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BUCKLING OF SHELLS OF REVOLUTION WITH VARIOUS WALL CONSTRUCTIONS

Volume 3 - User's Manual for BØSØR

by D. Bushnell, B. O. Almroth, and L. H. Sobel

Prepared by
LOCKHEED AIRCRAFT CORPORATION
Sunnyvale, Calif.
for Langley Research Center

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FOREWORD

This is the third of three volumes of a final report entitled, "Buckling of Shells of Revolution with Various Wall Constructions". The three volumes have the following titles:

Vol. 1	Numerical Results
Vol. 2	Basic Equations and Method of Solution
Vol. 3	User's Manual for BOSOR

The work described in these volumes was carried out under Contract NAS 1-6073 with the National Aeronautics and Space Administration.

ABSTRACT

Volume 1

Volume 1 presents the results of a parameter study performed with the computer program BØSØR (Buckling Of Shells Of Revolution) which is described in Volume 3. The axisymmetric collapse and the nonsymmetric bifurcation buckling behavior is studied for cylinders, cones, and spherical and toroidal shell segments subjected to axial compressive loads. Particular emphasis is placed on the effects of eccentricity in load application and on the influence of elastic end rings.

Volume 2

Volume 2 presents the equations on which the computer program BØSØR is based, as well as the method of solution of the equations. In addition, a set of more general stability equations is given in an appendix.

Volume 3

Volume 3 presents a comprehensive computer program (BØSØR) for the analysis of shells of revolution with axisymmetric loading. The program includes nonlinear prebuckling 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. The cards and a computer listing for this program are available from COSMIC, University of Georgia, Athens, Georgia, 30601.

NOTATION

A_{ij}	see Eq. (2)
B_{33}, B_{66}	see Eq. (2)
BA11, etc.	boundary condition coefficients at A, see Eqs. (3) and (4)
BB11, etc.	boundary condition coefficients at B, see Eqs. (3) and (4)
C_{ij}	coefficients of constitutive equations, see Eq. (1)
e	eccentricity (distance from shear center of shell wall to point of load application, positive outward)
H	horizontal (radial) force/unit length (see Fig. 1)
M	moment resultant
M_T	$M_{12} + M_{21}$
N	stress resultant
n	number of circumferential waves in buckling pattern
P	total axial load applied to shell, positive compression
p	normal pressure, positive internal
R	radius of curvature
r	horizontal radius from axis of rotation to middle surface
s	arc length measured from point A (see Fig. 1)
u	meridional displacement
u_H	horizontal (radial) displacement
u_V	vertical (axial) displacement
v	circumferential displacement

V	vertical (axial) force/unit length
w	normal displacement, positive outward
β	meridional rotation
ϵ	middle surface strain
$\varkappa$	change in curvature
ψ	stress function for prebuckling problem $\psi = rH$
θ	circumferential coordinate

Subscripts and superscripts

$(\ )'$	differentiation with respect to arc length s
$(\ )_x$	differentiation with respect to x
$(\ )_1$	pertains to meridional direction
$(\ )_2$	pertains to circumferential direction
$(\ )_{12}$	shear resultant, twisting moment, twisting change in curvature
$(\ )_o$, $(\ )_0$	prebuckling quantity
$(\ )_A$	at end A of the meridian (see Fig. 1)
$(\ )_B$	at end B of the meridian (see Fig. 1)

CONTENTS

Section 1

APPLICABILITY OF COMPUTER PROGRAM

The computer program is applicable to shells of revolution with a great variety of: 1. geometries of the shell meridian, 2. wall constructions, 3. boundary conditions, and 4. types of loading.

1. Geometry of the Meridian

Flexibility is provided through a "computed GØ TØ" statement, in which control is referred to various subroutines called GEØM1, GEØM2, etc. Each of these subroutines calculates geometrical parameters r, r', $1/R_1$, and $1/R_2$ as functions of meridional arc length (see Fig. 1). For example, GEØM1 corresponds to cylindrical or conical shells; GEØM2 corresponds to spherical segments; GEØM3 corresponds to toroidal segments; GEØM4 corresponds to general meridional shapes (input data consist of cartesian coordinates of points on the meridian). These geometries are shown in Fig. 1a. Additional shell types can be accommodated by the insertion of another subroutine to calculate parameters for a specific geometry where a dummy is now provided.

2. Wall Construction

Flexibility is provided as in the case of meridian geometry through a computed GØ TØ statement, in which control is referred to various subroutines called CFB1, CFB2, etc. Each of these subroutines calculates the coefficients of the constitutive equations for a given type of shell wall construction. Table 1 lists the subroutine names and associated types of shell wall.

Table 1 Subroutine Names and Corresponding Shell Wall Types

NWALL	Subroutine Name	Shell Wall Type
1	CFB1	General, stiffness coefficients are read in from data cards. This routine can also be called from CFB4 through CFB7 for addition of stiffeners.
2	CFB2	Ring-stringer stiffened shell (isotropic skin)
3	CFB3	Skew-stiffened shell
4	CFB4	Fiber reinforced shell (layered)
5	CFB5	Layered shell (orthotropic or isotropic layers)
6	CFB6	Corrugated skin (with rings)
7	CFB7	Corrugated and smooth skin (semi-sandwich)
8	CFB8	Dummy

Additional wall constructions can be accommodated by the insertion of appropriate subroutines.

The subroutines CFB1, etc. yield coefficients C_{ij} of the constitutive equations, which are defined by the equation:

$$\begin{Bmatrix} N_1 \\ N_2 \\ N_{12} \\ M_1 \\ M_2 \\ M_T \end{Bmatrix} = \begin{bmatrix} C_{11} & C_{12} & 0 & C_{14} & C_{15} & 0 \\ C_{21} & C_{22} & 0 & C_{24} & C_{25} & 0 \\ 0 & 0 & C_{33} & 0 & 0 & 0 \\ C_{41} & C_{42} & 0 & C_{44} & C_{45} & 0 \\ C_{51} & C_{52} & 0 & C_{54} & C_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & C_{66} \end{bmatrix} \begin{Bmatrix} \epsilon_1 \\ \epsilon_2 \\ \epsilon_{12} \\ \kappa_1 \\ \kappa_2 \\ \kappa_{12} \end{Bmatrix} \qquad (1)$$

Formulas for the C_{ij} are given in Volume 2 for the types of shell walls listed in Table 1. Since the prebuckling and stability problems as formulated in the computer program are governed by compatibility and equilibrium equations, it is more convenient to use a semi-inverted form of the constitutive equations:

$$\begin{Bmatrix} \epsilon_1 \\ \epsilon_2 \\ \epsilon_{12} \\ M_1 \\ M_2 \\ M_T \end{Bmatrix} = \begin{bmatrix} A_{11} & A_{12} & 0 & A_{13} & A_{14} & 0 \\ A_{21} & A_{22} & 0 & A_{23} & A_{24} & 0 \\ 0 & 0 & B_{33} & 0 & 0 & 0 \\ A_{31} & A_{32} & 0 & A_{33} & A_{34} & 0 \\ A_{41} & A_{42} & 0 & A_{43} & A_{44} & 0 \\ 0 & 0 & 0 & 0 & 0 & B_{66} \end{bmatrix} \begin{Bmatrix} N_1 \\ N_2 \\ N_{12} \\ \kappa_1 \\ \kappa_2 \\ \kappa_{12} \end{Bmatrix} \qquad (2)$$

In the computer program the A_{ij} and B_{kk} are calculated from the C_{ij} in a subroutine called CTØA.

3. Boundary Conditions

In the prebuckling equilibrium problem the boundary conditions are expressed in the form

$$\begin{aligned} BA11*\psi + BA12*M_1 + BA13*u_H + BA14*\beta &= \psi_A \\ BA21*\psi + BA22*M_1 + BA23*u_H + BA24*\beta &= M_{1A} \\ BB11*\psi + BB12*M_1 + BB13*u_H + BB14*\beta &= \psi_B \\ BB21*\psi + BB22*M_1 + BB23*u_H + BB24*\beta &= M_{1B} \end{aligned} \qquad (3)$$

Equations (3a,b) are the boundary conditions at the end A of the meridian (see Fig. 1). Equations (3c,d) are the boundary conditions at B. The right hand sides are shown as stress functions and moments at A and B. However, they can be considered horizontal displacements and rotations. The boundary conditions are given in this general form in order to permit for instance treatment of composite shells in which the elastic properties of adjacent structures are accounted for through their stiffness coefficients. In cases for which the axial load is applied eccentrically with respect to the shell reference surface, the resulting bending moments $e_A \bar{V}_A$ and $e_B \bar{V}_B$ are included in M_{1A} and M_{1B}, respectively.

The boundary conditions for the stability problem are expressed in the form

$$\begin{bmatrix} BA11 & BA12 & BA13 & BA14 & BA15 & BA16 & BA17 & BA18 \\ BA21 & BA22 & BA23 & BA24 & BA25 & BA26 & BA27 & BA28 \\ BA31 & BA32 & BA33 & BA34 & BA35 & BA36 & BA37 & BA38 \\ BA41 & BA42 & BA43 & BA44 & BA45 & BA46 & BA47 & BA48 \\ BB11 & BB12 & BB13 & BB14 & BB15 & BB16 & BB17 & BB18 \\ BB21 & BB22 & BB23 & BB24 & BB25 & BB26 & BB27 & BB28 \\ BB31 & BB32 & BB33 & BB34 & BB35 & BB36 & BB37 & BB38 \\ BB41 & BB42 & BB43 & BB44 & BB45 & BB46 & BB47 & BB48 \end{bmatrix} \begin{Bmatrix} rH \\ M_1 \\ u_H \\ \beta \\ v \\ rN_{12} \\ u_v \\ rV \end{Bmatrix} = 0 \qquad (4)$$

The first 4 of Eqs. (4) are the boundary conditions at A (see Fig. 1). The last 4 are the boundary conditions at B. The boundary conditions are expressed in the form given by Eqs. (3) and (4) in order to permit the treatment of shells bounded by elastic rings as well as shells for which more simple boundary conditions are assumed. From Eqs. (4) it can be seen for example that "simple-support" conditions at the ends A and B of the meridian can be simulated by the specification BA13 = 1.0, BA22 = 1.0, BA35 = 1.0, and BA48 = 1.0, for the non-zero coefficients at A; and BB13 = 1.0, BB22 = 1.0, BB35 = 1.0, and BB48 = 1.0 for the non-zero coefficients at B. All other BAij's and BBij's are set equal to zero for this case. Physically the above-specified input parameters correspond respectively to $u_H = 0$, $M_1 = 0$, $v = 0$, and $rV = 0$ at A and at B.

If the shell is supported by elastic rings at the boundaries, the BAij and BBij are computed from ring equations given by Cheney (Ref. 4). As used in in the program, they are valid for any ring, the centroid of which coincides with its shear center. The ring centroid need not coincide with the shell reference surface. It should be emphasized that the BAij and BBij corresponding to the boundary conditions (Eqs. 3) of the prebuckling equilibrium problem (wave number $n = 0$) are not the same as those corresponding to the boundary conditions (Eqs. 4) of the stability problem ($n \neq 0$). The effective stiffness of the ring depends on the wave number n.

The computer program has been rendered easy to use through the provision of input integers NTYPEA and NTYPEB. Specification of these integers causes appropriate boundary condition coefficients BAij and BBij to be generated within various subroutines BØU11, BØU12, etc. The alternatives available to the user are shown in Table 2. The boundary conditions at B can be specified independently of those at A.

Table 2 Boundary Conditions Specified By NTYPEA, NTYPEB

Boundary Conditions at A		Boundary Conditions at B	
NTYPEA	Boundary Conds. at A	NTYPEB	Boundary Conds. at B
1	either displacement component or corresponding load component equals zero: e.g. simple-support, clamped, free. Axial support or loading may be eccentric.	1	similar type of conditions, although not necessarily the same as at A.
2	support by elastic medium at A.	2	support by elastic medium at B.
3	support by elastic ring at A. The ring can be restrained from displacements as under 1 above.	3	support by elastic ring at B.
4	BA11, BA12, etc. read in from data cards.	4	BB11, BB12, etc. read in from data cards.
5	prebuckling and buckling behavior symmetric at A, which represents a plane of symmetry of the shell structure.		
6	prebuckling displacements are symmetric and buckling displacements antisymmetric at A, which represents a plane of symmetry of the shell structure.		

4. Loading

Flexibility is provided through a computed G0 T0 statement which occurs in SUBR0UTINE L0ADS. An integer L0AD is assigned a value 1 through 3. L0AD = 1 corresponds to normal pressure only. The input for pressure (RH00) is positive for internal pressure. L0AD = 2 corresponds to combined pressure and edge loading at the edge A which both vary proportionately as the load increases. The axial load at A divided by 2π is represented internally by R1V1 = $(Pr^2/2)$*RATI0, where RATI0 is the input parameter for this load. When RATI0 = 1.0, the shell is loaded by hydrostatic pressure only (RATI0 can be any number, positive or negative). L0AD = 3 corresponds to loading by axial tension or compression only, positive for axial tension.

Additional input parameters, R1V10 and P0, are provided to allow for a pressure, an axial load, or a combined load surcharge unrelated to the variable loadings. These quantities are held constant during the loading process.

Section 2

OVERALL DESCRIPTION OF THE COMPUTER PROGRAM BØSØR

Flow charts of the computer program (called BØSØR for Buckling of Shells of Revolution) are given in Figs. 2 and 3. The overlay technique is used so that the program will fit into core without extensive use of tapes. The overlay chart appears in Fig. 2. The program structure has two origins, one with three overlay links, and one with two overlay links.

Input Data

A list of the input data with format is given in Table 3. Tables 4-7 give an explanation of the data. Data concerning the meridian geometry, wall construction, boundary conditions, and type of loading are read into the first link of the overlay from data cards. Flexibility is provided through the introduction of integers NCST, NWALL, NTYPEA and NTYPEB, and LOAD, which control the switching in computed GØ TØ statements.

The integer NCST causes the selection of a meridian geometry, such as cylindrical, conical, spherical or toroidal. Corresponding geometrical data are calculated in subroutines called GEOM1, GEOM2, etc. Within each GEOM subroutine certain data must be read in from data cards. For example, in order to calculate r, r' , $1/R_1$, and $1/R_2$ at each meridional station along the generator of a cylinder or cone, the program must be provided with the radius at the small end R1, the slant height SL and the half-angle ALPH. For a spherical segment the program needs the radius R0T, the polar angle at A, ALPH1, and the polar angle at B, ALPH2. The master subroutine for meridian geometry, GE0M, provides arrays containing s, the arc length from point A; r, the radius of the parallel circle at s; r', the derivative of r with respect to s; $1/R_1$, the meridional curvature; and $1/R_2$, the normal circumferential curvature.

The integer NWALL governs the selection of a particular wall construction, such as layered, eccentrically stiffened, fiber-reinforced, etc. Within each subroutine CFB1, CFB2, etc. (see Table 1) certain basic data concerning the geometrical and material properties of the wall construction are read in from data cards and the coefficients C_{ij} of the constitutive equations are calculated (see Volume 2). For example, in order to calculate the C_{ij} for an eccentrically stiffened shell, the program needs the stiffener spacing and dimensions, skin thickness, information which tells whether the stiffeners are external or internal, and the Young's moduli and Poisson's ratio for stiffeners and skin. The output of the master subroutine for wall construction, C0EFS, consists of the C_{ij}. A small subroutine, CT0A, calculates the coefficients A_{ij} of the semi-inverted form of the constitutive equations [Eqs. (2)].

The integers NTYPEA and NTYPEB govern the selection of particular boundary conditions at A and B respectively. Table 2 shows the alternatives provided. For example when NTYPEA is equal to three, the shell is supported by elastic edge rings at A. In this case basic data on ring geometry and material properties are read in from data cards and the boundary condition coefficients BA11, BA12, etc. and BB11, BB12, etc. are calculated in B0U13 and B0U23. Values of the BA_{ij} and BB_{ij} are assigned in the other boundary condition subroutines B0U11, B0U12, etc.

Other input data include N1, the number of intervals in the finite-difference mesh; an integer L0AD, through which the type of loading is selected; ITER, the maximum number of iterations permitted for convergence of the prebuckling solution; ERR, the maximum allowable error in the prebuckling solution and in the determination of the critical load; INDIC, a flag indicating whether the linear or nonlinear analysis is to be used; NO, the original guess at the number of circumferential waves in the buckle pattern; NMAX and NMIN, the upper and lower limits of the range of wave numbers to be searched for a minimum buckling load; INCRO, the increment by which N, the current wave number, is increased or decreased; RH0O, the starting value for the load in the attempt to find the buckling load; RH0M, the maximum value for RH0, the current load; STEPO, the initial increment of loading for the prebuckling solution.

Table 3

DATA INPUT FOR BØSØR

CARD NO.	FORMAT	DATA TO BE READ IN
1	10I6	NWALL, NCST, NTYPEA, NTYPEB, LØAD, INDIC, NLIN, NDET, NTYPEP, NTYPEM
2	10I6	N1, ITER, NO, INCRO, NMAX, NMIN, INDX
3	6E12.8	RHØO, STEPO, RHØM, RATIØ, R1V10, PO
4	6E12.8	ERR
<u>NWALL = 1</u>		
5	6E12.8	C11, C12, C14, C15, C22, C24 C25, C33, C44, C45, C55, C66
6		ANRS
7		If ANRS = 1, Read also
8	6E12.8	TD, Z
9	6E12.8	E1, U1, XS, D1, A1, XI1,
10		XJ1, AK1
11	6E12.8	E2, U2, XR, D2, A2, XI2,
12		XJ2, AK2
<u>NWALL = 2</u>		
5	6E12.8	E, U, T
6	6E12.8	ØI, D1, D2, AK1, AK2
		If ØI = 0, Read
7	6E12.8	T1, T2, H1, H2
		If ØI = 1, Read

Table 3 (Cont'd)

CARD NO.	FORMAT	DATA TO BE READ IN
7	6E12.8	A1, SI1, S1, EX1
8	6E12.8	A2, SI2, S2, EX2
NWALL = 3		
5	6E12.8	E, U, T
6	6E12.8	TH, A, B, H, AK
NWALL = 4		
5	6E12.8	EF, EM, UF, UM, AK, ANRS
6	6E12.8	T(I), I = 1, AK
7	6E12.8	X(I), I = 1, AK
8	6E12.8	BE(I), I = 1, AK
9	6E12.8	C(I), I = 1, AK
		If ANRS = 1, Read also
10	6E12.8	E1, U1, XS, D1, A1, XI1,
11		XJ1, AK1
12	6E12.8	E2, U2, XR, D2, A2, XI2,
13		XJ2, AK2
NWALL = 5		
5	6E12.8	WRAPS, ANRS, ANI0
		If ANI0 = 0, Read
6	6E12.8	T(I), I = 1, WRAPS
7	6E12.8	E(I), I = 1, WRAPS
8	6E12.8	U(I), I = 1, WRAPS
		If ANI0 = 1, Read
6	6E12.8	T(I), I = 1, WRAPS
7	6E12.8	G(I), I = 1, WRAPS

Table 3 (Cont'd)

CARD NO.		FORMAT	DATA TO BE READ IN
	8	6E12.8	EX(I), I = 1, WRAPS
	9	6E12.8	EY(I), I = 1, WRAPS
	10	6E12.8	UXY(I), I = 1, WRAPS
For ANIO = 0	For ANIO = 1		If ANRS = 1, Read also
9	11	6E12.8	E1, U1, XS, D1, A1, XI1,
10	12		XJ1, AK1
11	13	6E12.8	E2, U2, XR, D2, A2, XI2,
12	14		XJ2, AK2
NWALL = 6			
	5	6E12.8	E, U, ANRS
	6	6E12.8	CC, CH, CD, CT, CB
			If ANRS = 1, Read also
	7	6E12.8	E1, U1, XS, D1, A1, XI1,
	8		XJ1, AK1
	9	6E12.8	E2, U2, XR, D2, A2, XI2,
	10		XJ2, AK2
NWALL = 7			
	5	6E12.8	E, U, ANRS
	6	6E12.8	CC, CH, CD, CT, CB, PHI
	7	6E12.8	ES, US, TS, ANC
			If ANRS = 1, Real also
	8	6E12.8	E1, U1, XS, D1, A1, XI1,
	9		XJ1, AK1
	10	6E12.8	E2, U2, XR, D2, A2, XI2,
	11		XJ2, AK2

Table 3 (Cont'd)

CARD NO.	FORMAT	DATA TO BE READ IN
NWALL = 8		No input; dummy subroutine

Next card contains data for geometry of meridian. Card number is between 7 and 15, depending on NWALL and ANRS. Assume NWALL = 3 for purposes of tabulation.

NCST = 1 7	6E12.8	R1, SL, ALPH
NCST = 2 7	6E12.8	RØT, ALPH1, ALPH2
NCST = 3 7	6E12.8	RØT, ALPH1, ALPH2, ALPHAT
NCST = 4 7	10I6	NRZIN
8, etc.	6E12.8	ZI(I), RI(I), I = 1, NRZIN
NCST = 5 7		No input; dummy subroutine
NTYPEA = 1		If INDX = 0, no input
8	5I1	KA1, KA2, KA3, KA4, KA5
		If KA5 = 3, Read also
9	6E12.8	EXA
NTYPEA = 2		
8	4I1	LA1, LA2, LA3, LA4
9	6E12.8	If LA1 = 1, Read AL11, AL12, AL13, AL14
9 or 10	6E12.8	If LA2 = 1, Read AL22, AL23, AL24
9, 10, or 11	6E12.8	If LA3 = 1, Read AL33, AL34
9, 10, 11, or 12	6E12.8	If LA4 = 1, Read AL44
NTYPEA = 3		
8	5I1	IA1, IA2, IA3, IA4, IA5
9	6E12.8	If IA5 = 3, Read also EXA
10	6E12.8	RSA, EA, AREAA, FIXA, FIYA, FIXYA
11	6E12.8	GJA, GAMMAA, ECCA, FIPA, PSIA, T1A

Table 3 (Cont'd)

CARD NO.	FORMAT	DATA TO BE READ IN
NTYPEA = 4		
8	6E12.8	A
9	6E12.8	BA11, BA12, BA13, BA14
10	6E12.8	BA15, BA16, BA17, BA18
11	6E12.8	BA21, BA22, BA23, BA24
12	6E12.8	BA25, BA26, BA27, BA28
13	6E12.8	BA31, BA32, BA33, BA34
14	6E12.8	BA35, BA36, BA37, BA38
15	6E12.8	BA41, BA42, BA43, BA44
16	6E12.8	BA45, BA46, BA47, BA48
17	6E12.8	PSIA, T1A
NTYPEA = 5		No input data read; see Table 2
NTYPEA = 6		No input data read; see Table 2

Next cards contain data for boundary conditions at end B of the meridian. If NTYPEA = 1 and NWALL = 3, for example, the next card number is 10.

CARD NO.	FORMAT	DATA TO BE READ IN
NTYPEB = 1		
10	5I1	KB1, KB2, KB3, KB4, KB5
		If KB5 = 3, Read also
11	6E12.8	EXB
NTYPEB = 2		
10	4I1	LB1, LB2, LB3, LB4
11	6E12.8	If LB1 = 1, Read BL11, BL12, BL13, BL14
11 or 12	6E12.8	If LB2 = 1, Read BL22, BL23, BL24
11, 12 or 13	6E12.8	If LB3 = 1, Read BL33, BL34
11, 12, 13 or 14	6E12.8	If LB4 = 1, Read BL44

Table 3 (Cont'd)

CARD NO.	FORMAT	DATA TO BE READ IN
NTYPEB = 3		
10	5I1	IB1, IB2, IB3, IB4, IB5
11	6E12.8	If IB5 = 1, Read also EXB
12	6E12.8	RSB, EB, AREAB, FIXB, FIYB, FIXYB
13	6E12.8	GJB, GAMMAB, ECCB, FIPB, PSIB, T1B
NTYPEB = 4		
10	6E12.8	A
11	6E12.8	BB11, BB12, BB13, BB14
12	6E12.8	BB15, BB16, BB17, BB18
13	6E12.8	BB21, BB22, BB23, BB24
14	6E12.8	BB25, BB26, BB27, BB28
15	6E12.8	BB31, BB32, BB33, BB34
16	6E12.8	BB35, BB36, BB37, BB38
17	6E12.8	BB41, BB42, BB43, BB44
18	6E12.8	BB45, BB46, BB47, BB48
19	6E12.8	PSIB, T1B

Table 4

EXPLANATION OF INPUT DATA LISTED IN TABLE 3
READ IN FROM SUBROUTINE CHAIN1

VARIABLE	RANGE	DESCRIPTION
NWALL	1-8	Governs choice of shell wall type, see Table 1
NCST	1-5	Governs choice of geometry = 1 for cylinder or cone = 2 for spherical segment = 3 for toroidal segment = 4 for other shells
NTYPEA	1-6	Governs choice of boundary conditions at A See Table 2
NTYPEB	1-4	Governs choice of boundary conditions at B See Table 2
LØAD	1-3	Governs choice of loading = 1 for normal pressure only = 2 for combined loading (hydrostatic pressure) = 3 for axial loading
INDIC	0 or 1	= 0-if linear prebuckling analysis is used as shown in Fig. 3 = 1 if nonlinear prebuckling analysis only is used
NLIN	0 or 1	= 0-if linear and nonlinear or just nonlinear prebuckling analysis is used. Minimum buckling load in range NMIN ≤ N ≤ NMAX is sought. = 1-linear prebuckling analysis only is used. Buckling loads calculated through power method in range NO ≤ N ≤ NMAX without regard to minimum
NDET	0 or 1	= 0-point at which stability determinant vanishes is sought within the accuracy prescribed by ERR = 1-stability determinant given in range RHØO ≤ RHØ ≤ RHØM regardless of change in sign
NTYPEP	0 or 1	Governs optional output = 0 if prebuckling solution is <u>not</u> printed = 1 if prebuckling solution <u>is</u> printed
NTYPEM	0 or 1	Governs optional output = 0 if buckling pattern is <u>not</u> printed = 1 if buckling pattern <u>is</u> printed

Table 4 (Cont'd)

VARIABLE	RANGE	DESCRIPTION
N1	N1 ≤ 99	Number of intervals in the finite difference mesh
ITER	about 10	Maximum number of iterations in the Newton-Raphson procedure
NO		Starting value for N (wave number) in the search for minimum eigenvalue
INCRO		Stepsize for variation of N
NMAX		Upper limit of range of N which is searched
NMIN		Lower limit of range of N which is searched
INDX		= 0 if shell closed at apex (A), = 1 if shell open
RHØO		Starting value of load in search for eigenvalue
STEPO		Original stepsize of load in search for eigenvalue
RHØM		Upper limit of load range which is searched for eigenvalue
RATIØ		(Effective only when LØAD = 2.) RATIØ occurs in SUBRØUTINE LØADS, in the equation $r_1 V_1 = (pr_1^2/2) * $ RATIØ, where V_1 is the line load (lbs/in) applied at the 1st meridional station, $(r = r_1)$, and p is the uniform pressure
R1V1O		Used for an applied constant circumferential line load and is equal to the total line load at A divided by 2π. The load is positive when it causes axial tension in the shell. (Since this load is in addition to the regular load, it is rarely required and, as such, is usually zero)
PO		Used for an applied constant pressure load;... positive for internal pressure. (This load too is in addition to the regular load, and thus it is nearly always zero.)
ERR		Tolerance limits on the prebuckling solution and the eigenvalue (buckling load) expressed in terms of variation between iterations; i.e., ERR = .01 represents a minimum variation between the final solution and the solution of the preceding iteration of within 1%

Table 5

SHELL WALL DATA

NWALL =	VARIABLE	DESCRIPTION
1	C11, C12, etc.	Stiffness coefficients of orthotropic shell wall, See Eq.1
	ANRS	= 0-Rings and stringers not to be added = 1-Rings and stringers to be added
	TD	Total thickness of shell wall
	Z	Distance from inner surface to shear center of shell wall
2	E	Young's modulus of skin
	U	Poisson's ratio of skin
	T	Thickness of skin
	ØI	= 0 if stiffeners are rectangular = 1 if stiffeners are not rectangular
	D1	Stringer spacing
	D2	Ring spacing
	AK1	= 0 if stringers are inside = 1 if stringers are outside
	AK2	= 0 if rings are inside = 1 if rings are outside
	T1	Thickness of rectangular stringer
	T2	Thickness of rectangular ring
	H1	Height of rectangular stringer
	H2	Height of rectangular ring
	A1	Cross-section area of stringer
	SI1	Moment of inertia of stringer with respect to its neutral axis

Table 5 (Cont'd)

NWALL =	VARIABLE	DESCRIPTION
2	S1	Torsional constant for stringer
	EX1	Distance from neutral surface of stringer to skin midsurface
	A2	Cross-section area of ring
	SI2	Moment of inertia of ring with respect to its neutral axis
	S2	Torsional constant for ring
	EX2	Distance from neutral surface of ring skin midsurface
3	E	Young's modulus
	U	Poisson's ratio
	T	Skin thickness
	TH	Angle between stiffeners and shell meridian
	A	Stiffener spacing (along circumference)
	B	Stiffener thickness
	H	Stiffener height
	AK	= 0 for inside stiffening = 1 for outside stiffening
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

Table 5 (Cont'd)

NWALL =	VARIABLE	DESCRIPTION
4	ANRS	= 0 rings and stringers not to be added = 1 rings and stringers to be added
	T(I)	Thickness of layer
	X(I)	Matrix content (by volume)
	BE(I)	Winding angle
	C(I)	Contiguity factor (See Section 1 of Vol. 2)
5	WRAPS	Number of layers
	ANRS	= 0 rings and stringers not to be added = 1 rings and stringers to be added
	ANIO	= 0 for isotropic layers = 1 for orthotropic layers
	T(I)	Thickness of layer
	E(I)	Young's modulus
	U(I)	Poisson's ratio
	G(I)	Shear modulus
	EX(I)	Modulus in meridional direction
	EY(I)	Modulus in circumferential direction
	UXY(I)	Poisson's ratio
6	E	Young's modulus
	U	Poisson's ratio
	ANRS	= 0 rings and stringers not to be added = 1 rings and stringers to be added
	CC, CH, CD, CT, CB	Dimensions of corrugated sheet c, h, d, t, b, respectively in Fig. 3, Vol. 2

Table 5 (Cont'd)

NWALL =	VARIABLE	DESCRIPTION
7	E	Young's modulus of corrugated skin
	U	Poisson's ratio of corrugated skin
	ANRS	= 0 rings and stringers not to be added = 1 rings and stringers to be added
	CC, CH, CD, CT, CB	Dimensions of corrugated skin c, h, d, t, b, respectively in Fig. 3, Vol. 2
	PHI	Reduction factor for torsional stiffness See Section 1 of Vol. 2
	ES	Young's modulus of smooth skin
	US	Poisson's ratio of smooth skin
	TS	Thickness of smooth skin
	ANC	= 0 for inside corrugation = 1 for outside corrugation
1,4,5,6,7 and ANRS = 1	E1, E2	Young's modulus of stringer and ring
	U1, U2	Poisson's ratio of stringer and ring
	XS, XR	Distance from neutral surface of stringer and ring to closest shell surface
	D1, D2	Spacing of stringers and rings
	A1, A2	Cross-section area of stringers and rings
	XI1, XI2	Moment of inertia of stringers and rings with respect to their neutral axes
	XJ1, XJ2	Torsional constants for stringers and rings
	AK1	= 0 stringers inside = 1 stringers outside
	AK2	= 0 rings inside = 1 rings outside

Table 6

SHELL GEOMETRY DATA

NCST	VARIABLE	DESCRIPTION
1 Cone or Cylinder	R1	Shell radius at small end of cone (to inner surface of shell wall)
	SL	Slant length (shell length for cylinder)
	ALPH	Half-angle of cone (zero for cylinder)
2 Spherical Segment	RØT	Radius of sphere (to inner surface of shell wall)
	ALPH1	Angle between shell axis and normal to meridian at A, Fig. 1a (in degrees)
	ALPH2	Angle between shell axis and normal to meridian at B, Fig. 1a (in degrees)
3 Toroidal Segment	RØT	Meridional radius of curvature (positive number) (see Fig. 1a)
	ALPH1	Angle between equator and normal to meridian at point A. (radians, positive number)
	ALPH2	Angle between equator and normal to meridian at point B. (radians, positive number)
	ALPHAT	Distance from axis of rotation to center of curvature of meridian (can be a negative number)
		Note: the points A and B must lie on the same side of the crown of the torus. (see Fig. 1a)
4 General Shell	NRZIN	Number of (ZI(I), RI(I)) pairs to be read. NRZIN must be less than 100
	RI(I)	Distances from axis of revolution to point on shell meridian
	ZI(I)	Axial coordinate measured from point A. (see Fig. 1)

Table 7

BOUNDARY CONDITION DATA

NTYPEA	VARIABLE	DESCRIPTION
1	KA1	= 0 shell is free in radial direction (H = 0) = 1 shell is restrained against radial displacement ($u_H = 0$)
	KA2	= 0 shell edge is free to rotate ($M_1 = 0$) = 1 shell edge is restrained against rotation ($w_x = 0$)
	KA3	= 0 shell edge is free in tangential direction ($N_{12} = 0$) = 1 shell edge is restrained against tangential displacements (v = 0)
	KA4	= 0 shell edge is free in axial direction ($N_1 = 0$) = 1 shell edge is restrained against axial displacements ($u_v = 0$)
	KA5	= 1 axial load is applied through neutral surface of shell wall = 2 axial load is applied through shear center of shell wall = 3 neither of above applies
	EXA	Distance from line of load application to inner surface of shell (positive if load applied outside)
2	LA1	= 0 H = 0 = 1 elastic restraint in radial direction
	LA2	= 0 $M_1 = 0$ = 1 elastically restrained rotation
	LA3	= 0 $N_{12} = 0$ = 1 elastic restraint in tangential direction

Table 7 (Cont'd)

NTYPEA	VARIABLE	DESCRIPTION
2	LA4	= 0 N_1 = 0 = 1 elastic restraint in axial direction
	AL11, AL12, etc.	Stiffness coefficients for substructure. See discussion below
	AL11P, etc.	Corresponding coefficients in prebuckling analysis
3	IA1, IA2 IA3, IA4 IA5, EXA	Same meaning as the KA1 - KA5 and EXA under NTYPEA = 1 above
	RSA	Radius of parallel circle measured to shear center of ring at A (see Fig. 1)
	EA	Young's modulus of ring
	AREAA	Cross-section area of ring
	FIXA	Moment of inertia about axis in plane of ring (about centroid)
	FIYA	Moment of inertia about axis normal to plane of ring (about centroid)
	FIXYA	Product of inertia of ring
	GJA	Torsion constant of ring
	GAMMAA	Warping function
	ECCA	Distance from inner surface of shell to centroid of ring (positive outward)
	FIPA	Polar moment of inertia
	PSIA	Radial force per unit length of circumference applied to ring (positive outward)
	T1A	Twisting moment per unit length of circumference applied to ring (positive counterclockwise)
4	A	Any text punched on a card will be printed. This can be used for identification of boundary conditions. If NTYPEA = 4 and no message is desired a blank card must be included

Table 7 (Cont'd)

NTYPEA	VARIABLE	DESCRIPTION
4	BA11, BA12 etc.	Coefficient in boundary conditions. See Eqs. (3) and (4)
	PSIA, T1A	Same meaning as under NTYPEA = 3 above
NTYPEB = 1,2,3,4	All Variables	Same meaning as for NTYPEA = 1, 2, 3, 4, except that T1B, the applied moment at B is clockwise positive

Flow of Calculations

Figure 3 shows the flow of calculations in the computer program. Once the geometry, stiffness coefficients, and boundary condition coefficients are available, the load-independent variable coefficients of the differential equations governing stability are calculated at each of the meridional stations in the finite-difference mesh. These coefficients are stored in two arrays C(I,J) and CN0NL(I,L). They are used in the calculation of the nonlinear algebraic equations which are obtained by introduction of the 5-point finite-difference expressions into the differential equations. These coefficients are calculated in SUBROUTINE BEQUAS.

From Fig. 2, it can be seen that all of the calculations described so far are performed in the first link of the overlays. The quantities required by the program for computation of the buckling load are all stored in cells or arrays which occur in COMMON in the main program MAINP. Hence, the first link is no longer needed for the current value of N, the wave number.

The buckling load is calculated in Links 2 and 3 of the overlay. If linear theory is used, only Link 3 (MAIN2) is needed. If nonlinear theory is used both Links 2 and 3 are needed. In a typical case the flow of calculations might be as follows: INDIC is initialized as 0, so that linear theory is used to calculate the buckling load for N = NO. N is increased by INCR, and a new buckling load is calculated from linear theory. If the second load is smaller than the first, N is again increased by INCR and another buckling load obtained. Calculations proceed until a minimum buckling load RH0(N) has been found. If the second load is greater than the first, the sign of INCR is reversed, and a buckling load is obtained for N = NO - |INCR| Calculations proceed until a minimum buckling load has been found. All of the subroutines except BBB are required in the calculation of the buckling loads from linear theory: In RINGN the boundary coefficients BA_{ij} and BB_{ij} are calculated anew for each value of N; in CBC0R the coefficients C(I,J) and CN0NL(I,L) calculated in BEQUAS are collected to form the final coefficients C(I,J) of the stability equations; in AB1 and EXCH the banded stability matrix A corresponding to the finite-difference equations is calculated; in BPWR a banded matrix B corresponding to the terms multiplied by the eigenvalue (load) is calculated; in EIGEN and VECT the eigenvalue is calculated from the power-iteration method (Ref. 12, Vol. 2); in M0DE the buckling mode shape is calculated; and in 0UT3 the buckling load, wave number, and mode shape can be printed out.

Once the minimum RH0(N) has been calculated from linear theory, INDIC is set equal to 1 and the minimum RH0(N) is calculated from nonlinear theory. In these calculations NO is initialized to the value of N for the minimum buckling load calculated from linear theory; RH00 is initialized to zero; STEPO is initialized to $RH0_{min}/5$ and RH0M is set equal to $2*RH0_{min}$. Prebuckling stresses and displacements are calculated for the first step in the load. This calculation is made in the second link of the overlays. Values of the dependent variables obtained from linear bending theory are used as starting values for the Newton-Raphson process. When the converged solution of the prebuckling problem has been obtained, the third link is called into core, and the stability determinant is calculated for the current value of RH0.

With increasing values of the load, calculations alternate between the second and third links until the point is determined at which the stability determinant first vanishes within a preassigned accuracy. For each new value of the load, the prebuckling solution found for the last value of the load is used as a starting value. A minimum RHØ(N) is again computed.

In the second link two branches are provided for the calculation of the prebuckling stresses and displacements: one for the case of cylindrical shells (SUBROUTINE CYL), and one for other shells of revolution (SUBROUTINE PRE). The subroutine CRØSIM, which is called from CYL, obtains the solution for the boundary condition coefficients B_i which occur in the prebuckling solution for u_{Ho} in the cylinder branch. Subroutines called from SUBROUTINE PRE are: RINGP, which calculates the BA_{ij} and BB_{ij} for the prebuckled shell with edge rings; EQUAS, which calculates the load-independent coefficients of the non-linear prebuckling differential equations; LØADS, which calculates the statically determinate vertical force/2π = rV; CPB2, which calculates the final load-dependent coefficients of the prebuckling equations; AA2 and AA3 which calculate the banded coefficient matrices needed for each iteration of the Newton-Raphson process; VECT2, which calculates the right-hand-side of the linear system for each iteration of the Newton-Raphson process; PREB, which calculates prebuckling changes in curvature and stress resultants from the dependent variables β and ψ; FINDUV, which calculates the vertical displacement distribution; AA, which calculates the stability matrix for the case N = 0; EIGEN1, which calculates correction factors for the buckling load when N = 0 ; and ØUT2, which causes the prebuckling solution to be printed out for the current value of the load RHØ.

In the third link the stability determinant is calculated in BUCK. The subroutines shown in Fig. 2 in the third link are all called from BUCK except for BPWR. Subroutine BBB calculates a banded matrix B which contains rates of change of the prebuckling quantities with load.

Section 3

INPUT QUANTITIES WHICH REQUIRE JUDGMENT

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

1. ERR Maximum allowable error in prebuckling solution and in buckling load. For example, if ERR = 0.001 the buckling load is calculated to three significant figures, the prebuckling solution is judged to have converged when consecutive iterations yield the same result to three significant figures. ERR should be somewhere between 0.01 and 0.0001. For most applications ERR = 0.01 yields results which are accurate enough for practical purposes. A demand for more accuracy naturally increases the computer time required per case.

2. RHØO Initial value for the buckling parameter must be chosen such that its absolute value is below the lowest eigenvalue. If one wishes to proceed to calculate the second eigenvalue, however, RHØO must, of course, be larger in absolute value than the first (already known) eigenvalue. The sign of RHØO must be correct. For example, axial <u>compression</u>, or <u>external</u> pressure correspond to negative values.

3. STEPO Initial value for load increment. The choice of STEPO and RHØO above is important for economy in the operations. The sign of STEPO is significant, negative values corresponding to axial <u>compression</u> or <u>external</u> pressure.

4. RHØM Maximum allowable <u>absolute</u> value of the buckling load. <u>Absolute</u> value of an upper limit for the eigenvalue. The search for a zero crossing is terminated at this value. Remember that RHØM should be at least one step beyond the maximum expectation for the eigenvalue corresponding to the initial wave number. If linear theory is used, no value need be assigned,as one is calculated internally from the results of linear theory. Use <u>positive</u> values only.

5. N1 Number of meridional intervals in the finite difference mesh. (The number of meridional stations equals N1 + 1.) This is an important parameter, as the accuracy of the results depends on it. It is difficult to make a general statement about what N1 should be, as it depends not only on shell geometry but also on loading. A good way to determine the accuracy of the results is to run the same case with two or more different values of N1, say 30 and 70. The results should approach a definite limit as N1 increases. If stresses and displacements vary rapidly over a small area of the shell surface, a larger value of N1 will be needed. N1 <u>must</u> always be less than 100. Numerical difficulties may be encountered as N1 is increased. This is discussed and examples are presented in Vol. 1.

6. ITER The maximum number of iterations in the nonlinear prebuckling solution. The Newton-Raphson scheme usually converges very fast, and consequently ITER should not be large. Try between 5 and 10 for input values.

7. NO Initial guess for the number of circumferential waves in the buckling pattern. Any loads calculated with N = 1 should be regarded with suspicion, since the stability equations generally do not apply. It should be pointed out that when N = 0 the axisymmetric collapse load is calculated. Since the buckling load RHØ is a function of N, the number of circumferential waves in the buckling pattern, it is necessary to find the N for which RHØ(N) is

a minimum. Much computer time can be saved by a good choice of NO. Experimental evidence is very useful in this regard. If none is available, 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 & 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 shown in Fig. 1a.

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 the appropriate values for NO, the initial guess at N.

8. INCRO Initital value for the increment by which N is increased in the search for the minimum RHØ(N); should be positive. For example, if one is certain that the N corresponding to the minimum buckling load lies in the range $2 \leq N \leq 5$, one would choose INCRO = 1. However, if one knows that N lies in the range $50 \leq N \leq 100$, one might choose INCRO = 10 and zero in on a more accurate value in an additional run.

9. **NMAX** Upper limit of the wavenumber range to be searched for a minimum load. Naturally it should be made larger than the value of N, which one suspects corresponds to the minimum RHØ(N).

10. **NMIN** Lower limit of the wavenumber range. Make it smaller than suspected N for minimum RHØ(N). With regard to both NMAX and NMIN, it is often useful to find the RHØ(N) which is minimum as predicted by the linear theory only (NLIN = 1). If for some reason, one is interested in calculating RHØ for a single given value of N. NMAX and NMIN should both be set equal to NO.

11. BA11, BA12...BA48
BB11, BB12...BB48

Boundary condition coefficients either read in or calculated internally. Some judgment may be required in order to model a given engineering problem in an appropriate manner.

Shell Wall Parameters

Equations for the stiffness coefficients can be derived as shown in Section 1 of Vol. 2 for any type of shell wall. By use of desk computer or slide rule these coefficients can be determined and read in through subroutine CFB1. It is also possible to program the computations in a separate subroutine, which is substituted for the dummy routine CFB8.

The subroutine CFB2 for ring and stringer stiffened cylinders is based on the assumption that the stiffeners and skin are of the same material. For cases in which this is not the case, and also for monocoque shells it is possible to use the routine for layered shells. The subroutine CFB5 is used for a shell with only one layer. With ANRS set equal to unity, stiffeners will be included.

Boundary Conditions

For the case in which the shell is supported by an elastic substructure, rigid support as well as complete freedom may be provided in any of the directions of loads and displacements shown in Fig. 1. These are referred to here as the principal directions. If for instance the edge is completely free from rotational restraint the integer LA2 should be zero. Elastic restraint is obtained if LA2 is set equal to unity and the substructure stiffness (AL22) is assigned its proper value. If the restraint against rotation is complete LA2 = 1 and AL22 = 0. The stiffness coefficients are defined in Table 8

Table 8 STIFFNESS OF SUBSTRUCTURE

A Unit Value of ↓	Causes the following displacements			
	u_H	$r\beta$	v	u_V
rH	AL11			
M_1	AL12	AL22		
rN_{12}	AL13	AL23	AL33	
rV	AL14	AL24	AL34	AL44

All of those coefficients need to be determined only if there is elastic support in all of the principal directions. Table 9 shows which of the coefficients need to be determined for the different possible combinations of the governing integers.

Table 9 STIFFNESS COEFFICIENTS REQUIRED IN THE ANALYSIS OF ELASTICALLY SUPPORTED SHELLS

LA1	LA2	LA3	LA4	AL11	AL12	AL13	AL14	AL22	AL23	AL24	AL33	AL34	AL44
1	1	1	1	x	x	x	x	x	x	x	x	x	x
0	1	1	1	0	0	0	0	x	x	x	x	x	x
1	0	1	1	x	0	x	x	0	0	0	x	x	x
1	1	0	1	x	x	0	x	x	0	x	0	0	x
1	1	1	0	x	x	x	0	x	x	0	x	0	0
0	0	1	1	0	0	0	0	0	0	0	x	x	x
0	1	0	1	0	0	0	0	x	0	x	0	0	x
0	1	1	0	0	0	0	0	x	x	0	x	0	0
1	0	0	1	x	0	0	x	0	0	0	0	0	x
1	0	1	0	x	0	x	0	0	0	0	x	0	0
1	1	0	0	x	x	0	0	x	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	0	0	x
0	0	1	0	0	0	0	0	0	0	0	x	0	0
0	1	0	0	0	0	0	0	x	0	0	0	0	0
1	0	0	0	x	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0

x indicates that the coefficient must be computed

In general the stiffness coefficients for the substructure are dependent on a number of waves in the displacement pattern. Therefore, the stiffness coefficients in the prebuckling analysis are read separately. They are defined as follows

AL11P is radial displacement of substructure due to a unit value of $r H$

AL12P is radial displacement of substructure due to a unit value of M_1

AL22P is value of $r \beta$ due to a unit value of M_1

For LA1 = 1 , LA2 = 1 compute AL11P , AL12P , AL22P

LA1 = 1 LA2 = 0 compute AL11P

LA1 = 0 LA2 = 1 compute AL22P

LA1 = 0 LA2 = 0 compute none

The branch in which all of the coefficients of the boundary conditions are directly read from data cards is added to provide complete generality. It would for instance be used when the boundary conditions require that displacements or loads in other than the principal directions be zero.

Internally in the program all quantities are nondimensionalized such that the shell wall stiffness coefficient C11 and the distance between two neighboring points in the finite difference mesh equal unity. This cannot be done for the coefficients of the boundary conditions in this branch of the program. If either displacements or loads in some specified direction equal zero there would be no problem but if elastic boundary conditions are used in this branch of the program, (NTYPEA or NTYPEB = 4) it is necessary that the shell be appropriately scaled before computations such that the above mentioned quantities equal unity.

Limitations of the Program

1. The loading on the shell must be axisymmetric. The pressure applied must be constant along the meridian. Shell wall properties along the meridian must be constant.

2. In studies involving imperfections, the imperfection must be axisymmetric.

3. Since the stability analysis is based on "Donnell-type" equations, the buckling loads calculated for low values of N, the circumferential wave number, may not be accurate if the shell is not geometrically shallow. For example, the buckling loads predicted for an externally pressurized cylindrical shell are about 33% too high when N = 2 and about 15% too high when N = 3.

4. Any results obtained for buckling modes in which N = 1 are not to be trusted. Such a buckling mode often has a large rigid-body component. Rigid-body motions are not adequately accounted for in a "Donnell-type" analysis.

5. The buckling analysis does not strictly hold for shells whose meridians are not smooth. A shell with a ridge can be analyzed, however, by "smoothing" the meridian in the neighborhood of the ridge. Composite shells cannot be analyzed directly with the program in its present form. An analysis of a composite shell structure requires that the components are analyzed separately with due consideration to elastic support provided by the other components.

6. The analysis is valid only for elastic shells of revolution. Plasticity can presently be accounted for only by use of an "effective" modulus of elasticity.

7. The program in its present form calculates only the general instability mode of failure. Thus, if a stiffened shell is being analyzed, it may be necessary to check for local buckling in a separate analysis.

8. If the shell is bounded by rings, the shear center and centroid of the rings must coincide.

9. The maximum number of meridional points is 100 (N1 = 99) . This may not be adequate for shells in which the prebuckling stresses and displacements vary rapidly in the neighborhood of the boundaries. On the other hand, if the buckling mode shape involves much of the shell surface, the calculated buckling load may represent a good approximation even though the prebuckling stresses and displacements in the neighborhood of the boundaries are not accurate.

Possible Pitfalls

Great effort has been made to make use of the BØSØR computer program as easy as possible. However, the subject is rather complicated and there are a few possible pitfalls the user should be aware of. If results are returned from the computer program which indicate that something may be wrong the input data should, of course, first be carefully checked. This is facilitated by the identifying output printed with each case. It may be a good idea also to rerun the case with utilization of the optional output (prebuckling deformations and buckling mode). From these data it is for instance easy to see whether appropriate boundary conditions are satisfied.

It is possible that the critical load has more than one minimum with respect to the wavenumber, but the program seeks only a single minimum value of the buckling load RHØ as a function of N. For example, axially compressed, eccentrically loaded toroidal segments exhibit this behavior. There are at least two minima each corresponding to a different kind of buckling: buckling due to critical axial stresses, and buckling due to critical hoop stresses. If it is suspected that this behavior is possible in some case, then the two corresponding ranges of N should both be explored.

A check should generally be made of the convergence of the buckling load with the number N1 of meridional intervals. An increase of the number of meridional intervals may not necessarily result in increased accuracy of the calculated buckling load, as numerical difficulties may be encountered. This is particularly true of ring-supported shells which buckle into two circumferential waves. See Vol. 1 of this report for further details in this regard.

The numerical difficulties may cause convergence failure in the eigenvalue procedure. Similar difficulties will be encountered also if the first two eigenvalues are close together. In the latter case it is of course possible that two eigenvalues are bypassed in one step in which case the determinant never changes sign. It is therefore worthwhile in most cases to study the values of the determinant which always are printed versus the applied load. If there is an indication that two zero-points have been bypassed the case must be rerun with a smaller value of STEPO. If numerical difficulties are encountered this would result in erratic variations in the determinant. If the determinant varies smoothly but convergence difficulties still are encountered it is possible that there is another eigenvalue close to the lowest. For the analysis of such cases it is possible to make the program ignore sign-changes in the determinant and thus terminate with the value of the determinant at RHØ = RHØM.

Section 4

OUTPUT FROM BØSØR

Sample data cards and corresponding output are given for five cases in Appendix A. Notice that some blank lines occur in the input data. Blank lines correspond to blank data cards. These cards correspond to zeroes read in, and must be included.

CASE #1

The first case involves the calculation of the buckling load of an axially compressed (LØAD = 3), longitudinally stiffened (NWALL = 2) cylindrical shell (NCST = 1), supported at the edges by rings of square cross-section (NTYPEA = 5, NTYPEB = 3). The stiffeners are rectangular in cross section. The buckling load is calculated from both the linear and the nonlinear theories. (INDIC = 0, NLIN = 0, NDET = 0).

On the first page of output the shell material properties, geometry, and type of loading are given. Data also appears for the stiffener geometry and spacing. The number of intervals N1 in the finite difference mesh is 21. The constant "surcharge" loads R1V10 and P0 are zero, and RATIØ is zero since the shell is submitted to pure axial compression and not some combination of external pressure and axial compression. The boundary conditions are also called out on the first page of output. In the first case symmetry of prebuckling and buckling behavior is specified at A (NTYPEA = 5) (see Fig. 1). At B the shell is supported by an elastic ring of square cross-section

(NTYPEB = 3). The ring properties printed out are identified in Table 7 .

On the remaining pages of Case #1 buckling loads are given from linear and nonlinear theories for various values of N, the wave number. Minimum values of RHØ(N) are obtained in both instances. Since NTYPEP and NTYPEM are both set equal to zero, the output for Case #1 is the minimum. With NTYPEP = 1 the prebuckling displacement and stress distributions are printed out for each load increment in the nonlinear theory. With NTYPEM = 1 the buckling modal displacement and stress distributions are given for each value of N. Case #5 shows output with both NTYPEP and NTYPEM = 1.

In Case #1 the minimum RHØ(N) is calculated first from the linear theory. The minimum corresponds to N = 20. The "buckling parameter" in this case is the axial load (negative for compression) in lbs/in. When the minimum RHØ(N) has been calculated from linear theory, an initial load, load increment, and maximum load are selected internally, and calculations proceed with N = 20 and the nonlinear theory. The stability determinant and corresponding value of RHØ are printed out, along with the number of iterations required for convergence of the prebuckling solution. In this case prebuckling stresses and displacements are calculated in the cylinder branch, and hence an iterative technique is not required. Therefore, the number of iterations is zero. When the determinant first changes sign, calculations proceed as explained in Vol. 2.
The correction factor is the quantity z in Eq. 78 of Vol. 2.
Buckling loads are calculated from the nonlinear theory until a new minimum RHØ(N) is obtained. In Case #1 this minimum occurs when N = 17.

CASES #2a, b

The second sample case given in Appendix A is for an axially compressed, meridionally stiffened spherical segment (NCST = 2). The stiffeners are rectangular in cross-section. The polar angle of 90° at point A of Fig. 1 corresponds to the shell equator and symmetry conditions are imposed there. At the other end B of the segment, the shell is simply-supported, with the axial load applied 1.0065 inches outside of the skin inner surface, which corresponds to the neutral surface for the stringers (NTYPEB = 1). In this case the stability determinant is calculated for N = 0 only and from the nonlinear theory only (INDIC = 1).

Note that at loads of -8300 lbs/in and -8400 lbs/in, more iterations are required for convergence, but that for higher loads fewer iterations are required. There are two branches in the prebuckling solution such as shown in Fig. 7 of Vol. 1. A printout of the prebuckling displacement distributions (NTYPEP = 1) would reveal the existence of these branches. Case 2b is for the same shell with a smaller initial load increment. The shell collapses axisymmetrically at a load of -8440.8 lbs/ in. Note that at RH0 = -8440 lbs/in the load increment is decreased by a factor of 100.

CASE #3

The third case is for a longitudinally stiffened 10° conical frustrum (NCST = 1) submitted to axial compression through the shear center and simply-supported at A and B (NTYPEA = NTYPEB = 1). Only the linear theory is used (NLIN = 1). The buckling loads are calculated in this case for

NO ≤ N ≤ NMAX. Calculations terminate when N > NMAX, or in this case when N = 23. A minimum is not sought and NO = NMIN.

CASE #4

The fourth case is for an axially compressed, fiber-reinforced (NWALL = 4) cylindrical shell with symmetry at A and clamped conditions at B (NTYPEA = 5, NTYPEB = 1). In this case nonlinear theory only is used (INDIC = 1), and the stability determinant is calculated as a function of the load without regard to changes in sign (NDET = 1). Calculations terminate when RHØ is greater than the maximum allowable value RHØM. By plotting of the determinant versus RHØ for the different values of N it is found that the critical load 713 lbs/in occurs for N = 11.

CASE #5

The fifth case is for an axially compressed, eccentrically stiffened, conical frustrum. The analysis is for the wave number N equal 25 only, and the maximum printout is called for (NTYPEP = 1, NTYPEM = 1). The shell is loaded through the centroids of the stiffeners and is simply-supported at A and B. Only the nonlinear theory is used (INDIC = 1).

With NTYPEP = 1 the prebuckling displacement and stress distributions are printed for each value of the load. Such data can be used if one wants to check whether appropriate boundary conditions have been prescribed or whether the shell wall material is stressed beyond the yield limit.

With NTYPEM = 1 the main diagonal of the factored stability matrix

A(I, J) is printed for each value of the applied load. The terms on the main diagonal should all be about the same size, and there should be no zeroes. Zeroes on the main diagonal indicate that the boundary conditions have been specified in the wrong order. In the case with NTYPEA or NTYPEB = 4 if elements on the main diagonal differ greatly in magnitude, numerical difficulties may prevent accurate determination of the stability determinant.

The prebuckling stress and displacement distributions and the main diagonal of the factored stability matrix are printed out for each load increment. When the determinant first changes sign, linear interpolation is used once to yield a reasonably good approximation for the eigenvalue. This process is explained in Vol. 2. The power iteration method is then used to yield a correction factor for the eigenvalue. The number of iterations in the power method and the eigenvector are then printed out, followed by the correction factor. If the correction factor is smaller than RHØ * ERR , the final buckling load and wave number are printed out. If the correction factor is larger than RHØ * ERR , a new correction factor is calculated.

When the buckling load for a particular value of N has been obtained within the accuracy specified by ERR, the modal stresses and displacements are printed out.

REFERENCES

1. Bushnell, D., "Nonlinear Analysis of Shells of Revolution," LMSC 6-67-66-6, April 1966

2. Bushnell, D., "Symmetric and Nonsymmetric Buckling of Finitely Deformed Eccentrically Stiffened Shells of Revolution," LMSC 6-67-66-15, August 1966

3. Reissner, E., "On Axisymmetrical Deformations of Thin Shells of Revolution," _Proc_. _Symp_ _in_ _Applied_ _Mathematics_, Vol. III, McGraw-Hill, New York 1949

4. Cheney, J. A., "Bending and Buckling of Thin-Walled Open-Section Rings," ASCE J. Eng. Mech. Div. Vol. 89, Part 1, October 1963, 17-44

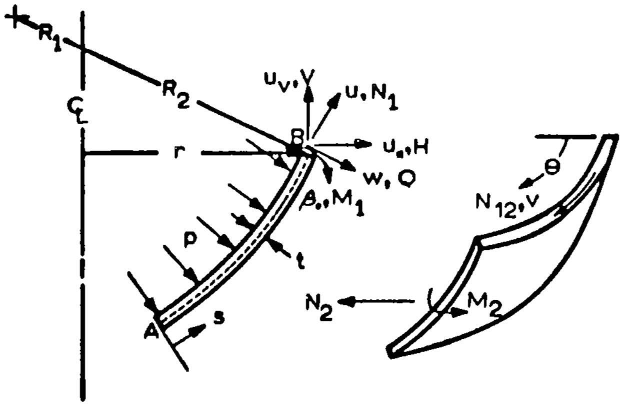
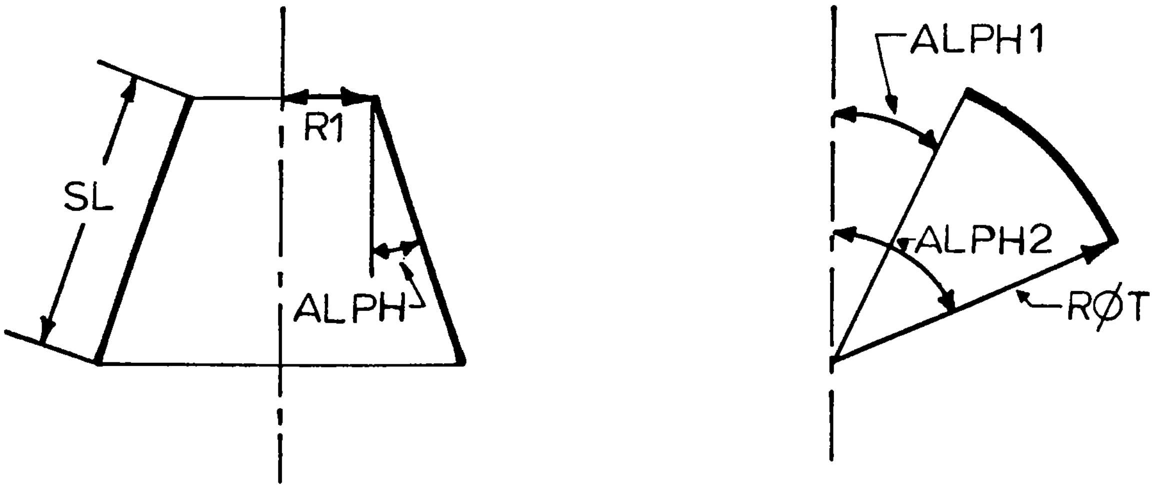
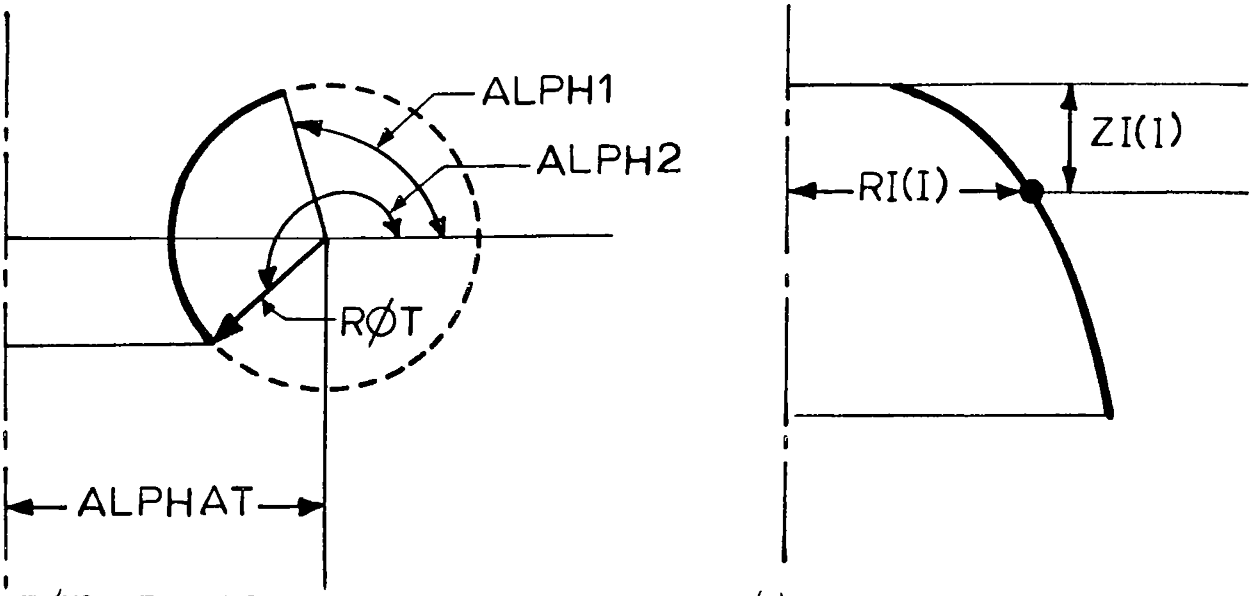


FIG. 1 - COORDINATES, GEOMETRY, LOADS, DISPLACEMENTS & STRESSES



GE0M1: Cylinder or Cone

GE0M2: Spherical Segment



GE0M3: Toroidal Segment

GE0M4: General Shell

Fig. 1a Shell Geometry Input Parameters

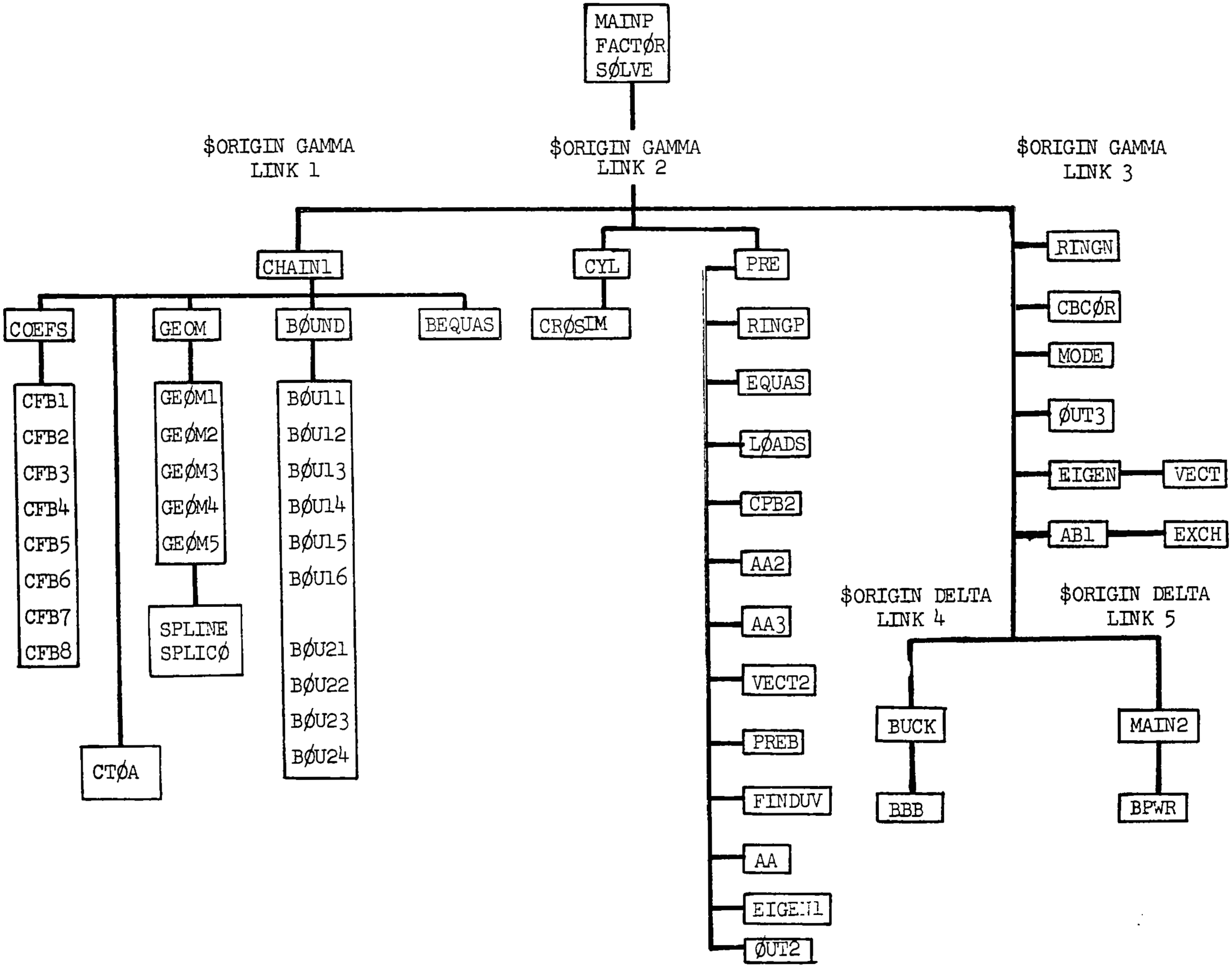


Fig. 2 Arrangement of Subroutines in Overlays

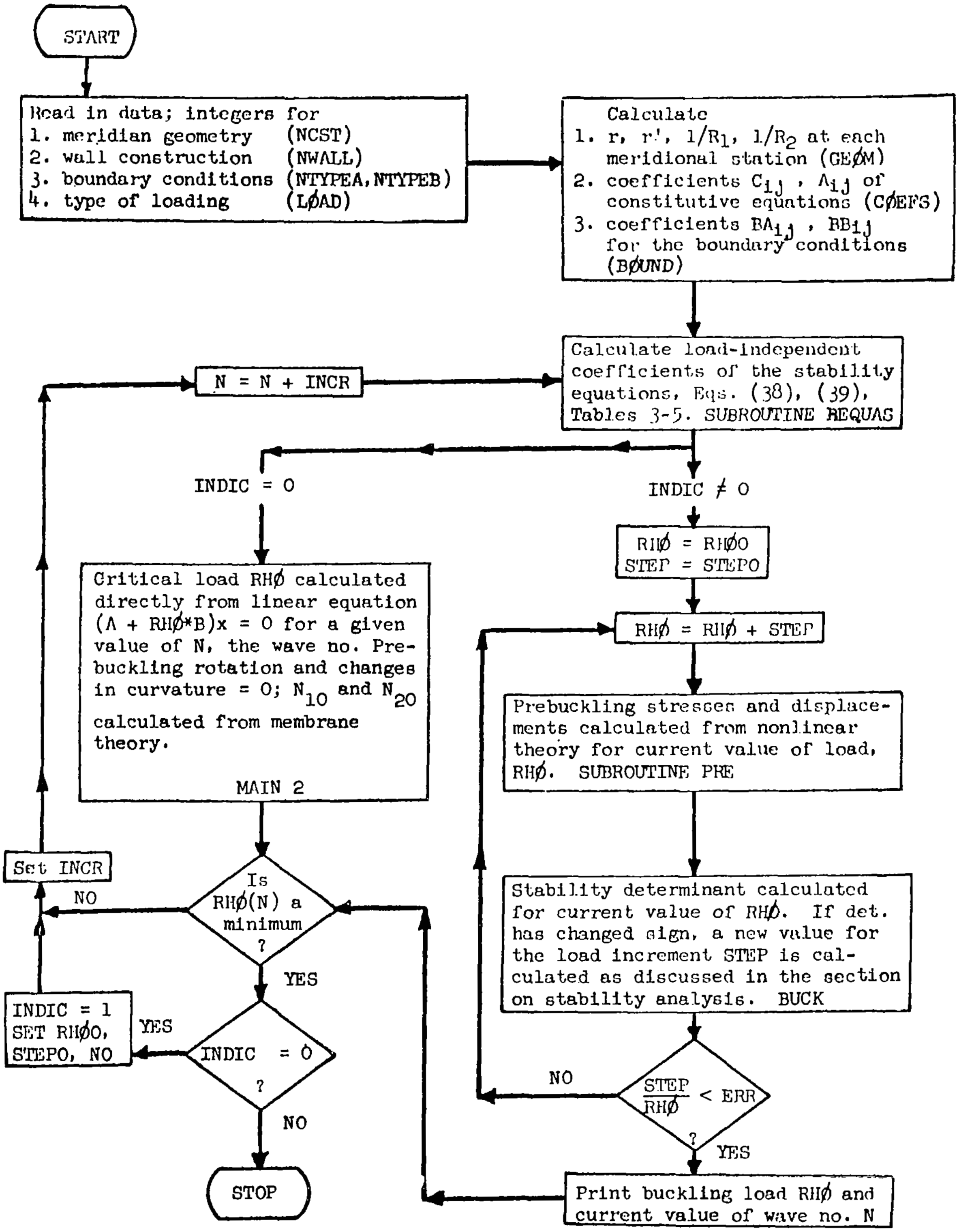


Fig. 3 Flow Chart of the Computer Program

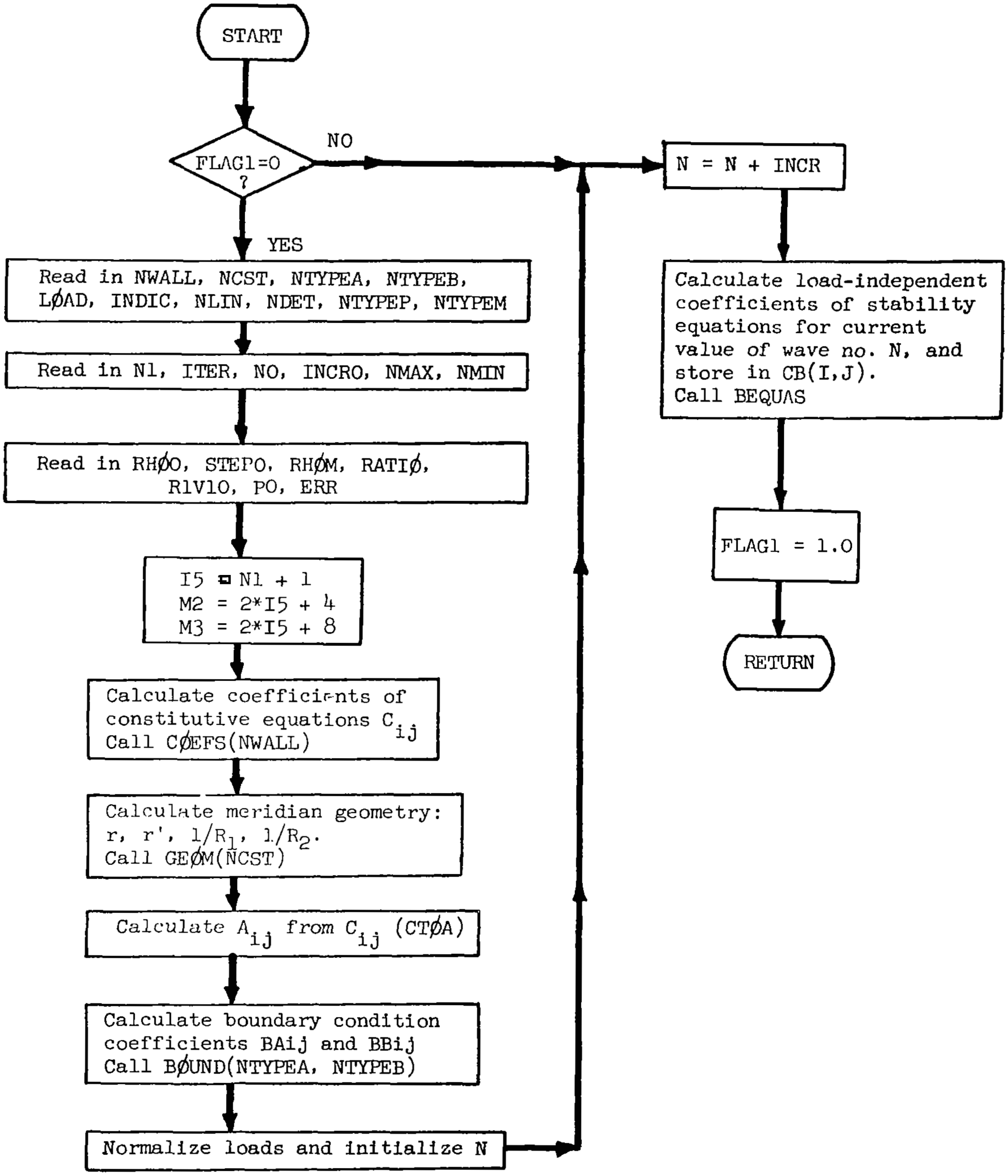


Fig. 4 Flow Chart of CHAIN1
Called from MAINP

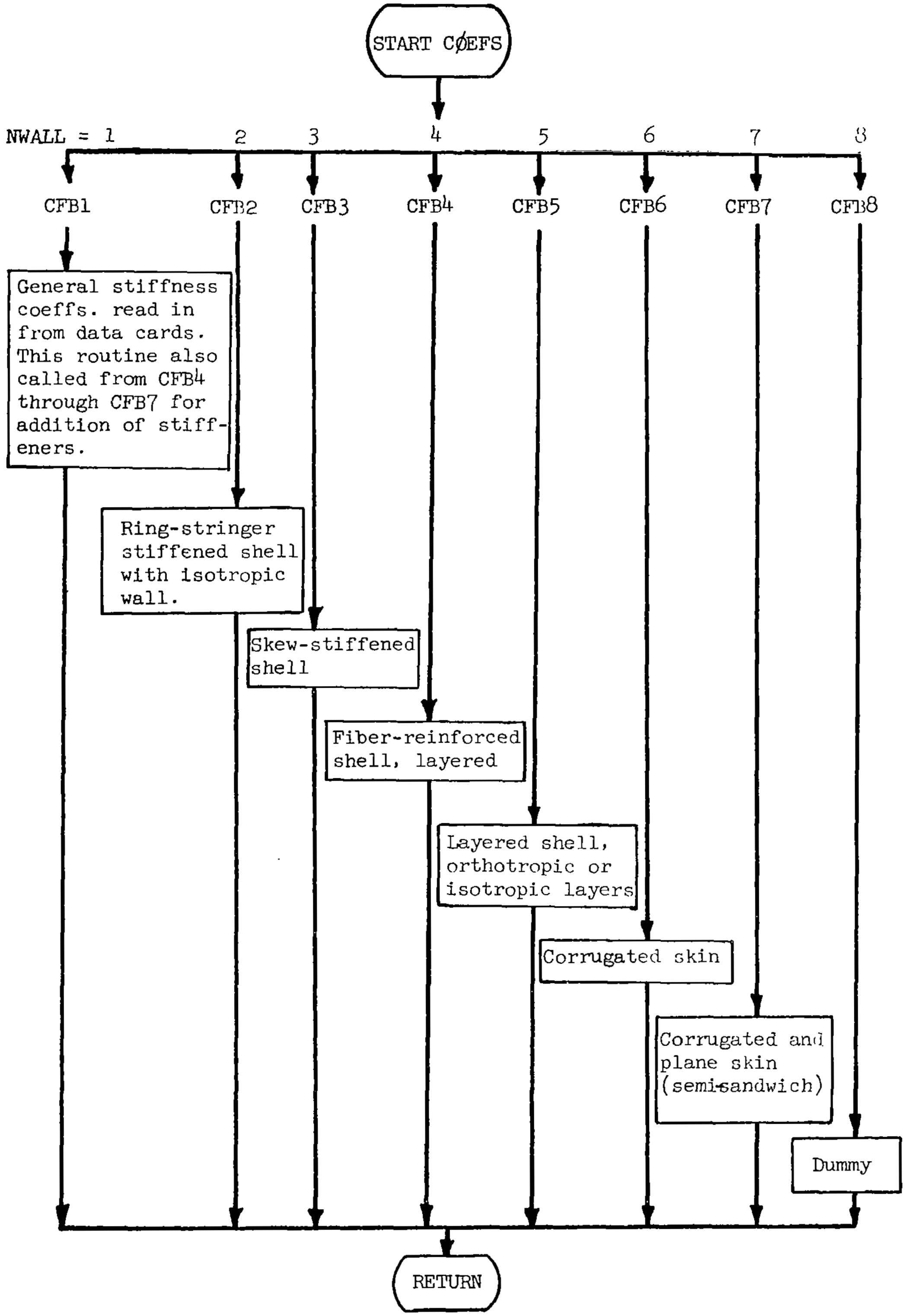


Fig. 5 Flow Chart of CØEFS with CFB1 through CFB8 Called from CHAIN1

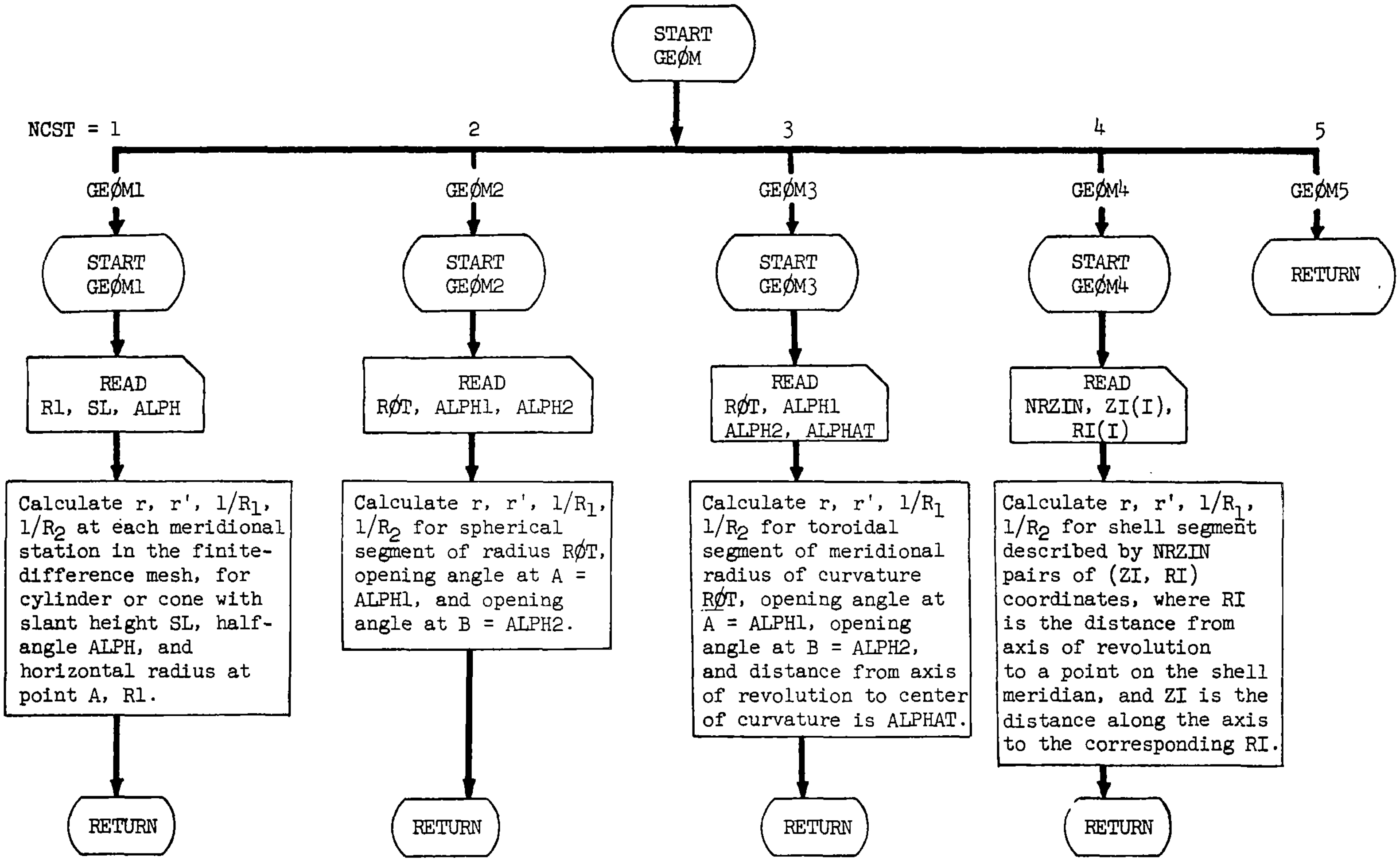


Fig. 6 Flow Chart of GEØM, GEØM1, etc.
Called from CHAIN1

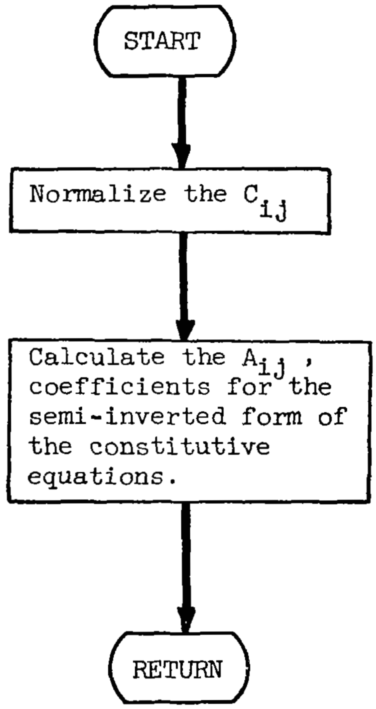


Fig. 7 Flow Chart of CT0A
Called from CHAIN1

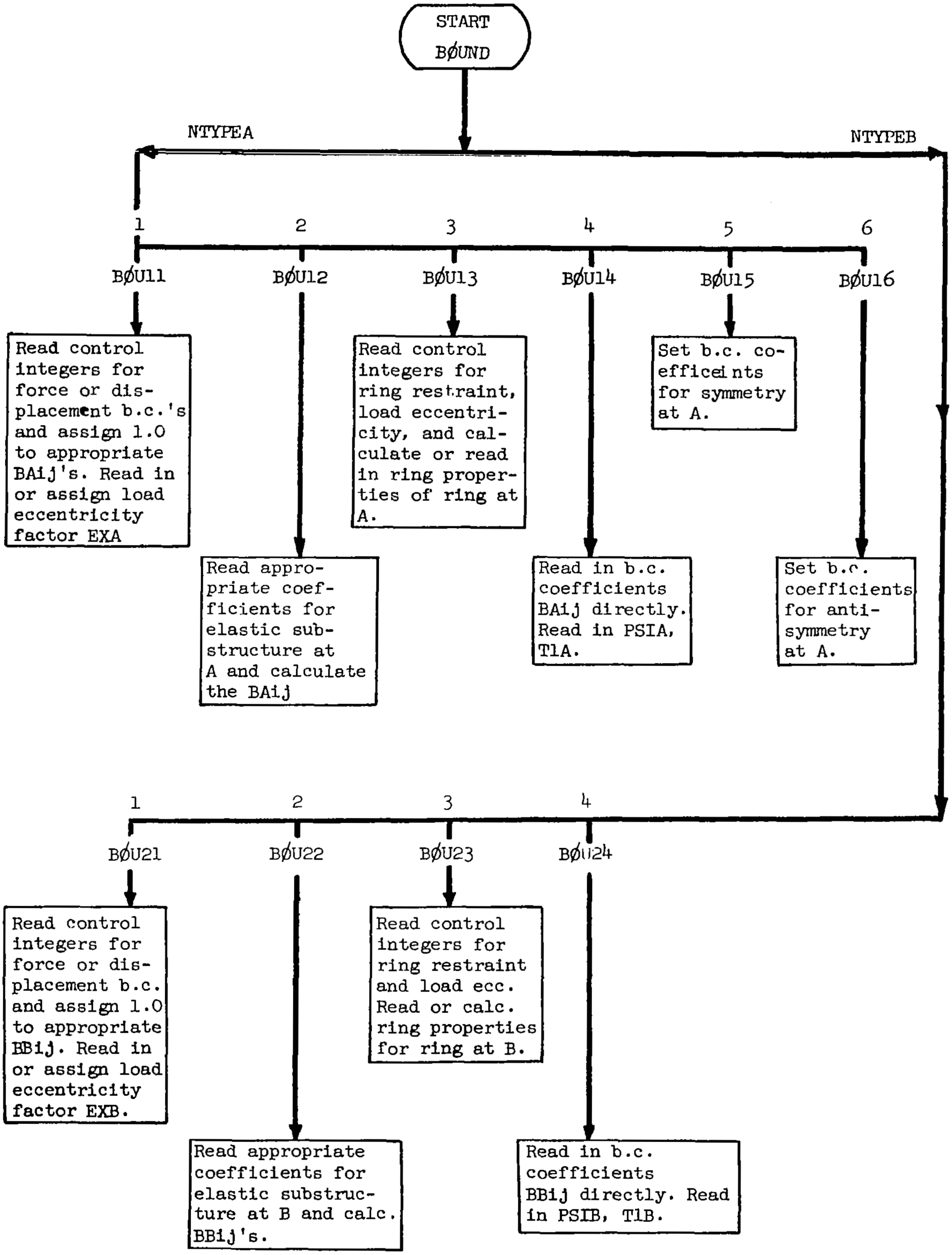


Fig. 8 Flow Chart for BOUND and BOU11, etc.
Called from CHAIN1

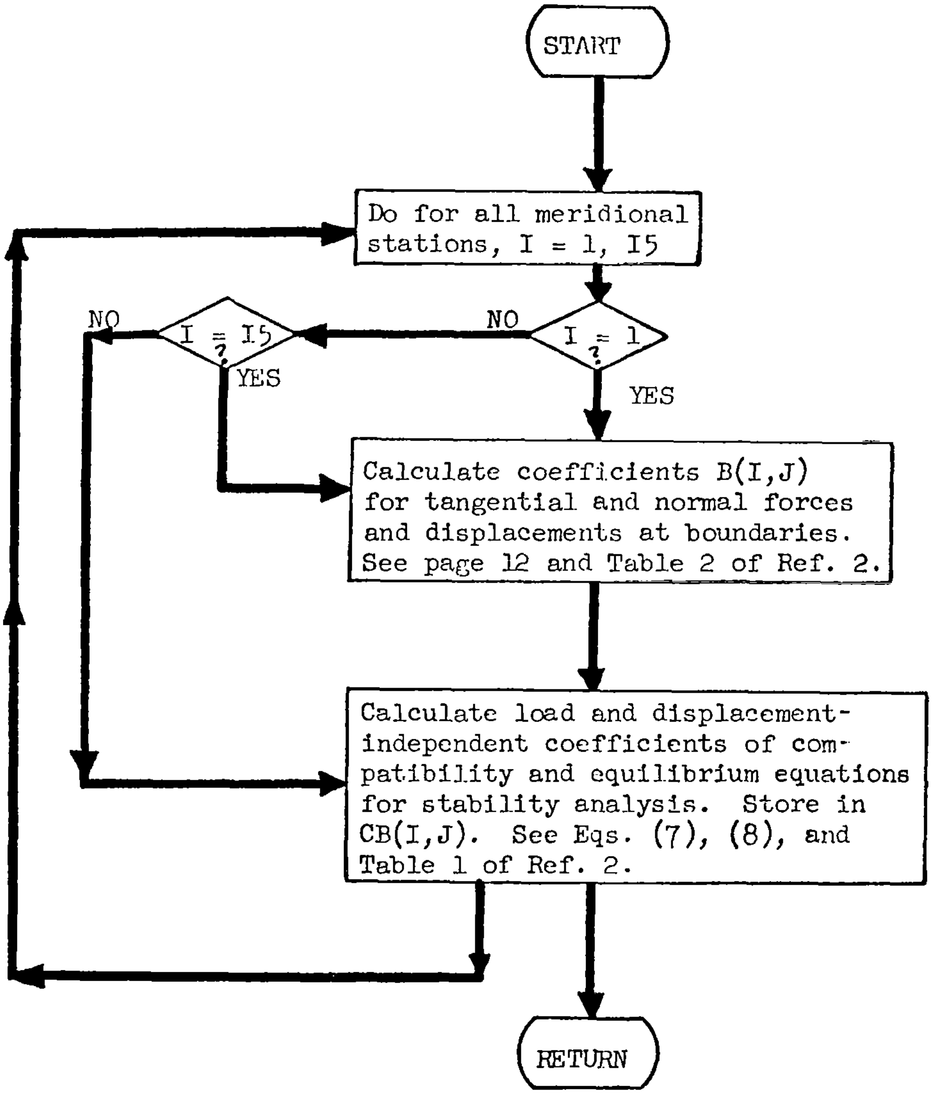
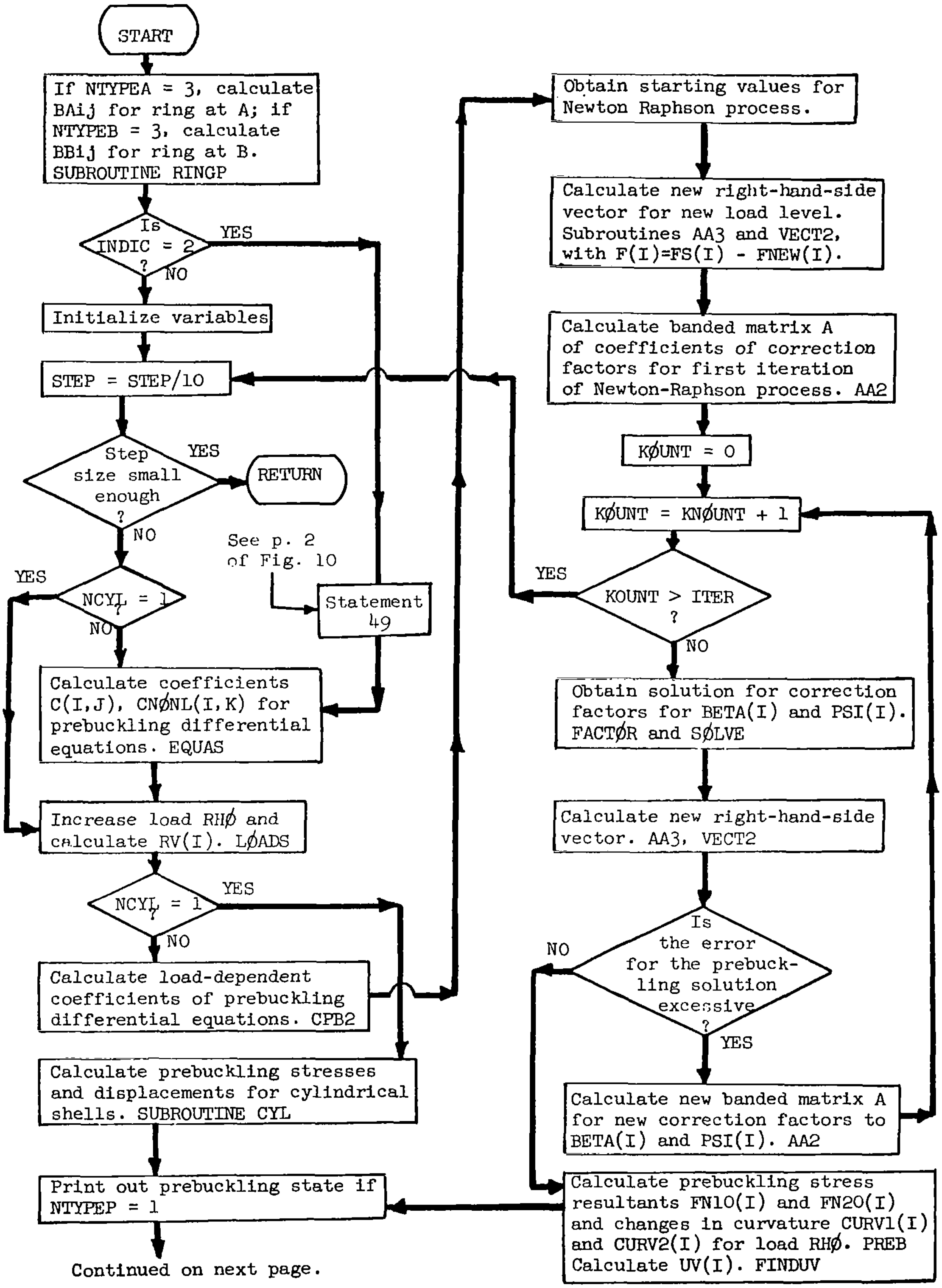


Fig. 9 Flow Chart of BEQUAS Called from CHAIN1



Page 1 of Fig. 10

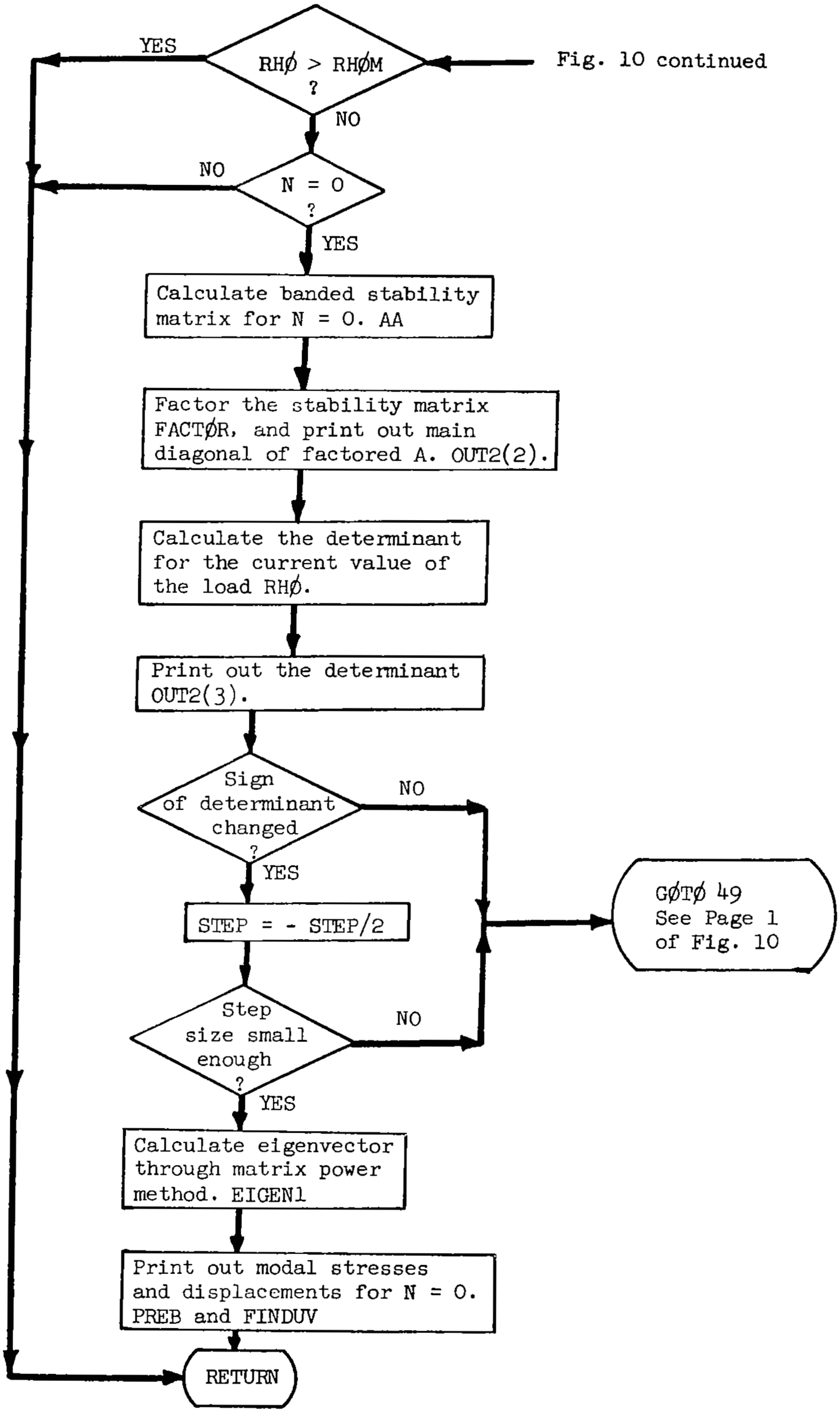


Fig. 10 (two pages) Flow Chart of SUBROUTINE PRE Called from MAINP

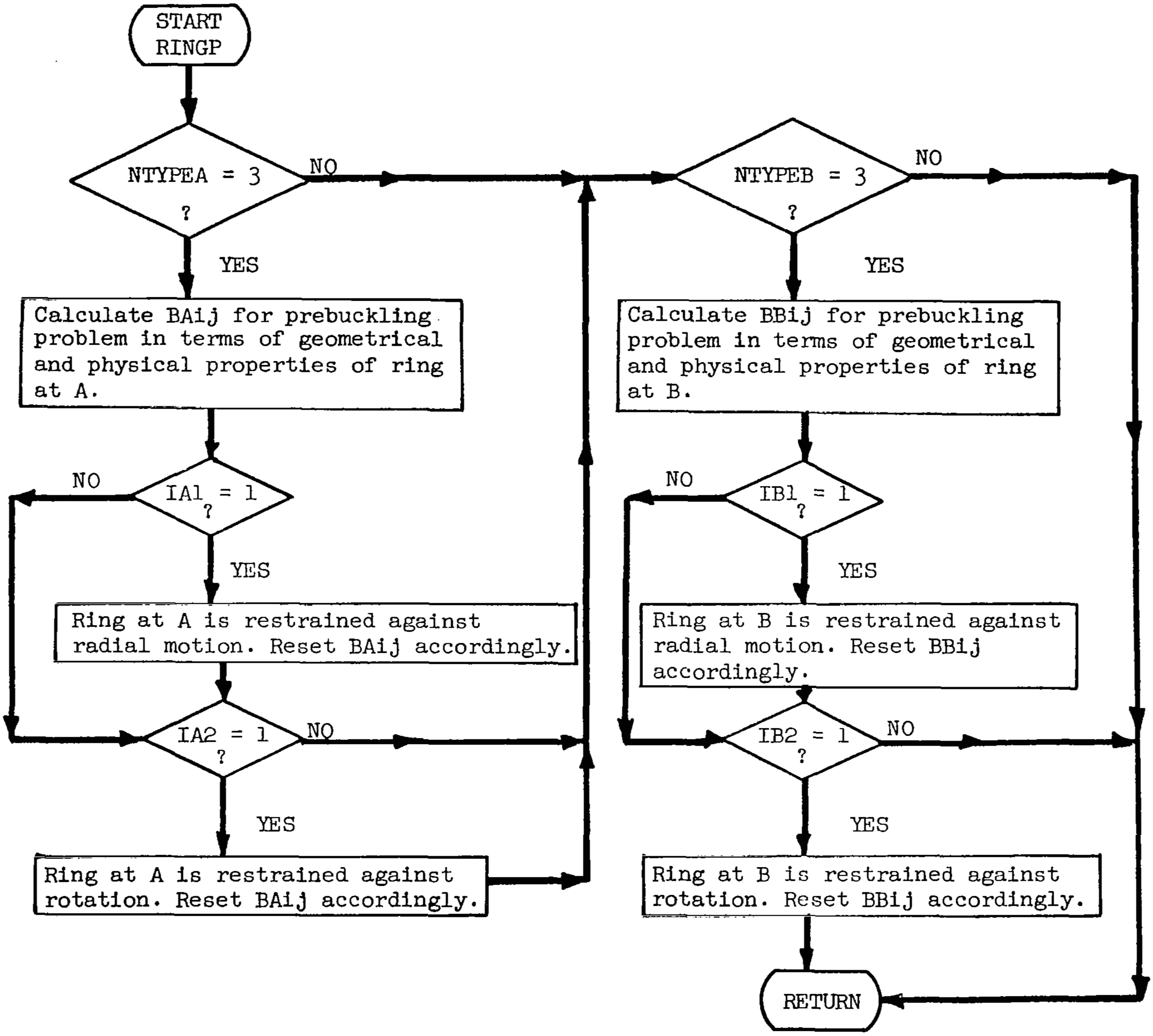


Fig. 11 Flow Chart of RINGP
Called from PRE

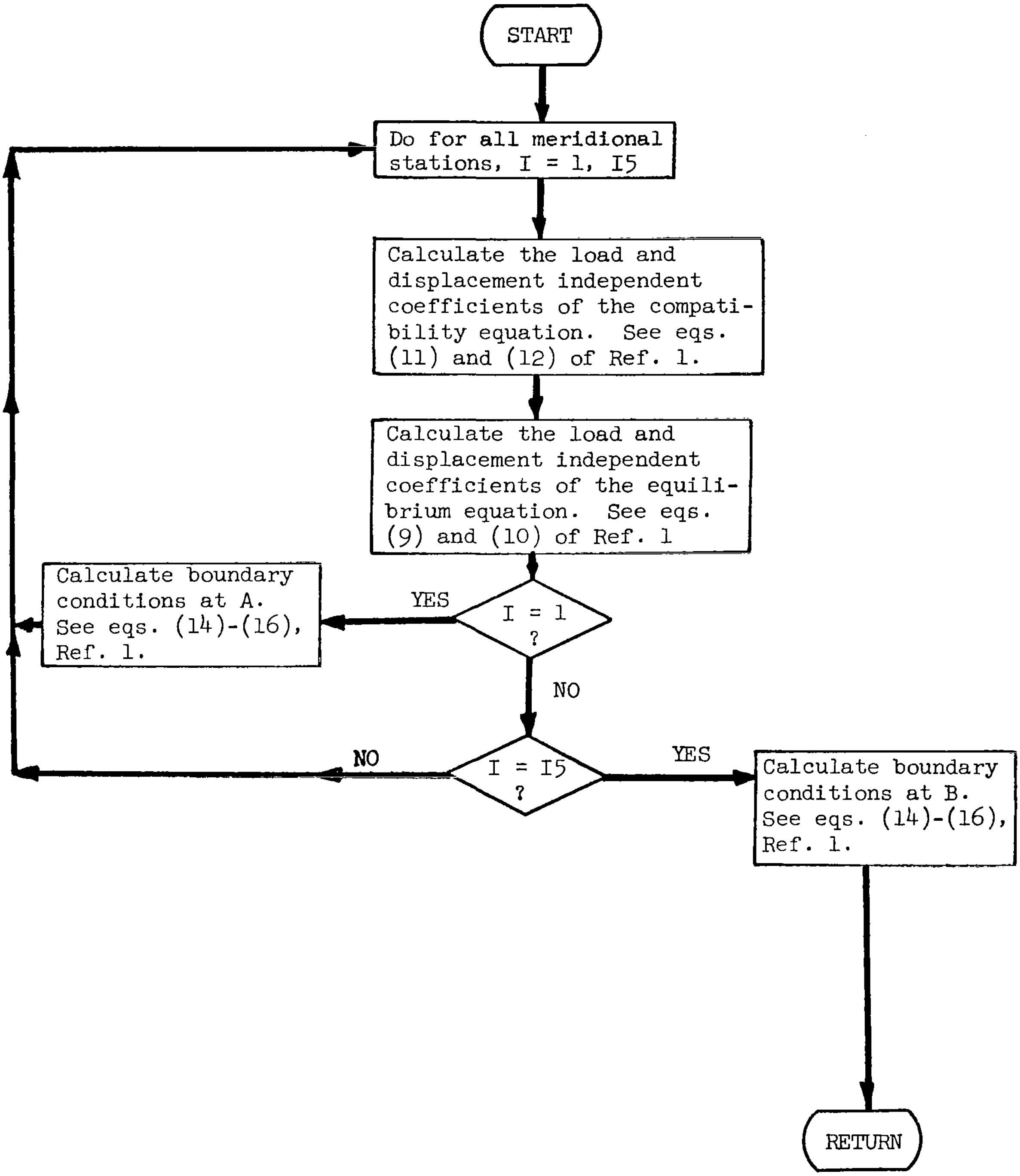


Fig. 12 Flow Chart of EQUAS
Called from PRE

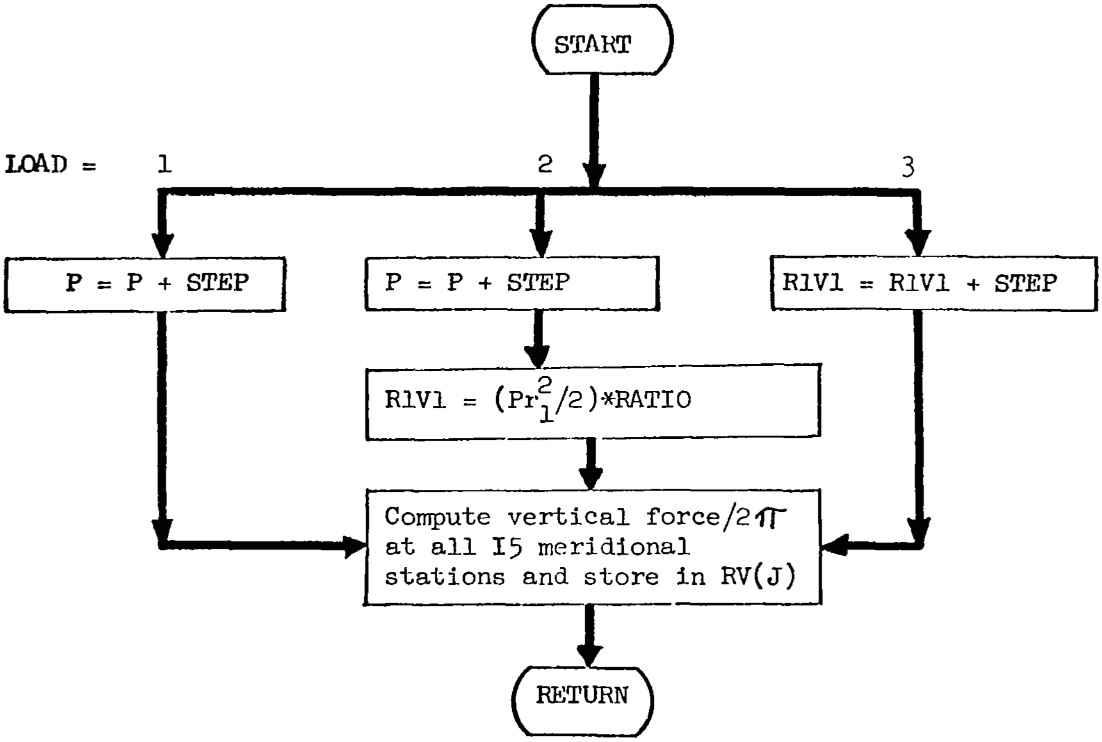


Fig. 13 Flow Chart of LØADS
Called from PRE

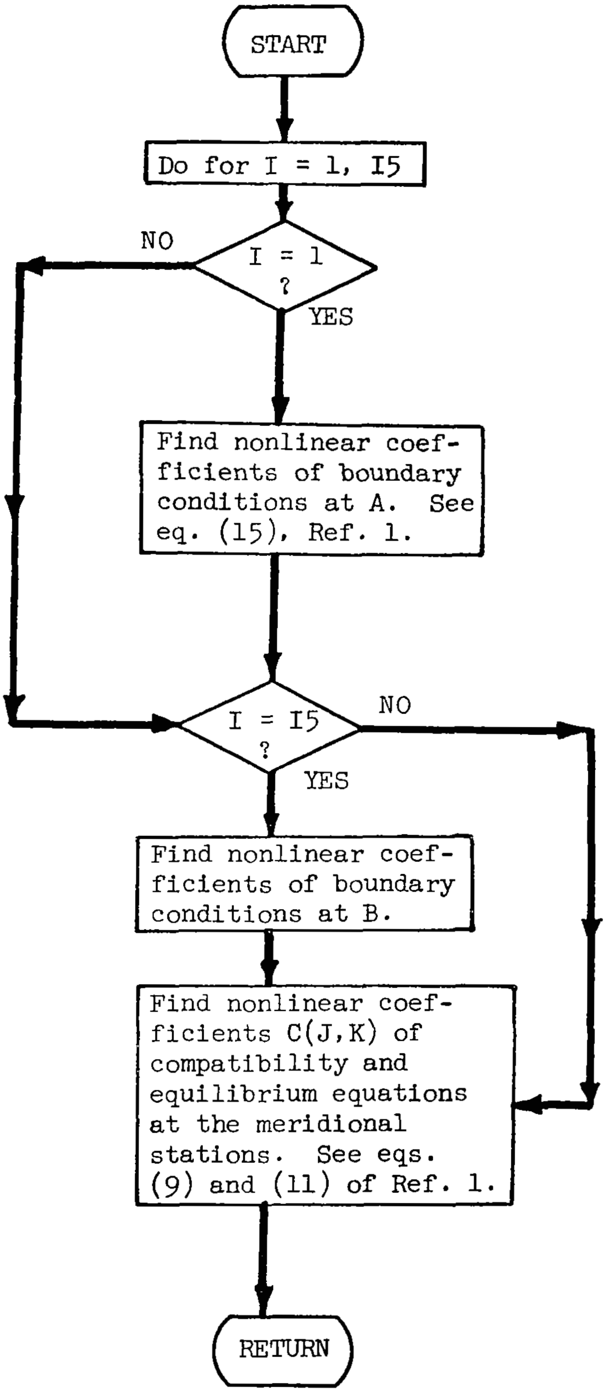


Fig. 14 Flow Chart of CPB2 Called from PRE

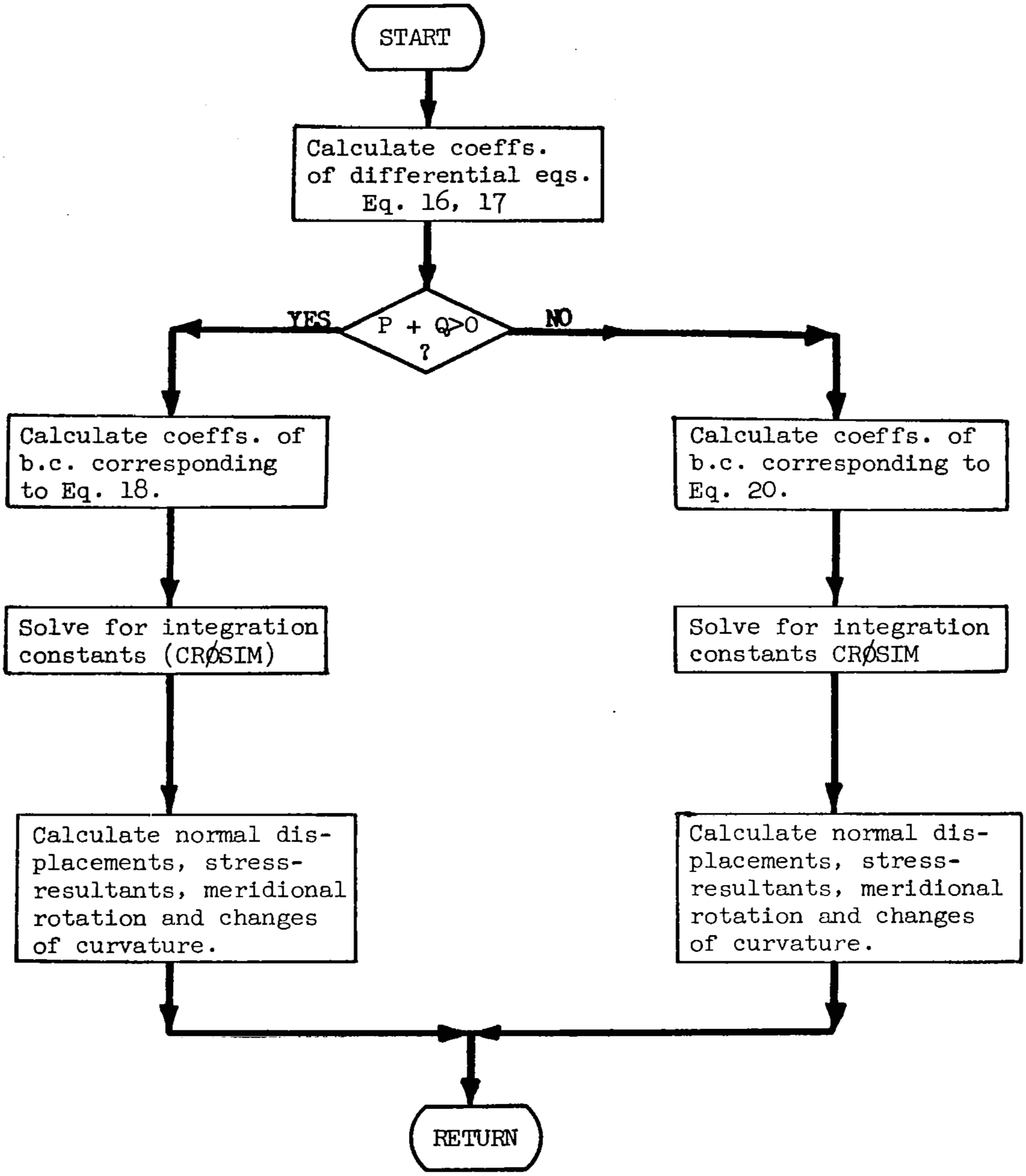


Fig. 15 Flow Chart of CYL Called from PRE

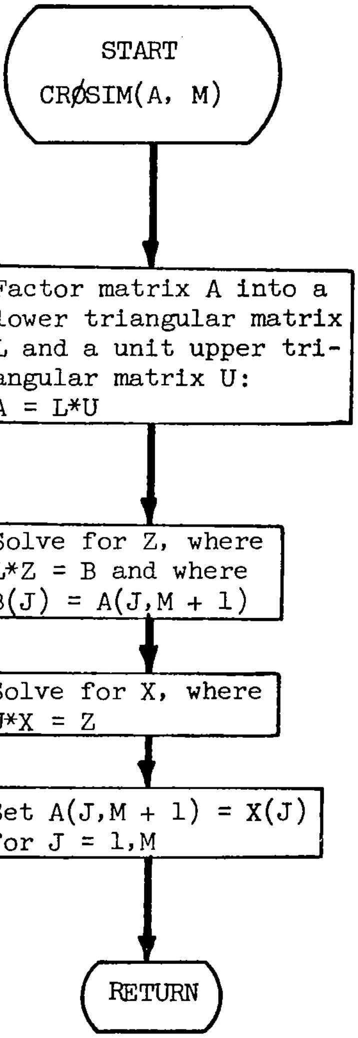


Fig. 16 Flow Chart of CRØSIM
Called from CYL

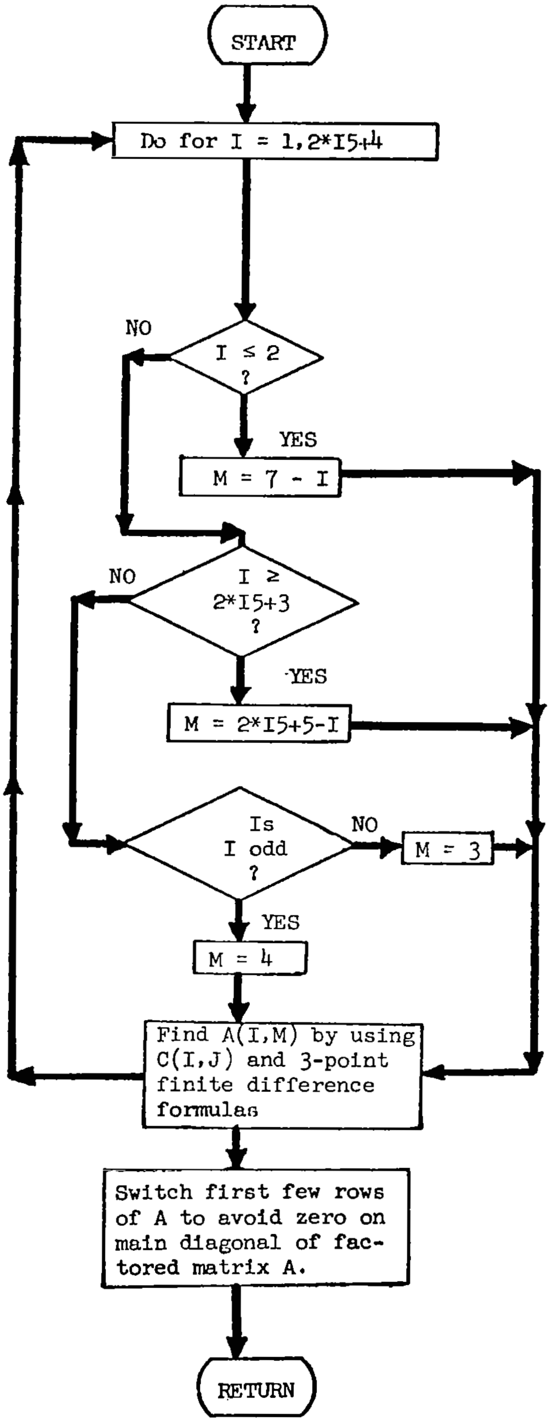


Fig. 17 Flow Chart of Subroutines AA, AA2, and AA3 Called from PRE

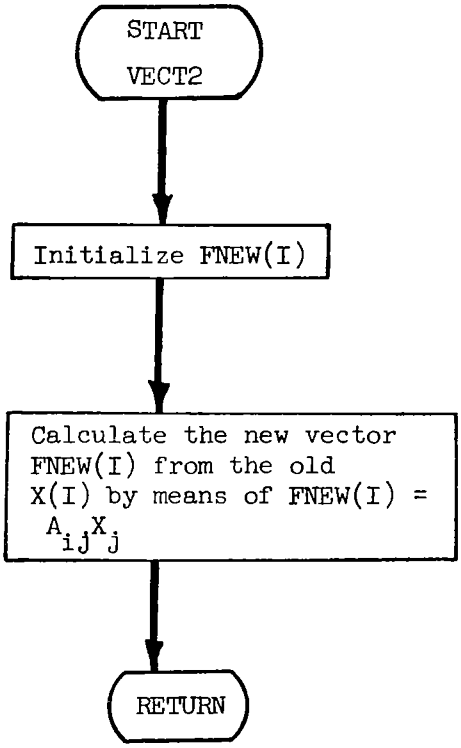


Fig. 18 Flow Chart for VECT2
Called from PRE

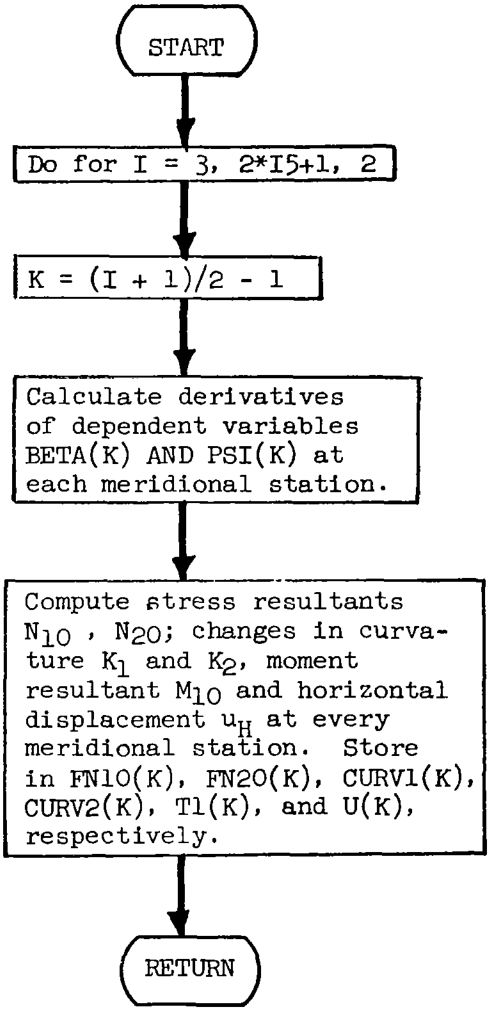


Fig. 19 Flow Chart of PREB
Called from PRE

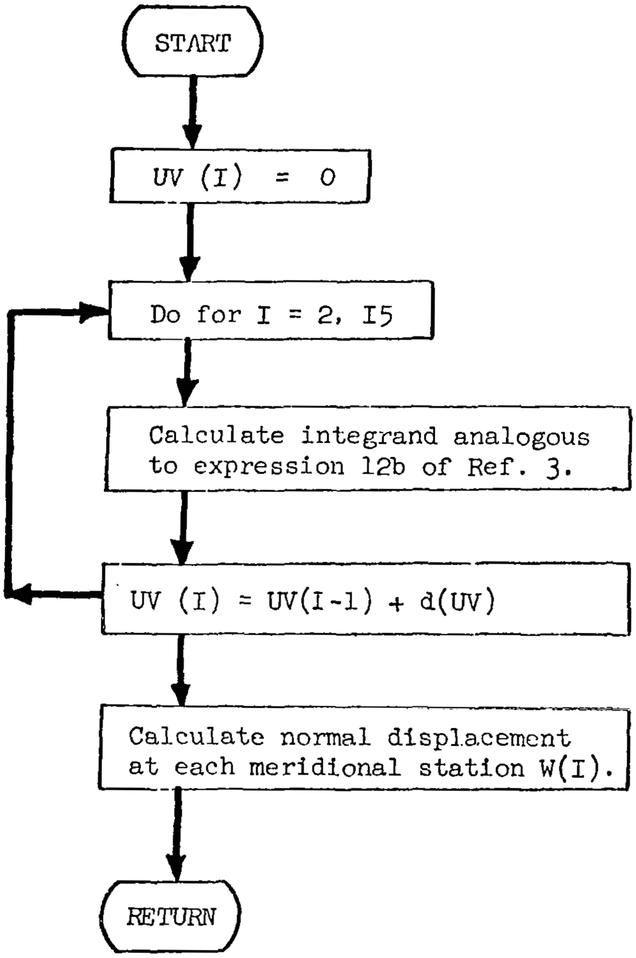


Fig. 20 Flow Chart of FINDUV
Called from PRE

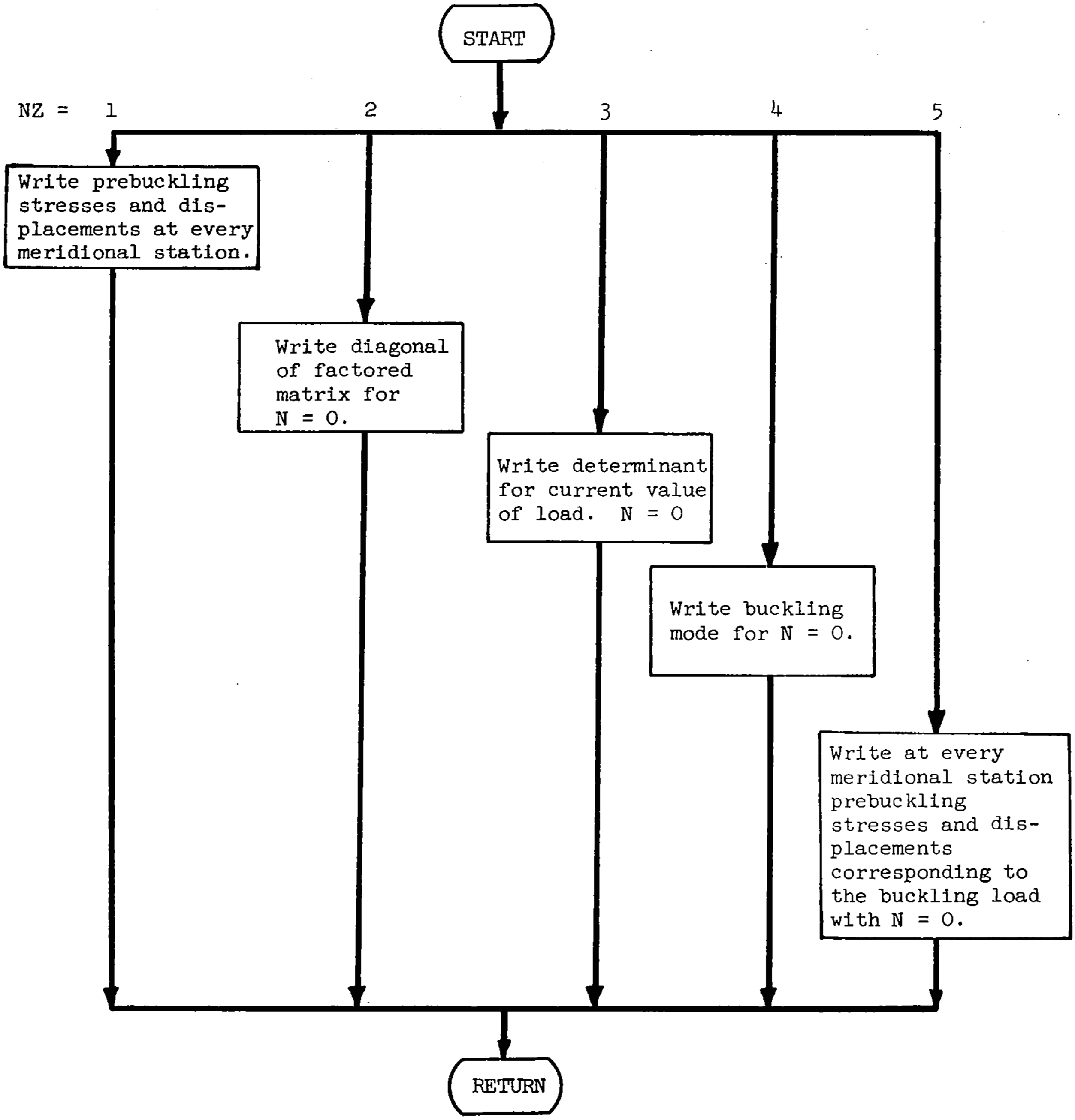


Fig. 21 Flow Chart of ØUT2
Called from PRE

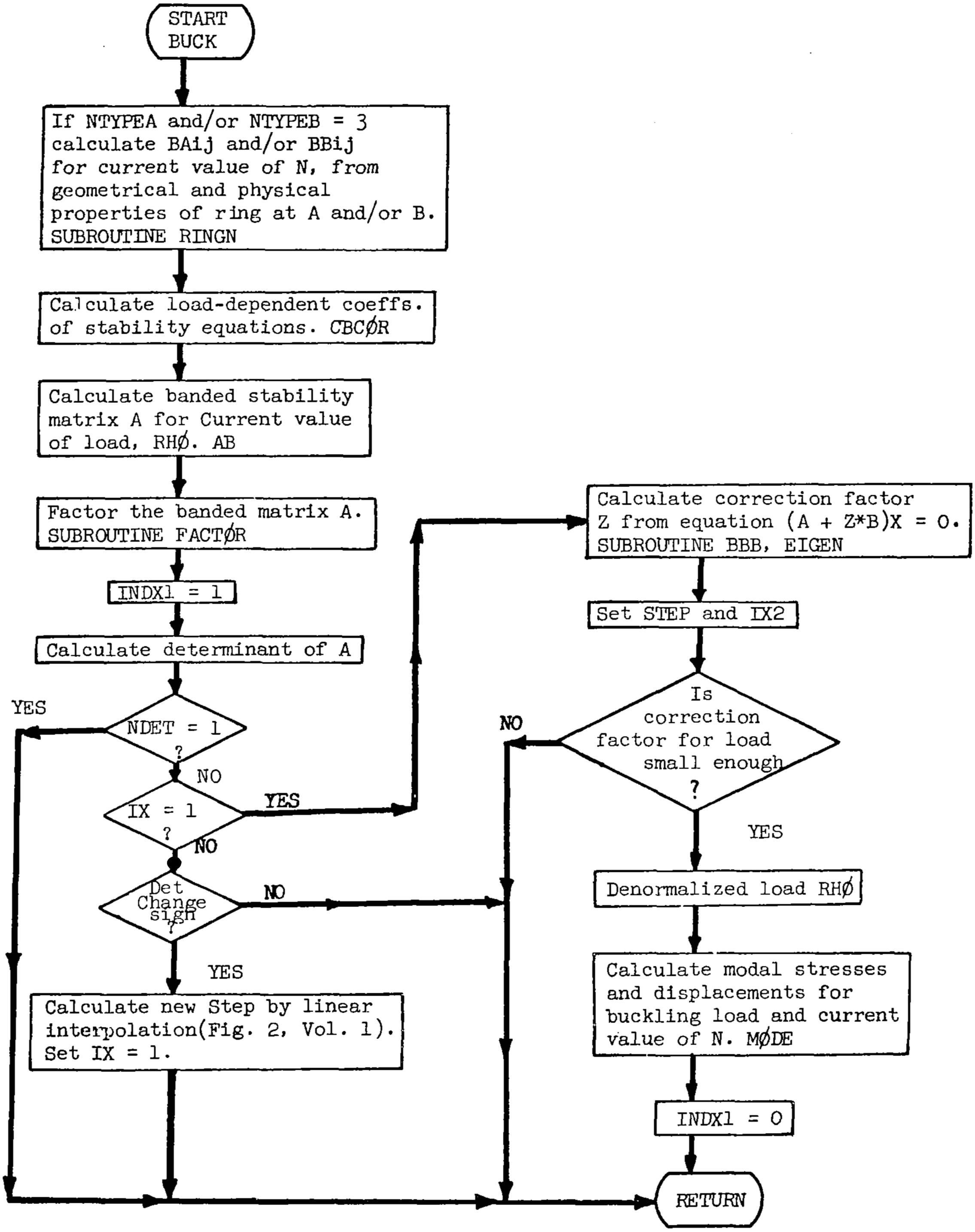


Fig. 22 Flow Chart of BUCK
Called from MAINP

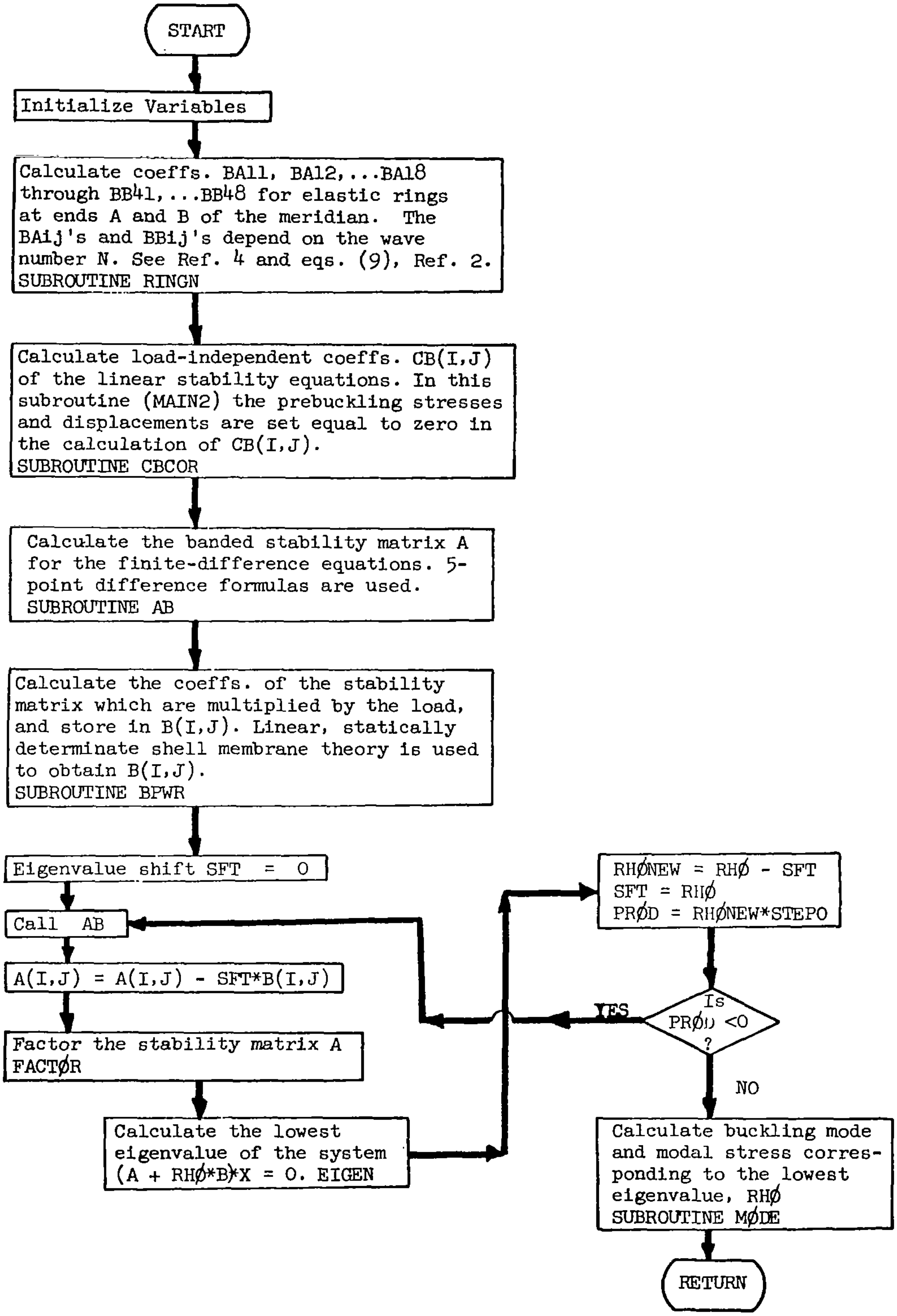
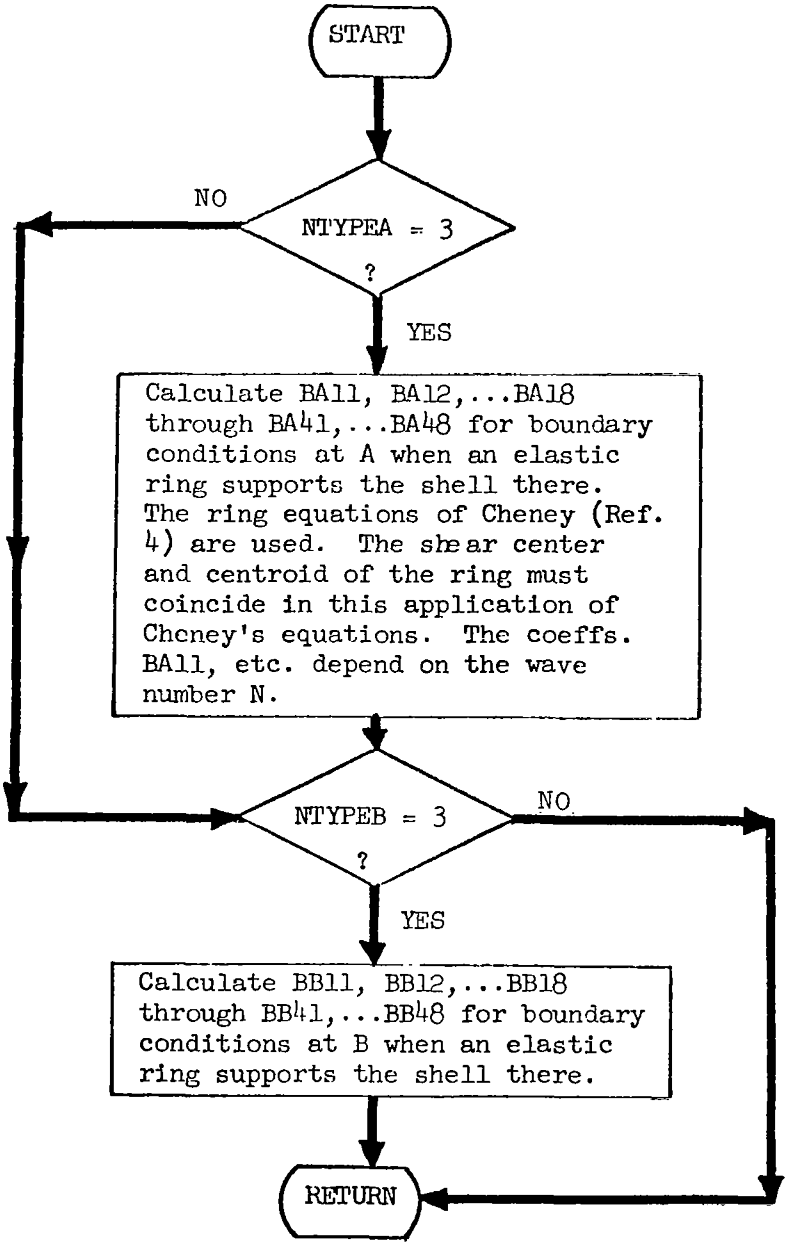


Fig. 23 Flow Chart of MAIN2
Called from MAINP



Calculate BA11, BA12,...BA18 through BA41,...BA48 for boundary conditions at A when an elastic ring supports the shell there. The ring equations of Cheney (Ref. 4) are used. The shear center and centroid of the ring must coincide in this application of Cheney's equations. The coeffs. BA11, etc. depend on the wave number N.

Calculate BB11, BB12,...BB18 through BB41,...BB48 for boundary conditions at B when an elastic ring supports the shell there.

Fig. 24 Flow Chart of RINGN
Called from BUCK & MAIN2

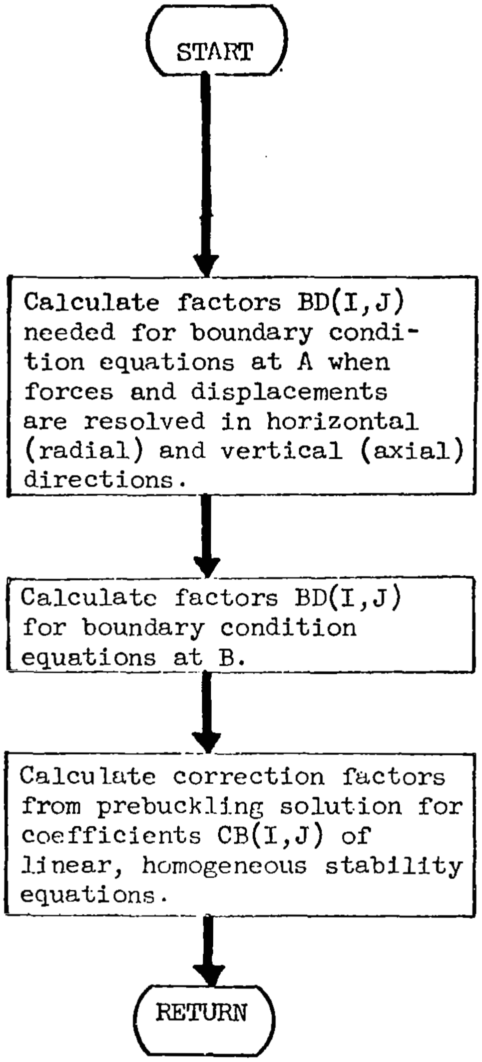


Fig. 25 Flow Chart of CBC0R
Called from BUCK & MAIN2

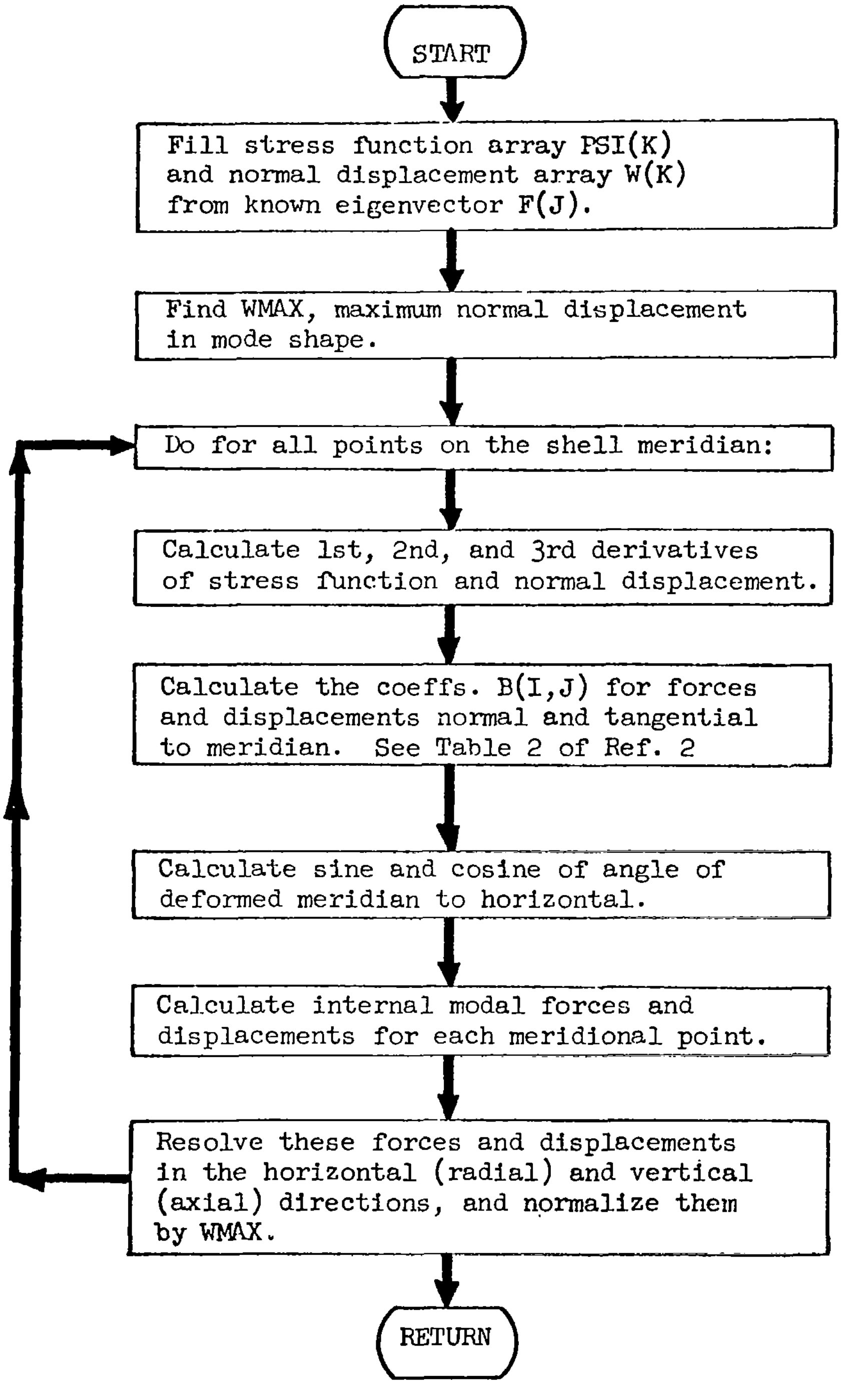


Fig. 26 Flow Chart of MØDE
Called BUCK & MAIN2

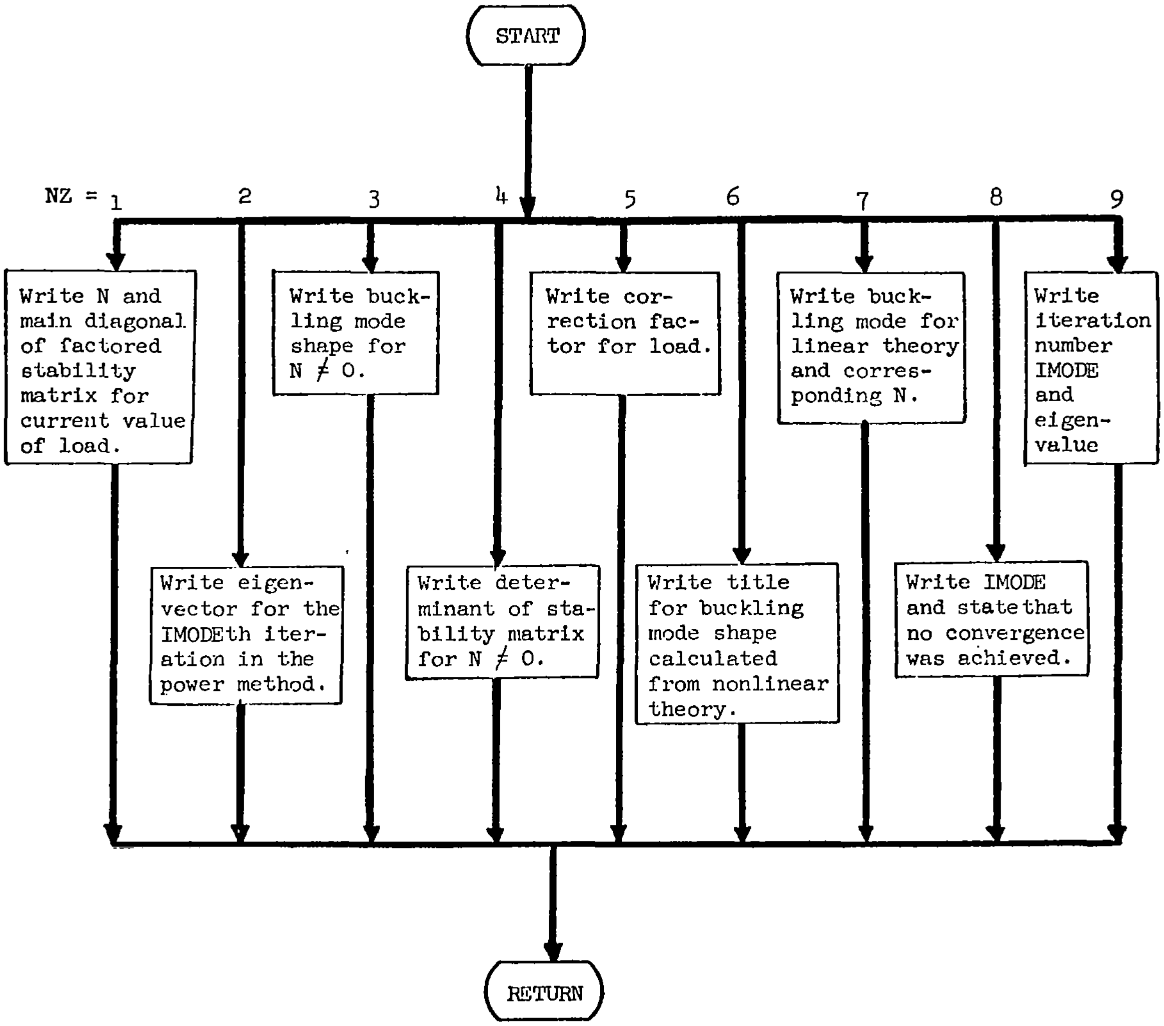


Fig. 27 Flow Chart of ØUT3
Called from BUCK & MAIN2

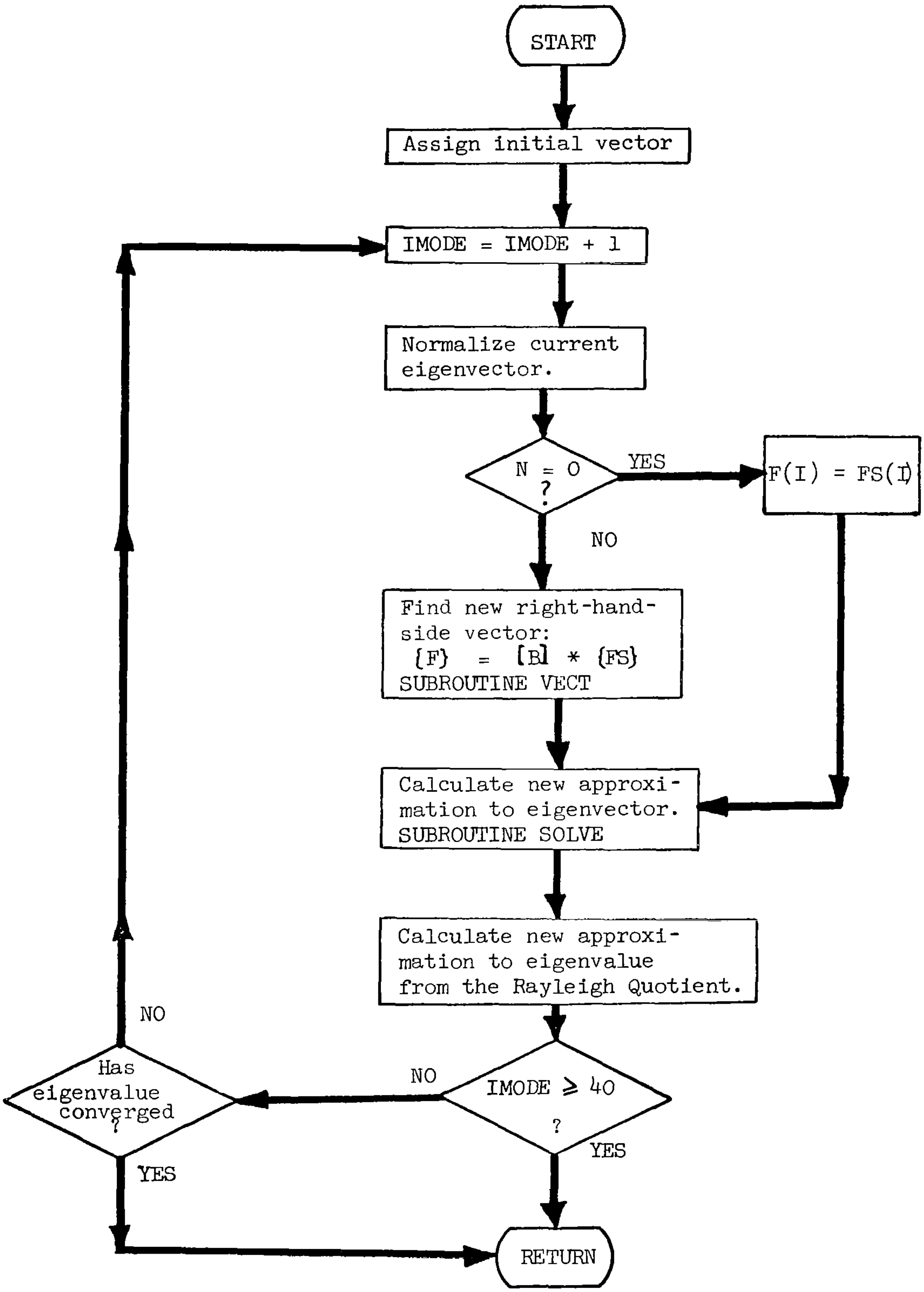


Fig. 28 Flow Chart of EIGEN
Called from BUCK & MAIN2

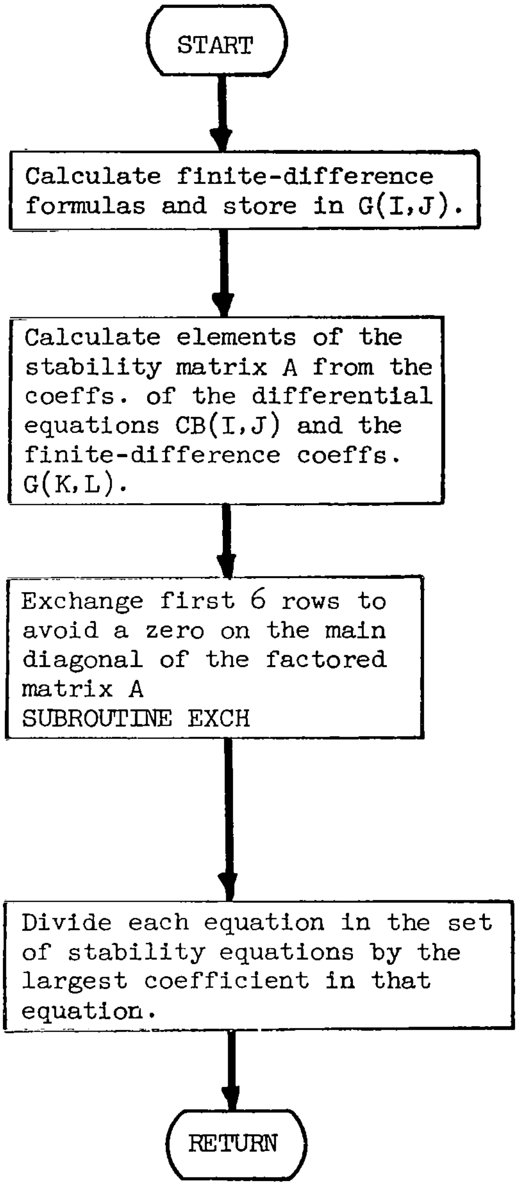


Fig. 29 Flow Chart of AB
Called from BUCK & MAIN2

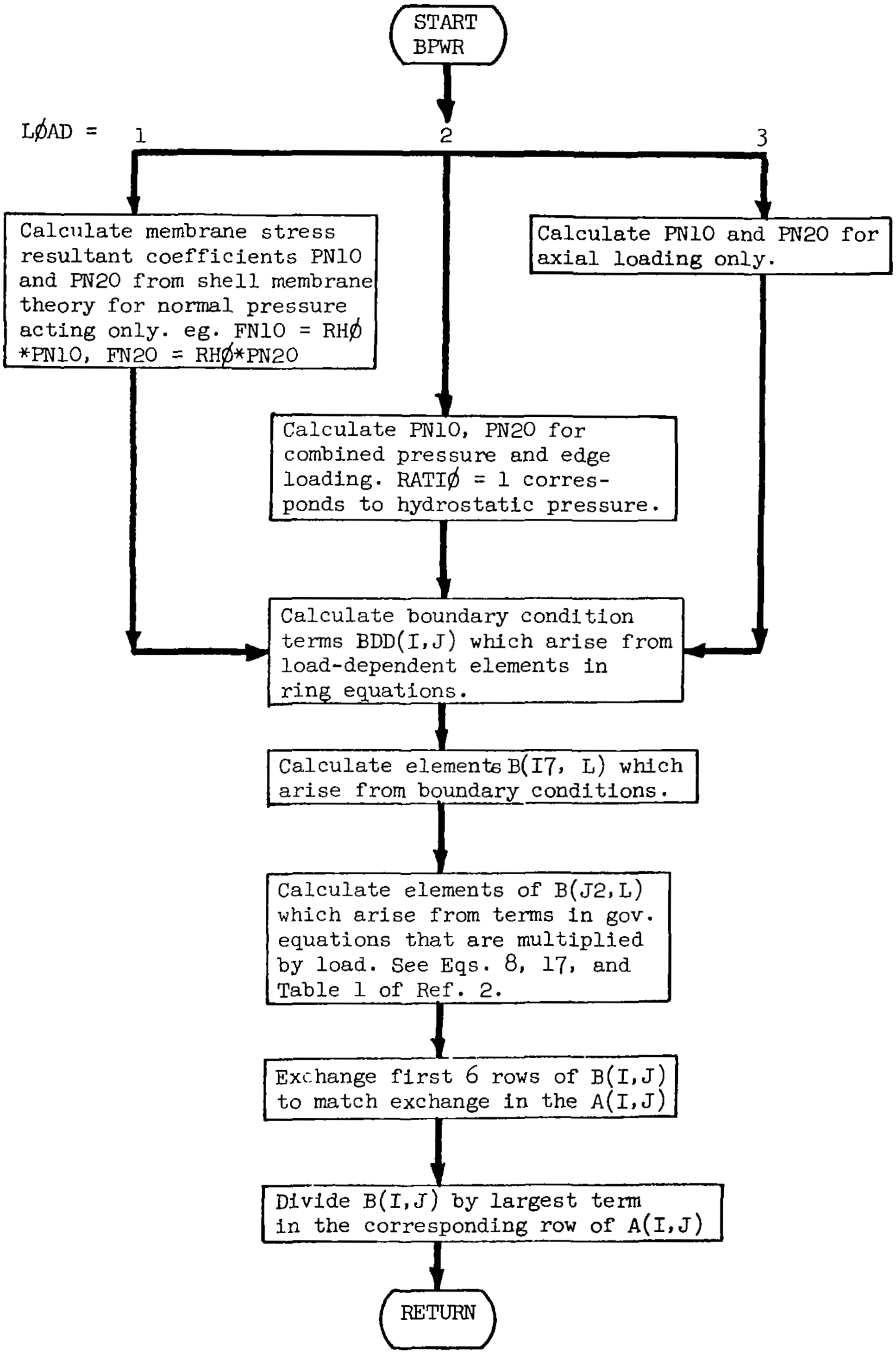


Fig. 30 Flow Chart of BPWR
Called from MAIN 2

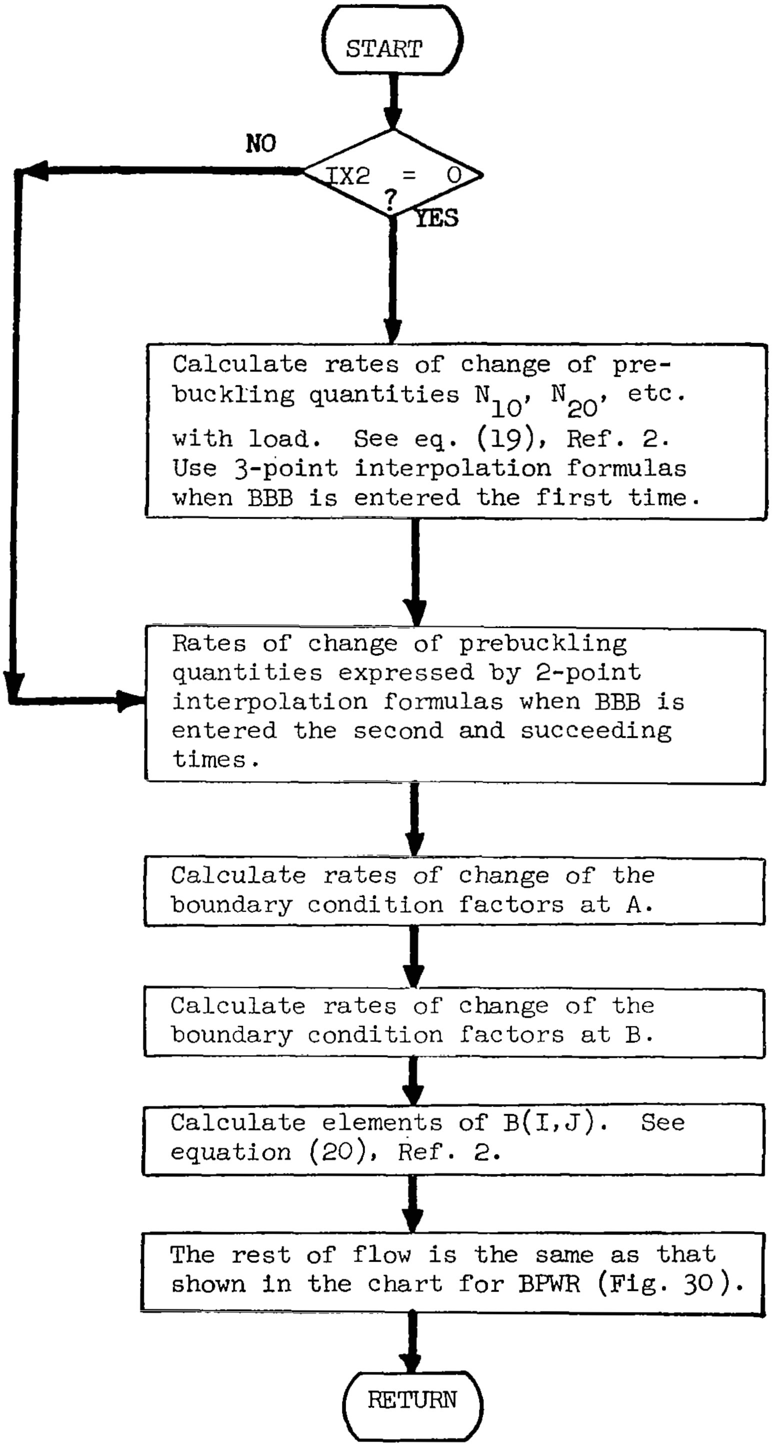


Fig. 31 Flow Chart of BBB
Called from BUCK

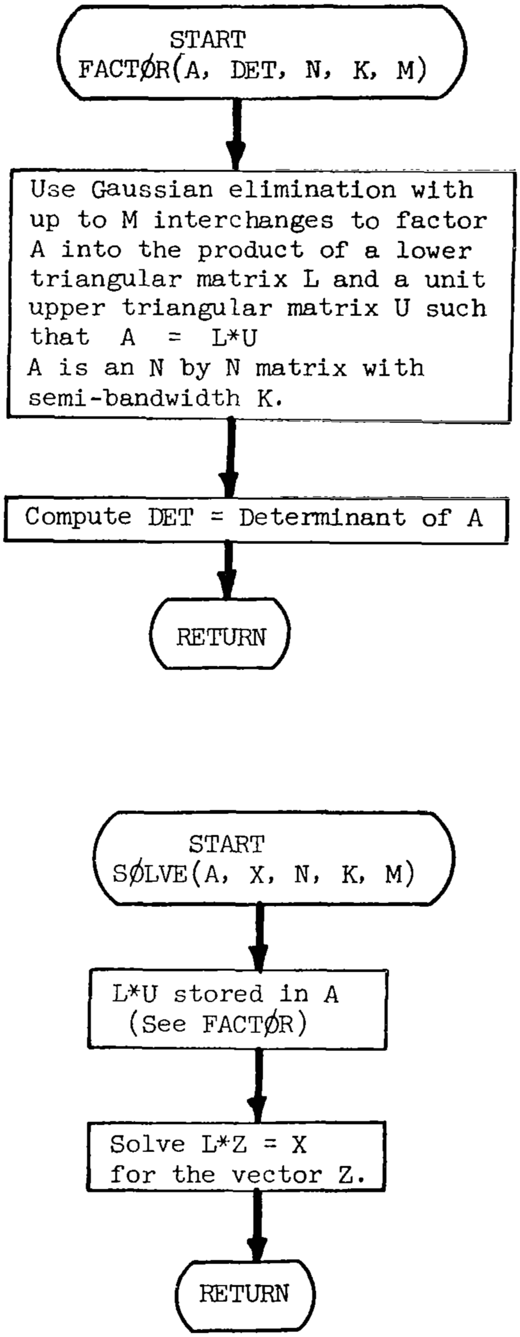


Fig. 32 Flow Charts of FACTØR and SØLVE
Called from PRE, BUCK, MAIN2, EIGEN

APPENDIX A

Input and Output Examples

The following example problems, demonstrating input and output for the BØSØR program are discussed in Section 4 of this volume. The cards and a computer listing for this program are available from COSMIC, University of Georgia, Athens, Georgia, 30601.

Case 1 Input

```
     2     1     5     3     3     0     0     0     0     0
    21     5    20     1    25    15     1

 1       -02
 105     +08 3       +00 163     +00
 0       +00 625     +01 625     +01 1       +01 1       +01
 22      +00 0       +00 1687    +01 0       +00
 198     +03 475     +02
10111
 1980815 +03+105     + 8+49      + 2 20008333+03 20008333+03 0        +00
+13671848+10+0       + 0+0       + 0+4001667 +03+0       + 0+0        + 0
```

Case 1 Output

```
        BUCKLING OF A CYLINDER OR CONE


RHO CORRESPONDS TO AXIAL LOAD(LBS/IN)

ANALYSIS IS FOR A SHELL STIFFENED BY RINGS AND STRINGERS,

MODULUS OF ELASTICITY= 0.10500000E 08     POISSON RATIO= 0.30000000E 00     SHELL THICKNESS= 0.16300000E 00

STRINGER SPACING= 0.62500000E 01     RING SPACING= 0.62500000E 01

EXTERNAL STRINGERS, EXTERNAL RINGS.

RECTANGULAR STIFFENER DATA,
STRINGER THICKNESS= 0.22000000E 00     RING THICKNESS= 0.00000000E-38
STRINGER    HEIGHT= 0.16870000E 01     RING    HEIGHT= 0.00000000E-38

RADIUS AT SMALL END= 0.19800000E 03         SLANT HEIGHT= 0.47500000E 02         HALF ANGLE(DEG.)=-0.00000000E-38


NUMBER OF INTERVALS= 21


R1V10=-0.00000000E-38          P0=-0.00000000E-38          RATIO=-0.00000000E-38

SYMMETRY AT A

AT B -- RING SUPPORT

AT B -- RING IS RESTRAINED AGAINST RADIAL DISPLACEMENT

AT B -- RING IS RESTRAINED AGAINST TANGENTIAL DISPLACEMENT

AT B -- RING IS RESTRAINED AGAINST AXIAL DISPLACEMENT

AT B -- AXIAL LOAD IS APPLIED THROUGH NEUTRAL SURFACE

   RSB=   0.198081E 03      AREAR=   0.490000E 02        EB=   0.105000E 08       FIXB=   0.200083E 03

  FIYB=   0.200083E 03      FIXYB=   0.000000E-38      FIPB=   0.400167E 03       ECCB=   0.000000E-38

   GJB=   0.136718E 10     GAMMAB=   0.000000E-38
```

Case 1 Output (Continued)

```
                                          CURRENT VALUE OF N IS  20
THE BUCKLING PARAMETER CALCULATED FROM LINEAR THEORY IS   -4.8694E 03. THE NUMBER OF CIRCUMFERENTIAL WAVES IS 20


                                          CURRENT VALUE OF N IS  21
THE BUCKLING PARAMETER CALCULATED FROM LINEAR THEORY IS   -4.8200E 03. THE NUMBER OF CIRCUMFERENTIAL WAVES IS 21


                                          CURRENT VALUE OF N IS  22
THE BUCKLING PARAMETER CALCULATED FROM LINEAR THEORY IS   -4.7949E 03. THE NUMBER OF CIRCUMFERENTIAL WAVES IS 22


                                          CURRENT VALUE OF N IS  23
THE BUCKLING PARAMETER CALCULATED FROM LINEAR THEORY IS   -4.7929E 03. THE NUMBER OF CIRCUMFERENTIAL WAVES IS 23


                                          CURRENT VALUE OF N IS  24
THE BUCKLING PARAMETER CALCULATED FROM LINEAR THEORY IS   -4.8149E 03. THE NUMBER OF CIRCUMFERENTIAL WAVES IS 24
                                          CURRENT VALUE OF N IS  23
DETERMINANT =  -3.53515E-01 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -9.39791E 02
DETERMINANT =  -2.43932E-01 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -1.87958E 03
DETERMINANT =  -1.63480E-01 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -2.81937E 03
DETERMINANT =  -1.05223E-01 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -3.75916E 03
DETERMINANT =  -6.28276E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -4.69896E 03
DETERMINANT =  -3.07467E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -5.63875E 03
DETERMINANT =  -2.99185E-03 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -6.57854E 03
DETERMINANT =   2.96976E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -7.51833E 03
DETERMINANT =  -4.00590E-04 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -6.66455E 03
THE CORRECTION FACTOR IS   -1.3142E 01

DETERMINANT =  -2.38531E-07 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -6.67769E 03
THE CORRECTION FACTOR IS   -7.8922F-03
   THE BUCKLING PARAMETER CALCULATED FROM NONLINEAR THEORY IS   -6.6777E 03.  THE NUMBER OF CIRCUMFERENTIAL WAVES IS 23
```

Case 1 Output (Continued)

```
                                        CURRENT VALUE OF N IS  24
DETERMINANT =  -5.79569E-01 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -9.39791E 02
DETERMINANT =  -4.03095E-01 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -1.87958E 03
DETERMINANT =  -2.74088E-01 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -2.81937E 03
DETERMINANT =  -1.80517E-01 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -3.75916E 03
DETERMINANT =  -1.12407E-01 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -4.69896E 03
DETERMINANT =  -6.00278E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -5.63875E 03
DETERMINANT =  -1.35684E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -6.57854E 03
DETERMINANT =   4.30470E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -7.51833E 03
DETERMINANT =  -1.83580E-03 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -6.80377E 03
THE CORRECTION FACTOR IS   -3.3692E 01

DETERMINANT =  -4.53667E-05 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -6.83746E 03
THE CORRECTION FACTOR IS   -8.4708E-01
     THE BUCKLING PARAMETER CALCULATED FROM NONLINEAR THEORY IS   -6.8383E 03.  THE NUMBER OF CIRCUMFERENTIAL WAVES IS 24



                                        CURRENT VALUE OF N IS  22
DETERMINANT =  -2.14773E-01 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -9.39791E 02
DETERMINANT =  -1.47202E-01 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -1.87958E 03
DETERMINANT =  -9.74427E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -2.81937E 03
DETERMINANT =  -6.13306E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -3.75916E 03
DETERMINANT =  -3.51604E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -4.69896E 03
DETERMINANT =  -1.55552E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -5.63875E 03
DETERMINANT =   9.42590E-04 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -6.57854E 03
DETERMINANT =   4.83009E-08 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -6.52484E 03
THE CORRECTION FACTOR IS    2.7799E-03
     THE BUCKLING PARAMETER CALCULATED FROM NONLINEAR THEORY IS   -6.5248E 03.  THE NUMBER OF CIRCUMFERENTIAL WAVES IS 22



                                        CURRENT VALUE OF N IS  21
DETERMINANT =  -1.29766E-01 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -9.39791E 02
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Case 1 Output (Continued)

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DETERMINANT =  -8.85004E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -1.87958E 03
DETERMINANT =  -5.79881E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -2.81937E 03
DETERMINANT =  -3.57888E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -3.75916E 03
DETERMINANT =  -1.97357E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -4.69896E 03
DETERMINANT =  -7.83713E-03 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -5.63875E 03
DETERMINANT =   1.89982E-03 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -6.57854E 03
DETERMINANT =   5.28623E-05 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -6.39517E 03
THE CORRECTION FACTOR IS    5.2063E 00
     THE BUCKLING PARAMETER CALCULATED FROM NONLINEAR THEORY IS   -6.3900E 03.  THE NUMBER OF CIRCUMFERENTIAL WAVES IS 21


                                              CURRENT VALUE OF N IS  20
DETERMINANT =  -7.80040E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -9.39791E 02
DETERMINANT =  -5.30184E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -1.87958E 03
DETERMINANT =  -3.44782E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -2.81937E 03
DETERMINANT =  -2.09401E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -3.75916E 03
DETERMINANT =  -1.11630E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -4.69896E 03
DETERMINANT =  -3.99304E-03 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -5.63875E 03
DETERMINANT =   1.74286E-03 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -6.57854E 03
DETERMINANT =   6.81746E-05 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -6.29298E 03
THE CORRECTION FACTOR IS    1.1417E 01

DETERMINANT =   4.58928E-06 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -6.28157E 03
THE CORRECTION FACTOR IS    7.7600E-01
     THE BUCKLING PARAMETER CALCULATED FROM NONLINEAR THEORY IS   -6.2808E 03.  THE NUMBER OF CIRCUMFERENTIAL WAVES IS 20


                                              CURRENT VALUE OF N IS  19
DETERMINANT =  -4.66114E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -9.39791E 02
DETERMINANT =  -3.16401E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -1.87958E 03
DETERMINANT =  -2.04826E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -2.81937E 03
DETERMINANT =  -1.22991E-02 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -3.75916E 03
DETERMINANT =  -6.38895E-03 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -4.69896E 03
DETERMINANT =  -2.09158E-03 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -5.63875E 03
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Case 1 Output (Continued)

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DETERMINANT =   1.26367E-03 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -6.57854E 03
DETERMINANT =   6.58068E-05 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -6.22459E 03
THE CORRECTION FACTOR IS    1.8730E 01

DETERMINANT =   4.77633E-07 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -6.20586E 03
THE CORRECTION FACTOR IS    1.3714E-01
     THE BUCKLING PARAMETER CALCULATED FROM NONLINEAR THEORY IS   -6.2057E 03.  THE NUMBER OF CIRCUMFERENTIAL WAVES IS 19



                                           CURRENT VALUE OF N IS  18
DETERMINANT =  -2.76635E-02 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -9.39791E 02
DETERMINANT =  -1.87994E-02 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -1.87958E 03
DETERMINANT =  -1.21473E-02 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -2.81937E 03
DETERMINANT =  -7.25428E-03 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -3.75916E 03
DETERMINANT =  -3.71233E-03 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -4.69896E 03
DETERMINANT =  -1.15378E-03 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -5.63875E 03
DETERMINANT =   8.04096E-04 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -6.57854E 03
DETERMINANT =   4.60886E-05 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -6.19257E 03
THE CORRECTION FACTOR IS    2.2430E 01

DETERMINANT =   2.13868E-06 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -6.17014E 03
THE CORRECTION FACTOR IS    1.0485E 00
     THE BUCKLING PARAMETER CALCULATED FROM NONLINEAR THEORY IS   -6.1691E 03.  THE NUMBER OF CIRCUMFERENTIAL WAVES IS 18



                                           CURRENT VALUE OF N IS  17
DETERMINANT =  -1.62961E-02 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -9.39791E 02
DETERMINANT =  -1.11002E-02 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -1.87958E 03
DETERMINANT =  -7.18446E-03 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -2.81937E 03
DETERMINANT =  -4.29020E-03 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -3.75916E 03
DETERMINANT =  -2.19212E-03 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -4.69896E 03
DETERMINANT =  -6.78372E-04 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -5.63875E 03
DETERMINANT =   4.56151E-04 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -6.57854E 03
DETERMINANT =   3.07684E-05 TIMES 10 TO THE -30TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS,  RHO = -6.20068E 03
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Case 1 Output (Continued)

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THE CORRECTION FACTOR IS    2.5917E 01

DETERMINANT =   4.55708E-07 TIMES 10 TO THE -30TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO = -6.17476E 03

THE CORRECTION FACTOR IS    3.8599E-01

     THE BUCKLING PARAMETER CALCULATED FROM NONLINEAR THEORY IS   -6.1744E 03.  THE NUMBER OF CIRCUMFERENTIAL WAVES IS 17

THIS RUN IS NOW COMPLETE.  THE MINIMUM VALUE FOR RHO HAS BEEN FOUND TO BE  -6.16909E 03 WHICH CORRESPONDS TO 18 BUCKLING WAVES.
PLEASE RETURN TO THAT OUTPUT SET FOR COMPLETE DATA PERTAINING TO THE MINIMUM BUCKLING LOAD.
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Case 2a Input

```
     2     2     5     1     3     1
    30     9     0     1     0     0     1
-7500    +04-100     +03 9000    +04
 1       -02
 105     +03 5       +00 163     +00
 0       +00 625     +01 625     +01 1       +01 1       +01
 22      +00 0       +00 1687    +01 0       +00
 1980815 +03 90      +02 103877  +03
10103
 10065   +01
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Case 2a Output

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          BUCKLING OF A SPHERICAL SHELL SEGMENT

RHO CORRESPONDS TO AXIAL LOAD(LBS/IN)

ANALYSIS IS FOR A SHELL STIFFENED BY RINGS AND STRINGERS.

MODULUS OF ELASTICITY= 0.10500000E 08     POISSON RATIO= 0.30000000E 00     SHELL THICKNESS= 0.16300000E 00

STRINGER SPACING= 0.62500000E 01     RING SPACING= 0.62500000E 01

EXTERNAL STRINGERS, EXTERNAL RINGS.

RECTANGULAR STIFFENER DATA.
STRINGER THICKNESS= 0.22000000E 00     RING THICKNESS= 0.00000000E-38
STRINGER    HEIGHT= 0.16870000E 01     RING    HEIGHT= 0.00000000E-38

RADIUS= 0.19808150E 03          POLAR ANGLE A(DEG.)= 0.90000000E 02          POLAR ANGLE B(DEG.)= 0.10387700E 03


NUMBER OF INTERVALS= 30


R1V10=-0.00000000E-38          P0=-0.00000000E-38          RATIO=-0.00000000E-38

SYMMETRY AT A

AT B -- SIMPLE BOUNDARY CONDITIONS

AT B -- AXIAL LOAD IS APPLIED  1.006500 IN OUTSIDE OF INNER SURFACE

AT B -- RADIAL DISPLACEMENT IS ZERO

AT B -- MOMENT IS ZERO

AT B -- TANGENTIAL DISPLACEMENT IS ZERO

AT B -- AXIAL LOAD IS ZERO
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Case 2a Output (Continued)

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                                              CURRENT VALUE OF N IS    0
DETERMINANT =   5.35986E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -7.50000E 03
DETERMINANT =   4.72549E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -7.60000E 03
DETERMINANT =   4.12566E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -7.70000E 03
DETERMINANT =   3.55916E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -7.80000E 03
DETERMINANT =   3.02487E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -7.90000E 03
DETERMINANT =   2.52185E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.00000E 03
DETERMINANT =   2.04947E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.10000E 03
DETERMINANT =   1.60808E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.20000E 03
DETERMINANT =   1.20308E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -8.30000E 03
DETERMINANT =   8.87133E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  6 ITERATIONS.  RHO = -8.40000E 03
DETERMINANT =   3.84566E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  4 ITERATIONS.  RHO = -8.50000E 03
DETERMINANT =   5.46845E 00 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.60000E 03
DETERMINANT =  -2.60164E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.70000E 03
DETERMINANT =  -1.05130E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.65000E 03
DETERMINANT =   5.46844E 00 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.60000E 03
DETERMINANT =  -2.57928E 00 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.62500E 03
DETERMINANT =   1.43070E 00 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.61250E 03
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Case 2a Output (Continued)

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                                                     BUCKLING MODE WHEN N EQUALS 0

 ARC            RADIUS*HORIZONTAL         HORIZONTAL            MERIDIONAL           MERIDIONAL            MERIDIONAL
LENGTH            FORCE/LENGTH          DISPLACEMENT             STRESS              CHANGE IN              MOMENT
                                                                RESULTANT            CURVATURE
         MERIDIONAL              NORMAL               VERTICAL          CIRCUMFERENTIAL       CIRCUMFERENTIAL
          ROTATION            DISPLACEMENT          DISPLACEMENT            STRESS              CHANGE IN
                                                                          RESULTANT             CURVATURE
   S         BETA        RH        W          UH         UV        N10        N20       CURV1      CURV2       M1

0.00E-39   7.54E-10   3.02E-03   1.25E 00   1.25E 00   0.00E-39  -2.12E-13   1.14E 04   6.42E-03  -1.35E-19   2.21E 03
1.60E 00  -1.53E-01   1.19E 05   1.25E 00   1.25E 00  -2.36E-03  -4.83E 00   1.14E 04   6.19E-03   1.59E-05   2.16E 03
3.20E 00  -3.02E-01   2.34E 05   1.26E 00   1.26E 00  -8.69E-03  -1.91E 01   1.15E 04   5.54E-03   6.29E-05   2.03E 03
4.80E 00  -4.43E-01   3.44E 05   1.28E 00   1.28E 00  -2.28E-02  -4.21E 01   1.15E 04   4.48E-03   1.39E-04   1.82E 03
6.40E 00  -5.74E-01   4.46E 05   1.30E 00   1.30E 00  -4.80E-02  -7.27E 01   1.16E 04   3.05E-03   2.39E-04   1.53E 03
8.00E 00  -6.90E-01   5.36E 05   1.32E 00   1.32E 00  -8.72E-02  -1.09E 02   1.18E 04   1.31E-03   3.60E-04   1.18E 03
9.60E 00  -7.90E-01   6.13E 05   1.34E 00   1.35E 00  -1.43E-01  -1.50E 02   1.19E 04  -6.79E-04   4.94E-04   7.73E 02
1.12E 01  -8.70E-01   6.75E 05   1.36E 00   1.37E 00  -2.15E-01  -1.93E 02   1.20E 04  -2.83E-03   6.35E-04   3.33E 02
1.28E 01  -9.28E-01   7.20E 05   1.37E 00   1.39E 00  -3.06E-01  -2.35E 02   1.20E 04  -5.07E-03   7.75E-04  -1.26E 02
1.44E 01  -9.64E-01   7.47E 05   1.38E 00   1.41E 00  -4.13E-01  -2.74E 02   1.21E 04  -7.29E-03   9.05E-04  -5.86E 02
1.60E 01  -9.76E-01   7.56E 05   1.37E 00   1.42E 00  -5.36E-01  -3.09E 02   1.20E 04  -9.41E-03   1.02E-03  -1.03E 03
1.76E 01  -9.63E-01   7.46E 05   1.35E 00   1.42E 00  -6.71E-01  -3.35E 02   1.20E 04  -1.13E-02   1.11E-03  -1.44E 03
1.92E 01  -9.27E-01   7.17E 05   1.32E 00   1.41E 00  -8.16E-01  -3.52E 02   1.18E 04  -1.30E-02   1.16E-03  -1.79E 03
2.08E 01  -8.68E-01   6.70E 05   1.27E 00   1.38E 00  -9.65E-01  -3.56E 02   1.15E 04  -1.42E-02   1.18E-03  -2.07E 03
2.24E 01  -7.87E-01   6.06E 05   1.21E 00   1.34E 00  -1.11E 00  -3.47E 02   1.11E 04  -1.50E-02   1.15E-03  -2.27E 03
2.40E 01  -6.87E-01   5.27E 05   1.13E 00   1.29E 00  -1.26E 00  -3.24E 02   1.06E 04  -1.53E-02   1.08E-03  -2.38E 03
2.56E 01  -5.69E-01   4.35E 05   1.03E 00   1.22E 00  -1.39E 00  -2.85E 02   1.01E 04  -1.50E-02   9.55E-04  -2.37E 03
2.72E 01  -4.37E-01   3.32E 05   9.21E-01   1.14E 00  -1.50E 00  -2.31E 02   9.38E 03  -1.42E-02   7.80E-04  -2.25E 03
2.88E 01  -2.94E-01   2.20E 05   7.98E-01   1.04E 00  -1.58E 00  -1.62E 02   8.60E 03  -1.27E-02   5.56E-04  -2.02E 03
3.04E 01  -1.44E-01   1.02E 05   6.66E-01   9.27E-01  -1.64E 00  -7.93E 01   7.74E 03  -1.07E-02   2.87E-04  -1.67E 03
3.20E 01   1.10E-02  -1.94E 04   5.29E-01   8.06E-01  -1.66E 00   1.59E 01   6.82E 03  -8.07E-03  -2.31E-05  -1.21E 03
3.36E 01   1.66E-01  -1.40E 05   3.92E-01   6.77E-01  -1.63E 00   1.21E 02   5.85E 03  -4.98E-03  -3.66E-04  -6.54E 02
3.52E 01   3.17E-01  -2.59E 05   2.57E-01   5.43E-01  -1.57E 00   2.34E 02   4.86E 03  -1.47E-03  -7.34E-04  -1.06E 01
3.68E 01   4.60E-01  -3.71E 05   1.32E-01   4.38E-01  -1.46E 00   3.52E 02   3.87E 03   2.37E-03  -1.12E-03   7.02E 02
3.84E 01   5.93E-01  -4.75E 05   2.02E-02   2.75E-01  -1.30E 00   4.71E 02   2.91E 03   6.42E-03  -1.50E-03   1.46E 03
4.00E 01   7.11E-01  -5.68E 05  -7.29E-02   1.49E-01  -1.09E 00   5.87E 02   2.01E 03   1.06E-02  -1.88E-03   2.25E 03
4.16E 01   8.12E-01  -6.48E 05  -1.43E-01   3.28E-02  -8.40E-01   6.96E 02   1.20E 03   1.47E-02  -2.23E-03   3.04E 03
4.32E 01   8.93E-01  -7.12E 05  -1.85E-01  -6.37E-02  -5.47E-01   7.96E 02   5.04E 02   1.86E-02  -2.55E-03   3.80E 03
4.48E 01   9.52E-01  -7.59E 05  -1.97E-01  -1.52E-01  -2.19E-01   8.81E 02  -4.85E 01   2.23E-02  -2.83E-03   4.51E 03
4.64E 01   9.88E-01  -7.88E 05  -1.75E-01  -2.13E-01   1.40E-01   9.49E 02  -4.31E 02   2.55E-02  -3.04E-03   5.14E 03
4.80E 01   1.00E 00  -7.99E 05  -1.18E-01  -2.49E-01   5.20E-01   9.96E 02  -6.22E 02   2.81E-02  -3.19E-03   5.67E 03
```

Case 2b Input

```
      2     2     5     1     3     1
     30     9     0     1     0     0     1
-3250    +04-10       +02 6450    +04
 1       -02
 105     +00 5        +00 163     +00
 5       +00 625      +01 625     +01 1        +01 1        +01
 22      +00 0        +00 1687    +01 0        +00
 1980815 +05 90       +02 103877  +03
10103
 10065   +01
```

Case 2b Output

```
          BUCKLING OF A SPHERICAL SHELL SEGMENT

RHO CORRESPONDS TO AXIAL LOAD(LBS/IN)

ANALYSIS IS FOR A SHELL STIFFENED BY RINGS AND STRINGERS,

MODULUS OF ELASTICITY= 0.10500000E 08     POISSON RATIO= 0,30000000E 00     SHELL THICKNESS= 0,16300000E 00

STRINGER SPACING= 0.62500000E 01     RING SPACING= 0.62500000E 01

EXTERNAL STRINGERS, EXTERNAL RINGS.

RECTANGULAR STIFFENER DATA.
STRINGER THICKNESS= 0,22000000E 00     RING THICKNESS= 0,00000000E-38
STRINGER    HEIGHT= 0.16870000E 01     RING    HEIGHT= 0.00000000E-38

RADIUS= 0,19808150E 03          POLAR ANGLE A(DEG.)= 0.90000000E 02          POLAR ANGLE B(DEG.)= 0,10387700E 03

NUMBER OF INTERVALS= 30

R1V10=-0.00000000E-38          P0=-0.00000000E-38          RATIO=-0.00000000E-38

SYMMETRY AT A

AT B -- SIMPLE BOUNDARY CONDITIONS

AT B -- AXIAL LOAD IS APPLIED  1.006500 IN OUTSIDE OF INNER SURFACE

AT B -- RADIAL DISPLACEMENT IS ZERO

AT B -- MOMENT IS ZERO

AT B -- TANGENTIAL DISPLACEMENT IS ZERO

AT B -- AXIAL LOAD IS ZERO
```

Case 2b Output (Continued)

```
                                                        CURRENT VALUE OF N IS    0
DETERMINANT =   1.40011E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -8.25000E 03
DETERMINANT =   1.35971E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.26000E 03
DETERMINANT =   1.31977E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.27000E 03
DETERMINANT =   1.28031E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.28000E 03
DETERMINANT =   1.24139E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.29000E 03
DETERMINANT =   1.20308E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.30000E 03
DETERMINANT =   1.16544E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.31000E 03
DETERMINANT =   1.12860E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.32000E 03
DETERMINANT =   1.09266E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.33000E 03
DETERMINANT =   1.05782E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.34000E 03
DETERMINANT =   1.02431E 02 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -8.35000E 03
DETERMINANT =   9.92414E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -8.36000E 03
DETERMINANT =   9.62437E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -8.37000E 03
DETERMINANT =   9.34738E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -8.38000E 03
DETERMINANT =   9.09594E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -8.39000E 03
DETERMINANT =   8.87133E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -8.40000E 03
DETERMINANT =   8.67217E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -8.41000E 03
DETERMINANT =   8.49392E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -8.42000E 03
DETERMINANT =   8.32628E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -8.43000E 03
DETERMINANT =   8.12323E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  4 ITERATIONS.  RHO = -8.44000E 03
DETERMINANT =   8.11964E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.44010E 03
DETERMINANT =   8.11589E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.44020E 03
DETERMINANT =   8.11175E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.44030E 03
DETERMINANT =   8.10744E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.44040E 03
DETERMINANT =   8.10273E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.44050E 03
DETERMINANT =   8.09734E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS.  RHO = -8.44060E 03
DETERMINANT =   8.09103E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -8.44070E 03
DETERMINANT =   8.08281E 01 TIMES 10 TO THE 100TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -8.44080E 03
SHELL COLLAPSES AXISYMMETRICALLY BEFORE BIFURCATION INTO     0  WAVES.
```

Case 3 Input

```
    2      1      1      1      3      0      1
   39      5     15      1     23     15      1

  1       -02
  105     +03 5         +00 163       +00
  0       +00 625       +01 625       +01 1         +01 1         +01
  22      +00 0         +00 1687      +01 0         +00
  1696    +03 9647      +02 10        +02
 10102
 10102
```

Case 3 Output

```
          BUCKLING OF A CYLINDER OR CONE

RHO CORRESPONDS TO AXIAL LOAD(LBS/IN)

ANALYSIS IS FOR A SHELL STIFFENED BY RINGS AND STRINGERS,

MODULUS OF ELASTICITY= 0,10500000E 08     POISSON RATIO= 0,30000000E 00     SHELL THICKNESS= 0,16300000E 00

STRINGER SPACING= 0.62500000E 01     RING SPACING= 0.62500000E 01

EXTERNAL STRINGERS, EXTERNAL RINGS,

RECTANGULAR STIFFENER DATA,
STRINGER THICKNESS= 0,22000000E 00     RING THICKNESS= 0,00000000E-38
STRINGER    HEIGHT= 0,16870000E 01     RING    HEIGHT= 0.00000000E-38

RADIUS AT SMALL END= 0,18960000E 03          SLANT HEIGHT= 0.96470000E 02          HALF ANGLE(DEG,)= 0,10000000E 02

NUMBER OF INTERVALS= 39

R1V10=-0,00000000E-38          P0=-0.00000000E-38          RATIO=-0,00000000E-38

AT A -- SIMPLE BOUNDARY CONDITIONS

AT A -- AXIAL LOAD IS APPLIED THROUGH SHEAR CENTER

AT A -- RADIAL DISPLACEMENT IS ZERO

AT A -- MOMENT IS ZERO

AT A -- TANGENTIAL DISPLACEMENT IS ZERO

AT A -- AXIAL LOAD IS ZERO

AT B -- SIMPLE BOUNDARY CONDITIONS

AT B -- AXIAL LOAD IS APPLIED THROUGH SHEAR CENTER

AT B -- RADIAL DISPLACEMENT IS ZERO

AT B -- MOMENT IS ZERO

AT B -- TANGENTIAL DISPLACEMENT IS ZERO

AT B -- AXIAL LOAD IS ZERO
```

Case 3 Output (Continued)

```
                                               CURRENT VALUE OF N IS  15
THE BUCKLING PARAMETER CALCULATED FROM LINEAR THEORY IS   -2.7328E 03. THE NUMBER OF CIRCUMFERENTIAL WAVES IS 15


                                               CURRENT VALUE OF N IS  16
THE BUCKLING PARAMETER CALCULATED FROM LINEAR THEORY IS   -2.5151E 03. THE NUMBER OF CIRCUMFERENTIAL WAVES IS 16


                                               CURRENT VALUE OF N IS  17
THE BUCKLING PARAMETER CALCULATED FROM LINEAR THEORY IS   -2.3584E 03. THE NUMBER OF CIRCUMFERENTIAL WAVES IS 17


                                               CURRENT VALUE OF N IS  18
THE BUCKLING PARAMETER CALCULATED FROM LINEAR THEORY IS   -2.2514E 03. THE NUMBER OF CIRCUMFERENTIAL WAVES IS 18


                                               CURRENT VALUE OF N IS  19
THE BUCKLING PARAMETER CALCULATED FROM LINEAR THEORY IS   -2.1861E 03. THE NUMBER OF CIRCUMFERENTIAL WAVES IS 19


                                               CURRENT VALUE OF N IS  20
THE BUCKLING PARAMETER CALCULATED FROM LINEAR THEORY IS   -2.1577E 03. THE NUMBER OF CIRCUMFERENTIAL WAVES IS 20


                                               CURRENT VALUE OF N IS  21
THE BUCKLING PARAMETER CALCULATED FROM LINEAR THEORY IS   -2.1616E 03. THE NUMBER OF CIRCUMFERENTIAL WAVES IS 21


                                               CURRENT VALUE OF N IS  22
THE BUCKLING PARAMETER CALCULATED FROM LINEAR THEORY IS   -2.1963E 03. THE NUMBER OF CIRCUMFERENTIAL WAVES IS 22


                                               CURRENT VALUE OF N IS  23
THE BUCKLING PARAMETER CALCULATED FROM LINEAR THEORY IS   -2.2600E 03. THE NUMBER OF CIRCUMFERENTIAL WAVES IS 23
```

Case 4 Input

```
     4     1     5     1     3     1     0     1
    50     5     9     1    14     9     1
-706     +03-2       +01 728     +03
 1       -02
 105     +08 45      +06 2       +00 4       +00 6       +01 0       +00
 863     -02 863     -02 863     -02 863     -02 863     -02 863     -02
 35      +00 35      +00 35      +00 35      +00 35      +00 35      +00
 90      +02 25      +02 90      +02 25      +02 90      +02 25      +02
 2       +00 2       +00 2       +00 2       +00 2       +00 2       +00
 75      +01 75      +01 0       +00
11111
```

Case 4 Output

```
          BUCKLING OF A CYLINDER OR CONE


RHO CORRESPONDS TO AXIAL LOAD(LBS/IN)

ANALYSIS IS FOR A FIBER REINFORCED SHELL.

FIBER  MODULUS=   .10500000+08     FIBER  POISSON RATIO=   .20000000-00
MATRIX MODULUS=   .45000000+06     MATRIX POISSON RATIO=   .40000000-00

             LAYER          THICKNESS      MATRIX CONTENT       WINDING ANGLE   CONTIGUITY FACTOR
               1         .86299999-02       .34999999-00        .90000000+02        .20000000-00
               2         .86299999-02       .34999999-00        .25000000+02        .20000000-00
               3         .86299999-02       .34999999-00        .90000000+02        .20000000-00
               4         .86299999-02       .34999999-00        .25000000+02        .20000000-00
               5         .86299999-02       .34999999-00        .90000000+02        .20000000-00
               6         .86299999-02       .34999999-00        .25000000+02        .20000000-00

RADIUS AT SMALL END=   .75000000+01          SLANT HEIGHT=   .75000000+01          HALF ANGLE(DEG.)=  -.00000000


NUMBER OF INTERVALS= 50

RIVIO=  -.00000000             PO=  -.00000000             RATIO=  -.00000000

SYMMETRY AT A

AT B -- SIMPLE BOUNDARY CONDITIONS

AT B -- AXIAL LOAD IS APPLIED THROUGH NEUTRAL SURFACE

AT B -- RADIAL DISPLACEMENT IS ZERO

AT B -- ROTATION IS ZERO

AT B -- TANGENTIAL DISPLACEMENT IS ZERO

AT B -- AXIAL DISPLACEMENT IS ZERO
```

Case 4 Output (Continued)

```
ELAPSED TIME TO THIS POINT IS 00:00:00.089
                                        CURRENT VALUE OF N IS   9
DETERMINANT =   -1.71753-03 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.06000+02
DETERMINANT =   -1.33675-03 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.08000+02
DETERMINANT =   -1.02973-03 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.10000+02
DETERMINANT =   -7.[illegible]4617-04 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.12000+02
DETERMINANT =   -5.[illegible]379-04 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.14000+02
DETERMINANT =   -4.35081-04 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.16000+02
DETERMINANT =   -3.20157-04 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.18000+02
DETERMINANT =   -2.29704-04 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.20000+02
DETERMINANT =   -1.61716-04 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.22000+02
DETERMINANT =   -1.10766-04 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.24000+02
DETERMINANT =   -7.37689-05 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.26000+02
DETERMINANT =   -4.71841-05 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.28000+02
ELAPSED TIME TO THIS POINT IS 00:00:04.511



                                        CURRENT VALUE OF N IS  10
DETERMINANT =   -3.36210-03 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.06000+02
DETERMINANT =   -2.11601-03 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.08000+02
DETERMINANT =   -1.24100-03 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.10000+02
DETERMINANT =   -6.53735-04 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.12000+02
DETERMINANT =   -2.79314-04 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.14000+02
DETERMINANT =   -5.88448-05 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.16000+02
DETERMINANT =     5.44282-05 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.18000+02
DETERMINANT =     9.67967-05 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.20000+02
DETERMINANT =     9.54014-05 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.22000+02
DETERMINANT =     7.33404-05 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.24000+02
DETERMINANT =     4.25181-05 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.26000+02
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Case 4 Output (Continued)

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DETERMINANT =    1.36722-05 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.28000+02
ELAPSED TIME TO THIS POINT IS 00:00:08.948



                                               CURRENT VALUE OF N IS  11
DETERMINANT =   -7.80006-02 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.06000+02
DETERMINANT =   -4.26374-02 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.08000+02
DETERMINANT =   -1.87448-02 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.10000+02
DETERMINANT =   -3.65585-03 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.12000+02
DETERMINANT =    4.99856-03 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.14000+02
DETERMINANT =    9.04239-03 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.16000+02
DETERMINANT =    9.97201-03 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.18000+02
DETERMINANT =    8.97174-03 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.20000+02
DETERMINANT =    6.95957-03 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.22000+02
DETERMINANT =    4.58073-03 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.24000+02
DETERMINANT =    2.36887-03 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.26000+02
DETERMINANT =    6.25446-04 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.28000+02
ELAPSED TIME TO THIS POINT IS 00:00:13.147



                                               CURRENT VALUE OF N IS  12
DETERMINANT =   -3.88491-09 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.06000+02
DETERMINANT =   -2.99472-09 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.08000+02
DETERMINANT =   -2.26911-09 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.10000+02
DETERMINANT =   -1.68148-09 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.12000+02
DETERMINANT =   -1.21426-09 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.14000+02
DETERMINANT =   -8.45950-10 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.16000+02
DETERMINANT =   -5.60344-10 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.18000+02
DETERMINANT =   -3.44279-10 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.20000+02
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Case 4 Output (Continued)

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DETERMINANT =   -1.84411-10 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.22000+02
DETERMINANT =   -7.02173-01 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.24000+02
DETERMINANT =    7.85440-02 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.26000+02
DETERMINANT =    5.73576-01 TIMES 10 TO THE -70TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.28000+02
ELAPSED TIME TO THIS POINT IS 00:00:17.438


                                                      CURRENT VALUE OF N IS  13
DETERMINANT =   -1.56663-06 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.06000+02
DETERMINANT =   -1.35928-06 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.08000+02
DETERMINANT =   -1.17528-06 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.10000+02
DETERMINANT =   -1.01270-06 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.12000+02
DETERMINANT =   -8.69041-07 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.14000+02
DETERMINANT =   -7.42770-07 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.16000+02
DETERMINANT =   -6.32068-07 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.18000+02
DETERMINANT =   -5.35193-07 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.20000+02
DETERMINANT =   -4.50746-07 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.22000+02
DETERMINANT =   -3.77520-07 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.24000+02
DETERMINANT =   -3.14090-07 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.26000+02
DETERMINANT =   -2.59449-07 TIMES 10 TO THE -60TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  0 ITERATIONS.  RHO =  -7.28000+02
ELAPSED TIME TO THIS POINT IS 00:00:21.653


                                                      CURRENT VALUE OF N IS  14
```

Case 5 Input

```
     2     1     1     1     3     1     0     0     1     1
    40     5    25     1    25    25     1
-1000    +04-100     +03 1400    +04
 1       -02
 105     +08 3       +00 153     +00
 0       +00 625     +01 625     +01 1       +01 1       +01
 22      +00 0       +00 1637    +01 0       +00
 1896    +03 9647    +02 10      +02
10103
 10065   +01
10103
 10065   +01
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Case 5 Output

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          BUCKLING OF A CYLINDER OR CONE

RHO CORRESPONDS TO AXIAL LOAD(LBS/IN)

ANALYSIS IS FOR A SHELL STIFFENED BY RINGS AND STRINGERS.

MODULUS OF ELASTICITY= 0.10500000E 08     POISSON RATIO= 0.30000000E 00     SHELL THICKNESS= 0.16300000E 00

STRINGER SPACING= 0.62500000E 01     RING SPACING= 0.62500000E 01

EXTERNAL STRINGERS. EXTERNAL RINGS.

RECTANGULAR STIFFENER DATA.
STRINGER THICKNESS= 0.22000000E 00     RING THICKNESS= 0.00000000E-38
STRINGER    HEIGHT= 0.16870000E 01     RING    HEIGHT= 0.00000000E-38

RADIUS AT SMALL END= 0.18960000E 03          SLANT HEIGHT= 0.96470000E 02          HALF ANGLE(DEG.)= 0.10000000E 02


NUMBER OF INTERVALS= 40


R1V10=-0.00000000E-38          PU=-0.00000000E-38          RATIO=-0.00000000E-38

AT A -- SIMPLE BOUNDARY CONDITIONS

AT A -- AXIAL LOAD IS APPLIED  1.006500 IN OUTSIDE OF INNER SURFACE

AT A -- RADIAL DISPLACEMENT IS ZERO

AT A -- MOMENT IS ZERO

AT A -- TANGENTIAL DISPLACEMENT IS ZERO

AT A -- AXIAL LOAD IS ZERO

AT B -- SIMPLE BOUNDARY CONDITIONS

AT B -- AXIAL LOAD IS APPLIED  1.006500 IN OUTSIDE OF INNER SURFACE

AT B -- RADIAL DISPLACEMENT IS ZERO

AT B -- MOMENT IS ZERO

AT B -- TANGENTIAL DISPLACEMENT IS ZERO

AT B -- AXIAL LOAD IS ZERO
```

Case 5 Output (Continued)

```
NUMBER OF CIRCUMFERENTIAL WAVES =  25

THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS, THE CURRENT LOADING INCREMENT IS   -1.00000E 02,        RHO =   -1.00000E 03

                                                  PREBUCKLING QUANTITIES

 ARC             RADIUS*HORIZONTAL        HORIZONTAL            MERIDIONAL            MERIDIONAL            MERIDIONAL
LENGTH             FORCE/LENGTH          DISPLACEMENT             STRESS              CHANGE IN               MOMENT
                                                                RESULTANT             CURVATURE
         MERIDIONAL             NORMAL               VERTICAL           CIRCUMFERENTIAL       CIRCUMFERENTIAL
          ROTATION           DISPLACEMENT          DISPLACEMENT             STRESS              CHANGE IN
                                                                          RESULTANT             CURVATURE
   S         BETA        RH          W          UH         UV        N10        N20      CURV1      CURV2         M1

0.00E-39  -8.43E-03  -2.33E 04   6.63E-09   6.73E-09   0.00E-39  -1.01E 03  -6.49E 01   7.25E-03  -4.38E-05   9.21E 02
2.41E 00  -5.63E-03  -2.37E 04  -1.70E-02  -1.68E-02   2.59E-03  -1.00E 03  -2.42E 02   6.23E-03  -2.94E-05   8.12E 02
4.82E 00  -3.27E-03  -2.45E 04  -2.77E-02  -2.74E-02   4.07E-03  -1.00E 03  -3.62E 02   5.18E-03  -1.72E-05   7.05E 02
7.24E 00  -1.34E-03  -2.55E 04  -3.32E-02  -3.29E-02   4.60E-03  -1.00E 03  -4.35E 02   4.16E-03  -7.04E-06   6.03E 02
9.65E 00   1.82E-04  -2.66E 04  -3.46E-02  -3.44E-02   4.33E-03  -1.00E 03  -4.69E 02   3.21E-03   9.63E-07   5.12E 02
1.21E 01   1.32E-03  -2.78E 04  -3.28E-02  -3.27E-02   3.42E-03  -9.99E 02  -4.72E 02   2.35E-03   7.00E-06   4.31E 02
1.45E 01   2.13E-03  -2.89E 04  -2.87E-02  -2.87E-02   2.02E-03  -9.98E 02  -4.51E 02   1.60E-03   1.13E-05   3.63E 02
1.69E 01   2.65E-03  -2.99E 04  -2.29E-02  -2.32E-02   2.60E-04  -9.97E 02  -4.14E 02   9.73E-04   1.40E-05   3.06E 02
1.93E 01   2.94E-03  -3.09E 04  -1.62E-02  -1.67E-02  -1.74E-03  -9.95E 02  -3.66E 02   4.58E-04   1.55E-05   2.62E 02
2.17E 01   3.03E-03  -3.17E 04  -8.96E-03  -9.78E-03  -3.88E-03  -9.94E 02  -3.11E 02   5.18E-05   1.60E-05   2.27E 02
2.41E 01   2.98E-03  -3.24E 04  -1.71E-03  -2.81E-03  -6.09E-03  -9.93E 02  -2.55E 02  -2.56E-04   1.57E-05   2.02E 02
2.65E 01   2.82E-03  -3.29E 04   5.28E-03   3.90E-03  -8.29E-03  -9.91E 02  -1.99E 02  -4.79E-04   1.48E-05   1.85E 02
2.89E 01   2.58E-03  -3.33E 04   1.18E-02   1.01E-02  -1.04E-02  -9.89E 02  -1.46E 02  -6.31E-04   1.35E-05   1.75E 02
3.14E 01   2.30E-03  -3.36E 04   1.77E-02   1.57E-02  -1.25E-02  -9.87E 02  -9.72E 01  -7.26E-04   1.20E-05   1.69E 02
3.38E 01   1.98E-03  -3.38E 04   2.28E-02   2.06E-02  -1.45E-02  -9.85E 02  -5.44E 01  -7.78E-04   1.03E-05   1.67E 02
3.62E 01   1.65E-03  -3.39E 04   2.72E-02   2.47E-02  -1.63E-02  -9.83E 02  -1.79E 01  -7.99E-04   8.55E-06   1.67E 02
3.86E 01   1.32E-03  -3.39E 04   3.08E-02   2.81E-02  -1.80E-02  -9.81E 02   1.18E 01  -8.01E-04   6.80E-06   1.68E 02
4.10E 01   9.87E-04  -3.38E 04   3.36E-02   3.06E-02  -1.96E-02  -9.79E 02   3.46E 01  -7.92E-04   5.06E-06   1.70E 02
4.34E 01   6.61E-04  -3.37E 04   3.55E-02   3.24E-02  -2.10E-02  -9.77E 02   5.05E 01  -7.81E-04   3.39E-06   1.72E 02
4.58E 01   3.39E-04  -3.36E 04   3.68E-02   3.34E-02  -2.23E-02  -9.75E 02   5.94E 01  -7.71E-04   1.74E-06   1.73E 02
4.82E 01   2.12E-05  -3.34E 04   3.72E-02   3.36E-02  -2.35E-02  -9.72E 02   6.15E 01  -7.67E-04   1.08E-07   1.73E 02
5.06E 01  -2.96E-04  -3.33E 04   3.69E-02   3.31E-02  -2.45E-02  -9.70E 02   5.67E 01  -7.68E-04  -1.51E-06   1.72E 02
5.31E 01  -6.16E-04  -3.32E 04   3.58E-02   3.18E-02  -2.54E-02  -9.68E 02   4.53E 01  -7.73E-04  -3.12E-06   1.70E 02
5.55E 01  -9.38E-04  -3.31E 04   3.39E-02   2.98E-02  -2.61E-02  -9.66E 02   2.71E 01  -7.79E-04  -4.74E-06   1.68E 02
5.79E 01  -1.26E-03  -3.30E 04   3.12E-02   2.70E-02  -2.67E-02  -9.64E 02   2.46E 00  -7.80E-04  -6.36E-06   1.65E 02
6.03E 01  -1.58E-03  -3.31E 04   2.78E-02   2.34E-02  -2.72E-02  -9.62E 02  -2.86E 01  -7.69E-04  -7.96E-06   1.64E 02
6.27E 01  -1.90E-03  -3.32E 04   2.36E-02   1.91E-02  -2.75E-02  -9.60E 02  -6.56E 01  -7.37E-04  -9.51E-06   1.63E 02
6.51E 01  -2.20E-03  -3.34E 04   1.87E-02   1.41E-02  -2.77E-02  -9.58E 02  -1.08E 02  -6.73E-04  -1.10E-05   1.66E 02
6.75E 01  -2.46E-03  -3.37E 04   1.31E-02   8.38E-03  -2.77E-02  -9.57E 02  -1.55E 02  -5.66E-04  -1.22E-05   1.72E 02
6.99E 01  -2.66E-03  -3.41E 04   6.88E-03   2.12E-03  -2.76E-02  -9.55E 02  -2.06E 02  -4.03E-04  -1.32E-05   1.83E 02
7.24E 01  -2.79E-03  -3.47E 04   3.07E-04  -4.52E-03  -2.74E-02  -9.53E 02  -2.58E 02  -1.74E-04  -1.38E-05   2.00E 02
7.48E 01  -2.81E-03  -3.54E 04  -6.44E-03  -1.13E-02  -2.71E-02  -9.52E 02  -3.09E 02   1.34E-04  -1.39E-05   2.25E 02
7.72E 01  -2.68E-03  -3.62E 04  -1.31E-02  -1.80E-02  -2.68E-02  -9.51E 02  -3.58E 02   5.30E-04  -1.32E-05   2.58E 02
7.96E 01  -2.37E-03  -3.71E 04  -1.92E-02  -2.41E-02  -2.65E-02  -9.50E 02  -3.99E 02   1.02E-03  -1.17E-05   3.00E 02
8.20E 01  -1.83E-03  -3.81E 04  -2.42E-02  -2.92E-02  -2.64E-02  -9.48E 02  -4.29E 02   1.61E-03  -9.04E-06   3.53E 02
8.44E 01  -1.03E-03  -3.92E 04  -2.77E-02  -3.28E-02  -2.64E-02  -9.47E 02  -4.43E 02   2.30E-03  -5.10E-06   4.16E 02
8.68E 01   7.13E-05  -4.02E 04  -2.88E-02  -3.40E-02  -2.68E-02  -9.46E 02  -4.36E 02   3.07E-03   3.52E-07   4.89E 02
8.92E 01   1.52E-03  -4.13E 04  -2.69E-02  -3.22E-02  -2.76E-02  -9.45E 02  -4.01E 02   3.93E-03   7.50E-06   5.70E 02
9.16E 01   3.33E-03  -4.22E 04  -2.11E-02  -2.65E-02  -2.90E-02  -9.44E 02  -3.31E 02   4.83E-03   1.65E-05   6.59E 02
9.41E 01   5.52E-03  -4.29E 04  -1.04E-02  -1.61E-02  -3.12E-02  -9.43E 02  -2.21E 02   5.74E-03   2.75E-05   7.53E 02
9.65E 01   8.09E-03  -4.32E 04   5.98E-03   8.64E-09  -3.44E-02  -9.42E 02  -6.42E 01   6.62E-03   4.05E-05   8.46E 02
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Case 5 Output (Continued)

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                                                    MAIN DIAGONAL OF FACTORED A(I,J), N NOT EQUAL 0

 -1.2946E-01   2.0245E-01  -4.0526E-01   4.3397E-01  -9.1947E-01   4.1531E-01  -7.7489E-01  -8.0945E-01  -4.9204E-01  -4.6710E-01
 -3.9191E-01  -3.5699E-01  -3.4807E-01  -3.0483E-01  -3.2530E-01  -2.7476E-01  -3.1233E-01  -2.5531E-01  -3.0452E-01  -2.4173E-01
 -2.9959E-01  -2.3171E-01  -2.9636E-01  -2.2400E-01  -2.9415E-01  -2.1766E-01  -2.9258E-01  -2.1284E-01  -2.9142E-01  -2.0866E-01
 -2.9052E-01  -2.0512E-01  -2.8979E-01  -2.0208E-01  -2.8919E-01  -1.9947E-01  -2.8868E-01  -1.9721E-01  -2.8823E-01  -1.9524E-01
 -2.8783E-01  -1.9355E-01  -2.8747E-01  -1.9209E-01  -2.8715E-01  -1.9084E-01  -2.8686E-01  -1.8977E-01  -2.8660E-01  -1.8888E-01
 -2.8638E-01  -1.8813E-01  -2.8618E-01  -1.8751E-01  -2.8600E-01  -1.8699E-01  -2.8585E-01  -1.8655E-01  -2.8572E-01  -1.8616E-01
 -2.8561E-01  -1.8577E-01  -2.8550E-01  -1.8536E-01  -2.8539E-01  -1.8487E-01  -2.8528E-01  -1.8427E-01  -2.8517E-01  -1.8350E-01
 -2.8504E-01  -1.8252E-01  -2.8491E-01  -1.8126E-01  -2.8477E-01  -1.7967E-01  -2.8463E-01  -1.7768E-01  -2.8449E-01  -1.7521E-01
 -2.8439E-01  -1.7214E-01  -2.8435E-01  -1.6834E-01  -2.8442E-01  -1.6358E-01  -4.6960E-02   5.6901E 00  -6.1462E-02   7.0254E-03

DETERMINANT =  -5.51565E-05 TIMES 10 TO THE -50TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  3 ITERATIONS.  RHO = -1.00000E 03
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Case 5 Output (Continued)

```
          NUMBER OF CIRCUMFERENTIAL WAVES =  25

THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS. THE CURRENT LOADING INCREMENT IS   -1.00000E 02.        RHO =   -1.10000E 03

                                                                      PREBUCKLING QUANTITIES

   ARC            RADIUS*HORIZONTAL            HORIZONTAL               MERIDIONAL               MERIDIONAL               MERIDIONAL
  LENGTH            FORCE/LENGTH              DISPLACEMENT                STRESS                CHANGE IN                 MOMENT
                                                                        RESULTANT                CURVATURE
            MERIDIONAL               NORMAL                 VERTICAL           CIRCUMFERENTIAL         CIRCUMFERENTIAL
             ROTATION             DISPLACEMENT            DISPLACEMENT              STRESS               CHANGE IN
                                                                                  RESULTANT              CURVATURE
    S         BETA        RH          W           UH          UV         N10        N20        CURV1       CURV2        M1

 0.00E-39  -9.34E-03  -2.56E 04  -6.63E-09  -6.73E-09   0.00E-39  -1.11E 03  -7.14E 01   7.97E-03  -4.84E-05   1.01E 03
 2.41E 00  -6.25E-03  -2.61E 04  -1.88E-02  -1.86E-02   2.87E-03  -1.11E 03  -2.67E 02   6.87E-03  -3.26E-05   8.95E 02
 4.82E 00  -3.64E-03  -2.69E 04  -3.07E-02  -3.04E-02   4.52E-03  -1.10E 03  -4.01E 02   5.73E-03  -1.91E-05   7.78E 02
 7.24E 00  -1.50E-03  -2.80E 04  -3.69E-02  -3.66E-02   5.12E-03  -1.10E 03  -4.82E 02   4.61E-03  -7.92E-06   6.67E 02
 9.65E 00   1.81E-04  -2.93E 04  -3.85E-02  -3.83E-02   4.84E-03  -1.10E 03  -5.19E 02   3.56E-03   9.58E-07   5.66E 02
 1.21E 01   1.45E-03  -3.05E 04  -3.66E-02  -3.65E-02   3.85E-03  -1.10E 03  -5.23E 02   2.62E-03   7.68E-06   4.77E 02
 1.45E 01   2.35E-03  -3.18E 04  -3.20E-02  -3.21E-02   2.31E-03  -1.10E 03  -5.00E 02   1.79E-03   1.24E-05   4.01E 02
 1.69E 01   2.94E-03  -3.29E 04  -2.56E-02  -2.59E-02   3.73E-04  -1.10E 03  -4.59E 02   1.09E-03   1.55E-05   3.39E 02
 1.93E 01   3.26E-03  -3.40E 04  -1.81E-02  -1.87E-02  -1.84E-03  -1.10E 03  -4.05E 02   5.21E-04   1.72E-05   2.89E 02
 2.17E 01   3.37E-03  -3.49E 04  -1.01E-02  -1.10E-02  -4.21E-03  -1.09E 03  -3.45E 02   6.81E-05   1.78E-05   2.51E 02
 2.41E 01   3.32E-03  -3.57E 04  -2.09E-03  -3.29E-03  -6.65E-03  -1.09E 03  -2.82E 02  -2.77E-04   1.74E-05   2.23E 02
 2.65E 01   3.14E-03  -3.63E 04   5.70E-03   4.18E-03  -9.08E-03  -1.09E 03  -2.20E 02  -5.27E-04   1.65E-05   2.04E 02
 2.89E 01   2.88E-03  -3.67E 04   1.30E-02   1.11E-02  -1.15E-02  -1.09E 03  -1.61E 02  -6.98E-04   1.51E-05   1.92E 02
 3.14E 01   2.56E-03  -3.70E 04   1.95E-02   1.74E-02  -1.38E-02  -1.09E 03  -1.06E 02  -8.06E-04   1.34E-05   1.85E 02
 3.38E 01   2.21E-03  -3.72E 04   2.53E-02   2.28E-02  -1.59E-02  -1.08E 03  -5.87E 01  -8.66E-04   1.15E-05   1.83E 02
 3.62E 01   1.84E-03  -3.73E 04   3.02E-02   2.75E-02  -1.80E-02  -1.08E 03  -1.79E 01  -8.91E-04   9.55E-06   1.83E 02
 3.86E 01   1.47E-03  -3.73E 04   3.41E-02   3.12E-02  -1.98E-02  -1.08E 03   1.53E 01  -8.94E-04   7.60E-06   1.84E 02
 4.10E 01   1.10E-03  -3.72E 04   3.73E-02   3.40E-02  -2.16E-02  -1.08E 03   4.07E 01  -8.86E-04   5.68E-06   1.86E 02
 4.34E 01   7.38E-04  -3.71E 04   3.95E-02   3.60E-02  -2.32E-02  -1.07E 03   5.85E 01  -8.73E-04   3.79E-06   1.88E 02
 4.58E 01   3.78E-04  -3.70E 04   4.08E-02   3.71E-02  -2.46E-02  -1.07E 03   6.84E 01  -8.63E-04   1.94E-06   1.89E 02
 4.82E 01   2.22E-05  -3.68E 04   4.13E-02   3.74E-02  -2.59E-02  -1.07E 03   7.08E 01  -8.58E-04   1.13E-07   1.89E 02
 5.06E 01  -3.33E-04  -3.66E 04   4.09E-02   3.68E-02  -2.70E-02  -1.07E 03   6.55E 01  -8.59E-04  -1.69E-06   1.88E 02
 5.31E 01  -6.90E-04  -3.65E 04   3.97E-02   3.54E-02  -2.80E-02  -1.06E 03   5.26E 01  -8.65E-04  -3.50E-06   1.86E 02
 5.55E 01  -1.05E-03  -3.64E 04   3.76E-02   3.31E-02  -2.88E-02  -1.06E 03   3.24E 01  -8.70E-04  -5.31E-06   1.84E 02
 5.79E 01  -1.41E-03  -3.63E 04   3.46E-02   3.00E-02  -2.95E-02  -1.06E 03   4.77E 00  -8.71E-04  -7.11E-06   1.81E 02
 6.03E 01  -1.77E-03  -3.63E 04   3.08E-02   2.60E-02  -3.00E-02  -1.06E 03  -2.99E 01  -8.57E-04  -8.90E-06   1.79E 02
 6.27E 01  -2.12E-03  -3.65E 04   2.61E-02   2.12E-02  -3.03E-02  -1.06E 03  -7.12E 01  -8.19E-04  -1.06E-05   1.79E 02
 6.51E 01  -2.45E-03  -3.67E 04   2.06E-02   1.55E-02  -3.05E-02  -1.05E 03  -1.19E 02  -7.46E-04  -1.22E-05   1.82E 02
 6.75E 01  -2.74E-03  -3.70E 04   1.43E-02   9.17E-03  -3.05E-02  -1.05E 03  -1.71E 02  -6.25E-04  -1.36E-05   1.89E 02
 6.99E 01  -2.97E-03  -3.75E 04   7.44E-03   2.20E-03  -3.04E-02  -1.05E 03  -2.27E 02  -4.42E-04  -1.47E-05   2.01E 02
 7.24E 01  -3.11E-03  -3.81E 04   1.15E-04  -5.19E-03  -3.01E-02  -1.05E 03  -2.85E 02  -1.85E-04  -1.54E-05   2.21E 02
 7.48E 01  -3.12E-03  -3.89E 04  -7.40E-03  -1.28E-02  -2.98E-02  -1.05E 03  -3.43E 02   1.59E-04  -1.54E-05   2.48E 02
 7.72E 01  -2.98E-03  -3.98E 04  -1.47E-02  -2.02E-02  -2.94E-02  -1.05E 03  -3.96E 02   6.01E-04  -1.47E-05   2.85E 02
 7.96E 01  -2.62E-03  -4.08E 04  -2.15E-02  -2.70E-02  -2.91E-02  -1.04E 03  -4.42E 02   1.15E-03  -1.29E-05   3.32E 02
 8.20E 01  -2.03E-03  -4.19E 04  -2.71E-02  -3.26E-02  -2.89E-02  -1.04E 03  -4.75E 02   1.80E-03  -9.97E-06   3.91E 02
 8.44E 01  -1.13E-03  -4.31E 04  -3.09E-02  -3.65E-02  -2.90E-02  -1.04E 03  -4.91E 02   2.56E-03  -5.57E-06   4.60E 02
 8.68E 01   9.86E-05  -4.43E 04  -3.22E-02  -3.78E-02  -2.94E-02  -1.04E 03  -4.82E 02   3.42E-03   4.87E-07   5.40E 02
 8.92E 01   1.70E-03  -4.54E 04  -3.00E-02  -3.58E-02  -3.03E-02  -1.04E 03  -4.43E 02   4.35E-03   8.42E-06   6.30E 02
 9.16E 01   3.71E-03  -4.64E 04  -2.35E-02  -2.94E-02  -3.19E-02  -1.04E 03  -3.66E 02   5.34E-03   1.84E-05   7.28E 02
 9.41E 01   6.13E-03  -4.72E 04  -1.16E-02  -1.78E-02  -3.43E-02  -1.04E 03  -2.44E 02   6.33E-03   3.06E-05   8.29E 02
 9.65E 01   8.96E-03  -4.76E 04   6.58E-03   5.44E-09  -3.79E-02  -1.04E 03  -7.07E 01   7.28E-03   4.49E-05   9.31E 02
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Case 5 Output (Continued)

```
                                                MAIN DIAGONAL OF FACTORED A(I,J), N NOT EQUAL 0

 -1,2952E-01   2,0243E-01  -4,0526E-01   4,3386E-01  -9,2002E-01   4,1688E-01  -7,7580E-01  -8,0976E-01  -4,9205E-01  -4,6697E-01
 -3,9191E-01  -3,5679E-01  -3,4806E-01  -3.0457E-01  -3,2529E-01  -2,7443E-01  -3,1232E-01  -2,5491E-01  -3,0450E-01  -2,4125E-01
 -2,9957E-01  -2,3114E-01  -2,9634E-01  -2,2333E-01  -2,9414E-01  -2.1709E-01  -2,9258E-01  -2,1197E-01  -2,9142E-01  -2,0768E-01
 -2,9052E-01  -2,0404E-01  -2,8981E-01  -2,0090E-01  -2,8921E-01  -1,9819E-01  -2,8870E-01  -1.9583E-01  -2,8826E-01  -1,9377E-01
 -2,8786E-01  -1,9199E-01  -2,8750E-01  -1.9044E-01  -2,8718E-01  -1,8910E-01  -2,8689E-01  -1,8796E-01  -2,8663E-01  -1,8699E-01
 -2,8641E-01  -1,8618E-01  -2,8622E-01  -1,8550E-01  -2,8606E-01  -1,8493E-01  -2,8592E-01  -1,8445E-01  -2,8581E-01  -1,8401E-01
 -2,8572E-01  -1,8358E-01  -2,8563E-01  -1,8312E-01  -2,8556E-01  -1,8257E-01  -2,8548E-01  -1,8188E-01  -2,8539E-01  -1,8100E-01
 -2.8530E-01  -1.7985E-01  -2,8520E-01  -1.7836E-01  -2,8510E-01  -1,7644E-01  -2,8500E-01  -1.7400E-01  -2,8493E-01  -1,7090E-01
 -2,8491E-01  -1,6693E-01  -2,8499E-01  -1,6179E-01  -2,8528E-01  -1,5496E-01  -8,8758E-02   2,8007E 00  -6,0254E-02  -2,7670E-02

DETERMINANT =   1.30651E-04 TIMES 10 TO THE -50TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS,  RHO = -1,10000E 03
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Case 5 Output (Continued)

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     NUMBER OF CIRCUMFERENTIAL WAVES =  25

THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS, THE CURRENT LOADING INCREMENT IS    7.03153E 01.        RHO =   -1.02968E 03

                                                       PREBUCKLING QUANTITIES

   ARC             RADIUS*HORIZONTAL          HORIZONTAL             MERIDIONAL              MERIDIONAL              MERIDIONAL
  LENGTH             FORCE/LENGTH            DISPLACEMENT              STRESS               CHANGE IN                MOMENT
                                                                      RESULTANT               CURVATURE
            MERIDIONAL             NORMAL                VERTICAL             CIRCUMFERENTIAL        CIRCUMFERENTIAL
             ROTATION           DISPLACEMENT           DISPLACEMENT              STRESS              CHANGE IN
                                                                               RESULTANT             CURVATURE
    S          BETA        RH          W          UH          UV         N10         N20        CURV1       CURV2        M1

 0.00E-39  -8.70E-03  -2.40E 04  -4.25E-09  -4.31E-09   0.00E-39  -1.04E 03  -6.68E 01   7.46E-03  -4.52E-05   9.48E 02
 2.41E 00  -5.82E-03  -2.44E 04  -1.75E-02  -1.73E-02   2.67E-03  -1.03E 03  -2.49E 02   6.42E-03  -3.04E-05   8.36E 02
 4.82E 00  -3.38E-03  -2.52E 04  -2.86E-02  -2.83E-02   4.20E-03  -1.03E 03  -3.74E 02   5.34E-03  -1.77E-05   7.26E 02
 7.24E 00  -1.39E-03  -2.62E 04  -3.43E-02  -3.40E-02   4.75E-03  -1.03E 03  -4.49E 02   4.29E-03  -7.30E-06   6.22E 02
 9.65E 00   1.83E-04  -2.74E 04  -3.58E-02  -3.55E-02   4.48E-03  -1.03E 03  -4.84E 02   3.31E-03   9.64E-07   5.28E 02
 1.21E 01   1.36E-03  -2.86E 04  -3.39E-02  -3.38E-02   3.55E-03  -1.03E 03  -4.87E 02   2.43E-03   7.20E-06   4.45E 02
 1.45E 01   2.20E-03  -2.97E 04  -2.96E-02  -2.97E-02   2.11E-03  -1.03E 03  -4.66E 02   1.66E-03   1.16E-05   3.74E 02
 1.69E 01   2.74E-03  -3.08E 04  -2.37E-02  -2.40E-02   2.92E-04  -1.03E 03  -4.27E 02   1.01E-03   1.45E-05   3.16E 02
 1.93E 01   3.03E-03  -3.18E 04  -1.67E-02  -1.73E-02  -1.77E-03  -1.03E 03  -3.78E 02   4.76E-04   1.60E-05   2.70E 02
 2.17E 01   3.13E-03  -3.26E 04  -9.31E-03  -1.02E-02  -3.98E-03  -1.02E 03  -3.21E 02   5.64E-05   1.65E-05   2.34E 02
 2.41E 01   3.08E-03  -3.33E 04  -1.82E-03  -2.95E-03  -6.25E-03  -1.02E 03  -2.63E 02  -2.62E-04   1.62E-05   2.08E 02
 2.65E 01   2.91E-03  -3.39E 04   5.40E-03   3.98E-03  -8.52E-03  -1.02E 03  -2.05E 02  -4.93E-04   1.53E-05   1.91E 02
 2.89E 01   2.67E-03  -3.43E 04   1.21E-02   1.04E-02  -1.07E-02  -1.02E 03  -1.50E 02  -6.51E-04   1.40E-05   1.80E 02
 3.14E 01   2.37E-03  -3.46E 04   1.82E-02   1.62E-02  -1.29E-02  -1.02E 03  -1.00E 02  -7.50E-04   1.24E-05   1.74E 02
 3.38E 01   2.05E-03  -3.48E 04   2.35E-02   2.13E-02  -1.49E-02  -1.01E 03  -5.57E 01  -8.04E-04   1.06E-05   1.71E 02
 3.62E 01   1.71E-03  -3.49E 04   2.81E-02   2.55E-02  -1.68E-02  -1.01E 03  -1.80E 01  -8.26E-04   8.84E-06   1.72E 02
 3.86E 01   1.36E-03  -3.49E 04   3.18E-02   2.90E-02  -1.85E-02  -1.01E 03   1.28E 01  -8.28E-04   7.04E-06   1.73E 02
 4.10E 01   1.02E-03  -3.48E 04   3.46E-02   3.16E-02  -2.02E-02  -1.01E 03   3.64E 01  -8.20E-04   5.25E-06   1.75E 02
 4.34E 01   6.83E-04  -3.47E 04   3.67E-02   3.35E-02  -2.16E-02  -1.01E 03   5.28E 01  -8.08E-04   3.51E-06   1.77E 02
 4.58E 01   3.51E-04  -3.46E 04   3.79E-02   3.45E-02  -2.30E-02  -1.00E 03   6.20E 01  -7.98E-04   1.79E-06   1.78E 02
 4.82E 01   2.15E-05  -3.44E 04   3.84E-02   3.47E-02  -2.42E-02  -1.00E 03   6.42E 01  -7.93E-04   1.10E-07   1.78E 02
 5.06E 01  -3.07E-04  -3.43E 04   3.81E-02   3.42E-02  -2.52E-02  -9.99E 02   5.93E 01  -7.95E-04  -1.56E-06   1.77E 02
 5.31E 01  -6.37E-04  -3.41E 04   3.69E-02   3.29E-02  -2.61E-02  -9.97E 02   4.74E 01  -8.00E-04  -3.23E-06   1.75E 02
 5.55E 01  -9.71E-04  -3.41E 04   3.50E-02   3.08E-02  -2.69E-02  -9.95E 02   2.86E 01  -8.06E-04  -4.90E-06   1.73E 02
 5.79E 01  -1.31E-03  -3.40E 04   3.22E-02   2.79E-02  -2.75E-02  -9.93E 02   3.11E 00  -8.07E-04  -6.58E-06   1.70E 02
 6.03E 01  -1.64E-03  -3.40E 04   2.87E-02   2.42E-02  -2.80E-02  -9.91E 02  -2.90E 01  -7.95E-04  -8.24E-06   1.68E 02
 6.27E 01  -1.97E-03  -3.41E 04   2.43E-02   1.97E-02  -2.83E-02  -9.89E 02  -6.73E 01  -7.61E-04  -9.84E-06   1.68E 02
 6.51E 01  -2.27E-03  -3.44E 04   1.92E-02   1.45E-02  -2.85E-02  -9.87E 02  -1.11E 02  -6.94E-04  -1.13E-05   1.71E 02
 6.75E 01  -2.54E-03  -3.47E 04   1.34E-02   8.61E-03  -2.85E-02  -9.85E 02  -1.60E 02  -5.83E-04  -1.27E-05   1.77E 02
 6.99E 01  -2.75E-03  -3.51E 04   7.05E-03   2.15E-03  -2.84E-02  -9.83E 02  -2.12E 02  -4.15E-04  -1.37E-05   1.88E 02
 7.24E 01  -2.89E-03  -3.57E 04   2.55E-04  -4.71E-03  -2.82E-02  -9.82E 02  -2.66E 02  -1.77E-04  -1.43E-05   2.06E 02
 7.48E 01  -2.90E-03  -3.64E 04  -6.72E-03  -1.17E-02  -2.79E-02  -9.80E 02  -3.19E 02   1.41E-04  -1.43E-05   2.32E 02
 7.72E 01  -2.77E-03  -3.72E 04  -1.36E-02  -1.86E-02  -2.76E-02  -9.79E 02  -3.69E 02   5.50E-04  -1.37E-05   2.66E 02
 7.96E 01  -2.45E-03  -3.82E 04  -1.98E-02  -2.50E-02  -2.73E-02  -9.78E 02  -4.12E 02   1.06E-03  -1.21E-05   3.10E 02
 8.20E 01  -1.89E-03  -3.92E 04  -2.51E-02  -3.02E-02  -2.71E-02  -9.77E 02  -4.43E 02   1.67E-03  -9.32E-06   3.64E 02
 8.44E 01  -1.06E-03  -4.03E 04  -2.86E-02  -3.39E-02  -2.72E-02  -9.76E 02  -4.57E 02   2.38E-03  -5.24E-06   4.29E 02
 8.68E 01   7.90E-05  -4.14E 04  -2.98E-02  -3.51E-02  -2.75E-02  -9.75E 02  -4.49E 02   3.18E-03   3.90E-07   5.04E 02
 8.92E 01   1.57E-03  -4.25E 04  -2.78E-02  -3.33E-02  -2.84E-02   9.73E 02  -4.13E 02   4.05E-03   7.77E-06   5.88E 02
 9.16E 01   3.44E-03  -4.34E 04  -2.18E-02  -2.74E-02  -2.98E-02  -9.72E 02  -3.42E 02   4.98E-03   1.71E-05   6.80E 02
 9.41E 01   5.70E-03  -4.41E 04  -1.08E-02  -1.66E-02  -3.21E-02  -9.71E 02  -2.28E 02   5.92E-03   2.84E-05   7.75E 02
 9.65E 01   8.34E-03  -4.45E 04   6.15E-03  -4.51E-09  -3.54E-02  -9.70E 02  -6.61E 01   6.82E-03   4.18E-05   8.71E 02
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Case 5 Output (Continued)

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                                            MAIN DIAGONAL OF FACTORED A(I,J), N NOT EQUAL 0

 -1,2948E-01   2.0244E-01  -4.0526F-01   4.3393E-01  -9.1963E-01   4.1577E-01  -7.7516E-01  -8,0954E-01  -4.9204E-01  -4.6706E-01
 -3,9191E-01  -3.5693E-01  -3.4806E-01  -3.0475E-01  -3.2530E-01  -2.7466E-01  -3.1233E-01  -2.5519E-01  -3.0451E-01  -2.4159E-01
 -2,9958F-01  -2.3154E-01  -2,9635E-01  -2.2380E-01  -2.9415E-01  -2.1763E-01  -2,9258E-01  -2.1259E-01  -2,9142E-01  -2.0837E-01
 -2,9052E-01  -2.0480E-01  -2.8980E-01  -2.0174E-01  -2.8920E-01  -1.9910E-01  -2,8869E-01  -1.9680E-01  -2.8824E-01  -1.9482E-01
 -2,8784F-01  -1,9310E-01  -2.8748E-01  -1.9161E-01  -2.8716E-01  -1.9034E-01  -2,8687E-01  -1,8925E-01  -2.8661E-01  -1,8834E-01
 -2,8639E-01  -1,8758E-01  -2.8619E-01  -1,8694E-01  -2.8602E-01  -1.8642E-01  -2,8587E-01  -1,8596E-01  -2.8575E-01  -1,8556E-01
 -2,8564E-01  -1.8517E-01  -2,8554F-01  -1,8474E-01  -2.8544E-01  -1.8424E-01  -2,8534E-01  -1,8362E-01  -2,8523E-01  -1.8282E-01
 -2,8511E-01  -1.8180E-01  -2,8499F-01  -1,8048E-01  -2.8485E-01  -1.7880E-01  -2,8472E-01  -1,7670E-01  -2,8460E-01  -1.7406E-01
 -2,8452E-01  -1.7077E-01  -2.8450E-01  -1.6664E-01  -2.8462E-01  -1.6138E-01  -5,6961E-02   4,6133E 00  -6,1174E-02  -8.4495E-04

DETERMINANT =   5,80030E-06 TIMES 10 TO THE -50TH POWER.  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS,  RHO = -1.02968E 03

    EIGENVECTOR INPUT FOR THE  4RD ITERATION

  2,4289E-03  -1.9693E-01   1.1717F-03  -9.8548E-02  -8.1175E-05   1.2814E-03  -1.3330E-03   1.0112E-01  -2.5860E-03   1.9956E-01
 -3,8355E-03   2.9519E-01  -5.0684E-03   3.8675E-01  -6.2647E-03   4.7309E-01  -7.3999E-03   5.5330E-01  -8.4492E-03   6.2672E-01
 -9,3903E-03   6.9290E-01  -1.0207E-02   7.5168E-01  -1.0889E-02   8.0311E-01  -1.1436E-02   8.4740E-01  -1.1853E-02   8.8493E-01
 -1,2154E-02   9.1618E-01  -1.2356E-02   9.4165E-01  -1.2479E-02   9.6190E-01  -1.2546E-02   9.7741E-01  -1.2574E-02   9.8866E-01
 -1,2583E-02   9.9600E-01  -1.2585E-02   9.9973E-01  -1.2588E-02   1.0000E 00  -1.2594E-02   9.9688E-01  -1.2598E-02   9.9031E-01
 -1.2592E-02   9.8013E-01  -1,2561E-02   9.6607E-01  -1.2487E-02   9.4779E-01  -1,2351E-02   9.2488E-01  -1.2132E-02   8.9690E-01
 -1.1811E-02   8.6338E-01  -1.1372E-02   8.2392E-01  -1.0806E-02   7.7813E-01  -1.0107E-02   7.2576E-01  -9.2791E-03   6.6669E-01
 -8,3312E-03   6.0095E-01  -7.2793F-03   5.2877E-01  -6.1437E-03   4.5061E-01  -4.9465E-03   3.6711E-01  -3.7096E-03   2.7910E-01
 -2,4510E-03   1.8758E-01  -1.1838E-03   9.3666E-02   8.4878E-05  -1.4674E-03   1.3516E-03  -9.6612E-02   2.6120E-03  -1.9056E-01

THE CORRECTION FACTOR IS    2.9280E 00
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Case 5 Output (Continued)

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     NUMBER OF CIRCUMFERENTIAL WAVES =  25

THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS. THE CURRENT LOADING INCREMENT IS    2.92796E 00.        RHO =   -1.02676E 03

                                                           PREBUCKLING QUANTITIES


   ARC               RADIUS*HORIZONTAL          HORIZONTAL              MERIDIONAL              MERIDIONAL              MERIDIONAL
  LENGTH               FORCE/LENGTH            DISPLACEMENT               STRESS               CHANGE IN                 MOMENT
                                                                         RESULTANT              CURVATURE
             MERIDIONAL              NORMAL                VERTICAL              CIRCUMFERENTIAL        CIRCUMFERENTIAL
              ROTATION            DISPLACEMENT           DISPLACEMENT                STRESS               CHANGE IN
                                                                                   RESULTANT              CURVATURE
     S          BETA        RH          W          UH          UV          N10         N20        CURV1       CURV2         M1

 0.00E-39   -8.67E-03  -2.40E 04  -3.40E-09  -3.45E-09   0.00E-39  -1.03E 03  -6.66E 01   7.44E-03  -4.51E-05   9.45E 02
 2.41E 00   -5.80E-03  -2.44E 04  -1.75E-02  -1.73E-02   2.66E-03  -1.03E 03  -2.49E 02   6.40E-03  -3.03E-05   8.34E 02
 4.82E 00   -3.37E-03  -2.52E 04  -2.85E-02  -2.82E-02   4.19E-03  -1.03E 03  -3.73E 02   5.33E-03  -1.77E-05   7.24E 02
 7.24E 00   -1.38E-03  -2.62E 04  -3.42E-02  -3.39E-02   4.74E-03  -1.03E 03  -4.48E 02   4.28E-03  -7.27E-06   6.20E 02
 9.65E 00    1.83E-04  -2.73E 04  -3.57E-02  -3.54E-02   4.47E-03  -1.03E 03  -4.82E 02   3.30E-03   9.64E-07   5.26E 02
 1.21E 01    1.36E-03  -2.85E 04  -3.38E-02  -3.37E-02   3.54E-03  -1.03E 03  -4.85E 02   2.42E-03   7.18E-06   4.43E 02
 1.45E 01    2.19E-03  -2.97E 04  -2.95E-02  -2.96E-02   2.10E-03  -1.02E 03  -4.64E 02   1.65E-03   1.16E-05   3.73E 02
 1.69E 01    2.73E-03  -3.07E 04  -2.36E-02  -2.39E-02   2.88E-04  -1.02E 03  -4.26E 02   1.00E-03   1.44E-05   3.15E 02
 1.93E 01    3.02E-03  -3.17E 04  -1.67E-02  -1.72E-02  -1.77E-03  -1.02E 03  -3.76E 02   4.74E-04   1.60E-05   2.69E 02
 2.17E 01    3.12E-03  -3.26E 04  -9.27E-03  -1.01E-02  -3.97E-03  -1.02E 03  -3.20E 02   5.59E-05   1.64E-05   2.34E 02
 2.41E 01    3.07E-03  -3.33E 04  -1.81E-03  -2.94E-03  -6.24E-03  -1.02E 03  -2.62E 02  -2.62E-04   1.61E-05   2.08E 02
 2.65E 01    2.90E-03  -3.38E 04   5.39E-03   3.98E-03  -8.50E-03  -1.02E 03  -2.04E 02  -4.92E-04   1.52E-05   1.90E 02
 2.89E 01    2.66E-03  -3.42E 04   1.21E-02   1.04E-02  -1.07E-02  -1.02E 03  -1.50E 02  -6.49E-04   1.39E-05   1.79E 02
 3.14E 01    2.37E-03  -3.45E 04   1.82E-02   1.62E-02  -1.28E-02  -1.01E 03  -9.97E 01  -7.47E-04   1.23E-05   1.73E 02
 3.38E 01    2.04E-03  -3.47E 04   2.35E-02   2.12E-02  -1.49E-02  -1.01E 03  -5.55E 01  -8.01E-04   1.06E-05   1.71E 02
 3.62E 01    1.70E-03  -3.48E 04   2.80E-02   2.55E-02  -1.67E-02  -1.01E 03  -1.80E 01  -8.23E-04   8.81E-06   1.71E 02
 3.86E 01    1.36E-03  -3.48E 04   3.17E-02   2.89E-02  -1.85E-02  -1.01E 03   1.27E 01  -8.26E-04   7.01E-06   1.73E 02
 4.10E 01    1.02E-03  -3.47E 04   3.45E-02   3.15E-02  -2.01E-02  -1.01E 03   3.62E 01  -8.17E-04   5.24E-06   1.75E 02
 4.34E 01    6.81E-04  -3.46E 04   3.66E-02   3.33E-02  -2.16E-02  -1.00E 03   5.26E 01  -8.05E-04   3.50E-06   1.76E 02
 4.58E 01    3.50E-04  -3.45E 04   3.78E-02   3.44E-02  -2.29E-02  -1.00E 03   6.18E 01  -7.95E-04   1.79E-06   1.77E 02
 4.82E 01    2.15E-05  -3.43E 04   3.83E-02   3.46E-02  -2.41E-02  -9.98E 02   6.39E 01  -7.91E-04   1.09E-07   1.78E 02
 5.06E 01   -3.06E-04  -3.42E 04   3.79E-02   3.41E-02  -2.52E-02  -9.96E 02   5.90E 01  -7.92E-04  -1.56E-06   1.77E 02
 5.31E 01   -6.35E-04  -3.40E 04   3.68E-02   3.28E-02  -2.61E-02  -9.94E 02   4.72E 01  -7.97E-04  -3.22E-06   1.75E 02
 5.55E 01   -9.67E-04  -3.40E 04   3.49E-02   3.07E-02  -2.68E-02  -9.92E 02   2.85E 01  -8.03E-04  -4.89E-06   1.72E 02
 5.79E 01   -1.30E-03  -3.39E 04   3.21E-02   2.78E-02  -2.75E-02  -9.90E 02   3.04E 00  -8.04E-04  -6.56E-06   1.70E 02
 6.03E 01   -1.63E-03  -3.39E 04   2.86E-02   2.41E-02  -2.79E-02  -9.88E 02  -2.90E 01  -7.93E-04  -8.21E-06   1.68E 02
 6.27E 01   -1.96E-03  -3.41E 04   2.43E-02   1.97E-02  -2.82E-02  -9.86E 02  -6.71E 01  -7.59E-04  -9.81E-06   1.68E 02
 6.51E 01   -2.26E-03  -3.43E 04   1.92E-02   1.45E-02  -2.84E-02  -9.84E 02  -1.11E 02  -6.92E-04  -1.13E-05   1.70E 02
 6.75E 01   -2.53E-03  -3.46E 04   1.34E-02   8.59E-03  -2.84E-02  -9.82E 02  -1.59E 02  -5.81E-04  -1.26E-05   1.76E 02
 6.99E 01   -2.75E-03  -3.50E 04   7.04E-03   2.15E-03  -2.83E-02  -9.80E 02  -2.11E 02  -4.14E-04  -1.36E-05   1.88E 02
 7.24E 01   -2.88E-03  -3.56E 04   2.61E-04  -4.69E-03  -2.81E-02  -9.79E 02  -2.65E 02  -1.77E-04  -1.42E-05   2.06E 02
 7.48E 01   -2.89E-03  -3.63E 04  -6.69E-03  -1.17E-02  -2.78E-02  -9.77E 02  -3.18E 02   1.40E-04  -1.43E-05   2.31E 02
 7.72E 01   -2.76E-03  -3.71E 04  -1.35E-02  -1.86E-02  -2.75E-02  -9.76E 02  -3.68E 02   5.48E-04  -1.36E-05   2.65E 02
 7.96E 01   -2.44E-03  -3.81E 04  -1.98E-02  -2.49E-02  -2.72E-02  -9.75E 02  -4.10E 02   1.05E-03  -1.20E-05   3.09E 02
 8.20E 01   -1.89E-03  -3.91E 04  -2.50E-02  -3.01E-02  -2.70E-02  -9.74E 02  -4.41E 02   1.66E-03  -9.29E-06   3.63E 02
 8.44E 01   -1.06E-03  -4.02E 04  -2.85E-02  -3.38E-02  -2.71E-02  -9.73E 02  -4.56E 02   2.37E-03  -5.22E-06   4.28E 02
 8.68E 01    7.82E-05  -4.13E 04  -2.97E-02  -3.50E-02  -2.75E-02  -9.72E 02  -4.48E 02   3.17E-03   3.86E-07   5.02E 02
 8.92E 01    1.57E-03  -4.24E 04  -2.77E-02  -3.32E-02  -2.83E-02  -9.71E 02  -4.12E 02   4.04E-03   7.74E-06   5.86E 02
 9.16E 01    3.43E-03  -4.33E 04  -2.17E-02  -2.73E-02  -2.98E-02  -9.70E 02  -3.40E 02   4.96E-03   1.70E-05   6.78E 02
 9.41E 01    5.68E-03  -4.40E 04  -1.07E-02  -1.66E-02  -3.20E-02  -9.68E 02  -2.27E 02   5.90E-03   2.83E-05   7.73E 02
 9.65E 01    8.32E-03  -4.44E 04   6.14E-03   4.51E-09  -3.53E-02  -9.67E 02  -6.59E 01   6.80E-03   4.17E-05   8.69E 02
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Case 5 Output (Continued)

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                                   MAIN DIAGONAL OF FACTORED A(I,J), N NOT EQUAL 0

 -1,2948E-01   2.0244E-01  -4.0526E-01   4.3394E-01  -9.1962E-01   4.1572E-01  -7,7513E-01  -8,0954E-01  -4.9204E-01  -4.6707E-01
 -3,9191E-01  -3.5694E-01  -3.4806E-01  -3.0476E-01  -3.2530E-01  -2.7467E-01  -3.1233E-01  -2.5520E-01  -3.0451E-01  -2.4160E-01
 -2,9958E-01  -2.3156E-01  -2.9635E-01  -2.2382E-01  -2,9415E-01  -2.1766E-01  -2,9258E-01  -2.1261E-01  -2,9142E-01  -2.0840E-01
 -2,9052E-01  -2.0483E-01  -2.8980E-01  -2.0177E-01  -2,8920E-01  -1.9913E-01  -2,8869E-01  -1.9684E-01  -2,8824E-01  -1,9486E-01
 -2,8784E-01  -1.9314E-01  -2.8748F-01  -1.9166E-01  -2.8716E-01  -1.9039E-C1  -2.8687E-01  -1.8931E-01  -2,8661E-01  -1,8839E-01
 -2,8638E-01  -1.8763E-01  -2,8619E-01  -1.8700E-01  -2,8602E-01  -1.8647E-01  -2,8587E-01  -1,8602E-01  -2.8575E-01  -1,8562E-01
 -2,8563E-01  -1.8523E-01  -2,8553E-01  -1,8481E-01  -2,8543E-01  -1.8431E-01  -2,8533E-01  -1,8369E-01  -2,8522E-01  -1,8289E-01
 -2,8510E-01  -1,8187E-01  -2.8498E-01  -1,8056E-01  -2,8484E-01  -1.7889E-01  -2,8471E-01  -1,7680E-01  -2,8459E-01  -1,7418E-01
 -2,8451E-01  -1.7091E-01  -2.8449E-01  -1.6681E-01  -2,8460E-01  -1.6161E-01  -5,5907E-02   4,7086E 00  -6,1204E-02  -1,4556E-06

DETERMINANT =   1.01302E-08 TIMES 10 TO THE -50TH POWER,  THE PREBUCKLING SOLUTION CONVERGED IN  2 ITERATIONS,  RHO = -1,02676E 03


     EIGENVECTOR INPUT FOR THE  3RD ITERATION

  2,4290E-03  -1,9694E-01   1,1718F-03  -9,8549E-02  -8,1169E-05   1.2814E-03  -1,3331E-03   1,0113E-01  -2,5861E-03   1.9956E-01
 -3,8356E-03   2.9520E-01  -5.0686E-03   3.8675E-01  -6,2649E-03   4.7310E-01  -7.4002E-03   5.5331E-01  -8.4495E-03   6,2673E-01
 -9,3906E-03   6.9291E-01  -1,0207E-02   7,5169E-01  -1,0889E-02   8.0312E-01  -1,1436E-02   8,4741E-01  -1,1854E-02   8.8494E-01
 -1,2154E-02   9,1618E-01  -1,2356E-02   9.4166E-01  -1,2480E-02   9.6190E-01  -1,2546E-02   9.7742E-01  -1,2575E-02   9.8866E-01
 -1,2584E-02   9.9601E-01  -1,2586E-02   9,9973E-01  -1,2588E-02   1.0000E 00  -1,2594E-02   9,9688E-01  -1,2598E-02   9,9031E-01
 -1,2592E-02   9.8012E-01  -1,2561E-02   9,6606E-01  -1,2487E-02   9.4778E-01  -1,2351E-02   9,2487E-01  -1,2131E-02   8,9688E-01
 -1,1810E-02   8.6337E-01  -1,1372F-02   8.2390E-01  -1,0805E-02   7.7812E-01  -1.0107E-02   7,2575E-01  -9.2787E-03   6,6667E-01
 -8,3309E-03   6.0093E-01  -7,2790E-03   5.2876E-01  -6.1434E-03   4,5060E-01  -4,9463E-03   3,6710E-01  -3,7094E-03   2,7909E-01
 -2.4509E-03   1.8758E-01  -1.1837E-03   9.3664E-02   8,4906E-05  -1.4674E-03   1.3516E-03  -9,6610E-02   2,6119E-03  -1.9056E-01

THE CORRECTION FACTOR IS    5,0918E-03

     THE BUCKLING PARAMETER CALCULATED FROM NONLINEAR THEORY IS   -1.0268E 03.  THE NUMBER OF CIRCUMFERENTIAL WAVES IS 25
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Case 5 Output (Continued)

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 THE BUCKLING PARAMETER CALCULATED FROM NONLINEAR THEORY IS   -1.0268E 03.  THE NUMBER OF CIRCUMFERENTIAL WAVES IS 25

                                        BUCKLING MODE WHEN N NOT EQUAL 0

   ARC       MERIDIONAL      HORIZ.        CIRCUM.       VERTICAL       RADIUS*    RADIUS*HORIZ. RADIUS*VERT.     MERID.         NORMAL
 LENGTH       ROTATION        DISP.         DISP.          DISP.  SHEAR RESULTANT    FORCE          FORCE        MOMENT           DISP.

   S            BETA           UH             V              UV          RN12           RH             RV            M1              W

0.0000E-39  -1.0008E-01  -7.3396E-09   4.4767E-09   7.7614E-03  -3.1294E-02  -2.5901E-03   8.5401E-10  -1.7456E-10  -1.2814E-03
1.0000E 00  -9.9374E-02  -9.8525E-02  -3.9392E-03   2.3825E-02  -3.1243E-02  -4.1587E-03  -9.7934E-03   6.7092E-05  -1.0113E-01
2.0000E 00  -9.7258E-02  -1.9554E-01  -7.7915E-03   4.0403E-02  -3.1176E-02  -5.7038E-03  -1.9557E-02   1.3242E-04  -1.9956E-01
3.0000E 00  -9.3797E-02  -2.8970E-01  -1.1501E-02   5.7065E-02  -3.0890E-02  -7.1579E-03  -2.9269E-02   1.9363E-04  -2.9520E-01
4.0000E 00  -8.9120E-02  -3.7978E-01  -1.5028E-02   7.3395E-02  -3.0182E-02  -8.4855E-03  -3.8831E-02   2.4833E-04  -3.8675E-01
5.0000E 00  -8.3413E-02  -4.6469E-01  -1.8346E-02   8.9015E-02  -2.8906E-02  -9.6712E-03  -4.8089E-02   2.9450E-04  -4.7310E-01
6.0000E 00  -7.6906E-02  -5.4356E-01  -2.1435E-02   1.0361E-01  -2.7002E-02  -1.0711E-02  -5.6851E-02   3.3081E-04  -5.5331E-01
7.0000E 00  -6.9849E-02  -6.1575E-01  -2.4285E-02   1.1694E-01  -2.4501E-02  -1.1609E-02  -6.4921E-02   3.5668E-04  -6.2673E-01
8.0000E 00  -6.2495E-02  -6.8086E-01  -2.6838E-02   1.2886E-01  -2.1513E-02  -1.2373E-02  -7.2125E-02   3.7230E-04  -6.9291E-01
9.0000E 00  -5.5079E-02  -7.3871E-01  -2.9243E-02   1.3926E-01  -1.8203E-02  -1.3013E-02  -7.8335E-02   3.7847E-04  -7.5169E-01
1.0000E 01  -4.7807E-02  -7.8936E-01  -3.1350E-02   1.4816E-01  -1.4765E-02  -1.3545E-02  -8.3478E-02   3.7650E-04  -8.0312E-01
1.1000E 01  -4.0842E-02  -8.3303E-01  -3.3212E-02   1.5558E-01  -1.1398E-02  -1.3984E-02  -8.7547E-02   3.6797E-04  -8.4741E-01
1.2000E 01  -3.4306E-02  -8.7008E-01  -3.4637E-02   1.6161E-01  -8.2799E-03  -1.4349E-02  -9.0593E-02   3.5465E-04  -8.8494E-01
1.3000E 01  -2.8273E-02  -9.0097E-01  -3.6230E-02   1.6635E-01  -5.5544E-03  -1.4660E-02  -9.2717E-02   3.3831E-04  -9.1618E-01
1.4000E 01  -2.2773E-02  -9.2621E-01  -3.7402E-02   1.6994E-01  -3.3177E-03  -1.4937E-02  -9.4060E-02   3.2061E-04  -9.4166E-01
1.5000E 01  -1.7799E-02  -9.4632E-01  -3.8363E-02   1.7249E-01  -1.6149E-03  -1.5198E-02  -9.4782E-02   3.0307E-04  -9.6190E-01
1.6000E 01  -1.3310E-02  -9.6179E-01  -3.9121E-02   1.7412E-01  -4.3998E-04  -1.5459E-02  -9.5050E-02   2.8695E-04  -9.7742E-01
1.7000E 01  -9.2388E-03  -9.7306E-01  -3.9688E-02   1.7494E-01   2.5951E-04  -1.5733E-02  -9.5023E-02   2.7331E-04  -9.8866E-01
1.8000E 01  -5.4955E-03  -9.8051E-01  -4.0069E-02   1.7504E-01   5.7505E-04  -1.6025E-02  -9.4834E-02   2.6291E-04  -9.9601E-01
1.9000E 01  -1.9779E-03  -9.8439E-01  -4.0273E-02   1.7448E-01   6.2774E-04  -1.6337E-02  -9.4588E-02   2.5629E-04  -9.9973E-01
2.0000E 01   1.4253E-03  -9.8487E-01  -4.0302E-02   1.7331E-01   5.5763E-04  -1.6662E-02  -9.4345E-02   2.5369E-04  -1.0000E 00
2.1000E 01   4.8281E-03  -9.8200E-01  -4.0158E-02   1.7156E-01   5.1262E-04  -1.6985E-02  -9.4125E-02   2.5516E-04  -9.9688E-01
2.2000E 01   8.3422E-03  -9.7574E-01  -3.9841E-02   1.6924E-01   6.3712E-04  -1.7286E-02  -9.3903E-02   2.6048E-04  -9.9031E-01
2.3000E 01   1.2072E-02  -9.6591E-01  -3.9347E-02   1.6633E-01   1.0612E-03  -1.7536E-02  -9.3611E-02   2.6920E-04  -9.8012E-01
2.4000E 01   1.6108E-02  -9.5225E-01  -3.8672E-02   1.6280E-01   1.8902E-03  -1.7702E-02  -9.3147E-02   2.8067E-04  -9.6606E-01
2.5000E 01   2.0525E-02  -9.3442E-01  -3.7809E-02   1.5862E-01   3.1959E-03  -1.7746E-02  -9.2384E-02   2.9401E-04  -9.4778E-01
2.6000E 01   2.5373E-02  -9.1202E-01  -3.6750E-02   1.5375E-01   5.0095E-03  -1.7632E-02  -9.1177E-02   3.0815E-04  -9.2487E-01
2.7000E 01   3.0676E-02  -8.8459E-01  -3.5489E-02   1.4812E-01   7.3165E-03  -1.7324E-02  -8.9382E-02   3.2184E-04  -8.9688E-01
2.8000E 01   3.6425E-02  -8.5169E-01  -3.4018E-02   1.4170E-01   1.0055E-02  -1.6793E-02  -8.6862E-02   3.3371E-04  -8.6337E-01
2.9000E 01   4.2575E-02  -8.1289E-01  -3.2330E-02   1.3444E-01   1.3120E-02  -1.6020E-02  -8.3508E-02   3.4230E-04  -8.2390E-01
3.0000E 01   4.9045E-02  -7.6783E-01  -3.0421E-02   1.2628E-01   1.6369E-02  -1.4996E-02  -7.9246E-02   3.4615E-04  -7.7812E-01
3.1000E 01   5.5715E-02  -7.1626E-01  -2.8287E-02   1.1720E-01   1.9631E-02  -1.3729E-02  -7.4047E-02   3.4390E-04  -7.2575E-01
3.2000E 01   6.2431E-02  -6.5804E-01  -2.5928E-02   1.0717E-01   2.2730E-02  -1.2242E-02  -6.7932E-02   3.3440E-04  -6.6667E-01
3.3000E 01   6.9012E-02  -5.9323E-01  -2.3344E-02   9.6161E-02   2.5500E-02  -1.0572E-02  -6.0972E-02   3.1680E-04  -6.0093E-01
3.4000E 01   7.5255E-02  -5.2206E-01  -2.0542E-02   8.4175E-02   2.7806E-02  -8.7684E-03  -5.3282E-02   2.9071E-04  -5.2876E-01
3.5000E 01   8.0953E-02  -4.4499E-01  -1.7527E-02   7.1202E-02   2.9565E-02  -6.8890E-03  -4.5008E-02   2.5627E-04  -4.5060E-01
3.6000E 01   8.5906E-02  -3.6267E-01  -1.4315E-02   5.7246E-02   3.0761E-02  -4.9907E-03  -3.6310E-02   2.1419E-04  -3.6710E-01
3.7000E 01   8.9937E-02  -2.7595E-01  -1.0923E-02   4.2316E-02   3.1447E-02  -3.1214E-03  -2.7345E-02   1.6573E-04  -2.7909E-01
3.8000E 01   9.2907E-02  -1.8583E-01  -7.3794E-03   2.6430E-02   3.1738E-02  -1.3091E-03  -1.8245E-02   1.1261E-04  -1.8758E-01
3.9000E 01   9.4722E-02  -9.3453E-02  -3.7211E-03   9.6183E-03   3.1779E-02   4.4886E-04  -9.1093E-03   5.6769E-05  -9.3664E-02
4.0000E 01   9.5338E-02   4.3530E-09  -4.1567E-08  -8.0699E-03   3.1703E-02   2.1958E-03   3.2272E-07   1.4160E-10   1.4674E-03

                                        CURRENT VALUE OF N IS  26
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