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USAAVLABS TECHNICAL REPORT 70-49B

FATIGUE STRENGTH OF LUGS CONTAINING LINERS

VOLUME II

COMPUTER PROGRAM USED FOR ANALYSES

By

Robert J. Mayerjak

November 1970

U. S. ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA

CONTRACT DAAJ02-67-C-0066

KAMAN AEROSPACE CORPORATION
BLOOMFIELD, CONNECTICUT

U.S. ARMY MATERIEL COMMAND

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The pin-loaded lug is a structural element of considerable importance in aircraft design, particularly in the design of helicopter rotor and control systems. Much work has been done in the analysis of lugs subjected to static loads. As a result, the static analysis of lugs has been reduced to a well-established rational convention, the most notable work being a much-referenced paper by Melcon and Hoblit wherein design allowables and an interaction formula for statically loaded aluminum and steel alloy lugs are reported. In contrast to the static case, no analogous design criterion exists for the design of lugs simultaneously subjected to axial and transverse fatigue loads. A most glaring testimony to the dearth of valid experimental data on pin-loaded lugs is demonstrated in MIL-HDBK-5A, wherein the section on joints offers no design guidance for lugs.

This contract was initiated to:

- Evaluate the fatigue strength of lugs subjected to vibratory loadings at various orientations to the lug axis of symmetry. More specifically, an interaction formula relating load orientation to lug endurance limit was sought.

- Substantiate the photoelastically established benefits in lug fatigue strength that can be derived through selection of interference fit.

- Determine the influence of edge distance and material on lug fatigue strength.

Seventy-three lug specimens were validly failed by step-testing leading to the development of design charts in the form of modified Goodman diagrams for each material, load direction, and interference fit at two probability-of-failure levels. These charts compare favorably with test results reported in the literature and satisfy structural requirements for a range of edge-distance and load ratios particularly suitable for use in helicopter design. Development of an interaction formula did not materialize. Excessive scatter in the data precluded development of a general interaction formula applicable to both steel and titanium for each edge-distance ratio tested. A specific interaction formula for each configuration tested, although possible, was not pursued.

Results conclusively demonstrate that lug fatigue strength is materially improved by the introduction of high interference fit. Verification of the existence of an optimum interference fit as photoelastically predicted was inconclusive. For the high-modulus materials tested, the level of interference obtainable was limited by attainable thermal size changes. Thus, the "optimum" was the maximum attainable interference fit not causing lug yield. For lugs of lower modulus, such as aluminum or steel and titanium lugs with liners having substantially heavier wall thickness, it is believed that an optimum interference fit does exist beyond which increased interference would be detrimental.

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USAAVLABS Technical Report 70-49B
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FATIGUE STRENGTH OF LUGS CONTAINING LINERS

VOLUME II
COMPUTER PROGRAM USED FOR ANALYSES

By
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Prepared by

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Bloomfield, Connecticut

For

U. S. ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA

SUMMARY

This report presents a FORTRAN program for the analysis of elastic, two-dimensional, plane-stress structures. Examples show the application of the program to the analysis of lugs.

FOREWORD

This project was performed under Contract DAAJ02-67-C-0066, Task 1F162204A14601, under the cognizance of Mr. Joseph H. McGarvey of the Aeromechanics Division of USAAVLABS.

The tests and analyses were conducted at the Kaman Aerospace Corporation.

The report consists of two volumes:

Volume I, Results

Volume II, Computer Program Used for Analyses

The computer program presented herein was developed with contractor funds prior to the contract. The very significant contributions of Mr. Alex Berman and Dr. John Hsu to the computer program are gratefully acknowledged.

TABLE OF CONTENTS

	Page
SUMMARY	iii
FOREWORD	v
LIST OF ILLUSTRATIONS	viii
LIST OF SYMBOLS	ix
INTRODUCTION	1
STIFFNESS MATRICES FOR QUADRILATERAL ELEMENT	3
INSTRUCTIONS FOR USER	6
GENERAL	6
INPUT DESCRIPTION	10
BLOCK OUTLINE FOR INPUT DATA	11
OUTPUT DESCRIPTION	12
EXAMPLE 1	13
EXAMPLE 2	15
EXAMPLE 3	25
SOURCE PROGRAM	53
PROCESSING INFORMATION	53
FLOW DIAGRAM FOR MA2B	53
SOURCE PROGRAM DESCRIPTION	54
FORTRAN LISTING	56
DISTRIBUTION	78

LIST OF ILLUSTRATIONS

Figure		Page
1	Coordinates for Quadrilateral Element	3
2	Local Coordinates	8
3	Node Identifications P-Q-R-S for Quadrilateral Element	9
4	Structure for Example 1	14
5	Structure and Results for Example 2	23
6	Structure for Example 3	45
7	Tangential Stress Versus Radial Position for Example 3	51
8	Tangential Stress Versus Angular Position for Example 3	52

LIST OF SYMBOLS

A	matrix of compatible strain distribution due to element displacements
$A_1\ A_2\ A_3$	components of matrix A
$B\ C$	matrices of coeffieients occurring in the generalized Hooke's Law Equation, $\sigma = Ce - B\alpha T$

$$B = \frac{E}{1-\nu}\begin{Bmatrix} 1 \\ 1 \\ 0 \end{Bmatrix} \qquad C = \frac{E}{(1-\nu^2)}\begin{bmatrix} 1 & \nu & 0 \\ \nu & 1 & 0 \\ 0 & 0 & \frac{1-\nu}{2} \end{bmatrix}$$

D	column matrix of constants for assumed strain function
e	column matrix of total strains
E	Young's modulus
F	matrix of coordinate terms
h	thermal stiffness matrix
K	element stiffness matrix
T	element temperature
u	column matrix of element displacements
$u_x\ u_y$	displacements in the x and y directions, respectively
V	volume
$x\ y$	local Catesian coordinates
$X\ Y$	datum Catesian coordinates
α	coefficient of thermal expansion
ν	Poisson's ratio
σ	column matrix of element stresses

INTRODUCTION

This volume presents a FORTRAN program which was used to calculate the stresses in the lugs reported in Volume I. The program is named MA2B, which is an abbreviation for matrix analysis, two-dimensional structures, program version B. The information reported herein will enable the reader to use the program and to modify it, if desired.

MA2B is itself a modification of another program*. This reference provides excellent, lucid derivations and descriptions of the structural analysis methods and the basic logic used in programming. It is believed that it contained the first well-documented, general-purpose structural analysis program made available without proprietary restrictions. This volume draws heavily from the referenced document.

Program MA2B differs from its parent in four ways:

1. It contains a general, quadrilateral-shaped element.
2. It uses a special Gauss-elimination algorithm for the solution of the simultaneous equations.
3. It is restricted to two-dimensional analysis.
4. It uses more compact input and output.

The incorporation of a general, quadrilateral-shaped element is particularly important for problems with curved boundaries, such as lugs. For these problems the quadrilateral element gives more accurate and more easily interpreted results. The special Gauss-elimination algorithm greatly increased the number of nodes which could be used for a given core memory size. The algorithm stores only the non-zero elements of the upper triangle of the master stiffness matrix plus up to five columns of non-zero forces. Two facts are noteworthy regarding this technique:

---

* Przemieniecki, J.S., and Berke, Laszlo, DIGITAL COMPUTER PROGRAM FOR THE ANALYSIS OF AEROSPACE STRUCTURES BY THE MATRIX DISPLACEMENT METHOD, FDL TDR 64-18, AF Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, April 1964, AD600418.

1. The economy of storage exists even if a few elements in the stiffness matrix are very widely spaced (not banded about the diagonal).

2. The number of nodes that can be used increases in linear proportion to the size of the available core.

MA2B was restricted to two-dimensional analysis to increase further the number of nodes that could be used. As a result of the changes, MA2B can solve problems with 300 node points using double precision arithmetic. For comparison, the referenced program allowed only 70 nodes and used single precision arithmetic. As a consequence of the increased size of the problem that could be handled, it became desirable to change the input and output to more compact block tabular forms.

STIFFNESS MATRICES FOR QUADRILATERAL ELEMENT

The referenced document provides a complete presentation of the method used, including derivations of all equations. This section describes only the additions that were made.

The coordinate system used for the quadrilateral element is shown in Figure 1.

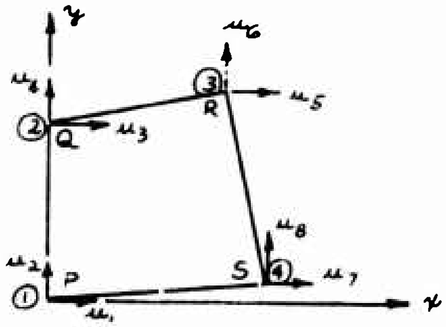


Figure 1. Coordinates for Quadrilateral Element.

The stiffness matrix for the quadrilateral element was calculated using the assumed displacement function:

$$u_x = D_1 + D_2 x + D_3 y + D_4 xy$$
$$u_y = D_5 + D_6 x + D_7 y + D_8 xy$$

If P-Q is not perpendicular to R-S, the constants can be determined from the given coordinates for points P-Q-R-S, called 1-2-3-4, respectively. Thus,

$$\begin{Bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \\ u_6 \\ u_7 \\ u_8 \end{Bmatrix} = \begin{bmatrix} 1 & x_1 & y_1 & x_1y_1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & x_1 & y_1 & x_1y_1 \\ 1 & x_2 & y_2 & x_2y_2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & x_2 & y_2 & x_2y_2 \\ 1 & x_3 & y_3 & x_3y_3 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & x_3 & y_3 & x_3y_3 \\ 1 & x_4 & y_4 & x_4y_4 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & x_4 & y_4 & x_4y_4 \end{bmatrix} \begin{Bmatrix} D_1 \\ D_2 \\ D_3 \\ D_4 \\ D_5 \\ D_6 \\ D_7 \\ D_8 \end{Bmatrix}$$

$$u = F^{-1} D$$
$$D = F u$$

It can be shown that all elements of F are zero except

$$
\begin{aligned}
F_{11} &= F_{52} = 1.0 \\
F_{21} &= F_{62} = (x_3 y_3 - x_4 y_4 + y_4 y_3 (x_4 - x_3)/y_2)/p \\
F_{23} &= F_{63} = y_3 y_4 (x_3 - x_4)/(p\, y_2) \\
F_{25} &= F_{66} = x_4 y_4 / p \\
F_{27} &= F_{68} = -x_3 y_3 / p \\
F_{31} &= -F_{33} = F_{72} = -F_{74} = -1.0/y_2 \\
F_{41} &= F_{82} = ((x_4 - x_3) + (x_3 y_4 - x_4 y_3)/y_2)/p \\
F_{43} &= F_{84} = (x_4 y_3 - x_3 y_4)/(p\, y_2) \\
F_{45} &= F_{86} = -x_4/p \\
F_{47} &= F_{88} = x_3/p
\end{aligned}
$$

where $p = x_3 x_4 (y_4 - y_3)$ and the hierarchy of operations of FORTRAN apply.

The strains become

$$
\mathbf{e} = \begin{bmatrix} e_{xx} \\ e_{yy} \\ e_{xy} \end{bmatrix} = \begin{bmatrix} \dfrac{\partial u_x}{\partial x} \\ \dfrac{\partial u_y}{\partial y} \\ \dfrac{\partial u_x}{\partial y} + \dfrac{\partial u_y}{\partial x} \end{bmatrix} = \begin{bmatrix} D_2 + D_4 y \\ D_7 + D_8 x \\ D_3 + D_4 x + D_6 + D_8 y \end{bmatrix}
$$

$$
\mathbf{e} = A u
$$

$$
A = \begin{bmatrix} (F_{21} + F_{41} y) & (F_{22} + F_{42} y) & \cdots & (F_{28} + F_{48} y) \\ (F_{71} + F_{81} x) & (F_{72} + F_{82} x) & \cdots & (F_{78} + F_{88} x) \\ (F_{31} + F_{61} + F_{41} x + F_{81} y) & \cdots & & (F_{38} + F_{68} + F_{48} x + F_{88} y) \end{bmatrix}
$$

The element stiffness matrices k and h were calculated using the unit displacement theorem.

$$k = \int_V A^T C A \, dV$$

$$h = \int_V A^T B \, dV$$

The matrix A was considered to be composed of 3 components.

$$A = A_1 + A_2 x + A_3 y$$

$$A_1 = \begin{bmatrix} F_{21} & \cdots & F_{28} \\ F_{71} & \cdots & F_{78} \\ (F_{31}+F_{61}) & \cdots & (F_{38}+F_{68}) \end{bmatrix}, \quad A_2 = \begin{bmatrix} 0 & \cdots & 0 \\ F_{81} & \cdots & F_{88} \\ F_{41} & \cdots & F_{48} \end{bmatrix}, \quad A_3 = \begin{bmatrix} F_{41} & \cdots & F_{48} \\ 0 & \cdots & 0 \\ F_{81} & \cdots & F_{88} \end{bmatrix}$$

Then,

$$\begin{aligned} k = {} & A_1^T C A_1 \int_V dV + (A_1^T C A_2 + A_2^T C A_1) \int_V x \, dV \\ & + (A_1^T C A_3 + A_3^T C A_1) \int_V y \, dV \\ & + (A_2^T C A_3 + A_3^T C A_2) \int_V xy \, dV \\ & + A_2^T C A_2 \int_V x^2 dV + A_3^T C A_3 \int_V y^2 dV \end{aligned}$$

$$h = -A_1^T B \int_V dV - A_2^T B \int_V x \, dV - A_3^T B \int_V y \, dV$$

INSTRUCTIONS FOR USER

This section provides instructions for using the program and describes in detail the input and output. Complete examples are given to demonstrate the use of the program.

GENERAL

The following comments provide general guidance for input preparation.

Units

Any consistent set of units may be used for the input. The output will have corresponding units. The following units are recommended:

input:	Loads, kips	output:	forces, kips
	lengths, in.		deflections, in.
	E, ksi		stresses, ksi

Shape of Elements

The program will run to completion with almost any combination of elements. The only element which kills the program is a special quadrilateral element described in more detail later in these comments. In most cases, the results will have engineering significance even for very oddly shaped elements. However, the best results for stress analysis will be obtained if the following rules are applied:

1. Avoid panel elements with large length-to-width ratios.
2. Avoid mixing triangular and quadrilateral elements in the region of interest. The triangular elements will appear to be stiffer and will disturb the stress distribution.
3. Use a gradual transition from large-to small-sized elements.
4. Use quadrilateral elements which are nearly rectangles.
5. Orient the local axes of the quadrilateral elements in the direction of anticipated principal stresses.

Number of Nodes

The permissible number of nodes is limited by the number of non-zero elements that are developed in the stiffness matrix and the loading conditions, both initially and during the course of the Gaussian elimination. The program is dimensioned to handle 6000 non-zero elements. How many nodes this corresponds to is indeterminate. However, for a typical structure, 300 node points can be used if the nodes are numbered judiciously. For example, the lug described herein had 258 node points and developed less than 4200 non-zero elements. The objective in node-point numbering is to avoid interspersing high and low node-point numbers. A good practice is to assign the node numbers consecutively, starting at one end of the structure and proceeding systematically to the other end. This will cause the stiffness matrix to become a desirable narrow band along the diagonal and will make the results more easily interpreted. If the structure is closed, the above-described procedure will cause the highest node numbers to become adjacent to the lowest numbers. This is not to be feared. It will not appreciably disturb the Gaussian elimination procedure used herein.

Number of Elements

Any number of elements can be used.

Number of Loading Cases

Up to five loading cases can be analyzed simultaneously, with a small increase in computation time. However, it is important to note that a large number of non-zero terms can be created if several loading conditions are used which have many node points loaded mechanically or by thermal forces. For such cases, the permissible number of nodes is less than if the load cases were done one at a time.

Datum Coordinates

Any convenient origin for datum coordinates may be used. Either right-hand or left-hand systems may be used.

Support Conditions

The support conditions are specified by placing the letter S after the coordinate, in a proper column. The computer will then prohibit the displacement of that node point in the direction of the coordinate. Sufficient supports must be defined to enable the structure to be stable for any loading condition.

Mechanical Loads

The actual mechanical loads acting upon the real structure must be applied as concentrated forces acting at the node points of the idealized structure. The directions of the forces must correspond to datum coordinates, not local coordinates.

Thermal Loads

Thermal stresses can be determined by specifying a coefficient of thermal expansion and a temperature for each element. The temperature distribution in the real structure must be represented by temperatures which can vary from element to element, but which are constant within each element. If no thermal loads are applied, simply leave the input spaces blank.

Element Identification

The element identification number IE may be assigned randomly. However, a systematic assignment will be very helpful for finding the element during the interpretation of the output.

Local Coordinates

The node numbers of the vertices of each element are used to define both the position of the element and a set of local coordinates. The node numbers appear in the input as IP, IQ, IR, and IS; they correspond to the points P-Q-R-S shown in Figure 2.

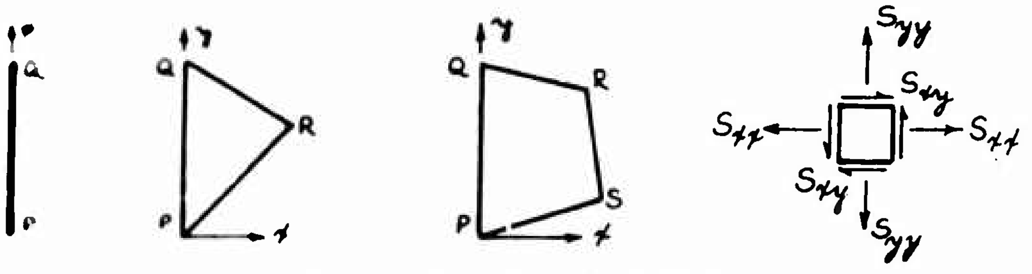


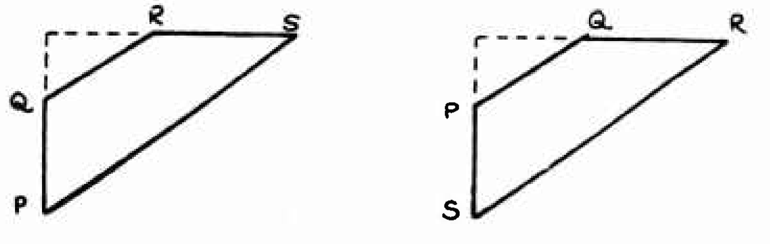
Figure 2. Local Coordinates.

The local coordinates xy shown in Figure 2 conform to the following rules: For bar elements, local x has the direction and sense of a line drawn from P to Q. For panel elements, y has the direction and sense of a line drawn from P to Q. Local x is perpendicular to y. Local x has a sense that can be established using the right-hand rule, considering local z to be coming out of the sheet.

The direction of local coordinates is important because the stresses will be calculated and presented in the output using the local coordinate system.

A Special Requirement for a ~~Quadrilateral~~

P-Q-R-S for a quadrilateral must be selected in consecutive order around the element. Best results will be obtained if R-S is relatively parallel to P-Q. If the R-S direction were chosen to be perpendicular to the P-Q direction, as shown in Figure 3, the method of analysis would break down. Under such conditions, the coefficients D for the assumed displacement function could not be determined uniquely from the coordinates of the vertices of the quadrilateral element. The matrix F would be singular. The condition can always be avoided by a simple change of designation for P-Q-R-S, as shown in Figure 3.



Very Bad,
Fatal to Program

Satisfactory

Figure 3. Node Identifications P-Q-R-S for Quadrilateral Element.

INPUT DESCRIPTION

Name	Description
RH	heading
NNØDES	number of nodes
NELEM	number of elements
NC	number of load cases, no more than 5
NLN	number of loaded nodes
M	node number for first coordinate on card. See Note 1.
N	node number for last coordinate on card. Note: $N \le M + 6$
C	identification symbol for coordinate direction, use: C = X for X-direction C = Y for Y-direction
X(J)	X-coordinate for node J, datum
Y(J)	Y-coordinate for node J, datum
S	support condition for node J in direction of coordinate. Leave blank if node is free of external support. Use S = S if support exists.
K	node number for load application point. See Note 2.
L	identification symbol for load direction, use: L = X for loads in X-direction L = Y for loads in Y-direction
QX(J)	X-direction load at node K for case J
QY(J)	Y-direction load at node K for case J

Name	Description
IE	identification number for element
IP, IQ, IR, IS	node numbers for corners of the element, corresponding to P, Q, R, S
NT	number identifying element type, use: NT = 1 for bar element NT = 2 for triangular panel element NT = 3 for quadrilateral panel element
TH	thickness of panel element or area of bar element
E	Young's modulus of elasticity
ALPHA	coefficient of thermal expansion
PR	Poisson's ratio
T(J)	temperature of element for loading case J
ICØNT	control symbol for next job. Use: ICØNT = 1 if analysis of a new structure is desired. Begin input for new structure at RH, heading card. ICØNT = 2 to end calculations

NOTES:

1. The input of coordinates is done in two groups. All X-coordinates must go in first; then, all Y-coordinates. Up to seven coordinates can be used per card. The number M and N identify the node numbers for the coordinates on each card.

2. The input of mechanical loading is done for each loading point in turn. Two cards are required for each point. The first must contain the X-direction loads: the second the Y-direction loads. If there are no mechanical loads but only thermally induced loads, omit items K, L, QX(J) and QY(J).

BLOCK OUTLINE FOR INPUT DATA

COLUMN NUMBER ON DATA CARD FOR END OF FIELD

10	20	30	40	
RH		(WHOLE	CARD MAY	BE USED)
NNODES	NELEM	NC	NLN	

4	8	10	19	20	29	30	39	40	49	50	59	60	69	70	79	80
M	N	C	X(M)	S	X(M+1)	S	X(M+2)	S	ETC. TO		X(N)	S				

CONTINUE UNTIL X-COORDINATE INPUT IS COMPLETE

4	8	10	19	20	29	30	39	40	49	50	59	60	69	70	79	80
M	N	C	Y(M)	S	Y(M+1)	S	Y(M+2)	S	ETC. TO		Y(N)	S				

CONTINUE UNTIL Y-COORDINATE INPUT IS COMPLETE

4	10	20	30	40	50	60	
K	L	QX(1)	QX(2)	QX(3)	QX(4)	QX(5)	
K	L	QY(1)	QY(2)	QY(3)	QY(4)	QY(5)	

CONTINUE UNTIL MECHANICAL LOADING INPUT IS COMPLETE

4	8	12	16	20	24	30	40	50	55	60	65	70	75	80
IE	IP	IQ	IR	IS	NT	TH	E	ALPHA	PR	T(1)	T(2)	T(3)	T(4)	T(5)

CONTINUE, ONE CARD FOR EACH ELEMENT

NOTE, IF TH IS LEFT BLANK, THE COMPUTER WILL MAKE THE QUANTITIES TH, E, ALPHA, PR, AND T(J) EQUAL TO THE LAST VALUES ESTABLISHED FOR THESE QUANTITES. THE USER SHOULD TAKE ADVANTAGE OF THIS FEATURE TO SAVE KEYPUNCHING.

1	
IC	

OUTPUT DESCRIPTION

Name	Description
XX	normal stress parallel to the local x-coordinate
YY	normal stress parallel to the local y-coordinate
XY	shear stress
ON	octahedral normal stress
OS	octahedral shear stress
NZE	non-zero elements
BARK	number of non-zero elements in the master stiffness matrix
+RHS	sum of BARK and the non-zero elements (forces) on the right-hand sides of the deflection equations
REDU	non-zero elements remaining in +RHS after reduction to account for support conditions

NOTES:

1. The first page of output is a listing in block tabular form of the input values for the X-coordinates. The coordinates are listed row-by-row, from left to right, in order of the node-point number to which they correspond. Index numbers at the top and to the left of the block assist the user in identifying the node number for each coordinate value. If the node is fully restrained by a support in the X-direction, a letter S appears following the value. The second page gives Y-coordinate data in a similar format. These data are followed by self-explanatory listings of the remaining input data.

2. The calcuated output begins with block tabular listings of deflections at each node point. These deflections are relative to the datum coordinate system used to define the input coordinates. Tables of calculated stresses are then presented for each element, row-by-row. The element identification number is shown at the extreme left of each row. The stresses are calcalated at the

centroid position for each element.

3. Next, forces in datum coordinates are listed at each node point. These forces are calculated from the computed deflections and thus represent a statement of forces which must be applied at each node to produce the calculated deflections. Generally, a small force will be found, even at nodes which were supposed to be unloaded. The magnitude of the force is an indication of numerical calculation errors. In some cases, oversight errors in the input make themselves apparent in these tables. Additional checking information is provided by a check row which sums the node forces calculated from deflections and also sums the moment of these forces about the origin of the datum coordinates.

4. The last items of output provide information on the initial number of non-zero elements contained in the simultaneous equations which were solved to find the deflections.

EXAMPLE 1

This example shows the preparation of input data and provides a short problem suitable for testing the operation of the program on the user's equipment. Table I shows a listing of the input data for the analysis of the structure and loadings shown in Figure 4.

The running time for this example is 1 minute on the IBM 360 model 40 computer.

TABLE I. LISTING OF INPUT CARDS FOR EXAMPLE 1.

SHORT CHECKOUT CASE FOR MA2B					
12	6	2	4		
1 4 X	. S	. S	. S	. S	
5 8 X	.5	.5	.5	.5	
9 12 X	1.1	1.1	1.1	1.1	
1 4 Y	1.	.7 S	.3	.	
5 8 Y	1.	.7	.3	.	
9 12 Y	1.	.7	.3	.	
9 X	4.	11.			
9 Y	.	.			
10 X	6.	.			
10 Y	.	.			
11 X	6.	.			
11 Y	.	.			
12 X	4.	-11.			
12 Y	.	.			
1 2	1 5 6	3 .50	30000.	.0000065	.3
2 4	3 7 8	3			
3 6	5 9 10	3			
4 8	7 11 12	3			
5 3	2 6 7	3 .25	30000.	.0000065	.3
6 7	6 10 11	3			
2					

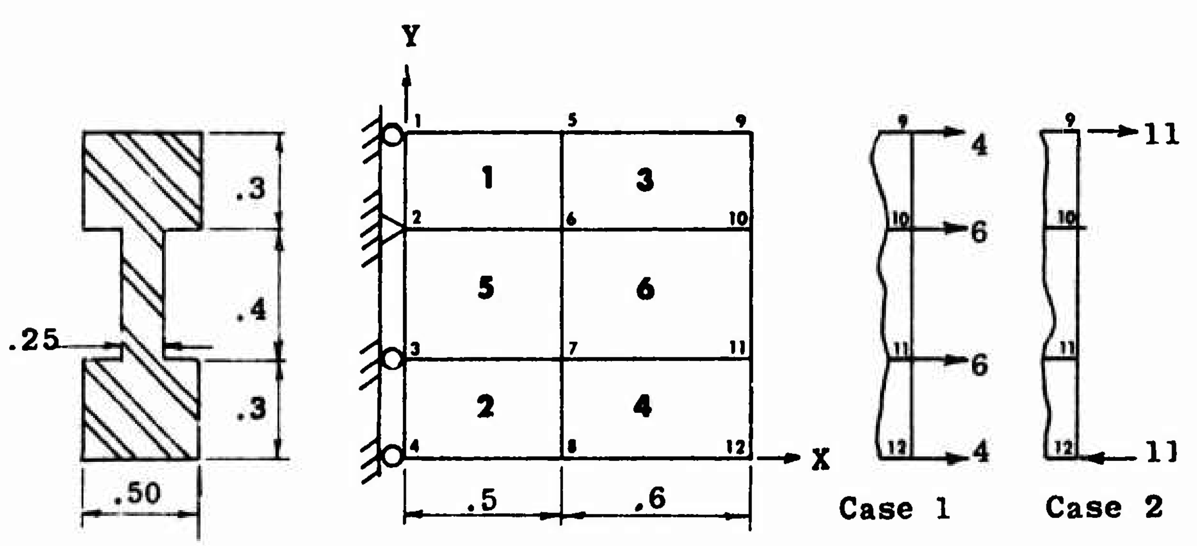


Figure 4. Structure for Example 1.

EXAMPLE 2

This example tests the ability of MA2B to find the stresses which result from an interference fit between two concentric circular cylinders. One-quarter of the assembly was analyzed using the finite-element pattern shown in Figure 5. This pattern is quite similar to those used for the lug analyses reported in Volume I.

Figure 5 also shows a comparison of the calculated stresses with the exact solution. The stresses from MA2B were in error by less than 2 percent for this case. The complete computer output for this example is shown in Table II. These data show a very symmetrical solution. The data also show that the interference (i/D = .001) was introduced by specifying a temperature rise of 134.1°F to the inner cylinder. No mechanical loads were applied.

The running time for this example is 10 minutes on the IBM 360 model 40 computer.

TABLE II. COMPUTER OUTPUT FOR EXAMPLE 2

LUG ANALYSIS NO. 100.1

X COORDINATES AND SUPPORTS

	1	2	3	4	5	6	7	8	9	10
1	0.5000	0.5460	0.5650	0.5520	0.6120	0.6520	0.7720	1.0000	0.4938	0.5393
11	0.5620	0.5847	0.6045	0.6440	0.7625	0.9877	0.4755	0.5193	0.5411	0.5630
21	0.5820	0.6201	0.7242	0.9511	0.4455	0.4865	0.5070	0.5275	0.5453	0.5809
31	0.6879	0.8910	0.4045	0.4417	0.4603	0.4789	0.4951	0.5275	0.6246	0.8090
41	0.3536	0.3861	0.4023	0.4166	0.4328	0.4610	0.5459	0.7071	0.2939	0.3209
51	0.3344	0.3480	0.3557	0.3832	0.4538	0.5878	0.2270	0.2479	0.2583	0.2688
61	0.2778	0.2960	0.3505	0.4540	0.1545	0.1687	0.1758	0.1825	0.1891	0.2015
71	0.2386	0.3090	0.0782	0.0854	0.0890	0.0926	0.0957	0.1020	0.1208	0.1564
81	0.0 S	0.0 S	0.0 S	0.0 S	0.0 S	0.0 S	0.0 S	0.0 S		

Y COORDINATES AND SUPPORTS

	1	2	3	4	5	6	7	8	9	10
1	0.0 S	0.0 S	0.0 S	0.0 S	0.0 S	0.0 S	0.0 S	0.0 S	-0.0782	-0.0854
11	-0.0890	-0.0926	-0.0557	-0.1020	-0.1208	-0.1564	-0.1545	-0.1687	-0.1758	-0.1829
21	-0.1891	-0.2015	-0.2366	-0.3090	-0.2270	-0.2479	-0.2583	-0.2688	-0.2778	-0.2960
31	-0.3505	-0.4540	-0.2539	-0.3209	-0.3344	-0.3480	-0.3597	-0.3832	-0.4538	-0.5878
41	-0.3536	-0.3861	-0.4023	-0.4166	-0.4328	-0.4610	-0.5459	-0.7071	-0.4045	-0.4417
51	-0.4603	-0.4789	-0.4551	-0.5275	-0.6246	-0.8090	-0.4455	-0.4865	-0.5070	-0.5275
61	-0.5453	-0.5809	-0.6675	-0.8910	-0.4755	-0.5193	-0.5411	-0.5630	-0.5820	-0.6201
71	-0.7342	-0.9511	-0.4536	-0.5393	-0.5620	-0.5847	-0.6045	-0.6440	-0.7625	-0.5877
81	-0.5000	-0.5460	-0.5650	-0.5920	-0.6120	-0.6520	-0.7720	-1.0000		

LOADS, CASE 1

LUG ANALYSIS NO. 100.1

ELEM	P	Q	R	S	TYPE	E	PR	THICK-AREA	ALPHA	TEM 1	TEM 2	TEM 3	TEM 4	TEM 5
1	9	1	2	10	3	29000.	0.3200	0.5000	0.00000630	134.				
2	10	2	3	11	3	29000.	0.3200	0.5000	0.00000630	134.				
3	12	4	5	13	3	29000.	0.3200	0.5000	0.00000630	0.				
4	13	5	6	14	3	29000.	0.3200	0.5000	0.00000630	0.				
5	14	6	7	15	3	29000.	0.3200	0.5000	0.00000630	0.				
6	15	7	8	16	3	29000.	0.3200	0.5000	0.00000630	0.				
7	17	9	10	18	3	29000.	0.3200	0.5000	0.00000630	134.				
8	18	10	11	19	3	29000.	0.3200	0.5000	0.00000630	134.				
9	20	12	13	21	3	29000.	0.3200	0.5000	0.00000630	0.				
10	21	13	14	22	3	29000.	0.3200	0.5000	0.00000630	0.				
11	22	14	15	23	3	29000.	0.3200	0.5000	0.00000630	0.				
12	23	15	16	24	3	29000.	0.3200	0.5000	0.00000630	0.				
13	25	17	18	26	3	29000.	0.3200	0.5000	0.00000630	134.				
14	26	18	19	27	3	29000.	0.3200	0.5000	0.00000630	134.				
15	28	20	21	29	3	29000.	0.3200	0.5000	0.00000630	0.				
16	29	21	22	30	3	29000.	0.3200	0.5000	0.00000630	0.				
17	30	22	23	31	3	29000.	0.3200	0.5000	0.00000630	0.				
18	31	23	24	32	3	29000.	0.3200	0.5000	0.00000630	0.				
19	33	25	26	34	3	29000.	0.3200	0.5000	0.00000630	134.				
20	34	26	27	35	3	29000.	0.3200	0.5000	0.00000630	134.				

TABLE II - Continued

21	36	28	29	37	3	29000.	0.3200	0.5000	0.00000630	0.
22	37	29	30	38	3	29000.	0.3200	0.5000	0.00000630	0.
23	38	30	31	39	3	29000.	0.3200	0.5000	0.00000630	0.
24	39	31	32	40	3	29000.	0.3200	0.5000	0.00000630	0.
25	41	33	34	42	3	29000.	0.3200	0.5000	0.00000630	134.
26	42	34	35	43	3	29000.	0.3200	0.5000	0.00000630	134.
27	44	36	37	45	3	29000.	0.3200	0.5000	0.00000630	0.
28	45	37	38	46	3	29000.	0.3200	0.5000	0.00000630	0.
29	46	38	39	47	3	29000.	0.3200	0.5000	0.00000630	0.
30	47	39	40	48	3	29000.	0.3200	0.5000	0.00000630	0.
31	49	41	42	50	3	29000.	0.3200	0.5000	0.00000630	134.
32	50	42	43	51	3	29000.	0.3200	0.5000	0.00000630	134.
33	52	44	45	53	3	29000.	0.3200	0.5000	0.00000630	0.
34	53	45	46	54	3	29000.	0.3200	0.5000	0.00000630	0.
35	54	46	47	55	3	29000.	0.3200	0.5000	0.00000630	0.
36	55	47	48	56	3	29000.	0.3200	0.5000	0.00000630	0.
37	57	49	50	58	3	29000.	0.3200	0.5000	0.00000630	134.
38	58	50	51	59	3	29000.	0.3200	0.5000	0.00000630	134.
39	60	52	53	61	3	29000.	0.3200	0.5000	0.00000630	0.
40	61	53	54	62	3	29000.	0.3200	0.5000	0.00000630	0.
41	62	54	55	63	3	29000.	0.3200	0.5000	0.00000630	0.
42	63	55	56	64	3	29000.	0.3200	0.5000	0.00000630	0.
43	65	57	58	66	3	29000.	0.3200	0.5000	0.00000630	134.
44	66	58	59	67	3	29000.	0.3200	0.5000	0.00000630	134.
45	68	60	61	69	3	29000.	0.3200	0.5000	0.00000630	0.
46	69	61	62	70	3	29000.	0.3200	0.5000	0.00000630	0.
47	70	62	63	71	3	29000.	0.3200	0.5000	0.00000630	0.
48	71	63	64	72	3	29000.	0.3200	0.5000	0.00000630	0.
49	73	65	66	74	3	29000.	0.3200	0.5000	0.00000630	134.
50	74	66	67	75	3	29000.	0.3200	0.5000	0.00000630	134.
51	76	68	69	77	3	29000.	0.3200	0.5000	0.00000630	0.
52	77	69	70	78	3	29000.	0.3200	0.5000	0.00000630	0.
53	78	70	71	79	3	29000.	0.3200	0.5000	0.00000630	0.
54	79	71	72	80	3	29000.	0.3200	0.5000	0.00000630	0.
55	81	73	74	82	3	29000.	0.3200	0.5000	0.00000630	134.
56	82	74	75	83	3	29000.	0.3200	0.5000	0.00000630	134.
57	84	76	77	85	3	29000.	0.3200	0.5000	0.00000630	0.
58	85	77	78	86	3	29000.	0.3200	0.5000	0.00000630	0.
59	86	78	79	87	3	29000.	0.3200	0.5000	0.00000630	0.
60	87	79	80	88	3	29000.	0.3200	0.5000	0.00000630	0.
61	11	3	4	12	3	29000.	0.3200	0.5000	0.00000630	134.
62	19	11	12	20	3	29000.	0.3200	0.5000	0.00000630	134.
63	27	19	20	28	3	29000.	0.3200	0.5000	0.00000630	134.
64	35	27	28	36	3	29000.	0.3200	0.5000	0.00000630	134.
65	43	35	36	44	3	29000.	0.3200	0.5000	0.00000630	134.
66	51	43	44	52	3	29000.	0.3200	0.5000	0.00000630	134.
67	59	51	52	60	3	29000.	0.3200	0.5000	0.00000630	134.
68	67	59	60	68	3	29000.	0.3200	0.5000	0.00000630	134.
69	75	67	68	76	3	29000.	0.3200	0.5000	0.00000630	134.
70	83	75	76	84	3	29000.	0.3200	0.5000	0.00000630	134.

TABLE II - Continued

LUG ANALYSIS NO. 100.1

X DEFLECTION, CASE 1

	1	2	3	4	5	6	7	8	9	10
1	5.431E-05	1.020E-04	1.247E-04	1.466E-04	1.433E-04	1.374E-04	1.243E-04	1.115E-04	5.365E-05	1.008E-04
11	1.232E-04	1.448E-04	1.415E-04	1.357E-04	1.228E-04	1.101E-04	5.165E-05	9.706E-05	1.186E-04	1.395E-04
21	1.363E-04	1.306E-04	1.182E-04	1.061E-04	4.835E-05	9.093E-05	1.111E-04	1.307E-04	1.277E-04	1.224E-04
31	1.104E-04	9.535E-05	4.394E-05	8.253E-05	1.009E-04	1.186E-04	1.159E-04	1.111E-04	1.006E-04	9.021E-05
41	3.842E-05	7.217E-05	8.817E-05	1.037E-04	1.013E-04	9.714E-05	8.790E-05	7.885E-05	3.192E-05	5.557E-05
51	7.329E-05	8.619E-05	8.423E-05	8.073E-05	7.307E-05	6.555E-05	2.467E-05	4.633E-05	5.661E-05	6.657E-05
61	6.505E-05	6.237E-05	5.644E-05	5.063E-05	1.678E-05	3.154E-05	3.853E-05	4.531E-05	4.428E-05	4.245E-05
71	3.842E-05	3.446E-05	8.457E-06	1.556E-05	1.951E-05	2.294E-05	2.241E-05	2.149E-05	1.946E-05	1.744E-05
81	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

Y DEFLECTION, CASE 1

	1	2	3	4	5	6	7	8	9	10
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-6.500E-06	-1.597E-05
11	-1.951E-05	-2.294E-05	-2.240E-05	-2.149E-05	-1.946E-05	-1.744E-05	-1.679E-05	-3.154E-05	-3.853E-05	-4.532E-05
21	-4.429E-05	-4.245E-05	-3.843E-05	-3.445E-05	-2.468E-05	-4.635E-05	-5.662E-05	-6.658E-05	-6.505E-05	-6.238E-05
31	-5.643E-05	-5.063E-05	-3.155E-05	-5.997E-05	-7.330E-05	-8.620E-05	-8.424E-05	-8.074E-05	-7.307E-05	-6.555E-05
41	-3.843E-05	-7.220E-05	-8.819E-05	-1.037E-04	-1.013E-04	-9.715E-05	-8.791E-05	-7.885E-05	-4.397E-05	-8.255E-05
51	-1.009E-04	-1.187E-04	-1.160E-04	-1.112E-04	-1.006E-04	-9.022E-05	-4.842E-05	-9.097E-05	-1.111E-04	-1.307E-04
61	-1.277E-04	-1.224E-04	-1.108E-04	-5.937E-05	-5.168E-05	-9.709E-05	-1.186E-04	-1.395E-04	-1.363E-04	-1.307E-04
71	-1.192E-04	-1.061E-04	-5.368E-05	-1.008E-04	-1.232E-04	-1.449E-04	-1.416E-04	-1.357E-04	-1.228E-04	-1.102E-04
81	-5.434E-05	-1.021E-04	-1.247E-04	-1.467E-04	-1.433E-04	-1.374E-04	-1.243E-04	-1.115E-04		

TABLE II - Continued

LUG ANALYSIS NO. 100.1

STRESS	XX	YY	XY	CN	CS	CASE
1	-0.9700	-20.5075	-0.0016	-7.1592	9.4470	1
2	-2.1230	-19.2874	-0.0040	-7.1368	8.6354	1
3	-2.9095	6.0544	0.0006	1.0483	3.7338	1
4	-2.4910	5.6489	0.0023	1.0526	3.4054	1
5	-1.6003	4.8579	0.0017	1.0858	2.7461	1
6	-0.4163	3.7879	0.0003	1.1239	1.8914	1
7	-0.9706	-20.5073	0.0012	-7.1593	9.4468	1
8	-2.1219	-19.2868	0.0020	-7.1362	8.6353	1
9	-2.9106	6.0559	-0.0006	1.0484	3.7349	1
10	-2.4911	5.6503	-0.0063	1.0531	3.4061	1
11	-1.6000	4.8577	-0.0012	1.0859	2.7459	1
12	-0.4161	3.7874	-0.0004	1.1238	1.8911	1
13	-0.9697	-20.5060	-0.0011	-7.1586	9.4464	1
14	-2.1224	-19.2878	-0.0006	-7.1367	8.6357	1
15	-2.9084	6.0554	-0.0002	1.0490	3.7339	1
16	-2.4925	5.6504	0.0028	1.0527	3.4066	1
17	-1.5958	4.8577	-0.0033	1.0859	2.7458	1
18	-0.4161	3.7875	0.0017	1.1238	1.8912	1
19	-0.9696	-20.5082	0.0016	-7.1553	9.4474	1
20	-2.1228	-19.2882	0.0096	-7.1370	8.6358	1
21	-2.9094	6.0559	-0.0011	1.0488	3.7345	1
22	-2.4908	5.6495	-0.0015	1.0529	3.4056	1
23	-1.6006	4.8569	0.0023	1.0854	2.7457	1
24	-0.4158	3.7883	-0.0001	1.1242	1.8915	1
25	-0.9704	-20.5085	-0.0010	-7.1556	9.4474	1
26	-2.1221	-19.2865	-0.0119	-7.1362	8.6351	1
27	-2.9110	6.0535	0.0007	1.0475	3.7339	1
28	-2.4915	5.6494	0.0084	1.0526	3.4058	1
29	-1.6000	4.8590	-0.0030	1.0864	2.7465	1
30	-0.4162	3.7879	-0.0011	1.1239	1.8914	1
31	-0.9688	-20.5073	0.0007	-7.1587	9.4472	1
32	-2.1239	-19.2905	0.0120	-7.1361	8.6367	1
33	-2.9113	6.0555	-0.0003	1.0481	3.7350	1
34	-2.4908	5.6507	-0.0091	1.0533	3.4062	1
35	-1.6004	4.8576	0.0028	1.0858	2.7460	1
36	-0.4161	3.7882	0.0008	1.1240	1.8915	1
37	-0.9707	-20.5096	-0.0007	-7.1601	9.4478	1
38	-2.1215	-19.2860	-0.0113	-7.1358	8.6350	1
39	-2.9095	6.0543	0.0001	1.0483	3.7338	1
40	-2.4919	5.6491	0.0011	1.0524	3.4058	1
41	-1.6003	4.8578	-0.0022	1.0858	2.7460	1
42	-0.4160	3.7882	-0.0002	1.1241	1.8915	1
43	-0.9695	-20.5069	0.0002	-7.1588	9.4468	1
44	-2.1238	-19.2895	0.0020	-7.1378	8.6362	1
45	-2.9089	6.0560	-0.0004	1.0490	3.7343	1
46	-2.4923	5.6495	-0.0030	1.0524	3.4061	1
47	-1.6005	4.8575	0.0029	1.0857	2.7460	1
48	-0.4162	3.7879	-0.0017	1.1239	1.8914	1
49	-0.9707	-20.5082	-0.0016	-7.1596	9.4472	1
50	-2.1215	-19.2870	-0.0022	-7.1362	8.6355	1

TABLE II - Continued

LUG ANALYSIS NO. 1C0.1

STRESS	XX	YY	XY	CA	CS	CASE
51	-2.91C7	6.C543	C.0CC3	1.C479	3.7342	1
52	-2.4918	5.6494	0.0071	1.C525	3.4C60	1
53	-1.6001	4.8575	0.0003	1.C858	2.7458	1
54	-C.4163	3.7879	C.00C6	1.1239	1.8914	1
55	-C.97CC	-20.5C85	C.0C13	-7.1595	9.4475	1
56	-2.1230	-19.2884	0.0041	-7.1371	8.6358	1
57	-2.9098	6.C544	C.0004	1.C482	3.7339	1
58	-2.4911	5.6491	-C.0029	1.C527	3.4C56	1
59	-1.6005	4.8577	-0.0017	1.C858	2.7461	1
60	-0.4162	3.7882	-0.0CC3	1.1240	1.8915	1
61	-2.7887	-18.6199	-0.0C11	-7.1362	8.1596	1
62	-2.7886	-18.6198	C.0C21	-7.1362	8.1596	1
63	-2.7895	-18.6198	-0.0004	-7.1364	8.1594	1
64	-2.7886	-18.62C0	-C.C001	-7.1362	8.1597	1
65	-2.7892	-18.6201	-C.0018	-7.1364	8.1596	1
66	-2.7889	-18.6196	0.0C16	-7.1362	8.1595	1
67	-2.7891	-18.6209	-C.0002	-7.1367	8.2C00	1
68	-2.7897	-18.6201	-C.0001	-7.1366	8.1596	1
69	-2.7889	-18.6203	-C.0019	-7.1364	8.1598	1
70	-2.7888	-18.6206	0.0C1C	-7.1365	8.1599	1

TABLE II - Continued

LUG ANALYSIS NC. 100.1

X FORCE, CASE 1

	1	2	3	4	5	6	7	8	9	10
1	5.960E-08	-8.792E-07	-3.576E-07	-5.364E-07	7.153E-07	3.017E-07	-1.021E-06	-1.043E-07	1.907E-06	-2.503E-06
11	-1.192E-06	-1.907E-06	-1.371E-06	-4.172E-07	1.788E-06	-1.267E-07	2.861E-06	2.980E-07	-5.960E-07	-9.537E-07
21	2.801E-06	1.550E-06	1.371E-06	1.192E-07	1.907E-06	3.576E-07	-2.980E-07	-9.537E-07	1.669E-06	-5.960E-08
31	7.421E-07	-5.960E-08	1.907E-06	3.576E-07	6.557E-07	0.0	2.146E-06	1.527E-06	6.519E-07	0.0
41	1.192E-07	1.609E-06	7.749E-07	-3.815E-06	2.325E-06	1.527E-07	8.345E-07	-4.768E-07	0.0	-1.073E-06
51	8.941E-07	-2.146E-06	5.141E-07	1.550E-06	-5.960E-08	1.788E-07	-1.192E-07	-4.843E-08	1.848E-06	1.431E-06
61	4.768E-07	1.013E-06	1.192E-07	-5.960E-08	-1.192E-07	-5.290E-07	-4.619E-07	-1.192E-06	5.960E-08	0.0
71	-2.384E-07	0.0	2.384E-07	-1.192E-07	0.0	-1.192E-06	-4.768E-07	0.0	-2.384E-07	1.863E-08
81	2.536E-01	3.380E-01	2.178E-01	6.633E-02	-8.861E-02	-2.176E-01	-3.854E-01	-1.844E-01		

Y FORCE, CASE 1

	1	2	3	4	5	6	7	8	9	10
1	-2.536E-01	-3.381E-01	-2.178E-01	-6.636E-02	8.865E-02	2.176E-01	3.853E-01	1.844E-01	-1.192E-07	6.557E-07
11	7.749E-07	1.848E-06	-4.172E-07	-5.960E-08	0.0	5.960E-08	-1.192E-07	1.371E-06	-5.960E-07	-6.557E-07
21	-1.311E-06	2.980E-07	7.749E-07	1.192E-07	1.192E-07	-2.384E-07	2.384E-07	5.960E-08	-1.848E-06	1.192E-06
31	-3.576E-07	-2.384E-07	1.788E-07	1.132E-06	-1.073E-06	-1.907E-06	7.153E-07	-1.192E-06	-5.960E-06	[illegible]92E-07
41	1.192E-07	1.550E-06	-7.749E-07	-9.537E-07	1.371E-06	-1.550E-06	-5.960E-08	1.788E-07	-9.537E-07	[illegible]9E-07
51	-5.960E-08	0.0	-9.537E-07	-2.027E-06	-9.537E-07	4.172E-07	-9.537E-07	2.027E-06	2.503E-06	[illegible]37E-07
61	-1.907E-06	-1.132E-06	-1.490E-06	4.768E-07	-9.537E-07	1.669E-06	-2.146E-06	2.861E-06	-2.861E-06	[illegible]669E-06
71	-7.153E-07	2.384E-07	-9.537E-07	1.132E-06	-2.623E-06	-1.907E-06	-9.537E-07	-8.345E-07	-1.490E-06	5.960E-07
81	1.192E-07	1.013E-06	-1.490E-06	-1.550E-06	-2.861E-06	-1.609E-06	-3.576E-07	-1.192E-07		

CHECKS, SUM		X-FORCES	Y-FORCES	Z-MOMENTS	CASE
		-3.946D-05	4.089D-05	-5.177D-06	1
NZE	BAPK	1453			
	+RHS	1541			
	RFCU	1387			

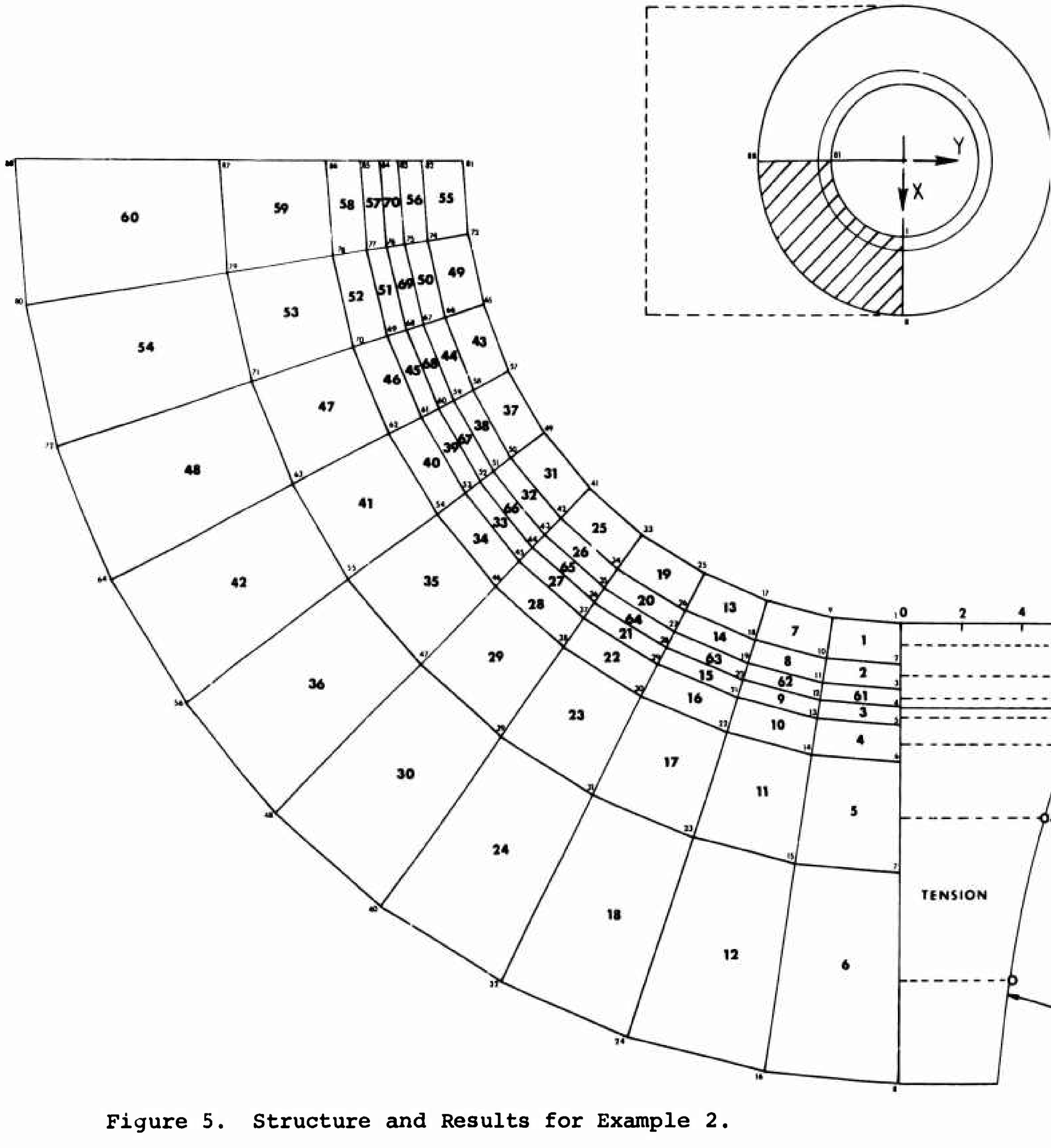
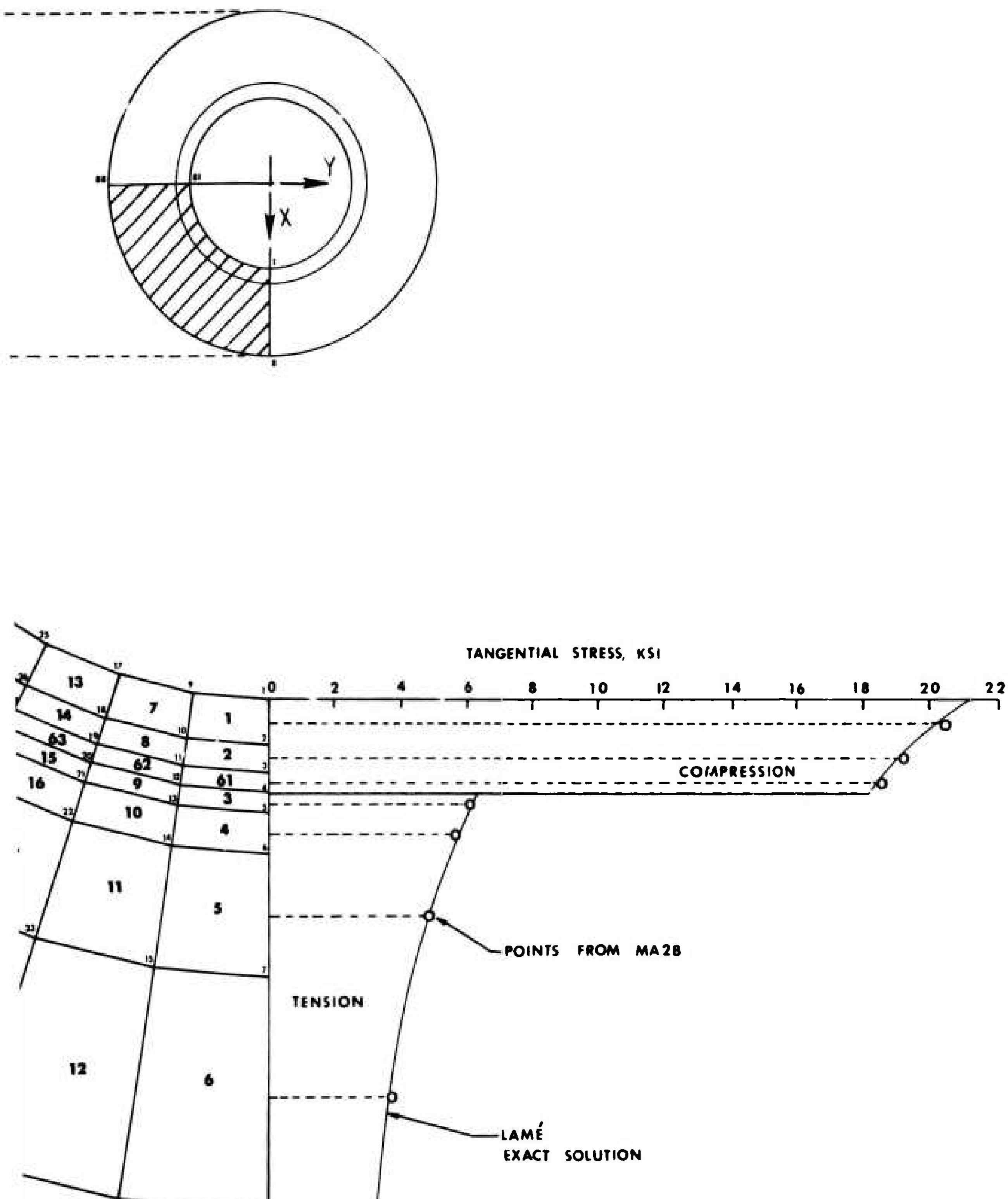


Figure 5. Structure and Results for Example 2.

A


Y
X
TANGENTIAL STRESS, KSI
0
2
4
6
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12
14
16
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COMPRESSION
POINTS FROM MA2B
TENSION
LAMÉ
EXACT SOLUTION

e 2.

B

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EXAMPLE 3

This example shows an analysis which is typical of those used to find the K_{br} factors reported in Volume I. The lug considered herein is loaded by a force of 1 kip in a direction 45° to the axis of symmetry of the lug. In the analysis it is assumed that only radial compressive forces exist between the lug and the liner. This corresponds to a perfectly greased liner.

Table III presents the entire output from the computer. The output is made more easily understandable by Figure 6, which shows the finite-element pattern and the numbering system. The node numbers are shown small; the element numbers, large and bold. For clarity, the radial bar elements which connect the pin to the liner, and the liner to the lug, are shown slightly curved; and the radial boundary positions of the liner have been shown with gaps. Two elements, numbers 266 and 267, are not shown. Their purpose is to provide a path for resistance to a tangential force, and thus avoid a singular condition in the master stiffness matrix.

The data in Table III show that a gap was permitted to occur between the liner and the lug by specifying a very low modulus (only 1 ksi) for all radial bar elements that were in tension. The proper assignment of moduli was determined by trial and error.

The tangential stress at the bore of the lug was found by extrapolation of plots of tangential stress along radial lines. Figure 7 shows these plots. Then the tangential stresses at the bore were plotted versus angular position, as shown in Figure 8. The magnitude and location of the maximum stress can be read from Figure 8.

TABLE III. COMPUTER OUTPUT FOR EXAMPLE 3

LUG ANALYSIS NO. 105

X COORDINATES AND SUPPORTS

	1	2	3	4	5	6	7	8	9	10
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1545	0.1545
11	0.1687	0.1829	0.1829	0.1953	0.2386	0.3090	0.2939	0.2939	0.3209	0.3480
21	0.3480	0.3715	0.4538	0.5878	0.4045	0.4045	0.4417	0.4789	0.4789	0.5113
31	0.5784	0.6246	0.8090	0.3804	0.4755	0.4755	0.5193	0.5630	0.5630	0.5820
41	0.6201	0.7342	0.9511	0.4938	0.4938	0.5393	0.5847	0.5847	0.6045	0.6440
51	0.7625	0.9877	0.4000	0.5000	0.5000	0.5460	0.5920	0.5920	0.6120	0.6520
61	0.7720	1.0000	0.4938	0.4938	0.5393	0.5847	0.5847	0.6045	0.6440	0.7625
71	1.0000	0.3804	0.4755	0.4755	0.5193	0.5630	0.5630	0.5820	0.6201	0.7342
81	0.9511	1.0000	0.4455	0.4455	0.4865	0.5275	0.5275	0.5453	0.5809	0.6879
91	0.8910	1.0000	0.3236	0.4045	0.4045	0.4417	0.4789	0.4789	0.4951	0.5275
101	0.6246	0.3090	1.0000	0.3536	0.3536	0.3861	0.4186	0.4186	0.4328	0.4610
111	0.5459	0.7071	1.0000	0.2351	0.2939	0.2939	0.3209	0.3480	0.3480	0.3557
121	0.3832	0.4538	0.5878	0.7209	1.0000	0.7347	1.0000	1.0000 S	0.7347 S	0.2270
131	0.2270	0.2479	0.2688	0.2688	0.2778	0.2960	0.3505	0.4540	0.5675	0.5675 S
141	0.1236	0.1545	0.1545	0.1687	0.1829	0.1829	0.1891	0.2015	0.2386	0.3090
151	0.3863	0.3863 S	0.0782	0.0782	0.0854	0.0926	0.0926	0.0957	0.1020	0.1208
161	0.1564	0.1955	0.1555 S	0.0	0.0	0.0	0.0	0.0	0.0	0.0
171	0.0	0.0	0.0	0.0	0.0 S	-0.1545	-0.1545	-0.1687	-0.1829	-0.1829
181	-0.1953	-0.2209	-0.2386	-0.3090	-0.3863	-0.3863 S	-0.2939	-0.2939	-0.3209	-0.3480
191	-0.3480	-0.3715	-0.4538	-0.5878	-0.7654	-0.7347	-0.7347 S	-0.4045	-0.4045	-0.4417
201	-0.4789	-0.4789	-0.5113	-0.6246	-0.8090	-1.0000	-1.0000	-1.0000	-1.0000 S	-0.4755
211	-0.4755	-0.5193	-0.5830	-0.5630	-0.6011	-0.7342	-1.0000	-0.5000	-0.5000	-0.5460
221	-0.5920	-0.5920	-0.6320	-0.7720	-1.0000	-0.4755	-0.4755	-0.5193	-0.5630	-0.5630
231	-0.6011	-0.7342	-0.9511	-0.4045	-0.4045	-0.4417	-0.4789	-0.4789	-0.5113	-0.6246
241	-0.8090	-0.2939	-0.2939	-0.3209	-0.3480	-0.3480	-0.3715	-0.4538	-0.5878	-0.1545
251	-0.1545	-0.1687	-0.1829	-0.1829	-0.1953	-0.2386	-0.3090	0.0		

TABLE III - Continued

LUG ANALYSIS NO. 105

Y COORDINATES AND SUPPORTS

	1	2	3	4	5	6	7	8	9	10
1	0.5000	0.5000	0.5460	0.5920	0.5520	0.6320	0.7720	1.0000	0.4755	0.4755
11	0.5193	0.5630	0.5630	0.6011	0.7342	0.9511	0.4045	0.4045	0.4417	0.4789
21	0.4789	0.5113	0.6246	0.8090	0.2939	0.2939	0.3209	0.3480	0.3480	0.3715
31	0.4703	0.4538	0.5878	0.1236	0.1545	0.1545	0.1687	0.1829	0.1829	0.1891
41	0.2015	0.2386	0.3090	0.0782	0.0782	0.0854	0.0926	0.0926	0.0957	0.1020
51	0.1208	0.1564	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61	0.0	0.0	-0.0782	-0.0782	-0.0854	-0.0926	-0.0926	-0.0957	-0.1020	-0.1208
71	-0.1594	-0.1236	-0.1545	-0.1545	-0.1667	-0.1829	-0.1829	-0.1891	-0.2015	-0.2386
81	-0.3090	-0.3090	-0.2270	-0.2270	-0.2479	-0.2688	-0.2688	-0.2778	-0.2960	-0.3505
91	-0.4540	-0.4540	-0.2351	-0.2939	-0.2939	-0.3209	-0.3480	-0.3480	-0.3597	-0.3832
101	-0.4538	-0.5878	-0.5878	-0.3536	-0.3536	-0.3861	-0.4186	-0.4186	-0.4328	-0.4610
111	-0.5459	-0.7071	-0.7071	-0.3236	-0.4045	-0.4045	-0.4417	-0.4789	-0.4789	-0.4951
121	-0.5275	-0.6246	-0.8090	-0.8592	-0.8592	-1.0113	-1.0113	-1.7500 S	-1.7500 S	-0.4455
131	-0.4455	-0.4865	-0.5275	-0.5275	-0.5453	-0.5809	-0.6879	-0.8910	-1.1138	-1.7500 S
141	-0.3804	-0.4755	-0.4155	-0.5193	-0.5630	-0.5630	-0.5820	-0.6201	-0.7342	-0.5511
151	-1.1888	-1.7500 S	-0.4538	-0.4938	-0.5353	-0.5847	-0.5847	-0.6045	-0.6440	-0.7625
161	-0.9877	-1.2346	-1.7500 S	-0.4000	-0.5000	-0.5000	-0.5460	-0.5920	-0.5920	-0.6120
171	-0.6520	-0.7720	-1.0000	-1.2500	-1.7500 S	-0.4755	-0.4755	-0.5193	-0.5630	-0.5630
181	-0.6011	-0.6800	-0.7342	-0.9511	-1.1888	-1.7500 S	-0.4045	-0.4045	-0.4417	-0.4789
191	-0.4789	-0.5113	-0.6246	-0.8090	-0.8050	-1.0113	-1.7500 S	-0.2939	-0.2939	-0.3209
201	-0.3480	-0.3480	-0.3715	-0.4538	-0.5878	-0.5878	-0.8090	-1.0113	-1.7500 S	-0.1545
211	-0.1545	-0.1687	-0.1829	-0.1829	-0.1953	-0.2386	-0.3249	0.0	0.0	0.0
221	0.0	0.0	0.0	0.0	0.0	0.1545	0.1545	0.1687	0.1829	0.1829
231	0.1953	0.2386	0.3090	0.2939	0.2939	0.3209	0.3480	0.3480	0.3715	0.4538
241	0.5878	0.4045	0.4045	0.4417	0.4789	0.4789	0.5113	0.6246	0.8090	0.4755
251	0.4755	0.5193	0.5630	0.5630	0.6011	0.7342	0.9511	0.0		

LOADS, CASE 1

258	X	0.707
258	Y	0.707

TABLE III - Continued

LUG ANALYSIS NO. 1C5

SLEM	P	Q	R	S	TYPE	E	PR	THICK-AREA	ALPHA	TEM 1	TEM 2	TEM 3	TEM 4	TEM 5
1	1	9	258	0	2	29000.	0.3200	0.5000	0.000006.	0.				
2	9	17	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
3	17	25	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
4	258	25	34	0	2	29000.	0.3200	0.5000	0.00000630	0.				
5	34	53	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
6	53	72	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
7	72	93	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
8	93	114	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
9	114	141	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
10	141	164	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
11	25	35	34	0	2	29000.	0.3200	0.5000	0.00000630	0.				
12	35	44	34	0	2	29000.	0.3200	0.5000	0.00000630	0.				
13	53	34	44	0	2	29000.	0.3200	0.5000	0.00000630	0.				
14	44	54	53	0	2	29000.	0.3200	0.5000	0.00000630	0.				
15	54	63	53	0	2	29000.	0.3200	0.5000	0.00000630	0.				
16	72	53	63	0	2	29000.	0.3200	0.5000	0.00000630	0.				
17	63	73	72	0	2	29000.	0.3200	0.5000	0.00000630	0.				
18	73	83	72	0	2	29000.	0.3200	0.5000	0.00000630	0.				
19	93	72	83	0	2	29000.	0.3200	0.5000	0.00000630	0.				
20	83	94	93	0	2	29000.	0.3200	0.5000	0.00000630	0.				
21	94	104	93	0	2	29000.	0.3200	0.5000	0.00000630	0.				
22	114	93	104	0	2	29000.	0.3200	0.5000	0.00000630	0.				
23	104	115	114	0	2	29000.	0.3200	0.5000	0.00000630	0.				
24	115	130	114	0	2	29000.	0.3200	0.5000	0.00000630	0.				
25	141	114	130	0	2	29000.	0.3200	0.5000	0.00000630	0.				
26	130	142	141	0	2	29000.	0.3200	0.5000	0.00000630	0.				
27	142	153	141	0	2	29000.	0.3200	0.5000	0.00000630	0.				
28	164	141	153	0	2	29000.	0.3200	0.5000	0.00000630	0.				
29	153	165	164	0	2	29000.	0.3200	0.5000	0.00000630	0.				
30	10	2	3	11	3	29000.	0.3200	0.5000	0.00000630	0.				
31	11	3	4	12	3	29000.	0.3200	0.5000	0.00000630	0.				
32	18	10	11	19	3	29000.	0.3200	0.5000	0.00000630	0.				
33	19	11	12	20	3	29000.	0.3200	0.5000	0.00000630	0.				
34	26	18	19	27	3	29000.	0.3200	0.5000	0.00000630	0.				
35	27	19	20	28	3	29000.	0.3200	0.5000	0.00000630	0.				
36	36	26	27	37	3	29000.	0.3200	0.5000	0.00000630	0.				
37	37	27	28	38	3	29000.	0.3200	0.5000	0.00000630	0.				
38	45	36	37	46	3	29000.	0.3200	0.5000	0.00000630	0.				
39	46	37	38	47	3	29000.	0.3200	0.5000	0.00000630	0.				
40	55	45	46	56	3	29000.	0.3200	0.5000	0.00000630	0.				
41	56	46	47	57	3	29000.	0.3200	0.5000	0.00000630	0.				
42	64	55	56	65	3	29000.	0.3200	0.5000	0.00000630	0.				
43	65	56	57	66	3	29000.	0.3200	0.5000	0.00000630	0.				
44	74	64	65	75	3	29000.	0.3200	0.5000	0.00000630	0.				
45	75	65	66	76	3	29000.	0.3200	0.5000	0.00000630	0.				
46	84	74	75	85	3	29000.	0.3200	0.5000	0.00000630	0.				
47	85	75	76	86	3	29000.	0.3200	0.5000	0.00000630	0.				
48	95	84	85	96	3	29000.	0.3200	0.5000	0.00000630	0.				
49	96	85	86	97	3	29000.	0.3200	0.5000	0.00000630	0.				
50	105	95	96	106	3	29000.	0.3200	0.5000	0.00000630	0.				

TABLE III - Continued

LUG ANALYSIS NO. 105

ELEM	P	Q	R	S	TYPE	E	PR	THICK-AREA	ALPHA	TEM 1	TEM 2	TEM 3	TEM 4	TEM 5
51	106	96	97	107	3	29000.	0.3200	0.5000	0.00000630	0.				
52	116	105	106	117	3	29000.	0.3200	0.5000	0.00000630	0.				
53	117	106	107	118	3	29000.	0.3200	0.5000	0.00000630	0.				
54	131	116	117	132	3	29000.	0.3200	0.5000	0.00000630	0.				
55	132	117	118	133	3	29000.	0.3200	0.5000	0.00000630	0.				
56	143	131	132	144	3	29000.	0.3200	0.5000	0.00000630	0.				
57	144	132	133	145	3	29000.	0.3200	0.5000	0.00000630	0.				
58	154	143	144	155	3	29000.	0.3200	0.5000	0.00000630	0.				
59	155	144	145	156	3	29000.	0.3200	0.5000	0.00000630	0.				
60	166	154	155	167	3	29000.	0.3200	0.5000	0.00000630	0.				
61	167	155	156	168	3	29000.	0.3200	0.5000	0.00000630	0.				
62	13	5	6	14	3	29000.	0.3200	0.5000	0.00000630	0.				
63	14	6	7	15	3	29000.	0.3200	0.5000	0.00000630	0.				
64	15	7	8	16	3	29000.	0.3200	0.5000	0.00000630	0.				
65	21	13	14	22	3	29000.	0.3200	0.5000	0.00000630	0.				
66	22	14	15	23	3	29000.	0.3200	0.5000	0.00000630	0.				
67	23	15	16	24	3	29000.	0.3200	0.5000	0.00000630	0.				
68	29	21	22	30	3	29000.	0.3200	0.5000	0.00000630	0.				
69	30	22	23	31	3	29000.	0.3200	0.5000	0.00000630	0.				
70	23	32	31	0	2	29000.	0.3200	0.5000	0.00000630	0.				
71	32	23	24	33	3	29000.	0.3200	0.5000	0.00000630	0.				
72	39	29	30	40	3	29000.	0.3200	0.5000	0.00000630	0.				
73	40	30	31	41	3	29000.	0.3200	0.5000	0.00000630	0.				
74	32	42	41	31	3	29000.	0.3200	0.5000	0.00000630	0.				
75	42	32	33	43	3	29000.	0.3200	0.5000	0.00000630	0.				
76	48	39	40	49	3	29000.	0.3200	0.5000	0.00000630	0.				
77	49	40	41	50	3	29000.	0.3200	0.5000	0.00000630	0.				
78	50	41	42	51	3	29000.	0.3200	0.5000	0.00000630	0.				
79	51	42	43	52	3	29000.	0.3200	0.5000	0.00000630	0.				
80	58	48	49	59	3	29000.	0.3200	0.5000	0.00000630	0.				
81	59	49	50	60	3	29000.	0.3200	0.5000	0.00000630	0.				
82	60	50	51	61	3	29000.	0.3200	0.5000	0.00000630	0.				
83	61	51	52	62	3	29000.	0.3200	0.5000	0.00000630	0.				
84	67	58	59	68	3	29000.	0.3200	0.5000	0.00000630	0.				
85	68	59	60	69	3	29000.	0.3200	0.5000	0.00000630	0.				
86	69	60	61	70	3	29000.	0.3200	0.5000	0.00000630	0.				
87	70	61	62	71	3	29000.	0.3200	0.5000	0.00000630	0.				
88	77	67	68	78	3	29000.	0.3200	0.5000	0.00000630	0.				
89	78	68	69	79	3	29000.	0.3200	0.5000	0.00000630	0.				
90	79	69	70	80	3	29000.	0.3200	0.5000	0.00000630	0.				
91	80	70	71	81	3	29000.	0.3200	0.5000	0.00000630	0.				
92	71	82	81	0	2	29000.	0.3200	0.5000	0.00000630	0.				
93	87	77	78	88	3	29000.	0.3200	0.5000	0.00000630	0.				
94	88	78	79	89	3	29000.	0.3200	0.5000	0.00000630	0.				
95	89	79	80	90	3	29000.	0.3200	0.5000	0.00000630	0.				
96	90	80	81	91	3	29000.	0.3200	0.5000	0.00000630	0.				
97	82	92	91	81	3	29000.	0.3200	0.5000	0.00000630	0.				
98	98	87	88	99	3	29000.	0.3200	0.5000	0.00000630	0.				
99	99	88	89	100	3	29000.	0.3200	0.5000	0.00000630	0.				
100	100	89	90	101	3	29000.	0.3200	0.5000	0.00000630	0.				

TABLE III - Continued

LUG ANALYSIS NO. 105

ELEM	P	C	R	S	TYPE	E	PR	THICK-AREA	ALPHA	TEM 1	TEM 2	TEM 3	TEM 4	TEM 5
101	101	90	91	102	3	29000.	0.3200	0.5000	0.00000630	0.				
102	92	103	102	91	3	29000.	0.3200	0.5000	0.00000630	0.				
103	108	98	99	109	3	29000.	0.3200	0.5000	0.00000630	0.				
104	109	99	100	110	3	29000.	0.3200	0.5000	0.00000630	0.				
105	110	100	101	111	3	29000.	0.3200	0.5000	0.00000630	0.				
106	111	101	102	112	3	29000.	0.3200	0.5000	0.00000630	0.				
107	103	113	112	102	3	29000.	0.3200	0.5000	0.00000630	0.				
108	119	108	109	120	3	29000.	0.3200	0.5000	0.00000630	0.				
109	120	109	110	121	3	29000.	0.3200	0.5000	0.00000630	0.				
110	121	110	111	122	3	29000.	0.3200	0.5000	0.00000630	0.				
111	122	111	112	123	3	29000.	0.3200	0.5000	0.00000630	0.				
112	123	112	124	0	2	29000.	0.3200	0.5000	0.00000630	0.				
113	126	123	124	0	2	29000.	0.3200	0.5000	0.00000630	0.				
114	113	125	124	112	3	29000.	0.3200	0.5000	0.00000630	0.				
115	125	127	126	124	3	29000.	0.3200	0.5000	0.00000630	0.				
116	129	126	127	128	3	29000.	0.3200	0.5000	0.00000630	0.				
117	134	119	120	135	3	29000.	0.3200	0.5000	0.00000630	0.				
118	135	120	121	136	3	29000.	0.3200	0.5000	0.00000630	0.				
119	136	121	122	137	3	29000.	0.3200	0.5000	0.00000630	0.				
120	137	122	123	138	3	29000.	0.3200	0.5000	0.00000630	0.				
121	138	123	126	139	3	29000.	0.3200	0.5000	0.00000630	0.				
122	140	139	126	129	3	29000.	0.3200	0.5000	0.00000630	0.				
123	146	134	135	147	3	29000.	0.3200	0.5000	0.00000630	0.				
124	147	135	136	148	3	29000.	0.3200	0.5000	0.00000630	0.				
125	148	136	137	149	3	29000.	0.3200	0.5000	0.00000630	0.				
126	149	137	138	150	3	29000.	0.3200	0.5000	0.00000630	0.				
127	150	138	139	151	3	29000.	0.3200	0.5000	0.00000630	0.				
128	152	151	139	140	3	29000.	0.3200	0.5000	0.00000630	0.				
129	157	146	147	158	3	29000.	0.3200	0.5000	0.00000630	0.				
130	158	147	148	159	3	29000.	0.3200	0.5000	0.00000630	0.				
131	159	148	149	160	3	29000.	0.3200	0.5000	0.00000630	0.				
132	160	149	150	161	3	29000.	0.3200	0.5000	0.00000630	0.				
133	161	150	151	162	3	29000.	0.3200	0.5000	0.00000630	0.				
134	163	162	151	152	3	29000.	0.3200	0.5000	0.00000630	0.				
135	169	157	158	170	3	29000.	0.3200	0.5000	0.00000630	0.				
136	170	158	159	171	3	29000.	0.3200	0.5000	0.00000630	0.				
137	171	159	160	172	3	29000.	0.3200	0.5000	0.00000630	0.				
138	172	160	161	173	3	29000.	0.3200	0.5000	0.00000630	0.				
139	173	161	162	174	3	29000.	0.3200	0.5000	0.00000630	0.				
140	175	174	162	163	3	29000.	0.3200	0.5000	0.00000630	0.				
141	1	3	0	0	1	29000.	0.3200	0.0880	0.00000630	0.				
142	9	11	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
143	17	19	0	0	1	29000.	0.3200	0.0880	0.00000630	0.				
144	25	27	0	0	1	29000.	0.3200	0.0880	0.00000630	0.				
145	35	37	0	0	1	29000.	0.3200	0.0850	0.00000630	0.				
146	44	46	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
147	54	56	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
148	63	65	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
149	73	75	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
150	83	85	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				

TABLE III - Continued

LUG ANALYSIS NO. 105

ELEM	P	Q	R	S	TYPE	E	PR	THICK-AREA	ALPHA	TEM 1	TEM 2	TEM 3	TEM 4	TEM 5
151	94	96	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
152	104	106	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
153	115	117	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
154	130	132	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
155	142	144	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
156	153	155	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
157	165	167	0	0	1	29000.	0.3200	0.0650	0.00000630	0.				
158	3	5	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
159	11	13	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
160	19	21	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
161	27	29	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
162	37	39	0	0	1	29000.	0.3200	0.0650	0.00000630	0.				
163	46	48	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
164	56	58	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
165	65	67	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
166	75	77	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
167	85	87	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
168	96	98	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
169	106	108	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
170	117	119	0	0	1	1.	0.3200	0.0430	0.00000630	0.				
171	132	134	0	0	1	1.	0.3200	0.0430	0.00000630	0.				
172	144	146	0	0	1	1.	0.3200	0.0430	0.00000630	0.				
173	155	157	0	0	1	1.	0.3200	0.0430	0.00000630	0.				
174	167	169	0	0	1	1.	0.3200	0.0650	0.00000630	0.				
175	165	176	164	0	2	29000.	0.3200	0.5000	0.00000630	0.				
176	258	164	176	0	2	29000.	0.3200	0.5000	0.00000630	0.				
177	176	187	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
178	187	198	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
179	198	210	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
180	210	218	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
181	218	226	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
182	226	234	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
183	234	242	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
184	242	250	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
185	250	1	258	0	2	29000.	0.3200	0.5000	0.00000630	0.				
186	177	166	167	178	3	29000.	0.3200	0.5000	0.00000630	0.				
187	178	167	168	179	3	29000.	0.3200	0.5000	0.00000630	0.				
188	188	177	178	189	3	29000.	0.3200	0.5000	0.00000630	0.				
189	189	178	179	190	3	29000.	0.3200	0.5000	0.00000630	0.				
190	199	188	189	200	3	29000.	0.3200	0.5000	0.00000630	0.				
191	200	189	190	201	3	29000.	0.3200	0.5000	0.00000630	0.				
192	211	199	200	212	3	29000.	0.3200	0.5000	0.00000630	0.				
193	212	200	201	213	3	29000.	0.3200	0.5000	0.00000630	0.				
194	219	211	212	220	3	29000.	0.3200	0.5000	0.00000630	0.				
195	220	212	213	221	3	29000.	0.3200	0.5000	0.00000630	0.				
196	227	219	220	228	3	29000.	0.3200	0.5000	0.00000630	0.				
197	228	220	221	229	3	29000.	0.3200	0.5000	0.00000630	0.				
198	235	227	228	236	3	29000.	0.3200	0.5000	0.00000630	0.				
199	236	228	229	237	3	29000.	0.3200	0.5000	0.00000630	0.				
200	243	235	236	244	3	29000.	0.3200	0.5000	0.00000630	0.				

TABLE III - Continued

LOG ANALYSIS NO. 105

ELEM	P	C	R	S	TYPE	E	FN	THICK-AREA	ALPHA	TEM 1	TEM 2	TEM 3	TEM 4	TEM 5
201	244	235	237	245	3	29000.	0.3200	0.5000	0.00000630	0.				
202	251	243	244	252	3	29000.	0.3200	0.5000	0.00000630	0.				
203	252	244	245	253	3	29000.	0.3200	0.5000	0.00000630	0.				
204	2	251	252	3	3	29000.	0.3200	0.5000	0.00000630	0.				
205	3	252	253	4	3	29000.	0.3200	0.5000	0.00000630	0.				
206	180	169	170	181	3	29000.	0.3200	0.5000	0.00000630	0.				
207	181	170	171	182	3	29000.	0.3200	0.5000	0.00000630	0.				
208	172	183	182	171	3	29000.	0.3200	0.5000	0.00000630	0.				
209	183	172	173	184	3	29000.	0.3200	0.5000	0.00000630	0.				
210	184	173	174	185	3	29000.	0.3200	0.5000	0.00000630	0.				
211	196	185	174	175	3	29000.	0.3200	0.5000	0.00000630	0.				
212	191	180	181	192	3	29000.	0.3200	0.5000	0.00000630	0.				
213	192	181	182	193	3	29000.	0.3200	0.5000	0.00000630	0.				
214	183	193	187	0	2	29000.	0.3200	0.5000	0.00000630	0.				
215	193	183	184	194	3	29000.	0.3200	0.5000	0.00000630	0.				
216	194	184	185	196	3	29000.	0.3200	0.5000	0.00000630	0.				
217	197	196	185	186	3	29000.	0.3200	0.5000	0.00000630	0.				
218	202	191	192	203	3	29000.	0.3200	0.5000	0.00000630	0.				
219	203	192	193	204	3	29000.	0.3200	0.5000	0.00000630	0.				
220	204	193	194	205	3	29000.	0.3200	0.5000	0.00000630	0.				
221	205	194	195	0	2	29000.	0.3200	0.5000	0.00000630	0.				
222	194	196	195	0	2	29000.	0.3200	0.5000	0.00000630	0.				
223	214	202	203	215	3	29000.	0.3200	0.5000	0.00000630	0.				
224	215	203	204	216	3	29000.	0.3200	0.5000	0.00000630	0.				
225	216	204	205	217	3	29000.	0.3200	0.5000	0.00000630	0.				
226	206	217	205	0	2	29000.	0.3200	0.5000	0.00000630	0.				
227	207	206	205	195	3	29000.	0.3200	0.5000	0.00000630	0.				
228	208	207	195	196	3	29000.	0.3200	0.5000	0.00000630	0.				
229	209	208	196	197	3	29000.	0.3200	0.5000	0.00000630	0.				
230	222	214	215	223	3	29000.	0.3200	0.5000	0.00000630	0.				
231	223	215	216	224	3	29000.	0.3200	0.5000	0.00000630	0.				
232	224	216	217	225	3	29000.	0.3200	0.5000	0.00000630	0.				
233	230	222	223	231	3	29000.	0.3200	0.5000	0.00000630	0.				
234	231	223	224	232	3	29000.	0.3200	0.5000	0.00000630	0.				
235	232	224	225	233	3	29000.	0.3200	0.5000	0.00000630	0.				
236	238	230	231	239	3	29000.	0.3200	0.5000	0.00000630	0.				
237	239	231	232	240	3	29000.	0.3200	0.5000	0.00000630	0.				
238	240	232	233	241	3	29000.	0.3200	0.5000	0.00000630	0.				
239	246	238	239	247	3	29000.	0.3200	0.5000	0.00000630	0.				
240	247	239	240	248	3	29000.	0.3200	0.5000	0.00000630	0.				
241	248	240	241	249	3	29000.	0.3200	0.5000	0.00000630	0.				
242	254	246	247	255	3	29000.	0.3200	0.5000	0.00000630	0.				
243	255	247	248	256	3	29000.	0.3200	0.5000	0.00000630	0.				
244	256	248	249	257	3	29000.	0.3200	0.5000	0.00000630	0.				
245	5	254	255	6	3	29000.	0.3200	0.5000	0.00000630	0.				
246	6	255	256	7	3	29000.	0.3200	0.5000	0.00000630	0.				
247	7	256	257	8	3	29000.	0.3200	0.5000	0.00000630	0.				
248	176	178	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
249	187	189	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
250	198	200	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				

TABLE III - Continued

LUG ANALYSIS NO. 105

ELEM	P	Q	R	S	TYPE	E	PR	THICK-AREA	ALPHA	TEM 1	TEM 2	TEM 3	TEM 4	TEM 5
251	210	212	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
252	218	220	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
253	226	228	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
254	234	236	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
255	242	244	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
256	250	252	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
257	178	180	0	0	1	1.	0.3200	0.0860	0.00000630	0.				
258	189	191	0	0	1	1.	0.3200	0.0860	0.00000630	0.				
259	200	202	0	0	1	1.	0.3200	0.0860	0.00000630	0.				
260	212	214	0	0	1	1.	0.3200	0.0860	0.00000630	0.				
261	220	222	0	0	1	1.	0.3200	0.0860	0.00000630	0.				
262	228	230	0	0	1	1.	0.3200	0.0860	0.00000630	0.				
263	236	238	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
264	244	246	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
265	252	254	0	0	1	29000.	0.3200	0.0860	0.00000630	0.				
266	25	36	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				
267	28	39	0	0	1	29000.	0.3200	0.0430	0.00000630	0.				

TABLE III - Continued

LUG ANALYSIS NO. 105

X DEFLECTION, CASE 1

	1	2	3	4	5	6	7	8	9	10
1	5.377E-04	5.502E-04	5.577E-04	5.692E-04	4.982E-04	5.016E-04	5.145E-04	5.346E-04	5.312E-04	5.400E-04
11	5.497E-04	5.594E-04	5.095E-04	5.137E-04	5.293E-04	5.559E-04	5.147E-04	5.192E-04	5.283E-04	5.374E-04
21	5.083E-04	5.127E-04	5.293E-04	5.583E-04	4.876E-04	4.881E-04	4.953E-04	5.026E-04	4.911E-04	4.541E-04
31	5.017E-04	5.074E-04	5.326E-04	4.497E-04	4.516E-04	4.491E-04	4.534E-04	4.576E-04	4.558E-04	4.563E-04
41	4.573E-04	4.607E-04	4.731E-04	4.302E-04	4.271E-04	4.295E-04	4.320E-04	4.306E-04	4.300E-04	4.290E-04
51	4.277E-04	4.307E-04	4.148E-04	4.080E-04	4.043E-04	4.047E-04	4.051E-04	4.013E-04	3.994E-04	3.561E-04
61	3.987E-04	3.811E-04	3.855E-04	3.818E-04	3.800E-04	3.784E-04	3.684E-04	3.653E-04	3.594E-04	3.452E-04
71	3.253E-04	3.809E-04	3.659E-04	3.612E-04	3.578E-04	3.545E-04	3.333E-04	3.288E-04	3.204E-04	2.997E-04
81	2.697E-04	2.694E-04	3.490E-04	3.435E-04	3.368E-04	3.346E-04	2.963E-04	2.906E-04	2.805E-04	2.551E-04
91	2.169E-04	2.177E-04	3.551E-04	3.373E-04	3.301E-04	3.251E-04	3.205E-04	2.589E-04	2.527E-04	2.416E-04
101	2.144E-04	1.733E-04	1.759E-04	3.284E-04	3.211E-04	3.159E-04	3.109E-04	2.215E-04	2.158E-04	2.057E-04
111	1.802E-04	1.393E-04	1.445E-04	3.393E-04	3.220E-04	3.152E-04	3.088E-04	3.021E-04	1.881E-04	1.842E-04
121	1.766E-04	1.547E-04	1.153E-04	1.064E-04	1.105E-04	7.679E-05	8.409E-05	0.0	0.0	3.149E-04
131	3.101E-04	3.014E-04	2.926E-04	1.641E-04	1.618E-04	1.565E-04	1.378E-04	9.970E-05	6.372E-05	0.0
141	3.310E-04	3.093E-04	3.059E-04	2.956E-04	2.853E-04	1.470E-04	1.461E-04	1.429E-04	1.271E-04	9.091E-05
151	5.542E-05	0.0	3.064E-04	3.041E-04	2.928E-04	2.815E-04	1.364E-04	1.362E-04	1.343E-04	1.208E-04
161	8.608E-05	5.088E-05	0.0	3.316E-04	3.065E-04	3.049E-04	2.932E-04	2.815E-04	1.313E-04	1.315E-04
171	1.309E-04	1.172E-04	8.389E-05	4.902E-05	0.0	3.160E-04	3.153E-04	3.042E-04	2.930E-04	1.358E-04
181	1.364E-04	1.260E-04	1.192E-04	6.674E-05	5.376E-05	0.0	3.402E-04	3.372E-04	3.278E-04	3.182E-04
191	1.668E-04	1.601E-04	1.380E-04	1.066E-04	1.118E-04	7.703E-05	0.0	3.710E-04	3.670E-04	3.603E-04
201	3.535E-04	2.129E-04	2.051E-04	1.841E-04	1.562E-04	1.648E-04	1.188E-04	8.886E-05	0.0	4.044E-04
211	4.014E-04	3.579E-04	3.942E-04	2.748E-04	2.707E-04	2.590E-04	2.381E-04	4.377E-04	4.378E-04	4.374E-04
221	4.370E-04	3.417E-04	3.437E-04	3.471E-04	3.503E-04	4.701E-04	4.744E-04	4.776E-04	4.810E-04	3.555E-04
231	4.040E-04	4.167E-04	4.333E-04	5.017E-04	5.109E-04	5.180E-04	5.250E-04	4.315E-04	4.363E-04	4.520E-04
241	4.695E-04	5.240E-04	5.370E-04	5.457E-04	5.542E-04	4.563E-04	4.597E-04	4.724E-04	4.861E-04	5.353E-04
251	5.495E-04	5.585E-04	5.675E-04	4.793E-04	4.827E-04	4.932E-04	5.076E-04	4.500E-04		

TABLE III - Continued

LUG ANALYSIS NO. 105

Y DEFLECTION, CASE 1

	1	2	3	4	5	6	7	8	9	10
1	1.845E-04	1.815E-04	1.819E-04	1.823E-04	1.791E-04	1.763E-04	1.686E-04	1.614E-04	1.554E-04	1.456E-04
11	1.469E-04	1.441E-04	1.572E-04	1.531E-04	1.405E-04	1.241E-04	1.270E-04	1.203E-04	1.142E-04	1.081E-04
21	1.255E-04	1.194E-04	9.804E-05	6.807E-05	1.021E-04	9.661E-05	8.735E-05	7.808E-05	6.875E-05	7.949E-05
31	6.140E-05	4.585E-05	2.712E-06	1.111E-04	8.532E-05	8.251E-05	7.081E-05	5.909E-05	5.424E-05	4.899E-05
41	3.845E-05	4.423E-06	-5.862E-05	8.073E-05	8.011E-05	6.728E-05	5.445E-05	4.196E-05	3.555E-05	2.306E-05
51	-1.312E-05	-6.275E-05	1.064E-04	6.010E-05	8.075E-05	6.748E-05	5.420E-05	3.112E-05	2.448E-05	1.160E-05
61	-2.555E-05	-9.939E-05	8.373E-05	6.436E-05	7.159E-05	5.878E-05	2.307E-05	1.654E-05	4.032E-06	-3.154E-05
71	-1.095E-04	1.119E-04	9.078E-05	5.059E-05	7.916E-05	6.766E-05	1.773E-05	1.184E-05	5.137E-07	-3.140E-05
81	-9.739E-05	-1.147E-04	1.006E-04	5.867E-05	8.938E-05	7.987E-05	1.531E-05	1.038E-05	5.252E-07	-2.574E-05
91	-7.874E-05	-1.115E-04	1.252E-04	1.111E-04	1.073E-04	1.004E-04	9.316E-05	1.579E-05	1.206E-05	4.901E-06
101	-1.558E-05	-5.560E-05	-1.035E-04	1.210E-04	1.166E-04	1.111E-04	1.054E-04	1.961E-05	1.702E-05	1.203E-05
111	-4.223E-06	-3.714E-05	-9.474E-05	1.444E-04	1.321E-04	1.281E-04	1.227E-04	1.176E-04	2.380E-05	2.251E-05
121	1.942E-05	8.373E-06	-1.310E-05	-3.266E-05	-8.364E-05	-3.179E-05	-7.062E-05	0.0	0.0	1.458E-04
131	1.437E-04	1.397E-04	1.339E-04	2.288E-05	2.315E-05	2.246E-05	1.600E-05	7.166E-07	-1.207E-05	0.0
141	1.713E-04	1.629E-04	1.619E-04	1.582E-04	1.544E-04	2.096E-05	2.154E-05	2.188E-05	1.883E-05	8.714E-06
151	-9.417E-08	0.0	1.812E-04	1.812E-04	1.790E-04	1.769E-04	1.849E-05	1.905E-05	1.953E-05	1.817E-05
161	1.240E-05	6.148E-06	0.0	2.030E-04	2.014E-04	2.014E-04	2.011E-04	2.007E-04	1.690E-05	1.676E-05
171	1.656E-05	1.651E-05	1.413E-05	5.839E-06	0.0	2.390E-04	2.395E-04	2.427E-04	2.460E-04	1.677E-05
181	1.676E-05	1.960E-05	2.015E-05	2.441E-05	2.318E-05	0.0	2.707E-04	2.729E-04	2.794E-04	2.859E-04
191	2.740E-05	1.046E-05	4.256E-05	5.780E-05	8.947E-05	6.678E-05	0.0	2.914E-04	2.971E-04	3.058E-04
201	1.145E-04	4.633E-05	5.749E-05	6.328E-05	1.160E-04	1.632E-04	1.313E-04	1.051E-04	0.0	3.006E-04
211	1.101E-04	3.201E-04	3.301E-04	7.652E-05	9.022E-05	1.281E-04	1.949E-04	2.992E-04	3.112E-04	3.220E-04
221	4.327E-04	1.564E-04	1.193E-04	1.557E-04	2.208E-04	2.882E-04	2.996E-04	3.113E-04	3.229E-04	1.344E-04
231	1.407E-04	1.647E-04	2.067E-04	2.669E-04	2.757E-04	2.858E-04	2.962E-04	1.629E-04	1.624E-04	1.653E-04
241	1.852E-04	2.401E-04	2.455E-04	2.520E-04	2.586E-04	1.829E-04	1.803E-04	1.775E-04	1.794E-04	2.126E-04
251	2.138E-04	2.171E-04	2.204E-04	1.880E-04	1.855E-04	1.801E-04	1.773E-04	2.178E-04		

TABLE III - Continued

LUG ANALYSIS NO. 105

STRESS	XX	YY	XY	CN	CS	CASE
1	-2.3526	-1.0982	0.0622	-1.1503	0.5625	1
2	-2.4151	-1.1005	0.0844	-1.1719	0.5897	1
3	-2.5172	-1.1033	0.1559	-1.2068	1.0381	1
4	-1.2756	-2.5903	-0.5103	-1.2886	1.1366	1
5	-2.8936	-1.1092	0.1688	-1.3343	1.1599	1
6	-2.8195	-0.5079	-0.2027	-1.2425	1.1867	1
7	-2.3003	-0.7853	-0.9434	-1.0285	1.2267	1
8	-1.3422	-1.0006	-1.4807	-0.7809	1.3364	1
9	-0.2843	-1.1977	-1.1673	-0.4940	1.0814	1
10	0.5029	-1.1265	-0.6519	-0.2079	0.8645	1
11	-2.0710	-0.9244	0.1156	-0.9965	0.8527	1
12	-2.1257	-0.8678	0.2462	-0.9978	0.8955	1
13	-2.0201	-0.8297	0.2219	-0.9499	0.8486	1
14	-2.2816	-1.1466	0.2669	-1.1447	0.9590	1
15	-2.5031	-1.4870	0.2546	-1.3300	1.0487	1
16	-2.5353	-0.8170	0.1868	-1.1174	1.0676	1
17	-2.7604	-1.7254	0.2330	-1.4953	1.1544	1
18	-2.8470	-1.8638	-0.0255	-1.5703	1.1809	1
19	-2.7299	-0.9228	-0.0204	-1.2176	1.1339	1
20	-2.4149	-1.8342	-0.2057	-1.4164	1.0433	1
21	-2.0837	-1.3118	-0.5930	-1.1318	0.9870	1
22	-1.2839	-0.5819	-0.2412	-0.7553	0.5824	1
23	-0.5021	-0.9985	-0.5973	-0.5002	0.6356	1
24	-0.1815	-0.4921	-0.1787	-0.2245	0.2501	1
25	0.0852	-1.0794	-0.0292	-0.3314	0.5306	1
26	0.2083	-0.4528	-0.0548	-0.0815	0.2796	1
27	0.2053	-0.4576	0.0618	-0.0841	0.2817	1
28	0.1435	-1.2415	0.0676	-0.3660	0.6243	1
29	0.2938	-0.5426	0.0333	-0.0829	0.3476	1
30	-0.0476	-0.8470	-0.0152	-0.2982	0.3888	1
31	0.0175	-0.6491	-0.0133	-0.2105	0.3104	1
32	-0.0511	-0.8704	-0.0092	-0.3071	0.3989	1
33	0.0119	-0.6201	-0.0081	-0.2027	0.2952	1
34	-0.0510	-0.8649	0.0135	-0.3053	0.3964	1
35	0.0178	-0.6209	0.0111	-0.2010	0.2971	1
36	-0.0443	-0.8530	-0.0024	-0.2991	0.3921	1
37	0.0091	-0.6354	-0.0022	-0.2088	0.3017	1
38	-0.0459	-0.8914	0.0355	-0.3124	0.4108	1
39	0.0289	-0.5795	0.0320	-0.1835	0.2814	1
40	-0.0340	-0.8209	0.0345	-0.2850	0.3803	1
41	0.0158	-0.6468	0.0278	-0.2103	0.3095	1
42	-0.0328	-0.7162	0.0733	-0.2497	0.3355	1
43	0.0327	-0.7429	0.0623	-0.2367	0.3618	1
44	-0.0213	-0.6111	0.0324	-0.2108	0.2844	1
45	0.0348	-0.8362	0.0239	-0.2671	0.4031	1
46	-0.0173	-0.5021	0.0764	-0.1731	0.2409	1
47	0.0452	-0.9295	0.0659	-0.2948	0.4524	1
48	-0.0366	-0.4559	-0.0265	-0.1642	0.2080	1
49	0.0682	-0.9747	-0.0206	-0.3021	0.4767	1
50	-0.0448	-0.6144	-0.1363	-0.2197	0.3010	1

TABLE III - Continued

LUG ANALYSIS NO. 105

STRESS	XX	YY	XY	CN	CS	CASE
51	0.0554	-0.8265	-0.1160	-0.2570	0.4143	1
52	-0.0251	-0.9199	-0.1771	-0.3150	0.4516	1
53	-0.0038	-0.5465	-0.1533	-0.1834	0.2856	1
54	-0.0247	-1.0551	0.0391	-0.3599	0.4927	1
55	-0.0236	-0.4226	0.0364	-0.1487	0.1962	1
56	-0.0633	-0.9468	0.0743	-0.3367	0.4364	1
57	0.0279	-0.5215	0.0646	-0.1645	0.2581	1
58	-0.0444	-0.8693	0.0025	-0.3046	0.3997	1
59	0.0179	-0.5921	-0.0013	-0.1914	0.2834	1
60	-0.0383	-0.8069	0.0594	-0.2818	0.3748	1
61	0.0219	-0.6490	0.0558	-0.2090	0.3146	1
62	-1.4903	1.8016	-0.0243	0.1038	1.3461	1
63	-1.0014	1.9616	-0.0813	0.3201	1.2324	1
64	-0.2991	2.2979	-0.0464	0.6663	1.1608	1
65	-1.4046	1.6522	-0.0201	0.0825	1.2494	1
66	-1.0342	1.8921	-0.0461	0.2860	1.2122	1
67	-0.2867	2.3496	-0.0042	0.6876	1.1810	1
68	-1.5274	1.7019	0.0281	0.0582	1.3192	1
69	-1.0681	1.8879	0.0194	0.2733	1.2223	1
70	-0.5230	2.0602	0.0131	0.5124	1.1151	1
71	-0.2955	2.3273	-0.0077	0.6773	1.1730	1
72	-1.4241	1.8032	0.0612	0.1264	1.3215	1
73	-1.0936	1.7821	-0.2306	0.2295	1.2001	1
74	-0.9968	1.9046	0.0388	0.3026	1.2041	1
75	-0.3116	2.3421	0.0238	0.6768	1.1845	1
76	-1.5307	1.4991	0.1407	-0.0106	1.2423	1
77	-1.3973	1.7791	0.2315	0.1272	1.3136	1
78	-1.1095	1.9468	0.1511	0.2791	1.2693	1
79	-0.2913	2.2878	0.0753	0.6655	1.1549	1
80	-1.8250	2.0491	0.0432	0.0747	1.5829	1
81	-1.6488	2.0326	0.1609	0.1279	1.5113	1
82	-1.0947	2.0175	0.2861	0.3076	1.3100	1
83	-0.3139	2.1935	0.1350	0.6265	1.1209	1
84	-2.0427	2.5966	0.0932	0.1846	1.9000	1
85	-1.7976	2.4953	0.2559	0.2326	1.7730	1
86	-1.2113	2.2012	0.4728	0.3300	1.4643	1
87	-0.3162	1.9639	0.2256	0.5492	1.0253	1
88	-2.2808	3.3401	0.0917	0.3531	2.3095	1
89	-2.0066	3.1134	0.3034	0.3689	2.1210	1
90	-1.3807	2.5756	0.6125	0.3983	1.7141	1
91	-0.4462	1.5609	0.4387	0.3716	0.9320	1
92	0.1846	1.0725	0.1761	0.4190	0.4898	1
93	-2.4246	4.1835	0.1244	0.5863	2.7313	1
94	-2.1215	3.8269	0.3427	0.5685	2.4773	1
95	-1.4796	3.0307	0.6523	0.5170	1.9514	1
96	-0.6570	1.4308	0.6349	0.2579	1.0141	1
97	-0.0119	-0.1968	0.3958	-0.0696	0.3355	1
98	-2.3468	5.0219	0.0885	0.8917	3.0745	1
99	-1.9970	4.5440	0.3126	0.8490	2.7489	1
100	-1.3460	3.4559	0.6022	0.7031	2.0812	1

TABLE III - Continued

LUG ANALYSIS NO. 105

STRESS	XX	YY	XY	CN	CS	CASE
101	-0.7143	1.5314	0.6061	0.2723	1.0595	1
102	0.0306	-0.8694	0.4748	-0.2796	0.5695	1
103	-1.7160	5.8337	0.1706	1.3726	3.2344	1
104	-1.3469	5.1547	0.3428	1.2693	2.8158	1
105	-0.8286	3.7728	0.4343	0.9834	2.0365	1
106	-0.5774	1.6713	0.4217	0.3646	1.0138	1
107	0.1279	-1.0278	0.4052	-0.2999	0.6141	1
108	-0.3421	6.5083	0.1604	2.0554	3.1545	1
109	-0.1832	5.4678	0.1439	1.7615	2.6244	1
110	-0.0827	3.8112	0.0250	1.2428	1.8166	1
111	-0.3009	1.8291	-0.0683	0.5094	0.9428	1
112	-0.6685	0.8726	0.1599	0.0680	0.6444	1
113	0.2328	-0.7961	-0.1352	-0.1878	0.4542	1
114	0.0765	-1.2448	0.2458	-0.3894	0.6380	1
115	0.1350	-1.4969	0.2253	-0.4540	0.7621	1
116	-0.2719	-2.0972	0.3924	-0.7857	0.9848	1
117	0.2568	6.1914	-0.2066	2.1494	2.8650	1
118	0.3814	5.1565	-0.3746	1.8460	2.3659	1
119	0.3711	3.5552	-0.6115	1.3087	1.6720	1
120	-0.0126	1.7854	-0.6661	0.5910	1.0046	1
121	-0.5665	0.4243	-0.4034	-0.0474	0.5227	1
122	-0.0717	-0.9307	0.5770	-0.3341	0.6331	1
123	0.0865	4.8885	-0.1959	1.6583	2.2899	1
124	0.2812	4.1960	-0.5886	1.4924	1.9746	1
125	0.4169	2.9835	-1.0733	1.1335	1.5837	1
126	0.1812	1.5479	-1.2105	0.5763	1.2059	1
127	-0.2352	0.6124	-0.8609	0.1257	0.7885	1
128	-0.0256	-0.2913	0.7511	-0.1056	0.6273	1
129	0.0298	3.2442	-0.2416	1.0914	1.5351	1
130	0.1903	2.8416	-0.6748	1.0106	1.4092	1
131	0.3635	2.1073	-1.3332	0.8236	1.4251	1
132	0.3105	1.1917	-1.5464	0.5007	1.3598	1
133	0.0825	0.5936	-1.2269	0.2254	1.0356	1
134	0.0615	0.1877	0.8970	0.0831	0.7366	1
135	0.2119	1.6080	-0.1693	0.6066	0.7266	1
136	0.2527	1.3232	-0.5891	0.5253	0.7485	1
137	0.2413	1.0318	-1.4613	0.4243	1.2719	1
138	0.4207	0.7575	-1.6440	0.3927	1.3776	1
139	0.4328	0.4409	-1.3829	0.2912	1.1477	1
140	0.1915	0.5190	0.9702	0.2369	0.8206	1
141	-1.6471					1
142	-1.5324					1
143	-1.4984					1
144	-1.5062					1
145	-1.7200					1
146	-1.7499					1
147	-2.0880					1
148	-2.2428					1
149	-2.6160					1
150	-2.5008					1

TABLE III - Continued

LUG ANALYSIS NO. 105

STRESS	XX	YY	XY	CN	CS	CASE
151	-2.2182					1
152	-1.1593					1
153	-0.0921					1
154	0.0922					1
155	0.1991					1
156	0.0649					1
157	0.1852					1
158	-1.7628					1
159	-1.6551					1
160	-1.6127					1
161	-1.6392					1
162	-1.8182					1
163	-1.8766					1
164	-2.1715					1
165	-2.4065					1
166	-2.6898					1
167	-2.7207					1
168	-2.4461					1
169	-1.3233					1
170	0.0002					1
171	0.0009					1
172	0.0018					1
173	0.0029					1
174	0.0040					1
175	0.2949	-0.5533	0.0229	-0.0861	0.3521	1
176	-1.0307	0.7471	0.4899	-0.0946	0.8314	1
177	0.9868	-1.0153	-0.0346	-0.0095	0.8179	1
178	0.9677	-1.0158	0.0794	-0.0160	0.8125	1
179	0.8475	-1.0188	0.2039	-0.0571	0.7809	1
180	0.5961	-1.0251	0.3881	-0.1430	0.7408	1
181	0.1364	-1.0368	0.6944	-0.3001	0.7719	1
182	-0.6299	-1.0560	1.1100	-0.5620	1.0048	1
183	-1.4774	-1.0775	0.8852	-0.8516	0.9548	1
184	-2.0292	-1.0909	0.4144	-1.0400	0.8555	1
185	-2.2655	-1.0959	0.1429	-1.1205	0.9324	1
186	-0.0438	-0.7890	-0.0301	-0.2776	0.3629	1
187	0.0283	-0.6918	-0.0237	-0.2212	0.3335	1
188	-0.0381	-0.7795	0.0362	-0.2725	0.3600	1
189	0.0199	-0.7010	0.0308	-0.2270	0.3362	1
190	-0.0328	-0.7456	-0.0039	-0.2595	0.3440	1
191	0.0352	-0.7322	-0.0033	-0.2323	0.3537	1
192	-0.0362	-0.7610	-0.0121	-0.2657	0.3507	1
193	0.0254	-0.7169	-0.0098	-0.2305	0.3442	1
194	-0.0407	-0.8041	-0.0255	-0.2816	0.3704	1
195	0.0327	-0.6760	-0.0220	-0.2145	0.3271	1
196	-0.0582	-0.9039	-0.0662	-0.3207	0.4166	1
197	-0.0070	-0.5857	-0.0590	-0.1976	0.2787	1
198	-0.0461	-0.8244	0.1385	-0.2902	0.3948	1
199	0.0083	-0.6593	0.1210	-0.2170	0.3280	1
200	-0.0161	-0.6448	0.0242	-0.2203	0.3009	1

TABLE III - Continued

LUG ANALYSIS NO. 105

STRESS	XX	YY	XY	CN	CS	CASE
201	0.0640	-0.8193	0.0207	-0.2518	0.4025	1
202	-0.0242	-0.6824	-0.0584	-0.2355	0.3157	1
203	0.0381	-0.7900	-0.0508	-0.2506	0.3835	1
204	-0.0399	-0.7906	-0.0354	-0.2768	0.3648	1
205	0.0193	-0.7008	-0.0285	-0.2272	0.3358	1
206	-0.0472	-1.0686	-0.4075	-0.3715	0.5548	1
207	-0.2473	-0.2762	-0.0128	-0.1745	0.6751	1
208	0.1397	-0.1915	-1.1725	-0.0174	0.5670	1
209	0.5548	0.0379	-1.3115	0.1576	1.1003	1
210	0.9958	0.1650	-1.0896	0.3070	0.5906	1
211	0.3671	1.0077	0.9014	0.4583	0.8454	1
212	-0.1534	-2.6480	-0.1674	-0.9336	1.2214	1
213	-0.0591	-1.6122	-0.4053	-0.5571	0.8165	1
214	0.1059	-0.7593	0.0226	-0.2178	0.3858	1
215	0.6518	-0.7943	-0.2728	0.1192	0.4538	1
216	1.3537	0.2834	0.0570	0.5457	0.5848	1
217	0.4355	2.0815	0.5948	0.8390	1.0195	1
218	-0.1639	-2.3761	0.1937	-0.8460	1.0541	1
219	0.0307	-1.1265	0.5341	-0.3652	0.6925	1
220	0.5975	0.2692	0.0816	0.2889	0.7603	
221	1.3674	1.0020	1.2540	0.7058	1.1758	
222	0.9123	1.4668	-1.2311	0.7930	1.1731	
223	-0.0380	-0.2800	0.4613	-0.1060	0.3566	1
224	0.1506	0.3783	1.1765	0.1763	0.9731	1
225	0.5316	1.5555	1.4400	0.6958	1.3414	1
226	-0.2097	3.4294	0.3441	1.0732	1.6517	1
227	-0.0509	3.2026	-0.1203	1.0506	1.5250	1
228	-0.0838	3.1203	-0.0448	1.0122	1.4515	1
229	0.4812	3.5288	0.4393	1.3367	1.6031	1
230	0.0984	2.7652	0.5155	0.9612	1.3573	1
231	0.3237	2.1672	1.2420	0.8286	1.3511	1
232	0.2796	1.8700	1.1162	0.7192	1.2308	1
233	0.4252	5.2403	0.3330	1.8665	2.3520	1
234	0.4523	3.5354	0.6256	1.3292	1.6518	1
235	0.1893	1.1507	0.3500	0.4467	0.5752	1
236	-0.3015	5.5147	-0.3345	1.7377	2.6875	1
237	-0.0152	3.6524	-0.4006	1.2124	1.7561	1
238	0.0781	1.0495	-0.2284	0.3755	0.5125	1
239	-1.6208	4.0560	-0.3020	0.8251	2.4183	1
240	-0.8214	3.0593	-0.6049	0.7460	1.7412	1
241	-0.1326	1.4508	-0.3685	0.4527	0.7552	1
242	-1.8081	2.8419	-0.1305	0.3446	1.5165	1
243	-1.0972	2.4570	-0.3747	0.4533	1.5171	1
244	-0.2595	1.9298	-0.2372	0.5565	0.5553	1
245	-1.6071	2.1428	-0.0710	0.1788	1.5372	1
246	-1.0542	2.1154	-0.1848	0.3537	1.3265	1
247	-0.2871	2.1810	-0.1102	0.6313	1.1057	1
248	0.0967					1
249	0.1484					1
250	0.1315					1

TABLE III - Continued

LUG ANALYSIS NO. 105

STRESS	XX	YY	XY	CN	CS	CASE
251	0.1332					1
252	0.1466					1
253	0.0235					1
254	-1.2792					1
255	-1.9588					1
256	-1.8504					1
257	0.0058					1
258	0.0065					1
259	0.0059					1
260	0.0042					1
261	0.0021					1
262	0.0004					1
263	-1.4571					1
264	-2.1193					1
265	-1.9613					1
266	0.0003					1
267	-0.0007					1

TABLE III - Continued

LUG ANALYSIS NO. 105

X FORCE, CASE 1

	1	2	3	4	5	6	7	8	9	10
1	-1.980E-06	-4.172E-07	-1.329E-05	-1.192E-07	-4.768E-06	1.192E-06	2.921E-06	-2.444E-06	-1.186E-05	-2.265E-06
11	4.411E-06	8.345E-07	2.563E-06	-1.049E-05	-2.205E-06	1.013E-06	-1.675E-05	-1.907E-06	2.265E-06	1.788E-06
21	-4.709E-06	5.253E-07	-5.517E-06	3.051E-06	-2.313E-05	-3.614E-06	1.893E-05	2.211E-05	2.480E-05	1.312E-05
31	-7.790E-06	3.141E-05	3.099E-06	-2.962E-05	-5.022E-06	-7.153E-07	3.815E-06	5.901E-06	1.017E-05	-4.657E-07
41	1.659E-05	7.153E-07	1.848E-06	-1.115E-05	-1.788E-07	2.116E-05	-1.099E-06	-1.977E-05	2.612E-05	-4.470E-06
51	-1.788E-06	2.775E-06	-7.629E-06	-1.001E-05	-2.146E-06	1.085E-05	1.527E-06	-2.548E-05	2.722E-05	-4.550E-06
61	5.007E-06	2.831E-07	-4.157E-06	1.609E-06	3.576E-06	2.325E-06	-3.413E-05	2.061E-05	-6.974E-06	4.888E-06
71	1.073E-06	-5.960E-08	3.338E-06	2.384E-06	-1.478E-05	1.907E-06	-3.964E-06	2.518E-05	-3.774E-06	5.066E-06
81	-8.166E-06	1.132E-06	-1.669E-06	-5.960E-08	-1.665E-06	-1.073E-06	-1.012E-05	-8.199E-06	3.688E-07	-3.230E-06
91	-6.557E-07	0.0	-6.735E-06	3.994E-06	4.172E-07	0.0	-9.537E-07	-4.888E-06	-4.891E-06	3.571E-06
101	3.337E-06	-1.371E-06	1.907E-06	4.292E-06	1.192E-07	-1.037E-05	1.967E-06	-1.967E-06	2.690E-06	1.080E-06
111	4.016E-06	1.848E-06	1.281E-06	-5.960E-06	2.861E-06	-6.631E-07	3.044E-06	1.311E-06	-3.092E-06	3.241E-06
121	8.270E-07	-7.770E-07	-2.053E-06	1.073E-06	7.600E-07	-2.399E-06	9.545E-07	-1.048E-01	3.797E-03	2.444E-06
131	1.669E-06	-1.550E-06	1.609E-06	-6.754E-07	1.192E-06	1.635E-06	3.017E-07	2.765E-06	2.300E-06	-3.506E-02
141	-6.616E-06	2.086E-06	-7.749E-07	4.828E-06	-1.788E-06	4.731E-07	1.032E-06	-3.055E-07	1.159E-06	5.327E-07
151	6.929E-07	-6.133E-02	-2.027E-06	-1.073E-06	4.530E-06	4.172E-07	-8.792E-07	7.153E-07	2.272E-06	3.539E-07
161	-1.788E-07	0.0	-7.560E-02	-7.331E-06	5.126E-06	-1.252E-06	3.874E-06	2.205E-06	-1.810E-06	1.371E-06
171	3.017E-06	2.682E-06	3.576E-06	1.110E-06	-1.189E-01	5.484E-06	0.0	-9.537E-07	4.709E-06	-1.132E-06
181	1.192E-06	2.347E-07	1.132E-06	7.749E-07	2.980E-07	-1.166E-01	-2.873E-05	-6.557E-07	-4.768E-06	4.768E-06
191	-1.550E-06	1.609E-06	4.694E-07	2.861E-06	-1.907E-06	1.717E-06	-3.083E-02	-1.711E-05	5.364E-07	4.715E-05
201	1.431E-05	-1.788E-06	1.669E-06	4.530E-06	1.311E-06	1.371E-06	3.032E-06	2.747E-06	-1.644E-01	-3.070E-05
211	-1.657E-05	3.225E-05	-2.980E-07	-1.729E-06	-1.538E-05	5.603E-06	0.0	-1.817E-05	-1.717E-05	3.052E-05
221	1.162E-05	-2.159E-05	6.676E-06	6.139E-06	3.576E-07	-2.366E-05	0.0	4.864E-05	2.563E-06	-1.812E-05
231	2.593E-05	-2.265E-06	2.384E-06	-2.205E-05	-2.086E-06	1.609E-05	2.861E-06	-5.364E-06	1.049E-05	-3.934E-06
241	1.192E-07	-1.866E-05	4.947E-06	-1.091E-05	7.212E-06	-2.390E-05	-8.047E-06	1.192E-07	1.252E-06	1.150E-05
251	3.815E-06	-1.526E-05	9.537E-07	0.0	8.523E-06	4.888E-06	2.086E-06	7.071E-01		

TABLE III - Continued

LUG ANALYSIS NO. 105

Y FORCE, CASE 1

	1	2	3	4	5	6	7	8	9	10
1	1.848E-06	-1.907E-06	-1.240E-05	9.537E-07	-5.722E-06	1.788E-06	2.623E-06	-3.576E-07	-3.576E-06	-2.384E-06
11	8.285E-06	1.490E-06	1.907E-06	-6.557E-07	1.431E-06	2.921E-06	-1.651E-05	-1.967E-06	9.954E-06	-7.153E-07
21	-1.019E-05	-5.364E-07	-4.459E-07	7.399E-07	1.490E-06	5.960E-07	-1.293E-05	2.861E-06	-7.808E-06	1.907E-06
31	-1.118E-08	1.132E-06	-5.960E-07	-1.907E-06	3.576E-07	2.384E-07	-5.603E-06	4.843E-07	2.682E-06	-1.863E-08
41	-5.327E-07	-3.576E-07	0.0	-3.755E-06	6.557E-07	3.695E-06	-1.132E-06	6.557E-07	3.010E-06	1.192E-06
51	-1.371E-06	-2.384E-06	-5.960E-08	-1.311E-06	1.132E-06	-2.861E-06	-1.874E-06	2.503E-06	-5.998E-07	7.749E-07
61	-1.490E-06	-3.397E-06	-2.980E-07	-1.788E-07	-2.027E-06	-2.213E-06	1.907E-06	-2.810E-06	2.384E-07	-6.557E-07
71	5.364E-07	1.490E-07	-1.609E-06	5.960E-08	-1.073E-06	-1.777E-06	-7.749E-07	-2.556E-06	-3.576E-07	7.749E-07
81	2.325E-06	-2.432E-06	-9.537E-07	9.537E-07	-6.020E-06	-1.192E-06	3.994E-06	-1.013E-06	-2.623E-06	-1.431E-06
91	5.364E-07	-2.027E-06	1.729E-06	1.192E-07	6.557E-07	-1.311E-06	3.576E-07	2.444E-06	-2.623E-06	5.364E-07
101	1.907E-06	-4.172E-07	-1.609E-06	1.907E-06	1.848E-06	3.517E-06	5.364E-07	5.960E-08	-2.921E-06	8.754E-07
111	-1.788E-07	-5.960E-08	-1.311E-06	1.073E-06	2.384E-06	5.960E-07	-5.960E-07	8.345E-07	9.537E-07	-5.960E-07
121	-1.013E-06	1.609E-06	1.192E-07	2.384E-07	-1.192E-06	-1.788E-07	-9.537E-07	2.798E-01	1.755E-01	6.557E-07
131	-9.537E-07	4.768E-06	2.384E-07	5.364E-07	-3.576E-07	-2.384E-07	1.065E-06	2.584E-07	-5.476E-08	6.233E-02
141	3.695E-06	3.815E-06	-9.537E-07	-2.861E-06	3.338E-06	1.252E-06	-1.788E-07	2.384E-07	2.507E-06	-2.235E-08
151	-4.098E-08	1.383E-02	1.788E-07	-9.537E-07	-9.537E-07	3.397E-06	-3.576E-07	2.384E-07	1.788E-07	-2.645E-07
161	4.098E-08	3.725E-08	-3.009E-02	9.537E-07	2.086E-06	-1.907E-06	-5.722E-06	2.861E-06	-1.431E-06	8.941E-07
171	4.172E-07	1.788E-07	4.172E-07	2.049E-07	-1.232E-01	-2.432E-05	-9.537E-07	8.583E-06	1.907E-06	-2.384E-06
181	1.311E-06	-8.345E-07	4.768E-07	5.960E-08	-1.578E-07	-2.985E-01	-1.460E-05	-3.815E-06	1.431E-05	1.907E-06
191	-2.384E-07	7.153E-07	5.960E-08	-2.503E-06	-5.960E-07	1.073E-06	-4.044E-01	-1.645E-05	-4.590E-06	9.537E-06
201	-2.861E-06	-1.252E-06	1.550E-06	1.013E-06	-4.172E-07	-9.537E-07	4.172E-07	9.537E-07	-3.826E-01	-6.389E-06
211	-1.907E-06	1.717E-05	1.252E-06	-1.192E-07	1.311E-06	1.252E-06	8.941E-07	9.477E-06	1.907E-06	2.861E-06
221	1.550E-06	4.768E-07	-1.431E-06	-1.907E-06	-1.788E-07	-6.441E-06	-3.815E-06	0.0	9.537E-07	0.0
231	-2.980E-07	1.907E-06	-1.550E-06	2.742E-06	-3.815E-06	9.537E-06	-9.537E-07	1.144E-05	0.0	2.861E-06
241	-1.010E-06	4.292E-06	-5.722E-06	1.240E-05	-3.815E-06	1.335E-05	1.907E-06	2.861E-06	7.153E-07	4.351E-06
251	-9.537E-07	7.629E-06	9.537E-07	-8.583E-06	-9.537E-07	1.907E-06	1.907E-06	7.071E-01		

CHECKS, SUM		X-FORCES	Y-FORCES	Z-MOMENTS	CASE
		-6.295D-04	-2.206D-04	2.893D-06	1
NZE	BANK	4191			
	+RHS	4193			
	REDU	4052			

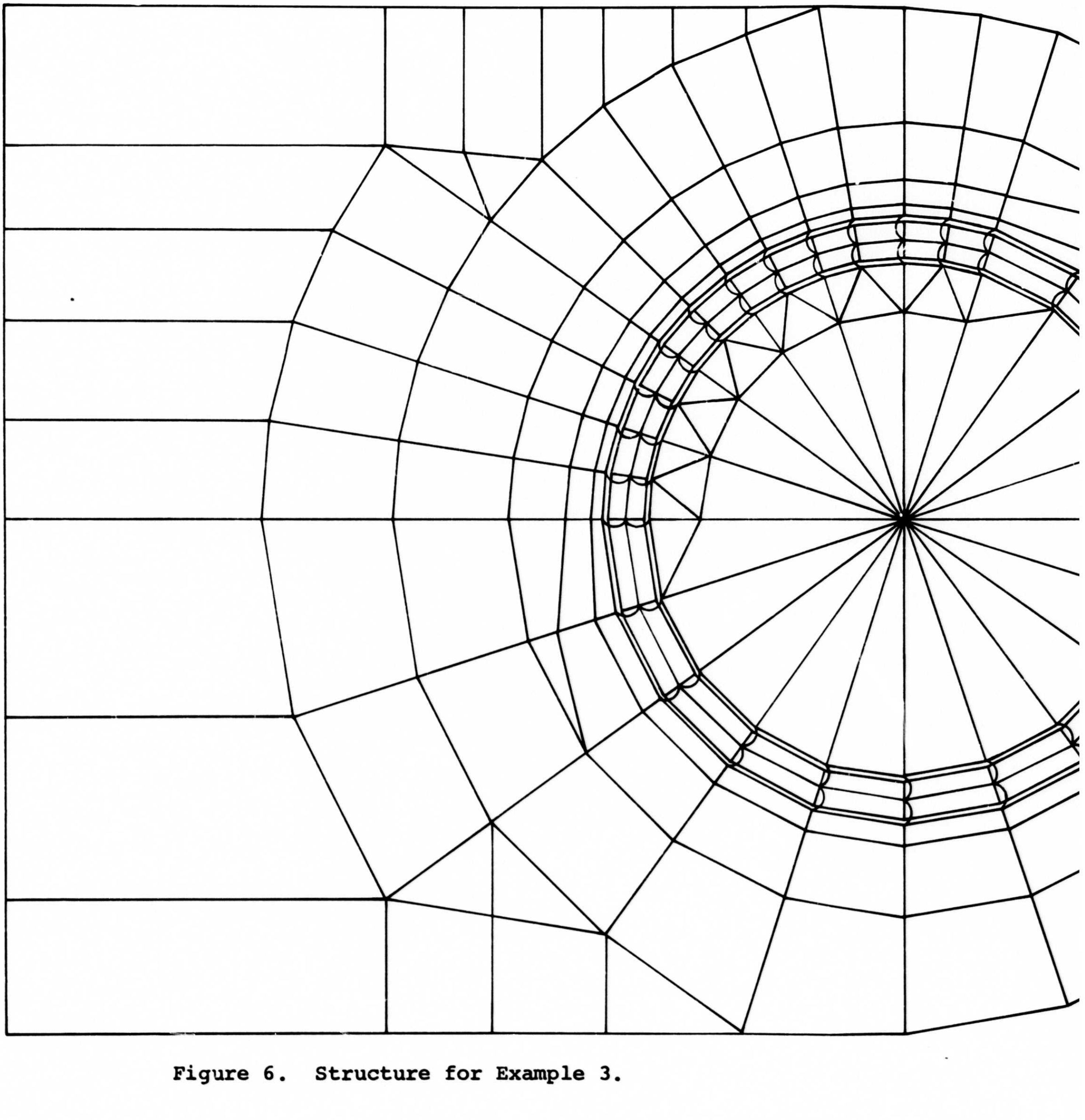
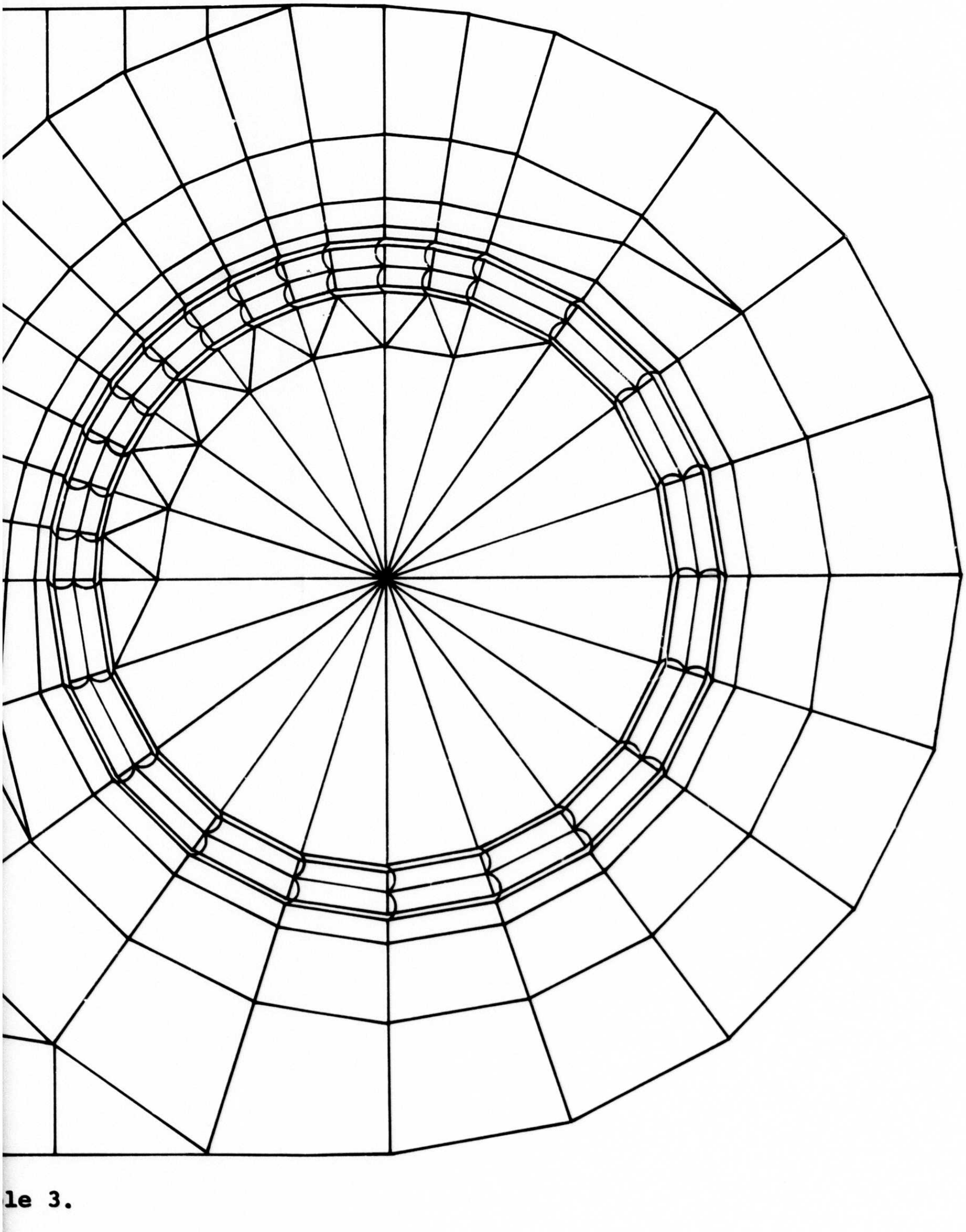


Figure 6. Structure for Example 3.



le 3.

B

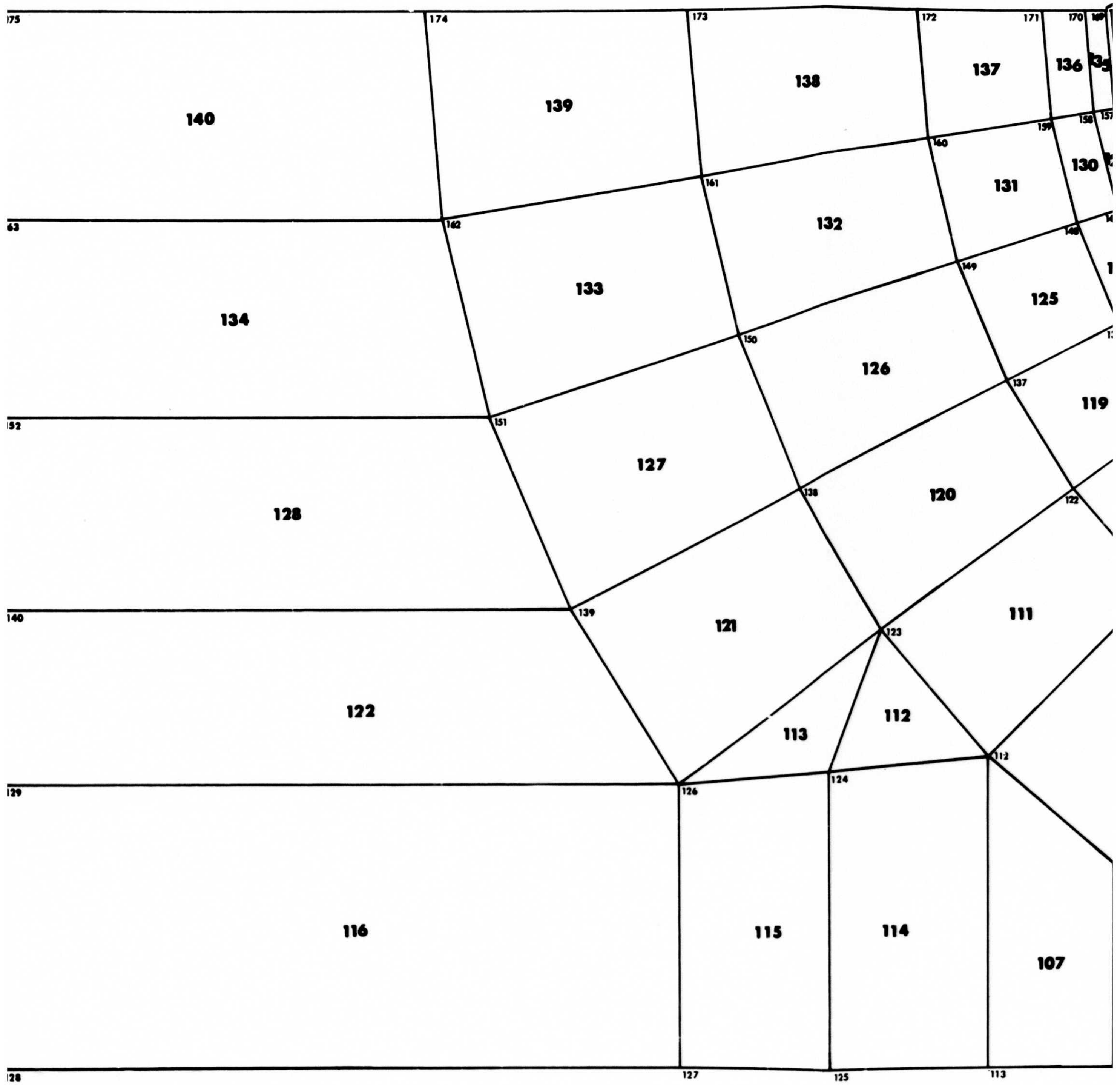
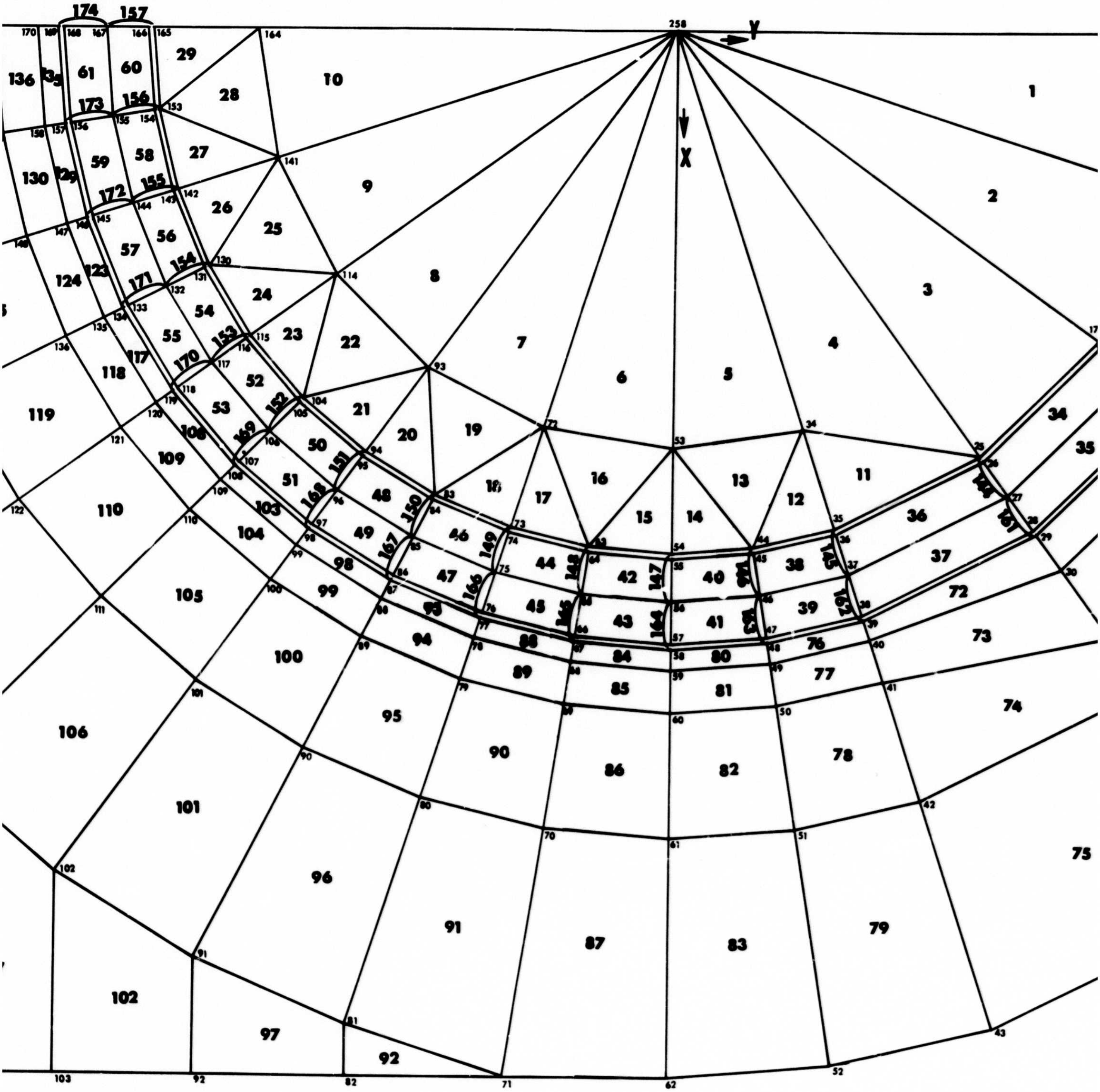


Figure 6 - Continued



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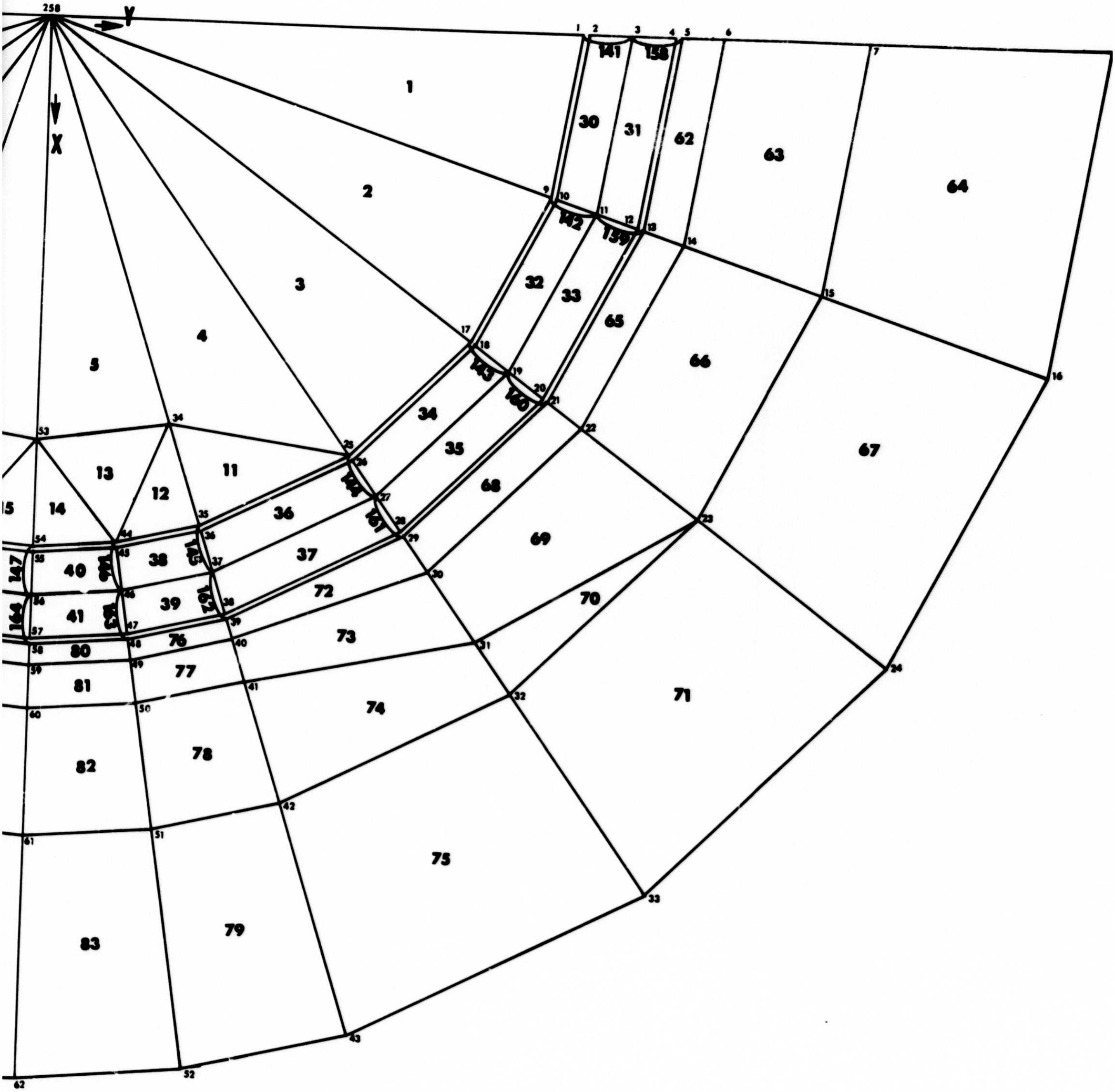


C

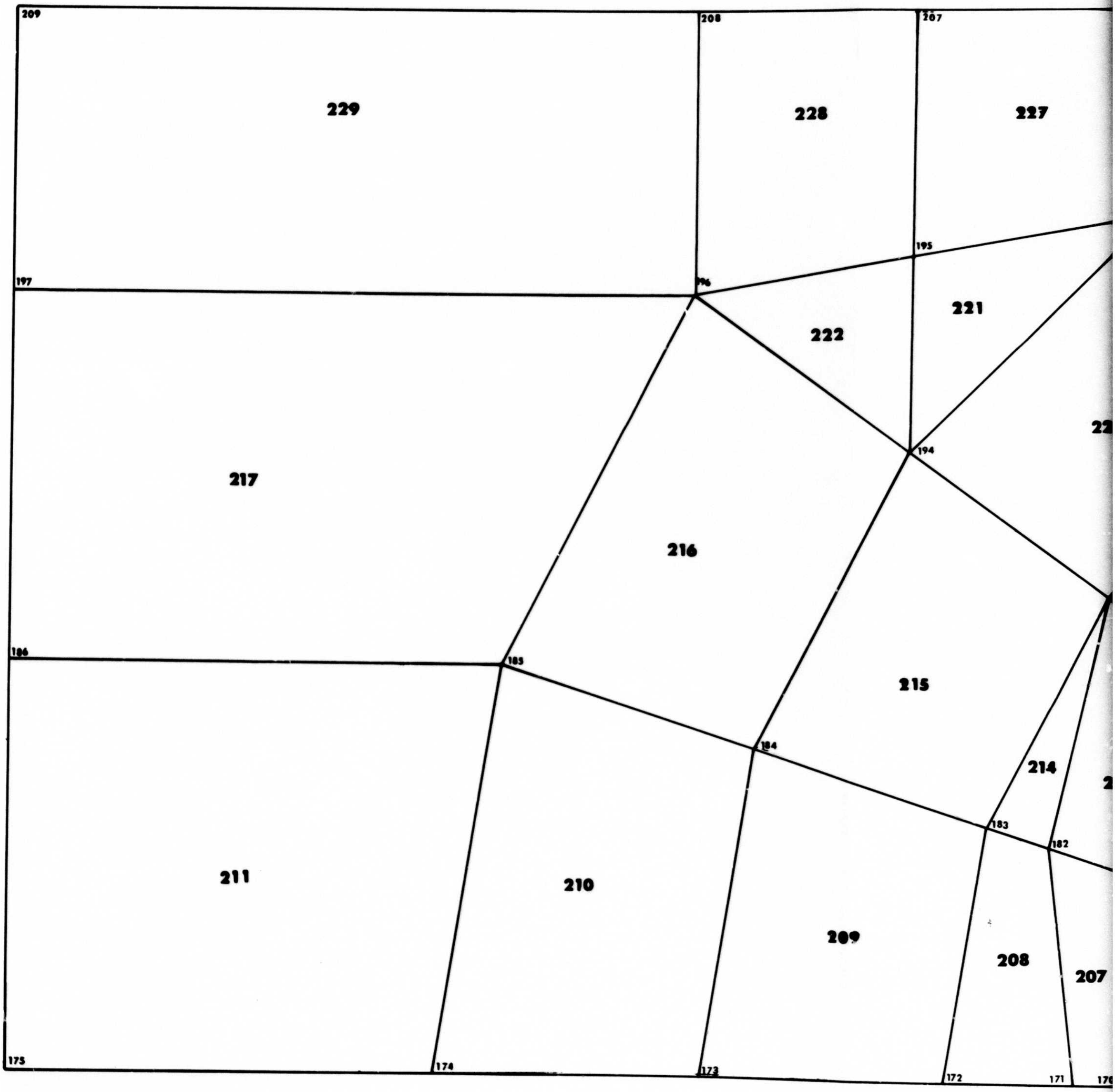
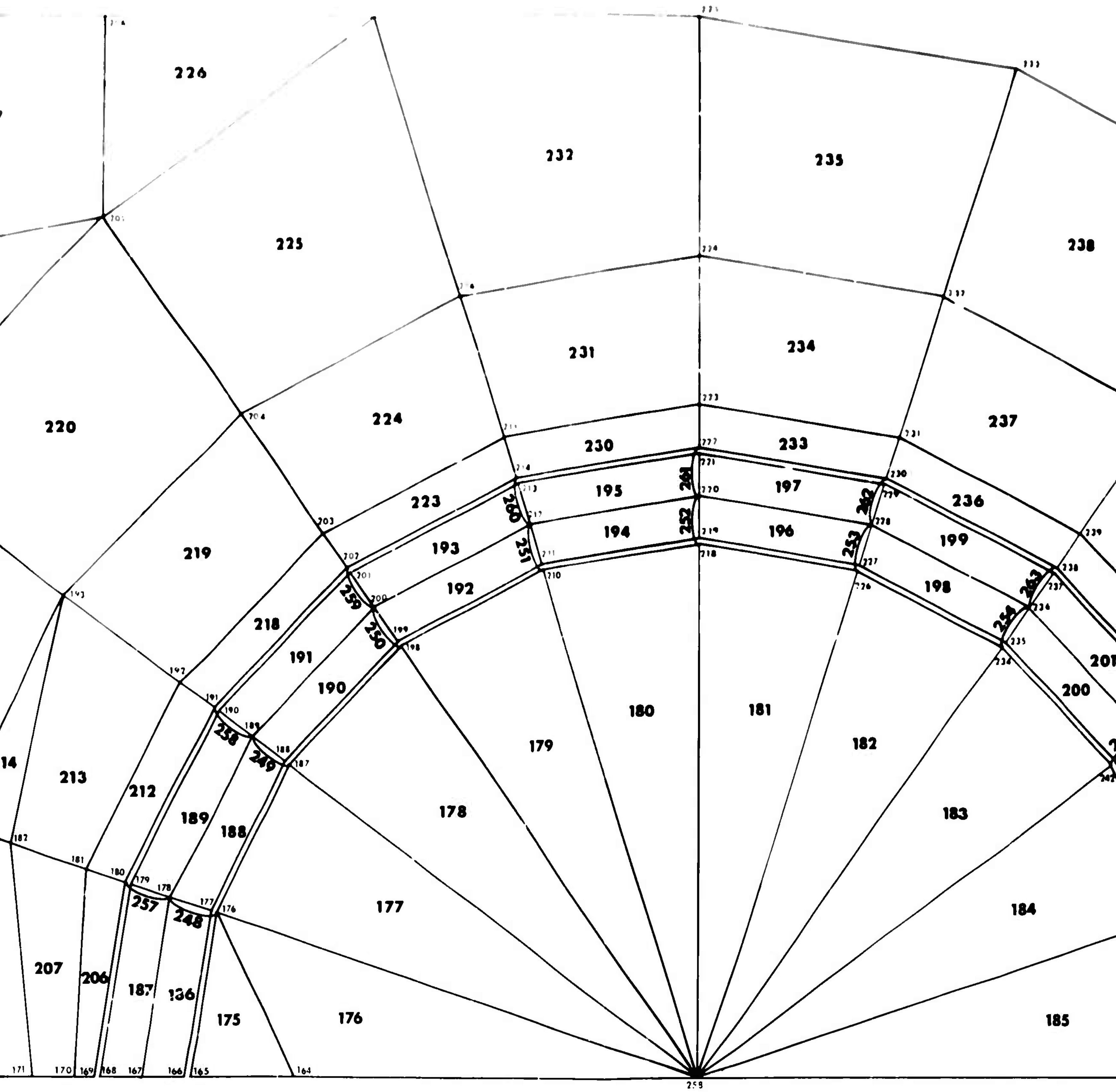


Figure 6 - Continued

A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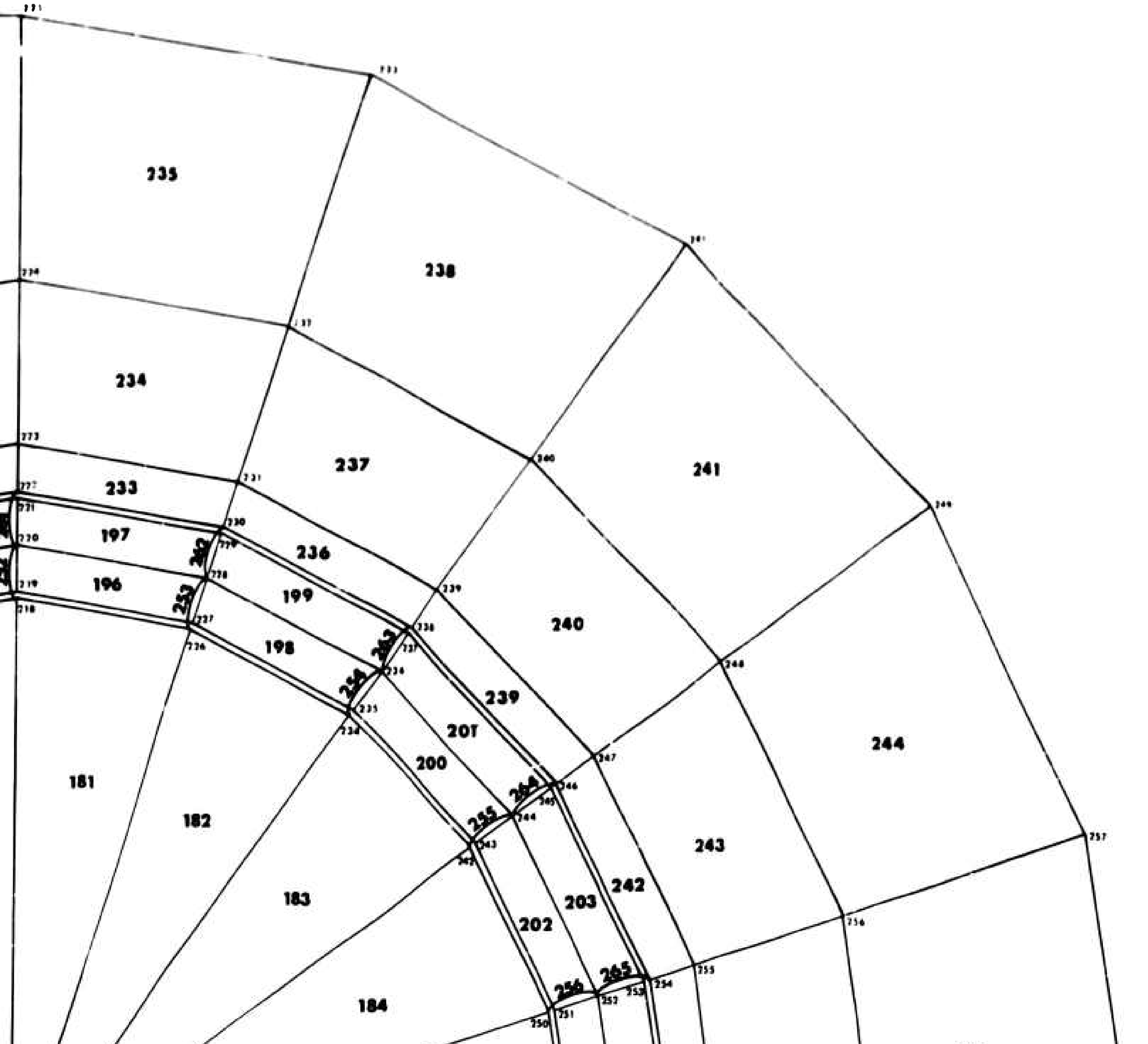
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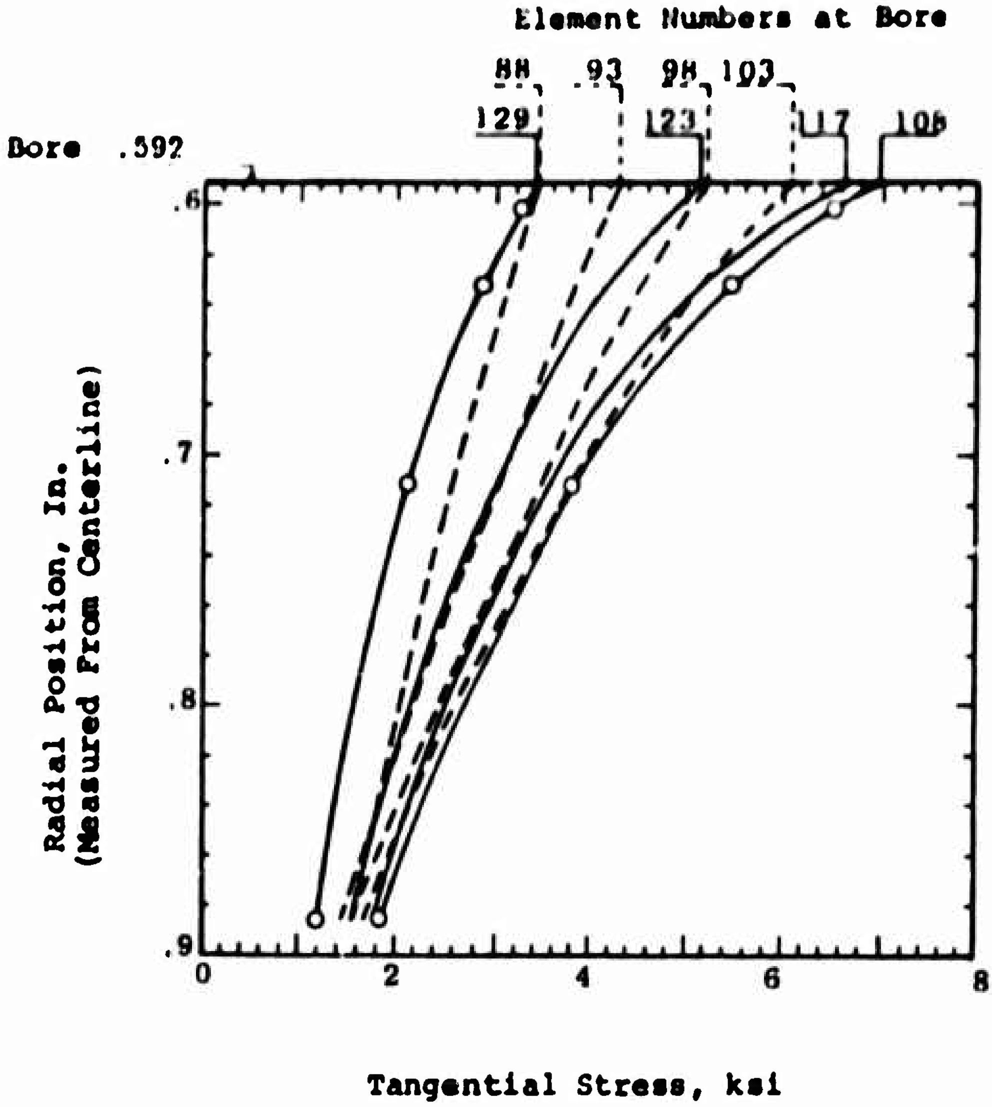


Figure 7. Tangential Stress Versus Radial Position for Example 3.

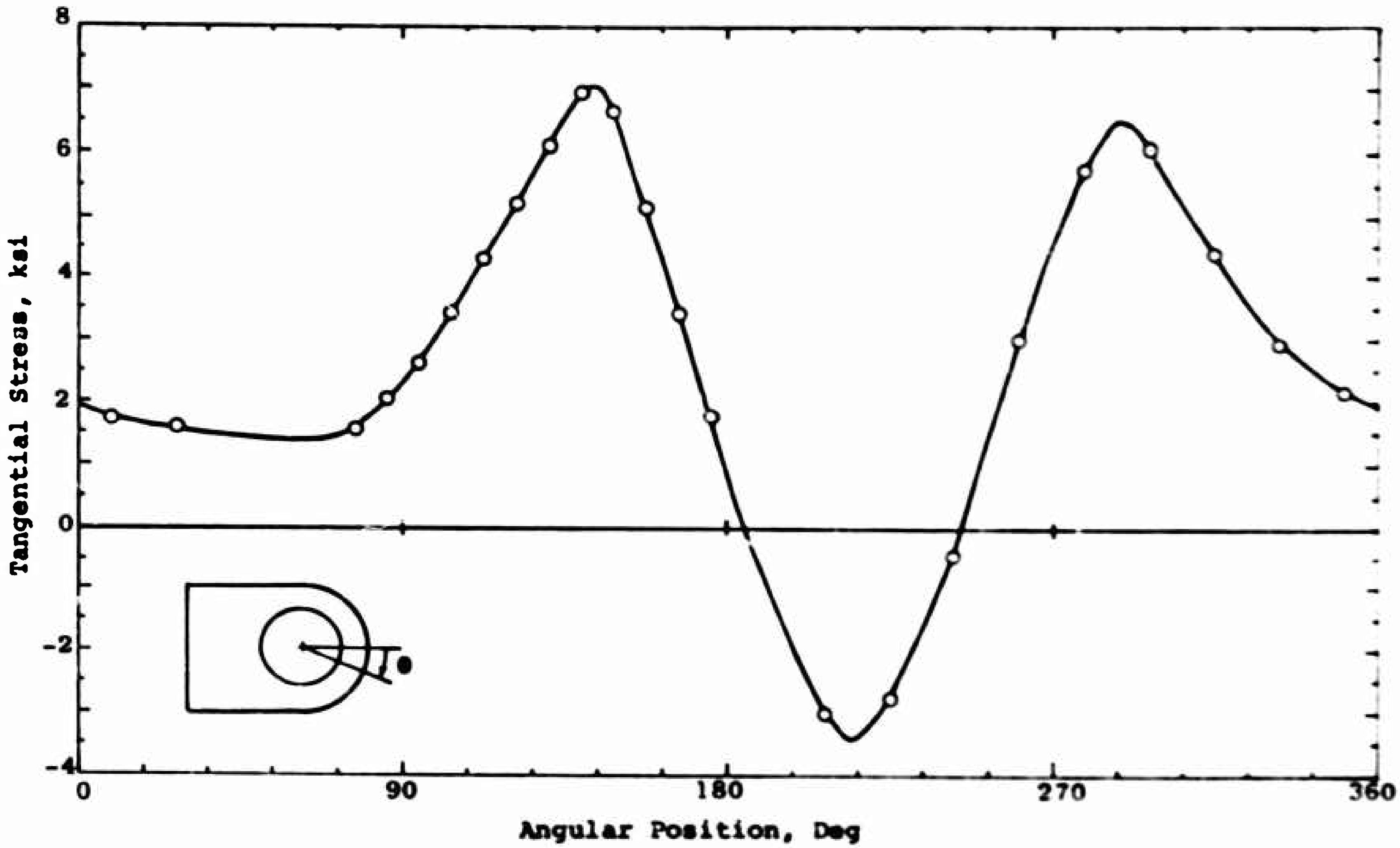


Figure 8. Tangential Stress Versus Angular Position for Example 3.

SOURCE PROGRAM

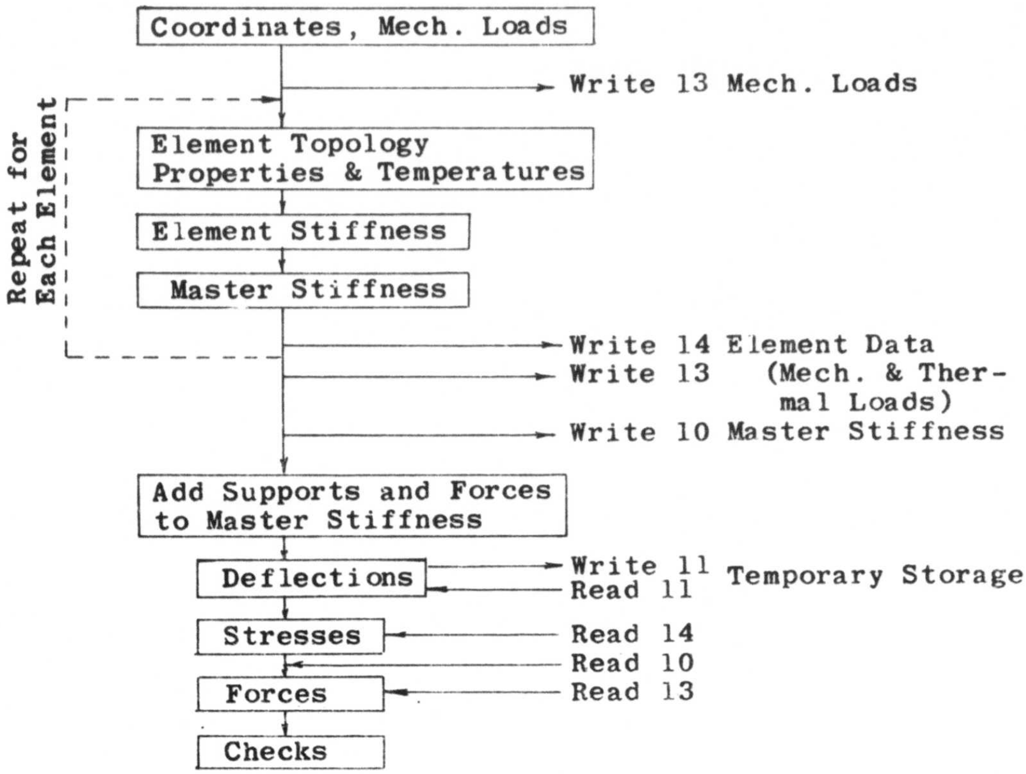
PROCESSING INFORMATION

Program MA2B is written in FORTRAN IV (E level) for the IBM system 360. It has been run on a model 40 using the Disc Operating System Version 3, Level (release 17). Four tape drives are required for temporary storage. It can be run without change on any IBM 360 having 128,000 bytes of storage. It may also be run on any computer having a FORTRAN IV compiler with only minor changes, providing sufficient storage is available. The program consists of a main program plus four subroutines.

An approximate running time for an IBM 360 model 40 computer can be found from the following expression:

$$\text{Time} = (\text{number of nodes})^2/1000 \text{ minutes}$$

FLOW DIAGRAM FOR MA2B



SOURCE PROGRAM DESCRIPTION

FORTRAN	DESCRIPTION
A	matrix of compatible strain distribution for unit element displacements
AL	direction cosines for PQ direction
AL2	direction cosines for TR direction
BARK	upper part of master stiffness matrix; also DBARK and DBAR
BLK	blank symbol on one of input cards
C	matrix occurring in Hooke's Law
CØE	an integration over the area of an element, used in development of stiffness matrix
DDSK	element stiffness matrix, datum coordinates
DSK	element stiffness matrix, local coordinates
DQRU	element thermal force matrix, datum coordinates
ECH	matrix used for equilibrium checks
F	matrix which relates assumed arbitrary coefficients in displacement function to the displacements
IBARK	identification number for non-zero element in master stiffness matrix
JLAM	dimension of ALAM array
JLAM2	JLAM/2
MPQRS	an array which contains the scheme for building the master stiffness matrix
NBC	identification of rows in master stiffness matrix corresponding to supports
NCRØSS	number of supports
NEL	N2 + 1

FORTRAN	Description
NUM	number of elements in upper half of master stiffness matrix
N2	number of nodes X 2
QBAR	array into which the mechanical loads are read at the beginning of the program. The thermal loads are subtracted as they are calculated. When all elements are processed, QBAR = sum of mechanical and thermal loads.
QØRU	element thermal force matrix, local coordinates
SCALEF	scale factor for master stiffness matrix, usually 1.0-5
STRESS	stresses

Notes:

1. Several source program symbols were defined in the list of input symbols.

2. All other source symbols are temporary storage.

FORTRAN LISTING

```
C      TITLE...MA2B,    MATRIX DISPLACEMENT ANALYSIS, 2-DIMENSIONS
C
C      KAMAN AEROSPACE CORP.
C      PROGRAMMED BY  J. HSU, A. BERMAN, R. MAYERJAK
C
C
C      DIMENSIONED FOR 300 NCDES WITH 6000 NZF
C      USE TAPES 10,13,14, 11
       DIMENSION DSK(8,8), ETA(5), IPQRS(4), MPQRS( 8), STRESS(5,5),
      1 R(12), QORU( 8,5), TEM(5), ECH(3,5),AL2(2),  DDSK(8,8),
      2 ALAM(8,8), AL(2), RH(2C),  WG(9),      NBC(300), QBAR(600,5),
      3 X(300),Y(300),UBAR(600,5),A(3,3,8),C(3,3),CCE(6),B(3),F(8,8),
      4 CA(3,8),ATD(8,8),DQCRU(8,5),IBARK(6000),BARK(6000)
       COMMON  DBARK, DBAR, X, Y, NBC
       DOUBLE PRECISION ECH,SCALEF,DSK,QCRL,F,CCE,A,DBARK(3000),
      1 SL43,X31,X41,Y31,Y41,SL41,SC43,H3,H1,H2,T,Y21, DBAR(3000)
C      DBAR INTRODUCED BECAUSE ARRAY DBARK(6000) WOULD BE TOO LARGE
C      WATCH OUT IF YOU CHANGE COMMON CR EQUIVALENCE STATEMENTS.
C      THE ORDER HEREIN ESTABLISHES AN EQUIVALENCE BETWEEN
C      DBARK(3001),DBAR(1), AND UBAR(1,1)
       EQUIVALENCE(IPQRS(4),IS),(IPQRS(3),IR),(IPQRS(2),IQ),(IPQRS(1),IP)
       EQUIVALENCE (BARK(1),DBARK(1)),(            UBAR(1,1),DBAR(1)),
      1 (DBAR(1501), QBAR(1,1))
       SCALEF =1.D-5
    10 REWIND 10
       REWIND 13
       REWIND 14
       READ(1,21) RH
    21 FORMAT(20A4)
    31 FORMAT(1H1  ///2X,2CA4/ )
       READ(1,41) BLK, NNODES, NELEM, NC, NLN
    41 FORMAT (A1, I9, 7I1C)
       N2= 2*NNODES
C      FOR IBM 360-30      USE N=110, NZE=2100
C      NUM=6000 HERE MUST SET EQUAL TC THE DIMENSICN CF IBARK
       NUM=6000
       DO 60 L=1,NUM
```

```
   60 BARK(L) = 0.                                                  E
C     INITIALIZATION MUST CORRESPCND TO CIMENSICN OF QBAR
      DO 62 L=1,600                                                 1
      DO 62 J=1,5                                                  21
   62 QBAR(L,J) = 0.                                               EE
      DO 75 K=1,2                                                   1
   50 GO TO (52,54), K                                              1
   52 READ (1,53) K1,K2,AC, (X(J), BARK(2*J-1), J=K1,K2)            1
   53 FORMAT (2I4,1X,A1, 7(F9.0,A1 ))                               1
      GO TO 58                                                      1
   54 READ (1,53) K1,K2,AC, (Y(J), BARK(2*J  ), J=K1,K2)            1
   58 IF(NNODES - K2) 64,64,50                                      1
   64 WRITE(3,31) RH                                                1
      WRITE(3,67) AC, (J,J=1,10)                                    1
   67 FORMAT(2X,A1,' COORDINATES AND SUPPCRTS'/2X,5(10X, I2),4X,    1
     1 5(10X,I2))                                                   1
      K2=0                                                          1
   68 K1=K2+1                                                       1
      K2=K1+9                                                       1
      IF(NNODES - K2) 69,66,66                                      1
   69 K2=NNODES                                                     1
   66 GO TO (70,73), K                                              1
   70 WRITE(3,71) K1,        (X(J), BARK(2*J-1), J=K1,K2)           1
   71 FORMAT( 2X,I4, 1X, 5(F10.4,1X,A1), 4X, 5(F10.4,1X,A1))        1
      GO TO 74                                                      1
   73 WRITE(3,71) K1,        (Y(J), BARK(2*J  ), J=K1,K2)           1
   74 IF(NNODES - K2) 75,75,68                                      1
   75 CONTINUE                                                      E
      WRITE(3,76) (J,J=1,NC)
   76 FORMAT(// 2X, 'LOADS,  CASE   '5(I1,9X))
      IF(NLN) 72,79,72
   72 DO 78 L=1,NLN                                                 1
      READ (1,77) K, AC, (QBAR(2*K-1,J),J=1,NC)                     1
   77 FORMAT (     I4, 5X, A1, 5F10.3)                              1
      WRITE(3,91) K, AC, (QBAR(2*K-1,J),J=1,NC)                     1
   91 FORMAT ( 2X, I4, 2X,A1,3X,5F10.3)                             1
      READ (1,77) K, AC, (QBAR(2*K  ,J),J=1,NC)                     1
```

```
   78 WRITE(3,91) K, AC, (QBAR(2*K   ,J),J=1,NC)                                E
C     THE NCROSS ROWS AND COLS. TC BE STRUCK FRCM K-BAR, AS DICTATEC BY
C     BOUNDARY CONDITIONS, ARE STCREC IN ARRAY NBC(I).
   79 IJ = 0
      DO 100 I=1,N2                                                             1
      IF (BARK(I) - BLK) 90,1C0,90                                              1
   90 IJ=IJ + 1                                                                 1
      NBC(IJ) = I                                                               1
  100 CONTINUE                                                                  E
      NCROSS = IJ
      DO 110 I=1,NUM                                                            1
  110 BARK(I) = 0.                                                              E
      WRITE(13) ((QBAR(I,J),I=1,N2),J=1,NC)
C     SET NZE IBARK DIAGONALS
      NEL=N2+1
      DO 102 I=1,N2                                                             1
      BARK(I)=0.                                                                1
  102 IBARK(I)=-I                                                               E
      IBARK(NEL)=0
      IJ=1
      KNO=1
      DO 740 NN=1,NELEM                                                         1
      IF ( MOD(NN+49,50))  104,103,104                                          1
  103 WRITE(3,31) RH                                                            1
      WRITE(3,81) (J,J=1,5)                                                     1
   81 FORMAT(2X,'ELEM   P   Q   R   S TYPE',7X,'E'. 8X,'PR',5X,'THICK-AR        1
     1EA' 4X,'ALPHA  ' 5(5X, 'TEM' I2))                                         1
  104 READ(1,111) IE,IP,IQ,IR,IS,NTYPE,  (WG(J), J=1,9)                         1
  111 FORMAT(6I4,F6.3,2F1C.0,6F5.0)                                             1
      IF (WG(1)) 1C5,118,1C5                                                    1
  105 T=WG(1)                                                                   1
      E=WG(2)                                                                   1
      ALPHA= WG(3)                                                              1
      PR= WG(4)                                                                 1
      DO 108 J=1,NC                                                            21
  108 TEM(J) = WG(J+4)                                                         E1
  118 DO 120 N=1,NC                                                            21
```

```
  120 ETA(N) = TEM(N) * ALPHA                                   E1
      XQP=X(IQ)-X(IP)                                            1
      YQP=Y(IQ)-Y(IP)                                            1
      D1 =SQRT(XQP*XQP+YQP*YQP)                                  1
C     CALCULATE THE PQ DIRECTION COSINES AND AREA*E              1
      AL(1)=XQP/D1                                               1
      AL(2)=YQP/D1                                               1
      AE=T*E                                                     1
      GO TO (130,160,160),NTYPE                                  1
C     BAR CALCULATIONS                                           1
  130 JLAM = 4                                                   1
      DO 150 I=1,2                                              21
      ALAM(1,I)= AL(I)                                          21
      ALAM(1,I+2)= 0.                                           21
      ALAM(2,I+2)=AL(I)                                         21
      ALAM(2,I) = 0.                                            21
      DO 140 J=1,NC                                            321
      DQORU(I,J)=AL(I)*AE*ETA(J)                               321
  140 DQORU(I+2,J)=-DQORU(I,J)                                 E21
      DO 150 J=1,2                                             321
      DDSK(I,J)= AL(I)*AL(J)*AE/D1                             321
      DDSK (I+2,J) =- DDSK(I,J)                                321
      DDSK (I,J+2) =- DDSK(I,J)                                321
  150 DDSK (I+2,J+2) =  DDSK(I,J)                              EE1
      GO TO 680                                                  1
C     TRIANGULAR OR RECTANGULAR PANELS  CALCULATIONS.            1
  160 JLAM= 2*(NTYPE+1)                                          1
      XRP = X(IR)-X(IP)                                          1
      YRP = Y(IR)-Y(IP)                                          1
C     THE TR DIRECTION COSINE  CALCULATIONS.                     1
      AL2(1) = AL(2)                                             1
      AL2(2) = -AL(1)                                            1
C     CHANGE FROM DATUM TO LOCAL COORDINATES                     1
      Y21= D1                                                    1
      X31= XRP*AL2(1)+YRP*AL2(2)                                 1
      Y31= XRP*AL (1)+YRP*AL (2)                                 1
      GO TO (680,176,175),NTYPE                                  1
```

```
175 XSP= X(IS)-X(IP)                                            1
    YSP= Y(IS)-Y(IP)                                            1
    X41= XSP*AL2(1)+YSP*AL2(2)                                  1
    Y41= XSP*AL (1)+YSP*AL (2)                                  1
176 DO 180 L=1,8                                               21
    DO 180 J=1,8                                              321
180 F(L,J)=0.                                                 EE1
183 GO TO (680,184,200),NTYPE                                   1
184 F(1,1)=Y31/(X31*Y21)-1./X31                                 1
    F(1,3)=-Y31/(X31*Y21)                                       1
    F(1,5)=1./X31                                               1
    F(2,1)=-1./Y21                                              1
    F(2,3)=1./Y21                                               1
    F(3,1)=1.                                                   1
    F(4,2)=F(1,1)                                               1
    F(4,4)=F(1,3)                                               1
    F(4,6)=F(1,5)                                               1
    F(5,2)=F(2,1)                                               1
    F(5,4)=F(2,3)                                               1
    F(6,2)=1.                                                   1
    GO TO 220                                                   1
200 H1=X31*X41*(Y41-Y31)                                        1
    F(1,1)=1.                                                   1
    F(2,1)=((X31*Y31-X41*Y41)+Y31*Y41*(X41-X31)/Y21)/H1         1
    F(2,3)=Y31*Y41*(X31-X41)/(H1*Y21)                           1
    F(2,5)=X41*Y41/H1                                           1
    F(2,7)=-X31*Y31/H1                                          1
    F(3,1)=-1./Y21                                              1
    F(3,3)=-F(3,1)                                              1
    F(4,1)=((X41-X31)+(X31*Y41-X41*Y31)/Y21)/H1                 1
    F(4,3)=(X41*Y31-X31*Y41)/(H1*Y21)                           1
    F(4,5)=-X41/H1                                              1
    F(4,7)=X31/H1                                               1
    F(5,2)=1.                                                   1
    F(6,2)=F(2,1)                                               1
    F(6,4)=F(2,3)                                               1
    F(6,6)=F(2,5)                                               1
```

```
      F(6,8)=F(2,7)                                   1
      F(7,2)=F(3,1)                                   1
      F(7,4)=F(3,3)                                   1
      F(8,2)=F(4,1)                                   1
      F(8,4)=F(4,3)                                   1
      F(8,6)=F(4,5)                                   1
      F(8,8)=F(4,7)                                   1
  220 DO  230 L=1,3                                  21
      DO  230 J=1,3                                 321
      DO  230 K=1,8                                4321
  230 A(L,J,K) = 0.                                EEE1
      GO  TO (680,235,270),NTYPE                      1
  235 DO  240 K=1,JLAM                               21
      A(1,1,K) = F(1,K)                              21
      A(1,2,K)=F(5,K)                                21
  240 A(1,3,K)=F(2,K)+F(4,K)                         E1
      GO  TO 290                                      1
  270 DO  280 K=1,JLAM                               21
      A(1,1,K)=F(2,K)                                21
      A(1,2,K)=F(7,K)                                21
      A(1,3,K)=F(3,K)+F(6,K)                         21
      A(2,2,K)=F(8,K)                                21
      A(2,3,K)=F(4,K)                                21
      A(3,1,K)=F(4,K)                                21
  280 A(3,3,K)=F(8,K)                                E1
  290 DO  330 L=1,3                                  21
      DO  330 J=1,3                                 321
  330 C(L,J)= 0.                                    EE1
      C(1,1)= E/(1.-PR*PR)                            1
      C(2,1)= PR*C(1,1)                               1
      C(3,3)=.5*(1.-PR)*C(1,1)                        1
      C(1,2)= C(2,1)                                  1
      C(2,2)= C(1,1)                                  1
C     CALCULATE COEFFICIENTS FOR A(L,J,K)             1
  350 DO  355 K=1,6                                  21
  355 COE(K)=0.                                      E1
      GO  TO (680,360,370),NTYPE                      1
```

```
360 COE(1)=.5*T*DABS(X31*Y21)                                          1
    GO TO 410                                                          1
370 H1= .5*DABS(X31*Y21)                                               1
    H2=.5*DABS(X41*Y31-X31*Y41)                                        1
    COE(1) = T *(H1+H2)                                                1
    COE(2) = T *(H1*X31/3.+H2*(X31+X41) /3.)                           1
    COE(3) = T *( H1*(Y31+Y21)/3.+ H2*(Y31+Y41)/3.)                    1
    XB= COE(2)/COE(1)                                                  1
    YB= COE(3)/COE(1)                                                  1
    SL32= (Y31-Y21) /X31                                               1
    SC32= Y21                                                          1
    SL41= Y41 /X41                                                     1
    COE(4) =T*(.125*(SL32*SL32-SL41*SL41)*X31**4 + SL32*SC32           1
   1              *X31**3/3. +.25*SC32*SC32*X31*X31)                   1
    COE(5)=(.25*(SL32-SL41)*X31**4 + SC32*X31**3/3.)*T                 1
    COE(6) =((SL32**3-SL41**3)*X31**4 /12. + SL32*SL32*SC32*X31**3/3.  1
   1 +.5*SL32*SC32*SC32*X31*X31+ SC32**3 *X31/3.)*T                    1
    IF(X31-X41) 385,410,385                                            1
385 H4=DABS(X31-X41)                                                   1
    IF(H4-.000000001) 410,410,386                                      1
386 SL43=(Y41-Y31)/(X41-X31)                                           1
    H4=DABS(SL43)                                                      1
    IF(H4-50.) 388,410,410                                             1
388 SC43=(X41*Y31-X31*Y41)/(X41-X31)                                   1
    H1= T*(.125*(SL43*SL43-SL41*SL41)*(X41**4-X31**4)+SL43*SC43*       1
   1 (X41**3-X31**3)/3.+.25*SC43*SC43*(X41*X41-X31*X31))               1
    H2=T*(.25*(SL43-SL41)*(X41**4-X31**4)+SC43*(X41**3-X31**3)/3.)     1
    H3=T*(              (SL43**3-SL41**3)*(X41**4-X31**4)/12.+         1
   1 SL43*SL43*SC43*(X41**3-X31**3)/3.+.5*SL43*SC43*SC43*(X41*X41-     1
   2 X31*X31)+SC43**3*(X41-X31)/3.)                                    1
    COE(4)=COE(4)+H1                                                   1
    COE(5)=COE(5)+H2                                                   1
    COE(6)=COE(6)+H3                                                   1
C   CALCULATE LOCAL STIFFNESS MATRIX DSK                               1
410 DO 420 K=1,8                                                      21
    DO 420 J=1,8                                                     321
420 DSK(J,K)=0.                                                      EE1
```

```
      KK=NTYPE-1                                                          1
      DO 530 KT=1,6                                                      21
      GO TO (430,440),KK                                                 21
  430 GO TO (450,540),KT                                                 21
  440 GO TO (450,460,470,480,490,500),KT                                 21
  450 K1=1                                                               21
      K2=1                                                               21
      GO TO 520                                                          21
  460 K2=2                                                               21
      GO TO 510                                                          21
  470 K2=3                                                               21
      GO TO 510                                                          21
  480 K1=2                                                               21
      GO TO 510                                                          21
  490 K2=2                                                               21
      GO TO 520                                                          21
  500 K1=3                                                               21
      K2=3                                                               21
      GO TO 520                                                          21
  510 CALL ATCA(A,C,COE,DSK,JLAM,K1,K2,KT)                               21
  520 CALL ATCA(A,C,COE,DSK,JLAM,K2,K1,KT)                               21
  530 CONTINUE                                                           E1
C     LOCAL THERMAL FORCE MATRIX  CDRU = -F*ALPHA*TEM                     1
  540 B(1)=E/(1.-PR)                                                      1
      B(2)=B(1)                                                           1
      B(3)=0.                                                             1
      DO 580 K=1,5                                                       21
      DO 580 L=1,JLAM                                                   321
      DDRU(L,K)=0.                                                      321
      DO 580 J=1,3                                                     4321
  580 DDRU(L,K)=DDRU(L,K)-(COE(1)*A(1,J,L)+COE(2)*A(2,J,L)+COE(3)      4321
     1  *A(3,J,L))*B(J)*DELTA(K)                                       EEE1
C     CALCULATE LAMBDA = ALAM                                             1
  610 DO 630 I=1,JLAM                                                    21
      DO 630 J=1,JLAM                                                   321
      ALAM(I,J)= 0.                                                     321
  630 DDSK (J,I)=0.                                                     EE1
```

```
      K=0                                                                 1
      DO 640 J=1,JLAM,2                                                  21
      DO 640 I=1,2                                                      321
      K=K+1                                                             321
      ALAM (J,K)=AL2(I)                                                 321
  640 ALAM(J+1,K)=AL(I)                                                 EE1
C     CALCULATE Q-BAR = ALAMT*QOPL, STORE IN CQCRU(I,J)                   1
      DO 645 J=1,NC                                                      21
      DO 645 I=1,JLAM                                                   321
      DQORU(I,J)=0.                                                     321
      DO 645 K=1,JLAM                                                  4321
  645 DQORU(I,J)=DQORU(I,J)+ALAM(K,I)*CCRU(K,J)                        EEE1
C     CALCULATE DATUM STIFFNESS MATRIX=DDSK                               1
      DO 650 K=1,JLAM                                                    21
      DO 650 J=1,JLAM                                                   321
  650 ATD(J,K)=0.                                                       EE1
      DO 660 J=1,JLAM                                                    21
      DO 660 K=1,JLAM                                                   321
      DO 660 L=1,JLAM                                                  4321
  660 ATD(J,K)= ATD(J,K) +ALAM (L,J)*CSK(L,K)                          EEE1
      DO 670 J=1,JLAM                                                    21
      DO 670 K=1,JLAM                                                   321
      DO 670 L=1,JLAM                                                  4321
  670 DDSK (J,K)=ATD(J,L)*ALAM (L,K)+ DDSK(J,K)                        EEE1
C     MPQRS CONTAINS THE SCHEME FOR BUILDING TOTAL K MATRIX               1
  680 WRITE(3,681) IE,IP,IQ,IR,IS,NTYPE,E,PR,T,ALPHA,(TEM(J),J=1,NC)      1
  681 FORMAT(1X,I5,4I4,I3,    F11.0,2F11.4,         F14.8,5F10.0)         1
      K=0                                                                 1
      JLAM2=JLAM/2                                                        1
      DO 690 I=1,JLAM2                                                   21
      DO 690 J=1,2                                                      321
      K=K+1                                                             321
  690 MPQRS(K)=2*IPQRS(I)-2+J                                           EE1
C     FOR ELEMENT, ADD K-BAR TO TOTAL K-BAR, SUBT.Q-BAR FROM TOTAL P.     1
      DO 720 LA=1,JLAM                                                   21
      KM=MPQRS(LA)                                                       21
      DO 700 MN=1,NC                                                    321
```

```
700 QBAR(KM,MN)=-DQORU(LA,MN) + QBAR(KM,MN)                      E21
    DO 720 L=1,JLAM                                              321
    KL=MPQRS(L)                                                  321
C            DEVELOP NZE BARK                                    321
    IF(KM-KL) 702, 702,720                                       321
702 IF(KM-KMO) 704, 706, 706                                     321
704 IO=KM                                                        321
706 DO   708 I=IO,NUM                                           4321
    IF (IBARK(I)+KM)  7C8, 710, 708                             4321
708 CONTINUE                                                    E321
    STOP  708                                                    321
710 IO=I                                                         321
    KMO=KM                                                       321
    IF(KM-KL)  712, 716, 712                                     321
712 I1=I+1                                                       321
    DO   714 I=I1,NUM                                           4321
    IF(IBARK(I))  717, 717, 713                                 4321
713 IF(IBARK(I)-KL)  714, 716, 717                              4321
714 CONTINUE                                                    E321
    STOP  714                                                    321
716 BARK(I)=BARK(I)+DDSK(LA,L)                                   321
    GO TO 720                                                    321
717 DO   718 J=I,NEL                                            4321
    J1=NEL-J+I                                                  4321
    IBARK(J1+1)=IBARK(J1)                                       4321
718  BARK(J1+1)= BARK(J1)                                       E321
    NEL=NEL+1                                                    321
    IBARK(I)=KL                                                  321
     BARK(I)=DDSK(LA,L)                                          321
720 CONTINUE                                                     EE1
    WRITE(14) T,AE,AL,ALAM,E,ETA,IE,JLAM,MPQRS,NTYPE,PR,D1,    C,   Y21,   1
   1 X31,Y31,          X41,Y41,            A,B,XB,YB                   1
740 CONTINUE                                                       E
    NEL1=NEL
    DO 742 J=1,NC                                                  1
742 WRITE(13)(QBAR(I,J),I=1,N2)                                    E
    WRITE (10) NEL,(IBARK(I),BARK(I),I =1,NEL)
```

```
C                 ADD QBAR TO BARK
      KA=0
      DO  756 I=1,N2                                          1
      DO  756 J=1,NC                                         21
      IF(QBAR(I,J)) 754, 756, 754                            21
  754 KA=KA+1                                                21
  756 CONTINUE                                               EE
      NEL1=NEL+KA
      I1=N2+1
      DO  766 I=1,NEL                                         1
      J=NEL-I+1                                               1
      KB=J+KA                                                 1
      IBARK(KB)=IBARK(J)                                      1
       BARK(KB)= BARK(J)                                      1
      IF(IBARK(J)) 758, 758, 766                              1
  758 I1=I1-1                                                 1
      DO  762 J1=1,NC                                        21
      J2=NC-J1+1                                             21
      IF(QBAR(I1,J2)) 760, 762, 760                          21
  760 KA=KA-1                                                21
      KB=J+KA                                                21
      IBARK(KB)=N2+J2                                        21
       BARK(KB)=QBAR(I1,J2)                                  21
  762 CONTINUE                                               E1
  766 CONTINUE                                                E
      NEL=NEL1
      MEL2=NEL
C             ELIMINATE VARIABLES AT SUPPORTS
      DO  796 LC=1,NCROSS                                     1
      LA=NBC(LC)                                              1
      KA=0                                                    1
      KB=1                                                    1
      I=0                                                     1
  776 I=I+1                                                   1
      IF( IBARK(I)) 778, 794, 788                             1
  778 IF( IBARK(I)+LA) 786, 780, 790                          1
  780 KB=I-KA                                                 1
```

```
      BARK(KB)=1.                                               1
      IBARK(KB)=IBARK(I)                                        1
  782 I=I+1                                                     1
      IF(IBARK(I)) 778, 794, 784                                1
  784 KA=KA+1                                                   1
      GO TO  782                                                1
  786 KB=I-KA                                                   1
      IBARK(KB)=IBARK(I)                                        1
       BARK(KB)= BARK(I)                                        1
      I=I+1                                                     1
      IF(IBARK(I)) 786, 794, 786                                1
  788 IF(IBARK(I)-LA) 790, 792, 790                             1
  790 KB=I-KA                                                   1
      IBARK(KB)=IBARK(I)                                        1
       BARK(KB)= BARK(I)                                        1
      GO TO  776                                                1
  792 KA=KA+1                                                   1
      GO TO  776                                                1
  794 VEL=NEL-KA                                                1
  796 IBARK(NEL)=0                                              E
      MEL3=NEL
C                         CONVERT BARK TO DBARK
      DO  802 I=1,NEL                                           1
      J=NEL-I+1                                                 1
  802 DBARK(J)=BARK(J)                                          E
C                              SOLVE EQUATIONS
      CALL GAUSS(IBARK,DBARK,N2,NLM,NEL,NC,I1,IP)
C                          RETURN DBARK TO BARK
      DO  804 I=1,NUM                                           1
  804 DAR K(I)=DBARK(I)                                         E
C                           TRANSFER SOLUTIONS TO UBAR
      DO  806 I=1,N2                                            1
      DO  806 J=1,NC                                           21
      I1=IP+NC*(I-1)+J-1                                       21
  806 UBAR(I,J)= BARK(I1)                                      EI
C     PRINT DEFLECTIONS
      CALL PRINT (NC, RM, UBAR, NNODES, 1)
```

```
      REWIND 14                                                              1
      NP= 50
      IF(NC-1) 925,925,924
  924 NP=50/(NC+1)
  925 NP1=NP-1
      DO 1092 NN=1,NELEM                                                     1
      IF( MOD(NN+NP1,NP))  940,930,940                                       1
  930 WRITE(3,31) RH                                                         1
      WRITE (3,951)                                                          1
  951 FORMAT(  2X,'STRESS     XX'9X,'YY'9X,'XY'9X,'CN'9X,'OS'6X,'CASE'/)     1
  940 READ(14) T,AE,AL,ALAM,E,ETA,IE,JLAM,MPQRS,NTYPE,PR,D1,    C,  Y21,    1
     1 X31,Y31,          X41,Y41,            A,B,XB,YB                        1
C     SELECT U-BAR-I FROM U-BAR AND STORE IT IN QORU(I,J)                    1
      DO 960 L=1,JLAM                                                       21
      KI=MPQRS(L)                                                           21
      DO 960 J=1,NC                                                        321
  960 QORU(L,J)=UBAR(KI,J)                                                 EE1
C     CHANGE COOR. SYSTEMS  ALAM(I,J)=   * UBAR                              1
      DO 1000 I=1,JLAM                                                      21
      DO  990 J=1,NC                                                       321
      R(J)=0.                                                              321
      DO 990 K1=1,JLAM                                                    4321
  990 R(J)= ALAM(I,K1)*QORU(K1,J)+R(J)                                    EE21
      DO 1000 J=1,NC                                                       321
 1000 ALAM(I,J)=R(J)                                                       EE1
      GO TO (1010,1020,1020),NTYPE                                           1
C     BAR STRESSES CALCULATIONS                                              1
 1010 DO 1005 I=1,NC                                                        21
      STRESS(1,I)=(ALAM(2,I)-ALAM(1,I)-ETA(I)*D1)*E/D1                      E1
 1005 WRITE (3,1011) IE,  STRESS(1,I), I                                     1
 1011 FORMAT( 2X, I4, F11.4, 46X, I4 )                                       1
      GO TO 1090                                                             1
C     TRIANGULAR AND RECTANGULAR PLATE STRESSES CALCULATIONS                 1
 1020 DO 1030 J=1,3                                                         21
      DO 1030 L=1,JLAM                                                     321
 1030 CA(J,L) = 0.                                                         EE1
      DO 1040 J=1,3                                                         21
```

```
      DO 1040 K=1,JLAM                                                    321
      DO 1040 L=1,3                                                      4321
 1040 CA(J,K)= CA(J,K)+ C(L,J)*(A(1,L,K)+A(2,L,K)*XB+A(3,L,K)*YB)        EEE1
      DO 1050 K=1,NC                                                       21
      DO 1050 J=1,3                                                       321
 1050 STRESS(J,K)=0.                                                      EE1
      DO 1060 K=1,NC                                                       21
      DO 1060 J=1,3                                                       321
      DO 1055 L=1,JLAM                                                   4321
 1055 STRESS(J,K)= STRESS(J,K)+CA(J,L)*ALAM(L,K)                         E321
 1060 STRESS(J,K)= STRESS(J,K) - B(J)*ETA(K)                              EE1
      DO 1065 K=1,NC                                                       21
      H1=STRESS(1,K)                                                       21
      H2=STRESS(2,K)                                                       21
      H3=STRESS(3,K)                                                       21
      STRESS(4,K) = (H1 + H2)/3.                                           21
 1065 STRESS(5,K) =(DSQRT(H1*H1+H2*H2+(H2-H1)*(H2-H1) + 6.*H3*H3))/3.      E1
      DO 1072 I=1,NC                                                       21
 1072 WRITE (3,1073)  IE, (STRESS(K,I), K=1,5), I                          E1
 1073 FORMAT( 2X, I4,  5F11.4, I6)
 1090 IF(NC-1) 1092,1092,1094                                               1
 1094 WRITE (3,1073)                                                        1
 1092 CONTINUE                                                              E
      REWIND 10
      READ(10) NEL,(IBARK(I),BARK(I),I=1,NEL)
C     CALCULATE FORCES
      CALL SNZMPY (IBARK,BARK,UBAR,QBAR,N2,NC,NUM)
      REWIND 13
      READ(13)((UBAR(I,J),I=1,N2),J=1,NC)
      DO 1100 J=1,NC                                                        1
      READ(13) (BARK(K),K=1,N2)                                             1
      DO 1100 I=1,N2                                                       21
 1100 UBAR(I,J)=QBAR(I,J)+UBAR(I,J)-BARK(I)                                EE
C     PRINT FORCES AT NODES
      CALL PRINT (NC, RH, UBAR, NNODES, 2 )
C     MAKE EQUILIBRIUM CHECK
      DO 1130 J=1,NC                                                        1
```

```
      DO 1120 L=1,3                                                   21
 1120 ECH(L,J)=0.                                                     E1
      DO 1130 K=1,NNODES                                              21
      ECH(1,J)=ECH(1,J)+UBAR(2*K-1,J)                                 21
      ECH(2,J)=ECH(2,J)+UBAR(2*K,J)                                   21
 1130 ECH(3,J)=ECH(3,J)+UBAR(2*K,J)*X(K)-LBAR(2*K-1,J)*Y(K)           EE
      WRITE(3,1131)
 1131 FORMAT(//2X,'CHECKS, SLP'9X,'X-FORCES    Y-FORCES   Z-MOMENTS
     1CASE' )
      DO 1140 J=1,NC                                                  1
 1140 WRITE(3,1141) (  ( ECH(K,J), K=1,3 ) , J)                       E
 1141 FORMAT (18X,  1P3E12.3, I7 )
      WRITE(3,1142) MEL1,MEL2,MEL3
 1142 FORMAT(2X, 'NZE'5X,'BARK'I10 /10X,' RHS'I10/10X, 'REDU' I10 )
 1150 READ(1,1151) ICONT
 1151 FORMAT(I1)
      GO TO (10,1160),ICONT
 1160 CALL EXIT
      END

      SUBROUTINE ATCA (A,C,COE,DSK,JLAM,K1,K2,K3)
C     CALCULATES  DSK =DSK + CCE(K3)* AT(K1)* C * A(K2)
      DIMENSION A(3,3,8),C(3,3),CCE(6),DSK(8,8),ATC(8,3)
      DOUBLE PRECISION DSK,COE,A
      DO 210 K=1,3                                                    1
      DO 210 J=1,JLAM                                                 21
  210 ATC(J,K) = 0.                                                   EE
      DO 230 J=1,JLAM                                                 1
      DO 230 K=1,3                                                    21
      DO 220 L=1,3                                                    321
  220 ATC(J,K) = ATC(J,K) + A(K1,L,J)*C(L,K)                          E21
  230 ATC(J,K) = ATC(J,K) * CCE(K3)                                   EE
      DO 240 J=1,JLAM                                                 1
      DO 240 K=1,JLAM                                                 21
      DO 240 L=1,3                                                    321
  240 DSK(J,K) = DSK(J,K) + ATC(J,L)*A(K2,L,K)                        EEE
```

```
      RETURN
      END

      SUBROUTINE GAUSS (I,A,N,MX,NEL,NRHS,NT,M)
      DIMENSION I(1),A(1)
      INTEGER STEP,P,PN,PC
      DOUBLE PRECISION A,TRM,PVT
      STEP(L)=MOD(L,MX)+1
      PO=1
      PN=NEL+1
   10 K=PO
      P=PN
      KN=PN
      PVT=A(PO)
      NPVT=0
   20 K=STEP(K)
      NPVT=NPVT+1
      IF(I(K))30,30,20
   30 IP=PO
      DO 500 L=1,NPVT                                    1
      I(KN)=I(IP)                                        1
      A(KN)=A(IP)                                        1
      A(IP)=A(IP)/PVT                                    1
      IP=STEP(IP)                                        1
  500 KN=STEP(KN)                                        E
      I(KN)=-1
      KN=STEP(KN)
      J=K-1
      IF(K-PO)32,31,35
   31 NSTOP=31
      GO TO 600
   32 IF(J)33,34,36
   33 NSTOP=33
      GO TO 600
   34 J=MX
   35 WRITE(NT) NPVT,(I(L),A(L),L=PC,J )
```

```
      GO TO 37
   36 WRITE(NT) NPVT,(I(L),A(L),L=PO,MX),(I(L),A(L),L=1,J)
   37 PO=KN
      NE=NPVT+1
      IF(I(K))40,300,38
   38 NSTOP=38
      GO TO 600
   40 P=STEP(P)
      IF(I(P))150,41,42
   41 NSTOP=41
      GO TO 600
   42 IF(I(P)-N)5C,50,150
   50 IF(I(K)+I(P))51,7C,6C
   51 NSTOP=51
      GO TO 600
   60 I(KN)=I(K)
      A(KN)=A(K)
      K=STEP(K)
      KN=STEP(KN)
      NE=NE+1
      IF(I(K))50,200,60
   70 TRM=A(P)/PVT
      I(KN)=I(K)
      A(KN)=A(K)-TRM*A(P)
      IP=P
   75 IP=STEP(IP)
   80 IF(I(IP))85,81,110
   81 NSTOP=81
      GO TO 600
   85 K=STEP(K)
      KN=STEP(KN)
      NE=NE+1
   90 IF(I(K))40,200,100
  100 I(KN)=I(K)
      A(KN)=A(K)
      GO TO 85
  110 K=STEP(K)
```

```
      KN=STEP(KN)
      NE=NE+1
      IF(I(K))120,120,130
  120 I(KN)=I(IP)
      A(KN)=-TRM*A(IP)
      IP=STEP(IP)
      KN=STEP(KN)
      NE=NE+1
      IF(I(IP))122,121,12C
  122 IF(I(K))40,200,40
  121 NSTOP=121
      GO TO 600
  130 IF(I(K)-I(IP))135,14C,145
  135 I(KN)=I(K)
      A(KN)=A(K)
      GO TO 110
  140 I(KN)=I(K)
      A(KN)=A(K)-TRM*A(IP)
      GO TO 75
  145 I(KN)=I(IP)
      A(KN)=-TRM*A(IP)
      KN=STEP(KN)
      IP=STEP(IP)
      NE=NE+1
      IF(I(IP))100,146,13C
  146 NSTOP=146
      GO TO 600
  150 I(KN)=I(K)
      A(KN)=A(K)
      K=STEP(K)
      KN=STEP(KN)
      NE=NE+1
      IF(I(K))150,20C,150
  200 I(KN)=0
      NEL=MAXO(NE,NEL)
      IF(NEL-MX)210,210,201
  201 NSTOP=201
```

```
      GO TO 600
  210 PN=STEP(KN)
      GO TO 10
  300 M=MX+1
  307 DO 400 LL=1,N                                           1
      BACKSPACE NT                                            1
      READ (NT) NPVT,(I(L),A(L),L=1,NPVT)                     1
  309 BACKSPACE NT                                            1
      M=M-NRHS                                                1
      IF(M-NPVT)3C1,301,302                                   1
  301 NSTOP=301                                               1
      GO TO 600                                               1
  302 IM=M                                                    1
      I(NPVT+1)=0                                             1
      K=2                                                     1
  305 IF(I(K)-N)310,310,32C                                   1
  310 IF(I(K))311,320,312                                     1
  311 NSTOP=311                                               1
      GO TO 600                                               1
  312 K=K+1                                                   1
      GO TO 305                                               1
  320 KR=1                                                    1
  325 IF(I(K)-N-KR)340,33C,34C                                1
  330 I(K)=0                                                  1
      A(IM)=A(K)                                              1
      K=K+1                                                   1
      GO TO 345                                               1
  340 A(IM)=0                                                 1
  345 KR=KR+1                                                 1
      IM=IM+1                                                 1
      IF(IM-M-NRHS)325,35C,350                                1
  350 K=2                                                     1
  360 IF(I(K))361,400,370                                     1
  361 NSTOP=361                                               1
      GO TO 600                                               1
  370 KM=M+NRHS*(I(K)+I(1))-1                                 1
      IM=M-1                                                  1
```

```
      DO 380 LLL=1,NRHS                                         700   21
      KM=KM+1                                                   701   21
      IM=IM+1                                                   702   21
  380 A(IM)=A(IM)-A(K)*A(KM)                                    703   E1
      K=K+1                                                     704    1
      GO TO 360                                                 705    1
  400 CONTINUE                                                  706    E
      IM=M                                                      707
      RETURN                                                    708
  600 WRITE (3,1060) NSTOP                                      709
 1060 FORMAT (///T10,'STOP'I5)                                  710
      CALL EXIT                                                 711
      END                                                       712

      SUBROUTINE SNZMPY (I,A,B,C,N,M,MX)                        713
      DIMENSION A(1),B(600,5),C(600,5),I(1)                     714
      DO 10 K=1,N                                               715    1
      DO 10 J=1,M                                               716   21
   10 C(K,J)=0                                                  717   EE
      DO 100 L=1,MX                                             718    1
      IF(I(L))20,150,50                                         719    1
   20 IA=-I(L)                                                  720    1
   25 DO 30 J=1,M                                               721   21
   30 C(IA,J)=C(IA,J)+A(L)*B(IA,J)                              722   E1
      GO TO 100                                                 723    1
   50 K=I(L)                                                    724    1
      DO 70 J=1,M                                               725   21
      C(IA,J)=C(IA,J)+A(L)*B(K,J)                               726   21
   70 C(K,J)=C(K,J)+A(L)*B(IA,J)                                727   E1
  100 CONTINUE                                                  728    E
  150 RETURN                                                    729
      END                                                       730

      SUBROUTINE PRINT ( NC,RM,UBAR, ANCDES,ATY)                731
      DIMENSION  RM(20), UBAR(600,5)                            732
```

```
      DO 900 J=1,NC                                                    733   1
      DO 900 K=1,2                                                     734  21
      WRITE(3,31)RH                                                    735  21
   31 FORMAT(1H1 ////2X,20A4/ )                                        736  21
      GO TO (810,820), K                                               737  21
  810 WRITE(3,811)                                                     738  21
  811 FORMAT( 2X,'X')                                                  739  21
      GO TO 822                                                        740  21
  820 WRITE(3,821)                                                     741  21
  821 FORMAT( 2X,'Y')                                                  742  21
  822 GO TO (825,827),NTY                                              743  21
  825 WRITE(3,826) J                                                   744  21
  826 FORMAT(1H+,'   DEFLECTION, CASE' I2)                             745  21
      GO TO 830                                                        746  21
  827 WRITE(3,828) J                                                   747  21
  828 FORMAT(1H+,'   FORCE, CASE' I2)                                  748  21
  830 WRITE (3,831) (M,M=1,10)                                         749  21
  831 FORMAT ( 1X, 5(10X, I2),4X, 5(10X, I2))                          750  21
      K2=0                                                             751  21
  840 K1=K2+1                                                          752  21
      K2=K1+9                                                          753  21
      IF(NNODES - K2) 845,846,846                                      754  21
  845 K2=NNODES                                                        755  21
  846 GO TO (850,855), K                                               756  21
  850 WRITE(3,851) K1, (UBAR(2*L-1, J), L=K1,K2)                       757  21
  851 FORMAT  (2X, I4, 1P5E12.3, 4X, 1P5E12.3)                         758  21
      GO TO 860                                                        759  21
  855 WRITE(3,851) K1, (UBAR(2*L  ,J), L=K1,K2)                        760  21
  860 IF(NNODES-K2) 900,900,840                                        761  21
  900 CONTINUE                                                         762  EE
  910 RETURN                                                           763
      END                                                              764
```

SHORT CHECKOUT CASE FOR MA2B

```
        12       6        2        4
   1   4 X     . S      . S      . S      . S
```

```
  5   8 X      .5         .5         .5         .5
  9  12 X     1.1        1.1        1.1        1.1
  1   4 Y     1.          .7 S       .3          .
  5   8 Y     1.          .7         .3          .
  9  12 Y     1.          .7         .3          .
  9     X     4.        11.
  9     Y      .           .
 10     X     6.           .
 10     Y      .           .
 11     X     6.           .
 11     Y      .           .
 12     X     4.       -11.
 12     Y      .           .
  1   2   1   5   6   3   .50    30000.   .0000065   .3
  2   4   3   7   8   3
  3   6   5   9  10   3
  4   8   7  11  12   3
  5   3   2   6   7   3   .25    30000.   .0000065   .3
  6   7   6  10  11   3
2
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13. ABSTRACT

This report presents the results of an investigation of the fatigue strength of structural lugs. The program included both experimental and analytical phases which were used in a complementary fashion to formulate design charts for fatigue-loaded steel and titanium lugs containing interference fit liners. These lugs are representative of design practice in highly loaded aircraft applications, particularly that found in helicopter blade attaching systems. A primary element in the analytical study was a two-dimensional structural analysis of lug configurations, which was done by finite-element methods using a computer program (Volume II).

The design charts presented will permit the designer to rapidly select lug proportions in either steel or titanium that will satisfy structural requirements for a range of steady and vibratory loading. The designs are considered to be particularly applicable to helicopter rotor and control systems.

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