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SYSTEM ENGINEERING REPORT

SUBJECT: Static Structural Analysis of Meniscus Mirror

PROJECT: Stratospheric Observatory for Infrared Astronomy (SOFIA)

(NASA-TM-110701) STATIC STRUCTURAL ANALYSIS OF MENISCUS MIRROR (NASA. Ames Research Center) 128 p

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ABSTRACT

A finite element model of the SOFIA primary mirror was developed to simulate structural deformation under static loading for various elevation angles. Further processing of the deflection data produced optical performance results.

Evaluation of the results revealed that the mirror's hydraulic support system reduced optical performance, contrary to Phase B findings. However, further examination showed that optical quality can be greatly improved by modification of the support system. Optimization of the hydraulic support system using an in-house developed code was recommended. The outcome of the optimization would then determine whether an active support system is necessary.

TABLE OF CONTENTS

SECTION	SUBJECT
1.	**INTRODUCTION**
2.	**FINITE ELEMENT MODEL**
2.1	GEOMETRY AND MATERIAL
2.2	ELEMENT FORMATION
2.3	COORDINATE SYSTEM
2.4	BOUNDARY CONDITIONS
2.4.1	Support Configuration
2.4.2	Formulation
2.4.3	Implementation
2.4.3.1	Model Alterations
2.4.3.2	Multipoint Constraint Application
3.	**ANALYSIS**
3.1	OBJECTIVE
3.2	LOAD CONDITIONS
3.2.1	Assumptions
3.2.2	Load Cases
3.3	STRUCTURAL ANALYSIS RESULTS
3.4	STRUCTURAL-OPTICAL INTEGRATION
3.5	OPTICAL ANALYSIS RESULTS
3.5.1	Wave Front Deviation
3.5.2	Radial Energy Distribution
3.5.2.1	Geometric Analysis
3.5.2.2	Diffraction Analysis
4.	**EVALUATION**
4.1	OPTICAL ANALYSIS RESULTS, HARD-MOUNTED MIRROR

4.1.1 Wave Front Deviation, Hard-mounted Mirror
4.1.2 Radial Energy Distribution, Hard-mounted Mirror
4.1.2.1 Geometric Analysis, Hard-mounted Mirror
4.1.2.2 Diffraction Analysis, Hard-mounted Mirror
4.1.3 Observation, Hard-mounted Mirror

4.2 OPTICAL ANALYSIS RESULTS, SEMI-HARD-MOUNTED MIRRORS
4.2.1 Wave Front Deviations, Semi-hard-mounted Mirrors
4.2.2 Radial Energy Distribution, Semi-hard-mounted Mirrors
4.2.2.1 Geometric Analysis, Semi-hard-mounted Mirrors
4.2.2.2 Diffraction Analysis, Semi-hard-mounted Mirrors
4.2.3 Observations, Semi-hard-mounted Mirrors

5. CONCLUSION

6. APPENDIX

6.1 SUPSYS
6.1.1 Executive Input
6.1.2 Input Commands Definitions
6.1.3 Source Code

6.2 NASTRAN Input

6.3 NASTRAN Output

6.4 SURFNODE

6.5 NAS2FR

6.6 FRINGE
6.6.1 Case 1 Executive Input
6.6.2 Case 1 Output
6.6.3 Case 2 Executive Input
6.6.4 Case 2 Output
6.6.5 Case 3 Executive Input
6.6.6 Case 3 Output
6.6.7 Case 4 Executive Input
6.6.8 Case 4 Output
6.6.9 Case 5 Executive Input
6.6.10 Case 5 Output

1. INTRODUCTION

The Stratosphere Observatory For Infrared Astronomy (SOFIA) has a flexible meniscus primary mirror mounted on a system of hydraulic actuators. Optical performance is affected by structural deflection of the primary mirror due to gravity, flight dynamics, vibration, turbulence, and thermal expansion. This report addresses the effects of gravity. A computer model based on the finite element method is developed to simulate static deflection under various elevation angles. The model also assesses the optical aberration resulting from the deflection.

2. FINITE ELEMENT MODEL

2.1 GEOMETRY AND MATERIAL

The finite element (FE) model of the SOFIA primary mirror is based on the following parameters taken from *SOFIA Phase B: Telescope Assembly Definition*, sections 4.2.1.0.1-4 and 4.2.1.2-8:

Outer diameter	2690.0 mm
Inner diameter	340.0 mm
Thickness	60.0 mm
Radius of curvature	6220.0 mm
Young's modulus	90250.0 N/mm^2
Poisson's ratio	0.24
Mass density	2.52E-6 kg/mm^3

Radius of curvature is based on the formula r = 2f, where r is the radius of curvature and f is the focal length. The actual mirror is parabolic. However, the FE model assumes a spherical surface.

Young's modulus, Poisson's ratio, and mass density are based on the material ZERODUR.

2.2 ELEMENT FORMATION

Figure 2.2-1 shows the CAD representation of the Primary Mirror. The mirror shape is formed by patches which are later subdivided into elements. These patches are positioned so that when an automated meshing routine is executed, the locations of the element nodes coincide with that of the prescribed support points.

Figure 2.2-2 shows the meshing and the placement of the support points. This basic FE model has 296 six-sided HEX solid elements,16 five-sided WEDG

FIGURE 2.2-1
CAD REPRESENTATION

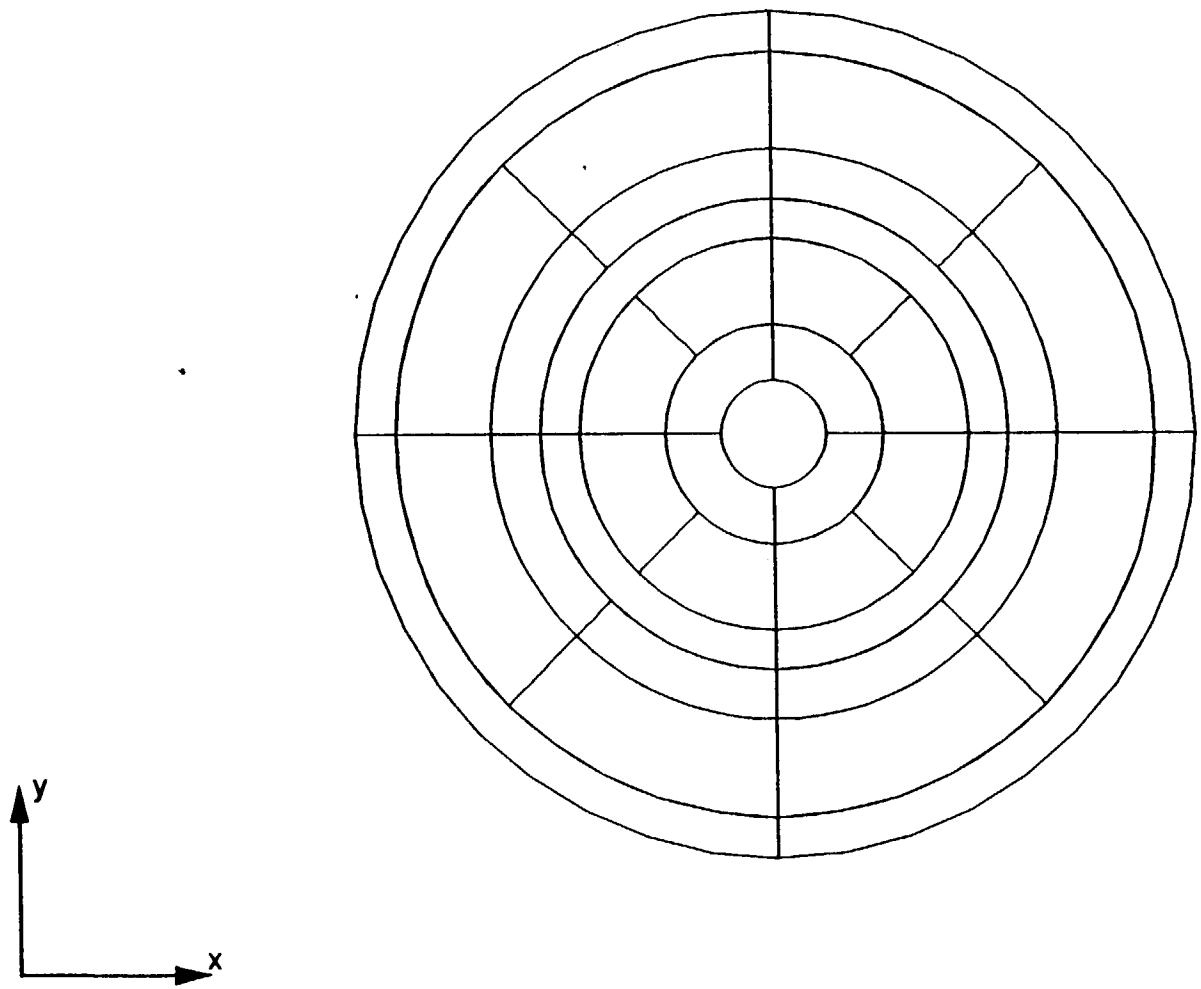
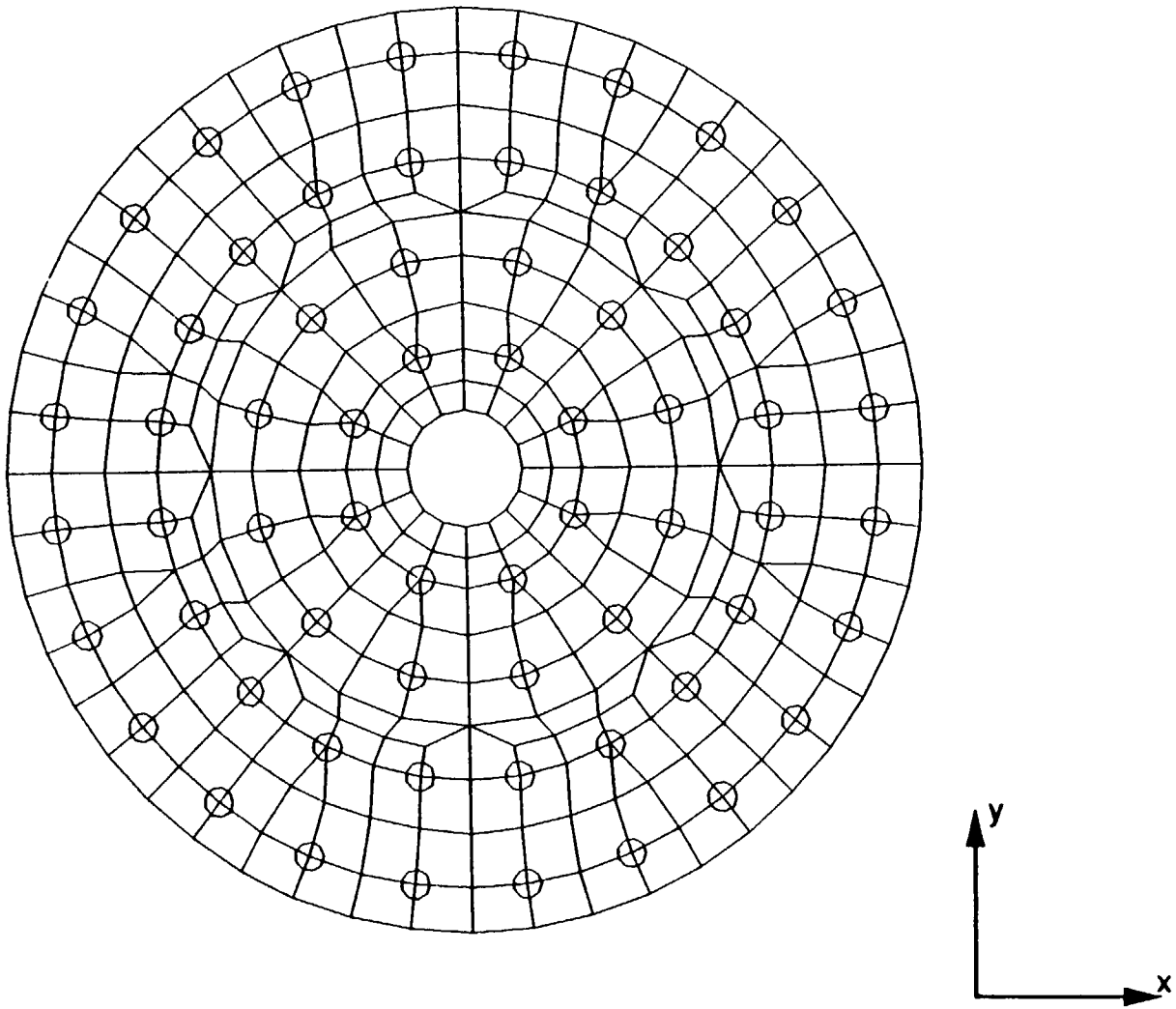


FIGURE 2.2-2
FINITE ELEMENT MESHING AND SUPPORT POINTS



solid elements, and 672 nodes. There are 64 support points as per the Phase B definition. Of these, 8 support points are at 349.7 mm, 12 are at 624.4 mm, 20 are at 907.2, and 24 are at 1215.2 mm from the mirror center.

The 672 nodes constitute 2016 degrees of freedom. Each node has 3 degrees of freedom --- x, y, and z translational displacements. The nodes of a solid element do not have rotational degrees of freedom; the x, y, and z rotational displacements are constrained. Rotation of the solid element is defined by a collective, charted translation of its nodes.

2.3 COORDINATE SYSTEM

The FE model is fixed on a local 3-axis Cartesian coordinate system; the coordinate system moves with the mirror. The z-axis is parallel to the line of sight (LOS), positive towards image source. The x-axis and y-axis are in the mirror plane. The origin is located such that the mirror's center of curvature has the coordinates (0, 0, 5300) mm.

Elevation is the angular displacement about the x-axis. Cross-elevation is the angular displacement about the y-axis. LOS angle is the angular displacement about the z-axis.

2.4 BOUNDARY CONDITIONS

The boundary conditions of the FE model is based on the hydraulic support system defined in the Phase B concept. No other boundary conditions are included.

2.4.1 Support Configuration

In the Phase B concept, the primary mirror is mounted on a system of 64 hydraulic support units that have both axial and lateral degrees of freedom. Referring to Figure 2.4.1-1, each unit has an axial support actuator, a lateral support actuator, and two lateral moment compensation actuators. All actuators are of the same type and dimensions. The lateral support actuators and lateral moment compensation actuators are members of the lateral support system, and the axial support actuator is a member of the axial support system. The axial support system is independent of the lateral support system, and both systems are further divided into subsystems. All of the actuators within a subsystem are hydraulically connected; they are activated by a common fluid reservoir. The hydrostatic compensation system is connected to all actuators and corrects hydrostatic pressure differences due to elevation level. The actuators within a subsystem therefore exert equal forces. The active force correction device compensates for fabrication errors and other effects. It is not included in the FE model.

FIGURE 2.4.1-1
HYDRAULIC SUPPORT UNIT DIAGRAM

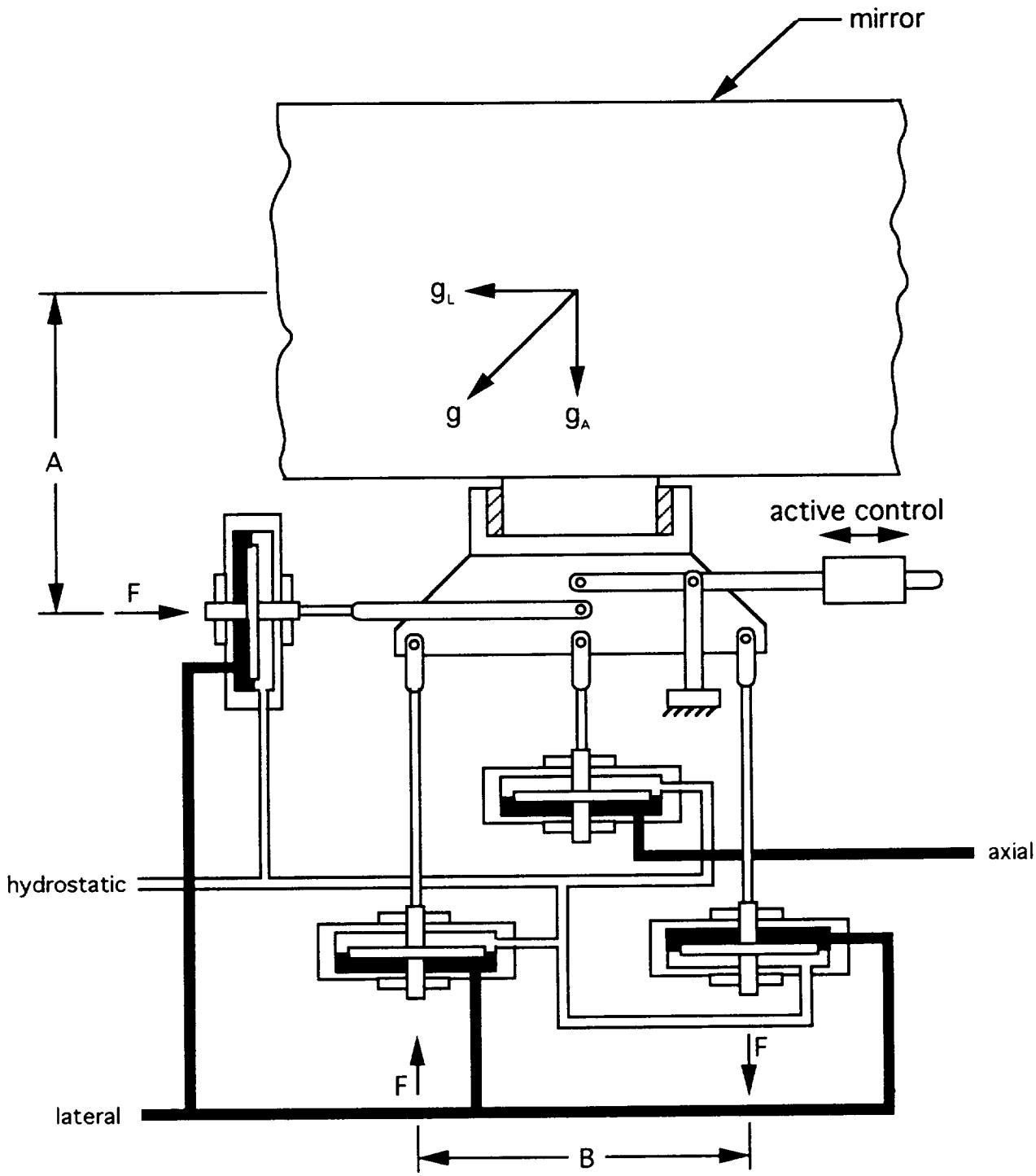


Figure 2.4.1-2 shows the axial support groups. There are 3 subsystems, each consisting of 21 or 22 elements within a 120° segment. Each element has a single support actuator.

Figure 2.4.1-3 shows the lateral support configuration. The support elements are tilted by ±30°. There are 2 subsystems, each consisting of 32 elements having the same tilt direction. Each element has one support actuator and two moment compensation actuators, as shown in Figure 2.4.1-1.

A more detailed description of the support system is given in *SOFIA Phase B: Telescope Assembly Definition*, sections 4.2.1.2.3 and 4.2.1.2.4.

2.4.2 Formulation

In the FE model, multipoint constraint (MPC) is used to impose a linear relationship between the degrees of freedom representing the movement of the hydraulic actuators. The MPC equation have the following format:

$$\sum_{i=1}^{n} R_i u_i = 0 \qquad (2.4.2\text{-}1)$$

where u_i is the displacement, R_i is the coefficient of constraint, and n is number of degrees of freedom in the constraint.

For the support system, the displacements of the individual actuators vary, but the net displacement of the actuators within a subsystem is zero since the total volume of the hydraulic fluid is constant. Equation 2.4.2-1 can be applied to each hydraulic subsystem where u_i is the displacement of the actuator, n is the number of actuators in the subsystem, and R_i is a quantity representing the ratio of fluid volume displacement to actuator displacement.

Since a condition defined by the support system is that the actuators within a hydraulic subsystem exert equal forces, force is a more readily known parameter than displacement. Therefore a constraint equation relating the forces of the actuators is desirable. The constraint force relation is based on the principle that because the fluid volume of a subsystem is constant, the net displacement of the actuators is zero. Therefore the total work done is also zero:

$$W = 1/2 \sum_{i=1}^{n} F_i u_i = 0 \qquad (2.4.2\text{-}2)$$

where W is the total work done by the actuators in a subsystem, and F_i is the actuator force. In order for Equations 2.4.2-1 and 2.4.2-2 to be true, the quantity 1/2 F_i must be proportional to R_i. Therefore, Equation 2.4.2-1 can be used as a constraint equation where R_i is proportional to actuator force.

FIGURE 2.4.1-2
AXIAL SUPPORT GROUPS

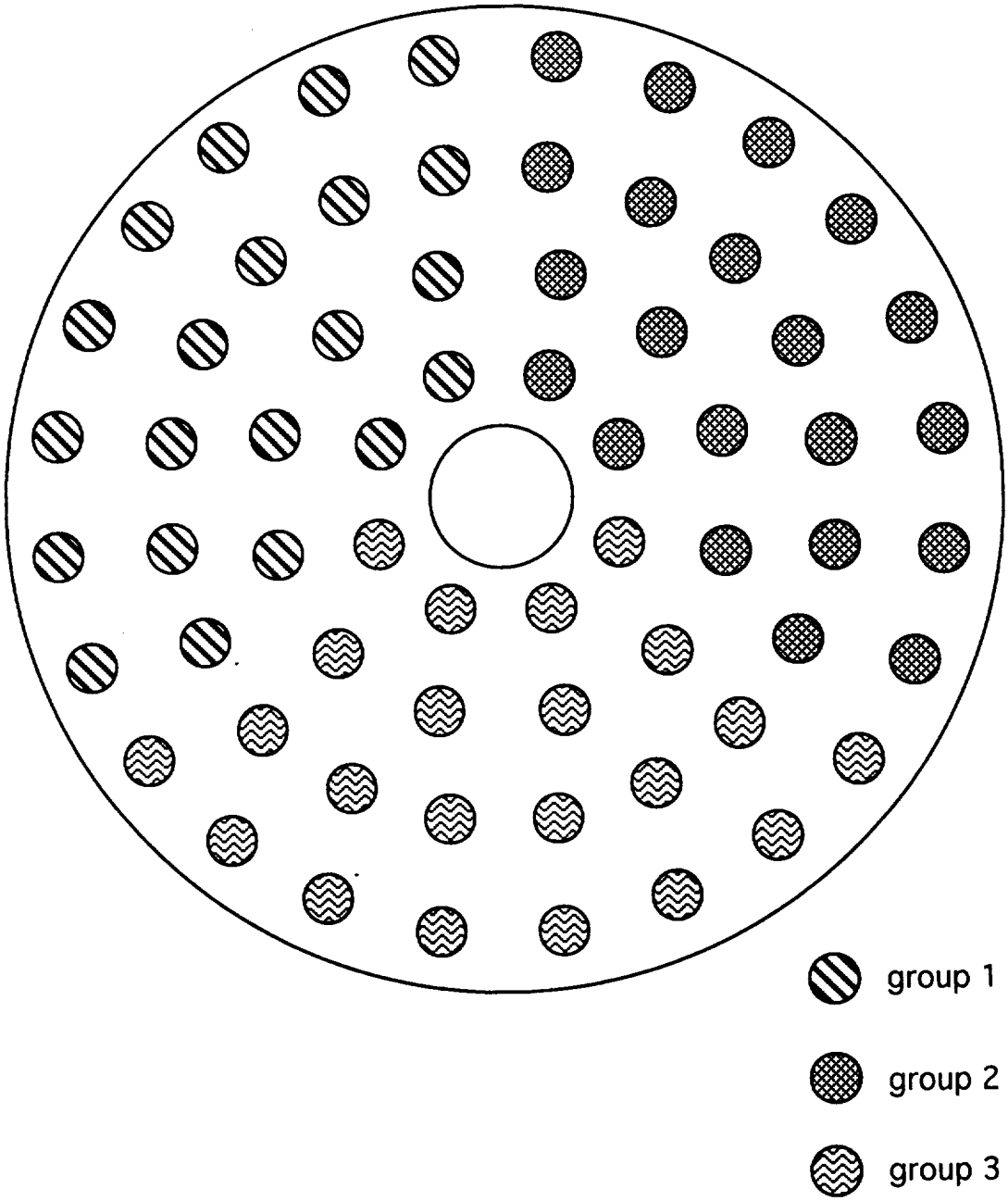
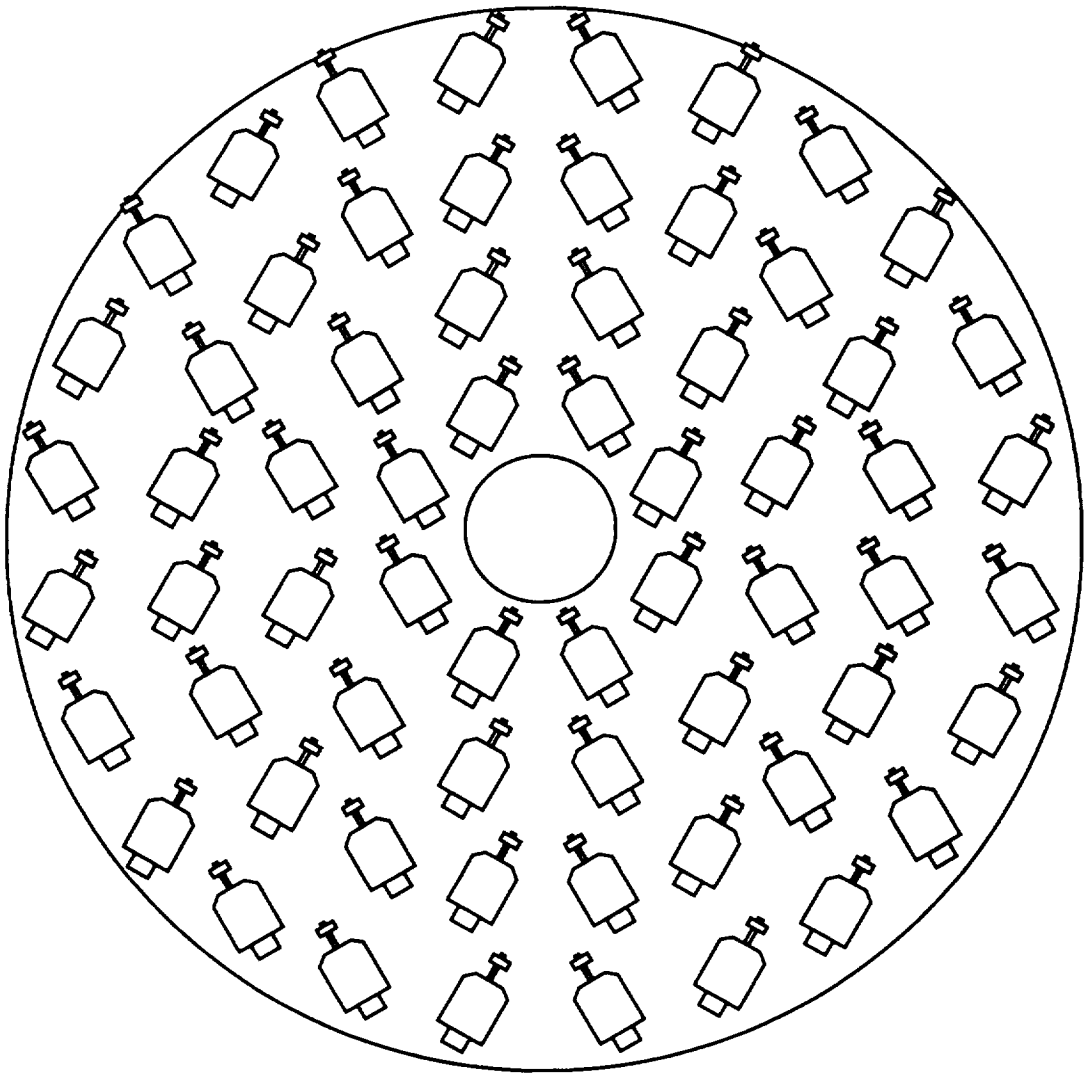


FIGURE 2.4.1-3
AXIAL SUPPORT GROUPS



2.4.3 Implementation

A computer program SUPSYS is developed to process support system parameters into the format of Equation 2.4.2-1, which can be readily input into the FE analysis code NASTRAN. SUPSYS reads a NASTRAN input file and generates a modified file containing MPC commands and the necessary FE model alterations reflecting support system parameters. The new file is then processed by NASTRAN.

SUPSYS provides for parameter variations. The number of subsystems, the number and nodal locations of the support units, the dimensions and tilt angles of the support units, and the forces of the individual actuators are variable. This may be useful in future analysis involving support system optimization.

The program's source code, executive input file for the primary mirror, and an explanation of the input commands are included in the Appendix section 6.1. Also included, in section 6.2, is the NASTRAN input file that has been processed by SUPSYS.

2.4.3.1 Model Alterations

Figure 2.4.3.1-1 shows the model alterations performed by SUPSYS for one of the 64 support units. Nodes b, c, d, e, f, g, and h are added to form a new element representing the support unit's dimensions. Nodes b, c, d, and e become edge nodes of the existing elements which are shown hubbed at node a. Node a is located along the axial center of the support unit. The distance g-h corresponds to L_B in Figure 2.4.1-1, and the distance a-f corresponds to L_A minus half the mirror thickness. The angle α is the tilt angle as shown in Figure 2.4.1-3. Nodes f, g, and h are in the same X-Y plane.

The axial support force F_A is applied at node a and is independent of the new element. The lateral support force F_L is applied at node f. The lateral moment compensation forces F_{C1} and F_{C2} are applied at nodes g and h, respectively.

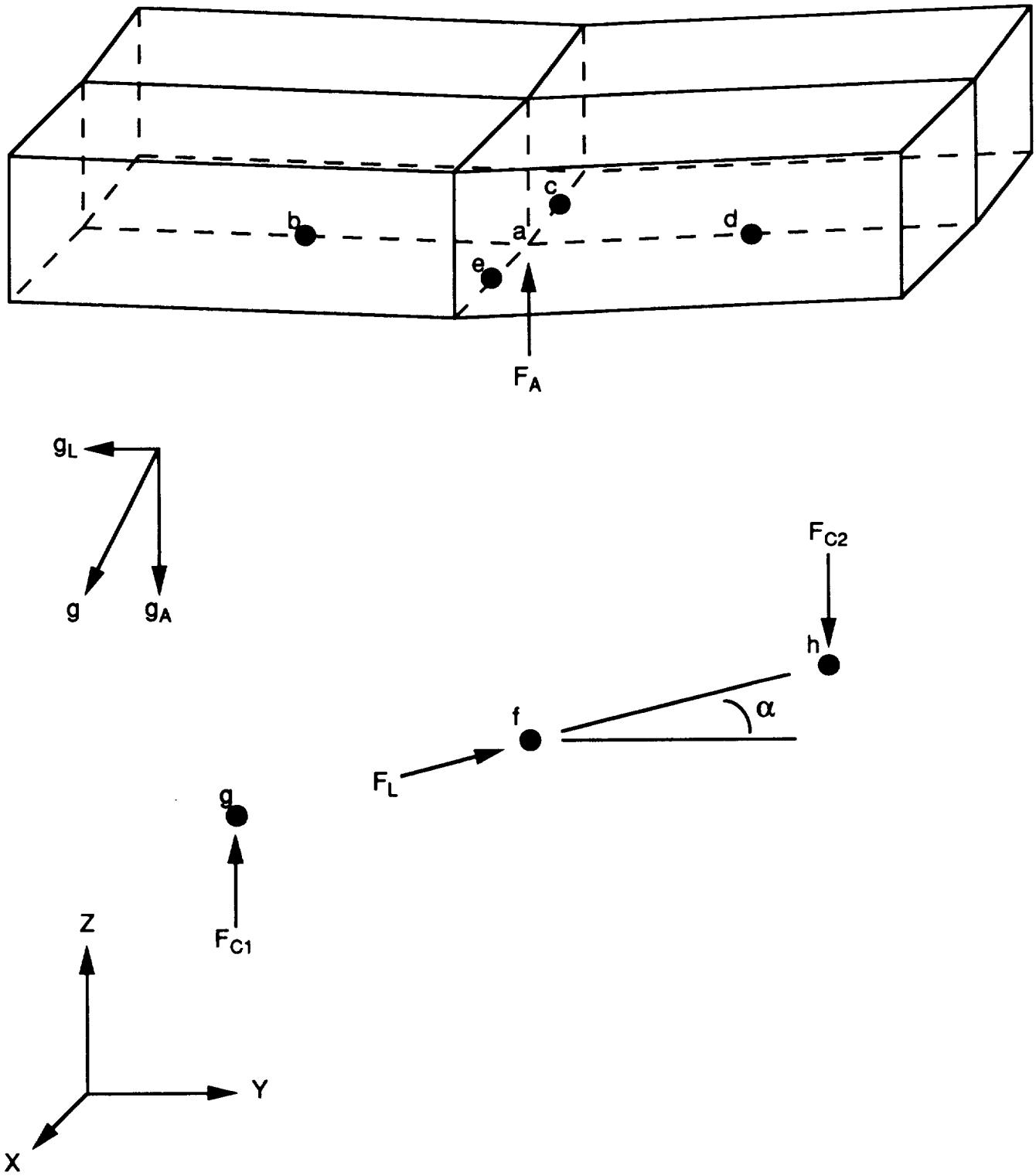
The new element formed by nodes b, c, d, e, f, g, and h is a rigid body element (RBE). Since the elasticity of the support unit is not known, infinite rigidity is assumed. This is a safe assumption, because deflection of the support unit, which is small, has very little effect on the actuator forces F_L, F_{C1}, and F_{C2} and their transmittance onto the mirror itself.

Since the size of the support unit is unknown, the dimensions of the rigid body element are assigned somewhat arbitrary values. For lateral moment compensation, it is necessary that the distance g-h is equal to the distance a-f plus half the mirror thickness. The moment created by the lateral support force F_L must be canceled by the counter moment created by the compensation forces F_{C1} and F_{C2}:

$$F_L\,(d_{a\text{-}f} + t/2) = F_{C1}\,d_{g\text{-}f} + F_{C2}\,d_{f\text{-}h} \qquad (2.4.3.1\text{-}1)$$

FIGURE 2.4.3.1-1

MODEL ALTERATION



where t is the mirror thickness, and $d_{a\text{-}f}$, $d_{g\text{-}f}$, and $d_{f\text{-}h}$ are the distances a-f, g-f, and f-h, respectively. Since point f is midway between points g and h, $d_{g\text{-}f}$ and $d_{f\text{-}h}$ are both equal to half the distance g-h. Equation 2.4.3.1-1 is then modified:

$$F_L\,(d_{a\text{-}f} + t/2) = (F_{C1} + F_{C2})\,d_{g\text{-}h}/2 \qquad (2.4.3.1\text{-}2)$$

where $d_{g\text{-}h}$ is the distance g-h. Knowing that the actuators within a hydraulic subsystem exert equal forces, F_L, F_{C1}, and F_{C2} are set equal to one another. Equation 2.4.3.1-2 is in turn modified:

$$d_{a\text{-}f} + t/2 = d_{g\text{-}h} \qquad (2.4.3.1\text{-}3)$$

Therefore, the values of $d_{a\text{-}f}$ and $d_{g\text{-}h}$ can be arbitrarily set as long as Equation 2.4.3.1-3 holds. With the thickness t being 60 mm, $d_{a\text{-}f}$ and $d_{g\text{-}h}$ are set to 170 mm and 200 mm, respectively.

A total of 460 nodes are added to the Primary Mirror model by SUPSYS. The final FE model has 1,132 nodes and 3,396 degrees of freedom.

2.4.3.2 Multipoint Constraint Application

Ideally the MPC equation for a lateral support subsystem would have the following form:

$$\sum_{i=1}^{n} (f_L u_L + f_{C1} u_{C1} + f_{C2} u_{C2})_i = 0 \qquad (2.4.3.2\text{-}1)$$

where f_L, f_{C1}, and f_{C2} are proportional to the actuator forces F_L, F_{C1}, and F_{C2}, respectively, u_L is the displacement of the support actuator, u_{C1} and u_{C2} are the displacements of the moment compensation actuators, and n is the number of support units employed by the subsystem. However, since u_L is not directed parallel to any of the axes of the FE model's coordinate system, it will be reduced into X and Y components. This is necessary because NASTRAN more readily processes degrees of freedom that are parallel to the axes of an established coordinate system. Equation 2.4.3-1 is then modified:

$$\sum_{i=1}^{n} [f_L(\cos\alpha)u_{LY} - f_L(\sin\alpha)u_{LX} + f_{C1}u_{C1} + f_{C2}u_{C2}]_i = 0 \qquad (2.4.3.2\text{-}2)$$

where α is the tilt angle, and u_{LY} and u_{LX} are the Y and X components of u_L, respectively.

The MPC equation for the axial support subsystem is simpler:

$$\sum_{i=1}^{n} (f_A u_A)_i = 0 \qquad (2.4.3.2\text{-}3)$$

where f_A is proportional to the axial force F_A, u_A is the displacement of the support actuator, and n is the number of support units employed by the subsystem.

Substituting the Phase B specified values for the parameters, Equation 2.4.3.2-2 becomes the following:

$$\sum_{i=1}^{32} [(\cos\alpha)u_{LY} - (\sin\alpha)u_{LX} + u_{C1} + u_{C2}]_i = 0 \qquad (2.4.3.2\text{-}4)$$

where α is 30° for one lateral subsystem and -30° for the other. The force parameters f_L, f_{C1}, and f_{C2} are factored out, because in the Phase B concept all actuators exert equal forces. Similarly, Equation 2.4.3-3 becomes the following:

$$\sum_{i=1}^{n} (u_A)_i = 0 \qquad (2.4.3.2\text{-}5)$$

where n is 22 for one axial subsystem and 21 for the other two. Again the force parameter f_A is factored out.

3. ANALYSIS

3.1 OBJECTIVE

The objective of the analysis is to determine the static deflection of the Primary Mirror under 1-g loading at various elevation angles. Deflection data is further processed to assess the mirror's wave front deviation and radial energy distribution.

3.2 LOAD CONDITIONS

3.2.1 Assumptions

1. Only gravitational loading is considered. Dynamic and other effects are not considered in this analysis.

2. The hydraulic support system form all the boundary conditions. No other effects contribute to the boundary conditions in this analysis.

3. Spherical mirror surface is assumed.

3.2.2 Load Cases

Different load cases are determined by the variation of elevation angle. Cross-elevation and LOS angle are held constant at 0°. (The x-axis of the mirror is parallel to the roll axis of the aircraft in all load cases). Five load cases are analyzed:

<u>Case 1</u>: The mirror is supported at a vertical position (0° elevation) under normal gravity (1 g).

<u>Case 2</u>: The mirror is supported at 20° elevation under 1 g.

<u>Case 3</u>: The mirror is supported at 40° elevation under 1 g.

<u>Case 4</u>: The mirror is supported at 60° elevation under 1 g.

<u>Case 5</u>: The mirror is supported at a horizontal position (90° elevation) under 1 g.

In the FE model, the mirror does not change orientation, but different gravity vectors are applied in order to simulate the effects of varying elevations. A gravity vector consist of a linear combination of a -1 g load along the z-axis (parallel to LOS) and a second -1 g load along the y-axis (parallel to mirror plane and perpendicular to roll axis). For example, let:

$-g\,\underline{k}$ = gravitational load along z-axis
$-g\,\underline{j}$ = gravitational load along y-axis

To produce the effect of gravitational load at 20° elevation (Case 2), a gravity vector $\underline{g}_{20}$ is applied where:

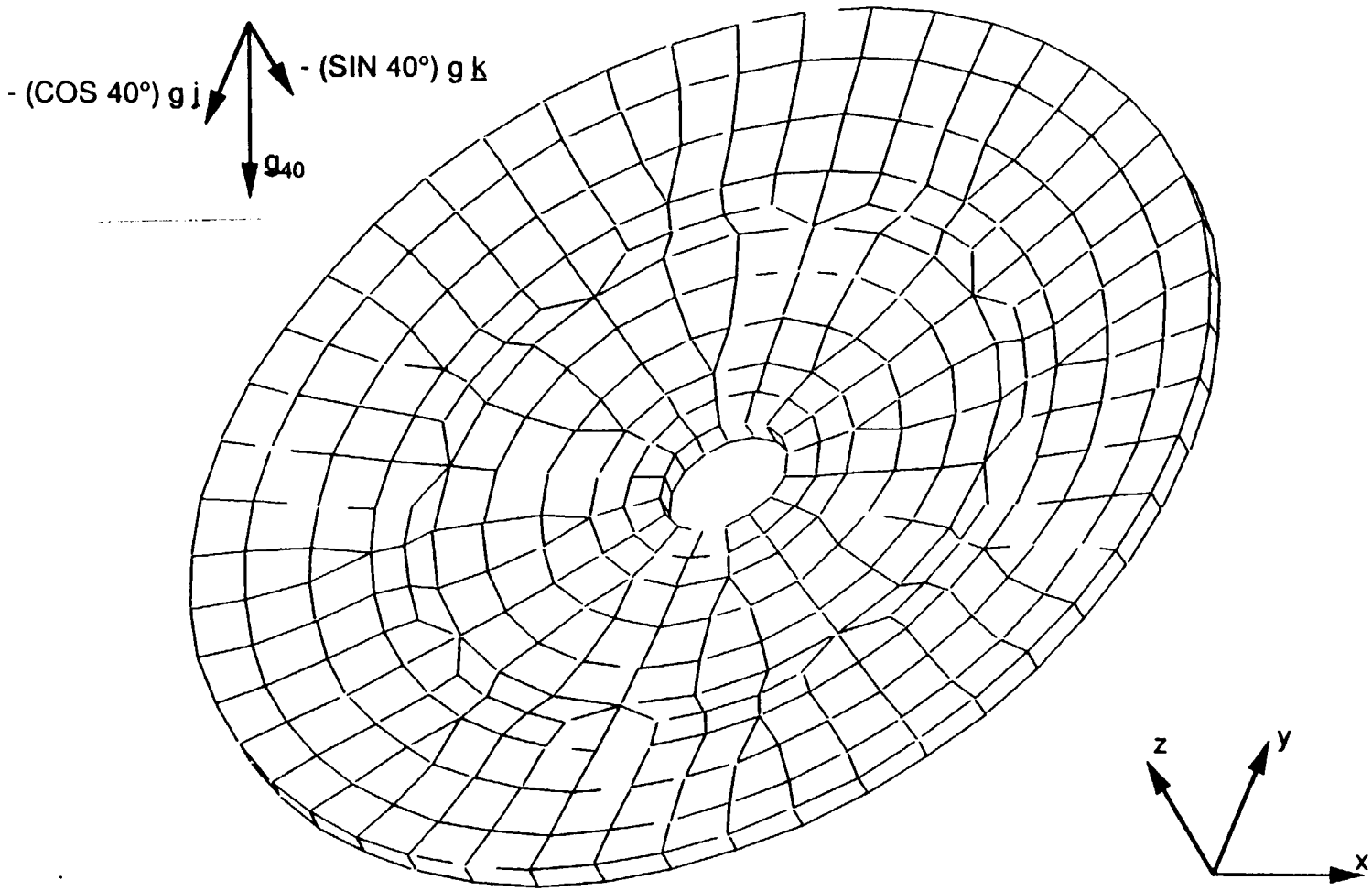
$$\underline{g}_{20} = -(\text{SIN } 20°)\, g\, \underline{k} - (\text{COS } 20°)\, g\, \underline{j}$$

Similarly, other elevations are produced:

$$\underline{g}_{0} = -(\text{SIN } 0°)\, g\, \underline{k} - (\text{COS } 0°)\, g\, \underline{j} = -g\, \underline{j} \qquad \text{(Case 1, 0° elevation)}$$
$$\underline{g}_{40} = -(\text{SIN } 40°)\, g\, \underline{k} - (\text{COS } 40°)\, g\, \underline{j} \qquad \text{(Case 3, 40° elevation)}$$
$$\underline{g}_{60} = -(\text{SIN } 60°)\, g\, \underline{k} - (\text{COS } 60°)\, g\, \underline{j} \qquad \text{(Case 4, 60° elevation)}$$
$$\underline{g}_{90} = -(\text{SIN } 90°)\, g\, \underline{k} - (\text{COS } 90°)\, g\, \underline{j} = -g\, \underline{k} \qquad \text{(Case 5, 90° elevation)}$$

The gravity vectors for Case 3 are illustrated in Figure 3.2.2-1.

FIGURE 3.2.2-1
GRAVITY SIMULATION, 40° ELEVATION--CASE 3



3.3 STRUCTURAL ANALYSIS RESULTS

The deflection data is summarized as follows:

Load case	Elevation	Deflection range
Case 1	0°	-0.922E-4 to 0.126E-3 mm
Case 2	20°	-0.151E-3 to 0.967E-4 mm
Case 3	40°	-0.210E-3 to 0.143E-3 mm
Case 4	60°	-0.276E-3 to 0.172E-3 mm
Case 5	90°	-0.312E-3 to 0.192E-3 mm

Deflections are in the degree of freedom parallel to the optical line of sight (LOS), positive towards image source.

Figures 3.3-1 through 3.3-5 show the contour plots for load cases 1 through 5. Figures 3.3-6 through 3.3-10 show the corresponding deformed shape. Deformation is shown exaggerated for clarity.

A hard copy of the NASTRAN output file is included in the Appendix section 6.3.

3.4 STRUCTURAL-OPTICAL INTEGRATION

The deflection data produced in the structural analysis are not the final results. The finite element analysis (FEA) output is further processed by the FRINGE optical analysis program which in turn generates the radial energy distribution of the Primary Mirror.

Interface programs are developed in order to effectively pass data between FEA and optical analysis codes. Figure 3.4-1 shows a flow schematic of data as they are processed by PATRAN, SUPSYS, NASTRAN, FRINGE, and interface programs. The programs, their supplier, and their functions are listed below:

Program	Supplier	Function
CONVFTP	MSC	Changes the format of the NASTRAN output
FRINGE	University of Arizona	Optical analysis
MM2CM	in-house	Converts spatial dimensions from millimeters to centimeters.
NAS2FR	in-house	Produces FRINGE input files containing the geometry and deflection of the mirror reflective surface.
NASTRAN	MSC	Finite element analysis
PATNAS	PDA Engineering	Writes FE geometry and material properties into a format readable by NASTRAN
PATRAN	PDA Engineering	Generates FE geometry and applies material properties
SUPSYS	in-house	Applies boundary conditions
SURFNODE	in-house	Selects nodes representing mirror reflective surface

The interface program MM2CM is necessary, because the FE model is in millimeters and the application FRINGE only processes centimeters.

NASTRAN run on the Cray Y-MP. All other programs run on the MicroVAX 3500.

The source codes of SURFNODE, NAS2FR, AND MM2CM are included in the Appendix sections 6.4 through 6.6.

FIGURE 3.3-1
DEFLECTION CONTOUR, 0° ELEVATION--CASE 1

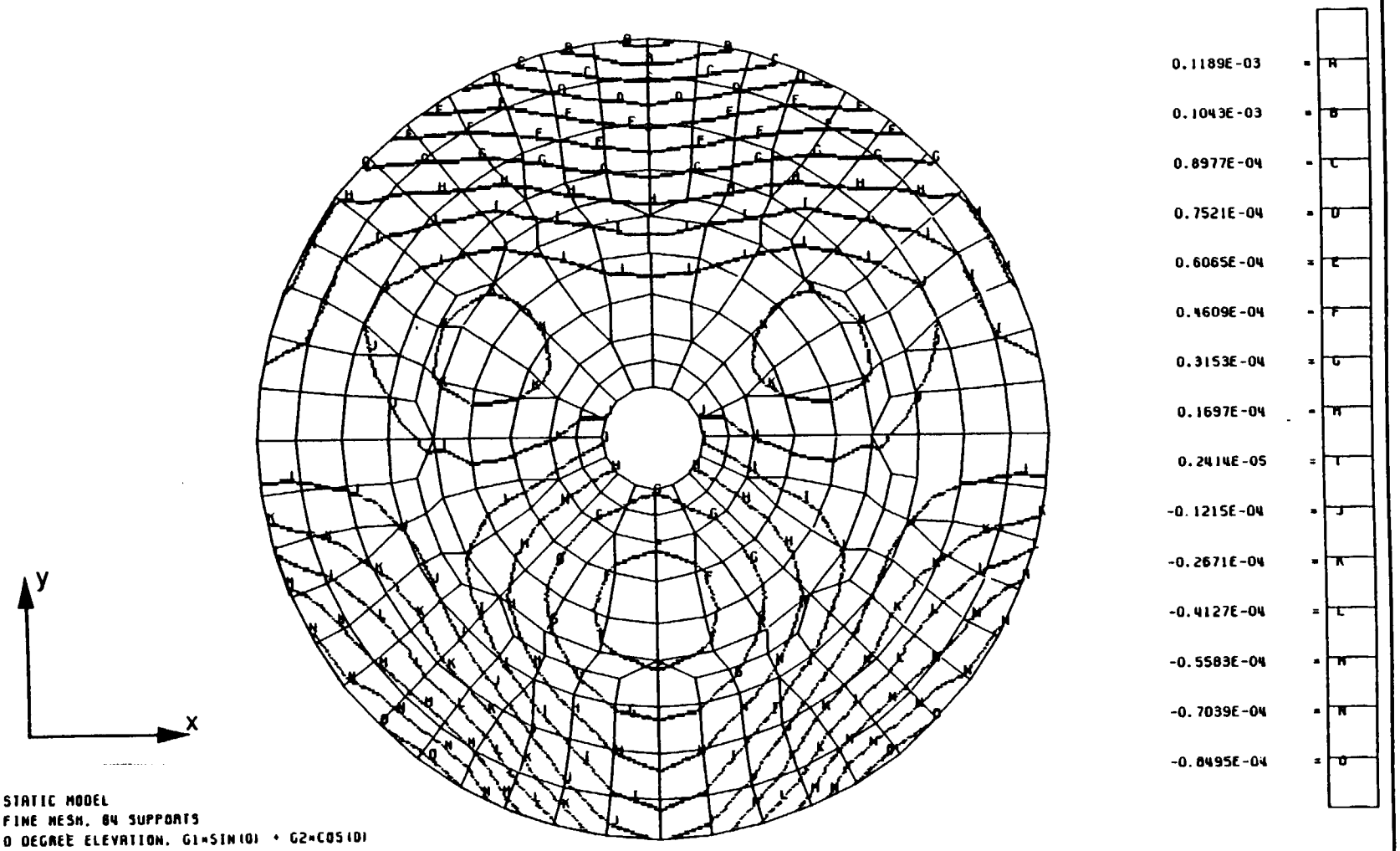


FIGURE 3.3-2
DEFLECTION CONTOUR, 20° ELEVATION--CASE 2

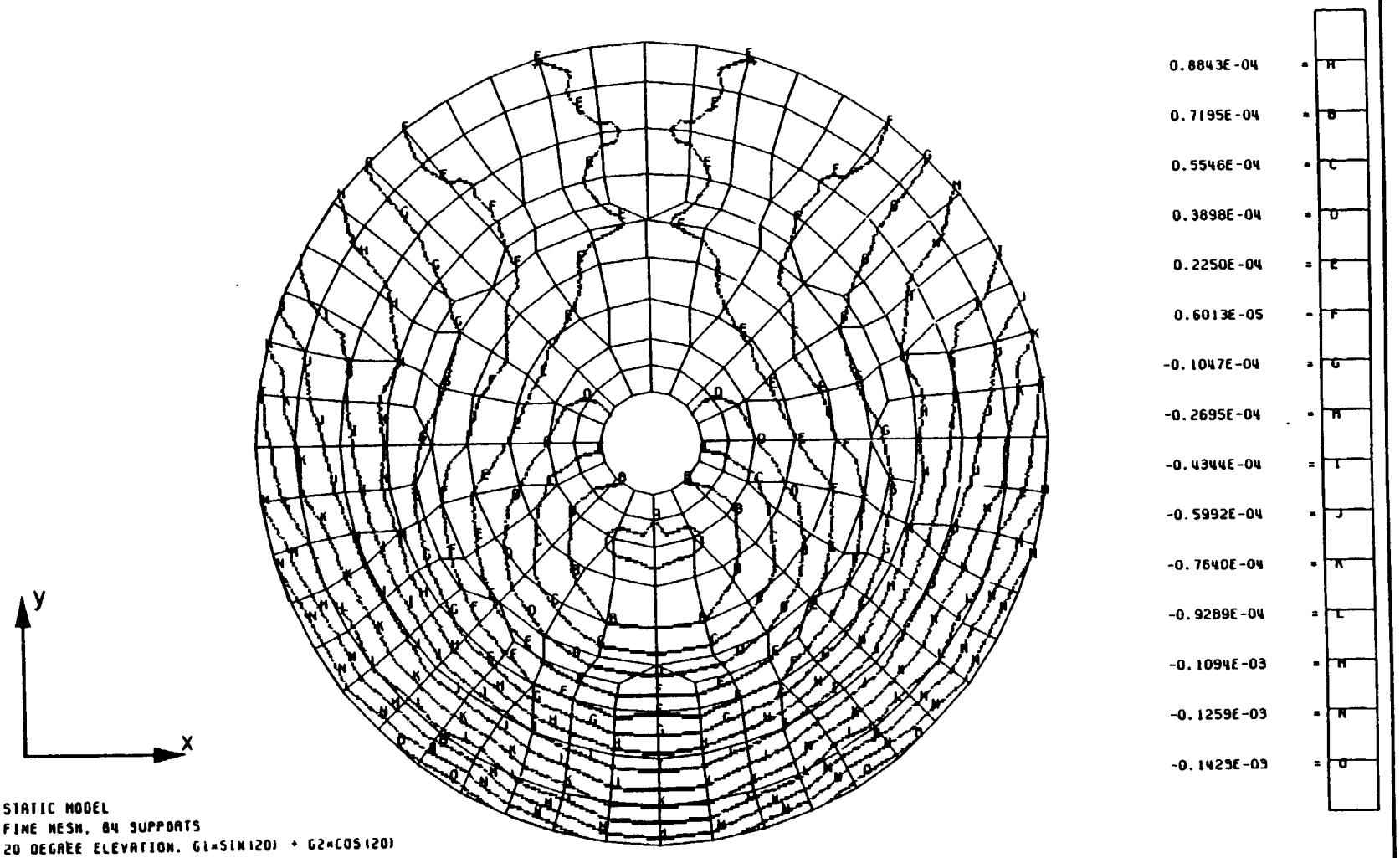


FIGURE 3.3-3
DEFLECTION CONTOUR, 40° ELEVATION--CASE 3

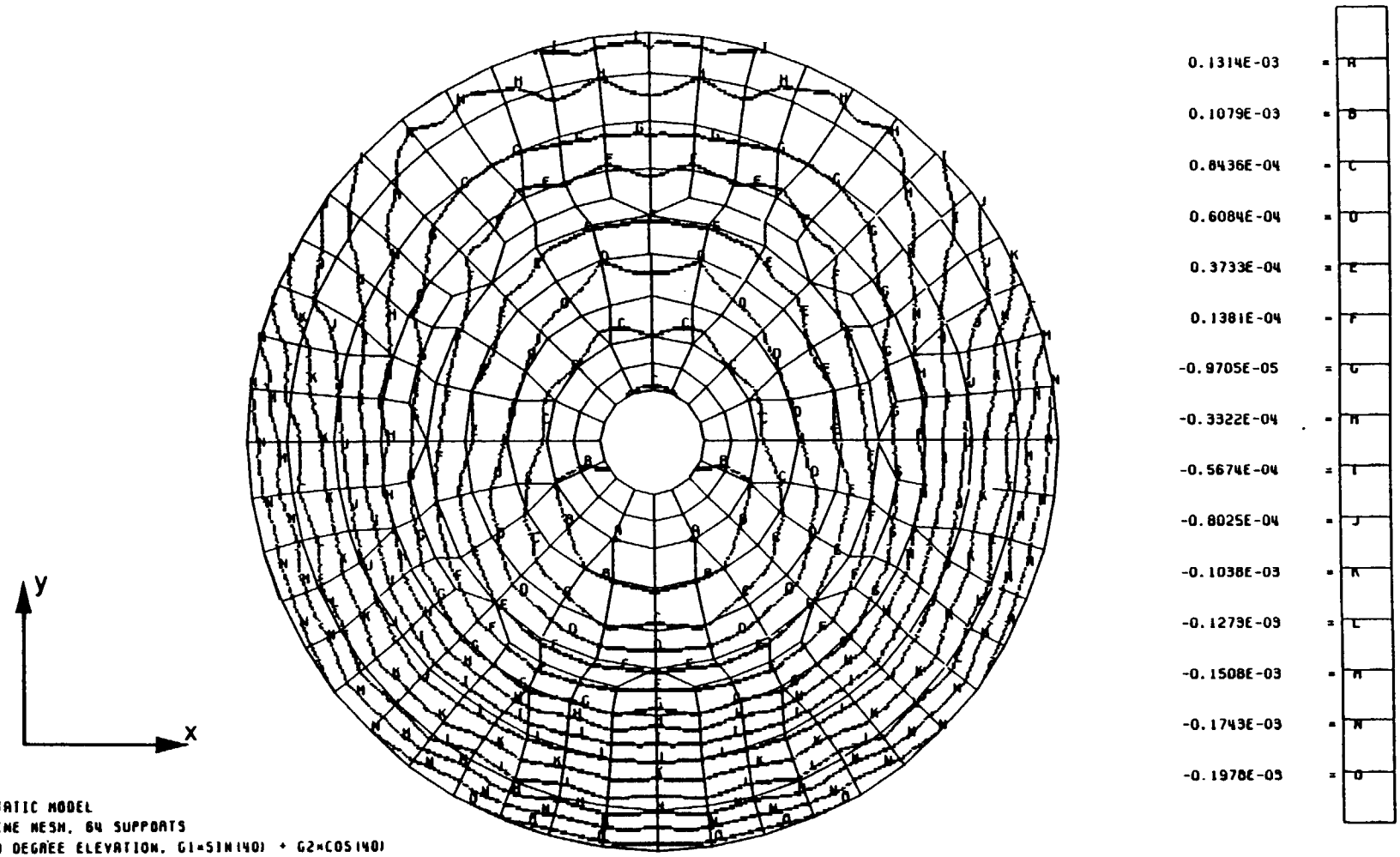


FIGURE 3.3-4
DEFLECTION CONTOUR, 60° ELEVATION--CASE 4

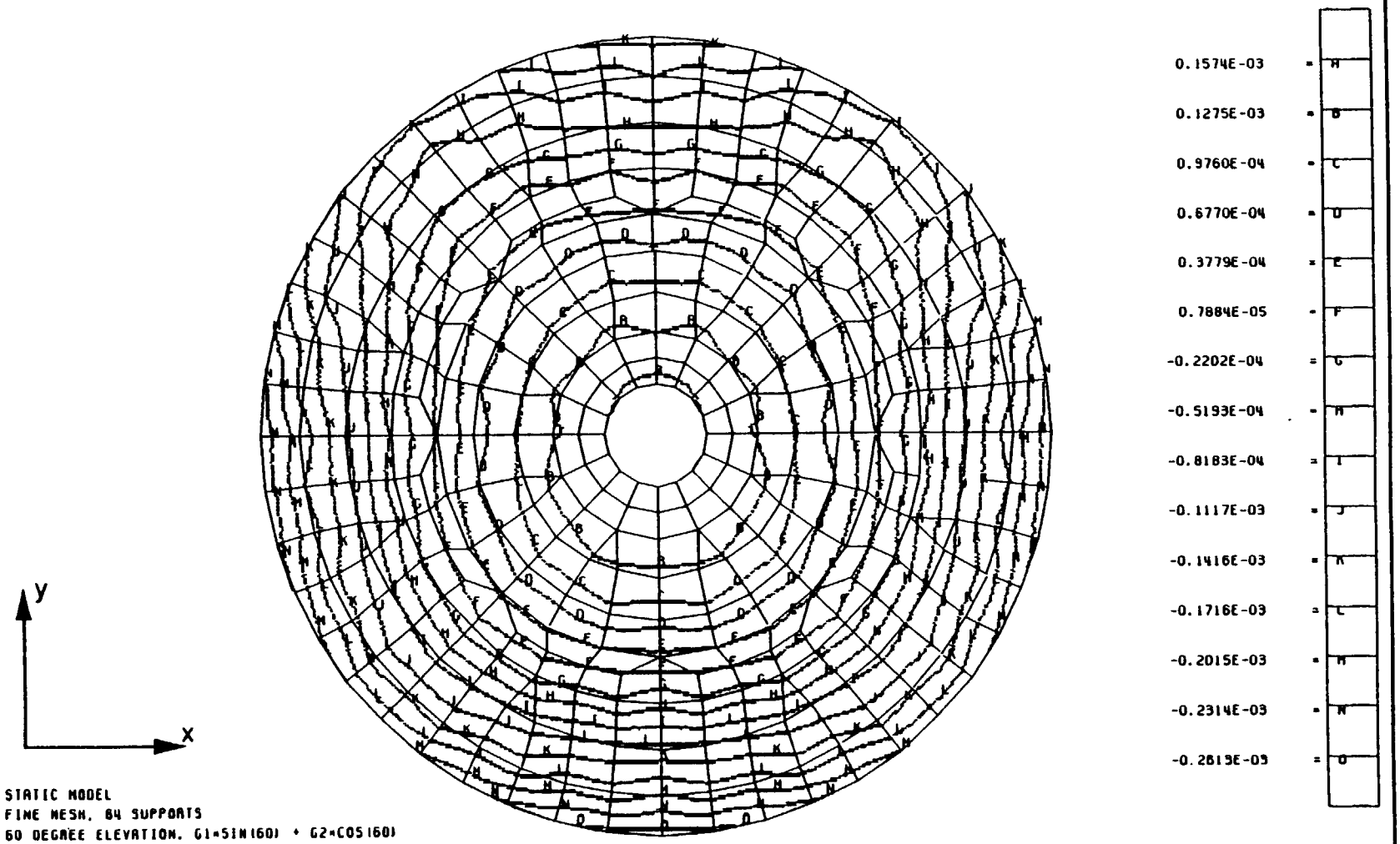


FIGURE 3.3-5
DEFLECTION CONTOUR, 90° ELEVATION--CASE 5

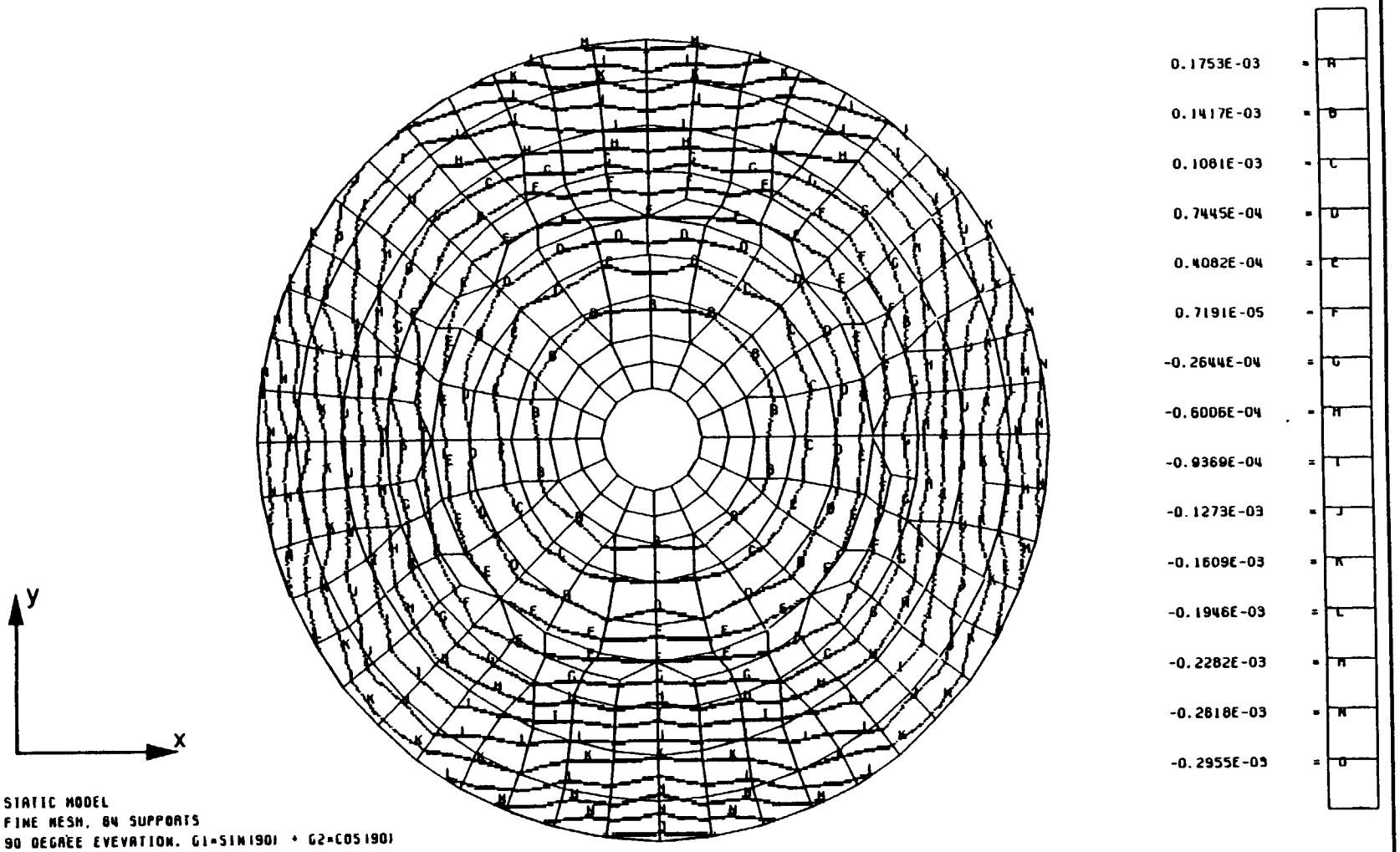


FIGURE 3.3-6
DEFORMED SHAPE, 0° ELEVATION--CASE 1

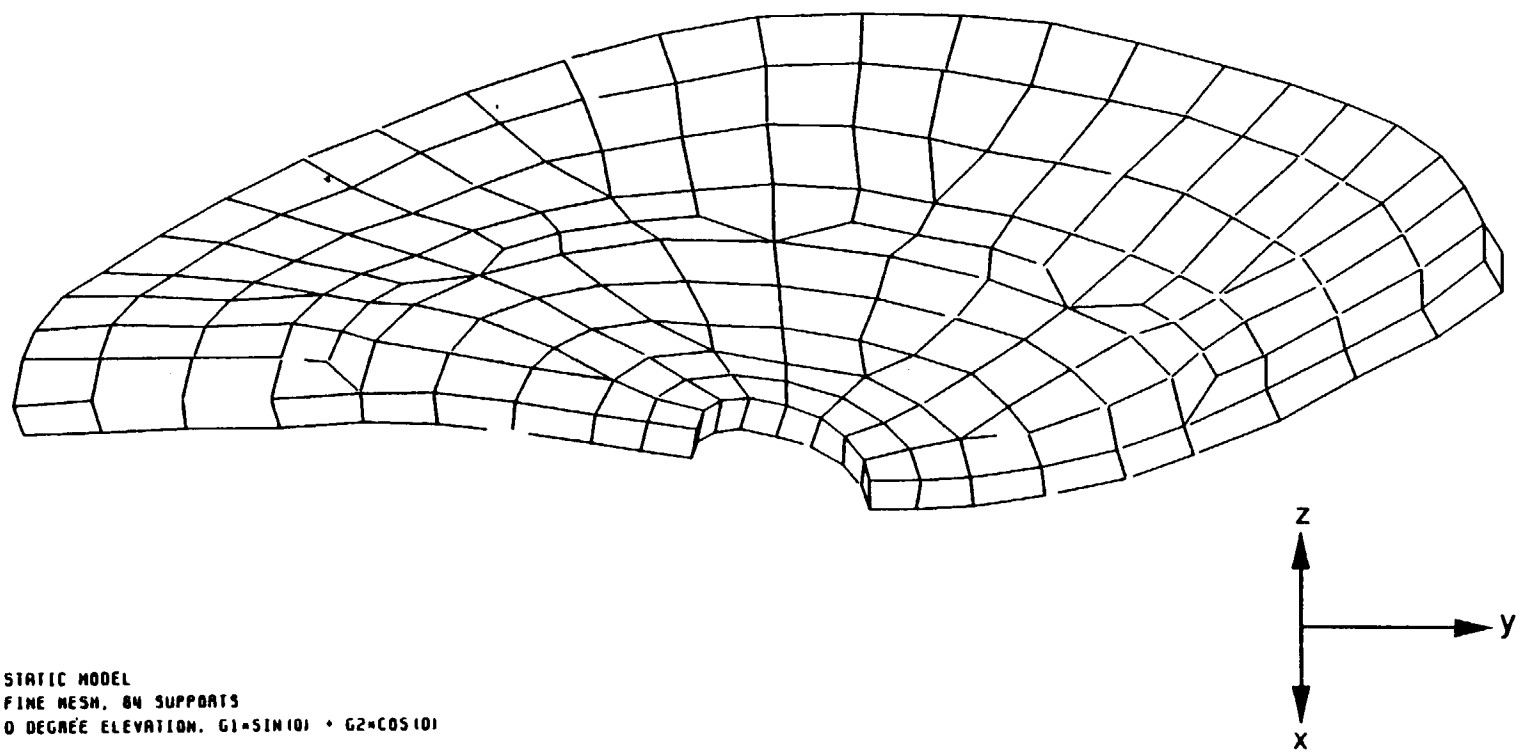
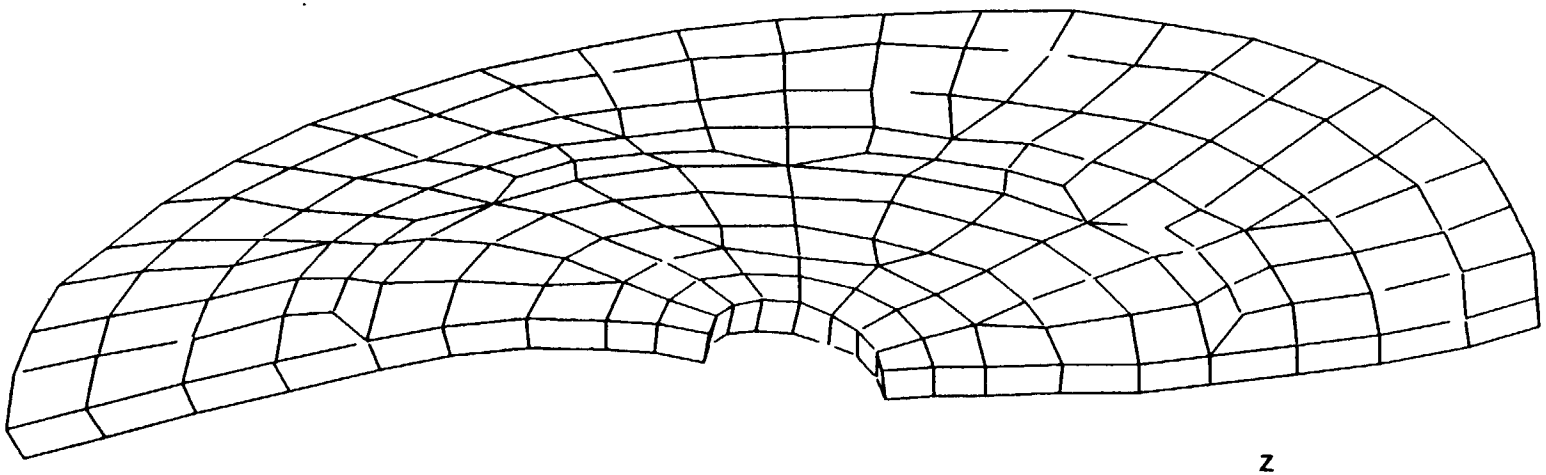
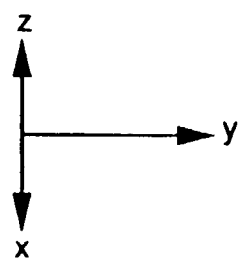


FIGURE 3.3-7
DEFORMED SHAPE, 20° ELEVATION--CASE 2





STATIC MODEL
FINE MESH, 64 SUPPORTS
20 DEGREE ELEVATION. G1=SIN(20) + G2=COS(20)

FIGURE 3.3-8
DEFORMED SHAPE, 40° ELEVATION--CASE 3

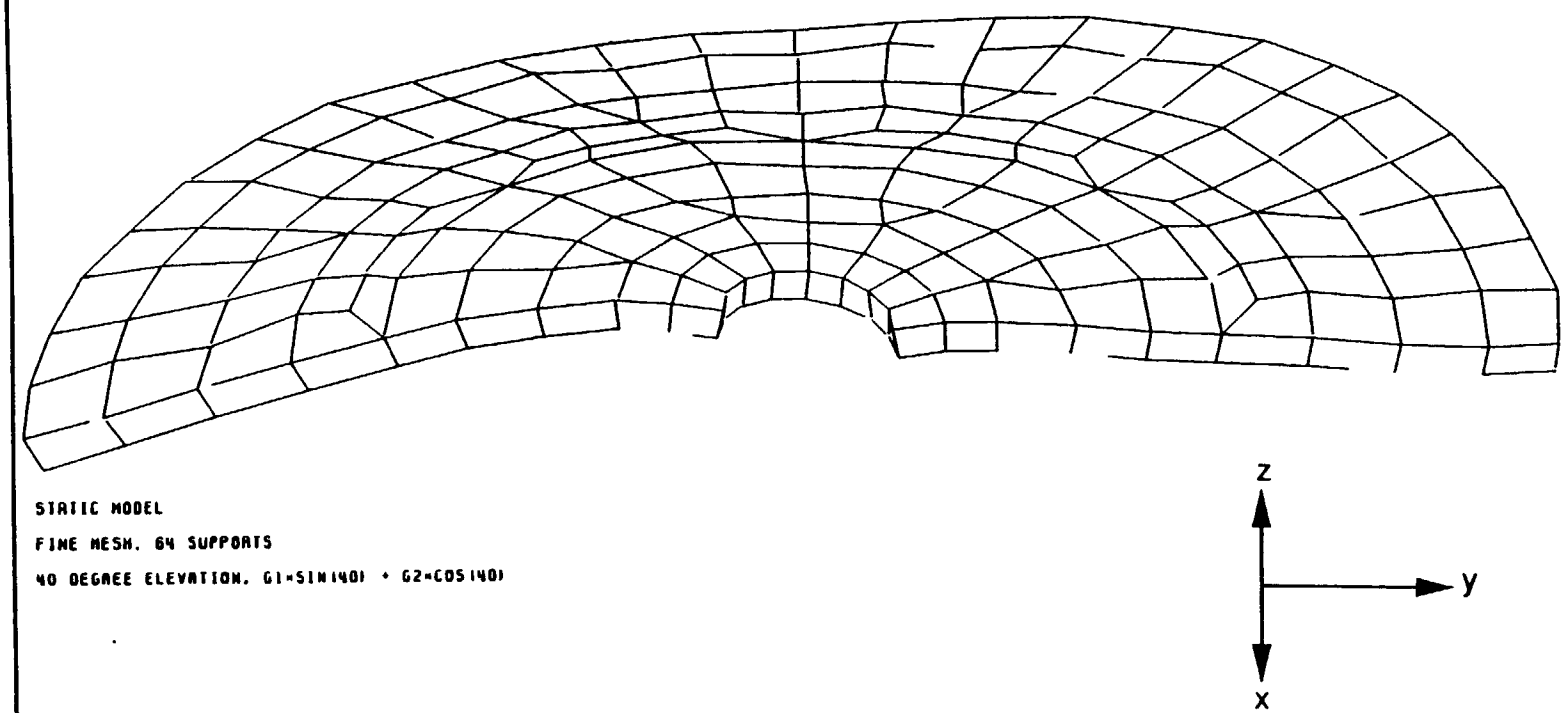


FIGURE 3.3-9
DEFORMED SHAPE, 60° ELEVATION--CASE 4

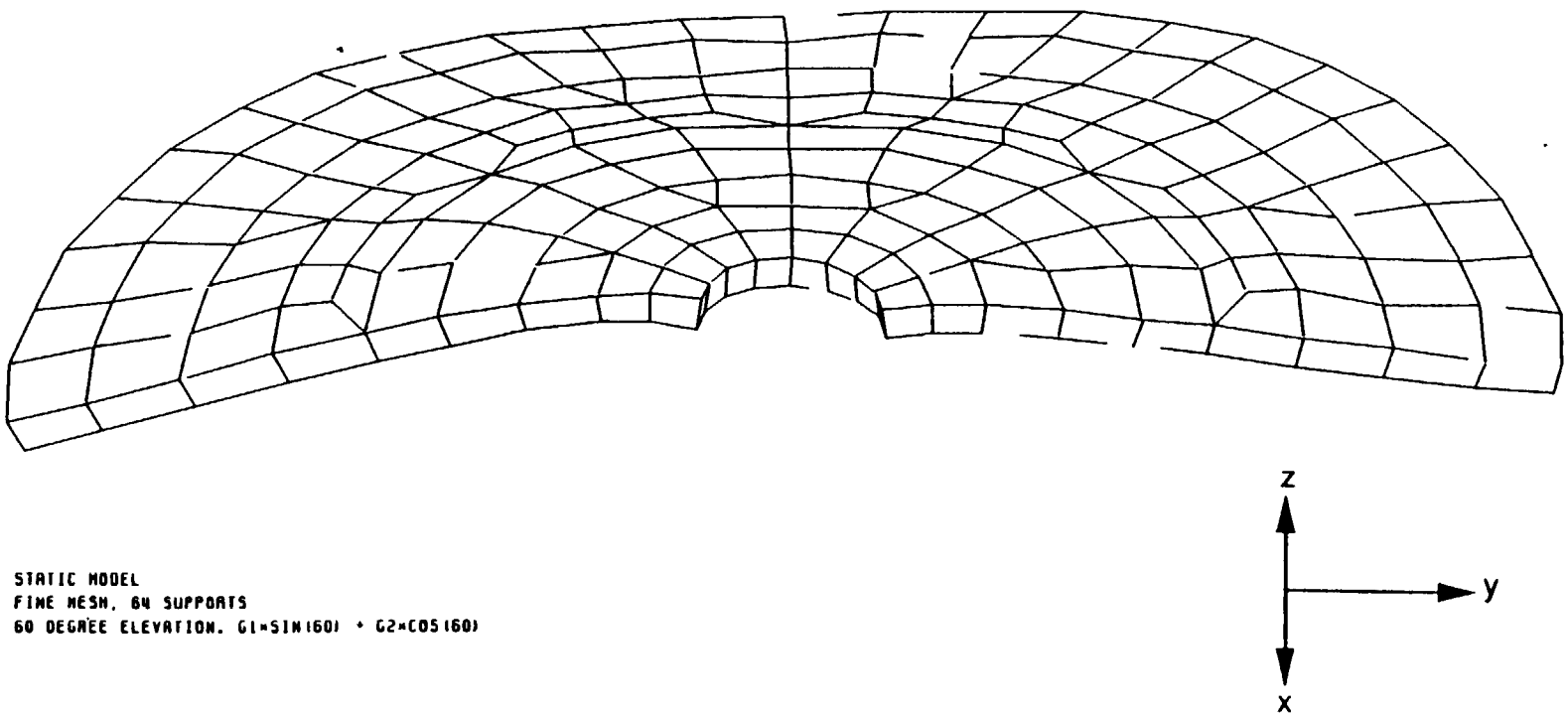
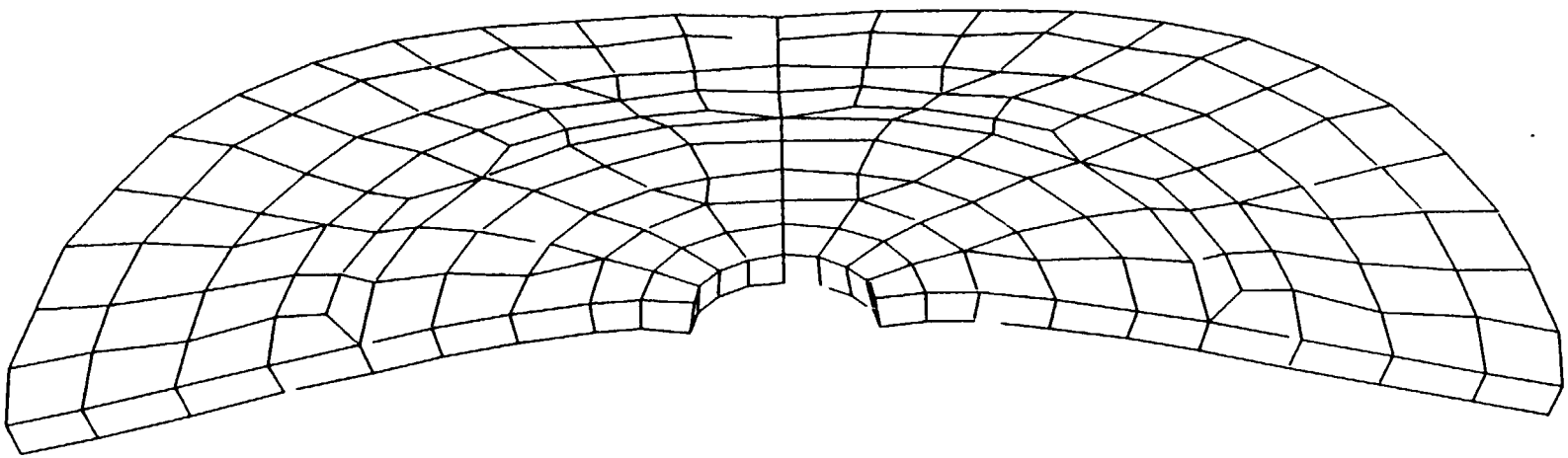


FIGURE 3.3-10
DEFORMED SHAPE, 90° ELEVATION--CASE 5



STATIC MODEL
FINE MESH, 84 SUPPORTS
90 DEGREE EVEVATION. G1=SIN(90) + G2=COS(90)

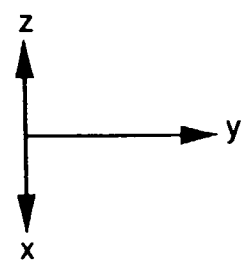
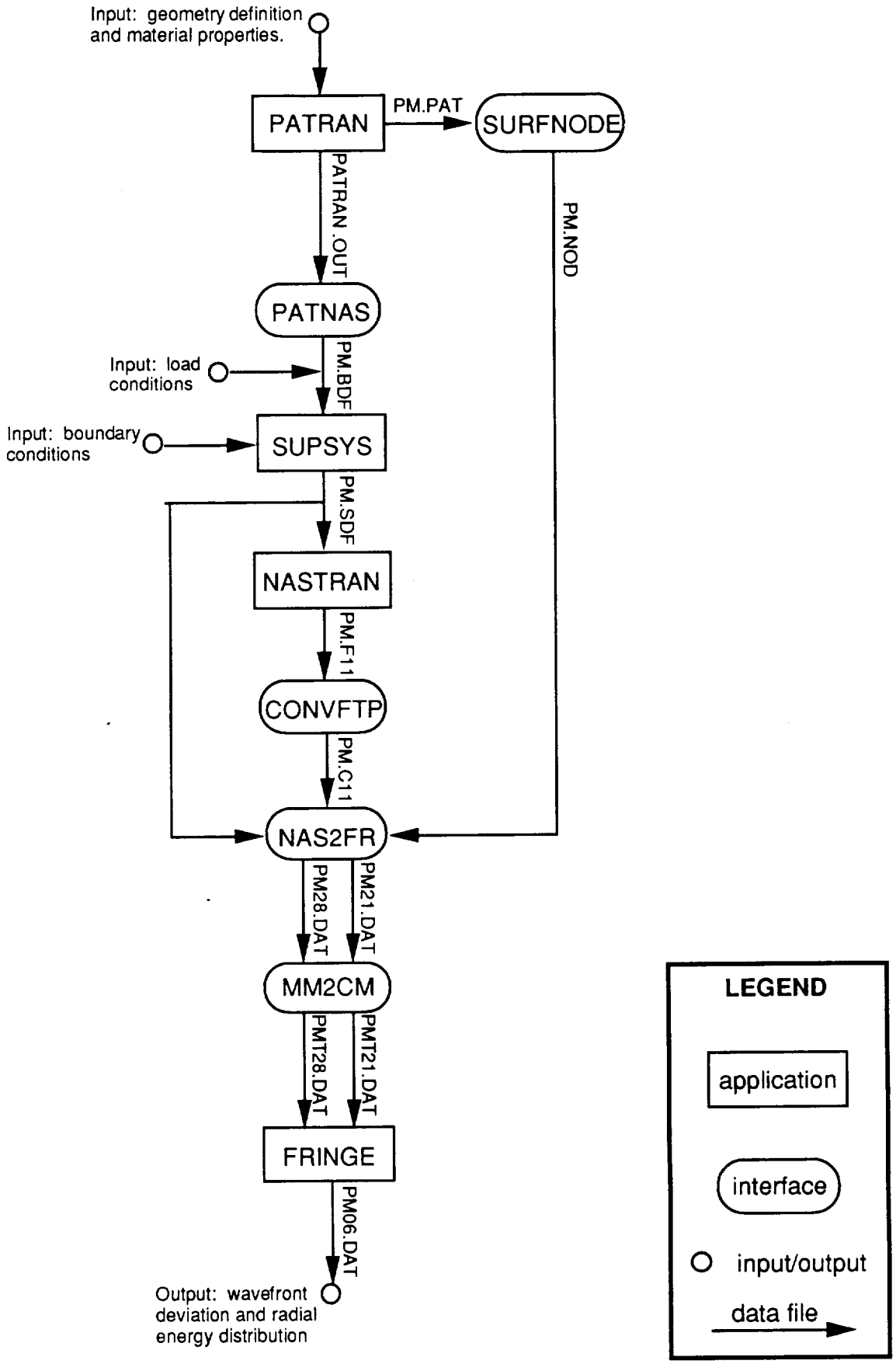


FIGURE 3.4-1
DATA FLOW



Referring again to Figure 3.4-1, the following is a list of the data files and their contents:

Filename	Format	Contents
PATRAN.OUT	binary	FE geometry and material properties
PM.BDF	ASCII	FE geometry, material properties, and load conditions
PM.C11	binary	FEA results (reformatted)
PM.F11	binary	FEA results
PM.NOD	ASCII	Nodes representing mirror reflective surface
PM.PAT	binary	PATRAN database
PM.SDF	ASCII	FE geometry, material properties, load conditions, and boundary conditions
PM06.DAT	ASCII	Optical analysis results
PM21.DAT	binary	Deflection in millimeters
PM28.DAT	binary	Reflective surface geometry in millimeters
PMT21.DAT	binary	Deflection in centimeters
PMT28.DAT	binary	Reflective surface geometry in centimeters

All data files reside on the MICROVAX 3500.

3.5 OPTICAL ANALYSIS RESULTS

Deflection data are processed by the FRINGE code to assess wave front deviation, radial energy distribution, and other optical characteristics of the Primary Mirror for the five load cases. Analysis is performed under the following conditions:

Wavelength	.633 microns
Aperture diameter	2500 mm
Central obscuration diameter	467.5 mm
Radius of curvature	6220 mm

36 polynomial terms are included in the Zernike fit. However, the tilt and focus coefficients are set to zero in order to remove aberrations due to these effects.

The FRINGE executive input and output files are included in the Appendix section 6.7. For an explanation of the input parameters, please refer to the FRINGE manual.

3.5.1 Wave Front Deviation

The wave front deviations are tabulated in units of RMS nanometers:

	0° elevation	20° elevation	40° elevation	60° elevation	90° elevation
Raw	187	292	456	588	667
Plane	164	270	440	577	662
Sphere	164	147	133	130	148
4th order	73.4	48	64.6	101	143
6th order	62	30	56	98.7	143
8th order	25	23	27	35	43
complete	17	18	21	24	27

3.5.2 Radial Energy Distribution

Radial energy distribution is calculated separately by geometric analysis and diffraction analysis. In both cases, the radial center of the total encircled energy is located at the ideal image point.

3.5.2.1 Geometric Analysis

The plots of geometric radial energy distribution for the five load cases are shown in Figures 3.5.2.1-1 through 3.5.2.1-5. A summary of the data, in units of arc seconds diameter, are tabulated as follows:

% energy	0° elevation	20° elevation	40° elevation	60° elevation	90° elevation
50.00	0.2275	0.2101	0.1955	0.2012	0.2291
80.00	0.3344	0.2869	0.2729	0.3023	0.3664
100.00	0.4690	0.6741	0.9362	1.1343	1.1258

FIGURE 3.5.2.1-1

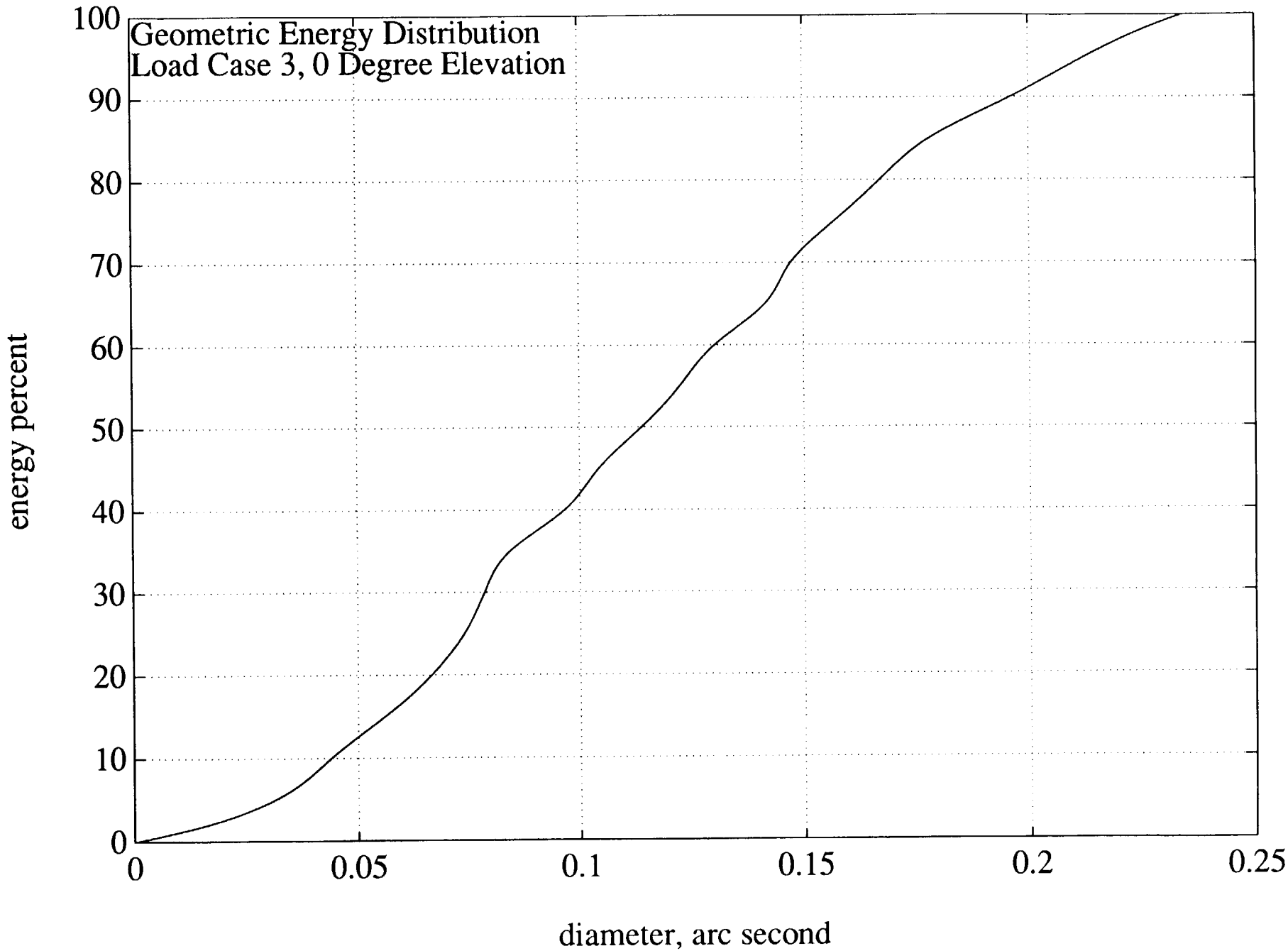


FIGURE 3.5.2.1-2

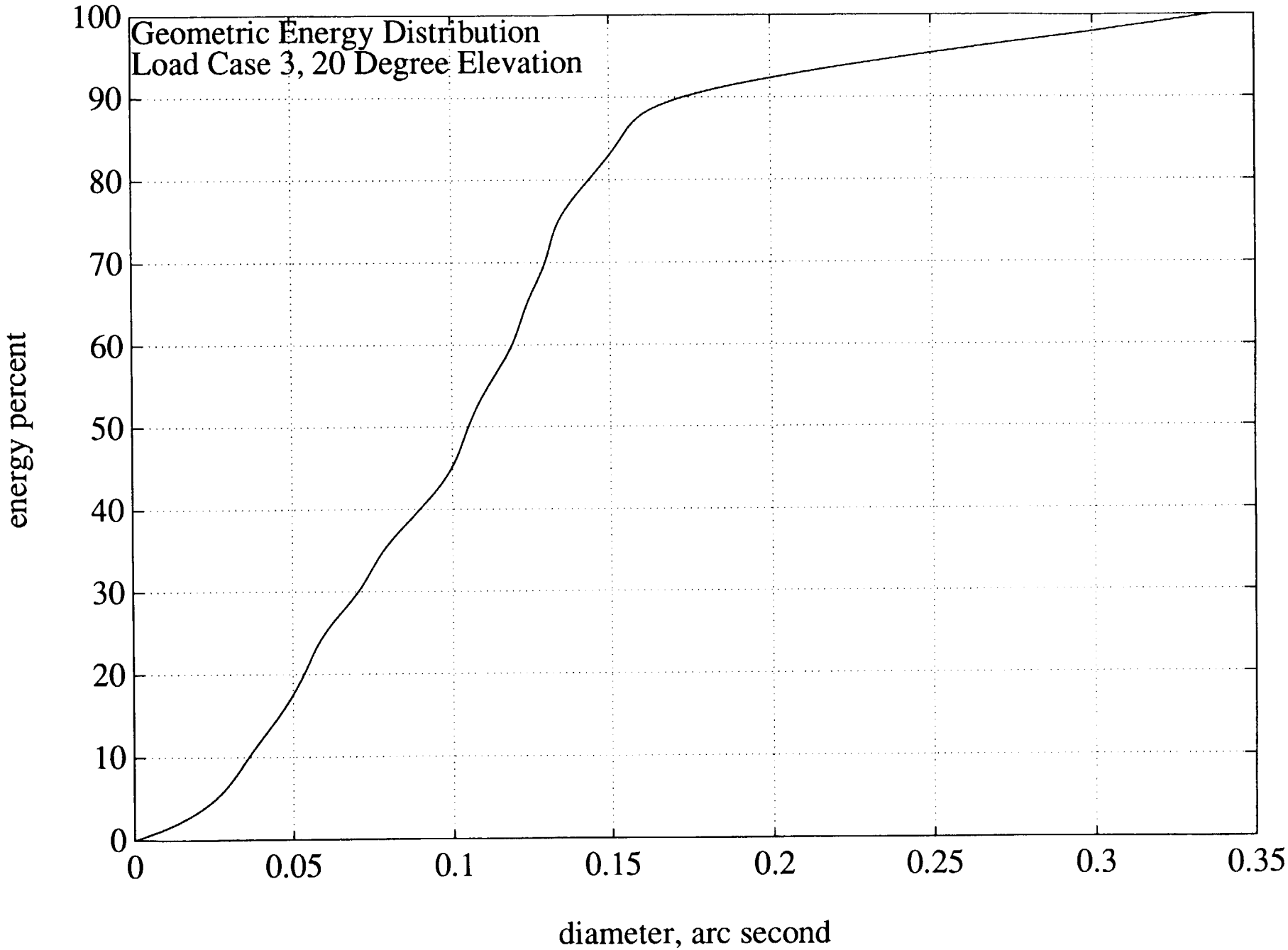


FIGURE 3.5.2.1-3

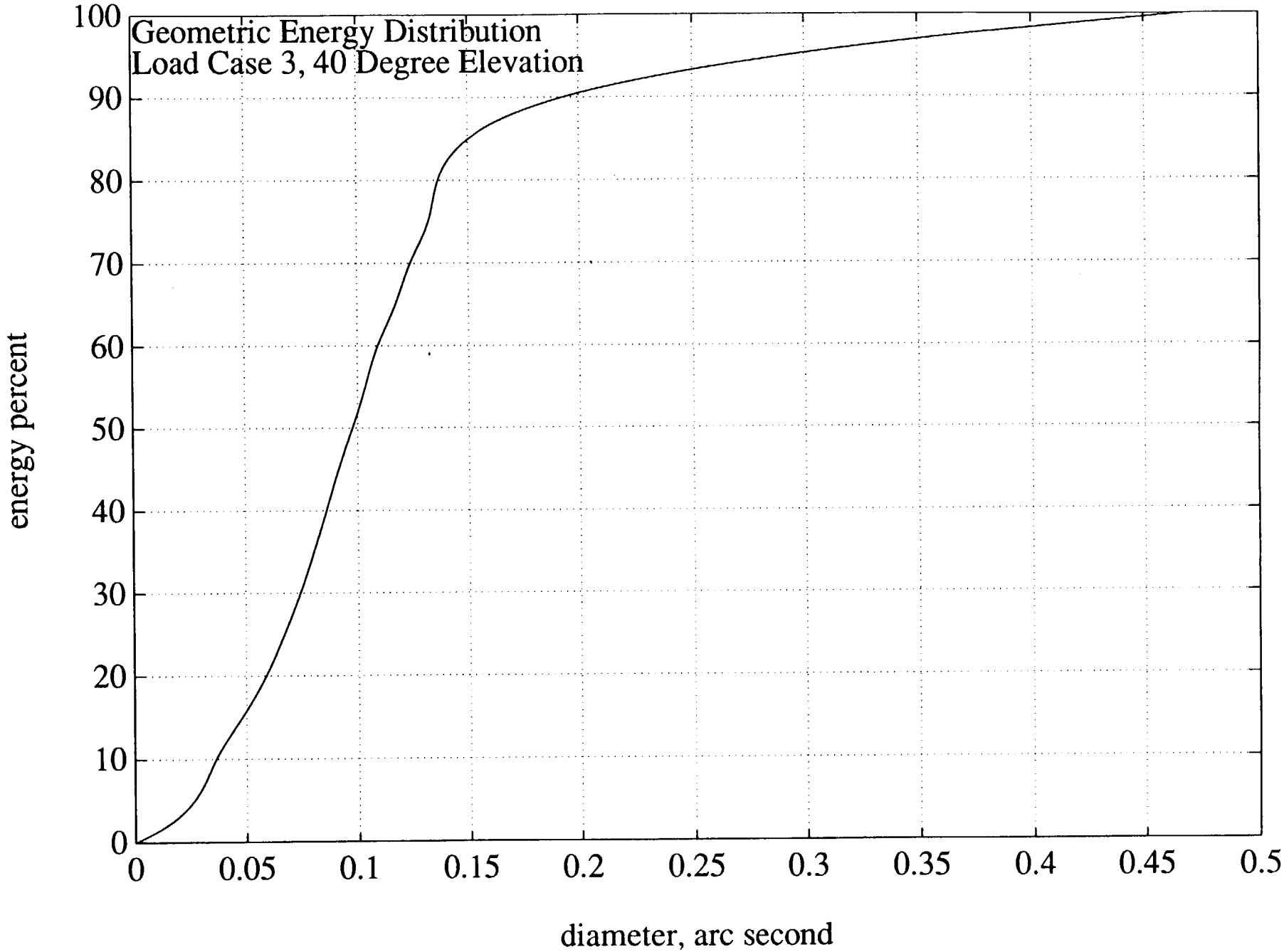


FIGURE 3.5.2.1-4

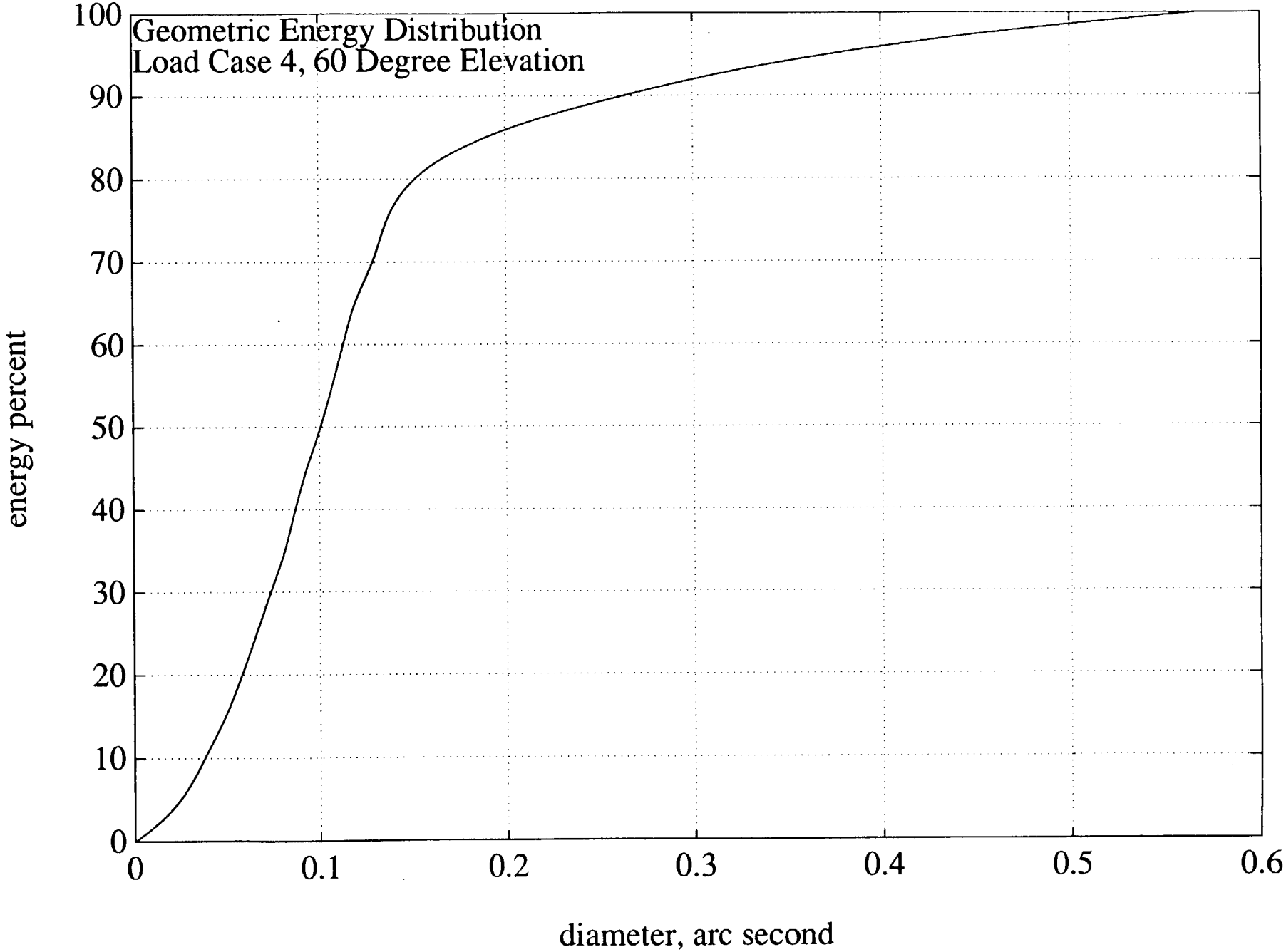
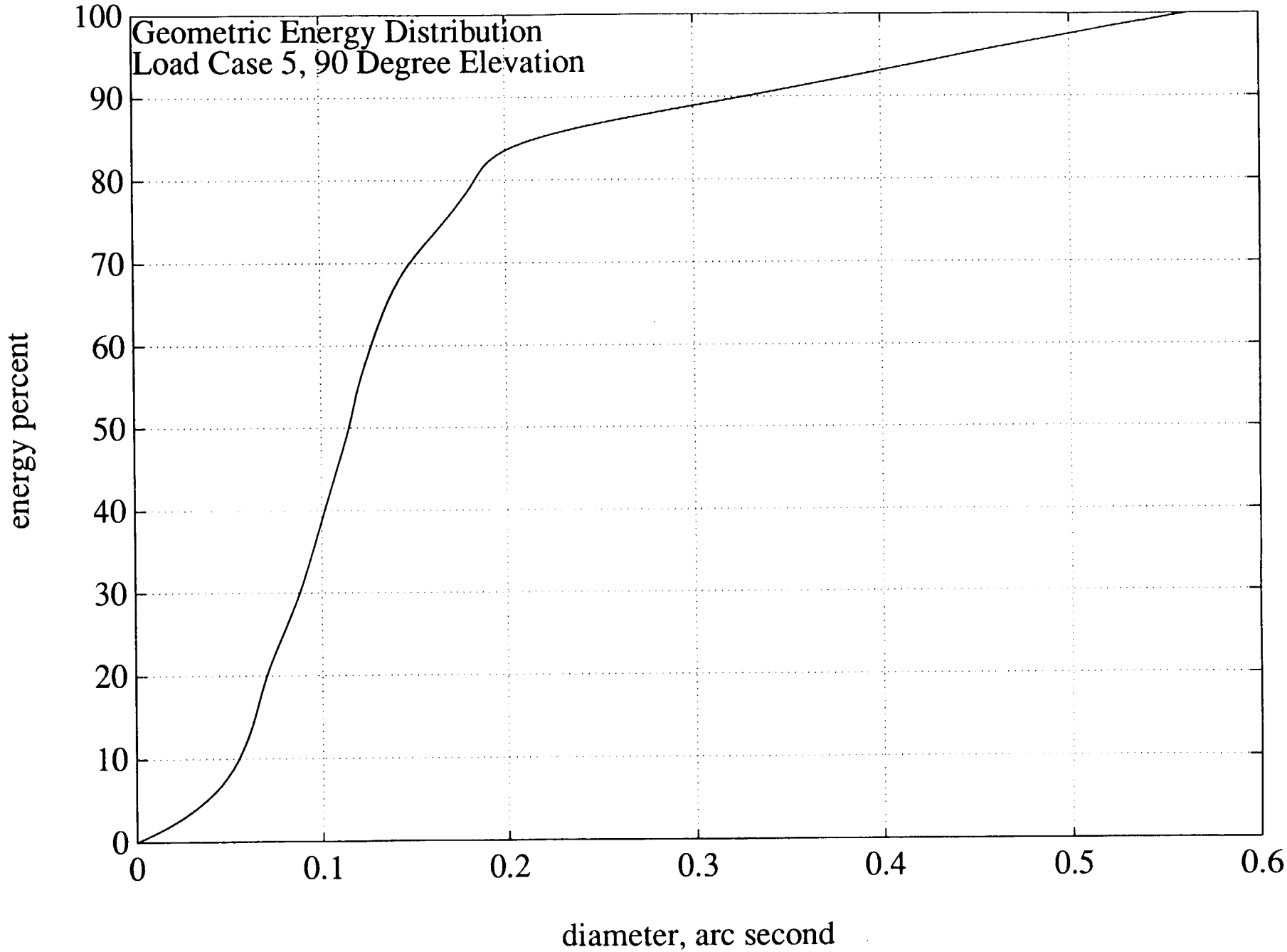


FIGURE 3.5.2.1-5



3.5.2.2 Diffraction Analysis

The plots of diffraction radial energy distribution for the five load cases are shown in Figures 3.5.2.2-1 through 3.5.2.2-5. A summary of the data, in units of arc seconds diameter, are tabulated as follows:

% energy	0° elevation	20° elevation	40° elevation	60° elevation	90° elevation
50.00	0.2127	0.2010	0.1861	0.1906	0.2247
80.00	0.3654	0.3269	0.3190	0.3364	0.3927
100.00	1.4708	1.4707	1.4732	1.4739	1.4629

4. EVALUATION

The effectiveness of the hydraulic support system is evaluated by comparing the above optical results with the results of a hard-mounted mirror model. The hard-mounted mirror model is analyzed using the same loading conditions, but the boundary conditions differ. Unlike the hydraulically supported mirror, all three translational degrees of freedom are constrained at the 64 support points.

Although various information are presented as results, comparisons will be based on *image diameter,* which is the arc second diameter of a circle enclosing 80% of the radial energy. Also, diffraction analysis results will take precedence over geometric results.

4.1 OPTICAL ANALYSIS RESULTS, HARD-MOUNTED MIRROR

4.1.1 Wave Front Deviation, Hard-mounted Mirror

The wave front deviations for the hard-mounted model are tabulated in units of RMS nanometers:

	0° elevation	20° elevation	40° elevation	60° elevation	90° elevation
Raw	41	43	49	54	58
Plane	32	35	45	53	58
Sphere	32	35	44	52	57
4th order	20	25	35	44	49
6th order	15	22	32	42	47
8th order	12	17	26	33	37
complete	9.5	13	19	24	27

FIGURE 3.5.2.2-1

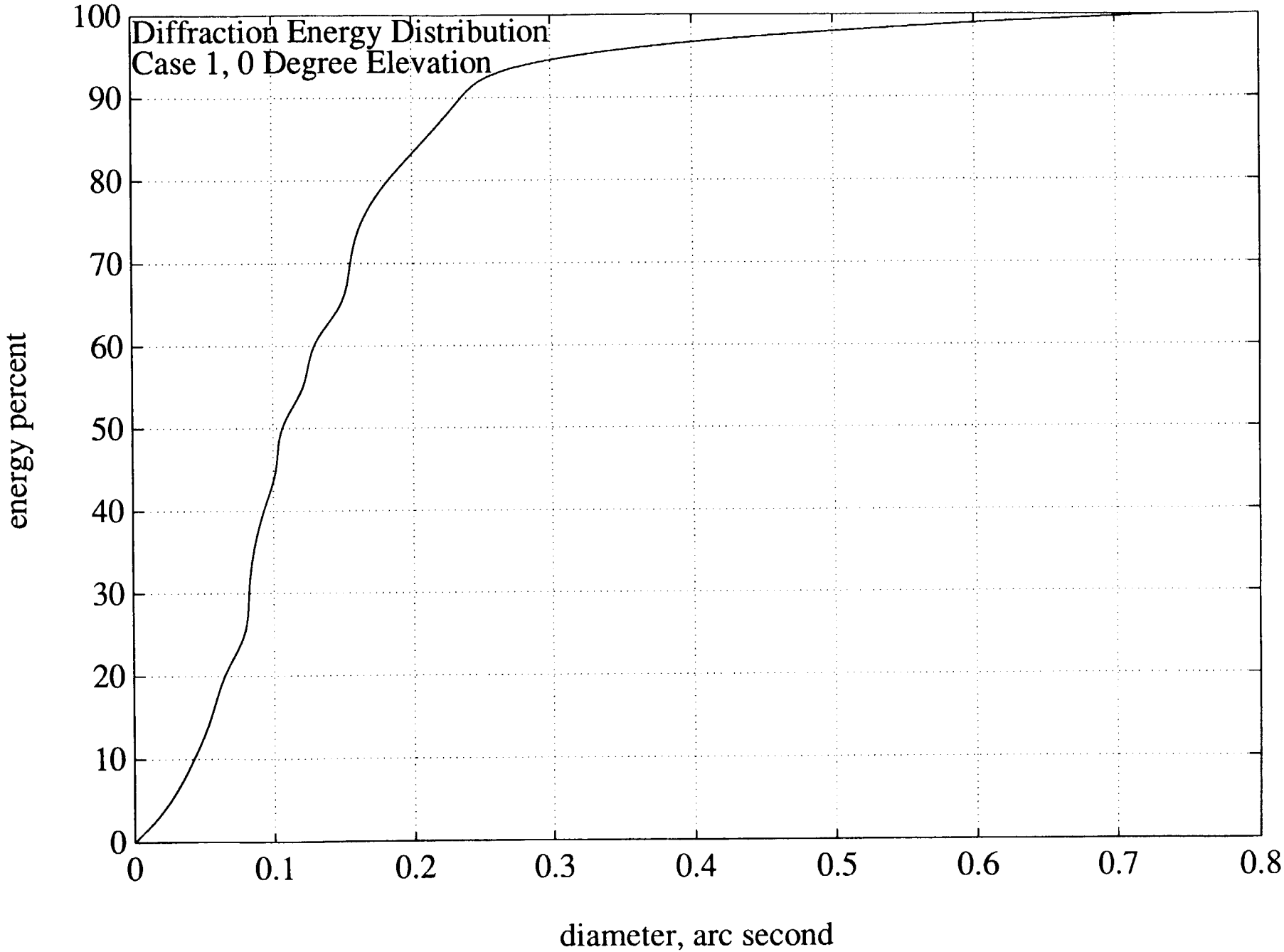


FIGURE 3.5.2.2-2

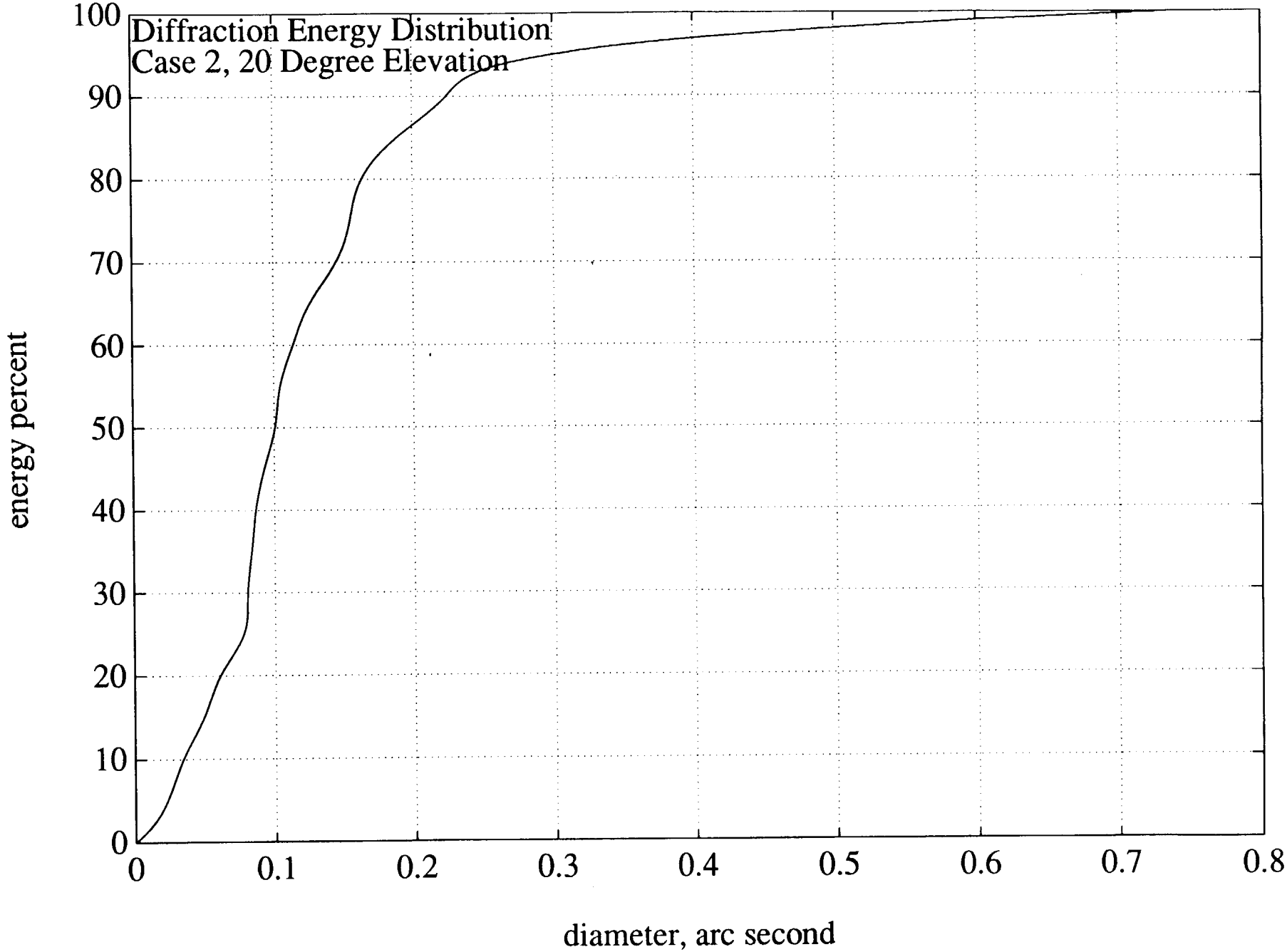


FIGURE 3.5.2.2-3

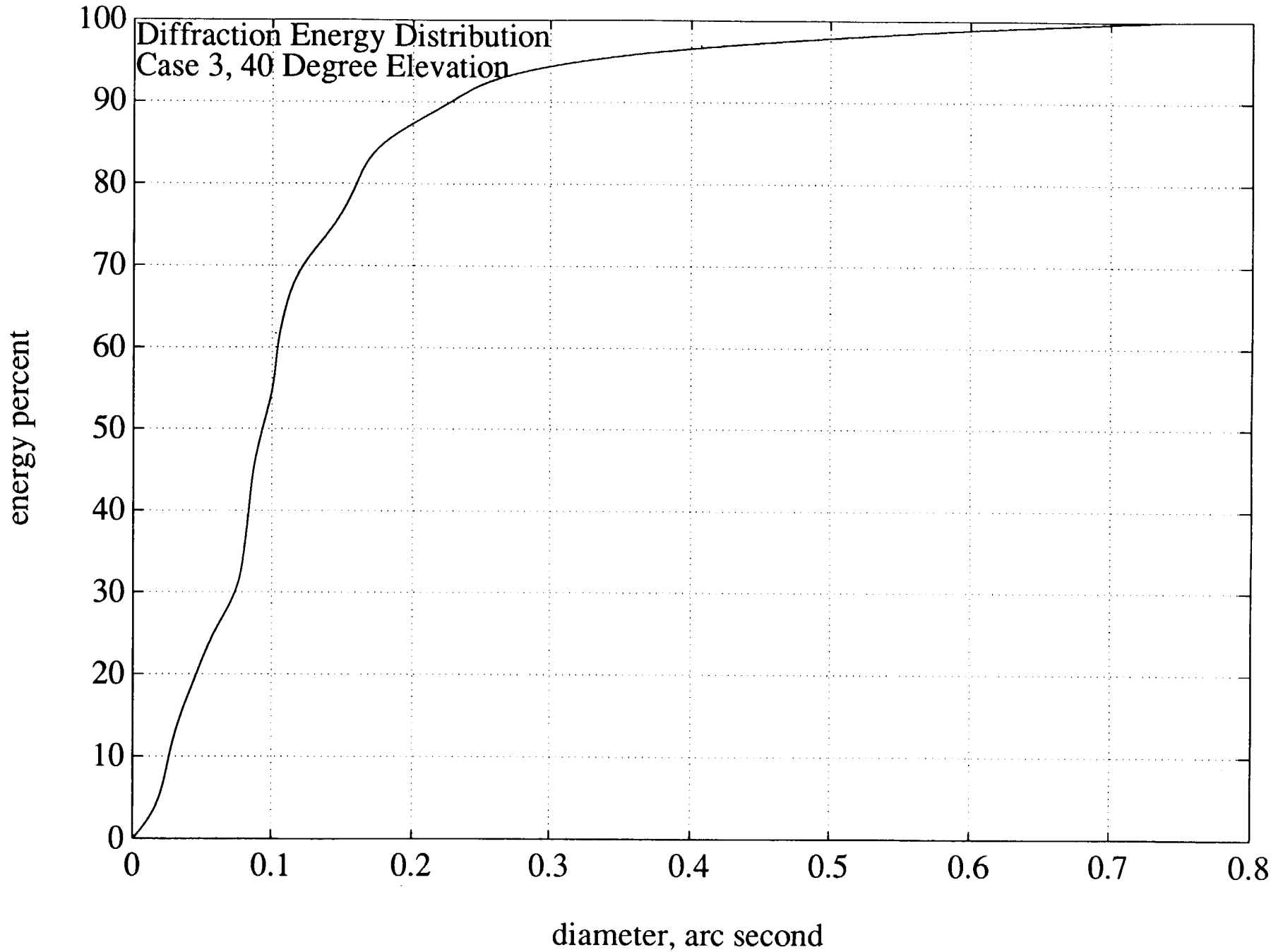


FIGURE 3.5.2.2-4

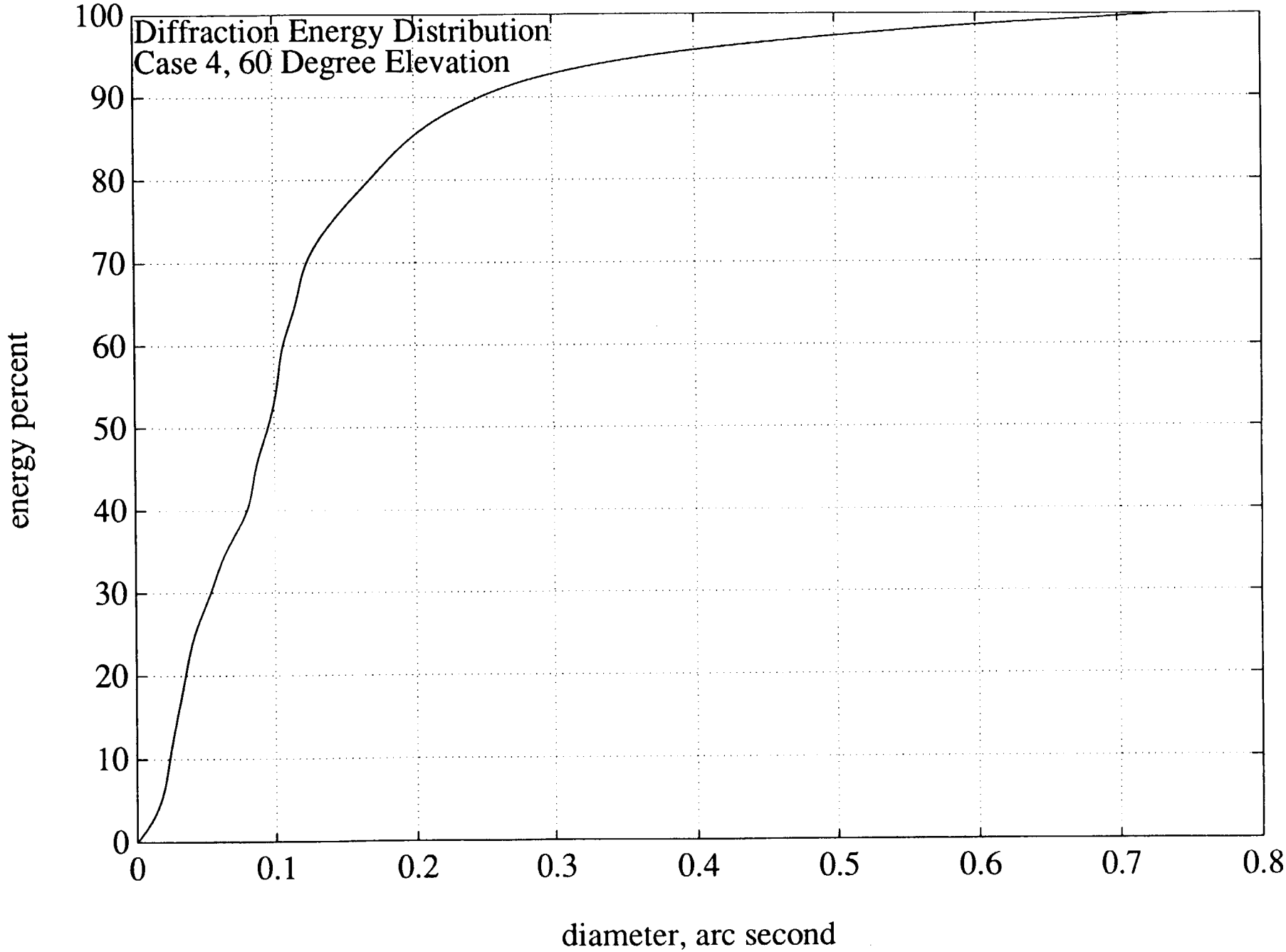
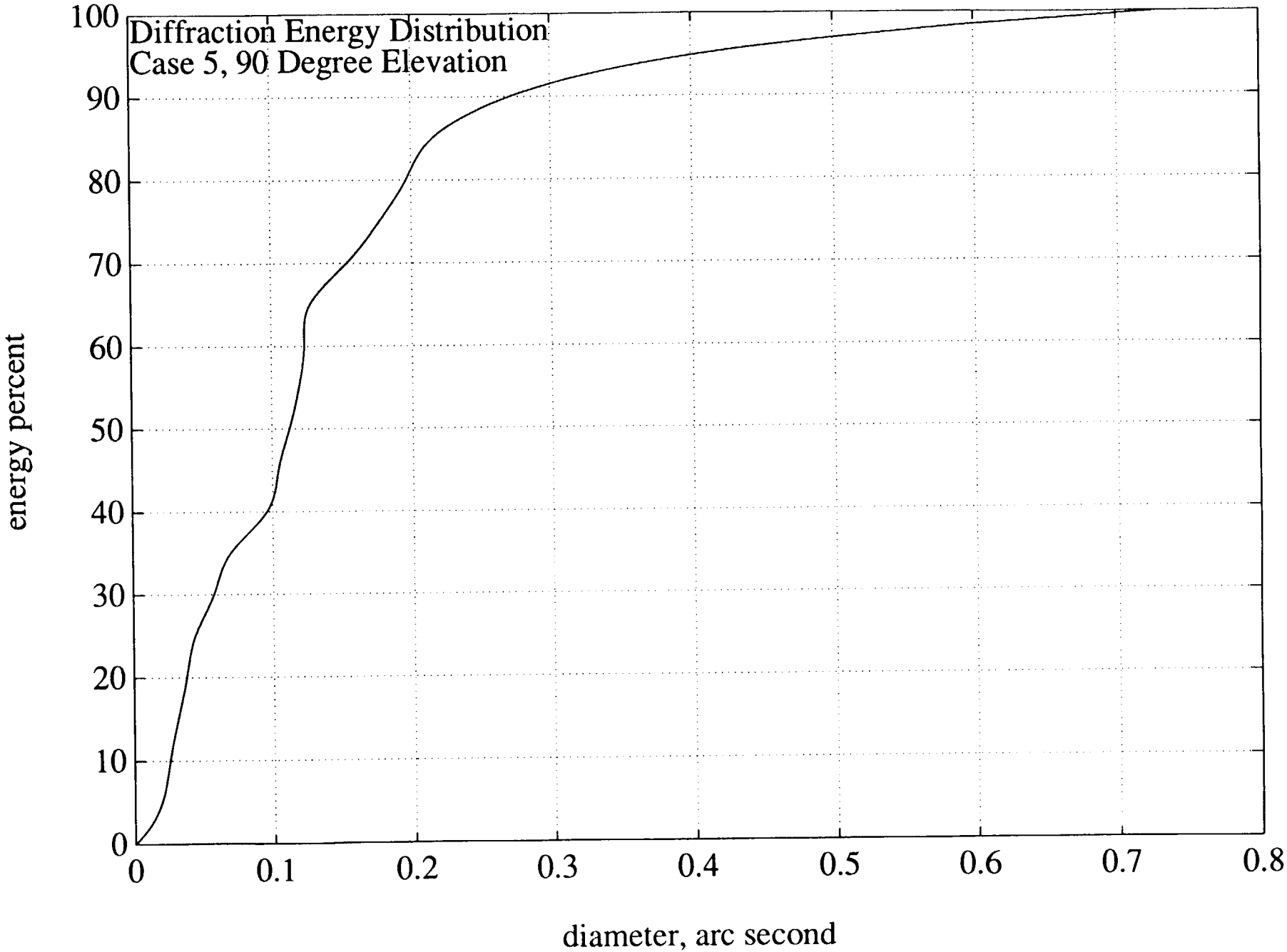


FIGURE 3.5.2.2-5



4.1.2 Radial Energy Distribution, Hard-mounted Mirror

4.1.2.1 Geometric Analysis, Hard-mounted Mirror

The geometric radial energy distribution for the hard-mounted model are tabulated in units of arc seconds diameter:

% energy	0° elevation	20° elevation	40° elevation	60° elevation	90° elevation
50.00	0.0319	0.0561	0.0853	0.1064	0.1244
80.00	0.0602	0.0938	0.1678	0.2140	0.2473
100.00	0.2900	0.5031	0.6625	0.7332	0.7000

4.1.2.2 Diffraction Analysis, Hard-mounted Mirror

The diffraction radial energy distribution for the hard-mounted model are tabulated in units of arc seconds diameter:

% energy	0° elevation	20° elevation	40° elevation	60° elevation	90° elevation
50.00	0.0635	0.0639	0.0650	0.0662	0.0675
80.00	0.1648	0.1689	0.1795	0.1926	0.2003
100.00	1.4675	1.4680	1.4694	1.4713	1.4718

4.1.3 Observation, Hard-mounted Mirror

As shown above, the diffraction and geometric image diameters of a hard-mounted mirror are less than those of a hydraulically supported mirror. This contradicts Phase B developments since the hydraulic support system was designed to minimize optical aberrations. An intuitive explanation would be that since the actuators within a hydraulic subsystem exert equal forces on the mirror, they lack the variable reaction forces needed to oppose localized sagging.

The subsequent task would be to identify any constituent of the support system that causes the greatest aberrations. Optimization of the hydraulic support system is beyond the scope of this report. Nonetheless, whether the lateral or axial support systems contribute more greatly to the aberrations should be determined.

Two additional mirror models are analyzed. One has axial degrees of freedom supported hydraulically and lateral degrees of freedom held rigid at the 64 support points. The other has lateral degrees of freedom supported hydraulically with lateral moment compensators included and axial degrees of freedom held rigid at the support points. These "semi-hard-mounted" mirror models are analyzed under the same loading conditions as before. Their results are shown in the following sections.

4.2 OPTICAL ANALYSIS RESULTS, SEMI-HARD-MOUNTED MIRRORS

4..2.1 Wave Front Deviation, Semi-hard-mounted Mirrors

The wave front deviations for the axially hydraulic, laterally rigid support model are tabulated in RMS nanometers:

	0° elevation	20° elevation	40° elevation	60° elevation	90° elevation
Raw	943	900	756	536	227
Plane	784	746	628	451	225
Sphere	782	738	607	407	110
4th order	105	116	122	120	104
6th order	76.0	95.6	110	115	103
8th order	49	49	46	42	39
complete	33	32	30	28	27

The wave front deviations for the laterally hydraulic, axially rigid support model are tabulated in RMS nanometers:

	0° elevation	20° elevation	40° elevation	60° elevation	90° elevation
Raw	16	25	39	51	58
Plane	13	23	39	51	58
Sphere	13	23	38	50	57
4th order	12	20	34	44	51
6th order	11	20	32	42	49
8th order	11	16	26	34	39
complete	10	14	20	25	28

4.2.2 Radial Energy Distribution, Semi-hard-mounted Mirrors

4.2.2.1 Geometric Analysis, Semi-hard-mounted Mirrors

The geometric radial energy distribution data for the axially hydraulic, laterally rigid support model are tabulated in arc seconds diameter:

% energy	0° elevation	20° elevation	40° elevation	60° elevation	90° elevation
50.00	0.8911	0.8557	0.7145	0.4964	0.1670
80.00	1.2977	1.1805	0.9676	0.6554	0.3488
100.00	2.2510	2.7381	2.4369	1.7848	0.7295

The geometric radial energy distribution data for the laterally hydraulic, axially rigid support model are tabulated in arc seconds diameter:

% energy	0° elevation	20° elevation	40° elevation	60° elevation	90° elevation
50.00	0.0116	0.0424	0.0792	0.1104	0.1283
80.00	0.0165	0.0913	0.1658	0.2228	0.2561
100.00	0.0572	0.3099	0.5215	0.6631	0.7633

4.2.2.2 Diffraction Analysis, Semi-hard-mounted Mirrors

The diffraction radial energy distribution data for the axially hydraulic, laterally rigid support model are tabulated in arc seconds diameter:

% energy	0° elevation	20° elevation	40° elevation	60° elevation	90° elevation
50.00	0.8181	0.7919	0.6677	0.4586	0.1352
80.00	1.0832	1.0509	0.9432	0.6925	0.2764
100.00	1.4690	1.4663	1.4679	1.4714	1.4820

The diffraction radial energy distribution data for the laterally hydraulic, axially rigid support model are tabulated in arc seconds diameter:

% energy	0° elevation	20° elevation	40° elevation	60° elevation	90° elevation
50.00	0.0631	0.0635	0.0648	0.0663	0.0680
80.00	0.1609	0.1653	0.1772	0.1932	0.2022
100.00	1.4669	1.4674	1.4694	1.4708	1.4723

4.2.3 Observations, Semi-hard-mounted Mirrors

The laterally hydraulic, axially rigid support model has the smallest overall image diameter. Whereas the axially hydraulic, laterally rigid support model has the greatest overall image diameter. This indicates that the mirror has the least optical aberration when the lateral hydraulic support system, including moment compensators, are activated while the axial support actuators are "locked." Therefore, the axial hydraulic support system is identified as the greatest contributor to optical aberrations.

The overall improvement of optical quality for the laterally hydraulic, axially rigid support model over the hard-mounted model can be attributed to the designed nature of the lateral supports and moment compensators. However, for elevation angle of 60° and higher, the hard-mounted mirror still has the lowest image diameter for both geometric and diffraction analysis. This indicates that the lateral hydraulic support system do contribute to optical aberrations at high elevation angles.

5. CONCLUSION

Evaluation of optical analysis results singles out the axial hydraulic support system as the chief contributor to the optical aberrations caused by the support system itself. Modification of the axial support system is necessary if a hydraulically supported mirror is to out-perform a hard-mounted one. It is

recommended that hydraulic systems consisting of non-uniform actuators be explored. For example, larger actuators (with higher force to fluid pressure ratios) can be placed where mirror sagging tends to occur. This can be simulated by manipulating the input parameters of the SUPSYS code described in section 2.4.3. Ultimately, an optimized axial hydraulic support system with different sized actuators located strategically can greatly reduce optical aberrations while maintaining the passive nature of the support system.

Further evaluation shows that although the lateral hydraulic support system lowers the overall image diameter, it does not work well at high elevation angles. Like the axial support system, the lateral system can also be optimized using the SUPSYS code. For the lateral system, tilt angles and moment arm dimensions (see Figure 2.4.3.1-1) can be also be varied in addition to actuator size by manipulating SUPSYS inputs.

Additional minimization of optical aberrations can be achieved by introducing active forces into the support system. Whether or not this is necessary depends on the outcome of the recommended optimization of the passive system.

6. APPENDIX

6.1 SUPSYS

6.1.1 Executive Input

```
TITLE    PRIMARY MIRROR LATERAL AND AXIAL SUPPORTS
INFILE   [MA.NASTRAN]PM.BDF
OUTFILE  [MA.NASTRAN]PM.SDF
EDGENODE .500000
LENGTHA  200.000
LENGTHB  200.000
APEN     30.0000

LATGROUP        1
TILT      30.0000
LATNODE        27 1.00000 1.00000 1.00000 1.00000
LATNODE        48 1.00000 1.00000 1.00000 1.00000
LATNODE        88 1.00000 1.00000 1.00000 1.00000
LATNODE        92 1.00000 1.00000 1.00000 1.00000
LATNODE        94 1.00000 1.00000 1.00000 1.00000
LATNODE       141 1.00000 1.00000 1.00000 1.00000
LATNODE       163 1.00000 1.00000 1.00000 1.00000
LATNODE       212 1.00000 1.00000 1.00000 1.00000
LATNODE       226 1.00000 1.00000 1.00000 1.00000
LATNODE       230 1.00000 1.00000 1.00000 1.00000
LATNODE       262 1.00000 1.00000 1.00000 1.00000
LATNODE       266 1.00000 1.00000 1.00000 1.00000
LATNODE       272 1.00000 1.00000 1.00000 1.00000
LATNODE       311 1.00000 1.00000 1.00000 1.00000
LATNODE       315 1.00000 1.00000 1.00000 1.00000
LATNODE       335 1.00000 1.00000 1.00000 1.00000
LATNODE       377 1.00000 1.00000 1.00000 1.00000
LATNODE       393 1.00000 1.00000 1.00000 1.00000
LATNODE       395 1.00000 1.00000 1.00000 1.00000
LATNODE       429 1.00000 1.00000 1.00000 1.00000
LATNODE       433 1.00000 1.00000 1.00000 1.00000
LATNODE       437 1.00000 1.00000 1.00000 1.00000
LATNODE       478 1.00000 1.00000 1.00000 1.00000
LATNODE       499 1.00000 1.00000 1.00000 1.00000
LATNODE       542 1.00000 1.00000 1.00000 1.00000
LATNODE       557 1.00000 1.00000 1.00000 1.00000
LATNODE       587 1.00000 1.00000 1.00000 1.00000
LATNODE       591 1.00000 1.00000 1.00000 1.00000
LATNODE       595 1.00000 1.00000 1.00000 1.00000
LATNODE       628 1.00000 1.00000 1.00000 1.00000
LATNODE       632 1.00000 1.00000 1.00000 1.00000
LATNODE       651 1.00000 1.00000 1.00000 1.00000

LATGROUP        2
TILT     -30.0000
LATNODE        29 1.00000 1.00000 1.00000 1.00000
LATNODE        46 1.00000 1.00000 1.00000 1.00000
LATNODE        50 1.00000 1.00000 1.00000 1.00000
LATNODE        86 1.00000 1.00000 1.00000 1.00000
LATNODE        90 1.00000 1.00000 1.00000 1.00000
LATNODE        96 1.00000 1.00000 1.00000 1.00000
LATNODE       139 1.00000 1.00000 1.00000 1.00000
LATNODE       143 1.00000 1.00000 1.00000 1.00000
LATNODE       165 1.00000 1.00000 1.00000 1.00000
LATNODE       210 1.00000 1.00000 1.00000 1.00000
LATNODE       228 1.00000 1.00000 1.00000 1.00000
LATNODE       264 1.00000 1.00000 1.00000 1.00000
LATNODE       268 1.00000 1.00000 1.00000 1.00000
LATNODE       270 1.00000 1.00000 1.00000 1.00000
LATNODE       313 1.00000 1.00000 1.00000 1.00000
LATNODE       333 1.00000 1.00000 1.00000 1.00000
LATNODE       379 1.00000 1.00000 1.00000 1.00000
LATNODE       397 1.00000 1.00000 1.00000 1.00000
LATNODE       431 1.00000 1.00000 1.00000 1.00000
LATNODE       435 1.00000 1.00000 1.00000 1.00000
LATNODE       439 1.00000 1.00000 1.00000 1.00000
LATNODE       476 1.00000 1.00000 1.00000 1.00000
LATNODE       480 1.00000 1.00000 1.00000 1.00000
LATNODE       501 1.00000 1.00000 1.00000 1.00000
LATNODE       540 1.00000 1.00000 1.00000 1.00000
LATNODE       553 1.00000 1.00000 1.00000 1.00000
LATNODE       555 1.00000 1.00000 1.00000 1.00000
LATNODE       585 1.00000 1.00000 1.00000 1.00000
LATNODE       589 1.00000 1.00000 1.00000 1.00000
LATNODE       593 1.00000 1.00000 1.00000 1.00000
LATNODE       630 1.00000 1.00000 1.00000 1.00000
LATNODE       649 1.00000 1.00000 1.00000 1.00000
```

```
AXGROUP        1
AXNODE        27 1.00000
AXNODE        29 1.00000
AXNODE       212 1.00000
AXNODE       210 1.00000
AXNODE        48 1.00000
AXNODE        50 1.00000
AXNODE       230 1.00000
AXNODE       228 1.00000
AXNODE       143 1.00000
AXNODE       163 1.00000
AXNODE       165 1.00000
AXNODE       335 1.00000
AXNODE       333 1.00000
AXNODE       315 1.00000
AXNODE        90 1.00000
AXNODE        92 1.00000
AXNODE        94 1.00000
AXNODE        96 1.00000
AXNODE       272 1.00000
AXNODE       270 1.00000
AXNODE       268 1.00000
AXNODE       266 1.00000

AXGROUP        2
AXNODE       379 1.00000
AXNODE       377 1.00000
AXNODE       397 1.00000
AXNODE       395 1.00000
AXNODE       393 1.00000
AXNODE        46 1.00000
AXNODE       501 1.00000
AXNODE       499 1.00000
AXNODE       480 1.00000
AXNODE       478 1.00000
AXNODE       476 1.00000
AXNODE       139 1.00000
AXNODE       141 1.00000
AXNODE       439 1.00000
AXNODE       437 1.00000
AXNODE       435 1.00000
AXNODE       433 1.00000
AXNODE       431 1.00000
AXNODE       429 1.00000
AXNODE        86 1.00000
AXNODE        88 1.00000

AXGROUP        3
AXNODE       540 1.00000
AXNODE       542 1.00000
AXNODE       226 1.00000
AXNODE       553 1.00000
AXNODE       555 1.00000
AXNODE       557 1.00000
AXNODE       313 1.00000
AXNODE       311 1.00000
AXNODE       628 1.00000
AXNODE       630 1.00000
AXNODE       632 1.00000
AXNODE       649 1.00000
AXNODE       651 1.00000
AXNODE       264 1.00000
AXNODE       262 1.00000
AXNODE       585 1.00000
AXNODE       587 1.00000
AXNODE       589 1.00000
AXNODE       591 1.00000
AXNODE       593 1.00000
AXNODE       595 1.00000
```

6.1.2 Input Commands Definitions

Each line of the input file is divided into 9 fields, each field consists of 8 columns. The input commands are placed in field 1 (columns 1 through 8). Single arguments for the commands are entered in field 2, unless otherwise indicated. Multiple arguments are entered in their designated fields. The commands' definitions are as follows:

title: The name of the input is entered in fields 2 through 9. This appears on the output.

infile: The name of the NASTRAN input file to be modified is entered in fields 2 through 9.

outfile: The name of the output file are entered in fields 2 through 9. The output file is readable by NASTRAN and contains commands reflecting hydraulic support system parameters.

edgenode: Designates the location of edge nodes to be planted on the existing elements adjacent to the support point. A value of 0. means the edge node coincides with the support point, and a value of 1. means the edge node is on the other end of the element edge. Since NASTRAN recommends that edge points be located within the middle third of the edge, the value should be between .333333 and .666666.

lengtha: The dimension "A" of the support mechanism (see Figure 2.4.1-1).

lengthb: The dimension "B" of the support mechanism (see Figure 2.4.1-1).

apen: The depth of penetration of *lengtha* into the mirror. This is usually half the mirror thickness.

latgroup: The label number of a lateral support subsystem.

tilt: The tilt angle, in degrees, counter-clockwise positive, of the lateral support units. The value is assigned to the lateral support subsystem declared by the most previous *latgroup* command.

latnode: The NASTRAN node number of a support point is entered in field 2. The *tilt* scale factor for this support point is entered in field 3. The *lengtha* and *lengthb* scale factors for this support point are entered in fields 4 and 5, respectively. The actuator force scale factor for this support point is entered in field 6. These values are assigned to the lateral support subsystem declared by the most previous *latgroup* command. The forces of the support actuators within a subsystem are proportional to their corresponding force scale factors. Moment compensator actuator forces are equal to the support actuator force in the same support unit. However, moment compensation can be adjusted by varying the moment arms *lengtha* and *lengthb*.

axgroup: The label number of an axial support subsystem.

axnode: The NASTRAN node number of a support point is entered in field 2. The actuator force scale factor for this support point are entered in field 3. These values are assigned to the axial support subsystem declared by the most previous *axgroup* command. The forces of the actuators within a subsystem are proportional to their corresponding force scale factors.

6.1.3 Source Code

```
      PROGRAM SUPSYS
C  SUPSYS (SUPport SYStem) simulates the hydraulic support system of the
C  SOFIA primary mirror.  SUPSYS reads support system parameters and a
C  NASTRAN input file and generates a new NASTRAN input file containing
C  the proper boundary condition commands.  Rigid body elements (RBE1)
C  and multipoint constraints (MPC) are produced.  The necessary
C  modifications to element connectivity are made.  This program
C  presently can process CHEXA and CPENTA element cards only.  The
C  maximum number of elements connecting a support point is 9.
      IMPLICIT INTEGER (A-Z)
      REAL TILT,FTILT,EDGE,LGTHA,FLGTHA,LGTHB,FLGTHB,FLCOMP,X1FBASE,
     &X2FBASE,X3FBASE,APEN,FCOMP
      CHARACTER F2*8,F20*72,TITLENAME*64
      DIMENSION LBNODE(100,50),LBSYS(50),NNODE(50),TILT(50),
     &FTILT(100,50),LBFBASE(6,100,50),LBELEM(6,100,50),NFBASE(100,50),
     &LBNEWNODE(9,100,50),NNEWNODE(100,50),FLGTHA(100,50),
     &FLGTHB(100,50),FLCOMP(100,50),X1FBASE(6),X2FBASE(6),X3FBASE(6),
     &LBANODE(100,50),LBASYS(50),NANODE(50),FCOMP(100,50)
      DATA DNEWNODE,DFBASE,DNODE,DSYS,DANODE,DASYS/9,6,100,50,100,50/
      WRITE(6,*) 'Enter the batch data file name.'
      WRITE(6,*) 'Default: SUPSYS.IN'
      READ(5,'(A72)') F20
      IF(INDEX(F20,' ').LE.1) F20='SUPSYS.IN'
      OPEN(UNIT=20,FILE=F20,STATUS='OLD',ERR=9010)
      CALL BADAIN(LBNODE,LBSYS,NNODE,NSYS,DNODE,DSYS,TILT,FTILT,
     &EDGE,LGTHA,FLGTHA,LGTHB,FLGTHB,FLCOMP,APEN,LBANODE,LBASYS,
     &NANODE,NASYS,DANODE,DASYS,FCOMP,TITLENAME)
      CALL OLDNODE(LBOLDNODE)
      CALL OLDELEM(LBOLDELEM)
      CALL FBASE(LBNODE,NNODE,NSYS,DNODE,DSYS,LBFBASE,LBELEM,
     &NFBASE,DFBASE)
      CALL REWRITE(LBELEM,NFBASE,NNODE,NSYS,DFBASE,DNODE,DSYS)
      WRITE(30,'(A65)') '$ALL CARDS BELOW ARE ADDED BY THE PROGRAM
     &SUPSYS.  ORIGINAL CARDS'
      WRITE(30,'(A48)') '$CORRESPONDING TO MODIFIED ELEMENTS ARE
     &DELETED.'
      WRITE(30,'(A1)') '$'
      WRITE(30,'(A20)') '$SUPSYS INPUT TITLE:'
      WRITE(30,'(A65)') '$'//TITLENAME
      CALL NEWNODE(LBOLDNODE,LBNEWNODE,NNEWNODE,DNEWNODE,LBFBASE,
     &NFBASE,DFBASE,LBNODE,NNODE,DNODE,NSYS,DSYS,TILT,FTILT,EDGE,
     &X1FBASE,X2FBASE,X3FBASE,LGTHA,FLGTHA,LGTHB,FLGTHB,APEN)
      CALL RIBOEL(LBOLDELEM,LBNEWNODE,NNEWNODE,DNEWNODE,
     &NNODE,DNODE,NSYS,DSYS)
      CALL ELCOMO(LBNEWNODE,NNEWNODE,DNEWNODE,LBFBASE,NFBASE,
     &DFBASE,LBELEM,LBNODE,NNODE,DNODE,NSYS,DSYS)
      CALL MPCLAT(TILT,FTILT,FLCOMP,LBNEWNODE,NNEWNODE,DNEWNODE,
     &NNODE,DNODE,LBSYS,NSYS,DSYS,ISID,ICONT)
      CALL MPCAXIAL(FCOMP,LBANODE,NANODE,DANODE,LBASYS,NASYS,DASYS,
     &ISID,ICONT)
      CALL MPCADD(NSYS,NASYS)
C
C  Echo for evaluation
C      F2='LASU.CHK'
C      OPEN(UNIT=2,FILE=F2,STATUS='NEW',FORM='FORMATTED')
C      WRITE(2,*) '# of systems =',NSYS
C      WRITE(2,*) '# of nodes, sys 1 =',NNODE(1)
C      WRITE(2,*) '# of nodes, sys 2 =',NNODE(2)
C      WRITE(2,*) 'LBOLDNODE =',LBOLDNODE
C      WRITE(2,*) 'LBOLDELEM =',LBOLDELEM
C      WRITE(2,*) 'EDGENODE =',EDGE
C      WRITE(2,*) 'LENGTHA =',LGTHA
C      WRITE(2,*) 'LENGTHB =',LGTHB
C      WRITE(2,*) 'APENETRATION =',APEN
C       DO I=1,NSYS
C       WRITE(2,*) 'SYSTEM #',I
C       WRITE(2,*) 'SYSTEM LABEL =',LBSYS(I)
C       WRITE(2,*) 'TILT =',TILT(I)
C        DO J=1,NNODE(I)
C        WRITE(2,'(1X,2I8,3(1X,G8.3),1X,I8)') J,LBNODE(J,I),FTILT(J,I),
C     &  FLGTHA(J,I),FLGTHB(J,I),NFBASE(J,I)
C        WRITE(2,*) (LBFBASE(K,J,I),K=1,NFBASE(J,I))
C        WRITE(2,*) (LBELEM(K,J,I),K=1,NFBASE(J,I))
C        END DO
C       END DO
      WRITE(30,'(A7)') 'ENDDATA'
      CLOSE (2)
      CLOSE (10)
      CLOSE (20)
      CLOSE (30)
      GOTO 9999
9010  WRITE(6,*)'ERROR: input file name F20, ',F20(1:INDEX(F20,' ')-1)
9999  STOP
      END
C
C
      SUBROUTINE BADAIN(LBNODE,LBSYS,NNODE,NSYS,DNODE,DSYS,TILT,FTILT,
```

```
     &EDGE,LGTHA,FLGTHA,LGTHB,FLGTHB,FLCOMP,APEN,LBANODE,LBASYS,NANODE,
     &NASYS,DANODE,DASYS,FCOMP,TITLENAME)
C  BADAIN (BAtch DAta INput) reads data from the input file which
C  contains lateral support tilt angle, support point node numbers, and
C  tilt direction.
      IMPLICIT INTEGER (A-Z)
      REAL TILT,FTILT,RVAL1,EDGE,LGTHA,LGTHB,FLGTHA,FLGTHB,FLCOMP,APEN,
     &FCOMP
      CHARACTER*80 RECORD1,INTU1,F10,F30
      CHARACTER TITLENAME*64
      DIMENSION LBNODE(DNODE,DSYS),LBSYS(DSYS),NNODE(DSYS),TILT(DSYS),
     &FTILT(DNODE,DSYS),FLGTHA(DNODE,DSYS),FLGTHB(DNODE,DSYS),
     &FLCOMP(DNODE,DSYS),LBANODE(DANODE,DASYS),LBASYS(DASYS),
     &NANODE(DASYS),FCOMP(DANODE,DASYS)
        DO I=1,DSYS
        NNODE(I)=0
        END DO
        NSYS=0
      REWIND (20)
10    READ(20,'(A80)',END=9000) RECORD1
      IF(RECORD1(1:1).EQ.'$') GOTO 10
C
       IF(RECORD1(1:5).EQ.'TITLE') THEN
       TITLENAME=RECORD1(9:72)
       GOTO 10
       ENDIF
C
       IF(RECORD1(1:6).EQ.'INFILE') THEN
       F10=RECORD1(9:72)
       OPEN(UNIT=10,FILE=F10,STATUS='OLD',ERR=9010)
       GOTO 10
       ENDIF
C
       IF(RECORD1(1:7).EQ.'OUTFILE') THEN
       F30=RECORD1(9:72)
       OPEN(UNIT=30,FILE=F30,STATUS='NEW',FORM='FORMATTED',ERR=9020)
       GOTO 10
       ENDIF
C
       IF(RECORD1(1:8).EQ.'EDGENODE') THEN
       WRITE(INTU1,*) RECORD1(9:16)
       READ(INTU1,*) EDGE
       GOTO 10
       ENDIF
C
       IF(RECORD1(1:7).EQ.'LENGTHA') THEN
       WRITE(INTU1,*) RECORD1(9:16)
       READ(INTU1,*) LGTHA
       GOTO 10
       ENDIF
C
       IF(RECORD1(1:7).EQ.'LENGTHB') THEN
       WRITE(INTU1,*) RECORD1(9:16)
       READ(INTU1,*) LGTHB
       GOTO 10
       ENDIF
C
       IF(RECORD1(1:4).EQ.'APEN') THEN
       WRITE(INTU1,*) RECORD1(9:16)
       READ(INTU1,*) APEN
       GOTO 10
       ENDIF
C
       IF(RECORD1(1:8).EQ.'LATGROUP') THEN
       NSYS=NSYS+1
       WRITE(INTU1,*) RECORD1(9:16)
       READ(INTU1,*) LBSYS(NSYS)
       GOTO 10
       ENDIF
C
       IF(RECORD1(1:4).EQ.'TILT') THEN
       WRITE(INTU1,*) RECORD1(9:16)
       READ(INTU1,*) TILT(NSYS)
       GOTO 10
       ENDIF
C
       IF(RECORD1(1:7).EQ.'LATNODE') THEN
       NNODE(NSYS)=NNODE(NSYS)+1
       WRITE(INTU1,*) RECORD1(9:16)
       READ(INTU1,*) LBNODE(NNODE(NSYS),NSYS)
       WRITE(INTU1,*) RECORD1(17:24)
       READ(INTU1,*) FTILT(NNODE(NSYS),NSYS)
       WRITE(INTU1,*) RECORD1(25:32)
       READ(INTU1,*) FLGTHA(NNODE(NSYS),NSYS)
       WRITE(INTU1,*) RECORD1(33:40)
       READ(INTU1,*) FLGTHB(NNODE(NSYS),NSYS)
       WRITE(INTU1,*) RECORD1(41:48)
       READ(INTU1,*) FLCOMP(NNODE(NSYS),NSYS)
       GOTO 10
       ENDIF
C
       IF(RECORD1(1:7).EQ.'AXGROUP') THEN
       NASYS=NASYS+1
       WRITE(INTU1,*) RECORD1(9:16)
       READ(INTU1,*) LBASYS(NASYS)
       GOTO 10
       ENDIF
C
       IF(RECORD1(1:6).EQ.'AXNODE') THEN
       NANODE(NASYS)=NANODE(NASYS)+1
       WRITE(INTU1,*) RECORD1(9:16)
       READ(INTU1,*) LBANODE(NANODE(NASYS),NASYS)
       WRITE(INTU1,*) RECORD1(17:24)
       READ(INTU1,*) FCOMP(NANODE(NASYS),NASYS)
       GOTO 10
       ENDIF
C
      GOTO 10
```

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9000  CONTINUE
      WRITE(30,'(A65)') '$'//TITLENAME
      GOTO 9999
9010  WRITE(6,*)'ERROR: input file name F10, ',F10
9020  WRITE(6,*)'ERROR: input file name F30, ',F30
9999  RETURN
      END
C
      SUBROUTINE OLDNODE(LBOLDNODE)
C  This routine determines the label number of the first node to be
C  added to an existing element.  The purpose is to prevent repeating of
C  an existing node number.
      IMPLICIT INTEGER (A-Z)
      CHARACTER*80 RECORD1,INTU1
      REWIND (10)
      HIGHVAL=0
10    READ(10,'(A80)',END=20) RECORD1
       IF(RECORD1(1:4).EQ.'GRID') THEN
       WRITE(INTU1,*) RECORD1(9:16)
       READ(INTU1,*) IVAL
        IF(IVAL.GT.HIGHVAL) THEN
        HIGHVAL=IVAL
        ENDIF
       ENDIF
      GOTO 10
20    LBOLDNODE=HIGHVAL
9000  GOTO 9999
9999  RETURN
      END
C
      SUBROUTINE OLDELEM(LBOLDELEM)
C  This routine determines the label number of the first node to be
C  added to an existing element.  The purpose is to prevent repeating of
C  an existing node number.
      IMPLICIT INTEGER (A-Z)
      CHARACTER*80 RECORD1,INTU1
      REWIND (10)
      HIGHVAL=0
10    READ(10,'(A80)',END=20) RECORD1
       IF(RECORD1(1:5).EQ.'CHEXA'.OR.RECORD1(1:6).EQ.'CPENTA') THEN
       WRITE(INTU1,*) RECORD1(9:16)
       READ(INTU1,*) IVAL
        IF(IVAL.GT.HIGHVAL) THEN
        HIGHVAL=IVAL
        ENDIF
       ENDIF
      GOTO 10
20    LBOLDELEM=HIGHVAL
9000  GOTO 9999
9999  RETURN
      END
C
      SUBROUTINE FBASE(LBNODE,NNODE,NSYS,DNODE,DSYS,LBFBASE,LBELEM,
     &NFBASE,DFBASE)
C  FBASE (First BASE) searches for elements attached to the support
C  nodes and searches for the node at the "first base" location relative
C  to the support node.  The support nodes must be located at corner of
C  the attached elements.
C
C  This subroutine supports CHEXA and CPENTA NASTRAN elements only.
C  More element types can be added.
C
      IMPLICIT INTEGER (A-Z)
      CHARACTER*80 F20,RECORD1,RECORD2,INTU1
      CHARACTER CONT*7
      DIMENSION LBNODE(DNODE,DSYS),NNODE(DSYS),
     &LBFBASE(DFBASE,DNODE,DSYS),LBELEM(DFBASE,DNODE,DSYS),
     &NFBASE(DNODE,DSYS)
       DO 990 I=1,NSYS
        DO 980 J=1,NNODE(I)
        REWIND (10)
        NFBASE(J,I)=0
10      READ(10,'(A80)',END=970) RECORD1
C***********************************************************************
C CHEXA elements:
C***********************************************************************
         IF(RECORD1(1:5).EQ.'CHEXA') THEN
         WRITE(INTU1,'(A80)') RECORD1
         READ(INTU1,'(8X,I8,8X,6I8,1X,A7)') EID,G1,G2,G3,G4,G5,G6,CONT
C COUNT1 is number of records read in searching for continuation card.
         COUNT1=0
C COUNT2 is number of end-of-files reached during search.
         COUNT2=0
20       READ(10,'(A80)',END=30) RECORD2
         COUNT1=COUNT1+1
          IF(RECORD2(1:8).EQ.'+'//CONT) THEN
          WRITE(INTU1,'(A80)') RECORD2
          READ(INTU1,'(8X,2I8)') G7,G8
           IF(COUNT1.GT.1) THEN
C  Set pointer back to the last CHEXA card.
           REWIND (10)
25         READ(10,'(A80)') RECORD2
           IF(RECORD2.EQ.RECORD1) GOTO 40
           GOTO 25
           ENDIF
          GOTO 40
          ENDIF
27       GOTO 20
30       COUNT2=COUNT2+1
          IF(COUNT2.GT.1) THEN
          WRITE(6,*) 'ERROR: missing NASTRAN CHEXA continuation card.'
          STOP
          ENDIF
         REWIND (10)
         GOTO 27
C  If support node is a CHEXA G1 GRID, "first base" is the G2 GRID:
40        IF(LBNODE(J,I).EQ.G1) THEN
          NFBASE(J,I)=NFBASE(J,I)+1
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          LBFBASE(NFBASE(J,I),J,I)=G2
          LBELEM(NFBASE(J,I),J,I)=EID
          GOTO 10
          ENDIF
C  If support node is a CHEXA G2 GRID, "first base" is the G3 GRID:
          IF(LBNODE(J,I).EQ.G2) THEN
          NFBASE(J,I)=NFBASE(J,I)+1
          LBFBASE(NFBASE(J,I),J,I)=G3
          LBELEM(NFBASE(J,I),J,I)=EID
          GOTO 10
          ENDIF
C  If support node is a CHEXA G3 GRID, "first base" is the G4 GRID:
          IF(LBNODE(J,I).EQ.G3) THEN
          NFBASE(J,I)=NFBASE(J,I)+1
          LBFBASE(NFBASE(J,I),J,I)=G4
          LBELEM(NFBASE(J,I),J,I)=EID
          GOTO 10
          ENDIF
C  If support node is a CHEXA G4 GRID, "first base" is the G1 GRID:
          IF(LBNODE(J,I).EQ.G4) THEN
          NFBASE(J,I)=NFBASE(J,I)+1
          LBFBASE(NFBASE(J,I),J,I)=G1
          LBELEM(NFBASE(J,I),J,I)=EID
          GOTO 10
          ENDIF
C  If support node is a CHEXA G5 GRID, "first base" is the G8 GRID:
          IF(LBNODE(J,I).EQ.G5) THEN
          NFBASE(J,I)=NFBASE(J,I)+1
          LBFBASE(NFBASE(J,I),J,I)=G8
          LBELEM(NFBASE(J,I),J,I)=EID
          GOTO 10
          ENDIF
C  If support node is a CHEXA G6 GRID, "first base" is the G5 GRID:
          IF(LBNODE(J,I).EQ.G6) THEN
          NFBASE(J,I)=NFBASE(J,I)+1
          LBFBASE(NFBASE(J,I),J,I)=G5
          LBELEM(NFBASE(J,I),J,I)=EID
          GOTO 10
          ENDIF
C  If support node is a CHEXA G7 GRID, "first base" is the G6 GRID:
          IF(LBNODE(J,I).EQ.G7) THEN
          NFBASE(J,I)=NFBASE(J,I)+1
          LBFBASE(NFBASE(J,I),J,I)=G6
          LBELEM(NFBASE(J,I),J,I)=EID
          GOTO 10
          ENDIF
C  If support node is a CHEXA G8 GRID, "first base" is the G7 GRID:
          IF(LBNODE(J,I).EQ.G8) THEN
          NFBASE(J,I)=NFBASE(J,I)+1
          LBFBASE(NFBASE(J,I),J,I)=G7
          LBELEM(NFBASE(J,I),J,I)=EID
          GOTO 10
          ENDIF
         ENDIF
C
C*********************************************************************
C CPENTA elements:
C*********************************************************************
         IF(RECORD1(1:6).EQ.'CPENTA') THEN
         WRITE(INTU1,'(A80)') RECORD1
         READ(INTU1,'(8X,I8,8X,6I8)') EID,G1,G2,G3,G4,G5,G6
C  If support node is a CPENTA G1 GRID, "first base" is the G2 GRID:
          IF(LBNODE(J,I).EQ.G1) THEN
          NFBASE(J,I)=NFBASE(J,I)+1
          LBFBASE(NFBASE(J,I),J,I)=G2
          LBELEM(NFBASE(J,I),J,I)=EID
          GOTO 10
          ENDIF
C  If support node is a CPENTA G2 GRID, "first base" is the G3 GRID:
          IF(LBNODE(J,I).EQ.G2) THEN
          NFBASE(J,I)=NFBASE(J,I)+1
          LBFBASE(NFBASE(J,I),J,I)=G3
          LBELEM(NFBASE(J,I),J,I)=EID
          GOTO 10
          ENDIF
C  If support node is a CPENTA G3 GRID, "first base" is the G1 GRID:
          IF(LBNODE(J,I).EQ.G3) THEN
          NFBASE(J,I)=NFBASE(J,I)+1
          LBFBASE(NFBASE(J,I),J,I)=G1
          LBELEM(NFBASE(J,I),J,I)=EID
          GOTO 10
          ENDIF
C  If support node is a CPENTA G4 GRID, "first base" is the G6 GRID:
          IF(LBNODE(J,I).EQ.G4) THEN
          NFBASE(J,I)=NFBASE(J,I)+1
          LBFBASE(NFBASE(J,I),J,I)=G6
          LBELEM(NFBASE(J,I),J,I)=EID
          GOTO 10
          ENDIF
C  If support node is a CPENTA G5 GRID, "first base" is the G4 GRID:
          IF(LBNODE(J,I).EQ.G5) THEN
          NFBASE(J,I)=NFBASE(J,I)+1
          LBFBASE(NFBASE(J,I),J,I)=G4
          LBELEM(NFBASE(J,I),J,I)=EID
          GOTO 10
          ENDIF
C  If support node is a CPENTA G6 GRID, "first base" is the G5 GRID:
          IF(LBNODE(J,I).EQ.G6) THEN
          NFBASE(J,I)=NFBASE(J,I)+1
          LBFBASE(NFBASE(J,I),J,I)=G5
          LBELEM(NFBASE(J,I),J,I)=EID
          GOTO 10
          ENDIF
         ENDIF
        GOTO 10
970     CONTINUE
980     CONTINUE
990    CONTINUE
```

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9999  RETURN
      END
C
      SUBROUTINE REWRITE(LBELEM,NFBASE,NNODE,NSYS,DFBASE,DNODE,DSYS)
C  ELCOMO (ELement COnnectivity MOdification) adds the newnodes to the
C  elements connected to the support point.
      IMPLICIT INTEGER (A-Z)
      CHARACTER CONT*7
      CHARACTER*80 RECORD1,RECORD2,INTU1
      DIMENSION NNODE(DSYS),NFBASE(DNODE,DSYS),LBELEM(DFBASE,DNODE,DSYS)
      REWIND (10)
      REWIND (30)
10    READ(10,'(A80)',END=9000) RECORD1
      IF(RECORD1(1:3).EQ.'END') GOTO 9000
C
       IF(RECORD1(1:1).EQ.'+') THEN
       CONT=RECORD1(2:8)
       IVAL2=0
       REWIND (10)
20     READ(10,'(A80)',END=30) RECORD2
        IF(RECORD2(74:80).EQ.CONT) THEN
         IF(RECORD2(1:5).EQ.'CHEXA'.OR.RECORD2(1:6).EQ.'CPENTA') THEN
         WRITE(INTU1,*) RECORD2(9:16)
         READ(INTU1,*) IVAL1
          DO I=1,NSYS
           DO J=1,NNODE(I)
            DO K=1,NFBASE(J,I)
             IF(LBELEM(K,J,I).EQ.IVAL1) THEN
             IVAL2=1
             GOTO 30
             ENDIF
            ENDDO
           ENDDO
          ENDDO
         ENDIF
        ENDIF
       GOTO 20
C Set pointer back
30     REWIND (10)
40     READ(10,'(A80)') RECORD2
        IF(RECORD2.EQ.RECORD1) THEN
        IF(IVAL2.EQ.1) GOTO 10
        GOTO 90
        ENDIF
       GOTO 40
       ENDIF
C
       IF(RECORD1(1:5).EQ.'CHEXA'.OR.RECORD1(1:6).EQ.'CPENTA') THEN
        WRITE(INTU1,*) RECORD1(9:16)
        READ(INTU1,*) IVAL1
        DO I=1,NSYS
         DO J=1,NNODE(I)
          DO K=1,NFBASE(J,I)
          IF(LBELEM(K,J,I).EQ.IVAL1) GOTO 10
          ENDDO
         ENDDO
        ENDDO
       ENDIF
90    WRITE(30,'(A80)') RECORD1
      GOTO 10
9000  GOTO 9999
9999  RETURN
      END
C
      SUBROUTINE NEWNODE(LBOLDNODE,LBNEWNODE,NNEWNODE,DNEWNODE,
     &LBFBASE,NFBASE,DFBASE,LBNODE,NNODE,DNODE,NSYS,DSYS,TILT,FTILT,
     &EDGE,X1FBASE,X2FBASE,X3FBASE,LGTHA,FLGTHA,LGTHB,FLGTHB,APEN)
C  NEWNODE generates the nodes forming the rigid elements which
C  represent the support units.
      IMPLICIT INTEGER (A-Z)
      REAL TILT,FTILT,X1,X2,X3,X1NODE,X2NODE,X3NODE,X1FBASE,X2FBASE,
     &X3FBASE,X1NEW,X2NEW,X3NEW,EDGE,LGTHA,FLGTHA,LGTHB,FLGTHB,APEN
      CHARACTER*80 RECORD1,INTU1
      DIMENSION LBNODE(DNODE,DSYS),NNODE(DSYS),TILT(DSYS),
     &FTILT(DNODE,DSYS),LBFBASE(DFBASE,DNODE,DSYS),
     &NFBASE(DNODE,DSYS),LBNEWNODE(DNEWNODE,DNODE,DSYS),
     &NNEWNODE(DNODE,DSYS),X1FBASE(DFBASE),X2FBASE(DFBASE),
     &X3FBASE(DFBASE),FLGTHA(DNODE,DSYS),FLGTHB(DNODE,DSYS)
      IVAL1=LBOLDNODE
       DO 490 I=1,NSYS
        DO 480 J=1,NNODE(I)
        FILL1=0
        FILL2=0
        REWIND (10)
C  Determine the coordinates of the support and "first base" nodes:
10        READ(10,'(A80)',END=9010) RECORD1
          IF(RECORD1(1:4).EQ.'GRID') THEN
          WRITE(INTU1,'(A80)') RECORD1
          READ(INTU1,'(8X,I8,8X,3F8.3)') ID,X1,X2,X3
           IF(ID.EQ.LBNODE(J,I)) THEN
           FILL1=1
           X1NODE=X1
           X2NODE=X2
           X3NODE=X3
           GOTO 10
           ENDIF
            DO K=1,NFBASE(J,I)
             IF(ID.EQ.LBFBASE(K,J,I)) THEN
             FILL2=FILL2+1
             X1FBASE(K)=X1
             X2FBASE(K)=X2
             X3FBASE(K)=X3
             GOTO 30
             ENDIF
            END DO
30        IF(FILL1.EQ.1.AND.FILL2.EQ.NFBASE(J,I)) GOTO 470
          GOTO 10
470     CONTINUE
```

```
C  Generate the newnodes:
         COUNT=0
C Base nodes
         IVAL1=IVAL1+1
         LBNEWNODE(1,J,I)=IVAL1
         X1NEW=X1NODE
         X2NEW=X2NODE-(FLGTHA(J,I)*LGTHA-APEN)
         X3NEW=X3NODE
         COUNT=COUNT+1
         WRITE(30,300) LBNEWNODE(1,J,I),X1NEW,X2NEW,X3NEW
         IVAL1=IVAL1+1
         LBNEWNODE(2,J,I)=IVAL1
         X1NEW=X1NODE-(.5*FLGTHB(J,I)*LGTHB*SIND(FTILT(J,I)*TILT(I)))
         X3NEW=X3NODE-(.5*FLGTHB(J,I)*LGTHB*COSD(FTILT(J,I)*TILT(I)))
         COUNT=COUNT+1
         WRITE(30,300) LBNEWNODE(2,J,I),X1NEW,X2NEW,X3NEW
         IVAL1=IVAL1+1
         LBNEWNODE(3,J,I)=IVAL1
         X1NEW=X1NODE+(.5*FLGTHB(J,I)*LGTHB*SIND(FTILT(J,I)*TILT(I)))
         X3NEW=X3NODE+(.5*FLGTHB(J,I)*LGTHB*COSD(FTILT(J,I)*TILT(I)))
         COUNT=COUNT+1
         WRITE(30,300) LBNEWNODE(3,J,I),X1NEW,X2NEW,X3NEW
C  Edge nodes
          DO K=1,NFBASE(J,I)
          IVAL1=IVAL1+1
          LBNEWNODE(K+3,J,I)=IVAL1
          X1NEW=EDGE*(X1FBASE(K)-X1NODE)+X1NODE
          X2NEW=EDGE*(X2FBASE(K)-X2NODE)+X2NODE
          X3NEW=EDGE*(X3FBASE(K)-X3NODE)+X3NODE
          COUNT=COUNT+1
          WRITE(30,300) LBNEWNODE(K+3,J,I),X1NEW,X2NEW,X3NEW
300       FORMAT('GRID     ',I8,8X,3F8.2)
          END DO
         NNEWNODE(J,I)=COUNT
         GOTO 480
         ENDIF
        GOTO 10
480     CONTINUE
490    CONTINUE
9000  GOTO 9999
9010  WRITE(6,*) 'ERROR:  node',LBNODE(J,I),'not found.'
9999  RETURN
      END
C
      SUBROUTINE ELCOMO(LBNEWNODE,NNEWNODE,DNEWNODE,LBFBASE,NFBASE,
     &DFBASE,LBELEM,LBNODE,NNODE,DNODE,NSYS,DSYS)
C  ELCOMO (ELement COnnectivity MOdification) adds the newnodes to the
C  elements connected to the support point.
      IMPLICIT INTEGER (A-Z)
      CHARACTER CONT*7
      CHARACTER*80 RECORD1,RECORD2,INTU1
      DIMENSION LBNODE(DNODE,DSYS),NNODE(DSYS),
     &LBFBASE(DFBASE,DNODE,DSYS),NFBASE(DNODE,DSYS),
     &LBNEWNODE(DNEWNODE,DNODE,DSYS),NNEWNODE(DNODE,DSYS),
     &LBELEM(DFBASE,DNODE,DSYS)
       DO 500 I=1,NSYS
        DO 450 J=1,NNODE(I)
         DO 400 K=1,NFBASE(J,I)
         REWIND (10)
10       READ(10,'(A80)') RECORD1
C*********************************************************************
C CHEXA elements:
C*********************************************************************
          IF(RECORD1(1:5).EQ.'CHEXA') THEN
          WRITE(INTU1,'(A80)') RECORD1
          READ(INTU1,'(8X,I8,8X,6I8,1X,A7)') EID,G1,G2,G3,G4,G5,G6,CONT
          IF(EID.NE.LBELEM(K,J,I)) GOTO 10
C COUNT2 is number of end-of-files reached during search.
          COUNT2=0
20        READ(10,'(A80)',END=30) RECORD2
           IF(RECORD2(1:8).EQ.'+'//CONT) THEN
           WRITE(INTU1,'(A80)') RECORD2
           READ(INTU1,'(8X,2I8)') G7,G8
           GOTO 40
           ENDIF
27        GOTO 20
30        COUNT2=COUNT2+1
           IF(COUNT2.GT.1) THEN
           WRITE(6,*) 'ERROR: missing NASTRAN CHEXA continuation card.'
           STOP
           ENDIF
          REWIND (10)
          GOTO 27
40        CONTINUE
C  If support node is a CHEXA G1 GRID, the "first base" side edge node
C  is the G9 GRID, and the "third base" side edge node is the G12 GRID:
           IF(LBNODE(J,I).EQ.G1) THEN
           G9=LBNEWNODE(K+3,J,I)
            DO L=1,NFBASE(J,I)
             IF(G4.EQ.LBFBASE(L,J,I)) THEN
             G12=LBNEWNODE(L+3,J,I)
             GOTO 110
             ENDIF
            ENDDO
110        WRITE(30,'(A80)') RECORD1
           WRITE(30,1020) '+'//CONT,G7,G8,G9,0,0,G12
           GOTO 390
           ENDIF
C  If support node is a CHEXA G2 GRID, the "first base" side edge node
C  is the G10 GRID, and the "third base" side edge node is the G9 GRID:
           IF(LBNODE(J,I).EQ.G2) THEN
           G10=LBNEWNODE(K+3,J,I)
            DO L=1,NFBASE(J,I)
             IF(G1.EQ.LBFBASE(L,J,I)) THEN
             G9=LBNEWNODE(L+3,J,I)
             GOTO 120
             ENDIF
            ENDDO
```

```
120         WRITE(30,'(A80)') RECORD1
            WRITE(30,1020)  '+'//CONT,G7,G8,G9,G10
            GOTO 390
            ENDIF
C  If support node is a CHEXA G3 GRID, the "first base" side edge node
C  is the G11 GRID, and the "third base" side edge node is the G10 GRID:
            IF(LBNODE(J,I).EQ.G3) THEN
            G11=LBNEWNODE(K+3,J,I)
             DO L=1,NFBASE(J,I)
              IF(G2.EQ.LBFBASE(L,J,I)) THEN
              G10=LBNEWNODE(L+3,J,I)
              GOTO 130
              ENDIF
             ENDDO
130         WRITE(30,'(A80)') RECORD1
            WRITE(30,1020)  '+'//CONT,G7,G8,0,G10,G11
            GOTO 390
            ENDIF
C  If support node is a CHEXA G4 GRID, the "first base" side edge node
C  is the G12 GRID, and the "third base" side edge node is the G11 GRID:
            IF(LBNODE(J,I).EQ.G4) THEN
            G12=LBNEWNODE(K+3,J,I)
             DO L=1,NFBASE(J,I)
              IF(G3.EQ.LBFBASE(L,J,I)) THEN
              G11=LBNEWNODE(L+3,J,I)
              GOTO 140
              ENDIF
             ENDDO
140         WRITE(30,'(A80)') RECORD1
            WRITE(30,1020)  '+'//CONT,G7,G8,0,0,G11,G12
            GOTO 390
            ENDIF
C  If support node is a CHEXA G5 GRID, the "first base" side edge node
C  is the G20 GRID, and the "third base" side edge node is the G17 GRID:
            IF(LBNODE(J,I).EQ.G5) THEN
            G20=LBNEWNODE(K+3,J,I)
             DO L=1,NFBASE(J,I)
              IF(G6.EQ.LBFBASE(L,J,I)) THEN
              G17=LBNEWNODE(L+3,J,I)
              GOTO 150
              ENDIF
             ENDDO
150         WRITE(30,'(A80)') RECORD1
            WRITE(30,1020)  '+'//CONT,G7,G8,0,0,0,0,0,0,'+E',EID,'B'
            WRITE(30,1030)  '+E',EID,'B',0,0,G17,0,0,G20
            GOTO 390
            ENDIF
C  If support node is a CHEXA G6 GRID, the "first base" side edge node
C  is the G17 GRID, and the "third base" side edge node is the G18 GRID:
            IF(LBNODE(J,I).EQ.G6) THEN
            G17=LBNEWNODE(K+3,J,I)
             DO L=1,NFBASE(J,I)
              IF(G7.EQ.LBFBASE(L,J,I)) THEN
              G18=LBNEWNODE(L+3,J,I)
              GOTO 160
              ENDIF
             ENDDO
160         WRITE(30,'(A80)') RECORD1
            WRITE(30,1020)  '+'//CONT,G7,G8,0,0,0,0,0,0,'+E',EID,'B'
            WRITE(30,1030)  '+E',EID,'B',0,0,G17,G18
            GOTO 390
            ENDIF
C  If support node is a CHEXA G7 GRID, the "first base" side edge node
C  is the G18 GRID, and the "third base" side edge node is the G19 GRID:
            IF(LBNODE(J,I).EQ.G7) THEN
            G18=LBNEWNODE(K+3,J,I)
             DO L=1,NFBASE(J,I)
              IF(G8.EQ.LBFBASE(L,J,I)) THEN
              G19=LBNEWNODE(L+3,J,I)
              GOTO 170
              ENDIF
             ENDDO
170         WRITE(30,'(A80)') RECORD1
            WRITE(30,1020)  '+'//CONT,G7,G8,0,0,0,0,0,0,'+E',EID,'B'
            WRITE(30,1030)  '+E',EID,'B',0,0,0,G18,G19
            GOTO 390
            ENDIF
C  If support node is a CHEXA G8 GRID, the "first base" side edge node
C  is the G19 GRID, and the "third base" side edge node is the G20 GRID:
            IF(LBNODE(J,I).EQ.G8) THEN
            G19=LBNEWNODE(K+3,J,I)
             DO L=1,NFBASE(J,I)
              IF(G5.EQ.LBFBASE(L,J,I)) THEN
              G20=LBNEWNODE(L+3,J,I)
              GOTO 180
              ENDIF
             ENDDO
180         WRITE(30,'(A80)') RECORD1
            WRITE(30,1020)  '+'//CONT,G7,G8,0,0,0,0,0,0,'+E',EID,'B'
            WRITE(30,1030)  '+E',EID,'B',0,0,0,0,G19,G20
            GOTO 390
            ENDIF
           ENDIF
C
C*********************************************************************
C CPENTA elements:
C*********************************************************************
           IF(RECORD1(1:6).EQ.'CPENTA') THEN
           WRITE(INTU1,'(A80)') RECORD1
           READ(INTU1,'(8X,I8,8X,6I8,1X,A7)') EID,G1,G2,G3,G4,G5,G6,CONT
           IF(EID.NE.LBELEM(K,J,I)) GOTO 10
C  If support node is a CPENTA G1 GRID, the "first base" side edge node
C  is the G7 GRID, and the "third base" side edge node is the G9 GRID:
            IF(LBNODE(J,I).EQ.G1) THEN
            G7=LBNEWNODE(K+3,J,I)
             DO L=1,NFBASE(J,I)
              IF(G3.EQ.LBFBASE(L,J,I)) THEN
              G9=LBNEWNODE(L+3,J,I)
```

```
            GOTO 190
            ENDIF
           ENDDO
190       WRITE(30,1010) RECORD1(1:72)//'+E',EID,'A'
          WRITE(30,1030) '+E',EID,'A',G7,0,G9
          GOTO 390
          ENDIF
C  If support node is a CPENTA G2 GRID, the "first base" side edge node
C  is the G8 GRID, and the "third base" side edge node is the G7 GRID:
          IF(LBNODE(J,I).EQ.G2) THEN
          G8=LBNEWNODE(K+3,J,I)
           DO L=1,NFBASE(J,I)
            IF(G1.EQ.LBFBASE(L,J,I)) THEN
            G7=LBNEWNODE(L+3,J,I)
            GOTO 200
            ENDIF
           ENDDO
200       WRITE(30,1010) RECORD1(1:72)//'+E',EID,'A'
          WRITE(30,1030) '+E',EID,'A',G7,G8
          GOTO 390
          ENDIF
C  If support node is a CPENTA G3 GRID, the "first base" side edge node
C  is the G9 GRID, and the "third base" side edge node is the G8 GRID:
          IF(LBNODE(J,I).EQ.G3) THEN
          G9=LBNEWNODE(K+3,J,I)
           DO L=1,NFBASE(J,I)
            IF(G2.EQ.LBFBASE(L,J,I)) THEN
            G8=LBNEWNODE(L+3,J,I)
            GOTO 210
            ENDIF
           ENDDO
210       WRITE(30,1010) RECORD1(1:72)//'+E',EID,'A'
          WRITE(30,1030) '+E',EID,'A',0,G8,G9
          GOTO 390
          ENDIF
C  If support node is a CPENTA G4 GRID, the "first base" side edge node
C  is the G15 GRID, and the "third base" side edge node is the G13 GRID:
          IF(LBNODE(J,I).EQ.G4) THEN
          G15=LBNEWNODE(K+3,J,I)
           DO L=1,NFBASE(J,I)
            IF(G5.EQ.LBFBASE(L,J,I)) THEN
            G13=LBNEWNODE(L+3,J,I)
            GOTO 220
            ENDIF
           ENDDO
220       WRITE(30,1010) RECORD1(1:72)//'+E',EID,'A'
          WRITE(30,1030) '+E',EID,'A',0,0,0,0,0,0,G13,0,'+E',EID,'B'
          WRITE(30,1030) '+E',EID,'B',G15
          GOTO 390
          ENDIF
C  If support node is a CPENTA G5 GRID, the "first base" side edge node
C  is the G13 GRID, and the "third base" side edge node is the G14 GRID:
          IF(LBNODE(J,I).EQ.G5) THEN
          G13=LBNEWNODE(K+3,J,I)
           DO L=1,NFBASE(J,I)
            IF(G6.EQ.LBFBASE(L,J,I)) THEN
            G14=LBNEWNODE(L+3,J,I)
            GOTO 230
            ENDIF
           ENDDO
230       WRITE(30,1010) RECORD1(1:72)//'+E',EID,'A'
          WRITE(30,1030) '+E',EID,'A',0,0,0,0,0,0,G13,G14
          GOTO 390
          ENDIF
C  If support node is a CPENTA G6 GRID, the "first base" side edge node
C  is the G14 GRID, and the "third base" side edge node is the G15 GRID:
          IF(LBNODE(J,I).EQ.G6) THEN
          G14=LBNEWNODE(K+3,J,I)
           DO L=1,NFBASE(J,I)
            IF(G4.EQ.LBFBASE(L,J,I)) THEN
            G15=LBNEWNODE(L+3,J,I)
            GOTO 240
            ENDIF
           ENDDO
240       WRITE(30,1010) RECORD1(1:72)//'+E',EID,'A'
          WRITE(30,1030) '+E',EID,'A',0,0,0,0,0,0,0,G14,'+E',EID,'B'
          WRITE(30,1030) '+E',EID,'B',G15
          GOTO 390
          ENDIF
         ENDIF
        GOTO 10
1010     FORMAT(A74,I5,A1)
1020     FORMAT(A8,8I8,A2,I5,A1)
1030     FORMAT(A2,I5,A1,8I8,A2,I5,A1)
390      CONTINUE
400      CONTINUE
450     CONTINUE
500    CONTINUE
9999  RETURN
      END
C
      SUBROUTINE RIBOEL(LBOLDELEM,LBNEWNODE,NNEWNODE,DNEWNODE,
     &NNODE,DNODE,NSYS,DSYS)
C RIBOEL(RIgid BOdy ELement) generates RBE1 elements representing mirror
C support units using the new nodes generated by the NEWNODE subroutine.
      IMPLICIT INTEGER (A-Z)
      DIMENSION LBNEWNODE(DNEWNODE,DNODE,DSYS),NNEWNODE(DNODE,DSYS),
     &NNODE(DSYS)
      LBRBE=LBOLDELEM
       DO 500 I=1,NSYS
        DO 450 J=1,NNODE(I)
        LBRBE=LBRBE+1
        WRITE(30,1010) 'RBE1',LBRBE,LBNEWNODE(1,J,I),13,
     &  LBNEWNODE(2,J,I),2,LBNEWNODE(3,J,I),2,'+E',LBRBE,'A'
        WRITE(30,1020) '+E',LBRBE,'A',LBNEWNODE(4,J,I),1,
     &  LBNEWNODE(5,J,I),1,'+E',LBRBE,'B'
        WRITE(30,1030) '+E',LBRBE,'B','UM',LBNEWNODE(1,J,I),2,
     &  LBNEWNODE(2,J,I),13,LBNEWNODE(3,J,I),13,'+E',LBRBE,'C'
```

```
        WRITE(30,1040) '+E',LBRBE,'C',LBNEWNODE(4,J,I),23,
     &  LBNEWNODE(5,J,I),23,LBNEWNODE(6,J,I),123,'+E',LBRBE,'D'
C
         IF(NNEWNODE(J,I).EQ.7) THEN
         WRITE(30,1050) '+E',LBRBE,'D',LBNEWNODE(7,J,I),123
         ENDIF
C
         IF(NNEWNODE(J,I).EQ.8) THEN
         WRITE(30,1050) '+E',LBRBE,'D',LBNEWNODE(7,J,I),123,
     &   LBNEWNODE(8,J,I),123
         ENDIF
C
         IF(NNEWNODE(J,I).EQ.9) THEN
         WRITE(30,1050) '+E',LBRBE,'D',LBNEWNODE(7,J,I),123,
     &   LBNEWNODE(8,J,I),123,LBNEWNODE(9,J,I),123
         ENDIF
C
450      CONTINUE
500     CONTINUE
1010  FORMAT(A4,4X,7I8,8X,A2,I5,A1)
1020  FORMAT(A2,I5,A1,8X,4I8,24X,A2,I5,A1)
1030  FORMAT(A2,I5,A1,6X,A2,6I8,8X,A2,I5,A1)
1040  FORMAT(A2,I5,A1,8X,6I8,8X,A2,I5,A1)
1050  FORMAT(A2,I5,A1,8X,6I8)
      RETURN
      END
C
      SUBROUTINE MPCLAT(TILT,FTILT,FLCOMP,LBNEWNODE,NNEWNODE,DNEWNODE,
     &NNODE,DNODE,LBSYS,NSYS,DSYS,ISID,ICONT)
C  MPCLAT GENERATES the Multipoint Constraint equations for the lateral
C  support system.
      IMPLICIT INTEGER (A-Z)
      REAL RVAL1,RVAL2,RVAL3,RVAL4,TILT,FTILT,FLCOMP
      DIMENSION NNODE(DSYS),LBNEWNODE(DNEWNODE,DNODE,DSYS),
     &NNEWNODE(DNODE,DSYS),LBSYS(DSYS),FTILT(DNODE,DSYS),TILT(DSYS),
     &FLCOMP(DNODE,DSYS)
      WRITE(30,'(A28)') '$LATERAL SUPPORT CONSTRAINTS'
      ICONT=0
      ISID=0
       DO I=1,NSYS
       WRITE(30,'(A23,I3)') '$LATERAL SUPPORT SYSTEM',LBSYS(I)
       ISID=ISID+1
        DO J=1,NNODE(I)
        RVAL1=FLCOMP(J,I)
        RVAL2=TAND(FTILT(J,I)*TILT(I)*FLCOMP(J,I))
        RVAL3=(RVAL1**2.+RVAL2**2.)**.5
        RVAL4=-RVAL3
         IF(J.EQ.1) THEN
         WRITE(30,1010) 'MPC',I,LBNEWNODE(1,J,I),3,RVAL1,
     &   LBNEWNODE(1,J,I),1,RVAL2,'+MPC',ICONT+1
         GOTO 10
         ENDIF
        ICONT=ICONT+1
        WRITE(30,1020) '+MPC',ICONT,LBNEWNODE(1,J,I),3,RVAL1,
     &  LBNEWNODE(1,J,I),1,RVAL2,'+MPC',ICONT+1
10      CONTINUE
        ICONT=ICONT+1
         IF(J.EQ.NNODE(I)) THEN
         WRITE(30,1020) '+MPC',ICONT,LBNEWNODE(2,J,I),2,RVAL3,
     &   LBNEWNODE(3,J,I),2,RVAL4
         GOTO 20
         ENDIF
        WRITE(30,1020) '+MPC',ICONT,LBNEWNODE(2,J,I),2,RVAL3,
     &  LBNEWNODE(3,J,I),2,RVAL4,'+MPC',ICONT+1
20      CONTINUE
        ENDDO
       ENDDO
1010  FORMAT(A3,5X,I8,2(2I8,F8.5),8X,A4,I4)
1020  FORMAT(A4,I4,8X,2(2I8,F8.5),8X,A4,I4)
      RETURN
      END
C
      SUBROUTINE MPCAXIAL(FCOMP,LBANODE,NANODE,DANODE,LBASYS,NASYS,
     &DASYS,ISID,ICONT)
C  MPCAXIAL generates the Multipoint Constraint equations for the axial
C  support system.
      IMPLICIT INTEGER (A-Z)
      REAL RVAL1,RVAL2,FCOMP
      DIMENSION LBANODE(DANODE,DASYS),NANODE(DASYS),FCOMP(DANODE,DASYS),
     &LBASYS(DASYS)
      WRITE(30,'(A26)') '$AXIAL SUPPORT CONSTRAINTS'
       DO I=1,NASYS
       WRITE(30,'(A21,I3)') '$AXIAL SUPPORT SYSTEM',LBASYS(I)
        DO J=1,NANODE(I),2
        RVAL1=FCOMP(J,I)
        RVAL2=FCOMP(J+1,I)
         IF(J.EQ.1.AND.J+1.EQ.NANODE(I)) THEN
         WRITE(30,1010) 'MPC',I+ISID,LBANODE(J,I),2,RVAL1,
     &   LBANODE(J+1,I),2,RVAL2
         GOTO 10
         ENDIF
         IF(J.EQ.1) THEN
         WRITE(30,1010) 'MPC',I+ISID,LBANODE(J,I),2,RVAL1,
     &   LBANODE(J+1,I),2,RVAL2,'+MPC',ICONT+1
         GOTO 10
         ENDIF
         ICONT=ICONT+1
         IF(J.EQ.NANODE(I)) THEN
         WRITE(30,1020) '+MPC',ICONT,LBANODE(J,I),2,RVAL1
         GOTO 20
         ENDIF
         IF(J+1.EQ.NANODE(I)) THEN
         WRITE(30,1020) '+MPC',ICONT,LBANODE(J,I),2,RVAL1,
     &   LBANODE(J+1,I),2,RVAL2
         GOTO 10
         ENDIF
        WRITE(30,1020) '+MPC',ICONT,LBANODE(J,I),2,RVAL1,
     &  LBANODE(J+1,I),2,RVAL2,'+MPC',ICONT+1
```

```
10      CONTINUE
20      CONTINUE
        ENDDO
       ENDDO
1010  FORMAT(A3,5X,I8,2(2I8,F8.5),8X,A4,I4)
1020  FORMAT(A4,I4,8X,2(2I8,F8.5),8X,A4,I4)
      RETURN
      END
C
      SUBROUTINE MPCADD(NSYS,NASYS)
C  MPCADD writes the NASTRAN "MPCADD" card which conglomerates the MPC
C  cards to be included for the current model.
      IMPLICIT INTEGER (A-Z)
      NMPC=NSYS+NASYS
       IF(NMPC.LE.7) THEN
       WRITE(30,1010) 'MPCADD',1001,(I,I=1,NMPC)
       GOTO 9000
       ENDIF
C
      IMPC=0
      ICONT=0
      IMPC=IMPC+7
      WRITE(30,1010) 'MPCADD',1001,(I,I=1,IMPC),'+MPCA',ICONT+1
10    CONTINUE
      IMPC=IMPC+8
      ICONT=ICONT+1
       IF(NMPC.LE.IMPC) THEN
       WRITE(30,1020) '+MPCA',ICONT,(I,I=IMPC-7,NMPC)
       GOTO 9000
       ENDIF
      WRITE(30,1020) '+MPCA',ICONT,(I,I=IMPC-7,IMPC),'+MPCA',ICONT+1
      GOTO 10
1010  FORMAT(A6,2X,8I8,A5,I3)
1020  FORMAT(A5,I3,8I8,A5,I3)
9000  CONTINUE
      RETURN
      END
```

6.2 NASTRAN Input

```
ID SOFIA TA PRIMARY MIRROR MODEL
SOL 24
TIME 5.
$ RF24D81 FOR GPS; RF24D41 FOR SORT STRESS OUTPUT(REF NUMOUT OR BIGGER)
$ RF24D74 FOR INTERNAL RESEQUENCING(REF NEWSEQ)
$ RF24D24 FOR CONTRAINT FORCES FROM MPCS AND RBES
$ USE ONLY RF24D24 AND RF24D81
READ 9
$ OUTPUT: CONSTRAINT FORCES - OQG1
$         NODAL DISPLACEMENTS - OUGV1
$         ELEMENT STRESSES  - OES1
$         ELEMENT FORCES    - OEF1
$         GRID POINT STRESSES - OGS1
$
ALTER 176  $
$OUTPUT2    ,OUGV1,OES1,OEF1,OGS1//-1/11  $
OUTPUT2    ,OUGV1,OES1,,//-1/11  $
CEND
TITLE=STATIC MODEL
ECHO=SORT(MAT1,MAT2,MAT9,PARAM,PSOLID,PSHELL,SUPORT,SPC1,
  RBE2,RBE3,CELAS2,RBAR,LOAD,GRAV,FORCE)
SPCFORCES(SORT1)=ALL
DISPL(PLOT)=ALL
$ELSTRESS(PLOT)=ALL
GPSTRESS(PLOT)= ALL
SUBTITLE=FINE MESH, 64 SUPPORTS
$ X-AXIS PARALLEL TO A.B. SHAFT, ROLL AXIS OF THE AIRCRAFT
$ THE MIRROR IS TO BE TILT ABOUT X-AXIS
SUBCASE = 1
  LABEL =0 DEGREE ELEVATION, G1*SIN(0)  + G2*COS(0)
  SPC = 1
  MPC = 1001
  LOAD = 210
SUBCASE = 2
  LABEL =20 DEGREE ELEVATION, G1*SIN(20)  + G2*COS(20)
  SPC = 1
  MPC = 1001
  LOAD = 220
SUBCASE = 3
  LABEL =40 DEGREE ELEVATION, G1*SIN(40)  + G2*COS(40)
  SPC = 1
  MPC = 1001
  LOAD = 230
SUBCASE = 4
  LABEL =60 DEGREE ELEVATION, G1*SIN(60)  + G2*COS(60)
  SPC = 1
  MPC = 1001
  LOAD = 240
SUBCASE = 5
  LABEL =90 DEGREE EVEVATION, G1*SIN(90)  + G2*COS(90)
  SPC = 1
  MPC = 1001
  LOAD = 250
OUTPUT(PLOT)
```

```
CSCALE=4.0
PLOTTER NASTRAN
PAPER SIZE 105 X 80
SET 1 = ALL
AXES Z,X,Y
VIEW 0.,0.,0.
PTITLE= GEOM PLOT, XY VIEW
PLOT SET 1
AXES X,Z,Y
VIEW 0.,0.,0.
PTITLE= GEOM PLOT, ZY VIEW
PLOT SET 1
AXES Y,X,Z
VIEW 0.,0.,0.
PTITLE= GEOM PLOT, XZ VIEW
PLOT  SET 1
AXES Z,X,Y
VIEW 0.,0.,0.
MAXIMUM DEFORMATION 40
FIND SCALE, ORIGIN 1, SET 1
PTITLE= DEFORM PLOT, XY PLANE
PLOT STATIC 0, SET 1
OUTPUT(POST)
SET 1 = ALL
VOLUME 1 SET 1
$*********************************************************************
$*SOFIATA1 MODEL: SOFIA TA ASSEMBLY, SPC1 AT AB CELAS END POINTS      *
$*STATIC ANALYSIS - WTS VERIFICATION        (LSC/ARC  19 MAR, 1991)   *
$*********************************************************************
$
BEGIN BULK
$ USE KG/MM^3 FOR DENSITY, GEOM IN MM, AND FORCE IN NEWTON(KG*M/SEC^2)
PARAM,WTMASS,.001
PARAM,GRDPNT,0
PARAM,K6ROT,1.0
$PARAM, NEWSEQ, 3
$PARAM,NUMOUT,40
$PARAM,BIGER,20000.
PARAM,AUTOSPC,YES
GRDSET                                                          456
LOAD        210      1.       0.      310       1.      320
LOAD        220      1. .342020       310 .939693       320
LOAD        230      1. .642788       310 .766044       320
LOAD        240      1. .866025       310       .5      320
LOAD        250      1.       1.      310       0.      320
GRAV        310       0 9806.65       0.      -1.       0.
GRAV        320       0 9806.65       0.       0.      -1.
$ TITLE = FINE MESH MODEL, ALL SUPPORTS INCLUDED
$ DATA DECK PRODUCED BY PATNAS VERSION 2.2: 26-JUN-91 14:58:17
SPC1          1       1     110     452
GRID          1         170.000-917.699 0.
GRID          2         156.641-917.699-66.1717
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GRID          4         66.1717-917.699-156.641
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GRID          6         259.903-914.620 0.
GRID          7         239.478-914.620-101.166
GRID          8         183.779-914.620-183.779
GRID          9         101.166-914.620-239.478
GRID         10         0.      -914.620-259.903
GRID         11         349.710-910.256 0.
GRID         12         322.228-910.256-136.123
GRID         13         247.282-910.256-247.282
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GRID         15         0.      -910.256-349.710
GRID         16         170.000-977.699 0.
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GRID         36         165.990-888.882-602.096
GRID         37         0.      -888.882-624.400
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GRID         40         647.603-875.054-378.539
GRID         41         530.330-875.054-530.330
GRID         42         378.539-875.054-647.603
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OF POOR QUALITY

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+E     1       22      21
CHEXA           2       1       2       3       8       7      17      18+E     2
+E     2       23      22
CHEXA           3       1       3       4       9       8      18      19+E     3
+E     3       24      23
CHEXA           4       1       4       5      10       9      19      20+E     4
+E     4       25      24
CPENTA        186       1     127     133     132     140     146     145
CHEXA         216       1      41      42     174     176      55      56+E    63
+E    63      178     180
CHEXA         217       1      42      43     173     174      56      57+E    64
+E    64      177     178
CHEXA         218       1      43      44     175     173      57      58+E    65
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+E     65      179     177
CHEXA          224       1      38      39     181     183      52     53+E     71
+E     71      185     187
CHEXA          225       1      39      40     182     181      53     54+E     72
+E     72      186     185
CHEXA          226       1      40      41     184     182      54     55+E     73
+E     73      188     186
CHEXA          232       1     189     193     194     190     201    205+E     79
+E     79      206     202
CHEXA          233       1     190     194     195     191     202    206+E     80
+E     80      207     203
CHEXA          234       1     191     195     196     192     203    207+E     81
+E     81      208     204
CHEXA          235       1     192     196      10       5     204    208+E     82
+E     82       25      20
CPENTA         272       1     299     304     305     312     317    318
CHEXA          294       1     222     344     342     223     234    348+E    141
+E    141      346     235
CHEXA          295       1     223     342     341     224     235    346+E    142
+E    142      345     236
CHEXA          296       1     224     341     343      44     236    345+E    143
+E    143      347      58
CHEXA          302       1     219     351     349     220     231    355+E    149
+E    149      353     232
CHEXA          303       1     220     349     350     221     232    353+E    150
+E    150      354     233
CHEXA          304       1     221     350     352     222     233    354+E    151
+E    151      356     234
CHEXA          310       1       1       6     361     357      16     21+E    157
+E    157      373     369
CHEXA          311       1     357     361     362     358     369    373+E    158
+E    158      374     370
CHEXA          312       1     358     362     363     359     370    374+E    159
+E    159      375     371
CHEXA          313       1     359     363     364     360     371    375+E    160
+E    160      376     372
CPENTA         350       1     466     471     472     477     482    483
CHEXA          372       1     389     512     510     390     401    516+E    219
+E    219      514     402
CHEXA          373       1     390     510     509     391     402    514+E    220
+E    220      513     403
CHEXA          374       1     391     509     511     392     403    513+E    221
+E    221      515     404
CHEXA          380       1      38     519     517     387      52    523+E    227
+E    227      521     399
CHEXA          381       1     387     517     518     388     399    521+E    228
+E    228      522     400
CHEXA          382       1     388     518     520     389     400    522+E    229
+E    229      524     401
CHEXA          388       1     189     525     528     193     201    534+E    235
+E    235      537     205
CHEXA          389       1     525     526     529     528     534    535+E    236
+E    236      538     537
CHEXA          390       1     526     527     530     529     535    536+E    237
+E    237      539     538
CHEXA          391       1     527     360     364     530     536    372+E    238
+E    238      376     539
CPENTA         428       1     618     624     623     629     635    634
CHEXA          450       1     550     551     658     660     560    561+E    297
+E    297      662     664
CHEXA          451       1     551     552     657     658     561    562+E    298
+E    298      661     662
CHEXA          452       1     552     392     659     657     562    404+E    299
+E    299      663     661
CHEXA          458       1     219     548     665     667     231    558+E    305
+E    305      669     671
CHEXA          459       1     548     549     666     665     558    559+E    306
+E    306      670     669
CHEXA          460       1     549     550     668     666     559    560+E    307
+E    307      672     670
PSOLID           1      11
MAT1            11 90250.0 36391.1 0.24000 2.520-6 1.200-7 0.      0.      +M     1
+M     1  0.      0.      0.
$ALL CARDS BELOW ARE ADDED BY THE PROGRAM SUPSYS.  ORIGINAL CARDS
$CORRESPONDING TO MODIFIED ELEMENTS ARE DELETED.
$
$SUPSYS INPUT TITLE:
$PRIMARY MIRROR LATERAL AND AXIAL SUPPORTS
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GRID           675          372.23-1140.26  -49.52
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GRID           678          335.97 -970.26  -68.06
GRID           679          389.62 -966.09 -135.00
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GRID           682          391.52-1118.88 -528.12
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GRID          1096         -378.33 -948.88  490.33
GRID          1097        -1204.18-1031.29  164.90
GRID          1098        -1154.18-1031.29   78.30
GRID          1099        -1254.18-1031.29  251.51
GRID          1100        -1209.73 -861.29   82.45
GRID          1101        -1268.45 -847.79  173.71
GRID          1102        -1124.21 -876.02  158.10
GRID          1103        -1188.02 -861.29  243.99
GRID          1104         -962.05-1031.29  742.61
GRID          1105         -912.05-1031.29  656.01
GRID          1106        -1012.05-1031.29  829.22
GRID          1107        -1005.70 -861.29  677.99
GRID          1108        -1013.40 -847.79  782.25
GRID          1109         -901.63 -876.05  689.41
GRID          1110         -910.69 -861.29  800.97
GRID          1111         -473.04-1031.29 1119.77
GRID          1112         -423.04-1031.29 1033.17
GRID          1113         -523.04-1031.29 1206.37
GRID          1114         -543.20 -861.29 1084.56
GRID          1115         -498.29 -847.79 1179.54
GRID          1116         -450.00 -876.10 1041.91
GRID          1117         -398.05 -861.29 1145.81
GRID          1118         -805.93-1084.13  416.91
GRID          1119         -755.93-1084.13  330.30
GRID          1120         -855.93-1084.13  503.51
GRID          1121         -833.44 -914.13  351.82
GRID          1122         -862.48 -902.58  466.00
GRID          1123         -765.12 -920.25  399.69
GRID          1124         -769.04 -914.13  476.34
GRID          1125         -416.91-1084.13  805.93
GRID          1126         -366.91-1084.13  719.33
GRID          1127         -466.91-1084.13  892.53
GRID          1128         -476.34 -914.13  769.04
GRID          1129         -469.96 -902.46  861.05
GRID          1130         -421.93 -902.52  884.99
GRID          1131         -399.81 -920.21  765.40
GRID          1132         -351.82 -914.13  833.44
RBE1           466     673      13     674       2     675       2        +E  466A
+E  466A               676       1     677       1                        +E  466B
+E  466B        UM     673       2     674      13     675      13        +E  466C
+E  466C               676      23     677      23     678     123        +E  466D
+E  466D               679     123     680     123
RBE1           467     681      13     682       2     683       2        +E  467A
+E  467A               684       1     685       1                        +E  467B
+E  467B        UM     681       2     682      13     683      13        +E  467C
+E  467C               684      23     685      23     686     123        +E  467D
+E  467D               687     123
RBE1           468     688      13     689       2     690       2        +E  468A
+E  468A               691       1     692       1                        +E  468B
+E  468B        UM     688       2     689      13     690      13        +E  468C
+E  468C               691      23     692      23     693     123        +E  468D
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+E 468D		694	123						
RBE1	469	695	13	696	2	697	2	+E	469A
+E 469A		698	1	699	1			+E	469B
+E 469B	UM	695	2	696	13	697	13	+E	469C
+E 469C		698	23	699	23	700	123	+E	469D
+E 469D		701	123						
RBE1	470	702	13	703	2	704	2	+E	470A
+E 470A		705	1	706	1			+E	470B
+E 470B	UM	702	2	703	13	704	13	+E	470C
+E 470C		705	23	706	23	707	123	+E	470D
+E 470D		708	123						
RBE1	471	709	13	710	2	711	2	+E	471A
+E 471A		712	1	713	1			+E	471B
+E 471B	UM	709	2	710	13	711	13	+E	471C
+E 471C		712	23	713	23	714	123	+E	471D
+E 471D		715	123						
RBE1	472	716	13	717	2	718	2	+E	472A
+E 472A		719	1	720	1			+E	472B
+E 472B	UM	716	2	717	13	718	13	+E	472C
+E 472C		719	23	720	23	721	123	+E	472D
+E 472D		722	123	723	123				
RBE1	473	724	13	725	2	726	2	+E	473A
+E 473A		727	1	728	1			+E	473B
+E 473B	UM	724	2	725	13	726	13	+E	473C
+E 473C		727	23	728	23	729	123	+E	473D
+E 473D		730	123	731	123				
RBE1	474	732	13	733	2	734	2	+E	474A
+E 474A		735	1	736	1			+E	474B
+E 474B	UM	732	2	733	13	734	13	+E	474C
+E 474C		735	23	736	23	737	123	+E	474D
+E 474D		738	123						
RBE1	475	739	13	740	2	741	2	+E	475A
+E 475A		742	1	743	1			+E	475B
+E 475B	UM	739	2	740	13	741	13	+E	475C
+E 475C		742	23	743	23	744	123	+E	475D
+E 475D		745	123						
RBE1	476	746	13	747	2	748	2	+E	476A
+E 476A		749	1	750	1			+E	476B
+E 476B	UM	746	2	747	13	748	13	+E	476C
+E 476C		749	23	750	23	751	123	+E	476D
+E 476D		752	123						
RBE1	477	753	13	754	2	755	2	+E	477A
+E 477A		756	1	757	1			+E	477B
+E 477B	UM	753	2	754	13	755	13	+E	477C
+E 477C		756	23	757	23	758	123	+E	477D
+E 477D		759	123						
RBE1	478	760	13	761	2	762	2	+E	478A
+E 478A		763	1	764	1			+E	478B
+E 478B	UM	760	2	761	13	762	13	+E	478C
+E 478C		763	23	764	23	765	123	+E	478D
+E 478D		766	123						
RBE1	479	767	13	768	2	769	2	+E	479A
+E 479A		770	1	771	1			+E	479B
+E 479B	UM	767	2	768	13	769	13	+E	479C
+E 479C		770	23	771	23	772	123	+E	479D
+E 479D		773	123						
RBE1	480	774	13	775	2	776	2	+E	480A
+E 480A		777	1	778	1			+E	480B
+E 480B	UM	774	2	775	13	776	13	+E	480C
+E 480C		777	23	778	23	779	123	+E	480D
+E 480D		780	123						
RBE1	481	781	13	782	2	783	2	+E	481A
+E 481A		784	1	785	1			+E	481B
+E 481B	UM	781	2	782	13	783	13	+E	481C
+E 481C		784	23	785	23	786	123	+E	481D
+E 481D		787	123						
RBE1	482	788	13	789	2	790	2	+E	482A
+E 482A		791	1	792	1			+E	482B
+E 482B	UM	788	2	789	13	790	13	+E	482C
+E 482C		791	23	792	23	793	123	+E	482D
+E 482D		794	123	795	123				
RBE1	483	796	13	797	2	798	2	+E	483A
+E 483A		799	1	800	1			+E	483B
+E 483B	UM	796	2	797	13	798	13	+E	483C
+E 483C		799	23	800	23	801	123	+E	483D
+E 483D		802	123						
RBE1	484	803	13	804	2	805	2	+E	484A
+E 484A		806	1	807	1			+E	484B
+E 484B	UM	803	2	804	13	805	13	+E	484C
+E 484C		806	23	807	23	808	123	+E	484D
+E 484D		809	123						
RBE1	485	810	13	811	2	812	2	+E	485A
+E 485A		813	1	814	1			+E	485B
+E 485B	UM	810	2	811	13	812	13	+E	485C
+E 485C		813	23	814	23	815	123	+E	485D
+E 485D		816	123						
RBE1	486	817	13	818	2	819	2	+E	486A
+E 486A		820	1	821	1			+E	486B
+E 486B	UM	817	2	818	13	819	13	+E	486C
+E 486C		820	23	821	23	822	123	+E	486D
+E 486D		823	123						
RBE1	487	824	13	825	2	826	2	+E	487A

+E	487A		827	1	828	1			+E 487B
+E	487B	UM	824	2	825	13	826	13	+E 487C
+E	487C		827	23	828	23	829	123	+E 487D
+E	487D		830	123					
RBE1		488	831	13	832	2	833	2	+E 488A
+E	488A		834	1	835	1			+E 488B
+E	488B	UM	831	2	832	13	833	13	+E 488C
+E	488C		834	23	835	23	836	123	+E 488D
+E	488D		837	123					
RBE1		489	838	13	839	2	840	2	+E 489A
+E	489A		841	1	842	1			+E 489B
+E	489B	UM	838	2	839	13	840	13	+E 489C
+E	489C		841	23	842	23	843	123	+E 489D
+E	489D		844	123	845	123			
RBE1		490	846	13	847	2	848	2	+E 490A
+E	490A		849	1	850	1			+E 490B
+E	490B	UM	846	2	847	13	848	13	+E 490C
+E	490C		849	23	850	23	851	123	+E 490D
+E	490D		852	123	853	123			
RBE1		491	854	13	855	2	856	2	+E 491A
+E	491A		857	1	858	1			+E 491B
+E	491B	UM	854	2	855	13	856	13	+E 491C
+E	491C		857	23	858	23	859	123	+E 491D
+E	491D		860	123					
RBE1		492	861	13	862	2	863	2	+E 492A
+E	492A		864	1	865	1			+E 492B
+E	492B	UM	861	2	862	13	863	13	+E 492C
+E	492C		864	23	865	23	866	123	+E 492D
+E	492D		867	123					
RBE1		493	868	13	869	2	870	2	+E 493A
+E	493A		871	1	872	1			+E 493B
+E	493B	UM	868	2	869	13	870	13	+E 493C
+E	493C		871	23	872	23	873	123	+E 493D
+E	493D		874	123					
RBE1		494	875	13	876	2	877	2	+E 494A
+E	494A		878	1	879	1			+E 494B
+E	494B	UM	875	2	876	13	877	13	+E 494C
+E	494C		878	23	879	23	880	123	+E 494D
+E	494D		881	123					
RBE1		495	882	13	883	2	884	2	+E 495A
+E	495A		885	1	886	1			+E 495B
+E	495B	UM	882	2	883	13	884	13	+E 495C
+E	495C		885	23	886	23	887	123	+E 495D
+E	495D		888	123					
RBE1		496	889	13	890	2	891	2	+E 496A
+E	496A		892	1	893	1			+E 496B
+E	496B	UM	889	2	890	13	891	13	+E 496C
+E	496C		892	23	893	23	894	123	+E 496D
+E	496D		895	123					
RBE1		497	896	13	897	2	898	2	+E 497A
+E	497A		899	1	900	1			+E 497B
+E	497B	UM	896	2	897	13	898	13	+E 497C
+E	497C		899	23	900	23	901	123	+E 497D
+E	497D		902	123					
RBE1		498	903	13	904	2	905	2	+E 498A
+E	498A		906	1	907	1			+E 498B
+E	498B	UM	903	2	904	13	905	13	+E 498C
+E	498C		906	23	907	23	908	123	+E 498D
+E	498D		909	123	910	123			
RBE1		499	911	13	912	2	913	2	+E 499A
+E	499A		914	1	915	1			+E 499B
+E	499B	UM	911	2	912	13	913	13	+E 499C
+E	499C		914	23	915	23	916	123	+E 499D
+E	499D		917	123					
RBE1		500	918	13	919	2	920	2	+E 500A
+E	500A		921	1	922	1			+E 500B
+E	500B	UM	918	2	919	13	920	13	+E 500C
+E	500C		921	23	922	23	923	123	+E 500D
+E	500D		924	123					
RBE1		501	925	13	926	2	927	2	+E 501A
+E	501A		928	1	929	1			+E 501B
+E	501B	UM	925	2	926	13	927	13	+E 501C
+E	501C		928	23	929	23	930	123	+E 501D
+E	501D		931	123					
RBE1		502	932	13	933	2	934	2	+E 502A
+E	502A		935	1	936	1			+E 502B
+E	502B	UM	932	2	933	13	934	13	+E 502C
+E	502C		935	23	936	23	937	123	+E 502D
+E	502D		938	123					
RBE1		503	939	13	940	2	941	2	+E 503A
+E	503A		942	1	943	1			+E 503B
+E	503B	UM	939	2	940	13	941	13	+E 503C
+E	503C		942	23	943	23	944	123	+E 503D
+E	503D		945	123					
RBE1		504	946	13	947	2	948	2	+E 504A
+E	504A		949	1	950	1			+E 504B
+E	504B	UM	946	2	947	13	948	13	+E 504C
+E	504C		949	23	950	23	951	123	+E 504D
+E	504D		952	123					
RBE1		505	953	13	954	2	955	2	+E 505A
+E	505A		956	1	957	1			+E 505B
+E	505B	UM	953	2	954	13	955	13	+E 505C

+E 505C		956	23	957	23	958	123	+E 505D
+E 505D		959	123					
RBE1	506	960	13	961	2	962	2	+E 506A
+E 506A		963	1	964	1			+E 506B
+E 506B	UM	960	2	961	13	962	13	+E 506C
+E 506C		963	23	964	23	965	123	+E 506D
+E 506D		966	123					
RBE1	507	967	13	968	2	969	2	+E 507A
+E 507A		970	1	971	1			+E 507B
+E 507B	UM	967	2	968	13	969	13	+E 507C
+E 507C		970	23	971	23	972	123	+E 507D
+E 507D		973	123	974	123			
RBE1	508	975	13	976	2	977	2	+E 508A
+E 508A		978	1	979	1			+E 508B
+E 508B	UM	975	2	976	13	977	13	+E 508C
+E 508C		978	23	979	23	980	123	+E 508D
+E 508D		981	123					
RBE1	509	982	13	983	2	984	2	+E 509A
+E 509A		985	1	986	1			+E 509B
+E 509B	UM	982	2	983	13	984	13	+E 509C
+E 509C		985	23	986	23	987	123	+E 509D
+E 509D		988	123					
RBE1	510	989	13	990	2	991	2	+E 510A
+E 510A		992	1	993	1			+E 510B
+E 510B	UM	989	2	990	13	991	13	+E 510C
+E 510C		992	23	993	23	994	123	+E 510D
+E 510D		995	123					
RBE1	511	996	13	997	2	998	2	+E 511A
+E 511A		999	1	1000	1			+E 511B
+E 511B	UM	996	2	997	13	998	13	+E 511C
+E 511C		999	23	1000	23	1001	123	+E 511D
+E 511D		1002	123					
RBE1	512	1003	13	1004	2	1005	2	+E 512A
+E 512A		1006	1	1007	1			+E 512B
+E 512B	UM	1003	2	1004	13	1005	13	+E 512C
+E 512C		1006	23	1007	23	1008	123	+E 512D
+E 512D		1009	123					
RBE1	513	1010	13	1011	2	1012	2	+E 513A
+E 513A		1013	1	1014	1			+E 513B
+E 513B	UM	1010	2	1011	13	1012	13	+E 513C
+E 513C		1013	23	1014	23	1015	123	+E 513D
+E 513D		1016	123	1017	123			
RBE1	514	1018	13	1019	2	1020	2	+E 514A
+E 514A		1021	1	1022	1			+E 514B
+E 514B	UM	1018	2	1019	13	1020	13	+E 514C
+E 514C		1021	23	1022	23	1023	123	+E 514D
+E 514D		1024	123	1025	123			
RBE1	515	1026	13	1027	2	1028	2	+E 515A
+E 515A		1029	1	1030	1			+E 515B
+E 515B	UM	1026	2	1027	13	1028	13	+E 515C
+E 515C		1029	23	1030	23	1031	123	+E 515D
+E 515D		1032	123					
RBE1	516	1033	13	1034	2	1035	2	+E 516A
+E 516A		1036	1	1037	1			+E 516B
+E 516B	UM	1033	2	1034	13	1035	13	+E 516C
+E 516C		1036	23	1037	23	1038	123	+E 516D
+E 516D		1039	123					
RBE1	517	1040	13	1041	2	1042	2	+E 517A
+E 517A		1043	1	1044	1			+E 517B
+E 517B	UM	1040	2	1041	13	1042	13	+E 517C
+E 517C		1043	23	1044	23	1045	123	+E 517D
+E 517D		1046	123					
RBE1	518	1047	13	1048	2	1049	2	+E 518A
+E 518A		1050	1	1051	1			+E 518B
+E 518B	UM	1047	2	1048	13	1049	13	+E 518C
+E 518C		1050	23	1051	23	1052	123	+E 518D
+E 518D		1053	123					
RBE1	519	1054	13	1055	2	1056	2	+E 519A
+E 519A		1057	1	1058	1			+E 519B
+E 519B	UM	1054	2	1055	13	1056	13	+E 519C
+E 519C		1057	23	1058	23	1059	123	+E 519D
+E 519D		1060	123					
RBE1	520	1061	13	1062	2	1063	2	+E 520A
+E 520A		1064	1	1065	1			+E 520B
+E 520B	UM	1061	2	1062	13	1063	13	+E 520C
+E 520C		1064	23	1065	23	1066	123	+E 520D
+E 520D		1067	123					
RBE1	521	1068	13	1069	2	1070	2	+E 521A
+E 521A		1071	1	1072	1			+E 521B
+E 521B	UM	1068	2	1069	13	1070	13	+E 521C
+E 521C		1071	23	1072	23	1073	123	+E 521D
+E 521D		1074	123					
RBE1	522	1075	13	1076	2	1077	2	+E 522A
+E 522A		1078	1	1079	1			+E 522B
+E 522B	UM	1075	2	1076	13	1077	13	+E 522C
+E 522C		1078	23	1079	23	1080	123	+E 522D
+E 522D		1081	123	1082	123			
RBE1	523	1083	13	1084	2	1085	2	+E 523A
+E 523A		1086	1	1087	1			+E 523B
+E 523B	UM	1083	2	1084	13	1085	13	+E 523C
+E 523C		1086	23	1087	23	1088	123	+E 523D
+E 523D		1089	123					

RBE1	524	1090	13	1091	2	1092	2	+E	524A
+E 524A		1093	1	1094	1			+E	524B
+E 524B	UM	1090	2	1091	13	1092	13	+E	524C
+E 524C		1093	23	1094	23	1095	123	+E	524D
+E 524D		1096	123						
RBE1	525	1097	13	1098	2	1099	2	+E	525A
+E 525A		1100	1	1101	1			+E	525B
+E 525B	UM	1097	2	1098	13	1099	13	+E	525C
+E 525C		1100	23	1101	23	1102	123	+E	525D
+E 525D		1103	123						
RBE1	526	1104	13	1105	2	1106	2	+E	526A
+E 526A		1107	1	1108	1			+E	526B
+E 526B	UM	1104	2	1105	13	1106	13	+E	526C
+E 526C		1107	23	1108	23	1109	123	+E	526D
+E 526D		1110	123						
RBE1	527	1111	13	1112	2	1113	2	+E	527A
+E 527A		1114	1	1115	1			+E	527B
+E 527B	UM	1111	2	1112	13	1113	13	+E	527C
+E 527C		1114	23	1115	23	1116	123	+E	527D
+E 527D		1117	123						
RBE1	528	1118	13	1119	2	1120	2	+E	528A
+E 528A		1121	1	1122	1			+E	528B
+E 528B	UM	1118	2	1119	13	1120	13	+E	528C
+E 528C		1121	23	1122	23	1123	123	+E	528D
+E 528D		1124	123						
RBE1	529	1125	13	1126	2	1127	2	+E	529A
+E 529A		1128	1	1129	1			+E	529B
+E 529B	UM	1125	2	1126	13	1127	13	+E	529C
+E 529C		1128	23	1129	23	1130	123	+E	529D
+E 529D		1131	123	1132	123				
CHEXA	5	1	6	7	12	11	21	22+E	5
+E 5	27	26	0	0	0	0	0	0+E	5B
+E 5B	0	0	0	676	678				
CHEXA	6	1	7	8	13	12	22	23+E	6
+E 6	28	27	0	0	0	0	0	0+E	6B
+E 6B	0	0	0	0	677	676			
CHEXA	153	1	11	12	111	113	26	27+E	27
+E 27	115	117	0	0	0	0	0	0+E	153B
+E 153B	0	0	678	679					
CPENTA	154	1	12	112	111	27	116	115+E	154A
+E 154A	0	0	0	0	0	0	680	0+E	154B
+E 154B	679								
CHEXA	155	1	12	13	114	112	27	28+E	29
+E 29	118	116	0	0	0	0	0	0+E	155B
+E 155B	0	0	677	0	0	680			
CHEXA	27	1	33	34	41	40	47	48+E	11
+E 11	55	54	0	0	0	0	0	0+E	27B
+E 27B	0	0	684	685					
CHEXA	28	1	34	35	42	41	48	49+E	12
+E 12	56	55	0	0	0	0	0	0+E	28B
+E 28B	0	0	687	0	0	685			
CHEXA	158	1	112	114	34	33	116	118+E	32
+E 32	48	47	0	0	0	0	0	0+E	158B
+E 158B	0	0	0	686	684				
CHEXA	162	1	114	119	35	34	118	122+E	36
+E 36	49	48	0	0	0	0	0	0+E	162B
+E 162B	0	0	0	0	687	686			
CHEXA	143	1	61	62	75	74	87	88+E	17
+E 17	101	100	0	0	0	0	0	0+E	143B
+E 143B	0	0	691	692					
CHEXA	144	1	62	63	76	75	88	89+E	18
+E 18	102	101	0	0	0	0	0	0+E	144B
+E 144B	0	0	694	0	0	692			
CHEXA	192	1	132	133	62	61	145	146+E	47
+E 47	88	87	0	0	0	0	0	0+E	192B
+E 192B	0	0	0	693	691				
CHEXA	193	1	133	131	63	62	146	144+E	48
+E 48	89	88	0	0	0	0	0	0+E	193B
+E 193B	0	0	0	0	694	693			
CHEXA	147	1	65	66	79	78	91	92+E	21
+E 21	105	104	0	0	0	0	0	0+E	147B
+E 147B	0	0	698	699					
CHEXA	148	1	66	67	80	79	92	93+E	22
+E 22	106	105	0	0	0	0	0	0+E	148B
+E 148B	0	0	701	0	0	699			
CHEXA	202	1	137	159	66	65	150	170+E	57
+E 57	92	91	0	0	0	0	0	0+E	202B
+E 202B	0	0	0	700	698				
CHEXA	203	1	159	158	67	66	170	169+E	58
+E 58	93	92	0	0	0	0	0	0+E	203B
+E 203B	0	0	0	0	701	700			
CHEXA	149	1	67	68	81	80	93	94+E	23
+E 23	107	106	0	0	0	0	0	0+E	149B
+E 149B	0	0	705	706					
CHEXA	150	1	68	69	82	81	94	95+E	24
+E 24	108	107	0	0	0	0	0	0+E	150B
+E 150B	0	0	708	0	0	706			
CHEXA	204	1	158	157	68	67	169	168+E	59
+E 59	94	93	0	0	0	0	0	0+E	204B
+E 204B	0	0	0	707	705				
CHEXA	205	1	157	156	69	68	168	167+E	60
+E 60	95	94	0	0	0	0	0	0+E	205B

+E 205B	0	0	0	0	708	707			
CHEXA	187	1	127	128	131	133	140	141+E	42
+E 42	144	146	0	0	0	0	0	0+E	187B
+E 187B	0	0	712	713					
CHEXA	188	1	128	129	135	131	141	142+E	43
+E 43	148	144	0	0	0	0	0	0+E	188B
+E 188B	0	0	715	0	0	713			
CHEXA	229	1	181	182	128	127	185	186+E	76
+E 76	141	140	0	0	0	0	0	0+E	229B
+E 229B	0	0	0	714	712				
CHEXA	230	1	182	184	129	128	186	188+E	77
+E 77	142	141	0	0	0	0	0	0+E	230B
+E 230B	0	0	0	0	715	714			
CHEXA	197	1	151	152	158	159	162	163+E	52
+E 52	169	170	0	0	0	0	0	0+E	197B
+E 197B	0	0	719	720					
CPENTA	198	1	152	157	158	163	168	169+E	198A
+E 198A	0	0	0	0	0	0	721	0+E	198B
+E 198B	720								
CHEXA	199	1	152	153	156	157	163	164+E	54
+E 54	167	168	0	0	0	0	0	0+E	199B
+E 199B	0	0	723	0	0	721			
CHEXA	220	1	176	174	152	151	180	178+E	67
+E 67	163	162	0	0	0	0	0	0+E	220B
+E 220B	0	0	0	722	719				
CHEXA	221	1	174	173	153	152	178	177+E	68
+E 68	164	163	0	0	0	0	0	0+E	221B
+E 221B	0	0	0	0	723	722			
CHEXA	238	1	195	199	200	196	207	211+E	85
+E 85	212	208	0	0	0	0	0	0+E	238B
+E 238B	0	0	0	727	728				
CHEXA	239	1	196	200	15	10	208	212+E	86
+E 86	30	25	0	0	0	0	0	0+E	239B
+E 239B	0	0	728	731					
CHEXA	264	1	199	288	293	200	211	292+E	111
+E 111	295	212	0	0	0	0	0	0+E	264B
+E 264B	0	0	0	0	729	727			
CPENTA	265	1	200	293	294	212	295	296+E	265A
+E 265A	0	0	0	0	0	0	729	0+E	265B
+E 265B	730								
CHEXA	266	1	200	294	121	15	212	296+E	113
+E 113	124	30	0	0	0	0	0	0+E	266B
+E 266B	0	0	730	0	0	731			
CHEXA	240	1	213	219	220	214	225	231+E	87
+E 87	232	226	0	0	0	0	0	0+E	240B
+E 240B	0	0	0	0	735	737			
CHEXA	241	1	214	220	221	215	226	232+E	88
+E 88	233	227	0	0	0	0	0	0+E	241B
+E 241B	0	0	735	0	0	736			
CHEXA	261	1	287	213	214	285	291	225+E	108
+E 108	226	289	0	0	0	0	0	0+E	261B
+E 261B	0	0	0	737	738				
CHEXA	262	1	285	214	215	286	289	226+E	109
+E 109	227	290	0	0	0	0	0	0+E	262B
+E 262B	0	0	738	736					
CHEXA	244	1	217	223	224	218	229	235+E	91
+E 91	236	230	0	0	0	0	0	0+E	244B
+E 244B	0	0	0	0	742	744			
CHEXA	245	1	218	224	44	37	230	236+E	92
+E 92	58	51	0	0	0	0	0	0+E	245B
+E 245B	0	0	742	0	0	743			
CHEXA	268	1	293	217	218	294	295	229+E	115
+E 115	230	296	0	0	0	0	0	0+E	268B
+E 268B	0	0	0	744	745				
CHEXA	269	1	294	218	37	121	296	230+E	116
+E 116	51	124	0	0	0	0	0	0+E	269B
+E 269B	0	0	745	743					
CHEXA	246	1	237	249	250	238	261	273+E	93
+E 93	274	262	0	0	0	0	0	0+E	246B
+E 246B	0	0	0	0	749	751			
CHEXA	247	1	238	250	251	239	262	274+E	94
+E 94	275	263	0	0	0	0	0	0+E	247B
+E 247B	0	0	749	0	0	750			
CHEXA	276	1	308	237	238	306	321	261+E	123
+E 123	262	319	0	0	0	0	0	0+E	276B
+E 276B	0	0	0	751	752				
CHEXA	277	1	306	238	239	304	319	262+E	124
+E 124	263	317	0	0	0	0	0	0+E	277B
+E 277B	0	0	752	750					
CHEXA	250	1	241	253	254	242	265	277+E	97
+E 97	278	266	0	0	0	0	0	0+E	250B
+E 250B	0	0	0	0	756	758			
CHEXA	251	1	242	254	255	243	266	278+E	98
+E 98	279	267	0	0	0	0	0	0+E	251B
+E 251B	0	0	756	0	0	757			
CHEXA	280	1	303	241	242	307	316	265+E	127
+E 127	266	320	0	0	0	0	0	0+E	280B
+E 280B	0	0	0	758	759				
CHEXA	281	1	307	242	243	309	320	266+E	128
+E 128	267	322	0	0	0	0	0	0+E	281B
+E 281B	0	0	759	757					
CHEXA	256	1	247	259	260	248	271	283+E	103

+E 103	284	272	0	0	0	0	0	0+E	256B
+E 256B	0	0	0	0	763	765			
CHEXA	257	1	248	260	84	71	272	284+E	104
+E 104	110	97	0	0	0	0	0	0+E	257B
+E 257B	0	0	763	0	0	764			
CHEXA	292	1	327	247	248	331	336	271+E	139
+E 139	272	340	0	0	0	0	0	0+E	292B
+E 292B	0	0	0	765	766				
CHEXA	293	1	331	248	71	161	340	272+E	140
+E 140	97	172	0	0	0	0	0	0+E	293B
+E 293B	0	0	766	764					
CHEXA	270	1	297	308	306	298	310	321+E	117
+E 117	319	311	0	0	0	0	0	0+E	270B
+E 270B	0	0	0	0	770	772			
CHEXA	271	1	298	306	304	299	311	319+E	118
+E 118	317	312	0	0	0	0	0	0+E	271B
+E 271B	0	0	770	0	0	771			
CHEXA	305	1	219	297	298	351	231	310+E	152
+E 152	311	355	0	0	0	0	0	0+E	305B
+E 305B	0	0	0	772	773				
CHEXA	306	1	351	298	299	349	355	311+E	153
+E 153	312	353	0	0	0	0	0	0+E	306B
+E 306B	0	0	773	771					
CHEXA	275	1	301	307	309	302	314	320+E	122
+E 122	322	315	0	0	0	0	0	0+E	275B
+E 275B	0	0	0	0	777	780			
CHEXA	282	1	302	309	330	323	315	322+E	129
+E 129	339	332	0	0	0	0	0	0+E	282B
+E 282B	0	0	777	0	0	778			
CHEXA	297	1	222	302	323	344	234	315+E	144
+E 144	332	348	0	0	0	0	0	0+E	297B
+E 297B	0	0	779	778					
CHEXA	309	1	352	301	302	222	356	314+E	156
+E 156	315	234	0	0	0	0	0	0+E	309B
+E 309B	0	0	0	780	779				
CHEXA	286	1	325	327	331	326	334	336+E	133
+E 133	340	335	0	0	0	0	0	0+E	286B
+E 286B	0	0	0	0	784	786			
CHEXA	287	1	326	331	161	155	335	340+E	134
+E 134	172	166	0	0	0	0	0	0+E	287B
+E 287B	0	0	784	0	0	785			
CHEXA	300	1	341	325	326	343	345	334+E	147
+E 147	335	347	0	0	0	0	0	0+E	300B
+E 300B	0	0	0	786	787				
CHEXA	301	1	343	326	155	44	347	335+E	148
+E 148	166	58	0	0	0	0	0	0+E	301B
+E 301B	0	0	787	785					
CHEXA	314	1	6	11	365	361	21	26+E	161
+E 161	377	373	0	0	0	0	0	0+E	314B
+E 314B	0	0	0	791	792				
CHEXA	315	1	361	365	366	362	373	377+E	162
+E 162	378	374	0	0	0	0	0	0+E	315B
+E 315B	0	0	792	795					
CHEXA	336	1	11	113	453	365	26	117+E	183
+E 183	456	377	0	0	0	0	0	0+E	336B
+E 336B	0	0	0	0	793	791			
CPENTA	337	1	365	453	454	377	456	457+E	337A
+E 337A	0	0	0	0	0	0	793	0+E	337B
+E 337B	794								
CHEXA	338	1	365	454	455	366	377	457+E	185
+E 185	458	378	0	0	0	0	0	0+E	338B
+E 338B	0	0	794	0	0	795			
CHEXA	318	1	31	38	387	381	45	52+E	165
+E 165	399	393	0	0	0	0	0	0+E	318B
+E 318B	0	0	0	0	799	801			
CHEXA	319	1	381	387	388	382	393	399+E	166
+E 166	400	394	0	0	0	0	0	0+E	319B
+E 319B	0	0	799	0	0	800			
CHEXA	339	1	113	31	381	453	117	45+E	186
+E 186	393	456	0	0	0	0	0	0+E	339B
+E 339B	0	0	0	801	802				
CHEXA	340	1	453	381	382	454	456	393+E	187
+E 187	394	457	0	0	0	0	0	0+E	340B
+E 340B	0	0	802	800					
CHEXA	320	1	382	388	389	383	394	400+E	167
+E 167	401	395	0	0	0	0	0	0+E	320B
+E 320B	0	0	0	0	806	808			
CHEXA	321	1	383	389	390	384	395	401+E	168
+E 168	402	396	0	0	0	0	0	0+E	321B
+E 321B	0	0	806	0	0	807			
CHEXA	341	1	454	382	383	455	457	394+E	188
+E 188	395	458	0	0	0	0	0	0+E	341B
+E 341B	0	0	0	808	809				
CHEXA	345	1	455	383	384	459	458	395+E	192
+E 192	396	462	0	0	0	0	0	0+E	345B
+E 345B	0	0	809	807					
CHEXA	324	1	59	72	417	405	85	98+E	171
+E 171	441	429	0	0	0	0	0	0+E	324B
+E 324B	0	0	0	0	813	815			
CHEXA	325	1	405	417	418	406	429	441+E	172
+E 172	442	430	0	0	0	0	0	0+E	325B
+E 325B	0	0	813	0	0	814			

CHEXA	354	1	136	59	405	473	149	85+E	201
+E 201	429	484	0	0	0	0	0	0+E	354B
+E 354B	0	0	0	815	816				
CHEXA	355	1	473	405	406	471	484	429+E	202
+E 202	430	482	0	0	0	0	0	0+E	355B
+E 355B	0	0	816	814					
CHEXA	328	1	408	420	421	409	432	444+E	175
+E 175	445	433	0	0	0	0	0	0+E	328B
+E 328B	0	0	0	0	820	822			
CHEXA	329	1	409	421	422	410	433	445+E	176
+E 176	446	434	0	0	0	0	0	0+E	329B
+E 329B	0	0	820	0	0	821			
CHEXA	358	1	470	408	409	474	481	432+E	205
+E 205	433	485	0	0	0	0	0	0+E	358B
+E 358B	0	0	0	822	823				
CHEXA	359	1	474	409	410	475	485	433+E	206
+E 206	434	486	0	0	0	0	0	0+E	359B
+E 359B	0	0	823	821					
CHEXA	332	1	412	424	425	413	436	448+E	179
+E 179	449	437	0	0	0	0	0	0+E	332B
+E 332B	0	0	0	0	827	829			
CHEXA	333	1	413	425	426	414	437	449+E	180
+E 180	450	438	0	0	0	0	0	0+E	333B
+E 333B	0	0	827	0	0	828			
CHEXA	368	1	494	412	413	493	505	436+E	215
+E 215	437	504	0	0	0	0	0	0+E	368B
+E 368B	0	0	0	829	830				
CHEXA	369	1	493	413	414	492	504	437+E	216
+E 216	438	503	0	0	0	0	0	0+E	369B
+E 369B	0	0	830	828					
CHEXA	351	1	466	472	470	467	477	483+E	198
+E 198	481	478	0	0	0	0	0	0+E	351B
+E 351B	0	0	0	0	834	836			
CHEXA	352	1	467	470	474	468	478	481+E	199
+E 199	485	479	0	0	0	0	0	0+E	352B
+E 352B	0	0	834	0	0	835			
CHEXA	385	1	517	466	467	518	521	477+E	232
+E 232	478	522	0	0	0	0	0	0+E	385B
+E 385B	0	0	0	836	837				
CHEXA	386	1	518	467	468	520	522	478+E	233
+E 233	479	524	0	0	0	0	0	0+E	386B
+E 386B	0	0	837	835					
CHEXA	361	1	487	495	494	488	498	506+E	208
+E 208	505	499	0	0	0	0	0	0+E	361B
+E 361B	0	0	0	0	841	844			
CPENTA	362	1	488	494	493	499	505	504+E	362A
+E 362A	0	0	0	0	0	0	841	0+E	362B
+E 362B	842								
CHEXA	363	1	488	493	492	489	499	504+E	210
+E 210	503	500	0	0	0	0	0	0+E	363B
+E 363B	0	0	842	0	0	843			
CHEXA	376	1	512	487	488	510	516	498+E	223
+E 223	499	514	0	0	0	0	0	0+E	376B
+E 376B	0	0	0	844	845				
CHEXA	377	1	510	488	489	509	514	499+E	224
+E 224	500	513	0	0	0	0	0	0+E	377B
+E 377B	0	0	845	843					
CHEXA	394	1	529	530	533	532	538	539+E	241
+E 241	542	541	0	0	0	0	0	0+E	394B
+E 394B	0	0	0	849	851				
CHEXA	395	1	530	364	368	533	539	376+E	242
+E 242	380	542	0	0	0	0	0	0+E	395B
+E 395B	0	0	0	0	850	849			
CHEXA	420	1	532	533	613	609	541	542+E	267
+E 267	615	612	0	0	0	0	0	0+E	420B
+E 420B	0	0	851	852					
CPENTA	421	1	533	614	613	542	616	615+E	421A
+E 421A	0	0	0	0	0	0	853	0+E	421B
+E 421B	852								
CHEXA	422	1	533	368	461	614	542	380+E	269
+E 269	464	616	0	0	0	0	0	0+E	422B
+E 422B	0	0	850	0	0	853			
CHEXA	400	1	546	547	552	551	556	557+E	247
+E 247	562	561	0	0	0	0	0	0+E	400B
+E 400B	0	0	857	858					
CHEXA	401	1	547	386	392	552	557	398+E	248
+E 248	404	562	0	0	0	0	0	0+E	401B
+E 401B	0	0	860	0	0	858			
CHEXA	424	1	613	614	547	546	615	616+E	271
+E 271	557	556	0	0	0	0	0	0+E	424B
+E 424B	0	0	0	859	857				
CHEXA	425	1	614	461	386	547	616	464+E	272
+E 272	398	557	0	0	0	0	0	0+E	425B
+E 425B	0	0	0	0	860	859			
CHEXA	404	1	564	565	576	575	586	587+E	251
+E 251	598	597	0	0	0	0	0	0+E	404B
+E 404B	0	0	864	865					
CHEXA	405	1	565	566	577	576	587	588+E	252
+E 252	599	598	0	0	0	0	0	0+E	405B
+E 405B	0	0	867	0	0	865			
CHEXA	434	1	623	624	565	564	634	635+E	281
+E 281	587	586	0	0	0	0	0	0+E	434B

+E 434B	0	0	0	866	864				
CHEXA	435	1	624	622	566	565	635	633+E	282
+E 282	588	587	0	0	0	0	0	0+E	435B
+E 435B	0	0	0	0	867	866			
CHEXA	408	1	568	569	580	579	590	591+E	255
+E 255	602	601	0	0	0	0	0	0+E	408B
+E 408B	0	0	871	872					
CHEXA	409	1	569	570	581	580	591	592+E	256
+E 256	603	602	0	0	0	0	0	0+E	409B
+E 409B	0	0	874	0	0	872			
CHEXA	444	1	627	646	569	568	638	655+E	291
+E 291	591	590	0	0	0	0	0	0+E	444B
+E 444B	0	0	0	873	871				
CHEXA	445	1	646	645	570	569	655	654+E	292
+E 292	592	591	0	0	0	0	0	0+E	445B
+E 445B	0	0	0	0	874	873			
CHEXA	412	1	572	573	584	583	594	595+E	259
+E 259	606	605	0	0	0	0	0	0+E	412B
+E 412B	0	0	878	879					
CHEXA	413	1	573	416	428	584	595	440+E	260
+E 260	452	606	0	0	0	0	0	0+E	413B
+E 413B	0	0	881	0	0	879			
CHEXA	448	1	643	647	573	572	652	656+E	295
+E 295	595	594	0	0	0	0	0	0+E	448B
+E 448B	0	0	0	880	878				
CHEXA	449	1	647	497	416	573	656	508+E	296
+E 296	440	595	0	0	0	0	0	0+E	449B
+E 449B	0	0	0	0	881	880			
CHEXA	426	1	297	617	625	308	310	628+E	273
+E 273	636	321	0	0	0	0	0	0+E	426B
+E 426B	0	0	885	886					
CHEXA	427	1	617	618	623	625	628	629+E	274
+E 274	634	636	0	0	0	0	0	0+E	427B
+E 427B	0	0	888	0	0	886			
CHEXA	461	1	219	667	617	297	231	671+E	308
+E 308	628	310	0	0	0	0	0	0+E	461B
+E 461B	0	0	0	887	885				
CHEXA	462	1	667	665	618	617	671	669+E	309
+E 309	629	628	0	0	0	0	0	0+E	462B
+E 462B	0	0	0	0	888	887			
CHEXA	431	1	620	621	627	626	631	632+E	278
+E 278	638	637	0	0	0	0	0	0+E	431B
+E 431B	0	0	892	893					
CHEXA	438	1	621	639	646	627	632	648+E	285
+E 285	655	638	0	0	0	0	0	0+E	438B
+E 438B	0	0	894	0	0	893			
CHEXA	453	1	550	660	639	621	560	664+E	300
+E 300	648	632	0	0	0	0	0	0+E	453B
+E 453B	0	0	0	0	894	895			
CHEXA	465	1	668	550	621	620	672	560+E	312
+E 312	632	631	0	0	0	0	0	0+E	465B
+E 465B	0	0	0	895	892				
CHEXA	442	1	641	642	647	643	650	651+E	289
+E 289	656	652	0	0	0	0	0	0+E	442B
+E 442B	0	0	899	900					
CHEXA	443	1	642	491	497	647	651	502+E	290
+E 290	508	656	0	0	0	0	0	0+E	443B
+E 443B	0	0	902	0	0	900			
CHEXA	456	1	657	659	642	641	661	663+E	303
+E 303	651	650	0	0	0	0	0	0+E	456B
+E 456B	0	0	0	901	899				
CHEXA	457	1	659	392	491	642	663	404+E	304
+E 304	502	651	0	0	0	0	0	0+E	457B
+E 457B	0	0	0	0	902	901			
CHEXA	7	1	8	9	14	13	23	24+E	7
+E 7	29	28	0	0	0	0	0	0+E	7B
+E 7B	0	0	0	906	908				
CHEXA	8	1	9	10	15	14	24	25+E	8
+E 8	30	29	0	0	0	0	0	0+E	8B
+E 8B	0	0	0	0	907	906			
CHEXA	159	1	13	14	119	114	28	29+E	33
+E 33	122	118	0	0	0	0	0	0+E	159B
+E 159B	0	0	908	909					
CPENTA	160	1	14	120	119	29	123	122+E	160A
+E 160A	0	0	0	0	0	0	910	0+E	160B
+E 160B	909								
CHEXA	161	1	14	15	121	120	29	30+E	35
+E 35	124	123	0	0	0	0	0	0+E	161B
+E 161B	0	0	907	0	0	910			
CHEXA	25	1	31	32	39	38	45	46+E	9
+E 9	53	52	0	0	0	0	0	0+E	25B
+E 25B	0	0	914	915					
CHEXA	26	1	32	33	40	39	46	47+E	10
+E 10	54	53	0	0	0	0	0	0+E	26B
+E 26B	0	0	917	0	0	915			
CHEXA	156	1	113	111	32	31	117	115+E	30
+E 30	46	45	0	0	0	0	0	0+E	156B
+E 156B	0	0	0	916	914				
CHEXA	157	1	111	112	33	32	115	116+E	31
+E 31	47	46	0	0	0	0	0	0+E	157B
+E 157B	0	0	0	0	917	916			
CHEXA	29	1	35	36	43	42	49	50+E	13

+E 13	57	56	0	0	0	0	0	0+E	29B
+E 29B	0	0	921	922					
CHEXA	30	1	36	37	44	43	50	51+E	14
+E 14	58	57	0	0	0	0	0	0+E	30B
+E 30B	0	0	924	0	0	922			
CHEXA	163	1	119	120	36	35	122	123+E	37
+E 37	50	49	0	0	0	0	0	0+E	163B
+E 163B	0	0	0	923	921				
CHEXA	164	1	120	121	37	36	123	124+E	38
+E 38	51	50	0	0	0	0	0	0+E	164B
+E 164B	0	0	0	0	924	923			
CHEXA	141	1	59	60	73	72	85	86+E	15
+E 15	99	98	0	0	0	0	0	0+E	141B
+E 141B	0	0	928	929					
CHEXA	142	1	60	61	74	73	86	87+E	16
+E 16	100	99	0	0	0	0	0	0+E	142B
+E 142B	0	0	931	0	0	929			
CHEXA	190	1	136	134	60	59	149	147+E	45
+E 45	86	85	0	0	0	0	0	0+E	190B
+E 190B	0	0	0	930	928				
CHEXA	191	1	134	132	61	60	147	145+E	46
+E 46	87	86	0	0	0	0	0	0+E	191B
+E 191B	0	0	0	0	931	930			
CHEXA	145	1	63	64	77	76	89	90+E	19
+E 19	103	102	0	0	0	0	0	0+E	145B
+E 145B	0	0	935	936					
CHEXA	146	1	64	65	78	77	90	91+E	20
+E 20	104	103	0	0	0	0	0	0+E	146B
+E 146B	0	0	938	0	0	936			
CHEXA	194	1	131	135	64	63	144	148+E	49
+E 49	90	89	0	0	0	0	0	0+E	194B
+E 194B	0	0	0	937	935				
CHEXA	195	1	135	137	65	64	148	150+E	50
+E 50	91	90	0	0	0	0	0	0+E	195B
+E 195B	0	0	0	0	938	937			
CHEXA	151	1	69	70	83	82	95	96+E	25
+E 25	109	108	0	0	0	0	0	0+E	151B
+E 151B	0	0	942	943					
CHEXA	152	1	70	71	84	83	96	97+E	26
+E 26	110	109	0	0	0	0	0	0+E	152B
+E 152B	0	0	945	0	0	943			
CHEXA	206	1	156	160	70	69	167	171+E	61
+E 61	96	95	0	0	0	0	0	0+E	206B
+E 206B	0	0	0	944	942				
CHEXA	207	1	160	161	71	70	171	172+E	62
+E 62	97	96	0	0	0	0	0	0+E	207B
+E 207B	0	0	0	0	945	944			
CHEXA	184	1	125	126	134	136	138	139+E	39
+E 39	147	149	0	0	0	0	0	0+E	184B
+E 184B	0	0	949	950					
CHEXA	185	1	126	127	132	134	139	140+E	40
+E 40	145	147	0	0	0	0	0	0+E	185B
+E 185B	0	0	952	0	0	950			
CHEXA	227	1	38	183	126	125	52	187+E	74
+E 74	139	138	0	0	0	0	0	0+E	227B
+E 227B	0	0	0	951	949				
CHEXA	228	1	183	181	127	126	187	185+E	75
+E 75	140	139	0	0	0	0	0	0+E	228B
+E 228B	0	0	0	0	952	951			
CHEXA	189	1	129	130	137	135	142	143+E	44
+E 44	150	148	0	0	0	0	0	0+E	189B
+E 189B	0	0	956	957					
CHEXA	196	1	130	151	159	137	143	162+E	51
+E 51	170	150	0	0	0	0	0	0+E	196B
+E 196B	0	0	958	0	0	957			
CHEXA	219	1	41	176	151	130	55	180+E	66
+E 66	162	143	0	0	0	0	0	0+E	219B
+E 219B	0	0	0	0	958	959			
CHEXA	231	1	184	41	130	129	188	55+E	78
+E 78	143	142	0	0	0	0	0	0+E	231B
+E 231B	0	0	0	959	956				
CHEXA	200	1	153	154	160	156	164	165+E	55
+E 55	171	167	0	0	0	0	0	0+E	200B
+E 200B	0	0	963	964					
CHEXA	201	1	154	155	161	160	165	166+E	56
+E 56	172	171	0	0	0	0	0	0+E	201B
+E 201B	0	0	966	0	0	964			
CHEXA	222	1	173	175	154	153	177	179+E	69
+E 69	165	164	0	0	0	0	0	0+E	222B
+E 222B	0	0	0	965	963				
CHEXA	223	1	175	44	155	154	179	58+E	70
+E 70	166	165	0	0	0	0	0	0+E	223B
+E 223B	0	0	0	0	966	965			
CHEXA	236	1	193	197	198	194	205	209+E	83
+E 83	210	206	0	0	0	0	0	0+E	236B
+E 236B	0	0	0	970	971				
CHEXA	237	1	194	198	199	195	206	210+E	84
+E 84	211	207	0	0	0	0	0	0+E	237B
+E 237B	0	0	971	974					
CHEXA	258	1	197	287	285	198	209	291+E	105
+E 105	289	210	0	0	0	0	0	0+E	258B
+E 258B	0	0	0	0	972	970			

CPENTA	259	1	198	285	286	210	289	290+E	259A
+E 259A	0	0	0	0	0	0	972	0+E	259B
+E 259B	973								
CHEXA	260	1	198	286	288	199	210	290+E	107
+E 107	292	211	0	0	0	0	0	0+E	260B
+E 260B	0	0	973	0	0	974			
CHEXA	242	1	215	221	222	216	227	233+E	89
+E 89	234	228	0	0	0	0	0	0+E	242B
+E 242B	0	0	0	0	978	980			
CHEXA	243	1	216	222	223	217	228	234+E	90
+E 90	235	229	0	0	0	0	0	0+E	243B
+E 243B	0	0	978	0	0	979			
CHEXA	263	1	286	215	216	288	290	227+E	110
+E 110	228	292	0	0	0	0	0	0+E	263B
+E 263B	0	0	0	980	981				
CHEXA	267	1	288	216	217	293	292	228+E	114
+E 114	229	295	0	0	0	0	0	0+E	267B
+E 267B	0	0	981	979					
CHEXA	248	1	239	251	252	240	263	275+E	95
+E 95	276	264	0	0	0	0	0	0+E	248B
+E 248B	0	0	0	0	985	987			
CHEXA	249	1	240	252	253	241	264	276+E	96
+E 96	277	265	0	0	0	0	0	0+E	249B
+E 249B	0	0	985	0	0	986			
CHEXA	278	1	304	239	240	305	317	263+E	125
+E 125	264	318	0	0	0	0	0	0+E	278B
+E 278B	0	0	0	987	988				
CHEXA	279	1	305	240	241	303	318	264+E	126
+E 126	265	316	0	0	0	0	0	0+E	279B
+E 279B	0	0	988	986					
CHEXA	252	1	243	255	256	244	267	279+E	99
+E 99	280	268	0	0	0	0	0	0+E	252B
+E 252B	0	0	0	0	992	994			
CHEXA	253	1	244	256	257	245	268	280+E	100
+E 100	281	269	0	0	0	0	0	0+E	253B
+E 253B	0	0	992	0	0	993			
CHEXA	288	1	309	243	244	330	322	267+E	135
+E 135	268	339	0	0	0	0	0	0+E	288B
+E 288B	0	0	0	994	995				
CHEXA	289	1	330	244	245	329	339	268+E	136
+E 136	269	338	0	0	0	0	0	0+E	289B
+E 289B	0	0	995	993					
CHEXA	254	1	245	257	258	246	269	281+E	101
+E 101	282	270	0	0	0	0	0	0+E	254B
+E 254B	0	0	0	0	999	1001			
CHEXA	255	1	246	258	259	247	270	282+E	102
+E 102	283	271	0	0	0	0	0	0+E	255B
+E 255B	0	0	999	0	0	1000			
CHEXA	290	1	329	245	246	328	338	269+E	137
+E 137	270	337	0	0	0	0	0	0+E	290B
+E 290B	0	0	0	1001	1002				
CHEXA	291	1	328	246	247	327	337	270+E	138
+E 138	271	336	0	0	0	0	0	0+E	291B
+E 291B	0	0	1002	1000					
CHEXA	273	1	299	305	303	300	312	318+E	120
+E 120	316	313	0	0	0	0	0	0+E	273B
+E 273B	0	0	0	0	1006	1008			
CHEXA	274	1	300	303	307	301	313	316+E	121
+E 121	320	314	0	0	0	0	0	0+E	274B
+E 274B	0	0	1006	0	0	1007			
CHEXA	307	1	349	299	300	350	353	312+E	154
+E 154	313	354	0	0	0	0	0	0+E	307B
+E 307B	0	0	0	1008	1009				
CHEXA	308	1	350	300	301	352	354	313+E	155
+E 155	314	356	0	0	0	0	0	0+E	308B
+E 308B	0	0	1009	1007					
CHEXA	283	1	323	330	329	324	332	339+E	130
+E 130	338	333	0	0	0	0	0	0+E	283B
+E 283B	0	0	0	0	1013	1016			
CPENTA	284	1	324	329	328	333	338	337+E	284A
+E 284A	0	0	0	0	0	0	1013	0+E	284B
+E 284B	1014								
CHEXA	285	1	324	328	327	325	333	337+E	132
+E 132	336	334	0	0	0	0	0	0+E	285B
+E 285B	0	0	1014	0	0	1015			
CHEXA	298	1	344	323	324	342	348	332+E	145
+E 145	333	346	0	0	0	0	0	0+E	298B
+E 298B	0	0	0	1016	1017				
CHEXA	299	1	342	324	325	341	346	333+E	146
+E 146	334	345	0	0	0	0	0	0+E	299B
+E 299B	0	0	1017	1015					
CHEXA	316	1	362	366	367	363	374	378+E	163
+E 163	379	375	0	0	0	0	0	0+E	316B
+E 316B	0	0	0	1021	1022				
CHEXA	317	1	363	367	368	364	375	379+E	164
+E 164	380	376	0	0	0	0	0	0+E	317B
+E 317B	0	0	1022	1025					
CHEXA	342	1	366	455	459	367	378	458+E	189
+E 189	462	379	0	0	0	0	0	0+E	342B
+E 342B	0	0	0	0	1023	1021			
CPENTA	343	1	367	459	460	379	462	463+E	343A
+E 343A	0	0	0	0	0	0	1023	0+E	343B

+E 343B	1024								
CHEXA	344	1	367	460	461	368	379	463+E	191
+E 191	464	380	0	0	0	0	0	0+E	344B
+E 344B	0	0	1024	0	0	1025			
CHEXA	322	1	384	390	391	385	396	402+E	169
+E 169	403	397	0	0	0	0	0	0+E	322B
+E 322B	0	0	0	0	1029	1031			
CHEXA	323	1	385	391	392	386	397	403+E	170
+E 170	404	398	0	0	0	0	0	0+E	323B
+E 323B	0	0	1029	0	0	1030			
CHEXA	346	1	459	384	385	460	462	396+E	193
+E 193	397	463	0	0	0	0	0	0+E	346B
+E 346B	0	0	0	1031	1032				
CHEXA	347	1	460	385	386	461	463	397+E	194
+E 194	398	464	0	0	0	0	0	0+E	347B
+E 347B	0	0	1032	1030					
CHEXA	326	1	406	418	419	407	430	442+E	173
+E 173	443	431	0	0	0	0	0	0+E	326B
+E 326B	0	0	0	0	1036	1038			
CHEXA	327	1	407	419	420	408	431	443+E	174
+E 174	444	432	0	0	0	0	0	0+E	327B
+E 327B	0	0	1036	0	0	1037			
CHEXA	356	1	471	406	407	472	482	430+E	203
+E 203	431	483	0	0	0	0	0	0+E	356B
+E 356B	0	0	0	1038	1039				
CHEXA	357	1	472	407	408	470	483	431+E	204
+E 204	432	481	0	0	0	0	0	0+E	357B
+E 357B	0	0	1039	1037					
CHEXA	330	1	410	422	423	411	434	446+E	177
+E 177	447	435	0	0	0	0	0	0+E	330B
+E 330B	0	0	0	0	1043	1045			
CHEXA	331	1	411	423	424	412	435	447+E	178
+E 178	448	436	0	0	0	0	0	0+E	331B
+E 331B	0	0	1043	0	0	1044			
CHEXA	366	1	475	410	411	495	486	434+E	213
+E 213	435	506	0	0	0	0	0	0+E	366B
+E 366B	0	0	0	1045	1046				
CHEXA	367	1	495	411	412	494	506	435+E	214
+E 214	436	505	0	0	0	0	0	0+E	367B
+E 367B	0	0	1046	1044					
CHEXA	334	1	414	426	427	415	438	450+E	181
+E 181	451	439	0	0	0	0	0	0+E	334B
+E 334B	0	0	0	0	1050	1052			
CHEXA	335	1	415	427	428	416	439	451+E	182
+E 182	452	440	0	0	0	0	0	0+E	335B
+E 335B	0	0	1050	0	0	1051			
CHEXA	370	1	492	414	415	496	503	438+E	217
+E 217	439	507	0	0	0	0	0	0+E	370B
+E 370B	0	0	0	1052	1053				
CHEXA	371	1	496	415	416	497	507	439+E	218
+E 218	440	508	0	0	0	0	0	0+E	371B
+E 371B	0	0	1053	1051					
CHEXA	348	1	125	136	473	465	138	149+E	195
+E 195	484	476	0	0	0	0	0	0+E	348B
+E 348B	0	0	0	0	1057	1059			
CHEXA	349	1	465	473	471	466	476	484+E	196
+E 196	482	477	0	0	0	0	0	0+E	349B
+E 349B	0	0	1057	0	0	1058			
CHEXA	383	1	38	125	465	519	52	138+E	230
+E 230	476	523	0	0	0	0	0	0+E	383B
+E 383B	0	0	0	1059	1060				
CHEXA	384	1	519	465	466	517	523	476+E	231
+E 231	477	521	0	0	0	0	0	0+E	384B
+E 384B	0	0	1060	1058					
CHEXA	353	1	468	474	475	469	479	485+E	200
+E 200	486	480	0	0	0	0	0	0+E	353B
+E 353B	0	0	0	0	1064	1067			
CHEXA	360	1	469	475	495	487	480	486+E	207
+E 207	506	498	0	0	0	0	0	0+E	360B
+E 360B	0	0	1064	0	0	1065			
CHEXA	375	1	389	469	487	512	401	480+E	222
+E 222	498	516	0	0	0	0	0	0+E	375B
+E 375B	0	0	1066	1065					
CHEXA	387	1	520	468	469	389	524	479+E	234
+E 234	480	401	0	0	0	0	0	0+E	387B
+E 387B	0	0	0	1067	1066				
CHEXA	364	1	489	492	496	490	500	503+E	211
+E 211	507	501	0	0	0	0	0	0+E	364B
+E 364B	0	0	0	0	1071	1073			
CHEXA	365	1	490	496	497	491	501	507+E	212
+E 212	508	502	0	0	0	0	0	0+E	365B
+E 365B	0	0	1071	0	0	1072			
CHEXA	378	1	509	489	490	511	513	500+E	225
+E 225	501	515	0	0	0	0	0	0+E	378B
+E 378B	0	0	0	1073	1074				
CHEXA	379	1	511	490	491	392	515	501+E	226
+E 226	502	404	0	0	0	0	0	0+E	379B
+E 379B	0	0	1074	1072					
CHEXA	392	1	193	528	531	197	205	537+E	239
+E 239	540	209	0	0	0	0	0	0+E	392B
+E 392B	0	0	0	1078	1080				
CHEXA	393	1	528	529	532	531	537	538+E	240

+E 240	541	540	0	0	0	0	0	0+E	393B
+E 393B	0	0	0	0	1079	1078			
CHEXA	414	1	197	531	607	287	209	540+E	261
+E 261	610	291	0	0	0	0	0	0+E	414B
+E 414B	0	0	1080	1081					
CPENTA	415	1	531	608	607	540	611	610+E	415A
+E 415A	0	0	0	0	0	0	1082	0+E	415B
+E 415B	1081								
CHEXA	416	1	531	532	609	608	540	541+E	263
+E 263	612	611	0	0	0	0	0	0+E	416B
+E 416B	0	0	1079	0	0	1082			
CHEXA	396	1	213	543	548	219	225	553+E	243
+E 243	558	231	0	0	0	0	0	0+E	396B
+E 396B	0	0	1086	1087					
CHEXA	397	1	543	544	549	548	553	554+E	244
+E 244	559	558	0	0	0	0	0	0+E	397B
+E 397B	0	0	1089	0	0	1087			
CHEXA	417	1	287	607	543	213	291	610+E	264
+E 264	553	225	0	0	0	0	0	0+E	417B
+E 417B	0	0	0	1088	1086				
CHEXA	418	1	607	608	544	543	610	611+E	265
+E 265	554	553	0	0	0	0	0	0+E	418B
+E 418B	0	0	0	0	1089	1088			
CHEXA	398	1	544	545	550	549	554	555+E	245
+E 245	560	559	0	0	0	0	0	0+E	398B
+E 398B	0	0	1093	1094					
CHEXA	399	1	545	546	551	550	555	556+E	246
+E 246	561	560	0	0	0	0	0	0+E	399B
+E 399B	0	0	1096	0	0	1094			
CHEXA	419	1	608	609	545	544	611	612+E	266
+E 266	555	554	0	0	0	0	0	0+E	419B
+E 419B	0	0	0	1095	1093				
CHEXA	423	1	609	613	546	545	612	615+E	270
+E 270	556	555	0	0	0	0	0	0+E	423B
+E 423B	0	0	0	0	1096	1095			
CHEXA	402	1	237	563	574	249	261	585+E	249
+E 249	596	273	0	0	0	0	0	0+E	402B
+E 402B	0	0	1100	1101					
CHEXA	403	1	563	564	575	574	585	586+E	250
+E 250	597	596	0	0	0	0	0	0+E	403B
+E 403B	0	0	1103	0	0	1101			
CHEXA	432	1	308	625	563	237	321	636+E	279
+E 279	585	261	0	0	0	0	0	0+E	432B
+E 432B	0	0	0	1102	1100				
CHEXA	433	1	625	623	564	563	636	634+E	280
+E 280	586	585	0	0	0	0	0	0+E	433B
+E 433B	0	0	0	0	1103	1102			
CHEXA	406	1	566	567	578	577	588	589+E	253
+E 253	600	599	0	0	0	0	0	0+E	406B
+E 406B	0	0	1107	1108					
CHEXA	407	1	567	568	579	578	589	590+E	254
+E 254	601	600	0	0	0	0	0	0+E	407B
+E 407B	0	0	1110	0	0	1108			
CHEXA	436	1	622	626	567	566	633	637+E	283
+E 283	589	588	0	0	0	0	0	0+E	436B
+E 436B	0	0	0	1109	1107				
CHEXA	437	1	626	627	568	567	637	638+E	284
+E 284	590	589	0	0	0	0	0	0+E	437B
+E 437B	0	0	0	0	1110	1109			
CHEXA	410	1	570	571	582	581	592	593+E	257
+E 257	604	603	0	0	0	0	0	0+E	410B
+E 410B	0	0	1114	1115					
CHEXA	411	1	571	572	583	582	593	594+E	258
+E 258	605	604	0	0	0	0	0	0+E	411B
+E 411B	0	0	1117	0	0	1115			
CHEXA	446	1	645	644	571	570	654	653+E	293
+E 293	593	592	0	0	0	0	0	0+E	446B
+E 446B	0	0	0	1116	1114				
CHEXA	447	1	644	643	572	571	653	652+E	294
+E 294	594	593	0	0	0	0	0	0+E	447B
+E 447B	0	0	0	0	1117	1116			
CHEXA	429	1	618	619	622	624	629	630+E	276
+E 276	633	635	0	0	0	0	0	0+E	429B
+E 429B	0	0	1121	1122					
CHEXA	430	1	619	620	626	622	630	631+E	277
+E 277	637	633	0	0	0	0	0	0+E	430B
+E 430B	0	0	1124	0	0	1122			
CHEXA	463	1	665	666	619	618	669	670+E	310
+E 310	630	629	0	0	0	0	0	0+E	463B
+E 463B	0	0	0	1123	1121				
CHEXA	464	1	666	668	620	619	670	672+E	311
+E 311	631	630	0	0	0	0	0	0+E	464B
+E 464B	0	0	0	0	1124	1123			
CHEXA	439	1	639	640	645	646	648	649+E	286
+E 286	654	655	0	0	0	0	0	0+E	439B
+E 439B	0	0	1128	1129					
CPENTA	440	1	640	644	645	649	653	654+E	440A
+E 440A	0	0	0	0	0	0	1130	0+E	440B
+E 440B	1129								
CHEXA	441	1	640	641	643	644	649	650+E	288
+E 288	652	653	0	0	0	0	0	0+E	441B
+E 441B	0	0	1132	0	0	1130			

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CHEXA          454        1      660      658      640      639      664      662+E   301
+E   301       649      648        0        0        0        0        0        0+E  454B
+E  454B         0        0        0     1131     1128
CHEXA          455        1      658      657      641      640      662      661+E   302
-E   302       650      649        0        0        0        0        0        0+E  455B
-E  455B         0        0        0        0     1132     1131
SLATERAL SUPPORT CONSTRAINTS
SLATERAL SUPPORT SYSTEM  1
MPC              1      673        3 1.00000      673        1 0.57735        +MPC    1
+MPC    1        674        2 1.15470      675       2-1.15470        +MPC    2
+MPC    2        681        3 1.00000      681        1 0.57735        +MPC    3
-MPC    3        682        2 1.15470      683       2-1.15470        +MPC    4
+MPC    4        688        3 1.00000      688        1 0.57735        +MPC    5
+MPC    5        689        2 1.15470      690       2-1.15470        +MPC    6
+MPC    6        695        3 1.00000      695        1 0.57735        +MPC    7
+MPC    7        696        2 1.15470      697       2-1.15470        +MPC    8
+MPC    8        702        3 1.00000      702        1 0.57735        +MPC    9
+MPC    9        703        2 1.15470      704       2-1.15470        +MPC   10
+MPC   10        709        3 1.00000      709        1 0.57735        +MPC   11
+MPC   11        710        2 1.15470      711       2-1.15470        +MPC   12
+MPC   12        716        3 1.00000      716        1 0.57735        +MPC   13
+MPC   13        717        2 1.15470      718       2-1.15470        +MPC   14
+MPC   14        724        3 1.00000      724        1 0.57735        +MPC   15
+MPC   15        725        2 1.15470      726       2-1.15470        +MPC   16
+MPC   16        732        3 1.00000      732        1 0.57735        +MPC   17
+MPC   17        733        2 1.15470      734       2-1.15470        +MPC   18
+MPC   18        739        3 1.00000      739        1 0.57735        +MPC   19
+MPC   19        740        2 1.15470      741       2-1.15470        +MPC   20
+MPC   20        746        3 1.00000      746        1 0.57735        +MPC   21
+MPC   21        747        2 1.15470      748       2-1.15470        +MPC   22
+MPC   22        753        3 1.00000      753        1 0.57735        +MPC   23
+MPC   23        754        2 1.15470      755       2-1.15470        +MPC   24
+MPC   24        760        3 1.00000      760        1 0.57735        +MPC   25
+MPC   25        761        2 1.15470      762       2-1.15470        +MPC   26
+MPC   26        767        3 1.00000      767        1 0.57735        +MPC   27
+MPC   27        768        2 1.15470      769       2-1.15470        +MPC   28
+MPC   28        774        3 1.00000      774        1 0.57735        +MPC   29
+MPC   29        775        2 1.15470      776       2-1.15470        +MPC   30
+MPC   30        781        3 1.00000      781        1 0.57735        +MPC   31
+MPC   31        782        2 1.15470      783       2-1.15470        +MPC   32
+MPC   32        788        3 1.00000      788        1 0.57735        +MPC   33
+MPC   33        789        2 1.15470      790       2-1.15470        +MPC   34
+MPC   34        796        3 1.00000      796        1 0.57735        +MPC   35
+MPC   35        797        2 1.15470      798       2-1.15470        +MPC   36
+MPC   36        803        3 1.00000      803        1 0.57735        +MPC   37
+MPC   37        804        2 1.15470      805       2-1.15470        +MPC   38
+MPC   38        810        3 1.00000      810        1 0.57735        +MPC   39
+MPC   39        811        2 1.15470      812       2-1.15470        +MPC   40
+MPC   40        817        3 1.00000      817        1 0.57735        +MPC   41
-MPC   41        818        2 1.15470      819       2-1.15470        +MPC   42
-MPC   42        824        3 1.00000      824        1 0.57735        +MPC   43
+MPC   43        825        2 1.15470      826       2-1.15470        +MPC   44
+MPC   44        831        3 1.00000      831        1 0.57735        +MPC   45
+MPC   45        832        2 1.15470      833       2-1.15470        +MPC   46
+MPC   46        838        3 1.00000      838        1 0.57735        +MPC   47
-MPC   47        839        2 1.15470      840       2-1.15470        +MPC   48
+MPC   48        846        3 1.00000      846        1 0.57735        +MPC   49
+MPC   49        847        2 1.15470      848       2-1.15470        +MPC   50
+MPC   50        854        3 1.00000      854        1 0.57735        +MPC   51
+MPC   51        855        2 1.15470      856       2-1.15470        +MPC   52
+MPC   52        861        3 1.00000      861        1 0.57735        +MPC   53
+MPC   53        862        2 1.15470      863       2-1.15470        +MPC   54
+MPC   54        868        3 1.00000      868        1 0.57735        +MPC   55
+MPC   55        869        2 1.15470      870       2-1.15470        +MPC   56
+MPC   56        875        3 1.00000      875        1 0.57735        +MPC   57
+MPC   57        876        2 1.15470      877       2-1.15470        +MPC   58
+MPC   58        882        3 1.00000      882        1 0.57735        +MPC   59
+MPC   59        883        2 1.15470      884       2-1.15470        +MPC   60
+MPC   60        889        3 1.00000      889        1 0.57735        +MPC   61
+MPC   61        890        2 1.15470      891       2-1.15470        +MPC   62
+MPC   62        896        3 1.00000      896        1 0.57735        +MPC   63
+MPC   63        897        2 1.15470      898       2-1.15470
SLATERAL SUPPORT SYSTEM  2
MPC              2      903        3 1.00000      903       1-0.57735        +MPC   64
+MPC   64        904        2 1.15470      905       2-1.15470        +MPC   65
+MPC   65        911        3 1.00000      911       1-0.57735        +MPC   66
+MPC   66        912        2 1.15470      913       2-1.15470        +MPC   67
+MPC   67        918        3 1.00000      918       1-0.57735        +MPC   68
+MPC   68        919        2 1.15470      920       2-1.15470        +MPC   69
-MPC   69        925        3 1.00000      925       1-0.57735        +MPC   70
+MPC   70        926        2 1.15470      927       2-1.15470        +MPC   71
+MPC   71        932        3 1.00000      932       1-0.57735        +MPC   72
+MPC   72        933        2 1.15470      934       2-1.15470        +MPC   73
+MPC   73        939        3 1.00000      939       1-0.57735        +MPC   74
+MPC   74        940        2 1.15470      941       2-1.15470        +MPC   75
+MPC   75        946        3 1.00000      946       1-0.57735        +MPC   76
+MPC   76        947        2 1.15470      948       2-1.15470        +MPC   77
-MPC   77        953        3 1.00000      953       1-0.57735        +MPC   78
+MPC   78        954        2 1.15470      955       2-1.15470        +MPC   79
+MPC   79        960        3 1.00000      960       1-0.57735        +MPC   80
+MPC   80        961        2 1.15470      962       2-1.15470        +MPC   81
+MPC   81        967        3 1.00000      967       1-0.57735        +MPC   82
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+MPC   82                968        2 1.15470      969        2-1.15470          +MPC   83
+MPC   83                975        3 1.00000      975        1-0.57735          +MPC   84
+MPC   84                976        2 1.15470      977        2-1.15470          +MPC   85
+MPC   85                982        3 1.00000      982        1-0.57735          +MPC   86
+MPC   86                983        2 1.15470      984        2-1.15470          +MPC   87
+MPC   87                989        3 1.00000      989        1-0.57735          +MPC   88
+MPC   88                990        2 1.15470      991        2-1.15470          +MPC   89
+MPC   89                996        3 1.00000      996        1-0.57735          +MPC   90
+MPC   90                997        2 1.15470      998        2-1.15470          +MPC   91
+MPC   91               1003        3 1.00000     1003        1-0.57735          +MPC   92
+MPC   92               1004        2 1.15470     1005        2-1.15470          +MPC   93
+MPC   93               1010        3 1.00000     1010        1-0.57735          +MPC   94
+MPC   94               1011        2 1.15470     1012        2-1.15470          +MPC   95
+MPC   95               1018        3 1.00000     1018        1-0.57735          +MPC   96
+MPC   96               1019        2 1.15470     1020        2-1.15470          +MPC   97
+MPC   97               1026        3 1.00000     1026        1-0.57735          +MPC   98
+MPC   98               1027        2 1.15470     1028        2-1.15470          +MPC   99
+MPC   99               1033        3 1.00000     1033        1-0.57735          +MPC  100
+MPC  100               1034        2 1.15470     1035        2-1.15470          +MPC  101
+MPC  101               1040        3 1.00000     1040        1-0.57735          +MPC  102
+MPC  102               1041        2 1.15470     1042        2-1.15470          +MPC  103
+MPC  103               1047        3 1.00000     1047        1-0.57735          +MPC  104
+MPC  104               1048        2 1.15470     1049        2-1.15470          +MPC  105
+MPC  105               1054        3 1.00000     1054        1-0.57735          +MPC  106
+MPC  106               1055        2 1.15470     1056        2-1.15470          +MPC  107
+MPC  107               1061        3 1.00000     1061        1-0.57735          +MPC  108
+MPC  108               1062        2 1.15470     1063        2-1.15470          +MPC  109
+MPC  109               1068        3 1.00000     1068        1-0.57735          +MPC  110
+MPC  110               1069        2 1.15470     1070        2-1.15470          +MPC  111
+MPC  111               1075        3 1.00000     1075        1-0.57735          +MPC  112
+MPC  112               1076        2 1.15470     1077        2-1.15470          +MPC  113
+MPC  113               1083        3 1.00000     1083        1-0.57735          +MPC  114
+MPC  114               1084        2 1.15470     1085        2-1.15470          +MPC  115
+MPC  115               1090        3 1.00000     1090        1-0.57735          +MPC  116
+MPC  116               1091        2 1.15470     1092        2-1.15470          +MPC  117
+MPC  117               1097        3 1.00000     1097        1-0.57735          +MPC  118
+MPC  118               1098        2 1.15470     1099        2-1.15470          +MPC  119
+MPC  119               1104        3 1.00000     1104        1-0.57735          +MPC  120
+MPC  120               1105        2 1.15470     1106        2-1.15470          +MPC  121
+MPC  121               1111        3 1.00000     1111        1-0.57735          +MPC  122
+MPC  122               1112        2 1.15470     1113        2-1.15470          +MPC  123
+MPC  123               1118        3 1.00000     1118        1-0.57735          +MPC  124
+MPC  124               1119        2 1.15470     1120        2-1.15470          +MPC  125
+MPC  125               1125        3 1.00000     1125        1-0.57735          +MPC  126
+MPC  126               1126        2 1.15470     1127        2-1.15470
$AXIAL SUPPORT CONSTRAINTS
$AXIAL SUPPORT SYSTEM  1
MPC              3        27        2 1.00000       29        2 1.00000          +MPC  127
+MPC  127               212        2 1.00000      210        2 1.00000          +MPC  128
+MPC  128                48        2 1.00000       50        2 1.00000          +MPC  129
+MPC  129               230        2 1.00000      228        2 1.00000          +MPC  130
+MPC  130               143        2 1.00000      163        2 1.00000          +MPC  131
+MPC  131               165        2 1.00000      335        2 1.00000          +MPC  132
+MPC  132               333        2 1.00000      315        2 1.00000          +MPC  133
+MPC  133                90        2 1.00000       92        2 1.00000          +MPC  134
+MPC  134                94        2 1.00000       96        2 1.00000          +MPC  135
+MPC  135               272        2 1.00000      270        2 1.00000          +MPC  136
+MPC  136               268        2 1.00000      266        2 1.00000
$AXIAL SUPPORT SYSTEM  2
MPC              4       379        2 1.00000      377        2 1.00000          +MPC  137
+MPC  137               397        2 1.00000      395        2 1.00000          +MPC  138
+MPC  138               393        2 1.00000       46        2 1.00000          +MPC  139
+MPC  139               501        2 1.00000      499        2 1.00000          +MPC  140
+MPC  140               480        2 1.00000      478        2 1.00000          +MPC  141
+MPC  141               476        2 1.00000      139        2 1.00000          +MPC  142
+MPC  142               141        2 1.00000      439        2 1.00000          +MPC  143
+MPC  143               437        2 1.00000      435        2 1.00000          +MPC  144
+MPC  144               433        2 1.00000      431        2 1.00000          +MPC  145
+MPC  145               429        2 1.00000       86        2 1.00000          +MPC  146
+MPC  146                88        2 1.00000
$AXIAL SUPPORT SYSTEM  3
MPC              5       540        2 1.00000      542        2 1.00000          +MPC  147
+MPC  147               226        2 1.00000      553        2 1.00000          +MPC  148
+MPC  148               555        2 1.00000      557        2 1.00000          +MPC  149
+MPC  149               313        2 1.00000      311        2 1.00000          +MPC  150
+MPC  150               628        2 1.00000      630        2 1.00000          +MPC  151
+MPC  151               632        2 1.00000      649        2 1.00000          +MPC  152
+MPC  152               651        2 1.00000      264        2 1.00000          +MPC  153
+MPC  153               262        2 1.00000      585        2 1.00000          +MPC  154
+MPC  154               587        2 1.00000      589        2 1.00000          +MPC  155
+MPC  155               591        2 1.00000      593        2 1.00000          +MPC  156
+MPC  156               595        2 1.00000
MPCADD       1001        1        2        3        4        5
ENDDATA
```

6.3 NASTRAN Output

```
1
0
0
0
0
0
0
0
```

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* * * * * * * * * * * * * * * * * * * *
* * * * * * * * * * * * * * * * * * * *
* *                                 * *
* *                                 * *
* *                                 * *
* *                                 * *
* *      M S C / N A S T R A N      * *
* *                                 * *
* *         VERSION - 65C           * *
* *                                 * *
* *         NOV 24, 1987            * *
* *                                 * *
* *       CRAY RESEARCH INC.        * *
* *                                 * *
* *        MODEL CRAY X-MP          * *
* *                                 * *
* *            UNICOS               * *
* *                                 * *
* *             GH5P                * *
* * * * * * * * * * * * * * * * * * * *
* * * * * * * * * * * * * * * * * * * *
```

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1                                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE     1

0        N A S T R A N   E X E C U T I V E   C O N T R O L   D E C K   E C H O
0


     ID SOFIA TA ASSEMBLY MODEL
     SOL 24
     TIME 5.
     $ RF24D81 FOR GPS; RF24D41 FOR SORT STRESS OUTPUT(REF NUMOUT OR BIGGER)
     $ RF24D74 FOR INTERNAL RESEQUENCING(REF NEWSEQ)
     $ RF24D24 FOR CONTRAINT FORCES FROM MPCS AND RBES
     $ USE ONLY RF24D24 AND RF24D81
     READ 9
     $ OUTPUT: CONSTRAINT FORCES - OQG1
     $         NODAL DISPLACEMENTS - OUGV1
     $         ELEMENT STRESSES  - OES1
     $         ELEMENT FORCES    - OEF1
     $         GRID POINT STRESSES - OGS1
     $
     ALTER 176  $
     $OUTPUT2   ,OUGV1,OES1,OEF1,OGS1//-1/11  $
     OUTPUT2   ,OUGV1,OES1,,//-1/11  $
     CEND
1   STATIC MODEL                                                     SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE     2
     FINE MESH, 64 SUPPORTS
0
0                                   C A S E   C O N T R O L   D E C K   E C H O
                 CARD
                 COUNT
                  1       TITLE=STATIC MODEL
                  2       ECHO=SORT(MAT1,MAT2,MAT9,PARAM,PSOLID,PSHELL,SUPORT,SPC1,
                  3         RBE2,RBE3,CELAS2,RBAR,LOAD,GRAV,FORCE)
                  4       SPCFORCES(SORT1)=ALL
                  5       DISPL(PLOT)=ALL
                  6       $ELSTRESS(PLOT)=ALL
                  7       GPSTRESS(PLOT)= ALL
                  8       SUBTITLE=FINE MESH, 64 SUPPORTS
                  9       $ X-AXIS PARALLEL TO A.B. SHAFT, ROLL AXIS OF THE AIRCRAFT
                 10       $ THE MIRROR IS TO BE TILT ABOUT X-AXIS
                 11       SUBCASE = 1
                 12         LABEL =0 DEGREE ELEVATION, G1*SIN(0) + G2*COS(0)
                 13         SPC = 1
                 14         MPC = 1001
                 15         LOAD = 210
                 16       SUBCASE = 2
                 17         LABEL =20 DEGREE ELEVATION, G1*SIN(20) + G2*COS(20)
                 18         SPC = 1
                 19         MPC = 1001
                 20         LOAD = 220
                 21       SUBCASE = 3
                 22         LABEL =40 DEGREE ELEVATION, G1*SIN(40) + G2*COS(40)
                 23         SPC = 1
                 24         MPC = 1001
                 25         LOAD = 230
                 26       SUBCASE = 4
                 27         LABEL =60 DEGREE ELEVATION, G1*SIN(60) + G2*COS(60)
                 28         SPC = 1
                 29         MPC = 1001
                 30         LOAD = 240 .
                 31       SUBCASE = 5
                 32         LABEL =90 DEGREE EVEVATION, G1*SIN(90) + G2*COS(90)
                 33         SPC = 1
                 34         MPC = 1001
                 35         LOAD = 250
                 36       OUTPUT(PLOT)
                 37       CSCALE=4.0
                 38       PLOTTER NASTRAN
                 39       PAPER SIZE 105 X 80
                 40       SET 1 = ALL
                 41       AXES Z,X,Y
                 42       VIEW 0.,0.,0.
                 43       PTITLE= GEOM PLOT, XY VIEW
                 44       PLOT SET 1
                 45       AXES X,Z,Y
                 46       VIEW 0.,0.,0.
                 47       PTITLE= GEOM PLOT, ZY VIEW
```

```
                48      PLOT SET 1
                49      AXES Y,X,Z
                50      VIEW 0.,0.,0.
1   STATIC MODEL                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE     3
    FINE MESH, 64 SUPPORTS
0
0                                   C A S E   C O N T R O L   D E C K   E C H O
                CARD
                COUNT
                51      PTITLE= GEOM PLOT, XZ VIEW
                52      PLOT  SET 1
                53      AXES Z,X,Y
                54      VIEW 0.,0.,0.
                55      MAXIMUM DEFORMATION 40
                56      FIND SCALE, ORIGIN 1, SET 1
                57      PTITLE= DEFORM PLOT, XY PLANE
                58      PLOT STATIC 0, SET 1
                59      OUTPUT(POST)
                60      SET 1 = ALL
                61      VOLUME 1 SET 1
                62      $*******************************************************************        *
                63      $*SOFIATA1 MODEL: SOFIA TA ASSEMBLY, SPC1 AT AB CELAS END POINTS          *
                64      $*STATIC ANALYSIS - WTS VERIFICATION        (LSC/ARC  19 MAR, 1991)       *
                65      $*******************************************************************        *
                66      $
                67      BEGIN BULK
0                            INPUT BULK DATA CARD COUNT =    2537
1   STATIC MODEL                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE     4
    FINE MESH, 64 SUPPORTS
0
0                                       S O R T E D   B U L K   D A T A   E C H O
                CARD
                COUNT          .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
                 889-          GRAV    310     0       9806.65 0.      -1.     0.
                 890-          GRAV    320     0       9806.65 0.      0.      -1.
                2024-          LOAD    210     1.      0.      310     1.      320
                2025-          LOAD    220     1.      .342020 310     .939693 320
                2026-          LOAD    230     1.      .642788 310     .766044 320
                2027-          LOAD    240     1.      .866025 310     .5      320
                2028-          LOAD    250     1.      1.      310     0.      320
                2029-          MAT1    11      90250.0 36391.1 0.24000 2.520-6 1.200-7 0.      0.      +M      1
                2030-          +M    1 0.      0.      0.
                2193-          PARAM   AUTOSPC YES
                2194-          PARAM   GRDPNT  0
                2195-          PARAM   K6ROT   1.0
                2196-          PARAM   WTMASS  .001
                2197-          PSOLID  1       11
                2518-          SPC1    1       1       110     452
                               ENDDATA
0                        TOTAL COUNT=  2519

1   STATIC MODEL                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE     5
    FINE MESH, 64 SUPPORTS
0
                                                MESSAGES FROM THE PLOT MODULE


 P L O T T E R   D A T A

          THE FOLLOWING PLOTS ARE FOR A NASTPLT PLOTTER

          PAPER SIZE =105.0 X 80.0,  PAPER TYPE = VELLUM

          PEN 1 - SIZE 1, BLACK
          PEN 2 - SIZE 1, BLACK
          PEN 3 - SIZE 1, BLACK
          PEN 4 - SIZE 1, BLACK


 E N G I N E E R I N G   D A T A

          ORTHOGRAPHIC PROJECTION
          ROTATIONS (DEGREES) - GAMMA =   0.00, BETA =   0.00, ALPHA =   0.00,  AXES = +Z,+X,+Y, SYMMETRIC
          SCALE (OBJECT-TO-PLOT SIZE) = 3.689219E-02

          ORIGIN       0   -   X0 = -4.962000E+01, Y0 = -7.327714E+01      (INCHES)

 L I S T   O F   P L O T S

          PLOT    1     UNDEFORMED SHAPE
1   STATIC MODEL                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE     6
    FINE MESH, 64 SUPPORTS
0
                                                MESSAGES FROM THE PLOT MODULE


 P L O T T E R   D A T A

          THE FOLLOWING PLOTS ARE FOR A NASTPLT PLOTTER
```

```
PAPER SIZE =105.0 X 80.0,  PAPER TYPE = VELLUM

PEN 1 - SIZE 1, BLACK
PEN 2 - SIZE 1, BLACK
PEN 3 - SIZE 1, BLACK
PEN 4 - SIZE 1, BLACK

E N G I N E E R I N G   D A T A

ORTHOGRAPHIC PROJECTION
ROTATIONS (DEGREES) - GAMMA =   0.00, BETA =   0.00, ALPHA =   0.00,  AXES = +X,+Z,+Y, SYMMETRIC
SCALE (OBJECT-TO-PLOT SIZE) = 3.689219E-02

ORIGIN       0   -   X0 = -4.962000E+01, Y0 = -7.327714E+01     (INCHES)

L I S T   O F   P L O T S

PLOT    2     UNDEFORMED SHAPE
1   STATIC MODEL                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE     7
    FINE MESH, 64 SUPPORTS
0
                                                MESSAGES FROM THE PLOT MODULE


P L O T T E R   D A T A

THE FOLLOWING PLOTS ARE FOR A NASTPLT PLOTTER

PAPER SIZE =105.0 X 80.0,  PAPER TYPE = VELLUM

PEN 1 - SIZE 1, BLACK
PEN 2 - SIZE 1, BLACK
PEN 3 - SIZE 1, BLACK
PEN 4 - SIZE 1, BLACK

E N G I N E E R I N G   D A T A

ORTHOGRAPHIC PROJECTION
ROTATIONS (DEGREES) - GAMMA =   0.00, BETA =   0.00, ALPHA =   0.00,  AXES = +Y,+X,+Z, SYMMETRIC
SCALE (OBJECT-TO-PLOT SIZE) = 3.689219E-02

ORIGIN       0   -   X0 = -4.962000E+01, Y0 = -7.327714E+01     (INCHES)

L I S T   O F   P L O T S

PLOT    3     UNDEFORMED SHAPE


1   STATIC MODEL                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE     8
    FINE MESH, 64 SUPPORTS
0
                    O U T P U T   F R O M   G R I D   P O I N T   W E I G H T   G E N E R A T O R
0                                                  REFERENCE POINT =        0
                                                          M O
                 *  8.437091E+02  0.000000E+00  0.000000E+00  0.000000E+00 -1.121592E-08  7.390361E+05 *
                 *  0.000000E+00  8.437091E+02  0.000000E+00  1.121592E-08  0.000000E+00 -1.675711E-05 *
                 *  0.000000E+00  0.000000E+00  8.437091E+02 -7.390361E+05  1.675711E-05  0.000000E+00 *
                 *  0.000000E+00  1.121592E-08 -7.390361E+05  1.038424E+09  2.026940E-03 -2.355591E-07 *
                 * -1.121592E-08  0.000000E+00  1.675711E-05  2.027055E-03  7.776111E+08 -2.586603E-06 *
                 *  7.390361E+05 -1.675711E-05  0.000000E+00 -4.638423E-08 -2.237357E-06  1.038395E+09 *
                                                          S
                                  *  1.000000E+00  0.000000E+00  0.000000E+00 *
                                  *  0.000000E+00  1.000000E+00  0.000000E+00 *
                                  *  0.000000E+00  0.000000E+00  1.000000E+00 *
                     DIRECTION
                MASS AXIS SYSTEM (S)     MASS              X-C.G.         Y-C.G.         Z-C.G.
                         X            8.437091E+02     0.000000E+00 -8.759371E+02 -1.329358E-11
                         Y            8.437091E+02    -1.986124E-08  0.000000E+00 -1.329358E-11
                         Z            8.437091E+02    -1.986124E-08 -8.759371E+02  0.000000E+00
                                                          I(S)
                                  *  3.910752E+08 -1.670512E-02  2.355591E-07 *
                                  * -1.670512E-02  7.776111E+08 -7.237835E-06 *
                                  *  2.355591E-07 -7.237835E-06  3.910459E+08 *
                                                          I(Q)
                                  *  3.910752E+08                             *
                                  *                7.776111E+08               *
                                  *                             3.910459E+08  *
                                                           Q
                                  *  1.000000E+00  0.000000E+00  0.000000E+00 *
                                  *  0.000000E+00  1.000000E+00  0.000000E+00 *
                                  *  0.000000E+00  0.000000E+00  1.000000E+00 *

1   STATIC MODEL                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE     9
```

```
    FINE MESH, 64 SUPPORTS
0


0*** USER INFORMATION MESSAGE 4158---STATISTICS FOR SYMMETRIC DECOMPOSITION OF DATA BLOCK KLL      FOLLOW
          MAXIMUM RATIO OF MATRIX DIAGONAL TO FACTOR DIAGONAL = 5.1E+03 AT ROW NUMBER 2321


0*** USER INFORMATION MESSAGE 5293 FOR DATA BLOCK KLL

    LOAD SEQ. NO.              EPSILON              EXTERNAL WORK      EPSILONS LARGER THAN 0.001 ARE FLAGGED WITH
ASTERISKS
                1          -6.3381160E-10          2.9931169E-02
                2          -1.4487788E-09          4.1780840E-02
                3          -2.0551065E-09          7.2096719E-02
                4          -2.2585581E-09          1.0669348E-01
                5          -2.2568597E-09          1.3256078E-01




0*** USER INFORMATION MESSAGE ****,      THE LABEL IS XXXXXXXX FOR FORTRAN UNIT 11
                                  (MAXIMUM SIZE OF FORTRAN RECORDS WRITTEN =         7 WORDS.)
                                       (NUMBER OF FORTRAN RECORDS WRITTEN =         8 RECORDS.)
                                       (TOTAL DATA WRITTEN FOR TAPE LABEL =        17 WORDS.)
0*** USER INFORMATION MESSAGE 4114, DATA BLOCK OUGV1    WRITTEN ON FORTRAN UNIT 11, TRL =
                101                 0            45280                0                0                0
0
                                     (MAXIMUM POSSIBLE FORTRAN RECORD SIZE =      9218 WORDS.)
                                  (MAXIMUM SIZE OF FORTRAN RECORDS WRITTEN =      9056 WORDS.)
                                       (NUMBER OF FORTRAN RECORDS WRITTEN =        64 RECORDS.)
                                       (TOTAL DATA WRITTEN FOR DATA BLOCK =     46077 WORDS.)
1   STATIC MODEL                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE    10
     FINE MESH, 64 SUPPORTS                                                                          SUBCASE = 1
0    0 DEGREE ELEVATION, G1*SIN(0) + G2*COS(0)

                              F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

      POINT ID.   TYPE          T1              T2              T3              R1              R2              R3
          110       G     -2.056738E-06   0.0             0.0             0.0             0.0             0.0
          452       G     -1.893578E-06   0.0             0.0             0.0             0.0             0.0
1   STATIC MODEL                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE    11
     FINE MESH, 64 SUPPORTS                                                                          SUBCASE = 2
0    20 DEGREE ELEVATION, G1*SIN(20) + G2*COS(20)

                              F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

      POINT ID.   TYPE          T1              T2              T3              R1              R2              R3
          110       G      4.095441E-06   0.0             0.0             0.0             0.0             0.0
          452       G      3.861213E-06   0.0             0.0             0.0             0.0             0.0
1   STATIC MODEL                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE    12
     FINE MESH, 64 SUPPORTS                                                                          SUBCASE = 3
0    40 DEGREE ELEVATION, G1*SIN(40) + G2*COS(40)

                              F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

      POINT ID.   TYPE          T1              T2              T3              R1              R2              R3
          110       G      9.753803E-06   0.0             0.0             0.0             0.0             0.0
          452       G      9.150174E-06   0.0             0.0             0.0             0.0             0.0
1   STATIC MODEL                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE    13
     FINE MESH, 64 SUPPORTS                                                                          SUBCASE = 4
0    60 DEGREE ELEVATION, G1*SIN(60) + G2*COS(60)

                              F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

      POINT ID.   TYPE          T1              T2              T3              R1              R2              R3
          110       G      1.423558E-05   0.0             0.0             0.0             0.0             0.0
          452       G      1.333558E-05   0.0             0.0             0.0             0.0             0.0
1   STATIC MODEL                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE    14
     FINE MESH, 64 SUPPORTS                                                                          SUBCASE = 5
0    90 DEGREE EVEVATION, G1*SIN(90) + G2*COS(90)

                              F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

      POINT ID.   TYPE          T1              T2              T3              R1              R2              R3
          110       G      1.762526E-05   0.0             0.0             0.0             0.0             0.0
          452       G      1.649185E-05   0.0             0.0             0.0             0.0             0.0
1   STATIC MODEL                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE    15
     FINE MESH, 64 SUPPORTS
0



1   STATIC MODEL                                                    SEPTEMBER  16, 1992  MSC/NASTRAN 11/24/87
PAGE    16
     FINE MESH, 64 SUPPORTS
0
                                        MESSAGES FROM THE PLOT MODULE


 P L O T T E R   D A T A
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THE FOLLOWING PLOTS ARE FOR A NASTPLT PLOTTER

PAPER SIZE =105.0 X 80.0,  PAPER TYPE = VELLUM

PEN 1 - SIZE 1, BLACK
PEN 2 - SIZE 1, BLACK
PEN 3 - SIZE 1, BLACK
PEN 4 - SIZE 1, BLACK


E N G I N E E R I N G   D A T A

ORTHOGRAPHIC PROJECTION
ROTATIONS (DEGREES) - GAMMA =   0.00, BETA =   0.00, ALPHA =   0.00,  AXES = +Z,+X,+Y, SYMMETRIC
SCALE (OBJECT-TO-PLOT SIZE) = 3.508494E-02

ORIGIN      0   -   X0 = -4.962000E+01, Y0 = -6.850603E+01     (INCHES)
ORIGIN      1   -   X0 = -4.962000E+01, Y0 = -7.169400E+01     (INCHES)


L I S T   O F   P L O T S

PLOT    4   STATIC DEFORM.       1 - SUBCASE     210 - LOAD
PLOT    5   STATIC DEFORM.       2 - SUBCASE     220 - LOAD
PLOT    6   STATIC DEFORM.       3 - SUBCASE     230 - LOAD
PLOT    7   STATIC DEFORM.       4 - SUBCASE     240 - LOAD
PLOT    8   STATIC DEFORM.       5 - SUBCASE     250 - LOAD


1                                   * * * END OF JOB * * *


---------- pms.f04 ----------
          M S C / N A S T R A N   C R A Y   E X E C U T I O N   S U M M A R Y

DAY TIME   ELAPSED   I/O SEC   CPU SEC   MODULE
=== BEGIN LINK  1 ===
11:11:53      0:00     0.000     0.000   SEM1 BEGNXSOR
11:11:53      0:00     0.070     0.132   XSOR
11:12:01      0:02     0.275     2.199   IFP
11:12:03      0:03     0.470     3.167   XGPI
=== BEGIN LINK  2 ===
11:12:06      0:00     0.545     3.806   9    GP1      BEGN
11:12:06      0:00     0.685     3.907   11   GP2      BEGN
11:12:06      0:00     0.735     3.955   15   PLTHBDY  BEGN
11:12:06      0:00     0.795     3.962   17   PLTSET   BEGN
11:12:06      0:00     0.890     4.007   17   PLTSET   END
11:12:06      0:00     0.930     4.009   19   PRTMSG   BEGN
11:12:06      0:00     0.945     4.013   22   PLOT     BEGN
11:12:11      0:02     1.085     6.148   22   PLOT     END
11:12:11      0:02     1.135     6.151   23   PRTMSG   BEGN
11:12:12      0:02     1.150     6.180   26   GP3      BEGN
11:12:12      0:02     1.235     6.188   28   TA1      BEGN
=== BEGIN LINK  9 ===
11:12:13      0:03     1.680     6.676   31   EMG      BEGN
11:12:32      0:09     1.930    13.395   31   EMG      END
11:12:32      0:09     1.970    13.400   37   EMA      BEGN
11:12:53      0:12     2.610    16.096   37   EMA      END
11:12:53      0:12     2.645    16.101   41   EMA      BEGN
11:12:58      0:14     2.910    17.967   41   EMA      END
=== BEGIN LINK  2 ===
11:12:58      0:14     2.955    17.981   43   ELTPRT   BEGN
11:12:58      0:14     3.005    17.991   43   ELTPRT   END
=== BEGIN LINK  4 ===
11:12:58      0:14     3.045    18.026   79   GPWG     BEGN
=== BEGIN LINK 14 ===
11:13:02      0:15     3.405    18.957   80   OFP      BEGN
=== BEGIN LINK  4 ===
11:13:03      0:15     3.440    19.002   97   GP4      BEGN
11:13:07      0:16     3.570    20.163   97   GP4      END
11:13:07      0:16     3.625    20.167   99   GPSP     BEGN
11:13:10      0:17     4.030    20.575   102  MCE1     BEGN
11:13:12      0:17     4.215    21.209   UDCO MP  TE= 1
11:13:12      0:17     4.275    21.417   UDCO MP  END
0*** USER INFORMATION MESSAGE 4234. UFBS TIME ESTIMATE TO FORM GM      ( TYPE=RSP ) CPU=     4. I/O=     0. TOTAL=
4. PASSES=   1
11:13:12      0:17     4.310    21.475   UFBS BEGN P= 1
11:13:37      0:18     4.410    21.790   UFBS END  NO
11:13:37      0:18     4.410    21.792   102  MCE1     END
11:13:38      0:18     4.430    21.796   106  MCE2     BEGN
                                         METHOD 1 NT, STORAGE 1, NBR PASSES=  12. EST. CPU=     2.4, I/O=     0.3, TOTAL=
2.8
11:13:43      0:19     4.985    23.358   MPYA D BGN P=12  D BG
11:13:51      0:22     5.555    26.161   MPYA D END   12
                                         METHOD 3 T , NBR PASSES=   1. EST. CPU=     5.3, I/O=     1.0, TOTAL=     6.4
11:13:51      0:22     5.555    26.165   MPYA D BGN P=1   D BG
11:14:13      0:26     6.360    30.319   MPYA D PASS= 1
11:14:13      0:26     6.360    30.320   MPYA D END   1
                                         METHOD 3 T , NBR PASSES=   1. EST. CPU=     7.0, I/O=     1.2, TOTAL=     8.2
11:14:13      0:26     6.360    30.324   MPYA D BGN P=1   D BG
11:14:52      0:35     7.515    38.886   MPYA D PASS= 1
11:14:52      0:35     7.515    38.888   MPYA D END   1
11:14:52      0:35     7.515    38.889   106  MCE2     END
11:14:53      0:35     7.540    38.893   110  SCE1     BEGN
11:14:59      0:37     8.280    41.028   110  SCE1     END
=== BEGIN LINK  7 ===
11:14:59      0:37     8.330    41.054   140  DCMP     BEGN
0*** USER INFORMATION MESSAGE 4157---PARAMETERS FOR SYMMETRIC DECOMPOSITION OF DATA BLOCK KLL      ( TYPE=RSP ) FOLLOW
              MATRIX SIZE =   2393 ROWS        CPU TIME ESTIMATE =      17 SEC
        ADDITIONAL MEMORY =-594850 WORDS         PASSIVE COLUMNS =       3 GROUPS
           ACTIVE COLUMNS =    886 MAX           PASSIVE COLUMNS =     697 MAX
```

```
            ACTIVE COLUMNS =     572 RMS          PASSIVE COLUMNS =     559 AVG
                     SPILL =       0 GROUPS      I/O TIME ESTIMATE =       4 SEC
                 SPILL ROWS =       0 AVG         NZ NBR IN FACTOR= 1265216 TERMS
          FACTOR STRNG LGTH =       9 AVG         FACTOR BAND WIDTH =   1178 AVG
 11:15:08       0:39     8.955    43.233   SDCO  BGN TE=17
 11:16:33       0:52    12.365    55.869   SDCO  END
 11:16:33       0:52    12.370    55.871   140  DCMP     END
 === BEGIN LINK  5 ===
 11:16:33       0:52    12.410    55.881   145  SSG1     BEGN
 11:16:35       0:52    12.570    56.237   145  SSG1     END
 11:16:35       0:52    12.615    56.243   148  SSG2     BEGN
 11:16:39       0:53    12.850    56.994   148  SSG2     END
 11:16:39       0:53    12.910    57.010   155  SSG3     BEGN
0*** USER INFORMATION MESSAGE 4153. FBS METHOD 1A TIME ESTIMATE TO FORM ULV       - CPU=      2, I/O=      4, TOTAL=      5,
PASSES=    1
 11:16:39       0:53    12.915    57.016   FBS  BEGN P=
 11:16:49       0:56    16.280    60.060   FBS  END  NO
                                         METHOD 1 NT, STORAGE 1, NBR PASSES=   1, EST. CPU=      1.7, I/O=      0.3, TOTAL=
2.0
 11:16:49       0:56    16.280    60.064   MPYA D BGN P=1    D BG
 11:16:59       0:57    16.625    60.575   MPYA D END    1
 11:16:59       0:57    16.670    60.729   155  SSG3     END
 === BEGIN LINK  7 ===
 11:17:00       0:57    16.730    60.749   160  SDR1     BEGN
 11:17:03       0:58    17.085    61.760   160  SDR1     END
 === BEGIN LINK 13 ===
 11:17:03       0:58    17.155    61.784   176  SDR2     BEGN
 11:17:03       0:58    17.365    62.136   176  SDR2     END
 === BEGIN LINK 14 ===
 11:17:04       0:58    17.450    62.146   176  OUTPUT2  BEGN
 11:17:04       0:58    17.515    62.162   185  OFP      BEGN
 11:17:04       0:58    17.640    62.368   186  SDRX     BEGN
 11:17:04       0:58    17.680    62.374   188  OFP      BEGN
 === BEGIN LINK 13 ===
 11:17:04       0:58    17.695    62.388   189  GPFDR    BEGN
 === BEGIN LINK 14 ===
 11:17:05       0:58    17.805    62.402   190  OFP      BEGN
 11:17:05       0:58    17.810    62.407   193  OFP      BEGN
 === BEGIN LINK  2 ===
 11:17:05       0:58    17.825    62.422   205  PLTSET   BEGN
 11:17:05       0:58    17.960    62.469   206  PRTMSG   BEGN
 11:17:05       0:58    17.975    62.472   207  PLOT     BEGN
 11:17:23       1:05    18.260    69.152   207  PLOT     END
 11:17:23       1:05    18.315    69.155   208  PRTMSG   BEGN
 === BEGIN LINK 13 ===
 11:17:23       1:05    18.340    69.180   210  SDR2     BEGN
 === BEGIN LINK 14 ===
 11:17:23       1:05    18.420    69.198   215  OFP      BEGN
 11:17:23       1:05    18.425    69.202   220  EXIT     BEGN
 ----------  pms.log  ----------
 started at  09/16/92 11:11:53 AM

 ------------------------
 PID=pms
 MEM=1000k
 SDIR=/scratch/tmpdir.024950a/25014
 SITE=GH5P
 FOR007=pms.pch
 ------------------------

  09/16/92  11:11:53  LINK  1 BEGINS

  ***** user warning message 5440 ***** msc/nastran will stop functioning within three mont.s
  please contact the macneal-schwendler corporation for an extension to the contract.
  09/16/92  11:12:06  LINK  2 BEGINS
  09/16/92  11:12:13  LINK  9 BEGINS
  09/16/92  11:12:58  LINK  2 BEGINS
  09/16/92  11:12:58  LINK  4 BEGINS
  09/16/92  11:13:02  LINK 14 BEGINS
  09/16/92  11:13:03  LINK  4 BEGINS
  09/16/92  11:14:59  LINK  7 BEGINS
  09/16/92  11:16:33  LINK  5 BEGINS
  09/16/92  11:16:59  LINK  7 BEGINS
  09/16/92  11:17:03  LINK 13 BEGINS
  09/16/92  11:17:04  LINK 14 BEGINS
  09/16/92  11:17:04  LINK 13 BEGINS
  09/16/92  11:17:05  LINK 14 BEGINS
  09/16/92  11:17:05  LINK  2 BEGINS
  09/16/92  11:17:23  LINK 13 BEGINS
  09/16/92  11:17:23  LINK 14 BEGINS
   STOP                in WRAPUP
 finished at 09/16/92 11:17:25 AM
```

6.4 SURFNODE

```
!FUNCTION SURFNODE(FILENAME)
!
!/*THIS FUNCTION EXTRACTS THE NODES THAT LIE ON THE REFLECTIVE
!  SURFACE OF THE SOLID ELEMENT SOFIA PRIMARY MIRROR MODEL.
!  THESE NODES ARE THEN WRITTEN TO AN ASCII FILE THAT WILL
!  BECOME ONE OF THE INPUT FILES FOR THE NAS2FR PROGRAM.*/
!
!/*VARIABLE DECLARATIONS*/
!REAL XYZ(3),RADCURV,NODERAD,XCENTER,YCENTER,ZCENTER,RADTOL
!INTEGER NODE,CONDEN,NODOF,CONFIG,COORDF,SPCF(6),STATUS,NODEMAX,@
!  NODEIN(700),NODEINCOUNT,WRITECOUNT,I,FID,NODEREMAIN
!STRING TYPE[1],FILENAME[31]
!
!/*INPUT CONSTANTS*/
!RADCURV=6220.
!XCENTER=0.
!YCENTER=5300.
```

```
!ZCENTER=0.
!RADTOL=10.
!
!/*ALGORITHMIC CONSTANTS*/
!NODE=0
!NODEINCOUNT=0
!NODEMAX=700
!FID=10
!
!/*************************************************************/
!/*BEGIN ALGORITHM*/
!/*************************************************************/
!
! IF(FILENAME=="") THEN
! FIO_OPENW("NAS2FR.NOD",FID)
! END_IF
!
! IF(FILENAME:="") THEN
! FIO_OPENW(FILENAME,FID)
! END_IF
!
!/*EXTRACT NODES LOCATED ON SURFACE*/
! WHILE(NODE<NODEMAX)
! NODE=NODE+1
! DB_NODE(NODE,XYZ,CONDEN,TYPE,NODOF,CONFIG,COORDF,SPCF,STATUS)
!  IF (STATUS==0) THEN
!  NODERAD=( (XYZ(1)-XCENTER)**2 + (XYZ(2)-YCENTER)**2 @
!          + (XYZ(3)-ZCENTER)**2 )**0.5
!   IF (MTH_ABS(NODERAD-RADCURV)<RADTOL) THEN
!   NODEINCOUNT=NODEINCOUNT+1
!   NODEIN(NODEINCOUNT)=NODE
!   END_IF
!  END_IF
! END_WHILE
!
!/*WRITE TO OUTPUT FILE*/
!WRITECOUNT=0
!/* WHILE(WRITECOUNT<(NODEINCOUNT-10))
! WRITECOUNT=WRITECOUNT+10
! FIO_WRITEF(FID,"(10I5)",NODEIN(WRITECOUNT-9:WRITECOUNT))
! END_WHILE
!NODEREMAIN=NODEINCOUNT-WRITECOUNT
!FIO_WRITEF(FID,"(10I5)",NODEIN(WRITECOUNT+1:@
!            WRITECOUNT+NODEREMAIN))*/
! WHILE(WRITECOUNT<NODEINCOUNT)
! WRITECOUNT=WRITECOUNT+10
! FIO_WRITEF(FID,"(10I5)",NODEIN(WRITECOUNT-9:WRITECOUNT))
! END_WHILE
!FIO_CLOSE(FID)
!END_FUNCTION
```

6.5 NAS2FR

```
C234567890c234567890c234567890c234567890c234567890c234567890c23456789012
C
C          MAIN PROGRAM
           PROGRAM NAS2FR
C
C          Purpose: to read NASTRAN input deck, user input sequencec of
C          selected and user specified initial ray, to calculate three unit
C          vectors of each selected optical elements, the hit coordinates of
C          each given incident ray and the reflected ray, and to continute
C          the process until all the reflected rays are computed for each
C          given incident ray, and to loop through the same process for each
C          optical surfaces/elements.
C
C          Subroutines:
C            fio_name:          specify/open the input/output file names to be
C                               used.  f11=NASTRAN input file, f31=output refl.rays
C
           implicit integer (a-z)
           real xyz
           data n1/10000*0/,xyz/30000*0./
           common/nasgd/n1(10000),xyz(3,10000),cord(36),crid(2,5),cdof(9000),
     &                ncrd,ng /nasel/nt,nq,np,nh,e3(4,5000),e4(5,5000),e6(7,5000),
     &                e8(9,5000)
           common /selq/noeq,tno,idg(10),sgn(500)
         COMMON /BLNKIN/SCTIT(20,200),NOTBLNK
           call fio_name
           call nasBdf
           call chknasin
         CALL READGD
           call selgd
           call chksgn
           call xyztab
         CALL XYZBIN
         CALL DEFTAB
           close (31)
         CLOSE (28)
C         CLOSE (21)
           close (22)
           close (11)
           stop
           end
C
           subroutine fio_name
C          specify/open the input/output file names to be used. Max length
C          of file name is 72 characters including directories.
C          f11=NASTRAN input file
C          f31=output file of reflected rays for PATRAN graphic viewing
C        F28=OUTPUT BINARY FILE OF GRID GEOMETRY FOR FRINGE INPUT
C        F21=OUTPUT BINARY FILE OF GRID DEFLECTIONS FOR FRINGE INPUT
           character*72 f11,f31,F28,F21,f99
```

```
      COMMON /FIO/F11
        write(6,*) 'Enter the NASTRAN input file name: '
        write(6,*) 'default NAS2FR.BDF '
        read(5, '(a72)') f11
        if(index(f11,' ').le.0) f11='NAS2FR.BDF'
        write(6,*) 'Enter the NAS2FR output file name: '
        write(6,*) 'default NAS2FR.OUT '
        read(5, '(a72)') f31
C       write(6,*) '  index(f31,'' '') = ',index(f31,' ')
          if(index(f31,' ').le.1) THEN
        f31='NAS2FR.OUT'
C        F28='NAS2FR.GEO'
C        F21='NAS2FR.DEF'
        END IF
        IF(INDEX(F31,'.').EQ.0) THEN
        F31=F31(1:(INDEX(F31,' ')-1))//'.OUT'
C        F28=F31(1:(INDEX(F31,' ')-1))//'.GEO'
C        F21=F31(1:(INDEX(F31,' ')-1))//'.DEF'
        END IF
C        IF(INDEX(F31,'.').GT.0) THEN
C        F28=F31(1:(INDEX(F31,'.'))-1)//'.GEO'
C        F21=F31(1:(INDEX(F31,'.'))-1)//'.DEF'
C        END IF
        WRITE(6,*) 'Enter the FRINGE geometry input file name: '
        WRITE(6,*) 'default NAS2FR28.DAT'
      READ(5, '(A72)') F28
        IF(INDEX(F28,' ').LE.1) THEN
        F28='NAS2FR28.DAT'
        END IF
        IF(INDEX(F28,'.').EQ.0) THEN
        F28=F28(1:(INDEX(F28,' ')-1))//'28.DAT'
        END IF
C       WRITE(6,*) 'Enter the FRINGE deflection input file name: '
C       WRITE(6,*) 'default NAS2FR.DEF '
C      READ(5, '(A72)') F21
C        IF(INDEX(F21,' ').LE.1) THEN
C        F21='NAS2FR.DEF'
C        END IF
C        IF(INDEX(F21,'.').EQ.0) THEN
C        F21=F21(1:(INDEX(F21,' ')-1))//'.DEF'
C        END IF
        open(unit=11,file=f11,status='OLD',err=9001)
        open(unit=31,file=f31(1:index(f31,' ')),status='NEW',err=9002,
     &          form='formatted')
      OPEN(UNIT=28,FILE=F28(1:INDEX(F28,' ')),STATUS='NEW',ERR=9003,
     &       FORM='UNFORMATTED')
C      OPEN(UNIT=21,FILE=F21(1:INDEX(F21,' ')),STATUS='NEW',ERR=9004,
C     &       FORM='UNFORMATTED')
        goto 101
9001    write(6,*) ' *ERROR* input file name(f11): ',f11(1:index(f11,' '))
        go to 109
9002    write(6,*) ' *ERROR* output file name(f31):',f31(1:index(f31,' '))
        GO TO 109
9003    write(6,*) ' *ERROR* output file name(f28):',f28(1:index(f28,' '))
        GO TO 109
9004    write(6,*) ' *ERROR* output file name(f21):',f21(1:index(f21,' '))
109     stop
101     return
        end
C
        subroutine nasbdf
C       read NASTRAN input file from f11 (unit 11)
        implicit integer (a-z)
        character kword*4, keywd*4, card*80
        real xyz
        dimension kword(6)
        common/nasgd/nl(10000),xyz(3,10000),cord(36),crid(2,5),cdof(9000),
     &              ncrd,ng /nasel/nt,nq,np,nh,e3(4,5000),e4(5,5000),e6(7,5000),
     &              e8(9,5000)
        data kword,keywd/'CORD','GRID','CTRI','CQUA','CPEN','CHEX','XXXX'/
C       max keyword = maxk
        maxk=6
        do 101 i=1,maxk
102       read(11,fmt='(a)',err=9001) card
          if(card(1:4).eq.kword(i) .or. card(1:1).eq.keywd(1:1)) then
            call rcard(card,i,keywd)
            go to 102
          elseif (card(1:3).eq.'END') then
            rewind 11
            go to 101
          endif
          go to 102
101     continue
          go to 600
9001    write(6,*) ' *ERROR* subr_nasbdf during read unit 11: '
        write(6,*) ' Card: ',card(1:index(card,' '))
          stop
600     return
        end
C
        subroutine rcard(kard,n,keywd)
        implicit integer (a-z)
        character keywd*4, kard*(*),cp0(5)*2
        real xyz,cord
        common/nasgd/nl(10000),xyz(3,10000),cord(36),crid(2,5),cdof(9000),
     &              ncrd,ng /nasel/nt,nq,np,nh,e3(4,5000),e4(5,5000),e6(7,5000),
     &              e8(9,5000)
        data ncrd,ng,nt,nq,np,nh,cord/6*0,36*0/
C
C               CORD  GRID  CTRI  CQUA  CPEN  CHEX
        go to (100,  110,  120,  130,  140,  150) n
C
C..................................................... Process CORD card
C       max 4 local and one basic coordinate systems
100     if(keywd(1:1).ne.'+') then
          if(kard(1:5).ne.'CORD2') go to 9001
          ncrd=ncrd+1
          i=(ncrd-1)*12+1
```

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```
          k=i+5
          read(kard,fmt='(4x,a2,2x,2i8,6f8.4)',err=9002) cp0(ncrd),
     &          crid(1,ncrd),crid(2,ncrd),(cord(j),j=i,k)
          keywd='+XXX'
        else
          i=k+1
          k=i+2
          read(kard,fmt='(8x,3f8.4)',err=9002) (cord(j),j=i,k)
          keywd='XXXX'
          i=(ncrd-1)*12+1
          call tfc0(cord(i))
        endif
        go to 600
C..................................................... Process GRID card
110     if(kard(1:5).eq.'GRID,') go to 9011
        if(kard(1:5).ne.'GRID ') go to 9012
        nq=nq+1
      read(kard,fmt='(8x,2i8,3f8.4,i8)') nn,cpl,(xyz(j,nq),j=1,3)
     &          ,cdof(nq)
        cp=cpl
        nl(nq)=nn
        if(maxnd.lt.nn) maxnd=nn
        if (cp.eq.0) go to 600
        call cptype(cp,cp0,abs(ncrd),crid,js)
        if(cp.ne.0 .and. ncrd.ne.0) then
          if (ncrd.lt.0) go to 115
          call chkcrid(ncrd,crid,cord)
C               CORD2R  CORD2C  CORD2S
115       go to (111,     112,     113) cp
111       call tfc1(cpl,xyz(1,nq),cord(js),crid,abs(ncrd))
          go to 600
112       call tfc2(cpl,xyz(1,nq),cord(js),crid,abs(ncrd))
          go to 600
113       call tfc3(cpl,xyz(1,nq),cord(js),crid,abs(ncrd))
          go to 600
        else
          go to 9013
        endif
        go to 600
C
C..................................................... Process CTRI card
120     if(kard(1:7).ne.'CTRIA3 ') go to 9021
        nt=nt+1
        read(kard,fmt='(8x,i8,8x,3i8)') (e3(j,nt),j=1,4)
        go to 600
C
C..................................................... Process CQUA card
130     if(kard(1:7).ne.'CQUAD4 ') go to 9031
        nq=nq+1
        read(kard,fmt='(8x,i8,8x,4i8)') (e4(j,nq),j=1,5)
        go to 600
C
C..................................................... Process CPEN card
140     if(kard(1:7).ne.'CPENTA ') go to 9041
        np=np+1
        read(kard,fmt='(8x,i8,8x,6i8)') (e6(j,np),j=1,7)
        go to 600
C
C..................................................... Process CHEX card
150     if(keywd(1:1).ne.'+') then
          if(kard(1:6).ne.'CHEXA ') go to 9051
          nh=nh+1
          read(kard,fmt='(8x,i8,8x,6i8)') (e8(j,nh),j=1,7)
          keywd='+XXX'
        else
          read(kard,fmt='(8x,2i8)') (e8(j,nh),j=8,9)
          keywd='XXXX'
        endif
        go to 600
C
9001    write(31,2101) kard
2101    format(' *ERROR: ONLY CORD2-R,C,S ARE ALLOWED. '/,2x,A)
        go to 599
9002    write(31,2102) kard
2102    format(' *ERROR: READING THE FOLLOWING CARD:'/,2x,A)
        go to 599
9011    write(31,2111) kard
2111    format(' *ERROR: FREE FORMAT IS NOT CODED'/,2x,A)
        go to 599
9012    write(31,2112) kard
2112    format(' *ERROR: ONLY GRID IS ALLOWED IN THIS VERSION. '/,2x,a)
        go to 599
9013    write(31,2113) kard,cpl,ncrd
2113    format(' *ERROR: LOCAL COORD SYSTEM USED.'/,2x,A,'          CP='
     &          ,i3,5X,'NCRD=',i3,/,9x,'CHECK CARD SEQUENCE')
        go to 599
9021    write(31,2121) kard
2121    format(' *ERROR: ONLY CTRIA3 IS ALLOWED IN THIS VERSION. '/,2x,a)
        go to 599
9031    write(31,2131) kard
2131    format(' *ERROR: ONLY CQUAD4 IS ALLOWED IN THIS VERSION. '/,2x,a)
        go to 599
9041    write(31,2141) kard
2141    format(' *ERROR: ONLY CPENTA-6 IS ALLOWED IN THIS VERSION. '/,2x,a)
        go to 599
9051    write(31,2151) kard
2151    format(' *ERROR: ONLY CHEXA-8 IS ALLOWED IN THIS VERSION. '/,2x,a)
        go to 599
599     stop
600     return
        end
C
        subroutine cptype(cp,cp0,n,crid,js)
C       determine which local coordinate system that a GRID was defined.
C       js=starting index for direction cosine, cord(36)
        integer cp,crid(2,n),js
        character cp0(n)*2
        do i=1,n
```

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```
          if (cp.eq.crid(1,i)) then
            if(cp0(i).eq.'2R') cp=1
            if(cp0(i).eq.'2C') cp=2
            if(cp0(i).eq.'2S') cp=3
            js=(i-1)*12+1
            go to 600
          endif
          end do
          write(31,9001) cp,(crid(1,i),i=1,n)
9001      format(' *ERROR* local coord is not defined'/,2x,'cp=',i4,4x,
     &          'crid(1,1:',i1,')=',(i3))
600       end
C
          subroutine chkcrid(n,crid,cord)
C         find the basic coord system of crid
C         a=basic (rid) matrix, b=local (cid) matrix
          integer n,crid(2,n)
          real a(3,3),b(3,3),cord(36)
          do i=1,n
            do j=i,n
            if(crid(1,i).eq.crid(2,j)) then
              write(6,fmt='(a5,i4,a44,i4)') ' RID=',crid(2,j),
     &        ' is referenced to another coord system, CID=',crid(1,i)
              k1=(i-1)*12
              k2=(j-1)*12
C         initialize a, b arrays for matrix multiplication
              do ii=1,3
                do jj=1,3
                k1=k1+1
                k2=k2+1
                a(ii,jj)=cord(k1)
                b(ii,jj)=cord(k2)
                end do
              end do
              k2=(j-1)*12+1
C         calc  rotm-a(1:3,1:3) * rotm-b(1:3,1:3)
              do jj=1,3
                do ii=1,3
                k2=k2+1
                cord(k2)=a(ii,1)*b(1,jj)+a(ii,2)*b(2,jj)+a(ii,3)*b(3,jj)
                end do
              end do
              k1=(i-1)*12+9
              k2=(j-1)*12+9
C         calc translational vector, rotm-a * vector2 + vector1
              do ii=1,3
              b(ii,1)=a(ii,1)*cord(k2+1)+a(ii,2)*cord(k2+2)
     &                +a(ii,3)*cord(k2+3)
              end do
              do ii=1,3
              cord(k2+ii)=b(ii,1)+cord(k1+ii)
              end do
            endif
           end do
          end do
C         change ncrd to negative value for verification,n=ncrd
          n=-n
          end
C
          subroutine tfc0(a)
C         calc direction cosines in rid coord system and store them in a(1:9)
C         store translational vector in a(10:12) for each input of cord array
          real a(12),rm(3,3)
          do i=1,3
            a(i+9)=a(i)
          end do
          call rotm(a(1),a(4),a(7),rm)
          k=0
          do j=1,3
            do i=1,3
              k=k+1
              a(k)=rm(i,j)
            end do
          end do
          end
C
          subroutine chknasin
C         to print the first/last of each arrays read in subr. nasbdf
          implicit integer (a-z)
          real xyz,cord
          common/nasgd/nl(10000),xyz(3,10000),cord(36),crid(2,5),cdof(9000),
     &                ncrd,ng /nasel/nt,nq,np,nh,e3(4,5000),e4(5,5000),e6(7,5000),
     &                e8(9,5000)
          write(6,'(1x,a19,i4)') ' No. of Grid, ng = ',ng
          write(6,'(3x,a6,i4,2(5x,a3,i4,a2,i4)/)') 'nl(1)=',nl(1),
     &          'nl(',(ng+1)/2,')=',nl((ng+1)/2),'nl(',ng,')=',ng
          kk=abs(ncrd)
          write(6,'(a26,i3,a8)') ' Direction Cosines, total ',kk,' set(s):'
          do i=1,kk
          write(6,'(/3x,a4,i2,a3,3(5x,a,4x),10x,a2)') 'set ',i,' : ','x','y'
     &          ,'z','t0'
          j=(i-1)*12
            do k=1,3
            jj=j+k
          write(6,'(12x,3f10.4,5x,f10.4)') cord(jj),cord(jj+3),cord(jj+6),
     &          cord(jj+9)
            end do
          end do
          write(6,'(/a13)') ' Coordinates:'
          write(6,'(3x,a11,3f14.4)') 'xyz(1:3,1)=',(xyz(j,1),j=1,3)
          write(6,'(3x,a8,i4,a2,3f14.4)') 'xyz(1:3,',(ng+1)/2,')=',
     &        (xyz(j,(ng+1)/2),j=1,3)
          write(6,'(3x,a8,i4,a2,3f14.4/)') 'xyz(1:3,',ng,')=',(xyz(j,ng),j=1,3)
          if (nt.ne.0) then
          write(6,*) ' No. of Tri-plate nt = ',nt
          write(6,'(3x,a10,4i6)') 'e3(1:3,1)=',(e3(j,1),j=1,4)
          write(6,'(3x,a7,i4,a2,4i6/)') 'e3(1:3,',nt,')=',(e3(j,nt),j=1,4)
          endif
```

```
      if (nq.ne.0) then
      write(6,*) ' No. of Quad-plate nq = ',nq
      write(6,'(3x,a10,5i6)') ' e4(1:4,1)=',(e4(j,1),j=1,5)
      write(6,'(3x,a7,i4,a2,5i6/)') 'e4(1:4,',nq,')=',(e4(j,nq),j=1,5)
      endif
      if (np.ne.0) then
      write(6,*) ' No. of Penta-Solid elem, np = ',np
      write(6,'(3x,a10,i4,7i6)') 'e6(1:6,1)=',(e6(j,1),j=1,7)
      write(6,'(3x,a7,i4,a2,7i6/)') 'e6(1:6,',np,')=',(e6(j,np),j=1,7)
      endif
      if (nh.ne.0) then
      write(6,*) ' No. of Hexa-Solid elem, nh = ',nh
      write(6,'(3x,a10,i4,9i6)') 'e8(1:8,1)=',(e8(j,1),j=1,9)
      write(6,'(3x,a7,i4,a2,9i6/)') 'e8(1:8,',nh,')=',(e8(j,nh),j=1,9)
      endif
      end
C
      real function lenv(a,b,c)
C     length of a vector, ai+bj+ck.  i,j,k are unit vectors.
      real a,b,c
      lenv=sqrt(a*a+b*b+c*c)
      end
C
      subroutine vb2e(vb,ve,vbe)
C     calc component of vector, vbe=ve-vb; position vectors, vb & ve.
      dimension vb(3),ve(3),vbe(3)
      do i=1,3
        vbe(i)=ve(i)-vb(i)
      end do
      end
C
      subroutine axb(a,b,c)
C     cross product of vectors; vector a x vector b = vector c
      real a(3),b(3),c(3)
      c(1)=a(2)*b(3)-a(3)*b(2)
      c(2)=a(3)*b(1)-a(1)*b(3)
      c(3)=a(1)*b(2)-a(2)*b(1)
      end
C
      subroutine rotm(a,b,c,rm)
C     calc rotational matrix, rm, from position vectors, a,b,c given
C     in a basic coord system.
C     a is at a orgin of a local coord system,
C     b at a local z axis, and c and is in a local zx plan.
C     rm=the rotational matrix of the coord system defined by a,b,c.
C     rm * xyz(defined by abc) + a = xyz(in the basic coord system)
      external lenv
      real a(3),b(3),c(3),rm(3,3),lrm(3),lenv
      call vb2e(a,b,rm(1,3))
      call vb2e(a,c,rm(1,1))
      call axb(rm(1,3),rm(1,1),rm(1,2))
      do i=1,3
        lrm(i)=lenv(rm(1,i),rm(2,i),rm(3,i))
      end do
      do i=1,3
        do j=1,3
          rm(i,j)=rm(i,j)/lrm(i)
        end do
      end do
      end
C
      subroutine l2b(rm,tv,xl,xb)
C     transformation of coord system: xb = rm * xl + tv
C     rm = rotational matrix;  tv = translational vector;
C     xl = xyz in local coord system;  xb = xyz in basic coord system
      real rm(3,3),tv(3),xl(3),xb(3)
      do j=1,3
        xb(j)=0.0
        do i=1,3
          xb(j) = xb(j) + rm(i,j) * xl(i)
        end do
        xb(j)=xb(j)+tv(j)
      end do
      end
C
      subroutine tfc1(cpl,x,a,crid,n)
C     calc coordinate transformation for CORD2R option
      real x(3),xp(3),rm(3,3),a(12)
      integer crid(2,n),cpl
      do i=1,n
        if(cpl.eq.crid(1,i)) then
        j=0
        do ii=1,3
          do jj=1,3
          j=j+1
          rm(jj,ii)=a(j)
          end do
        end do
        call l2b(rm,a(j+1),x,xp)
        endif
      end do
      do i=1,3
        x(i)=xp(i)
      end do
      end
C
      subroutine tfc2(cpl,x,a,crid,n)
C     calc coordinate transformation for CORD2C option
      real x(3),xp(3),rm(3,3),dtr,a(12)
      integer crid(2,n),cpl
      data d2r/0.0174532925/
      x(2)=x(2)*d2r
      xp(1)=x(1)*cos(x(2))
      xp(2)=x(1)*sin(x(2))
      xp(3)=x(3)
      do i=1,n
        if(cpl.eq.crid(1,i)) then
        j=0
```

```
            do ii=1,3
              do jj=1,3
              j=j+1
              rm(jj,ii)=a(j)
              end do
            end do
            call l2b(rm,a(j+1),xp,x)
            endif
          end do
          end
C
          subroutine tfc3(cpl,x,a,crid,n)
C         calc coordinate transformation for CORD2S option
          real x(3),xp(3),rm(3,3),dtr,a(12)
          integer crid(2,n),cpl
          data d2r/0.0174532925/
          x(2)=x(2)*d2r
          x(3)=x(3)*d2r
          xp(1)=x(1)*sin(x(2))*cos(x(3))
          xp(2)=x(1)*sin(x(2))*sin(x(3))
          xp(3)=x(3)*cos(x(2))
          do i=1,n
            if(cpl.eq.crid(1,i)) then
            j=0
            do ii=1,3
              do jj=1,3
              j=j+1
              rm(jj,ii)=a(j)
              end do
            end do
            call l2b(rm,a(j+1),xp,x)
            endif
          end do
          end
          subroutine selgd
C         select support grids or grids on an equivalent mirror surface from
C         a NASTRAN model.
          implicit integer (a-z)
          common /selg/noeg,tno,idg(10),sgn(500),NOSELGD
          character string*80
C         write(6,*) ' Enter total no of optical element groups : '
C         read(5,*) noeg
      IF(NOSELGD.EQ.1) GOTO 9999
      NOEG=1
          data tno,tnop/1,1/
          do i=1,noeg
C         write(6,*) ' Enter the NASTRAN support grid nos for group No.',i
      WRITE(6,*) 'NOSELGD=',NOSELGD
      WRITE(6,*) 'Enter the NASTRAN support grid numbers.'
          read(5,'(a)') string
          call xstrng(string,sgn(tno),tnop)
          idg(i)=tnop
          tno=tno+tnop
          end do
          tno=tno-1
9999      end
c
          subroutine chksgn
c         check input sgn() array
          implicit integer (a-z)
          common /selg/noeg,tno,idg(10),sgn(500)
          write(6,*) ' '
C         write(6,*) ' Check input selected grid no for each optical element'
        WRITE(6,*) 'Check input selected grid numbers.'
          j1=0
          j2=0
          do i=1,noeg
c           write(6,'(/a27,i2,5x,a22,i3)') ' Optical element group no. ',i,
c     &             'sub-total no of grids:',idg(i)
            if(i.eq.1) j1=1
            if(i.ge.2) j1=idg(i-1)+j1
            j2=idg(i)+j2
            do k=j1,j2,8
              write(6,'(8i6)') (sgn(k+j-1),j=1,8)
            end do
          end do
          end
C
c
          subroutine xstrng(a,c,n1)
          implicit integer(b-z)
          character a*(*),s*13
c...      assume max strings xxxxtyyyy and use comma to separate input
c...      use ",+" to continue input
          dimension c(n1)
          n1=0
10        lens=index(a,',')
          if(lens.ne.0) then
            s=a(1:lens-1)
            call stype(s,s_type,jt)
          else
            s=a(1:index(a,' ')-1)
            call stype(s,s_type,jt)
            lens=index(a,' ')
          endif
c...      with xxtyy   or no from/to
c... string type:  1    or    2   s_type
          go to (   12,        14) s_type
12          call cnvt(s,jt,i1)
            s(1:)=s(jt+2:index(s,' '))
            call cnvt(s,index(s,' '),i2)
            do k=i1,i2
            n1=n1+1
            c(n1)=k
            end do
            go to 20
14          call cnvt(s,index(s,' '),i1)
            n1=n1+1
```

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          c(n1)=i1
20        s='                    '
          a(1:)=a(lens+1:index(a,'    '))
          if(index(a,'  ').eq.1) return
          if(index(a,'+').eq.1) read(5,'(a)') a
          go to 10
          end
c
          subroutine stype(ss,s_type,jt)
c...      jt chechk for both 't' and 'T' in the input string
          character ss*(*)
          integer jt,s_type
            jt=index(ss,'t')
            if(jt.eq.0) jt=index(ss,'T')
c...      assume it is string type 2, ie. w/o 't' or 'T'
            s_type=2
            if(jt.ne.0) s_type=1
          return
          end
c
          subroutine cnvt(ss,i1,i2)
c         i1=length(ss)+1;  i2=retruned integer
          character ss*(*)
          integer i,i1,i2
          i1=i1-1
          i2=0
          do i=1,i1
          i2=i2*10+ichar(ss(i:i))-48
          end do
          end
c
          subroutine xyztab
c         output a table of coordinates for selected grids
          implicit integer (a-z)
          real xyz
          common/nasgd/n1(10000),xyz(3,10000),cord(36),crid(2,5),cdof(9000),
     &                ncrd,ng /selg/noeg,tno,idg(10),sgn(500)
          dimension n2(500)
          do i=1,tno
            do j=1,ng
              if(n1(j).eq.sgn(i)) n2(i)=j
            end do
          end do
c
          j1=0
          j2=0
          do i=1,noeg
c           write(6,'(/a27,i2,5x,a22,i3)') ' Optical element group no. ',i,
c     &                'sub-total no of grids:',idg(i)
          WRITE(6,'(/1X,A17,I3)') 'Number of grids: ',IDG(I)
            write(6,'(/1x,a7,3(6x,a1,7x),2x,a8)') 'Grid ID','X','Y','Z',
     &                'Coord ID'
c           write(31,'(/a27,i2,5x,a22,i3)') ' Optical element group no. ',i,
c     &                'sub-total no of grids:',idg(i)
          WRITE(31,'(/1X,A17,I3)') 'Number of grids: ',IDG(I)
            write(31,'(/1x,a7,3(6x,a1,7x),2x,a8)') 'Grid ID','X','Y','Z',
     &                'Coord ID'
            if(i.eq.1) j1=1
            if(i.ge.2) j1=idg(i-1)+j1
            j2=idg(i)+j2
            do k=j1,j2
             write(6,'(i8,3f14.6,i8)') sgn(k),(xyz(j,n2(k)),j=1,3),cdof(n2(k))
             write(31,'(i8,3f14.6,i8)') sgn(k),(xyz(j,n2(k)),j=1,3),cdof(n2(k))
            end do
          end do
          end
c
      SUBROUTINE XYZBIN
      IMPLICIT INTEGER (A-Z)
      REAL XYZ
      CHARACTER*4 DUM1
      common/nasgd/n1(10000),xyz(3,10000),cord(36),crid(2,5),cdof(9000),
     &                ncrd,ng /selg/noeg,tno,idg(10),sgn(500)
      COMMON/BLNKIN/SCTIT(20,200)
      dimension n2(500),DUM1(12)
      DATA DUM1/12*'XXXX'/
       do i=1,tno
        do j=1,ng
        if(n1(j).eq.sgn(i)) n2(i)=j
        end do
       end do
c
      j1=0
      j2=0
       do i=1,noeg
        if(i.eq.1) j1=1
        if(i.ge.2) j1=idg(i-1)+j1
       j2=idg(i)+j2
       WRITE(28) (DUM1(J),J=1,12),IDG(I)
       WRITE(28)
       WRITE(28)
       WRITE(28) (XYZ(1,N2(J)),J=J1,J2)
       WRITE(28) (XYZ(2,N2(J)),J=J1,J2)
       WRITE(28) (XYZ(3,N2(J)),J=J1,J2)
       end do
      end
c     23AUG91
c     THE PURPOSE OF THIS ROUTINE IS TO TRANSLATE A NASTRAN INPUT DECK
c     INTO A BINARY FILE CONTAINING NODAL DEFLECTIONS IN A FORMAT
c     READABLE BY THE PROGRAM FRINGE.
c
c     THIS VERSION PROCESSES THE NODAL DISPLACEMENTS ONLY.
c
c     ONLY THE GRIDS AND ELEMENTS ARE TRANSLATED.  THE ASSOCIATE
c     INFORMATION SUCH AS CONSTRAINTS, MATERIAL, AND PROPERTIES ARE
c     NOT INCLUDED.
c
c     N1: NODAL SEQUENCE AS IT WAS INPUT.(NOT CODED)
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C     N2: NEW NODAL SEQUENCE AS WAS STORED IN ORIGINAL ORDER
C     E2: TWO NODES ELEMENTS(CROD,CBAR,CBEAM)
C     E3: THREE NODES ELEMENTS(CTRIA3)
C     E4: FOUR NODES ELEMENTS(CQUAD4)
C     OTHER DETAILED INFORMATION ARE NOT TRANSLATED IN THIS VERSION.
C
C     F22: NASTRAN output2 file
C     MAX 72 CHARACTERS IS ALLOWED FOR A FILE NAME.
C
C     XYZ: COORDINATES IN THE NASTRAN BASIC COORDINATE SYSTEM. IT USES
C          THE NEW NODAL SEQUENCE, IS.  MAX. 10000 NODES
C     MS : MODE SHAPES
C
c          PROGRAM OUGV1
      SUBROUTINE DEFTAB
      IMPLICIT INTEGER (A-Z)
c      CHARACTER*72 F11,F12,F21,F22,F23
      CHARACTER*72 F22,F11
c      REAL XYZ(10000,3), MS, DB, defmax, def
      real avgdef,rmsdef,def
c      COMMON /dbpin/n2(10000),db(15),ms(10000,6)
      COMMON /dbpin/n2(10000),db(15)
      COMMON /BUFFER/IN,ICBP,IRL
      common /selg/noeq,tno,idg(10),sgn(500)
      common /blnkin/sctit(20,200),notblnk
      common /avgin/def(20,10000,6),avgdef(6),rmsdef(6),LCIN(20),
     &LCMAX,LCEND
C      COMMON /FILENM/F22
      COMMON /FIO/F11
      DIMENSION GP (10000),NAM(2),T(7),LAB(2),TIT(20),DBNAME(5),IDB(5),
     &  ect(22),nodein(500)
      EQUIVALENCE  (IGRID,ICS,DB(1)),(IGTYP,ICYL,DB(2))
      equivalence (n11,tno),(nodein,sgn)
      DATA DBNAME/'OUGV','GPL ','BGPD',
     &  'GEOM','CSTM'/
      DATA (IDB(I),I=2,5)/3000,4,22,14/
      DATA LC,LCMAX/2*0/
c      DATA IUN/11/
c      DATA IOUT/23/
      DATA IUN/22/
      DATA IOUT/31/
      data nnodes,maxnod,defmax,ndmax,nwidth/2*0,0.0,2*0/
      CALL FILENAME
10    CONTINUE
      DBTYP=1
      CALL IOPEN(IUN,IOUT,LAB)
C      WRITE(IOUT,6010) LAB
C6010  FORMAT('# USER FILE LABELED ',2A4,' WAS OPENED. ')
C
C.....CALL IHEADR ONLY ONCE FOR EACH DATA BLOCK
12    CALL IHEADR(IUN,IOUT,NAM,T)
C
C          CHECK DBNAMES
C     write(6,'(1x,A6,i1,2x,a6)') dbname(dbtyp),dbtyp,nam(1)
        IF(DBNAME(DBTYP) .NE. NAM(1)) THEN
C     write(6,*)'values are not equal',nam(1),dbname(dbtyp)
11        CALL IREAD(IUN,IOUT,TIT,0,1,IWR,IRTN)
        IF(IRTN.EQ.2) GO TO 12
        GO TO 11
        ENDIF
CC        WRITE(IOUT,6000) NAM,T
CC6000  FORMAT('# DATA BLOCK',2A4/,'# TRAILER T=',7I8,' STRATED')
101     NNODES=0
C......SKIP TO EXTRACT MODEL TITLE AND SUBTITLE
      NWORD=0
      CALL IREAD(IUN,IOUT,TIT,10,0,IWR,IRTN)
C         icbp=10
      if (irtn.eq.2) go to 16
      LC=LC+1
      LC1=48+LC/10
      LC2=48+LC-(LC/10)*10
      IF (LCMAX.LT.LC) LCMAX=LC
C
      IDB(DBTYP)=TIT(10)
CC    write(6,*) tit(10,dbtyp,idb(dbtyp)
      CALL IREAD(IUN,IOUT,SCTIT,-40,0,IWR,IRTN)
C        icbp=50
      CALL LABREAD(IUN,IOUT,SCTIT,20,0,IWR,IRTN,LC,NWORD)
C        icbp=70
      CALL LABREAD(IUN,IOUT,SCTIT,12,0,IWR,IRTN,LC,NWORD)
C        icbp=82
      CALL LABREAD(IUN,IOUT,SCTIT,20,0,IWR,IRTN,LC,NWORD)
C          icbp=102
      CALL LABREAD(IUN,IOUT,SCTIT,12,0,IWR,IRTN,LC,NWORD)
C        icbp=114
      CALL LABREAD(IUN,IOUT,SCTIT,20,0,IWR,IRTN,LC,NWORD)
C          icbp=134
      CALL LABREAD(IUN,IOUT,SCTIT,12,0,IWR,IRTN,LC,NWORD)
C        icbp=146
      IF(IRTN.EQ.1) GO TO 110
C......SKIP TO EOR
      CALL IREAD(IUN,IOUT,TIT,0,1,IWR,IRTN)
C.......START OUGV1
110   CONTINUE
      nwidth=idb(dbtyp)-2
111   CALL IREAD(IUN,IOUT,DB,IDB(DBTYP),0,IWR,IRTN)
      IF(IRTN .EQ. 1) GO TO 15
      IF(IRTN .EQ. 2) GO TO 910
      IGRID=IGRID/10
      CALL GDBP(3,IDB(DBTYP),IGRID,NNODES,MAXNOD,DEFMAX,NDMAX,DEF,LC)
C        call dbp(3,idb(dbtyp),igrid,nnodes,maxnod,defmax,ndmax)
      IF(IGTYP.GT.1) WRITE(IOUT,6112) IGTYP
6112  FORMAT(1X,'# *WARNING* ABOVE GRID ID IS A SCLAR(2), OR TXTRA(3)',
     &  'OR MODAL(4) POINT; TYPE ID =',I2)
      GO TO 111
C
15    CONTINUE
C
```

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C.....NORMALIZE THE MODE SHAPE AND OUTPUT TO *.MOD FILE
C       write(22,2201) lc
C2201   format(2x,i10,4x,'0.000000E+00')
C       do 17 i=1,nnodes
C       if(defmax.eq.0) go to 902
C       do 18 j=1,6
C       ms(i,j)=ms(i,j)/defmax
C       write(22,fmt='(2x,1pe23.15)') ms(i,j)
C18     continue
C17     continue
        IF(IRTN .EQ. 2) GO TO 16
        GO TO 101
C
C       ASK FOR OTHER OPTIONS
C
16      continue
        CALL READMLC(N12)
C        CALL READSLC(N12)
740     CALL WRITETAB(NODEIN,N11,N12)
        CALL WRITEBIN(NODEIN,N11,N12)
cc        write(6,*) 'Other entrees? (y/n)'
cc        read(5,'(a1)') yorn
cc        if(yorn.eq.'Y' .or. yorn.eq.'y') go to 6300
C       WRITE(6,*) ' OTHER OPTIONS(Y/N) ?'
C       READ(5,'(A1)') YORN
C       IF(YORN.EQ.'Y' .OR. YORN.EQ.'y') THEN
C         REWIND(IUN)
C         GO TO 10
C       ENDIF
c.....last two lines of *.mod file and to be moved to the top of file.
C          write(22,6201) tit
C6201   format(20a4)
C          write(22,6202) nodes,lc
C6202   format(2i12,11x,'2',11x,'0')
c
c.....start processing *.seq
c       write(6,*) '                START PROCESSING  *.SEQ;'
c       call toseq(nnodes)
        GO TO 800
C
C       ERRORS
910     WRITE(IOUT,6910) IRTN
6910    FORMAT('# *ERROR BAD IRTN=',I8,' WHEN EXTRACTING TITLE IN DATA',
     &          ' BLOCK CUGV1')
        GO TO 800
902     WRITE(IOUT,6902) LC,NOMAX,DEFMAX
6902      FORMAT('*ERROR: MODE NO',I3,3X,'NODE=',I6,2X,'DEFMAX=',E14.5)
800     STOP
        END
C
        SUBROUTINE FILENAME
        IMPLICIT INTEGER (A-Z)
        CHARACTER*72 F22,F11
C        COMMON /FILENM/F22
        COMMON /FIO/F11
        WRITE(6,*) ' '
        WRITE(6,*) 'Enter the NASTRAN *.C11 file name:'
        WRITE(6,*) 'default ',F11(1:(INDEX(F11,'.'))-1),'.C11'
        READ(5,'(A72)') f22
          IF(INDEX(F22,' ').LE.1) THEN
          F22=F11(1:(INDEX(F11,'.'))-1)//'.C11'
          ENDIF
        len1 = INDEX(f22,' ')
          if(len1.gt.14) then
          f22=f22(1:9)//'.'//'F22'
          write(6,'(A72)') 'New file name is: ',f22
          endif
            if(INDEX(f22,'.').eq.0) f22=f22(1:len1-1)//'.'//'F22'
        OPEN(UNIT=22,FILE=f22,STATUS='OLD',form='unformatted')
        RETURN
        END
C
        subroutine labread(liun,liout,lsctit,lnwl,liflag,lnwr,lirtn,
     &llc,lnword)
C           this subroutine creates an array containing load case number,
C           title, and subtitle.
C           lsctit(lc,1:32) contain the title
C           lsctit(lc,33:64) contain the subtitle
C           lsctit(lc,65:96) contain the label
        implicit integer (a-z)
        dimension lsctit(20,200), lid(20)
        common /buffer/in,icbp,irl
        call iread(liun,liout,lid,lnwl,liflag,lnwr,lirtn)
        if(lnwl .le. 0) go to 1020
          do 1010 i=1,lnwl
          lnword=lnword+1
          lsctit(llc,lnword)=lid(i)
1010        continue
1020    return
        end
C
        SUBROUTINE READMLC(SN12)
C.....READ IN MULTIPLE LOAD CASES AND NODE SELECTIONS.
        IMPLICIT INTEGER (A-Z)
        CHARACTER*72 F100
        CHARACTER*2 TAIL
        common /blnkin/sctit(20,200),notblnk
        common /avgin/def(20,10000,6),avgdef(6),rmsdef(6),LCIN(20),
     &LCMAX,LCEND
        write(31,6113)
6113    format(/)
        write(31,6301) (sctit(1,i), i=1,18)
        call blnkskip(1,19,32)
          if (notblnk.eq.1) then
          write(31,6301) (sctit(1,i), i=19,32)
          endif
        write(31,6301) (sctit(1,i), i=33,50)
        call blnkskip(1,51,64)
```

```
        if (notblnk.eq.1) then
        write(31,6301) (sctit(1,i), i=51,64)
        endif
6300  continue
      Sn12=1
cc      n11=0
      write(6,*)' '
      write(6,6301) (sctit(1,i), i=1,18)
      call blnkskip(1,19,32)
        if (notblnk.eq.1) then
        write(6,6301) (sctit(1,i), i=19,32)
        endif
6301  format(1x,18a4)
      write(6,6301) (sctit(1,i), i=33,50)
      call blnkskip(1,51,64)
        if (notblnk.eq.1) then
        write(6,6301) (sctit(1,i), i=51,64)
        endif
699     WRITE(6,'(/1X,A11)') 'LOAD CASES:'
        do 710 j=1,lcmax
          write(6,6303) j, (sctit(j,i), i=65,81)
6303      format(/1x,i2,'. ',17a4)
        call blnkskip(j,82,90)
          if(notblnk.eq.1) then
          write(6,700) (sctit(j,i), i=82,90)
700       format(5x,9a4)
          endif
          call blnkskip(j,91,96)
          if(notblnk.eq.1) then
            write(6,6304) (sctit(j,i), i=91,96)
6304      format(5x,6a4)
            endif
710       continue
      write(6,*)' '
720   write(6,6306)lcmax
6306  format(' Enter a load case selection number.  (1 -',i2,')')
      write(6,*)'(Use "0" to end)'
722   continue
      read(5,'(i2)') lcin(Sn12)
      if(lcin(Sn12).eq.0) go to 728
        if(lcin(Sn12).lt.0 .or. lcin(Sn12).gt.lcmax) then
        write(6,*)'Invalid load case selection.'
        go to 720
        endif
      if(Sn12.eq.1) go to 727
      call chkrpt(lcin,Sn12,repeat)
        if(repeat.eq.1) then
        write(6,724)lcin(Sn12)
724     format(' Load case selection ',i2,' is already entered.')
        write(6,*)'Enter different selection.  (Use "0" to end.)'
        go to 722
        endif
727   CONTINUE
      WRITE(6,*) 'Enter the FRINGE deformation input filename for
     & this load case selection.'
      WRITE(6,'(1x,A14,I2.2,A6)') 'default NAS2FR',LCIN(SN12),'21.DAT'
      READ(5,'(A72)') F100
        IF(INDEX(F100,' ').LE.1) THEN
        WRITE(F100,'(A6,I2.2,A6)') 'NAS2FR',LCIN(SN12),'21.DAT'
        ENDIF
        IF(INDEX(F100,'.').EQ.0) THEN
        WRITE(TAIL,'(I2.2)') LCIN(SN12)
        F100=F100(1:(INDEX(F100,' ')-1)//TAIL//'21.DAT'
        ENDIF
      BDU=100+SN12
      OPEN(UNIT=BDU,FILE=F100(1:(INDEX(F100,' '))-1),STATUS='NEW'
     &,ERR=9001,FORM='UNFORMATTED')
      Sn12=Sn12+1
      go to 699
c-----------------------------------------------------------------------
c         skip the nodein definition, see equivalence
C728      go to 740
728     GO TO 745
c-----------------------------------------------------------------------
c728      continue
cc      if(lcin(1).eq.lcend) go to 800
cc      write(6,*)'Enter node numbers.  (Use "0" to end.)'
cc730   continue
cc      n11=n11+1
cc      read(5,'(i4)') nodein(n11)
cc        if (nodein(n11).eq.0) then
cc        n11=n11-1
cc        go to 740
cc        endif
cc        if (n2(nodein(n11)).eq.0) then
cc        write(6,6314) nodein(n11)
cc6314    format(' Node 'i4' does not exist.')
cc        write(6,*)'Please enter proper node numbers.  (Use "0" to end.)'
cc        n11=n11-1
cc        go to 730
cc        endif
cc        if(n11.eq.1) goto 730
cc        call chkrpt(nodein,n11,repeat)
cc        if(repeat.eq.1) then
cc        write(6,734)nodein(n11)
cc734     format(1x,'Node ',i4,' is already entered.')
cc        write(6,*)'Please enter different node number.  (Use "0" to end
cc     &.)'
cc        n11=n11-1
cc        endif
cc      goto 730
745   GOTO 750
9001  WRITE(6,*) '*ERROR* output file name(f100): '
     &,F100(1:INDEX(F100,' '))
      STOP
750   RETURN
      END
C
```

```
      SUBROUTINE READSLC(SN12)
C.....READ IN SINGLE LOAD CASE.
      IMPLICIT INTEGER (A-Z)
      common /blnkin/sctit(20,200),notblnk
      common /avgin/def(20,10000,6),avgdef(6),rmsdef(6),LCIN(20),
     &LCMAX,LCEND
      write(31,6113)
6113  format(/)
      write(31,6301) (sctit(1,i), i=1,18)
      call blnkskip(1,19,32)
        if (notblnk.eq.1) then
        write(31,6301) (sctit(1,i), i=19,32)
        endif
      write(31,6301) (sctit(1,i), i=33,50)
      call blnkskip(1,51,64)
        if (notblnk.eq.1) then
        write(31,6301) (sctit(1,i), i=51,64)
        endif
6300  continue
      Sn12=1
      write(6,*)' '
      write(6,6301) (sctit(1,i), i=1,18)
      call blnkskip(1,19,32)
        if (notblnk.eq.1) then
        write(6,6301) (sctit(1,i), i=19,32)
        endif
6301  format(1x,18a4)
      write(6,6301) (sctit(1,i), i=33,50)
      call blnkskip(1,51,64)
        if (notblnk.eq.1) then
        write(6,6301) (sctit(1,i), i=51,64)
        endif
        WRITE(6,'(/1x,A11)') 'LOAD CASES:'
        do 710 j=1,lcmax
          write(6,6303) j, (sctit(j,i), i=65,81)
6303      format(/1x,i2,'. ',17a4)
        call blnkskip(j,82,90)
          if(notblnk.eq.1) then
          write(6,700) (sctit(j,i), i=82,90)
700       format(5x,9a4)
          endif
          call blnkskip(j,91,96)
          if(notblnk.eq.1) then
            write(6,6304) (sctit(j,i), i=91,96)
6304      format(5x,6a4)
            endif
710       continue
      write(6,*)' '
720   write(6,6306)lcmax
6306  format(' Enter a load case selection number.  (1 -',i2,')')
722   continue
      read(5,'(i2)') lcin(Sn12)
        if(lcin(Sn12).LE.0 .or. lcin(Sn12).gt.lcmax) then
        write(6,*)'Invalid load case selection.'
        go to 720
        endif
727   Sn12=Sn12+1
      RETURN
      END
C
      SUBROUTINE WRITETAB(TNODEIN,TN11,TN12)
C.....OUTPUT TO *.TAB FILE
      IMPLICIT INTEGER (A-Z)
      REAL DEF
      DIMENSION TNODEIN(TN11)
      common /blnkin/sctit(20,200),notblnk
      common /avgin/def(20,10000,6),avgdef(6),rmsdef(6),LCIN(20)
      do 760 i=1,Tn12-1
      write(31,6307) lcin(i)
6307  format(/1x,'Load case selection ',i2,'.')
      write(31,6308) (sctit(lcin(i),j), j=65,82)
      call blnkskip(i,83,90)
        if(notblnk.eq.1)then
        write(31,6308) (sctit(lcin(i),j), j=83,90)
        endif
6308  format(1x,18a4)
      call blnkskip(i,91,96)
        if(notblnk.eq.1)then
        write(31,6309) (sctit(lcin(i),j), j=91,96)
        endif
6309  format(1x,6a4/)
      write(31,6310)
6310  format(1x,'NODE #',30x,'DEFLECTION')
      write(31,6311)
6311  format(14x,'TX',10x,'TY',10x,'TZ',10x,'RX',10x,'RY',10x,'RZ'/)
        do 750 j=1,Tn11
        write(31,6312) TNODEIN(j),(def(lcin(i),TNODEIN(j),k),k=1,6)
6312    format(2x,i4,3x,6(e11.4,1x))
750     continue
      call average(lcin(i),TNODEIN,Tn11)
C      call rms(lcin(i),TNODEIN,Tn11)
760   continue
      RETURN
      END
C
      subroutine average(slcin,snodein,sn11)
c     This subroutine computes the average of nodal deflections
      implicit integer (a-z)
      real sumdef, def, avgdef
      dimension sumdef(6), snodein(sn11)
      common /avgin/def(20,10000,6),avgdef(6)
        do 756 i=1,6
        sumdef(i)=0.
          do 754 j=1,sn11
          sumdef(i)=sumdef(i)+def(slcin,snodein(j),i)
754       continue
        avgdef(i)=sumdef(i)/sn11
756     continue
```

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OF POOR QUALITY

```
      write(31,758) (avgdef(j),j=1,6)
758   format(/1x,'Average',6(1x,e11.4))
      return
      end
c
c
      subroutine rms(slcin,snodein,sn11)
c     This subroutine computes the RMS values of nodal deflections.
      implicit integer(a-z)
      real def, sumsqdef, rmsdef
      dimension sumsqdef(6), snodein(sn11)
      common /avgin/def(20,10000,6),avgdef(6),rmsdef(6)
        do 770 i=1,6
        sumsqdef(i)=0.
          do 768 j=1,sn11
          sumsqdef(i)=sumsqdef(i)+def(slcin,snodein(j),i)**2
768       continue
        rmsdef(i)=(sumsqdef(i)/sn11)**0.5
770     continue
      write(31,772) (rmsdef(j),j=1,6)
772   format(/1x,'RMS     ',6(1x,e11.4))
      return
      end
c
      SUBROUTINE WRITEBIN(TNODEIN,TN11,TN12)
      IMPLICIT INTEGER (A-Z)
      REAL DEF,DUM2
      common /blnkin/sctit(20,200),notblnk
      common /avgin/def(20,10000,6),avgdef(6),rmsdef(6),LCIN(20)
      common /selg/noeg,tno,idg(10),sgn(500)
      DIMENSION TNODEIN(TN11),DUM2(500)
      REWIND 28
        DO 110 I=1,NOEG
        READ(28)
        REWRITE(28) (SCTIT(1,J),J=1,12),IDG(I)
        READ(28)
        READ(28)
          DO 100 J=1,3
          READ(28)
C          READ(28) (DUM2(K),K=1,IDG(I))
100       CONTINUE
110     CONTINUE
        do 760 i=1,Tn12-1
        BDU=100+I
        WRITE(BDU) LCIN(I)
          do 750 j=1,Tn11
          write(BDU) TNODEIN(j),TNODEIN(J),(def(lcin(i),TNODEIN(j),k),
     &    k=1,3)
750       continue
        CLOSE(BDU)
760     continue
      RETURN
      END
C
c
        subroutine gdbp(gi1,gi2,gigrid,gnnodes,gmaxnod,gdefmax,gndmax,
     &  gdef,glc)
C         similar to subroutine dbp
C
C         This subroutine creates an array containing deformation,
C         specified by load case number, grid number, and degree of
C         freedom.
          implicit integer (a-z)
          real db,gdefmax,gdef
          dimension gdef(20,10000,6)
          common /dbpin/n2(10000),db(15)
          gnnodes=gnnodes+1
          n2(gigrid)=gnnodes
          do 300 i=gi1,gi2
          j=i-gi1+1
          gdef(glc,gigrid,j)=db(i)
          if(abs(gdefmax).lt.abs(db(i))) then
            gdefmax=db(i)
            gndmax=gigrid
          endif
300       continue
          if(gmaxnod.lt.gigrid) gmaxnod=gigrid
          return
          end
C
      subroutine blnkskip(b1,b2,b3)
      implicit integer (a-z)
      common /blnkin/sctit(20,200),notblnk
      notblnk=0
        do 100 i=b2,b3
          if (sctit(b1,i).ne.'    ') then
          notblnk=1
          goto 200
          endif
100     continue
200   return
      end
C
c
      subroutine chkrpt(sarray,sn,srepeat)
      implicit integer(a-z)
      dimension sarray(sn)
      srepeat=0
        do 723 i=1,sn-1
        if(sarray(sn).eq.sarray(i)) srepeat=1
723     continue
      return
      end
c
C.......revised from YNASPAT2.F for images-3D animation
          subroutine dbp(i1,i2,igd,nnod,mxnod,dmx,ndmx)
          implicit integer (a-z)
          real db,dmx
```

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OF POOR QUALITY

```
      common /dbpin/n2(10000),db(15)
      nnod=nnod+1
      n2(igd)=nnod
      do 200 i=i1,i2
      j=i-i1+1
c     ms(nnod,j)=db(i)
      if(abs(dmx).lt.abs(db(i))) then
        dmx=db(i)
        ndmx=igd
      endif
200   continue
      if(mxnod.lt.igd) mxnod=igd
      return
      end
C
      SUBROUTINE IOPEN(IUN,IOUT,L)
C
C     THIS ROUTINE OPENS (TO READ) AN INPUTT2 FILE
C
      IMPLICIT INTEGER (A-Z)
C
C     IT MUST BE CALLED ONCE AND ONLY ONCE PER UNIT
C
C     IUN--INPUT--INTEGER--FORTRAN UNIT NUMBER (IE 11)
C     L(2)--OUTPUT--INTEGER--LABEL FROM DMAP (IE MYPROG)
C
      DIMENSION T(7),L(2)
C
      REWIND (IUN)
      READ (IUN) KEY
      IF(KEY .NE. 3) GO TO 9000
C     BRING IN DATE
      READ (IUN) M,D,Y
      READ (IUN) KEY
      IF(KEY .NE. 7) GO TO 9000
C     BRING IN TITLE
      READ (IUN) (T(I),I=1,7)
      READ (IUN) KEY
      IF(KEY .NE. 2) GO TO 9000
C     BRING IN LABEL
      READ (IUN) L
      READ (IUN) KEY
      IF(KEY .NE. -1) GO TO 9000
      READ (IUN) KEY
      IF(KEY .NE. 0) GO TO 9000
      RETURN
 9000 WRITE(IOUT,900) KEY
  900 FORMAT(1H1,15HIOPEN BAD KEY =,I8)
      STOP
      END
      SUBROUTINE IHEADR(IUN,IOUT,NAM,T)
C
C     IHEADR IS CALLED ONCE PER DATA BLOCK ON UNIT IUN
C
      IMPLICIT INTEGER (A-Z)
C
C     IUN--INTEGER--INPUT--FORTRAN UNIT NUMBER (IE 11)
C     NAM--BCD--OUTPUT--DATA BLOCK NAME (2 WORDS) (IE EQEXIN)
C     T--OUTPUT--INTEGER--DATA BLOCK CONTROL BLOCK (7 WORDS IE
C     TRAILER(1)=T(2)
C
      DIMENSION NAM(2),T(7),IH(2)
C
      COMMON /BUFFER/IN
C
      READ (IUN) KEY
      IF(KEY .NE. 2) GO TO 9000
C     READ IN DATA BLOCK NAME
      READ (IUN) NAM
      READ (IUN) KEY
      IF(KEY .NE. -1) GO TO 9000
      READ (IUN) KEY
      IF (KEY .NE. 7) GO TO 9000
C     READ IN TRAILER
      READ (IUN) T
      READ (IUN) KEY
      IF(KEY .NE. -2) GO TO 9000
      READ (IUN) KEY
      IF(KEY .NE. 1) GO TO 9000
      READ (IUN) KEY
      IF(KEY .NE. 0) GO TO 9000
      READ (IUN) KEY
      IF (KEY .LT. 2) GO TO 9000
C     READ IN (SKIP) DATA FROM DATA BLOCK HEADER
      READ (IUN) IH
      READ (IUN) KEY
      IF(KEY .NE. -3) GO TO 9000
C
C     START BUFFER ROUTINE A BEGINING
C
      IN=0
      RETURN
 9000 WRITE(IOUT,900) KEY
  900 FORMAT (1H1,16HIHEADR BAD KEY = , I8)
      STOP
      END
      SUBROUTINE IREAD(IUN,IOUT,ID,NW1,IFLAG,NWR,IRTN)
C
C     THIS ROUTINE READS IN INPUTT2 FILE WITH USER CONTROLS
C
      IMPLICIT INTEGER (A-Z)
C
C     IUN--INPUT--FORTRAN UNIT NUMBER (IE 11)
C     ID--OUTPUT--ARRAY CONTAINING RETURNED WORDS
C     NW1--INPUT--INTEGER--THE NUMBER OF WORDS TO RETURN
C                 IF NW1 IS NEGATIVE THIS MANY WORDS WILL BE SKIPPED
C     IFLAG--INPUT--IF IFLAG IS 0 , A CONTINUATION READ WILL OCCUR
C                   IF IFLAG IS 1 THE REMAINER OF THE RECORD WILL BE
```

```
C                                   SKIPPED
C     NWR--OUTPUT--IF THE RECORD DOES NOT CONTAIN NW1 REMAINING
C                  WORDS THEN NWR WILL INDICATE THE ACTUAL NUMBER
C                  RETURNED
C     IRTN--OUTPUT--0 NORMAL RETURN
C                   1 END OF RECORD (NWR WILL BE SET)
C                   2 END OF DATA BLOCK
C
      DIMENSION ID(1)
C
      COMMON /BUFFER/IN,ICBP,IRL,IZ(10000)
C
C     IN INDICATES PRESENCE IN IZ
C     ICBP IS THE CURRENT BUFFER POINTER
C     IRL IS THE CURRENT RECORD LENGTH
C     IZ CONTAINS THE DATA
C
C     THIS ROUTINE CAN ONLY HANDLE ONE FORTRAN FILE AT A TIME
C     MORE CODE COULD EXTEND THIS CONCEPT
C
      NW = NW1
      IRTN= 0
      IUAP=0
      IF(IN .NE. 0) GO TO 70
C
C     READ INTO BUFFER ON INITIAL READ START OF RECORD FLAG
C
      READ(IUN) KEY
      IF(KEY .NE. 1) GO TO 9000
C     READ RECORD TYPE (TABLES=0, ONLY TABLES ALLOWED)
      READ (IUN) KEY
      IF(KEY .NE. 0) GO TO 9000
   30 READ (IUN) KEY
C     END-OF-RECORD OR END-OF-FILE OR LENGTH-OF-RECORD INDICATION
      IF( KEY )160,200,40
   40 IF(KEY.LE.20000)GO TO 60
C     OUTPUT2 RECORD IS LARGER THAN 20000 DIMENSION OF IZ ARRAY
      WRITE(IOUT,50)
   50 FORMAT(50H0 ARRAY IZ DIMENSION EXCEEDED IN SUBROUTINE IREAD.)
      KEY = 20000
   60 READ (IUN) (IZ(I),I=1,KEY)
      IRL = KEY
      ICBP = 0
      IN = 1
C
C     DATA IS IN IZ
C
   70 CONTINUE
      IF(NW) 180,170,80
C
C     ARE ENOUGH WORDS IN BUFFER
C
   80 CONTINUE
      IF(IRL -ICBP .LT. NW) GO TO 140
C
C     SUPPLY WORDS
C
      DO 90 I = 1,NW
      ID(IUAP+I) = IZ(ICBP+I)
   90 CONTINUE
      IUAP = IUAP + NW
C
C     UPDATE BUFFER POINTER
C
      ICBP=ICBP+NW
  100 IF(IFLAG .NE. 0) GO TO 120
  110 RETURN
C
C     SKIP TO NEXT LOGICAL RECORD
C
  120 CONTINUE
C     READ END OF RECORD FLAG IF NOT NEGATIVE IS MORE DATA FOR
C     CURRENT RECORD, READ DATA LENGTH KEY AND NEXT RECORD TO
C     SKIP THAT LENGTH OF DATA, AND LOOK FOR END-OF-RECORD FLAG
      READ (IUN) KEY
      IF(KEY .GT. 0) GO TO 130
      IN = 0
      GO TO 110
C
C     SKIP MORE
C
  130 READ(IUN) KEY
      GO TO 120
C
C     MORE WORDS REQUESTED THAN AVAILABLE
C
  140 CONTINUE
      K = IRL-ICBP
C
C     SUPPLY REMAINDER OF CURRENT BUFFER
C
      DO 150 I = 1,K
      ID(IUAP+I) = IZ(ICBP+I)
  150 CONTINUE
C
C     BUMP USER POINTER AND DECREMENT WORDS
C
      IUAP = IUAP +K
      NW = NW-K
C
C     READ REMAINDER OF DATA RECORD
C
      GO TO 30
C
C     END OF RECORD
C
  160 CONTINUE
      NWR = IUAP
```

```
      IRTN = 1
      IN = 0
      GO TO 110
C
C     USER REQUESTED ZERO WORDS HONOR IFLAG AND QUIT
C
  170 CONTINUE
      GO TO 100
C
C     USER REQUESTED WORDS BE SKIPPED ( NW IS NEGATIVE HERE )
C
  180 CONTINUE
      IF(ICBP-IRL .GT. NW) GO TO 190
C
C     SKIP WITHIN CURRENT BUFFER
C
      ICBP = ICBP - NW
      GO TO 100
C
C     SKIP OVER MORE THAN CURRENT BUFFER
C
  190 CONTINUE
C     REDUCE THE NEGATIVE COUNT, MAKE IT LESS NEGATIVE
      NW = NW+IRL-ICBP
C
C     READ REMAINDER OF DATA RECORD
C
      GO TO 30
C
C     END OF FILE
C
  200 CONTINUE
      IRTN = 2
      IN = 0
      GO TO 110
C
C     ERRORS
C
 9000 WRITE(IOUT,9001)  KEY,ICBP,IRL,NW,NW1,IFLAG
 9001 FORMAT(1H0,6I8)
      STOP
      END
```

6.6 MM2CM

```
      PROGRAM MM2CMAX
      IMPLICIT INTEGER (A-Z)
      REAL X2,Y2,Z2,XAX,YAX,ZAX,UU,VV,WW,UUAX,VVAX,WWAX
      CHARACTER*72 F28,F29,F21,F22
      DIMENSION X2(500),Y2(500),Z2(500)
      DIMENSION XAX(500),YAX(500),ZAX(500)
      DIMENSION TITLE(12)
      WRITE(6,*)'Enter the geometry(*28.DAT) filename.'
      READ(5,'(A72)') F28
      WRITE(6,*)'Enter the geometry output filename.'
      READ(5,'(A72)') F29
      WRITE(6,*)'Enter the deformation(*21.DAT) filename.'
      READ(5,'(A72)') F21
      WRITE(6,*)'Enter the deformation output filename.'
      READ(5,'(A72)') F22
      OPEN(UNIT=28,FILE=F28(1:(INDEX(F28,' ')-1)),STATUS='OLD',
     &     ERR=9001,FORM='UNFORMATTED')
      OPEN(UNIT=21,FILE=F21(1:(INDEX(F21,' ')-1)),STATUS='OLD',
     &     ERR=9002,FORM='UNFORMATTED')
      OPEN(UNIT=29,FILE=F29(1:(INDEX(F29,' ')-1)),STATUS='NEW',
     &     ERR=9003,FORM='UNFORMATTED')
      OPEN(UNIT=22,FILE=F22(1:(INDEX(F22,' ')-1)),STATUS='NEW',
     &     ERR=9004,FORM='UNFORMATTED')
      REWIND 28
      REWIND 29
      READ(28)(TITLE(K),K=1,12),NUMNP
      WRITE(29)(TITLE(K),K=1,12),NUMNP
      READ(28)
      WRITE(29)
      READ(28)(X2(I),I=1,NUMNP)
       DO 10 I=1,NUMNP
       X2(I)=X2(I)/10.
       XAX(I)=-X2(I)
 10    CONTINUE
      READ(28)(Y2(I),I=1,NUMNP)
       DO 20 I=1,NUMNP
       Y2(I)=Y2(I)/10.
       ZAX(I)=Y2(I)
 20    CONTINUE
      READ(28)(Z2(I),I=1,NUMNP)
       DO 30 I=1,NUMNP
       Z2(I)=Z2(I)/10.
       YAX(I)=Z2(I)
 30    CONTINUE
      WRITE(29)(XAX(I),I=1,NUMNP)
      WRITE(29)(YAX(I),I=1,NUMNP)
      WRITE(29)(ZAX(I),I=1,NUMNP)
      REWIND 21
      REWIND 22
      READ (21) N11
      WRITE(22) N11
      DO 5 I=1,NUMNP
      READ (21) J,N11,UU,VV,WW
      UU=UU/10.
      VV=VV/10.
      WW=WW/10.
      UUAX=-UU
      VVAX=WW
```

```
      WWAX=VV
      WRITE (22) J,N11,UUAX,VVAX,WWAX
 5    CONTINUE
      CLOSE(28)
      CLOSE(29)
      CLOSE(21)
      CLOSE(22)
      GOTO 9999
9001  WRITE(6,*) 'FILENAME ERROR:  UNIT 28'
9002  WRITE(6,*) 'FILENAME ERROR:  UNIT 21'
9003  WRITE(6,*) 'FILENAME ERROR:  UNIT 29'
9004  WRITE(6,*) 'FILENAME ERROR:  UNIT 22'
9999  STOP
      END
```

6.7 FRINGE

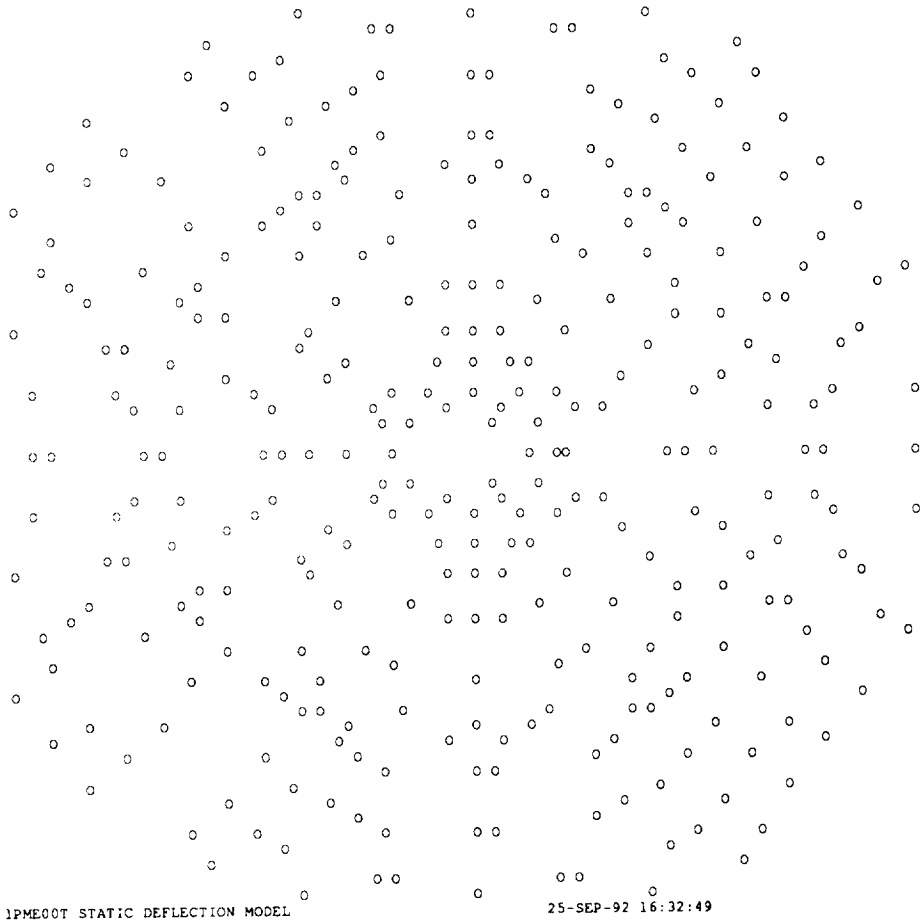
6.7.1 Case 1 Executive Input

```
PME00T STATIC DEFLECTION MODEL
DEFLECT OPTAX 3 UNITS CM XCIR 0 0 125. RADIUS 125. RADCV 622.
VERIFY COEFF NPOLY 36
CONTOUR 1. WIDTH .4 WEDGE 80252. FITERR .25
COBS 0.187 0.187
END
DANA RED PSF ESCAN e CENT 0. 0.
END
GSPOT RED ESCAN e SPOT CENTROID 0. 0.
END
```

6.7.2 Case 1 Output

```
1PME00T STATIC DEFLECTION MODEL                                  25-SEP-92 16:32:46
 --DEFLECT OPTAX 3 UNITS CM XCIR 0 0 125. RADIUS 125. RADCV 622.
 --VERIFY COEFF NPOLY 36
 --CONTOUR 1. WIDTH .4 WEDGE 80252. FITERR .25
 --COBS 0.187 0.187
 --TILT FOCUS
 --END

 PUPIL RADIUS   125.000   CM       WAVELENGTH  0.633 MICRONS

 DIFFRACTION ANGLE    0.0637    ARC SEC

 CUT-OFF FREQUENCY     3950.70    1/MR


 APERTURE MASKING
 TYPE        CAX        CAY        COX        COY
 ELIP     1.0000     1.0000     0.1870     0.1870


 ZERNIKE POLYNOMIAL COEFFICIENTS OF REFERENCE   WAVEFRON

     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000


 PUPIL CENTER AND RADIUS
          XC          YC          RAD
       0.0000      0.0000    125.0000
```

1PME00T STATIC DEFLECTION MODEL 25-SEP-92 16:32:48
FRINGE VERIFICATION



1PME00T STATIC DEFLECTION MODEL 25-SEP-92 16:32:49

WAVEFRON DEVIATION IN UNITS OF WAVES
TILT AND DEFOCUS MEASURED FROM DIFFRACTION FOCUS
WAVELENGTH 0.633 MICRONS
DEFLECTIONS ARE MAGNIFIED BY A FACTOR OF 0.0000E+00

	N	RMS
RAW	0	0.295
PLANE	2	0.259
SPHERE	3	0.259
4H ORDER	8	0.116
6H ORDER	15	0.098
8H ORDER	24	0.040
COMPLETE	36	0.027

STREHL RATIO 0.071 AT DIFFRACTION FOCUS

FOURTH ORDER ABERRATIONS

MAGNITUDE WAVES	ANGLE DEG	DESIGNATION
0.265	0.0	TILT
-0.025		DEFOCUS
0.497	0.0	ASTIGMATISM
1.212	0.0	COMA
-0.056		SPHERICAL ABERRATION

FOLLOWING TERMS WERE SUBTRACTED FROM DATA-

TILT	FOCUS		
1.23056E-01	-1.19276E-06	-4.06118E-03	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

RESIDUAL WAVEFRON VARIATIONS EVALUATED AT DATA POINTS

PTS	RMS	MAX	MIN	SPAN	STREHL
336	0.270	0.938	-0.668	1.606	0.057

0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

RESIDUAL WAVEFRON VARIATIONS OVER UNIFORM GRID

PTS	RMS	MAX	MIN	SPAN	STREHL
676.	0.229	0.573	-0.513	1.086	0.127

1PME00T STATIC DEFLECTION MODEL 25-SEP-92 16:32:50

RMS CALCULATED FROM ZERNIKE COEFFICIENTS=0.228

ZERNIKE POLYNOMIAL COEFFICIENTS

0.0000	0.0000	0.0000	0.2923	0.0000	0.4743	0.0000	-0.0103	-0.0098	0.0000	-0.1324	0.0000
-0.1201	0.0000	-0.0070	0.2379	0.0000	-0.0580	0.0000	0.0824	0.0000	0.0316	0.0000	0.0096
-0.0327	0.0000	-0.0434	0.0000	0.0216	0.0000	-0.0236	0.0000	-0.0044	0.0000	-0.0018	-0.0006

GENERAL POLYNOMIAL COEFFICIENTS

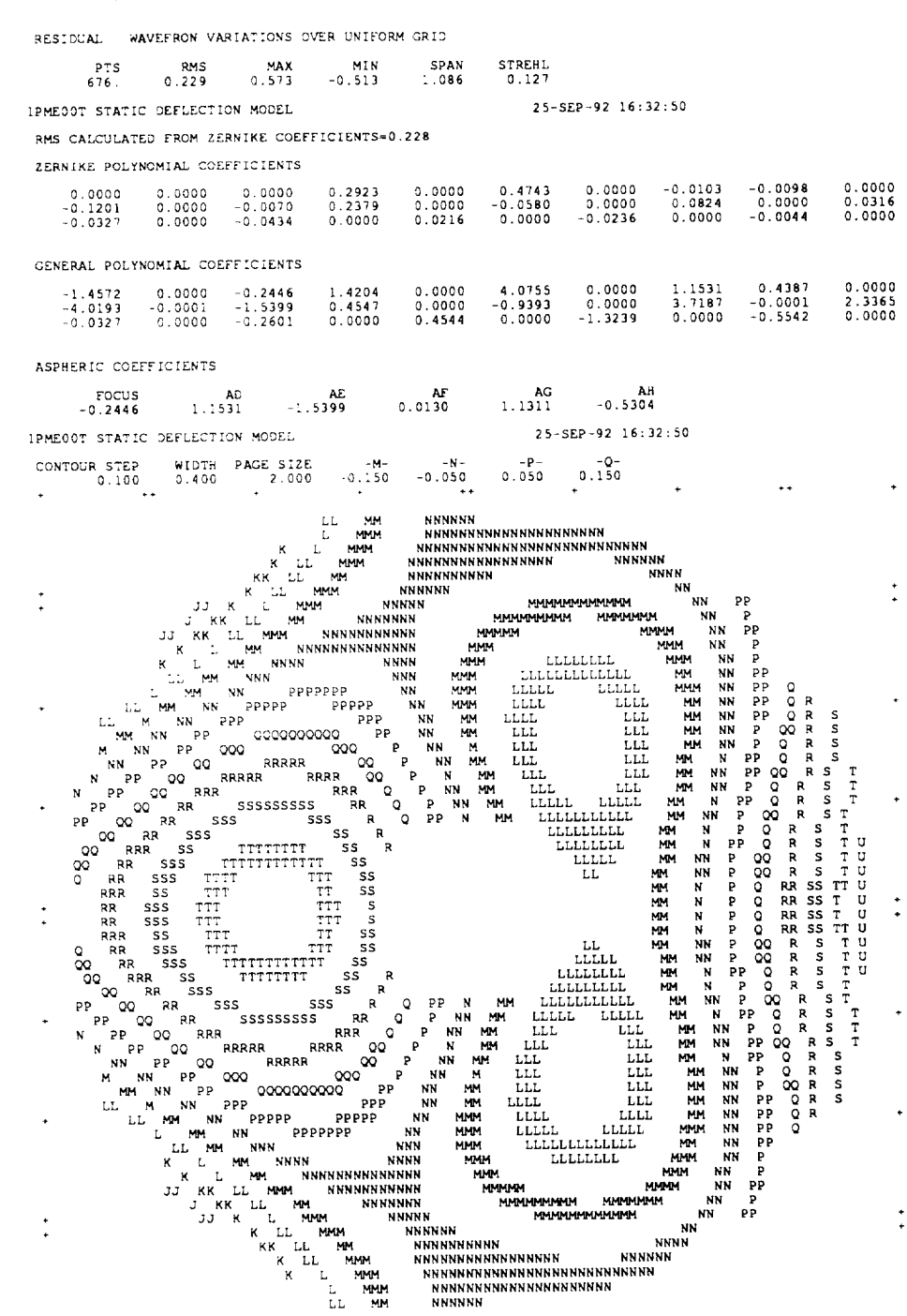
-1.4572	0.0000	-0.2446	1.4204	0.0000	4.0755	0.0000	1.1531	0.4387	0.0000	-3.5966	0.0000
-4.0193	-0.0001	-1.5399	0.4547	0.0000	-0.9393	0.0000	3.7187	-0.0001	2.3365	0.0001	0.0130
-0.0327	0.0000	-0.2601	0.0000	0.4544	0.0000	-1.3239	0.0000	-0.5542	0.0000	1.1311	-0.5304

ASPHERIC COEFFICIENTS

FOCUS	AD	AE	AF	AG	AH
-0.2446	1.1531	-1.5399	0.0130	1.1311	-0.5304

1PME00T STATIC DEFLECTION MODEL 25-SEP-92 16:32:50

CONTOUR STEP	WIDTH	PAGE SIZE	-M-	-N-	-P-	-Q-
0.100	0.400	2.000	-0.150	-0.050	0.050	0.150



1PME00T STATIC DEFLECTION MODEL 25-SEP-92 16:32:52

ZERNIKE POLYNOMIAL COEFFICIENTS

0.0000	0.0000	0.0000	0.2923	0.0000	0.4743	0.0000	-0.0103
-0.0098	0.0000	-0.1324	0.0000	-0.1201	0.0000	-0.0070	0.2379
0.0000	-0.0580	0.0000	0.0824	0.0000	0.0316	0.0000	0.0096
-0.0327	0.0000	-0.0434	0.0000	0.0216	0.0000	-0.0236	0.0000
-0.0044	0.0000	-0.0018	-0.0006				

```
RESIDUAL   WAVEFRON VARIATIONS OVER UNIFORM MESH

        PTS        RMS        MAX        MIN       SPAN     VOLUM
       676.      0.229      0.573     -0.513      1.086      1.541

 --DANA RED PSF ESCAN e CENT 0. 0.

   FUNCTION            MAX            VOL    AREA
      ASF    0.592559E-02 0.244141E+00   4096
* STREHL RATIO*  0.1410

            SPOT    PERCENT
          RADIUS     ENERGY
        0.000000       0.00
        0.026056       5.00
        0.042540      10.00
        0.054991      15.00
        0.064883      20.00
        0.078939      25.00
        0.082401      30.00
        0.085863      35.00
        0.093164      40.00
        0.101778      45.00
        0.106327      50.00
        0.121280      55.00
        0.129818      60.00
        0.148661      65.00
        0.155845      70.00
        0.163909      75.00
        0.182704      80.00
        0.209453      85.00
        0.235218      90.00
        0.315660      95.00
        0.735406     100.00

 --END
 --GSPOT RED ESCAN e SPOT CENTROID 0. 0.
1PME00T STATIC DEFLECTION MODEL                                  25-SEP-92 16:32:54
1PME00T STATIC DEFLECTION MODEL                                  25-SEP-92 16:32:56

            SPOT    PERCENT
          RADIUS     ENERGY
        0.000000       0.00
        0.031464       5.00
        0.043987      10.00
        0.055935      15.00
        0.066413      20.00
        0.073961      25.00
        0.078615      30.00
        0.084311      35.00
        0.096635      40.00
        0.104209      45.00
        0.113760      50.00
        0.122328      55.00
        0.130015      60.00
        0.141451      65.00
        0.147272      70.00
        0.156984      75.00
        0.167199      80.00
        0.178106      85.00
        0.196076      90.00
        0.213169      95.00
        0.234515     100.00

 --END
 END OF DATA
```

6.7.3 Case 2 Executive Input

```
PME20T STATIC DEFLECTION MODEL
DEFLECT OPTAX 3 UNITS CM XCIR 0 0 125. RADIUS 125. RADCV 622.
VERIFY COEFF NPOLY 36
CONTOUR 1. WIDTH .4 WEDGE 80252. FITERR .25
COBS 0.187 0.187
END
DANA RED PSF ESCAN e CENT 0. 0.
END
GSPOT RED ESCAN e SPOT CENTROID 0. 0.
END
```

6.7.4 Case 2 Output

```
1PME20T STATIC DEFLECTION MODEL                                  25-SEP-92 16:37:16
 --DEFLECT OPTAX 3 UNITS CM XCIR 0 0 125. RADIUS 125. RADCV 622.
 --VERIFY COEFF NPOLY 36
 --CONTOUR 1. WIDTH .4 WEDGE 80252. FITERR .25
 --COBS 0.187 0.187
 --TILT FOCUS
 --END

 PUPIL RADIUS   125.000   CM       WAVELENGTH  0.633 MICRONS

 DIFFRACTION ANGLE    0.0637    ARC SEC

 CUT-OFF FREQUENCY     3950.70    1/MR
```

APERTURE MASKING

TYPE	CAX	CAY	COX	COY
ELIP	1.0000	1.0000	0.1870	0.1870

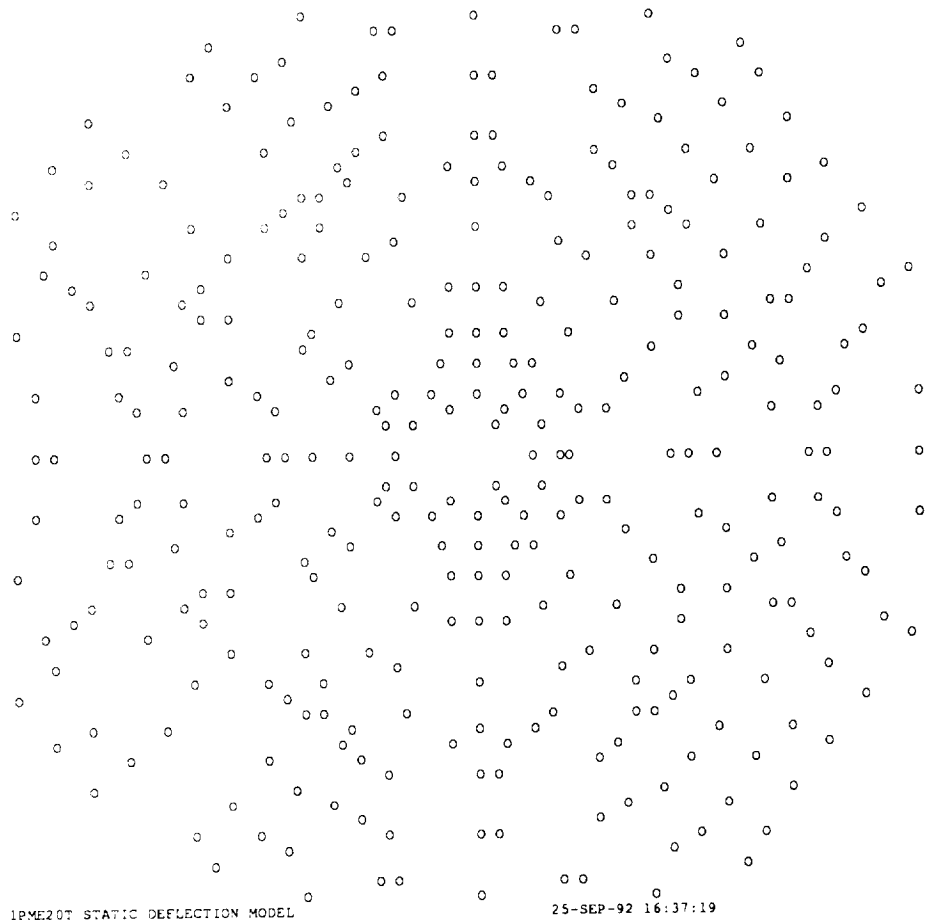
ZERNIKE POLYNOMIAL COEFFICIENTS OF REFERENCE WAVEFRON

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PUPIL CENTER AND RADIUS

XC	YC	RAD
0.0000	0.0000	125.0000

1PME20T STATIC DEFLECTION MODEL 25-SEP-92 16:37:18
FRINGE VERIFICATION



1PME20T STATIC DEFLECTION MODEL 25-SEP-92 16:37:19

WAVEFRON DEVIATION IN UNITS OF WAVES
TILT AND DEFOCUS MEASURED FROM DIFFRACTION FOCUS
WAVELENGTH 0.633 MICRONS
DEFLECTIONS ARE MAGNIFIED BY A FACTOR OF 0.0000E+00

	N	RMS
RAW	0	0.461
PLANE	2	0.426
SPHERE	3	0.232
4H ORDER	8	0.076
6H ORDER	15	0.047
8H ORDER	24	0.037
COMPLETE	36	0.028

STREHL RATIO 0.119 AT DIFFRACTION FOCUS

FOURTH ORDER ABERRATIONS

MAGNITUDE WAVES	ANGLE DEG	DESIGNATION
0.330	0.0	TILT
-0.966		DEFOCUS
0.484	0.0	ASTIGMATISM
1.139	0.0	COMA
0.109		SPHERICAL ABERRATION

FOLLOWING TERMS WERE SUBTRACTED FROM DATA-

TILT	FOCUS		
1.96758E-01	-1.52235E-06	-4.99930E-01	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

RESIDUAL WAVEFRON VARIATIONS EVALUATED AT DATA POINTS

PTS	RMS	MAX	MIN	SPAN	STREHL
336	0.243	0.749	-0.420	1.169	0.097

0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

RESIDUAL WAVEFRON VARIATIONS OVER UNIFORM GRID

PTS	RMS	MAX	MIN	SPAN	STREHL
676.	0.205	0.530	-0.276	0.807	0.189

1PME20T STATIC DEFLECTION MODEL 25-SEP-92 16:37:20

RMS CALCULATED FROM ZERNIKE COEFFICIENTS=0.205

ZERNIKE POLYNOMIAL COEFFICIENTS

0.0000	0.0000	0.0000	0.2821	0.0000	0.4457	0.0000	0.0219	-0.0092	0.0000	-0.1232	0.0000
-0.1129	0.0000	0.0273	0.0248	0.0000	-0.0545	0.0000	0.0765	0.0000	0.0297	0.0000	0.0119
-0.0308	0.0000	-0.0092	0.0000	0.0203	0.0000	-0.0220	0.0000	-0.0041	0.0000	0.0359	-0.0250

GENERAL POLYNOMIAL COEFFICIENTS

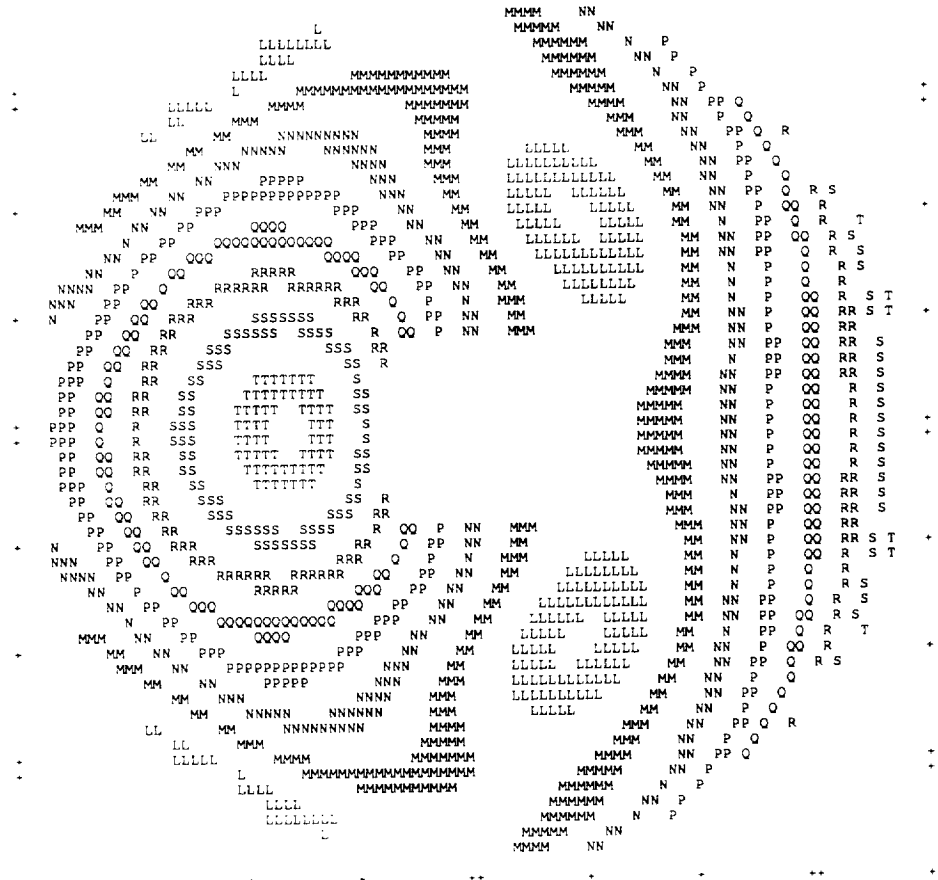
-1.3693	0.0000	2.0857	1.3313	0.0000	3.8296	-0.0001	-17.6478	0.4122	0.0000	-3.3455	0.0000
-3.7766	0.0002	60.9297	0.0707	0.0000	-0.8826	0.0000	3.4613	-0.0001	2.1953	-0.0002	-100.4069
-0.0308	0.0000	-0.0551	0.0000	0.4270	0.0000	-1.2336	0.0000	-0.5207	0.0001	78.2204	-23.0545

ASPHERIC COEFFICIENTS

FOCUS	AD	AE	AF	AG	AH
2.0857	-17.6478	60.9297	-100.4069	78.2204	-23.0545

1PME20T STATIC DEFLECTION MODEL 25-SEP-92 16:37:20

CONTOUR STEP	WIDTH	PAGE SIZE	-M-	-N-	-P-	-Q-
0.100	0.400	2.000	-0.150	-0.050	0.050	0.150



1PME20T STATIC DEFLECTION MODEL 25-SEP-92 16:37:22

ZERNIKE POLYNOMIAL COEFFICIENTS

0.0000	0.0000	0.0000	0.2821	0.0000	0.4457	0.0000	0.0219
-0.0092	0.0000	-0.1232	0.0000	-0.1129	0.0000	0.0273	0.0248
0.0000	-0.0545	0.0000	0.0765	0.0000	0.0297	0.0000	0.0119
-0.0308	0.0000	-0.0092	0.0000	0.0203	0.0000	-0.0220	0.0000
-0.0041	0.0000	0.0359	-0.0250				

RESIDUAL WAVEFRON VARIATIONS OVER UNIFORM MESH

PTS	RMS	MAX	MIN	SPAN	VOLUM
676.	0.205	0.530	-0.276	0.807	0.830

--DANA RED PSF ESCAN @ CENT 0. 0.

FUNCTION	MAX	VOL	AREA
ASF	0.819546E-02	0.244141E+00	4094

* STREHL RATIO* 0.1950

SPOT RADIUS	PERCENT ENERGY
0.000000	0.00
0.022885	5.00
0.034200	10.00
0.049228	15.00
0.060648	20.00
0.077269	25.00
0.080334	30.00
0.083399	35.00
0.086465	40.00
0.092727	45.00
0.100495	50.00
0.104356	55.00
0.113829	60.00
0.125881	65.00
0.144798	70.00
0.155105	75.00
0.163454	80.00
0.188949	85.00
0.224223	90.00
0.299491	95.00
0.735357	100.00

```
 --END
 --GSPOT RED ESCAN e CENTROID 0. 0.
1PME20T STATIC DEFLECTION MODEL                                    25-SEP-92 16:37:24

            SPOT    PERCENT
          RADIUS     ENERGY
        0.000000       0.00
        0.025692       5.00
        0.036022      10.00
        0.045723      15.00
        0.053491      20.00
        0.060170      25.00
        0.070436      30.00
        0.078315      35.00
        0.089811      40.00
        0.099725      45.00
        0.105038      50.00
        0.111562      55.00
        0.119129      60.00
        0.123897      65.00
        0.129628      70.00
        0.133862      75.00
        0.143447      80.00
        0.153726      85.00
        0.172933      90.00
        0.244515      95.00
        0.337056     100.00

 --END
 END OF DATA
```

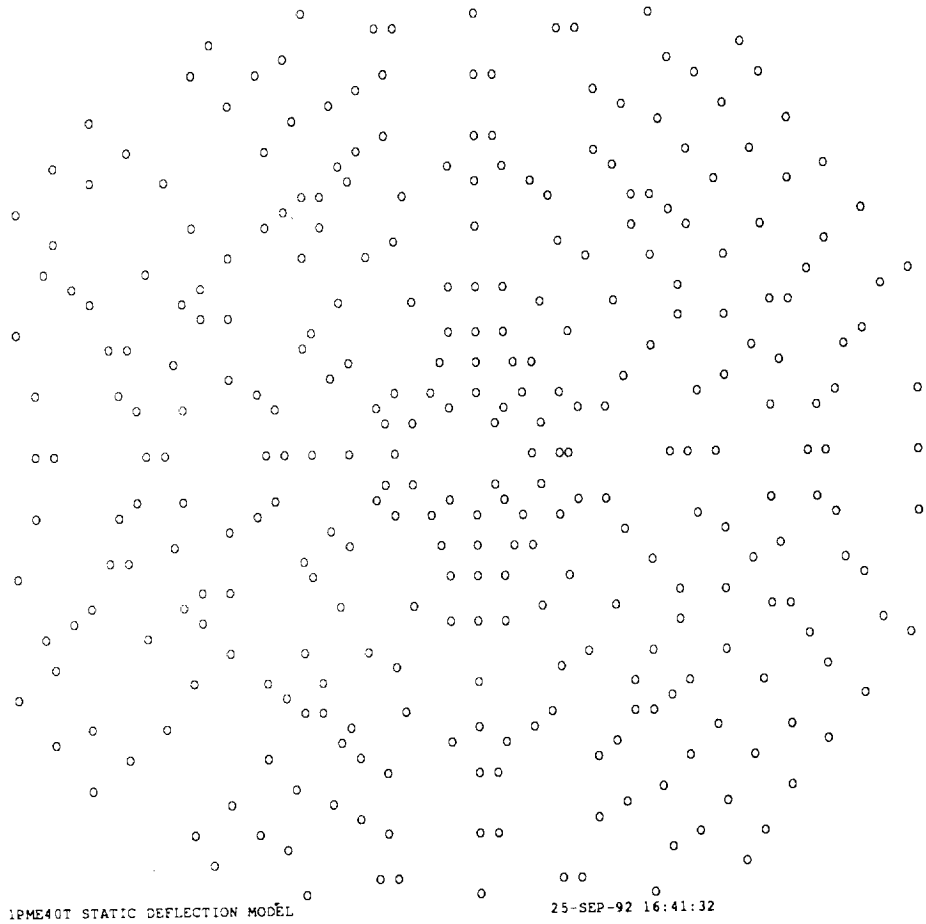
6.7.5 Case 3 Executive Input

```
PME40T STATIC DEFLECTION MODEL
DEFLECT OPTAX 3 UNITS CM XCIR 0 0 125. RADIUS 125. RADCV 622.
VERIFY COEFF NPOLY 36
CONTOUR 1. WIDTH .4 WEDGE 80252. FITERR .25
COBS 0.187 0.187
END
DANA RED PSF ESCAN e CENT 0. 0.
END
GSPOT RED ESCAN e SPOT CENTROID 0. 0.
END
```

6.7.6 Case 3 Output

```
1PME40T STATIC DEFLECTION MODEL                                    25-SEP-92 16:41:29
 --DEFLECT OPTAX 3 UNITS CM XCIR 0 0 125. RADIUS 125. RADCV 622.
 --VERIFY COEFF NPOLY 36
 --CONTOUR 1. WIDTH .4 WEDGE 80252. FITERR .25
 --COBS 0.187 0.187
 --TILT FOCUS
 --END

 PUPIL RADIUS    125.000    CM        WAVELENGTH  0.633 MICRONS

 DIFFRACTION ANGLE     0.0637     ARC SEC

 CUT-OFF FREQUENCY      3950.70     1/MR


 APERTURE MASKING
 TYPE        CAX        CAY        COX        COY
 ELIP     1.0000     1.0000     0.1870     0.1870


 ZERNIKE POLYNOMIAL COEFFICIENTS OF REFERENCE   WAVEFRON

     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000


 PUPIL CENTER AND RADIUS
            XC            YC           RAD
        0.0000        0.0000      125.0000
```

1PME40T STATIC DEFLECTION MODEL 25-SEP-92 16:41:31
FRINGE VERIFICATION



1PME40T STATIC DEFLECTION MODEL 25-SEP-92 16:41:32

WAVEFRON DEVIATION IN UNITS OF WAVES
TILT AND DEFOCUS MEASURED FROM DIFFRACTION FOCUS
WAVELENGTH 0.633 MICRONS
DEFLECTIONS ARE MAGNIFIED BY A FACTOR OF 0.0000E+00

	N	RMS
RAW	0	0.720
PLANE	2	0.695
SPHERE	3	0.210
4H ORDER	8	0.102
6H ORDER	15	0.089
8H ORDER	24	0.043
COMPLETE	36	0.033

STREHL RATIO 0.176 AT DIFFRACTION FOCUS

FOURTH ORDER ABERRATIONS

MAGNITUDE WAVES	ANGLE DEG	DESIGNATION
0.355	0.0	TILT
-1.790		DEFOCUS
0.412	0.0	ASTIGMATISM
0.929	0.0	COMA
0.261		SPHERICAL ABERRATION

FOLLOWING TERMS WERE SUBTRACTED FROM DATA-

TILT FOCUS

2.46727E-01	-1.75604E-06	-9.35500E-01	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

RESIDUAL WAVEFRON VARIATIONS EVALUATED AT DATA POINTS

PTS	RMS	MAX	MIN	SPAN	STREHL
336	0.220	0.699	-0.328	1.027	0.149

0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

RESIDUAL WAVEFRON VARIATIONS OVER UNIFORM GRID

PTS	RMS	MAX	MIN	SPAN	STREHL
676.	0.184	0.541	-0.324	0.866	0.264

1PME40T STATIC DEFLECTION MODEL 25-SEP-92 16:41:33

RMS CALCULATED FROM ZERNIKE COEFFICIENTS=0.182

ZERNIKE POLYNOMIAL COEFFICIENTS

0.0000	0.0000	0.0000	0.2379	0.0000	0.3633	0.0000	0.0514	-0.0075	0.0000	-0.0991	0.0000
-0.0920	0.0000	0.0583	-0.1913	0.0000	-0.0445	0.0000	0.0614	0.0000	0.0242	0.0000	0.0127
-0.0251	0.0000	0.0261	0.0000	0.0166	0.0000	-0.0178	0.0000	-0.0034	0.0000	0.0694	-0.0463

GENERAL POLYNOMIAL COEFFICIENTS

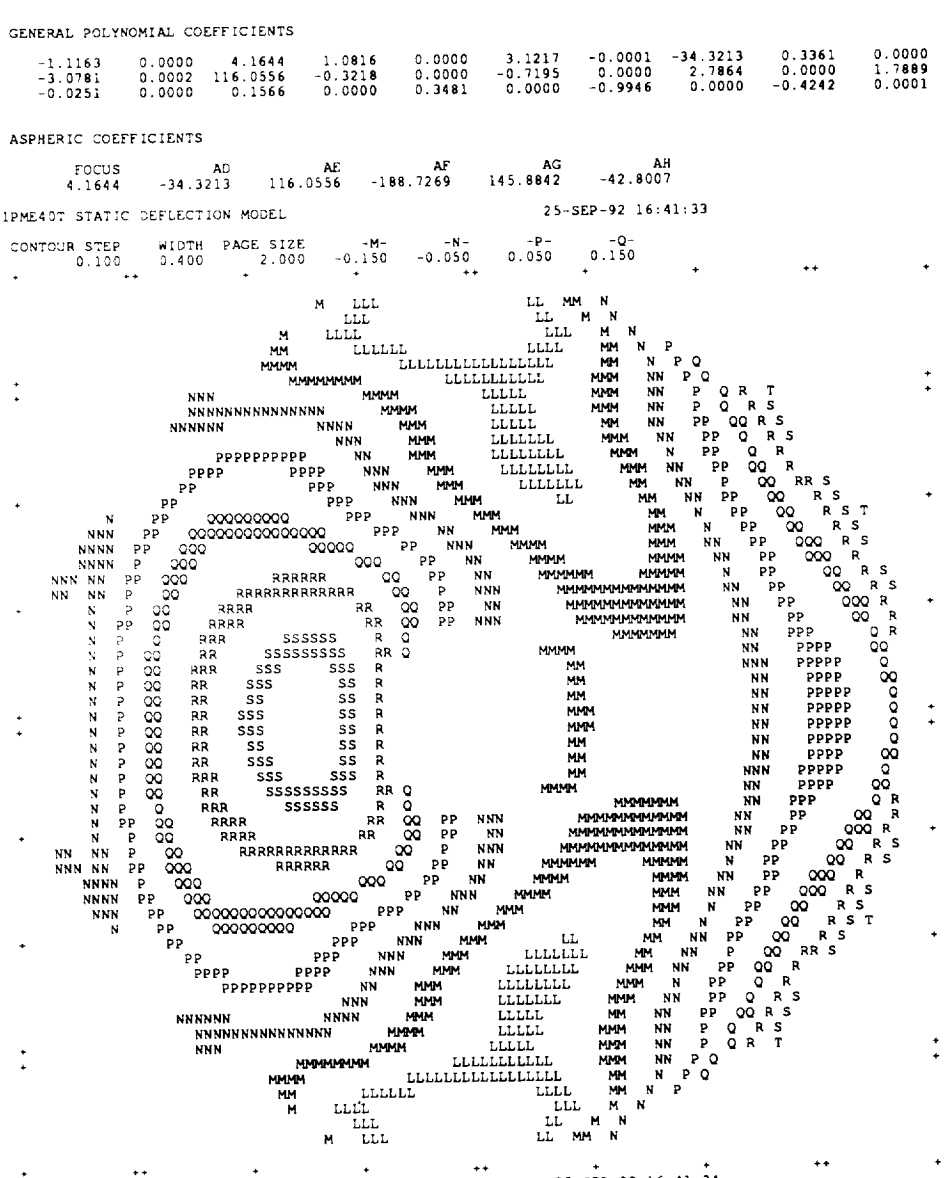
-1.1163	0.0000	4.1644	1.0816	0.0000	3.1217	-0.0001	-34.3213	0.3361	0.0000	-2.6909	0.0000
-3.0781	0.0002	116.0556	-0.3218	0.0000	-0.7195	0.0000	2.7864	0.0000	1.7889	-0.0002	-188.7269
-0.0251	0.0000	0.1566	0.0000	0.3481	0.0000	-0.9946	0.0000	-0.4242	0.0001	145.8842	-42.8007

ASPHERIC COEFFICIENTS

FOCUS	AD	AE	AF	AG	AH
4.1644	-34.3213	116.0556	-188.7269	145.8842	-42.8007

1PME40T STATIC DEFLECTION MODEL 25-SEP-92 16:41:33

CONTOUR STEP	WIDTH	PAGE SIZE	-M-	-N-	-P-	-Q-
0.100	0.400	2.000	-0.150	-0.050	0.050	0.150



1PME40T STATIC DEFLECTION MODEL 25-SEP-92 16:41:34

ZERNIKE POLYNOMIAL COEFFICIENTS

0.0000	0.0000	0.0000	0.2379	0.0000	0.3633	0.0000	0.0514
-0.0075	0.0000	-0.0991	0.0000	-0.0920	0.0000	0.0583	-0.1913
0.0000	-0.0445	0.0000	0.0614	0.0000	0.0242	0.0000	0.0127
-0.0251	0.0000	0.0261	0.0000	0.0166	0.0000	-0.0178	0.0000
-0.0034	0.0000	0.0694	-0.0463				

```
RESIDUAL   WAVEFRON VARIATIONS OVER UNIFORM MESH

       PTS        RMS        MAX        MIN       SPAN     VOLUM
      676.      0.184      0.541     -0.324      0.866     0.975

--DANA RED PSF ESCAN e CENT 0. 0.

  FUNCTION            MAX            VOL    AREA
     ASF    0.108528E-01 0.244141E+00    4096
* STREHL RATIO*  0.2583

            SPOT    PERCENT
          RADIUS     ENERGY
        0.000000       0.00
        0.019532       5.00
        0.026999      10.00
        0.035083      15.00
        0.046161      20.00
        0.058562      25.00
        0.073582      30.00
        0.079963      35.00
        0.083335      40.00
        0.086707      45.00
        0.093065      50.00
        0.100166      55.00
        0.103840      60.00
        0.109661      65.00
        0.121612      70.00
        0.143457      75.00
        0.159477      80.00
        0.179352      85.00
        0.227201      90.00
        0.322646      95.00
        0.736605     100.00

--END
--GSPOT RED ESCAN e CENTROID 0. 0.
1PME40T STATIC DEFLECTION MODEL                                  25-SEP-92 16:41:37

            SPOT    PERCENT
          RADIUS     ENERGY
        0.000000       0.00
        0.026638       5.00
        0.036448      10.00
        0.048134      15.00
        0.058880      20.00
        0.067096      25.00
        0.074318      30.00
        0.080465      35.00
        0.086143      40.00
        0.091533      45.00
        0.097725      50.00
        0.103583      55.00
        0.109251      60.00
        0.117258      65.00
        0.123911      70.00
        0.132051      75.00
        0.136437      80.00
        0.150257      85.00
        0.193028      90.00
        0.293016      95.00
        0.468102     100.00

--END
END OF DATA
```

6.7.7 Case 4 Executive Input

```
PME60T STATIC DEFLECTION MODEL
DEFLECT OPTAX 3 UNITS CM XCIR 0 0 125. RADIUS 125. RADCV 622.
VERIFY COEFF NPOLY 36
CONTOUR 1. WIDTH .4 WEDGE 80252. FITERR .25
COBS 0.187 0.187
END
DANA RED PSF ESCAN e CENT 0. 0.
END
GSPOT RED ESCAN e SPOT CENTROID 0. 0.
END
```

6.7.8 Case 4 Output

```
1PME60T STATIC DEFLECTION MODEL                                  25-SEP-92 17:14:24
 --DEFLECT OPTAX 3 UNITS CM XCIR 0 0 125. RADIUS 125. RADCV 622.
 --VERIFY COEFF NPOLY 36
 --CONTOUR 1. WIDTH .4 WEDGE 80252. FITERR .25
 --COBS 0.187 0.187
 --TILT FOCUS
 --END

 PUPIL RADIUS    125.000    CM        WAVELENGTH  0.633 MICRONS

 DIFFRACTION ANGLE     0.0637     ARC SEC

 CUT-OFF FREQUENCY      3950.70     1/MR
```

APERTURE MASKING

TYPE	CAX	CAY	COX	COY
ELIP	1.0000	1.0000	0.1870	0.1870

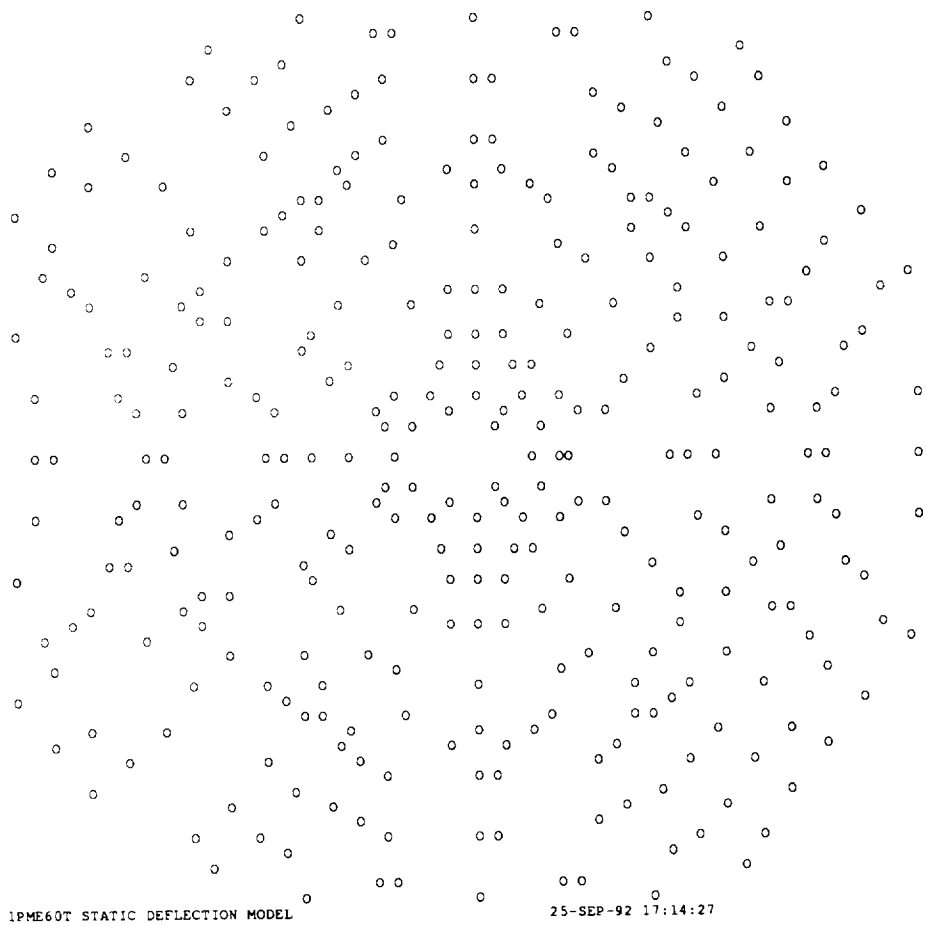
ZERNIKE POLYNOMIAL COEFFICIENTS OF REFERENCE WAVEFRON

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PUPIL CENTER AND RADIUS

XC	YC	RAD
0.0000	0.0000	125.0000

1PME60T STATIC DEFLECTION MODEL 25-SEP-92 17:14:27
FRINGE VERIFICATION



1PME60T STATIC DEFLECTION MODEL 25-SEP-92 17:14:27

WAVEFRON DEVIATION IN UNITS OF WAVES
TILT AND DEFOCUS MEASURED FROM DIFFRACTION FOCUS
WAVELENGTH 0.633 MICRONS
DEFLECTIONS ARE MAGNIFIED BY A FACTOR OF 0.0000E+00

	N	RMS
RAW	0	0.929
PLANE	2	0.911
SPHERE	3	0.205
4H ORDER	8	0.159
6H ORDER	15	0.156
8H ORDER	24	0.055
COMPLETE	36	0.038

STREHL RATIO 0.190 AT DIFFRACTION FOCUS

FOURTH ORDER ABERRATIONS

MAGNITUDE WAVES	ANGLE DEG	DESIGNATION
0.338	0.0	TILT
-2.399		DEFOCUS
0.290	0.0	ASTIGMATISM
0.606	0.0	COMA
0.381		SPHERICAL ABERRATION

FOLLOWING TERMS WERE SUBTRACTED FROM DATA-

TILT	FOCUS		
2.66937E-01	-1.72228E-06	-1.25823E+00	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

RESIDUAL WAVEFRON VARIATIONS EVALUATED AT DATA POINTS

PTS	RMS	MAX	MIN	SPAN	STREHL
336	0.215	0.722	-0.431	1.153	0.167

0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

RESIDUAL WAVEFRON VARIATIONS OVER UNIFORM GRID

PTS	RMS	MAX	MIN	SPAN	STREHL
676.	0.176	0.652	-0.415	1.067	0.295

1PME60T STATIC DEFLECTION MODEL 25-SEP-92 17:14:29

RMS CALCULATED FROM ZERNIKE COEFFICIENTS=0.174

ZERNIKE POLYNOMIAL COEFFICIENTS

0.0000	0.0000	0.0000	0.1651	0.0000	0.2371	0.0000	0.0747	-0.0049	0.0000	-0.0631	0.0000
-0.0601	0.0000	0.0823	-0.3843	0.0000	-0.0290	0.0000	0.0389	0.0000	0.0158	0.0000	0.0120
-0.0164	0.0000	0.0582	0.0000	0.0108	0.0000	-0.0114	0.0000	-0.0022	0.0000	0.0944	-0.0621

GENERAL POLYNOMIAL COEFFICIENTS

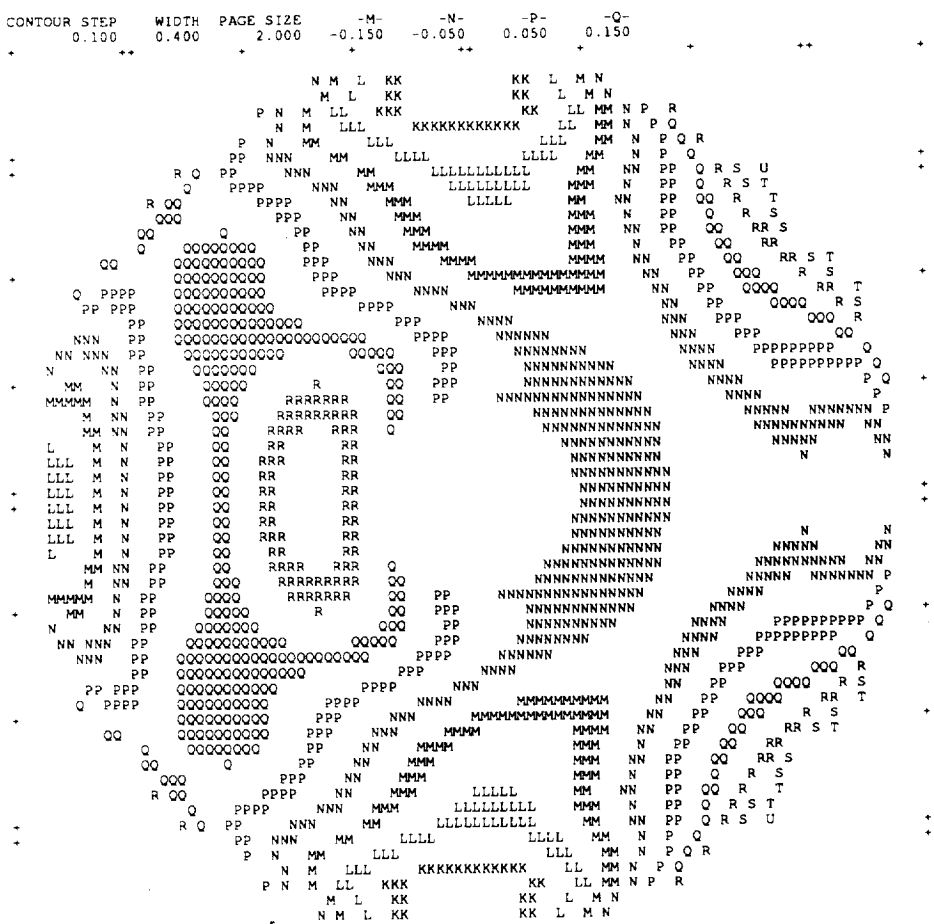
-0.7285	0.0000	5.7411	0.7014	0.0000	2.0371	0.0000	-46.8547	0.2193	0.0000	-1.7117	0.0000
-2.0078	0.0000	157.1767	-0.6755	0.0000	-0.4696	0.0000	1.7754	-0.0001	1.1661	0.0000	-254.2660
-0.0164	0.0000	0.3495	0.0000	0.2272	0.0000	-0.6356	0.0000	-0.2763	0.0000	195.9352	-57.3788

ASPHERIC COEFFICIENTS

FOCUS	AD	AE	AF	AG	AH
5.7411	-46.8547	157.1767	-254.2660	195.9352	-57.3788

1PME60T STATIC DEFLECTION MODEL 25-SEP-92 17:14:29

CONTOUR STEP	WIDTH	PAGE SIZE	-M-	-N-	-P-	-Q-
0.100	0.400	2.000	-0.150	-0.050	0.050	0.150



1PME60T STATIC DEFLECTION MODEL 25-SEP-92 17:14:30

ZERNIKE POLYNOMIAL COEFFICIENTS

0.0000	0.0000	0.0000	0.1651	0.0000	0.2371	0.0000	0.0747
-0.0049	0.0000	-0.0631	0.0000	-0.0601	0.0000	0.0823	-0.3843
0.0000	-0.0290	0.0000	0.0389	0.0000	0.0158	0.0000	0.0120
-0.0164	0.0000	0.0582	0.0000	0.0108	0.0000	-0.0114	0.0000
-0.0022	0.0000	0.0944	-0.0621				

RESIDUAL WAVEFRON VARIATIONS OVER UNIFORM MESH

PTS	RMS	MAX	MIN	SPAN	VOLUM
676.	0.176	0.652	-0.415	1.067	1.247

--DANA RED PSF ESCAN e

FUNCTION	MAX	VOL	AREA
ASF	0.125357E-01	0.244141E+00	4096

* STREHL RATIO* 0.2983

SPOT RADIUS	PERCENT ENERGY
0.000000	0.00
0.124184	5.00
0.159398	10.00
0.177572	15.00
0.194657	20.00
0.203422	25.00
0.213197	30.00
0.220968	35.00
0.231561	40.00
0.241570	45.00
0.244607	50.00
0.254212	55.00
0.258431	60.00
0.266700	65.00
0.274795	70.00
0.291273	75.00
0.308712	80.00
0.328775	85.00
0.360362	90.00
0.438163	95.00
0.728544	100.00

```
 --END
 --GSPOT RED ESCAN e
1PME60T STATIC DEFLECTION MODEL                                    25-SEP-92 17:14:33

            SPOT    PERCENT
          RADIUS     ENERGY
        0.000000       0.00
        0.027996       5.00
        0.040940      10.00
        0.045915      15.00
        0.059095      20.00
        0.065434      25.00
        0.071678      30.00
        0.079513      35.00
        0.085950      40.00
        0.091776      45.00
        0.098620      50.00
        0.107487      55.00
        0.114690      60.00
        0.120323      65.00
        0.126303      70.00
        0.138700      75.00
        0.156914      80.00
        0.193845      85.00
        0.272562      90.00
        0.377036      95.00
        0.540762     100.00

 --END
 END OF DATA
```

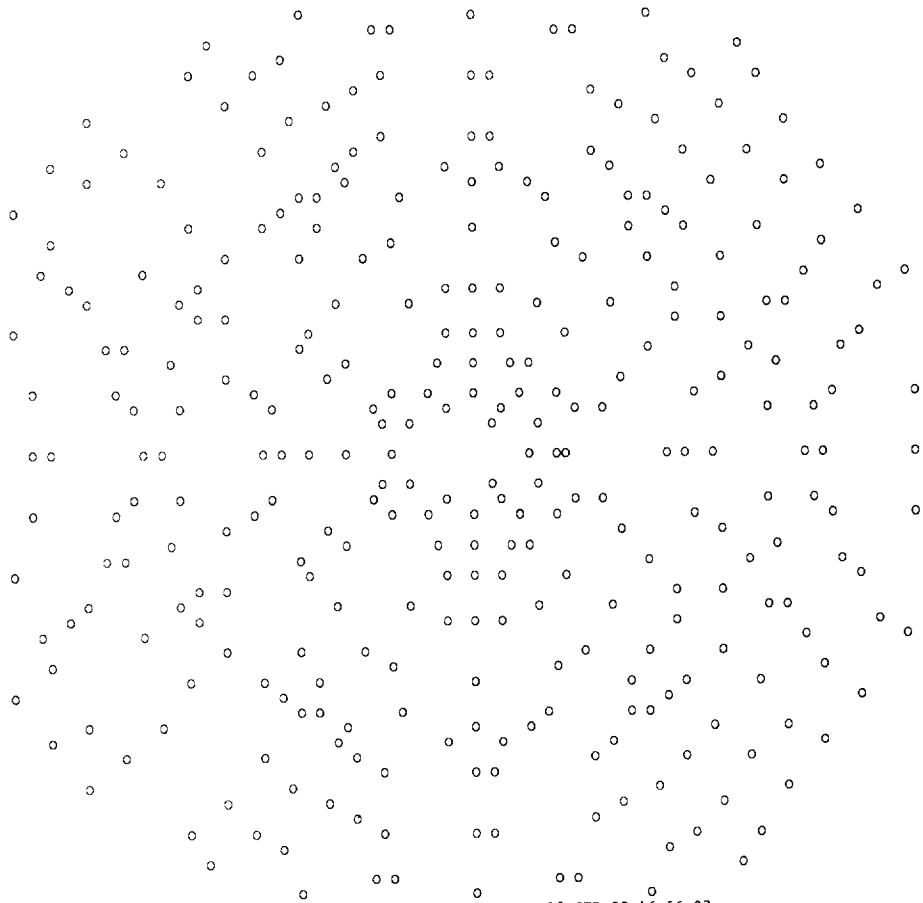
6.7.9 Case 5 Executive Input

```
PME90T STATIC DEFLECTION MODEL
DEFLECT OPTAX 3 UNITS CM XCIR 0 0 125. RADIUS 125. RADCV 622.
VERIFY COEFF NPOLY 36
CONTOUR 1. WIDTH .4 WEDGE 80252. FITERR .25
COBS 0.187 0.187
END
DANA RED PSF ESCAN e CENT 0. 0.
END
GSPOT RED ESCAN e SPOT CENTROID 0. 0.
END
```

6.7.10 Case 5 Output

```
1PME90T STATIC DEFLECTION MODEL                                    25-SEP-92 16:56:24
 --DEFLECT OPTAX 3 UNITS CM XCIR 0 0 125. RADIUS 125. RADCV 622.
 --VERIFY COEFF NPOLY 36
 --CONTOUR 1. WIDTH .4 WEDGE 80252. FITERR .25
 --COBS 0.187 0.187
 --TILT FOCUS
 --END

 PUPIL RADIUS   125.000   CM       WAVELENGTH  0.633 MICRONS

 DIFFRACTION ANGLE    0.0637    ARC SEC

 CUT-OFF FREQUENCY     3950.70    1/MR


 APERTURE MASKING
 TYPE       CAX       CAY       COX       COY
 ELIP    1.0000    1.0000    0.1870    0.1870


 ZERNIKE POLYNOMIAL COEFFICIENTS OF REFERENCE   WAVEFRON

     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000


 PUPIL CENTER AND RADIUS
            XC          YC          RAD
        0.0000      0.0000     125.0000
```

1PME90T STATIC DEFLECTION MODEL 25-SEP-92 16:56:26
FRINGE VERIFICATION



1PME90T STATIC DEFLECTION MODEL 25-SEP-92 16:56:27

WAVEFRON DEVIATION IN UNITS OF WAVES
TILT AND DEFOCUS MEASURED FROM DIFFRACTION FOCUS
WAVELENGTH 0.633 MICRONS
DEFLECTIONS ARE MAGNIFIED BY A FACTOR OF 0.0000E+00

	N	RMS
RAW	0	1.054
PLANE	2	1.046
SPHERE	3	0.234
4H ORDER	8	0.226
6H ORDER	15	0.226
8H ORDER	24	0.068
COMPLETE	36	0.042

STREHL RATIO 0.116 AT DIFFRACTION FOCUS

FOURTH ORDER ABERRATIONS

MAGNITUDE WAVES	ANGLE DEG	DESIGNATION
0.237	0.0	TILT
-2.755		DEFOCUS
0.048	0.0	ASTIGMATISM
0.000	-179.7	COMA
0.472		SPHERICAL ABERRATION

FOLLOWING TERMS WERE SUBTRACTED FROM DATA-

TILT	FOCUS		
2.37186E-01	-1.29732E-06	-1.45054E+00	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

RESIDUAL WAVEFRON VARIATIONS EVALUATED AT DATA POINTS

PTS	RMS	MAX	MIN	SPAN	STREHL
336	0.240	0.702	-0.485	1.187	0.103

0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

RESIDUAL WAVEFRON VARIATIONS OVER UNIFORM GRID

PTS	RMS	MAX	MIN	SPAN	STREHL
676.	0.198	0.668	-0.460	1.127	0.213

1PME90T STATIC DEFLECTION MODEL 25-SEP-92 16:56:29

RMS CALCULATED FROM ZERNIKE COEFFICIENTS=0.196

ZERNIKE POLYNOMIAL COEFFICIENTS

0.0000	0.0000	0.0000	0.0218	0.0000	0.0000	0.0000	0.0921	0.0000	0.0000	0.0035	0.0000
0.0000	0.0000	0.0991	-0.5811	0.0000	0.0000	0.0000	-0.0027	0.0000	0.0000	0.0000	0.0084
0.0000	0.0000	0.0923	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000	0.1101	-0.0714

GENERAL POLYNOMIAL COEFFICIENTS

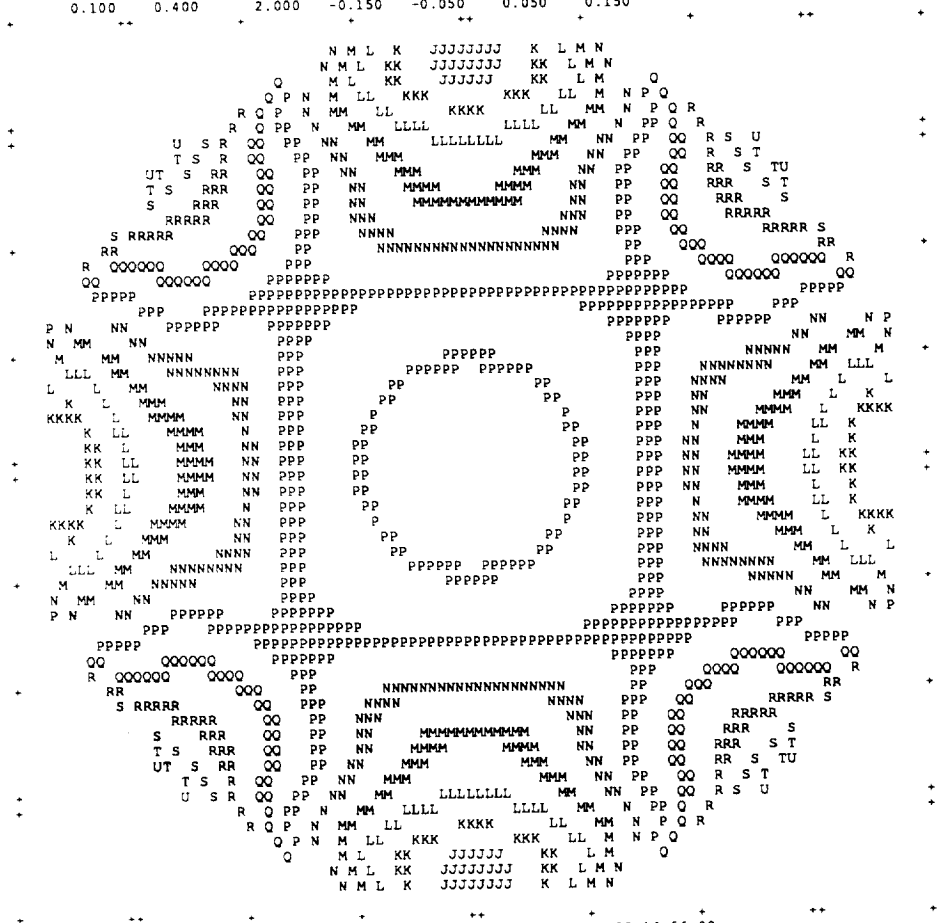
0.0001	0.0000	6.7708	-0.0101	0.0000	-0.0003	0.0000	-54.7729	0.0000	0.0000	0.0999	0.0000
0.0009	0.0000	182.4009	-1.0425	0.0000	0.0000	0.0000	-0.0970	0.0000	-0.0010	0.0000	-293.6491
0.0000	0.0000	0.5537	0.0000	0.0000	0.0000	0.0304	0.0000	0.0004	0.0000	225.6295	-65.9607

ASPHERIC COEFFICIENTS

FOCUS	AD	AE	AF	AG	AH
6.7708	-54.7729	182.4009	-293.6491	225.6295	-65.9607

1PME90T STATIC DEFLECTION MODEL 25-SEP-92 16:56:29

CONTOUR STEP	WIDTH	PAGE SIZE	-M-	-N-	-P-	-Q-
0.100	0.400	2.000	-0.150	-0.050	0.050	0.150



1PME90T STATIC DEFLECTION MODEL 25-SEP-92 16:56:30

ZERNIKE POLYNOMIAL COEFFICIENTS

0.0000	0.0000	0.0000	0.0218	0.0000	0.0000	0.0000	0.0921
0.0000	0.0000	0.0035	0.0000	0.0000	0.0000	0.0991	-0.5811
0.0000	0.0000	0.0000	-0.0027	0.0000	0.0000	0.0000	0.0084
0.0000	0.0000	0.0923	0.0000	0.0000	0.0000	0.0005	0.0000
0.0000	0.0000	0.1101	-0.0714				

RESIDUAL WAVEFRON VARIATIONS OVER UNIFORM MESH

PTS	RMS	MAX	MIN	SPAN	VOLUM
676.	0.198	0.668	-0.460	1.127	1.381

--DANA RED PSF ESCAN e CENT 0. 0.

FUNCTION	MAX	VOL	AREA
ASF	0.103907E-01	0.244141E+00	4096

* STREHL RATIO* 0.2473

SPOT RADIUS	PERCENT ENERGY
0.000000	0.00
0.019153	5.00
0.025097	10.00
0.031041	15.00
0.037208	20.00
0.043488	25.00
0.056965	30.00
0.069241	35.00
0.095848	40.00
0.104202	45.00
0.112350	50.00
0.119174	55.00
0.123250	60.00
0.127326	65.00
0.153854	70.00
0.177128	75.00
0.196361	80.00
0.215069	85.00
0.271191	90.00
0.405913	95.00
0.731437	100.00

--END
--GSPOT RED ESCAN e CENTROID 0. 0.
1PME90T STATIC DEFLECTION MODEL 25-SEP-92 16:56:32

SPOT RADIUS	PERCENT ENERGY
0.000000	0.00
0.038065	5.00
0.055180	10.00
0.063838	15.00
0.070349	20.00
0.079327	25.00
0.088204	30.00
0.095193	35.00
0.101623	40.00
0.108143	45.00
0.114530	50.00
0.119818	55.00
0.126884	60.00
0.135362	65.00
0.147975	70.00
0.166458	75.00
0.183208	80.00
0.216471	85.00
0.327806	90.00
0.442765	95.00
0.562876	100.00

--END
END OF DATA