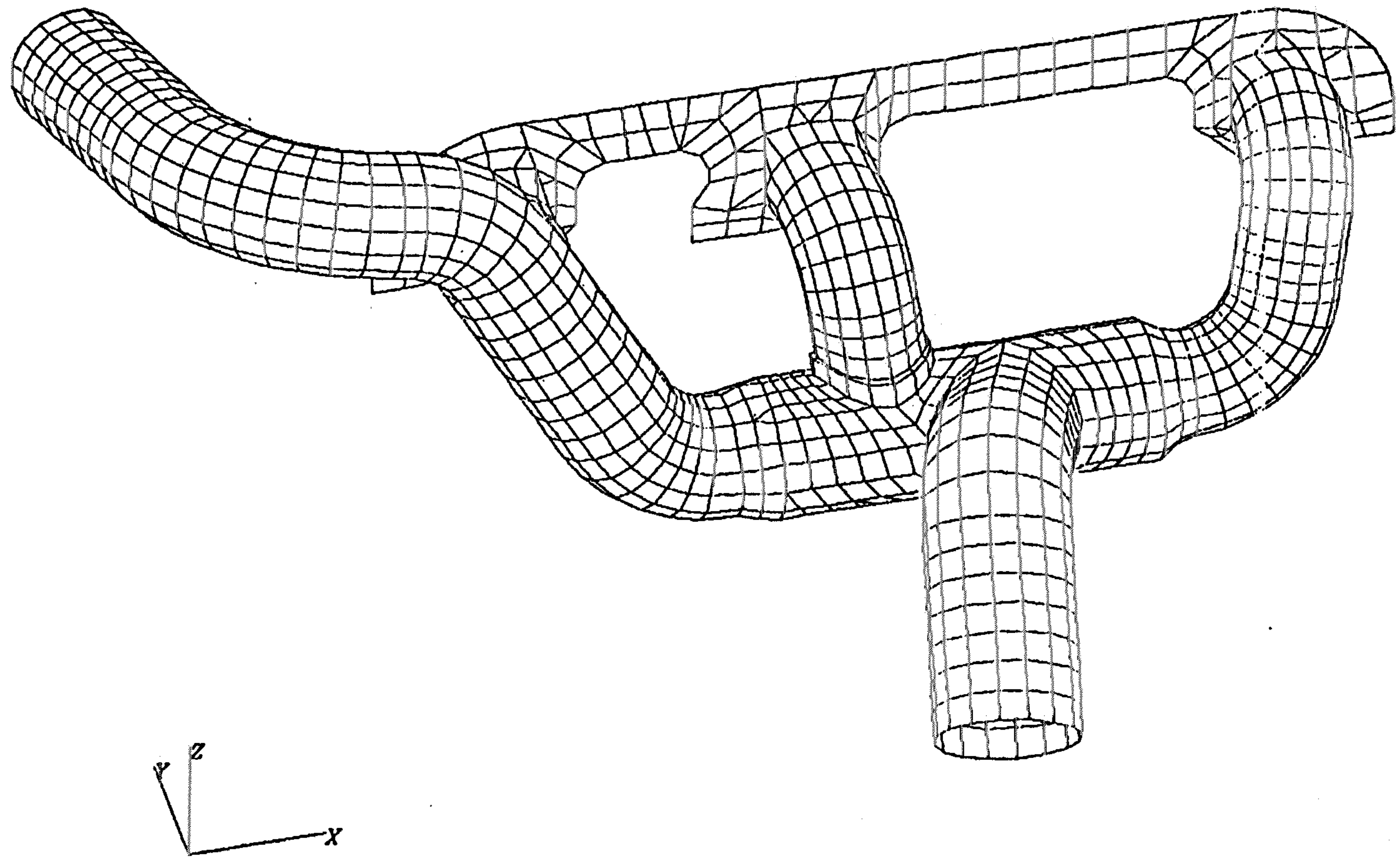


FIGURE 10. Exhaust manifold

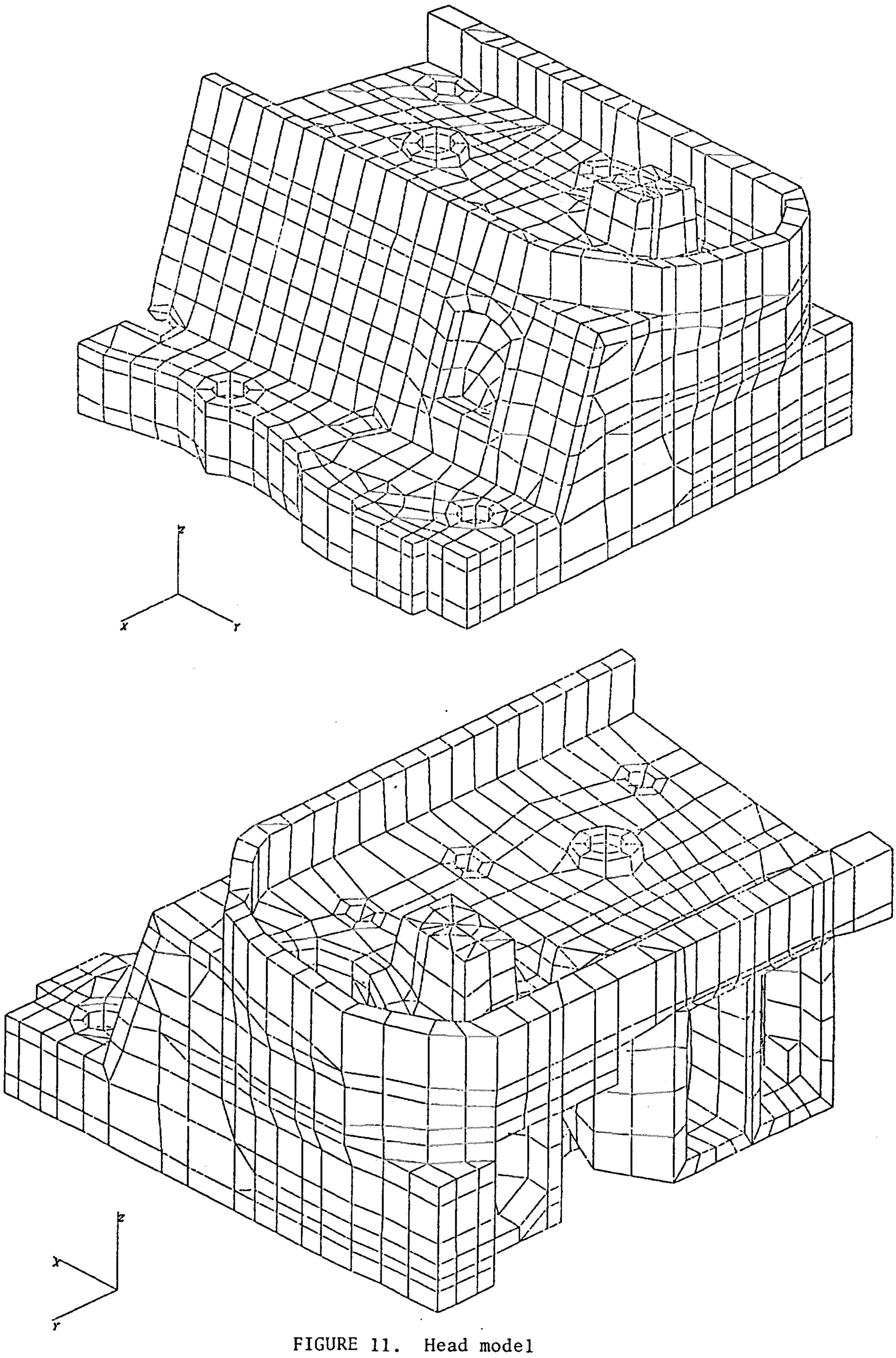


FIGURE 11. Head model

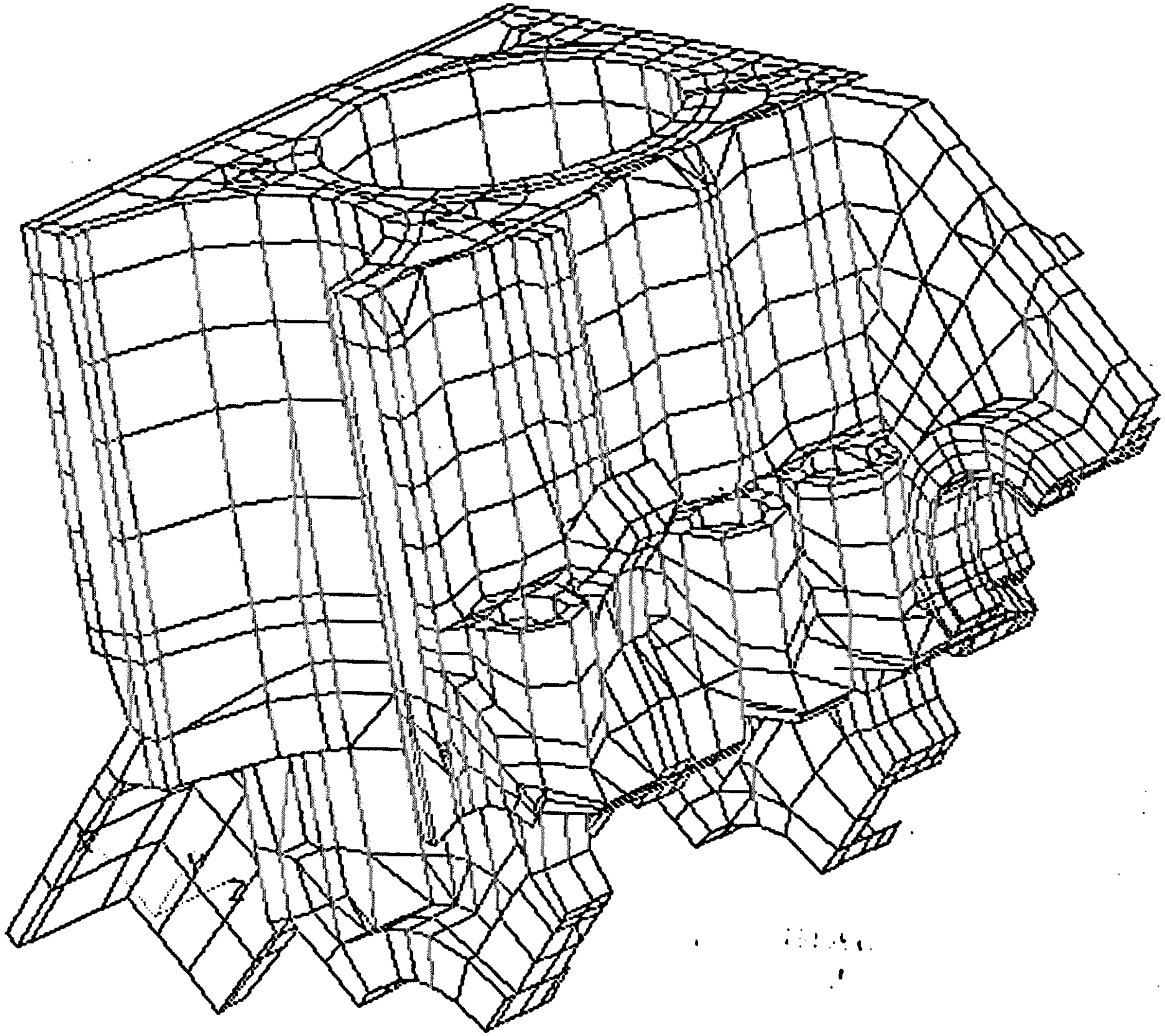
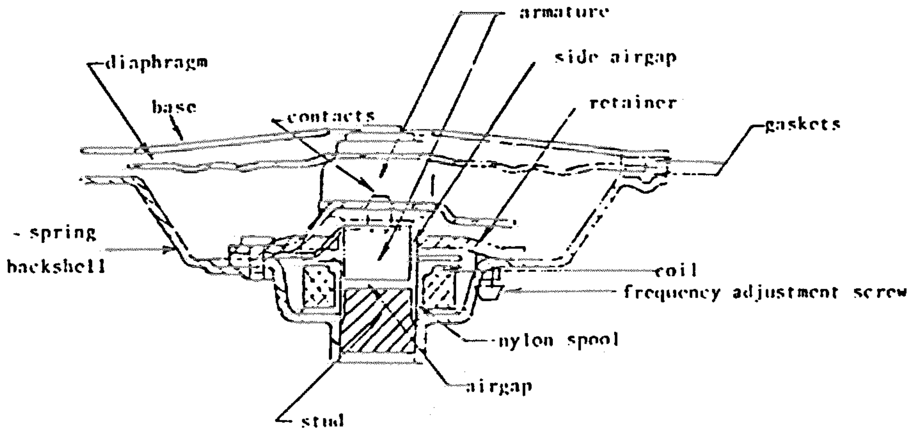
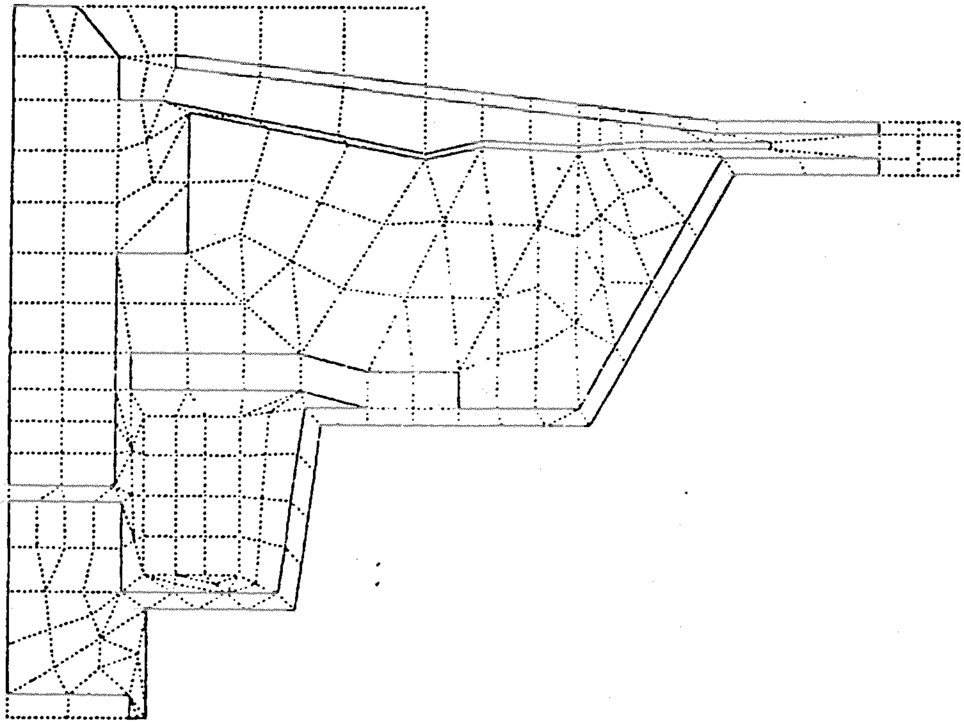


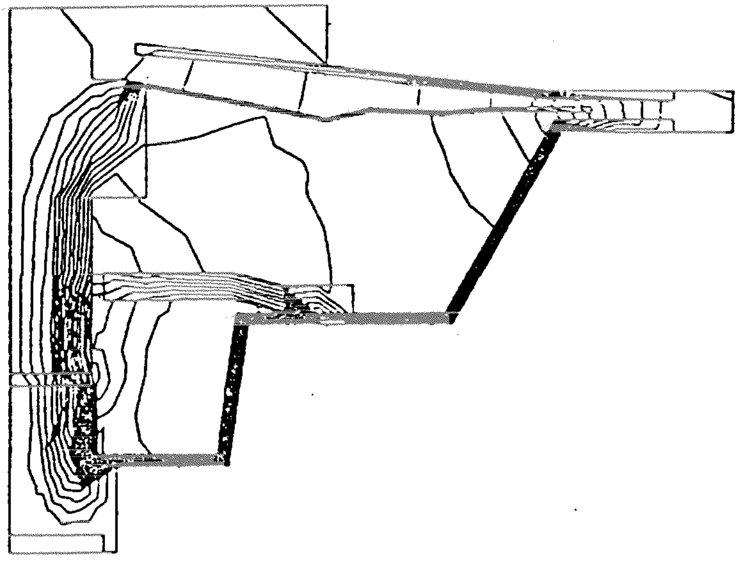
FIGURE 12. Block model



a).



b).



c).

FIGURE 13. Automotive horn

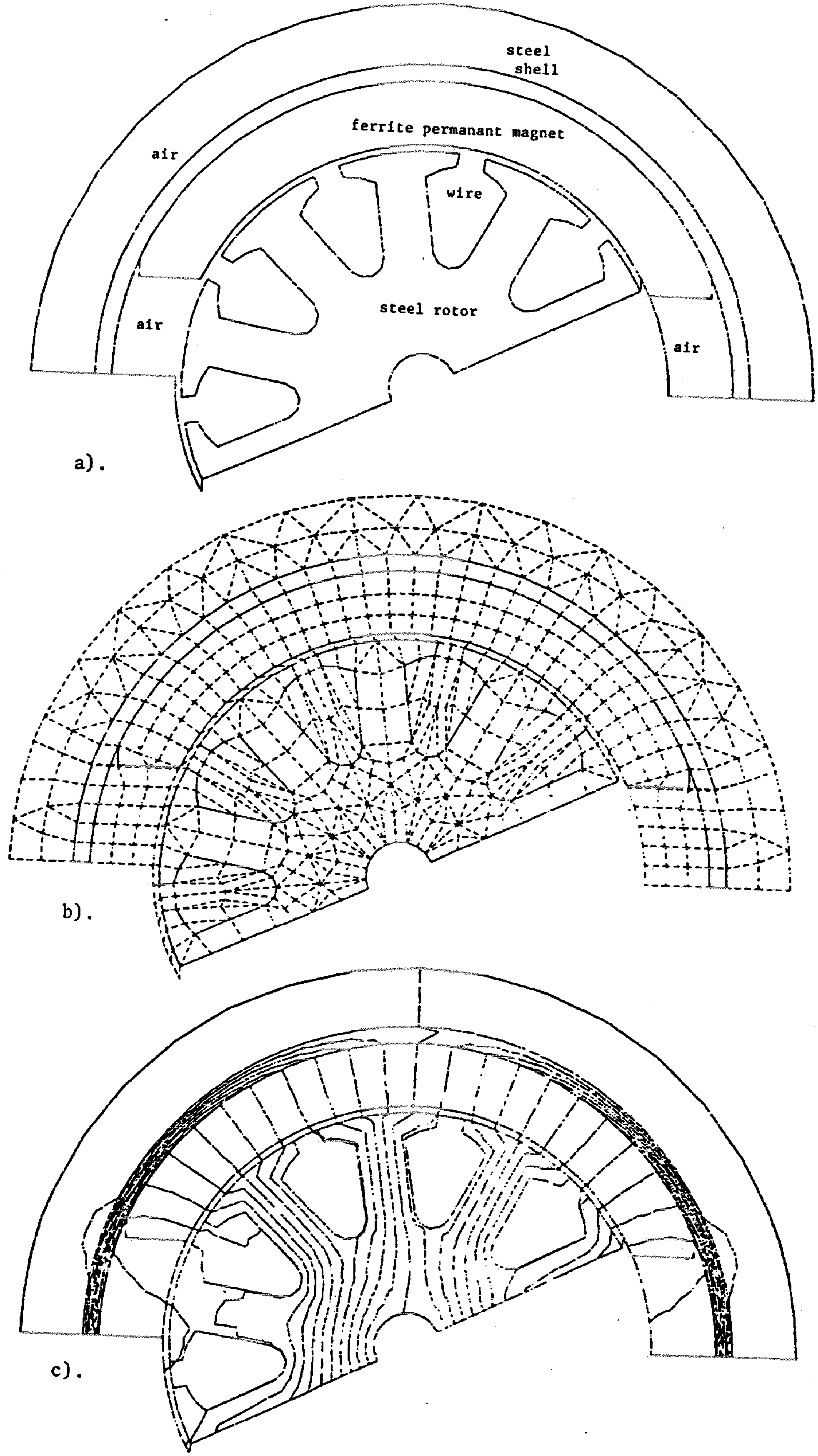


FIGURE 14. Permanent magnet motor

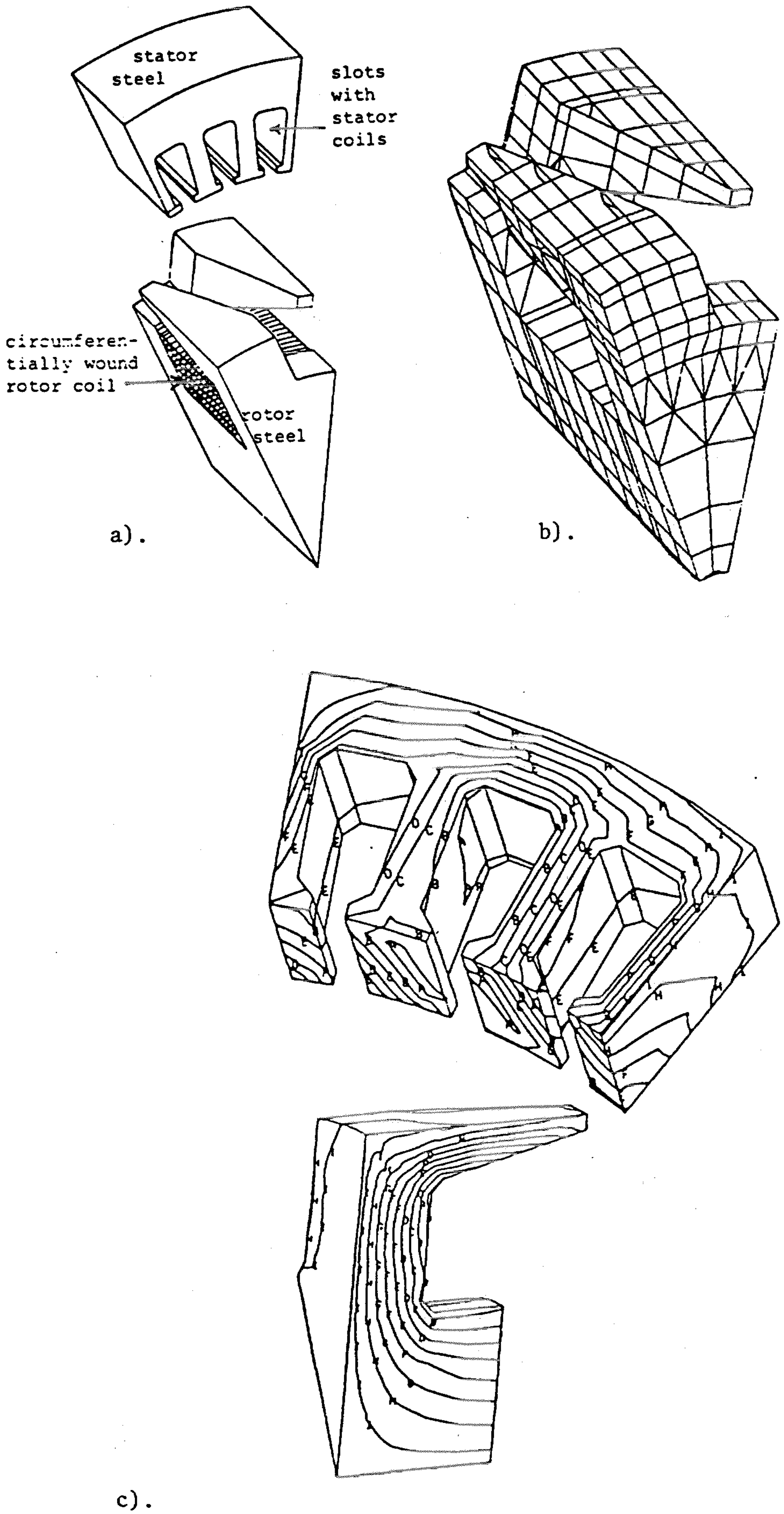


FIGURE 15. Automotive alternator