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STRESS, STABILITY AND VIBRATION OF COMPLEX BRANCHED SHELLS OF REVOLUTION: ANALYSIS AND USER MANUAL FOR BOSOR4

by David Bushnell

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16. Abstract

A COMPREHENSIVE COMPUTER PROGRAM BOSOR4 FOR THE STRESS, STABILITY, AND VIBRATION ANALYSES OF SEGMENTED, RING-STIFFENED, BRANCHED SHELLS OF REVOLUTION IS PRESENTED. THE PROGRAM INCLUDES NONLINEAR PRESTRESS EFFECTS AND IS VERY GENERAL WITH RESPECT TO GEOMETRY OF MERIDIAN, SHELL WALL DESIGN, EDGE CONDITIONS, AND LOADING. DESPITE ITS GENERALITY, THE PROGRAM IS EASY TO USE. BRANCHES ARE PROVIDED SUCH THAT FOR COMMONLY OCCURRING CASES THE INPUT DATA INVOLVES ONLY BASIC INFORMATION SUCH AS GEOMETRICAL AND MATERIAL PROPERTIES. THE COMPUTER PROGRAM HAS BEEN VERIFIED BY COMPARISONS WITH OTHER KNOWN SOLUTIONS AND TEST RESULTS.

THIS MANUAL CONSISTS OF SEVERAL SECTIONS IN WHICH THE PROGRAM SCOPE IS DESCRIBED, THE ANALYSIS ON WHICH IT IS BASED IS GIVEN, THE FLOW OF CALCULATIONS IS OUTLINED, THE INPUT DATA ARE DEFINED WITH SAMPLE CASES, VARIOUS POSSIBLE PITFALLS ARE EMPHASIZED, AND SAMPLE LIST AND PLOT OUTPUT ARE GIVEN AND DESCRIBED.

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FOREWORD

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The author is indebted to Mr. Frank Brogan, who wrote the computer subroutines FACTR and SOLVE for solving linear equation systems and EBAND and EBAND2 for extracting eigenvalues; to Mr. Tom Petersen, who wrote subroutine GEOPLT for depicting undeformed and deformed geometries; to Mr. Chet Dyche, who wrote subroutine PLOTOP for plotting displacements, stresses, and stress resultants; to Mr. B. O. Almroth, who wrote the original versions of the wall stiffness subroutines CFB2 through CFB7; to Mr. William A. Loden, who wrote the subroutines GASP for mass storage transfer and MATMU1 through MATMU3 for matrix multiplication; and to Mr. Rod Kure, who wrote the subroutines SPLINE and SPLICO for spline fit approximation of meridian shapes.

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NOMENCLATURE

A	discrete ring cross-section area
[B]	kinematic relations in finite form, Eq. (8)
C_{ij}, [C], C	constitutive equation coefficients, Eq. (0), or Eq. (15)
d_1, d_2	radial, axial components of reference surface discontinuity (Fig. 19)
[d]	displacement vector [u,v,w]
E	Young's modulus
e_1, e_2	radial, axial components of discrete ring eccentricity (Fig. 21)
G	shear modulus
[G]	discrete ring constitutive law, Eq. (69)
H	radial line load applied at discrete ring centroid (Fig. 21)
h, k	finite difference mesh spacing (Fig. 3)
I	discrete ring moment of inertia (subscripted)
IPØINT	local mesh point number in current shell segment, JSEG
I5(I)	quantity of w-mesh points in Ith segment, not including "fictitious" points
J	discrete ring torsion constant
$[K_1]$, $[K_2]$, $[K_3]$	matrices, Eq. (37)
K	constraint condition multipliers, Eq. (4)
ℓ	length of finite difference element (Fig. 3)
M	line moment applied at discrete ring centroid (Fig. 21); bending moment resultants (subscripted) (Fig. 35)
n	number of circumferential waves; also n-axis in s-n system (Fig. 20)
N	in-plane stress resultants (subscripted) (Fig. 35); number of circumferential waves
NSEG	quantity of shell segments

p_1, p_2, p_3	pressure and surface traction components (Fig. 35)
$[P]$	"pressure-rotation" matrix, Eq. (42)
p	normal pressure, positive as shown in Fig. 20
q_i	dependent variables of energy
r	parallel circle radius, Fig. 20
R	radius of curvature (subscripted), (Figs. 20, 35)
s	meridional arc length. Also s-axis in s-n system (Fig. 21)
S	shear force/length applied to discrete ring axis (Fig. 21)
t	shell thickness
T	temperature rise above zero-stress state
T_s, T_r	kinetic energy of shell, ring
u, u^*	meridional, axial displacement (Fig. 20)
U	total potential energy
U_s, U_r	strain energy of shell, ring
U_{p1}, U_{p2}	potential energy of line loads, distributed loads
U_c	constraint "energy"
v, v^*	circumferential displacement (Fig. 35)
w, w^*	normal, radial displacement (Fig. 20)
δu, δv, δw	infinitesimal variations in u, v, w
x, y	axis system attached to discrete ring centroid (Fig. 21)
x	also denotes eigenvector
z	distance from reference surface, positive outward (Fig. 35)
α	coefficient of thermal expansion
γ	rotation around normal, Eq. (40), (Fig. 35)
δ^i_j	0 if $i \neq j$; 1 if $i = j$
ϵ	reference surface strains (subscripted) Eq.(0)
$\lfloor \epsilon \rfloor$	strain vector, Eq. (1)

$\lfloor \bar{\epsilon}_r \rfloor$	discrete ring strain vector, Eq. (67)
λ_i	Lagrange multipliers for constraint conditions
λ	eigenvalue for bifurcation buckling
$[K\lambda]$	constraint condition vector, Eq. (4)
$\varkappa$	reference surface changes in curvature; discrete ring axis changes in curvature
Ω	eigenfrequency
ψ	rotation about meridian, (Fig. 35), Eq. (40)
ψ_i	derivative of total potential energy U with respect to q_i
χ	rotation of meridian, (Fig. 20), Eq. (16)
ρ	discrete ring material density (lb/in^4)
σ	normal stress
τ	shear stress
θ	circumferential coordinate
ν	Poisson's ratio

Subscripts

c	discrete ring centroid. Displacements u_c, v_c, w_c shown in Fig. 21
f	"fixed" quantity
i	ith mesh point
LIN	including only terms linear in displacements
min, max	minimum, maximum
n	circumferential wave number; also n-axis in s-n system (Fig. 21)
NL	including only terms nonlinear in displacements
p	polar
r	discrete ring quantity

s	shell, or with respect to axis parallel to shell meridian, or portion of strain independent of prestress
t	differentiation with respect to time
v	variable quantity
x, y, xy	with respect to x-y system (Figs. 20, 21)
0,o	prebuckling quantity
1, 2	meridional, circumferential directions
12	shear, twist

Superscripts

f	"fixed" quantity
ff	prestress strain terms quadratic in "fixed" displacements
vv	prestress strain terms quadratic in "variable" displacements
fv	prestress strain terms involving cross-products between "fixed" and "variable" displacements
T	transpose, thermal effect
v	"variable" quantity
+,-	meridional discontinuity (Fig. 20)
$(\ )^{\cdot}$	differentiation with respect to circumferential coordinate θ
$(\ )'$	differentiation with respect to meridional arc length s
*	axial, radial system (u^*, w^*, for example, Fig. 20)
0	prestress state (zeroth order in variations δu, δv, δw)
1	first order variations (linear in δu, δv, δw), or first order (linear) prestress terms
2	second order variations (quadratic in δu, δv, δw), or second order (quadratic) prestress terms

Section 1

THE SCOPE OF THE BØSØR4 COMPUTER PROGRAM

1.0 Introduction

The BØSØR4 computer program was developed in response to the need for a tool which would help the engineer to design practical shell structures. An important class of such shell structures includes segmented, ring-stiffened branched shells of revolution. These shells may have various meridional geometries, wall constructions, boundary conditions, ring reinforcements, and types of loading, including thermal loading. An example is shown in Fig. 1. The meridian of the shell of revolution consists of six segments with various geometries and wall constructions. The first segment (nearest the bottom, end "A") is a monocoque ogive with variable thickness; the second is a conical shell with three layers of temperature-dependent, orthotropic material; the third is a layered, fiber-wound cylinder; the fourth is a toroidal segment with eccentric rings and stringers; the fifth is a spherical segment with eccentric rings and stringers; and the sixth is a flat plate with sandwich construction and eccentric meridional stiffeners. The reference surface is indicated by the dark dash-dot line. It is seen that the meridian of the composite shell structure is discontinuous between the first and second segments, the second and third segments, and the third and fourth segments. In the analysis these discontinuities are accounted for. The shell is supported at the end "A" by a ring which is restrained as shown: displacements u^* and w^* are not permitted at the point "A", which is located a specified distance from the beginning of the reference surface. In the analysis of actual shell structures it is important that support points, junctures, and ring reinforcements be accurately modeled. Seemingly insignificant parameters sometimes have a large effect on the stress, buckling loads, and vibration frequencies. The shell is reinforced by 6 rings of rectangular cross-section, the centroids of which are shown in the figure. These rings are treated as discrete elastic structures in the analysis. The shell is submitted to uniform external pressure (not shown), line loads applied at the first and second rings, and the thermal environment depicted on the second segment.

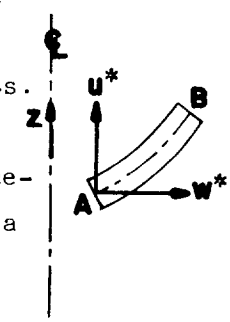


Figure 2 shows a branched shell typical of a submarine pressure hull. The hull contains three bulkheads which are treated as shell branch segments ③ , ⑤ , and ⑦ . The hull is reinforced by T-section heavy frames which can be treated as discrete rings or branches from the main shell. Arrows show increasing arc length, s.

The BØSØR4 program is very general with respect to the type of analysis which it will perform. Depending on the value of a control integer, the program will calculate axisymmetric stresses and displacements from a nonlinear theory for a series of step-wise increasing thermal or mechanical loads; will determine critical loads corresponding to axisymmetric collapse; will determine buckling loads corresponding to nonsymmetric buckling modes for a range of circumferential wave numbers, seeking the minimum load; will calculate vibration frequencies of prestressed shells corresponding to axisymmetric and nonsymmetric modes; will calculate displacements and stresses in nonsymmetrically loaded shells, and will calculate buckling loads of nonsymmetrically loaded shells. The program is an extension of the programs BØSØR, BØSØR2, and BØSØR3 described in Refs. 1, 2, and 3, respectively.

Other computer programs have also been written for the analysis of shells of revolution. In his computer analysis Cohen (Ref. 4) uses a step-by-step numerical integration technique to calculate buckling loads of ring-stiffened orthotropic shells of revolution. Kalnins (Ref. 5) employs a similar method to calculate nonsymmetric deformations of segmented shells of revolution submitted to nonsymmetric loads. Percy, Pian, Klein, and Navaratna (Ref. 6) use the finite element method for the linear stress analysis of general shells of revolution. Navaratna, Pian, and Witmer (Ref. 7) extend the analysis of Ref. 6 to treat buckling of shells of revolution. The work of Refs. 6 and 7 led to a series of computer programs under the name SABOR. The latest program in this series, SABOR5-DRASTIC, is documented in Ref. 8. Other computer programs on stress, buckling and vibration of shells of revolution have been written by Fulton and his co-workers (Ref. 9).

The assumptions upon which the BØSØR4 code is based are:

1. The material is elastic.
2. Thin shell theory is valid, that is, normals to the undeformed surface remain normal and undeformed.

3. The structure is axisymmetric, and in vibration analysis and nonlinear stress analysis the loads and prebuckling or prestress deformations are axisymmetric.

4. The prebuckling deflections, while considered finite, are moderate. That is, the square of the meridional rotation can be neglected compared to unity.

5. In the calculation of displacements and stresses in nonsymmetrically loaded shells, linear theory is used. This branch of the program is based on standard small-deflection analysis.

6. A typical cross-section dimension of a ring stiffener is small compared to the radius of the ring.

7. The cross-sections of the rings remain undeformed during the deformations of the structure, and the rotation about the ring centroid is equal to the rotation of the shell meridian at the attachment point of the ring. (Except, of course, if the ring is treated as a shell branch.)

8. The ring centroids coincide with the ring shear centers.

9. If meridional stiffeners are present, they are numerous enough to include in the analysis by an averaging or "smearing" of their properties over any parallel circle of the shell structure.

One of the more important extensions of the analysis of Ref. 3 is the capability of treating branched shells. This extension permits, for example, the analysis of pressure hulls with bulkheads; the treatment of ring-stiffened shells as shells with branches, thus accounting for the deformation of ring cross-sections; and the investigation of double-hulled vessels.

Two additional important extensions of the analysis include variable mesh point spacing within each shell segment and a reformulation of the buckling eigenvalue problem to account for prebuckling shape change of the shell in linear buckling analyses.

The BØSØR4 code is easy to use yet very general with respect to the

1. Type of analysis to be performed
2. Geometry of the shell meridian
3. Type of wall construction
4. Type of boundary conditions and ring supports, and branching configuration
5. Type of loading

1.1 Types of Analyses

The program can perform various types of analyses (see Fig. 24a). The choice of analysis is governed by an integer INDIC. The overall control in the program depends on this integer. The relationship between INDIC and the type of analysis to be performed is as follows:

INDIC = -2 . . . Stability determinant calculated for given circumferential wave number N for increasing loads until it changes sign. Nonlinear prebuckling effects included. INDIC then changed automatically to -1 and calculations proceed as if INDIC has always been -1. (See INDIC = -1.) See Table 10, Fig. 36, Page A93 - A101 for sample case.

-1 . . . Buckling load and corresponding wave number N determined, including nonlinear prebuckling effects. Initial load estimate and range of N provided by user. N corresponding to local minimum critical load is automatically sought. See Table 5, Fig. 27, Pages A14 - A29 for sample case.

0 . . . Axisymmetric stresses and displacements calculated for a sequence of stepwise increasing loads from some starting value to some maximum value, including nonlinear effects. Axisymmetric collapse loads can be calculated. See Table 6, Fig. 28, Pages A30 - A38 for sample case.

1 . . . Buckling loads calculated with linear bending theory for the prebuckling analysis. Buckling loads calculated for some range of wave numbers. Several buckling loads for each wave number can be calculated. N corresponding to minimum critical load is not sought automatically, however. See Table 4, Fig. 26, Pages A1 - A13 for sample case.

2 . . . Vibration frequencies calculated, including the effects of prestress obtained from nonlinear analysis, for a range of wave numbers. See Table 8, Fig. 30, Pages A58 - A75 for sample case.

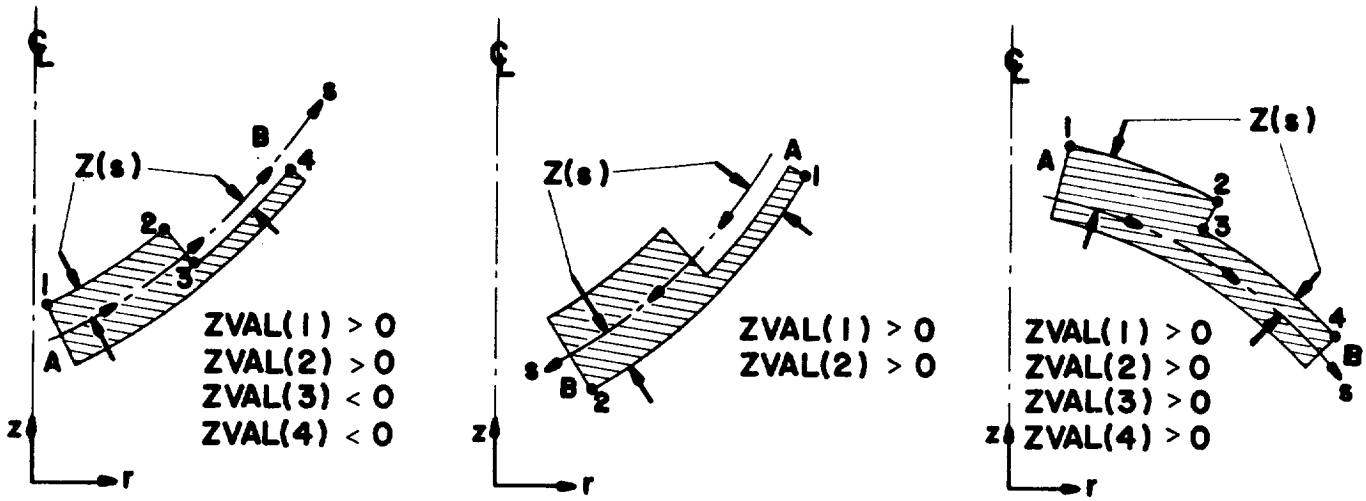
3 . . . Nonsymmetric stress and displacements calculated for a range of wave numbers for nonsymmetrically loaded shell. Linear theory used. See Table 7, Fig. 29, Pages A38 - A58 for sample case.

4 . . . Buckling loads calculated for nonsymmetrically loaded shells. Prebuckled state obtained from linear theory or read in directly. "Worst" meridional prestress distribution assumed axisymmetric in stability calculations. Several buckling loads for each wave number N can be calculated. N corresponding to minimum critical load not sought automatically. See Table 9, Fig. 31, Pages A75 - A92 for sample case.

1.2 Geometry of the Meridian of Each Segment

The entire shell structure consists of a number of shell segments joined together in series or branched. The reference surfaces of adjacent segments need not be continuous, as seen in Fig. 1. Both axial and radial discontinuities are permitted. In the determination of the geometry parameters of each segment flexibility is provided through a "computed GO TO" statement, in which control is referred to various subroutines called GEOM1, GEOM2, etc. Each of these subroutines calculates geometry parameters r, r', $1/R_1$, $1/R_2$, and $(1/R_1)'$ (Fig. 20) as functions of meridional arc length, s. For example, GEOM1 corresponds to cylindrical or conical shells or flat circular plates; GEOM2 corresponds to spherical, toroidal, ogival segments; and GEOM4 corresponds to general meridional shapes. Additional shell types can be accommodated by the insertion of other subroutines to calculate parameters for a specific geometry where dummies are now provided. Reference surfaces can be located anywhere inside or outside the shell walls. For the purpose of sign convention, the shell is always depicted with the axis oriented vertically and the meridian on the right-hand side of the axis, as shown in Figs. 1, 2 and 33-35.

The geometry parameters r, r', $1/R_1$, $1/R_2$, and $(1/R_1)'$ refer to a reference meridian, which need not be the "middle" surface. Figure 33 shows several shapes for which special branches are provided. Figure 34 shows a variable thickness shell with the reference surface. Appropriate input data determine the geometry of the reference surface. Additional input data are required for determination of the location of the material of the shell wall relative to the reference surface. An example of these data is given in Fig. 34. ZVAL(K) is positive if at the Kth callout point, IZVAL(K), material exists on our left-hand-side if we face in the direction of increasing arc length s. (Arc length s is measured along the reference meridian.) The sketches below illustrate this sign convention.



The concept of "inner" and "outer" surface is not general enough for proper application of BØSØR4. However, stresses are so labeled in output lists and plots. The user will interpret this output correctly if he translates "inner" as "left-most surface" and "outer" as "right-most surface", in which "left" and "right" are referenced to the direction of increasing arc length s. For example, in the above right-hand figure for the ZVAL sign convention, the "inner" surface in the sense just described is actually the outer surface in a physical sense. For simple problems the user is advised to follow the convention shown in the left-hand figure above. Increasing s is in the "northeastward" direction. Then "inner" and "outer", as defined precisely, generally coincide with the simple physical connotation.

1.3 Wall Construction of Each Segment

With regard to type of wall construction, the following special branches calling for simple input data are provided:

1. Monocoque shells
2. Shells with skew stiffeners
3. Fiber-reinforced shells laid up in layers (fiberglas)
4. Layered shells with orthotropic layers
5. Corrugated shells
6. Shells with one corrugated and one smooth skin

7. Layered shells with orthotropic layers, each layer of which has temperature-dependent material properties.

Any of these types of shells can be reinforced by two types of stiffeners: (1) rings and stringers which are "smeared out" in the analysis (as in the analysis of Ref. 10) and (2) by the addition of rings which are treated as discrete elastic structures. In Ref. 10 the BØSØR2 program is used to calculate buckling loads of externally pressurized cylinders reinforced by many small rings, which are "smeared out" in the analysis, and by large frames which are treated as discrete elastic structures. A test case in this manual provides an additional example. The shell wall properties are permitted to vary along the meridian. The "smeared" ring and stringer properties are also permitted to vary along the meridian. A structure composed of many segments can be analyzed, and the properties of each shell segment are independent of those of the other segments. The structure of a typical input deck is shown in Fig. 25.

In BØSØR4 the wall properties of each segment are determined in one of the subroutines CFB1, CFB2, etc. Each of these subroutines calculates the coefficients C_{ij} of the constitutive equations for a given type of shell wall construction. Additional wall constructions can be accommodated by the insertion of appropriate subroutines. Details of the derivation of the coefficients of the constitutive equations are given in Ref. 3, Ref. 11, and in the list of the BØSØR4 program itself.

The coefficients C_{ij} of the constitutive equations are defined by the equation:

$$\begin{Bmatrix} N_1 \\ N_2 \\ N_{12} \\ M_1 \\ M_2 \\ M_{12} \end{Bmatrix} = [C]\,\{\epsilon\} = \begin{bmatrix} C_{11} & C_{12} & 0 & C_{14} & C_{15} & 0 \\ C_{12} & C_{22} & 0 & C_{24} & C_{25} & 0 \\ 0 & 0 & C_{33} & 0 & 0 & C_{36} \\ C_{14} & C_{24} & 0 & C_{44} & C_{45} & 0 \\ C_{15} & C_{25} & 0 & C_{45} & C_{55} & 0 \\ 0 & 0 & C_{36} & 0 & 0 & C_{66} \end{bmatrix} \begin{Bmatrix} \epsilon_1 \\ \epsilon_2 \\ \epsilon_{12} \\ \kappa_1 \\ \kappa_2 \\ 2\kappa_{12} \end{Bmatrix} \quad (0)$$

1.4 Boundary Conditions and Ring Supports

A composite shell structure is shown in Fig. 1. In this example the shell is composed of six segments, has a ring support at A, and is free at B. There are also intermediate ring supports as shown. These rings are treated as discrete elastic structures, and the ring equations developed by Cohen (Ref. 4) are used. Figure 21 is a schematic of an arbitrary discrete ring considered to be attached to the reference surface at the point so labeled. The ring centroid is located a radial distance e_1 and axial distance e_2 from the attachment point. These components e_1 and e_2 of ring "eccentricity" are positive as shown. Their sign, incidentally, does not depend upon the direction in which the arc length s is traversed, but only upon the relative positions of the attachment point and the centroid. Similar comments apply to discrete rings, the eccentricity of which is specified by Z_c and S_c, shown in Fig. 21(b).

Displacement constraints in addition to those associated with ring supports are treated somewhat differently in BØSØR4 than they are in BØSØR3 (see discussion on pages 1-7 and 1-8 of Ref. 3). The Lagrange multiplier method is still used and the constraint conditions still apply to the global displacement components u^*, v^*, w^*, and χ (Fig. 19). However, introduction of branched shells adds another dimension to the definition of the constraint conditions. Figure 2 can be used as an example. Table 1.1 shows the input data pertaining to the constraint conditions corresponding to Fig. 2. Each segment has 15 mesh points. Three groups of data appear for each input card: location of constraint, which of the global variables u^*, v^*, w^*, and χ are involved, and the radial and axial components of reference surface discontinuity, D1 and D2 (d_1 and d_2 in Fig. 19). For example, the last card reads "Segment 8 point 15 connected to Segment 8 point 15; u^*, v^*, w^*, χ are constrained; zero discontinuity". This card illustrates the treatment of a boundary condition. The second card represents a juncture compatibility condition. The location of pole conditions (r=0) must be specified by the user, but the appropriate displacement constraints depend on circumferential wave number n, and these are automatically generated internally. Hence, the integers in columns 18, 24, 30 and 36 of the first, fourth, eighth, and eleventh "cards" in Table 1.1 are ignored by the program. Assignment of

unity in the columns labeled u^*, v^*, w^*, χ means the corresponding global displacement component is constrained or is involved in a juncture condition. Zero denotes no constraint or juncture continuity condition.

Figure 19 shows a meridional discontinuity (a) and boundary support points at the beginning of a segment and at the end of a segment (b). In Fig. 19(a):

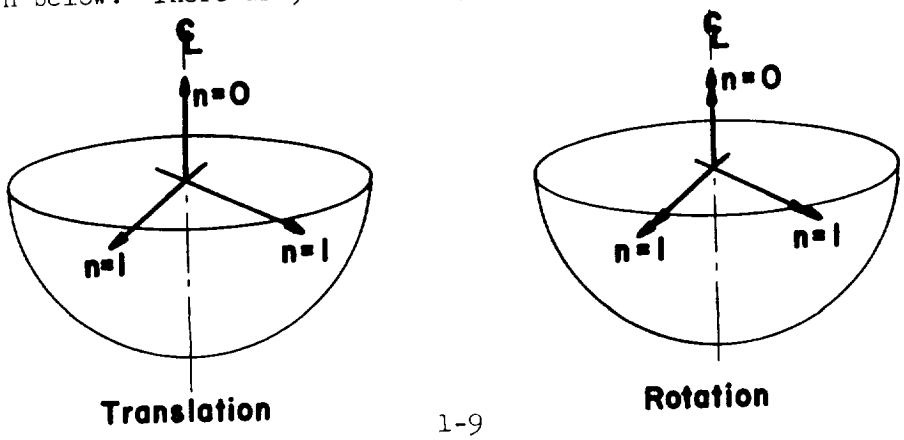
1) d_1 and d_2 are positive as shown if $J > 0$

2) d_1 and d_2 are negative as shown if $J < 0$

This sign convention thus depends only on the relative numbering of the segments involved in the junction. It does not depend on the direction of increasing arc length s. Nor does it depend on whether the user specifies "Segment ISEG is connected to segment ISEG + J" or "Segment ISEG + J is connected to ISEG". In Fig. 19(b) the "discontinuities" d_1 and d_2 are positive as shown independent of the direction of increasing arc length s.

The treatment of cases in which stability or vibration constraint conditions are different from prestress conditions is described in the section on input data. For example, antisymmetrical behavior at symmetry planes of a shell is permitted through the introduction of additional constraint condition cards, as described on Page B-3.

Rigid body modes are prevented by the user through introduction of appropriate input as described in the input data section (Page B-3). Of course, these additional input data are required only in cases involving n = 0 or n = 1, in which rigid body motion is possible because of the absence of certain constraints. Examples of rigid body modes are shown in the sketch below. There are, of course, six possible rigid body modes,



three translational and three rotational. Two of these modes correspond to axisymmetric motion ($n = 0$) and four to motion involving one circumferential "wave" ($n = 1$). If $n = 0$ or $n = 1$ are involved in either the prestress or the eigenvalue analysis, and if the constraint conditions already introduced by the user permit rigid body motion, the user must provide two additional constraint condition cards, one which prevents the $n = 0$ rigid body modes and the other which prevents $n = 1$ rigid body modes. These additional constraint conditions (called ISTØPO(I) and ISTØP1(I) on Page B-3) must correspond to a location in the structure at which a constraint condition, IFIX, has already been introduced, but they may not be introduced at a pole ($r = 0$). It may be necessary on occasion to introduce a "fictitious" IFIX constraint condition (location, but no constraint)

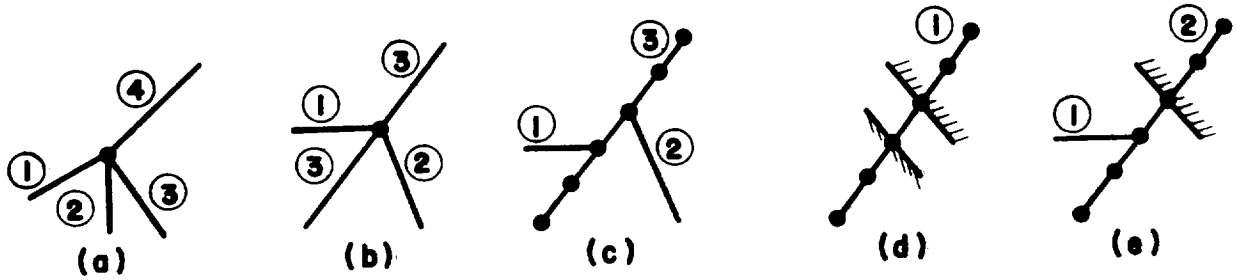
$$\text{e.g:} \quad \text{IFIX} = \underbrace{\overbrace{1015,}^{(\text{Seg},\text{Pt})}\ \overbrace{1015,}^{(\text{Seg},\text{Pt})}}_{\text{location}} \quad \underbrace{\overbrace{0\ ,\ 0\ ,\ 0\ ,\ 0}^{u^*\quad v^*\quad w^*\quad \chi}}_{\text{constraint}}$$

in order to be able to provide appropriate constraints against rigid body movements.

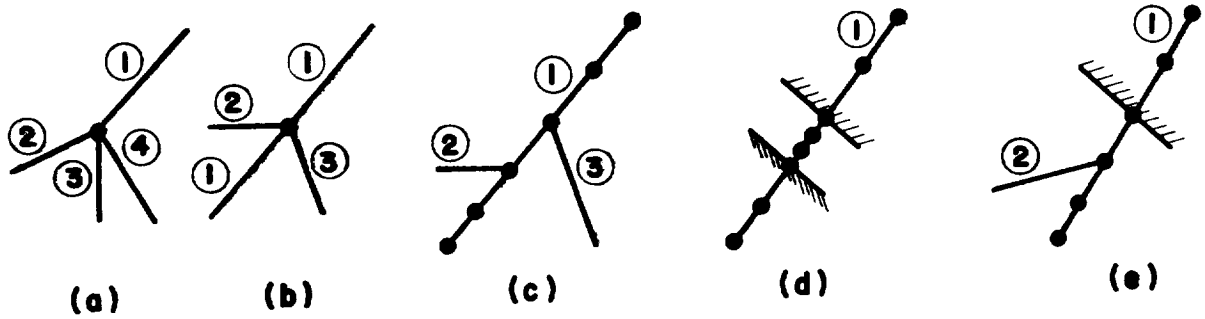
$$\text{e.g:} \begin{cases} \text{ISTØPO} = 1015\ ,\ 1015\ ,\ 1\ ,\ 1\ ,\ 0\ ,\ 0 \\ \text{ISTØP1} = 1015\ ,\ 1015\ ,\ 0\ ,\ 0\ ,\ 1\ ,\ 1 \end{cases}$$

The above example would apply to a buckling analysis of a free hemisphere. In the BØSØR4 program the constraint conditions ISTØPO are only applied if $n = 0$; ISTØP1 are only applied if $n = 1$. They are released automatically for all other values of n. It is up to the user to provide adequate conditions to prevent rigid body motions, while not introducing additional "fictitious" structural stiffness. The sample case involving vibration of a free hemisphere (Table 8, Pages A58-A75) demonstrates the appropriate use of rigid body mode constraints.

There are certain limitations on the types of branching permitted by the BOSOR4 code. The sketches below illustrate branch conditions, which if provided as input to BØSØR4, will elicit the message "Constraint condition number K illegal. See User's Manual for fix."



The encircled numbers refer to segment numbers. These same configurations can be modeled successfully, however, with appropriate changes in segment numbering and mesh points, as illustrated below:



1.5 Loading

Mechanical or thermal line loads or distributed loads (pressures) are permitted in the analysis. These loads may be axisymmetric or may vary around the circumference. The pressures and temperatures may vary along the meridian as well as around the circumference, and the temperature may vary through the thickness. In cases involving nonsymmetric loading a linear analysis is used. The program finds the Fourier series for the loads, calculates the shell response in each harmonic to the load components with that harmonic, and superposes the results for all harmonics. The superposed displacements and stress resultants are printed and plotted for selected meridional and circumferential stations. Line loads and moments are assumed to be applied at ring centroids. Thermal line loads arise from the presence of discrete rings which may be heated above their zero-stress

states. Distributed thermal loads arise from temperature distributions over the shell surface and through the shell wall thickness. It is emphasized that the input temperature is "delta T", that is the rise in temperature above the zero-stress state, not the absolute temperature.

As seen from Fig. 25, which shows a schematic of a BØSØR4 input data deck, there are four groups of input cards corresponding to four different classes of loads:

1. Line loads at discrete rings
2. Thermal line loads at discrete rings
3. Pressure and surface tractions distributed over shell surface
4. Temperature distribution through thickness and over shell surface

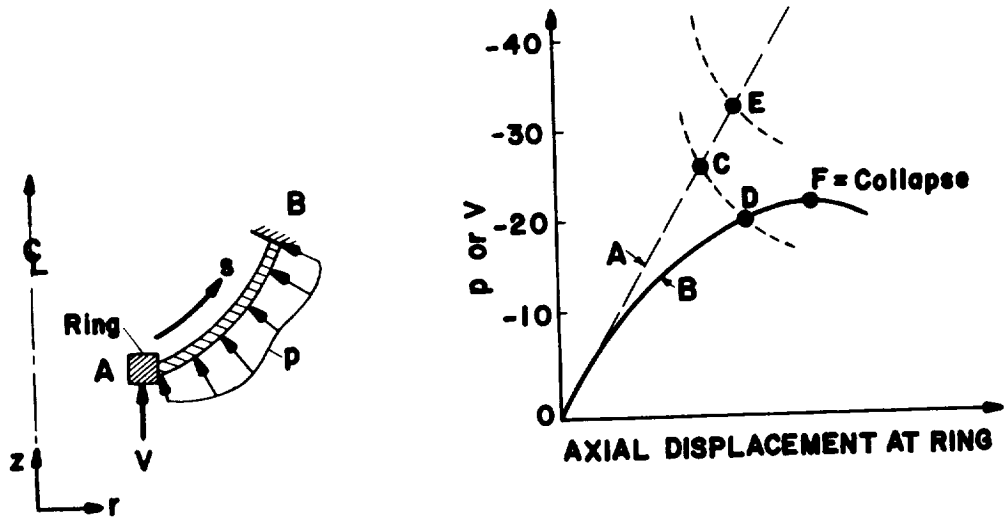
In addition, there are two cards among the first group, labeled "General Input" in Fig. 25, which control the loading under certain circumstances. These two cards contain load factors P, DP, TEMP, and DTEMP; and load range delimiters FSTART, FMAX, and DF.

In many cases a load is represented in the BØSØR4 program as a product of quantities. For example, the initial normal pressure in a nonlinear axisymmetric stress analysis (INDIC = 0) is represented as a product of a factor P and a meridional distribution PN(s). The normal pressure amplitude for each harmonic in a linear nonsymmetric stress analysis (INDIC = 3) is represented as a product of a meridional distribution PN(s) and a circumferential harmonic amplitude PDIST1(n).

Table 1.2 gives a summary of load magnitudes for the four classes of loads and the seven types of analysis (INDIC). Definitions of the variables in Table 1.2 appear on Pages B-9, B-11, B-13, and B-15. The sign convention for the loads is shown in Fig. 21 and summarized in Table 1.3. A negative normal pressure, for example, could be provided as input data for a nonlinear stress analysis (INDIC = 0) either with $P < 0.0$ and $PN(s) > 0.0$ or with $P > 0.0$ and $PN(s) < 0.0$. A similar consideration holds for the other products shown in Table 1.2.

Two types of loads are specified in Table 1.2, an initial or fixed type and an incremental or eigenvalue type. The appropriate use of these two types of loads for various kinds of analysis (INDIC) is best communicated

by an example. The sketch below shows a clamped spherical segment, subjected to a combination of axial compression V and normal pressure, p.



Also shown are typical load-deflection curves from linear (A) and nonlinear (B) theory. Suppose that it is desired to:

1. Calculate the nonlinear axisymmetric behavior (B) (INDIC = 0)
2. Calculate the bifurcation load D (INDIC = -1)
3. Calculate the bifurcation loads C and E (INDIC = 1)
4. Calculate vibration frequencies for given V_o and p_o (INDIC = 2)
5. Calculate linear-theory stress with symmetric or nonsymmetric V and p (INDIC = 3)
6. Calculate linear-theory bifurcation with symmetric or nonsymmetric V and p (INDIC = 4)
7. Calculate the stability determinant as a function of load, nonlinear theory (INDIC = -2)

Let us suppose for the moment that p is known and fixed at p_o = -10 psi (uniform) and that we wish to investigate the above behavior with V unknown. All loads are assumed to be axisymmetric in this example. The scale 0 to 40 in the above sketch refers then to V, and the characteristics of the curves A and B and location of the points C and D depend on the specified pressure p_o as well as on the geometry, boundary conditions, and material properties.

The table below shows appropriate example values of the load input data for BOSOR4 for the seven types of analysis listed above. The same data names are given in Table 1.2.

INDIC	P	DP	V(1)	DV(1)	PN(J)	PDIST1(L,1)	PLIN(L,1)	FSTART[a]	FMAX[a]	DF[a]
-2	-10.0	0.	0.	-5.0	+1.0	not applicable		0.	-40.0	-5.0
-1	-10.0	0.	-15.0	-1.0	+1.0	not applicable		not applicable		
0	-10.0	0.	0.	-5.0	+1.0	not applicable		0.	-40.0	-5.0
1	-10.0	0.	0.	-1.0	+1.0	not applicable		not applicable		
2	-10.0	0.	$V_o < F$[b]	0.	+1.0	not applicable		not applicable		
3[c]	0.	0.	V_o	0.	-10.0	+1.0	+1.0	not applicable		
4[d]	0.	0.	V_o	0.	-10.0	+1.0	+1.0	not applicable		

NOTES: [a]See page B-3 for definitions of load range delimiters FSTART, FMAX, DF.

[b]F = collapse load of spherical segment. V_o is fixed and known in this case.

[c]Both pressure and axial load are fixed and known in this case. The pressure multipliers P and DP are ignored. (See Table 1.2)

[d]Both pressure and axial load are treated as eigenvalue parameters in this case. The pressure multipliers P and DP are ignored. (See Table 1.2)

Analyses with INDIC = -1, 1, and 4 involve the calculation of bifurcation buckling eigenvalues. With INDIC = -1 both V(1) and DV(1) are changed during the case, and the buckling load $V(1)_{crit}$ is printed with the mode shape at the end of the run. With INDIC = 1 the eigenvalues are printed, and the user obtains the corresponding buckling loads $V(1)_{crit}$ from the equation:

$$V(1)_{crit.} = V(1) + (\text{eigenvalue}) * DV(1)$$

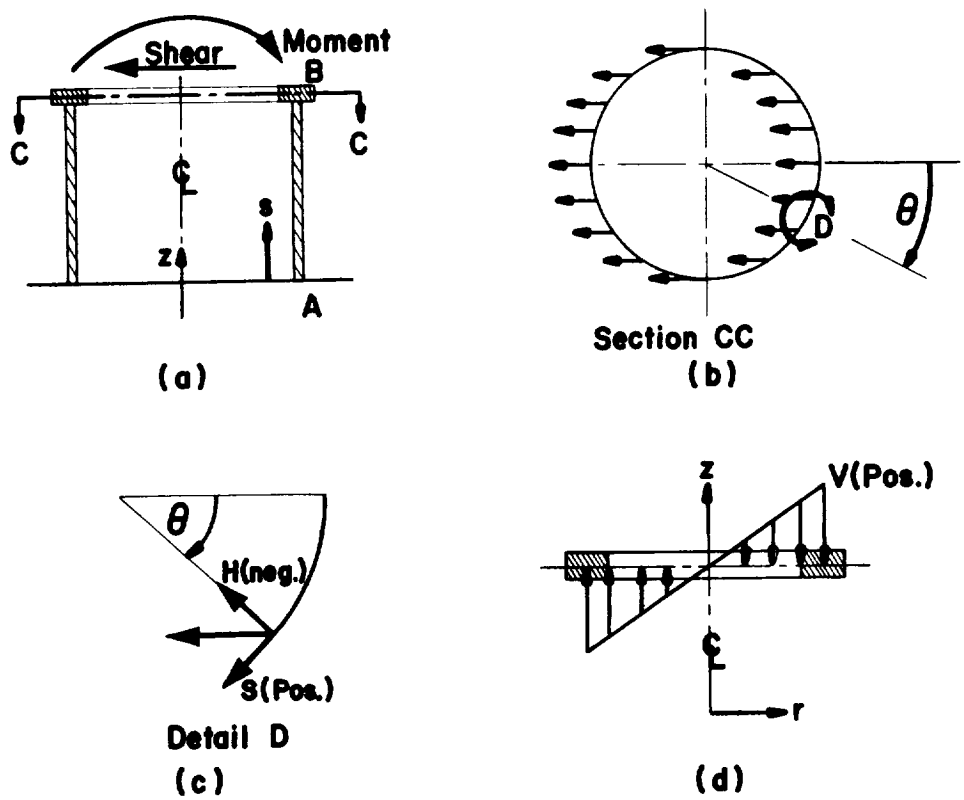
with INDIC = 4 the eigenvalues are printed, and the user obtains the corresponding buckling loads from the equation

$$V(1)_{crit.} = (\text{eigenvalue}) * V(1) * PLIN1(L,ISEG)$$

This discussion also holds for cases involving many different types and classes of loads which are applied simultaneously.

The sign convention for various loads is summarized in Table 1.3. Please bear in mind that in this manual it is always assumed that the axis of revolution is depicted vertically and that the shell meridian is drawn on the right-hand-side of the axis (see Figs. 1 and 2).

Table 1.3 also shows the circumferential harmonic variation of the various types of loads. Given a linear nonsymmetric stress analysis problem to solve, the user must know in advance the range in circumferential wave number n, whether it involves positive n, negative n, or both. A simple example is sketched below. A cylinder with an end ring is loaded by a net



shear force and moment (a). The shear force is assumed to act uniformly around the circumference as shown in (b). At every circumferential station θ, the shear force in (b) is resolved into components normal (H) and tangential (S) to the ring centroidal axis (c). The "global" moment M is modeled as an axial load which varies around the circumference as shown in (d). With the coordinate system shown it is clear that

$$V = V_o \cos\theta \ , \ S = S_o \sin\theta \ , \ H = H_o \cos\theta$$

with V_o and S_o positive and H_o negative. Referring to Table 1.3, we see that for this circumferential distribution of line loads we must use n = -1 as input to BØSØR4. (NSTART = NFIN = -1, INCR = 1 or -1, see Pages B-2 and B-3).

More on the Load Range Delimiters, FSTART, FMAX and DF

The load range delimiters FSTART, FMAX and DF, defined on Page B-3 and examples of which are given in test cases 3 and 7 and in the discussion and table on Pages 1-13 and 1-14, play the same role as PINIT, PMAX, and DPMAX, respectively, in BØSØR3 (Ref. 3). Since users of BØSØR3 have expressed confusion concerning these parameters, it is perhaps helpful to include at this point some additional description with further examples. The load range delimiters FSTART, FMAX, and DF serve only to establish the range of loading, and these quantities are not used as actual loads in the computer program. They simply "tell" the computer when to terminate the case. That is their only function in the program. Some examples follow:

Example 1: shell loaded by "fixed" pressure, "variable-in-time" axial load:

P = 10 psi DP = 0.0 V(1) = -1000 lb/in DV(1) = -200 lb/in

FSTART = -1000 FMAX = -5000 DF = -200

Example 2: shell loaded by "variable-in-time" pressure, "fixed" axial load:

P = 20 psi DP = 5 psi V(1) = -3000 lb/in DV(1) = 0.0 lb/in

FSTART = 20 FMAX = 100 DF = 5

Example 3: shell loaded by "variable-in-time" pressure and "variable-in-time" axial load:

P = 20 psi DP = 5 psi V(1) = -1000 lb/in DV(1) = -200 lb/in

FSTART = 20, FMAX = 100, DF = 5 or FSTART = -1000, FMAX = -5000, DF = -200

From the above three examples it is seen that:

1) The load range delimiters represent the range of one of the "variable-in-time" loads.

2) The load range delimiters have the same algebraic signs as the corresponding "variable-in-time" load.

3) In cases involving more than one "variable-in-time" load the load range delimiters may represent the range of any one of the "variable-in-time" loads.

Section 2

ANALYSIS ON WHICH BØSØR4 IS BASED

2.1 Introduction

The BØSØR4 program represents the codification of three distinct analyses:

1. A nonlinear stress analysis for axisymmetric behavior of axisymmetric shell systems
2. A linear stress analysis for axisymmetric and nonsymmetric behavior of axisymmetric shell systems submitted to axisymmetric and nonsymmetric loads.
3. An eigenvalue analysis in which the eigenvalues represent buckling loads or vibration frequencies of axisymmetric shell systems submitted to axisymmetric loads* (eigenvectors may correspond to axisymmetric or nonsymmetric modes)

The independent variables of the analysis are the meridional arc length, s, measured along the shell reference surface and the circumferential coordinate, θ. The dependent variables are the displacement components u, v, and w of the shell wall reference surface. The numerical analysis is based on the finite difference energy method, so that in the computer program the dependent variables are the displacement components u_i, v_i, and w_i at discrete points (mesh points) on the shell reference surface.

For the three analyses listed above it is possible to eliminate the circumferential coordinate, θ, by separation of variables: in the nonlinear stress analysis θ is not present; in the linear stress analysis the nonsymmetric load system is expressed as a sum of harmonically varying quantities, the shell response to each harmonic being calculated separately; and in the eigenvalue analysis the eigenvectors vary harmonically around the circumference. Thus, the θ-dependence (where applicable) is eliminated by the assumption that $u(s,\theta)$, $v(s,\theta)$, $w(s,\theta)$ are given by $u_n(s)\sin n\theta$, $v_n(s)\cos n\theta$, $w_n(s)\sin n\theta$ or by $u_n(s)\cos n\theta$, $v_n(s)\sin n\theta$, $w_n(s)\cos n\theta$. <u>In the following analysis the first three harmonically varying displacement components correspond to values of $n > 0$; the last three to $n \leq 0$.</u>

*Note that if INDIC = 4 the prestress state is calculated for nonsymmetric loads, but in the stability analysis a "worst" meridional distribution of prestress is assumed axisymmetric.

The advantages of being able to eliminate one of the independent variables cannot be overemphasized. The number of calculations performed by the computer for a given mesh point spacing along the arc length s is greatly reduced, leading to significant reductions in computer time. Because the numerical analysis is "one-dimensional" a rather elaborate composite shell structure, such as that represented in Fig. 1, can be analyzed in a single "pass" through the computer. The disadvantage is, of course, the restriction to axisymmetric structures.*

2.2 Energy Formulation Summary

The BOSOR4 program is based on energy minimization with constraint conditions. The total energy of the system involves:

1. Strain energy of the shell segments U_s
2. Strain energy of the discrete rings U_r
3. Potential energy of the applied line loads and pressures, U_p
4. Kinetic energy of the shell segments T_s
5. Kinetic energy of the discrete rings T_r

The constraint conditions U_c arise from

1. Displacement conditions imposed anywhere in the composite shell
2. Compatibility conditions between segments and branches of the composite shell

These components of energy and the constraint conditions are initially integro-differential forms. They are then written in terms of the shell reference surface displacement components u_i, v_i, and w_i at the finite-difference mesh points and Lagrange multipliers, λ_i. The integration is performed numerically by the trapezoidal rule. Now an algebraic form, the energy is minimized with respect to the discrete dependent variables.

In the nonlinear stress analysis the energy expression has terms linear, quadratic, cubic, and quartic in the dependent variables. The cubic and quartic terms arise from the "rotation-squared" terms which appear in the

*The reader is referred to Ref. 12 for description of a method through which BOSOR4 can be used to analyze nonsymmetric structures of a prismatic form.

constraint conditions and in the kinematic expressions for reference surface strains ϵ_1, ϵ_2, and ϵ_{12}. Nonlinear material properties (plasticity) are not included in the analysis. Energy minimization leads to a set of nonlinear algebraic equations which are solved by the Newton-Raphson method. Stress and moment resultants are calculated in a straight forward manner from the mesh point displacement components through the constitutive equations (stress-strain law) and kinematic (strain-displacement) relations.

The results from the nonlinear axisymmetric stress analysis are used in the eigenvalue analyses for buckling and vibration. The "prebuckling" or "prestress" meridional and circumferential stress resultants N_{10} and N_{20} and the meridional rotation χ_o appear as known variable coefficients in the energy expression which governs buckling and vibration. This expression is a homogeneous quadratic form. The values of a parameter (load or frequency) which render the quadratic form stationary with respect to infinitesimal variations of the dependent variables represent buckling loads or natural frequencies. These "eigenvalues" are calculated from a set of linear, homogeneous equations.

The same linear "stability" equations, with a "right-hand-side" vector added, are used for the linear stress analysis of axisymmetrically and nonsymmetrically loaded shells. The "right-hand-side" vector represents load terms and terms due to thermal stress. The variable coefficients, N_{10}, N_{20}, and χ_o, mentioned above are zero of course since there is no nonlinear "prestress" analysis.

2.3 General Theory for Nonsymmetric Displacements

The total potential energy consists of (1) shell strain energy, (2) ring strain energy, and (3) potential energy of applied loads. The constraint conditions are written in terms of Lagrange multipliers and displacements of points on the "plus" and "minus" sides of the junctures or boundaries. These energy components and constraint conditions appear as Eqs. (9), (15), (18), (19), and (24) and (25) in Ref. 13. Equation (19) is incomplete, as it does not include "pressure-rotation" effects. The following analysis is based on these equations.

The various components of energy follow:

1) Shell Strain Energy

$$U_s = \frac{1}{2} \int_s \int_\theta \left[\lfloor \epsilon \rfloor \, [C] \, \{\epsilon\} + 2 \lfloor N^T \rfloor \, \{\epsilon\} \right] r \, d\theta \, ds \tag{1}$$

2) Ring Strain Energy

$$U_r = \frac{r_c}{2} \int \left\{ \epsilon_r^{\,2} \, EA + \kappa_x^{\,2} \, EI_y + \kappa_y^{\,2} \, EI_x - 2 \, \kappa_x \kappa_y \, EI_{xy} \right.$$

$$\left. + \frac{GJ}{r_c^2} \left(\dot{\chi} + \dot{u}_c / r_c \right)^2 + 2 \left[\epsilon_r N_r^T - \kappa_x M_y^T + \kappa_y M_x^T \right] \right\} d\theta \tag{2}$$

3) Potential Energy of Mechanical Loads

$$U_{p1} = - \int_\theta \left(-V u_c + S v_c + H w_c + M \chi \right) r_c \, d\theta$$

$$U_{p2} = - \int_s \int_\theta \left[\left(p_1 u + p_2 v + p_3 w \right) - \frac{1}{2} p_3 \left(\frac{1}{R_1} + \frac{1}{R_2} \right) w^2 \right.$$

$$\left. + \frac{1}{2} p_3 \left(\frac{u^2}{R_1} + \frac{v^2}{R_2} \right) + u \, w \, p_3' \right] r \, d\theta \, ds \tag{3}$$

4) Constraint Conditions

$$U_c = \lfloor K \lambda \rfloor \left\{ \vec{d}^{\,*+} - \vec{d}^{\,*-} - \Delta \vec{d} \right\} \tag{4}$$

Note that Eq. (3) has terms quadratic in the displacement. These are the "pressure-rotation" terms taken from Reference 14 and omitted in Eq. (19) of Reference 13. Also note that Eq. (4) contains $\lfloor K\lambda \rfloor$, implying input constants K which are applicable to juncture conditions as well as to boundary conditions. The kinetic energy is not written here. It is given in Ref. 15 as Eqs. (28) - (32).

2.4 Nonlinear Axisymmetric Prestress Analysis

Equation (36) of Reference 16 governs the nonlinear prebuckling analysis. This equation must be solved for each Newton-Raphson iteration. In the following pages, this equation will be developed, and variables in the BØSØR4 computer program will be identified along with the analytical development.

The equilibrium equation to be solved at each Newton-Raphson iteration is

$$\sum_{j=1}^{M2} \frac{\partial \psi_i}{\partial q_j} \Delta q_j = - \psi_i \tag{5}$$

in which M2 is the system rank, $\psi_i = \partial U/\partial q_i$, q_i represents the ith dependent variable (either u or w or a Lagrange multiplier), and Δq_j represents the jth correction addend for the current Newton-Raphson iteration. The following sections will establish ψ_i and $\partial \psi_i/\partial q_j$ for the shell, discrete rings, applied loads, and constraint conditions.

2.4.1 Shell Strain Energy

From Eq. (1) is follows that

$$\frac{\partial U_s}{\partial q_i} = \psi_i = 2\pi \sum_{JSEG=1}^{NSEG} \sum_{k=1}^{I5(JSEG)} r_k \Delta s_k \left(\lfloor \epsilon \rfloor [C] + \lfloor N^T \rfloor \right) \frac{\partial \{\epsilon\}}{\partial q_i} \tag{6}$$

where integration over θ has been performed and integration over s is replaced by a weighted summation. NSEG is the number of shell segments and I5(JSEG) is the number of mesh points in segment no. JSEG. Δs_k is the length of the kth finite difference "element", in other words the integration weight

The vector $\lfloor \epsilon \rfloor$ is given by

$$\lfloor \epsilon \rfloor = \lfloor \epsilon_1, \epsilon_2, \kappa_1, \kappa_2 \rfloor \tag{7}$$

in which

$$\begin{Bmatrix} \epsilon_1 \\ \epsilon_2 \\ \varkappa_1 \\ \varkappa_2 \end{Bmatrix} = [B] \begin{Bmatrix} q_{i-2} \\ q_{i-1} \\ q_i \\ q_{i+1} \\ q_{i+2} \end{Bmatrix} + \begin{Bmatrix} \frac{1}{2} x^2 \\ 0 \\ 0 \\ 0 \end{Bmatrix} \tag{8}$$

The array [B] is calculated in subroutine PGETB, which is called from PRESTS. These subroutines apply to the finite difference energy method with variable mesh point spacing. The appropriate formulas for w and its derivatives are:

$$\begin{aligned}
w &= c_1 \; w_{i-1} + c_2 \, w_i + c_3 \, w_{i+1} \\
w' &= -w_{i-1}/2h + w_i(1/2h - 1/2k) + w_{i+1}/2k \\
w'' &= 2\left(w_{i-1}/[h(h+k)] - w_i/hk + w_{i+1}/[k(h+k)]\right) \\
c_1 &= (h-k)(3k+h)/[16(h^2+hk)] \\
c_2 &= (h+3k)(3h+k)/(16hk) \\
c_3 &= (k-h)(3h+k)/[16(k^2+hk)]
\end{aligned} \tag{9}$$

The mesh spacing scheme is shown in Fig. 3, which also applies to non-symmetric analyses. The energy is evaluated at the station marked "E", which is at the centroid of the finite difference "element". Appropriate finite difference expressions such as given by Eq. (9) are found by expansion of the displacements in Taylor series about the point "E" and expression of

these displacements in terms of the nodal quantities w_{i-1}, u_i, v_i, w_i, u_{i+1}, v_{i+1}, w_{i+1}. As is pointed out in Ref. 17 this procedure is equivalent to the finite element method in which a constant strain, incompatible element is being used. (For a deeper understanding of the finite difference energy method the reader is referred to Ref. 17.)

The thermal load vector $\lfloor N^T \rfloor$ is given by

$$\lfloor N^T \rfloor = \lfloor N_1^T , N_2^T , M_1^T , M_2^T \rfloor \tag{10}$$

which are defined in Eq. (6) of Reference 13.

The contribution of the shell strain energy to the left-hand side of Eq. (5) follows:

$$\frac{\partial \psi_i}{\partial q_j} = 2\pi \sum_{JSEG=1}^{NSEG} \sum_{k=1}^{I5(JSEG)} r_k \, \Delta s_k \left[\left(\lfloor \epsilon \rfloor [C] + \lfloor N^T \rfloor \right) \frac{\partial^2 \{\epsilon\}}{\partial q_i \partial q_j} + \frac{\partial \lfloor \epsilon \rfloor}{\partial q_j} [C] \frac{\partial \{\epsilon\}}{\partial q_i} \right] \tag{11}$$

If Eq. (8) is incorporated into Eqs (6) and (11), the following equations result:

$$\overbrace{\psi_i}^{PSI(I)} = 2\pi \sum_{JSEG=1}^{NSEG} \sum_{k=1}^{I5(JSEG)} \overbrace{r_k \, \Delta s_k}^{RDS} \Bigg[\lfloor q \rfloor \overbrace{[B]^T [C]}^{QBCB(I)} \{B_i\} + \overbrace{\lfloor N^T \rfloor \{B_i\}}^{TNB(I)} + \frac{1}{2} \chi^2 \overbrace{\lfloor C_1 \rfloor \{B_i\}}^{CB(1,I)} + \underbrace{\left(\overbrace{\lfloor q \rfloor [B]^T \{C_1\}}^{QBC1} \overbrace{\chi}^{CHI} + \frac{1}{2} \chi^3 C_{11} + N_1^T \chi \right)}_{F1} \overbrace{\frac{\partial \chi}{\partial q_i}}^{R\emptyset T(I)} \Bigg] \tag{12}$$

$$\overbrace{\frac{\partial \psi_i}{\partial q_j}}^{BCB(I,J)} = 2\pi \sum_{JSEG=1}^{NSEG} \sum_{k=1}^{I5(JSEG)} r_k \, \Delta s_k \left[\overbrace{\{B_j\}^T [C] \{B_i\}}^{B*CB} + \right.$$

$$\overbrace{\left(\lfloor q \rfloor [B]^T \{C_1\} + \frac{3}{2} \chi^2 C_{11} + N_1^T \right)}^{F2} \overbrace{\frac{\partial \chi}{\partial q_i} \frac{\partial \chi}{\partial q_j}}^{R\emptyset T(I)*R\emptyset T(J)} +$$

$$\left. \underbrace{\chi}_{CHI} \underbrace{\left([C_1] \{B_i\} \frac{\partial \chi}{\partial q_j} + \{B_j\}^T \{C_1\} \frac{\partial \chi}{\partial q_i} \right)}_{CB(1,I)*R\emptyset T(J) = CB(1,J)*R\emptyset T(I)} \right] \tag{13}$$

In Eqs. (12) and (13)

$$\lfloor q \rfloor = \underbrace{\lfloor q_{i-2}, q_{i-1}, q_i, q_{i+1}, q_{i+2} \rfloor}_{\lfloor F(I2M), F(I1M), F(I0), F(I1P), F(I2P) \rfloor} \tag{14}$$

[C] is the local 4x4 matrix of constitutive equation coefficients corresponding to:

$$\begin{Bmatrix} N_1 \\ N_2 \\ M_1 \\ M_2 \end{Bmatrix} = [C] \begin{Bmatrix} \epsilon_1 \\ \epsilon_2 \\ \kappa_1 \\ \kappa_2 \end{Bmatrix} \tag{15}$$

This local matrix corresponding to local mesh point IPØINT is set up in subroutine PGETC. $\{B_i\}$ signifies the ith column of the matrix [B]; $\{C_1\}$ is the first column of [C]; and the rotation χ is given by

$$\chi \equiv w' - u/R_1 = [R\emptyset T]\{q\} \tag{16}$$

in which

$$\begin{aligned}[R\emptyset T] &= \lfloor R\emptyset T(1)\ ,\ R\emptyset T(2)\ ,\ R\emptyset T(3)\ ,\ R\emptyset T(4)\ ,\ R\emptyset T(5)\rfloor \\ &= \lfloor WBD(1)\ ,\ -.5/R_1\ ,\ WBD(3)\ ,\ -.5/R_1,\ WBD(5)\rfloor\end{aligned} \tag{17}$$

corresponding to variable station spacing. The quantities WBD(1), WBD(3), and WBD(5) correspond respectively to the coefficients of w_{i-1}, w_i, and w_{i+1} in the second of Eqs. (9). In Eqs. (12) - (17) program variables are identified. Additional variables are:

$$\begin{aligned} r &= R \qquad & 1/R_1 &= FK1 \\ r' &= RD \qquad & 1/R_2 &= FK2 \end{aligned} \qquad (1/R_1)' = CURD \tag{18}$$

The indices I2M, I1M, I0, I1P, and I2P identify the global row numbers corresponding respectively to I = 1, 2, 3, 4, and 5 in the local stiffness matrix BCB(I,J) and right-hand side, PSI(I). These global row numbers are established through use of array IW(II). Array IW(II) is set up in subroutine SKILIN, which is called from subroutine READIT. IW(II) contains the global row number of the IIth w-mesh point, in which II is

$$II = \left\{ \sum_{I=1}^{JSEG-1} [I5(I) + 2] \right\} + 1 + IP\emptyset INT \tag{19}$$

The program variables TN1, TN2, TN3, and TN4 correspond to the thermal loads given in Eq. (10). P1, P3, and PPRIME correspond respectively to the meridional traction, normal pressure, and meridional derivative of normal pressure dp/ds. The program data IW(II), THERM(I,J), C(I,K), BG(I,L), and PR(I,M) are stored on drum or disk. Arrays WB(I) and UB(I) represent coefficients in the equations

$$w = \lfloor WB \rfloor \{q\} \qquad u = \lfloor UB \rfloor \{q\} \tag{20}$$

The local stiffness matrix BCB(I,J) and right-hand side PSI(I) for the current Newton-Raphson iteration are calculated in subroutine PRESTS, which is called from APREB, which in turn is called from PRE.

2.4.2 Potential Energy of Distributed Loads

In PRESTS, the last two terms in the expression for PSI(I) and the last two lines of the expression for BCB(I,J) contain the contributions to the total energy of the meridional surface traction p_1 and normal pressure p_3. These terms arise from differentiation of Eq. (3b) with respect to q_i and q_j. With $v = 0$ the following expressions result:

$$dU_{p2}\Big/dq_i = -2\pi \sum_{JSEG=1}^{NSEG} \sum_{k=1}^{I5(JSEG)} r_k \, \Delta s_k \left[\overbrace{\left(p_1 + p_3' \, w + p_3 \, u/R_1 \right)}^{F3} \overbrace{\frac{\partial u}{\partial q_i}}^{UB(I)} \right.$$

$$\left. + \overbrace{\left(p_3 + p_3' \, u - p_3 \left[\frac{1}{R_1} + \frac{1}{R_2} \right] w \right)}^{F4} \overbrace{\frac{\partial w}{\partial q_i}}^{WB(I)} \right] \tag{21}$$

$$\frac{\partial^2 U_{p2}}{\partial q_i \, \partial q_j} = -2\pi \sum_{JSEG=1}^{NSEG} \sum_{k=1}^{I5(JSEG)} r_k \, \Delta s_k \left[p_3' \left(\frac{\partial u}{\partial q_j} \frac{\partial w}{\partial q_i} + \frac{\partial w}{\partial q_j} \frac{\partial u}{\partial q_i} \right) \right.$$

$$\left. + p_3 \left(\frac{1}{R_1} \frac{\partial u}{\partial q_i} \frac{\partial u}{\partial q_j} - \left(\frac{1}{R_1} + \frac{1}{R_2} \right) \frac{\partial w}{\partial q_i} \frac{\partial w}{\partial q_j} \right) \right] \tag{22}$$

2.4.3 Discrete Ring Strain Energy and Potential Energy of Line Loads

Discrete rings and/or line loads are located at certain mesh point stations along the shell meridian. These stations are identified by the array IRING(JSEG,IK). Thus, IRING(3,2) = 27 signifies that the second discrete ring and/or line load in the third segment are located at the 27th point at which the shell energy is evaluated in that segment.

The ring strain energy is given by Eq. (2). For axisymmetric displacements

$$\epsilon_r = w_c/r_c \qquad \kappa_x = 0 \qquad \kappa_y = \chi/r_c \tag{23}$$

in which w_c is the radial displacement of the ring centroid and r_c is the radius of the ring measured to the centroid. With Eqs. (23) inserted into Eq. (2), the ring strain energy becomes

$$U_r = 2\pi \left[\frac{1}{2} \frac{EA}{r_c} w_c^2 + \frac{1}{2} \frac{EI_x}{r_c} \chi^2 + N_r^T w_c + M_x^T \chi \right] \tag{24}$$

For axisymmetric line loads, the potential energy is

$$U_{pl} = -2\pi r_c \left[-V u_c + H w_c + M \chi \right] \tag{25}$$

The line loads are assumed to be applied along the centroidal axis of the ring. The axial and radial centroidal displacements u_c and w_c can be written in terms of the shell wall reference surface meridional and normal displacements u and w corresponding to the attachment point of the ring

$$\begin{aligned} u_c &= ur/R_2 - wr' - e_1 \chi - e_2 \chi^2/2 \\ w_c &= ur' + wr/R_2 + e_2 \chi - e_1 \chi^2/2 \end{aligned} \tag{26}$$

The first and second derivatives of the ring strain energy plus the line-load potential energy are

$$\frac{d(U_r + U_{pl})}{\partial q_i} = 2\pi \left[\overbrace{\left(\frac{EA}{r_c} w_c + N_r^T - r_c H \right)}^{FR1} \overbrace{\frac{\partial w_c}{\partial q_i}}^{WCD} + \overbrace{r_c V}^{FR2} \overbrace{\frac{\partial u_c}{\partial q_i}}^{UCD} \right.$$

$$\left. + \overbrace{\left(\frac{EI_x}{r_c} \chi + M_x^T - r_c M \right)}^{FR3} \overbrace{\frac{\partial \chi}{\partial q_i}}^{R\emptyset T(I)} \right] \tag{27}$$

$$\frac{\partial^2 (U_r + U_{pl})}{\partial q_i \, \partial q_j} = 2\pi \left[\overbrace{\left(\frac{EA}{r_c} w_c + N_r^T - r_c H \right)}^{FR1} \frac{\partial^2 w_c}{\partial q_i \partial q_j} + \frac{EA}{r_c} \frac{\partial w_c}{\partial q_i} \frac{\partial w_c}{\partial q_j} \right.$$

$$\left. + \overbrace{r_c V}^{FR2} \frac{\partial^2 u_c}{\partial q_i \partial q_j} + \frac{EI_x}{r_c} \frac{\partial \chi}{\partial q_i} \frac{\partial \chi}{\partial q_j} \right] \tag{28}$$

in which

$$\overbrace{\frac{\partial u_c}{\partial q_i}}^{UCD} = \frac{\partial u}{\partial q_i}(r/R_2) - \frac{\partial w}{\partial q_i} r' - (e_1 + e_2 \chi) \frac{\partial \chi}{\partial q_i}$$

$$\underbrace{\frac{\partial w_c}{\partial q_i}}_{WCD} = \frac{\partial u}{\partial q_i} r' + \frac{\partial w}{\partial q_i}(r/R_2) + \overbrace{(e_2 - e_1 \chi)}^{FR4} \frac{\partial \chi}{\partial q_i} \tag{29}$$

$$\frac{\partial^2 u_c}{\partial q_i \partial q_j} = - e_2 \frac{\partial \chi}{\partial q_i} \frac{\partial \chi}{\partial q_j}$$

$$\frac{\partial^2 w_c}{\partial q_i \partial q_j} = - e_1 \frac{\partial \chi}{\partial q_i} \frac{\partial \chi}{\partial q_j}$$

Collection of terms in Eq. (28) through use of Eq. (29) leads to:

$$\frac{\partial^2 (U_r + U_{pl})}{\partial q_i \partial q_j} = 2\pi \left[\overbrace{\left[-e_1 \left(\frac{EA}{r_c} w_c + N_r^T - r_c H \right) - e_2 r_c V + \frac{EI_x}{r_c} \right]}^{FR5} \frac{\partial \chi}{\partial q_i} \frac{\partial \chi}{\partial q_j} + \frac{EA}{r_c} \frac{\partial w_c}{\partial q_i} \frac{\partial w_c}{\partial q_j} \right] \tag{30}$$

2.4.4 Constraint Conditions

The constraint conditions are given by Eq. (4). For axisymmetric displacements, each juncture condition and boundary condition takes the form:

$$U_c = K_1\lambda_1(u^{*+} - u^{*-} - \Delta u^*) + K_3\lambda_2(w^{*+} - w^{*-} - \Delta w^*) + K_4\lambda_3(\chi^+ - \chi^-) \tag{31}$$

in which

$$\begin{aligned} u^* &= ur/R_2 - r'w \\ w^* &= ur' + wr/R_2 \\ \Delta u^* &= -[d_1\chi^- + d_2(\chi)^2/2] \\ \Delta w^* &= +[d_2\chi^- - d_1(\chi)^2/2] \end{aligned} \tag{32}$$

Superscripts "plus" and "minus" refer to plus and minus sides of the juncture conditions (see Fig. 20). In the case of displacement boundary conditions, the "plus" variables are simply omitted from Eq. (31). The K_1, K_3, K_4 are input integers governing whether or not juncture compatibility conditions are to be enforced.

Figures 4 through 6 show various types of juncture conditions which have various effects on the configuration of the stiffness matrix for each Newton-Raphson iteration. The shaded areas correspond to elements in the matrix affected by the juncture or boundary conditions. "Minus" elements are denoted QD and "plus" elements are denoted D. The dark line in each figure represents the "skyline" of the matrix. There are essentially five kinds of constraint conditions:

1. Simple "one-sided" constraint conditions not at end IPØINT=I5(JSEG) of Jth segment.
2. Boundary conditions at end IPØINT=I5(JSEG) of Jth segment.
3. Segment end connected to non-adjacent previous point.
4. Juncture condition not at end IPØINT=I5(JSEG) of Jth segment.
5. Beginning of (J+1)st segment attached to end of Jth segment.

All five types of constraint conditions are shown in Figures 4(a), 5(a), and 6(a) and identified in Figures 4(b), 5(b), and 6(b). Constraint condition types 1 and 3 are shown in Figure 4. In Figure 4(b) the shaded areas labeled QD_1 and QD_1^T represent the boundary conditions [Eq. (31) without u^{*+}, w^{*+}, and χ^+]. The shaded areas QD_2 and QD_2^T represent the "minus" parts of the juncture condition between mesh points #4 and #10. The shaded areas D_2 and D_2^T represent the "plus" parts of the juncture condition. Figure 5 shows constraint condition types 5 and 4. Again the shaded QD's and the D's represent respectively the "minus" and "plus" parts of the constraint conditions. Constraint condition types 2 and 4 are shown in Figure 6.

The contribution of the constraint condition "energy" to the shaded areas in Figures 4(b), 5(b), and 6(b) will now be derived. In subroutine PRESTS the "minus" contributions QD are computed first. The vector IFX(ICØND1,1) contains the segment numbers and local mesh point numbers of the "minus" sides of the constraint conditions in monotonically increasing order. If IPØINT=IFX(ICØND1,1), the flow of calculations enters the branch of PRESTS in which QD is filled and constraint condition contributions to the local matrix BCB(I,J) are calculated. The global matrix row numbers corresponding to λ_1, λ_2, and λ_3 are indicated in PRESTS by IR, IR1, and IR2, respectively.

From Eq. (31), it is seen that

$$\frac{\partial U_c}{\partial q_i} = \overbrace{\lambda_1 U_{,i} + \lambda_2 W_{,i} + \lambda_3 X_{,i}}^{\text{PSI(I)}} + \underbrace{\delta_i^{\lambda_1} U}_{\text{FNEW(IR)}} + \underbrace{\delta_i^{\lambda_2} W}_{\text{FNEW(IR1)}} + \underbrace{\delta_i^{\lambda_3} X}_{\text{FNEW(IR2)}} \tag{33}$$

in which

$$U_{,i} \equiv K_1 \left[\underbrace{\frac{\partial u^{*+}}{\partial q_i}}_{D(1,I)} - \underbrace{\overbrace{\frac{\partial u^{*-}}{\partial q_i}}^{USTAR} + \overbrace{(d_1 + d_2 \chi^-)}^{FC3} \overbrace{\frac{\partial \chi^-}{\partial q_i}}^{R\emptyset T(I)}}_{QD(1,I)} \right]$$

$$W_{,i} \equiv K_3 \left[\underbrace{\frac{\partial w^{*+}}{\partial q_i}}_{D(2,I)} - \underbrace{\overbrace{\frac{\partial w^{*-}}{\partial q_i}}^{WSTAR} - \overbrace{(d_2 - \chi^- d_1)}^{FC1} \frac{\partial \chi^-}{\partial q_i}}_{QD(2,I)} \right]$$

$$X_{,i} \equiv K_4 \left[\underbrace{\frac{\partial \chi^+}{\partial q_i}}_{D(3,I)} - \underbrace{\frac{\partial \chi^-}{\partial q_i}}_{QD(3,I)} \right] \tag{34}$$

$$U \equiv K_1 \left(u^{*+} - u^{*-} - \Delta u^*\right) \qquad W \equiv K_3 \left(w^{*+} - w^{*-} - \Delta w^*\right)$$

$$X \equiv K_4 \left(\chi^+ - \chi^-\right)$$

$$\delta_i^{\lambda_1} = \begin{cases} 1 & \text{if } i = IR \\ 0 & \text{otherwise} \end{cases} \qquad \delta_i^{\lambda_2} = \begin{cases} 1 & \text{if } i = IR1 \\ 0 & \text{otherwise} \end{cases}$$

$$\delta_i^{\lambda_3} = \begin{cases} 1 & \text{if } i = IR2 \\ 0 & \text{otherwise} \end{cases}$$

Contributions from the "minus" part of the constraint conditions to the real global right-hand side vector are stored in FNEW(IR), etc. Contributions to the "local" right-hand side vector are stored in PSI(I). The Lagrange multipliers λ_1, λ_2, and λ_3 for the current Newton-Raphson iteration are stored in F(IR), F(IR1), and F(IR2). K_1, K_3, and K_4 are identified in PRESTS as FIFX1, FIFX3, and FIFX4, respectively.

The second derivative of U_c with respect to the dependent variables q_i and q_j is given by

$$\frac{\partial^2 U_c}{\partial q_i \partial q_j} = (K_1 \lambda_1 d_2 + K_3 \lambda_2 d_1) \frac{\partial X^-}{\partial q_i} \frac{\partial X^-}{\partial q_j}$$

$$+ \delta_i^{\lambda_1} U_{,j} + \delta_j^{\lambda_1} U_{,i} + \lambda_i^{\lambda_2} W_{,j} + \delta_j^{\lambda_2} W_{,i} \qquad (35)$$

$$+ \delta_i^{\lambda_3} X_{ij} + \delta_j^{\lambda_3} X_{,i}$$

If $j \le i$ the terms with $\delta_j^{\lambda_k}$, $k = 1, 2, 3$ contribute elements to QD and D, and the terms with $\delta_i^{\lambda_k}$ contribute elements to QD^T and D^T in Figures 4 to 6. In the program PRESTS only the terms with $j \le i$ are computed, since the stiffness matrix is symmetric.

Figures 7 through 16 show additional global stiffness matrix configurations corresponding to the branched configurations drawn on each figure. Mesh points are indicated by dots and numbered according to the directions of the arrows. "Minus" parts of constraint conditions are indicated by arrays of Q's; "plus" parts by D's. Additional non-zero elements are indicated by X's.

The array QD(I,J) containing the "minus" part of the constraint condition must be stored in the global stiffness matrix. This matrix is divided into blocks, the sizes of which are limited by an input parameter IMAX, and the numbers of rows of which are established in subroutine GETBLK. The array ILØC contains the position of the main diagonal element relative to the beginning of the block, and the array NGBKP gives the global row numbers of the

last equation in each block. In subroutine PRESTS, III is the current block number, IV is the number of QD array which has been saved because it belongs to a future block, IC is the number of equations per constraint condition, (IC=3 for prebuckling analysis), and N is the dimension of the local stiffness array BCB(N,N). The global stiffness matrix is stored in array BB.

The logic associated with the "plus" side of the constraint conditions is similar to that for the "minus" side. The contribution from the "plus" side is stored in D(I,J), as shown in Eqs. (34), and this branch of PRESTS is entered if IPØINT equals the segment and local mesh point corresponding to the "plus" side of the constraint.

The current block III is stored on drum or disk for subsequent processing by subroutines FACTOR and SOLVE. Figure 17 shows a flow chart of PRESTS.

2.5 Stability, Vibration, and Nonsymmetric Stress Analysis

These three categories have several common characteristics: They represent two-dimensional problems in that the restriction to axisymmetric displacements is no longer imposed. They are based on linear theory (although the axisymmetric prestress analysis in stability and vibration problems may be nonlinear). They all make use of essentially the same stiffness matrix.

By stability analysis we mean bifurcation buckling, not nonlinear collapse. By vibration analysis we mean determination of natural modes and frequencies. Hence, both of these analyses are eigenvalue problems.

2.5.1 Formulation of the Stability Problem: Introduction

The bifurcation buckling problem represents perhaps the most difficult of the three types of analyses with which we are concerned. It is practical to consider bifurcation buckling of complex, ring-stiffened shell structures under various systems of loads, some of which are considered to be known and constant, or "fixed" and some of which are considered to be unknown eigenvalue parameters, or "variable".

The notion of "fixed" and "variable" systems of loads not only permits analysis of structures submitted to nonproportionally time-varying loads,

but also helps in the formulation of a sequence of simple of "classical" eigenvalue problems for the solution of problems governed by "nonclassical" eigenvalue problems. An example is a shallow spherical cap under external pressure. Very shallow caps fail by nonlinear collapse, or snap-through buckling, not by bifurcation buckling. Deep spherical caps fail by bifurcation buckling in which nonlinear prebuckling effects are not important. There is a range of cap geometries that buckle by bifurcation buckling in which the critical pressures are affected by nonlinear prebuckling behavior. The analysis of this intermediate class of spherical caps is simplified by the concept of "fixed" and "variable" pressure.

Figure 18 shows the load-deflection curve of a shallow cap in this intermediate range. Nonlinear axisymmetric collapse ($p_{n\ell}$), linear bifurcation ($p_{\ell b}$) and nonlinear bifurcation (p_{nb}) loads are shown. The purpose of the analysis to which we are referring in this section is to determine the pressure p_{nb}. It is useful to consider the pressure p_{nb} as composed of two parts

$$p_{nb} = p^f + p^v \tag{36}$$

in which p^f denotes a known or "fixed" quantity and p^v denotes an undetermined or "variable" quantity. The fixed portion p^f is an initial guess or represents the results of a previous iteration. The variable portion p^v is the remainder, which can be determined from a reasonably simple eigenvalue problem, as will be described. It is clear from Fig. 18 that if p^f is fairly close to p_{nb} the behavior in the range $p = p^f \pm p^v$ is reasonably linear. Thus, the eigenvalue p_{nb} can be calculated by means of a sequence of linear eigenvalue problems through which ever and ever smaller values p^v are determined and added to the known results p^f from the previous iterations. As the BØSØR4 computer program is written the initial guess p^f need not be close to the solution p_{nb}.

In the bifurcation stability analysis it is necessary to develop three matrices corresponding to the eigenvalue problem

$$K_1 x + \lambda K_2 x + \lambda^2 K_3 x = 0 \tag{37}$$

The matrix K_1 is the stiffness matrix and contains "fixed" load effects; the matrix K_2 is commonly called the "load-geometric" matrix and contains

linear terms involving the "variable" loads; and the matrix K_3, another "variable"-load quantity, is called the λ^2-matrix, for obvious reasons. These matrices all contain known numbers and are all banded. They all have forms similar to those shown in Figs. 4-16. They will be derived in the following three sections, which will be concerned, respectively, with the shell strain energy and pressure-rotation effect, the ring strain energy and radial-line-load-rotation effect, and the constraint conditions.

2.5.2 Shell Strain Energy and Pressure-Rotation Effect

The shell strain energy and pressure-rotation effect combine Eq. (1) and the terms in Eq. (3) quadratic in displacement components u, v, w. This energy, denoted U_s, can be written in the form:

$$U_s = \frac{1}{2}\int_s\int_\theta \left[\lfloor\epsilon\rfloor[C]\{\epsilon\} + 2\lfloor N^T\rfloor\{\epsilon\} + \lfloor d\rfloor[P]\{d\}\right] r\,d\theta\,ds \tag{38}$$

The strain vector is given by

$$\{\epsilon\} = \begin{Bmatrix} \epsilon_1 \\ \epsilon_2 \\ \epsilon_{12} \\ \varkappa_1 \\ \varkappa_2 \\ 2\varkappa_{12} \end{Bmatrix} = \begin{Bmatrix} u' + w/R_1 + \frac{1}{2}(\chi^2 + \gamma^2) \\ \dot{v}/r + ur'/r + w/R_2 + \frac{1}{2}(\psi^2 + \gamma^2) \\ \dot{u}/r + r(v/r)' + \chi\psi \\ \chi' \\ \dot{\psi}/r + r'\chi/r \\ 2\left(-\dot{\chi}/r + r'\psi/r + v'/R_2\right) \end{Bmatrix} \tag{39}$$

in which

$$\begin{aligned} \chi &= w' - u/R_1 \\ \psi &= \dot{w}/r - v/R_2 \\ \gamma &= \frac{1}{2}(\dot{u}/r - v' - r'v/r) \end{aligned} \tag{40}$$

In Eq. (38) [C] is the 6x6 matrix of constitutive equation coefficients given in Eq. (5) of Ref. 13; $\lfloor N^T\rfloor$ is the six-component vector of thermal

loads given in Eqs. (1) and (6) of Ref. 13; and [d] and [P] are given by

$$\lfloor d \rfloor = \lfloor u, v, w \rfloor \tag{41}$$

$$[P] = \begin{bmatrix} -p/R_1 & 0 & -p' \\ 0 & -p/R_2 & 0 \\ -p' & 0 & p(1/R_1 + 1/R_2) \end{bmatrix} \tag{42}$$

These expressions are referred to the undeformed surface of the shell. We wish now to expand the energy in a Taylor series about some equilibrium point, u_o, v_o, w_o : We assume that

$$(u, v, w) = u_o^f + u_o^v + \delta u \quad , \quad v_o^f + v_o^v + \delta v \quad , \quad w_o^f + w_o^v + \delta w \tag{43}$$

in which $(\ )^f$ means "fixed" and $(\ )^v$ means "variable" and δu, δv, δw are infinitesimal variations from the equilibrium state given by $u_o^f + u_o^v$, $v_o^f + v_o^v$, $w_o^f + w_o^v$.

The energy U_s is given by

$$U_s = U_o + \delta U + \frac{1}{2}\delta^2 U + \ldots \tag{44}$$

in which δU contains all first order terms in the variations and $\delta^2 U$ contains the second-order terms. Because the system is in equilibrium the first variation δU is zero, and we are concerned only with the second variation $\delta^2 U$:

$$\delta^2 U = \int_s \int_\theta \Big[\lfloor \epsilon^1 \rfloor [C] \{\epsilon^1\} + \lfloor \epsilon^2 \rfloor [C] \{\epsilon^0\} + \lfloor \epsilon^0 \rfloor [C] \{\epsilon^2\} + 2 \lfloor N^T \rfloor \{\epsilon^2\} + \lfloor \delta u, \delta v, \delta w \rfloor [P] \begin{Bmatrix} \delta u \\ \delta v \\ \delta w \end{Bmatrix} \Big] r\, d\theta\, ds \tag{45}$$

in which ϵ^0, ϵ^1, ϵ^2 signify respectively zeroth, first, and second-order terms in variations δu, δv, δw:

$$\{\epsilon^1\} = \begin{Bmatrix} \delta u' + \delta w/R_1 + \chi_o \delta\chi + \gamma_o \delta\gamma \\ \delta\dot{v}/r + \delta u r'/r + \delta w/R_2 + \psi_o \delta\psi + \gamma_o \delta\gamma \\ \delta\dot{u}/r + r(\delta v/r)' + \chi_o \delta\psi + \psi_o \delta\chi \\ \delta\chi' \\ \delta\dot{\psi}/r + r'\delta\chi/r \\ 2(-\delta\dot{\chi}/r + r'\delta\psi/r + \delta v'/R_2) \end{Bmatrix} \tag{46}$$

$$\{\epsilon^2\} = \begin{Bmatrix} \frac{1}{2}(\delta\chi)^2 + \frac{1}{2}(\delta\gamma)^2 \\ \frac{1}{2}(\delta\psi)^2 + \frac{1}{2}(\delta\gamma)^2 \\ \delta\chi\delta\psi \\ 0 \\ 0 \\ 0 \end{Bmatrix} \tag{47}$$

$$\{\epsilon^0\} = \text{Expressions (39) with subscript zero.} \tag{48}$$

For convenience from now on the variation symbol δ will be dropped. The infinitesimal components u, v, w, χ denote "buckling displacements" and the finite components u_o, v_o, w_o, χ_o denote "prebuckling displacements". It is understood that u_o, v_o, w_o, χ_o are composed of two parts, a "fixed" part $(\ )^f$ and a "variable" part $(\ )^v$.

If we consider in Eq. (45) that

$$\lfloor \epsilon^2 \rfloor [C] \{\epsilon^0\} = \lfloor \epsilon^0 \rfloor [C] \{\epsilon^2\} \tag{49}$$

(since C is symmetric), the second variation (45) can be written in the form

$$\delta^2 U = \int_s \int_\theta \Big(\lfloor \epsilon^1 \rfloor [C] \{\epsilon^1\} + 2 \lfloor \epsilon^2 \rfloor \big([C] \{\epsilon_o^{\,1} + \epsilon_o^{\,2}\} + \{N^T\} \big)$$

$$\lfloor d \rfloor [P] \{d\} \Big) r d\theta ds \tag{50}$$

in which the linear prebuckling strain vector $\epsilon_o^{\,1}$ is:

$$\{\epsilon_o^{\,1}\} = \begin{Bmatrix} u_o' + w_o/R_1 \\ \dot{v}_o/r + u_o r'/r + w_o/R_2 \\ \dot{u}_o/r + r(v_o/r)' \\ \chi_o' \\ \dot{\psi}_o/r + r'\chi_o/r \\ 2\left(-\dot{\chi}_o/r + r'\psi_o/r + v_o'/R_2\right) \end{Bmatrix} \tag{51}$$

and the nonlinear portion of the prebuckling strain is:

$$\{\epsilon_o^{\,2}\} = \begin{Bmatrix} \frac{1}{2}\left(\chi_o^{\,2} + \gamma_o^{\,2}\right) \\ \frac{1}{2}\left(\psi_o^{\,2} + \gamma_o^{\,2}\right) \\ \chi_o \psi_o \\ 0 \\ 0 \\ 0 \end{Bmatrix} \tag{52}$$

The linear infinitesimal strain vector ϵ^1, Eq. (46), can be divided into three components

$$\epsilon^1 = \epsilon_s^{\,1} + \epsilon_f^{\,1} + \epsilon_v^{\,1} \tag{53}$$

in which $\epsilon_s^{\,1}$ is given by Eqs. (51) with subscript zero dropped and in which

$$\left\{\epsilon_f^{\,1}\right\} \equiv \begin{Bmatrix} \chi_o^{\,f}\chi + \gamma_o^{\,f}\gamma \\ \psi_o^{\,f}\psi + \gamma_o^{\,f}\gamma \\ \chi_o^{\,f}\psi + \psi_o^{\,f}\chi \\ 0 \\ 0 \\ 0 \end{Bmatrix} , \quad \left\{\epsilon_v^{\,1}\right\} \equiv \begin{Bmatrix} \chi_o^{\,v}\chi + \gamma_o^{\,v}\gamma \\ \psi_o^{\,v}\psi + \gamma_o^{\,v}\gamma \\ \chi_o^{\,v}\psi + \gamma_o^{\,v}\gamma \\ 0 \\ 0 \\ 0 \end{Bmatrix} \tag{54}$$

The "pressure-rotation" matrix [P], Eq. (42), and the thermal load vector $\lfloor N^T \rfloor$ can also be considered split into "fixed" and "variable" parts. Now divide the prebuckling strain vectors $\epsilon_o^{\,1}$ and $\epsilon_o^{\,2}$ into "fixed" and "variable" parts:

$$\begin{aligned} \epsilon_o^{\,1} &= \epsilon_o^{\,f} + \epsilon_o^{\,v} \\ \epsilon_o^{\,2} &= \epsilon_o^{\,ff} + \epsilon_o^{\,vv} + \epsilon_o^{\,fv} \end{aligned} \tag{55}$$

in which

$$\left\{\epsilon_o^{\,fv}\right\} = \begin{Bmatrix} \chi_o^{\,f}\chi_o^{\,v} + \gamma_o^{\,f}\gamma_o^{\,v} \\ \psi_o^{\,f}\psi_o^{\,v} + \gamma_o^{\,f}\gamma_o^{\,v} \\ \chi_o^{\,v}\psi_o^{\,f} + \chi_o^{\,f}\psi_o^{\,v} \\ 0 \\ 0 \\ 0 \end{Bmatrix} , \quad \left\{\epsilon_o^{\,ff}, \epsilon_o^{\,vv}\right\} \text{ are analogous} \tag{56}$$

The term

$$2\lfloor \epsilon^2 \rfloor \left([C] \left\{ \epsilon_o^{\,1} + \epsilon_o^{\,2} \right\} + \left\{ N^T \right\} \right)$$

in Eq. (50) becomes

$$2[\epsilon^2]\left([C]\left\{\epsilon_o^{\ f} + \epsilon_o^{\ v} + \epsilon_o^{\ ff} + \epsilon_o^{\ vv} + \epsilon_o^{\ fv}\right\} + \left\{N_f^{\ T} + N_v^{\ T}\right\}\right) \tag{57}$$

which can be expressed as:

$$2\lfloor\epsilon^2\rfloor\left\{N_o^{\ f} + N_{oLIN}^{v} + C\epsilon_o^{\ vv} + C\epsilon_o^{\ fv}\right\} \tag{58}$$

in which

$$\begin{aligned} N_o^{\ f} &\equiv C\left\{\epsilon_o^{\ f} + \epsilon_o^{\ ff}\right\} + N_f^{\ T} \\ N_{oLIN}^{v} &\equiv C\left\{\epsilon_o^{\ v}\right\} + N_v^{\ T} \end{aligned} \tag{59}$$

With the above development, we can now express Eq. (50) in the form

$$\delta^2 U = \iint_{s\ \theta} (A_1 + \lambda A_2 + \lambda^2 A_3)\ r ds d\theta \tag{60}$$

in which

$$\begin{aligned} A_1 &= \lfloor\epsilon_s^{\ 1} + \epsilon_f^{\ 1}\rfloor\ [C]\left\{\epsilon_s^{\ 1} + \epsilon_f^{\ 1}\right\} + \lfloor d\rfloor\ [P^f]\ \{d\} \\ &+ [\chi, \psi, \gamma]\begin{bmatrix} N_{10}^f & N_{120}^f & 0 \\ N_{120}^f & N_{20}^f & 0 \\ 0 & 0 & \left(N_{10}^f + N_{20}^f\right) \end{bmatrix}\begin{Bmatrix} \chi \\ \psi \\ \gamma \end{Bmatrix} \end{aligned} \tag{61}$$

$$A_2 = 2\lfloor \epsilon_v^{\,1} \rfloor [C] \left\{ \epsilon_s^{\,1} + \epsilon_f^{\,1} \right\} + \lfloor d \rfloor [P^v] \{d\}$$

$$+ \lfloor \chi, \psi, \gamma \rfloor \begin{bmatrix} \bar{N}^{\,v}_{1OLIN} & \bar{N}^{\,v}_{12OLIN} & 0 \\ \bar{N}^{\,v}_{12OLIN} & \bar{N}^{\,v}_{2OLIN} & 0 \\ 0 & 0 & \left(\bar{N}^{\,v}_{1OLIN} + \bar{N}^{\,v}_{2OLIN}\right) \end{bmatrix} \begin{Bmatrix} \chi \\ \psi \\ \gamma \end{Bmatrix} \tag{62}$$

with

$$\begin{aligned} \bar{N}^{\,v}_{1OLIN} &= N^{\,v}_{1OLIN} + \lfloor C_{1i} \rfloor \left\{ e_o^{\,fv} \right\} \\ \bar{N}^{\,v}_{2OLIN} &= N^{\,v}_{2OLIN} + \lfloor C_{2i} \rfloor \left\{ e_o^{\,fv} \right\} \\ \bar{N}^{\,v}_{12OLIN} &= N^{\,v}_{12OLIN} + \lfloor C_{3i} \rfloor \left\{ e_o^{\,fv} \right\} \end{aligned} \tag{63}$$

$$A_3 = \lfloor \epsilon_v^{\,1} \rfloor [C] \left\{ \epsilon_v^{\,1} \right\} + \lfloor \chi, \psi, \gamma \rfloor \begin{bmatrix} N^{\,v}_{1ONL} & N^{\,v}_{12ONL} & \\ N^{\,v}_{12ONL} & N^{\,v}_{2ONL} & \\ 0 & 0 & \left(N^{\,v}_{1ONL} + N^{\,v}_{2ONL}\right) \end{bmatrix} \begin{Bmatrix} \chi \\ \psi \\ \gamma \end{Bmatrix} \tag{64}$$

with

$$\begin{aligned} N^{\,v}_{1ONL} &= \lfloor C_{1i} \rfloor \left\{ e_o^{\,vv} \right\}, \quad N^{\,v}_{2ONL} = \lfloor C_{2i} \rfloor \left\{ e_o^{\,vv} \right\} \\ N^{\,v}_{12ONL} &= \lfloor C_{3i} \rfloor \left\{ e_o^{\,vv} \right\} \end{aligned} \tag{65}$$

The second variation of the shell strain energy and pressure-rotation effect given by Eq. (60) with Eqs. (61) - (65) is valid for arbitrary segments of shells of revolution with arbitrary nonsymmetric prestress distributions. It is an integro-differential form. The discretization model is shown in Fig. 3.

2.5.3 Ring Strain Energy and Radial-Line-Load-Rotation Effect

The ring strain energy and radial-line-load-rotation effect has a form analogous to Eq. (38)

$$U_r = \frac{1}{2}\int_\theta \left[\lfloor \bar{\epsilon}_r \rfloor [G] \{\bar{\epsilon}_r\} + 2\lfloor \bar{N}_r^T \rfloor \{\bar{\epsilon}_r\} + \lfloor v_c, w_c \rfloor \begin{bmatrix} -H/r_c & 0 \\ 0 & H/r_c \end{bmatrix} \begin{Bmatrix} v_c \\ w_c \end{Bmatrix} \right] r_c d\theta \tag{66}$$

in which the ring hoop strain vector $\bar{\epsilon}_r$ is given by:

$$\{\bar{\epsilon}_r\} = \begin{Bmatrix} \epsilon_r \\ \kappa_x \\ \kappa_y \\ \kappa_{xy} \end{Bmatrix} = \begin{Bmatrix} \dot{v}_c/r_c + w_c/r_c + \frac{1}{2}(\psi_c^2 + \gamma_c^2) \\ \dot{\psi}_c/r_c \\ -\dot{\gamma}_c/r_c + \chi/r_c \\ \dot{\chi}/r_c + \dot{u}_c/r_c^2 \end{Bmatrix} . \tag{67}$$

with

$$\begin{aligned} \psi_c &= (\dot{w}_c - v_c)/r_c \\ \gamma_c &= \dot{u}_c/r_c \end{aligned} \tag{68}$$

Subscript c denotes "ring centroid" or shear center. Fig. 21 shows u_c, v_c, w_c. In Eq. (66) [G] is the 4x4 ring constitutive law:

$$[G] = \begin{bmatrix} E_rA & 0 & 0 & 0 \\ 0 & E_rI_y & -E_rI_{xy} & 0 \\ 0 & -E_rI_{xy} & E_rI_x & 0 \\ 0 & 0 & 0 & GJ \end{bmatrix} \tag{69}$$

$\lfloor \bar{N}_r^T \rfloor$ is the four-component vector of ring thermal loads

$$\left\{\bar{N}_r^T\right\} = \begin{Bmatrix} N_r^T \\ -M_x^T \\ M_y^T \\ 0 \end{Bmatrix} = \begin{Bmatrix} -\int E_r \alpha_r T dA \\ +\int E_r \alpha_r T x dA \\ -\int E_r \alpha_r T y dA \\ 0 \end{Bmatrix} \tag{70}$$

and H is the radial load/length applied to the ring centroidal axis, positive as shown in Fig. 21.

We follow the same development as with the shell strain energy. The second variation of ring energy is given by an expression analogous to Eq. (50):

$$\delta^2 U_r = r_c \int_\theta \left[\lfloor \bar{\epsilon}_r^{\,1} \rfloor [G] \{\bar{\epsilon}_r^{\,1}\} + 2 \lfloor \bar{\epsilon}_r^{\,2} \rfloor \left([G] \left\{ \bar{\epsilon}_{ro}^{\,1} + \bar{\epsilon}_{ro}^{\,2} \right\} + \left\{ \bar{N}_r^T \right\} \right) \right.$$

$$\left. + \lfloor v_c, w_c \rfloor \begin{bmatrix} -H/r_c & 0 \\ 0 & H/r_c \end{bmatrix} \begin{Bmatrix} v_c \\ w_c \end{Bmatrix} \right] d\theta \tag{71}$$

in which $\lfloor \bar{\epsilon}_r^{\,1} \rfloor$ is given by Eq. (67) with variables u_c, v_c, w_c interpreted as variations; and with the nonlinear term in ϵ_r, that is $\left[\frac{1}{2}\left(\psi_c^2 + \gamma_c^2\right)\right]$ replaced by $\psi_{co}\psi_c + \gamma_{co}\gamma_c$. The quantity $\bar{\epsilon}_r^{\,2}$ is given by:

$$\left\{\bar{\epsilon}_r^{\,2}\right\} = \begin{Bmatrix} \frac{1}{2}\left(\psi_c^2 + \gamma_c^2\right) \\ 0 \\ 0 \\ 0 \end{Bmatrix} \tag{72}$$

and $\bar{\epsilon}_{ro}^{\,1}$ and $\bar{\epsilon}_{ro}^{\,2}$ are the linear and nonlinear parts, respectively of the prestress strain given by Eq. (67) with subscripts zero.

Again, as in the case of the shell strain energy and applied loads, we consider "fixed" and "variable" loads separately, so that

$$\bar{\epsilon}_r^{\,1} = \bar{\epsilon}_{rs}^{\,1} + \bar{\epsilon}_{rf}^{\,1} + \bar{\epsilon}_{rv}^{\,1} \quad , \quad H = H_f + H_v$$

$$\bar{N}_r^{\,T} = \bar{N}_{rf}^{\,T} + \bar{N}_{rv}^{\,T} \quad , \quad \bar{\epsilon}_{ro}^{\,1} = \epsilon_{ro}^{f} + \epsilon_{ro}^{v} \tag{73}$$

$$\bar{\epsilon}_{ro}^{\,2} = \epsilon_{ro}^{ff} + \epsilon_{ro}^{fv} + \epsilon_{ro}^{vv}$$

The discrete ring energy then has a form completely analogous to Eq. (60) in which

$$A_1 = \lfloor \bar{\epsilon}_{rs}^{\,1} + \bar{\epsilon}_{rf}^{\,1} \rfloor [G] \left\{ \bar{\epsilon}_{rs}^{\,1} + \bar{\epsilon}_{rf}^{\,1} \right\} + \lfloor d_c \rfloor [H^f] \{d_c\} + \left(\psi_c^2 + \gamma_c^2\right) F_{rf} \tag{74}$$

with

$$\lfloor d_c \rfloor = \lfloor v_c, w_c \rfloor \qquad [H^f] = \begin{bmatrix} -H^f/r_c & 0 \\ 0 & H^f/r_c \end{bmatrix}$$

$$F_{rf} = [G] \left\{ \epsilon_{ro}^{f} + \epsilon_{ro}^{ff} \right\} + \bar{N}_{rf}^{\,T} \tag{75}$$

$$A_2 = 2\lfloor \bar{\epsilon}_{rv}^{\,1} \rfloor [G] \left\{ \bar{\epsilon}_{rs}^{\,1} + \bar{\epsilon}_{rf}^{\,1} \right\} + \lfloor d_c \rfloor [H^v] \{d_c\} + \left(\psi_c^2 + \gamma_c^2\right) \left(F_{rvLIN} + [G] \left\{ \epsilon_{ro}^{fv} \right\} \right) \tag{76}$$

with

$$F_{rvLIN} = [G] \left\{ \epsilon_{ro}^{v} \right\} + \bar{N}_{rv}^{\,T} \tag{77}$$

and

$$A_3 = \lfloor \bar{\epsilon}_{rv}^{\,1} \rfloor [G] \left\{ \bar{\epsilon}_{rv}^{\,1} \right\} + \left(\psi_c^2 + \gamma_c^2\right) [G] \left\{ \epsilon_{or}^{vv} \right\} \tag{78}$$

The expressions (74), (76), and (78) for the ring are clearly analogous to those for the shell [Eqs. (61), (62), and (64)]. The above ring equations are valid for nonsymmetric prestress. If the prestress solution is axisymmetric the following expressions result:

$$A_1 = \lfloor \bar{\epsilon}_{rs}^{\,1} \rfloor [G] \left\{ \bar{\epsilon}_{rs}^{\,1} \right\} + H^f \left(-v_c^2 + w_c^2 \right) / r_c + \left(\psi_c^2 + \gamma_c^2 \right) \left[G_{11} w_c^f / r_c - \int E_r \alpha_r T^f dA \right] \tag{79}$$

$$A_2 = \left(\psi_c^2 + \gamma_c^2 \right) \left[G_{11} w_c^v / r_c - \int E_r \alpha_r T^v dA \right] + H^v \left(-v_c^2 + w_c^2 \right) / r_c \tag{80}$$

$$A_3 = 0 \tag{81}$$

in which $\bar{\epsilon}_{rs}^{\,1}$ is the linear part of the strain vector given by Eq. (67).

2.5.4 Constraint Conditions

The constraint conditions are handled in a manner analogous to that described for the axisymmetric prestress analysis. The constraint conditions given in vector form by Eq. (4) are

$$U_c = K_1 \lambda_1 (u^{*+} - u^{*-} + d_1 \chi^-) + K_2 \lambda_2 \left[v^{*+} - v^{*-} + d_1 (\dot{w}^{*-} - v^{*-}) / r^- + d_2 \dot{u}^{*-} / r^- \right] + K_3 \lambda_3 (w^{*+} - w^{*-} - d_2 \chi^-) + K_4 \lambda_4 (\chi^+ - \chi^-) \tag{82}$$

in which d_1 and d_2 are the radial and axial components of the meridional discontinuity or support point eccentricity as shown in Fig. 19. Starred quantities are displacement components in the "global" coordinate system, as shown in Fig. 20.

2.5.5 Variable Transformations

The components of energy of the system are represented by the shell strain energy U_s [Eq. (1)], the strain energy of a discrete ring U_r [Eq. (2)], the potential energy of line loads U_{p1} and normal pressure and surface tractions U_{p2} [Eqs. (3)], the shell kinetic energy T_s [Eq. (2.20) of Ref.3], and the discrete ring kinetic energy T_r [Eqs. (2.21) of Ref. 3]. The constraint conditions U_c are given by Eqs. (4).

It is desired to express all energy components in terms of the shell reference surface displacements u, v, and w. The displacements u_c, v_c,

and w_c of the ring centroid (Fig. 21), which appear in Eqs. (79) - (81) are given by

$$u_c = u^* - e_1\chi \qquad v_c = v^* - e_1(\dot{w}^* - v^*)/r - e_2\dot{u}^*/r$$
$$w_c = w^* + e_2\chi \tag{83}$$

The ring eccentricity components e_1 and e_2 are shown in Fig. 21. The axial, circumferential and radial displacement components u^*, v^*, and w^*, which appear in Fig. 20, are given by

$$\begin{aligned} u^* &= u\, r/R_2 - w\, r' \\ v^* &= v \\ w^* &= u\, r' + w\, r/R_2 \end{aligned} \tag{84}$$

Eqs. (83) and (84) can be used to eliminate u_c, v_c, w_c, u^*, v^*, and w^* from the energy components and constraint conditions. The dependent variables are then u, v, w and the Lagrange multipliers λ_1, λ_2, λ_3, and λ_4.

The total energy in the system is obtained by summing over all shell segments, discrete ring stiffeners, and junctures.

2.5.6 Separation of Variables

The dependent variables u, v, and w are functions of arc length s and circumferential coordinate θ. The θ-dependence can be eliminated from the analysis by the assumption that

$$\begin{aligned} u(s,\theta) &= \sum_{n=n_{min}}^{n_{max}} u_{n1}(s) \sin n\theta + \sum_{n_{min}}^{n_{max}} u_{n2}(s) \cos n\theta \\ v(s,\theta) &= \sum_{n} v_{n1}(s) \cos n\theta + \sum_{n} v_{n2}(s) \sin n\theta \\ w(s,\theta) &= \sum_{n} w_{n1}(s) \sin n\theta + \sum_{n} w_{n2}(s) \cos n\theta \end{aligned} \tag{85}$$

The temperature distribution, surface tractions and pressures, and thermal and mechanical line loads have similar expansions:

$$
\begin{aligned}
T(s,\theta) &= \sum_n T_{n1}(s) \sin n\theta + \sum_n T_{n2}(s) \cos n\theta \\
p_1(s,\theta) &= \sum_n p_{1n1}(s) \sin n\theta + \sum_n p_{1n2}(s) \cos n\theta \\
p_2(s,\theta) &= \sum_n p_{2n1}(s) \cos n\theta + \sum_n p_{2n2}(s) \sin n\theta \\
p_3(s,\theta) &= \sum_n p_{3n1}(s) \sin n\theta + \sum_n p_{3n2}(s) \cos n\theta \\
V(\theta) &= \sum_n V_{n1} \sin n\theta + \sum_n V_{n2} \cos n\theta \\
S(\theta) &= \sum_n S_{n1} \cos n\theta + \sum_n S_{n2} \sin n\theta \\
H(\theta) &= \sum_n H_{n1} \sin n\theta + \sum_n H_{n2} \cos n\theta \\
M(\theta) &= \sum_n M_{n1} \sin n\theta + \sum_n M_{n2} \cos n\theta \\
N_r^T(\theta) &= \sum_n N_{rn1}^T \sin n\theta + \sum_n N_{rn2}^T \cos n\theta \\
M_y^T(\theta) &= \sum_n M_{yn1}^T \sin n\theta + \sum_n M_{yn2}^T \cos n\theta \\
M_x^T(\theta) &= \sum_n M_{xn1}^T \sin n\theta + \sum_n M_{xn2}^T \cos n\theta
\end{aligned}
\tag{86}
$$

In the BOSOR4 program large deflections are permitted in the axisymmetric components, but the nonsymmetric harmonics are considered to be small. The various harmonics do not couple, and a solution for each $u_n(s)$, $v_n(s)$, and $w_n(s)$ can be obtained with the circumferential wavenumber n appearing as a parameter in the analysis. The θ integration indicated in Eqs. (1) - (3) is replaced by a factor of π for $n \neq 0$ and

2π for $n = 0$. In a linear stress analysis for nonsymmetrically loaded shells the static response of a shell to arbitrarily varying loads is obtained by superposition. (In this case even the axisymmetric components are assumed to be small.) In buckling and vibration analyses the "small" deflections u_{n1}, v_{n1}, w_{n1}, u_{n2}, v_{n2}, w_{n2} are considered to be kinematically admissible variations from the "prebuckled" or "prestressed" axisymmetric state represented by the large deflections $u_o(s)$ and $w_o(s)$ determined in the nonlinear prebuckling analysis.

In the linear analysis for nonsymmetric behavior and in the buckling and vibration analyses the second summations in Eqs. (85) and (86) can be represented by negative values of the wavenumber n. Positive values of n correspond to the first summations. In the remainder of this section the subscripts $(\ )_{n1}$ and $(\ )_{n2}$ will be dropped. It is emphasized that the analysis and computer program are also valid for negative values of n.

2.5.7 Finite Difference Scheme

The θ dependence has been replaced with a circumferential wavenumber n, so that only one independent variable remains - the arc length s. Figure 3 shows a shell meridian with the finite difference discretization. The continuous variables $u(s)$, $v(s)$ and $w(s)$ are replaced by discrete variables u_i, v_i and w_i. The u_i and v_i occur at stations midway between the w_i. This arrangement of discrete variables has been determined to be superior to an arrangement in which u_i, v_i, and w_i correspond to displacement components at a single point. Detailed comparisons between the two schemes for constant mesh spacing are given in Ref. 15. The energy is evaluated at the midpoint of the integration area, denoted in Fig. 3 by a heavy line. At the energy point "E", u, v, and s-derivatives u' and v' are given by:

$$u = (u_i + u_{i-1})/2 \qquad v = (v_i + v_{i-1})/2$$
$$u' = (u_i - u_{i-1})/\ell \qquad v' = (v_i - v_{i-1})/\ell \tag{87}$$

in which ℓ is the length of the finite difference "element". The normal

displacement w and its derivatives w' and w'' are given by Eq. (9).

The s-integration indicated in Eqs. (1) and (3) is performed numerically by multiplication of the energy density at "E" in Fig. 3 by the element length ℓ.

With the substitution of Eqs. (85) and (86) in the various energy components and constraint conditions, the replacement of s-derivatives by Eqs. (87) and (9), the replacement of time derivatives by a frequency parameter and the numerical integration over s and exact integration over θ, the system energy and constraint conditions can be represented as an algebraic form which contains as dependent variables u_i, v_i, and w_i and the Lagrange multipliers λ_1, λ_2, λ_3, and λ_4 (for each juncture and constraint condition). The algebraic form also contains as parameters the shell and ring properties, the loads and temperature, and the frequency parameter Ω.

2.5.8 Transformation of Energy to Algebraic Form

To express the second variation of the energy as an algebraic form, we must operate on the integro-differential forms given by Eqs. (60) with Eqs. (61) - (65) (Shell strain energy and pressure-rotation effect), Eq. (60) with Eqs. (79) - (81) (Discrete ring strain energy), and Eq. (82) (Constraint conditions). The kinetic energy expressions are given in Ref. 3 and will not be repeated here. They are unchanged from the BØSØR3 analysis except for the fact that the discrete model now includes variable mesh spacing.

Expression of the energy in algebraic form is performed in Subroutine STABIL. This subroutine calculates the stiffness matrix, load-geometric matrix, λ^2 matrix, mass matrix, and load vector for the linear stress buckling and vibration analyses. In the equations which follow certain variables and subroutines in STABIL are identified. This identification enables the user to understand the program more thoroughly.

In Eq. (60) the elements of the matrices A_1, A_2, and A_3 are functions. To express the energy density at the midlength of a finite difference element, we introduce a vector $\lfloor q \rfloor$, defined as

$$[q] = [q]_i = \overbrace{\lfloor \underbrace{q_{i-3},\ q_{i-2},\ q_{i-1},\ q_i,\ q_{i+1},\ q_{i+2},\ q_{i+3}}_{\text{I3M, I2M, I1M, I0, I1P, I2P, I3P}} \rfloor}$$

$$= \lfloor w_{i-1},\ u_i,\ v_i,\ w_i,\ u_{i+1},\ v_{i+1},\ w_{i+1} \rfloor \tag{88}$$

in which w_{i-1}, u_i, etc. are shown in Fig. 3. If θ-derivatives in Eqs. (40) and (51) are eliminated by means of separation of variables, as shown in Eqs. (85), and appropriate finite difference formulas such as those given by Eqs. (9) and (87) are introduced to eliminate s-derivatives of u, v, and w and to express u, v, and w themselves in terms of nodal quantities, the following definitions can be made:

$$\lfloor \epsilon_s^1 + \epsilon_f^1 \rfloor = \underbrace{\overset{6\times 7}{[B]}}_{\text{GETB1}} \overset{7}{\{q\}} \qquad [d] = [u,v,w] = \overbrace{\overset{3\times 7}{[D]}}^{\text{UB,VB,WB}} \overset{7}{\{q\}}$$

$$[\chi,\psi,\gamma] = \overbrace{\underbrace{\overset{3\times 7}{[R]}}_{\text{GETRØT}} \overset{7}{\{q\}}}^{\text{RØT}} \tag{89}$$

If the prestress is axisymmetric the quantity ϵ_v^1 given by Eq. (54) is simplified to

$$\epsilon_v^1 = \overset{\text{CHIVAR}}{X_o^v X} \tag{90}$$

With Eqs. (89) and (90) used in Eqs. (61) - (65) and the assumption of axisymmetric prestress, the shell energy density arrays A_1, A_2, and A_3 at an element centroid can be written in the algebraic form:

$$A_1 = \lfloor q \rfloor \left(\overbrace{B^T C B}^{\text{MATMU4(C,B1,U,6,7,1)}} + \overbrace{D^T P^f D}^{\text{GETP}} + \overbrace{R^T N^f R}^{\text{MATMU4(PRE,ROT,U,3,7,1)}} \right) \{q\} \tag{91}$$

$$A_2 = \lfloor q \rfloor \Bigg(\chi_o^v \Big[\{R_{1i}\} \lfloor C_{1i} \rfloor + \{R_{2i}\} \lfloor C_{3i} \rfloor \Big] [B]$$

$$+ \chi_o^v [B]^T \Big[\{C_{1i}\} \lfloor R_{1i} \rfloor + \{C_{3i}\} \lfloor R_{2i} \rfloor \Big] \tag{92}$$

$$+ \overbrace{D^T P^v D}^{\text{GETP}} + R^T N_{LIN}^v R \Bigg) \{q\}$$

$$A_3 = \lfloor q \rfloor R^T \left(V^T C_{mem} V + N_{NL}^v \right) R \{q\} \tag{93}$$

in which

$$N^f = \begin{bmatrix} N_{10}^f & 0 & 0 \\ 0 & N_{20}^f & 0 \\ 0 & 0 & \left(N_{10}^f + N_{20}^f\right) \end{bmatrix} \quad N_{LIN}^v = \begin{bmatrix} \bar{N}_{1OLIN}^v & 0 & 0 \\ 0 & \bar{N}_{2OLIN}^v & 0 \\ 0 & 0 & \left(\bar{N}_{1OLIN}^v + \bar{N}_{2OLIN}^v\right) \end{bmatrix} \tag{94}$$

$$N_{NL}^v = \begin{bmatrix} N_{1ONL}^v & 0 & 0 \\ 0 & N_{2ONL}^v & 0 \\ 0 & 0 & \left(N_{1ONL}^v + N_{2ONL}^v\right) \end{bmatrix}$$

$$V = \begin{bmatrix} \chi_o^v & 0 & 0 \\ 0 & 0 & 0 \\ 0 & \chi_o^v & 0 \end{bmatrix} \qquad C_{mem} = \begin{bmatrix} C_{11} & C_{12} & 0 \\ C_{12} & C_{22} & 0 \\ 0 & 0 & C_{33} \end{bmatrix}$$

In a similar way the discrete ring strain energy can be expressed in terms of the nodal point variables corresponding to the attachment point of the ring. The following definitions are useful:

$$F^f = \overbrace{G_{11} w_c{}^f / r_c - \int E_r \alpha_r T^f dA}^{\text{RHFIX(IK)}}$$

$$F^v = \overbrace{G_{11} w_c{}^v / r_c - \int E_r \alpha_r T^v dA}^{\text{RHFIK}}$$

$$\left\{ \bar{\epsilon}_{rs}{}^{1} \right\} = \overset{4\times4}{[B_r]} \begin{Bmatrix} u_c \\ v_c \\ w_c \\ \chi \end{Bmatrix} \tag{95}$$

$$\begin{Bmatrix} \psi_c \\ \gamma_c \end{Bmatrix} = \overset{2\times4}{[R_r]} \begin{Bmatrix} u_c \\ v_c \\ w_c \\ \chi \end{Bmatrix} \qquad \begin{Bmatrix} u_c \\ v_c \\ w_c \\ \chi \end{Bmatrix} = \underset{\text{E*D from GETE, GETD}}{\overset{4\times7}{[T]}} \{q\}$$

The contribution of a discrete ring to the matrices A_1, A_2, and A_3 is

$$A_1 = \lfloor q \rfloor T^T \overbrace{\left(B_r^T G B_r + \bar{H}^f + R_r^T \bar{F}^f R_r \right)}^{\text{GETG}} T \{q\} \tag{96}$$

$$A_2 = \lfloor q \rfloor T^T \left(\bar{H}^v + R_r^T \bar{F}^v R_r \right) T \{q\}$$

$$A_3 = 0$$

in which

$$\bar{H}^f = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & \frac{-H^f}{r_c} & 0 & 0 \\ 0 & 0 & \frac{H^f}{r_c} & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \tag{97}$$

$$\bar{F}^f = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & F^f & 0 & 0 \\ 0 & 0 & F^f & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \tag{98}$$

The stability constraint conditions are handled in a way analogous to those for the prebuckling problem. We are interested in calculating $\partial U_c/\partial q_i$, which from Eq. (82) is given by

$$\begin{aligned} \frac{\partial U_c}{\partial q_i} &= \lambda_1 U_{,i} + \lambda_2 V_{,i} + \lambda_3 W_{,i} + \lambda_4 X_{,i} \\ &\quad + \delta_i^{\lambda_1} U + \delta_i^{\lambda_2} V + \delta_i^{\lambda_3} W + \delta_i^{\lambda_4} X \end{aligned} \tag{99}$$

in which

$$U_{,i} = K_1 \left[\underbrace{\frac{\partial u^{*+}}{\partial q_i}}_{D(1,I)} \underbrace{- \frac{\partial u^{*-}}{\partial q_i} + d_1 \frac{\partial x^-}{\partial q_i}}_{QD(1,I)} \right]$$

$$V_{,i} = K_2 \left[\underbrace{\frac{\partial v^{*+}}{\partial q_i}}_{D(2,I)} \underbrace{- \frac{\partial v^{*-}}{\partial q_i} + \frac{d_1}{r} \frac{\partial(\dot{w}^{*-} - v^{*-})}{\partial q_i} + \frac{d_2}{r} \frac{\partial(\dot{u}^{*-})}{\partial q_i}}_{QD(2,I)} \right] \tag{100}$$

$$w_{,i} = K_3 \left[\underbrace{\frac{\partial w^{*+}}{\partial q_i}}_{D(3,I)} - \underbrace{\frac{\partial w^{*-}}{\partial q_i} - d_2 \frac{\partial \chi^-}{\partial q_i}}_{QD(3,I)} \right]$$

(100 Cont'd)

$$X_{,i} = K_4 \left[\underbrace{\frac{\partial \chi^+}{\partial q_i}}_{D(4,I)} - \underbrace{\frac{\partial \chi^-}{\partial q_i}}_{QD(4,I)} \right]$$

$$U = K_1(u^{*+} - u^{*-} + d_1\chi^-) \; ; \quad V = K_2\left(v^{*+} - v^{*-} + d_1(\dot{w}^{*-} - v^{*-})/r + d_2\dot{u}^{*-}/r\right)$$

$$W = K_3(w^{*+} - w^{*-} - d_2\chi^-) \; ; \quad X = K_4(\chi^+ - \chi^-)$$

The computer arrays D(1,I) - D(4,I) and QD(1,I) - QD(4,I) appear in STABIL. The variables K_1 , K_2 , K_3 , and K_4 are called FIFX1, FIFX2, FIFX3, and FIFX4, respectively.

The local matrices A_1, A_2, and A_3 are multiplied by $r\Delta s$ or $r\ell$ to get the energy once the energy density is known. In stress, buckling, and vibration problems A_1 is called the local stiffness matrix; in buckling problems A_2 is commonly called the "load-geometric" matrix and A_3 is called the "λ^2-matrix" because it is multiplied by λ^2. In subroutine STABIL if IBUCK=1 the local stiffness matrix A_1 is being calculated; if IBUCK=2 the local load-geometric matrix A_2 is being calculated; if IBUCK-3 the local mass matrix M_ℓ is being calculated, and if IBUCK=4 the local λ^2-matrix is being calculated. Assembly of these local matrices into the corresponding global matrices K_1, K_2, K_3, and M is accomplished in a manner completely analogous to that described in connection with the axisymmetric prebuckling analysis. The role of the global matrices K_1, K_2, and K_3 is implied in Eq. (37).

For a better understanding of the form of the global stiffness matrix and the method by which the constraint conditions enter the algorithm, the reader is referred to the section on prebuckling analysis and Figures 7-16. The algorithm for nonsymmetric linear stress, buckling, and vibration analyses, the subroutine STABIL, is analogous to subroutine PRESTS in this regard. Note from Figures 4-6 that in the prestress analysis the local matrices labeled "BCB" are 5x5 and the constraint condition matrices "QD"

and "D" are 3x5. In the nonsymmetric stress, buckling, and vibration analyses the local stiffness, load-geometric, λ^2 , and mass matrices are 7x7 and "QD" and "D" are 4x7.

A flow chart of STABIL is shown in Fig. 22.

2.5.9 Linear Stress Analysis for Symmetrically and Nonsymmetrically Loaded Shells

The linear stress analysis is based on the same equations as the stability and vibration analysis, except that the "prestress" terms which appear in the stability and vibration quadratic form are not present, and the energy functional is not homogeneous, since a "right-hand-side" load vector is non-zero. This load vector arises from the thermal terms in Eqs. (1) and (2) and the linear load terms in Eqs. (3). The thermal and mechanical loads are distributed circumferentially as given in Eqs. (86).

The load terms corresponding to distributed thermal and mechanical loads are calculated in Subroutine SRHS, which is called from STABIL; the line thermal and mechanical loads are calculated in Subroutine RRHS, which is also called from STABIL.

2.6 Solution of the Eigenvalue Problems

In the bifurcation buckling problem the eigenvalues λ are sought for the system

$$K_1 x + \lambda K_2 x + \lambda^2 K_3 x = 0 \tag{37}$$

In the vibration analyses the eigenvalues Ω^2 are sought for the system

$$K_1 x - \Omega^2 M x = 0 \tag{101}$$

In bifurcation buckling problems with nonlinear prestress analysis Eq. (37) is solved for the smallest λ only. This solution is obtained in Subroutine EIGEN. In bifurcation buckling problems with linear prestress analysis Eq. (37) is solved for the smallest NVEC eigenvalues for each circumferential wavenumber, n . Subroutine EBAND, written by Frank Brogan is used for

the analysis. In modal vibration analysis Eq. (101) is solved for the smallest NVEC eigenvalues for each n. Subroutine EBAND2, written by Frank Brogan, is used. In all cases the eigenvalues are determined by the inverse power method with spectral shifts.

The "quadratic" eigenvalue problem given by Eq. (37) can be expressed in the form

$$Pz = \lambda Qz \tag{102}$$

in the following way:

Let

$$y = -\lambda K_3 x \tag{103}$$

then from Eq. (37)

$$K_1 x = -\lambda K_2 x + \lambda y \tag{104}$$

Eqs. (103) and (104) can be expressed in the matrix form

$$\begin{bmatrix} K_1 & 0 \\ 0 & I \end{bmatrix} \begin{Bmatrix} x \\ y \end{Bmatrix} = \lambda \begin{bmatrix} -K_2 & I \\ -K_3 & 0 \end{bmatrix} \begin{Bmatrix} x \\ y \end{Bmatrix} \tag{105}$$

which is the form of Eq. (102). If μ is the shift scalar, each inverse power iteration has the form

$$(P - \mu Q)z_{n+1} = s_n Q z_n \tag{106}$$

in which s_n is a normalizing vector. Eq. (106) can be written in terms of x and y, as follows:

$$\begin{aligned} (K_1 + \mu K_2 + \mu^2 K_3)\, x_{n+1} &= s_n\left[(-K_2 - \mu K_3)x_n + y_n\right] \\ y_{n+1} &= \mu K_3 x_{n+1} - s_n K_3 x_n \end{aligned} \tag{107}$$

Inverse power iterations continue until the eigenvalue

$$(\lambda - \mu) = (s_n x_n \cdot x_{n+1})/(x_{n+1} \cdot x_{n+1}) \tag{108}$$

has converged to a pre-determined number of significant figures.

If several eigenvalues are being sought, it is necessary to orthogonalize the system with respect to those eigenvectors already calculated. This is done for buckling and vibration problems in subroutines ØRTHØ and ØRTHØ2, respectively. In ØRTHØ, which is called from EBAND, the orthogonalization process is based on the system

$$\begin{bmatrix} K_1 & 0 \\ 0 & -K_3^{-1} \end{bmatrix} \begin{Bmatrix} x \\ y \end{Bmatrix} = \lambda \begin{bmatrix} -K_2 & I \\ I & 0 \end{bmatrix} \begin{Bmatrix} x \\ y \end{Bmatrix} \tag{109}$$

If $\begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix}$ represents an eigenvector, then

$$\begin{Bmatrix} x \\ y \end{Bmatrix}_{new} = \begin{Bmatrix} x \\ y \end{Bmatrix} - \frac{\left[(u_2 - K_2u_1).x + u_1.y\right]}{\left[(u_2 - K_2u_1).u_1 + u_1.u_2\right]} \begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix} \tag{110}$$

In bifurcation buckling analyses in which nonlinear prebuckling effects are included, the eigenvalue λ represents a quantity to be multiplied by the difference between two known prestress distributions: the one corresponding to a load P, for example, and stored in array PSFIX in subroutine STABIL; and the other corresponding to a load P + DP and stored in array PSVAR in subroutine STABIL.

Initially P and DP are set by the program user. For example, $P_o = 0$, $DP_o = 1.0$. The eigenvalue λ_n corresponding to n circumferential waves is calculated. The wavenumber n is varied until a minimum value $\lambda_1 = \lambda(n)$ is determined. The nonlinear prestress analysis is then performed for $P_1 = P_o + \lambda_1 DP_o$. DP_1 is set equal to $P_1/1000$ and the nonlinear prestress analysis is performed for $P_2 = P_1 + DP_1$. The prestress distribution corresponding to P_1 is stored in PSFIX and that corresponding to P_2 is stored in PSVAR. The stiffness matrix K_1 includes PSFIX terms. The "load-geometric" matrix K_2 and "λ^2" matrix K_3 include terms involving the difference PSVAR-PSFIX. A new $\lambda = \lambda_2$ is calculated, and a new load $P_3 = P_2 + \lambda_2 DP_1$ is thus determined.

Iterations continue until $\lambda_k DP_{k-1}$ is smaller than .005 P_k.

With this technique it is possible that the origin P_k of the eigenvalue problem gets shifted too much, such that the new origin is closer to the second or higher eigenvalue than it is to the first. To avoid resulting convergence to a higher root, careful track is maintained in EIGEN of the number of negative roots of the shifted system. In this way convergence to the fundamental buckling load is assured.

Section 3

BØSØR4 PROGRAM ORGANIZATION

The BØSØR4 program consists of a main program MAIN and six overlays called READIT, PRE, ARRAYS, BUCKLE, MØDE, and PLØT. Figures 23(a-g) show the overall Univac 1108 program organization. Figure 23(h) gives the core storage required for each of the program segments for the CDC 6600. For the Univac 1108, EXEC 8, core storage allocations are given in decimal for the code and the data in Appendix C. The 1108, EXEC 8 version is written in double precision FORTRAN IV. The CDC 6600 version is written in single precision. In Figs. 23(a-g) a box around a subroutine name indicates that this subroutine calls other subroutines. The names of the subroutines called are given only the first time the name of the calling subroutine appears.

3.1 Flow of Calculations

Overall control in BØSØR4 depends on an integer INDIC. The various types of analyses chosen by the input variable INDIC are listed in Section 1.1. The flow of calculations for each value of INDIC is given in Figs. 24(a), which is a flow chart of the main program, MAIN. Figures 24(b-g) are flow charts of some of the [illegible] subroutines in BØSØR4. Flow charts of PRESTS and STABIL are [illegible] Figs. 17 and 22, respectively. A brief description of the f[illegible] within each overlay follows.

All of the inp[illegible] read in READIT. A call to READIT also causes results of calculat[illegible] printed out. Some general data which pertain to the entire shell [illegible] first. Then for each shell segment the meridian geometry [illegible] ring properties (RGDATA), mechanical and thermal line [illegible] pressure distribution (DISTP), temperature distribution (DIST[illegible] wall properties (WALLCF) are read in. Figure 23(b) show[illegible] subroutines called in the first overlay. The subroutine GASP, w[illegible] several places, causes certain data to be [illegible] disk. These data will be used in the calculations to be [illegible] later overlays. The calculations in the [illegible] precision on both the 1108 and [illegible] in Fig. 24(b).

The nonlinear stress analysis for axisymmetric behavior of axisymmetric systems is performed in the overlay PRE, a flow chart of which is given in Fig. 24(c). The subroutines called from PRE are shown in Fig. 23(c). Data for shell and discrete ring properties, temperature and pressure distributions, and thermal and mechanical line loads are read into core from drum or disk (GASP), "variable" loads are increased or decreased by appropriate increments or decrements (LOADS), the coefficient matrix $\partial U_o/\partial q_i \partial q_j$ and the "right-hand-side" vector $-\partial U_o/\partial q_i$ are derived for the current Newton-Raphson iteration (APREB), the coefficient matrix is factored (FACTR), the equation system is solved for the Δq_j (SOLVE), if iterations fail to converge the load is reset to the last value at which convergence was achieved (UNLOAD), and the prebuckling or prestress stress resultants and stresses are calculated from the converged displacement vector (PREB). These prestress quantities are stored on the drum or disk for later use in the buckling and vibration analysis and for later plotting. Figure 17 gives a flow chart of PRESTS, in which the linear equation system for each Newton-Raphson iteration is set up.

In the next overlay ARRAYS the coefficient matrices corresponding to the buckling analysis, vibration analysis, and linear symmetric and nonsymmetric stress analysis are derived. A flow chart of ARRAYS is given in Fig. 24(d). Figure 23(d) shows all the subroutines called from ARRAYS. If INDIC = 3 the load vector Q is calculated in ARRAYS and the linear system $K_1 x = Q$ is solved for given circumferential wavenumber, N. Depending on INDIC various coefficient matrices are derived. With buckling analyses, for example, three matrices are obtained in ARRAYS for each value of N, the number of circumferential waves: the stiffness matrix K_1 for the composite shell which corresponds to the structure loaded by the "fixed" parts of the loads (see Section 2.5); the "load-geometric" matrix K_2 which contains the linear eigenvalue parameters, and the "λ^2" matrix K_3 which contains the quadratic eigenvalue parameters. These matrices are derived for a given value of the circumferential wavenumber N. Figure 22 gives the flow chart of STABIL. The "fixed" and "variable" prestress matrices PSFIX and PSVAR contain elements which were derived in the overlay PRE and stored on drum or disk. The arrays K_1, K_2, and K_3 are stored on drum or disk in blocks of length IMAXB for use by the next overlay BUCKLE. In modal vibration analysis two matrices are derived in ARRAYS: the stiffness matrix K_1

for the prestressed shell, and the mass matrix M. These arrays are stored on drum or disk in blocks of length IMAXB for later use in overlay BUCKLE.

The linear equation system for the stability or vibration analysis is solved in the overlay BUCKLE, a flow chart of which appears in Fig. 24(e). Figure 23(e) shows all the subroutines which are called by BUCKLE. Subroutine BUCKLE is called for each value of the circumferential wavenumber N. The arrays derived in ARRAYS are read in from drum or disk.

If INDIC = 1 (linear buckling analysis) the eigenvalue problem

$$(K_1 + \lambda K_2 + \lambda^2 K_3)\ \{x\} = 0 \tag{111}$$

is solved for the first NVEC eigenvalues with the correct sign (EBAND). In many structural systems buckling is physically possible with loads of opposite sign than those actually present. Therefore in EBAND eigenvalues which are negative are not counted as "accepted" roots. It is possible, for example, for the user to specify NVEC = 3 and for more than 3 eigenvalues to be obtained. The negative eigenvalues are given (printed out), and orthogonalizations (ØRTHØ) are of course performed with respect to their associated eigenvectors, but calculations will continue until the prescribed number (NVEC) of positive eigenvalues has been determined. With INDIC = 2 the eigenvalue problem to be solved for NVEC eigenvalues is

$$(K_1 - \Omega^2 M)\ \{x\} = 0 \tag{112}$$

in which M is the mass matrix. (M, incidentally, is not diagonal because u_i and v_i are at "half" stations and discrete ring rotatory inertia is included.) This solution occurs in subroutine EBAND2. The procedure for finding the lowest buckling load with nonlinear prebuckling effects included is described in Section 2.6.

Figure 24(f) is a flow chart of the overlay MØDE. In this overlay the solution vectors of the linear stress, buckling, and vibration analyses are processed to provide displacement and stress or stress resultant distributions in the shell and in the discrete rings. Figure 23(f) shows the subroutines which are called from MØDE. Figure 24(g) is a flow chart of the overlay PLOT. In this overlay the data which are printed out from READIT(2) are plotted. Figure 23(g) shows the subroutines which are called from PLØT. These routines are written for the SC4020 plotter.

Section 4

INPUT DATA

4.1 Tables with Input Data

Tables 2-3 give the input data for BØSØR4. The tables show the data names and definitions of the program variables. Further explanation for some of the data variables is provided in Section 1, Tables 1.1 - 1.3, and Section 4.2 below. The tables are presented in the order in which the data are read in. THE FORMAT OF INTEGER VARIABLES (VARIABLES WITH NAMES BEGINNING WITH I, J, K, L, M, N) IS 10I6; THE FORMAT OF FLOATING-POINT VARIABLES IS 6E12.8. Figure 25 shows the general arrangement of a data deck for the BØSØR4 program.

Tables 4-10 show the input data for samples cases 1-7, respectively. Cases 1-6 are shown in Figs. 26-31, respectively; and Case 7 is shown in Fig. 36. The output for these cases is described in Section 6. Reference 3 contains other sample cases, in particular cases based on the complex shell shown in Fig. 1. The input data for these cases are very similar to those for BØSØR4, although it is not identical.

Several of the input data definitions in Table 2 contain the advice "See Section 1.5", or "See Table 1.2", etc. The user must follow this advice, especially during his initial acquaintance with BØSØR4.

4.2 Input Variables which Require Judgment

Some judgment is required in the selection of some of the input quantities listed in Tables 2-3. A knowledge of shell theory is helpful in this regard. These input quantities are given below.

INDIC ... Control integer for type of analysis. It is often advisable in buckling analyses to use INDIC = 1 with a rather wide range for N for the first run through the computer (linear buckling analysis). With this choice NVEC buckling loads are obtained for circumferential wavenumbers from N = NOB to N = NMAXB in steps of INCRB. The user can obtain multiple buckling loads at a given N only with INDIC = 1 and 4. Computer time is often saved in this manner, since the wavenumber corresponding to the minimum load is often not known a priori, even approximately. Also, there are cases for which two minima exist, and the user must find the absolute minimum. With INDIC = -1, only the relative minimum will be found unless more than one case is run, each case with its own range of N.

The capability of finding more than one buckling load at a given N is particularly useful to the designer who wishes to find the buckling allowable of a complex shell such as that shown in Fig. 1. The lowest buckling pressure might correspond to buckling of the cylinder, but at a few psi higher the ogive might buckle. Thus, the designer would not greatly improve the overall structure by strengthening just the cylinder. He must know the loads for which each of the segments buckles when these segments are analyzed as part of a larger structure.

In cases for which two eigenvalues are close together or for which bifurcation buckling loads are close to axisymmetric collapse loads, it is occasionally advisable to use INDIC = -2. In this way the first vanishing point of the stability determinant is approached gradually, and if axisymmetric collapse occurs at higher loads than nonsymmetric buckling, the stability determinant will change sign and the bifurcation buckling load will be determined.

With INDIC = 4 there are two possible flows of calculations: If IPRE = 0 the prebuckling stress resultants N_{10} and N_{20} and the prebuckling meridional rotation χ_0 are read in directly for a certain number, NSTRES, of meridional stations. Linear interpolation is performed internally for calculation of these prebuckling quantities at all of the mesh stations of each segment. Buckling loads (NVEC eigenvalues for each circumferential wave number N) are then calculated for the range NOB to NMAXB in steps of INCRB. If IPRE $\neq$ 0 the prebuckling quantities are calculated from the linear theory for nonsymmetrically loaded shells, just as if INDIC were equal to 3. The user preselects the meridian (value of θ, called THETAS in Table 2) which he feels represents the "worst" prestress from the point of view of stability. For example, a cylinder submitted to external pressure which varies around the circumference will generally buckle where the pressure has the highest amplitude. The BØSØR4 program will use the meridional stress distribution at θ = THETAS in the stability calculations. In the stability analysis the flow of calculations for both cases IPRE = 0 and IPRE $\neq$ 0 is the same as that for INDIC = 1.

NOB, NMINB, NMAXB ... Initial circumferential wave number, minimum wave number, maximum wave number. Judgment is required here in the case of buckling analyses, for which the minimum buckling load with circumferential wave number is being searched for. The computer times goes up approximately linearly with the number of values of wave number N which must be investigated in order to find the minimum. Experimental evidence is of course very useful in determining a good choice of NOB, NMINB, and NMAXB. If none is available the user is advised to try the following formulas:

(1) For monocoque deep shells, axial compression:

$N = [(\text{Nominal circumferential rad. of curv.})/t]^{1/2}(1 - \nu^2)$

(2) For shallow spherical caps supported rigidly at their edges; external pressure

$N = 1.8*\alpha_2*(R/t)^{1/2} - 5$

(3) For axially compressed conical shells and frustrums

Use formula 1 where the circumferential radius of curvature, R, is the average of the curvatures at the ends.

(4) Spherical segments of any depth under axial tension

$N = 1.8*(R/t)^{1/2} \sin [\alpha_1 + 4.2 (t/R)^{1/2}]$

where α_1 and α_2 are the meridional angles at the segment beginning and end, respectively.

(5) "Square" buckles for short shells or panel buckling

$N = \pi r/L$, where L is the shell arc length.

The above list of formulas is by no means complete. However, notice that $(R/t)^{1/2}$ is a significant parameter. If N is known for a shell of a given geometry loaded in a certain way, a new value can be predicted for a new R/t through the knowledge that N often seems to vary as $(R/t)^{1/2}$. (R is the circumferential radius of curvature.) Experience in the use of the program will lead to further competence in the selection of appropriate values for NOB, the initial guess at N. The user must be sure that the input range NMINB $\leq$ N $\leq$ NMAXB includes the minimum minimum buckling load. (see pitalls)

With INDIC = 3 and symmetric and nonsymmetric load harmonics with both sin Nθ and cos Nθ components, the user must include both negative and positive values of N in the range.

With INDIC = 1 or 2 the program calculates buckling loads or vibration frequencies, respectively, for N = NOB through NMAXB or NMINB in increments INCRB. A minimum buckling load with wave number is not sought automatically. That is, INCRB is not changed during the calculations.

INCRB ... Initial value for the increment (or decrement) by which N is increased or decreased in buckling and vibration problems. In the search for the minimum buckling load, for example, one may only be certain that the N corresponding to the minimum buckling load lies in the range $2 \leq N \leq 100$. One might, therefore, choose INCRB = 10 and "zero in" on a more accurate value in an additional run. If INDIC = 3 the value of INCR (positive or negative, magnitude) depends upon which circumferential load harmonics are present.

NVEC ... Number of eigenvalues to be calculated for each value of N. Applies only if INDIC = 1, 2 or 4. The number of eigenvalues to be calculated depends to a great extent on computer time available to the user and the number of mesh points being used in the particular case. If one tries to find many eigenvalues of a system with few degrees of freedom, the higher eigenvalues will not be accurately determined. In general, it is advisable with BØSØR4 to keep NVEC between 1 and 20. BØSØR4 contains an eigenvalue shift capability. Hence, negative eigenvalues are not included as "acceptable" roots, even though they are calculated and printed out. Also there is no loss in accuracy of successive roots as occurs in analyses with no "shifting".

IFIX, IFIXB ... Displacement restraint coefficients. Although most practical shell structures are supported at their ends by discrete rings or other structures which can be modeled as discrete rings, it is often desirable to be able to specify any combination of the displacements u^*, v^*, w^*, and the meridional rotation χ equal to zero at the boundaries of the composite shell. These restraints may be applied even though there is a ring present at the boundary. The displacements can be specified equal to zero at a support point which does not necessarily correspond to the edge of the reference surface. In Fig. 1 is shown a shell which has a support ($u^* = w^* = 0$) at a point "A" which is removed a certain distance from the end of the reference surface meridian.

Certain displacement restraint conditions apply for planes of symmetry in shell structures. In buckling problems if use is made of symmetry conditions one must test for buckling loads corresponding to modes both symmetric and antisymmetric at that end of the shell which corresponds to its plane of symmetry.

If one wishes to analyze a shell with a ring support at a plane of symmetry, one may cut the shell at the ring station and use as ring modulus ER, torsional rigidity GJ, and mass density ρ, one-half the actual quantities. The other ring properties such as AREA, IY, IX, E1, E2 remain unchanged.

D1(I), D2(I) ... Axial, radial discontinuities in meridian between adjacent segments or distances from support points to meridian. The specification of these parameters sometimes depends upon how the [illegible] to construct the model of the actual composite shell structure. A shell with discrete rings, for example, might be modeled as a single segment with the discrete rings considered to be attached at certain points along the meridian. In [illegible] analysis "permits" the shell wall to bend under the [illegible] ring which is attached to it, since the

attachment point is assumed to have zero length. However, the analyst can also treat the same problem as a shell of many segments in which the portions of shell wall in contact with the discrete rings are considered to be parts of the rings. In this case discontinuities exist between the reference surfaces of adjacent segments. In especially important cases the user is urged to model the structure in various ways and to compare the results. It is particularly advantageous to construct the models in such ways as to obtain upper and lower bounds on stresses, buckling loads, and vibration frequencies.

P, DP, TEMP, DTEMP ... "Fixed" pressure, "variable" pressure. "Fixed" temperature rise, "variable" temperature rise. In BØSØR4, if INDIC $\neq$ 3, the pressure distribution on the shell reference surface is given by

P*f(s) or DP*f(s)

where f(s) is the meridional distribution, read in as indicated in Table 2 (P11, P12, etc., PT, PC, etc.). The temperature distribution has an analogous form. TEMP must equal unity and DTEMP = 0 if any shell segment has NWALL = 8 (temperature-dependent material properties).

NPSTAT, NTSTAT ... Number of meridional stations in current shell segment for which pressure, temperature are called out. Arbitrary pressure and temperature distributions are permitted in BØSØR4. The user can supply pressures and temperatures at certain stations on the meridian, and the program will supply the pressures and temperatures at all meridian stations in the finite-difference mesh by linear interpolation. If mechanical/thermal loading are present with INDIC = 3 or 4, NPSTAT/NTSTAT must be ≥ 2.

NTGRAD ... Type of thermal gradient through shell thickness:

NTGRAD	Type of Gradient
1	$T = T1 + T2*z + T3*z^2$
2	$T = T1 + T2*z^{T3}$
3	$T = T1 + T2*\exp(z*T3)$

z is measured from the reference surface, positive in same sense as positive w.

NWALL ... Type of shell wall construction. Judgment may be required here particularly in the case of shells stiffened by rings. In many instances, it may be difficult for the user to decide whether in the analysis to treat the rings as discrete elastic structures or whether to smear them out.

Some experience with shell behavior is a valuable guide, of course. If computer time is no obstacle, then the user is advised to analyze a given shell structure both ways.

In important analyses it is always advisable to set up various models of the structure, which leads to better understanding of the behavior of the system and more confidence in the results. An analysis in which the rings are smeared out leads to prediction of general instability or vibration behavior in which both rings and shells are in motion. Local "panel" buckling or vibration can be predicted only if the rings are treated as discrete. In stress analyses, stress concentrations which occur in the neighborhoods of ring stiffeners can be obtained only if the rings are treated as discrete.

The user will note from Table 2 that two branches are provided for the analysis of layered, orthotropic shell segments, NWALL = 5 and NWALL = 8. With NWALL = 5 the material properties of the layers are regarded as temperature-independent. With this branch the temperature can be treated as an eigenvalue, and buckling temperatures can be calculated. With NWALL = 8, the material properties are regarded as temperature-dependent, and the temperature cannot be an eigenvalue (DTEMP = 0). If NWALL = 8 for any of the shell segments, TEMP must be equal to 1 and DTEMP = 0. The temperature distribution on those segments must be axisymmetric. If INDIC = 3 the N = 0 harmonic must be the first harmonic investigated.

NMESH ... Number of mesh points in a shell segment. The values of NMESH are among the most important variables in the analysis, since they govern, to a large extent, the accuracy of the solution. It is sometimes advisable to vary the mesh spacing in a given shell in order to achieve rapid convergence with increasing numbers of points. A feeling for proper values for NMESH comes with experience. Few points are needed for cases in which the solution is expected to vary slowly along the shell meridian. Points should be concentrated in areas where the solution is expected to vary rapidly. Note that buckling or vibration modal displacements may not necessarily vary rapidly in the same areas as prebuckling quantities. If the accuracy of some numerical results is in doubt one may run the case again with more or with fewer mesh points. A jagged solution for the buckling or vibration mode indicates the need for more mesh points. If one is planning to perform a parameter study based on shells of similar geometries one should choose a sample case and run with different numbers and distributions of mesh points. In this way, the user more or less "optimizes" the computer analysis with respect to accuracy and economy.

NST, NRZIN ... Meridional shape selector within the branch NSHAPE = 4 (general shapes), number of mesh points for curve fit. The geometry parameters r, r', $1/R_2$, $1/R_1$ and $(1/R_1)'$ are calculated in the branch NSHAPE = 4 by a spline fit method. (Subroutines SPLINE, SPLICO). Various meridian shapes are associated with various values of NST. For each value of NST there is an input parameter called NRZIN or ZNUMB. This signifies the number of

points used for the spline fit, and does not have to be the same as the number of mesh points in the current segment NMESH. In most cases, it is advisable to make NRZIN less than NMESH. In any case NRZIN should be greater than about 10. The choices NST = 2 and NST = 5 correspond to meridians with the shapes given by the formulas for R in Fig. 33(d). NST = 2 corresponds to a meridian the shape of which is generated "left-to-right"; NST = 5 corresponds to the same formula, but with the shape generated "right-to-left", as shown in Fig. 33(d). These branches can be used to describe weld sinkages, for example. The user can broaden the applicability by changing the appropriate formula for R in Subroutine SHELL.

NRINGS ... Number of discrete rings in a given segment. It is pointed out here that line loads can be applied only at mesh stations which correspond to discrete ring locations. Hence, the input parameter NRINGS must allow for any "fictitious" rings which correspond to points on the meridian at which line loads are applied, but at which no actual rings exist.

PLIN1(L,ISEG)
PLIN2(L,ISEG)
TLIN (L,ISEG)
PDIST1(L,ISEG)
PDIST2(L,ISEG)
TDIST(L,ISEG)
... Load harmonic amplitudes corresponding to the Lth harmonic to be treated by the program. Note that the circumferential wavenumber N is not necessarily equal to L, since five harmonics (L = 1, 2, 3, 4, 5) may correspond to N = 0, 3, 6, 9, 12, for example. The order in which the harmonics are read in is determined by NSTART, NFIN, INCR, as discussed above. The loads are harmonic functions of the circumferential coordinate θ are given by Eqs. (86), where the Nth harmonics are denoted V_{n1}, S_{n1}, H_{n1}, M_{n1}, etc. and V_{n2}, S_{n2}, H_{n2}, M_{n2}, etc. The subscript "one" corresponds to positive values of N. With N = 0 and N = ± 1 the user must make sure that all of the line loads and pressures for the entire structure are in static equilibrium, since the load components and moments are not self-equilibrating for these wave numbers. The line loads are assumed to act at the centroids of the discrete rings. See Section 1.5, Table 1.3 for further explanation, examples, sign convention.

Section 5

POSSIBLE PITFALLS AND RECOMMENDED SOLUTIONS

The following is a compilation of items which may cause the user of the BØSØR4 program some difficulty. Suggestions are given for overcoming the difficulties.

5.1 Provision of Consistent Input Data

In the initial use of a complex program such as BØSØR4 it is possible that the input data may not be consistent. The user is urged to check carefully the list and plot output for errors in the input data. It is advisable to use the option NPRT = 2 (medium output) for any new investigation. In particular, boundary conditions, position of discrete ring stiffeners, meridian line, line loads and surface loads should be checked. The user must see to it that the input loads are self-equilibrating. Often the best way the user can familiarize himself with the input procedures is to run cases for which he knows the answers beforehand. A check of the mode shapes and stress distributions often reveals possible errors in input. It is emphasized that the user should check the sample cases to see if they can help him to set up a new case.

5.2 Finding the Minimum Buckling Load

The theory on which BØSØR4 is based does not exclude the possibility that several values of circumferential wave number N may be associated with minimum buckling loads. One must always find the minimum minimum. This problem frequently arises in the calculation of buckling loads for complex shells or ring stiffened shells. A ring-stiffened conical shell under external pressure is such a case. Here there could be a minimum buckling load corresponding to general instability and additional minima (at higher values of N) corresponding to the local failure of each conical frustrum (the bays between the rings). Physical intuition is invaluable as a guide to finding the absolute minimum load in this respect. One may idealize each bay of a ring-stiffened shell by assuming that the bay is simply-supported, calculate corresponding "panel" buckling loads with corresponding values of

N (perhaps with linear prebuckling theory in order to save computer time), and then use the critical loads and values of N as starting points in an investigation of the assembled structure. For problems in which it is felt that linear prebuckling theory is rather accurate, one may treat the assembled structure by exploring a wide range of N with INDIC = 1. Further calculations with the critical values of N could then be made in subsequent runs.

5.3 Multiple or Closely-Space Eigenvalues

In the case of ring stiffened shells it may turn out that eigenvalues corresponding to vibration frequencies or buckling loads are close together. This is particularly true of ring stiffened cylinders where the rings are equally spaced and rather stiff in bending compared to the shell bending stiffness. With such a configuration there are many modes in which the motion of the rings is of small amplitude compared to that of the shell. The bays between the rings vibrate at frequencies or buckle at loads which may approximate those corresponding to a simply-supported cylinder of the same geometry as the bay. Multiple or close-spaced eigenvalues correspond to modes in which one or more of the bays is vibrating or buckling while others are unaffected. True multiple eigenvalues are eliminated by use of symmetry and antisymmetry conditions at planes of symmetry in the shell. In eigenvalue problems the user should always analyze as small a segment of shell as possible in order to avoid numerical difficulties associated with multiple eigenvalues.

5.4 Behavior at Apex of Shell

Certain regularity conditions exist at the apex of shells the meridians of which intersect the axis of revolution. These conditions have been satisfied to the extent which the finite difference model permits. Because of the "half-station" spacing of u and v , however, all of the regularity conditions are not satisfied exactly at the apex. This truncation error leads to errors in the local values of the stress resultants in the immediate neighborhood of the apex. The actual stress resultants at the apex can be obtained simply by extrapolating the solution from a region slightly away from the apex in which it is regular.

5.5 Calculation of Same Eigenvalue Twice, Eigenvalues Out of Order

In problems for which the user requires more than about 5 eigenvalues for a given circumferential wave number N, the subroutines EBAND and EBAND2 may occasionally compute the same eigenvalue and eigenvector more than once. It is also possible on occasion that eigenvalues will be calculated out of order or that an eigenvalue will be missed. Unfortunately, there is no way to make an eigenvalue finder based on equations of the type used in the BØSØR4 program 100% reliable. The calculated eigenvalues are always eigenvalues of the system, but occasionally some eigenvalues may be repeated or missed. If it is suspected that an eigenvalue has been missed, it may help to run the case with a different number of mesh points, or to run the same case with a higher value of NVEC.

5.6 Buckling and Vibration of Structures with Planes of Symmetry

A fairly common oversight on the part of a program user is the failure to run a case in which buckling and vibration modes are sought which are antisymmetric with respect to a plane of symmetry. If half a shell or a part of a shell is being analyzed because of the existence of planes of symmetry, then the analyst must check for buckling and vibration both symmetrical and antisymmetrical with respect to the planes of symmetry.

5.7 Thermal Buckling in Cases with Weak Temperature Dependence

Consider a shell with combined external pressure and a temperature distribution. It is desired to find the combination of pressure and temperature which cause buckling. Either the pressure or the temperature or both can be considered variable (eigenvalue parameters) or constant. In some cases buckling may be due almost entirely to the pressure, with variations in the temperature having little effect. This would be the case in a long cylinder with external pressure in which the cylinder is free to expand in the axial direction but restrained radially near the edges. The temperature rise causes local hoop compression near the edges, but the buckling mode corresponding to pressure as the eigenvalue has a maximum amplitude away from the edges. Hence, the temperature has little effect on the buckling load. If the temperature is considered to be the eigenvalue and the pressure is held constant, it is possible

that no eigenvalue will be found, indeed that one may not exist. In cases in which both mechanical and thermal loads are present it is advisable to consider the mechanical loads to be the eigenvalues and to determine the effect of temperature by the performance of a parameter study with temperature as the parameter.

5.8 Stress Resultant or Stress Discontinuities at Junctures and Boundaries

Stress resultants and stresses need not be continuous at segment junctures in all cases, of course. However, the user of BOSOR4 will notice that for some cases in which these quantities should be continuous there exist small discontinuities right at junctures. These discontinuities arise from the fact that the finite-difference energy method leads to larger truncation errors at boundaries than inside domains. If the user is particularly interested in stress at a juncture or boundary, it is urged that he concentrate mesh points in this area to minimize truncation error. In any case, the BOSOR4 program is written so as to minimize the effect of boundary truncation error. The stress resultants are "corrected" as described on pages 172 and 173 of Ref. 15. In addition, "extra" mesh points are automatically inserted near the points on junctures and boundaries in order to make the truncation error as small as is feasible without encountering difficulties associated with precision round-off error. This feature is more completely described in Section 6.

5.9 Nonconvergence of Inverse Power Iteration Method

In certain cases the inverse power iteration method for finding real eigenvalues may not converge. The reason for lack of convergence is usually that complex roots are present corresponding to the eigenvalue problem

$$(K_1 + \lambda K_2 + \lambda^2 K_3)x = 0 \tag{37}$$

An example is buckling of a simply-supported flat plate with uniform lateral load. The prebuckling behavior of the plate is very nonlinear, and there are large meridional rotations at the edge of the plate where destabilizing hoop compressive forces occur. Another example is a uniformly heated cylinder

simply supported at its edges. The local restraint near the edges causes hoop compressive stresses to develop. These destabilizing stresses occur in the neighborhoods of the edges where the meridional rotations are large. In both of these examples the large meridional rotations cause K_3 to be of greater importance in relation to K_1 and K_2 than is usually the case. In situations such as these complex roots are present and generally prevent convergence of the inverse power iteration method as formulated in Eq. (37). The BØSØR4 program is written such that if, during inverse power iterations, the sign of the eigenvalue changes 5 times or more, the solution is automatically attempted with the prebuckling rotations set equal to zero. If the user desires a solution of a case including prebuckling rotations for which the presence of complex roots prevent convergence, he is urged to use the INDIC = -2 option.

5.10 Correct Modeling of Discrete Rings

It has been common in past analysis to neglect out-of-plane bending stiffness (terms involving I_x) and torsional stiffness (terms involving GJ) in the analysis of shells with discrete rings. The user is cautioned not to neglect these terms, in particular not to neglect the out-of-plane bending stiffness of the discrete rings (I_x). Such neglect may lead to very low estimates of the buckling loads, particularly in cases in which the ring is prestressed in compression and in which its centroid is located at several shell thicknesses away from the reference surface. Note also, that if the web of the ring is very thin in comparison with its length (height), the composite shell-ring structure may fail by crippling of "sidesway" of the web. These failure modes can be predicted by treatment of the webs as shell branches rather than as parts of the discrete rings.

Section 6

DESCRIPTION OF BØSØR4 OUTPUT

In this section a glossary is given and the output corresponding to the seven test cases shown in Figs. 26-31 and Fig. 36 is described.

6.1 Nomenclature of the BØSØR4 Output

ALPHA1	angle from axis to beginning of spherical segment (degrees)
ALPHA2	angle from axis to end of spherical segment (see Fig. 3)
ALPHAT	distance from axis to ctr. curvature of spherical segment
AREA	discrete ring cross-section area (in.^{2})
BETA	meridional rotation, denoted χ in analysis
CHIO	prebuckling rotation χ_o
CUR1	meridional curvature, $1/R_1$ (in.$^{-1}$)
CUR2	normal circumferential curvature, $1/R_2$ (in.$^{-1}$)
CUR1D	s-derivative of meridional curvature, $(1/R_1)'$ (in.$^{-2}$)
DET	stability determinant "mantissa": Determinant = DET*10^{NEX}
DH	"variable" radial line load or radial line load increment (lbs/in) (Fig. 21)
DM	"variable" meridional moment, or meridional moment increment (in-lb/in) (Fig. 21)
DP	"variable" pressure multiplier, or pressure increment multiplier (psi), positive internal
DTEMP	"variable" temperature rise multiplier, or temperature rise increment multiplier
DV	"variable" axial line load or axial line load increment (lbs/in) (Fig. 21)
EIGENVALUE	Meaning depends upon case. See sample output.
ER	discrete ring modulus of elasticity (psi)
E1	discrete ring radial eccentricity (in.) (Fig. 21)
E2	discrete ring axial eccentricity (in.) (Fig. 21)
GJ	discrete ring torsional rigidity (lb-in^2)
H	"fixed" or initial radial line load (lbs/in) (Fig. 21)
ITER	number of Newton-Raphson iterations for convergence of nonlinear axisymmetric stress analysis to within 0.1%

IX	discrete ring moment of inertia about x-axis (in^4) (Fig. 21)
IY	discrete ring moment of inertia about y-axis (in^4) (Fig. 21)
IXY	discrete ring product of inertia (in^4)
M	"fixed" or initial meridional line moment (in-lb/in) (Fig. 21)
M10, M20	prestress or prebuckling meridional, circumferential moment resultants, positive as shown in Fig. 35 (in-lb/in)
M1, M2, MT	linear stress analysis meridional, circumferential, twisting moment resultants, positive as shown in Fig. 35 (in-lb/in)
N10, N20	prestress or prebuckling meridional, circumferential, resultants (lb/in) (Fig. 35)
N	circumferential wave number
NEX	exponent for stability determinant (see DET)
P	pressure multiplier, positive internal (psi)
PU, PV, PW	p_1, p_2, p_3 in Fig. 35: meridional, circumferential, normal outward pressure components (psi) for given wave number N
PND	derivative of normal pressure with respect to arc length s
RADIUS	same meaning as ROT in Fig. 32(b) (in)
RAD	radius of parallel circle, r, in Fig. 35 (in)
RADD	derivative of r with respect to arc length s (r′)
RC	radius of discrete ring measured to centroid (in.)
RM	ring material mass density ($lb\text{-}sec^2/in^4$)
S(K)	arc length to kth discrete ring from "A" end of reference surface (in)
SHEAR	applied shear line load, Fig. 21 (lb/in)
SIGMA1(IN), S1(IN)	inner fiber meridional stress (psi)
SIGMA1(OUT), S1(OUT)	outer fiber meridional stress (psi)
SIGMA2(IN), S1(IN)	inner fiber circumferential stress (psi)
SIGMA2(OUT), S2(OUT)	outer fiber circumferential stress (psi)
SIGMAE(IN), SVON(IN)	inner fiber von Mises "effective" stress (psi)
SIGMAE(OUT), SVON(OUT)	outer fiber von Mises "effective" stress (psi)
TEMP	"fixed" or initial temperature rise multiplier
TMR	"fixed" or initial thermal line moment about x-axis M_x^T

"Inner" fiber on left side of increasing arc length. Outer fiber on right side.

TMRX	"fixed" or initial thermal line moment about y-axis M_y^T
TNR	"fixed" or initial thermal hoop force N_r^T
TN1, TN2	meridional, circumferential thermal stress resultants N_1^T , N_2^T
TM1, TM2	meridional, circumferential thermal moment resultants M_1^T , M_2^T
U, UO	meridional displacement component (modal or linear stress analysis, prestress analysis) as shown in Fig. 35 (in)
UV, USTAR	axial displacement (u^* in Fig. 20) for prestress analysis (in)
V, VSTAR	circumferential displacement component v, v^* in nonsymmetric analysis (in) (Fig. 35)
V	"fixed" or initial axial line load (lb/in) (Fig. 21)
W, WO	normal outward displacement component (modal or linear stress analysis, prestress analysis) as shown in Fig. 35 (in)
WSTAR	radial displacement w^* (Fig. 20)
Z	distance from shell inner surface to reference surface (in)

6.2 Description of Computer Output from BØSØR4

The output from BØSØR4 consists of print output and SC4020 plot output. Seven cases are described in this section. These cases correspond to the types of analyses INDIC = -2, -1, 0, 1, 2, 3, and 4. The structures being analyzed and some results are shown in Figs. 26-31 and Fig. 36. The list and plot output for these seven cases is given in Appendix A. The input data are given in Tables 4-10 (Appendix B).

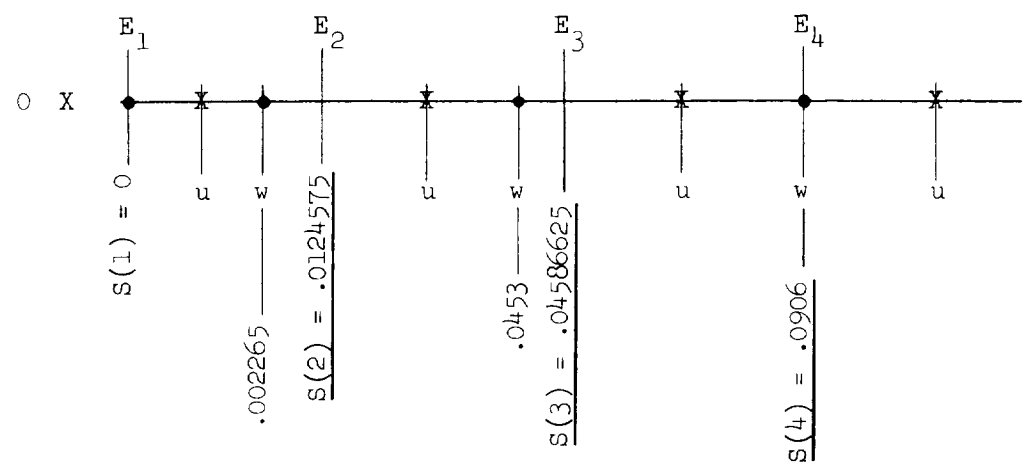
Case #1: Aluminum Frame Buckling

Figure 26 shows the problem. The input data are listed in Table 4. This case exercises the INDIC = 1 option. It represents a general buckling and crippling analysis of a "T"-shaped frame, and illustrates the phenomenon of more than one minimum in the "plot" of buckling load vs. circumferential wave number.

The frame is treated as a branched "shell" of three segments, the geometry of which is given (with constraint conditions) on the first three pages (A1) - (A3) of output. The user will notice that each segment has two mesh points more than the number provided as input (see values for NMESH in Table 4).

Two additional w-points (see Fig. 3) are "inserted" automatically between the first and second and last and second-to-last points in each segment. This measure is taken in order to reduce the truncation errors associated with boundaries and to prevent spurious modes associated with the fictitious points (see Ref. 15). If h is the original mesh spacing at the edges, the "extra" w-points are located at h/20 in from the edges. It is emphasized that the user does not need to consider these extra points in making up a case. All quantities are automatically "shifted" to account for the internal change.

It is important to point out that the "stations" and "arc lengths" printed out on Page A2 refer to the points at which the energy density E is evaluated (see Fig. 3), and not in general to the "w" mesh points. Each "energy point" is located half-way between adjacent "u-points". As seen from the sketch below, if the mesh spacing varies, as it does at the ends of each segment, the "energy points" do not coincide with the "w-points" in regions of varying spacing.



The positions of the first four stations, S(1) - S(4) in this case are shown in the above sketch. All of the output quantities correspond to the "energy stations" E_i. In addition, discrete rings are assumed to be attached at the "energy stations", and not at the "w-points". Branch

locations also correspond to "energy points", and not to "w-points".

Page A4 gives data related to the constraint conditions. Two sets of data appear: those corresponding to the axisymmetric prestress problem, and those corresponding to the nonsymmetric bifurcation buckling problem. "Types of Constraint" refers to the discussion on Pages 2-14 and 2-15. This data need be looked at only if the user suspects a bug in the input or in the program itself.

The end of Pages A4 and A5 shows the prestress distribution corresponding to the "fixed" or "initial" components of the loads, that is, corresponding to P and TEMP (and line loads V, H, and M, if such were present). Pages A6 and A7 show the "total" prestress state, that is the prestress quantities N_{10}, N_{20}, and χ_o which correspond to loads P+DP and TEMP+DTEMP (also V+DV, H+DF, M+DM, if such were present). The prestress distributions corresponding to the predicted buckling loads λ are given by:

$$
\begin{aligned}
N_{10_{cr}} &= \left(N_{10_{tot}} - N_{10_{fixed}}\right)\lambda + N_{10_{fixed}} \\
N_{20_{cr}} &= \left(N_{20_{tot}} - N_{20_{fixed}}\right)\lambda + N_{20_{fixed}} \\
\chi_{o_{cr}} &= \left(\chi_{o_{tot}} - \chi_{o_{fixed}}\right)\lambda + \chi_{o_{fixed}}
\end{aligned}
\tag{113}
$$

in which subscript "fixed" denotes the quantities listed on Page A5 and "tot" denotes the quantities listed on Pages A6 and A7.

The output on Page A7 has to do with calculation of the matrices K_1, K_2, and K_3 [Eq. (37)], which is done in the overlay ARRAYS (Fig. 23a), and calculation of the lowest eigenvalue, which is done in the overlay BUCKLE (Figs. 23a, 23e). All of these calculations correspond to two circumferential waves. The line "9 NEGATIVE ROOTS FOR SHIFT, AXT = 0.00000" may help the user

to determine if any eigenvalues (roots) have been missed. In this case there are nine negative roots for zero shift because there are nine Lagrange multipliers associated with the nine "non-zero" constraint conditions (see integers listed under USTAR VSTAR WSTAR BETA on page A1). The quantity of negative roots for zero shift should always be equal to the quantity of "ones" listed under USTAR VSTAR WSTAR BETA for the stability and vibration and nonsymmetric stress constraint conditions. If several eigenvalues are to be calculated for each wavenumber N, and if the user discovers that a root has been skipped, the lines "9 negative roots ..." can be used with the shifts, AXT to bracket the missing roots, if any. The statement "THERE ARE 1 EIGENVALUES BETWEEN .000 AND .4258846+03" will tell the user if all of the roots in a given load range have been found. This number of roots should equal the input value, NVEC.

The buckling eigenvalues λ and mode shapes for N = 2, 6, 10, and 14 waves are given on pages A7 to A13. The user can see that N = 2 corresponds to overall "ovalization" of the ring with virtually no distortion of the ring cross-section. The buckling load q for this type of deformation is approximately

$$L_1\lambda = q = EI(N^2 - 1)/r_c^3 \tag{114}$$

in which L_1 is the length of the first segment (L_1 = .453 in Fig. 26) over which the uniform pressure is applied. The buckling loads for higher values of N correspond to crippling of the web (Segment 2).

The SC4020 plots for this case are shown with the list output of the modes. The displacements for the three segments are plotted in series, even though the structure is branched.

Case #2: Buckling of Hydrostatically Compressed Cylinder

This case provides a test of the INDIC = -1 branch of the program for the shell shown in Fig. 27 and the input data are listed in Table 5. Notice on pages A14 and A15 that two sets of constraint conditions are given. The first set corresponds to the axisymmetric prebuckling conditions, in which the axial displacement u^* is permitted at the beginning of the shell (s=0).

The second set corresponds to the buckling constraint conditions, in which the shell is assumed to be clamped at s = 0. Symmetry conditions are used at mesh station #80 both in the prebuckling and in the stability analyses. Pages A15 to A21 give geometrical data and physical properties of the system, which is treated as a branched shell as shown in Fig. 27. (The frame flanges are treated as discrete rings, not as flexible shell segments.)

Prebuckling behavior is determined for the "fixed" loads (P = 0.0) and for the "fixed" + "variable" loads (P + DP = -1.0, V+ DV = -.5075). The load summary is given on page A22.

A search for the minimum buckling load with circumferential wave number N is being made on page A23, with the prestress distribution corresponding to zero "fixed" loads and a "variable" pressure of -1.0 psi and "variable" axial load of -.5075 lb/in (hydrostatic line load = pr/2). The three eigenvalues 1104.97, 1475.91, and 1301.55 correspond to the three points labeled (1), (2), and (3) in Fig. 27. At the end of page A23 a new estimate of the buckling hydrostatic pressure p = -1104.973 psi corresponding to N = 4 is available, and prestress quantities N_{10}, N_{20}, and χ_o are calculated from the nonlinear axisymmetric analysis for p and p + p/1000 (top of A24). The new load step is p/1000, or about -1.1 psi. The new eigenvalue is -2.875, which, when multiplied by the load step, gives a correction to p which is less than 0.5% of p. The process is thus judged to have converged, and the prebuckling distributions and buckling mode are listed on pages A25 through A29.

Pages A27 - A29 also show the SC4020 plots of the prebuckling quantities and buckling mode. Again the quantities are plotted as if the segments were arranged in series rather than branched.

Case #3: Nonlinear Analysis of a Uniformly Loaded Flat Circular Plate

This case is a test of the INDIC = 0 branch of the program - nonlinear axisymmetric stress analysis for a series of load steps. Figure 28 shows the problem with some results and the input data are listed in Table 6. The first constraint condition (Page A30) corresponds to a "pole" - the center of the flat circular plate, which is on the axis of revolution. In this case NPRT = 2, so that we expect more output than the minimum corresponding to

NPRT = 1. The additional output consists of printout of the wall stiffness coefficients C_{ij} (A31) and printout of computer times and Newton-Raphson iteration numbers in the nonlinear analysis (A33-A34). In buckling and vibration analyses the NPRT = 2 output option provides similar tracking of computer times for formation of stiffness matrices, factoring, and inverse power iterations. The user is advised to use NPRT = 2 until he is thoroughly familiar with BØSØR4. The displacements, stress resultants and stresses for the two load steps given on pages A32 and A33 are listed on pages A35 and A38. The SC4020 plot output is shown on pages A36 and A37. In the plots one can clearly see the effects of boundary truncation error referred to in Section 5.8.

Case #4: Cylinder with Three Point Loads

This case is a test of the INDIC = 3 branch of BØSØR4 - linear, non-symmetric stress analysis. The problem with some results is shown in Fig. 29 and the input data listed in Table 7. Advantage is taken of the symmetry plane at s = 240". The user can look at page A43 to see how a discrete ring at a symmetry plane is handled.

In addition to providing a test of the INDIC = 3 branch of BØSØR4, this case is included to demonstrate the use of BOSOR4 for analysis of point-loaded shells and to illustrate the treatment of loads which repeat at a number of stations around the circumference. In this particular case the load can be expanded in a Fourier series in the interval $-\pi/3 \le \theta \le \pi/3$ ($L = \pi/3$). Page A41 shows the input load distribution in that interval. (Only the plus θ coordinates and loads need be read in, since we know that the function is even; see input data in Table 7.) The range of circumferential wave numbers N is negative, since we have a Fourier cosine series for the radial load H. (See Eqs. (86) and pages 2-32, 2-33.) Also, we know in advance that only every third N contributes to the Fourier series for the load distribution shown in Fig. 29. The calculated Fourier harmonics corresponding to the input load distribution are given on page A41. In this case the minimum output option NPRT = 1 is used; with NPRT = 2 the user obtains the summed-up Fourier series of the loads.

Page A42 gives the distance of the reference surface from the inner surface and the thickness. Pages A43 through A46 give the line mechanical

and thermal loads for all harmonics to be processed. The constraint condition data follow immediately. Virtually all of the machine calculations are being performed while pages A46 and A47 are being printed out.

On pages A48 to A53 the meridional distributions of displacements and extreme fiber stresses for $\theta = 0$, 10, 20, 35, and 60 degrees are printed out. On pages A53 to A56 the circumferential distributions for $0 \leq \theta \leq$ THETAM for various meridional stations are printed out. Page A58 gives the force and moment distribution in the discrete ring. Page A57 shows the SC4020 plots. Notice the very large change in mesh spacing within the segment.

Case #5: Free Hemisphere Vibration

This case represents a test of the INDIC = 2 branch of BØSØR4. The problem is shown in Fig. 30 and the input data listed in Table 8. The eigenvalues (frequencies in cycles/second), generalized masses, and mode shapes are given on pages A63 through A75. SC4020 plots of the eigenvectors are also given.

The generalized mass is calculated from

$$G_{mass} = (\phi_n^T M \phi_n) \tag{115}$$

in which ϕ_n is the normalized mode shape corresponding to N circumferential waves, and M is the mass matrix calculated in subroutine STABIL.

Test Case #6: Buckling of Cone Heated on Axial Strip

This case represents a test of the INDIC = 4 branch of BØSØR4 - buckling of a nonsymmetrically loaded shell. The problem is shown in Fig. 31 and the input data listed in Table 9. It is similar to Test Case #9 in the BØSØR3 User's Manual (Ref. 3), except that here advantage is taken of the variable mesh spacing capability of BØSØR4 and the shell is run as consisting of one segment.

The temperature rise distribution is given by $T = f(s)g(\theta)$ in which $g(\theta)$ is computed in Subroutine GETY, written especially for this run and listed below:

```
      SUBROUTINE GETY(NX,XMINUS,XPLUS,YMINUS,YPLUS)
      DIMENSION XMINUS(100),XPLUS(100),YMINUS(100),YPLUS(100)
      DO 10 I = 1,NX
      YPLUS(I) =        EXP(-12.0*XPLUS(I)**2)
   10 YMINUS(I) = YPLUS(I)
      RETURN
      END
```

The meridional distribution $f(s)$ is read in at certain stations from the experimental data given in Fig. 31 (see Table 9).

Twenty harmonics (N = 0 to -19 in steps of -1) are used for calculation of the prebuckling stress state. Negative N is used because the function $g(\theta)$ is even and therefore to be expanded in a Fourier cosine series.

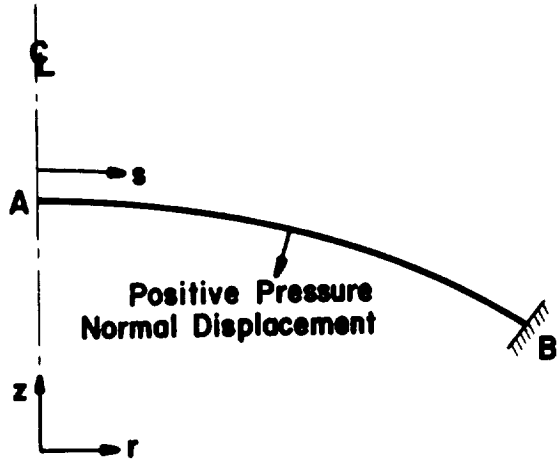
The eigenvalues given on page A86 are factors to be multiplied by the input temperature rise distribution in order to obtain the distribution corresponding to buckling with 20 circumferential waves. No distinction is made in the INDIC = 4 branch between "fixed" and "variable" loads. All loads are treated as if multiplied by the eigenvalue λ.

The mode shapes follow on pages A87 through A92. SC4020 plots are also given of the prestress and the modes.

Test Case #7: Bifurcation Buckling of Shallow Cap

This case represents a test of the INDIC = -2 branch of BØSØR4 - a "plot" of the stability determinant with increasing load, with subsequent change of INDIC to -1 upon a change in sign of the determinant. Nonlinear prebuckling effects are included.

Note on Page A94 that the curvatures CUR1 and CUR2 are negative. This geometry corresponds to the sketch below, in which increasing s is clockwise about the center of meridional curvature. Positive pressure is in this case "external" to the shell in a physical sense. Note from the output that the pressure multiplier, P, is positive. From the input cards (Table 10) it can be seen that the pressure distribution function, P11, etc. is also positive. It can be seen (Pages A97-A98) that the determinant



changes sign between 26 and 30 psi. From linear interpolation, based on the determinant values +12.837 and -10.548, a new load guess of 28.19572 psi is tried, and INDIC is changed to -1. On Page A99 appear eigenvalues corresponding to the problem

$$(K_1 + \lambda K_2 + \lambda^2 K_3)\ x = 0$$

in which K_1 is the stiffness matrix for the shell loaded by a pressure of 28.19572; K_2 is the load-geometric matrix for a load increment equal to 30.00000 - 28.19572 = .180428 psi (see Page A98); and K_3 is the "prebuckling rotation-squared" matrix, also corresponding to a pressure increment of .180428 psi. The lowest eigenvalue is -.0433571 corresponding to two circumferential waves, and the new estimate of buckling pressure is 28.11749 psi. An increment of $1/1000^{th}$ of 28.11749 is added to this estimate; the nonlinear prebuckling equations are again solved; and a new eigenvalue problem $(K_1 + \lambda K_2 + \lambda^2 K_3)\ x = 0$ is solved. This time K_1 is the stiffness matrix at 28.11749 psi and K_2 and K_3 correspond to a pressure increment of .028117. The eigenvalue is small enough ($|\lambda * DP| < |.005 * P|$) such that the pressure 28.14561 is accepted as the buckling pressure.

Section 7

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APPENDIX A

SAMPLE CASES OUTPUT

```
BEGINNING OF NEXT CASE

ALUMINUM FRAME BUCKLING.

STABILITY ANALYSIS WITH LINEAR BENDING PREBUCKLING
ANALYSIS. BUCKLING LOADS CALCULATED FOR NO.LT.N.LT.NM
AX.

ANALYSIS TYPE =   1, PRINT OPTION = 1, PLOT OPTION = 0, STRESS OPTION = 0, PRESTRESS CALCULATION OPTION = 1

  NUMBER OF SHELL SEGMENTS =  3

STRESS CALCULATED FOR CIRCUMFERENTIAL WAVES FROM      0 TO      0 IN INCREMENTS OF      1

INITIAL BUCKLING OR VIBRATION WAVE NO.=     2, MINIMUM WAVE NO.=     2, MAXIMUM WAVE NO.=    16, INCREMENT=     4

   1 EIGENVALUES SOUGHT FOR EACH CIRCUMFERENTIAL WAVE NUMBER.

                                        CONSTRAINT CONDITION DATA FOLLOW

SEG. POINT CONNECTED TO SEG. POINT     USTAR VSTAR WSTAR  BETA     RADIAL DISC. D1(I)   AXIAL DISC. D2(I)

  1     1                1     1        1     0     0     0       0.00000000           0.00000000
  1     6                2     1        1     1     1     1       0.00000000           0.00000000
  2    10                3     4        1     1     1     1       0.00000000           0.00000000

PRESSURE MULTIPLIER P =   0.0000   , INCREMENT DP=  -1.0000+00, TEMPERATURE MULT.TEMP=   0.0000   , INCREMENT DTEMP=  0.0000

INITIAL LOAD, FSTART =   0.0000   , MAXIMUM LOAD, FMAX =  -1.0000+00, STEP SIZE, DF=  -1.0000+00

SEGMENT NO.  1 IS A CYLINDER OR CONE.
    END POINT COORDINATES (  .5218+01,  .0000   ) AND (  .5218+01,  .4530+00)
                                        REFERENCE SURFACE GEOMETRY FOR SEGMENT NO.    1
```

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STATION	ARC LENGTH	RAD	RADD	CUR1	CUR2	CURID	Z
1	.00000000	.52180000+01	.00000000	.00000000	.19164431+00	.00000000	.00000000
2	.12457500-01	.52180000+01	.00000000	.00000000	.19164431+00	.00000000	.00000000
3	.45866249-01	.52180000+01	.00000000	.00000000	.19164431+00	.00000000	.00000000
4	.90599999-01	.52180000+01	.00000000	.00000000	.19164431+00	.00000000	.00000000
5	.13590000+00	.52180000+01	.00000000	.00000000	.19164431+00	.00000000	.00000000
6	.18120000+00	.52180000+01	.00000000	.00000000	.19164431+00	.00000000	.00000000
7	.22650000+00	.52180000+01	.00000000	.00000000	.19164431+00	.00000000	.00000000
8	.27180000+00	.52180000+01	.00000000	.00000000	.19164431+00	.00000000	.00000000
9	.31710000+00	.52180000+01	.00000000	.00000000	.19164431+00	.00000000	.00000000
10	.36240000+00	.52180000+01	.00000000	.00000000	.19164431+00	.00000000	.00000000
11	.40713374+00	.52180000+01	.00000000	.00000000	.19164431+00	.00000000	.00000000
12	.44054249+00	.52180000+01	.00000000	.00000000	.19164431+00	.00000000	.00000000
13	.45299999+00	.52180000+01	.00000000	.00000000	.19164431+00	.00000000	.00000000

PHYSICAL PROPERTIES OF SEGMENT NO. 1

ANALYSIS IS FOR A MONOCOQUE SHELL

MODULUS OF ELASTICITY= .10800+08 POISSON RATIO= .33300+00 SHELL DENSITY = .00000 THERMAL EXP COEF.= .00000

MESH POINT	STATION	REF. SURFACE	THICKNESS
1	0.00000	0.00000	1.82000-01
2	1.24575-02	0.00000	1.82000-01
3	4.58662-02	0.00000	1.82000-01
4	9.06000-02	0.00000	1.82000-01
5	1.35900-01	0.00000	1.82000-01
6	1.81200-01	0.00000	1.82000-01
7	2.26500-01	0.00000	1.82000-01
8	2.71800-01	0.00000	1.82000-01
9	3.17100-01	0.00000	1.82000-01
10	3.62400-01	0.00000	1.82000-01
11	4.07134-01	0.00000	1.82000-01
12	4.40542-01	0.00000	1.82000-01
13	4.53000-01	0.00000	1.82000-01

SEGMENT NO. 2 IS A CYLINDER OR CONE,
END POINT COORDINATES (.5218+01, .0000) AND (.4882+01, .0000)

REFERENCE SURFACE GEOMETRY FOR SEGMENT NO. 2

STATION	ARC LENGTH	RAD	RADD	CUR1	CUR2	CURID	Z
1	.00000000	.52180000+01	-.10000000+01	.00000000	.00000000	.00000000	.75000000-02
2	.10266665-01	.52077333+01	-.10000000+01	.00000000	.00000000	.00000000	.75000000-02
3	.37799995-01	.51802000+01	-.10000000+01	.00000000	.00000000	.00000000	.75000000-02
4	.74666657-01	.51433334+01	-.10000000+01	.00000000	.00000000	.00000000	.75000000-02
5	.11199999+00	.51060001+01	-.10000000+01	.00000000	.00000000	.00000000	.75000000-02
6	.14933331+00	.50686667+01	-.10000000+01	.00000000	.00000000	.00000000	.75000000-02
7	.18666664+00	.50313334+01	-.10000000+01	.00000000	.00000000	.00000000	.75000000-02
8	.22399997+00	.49940001+01	-.10000000+01	.00000000	.00000000	.00000000	.75000000-02

9	.26133330+00	.49566667+01	-.10000000+01	.00000000	.00000000	.00000000	.75000000-02
10	.29819996+00	.49198000+01	-.10000000+01	.00000000	.00000000	.00000000	.75000000-02
11	.32573329+00	.48922668+01	-.10000000+01	.00000000	.00000000	.00000000	.75000000-02
12	.33599995+00	.48820001+01	-.10000000+01	.00000000	.00000000	.00000000	.75000000-02

PHYSICAL PROPERTIES OF SEGMENT NO. 2

ANALYSIS IS FOR A MONOCOQUE SHELL

MODULUS OF ELASTICITY= .10800+08 POISSON RATIO= .33300+00 SHELL DENSITY = .00000 THERMAL EXP COEF.= .00000

MESH POINT	STATION	REF. SURFACE	THICKNESS
1	0.00000	7.50000-03	1.50000-02
2	1.02667-02	7.50000-03	1.50000-02
3	3.78000-02	7.50000-03	1.50000-02
4	7.46667-02	7.50000-03	1.50000-02
5	1.12000-01	7.50000-03	1.50000-02
6	1.49333-01	7.50000-03	1.50000-02
7	1.86667-01	7.50000-03	1.50000-02
8	2.24000-01	7.50000-03	1.50000-02
9	2.61333-01	7.50000-03	1.50000-02
10	2.98200-01	7.50000-03	1.50000-02
11	3.25733-01	7.50000-03	1.50000-02
12	3.36000-01	7.50000-03	1.50000-02

SEGMENT NO. 3 IS A CYLINDER OR CONE,
END POINT COORDINATES (.4882+01, .0000) AND (.4882+01, .8900-01)

REFERENCE SURFACE GEOMETRY FOR SEGMENT NO. 3

STATION	ARC LENGTH	RAD	RADD	CUR1	CUR2	CUR1D	Z
1	.00000000	.48820000+01	.00000000	.00000000	.20483408+00	.00000000	.15000000-01
2	.40791666-02	.48820000+01	.00000000	.00000000	.20483408+00	.00000000	.15000000-01
3	.15018750-01	.48820000+01	.00000000	.00000000	.20483408+00	.00000000	.15000000-01
4	.29666666-01	.48820000+01	.00000000	.00000000	.20483408+00	.00000000	.15000000-01
5	.44499999-01	.48820000+01	.00000000	.00000000	.20483408+00	.00000000	.15000000-01
6	.59333332-01	.48820000+01	.00000000	.00000000	.20483408+00	.00000000	.15000000-01
7	.73981248-01	.48820000+01	.00000000	.00000000	.20483408+00	.00000000	.15000000-01
8	.84920830-01	.48820000+01	.00000000	.00000000	.20483408+00	.00000000	.15000000-01
9	.88999996-01	.48820000+01	.00000000	.00000000	.20483408+00	.00000000	.15000000-01

PHYSICAL PROPERTIES OF SEGMENT NO. 3

ANALYSIS IS FOR A MONOCOQUE SHELL

MODULUS OF ELASTICITY= .10800+08 POISSON RATIO= .33300+00 SHELL DENSITY = .00000 THERMAL EXP COEF.= .00000

```
AXISYMMETRIC PRESTRESS INPUT CONSTRAINT CONDITIONS FOLLOW

CONSTRAINT NO.   1 SEGMENT NO.   1 POINT   1 CONNECTED TO SEGMENT NO.  1 POINT   1.. TYPE OF CONSTRAINT =  1
CONSTRAINT NO.   2 SEGMENT NO.   1 POINT   7 CONNECTED TO SEGMENT NO.  2 POINT   1.. TYPE OF CONSTRAINT =  4
CONSTRAINT NO.   3 SEGMENT NO.   2 POINT  12 CONNECTED TO SEGMENT NO.  3 POINT   5.. TYPE OF CONSTRAINT =  4

LOCAL MATRIX DIMENSION=  5 OVERLAP=  3 NO. CONSTRAINT CONDS. PER CONSTRAINT POINT=  3 SYSTEM RANK=   86 NUMBER OF BLOCKS=   1

NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  1 EQUALS  32 .  NO. OF CONSTRAINT PTS. EQUALS    1
NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  2 EQUALS  30 .  NO. OF CONSTRAINT PTS. EQUALS    1
NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  3 EQUALS  24 .  NO. OF CONSTRAINT PTS. EQUALS    1
BLOCK NUMBER=  1 LAST EQ. IN BLOCK=  86 LOWEST UNK IN BLOCK=    1, MAX. OFF-DIAGONAL WIDTH=  24


STABILITY, VIBRATION OR NON-SYMMETRIC STRESS INPUT CONSTRAINT CONDITIONS FOLLOW

CONSTRAINT NO.   1 SEGMENT NO.   1 POINT   1 CONNECTED TO SEGMENT NO.  1 POINT   1.. TYPE OF CONSTRAINT =  1
CONSTRAINT NO.   2 SEGMENT NO.   1 POINT   7 CONNECTED TO SEGMENT NO.  2 POINT   1.. TYPE OF CONSTRAINT =  4
CONSTRAINT NO.   3 SEGMENT NO.   2 POINT  12 CONNECTED TO SEGMENT NO.  3 POINT   5.. TYPE OF CONSTRAINT =  4

LOCAL MATRIX DIMENSION=  7 OVERLAP=  4 NO. CONSTRAINT CONDS. PER CONSTRAINT POINT=  4 SYSTEM RANK=  126 NUMBER OF BLOCKS=   1

NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  1 EQUALS  47 .  NO. OF CONSTRAINT PTS. EQUALS    1
NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  2 EQUALS  44 .  NO. OF CONSTRAINT PTS. EQUALS    1
NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  3 EQUALS  35 .  NO. OF CONSTRAINT PTS. EQUALS    1
BLOCK NUMBER=  1 LAST EQ. IN BLOCK= 126 LOWEST UNK IN BLOCK=    1, MAX. OFF-DIAGONAL WIDTH=  35

DATA READ IN AND PROCESSED FOR THIS CASE. LEAVING SUBROUTINE READIT


ENTERING SUBROUTINE PRE, AXISYMMETRIC PRESTRESS CALCULATOR



*****************************************************


PRESSURE MULTIPLIER,P =      0.000000


FIXED PART OF AXISYMMETRIC PRESTRESS STATE. THESE QUANTTITIES ARE NOT MULTIPLIED BY EIGENVALUE.

PRESTRESS-- MERIDIONAL RESULTANT, N10   CIRCUMFERENTIAL RESULTANT,N20  MERIDIONAL ROTATION, CHI0   FOR SEGMENT  1
```

1	0.00000000	0.00000000	0.00000000
2	0.00000000	0.00000000	0.00000000
3	0.00000000	0.00000000	0.00000000
4	0.00000000	0.00000000	0.00000000
5	0.00000000	0.00000000	0.00000000
6	0.00000000	0.00000000	0.00000000
7	0.00000000	0.00000000	0.00000000
8	0.00000000	0.00000000	0.00000000
9	0.00000000	0.00000000	0.00000000
10	0.00000000	0.00000000	0.00000000
11	0.00000000	0.00000000	0.00000000
12	0.00000000	0.00000000	0.00000000
13	0.00000000	0.00000000	0.00000000

FIXED PART OF AXISYMMETRIC PRESTRESS STATE. THESE QUANTTITIES ARE NOT MULTIPLIED BY EIGENVALUE.

PRESTRESS-- MERIDIONAL RESULTANT, N10 CIRCUMFERENTIAL RESULTANT,N20 MERIDIONAL ROTATION, CHI0 FOR SEGMENT 2

1	0.00000000	0.00000000	0.00000000
2	0.00000000	0.00000000	0.00000000
3	0.00000000	0.00000000	0.00000000
4	0.00000000	0.00000000	0.00000000
5	0.00000000	0.00000000	0.00000000
6	0.00000000	0.00000000	0.00000000
7	0.00000000	0.00000000	0.00000000
8	0.00000000	0.00000000	0.00000000
9	0.00000000	0.00000000	0.00000000
10	0.00000000	0.00000000	0.00000000
11	0.00000000	0.00000000	0.00000000
12	0.00000000	0.00000000	0.00000000

FIXED PART OF AXISYMMETRIC PRESTRESS STATE. THESE QUANTTITIES ARE NOT MULTIPLIED BY EIGENVALUE.

PRESTRESS-- MERIDIONAL RESULTANT, N10 CIRCUMFERENTIAL RESULTANT,N20 MERIDIONAL ROTATION, CHI0 FOR SEGMENT 3

1	0.00000000	0.00000000	0.00000000
2	0.00000000	0.00000000	0.00000000
3	0.00000000	0.00000000	0.00000000
4	0.00000000	0.00000000	0.00000000
5	0.00000000	0.00000000	0.00000000
6	0.00000000	0.00000000	0.00000000
7	0.00000000	0.00000000	0.00000000
8	0.00000000	0.00000000	0.00000000
9	0.00000000	0.00000000	0.00000000

ENTERING SUBROUTINE PRE, AXISYMMETRIC PRESTRESS CALCULATOR

********** 27 OCT 71

PRESSURE MULTIPLIER,P = -1.000000+00

TOTAL PRESTRESS STATE. THESE QUANTITIES MINUS CORRESPONDING FIXED QUANTITIES ARE MULTIPLIED BY EIGENVALUE.

PRESTRESS-- MERIDIONAL RESULTANT, N10 CIRCUMFERENTIAL RESULTANT,N20 MERIDIONAL ROTATION, CHI0 FOR SEGMENT 1

1	3.44589353-08	-4.81370348+00	-1.08461666-08
2	-3.67353205-04	-4.81386745+00	-8.90927732-09
3	1.02380291-05	-4.81382757+00	-3.96966543-09
4	2.04599928-05	-4.81385130+00	1.59870565-09
5	2.04563839-05	-4.81380886+00	4.93219665-09
6	2.04402022-05	-4.81374472+00	4.78595513-09
7	2.04741955-05	-4.81372678+00	1.53263963-15
8	2.04403186-05	-4.81374472+00	-4.78595208-09
9	2.04563839-05	-4.81380886+00	-4.93219360-09
10	2.04599928-05	-4.81385130+00	-1.59870260-09
11	1.02377962-05	-4.81382757+00	3.96966854-09
12	-3.26613896-04	-4.81385446+00	8.91237961-09
13	-5.22706751-03	-4.81540453+00	1.08461697-08

TOTAL PRESTRESS STATE. THESE QUANTITIES MINUS CORRESPONDING FIXED QUANTITIES ARE MULTIPLIED BY EIGENVALUE.

PRESTRESS-- MERIDIONAL RESULTANT, N10 CIRCUMFERENTIAL RESULTANT,N20 MERIDIONAL ROTATION, CHI0 FOR SEGMENT 2

1	-3.50918015-02	-4.15291220-01	1.54882066-15
2	-3.43409255-02	-4.16042119-01	3.55048351-13
3	-3.23049873-02	-4.18078050-01	-9.42504651-16
4	-2.95297522-02	-4.20853291-01	-3.38800810-15
5	-2.66580284-02	-4.23725009-01	-5.88242428-15
6	-2.37226170-02	-4.26660426-01	-8.39540009-15
7	-2.07216162-02	-4.29661423-01	-1.09273326-14
8	-1.76530629-02	-4.32729982-01	-1.34786366-14
9	-1.45149082-02	-4.35868133-01	-1.60497467-14
10	-1.13457628-02	-4.39037282-01	-1.86084706-14
11	-8.93414393-03	-4.41448901-01	-3.74705187-13
12	-8.02440057-03	-4.42358617-01	-2.12505805-14

TOTAL PRESTRESS STATE. THESE QUANTITIES MINUS CORRESPONDING FIXED QUANTITIES ARE MULTIPLIED BY EIGENVALUE.

PRESTRESS-- MERIDIONAL RESULTANT, N10 CIRCUMFERENTIAL RESULTANT,N20 MERIDIONAL ROTATION, CHI0 FOR SEGMENT 3

1	-5.64080554-04	-4.40089453-01	-3.87267932-07
2	-3.96452779-05	-4.39967081-01	-3.88337050-07

3	1.10545079-06	-4.40094497-01	-3.71914766-07
4	4.65661287-10	-4.40265331-01	-2.72304440-07
5	2.79396772-09	-4.40355629-01	-2.26490232-14
6	1.39698386-09	-4.40265331-01	2.72304398-07
7	2.56113708-09	-4.40094866-01	3.71914727-07
8	2.86626564-05	-4.39944323-01	3.88242363-07
9	5.63880429-04	-4.39713087-01	3.87267889-07

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,1**2 MATRIX, OR MASS MATRIX. 2 WAVES

ENTER EBAND TO CALCULATE LOWEST 1 BUCKLING LOADS. WAVENUMBER,N = 2 WAVES

9 NEGATIVE ROOTS FOR SHIFT, AXT = 0.00000

9 NEGATIVE ROOTS FOR SHIFT, AXT = 4.21499+02

THERE ARE 0 EIGENVALUES BETWEEN .0000000 AND .4214993+03

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO. 1. BUCKLING LOAD FACTOR= 4.25757+02. 2 CIRCUMFERENTIAL WAVES
ELAPSED TIME = 0: 0: 6.645

10 NEGATIVE ROOTS FOR SHIFT, AXT = 4.25885+02

THERE ARE 1 EIGENVALUES BETWEEN .0000000 AND .4258846+03

BUCKLING LOADS AND MODES FOLLOW

CIRCUMFERENTIAL WAVE NUMBER, N = 2

EIGENVALUES = 4.25757+02

MODE SHAPE FOR EIGENVALUE NO. 1 FOLLOWS

BUCKLING MODE FOR SEGMENT 1

POINT STATION U V W

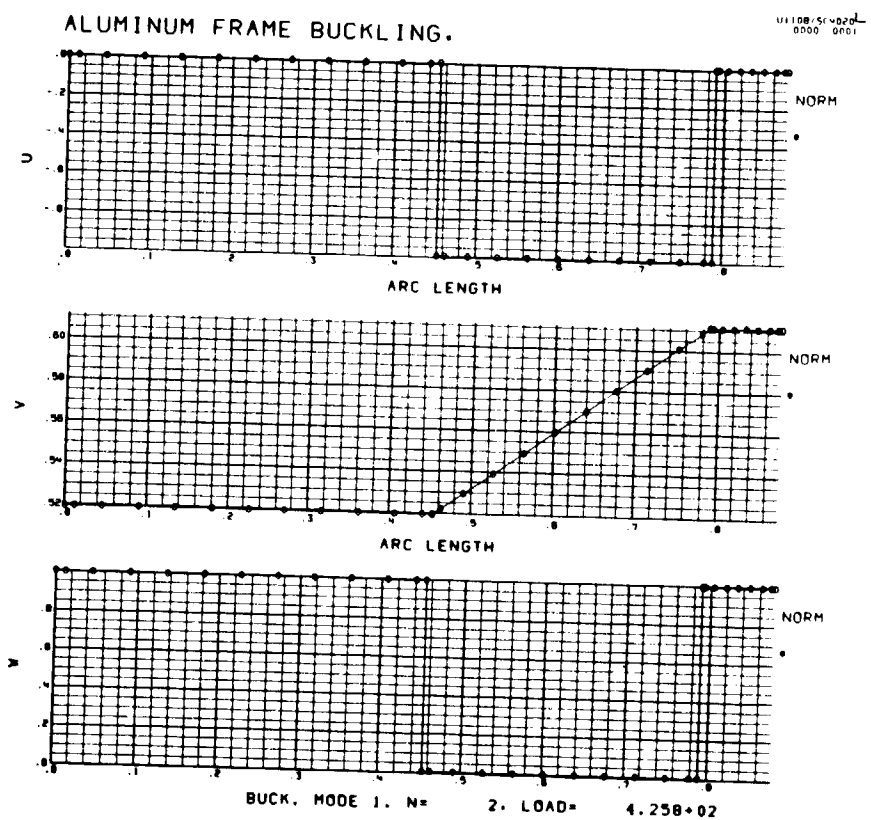
1	0.000	5.431-21	5.190-01	1.000+00
2	1.246-02	2.989-05	5.190-01	9.999-01
3	4.587-02	1.100-04	5.190-01	9.996-01
4	9.060-02	2.168-04	5.190-01	9.994-01
5	1.359-01	3.232-04	5.190-01	9.992-01
6	1.812-01	4.268-04	5.189-01	9.991-01
7	2.265-01	5.265-04	5.189-01	9.991-01
8	2.718-01	6.262-04	5.189-01	9.991-01
9	3.171-01	7.298-04	5.189-01	9.992-01
10	3.624-01	8.361-04	5.189-01	9.993-01
11	4.071-01	9.427-04	5.189-01	9.996-01
12	4.405-01	1.023-03	5.189-01	9.998-01
13	4.530-01	1.053-03	5.189-01	9.999-01

BUCKLING MODE FOR SEGMENT 2

POINT	STATION	U	V	W
1	4.530-01	-9.991-01	5.189-01	5.265-04
2	4.633-01	-9.990-01	5.217-01	5.238-04
3	4.908-01	-9.990-01	5.292-01	5.166-04
4	5.277-01	-9.989-01	5.392-01	5.071-04
5	5.650-01	-9.988-01	5.493-01	4.975-04
6	6.023-01	-9.985-01	5.595-01	4.881-04
7	6.397-01	-9.983-01	5.697-01	4.787-04
8	6.770-01	-9.980-01	5.800-01	4.693-04
9	7.143-01	-9.976-01	5.902-01	4.600-04
10	7.512-01	-9.972-01	6.005-01	4.508-04
11	7.787-01	-9.968-01	6.081-01	4.440-04
12	7.890-01	-9.966-01	6.110-01	4.414-04

BUCKLING MODE FOR SEGMENT 3

POINT	STATION	U	V	W
1	7.890-01	-1.921-04	6.109-01	9.969-01
2	7.931-01	-1.293-04	6.109-01	9.969-01
3	8.040-01	3.671-05	6.109-01	9.968-01
4	8.187-01	2.489-04	6.110-01	9.967-01
5	8.335-01	4.414-04	6.110-01	9.966-01
6	8.483-01	6.339-04	6.109-01	9.967-01
7	8.630-01	8.461-04	6.109-01	9.968-01
8	8.739-01	1.012-03	6.109-01	9.969-01
9	8.780-01	1.075-03	6.109-01	9.969-01



ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,1**2 MATRIX, OR MASS MATRIX. 6 WAVES

ENTER EBAND TO CALCULATE LOWEST 1 BUCKLING LOADS. WAVENUMBER,N = 6 WAVES

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9 NEGATIVE ROOTS FOR SHIFT, AXT = 0.00000

9 NEGATIVE ROOTS FOR SHIFT, AXT = 2.04977+03

THERE ARE 0 EIGENVALUES BETWEEN .0000000 AND .2049767+04

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO. 1, BUCKLING LOAD FACTOR= 2.07047+03. 6 CIRCUMFERENTIAL WAVES
ELAPSED TIME = 0: 0:11. 75

10 NEGATIVE ROOTS FOR SHIFT, AXT = 2.07109+03

THERE ARE 1 EIGENVALUES BETWEEN .0000000 AND .2071092+04

BUCKLING LOADS AND MODES FOLLOW

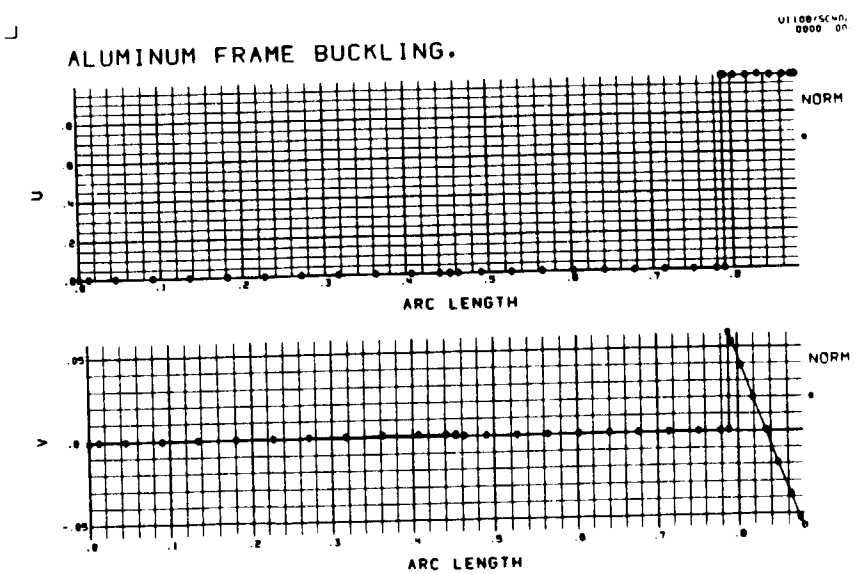
CIRCUMFERENTIAL WAVE NUMBER, N = 6

EIGENVALUES = 2.07047+03

MODE SHAPE FOR EIGENVALUE NO. 1 FOLLOWS

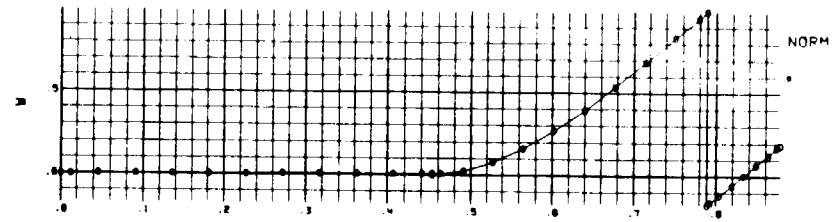
BUCKLING MODE FOR SEGMENT 1

POINT	STATION	U	V	W
1	0.000	4.653-23	-8.856-04	-4.437-03
2	1.246-02	4.143-06	-8.345-04	-4.188-03
3	4.587-02	1.786-05	-6.969-04	-3.520-03
4	9.060-02	4.146-05	-5.114-04	-2.620-03
5	1.359-01	7.248-05	-3.219-04	-1.699-03
6	1.812-01	1.109-04	-1.306-04	-7.634-04
7	2.265-01	1.361-04	6.225-05	1.899-04
8	2.718-01	1.273-04	2.554-04	1.146-03
9	3.171-01	1.052-04	4.476-04	2.090-03
10	3.624-01	9.068-05	6.383-04	3.027-03
11	4.071-01	8.341-05	8.253-04	3.947-03
12	4.405-01	8.195-05	9.643-04	4.635-03
13	4.530-01	8.240-05	1.016-03	4.891-03



BUCKLING MODE FOR SEGMENT 2

POINT	STATION	U	V	W
1	4.530-01	-1.099-04	6.225-05	1.361-04
2	4.633-01	-1.097-04	6.348-05	1.800-03
3	4.908-01	-1.893-04	6.682-05	2.052-02
4	5.277-01	-1.887-04	7.139-05	7.438-02
5	5.650-01	-1.881-04	7.616-05	1.583-01
6	6.023-01	-1.874-04	8.112-05	2.664-01
7	6.397-01	-1.866-04	8.629-05	3.936-01
8	6.770-01	-1.858-04	9.170-05	5.343-01
9	7.143-01	-1.849-04	9.738-05	6.837-01
10	7.512-01	-1.839-04	1.033-04	8.356-01
11	7.787-01	-1.831-04	1.079-04	9.499-01
12	7.890-01	-1.828-04	1.097-04	9.923-01



BUCK. MODE 1. N= 6. LOAD= 2.070+03

BUCKLING MODE FOR SEGMENT 3

POINT	STATION	U	V	W
1	7.890-01	9.915-01	5.812-02	-1.832-01
2	7.931-01	9.916-01	5.279-02	-1.664-01
3	8.040-01	9.920-01	3.851-02	-1.214-01
4	8.187-01	9.922-01	1.942-02	-6.105-02
5	8.335-01	9.923-01	1.097-04	1.828-04
6	8.483-01	9.922-01	-1.920-02	6.141-02
7	8.630-01	9.920-01	-3.829-02	1.218-01
8	8.739-01	9.916-01	-5.257-02	1.668-01
9	8.780-01	9.915-01	-5.790-02	1.836-01

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX. 10 WAVES

ENTER EBAND TO CALCULATE LOWEST 1 BUCKLING LOADS. WAVENUMBER,N = 10 WAVES

9 NEGATIVE ROOTS FOR SHIFT, AXT = 0.00000

9 NEGATIVE ROOTS FOR SHIFT, AXT = 1.60488+03

THERE ARE 0 EIGENVALUES BETWEEN .0000000 AND .1604881+04

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO. 1. BUCKLING LOAD FACTOR= 1.62109+03. 10 CIRCUMFERENTIAL WAVES
ELAPSED TIME = 0: 0:15.202

10 NEGATIVE ROOTS FOR SHIFT, AXT = 1.62158+03

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THERE ARE 1 EIGENVALUES BETWEEN .0000000 AND .1621576+04

BUCKLING LOADS AND MODES FOLLOW

CIRCUMFERENTIAL WAVE NUMBER, N = 10

EIGENVALUES = 1.62109+03

MODE SHAPE FOR EIGENVALUE NO. 1 FOLLOWS

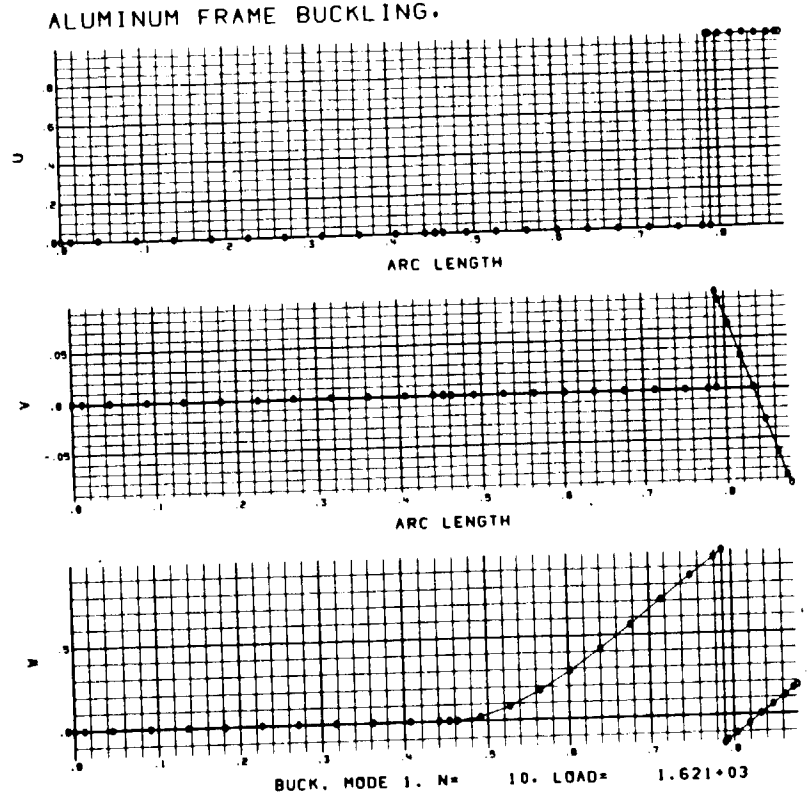
BUCKLING MODE FOR SEGMENT 1

POINT	STATION	U	V	W
1	0.000	5.294-23	-4.930-04	-1.641-03
2	1.246-02	7.091-06	-4.638-04	-1.556-03
3	4.587-02	3.217-05	-3.856-04	-1.321-03
4	9.060-02	7.090-05	-2.805-04	-9.960-04
5	1.359-01	1.187-04	-1.728-04	-6.495-04
6	1.812-01	1.756-04	-6.290-05	-2.816-04
7	2.265-01	2.153-04	4.949-05	1.123-04
8	2.718-01	2.111-04	1.629-04	5.124-04
9	3.171-01	1.898-04	2.755-04	8.993-04
10	3.624-01	1.780-04	3.871-04	1.278-03
11	4.071-01	1.756-04	4.974-04	1.647-03
12	4.405-01	1.790-04	5.802-04	1.923-03
13	4.530-01	1.815-04	6.112-04	2.026-03

BUCKLING MODE FOR SEGMENT 2

POINT	STATION	U	V	W
1	4.530-01	-1.123-04	4.949-05	2.153-04
2	4.633-01	-1.118-04	4.960-05	1.966-03
3	4.908-01	-1.106-04	5.001-05	2.300-02
4	5.277-01	-1.090-04	5.080-05	8.241-02
5	5.650-01	-1.075-04	5.196-05	1.729-01
6	6.023-01	-1.061-04	5.353-05	2.868-01
7	6.397-01	-1.048-04	5.556-05	4.174-01
8	6.770-01	-1.035-04	5.810-05	5.583-01
9	7.143-01	-1.022-04	6.122-05	7.039-01
10	7.512-01	-1.009-04	6.493-05	8.480-01
11	7.787-01	-9.984-05	6.809-05	9.540-01
12	7.890-01	-9.945-05	6.937-05	9.930-01

ALUMINUM FRAME BUCKLING.



BUCK. MODE 1. N= 10. LOAD= 1.621+03

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BUCKLING MODE FOR SEGMENT 3

POINT	STATION	U	V	W
1	7.890-01	9.914-01	9.573-02	-1.675-01
2	7.931-01	9.917-01	8.692-02	-1.521-01
3	8.040-01	9.923-01	6.334-02	-1.110-01
4	8.187-01	9.928-01	3.186-02	-5.596-02
5	8.335-01	9.930-01	6.937-05	9.945-05
6	8.483-01	9.928-01	-3.173-02	5.616-02
7	8.630-01	9.923-01	-6.320-02	1.112-01
8	8.739-01	9.917-01	-8.678-02	1.523-01
9	8.780-01	9.914-01	-9.560-02	1.677-01

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD=GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX. 14 WAVES

ENTER EBAND TO CALCULATE LOWEST 1 BUCKLING LOADS. WAVENUMBER,N = 14 WAVES

9 NEGATIVE ROOTS FOR SHIFT, AXT = 0.00000

9 NEGATIVE ROOTS FOR SHIFT, AXT = 1.76351+03

THERE ARE 0 EIGENVALUES BETWEEN .0000000 AND .1763512+04

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO. 1. BUCKLING LOAD FACTOR= 1.78129+03. 14 CIRCUMFERENTIAL WAVES
ELAPSED TIME = 01 0:19.358

10 NEGATIVE ROOTS FOR SHIFT, AXT = 1.78183+03

THERE ARE 1 EIGENVALUES BETWEEN .0000000 AND .1781828+04

BUCKLING LOADS AND MODES FOLLOW

CIRCUMFERENTIAL WAVE NUMBER, N = 14

EIGENVALUES = 1.78129+03

MODE SHAPE FOR EIGENVALUE NO. 1 FOLLOWS

BUCKLING MODE FOR SEGMENT 1

POINT	STATION	U	V	W
1	0.000	-7.610-23	-2.688-04	-8.187-04
2	1.246-02	1.494-05	-2.528-04	-7.845-04
3	4.587-02	5.777-05	-2.093-04	-6.857-04
4	9.060-02	1.210-04	-1.493-04	-5.342-04
5	1.359-01	1.939-04	-8.542-05	-3.550-04
6	1.812-01	2.771-04	-1.687-05	-1.453-04
7	2.265-01	3.357-04	5.656-05	1.005-04
8	2.718-01	3.334-04	1.320-04	3.560-04
9	3.171-01	3.070-04	2.061-04	5.949-04
10	3.624-01	2.925-04	2.783-04	8.234-04
11	4.071-01	2.892-04	3.492-04	1.044-03
12	4.405-01	2.929-04	4.025-04	1.209-03
13	4.530-01	2.958-04	4.226-04	1.271-03

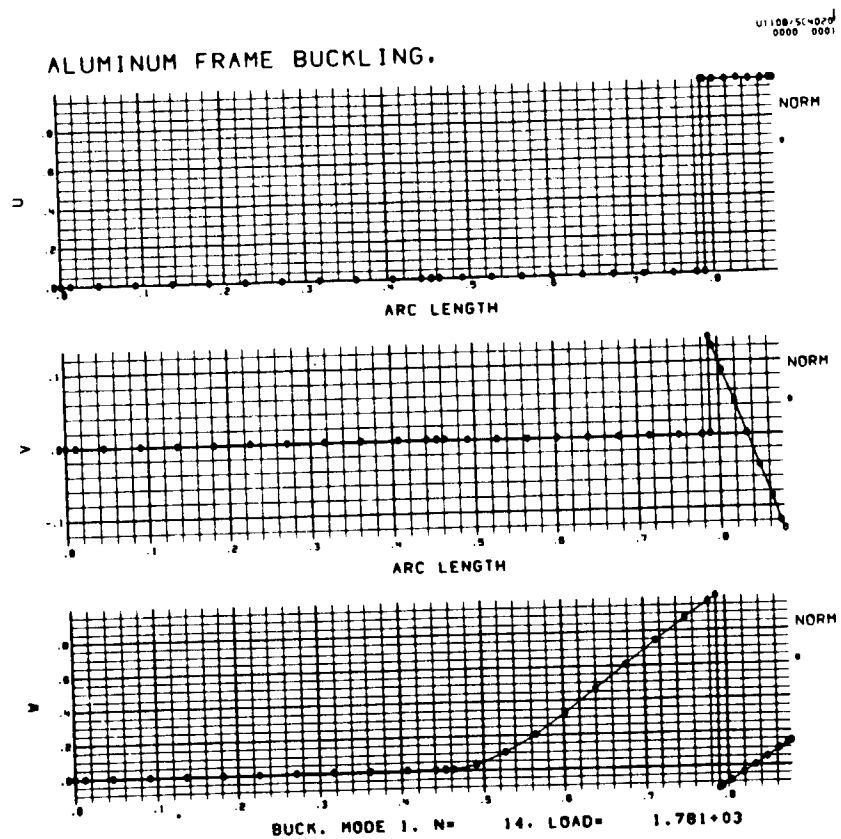
BUCKLING MODE FOR SEGMENT 2

POINT	STATION	U	V	W
1	4.530-01	-1.005-04	5.656-05	3.357-04
2	4.633-01	-9.940-05	5.566-05	2.422-03
3	4.908-01	-9.673-05	5.347-05	2.796-02
4	5.277-01	-9.348-05	5.101-05	9.788-02
5	5.650-01	-9.057-05	4.918-05	2.009-01
6	6.023-01	-8.802-05	4.806-05	3.258-01
7	6.397-01	-8.577-05	4.772-05	4.630-01
8	6.770-01	-8.376-05	4.823-05	6.039-01
9	7.143-01	-8.193-05	4.968-05	7.420-01
10	7.512-01	-8.022-05	5.213-05	8.710-01
11	7.787-01	-7.897-05	5.459-05	9.615-01
12	7.890-01	-7.050-05	5.568-05	9.941-01

BUCKLING MODE FOR SEGMENT 3

POINT	STATION	U	V	W
1	7.890-01	9.915-01	1.321-01	-1.389-01
2	7.931-01	9.920-01	1.199-01	-1.263-01
3	8.040-01	9.931-01	8.725-02	-9.227-02
4	8.187-01	9.939-01	4.383-02	-4.662-02
5	8.335-01	9.941-01	5.568-05	7.850-05
6	8.483-01	9.939-01	-4.372-02	4.678-02
7	8.630-01	9.931-01	-8.714-02	9.243-02
8	8.739-01	9.920-01	-1.197-01	1.264-01
9	8.780-01	9.915-01	-1.320-01	1.391-01

ELAPSED TIME = 0: 0:20.199



BEGINNING OF NEXT CASE 27 OCT 71

CYL. UNDER HYDROSTATIC PRESS. INDIC=-1 BUCKLING

STABILITY ANALYSIS WITH NONLINEAR PREBUCKLING EFFECTS INCLUDED. EIGENVALUE REPRESENTS CORRECTION FACTOR TO THE LOAD. CALCULATIONS FOR GIVEN VALUE OF N TERMINATE IF THE EIGENVALUE IS SMALLER THAN ERR. N IS CHANGED IN INCREMENTS (OR DECREMENTS) OF INCR UNTIL N IS LESS THAN NMIN, GREATER THAN NMAX, OR UNTIL A MINIMUM BUCKLING LOAD HAS BEEN FOUND. CALCULATIONS ALSO TERMINATE IF MORE THAN 10 ESTIMATES OF THE CRITICAL LOAD AT A GIVEN N ARE REQUIRED FOR CONVERGENCE OF THE EIGENVALUE TO WITHIN THE ACCURACY SPECIFIED BY ERR, OR IF THE PREBUCKLING SOLUTION FAILS TO CONVERGE WITHIN THE ACCURACY SPECIFIED BY ERR.

ANALYSIS TYPE = -1, PRINT OPTION = 1, PLOT OPTION = 0, STRESS OPTION = 0, PRESTRESS CALCULATION OPTION = 1

NUMBER OF SHELL SEGMENTS = 3

STRESS CALCULATED FOR CIRCUMFERENTIAL WAVES FROM 0 TO 0 IN INCREMENTS OF 1

INITIAL BUCKLING OR VIBRATION WAVE NO.= 4, MINIMUM WAVE NO.= 1, MAXIMUM WAVE NO.= 6, INCREMENT= 1

1 EIGENVALUES SOUGHT FOR EACH CIRCUMFERENTIAL WAVE NUMBER.

CONSTRAINT CONDITION DATA FOLLOW

SEG.	POINT	CONNECTED TO SEG.	POINT	USTAR	VSTAR	WSTAR	BETA	RADIAL DISC. D1(I)	AXIAL DISC. D2(I)
1	1	1	1	0	1	1	1	0.00000000	0.00000000
1	30	2	1	1	1	1	1	0.00000000	0.00000000
1	63	3	1	1	1	1	1	0.00000000	0.00000000
1	80	1	80	1	0	0	1	0.00000000	0.00000000

CONSTRAINT CONDITIONS FOR STABILITY OR VIBRATION PROBLEM FOLLOW

27 OCT 71

SEG.	POINT	CONNECTED TO SEG.	POINT	USTAR	VSTAR	WSTAR	BETA	RADIAL DISC. D1(I)	AXIAL DISC. D2(I)
1	1	1	1	1	1	1	1	0.00000000	0.00000000
1	30	2	1	1	1	1	1	0.00000000	0.00000000
1	63	3	1	1	1	1	1	0.00000000	0.00000000
1	80	1	80	1	0	0	1	0.00000000	0.00000000

PRESSURE MULTIPLIER P = 0.0000 , INCREMENT DP= -1.0000+00, TEMPERATURE MULT.TEMP= 0.0000 , INCREMENT DTEMP= 0.0000

INITIAL LOAD, FSTART = 0.0000 , MAXIMUM LOAD, FMAX = -1.0000+00, STEP SIZE, DF= -1.0000+00

SEGMENT NO. 1 IS A CYLINDER OR CONE.
END POINT COORDINATES (.1015+01, .0000) AND (.1015+01, .6280+01)

REFERENCE SURFACE GEOMETRY FOR SEGMENT NO. 1

STATION	ARC LENGTH	RAD	RADD	CUR1	CUR2	CURID	Z
1	.00000000	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
2	.27500000-01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
3	.10125000+00	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
4	.20000000+00	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
5	.29999999+00	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
6	.39999999+00	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
7	.49999999+00	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
8	.59999999+00	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
9	.69999998+00	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
10	.79999997+00	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
11	.89999997+00	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
12	.99999996+00	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
13	.10999999+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
14	.11999999+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
15	.12999999+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
16	.13999999+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
17	.14999999+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
18	.15999999+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
19	.16999999+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
20	.17999999+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
21	.18999999+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
22	.19999999+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
23	.20874999+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
24	.21499999+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
25	.21999998+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
26	.22499998+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
27	.22999998+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
28	.23499998+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
29	.23999998+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
30	.24499997+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
31	.24999997+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
32	.25499997+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
33	.25999997+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
34	.26499997+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
35	.26999997+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
36	.27499996+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01

37	.27999996+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
38	.28499996+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
39	.29124996+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
40	.29999996+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
41	.30999995+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
42	.31999995+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
43	.32999995+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
44	.33999995+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
45	.34999995+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
46	.35999995+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
47	.36999995+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
48	.37999995+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
49	.38999995+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
50	.39999995+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
51	.40999995+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
52	.41999995+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
53	.42999994+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
54	.43999994+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
55	.44999993+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
56	.45874993+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
57	.46499993+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
58	.46999992+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
59	.47499992+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
60	.47999991+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
61	.48499991+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
62	.48999990+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
63	.49499990+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
64	.49999989+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
65	.50499989+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
66	.50999988+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
67	.51499988+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
68	.51999987+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
69	.52499987+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
70	.52999986+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
71	.53499986+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
72	.54124985+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
73	.54999985+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
74	.55999985+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
75	.56999984+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
76	.57999984+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
77	.58999984+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
78	.59999983+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
79	.60999983+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
80	.61939983+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
81	.62579982+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01
82	.62799982+01	.10150000+01	.00000000	.00000000	.98522167+00	.00000000	.15000000-01

PHYSICAL PROPERTIES OF SEGMENT NO. 1

ANALYSIS IS FOR A MONOCOQUE SHELL

MODULUS OF ELASTICITY= .10800+08 POISSON RATIO= .32000+00 SHELL DENSITY = .00000 THERMAL EXP COEF.= .00000

MESH POINT	STATION	REF. SURFACE	THICKNESS
1	0.00000	1.50000-02	3.00000-02
2	2.75000-02	1.50000-02	3.00000-02
3	1.01250-01	1.50000-02	3.00000-02
4	2.00000-01	1.50000-02	3.00000-02
5	3.00000-01	1.50000-02	3.00000-02
6	4.00000-01	1.50000-02	3.00000-02
7	5.00000-01	1.50000-02	3.00000-02
8	6.00000-01	1.50000-02	3.00000-02
9	7.00000-01	1.50000-02	3.00000-02
10	8.00000-01	1.50000-02	3.00000-02
11	9.00000-01	1.50000-02	3.00000-02
12	1.00000+00	1.50000-02	3.00000-02
13	1.10000+00	1.50000-02	3.00000-02
14	1.20000+00	1.50000-02	3.00000-02
15	1.30000+00	1.50000-02	3.00000-02
16	1.40000+00	1.50000-02	3.00000-02
17	1.50000+00	1.50000-02	3.00000-02
18	1.60000+00	1.50000-02	3.00000-02
19	1.70000+00	1.50000-02	3.00000-02
20	1.80000+00	1.50000-02	3.00000-02
21	1.90000+00	1.50000-02	3.00000-02
22	2.00000+00	1.50000-02	3.00000-02
23	2.08750+00	1.50000-02	3.00000-02
24	2.15000+00	1.50000-02	3.00000-02
25	2.20000+00	1.50000-02	3.00000-02
26	2.25000+00	1.50000-02	3.00000-02
27	2.30000+00	1.50000-02	3.00000-02
28	2.35000+00	1.50000-02	3.00000-02
29	2.40000+00	1.50000-02	3.00000-02
30	2.45000+00	1.50000-02	3.00000-02
31	2.50000+00	1.50000-02	3.00000-02
32	2.55000+00	1.50000-02	3.00000-02
33	2.60000+00	1.50000-02	3.00000-02
34	2.65000+00	1.50000-02	3.00000-02
35	2.70000+00	1.50000-02	3.00000-02
36	2.75000+00	1.50000-02	3.00000-02
37	2.80000+00	1.50000-02	3.00000-02
38	2.85000+00	1.50000-02	3.00000-02
39	2.91250+00	1.50000-02	3.00000-02
40	3.00000+00	1.50000-02	3.00000-02
41	3.10000+00	1.50000-02	3.00000-02
42	3.20000+00	1.50000-02	3.00000-02
43	3.30000+00	1.50000-02	3.00000-02
44	3.40000+00	1.50000-02	3.00000-02
45	3.50000+00	1.50000-02	3.00000-02
46	3.60000+00	1.50000-02	3.00000-02
47	3.70000+00	1.50000-02	3.00000-02
48	3.80000+00	1.50000-02	3.00000-02
49	3.90000+00	1.50000-02	3.00000-02
50	4.00000+00	1.50000-02	3.00000-02
51	4.10000+00	1.50000-02	3.00000-02
52	4.20000+00	1.50000-02	3.00000-02
53	4.30000+00	1.50000-02	3.00000-02
54	4.40000+00	1.50000-02	3.00000-02
55	4.50000+00	1.50000-02	3.00000-02

56	4.58750+00	1.50000-02	3.00000-02
57	4.65000+00	1.50000-02	3.00000-02
58	4.70000+00	1.50000-02	3.00000-02
59	4.75000+00	1.50000-02	3.00000-02
60	4.80000+00	1.50000-02	3.00000-02
61	4.85000+00	1.50000-02	3.00000-02
62	4.90000+00	1.50000-02	3.00000-02
63	4.95000+00	1.50000-02	3.00000-02
64	5.00000+00	1.50000-02	3.00000-02
65	5.05000+00	1.50000-02	3.00000-02
66	5.10000+00	1.50000-02	3.00000-02
67	5.15000+00	1.50000-02	3.00000-02
68	5.20000+00	1.50000-02	3.00000-02
69	5.25000+00	1.50000-02	3.00000-02
70	5.30000+00	1.50000-02	3.00000-02
71	5.35000+00	1.50000-02	3.00000-02
72	5.41250+00	1.50000-02	3.00000-02
73	5.50000+00	1.50000-02	3.00000-02
74	5.60000+00	1.50000-02	3.00000-02
75	5.70000+00	1.50000-02	3.00000-02
76	5.80000+00	1.50000-02	3.00000-02
77	5.90000+00	1.50000-02	3.00000-02
78	6.00000+00	1.50000-02	3.00000-02
79	6.10000+00	1.50000-02	3.00000-02
80	6.19400+00	1.50000-02	3.00000-02
81	6.25800+00	1.50000-02	3.00000-02
82	6.28000+00	1.50000-02	3.00000-02

0 INTERNAL STRINGERS

EXTERNAL RINGS

STRINGER PROPERTIES-MODULUS= 0.00000 , POISSON,S RATIO= 0.00000 , MASS DENSITY= 0.00000

STRINGERS OF RECTANGULAR CROSS-SECTION

STRINGER THICKNESS,T1= 0.00000 , STRINGER HEIGHT,H1= 0.00000

RING PROPERTIES- MODULUS= 1.08000+07, POISSON,S RATIO= 3.20000-01, MASS DENSITY= 0.00000

RINGS OF RECTANGULAR CROSS-SECTION

RING SPACING,D2= 2.50000-01, RING THICKNESS,T2= 2.00000-02, RING HEIGHT,H2= 3.50000-02

SEGMENT NO. 2 IS A CYLINDER OR CONE.
END POINT COORDINATES (.1015+01, .0000) AND (.1150+01, .0000)

REFERENCE SURFACE GEOMETRY FOR SEGMENT NO. 2

STATION	ARC LENGTH	RAD	RADD	CUR1	CUR2	CURID	Z

1	.00000000	.10150000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
2	.27500000-02	.10177500+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
3	.10125000-01	.10251250+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
4	.20000000-01	.10350000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
5	.30000000-01	.10450000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
6	.40000001-01	.10550000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
7	.50000001-01	.10650000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
8	.60000001-01	.10750000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
9	.70000001-01	.10850000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
10	.80000001-01	.10950000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
11	.90000001-01	.11050000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
12	.10000000+00	.11150000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
13	.11000000+00	.11250000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
14	.12000000+00	.11350000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
15	.12868750+00	.11436875+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
16	.13362500+00	.11486250+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
17	.13500000+00	.11500000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01

PHYSICAL PROPERTIES OF SEGMENT NO. 2

ANALYSIS IS FOR A MONOCOQUE SHELL

MODULUS OF ELASTICITY= .10800+08 POISSON RATIO= .32000+00 SHELL DENSITY = .00000 THERMAL EXP COEF.= .00000

MESH POINT	STATION	REF. SURFACE	THICKNESS
1	0.00000	2.00000-02	4.00000-02
2	2.75000-03	2.00000-02	4.00000-02
3	1.01250-02	2.00000-02	4.00000-02
4	2.00000-02	2.00000-02	4.00000-02
5	3.00000-02	2.00000-02	4.00000-02
6	4.00000-02	2.00000-02	4.00000-02
7	5.00000-02	2.00000-02	4.00000-02
8	6.00000-02	2.00000-02	4.00000-02
9	7.00000-02	2.00000-02	4.00000-02
10	8.00000-02	2.00000-02	4.00000-02
11	9.00000-02	2.00000-02	4.00000-02
12	1.00000-01	2.00000-02	4.00000-02
13	1.10000-01	2.00000-02	4.00000-02
14	1.20000-01	2.00000-02	4.00000-02
15	1.28687-01	2.00000-02	4.00000-02
16	1.33625-01	2.00000-02	4.00000-02
17	1.35000-01	2.00000-02	4.00000-02

SEGMENT NO. 3 IS A CYLINDER OR CONE.
END POINT COORDINATES (.1015+01, .0000) AND (.1150+01, .0000)

REFERENCE SURFACE GEOMETRY FOR SEGMENT NO. 3

STATION	ARC LENGTH	RAD	RADD	CUR1	CUR2	CUR1D	Z
1	.00000000	.10150000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
2	.27500000-02	.10177500+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01

3	.10125000-01	.10251250+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
4	.20000000-01	.10350000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
5	.30000000-01	.10450000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
6	.40000001-01	.10550000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
7	.50000001-01	.10650000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
8	.60000001-01	.10750000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
9	.70000001-01	.10850000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
10	.80000001-01	.10950000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
11	.90000001-01	.11050000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
12	.10000000+00	.11150000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
13	.11000000+00	.11250000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
14	.12000000+00	.11350000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
15	.12868750+00	.11436875+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
16	.13362500+00	.11486250+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01
17	.13500000+00	.11500000+01	.10000000+01	.00000000	.00000000	.00000000	.20000000-01

PHYSICAL PROPERTIES OF SEGMENT NO. 3

ANALYSIS IS FOR A MONOCOQUE SHELL

MODULUS OF ELASTICITY= .10800+08 POISSON RATIO= .32000+00 SHELL DENSITY = .00000 THERMAL EXP COEF.= .00000

MESH POINT	STATION	REF. SURFACE	THICKNESS
1	0.00000	2.00000-02	4.00000-02
2	2.75000-03	2.00000-02	4.00000-02
3	1.01250-02	2.00000-02	4.00000-02
4	2.00000-02	2.00000-02	4.00000-02
5	3.00000-02	2.00000-02	4.00000-02
6	4.00000-02	2.00000-02	4.00000-02
7	5.00000-02	2.00000-02	4.00000-02
8	6.00000-02	2.00000-02	4.00000-02
9	7.00000-02	2.00000-02	4.00000-02
10	8.00000-02	2.00000-02	4.00000-02
11	9.00000-02	2.00000-02	4.00000-02
12	1.00000-01	2.00000-02	4.00000-02
13	1.10000-01	2.00000-02	4.00000-02
14	1.20000-01	2.00000-02	4.00000-02
15	1.28687-01	2.00000-02	4.00000-02
16	1.33625-01	2.00000-02	4.00000-02
17	1.35000-01	2.00000-02	4.00000-02

STATION	ER	AREA	IY	IX	IXY	E1	E2	GJ	RM	RC
RING PROPERTIES FOR RINGS IN SEGMENT 1										
1 0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0150+00

RING PROPERTIES FOR RINGS IN SEGMENT 2

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17  6.4150+00  1.0800+07  1.4400-02  7.6800-06  3.8880-05  0.0000     4.0000-02  0.0000     9.0400+01  0.0000     1.1900+08
                                    RING PROPERTIES FOR RINGS IN SEGMENT   3
17  6.5500+00  1.0800+07  1.4400-02  7.6800-06  3.8880-05  0.0000     4.0000-02  0.0000     9.0400+01  0.0000     1.1900+00
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MECHANICAL AND THERMAL LINE LOADS FOR SYMMETRIC LOADING

STATION S(K)	AXIAL LOAD V(K)	RADIAL LOAD H(K)	MOMENT M(K)	THERMAL HOOP STRESS TNR(K)	THERMAL MOMENT TMR(K)
.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
.64149982+01	.00000000	.00000000	.00000000	.00000000	.00000000
.65499982+01	.00000000	.00000000	.00000000	.00000000	.00000000

SYMMETRIC LINE LOAD INCREMENTS

S(K)	DV(K)	DH(K)	DM(K)	DTNR(K)	DTMR(K)
.00000000	-.50750000+00	.00000000	.00000000	.00000000	.00000000
.64149982+01	.00000000	.00000000	.00000000	.00000000	.00000000
.65499982+01	.00000000	.00000000	.00000000	.00000000	.00000000

AXISYMMETRIC PRESTRESS INPUT CONSTRAINT CONDITIONS FOLLOW

```
CONSTRAINT NO.   1 SEGMENT NO.   1 POINT   1 CONNECTED TO SEGMENT NO.  1 POINT   1.. TYPE OF CONSTRAINT =  1
CONSTRAINT NO.   2 SEGMENT NO.   1 POINT  82 CONNECTED TO SEGMENT NO.  1 POINT  82.. TYPE OF CONSTRAINT =  2
CONSTRAINT NO.   3 SEGMENT NO.   1 POINT  31 CONNECTED TO SEGMENT NO.  2 POINT   1.. TYPE OF CONSTRAINT =  4
CONSTRAINT NO.   4 SEGMENT NO.   1 POINT  64 CONNECTED TO SEGMENT NO.  3 POINT   1.. TYPE OF CONSTRAINT =  4

LOCAL MATRIX DIMENSION=  5 OVERLAP=  3 NO. CONSTRAINT CONDS. PER CONSTRAINT POINT=  3 SYSTEM RANK=  253 NUMBER OF BLOCKS=   1

NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  1 EQUALS 173 .  NO. OF CONSTRAINT PTS. EQUALS   2
NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  2 EQUALS  40 .  NO. OF CONSTRAINT PTS. EQUALS   1
NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  3 EQUALS  40 .  NO. OF CONSTRAINT PTS. EQUALS   1
BLOCK NUMBER=  1 LAST EQ. IN BLOCK= 253 LOWEST UNK IN BLOCK=   1. MAX. OFF-DIAGONAL WIDTH= 117
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STABILITY, VIBRATION OR NON-SYMMETRIC STRESS INPUT CONSTRAINT CONDITIONS FOLLOW.

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CONSTRAINT NO.   1 SEGMENT NO.   1 POINT   1 CONNECTED TO SEGMENT NO.  1 POINT   1.. TYPE OF CONSTRAINT =  1
CONSTRAINT NO.   2 SEGMENT NO.   1 POINT  82 CONNECTED TO SEGMENT NO.  1 POINT  82.. TYPE OF CONSTRAINT =  2
CONSTRAINT NO.   3 SEGMENT NO.   1 POINT  31 CONNECTED TO SEGMENT NO.  2 POINT   1.. TYPE OF CONSTRAINT =  4
CONSTRAINT NO.   4 SEGMENT NO.   1 POINT  64 CONNECTED TO SEGMENT NO.  3 POINT   1.. TYPE OF CONSTRAINT =  4

LOCAL MATRIX DIMENSION=  7 OVERLAP=  4 NO. CONSTRAINT CONDS. PER CONSTRAINT POINT=  4 SYSTEM RANK=  376 NUMBER OF BLOCKS=   2
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                                                                                                                                27 OCT 71
NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  1 EQUALS 258 .  NO. OF CONSTRAINT PTS. EQUALS   2
NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  2 EQUALS  59 .  NO. OF CONSTRAINT PTS. EQUALS   1
NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  3 EQUALS  59 .  NO. OF CONSTRAINT PTS. EQUALS   1
BLOCK NUMBER=  1 LAST EQ. IN BLOCK= 317 LOWEST UNK IN BLOCK=   1, MAX. OFF-DIAGONAL WIDTH= 174
BLOCK NUMBER=  2 LAST EQ. IN BLOCK= 376 LOWEST UNK IN BLOCK= 194, MAX. OFF-DIAGONAL WIDTH= 134

DATA READ IN AND PROCESSED FOR THIS CASE. LEAVING SUBROUTINE READIT


ENTERING SUBROUTINE PRE, AXISYMMETRIC PRESTRESS CALCULATOR



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PRESSURE MULTIPLIER,P =      0.000000

RING NO.  1, AXIAL LOAD/LENGTH =   .00000000   , RADIAL LOAD/LENGTH =   .00000000   , MOMENT/LENGTH =   .00000000
RING NO.  2, AXIAL LOAD/LENGTH =   .00000000   , RADIAL LOAD/LENGTH =   .00000000   , MOMENT/LENGTH =   .00000000
RING NO.  3, AXIAL LOAD/LENGTH =   .00000000   , RADIAL LOAD/LENGTH =   .00000000   , MOMENT/LENGTH =   .00000000

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ENTERING SUBROUTINE PRE, AXISYMMETRIC PRESTRESS CALCULATOR



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PRESSURE MULTIPLIER,P =     -1.000000+00

RING NO.  1, AXIAL LOAD/LENGTH =  -.50750000+00, RADIAL LOAD/LENGTH =   .00000000   , MOMENT/LENGTH =   .00000000
RING NO.  2, AXIAL LOAD/LENGTH =   .00000000   , RADIAL LOAD/LENGTH =   .00000000   , MOMENT/LENGTH =   .00000000
RING NO.  3, AXIAL LOAD/LENGTH =   .00000000   , RADIAL LOAD/LENGTH =   .00000000   , MOMENT/LENGTH =   .00000000
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ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.      4 WAVES
 CIRCUMFERENTIAL WAVES,N=     4,  ITERATION NO.=  7, EIGENVALUE (FACTOR TO BE MULT. BY LOAD STEP)=   1.10496+03
 CIRCUMFERENTIAL WAVES,N=     4,  ITERATION NO.=  6, EIGENVALUE (FACTOR TO BE MULT. BY LOAD STEP)=   1.10497+03

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.      5 WAVES
 CIRCUMFERENTIAL WAVES,N=     5,  ITERATION NO.=  4, EIGENVALUE (FACTOR TO BE MULT. BY LOAD STEP)=   1.47591+03

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.      3 WAVES
 CIRCUMFERENTIAL WAVES,N=     3,  ITERATION NO.=  5, EIGENVALUE (FACTOR TO BE MULT. BY LOAD STEP)=   1.30155+03

ENTERING SUBROUTINE PRE, AXISYMMETRIC PRESTRESS CALCULATOR


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PRESSURE MULTIPLIER,P =    -1.10497+03

RING NO.  1, AXIAL LOAD/LENGTH =  -.56077365+03, RADIAL LOAD/LENGTH =   .00000000   , MOMENT/LENGTH =   .00000000
RING NO.  2, AXIAL LOAD/LENGTH =   .00000000   , RADIAL LOAD/LENGTH =   .00000000   , MOMENT/LENGTH =   .00000000
RING NO.  3, AXIAL LOAD/LENGTH =   .00000000   , RADIAL LOAD/LENGTH =   .00000000   , MOMENT/LENGTH =   .00000000

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ENTERING SUBROUTINE PRE, AXISYMMETRIC PRESTRESS CALCULATOR


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PRESSURE MULTIPLIER,P = -1.106078+03

RING NO. 1, AXIAL LOAD/LENGTH = -.56133442+03, RADIAL LOAD/LENGTH = .00000000 , MOMENT/LENGTH = .00000000
RING NO. 2, AXIAL LOAD/LENGTH = .00000000 , RADIAL LOAD/LENGTH = .00000000 , MOMENT/LENGTH = .00000000
RING NO. 3, AXIAL LOAD/LENGTH = .00000000 , RADIAL LOAD/LENGTH = .00000000 , MOMENT/LENGTH = .00000000

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ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX. 4 WAVES
CIRCUMFERENTIAL WAVES,N= 4, ITERATION NO.= 5, EIGENVALUE (FACTOR TO BE MULT. BY LOAD STEP)= -2.87575+00

ANALYSIS TYPE (INDIC) = -1 NEWTON-RAPHSON ITERATIONS REQUIRED FOR LAST PRESTRESS SOLUTION = 1

VALUE OF STABILITY DETERMINANT = 0.0000 TIMES TEN TO THE 0 POWER

PRESSURE,TEMPERATURE RISE, AND LINE LOADS FOLLOW

PRESSURE MULTIPLIER = -1.106078+03 TEMPERATURE MULTIPLIER = 0.000000

LINE LOADS FOLLOW

I = 1 AXIAL LOAD/LENGTH V(I)= -5.6133+02 RADIAL LOAD/LENGTH H(I)= 0.0000 MOMENT/LENGTH M(I)= 0.0000
I = 2 AXIAL LOAD/LENGTH V(I)= 0.0000 RADIAL LOAD/LENGTH H(I)= 0.0000 MOMENT/LENGTH M(I)= 0.0000
I = 3 AXIAL LOAD/LENGTH V(I)= 0.0000 RADIAL LOAD/LENGTH H(I)= 0.0000 MOMENT/LENGTH M(I)= 0.0000

PREBUCKLING DISPLACEMENTS AND STRESS RESULTANTS CORRESPONDING TO CRITICAL LOAD

AXISYMMETRIC PRESTRESS DISTRIBUTION FOR SEGMENT 1

POINT	STATION	WO	UO	BETA	UV	N10	N20	M10	M20
1	0.000	4.776-23	4.810-03	6.564-12	4.810-03	-5.613+02	-1.820+02	-7.411+00	-2.385+00
2	2.750-02	-8.875-05	4.767-03	-6.330-03	4.767-03	-5.613+02	-2.125+02	-6.069+00	-1.872+00
3	1.012-01	-1.155-03	4.666-03	-1.147-02	4.666-03	-5.613+02	-5.827+02	3.106-01	1.177+00

4	2.000-01	-2.238-03	4.561-03	-7.970-03	4.561-03	-5.613+02	-9.601+02	1.646+00	2.627+00
5	3.000-01	-2.735-03	4.483-03	-2.988-03	4.483-03	-5.613+02	-1.134+03	1.093+00	2.920+00
6	4.000-01	-2.035-03	4.415-03	-2.897-04	4.415-03	-5.613+02	-1.169+03	4.045-01	2.795+00
7	5.000-01	-2.793-03	4.348-03	4.764-04	4.348-03	-5.613+02	-1.154+03	4.586-02	2.640+00
8	6.000-01	-2.740-03	4.280-03	4.014-04	4.280-03	-5.613+02	-1.136+03	-5.002-02	2.559+00
9	7.000-01	-2.713-03	4.210-03	1.742-04	4.210-03	-5.613+02	-1.126+03	-3.588-02	2.538+00
10	8.000-01	-2.705-03	4.140-03	3.128-05	4.140-03	-5.613+02	-1.124+03	-4.108-03	2.541+00
11	9.000-01	-2.706-03	4.070-03	-1.775-05	4.070-03	-5.613+02	-1.124+03	1.502-02	2.548+00
12	1.000+00	-2.709-03	4.000-03	-1.992-05	4.000-03	-5.613+02	-1.125+03	2.123-02	2.552+00
13	1.100+00	-2.710-03	3.930-03	-1.046-05	3.930-03	-5.613+02	-1.126+03	2.128-02	2.554+00
14	1.200+00	-2.711-03	3.860-03	-2.956-06	3.860-03	-5.613+02	-1.126+03	2.015-02	2.554+00
15	1.300+00	-2.711-03	3.790-03	1.971-06	3.790-03	-5.613+02	-1.126+03	1.989-02	2.554+00
16	1.400+00	-2.710-03	3.720-03	7.793-06	3.720-03	-5.613+02	-1.126+03	2.063-02	2.554+00
17	1.500+00	-2.709-03	3.650-03	1.543-05	3.650-03	-5.613+02	-1.125+03	2.088-02	2.553+00
18	1.600+00	-2.707-03	3.579-03	1.604-05	3.579-03	-5.613+02	-1.125+03	1.686-02	2.550+00
19	1.700+00	-2.706-03	3.509-03	-1.636-05	3.509-03	-5.613+02	-1.124+03	3.039-03	2.544+00
20	1.800+00	-2.711-03	3.439-03	-1.203-04	3.439-03	-5.613+02	-1.126+03	-2.192-02	2.540+00
21	1.900+00	-2.730-03	3.369-03	-3.002-04	3.369-03	-5.613+02	-1.133+03	-3.828-02	2.554+00
22	2.000+00	-2.771-03	3.301-03	-4.002-04	3.301-03	-5.613+02	-1.147+03	2.088-02	2.611+00
23	2.087+00	-2.811-03	3.241-03	-1.583-05	3.241-03	-5.613+02	-1.161+03	2.917-01	2.735+00
24	2.150+00	-2.792-03	3.200-03	8.551-04	3.200-03	-5.613+02	-1.154+03	5.503-01	2.800+00
25	2.200+00	-2.725-03	3.165-03	2.096-03	3.165-03	-5.613+02	-1.130+03	8.299-01	2.826+00
26	2.250+00	-2.582-03	3.129-03	3.824-03	3.129-03	-5.613+02	-1.081+03	1.079+00	2.772+00
27	2.300+00	-2.342-03	3.090-03	5.859-03	3.090-03	-5.613+02	-9.968+02	1.166+00	2.572+00
28	2.350+00	-1.997-03	3.045-03	7.706-03	3.045-03	-5.613+02	-8.762+02	8.807-01	2.155+00
29	2.400+00	-1.572-03	2.994-03	8.422-03	2.994-03	-5.613+02	-7.282+02	-5.250-02	1.455+00
30	2.450+00	-1.154-03	2.936-03	6.522-03	2.936-03	-5.613+02	-5.832+02	-1.945+00	4.548-01
31	2.500+00	-9.196-04	2.874-03	4.342-11	2.874-03	-5.613+02	-5.022+02	-5.051+00	-7.611-01
32	2.550+00	-1.154-03	2.811-03	-6.522-03	2.811-03	-5.613+02	-5.832+02	-1.945+00	4.548-01
33	2.600+00	-1.572-03	2.754-03	-8.422-03	2.754-03	-5.613+02	-7.282+02	-5.250-02	1.455+00
34	2.650+00	-1.997-03	2.702-03	-7.706-03	2.702-03	-5.613+02	-8.762+02	8.807-01	2.155+00
35	2.700+00	-2.342-03	2.658-03	-5.859-03	2.658-03	-5.613+02	-9.968+02	1.166+00	2.572+00
36	2.750+00	-2.582-03	2.618-03	-3.824-03	2.618-03	-5.613+02	-1.081+03	1.079+00	2.772+00
37	2.800+00	-2.725-03	2.582-03	-2.096-03	2.582-03	-5.613+02	-1.130+03	8.299-01	2.826+00
38	2.850+00	-2.792-03	2.548-03	-8.551-04	2.548-03	-5.613+02	-1.154+03	5.503-01	2.800+00
39	2.912+00	-2.811-03	2.506-03	1.583-05	2.506-03	-5.613+02	-1.161+03	2.917-01	2.735+00
40	3.000+00	-2.771-03	2.447-03	4.002-04	2.447-03	-5.613+02	-1.147+03	2.088-02	2.611+00
41	3.100+00	-2.730-03	2.378-03	3.002-04	2.378-03	-5.613+02	-1.133+03	-3.828-02	2.554+00
42	3.200+00	-2.711-03	2.308-03	1.203-04	2.308-03	-5.613+02	-1.126+03	-2.192-02	2.540+00
43	3.300+00	-2.706-03	2.238-03	1.636-05	2.238-03	-5.613+02	-1.124+03	3.046-03	2.544+00
44	3.400+00	-2.707-03	2.168-03	-1.598-05	2.168-03	-5.613+02	-1.125+03	1.688-02	2.550+00
45	3.500+00	-2.709-03	2.098-03	-1.528-05	2.098-03	-5.613+02	-1.125+03	2.091-02	2.553+00
46	3.600+00	-2.710-03	2.028-03	-7.591-06	2.028-03	-5.613+02	-1.126+03	2.064-02	2.554+00
47	3.700+00	-2.711-03	1.958-03	-1.995-06	1.958-03	-5.613+02	-1.126+03	1.976-02	2.554+00
48	3.800+00	-2.711-03	1.888-03	1.995-06	1.888-03	-5.613+02	-1.126+03	1.976-02	2.554+00
49	3.900+00	-2.710-03	1.818-03	7.591-06	1.818-03	-5.613+02	-1.126+03	2.064-02	2.554+00
50	4.000+00	-2.709-03	1.748-03	1.528-05	1.748-03	-5.613+02	-1.125+03	2.091-02	2.553+00
51	4.100+00	-2.707-03	1.678-03	1.598-05	1.678-03	-5.613+02	-1.125+03	1.688-02	2.550+00
52	4.200+00	-2.706-03	1.607-03	-1.636-05	1.607-03	-5.613+02	-1.124+03	3.046-03	2.544+00
53	4.300+00	-2.711-03	1.537-03	-1.203-04	1.537-03	-5.613+02	-1.126+03	-2.192-02	2.540+00
54	4.400+00	-2.730-03	1.468-03	-3.002-04	1.468-03	-5.613+02	-1.133+03	-3.828-02	2.554+00
55	4.500+00	-2.771-03	1.399-03	-4.002-04	1.399-03	-5.613+02	-1.147+03	2.088-02	2.611+00
56	4.587+00	-2.811-03	1.340-03	-1.583-05	1.340-03	-5.613+02	-1.161+03	2.917-01	2.735+00
57	4.650+00	-2.792-03	1.298-03	8.551-04	1.298-03	-5.613+02	-1.154+03	5.503-01	2.800+00
58	4.700+00	-2.725-03	1.263-03	2.096-03	1.263-03	-5.613+02	-1.130+03	8.299-01	2.826+00
59	4.750+00	-2.582-03	1.227-03	3.824-03	1.227-03	-5.613+02	-1.081+03	1.079+00	2.772+00
60	4.800+00	-2.342-03	1.188-03	5.859-03	1.188-03	-5.613+02	-9.968+02	1.166+00	2.572+00
61	4.850+00	-1.997-03	1.143-03	7.706-03	1.143-03	-5.613+02	-8.762+02	8.807-01	2.155+00

62	4.900+00	-1.572-03	1.092-03	8.422-03	1.092-03	-5.613+02	-7.282+02	-5.250-02	1.455+00
63	4.950+00	-1.154-03	1.034-03	6.522-03	1.034-03	-5.613+02	-5.832+02	-1.945+00	4.548-01
64	5.000+00	-9.196-04	9.719-04	5.840-11	9.719-04	-5.613+02	-5.022+02	-5.051+00	-7.611-01
65	5.050+00	-1.154-03	9.095-04	-6.522-03	9.095-04	-5.613+02	-5.832+02	-1.945+00	4.548-01
66	5.100+00	-1.572-03	8.517-04	-8.422-03	8.517-04	-5.613+02	-7.282+02	-5.250-02	1.455+00
67	5.150+00	-1.997-03	8.005-04	-7.706-03	8.005-04	-5.613+02	-8.762+02	8.807-01	2.155+00
68	5.200+00	-2.342-03	7.559-04	-5.859-03	7.559-04	-5.613+02	-9.968+02	1.166+00	2.572+00
69	5.250+00	-2.582-03	7.165-04	-3.824-03	7.165-04	-5.613+02	-1.081+03	1.079+00	2.772+00
70	5.300+00	-2.725-03	6.805-04	-2.096-03	6.805-04	-5.613+02	-1.130+03	8.299-01	2.826+00
71	5.350+00	-2.792-03	6.462-04	-8.551-04	6.462-04	-5.613+02	-1.154+03	5.503-01	2.800+00
72	5.412+00	-2.811-03	6.043-04	1.583-05	6.043-04	-5.613+02	-1.161+03	2.917-01	2.735+00
73	5.500+00	-2.771-03	5.452-04	4.002-04	5.452-04	-5.613+02	-1.147+03	2.088-02	2.611+00
74	5.600+00	-2.730-03	4.764-04	3.002-04	4.764-04	-5.613+02	-1.133+03	-3.828-02	2.554+00
75	5.700+00	-2.711-03	4.066-04	1.203-04	4.066-04	-5.613+02	-1.126+03	-2.192-02	2.540+00
76	5.800+00	-2.706-03	3.365-04	1.639-05	3.365-04	-5.613+02	-1.124+03	3.058-03	2.544+00
77	5.900+00	-2.707-03	2.663-04	-1.589-05	2.663-04	-5.613+02	-1.125+03	1.690-02	2.550+00
78	6.000+00	-2.709-03	1.962-04	-1.510-05	1.962-04	-5.613+02	-1.125+03	2.093-02	2.553+00
79	6.100+00	-2.710-03	1.261-04	-7.420-06	1.261-04	-5.613+02	-1.126+03	2.061-02	2.554+00
80	6.194+00	-2.711-03	6.024-05	-2.424-06	6.024-05	-5.613+02	-1.126+03	1.958-02	2.554+00
81	6.258+00	-2.711-03	1.541-05	-5.111-07	1.541-05	-5.613+02	-1.126+03	1.931-02	2.554+00
82	6.280+00	-2.711-03	3.855-18	-6.501-16	3.855-18	-5.613+02	-1.126+03	1.941-02	2.554+00

AXISYMMETRIC PRESTRESS DISTRIBUTION FOR SEGMENT 2

POINT	STATION	WO	UO	BETA	UV	N10	N20	M10	M20
1	6.280+00	-2.874-03	-9.196-04	6.638-11	2.874-03	1.512+02	-3.430+02	-1.397-08	-7.042-10
2	6.283+00	-2.874-03	-9.179-04	-1.305-09	2.874-03	1.499+02	-3.417+02	-2.702-04	-8.653-05
3	6.290+00	-2.874-03	-9.135-04	6.400-11	2.874-03	1.464+02	-3.381+02	-4.504-05	-1.441-05
4	6.300+00	-2.874-03	-9.078-04	6.170-11	2.874-03	1.418+02	-3.335+02	-1.353-08	-8.968-10
5	6.310+00	-2.874-03	-9.021-04	5.942-11	2.874-03	1.372+02	-3.290+02	-1.333-08	-9.898-10
6	6.320+00	-2.874-03	-8.966-04	5.719-11	2.874-03	1.328+02	-3.246+02	-1.313-08	-1.081-09
7	6.330+00	-2.874-03	-8.912-04	5.498-11	2.874-03	1.286+02	-3.203+02	-1.295-08	-1.170-09
8	6.340+00	-2.874-03	-8.859-04	5.282-11	2.874-03	1.244+02	-3.162+02	-1.277-08	-1.257-09
9	6.350+00	-2.874-03	-8.807-04	5.069-11	2.874-03	1.204+02	-3.121+02	-1.260-08	-1.342-09
10	6.360+00	-2.874-03	-8.757-04	4.859-11	2.874-03	1.164+02	-3.082+02	-1.244-08	-1.425-09
11	6.370+00	-2.874-03	-8.707-04	4.653-11	2.874-03	1.126+02	-3.044+02	-1.229-08	-1.507-09
12	6.380+00	-2.874-03	-8.659-04	4.449-11	2.874-03	1.089+02	-3.007+02	-1.214-08	-1.587-09
13	6.390+00	-2.874-03	-8.613-04	4.249-11	2.874-03	1.052+02	-2.970+02	-1.200-08	-1.665-09
14	6.400+00	-2.874-03	-8.567-04	4.051-11	2.874-03	1.017+02	-2.935+02	-1.187-08	-1.742-09
15	6.409+00	-2.874-03	-8.528-04	1.409-09	2.874-03	9.873+01	-2.905+02	4.504-05	1.448-05
16	6.414+00	-2.874-03	-8.506-04	1.374-08	2.874-03	9.706+01	-2.888+02	1.261-03	4.042-04
17	6.415+00	-2.874-03	-8.500-04	3.759-11	2.874-03	9.659+01	-2.884+02	-1.168-08	-1.856-09

AXISYMMETRIC PRESTRESS DISTRIBUTION FOR SEGMENT 3

POINT	STATION	WO	UO	BETA	UV	N10	N20	M10	M20

1	6.415+00	-9.719-04	-9.196-04	3.397-11	9.719-04	1.512+02	-3.430+02	-7.150-09	-3.603-10
2	6.418+00	-9.719-04	-9.179-04	-4.298-10	9.719-04	1.499+02	-3.417+02	-9.138-05	-2.927-05
3	6.425+00	-9.719-04	-9.135-04	3.275-11	9.719-04	1.464+02	-3.381+02	-1.523-05	-4.873-06
4	6.435+00	-9.719-04	-9.078-04	3.157-11	9.719-04	1.418+02	-3.335+02	-6.925-09	-4.589-10
5	6.445+00	-9.719-04	-9.021-04	3.041-11	9.719-04	1.372+02	-3.290+02	-6.821-09	-5.065-10
6	6.455+00	-9.719-04	-8.966-04	2.926-11	9.719-04	1.328+02	-3.246+02	-6.721-09	-5.530-10
7	6.465+00	-9.719-04	-8.912-04	2.814-11	9.719-04	1.286+02	-3.203+02	-6.626-09	-5.986-10
8	6.475+00	-9.719-04	-8.859-04	2.703-11	9.719-04	1.244+02	-3.162+02	-6.535-09	-6.431-10
9	6.485+00	-9.719-04	-8.807-04	2.594-11	9.719-04	1.204+02	-3.121+02	-6.449-09	-6.867-10
10	6.495+00	-9.719-04	-8.757-04	2.486-11	9.719-04	1.164+02	-3.082+02	-6.366-09	-7.293-10
11	6.505+00	-9.719-04	-8.707-04	2.381-11	9.719-04	1.126+02	-3.044+02	-6.288-09	-7.711-10
12	6.515+00	-9.719-04	-8.659-04	2.277-11	9.719-04	1.089+02	-3.007+02	-6.213-09	-8.121-10
13	6.525+00	-9.719-04	-8.613-04	2.174-11	9.719-04	1.052+02	-2.970+02	-6.141-09	-8.522-10
14	6.535+00	-9.719-04	-8.567-04	2.073-11	9.719-04	1.017+02	-2.935+02	-6.073-09	-8.914-10
15	6.544+00	-9.719-04	-8.528-04	4.833-10	9.719-04	9.873+01	-2.905+02	1.523-05	4.898-06
16	6.549+00	-9.719-04	-8.506-04	4.654-09	9.719-04	9.706+01	-2.888+02	4.264-04	1.367-04
17	6.550+00	-9.719-04	-8.500-04	1.923-11	9.719-04	9.659+01	-2.884+02	-5.980-09	-9.501-10

HOOP FORCES IN DISCRETE RINGS

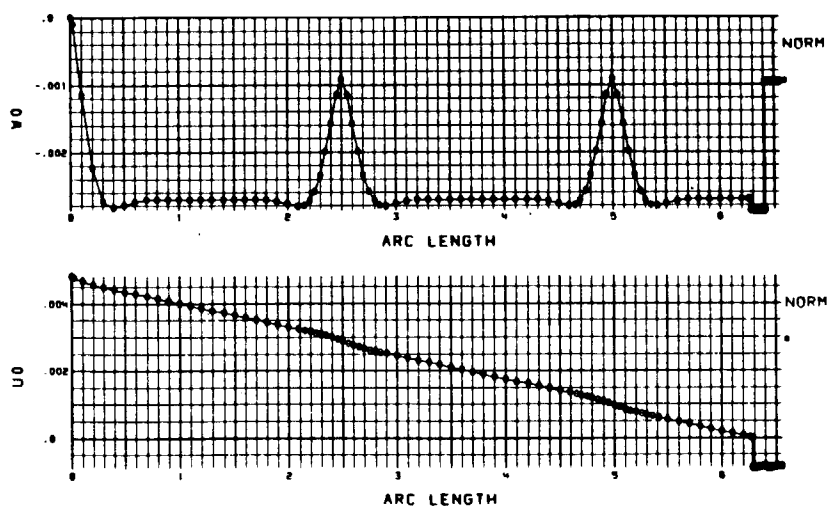
RING NO.	HOOP FORCE
1	0.00000000
2	-1.11083213+02
3	-1.11083213+02

BUCKLING MODE FOR 4 CIRCUMFERENTIAL WAVES

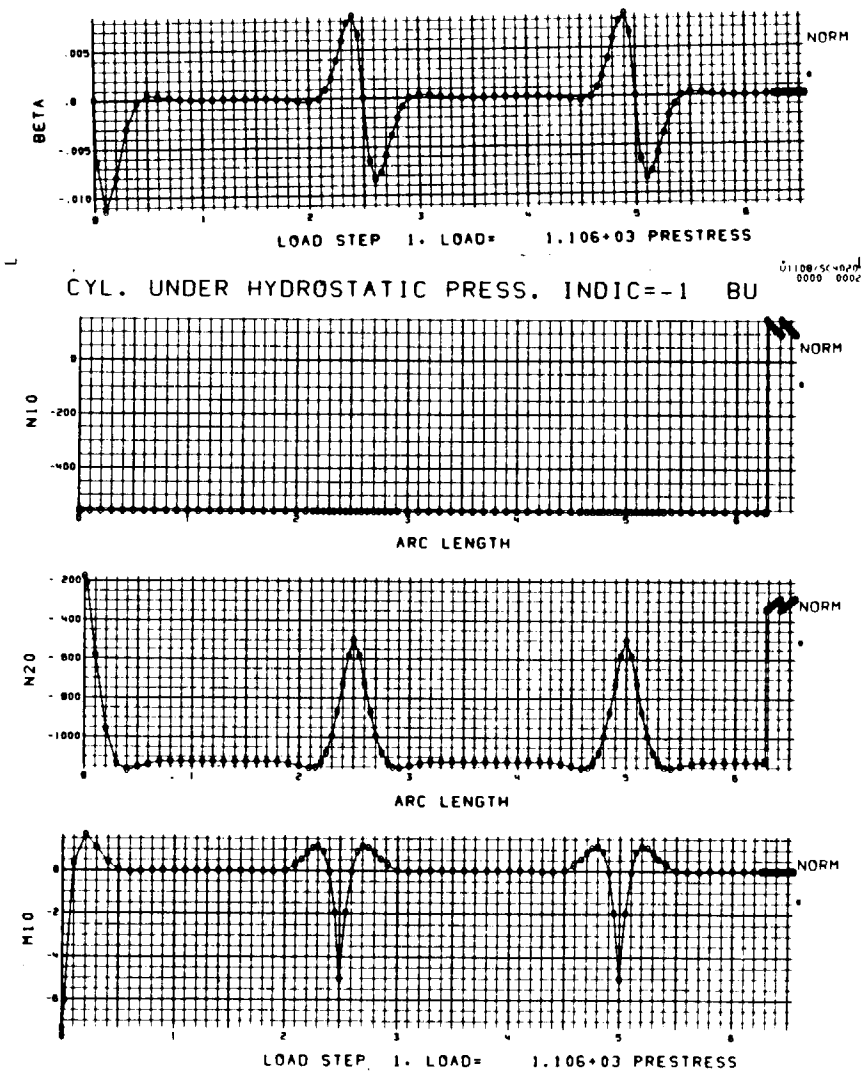
BUCKLING MODE FOR SEGMENT 1

POINT	STATION	U	V	W
1	0.000	-1.006-21	2.859-21	4.355-20
2	2.750-02	-6.242-04	4.911-04	7.605-04
3	1.012-01	-2.162-03	2.459-03	1.009-02
4	2.000-01	-4.005-03	6.163-03	2.676-02
5	3.000-01	-5.597-03	1.095-02	4.609-02
6	4.000-01	-6.855-03	1.638-02	6.678-02
7	5.000-01	-7.710-03	2.216-02	8.827-02
8	6.000-01	-8.129-03	2.809-02	1.101-01
9	7.000-01	-8.113-03	3.396-02	1.317-01
10	8.000-01	-7.682-03	3.960-02	1.525-01
11	9.000-01	-6.863-03	4.482-02	1.717-01
12	1.000+00	-5.689-03	4.946-02	1.888-01
13	1.100+00	-4.193-03	5.337-02	2.031-01
14	1.200+00	-2.411-03	5.640-02	2.142-01
15	1.300+00	-3.811-04	5.843-02	2.214-01
16	1.400+00	1.855-03	5.937-02	2.246-01
17	1.500+00	4.255-03	5.915-02	2.233-01
18	1.600+00	6.776-03	5.770-02	2.173-01
19	1.700+00	9.376-03	5.499-02	2.066-01

CYL. UNDER HYDROSTATIC PRESS. INDIC=-1 BU



20	1.800+00	1.201-02	5.102-02	1.912-01
21	1.900+00	1.464-02	4.579-02	1.709-01
22	2.000+00	1.722-02	3.933-02	1.459-01
23	2.087+00	1.943-02	3.277-02	1.198-01
24	2.150+00	2.100-02	2.757-02	9.891-02
25	2.200+00	2.225-02	2.308-02	8.096-02
26	2.250+00	2.352-02	1.837-02	6.218-02
27	2.300+00	2.481-02	1.345-02	4.312-02
28	2.350+00	2.611-02	8.341-03	2.459-02
29	2.400+00	2.736-02	3.013-03	7.747-03
30	2.450+00	2.847-02	-2.627-03	-6.079-03
31	2.500+00	2.940-02	-8.621-03	-1.568-02
32	2.550+00	3.018-02	-1.511-02	-3.445-02
33	2.600+00	3.080-02	-2.246-02	-6.636-02
34	2.650+00	3.131-02	-3.079-02	-1.049-01
35	2.700+00	3.176-02	-3.984-02	-1.460-01
36	2.750+00	3.216-02	-4.937-02	-1.875-01
37	2.800+00	3.247-02	-5.914-02	-2.282-01
38	2.850+00	3.262-02	-6.900-02	-2.677-01
39	2.912+00	3.249-02	-8.122-02	-3.151-01
40	3.000+00	3.169-02	-9.786-02	-3.783-01
41	3.100+00	2.993-02	-1.159-01	-4.457-01
42	3.200+00	2.724-02	-1.326-01	-5.076-01
43	3.300+00	2.371-02	-1.474-01	-5.628-01
44	3.400+00	1.944-02	-1.600-01	-6.101-01
45	3.500+00	1.457-02	-1.702-01	-6.481-01
46	3.600+00	9.194-03	-1.776-01	-6.758-01
47	3.700+00	3.449-03	-1.821-01	-6.923-01
48	3.800+00	-2.541-03	-1.835-01	-6.971-01
49	3.900+00	-8.649-03	-1.817-01	-6.900-01
50	4.000+00	-1.474-02	-1.767-01	-6.708-01
51	4.100+00	-2.070-02	-1.686-01	-6.397-01
52	4.200+00	-2.639-02	-1.574-01	-5.974-01
53	4.300+00	-3.169-02	-1.435-01	-5.444-01
54	4.400+00	-3.648-02	-1.269-01	-4.817-01
55	4.500+00	-4.066-02	-1.079-01	-4.098-01
56	4.587+00	-4.383-02	-8.976-02	-3.393-01
57	4.650+00	-4.580-02	-7.593-02	-2.848-01
58	4.700+00	-4.724-02	-6.444-02	-2.387-01
59	4.750+00	-4.860-02	-5.271-02	-1.909-01
60	4.800+00	-4.993-02	-4.090-02	-1.422-01
61	4.850+00	-5.124-02	-2.913-02	-9.446-02
62	4.900+00	-5.247-02	-1.755-02	-5.031-02
63	4.950+00	-5.346-02	-6.178-03	-1.389-02
64	5.000+00	-5.414-02	5.090-03	9.299-03
65	5.050+00	-5.456-02	1.666-02	3.800-02
66	5.100+00	-5.467-02	2.907-02	8.532-02
67	5.150+00	-5.457-02	4.247-02	1.426-01
68	5.200+00	-5.438-02	5.665-02	2.040-01
69	5.250+00	-5.413-02	7.128-02	2.664-01
70	5.300+00	-5.378-02	8.611-02	3.276-01
71	5.350+00	-5.326-02	1.009-01	3.870-01
72	5.412+00	-5.223-02	1.191-01	4.579-01
73	5.500+00	-5.004-02	1.435-01	5.514-01
74	5.600+00	-4.650-02	1.697-01	6.499-01
75	5.700+00	-4.181-02	1.935-01	7.389-01
76	5.800+00	-3.611-02	2.143-01	8.173-01
77	5.900+00	-2.957-02	2.319-01	8.833-01



78	6.000+00	-2.235-02	2.457-01	9.356-01
79	6.100+00	-1.463-02	2.556-01	9.730-01
80	6.194+00	-7.069-03	2.611-01	9.938-01
81	6.258+00	-1.821-03	2.629-01	9.996-01
82	6.280+00	1.271-21	2.631-01	1.000+00

BUCKLING MODE FOR SEGMENT 2

POINT	STATION	U	V	W
1	6.280+00	-1.563-02	-8.621-03	-2.940-02
2	6.283+00	-1.568-02	-8.507-03	-3.016-02
3	6.290+00	-1.568-02	-8.209-03	-3.204-02
4	6.300+00	-1.568-02	-7.823-03	-3.421-02
5	6.310+00	-1.567-02	-7.447-03	-3.606-02
6	6.320+00	-1.566-02	-7.086-03	-3.760-02
7	6.330+00	-1.565-02	-6.738-03	-3.887-02
8	6.340+00	-1.563-02	-6.400-03	-3.992-02
9	6.350+00	-1.561-02	-6.073-03	-4.080-02
10	6.360+00	-1.559-02	-5.753-03	-4.153-02
11	6.370+00	-1.557-02	-5.441-03	-4.216-02
12	6.380+00	-1.555-02	-5.134-03	-4.273-02
13	6.390+00	-1.552-02	-4.832-03	-4.327-02
14	6.400+00	-1.550-02	-4.533-03	-4.383-02
15	6.409+00	-1.548-02	-4.275-03	-4.435-02
16	6.414+00	-1.546-02	-4.130-03	-4.467-02
17	6.415+00	-1.546-02	-4.089-03	-4.476-02

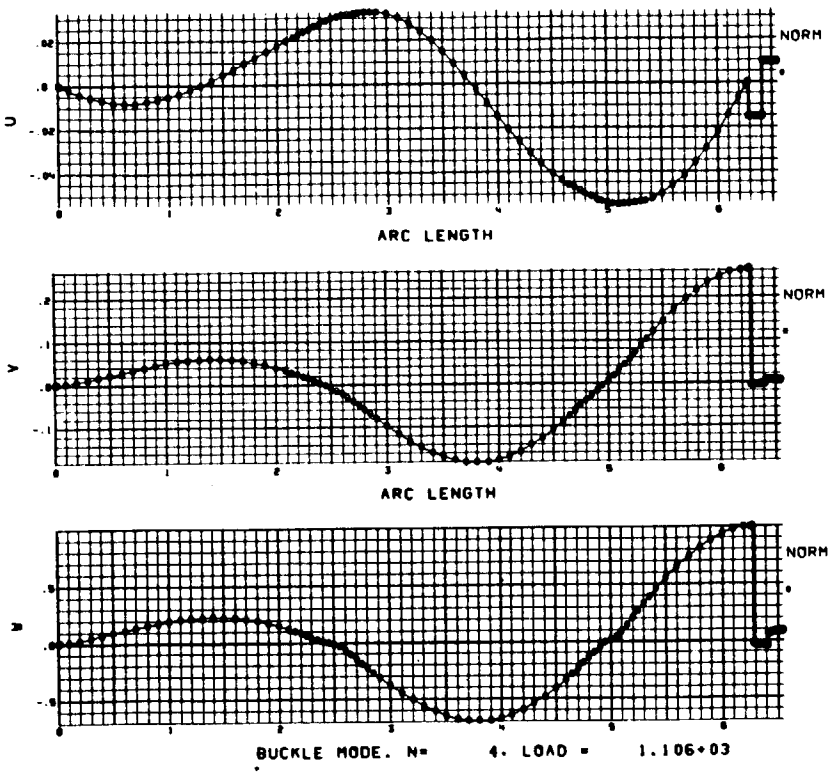
BUCKLING MODE FOR SEGMENT 3

POINT	STATION	U	V	W
1	6.415+00	9.299-03	5.090-03	5.414-02
2	6.418+00	9.300-03	5.023-03	5.554-02
3	6.425+00	9.300-03	4.847-03	5.897-02
4	6.435+00	9.298-03	4.619-03	6.295-02
5	6.445+00	9.293-03	4.398-03	6.632-02
6	6.455+00	9.287-03	4.185-03	6.913-02
7	6.465+00	9.279-03	3.979-03	7.145-02
8	6.475+00	9.269-03	3.781-03	7.337-02
9	6.485+00	9.258-03	3.587-03	7.496-02
10	6.495+00	9.245-03	3.399-03	7.629-02
11	6.505+00	9.232-03	3.215-03	7.744-02
12	6.515+00	9.218-03	3.034-03	7.848-02
13	6.525+00	9.203-03	2.855-03	7.947-02
14	6.535+00	9.188-03	2.679-03	8.048-02
15	6.544+00	9.175-03	2.527-03	8.142-02
16	6.549+00	9.167-03	2.441-03	8.201-02
17	6.550+00	9.165-03	2.417-03	8.218-02

ELAPSED TIME = 01 1:19.416

BEGINNING OF NEXT CASE

CYL. UNDER HYDROSTATIC PRESS. INDIC=-1 BU



UNIFORMLY LOADED FLAT CIRCULAR PLATE

27 OCT 71

STRESS ANALYSIS INCLUDING NONLINEAR EFFECTS. THIS AN-
ALYSIS YIELDS THE AXISYMMETRIC PREBUCKLING STRESSES
AND DISPLACEMENTS FOR A GIVEN VALUE OR SEQUENCE OF
VALUES OF THE APPLIED LOAD OR LOADS.

ANALYSIS TYPE = 0, PRINT OPTION = 2, PLOT OPTION = 0, STRESS OPTION = 1, PRESTRESS CALCULATION OPTION = 1

NUMBER OF SHELL SEGMENTS = 1

STRESS CALCULATED FOR CIRCUMFERENTIAL WAVES FROM 0 TO 0 IN INCREMENTS OF 1

INITIAL BUCKLING OR VIBRATION WAVE NO.= 0, MINIMUM WAVE NO.= 0, MAXIMUM WAVE NO.= 0, INCREMENT= 1

1 EIGENVALUES SOUGHT FOR EACH CIRCUMFERENTIAL WAVE NUMBER.

CONSTRAINT CONDITION DATA FOLLOW

SEG.	POINT	CONNECTED TO SEG.	POINT	USTAR	VSTAR	WSTAR	BETA	RADIAL DISC. D1(I)	AXIAL DISC. D2(I)
1	1	1	1	0	0	0	0	0.00000000	0.00000000
1	11	1	11	1	1	0	0	0.00000000	0.00000000

PRESSURE MULTIPLIER P = 1.0000-03, INCREMENT DP= 9.9900-01, TEMPERATURE MULT.TEMP= 0.0000 , INCREMENT DTEMP= 0.0000

INITIAL LOAD, FSTART = 1.0000-03, MAXIMUM LOAD, FMAX = 1.0000+00, STEP SIZE, DF= 9.9900-01

SEGMENT NO. 1 IS A CYLINDER OR CONE,
END POINT COORDINATES (.0000 , .0000) AND (.1000+02, .0000)

REFERENCE SURFACE GEOMETRY FOR SEGMENT NO. 1

STATION	ARC LENGTH	RAD	RADD	CUR1	CUR2	CURID	Z
1	.00000000	.00000000	.10000000+01	.00000000	.00000000	.00000000	.50000000-01
2	.27499999+00	.27499999+00	.10000000+01	.00000000	.00000000	.00000000	.50000000-01
3	.10125000+01	.10125000+01	.10000000+01	.00000000	.00000000	.00000000	.50000000-01
4	.20000000+01	.19999999+01	.10000000+01	.00000000	.00000000	.00000000	.50000000-01

5	.30000000+01	.29999999+01	.10000000+01	.00000000	.00000000	.00000000	.50000000-01
6	.40000000+01	.39999999+01	.10000000+01	.00000000	.00000000	.00000000	.50000000-01
7	.49999999+01	.49999999+01	.10000000+01	.00000000	.00000000	.00000000	.50000000-01
8	.59999999+01	.59999999+01	.10000000+01	.00000000	.00000000	.00000000	.50000000-01
9	.69999999+01	.69999999+01	.10000000+01	.00000000	.00000000	.00000000	.50000000-01
10	.79999999+01	.79999999+01	.10000000+01	.00000000	.00000000	.00000000	.50000000-01
11	.89874998+01	.89874997+01	.10000000+01	.00000000	.00000000	.00000000	.50000000-01
12	.97249998+01	.97249997+01	.10000000+01	.00000000	.00000000	.00000000	.50000000-01
13	.99999998+01	.99999996+01	.10000000+01	.00000000	.00000000	.00000000	.50000000-01

PHYSICAL PROPERTIES OF SEGMENT NO. 1

ANALYSIS IS FOR A MONOCOQUE SHELL

MODULUS OF ELASTICITY= .10000+08 POISSON RATIO= .30000+00 SHELL DENSITY = .00000 THERMAL EXP COEF.= .00000

MESH POINT	STATION	REF. SURFACE	THICKNES-
1	0.00000	5.00000-02	1.00000-01
2	2.75000-01	5.00000-02	1.00000-01
3	1.01250+00	5.00000-02	1.00000-01
4	2.00000+00	5.00000-02	1.00000-01
5	3.00000+00	5.00000-02	1.00000-01
6	4.00000+00	5.00000-02	1.00000-01
7	5.00000+00	5.00000-02	1.00000-01
8	6.00000+00	5.00000-02	1.00000-01
9	7.00000+00	5.00000-02	1.00000-01
10	8.00000+00	5.00000-02	1.00000-01
11	8.98750+00	5.00000-02	1.00000-01
12	9.72500+00	5.00000-02	1.00000-01
13	1.00000+01	5.00000-02	1.00000-01

WALL STIFFNESS COEFFICIENTS,CIJ, AND MASS/AREA, SMPA, FOR SEGMENT NUMBER 1

C11	C12	C14	C15	C22	C24	C25	C44	C45	C55	C33	C36	C66	SMPA
1.10+06	3.30+05	0.00	0.00	1.10+06	0.00	0.00	9.16+02	2.75+02	9.16+02	3.85+05	0.00	3.21+02	0.00
1.10+06	3.30+05	0.00	0.00	1.10+06	0.00	0.00	9.16+02	2.75+02	9.16+02	3.85+05	0.00	3.21+02	0.00
1.10+06	3.30+05	0.00	0.00	1.10+06	0.00	0.00	9.16+02	2.75+02	9.16+02	3.85+05	0.00	3.21+02	0.00
1.10+06	3.30+05	0.00	0.00	1.10+06	0.00	0.00	9.16+02	2.75+02	9.16+02	3.85+05	0.00	3.21+02	0.00
1.10+06	3.30+05	0.00	0.00	1.10+06	0.00	0.00	9.16+02	2.75+02	9.16+02	3.85+05	0.00	3.21+02	0.00
1.10+06	3.30+05	0.00	0.00	1.10+06	0.00	0.00	9.16+02	2.75+02	9.16+02	3.85+05	0.00	3.21+02	0.00
1.10+06	3.30+05	0.00	0.00	1.10+06	0.00	0.00	9.16+02	2.75+02	9.16+02	3.85+05	0.00	3.21+02	0.00
1.10+06	3.30+05	0.00	0.00	1.10+06	0.00	0.00	9.16+02	2.75+02	9.16+02	3.85+05	0.00	3.21+02	0.00
1.10+06	3.30+05	0.00	0.00	1.10+06	0.00	0.00	9.16+02	2.75+02	9.16+02	3.85+05	0.00	3.21+02	0.00
1.10+06	3.30+05	0.00	0.00	1.10+06	0.00	0.00	9.16+02	2.75+02	9.16+02	3.85+05	0.00	3.21+02	0.00
1.10+06	3.30+05	0.00	0.00	1.10+06	0.00	0.00	9.16+02	2.75+02	9.16+02	3.85+05	0.00	3.21+02	0.00
1.10+06	3.30+05	0.00	0.00	1.10+06	0.00	0.00	9.16+02	2.75+02	9.16+02	3.85+05	0.00	3.21+02	0.00

1.10+06	3.30+05	0.00	0.00	1.10+06	0.00	0.00	9.16+02	2.75+02	9.16+02	3.85+05	0.00	3.21+02	0.00
1.10+06	3.30+05	0.00	0.00	1.10+06	0.00	0.00	9.16+02	2.75+02	9.16+02	3.85+05	0.00	3.21+02	0.00

SYMMETRIC DISTRIBUTED MECHANICAL AND THERMAL LOAD COMPONENTS FOLLOW

LOAD COMPONENTS FOR SEGMENT NO. 1

	STATION	PU	PW	PND	TN1	TN2	TM1	TM2
1	0.00000	0.00000	1.00000+00	0.00000	0.00000	0.00000	0.00000	0.00000
2	2.75000-01	0.00000	1.00000+00	0.00000	0.00000	0.00000	0.00000	0.00000
3	1.01250+00	0.00000	1.00000+00	0.00000	0.00000	0.00000	0.00000	0.00000
4	2.00000+00	0.00000	1.00000+00	0.00000	0.00000	0.00000	0.00000	0.00000
5	3.00000+00	0.00000	1.00000+00	0.00000	0.00000	0.00000	0.00000	0.00000
6	4.00000+00	0.00000	1.00000+00	0.00000	0.00000	0.00000	0.00000	0.00000
7	5.00000+00	0.00000	1.00000+00	0.00000	0.00000	0.00000	0.00000	0.00000
8	6.00000+00	0.00000	1.00000+00	0.00000	0.00000	0.00000	0.00000	0.00000
9	7.00000+00	0.00000	1.00000+00	0.00000	0.00000	0.00000	0.00000	0.00000
10	8.00000+00	0.00000	1.00000+00	0.00000	0.00000	0.00000	0.00000	0.00000
11	8.98750+00	0.00000	1.00000+00	0.00000	0.00000	0.00000	0.00000	0.00000
12	9.72500+00	0.00000	1.00000+00	0.00000	0.00000	0.00000	0.00000	0.00000
13	1.00000+01	0.00000	1.00000+00	0.00000	0.00000	0.00000	0.00000	0.00000

AXISYMMETRIC PRESTRESS INPUT CONSTRAINT CONDITIONS FOLLOW

CONSTRAINT NO. 1 SEGMENT NO. 1 POINT 1 CONNECTED TO SEGMENT NO. 1 POINT 1.. TYPE OF CONSTRAINT = 1
CONSTRAINT NO. 2 SEGMENT NO. 1 POINT 13 CONNECTED TO SEGMENT NO. 1 POINT 13.. TYPE OF CONSTRAINT = 2

LOCAL MATRIX DIMENSION= 5 OVERLAP= 3 NO. CONSTRAINT CONDS. PER CONSTRAINT POINT= 3 SYSTEM RANK= 35 NUMBER OF BLOCKS= 1

NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO. 1 EQUALS 35 . NO. OF CONSTRAINT PTS. EQUALS 2
BLOCK NUMBER= 1 LAST EQ. IN BLOCK= 35 LOWEST UNK IN BLOCK= 1, MAX. OFF-DIAGONAL WIDTH= 7

DATA READ IN AND PROCESSED FOR THIS CASE. LEAVING SUBROUTINE READIT
ELAPSED TIME = 0: 0: 0.763

ENTERING SUBROUTINE PRE, AXISYMMETRIC PRESTRESS CALCULATOR

ELAPSED TIME = 0: 0: 0.786

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PRESSURE MULTIPLIER,P = 9.999946-04

```
START CALCULATION OF PRESTRESS STIFFNESS MATRIX FOR NEWTON-RAPHSON ITERATION NO.  0
                    ELAPSED TIME =  0: 0: 0.824
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.  0.   START FACTORING AND SOLVING
                    ELAPSED TIME =  0: 0: 0.942
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  0
                    ELAPSED TIME =  0: 0: 1.  6
START CALCULATION OF PRESTRESS STIFFNESS MATRIX FOR NEWTON-RAPHSON ITERATION NO.  1
                    ELAPSED TIME =  0: 0: 1. 16
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.  1.   START FACTORING AND SOLVING
                    ELAPSED TIME =  0: 0: 1.131
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  1
                    ELAPSED TIME =  0: 0: 1.194
 NUMBER OF NEWTON-RAPHSON ITERATIONS REQUIRED FOR CONVERGENCE = ITER =  1
START CALCULATION OF PRESTRESS FROM DISPLACEMENT SOLUTION VECTOR
                    ELAPSED TIME =  0: 0: 1.208
STRESSES OR STRESS RESULTANTS CALCULATED AND STORED ON DRUM OR DISK
                    ELAPSED TIME =  0: 0: 1.255


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PRESSURE MULTIPLIER,P =      1.000000+00

START CALCULATION OF PRESTRESS STIFFNESS MATRIX FOR NEWTON-RAPHSON ITERATION NO.  0
                    ELAPSED TIME =  0: 0: 1.279
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.  0.   START FACTORING AND SOLVING
                    ELAPSED TIME =  0: 0: 1.404
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  0
                    ELAPSED TIME =  0: 0: 1.463
START CALCULATION OF PRESTRESS STIFFNESS MATRIX FOR NEWTON-RAPHSON ITERATION NO.  1
                    ELAPSED TIME =  0: 0: 1.473
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.  1.   START FACTORING AND SOLVING
                    ELAPSED TIME =  0: 0: 1.594
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  1
                    ELAPSED TIME =  0: 0: 1.656
START CALCULATION OF PRESTRESS STIFFNESS MATRIX FOR NEWTON-RAPHSON ITERATION NO.  2
                    ELAPSED TIME =  0: 0: 1.668
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.  2.   START FACTORING AND SOLVING
                    ELAPSED TIME =  0: 0: 1.788
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  2
                    ELAPSED TIME =  0: 0: 1.854
START CALCULATION OF PRESTRESS STIFFNESS MATRIX FOR NEWTON-RAPHSON ITERATION NO.  3
                    ELAPSED TIME =  0: 0: 1.864
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.  3.   START FACTORING AND SOLVING
                    ELAPSED TIME =  0: 0: 1.980
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  3
                    ELAPSED TIME =  0: 0: 2. 42
START CALCULATION OF PRESTRESS STIFFNESS MATRIX FOR NEWTON-RAPHSON ITERATION NO.  4
                    ELAPSED TIME =  0: 0: 2. 53
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.  4.   START FACTORING AND SOLVING
                    ELAPSED TIME =  0: 0: 2.162
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  4
                    ELAPSED TIME =  0: 0: 2.218
START CALCULATION OF PRESTRESS STIFFNESS MATRIX FOR NEWTON-RAPHSON ITERATION NO.  5
```

```
                    ELAPSED TIME =  0: 0: 2.229
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.  5.   START FACTORING AND SOLVING
                    ELAPSED TIME =  0: 0: 2.332
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  5
                    ELAPSED TIME =  0: 0: 2.389
START CALCULATION OF PRESTRESS STIFFNESS MATRIX FOR NEWTON-RAPHSON ITERATION NO.  6
                    ELAPSED TIME =  0: 0: 2.399
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.  6.   START FACTORING AND SOLVING
                    ELAPSED TIME =  0: 0: 2.502
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  6
                    ELAPSED TIME =  0: 0: 2.561
START CALCULATION OF PRESTRESS STIFFNESS MATRIX FOR NEWTON-RAPHSON ITERATION NO.  7
                    ELAPSED TIME =  0: 0: 2.571
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.  7.   START FACTORING AND SOLVING
                    ELAPSED TIME =  0: 0: 2.679
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  7
                    ELAPSED TIME =  0: 0: 2.740
START CALCULATION OF PRESTRESS STIFFNESS MATRIX FOR NEWTON-RAPHSON ITERATION NO.  8
                    ELAPSED TIME =  0: 0: 2.750
PRESTRESS STIFFNESS MATRIX CALCULATED FOR ITERATION NO.  8.   START FACTORING AND SOLVING
                    ELAPSED TIME =  0: 0: 2.854
FACTORING AND SOLVING COMPLETED FOR PRESTRESS ITERATION NO.  8
                    ELAPSED TIME =  0: 0: 2.913
 NUMBER OF NEWTON-RAPHSON ITERATIONS REQUIRED FOR CONVERGENCE = ITER =  8
START CALCULATION OF PRESTRESS FROM DISPLACEMENT SOLUTION VECTOR
                    ELAPSED TIME =  0: 0: 2.927
STRESSES OR STRESS RESULTANTS CALCULATED AND STORED ON DRUM OR DISK
                    ELAPSED TIME =  0: 0: 2.977


LOAD EXCEEDS MAXIMUM ALLOWABLE VALUE, CASE TERMINATED.


ENTER SUBROUTINE OUT2
                    ELAPSED TIME =  0: 0: 2.999


AXISYMMETRIC MERIDIONAL STRESS DISTRIBUTIONS FOR THE SEQUENCE OF LOADS GIVEN ABOVE

OUTPUT FOR LOAD STEP NO.   1

                    AXISYMMETRIC PRESTRESS DISTRIBUTION FOR SEGMENT  1
```

POINT	STATION	WO	UO	BETA	UV	N10	N20	M10	M20
1	0.000	7.022-04	1.262-29	0.000	-7.022-04	1.551-03	1.551-03	-2.012-02	-2.012-02
2	2.750-01	7.016-04	2.866-10	-4.776-06	-7.016-04	1.497-03	1.491-03	-2.072-02	-2.069-02
3	1.012+00	6.933-04	9.722-10	-1.753-05	-6.933-04	1.446-03	1.394-03	-2.053-02	-2.059-02
4	2.000+00	6.676-04	1.611-09	-3.423-05	-6.676-04	1.376-03	1.218-03	-1.991-02	-2.024-02
5	3.000+00	6.251-04	1.687-09	-5.033-05	-6.251-04	1.278-03	9.459-04	-1.888-02	-1.964-02
6	4.000+00	5.669-04	9.756-10	-6.520-05	-5.669-04	1.151-03	5.891-04	-1.744-02	-1.881-02

7	5.000+00	4.947-04	-6.646-10	-7.843-05	-4.947-04	9.960-04	1.659-04	-1.558-02	-1.774-02
8	6.000+00	4.101-04	-3.282-09	-8.961-05	-4.101-04	8.187-04	-3.014-04	-1.331-02	-1.644-02
9	7.000+00	3.154-04	-6.822-09	-9.833-05	-3.154-04	6.239-04	-7.874-04	-1.063-02	-1.490-02
10	8.000+00	2.134-04	-1.112-08	-1.042-04	-2.134-04	4.177-04	-1.265-03	-7.536-03	-1.311-02
11	8.987+00	1.084-04	-1.587-08	-1.068-04	-1.084-04	2.090-04	-1.703-03	-4.014-03	-1.110-02
12	9.725+00	2.913-05	-1.954-08	-1.064-04	-2.913-05	5.660-05	-1.993-03	-7.990-05	-9.137-03
13	1.000+01	-2.456-13	-2.092-08	-1.055-04	2.456-13	-2.149-11	-2.092-03	3.700-07	-8.789-03

AXISYMMETRIC PRESTRESS DISTRIBUTION FOR SEGMENT 1

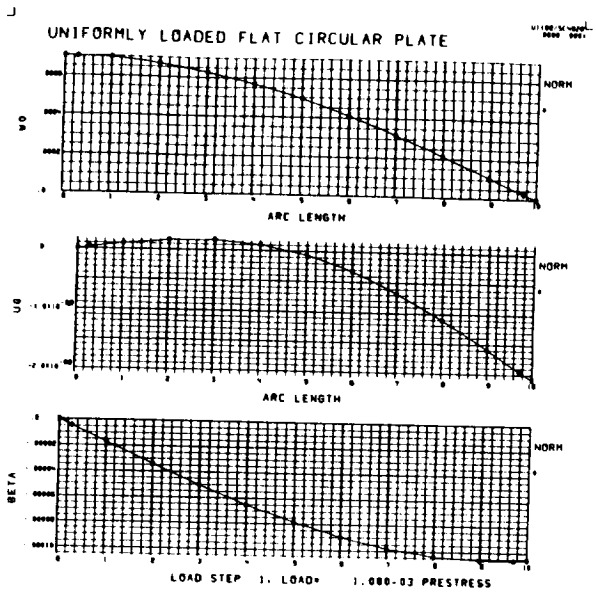
POINT	STATION	WO	UO	SIGMA1(IN)	SIGMA1(OUT)	SIGMA2(IN)	SIGMA2(OUT)	SIGMAE(IN)	SIGMAE(OUT)
1	0.000	7.022-04	1.262-29	-1.206+01	1.209+01	-1.206+01	1.209+01	1.206+01	1.209+01
2	2.750-01	7.016-04	2.866-10	-1.242+01	1.245+01	-1.240+01	1.243+01	1.241+01	1.244+01
3	1.012+00	6.933-04	9.722-10	-1.231+01	1.233+01	-1.234+01	1.237+01	1.232+01	1.235+01
4	2.000+00	6.676-04	1.611-09	-1.193+01	1.196+01	-1.213+01	1.215+01	1.203+01	1.206+01
5	3.000+00	6.251-04	1.687-09	-1.132+01	1.134+01	-1.178+01	1.180+01	1.155+01	1.158+01
6	4.000+00	5.669-04	9.756-10	-1.045+01	1.047+01	-1.128+01	1.129+01	1.089+01	1.091+01
7	5.000+00	4.947-04	-6.646-10	-9.338+00	9.358+00	-1.065+01	1.065+01	1.006+01	1.007+01
8	6.000+00	4.101-04	-3.282-09	-7.978+00	7.995+00	-9.866+00	9.860+00	9.071+00	9.072+00
9	7.000+00	3.154-04	-6.822-09	-6.372+00	6.384+00	-8.945+00	8.929+00	7.976+00	7.968+00
10	8.000+00	2.134-04	-1.112-08	-4.517+00	4.526+00	-7.881+00	7.856+00	6.849+00	6.829+00
11	8.987+00	1.084-04	-1.587-08	-2.407+00	2.411+00	-6.678+00	6.644+00	5.858+00	5.826+00
12	9.725+00	2.913-05	-1.954-08	-4.737-02	4.850-02	-5.502+00	5.462+00	5.479+00	5.438+00
13	1.000+01	-2.456-13	-2.092-08	1.345-02	-1.334-02	-5.291+00	5.249+00	5.297+00	5.255+00

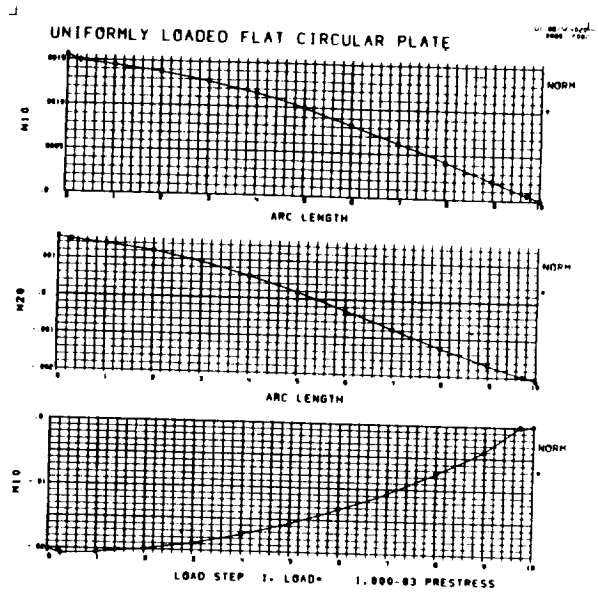
OUTPUT FOR LOAD STEP NO. 2

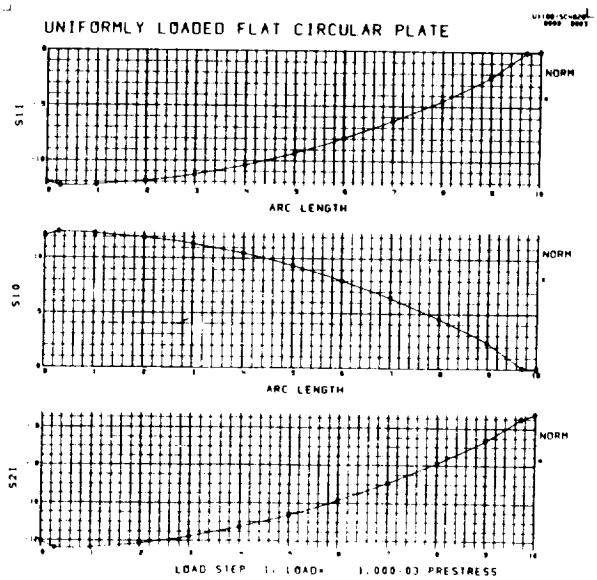
AXISYMMETRIC PRESTRESS DISTRIBUTION FOR SEGMENT 1

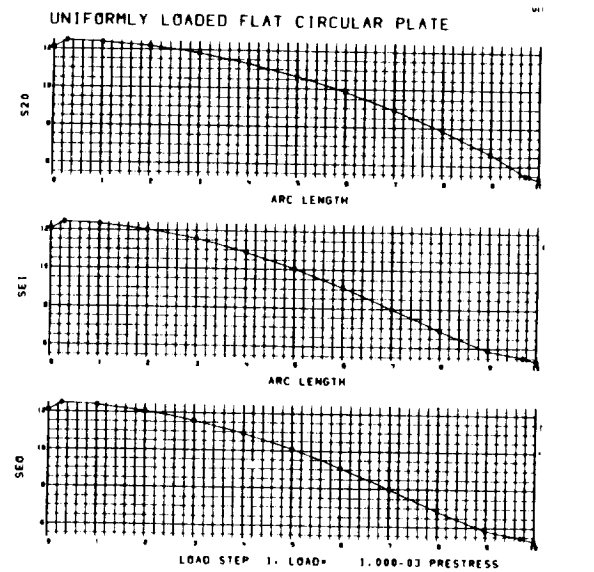
POINT	STATION	WO	UO	BETA	UV	N10	N20	M10	M20
1	0.000	2.520-01	0.000	0.000	-2.520-01	1.614+02	1.614+02	-4.028+00	-4.028+00
2	2.750-01	2.519-01	3.041-05	-1.129-03	-2.519-01	1.584+02	1.581+02	-4.954+00	-4.907+00
3	1.012+00	2.499-01	1.069-04	-4.350-03	-2.499-01	1.553+02	1.521+02	-5.269+00	-5.161+00
4	2.000+00	2.434-01	1.903-04	-8.887-03	-2.434-01	1.508+02	1.404+02	-5.544+00	-5.366+00
5	3.000+00	2.322-01	2.313-04	-1.379-02	-2.322-01	1.440+02	1.203+02	-5.923+00	-5.608+00
6	4.000+00	2.158-01	2.001-04	-1.910-02	-2.158-01	1.343+02	9.031+01	-6.376+00	-5.893+00
7	5.000+00	1.940-01	6.152-05	-2.484-02	-1.940-01	1.214+02	4.871+01	-6.818+00	-6.186+00
8	6.000+00	1.662-01	-2.251-04	-3.092-02	-1.662-01	1.047+02	-6.119+00	-7.085+00	-6.420+00
9	7.000+00	1.321-01	-6.998-04	-3.700-02	-1.321-01	8.394+01	-7.479+01	-6.917+00	-6.479+00
10	8.000+00	9.217-02	-1.386-03	-4.243-02	-9.217-02	5.905+01	-1.555+02	-5.940+00	-6.202+00
11	8.987+00	4.787-02	-2.251-03	-4.610-02	-4.787-02	3.083+01	-2.412+02	-3.707+00	-5.387+00
12	9.725+00	1.287-02	-2.970-03	-4.699-02	-1.287-02	8.618+00	-3.028+02	-1.207-01	-4.063+00
13	1.000+01	-1.086-10	-3.246-03	-4.663-02	1.086-10	-4.604-06	-3.246+02	1.635-04	-3.886+00

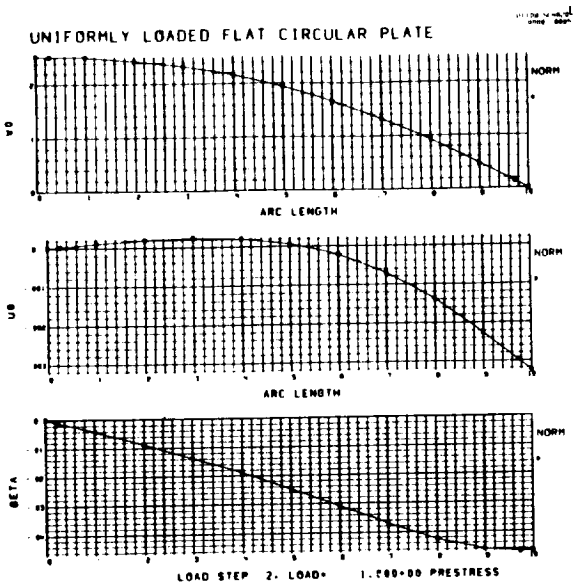
AXISYMMETRIC PRESTRESS DISTRIBUTION FOR SEGMENT 1

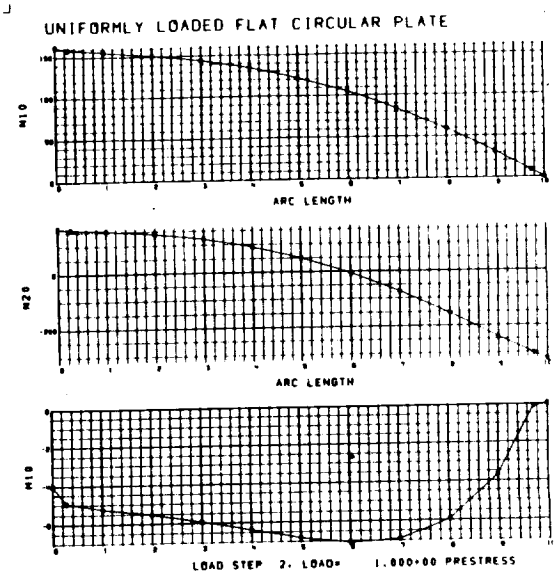

UNIFORMLY LOADED FLAT CIRCULAR PLATE
W0
U0
BETA
NORM
ARC LENGTH
LOAD STEP 1. LOAD= 1.000-03 PRESTRESS

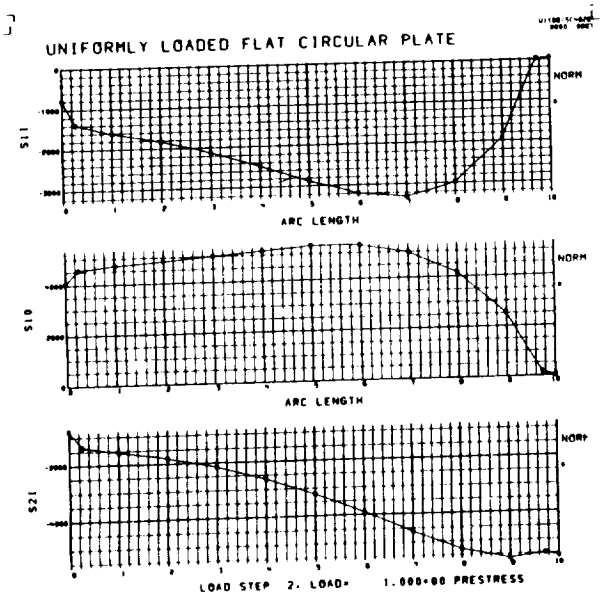

UNIFORMLY LOADED FLAT CIRCULAR PLATE
M10
M20
M10
NORM
ARC LENGTH
LOAD STEP 1. LOAD= 1.000-03 PRESTRESS

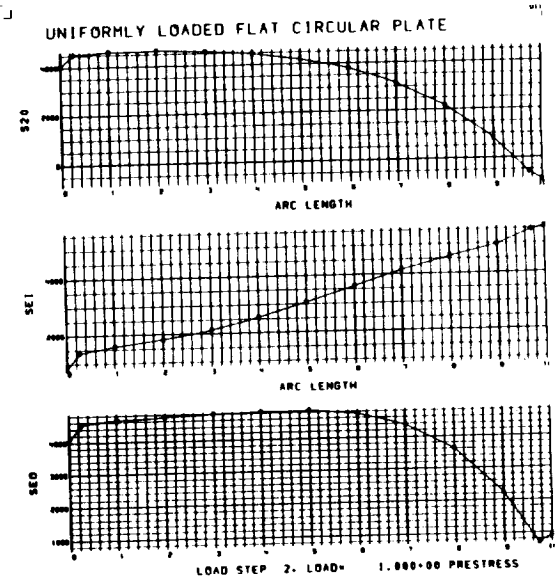

UNIFORMLY LOADED FLAT CIRCULAR PLATE
S11
S10
S21
NORM
ARC LENGTH
LOAD STEP 1. LOAD= 1.000-03 PRESTRESS


UNIFORMLY LOADED FLAT CIRCULAR PLATE
S20
SE1
SE0
ARC LENGTH
LOAD STEP 1. LOAD= 1.000-03 PRESTRESS


UNIFORMLY LOADED FLAT CIRCULAR PLATE
V0
NORM
ARC LENGTH
U0
NORM
ARC LENGTH
BETA
NORM
LOAD STEP 2. LOAD= 1.000+00 PRESTRESS


UNIFORMLY LOADED FLAT CIRCULAR PLATE
N10
ARC LENGTH
N20
ARC LENGTH
M10
LOAD STEP 2. LOAD= 1.000+00 PRESTRESS


UNIFORMLY LOADED FLAT CIRCULAR PLATE
S11
NORM
ARC LENGTH
S10
NORM
ARC LENGTH
S21
NORM
LOAD STEP 2. LOAD= 1.000+00 PRESTRESS


UNIFORMLY LOADED FLAT CIRCULAR PLATE
S20
ARC LENGTH
SE1
ARC LENGTH
SE0
LOAD STEP 2. LOAD= 1.000+00 PRESTRESS

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POINT	STATION	WO	UO	SIGMA1(IN)	SIGMA1(OUT)	SIGMA2(IN)	SIGMA2(OUT)	SIGMAE(IN)	SIGMAE(OUT)
1	0.000	2.520-01	0.000	-8.024+02	4.031+03	-8.024+02	4.031+03	8.024+02	4.031+03
2	2.750-01	2.519-01	3.041-05	-1.388+03	4.556+03	-1.363+03	4.526+03	1.376+03	4.541+03
3	1.012+00	2.499-01	1.069-04	-1.608+03	4.714+03	-1.575+03	4.618+03	1.592+03	4.667+03
4	2.000+00	2.434-01	1.903-04	-1.819+03	4.835+03	-1.816+03	4.624+03	1.817+03	4.733+03
5	3.000+00	2.322-01	2.313-04	-2.114+03	4.994+03	-2.162+03	4.568+03	2.138+03	4.795+03
6	4.000+00	2.158-01	2.001-04	-2.483+03	5.169+03	-2.632+03	4.439+03	2.561+03	4.845+03
7	5.000+00	1.940-01	6.152-05	-2.877+03	5.304+03	-3.225+03	4.199+03	3.066+03	4.847+03
8	6.000+00	1.662-01	-2.251-04	-3.204+03	5.298+03	-3.913+03	3.791+03	3.611+03	4.728+03
9	7.000+00	1.321-01	-6.998-04	-3.310+03	4.989+03	-4.636+03	3.140+03	4.135+03	4.369+03
10	8.000+00	9.217-02	-1.386-03	-2.974+03	4.155+03	-5.276+03	2.166+03	4.582+03	3.599+03
11	8.987+00	4.787-02	-2.251-03	-1.916+03	2.533+03	-5.644+03	8.200+02	4.971+03	2.238+03
12	9.725+00	1.287-02	-2.970-03	1.375+01	1.586+02	-5.466+03	-5.901+02	5.473+03	6.833+02
13	1.000+01	-1.086-10	-3.246-03	1.460+01	1.619+00	-5.573+03	-9.138+02	5.580+03	9.146+02

JUST LEFT SUBROUTINE OUT2
ELAPSED TIME = 0: 0: 3.464

ENTERING SUBROUTINE PLOT
ELAPSED TIME = 0: 0: 3.480
LEAVING SUBROUTINE PLOT
ELAPSED TIME = 0: 0: 4.838
ELAPSED TIME = 0: 0: 4.842

START READING DATA FOR THIS CASE
ELAPSED TIME = 0: 0: 0. 14

BEGINNING OF NEXT CASE

CYLINDER WITH THREE POINT LOADS

LINEAR STATIC ANALYSIS FOR NON-SYMMETRIC LOADS

ANALYSIS TYPE = 3, PRINT OPTION = 1, PLOT OPTION = 0, STRESS OPTION = 1, PRESTRESS CALCULATION OPTION = 1

NUMBER OF SHELL SEGMENTS = 1

STRESS CALCULATED FOR CIRCUMFERENTIAL WAVES FROM 0 TO -57 IN INCREMENTS OF -3

INITIAL BUCKLING OR VIBRATION WAVE NO.= 0, MINIMUM WAVE NO.= 0, MAXIMUM WAVE NO.= 0, INCREMENT= 1

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1 EIGENVALUES SOUGHT FOR EACH CIRCUMFERENTIAL WAVE NUMBER.

CONSTRAINT CONDITION DATA FOLLOW

SEG.	POINT	CONNECTED TO SEG.	POINT	USTAR	VSTAR	WSTAR	BETA	RADIAL DISC. D1(I)	AXIAL DISC. D2(I)
1	1	1	1	0	1	1	0	0.00000000	0.00000000
1	52	1	52	1	0	0	1	0.00000000	0.00000000

PRESSURE MULTIPLIER P = 0.0000 , INCREMENT DP= 0.0000 , TEMPERATURE MULT.TEMP= 1.0000+00, INCREMENT DTEMP= 0.0000

INITIAL LOAD, FSTART = 0.0000 , MAXIMUM LOAD, FMAX = 0.0000 , STEP SIZE, DF= 0.0000

SEGMENT NO. 1 IS A CYLINDER OR CONE,
END POINT COORDINATES (.1005+03, .0000) AND (.1005+03, .2400+03)

REFERENCE SURFACE GEOMETRY FOR SEGMENT NO. 1

STATION	ARC LENGTH	RAD	RADD	CUR1	CUR2	CUR1D	Z
1	.00000000	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
2	.54771792+01	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
3	.20165978+02	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
4	.39834031+02	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
5	.59751046+02	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
6	.79668061+02	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
7	.99585076+02	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
8	.11950209+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
9	.13941911+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
10	.15933612+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
11	.17925314+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
12	.19443986+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
13	.20016600+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
14	.20116185+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
15	.20215770+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
16	.20315355+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
17	.20414940+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
18	.20514525+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
19	.20614110+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
20	.20713695+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
21	.20813280+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
22	.20912865+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
23	.21012450+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
24	.21112035+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
25	.21211620+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
26	.21311205+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
27	.21410789+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
28	.21510374+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
29	.21609959+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
30	.21709544+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00

31	.21809129+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
32	.21908714+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
33	.22008299+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
34	.22107884+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
35	.22207469+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
36	.22307054+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
37	.22406639+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
38	.22506224+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
39	.22605809+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
40	.22705394+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
41	.22804979+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
42	.22904564+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
43	.23004149+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
44	.23103734+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
45	.23203319+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
46	.23302904+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
47	.23402489+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
48	.23502074+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
49	.23601659+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
50	.23701244+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
51	.23800829+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
52	.23899169+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
53	.23972613+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00
54	.23999998+03	.10050000+03	.00000000	.00000000	.99502486-02	.00000000	.50000000+00

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THERMAL OR MECHANICAL LINE OR DISTRIBUTED LOADS FOR THE 1 SEGMENT. VALID FOR LOADS EXPRESSED IN FORM FS(S)*Y(THETA)

CIRCUMFERENTIAL DISTRIBUTION OF RADIAL LINE LOADS H(K)

INPUT LOAD DISTRIBUTION

```
CIRC. STA  1 CIRC. COORD.(DEGREES) =  0.000     INPUT LOAD VALUE= -1.000+00 CIRC. COORD.=  0.000     INPUT LOAD VALUE= -1.000+00
CIRC. STA  2 CIRC. COORD.(DEGREES) =  5.000+00 INPUT LOAD VALUE=  0.000     CIRC. COORD.= -5.000+00 INPUT LOAD VALUE=  0.000
CIRC. STA  3 CIRC. COORD.(DEGREES) =  6.000+01 INPUT LOAD VALUE=  0.000     CIRC. COORD.= -6.000+01 INPUT LOAD VALUE=  0.000
```

CALCULATED FOURIER HARMONICS OF LOAD

```
WAVE NO. FOR INTERVAL L=      0 WAVE NO. FOR -PI TO +PI =      0 FOURIER HARMONIC =      -.41667-01
WAVE NO. FOR INTERVAL L=     -1 WAVE NO. FOR -PI TO +PI =     -3 FOURIER HARMONIC =      -.82858-01
WAVE NO. FOR INTERVAL L=     -2 WAVE NO. FOR -PI TO +PI =     -6 FOURIER HARMONIC =      -.81447-01
WAVE NO. FOR INTERVAL L=     -3 WAVE NO. FOR -PI TO +PI =     -9 FOURIER HARMONIC =      -.79137-01
WAVE NO. FOR INTERVAL L=     -4 WAVE NO. FOR -PI TO +PI =    -12 FOURIER HARMONIC =      -.75991-01
WAVE NO. FOR INTERVAL L=     -5 WAVE NO. FOR -PI TO +PI =    -15 FOURIER HARMONIC =      -.72093-01
WAVE NO. FOR INTERVAL L=     -6 WAVE NO. FOR -PI TO +PI =    -18 FOURIER HARMONIC =      -.67547-01
WAVE NO. FOR INTERVAL L=     -7 WAVE NO. FOR -PI TO +PI =    -21 FOURIER HARMONIC =      -.62471-01
WAVE NO. FOR INTERVAL L=     -8 WAVE NO. FOR -PI TO +PI =    -24 FOURIER HARMONIC =      -.56993-01
WAVE NO. FOR INTERVAL L=     -9 WAVE NO. FOR -PI TO +PI =    -27 FOURIER HARMONIC =      -.51249-01
WAVE NO. FOR INTERVAL L=    -10 WAVE NO. FOR -PI TO +PI =    -30 FOURIER HARMONIC =      -.45376-01
WAVE NO. FOR INTERVAL L=    -11 WAVE NO. FOR -PI TO +PI =    -33 FOURIER HARMONIC =      -.39509-01
WAVE NO. FOR INTERVAL L=    -12 WAVE NO. FOR -PI TO +PI =    -36 FOURIER HARMONIC =      -.33774-01
WAVE NO. FOR INTERVAL L=    -13 WAVE NO. FOR -PI TO +PI =    -39 FOURIER HARMONIC =      -.28287-01
WAVE NO. FOR INTERVAL L=    -14 WAVE NO. FOR -PI TO +PI =    -42 FOURIER HARMONIC =      -.23151-01
WAVE NO. FOR INTERVAL L=    -15 WAVE NO. FOR -PI TO +PI =    -45 FOURIER HARMONIC =      -.18450-01
WAVE NO. FOR INTERVAL L=    -16 WAVE NO. FOR -PI TO +PI =    -48 FOURIER HARMONIC =      -.14248-01
WAVE NO. FOR INTERVAL L=    -17 WAVE NO. FOR -PI TO +PI =    -51 FOURIER HARMONIC =      -.10592-01
WAVE NO. FOR INTERVAL L=    -18 WAVE NO. FOR -PI TO +PI =    -54 FOURIER HARMONIC =      -.75053-02
WAVE NO. FOR INTERVAL L=    -19 WAVE NO. FOR -PI TO +PI =    -57 FOURIER HARMONIC =      -.49926-02
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PHYSICAL PROPERTIES OF SEGMENT NO. 1

ANALYSIS IS FOR A MONOCOQUE SHELL

MODULUS OF ELASTICITY= .10800+08 POISSON RATIO= .33000+00 SHELL DENSITY = .00000 THERMAL EXP COEF.= .00000

MESH POINT	STATION	REF. SURFACE	THICKNESS
1	0.00000	5.00000-01	1.00000+00
2	5.47718+00	5.00000-01	1.00000+00
3	2.01660+01	5.00000-01	1.00000+00
4	3.98340+01	5.00000-01	1.00000+00
5	5.97510+01	5.00000-01	1.00000+00
6	7.96681+01	5.00000-01	1.00000+00
7	9.95851+01	5.00000-01	1.00000+00
8	1.19502+02	5.00000-01	1.00000+00
9	1.39419+02	5.00000-01	1.00000+00
10	1.59336+02	5.00000-01	1.00000+00
11	1.79253+02	5.00000-01	1.00000+00
12	1.94440+02	5.00000-01	1.00000+00
13	2.00166+02	5.00000-01	1.00000+00
14	2.01162+02	5.00000-01	1.00000+00
15	2.02158+02	5.00000-01	1.00000+00
16	2.03154+02	5.00000-01	1.00000+00
17	2.04149+02	5.00000-01	1.00000+00
18	2.05145+02	5.00000-01	1.00000+00
19	2.06141+02	5.00000-01	1.00000+00
20	2.07137+02	5.00000-01	1.00000+00
21	2.08133+02	5.00000-01	1.00000+00
22	2.09129+02	5.00000-01	1.00000+00
23	2.10124+02	5.00000-01	1.00000+00
24	2.11120+02	5.00000-01	1.00000+00
25	2.12116+02	5.00000-01	1.00000+00
26	2.13112+02	5.00000-01	1.00000+00
27	2.14108+02	5.00000-01	1.00000+00
28	2.15104+02	5.00000-01	1.00000+00
29	2.16100+02	5.00000-01	1.00000+00
30	2.17095+02	5.00000-01	1.00000+00
31	2.18091+02	5.00000-01	1.00000+00
32	2.19087+02	5.00000-01	1.00000+00
33	2.20083+02	5.00000-01	1.00000+00
34	2.21079+02	5.00000-01	1.00000+00
35	2.22075+02	5.00000-01	1.00000+00
36	2.23071+02	5.00000-01	1.00000+00
37	2.24066+02	5.00000-01	1.00000+00
38	2.25062+02	5.00000-01	1.00000+00
39	2.26058+02	5.00000-01	1.00000+00
40	2.27054+02	5.00000-01	1.00000+00
41	2.28050+02	5.00000-01	1.00000+00
42	2.29046+02	5.00000-01	1.00000+00
43	2.30041+02	5.00000-01	1.00000+00
44	2.31037+02	5.00000-01	1.00000+00
45	2.32033+02	5.00000-01	1.00000+00

46	2.33029+02	5.00000-01	1.00000+00
47	2.34025+02	5.00000-01	1.00000+00
48	2.35021+02	5.00000-01	1.00000+00
49	2.36017+02	5.00000-01	1.00000+00
50	2.37012+02	5.00000-01	1.00000+00
51	2.38008+02	5.00000-01	1.00000+00
52	2.38992+02	5.00000-01	1.00000+00
53	2.39726+02	5.00000-01	1.00000+00
54	2.40000+02	5.00000-01	1.00000+00

RING PROPERTIES FOR RINGS IN SEGMENT 1

STATION	ER	AREA	IY	IX	IXY	EI	E2	GJ	RM	RC
54	2.4000+02	5.4000+06	3.0000+00	2.2500+00	2.5000-01	0.0000	2.0000+00	0.0000	1.6390+06	0.0000	1.0250+02

MECHANICAL LINE LOADS FOR NONSYMMETRIC LOADING

STATION S(K)	AXIAL LOAD V(K)	SHEAR LOAD SHEAR(K)	RADIAL LOAD H(K)	MOMENT M(K)
MECHANICAL LINE LOADS FOR 0 CIRCUMFERENTIAL WAVES				
.23999998+03	.00000000	.00000000	-.41666667-01	.00000000
MECHANICAL LINE LOADS FOR -3 CIRCUMFERENTIAL WAVES				
.23999998+03	.00000000	.00000000	-.82858449-01	.00000000
MECHANICAL LINE LOADS FOR -6 CIRCUMFERENTIAL WAVES				
.23999998+03	.00000000	.00000000	-.81446786-01	.00000000
MECHANICAL LINE LOADS FOR -9 CIRCUMFERENTIAL WAVES				
.23999998+03	.00000000	.00000000	-.79136764-01	.00000000
MECHANICAL LINE LOADS FOR -12 CIRCUMFERENTIAL WAVES				
.23999998+03	.00000000	.00000000	-.75990885-01	.00000000
MECHANICAL LINE LOADS FOR -15 CIRCUMFERENTIAL WAVES				
.23999998+03	.00000000	.00000000	-.72093436-01	.00000000
MECHANICAL LINE LOADS FOR -18 CIRCUMFERENTIAL WAVES				
.23999998+03	.00000000	.00000000	-.67547454-01	.00000000
MECHANICAL LINE LOADS FOR -21 CIRCUMFERENTIAL WAVES				
.23999998+03	.00000000	.00000000	-.62471035-01	.00000000

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                MECHANICAL LINE LOADS FOR     -24 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          -.56993164-01        .00000000
                MECHANICAL LINE LOADS FOR     -27 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          -.51249207-01        .00000000
                MECHANICAL LINE LOADS FOR     -30 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          -.45376295-01        .00000000
                MECHANICAL LINE LOADS FOR     -33 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          -.39508746-01        .00000000
                MECHANICAL LINE LOADS FOR     -36 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          -.33773727-01        .00000000
                MECHANICAL LINE LOADS FOR     -39 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          -.28287328-01        .00000000
                MECHANICAL LINE LOADS FOR     -42 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          -.23151171-01        .00000000
                MECHANICAL LINE LOADS FOR     -45 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          -.18449715-01        .00000000
                MECHANICAL LINE LOADS FOR     -48 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          -.14248291-01        .00000000
                MECHANICAL LINE LOADS FOR     -51 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          -.10591975-01        .00000000
                MECHANICAL LINE LOADS FOR     -54 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          -.75052727-02        .00000000
                MECHANICAL LINE LOADS FOR     -57 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          -.49926201-02        .00000000
                                THERMAL LINE LOADS FOR NONSYMMETRIC LOADING
 STATION              TNR                TMR                TMRX

                THERMAL LINE LOADS FOR       0 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
                THERMAL LINE LOADS FOR      -3 CIRCUMFERENTIAL WAVES
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.23999998+03        .00000000          .00000000          .00000000
            THERMAL LINE LOADS FOR      -6 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
            THERMAL LINE LOADS FOR      -9 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
            THERMAL LINE LOADS FOR     -12 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
            THERMAL LINE LOADS FOR     -15 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
            THERMAL LINE LOADS FOR     -18 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
            THERMAL LINE LOADS FOR     -21 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
            THERMAL LINE LOADS FOR     -24 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
            THERMAL LINE LOADS FOR     -27 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
            THERMAL LINE LOADS FOR     -30 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
            THERMAL LINE LOADS FOR     -33 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
            THERMAL LINE LOADS FOR     -36 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
            THERMAL LINE LOADS FOR     -39 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
            THERMAL LINE LOADS FOR     -42 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
            THERMAL LINE LOADS FOR     -45 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
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                THERMAL LINE LOADS FOR     -48 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
                THERMAL LINE LOADS FOR     -51 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
                THERMAL LINE LOADS FOR     -54 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000
                THERMAL LINE LOADS FOR     -57 CIRCUMFERENTIAL WAVES
.23999998+03        .00000000          .00000000          .00000000

STABILITY, VIBRATION OR NON-SYMMETRIC STRESS INPUT CONSTRAINT CONDITIONS FOLLOW

CONSTRAINT NO.   1 SEGMENT NO.   1 POINT   1 CONNECTED TO SEGMENT NO.  1 POINT   1., TYPE OF CONSTRAINT =  1
CONSTRAINT NO.   2 SEGMENT NO.   1 POINT  54 CONNECTED TO SEGMENT NO.  1 POINT  54., TYPE OF CONSTRAINT =  2

LOCAL MATRIX DIMENSION=  7 OVERLAP=  4 NO. CONSTRAINT CONDS. PER CONSTRAINT POINT=  4 SYSTEM RANK=  174 NUMBER OF BLOCKS=   1

NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  1 EQUALS 174 .  NO. OF CONSTRAINT PTS. EQUALS   2
BLOCK NUMBER=  1 LAST EQ. IN BLOCK= 174 LOWEST UNK IN BLOCK=   1, MAX. OFF-DIAGONAL WIDTH=  10

DATA READ IN AND PROCESSED FOR THIS CASE, LEAVING SUBROUTINE READIT

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.      0 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.     -3 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.     -6 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.     -9 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -12 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -15 WAVES
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ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -18 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -21 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -24 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -27 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -30 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -33 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -36 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -39 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -42 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -45 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -48 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -51 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -54 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -57 WAVES

MERIDIONAL DISTRIBUTION OF SUPERPOSED QUANTITIES CORRESPONDING TO CIRCUMFERENTIAL STATION, THETA=   0.0000    DEG.
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STRESS RESULTANTS OR STRESSES IN SEGMENT 1

POINT	STATION	U	V	W	S1(IN)	S1(OUT)	TAU(IN)	S2(IN)	S2(OUT)	TAU(OUT)	SVON(IN)	SVON(OUT)
1	0.00	1.34-05	0.00	-3.35-23	-5.93-03	2.16-03	0.00	-1.96-03	7.11-04	0.00	5.23-03	1.90-03
2	5.48+00	1.33-05	0.00	-7.00-06	-2.69-02	-1.49-02	0.00	4.04-02	-1.53-02	0.00	5.86-02	1.51-02
3	2.02+01	1.33-05	0.00	-2.62-05	-3.35-02	-1.21-01	0.00	1.27-01	-1.26-01	0.00	1.47-01	1.23-01
4	3.98+01	1.30-05	0.00	-5.16-05	-6.77-02	-2.38-01	0.00	2.56-01	-2.48-01	0.00	2.96-01	2.43-01
5	5.98+01	1.27-05	0.00	-7.72-05	-9.99-02	-3.60-01	0.00	3.92-01	-3.78-01	0.00	4.50-01	3.69-01
6	7.97+01	1.22-05	0.00	-1.03-04	-1.31-01	-4.87-01	0.00	5.37-01	-5.16-01	0.00	6.13-01	5.02-01
7	9.96+01	1.15-05	0.00	-1.28-04	-1.62-01	-6.20-01	0.00	6.96-01	-6.67-01	0.00	7.89-01	6.45-01
8	1.20+02	1.07-05	0.00	-1.52-04	-1.92-01	-7.65-01	0.00	8.74-01	-8.34-01	0.00	9.84-01	8.02-01
9	1.39+02	9.74-06	0.00	-1.77-04	-2.24-01	-9.26-01	0.00	1.08+00	-1.02+00	0.00	1.21+00	9.79-01
10	1.59+02	8.56-06	0.00	-2.01-04	-2.59-01	-1.11+00	0.00	1.32+00	-1.25+00	0.00	1.47+00	1.19+00
11	1.79+02	7.13-06	0.00	-2.25-04	-3.10-01	-1.35+00	0.00	1.64+00	-1.52+00	0.00	1.82+00	1.44+00
12	1.94+02	5.87-06	0.00	-2.43-04	-3.14-01	-1.62+00	0.00	1.94+00	-1.84+00	0.00	2.12+00	1.74+00
13	2.00+02	5.35-06	0.00	-2.50-04	-4.21-01	-1.63+00	0.00	2.08+00	-1.91+00	0.00	2.32+00	1.79+00
14	2.01+02	5.25-06	0.00	-2.51-04	-4.17-01	-1.66+00	0.00	2.11+00	-1.93+00	0.00	2.35+00	1.81+00
15	2.02+02	5.15-06	0.00	-2.52-04	-4.14-01	-1.68+00	0.00	2.15+00	-1.95+00	0.00	2.38+00	1.83+00
16	2.03+02	5.05-06	0.00	-2.53-04	-4.12-01	-1.71+00	0.00	2.18+00	-1.97+00	0.00	2.41+00	1.86+00
17	2.04+02	4.95-06	0.00	-2.55-04	-4.11-01	-1.73+00	0.00	2.21+00	-2.00+00	0.00	2.45+00	1.88+00
18	2.05+02	4.85-06	0.00	-2.56-04	-4.12-01	-1.76+00	0.00	2.25+00	-2.02+00	0.00	2.48+00	1.90+00
19	2.06+02	4.74-06	0.00	-2.57-04	-4.14-01	-1.78+00	0.00	2.28+00	-2.05+00	0.00	2.51+00	1.93+00
20	2.07+02	4.64-06	0.00	-2.58-04	-4.17-01	-1.80+00	0.00	2.32+00	-2.08+00	0.00	2.55+00	1.95+00
21	2.08+02	4.53-06	0.00	-2.59-04	-4.22-01	-1.83+00	0.00	2.35+00	-2.10+00	0.00	2.59+00	1.98+00
22	2.09+02	4.42-06	0.00	-2.61-04	-4.28-01	-1.85+00	0.00	2.39+00	-2.13+00	0.00	2.63+00	2.00+00
23	2.10+02	4.31-06	0.00	-2.62-04	-4.36-01	-1.87+00	0.00	2.42+00	-2.16+00	0.00	2.67+00	2.03+00
24	2.11+02	4.20-06	0.00	-2.63-04	-4.45-01	-1.89+00	0.00	2.46+00	-2.19+00	0.00	2.71+00	2.06+00
25	2.12+02	4.09-06	0.00	-2.64-04	-4.56-01	-1.91+00	0.00	2.50+00	-2.22+00	0.00	2.75+00	2.08+00
26	2.13+02	3.98-06	0.00	-2.65-04	-4.68-01	-1.93+00	0.00	2.54+00	-2.25+00	0.00	2.80+00	2.11+00
27	2.14+02	3.86-06	0.00	-2.67-04	-4.82-01	-1.95+00	0.00	2.57+00	-2.29+00	0.00	2.85+00	2.14+00
28	2.15+02	3.74-06	0.00	-2.68-04	-4.96-01	-1.97+00	0.00	2.61+00	-2.32+00	0.00	2.89+00	2.17+00
29	2.16+02	3.62-06	0.00	-2.69-04	-5.12-01	-1.98+00	0.00	2.65+00	-2.36+00	0.00	2.94+00	2.20+00
30	2.17+02	3.50-06	0.00	-2.71-04	-5.29-01	-2.00+00	0.00	2.69+00	-2.40+00	0.00	2.99+00	2.23+00
31	2.18+02	3.38-06	0.00	-2.72-04	-5.46-01	-2.02+00	0.00	2.73+00	-2.44+00	0.00	3.04+00	2.26+00
32	2.19+02	3.26-06	0.00	-2.73-04	-5.62-01	-2.04+00	0.00	2.78+00	-2.49+00	0.00	3.10+00	2.30+00
33	2.20+02	3.13-06	0.00	-2.75-04	-5.78-01	-2.06+00	0.00	2.82+00	-2.54+00	0.00	3.15+00	2.34+00
34	2.21+02	3.01-06	0.00	-2.76-04	-5.93-01	-2.09+00	0.00	2.86+00	-2.60+00	0.00	3.20+00	2.39+00
35	2.22+02	2.88-06	0.00	-2.77-04	-6.04-01	-2.12+00	0.00	2.91+00	-2.66+00	0.00	3.25+00	2.43+00
36	2.23+02	2.75-06	0.00	-2.79-04	-6.12-01	-2.15+00	0.00	2.96+00	-2.73+00	0.00	3.31+00	2.49+00
37	2.24+02	2.62-06	0.00	-2.80-04	-6.15-01	-2.19+00	0.00	3.01+00	-2.80+00	0.00	3.36+00	2.55+00
38	2.25+02	2.48-06	0.00	-2.82-04	-6.11-01	-2.24+00	0.00	3.06+00	-2.88+00	0.00	3.41+00	2.62+00
39	2.26+02	2.35-06	0.00	-2.83-04	-5.99-01	-2.30+00	0.00	3.12+00	-2.97+00	0.00	3.46+00	2.70+00
40	2.27+02	2.21-06	0.00	-2.85-04	-5.75-01	-2.37+00	0.00	3.18+00	-3.06+00	0.00	3.51+00	2.78+00
41	2.28+02	2.07-06	0.00	-2.87-04	-5.39-01	-2.46+00	0.00	3.26+00	-3.16+00	0.00	3.56+00	2.88+00
42	2.29+02	1.93-06	0.00	-2.88-04	-4.87-01	-2.57+00	0.00	3.34+00	-3.27+00	0.00	3.61+00	2.98+00
43	2.30+02	1.79-06	0.00	-2.90-04	-4.17-01	-2.69+00	0.00	3.44+00	-3.39+00	0.00	3.67+00	3.10+00
44	2.31+02	1.64-06	0.00	-2.91-04	-3.25-01	-2.85+00	0.00	3.55+00	-3.51+00	0.00	3.73+00	3.23+00
45	2.32+02	1.49-06	0.00	-2.93-04	-2.10-01	-3.03+00	0.00	3.69+00	-3.63+00	0.00	3.80+00	3.37+00
46	2.33+02	1.34-06	0.00	-2.95-04	-6.69-02	-3.26+00	0.00	3.85+00	-3.75+00	0.00	3.89+00	3.53+00
47	2.34+02	1.18-06	0.00	-2.96-04	1.05-01	-3.52+00	0.00	4.05+00	-3.86+00	0.00	4.00+00	3.70+00
48	2.35+02	1.02-06	0.00	-2.98-04	3.09-01	-3.83+00	0.00	4.29+00	-3.96+00	0.00	4.15+00	3.90+00
49	2.36+02	8.47-07	0.00	-2.99-04	5.45-01	-4.20+00	0.00	4.59+00	-4.03+00	0.00	4.34+00	4.12+00
50	2.37+02	6.64-07	0.00	-3.00-04	8.12-01	-4.64+00	0.00	4.95+00	-4.06+00	0.00	4.60+00	4.38+00
51	2.38+02	4.65-07	0.00	-3.01-04	1.11+00	-5.16+00	0.00	5.40+00	-4.02+00	0.00	4.94+00	4.69+00
52	2.39+02	2.48-07	0.00	-3.01-04	1.42+00	-5.78+00	0.00	5.95+00	-3.88+00	0.00	5.38+00	5.10+00
53	2.40+02	7.06-08	0.00	-3.02-04	1.79+00	-6.43+00	0.00	6.47+00	-3.73+00	0.00	5.79+00	5.59+00

47	2.34+02	5.27-07	-4.72-05	-2.16-04	-8.27-01	-1.68+00	-6.51-01	3.82-01	-1.42+00	-3.53-01	1.55+00	1.68+00
48	2.35+02	4.29-07	-4.73-05	-2.16-04	-7.44-01	-1.75+00	-6.46-01	3.02-01	-1.51+00	-4.04-01	1.46+00	1.78+00
49	2.36+02	3.34-07	-4.75-05	-2.17-04	-6.37-01	-1.83+00	-6.41-01	2.26-01	-1.60+00	-4.56-01	1.35+00	1.90+00
50	2.37+02	2.43-07	-4.76-05	-2.17-04	-4.99-01	-1.94+00	-6.37-01	1.59-01	-1.72+00	-5.10-01	1.25+00	2.04+00
51	2.38+02	1.57-07	-4.78-05	-2.18-04	-3.28-01	-2.06+00	-6.35-01	1.03-01	-1.85+00	-5.63-01	1.17+00	2.19+00
52	2.39+02	7.71-08	-4.80-05	-2.18-04	-1.17-01	-2.22+00	-6.36-01	6.53-02	-1.99+00	-6.11-01	1.11+00	2.36+00
53	2.40+02	2.04-08	-4.81-05	-2.18-04	1.20-01	-2.41+00	-6.40-01	6.81-02	-2.12+00	-6.44-01	1.11+00	2.54+00
54	2.40+02	2.21-22	-4.81-05	-2.18-04	1.46-01	-2.42+00	-6.42-01	4.98-02	-2.15+00	-6.54-01	1.12+00	2.56+00

MERIDIONAL DISTRIBUTION OF SUPERPOSED QUANTITIES CORRESPONDING TO CIRCUMFERENTIAL STATION, THETA= 2.0000+01 DEG.

STRESS RESULTANTS OR STRESSES IN SEGMENT 1

POINT	STATION	U	V	W	S1(IN)	S1(OUT)	TAU(IN)	S2(IN)	S2(OUT)	TAU(OUT)	SVON(IN)	SVON(OUT)
1	0.00	6.58-06	3.25-24	-1.69-23	-3.40-03	7.06-04	-2.39-01	-1.12-03	2.33-04	-3.27-03	4.14-01	5.69-03
2	5.48+00	6.57-06	-2.08-06	-3.51-06	-1.65-02	-1.34-02	-2.42-01	2.15-02	-7.59-03	-3.15-03	4.21-01	1.28-02
3	2.02+01	6.52-06	-7.63-06	-1.31-05	-3.02-02	-8.05-02	-2.45-01	6.49-02	-6.37-02	-2.70-03	4.33-01	7.37-02
4	3.98+01	6.36-06	-1.50-05	-2.56-05	-6.24-02	-1.58-01	-2.47-01	1.26-01	-1.21-01	-2.08-03	4.59-01	1.43-01
5	5.98+01	6.11-06	-2.24-05	-3.77-05	-9.67-02	-2.36-01	-2.51-01	1.83-01	-1.75-01	-1.74-03	5.00-01	2.12-01
6	7.97+01	5.74-06	-2.96-05	-4.91-05	-1.35-01	-3.12-01	-2.58-01	2.30-01	-2.22-01	-2.00-03	5.50-01	2.78-01
7	9.96+01	5.28-06	-3.66-05	-5.95-05	-1.78-01	-3.87-01	-2.69-01	2.66-01	-2.57-01	-3.69-03	6.05-01	3.41-01
8	1.20+02	4.70-06	-4.34-05	-6.84-05	-2.27-01	-4.59-01	-2.85-01	2.85-01	-2.76-01	-8.32-03	6.63-01	4.01-01
9	1.39+02	4.00-06	-4.98-05	-7.57-05	-2.84-01	-5.26-01	-3.06-01	2.80-01	-2.74-01	-1.85-02	7.21-01	4.57-01
10	1.59+02	3.20-06	-5.58-05	-8.08-05	-3.50-01	-5.83-01	-3.35-01	2.35-01	-2.37-01	-4.02-02	7.72-01	5.13-01
11	1.79+02	2.30-06	-6.14-05	-8.30-05	-4.27-01	-6.03-01	-3.69-01	1.13-01	-1.47-01	-8.21-02	8.07-01	5.63-01
12	1.94+02	1.58-06	-6.52-05	-8.24-05	-4.88-01	-5.76-01	-3.87-01	-3.22-02	-4.05-03	-1.28-01	8.20-01	6.16-01
13	2.00+02	1.30-06	-6.65-05	-8.17-05	-4.62-01	-6.00-01	-3.87-01	-9.02-02	4.19-02	-1.50-01	7.94-01	6.74-01
14	2.01+02	1.25-06	-6.68-05	-8.15-05	-4.68-01	-5.93-01	-3.89-01	-1.06-01	5.23-02	-1.54-01	7.96-01	6.76-01
15	2.02+02	1.20-06	-6.70-05	-8.14-05	-4.73-01	-5.86-01	-3.90-01	-1.23-01	6.39-02	-1.59-01	7.98-01	6.78-01
16	2.03+02	1.15-06	-6.72-05	-8.12-05	-4.79-01	-5.77-01	-3.91-01	-1.39-01	7.65-02	-1.64-01	8.00-01	6.81-01
17	2.04+02	1.11-06	-6.74-05	-8.09-05	-4.84-01	-5.68-01	-3.92-01	-1.55-01	9.02-02	-1.69-01	8.02-01	6.84-01
18	2.05+02	1.06-06	-6.76-05	-8.07-05	-4.90-01	-5.58-01	-3.92-01	-1.72-01	1.05-01	-1.74-01	8.04-01	6.87-01
19	2.06+02	1.01-06	-6.78-05	-8.05-05	-4.96-01	-5.47-01	-3.92-01	-1.88-01	1.20-01	-1.80-01	8.06-01	6.91-01
20	2.07+02	9.64-07	-6.80-05	-8.02-05	-5.03-01	-5.36-01	-3.92-01	-2.05-01	1.37-01	-1.86-01	8.08-01	6.94-01
21	2.08+02	9.17-07	-6.82-05	-7.99-05	-5.10-01	-5.23-01	-3.91-01	-2.22-01	1.54-01	-1.91-01	8.10-01	6.98-01
22	2.09+02	8.71-07	-6.84-05	-7.97-05	-5.17-01	-5.08-01	-3.90-01	-2.39-01	1.72-01	-1.97-01	8.12-01	7.02-01
23	2.10+02	8.25-07	-6.86-05	-7.94-05	-5.26-01	-4.92-01	-3.89-01	-2.57-01	1.91-01	-2.04-01	8.14-01	7.05-01
24	2.11+02	7.79-07	-6.88-05	-7.91-05	-5.35-01	-4.75-01	-3.88-01	-2.76-01	2.10-01	-2.10-01	8.16-01	7.08-01
25	2.12+02	7.34-07	-6.90-05	-7.87-05	-5.45-01	-4.55-01	-3.86-01	-2.95-01	2.30-01	-2.16-01	8.19-01	7.11-01
26	2.13+02	6.89-07	-6.92-05	-7.84-05	-5.57-01	-4.34-01	-3.84-01	-3.15-01	2.50-01	-2.22-01	8.22-01	7.13-01
27	2.14+02	6.44-07	-6.93-05	-7.81-05	-5.70-01	-4.10-01	-3.81-01	-3.36-01	2.71-01	-2.29-01	8.26-01	7.14-01
28	2.15+02	6.01-07	-6.95-05	-7.78-05	-5.85-01	-3.84-01	-3.79-01	-3.59-01	2.92-01	-2.35-01	8.31-01	7.14-01
29	2.16+02	5.57-07	-6.97-05	-7.74-05	-6.01-01	-3.56-01	-3.76-01	-3.83-01	3.13-01	-2.41-01	8.37-01	7.14-01
30	2.17+02	5.14-07	-6.99-05	-7.71-05	-6.19-01	-3.25-01	-3.72-01	-4.08-01	3.33-01	-2.47-01	8.44-01	7.12-01
31	2.18+02	4.72-07	-7.00-05	-7.68-05	-6.39-01	-2.91-01	-3.68-01	-4.35-01	3.53-01	-2.53-01	8.52-01	7.10-01
32	2.19+02	4.31-07	-7.02-05	-7.64-05	-6.61-01	-2.54-01	-3.64-01	-4.65-01	3.72-01	-2.58-01	8.62-01	7.06-01
33	2.20+02	3.91-07	-7.03-05	-7.61-05	-6.84-01	-2.16-01	-3.60-01	-4.97-01	3.89-01	-2.64-01	8.73-01	7.01-01
34	2.21+02	3.52-07	-7.05-05	-7.58-05	-7.08-01	-1.75-01	-3.55-01	-5.31-01	4.04-01	-2.69-01	8.86-01	6.94-01
35	2.22+02	3.13-07	-7.07-05	-7.56-05	-7.33-01	-1.32-01	-3.49-01	-5.68-01	4.17-01	-2.74-01	9.00-01	6.87-01
36	2.23+02	2.76-07	-7.08-05	-7.53-05	-7.59-01	-8.87-02	-3.44-01	-6.08-01	4.26-01	-2.78-01	9.16-01	6.78-01
37	2.24+02	2.41-07	-7.09-05	-7.51-05	-7.84-01	-4.45-02	-3.38-01	-6.50-01	4.32-01	-2.82-01	9.33-01	6.68-01
38	2.25+02	2.07-07	-7.11-05	-7.49-05	-8.08-01	-8.41-04	-3.32-01	-6.96-01	4.32-01	-2.85-01	9.51-01	6.56-01
39	2.26+02	1.74-07	-7.12-05	-7.48-05	-8.29-01	4.11-02	-3.25-01	-7.45-01	4.27-01	-2.88-01	9.71-01	6.44-01

54	2.40+02	2.60-22	0.00	-3.02-04	1.75+00	-6.51+00	0.00	6.63+00	-3.59+00	0.00	5.95+00	5.65+00

MERIDIONAL DISTRIBUTION OF SUPERPOSED QUANTITIES CORRESPONDING TO CIRCUMFERENTIAL STATION, THETA= 1.0000+01 DEG.

STRESS RESULTANTS OR STRESSES IN SEGMENT 1

POINT	STATION	U	V	W	S1(IN)	S1(OUT)	TAU(IN)	S2(IN)	S2(OUT)	TAU(OUT)	SVON(IN)	SVON(OUT)
1	0.00	1.15-05	1.88-24	-2.91-23	-5.29-03	1.73-03	-1.33-01	-1.75-03	5.71-04	2.87-03	2.30-01	5.21-03
2	5.48+00	1.15-05	-1.20-06	-6.06-06	-2.44-02	-1.50-02	-1.35-01	3.55-02	-1.32-02	3.10-03	2.39-01	1.52-02
3	2.02+01	1.14-05	-4.40-06	-2.27-05	-3.39-02	-1.12-01	-1.37-01	1.10-01	-1.09-01	4.01-03	2.71-01	1.11-01
4	3.98+01	1.12-05	-8.68-06	-4.46-05	-6.89-02	-2.20-01	-1.39-01	2.21-01	-2.14-01	5.79-03	3.56-01	2.17-01
5	5.98+01	1.09-05	-1.30-05	-6.65-05	-1.03-01	-3.32-01	-1.43-01	3.35-01	-3.23-01	8.32-03	4.68-01	3.28-01
6	7.97+01	1.04-05	-1.72-05	-8.80-05	-1.39-01	-4.47-01	-1.50-01	4.52-01	-4.35-01	1.14-02	5.95-01	4.41-01
7	9.96+01	9.82-06	-2.14-05	-1.09-04	-1.75-01	-5.66-01	-1.61-01	5.75-01	-5.51-01	1.49-02	7.34-01	5.59-01
8	1.20+02	9.05-06	-2.55-05	-1.29-04	-2.14-01	-6.93-01	-1.77-01	7.04-01	-6.73-01	1.84-02	8.87-01	6.84-01
9	1.39+02	8.12-06	-2.95-05	-1.48-04	-2.59-01	-8.32-01	-2.00-01	8.43-01	-8.02-01	2.19-02	1.06+00	8.18-01
10	1.59+02	7.00-06	-3.34-05	-1.67-04	-3.12-01	-9.90-01	-2.36-01	9.91-01	-9.38-01	2.59-02	1.25+00	9.66-01
11	1.79+02	5.66-06	-3.73-05	-1.83-04	-3.89-01	-1.17+00	-3.01-01	1.14+00	-1.07+00	2.11-02	1.48+00	1.13+00
12	1.94+02	4.49-06	-4.01-05	-1.95-04	-4.40-01	-1.36+00	-3.63-01	1.25+00	-1.19+00	9.88-03	1.64+00	1.28+00
13	2.00+02	4.01-06	-4.12-05	-1.99-04	-4.99-01	-1.40+00	-3.86-01	1.29+00	-1.19+00	6.54-03	1.73+00	1.30+00
14	2.01+02	3.92-06	-4.14-05	-1.99-04	-5.01-01	-1.41+00	-3.96-01	1.30+00	-1.19+00	7.96-03	1.75+00	1.32+00
15	2.02+02	3.83-06	-4.16-05	-2.00-04	-5.04-01	-1.43+00	-4.05-01	1.30+00	-1.20+00	8.83-03	1.76+00	1.33+00
16	2.03+02	3.74-06	-4.17-05	-2.01-04	-5.07-01	-1.44+00	-4.14-01	1.31+00	-1.20+00	9.21-03	1.78+00	1.34+00
17	2.04+02	3.64-06	-4.19-05	-2.01-04	-5.11-01	-1.46+00	-4.24-01	1.32+00	-1.20+00	9.17-03	1.79+00	1.35+00
18	2.05+02	3.55-06	-4.21-05	-2.02-04	-5.16-01	-1.47+00	-4.34-01	1.32+00	-1.21+00	8.75-03	1.81+00	1.36+00
19	2.06+02	3.46-06	-4.23-05	-2.02-04	-5.23-01	-1.49+00	-4.44-01	1.33+00	-1.21+00	8.00-03	1.82+00	1.37+00
20	2.07+02	3.36-06	-4.25-05	-2.03-04	-5.30-01	-1.50+00	-4.54-01	1.33+00	-1.21+00	6.96-03	1.84+00	1.38+00
21	2.08+02	3.27-06	-4.26-05	-2.03-04	-5.39-01	-1.51+00	-4.64-01	1.33+00	-1.21+00	5.66-03	1.85+00	1.39+00
22	2.09+02	3.17-06	-4.28-05	-2.04-04	-5.49-01	-1.52+00	-4.74-01	1.34+00	-1.21+00	4.10-03	1.87+00	1.39+00
23	2.10+02	3.07-06	-4.30-05	-2.04-04	-5.60-01	-1.53+00	-4.85-01	1.34+00	-1.21+00	2.32-03	1.89+00	1.40+00
24	2.11+02	2.97-06	-4.32-05	-2.05-04	-5.73-01	-1.54+00	-4.96-01	1.34+00	-1.20+00	3.03-04	1.90+00	1.40+00
25	2.12+02	2.87-06	-4.34-05	-2.05-04	-5.88-01	-1.55+00	-5.07-01	1.33+00	-1.20+00	-1.95-03	1.92+00	1.41+00
26	2.13+02	2.77-06	-4.35-05	-2.06-04	-6.04-01	-1.55+00	-5.18-01	1.33+00	-1.20+00	-4.45-03	1.93+00	1.41+00
27	2.14+02	2.67-06	-4.37-05	-2.06-04	-6.22-01	-1.56+00	-5.29-01	1.32+00	-1.19+00	-7.24-03	1.95+00	1.41+00
28	2.15+02	2.57-06	-4.39-05	-2.07-04	-6.42-01	-1.56+00	-5.40-01	1.32+00	-1.18+00	-1.04-02	1.97+00	1.41+00
29	2.16+02	2.46-06	-4.41-05	-2.07-04	-6.63-01	-1.56+00	-5.52-01	1.30+00	-1.18+00	-1.38-02	1.98+00	1.41+00
30	2.17+02	2.36-06	-4.43-05	-2.08-04	-6.86-01	-1.56+00	-5.63-01	1.29+00	-1.17+00	-1.78-02	1.99+00	1.41+00
31	2.18+02	2.25-06	-4.44-05	-2.08-04	-7.11-01	-1.56+00	-5.74-01	1.27+00	-1.16+00	-2.23-02	2.01+00	1.40+00
32	2.19+02	2.14-06	-4.46-05	-2.09-04	-7.37-01	-1.55+00	-5.85-01	1.25+00	-1.16+00	-2.75-02	2.02+00	1.40+00
33	2.20+02	2.04-06	-4.48-05	-2.09-04	-7.64-01	-1.55+00	-5.96-01	1.23+00	-1.15+00	-3.34-02	2.02+00	1.39+00
34	2.21+02	1.93-06	-4.50-05	-2.10-04	-7.93-01	-1.54+00	-6.07-01	1.20+00	-1.14+00	-4.04-02	2.03+00	1.39+00
35	2.22+02	1.82-06	-4.51-05	-2.10-04	-8.21-01	-1.54+00	-6.17-01	1.17+00	-1.14+00	-4.86-02	2.03+00	1.38+00
36	2.23+02	1.71-06	-4.53-05	-2.11-04	-8.50-01	-1.53+00	-6.26-01	1.13+00	-1.14+00	-5.81-02	2.03+00	1.38+00
37	2.24+02	1.60-06	-4.55-05	-2.11-04	-8.78-01	-1.52+00	-6.35-01	1.08+00	-1.13+00	-6.94-02	2.03+00	1.38+00
38	2.25+02	1.49-06	-4.57-05	-2.11-04	-9.04-01	-1.52+00	-6.42-01	1.04+00	-1.14+00	-8.27-02	2.02+00	1.38+00
39	2.26+02	1.38-06	-4.58-05	-2.12-04	-9.27-01	-1.51+00	-6.49-01	9.80-01	-1.14+00	-9.84-02	2.00+00	1.38+00
40	2.27+02	1.27-06	-4.60-05	-2.12-04	-9.47-01	-1.51+00	-6.54-01	9.20-01	-1.15+00	-1.17-01	1.97+00	1.38+00
41	2.28+02	1.16-06	-4.62-05	-2.13-04	-9.61-01	-1.51+00	-6.58-01	8.55-01	-1.17+00	-1.39-01	1.94+00	1.39+00
42	2.29+02	1.05-06	-4.63-05	-2.13-04	-9.68-01	-1.52+00	-6.61-01	7.84-01	-1.19+00	-1.64-01	1.90+00	1.41+00
43	2.30+02	9.43-07	-4.65-05	-2.14-04	-9.67-01	-1.54+00	-6.61-01	7.09-01	-1.22+00	-1.93-01	1.85+00	1.44+00
44	2.31+02	8.37-07	-4.67-05	-2.14-04	-9.54-01	-1.56+00	-6.61-01	6.30-01	-1.25+00	-2.26-01	1.79+00	1.48+00
45	2.32+02	7.31-07	-4.68-05	-2.15-04	-9.28-01	-1.59+00	-6.59-01	5.48-01	-1.30+00	-2.64-01	1.72+00	1.53+00
46	2.33+02	6.28-07	-4.70-05	-2.15-04	-8.87-01	-1.63+00	-6.55-01	4.65-01	-1.36+00	-3.07-01	1.64+00	1.60+00

40	2.27+02	1.44-07	-7.13-05	-7.47-05	-8.47-01	7.98-02	-3.18-01	-7.96-01	4.14-01	-2.89-01	9.90-01	6.29-01
41	2.28+02	1.15-07	-7.15-05	-7.47-05	-8.58-01	1.14-01	-3.11-01	-8.50-01	3.94-01	-2.90-01	1.01+00	6.13-01
42	2.29+02	8.92-08	-7.16-05	-7.47-05	-8.62-01	1.40-01	-3.04-01	-9.06-01	3.65-01	-2.90-01	1.03+00	5.95-01
43	2.30+02	6.55-08	-7.17-05	-7.47-05	-8.55-01	1.57-01	-2.96-01	-9.63-01	3.26-01	-2.89-01	1.05+00	5.74-01
44	2.31+02	4.44-08	-7.18-05	-7.48-05	-8.35-01	1.62-01	-2.88-01	-1.02+00	2.76-01	-2.86-01	1.07+00	5.51-01
45	2.32+02	2.62-08	-7.19-05	-7.50-05	-7.98-01	1.51-01	-2.80-01	-1.08+00	2.15-01	-2.82-01	1.08+00	5.25-01
46	2.33+02	1.11-08	-7.20-05	-7.52-05	-7.42-01	1.21-01	-2.71-01	-1.13+00	1.41-01	-2.77-01	1.10+00	4.97-01
47	2.34+02	-8.41-10	-7.21-05	-7.55-05	-6.61-01	6.79-02	-2.62-01	-1.18+00	5.40-02	-2.70-01	1.12+00	4.72-01
48	2.35+02	-9.33-09	-7.22-05	-7.57-05	-5.52-01	-1.25-02	-2.53-01	-1.22+00	-4.60-02	-2.61-01	1.15+00	4.54-01
49	2.36+02	-1.43-08	-7.22-05	-7.60-05	-4.10-01	-1.25-01	-2.42-01	-1.25+00	-1.59-01	-2.51-01	1.18+00	4.58-01
50	2.37+02	-1.57-08	-7.23-05	-7.63-05	-2.31-01	-2.73-01	-2.31-01	-1.27+00	-2.83-01	-2.39-01	1.24+00	4.98-01
51	2.38+02	-1.36-08	-7.24-05	-7.66-05	-9.43-03	-4.63-01	-2.18-01	-1.27+00	-4.18-01	-2.24-01	1.32+00	5.89-01
52	2.39+02	-8.30-09	-7.24-05	-7.68-05	2.59-01	-7.00-01	-2.04-01	-1.24+00	-5.59-01	-2.09-01	1.43+00	7.36-01
53	2.40+02	-2.56-09	-7.25-05	-7.68-05	5.59-01	-9.76-01	-1.92-01	-1.18+00	-6.90-01	-1.96-01	1.57+00	9.33-01
54	2.40+02	1.24-22	-7.25-05	-7.68-05	5.84-01	-9.93-01	-1.87-01	-1.18+00	-7.08-01	-1.91-01	1.59+00	9.45-01

MERIDIONAL DISTRIBUTION OF SUPERPOSED QUANTITIES CORRESPONDING TO CIRCUMFERENTIAL STATION, THETA= 3.5000+01 DEG.

STRESS RESULTANTS OR STRESSES IN SEGMENT 1

POINT	STATION	U	V	W	S1(IN)	S1(OUT)	TAU(IN)	S2(IN)	S2(OUT)	TAU(OUT)	SVON(IN)	SVON(OUT)
1	0.00	-3.62-06	3.58-24	8.36-24	1.26-03	-7.91-04	-2.87-01	4.17-04	-2.61-04	-2.30-02	4.98-01	3.99-02
2	5.48+00	-3.62-06	-2.32-06	1.81-06	5.08-03	9.68-05	-2.91-01	-9.60-03	3.98-03	-2.36-02	5.04-01	4.11-02
3	2.02+01	-3.61-06	-8.52-06	6.78-06	2.98-04	1.86-02	-2.93-01	-3.20-02	3.21-02	-2.59-02	5.08-01	5.29-02
4	3.98+01	-3.58-06	-1.67-05	1.35-05	-4.60-04	3.74-02	-2.90-01	-6.78-02	6.62-02	-3.15-02	5.06-01	7.93-02
5	5.98+01	-3.54-06	-2.48-05	2.05-05	-3.78-03	5.87-02	-2.85-01	-1.12-01	1.08-01	-4.11-02	5.06-01	1.18-01
6	7.97+01	-3.48-06	-3.25-05	2.79-05	-1.00-02	8.47-02	-2.79-01	-1.68-01	1.61-01	-5.45-02	5.10-01	1.68-01
7	9.96+01	-3.39-06	-3.98-05	3.59-05	-1.89-02	1.19-01	-2.69-01	-2.43-01	2.29-01	-7.16-02	5.22-01	2.34-01
8	1.20+02	-3.28-06	-4.65-05	4.44-05	-2.82-02	1.69-01	-2.56-01	-3.39-01	3.15-01	-9.26-02	5.49-01	3.17-01
9	1.39+02	-3.11-06	-5.25-05	5.36-05	-3.33-02	2.43-01	-2.36-01	-4.57-01	4.21-01	-1.17-01	6.01-01	4.19-01
10	1.59+02	-2.85-06	-5.76-05	6.34-05	-2.58-02	3.50-01	-2.05-01	-5.93-01	5.41-01	-1.43-01	6.81-01	5.36-01
11	1.79+02	-2.45-06	-6.17-05	7.31-05	1.04-02	4.84-01	-1.61-01	-7.18-01	6.56-01	-1.58-01	7.75-01	6.49-01
12	1.94+02	-2.05-06	-6.41-05	8.01-05	4.81-02	6.07-01	-1.23-01	-7.85-01	7.34-01	-1.62-01	8.38-01	7.35-01
13	2.00+02	-1.87-06	-6.49-05	8.24-05	9.49-02	6.27-01	-1.10-01	-8.02-01	7.36-01	-1.63-01	8.75-01	7.43-01
14	2.01+02	-1.84-06	-6.50-05	8.28-05	9.69-02	6.37-01	-1.06-01	-8.05-01	7.40-01	-1.63-01	8.77-01	7.49-01
15	2.02+02	-1.80-06	-6.51-05	8.32-05	9.91-02	6.46-01	-1.02-01	-8.07-01	7.43-01	-1.63-01	8.79-01	7.55-01
16	2.03+02	-1.77-06	-6.52-05	8.36-05	1.01-01	6.56-01	-9.87-02	-8.09-01	7.47-01	-1.63-01	8.81-01	7.61-01
17	2.04+02	-1.73-06	-6.53-05	8.39-05	1.04-01	6.66-01	-9.52-02	-8.10-01	7.51-01	-1.63-01	8.82-01	7.66-01
18	2.05+02	-1.69-06	-6.54-05	8.43-05	1.07-01	6.75-01	-9.19-02	-8.10-01	7.55-01	-1.63-01	8.83-01	7.72-01
19	2.06+02	-1.66-06	-6.55-05	8.47-05	1.09-01	6.85-01	-8.86-02	-8.11-01	7.59-01	-1.62-01	8.84-01	7.77-01
20	2.07+02	-1.62-06	-6.56-05	8.51-05	1.11-01	6.94-01	-8.55-02	-8.10-01	7.63-01	-1.61-01	8.84-01	7.83-01
21	2.08+02	-1.58-06	-6.57-05	8.54-05	1.14-01	7.04-01	-8.26-02	-8.10-01	7.67-01	-1.60-01	8.84-01	7.88-01
22	2.09+02	-1.54-06	-6.58-05	8.58-05	1.15-01	7.14-01	-7.98-02	-8.09-01	7.72-01	-1.59-01	8.83-01	7.94-01
23	2.10+02	-1.50-06	-6.59-05	8.61-05	1.17-01	7.25-01	-7.72-02	-8.08-01	7.76-01	-1.58-01	8.82-01	8.00-01
24	2.11+02	-1.46-06	-6.60-05	8.65-05	1.17-01	7.36-01	-7.49-02	-8.07-01	7.80-01	-1.57-01	8.81-01	8.06-01
25	2.12+02	-1.42-06	-6.61-05	8.68-05	1.18-01	7.48-01	-7.27-02	-8.06-01	7.85-01	-1.55-01	8.80-01	8.13-01
26	2.13+02	-1.38-06	-6.62-05	8.71-05	1.17-01	7.60-01	-7.08-02	-8.06-01	7.89-01	-1.53-01	8.79-01	8.19-01
27	2.14+02	-1.34-06	-6.63-05	8.74-05	1.15-01	7.74-01	-6.92-02	-8.05-01	7.93-01	-1.52-01	8.77-01	8.26-01
28	2.15+02	-1.30-06	-6.63-05	8.77-05	1.12-01	7.88-01	-6.78-02	-8.06-01	7.97-01	-1.50-01	8.75-01	8.34-01
29	2.16+02	-1.26-06	-6.64-05	8.80-05	1.08-01	8.03-01	-6.67-02	-8.07-01	8.00-01	-1.47-01	8.74-01	8.41-01
30	2.17+02	-1.22-06	-6.65-05	8.83-05	1.03-01	8.19-01	-6.58-02	-8.09-01	8.03-01	-1.45-01	8.72-01	8.49-01
31	2.18+02	-1.17-06	-6.65-05	8.85-05	9.70-02	8.36-01	-6.53-02	-8.12-01	8.06-01	-1.42-01	8.72-01	8.57-01
32	2.19+02	-1.13-06	-6.66-05	8.87-05	8.98-02	8.54-01	-6.51-02	-8.16-01	8.07-01	-1.39-01	8.72-01	8.66-01

33	2.20+02	-1.09-06	-6.67-05	8.90-05	8.16-02	8.73-01	-6.51-02	-8.22-01	8.08-01	-1.36-01	8.73-01	8.74-01
34	2.21+02	-1.04-06	-6.67-05	8.91-05	7.28-02	8.92-01	-6.55-02	-8.29-01	8.06-01	-1.32-01	8.75-01	8.83-01
35	2.22+02	-9.96-07	-6.68-05	8.93-05	6.35-02	9.12-01	-6.61-02	-8.39-01	8.04-01	-1.28-01	8.80-01	8.91-01
36	2.23+02	-9.50-07	-6.68-05	8.94-05	5.42-02	9.31-01	-6.68-02	-8.50-01	7.98-01	-1.23-01	8.86-01	8.98-01
37	2.24+02	-9.04-07	-6.69-05	8.95-05	4.54-02	9.50-01	-6.78-02	-8.63-01	7.91-01	-1.18-01	8.95-01	9.04-01
38	2.25+02	-8.56-07	-6.69-05	8.96-05	3.78-02	9.67-01	-6.89-02	-8.79-01	7.80-01	-1.12-01	9.06-01	9.09-01
39	2.26+02	-8.08-07	-6.70-05	8.96-05	3.22-02	9.82-01	-6.99-02	-8.96-01	7.66-01	-1.05-01	9.21-01	9.12-01
40	2.27+02	-7.59-07	-6.70-05	8.96-05	2.97-02	9.94-01	-7.09-02	-9.16-01	7.48-01	-9.80-02	9.39-01	9.13-01
41	2.28+02	-7.08-07	-6.71-05	8.96-05	3.14-02	1.00+00	-7.16-02	-9.37-01	7.25-01	-9.01-02	9.62-01	9.09-01
42	2.29+02	-6.57-07	-6.71-05	8.95-05	3.86-02	1.00+00	-7.19-02	-9.60-01	6.97-01	-8.14-02	9.88-01	9.01-01
43	2.30+02	-6.04-07	-6.71-05	8.94-05	5.30-02	9.98-01	-7.16-02	-9.84-01	6.63-01	-7.19-02	1.02+00	8.88-01
44	2.31+02	-5.50-07	-6.72-05	8.93-05	7.62-02	9.83-01	-7.05-02	-1.01+00	6.24-01	-6.18-02	1.06+00	8.68-01
45	2.32+02	-4.95-07	-6.72-05	8.91-05	1.10-01	9.57-01	-6.83-02	-1.03+00	5.78-01	-5.10-02	1.10+00	8.39-01
46	2.33+02	-4.38-07	-6.72-05	8.89-05	1.57-01	9.18-01	-6.46-02	-1.05+00	5.26-01	-3.96-02	1.14+00	8.01-01
47	2.34+02	-3.80-07	-6.72-05	8.86-05	2.19-01	8.64-01	-5.93-02	-1.07+00	4.68-01	-2.79-02	1.20+00	7.51-01
48	2.35+02	-3.20-07	-6.73-05	8.84-05	2.99-01	7.92-01	-5.19-02	-1.08+00	4.03-01	-1.60-02	1.26+00	6.87-01
49	2.36+02	-2.58-07	-6.73-05	8.81-05	3.98-01	7.01-01	-4.20-02	-1.09+00	3.33-01	-4.28-03	1.33+00	6.07-01
50	2.37+02	-1.96-07	-6.73-05	8.79-05	5.19-01	5.87-01	-2.92-02	-1.08+00	2.59-01	6.90-03	1.42+00	5.09-01
51	2.38+02	-1.31-07	-6.73-05	8.77-05	6.64-01	4.49-01	-1.31-02	-1.07+00	1.82-01	1.70-02	1.51+00	3.92-01
52	2.39+02	-6.70-08	-6.73-05	8.75-05	8.35-01	2.84-01	6.28-03	-1.04+00	1.03-01	2.52-02	1.62+00	2.53-01
53	2.40+02	-1.83-08	-6.73-05	8.75-05	1.02+00	1.02-01	2.32-02	-9.87-01	3.01-02	2.97-02	1.74+00	1.04-01
54	2.40+02	-6.76-23	-6.73-05	8.75-05	1.04+00	9.03-02	2.98-02	-9.85-01	2.33-02	3.04-02	1.75+00	9.68-02

MERIDIONAL DISTRIBUTION OF SUPERPOSED QUANTITIES CORRESPONDING TO CIRCUMFERENTIAL STATION, THETA= 6.0000+01 DEG.

STRESS RESULTANTS OR STRESSES IN SEGMENT 1

POINT	STATION	U	V	W	S1(IN)	S1(OUT)	TAU(IN)	S2(IN)	S2(OUT)	TAU(OUT)	SVON(IN)	SVON(OUT)
1	0.00	-1.35-05	-1.09-30	3.34-23	6.80-03	-1.40-03	9.44-08	2.25-03	-4.62-04	1.30-08	6.01-03	1.24-03
2	5.48+00	-1.35-05	7.14-13	7.01-06	3.30-02	2.70-02	9.54-08	-4.31-02	1.52-02	1.34-08	6.61-02	2.34-02
3	2.02+01	-1.34-05	2.62-12	2.62-05	6.07-02	1.62-01	9.54-08	-1.30-01	1.27-01	1.51-08	1.68-01	1.48-01
4	3.98+01	-1.31-05	5.12-12	5.11-05	1.26-01	3.17-01	9.29-08	-2.52-01	2.42-01	1.88-08	3.33-01	2.87-01
5	5.98+01	-1.25-05	7.55-12	7.54-05	1.95-01	4.73-01	8.84-08	-3.61-01	3.47-01	2.51-08	4.89-01	4.24-01
6	7.97+01	-1.18-05	9.82-12	9.81-05	2.73-01	6.24-01	8.12-08	-4.50-01	4.35-01	3.31-08	6.32-01	5.54-01
7	9.96+01	-1.09-05	1.19-11	1.19-04	3.58-01	7.65-01	7.03-08	-5.11-01	4.98-01	4.17-08	7.57-01	6.72-01
8	1.20+02	-9.74-06	1.37-11	1.36-04	4.51-01	8.89-01	5.55-08	-5.38-01	5.30-01	4.84-08	8.57-01	7.74-01
9	1.39+02	-8.41-06	1.51-11	1.51-04	5.46-01	9.86-01	3.80-08	-5.28-01	5.30-01	5.03-08	9.30-01	8.55-01
10	1.59+02	-6.93-06	1.63-11	1.62-04	6.35-01	1.05+00	2.13-08	-4.92-01	5.04-01	4.55-08	9.79-01	9.11-01
11	1.79+02	-5.33-06	1.71-11	1.70-04	7.13-01	1.08+00	9.26-09	-4.45-01	4.66-01	3.57-08	1.01+00	9.43-01
12	1.94+02	-4.05-06	1.75-11	1.75-04	7.55-01	1.11+00	3.97-09	-4.21-01	4.35-01	2.71-08	1.03+00	9.65-01
13	2.00+02	-3.56-06	1.76-11	1.76-04	7.61-01	1.12+00	2.98-09	-4.14-01	4.30-01	2.38-08	1.03+00	9.76-01
14	2.01+02	-3.48-06	1.77-11	1.76-04	7.64-01	1.12+00	2.74-09	-4.10-01	4.29-01	2.33-08	1.03+00	9.75-01
15	2.02+02	-3.39-06	1.77-11	1.77-04	7.68-01	1.12+00	2.53-09	-4.07-01	4.28-01	2.27-08	1.03+00	9.75-01
16	2.03+02	-3.30-06	1.77-11	1.77-04	7.71-01	1.11+00	2.34-09	-4.05-01	4.28-01	2.22-08	1.03+00	9.74-01
17	2.04+02	-3.22-06	1.77-11	1.77-04	7.74-01	1.11+00	2.19-09	-4.02-01	4.27-01	2.17-08	1.04+00	9.74-01
18	2.05+02	-3.13-06	1.77-11	1.77-04	7.78-01	1.11+00	2.08-09	-3.99-01	4.26-01	2.11-08	1.04+00	9.73-01
19	2.06+02	-3.04-06	1.77-11	1.77-04	7.80-01	1.11+00	2.00-09	-3.97-01	4.26-01	2.06-08	1.04+00	9.73-01
20	2.07+02	-2.96-06	1.78-11	1.77-04	7.83-01	1.11+00	1.96-09	-3.95-01	4.25-01	2.01-08	1.04+00	9.73-01
21	2.08+02	-2.87-06	1.78-11	1.78-04	7.85-01	1.11+00	1.96-09	-3.93-01	4.24-01	1.96-08	1.04+00	9.73-01
22	2.09+02	-2.78-06	1.78-11	1.78-04	7.87-01	1.11+00	2.01-09	-3.91-01	4.24-01	1.91-08	1.04+00	9.73-01
23	2.10+02	-2.69-06	1.78-11	1.78-04	7.89-01	1.11+00	2.10-09	-3.89-01	4.23-01	1.86-08	1.04+00	9.74-01
24	2.11+02	-2.61-06	1.78-11	1.78-04	7.90-01	1.12+00	2.24-09	-3.88-01	4.23-01	1.80-08	1.04+00	9.75-01
25	2.12+02	-2.52-06	1.78-11	1.78-04	7.91-01	1.12+00	2.44-09	-3.87-01	4.23-01	1.75-08	1.04+00	9.77-01

26	2.13+02	-2.43-06	1.78-11	1.78-04	7.91-01	1.12+00	2.69-09	-3.86-01	4.23-01	1.70-08	1.04+00	9.79-01
27	2.14+02	-2.34-06	1.79-11	1.78-04	7.90-01	1.12+00	3.00-09	-3.86-01	4.23-01	1.65-08	1.04+00	9.81-01
28	2.15+02	-2.26-06	1.79-11	1.79-04	7.90-01	1.12+00	3.37-09	-3.86-01	4.23-01	1.60-08	1.04+00	9.84-01
29	2.16+02	-2.17-06	1.79-11	1.79-04	7.88-01	1.13+00	3.80-09	-3.86-01	4.23-01	1.54-08	1.04+00	9.87-01
30	2.17+02	-2.08-06	1.79-11	1.79-04	7.86-01	1.13+00	4.29-09	-3.87-01	4.24-01	1.48-08	1.04+00	9.91-01
31	2.18+02	-1.99-06	1.79-11	1.79-04	7.84-01	1.14+00	4.85-09	-3.88-01	4.24-01	1.41-08	1.03+00	9.95-01
32	2.19+02	-1.91-06	1.79-11	1.79-04	7.81-01	1.14+00	5.46-09	-3.90-01	4.23-01	1.33-08	1.03+00	1.00+00
33	2.20+02	-1.82-06	1.79-11	1.79-04	7.78-01	1.15+00	6.14-09	-3.93-01	4.23-01	1.25-08	1.03+00	1.01+00
34	2.21+02	-1.73-06	1.79-11	1.79-04	7.75-01	1.15+00	6.86-09	-3.96-01	4.22-01	1.16-08	1.03+00	1.01+00
35	2.22+02	-1.64-06	1.79-11	1.79-04	7.71-01	1.16+00	7.63-09	-4.00-01	4.21-01	1.05-08	1.03+00	1.02+00
36	2.23+02	-1.55-06	1.79-11	1.79-04	7.68-01	1.16+00	8.41-09	-4.05-01	4.19-01	9.36-09	1.03+00	1.02+00
37	2.24+02	-1.46-06	1.79-11	1.79-04	7.64-01	1.17+00	9.21-09	-4.11-01	4.17-01	8.04-09	1.03+00	1.03+00
38	2.25+02	-1.37-06	1.80-11	1.79-04	7.62-01	1.17+00	9.98-09	-4.17-01	4.14-01	6.55-09	1.04+00	1.03+00
39	2.26+02	-1.28-06	1.80-11	1.79-04	7.60-01	1.18+00	1.07-08	-4.24-01	4.09-01	4.90-09	1.04+00	1.04+00
40	2.27+02	-1.19-06	1.80-11	1.79-04	7.59-01	1.18+00	1.13-08	-4.32-01	4.04-01	3.06-09	1.04+00	1.04+00
41	2.28+02	-1.10-06	1.80-11	1.79-04	7.59-01	1.18+00	1.18-08	-4.40-01	3.97-01	1.05-09	1.05+00	1.04+00
42	2.29+02	-1.01-06	1.80-11	1.79-04	7.62-01	1.18+00	1.21-08	-4.49-01	3.89-01	-1.14-09	1.06+00	1.04+00
43	2.30+02	-9.23-07	1.80-11	1.79-04	7.67-01	1.18+00	1.21-08	-4.58-01	3.80-01	-3.50-09	1.07+00	1.04+00
44	2.31+02	-8.32-07	1.80-11	1.79-04	7.74-01	1.17+00	1.18-08	-4.66-01	3.69-01	-6.00-09	1.09+00	1.04+00
45	2.32+02	-7.40-07	1.80-11	1.79-04	7.85-01	1.16+00	1.11-08	-4.74-01	3.57-01	-8.62-09	1.10+00	1.03+00
46	2.33+02	-6.48-07	1.80-11	1.79-04	8.00-01	1.15+00	9.79-09	-4.81-01	3.43-01	-1.13-08	1.12+00	1.02+00
47	2.34+02	-5.56-07	1.80-11	1.79-04	8.20-01	1.13+00	7.90-09	-4.86-01	3.28-01	-1.41-08	1.14+00	1.01+00
48	2.35+02	-4.64-07	1.80-11	1.79-04	8.44-01	1.10+00	5.31-09	-4.89-01	3.12-01	-1.68-08	1.17+00	9.86-01
49	2.36+02	-3.71-07	1.80-11	1.79-04	8 73-01	1.07+00	1.93-09	-4.90-01	2.95-01	-1.93-08	1.20+00	9.61-01
50	2.37+02	-2.79-07	1.80-11	1.79-04	9.08-01	1.04+00	-2.26-09	-4.86-01	2.77-01	-2.15-08	1.23+00	9.30-01
51	2.38+02	-1.86-07	1.80-11	1.79-04	9.49-01	9.93-01	-7.19-09	-4.78-01	2.60-01	-2.28-08	1.26+00	8.92-01
52	2.39+02	-9.39-08	1.80-11	1.79-04	9.96-01	9.44-01	-1.25-08	-4.65-01	2.43-01	-2.24-08	1.29+00	8.49-01
53	2.40+02	-2.55-08	1.80-11	1.79-04	1.05+00	8.91-01	-1.67-08	-4.48-01	2.27-01	-2.02-08	1.33+00	8.02-01
54	2.40+02	-2.50-22	1.80-11	1.79-04	1.05+00	8.88-01	-1.83-08	-4.46-01	2.26-01	-1.87-08	1.33+00	7.99-01

CIRCUMFERENTIAL VARIATION OF SUPERPOSED QUANTITIES AT POINT NO. 12, SEGMENT NO. 1, MERIDIONAL STATION= 1.944+02

POINT	STATION	U	V	W	S1(IN)	S1(OUT)	TAU(IN)	S2(IN)	S2(OUT)	TAU(OUT)	SVON(IN)	SVON(OUT)
1	0.00	5.87-06	0.00	-2.43-04	-3.14-01	-1.62+00	0.00	1.94+00	-1.84+00	0.00	2.12+00	1.74+00
2	2.00+00	5.81-06	-8.58-06	-2.41-04	-3.21-01	-1.61+00	-8.84-02	1.91+00	-1.81+00	1.44-02	2.10+00	1.72+00
3	4.00+00	5.63-06	-1.70-05	-2.35-04	-3.40-01	-1.58+00	-1.73-01	1.82+00	-1.72+00	2.50-02	2.03+00	1.66+00
4	6.00+00	5.34-06	-2.52-05	-2.25-04	-3.69-01	-1.53+00	-2.49-01	1.67+00	-1.59+00	2.87-02	1.93+00	1.56+00
5	8.00+00	4.96-06	-3.29-05	-2.12-04	-4.04-01	-1.45+00	-3.13-01	1.48+00	-1.41+00	2.38-02	1.80+00	1.43+00
6	1.00+01	4.49-06	-4.01-05	-1.95-04	-4.40-01	-1.36+00	-3.63-01	1.25+00	-1.19+00	9.88-03	1.64+00	1.28+00
7	1.20+01	3.96-06	-4.67-05	-1.76-04	-4.72-01	-1.24+00	-3.98-01	9.92-01	-9.53-01	-1.19-02	1.47+00	1.12+00
8	1.40+01	3.39-06	-5.25-05	-1.54-04	-4.96-01	-1.09+00	-4.16-01	7.24-01	-7.05-01	-3.95-02	1.28+00	9.63-01
9	1.60+01	2.79-06	-5.76-05	-1.31-04	-5.08-01	-9.34-01	-4.19-01	4.57-01	-4.58-01	-6.99-02	1.11+00	8.18-01
10	1.80+01	2.18-06	-6.18-05	-1.07-04	-5.06-01	-7.59-01	-4.09-01	2.02-01	-2.22-01	-1.00-01	9.48-01	6.98-01
11	2.00+01	1.58-06	-6.52-05	-8.24-05	-4.88-01	-5.76-01	-3.87-01	-3.22-02	-4.05-03	-1.28-01	8.20-01	6.16-01
12	2.20+01	9.88-07	-6.77-05	-5.78-05	-4.54-01	-3.90-01	-3.57-01	-2.38-01	1.88-01	-1.52-01	7.32-01	5.75-01
13	2.40+01	4.25-07	-6.93-05	-3.36-05	-4.04-01	-2.06-01	-3.21-01	-4.11-01	3.52-01	-1.69-01	6.89-01	5.70-01
14	2.60+01	-1.07-07	-7.01-05	-1.00-05	-3.41-01	-2.90-02	-2.82-01	-5.49-01	4.85-01	-1.80-01	6.85-01	5.90-01
15	2.80+01	-6.05-07	-7.01-05	1.24-05	-2.66-01	1.38-01	-2.43-01	-6.53-01	5.87-01	-1.85-01	7.07-01	6.21-01
16	3.00+01	-1.07-06	-6.92-05	3.36-05	-1.83-01	2.91-01	-2.04-01	-7.24-01	6.60-01	-1.84-01	7.42-01	6.56-01
17	3.20+01	-1.49-06	-6.77-05	5.34-05	-9.28-02	4.29-01	-1.69-01	-7.67-01	7.07-01	-1.78-01	7.82-01	6.89-01
18	3.40+01	-1.87-06	-6.55-05	7.16-05	7.88-04	5.52-01	-1.37-01	-7.85-01	7.30-01	-1.68-01	8.20-01	7.20-01
19	3.60+01	-2.22-06	-6.26-05	8.82-05	9.54-02	6.58-01	-1.10-01	-7.81-01	7.34-01	-1.55-01	8.55-01	7.49-01

20	3.80+01	-2.53-06	-5.93-05	1.03-04	1.89-01	7.50-01	-8.60-02	-7.62-01	7.23-01	-1.40-01	8.85-01	7.76-01
21	4.00+01	-2.81-06	-5.54-05	1.17-04	2.79-01	8.27-01	-6.65-02	-7.31-01	7.00-01	-1.24-01	9.11-01	8.01-01
22	4.20+01	-3.06-06	-5.10-05	1.28-04	3.64-01	8.92-01	-5.06-02	-6.92-01	6.69-01	-1.08-01	9.33-01	8.26-01
23	4.40+01	-3.27-06	-4.63-05	1.39-04	4.42-01	9.45-01	-3.80-02	-6.49-01	6.33-01	-9.28-02	9.53-01	8.50-01
24	4.60+01	-3.46-06	-4.12-05	1.48-04	5.13-01	9.89-01	-2.82-02	-6.04-01	5.96-01	-7.79-02	9.70-01	8.73-01
25	4.80+01	-3.62-06	-3.58-05	1.55-04	5.76-01	1.02+00	-2.06-02	-5.61-01	5.59-01	-6.40-02	9.86-01	8.94-01
26	5.00+01	-3.76-06	-3.02-05	1.61-04	6.30-01	1.05+00	-1.48-02	-5.21-01	5.24-01	-5.12-02	9.99-01	9.14-01
27	5.20+01	-3.86-06	-2.44-05	1.66-04	6.75-01	1.07+00	-1.04-02	-4.87-01	4.94-01	-3.95-02	1.01+00	9.31-01
28	5.40+01	-3.95-06	-1.84-05	1.70-04	7.09-01	1.09+00	-7.02-03	-4.59-01	4.69-01	-2.87-02	1.02+00	9.45-01
29	5.60+01	-4.01-06	-1.24-05	1.73-04	7.34-01	1.10+00	-4.32-03	-4.38-01	4.50-01	-1.87-02	1.03+00	9.56-01
30	5.80+01	-4.04-06	-6.19-06	1.74-04	7.49-01	1.10+00	-2.05-03	-4.25-01	4.39-01	-9.20-03	1.03+00	9.62-01
31	6.00+01	-4.05-06	-1.73-10	1.75-04	7.55-01	1.11+00	-5.81-08	-4.21-01	4.35-01	-2.54-07	1.03+00	9.65-01

CIRCUMFERENTIAL VARIATION OF SUPERPOSED QUANTITIES AT POINT NO. 27, SEGMENT NO. 1, MERIDIONAL STATION= 2.141+02

POINT	STATION	U	V	W	S1(IN)	S1(OUT)	TAU(IN)	S2(IN)	S2(OUT)	TAU(OUT)	SVON(IN)	SVON(OUT)
1	0.00	3.86-06	0.00	-2.67-04	-4.82-01	-1.95+00	0.00	2.57+00	-2.29+00	0.00	2.85+00	2.14+00
2	2.00+00	3.80-06	-9.45-06	-2.64-04	-4.90-01	-1.94+00	-1.51-01	2.51+00	-2.23+00	3.57-02	2.80+00	2.10+00
3	4.00+00	3.64-06	-1.87-05	-2.56-04	-5.15-01	-1.90+00	-2.89-01	2.33+00	-2.07+00	5.80-02	2.68+00	1.99+00
4	6.00+00	3.38-06	-2.76-05	-2.44-04	-5.50-01	-1.82+00	-4.02-01	2.06+00	-1.83+00	5.83-02	2.48+00	1.83+00
5	8.00+00	3.05-06	-3.60-05	-2.27-04	-5.88-01	-1.71+00	-4.83-01	1.71+00	-1.53+00	3.50-02	2.23+00	1.63+00
6	1.00+01	2.67-06	-4.37-05	-2.06-04	-6.22-01	-1.56+00	-5.29-01	1.32+00	-1.19+00	-7.24-03	1.95+00	1.41+00
7	1.20+01	2.26-06	-5.07-05	-1.83-04	-6.46-01	-1.36+00	-5.42-01	9.27-01	-8.48-01	-6.01-02	1.66+00	1.20+00
8	1.40+01	1.84-06	-5.67-05	-1.58-04	-6.55-01	-1.14+00	-5.26-01	5.48-01	-5.18-01	-1.15-01	1.38+00	1.01+00
9	1.60+01	1.42-06	-6.19-05	-1.32-04	-6.45-01	-8.99-01	-4.90-01	2.04-01	-2.17-01	-1.64-01	1.14+00	8.61-01
10	1.80+01	1.02-06	-6.61-05	-1.05-04	-6.17-01	-6.52-01	-4.39-01	-9.29-02	4.80-02	-2.02-01	9.54-01	7.63-01
11	2.00+01	6.44-07	-6.93-05	-7.81-05	-5.70-01	-4.10-01	-3.81-01	-3.36-01	2.71-01	-2.29-01	8.26-01	7.14-01
12	2.20+01	2.92-07	-7.16-05	-5.18-05	-5.06-01	-1.82-01	-3.23-01	-5.26-01	4.51-01	-2.42-01	7.61-01	7.03-01
13	2.40+01	-3.19-08	-7.30-05	-2.63-05	-4.29-01	2.68-02	-2.66-01	-6.65-01	5.89-01	-2.45-01	7.44-01	7.16-01
14	2.60+01	-3.28-07	-7.35-05	-2.15-06	-3.40-01	2.13-01	-2.15-01	-7.60-01	6.90-01	-2.38-01	7.57-01	7.38-01
15	2.80+01	-5.96-07	-7.32-05	2.06-05	-2.43-01	3.76-01	-1.71-01	-8.16-01	7.56-01	-2.24-01	7.83-01	7.61-01
16	3.00+01	-8.38-07	-7.21-05	4.18-05	-1.41-01	5.15-01	-1.34-01	-8.40-01	7.94-01	-2.06-01	8.13-01	7.83-01
17	3.20+01	-1.06-06	-7.02-05	6.13-05	-3.79-02	6.33-01	-1.03-01	-8.40-01	8.07-01	-1.85-01	8.41-01	8.02-01
18	3.40+01	-1.25-06	-6.77-05	7.91-05	6.46-02	7.31-01	-7.91-02	-8.20-01	8.01-01	-1.63-01	8.66-01	8.19-01
19	3.60+01	-1.43-06	-6.46-05	9.53-05	1.64-01	8.12-01	-6.05-02	-7.88-01	7.81-01	-1.41-01	8.88-01	8.34-01
20	3.80+01	-1.58-06	-6.10-05	1.10-04	2.59-01	8.79-01	-4.63-02	-7.46-01	7.50-01	-1.20-01	9.08-01	8.48-01
21	4.00+01	-1.72-06	-5.69-05	1.23-04	3.48-01	9.34-01	-3.58-02	-6.99-01	7.12-01	-1.01-01	9.26-01	8.63-01
22	4.20+01	-1.84-06	-5.23-05	1.34-04	4.31-01	9.78-01	-2.80-02	-6.50-01	6.71-01	-8.36-02	9.44-01	8.78-01
23	4.40+01	-1.95-06	-4.74-05	1.44-04	5.05-01	1.01+00	-2.22-02	-6.02-01	6.28-01	-6.84-02	9.61-01	8.94-01
24	4.60+01	-2.05-06	-4.21-05	1.52-04	5.71-01	1.04+00	-1.79-02	-5.55-01	5.86-01	-5.52-02	9.76-01	9.10-01
25	4.80+01	-2.13-06	-3.66-05	1.59-04	6.29-01	1.07+00	-1.45-02	-5.13-01	5.46-01	-4.38-02	9.91-01	9.26-01
26	5.00+01	-2.19-06	-3.09-05	1.65-04	6.78-01	1.08+00	-1.16-02	-4.76-01	5.10-01	-3.40-02	1.00+00	9.41-01
27	5.20+01	-2.25-06	-2.49-05	1.70-04	7.19-01	1.10+00	-9.12-03	-4.44-01	4.80-01	-2.56-02	1.02+00	9.55-01
28	5.40+01	-2.29-06	-1.88-05	1.74-04	7.50-01	1.11+00	-6.78-03	-4.19-01	4.56-01	-1.83-02	1.03+00	9.66-01
29	5.60+01	-2.32-06	-1.26-05	1.76-04	7.72-01	1.12+00	-4.51-03	-4.00-01	4.38-01	-1.17-02	1.03+00	9.74-01
30	5.80+01	-2.34-06	-6.32-06	1.78-04	7.86-01	1.12+00	-2.26-03	-3.89-01	4.27-01	-5.73-03	1.04+00	9.79-01
31	6.00+01	-2.34-06	-1.77-10	1.78-04	7.90-01	1.12+00	-6.62-08	-3.86-01	4.23-01	-1.59-07	1.04+00	9.81-01

CIRCUMFERENTIAL VARIATION OF SUPERPOSED QUANTITIES AT POINT NO. 44, SEGMENT NO. 1, MERIDIONAL STATION= 2.310+02

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POINT	STATION	U	V	W	S1(IN)	S1(OUT)	TAU(IN)	S2(IN)	S2(OUT)	TAU(OUT)	SVON(IN)	SVON(OUT)
1	0.00	1.64-06	0.00	-2.91-04	-3.25-01	-2.85+00	0.00	3.55+00	-3.51+00	0.00	3.73+00	3.23+00
2	2.00+00	1.59-06	-1.03-05	-2.88-04	-3.79-01	-2.81+00	-3.10-01	3.34+00	-3.34+00	7.39-02	3.59+00	3.11+00
3	4.00+00	1.44-06	-2.03-05	-2.77-04	-5.17-01	-2.66+00	-5.45-01	2.78+00	-2.89+00	7.05-02	3.21+00	2.79+00
4	6.00+00	1.25-06	-2.99-05	-2.60-04	-6.87-01	-2.38+00	-6.71-01	2.04+00	-2.33+00	-1.43-02	2.72+00	2.35+00
5	8.00+00	1.04-06	-3.87-05	-2.39-04	-8.41-01	-1.99+00	-6.99-01	1.29+00	-1.76+00	-1.29-01	2.22+00	1.90+00
6	1.00+01	8.37-07	-4.67-05	-2.14-04	-9.54-01	-1.56+00	-6.61-01	6.30-01	-1.25+00	-2.26-01	1.79+00	1.48+00
7	1.20+01	6.46-07	-5.37-05	-1.88-04	-1.02+00	-1.12+00	-5.90-01	8.97-02	-8.13-01	-2.90-01	1.47+00	1.12+00
8	1.40+01	4.71-07	-5.97-05	-1.59-04	-1.03+00	-7.25-01	-5.07-01	-3.30-01	-4.45-01	-3.21-01	1.26+00	8.43-01
9	1.60+01	3.13-07	-6.48-05	-1.31-04	-9.96-01	-3.78-01	-4.26-01	-6.44-01	-1.46-01	-3.26-01	1.14+00	6.54-01
10	1.80+01	1.71-07	-6.88-05	-1.03-04	-9.28-01	-8.28-02	-3.52-01	-8.68-01	9.25-02	-3.12-01	1.09+00	5.61-01
11	2.00+01	4.44-08	-7.18-05	-7.48-05	-8.35-01	1.62-01	-2.88-01	-1.02+00	2.76-01	-2.86-01	1.07+00	5.51-01
12	2.20+01	-6.85-08	-7.38-05	-4.81-05	-7.23-01	3.62-01	-2.35-01	-1.12+00	4.14-01	-2.54-01	1.06+00	5.88-01
13	2.40+01	-1.69-07	-7.50-05	-2.26-05	-6.01-01	5.24-01	-1.91-01	-1.17+00	5.12-01	-2.19-01	1.06+00	6.42-01
14	2.60+01	-2.58-07	-7.52-05	1.39-06	-4.73-01	6.54-01	-1.56-01	-1.18+00	5.78-01	-1.84-01	1.06+00	6.97-01
15	2.80+01	-3.37-07	-7.47-05	2.38-05	-3.44-01	7.58-01	-1.28-01	-1.17+00	6.18-01	-1.51-01	1.06+00	7.46-01
16	3.00+01	-4.07-07	-7.34-05	4.46-05	-2.18-01	8.41-01	-1.06-01	-1.14+00	6.38-01	-1.21-01	1.06+00	7.88-01
17	3.20+01	-4.69-07	-7.14-05	6.37-05	-9.55-02	9.07-01	-8.93-02	-1.09+00	6.41-01	-9.44-02	1.06+00	8.24-01
18	3.40+01	-5.25-07	-6.87-05	8.12-05	2.07-02	9.60-01	-7.60-02	-1.04+00	6.32-01	-7.17-02	1.06+00	8.54-01
19	3.60+01	-5.74-07	-6.55-05	9.69-05	1.30-01	1.00+00	-6.55-02	-9.77-01	6.14-01	-5.28-02	1.05+00	8.81-01
20	3.80+01	-6.18-07	-6.17-05	1.11-04	2.31-01	1.04+00	-5.71-02	-9.13-01	5.90-01	-3.73-02	1.05+00	9.04-01
21	4.00+01	-6.57-07	-5.75-05	1.24-04	3.24-01	1.07+00	-5.00-02	-8.49-01	5.63-01	-2.49-02	1.05+00	9.25-01
22	4.20+01	-6.91-07	-5.29-05	1.35-04	4.09-01	1.09+00	-4.40-02	-7.85-01	5.34-01	-1.54-02	1.05+00	9.44-01
23	4.40+01	-7.21-07	-4.79-05	1.45-04	4.85-01	1.11+00	-3.86-02	-7.24-01	5.04-01	-8.35-03	1.06+00	9.62-01
24	4.60+01	-7.48-07	-4.25-05	1.53-04	5.53-01	1.13+00	-3.36-02	-6.68-01	4.76-01	-3.25-03	1.06+00	9.78-01
25	4.80+01	-7.70-07	-3.69-05	1.60-04	6.11-01	1.14+00	-2.88-02	-6.17-01	4.50-01	5.95-05	1.07+00	9.93-01
26	5.00+01	-7.89-07	-3.11-05	1.66-04	6.61-01	1.15+00	-2.40-02	-5.73-01	4.26-01	1.99-03	1.07+00	1.01+00
27	5.20+01	-8.04-07	-2.51-05	1.71-04	7.02-01	1.16+00	-1.93-02	-5.35-01	4.06-01	2.88-03	1.07+00	1.02+00
28	5.40+01	-8.16-07	-1.90-05	1.75-04	7.33-01	1.16+00	-1.45-02	-5.05-01	3.90-01	2.85-03	1.08+00	1.03+00
29	5.60+01	-8.25-07	-1.27-05	1.77-04	7.56-01	1.17+00	-9.72-03	-4.84-01	3.79-01	2.20-03	1.08+00	1.03+00
30	5.80+01	-8.30-07	-6.37-06	1.79-04	7.70-01	1.17+00	-4.87-03	-4.71-01	3.71-01	1.24-03	1.08+00	1.04+00
31	6.00+01	-8.32-07	-1.78-10	1.79-04	7.74-01	1.17+00	-1.36-07	-4.66-01	3.69-01	3.24-08	1.09+00	1.04+00

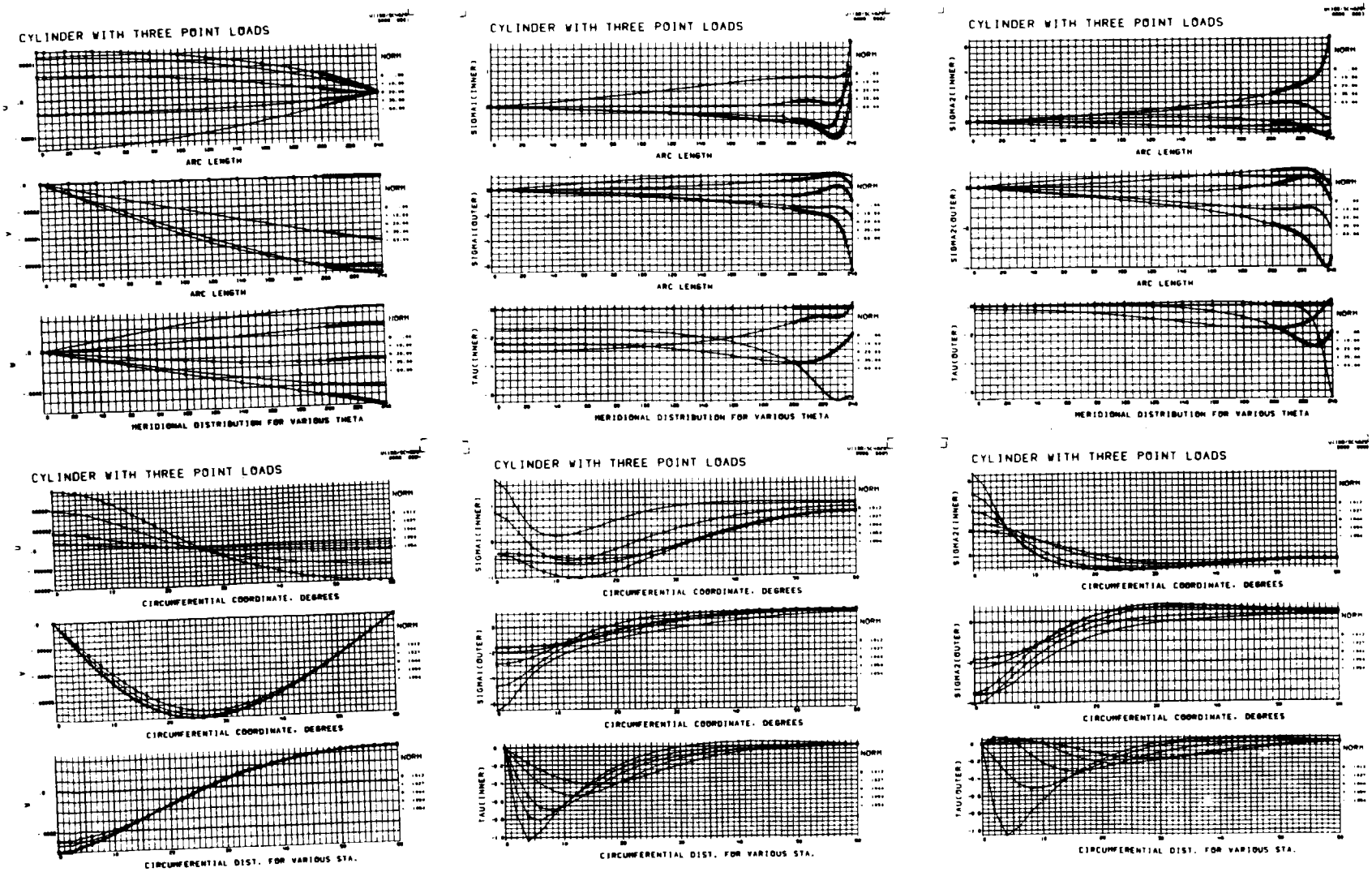
CIRCUMFERENTIAL VARIATION OF SUPERPOSED QUANTITIES AT POINT NO. 50, SEGMENT NO. 1, MERIDIONAL STATION= 2.370+02

POINT	STATION	U	V	W	S1(IN)	S1(OUT)	TAU(IN)	S2(IN)	S2(OUT)	TAU(OUT)	SVON(IN)	SVON(OUT)
1	0.00	6.64-07	0.00	-3.00-04	8.12-01	-4.64+00	0.00	4.95+00	-4.06+00	0.00	4.60+00	4.38+00
2	2.00+00	6.20-07	-1.07-05	-2.96-04	6.43-01	-4.44+00	-4.88-01	4.42+00	-3.84+00	-1.58-01	4.22+00	4.18+00
3	4.00+00	5.19-07	-2.11-05	-2.84-04	2.60-01	-3.91+00	-7.64-01	3.18+00	-3.31+00	-3.30-01	3.33+00	3.69+00
4	6.00+00	4.11-07	-3.08-05	-2.66-04	-1.14-01	-3.21+00	-8.11-01	1.90+00	-2.72+00	-4.66-01	2.41+00	3.10+00
5	8.00+00	3.20-07	-3.97-05	-2.43-04	-3.66-01	-2.52+00	-7.39-01	8.90-01	-2.18+00	-5.21-01	1.70+00	2.54+00
6	1.00+01	2.43-07	-4.76-05	-2.17-04	-4.99-01	-1.94+00	-6.37-01	1.59-01	-1.72+00	-5.10-01	1.25+00	2.04+00
7	1.20+01	1.77-07	-5.46-05	-1.90-04	-5.40-01	-1.45+00	-5.34-01	-3.67-01	-1.31+00	-4.70-01	1.04+00	1.61+00
8	1.40+01	1.19-07	-6.06-05	-1.61-04	-5.12-01	-1.06+00	-4.40-01	-7.37-01	-9.77-01	-4.15-01	1.00+00	1.25+00
9	1.60+01	6.84-08	-6.55-05	-1.33-04	-4.42-01	-7.44-01	-3.59-01	-9.94-01	-6.96-01	-3.54-01	1.06+00	9.47-01
10	1.80+01	2.36-08	-6.94-05	-1.04-04	-3.44-01	-4.86-01	-2.89-01	-1.16+00	-4.66-01	-2.95-01	1.15+00	6.99-01
11	2.00+01	-1.57-08	-7.23-05	-7.63-05	-2.31-01	-2.73-01	-2.31-01	-1.27+00	-2.83-01	-2.39-01	1.24+00	4.98-01
12	2.20+01	-5.06-08	-7.43-05	-4.96-05	-1.13-01	-9.72-02	-1.83-01	-1.32+00	-1.36-01	-1.86-01	1.31+00	3.45-01
13	2.40+01	-8.12-08	-7.53-05	-2.41-05	3.27-03	5.10-02	-1.43-01	-1.34+00	-2.09-02	-1.41-01	1.36+00	2.53-01
14	2.60+01	-1.08-07	-7.55-05	-1.48-07	1.16-01	1.78-01	-1.11-01	-1.33+00	6.72-02	-1.02-01	1.40+00	2.36-01

15	2.80+01	-1.32-07	-7.49-05	2.23-05	2.20-01	2.88-01	-8.49-02	-1.29+00	1.35-01	-6.81-02	1.43+00	2.76-01
16	3.00+01	-1.53-07	-7.36-05	4.31-05	3.17-01	3.85-01	-6.38-02	-1.25+00	1.86-01	-4.08-02	1.44+00	3.41-01
17	3.20+01	-1.71-07	-7.15-05	6.22-05	4.05-01	4.72-01	-4.73-02	-1.19+00	2.22-01	-1.84-02	1.43+00	4.10-01
18	3.40+01	-1.88-07	-6.88-05	7.97-05	4.83-01	5.50-01	-3.46-02	-1.12+00	2.49-01	-2.38-04	1.42+00	4.77-01
19	3.60+01	-2.03-07	-6.56-05	9.56-05	5.53-01	6.21-01	-2.43-02	-1.05+00	2.67-01	1.29-02	1.41+00	5.40-01
20	3.80+01	-2.16-07	-6.18-05	1.10-04	6.16-01	6.87-01	-1.65-02	-9.75-01	2.78-01	2.27-02	1.39+00	5.99-01
21	4.00+01	-2.27-07	-5.76-05	1.23-04	6.70-01	7.46-01	-1.10-02	-9.03-01	2.85-01	2.97-02	1.37+00	6.54-01
22	4.20+01	-2.37-07	-5.29-05	1.34-04	7.18-01	7.99-01	-6.48-03	-8.33-01	2.89-01	3.33-02	1.35+00	7.03-01
23	4.40+01	-2.46-07	-4.79-05	1.44-04	7.60-01	8.48-01	-3.32-03	-7.66-01	2.89-01	3.47-02	1.32+00	7.49-01
24	4.60+01	-2.54-07	-4.26-05	1.52-04	7.96-01	8.91-01	-1.44-03	-7.05-01	2.88-01	3.46-02	1.30+00	7.90-01
25	4.80+01	-2.60-07	-3.70-05	1.60-04	8.27-01	9.29-01	1.04-04	-6.50-01	2.87-01	3.22-02	1.28+00	8.26-01
26	5.00+01	-2.66-07	-3.11-05	1.66-04	8.52-01	9.62-01	9.63-04	-6.01-01	2.84-01	2.87-02	1.26+00	8.57-01
27	5.20+01	-2.70-07	-2.51-05	1.70-04	8.73-01	9.89-01	1.04-03	-5.60-01	2.82-01	2.45-02	1.25+00	8.83-01
28	5.40+01	-2.74-07	-1.90-05	1.74-04	8.88-01	1.01+00	1.17-03	-5.28-01	2.80-01	1.89-02	1.24+00	9.03-01
29	5.60+01	-2.76-07	-1.27-05	1.77-04	9.00-01	1.02+00	1.02-03	-5.04-01	2.78-01	1.28-02	1.23+00	9.18-01
30	5.80+01	-2.78-07	-6.37-06	1.78-04	9.06-01	1.03+00	3.65-04	-4.90-01	2.77-01	6.76-03	1.23+00	9.27-01
31	6.00+01	-2.79-07	-1.78-10	1.79-04	9.08-01	1.04+00	8.17-09	-4.86-01	2.77-01	1.96-07	1.23+00	9.30-01

CIRCUMFERENTIAL VARIATION OF SUPERPOSED QUANTITIES AT POINT NO. 54, SEGMENT NO. 1, MERIDIONAL STATION= 2.400+02

POINT	STATION	U	V	W	S1(IN)	S1(OUT)	TAU(IN)	S2(IN)	S2(OUT)	TAU(OUT)	SVON(IN)	SVON(OUT)
1	0.00	2.60-22	0.00	-3.02-04	1.75+00	-6.51+00	0.00	6.63+00	-3.59+00	0.00	5.95+00	5.65+00
2	2.00+00	2.58-22	-1.12-05	-2.97-04	1.46+00	-5.93+00	-7.55-01	5.61+00	-3.57+00	-7.70-01	5.21+00	5.34+00
3	4.00+00	2.53-22	-2.17-05	-2.85-04	8.67-01	-4.72+00	-1.04+00	3.49+00	-3.42+00	-1.06+00	3.63+00	4.60+00
4	6.00+00	2.45-22	-3.14-05	-2.66-04	4.08-01	-3.65+00	-9.40-01	1.76+00	-3.06+00	-9.59-01	2.28+00	3.78+00
5	8.00+00	2.34-22	-4.02-05	-2.44-04	2.02-01	-2.94+00	-7.74-01	7.38-01	-2.59+00	-7.90-01	1.49+00	3.10+00
6	1.00+01	2.21-22	-4.81-05	-2.18-04	1.46-01	-2.42+00	-6.42-01	4.98-02	-2.15+00	-6.54-01	1.12+00	2.56+00
7	1.20+01	2.05-22	-5.50-05	-1.90-04	1.74-01	-2.01+00	-5.17-01	-4.33-01	-1.77+00	-5.27-01	1.05+00	2.11+00
8	1.40+01	1.87-22	-6.09-05	-1.62-04	2.58-01	-1.69+00	-4.13-01	-7.43-01	-1.43+00	-4.21-01	1.15+00	1.74+00
9	1.60+01	1.68-22	-6.58-05	-1.33-04	3.61-01	-1.42+00	-3.28-01	-9.67-01	-1.15+00	-3.35-01	1.32+00	1.43+00
10	1.80+01	1.46-22	-6.96-05	-1.05-04	4.72-01	-1.19+00	-2.50-01	-1.11+00	-9.10-01	-2.55-01	1.47+00	1.16+00
11	2.00+01	1.24-22	-7.25-05	-7.68-05	5.84-01	-9.93-01	-1.87-01	-1.18+00	-7.08-01	-1.91-01	1.59+00	9.45-01
12	2.20+01	1.00-22	-7.44-05	-5.01-05	6.83-01	-8.12-01	-1.37-01	-1.23+00	-5.42-01	-1.40-01	1.69+00	7.56-01
13	2.40+01	7.56-23	-7.54-05	-2.47-05	7.71-01	-6.46-01	-9.13-02	-1.24+00	-4.05-01	-9.31-02	1.76+00	5.88-01
14	2.60+01	5.01-23	-7.56-05	-6.53-07	8.49-01	-4.99-01	-5.59-02	-1.21+00	-2.88-01	-5.71-02	1.80+00	4.45-01
15	2.80+01	2.41-23	-7.50-05	2.18-05	9.10-01	-3.54-01	-2.96-02	-1.18+00	-1.95-01	-3.02-02	1.82+00	3.12-01
16	3.00+01	-2.23-24	-7.36-05	4.26-05	9.59-01	-2.18-01	-4.71-03	-1.14+00	-1.18-01	-4.80-03	1.82+00	1.89-01
17	3.20+01	-2.86-23	-7.15-05	6.18-05	9.99-01	-9.31-02	1.29-02	-1.07+00	-5.17-02	1.32-02	1.80+00	8.40-02
18	3.40+01	-5.47-23	-6.89-05	7.93-05	1.03+00	3.01-02	2.41-02	-1.01+00	8.67-04	2.46-02	1.77+00	5.19-02
19	3.60+01	-8.03-23	-6.56-05	9.52-05	1.05+00	1.47-01	3.54-02	-9.53-01	4.43-02	3.61-02	1.73+00	1.45-01
20	3.80+01	-1.05-22	-6.18-05	1.10-04	1.06+00	2.54-01	4.19-02	-8.81-01	8.23-02	4.27-02	1.68+00	2.36-01
21	4.00+01	-1.28-22	-5.76-05	1.22-04	1.07+00	3.57-01	4.35-02	-8.17-01	1.12-01	4.44-02	1.64+00	3.25-01
22	4.20+01	-1.50-22	-5.29-05	1.34-04	1.07+00	4.54-01	4.63-02	-7.58-01	1.37-01	4.72-02	1.59+00	4.11-01
23	4.40+01	-1.70-22	-4.79-05	1.44-04	1.07+00	5.38-01	4.60-02	-6.92-01	1.59-01	4.69-02	1.54+00	4.86-01
24	4.60+01	-1.88-22	-4.26-05	1.52-04	1.07+00	6.17-01	4.18-02	-6.39-01	1.76-01	4.26-02	1.50+00	5.56-01
25	4.80+01	-2.04-22	-3.70-05	1.59-04	1.06+00	6.88-01	3.93-02	-5.93-01	1.90-01	4.01-02	1.46+00	6.20-01
26	5.00+01	-2.18-22	-3.11-05	1.65-04	1.06+00	7.46-01	3.50-02	-5.44-01	2.03-01	3.57-02	1.42+00	6.71-01
27	5.20+01	-2.29-22	-2.51-05	1.70-04	1.06+00	7.96-01	2.74-02	-5.09-01	2.12-01	2.80-02	1.39+00	7.16-01
28	5.40+01	-2.38-22	-1.90-05	1.74-04	1.05+00	8.37-01	2.20-02	-4.84-01	2.18-01	2.25-02	1.36+00	7.53-01
29	5.60+01	-2.44-22	-1.27-05	1.77-04	1.05+00	8.63-01	1.58-02	-4.58-01	2.24-01	1.61-02	1.34+00	7.76-01
30	5.80+01	-2.48-22	-6.37-06	1.78-04	1.05+00	8.80-01	6.61-03	-4.46-01	2.26-01	6.74-03	1.33+00	7.91-01
31	6.00+01	-2.50-22	-1.78-10	1.79-04	1.05+00	8.88-01	1.52-07	-4.46-01	2.26-01	1.56-07	1.33+00	7.99-01


CYLINDER WITH THREE POINT LOADS
ARC LENGTH
MERIDIONAL DISTRIBUTION FOR VARIOUS THETA
CIRCUMFERENTIAL COORDINATE, DEGREES
CIRCUMFERENTIAL DIST. FOR VARIOUS STA.
SIGMA1(INNER)
SIGMA1(OUTER)
TAU(INNER)
SIGMA2(INNER)
SIGMA2(OUTER)
TAU(OUTER)
NORM

FORCE,MOMENT, AND TORQUE RESULTANTS FOR RING NO. 1

STATION NO.	CIRC. ANGLE	HOOP FORCE	OUT-OF-PLANE MOMENT	IN-PLANE-MOMENT	TORQUE
1	0.000000	-1.861109+01	-2.437710-10	8.241318+00	0.000000
2	1.999998+00	-1.720373+01	-8.648669-11	7.411744+00	5.816090-10
3	3.999997+00	-1.392539+01	1.461972-10	5.585828+00	6.440602-10
4	5.999995+00	-1.042526+01	1.738959-10	3.843108+00	3.747768-10
5	7.999993+00	-7.462186+00	9.469420-11	2.533168+00	1.758559-10
6	9.999991+00	-5.014929+00	6.503671-11	1.505220+00	9.030389-11
7	1.199999+01	-3.011753+00	5.425856-11	6.879464-01	2.946965-11
8	1.399999+01	-1.411041+00	3.505809-11	5.958790-02	2.257269-12
9	1.599999+01	-1.312467-01	3.319934-11	-4.373502-01	-1.031209-12
10	1.799998+01	8.664527-01	3.243740-11	-8.163774-01	-6.702713-12
11	1.999998+01	1.616319+00	2.446105-11	-1.088997+00	1.052940-13
12	2.199998+01	2.175455+00	2.658713-11	-1.290389+00	1.427628-11
13	2.399998+01	2.568421+00	2.791516-11	-1.425606+00	2.031006-11
14	2.599998+01	2.817731+00	2.273295-11	-1.500409+00	3.122721-11
15	2.799998+01	2.963574+00	2.466111-11	-1.539397+00	4.477436-11
16	2.999997+01	3.020870+00	2.593653-11	-1.544280+00	4.928652-11
17	3.199997+01	3.002359+00	2.129266-11	-1.516705+00	5.583591-11
18	3.399997+01	2.936696+00	2.224417-11	-1.475054+00	6.400486-11
19	3.599997+01	2.832455+00	2.315583-11	-1.419462+00	6.378284-11
20	3.799997+01	2.695347+00	1.863540-11	-1.348699+00	6.454554-11
21	3.999996+01	2.546379+00	1.879770-11	-1.277233+00	6.717295-11
22	4.199996+01	2.390270+00	1.960789-11	-1.204573+00	6.243269-11
23	4.399996+01	2.227928+00	1.535132-11	-1.127468+00	5.825734-11
24	4.599996+01	2.075290+00	1.511947-11	-1.057786+00	5.656630-11
25	4.799996+01	1.934856+00	1.618595-11	-9.949386-01	4.851473-11
26	4.999995+01	1.804166+00	1.243163-11	-9.341549-01	4.080318-11
27	5.199995+01	1.695627+00	1.214897-11	-8.854404-01	3.627985-11
28	5.399995+01	1.610454+00	1.375734-11	-8.483722-01	2.629564-11
29	5.599995+01	1.543579+00	1.068451-11	-8.168973-01	1.647633-11
30	5.799995+01	1.504711+00	1.056619-11	-7.995557-01	1.056630-11
31	5.999994+01	1.494210+00	1.288434-11	-7.961971-01	3.522412-16

ELAPSED TIME = 0: 0:33. 44

BEGINNING OF NEXT CASE

FREE HEMISPHERE VIBRATION

VIBRATION ANALYSIS OF PRESTRESSED SHELLS. THE EIGEN-
VALUE REPRESENTS THE FREQUENCY IN CPS. FREQUENCIES
ARE OBTAINED FOR NO.LE.N.LE.NMAX.

ANALYSIS TYPE = 2, PRINT OPTION = 1, PLOT OPTION = 0, STRESS OPTION = 0, PRESTRESS CALCULATION OPTION = 1

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NUMBER OF SHELL SEGMENTS = 1

STRESS CALCULATED FOR CIRCUMFERENTIAL WAVES FROM 0 TO 0 IN INCREMENTS OF 1

INITIAL BUCKLING OR VIBRATION WAVE NO.= 0, MINIMUM WAVE NO.= 0, MAXIMUM WAVE NO.= 3, INCREMENT= 1

3 EIGENVALUES SOUGHT FOR EACH CIRCUMFERENTIAL WAVE NUMBER.

CONSTRAINT CONDITION DATA FOLLOW

SEG.	POINT	CONNECTED TO SEG.	POINT	USTAR	VSTAR	WSTAR	BETA	RADIAL DISC. D1(I)	AXIAL DISC. D2(I)
1	1	1	1	0	0	0	0	0.00000000	0.00000000
1	31	1	31	0	0	0	0	0.00000000	0.00000000

PRESSURE MULTIPLIER P = 0.0000 , INCREMENT DP= 0.0000 , TEMPERATURE MULT.TEMP= 1.0000+00, INCREMENT DTEMP= 0.0000

INITIAL LOAD, FSTART = 0.0000 , MAXIMUM LOAD, FMAX = 0.0000 , STEP SIZE, DF= 0.0000

SEGMENT NO. 1 IS SPHERICAL OR TOROIDAL.
END POINT COORDINATES (.0000 , .0000) AND (.1000+03, .1000+03) AND CENTER (.0000 , .1000+03)
RADIUS = 1.0000+02 ALPHA1 = 0.0000 ALPHA2 = 9.0000+01 INCREASING ARC LENGTH ANTICLOCKWISE

REFERENCE SURFACE GEOMETRY FOR SEGMENT NO. 1

STATION	ARC LENGTH	RAD	RADD	CUR1	CUR2	CURID	Z
1	.00000000	.00000000	.10000000+01	.99999999-02	.99999999-02	.00000000	.50000000+00
2	.14398966+01	.14398468+01	.99989634+00	.99999999-02	.10000000-01	.00000000	.50000000+00
3	.53014375+01	.52989545+01	.99859507+00	.99999999-02	.10000000-01	.00000000	.50000000+00
4	.10471975+02	.10452846+02	.99452189+00	.99999999-02	.10000000-01	.00000000	.50000000+00
5	.15707963+02	.15643446+02	.98768834+00	.99999999-02	.10000000-01	.00000000	.50000000+00
6	.20943951+02	.20791169+02	.97814760+00	.99999999-02	.99999999-02	.00000000	.50000000+00
7	.26179938+02	.25881903+02	.96592583+00	.99999999-02	.10000000-01	.00000000	.50000000+00
8	.31415926+02	.30901699+02	.95105652+00	.99999999-02	.10000000-01	.00000000	.50000000+00
9	.36651914+02	.35836794+02	.93358043+00	.99999999-02	.10000000-01	.00000000	.50000000+00
10	.41887901+02	.40673664+02	.91354546+00	.99999999-02	.10000000-01	.00000000	.50000000+00
11	.47123889+02	.45399049+02	.89100653+00	.99999999-02	.10000000-01	.00000000	.50000000+00
12	.52359877+02	.49999998+02	.86602541+00	.99999999-02	.10000000-01	.00000000	.50000000+00
13	.57595864+02	.54463902+02	.83867057+00	.99999999-02	.10000000-01	.00000000	.50000000+00
14	.62831852+02	.58778524+02	.80901700+00	.99999999-02	.99999999-02	.00000000	.50000000+00
15	.68067840+02	.62932037+02	.77714597+00	.99999999-02	.10000000-01	.00000000	.50000000+00
16	.73303827+02	.66913059+02	.74314484+00	.99999999-02	.10000000-01	.00000000	.50000000+00
17	.78539815+02	.70710676+02	.70710679+00	.99999999-02	.10000000-01	.00000000	.50000000+00
18	.83775803+02	.74314482+02	.66913062+00	.99999999-02	.99999999-02	.00000000	.50000000+00
19	.89011790+02	.77714594+02	.62932041+00	.99999999-02	.10000000-01	.00000000	.50000000+00

20	.94247778+02	.80901697+02	.58778527+00	.99999999-02	.10000000-01	.00000000	.50000000+00
21	.99483766+02	.83867055+02	.54463906+00	.99999999-02	.10000000-01	.00000000	.50000000+00
22	.10471975+03	.86602538+02	.50000003+00	.99999999-02	.10000000-01	.00000000	.50000000+00
23	.10995574+03	.89100651+02	.45399053+00	.99999999-02	.10000000-01	.00000000	.50000000+00
24	.11519173+03	.91354544+02	.40673667+00	.99999999-02	.10000000-01	.00000000	.50000000+00
25	.12042772+03	.93358042+02	.35836797+00	.99999999-02	.10000000-01	.00000000	.50000000+00
26	.12566370+03	.95105651+02	.30901702+00	.99999999-02	.10000000-01	.00000000	.50000000+00
27	.13089969+03	.96592582+02	.25881908+00	.99999999-02	.10000000-01	.00000000	.50000000+00
28	.13613568+03	.97814758+02	.20791174+00	.99999999-02	.10000000-01	.00000000	.50000000+00
29	.14137166+03	.98768833+02	.15643453+00	.99999999-02	.10000000-01	.00000000	.50000000+00
30	.14660765+03	.99452188+02	.10452853+00	.99999999-02	.10000000-01	.00000000	.50000000+00
31	.15177819+03	.99859506+02	.52989644-01	.99999999-02	.10000000-01	.00000000	.50000000+00
32	.15563973+03	.99989633+02	.14398570-01	.99999999-02	.10000000-01	.00000000	.50000000+00
33	.15707962+03	.10000000+03	.10530022-06	.99999999-02	.99999999-02	.00000000	.50000000+00

PHYSICAL PROPERTIES OF SEGMENT NO. 1

ANALYSIS IS FOR A MONOCOQUE SHELL

MODULUS OF ELASTICITY= .10000+08 POISSON RATIO= .30000+00 SHELL DENSITY = .25350-03 THERMAL EXP COEF.= .00000

MESH POINT	STATION	REF. SURFACE	THICKNESS
1	0.00000	5.00000-01	1.00000+00
2	1.43990+00	5.00000-01	1.00000+00
3	5.30144+00	5.00000-01	1.00000+00
4	1.04720+01	5.00000-01	1.00000+00
5	1.57080+01	5.00000-01	1.00000+00
6	2.09440+01	5.00000-01	1.00000+00
7	2.61799+01	5.00000-01	1.00000+00
8	3.14159+01	5.00000-01	1.00000+00
9	3.66519+01	5.00000-01	1.00000+00
10	4.18879+01	5.00000-01	1.00000+00
11	4.71239+01	5.00000-01	1.00000+00
12	5.23599+01	5.00000-01	1.00000+00
13	5.75959+01	5.00000-01	1.00000+00
14	6.28319+01	5.00000-01	1.00000+00
15	6.80678+01	5.00000-01	1.00000+00
16	7.33038+01	5.00000-01	1.00000+00
17	7.85398+01	5.00000-01	1.00000+00
18	8.37758+01	5.00000-01	1.00000+00
19	8.90118+01	5.00000-01	1.00000+00
20	9.42478+01	5.00000-01	1.00000+00
21	9.94838+01	5.00000-01	1.00000+00
22	1.04720+02	5.00000-01	1.00000+00
23	1.09956+02	5.00000-01	1.00000+00
24	1.15192+02	5.00000-01	1.00000+00
25	1.20428+02	5.00000-01	1.00000+00
26	1.25664+02	5.00000-01	1.00000+00
27	1.30900+02	5.00000-01	1.00000+00
28	1.36136+02	5.00000-01	1.00000+00
29	1.41372+02	5.00000-01	1.00000+00

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 30    1.46608+02    5.00000-01    1.00000+00
 31    1.51778+02    5.00000-01    1.00000+00
 32    1.55640+02    5.00000-01    1.00000+00
 33    1.57080+02    5.00000-01    1.00000+00


AXISYMMETRIC PRESTRESS INPUT CONSTRAINT CONDITIONS FOLLOW


CONSTRAINT NO.   1 SEGMENT NO.   1 POINT   1 CONNECTED TO SEGMENT NO.  1 POINT   1.. TYPE OF CONSTRAINT =  1
CONSTRAINT NO.   2 SEGMENT NO.   1 POINT  33 CONNECTED TO SEGMENT NO.  1 POINT  33.. TYPE OF CONSTRAINT =  2


LOCAL MATRIX DIMENSION=  5 OVERLAP=  3 NO. CONSTRAINT CONDS. PER CONSTRAINT POINT=  3 SYSTEM RANK=   75 NUMBER OF BLOCKS=   1


NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  1 EQUALS  75 .  NO. OF CONSTRAINT PTS. EQUALS   2
BLOCK NUMBER=  1 LAST EQ. IN BLOCK=  75 LOWEST UNK IN BLOCK=   1, MAX. OFF-DIAGONAL WIDTH=   7


STABILITY, VIBRATION OR NON-SYMMETRIC STRESS INPUT CONSTRAINT CONDITIONS FOLLOW


CONSTRAINT NO.   1 SEGMENT NO.   1 POINT   1 CONNECTED TO SEGMENT NO.  1 POINT   1.. TYPE OF CONSTRAINT =  1
CONSTRAINT NO.   2 SEGMENT NO.   1 POINT  33 CONNECTED TO SEGMENT NO.  1 POINT  33.. TYPE OF CONSTRAINT =  2


LOCAL MATRIX DIMENSION=  7 OVERLAP=  4 NO. CONSTRAINT CONDS. PER CONSTRAINT POINT=  4 SYSTEM RANK=  111 NUMBER OF BLOCKS=   1


NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  1 EQUALS 111 .  NO. OF CONSTRAINT PTS. EQUALS   2
BLOCK NUMBER=  1 LAST EQ. IN BLOCK= 111 LOWEST UNK IN BLOCK=   1, MAX. OFF-DIAGONAL WIDTH=  10


DATA READ IN AND PROCESSED FOR THIS CASE. LEAVING SUBROUTINE READIT


ENTERING SUBROUTINE PRE, AXISYMMETRIC PRESTRESS CALCULATOR


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PRESSURE MULTIPLIER,P =      0.000000


FIXED PART OF AXISYMMETRIC PRESTRESS STATE. THESE QUANTITIES ARE NOT MULTIPLIED BY EIGENVALUE.
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PRESTRESS-- MERIDIONAL RESULTANT, N10 CIRCUMFERENTIAL RESULTANT,N20 MERIDIONAL ROTATION, CHI0 FOR SEGMENT 1

1	0.00000000	0.00000000	0.00000000
2	0.00000000	0.00000000	0.00000000
3	0.00000000	0.00000000	0.00000000
4	0.00000000	0.00000000	0.00000000
5	0.00000000	0.00000000	0.00000000
6	0.00000000	0.00000000	0.00000000
7	0.00000000	0.00000000	0.00000000
8	0.00000000	0.00000000	0.00000000
9	0.00000000	0.00000000	0.00000000
10	0.00000000	0.00000000	0.00000000
11	0.00000000	0.00000000	0.00000000
12	0.00000000	0.00000000	0.00000000
13	0.00000000	0.00000000	0.00000000
14	0.00000000	0.00000000	0.00000000
15	0.00000000	0.00000000	0.00000000
16	0.00000000	0.00000000	0.00000000
17	0.00000000	0.00000000	0.00000000
18	0.00000000	0.00000000	0.00000000
19	0.00000000	0.00000000	0.00000000
20	0.00000000	0.00000000	0.00000000
21	0.00000000	0.00000000	0.00000000
22	0.00000000	0.00000000	0.00000000
23	0.00000000	0.00000000	0.00000000
24	0.00000000	0.00000000	0.00000000
25	0.00000000	0.00000000	0.00000000
26	0.00000000	0.00000000	0.00000000
27	0.00000000	0.00000000	0.00000000
28	0.00000000	0.00000000	0.00000000
29	0.00000000	0.00000000	0.00000000
30	0.00000000	0.00000000	0.00000000
31	0.00000000	0.00000000	0.00000000
32	0.00000000	0.00000000	0.00000000
33	0.00000000	0.00000000	0.00000000

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX. 0 WAVES

ENTER EBAND2 TO CALCULATE LOWEST 3 VIBRATION FREQUENCIES. WAVENUMBER,N = 0 WAVES

5 NEGATIVE ROOTS FOR SHIFT, AXT = 0.00000

5 NEGATIVE ROOTS FOR SHIFT, AXT = -2.10947+06

THERE ARE 0 FREQUENCIES BETWEEN .0000000 AND .2311567+03

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ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO. 1. FREQUENCY (CPS) = 2.32311+02. 0 CIRCUMFERENTIAL WAVES
ELAPSED TIME = 0: 0: 3.612

6 NEGATIVE ROOTS FOR SHIFT, AXT = -3.30233+06

THERE ARE 1 FREQUENCIES BETWEEN .0000000 AND .2892212+03

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO. 2. FREQUENCY (CPS) = 2.92225+02. 0 CIRCUMFERENTIAL WAVES
ELAPSED TIME = 0: 0: 5.493

7 NEGATIVE ROOTS FOR SHIFT, AXT = -3.68845+06

THERE ARE 2 FREQUENCIES BETWEEN .0000000 AND .3056624+03

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO. 3. FREQUENCY (CPS) = 3.06547+02. 0 CIRCUMFERENTIAL WAVES
ELAPSED TIME = 0: 0: 7.363

8 NEGATIVE ROOTS FOR SHIFT, AXT = -3.71093+0

THERE ARE 3 FREQUENCIES BETWEEN .0000000 AND .3065926+03

VIBRATION MODES FOLLOW

CIRCUMFERENTIAL WAVE NUMBER, N = 0

EIGENVALUES = 2.32311+02 2.92225+02 3.06547+02

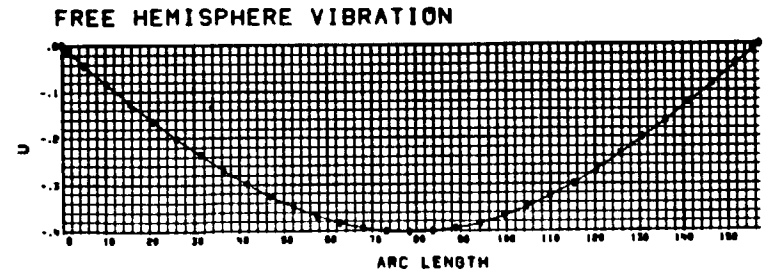
GENERALIZED MASS= 7.26842-01 3.12020-01 2.25454-01

MODE SHAPE FOR EIGENVALUE NO. 1 FOLLOWS

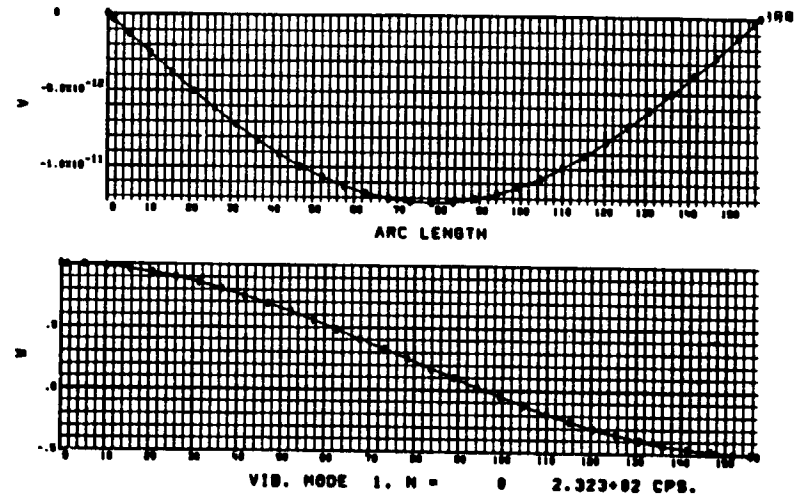
VIBRATION MODE FOR SEGMENT 1

POINT	STATION	U	V	W
1	0.000	-2.618-08	0.000	1.000+00
2	1.440+00	-1.168-02	-3.572-13	9.997-01
3	5.301+00	-4.289-02	-1.309-12	9.956-01
4	1.047+01	-8.425-02	-2.569-12	9.832-01

FREE HEMISPHERE VIBRATION



5	1.571+01	-1.252-01	-3.815-12	9.625-01
6	2.094+01	-1.648-01	-5.019-12	9.341-01
7	2.618+01	-2.025-01	-6.168-12	8.983-01
8	3.142+01	-2.380-01	-7.249-12	8.554-01
9	3.665+01	-2.709-01	-8.250-12	8.059-01
10	4.189+01	-3.008-01	-9.161-12	7.503-01
11	4.712+01	-3.274-01	-9.971-12	6.893-01
12	5.236+01	-3.505-01	-1.067-11	6.236-01
13	5.760+01	-3.697-01	-1.126-11	5.537-01
14	6.283+01	-3.848-01	-1.172-11	4.805-01
15	6.807+01	-3.958-01	-1.205-11	4.048-01
16	7.330+01	-4.024-01	-1.225-11	3.274-01
17	7.854+01	-4.045-01	-1.232-11	2.491-01
18	8.378+01	-4.023-01	-1.225-11	1.709-01
19	8.901+01	-3.957-01	-1.205-11	9.354-02
20	9.425+01	-3.847-01	-1.171-11	1.787-02
21	9.948+01	-3.695-01	-1.125-11	-5.527-02
22	1.047+02	-3.503-01	-1.066-11	-1.251-01
23	1.100+02	-3.272-01	-9.961-12	-1.908-01
24	1.152+02	-3.006-01	-9.149-12	-2.516-01
25	1.204+02	-2.706-01	-8.238-12	-3.069-01
26	1.257+02	-2.377-01	-7.236-12	-3.559-01
27	1.309+02	-2.023-01	-6.155-12	-3.980-01
28	1.361+02	-1.646-01	-5.007-12	-4.329-01
29	1.414+02	-1.252-01	-3.804-12	-4.605-01
30	1.466+02	-8.443-02	-2.560-12	-4.814-01
31	1.518+02	-4.313-02	-1.303-12	-4.968-01
32	1.556+02	-1.180-02	-3.550-13	-5.062-01
33	1.571+02	-5.364-08	5.897-29	-5.094-01

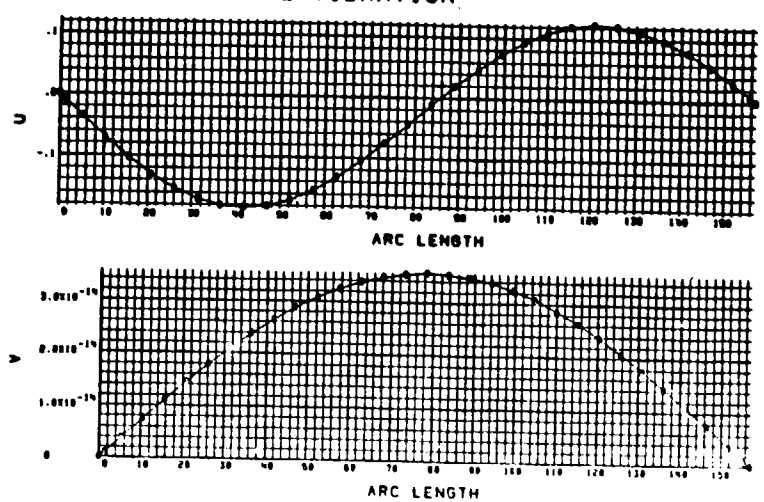


MODE SHAPE FOR EIGENVALUE NO. 2 FOLLOWS

VIBRATION MODE FOR SEGMENT 1

POINT	STATION	U	V	W
1	0.000	-2.618-08	9.630-35	1.000+00
2	1.440+00	-1.011-02	1.029-15	9.990-01
3	5.301+00	-3.689-02	3.770-15	9.858-01
4	1.047+01	-7.143-02	7.397-15	9.453-01
5	1.571+01	-1.036-01	1.099-14	8.792-01
6	2.094+01	-1.316-01	1.445-14	7.906-01
7	2.618+01	-1.545-01	1.776-14	6.831-01
8	3.142+01	-1.713-01	2.087-14	5.609-01
9	3.665+01	-1.815-01	2.376-14	4.287-01
10	4.189+01	-1.847-01	2.638-14	2.917-01
11	4.712+01	-1.810-01	2.871-14	1.549-01
12	5.236+01	-1.705-01	3.073-14	2.358-02
13	5.760+01	-1.539-01	3.241-14	-9.755-02
14	6.283+01	-1.318-01	3.374-14	-2.042-01
15	6.807+01	-1.054-01	3.470-14	-2.926-01
16	7.330+01	-7.580-02	3.528-14	-3.600-01
17	7.854+01	-4.433-02	3.547-14	-4.046-01
18	8.378+01	-1.237-02	3.527-14	-4.255-01
19	8.901+01	1.871-02	3.469-14	-4.227-01

FREE HEMISPHERE VIBRATION

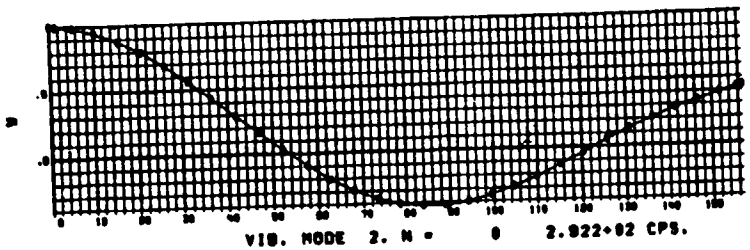


20	9.425+01	4.756-02	3.372-14	-3.976-01
21	9.948+01	7.298-02	3.239-14	-3.523-01
22	1.047+02	9.393-02	3.071-14	-2.899-01
23	1.100+02	1.096-01	2.868-14	-2.143-01
24	1.152+02	1.194-01	2.635-14	-1.297-01
25	1.204+02	1.230-01	2.372-14	-4.085-02
26	1.257+02	1.205-01	2.084-14	4.768-02
27	1.309+02	1.120-01	1.773-14	1.318-01
28	1.361+02	9.811-02	1.442-14	2.085-01
29	1.414+02	7.937-02	1.095-14	2.760-01
30	1.466+02	5.640-02	7.371-15	3.349-01
31	1.518+02	3.008-02	3.753-15	3.866-01
32	1.556+02	8.512-03	1.022-15	4.231-01
33	1.571+02	4.596-08	-1.204-31	4.365-01

MODE SHAPE FOR EIGENVALUE NO. 3 FOLLOWS

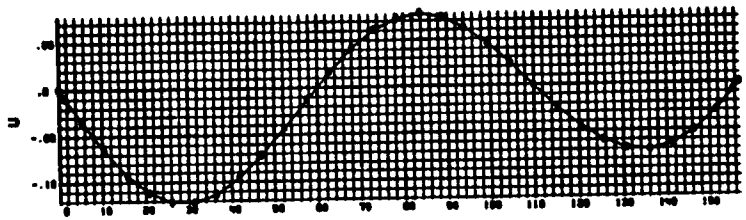
VIBRATION MODE FOR SEGMENT 1

POINT	STATION	U	V	W
1	0.000	-2.618-08	-3.762-37	1.000+00
2	1.440+00	-9.721-03	-5.440-18	9.979-01
3	5.301+00	-3.516-02	-1.994-17	9.714-01
4	1.047+01	-6.668-02	-3.912-17	8.904-01
5	1.571+01	-9.314-02	-5.811-17	7.619-01
6	2.094+01	-1.120-01	-7.645-17	5.972-01
7	2.618+01	-1.219-01	-9.394-17	4.096-01
8	3.142+01	-1.223-01	-1.104-16	2.141-01
9	3.665+01	-1.132-01	-1.257-16	2.586-02
10	4.189+01	-9.575-02	-1.395-16	-1.409-01
11	4.712+01	-7.174-02	-1.519-16	-2.744-01
12	5.236+01	-4.342-02	-1.625-16	-3.659-01
13	5.760+01	-1.343-02	-1.714-16	-4.107-01
14	6.283+01	1.553-02	-1.785-16	-4.083-01
15	6.807+01	4.092-02	-1.835-16	-3.624-01
16	7.330+01	6.058-02	-1.866-16	-2.806-01
17	7.854+01	7.297-02	-1.876-16	-1.731-01
18	8.378+01	7.721-02	-1.865-16	-5.239-02
19	8.901+01	7.326-02	-1.835-16	6.866-02
20	9.425+01	6.182-02	-1.784-16	1.776-01
21	9.948+01	4.427-02	-1.713-16	2.639-01
22	1.047+02	2.255-02	-1.624-16	3.194-01
23	1.100+02	-1.083-03	-1.517-16	3.395-01
24	1.152+02	-2.422-02	-1.393-16	3.234-01
25	1.204+02	-4.458-02	-1.255-16	2.735-01
26	1.257+02	-6.015-02	-1.102-16	1.952-01
27	1.309+02	-6.939-02	-9.375-17	9.592-02
28	1.361+02	-7.125-02	-7.626-17	-1.641-02
29	1.414+02	-6.518-02	-5.794-17	-1.344-01
30	1.466+02	-5.105-02	-3.898-17	-2.529-01
31	1.518+02	-2.932-02	-1.985-17	-3.676-01
32	1.556+02	-8.760-03	-5.406-18	-4.518-01
33	1.571+02	-5.086-08	2.753-34	-4.830-01



VIB. MODE 2. N = 0 2.922+02 CPS.

FREE HEMISPHERE VIBRATION



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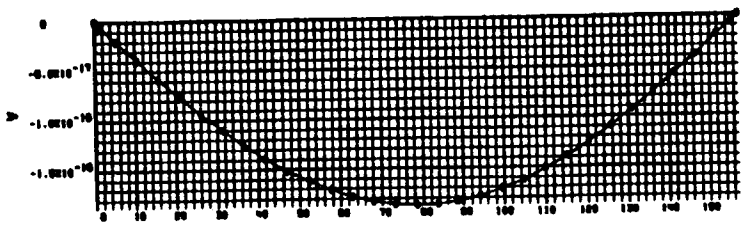

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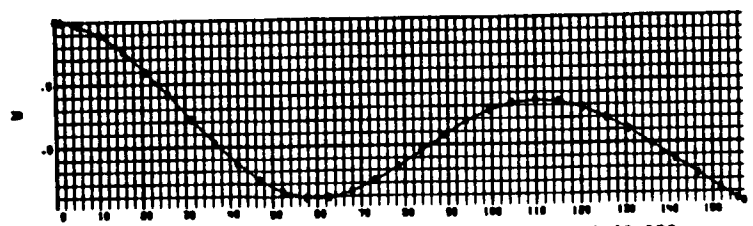

VIB. MODE 3. N = 0 3.065+02 CPS.

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                                                                                                                    27 OCT 71
ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX,      1 WAVES

ENTER EBAND2 TO CALCULATE LOWEST  3  VIBRATION FREQUENCIES,  WAVENUMBER,N =      1 WAVES

   3  NEGATIVE ROOTS  FOR SHIFT, AXT =   0.00000


   3  NEGATIVE ROOTS  FOR SHIFT, AXT =  -1.19869+06

 THERE ARE      0 FREQUENCIES BETWEEN    .0000000    AND    .1742505+03

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO.  1.  FREQUENCY (CPS) =   1.75191+02.      1  CIRCUMFERENTIAL WAVES
                        ELAPSED TIME =  0: 0:10.563

   4  NEGATIVE ROOTS  FOR SHIFT, AXT =  -2.95394+06

 THERE ARE      1 FREQUENCIES BETWEEN    .0000000    AND    .2735401+03

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO.  2.  FREQUENCY (CPS) =   2.77053+02.      1  CIRCUMFERENTIAL WAVES
                        ELAPSED TIME =  0: 0:12.651

   5  NEGATIVE ROOTS  FOR SHIFT, AXT =  -3.57565+06

 THERE ARE      2 FREQUENCIES BETWEEN    .0000000    AND    .3009523+03

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO.  3.  FREQUENCY (CPS) =   3.01206+02.      1  CIRCUMFERENTIAL WAVES
                        ELAPSED TIME =  0: 0:14.200

   6  NEGATIVE ROOTS  FOR SHIFT, AXT =  -3.58276+06

 THERE ARE      3 FREQUENCIES BETWEEN    .0000000    AND    .3012513+03

VIBRATION MODES FOLLOW


CIRCUMFERENTIAL WAVE NUMBER, N =
```

27 OCT 71

EIGENVALUES = 1.75131+02 2.77053+02 3.01206+02

GENERALIZED MASS= 2.43727+00 1.22552+00 7.52031-01

MODE SHAPE FOR EIGENVALUE NO. 1 FOLLOWS

VIBRATION MODE FOR SEGMENT 1

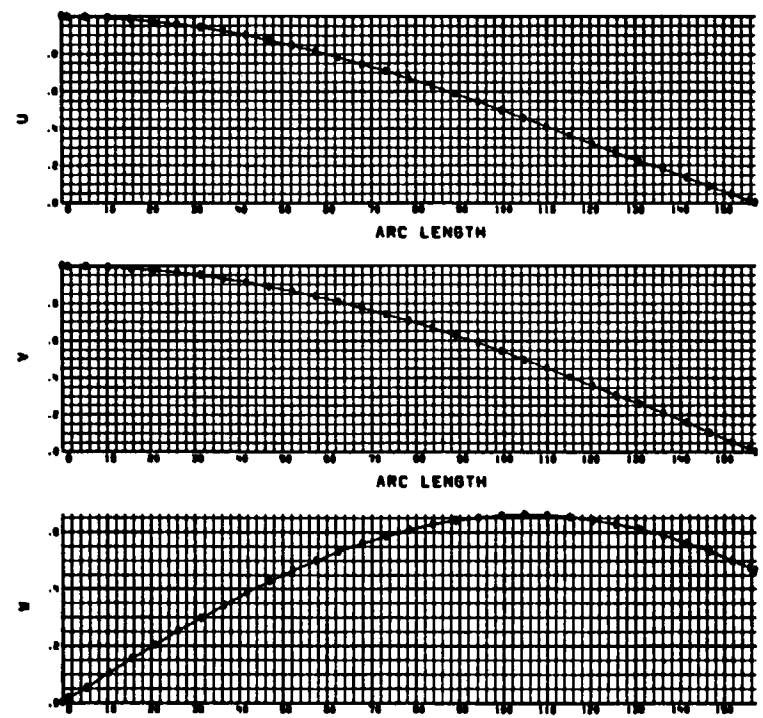
POINT	STATION	U	V	W
1	0.000	1.000+00	1.000+00	2.619-08
2	1.440+00	9.997-01	9.998-01	1.442-02
3	5.301+00	9.978-01	9.980-01	5.303-02
4	1.047+01	9.929-01	9.937-01	1.039-01
5	1.571+01	9.847-01	9.867-01	1.543-01
6	2.094+01	9.735-01	9.769-01	2.037-01
7	2.618+01	9.591-01	9.645-01	2.518-01
8	3.142+01	9.418-01	9.494-01	2.985-01
9	3.665+01	9.216-01	9.317-01	3.434-01
10	4.189+01	8.985-01	9.114-01	3.862-01
11	4.712+01	8.728-01	8.887-01	4.267-01
12	5.236+01	8.444-01	8.635-01	4.647-01
13	5.760+01	8.137-01	8.360-01	4.999-01
14	6.283+01	7.806-01	8.062-01	5.320-01
15	6.807+01	7.454-01	7.742-01	5.609-01
16	7.330+01	7.083-01	7.402-01	5.864-01
17	7.854+01	6.694-01	7.042-01	6.083-01
18	8.378+01	6.288-01	6.663-01	6.265-01
19	8.901+01	5.869-01	6.266-01	6.408-01
20	9.425+01	5.438-01	5.853-01	6.512-01
21	9.948+01	4.997-01	5.425-01	6.576-01
22	1.047+02	4.547-01	4.982-01	6.599-01
23	1.100+02	4.092-01	4.526-01	6.581-01
24	1.152+02	3.632-01	4.058-01	6.522-01
25	1.204+02	3.169-01	3.579-01	6.421-01
26	1.257+02	2.706-01	3.090-01	6.280-01
27	1.309+02	2.244-01	2.592-01	6.098-01
28	1.361+02	1.785-01	2.087-01	5.875-01
29	1.414+02	1.330-01	1.574-01	5.615-01
30	1.466+02	8.807-02	1.055-01	5.319-01
31	1.518+02	4.429-02	5.362-02	4.996-01
32	1.556+02	1.196-02	1.461-02	4.740-01
33	1.571+02	4.888-08	-2.965-20	4.642-01

MODE SHAPE FOR EIGENVALUE NO. 2 FOLLOWS

VIBRATION MODE FOR SEGMENT 1

POINT	STATION	U	V	W
1	0.000	2.489-01	2.489-01	6.544-09

FREE HEMISPHERE VIBRATION



VIB. MODE 1. N = 1 1.751+02 CPS.

2	1.440+00	2.484-01	2.486-01	4.303-02
3	5.301+00	2.437-01	2.472-01	1.584-01
4	1.047+01	2.314-01	2.443-01	3.090-01
5	1.571+01	2.110-01	2.397-01	4.534-01
6	2.094+01	1.832-01	2.335-01	5.864-01
7	2.618+01	1.489-01	2.255-01	7.049-01
8	3.142+01	1.088-01	2.161-01	8.061-01
9	3.665+01	6.409-02	2.053-01	8.878-01
10	4.189+01	1.590-02	1.933-01	9.481-01
11	4.712+01	-3.451-02	1.801-01	9.858-01
12	5.236+01	-8.582-02	1.661-01	1.000+00
13	5.760+01	-1.367-01	1.514-01	9.906-01
14	6.283+01	-1.858-01	1.361-01	9.581-01
15	6.807+01	-2.318-01	1.206-01	9.034-01
16	7.330+01	-2.736-01	1.051-01	8.282-01
17	7.854+01	-3.099-01	8.962-02	7.346-01
18	8.378+01	-3.399-01	7.455-02	6.250-01
19	8.901+01	-3.628-01	6.006-02	5.026-01
20	9.425+01	-3.778-01	4.637-02	3.706-01
21	9.948+01	-3.847-01	3.366-02	2.326-01
22	1.047+02	-3.831-01	2.214-02	9.239-02
23	1.100+02	-3.731-01	1.197-02	-4.624-02
24	1.152+02	-3.549-01	3.308-03	-1.794-01
25	1.204+02	-3.289-01	-3.702-03	-3.033-01
26	1.257+02	-2.959-01	-8.949-03	-4.146-01
27	1.309+02	-2.567-01	-1.234-02	-5.105-01
28	1.361+02	-2.122-01	-1.381-02	-5.892-01
29	1.414+02	-1.635-01	-1.331-02	-6.510-01
30	1.466+02	-1.115-01	-1.082-02	-6.977-01
31	1.518+02	-5.747-02	-6.390-03	-7.334-01
32	1.556+02	-1.584-02	-1.946-03	-7.566-01
33	1.571+02	-8.055-08	4.909-19	-7.649-01

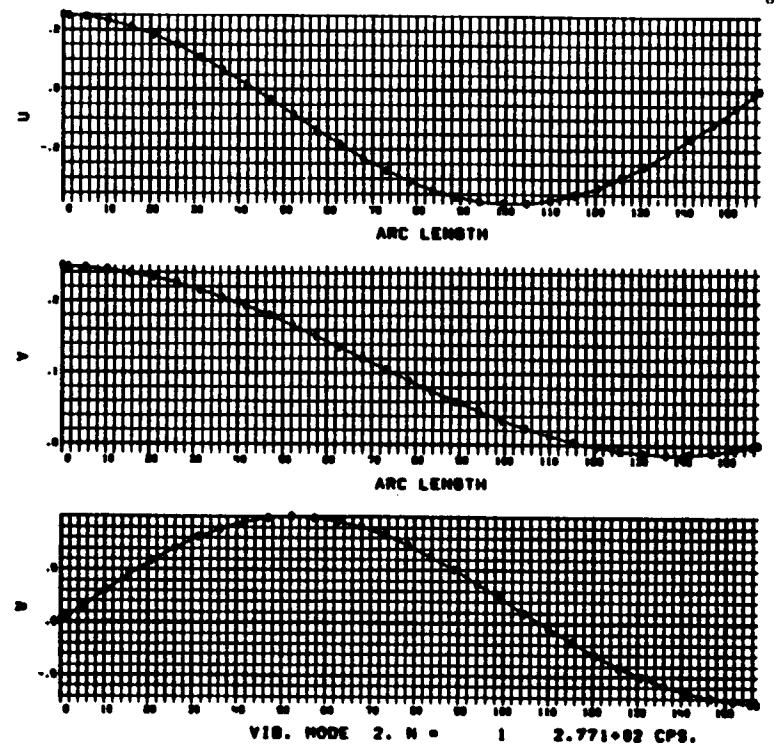
MODE SHAPE FOR EIGENVALUE NO. 3 FOLLOWS

VIBRATION MODE FOR SEGMENT 1

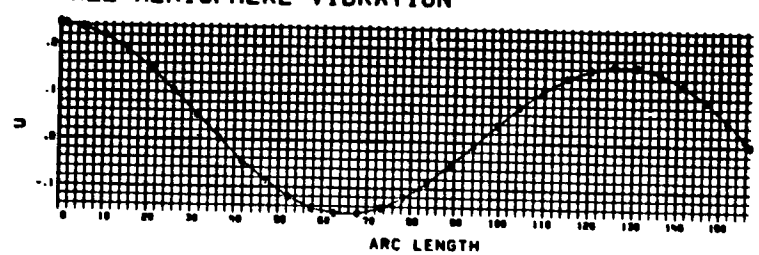
POINT	STATION	U	V	W
1	0.000	2.446-01	2.446-01	6.447-09
2	1.440+00	2.438-01	2.441-01	6.711-02
3	5.301+00	2.367-01	2.414-01	2.467-01
4	1.047+01	2.179-01	2.347-01	4.740-01
5	1.571+01	1.877-01	2.243-01	6.753-01
6	2.094+01	1.482-01	2.101-01	8.354-01
7	2.618+01	1.021-01	1.928-01	9.456-01
8	3.142+01	5.228-02	1.729-01	1.000+00
9	3.665+01	2.014-03	1.510-01	9.966-01
10	4.189+01	-4.552-02	1.279-01	9.369-01
11	4.712+01	-8.732-02	1.042-01	8.260-01
12	5.236+01	-1.208-01	8.079-02	6.721-01
13	5.760+01	-1.441-01	5.823-02	4.862-01
14	6.283+01	-1.557-01	3.717-02	2.809-01
15	6.807+01	-1.552-01	1.816-02	7.010-02
16	7.330+01	-1.430-01	1.627-03	-1.324-01

FREE HEMISPHERE VIBRATION

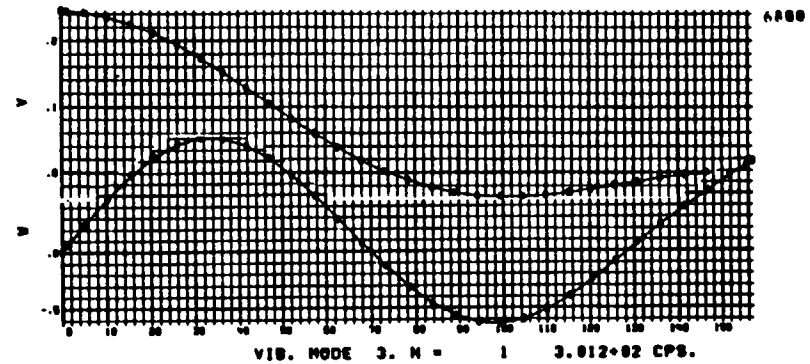
6788



FREE HEMISPHERE VIBRATION



17	7.854+01	-1.201-01	-1.211-02	-3.137-01
18	8.378+01	-8.829-02	-2.288-02	-4.623-01
19	8.901+01	-4.998-02	-3.061-02	-5.694-01
20	9.425+01	-7.957-03	-3.538-02	-6.294-01
21	9.948+01	3.480-02	-3.739-02	-6.398-01
22	1.047+02	7.530-02	-3.695-02	-6.017-01
23	1.100+02	1.108-01	-3.444-02	-5.199-01
24	1.152+02	1.388-01	-3.034-02	-4.017-01
25	1.204+02	1.576-01	-2.515-02	-2.569-01
26	1.257+02	1.660-01	-1.940-02	-9.613-02
27	1.309+02	1.633-01	-1.360-02	6.984-02
28	1.361+02	1.498-01	-8.267-03	2.320-01
29	1.414+02	1.260-01	-3.856-03	3.841-01
30	1.466+02	9.246-02	-7.976-04	5.243-01
31	1.518+02	5.063-02	5.176-04	6.529-01
32	1.556+02	1.462-02	3.693-04	7.454-01
33	1.571+02	8.210-08	1.265-18	7.797-01

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ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.      2 WAVES

ENTER EBAND2 TO CALCULATE LOWEST  3  VIBRATION FREQUENCIES.  WAVENUMBER,N =     2 WAVES

   4  NEGATIVE ROOTS  FOR SHIFT, AXT =   0.00000


ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO.  1.  FREQUENCY (CPS) =   4.06726+00.      2  CIRCUMFERENTIAL WAVES
                        ELAPSED TIME =  0: 0:16.759

   5  NEGATIVE ROOTS  FOR SHIFT, AXT =  -3.16562+06

 THERE ARE     1 FREQUENCIES BETWEEN    .0000000    AND    .2831715+03

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO.  2.  FREQUENCY (CPS) =   2.89995+02.      2  CIRCUMFERENTIAL WAVES
                        ELAPSED TIME =  0: 0:18.841

   6  NEGATIVE ROOTS  FOR SHIFT, AXT =  -3.69439+06

 THERE ARE     2 FREQUENCIES BETWEEN    .0000000    AND    .3059086+03

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO.  3.  FREQUENCY (CPS) =   3.06092+02.      2  CIRCUMFERENTIAL WAVES
                        ELAPSED TIME =  0: 0:20.222

   7  NEGATIVE ROOTS  FOR SHIFT, AXT =  -3.69994+06
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27 OCT 71

THERE ARE 3 FREQUENCIES BETWEEN .0000000 AND .3061381+03

VIBRATION MODES FOLLOW

CIRCUMFERENTIAL WAVE NUMBER, N = 2

EIGENVALUES = 4.06726+00 2.89995+02 3.06092+02

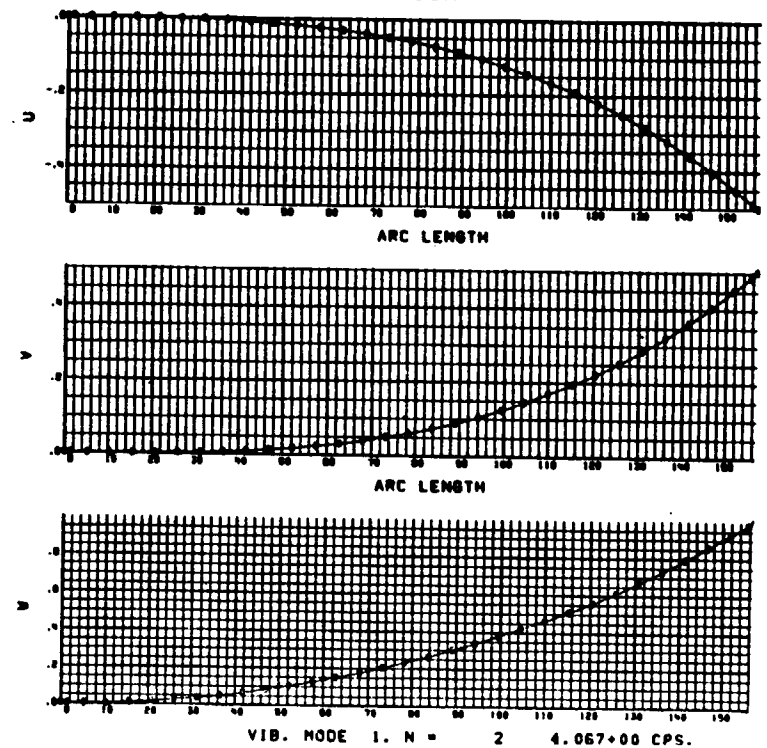
GENERALIZED MASS= 9.76454-01 1.19244+00 8.90596-01

MODE SHAPE FOR EIGENVALUE NO. 1 FOLLOWS

VIBRATION MODE FOR SEGMENT 1

POINT	STATION	U	V	W
1	0.000	6.617-24	6.617-24	2.811-22
2	1.440+00	8.203-06	5.791-06	6.874-05
3	5.301+00	-6.192-06	2.698-05	1.043-03
4	1.047+01	-1.273-04	1.492-04	4.032-03
5	1.571+01	-4.649-04	4.874-04	9.119-03
6	2.094+01	-1.125-03	1.150-03	1.630-02
7	2.618+01	-2.217-03	2.247-03	2.557-02
8	3.142+01	-3.850-03	3.885-03	3.693-02
9	3.665+01	-6.132-03	6.172-03	5.036-02
10	4.189+01	-9.172-03	9.217-03	6.587-02
11	4.712+01	-1.308-02	1.313-02	8.346-02
12	5.236+01	-1.796-02	1.802-02	1.031-01
13	5.760+01	-2.393-02	2.399-02	1.249-01
14	6.283+01	-3.109-02	3.115-02	1.487-01
15	6.807+01	-3.955-02	3.962-02	1.747-01
16	7.330+01	-4.943-02	4.950-02	2.028-01
17	7.854+01	-6.084-02	6.092-02	2.331-01
18	8.378+01	-7.390-02	7.397-02	2.656-01
19	8.901+01	-8.871-02	8.879-02	3.003-01
20	9.425+01	-1.054-01	1.055-01	3.373-01
21	9.948+01	-1.241-01	1.242-01	3.767-01
22	1.047+02	-1.449-01	1.450-01	4.185-01
23	1.100+02	-1.680-01	1.680-01	4.628-01
24	1.152+02	-1.934-01	1.935-01	5.097-01
25	1.204+02	-2.214-01	2.215-01	5.595-01
26	1.257+02	-2.521-01	2.522-01	6.122-01
27	1.309+02	-2.856-01	2.857-01	6.683-01
28	1.361+02	-3.222-01	3.222-01	7.279-01
29	1.414+02	-3.619-01	3.619-01	7.913-01
30	1.466+02	-4.051-01	4.050-01	8.582-01
31	1.518+02	-4.513-01	4.511-01	9.264-01

FREE HEMISPHERE VIBRATION



VIB. MODE 1. N = 2 4.067+00 CPS.

32	1.556+02	-4.877-01	4.876-01	9.776-01
33	1.571+02	-5.018-01	5.018-01	9.966-01

MODE SHAPE FOR EIGENVALUE NO. 2 FOLLOWS

VIBRATION MODE FOR SEGMENT 1

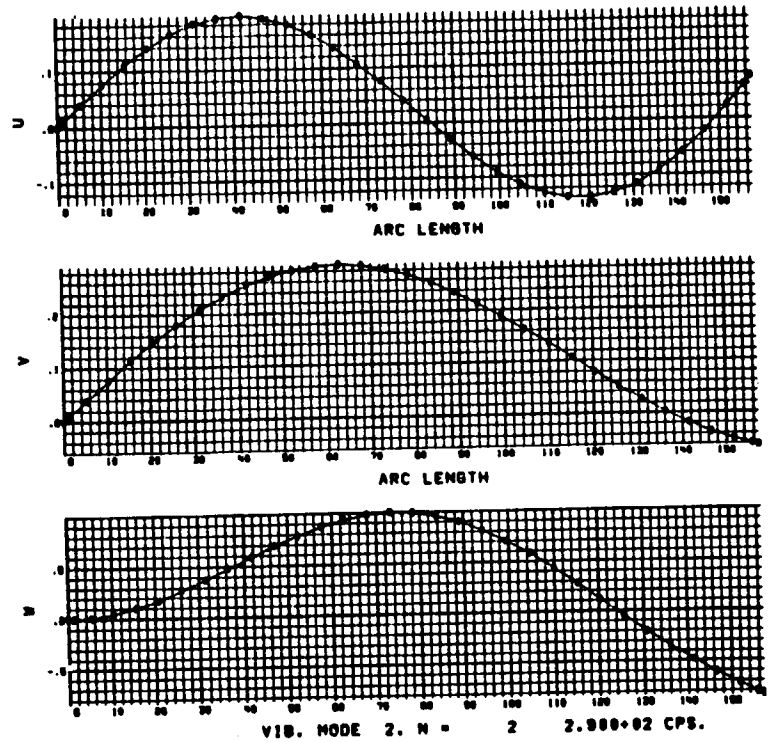
POINT	STATION	U	V	W
1	0.000	-5.082-21	-5.336-20	6.377-22
2	1.440+00	1.073-02	1.073-02	7.573-04
3	5.301+00	3.906-02	3.922-02	1.152-02
4	1.047+01	7.556-02	7.665-02	4.499-02
5	1.571+01	1.095-01	1.132-01	1.003-01
6	2.094+01	1.392-01	1.477-01	1.747-01
7	2.618+01	1.633-01	1.795-01	2.647-01
8	3.142+01	1.810-01	2.081-01	3.660-01
9	3.665+01	1.916-01	2.331-01	4.739-01
10	4.189+01	1.947-01	2.539-01	5.834-01
11	4.712+01	1.903-01	2.703-01	6.893-01
12	5.236+01	1.785-01	2.820-01	7.864-01
13	5.760+01	1.600-01	2.890-01	8.701-01
14	6.283+01	1.356-01	2.911-01	9.358-01
15	6.807+01	1.064-01	2.884-01	9.801-01
16	7.330+01	7.354-02	2.812-01	1.000+00
17	7.854+01	3.864-02	2.697-01	9.936-01
18	8.378+01	3.172-03	2.542-01	9.600-01
19	8.901+01	-3.126-02	2.351-01	8.993-01
20	9.425+01	-6.310-02	2.130-01	8.129-01
21	9.948+01	-9.087-02	1.885-01	7.031-01
22	1.047+02	-1.133-01	1.621-01	5.732-01
23	1.100+02	-1.291-01	1.345-01	4.276-01
24	1.152+02	-1.376-01	1.064-01	2.712-01
25	1.204+02	-1.382-01	7.839-02	1.095-01
26	1.257+02	-1.306-01	5.121-02	-5.195-02
27	1.309+02	-1.148-01	2.547-02	-2.080-01
28	1.361+02	-9.116-02	1.779-03	-3.544-01
29	1.414+02	-6.005-02	-1.929-02	-4.889-01
30	1.466+02	-2.196-02	-3.721-02	-6.116-01
31	1.518+02	2.219-02	-5.129-02	-7.240-01
32	1.556+02	5.885-02	-5.952-02	-8.052-01
33	1.571+02	7.347-02	-6.197-02	-8.355-01

MODE SHAPE FOR EIGENVALUE NO. 3 FOLLOWS

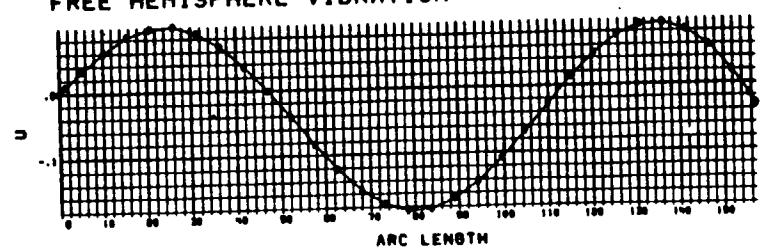
VIBRATION MODE FOR SEGMENT 1

POINT	STATION	U	V	W
1	0.000	-1.271-21	-2.880-20	8.514-21
2	1.440+00	9.187-03	9.190-03	1.768-03
3	5.301+00	3.276-02	3.314-02	2.681-02

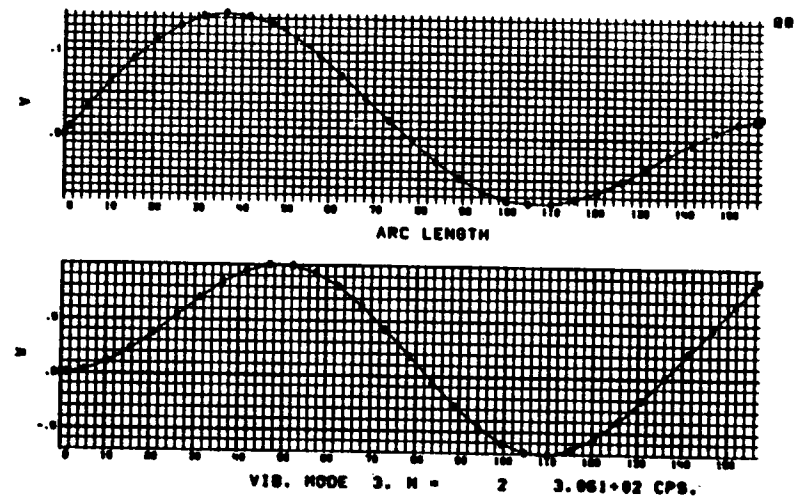
FREE HEMISPHERE VIBRATION



FREE HEMISPHERE VIBRATION



4	1.047+01	6.099-02	6.349-02	1.024-01
5	1.571+01	8.287-02	9.099-02	2.220-01
6	2.094+01	9.548-02	1.139-01	3.724-01
7	2.618+01	9.716-02	1.310-01	5.376-01
8	3.142+01	8.729-02	1.416-01	6.999-01
9	3.665+01	6.636-02	1.453-01	8.412-01
10	4.189+01	3.594-02	1.421-01	9.456-01
11	4.712+01	-1.477-03	1.323-01	1.000+00
12	5.236+01	-4.270-02	1.166-01	9.960-01
13	5.760+01	-8.416-02	9.618-02	9.304-01
14	6.283+01	-1.222-01	7.225-02	8.058-01
15	6.807+01	-1.534-01	4.627-02	6.303-01
16	7.330+01	-1.750-01	1.977-02	4.165-01
17	7.854+01	-1.851-01	-5.758-03	1.809-01
18	8.378+01	-1.828-01	-2.893-02	-5.784-02
19	8.901+01	-1.682-01	-4.857-02	-2.807-01
20	9.425+01	-1.428-01	-6.373-02	-4.699-01
21	9.948+01	-1.087-01	-7.382-02	-6.106-01
22	1.047+02	-6.899-02	-7.855-02	-6.921-01
23	1.100+02	-2.731-02	-7.802-02	-7.090-01
24	1.152+02	1.267-02	-7.261-02	-6.613-01
25	1.204+02	4.736-02	-6.305-02	-5.546-01
26	1.257+02	7.165-02	-5.027-02	-3.988-01
27	1.309+02	8.906-02	-3.541-02	-2.069-01
28	1.361+02	9.190-02	-1.971-02	7.175-03
29	1.414+02	8.122-02	-4.474-03	2.304-01
30	1.466+02	5.668-02	8.969-03	4.534-01
31	1.518+02	1.887-02	1.921-02	6.690-01
32	1.556+02	-1.708-02	2.458-02	8.272-01
33	1.571+02	-3.247-02	2.591-02	8.860-01

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ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,1**2 MATRIX, OR MASS MATRIX.      3 WAVES

ENTER EBAND2 TO CALCULATE LOWEST  3  VIBRATION FREQUENCIES.  WAVENUMBER,N =      3 WAVES

   4  NEGATIVE ROOTS  FOR SHIFT, AXT =   0.00000


ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO.  1.  FREQUENCY (CPS) =   1.11768+01.      3  CIRCUMFERENTIAL WAVES
                        ELAPSED TIME =  0: 0:22.851

   5  NEGATIVE ROOTS  FOR SHIFT, AXT =  -3.36915+06

 THERE ARE      1 FREQUENCIES BETWEEN     .0000000     AND     .2921327+03

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO.  2.  FREQUENCY (CPS) =   2.98806+02.      3  CIRCUMFERENTIAL WAVES
                        ELAPSED TIME =  0: 0:24.929
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6 NEGATIVE ROOTS FOR SHIFT, AXT = -3.80042+06

THERE ARE 2 FREQUENCIES BETWEEN .0000000 AND .3102672+03

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO. 3. FREQUENCY (CPS) = 3.10424+02. 3 CIRCUMFERENTIAL WAVES
ELAPSED TIME = 01 0:26.268

7 NEGATIVE ROOTS FOR SHIFT, AXT = -3.80539+06

THERE ARE 3 FREQUENCIES BETWEEN .0000000 AND .3104701+03

VIBRATION MODES FOLLOW

CIRCUMFERENTIAL WAVE NUMBER, N = 3

EIGENVALUES = 1.11768+01 2.98806+02 3.10424+02

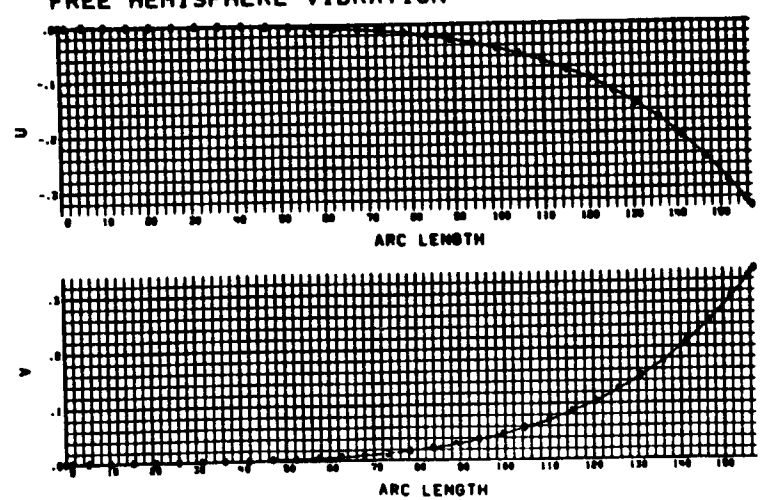
GENERALIZED MASS= 5.44397-01 1.12737+00 9.37636-01

MODE SHAPE FOR EIGENVALUE NO. 1 FOLLOWS

VIBRATION MODE FOR SEGMENT 1

POINT	STATION	U	V	W
1	0.000	-1.034-25	-1.086-24	3.540-24
2	1.440+00	1.971-07	1.984-07	8.367-07
3	5.301+00	1.290-06	1.577-06	2.772-05
4	1.047+01	-9.183-07	7.586-06	1.836-04
5	1.571+01	-1.806-05	2.906-05	6.204-04
6	2.094+01	-6.901-05	8.539-05	1.492-03
7	2.618+01	-1.806-04	2.039-04	2.957-03
8	3.142+01	-3.880-04	4.198-04	5.174-03
9	3.665+01	-7.348-04	7.769-04	8.307-03
10	4.189+01	-1.273-03	1.327-03	1.252-02
11	4.712+01	-2.065-03	2.132-03	1.800-02
12	5.236+01	-3.180-03	3.262-03	2.493-02
13	5.760+01	-4.701-03	4.798-03	3.351-02
14	6.283+01	-6.719-03	6.833-03	4.395-02
15	6.807+01	-9.337-03	9.469-03	5.649-02
16	7.330+01	-1.267-02	1.282-02	7.138-02
17	7.854+01	-1.686-02	1.702-02	8.890-02
18	8.378+01	-2.203-02	2.222-02	1.093-01

FREE HEMISPHERE VIBRATION

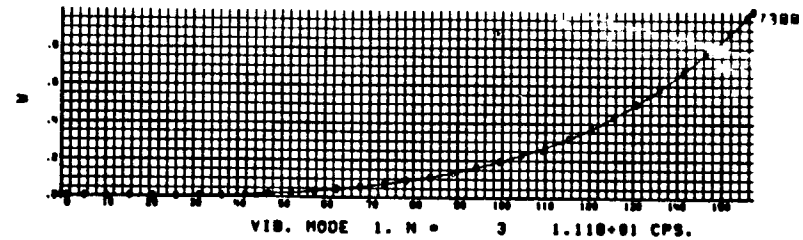


19	8.901+01	-2.836-02	2.857-02	1.331-01
20	9.425+01	-3.603-02	3.625-02	1.604-01
21	9.948+01	-4.523-02	4.547-02	1.919-01
22	1.047+02	-5.620-02	5.646-02	2.279-01
23	1.100+02	-6.919-02	6.946-02	2.689-01
24	1.152+02	-8.448-02	8.476-02	3.158-01
25	1.204+02	-1.024-01	1.027-01	3.691-01
26	1.257+02	-1.233-01	1.236-01	4.300-01
27	1.309+02	-1.476-01	1.479-01	4.995-01
28	1.361+02	-1.758-01	1.760-01	5.791-01
29	1.414+02	-2.085-01	2.085-01	6.696-01
30	1.466+02	-2.463-01	2.460-01	7.710-01
31	1.518+02	-2.889-01	2.885-01	8.793-01
32	1.556+02	-3.239-01	3.237-01	9.629-01
33	1.571+02	-3.377-01	3.378-01	9.943-01

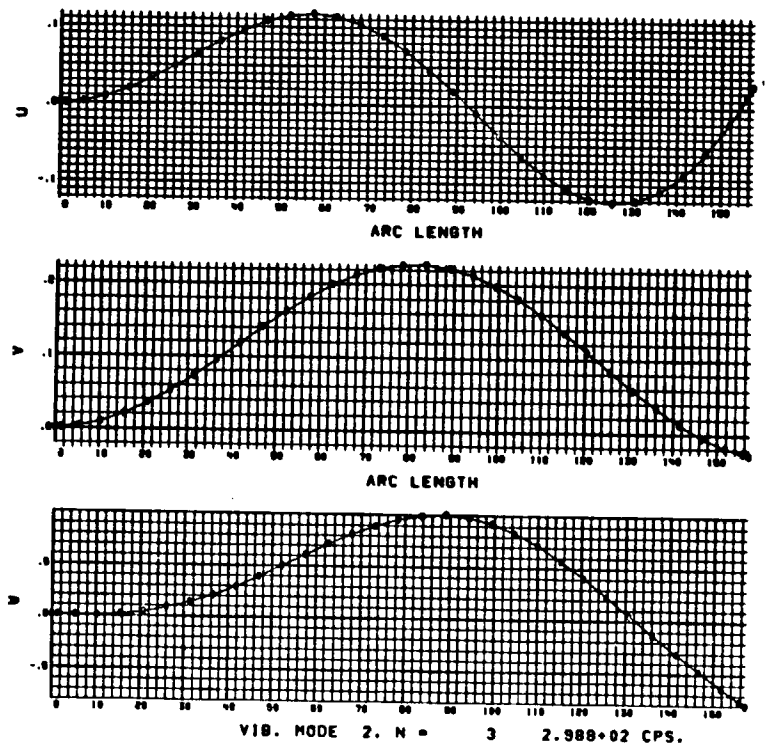
MODE SHAPE FOR EIGENVALUE NO. 2 FOLLOWS

VIBRATION MODE FOR SEGMENT 1

POINT	STATION	U	V	W
1	0.000	-1.721-22	1.323-23	2.367-22
2	1.440+00	3.673-05	3.693-05	2.511-05
3	5.301+00	2.354-03	2.361-03	8.346-04
4	1.047+01	9.014-03	9.121-03	5.601-03
5	1.571+01	1.961-02	2.012-02	1.868-02
6	2.094+01	3.331-02	3.490-02	4.363-02
7	2.618+01	4.906-02	5.287-02	8.307-02
8	3.142+01	6.566-02	7.331-02	1.384-01
9	3.665+01	8.177-02	9.541-02	2.096-01
10	4.189+01	9.607-02	1.183-01	2.954-01
11	4.712+01	1.073-01	1.410-01	3.930-01
12	5.236+01	1.144-01	1.627-01	4.985-01
13	5.760+01	1.164-01	1.823-01	6.070-01
14	6.283+01	1.129-01	1.992-01	7.129-01
15	6.807+01	1.037-01	2.126-01	8.102-01
16	7.330+01	8.888-02	2.219-01	8.928-01
17	7.854+01	6.902-02	2.267-01	9.551-01
18	8.378+01	4.502-02	2.267-01	9.921-01
19	8.901+01	1.807-02	2.219-01	1.000+00
20	9.425+01	-1.040-02	2.124-01	9.763-01
21	9.948+01	-3.879-02	1.984-01	9.199-01
22	1.047+02	-6.542-02	1.805-01	8.317-01
23	1.100+02	-8.863-02	1.592-01	7.140-01
24	1.152+02	-1.069-01	1.354-01	5.711-01
25	1.204+02	-1.189-01	1.100-01	4.082-01
26	1.257+02	-1.235-01	8.398-02	2.320-01
27	1.309+02	-1.200-01	5.829-02	4.930-02
28	1.361+02	-1.080-01	3.402-02	-1.335-01
29	1.414+02	-8.719-02	1.225-02	-3.114-01
30	1.466+02	-5.746-02	-5.961-03	-4.815-01
31	1.518+02	-1.922-02	-1.938-02	-6.423-01
32	1.556+02	1.455-02	-2.632-02	-7.600-01
33	1.571+02	2.053-02	-2.804-02	-8.041-01



FREE HEMISPHERE VIBRATION



MODE SHAPE FOR EIGENVALUE NO. 3 FOLLOWS

VIBRATION MODE FOR SEGMENT 1

POINT	STATION	U	V	W
1	0.000	-8.735-22	-9.000-22	8.743-22
2	1.440+00	6.305-05	6.337-05	7.769-05
3	5.301+00	3.478-03	3.503-03	2.578-03
4	1.047+01	1.292-02	1.324-02	1.708-02
5	1.571+01	2.692-02	2.844-02	5.568-02
6	2.094+01	4.307-02	4.765-02	1.259-01
7	2.618+01	5.851-02	6.906-02	2.300-01
8	3.142+01	7.028-02	9.065-02	3.637-01
9	3.665+01	7.574-02	1.103-01	5.170-01
10	4.189+01	7.295-02	1.261-01	6.751-01
11	4.712+01	6.099-02	1.365-01	8.200-01
12	5.236+01	4.010-02	1.401-01	9.330-01
13	5.760+01	1.171-02	1.364-01	9.973-01
14	6.283+01	-2.167-02	1.255-01	1.000+00
15	6.807+01	-5.675-02	1.078-01	9.393-01
16	7.330+01	-8.983-02	8.464-02	8.006-01
17	7.854+01	-1.172-01	5.759-02	6.070-01
18	8.378+01	-1.358-01	2.863-02	3.685-01
19	8.901+01	-1.432-01	-1.610-04	1.059-01
20	9.425+01	-1.384-01	-2.671-02	-1.567-01
21	9.948+01	-1.215-01	-4.919-02	-3.943-01
22	1.047+02	-9.430-02	-6.612-02	-5.838-01
23	1.100+02	-5.952-02	-7.654-02	-7.069-01
24	1.152+02	-2.094-02	-8.006-02	-7.517-01
25	1.204+02	1.720-02	-7.690-02	-7.144-01
26	1.257+02	5.057-02	-6.785-02	-5.993-01
27	1.309+02	7.522-02	-5.424-02	-4.181-01
28	1.361+02	8.789-02	-3.780-02	-1.874-01
29	1.414+02	8.623-02	-2.056-02	7.372-02
30	1.466+02	6.877-02	-4.754-03	3.477-01
31	1.518+02	3.531-02	7.180-03	6.187-01
32	1.556+02	8.790-04	1.300-02	8.184-01
33	1.571+02	-1.442-02	1.420-02	8.928-01

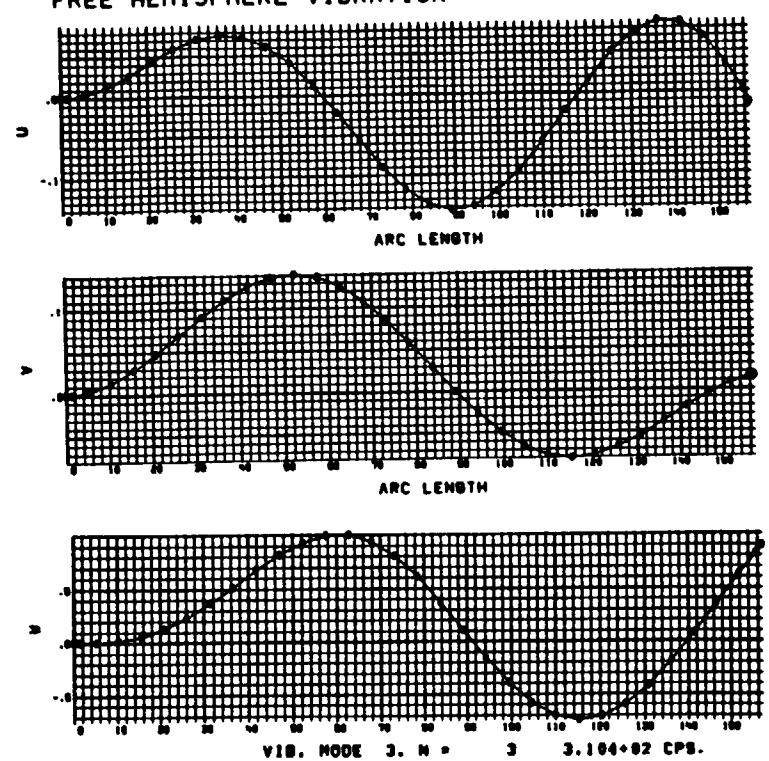
ELAPSED TIME = 0: 0:27.715

BEGINNING OF NEXT CASE

BUCKLING OF CONE HEATED ON AXIAL STRIP

BUCKLING OF A NONSYMMETRICALLY LOADED SHELL.
PREBUCKLING STATE CALCULATED FROM LINEAR THEORY
FOR HARMONICS NO THRU NMAX, PRESTRESS N10,N20 AND
PREBUCKLING ROTATIONS BETA0 IN THE STABILITY EQUA-
TIONS ARE THOSE CORRESPONDING TO CIRCUMFERENTIAL

FREE HEMISPHERE VIBRATION



LOCATION THETAS, AND ARE ASSUMED AXISYMMETRIC IN THE
STABILITY PART OF THE PROGRAM. BUCKLING LOADS CAL-
CULATED FOR WAVES NOB THRU NMAXB IN INCREMENTS OF
INCRB FROM LINEAR THEORY.

ANALYSIS TYPE = 4, PRINT OPTION = 1, PLOT OPTION = 0, STRESS OPTION = 0, PRESTRESS CALCULATION OPTION = 1

NUMBER OF SHELL SEGMENTS = 1

STRESS CALCULATED FOR CIRCUMFERENTIAL WAVES FROM 0 TO -19 IN INCREMENTS OF -1

INITIAL BUCKLING OR VIBRATION WAVE NO.= 20, MINIMUM WAVE NO.= 20, MAXIMUM WAVE NO.= 20, INCREMENT= 1

3 EIGENVALUES SOUGHT FOR EACH CIRCUMFERENTIAL WAVE NUMBER.

CONSTRAINT CONDITION DATA FOLLOW

SEG.	POINT	CONNECTED TO SEG.	POINT	USTAR	VSTAR	WSTAR	BETA	RADIAL DISC. D1(I)	AXIAL DISC. D2(I)
1	1	1	1	1	1	1	1	0.00000000	0.00000000
1	97	1	97	1	1	1	1	0.00000000	0.00000000

PRESSURE MULTIPLIER P = 0.0000 , INCREMENT DP= 0.0000 , TEMPERATURE MULT.TEMP= 1.0000+00, INCREMENT DTEMP= 0.0000

INITIAL LOAD, FSTART = 0.0000 , MAXIMUM LOAD, FMAX = 0.0000 , STEP SIZE, DF= 0.0000

SEGMENT NO. 1 IS A CYLINDER OR CONE.
END POINT COORDINATES (.6000+01, .0000) AND (.1200+02, .2735+02)

REFERENCE SURFACE GEOMETRY FOR SEGMENT NO. 1

STATION	ARC LENGTH	RAD	RADD	CUR1	CUR2	CURID	Z
1	.00000000	.60000000+01	.21427965+00	.00000000	.16279539+00	.00000000	.77500000-02
2	.40244046-01	.60086234+01	.21427965+00	.00000000	.16256175+00	.00000000	.77500000-02
3	.14817126+00	.60317501+01	.21427965+00	.00000000	.16193847+00	.00000000	.77500000-02
4	.29268397+00	.60627162+01	.21427965+00	.00000000	.16111134+00	.00000000	.77500000-02
5	.43902596+00	.60940743+01	.21427965+00	.00000000	.16028232+00	.00000000	.77500000-02
6	.58536794+00	.61254324+01	.21427965+00	.00000000	.15946178+00	.00000000	.77500000-02
7	.73170993+00	.61567905+01	.21427965+00	.00000000	.15864960+00	.00000000	.77500000-02
8	.87805191+00	.61881486+01	.21427965+00	.00000000	.15784565+00	.00000000	.77500000-02
9	.10243939+01	.62195067+01	.21427965+00	.00000000	.15704981+00	.00000000	.77500000-02
10	.11707359+01	.62508649+01	.21427965+00	.00000000	.15626195+00	.00000000	.77500000-02

11	.13170779+01	.62822229+01	.21427965+00	.00000000	.15548196+00	.00000000	.77500000-02
12	.14634198+01	.63135810+01	.21427965+00	.00000000	.15470972+00	.00000000	.77500000-02
13	.16097618+01	.63449392+01	.21427965+00	.00000000	.15394511+00	.00000000	.77500000-02
14	.17561038+01	.63762973+01	.21427965+00	.00000000	.15318802+00	.00000000	.77500000-02
15	.19024458+01	.64076554+01	.21427965+00	.00000000	.15243834+00	.00000000	.77500000-02
16	.20487877+01	.64390135+01	.21427965+00	.00000000	.15169596+00	.00000000	.77500000-02
17	.21951297+01	.64703716+01	.21427965+00	.00000000	.15096078+00	.00000000	.77500000-02
18	.23414717+01	.65017297+01	.21427965+00	.00000000	.15023269+00	.00000000	.77500000-02
19	.24878137+01	.65330878+01	.21427965+00	.00000000	.14951159+00	.00000000	.77500000-02
20	.26341557+01	.65644459+01	.21427965+00	.00000000	.14879738+00	.00000000	.77500000-02
21	.27804976+01	.65958040+01	.21427965+00	.00000000	.14808996+00	.00000000	.77500000-02
22	.29268396+01	.66271622+01	.21427965+00	.00000000	.14738923+00	.00000000	.77500000-02
23	.30731816+01	.66585202+01	.21427965+00	.00000000	.14669511+00	.00000000	.77500000-02
24	.32195236+01	.66898783+01	.21427965+00	.00000000	.14600749+00	.00000000	.77500000-02
25	.33658656+01	.67212365+01	.21427965+00	.00000000	.14532629+00	.00000000	.77500000-02
26	.35122075+01	.67525946+01	.21427965+00	.00000000	.14465141+00	.00000000	.77500000-02
27	.36585495+01	.67839527+01	.21427965+00	.00000000	.14398278+00	.00000000	.77500000-02
28	.38048915+01	.68153108+01	.21427965+00	.00000000	.14332030+00	.00000000	.77500000-02
29	.39512335+01	.68466689+01	.21427965+00	.00000000	.14266388+00	.00000000	.77500000-02
30	.41890388+01	.68976257+01	.21427965+00	.00000000	.14160994+00	.00000000	.77500000-02
31	.46097709+01	.69877801+01	.21427965+00	.00000000	.13978293+00	.00000000	.77500000-02
32	.51219664+01	.70975331+01	.21427965+00	.00000000	.13762139+00	.00000000	.77500000-02
33	.56341618+01	.72072862+01	.21427965+00	.00000000	.13552568+00	.00000000	.77500000-02
34	.61463573+01	.73170393+01	.21427965+00	.00000000	.13349284+00	.00000000	.77500000-02
35	.66585528+01	.74267923+01	.21427965+00	.00000000	.13152009+00	.00000000	.77500000-02
36	.71707482+01	.75365454+01	.21427965+00	.00000000	.12960479+00	.00000000	.77500000-02
37	.76829437+01	.76462985+01	.21427965+00	.00000000	.12774447+00	.00000000	.77500000-02
38	.81951392+01	.77560515+01	.21427965+00	.00000000	.12593681+00	.00000000	.77500000-02
39	.87073346+01	.78658046+01	.21427965+00	.00000000	.12417959+00	.00000000	.77500000-02
40	.92195301+01	.79755577+01	.21427965+00	.00000000	.12247073+00	.00000000	.77500000-02
41	.97317256+01	.80853107+01	.21427965+00	.00000000	.12080827+00	.00000000	.77500000-02
42	.10243921+02	.81950637+01	.21427965+00	.00000000	.11919033+00	.00000000	.77500000-02
43	.10756117+02	.83048168+01	.21427965+00	.00000000	.11761516+00	.00000000	.77500000-02
44	.11268312+02	.84145699+01	.21427965+00	.00000000	.11608108+00	.00000000	.77500000-02
45	.11780507+02	.85243230+01	.21427965+00	.00000000	.11458650+00	.00000000	.77500000-02
46	.12292703+02	.86340760+01	.21427965+00	.00000000	.11312992+00	.00000000	.77500000-02
47	.12804898+02	.87438291+01	.21427965+00	.00000000	.11170991+00	.00000000	.77500000-02
48	.13317094+02	.88535821+01	.21427965+00	.00000000	.11032510+00	.00000000	.77500000-02
49	.13829289+02	.89633353+01	.21427965+00	.00000000	.10897421+00	.00000000	.77500000-02
50	.14341485+02	.90730883+01	.21427965+00	.00000000	.10765600+00	.00000000	.77500000-02
51	.14853680+02	.91828413+01	.21427965+00	.00000000	.10636930+00	.00000000	.77500000-02
52	.15365876+02	.92925944+01	.21427965+00	.00000000	.10511299+00	.00000000	.77500000-02
53	.15878071+02	.94023474+01	.21427965+00	.00000000	.10388601+00	.00000000	.77500000-02
54	.16390267+02	.95121006+01	.21427965+00	.00000000	.10268734+00	.00000000	.77500000-02
55	.16902462+02	.96218536+01	.21427965+00	.00000000	.10151603+00	.00000000	.77500000-02
56	.17414657+02	.97316066+01	.21427965+00	.00000000	.10037113+00	.00000000	.77500000-02
57	.17926853+02	.98413597+01	.21427965+00	.00000000	.99251769-01	.00000000	.77500000-02
58	.18439048+02	.99511127+01	.21427965+00	.00000000	.98157099-01	.00000000	.77500000-02
59	.18951243+02	.10060866+02	.21427965+00	.00000000	.97086312-01	.00000000	.77500000-02
60	.19463439+02	.10170619+02	.21427965+00	.00000000	.96038636-01	.00000000	.77500000-02
61	.19975634+02	.10280372+02	.21427965+00	.00000000	.95013329-01	.00000000	.77500000-02
62	.20487829+02	.10390125+02	.21427965+00	.00000000	.94009683-01	.00000000	.77500000-02
63	.21000025+02	.10499878+02	.21427965+00	.00000000	.93027020-01	.00000000	.77500000-02
64	.21512220+02	.10609631+02	.21427965+00	.00000000	.92064687-01	.00000000	.77500000-02
65	.22024415+02	.10719384+02	.21427965+00	.00000000	.91122061-01	.00000000	.77500000-02
66	.22451251+02	.10810846+02	.21427965+00	.00000000	.90351147-01	.00000000	.77500000-02
67	.22707366+02	.10865726+02	.21427965+00	.00000000	.89894804-01	.00000000	.77500000-02
68	.22878122+02	.10902316+02	.21427965+00	.00000000	.89593107-01	.00000000	.77500000-02

69	.23048878+02	.10938905+02	.21427965+00	.00000000	.89293427-01	.00000000	.77500000-02
70	.23219633+02	.10975495+02	.21427965+00	.00000000	.88995746-01	.00000000	.77500000-02
71	.23390389+02	.11012084+02	.21427965+00	.00000000	.88700044-01	.00000000	.77500000-02
72	.23561145+02	.11048674+02	.21427965+00	.00000000	.88406299-01	.00000000	.77500000-02
73	.23731900+02	.11085263+02	.21427965+00	.00000000	.88114494-01	.00000000	.77500000-02
74	.23902656+02	.11121853+02	.21427965+00	.00000000	.87824608-01	.00000000	.77500000-02
75	.24073411+02	.11158442+02	.21427965+00	.00000000	.87536624-01	.00000000	.77500000-02
76	.24244167+02	.11195032+02	.21427965+00	.00000000	.87250522-01	.00000000	.77500000-02
77	.24414923+02	.11231621+02	.21427965+00	.00000000	.86966285-01	.00000000	.77500000-02
78	.24585678+02	.11268210+02	.21427965+00	.00000000	.86683894-01	.00000000	.77500000-02
79	.24756434+02	.11304800+02	.21427965+00	.00000000	.86403330-01	.00000000	.77500000-02
80	.24927190+02	.11341389+02	.21427965+00	.00000000	.86124576-01	.00000000	.77500000-02
81	.25097945+02	.11377979+02	.21427965+00	.00000000	.85847615-01	.00000000	.77500000-02
82	.25268701+02	.11414568+02	.21427965+00	.00000000	.85572431-01	.00000000	.77500000-02
83	.25439456+02	.11451158+02	.21427965+00	.00000000	.85299004-01	.00000000	.77500000-02
84	.25610212+02	.11487747+02	.21427965+00	.00000000	.85027320-01	.00000000	.77500000-02
85	.25780968+02	.11524337+02	.21427965+00	.00000000	.84757360-01	.00000000	.77500000-02
86	.25951723+02	.11560926+02	.21427965+00	.00000000	.84489110-01	.00000000	.77500000-02
87	.26122479+02	.11597516+02	.21427965+00	.00000000	.84222551-01	.00000000	.77500000-02
88	.26293235+02	.11634105+02	.21427965+00	.00000000	.83957670-01	.00000000	.77500000-02
89	.26463990+02	.11670695+02	.21427965+00	.00000000	.83694450-01	.00000000	.77500000-02
90	.26634746+02	.11707284+02	.21427965+00	.00000000	.83432875-01	.00000000	.77500000-02
91	.26805501+02	.11743873+02	.21427965+00	.00000000	.83172929-01	.00000000	.77500000-02
92	.26976257+02	.11780463+02	.21427965+00	.00000000	.82914599-01	.00000000	.77500000-02
93	.27147013+02	.11817052+02	.21427965+00	.00000000	.82657868-01	.00000000	.77500000-02
94	.27317768+02	.11853642+02	.21427965+00	.00000000	.82402723-01	.00000000	.77500000-02
95	.27488524+02	.11890231+02	.21427965+00	.00000000	.82149147-01	.00000000	.77500000-02
96	.27659280+02	.11926821+02	.21427965+00	.00000000	.81897127-01	.00000000	.77500000-02
97	.27829901+02	.11962953+02	.21427965+00	.00000000	.81649771-01	.00000000	.77500000-02
98	.27953833+02	.11989937+02	.21427965+00	.00000000	.81466010-01	.00000000	.77500000-02
99	.28000791+02	.12000000+02	.21427965+00	.00000000	.81397698-01	.00000000	.77500000-02

THERMAL OR MECHANICAL LINE OR DISTRIBUTED LOADS FOR THE 1 SEGMENT. VALID FOR LOADS EXPRESSED IN FORM FS(S)*Y(THETA)

CIRCUMFERENTIAL DISTRIBUTION OF TEMP COEFFICIENT T1

INPUT LOAD DISTRIBUTION

CIRC, STA 1	CIRC, COORD,(DEGREES) =	0.000	INPUT LOAD VALUE=	1.000+00	CIRC, COORD,= 0.000	INPUT LOAD VALUE=	1.000+0
CIRC, STA 2	CIRC, COORD,(DEGREES) =	1.719+00	INPUT LOAD VALUE=	9.885-01	CIRC, COORD,= -1.719+00	INPUT LOAD VALUE=	9.885-0
CIRC, STA 3	CIRC, COORD,(DEGREES) =	3.438+00	INPUT LOAD VALUE=	9.550-01	CIRC, COORD,= -3.438+00	INPUT LOAD VALUE=	9.550-0
CIRC, STA 4	CIRC, COORD,(DEGREES) =	5.157+00	INPUT LOAD VALUE=	9.015-01	CIRC, COORD,= -5.157+00	INPUT LOAD VALUE=	9.015-01
CIRC, STA 5	CIRC, COORD,(DEGREES) =	6.875+00	INPUT LOAD VALUE=	8.317-01	CIRC, COORD,= -6.875+00	INPUT LOAD VALUE=	8.317-01
CIRC, STA 6	CIRC, COORD,(DEGREES) =	8.594+00	INPUT LOAD VALUE=	7.498-01	CIRC, COORD,= -8.594+00	INPUT LOAD VALUE=	7.498-01
CIRC, STA 7	CIRC, COORD,(DEGREES) =	1.031+01	INPUT LOAD VALUE=	6.605-01	CIRC, COORD,= -1.031+01	INPUT LOAD VALUE=	6.605-01
CIRC, STA 8	CIRC, COORD,(DEGREES) =	1.203+01	INPUT LOAD VALUE=	5.687-01	CIRC, COORD,= -1.203+01	INPUT LOAD VALUE=	5.687-01
CIRC, STA 9	CIRC, COORD,(DEGREES) =	1.375+01	INPUT LOAD VALUE=	4.784-01	CIRC, COORD,= -1.375+01	INPUT LOAD VALUE=	4.784-01
CIRC, STA 10	CIRC, COORD,(DEGREES) =	1.547+01	INPUT LOAD VALUE=	3.933-01	CIRC, COORD,= -1.547+01	INPUT LOAD VALUE=	3.933-01
CIRC, STA 11	CIRC, COORD,(DEGREES) =	1.719+01	INPUT LOAD VALUE=	3.160-01	CIRC, COORD,= -1.719+01	INPUT LOAD VALUE=	3.160-01
CIRC, STA 12	CIRC, COORD,(DEGREES) =	2.063+01	INPUT LOAD VALUE=	1.904-01	CIRC, COORD,= -2.063+01	INPUT LOAD VALUE=	1.904-01
CIRC, STA 13	CIRC, COORD,(DEGREES) =	2.406+01	INPUT LOAD VALUE=	1.046-01	CIRC, COORD,= -2.406+01	INPUT LOAD VALUE=	1.046-01
CIRC, STA 14	CIRC, COORD,(DEGREES) =	2.750+01	INPUT LOAD VALUE=	5.239-02	CIRC, COORD,= -2.750+01	INPUT LOAD VALUE=	5.239-02
CIRC, STA 15	CIRC, COORD,(DEGREES) =	3.094+01	INPUT LOAD VALUE=	2.393-02	CIRC, COORD,= -3.094+01	INPUT LOAD VALUE=	2.393-02
CIRC, STA 16	CIRC, COORD,(DEGREES) =	3.437+01	INPUT LOAD VALUE=	9.989-03	CIRC, COORD,= -3.437+01	INPUT LOAD VALUE=	9.989-03
CIRC, STA 17	CIRC, COORD,(DEGREES) =	3.781+01	INPUT LOAD VALUE=	3.789-03	CIRC, COORD,= -3.781+01	INPUT LOAD VALUE=	3.789-03
CIRC, STA 18	CIRC, COORD,(DEGREES) =	4.125+01	INPUT LOAD VALUE=	1.313-03	CIRC, COORD,= -4.125+01	INPUT LOAD VALUE=	1.313-03
CIRC, STA 19	CIRC, COORD,(DEGREES) =	5.157+01	INPUT LOAD VALUE=	3.142-05	CIRC, COORD,= -5.157+01	INPUT LOAD VALUE=	3.142-05
CIRC, STA 20	CIRC, COORD,(DEGREES) =	1.800+02	INPUT LOAD VALUE=	0.000	CIRC, COORD,= -1.800+02	INPUT LOAD VALUE=	0.000

CALCULATED FOURIER HARMONICS OF LOAD

WAVE NO. FOR INTERVAL L=	0	WAVE NO. FOR -PI TO +PI =	0	FOURIER HARMONIC =	.79048-01
WAVE NO. FOR INTERVAL L=	-1	WAVE NO. FOR -PI TO +PI =	-1	FOURIER HARMONIC =	.15497+00
WAVE NO. FOR INTERVAL L=	-2	WAVE NO. FOR -PI TO +PI =	-2	FOURIER HARMONIC =	.14601+00
WAVE NO. FOR INTERVAL L=	-3	WAVE NO. FOR -PI TO +PI =	-3	FOURIER HARMONIC =	.13225+00
WAVE NO. FOR INTERVAL L=	-4	WAVE NO. FOR -PI TO +PI =	-4	FOURIER HARMONIC =	.11516+00
WAVE NO. FOR INTERVAL L=	-5	WAVE NO. FOR -PI TO +PI =	-5	FOURIER HARMONIC =	.96413-01
WAVE NO. FOR INTERVAL L=	-6	WAVE NO. FOR -PI TO +PI =	-6	FOURIER HARMONIC =	.77614-01
WAVE NO. FOR INTERVAL L=	-7	WAVE NO. FOR -PI TO +PI =	-7	FOURIER HARMONIC =	.60087-01
WAVE NO. FOR INTERVAL L=	-8	WAVE NO. FOR -PI TO +PI =	-8	FOURIER HARMONIC =	.44736-01
WAVE NO. FOR INTERVAL L=	-9	WAVE NO. FOR -PI TO +PI =	-9	FOURIER HARMONIC =	.32036-01
WAVE NO. FOR INTERVAL L=	-10	WAVE NO. FOR -PI TO +PI =	-10	FOURIER HARMONIC =	.22074-01
WAVE NO. FOR INTERVAL L=	-11	WAVE NO. FOR -PI TO +PI =	-11	FOURIER HARMONIC =	.14648-01
WAVE NO. FOR INTERVAL L=	-12	WAVE NO. FOR -PI TO +PI =	-12	FOURIER HARMONIC =	.93809-02
WAVE NO. FOR INTERVAL L=	-13	WAVE NO. FOR -PI TO +PI =	-13	FOURIER HARMONIC =	.58197-02
WAVE NO. FOR INTERVAL L=	-14	WAVE NO. FOR -PI TO +PI =	-14	FOURIER HARMONIC =	.35155-02
WAVE NO. FOR INTERVAL L=	-15	WAVE NO. FOR -PI TO +PI =	-15	FOURIER HARMONIC =	.20784-02
WAVE NO. FOR INTERVAL L=	-16	WAVE NO. FOR -PI TO +PI =	-16	FOURIER HARMONIC =	.12031-02
WAVE NO. FOR INTERVAL L=	-17	WAVE NO. FOR -PI TO +PI =	-17	FOURIER HARMONIC =	.67497-03
WAVE NO. FOR INTERVAL L=	-18	WAVE NO. FOR -PI TO +PI =	-18	FOURIER HARMONIC =	.35706-03
WAVE NO. FOR INTERVAL L=	-19	WAVE NO. FOR -PI TO +PI =	-19	FOURIER HARMONIC =	.16930-03

27 OCT 71

PHYSICAL PROPERTIES OF SEGMENT NO. 1

ANALYSIS IS FOR A MONOCOQUE SHELL

MODULUS OF ELASTICITY= .26900+08 POISSON RATIO= .30000+00 SHELL DENSITY = .00000 THERMAL EXP COEF.= .11900-04

MESH POINT	STATION	REF. SURFACE	THICKNESS
1	0.00000	7.75000-03	1.55000-02
2	4.02440-02	7.75000-03	1.55000-02
3	1.48171-01	7.75000-03	1.55000-02
4	2.92684-01	7.75000-03	1.55000-02
5	4.39026-01	7.75000-03	1.55000-02
6	5.85368-01	7.75000-03	1.55000-02
7	7.31710-01	7.75000-03	1.55000-02
8	8.78052-01	7.75000-03	1.55000-02
9	1.02439+00	7.75000-03	1.55000-02
10	1.17074+00	7.75000-03	1.55000-02
11	1.31708+00	7.75000-03	1.55000-02
12	1.46342+00	7.75000-03	1.55000-02
13	1.60976+00	7.75000-03	1.55000-02
14	1.75610+00	7.75000-03	1.55000-02
15	1.90245+00	7.75000-03	1.55000-02
16	2.04879+00	7.75000-03	1.55000-02
17	2.19513+00	7.75000-03	1.55000-02
18	2.34147+00	7.75000-03	1.55000-02
19	2.48781+00	7.75000-03	1.55000-02
20	2.63416+00	7.75000-03	1.55000-02
21	2.78050+00	7.75000-03	1.55000-02
22	2.92684+00	7.75000-03	1.55000-02
23	3.07318+00	7.75000-03	1.55000-02
24	3.21952+00	7.75000-03	1.55000-02
25	3.36587+00	7.75000-03	1.55000-02
26	3.51221+00	7.75000-03	1.55000-02
27	3.65855+00	7.75000-03	1.55000-02
28	3.80489+00	7.75000-03	1.55000-02
29	3.95123+00	7.75000-03	1.55000-02
30	4.18904+00	7.75000-03	1.55000-02
31	4.60977+00	7.75000-03	1.55000-02
32	5.12197+00	7.75000-03	1.55000-02
33	5.63416+00	7.75000-03	1.55000-02
34	6.14636+00	7.75000-03	1.55000-02
35	6.65855+00	7.75000-03	1.55000-02
36	7.17075+00	7.75000-03	1.55000-02
37	7.68294+00	7.75000-03	1.55000-02
38	8.19514+00	7.75000-03	1.55000-02
39	8.70733+00	7.75000-03	1.55000-02
40	9.21953+00	7.75000-03	1.55000-02
41	9.73173+00	7.75000-03	1.55000-02
42	1.02439+01	7.75000-03	1.55000-02
43	1.07561+01	7.75000-03	1.55000-02
44	1.12683+01	7.75000-03	1.55000-02
45	1.17805+01	7.75000-03	1.55000-02

46	1.22927+01	7.75000-03	1.55000-02
47	1.28049+01	7.75000-03	1.55000-02
48	1.33171+01	7.75000-03	1.55000-02
49	1.38293+01	7.75000-03	1.55000-02
50	1.43415+01	7.75000-03	1.55000-02
51	1.48537+01	7.75000-03	1.55000-02
52	1.53659+01	7.75000-03	1.55000-02
53	1.58781+01	7.75000-03	1.55000-02
54	1.63903+01	7.75000-03	1.55000-02
55	1.69025+01	7.75000-03	1.55000-02
56	1.74147+01	7.75000-03	1.55000-02
57	1.79269+01	7.75000-03	1.55000-02
58	1.84390+01	7.75000-03	1.55000-02
59	1.89512+01	7.75000-03	1.55000-02
60	1.94634+01	7.75000-03	1.55000-02
61	1.99756+01	7.75000-03	1.55000-02
62	2.04878+01	7.75000-03	1.55000-02
63	2.10000+01	7.75000-03	1.55000-02
64	2.15122+01	7.75000-03	1.55000-02
65	2.20244+01	7.75000-03	1.55000-02
66	2.24513+01	7.75000-03	1.55000-02
67	2.27074+01	7.75000-03	1.55000-02
68	2.28781+01	7.75000-03	1.55000-02
69	2.30489+01	7.75000-03	1.55000-02
70	2.32196+01	7.75000-03	1.55000-02
71	2.33904+01	7.75000-03	1.55000-02
72	2.35611+01	7.75000-03	1.55000-02
73	2.37319+01	7.75000-03	1.55000-02
74	2.39027+01	7.75000-03	1.55000-02
75	2.40734+01	7.75000-03	1.55000-02
76	2.42442+01	7.75000-03	1.55000-02
77	2.44149+01	7.75000-03	1.55000-02
78	2.45857+01	7.75000-03	1.55000-02
79	2.47564+01	7.75000-03	1.55000-02
80	2.49272+01	7.75000-03	1.55000-02
81	2.50979+01	7.75000-03	1.55000-02
82	2.52687+01	7.75000-03	1.55000-02
83	2.54395+01	7.75000-03	1.55000-02
84	2.56102+01	7.75000-03	1.55000-02
85	2.57810+01	7.75000-03	1.55000-02
86	2.59517+01	7.75000-03	1.55000-02
87	2.61225+01	7.75000-03	1.55000-02
88	2.62932+01	7.75000-03	1.55000-02
89	2.64640+01	7.75000-03	1.55000-02
90	2.66347+01	7.75000-03	1.55000-02
91	2.68055+01	7.75000-03	1.55000-02
92	2.69763+01	7.75000-03	1.55000-02
93	2.71470+01	7.75000-03	1.55000-02
94	2.73178+01	7.75000-03	1.55000-02
95	2.74885+01	7.75000-03	1.55000-02
96	2.76593+01	7.75000-03	1.55000-02
97	2.78279+01	7.75000-03	1.55000-02
98	2.79538+01	7.75000-03	1.55000-02
99	2.80008+01	7.75000-03	1.55000-02

STABILITY, VIBRATION OR NON-SYMMETRIC STRESS INPUT CONSTRAINT CONDITIONS FOLLOW

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CONSTRAINT NO.   1 SEGMENT NO.   1 POINT    1 CONNECTED TO SEGMENT NO.  1 POINT   1,. TYPE OF CONSTRAINT =  1
CONSTRAINT NO.   2 SEGMENT NO.   1 POINT   99 CONNECTED TO SEGMENT NO.  1 POINT  99,. TYPE OF CONSTRAINT =  2

LOCAL MATRIX DIMENSION=  7 OVERLAP=  4 NO. CONSTRAINT CONDS. PER CONSTRAINT POINT=  4 SYSTEM RANK=  309 NUMBER OF BLOCKS=  1

NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  1 EQUALS 309 .  NO. OF CONSTRAINT PTS. EQUALS   2
BLOCK NUMBER=  1 LAST EQ. IN BLOCK= 309 LOWEST UNK IN BLOCK=   1, MAX. OFF-DIAGONAL WIDTH=  10

DATA READ IN AND PROCESSED FOR THIS CASE. LEAVING SUBROUTINE READIT


ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.     0 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -1 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -2 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -3 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -4 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -5 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -6 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -7 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -8 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.    -9 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX.   -10 WAVES
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ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX. -11 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX. -12 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX. -13 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX. -14 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX. -15 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX. -16 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX. -17 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX. -18 WAVES

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX. -19 WAVES

MERIDIONAL DISTRIBUTION OF SUPERPOSED QUANTITIES CORRESPONDING TO CIRCUMFERENTIAL STATION, THETA= 0.0000 DEG.

STRESS RESULTANTS OR STRESSES IN SEGMENT 1

POINT	STATION	U	V	W	N1	N2	N12	M1	M2	MT
1	0.000	-5.915-21	0.000	3.235-20	-5.275+02	-4.949+02	0.000	2.072+00	6.217-01	0.000
3	1.482-01	-2.488-05	0.000	2.157-03	-5.351+02	-3.345+02	0.000	1.554-01	4.163-02	0.000
5	4.390-01	-1.227-04	0.000	6.415-03	-5.381+02	-4.579+01	0.000	-3.839-01	-1.398-01	0.000
7	7.317-01	-2.500-04	0.000	7.535-03	-5.356+02	1.575+01	0.000	-9.881-02	-5.904-02	0.000
9	1.024+00	-3.734-04	0.000	7.687-03	-5.331+02	7.193+00	0.000	7.816-03	-2.612-02	0.000
11	1.317+00	-4.873-04	0.000	7.942-03	-5.310+02	3.504-01	0.000	9.642-03	-2.505-02	0.000
13	1.610+00	-5.930-04	0.000	8.370-03	-5.290+02	-5.704-01	0.000	8.141-04	-2.832-02	0.000
15	1.902+00	-6.914-04	0.000	8.898-03	-5.269+02	-2.395-01	0.000	-2.485-03	-3.077-02	0.000
17	2.195+00	-7.824-04	0.000	9.497-03	-5.249+02	-1.197-01	0.000	-3.744-03	-3.326-02	0.000
19	2.488+00	-8.661-04	0.000	1.016-02	-5.228+02	-2.818-01	0.000	-4.710-03	-3.624-02	0.000
21	2.780+00	-9.425-04	0.000	1.089-02	-5.206+02	-5.644-01	0.000	-3.651-03	-3.917-02	0.000
23	3.073+00	-1.011-03	0.000	1.171-02	-5.185+02	-1.396+00	0.000	1.633-03	-4.144-02	0.000
25	3.366+00	-1.070-03	0.000	1.269-02	-5.163+02	1.637+00	0.000	1.840-02	-4.107-02	0.000
27	3.659+00	-1.117-03	0.000	1.397-02	-5.142+02	1.699+00	0.000	7.902-04	-5.235-02	0.000

29	3.951+00	-1.129-03	0.000	1.541-02	-5.123+02	-8.886+00	0.000	-4.768-02	-7.381-02	0.000
31	4.610+00	-1.075-03	0.000	1.800-02	-5.070+02	1.775-01	0.000	-3.065-02	-8.083-02	0.000
33	5.634+00	-8.763-04	0.000	2.084-02	-4.980+02	-3.108-01	0.000	-3.468-02	-9.278-02	0.000
35	6.659+00	-6.535-04	0.000	2.243-02	-4.880+02	-6.891-01	0.000	-3.357-02	-9.484-02	0.000
37	7.683+00	-4.395-04	0.000	2.344-02	-4.773+02	-5.844-01	0.000	-3.255-02	-9.314-02	0.000
39	8.707+00	-2.385-04	0.000	2.389-02	-4.662+02	-5.031-01	0.000	-3.044-02	-8.856-02	0.000
41	9.732+00	-7.113-05	0.000	2.387-02	-4.549+02	-4.913-01	0.000	-2.728-02	-8.205-02	0.000
43	1.076+01	5.948-05	0.000	2.360-02	-4.438+02	-4.232-01	0.000	-2.443-02	-7.539-02	0.000
45	1.178+01	1.529-04	0.000	2.319-02	-4.328+02	-8.876-02	0.000	-1.790-02	-6.807-02	0.000
47	1.280+01	2.232-04	0.000	2.295-02	-4.222+02	-3.250-01	0.000	-2.025-02	-6.492-02	0.000
49	1.383+01	2.843-04	0.000	2.270-02	-4.118+02	-2.915-01	0.000	-1.906-02	-6.157-02	0.000
51	1.485+01	3.353-04	0.000	2.243-02	-4.018+02	-3.013-01	0.000	-1.820-02	-5.903-02	0.000
53	1.588+01	3.755-04	0.000	2.216-02	-3.921+02	3.514-02	0.000	-1.306-02	-5.592-02	0.000
55	1.690+01	4.198-04	0.000	2.218-02	-3.828+02	-3.366-01	0.000	-1.793-02	-5.704-02	0.000
57	1.793+01	4.834-04	0.000	2.217-02	-3.736+02	-1.541-01	0.000	-1.598-02	-5.639-02	0.000
59	1.895+01	5.738-04	0.000	2.220-02	-3.646+02	-3.764-01	0.000	-1.931-02	-5.740-02	0.000
61	1.998+01	6.989-04	0.000	2.203-02	-3.557+02	-4.123-01	0.000	-2.054-02	-5.703-02	0.000
63	2.100+01	8.565-04	0.000	2.150-02	-3.469+02	-7.748-01	0.000	-2.539-02	-5.635-02	0.000
65	2.202+01	1.026-03	0.000	2.020-02	-3.381+02	-8.102-01	0.000	-2.611-02	-5.213-02	0.000
67	2.271+01	1.127-03	0.000	1.877-02	-3.323+02	5.009-01	0.000	-2.844-02	-4.839-02	0.000
69	2.305+01	1.167-03	0.000	1.783-02	-3.294+02	-4.892+00	0.000	-4.011-02	-4.921-02	0.000
71	2.339+01	1.192-03	0.000	1.657-02	-3.265+02	2.226-01	0.000	-2.439-02	-4.125-02	0.000
73	2.373+01	1.193-03	0.000	1.514-02	-3.236+02	-5.052-02	0.000	-1.099-02	-3.362-02	0.000
75	2.407+01	1.171-03	0.000	1.371-02	-3.207+02	-4.416-01	0.000	5.285-04	-2.652-02	0.000
77	2.441+01	1.125-03	0.000	1.239-02	-3.179+02	3.293+00	0.000	1.238-02	-1.956-02	0.000
79	2.476+01	1.061-03	0.000	1.131-02	-3.151+02	-5.821-01	0.000	3.743-03	-1.922-02	0.000
81	2.510+01	9.872-04	0.000	1.036-02	-3.124+02	-7.573-01	0.000	-1.963-03	-1.840-02	0.000
83	2.544+01	9.016-04	0.000	9.464-03	-3.097+02	-5.070-01	0.000	-1.003-03	-1.584-02	0.000
85	2.578+01	8.046-04	0.000	8.626-03	-3.070+02	-6.855-02	0.000	4.314-03	-1.218-02	0.000
87	2.612+01	6.966-04	0.000	7.898-03	-3.044+02	2.322-01	0.000	8.761-03	-9.076-03	0.000
89	2.646+01	5.800-04	0.000	7.328-03	-3.018+02	1.826+00	0.000	8.744-03	-7.671-03	0.000
91	2.681+01	4.546-04	0.000	6.896-03	-2.993+02	5.979+00	0.000	-1.089-02	-1.253-02	0.000
93	2.715+01	3.207-04	0.000	6.316-03	-2.968+02	2.723+00	0.000	-8.522-02	-3.402-02	0.000
95	2.749+01	1.835-04	0.000	4.663-03	-2.945+02	-3.990+01	0.000	-1.646-01	-5.637-02	0.000
97	2.783+01	5.748-05	0.000	1.262-03	-2.919+02	-1.460+02	0.000	1.795-01	5.084-02	0.000
99	2.800+01	-2.905-19	0.000	-8.580-18	-2.900+02	-1.860+02	0.000	8.542-01	2.562-01	0.000

CIRCUMFERENTIAL VARIATION OF SUPERPOSED QUANTITIES AT POINT NO. 67, SEGMENT NO. 1, MERIDIONAL STATION= 2.271+01

POINT	STATION	U	V	W	N1	N2	N12	M1	M2	MT
1	0.000	1.127-03	0.000	1.877-02	-3.323+02	5.009-01	0.000	-2.844-02	-4.839-02	0.000
2	3.000+00	1.100-03	3.053-04	1.800-02	-3.212+02	5.308-01	1.012+00	-2.641-02	-4.396-02	2.897-03
3	6.000+00	1.023-03	5.765-04	1.580-02	-2.899+02	6.042-01	1.698+00	-2.089-02	-3.191-02	5.272-03
4	9.000+00	9.047-04	7.852-04	1.260-02	-2.446+02	6.807-01	1.850+00	-1.329-02	-1.551-02	6.738-03
5	1.200+01	7.590-04	9.130-04	8.915-03	-1.930+02	7.154-01	1.441+00	-5.426-03	1.124-03	7.137-03
6	1.500+01	6.009-04	9.545-04	5.311-03	-1.427+02	6.798-01	6.198-01	1.099-03	1.438-02	6.550-03
7	1.800+01	4.447-04	9.166-04	2.222-03	-9.878+01	5.736-01	-3.654-01	5.326-03	2.215-02	5.243-03
8	2.100+01	3.020-04	8.164-04	-9.466-05	-6.397+01	4.212-01	-1.264+00	7.078-03	2.420-02	3.566-03
9	2.400+01	1.810-04	6.766-04	-1.572-03	-3.840+01	2.593-01	-1.900+00	6.816-03	2.170-02	1.859-03
10	2.700+01	8.555-05	5.206-04	-2.295-03	-2.082+01	1.205-01	-2.204+00	5.321-03	1.658-02	3.754-04
11	3.000+01	1.635-05	3.684-04	-2.439-03	-9.461+00	2.301-02	-2.199+00	3.381-03	1.071-02	-7.383-04
12	3.300+01	-2.872-05	2.344-04	-2.203-03	-2.617+00	-3.099-02	-1.967+00	1.576-03	5.451-03	-1.441-03

13	3.600+01	-5.345-05	1.262-04	-1.769-03	1.095+00	-5.034-02	-1.603+00	2.166-04	1.486-03	-1.766-03
14	3.900+01	-6.246-05	4.625-05	-1.275-03	2.757+00	-4.783-02	-1.196+00	-6.164-04	-1.045-03	-1.791-03
15	4.200+01	-6.047-05	-7.262-06	-8.093-04	3.191+00	-3.492-02	-8.111-01	-9.907-04	-2.347-03	-1.608-03
16	4.500+01	-5.178-05	-3.823-05	-4.204-04	2.977+00	-1.965-02	-4.924-01	-1.040-03	-2.766-03	-1.307-03
17	4.800+01	-3.994-05	-5.147-05	-1.249-04	2.478+00	-6.749-03	-2.606-01	-9.044-04	-2.654-03	-9.601-04
18	5.100+01	-2.763-05	-5.189-05	7.900-05	1.880+00	1.601-03	-1.178-01	-7.006-04	-2.291-03	-6.207-04
19	5.400+01	-1.668-05	-4.401-05	2.025-04	1.278+00	5.226-03	-5.209-02	-5.010-04	-1.853-03	-3.220-04
20	5.700+01	-8.107-06	-3.165-05	2.598-04	7.440-01	5.441-03	-4.392-02	-3.363-04	-1.422-03	-8.198-05
21	6.000+01	-2.314-06	-1.788-05	2.658-04	3.477-01	4.237-03	-7.288-02	-2.069-04	-1.015-03	9.478-05
22	6.300+01	7.946-07	-4.923-06	2.347-04	1.307-01	3.245-03	-1.217-01	-1.018-04	-6.284-04	2.071-04
23	6.600+01	1.645-06	5.764-06	1.803-04	8.074-02	3.039-03	-1.773-01	-1.360-05	-2.680-04	2.610-04
24	6.900+01	8.428-07	1.339-05	1.153-04	1.372-01	3.211-03	-2.292-01	5.642-05	4.132-05	2.660-04
25	7.200+01	-9.534-07	1.771-05	5.103-05	2.293-01	3.071-03	-2.691-01	1.030-04	2.706-04	2.344-04
26	7.500+01	-3.139-06	1.896-05	-4.302-06	3.146-01	2.347-03	-2.912-01	1.240-04	4.048-04	1.801-04
27	7.800+01	-5.227-06	1.768-05	-4.565-05	3.877-01	1.349-03	-2.938-01	1.237-04	4.507-04	1.165-04
28	8.100+01	-6.885-06	1.468-05	-7.115-05	4.573-01	5.694-04	-2.791-01	1.094-04	4.287-04	5.437-05
29	8.400+01	-7.930-06	1.080-05	-8.140-05	5.196-01	1.962-04	-2.526-01	8.730-05	3.606-04	1.200-06
30	8.700+01	-8.315-06	6.784-06	-7.872-05	5.528-01	3.479-06	-2.197-01	6.026-05	2.629-04	-3.850-05
31	9.000+01	-8.103-06	3.192-06	-6.654-05	5.368-01	-3.313-04	-1.847-01	2.997-05	1.495-04	-6.281-05
32	9.300+01	-7.424-06	3.598-07	-4.886-05	4.748-01	-8.469-04	-1.505-01	9.649-08	3.729-05	-7.205-05
33	9.600+01	-6.448-06	-1.565-06	-2.963-05	3.938-01	-1.244-03	-1.192-01	-2.357-05	-5.428-05	-6.857-05
34	9.900+01	-5.344-06	-2.580-06	-1.210-05	3.248-01	-1.195-03	-9.288-02	-3.622-05	-1.107-04	-5.621-05
35	1.020+02	-4.256-06	-2.789-06	1.694-06	2.791-01	-6.874-04	-7.351-02	-3.746-05	-1.298-04	-3.940-05
36	1.050+02	-3.289-06	-2.382-06	1.098-05	2.447-01	-6.943-05	-6.147-02	-3.155-05	-1.222-04	-2.201-05
37	1.080+02	-2.504-06	-1.596-06	1.593-05	2.039-01	2.595-04	-5.538-02	-2.405-05	-1.027-04	-6.636-06
38	1.110+02	-1.927-06	-6.749-07	1.718-05	1.537-01	1.938-04	-5.275-02	-1.792-05	-8.048-05	5.452-06
39	1.140+02	-1.552-06	1.897-07	1.553-05	1.095-01	-1.717-05	-5.139-02	-1.238-05	-5.664-05	1.380-05
40	1.170+02	-1.349-06	8.831-07	1.183-05	8.981-02	-4.065-05	-5.031-02	-5.417-06	-2.887-05	1.830-05
41	1.200+02	-1.278-06	1.362-06	7.068-06	9.689-02	2.104-04	-4.959-02	3.023-06	1.170-06	1.909-05
42	1.230+02	-1.288-06	1.628-06	2.302-06	1.137-01	5.055-04	-4.927-02	1.021-05	2.606-05	1.676-05
43	1.260+02	-1.335-06	1.693-06	-1.610-06	1.187-01	5.396-04	-4.875-02	1.295-05	3.799-05	1.245-05
44	1.290+02	-1.384-06	1.582-06	-4.240-06	1.050-01	2.431-04	-4.691-02	1.067-05	3.561-05	7.583-06
45	1.320+02	-1.411-06	1.336-06	-5.632-06	8.509-02	-1.443-04	-4.317-02	6.092-06	2.558-05	3.276-06
46	1.350+02	-1.406-06	1.018-06	-6.095-06	7.685-02	-3.018-04	-3.803-02	2.928-06	1.697-05	9.146-09
47	1.380+02	-1.368-06	6.999-07	-5.913-06	8.564-02	-1.316-04	-3.276-02	2.668-06	1.389-05	-2.317-06
48	1.410+02	-1.298-06	4.357-07	-5.211-06	9.902-02	1.566-04	-2.843-02	3.613-06	1.310-05	-3.940-06
49	1.440+02	-1.204-06	2.440-07	-4.050-06	9.917-02	2.565-04	-2.510-02	2.928-06	8.631-06	-4.872-06
50	1.470+02	-1.094-06	1.137-07	-2.600-06	8.054-02	6.250-05	-2.201-02	-3.286-07	-1.285-06	-4.919-06
51	1.500+02	-9.807-07	2.621-08	-1.194-06	5.539-02	-2.338-04	-1.850-02	-4.181-06	-1.190-05	-4.006-06
52	1.530+02	-8.765-07	-2.502-08	-1.801-07	4.210-02	-3.368-04	-1.474-02	-5.639-06	-1.630-05	-2.455-06
53	1.560+02	-7.886-07	-3.512-08	2.940-07	4.767-02	-1.382-04	-1.158-02	-3.637-06	-1.207-05	-8.826-07
54	1.590+02	-7.192-07	-3.712-09	3.558-07	6.143-02	1.781-04	-9.680-03	-1.132-07	-3.773-06	1.934-07
55	1.620+02	-6.669-07	5.146-08	2.642-07	6.571-02	3.150-04	-8.845-03	1.809-06	1.272-06	6.871-07
56	1.650+02	-6.292-07	9.896-08	1.831-07	5.316-02	1.501-04	-8.103-03	7.650-07	-2.370-07	9.004-07
57	1.680+02	-6.046-07	1.135-07	7.599-08	3.372-02	-1.473-04	-6.592-03	-1.632-06	-4.771-06	1.153-06
58	1.710+02	-5.918-07	9.261-08	-1.859-07	2.475-02	-2.827-04	-4.313-03	-2.464-06	-5.787-06	1.444-06
59	1.740+02	-5.881-07	5.516-08	-6.241-07	3.397-02	-1.225-04	-2.066-03	-4.156-07	-3.825-07	1.468-06
60	1.770+02	-5.889-07	2.237-08	-1.063-06	5.183-02	1.779-04	-6.339-04	2.902-06	7.675-06	9.552-07
61	1.800+02	-5.899-07	1.527-11	-1.250-06	6.068-02	3.261-04	1.545-08	4.500-06	1.149-05	1.740-10

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX. 20 WAVES

ENTER EBAND TO CALCULATE LOWEST 3 BUCKLING LOADS. WAVENUMBER,N = 20 WAVES

BUCKLING OF CONE HEATED ON AXIAL STRIP

```
  8  NEGATIVE ROOTS  FOR SHIFT, AXT =   0.00000

  8  NEGATIVE ROOTS  FOR SHIFT, AXT =   1.10157+00

  8  NEGATIVE ROOTS  FOR SHIFT, AXT =   1.14043+00
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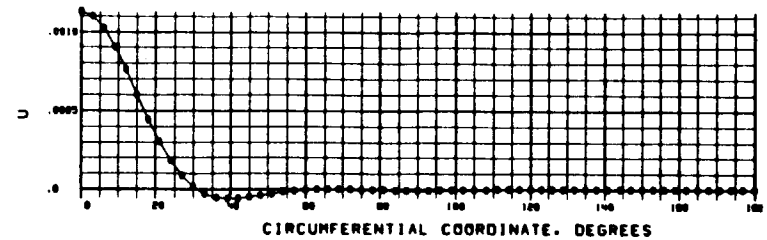


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ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO.  1.  BUCKLING LOAD FACTOR=   1.14061+00.     20  CIRCUMFERENTIAL WAVES
                        ELAPSED TIME =  0: 1: 2.781

  9  NEGATIVE ROOTS  FOR SHIFT, AXT =   1.15857+00

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO.  2.  BUCKLING LOAD FACTOR=   1.15872+00.     20  CIRCUMFERENTIAL WAVES
                        ELAPSED TIME =  0: 1: 6.770

 10  NEGATIVE ROOTS  FOR SHIFT, AXT =   1.17802+00

ITERATIONS HAVE CONVERGED FOR EIGENVALUE NO.  3.  BUCKLING LOAD FACTOR=   1.17819+00.     20  CIRCUMFERENTIAL WAVES
                        ELAPSED TIME =  0: 1:10.991

 11  NEGATIVE ROOTS  FOR SHIFT, AXT =   1.17854+00

 BUCKLING LOADS AND MODES FOLLOW

 CIRCUMFERENTIAL WAVE NUMBER, N =      20

 EIGENVALUES =      1.14061+00     1.15872+00     1.17819+00

MODE SHAPE FOR EIGENVALUE NO.  1  FOLLOWS
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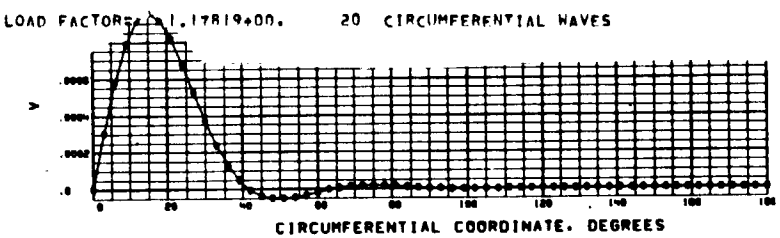
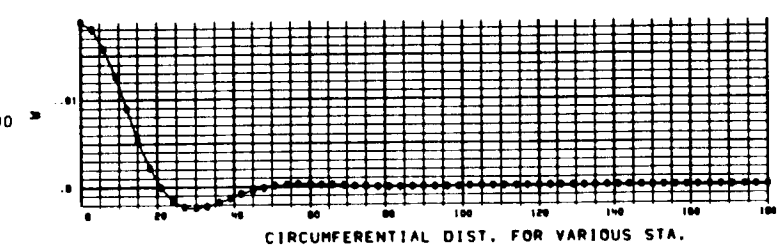
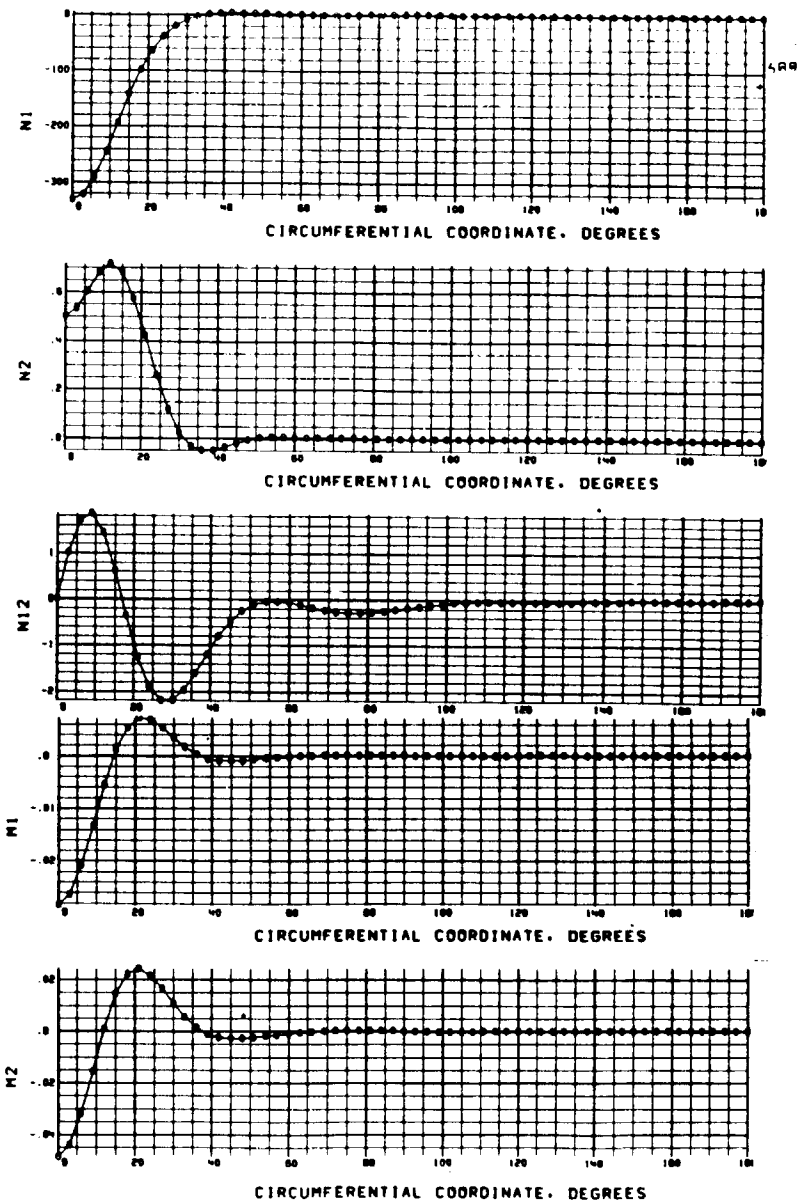




BUCKLING MODE FOR SEGMENT 1

POINT	STATION	U	V	W
1	0.000	6.731-23	5.622-25	1.447-22
2	4.024-02	4.599-08	7.917-08	1.427-07
3	1.482-01	1.740-07	2.491-07	1.923-06
4	2.927-01	3.689-07	3.813-07	5.365-06
5	4.390-01	6.163-07	3.430-07	8.061-06
6	5.854-01	8.944-07	2.695-08	6.857-06
7	7.317-01	1.134-06	-7.046-07	-2.231-06
8	8.781-01	1.255-06	-1.960-06	-2.288-05
9	1.024+00	1.195-06	-3.753-06	-5.680-05
10	1.171+00	9.053-07	-5.954-06	-1.025-04
11	1.317+00	3.498-07	-8.288-06	-1.5[illegible]9-04
12	1.463+00	-4.893-07	-1.035-05	-2.[illegible]06-04
13	1.610+00	-1.593-06	-1.163-05	-2.440-04
14	1.756+00	-2.891-06	-1.161-05	-2.532-04
15	1.902+00	-4.256-06	-9.827-06	-2.367-04
16	2.049+00	-5.511-06	-5.952-06	-1.704-04
17	2.195+00	-6.446-06	6.539-08	-5.499-05
18	2.341+00	-6.848-06	7.932-06	1.069-04
19	2.488+00	-6.529-06	1.695-05	3.033-04
20	2.634+00	-5.364-06	2.604-05	5.126-04
21	2.780+00	-3.321-06	3.382-05	7.040-04
22	2.927+00	-4.787-07	3.878-05	8.413-04
23	3.073+00	2.976-06	3.958-05	8.890-04
24	3.220+00	6.776-06	3.529-05	8.193-04
25	3.366+00	1.062-05	2.570-05	6.214-04
26	3.512+00	1.419-05	1.144-05	3.076-04
27	3.659+00	1.711-05	-5.978-06	-8.645-05
28	3.805+00	1.888-05	-2.450-05	-5.069-04
29	3.951+00	1.894-05	-4.208-05	-8.911-04
30	4.189+00	1.446-05	-6.179-05	-1.314-03
31	4.610+00	-1.380-06	-7.185-05	-1.402-03
32	5.122+00	-2.508-05	-4.597-05	-9.283-04
33	5.634+00	-4.228-05	2.689-05	4.687-04
34	6.146+00	-3.934-05	1.330-04	2.557-03
35	6.659+00	-5.874-06	2.261-04	4.450-03
36	7.171+00	5.567-05	2.348-04	4.731-03
37	7.683+00	1.228-04	9.505-05	2.085-03
38	8.195+00	1.554-04	-2.029-04	-3.761-03
39	8.707+00	1.119-04	-5.769-04	-1.126-02
40	9.220+00	-2.490-05	-8.522-04	-1.697-02
41	9.732+00	-2.270-04	-8.160-04	-1.659-02
42	1.024+01	-4.177-04	-3.206-04	-7.024-03
43	1.076+01	-4.919-04	6.073-04	1.140-02
44	1.127+01	-3.602-04	1.708-03	3.364-02
45	1.178+01	1.019-06	2.525-03	5.055-02
46	1.229+01	5.194-04	2.558-03	5.198-02
47	1.280+01	1.029-03	1.489-03	3.120-02
48	1.332+01	1.310-03	-6.341-04	-1.110-02
49	1.383+01	1.170-03	-3.309-03	-6.510-02
50	1.434+01	5.277-04	-5.662-03	-1.133-01
51	1.485+01	-5.247-04	-6.692-03	-1.353-01
52	1.537+01	-1.718-03	-5.626-03	-1.152-01
53	1.588+01	-2.675-03	-2.252-03	-4.815-02

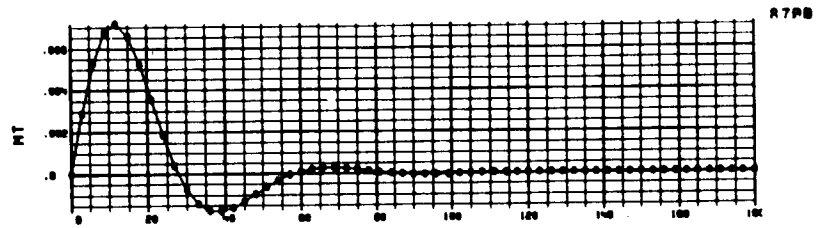


54	1.639+01	-3.017-03	2.865-03	5.492-02
55	1.690+01	-2.480-03	8.437-03	1.682-01
56	1.741+01	-1.032-03	1.278-02	2.574-01
57	1.793+01	1.071-03	1.428-02	2.895-01
58	1.844+01	3.331-03	1.193-02	2.436-01
59	1.895+01	5.125-03	5.690-03	1.186-01
60	1.946+01	5.857-03	-3.384-03	-6.441-02
61	1.998+01	5.136-03	-1.337-02	-2.663-01
62	2.049+01	2.895-03	-2.189-02	-4.389-01
63	2.100+01	-5.823-04	-2.675-02	-5.364-01
64	2.151+01	-4.736-03	-2.648-02	-5.272-01
65	2.202+01	-8.721-03	-2.027-02	-4.120-01
66	2.245+01	-1.083-02	-1.002-02	-2.818-01
67	2.271+01	-1.100-02	-7.583-04	-5.876-02
68	2.288+01	-1.054-02	6.873-03	1.182-01
69	2.305+01	-9.595-03	1.478-02	2.970-01
70	2.322+01	-8.173-03	2.253-02	4.673-01
71	2.339+01	-6.322-03	2.973-02	6.227-01
72	2.356+01	-4.140-03	3.602-02	7.587-01
73	2.373+01	-1.752-03	4.107-02	8.707-01
74	2.390+01	6.994-04	4.460-02	9.526-01
75	2.407+01	3.069-03	4.638-02	9.977-01
76	2.424+01	5.227-03	4.624-02	1.000+00
77	2.441+01	7.076-03	4.414-02	9.565-01
78	2.459+01	8.553-03	4.018-02	8.683-01
79	2.476+01	9.616-03	3.461-02	7.408-01
80	2.493+01	1.024-02	2.785-02	5.832-01
81	2.510+01	1.043-02	2.037-02	4.080-01
82	2.527+01	1.019-02	1.270-02	2.286-01
83	2.544+01	9.594-03	5.338-03	5.825-02
84	2.561+01	8.698-03	-1.261-03	-9.164-02
85	2.578+01	7.596-03	-6.732-03	-2.120-01
86	2.595+01	6.377-03	-1.083-02	-2.966-01
87	2.612+01	5.122-03	-1.344-02	-3.429-01
88	2.629+01	3.895-03	-1.459-02	-3.522-01
89	2.646+01	2.745-03	-1.445-02	-3.293-01
90	2.663+01	1.708-03	-1.328-02	-2.829-01
91	2.681+01	8.199-04	-1.141-02	-2.232-01
92	2.698+01	1.184-04	-9.204-03	-1.610-01
93	2.715+01	-3.575-04	-6.958-03	-1.048-01
94	2.732+01	-5.895-04	-4.908-03	-6.004-02
95	2.749+01	-6.029-04	-3.184-03	-2.859-02
96	2.766+01	-4.677-04	-1.821-03	-9.668-03
97	2.783+01	-2.621-04	-7.980-04	-1.257-03
98	2.795+01	-7.904-05	-1.916-04	-9.249-05
99	2.800+01	1.305-19	1.300-20	-1.821-18

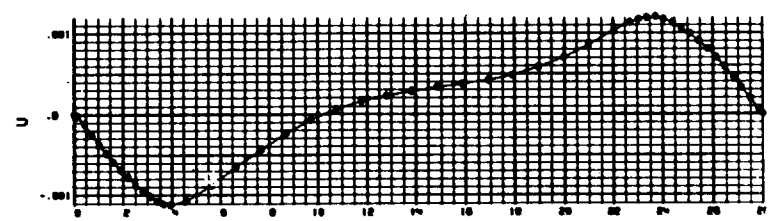
MODE SHAPE FOR EIGENVALUE NO. 2 FOLLOWS

BUCKLING MODE FOR SEGMENT 1

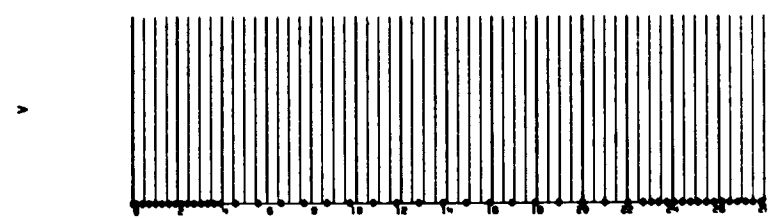
POINT	STATION	U	V	W
1	0.000	2.144-22	-3.257-24	-7.084-22
2	4.024-02	1.634-07	-4.700-08	7.820-08



CIRCUMFERENTIAL DIST. FOR VARIOUS STA.



ARC LENGTH



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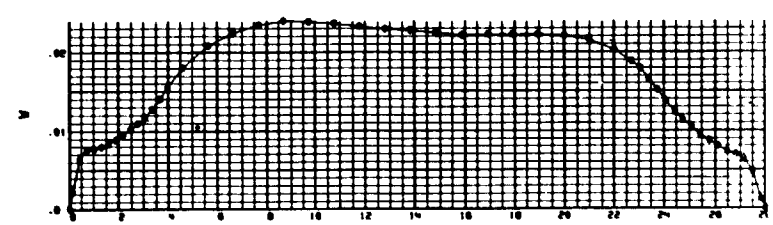
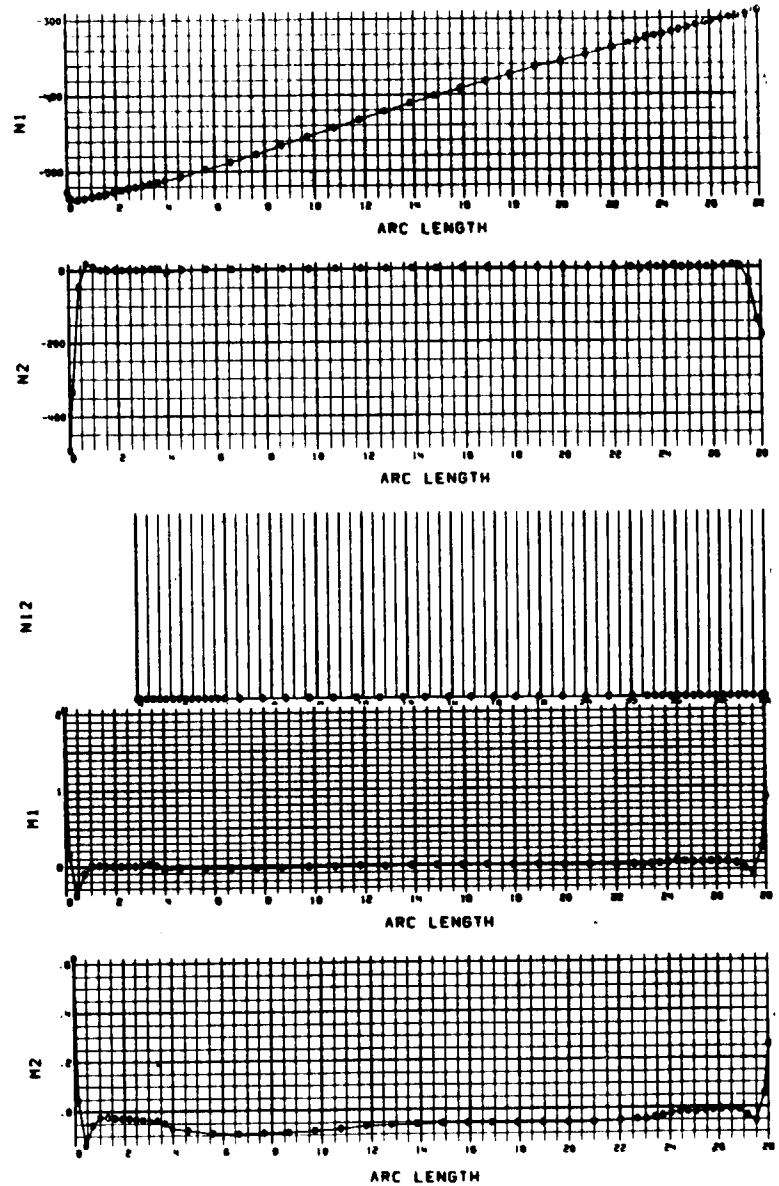


MERIDIONAL DISTRIBUTION FOR VARIOUS THETA

3	1.482-01	5.918-07	-4.544-07	1.021-06
4	2.927-01	1.176-06	-1.647-06	-9.031-06
5	4.390-01	1.650-06	-3.889-06	-4.100-05
6	5.854-01	1.663-06	-7.309-06	-1.025-04
7	7.317-01	9.434-07	-1.172-05	-1.946-04
8	8.781-01	-5.581-07	-1.646-05	-3.070-04
9	1.024+00	-2.720-06	-2.036-05	-4.158-04
10	1.171+00	-5.335-06	-2.200-05	-4.877-04
11	1.317+00	-8.134-06	-1.998-05	-4.871-04
12	1.463+00	-1.075-05	-1.323-05	-3.845-04
13	1.610+00	-1.272-05	-1.331-06	-1.632-04
14	1.756+00	-1.353-05	1.524-05	1.742-04
15	1.902+00	-1.269-05	3.501-05	6.027-04
16	2.049+00	-9.855-06	5.548-05	1.073-03
17	2.195+00	-4.940-06	7.334-05	1.515-03
18	2.341+00	1.855-06	8.488-05	1.842-03
19	2.488+00	1.000-05	8.660-05	1.967-03
20	2.634+00	1.867-05	7.590-05	1.815-03
21	2.780+00	2.683-05	5.186-05	1.346-03
22	2.927+00	3.341-05	1.572-05	5.691-04
23	3.073+00	3.744-05	-2.884-05	-4.428-04
24	3.220+00	3.823-05	-7.633-05	-1.558-03
25	3.366+00	3.545-05	-1.187-04	-2.599-03
26	3.512+00	2.908-05	-1.495-04	-3.381-03
27	3.659+00	1.927-05	-1.629-04	-3.741-03
28	3.805+00	6.477-06	-1.566-04	-3.580-03
29	3.951+00	-8.161-06	-1.329-04	-2.897-03
30	4.189+00	-3.022-05	-7.857-05	-1.249-03
31	4.610+00	-4.968-05	1.645-05	3.657-04
32	5.122+00	-4.560-05	1.231-04	2.394-03
33	5.634+00	-1.415-05	2.012-04	3.934-03
34	6.146+00	3.920-05	2.079-04	4.147-03
35	6.659+00	9.731-05	9.593-05	2.040-03
36	7.171+00	1.289-04	-1.461-04	-2.684-03
37	7.683+00	9.845-05	-4.553-04	-8.857-03
38	8.195+00	-1.247-05	-6.867-04	-1.365-02
39	8.707+00	-1.025-04	-6.564-04	-1.335-02
40	9.220+00	-3.435-04	-2.314-04	-5.165-03
41	9.732+00	-4.000-04	5.644-04	1.062-02
42	1.024+01	-2.708-04	1.490-03	2.934-02
43	1.076+01	6.106-05	2.125-03	4.262-02
44	1.127+01	5.162-04	2.022-03	4.129-02
45	1.178+01	9.275-04	9.157-04	1.969-02
46	1.229+01	1.093-03	-1.075-03	-2.013-02
47	1.280+01	8.518-04	-3.387-03	-6.704-02
48	1.332+01	1.679-04	-5.141-03	-1.033-01
49	1.383+01	-8.169-04	-5.436-03	-1.106-01
50	1.434+01	-1.802-03	-3.715-03	-7.697-02
51	1.485+01	-2.415-03	-6.752-05	-3.882-03
52	1.537+01	-2.340-03	4.664-03	9.206-02
53	1.588+01	-1.453-03	9.050-03	1.818-01
54	1.639+01	1.219-04	1.150-02	2.330-01
55	1.690+01	2.016-03	1.083-02	2.209-01
56	1.741+01	3.694-03	6.674-03	1.379-01
57	1.793+01	4.606-03	-3.080-04	-3.002-03
58	1.844+01	4.362-03	-8.522-03	-1.698-01
59	1.895+01	2.046-03	-1.583-02	-3.188-01
60	1.946+01	2.909-04	-2.011-02	-4.069-01

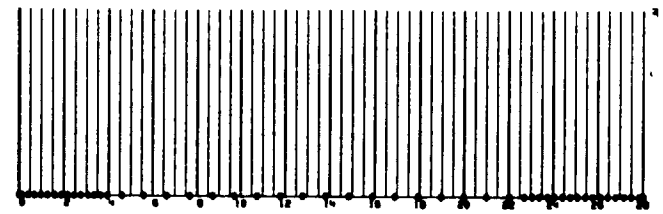


61	1.998+01	-2.756-03	-1.987-02	-4.033-01
62	2.049+01	-5.563-03	-1.466-02	-2.981-01
63	2.100+01	-7.372-03	-5.172-03	-1.074-01
64	2.151+01	-7.502-03	7.066-03	1.315-01
65	2.202+01	-5.229-03	2.054-02	3.769-01
66	2.245+01	-9.360-04	3.207-02	5.624-01
67	2.271+01	2.075-03	3.876-02	8.031-01
68	2.288+01	5.563-03	4.190-02	9.369-01
69	2.305+01	8.097-03	4.280-02	1.000+00
70	2.322+01	1.027-02	4.092-02	9.742-01
71	2.339+01	1.189-02	3.613-02	8.591-01
72	2.356+01	1.286-02	2.871-02	6.687-01
73	2.373+01	1.315-02	1.931-02	4.266-01
74	2.390+01	1.283-02	8.783-03	1.614-01
75	2.407+01	1.200-02	-1.936-03	-9.913-02
76	2.424+01	1.079-02	-1.200-02	-3.316-01
77	2.441+01	9.292-03	-2.074-02	-5.203-01
78	2.459+01	7.603-03	-2.773-02	-6.585-01
79	2.476+01	5.780-03	-3.279-02	-7.466-01
80	2.493+01	3.886-03	-3.594-02	-7.909-01
81	2.510+01	1.999-03	-3.737-02	-8.000-01
82	2.527+01	2.047-04	-3.730-02	-7.824-01
83	2.544+01	-1.415-03	-3.597-02	-7.440-01
84	2.561+01	-2.794-03	-3.362-02	-6.882-01
85	2.578+01	-3.890-03	-3.045-02	-6.171-01
86	2.595+01	-4.689-03	-2.669-02	-5.329-01
87	2.612+01	-5.206-03	-2.259-02	-4.399-01
88	2.629+01	-5.472-03	-1.840-02	-3.444-01
89	2.646+01	-5.521-03	-1.437-02	-2.542-01
90	2.663+01	-5.383-03	-1.072-02	-1.770-01
91	2.681+01	-5.076-03	-7.618-03	-1.176-01
92	2.698+01	-4.610-03	-5.113-03	-7.663-02
93	2.715+01	-3.999-03	-3.190-03	-5.075-02
94	2.732+01	-3.268-03	-1.783-03	-3.402-02
95	2.749+01	-2.448-03	-8.083-04	-2.107-02
96	2.766+01	-1.586-03	-2.062-04	-9.806-03
97	2.783+01	-7.653-04	5.125-05	-2.041-03
98	2.795+01	-1.984-04	5.089-05	-1.562-04
99	2.800+01	5.092-18	-4.374-18	-1.155-16

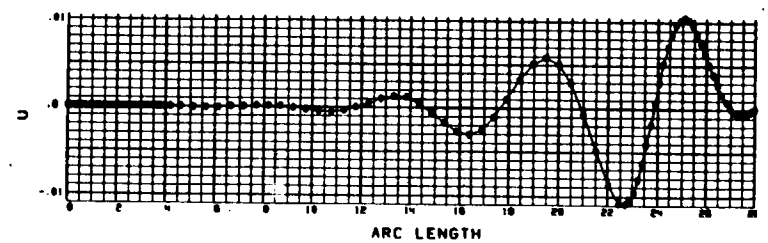
MODE SHAPE FOR EIGENVALUE NO. 3 FOLLOWS

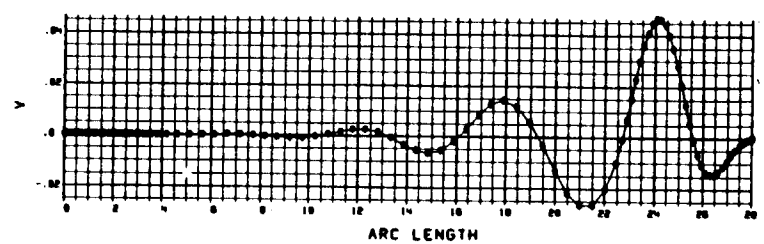
BUCKLING MODE FOR SEGMENT 1

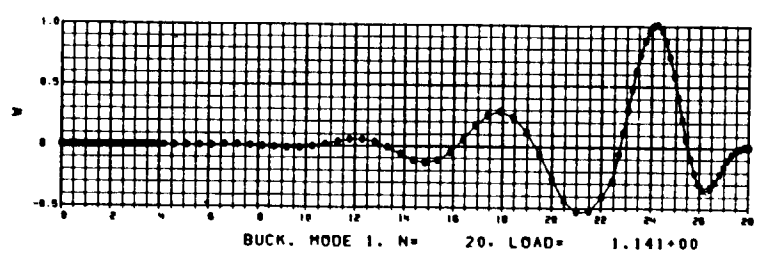
POINT	STATION	U	V	W
1	0.000	-4.281-22	-3.360-25	-2.327-22
2	4.024-02	-1.231-07	3.048-07	2.246-07
3	1.482-01	-4.202-07	1.453-06	3.108-06
4	2.927-01	-7.779-07	3.759-06	2.895-05
5	4.390-01	-8.274-07	7.258-06	8.997-05
6	5.854-01	-6.383-08	1.180-05	1.888-04
7	7.317-01	1.732-06	1.659-05	3.129-04
8	8.781-01	4.365-06	2.014-05	4.304-04
9	1.024+00	7.408-06	2.049-05	4.938-04



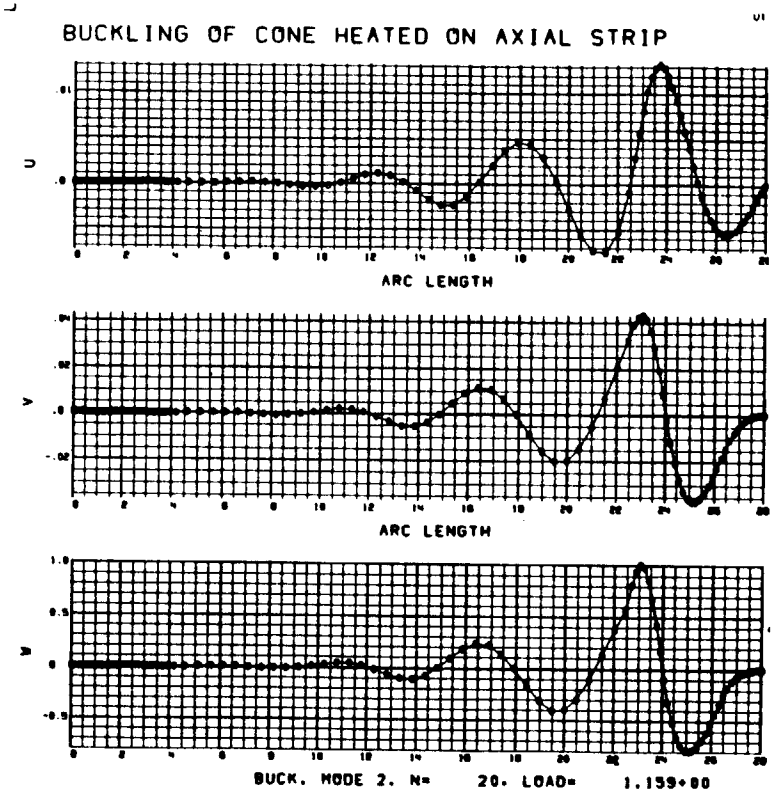
BUCKLING OF CONE HEATED ON AXIAL STRIP





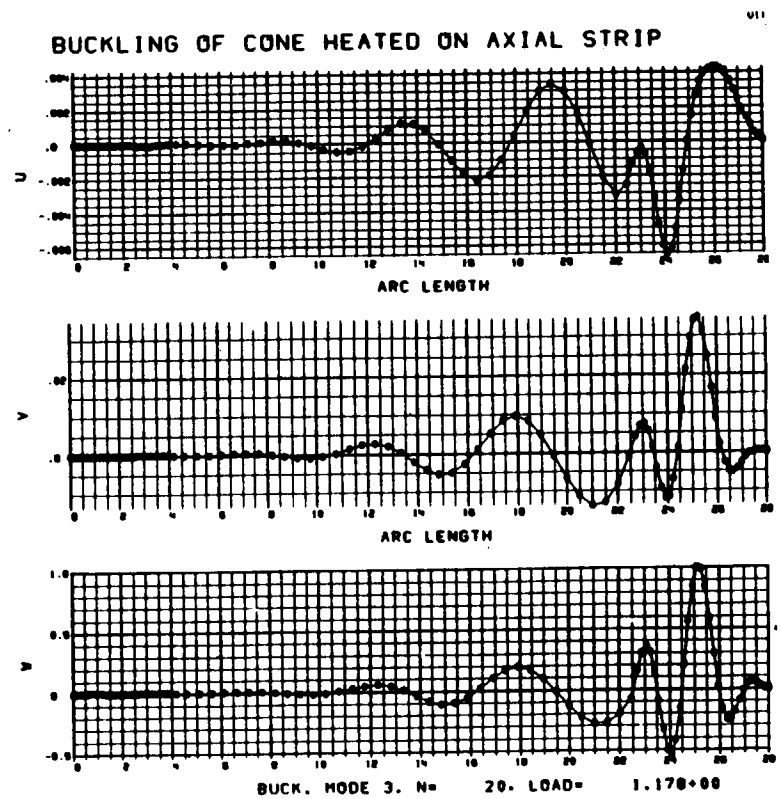


10	1.171+00	1.038-05	1.583-05	4.530-04
11	1.317+00	1.275-05	5.016-06	2.698-04
12	1.463+00	1.396-05	-1.196-05	-6.833-05
13	1.610+00	1.343-05	-3.367-05	-5.403-04
14	1.756+00	1.071-05	-5.727-05	-1.089-03
15	1.902+00	5.617-06	-7.869-05	-1.625-03
16	2.049+00	-1.667-06	-9.329-05	-2.039-03
17	2.195+00	-1.055-05	-9.661-05	-2.218-03
18	2.341+00	-2.004-05	-8.535-05	-2.067-03
19	2.488+00	-2.891-05	-5.834-05	-1.536-03
20	2.634+00	-3.581-05	-1.717-05	-6.424-04
21	2.780+00	-3.956-05	3.361-05	5.235-04
22	2.927+00	-3.930-05	8.695-05	1.797-03
23	3.073+00	-3.467-05	1.343-04	2.966-03
24	3.220+00	-2.584-05	1.674-04	3.809-03
25	3.366+00	-1.347-05	1.797-04	4.148-03
26	3.512+00	1.460-06	1.682-04	3.898-03
27	3.659+00	1.757-05	1.341-04	3.090-03
28	3.805+00	3.281-05	8.317-05	1.856-03
29	3.951+00	4.467-05	2.358-05	4.135-04
30	4.189+00	5.096-05	-5.724-05	-1.656-03
31	4.610+00	3.259-05	-1.347-04	-2.691-03
32	5.122+00	-1.144-05	-1.425-04	-2.834-03
33	5.634+00	-5.221-05	-6.001-05	-1.243-03
34	6.146+00	-6.799-05	9.098-05	1.721-03
35	6.659+00	-4.285-05	2.539-04	4.987-03
36	7.171+00	2.504-05	3.387-04	6.784-03
37	7.683+00	1.144-04	2.542-04	5.255-03
38	8.195+00	1.809-04	-3.831-05	-4.596-04
39	8.707+00	1.727-04	-4.766-04	-9.224-03
40	9.220+00	5.845-05	-8.841-04	-1.757-02
41	9.732+00	-1.464-04	-1.019-03	-2.063-02
42	1.024+01	-3.714-04	-6.823-04	-1.425-02
43	1.076+01	-5.088-04	1.585-04	2.433-03
44	1.127+01	-4.571-04	1.292-03	2.535-02
45	1.178+01	-1.743-04	2.287-03	4.582-02
46	1.229+01	2.892-04	2.635-03	5.352-02
47	1.280+01	7.897-04	1.975-03	4.084-02
48	1.332+01	1.128-03	2.826-04	7.034-03
49	1.383+01	1.122-03	-2.044-03	-4.009-02
50	1.434+01	6.875-04	-4.259-03	-8.548-02
51	1.485+01	-1.115-04	-5.494-03	-1.114-01
52	1.537+01	-1.060-03	-5.075-03	-1.040-01
53	1.588+01	-1.858-03	-2.805-03	-5.855-02
54	1.639+01	-2.213-03	8.794-04	1.612-02
55	1.690+01	-1.933-03	4.983-03	9.993-02
56	1.741+01	-1.011-03	8.252-03	1.672-01
57	1.793+01	3.516-04	9.564-03	1.947-01
58	1.844+01	1.800-03	8.297-03	1.696-01
59	1.895+01	2.923-03	4.564-03	9.403-02
60	1.946+01	3.371-03	-8.149-04	-1.528-02
61	1.998+01	2.956-03	-6.553-03	-1.318-01
62	2.049+01	1.703-03	-1.125-02	-2.267-01
63	2.100+01	-1.434-04	-1.371-02	-2.776-01
64	2.151+01	-2.068-03	-1.302-02	-2.725-01
65	2.202+01	-3.125-03	-8.315-03	-2.015-01
66	2.245+01	-2.515-03	-1.279-03	-8.182-02
67	2.271+01	-1.337-03	4.050-03	1.526-01



68	2.288+01	-6.610-04	6.719-03	2.950-01
69	2.305+01	-3.898-04	7.305-03	3.568-01
70	2.322+01	-7.334-04	5.356-03	3.051-01
71	2.339+01	-1.749-03	1.161-03	1.419-01
72	2.356+01	-3.252-03	-4.225-03	-9.335-02
73	2.373+01	-4.852-03	-9.206-03	-3.338-01
74	2.390+01	-6.090-03	-1.207-02	-5.038-01
75	2.407+01	-6.601-03	-1.151-02	-5.420-01
76	2.424+01	-6.237-03	-6.992-03	-4.208-01
77	2.441+01	-5.108-03	9.852-04	-1.558-01
78	2.459+01	-3.497-03	1.102-02	1.972-01
79	2.476+01	-1.706-03	2.115-02	5.587-01
80	2.493+01	2.164-05	2.936-02	8.468-01
81	2.510+01	1.510-03	3.411-02	1.000+00
82	2.527+01	2.659-03	3.467-02	9.922-01
83	2.544+01	3.443-03	3.120-02	8.372-01
84	2.561+01	3.912-03	2.469-02	5.814-01
85	2.578+01	4.154-03	1.662-02	2.896-01
86	2.595+01	4.255-03	8.576-03	2.589-02
87	2.612+01	4.255-03	1.881-03	-1.619-01
88	2.629+01	4.144-03	-2.680-03	-2.523-01
89	2.646+01	3.889-03	-4.939-03	-2.515-01
90	2.663+01	3.474-03	-5.256-03	-1.871-01
91	2.681+01	2.935-03	-4.315-03	-9.626-02
92	2.698+01	2.354-03	-2.869-03	-1.340-02
93	2.715+01	1.817-03	-1.511-03	3.951-02
94	2.732+01	1.345-03	-5.578-04	5.668-02
95	2.749+01	8.990-04	-6.128-05	4.635-02
96	2.766+01	4.718-04	9.267-05	2.430-02
97	2.783+01	1.580-04	6.888-05	6.128-03
98	2.795+01	2.483-05	1.735-05	4.548-04
99	2.800+01	4.272-20	-2.407-22	8.263-18

ELAPSED TIME = 01 1:13.956



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BEGINNING OF NEXT CASE


SPHERICAL CAP BUCKLING, INDIC=-2


STABILITY ANALYSIS WITH PLOT OF STABILITY DETERMINANT
NONLINEAR PREBUCKLING EFFECTS INCLUDED. SEE DET AND
NEX IN OUTPUT BELOW. INDIC CHANGED TO -1 WHEN DET
CHANGES SIGN.

          CALCULATIONS TERMINATE WHEN THE LOAD EX-
CEEDS THE MAXIMUM ALLOWABLE VALUE, OR WHEN THE COR-
RECTION FACTOR IS LESS THAN ERR, OR WHEN THE PREBUCK-
LING SOLUTION FAILS TO CONVERGE.


ANALYSIS TYPE =  -2, PRINT OPTION = 1, PLOT OPTION = 0, STRESS OPTION=  0, PRESTRESS CALCULATION OPTION = 1

  NUMBER OF SHELL SEGMENTS =  1

STRESS CALCULATED FOR CIRCUMFERENTIAL WAVES FROM      0 TO      0 IN INCREMENTS OF      1

INITIAL BUCKLING OR VIBRATION WAVE NO.=     2, MINIMUM WAVE NO.=     0, MAXIMUM WAVE NO.=    10, INCREMENT=     1

   1 EIGENVALUES SOUGHT FOR EACH CIRCUMFERENTIAL WAVE NUMBER.


                                        CONSTRAINT CONDITION DATA FOLLOW

SEG. POINT CONNECTED TO SEG. POINT     USTAR VSTAR WSTAR RETA     RADIAL DISC. D1(I)   AXIAL DISC. D2(I)

  1     1                  1     1        0     0     0     0       0.00000000           0.00000000
  1    20                  1    20        1     1     1     1       0.00000000           0.00000000

PRESSURE MULTIPLIER P =   1.8000+01, INCREMENT DP=   4.0000+00, TEMPERATURE MULT.TEMP=   0.0000   , INCREMENT DTEMP=   0.0000

INITIAL LOAD, FSTART =   1.8000+01, MAXIMUM LOAD, FMAX =    5.0000+01, STEP SIZE, DF=   4.0000+00
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SEGMENT NO. 1 IS SPHERICAL OR TOROIDAL.
END POINT COORDINATES (.0000 , .5447+01) AND (.1044+03, .0000) AND CENTER (.0000 , -.9946+03)
RADIUS = 1.0000+03 ALPHA1 = 1.8000+02 ALPHA2 = 1.7401+02 INCREASING ARC LENGTH CLOCKWISE

REFERENCE SURFACE GEOMETRY FOR SEGMENT NO. 1

STATION	ARC LENGTH	RAD	RADD	CUR1	CUR2	CUR10	Z
1	.00000000	.00000000	.10000000+01	-.99995300-03	-.99995300-03	.00000000	.50000000+00
2	.15137844+01	.15137623+01	.99999885+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
3	.55734791+01	.55734481+01	.99998447+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
4	.11009341+02	.11009096+02	.99993940+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
5	.16514012+02	.16513256+02	.99986366+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
6	.22018683+02	.22016886+02	.99975763+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
7	.27523353+02	.27519878+02	.99962129+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
8	.33028024+02	.33022007+02	.99945468+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
9	.38532694+02	.38523135+02	.99925778+00	-.99995300-03	-.99995302-03	.00000000	.50000000+00
10	.44037365+02	.44023126+02	.99903060+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
11	.49542036+02	.49521754+02	.99877316+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
12	.55046706+02	.55018910+02	.99848545+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
13	.60551377+02	.60514370+02	.99816750+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
14	.66056047+02	.66007997+02	.99781930+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
15	.71560718+02	.71499653+02	.99744087+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
16	.77065388+02	.76989113+02	.99703221+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
17	.82570058+02	.82476270+02	.99659335+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
18	.88074728+02	.87960899+02	.99612429+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
19	.93579398+02	.93442892+02	.99562506+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
20	.99015260+02	.98853545+02	.99510246+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
21	.10307495+03	.10289255+03	.99469297+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00
22	.10458874+03	.10439816+03	.99453609+00	-.99995300-03	-.99995300-03	.00000000	.50000000+00

PHYSICAL PROPERTIES OF SEGMENT NO. 1

ANALYSIS IS FOR A MONOCOQUE SHELL

MODULUS OF ELASTICITY= .30000+08 POISSON RATIO= .30000+00 SHELL DENSITY = .00000 THERMAL EXP COEF.= .00000

1	0.00000	5.00000-01	1.00000+00
2	1.51378+00	5.00000-01	1.00000+00
3	5.57348+00	5.00000-01	1.00000+00
4	1.10093+01	5.00000-01	1.00000+00
5	1.65140+01	5.00000-01	1.00000+00
6	2.20187+01	5.00000-01	1.00000+00
7	2.75234+01	5.00000-01	1.00000+00
8	3.30280+01	5.00000-01	1.00000+00
9	3.85327+01	5.00000-01	1.00000+00
10	4.40374+01	5.00000-01	1.00000+00
11	4.95420+01	5.00000-01	1.00000+00
12	5.50467+01	5.00000-01	1.00000+00
13	6.05514+01	5.00000-01	1.00000+00

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 14    6.60560+01    5.00000-01    1.00000+00
 15    7.15607+01    5.00000-01    1.00000+00
 16    7.70654+01    5.00000-01    1.00000+00
 17    8.25701+01    5.00000-01    1.00000+00
 18    8.80747+01    5.00000-01    1.00000+00
 19    9.35794+01    5.00000-01    1.00000+00
 20    9.90153+01    5.00000-01    1.00000+00
 21    1.03075+02    5.00000-01    1.00000+00
 22    1.04589+02    5.00000-01    1.00000+00


AXISYMMETRIC PRESTRESS INPUT CONSTRAINT CONDITIONS FOLLOW


CONSTRAINT NO.   1 SEGMENT NO.   1 POINT   1 CONNECTED TO SEGMENT NO.  1 POINT   1...TYPE OF CONSTRAINT =   1
CONSTRAINT NO.   2 SEGMENT NO.   1 POINT  22 CONNECTED TO SEGMENT NO.  1 POINT  22...TYPE OF CONSTRAINT =   2


LOCAL MATRIX DIMENSION=  5 OVERLAP=  3 NO. CONSTRAINT CONDS. PER CONSTRAINT POINT=  3 SYSTEM RANK=   53 NUMBER OF BLOCKS=   1


NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  1 EQUALS  53.   NO. OF CONSTRAINT PTS. EQUALS   2
BLOCK NUMBER=  1 LAST EQ. IN BLOCK=   53 LOWEST UNK IN BLOCK=    1. MAX. OFF-DIAGONAL WIDTH=   7


STABILITY,VIBRATION OR NON-SYMMETRIC STRESS INPUT CONSTRAINT CONDITIONS FOLLOW


CONSTRAINT NO.   1 SEGMENT NO.   1 POINT   1 CONNECTED TO SEGMENT NO.  1 POINT   1...TYPE OF CONSTRAINT =   1
CONSTRAINT NO.   2 SEGMENT NO.   1 POINT  22 CONNECTED TO SEGMENT NO.  1 POINT  22...TYPE OF CONSTRAINT =   2


LOCAL MATRIX DIMENSION=  7 OVERLAP=  4 NO. CONSTRAINT CONDS. PER CONSTRAINT POINT=  4 SYSTEM RANK=   78 NUMBER OF BLOCKS=   1


NUMBER OF EQUATIONS ASSOCIATED WITH SEGMENT NO.  1 EQUALS  78.   NO. OF CONSTRAINT PTS. EQUALS   2
BLOCK NUMBER=  1 LAST EQ. IN BLOCK=   78 LOWEST UNK IN BLOCK=    1. MAX. OFF-DIAGONAL WIDTH=  10


DATA READ IN AND PROCESSED FOR THIS CASE. LEAVING SUBROUTINE READIT
                        ELAPSED TIME =  0: 0: 0.715


ENTERING SUBROUTINE PRE. AXISYMMETRIC PRESTRESS CALCCULATOR


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PRESSURE MULTIPLIER,P =      1.000000+01
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ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX,      2 WAVES

ANALYSIS TYPE (INDIC) = -2  NEWTON-RAPHSON ITERATIONS REQUIRED FOR LAST PRESTRESS SOLUTION = 3

VALUE OF STABILITY DETERMINANT =    3.6140+01 TIMES TEN TO THE  300 POWER

PRESSURE,TEMPERATURE RISE, AND LINE LOADS FOLLOW

PRESSURE MULTIPLIER =    1.800000+01 TEMPERATURE MULTIPLIER =     0.000000
LINE LOADS FOLLOW

                        ELAPSED TIME =  0: 0: 2.105

ENTERING SUBROUTINE PRE, AXISYMMETRIC PRESTRESS CALCCULATOR


****************************************

PRESSURE MULTIPLIER,P =     2.200000+01


ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX,      2 WAVES

ANALYSIS TYPE (INDIC) = -2  NEWTON-RAPHSON ITERATIONS REQUIRED FOR LAST PRESTRESS SOLUTION = 2

VALUE OF STABILITY DETERMINANT =    2.4870+01 TIMES TEN TO THE  300 POWER

PRESSURE,TEMPERATURE RISE, AND LINE LOADS FOLLOW

PRESSURE MULTIPLIER =    2.200000+01 TEMPERATURE MULTIPLIER =     0.000000
LINE LOADS FOLLOW
```

```
                    ELAPSED TIME =  0: 0: 3.298

ENTERING SUBROUTINE PRE. AXISYMMETRIC PRESTRESS CALCCULATOR


****************************************

PRESSURE MULTIPLIER,P =     2.600000+01


ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX. LOAD-GEOMETRIC MATRIX.L**2 MATRIX. OR MASS MATRIX.      2 WAVES


ANALYSIS TYPE (INDIC) = -2  NEWTON-RAPHSON ITERATIONS REQUIRED FOR LAST PRESTRESS SOLUTION = 2

VALUE OF STABILITY DETERMINANT =    1.2837+01 TIMES TEN TO THE  300 POWER

PRESSURE.TEMPERATURE RISE. AND LINE LOADS FOLLOW

PRESSURE MULTIPLIER =    2.600000+01 TEMPERATURE MULTIPLIER =     0.000000
LINE LOADS FOLLOW

                    ELAPSED TIME =  0: 0: 4.496

ENTERING SUBROUTINE PRE. AXISYMMETRIC PRESTRESS CALCCULATOR


****************************************

PRESSURE MULTIPLIER,P =     3.000000+01
```

```
ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX,      2 WAVES

ANALYSIS TYPE (INDIC) = -2  NEWTON-RAPHSON ITERATIONS REQUIRED FOR LAST PRESTRESS SOLUTION = 3

VALUE OF STABILITY DETERMINANT =   -1.0548+01 TIMES TEN TO THE  300 POWER

PRESSURE,TEMPERATURE RISE, AND LINE LOADS FOLLOW

PRESSURE MULTIPLIER =    3.000000+01 TEMPERATURE MULTIPLIER =     0.000000
LINE LOADS FOLLOW

                        ELAPSED TIME =  0: 0: 5.879

ENTERING SUBROUTINE PRE, AXISYMMETRIC PRESTRESS CALCCULATOR


****************************************

PRESSURE MULTIPLIER,P =     2.819572+01


ENTERING SUBROUTINE PRE, AXISYMMETRIC PRESTRESS CALCCULAT


****************************************

PRESSURE MULTIPLIER,P =     3.000000+01


ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX,      2 WAVES
 CIRCUMFERENTIAL WAVES,N=     2,  ITERATION NO.=  4, EIGENVALUE (FACTOR TO BE MULT. BY LOAD STEP)=  -4.33571-02
```

```
ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX,      3 WAVES
 CIRCUMFERENTIAL WAVES,N=     3,  ITERATION NO.=  6, EIGENVALUE (FACTOR TO BE MULT. BY LOAD STEP)=   1.07724+00

ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX,      1 WAVES
 CIRCUMFERENTIAL WAVES,N=     1,  ITERATION NO.=  9, EIGENVALUE (FACTOR TO BE MULT. BY LOAD STEP)=   2.95544+00

ENTERING SUBROUTINE PRE, AXISYMMETRIC PRESTRESS CALCCULATOR


****************************************

PRESSURE MULTIPLIER,P =     2.81174+01


ENTERING SUBROUTINE PRE, AXISYMMETRIC PRESTRESS CALCCULATOR


****************************************

PRESSURE MULTIPLIER,P =     2.81456+01


ENTER SUBROUTINE ARRAYS TO CALCULATE STIFFNESS MATRIX, LOAD-GEOMETRIC MATRIX,L**2 MATRIX, OR MASS MATRIX,      2 WAVES
 CIRCUMFERENTIAL WAVES,N=     2,  ITERATION NO.=  4, EIGENVALUE (FACTOR TO BE MULT. BY LOAD STEP)=  -1.99561-01


ANALYSIS TYPE (INDIC) = -1  NEWTON-RAPHSON ITERATIONS REQUIRED FOR LAST PRESTRESS SOLUTION = 1

VALUE OF STABILITY DETERMINANT =   -1.0548+01 TIMES TEN TO THE  300 POWER

PRESSURE,TEMPERATURE RISE, AND LINE LOADS FOLLOW

PRESSURE MULTIPLIER =    2.81456+01 TEMPERATURE MULTIPLIER =     0.000000
```

LINE LOADS FOLLOW

PREBUCKLING DISPLACEMENTS AND STRESS RESULTANTS CORRESPONDING TO CRITICAL LOAD

AXISYMMETRIC PRESTRESS DISTRIBUTION FOR SEGMENT 1

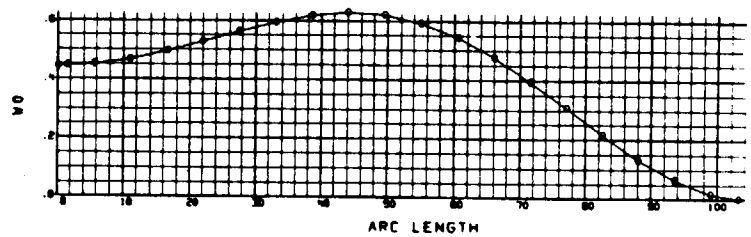
POINT	STATION	WO	UO	BETA	UV	N10	N20	M10	M20
1	0.000	4.433-01	1.220-09	-2.512-13	-4.433-01	-1.395+04	-1.395+04	1.590+03	1.590+03
2	1.514+00	4.437-01	1.773-04	6.373-04	-4.437-01	-1.399+04	-1.399+04	1.496+03	1.501+03
3	5.573+00	4.498-01	6.598-04	2.230-03	-4.498-01	-1.407+04	-1.416+04	1.369+03	1.410+03
4	1.101+01	4.675-01	1.341-03	4.093-03	-4.675-01	-1.424+04	-1.464+04	1.152+03	1.274+03
5	1.651+01	4.947-01	2.115-03	5.488-03	-4.946-01	-1.449+04	-1.534+04	8.191+02	1.076+03
6	2.202+01	5.279-01	3.014-03	6.191-03	-5.278-01	-1.481+04	-1.617+04	3.860+02	8.178+02
7	2.752+01	5.628-01	4.077-03	6.047-03	-5.627-01	-1.516+04	-1.699+04	-1.191+02	5.125+02
8	3.303+01	5.944-01	5.316-03	4.969-03	-5.943-01	-1.552+04	-1.766+04	-6.534+02	1.791+02
9	3.853+01	6.175-01	6.710-03	2.965-03	-6.173-01	-1.585+04	-1.806+04	-1.162+03	-1.572+02
10	4.404+01	6.270-01	8.183-03	1.505-04	-6.267-01	-1.613+04	-1.808+04	-1.583+03	-4.673+02
11	4.954+01	6.190-01	9.605-03	-3.244-03	-6.187-01	-1.632+04	-1.765+04	-1.858+03	-7.218+02
12	5.505+01	5.912-01	1.080-02	-6.890-03	-5.909-01	-1.641+04	-1.678+04	-1.941+03	-8.957+02
13	6.055+01	5.430-01	1.159-02	-1.040-02	-5.427-01	-1.638+04	-1.547+04	-1.808+03	-9.720+02
14	6.606+01	4.765-01	1.181-02	-1.337-02	-4.763-01	-1.624+04	-1.381+04	-1.464+03	-9.449+02
15	7.156+01	3.957-01	1.139-02	-1.543-02	-3.955-01	-1.598+04	-1.190+04	-9.379+02	-8.197+02
16	7.707+01	3.066-01	1.033-02	-1.629-02	-3.065-01	-1.561+04	-9.867+03	-2.786+02	-6.112+02
17	8.257+01	2.163-01	8.728-03	-1.578-02	-2.163-01	-1.516+04	-7.874+03	4.552+02	-3.401+02
18	8.807+01	1.327-01	6.731-03	-1.383-02	-1.328-01	-1.465+04	-6.093+03	1.206+03	-2.944+01
19	9.358+01	6.397-02	4.516-03	-1.047-02	-6.412-02	-1.411+04	-4.710+03	1.924+03	2.987+02
20	9.902+01	1.786-02	2.269-03	-5.888-03	-1.800-02	-1.358+04	-3.924+03	2.569+03	6.230+02
21	1.031+02	1.323-03	6.076-04	-1.745-03	-1.378-03	-1.320+04	-3.823+03	3.148+03	9.025+02
22	1.046+02	-2.844-19	0.000	-1.514-11	2.829-19	-1.306+04	-3.919+03	3.203+03	9.612+02

BUCKLING MODE FOR 2 CIRCUMFERENTIAL WAVES

BUCKLING MODE FOR SEGMENT 1

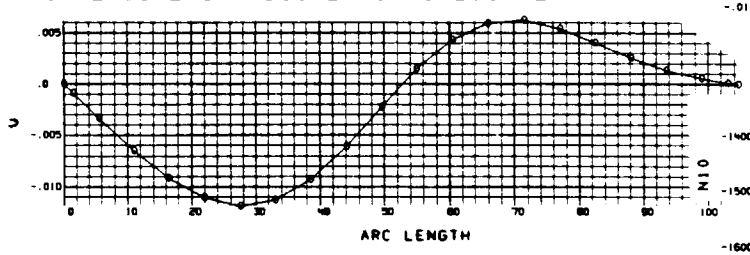
POINT	STATION	U	V	W
1	0.000	7.412-22	2.065-21	2.412-21
2	1.514+00	-9.368-04	-9.381-04	2.104-03
3	5.573+00	-3.389-03	-3.415-03	3.176-02
4	1.101+01	-6.480-03	-6.677-03	1.198-01
5	1.651+01	-9.166-03	-9.896-03	2.565-01
6	2.202+01	-1.109-02	-1.294-02	4.244-01

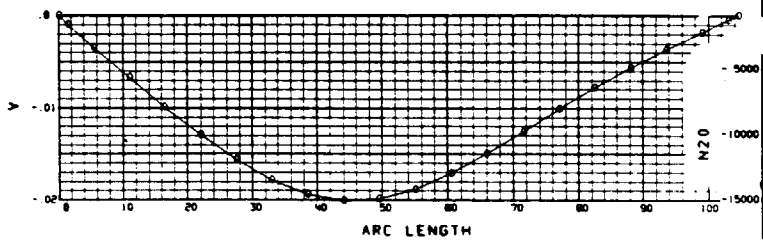
SPHERICAL CAP BUCKLING, INDIC=-2

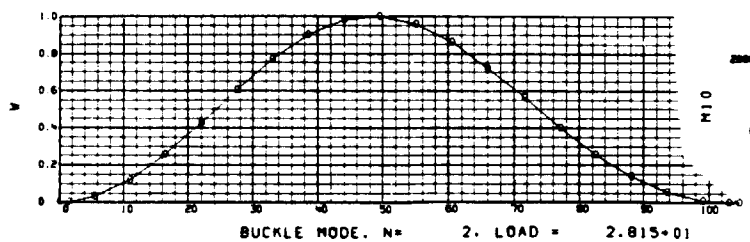


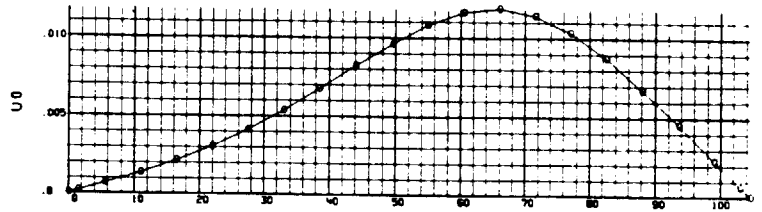
7	2.752+01	-1.190-02	-1.567-02	6.023-01
8	3.303+01	-1.132-02	-1.790-02	7.676-01
9	3.853+01	-9.303-03	-1.943-02	8.990-01
10	4.404+01	-6.099-03	-2.011-02	9.798-01
11	4.954+01	-2.269-03	-1.990-02	1.000+00
12	5.505+01	1.441-03	-1.885-02	9.581-01
13	6.055+01	4.323-03	-1.712-02	8.613-01
14	6.606+01	5.923-03	-1.493-02	7.235-01
15	7.156+01	6.171-03	-1.254-02	5.637-01
16	7.707+01	5.356-03	-1.013-02	4.015-01
17	8.257+01	3.973-03	-7.824-03	2.549-01
18	8.807+01	2.518-03	-5.680-03	1.373-01
19	9.358+01	1.330-03	-3.690-03	5.597-02
20	9.902+01	5.268-04	-1.836-03	1.225-02
21	1.031+02	1.163-04	-4.939-04	8.965-04
22	1.046+02	-1.298-19	-7.226-21	-1.525-18

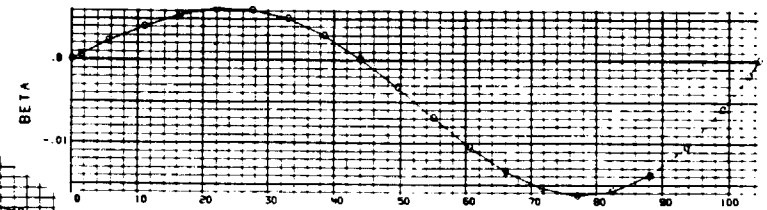
SPHERICAL CAP BUCKLING. INDIC=-2

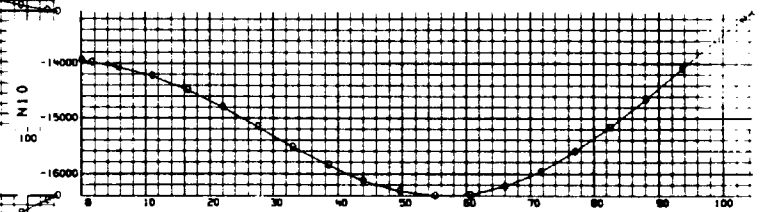


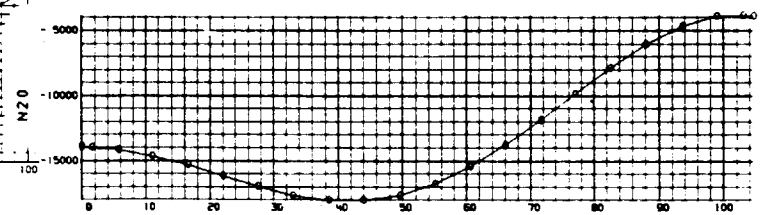


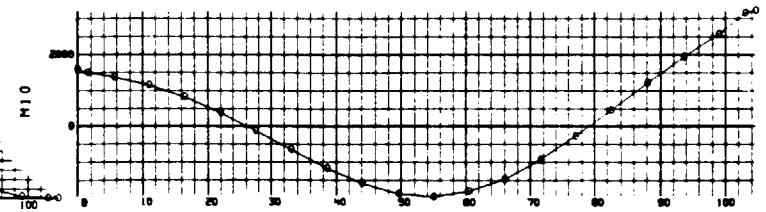












APPENDIX B

TABLES AND FIGURES

COLUMN
WORK SHEET

TABLE 1.1

CONSTRAINT CONDITION INPUT CORRESPONDING TO FIG. 2

LOCATION				YES(1) or NO(0) CONSTRAINT			DISCONTINUITIES	
SEG	PT.	SEG	PT.	u^*	v^*	w^*	x D1	D2
001	001	001	001	1	1	1	1 + 0.	+ 0.
001	015	002	001	1	1	1	1 + 0.	+ 0.
001	015	003	001	1	1	1	1 + 0.	+ 0.
003	015	003	015	1	1	1	1 + 0.	+ 0.
002	015	004	001	1	1	1	1 + 0.	+ 0.
004	015	005	001	1	1	1	1 + 0.	+ 0.
004	015	006	001	1	1	1	1 + 0.	+ 0.
005	015	005	015	1	1	1	1 + 0.	+ 0.
006	012	007	001	1	1	1	1 + 0.	+ 0.
006	015	008	001	1	1	1	1 + 0.	+ 0.
007	015	007	015	1	1	1	1 + 0.	+ 0.
008	015	008	015	1	1	1	1 + 0.	+ 0.

Table 1-2

BOSOR4 LOADS NOMENCLATURE

LOAD CLASS	LOAD TYPE		APPROPRIATE LOAD MAGNITUDES FOR VARIOUS VALUES OF INDIC			
			INDIC = -2, -1, 0, and 1	INDIC = 2	INDIC = 3	INDIC = 4
1 Mechanical Line Loads	Initial or fixed	Axial	V(I)	V(I)	V(I)*PLIN1(L,ISEG)	not applicable
		Shear	not applicable	not applicable	S(I)*PLIN2(L,ISEG)	not applicable
		Radial	H(I)	H(I)	H(I)*PLIN1(L,ISEG)	not applicable
		Moment	M(I)	M(I)	M(I)*PLIN1(L,ISEG)	not applicable
	Increment or eigenv. parameter	Axial	DV(I)	not applicable	not applicable	V(I)*PLIN1(L,ISEG)
		Shear	not applicable	not applicable	not applicable	S(I)*PLIN2(L,ISEG)
		Radial	DH(I)	not applicable	not applicable	H(I)*PLIN1(L,ISEG)
		Moment	DM(I)	not applicable	not applicable	M(I)*PLIN1(L,ISEG)
2 Thermal Line Loads	Initial or fixed	Hoop	TNR(I)*TEMP	TNR(I)*TEMP	TNR(I)*TLIN(L,ISEG)	not applicable
		x-Moment	TMX(I)*TEMP	TMX(I)*TEMP	TMX(I)*TLIN(L,ISEG)	not applicable
		y-Moment	TMRY(I)*TEMP	TMRY(I)*TEMP	TMRY(I)*TLIN(L,ISEG)	not applicable
	Increment or eigenv. parameter	Hoop	TNR(I)*DTEMP	not applicable	not applicable	TNR(I)*TLIN(L,ISEG)
		x-Moment	TMX(I)*DTEMP	not applicable	not applicable	TMX(I)*TLIN(L,ISEG)
		y-Moment	TMRY(I)*DTEMP	not applicable	not applicable	TMRY(I)*TLIN(L,ISEG)
3 Surface Traction & Pressure	Initial or fixed	Merid.	P*PT(J) or P*(P21+...)	same as INDIC=1	PT(J)*PDIST1(L,ISEG)	not applicable
		Circum.	not applicable	same as INDIC=1	PC(J)*PDIST2(L,ISEG)	not applicable
		Normal	P*PN(J) or P*(P31+...)	same as INDIC=1	PN(J)*PDIST1(L,ISEG)	not applicable
	Increment or eigenv. parameter	Merid.	DP*PT(J) or DP*(P21+..)	not applicable	not applicable	PT(J)*PDIST1(L,ISEG)
		Circum.	not applicable	not applicable	not applicable	PC(J)*PDIST2(L,ISEG)
		Normal	DP*PN(J) or DP*(P31+..)	not applicable	not applicable	PN(J)*PDIST1(L,ISEG)
4 Temperature Distribution	Initial or fixed	Temp. rise at points as function of dist. z from reference surface	FUNCT(T1(J),T2(J),T3(J),z)*TEMP or FUNCT(T11+..,T21+..,T31+..,z)*TEMP		FUNCT(T1,T2,T3,z)* TDIST(L,ISEG)	not applicable
	Increment or eigenv. parameter		FUNCT(T1,T2,T3,z)*DTEMP or FUNCT(T11+,T21+,T31+,z)* DTEMP	not applicable	not applicable	FUNCT(T1,T2,T3,z)* TDIST(L,ISEG)

Sign convention for loads shown in Fig. 21 and given in Table 1.3

I = Ith discrete ring in current segment, ISEG

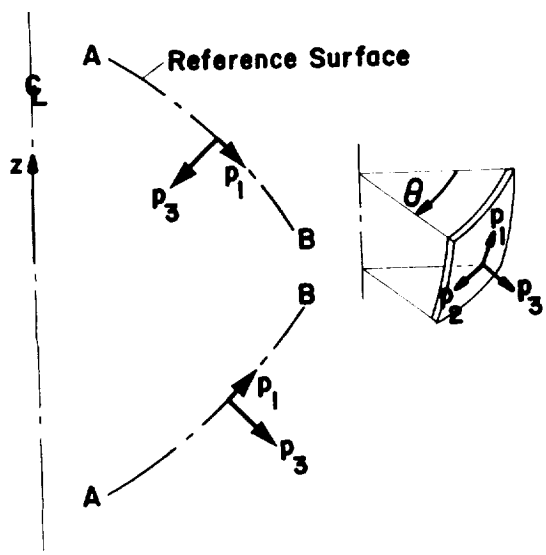
L = Lth harmonic; number of circumferential waves, N, not necessarily equal to L; e.g. L = 1, 2, 3, 4, 5; N = 5, 7, 9, 11, 13

J = Jth point in current segment, ISEG, for which distribution of load or temperature is called out

FUNCT (T1,T2,T3,z) given for three values of NTGRAD on Page B-13

TABLE 1.3 SIGN CONVENTION AND ORIENTATION OF LOADS

LOAD CLASS	LOAD TYPE	NAME	SIGN CONVENTION (axis of revolution vertical, shell meridian to right of axis)	CIRCUMFERENTIAL VARIATION FOR NONSYMMETRIC LOADS	
				(positive n)	(zero or) (negative n)
Mechanical Line Loads	Axial	V	positive downward	Sin nθ	Cos nθ
	Shear	S	positive out of paper	Cos nθ	Sin nθ
	Radial	H	positive away from axis	Sin nθ	Cos nθ
	Moment	M	positive clockwise	Sin nθ	Cos nθ
Thermal Line Loads	Hoop	N_r^T	see page B-11, TNR(I)	Sin nθ	Cos nθ
	x-Moment	M_x^T	see page B-11, TMX(I)	Sin nθ	Cos nθ
	y-Moment	M_y^T	see page B-11, TMRY(I)	Sin nθ	Cos nθ
Surface Traction & Pressure	Meridional traction	p_1	positive parallel to increasing arc length, s	Sin nθ	Cos nθ
	Circumfer. traction	p_2	positive out of paper, in same direction as v	Cos nθ	Sin nθ
	Normal pressure	p_3	positive to right of increasing arc length, s	Sin nθ	Cos nθ
Temperature Distribution	Temp. rise	T	positive for temperature above zero-stress temp.	Sin nθ	Cos nθ



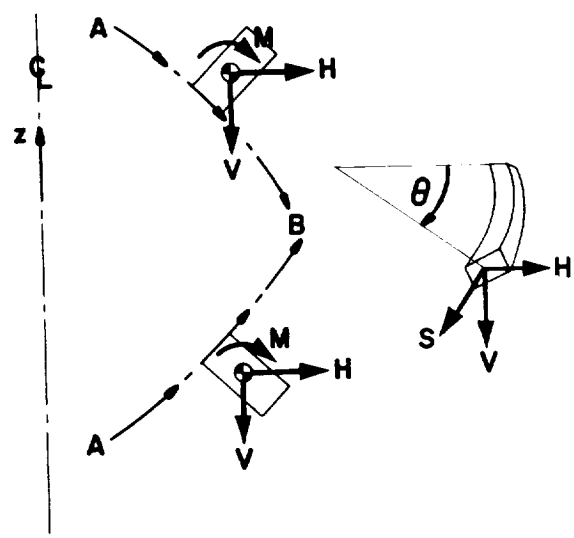


TABLE 2

INPUT DATA FOR BOSOR4. INTEGER FORMAT 10I6; FLOATING PT. FORMAT 6E12.8

- Read TITLE
- Read INDIC, NPRT, NLAST, ISTRES, IPRE
- Read NSEG, NCOND, IBOUND, IRIGID
- Read NSTART, NFIN, INCR (Blank if INDIC = -2, -1, 0, 1, 2)
- Read NOB, NMINB, NMAXB, INCRB, NVEC (Blank if INDIC = 0,3)
- Read NDIST, NCIRC, NTHETA
- Read ITHETA(I), I = 1, NCIRC
- Read THETA(I), I = 1, NDIST

  (Blank if INDIC = -2, -1, 0, 1, 2)
- Read THETAM, THETAS, PREROT (Blank if INDIC = 0, 2)
- Read ((IFIX(I,J), J = 1,6), D1(I), D2(I), I = 1, NCOND)

  If IBOUND≠0 and INDIC= -2,-1,1, or 2 ● Read ((IFIXB(I,J), J = 3,6), I = 1, NCOND)

  Note

  If IRIGID ≠ 0 ● Read (ISTOPO(I), I = 1,6)

  If IRIGID ≠ 0 ● Read (ISTOP1(I), I = 1,6)
- Read P, DP, TEMP, DTEMP
- Read FSTART, FMAX, DF

  (Blank if INDIC = 3 or INDIC = 4)

10 Do 5000 ISEG = 1, NSEG

- Read NMESH, NTYPEH, INTVAL

  If NTYPEH = 1 ● Read NHVALU
  ● Read (IHVALU(I), I = 1, NHVALU)
  ● Read (HVALU(I), I = 1, NHVALU)

  If NTYPEH = 2 ● Read (HVALU(I), I = 1, NMESH - 1)

  If NTYPEH = 3 No cards read, constant mesh spacing.
- Read shell geometry parameters, imperfection shapes, location of reference surface relative to shell inner surface. (go to 15)
- Read discrete ring parameters; number of rings, locations of rings, cross section properties and material properties. (go to 25)
- Read load parameters: mechanical line loads, thermal line loads, mechanical distributed loads, thermal distributed loads, prestress distributions. (go to 100)
- Read shell wall construction parameters: monocoque, layered, fiber-wound, corrugated, semi-sandwich corrugated, temperature-dependent layered, all with or without rings and stringers which are "smeared out" in the analysis. (go to 3000)

5000 Continue

TITLE .. 72 or less alphanumeric characters, first 41 of which appear on plots.

INDIC .. -2 = determinant "plot"; -1 = bifurcation buckling with nonlinear prestress; 0 = nonlinear stress analysis; 1 = linear buckling, several eigenvalues/N; 2= modal vibration; 3 = linear stress; 4 = linear buckling with non-symmetric prestress. See Section 1.1, samples cases in Appendix A, Section 4.2.

NPRT .. 1 = minimum printout; 2 = medium printout; 3 = maximum printout. (Use 2 almost always.)

NLAST .. 0 = plots provided for this case; -1 = no plots this case. (SC 4020 plot package required)

ISTRES .. 0 = stress resultants and displacements; 1 = stresses and displacements (1 with monocoque isotropic only).

IPRE .. meaningful only if INDIC = 4: 0 = prestress read in from cards; 1 = prestress computed internally.

NSEG .. number of shell segments (less than 25).

NCOND .. number of points at which constraint conditions are to be imposed (less than 50).

IBOUND .. 0 = buckling, vibration constraint conditions same as those for axisymmetric prestress analysis; 1 = different fr.

IRIGID .. 0 = no additional rigid body prevention constraints necessary; 1 = additional such constraints are necessary. (See Sec. 1.4)

NSTART .. starting circumferential harmonic for nonsymmetric stress analysis. (See Sec. 1.5, Table 1.3, pp 2-32, 2-33) (Maximum of 20 harmonics permitted.)

NFIN .. ending circumferential harmonic for nonsymmetric stress analysis.

INCR .. increment or decrement in circumferential waves for nonsymmetric stress analysis.

NOB .. initial circumferential wave number in buckling or vibration analysis.

NMINB .. minimum circumferential wave number in buckling or vibration analysis. (see pg 4-2, 4-3, 4-4)

NMAXB .. maximum circumferential wave number in buckling or vibration analysis.

INCRB .. increment in circumferential wave number in buckling or vibration analysis.

NVEC .. number of eigenvalues to be calculated for each circumferential wave, N (maximum of 20 permitted).

NDIST .. number of circumferential stations for which meridional distributions will be printed and plotted (less than 20).

NCIRC .. number of meridional stations for which circumferential distributions will be printed and plotted (less than 20).

NTHETA .. number of points in the output for circumferential distributions (less than 100) (NTHETA*NCIRC*9 less than 4500)

THETA .. meridional stations for circumferential distributions: e.g., 001010 means segment 1, mesh point 10.

ETA .. circumferential stations in degrees for which meridional distributions will be printed and plotted (≤ THETAM).

THETAM .. circum. dist. printed and plotted for 0 ≤ θ ≤ THETAM (deg). Loads expanded in Fourier series in interval - THETAM ≤ θ ≤ THETAM. Meaningful only if INDIC = 3 or 4.

THETAS .. meridional prestress at θ = THETAS used in stability analysis with option INDIC = 4, IPRE = 1.

PREROT .. 0.0 = prebuckling rotations included in stability analysis; 1.0 = not included.

IFIX .. constraint condition matrix; see Table 1.1 for example; also see Section 1.4, and immediately below.

D1 .. radial component of distance from constrained point to reference surface at "minus" side of point (see Fig. 19).

D2 .. axial component of distance from constrained point to reference surface at "minus" side of point (see Fig. 19). D1 and D2, as seen in Fig. 19, are also the radial and axial components of discontinuity between two shell segm. (See Section 1.4, also page 4-4)

Examples of constraint condition cards follow:

Input Card Column No.	1	6		12	18	24	30	36	48	60	Comments
(IFIX(1, J), J=1, 6), D1(1), D2(1)	001	001	001	001	0	1	1	0	+1.75	+1.25	+1	bound. cond. card
(IFIX(2, J), J=1, 6), D1(2), D2(2)	001	095	002	001	1	1	1	1	+0	+0	+0	junct. compat. card
(IFIX(3, J), J=1, 6), D1(3), D2(3)	001	095	003	001	1	1	1	1	+0	+0	+0	branch compat. card
Definitions	Seg	Pt	Seg	Pt	u*	v*	w*	X	D1	D2	
Identifications	location				variables constrained				radial disc.	axial disc.	

Translation of constraint #3: Seg. 1, point 95 is connected to Seg. 3, point 1. All variables are compatible.

IFIXB .. constraint condition matrix for bifurcation buckling and vibration, if different from IFIX. J = 3, 6 corresponds to the four integers in columns 18, 24, 30, and 36 above. However, on this card these values are punched in columns 6, 12, 18, and 24, respectively. Used only if IBOUND ≠ 0.

ISTOP0 .. constraint condition for prevention of axisymmetric rigid body modes (N = 0). First 12 columns must be the same as one of the constraint conditions defined by IFIX. Used only if IRIGID ≠ 0. (See Section 1.4)

ISTOP1 .. constraint condition for prevention of rigid body modes associated with one circumferential wave (N = 1). First 12 columns must be the same as one of the constraint conditions defined by IFIX. Use only if IRIGID ≠ 0. (Sec. 1.4)

P .... pressure or surface traction multiplier. Actual pressure p(s) = P*f(s), in which f(s) is read in later for each shell segment (see table entitled "Pressure and Surface Tractions on Shell Segment, ISEG"). This quantity is associated with "fixed" loads. See Sec. 1.5, Tbls 1.2, 1.3 for further explanation, examples, sign convention.

DP ... pressure or surface traction increment multiplier. Actual increment = dp(s) = DP*f(s). With INDIC = 0 or -2 the first load treated is P*f(s), the second is (P+DP)*f(s), and so on, up to FMAX*f(s), where FMAX is defined below. With INDIC = -1 or 1, DP is an eigenvalue parameter. See test cases 1 and 2, Sec. 1.5, Tbls 1.2, 1.3

TEMP .. temperature rise multiplier. See explanation for P above.

DTEMP .. temperature rise increment multiplier. See explanation for DP above.

FSTART .. starting value of load multiplier. May represent pressure, temperature or discrete ring thermal or mechanical line load. See Sec. 1.5, sample case 3. Effective only if INDIC = 0, -2.

FMAX .. maximum value of load multiplier. Effective only if INDIC = 0 or -2.

DF ... load increment multiplier. Use correct signs for P, DP, TEMP, DTEMP, FSTART, FMAX, DF, not absolute values. Effective only if INDIC = 0, -2. See Section 1.5.

NMESH .. number of w-mesh points in ISEGth segment, not including fictitious points (max. 98/segment, total = 450).

NTYPEH .. 1, 2 variable mesh spacing; 3 = constant mesh spacing.

INTVAL .. used with INDIC = 3 and INDIC = 4 options: meridional distributions printed out for every INTVALth mesh point.

NHVALU .. number of values of mesh spacing (distance between adjacent w-points) which will be read in. (Max. = 50)

IHVALU .. mesh point callouts for which spacing is to be given. Spacing will vary linearly between these callouts.

HVALU .. mesh point spacing at callout points. HVALU(I) = meridional arc length between W(IHVALU(I)) and W(IHVALU(I) + 1). See Fig. 32. Only relative sizes of spacing required, not absolute values. (See Fig. 32)

SHELL GEOMETRY INPUT PARAMETERS FOR SHELL SEGMENT, ISEG

```
15 ● Read  NSHAPE, NTYPEZ, IMP

   If NSHAPE = 1 ● Read R1, Z1, R2, Z2

   If NSHAPE = 2 ● Read R1, Z1, R2, Z2, RC, ZC
                 ● Read SROT

   If NSHAPE = 3 ● Read  ARCLTH
                 ● Read  NGVAL
                 ● Read (IGVAL(I), I = 1, NGVAL )
                 ● Read ( RIN(I),  I = 1, NGVAL )
                 ● Read (RDIN(I),  I = 1, NGVAL )
                 ● Read (C1IN(I),  I = 1, NGVAL )
                 ● Read (C2IN(I),  I = 1, NGVAL )
                 ● Read (C1DIN(I), I = 1, NGVAL )

   If NSHAPE = 4 ● Read  NST

                   If NST = 1 ● Read  NRZIN
                              ● Read (Z(I), R(I), I = 1, NRZIN )

                   If NST = 2 ● Read  NRZIN
                              ● Read  RSTART, A, B, PHIS, PHIE
                              ● Read  CM, CN

                   If NST = 3 ● Read  NRZIN
                              ● Read  ALPHA, ROT
                              ● Read (DZ(I), R(I), I = 1, NRZIN )

                   If NST = 4 ● Read  ZMAX, XMAX, ZA, ZB, ZNUMB, ALPHAT

   If NSHAPE = 5   Dummy geometry subroutine, no cards read.

   If IMP ≠ 0   ●  Read  ITYPE

                   If ITYPE = 1 ● Read  FM, C, FLMIN, FLMAX

                   If ITYPE = 2 ● Read  WO, WLNGTH

                   If ITYPE = 3 ● Dummy position, no cards read.

   If NTYPEZ = 1 ● Read  NZVALU
                 ● Call  STA(NZVALU) (See Page B-26 for input data read in from STA )
                 ● Read  (ZVAL(I), I = 1, NZVALU )
   If NTYPEZ = 2 ● Read  ZSURF1, ZSURF2, ZSURF3, ZSURF4, ZSURF5
   If NTYPEZ = 3 ● Read  ZVAL

   Geometry parameters have now been read in for current shell segment,
   ISEG - go to 25
```

SHELL GEOMETRY INPUT PARAMETERS FOR SHELL SEGMENT, ISEG

NSHAPE .... 1 = cone or cylinder; 2 = spherical or ogival or toroidal segment; 3 = general shape; 4 = general shape.

NTYPEZ ... 1 = reference surface is variable distance from "inner" surface; 2 = reference surface is variable distance from "inner" surface, with variation given by a certain function (see below); 3 = reference surface a constant distance from "inner" surface. See Section 1.2 for definition of "inner" surface, examples. See Figure 34.

IMP ..... 0 = no imperfection; 1 = yes imperfection. (Use 1 with care, not checked out.)

R1 ..... radius from axis of revolution to beginning of reference surface (radius of parallel circle of shell) (see below).

Z1 ..... axial distance from some datum to beginning of reference surface (see below).

R2 ..... radius from axis of revolution to end of reference surface (see below).

Z2 ..... axial distance from datum to end of reference surface (see below).

RC ..... radius from axis of revolution to center of meridional curvature for spherical and ogival and toroidal shells (see below).

ZC ..... axial distance from datum to center of meridional curvature for spherical, ogival, toroidal shells (see below).

SROT ..... + 1.0 if direction from (R1, Z1) to (R2, Z2) represents clockwise motion about (RC, ZC); -1.0 otherwise.

ARCLTH ... arc length of segment.

NGVAL .... number of values for which r, r', $1/R_1$, $1/R_2$, and $(1/R_1)'$ will be read in as input data (maximum = 50).

IGVAL ..... mesh point callouts for which r, r', $1/R_1$, $1/R_2$, and $(1/R_1)'$ will be read in.

RIN ..... values of parallel circle radius, r, at callouts IGVAL.

RDIN ..... values of derivative of r with respect to arc length s (r') at the callout points IGVAL.

C1IN ..... meridional curvature $1/R_1$ at the callout points IGVAL.

C2IN ..... normal circumferential curvature $1/R_2$ at the callout points.

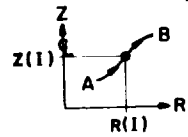
C1DIN ..... derivative of meridional curvature with respect to arc length s $(1/R_1)'$ at the callout points IGVAL.

NST ..... 1 = general shell shape for which cartesian coordinates of reference surface will be given; 2 = shell with local weld "sinkage"; 3 = spherical shell with imperfection at apex; 4 = toroidal segment with elliptic cross-section. See Figure 33 and below for illustrations of these types of shell segments.

NRZIN ..... number of (R, Z) pairs or (R, DZ) pairs to be read in if NST = 1 or 3; otherwise number of points for spline fit (max = 100).

Z(I) ..... axial coordinates of reference surface curve. See Figure

R(I) ..... radial coordinates of reference surface curve. See Figure



RSTART ... See Figure 33d.

A ..... See Figure 33d.

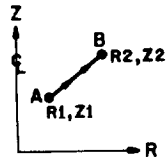
B ..... See Figure 33d.

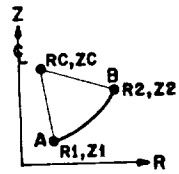
PHIS ..... See Figure 33d

PHIE ..... See Figure 33d.

CM ..... See Figure 33d.

CN ..... See Figure 33d.



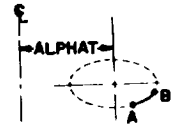


ALPHA .... See Figure 33d.

ROT ..... See Figure 33d.

DZ(I) ..... See Figure 33d.

R(I) ..... See Figure 33d.



ZMAX ..... axial dimension of ellipse (see Fig. 33e).

XMAX ..... radial dimension of ellipse (see Fig. 33e).

ZA ..... axial coordinate of beginning of segment (see Fig. 33e)

ZB ..... axial coordinate of end of segment (see Fig. 33e).

ZNUMB .... number of points for spline fit. Maximum value = 100, but recommend use of no more than 50-75.

ALPHAT ... distance from axis of revolution to point of intersection of major and minor axes. (See above figure).

ITYPE ..... 1 = sinusoidal imperfections with random amplitudes and wavelengths; 2 = sinusoidal imperfections; 3 = dummy.

FM ..... number of wavelengths to be included in representation of imperfection.

C ..... maximum amplitude of imperfection.

FLMIN ..... minimum half-wavelength to be included in representation of imperfection.

FLMAX .... maximum half-wavelength to be included in representation of imperfection.

W0 ..... amplitude of sinusoidal imperfection.

WLNGTH ... half-wavelength of sinusoidal imperfection.

NZVALU ... number of stations for which the distance from shell "inner" surface to reference surface will be specified (Fig 34, Section 1.2).

ZVAL(I) ... distances from shell "inner" surface to reference surface, measured normal to the reference surface (see Fig. 34, Section 1.2).

ZSURF1, ZSURF2, ZSURF3, ZSURF4, ZSURF5 ... coefficients in function $F = Z1 + Z2*s^{Z3} + Z4*s^{Z5} = ZVAL$

ZVAL .... distance from shell "inner" surface to reference surface, measured normal to reference surface and positive if reference surface lies "outside" of inner surface, that is "to the right" of the inner surface as s increases. See Figure 34, discussion and examples in Section 1.2.

25 • Read NRINGS

If NRINGS = 0, go to 100

• Read NTYPE

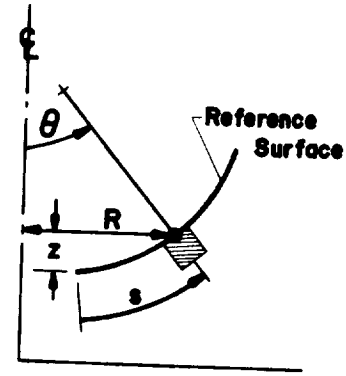
If NTYPE = 1 • Read (IPOINT(I), I = 1, NRINGS)

If NTYPE = 2 • Read (Z(I), I = 1, NRINGS)

If NTYPE = 3 • Read (R(I), I = 1, NRINGS)

If NTYPE = 4 • Read (S(I), I = 1, NRINGS)

If NTYPE = 5 • Read (THETA(I), I = 1, NRINGS)



• Read (NTYPER(I), I = 1, NRINGS)

Do 50 I = 1, NRINGS

If NTYPER(I) = 0 no data read for current value of do-loop index I

If NTYPER(I) = 1 • Read E, A, IY, IX, IXY, E1, E2, GJ, RM

If NTYPER(I) = 2 • Read E, A, IS, IN, ISN, ZC, SC, GJ, RM

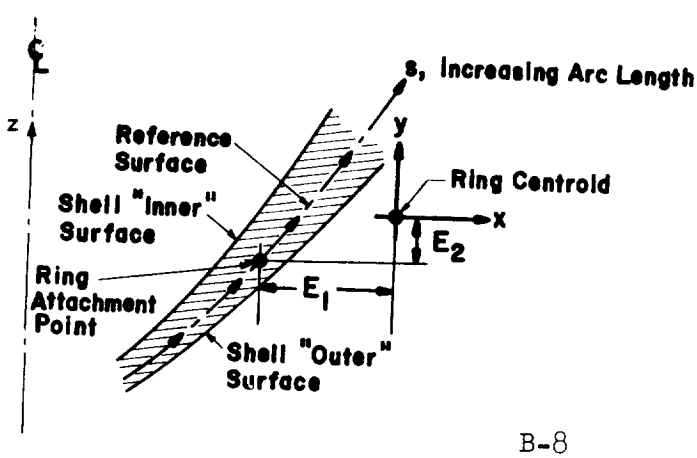
If NTYPER(I) = 3 Do not use this option

If NTYPER(I) = 4 • Read L(1), T(1), L(2), T(2), L(3), T(3), (See Fig. 37)
• Read E, U, X1P, Y(1), Y(2), Y(3) (See Fig. 37)
• Read RM

If NTYPER(I) = 5 • Same input as for NTYPER(I) = 4, except X,Y axes (Fig. 37) considered to be normal, tangential, respectively, to shell ref. surface at ring attachment point.

50 End of do-loop on I

Ring parameters have now been read in for discrete rings associated with current shell segment, ISEG. Go to 100



DISCRETE RING INPUT PARAMETERS FOR SHELL SEGMENT, ISEG

NRINGS ... number of discrete rings. If a discrete ring is located at the juncture between two segments, it is considered to be attached to the segment with the lowest identifying number. If line loads are applied at some station, the user must assume that a discrete ring is located there, even if no ring is present in the actual structure at that point. Maximum of 20 rings in one segment. Maximum of 50 rings in entire shell structure.

NTYPE ... 1 = mesh point numbers of discrete ring attachment points to be read in (one attachment point for each ring); 2 = axial distances measured from segment start to ring attachment points to be read in; 3 = distances from axis of revolution to ring attachment points to be read in; 4 = arc lengths from beginning of segment ISEG to ring attachment points to be read in; 5 = angles between axis of revolution and normals to shell reference surface at ring attachment points to be read in. Note that attachment points are considered to be on the shell reference surface.

IPOINT ... mesh point numbers of attachment points of discrete rings.
Z ... axial distances measured from segment start to ring attachment points.
R ... radial distances measured from axis of revolution to ring attachment points.
S ... arc lengths measured from beginning of segment ISEG to ring attachment points.
THETA ... angles between axis of revolution to ring attachment points, normal to reference surface.

NTYPER .. 0 = no rings at this station, no cards read (used if line loads present without discrete ring being present).
1 = principal axes of ring located in x-y directions (x = radial, y = axial).
2 = principal axes of ring located in s-n directions (s = tangential, n = normal (see Fig. 21).
3 = do not use this option.
4 = dimensions of ring parts read in. See Fig. 37. X, Y axes normal and tangential, respectively, to shell axis of revolution.
5 = dimensions of ring parts read in. See Fig. 37. X, Y axes normal and tangential, respectively, to shell reference surface at attachment point.

U ..... discrete ring Poisson ratio.
E ..... discrete ring elastic modulus.
A ..... discrete ring cross-section area.
IY ..... moment of inertia about y-axis (axis in axial direction through ring centroid).
IX ..... moment of inertia about x-axis (axis in radial direction through ring centroid).
IXY ..... product of inertia relative to the x-y axis system.
E1 ..... radial component of distance from ring attachment point to ring centroid (Fig. 21).
E2 ..... axial component of distance from ring attachment point to ring centroid.
GJ ..... ring shear modulus G times torsion constant J.
RM ..... ring material mass density.

IS ..... moment of inertia about s-axis (axis parallel to reference surface through ring centroid).
IN ..... moment of inertia about n-axis (axis normal to reference surface through ring centroid).
ISN ..... product of inertia in s-n system.
ZC ..... distance from ring centroid to tangent of reference surface at ring attachment point, positive as shown in Fig. 21.
SC ..... distance from ring centroid to normal to reference surface at ring attachment point, positive as shown in Fig. 21.

100 If (INDIC = 4 and IPRE = 0) go to 2000

● Read LINTYP

If LINTYP = 0 or LINTYP = 2, or NRINGS = 0, no mechanical line loads. Go to 300.

If (INDIC = 3 or INDIC = 4) ● Read NTYPEL

● Read NLOAD(1), NLOAD(2), NLOAD(3), NLOAD(4)

If (NLOAD(1) = 1) ● Read (V(I), I = 1, NRINGS)
If (NLOAD(2) = 1) ● Read (S(I), I = 1, NRINGS)
If (NLOAD(3) = 1) ● Read (H(I), I = 1, NRINGS)
If (NLOAD(4) = 1) ● Read (M(I), I = 1, NRINGS)

If (INDIC = 3 or INDIC = 4) Go to 105

● Read NLOAD(1), NLOAD(2), NLOAD(3), NLOAD(4)

If (NLOAD(1) = 1) ● Read (DV(I), I = 1, NRINGS)
If (NLOAD(2) = 1) ● Read (DS(I), I = 1, NRINGS)
If (NLOAD(3) = 1) ● Read (DH(I), I = 1, NRINGS)
If (NLOAD(4) = 1) ● Read (DM(I), I = 1, NRINGS)

Axisymmetric mechanical line loads have now been read in for segment ISEG. Go to 300.

105 If (NTYPEL = 4) Go to 120

● Read (PLIN1(L, ISEG), L = 1, number of harmonics)
● Read (PLIN2(L, ISEG), L = 1, number of harmonics)

Nonsymmetric mechanical line loads have now been read in for segment ISEG. Go to 300.

120 Continue

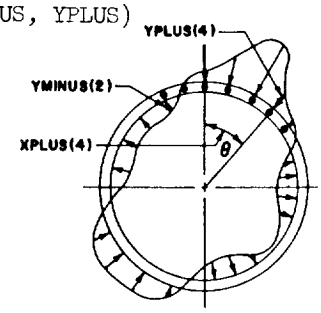
If (NLOAD(1) = 0 and NLOAD(3) = 0 and NLOAD(4) = 0) Go to 330

● Read NX, NOPT, NODD
● Read (XPLUS(J), J = 1, NX)

: If NOPT = 1 ● Read (YPLUS(J), J = 1, NX)
● Read (YMINUS(J), J = 1, NX)

: If NOPT = 2 ● Read (YPLUS(J), J = 1, NX)

: If NOPT = 3 ● Call GETY(NX, XMINUS, XPLUS, YMINUS, YPLUS)



330 Continue

If (NLOAD(2) = 0) Go to 350

● Read NX, NOPT, NODD
● Read (XPLUS(J), J = 1, NX)

If NOPT = 1 ● Read (YPLUS(J), J = 1, NX)
● Read (YMINUS(J), J = 1, NX)

: If NOPT = 2 ● Read (YPLUS(J), J = 1, NX)

: If NOPT = 3 ● Call GETY(NX, XMINUS, XPLUS, YMINUS, YPLUS)

350 Continue

All data for mechanical line loads in current segment ISEG have been read in. Go to 300.

MECHANICAL LINE LOADS ON SHELL SEGMENT, ISEG

INDIC . . . analysis type. INDIC = 3 corresponds to linear symmetric and nonsymmetric stress analysis.
INDIC = 4 corresponds to linear buckling with nonsymmetric prestress analysis.

IPRE . . . 1 = prestress calculated in program; 0 = prestress read in from data cards. IPRE only applies if INDIC = 4.

LINTYP . . 0 = no line loads of any type, either thermal or mechanical, for this shell segment.
1 = mechanical line loads only. No thermal line loads, for this shell segment.
2 = thermal line loads only, no mechanical line loads, for this shell segment.
3 = both mechanical and thermal line loads present for this shell segment.

NRINGS . . number of discrete rings in this segment, including "fictitious" discrete rings required for those stations where line loads are applied but no rings actually exist.

NTYPEL. . 3 = Fourier amplitudes for circumferential distribution of line loads read in, including axisymmetric harmonic. These harmonic load amplitudes correspond to the circumferential wave numbers NSTART to NFIN in increments of INCR, where NSTART = starting harmonic, NFIN = ending harmonic, and INCR = increment or decrement in the circumferential wave number between harmonics.
4 = line load amplitudes at various circumferential stations either read in directly or computed by user-written subroutine, then developed into Fourier series internally for circumferential waves NSTART to NFIN in steps of INCR.

IMPORTANT NOTE: In each shell segment the line loads must be expressible as a product $f(I)*g(\theta)$, in which I represents the Ith discrete ring. The series can differ from segment to segment, but must involve the same circumferential wave numbers, NSTART to NFIN in steps of INCR, for all segments. The Fourier series for line loads V, H, and M must be identical in a given segment. The Fourier series for S (shear load) may be different (see definitions for PLIN1, PLIN2, below). See Section 1.5.

NLOAD(1) . 1 = axial line loads V(I) present in this segment; 0 = no axial line loads in this segment.
NLOAD(2) . 1 = shear line loads S(I) present in this segment; 0 = no shear line loads in this segment.
NLOAD(3) . 1 = radial line loads H(I) present in this segment; 0 = no radial line loads in this segment.
NLOAD(4) . 1 = line moments M(I) present in this segment; 0 = no line moments in this segment.

V(I) . . . . axial "fixed" or initial line load factor associated with Ith discrete ring.
S(I) . . . . shear "fixed" or initial line load factor associated with Ith discrete ring.
H(I) . . . . radial "fixed" or initial line load factor associated with Ith discrete ring.
M(I) . . . . "fixed" or initial line moment factor associated with Ith discrete ring.

(See Tables 1.2, 1.3, Section 1.5 for sign convention, examples, further explanation.)

DV(I) . . . axial "variable" line load or line load increment associated with Ith discrete ring. (Do not use in BOSOR4.)
DS(I) . . . shear "variable" line load or line load increment associated with Ith discrete ring.
DH(I) . . . radial "variable" line load or line load increment associated with Ith discrete ring.
DM(I) . . . "variable" line moment or line moment increment associated with Ith discrete ring.

IMPORTANT NOTES:
1. If INDIC = 3 or INDIC = 4, actual line loads are given by $V(I)*G_1(\theta)$, $S(I)*G_2(\theta)$, $H(I)*G_1(\theta)$, $M(I)*G_1(\theta)$, in which $G_1(\theta)$ and $G_2(\theta)$ are defined below.
2. Line loads are positive as shown in Figure 21, Table 1.3, Section 1.5.
3. Line loads are assumed by the program to act at centroids of discrete rings.
4. With N = 0 or N = 1 circumferential waves the user must make sure either that the loads applied are in static equilibrium or that the constraint conditions prevent rigid body deformations. User need not provide input for line loads corresponding to reactions which do no work during deformation.
5. "fixed" means a problem parameter that does not change during execution of a case. "variable" means an eigenvalue parameter. If INDIC = 4 all loads are considered eigenvalue parameters. See Table 1.2, Section 1.5.

PLIN1(L, ISEG) . . circumferential harmonic amplitude factors for axial, radial line loads and line moments. (See Sec. 1.5, Table 1.2, pg 4-7)
PLIN2(L, ISEG) . . circumferential harmonic amplitude factors for shear line load.

IMPORTANT NOTES:
1. Maximum number of circumferential harmonics is 20.
2. Circumferential wave numbers associated with these amplitudes are NSTART to NFIN in steps of INCR. See Section 1.5.
3. The various line loads at the Ith discrete ring and at a circumferential station θ have the forms given by:

$$\text{Line load} = \begin{Bmatrix} V(I) \\ S(I) \\ H(I) \\ M(I) \end{Bmatrix} * \sum_{\substack{N = NSTART \\ \Delta N = INCR \\ L = 1}}^{\substack{N = NFIN \\ L = \text{no. of harmonics}}} \begin{matrix} PLIN1(L, ISEG)*\sin(N\theta) + PLIN1(L, ISEG)*\cos(N\theta) \\ PLIN2(L, ISEG)*\cos(N\theta) + PLIN2(L, ISEG)*\sin(N\theta) \\ \underbrace{PLIN1(L, ISEG)*\sin(N\theta) + PLIN1(L, ISEG)*\cos(N\theta)}_{\text{positive N}} \\ \underbrace{PLIN1(L, ISEG)*\sin(N\theta) + PLIN1(L, ISEG)*\cos(N\theta)}_{\text{negative N}} \end{matrix} \qquad \text{(B1)}$$

NX . . . . number of circumferential points for data input in range $0 \le XPLUS(J) \le THETAM$, where XPLUS(J) is the Jth circumferential point and THETAM is the bound on the range of θ. J goes from 1 to NX. (NX must be less than 100, greater than 2).

NOPT . . . 1 = YPLUS(J) and YMINUS(J) are going to be read in; 2 = YPLUS(J) only is going to be read in; 3 = YPLUS(J) and YMINUS(J) are calculated from user-written subroutine GETY(NX, XMINUS, XPLUS, YMINUS, YPLUS). (pg 6-9)

NODD . . . 1 = function g(θ) is even in range $-THETAM \le \theta \le +THETAM$; 2 = function g(θ) is odd; 3 = function g(θ) neither even nor odd in range of θ.

Note: Theta-range corresponds to range XMINUS(NX) to XPLUS(NX) or $-THETAM \le \theta \le +THETAM$. This range need not be from -pi to +pi, but the interval it covers must be an integer fraction of the interval -pi to +pi.

XPLUS(J) . values of circumferential coordinate in degrees. Need not be evenly spaced and need not cover the entire θ-range 0 to pi. Range must be an integer fraction of pi and XPLUS(NX) must equal THETAM. Also, XMINUS(J) are generated internally and are equal to the negatives of XPLUS(J), respectively. XPLUS(1) = 0.

YPLUS(J) . values of g(θ) corresponding to circumferential coordinates XPLUS(J).
YMINUS(J) values of g(-θ) corresponding to circumferential coordinates XMINUS(J). Note again that XMINUS(J) = -XPLUS(J).

Note: The Fourier coefficients PLIN1(L,ISEG) and PLIN2(L, ISEG) in Eq. (B1) are calculated by BØSØR4 with use of the input data NX, NØPT, ... YMINUS(J).

THERMAL LINE LOADS ON SHELL SEGMENT, ISEG

300 If LINTYP = 0 or LINTYP = 1 or NRINGS = 0, no thermal line loads. Go to 500.

If (INDIC = 3 or INDIC = 4) ● Read NTYPEL

● Read NLOAD(1), NLOAD(2), NLOAD(3)

If (NLOAD(1) = 1) ● Read (TNR(I), I = 1, NRINGS)
If (NLOAD(2) = 1) ● Read (TMX(I), I = 1, NRINGS)
If (NLOAD(3) = 1) ● Read (TMRY(I), I = 1, NRINGS)

If (INDIC = 3 or INDIC = 4) go to 305

● Read NLOAD(1), NLOAD(2), NLOAD(3)

If (NLOAD(1) = 1) ● Read (DTNR(I), I = 1, NRINGS)
If (NLOAD(2) = 1) ● Read (DTMX(I), I = 1, NRINGS)
If (NLOAD(3) = 1) ● Read (DTMRY(I), I = 1, NRINGS)

Axisymmetric thermal line loads have now been read in for segment ISEG. Go to 500.

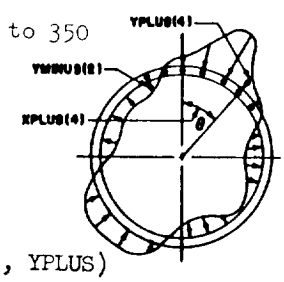
305 If (NTYPEL = 4) go to 320

● Read (TLIN(L, ISEG), L = 1, number of harmonics)

Nonsymmetric thermal line loads have now been read in for segment ISEG. Go to 500.

320 Continue

If (NLOAD(1) = 0 and NLOAD(2) = 0 and NLOAD(3) = 0) go to 350



● Read NX, NOPT, NODD
● Read (XPLUS(J), J = 1, NX)

If NOPT = 1 ● Read (YPLUS(J), J = 1, NX)
● Read (YMINUS(J), J = 1, NX)

If NOPT = 2 ● Read (YPLUS(J), J = 1, NX)

If NOPT = 3 ● Call GETY(NX, XMINUS, XPLUS, YMINUS, YPLUS)

350 Continue

All data for thermal line loads in current segment ISEG have now been read in. Go to 500.

LINTYP. . . 0 = no line loads of any type, either thermal or mechanical, for this shell segment
1 = mechanical line loads only.
2 = thermal line loads only.
3 = mechanical and thermal line loads.

NRINGS . . . number of discrete rings in this segment, including "fictitious" rings required for those stations where thermal line loads are applied but no actual rings exist.

NTYPEL . . 3 = Fourier amplitudes for circumferential distribution of thermal line loads read in, including axisymmetric harmonic. These harmonic load amplitudes correspond to the circumferential wave numbers NSTART to NFIN in increments of INCR, where NSTART = starting harmonic, NFIN = ending harmonic, and INCR = increment or decrement in the circumferential wave number between harmonics.
4 = thermal line load amplitudes at various circumferential stations either read in directly or computed by user-written subroutine, then developed into Fourier series internally for circumferential waves NSTART to NFIN in steps of INCR.

IMPORTANT NOTE: In each shell segment the thermal line loads must be expressible as a product $f(I)*g(\theta)$, in which I represents the Ith discrete ring. The series can differ from segment to segment, but must involve the same circumferential wave numbers, NSTART to NFIN in steps of INCR, for all segments. The Fourier series for thermal line loads TNR, TMX, and TMRY must be identical in a given segment. (See Sec. 1.5)

NLOAD(1). . 1 = thermal hoop loads TNR(I) present in this segment; 0 = no thermal hoop loads present in this segment.
NLOAD(2). . 1 = thermal moments about x-axis TMX(I) present in this segment; 0 = no thermal moments TMX(I) in this segment.
NLOAD(3). . 1 = thermal moments about y-axis TMRY(I) present in this segment; 0 = no thermal moments TMRY(I) in this segment.

TNR(I) . . . "fixed" or initial thermal line hoop load in Ith ring, given by: $N_r^T = -(\int E_r\,\alpha_r T dA)*TEMP$ (If INDIC = 3 or 4, TEMP = 1)

TMX(I) . . . "fixed" or initial thermal moment about x-axis (Fig. 21), Ith ring: $M_x^T = -(\int E_r\,\alpha_r T y dA)*TEMP$

TMRY(I) . . "fixed" or initial thermal moment about y-axis (Fig. 21), Ith ring: $M_y^T = -(\int E_r\,\alpha_r T x dA)*TEMP$

NOTE: TEMP is a multiplier provided as input on one of the earlier cards (see page B-3).

DTNR(I) . . "variable" thermal line hoop load or increment. Given by same expression as TNR, except multiplier is DTEMP.
DTMX(I) . . "variable" thermal moment about x-axis. Given by same expression as TMX, except multiplier is DTEMP.
DTMRY(I). . "variable" thermal moment about y-axis. Given by same expression as TMRY, except multiplier is DTEMP.

IMPORTANT NOTES:
1. If INDIC = 3 or INDIC = 4, actual thermal line loads are given by $TNR(I)*G_1(\theta)$, $TMX(I)*G_1(\theta)$, and $TMRY(I)*G_1(\theta)$, in which $G_1(\theta)$ is given below.
2. "fixed" means a problem parameter that does not change during execution of a case. "variable" means an eigenvalue parameter. If INDIC = 4 all loads are considered eigenvalue parameters. See Table 1.2, Section 1.5.

TLIN(L, ISEG). . circumferential harmonic amplitude factors for TNR(I), TMX(I), TMRY(I). (Sec. 1.5, Table 1.2, pg 4-7)

IMPORTANT NOTES:
1. Maximum number of circumferential harmonics is 20.
2. Circumferential wave numbers associated with these amplitudes are NSTART to NFIN in steps of INCR. See Section 1.5.
3. The various thermal line loads at the Ith discrete ring and at a circumferential station θ have the forms given by:

$$\text{Thermal line load} = \begin{Bmatrix} TNR(I) \\ TMX(I) \\ TMRY(I) \end{Bmatrix} * \sum_{\substack{N = NSTART \\ \Delta N = INCR \\ L = 1}}^{\substack{N = NFIN \\ L = \text{no. harmonics}}} \begin{matrix} TLIN(L, ISEG)*\sin(N\theta) & + & TLIN(L, ISEG)*\cos(N\theta) \\ TLIN(L, ISEG)*\sin(N\theta) & + & TLIN(L, ISEG)*\cos(N\theta) \\ \underbrace{TLIN(L, ISEG)*\sin(N\theta)}_{\text{positive N}} & + & \underbrace{TLIN(L, ISEG)*\cos(N\theta)}_{\text{negative N}} \end{matrix} \qquad (B2)$$

NX . . . . number of circumferential points for data input in range $0 \le XPLUS(J) \le THETAM$, where XPLUS(J) is the Jth circumferential point and THETAM is the bound on the range of θ. J goes from 1 to NX. (NX must be less than 100, greater than 2).

NOPT . . . 1 = YPLUS(J) and YMINUS(J) are going to be read in; 2 = YPLUS(J) only is going to be read in; 3 = YPLUS(J) and YMINUS(J) are calculated from user-written subroutine GETY(NX, XMINUS, XPLUS, YMINUS, YPLUS). (pg 6-9)

NODD . . . 1 = function g(θ) is even in range - THETAM ≤ θ ≤ + THETAM; 2 = function g(θ) is odd; 3 = function g(θ) neither even nor odd in range of θ.

Note: Theta-range corresponds to range XMINUS(NX) to XPLUS(NX) or -THETAM ≤ θ ≤ + THETAM. This range need not be from -pi to +pi, but the interval it covers must be an integer fraction of the interval -pi to +pi.

XPLUS(J). . values of circumferential coordinate in degrees. Need not be evenly spaced and need not cover the entire θ-range 0 to pi. Range must be an integer fraction of pi and XPLUS(NX) must equal THETAM. Also, XMINUS(J) are generated internally and are equal to the negatives of XPLUS(J), respectively. XPLUS(1) = 0.

YPLUS(J). . values of g(θ) corresponding to circumferential coordinates XPLUS(J).
YMINUS(J) . values of g(-θ) corresponding to circumferential coordinates XMINUS(J). Note again that XMINUS(J) = -XPLUS(J).

Note: The Fourier coefficients TLIN(L, ISEG) in Eq. (B2) are calculated by BØSØR4 with use of the input data NX, NØPT, ... YMINUS(J).

500 ● Read NLTYPE, NPSTAT, NTSTAT, NTGRAD

If NLTYPE = 0 or NLTYPE = 2, no pressure or surface traction. Go to 900.

If NPSTAT = 0 ● Read P11, P12, P13, P14, P15
If NPSTAT = 0 ● Read P21, P22, P23, P24, P25
If NPSTAT = 0 , Go to 900

If (INDIC = 3 or INDIC = 4) ● Read NTYPEL

● Read NLOAD(1), NLOAD(2), NLOAD(3)

If (NLOAD(1) = 1) ● Read (PT(I), I = 1, NPSTAT)
If (NLOAD(2) = 1) ● Read (PC(I), I = 1, NPSTAT)
If (NLOAD(3) = 1) ● Read (PN(I), I = 1, NPSTAT)

If (INDIC ≠ 3 and INDIC ≠ 4) go to 700

If (NTYPEL = 4) go to 520

● Read (PDIST1(L, ISEG), L = 1, number of harmonics)
● Read (PDIST2(L, ISEG), L = 1, number of harmonics)

Go to 700

520 Continue

If (NLOAD(1) = 0 and NLOAD(3) = 0) go to 530

● Read NX, NOPT, NODD
● Read (XPLUS(J), J = 1, NX)

● If NOPT = 1 ● Read (YPLUS(J), J = 1, NX)
● Read (YMINUS(J), J = 1, NX)

If NOPT = 2 ● Read (YPLUS(J), J = 1, NX)

If NOPT = 3 ● Call GETY(NX, XMINUS, XPLUS, YMINUS, YPLUS)

530 Continue

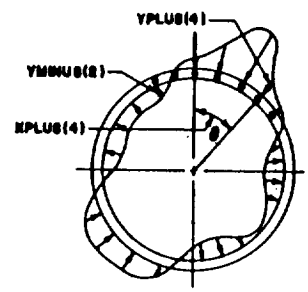
If (NLOAD(2) = 0) go to 700

● Read NX, NOPT, NODD
● Read (XPLUS(J), J = 1, NX)

If NOPT = 1 ● Read (YPLUS(J), J = 1, NX)
● Read (YMINUS(J), J = 1, NX)

If NOPT = 2 ● Read (YPLUS(J), J = 1, NX)

If NOPT = 3 ● Call GETY(NX, XMINUS, XPLUS, YMINUS, YPLUS)



700 ● Call STA(NPSTAT) (See Page B26 for input data read in from STA)

All data for pressure and surface tractions on current segment ISEG have now been read in. Go to 900.

PRESSURE AND SURFACE TRACTIONS OF SHELL SEGMENT, ISEG

NLTYPE . 0 = no distributed thermal or pressure or surface traction loads in this segment.
1 = pressure and surface tractions only. No temperature rise distribution in this segment.
2 = temperature rise distribution only. No pressure or surface traction on this segment.
3 = pressure and surface traction as well as temperature rise distribution in this segment.

NPSTAT . number of mesh points for which pressure and surface traction components will be read in. If INDIC = 3 or 4 and NLTYPE = 1 or 3, NPSTAT must be larger than 1 and less than 50. NPSTAT = 0 option for use if INDIC ≠ (3 or 4.)

NTSTAT . number of mesh points for which temperature rise coefficients T1, T2, and T3 will be read in. Same discussion applies here as applies to NPSTAT.

NTGRAD . type of thermal gradient through shell wall thickness: NTGRAD = 1. . . $T = T1 + T2*z + T3*z^2$ (z is measured from the reference surface positive to the right of increasing s).

NTGRAD = 2 . . $T = T1 + T2*z^{T3}$

NTGRAD = 3 . . $T = T1 + T2*\exp(z*T3)$

P11, P12, P13, P14, P15 . . . coefficients for $f(s) = P11 + P12*s^{P13} + P14*s^{P15}$, in which s is the arc length from beginning of segment. This function represents the normal pressure distribution. Actual pressure = P*f(s) or DP*f(s). Positive to right of increasing arc length, s .

P21, P22, P23, P24, P25. . coefficients for f(s) of same form as above, but f(s) in this case refers to the meridional traction.

NTYPEL . 3 = Fourier amplitudes for circumferential distribution of pressure and surface tractions read in, including axisymmetric harmonic. These harmonic pressure and surface traction amplitudes correspond to the circumferential wave numbers NSTART to NFIN in increments of INCR, where NSTART = starting harmonic, NFIN = ending harmonic, and INCR = increment or decrement in the circumferential wave number between harmonics.
4 = pressure and surface traction amplitudes at various circumferential stations either read in directly or computed by user-written subroutine, then developed into Fourier series internally for circumferential waves NSTART to NFIN in steps of INCR.

IMPORTANT NOTE: In each shell segment the pressure and surface tractions must be expressible as a product f(s)*g(θ), in which s is the meridional station. The series can differ from segment to segment, but must involve the same circumferential wave numbers, NSTART to NFIN in steps of INCR, for all segments. The Fourier series for pressure components PT and PN must be identical in a given segment. The Fourier series for PC may be different (see definitions for PDIST1, PDIST2). See Section 1. 5.

NLOAD(1). 1 = meridional surface traction PT(I) present in this segment; 0 = no meridional surface traction in this segment.
NLOAD(2). 1 = circumferential surface traction PC(I) present in this segment; 0 = no circumferential surface traction.
NLOAD(3). 1 = normal pressure PN(I) present in this segment; 0 = no normal pressure present in this segment.

PT(I) . . . meridional surface traction at Ith callout point. Positive in direction of increasing arc length, s . (See Sec. 1. 5
PC(I) . . . circumferential surface traction at Ith callout point. Positive in direction of increasing circ. angle, θ . Tables
PN(I) . . . normal pressure, positive outward, at Ith callout point. Positive to right of increasing s . 1. 2, 1. 3)

IMPORTANT NOTES:
1. If INDIC = 3 or INDIC = 4, actual pressure and surface tractions are given by $PT(I)*G_1(\theta)$, $PC(I)*G_2(\theta)$, and $PN(I)*G_1(\theta)$, in which $G_1(\theta)$ and $G_2(\theta)$ are defined below.
2. With N = 0 or N ±1 circumferential waves the user must make sure either that the applied loads are in static equilibrium or that the constraint conditions prevent rigid body deformations.
3. If INDIC ≠ 3 and INDIC ≠4, actual components=P*PT, P*PC, and P*PN; also DP*PT, DP*PN.

PDIST1(L, ISEG) . . circumferential harmonic amplitude factors for meridional traction and normal pressure. (Section 1. 5,
PDIST2(L, ISEG) . . circumferential harmonic amplitude factors for circumferential traction. Table 1. 2, pg 4-7)

IMPORTANT NOTES:
1. Maximum number of circumferential harmonics is 20.
2. Circumferential waves associated with these amplitudes are NSTART to NFIN in steps of INCR. See Section 1. 5.
3. The surface tractions and pressure at the Ith callout point and at a circumferential station θ have the forms given by:

$$\text{Pressure components} = \begin{Bmatrix} PT(I) \\ PC(I) \\ PN(I) \end{Bmatrix} * \sum_{\substack{N = NSTART \\ \Delta N = INCR \\ L = 1}}^{\substack{N = NFIN \\ L = \text{no. harmonics}}} \begin{matrix} PDIST1(L, ISEG)*\sin(N\theta) + PDIST1(L, ISEG)*\cos(N\theta) \\ PDIST2(L, ISEG)*\cos(N\theta) + PDIST2(L, ISEG)*\sin(N\theta) \\ \underbrace{PDIST1(L, ISEG)*\sin(N\theta)}_{\text{positive N}} + \underbrace{PDIST1(L, ISEG)*\cos(N\theta)}_{\text{negative N}} \end{matrix}$$

NX . . . number of circumferential points for data input in range 0 ≤ XPLUS(J) < THETAM, where XPLUS(J) is the Jth circumferential point and THETAM is the bound on the range of θ. J goes from 1 to NX. (NX must be less than 100, greater than 2).

NOPT. . . 1 = YPLUS(J) and YMINUS(J) are going to be read in; 2 = YPLUS(J) only is going to be read in; 3 = YPLUS(J) and YMINUS(J) are calculated from user-written subroutine GETY(NX, XMINUS, XPLUS, YMINUS, YPLUS). (pg 6-9)

NODD . . 1 = function g(θ) is even in range -THETAM ≤ θ ≤ + THETAM; 2 = function g(θ) is odd; 3 = function g(θ) neither even nor odd in range of θ.

Note: Theta-range corresponds to range XMINUS(NX) to XPLUS(NX) or -THETAM ≤ θ ≤ + THETAM. This range need not be from -pi to +pi, but the interval it covers must be an integer fraction of the interval -pi to + pi.

XPLUS(J) values of circumferential coordinate in degrees. Need not be evenly spaced and need not cover the entire θ-range 0 to pi. Range must be an integer fraction of pi and XPLUS(NX) must equal THETAM. Also, XMINUS(J) are generated internally and are equal to the negatives of XPLUS(J), respectively. XPLUS(1) = 0.

YPLUS(J) values of g(θ) corresponding to circumferential coordinates XPLUS(J).
YMINUS(J) values of g(-θ) corresponding to circumferential coordinates XMINUS(J). Note again that XMINUS(J) = -XPLUS(J).

Note: The Fourier coefficients PDIST1(L, ISEG), PDIST2(L, ISEG) in Eq. (B-3) are calculated by BØSØR4 with use of the input data NX, NØPT, ... YMINUS(J).

TEMPERATURE DISTRIBUTION IN SHELL SEGMENT, ISEG

900 If NLTYPE = 0 or NLTYPE = 1, no thermal distributed loads. Go to 3000.

If NTSTAT = 0 ● Read T11, T12, T13, T14, T15
If NTSTAT = 0 ● Read T21, T22, T23, T24, T25
If NTSTAT = 0 ● Read T31, T32, T33, T34, T35
If NTSTAT = 0 , go to 3000

If (INDIC = 3 or INDIC = 4) ● Read NTYPEL

● Read NLOAD(1), NLOAD(2), NLOAD(3)

If (NLOAD(1) = 1) ● Read (T1(I), I = 1, NTSTAT)
If (NLOAD(2) = 1) ● Read (T2(I), I = 1, NTSTAT)
If (NLOAD(3) = 1) ● Read (T3(I), I = 1, NTSTAT)

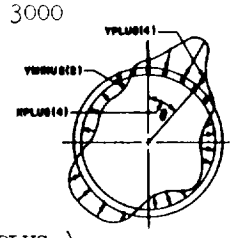
If (INDIC ≠ 3 and INDIC ≠ 4) go to 970

If (NTYPEL = 4) go to 920

● Read (TDIST(L, ISEG), L = 1, number of harmonics)

Go to 970

920 If (NLOAD((1) = 0 and NLOAD(2) = 0 and NLOAD(3) = 0) go to 3000



● Read NX, NOPT, NODD
● Read (XPLUS(J), J = 1, NX)

If NOPT = 1 ● Read (YPLUS(J), J = 1, NX)
● Read (YMINUS(J), J = 1, NX)

If NOPT = 2 ● Read (YPLUS(J), J = 1, NX)

If NOPT = 3 ● Call GETY(NX, XMINUS, XPLUS, YMINUS, YPLUS)

970 ● Call STA(NTSTAT) (See Page B26 for input data read in from STA.)

All data for temperature distribution on current segment ISEG have now been read in. Go to 3000.

Data for all loads (line and distributed, mechanical and thermal) have now been read in for current segment, ISEG.

NLTYPE . 0 = no distributed thermal or pressure or surface traction loads in this segment.
1 = no temperature rise distribution in this segment.

NTSTAT . number of mesh points for which temperature rise distribution through thickness is given. If INDIC = 3 or 4 and NLTYPE = 2 or 3, NTSTAT must be larger than 1 and less than 50. NTSTAT = 0 option for use only if INDIC ≠ 3 or 4.

T11, T12, T13, T14, T15 . . coefficients for T1(s) = $T11 + T12*s^{T13} + T14*s^{T15}$, with s measured from beginning of segment. T1(s) appears in the formulas given in the definition of NTGRAD on the previous page. These formulas (functions of thickness coordinate z) give the temperature rise distribution through the shell wall at a given station s.

T21, T22, T23, T24, T25 . coefficients for T2(s), which has the same functional form as T1(s). See definition of NTGRAD for role of T2.

T31, T32, T33, T34, T35 . coefficients for T3(s), which has the same functional form as T1(s) and T2(s). See definition of NTGRAD.

Note: The actual temperature distribution is given by TEMP*T or DTEMP*T, where T depends on NTGRAD, as given on previous page.

NTYPEL . 3 = Fourier amplitudes for circumferential distribution of temperature rise coefficients T1, T2, and T3 to be read in, including axisymmetric harmonic. These harmonic coefficient amplitudes correspond to the circumferential wave numbers NSTART to NFIN in increments of INCR, where NSTART = starting harmonic, NFIN = ending harmonic, and INCR = increment or decrement in circumferential wave number between harmonics.
4 = temperature rise coefficients T1, T2, T3 read in for various circumferential stations or computed by user-written subroutine, then developed into Fourier series internally for circumferential waves NSTART to NFIN in steps of INCR.

IMPORTANT NOTE: In each shell segment the temperature rise coefficients must be expressible as a product f(s)*g(θ), in which s is the meridional station. The series can differ from segment to segment, but must involve the same circumferential wave numbers, NSTART to NFIN in steps of INCR, for all segments. The Fourier series for all coefficients T1, T2, and T3 must be identical in a given segment. See Section 1.5.

NLOAD(1) 1 = temperature rise coefficient, T1, present in segment; 0 = T1 not present in this segment.
NLOAD(2) 1 = temperature rise coefficient, T2, present in segment; 0 = T2 not present in this segment.
NLOAD(3) 1 = temperature rise coefficient, T3, present in segment; 0 = T3 not present in this segment.

T1(I) . . . temperature rise coefficient at Ith mesh point callout; see formulas for T under def. of NTGRAD, previous page.
T2(I) . . . temperature rise coefficient at Ith mesh point callout; see formulas for T under def. of NTGRAD, previous page.
T3(I) . . . temperature rise coefficient at Ith mesh point callout; see formulas for T under def. of NTGRAD, previous page.

IMPORTANT NOTES:
1. If INDIC = 3 or INDIC = 4, actual temperature rise coefficients are given by $T1(I)*G_1(\theta)$, $T2(I)*G_1(\theta)$, and $T3(I)*G_1(\theta)$, in which $G_1(\theta)$ is defined below.
2. If INDIC ≠ 3 and INDIC ≠ 4, actual temperature rise is given by TEMP*T or DTEMP*T, where T is a function of T1, T2, T3, and z, as shown on previous page (see NTGRAD).

TDIST(L, ISEG) . . circumferential harmonic amplitude factors for temperature rise coefficients T1, T2 and T3. (Sec. 1.5, pg 4-7)

IMPORTANT NOTES:
1. Maximum number of circumferential harmonics is 20.
2. Circumferential waves associated with these amplitudes are NSTART to NFIN in steps of INCR. See Section 1.5.
3. The temperature rise coefficients T1, T2, T3 at the Ith mesh point callout and at some circumferential station θ have the form:

$$\text{Temperature rise} = \begin{Bmatrix} T1(I) \\ T2(I) \\ T3(I) \end{Bmatrix} * \sum_{\substack{N = NSTART \\ \Delta N = INCR \\ L = 1}}^{\substack{N = NFIN \\ L = \text{no. of harmonics}}} \begin{matrix} TDIST(L, ISEG)*\sin(N\theta) + TDIST(L, ISEG)*\cos(N\theta) \\ TDIST(L, ISEG)*\sin(N\theta) + TDIST(L, ISEG)*\cos(N\theta) \\ TDIST(L, ISEG)*\sin(N\theta) + TDIST(L, ISEG)*\cos(N\theta) \end{matrix} \quad \text{(B4)}$$

positive N negative N

NX . . . number of circumferential points for data input in range 0 ≤ XPLUS(J) ≤ THETAM, where XPLUS(J) is the Jth circumferential point and THETAM is the bound on the range of θ. J goes from 1 to NX. (NX must be less than 100, greater than 2).

NOPT . . 1 = YPLUS(J) and YMINUS(J) are going to be read in; 2 = YPLUS(J) only is going to be read in; 3 = YPLUS(J) and YMINUS(J) are calculated from user-written subroutine GETY(NX, XMINUS, XPLUS, YMINUS, YPLUS) (pg 6-9)

NODD . . 1 = function g(θ) is even in range -THETAM ≤ θ ≤ + THETAM; 2 = function g(θ) is odd; 3 = function g(θ) neither even nor odd in range of θ.

Note: Theta-range corresponds to range XMINUS(NX) to XPLUS(NX) or -THETAM ≤ θ ≤ + THETAM. This range need not be from -pi to + pi, but the interval it covers must be an integer fraction of the interval -pi to + pi.

XPLUS(J) values of circumferential coordinate in degrees. Need not be evenly spaced and need not cover the entire θ-range 0 to pi. Range must be an integer fraction of pi and XPLUS(NX) must equal THETAM. Also, XMINUS(J) are generated internally and are equal to the negatives of XPLUS(J), respectively. XPLUS(1) = 0.

YPLUS(J) values of g(θ) corresponding to circumferential coordinates XPLUS(J).

YMINUS(J) values of g(-θ) corresponding to circumferential coordinates XMINUS(J). Note again that XMINUS(J) = XPLUS(J).

Note: The Fourier coefficients TDIST(L, ISEG) in Eq. (B4) are calculated by BØSØR4 with use of the input data NX, NØPT, ... YMINUS(J).

PRESTRESS INPUT DATA FOR OPTION INDIC = 4, IPRE = 0
FOR SHELL SEGMENT, ISEG

2000 Continue

If JNDIC $\neq$ 4 , go to 3000

If IPRE $\neq$ 0 , go to 3000

- Read NSTRES, NRLOAD

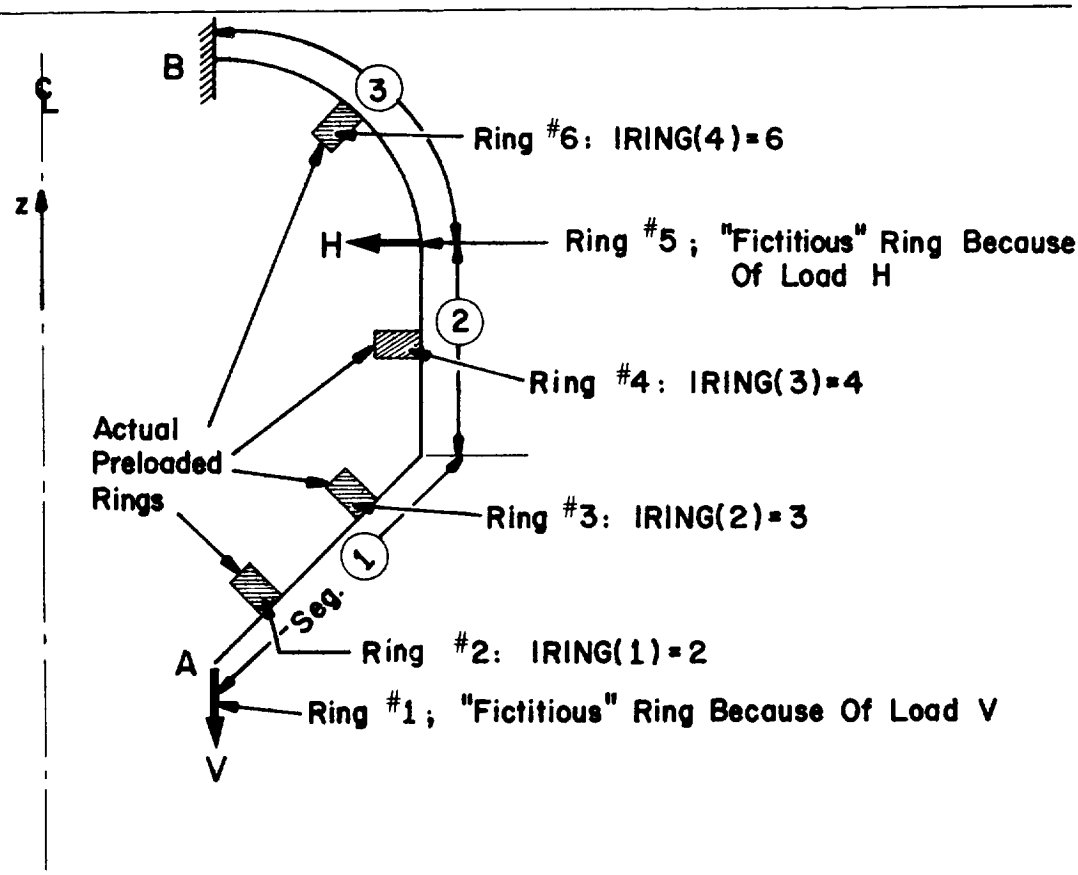
If NSTRES $\neq$ 0 ● Call STA(NSTRES) (See Page B-26 for input data read in from STA)

If NSTRES $\neq$ 0 ● Read (N10(I), I = 1, NSTRES)
● Read (N20(I), I = 1, NSTRES)
● Read (CHI0(I), I = 1, NSTRES)

If NRLOAD $\neq$ 0 ● Read (IRING(I), I - 1, NRLOAD)
● Read (RLOAD(I), I = 1, NRLOAD)

All data for shell and ring prestress have now been read in for shell segment, ISEG

Go to 3000



PRESTRESS INPUT DATA FOR OPTION INDIC = 4, IPRE = 0 FOR SHELL SEGMENT, ISEG

INDIC ... analysis type: INDIC = 4 means buckling with nonsymmetric prestress.

IPRE ... used only with INDIC = 4; 0 = prestress meridional distribution read in.
1 = prestress meridional distribution calculated.

NSTRES . number of stations along the meridian in segment ISEG for which prestress resultants N10 and N20 and meridional rotation CHI0 will be read in (less than 50).

NRLOAD . number of discrete rings in entire shell for which prebuckling hoop loads will be read in. Note that NRLOAD applies to all of the preloaded rings in the entire shell, an exception to the segment-by-segment handling of the input data in BOSOR4. This quantity is read in only with data associated segment #1 (less than 50).

STA(NSTRES) ... subroutine STA used to find mesh points for which prestress quantities will be read in. See page B-26.

N10(I) ... meridional prestress resultant at Ith mesh point callout (positive for tension). (floating point)

N20(I) ... circumferential prestress resultant at Ith mesh point callout (tension positive). (floating point)

CHI0(I) .. meridional prestress rotation at Ith mesh point callout (positive as shown in Fig. 20).

IRING(I) . index number of discrete ring with hoop prestress RLOAD(I). Indices for <u>all preloaded</u> discrete rings are read in when ISEG = 1.

RLOAD(I) hoop preload in discrete rings. Tension is positive. Read in data for all preloaded discrete rings in shell when ISEG, the current segment number equals one.

Never include cards for IRING or RLOAD if ISEG is greater than 1.

3000 Continue

- Read NWALL

If NWALL = 1
- Read SMPA
- Read C11, C12, C14, C15, C22, C24
- Read C25, C33, C44, C45, C55, C66
- Read C36, ANRS

If ANRS ≠ 0 ● Read data as given in TABLE 3

Go to 5000

If NWALL = 2
- Read E, U, SM, ALPHA, ANRS, SUR

If SUR = - 1 ● Read NTYPET

If NTYPET = 1
- Read NTVALU
- Call STA(NTVALU) (see page B-26)
- Read (TVAL(I), I = 1, NTVALU)

If NTYPET = 2 ● Read TH1, TH2, TH3, TH4, TH5

If NTYPET = 3 ● Read TVAL

If ANRS ≠ 0 ● Read data as given in TABLE 3

Go to 5000

If NWALL = 3
- Read E, U, T, SM
- Read TH, A, B, H, AK, STFMD

Go to 5000

If NWALL = 4
- Read EF, EM, UF, UM, AK, ANRS
- Read (T(I), I = 1, AK)
- Read (X(I), I = 1, AK)
- Read (BE(I), I = 1, AK)
- Read (C(I), I = 1, AK)
- Read (SM(I), I = 1, AK)

If ANRS ≠ 0 ● Read data as given in TABLE 3

Go to 5000

SHELL WALL PROPERTIES FOR SHELL SEGMENT, ISEG

NWALL .. 1 = general shell, coefficients C_{ij} read in. Properties constant along s.
2 = monocoque shell with variable thickness. Smeared stiffeners may be added.
3 = skew-stiffened shell, constant properties along arc length s.
4 = fiber-wound, layered shell; constant thickness; smeared stiffeners possible.
5 = layered orthotropic; variable thickness; smeared stiffeners possible.
6 = corrugated; properties constant along s; smeared stiffeners possible.
7 = semi-sandwich corrugated; smooth skin variable thickness; smeared stiffeners.
8 = layered, orthotropic, temperature-dependent material properties; variable thickness; smeared stiffeners may be added.

1

SMPA ... shell wall mass/area.
C11, C12, etc. ... coefficients of constitutive law given by Eq. (0).
ANRS ... 0. = no smeared rings and stringers to be added; 1. = yes, smeared rings and stringers. (floating point number)

2

E ..... Young's modulus.
U ..... Poisson's ratio.
SM ..... shell wall material mass density (e. g. aluminum = .0002535 lb-sec^2/in.^{4}).
ALPHA .. shell wall coefficient of thermal expansion.
ANRS .... 0. = no smeared stiffeners; 1. = yes, smeared stiffeners.
SUR .... -1. = position of reference surface arbitrary with respect to inner surface.
0. = reference surface is middle surface (thickness = twice z, so no input req'd).
+1. = reference surface is "outer" surface (thickness = z, so no input req'd for t).

NTYPET . 1 = variable thickness; 2 = variable thickness; 3 = constant thickness.
NTVALU . number of mesh point callouts for which thickness will be read in.
STA(NTVALU) .. subroutine STA finds which mesh points thickness input corresponds to.
TVAL(I) .. thickness at Ith mesh point callout. (See Fig. 34.)
TH1, TH2, TH3, TH4, TH5 .. coefficients in function thickness = $TH1+TH2*s^{TH3}+TH4*s^{TH5}$
TVAL ... shell wall thickness, constant for this segment.

3

E ..... Young's modulus.
U ..... Poisson's ratio.
T ..... thickness of skin in shell with skew stiffeners.
SM ..... shell wall material mass density.
TH ..... angle (degrees) between stiffeners and shell meridian.
A ..... stiffener spacing along circumference.
B ..... stiffener thickness (dimension parallel to skin).
H ..... stiffener height.
AK ..... 0. = for "inside" stiffening; 1. = for "outside" stiffening. (floating point number)
STIFMD .. stiffener material mass density.

(Note: Do not use this option for shells with stiffeners on lines of curvature.)

4

EF ..... Young's modulus for fibers.
EM ..... Young's modulus for matrix.
UF ..... Poisson's ratio for fibers.
UM ..... Poisson's ratio for matrix.
AK ..... number of layers (maximum = 20). (floating point number)
ANRS .... 0. = for no smeared stiffeners; 1. = for smeared stiffeners present.
T(I) .... thickness of "double-layer"; "inner" layer has index 1, "outer" layer as index AK.
X(I) .... matrix content by volume of Ith layer.
BE(I) .... winding angle between fiber and meridian (degrees) of Ith layer.
C(I) .... contiguity factor; 0.2 to 0.3 is usual range; see BOSOR4 list.
SM(I) .... mass density of Ith layer (e. g., aluminum = .0002535 lb-sec^2/in.^{4}).

(Note: "inner" and "outer" are defined precisely in Section 1.2. Please read that section carefully.)

```
If NWALL = 5 ● Read  WRAPS, ANRS, TYPET

             If (TYPET = 0)   Read  (    T(I), I = 1, WRAPS )

           ● Read  (     G(I), I = 1, WRAPS )
           ● Read  (    EX(I), I = 1, WRAPS )
           ● Read  (    EY(I), I = 1, WRAPS )
           ● Read  (   UXY(I), I = 1, WRAPS )
           ● Read  (    SM(I), I = 1, WRAPS )
           ● Read  (ALPHA1(I), I = 1, WRAPS )
           ● Read  (ALPHA2(I), I = 1, WRAPS )

             If (TYPET ≠ 0)● Read  NTIN
                           ● Call STA(NTIN) (see Page B-26 for input from STA )

             If (TYPET ≠ 0)  Do 3100  I = 1, WRAPS

                      3100 ● Read  (TIN(II), II = 1, NTIN )

             If ANRS ≠ 0   ● Read data as given in TABLE 3

             Go to 5000

If NWALL = 6 ● Read  E, U, ANRS, SMPA
           ● Read  CC, CH, CD, CT, CB

             If ANRS ≠ 0 ●Read data as given in TABLE 3
             Go to 5000

If NWALL = 7 ● Read  E, U, ANRS, SMPA
           ● Read  CC, CH, CD, CT, CB, PHI
           ● Read  ES, US, TS, ANC, TYPET

             If TYPET = 0  Go to 3200

             If TYPET = 1 ● Read NTYPET

                            If NTYPET = 1 ● Read  NTVALU
                                          ● Call STA( NTVALU ) (see page B-26)
                                          ● Read  (TVAL(I), I = 1, NTVALU )

                            If NTYPET = 2 ● Read  TH1, TH2, TH3, TH4, TH5

                            If NTYPET = 3 ● Read  TVAL

        3200 If ANRS ≠ 0 ● Read data as given in TABLE 3

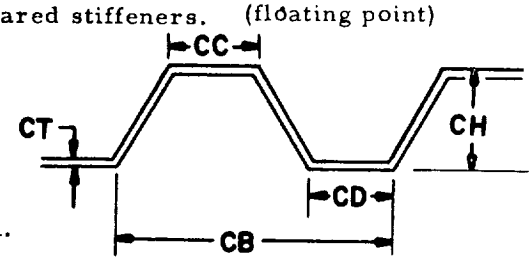
             Go to 5000
```

SHELL WALL PROPERTIES FOR SHELL SEGMENT, ISEG
(Continued)

	NWALL	5 = layered orthotropic; variable thickness; smeared stiffeners possible. 6 = corrugated; properties constant along length; smeared stiffeners possible. 7 = semi-sandwich corrugated; variable thickness skin; smeared stiffeners.

	WRAPS ..	number of layers (maximum 20). (floating point)
	ANRS ...	0. = no smeared stiffeners; 1. = yes, smeared stiffeners. (floating point)
	TYPET ..	0. = layer thicknesses constant; 1. = layer thicknesses vary with s. (floating point)
	T(I) ...	thickness of Ith layer (1 = "inner" layer, with "inner" defined in Sec. 1.2).
	G(I) ...	shear modulus of Ith layer.
	EX(I) ...	modulus in meridional direction of Ith layer.
	EY(I) ...	modulus in circumferential direction of Ith layer.
5	UXY(I) ...	Poisson's ratio of Ith layer; EY*UXY = EX*UYX.
	SM(I) ...	material mass density of Ith layer (e.g., aluminum = .0002535 lb-sec^2/in.^{4}).
	ALPHA1(I)	thermal expansion coefficient in meridional direction of Ith layer.
	ALPHA2(I)	thermal expansion coefficient in circumferential direction of Ith layer.
	NTIN ...	number of mesh point callouts for which thicknesses of layers will be read in.
	STA(NTIN)	subroutine STA finds which mesh points thickness input corresponds to.
	TIN(II) ...	thickness of a layer at the IIth mesh point callout.

	E	Young's modulus.
	U	Poisson's ratio.
	ANRS	0. = no smeared stiffeners; 1. = yes, smeared stiffeners. (floating point)
	SMPA ...	shell wall mass/(area of ref. surface).
6	CC	dimension shown in Fig.
	CH	shown in Fig.
	CD	shown in Fig.
	CT	shown in Fig.
	CB	shown in Fig.



	E	Young's modulus of corrugated material.
	U	Poisson's ratio of corrugated material.
	ANRS	0. = no smeared stiffeners; 1. = yes, smeared stiffeners. (floating point)
	SMPA ...	mass/(area of ref. surface).
	CC	dimension shown in Fig.
	CH	shown in Fig.
	CD	shown in Fig.
	CT	shown in Fig.
	CB	shown in Fig.
	PHI	"knockdown" factor for torsion constant associated with area enclosed by
7		corrugation and skin. From experience 0.3 seems to be a good estimate for PHI.
	ES	Young's modulus of smooth skin.
	US	Poisson's ratio of smooth skin.
	TS	thickness of smooth skin (if constant thickness skin is used).
	ANC	0. for "inside" corrugations; 1. for "outside" corrugations. (floating) (see Sec. 1.2)
	TYPET ..	0. for constant thickness smooth skin; 1. for variable thickness skin. (floating)
	NTYPET .	1 = variable thickness; 2 = variable thickness; 3 = constant thickness.
	NTVALU .	number of mesh point callouts for which thickness of smooth skin will be read in.
	STA(NTVALU) ..	subroutine STA finds which mesh points thickness input corresponds to.
	TVAL(I) .	thickness of smooth skin at Ith mesh point callout. (Fig. 34)
	TH1, TH2, TH3, TH4, TH5 ...	coefficients in function thickness(s) = $TH1+TH2*s^{TH3}+TH4*s^{TH5}$.
	TVAL ..	thickness of smooth skin which is constant.

```
If NWALL = 8 ● Read  WRAPS, ANRS, TYPET

             If (TYPET = 0) ● Read ( T(I), I = 1, WRAPS )

             If (TYPET ≠ 0) ● Read NTIN
                            ● Call STA( NTIN) (see Page B-26 for input)

             If (TYPET ≠ 0)   Do 3300  I = 1, WRAPS

                       3300 ● Read ( TIN(II), II = 1, NTIN )

           ● Read (    SM(I), I = 1, WRAPS )
           ● Read (NPOINT(I), I = 1, WRAPS )

             Do 3400  I = 1, WRAPS

                    ● Read (HEAT(I,K), K = 1, NPOINT(I))
                    ● Read (   G(K,I), K = 1, NPOINT(I))
                    ● Read (  EX(K,I), K = 1, NPOINT(I))
                    ● Read (  EY(K,I), K = 1, NPOINT(I))
                    ● Read ( UXY(K,I), K = 1, NPOINT(I))
                    ● Read (  A1(K,I), K = 1, NPOINT(I))
                    ● Read (  A2(K,I), K = 1, NPOINT(I))

                 3400 Continue

             If ANRS ≠ 0 ● Read data as given in TABLE 3

             Go to 5000
```

5000 Continue

End of data input for current shell segment. If (ISEG = NSEG), all data for this case have been read in. Data for the next case can be stacked immediately.

If (ISEG is less than NSEG) go to 10.

SHELL WALL PROPERTIES FOR SHELL SEGMENT, ISEG
(Continued)

NWALL ..	8 = layered, orthotropic, temperature-dependent material properties: variable thickness; smeared rings and stringers may be added. TEMP MUST BE UNITY FOR THIS CASE.	
WRAPS ..	number of layers (maximum = 5).	(floating point)
ANRS ..	0. = no smeared stiffeners; 1. = yes, smeared stiffeners.	(floating point)
TYPET ..	0. = constant thickness; 1. = variable thickness.	(floating point)
T(I)	thickness of Ith layer, with "inner" layer having index 1 (see Sec 1.2 for "inner")	
NTIN	number of mesh point callouts for which thicknesses of layers will be read in.	
STA(NTIN)	subroutine STA finds which mesh points thickness input corresponds to.	
TIN(II) ...	thickness of a layer at the IIth mesh point callout.	
8 SM(I) ...	mass density of Ith layer (e.g., aluminum = .0002535 lb-sec^2/in.^{4}).	
NPOINT(I)	number of temperature rise values for which properties of Ith layer are given. Maximum of 20 values/layer.	
HEAT(I, K)	temperatures above zero - stress temperature for which wall properties of Ith layer will be read in.	
G(K, I) ...	shear moduli of Ith layer at the Kth temperature value, HEAT(I, K).	
EX(K, I) ..	Young's modulus in meridional direction of Ith layer at Kth temperature value.	
EY(K, I) ..	Young's modulus in circumferential direction.	
UXY(K, I).	Poisson's ratio: EY*UXY = EX*UYX.	
A1(K, I) ..	thermal expansion coefficient in meridional direction.	
A2(K, I) ..	thermal expansion coefficient in circumferential direction.	

TABLE 5

"SMEARED" STRINGER AND RING PROPERTIES

Data read in if ANRS = 1 for any of the NWALL options

- Read IRECT1, IRECT2, IVAR1, IVAR2

If IRECT1 = 1 and IVAR1 = 0
- Read N1, K1
- Read E1, U1, STIFMD
- Read T1, H1

Go to 4000

If IRECT1 = 1 and IVAR1 ≠ 0
- Read NSTATN, N1, K1
- Call STA(NSTATN) (see page B-26)
- Read E1, U1, STIFMD

Do 3500 I = 1, NSTATN

3500
- Read T(I), H(I)

Go to 4000

If IRECT1 = 0 and IVAR1 = 0
- Read N1, K1
- Read E1, U1, STIFMD
- Read XS, A1, XI1, XJ1

Go to 4000

If IRECT1 = 0 and IVAR1 ≠ 0
- Read NSTATN, N1, K1
- Call STA(NSTATN) (see page B-26)
- Read E1, U1, STIFMD

Do 3550 I = 1, NSTATN

3550
- Read X(I), A(I), XI(I), XJ(I)

Go to 4000

4000 If IRECT2 = 1 and IVAR2 = 0
- Read K2
- Read E2, U2, RGMD
- Read D2, T2, H2

Go to 4500

If IRECT2 = 1 and IVAR2 ≠ 0
- Read NRINGS, K2
- Call STA(NRINGS) (see page B-26)
- Read E2, U2, RGMD

Do 4100 I = 1, NRINGS

4100
- Read D(I), T(I), H(I)

Go to 4500

If IRECT2 = 0 and IVAR2 = 0
- Read K2
- Read E2, U2, RGMD
- Read XR, D2, A2, XI2, XJ2

Go to 4500

If IRECT2 = 0 and IVAR2 ≠ 0
- Read NRINGS, K2
- Call STA(NRINGS) (see page B-26)
- Read E2, U2, RGMD

Do 4200 I = 1, NRINGS

4200
- Read X(I), D(I), A(I), XI(I), XJ(I)

Go to 4500

4500 All data for "smeared" stringers and rings have been read in.

TABLE 3

"SMEARED" STRINGER AND RING PROPERTIES

Data read in if ANRS = 1 for any of the NWALL options

GENERAL	IRECT1 ...	1 = stringers have rectangular cross sections; 0 = arbitrary cross sections.
	IRECT2 ...	1 = rings have rectangular cross sections; 0 = arbitrary cross sections.
	IVAR1 ...	1 = stringer properties vary with arc length s; 0 = stringer properties constant.
	IVAR2 ...	1 = ring properties vary with arc length s; 0 = ring properties constant.
SMEARED STRINGERS	N1	number of stringers in 360 degrees.
	K1	0 for "internal" stringers; 1 for "external" stringers (see Sec. 1.2 for "inner").
	E1	stringer modulus.
	U1	stringer poisson ratio
	ST1FMD ..	stringer material mass density (e.g. aluminum = .0002535 lb-sec^2/in.^{4}).
	T1	stringer thickness (dimension parallel to shell wall) (constant).
	H1	stringer height (constant).
	NSTATN ..	number of mesh point stations for which stringer properties will be read in.
	STA(NSTATN) ..	subroutine STA finds mesh point callouts corresponding to input data.
	T(I)	stringer thickness at Ith mesh point callout.
	H(I)	stringer height at Ith mesh point callout.
	XS	distance from neutral axis of stringer to closest shell surface (constant).
	A1	cross section area of stringer (constant).
	XI1	centroidal moment of inertia of stringer about axis perpendicular to meridian.
	XJ1	torsional constant J of stringer (constant).
	X(I)	distance from neutral axis of stringer to closest shell surface at Ith callout.
	A(I)	cross section area of stringer at Ith mesh point callout.
	XI(I)	centroidal moment of inertia of stringer at Ith mesh point callout.
	XJ(I)	torsional constant J of stringer at Ith mesh point callout.
SMEARED RINGS	K2	0 for "internal" rings; 1 for "external" rings (see Sec. 1.2 for "inner").
	E2	ring modulus.
	U2	ring Poisson's ratio.
	RGMD	ring material mass density (eg, aluminum = .0002535 lb-sec^2/in.^{4}).
	D2	arc length between adjacent rings (constant).
	T2	ring thickness (dimension parallel to shell wall) (constant).
	H2	ring height (constant).
	NRINGS ...	number of mesh point stations for which ring properties will be read in.
	STA(NRINGS) ..	subroutine STA finds mesh point callouts corresponding to input data.
	D(I)	average ring spacing at Ith mesh point callout.
	T(I)	average ring thickness at Ith mesh point callout.
	H(I)	average ring height at Ith mesh point callout.
	XR	distance from neutral axis of ring to closest shell surface (constant).
	A2	ring cross section area (constant).
	XI2	ring centroidal moment of inertia about axis parallel to meridian (constant).
	XJ2	ring torsional constant (constant).
	X(I)	distance from neutral axis of ring to closest shell surface at Ith callout.
	A(I)	average ring cross section area at Ith mesh point callout.
	XI(I)	average ring centroidal moment of inertia at Ith mesh point callout.
	XJ(I)	average ring torsional constant J at Ith mesh point callout.

INPUT DATA READ IN FROM SUBROUTINE STA(NPOINT)

● Read NTYPE

If NTYPE = 1 ● Read (IPOINT(I), I = 1, NPOINT)

If NTYPE = 2 ● Read (Z(I), I = 1, NPOINT)

If NTYPE = 3 ● Read (R(I), I = 1, NPOINT)

If NTYPE = 4 ● Read (S(I), I = 1, NPOINT)

If NTYPE = 5 ● Read (THETA(I), I = 1, NPOINT)

Note: NPOINT is the number of stations for which input data are to be read in

Z(I) is the axial coordinate of the Ith data element.

R(I) is the radial coordinate of the Ith data element.

S(I) is the length of meridional arc from the beginning of the local segment to the Ith data element.

THETA(I) is the angle in degrees from the axis of revolution to a normal through the station corresponding to the Ith data element.

IPOINT(I) Mesh point callouts for which data will be read in.

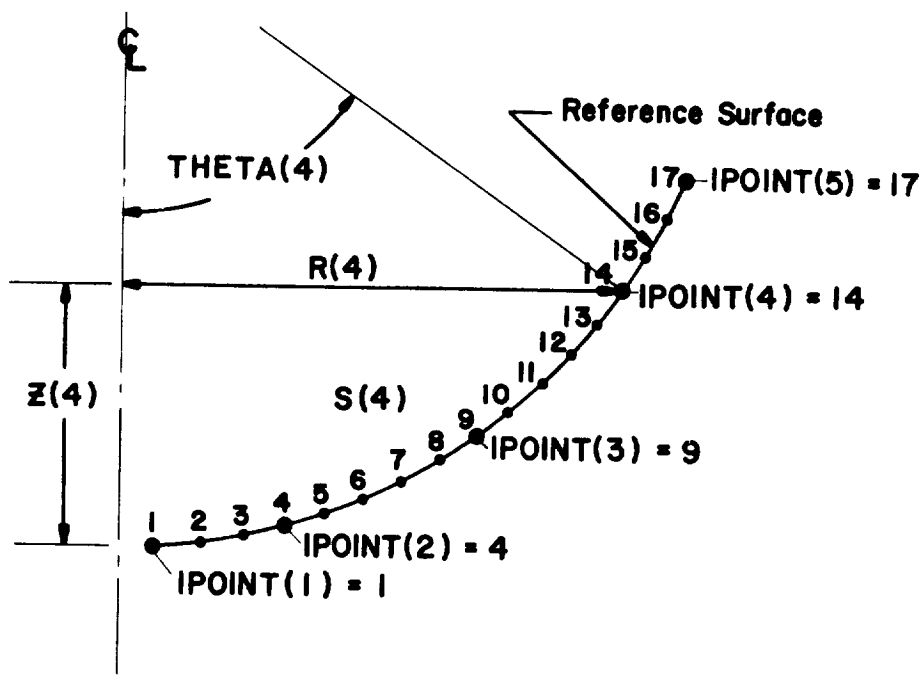


TABLE 4

INPUT DATA FOR ALUMINUM FRAME BUCKLING (FIG. 26)

80 COLUMN WORK SHEET

ALUMINUM FRAME BUCKLING	TITLE
1 1 0 1 1	INDEC, NPRT, NLAST, ISTRES, IPRE
3 3 0 0	NSEG, NCOND, IBOUND, IBSED
0 0 1	NSTART, NFIN, INCR
2 2 16 4 1	NOB, NMEMB, NMAXB, INCRB, NVEC
0 0 0	NDIST, NCIRC, NTHETA
(BLANK)	(ITHETA(I), I=1,NCIRC)
(BLANK)	(THETA(I), I=1,NDIST)
(BLANK)	THETAM, THETAS, PREROT
001001 001001 1 0 0 0+0 +00+0 +00	(IFIX(1,J), J=1,6), D1(1), D2(1)
001006 002001 1 1 1 1+0 +00+0 +00	(IFIX(2,J), J=1,6), D1(2), D2(2)
002010 003004 1 1 1 1+0 +00+0 +00	(IFIX(3,J), J=1,6), D1(3), D2(3)
+0 +00-1 +01+0 +00+0 +00	P, DP, TEMP, DTEMP
+0 +00-1 +01-1 +01	FSTART, FMAX, DF
11 3 1	NMESH, NTYPEH, INTVAL ..... SEGMENT 1
1 3 0	NSHAPE, NTYPEZ, IMP
+5218 +01+0 +00+5218 +01+483 +00	R1, Z1, R2, Z2
+0 +00	ZVAL
0	NRINGS
0	LINTYP
1 0 0 0	NLTYPE, NPSTAT, NTSTAT, NTGRAD
+1 +01+0 +00+0 +00+0 +00+0 +00	P11, P12, P13, P14, P15
+0 +00+0 +00+0 +00+0 +00+0 +00	P21, P22, P23, P24, P25
2	NWALL
+108 +08+333 +00+0 +00+0 +00+0 +00-1 +01	E, U, SM, ALPHA, ANRS, SUR
3	NTYPET
+182 +00	TVAL
10 3 1	NMESH, NTYPEH, INTVAL ..... BEGINNING SEGMENT 2
1 3 0	NSHAPE, NTYPEZ, IMP
+5218 +01+0 +00+4882 +01+0 +00	R1, Z1, R2, Z2
+0075 +00	ZVAL
0	NRINGS
0	LINTYP
0 0 0 0	NLTYPE, NPSTAT, NTSTAT, NTGRAD
2	NWALL
+108 +08+333 +00+0 +00+0 +00+0 +00+0 +00	E, U, SM, ALPHA, ANRS, SUR
7 3 1	NMESH, NTYPEH, INTVAL ..... BEGINNING SEGMENT 3
1 3 0	NSHAPE, NTYPEZ, IMP
+4882 +01+0 +00+4882 +01+089 +00	R1, Z1, R2, Z2
+015 +00	ZVAL
0	NRINGS
0	LINTYP
0 0 0 0	NLTYPE, NPSTAT, NTSTAT, NTGRAD
2	NWALL
+108 +08+333 +00+0 +00+0 +00+0 +00+1 +01	E, U, SM, ALPHA, ANRS, SUR

Table 5

INPUT DATA FOR CYLINDER UNDER HYDROSTATIC PRESSURE (Fig. 27)

80 COLUMN WORK SHEET

```
CYL. UNDER HYDROSTATIC PRESS. INDIC=-1 BUCKLING                                  TITLE
   -1    1    0    0    0                                                        INDIC,NPRT,NLAST,ISTRES,IPRE
    3    4    1    0                                                             NSEG,NCOND,IBOUND,IRIGID
    0    0    1                                                                  NSTART,NFIN,INCR
    4    1    6    1    1                                                        NOB,NMINB,NMAXB,INCRB,NVEC
    0    0    0                                                                  NDIST,NCIRC,NTHETA
    0                                                                            (ITHETA(I), I=1,NCIRC)
+0       +00                                                                     ( THETA(I), I=1,NDIST)
+0       +00+0      +00+0      +00                                               THETAM,THETAB,PREROT
001001001001    0    1    1    1+0      +00+0      +00                           (IFIX(1,J), J=1,6), D1(1), D2(1)
001030002001    1    1    1    1+0      +00+0      +00                           (IFIX(2,J), J=1,6), D1(2), D2(2)
001063003001    1    1    1    1+0      +00+0      +00                           (IFIX(3,J), J=1,6), D1(3), D2(3)
001080001080    1    0    0    1+0      +00+0      +00                           (IFIX(4,J), J=1,6), D1(4), D2(4)
    1    1    1    1                                                             (IFIXB(1,J), J=3,6)
    1    1    1    1                                                             (IFIXB(2,J), J=3,6)
    1    1    1    1                                                             (IFIXB(3,J), J=3,6)
    1    0    0    1                                                             (IFIXB(4,J), J=3,6)
+0       +00-1      +01+0      +00+0      +00                                     P,DP,  TEMP,DTEMP
+0       +00-1      +01-1      +01                                               FSTART,FMAX,DF
   80    1    0                                                                  NMESH,NTYPEH,INTVAL ..... SEGMENT 1
   11                                                                            NHVALU
    1   21   22   37   38   54   55   70   71   78                               (IHVALU(I),I=1,10)
   79                                                                            (IHVALU(I),I=11,NHVALU)
+1       +01+1      +01+5      +00+5      +00+1      +01+1      +01              ( HVALU(I),I=1,6 )
+5       +00+5      +00+1      +01+1      +01+8      +00                         ( HVALU(I),I=7,NHVALU)
    1    3    0                                                                  NSHAPE,NTYPEZ,IMP
+1015    +01+0      +00+1015   +01+628    +01                                   R1,Z1,R2,Z2
+015     +00                                                                     ZVAL
    1                                                                            NRINGS
    1                                                                            NTYPE
    1                                                                            IPOINT(1)
    0                                                                            NTYPER(1)
    1                                                                            LINTYP
    0    0    0    0                                                             (NLOAD(M), M=1,4)
    1    0    0    0                                                              (NLOAD(M), M=1,4)
-5075    +00                                                                     DV(1)
    1    0    0    0                                                             NLTYPE,NPSTAT,NTSTAT,NTGRAD
+1       +01+0      +00+0      +00+0      +00+0      +00                         P11,P12,P13,P14,P15
+0       +00+0      +00+0      +00+0      +00+0      +00                         P21,P22,P23,P24,P25
    2                                                                            NWALL
+108     +08+32     +00+0      +00+0      +00+1      +01+0      +00              E,U,SM,ALPHA,ANRS,SUR
    1    1    0    0                                                             IRECT1,IRECT2,IVAR1,IVAR2
    0    0                                                                       N1,K1
+0       +00+0      +00+0      +00                                               E1,U1,STIFMD
+0       +00+0      +00                                                         T1,H1
    1                                                                            K2
+108     +08+32     +00+0      +00                                               E2,U2,RGMD
+25      +00+02     +00+035    +00                                               D2,H2,T2
   15    1    0                                                                  NMESH,NTYPEH,INTVAL ..... BEGINNING SEGMENT 2
    3                                                                            NHVALU
    1   13   14                                                                  (IHVALU(I),I=1,NHVALU)
+1       +01+1      +01+5      +00                                               ( HVALU(I),I=1,NHVALU)
    1    3    0                                                                  NSHAPE,NTYPEZ,IMP
+1015    +01+0      +00+1150   +01+0      +00                                   R1,Z1,R2,Z2
+02      +00                                                                     ZVAL
    1                                                                            NRINGS
    1                                                                            NTYPE
   15                                                                            IPOINT(1)
    1                                                                            NTYPER(1)
+108     +08+0144   +00+768    -05+3888   -04+0      +00+04     +00              E,A,IY,IX,IXY,E1
+0       +00+904    +02+0      +00                                               E2,GJ,RM
    0                                                                            LINTYP
    0    0    0    0                                                             NLTYPE,NPSTAT,NTSTAT,NTGRAD
    2                                                                            NWALL
+108     +08+32     +00+0      +00+0      +00+0      +00+0      +00              E,U,SM,ALPHA,ANRS,SUR
   15    1    0                                                                  NMESH,NTYPEH,INTVAL ..... BEGINNING SEGMENT 3
    3                                                                            NHVALU
    1   13   14                                                                  (IHVALU(I), I=1,NHVALU)
+1       +01+1      +01+5      +00                                               ( HVALU(I), I=1,NHVALU)
    1    3    0                                                                  NSHAPE,NTYPEZ,IMP
+1015    +01+0      +00+1150   +01+0      +00                                   R1,Z1,R2,Z2
+02      +00                                                                     ZVAL
    1                                                                            NRINGS
    1                                                                            NTYPE
   15                                                                            IPOINT(1)
    1                                                                            NTYPER(1)
+108     +08+0144   +00+768    -05+3888   -04+0      +00+04     +00              E,A,IY,IX,IXY,E1
+0       +00+904    +02+0      +00                                               E2,GJ,RM
    0                                                                            LINTYP
    0    0    0    0                                                             NLTYPE,NPSTAT,NTSTAT,NTGRAD
    2                                                                            NWALL
+108     +08+32     +00+0      +00+0      +00+0      +00+0      +00              E,U,SM,ALPHA,ANRS,SUR
```

TABLE 6

INPUT DATA FOR UNIFORMLY LOADED FLAT CIRCULAR PLATE (FIG. 28)

80 COLUMN WORK SHEET

UNIFORMLY LOADED FLAT CIRCULAR PLATE	TITLE
0 2 0 1 0	INDIC, NPRT, NLAST, ISTRES, IPRE
1 2 0 0	NSEG, NCOND, IBOUND, IRIGID
0 0 1	NSTART, NFIN, INCR
0 0 0 0	NOB, NMINB, NMAXB, INCRB, NVEC
	NDIST, NCIRC, NTHETA
(BLANK)	(ITHETA(I), I=1,NCIRC)
(BLANK)	(THETA(I), I=1,NDIST)
(BLANK)	THETAM, THETAS, PREROT
(BLANK)	(IFIX(1,J), J=1,6), D1(1), D2(1)
1001 1001 0 0 0 0 +0 +00 +0 +00	(IFIX(2,J), J=1,6), D1(2), D2(2)
1011 1011 1 1 0 0 +0 +00 +0 +00	P, DP, TEMP, DTEMP
+001 +00 +999 +00 +0 +00 +0 +00	FSTART, FMAX, DF
+001 +00 +1 +01 +999 +00	NMESH, NTYPEH, INTVAL
11 3 0	NSHAPE, NTYPEZ, IMP
1 3 0	R1, Z1, R2, Z2
+0 +00 +0 +00 +10 +02 +0 +00	ZVAL
+05 +00	NRINGS
0	LINTYP
0	NLTYPE, NPSTAT, NTSTAT, NTGRAD
1 0 0 0	P11, P12, P13, P14, P15
+1 +01 +0 +00 +0 +00 +0 +00 +0 +00	P21, P22, P23, P24, P25
+0 +00 +0 +00 +0 +00 +0 +00 +0 +00	NWALL
2	E, U, SM, ALPHA, ANRS, SUR
+1 +08 +3 +00 +0 +00 +0 +00 +0 +00 +0 +00	

TABLE 7

INPUT DATA FOR CYLINDER WITH THREE POINT LOADS (FIG. 29)

80 COLUMN WORK SHEET

CYLINDER WITH THREE POINT LOADS																		TITLE
3		1		0		1		1										INDIC, NPRT, NLAST, ISTRES, IPRE
1		2		0		0												NSEG, NCOND, IBOUND, IRIGID
0		-57		-3														NSTART, NFIN, INCR
0		0		0		0		0										NOB, NMINB, NMAXB, INCRB, NVEC
5		5		31														NDIST, NCIRC, NTHETA
1011		1026		1043		1049		1052										(ITHETA(I), I=1,NCIRC)
+0		+00	+10			+02	+20			+02	+35		+02	+60		+02		(THETA(I), I=1,NDIST)
+60		+02	+0			+00	+0			+00								THETAM, THETAS, PREROT
1001		1001		0		1		1		0	+0		+00	+0		+00		(IFIX(1,J), J=1,6), D1(1), D2(1)
1052		1052		1		0		0		1	+0		+00	+0		+00		(IFIX(2,J), J=1,6), D1(2), D2(2)
+0		+00	+0			+00	+0			+00	+0		+00					P, DP, TEMP, DTEMP
+0		+00	+0			+00	+0			+00								FSTART, FMAX, DF
52		1		1														NMESH, NTYPEH, INTVAL
4																		NHVALU
1		10		11		51												(IHVALU(I), I=1,NHVALU)
+1		+01	+1			+01	+05			+00	+05		+00					(HVALU(I), I=1,NHVALU)
1		3		0														NSHAPE, NTYPEZ, IMP
+1005		+03	+0			+00	+1005			+03	+240		+03					R1, Z1, R2, Z2
+5		+00																ZVAL
1																		NRINGS
1																		NTYPE
52																		IPOINT(1)
1																		NTYPER(1)
+54		+07	+3			+01	+225			+01	+25		+00	+0		+00	+2	E, A, IY, IX, IXY, EI
+0		+00	+1639			+07	+0			+00							+01	E2, GJ, RM
1																		LINTYP
4																		NTYPEL
0		0		1		0												(NLOAD(M), M=1,4)
+1		+01																H(1)
3		2		1														NX, NOPT, NODD
+0		+00	+5			+01	+60			+02								(XPLUS(J), J=1,NX)
-1		+01	+0			+00	+0			+00								(YPLUS(J), J=1,NX)
0		0		0		0												NLTYPE, NPSTAT, NTSTAT, NTGRAD
2																		NWALL
+108		+08	+33			+00	+0			+00	+0		+00	+0		+00	+0	E, U, SM, ALPHA, ANRS, SUR

TABLE 8

INPUT DATA FOR FREE HEMISPHERE VIBRATION (FIG. 30)

80 COLUMN WORK SHEET

FREE HEMISPHERE VIBRATION	TITLE
2 1 0 0	INDIC, NPRT, NLAST, ISTRES, IPRE
1 2 0 1	NSEG, NCOND, IBOUND, IRIGID
0 0 1	NSTART, NFIN, INCR
0 0 3 1 3	NOB, NMINB, NMAXB, INCRB, NVEC
(BLANK)	NDIST, NCIRC, NTHETA
(BLANK)	(ITHETA(I), I=1,NCIRC)
(BLANK)	(THETA(I), I=1,NDIST)
(BLANK)	THETAM, THETAS, PREROT
1001 1001 0 0 0 0 +0 +00 +0 +00	(IFIX(1,J), J=1,6), D1(1), D2(1)
1031 1031 0 0 0 0 +0 +00 +0 +00	(IFIX(2,J), J=1,6), D1(2), D2(2)
1031 1031 1 1 0 0	(ISTOPO(J), J=1,6)
1031 1031 1 1 0 0	(ISTOP1(J), J=1,6)
+0 +00 +0 +00 +0 +00 +0 +00	P, DP, TEMP, DTEMP
+0 +00 +0 +00 +0 +00	FSTART, FMAX, DF
31 3 1	NMESH, NTYPEH, INTVAL
2 3 0	NSHAPE, NTYPEZ, IMP
+0 +00 +0 +00 +100 +03 +100 +03 +0 +00 +100 +03	R1,Z1, R2,Z2, RC,ZC
-1 +01	SROT
+5 +00	ZVAL
0	NRINGS
0	LINTYP
0 0 0	NLTYPE, NPSTAT, NTSTAT, NTGRAD
2	NWALL
+1 +08 +3 +00 +00025535 +00 +0 +00 +0 +00 +0 +00	E,U,SM,ALPHA,ANRS,SUR

TABLE 9

INPUT DATA FOR CONE HEATED ON AXIAL STRIP (FIG. 31)

80 COLUMN WORK SHEET

6	12	18	24	30	36	42	48	54	60	66	72	
BUCKLING OF CONE HEATED ON AXIAL STRIP												TITLE
4	1	0	0	1								INDIC, NPRT, NLAST, ISTRES, IPRE
1	2	0	0									NSEG, NCOND, IBOUND, IRIGID
0	-19	-1										NSTART, NFIN, INCR
20	20	20	1	3								NOB, NMINB, NMAXB, INCRB, NVEC
1	1	61										NDIST, NCIRC, NTHETA
1066												
+0	+00											(ITHETA(I), I=1,NCIRC)
+180	+03 +0		+00 +0		+00							(THETA(I), I=1,NDIST)
1001	1001	1	1	1	1 +0		+00 +0		+00			THETAM, THETAS, PREROT
1097	1097	1	1	1	1 +0		+00 +0		+00			(IFIX(1,J), J=1,6), DI(1), D2(1)
+0	+00 +0		+00 +0		+00 +0		+00					(IFIX(2,J), J=1,6), DI(2), D2(2)
+0	+00 +0		+00		+00							P, DP, TEMP, DTEMP
97	1	2										FSTART, FMAX, DF
6												NMESH, NTYPEH, INTVAL
1	28	29	64	65	96							NHVALU
+14285755 +00	+14285755 +00		+5		+00 +5		+00 +16669		+00 +16669		+00	(IHVALU(I), I=1,NHVALU)
1	3	0										(HVALU(I), I=1,NHVALU)
+6	+01 +0		+00 +12		+02 +273504		+02					NSHAPE, NTYPEZ, IMP
+00775	+00											R1, Z1, R2, Z2
0												ZVAL
0												NRINGS
2	0	18	1									LINTYP
4												NLTYPE, NPSTAT, NTSTAT, NTSRAD
1	0	0										NTYPEL
												NLOAD(1), NLOAD(2), NLOAD(3)
+68	+02 +80		+02 +85		+02 +90		+02 +105		+03 +1195		+03	(T1(L), L=1,6)
+118	+03 +112		+03 +935		+02 +82		+02 +814		+02 +835		+02	(T1(L), L=7,12)
+842	+02 +82		+02 +755		+02 +50		+02 +35		+02 +20		+02	(T1(L), L=13,NTSTAT)
20	3	1										NX, NOPT, NODD
+0	+00 +171887		+01 +34377		+01 +515662		+01 +687549		+01 +859437		+01	(XPLUS(J), J=1,6)
+103132	+02 +120321		+02 +13751		+02 +1547		+02 +171887		+02 +206265		+02	(XPLUS(J), J=7,12)
+24064	+02 +27502		+02 +3094		+02 +34371		+02 +37815		+02 +41253		+02	(XPLUS(J), J=13,18)
+51566	+02 +180		+03									(XPLUS(J), J=19,NX)
4												NTYPE
+0	+00 +2		+01 +3		+01 +35		+01 +4		+01 +5		+01	(S(I), I=1,6)
+6	+01 +8		+01 +12		+02 +16		+02 +18		+02 +20		+02	(S(I), I=7,12)
+21	+02 +22		+02 +23		+02 +245		+02 +26		+02 +28		+02	(S(I), I=13,NTSTAT)
2												NWALL
+269	+08 +3		+00 +0		+00 +119		-04 +0		+00 +0		+00	E,U,SM,ALPHA,AMRS,SUR

80 COLUMN
WORK SHEET

6	12	18	24	30	36	42	48	54	60	66	72	
SPHERICAL CAP BUCKLING, INDIC=-2												TITLE
-2	2	0	0	0								INDIC, NPRT, NLAST, ISTRES, IPRE
1	2	0	0									NSEG, NCOND, IBOUND, IRIGID
0	0	0										NSTART, NFIN, INCR
2	0	10	1	1								NOB, NMINB, NMAXB, INCRB, NVEC
	(BLANK)											NDIST, NCIRC, NTHETA
	(BLANK)											(ITHETA(I), I=1,NCIRC)
	(BLANK)											(THETA(I), I=1,NDIST)
	(BLANK)											THETAM, THETAS, PREROT
1001	1001											(IFIX(1,J), J=1,6), D1(1),D2(1)
1020	1020	1	1	1	1							(IFIX(2,J), J=1,6), D1(2),D2(2)
+18	+2+4		+1+0		+0+0		+0					P,DP, TEMP,DTEMP
+18	+2+50		+2+4		+1							FSTART, FMAX, DF
20	3	0										NMESH, NTYPEH, INTVAL
2	3	0										NSHAPE, NTYPEZ, IMP
+0	+0+5447		+1+1044		+3+0		+0+0		+0-9946		+3	R1,Z1, R2,Z2, RC,ZC
+1	+1											SROT
+5	+0											ZVAL
0												NRINGS
0												LINTYP
1	0	0	0									NLTYPE, NPSTAT, NTSTAT, NTGRAD
+1	+1+0		+0+0		+0+0		+0+0		+0			P11,P12,P13,P14,P15
+0	+0+0		+0+0		+0+0		+0+0		+0			P21,P22,P23,P24,P25
2												NWALL
+3	+8+3		+0+0		+0+0		+0+0		+0+0		+0	E,U,SM,ALPHA,ANRS,SUR

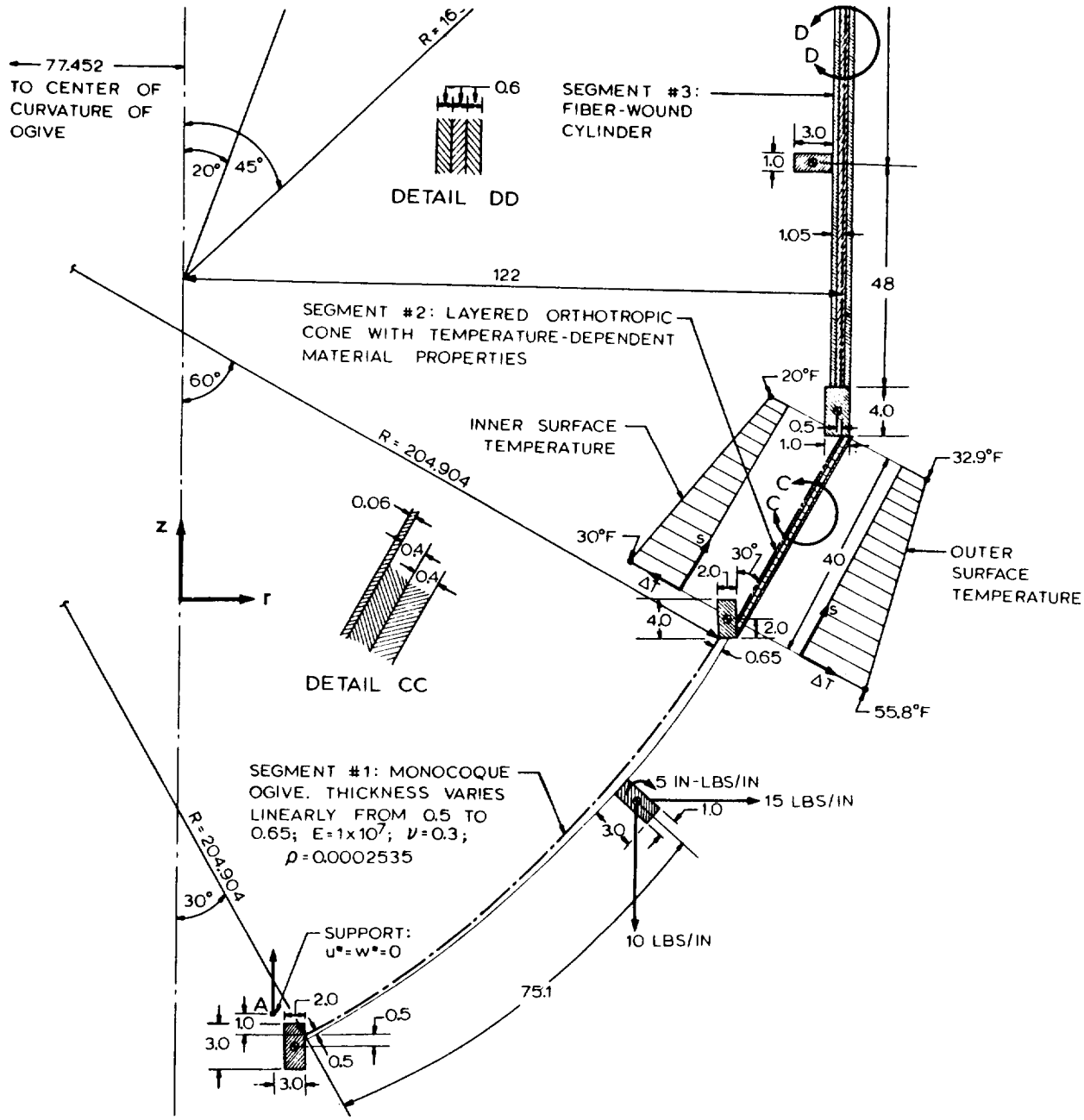


Fig. 1 Segmented Composite Shell for Analysis by BOSOR4 (Page 1 of 2)

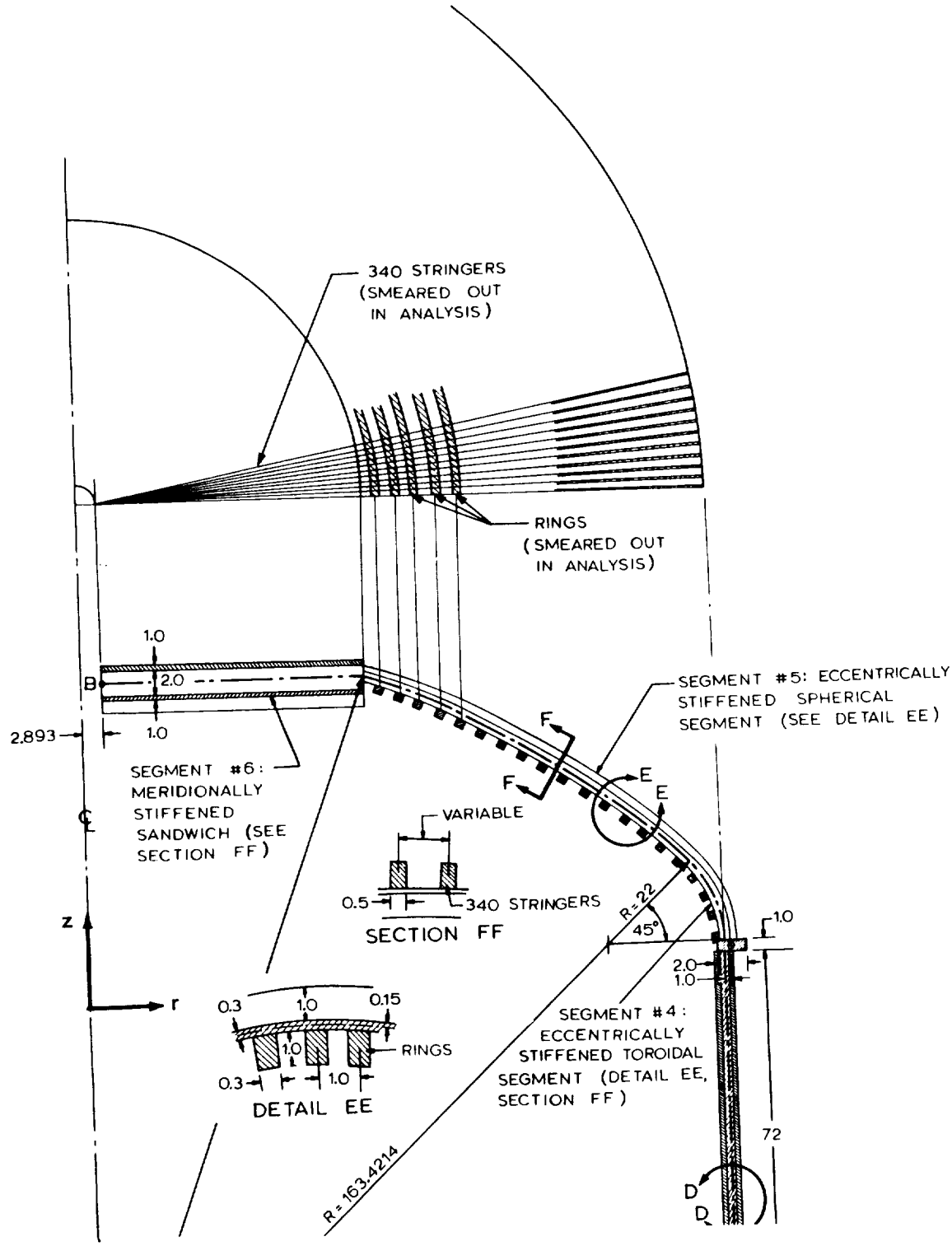


Fig. 1 Segmented Composite Shell for Analysis by BOSOR4 (Page 2 of 2)

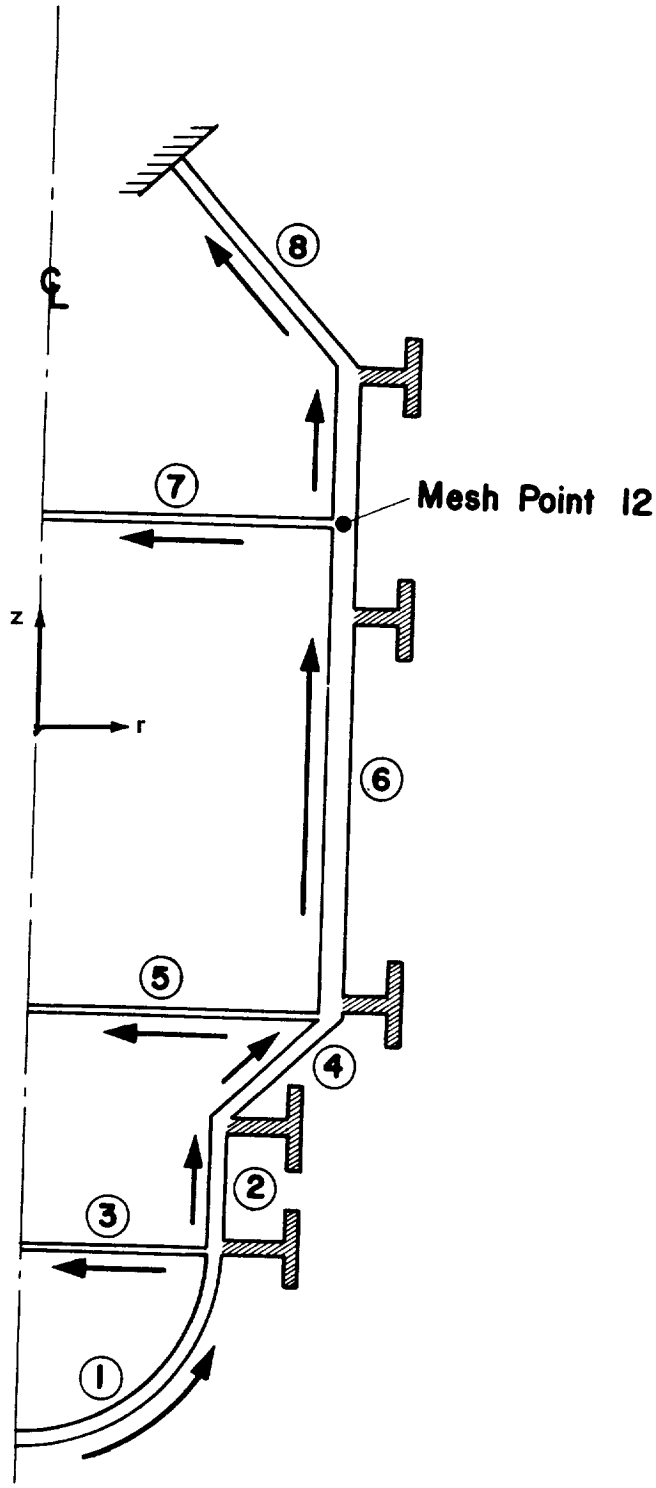


Fig. 2 Typical Branched Shell of Revolution for Analysis by BOSOR4. Table 1 gives the Constraint Condition Input Data.

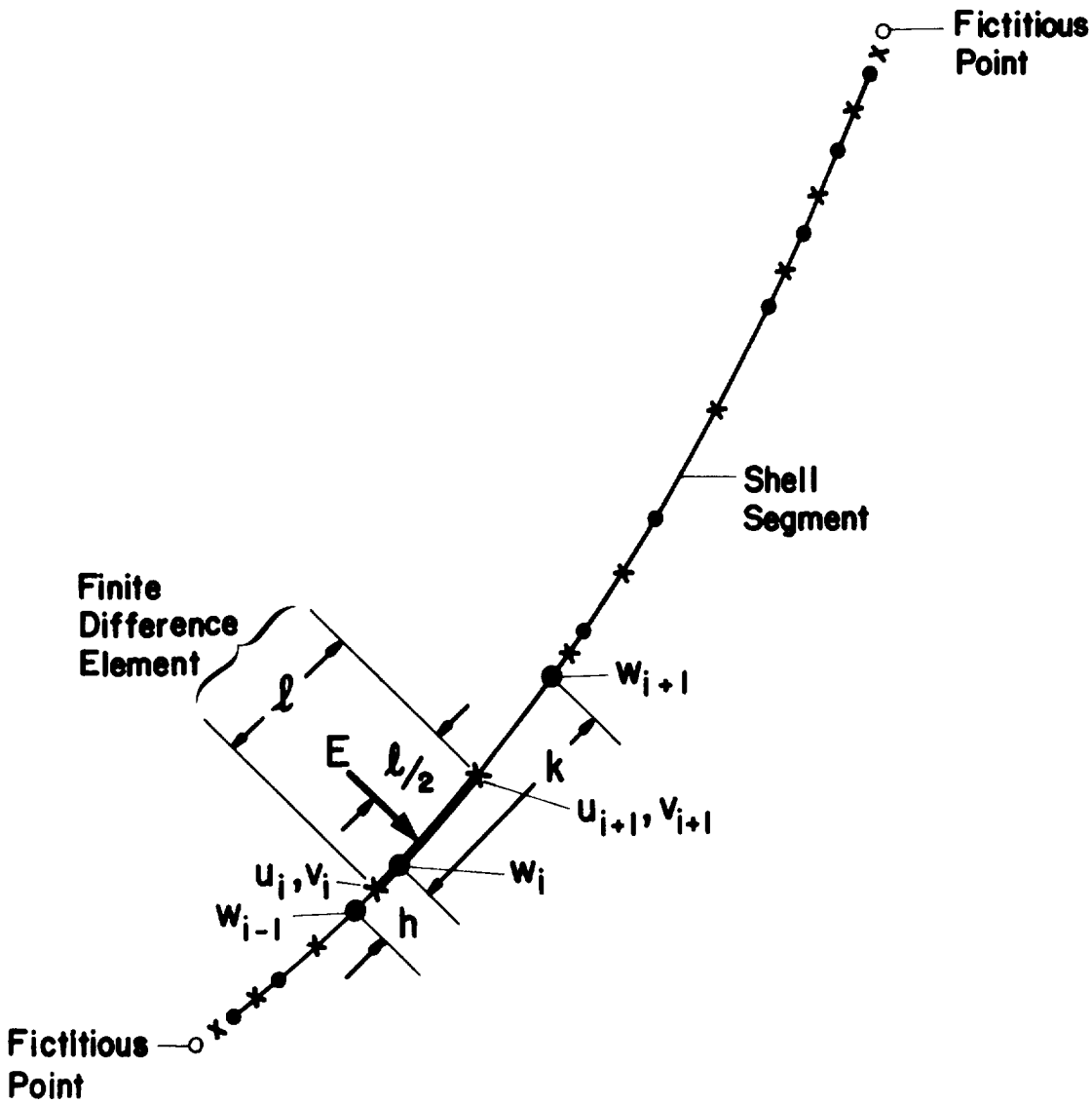


Fig. 3 Finite Difference Scheme with Variable Spacing. Energy Density Evaluated at E. Integration "Area" = ℓ.

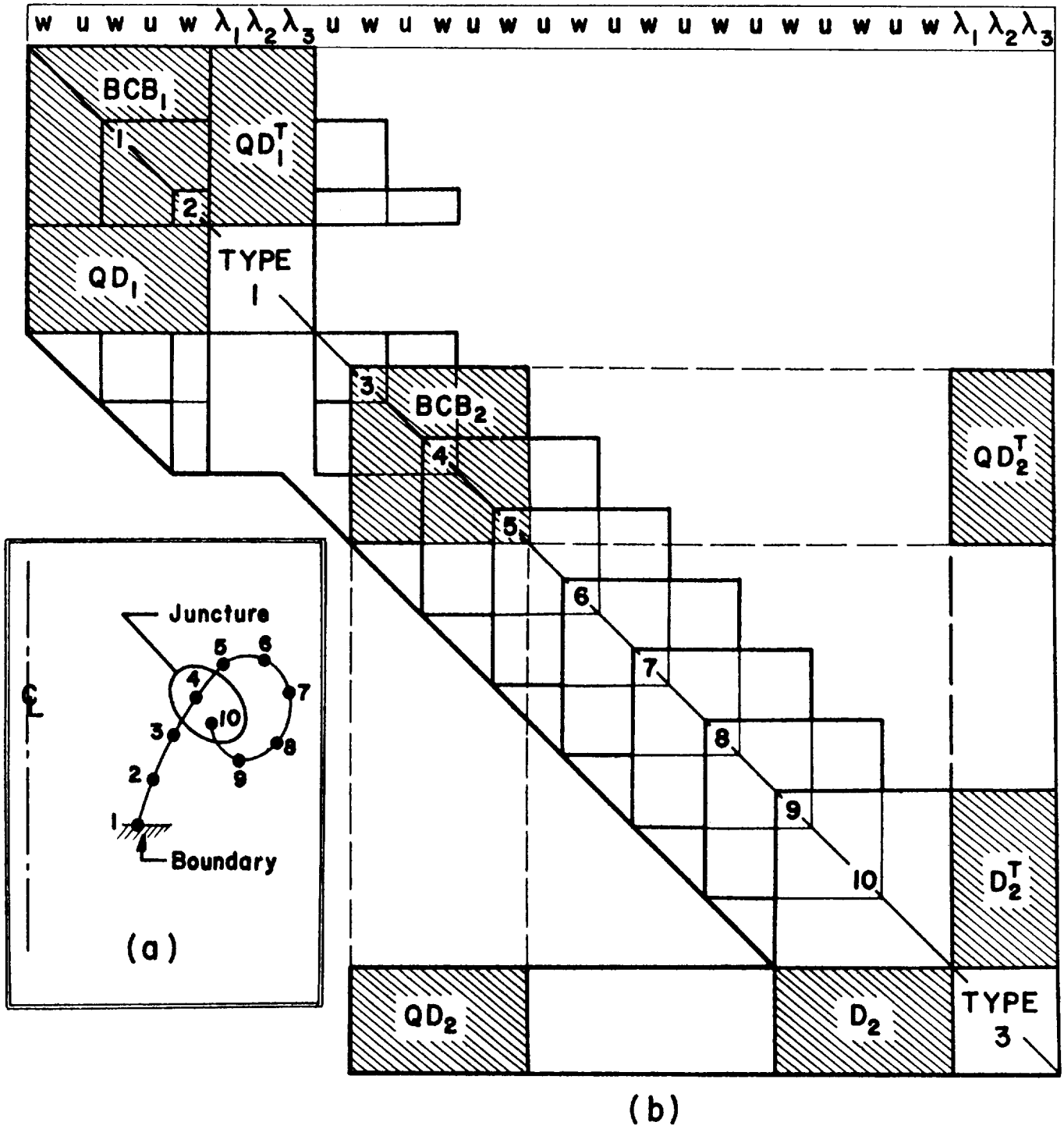


Fig. 4 Stiffness Matrix Configuration with Type 1 and Type 3 Constraint Conditions

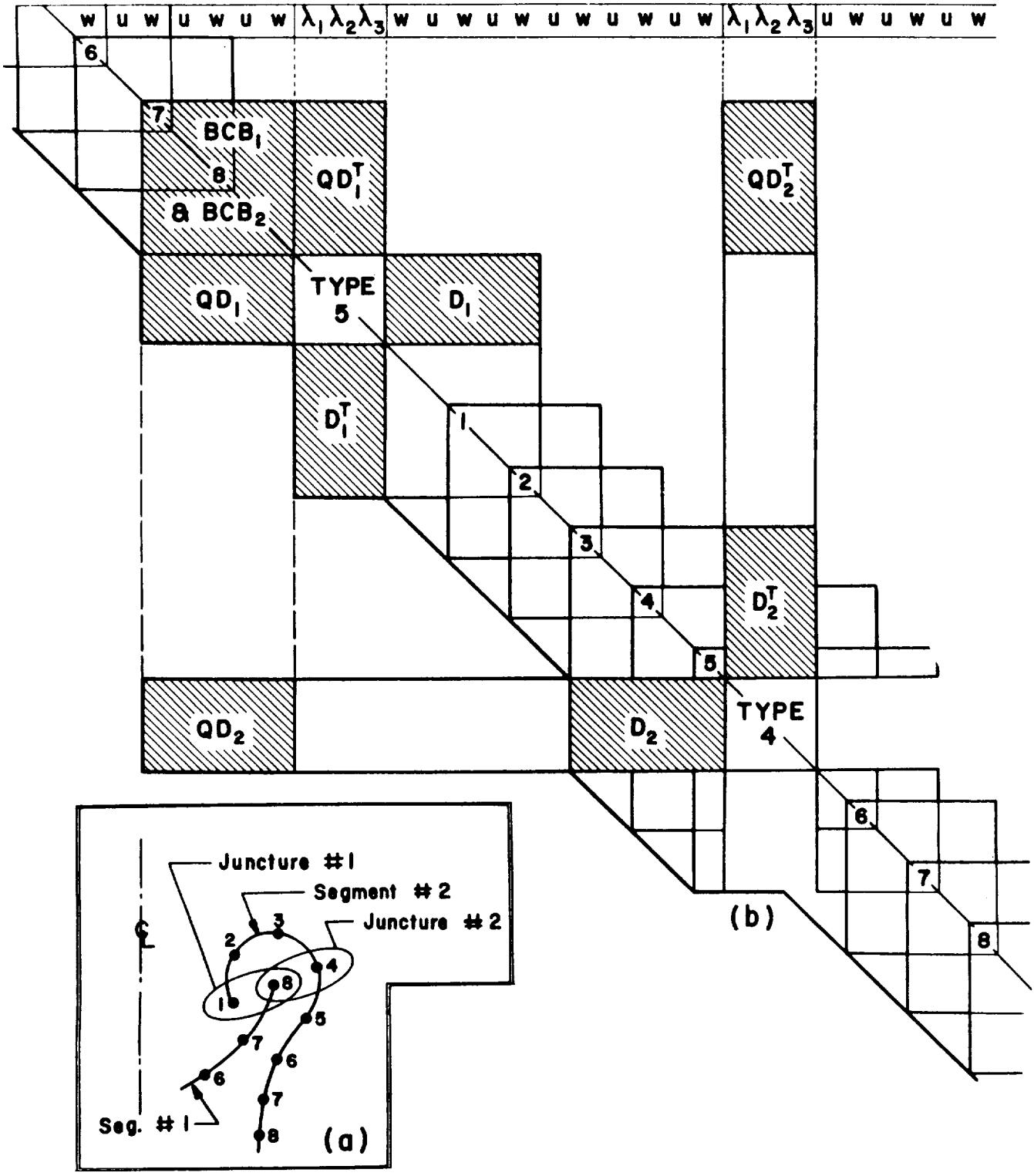


Fig. 5 Stiffness Matrix Configuration with Type 4 and Type 5 Constraint Conditions

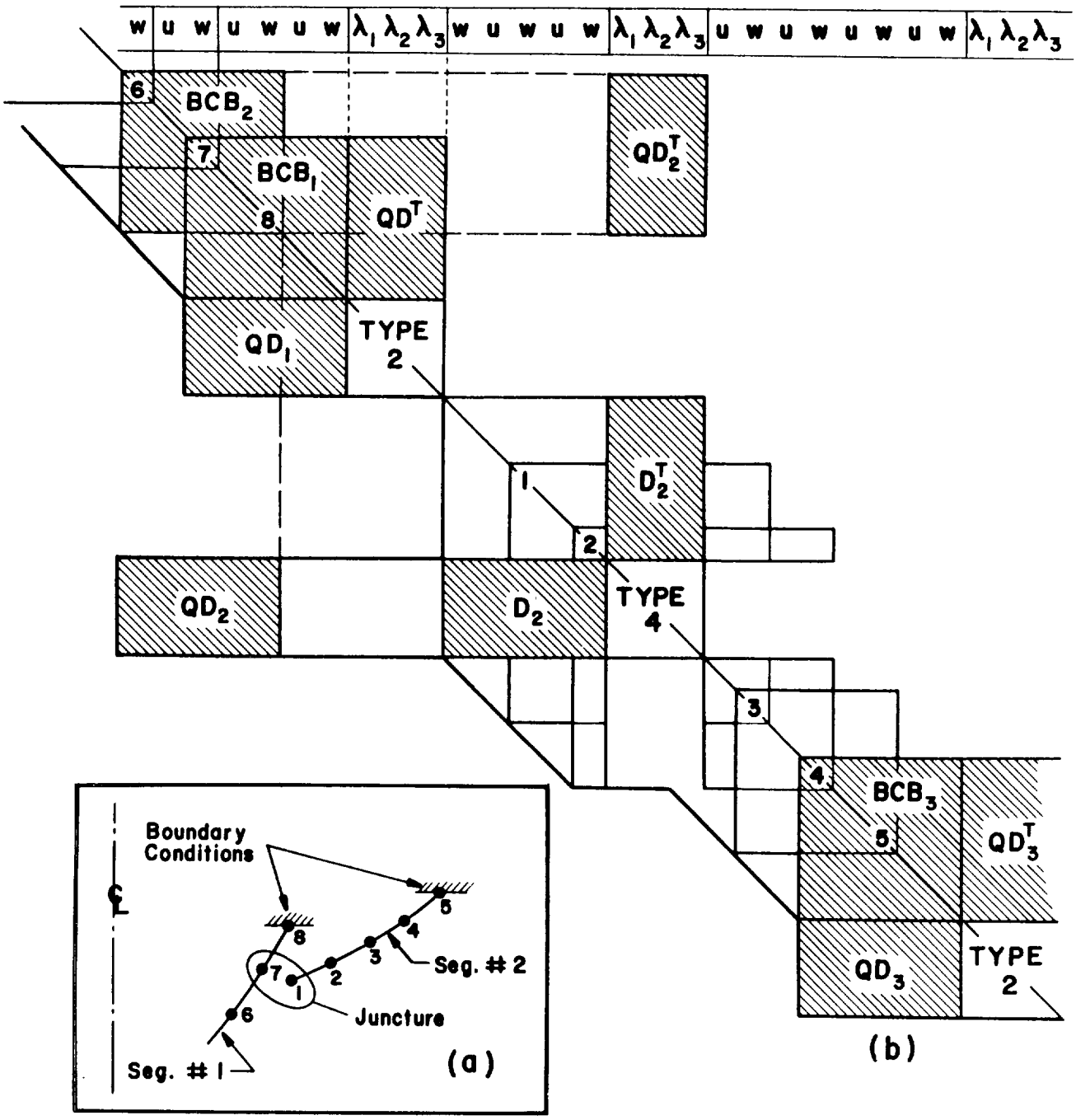


Fig. 6 Stiffness Matrix Configuration with Type 2 and Type 4 Constraint Conditions

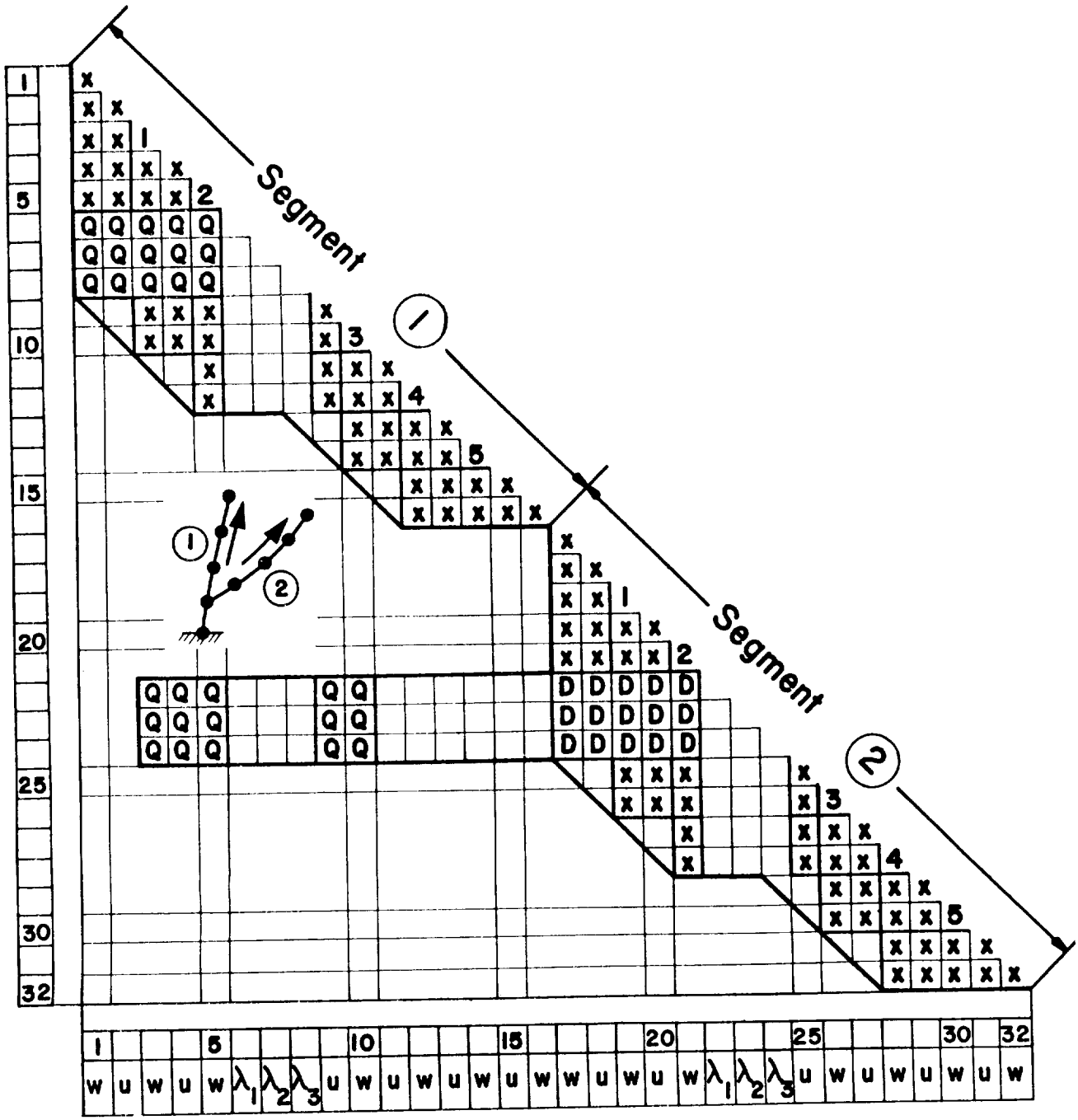


Fig. 7 Stiffness Matrix Configuration with "Split" Q Matrix

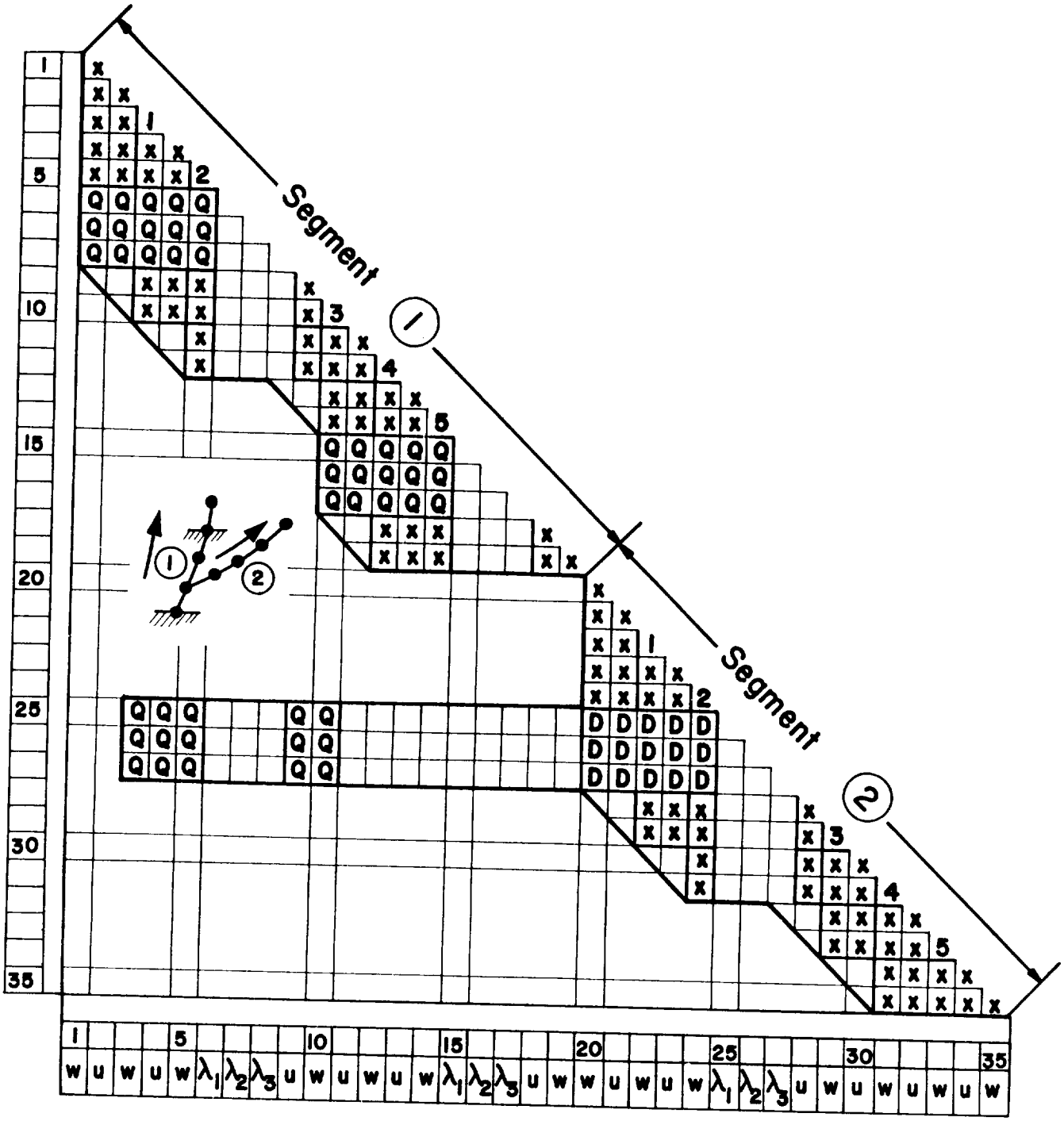
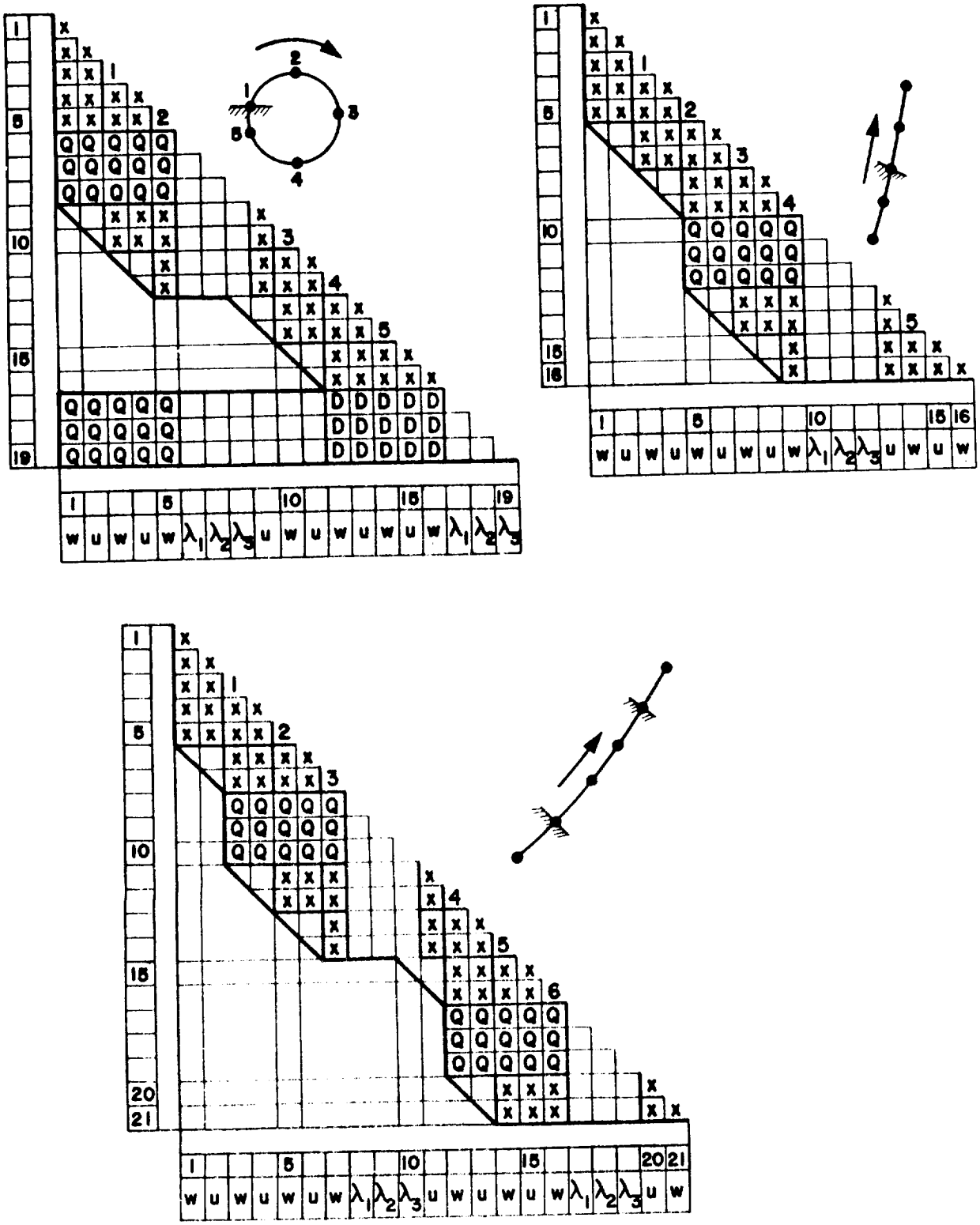


Fig. 8 Stiffness Matrix Configuration with Boundary Type Constraint Condition Not at Edge



Figs. 9, 10 and 11 Variety of Stiffness Matrices with Constraints as Shown

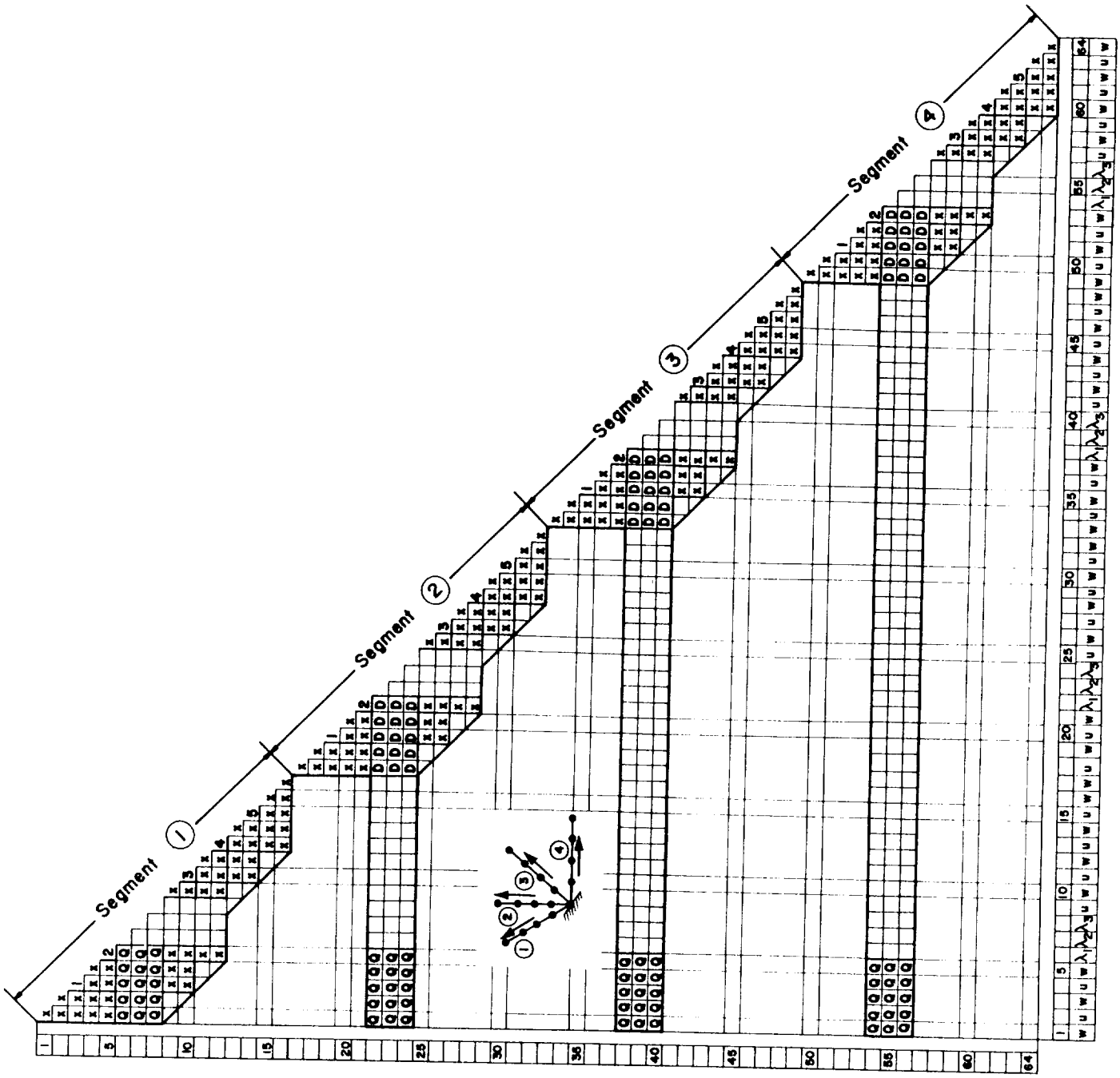


Fig. 12 Stiffness Matrix Configuration for Structure with Many Branches at a Point

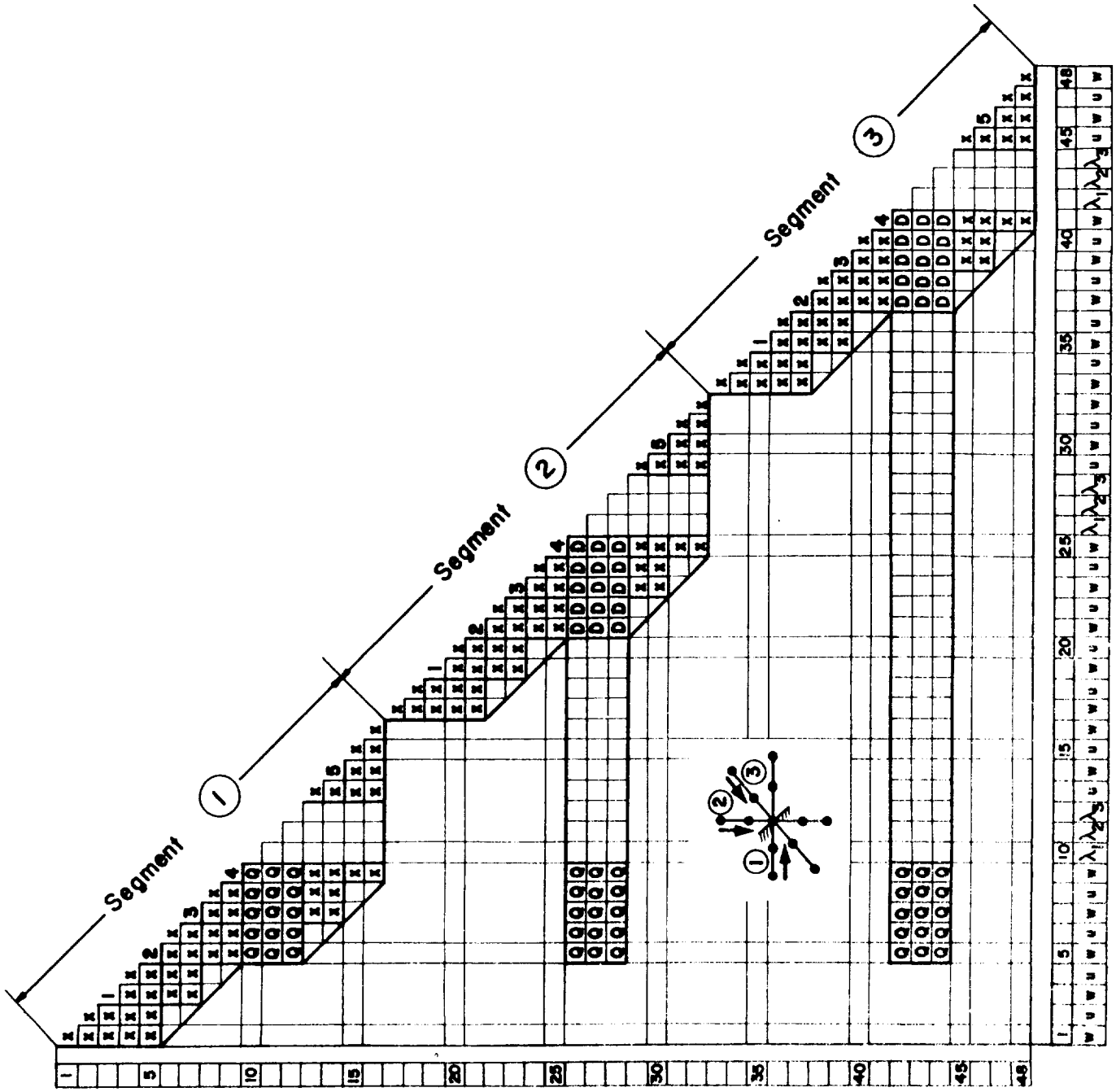


Fig. 13 Stiffness Matrix Configuration for Crossing Branches with Additional Constraint

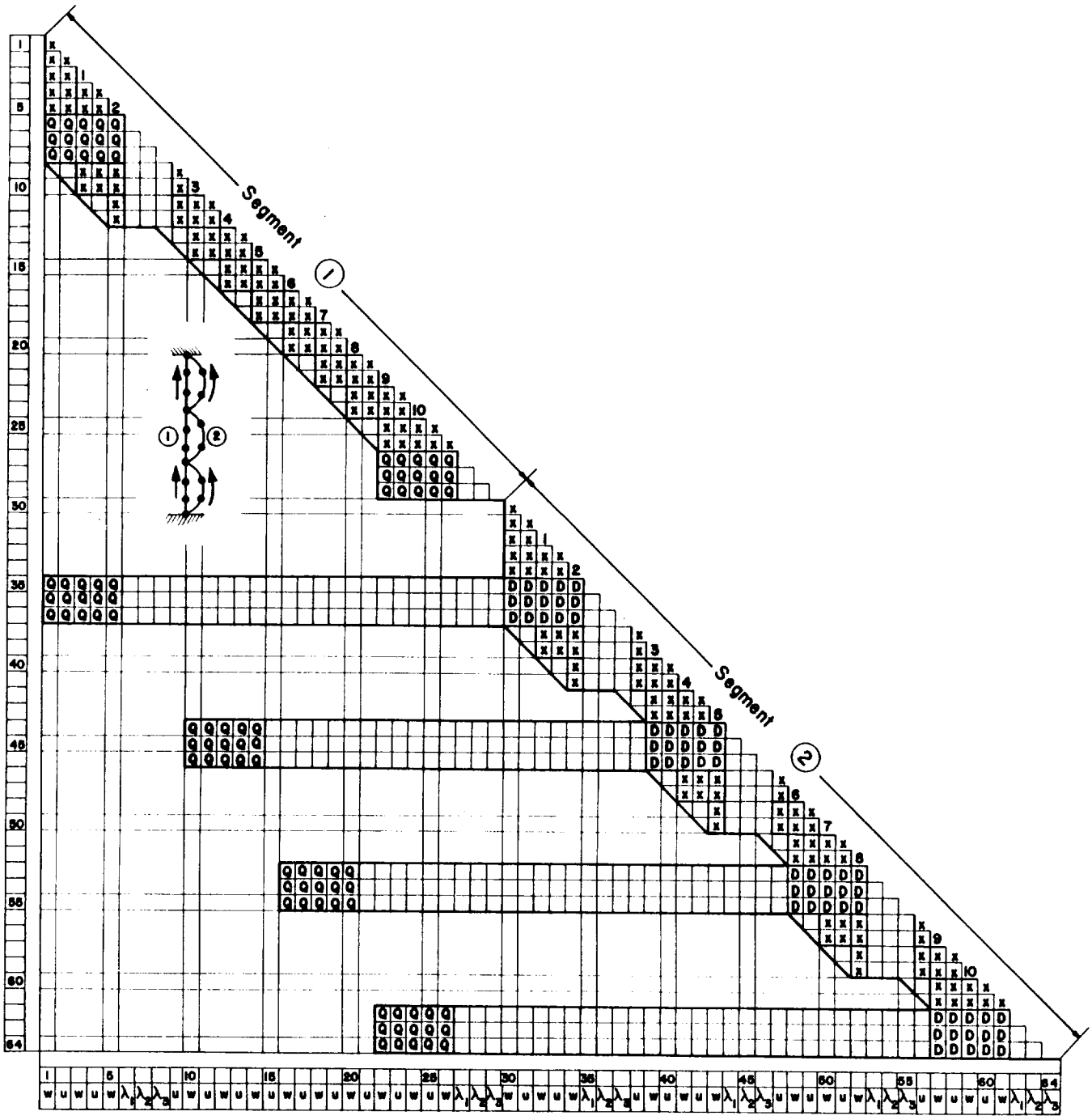


Fig. 14 Stiffness Matrix Configuration for Double-Walled Structure Fastened Intermittently

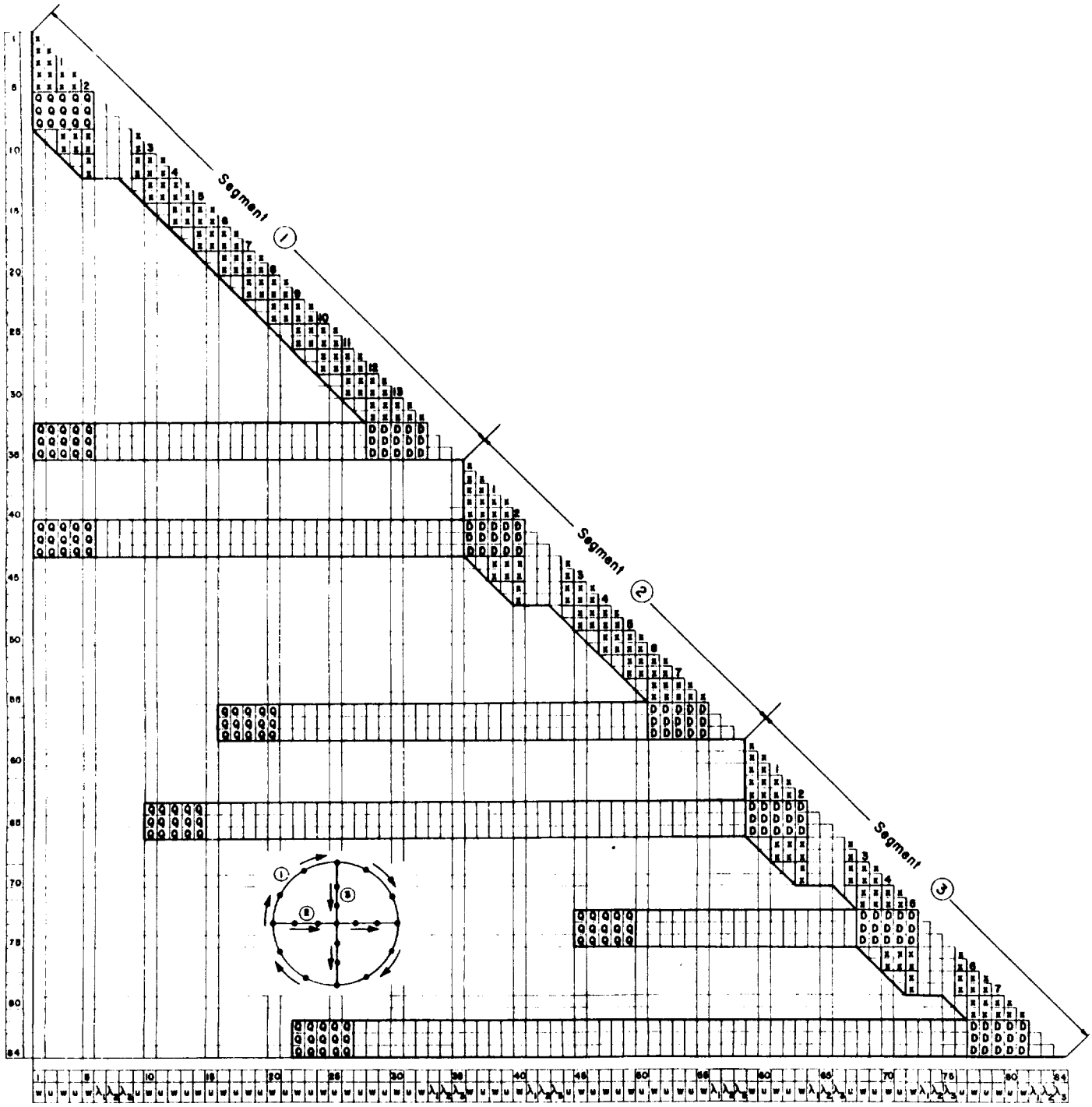


Fig. 15 Stiffness Matrix Configuration for Shell with Crossing Bulkheads

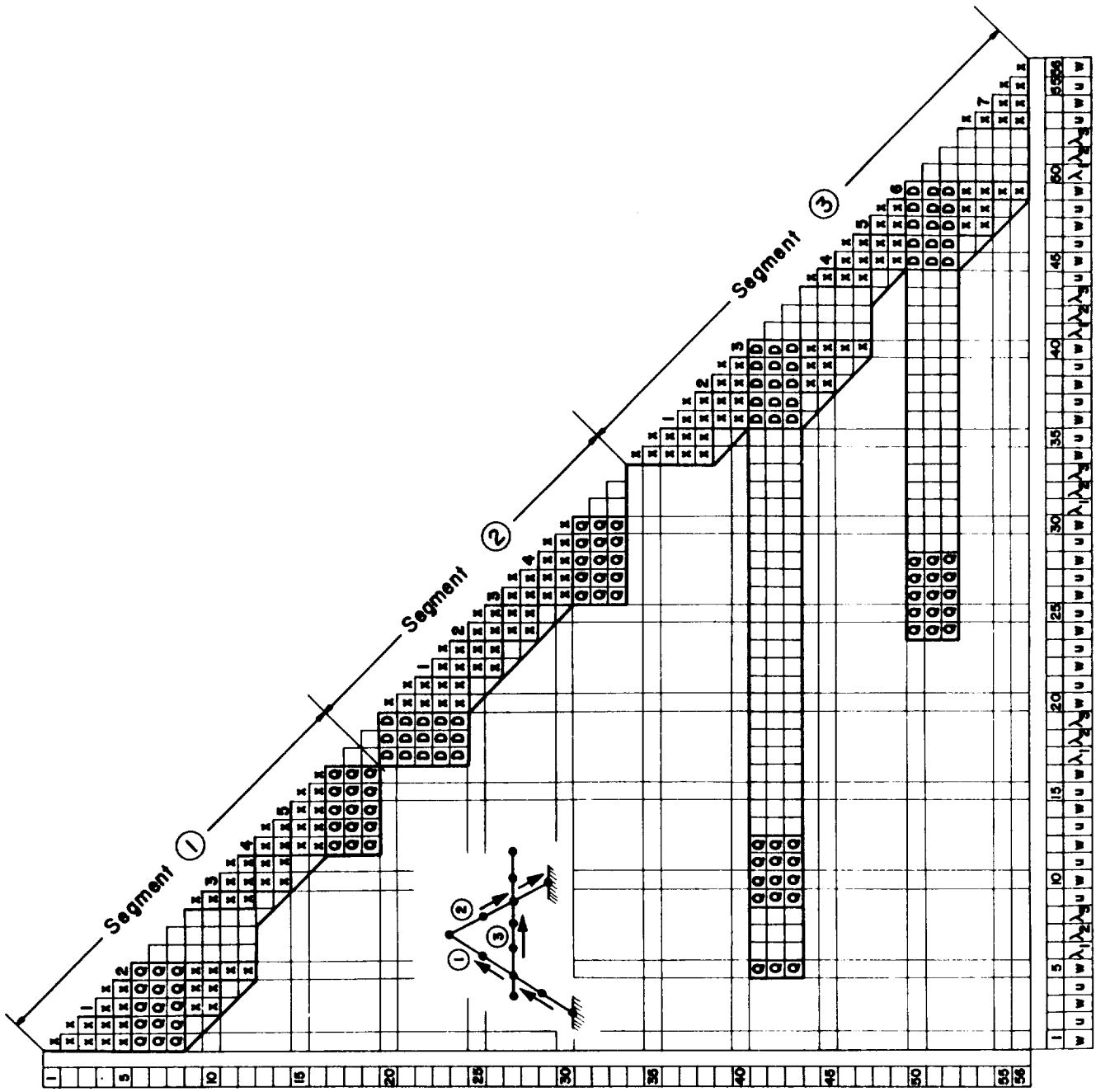


Fig. 16 Stiffness Matrix Configuration for Three-Segment Shell With Split Q Matrix

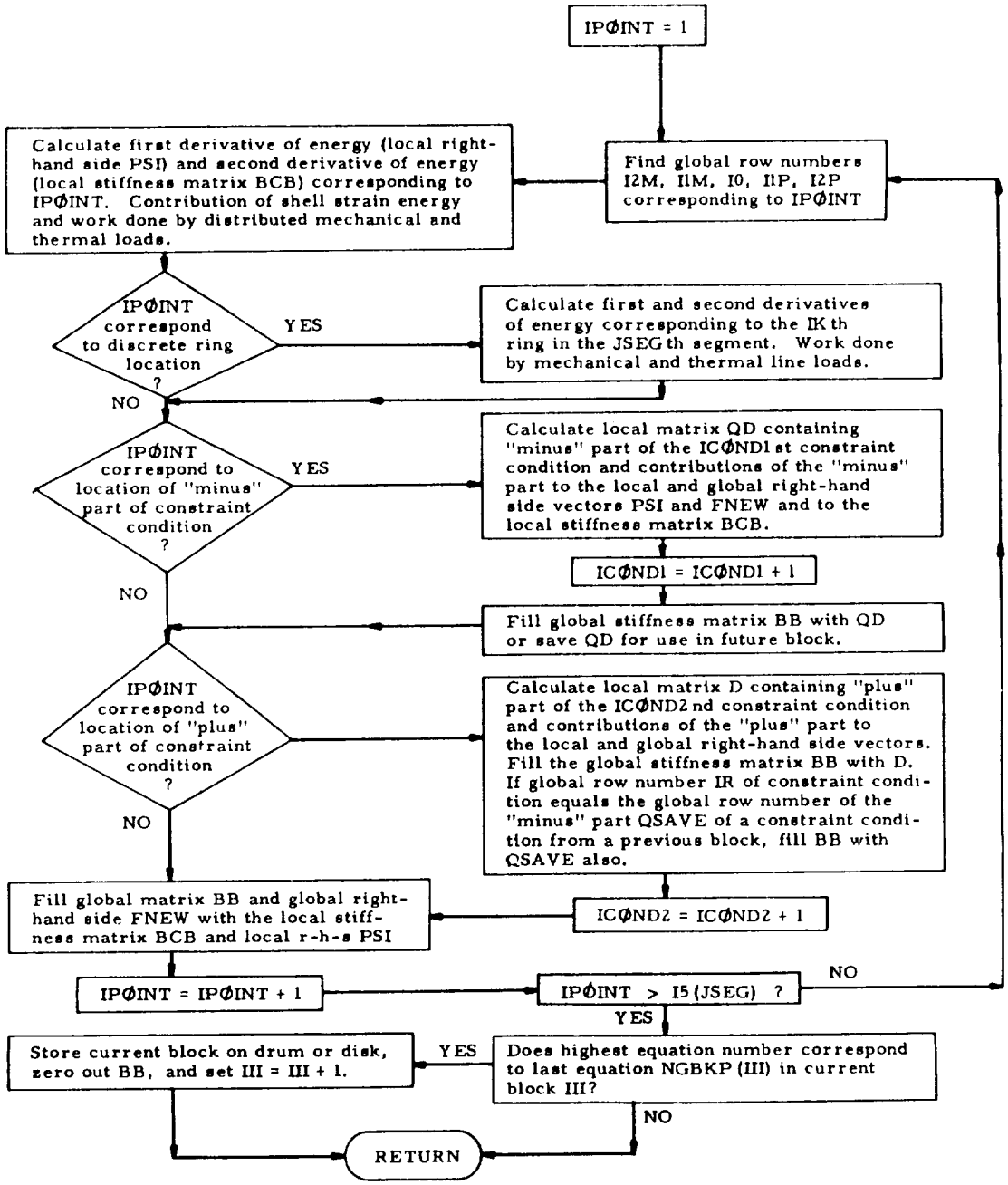


Fig. 17 Flow Chart of Subroutine PRESTS. PRESTS is entered for each segment of a shell of NSEG segments and for each Newton-Raphson iteration of the nonlinear solution.

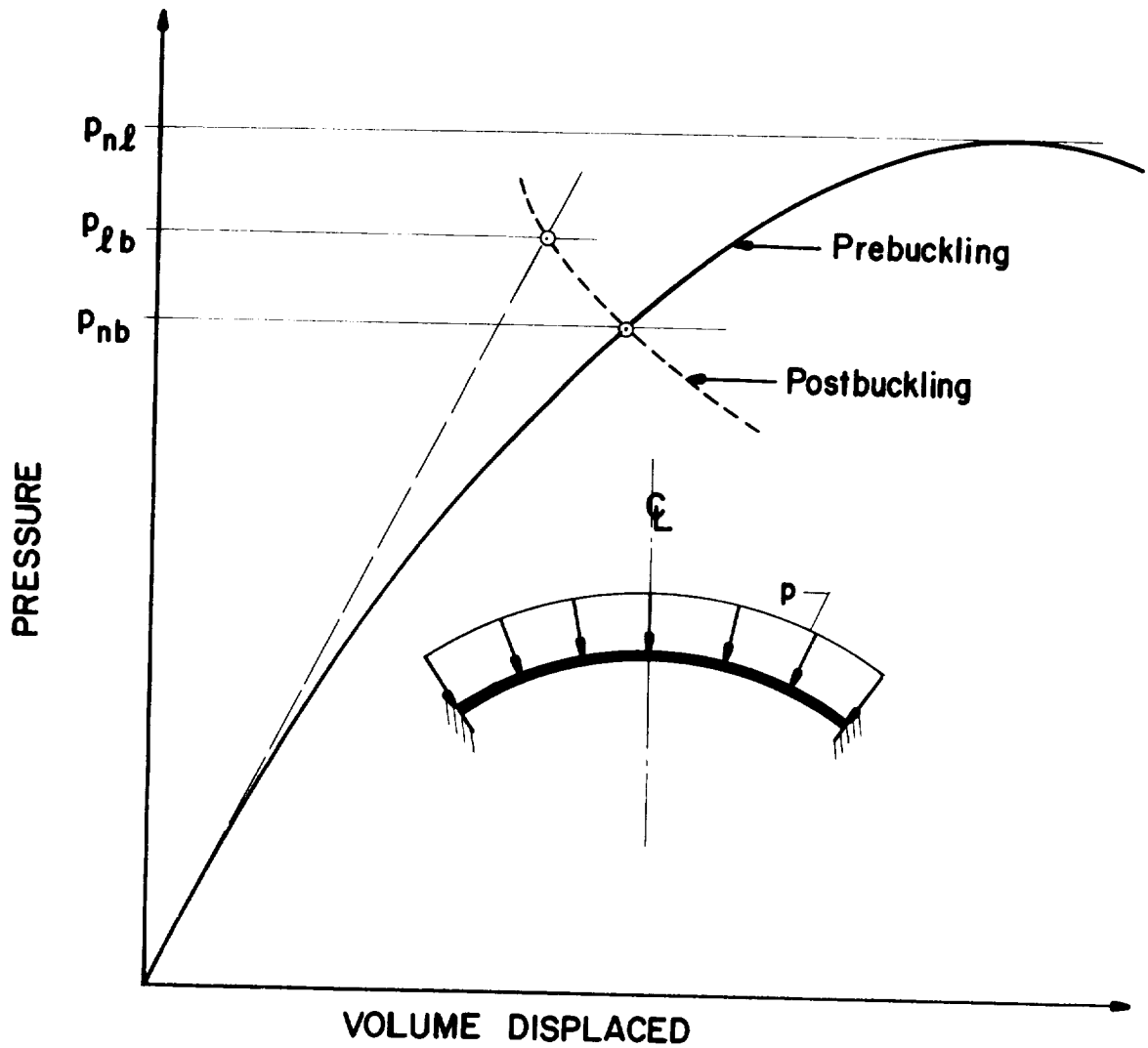


Fig. 18 Load Deflection Curves for Shallow Spherical Cap, Showing Bifurcation Points from Linear Prebuckling Curve ($p_{\ell b}$) and Nonlinear Prebuckling Curve (p_{nb})

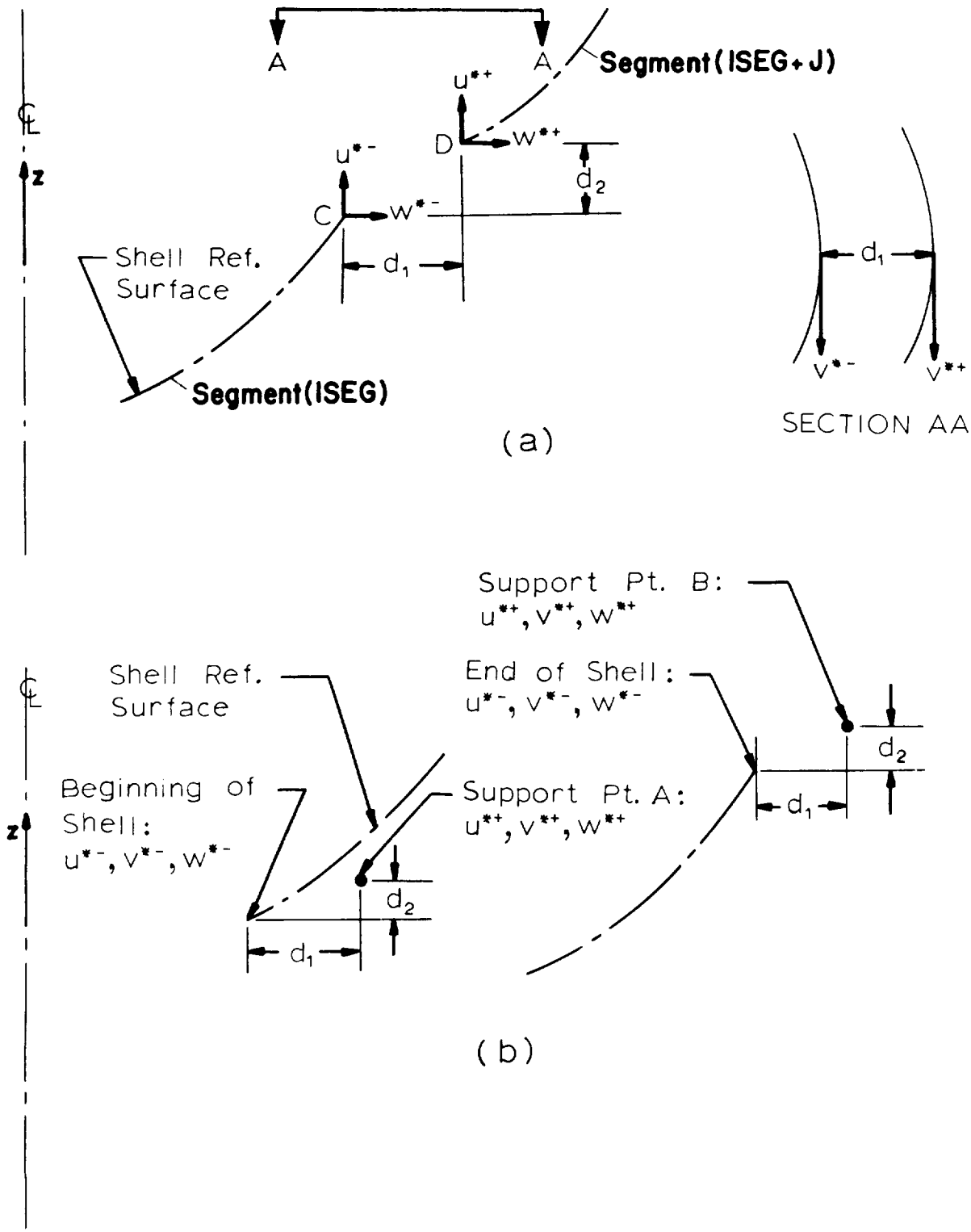


Fig. 19 (a) Shell Reference Surface Discontinuity
(b) Support Points

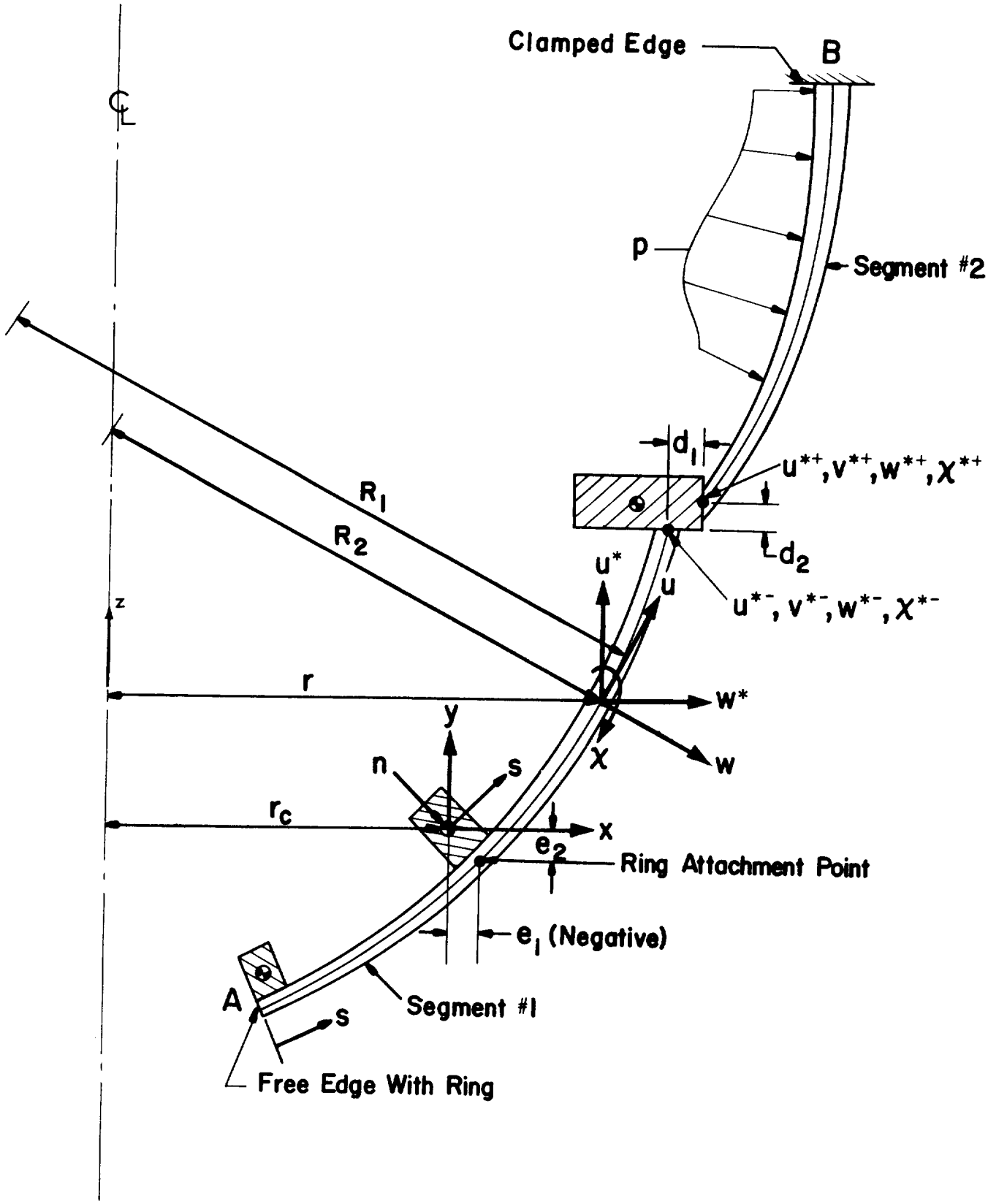


Fig. 20 Two-Segment Shell Meridian with Discrete Rings, Discontinuity, and Various Quantities Identified

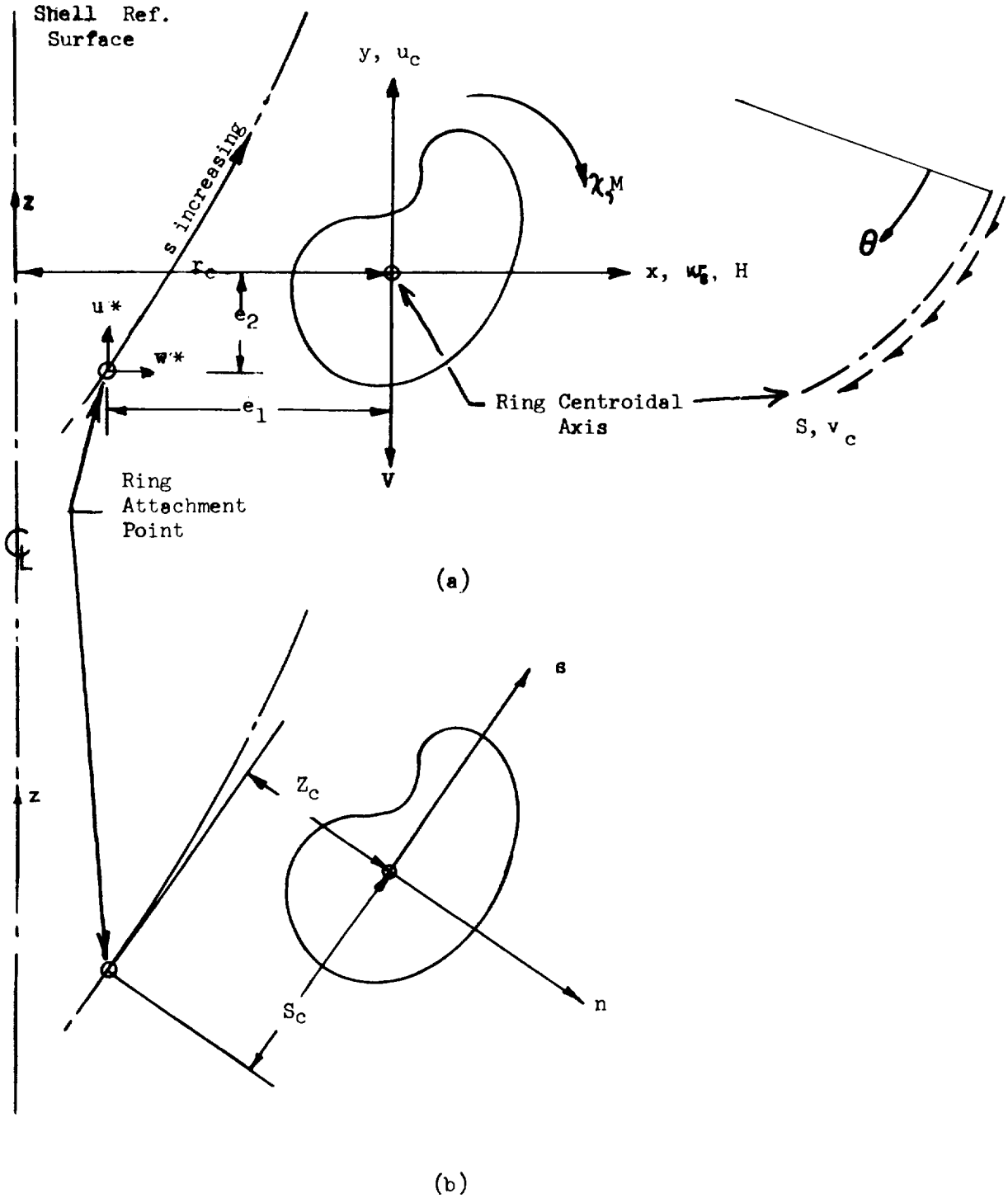


Fig.21 (a) Discrete Ring with Centroidal Displacements, Forces
(b) Normal and Tangential Axes

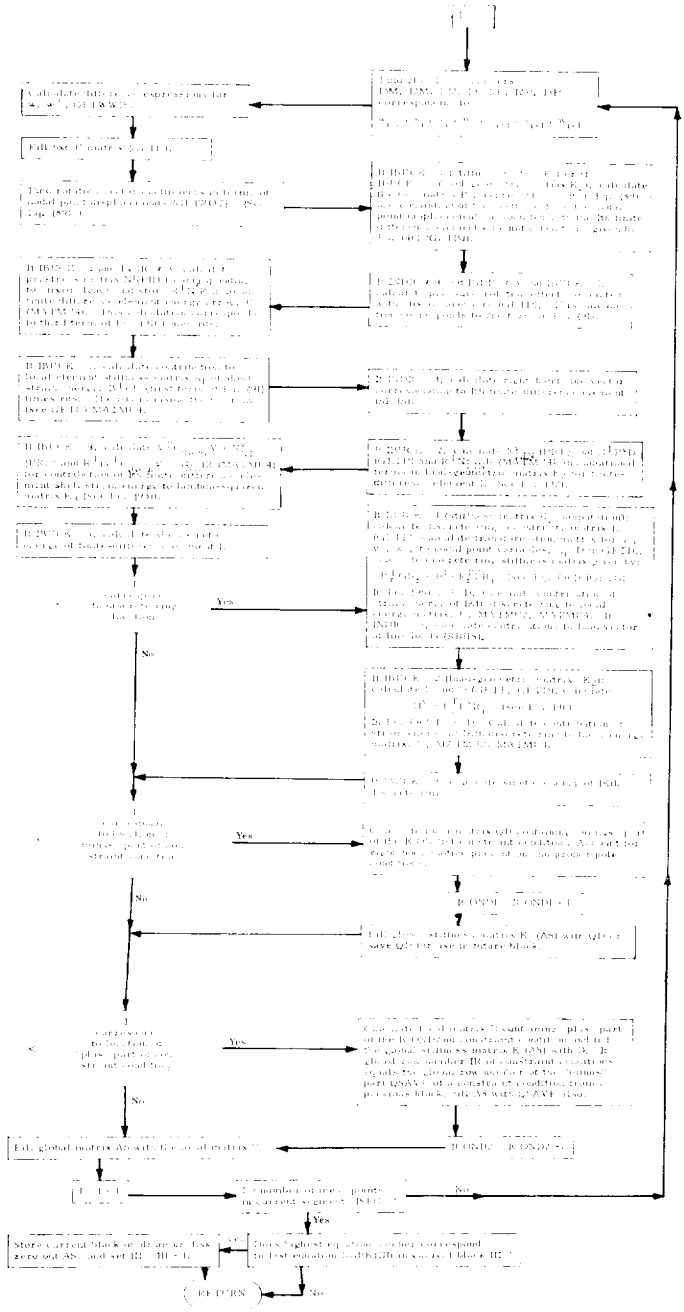


Fig. 22 Flow Chart of Subroutine STABIL, Which is Analogous to Subroutine PRESTS (See Fig. 17)

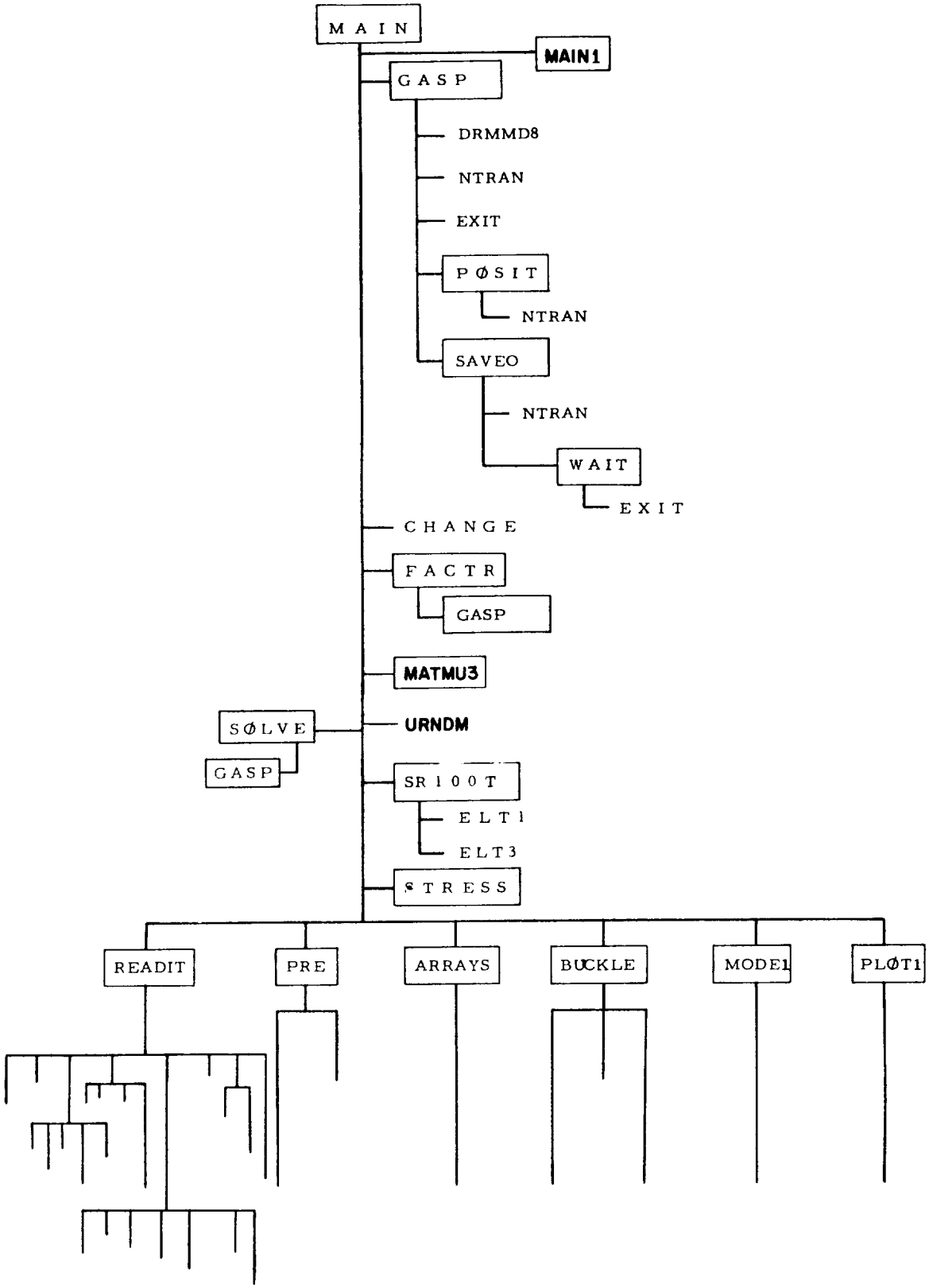


Fig. 23(a) MAIN Program with Six Overlay Links
(UNIVAC 1108 Configuration)

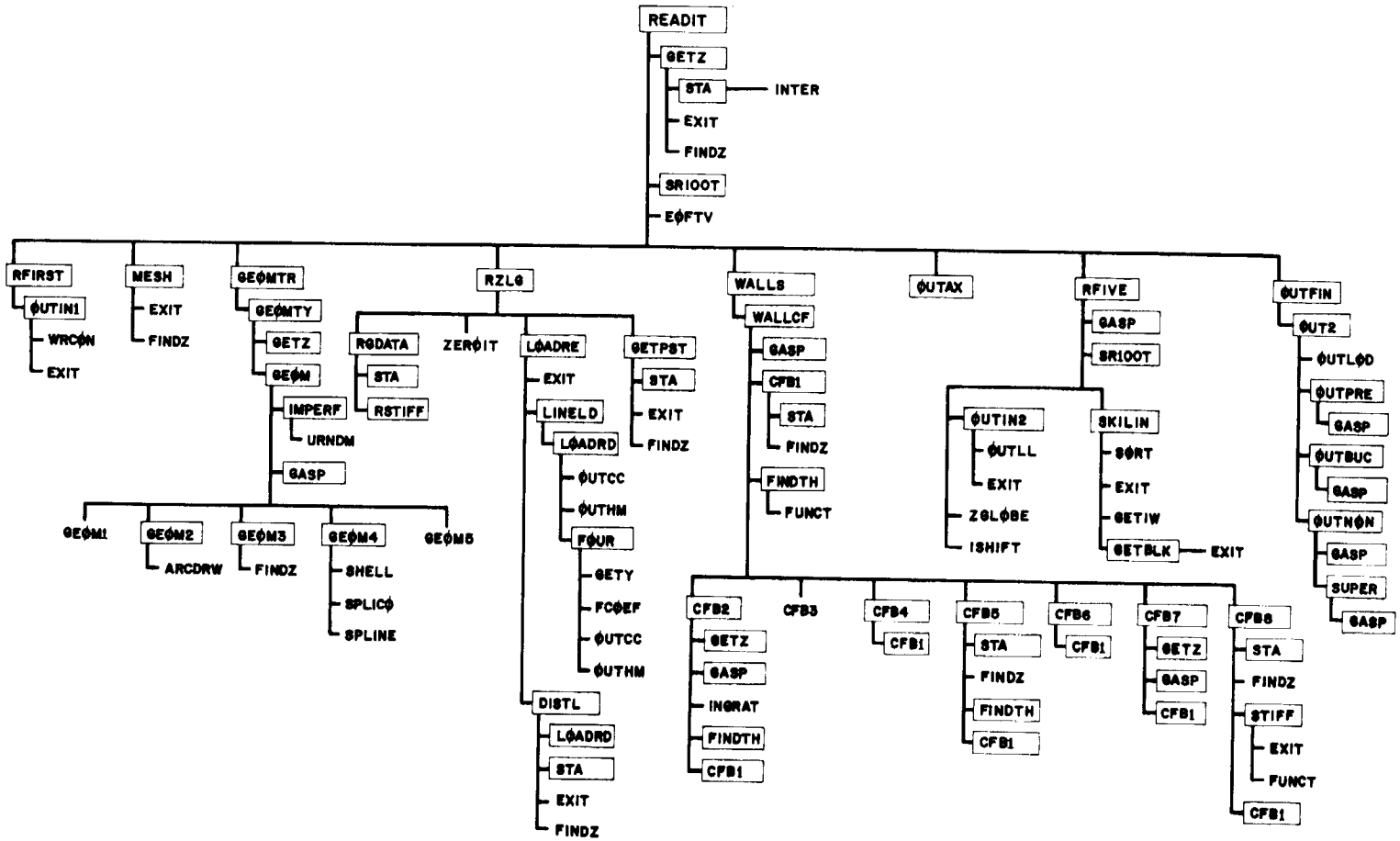


Fig. 23(b) READIT LINK (Input-Output) UNIVAC 1108 Configuration

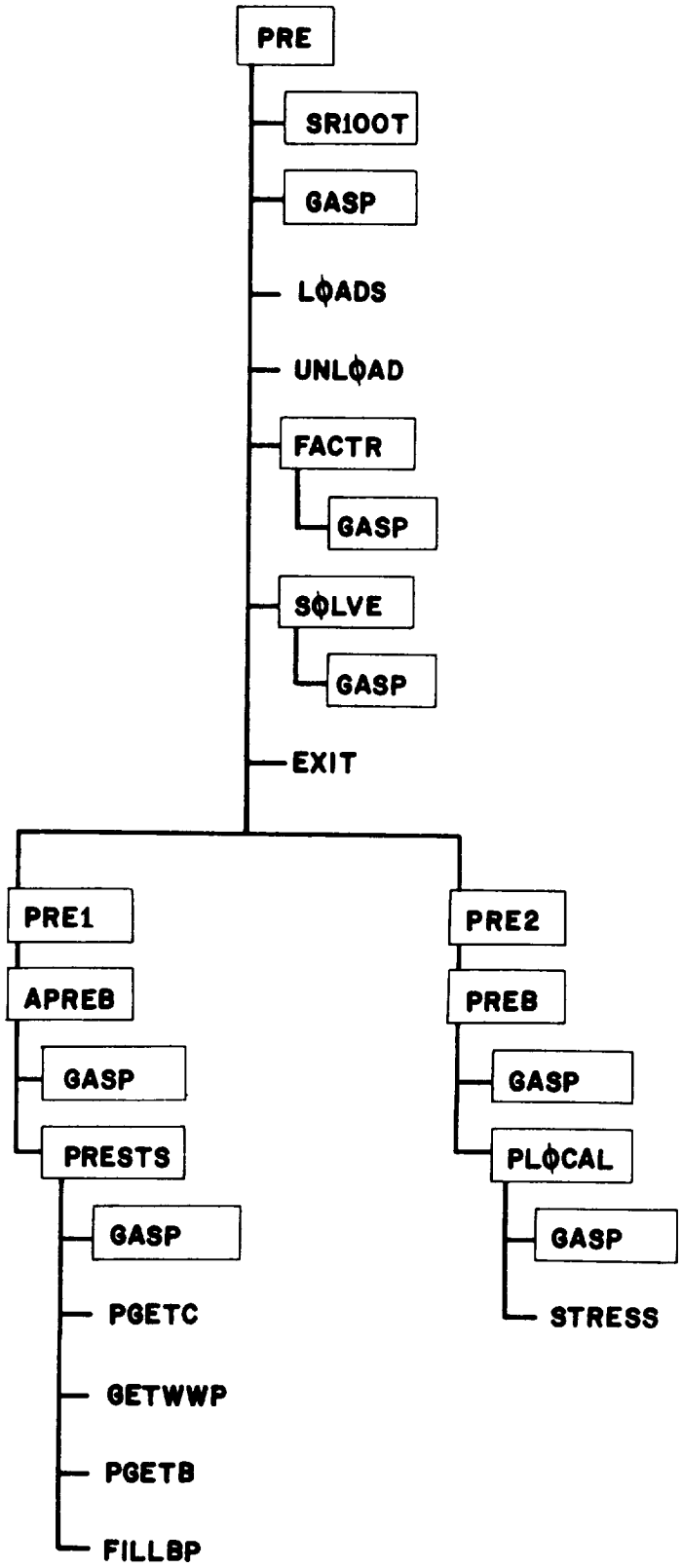


Fig. 23(c) PRE Link (Nonlinear Axisymmetric Prestress)

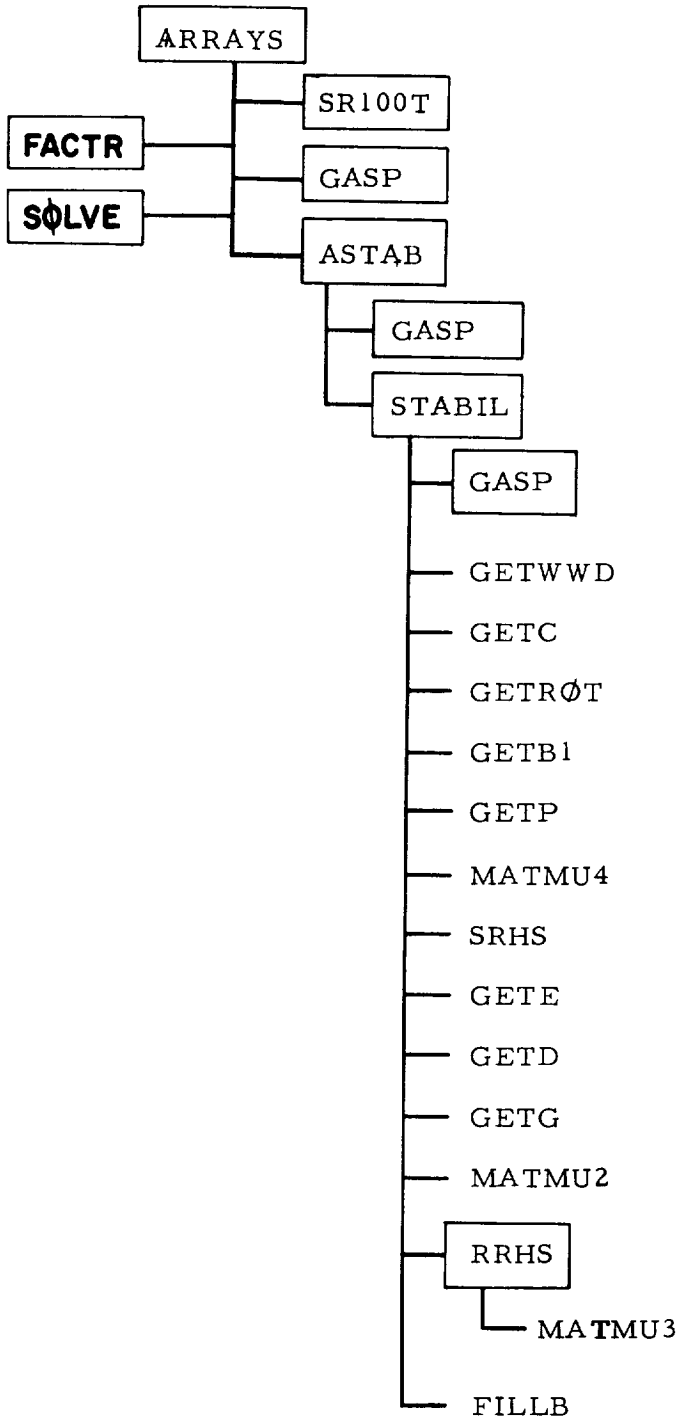


Fig. 23(d) ARRAYS Link (Linear Stress, Stability, Vibration Equations Set Up)

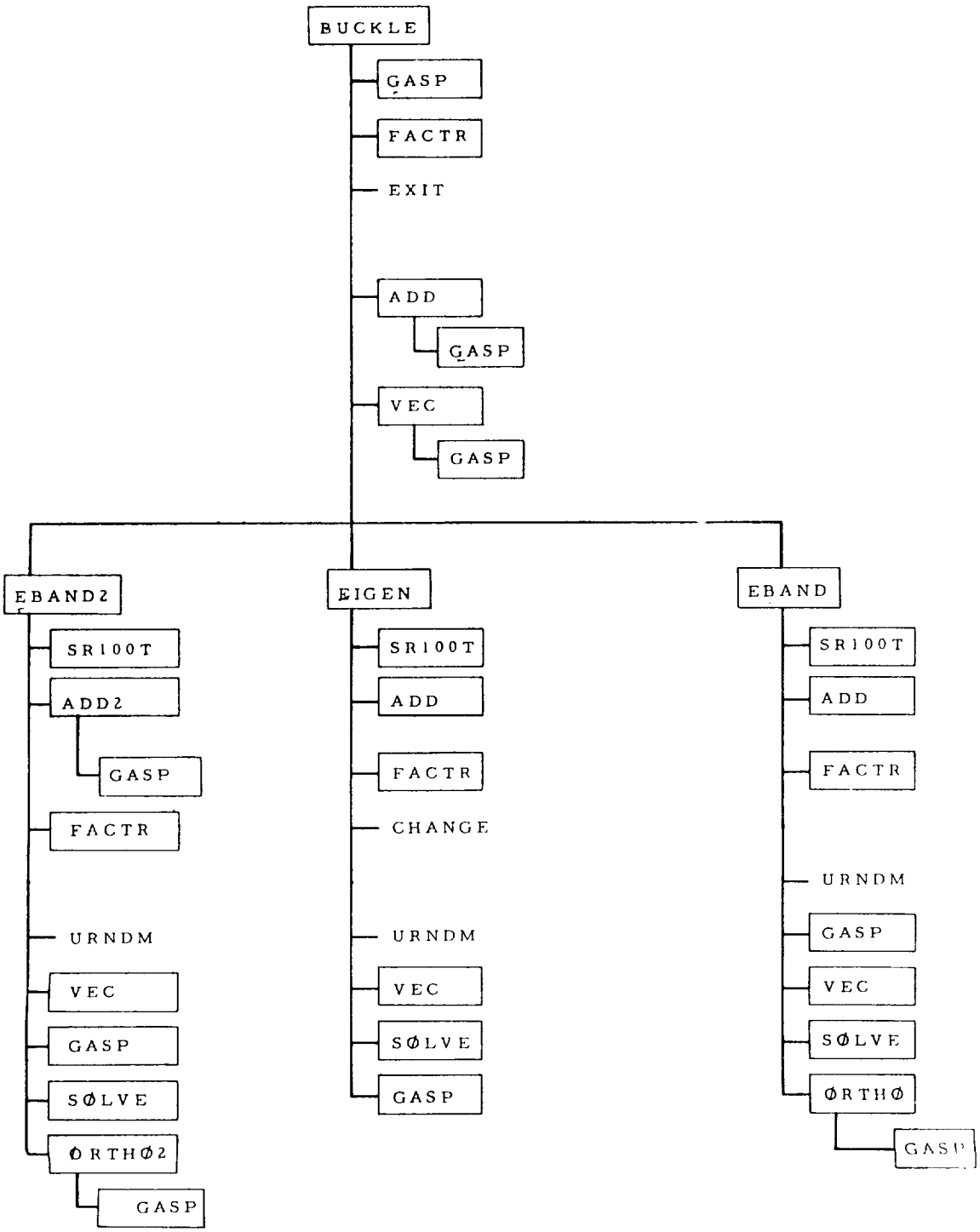


Fig. 23(e) BUCKLE Link (Linear Stress, Stability, Vibration Equations Solved)

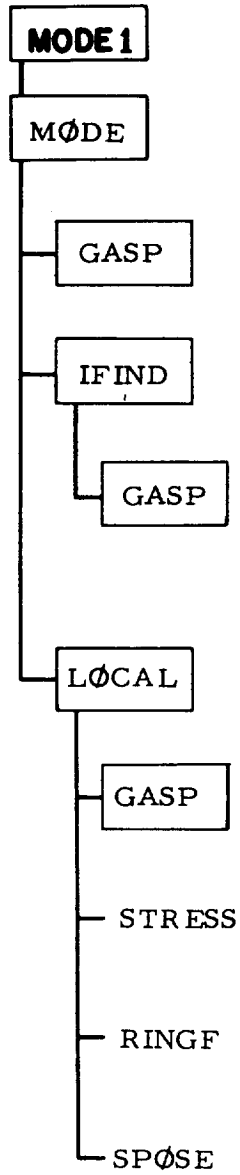


Fig. 23(f) MØDE Link (Linear Stresses, Buckling and Vibration Modes Obtained)

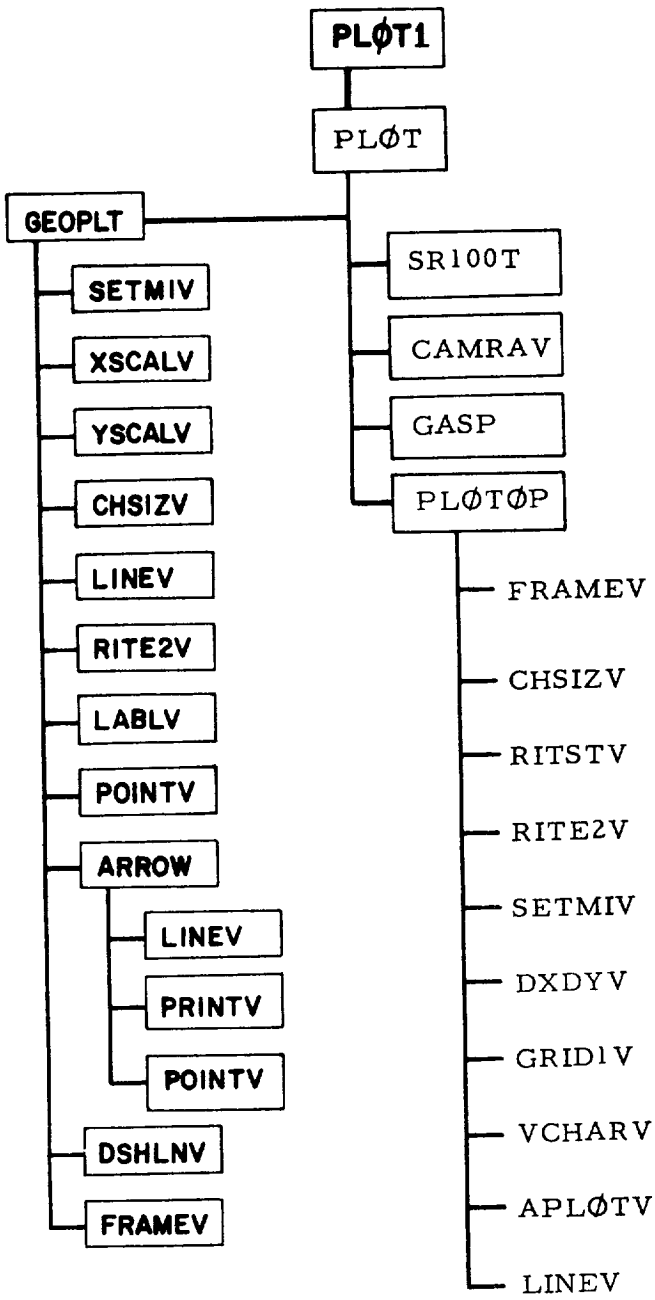


Fig. 23(g) PLØT Link (Important Results Plotted with SC4020)

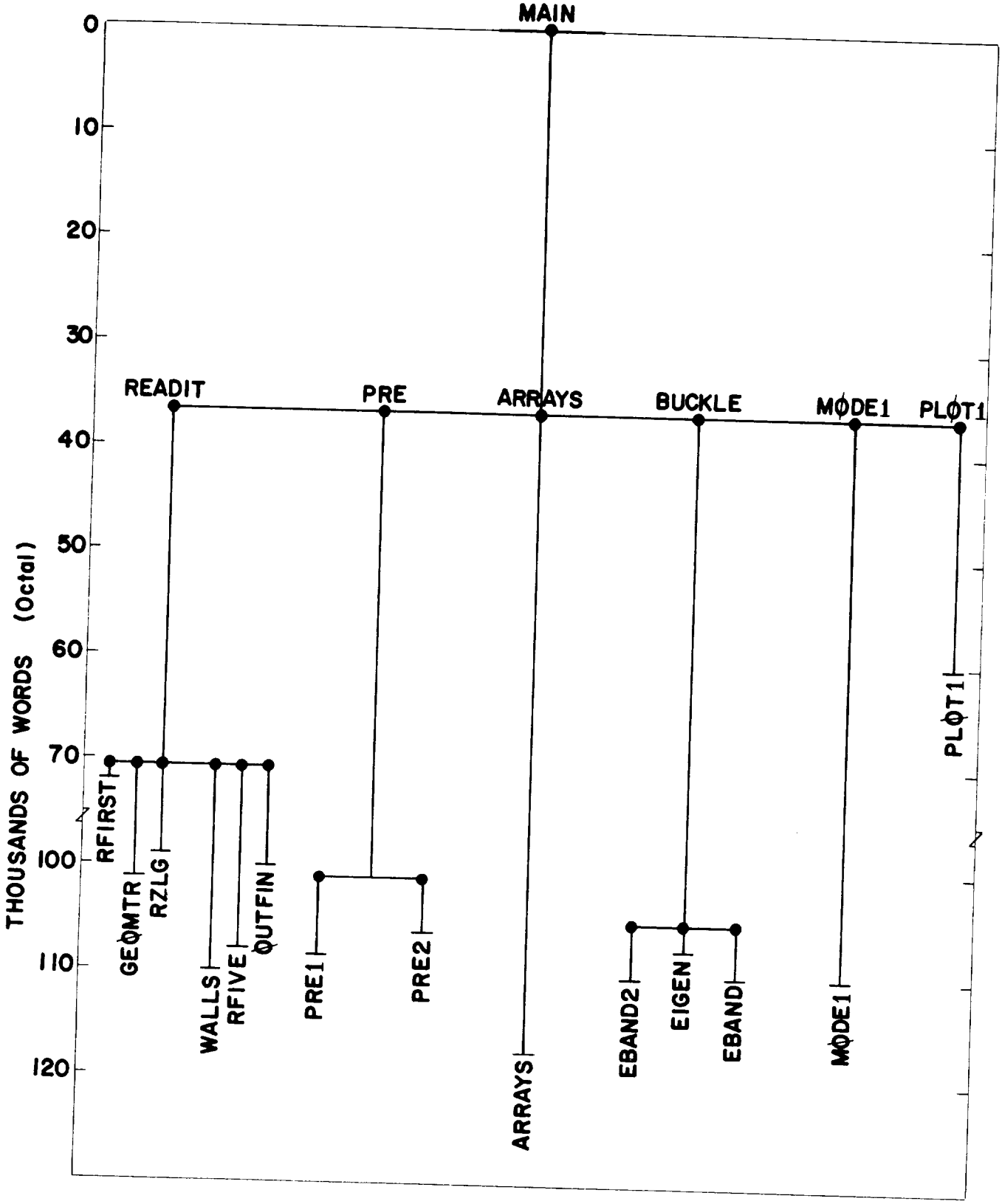


Fig. 23(n) CDC 6600 Storage Requirements in Octal Words

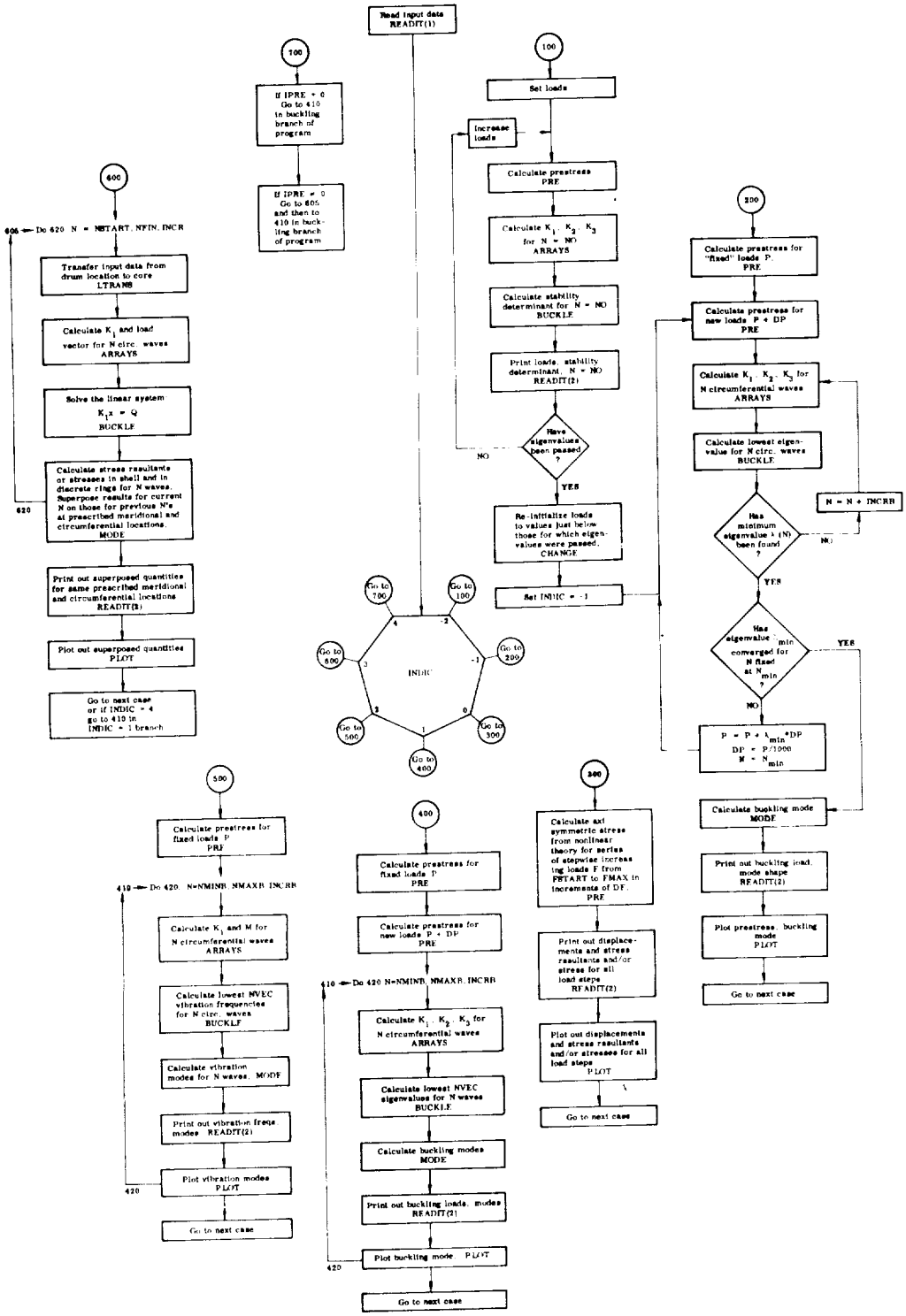


Fig. 24(a) Flow Chart of MAIN

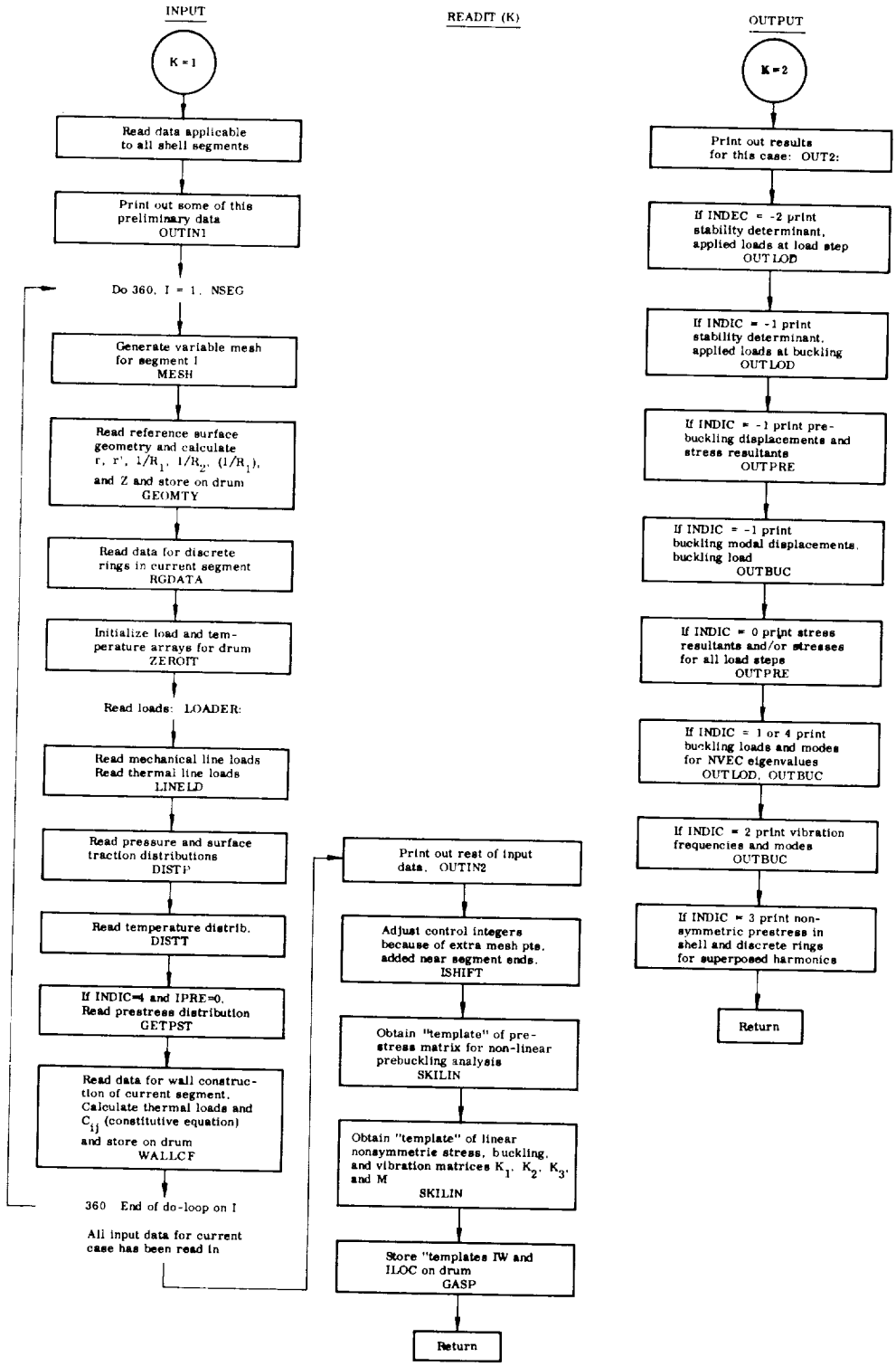


Fig. 24(b) Flow Chart of READIT

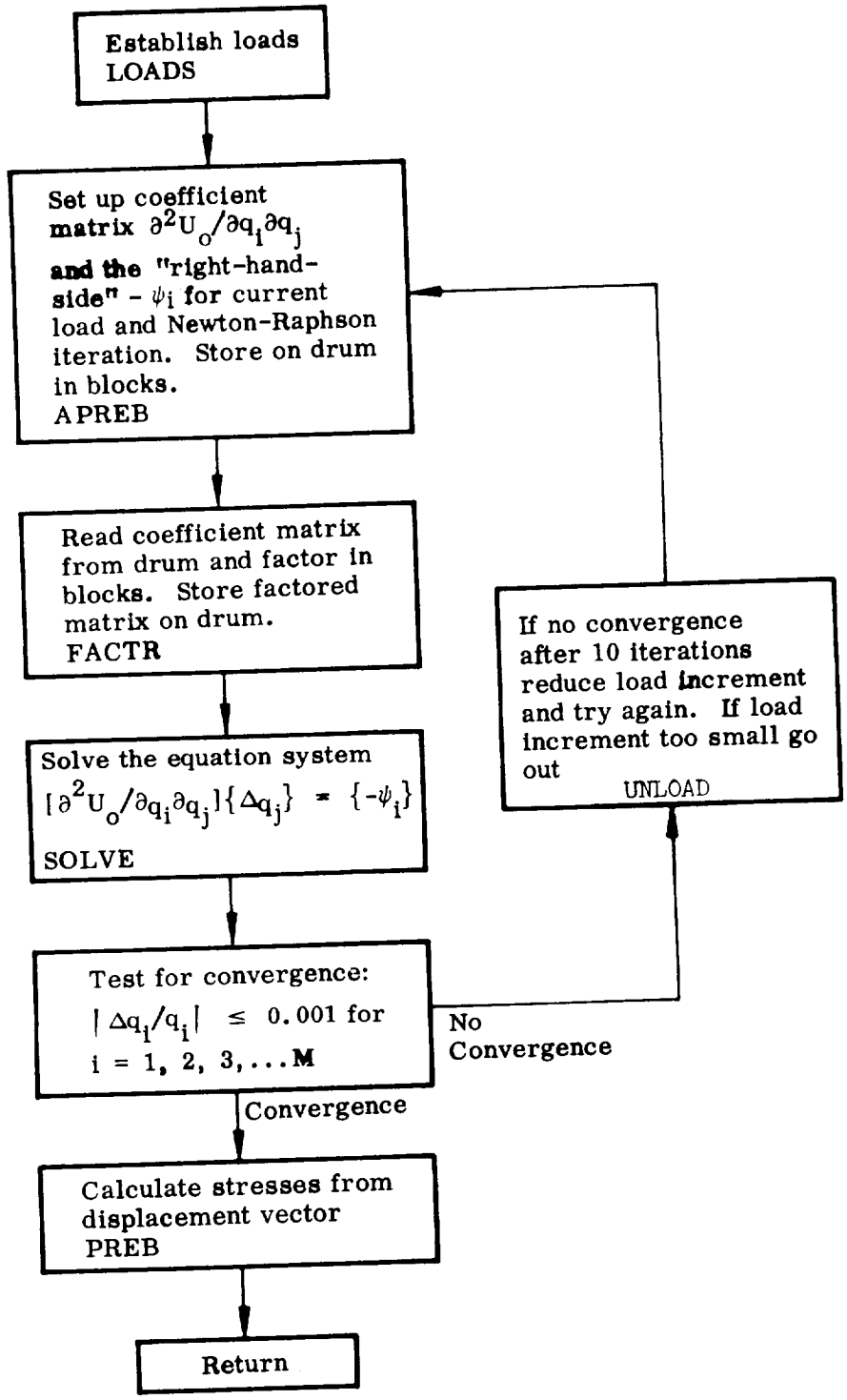


Fig. 24(c) Flow Chart of Subroutine PRE

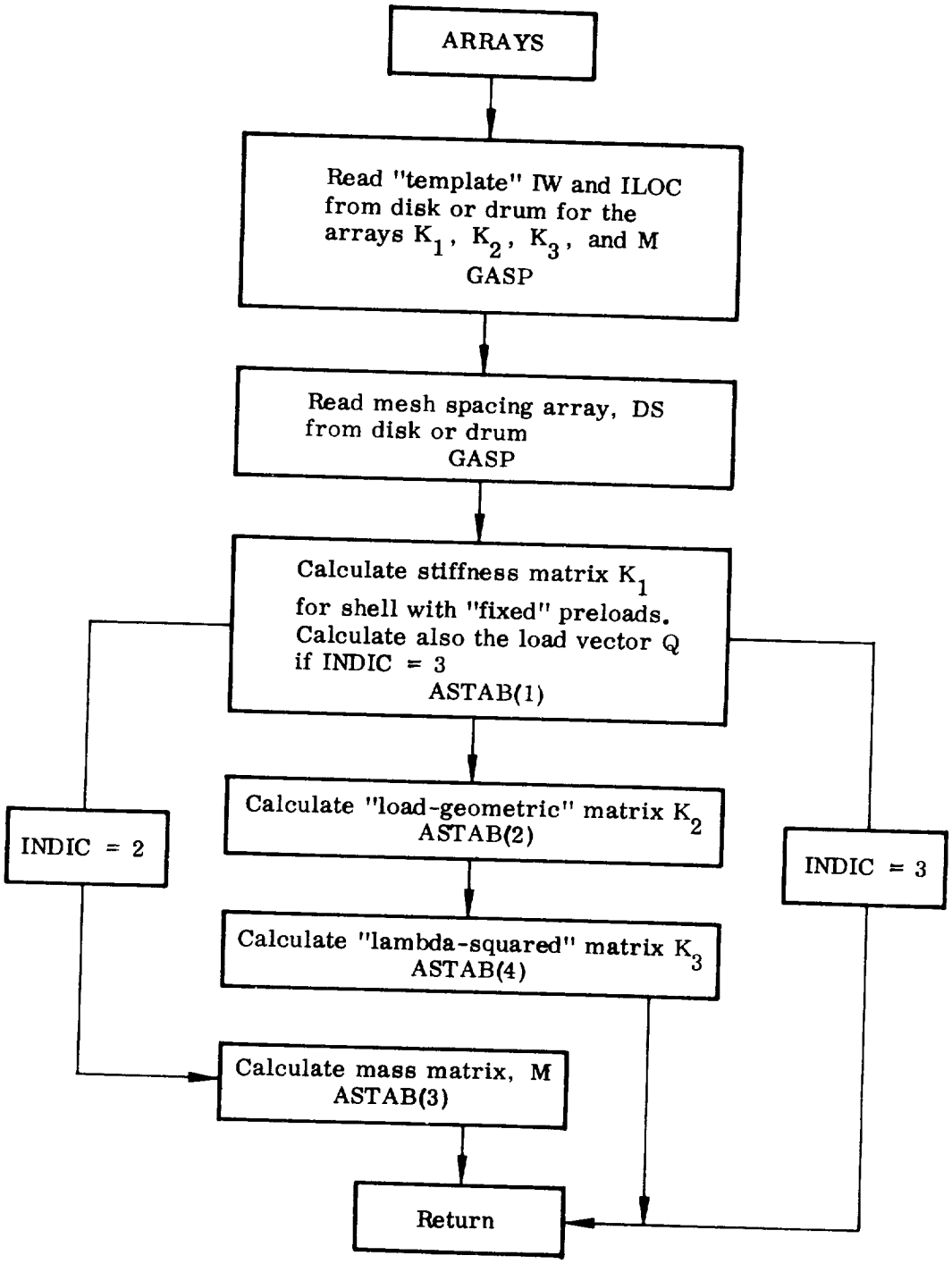


Fig. 24(d) Flow Chart of Subroutine ARRAYS

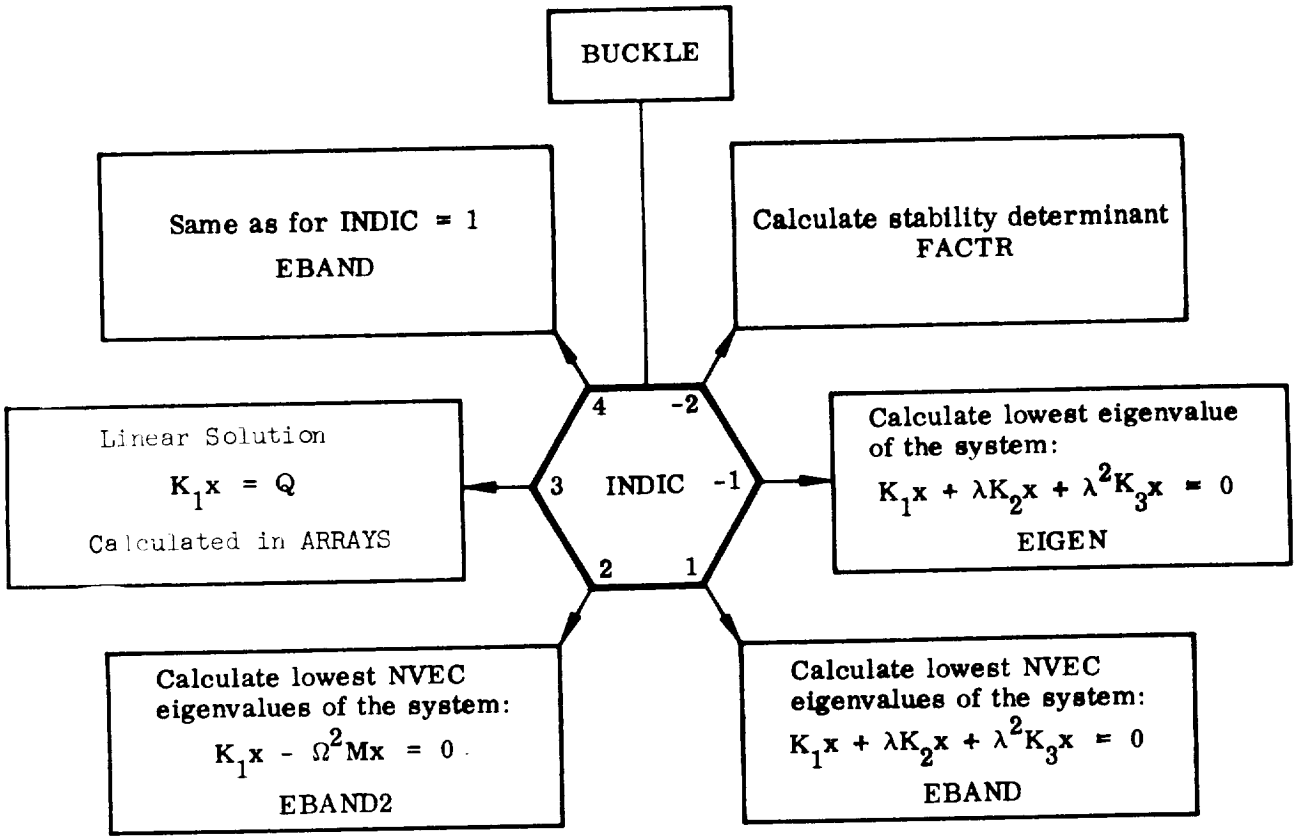


Fig. 24(e) Flow Chart of Subroutine BUCKLE

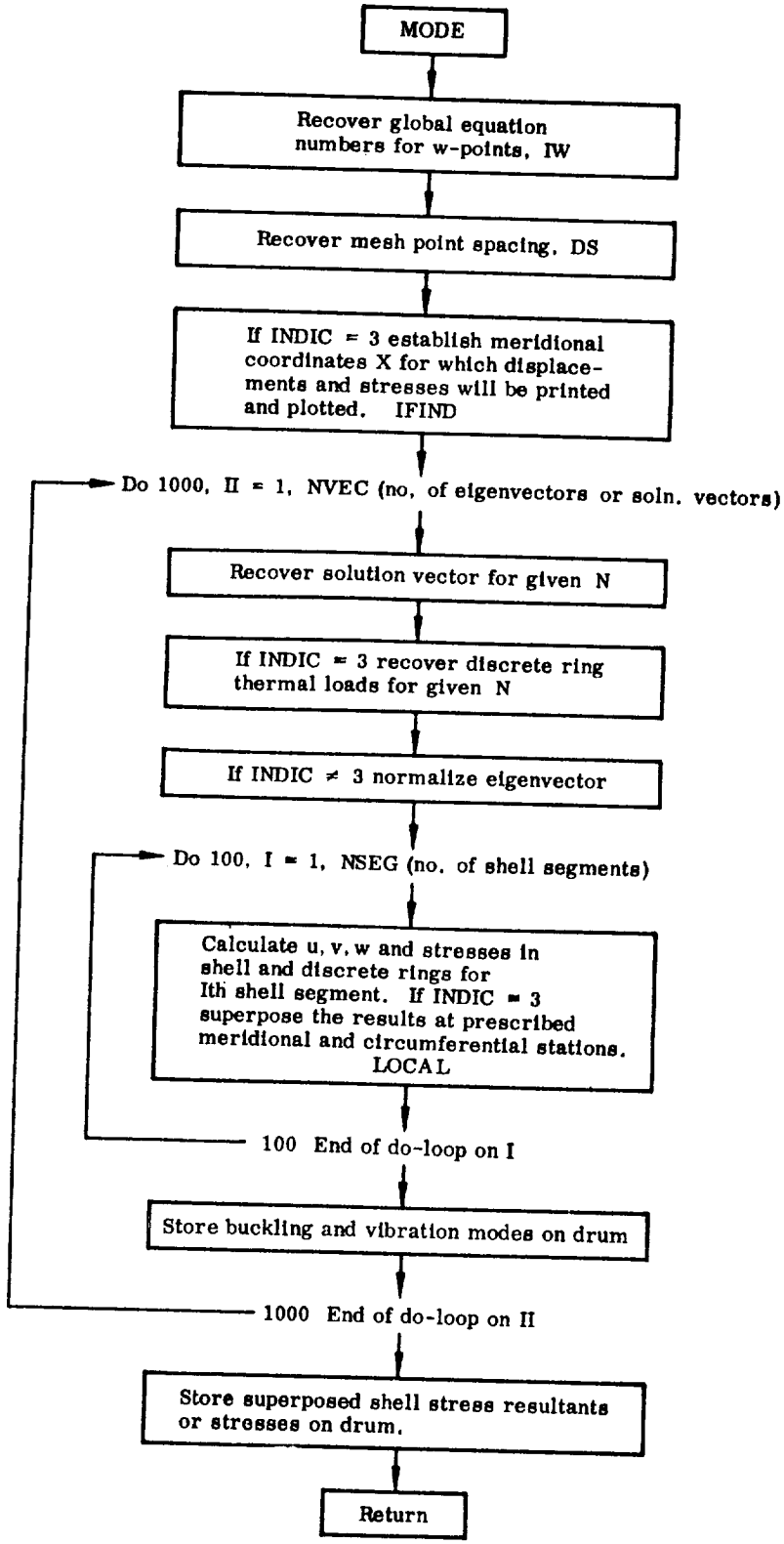


Fig. 24(f) Flow Chart of Subroutine MODE

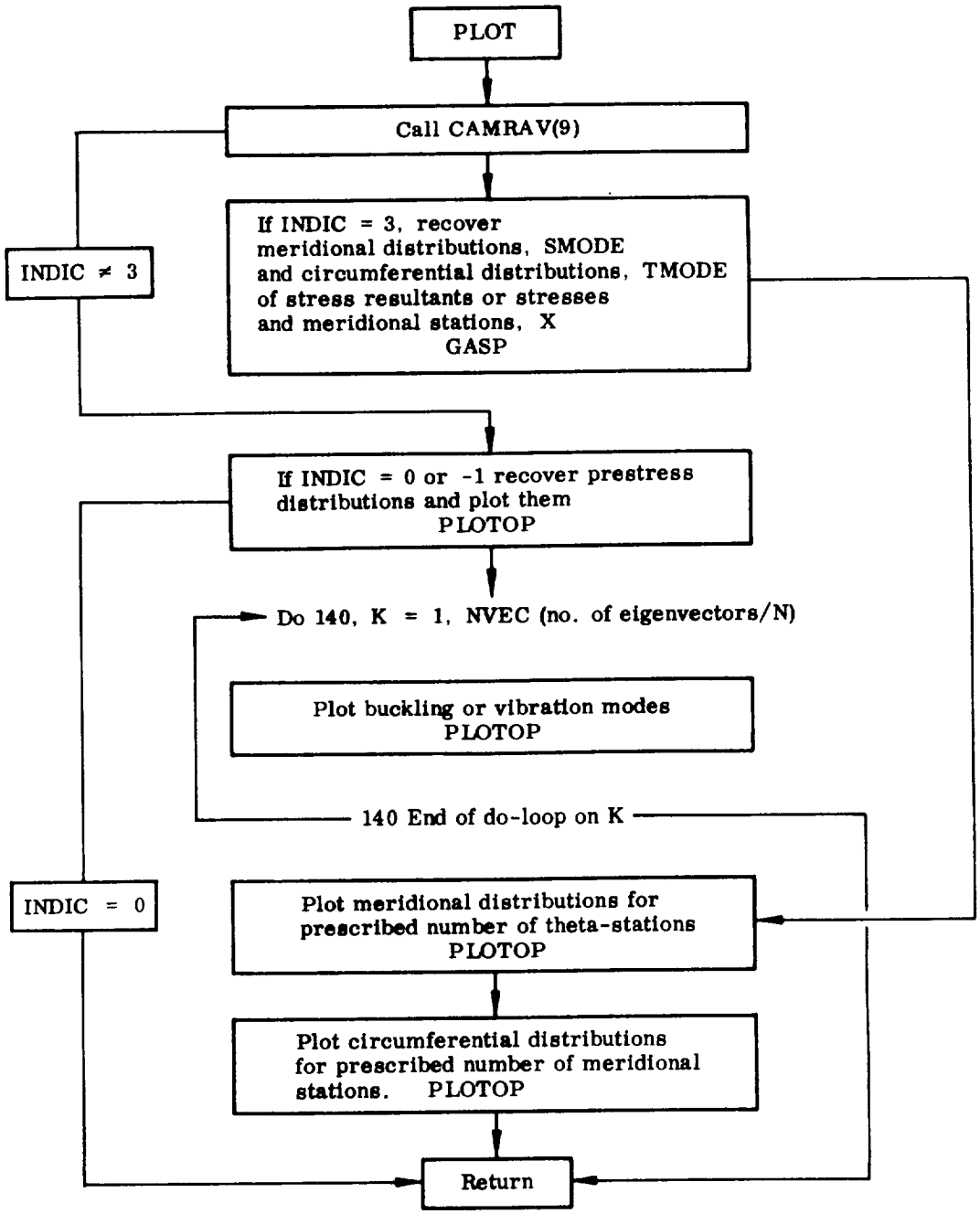


Fig. 24(g) Flow Chart of Subroutine PLOT

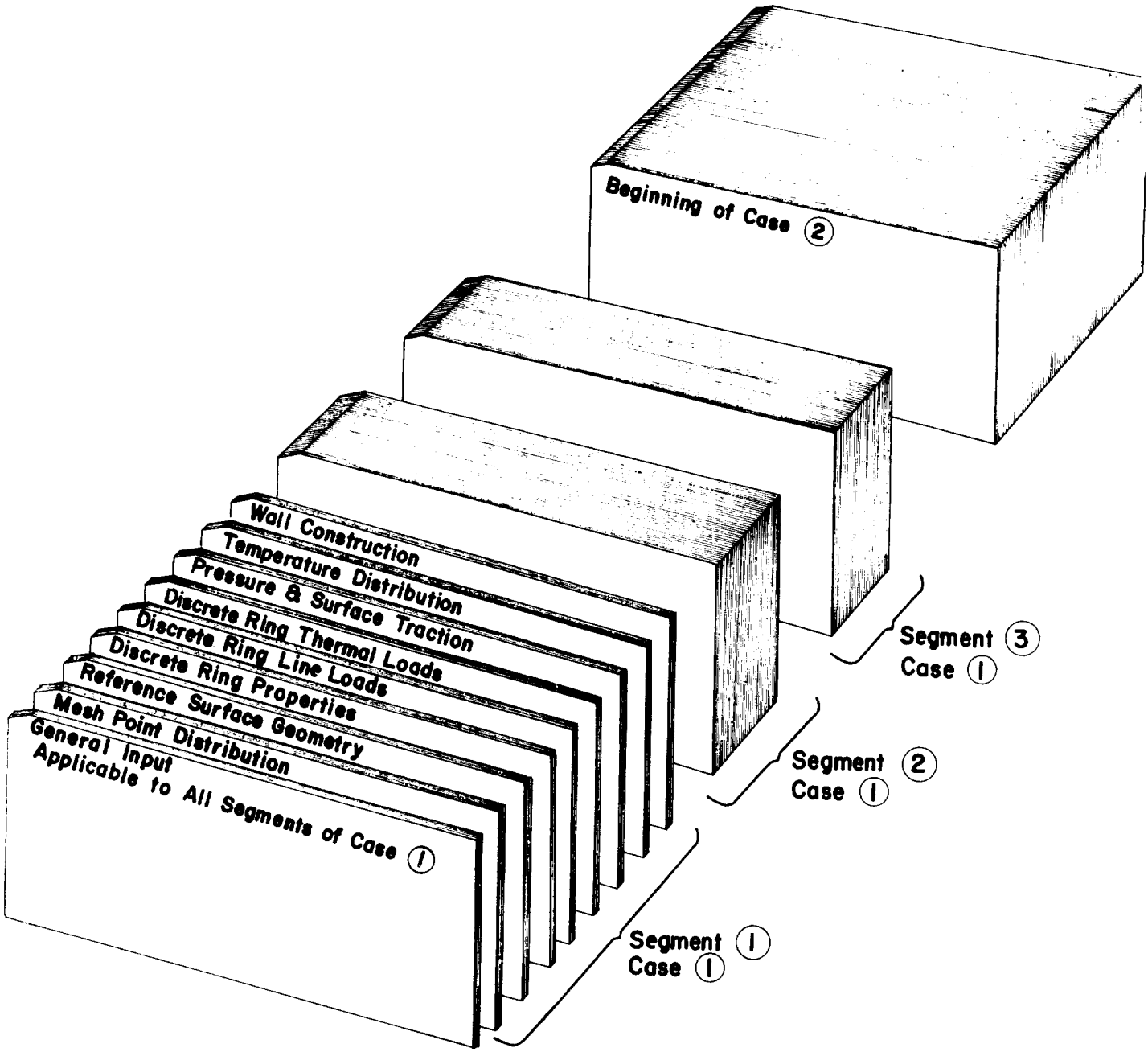


Fig. [illegible] BØSØR4 Data Deck Format

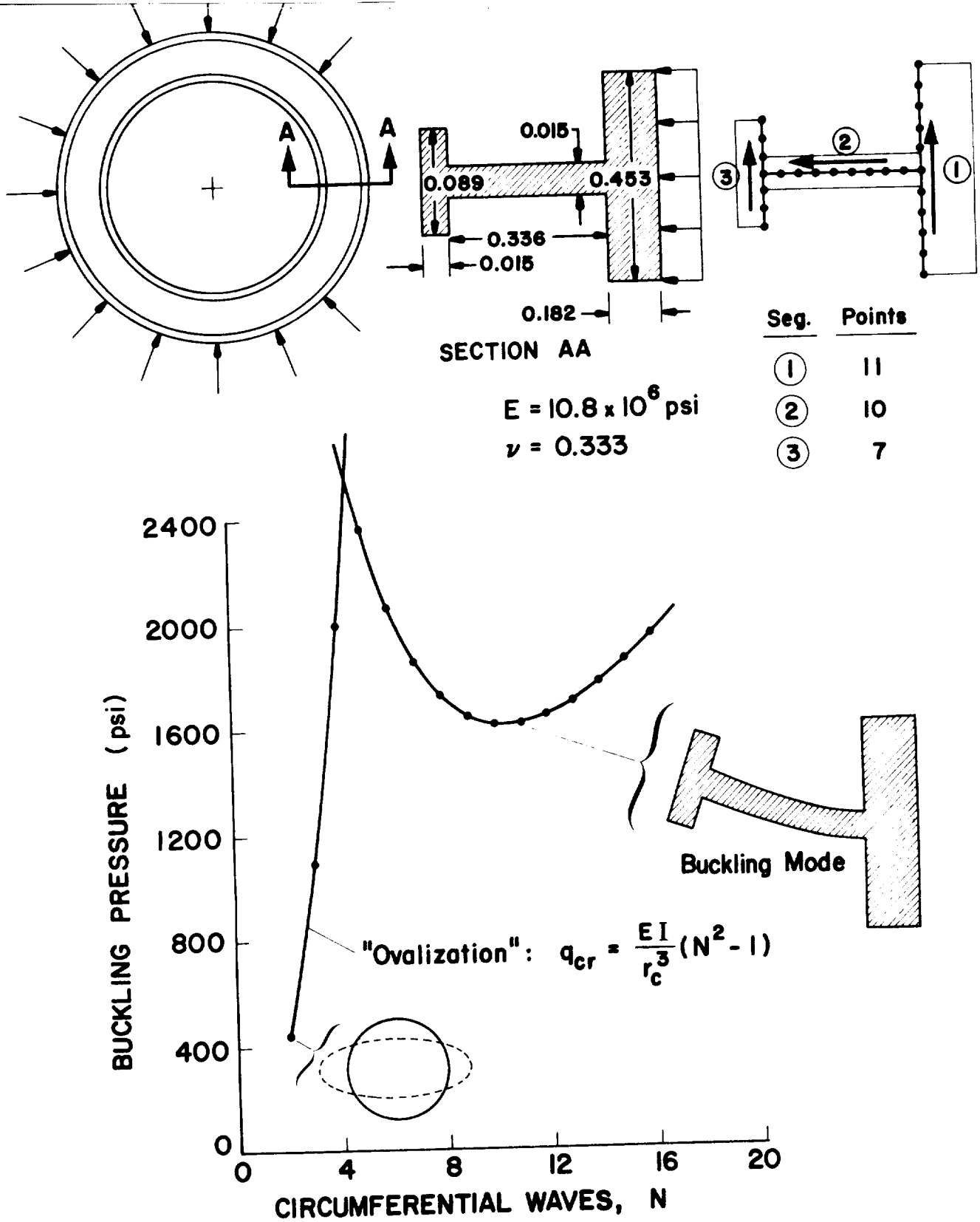


Fig. 26 Sample Case #1: Buckling of Ring Treated as Branched Shell

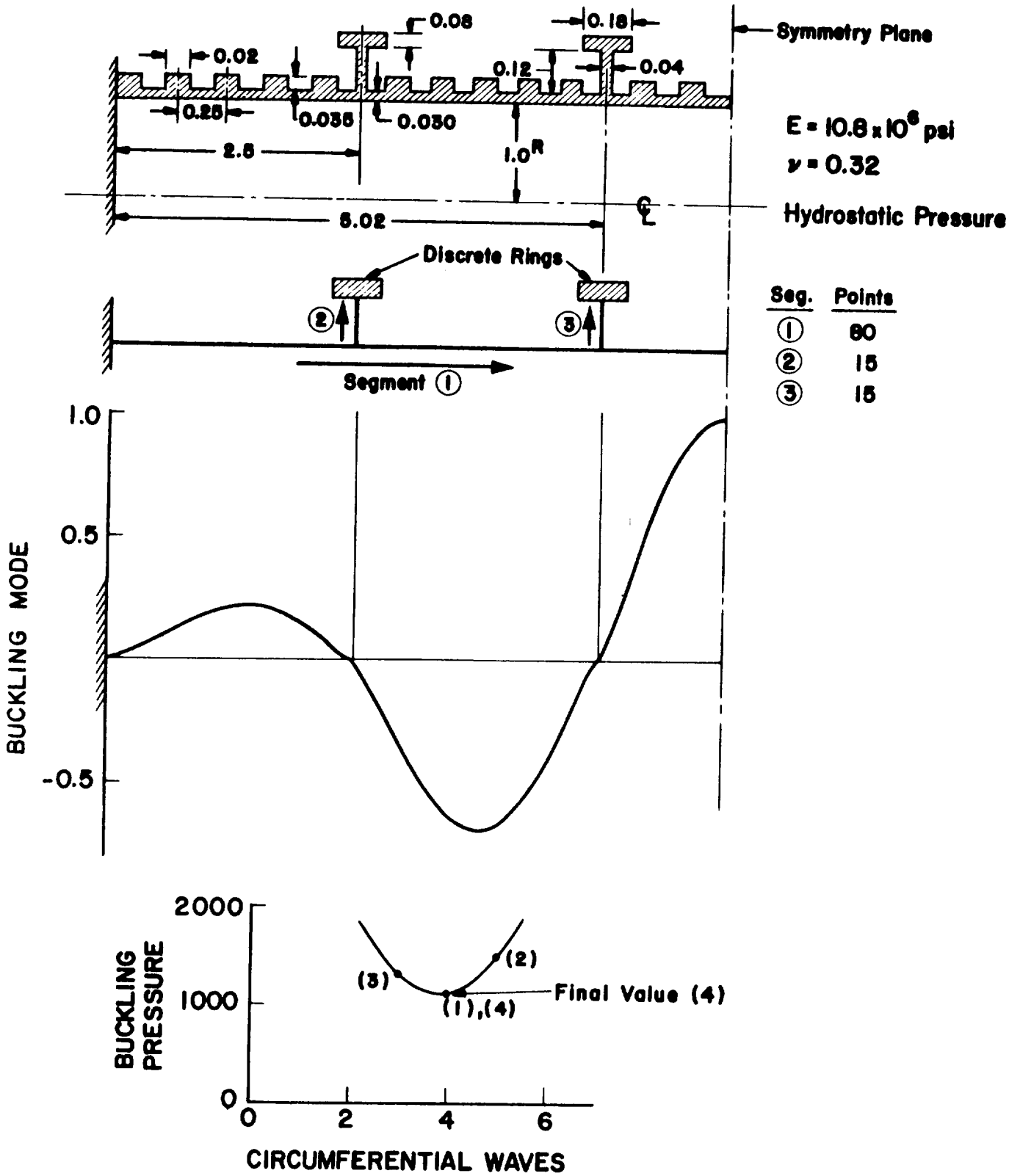


Fig. 27 BØSØR4 Test Case No. 2: Buckling of Ring-Stiffened Cylinder Under External Hydrostatic Pressure

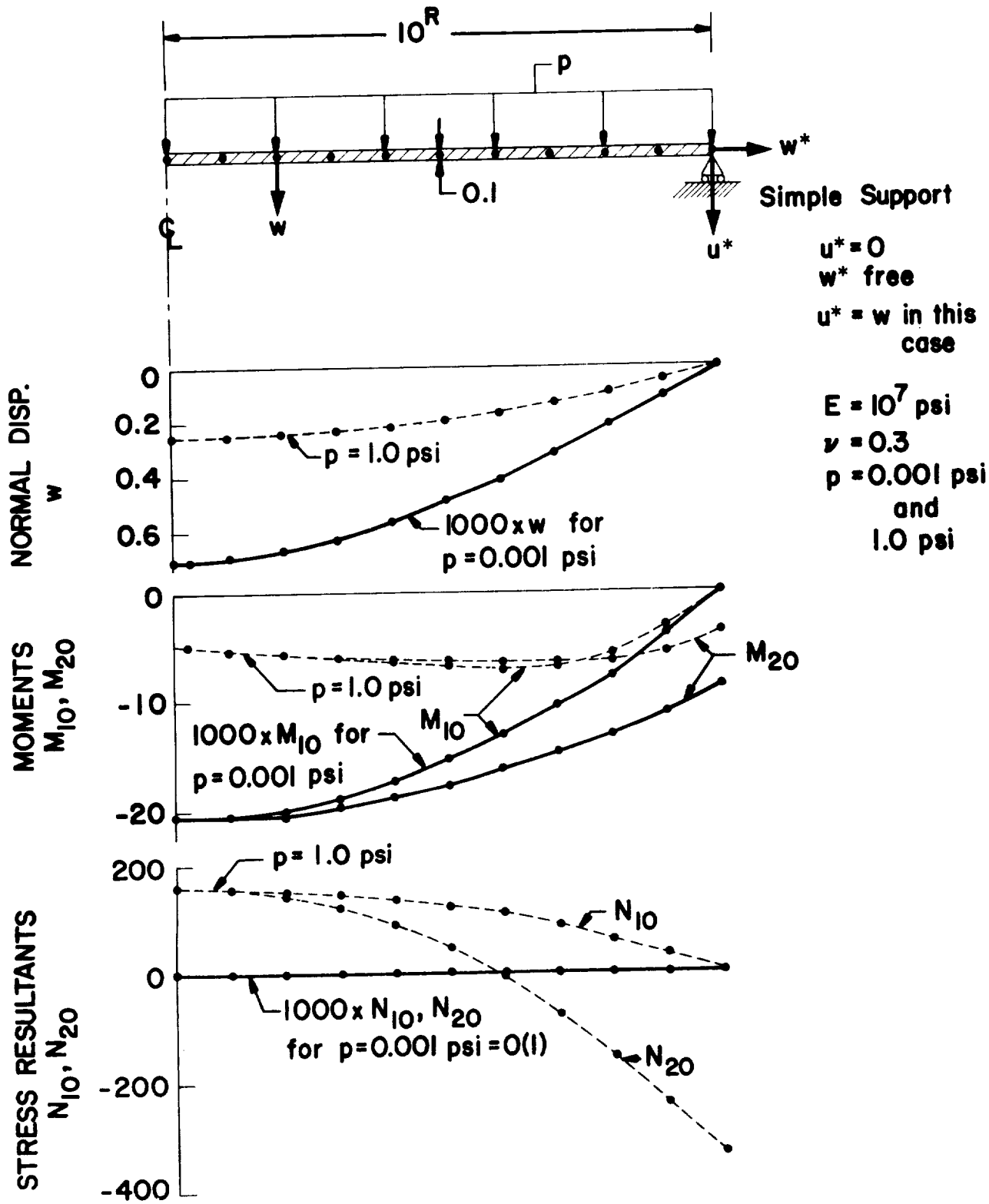


Fig. 28 BOSOR4 Test Case No. 3: Simply-Supported Flat Plate with Uniform Load P

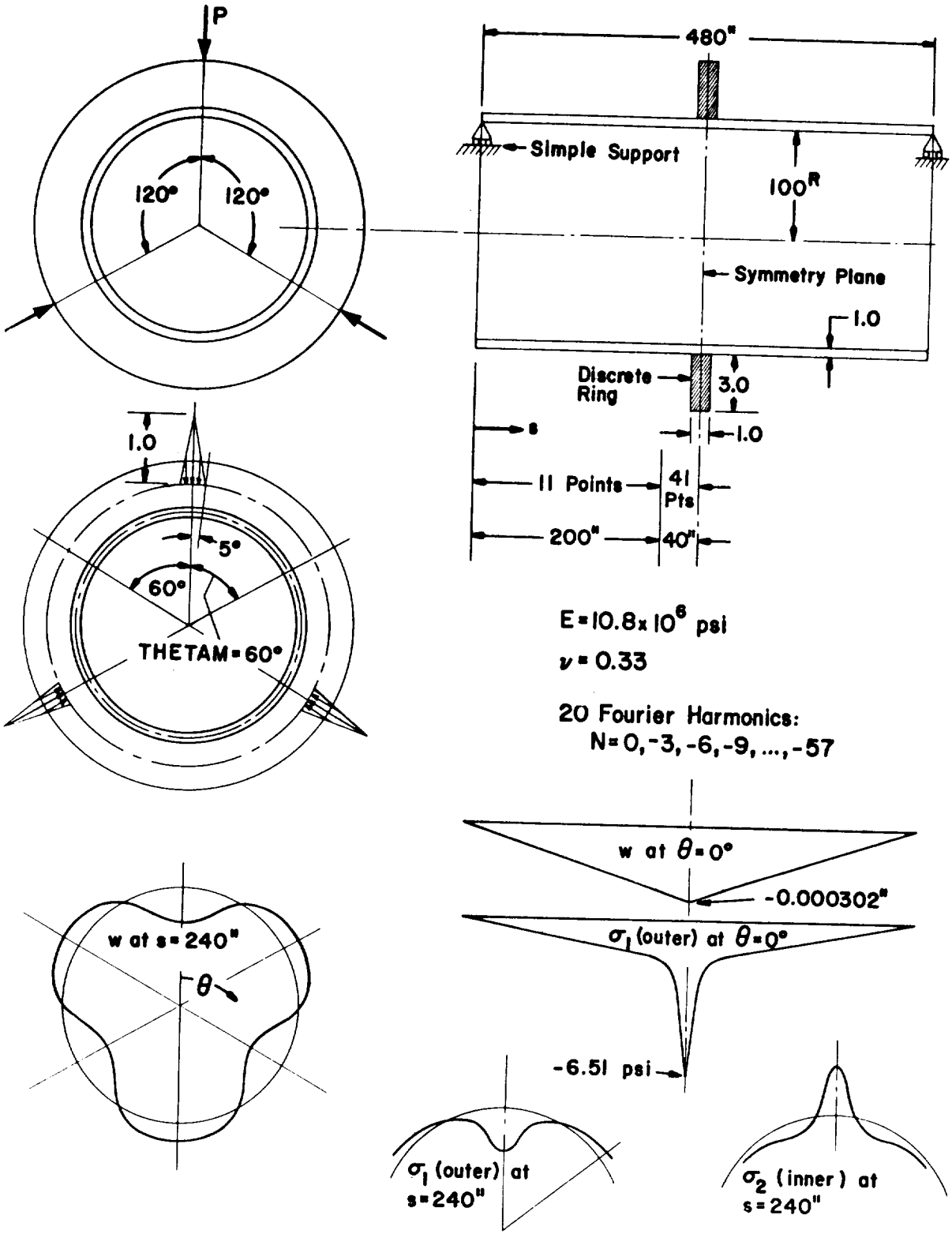


Fig. 29 BØSØR Test Case No. 4: Ring-Stiffened Cylinder with Three Point Loads

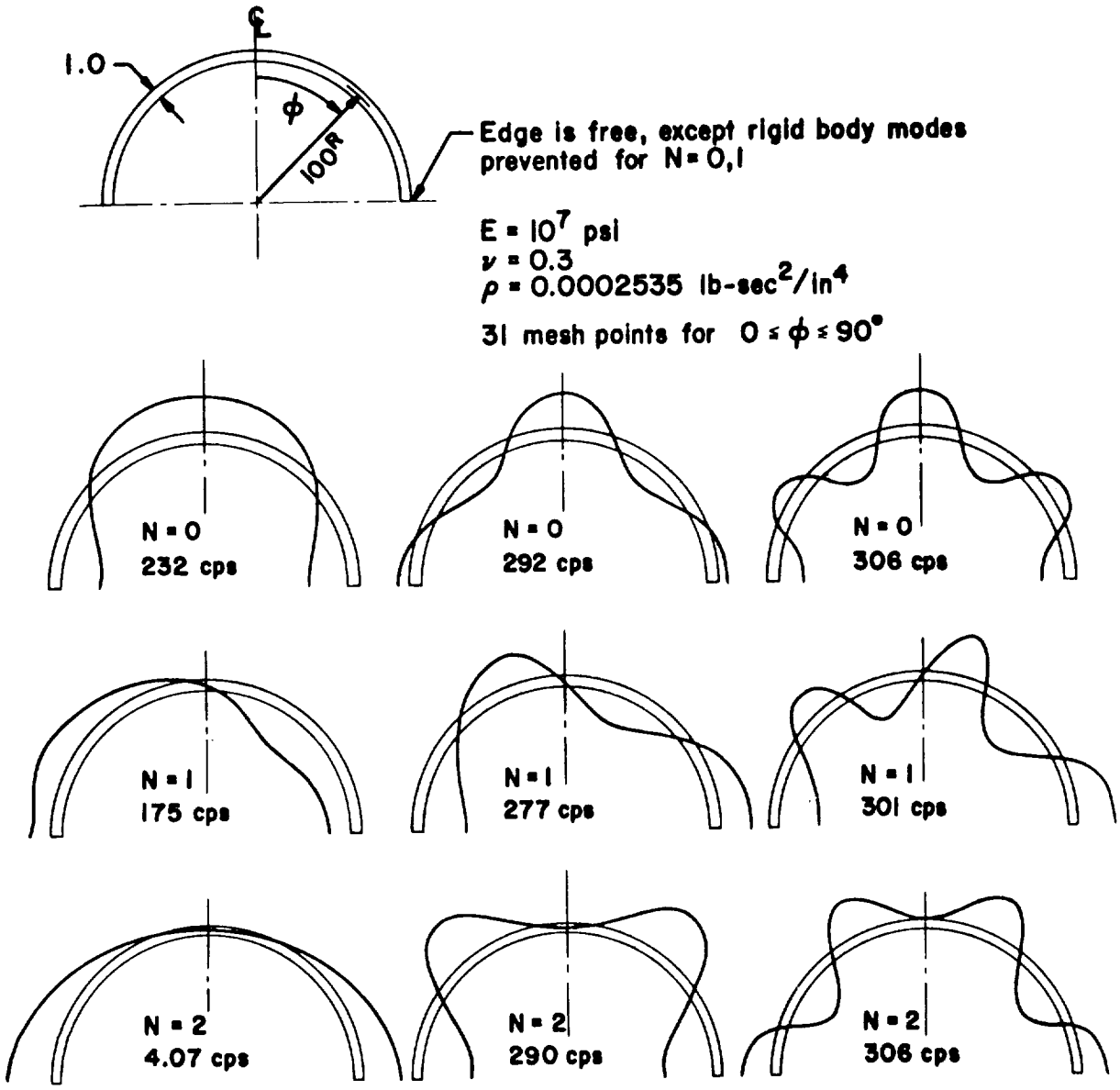


Fig. 30 BØSØR4 Test Case No. 5: Vibration of Free Hemisphere

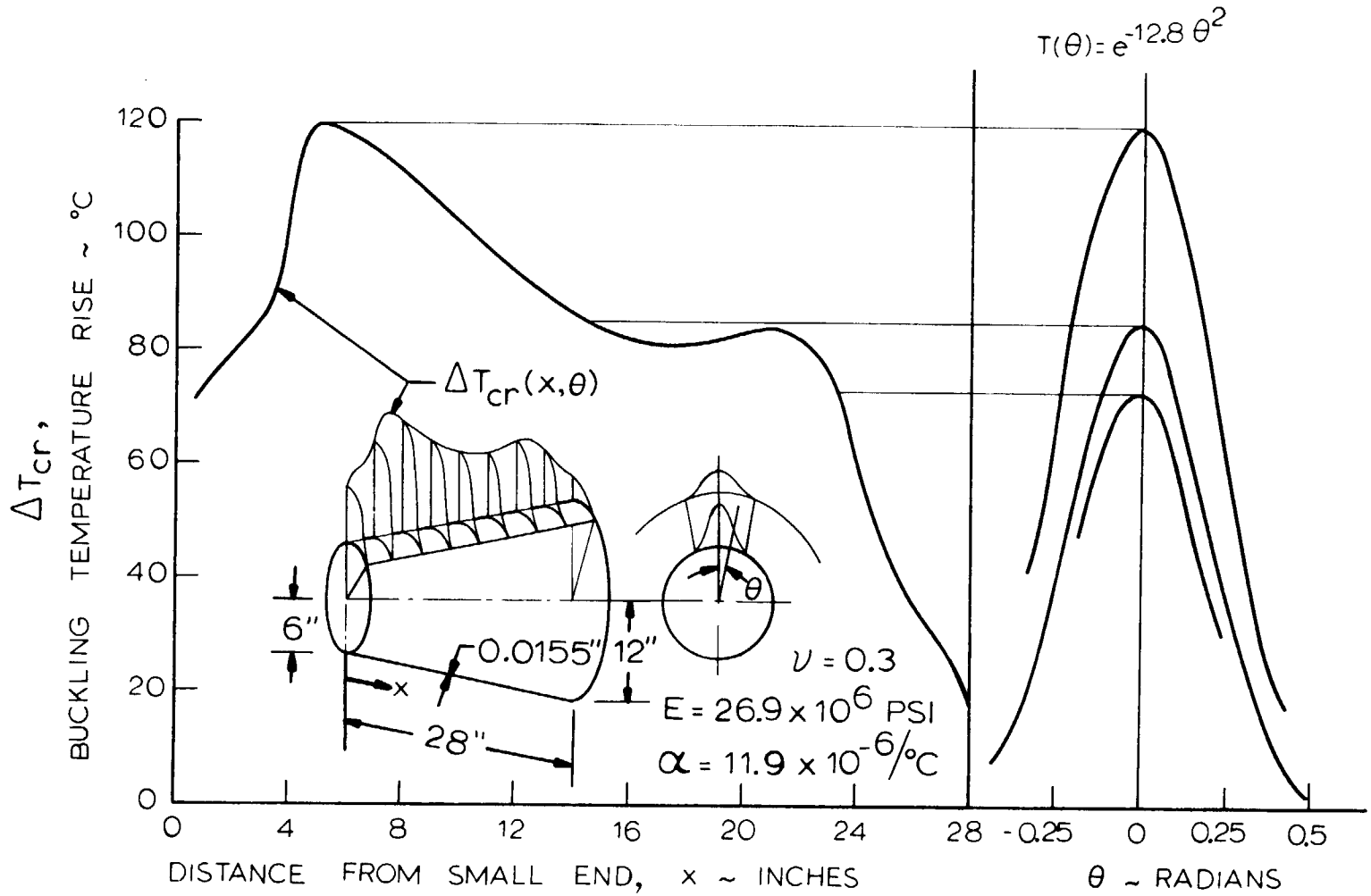


Fig. 31 BOSOR4 Test Case No. 6: Buckling of Conical Shell Heated Along an Axial Strip

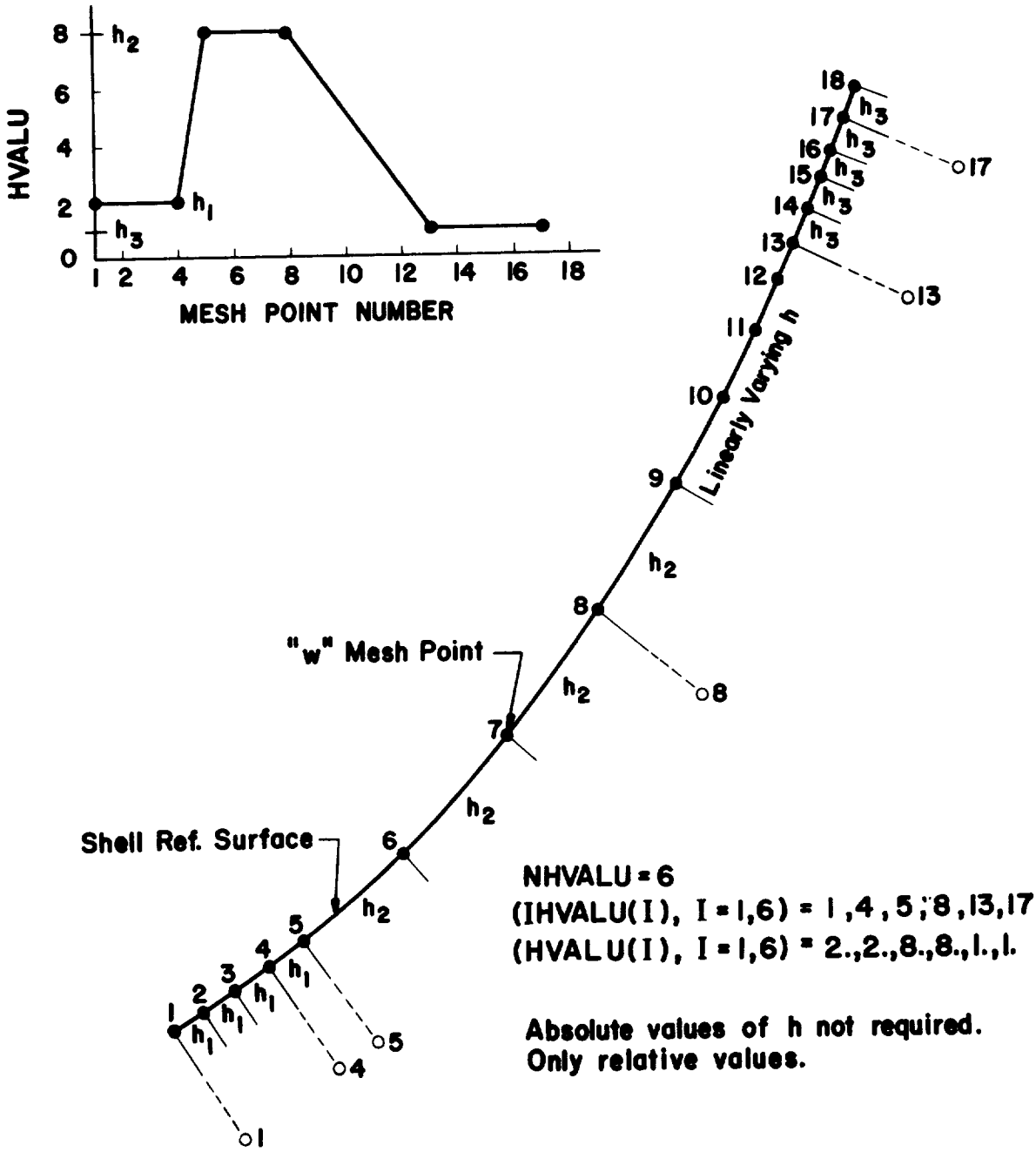


Fig. 32 Mesh Point Spacing Callouts

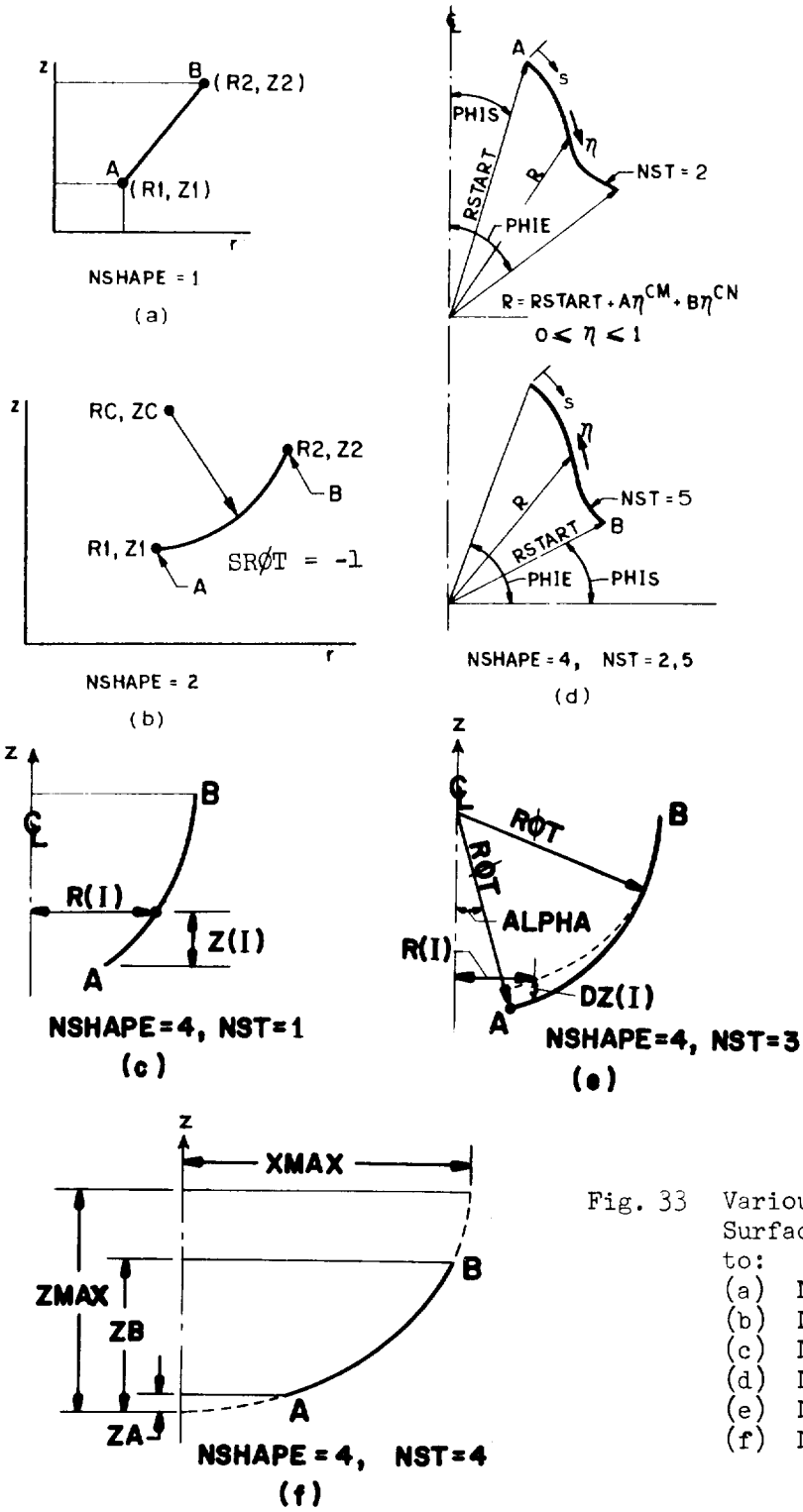


Fig. 33 Various Meridian Reference Surface Geometries Corresponding to:

(a) NSHAPE = 1
(b) NSHAPE = 2
(c) NSHAPE = 4, NST = 1
(d) NSHAPE = 4, NST = 2
(e) NSHAPE = 4, NST = 3
(f) NSHAPE = 4, NST = 4

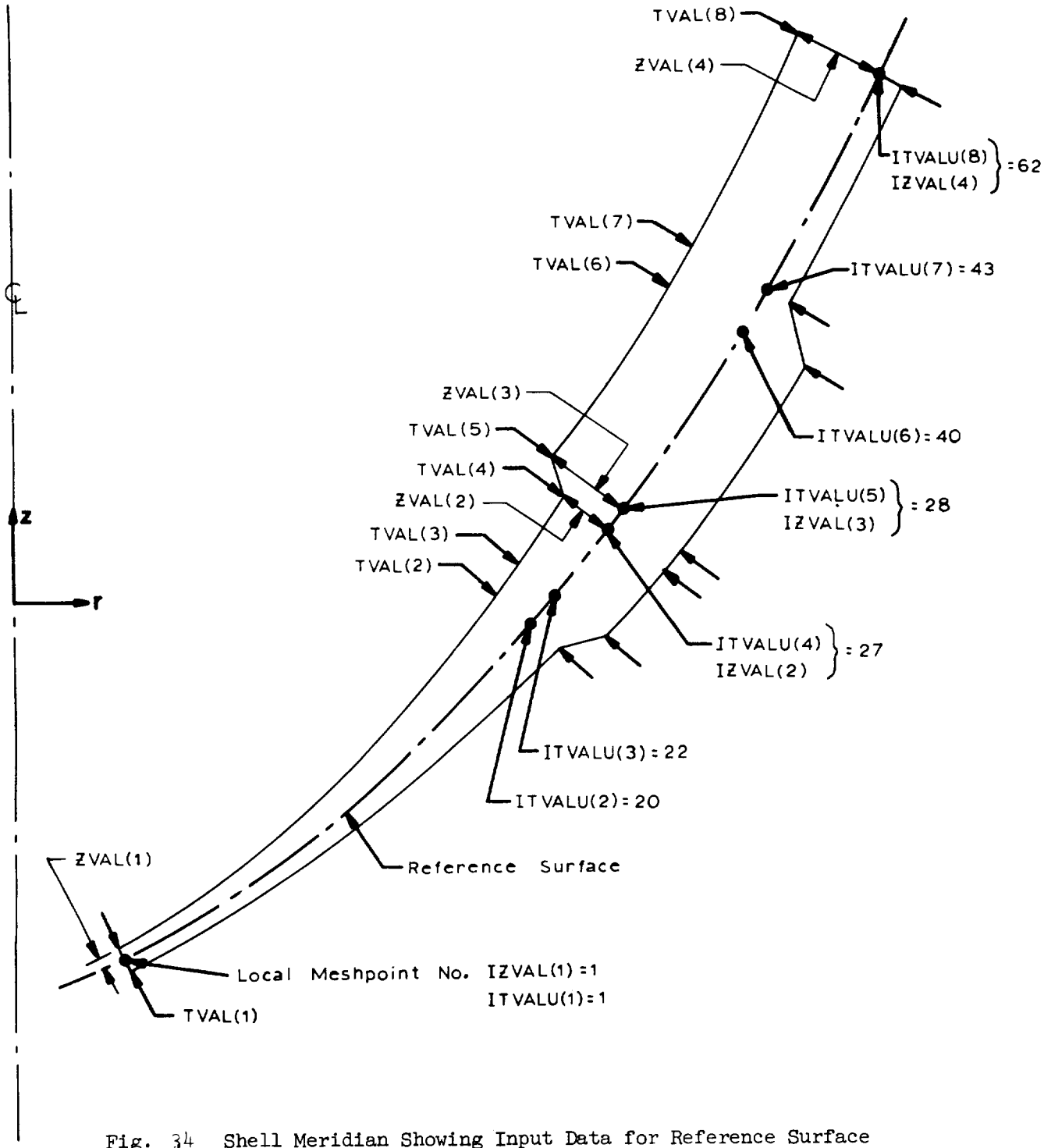
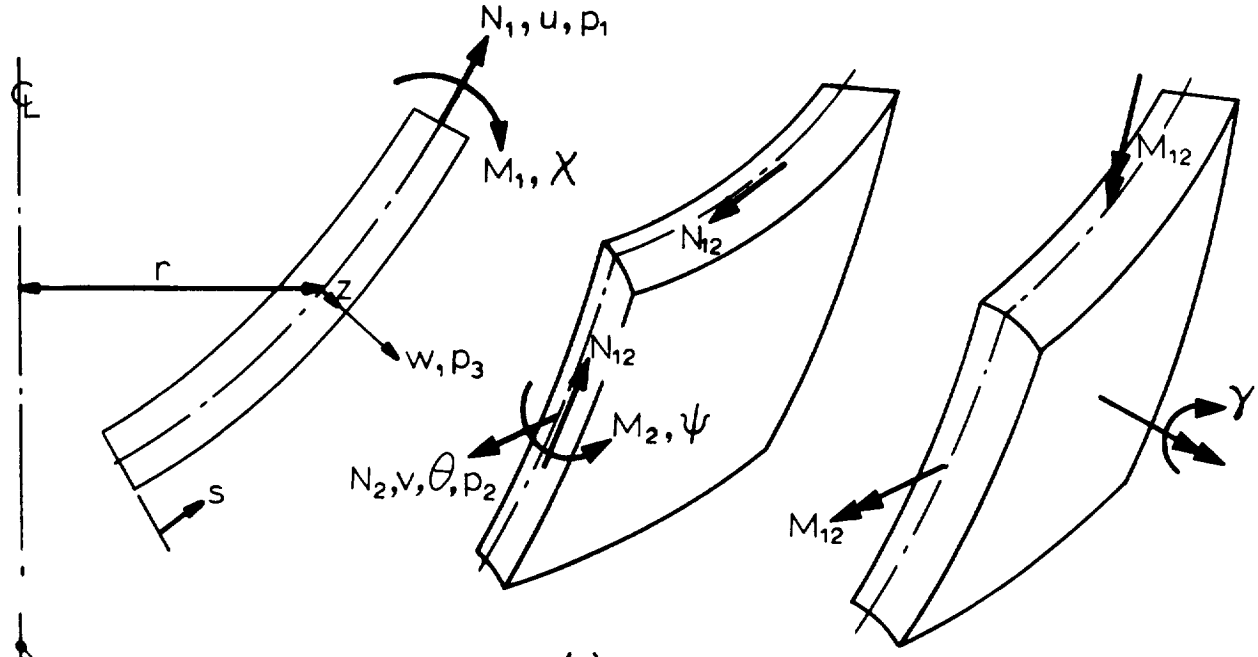
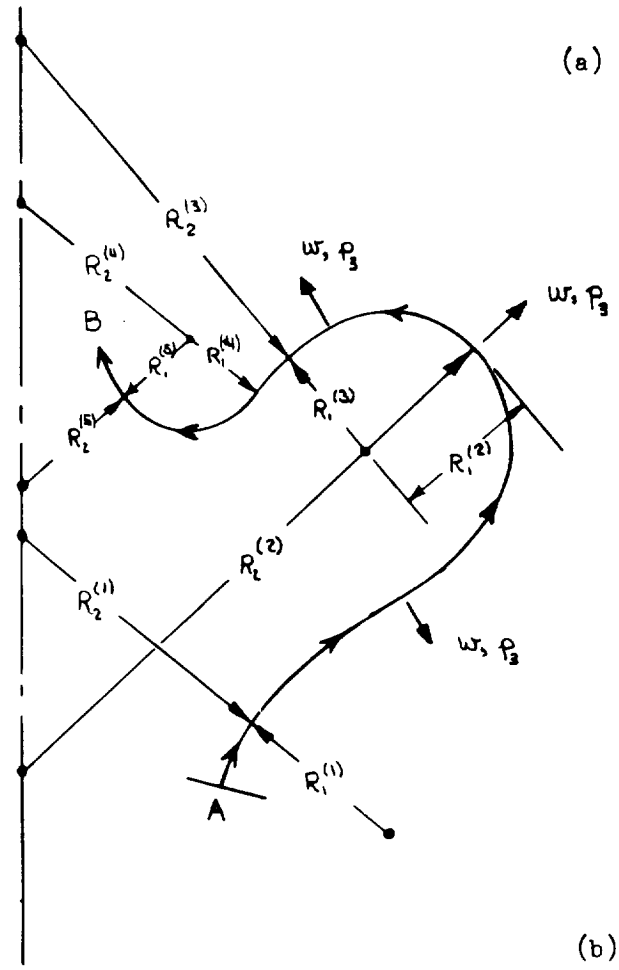


Fig. 34 Shell Meridian Showing Input Data for Reference Surface Location (ZVAL, IZVAL) and Thickness Distribution (TVAL, ITVALU). Reference Surface Location and Thickness Distribution Vary Linearly Between Callout Points IZVAL and ITVAL



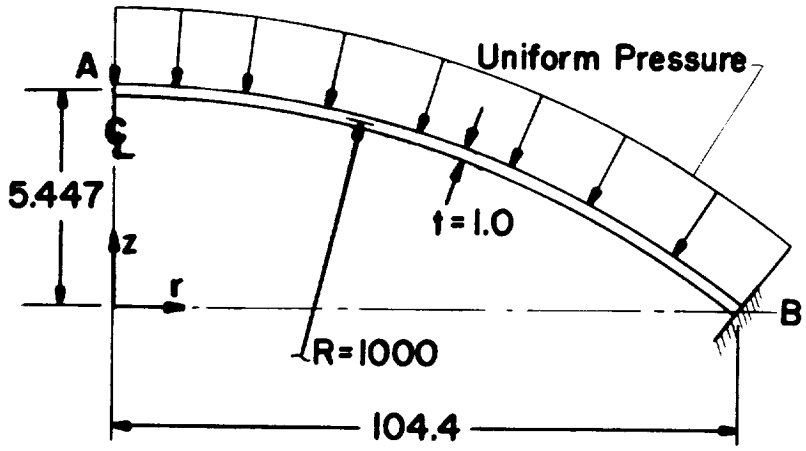
(a)



$R_1^{(1)}$	Negative	$R_2^{(1)}$	Positive
$R_1^{(2)}$	Positive	$R_2^{(2)}$	Positive
$R_1^{(3)}$	Positive	$R_2^{(3)}$	Negative
$R_1^{(4)}$	Negative	$R_2^{(4)}$	Negative
$R_1^{(5)}$	Negative	$R_2^{(5)}$	Positive

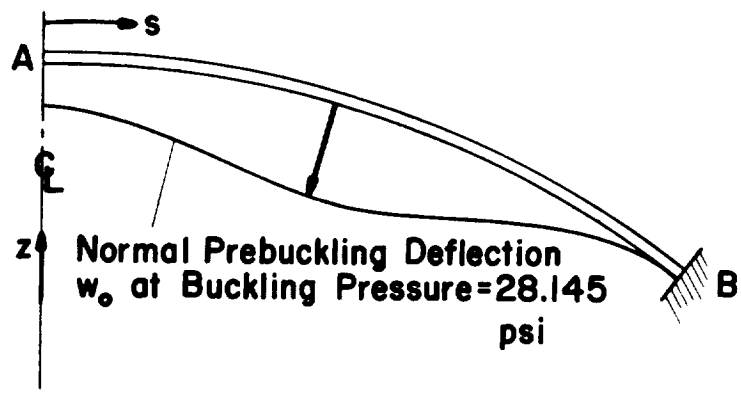
(b)

Fig. 35(a) Shell Element With Displacements, Rotations, Forces. (b) Radii of Curvature. u, v, w Form a Right-Handed System. w and p_3 Positive to the Right of Increasing Arc Lengths.



$E = 30 \times 10^6$ psi

$\nu = 0.3$



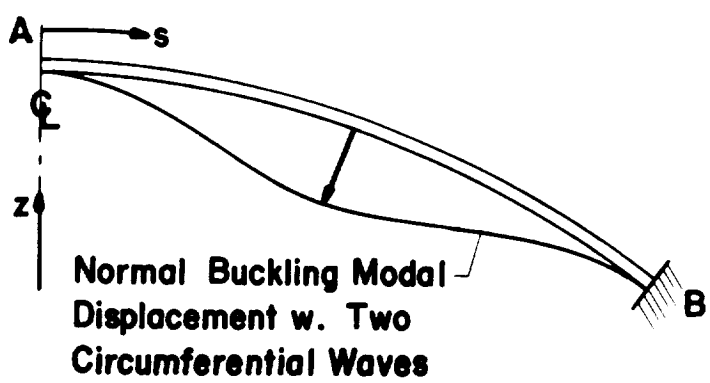


Fig. 36 Test Case 7 - Buckling of Shallow Spherical Cap (see Table 10 and Page A93)

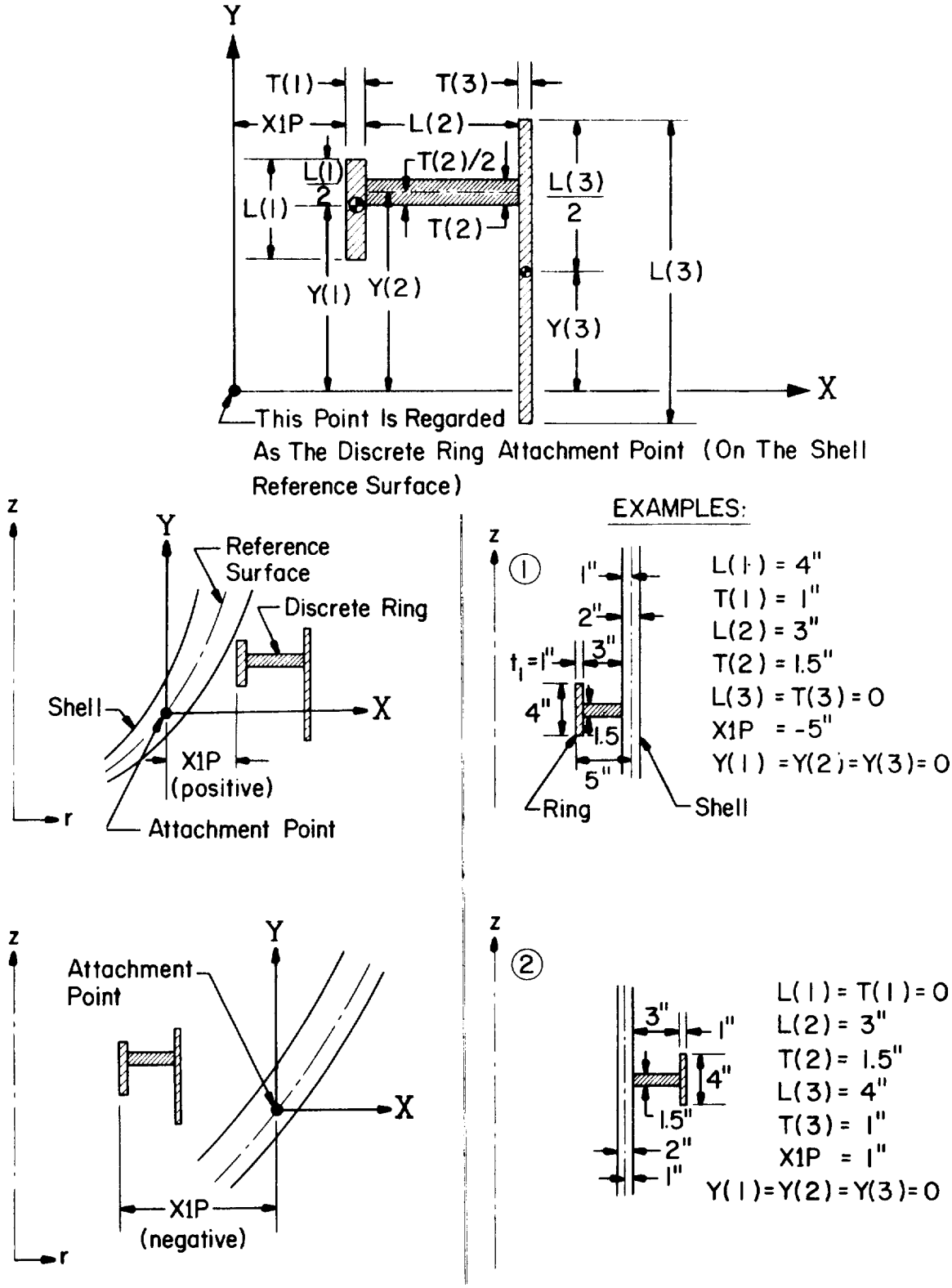


Fig. 37 Input parameters for discrete ring properties with NTYPER(I) = 4 or NTYPER(I) = 5 . X,Y axes as shown for NTYPER(I) = 4 option. With NTYPER (I) = 5 option, the X,Y axes are normal, tangential to ref. surface

APPENDIX C

CDC 6600 AND UNIVAC 1108 (EXEC 8)

BØSØR4 OVERLAY CONFIGURATIONS

CDC 6600 OVERLAY STRUCTURE

REC	NAME	TYPE	LENGTH	CKSUM	DATE
1	OVERLAY	TEXT	2	5548	
		OVERLAY(BOSOR,0,0)			
2	MAIN	REL	2012	5361	01/07/72
3	MAIN1	REL	47	1537	01/07/72
4	SR100T	REL	47	1467	01/07/72
5	ELT1	REL	30	7357	01/07/72
6	ELT3	REL	100	4144	01/07/72
7	GASP	REL	233	0407	01/07/72
8	URNDM	REL	140	6708	01/07/72
9	FACTR	REL	745	3108	01/07/72
10	SOLVE	REL	465	1341	01/07/72
11	CHANGE	REL	116	0678	01/07/72
12	STRESS	REL	443	7024	01/07/72
13	MATMU3	REL	142	4728	01/07/72
14	OVERLAY	TEXT	2	5067	
		OVERLAY(1,0)			
15	READIT	REL	1246	3726	01/07/72
16	MESH	REL	524	3163	01/07/72
17	STA	REL	430	3067	01/07/72
18	INTER	REL	154	1067	01/07/72
19	FINDZ	REL	156	1576	01/07/72
20	GETZ	REL	364	3437	01/07/72
21	OUTAX	REL	476	1035	01/07/72
22	OVERLAY	TEXT	2	4267	
		OVERLAY(1,1)			
23	RFIRST	REL	341	7724	01/07/72
24	OUTIN1	REL	1304	4672	01/07/72
25	WRCON	REL	223	4665	01/07/72
26	OVERLAY	TEXT	2	4467	
		OVERLAY(1,2)			
27	GEOMTR	REL	232	7405	01/07/72
28	GEOMTY	REL	517	1231	01/07/72
29	GEOM	REL	410	4507	01/07/72
30	IMPERF	REL	1072	5048	01/07/72
31	GEOM1	REL	452	3477	01/07/72
32	GEOM2	REL	727	5404	01/07/72
33	ARCDRW	REL	231	0257	01/07/72
34	GEOM3	REL	512	4504	01/07/72
35	GEOM4	REL	1204	0060	01/07/72
36	SHELL	REL	705	0611	01/07/72
37	SPLINE	REL	315	5477	01/07/72
38	SPLICO	REL	526	5610	01/07/72
39	GEOM5	REL	623	0007	01/07/72
40	OVERLAY	TEXT	2	3667	
		OVERLAY(1,3)			
41	RZLG	REL	370	2174	01/07/72
42	RGDATA	REL	1110	3204	01/07/72
43	ZEROIT	REL	346	1410	01/07/72
44	LOADRE	REL	340	1077	01/07/72
45	LINELD	REL	445	6265	01/07/72

REC	NAME	TYPE	LENGTH	CKSUM	DATE
46	DISTL	REL	1243	6066	01/07/72
47	LOADRD	REL	474	2346	01/07/72
48	GETFS	REL	120	2005	01/07/72
49	FOUR	REL	1120	0707	01/07/72
50	GETY	REL	113	4663	01/07/72
51	FCOEF	REL	345	2043	01/07/72
52	OUTCC	REL	306	7017	01/07/72
53	OUTHM	REL	214	7346	01/07/72
54	GETPST	REL	450	1127	01/07/72
55	OVERLAY	TEXT	2	4067	
		OVERLAY(1,4)			
56	WALLS	REL	211	3634	01/07/72
57	WALLCF	REL	1151	7765	01/07/72
58	FINDTH	REL	207	2167	01/07/72
59	FUNCT	REL	117	6323	01/07/72
60	CFB1	REL	3460	4336	01/07/72
61	CFB2	REL	1235	2273	01/07/72
62	INGRAT	REL	324	2734	01/07/72
63	CFB3	REL	607	2375	01/07/72
64	CFB4	REL	1316	0076	01/07/72
65	CFB5	REL	1630	7405	01/07/72
66	CFB6	REL	555	5165	01/07/72
67	CFB7	REL	1336	2235	01/07/72
68	CFB8	REL	1576	2463	01/07/72
69	STIFF	REL	1303	4203	01/07/72
70	OVERLAY	TEXT	2	3276	
		OVERLAY(1,5)			
71	RFIVE	REL	643	2605	01/07/72
72	ZGLORF	REL	370	2623	01/07/72
73	OUTTN2	REL	1102	1523	01/07/72
74	OUTLL	REL	465	1406	01/07/72
75	ISHTFT	REL	127	6576	01/07/72
76	SKILIN	REL	2523	5077	01/07/72
77	SORT	REL	241	6256	01/07/72
78	GETTW	REL	232	7217	01/07/72
79	GETBLK	REL	374	2606	01/07/72
80	OVERLAY	TEXT	2	3476	
		OVERLAY(1,6)			
81	OUTFIN	REL	47	1105	01/07/72
82	OUT2	REL	1017	0515	01/07/72
83	OUTNON	REL	1271	2457	01/07/72
84	SUPER	REL	625	0646	01/07/72
85	OUTLOD	REL	315	4607	01/07/72
86	OUTPRE	REL	374	2603	01/07/72
87	OUTRUC	REL	264	5707	01/07/72
88	OVERLAY	TEXT	2	5467	
		OVERLAY(2,0)			
89	PRE	REL	1545	3235	01/07/72
90	LOADS	REL	136	7225	01/07/72
91	UNLOAD	REL	206	0747	01/07/72
92	OVERLAY	TEXT	2	4667	
		OVERLAY(2,1)			

REC	NAME	TYPE	LENGTH	CKSUM	DATE
93	PRE1	REL	50	0067	01/07/72
94	APREB	REL	342	6150	01/07/72
95	PRESTS	REL	3345	5365	01/07/72
96	GETWWP	REL	142	0006	01/07/72
97	PGETB	REL	304	3505	01/07/72
98	PGETC	REL	243	5056	01/07/72
99	FILLBP	REL	166	7125	01/07/72
100	OVERLAY	TEXT	2	5067	
		OVERLAY(2,2)			
101	PRE2	REL	60	3770	01/07/72
102	PREB	REL	406	2437	01/07/72
103	PLOCAL	REL	2037	4475	01/07/72
104	OVERLAY	TEXT	2	6067	
		OVERLAY(3,0)			
105	ARRAYS	REL	1002	7235	01/07/72
106	ASTAB	REL	414	5537	01/07/72
107	STABIL	REL	4345	4774	01/07/72
108	GETWWD	REL	142	6510	01/07/72
109	FILLB	REL	206	7473	01/07/72
110	GETB1	REL	736	5146	01/07/72
111	GETC	REL	332	4071	01/07/72
112	GETD	REL	151	6105	01/07/72
113	GETE	REL	127	4551	01/07/72
114	GETG	REL	365	0340	01/07/72
115	GETP	REL	277	1447	01/07/72
116	GETROT	REL	323	6203	01/07/72
117	MATMU1	REL	243	7020	01/07/72
118	MATMU2	REL	240	5746	01/07/72
119	MATMU4	REL	237	3367	01/07/72
120	RRHS	REL	502	4556	01/07/72
121	SRHS	REL	476	7455	01/07/72
122	OVERLAY	TEXT	2	6467	
		OVERLAY(4,0)			
123	BUCKLE	REL	256	6415	01/07/72
124	VEC	REL	256	5333	01/07/72
125	ADD	REL	253	7115	01/07/72
126	OVERLAY	TEXT	2	5667	
		OVERLAY(4,1)			
127	EBAND2	REL	3126	0707	01/07/72
128	ADD2	REL	173	5155	01/07/72
129	ORTHO2	REL	222	1546	01/07/72
130	OVERLAY	TEXT	2	6067	
		OVERLAY(4,2)			
131	EIGEN	REL	1420	1277	01/07/72
132	OVERLAY	TEXT	2	5267	
		OVERLAY(4,3)			
133	EBAND	REL	3077	4175	01/07/72
134	ORTHO	REL	154	5774	01/07/72
135	OVERLAY	TEXT	2	7076	

REC	NAME	TYPE	LENGTH	CKSUM	DATE
		OVERLAY(5,0)			
136	MODF1	REL	65	6726	01/07/72
137	MODF	REL	1072	6077	01/07/72
138	IFIND	REL	170	7500	01/07/72
139	LOCAL	REL	1767	2000	01/07/72
140	RTNGF	REL	655	7345	01/07/72
141	SPOSE	REL	601	7045	01/07/72
142	OVERLAY	TEXT	5	7476	
		OVERLAY(6,0)			
143	PLOT1	REL	52	0716	01/07/72
144	PLOT			3276	01/07/72
145	PLOTOP	REL	1515	5107	01/07/72
146	* EOF *	SUM =	136375		

```
@MAP,S BOSORB,BOSORB
MAP 0022-02/11-09:12 -(0.)

 1.        SEG  MN
 2.        IN  MAIN
 3.       IN SYS$*RLIB$.PLOT$
 4.       IN SYS$*RLIB$.PLOT$$
 5.        SEG  LINK1*,(MN)
 6.        IN  READIT,GETZ,FIND7
 7.        SEG  SL1*,(LINK1)
 8.        IN  RFIRST
 9.        SEG  SL2*,(LINK1)
10.        IN MESH
11.        SEG  SL3*,(LINK1)
12.        IN  GEOMTR
13.        SEG GEO1*,(SL3)
14.        IN  GEOM1
15.        SEG GEO2*,(SL3)
16.        IN  GEOM2
17.        SEG GEO3*,(SL3)
18.        IN  GEOM3
19.        SEG GEO4*,(SL3)
20.        IN  GEOM4
21.        SEG GEO5*,(SL3)
22.        IN  GEOM5
23.        SEG  SL4*,(LINK1)
24.        IN  RZLG
25.        SEG RG*,(SL4)
26.        IN RGDATA
27.        SEG ZT*,(SL4)
```

```
28.        IN ZEROTT
29.        SEG LD*,(SL4)
30.        IN LOADRE
31.        SEG GT*,(SL4)
32.        IN GETPST
33.        SEG  SL5*,(LINKI)
34.        IN WALLS,WALLCF,CFB1,FUNCT
35.        SEG  CB2*,(SL5)
36.        IN  CFB2
37.        SEG  CB3*,(SL5)
38.        IN  CFB3
39.        SEG  CB4*,(SL5)
40.        IN  CFB4
41.        SEG  CB5*,(SL5)
42.        IN  CFB5
43.        SEG  CB6*,(SL5)
44.        IN  CFB6
45.        SEG  CB7*,(SL5)
46.        IN  CFB7
47.        SEG  CB8*,(SL5)
48.        IN  CFB8
49.        SEG  SL6*,(LINKI)
50.        IN OUTAX
51.        SEG  SL7*,(LINKI)
52.        IN  REIVE
53.        SEG ZOI*,(SL7)
54.        IN ZGLOBE,OUTIN2,ISHIFT
55.        SEG SKY*,(SL7)
56.        IN SKILIN
```

```
57.        SEG  SL8*,(LINK1)
58.        IN  OUTFIN
59.        SEG  LINK2*,(MN)
60.        IN  PRE,LOADS,UNLOAD
61.        SEG  SL21*,(LINK2)
62.        IN  PRE1
63.        SEG  SL22*,(LINK2)
64.        IN  PRE2
65.        SEG  LINK3*,(MN)
66.        IN  ARRAYS
67.        SEG  LINK4*,(MN)
68.        IN  BUCKLE
69.        SEG  SL41*,(LINK4)
70.        IN  EBAND2
71.        SEG  SL42*,(LINK4)
72.        IN  EIGEN
73.        SEG  SL43*,(LINK4)
74.        IN  EBAND
75.        SEG  LINK5*,(MN)
76.        IN  MODE1
77.        SEG  LINK6*,(MN)
78.        IN  PLOT1
```

```
ADDRESS LIMITS     001000 033647      040000 173106
SEGMENT LOAD TABLE                    040000 040227
INDIRECT LOAD TABLE                   040230 041156
STARTING ADDRESS  020262

WORDS DECIMAL        13736 IBANK        46663 DBANK
```

IBANK SEGMENTS DRAWN TO SCALE: 200 WORDS DECIMAL PER DASH

```
MN (8782)
-------------------------------------------
                                                LINK1* (1704)
                                                --------
                                                        SL1* (480)
                                                        ---
                                                        SL2* (294)
                                                        --
                                                        SL3* (1230)
                                                        -------
                                                                GE01* (284)
                                                                -
                                                                GE02* (657)
                                                                ---
                                                                GE03* (315)
                                                                -
                                                                GE04* (1320)
                                                                ------
                                                                GE05* (427)
                                                                --
                                                        SL4* (200)
                                                        -
                                                         RG* (356)
                                                         --
                                                         ZT* (194)
                                                         -
                                                         LD* (2015)
                                                         -----------
                                                         GT* (222)
                                                         --
                                                        SL5* (2047)
                                                        -----------
                                                                    CB2* (823)
                                                                    ----
                                                                    CB3* (316)
                                                                    -
                                                                    CB4* (612)
                                                                    ---
                                                                    CB5* (739)
                                                                    ---
                                                                    CB6* (309)
                                                                    -
                                                                    CB7* (612)
                                                                    ---
                                                                    CB8* (1203)
                                                                    ------
                                                        SL6* (191)
                                                        -
                                                        SL7* (256)
                                                        --
                                                          ZOI* (703)
                                                          ---
                                                          SKY* (1603)
                                                          --------
                                                        SL8* (1759)
```

```
                                                  ---------
                                          LINK2* (645)
                                          ---
                                             SL21* (2453)
                                             ------------
                                             SL22* (1269)
                                             ------
                                          LINK3* (4849)
                                          ------------------------
                                          LINK4* (408)
                                          --
                                            SL41* (1477)
                                            -------
                                            SL42* (532)
                                            ---
                                            SL43* (1257)
                                            ------
                                          LINK5* (2416)
                                          ------------
                                          LINK6* (3821)
                                          -------------------
```

DBANK SEGMENTS DRAWN TO SCALE: 700 WORDS DECIMAL PER DASH

```
MN (14833)
---------------------
                      LINK1* (11248)
                      ----------------
                                      SL1* (639)
                                      -
                                      SL2* (70)
                                      -
                                      SL3* (517)
                                      -
                                       GE01* (91)
                                       -
                                       GE02* (234)
                                       -
                                       GE03* (347)
                                       -
                                       GE04* (420)
                                       -
                                       GE05* (116)
                                       -
                                      SL4* (15)
                                      -
                                      RG* (202)
                                      -
                                      ZT* (35)
                                      -
                                      LD* (676)
                                      -
```

```
                                    GT* (75)
                                    -
                                    SL5* (758)
                                    -
                                     CB2* (157)
                                     -
                                     CB3* (118)
                                     -
                                     CB4* (318)
                                     -
                                     CB5* (519)
                                     -
                                     CB6* (83)
                                     -
                                     CB7* (261)
                                     -
                                     CB8* (652)
                                     -
                                    SL6* (138)
                                    -
                                    SL7* (30)
                                    -
                                    ZOI* (469)
                                    -
                                    SKY* (623)
                                    -
                                    SL8* (7356)
                                    -----------
                LINK2* (26272)
                ------------------------------------
                                                    SL21* (790)
                                                    -
                                                    SL22* (442)
                                                    -
                LINK3* (29474)
                ------------------------------------------
                LINK4* (30551)
                ---------------------------------------------
                                                            SL41* (592)
                                                            -
                                                            SL42* (308)
                                                            -
                                                            SL43* (656)
                                                            -
                LINK5* (26138)
                ------------------------------------
                LINK6* (15780)
                ----------------------

SYS$*RLIB$. LEVEL 57
END OF COLLECTION - TIME 11.921 SECONDS


@PACK
FURPUR 0021-02/11-09:13
```

APPENDIX D

RECENT BOSOR4 UPDATES INCLUDING NEW PLOTTING PACKAGE

NEW PLOTTING CAPABILITY IN BOSOR4

The main purpose of Appendix D is to demonstrate an additional plot capability added to BOSOR4 just before the User's Manual went to press. Figures D-1 through D-7 show additional plot output corresponding to the test cases given in Appendix A. No additional input data are required for obtaining this plot output. Figure D-8 shows some plot output from a new case involving a ring-stiffened cylinder. The purpose of this figure is to show that portions of the geometry can be selected for expanded plots. However, in order to obtain expanded plots the user must provide a few additional input control parameters which are not given on page B-2 nor defined on page B-3. The affected "cards" are given below:

SECOND AND THIRD CARDS NOW READ	CORRESPONDING INPUT FOR EXPANDED PLOTS
• Read INDIC, NPRT, NLAST, ISTRES, IPRE	• Read INDIC, NPRT, NLAST, ISTRES, IPRE, JPLOT If (JPLOT. EQ. 0) go to 5 • Read (KPLOT(I), I=1, JPLOT) • Read (LPLOT(I), I=1, JPLOT) 5 Continue
• Read NSEG, NCOND, IBOUND, IRIGID	• Read NSEG, NCOND, IBOUND, IRIGID

Definitions:

JPLOT..... quantity of stations at which expanded plots are desired. (maximum = 20) (With JPLOT = 0 no expanded plots are given, but the entire undeformed and deformed geometry are shown.)

KPLOT(I) .... location of the Ith station for which expanded plots are desired. Example: 001053 denotes Segment #1, mesh point #53

LPLOT(I) .... factor by which entire structure should be magnified for expanded plots about the Ith station identified by KPLOT(I). Example: 000004 denotes a factor of 4.

The input data for expanded plots corresponding to Fig. D-8 are:

JPLOT	=	2			
KPLOT(1)	=	001022	KPLOT(2)	=	002022
LPLOT(1)	=	000004	LPLOT(2)	=	000008

With these data the 22nd mesh point in Segment #1 is placed approximately at the center of the frame and a portion of the structure about that point is plotted, however much can be fit into the frame given the magnification factor of 4. Then the 22nd mesh point of Segment #2 is placed in the center of the next frame and a portion of the structure about that point is plotted, however much can be fit into the frame with the magnification factor of 8.

The points shown on the plots are the "energy" points (See Section 6), not the w-points. The deformed structures are plotted by means of a normalization through which the maximum amplitude of the deformation represents approximately ten percent of the longest dimension of the structure. Therefore, the user is cautioned not to use these pictorial representations for quantitative measurement. Their purpose is, of course, to give the user a better physical picture of what is going on and to help him correct any mistakes in the input data.

Note in Fig. D-4 that the line load H is shown pointing outward, but that the displacement w is inward. The reason for this apparent anomaly is that the actual line load is given as a product of two quantities, H(I) and the circumferential distribution, in this case PLIN1(L, 1). In this case PLIN1(L, 1) is negative and H(I) is positive. (See Tables 1.2 and 1.3 for other examples).

Figure D-12 shows a case of a cylinder with various line loads and moments, both "fixed" and "variable" (or in this case "initial" and "incremental"). The plots show the attachment points of the discrete rings and the locations of the ring centroids, as well as the directions of the applied loads.

USE OF BOSOR4 FOR THE ANALYSIS OF COMPLEX PANELS

BOSOR4 can be used for the stress, buckling and vibration analysis of prismatic structures as well as shells of revolution. Complex panels are an example. Figure D-13 shows examples of two models of corrugated, semi-sandwich panels, one in which the troughs of the corrugations are considered to be bonded to the flat skin, and the other in which they are riveted. Alternate models, in which the panel is treated as a giant annulus rather than a giant cylinder, appear in Fig. D-14. In this figure the length L is the half-wavelength of the buckling pattern in the circumferential direction of the large annulus. Simple support conditions are imposed at the inner and outer radii of the giant annulus. The user has no choice as to boundary conditions on the other two edges, i.e. these are the classical "simple support" conditions which result from the harmonic variation of the buckling modal displacements around the circumference of the giant annulus.

Figures D-9 and D-10 show the semi-sandwich corrugated panels with local expansions. Note in the case of the riveted panel that parts of the corrugations "penetrate" parts of the flat sheet, a phenomenon which of course is impossible in reality. However, if the mode shape in Fig. D-10 is multiplied by minus one, the right-hand mode shape shown in Fig. D-14(e) results. This failure is clearly possible.

Figure D-11 shows buckling modes of an odd-shaped branched column, called the "NACA-Y". In all of these cases the structures are submitted to axial compression and the INDIC = 4, IPRE = 0 branch of BOSOR4 is used.

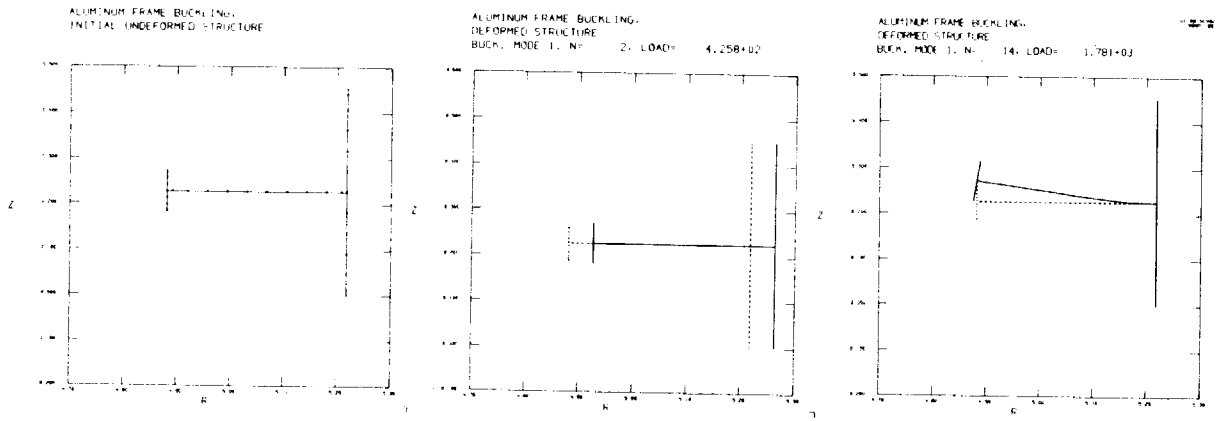


Fig. D-1 SAMPLE CASE #1: BUCKLING OF RING TREATED AS BRANCHED SHELL (Fig. 26)

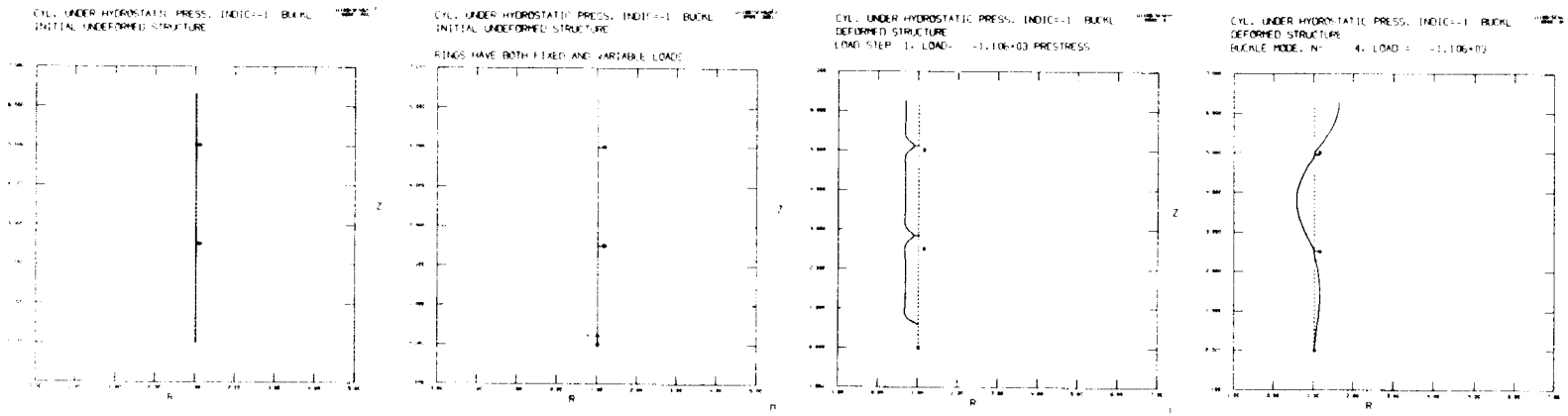


Fig. D-2 SAMPLE CASE #2: BUCKLING OF RING-STIFFENED CYLINDER UNDER EXTERNAL HYDROSTATIC PRESSURE (Fig. 27)

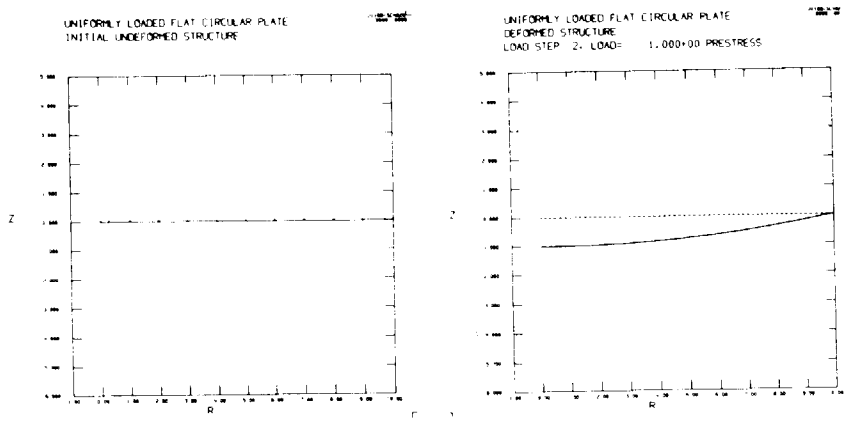


Fig. D-3 TEST CASE #3: SIMPLY-SUPPORTED FLAT PLATE WITH UNIFORM LOAD p (Fig. 28)

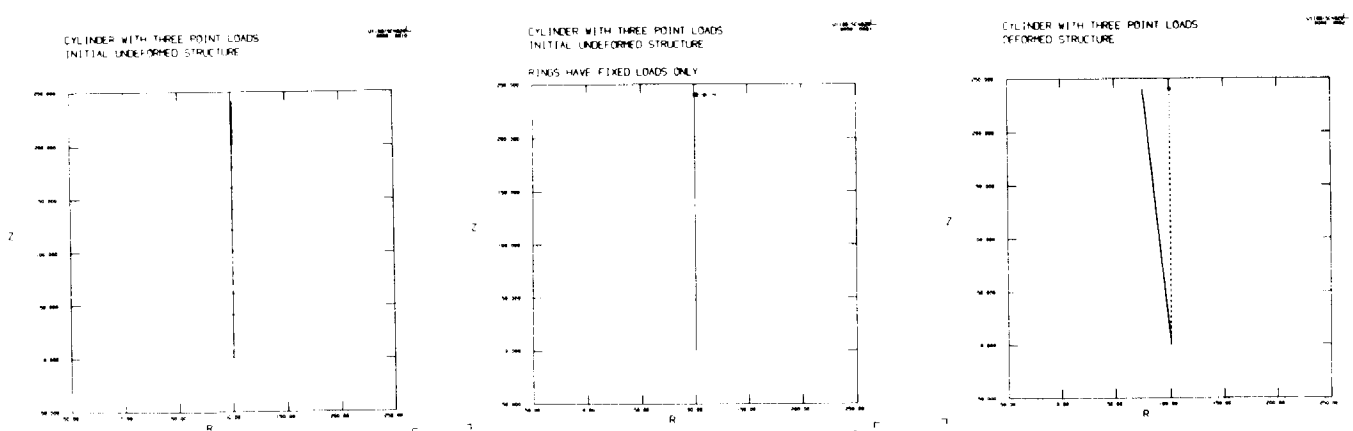


Fig. D-4 TEST CASE #4: RING-STIFFENED CYLINDER WITH THREE POINT LOADS (Fig. 29) [H is positive because the circumferential distribution (YPLUS(J), J=1,NX) is negative]

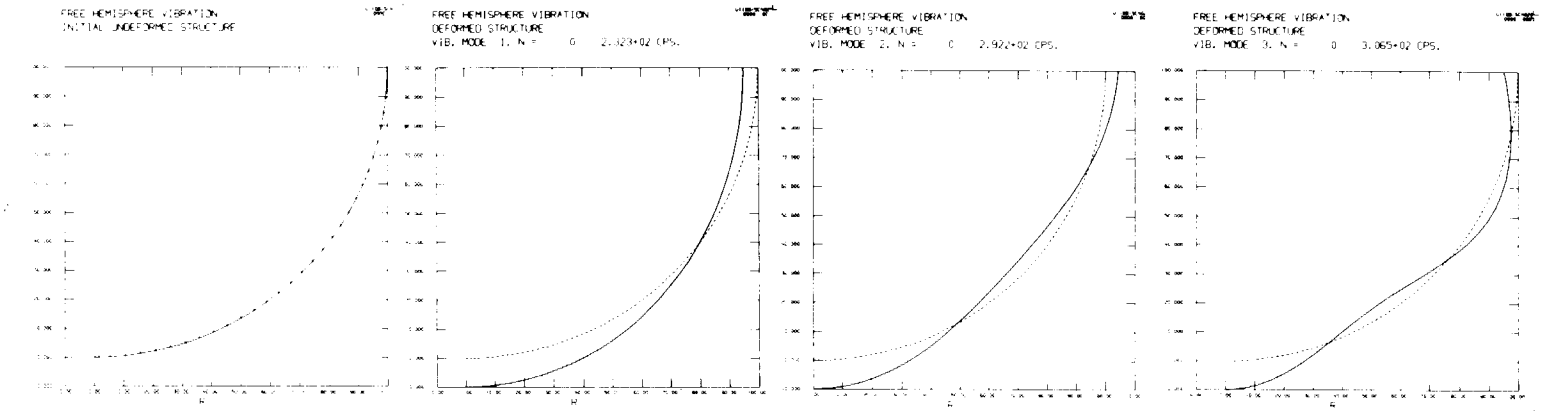


Fig. D-5 TEST CASE #5: VIBRATION OF FREE HEMISPHERE (Fig. 30)

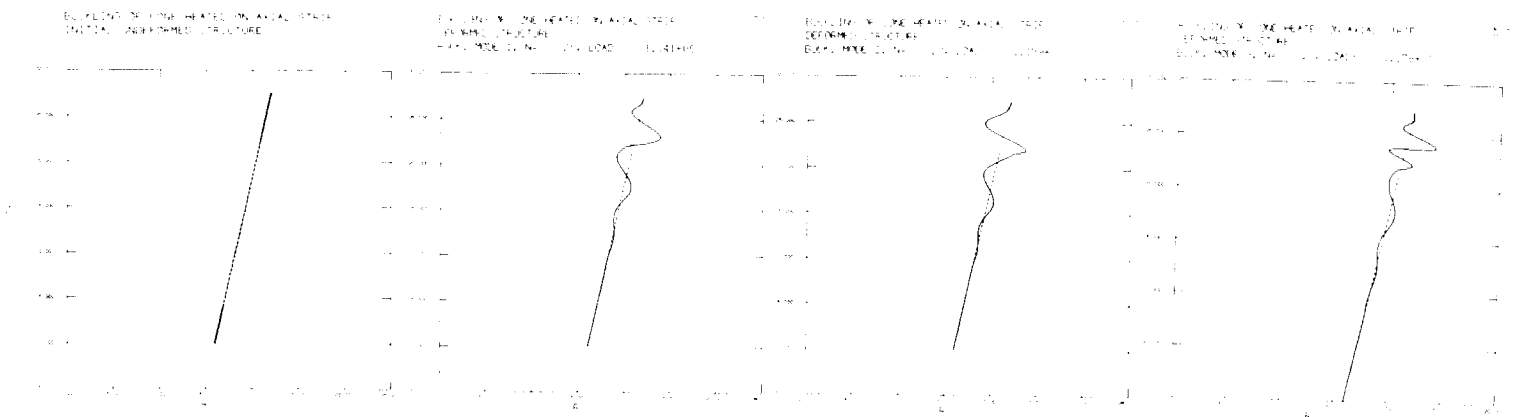


Fig. D-6 TEST CASE #6: CONICAL SHELL HEATED ON AXIAL STRIP (Fig. 31)

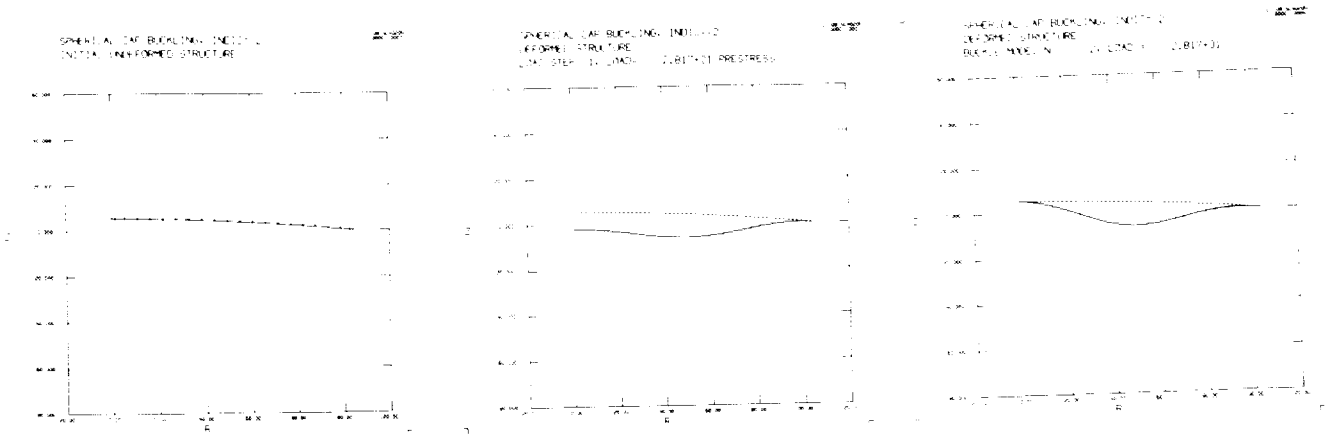


Fig. D-7 TEST CASE #7: SPHERICAL CAP BUCKLING, UNIFORM EXTERNAL BUCKLING (Fig. 36)

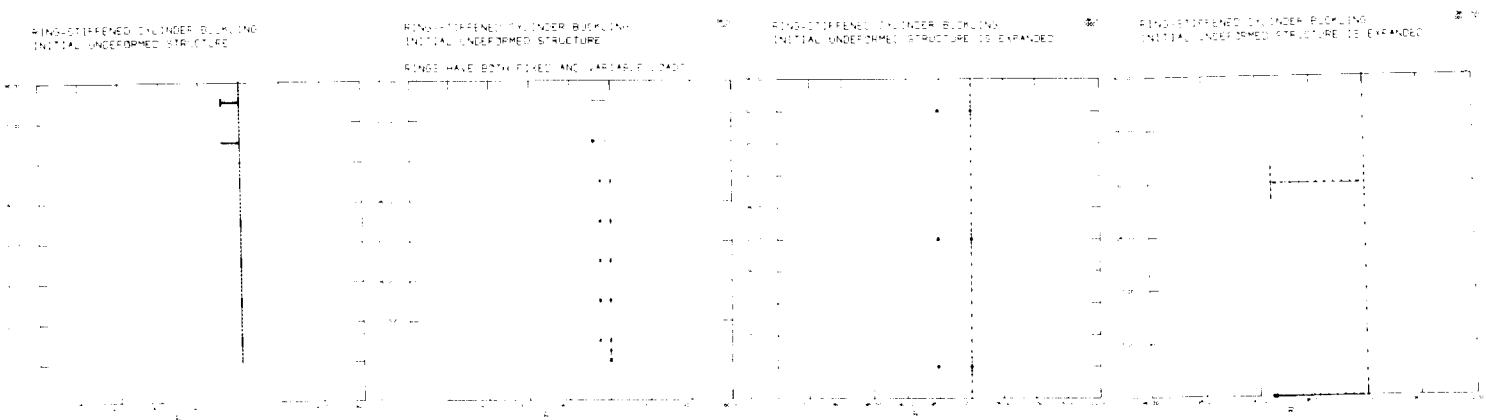


Fig. D-8 RING-STIFFENED CYLINDER SHOWING EXPANDED REGIONS

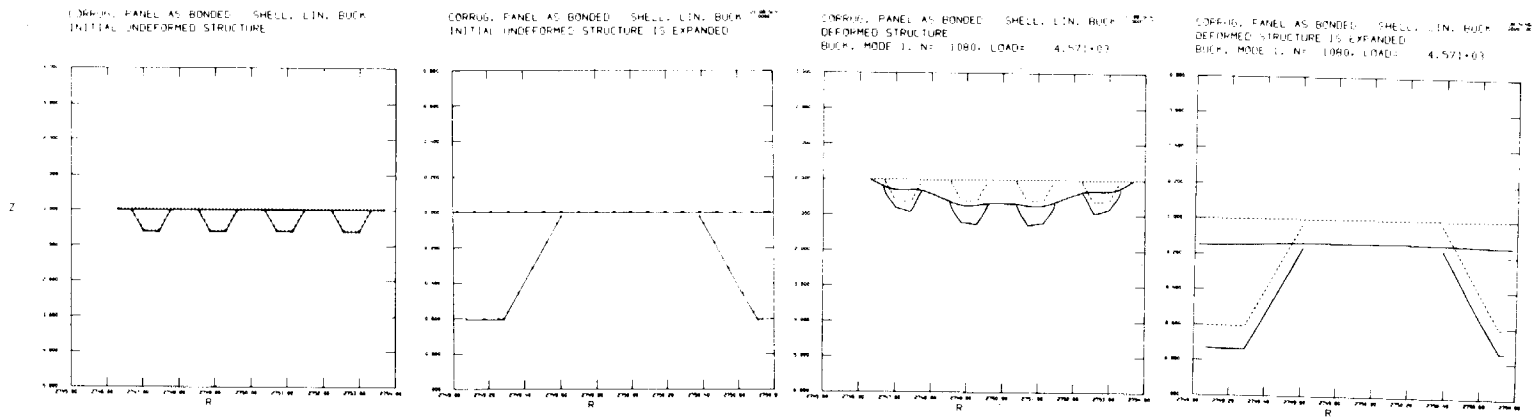


Fig. D-9 BONDED PANEL UNDER AXIAL COMPRESSION

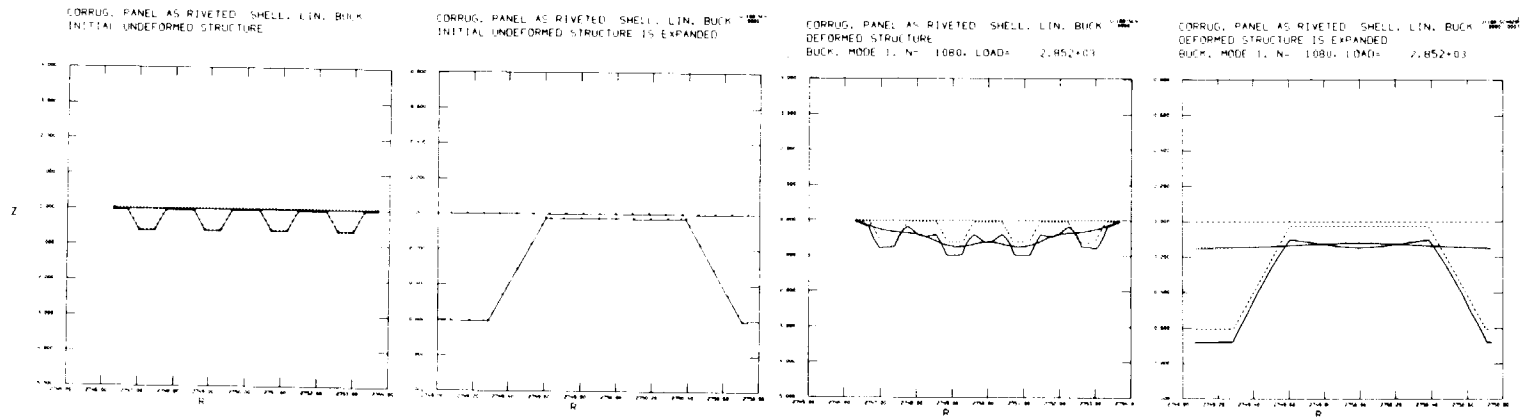


Fig. D-10 RIVETED PANEL UNDER AXIAL COMPRESSION

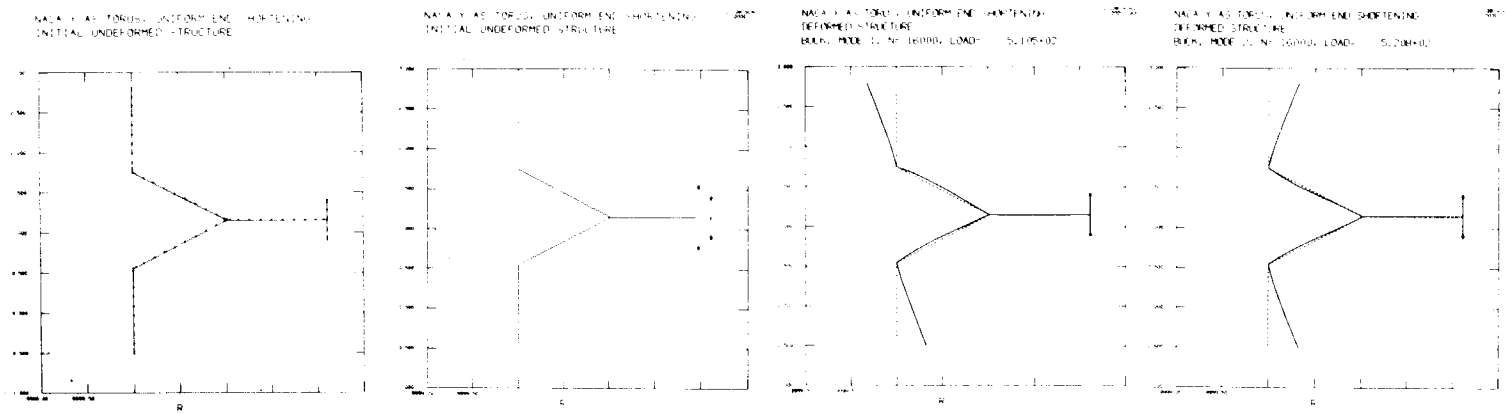


Fig. D-11 BRANCHED COLUMN BUCKLING, COMPRESSIVE FORCE NORMAL TO PLANE OF PAPER

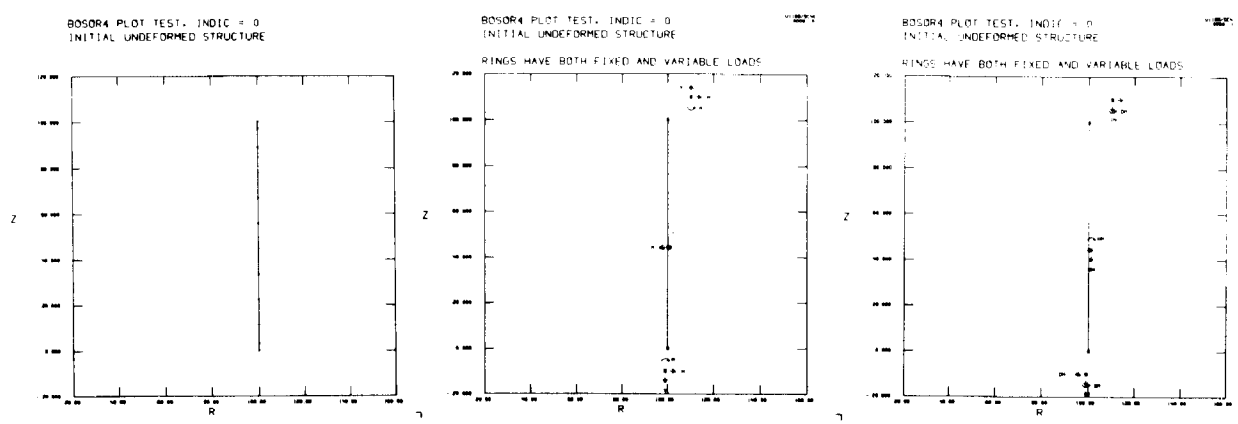


Fig. D-12 BOSOR4 PLOT OUTPUT, SHOWING DISCRETE RING ATTACHMENT POINTS, CENTROIDAL AXES, AND APPLIED LINE LOADS

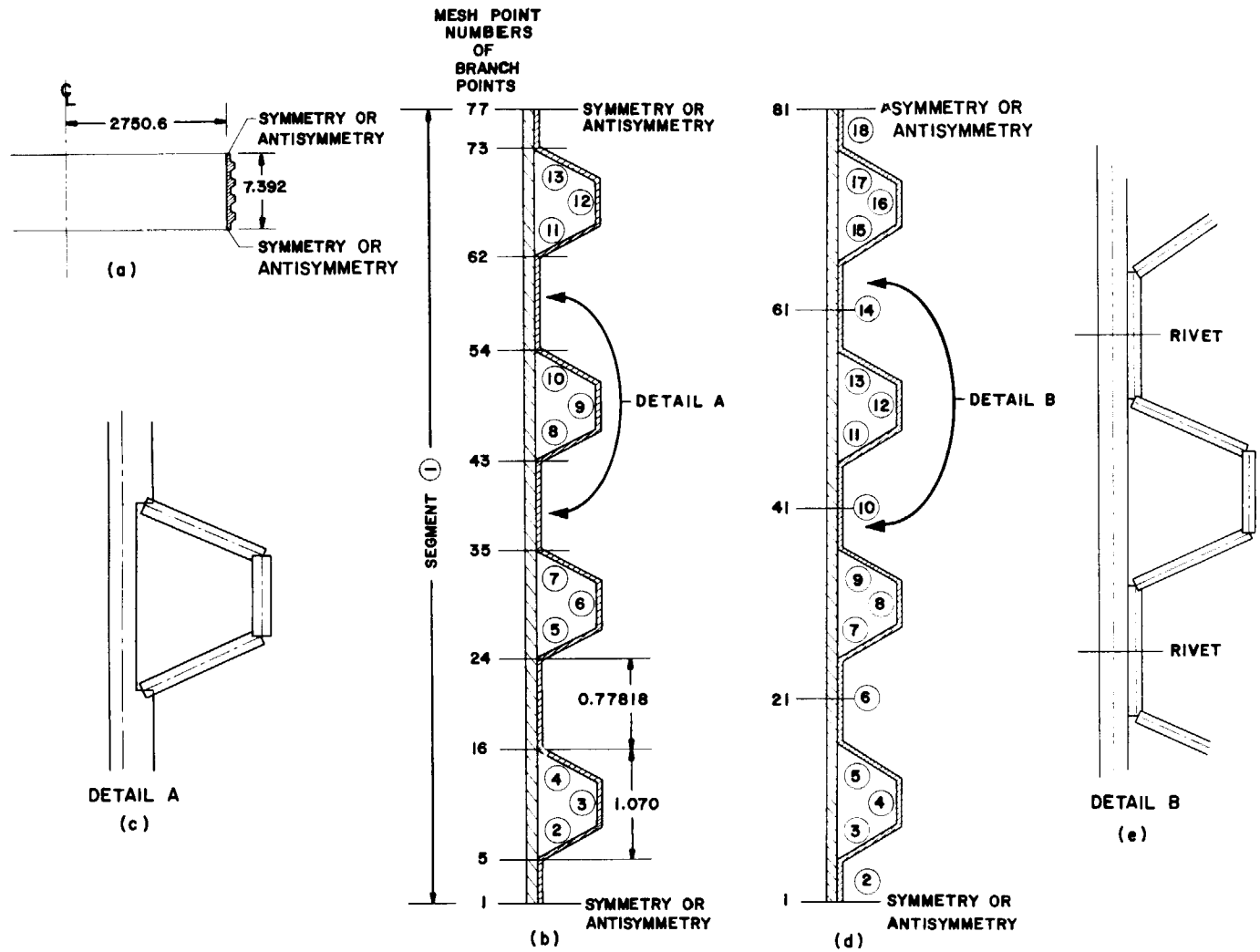
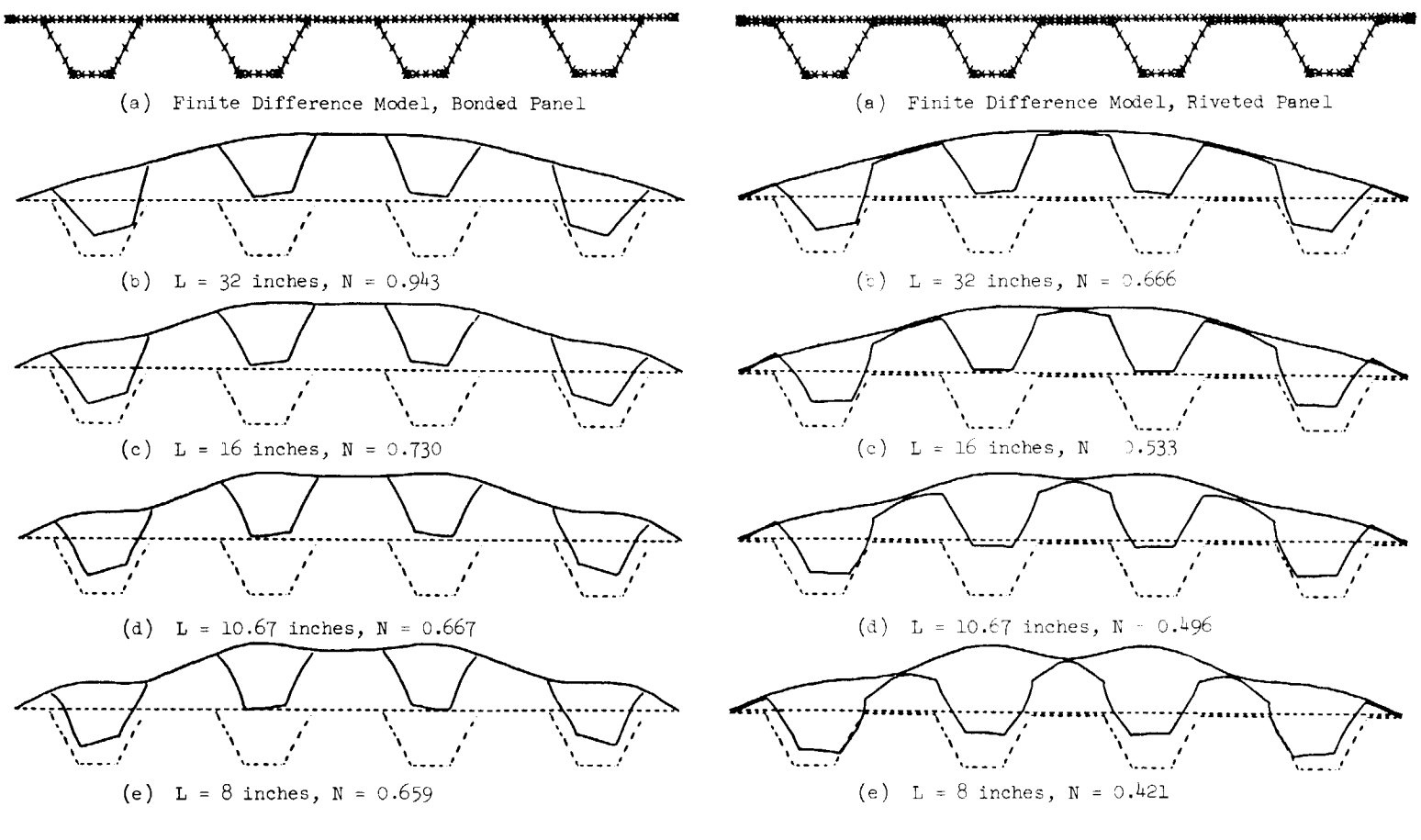


Fig. D-13 Corrugated Panel Model: (a) Cylinder With Large Radius, (b) Segmented Bonded Model, (c) Detail of Branches, Bonded Model, (d) Segmented Riveted Model, (e) Detail of Branches, Riveted Model



L = axial half-wavelength of buckling mode

N = (critical axial load)/(critical axial load with local distortion of wall cross-section not permitted)

Fig. D-14 Buckling Modes of Axially Compressed Semi-Sandwich Bonded and Riveted Corrugated Panels