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NASA CR-2559 VOL. II

NUMERICAL NONLINEAR INELASTIC ANALYSIS OF STIFFENED SHELLS OF REVOLUTION

Volume II - User's Manual for STARS-2P Digital Computer Program

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16. ABSTRACT

Volume II of this report contains the information necessary for application of the STARS-2P (Shell Theory Automated for Rotational Structures -2 (Pasticity)) program. This addition to the STARS system of programs retains the basic features characteristic of the system.

This report is prepared in four volumes. The other volumes are:

Volume I — Theory Manual for STARS-2P Digital Computer Program
Volume III — Engineer's Program Manual for STARS-2P Digital Computer Program
Volume IV — SATELLITE-1P Program for STARS-2P Digital Computer Program

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SYMBOLS

Lower Case Latin

a	semi-diameter perpendicular to Z-axis in ellipsoid
b	semi-diameter parallel to Z-axis in ellipsoid
f	distributed loads in local coordinates
h	shell thickness; face sheet thickness
i	index: beginning edge of shell segment; independent joint of kinematic link; subscript "inside"
j	index: ending edge of shell segment; dependent joint of kinematic link
n	index on harmonic
o	subscript "outside"
r	radius
s	index of segment; coordinate in cylinder or cone
t	core thickness in sandwich shell
w	normal deflection, positive inward

Upper Case Latin

C	stiffness eccentricity parameters; offset distance in ogive, ellipse
D	bending stiffness parameters
E	Young's modulus (lb/in^2)
F	lineal force (lb/in)
G	shear modulus (lb/in^2)
K	extensional stiffness parameters
M	bending moment on shell (in-lb/in)
N	membrane stress resultant (lb/in)
Q	transverse shear stress resultant (lb/in)
R	radius; "global" coordinate, positive radially outward

SYMBOLS (continued)

T temperature; "global" coordinate, tangential

X Cartesian coordinate, $\theta = 0$ at X-axis

Y Cartesian coordinate

Z Cartesian and "global" coordinate, coincides with axis of revolution

Greek

α angle between rotated coordinates

β ratio of semi-diameter parallel to Z-axis in ellipsoid to semi-diameter perpendicular to Z-axis

γ shear strain; non-linear parameter; angle of inclination of kinematic link

ζ normal coordinate, positive inward

θ circumferential angular coordinate (rad)

λ shell parameter

ν Poisson's ratio

σ normal stress (lb/in^2)

τ shear stress (lb/in^2)

ϕ meridional angular coordinate (rad)

ω rotational displacement (rad)

Ω rotational displacement in "global" coordinates (rad)

Δ displacements in fixed or "global" coordinates

Λ segment length parameter

Miscellaneous

eq equivalent

$s\phi$ $\sin \phi$

$c\phi$ $\cos \phi$

Other symbols are defined in the text where used.

SECTION 1

PROGRAM CAPABILITY

The use of an accurate shell theory to analyze structural shell problems usually involves complex mathematics and numerical techniques, which are nearly impossible to treat without the aid of automated procedures. On this basis, a digital computer program based upon the Love-Reissner first order shell theory has been developed. Isotropic and kinematic hardening laws are available using an orthotropic yield surface and including the Bauschinger effect. This program can perform a nonlinear geometric and material analysis of orthotropic thin shells of revolution, subjected to nonproportional cyclic axisymmetric distributed loading or concentrated line loads, as well as thermal strains (Reference 1). Furthermore, a shell with artitrary boundary conditions, under loads which vary arbritrarily with position and under a temperature variation through the thickness, is tractable with this program. The shell can consist of any combination of the following geometric shapes:

1) Ellipsoidal - spherical (offset from the axis of revolution allowed)
2) Ogival - toroidal
3) Modified ellipse shape
4) Conical - circular plate
5) Cylindrical
6) General point input geometry
7) Dummy geometry slot to be filled by the user
8) Discrete ring

The shell wall crossection can be a sheet, sandwich, or reinforced sheet or sandwich. The reinforcement can consist of rings and/or stringers, a waffle construction rotated at any angle to the principal coordinates, or an isogrid construction. General stiffness input options are also available. The reinforcement material properties can differ from those of the main shell, and a temperature variation can cause different properties in the two face sheets of a sandwich shell.

The basic approach to the problem (Reference 1) is to cut the structure into several shell regions. These regions need to be singly-connected shells, and can only have line loads applied at their end points. There are no restrictions on geometry, or uniform or thermal loads. The regions are further subdivided into several shell segments, each being free to have its own geometric shape, provided that the shape falls into one of the categories mentioned above.

Stiffness matrices obtained for each segment, are coupled by standard matrix methods to obtain region stiffnesses, which, after being reduced in size, are in turn coupled to form the total shell structure under analysis. Currently, **the computer programs are sized to handle a structure composed of up to 29 segments in each of 29 regions arbitrarily connected to each other.** There is a limitation on the size of a shell segment, which is a consequence of the demand that boundary disturbances be felt throughout the segment. This limitation is mathematically described in Section 2 (pages 2-35 to 2-37) as a length parameter. This parameter, however, is not reliable near the apex of any shell shape ($\phi = 0$), and the segments needed in this region are actually much smaller than predicted by the parameter. A mathematical singularity occurs at the apex where r_o (the radius of revolution) becomes zero. It is this singularity which prevents the length parameter from being meaningful near the apex. Furthermore, the point ($\phi = 0$) is not an acceptable input point of the program (except for the torus-ogive and offset ellipsoid), although any point outside a circle of infinitesimal radius is satisfactory.

There is a considerable latitude in what can be done within each shell segment. The thickness of any segment can be symmetrically tapered and it can contain up to 14 points of discontinuity, provided that the segment centerline remains continuous and describable by a single shell geometry. A temperature distribution through the thickness can be specified at three points in a homogeneous shell, and 4 points in a shell of rigid core sandwich construction. The distribution is considered to be linear between these points. Thus, it is possible to approximate temperature distributions other than linear distributions. In the event of physically discontinuous shell centerlines, a kinematic link is available for use in the analysis. The link relates displacements across the discontinuity. This link may be used between regions, and between segments within a region. Discrete offset rings are also available for use within or between regions.

SECTION 2

INPUT INFORMATION

2.1 GENERAL NOTES

The preceding section provides some insight into the capability of the program, and the potential that it might have for future use. If the program is applied judiciously it can be an extremely powerful tool. The mechanics of applying it should be clearly understood. With this in mind, the remaining section should be studied carefully.

The required input data may be subdivided into three main parts, namely: geometric, topological (or coupling orientation) and joint data (degree of freedom description for each joint component). Each segment requires its own geometric configuration and numerical integration control.

The output consists of stiffness coefficients for each shell segment and the actual symmetry of the coefficients is presented in a convenient form for a check on the accuracy of the integration through the segment. Region stiffnesses and their symmetry checks are also provided. Final stresses, displacements, and plastic strains are printed out for each shell segment at intervals along the segment as specified by the user of the program. The output will be further discussed in Section 3.

The present program size is described in the table below.

Table of Program Sizing

I.	Segments per region:	29
II.	Segment joints per region:	30
III.	Regions:	29
IV.	Region joints:	30

Table of Program Sizing (continued)

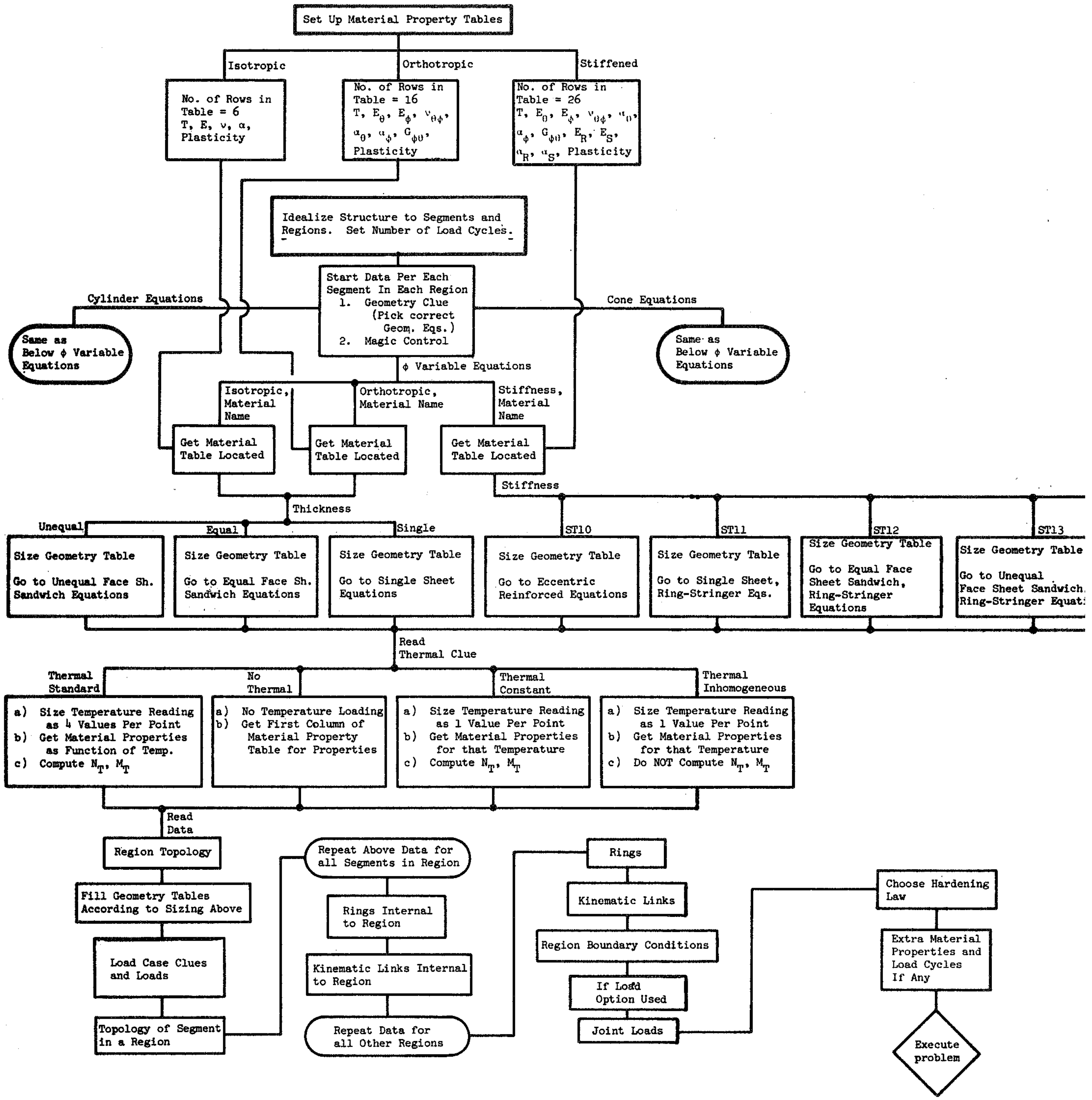
V.	Number of points available per segment for specifying geometric or load data:	30
VI.	Number of points available through the thickness for specifying temperature data:	4 plus reinforcement temperatures.
VII.	Geometries:	ellipsoid, sphere, offset ellipsoid, modified ellipsoid, ogive, toroid, cone, annular plate, cylinder, general geometry, ring, elastic support, dummy geometry.
VIII.	Wall cross-section options:	single sheet, equal face sheet sandwich, unequal face sheet sandwich, eccentric reinforcement (rings, stringers or both), waffle reinforcement rotated at an arbitrary angle to coordinate axes, isogrid reinforcement, arbitrary stiffness input.
IX.	Number of material property tables per submission:	10
X.	Number of points per material property table:	10
XI.	Hardening laws:	kinematic, isotropic, perfect plasticity
XII.	Orthotropy options:	isotropic or orthotropic sheet, isotropic or orthotropic sandwich, isotropic or orthotropic sandwich with different face sheet properties caused by thermal gradients, isotropic or orthotropic sheet or sandwich reinforced by different property rings or different property stringers or both, isotropic or orthotropic sheet or sandwich reinforced by a different property waffle system rotated by an angle β to coordinate axes, isotropic or orthotropic sheet or sandwich reinforced by a different property general isogrid reinforcing system, arbitrary stiffness input options used to describe other configurations.

XIII.	Number of rings per region:	28
XIV.	Total number of rings at region joints in structure:	28

Figure 2-1 shows the detailed option flow chart for the present programs.

GENERAL NOTES - Idealizations

Before discussing the specific card input order, it would be advantageous to introduce some general guidelines in the area of idealizations and topology. In many computer programs there is such an abundance of numerical computation, that minimizing numerical roundoff errors becomes as important as getting the final answers. In some cases the engineer can aid the program in this effort throught the use of judicious idealizations. Such a possibility exists in the STARS-2 programs, since many internal operations are involved with building and inverting stiffness matrices. The object of the user therefore, should be to help the computer by avoiding the creation of ill-conditioned matrices at any step (see Reference 2). Physically, the way to achieve this end is to have all the segment stiffness matrices of the same order of magnitude. This will in turn produce region stiffness matrices which are of similar orders of magnitude, and minimize possible ill-conditioning in the total structure matrices. The user can help to achieve this end by sizing his segments in such a way so that no short stiff segment is contained alone in a region with all other long flexible segments, or that no region comprised of all short stiff segments exists in a structure whose other regions contain only long flexible segments. No accurate measure can be given on the relative stiffness or flexibility of segments allowed, and thus the best check is



Set Up Material Property Tables
Isotropic
Orthotropic
Stiffened
No. of Rows in Table = 6 T, E, ν, α, Plasticity
No. of Rows in Table = 16 T, E_θ, E_ϕ, $\nu_{\theta\phi}$, α_θ, α_ϕ, $G_{\phi\theta}$, Plasticity
No. of Rows in Table = 26 T, E_θ, E_ϕ, $\nu_{\theta\phi}$, α_θ, α_ϕ, $G_{\phi\theta}$, E_R, E_S, α_R, α_S, Plasticity
Idealize Structure to Segments and Regions. Set Number of Load Cycles.
Start Data Per Each Segment In Each Region 1. Geometry Clue (Pick correct Geom. Eqs.) 2. Magic Control
Cylinder Equations
Same as Below ϕ Variable Equations
Cone Equations
Same as Below ϕ Variable Equations
ϕ Variable Equations
Isotropic, Material Name
Orthotropic, Material Name
Stiffness, Material Name
Get Material Table Located
Get Material Table Located
Get Material Table Located
Stiffness
Thickness
Unequal
Equal
Single
ST10
ST11
ST12
ST13
Size Geometry Table Go to Unequal Face Sh. Sandwich Equations
Size Geometry Table Go to Equal Face Sh. Sandwich Equations
Size Geometry Table Go to Single Sheet Equations
Size Geometry Table Go to Eccentric Reinforced Equations
Size Geometry Table Go to Single Sheet, Ring-Stringer Eqs.
Size Geometry Table Go to Equal Face Sheet Sandwich, Ring-Stringer Equations
Size Geometry Table Go to Unequal Face Sheet Sandwich Ring-Stringer Equati
Read Thermal Clue
Thermal Standard
No Thermal
Thermal Constant
Thermal Inhomogeneous
a) Size Temperature Reading as 4 Values Per Point b) Get Material Properties as Function of Temp. c) Compute N_T, M_T
a) No Temperature Loading b) Get First Column of Material Property Table for Properties
a) Size Temperature Reading as 1 Value Per Point b) Get Material Properties for that Temperature c) Compute N_T, M_T
a) Size Temperature Reading as 1 Value Per Point b) Get Material Properties for that Temperature c) Do NOT Compute N_T, M_T
Read Data
Region Topology
Fill Geometry Tables According to Sizing Above
Load Case Clues and Loads
Topology of Segment in a Region
Repeat Above Data for all Segments in Region
Rings Internal to Region
Kinematic Links Internal to Region
Repeat Data for all Other Regions
Rings
Kinematic Links
Region Boundary Conditions
If Load Option Used
Joint Loads
Choose Hardening Law
Extra Material Properties and Load Cycles If Any
Execute problem

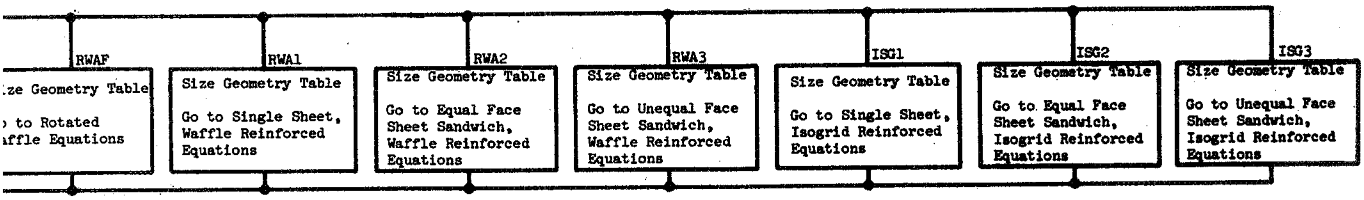


Figure 2-1 Program Option Flow Chart

to see if a structure is in equilibrium under the applied loading. In the case of the nonlinear analysis an internal equilibrium correction may be specified in the input. The symmetry checks of segment and region stiffness matrices are useful for many reasons, but will not necessarily alert a user to ill-conditioning.

In the use of regions, one other type of accident must be avoided. This is the creation of a single region structure with both ends fixed, wherein no suitable boundary condition matrix can be formed. Thus, in the use of region idealizations, which are less physically meaningful to a user than pure segment idealizations, care should be taken so that all boundary conditions are not zeroed out. To avoid this problem, and to minimize program running time, it is best to maximize the number of regions in a structure, and minimize the number of segments per region. Thus, in small problems, for best numerical efficiency, there should only be one segment per region.

In the solution of static axisymmetric problems, torsional and non-torsional states may be uncoupled. Thus if no torsional loads exist in combination with non-torsional loads, all torsional degrees of freedom can be removed. When both types of loads exist, the nonlinear analysis will be coupled.

In an incremental analysis such as the present, the number of load increments is part of the user specified "idealization". The current analysis uses each load step as a one step Newton-Raphson cycle. Thus the number of load steps necessary is directly proportional to the nonlinearity of the material stress-strain behavior. In general it may be necessary to run each problem twice: once with large steps to determine gross behavior and then, after comparing the analysis strain increments in the shell to the material property curves, with smaller steps.

GENERAL NOTES - Restarts

Since the solution of a nonlinear geometric and material problem requires the consecutive execution of a series of analyses, the program may be inadvertently cut off due to an insufficient time estimate, or the user may wish to examine the solutions of a cycling or consecutive loading problem before executing further. In order to allow the user to utilize the good data generated in such runs, a restart option has been incorporated into the STARS-2P program. This option is used as follows:

1. After the complete execution of any load step the completed load step number is printed. In a load cycling run both the overall step counter (initially started from zero) and the local step counter (initialized to zero at every load change) are printed. In order to be able to restart, the tapes on units 11, 12, 13 and 15 must be saved. (The first two are necessary only if the run contains discrete rings.) These are called respectively RINGER11, RINGER12, SHPLAS13, and SHPLAS15.

2. Upon receipt of an aborted run the necessary restart tapes can be obtained from the completed load step printout. If the last overall load step completed was odd, the necessary tapes are RINGER11 and SHPLAS15; the other two may be released. If the last overall load step completed was even, the necessary tapes are RINGER12 and SHPLAS13; the other two may be released. (An exception to the above formula involves restarting restarted runs: If the previous restart started on an even load step the above formula is reversed.)

3. In order to initiate a restart run the following must be done:

   a. In a single load run adjust the Program Control Card as noted in items 2I and 2J.

   b. In a load-time history or cycling run convert the load data by removing the completed cycles from the deck, and adjust the Program Control Card accordingly. Note the item about the Ramberg-Osgood "s" parameter in the cycling input description on p 2-79.

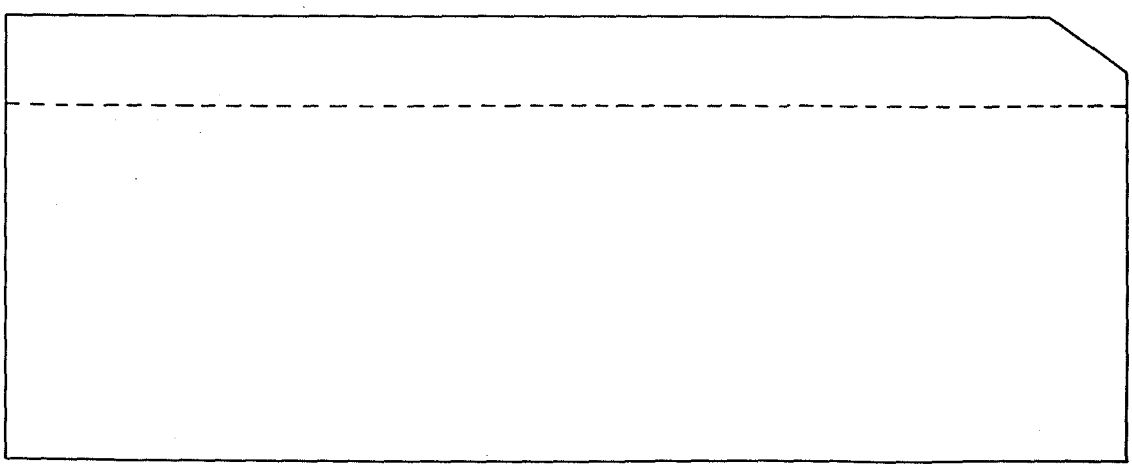
c. Operator instructions must be given to mount the SHPLAS restart tape on logical unit 13, and the RINGER restart tape (if necessary) on logical unit 11 (regardless of the numbers associated with the restart tape names). Scratch tapes will be mounted as usual on logical units 12 and 15.

d. The run will now proceed as normal (even restarts of restarts).

4. Note: The restart tapes for any given run are not useable more than once. Upon the initiation of the computer run these tapes become scratch tapes and additional information (more load step data) will be written on them.

GENERAL NOTES - Data debugging

The STARS programs have been provided with special separate data debugging packages called SATELLITE programs. In order to be able to debug as much of a given data deck as possible in one computer submission, the data is grouped by inserting special cards, termed "dash-separator cards", appropriately. In order so that additional errors are not made by requiring insertion and removal of these cards, the STARS program has been coded to accept these dash-separator cards in the input. A dash-separator card is shown below:



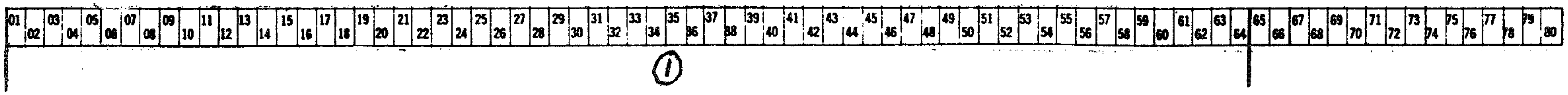
As can be seen, a minus·symbol is inserted straight across the computer card from column 1 through column 80.

Since the dash-separator cards subdivide the data deck, there exists the possibility that a separated data block may be completely omitted (for example no kinematic links in a structure). In this case one dash-separator card is also omitted. Under no circumstances can there exist two adjacent dash-separator cards in a data deck. The SATELLITE programs are described in Reference 3.

2.2 CARD FORMATS

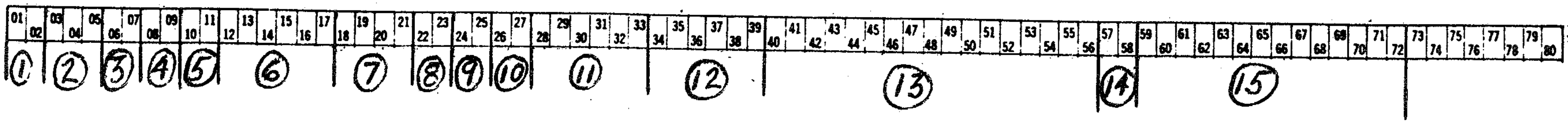
The following different card formats are presently required by the STARS-2P program. A full description and explanation of the information to be entered on the cards is presented in Section 2.3.

Title Card



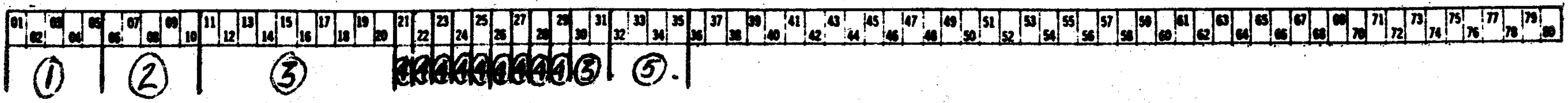
(1)	Alphameric Title	16A4

Program Control, Program Cycling Cards



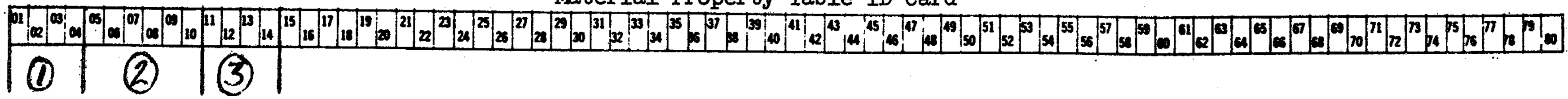
(1)	Number of regions	I2
(2)	Total number of segments	I3
(3)	Number of material property tables	I2
(4)	Intermediate print clue	I2
(5)	Number of load cycles	I2
(6)	Number of load steps	F6.0
(7)	Load step print increment	F4.0
(8)	Load unit clue	I2
(9)	Nonproportional load clue	I2
(10)	New material table clue	I2
(11)	Completed load steps in last cycle for restart	F6.0
(12)	Total completed load step for restart	F6.0
(13)	Blank	-
(14)	Rotation clue	I2
(15)	Rotational speed	E14.7

Analysis Option Card



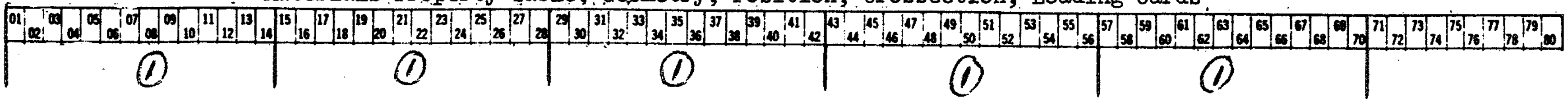
(1)	Problem Identification	A4
(2)	Equilibrium correction	I6
(3)	Blank	-
(4)	Graphics clues	I1
(5)	Graphics Print Cycle	F4.0

Material Property Table ID Card



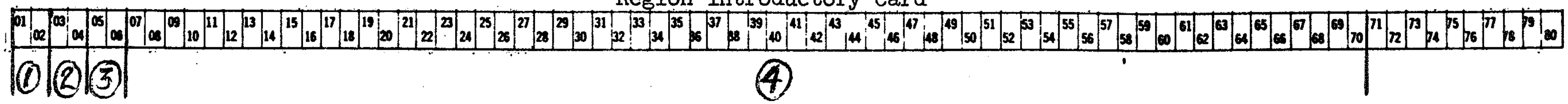
(1)	Material Name	A4
(2)	Blank	-
(3)	Table Type	A4

Materials Property Table, Geometry, Position, Crossection, Loading Cards



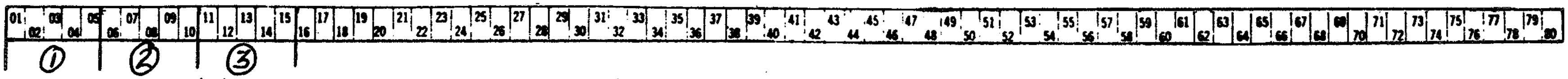
(1)	Input table item (as many cards and fields are necessary)	E14.7

Region Introductory Card



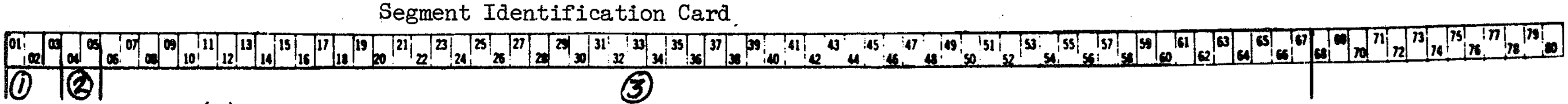
(1)	Number of segments	I2
(2)	Number of kinematic links	I2
(3)	Number of rings	I2
(4)	Title	16A4

Topology Cards, (Region Joint Control Card)



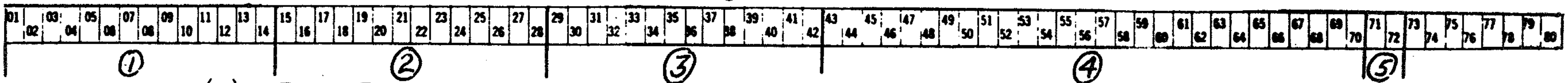
(1) Region or segment number, (number of joints) — I5
(2) Beginning joint, (number of rings) — I5
(3) End joint, (number of links) — I5

Segment Identification Card



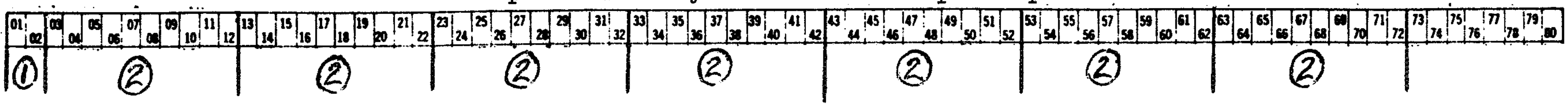
(1) Segment code — F2.0, A1
(2) Number of plastic layers — I2
(3) Title — 16A4

MAGIC Integration Card



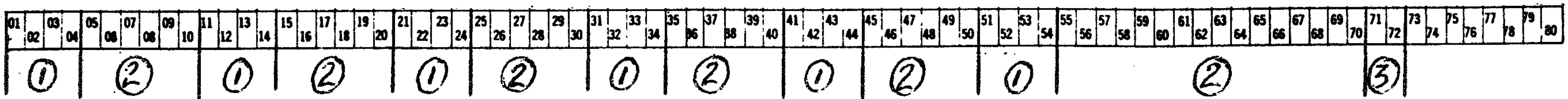
(1) Print Interval — E14.1
(2) Accuracy control — E14.1
(3) Integration interval — E14.1
(4) Blank — -
(5) Step control — F2.0

Special Geometry Card for Point Input Shape



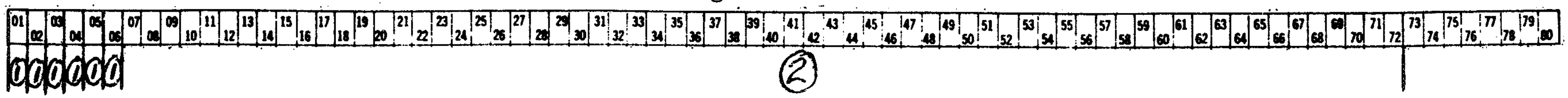
(1) Number of input points — I2
(2) Input points (as many pairs as specified) — F10.0

Master Clue Card



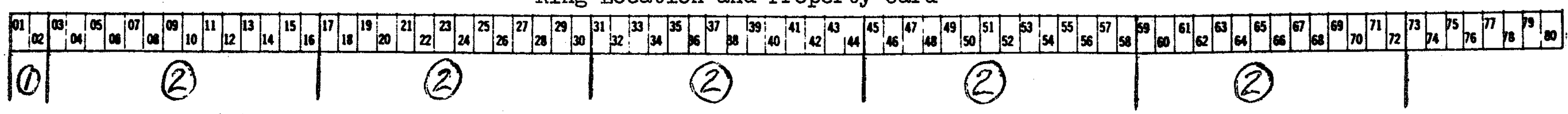
(1) Clues — A4
(2) Blank — -
(3) Number of Table points — I2

Loading Clue Card



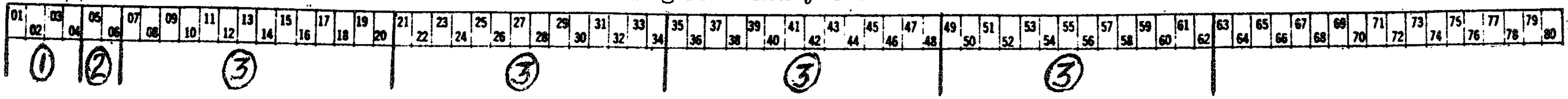
(1) Load Clues — I1
(2) Title — 16A4

Ring Location and Property Card



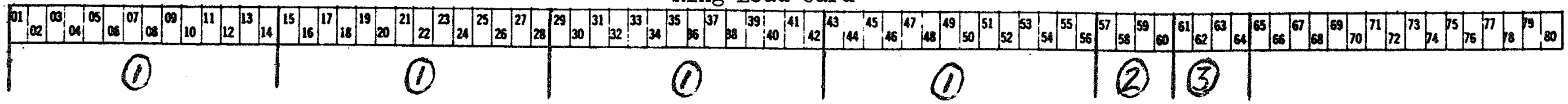
(1) Ring joint number — I2
(2) Ring properties — E14.7

Ring Plasticity Card



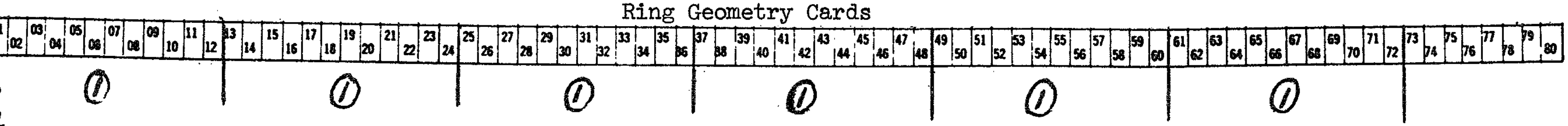
(1)	Geometry description clue	A4
(2)	Blank	-
(3)	Plasticity properties	E14.7

Ring Load Card



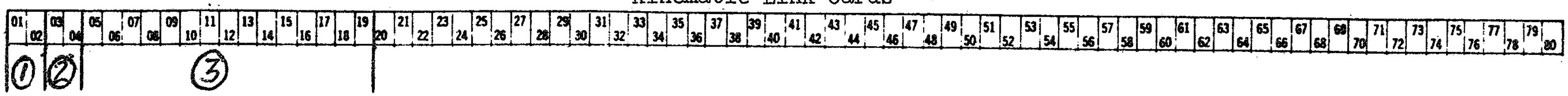
(1)	Ring loads	E14.7
(2)	Blank	-
(3)	Hardening law clue	A4

Ring Geometry Cards



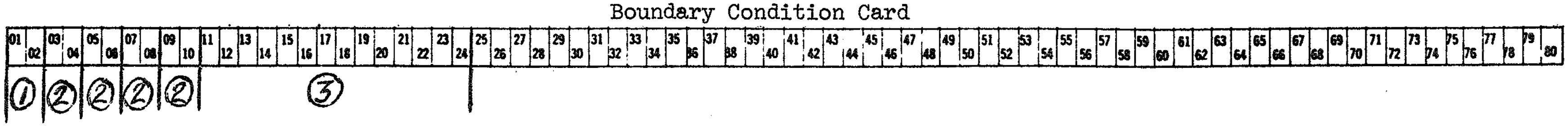
(1)	Ring geometric properties	E12.5

Kinematic Link Cards



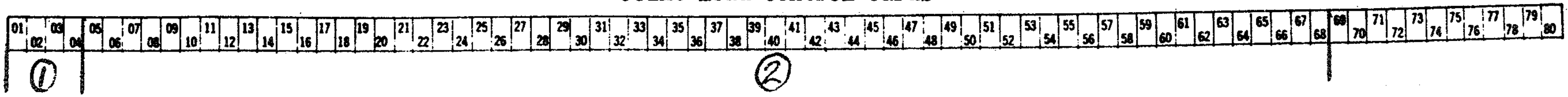
(1)	Dependent joint	I2
(2)	Independent joint	I2
(3)	Angle of inclination	E14.7

Boundary Condition Card



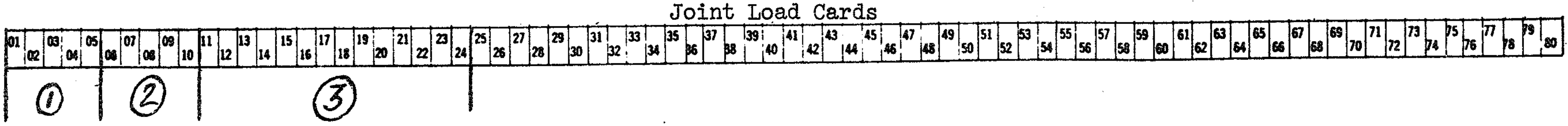
(1)	Joint Number	I2
(2)	Boundary conditions	F2.0
(3)	Axis rotation angle	E14.1

Joint Load Control Cards



(1)	Number of joint loads	I4
(2)	Title	16A4

Joint Load Cards



(1)	Load condition number	I5
(2)	Row Identification	I5
(3)	Applied load	E14.7

2.3 DETAILED ORDER OF INPUT (See Figures 2-1, 2-2)

GENERAL INTRODUCTORY CARDS	Column	Format
1. Title Card		
A. Alphameric title (submission description)	1-64	16A4
2. Program Control Card		
A. Number of regions to be coupled (Max. = 29)	1-2	I2
B. Total number of segments (Max. = 29 x 29 = 841)	3-5	I3
C. Number of Material Property Tables (Max. = 10)	6-7	I2
D. Intermediate print clue	8-9	I2
If this clue is set to unity, stiffness matrices and symmetry checks will be printed for all segments and regions at the specified load step print interval (item G below). To delete this intermediate print the clue should be set to zero.		
E. Number of load changes	10-11	I2
Number of load patterns or cycles to be applied in a cycling load analysis (see p 2-76).		
F. Number of load steps	12-17	F6.0
Number of loading increments to be made for the first loading cycle.		

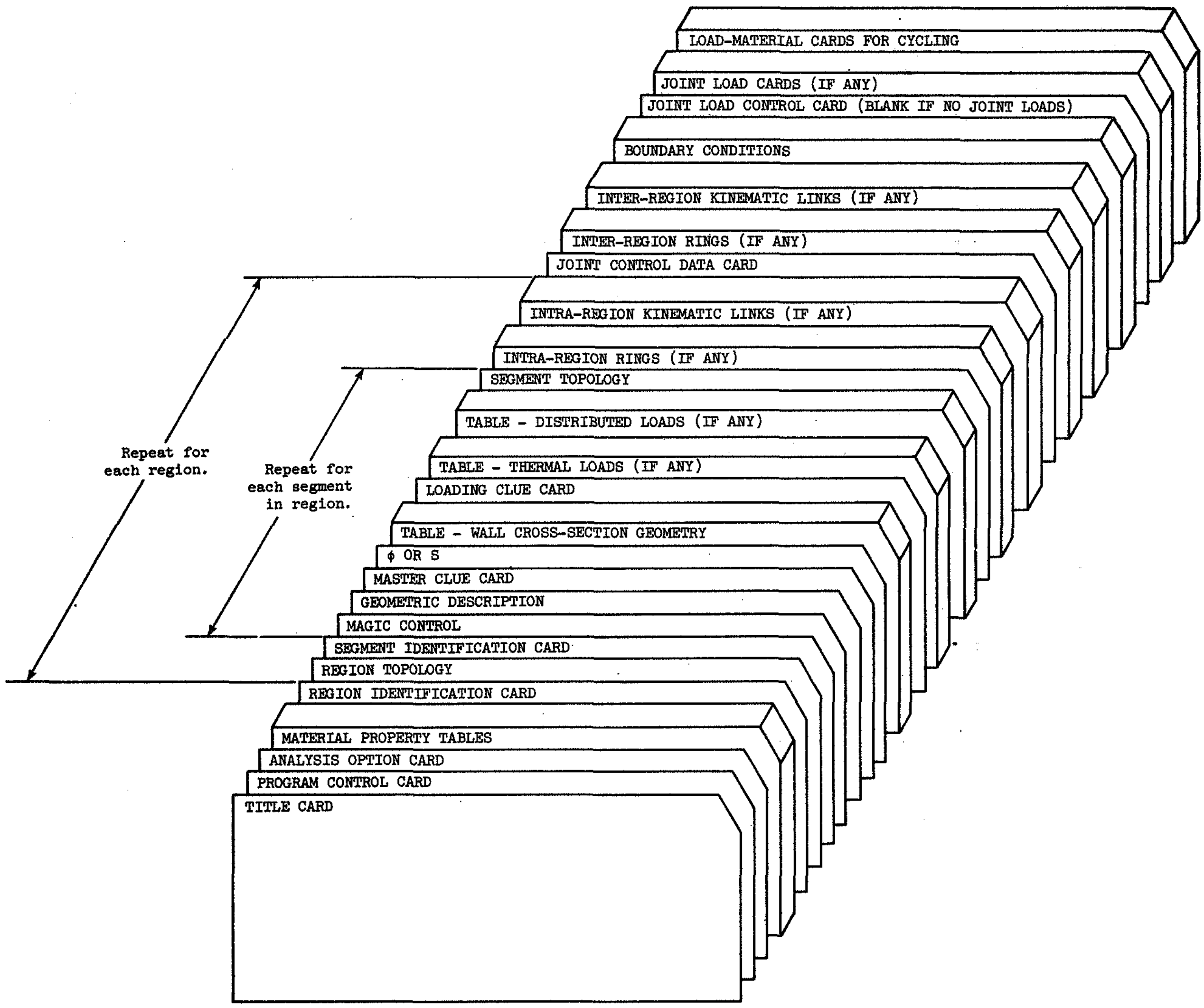


Figure 2-2 Data Sequence

		Column	Format
G.	Load step print increment	18-21	F4.0

The interval number of load increments at which printout is desired. (Ex: print every 20 steps).

H.	Load unit clue	22-23	I2

This clue is zero (0) for a single loading analysis. If there is a change of load distribution with time (sequential loading) this clue is two (2). For further information and load cycling see the input for the Load Cycling Program Control Card on p 2-76 .

I.	Local cycle load step count for restart	28-33	F6.0

If the restart submission is concerned with load amplitude changes or cycling, this entry is the local count of load steps completed with the last loading amplitude input. If there is no load amplitude changes item J below and the present item are equal for restart. (See p 2-7 for restart information.)

J.	Total load step count for restart	34-39	F6.0

In the event that the submission is a restart problem, this entry provides the total count of previously completed load steps.

K.	Shell rotation clue	57-58	I2

If the shell is rotating at an angular velocity about its centerline, the input clue is unity. If there is no rotation the clue is zero.

L.	Angular Velocity in rad./sec.	59-72	E14.7

The maximum amplitude of angular velocity of the rotating shell. This velocity will be attained in a series of steps in a nonlinear analysis analogous to a mechanical or thermal loading. The step size has been defined in item F of this card.

	Column	Format
3. Analysis Option Card		
A. Analysis Description Clue	1-4	A4

There are three possible analysis formulations. If the problem is to be a small deflection plastic analysis, then the clue word is PLAS. If the problem is to be a large deflection elastic analysis then the clue word is NLIN. If the problem is to be a large deflection inelastic analysis then the clue word is NLPL.

B. Equilibrium Correction Clue	5-10	I6

Equilibrium correction loads can be used with all three analysis options above. To utilize this option set the clue to unity. To eliminate equilibrium corrections set the clue to zero. It is recommended that equilibrium corrections always be included.

C. Graphics Control Clues

The following nine (9) data fields determine the plotting required for the run.

a. Circumferential displacement clue Clue = 1 plot u Clue = 0 or blank, do not plot u	21	I1
b. Meridional displacement clue Clue = 1, plot v Clue = 0 or blank, do not plot v	22	I1
c. Normal displacement clue Clue = 0, plot w Clue = 0 or blank, do not plot w	23	I1
d. Hoop stress (inner face) clue Clue = 1, plot $\sigma_{\theta\ in}$ Clue = 0 or blank, do not plot $\sigma_{\theta\ in}$	24	I1
e. Meridional stress (inner face) clue Clue = 1, plot $\sigma_{\varphi\ in}$ Clue = or blank, do not plot $\sigma_{\varphi\ in}$	25	I1

		Column	Format
f.	In-plane shear stress (inner face) clue Clue = 1, plot $\tau_{\varphi\theta}$ in Clue = 0 or blank, do not plot $\tau_{\varphi\theta}$ in	26	I1
g.	Hoop stress (outer face) clue Clue = 1, plot $\sigma_{\theta\ out}$ Clue = 0 or blank, do not plot $\sigma_{\theta\ out}$	27	I1
h.	Meridional stress (outer face) clue Clue = 1, plot $\sigma_{\varphi\ out}$ Clue = 0 or blank, do not plot $\sigma_{\varphi\ out}$	28	I1
i.	In-plane shear stress (outer face) clue Clue = 1, plot $\tau_{\varphi\theta}$ out Clue = 0 or blank, do not plot $\tau_{\varphi\theta}$ out	29	I1
D.	Graphics Print Cycle	32-35	F4.0

Graphical output will be provided in accordance with the Graphics Control Clues above at every 'X' load step as input here.

MATERIAL PROPERTY TABLES (Max. = 10 sets)

As many sets of these cards are used (≤ 10) as there are different material property segments in the structure to be analyzed. These tables will be used to obtain the thermal variation of material properties if thermal loadings exist. Thus the range of temperature in this table should be greater than that of the thermal loads. If no thermal loads exist, the values given in the first column of this table will be used, and the rest of the table can be left blank. If there are thermal loads, the range of the table is to be considered as that between the second and tenth columns.

Since apex segments should not be allowed to go plastic, separate tables with fictitiously high yield stresses should be prepared for this case (see p. 2-35).

	Column	Format
1. Identification Card		
A. Material Title (Alphameric) Any name can be made up as long as it is consistently used on the segment cards to which it refers. The same name cannot appear on more than one (1) table.	1-4	A4
B. Type of Table One of several possible alphameric clues is written here. These clues serve to size the number of cards in the property table, and define which properties belong on which card. The possible clues are: ISOT ORTH STIF Their definitions are provided in Item 2 below.	11-14	A4
2. Material Property Cards The material property cards below are given depending upon which table type clue is used. If the table type clue is "ISOT" (isotropic table):		
A. Temperature values (5 values per card; 2 cards) These are the temperatures at which the values of material properties will be given. The first value in the table must always be the room or stress-free temperature, since the material properties in only the first column of the table will be used in an analysis involving no thermal load. The values of temperature in table columns 2 through 10 must be in algebraically increasing order.		5E14.7
B. Values of Young's Modulus at the given temperatures. (5 values per card; 2 cards)		5E14.7
C. Values of Poisson's Ratio at the given temperatures. (5 values per card; 2 cards)		5E14.7
D. Values of the thermal coefficient of expansion at the given temperatures. (5 values per card; 2 cards)		5E14.7

	Column	Format
E. Values of the Ramberg-Osgood "s" (see Ref. 1) at the given temperatures. (5 values per card; 2 cards).		5E14.7
F. Values of the Ramberg-Osgood "n" (see Ref. 1) at the given temperatures. (5 values per card; 2 cards).		5E14.7
G. Values of the yield stress at the given temperatures. (5 values per card; 2 cards)		5E14.7

Note: If the hardening law for the segment is perfect plasticity (PERF on the Master Clue Card) the items E and F above are zero.

If the table type clue is "ORTH" (orthotropic table):

	Column	Format
A. Temperature values (5 values per card; 2 cards) These are the temperatures at which the values of material properties will be given.		5E14.7
B. Values of Young's Modulus in the θ direction (E_θ) at the given temperatures. (5 values per card; 2 cards)		5E14.7
C. Values of Young's Modulus in the ϕ direction (E_ϕ) at the given temperatures. (5 values per card; 2 cards)		5E14.7
D. Values of the Poisson's Ratio $\nu_{\theta\phi}$ at the given temperatures. Orthotropic identity defined as $E_\theta \nu_{\theta\varphi} = E_\varphi \nu_{\varphi\theta}$. (5 values per card; 2 cards)		5E14.7
E. Values of the thermal coefficient of expansion in the θ direction (α_θ) at the given temperatures. (5 values per card; 2 cards)		5E14.7
F. Values of the thermal coefficient of expansion in the ϕ direction (α_ϕ) at the given temperatures. (5 values per card; 2 cards)		5E14.7
G. Values of the Shear Modulus $G_{\phi\theta}$ at the given temperatures. (5 values per card; 2 cards)		5E14.7

		Column	Format
H.	Values of the Ramberg - Osgood "s" in the φ direction (see Ref. 1) at the given temperatures. (5 values per card; 2 cards)		5E14.7
I.	Values of the Ramberg - Osgood "n" in the φ direction (see Ref. 1) at the given temperatures. (5 values per card; 2 cards)		5E14.7
J.	Values of the yield stress in the φ direction at the given temperatures. (5 values per card; 2 cards)		5E14.7
K.	Values of the yield stress in the θ direction at the given temperatures. (5 values per card; 2 cards)		5E14.7
L.	Values of the yield stress in the normal (ζ) direction at the given temperatures. (5 values per card; 2 cards)		5E14.7
M.	Values of the shear yield stress in the $\varphi\theta$ plane at the given temperatures. (5 values per card; 2 cards)		5E14.7
N.	Values of the Ramberg - Osgood "s" in the θ direction (see Ref. 1) at the given temperatures. (5 values per card; 2 cards)		5E14.7
O.	Values of the Ramberg - Osgood "n" in the θ direction (see Ref. 1) at the given temperatures. (5 values per card; 2 cards)		5E14.7
P.	Values of the Ramberg - Osgood "s" in the $\varphi\theta$ directions (see Ref. 1) at the given temperatures. (5 values per card; 2 cards)		5E14.7
Q.	Values of the Ramberg - Osgood "n" in the $\varphi\theta$ directions (see Ref. 1) at the given temperatures. (5 values per card; 2 cards)		5E14.7

Note: If the hardening law for the segment is perfect plasticity (PERF on the Master Clue Card) items H, I, and N through Q are zero.

		Column	Format
	If the table type is "STIF" (table to be used for reinforced shells):		
A.-Q.	The values in these locations are the same as those above for the "ORTH" clue case, and refer to the basic shell.		5E14.7
R.	Values of ring Young's Modulus (E_R) at the given temperatures. (5 values per card; 2 cards)		5E14.7
S.	Values of stringer Young's Modulus (E_s) at the given temperatures. (5 values per card; 2 cards)		5E14.7
T.	Values of ring thermal coefficient of expansion (α_R) at the given temperatures. (5 values per card; 2 cards)		5E14.7
U.	Values of stringer thermal coefficient of expansion (α_s) at the given temperatures. (5 values per card; 2 cards)		5E14.7
V.	Values of the Ramberg - Osgood "s" in the rings (see Ref. 1) at the given temperatures. (5 values per card; 2 cards)		5E14.7
W.	Values of the Ramberg - Osgood "n" in the rings (see Ref. 1) at the given temperatures. (5 values per card; 2 cards)		5E14.7
X.	Values of the ring yield stress at the given temperatures. (5 values per card; 2 cards)		5E14.7
Y.	Values of the Ramberg - Osgood "s" in the stringers (see Ref. 1) at the given temperatures. (5 values per card; 2 cards)		5E14.7
Z.	Values of the Ramberg - Osgood "n" in the stringers (see Ref. 1) at the given temperatures. (5 values per card; 2 cards)		5E14.7
α.	Values of the stringer yield stress at the given temperatures. (5 values per card; 2 cards)		5E14.7

Notes: If the hardening law for the segment is perfect plasticity (PERF on the Master Clue Card) items H, I, N through Q, V, W, Y, and Z are zero.

	Column	Format
In a rotated waffle or isogrid constructions, items R and S, T, and U, V and Y, W and Z, X and α refer to the grid directions and are respectively identical.		
D-A-S-H S-E-P-A-R-A-T-O-R C-A-R-D (See General Notes - Data Debugging)	minus in 1-80	

REGION INTRODUCTORY CARDS

These two cards are placed at the beginning of each region data information. Each region contains the following data set (see Figure 2-2): a) Two region introductory cards; b) data cards for each segment within the region; c) ring cards describing the discrete rings within the region, if any; and d) kinematic link cards describing the kinematic links within the region, if any.

	Column	Format
1. Identification Card		
A. Number of segments within the region (<29)	1-2	I2
B. Number of kinematic links between segments within the region.	3-4	I2
C. Number of discrete rings between segments within the region.	5-6	I2
D. Any alphameric information (region description)	7-70	16A4
2. Topology Card (Coupling Orientation)		
A. Region Number Number of the region under consideration.	1-5	I5
B. Joint (i) Joint associated with i^{th} (beginning) end of the region.	6-10	I5
C. Joint (j) Joint associated with j^{th} (ending) end of the region.	11-15	I5

There is no coordinate flow in regions (unless 1 region = 1 segment), such as that shown for segments in Figures 2-3 to 2-9. However, the start joint of a region must match with 1 in segment numbering, and the end joint must match with the highest segment joint number in the region (see Figure 2-12 and page 2-57). If 1 region = 1 segment, the segment topology card will be a dummy card [1 1 2] (see page 2-57).

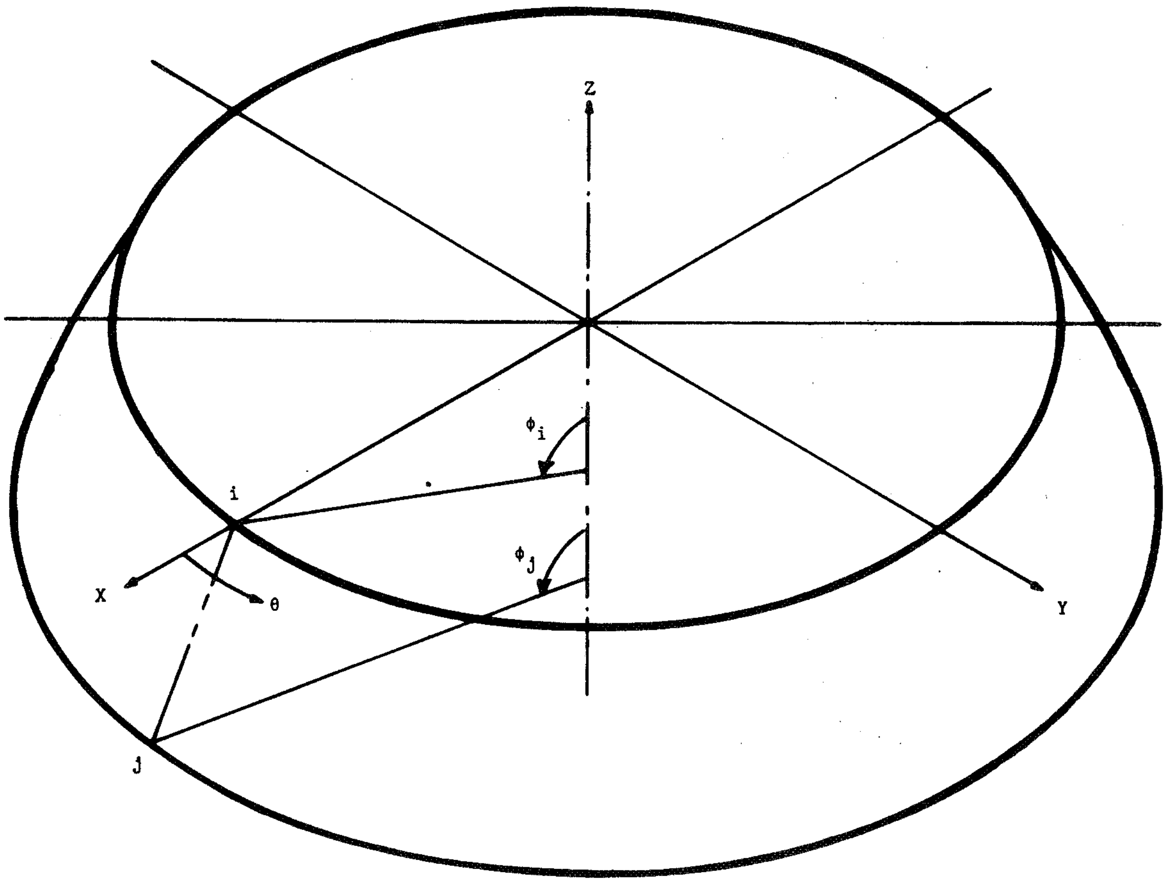


Figure 2-3. Typical Shell Segment

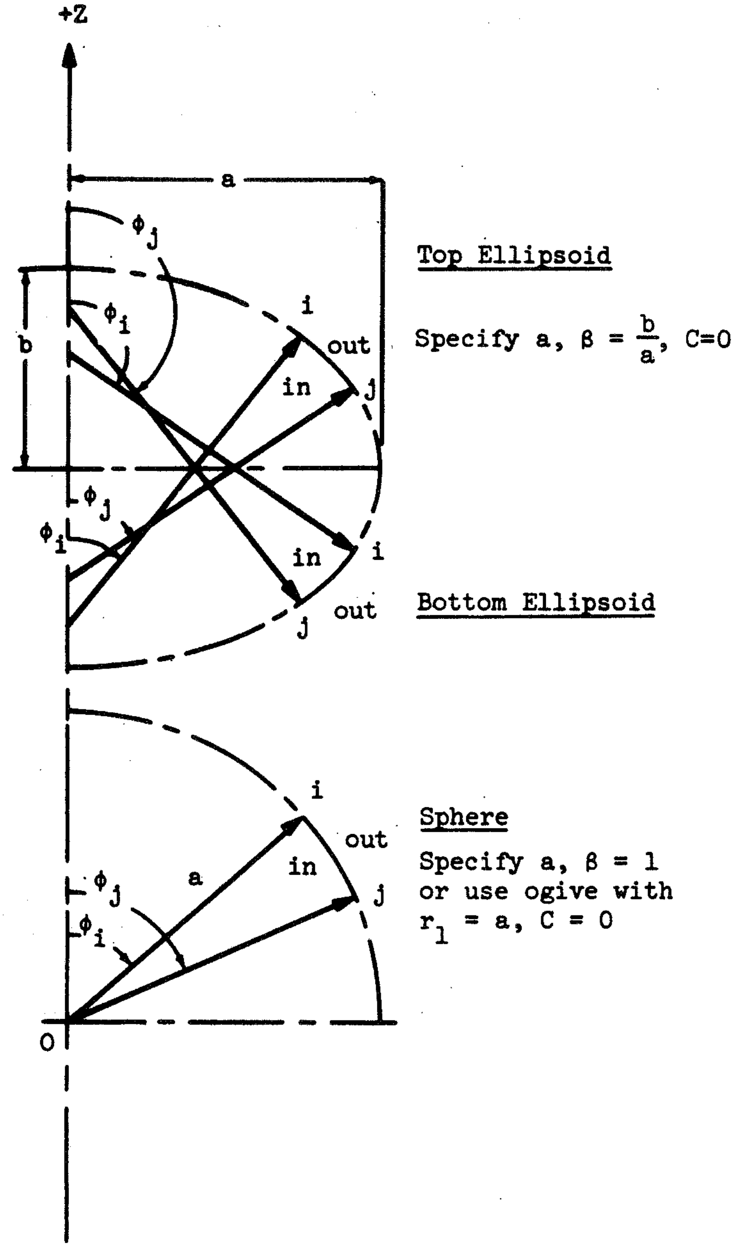


Figure 2-4a. Ellipsoid

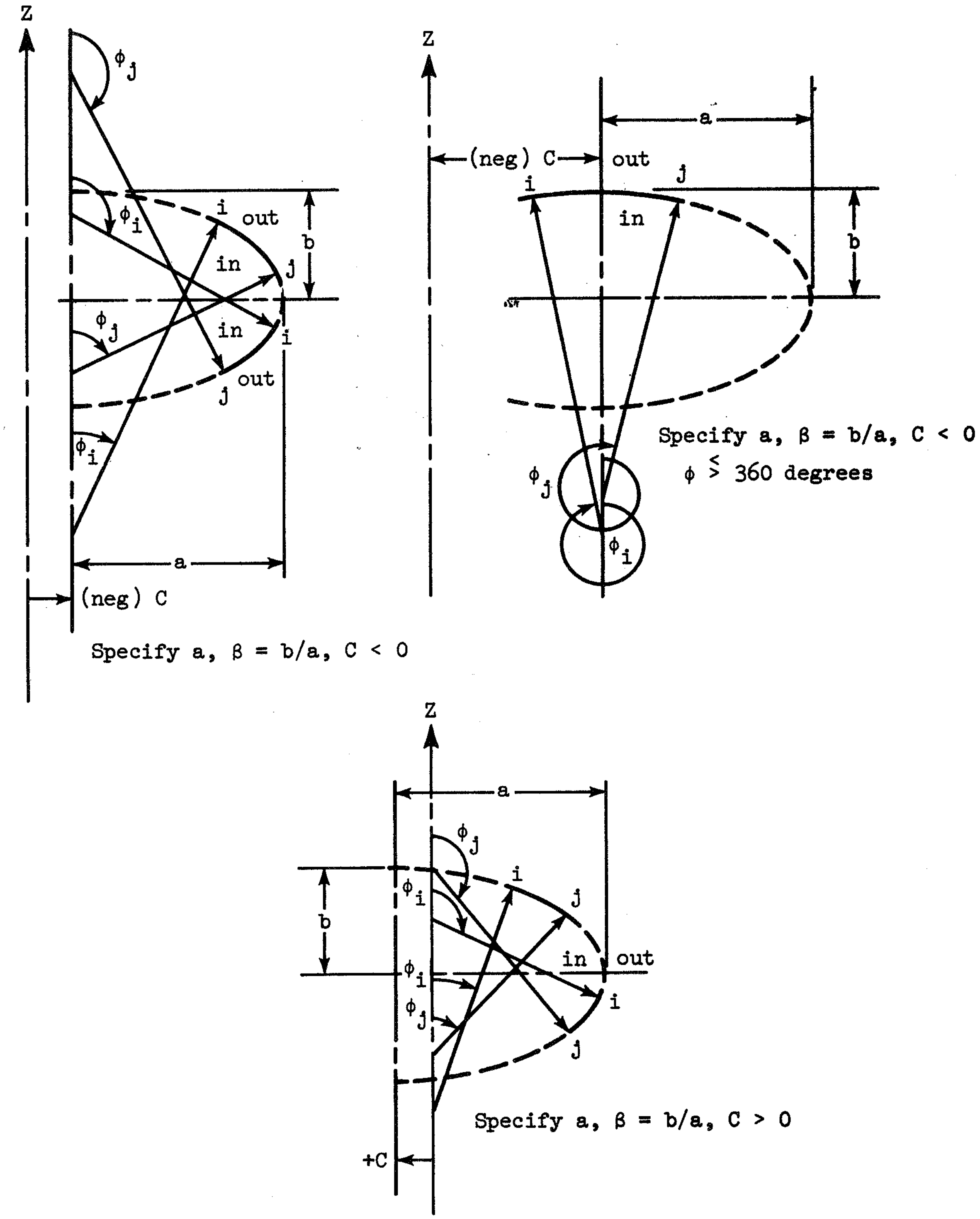


Figure 2-4b. Translated Ellipsoid

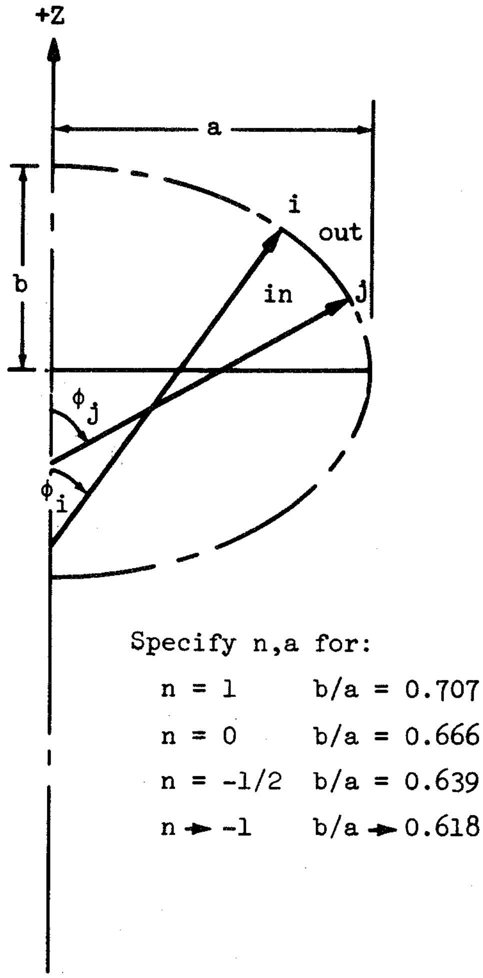


Figure 2-5. Modified Ellipsoid

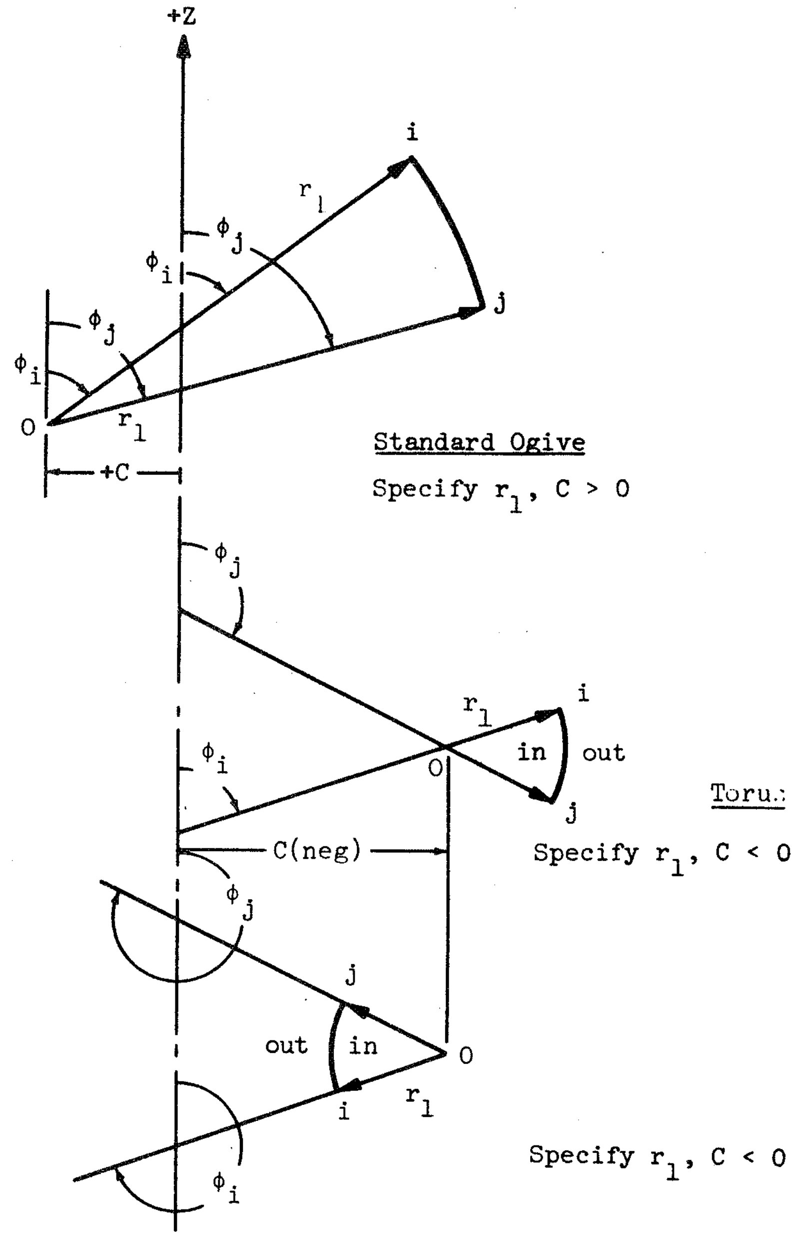


Figure 2-6. Ogive

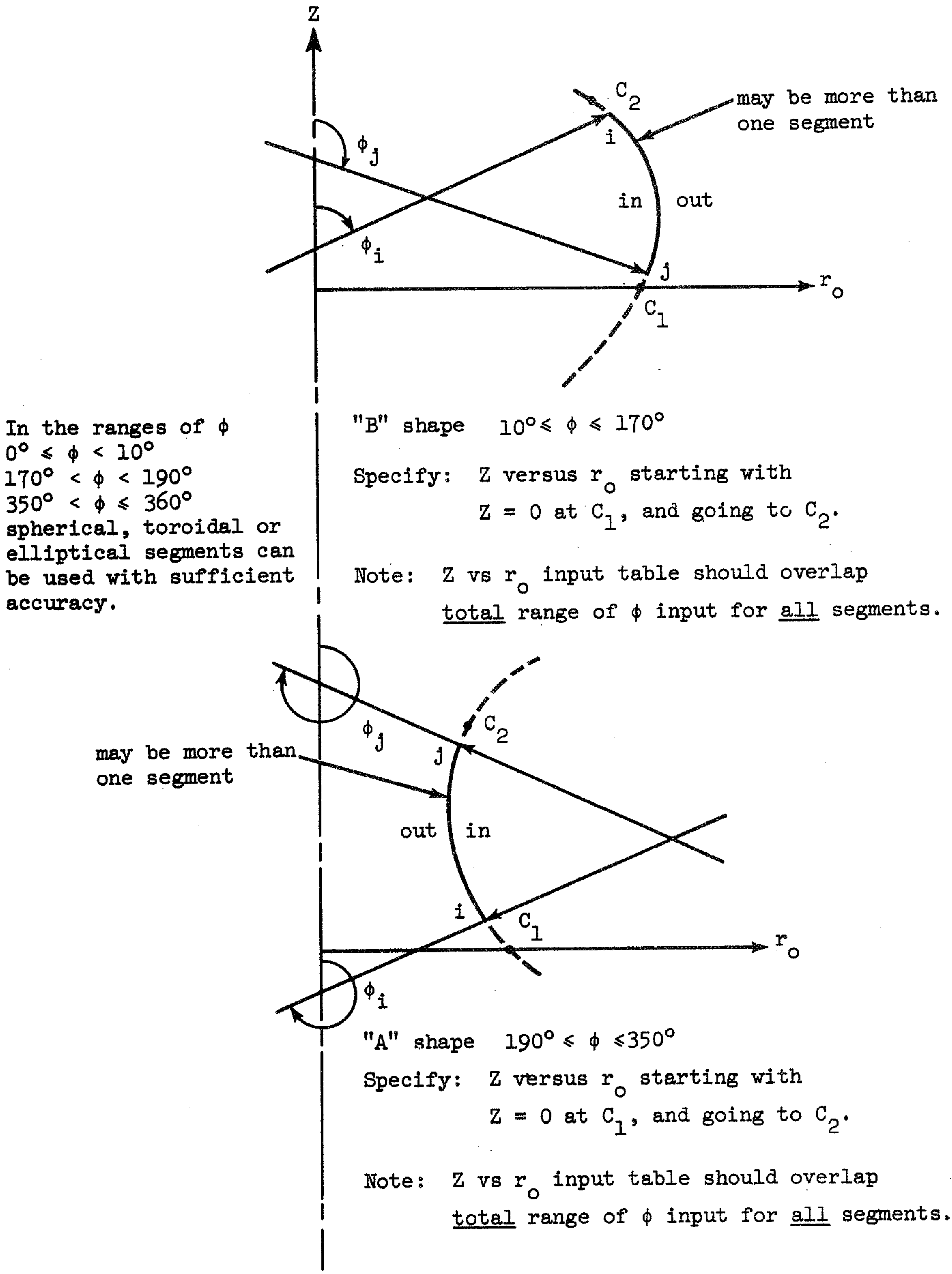


Figure 2-7. General Geometry

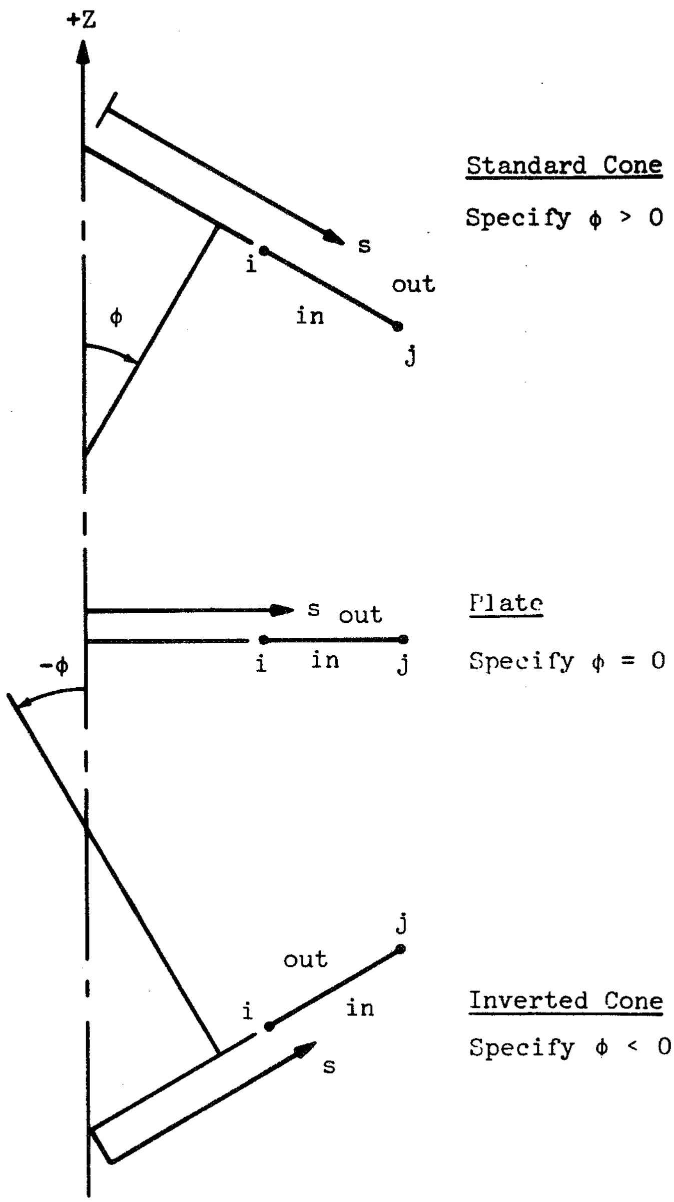


Figure 2-8. Cone

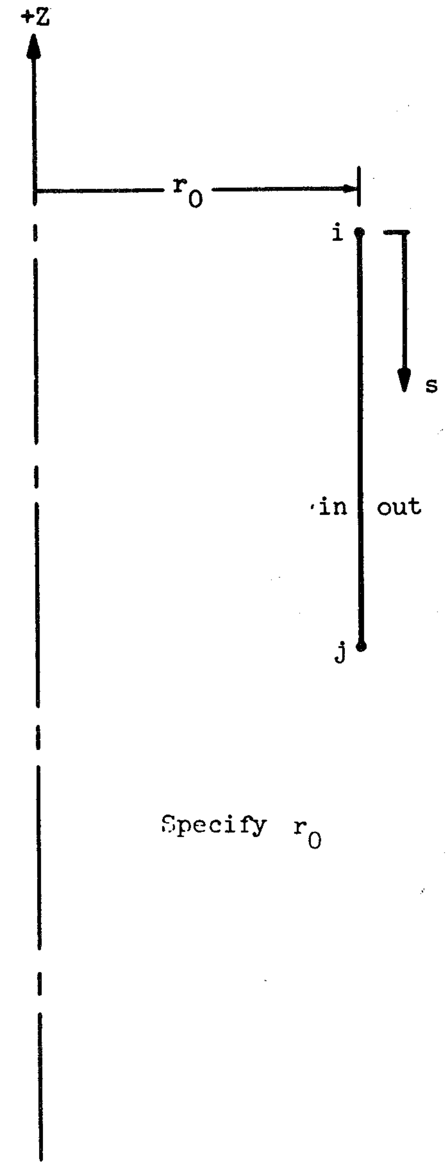


Figure 2-9. Cylinder

SEGMENT CARDS — Column — Format

This sequence of cards is repeated for each segment within the region.

1. Identification Card

   A. Segment identification code (see Figures 2-4 to 2-9)

			Column	Format
1.	Ellipsoidal or spherical shell	Code = 11	1-2	F2.0
2.	Modified ellipse shape	Code = 12	1-2	F2.0
3.	Ogival - Toroidal	Code = 13	1-2	F2.0
4.	General Geometry (see Figure 2-7)	Code = 14A or 14B	1-3	F2.0A1
5.	Dummy geometry slot (ϕ coordinate)	Code = 15	1-2	F2.0
6.	Conical - Circular Plate	Code = 21	1-2	F2.0

   The plate is treated as a cone with zero angle.

			Column	Format
7.	Cylindrical shell	Code = 31	1-2	F2.0

   B. Number of layers through the thickness — Column 4-5 — Format I2

   This is the number of layers through the thickness for plastic strain integration. In a single sheet construction the maximum number of layers is 20. In a sandwich construction both face sheets are divided into the same number of layers and this is the required input. The maximum number of layers for the sandwich face sheet is 8.

   C. Any alphameric information (segment description) — Column 6-67 — Format 16A4

2. "MAGIC" Control Card

   A. Interval at which final answers are to be printed (in radians or inches). — Column 1-14 — Format E14.1

   The ϕ-coordinate is defined for all geometric shapes except the cylinder, cone and plate, for which the s coordinate is used. Figures 2-4 through 2-9 describe these coordinates for each shape.

   B. Difference — Column 15-28 — Format E14.1

   The value recommended depends upon the computer used. For eight figure accuracy computers it is 1.0 E-6; for the IBM 360 it is 1.0 E-4.

   C. Integration interval — Column 29-42 — Format E14.1

   The Runge Kutta numerical integration procedure is substantially more accurate than finite differencing. An interval of (.01 to.03) x segment size (in radians or inches)is recommended in eigenvalue analysis so as to be able to represent eigenvectors with high wrinkling in the segment interior. (In using a 30 point segment table (see p.2-41)there should be at least 30 integration steps.)

	Column	Format
D. Apex Clue	46-49	A4

In the STARS program an apex segment is liable to have fictitiously high stresses due to the singularity effect of $r_o \to 0$. Thus such a segment should not be allowed to go plastic, since it may prematurely stop the run. Therefore a separate material property table should be prepared containing fictitiously high yield stresses. The word APEX should also be entered here as a reminder, and will trigger a reminder message in the output.

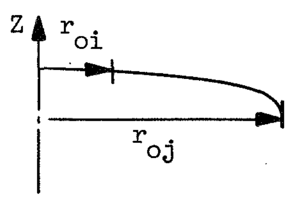
E. Delta	71-72	F2.0

For a fixed-step integration, Delta = 0.

This card controls the Runge-Kutta numerical integration scheme. The suggested values above yield accurate results for a fixed-step integration method.

Calculation of Segment Length

There is a restriction on the length of the shell segments. Physically, the restriction demands that boundary disturbances at one edge be distinctly felt at the other edge. This is a consequence of using a numerical integration procedure. Since the segment stiffness matrices must be symmetric, the calculations involved in obtaining each matrix element must be such that a computer round off error never becomes prominent. Limiting the segment length insures satisfaction of this criterion. This length is a function of both geometric shape and segment location within a specific geometry. One of the limiting factors is that the ratio of the radii of revolution at the initial and final points of a segment be greater than one hundredth and less than one hundred. Thus $\frac{1}{100} < \left(\frac{r_{oi}}{r_{oj}}\right) < 100$ where:



This requires smaller segments than will normally be predicted by formula in the area of an apex. In addition, note that ($\phi = 0$) is not an acceptable input point (except for the torus-ogive or offset ellipsoid). Also the apex segment should not be allowed to go plastic by adjusting the corresponding material property table.

For a cylinder, the segment length parameter,

$$\Lambda = (1 + \gamma)^{\frac{1}{2}} \beta \Delta s$$

should be held to about 4.0. In this expression, "γ" is a non-linear parameter. For homogeneous shells:

$$\gamma = \left[3(1 - \nu^2)\right]^{\frac{1}{2}} \left(\frac{\bar{N}_\phi r_o}{EH^2} \right)$$

It is zero for a linear problem.

"β" is a measure of the rate of decay of a disturbance in the shell.

"Δs" is the meridional length.

$r_o = r_2 \sin \phi$

The values of β^4 and Δs for various shell geometries are given below:

		For $\nu = 0.3$, $\Lambda \le 4$
Homogeneous Cylinder (H)	$\beta^4 = \frac{3(1 - \nu^2)}{r_0^2 H^2}$	$\Delta s \le \frac{3.11 (r_0 H)^{\frac{1}{2}}}{(1 + \gamma)^{\frac{1}{2}}}$
Sandwich Cylinder - Equal Face Sheets (h, t, h)	$\beta^4 = \frac{3(1 - \nu^2)}{r_0^2 (4h^2 + 6ht + 3t^2)}$	$\Delta s \le 3.11 \left[r_0^2 (4h^2 + 6ht + 3t^2) \right]^{\frac{1}{4}}$
Sandwich Cylinder - Unequal Face Sheets (h_i, t, h_o)	$\beta^4 = \frac{3(1 - \nu^2)}{(h_i + h_o)^4 + 12 h_i h_o t (h_i + h_o + t)} \left[\frac{h_i + h_o}{r_0} \right]^2$	$\Delta s \le 3.11 \left[\frac{r_0}{h_i + h_o} \right]^{\frac{1}{2}} \left[(h_i + h_o)^4 + 12 h_i h_o t (h_i + h_o + t) \right]^{\frac{1}{4}}$

Approximate formulas can be obtained for near cylindrical regions of generally curved surfaces. The length parameter,

$$\Lambda = (1 + \gamma)^{\frac{1}{2}} \lambda \Delta \phi$$

should be held to about 4.0. In this expression "γ" has the same definition as in the cylinder case.

"λ" is a measure of the rate of decay of a disturbance in the shell.

"$\Delta\phi$" = $\frac{\Delta s}{r_1}$ is the angle intercepted by a meridional arc length "Δs".

The values of λ^4 and Δs for various shell geometries are given below:

		For $\nu = 0.3$, $\Lambda \leq 4$:
Homogeneous Construction	$\lambda^4 = 3(1 - \nu^2) \frac{r_1^4}{r_2^2 H^2}$	$\Delta s \leq \frac{3.11 (r_2 H)^{\frac{1}{2}}}{(1 + \gamma)^{\frac{1}{4}}}$
Sandwich Construction - Equal Face Sheets	$\lambda^4 = \frac{3(1 - \nu^2) r_1^4}{r_2^2 (4h^2 + 6ht + 3t^2)}$	$\Delta s \leq 3.11 \left[r_2^2 (4h^2 + 6ht + 3t^2) \right]^{\frac{1}{4}}$
Sandwich Construction - Unequal Face Sheets	$\lambda^4 = \frac{3(1 - \nu^2) r_1^4}{(h_i + h_o)^4 + 12 h_i h_o t (h_i + h_o + t)} \left[\frac{h_i + h_o}{r_2} \right]^2$	$\Delta s \leq 3.11 \left[\frac{r_2}{h_i + h_o} \right]^{\frac{1}{2}} \left[(h_i + h_o)^4 + 12 h_i h_o t (h_i + h_o + t) \right]^{\frac{1}{4}}$

The minimum allowable segment length is 1×10^{-3} (inches or radians according to segment sizing).

3. Geometric Description Card

	Column	Format
A. Ellipsoid and sphere (Figure 2-4)		
1. Semi-axis perpendicular to Z-direction (a)	1-14	E14.1
2. Ratio of semi-axis in the Z-direction (b) to (a), $\beta = \left(\frac{b}{a}\right)$	15-28	E14.1
3. C = offset distance (±) (C = 0.0 if no offset)	29-42	E14.1
B. Modified ellipse shape (Figure 2-5)		
1. Axis ratio coefficient (n)	1-14	E14.1
2. Semi-axis perpendicular to Z-direction (a)	15-28	E14.1
C. Ogive (Figure 2-6)		
1. r_1 = radius	1-14	E14.1
2. C = offset distance (±)	15-28	E14.1
D. General Geometry (Figure 2-7)		
1. Number of pairs of Z versus r_o points (≤14)	1-2	I2
2. Z versus r_o points, in pairs, starting with Z value (7 values per card, including first card, for up to 4 cards total).	3-72 or 1-70	F10.0 / F10.0

In the input table the first Z value is taken as $Z_1 = 0$, and furthermore $Z_i > 0$ ($i = 2 - 14$) (see Figure 2-7).

	Column	Format
E. Cone (Figure 2-8)		
1. **Angle ϕ in radians (for flat plate, ϕ = 0).** Keep in mind that this ϕ is a constant for a given cone and should not be confused with the ϕ on **card** set 5.	1-14	E14.1
F. Cylinder (Figure 2-9)		
1. Radius	1-14	E14.1

4. Master Clue Card

This card contains a series of clues which determine the program and table locations to be used for the segment being described. For a master flow chart of clues and options in the program see Figure 2-1.

	Column	Format
A. Material Table Type Clue	1-4	A4

This clue defines the type of material property table to be expected for the segment. This, as well as the following clue determines the material properties that will be used in the structural analysis for the segment. Thus these two clues should match the two clues used on the identification card of the corresponding material property table. As mentioned before on page 2-21, the three possibilities are:

ISOT
ORTH
STIF

	Column	Format
B. Material Title	11-14	A4

This name should be the same as the name which appears on the material property table which contains the properties to be utilized for this segment.

	Column	Format
C. Sheet Clue	21-24	A4

This clue informs the program as to what kind of shell wall crossection to expect. If the shell is of single sheet construction, the clue to be used is: SING. If the shell wall is an equal-size face sheet sandwich, the clue to be used is: EQUA. If the shell wall is a sandwich but the face sheets are not equal, the clue to be used is: UNEQ. Finally, if the shell segment is reinforced by rings, stringers, a waffle, or an isogrid, the clue to be used is: BLAN.

	Column	Format
D. Reinforcement Clue	31-34	A4

This clue describes the type of reinforcement that is present on the shell. If the shell is purely of single sheet or equal or unequal-size face sheet honeycomb construction (no reinforcing), the clue to be used is: THIC. If the reinforcement consists of rings or stringers or both, located along the coordinate axes (θ and ϕ or s), three clues are possible depending upon the basic shell wall construction. If the basic wall construction is a single sheet, the clue to be used is ST11. If the basic shell wall is an equal-size face sheet sandwich, the clue to be used is ST12. If the basic shell wall is a sandwich but the face sheets are unequal, the clue to be used is ST13. If the reinforcement consists of a waffle which is rotated at an arbitrary angle β from the meridional axis the following three clues are possible depending upon the basic shell wall construction. If the basic wall construction is a single sheet, the clue to be used is RWA1. If the basic shell wall is an equal-size face sheet sandwich, the clue to be used is RWA2. If the basic shell wall is a sandwich but the face sheets are unequal, the clue to be used is RWA3. If the reinforcement consists of an isogrid construction of general angle β from the meridional axis (normally $\beta = 30°$) the following three clues are possible depending upon the basic shell wall construction. If the basic wall construction is a single sheet, the clue to be used is ISG1. If the basic shell wall is an equal-size face sheet sandwich, the clue to be used is ISG2. If the basic shell wall is a sandwich but the face sheets are unequal, the clue to be used is ISG3. Two other clues are available, namely ST10 and RWAF, if the user wishes to input his own stiffness constants. These constants may represent any wall construction as long as the basic Hooke's Laws used with the clues are appropriate to describe the construction to be considered. The Hooke's Laws used with these clues are given under the description of segment card set 6. No plastic analysis is allowed with the last two clues since a geometric description of the crossection is not input.

		Column	Form
	<u>Note</u>: The reinforcement described in the segment cards is closely spaced reinforcement which will be smeared over the segment. <u>Discrete rings</u> at segment ends in a region are described at the end of all segment data for that region.		
E.	Thermal Clue	41-44	A4
	This clue describes the type of thermal problem which exists in the segment. The user is reminded that in a cycling run this clue is constant for all cycles, requiring zero thermal loads to be input if necessary. If there is no thermal load on the segment, the clue to be used is <u>NOTH</u>. If the thermal loading on the segment is of general, standard type, that is if there is variation of temperature through the thickness as well as in the coordinate directions, the clue to be used is <u>THST</u>. If the thermal load is such that the variation is all in the coordinate directions, and there is no thermal variation through the thickness, the clue to be used is <u>THCN</u>. The last clue concerns a shell which is inhomogeneous in the meridional direction. This is not really a thermal problem at all, but merely a manipulation of the material property tables. If a structure has a wide variation in material properties in the meridional direction, without this last option one must take short segments of constant properties for analysis. With this option, however, the property variation is placed in the material property table, and expressed on the segment as a function of temperature. No thermal loads are calculated, however, and the temperatures are only used to interpolate for material properties as integration is progressing along the segment. Thus continual variation of properties in the meridional direction is accommodated. The clue for this option is <u>THIN</u>.		
F.	Hardening Law Clue	51-54	A4
	This clue determines the hardening law to be used for the segment. If isotropic hardening is to be used the clue is <u>ISOT</u>. If kinematic hardening is to be used the clue is <u>KINE</u>. If perfect plasticity is to be used the clue is <u>PERF</u>.		
	<u>Note</u>: ISOT hardening law is <u>not</u> allowed with ORTH material (item A on this card).		

	Column	Format
G. Table control - Number of points in each of the following tables.	71-72	I2

This can vary from 2 to 30 depending upon the shell geometry and loading. For a linearly varying geometry and/or loading only 2 input points would be required. These two points would be the end points. For more general loading and/or geometry a larger number of points are required. In particular, each abrupt change is specified by two points. One should use as many points as necessary (up to 30) in order to completely describe the problem, rather than using very short segments.

5. Table of ϕ or s Values

A. Initial, intermediate and final values of ϕ or s. Each point requires 14 columns on a card and thus there can be 5 values per card and up to 6 cards to make a total of up to 30 points. The points to be specified are the beginning point of the segment, any point of discontinuity, and the end point of the segment. The input must be consistent with item G of the previous card. — Format: 5E14.7

6. Table of Wall Crossection Geometry

The contents of these cards (up to 6 cards per item below) are dependent upon the clues registered on the Master Clue Card. If the shell to be described contains no reinforcing, the pertinent clue is item 4C, the Sheet Clue. The geometry is input and the stiffnesses are calculated by the program (see Figure 2-10). The input is presented below as a function of the Sheet Clue.

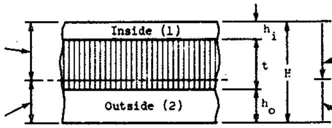
If the Sheet Clue is SING (single sheet construction):

A. Initial, intermediate and final values of wall thickness (h_i) at points defined by table of ϕ or s values. — Format: 5E14.7

$$\bar{\zeta}_{in} = \frac{h_i^2 + h_o^2 + 2h_ih_o + 2h_ot}{2(h_i + h_o)}$$

$$\bar{\zeta}_{out} = \frac{h_i^2 + h_o^2 + 2h_ih_o + 2h_it}{2(h_i + h_o)}$$

E, ν, Constant through thickness



$$\bar{\zeta}_{in} = \frac{E_1h_i^2 + E_2h_o^2 + 2E_2h_oh_i + 2E_2h_ot}{2(E_1h_i + E_2h_o)}$$

$$\bar{\zeta}_{out} = \frac{E_1h_i^2 + E_2h_o^2 + 2E_1h_ih_o + 2E_1h_it}{2(E_1h_i + E_2h_o)}$$

Unequal material properties for the face sheets.
Restriction: properties are such that a neutral plane exists.

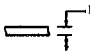
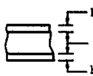
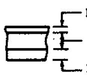
Configuration	Extensional Stiffness	Flexural Stiffness	Shear Stiffness
 h_i Ortho-tropic	$K_{11} = \frac{E_\theta h_i}{1 - \nu_{\phi\theta}\nu_{\theta\phi}}$ $K_{22} = \frac{E_\phi h_i}{1 - \nu_{\phi\theta}\nu_{\theta\phi}}$	$D_{11} = \frac{E_\theta h_i^3}{12(1 - \nu_{\phi\theta}\nu_{\theta\phi})}$ $D_{22} = \frac{E_\phi h_i^3}{12(1 - \nu_{\phi\theta}\nu_{\theta\phi})}$	$K_{33} = G_{\phi\theta}h_i$ $D_{33} = \frac{G_{\phi\theta}h_i^3}{12}$
 h_i, t, h_i Equal Face Sheets	$K_{11} = \frac{E_{\theta_1}h_i}{1-\nu_{\phi\theta_1}\nu_{\theta\phi_1}} + \frac{E_{\theta_2}h_i}{1-\nu_{\phi\theta_2}\nu_{\theta\phi_2}}$ $K_{22} = \frac{E_{\phi_1}h_i}{1-\nu_{\phi\theta_1}\nu_{\theta\phi_1}} + \frac{E_{\phi_2}h_i}{1-\nu_{\phi\theta_2}\nu_{\theta\phi_2}}$	$D_{11} = \frac{E_{\theta_1}h_i^3}{12(1-\nu_{\phi\theta_1}\nu_{\theta\phi_1})} + \frac{E_{\theta_2}h_i^3}{12(1-\nu_{\phi\theta_2}\nu_{\theta\phi_2})} + h_i\left\{\frac{E_{\theta_1}(\bar{\zeta}_{in}-\frac{h_i}{2})^2}{1-\nu_{\phi\theta_1}\nu_{\theta\phi_1}} + \frac{E_{\theta_2}(\bar{\zeta}_{out}-\frac{h_i}{2})^2}{1-\nu_{\phi\theta_2}\nu_{\theta\phi_2}}\right\}$ $D_{22} = \frac{E_{\phi_1}h_i^3}{12(1-\nu_{\phi\theta_1}\nu_{\theta\phi_1})} + \frac{E_{\phi_2}h_i^3}{12(1-\nu_{\phi\theta_2}\nu_{\theta\phi_2})} + h_i\left\{\frac{E_{\phi_1}(\bar{\zeta}_{in}-\frac{h_i}{2})^2}{1-\nu_{\phi\theta_1}\nu_{\theta\phi_1}} + \frac{E_{\phi_2}(\bar{\zeta}_{out}-\frac{h_i}{2})^2}{1-\nu_{\phi\theta_2}\nu_{\theta\phi_2}}\right\}$	$K_{33} = h_i(G_{\phi\theta_1} + G_{\phi\theta_2})$ $D_{33} = \frac{h_i^3}{12}(G_{\phi\theta_1} + G_{\phi\theta_2}) + h_i[G_{\phi\theta_1}(\bar{\zeta}_{in} - \frac{h_i}{2})^2 + G_{\phi\theta_2}(\bar{\zeta}_{out} - \frac{h_i}{2})^2]$
 h_i, t, h_o Unequal Face Sheets	$K_{11} = \frac{E_{\theta_1}h_i}{1-\nu_{\phi\theta_1}\nu_{\theta\phi_1}} + \frac{E_{\theta_2}h_o}{1-\nu_{\phi\theta_2}\nu_{\theta\phi_2}}$ $K_{22} = \frac{E_{\phi_1}h_i}{1-\nu_{\phi\theta_1}\nu_{\theta\phi_1}} + \frac{E_{\phi_2}h_o}{1-\nu_{\phi\theta_2}\nu_{\theta\phi_2}}$	$D_{11} = \frac{E_{\theta_1}h_i^3}{12(1-\nu_{\phi\theta_1}\nu_{\theta\phi_1})} + \frac{E_{\theta_2}h_o^3}{12(1-\nu_{\phi\theta_2}\nu_{\theta\phi_2})} + \frac{E_{\theta_1}h_i(\bar{\zeta}_{in}-\frac{h_i}{2})^2}{1-\nu_{\phi\theta_1}\nu_{\theta\phi_1}} + \frac{E_{\theta_2}h_o(\bar{\zeta}_{out}-\frac{h_o}{2})^2}{1-\nu_{\phi\theta_2}\nu_{\theta\phi_2}}$ $D_{22} = \frac{E_{\phi_1}h_i^3}{12(1 - \nu_{\phi\theta_1}\nu_{\theta\phi_1})} + \frac{E_{\phi_2}h_o^3}{12(1 - \nu_{\phi\theta_2}\nu_{\theta\phi_2})} + \frac{E_{\phi_1}h_i(\bar{\zeta}_{in}-h_1/2)^2}{1 - \nu_{\phi\theta_1}\nu_{\theta\phi_1}} + \frac{E_{\phi_2}h_o(\bar{\zeta}_{out}-h_o/2)^2}{1 - \nu_{\phi\theta_2}\nu_{\theta\phi_2}}$	$K_{33} = G_{\phi\theta_1}h_i + G_{\phi\theta_2}h_o$ $D_{33} = \frac{G_{\phi\theta_1}h_i^3}{12} + \frac{G_{\phi\theta_2}h_o^3}{12} + G_{\phi\theta_1}h_i(\bar{\zeta}_{in}-\frac{h_i}{2})^2 + G_{\phi\theta_2}h_o(\bar{\zeta}_{out}-\frac{h_o}{2})^2$

Figure 2-10 Shell Section Properties

	Column	Format
If the Sheet Clue is EQUA (equal-size face sheet sandwich):		
A. Initial, intermediate and final values of face sheet thickness (h_i) at points defined by table of ϕ or s values.		5E14.7
B. Initial, intermediate and final values of core thickness (t) at points defined by table of ϕ or s values.		5E14.7
If the Sheet Clue is UNEQ (unequal-size face sheet sandwich):		
A. Initial, intermediate and final values of <u>inner</u> face sheet thickness (h_i) at points defined by table of ϕ or s values.		5E14.7
B. Initial, intermediate and final values of core thickness (t) at points defined by table of ϕ or s values.		5E14.7
C. Initial, intermediate and final values of <u>outer</u> face sheet thickness (h_o) at points defined by table of ϕ or s values.		5E14.7
If the shell is reinforced, the Sheet Clue will be BLAN. In this case it is the following, or Reinforcement Clue (item 4D) which will determine the contents of card series 6. For the reinforcement cases the geometry can be complex and varied, since all types of reinforcing are to be included. The reinforced shell input is presented below as a function of the Reinforcement Clue.		
If the Reinforcement Clue is ST11 (single sheet reinforced by rings and/or stringers):		
A. Initial, intermediate and final values of the torsional stiffness in the ϕ direction (GJ_ϕ) at points defined by table of ϕ or s values.		5E14.7
B. Initial, intermediate and final values of the torsional stiffness in the θ direction (GJ_θ) at points defined by table of ϕ or s values.		5E14.7
C. Initial, intermediate and final values of stringer area (A_ϕ) at points defined by table of ϕ or s values.		5E14.7
D. Initial, intermediate and final values of ring area (A_θ) at points defined by table of ϕ or s values.		5E14.7
E. Initial, intermediate and final values of stringer eccentricity (measured inwards from base shell centroid as positive) at points defined by table of ϕ or s values.		5E14.7

	Column	Format
F. Initial, intermediate and final values of ring eccentricity (measured inwards from base shell centroid as positive) at points defined by table of ϕ or s values.		5E14.7
G. Initial, intermediate and final values of stringer moment of inertia (about base shell centroidal axis) at points defined by table of ϕ or s values.		5E14.7
H. Initial, intermediate and final values of ring moment of inertia (about base shell centroidal axis) at points defined by table of ϕ or s values.		5E14.7
I. Initial, intermediate and final values of stringer spacing at points defined by table of ϕ or s values. (Do not set to zero if no stringers.)		5E14.7
J. Initial, intermediate and final values of ring spacing at points defined by table of ϕ or s values. (Do not set to zero if no rings.)		5E14.7
K. Initial, intermediate and final values of base shell wall thickness (h_i) at points defined by table of ϕ or s values.		5E14.7
If the Reinforcement Clue is ST12 (equal face sheet sandwich reinforced by rings and/or stringers):		
A. through J. The items contained on these cards are those described for the ST11 clue above.	10 sets of	5E14.7
K. Initial, intermediate and final values of base shell face sheet thickness (h_i) at points defined by table of ϕ or s values.		5E14.7
L. Initial, intermediate and final values of base shell core thickness (t) at points defined by table of ϕ or s values.		5E14.7
If the Reinforcement Clue is ST13 (unequal face sheet sandwich reinforced by rings and/or stringers):		
A. through J. The items contained on these cards are those described for the ST11 clue above.	10 sets of	5E14.7
K. Initial, intermediate and final values of base shell inner face sheet thickness (h_i) at points defined by table of ϕ or s values.		5E14.7
L. Initial, intermediate and final values of base shell core thickness (t) at points defined by table of ϕ or s values.		5E14.7

	Column	Format
M. Initial, intermediate and final values of base shell <u>outer</u> face sheet thickness (h_o) at points defined by table of ϕ or s values.		5E14.7

If the Reinforcement Clue is RWA1 (single sheet reinforced by a waffle rotated at an arbitrary angle from the meridional direction):

	Column	Format
A. Initial, intermediate and final values of waffle grid area at points defined by table of ϕ or s values.		5E14.7
B. Initial, intermediate and final values of waffle grid eccentricity (measured inwards from base shell centroid as positive) at points defined by table of ϕ or s values.		5E14.7
C. Initial, intermediate and final values of waffle grid moment of inertia (about base shell centroidal axis) at points defined by table of ϕ or s values.		5E14.7
D. Initial, intermediate and final values of waffle grid spacing at points defined by table of ϕ or s values.		5E14.7
E. Initial, intermediate and final values of waffle grid rotation angle, β, (in radians from the meridional direction) at points defined by table of ϕ or s values.		5E14.7
F. Initial, intermediate and final values of extreme distance from base shell centroid to waffle outer edge (± value, positive inwards), at points defined by table of φ or s values.		5E14.7
G. Initial, intermediate and final values of base shell wall thickness (h_i) at points defined by table of ϕ or s values.		5E14.7

If the Reinforcing Clue is RWA2 (equal face sheet sandwich reinforced by a waffle rotated at an arbitrary angle from the meridional direction):

	Column	Format
A. through F. The items contained on these cards are those described for the RWA1 clue above.	6 sets of	5E14.7
G. and H. The items contained on these cards are those described for the ST12 clue above as items K. and L.	2 sets of	5E14.7

If the Reinforcing Clue is RWA3 (unequal face sheet sandwich reinforced by a waffle rotated at an arbitrary angle from the meridional direction):

	Column	Format
A. through F. The items contained on these cards are those described for the RWA1 clue above.	6 sets of	5E14.7
G. through I. The items contained on these cards are those described for the ST13 clue above as items K. through M.	3 sets of	5E14.7

	Column	Format
If the Reinforcing Clue is ISG1 (single sheet reinforced by a general angle isogrid construction):		
A. through D. The items contained on these cards are identical to those described for the RWA1 clue above, but with reference to the isogrid.	4 sets of	5E14.7
E. Initial, intermediate and final values of the isogrid angle, β, (in radians from the meridional direction, see Reference 4 Appendix A). For the normal isogrid, the angle is 30° (input in radians).		5E14.7
F. Initial, intermediate and final values of base shell wall thickness (h_i) at points defined by table of ϕ or s values.		5E14.7
If the Reinforcing Clue is ISG2 (equal face sheet sandwich reinforced by a general angle isogrid construction):		
A. through E. The items contained on these cards are those described for the ISG1 clue above.	5 sets of	5E14.7
F. and G. The items contained on these cards are those described for the ST12 clue above as items K. and L.	2 sets of	5E14.7
If the Reinforcing Clue is ISG3 (unequal face sheet sandwich reinforced by a general angle isogrid construction):		
A. through E. The items contained on these cards are those described for the ISG1 clue above.	5 sets of	5E14.7
F. through H. The items contained on these cards are those described for the ST13 clue above as items K. through M.	3 sets of	5E14.7

If the Reinforcing Clue is ST10 the following Hooke's Laws will be used by the program for the description of the shell wall:

$$N_\theta = K_{11}\varepsilon_{\theta_o} + K_{12}\varepsilon_{\phi_o} - C_{11}k_\theta - N_{T\theta}$$

$$N_\phi = K_{22}\varepsilon_{\phi_o} + K_{12}\varepsilon_{\theta_o} - C_{22}k_\phi - N_{T\phi}$$

$$N_{\phi\theta} = N_{\theta\phi} = K_{33}\,\gamma_{\phi\theta_o}$$

	Column	Format

$$M_\theta = D_{11}k_\theta + D_{12}k_\phi + C_{11}\varepsilon_{\theta_o} - M_{T\theta}$$

$$M_\phi = D_{22}k_\phi + D_{12}k_\theta + C_{22}\varepsilon_{\phi_o} - M_{T\phi}$$

$$M_{\phi\theta} = -M_{\theta\phi} = -2D_{33}k_{\phi\theta}$$

Therefore the input is (see Ref. 4 Appendix A):

		Format
A.	Initial, intermediate and final values of K_{11} at points defined by table of ϕ or s values.	5E14.7
B.	Initial, intermediate and final values of K_{12} at points defined by table of ϕ or s values.	5E14.7
C.	Initial, intermediate and final values of K_{22} at points defined by table of ϕ or s values.	5E14.7
D.	Initial, intermediate and final values of K_{33} at points defined by table of ϕ or s values.	5E14.7
E.	Initial, intermediate and final values of D_{11} at points defined by table of ϕ or s values. (Should be input as negative for sign convention.)	5E14.7
F.	Initial, intermediate and final values of D_{12} at points defined by table of ϕ or s values. (Should be input as negative for sign convention.)	5E14.7
G.	Initial, intermediate and final values of D_{22} at points defined by table of ϕ or s values. (Should be input as negative for sign convention.)	5E14.7
H.	Initial, intermediate and final values of D_{33} at points defined by table of ϕ or s values.	5E14.7
I.	Initial, intermediate and final values of C_{11} at points defined by table of ϕ or s values.	5E14.7
J.	Initial, intermediate and final values of C_{22} at points defined by table of ϕ or s values.	5E14.7

Note: No plasticity is allowed for this option.

If the Reinforcing Clue is RWAF the following Hooke's Laws will be used by the program for the description of the shell wall:

$$N_\theta = K_{11}\,\varepsilon_{\theta_o} + K_{12}\,\varepsilon_{\phi_o} - C_{11}\,k_\theta - C_{15}\,k_\phi - N_{T\theta}$$

$$N_\phi = K_{22}\,\varepsilon_{\phi_o} + K_{12}\,\varepsilon_{\theta_o} - C_{15}\,k_\theta - C_{22}\,k_\phi - N_{T\phi}$$

$$N_{\phi\theta} = K_{33}\,\gamma_{\phi\theta_o} - 2C_{16}\,k_{\phi\theta}$$

	Column	Format

$$M_\theta = D_{11} k_\theta + D_{12} k_\phi + C_{11} \varepsilon_{\theta_o} + C_{15} \varepsilon_{\phi_o} - M_{T\theta}$$

$$M_\phi = D_{22} k_\phi + D_{12} k_\theta + C_{15} \varepsilon_{\theta_o} + C_{22} \varepsilon_{\phi_o} - M_{T\phi}$$

$$M_{\phi\theta} = -2D_{33} k_{\phi\theta} + C_{16} \gamma_{\phi\theta_o}$$

Therefore the input is (see Ref. 4 Appendix A):

Item	Column	Format
A. through J. The items contained on these cards are those described for the ST10 clue above.	10 sets of	5E14.7
K. Initial, intermediate and final values of C_{15} at points defined by table of ϕ or s values.		5E14.7
L. Initial, intermediate and final values of C_{16} at points defined by table of ϕ or s values.		5E14.7

Note: No plasticity is allowed for this option.

7. Table of Reinforcement Temperatures

This card set is included only if the Reinforcement Clue (Item D page 2-39) is ST11, ST12, ST13, RWA1, RWA2, RWA3, ISG1, ISG2, or ISG3 and the Thermal Clue (Item E page 2-40) is THST or THCN. The input is presented below as a function of the Reinforcement Clue.

If the Reinforcement Clue is ST11, ST12, or ST13:

Item	Format
A. Initial, intermediate and final values of the stringer temperature, at points defined by table of φ or s values.	5E14.7
B. Initial, intermediate and final values of the ring (smeared) temperature, at points defined by table of φ or s values.	5E14.7

If the Reinforcement Clue is RWA1, RWA2, RWA3, ISG1, ISG2, or ISG3:

Item	Format
A. Initial, intermediate and final values of the reinforcement (waffle or isogrid) temperature, at points defined by table of φ or s values.	5E14.7

8. Table of Mass Densities (Dimensions = weight/volume/acceleration due to gravity.)

	Column	Format
This card set is included only if the Shell Rotation Clue (Item K page 2-18) is set to unity, i.e. if the shell undergoes rotation. In such a case, the contents of these cards (up to 6 cards per item below) are dependent upon the clues registered on the Master Clue Card. If the shell to be described contains no reinforcing, the pertinent clue is item 4C, the sheet clue. The input is presented below as a function of the Sheet Clue.		
If the Sheet Clue is SING (single sheet construction):		
A. Initial, intermediate and final values of the wall mass density at points defined by table of φ or s values.		5E14.7
If the Sheet Clue is EQUA or UNEQ (sandwich construction):		
A. Initial, intermediate and final values of the core mass density at points defined by table of φ or s values.		5E14.7
B. Initial, intermediate and final values of the face sheet mass density at points defined by table of φ or s values.		5E14.7
If the shell is reinforced, the Sheet Clue will be BLAN. In this case it is the following, or Reinforcement Clue (item 4D) which will determine the contents of card series 8. The reinforced shell input is presented below as a function of the Reinforcement Clue.		
If the Reinforcement Clue is ST11 (single sheet reinforced by rings and/or stringers):		
A. Initial, intermediate and final values of the base shell mass density at points defined by table of φ or s values.		5E14.7
B. Initial, intermediate and final values of the stringer mass density at points defined by table of φ or s values.		5E14.7
C. Initial, intermediate and final values of the ring mass density at points defined by table of φ or s values.		5E14.7
If the Reinforcement Clue is ST12 or ST13 (sandwich reinforced by rings and/or stringers):		
A. Initial, intermediate and final values of the base shell core mass density at points defined by table of φ or s values.		5E14.7

	Column	Format
B. Initial, intermediate and final values of the base shell face sheet mass density at points defined by table of φ or s values.		5E14.7
C. and D. The items contained on these cards are those described for the ST11 clue as items B. and C.	2 sets of	5E14.7

If the Reinforcement Clue is RWA1 or ISG1 (single sheet reinforced by a rotated waffle or isogrid):

A. Initial, intermediate and final values of the base shell mass density at points defined by table of φ or s values.		5E14.7
B. Initial, intermediate and final values of the reinforcement mass density at points defined by table of φ or s values.		5E14.7

If the Reinforcement Clue is RWA2, RWA3, ISG2 or ISG3 (sandwich reinforced by a rotated waffle or isogrid):

A. Initial, intermediate and final values of the base shell core mass density at points defined by table of φ or s values.		5E14.7
B. Initial, intermediate and final values of the base shell face sheet mass density at points defined by table of φ or s values.		5E14.7
C. Initial, intermediate and final values of the reinforcement mass density at points defined by table of φ or s values.		5E14.7

If the Reinforcing Clue is ST10 or RWAF the program does not have any crossection description available to it for calculations. Thus no plasticity analysis is allowed, and the required input in card set 8 for these clues is (see Refs. 1, 4 and 5):

A. The meridional distributed load on the crossection due to rotation at points defined by table of φ or s values. For example for a layered section this can be expressed as: — 5E14.7

$$f^1_\varphi = \sum_{i=1}^{n} \rho_i \omega^2 r_i t_i \cos \varphi$$

B. The normal distributed load on the crossection due to rotation at points defined by table of φ or s values. For example for a layered section this can be expressed as: — 5E14.7

$$f^1_\zeta = -\sum_{i=1}^{n} \rho_i \omega^2 r_i t_i \sin \varphi$$

	Column	Format
C. The circumferential distributed moment load on the crossection due to rotation at points defined by table of φ or s values. For example for a layered section this can be expressed as:		5E14.7

$$m_\theta = -\sum_{i=1}^{n} \rho_i \omega^2 r_i t_i \bar{y}_i \cos \varphi$$

Note: The sign convention for the above loads is as shown in Figures 2-11.

9. Loading Clue Card

The contents of this card are numerical clues which alert the program to the types of loads that exist on the segment. In addition, if the clue indicates that some load does not exist, the appropriate cards in series 10 which would ordinarily contain the numerical values of this load are omitted from the sequence. In the case of a rotating shell the inertia loads are calculated internally by the program.

The appropriate clues are as follows:

	Column	Format
A. Thermal Clue	1	I1
If there are no thermal loads (Item 4E is NOTH) the clue number is zero (0).		
If there is a standard thermal variation through the thickness (Item 4E is THST) the clue number is four (4).		
If the temperature is constant through the thickness (Item 4E is THCN) or if the in-homogeneous option is used (Item 4E is THIN) the clue number is one (1).		
B. Circumferential Load Clue (f_θ)	2	I1
If there are no circumferential loads, then the clue number is zero (0).		
If there are circumferential loads, then the clue number is one (1).		

		Column	Format
C.	Meridional Load Clue (f_ϕ) If there are no meridional loads, then the clue number is zero (0). If there are meridional loads, then the clue number is one (1).	3	I1
D.	Normal Load Clue (f_ζ) If there are no normal loads, then the clue number is zero (0). If there are normal loads, then the clue number is one (1).	4	I1
E.	Circumferential Moment Load Clue (m_θ) If there are no circumferential moment loads, then the clue number is zero (0). If there are circumferential moment loads, then the clue number is one (1).	5	I1
F.	**Meridional Moment Clue** (m_φ) If there are no meridional moment loads, then the clue number is zero (0). If there are meridional moment loads, then the clue number is one (1).	6	I1
G.	Any alphameric information (load description)	7-70	16A4

10. Table of Applied Loads (see Figures 2-11a, b for sign convention).

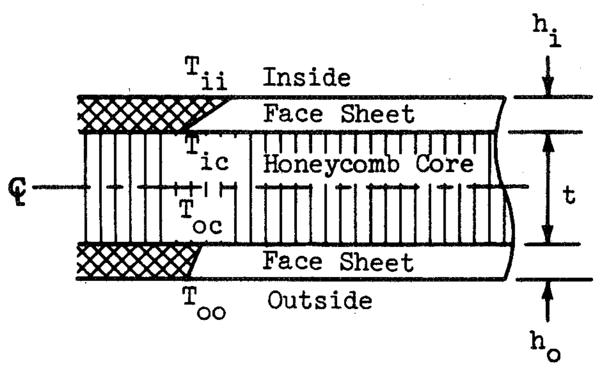
The appropriate card sequence is given below as a function of the Loading Clues on card 9. If the Thermal Clue is one (1):

		Column	Format
A.	Initial, intermediate and final values of the temperature of the shell at points defined by table of ϕ or s values. (These values will be used either for a thermal problem where there is no thermal variation through the thickness {Clue = THCN}, or to calculate varying material properties along the shell for an inhomogeneous problem {Clue = THIN}.)		5E14.7

	Column	Format

If the Thermal Clue is four (4):

A. Initial, intermediate and final values of the temperature T_{ii} at points defined by table of ϕ or s values. (The subscripts "nm" indicate temperature location - see below.) 5E14.7



B. Initial, intermediate and final values of the temperature T_{ic} at points defined by table of ϕ or s values. 5E14.7

C. Initial, intermediate and final values of the temperature T_{oc} at points defined by table of ϕ or s values. 5E14.7

D. Initial, intermediate and final values of the temperature T_{oo} at points defined by table of ϕ or s values. 5E14.7

If the Thermal Clue is zero (0), the above cards are omitted. All temperature values above refer to the base shell.

If the Circumferential Load Clue is one (1):

E. Initial, intermediate and final values of the circumferential loads f_θ at points defined by table of φ or s values. 5E14.7

If the Circumferential Load Clue is zero (0), cards E are omitted.

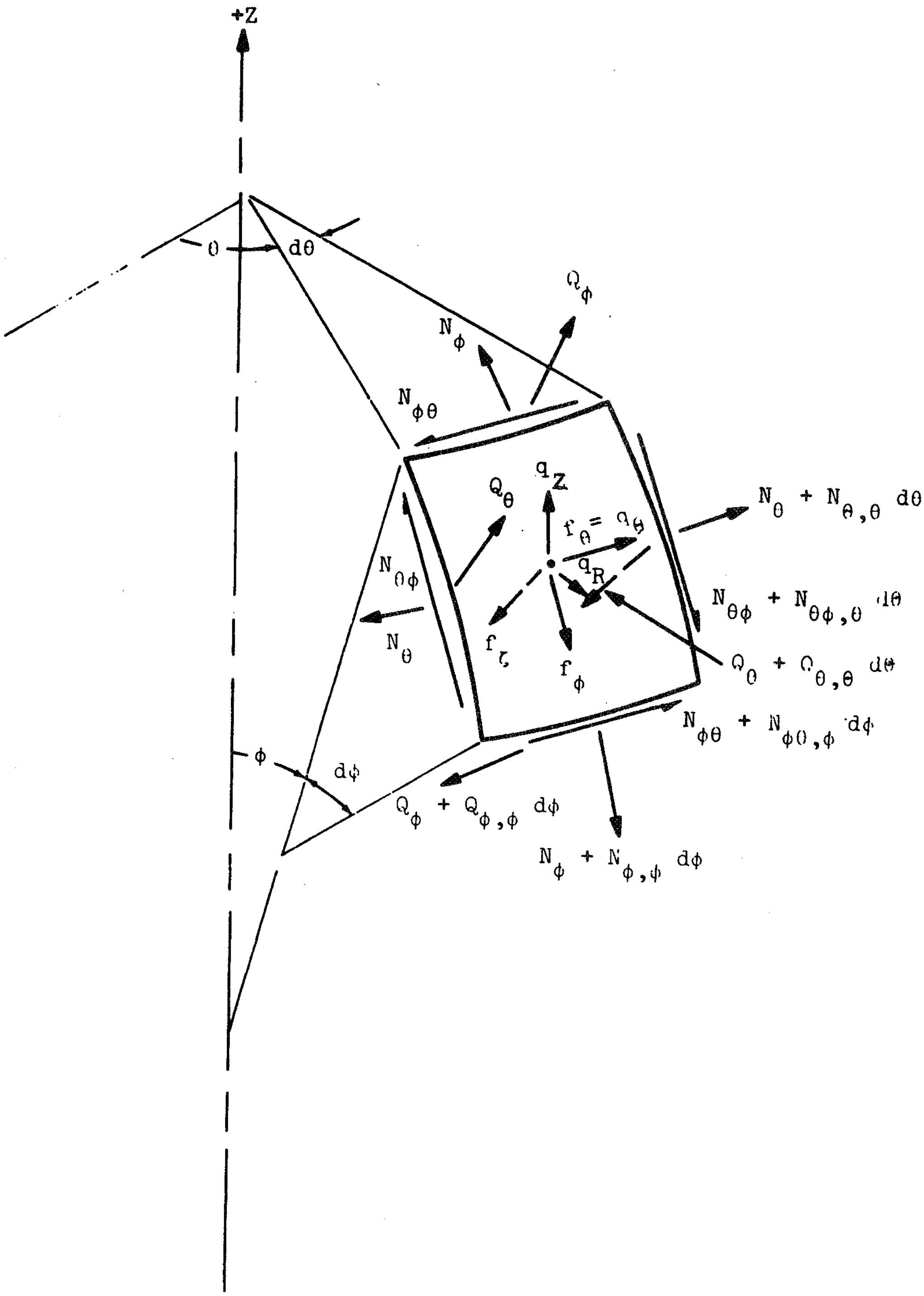


Figure 2-11a. Forces on Shell Element

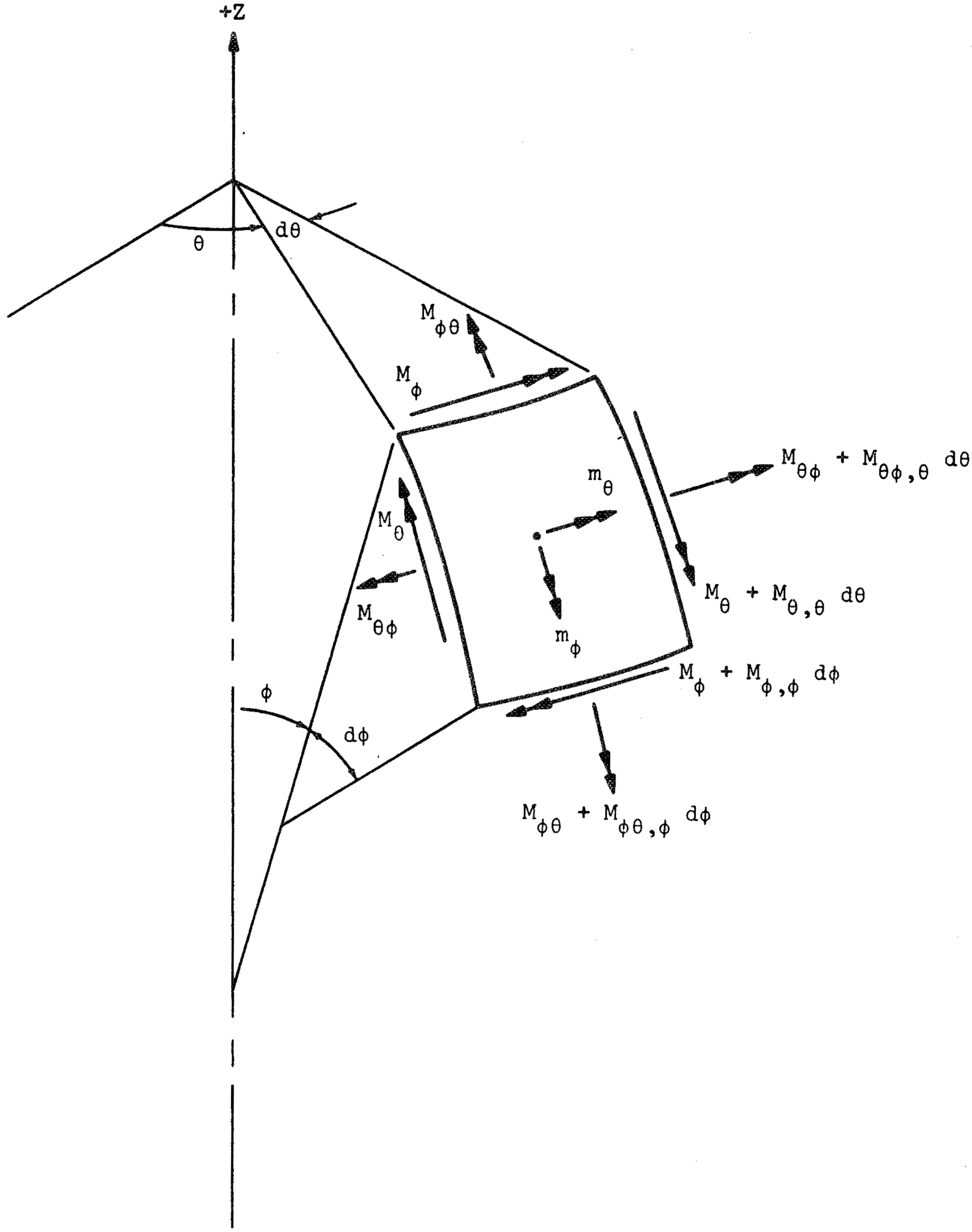


Figure 2-11b. Moments on Shell Element

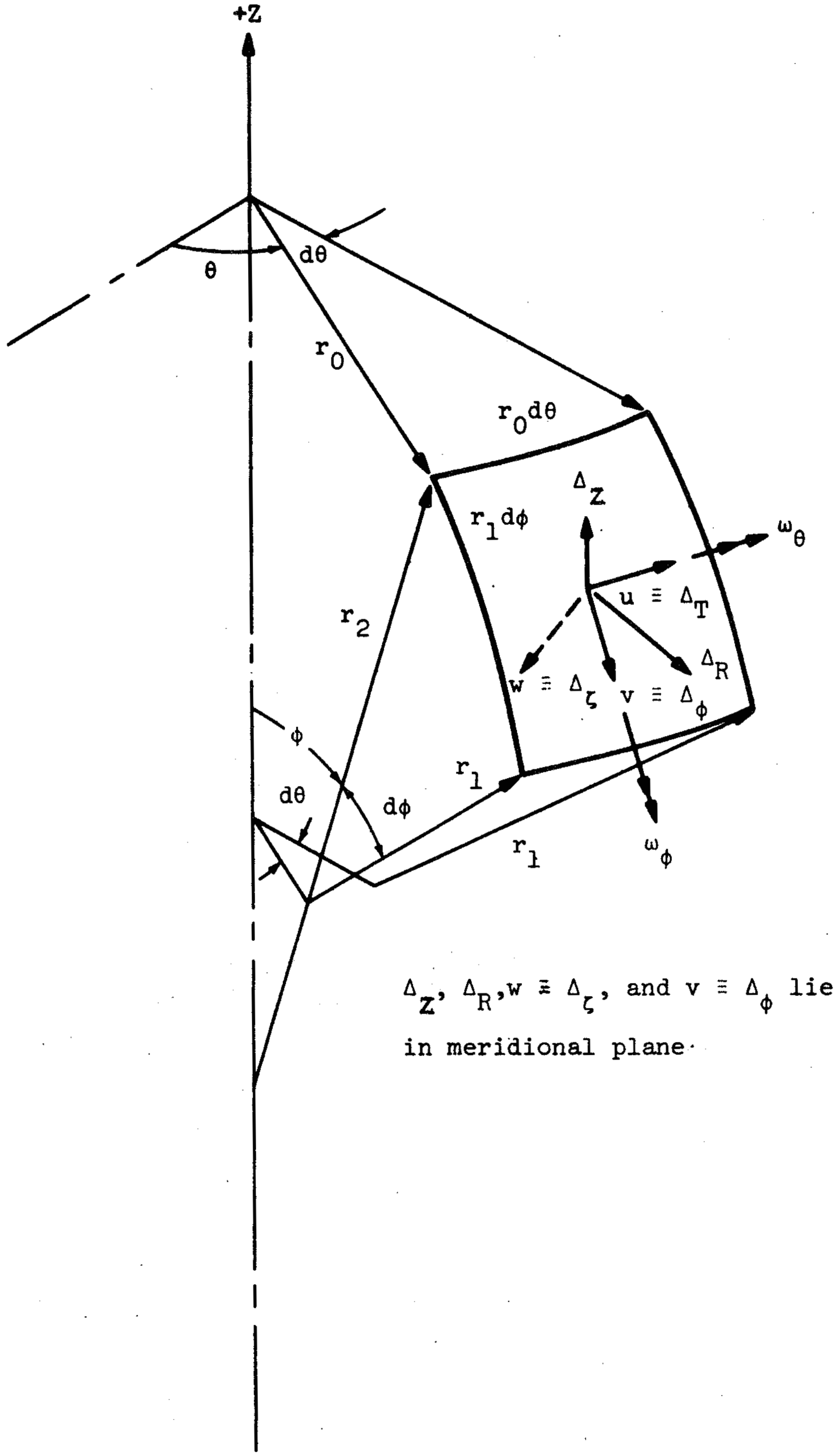


Figure 2-11c. Shell Element Geometry and Displacements

	Column	Format
If the Meridional Load Clue is one (1):		
F. Initial, intermediate and final values of the meridional loads f_ϕ at points defined by table of ϕ or s values.		5E14.7
If the Meridional Load Clue is zero (0), cards F are omitted.		
If the Normal Load Clue is one (1):		
G. Initial, intermediate and final values of the normal loads f_ζ at points defined by table of ϕ or s values.		5E14.7
If the Normal Load Clue is zero (0), cards G are omitted.		
If the Circumferential Moment Load Clue is one (1):		
H. Initial, intermediate and final values of the circumferential moment loads m_θ at points defined by table of ϕ or s values.		5E14.7
If the Circumferential Moment Load Clue is zero (0), cards H are omitted.		
If the Meridional Moment Load Clue is one (1):		
I. Initial, intermediate and final values of the meridional moment load m_φ at points defined by table of φ or s values.		5E14.7
If the Meridional Moment Load Clue is zero (0), cards I are omitted.		
11. Segment Topology Cards		
A. Segment number	1-5	I5
Number of the segment under consideration.		
B. Joint (i)	6-10	I5
Joint associated with i^{th} end of the segment (TIC).		
C. Joint (j)	11-15	I5
Joint associated with the j^{th} end of the segment (STOP).		
Since within a region the segments are all singly connected, the segment joint numbers should be in adjacent numerical pairs. That is, if joint (j) is 6, joint (i) could only be 5 or 7. This is true only within a region.		

	Column	Format
In addition, the initial joint of each region must be 1 in segment topology numbering, and the final joint of each region must be the last (highest) number in the segment topology numbering (see Figure 2-12). The coordinate ϕ or s increases from TIC to STOP, i to j. The user is again advised to see Figures 2-3 to 2-9.		
D-A-S-H S-E-P-A-R-A-T-O-R C-A-R-D (See General Notes - Data Debugging)	minus in 1-80	

INTRA-REGION DISCRETE RING CARDS

These cards, if any exist (region introductory card, item 1C), are placed at the end of all the segment data for the region. They contain the following information for each ring (in groups of 5 cards):

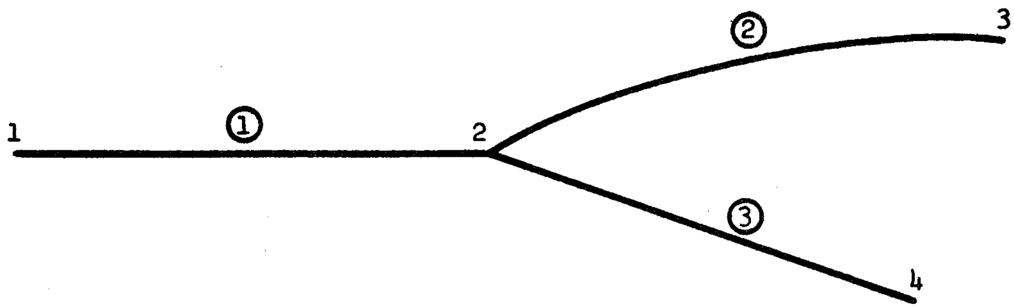
1. Ring Property Card

	Column	Format
A. Segment joint number to which the ring is attached. If there is also a radial discontinuity at this location necessitating a kinematic link, the joint number of the ring is the independent joint number of the link (see Figure 2-13a).	1-2	I2
B. Ring extensional stiffness (EA)	3-16	E14.7
C. Ring bending stiffness about centroidal y axis (EI_y). See Figure 2-14.	17-30	E14.7
D. Ring cross-bending stiffness about centroidal axes (EI_{xy}).	31-44	E14.7
E. Ring bending stiffness about centroidal x axis (EI_x).	59-72	E14.7
F. Ring Young's Modulus	45-58	E14.7

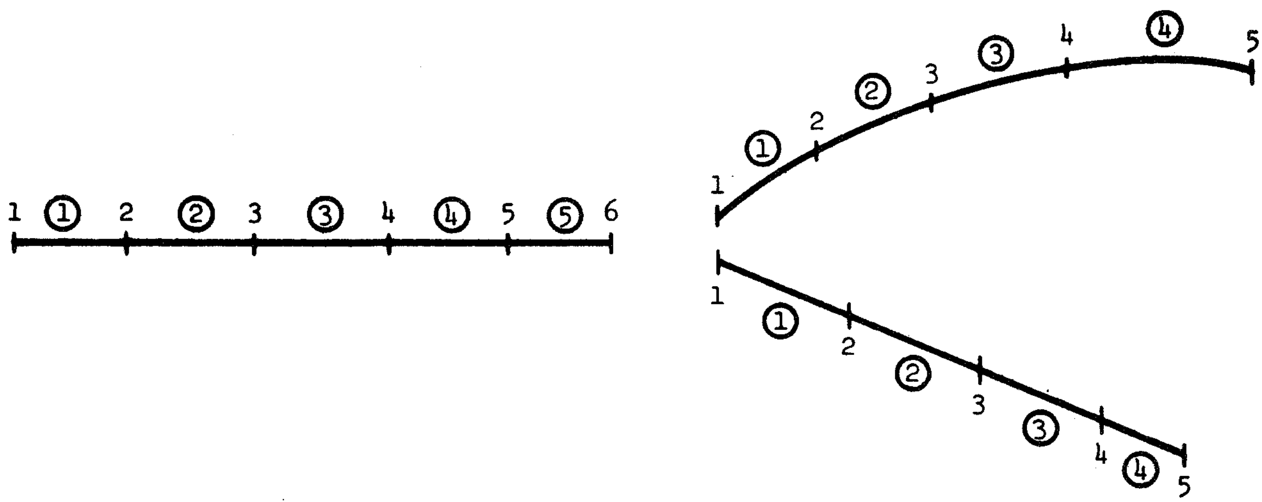
2. Ring Plasticity Card

	Column	Format
A. Ring Geometry Description Clue	1-4	A4

A specific clue word is necessary to describe the ring shape. The possible clue words and the associated shapes are presented in Figure 2-15.

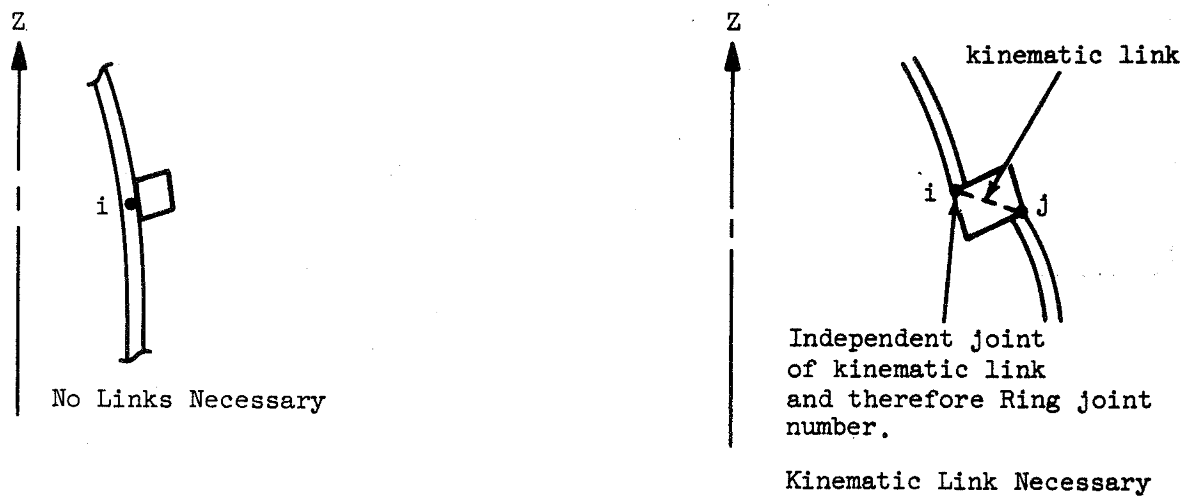


Region Numbering

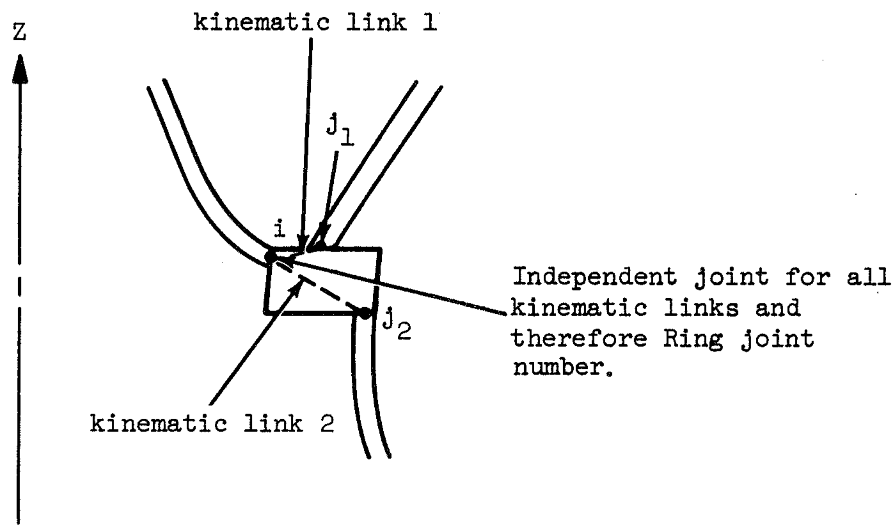


Numbering of Segments Within Regions

Figure 2-12. Topology Schemes



(a) Segment or Simple Region Rings



(b) Possible Region Multi-connected Rings

Figure 2-13. Discrete Ring Topology

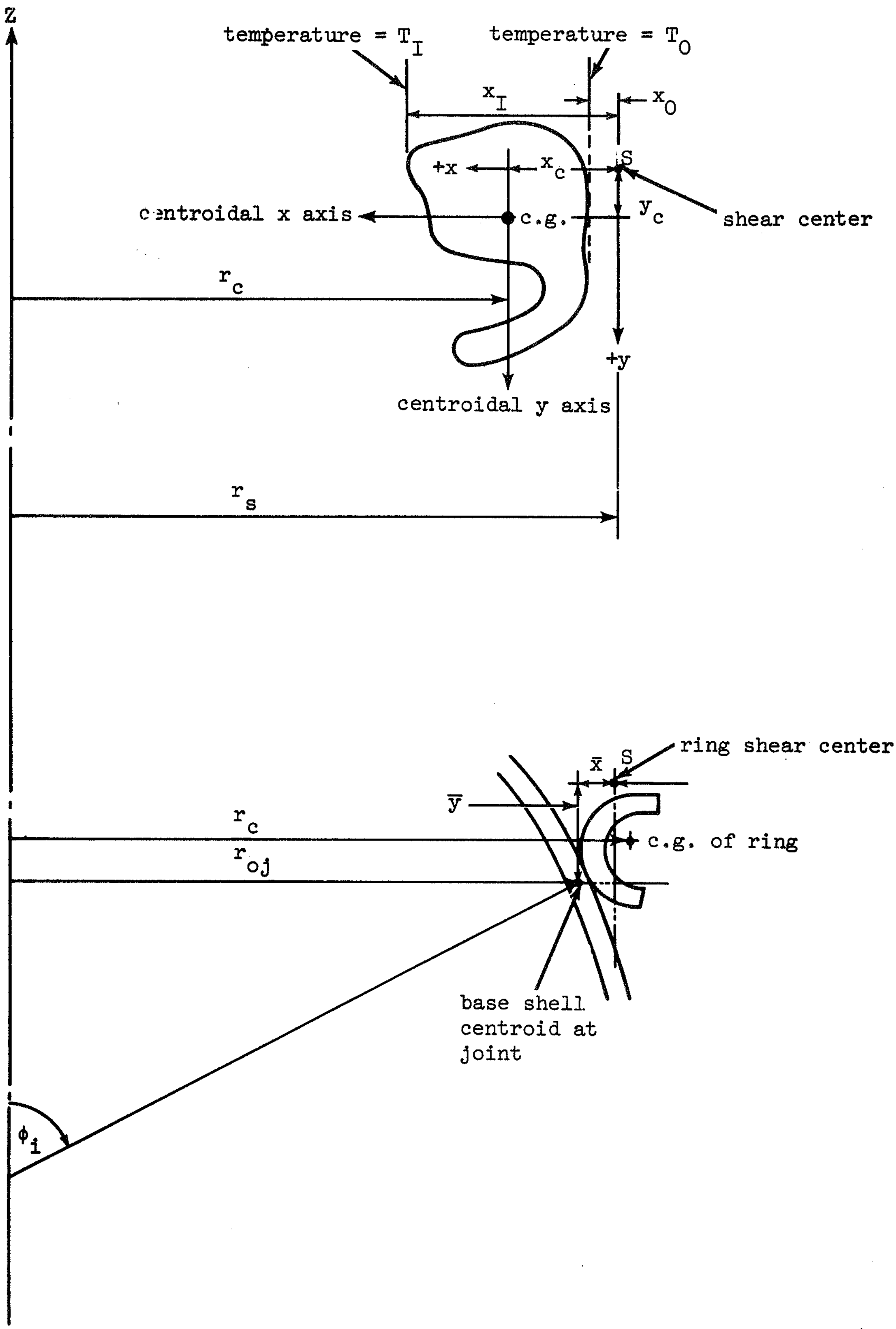


Figure 2-14. Discrete Ring Geometry

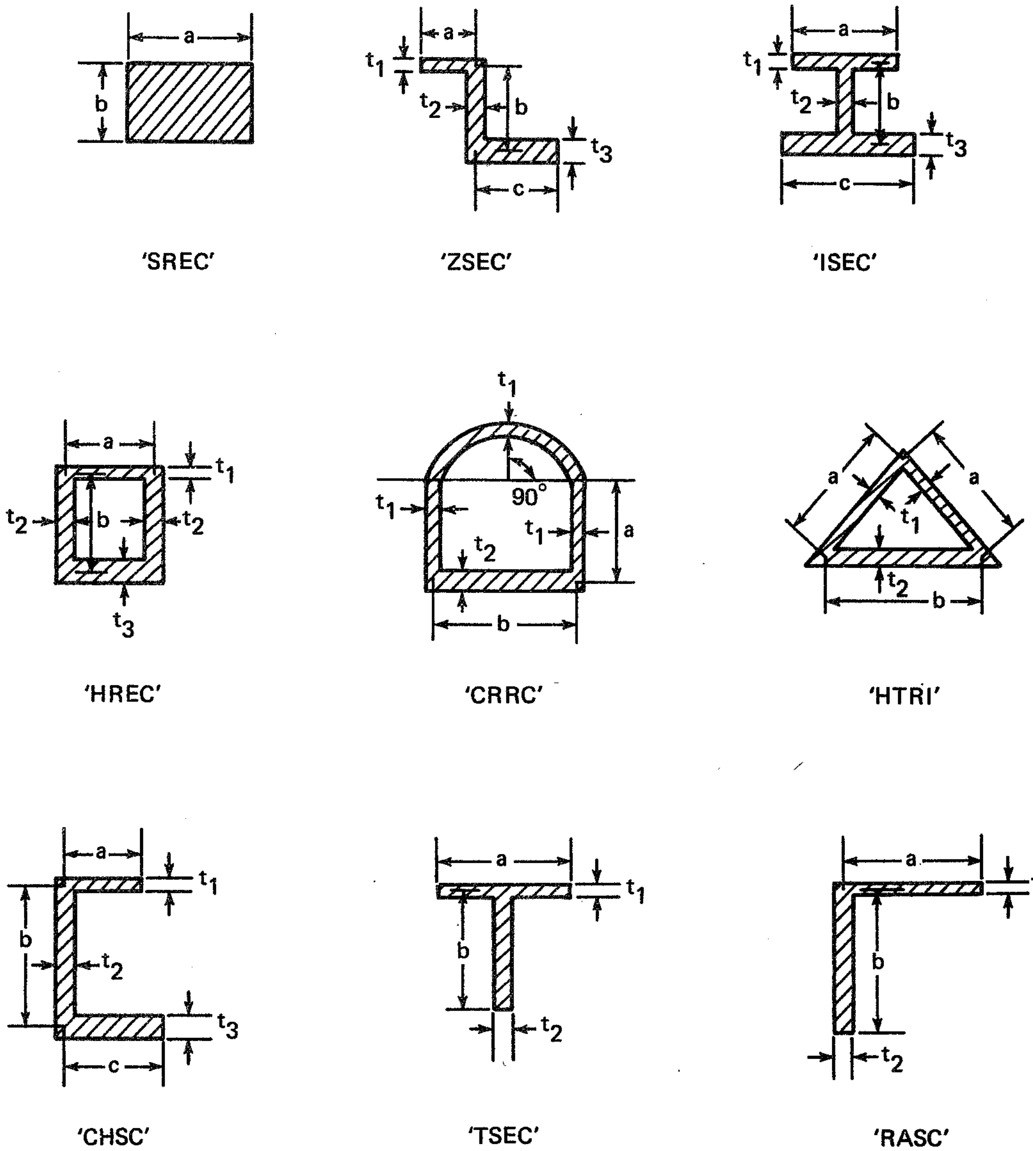


Figure 2-15. DISCRETE RING CONFIGURATIONS

		Column	Format
	B. Ring Orientation Angle	7-20	E14.7

Angle (in radians) at which ring is oriented. Normally this entry is the same as the "phi input" for a curved shell; or is equal to the angle input for a cone (see Figure 2-8, but φ range here is between 0 and 3π radians [no negative angles in inverted cone]); or is equal to $\pi/2$ for a cylinder.

Notes: 1. In order to "invert" the ring, i.e., turn it upside down from the position shown in Figure 2-15, as it rotates clockwise, and attach it to the inside part of the shell, add π to the angle above.

2. If the ring is oriented at another angle rather than tangent to the shell wall, the angle should be entered accordingly above.

		Column	Format
	C. Ring Yield Stress	21-34	E14.7
	D. Ramberg - Osgood constant "s" for the discrete ring (see Ref. 1).	35-48	E14.7
	E. Ramberg - Osgood constant "n" for the discrete ring (see Ref. 1).	49-62	E14.7
3.	Ring Location Card (see Figure 2-14)		
	A. Ring thermal coefficient of expansion (α_R).	1-12	E12.5
	B. Ring centroidal radius (r_c).	13-24	E12.5
	C. Distance (±) between ring centroid and shear center in the x direction (x_c).	25-36	E12.5
	D. Distance (±) between ring centroid and shear center in the y direction (y_c).	37-48	E12.5
	E. Offset (±) of ring shear center from attached shell joint (see item 1A) in the x direction ($\bar{x}$).	49-60	E12.5
	F. Offset (±) of ring shear center from attached shell joint (see item 1A) in the y direction ($\bar{y}$). Note: The shear center (S) is the origin of the x, y axes shown in Figure 2-14.	61-72	E12.5

4. Ring Thermal Description Card (See Figure 2-14)

	Column	Format
A. Innermost point temperature (T_I)	1-14	E14.7
B. Outermost point temperature (T_O)	15-28	E14.7
C. Radius of revolution at the segment joint which is used to identify the ring (Item 1A).	29-42	E14.7
D. Ring mass density (ρ)	43-56	E14.7
E. Hardening Law Clue	61-64	A4

Different hardening laws can be used for each ring (as well as each segment). If isotropic hardening is to be used the clue is ISOT. If kinematic hardening is to be used the clue is KINE. If perfect plasticity is to be used the clue is PERF. For this last clue word items 2D, E(above) are set to zero.

5. Ring Geometry Card (see Figure 2-15)

The ring geometry is specified on this card (as many items as necessary) as a function of the Ring Geometry Description Clue (item 2A).

If the clue word is ZSEC, ISEC, or CHSC:

A. Length dimension, a	1-12	E12.5
B. Length dimension, b	13-24	E12.5
C. Length dimension, c	25-36	E12.5
D. Thickness dimension, t_1	37-48	E12.5
E. Thickness dimension, t_2	49-60	E12.5
F. Thickness dimension, t_3	61-72	E12.5

If the clue word is HTRI, CRRC, TSEC, or RASC:

A., B. These items are the same as those identified above for the ZSEC clue.	1-24	2E12.5
C., D. These items are those identified above for the ZSEC clue as items D and E.	25-48	2E12.5

		Column	Format
If the clue word is HREC:			
A-D.	These items are the same as those identified above for the HTRI clue	1-48	4E12.5
E.	Thickness dimension, t_3	49-60	E12.5
If the clue word is SREC:			
A.	Length dimension, b	1-12	E12.5
B.	Length dimension, a	13-24	E12.5
	D-A-S-H S-E-P-A-R-A-T-O-R C-A-R-D (See General Notes - Data Debugging)	minum in 1-80	

INTRA-REGION KINEMATIC LINK CARDS

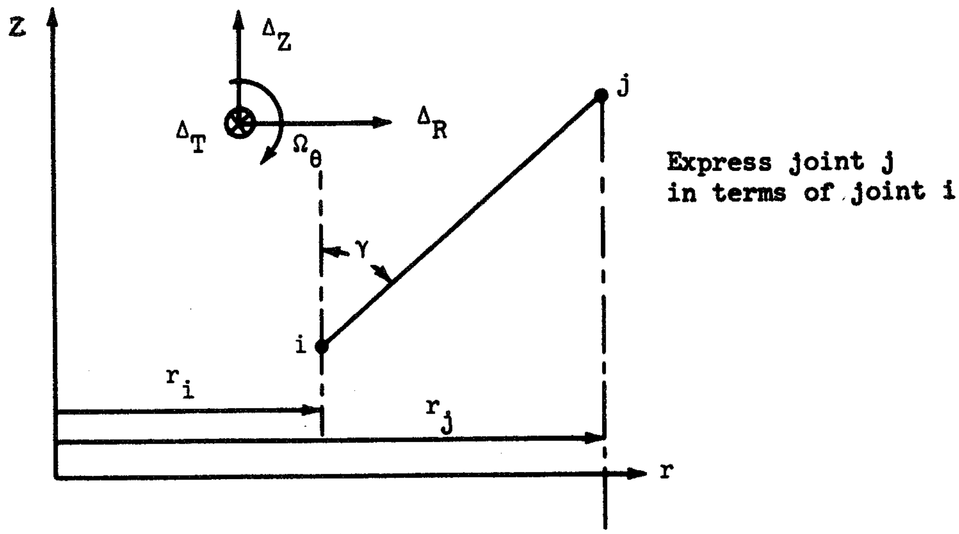
These cards, if any exist (region introductory card, item 1B), are placed at the end of all the discrete ring data for the region. They contain the following information:

		Column	Format
A.	Joint (j) dependent joint	1-2	I2
B.	Joint (i) independent joint For intra-region kinematic links these joints must be in consecutive decending order. That is, joint (j) should always be greater than joint (i) by one.	3-4	I2
C.	Angle γ in radians (see Figure 2-16) γ cannot equal 0 or π. The angle γ describes the orientation of the link; it is the inclination angle of the link from the vertical (Z axis). The number of kinematic link cards must equal the number specified in item 1B, of the region introductory card.	5-19	E14.7
	D-A-S-H S-E-P-A-R-A-T-O-R C-A-R-D (See General Notes - Data Debugging)	minus in 1-80	

REGION JOINT CONTROL DATA

These cards are placed at the end of all the data for all regions.

1. Joint Control Data Card



$$
\begin{Bmatrix} \Delta_{T_j} \\ \Delta_{Z_j} \\ \Delta_{R_j} \\ \Omega_{\theta_j} \end{Bmatrix} = \left[\begin{array}{c:c:c:c} \frac{r_j}{r_i} & 0 & 0 & 0 \\ 0 & +1 & 0 & -(r_j - r_i) \\ 0 & 0 & +1 & (r_j - r_i) \cot \gamma \\ 0 & 0 & 0 & +1 \end{array} \right] \begin{Bmatrix} \Delta_{T_i} \\ \Delta_{Z_i} \\ \Delta_{R_i} \\ \Omega_{\theta_i} \end{Bmatrix}
$$

Figure 2-16. Kinematic Link

		Column	Format
A.	Number of region joints Total number of region joints (Max. = 20).	1-5	I5
B.	Number of discrete rings Total number of discrete rings between regions.	6-10	I5
C.	Number of kinematic links Total number of kinematic links between regions.	11-15	I5

2. Discrete Ring Cards (inter-region, if any exist)

A. Ring Property Card

		Column	Format
a.	Region joint number to which the ring is attached. If there are also radial discontinuities at this location necessitating kinematic links, or multi-connections, the joint number of the ring is the independent joint number of all the links (see Figure 2-13b).	1-2	I2
b.	Ring extensional stiffness (EA)	3-16	E14.7
c.	Ring bending stiffness about centroidal y axis (EI_y). See Figure 2-14.	17-30	E14.7
d.	Ring cross-bending stiffness about centroidal axes (EI_{xy}).	31-44	E14.7
e.	Ring bending stiffness about centroidal x axis (EI_x).	45-58	E14.7
f.	Ring Young's Modulus	59-72	E14.7

B. Ring Plasticity Card

		Column	Format
a.	Ring Geometry Description Clue A specific clue word is necessary to describe the ring shape. The possible clue words and the associated shapes are presented in Figure 2-15.	1-4	A4

	Column	Format
b. Ring Orientation Angle	7-20	E14.7

Angle (in radians) at which ring is oriented. Normally this entry is the same as the "phi input" for a curved shell; or is equal to the angle input for a cone (see Figure 2-8, but φ range here is between 0 and 3π radians [no negative angles in inverted cone]); or is equal to $\pi/2$ for a cylinder.

Notes: 1. In order to "invert" the ring, i.e., turn it upside down from the position shown in Figure 2-15, as it rotates clockwise, and attach it to the inside part of the shell, add π to the angle above.

2. If the ring is oriented at another angle rather than tangent to the shell wall, the angle should be entered accordingly above.

	Column	Format
c. Ring Yield Stress	21-34	E14.7
d. Ramberg - Osgood constant "s" for the discrete ring (see Ref. 1).	35-48	E14.7
e. Ramberg - Osgood constant "n" for the discrete ring (see Ref. 1).	49-62	E14.7

C. Ring Location Card (see Figure 2-14)

	Column	Format
a. Ring thermal coefficient of expansion (α_R).	1-12	E12.5
b. Ring centroidal radius (r_c).	13-24	E12.5
c. Distance (±) between ring centroid and shear center in the x direction (x_c).	25-36	E12.5
d. Distance (±) between ring centroid and shear center in the y direction (y_c).	37-48	E12.5
e. Offset (±) of ring shear center from attached shell joint (see item Aa) in the x direction ($\overline{x}$).	49-60	E12.5
f. Offset (±) of ring shear center from shell joint (see item Aa) in the y direction ($\overline{y}$).	61-72	E12.5

Note: The shear center (S) is the origin of the x,y axes shown in Figure 2-14.

		Column	Format
D.	Ring Thermal Description Card (See Figure 2-14)		
	a. Innermost point temperature (T_I).	1-14	E14.7
	b. Outermost point temperature (T_O).	15-28	E14.7
	c. Radius of revolution at the region joint which is used to identify the ring (Item Aa).	24-42	E14.7
	d. Ring mass density (ρ).	43-56	E14.7
	e. Hardening Law Clue	61-64	A4

Different hardening laws can be used for each ring (as well as each segment). If isotropic hardening is to be used the clue is ISOT. If kinematic hardening is to be used the clue is KINE. If perfect plasticity is to be used the clue is PERF. For this last clue word items Bd, e (above) are set to zero.

E. Ring Geometry Card (see Figure 2-15)

The ring geometry is specified on this card (as many items as necessary) as a function of the Ring Geometry Description Clue (item Aa).

If the clue word is ZSEC, ISEC, or CHSC:

	Column	Format
a. Length dimension, a	1-12	E12.5
b. Length dimension, b	13-24	E12.5
c. Length dimension, c	25-36	E12.5
d. Thickness dimension, t_1	37-48	E12.5
e. Thickness dimension, t_2	49-60	E12.5
f. Thickness dimension, t_3	61-72	E12.5

If the clue word is HTRI, CRRC, TSEC, or RASC:

	Column	Format
a., b. These items are the same as those identified above for the ZSEC clue.	1-24	2E12.5
c., d. These items are those identified above for the ZSEC clue as items d and e.	25-48	2E12.5

	Column	Format
If the clue word is HREC:		
a-d. These items are the same as those identified above for the HTRI clue	1-48	4E12.5
e. Thickness dimension, t_3	49-60	E12.5
If the clue word is SREC:		
a. Length dimension, b	1-12	E12.5
b. Length dimension, a	13-24	E12.5
D-A-S-H S-E-P-A-R-A-T-O-R C-A-R-D (See General Notes - Data Debugging)	minus in 1-80	

3. Kinematic Link Cards (inter-region, if any exist)

	Column	Format
A. Joint (j) dependent joint	1-2	I2
B. Joint (i) independent joint	3-4	I2

For kinematic links between regions there are no restrictions upon joint numbering.

The only restriction is that between successive kinematic link data cards the (j) joint entry should be in increasing order (not necessarily consecutive). For example:

	j	i	γ
Must be in increasing order.	3	2	–
	4	2	–
	9	1	–
	12	6	–

	Column	Format
C. Angle γ in radians (see Figure 2-16)	5-19	E14.7

γ cannot equal 0 or π.

The angle γ describes the orientation of the link; it is the inclination angle of the link from the vertical (Z axis). The number of kinematic link cards must equal the number specified in item 1C of the joint Control Data Card.

		Column	Format
	D-A-S-H S-E-P-A-R-A-T-O-R C-A-R-D (See General Notes - Data Debugging)		minus in 1-80
4.	Boundary Condition Cards (Joint Data - one card per region joint)		
	A. Joint Number	1-2	I2
	B. Joint component conditions on:		
	1) Δ_T	3-4	F2.0
	2) Δ_Z or Δ_N (see Figure 2-17)	5-6	F2.0
	3) Δ_R or Δ_Q	7-8	F2.0
	4) Ω_θ	9-10	F2.0
	C. Angle α in radians	11-24	E14.1

To be used only in conjunction with a 2 or 3 code.

Note: There must be as many boundary condition cards as there are joints as indicated in item 1A of the Joint Control Data Card.

There are 4 different codes that are used to prescribe joint component conditions. They are:

a. 0 = no displacement allowed.

b. 1 = displacement allowed in the indicated direction.

c. 2 = Δ_Z and Δ_R are rotated through an angle of $(\pi/2 - \alpha)$ and become Δ_N and Δ_Q respectively, while a displacement is allowed in the Δ_N direction.

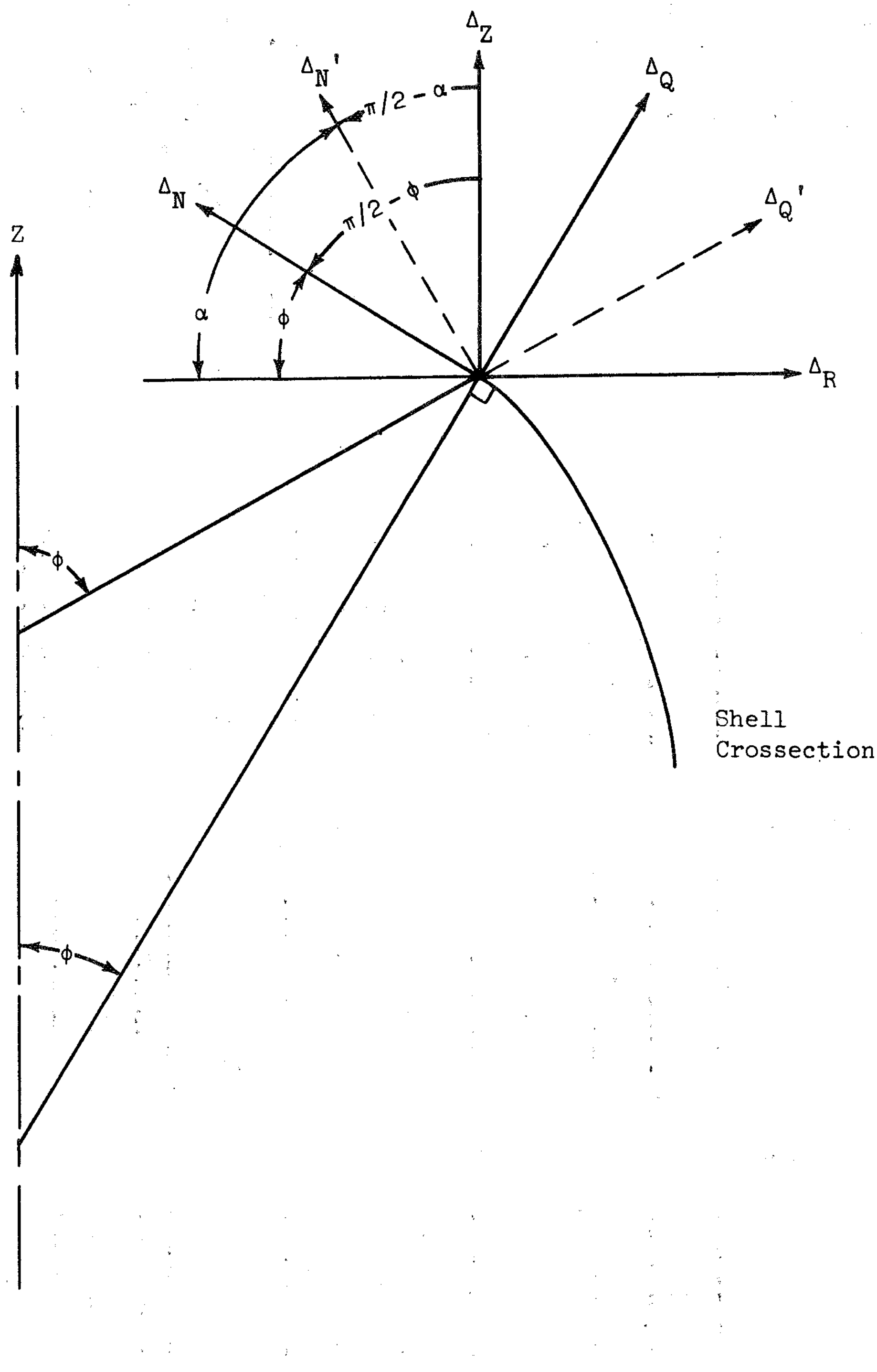
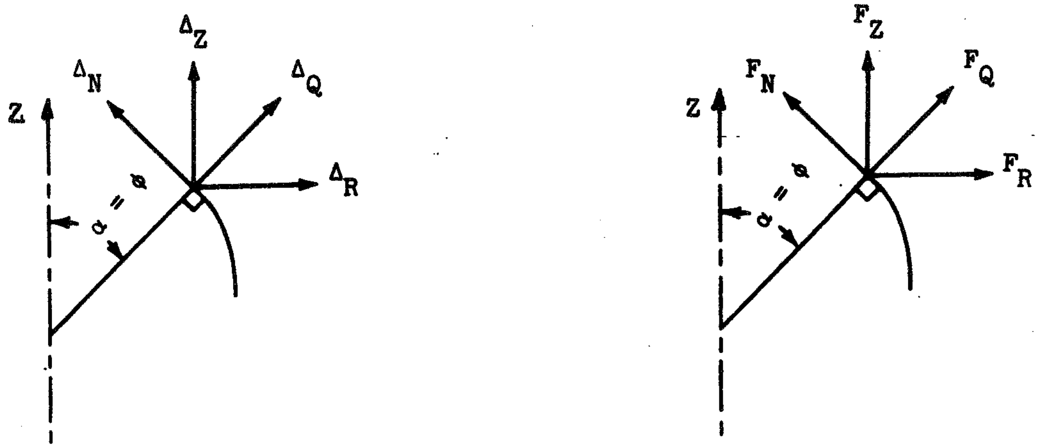


Figure 2-17a. Description of General Coordinate Rotation ($\alpha \neq \phi$)



Rotation Code 1 2 3 1

Matrix
$$\begin{Bmatrix} \Delta_T \\ \Delta_Z \\ \Delta_R \\ \Omega_\theta \end{Bmatrix} = \left[\begin{array}{c|c|c|c} +1 & 0 & 0 & 0 \\ 0 & \sin\alpha & \cos\alpha & 0 \\ 0 & -\cos\alpha & \sin\alpha & 0 \\ 0 & 0 & 0 & +1 \end{array}\right] \begin{Bmatrix} \Delta_T \\ \Delta_N \\ \Delta_Q \\ \Omega_\theta \end{Bmatrix}$$

Rotation Code 1 2 0 1

Matrix
$$\begin{Bmatrix} \Delta_T \\ \Delta_Z \\ \Delta_R \\ \Omega_\theta \end{Bmatrix} = \left[\begin{array}{c|c|c} +1 & 0 & 0 \\ 0 & \sin\alpha & 0 \\ 0 & -\cos\alpha & 0 \\ 0 & 0 & +1 \end{array}\right] \begin{Bmatrix} \Delta_T \\ \Delta_N \\ \Omega_\theta \end{Bmatrix}$$

Rotation Code 1 0 3 1

Matrix
$$\begin{Bmatrix} \Delta_T \\ \Delta_Z \\ \Delta_R \\ \Omega_\theta \end{Bmatrix} = \left[\begin{array}{c|c|c} +1 & 0 & 0 \\ 0 & \cos\alpha & 0 \\ 0 & \sin\alpha & 0 \\ 0 & 0 & +1 \end{array}\right] \begin{Bmatrix} \Delta_T \\ \Delta_Q \\ \Omega_\theta \end{Bmatrix}$$

Figure 2-17b. Provision for Local Rotations

d. 3 = Δ_Z and Δ_R are rotated through an angle of $(\pi/2 - \alpha)$ and become Δ_N and Δ_Q respectively, while a displacement is allowed in the Δ_Q direction.

See Figure 2-17 for a geometric explanation of codes 2 and 3.

When using rotation codes:

Code 2 can exist only as Δ_Z coding.

Code 3 can exist only as Δ_R coding.

Codes 0 and 1 can appear in either column 4 or column 6, in addition to columns 8 and 10. Thus, there are twelve possible boundary conditions when rotation codes are used. ($\alpha = \phi$ for table below.)

	Free edge (possible to apply shear and/ or membrane loads)	$\Delta_Q = 0$, normal support (possible to apply membrane load)	$\Delta_N = 0$, membrane support (possible to apply shear load)
Δ_T, Ω_θ free	1,2,3,1	1,2,0,1	1,0,3,1
Δ_T, Ω_θ fixed	0,2,3,0	0,2,0,0	0,0,3,0
Δ_T fixed Ω_θ free	0,2,3,1	0,2,0,1	0,0,3,1
Δ_T free Ω_θ fixed	1,2,3,0	1,2,0,0	1,0,3,0

Column | Format

Apex boundary conditions:

Since the closed apex ($\phi = 0$) angle is not acceptable input, the apex boundary conditions must be simulated at a small ϕ angle. These boundary conditions vary per Fourier harmonic, and are as follows:

n	Δ_T	Δ_Z	Δ_R	Ω_θ	angle
0.0	0	0	3	0	$\alpha = \phi$
1.0	1	2	0	1	$\alpha = \phi$
$\geq$ 2.0	0	0	0	0	---

General Notes:

1) To establish a datum for measuring displacement, free body motion must be eliminated from the structure. This should be accomplished by suitably applied boundary conditions.

2) The ability of a dependent joint in a kinematic link to prescribe motion independently should be removed by setting all boundary conditions of that joint to zero. See pages 2-65 and 2-84

D-A-S-H S-E-P-A-R-A-T-O-R C-A-R-D
(See General Notes - Data Debugging) — minus in 1-80

JOINT LOAD DATA

1. Load Control Data Card

A. Number of Joint Loads — 1-4 — I4

Total number of joint loads in analysis. (Line loads can only be applied to region joints.)

B. Any alphameric information (load description) — 5-68 — 16A4

Note: If there are no Joint Loads for the structure, card 1 of the JOINT LOAD DATA is blank and card set 2 is omitted.

	Column	Format
2. Joint Load Cards (as many as in item 1A above)		
A. Enter unity in column 5	1-5	I5
B. Row Identification	6-10	I5

The identification is the location of the degree of freedom at which the load is applied. This is obtained by counting the non-zero codes entered in the Boundary Conditions Cards, starting with Joint 1; T, Z, R, Ω_θ, Joint 2; T, Z,......etc., and stopping at the joint and degree of freedom where the line load is to be applied. The location number of this degree of freedom is the information necessary.

	Column	Format
C. Applied Joint Load	11-24	E14.7

The input is $2\pi r_o$ times the running load in lb./in. In the particular case of the axial axisymmetric load, this is simply the net force. For sign convention see Figures 2-11, 2-17 and 2-18.

D-A-S-H S-E-P-A-R-A-T-O-R C-A-R-D (See General Notes - Data Debugging) — minus in 1-80

LOAD CYCLING CARDS

If only a single loading is being investigated these cards are omitted. For changes of load distribution, magnitude, or material property tables with time, the appropriate cards below are included. (See also item 2H in the General Introductory Cards p 2-18). These cards are repeated to amount described in Item 2E on p 2-16

1. Load Cycling Program Control Card

	Column	Format
A. Intermediate print clue	8-9	I2

(See item 2D General Introductory Cards p 2- 16).

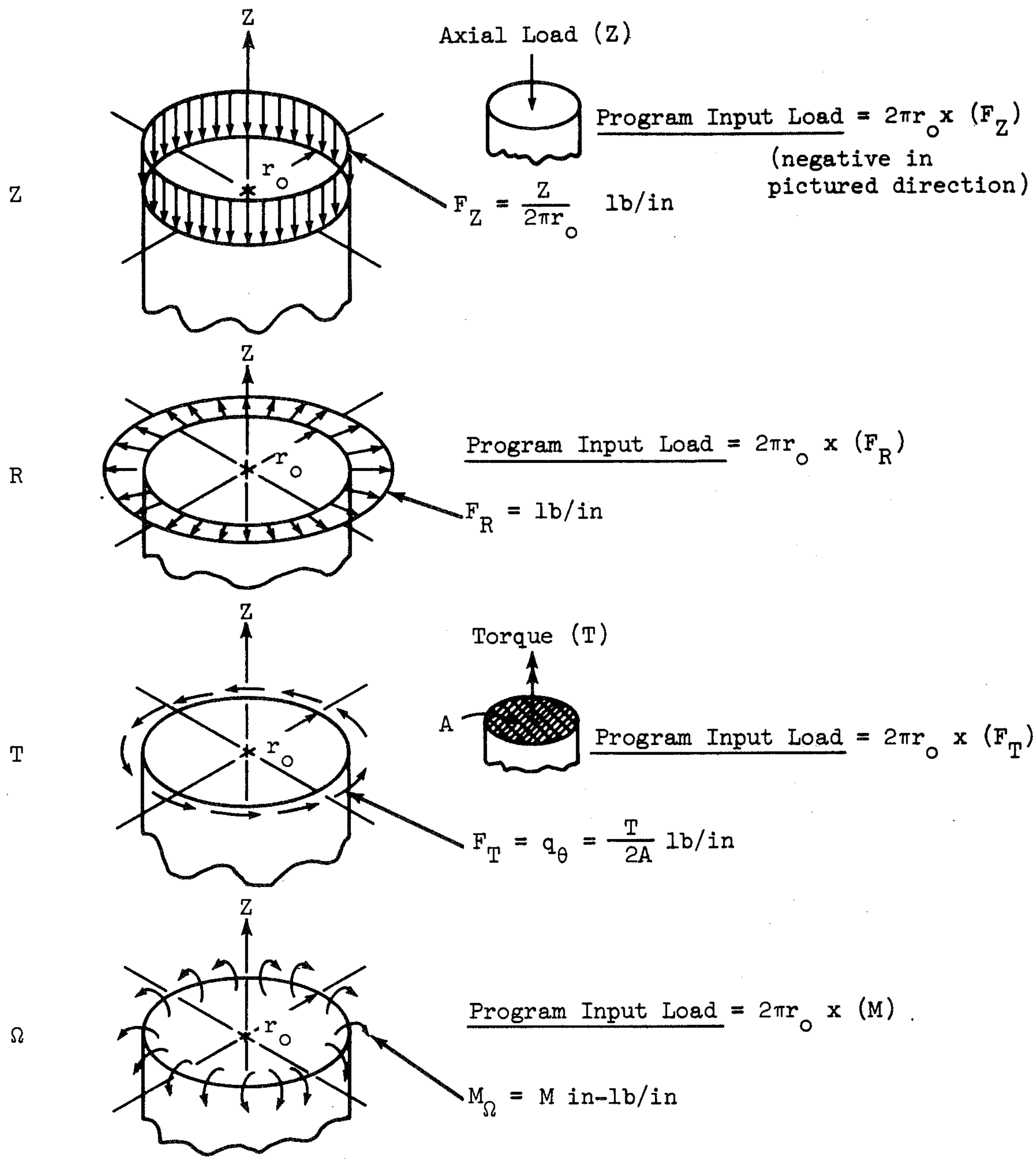


Figure 2-18 Line Loading for Harmonic n = 0.0

		Column	Format
B.	Number of load steps	12-17	F6.0

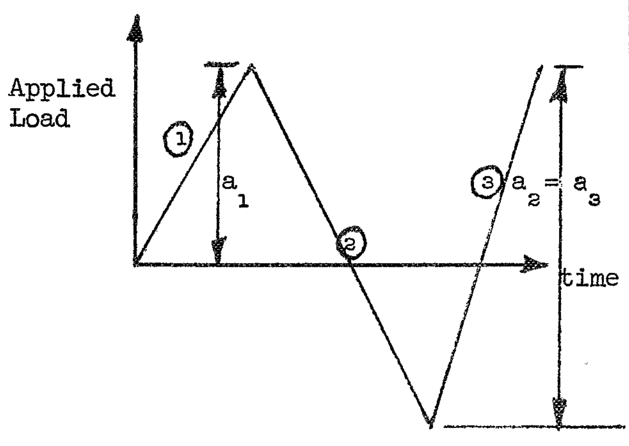
Number of loading increments to be made for the next loading cycle. If the loading reverses in direction, this number is input as being of <u>opposite sign</u> to the same entry for the previous loading cycle.

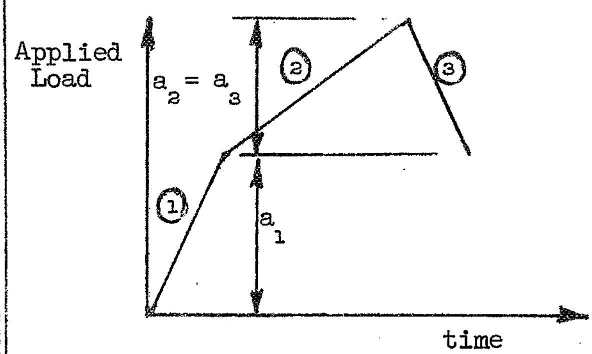
		Column	Format
C.	Load step print increment for next loading cycle. (See Item 2G General Introductory Cards p 2-18 .)	18-21	F4.0
D.	Load amplitude change clue	24-25	I2

If the previous loading cycle load amplitudes are to be reused, and the only changes involved are load directions or step sizes (controlled by item C above) or material property tables, the clue is <u>zero.</u> If the load amplitudes are also changed, the clue is <u>five</u>, and new load cards will be expected to be read. It should be noted that load amplitudes are sequential. For further clarification see Figures below.

Load Cycle	No. Load Steps	Amplitude
1	Ex: 10	a_1
2	-20	change to a_2
3	30	no change

Load Cycle	No. Load Steps	Amplitude
1	Ex: 5	a_1
2	5	change to a_2
3	-5	no change





	Column	Format
E. Material Table Change Clue	26-27	I2

If the previous loading cycle material property tables are to be reused the clue is zero. If new material property tables are supplied the clue is one.

Note: At the first load reversal in direction the material property tables must be re-read with all the Ramberg - Osgood "s" constants being doubled in value. This is done only at the first load reversal, and the new tables can be reused thereafter. If the constants above are all zero this can be disregarded. This is true for all reinforcement as well as the shell.

F. Angluar velocity in rad./sec. for next loading cycle.	59-72	E14.7

Since the shell rotation clue (item 2K in the General Introductory Cards p 2-18) is constant for the total run, the above item is significant only if that clue was initially set to one. In order to apply or delete an angular velocity in the middle of a loading history, the velocity values for other load cycles may be set to zero.

2. Material Property Tables for Next Loading Cycle

If the preceeding Material Table change clue was set to one a complete new set of material property tables must be provided. Note the special item above for the Ramberg - Osgood "s" parameter. The names of the material tables may not be changed. The necessary formats and card sequences are provided on p 2-21

D-A-S-H S-E-P-A-R-A-T-O-R C-A-R-D (see General Notes - Data Dubugging)	minus in 1-80

	Column	Format
If the preceeding Material Table Change Clue was set to zero, item 2 above and the separator card are omitted.		
3. Shell loading data for next loading cycle		
If the preceeding Load Amplitude Change Clue was set to five, the following card sequence must follow.		
A. Segment Loading Clue Card for next loading cycle		
a. Load clues for temperature, circumferential, meridional, normal, circumferential moment, and meridional moment load, for next loading cycle.	1-6	6I1
Note: Variations in types of loadings as well as magnitudes are allowed per cycle. The thermal clue, however, is fixed and must remain constant. Thus $\Delta T = 0$ may have to be input as appropriate.		
B. Table of Applied Loads for next load cycle (see segment card set 10). These cards contain the next set of loads as described previously in the segment data according to the Load Clues above.		5E14.7
Note: The above data sets (3A and 3B) are repeated until all the segments in the first region are completed for the next load cycle.		
C. Region Ring Load Cards for next loading cycle.		
a. Ring Yield Stress	1-14	E14.7
b. Ring Ramberg - Osgood "s" value (see note about doubling this value for first load reversal, above.)	15-28	E14.7
c. Ring Ramberg - Osgood "n" value.	29-42	E14.7
d. Innermost point temperature (T_I).	43-56	E14.7
e. Outermost point temperature (T_O).	56-70	E14.7
Note: The above data set (3C) is repeated until all the rings in region one are completed for the next load cycle.		
The above data sets (3A through 3C) are then repeated until all the segments and rings in all the regions are completed for the next load cycle.		

		Column	Format
	The above data set (3C) is then repeated until all the structure rings are completed for the next load cycle.		
D.	Joint Load Control Data Card for next loading cycle.		
	a. Number of Joint Loads	1-4	I4
	b. Any alphameric information	5-68	16A4
	Note: If no joint load changes exist in this load cycle, the above card is blank and card set 3E (below) is omitted.		
E.	Joint Load Cards for next loading cycle		
	a. Enter unity is column 5	1-5	I5
	b. Row identification (see previous Joint Load Card description)	6-10	I5
	Note: Locations of line loads may change from load cycle to cycle.		
	c. Applied Joint Load	11-24	E14.7
	The input is $2\pi r_o$ times the running load in lb./in. for this load cycle (see Figure 2-18).		
	D-A-S-H S-E-P-A-R-A-T-O-R C-A-R-D (see General Notes - Data Debugging)	minus in 1-80	

If the preceeding Load Amplitude change clue was set to zero, item 3 above and the separator card are omitted.

The above cycling cards (items 1-3) are repeated until all the load cycles input in item 2E on p 2-16 are completed.

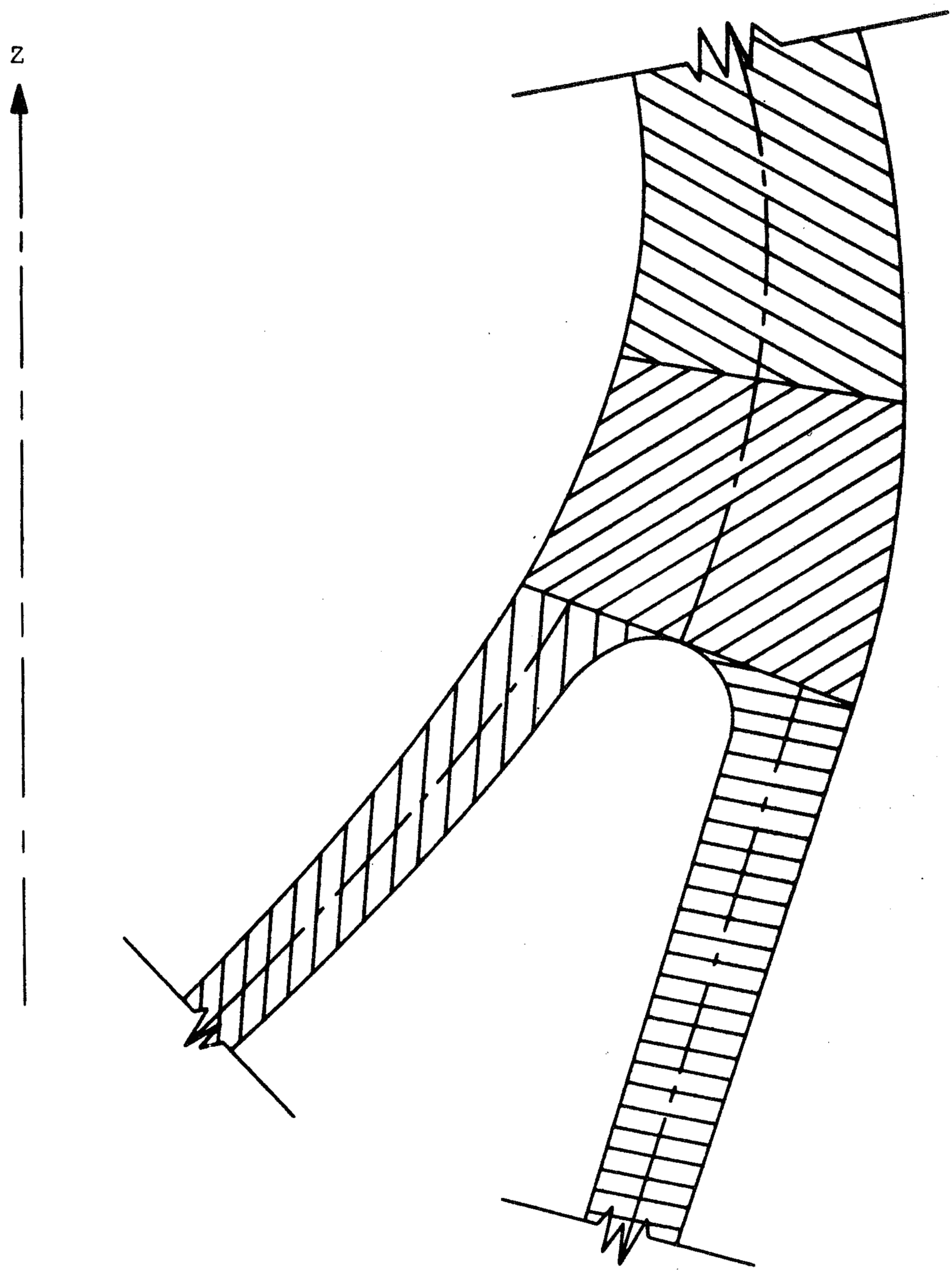


Figure 2-19. Y-Joint (Distorted Geometry)

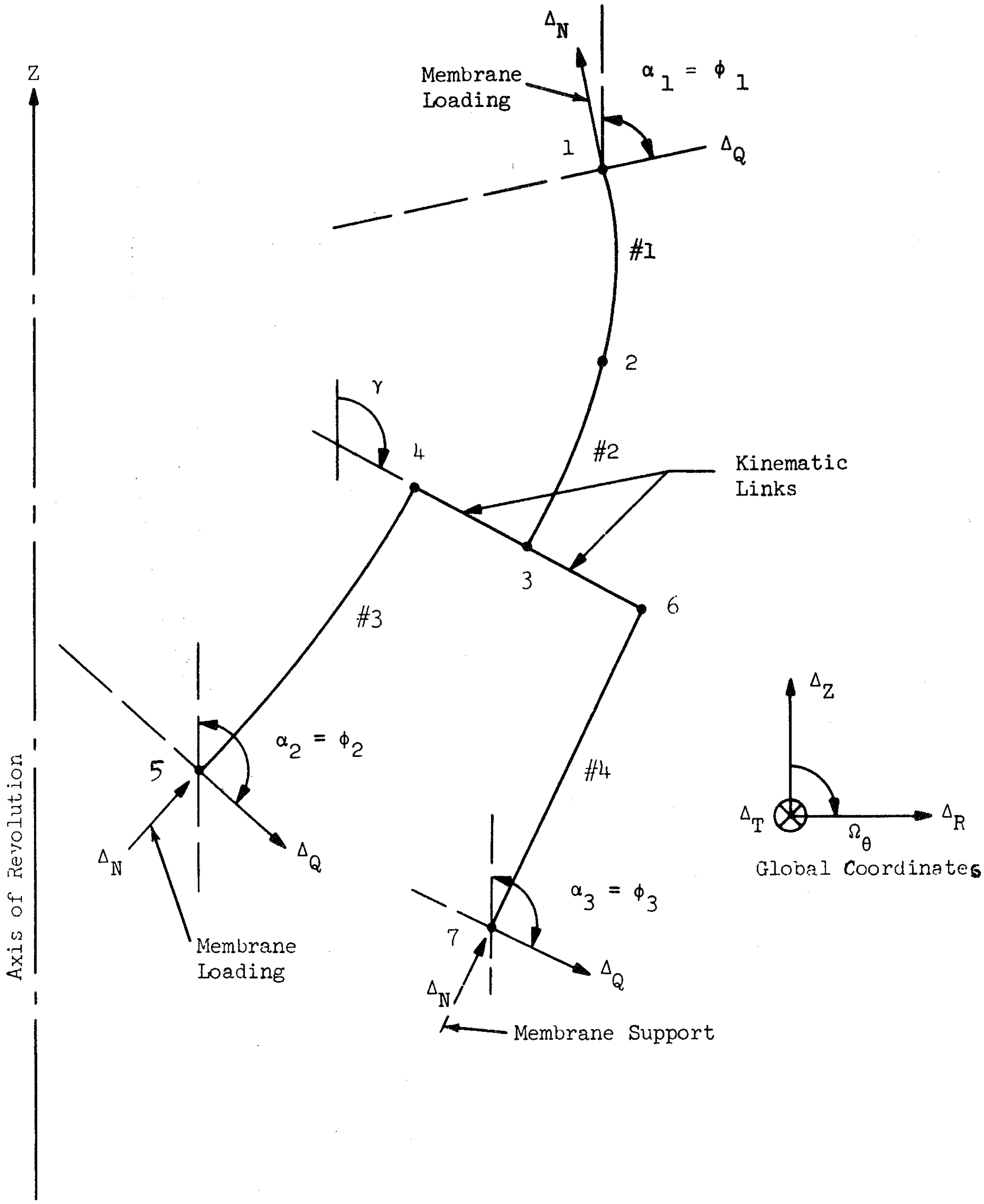


Figure 2-20. Idealized Y-Joint

It is hoped that the user is now able to use the STARS-2P program to good advantage. It is a powerful tool which will increase in value to the user as he uses it. One of the more complex areas of usage is the description of topology, especially when involved with rotation codes and joint loads. An illustrative example of a Y joint representation is therefore presented below. (See Figures 2-19 and 2-20 for the structure and idealization.) The idealized structure contains four regions and two kinematic links. The joints are numbered from 1 to 7. Membrane loading is applied to joints 1 and 5 and the structure is supported by membrane action at joint 7. All regions must be coupled.

The second card in each region description (topology card) is as follows:

Region	Joint (i)	Joint (j)
1	1	2
2	2	3
3	4	5
4	6	7

The Joint Control Data card would contain a 7 in column 5 and a 2 in column 15.

In this example, the restraints at joints 1, 5 and 7 must be rotated from the fixed (global system) to a local system such that membrane action may be applied. In addition, joints 3 and 4, and 6 and 3 are to be coupled with kinematic links. Thus, the motions of joints 4 and 6 are dependent upon the motion of joint 3. This dependence will be insured by using 2 kinematic link cards and setting the independent degrees of freedom of joints 4 and 6 equal to zero. It should be noted in this particular case that the motion of joints 4 and 6 is not being equated to zero, but rather, the ability to prescribe motion independently is being removed. The required data has the following appearance.

A. Kinematic Link Cards (2 cards)

Joint (j)	Joint (i)	Angle
4	3	$\gamma + \pi$
6	3	γ

Note: In a double link of the type shown in Figure 2-20, one joint must be consistently independent (joint 3 in example).

B. Bountary Condition Cards for a coupled torsional case (7 cards)

Joint	T	Z	R	θ	Angle
1	1	2	3	1	α_1
2	1	1	1	1	
3	1	1	1	1	
4	0	0	0	0	
5	1	2	3	1	α_2
6	0	0	0	0	
7	0	0	3	1	α_3

The Load Control Data card would contain a 2 in column 4.

The external membrane loads are applied to the structure through the Joint Load Cards which, in this example, would appear as (2 cards):

Problem No.	Row	Load
1	2	$2\pi r_o$ x Membrane Load (lb./in.)
1	14	$2\pi r_o$ x Membrane Load (lb./in.)

SECTION 3

OUTPUT INFORMATION

The output of the STARS-2P program is straightforward, however a description is in order since the user should learn the significance of the various checks that are provided. It is important to point out that the output of the program will include a print-out of the input data. This gives the user the opportunity to check whether or not the input data was correct. In the detailed description of the complete output which follows, the user should refer to the output of the problem in Section 4 as an example.

The title page of the output contains all the data from the General Introductory Cards, prominently placed, and needs no comment. The next page of the output contains the first region Identification Card in the center. The following output is then presented for each segment in this region (in order of appearance):

1. Contents of segment Identification Card.
2. Contents of MAGIC Control Card
3. Contents of Geometric Description Card (Cards)
4. Contents of Master Clue Card
5. The material property table used for the segment
6. Crossection description table
7. Temperature load table (if any)
8. Distributed load tables
9. Segment influence coefficients (MAGIC output)
10. Segment stiffness matrix
11. Stiffness matrix symmetry check
12. Segment load matrices
13. Radius of revolution at i^{th} and j^{th} ends of segment

Item 11, the stiffness matrix symmetry check, is a check upon the validity of segment sizing and the accumulation of round-off error. For perfect symmetry to exist, it is necessary to have zeros above the main diagonal, and zeros or ones below the diagonal. The amount of error induced by improper sizing or round-off is related to the amount that the off-diagonal terms in the lower triangle differ from unity. An attempt should be made to keep the upper limit on this difference at one percent (maximum number in lower triangle should be 0.1010... E 01).

As mentioned previously, items 1-13 are repeated for all the segments within region one. The radius of revolution at every joint should be checked at corresponding joints of adjacent segments to make sure that proper coupling has been specified. At this stage in the output, the topology of the segments within the region, and the description of the intra-region rings and kinematic links is presented.

Next the region matrices are presented. Given in order are: the region stiffness matrix, the stiffness matrix symmetry check, and the region load matrices. Again the numerical round-off, evident in the symmetry check, should be kept to a maximum of one percent (0.1010... E 01 in lower triangle). The output to this point, that is, sets of items 1-13, segment topology and links, and the region matrices, are now repeated as a group for each region within the structure. When this is completed, the region topology is presented. The next items to be provided by the output are the descriptions of the inter-region rings and kinematic links and the boundary conditions. At external points of the structure these are physical boundary conditions. At internal points they merely state the fact that no restraint exists and the joint in question is free to move. The last column in this set, gives the angle α, which is zero unless a rotation code is indicated. It is important to refer to Figure 2-17once more and point out that α represents a rotation of the coordinate system.

There are a variety of errors that can be made in submitting input data. The STARS-2P program is set so that as an error is detected, (input or in the matrix calculations) the program is stopped. Therefore, to avoid delays in getting an answer, the SATELLITE-1P program was created to debug input data, and to check for other possbile inconsistencies. The use of this program is described in Reference 3, and all the STARS error messages are contained in the listings therein.

After having corrected any errors, so that it is now possible for the program to run to completion, the problem solution can be discussed. From the above point in the output, further output will depend upon the intermediate print clue. If this clue is set for full output, all stiffness matrices will be printed for all segments, regions, and structures in all print cycles specified. If the print clue is set for abbreviated print, only that noted below will be printed:

1. The applied line loads.
2. The region end deflections starting from region joint 1.
3. Tabulation of final print (per print interval) as shown in Table 3-1. Below this tabulation will appear the numerical results. In addition, if the crossection has gone plastic the following results will be available:
   a. NPLA: if this indicator is zero the layer is elastic.
      if this indicator is + the layer is plastic.
      if this indicator is - the layer is elastic
      but has previously been plastic.
   b. Total stresses through the crossection.
   c. Plastic strains through the crossection.

In item 3 above the following special cases may arise:

1. The 1,2 element will be zero for cylinders or cones.
2. No stresses will be calculated for the ST10 or RWAF options.
4. A restarted run will provide the initial print and start item 3 at the next print interval.

This completes the program output. The user is reminded to check continuity of stress resultants across segment boundaries where applicable.

	TABLE 3-1. Tabulated Final Output Information	
1,1	PHI (RAD. OR IN.)	φ or s at which calculations are made
2,1	EPSILON THETA	ϵ_θ, circumferential strain
3,1	U	circumferential displacement
4,1	V	meridional displacement
5,1	W	normal displacement
6,1	OMEGA THETA	ω_θ, circumferential rotational displacement (rad)
1,2	DEGREES	φ, expressed in degrees
2,2	EPSILON PHI	ϵ_φ, meridional strain
3,2	K PHI THETA	$k_{\varphi\theta}$, specific twist
4,2	J PHI STAR	J^*_φ, non-linear effective transverse shear stress resultant
5,2	T PHI THETA	$T_{\varphi\theta}$, effective in-plane shear stress resultant
6,2	OMEGA PHI	ω_φ, meridional rotational displacement (rad)
1,3	R ZERO	r_o, radius of revolution
2,3	GAMMA PHI THETA	$\gamma_{\varphi\theta}$, shear strain
3,3	N THETA	N_θ, circumferential force resultant
4,3	M THETA	M_θ, circumferential bending moment resultant
5,3	SIGMA THETA IN	$\sigma_{\theta in}$, circumferential stress on inside fiber
6,3	SIGMA THETA OUT	$\sigma_{\theta out}$, circumferential stress on outside fiber
1,4	BASE THICKNESS	basic shell wall thickness
2,4	K PHI	k_φ, meridional curvature
3,4	N PHI	N_φ, meridional force resultant
4,4	M PHI	M_φ, meridional bending moment resultant
5,4	SIGMA PHI IN	$\sigma_{\varphi in}$, meridional stress on inside fiber
6,4	SIGMA PHI OUT	$\sigma_{\varphi out}$, meridional stress on outside fiber

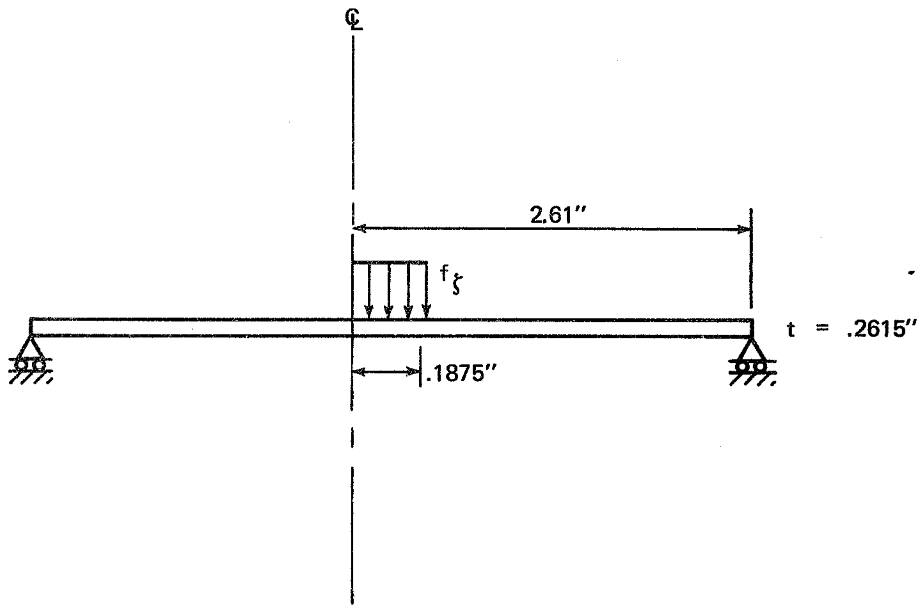
	TABLE 3-1. Tabulated Final Output Information (Continued)	
1,5	STEP	numerical integration step size
2,5	K THETA	k_{θ}, circumferential curvature
3,5	N PHI THETA	$N_{\varphi\theta}$, in-plane shear stress resultant
4,5	M PHI THETA	$M_{\varphi\theta}$, twisting moment resultant
5,5	TAU PHI THETA IN	$\tau_{\varphi\theta in}$, in-plane shear stress on inside fiber
6,5	TAU PHI THETA OUT	$\tau_{\varphi\theta out}$, in-plane shear stress on outside fiber
1,6	EPSILON THETA IN	Extreme edge strain for base shell (inner)
2,6	EPSILON THETA OUT	Extreme edge strain for base shell (outer)
3,6	EPSILON PHI IN	Extreme edge strain for base shell (inner)
4,6	EPSILON PHI OUT	Extreme edge strain for base shell (outer)
5,6	GAMMA PHI THETA IN	Extreme edge strain for base shell (inner)
6,6	GAMMA PHI THETA OUT	Extreme edge strain for base shell (outer)

SECTION 4

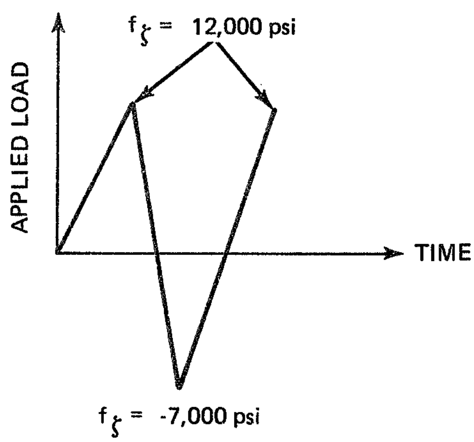
EXAMPLES OF INPUT AND SOLUTIONS

This section contains the full input for two example test problems, and the full output of the second test problem for the STARS-2P program. The first input problem was chosen simply to illustrate a load cycling run data set-up.

The test problem is presented in Figure 4-1. The loading involves both distributed and line loads. The intermediate print clue has been set for abbreviated output and graphic displays of some output variables have been requested. The necessary input is presented on the following pages.



(a) STRUCTURE



(b) LOADING PATTERN

Figure 4-1 TEST PROBLEM 1

```
  PLATE UNDER CYCLIC LOAD
 4   4 2   3   120  20 2         56    56
NLPL     1
ALUM       ISOT


 10.05     E 06

 .33



  8.417    E 03

  3.967

  4.0      E 03

ALU1       ISOT


 10.05     E 06

  .33



  8.417    E 03

  3.967

  4.0      E 08
-----------------------------------------------------------------------------------
 1 0 0  PLATE
    1    1    2
21 20
    .002        1.0      E-04   .0006                                          0.
 0.0
ISOT      ALU1       SING       THIC       NOTH       KINE                      2
 .0020          .02
 .2615          .2615
000100
 12.000    E 03 12.000    E 03
    1    1    2
-----------------------------------------------------------------------------------
 1 0 0  PLATE
    2    2    3
21 20
    .01780      1.0      E-04   .005933                                        0.
 0.0
ISOT      ALUM       SING       THIC       NOTH       KINE                      2
 .0200          .1875
 .2615          .2615
000100
 12.000    E 03 12.000    E 03
    1    1    2
-----------------------------------------------------------------------------------
 1 0 0  PLATE
    3    3    4
21 20
```

```
   .21130        1.0       E-04   .042250                                              0.
 0.0
ISOT       ALUM       SING       THIC       NOTH       KINE                              2
 .1875          .61
 .2615          .2615

    1    1    2
--------------------------------------------------------------------------------
 1 0 0  PLATE
    4    4    5
21 20
   1.0           1.0       E-04   .2                                                   0.
 0.0
ISOT       ALUM       SING       THIC       NOTH       KINE                              2
 .61            2.61
 .2615          .2615

    1    1    2
--------------------------------------------------------------------------------
    5    0    0
 1 0 1 0 0
 2 0 1 1 1
 3 0 1 1 1
 4 0 1 1 1
 5 0 0 1 1
--------------------------------------------------------------------------------
   1
    1    1  -.150797
--------------------------------------------------------------------------------
 4  4 2   3  -190  20   5 1
ALUM       ISOT


 10.05     E 06

 .33



 1.6834    E 04

  3.967

  4.0      E 03
ALU1       ISOT


 10.05     E 06

  .33



 1.6834    E 04

  3.967

  4.0      E 08
```

```
------------------------------------------------------------------------------------------------
000100
 19.000    E 03 19.000    E 03
000100
 19.000    E 03 19.000    E 03


   1
    1    1  -.238762
------------------------------------------------------------------------------------------------
 4   4 2   3   190  20   0
```

The second test problem involves monotonic loading of a structure similar to that shown in Figure 4-1. The thickness of the plate for this problem is 0.1286" and the loaded area radius is 0.18675". The applied load increases monotonically to 5,000 psi. The input and output for the problem is presented on the following pages. The apex segment was treated as an elastic plug in this problem because of a local stress singularity at the apex which is dependent upon computer accuracy. Further discussions of this and other problem results are available in Ref. 1.

```
 CIRCULAR PLATE          TP1
 4  4 2   1     50  50
NLPL     1                1  1      25
ALUM       ISOT


 10.5      E 06

  .33



  6.634    E 03

  3.661

  4.0      E 03

ALU1       ISOT


 10.5      E 06

  .33



  6.634    E 03

  3.661

  4.0      E 08
------------------------------------------------------------------------------------
 1 0 0  PLATE
    1     1     2
21 20
    .002          1.0       E-04   .0006                                        0.
 0.0
ISOT       ALU1       SING       THIC       NOTH       KINE                    2
 .0020          .02
 .1283          .1283
000100
 0.5000    E 04 0.5000    E 04
    1     1     2
------------------------------------------------------------------------------------
 1 0 0  PLATE
    2     2     3
21 20
    .01780        1.0       E-04   .005933                                      0.
 0.0
ISOT       ALUM       SING       THIC       NOTH       KINE                    2
 .0200          .1875
 .1283          .1283
000100
 0.5000    E 04 0.5000    E 04
    1     1     2
------------------------------------------------------------------------------------
 1 0 0  PLATE
    3     3     4
```

```
21 20
   .21130       1.0      E-04  .042250                                       0.
 0.0
ISOT      ALUM      SING      THIC      NOTH      KINE                        2
 .1875         .61
 .1283         .1283

    1    1    2
--------------------------------------------------------------------------------
 1 0 0  PLATE
    4    4    5
21 20
   1.0          1.0      E-04  .2                                            0.
 0.0
ISOT      ALUM      SING      THIC      NOTH      KINE                        2
 .61           2.61
 .1283         .1283

    1    1    2
--------------------------------------------------------------------------------
    5    0    0
 1 0 1 0 0
 2 0 1 1 1
 3 0 1 1 1
 4 0 1 1 1
 5 0 0 1 1
--------------------------------------------------------------------------------
   1
    1    1  -.125664
--------------------------------------------------------------------------------
```

UNSYMMETRIC, ORTHOTROPIC, REINFORCED SHELL ANALYSIS WITH COUPLING OF AT MOST 29 SHELL REGIONS

STARS-2P

AS OF JULY 1, 1973

NUMBER OF SEGMENTS = 4 NUMBER OF REGIONS = 4 NUMBER OF MATERIAL PROPERTY TABLES USED = 2 NO. OF CYCLES = 50.

LARGE DEFLECTION PLASTIC PROBLEM

4-9

CIRCULAR PLATE TP1

FOR INFORMATION CALL V. SVALBONAS (516) 575-7701
P. OGILVIE
H. LEVINE

REGION NUMBER 1

THERE ARE 1 SEGMENTS AND 0 KINEMATIC LINKS WITHIN THIS REGION

SEGMENT NUMBER 1 SEGMENT CODE 21

DTAU	DIFF	STEP	DELTA
.2000000-02	.1000000-03	.4000000-03	.0000000

GEOMETRY INPUT VARIABLES

.0000000	.0000000	.0000000

ISOT ALUI SING THIC MOTH HARDENING LAW = KINE NUMBER OF TABLE COLUMNS = 2

MATERIAL PROPERTY TABLE USED

.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.10500+08	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.33000+00	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.66290+04	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.34610+01	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.40000+09	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

TABLE ORDER PHI OR S VS. CROSSECTION PROPERTIES

.2000000-02	.2000000-01
.1283000+00	.1283000+00

PROBLEM 1 TABLE ORDER PHI OR S VS. DISTRIBUTED LOADS (F THETA, F PHI, F ZETA, M THETA, M PHI)

LOAD IDENTIFICATION CLUES 000100

.6000000+04	.6000000+04

MATRIX X AND Y (TRANSPOSED) MAGIC OUTPUT

.0000000	.0000000	.0000000	.0000000	.1000000+02	.0000000	.0000000	.0000000
.0000000	.3334667+09	.0000000	.0000000	.0000000	.3417167+01	.0000000	.0000000
.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.1000000+01	.0000000
.0000000	.0000000	.0000000	-.9574560+06	.0000000	.0000000	.3423913-01	.3417167+01
.1000485-01	.0000000	.0000000	.0000000	.1993879-07	.0000000	.0000000	.0000000
.0000000	.6682843+00	.0000000	.0000000	.0000000	.6897892-04	.0000000	.0000000
.0000000	.0000000	.7777777-01	.3374067-02	.0000000	.0000000	-.1288099-09	-.1793279-07
.0000000	.0000000	.0000000	.6682843+00	.0000000	.0000000	-.4551351-07	-.9773910-06
.0000000	.0000000	-.9999999+00	-.7918924-02	.0000000	.0000000	.1029973-09	.2198788-07

STIFFNESS COEFFICIENTS

	DELTA T1	DELTA Z1	DELTA R1	THETA 1	DELTA T2	DELTA Z2	DELTA R2	THETA 2
FORCE	.6431515+07	.0000000	.0000000	.0000000	-.6431515+06	.0000000	.0000000	.0000000
FORCE	.0000000	.3359318+09	.0000000	-.1226876+07	.0000000	-.3359318+09	.0000000	-.3203037+07
FORCE	.0000000	.0000000	.6558052+07	.0000000	.0000000	.0000000	-.1919147+07	.0000000
MOMENT	.0000000	-.1226838+07	.0000000	.1347656+05	.0000000	.1226838+07	.0000000	.9065067+04
FORCE	-.6435922+06	.0000000	.0000000	.0000000	.6435922+05	.0000000	.0000000	.0000000
FORCE	.0000000	-.3359317+09	.0000000	.1226876+07	.0000000	.3359317+09	.0000000	.3203036+07
FORCE	.0000000	.0000000	-.1919380+07	.0000000	.0000000	.0000000	.1282536+08	.0000000
MOMENT	.0000000	-.3202986+07	.0000000	.9064923+04	.0000000	.3202986+07	.0000000	.4813285+05

SEGMENT SYMMETRY CHECK

.6431515+07	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
.1000000+01	.3359318+09	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
.1000000+01	.1000000+01	.6558052+07	.0000000	.0000000	.0000000	.0000000	.0000000
.1000000+01	.1000031+01	.1000000+01	.1347656+05	.0000000	.0000000	.0000000	.0000000
.1000685+01	.1000000+01	.1000000+01	.1000000+01	.6435922+05	.0000000	.0000000	.0000000
.1000000+01	.1000000+01	.1000000+01	.1000031+01	.1000000+01	.3359317+09	.0000000	.0000000
.1000000+01	.1000000+01	.1000121+01	.1000000+01	.1000000+01	.1000000+01	.1282536+08	.0000000
.1000000+01	.1000016+01	.1000000+01	.1000016+01	.1000000+01	.1000016+01	.1000000+01	.4813285+05

SEGMENT LOAD MATRICES

.0000000
.3550658-01
.0000000
-.7205110-04
.0000000
.8890047-01
.0000000
.2715100-03

RZERO(I) = 2.000000-03 RZERO(J) = 2.000000-02

REGION NUMBER 2

THERE ARE 1 SEGMENTS AND 0 KINEMATIC LINKS WITHIN THIS REGION

SEGMENT NUMBER 1 SEGMENT CODE 21

DTAU	DIFF	STEP	DELTA
.1780000-01	.1000000-03	.5933000-02	.0000000

GEOMETRY INPUT VARIABLES

.0000000	.0000000	.0000000

ISOT ALUM SING THIC NOTH HARDENING LAW = KINE NUMBER OF TABLE COLUMNS = 2

MATERIAL PROPERTY TABLE USED

.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.10500+08	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.33000+00	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.66340+04	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.36610+01	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.40000+04	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

TABLE ORDER PHI OR S VS. CROSSECTION PROPERTIES

.2000000-01	.1875000+00
.1283000+00	.1283000+00

PROBLEM 1 TABLE ORDER PHI OR S VS. DISTRIBUTED LOADS (F THETA, F PHI, F ZETA, M THETA, M PHI)
LOAD IDENTIFICATION CLUES 000100

.5000000+04	.5000000+04

MATRIX X AND Y (TRANSPOSED) MAGIC OUTPUT

.0000000	.0000000	.0000000	.0000000	.9375002+01	.0000000	.0000000	.0000000
.0000000	.3330188+08	.0000000	.0000000	.0000000	.3212160+01	.0000000	.0000000
.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.1000000+01	.0000000
.0000000	.0000000	.0000000	-.4568155+05	.0000000	.0000000	.3209060+00	.3212160+01
.1138521-01	.0000000	.0000000	.0000000	.1829242-06	.0000000	.0000000	.0000000
.0000000	.6687487+00	.0000000	.0000000	.0000000	.6130132-07	.0000000	.0000000
.0000000	.0000000	.1066666+00	.3307772-01	.0000000	.0000000	-.1080649-06	-.1576592-05
.0000000	.0000000	.0000000	.6687487+00	.0000000	.0000000	-.3973724-05	-.4468870-04
.0000000	.0000000	-.9268334+01	-.4919429+00	.0000000	.0000000	.7822394-06	.1784046-04

STIFFNESS COEFFICIENTS

	DELTA T1	DELTA Z1	DELTA R1	THETA 1	DELTA T2	DELTA Z2	DELTA R2	THETA 2
FORCE	.6440357+07	.0000000	.0000000	.0000000	-.6849713+06	.0000000	.0000000	.0000000
FORCE	.0000000	.3911615+07	.0000000	-.1380031+06	.0000000	-.3911615+07	.0000000	-.3478212+06
FORCE	.0000000	.0000000	.6584719+07	.0000000	.0000000	.0000000	-.2049935+07	.0000000
MOMENT	.0000000	-.1379995+06	.0000000	.1390120+05	.0000000	.1379995+06	.0000000	.9458953+04
FORCE	-.6874202+06	.0000000	.0000000	.0000000	.7332481+05	.0000000	.0000000	.0000000
FORCE	.0000000	-.3911614+07	.0000000	.1380031+06	.0000000	.3911614+07	.0000000	.3478212+06
FORCE	.0000000	.0000000	-.2050173+07	.0000000	.0000000	.0000000	.1285211+08	.0000000
MOMENT	.0000000	-.3478152+06	.0000000	.9458737+04	.0000000	.3478152+06	.0000000	.4855753+05

SEGMENT SYMMETRY CHECK

.6440357+07	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
.1000000+01	.3911615+07	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
.1000000+01	.1000000+01	.6584719+07	.0000000	.0000000	.0000000	.0000000	.0000000
.1000000+01	.1000026+01	.1000000+01	.1390120+05	.0000000	.0000000	.0000000	.0000000
.1000653+01	.1000000+01	.1000000+01	.1000000+01	.7332481+05	.0000000	.0000000	.0000000
.1000000+01	.1000000+01	.1000000+01	.1000026+01	.1000000+01	.3911614+07	.0000000	.0000000
.1000000+01	.1000000+01	.1000116+01	.1000000+01	.1000000+01	.1000000+01	.1285211+08	.0000000
.1000000+01	.1000017+01	.1000000+01	.1000023+01	.1000000+01	.1000017+01	.1000000+01	.4855753+05

SEGMENT LOAD MATRICES

.0000000
.3145472+01
.0000000
-.6080342-01
.0000000
.7773528+01
.0000000
.2209621+00

RZERO(I) = 2.000000-02 RZERO(J) = 1.875000-01

REGION NUMBER 3

THERE ARE 1 SEGMENTS AND 0 KINEMATIC LINKS WITHIN THIS REGION

SEGMENT NUMBER 1 SEGMENT CODE 21

DTAU	DIFF	STEP	DELTA
.2113000+00	.1000000-03	.4225000-01	.0000000

GEOMETRY INPUT VARIABLES

.0000000	.0000000	.0000000

ISOT ALUM SING THIC NOTH HARDENING LAW = KINE NUMBER OF TABLE COLUMNS = 2

MATERIAL PROPERTY TABLE USED

.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.10500+08	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.33000+00	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.66340+04	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.36610+01	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.40000+04	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

TABLE ORDER PHI OR S VS. CROSSECTION PROPERTIES

.1875000+00	.6100000+00
.1283000+00	.1283000+00

MATRIX X AND Y (TRANSPOSED) MAGIC OUTPUT

.0000000	.0000000	.0000000	.0000000	.3253333+01	.0000000	.0000000	.0000000
.0000000	.3253206+07	.0000000	.0000000	.0000000	.1294350+01	.0000000	.0000000
.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.1000000+01	.0000000
.0000000	.0000000	.0000000	-.4462555+04	.0000000	.0000000	.4481130+00	.1294350+01
.9449984-01	.0000000	.0000000	.0000000	.5452342-06	.0000000	.0000000	.0000000
.0000000	.6966307+00	.0000000	.0000000	.0000000	.1826800-06	.0000000	.0000000
.0000000	.0000000	.3073770+00	.1755290+00	.0000000	.0000000	-.3243403-05	-.2004628-04
.0000000	.0000000	.0000000	.6966307+00	.0000000	.0000000	-.3061892-04	-.1331738-03
.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000

STIFFNESS COEFFICIENTS

	DELTA T1	DELTA Z1	DELTA R1	THETA 1	DELTA T2	DELTA Z2	DELTA R2	THETA 2
FORCE	.7029535+07	.0000000	.0000000	.0000000	-.2160718+07	.0000000	.0000000	.0000000
FORCE	.0000000	.8627105+06	.0000000	-.1298552+06	.0000000	-.8627105+06	.0000000	-.1983518+06
FORCE	.0000000	.0000000	.8347220+07	.0000000	.0000000	.0000000	-.6448968+07	.0000000
MOMENT	.0000000	-.1298614+06	.0000000	.3099696+05	.0000000	.1298614+06	.0000000	.2101102+05
FORCE	-.2161156+07	.0000000	.0000000	.0000000	.6642899+06	.0000000	.0000000	.0000000
FORCE	.0000000	-.8627104+06	.0000000	.1298552+06	.0000000	.8627104+06	.0000000	.1983518+06
FORCE	.0000000	.0000000	-.6449203+07	.0000000	.0000000	.0000000	.1461576+08	.0000000
MOMENT	.0000000	-.1983404+06	.0000000	.2100756+05	.0000000	.1983404+06	.0000000	.6565086+05

SEGMENT SYMMETRY CHECK

.7029535+07	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
.1000000+01	.8627105+06	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
.1000000+01	.1000000+01	.8347220+07	.0000000	.0000000	.0000000	.0000000	.0000000
.1000000+01	.1000047+01	.1000000+01	.3099696+05	.0000000	.0000000	.0000000	.0000000
.1000203+01	.1000000+01	.1000000+01	.1000000+01	.6642899+06	.0000000	.0000000	.0000000
.1000000+01	.1000000+01	.1000000+01	.1000047+01	.1000000+01	.8627104+06	.0000000	.0000000
.1000000+01	.1000000+01	.1000036+01	.1000000+01	.1000000+01	.1000000+01	.1461576+08	.0000000
.1000000+01	.1000057+01	.1000000+01	.1000164+01	.1000000+01	.1000057+01	.1000000+01	.6565086+05

SEGMENT LOAD MATRICES

.0000000
.0000000
.0000000
.0000000
.0000000
.0000000
.0000000
.0000000

RZERO(I) = 1.875000-01 RZERO(J) = 6.100000-01

REGION NUMBER 4

THERE ARE 1 SEGMENTS AND 0 KINEMATIC LINKS WITHIN THIS REGION

SEGMENT NUMBER 1 SEGMENT CODE 21

DTAU	DIFF	STEP	DELTA
.1000000+01	.1000000-03	.2000000+00	.0000000

GEOMETRY INPUT VARIABLES

.0000000	.0000000	.0000000

ISOT ALUM SING THIC NOTH HARDENING LAW = KINE NUMBER OF TABLE COLUMNS = 2

MATERIAL PROPERTY TABLE USED

.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.10500+08	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.33000+00	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.66340+04	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.36610+01	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.40000+04	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

TABLE ORDER PHI OR S VS. CROSSECTION PROPERTIES

.6100000+00	.2610000+01
.1283000+00	.1283000+00

MATRIX X AND Y (TRANSPOSED) MAGIC OUTPUT

.0000000	.0000000	.0000000	.0000000	.4278689+01	.0000000	.0000000	.0000000
.0000000	.1044202+07	.0000000	.0000000	.0000000	.1589209+01	.0000000	.0000000
.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.1000000+01	.0000000
.0000000	.0000000	.0000000	-.1432375+04	.0000000	.0000000	.2358528+01	.1589209+01
.5467789-01	.0000000	.0000000	.0000000	.2434207-05	.0000000	.0000000	.0000000
.0000000	.6832087+00	.0000000	.0000000	.0000000	.8159376-06	.0000000	.0000000
.0000000	.0000000	.2337165+00	.6862495+00	.0000000	.0000000	-.2944033-03	-.3765662-03
.0000000	.0000000	.0000000	.6832087+00	.0000000	.0000000	-.6458375-03	-.5948191-03
.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000

STIFFNESS COEFFICIENTS

	DELTA T1	DELTA Z1	DELTA R1	THETA 1	DELTA T2	DELTA Z2	DELTA R2	THETA 2
FORCE	.6736942+07	.0000000	.0000000	.0000000	-.1574534+07	.0000000	.0000000	.0000000
FORCE	.0000000	.3348499+05	.0000000	-.2119636+05	.0000000	-.3348499+05	.0000000	-.3635709+05
FORCE	.0000000	.0000000	.7465068+07	.0000000	.0000000	.0000000	-.4697348+07	.0000000
MOMENT	.0000000	-.2119857+05	.0000000	.2365907+05	.0000000	.2119857+05	.0000000	.1687328+05
FORCE	-.1576105+07	.0000000	.0000000	.0000000	.3683618+06	.0000000	.0000000	.0000000
FORCE	.0000000	-.3348499+05	.0000000	.2119636+05	.0000000	.3348499+05	.0000000	.3635709+05
FORCE	.0000000	.0000000	-.4698177+07	.0000000	.0000000	.0000000	.1373146+08	.0000000
MOMENT	.0000000	-.3635178+05	.0000000	.1656639+05	.0000000	.3635178+05	.0000000	.5830573+05

SEGMENT SYMMETRY CHECK

.6736942+07	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
.1000000+01	.3348499+05	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
.1000000+01	.1000000+01	.7465068+07	.0000000	.0000000	.0000000	.0000000	.0000000
.1000000+01	.1000104+01	.1000000+01	.2365907+05	.0000000	.0000000	.0000000	.0000000
.1000998+01	.1000000+01	.1000000+01	.1000000+01	.3683618+06	.0000000	.0000000	.0000000
.1000000+01	.1000000+01	.1000000+01	.1000104+01	.1000000+01	.3348499+05	.0000000	.0000000
.1000000+01	.1000000+01	.1000176+01	.1000000+01	.1000000+01	.1000000+01	.1373146+08	.0000000
.1000000+01	.1000145+01	.1000000+01	.1000415+01	.1000000+01	.1000145+01	.1000000+01	.5830573+05

SEGMENT LOAD MATRICES

.0000000
.0000000
.0000000
.0000000
.0000000
.0000000
.0000000
.0000000

RZERO(I) = 6.100000+01 RZERO(J) = 2.610000+00

INPUT DATA FOR REGION COUPLING

NUMBER OF REGION JOINTS 5 NUMBER OF KINEMATIC LINKS 0

REGION	JOINT(I)	JOINT(J)
1	1	2
2	2	3
3	3	4
4	4	5

BOUNDARY CONDITIONS

JOINT	DELTA T	DELTA Z	DELTA R	THETA	ANGLE ALPHA
1	0	1	0	0	.0000000
2	0	1	1	1	.0000000
3	0	1	1	1	.0000000
4	0	1	1	1	.0000000
5	0	0	1	1	.0000000

EXTERNAL LINE LOADS

PROBLEM NUMBER	POINT OF APPLICATION	APPLIED LOAD
1	1	-.628320D-01

THE EXPANDED REGION JOINT DISPLACEMENT MATRIX (REGION END DEFLECTIONS)

JOINT	PROBLEM	DELTA T	DELTA Z	DELTA R	OMEGA-THETA
1	1	.0000000	-.1788975-02	.0000000	.0000000
2	1	.0000000	-.1788705-02	.0000000	-.2831105-04
3	1	.0000000	-.1764763-02	.0000000	-.2486659-03
4	1	.0000000	-.1585095-02	.0000000	-.5630631-03
5	1	.0000000	.0000000	.0000000	-.8283122-03

REGION NUMBER 1

THERE ARE 1 SEGMENTS AND 0 KINEMATIC LINKS WITHIN THIS REGION

SEGMENT NUMBER 1 SEGMENT CODE 21 NO. OF LAYERS 20

TABLE ORDER PHI OR S VS. CROSSECTION PROPERTIES

.2000000-02	.2000000-01
.1283000+00	.1283000+00

TABLE ORDER PHI OR S VS. DISTRIBUTED LOADS (F THETA, F PHI, F ZETA, M THETA, M PHI)

LOAD IDENTIFICATION CLUES 000100

.5000000+04	.5000000+04

PHI (RAD. OR IN.)	DEGRES	R ZERO	BASE THICKNESS	STEP	EPSILON THETA IN
EPSILON THETA	EPSILON PHI	GAMMA PHI THETA	K PHI	K THETA	EPSILON THETA OUT
U	K PHI THETA	N THETA	N PHI	N PHI THETA	EPSILON PHI IN
V	J PHI STAR	M THETA	M PHI	M PHI THETA	EPSILON PHI OUT
W	T PHI THETA	SIGMA THETA IN	SIGMA PHI IN	TAU PHI THETA IN	GAMMA PHI THETA IN
OMEGA THETA	OMEGA PHI	SIGMA THETA OUT	SIGMA PHI OUT	TAU PHI THETA OUT	GAMMA PHI THETA OUT

CYCLE 1.

2.0000000-03	0.0000000	2.0000000-03	1.2830000-01	6.0000000-04	0.0000000
0.0000000	0.0000000	0.0000000	-2.8485829-03	0.0000000	0.0000000
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-1.8273659-04
0.0000000	8.0168692+00	1.9494153+00	5.9073192+00	0.0000000	1.8273659-04
1.7889746-03	0.0000000	7.1056255+02	2.1532198+03	0.0000000	0.0000000
0.0000000	0.0000000	-7.1056255+02	-2.1532198+03	0.0000000	0.0000000

4.9999998-03	0.0000000	4.9999998-03	1.2830000-01	6.0000000-04	-7.6859803-05
0.0000000	0.0000000	0.0000000	-1.6570942-03	-1.1981263-03	7.6859803-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-1.0630259-04
0.0000000	2.9967476+00	3.6186692+00	4.2563725+00	0.0000000	1.0630259-04
1.7889649-03	0.0000000	1.3190062+03	1.5514492+03	0.0000000	0.0000000
-5.9906313-06	0.0000000	-1.3190062+03	-1.5514492+03	0.0000000	0.0000000

7.3999994-03	0.0000000	7.3999994-03	1.2830000-01	6.0000000-04	-8.4887364-05
0.0000000	0.0000000	0.0000000	-1.5346660-03	-1.3232637-03	8.4887364-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-9.8448822-05
0.0000000	1.8237484+00	3.7943927+00	4.0881212+00	0.0000000	9.8448822-05
1.7889459-03	0.0000000	1.3830574+03	1.4901216+03	0.0000000	0.0000000
-9.7921503-06	0.0000000	-1.3830574+03	-1.4901216+03	0.0000000	0.0000000
9.7999991-03	0.0000000	9.7999991-03	1.2830000-01	6.0000000-04	-8.7815001-05
0.0000000	0.0000000	0.0000000	-1.4907298-03	-1.3689010-03	8.7815001-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-9.5630318-05
0.0000000	1.1665038+00	3.8589668+00	4.0282393+00	0.0000000	9.5630318-05
1.7889180-03	0.0000000	1.4065947+03	1.4682946+03	0.0000000	0.0000000
-1.3415229-05	0.0000000	-1.4065947+03	-1.4682946+03	0.0000000	0.0000000
1.2199999-02	0.0000000	1.2199999-02	1.2830000-01	6.0000000-04	-8.9208062-05
0.0000000	0.0000000	0.0000000	-1.4700924-03	-1.3906167-03	8.9208062-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-9.4306428-05
0.0000000	7.2063422-01	3.8898771+00	4.0003029+00	0.0000000	9.4306428-05
1.7888815-03	0.0000000	1.4178615+03	1.4581118+03	0.0000000	0.0000000
-1.6965522-05	0.0000000	-1.4178615+03	-1.4581118+03	0.0000000	0.0000000
1.4599998-02	0.0000000	1.4599998-02	1.2830000-01	6.0000000-04	-8.9980726-05
0.0000000	0.0000000	0.0000000	-1.4586782-03	-1.4026613-03	8.9980726-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-9.3574207-05
0.0000000	3.8189983-01	3.9070437+00	3.9848762+00	0.0000000	9.3574207-05
1.7888366-03	0.0000000	1.4241187+03	1.4524883+03	0.0000000	0.0000000
-2.0478853-05	0.0000000	-1.4241187+03	-1.4524883+03	0.0000000	0.0000000
1.6999998-02	0.0000000	1.6999998-02	1.2830000-01	6.0000000-04	-9.0453653-05
0.0000000	0.0000000	0.0000000	-1.4515831-03	-1.4100336-03	9.0453653-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-9.3119058-05
0.0000000	1.0492573-01	3.9174765+00	3.9752067+00	0.0000000	9.3119058-05
1.7887833-03	0.0000000	1.4279215+03	1.4489642+03	0.0000000	0.0000000
-2.3970568-05	0.0000000	-1.4279215+03	-1.4489642+03	0.0000000	0.0000000
1.9399998-02	0.0000000	1.9399998-02	1.2830000-01	6.0000000-04	-9.0763096-05
0.0000000	0.0000000	0.0000000	-1.4467400-03	-1.4148573-03	9.0763096-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-9.2808373-05

0.0000000	-1.3320940-01	3.9241655+00	3.9684643+00	0.0000000	9.2808373-05
1.7887216-03	0.0000000	1.4303597+03	1.4465066+03	0.0000000	0.0000000
-2.7448228-05	0.0000000	-1.4303597+03	-1.4465066+03	0.0000000	0.0000000

1.9999997-02	0.0000000	1.9999997-02	1.2830000-01	6.0000000-04	-9.0823492-05
0.0000000	0.0000000	0.0000000	-1.4457520-03	-1.4157988-03	9.0823492-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-9.2744990-05
0.0000000	-1.8831312-01	3.9254418+00	3.9670596+00	0.0000000	9.2744990-05
1.7887048-03	0.0000000	1.4308249+03	1.4459946+03	0.0000000	0.0000000
-2.8315972-05	0.0000000	-1.4308249+03	-1.4459946+03	0.0000000	0.0000000

REGION NUMBER 2

THERE ARE 1 SEGMENTS AND 0 KINEMATIC LINKS WITHIN THIS REGION

SEGMENT NUMBER 1 SEGMENT CODE 21 NO. OF LAYERS 20

TABLE ORDER PHI OR S VS. CROSSECTION PROPERTIES

.2000000-01 .1875000+00
.1283000+00 .1283000+00

TABLE ORDER PHI OR S VS. DISTRIBUTED LOADS (F THETA, F PHI, F ZETA, M THETA, M PHI)

LOAD IDENTIFICATION CLUES 000100

.5000000+04 .5000000+04

PHI (RAD. OR IN.)	DEGRES	R ZERO	BASE THICKNESS	STEP	EPSILON THETA IN
EPSILON THETA	EPSILON PHI	GAMMA PHI THETA	K PHI	K THETA	EPSILON THETA OUT
U	K PHI THETA	N THETA	N PHI	N PHI THETA	EPSILON PHI IN
V	J PHI STAR	M THETA	M PHI	M PHI THETA	EPSILON PHI OUT
W	T PHI THETA	SIGMA THETA IN	SIGMA PHI IN	TAU PHI THETA IN	GAMMA PHI THETA IN
OMEGA THETA	OMEGA PHI	SIGMA THETA OUT	SIGMA PHI OUT	TAU PHI THETA OUT	GAMMA PHI THETA OUT

CYCLE 1.

2.0000000-02	0.0000000	2.0000000-02	1.2830000-01	5.9330000-03	-9.0807690-05
0.0000000	0.0000000	0.0000000	-1.4419423-03	-1.4155525-03	9.0807690-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-9.2500601-05
0.0000000	-8.5943270-01	3.9223238+00	3.9589907+00	0.0000000	9.2500601-05
1.7887049-03	0.0000000	1.4296884+03	1.4430535+03	0.0000000	0.0000000
-2.8311049-05	0.0000000	-1.4296884+03	-1.4430535+03	0.0000000	0.0000000
4.9664999-02	0.0000000	4.9664999-02	1.2830000-01	5.9330000-03	-9.1203358-05
0.0000000	0.0000000	0.0000000	-1.4120913-03	-1.4217203-03	9.1203358-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-9.0585655-05
0.0000000	-2.4266438+00	3.9146862+00	3.9013073+00	0.0000000	9.0585655-05
1.7872356-03	0.0000000	1.4269044+03	1.4220278+03	0.0000000	0.0000000
-7.0609738-05	0.0000000	-1.4269044+03	-1.4220278+03	0.0000000	0.0000000

7.3396998-02	0.0000000	7.3396998-02	1.2830000-01	5.9330000-03	-9.0735011-05
0.0000000	0.0000000	0.0000000	-1.3847140-03	-1.4144195-03	9.0735011-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-8.8829403-05
0.0000000	-3.6315466+00	3.8808104+00	3.8395367+00	0.0000000	8.8829403-05
1.7851646-03	0.0000000	1.4145567+03	1.3995124+03	0.0000000	0.0000000
-1.0381415-04	0.0000000	-1.4145567+03	-1.3995124+03	0.0000000	0.0000000
9.7128997-02	0.0000000	9.7128997-02	1.2830000-01	5.9330000-03	-8.9993508-05
0.0000000	0.0000000	0.0000000	-1.3478658-03	-1.4028606-03	8.9993508-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-8.6465589-05
0.0000000	-4.8275054+00	3.8316229+00	3.7552115+00	0.0000000	8.6465589-05
1.7823142-03	0.0000000	1.3966279+03	1.3687759+03	0.0000000	0.0000000
-1.3625844-04	0.0000000	-1.3966279+03	-1.3687759+03	0.0000000	0.0000000
1.2086100-01	0.0000000	1.2086100-01	1.2830000-01	5.9330000-03	-8.9016363-05
0.0000000	0.0000000	0.0000000	-1.3010281-03	-1.3876284-03	8.9016363-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-8.3460955-05
0.0000000	-6.0197888+00	3.7679816+00	3.6476567+00	0.0000000	8.3460955-05
1.7787051-03	0.0000000	1.3734306+03	1.3295721+03	0.0000000	0.0000000
-1.6771015-04	0.0000000	-1.3734306+03	-1.3295721+03	0.0000000	0.0000000
1.4459299-01	0.0000000	1.4459279-01	1.2830000-01	5.9330000-03	-8.7813630-05
0.0000000	0.0000000	0.0000000	-1.2440745-03	-1.3688797-03	8.7813630-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-7.9807378-05
0.0000000	-7.2102066+00	3.6901250+00	3.5167170+00	0.0000000	7.9807378-05
1.7743637-03	0.0000000	1.3450518+03	1.2818445+03	0.0000000	0.0000000
-1.9793040-04	0.0000000	-1.3450518+03	-1.2818445+03	0.0000000	0.0000000
1.6832498-01	0.0000000	1.6832498-01	1.2830000-01	5.9330000-03	-8.6389011-05
0.0000000	0.0000000	0.0000000	-1.1769634-03	-1.3466720-03	8.6389011-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-7.5502201-05
0.0000000	-8.3995477+00	3.5981442+00	3.3623460+00	0.0000000	7.5502201-05
1.7693221-03	0.0000000	1.3115248+03	1.2255763+03	0.0000000	0.0000000
-2.2667855-04	0.0000000	-1.3115248+03	-1.2255763+03	0.0000000	0.0000000
1.8612397-01	0.0000000	1.8612397-01	1.2830000-01	5.9330000-03	-8.5175971-05
0.0000000	0.0000000	0.0000000	-1.1199541-03	-1.3277626-03	8.5175971-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-7.1845056-05

0.0000000	-9.2910948+00	3.5199162+00	3.2311811+00	0.0000000	7.1845056-05
1.7661040-03	0.0000000	1.2830107+03	1.1777666+03	0.0000000	0.0000000
-2.4712845-04	0.0000000	-1.2830107+03	-1.1777666+03	0.0000000	0.0000000

1.8750000-01	0.0000000	1.8750000-01	1.2830000-01	5.9330000-03	-8.5077046-05
0.0000000	0.0000000	0.0000000	-1.1153084-03	-1.3262205-03	8.5077046-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-7.1547031-05
0.0000000	-9.3600069+00	3.5135390+00	3.2204915+00	0.0000000	7.1547031-05
1.7647629-03	0.0000000	1.2806861+03	1.1738702+03	0.0000000	0.0000000
-2.4866635-04	0.0000000	-1.2806861+03	-1.1738702+03	0.0000000	0.0000000

REGION NUMBER 3

THERE ARE 1 SEGMENTS AND 0 KINEMATIC LINKS WITHIN THIS REGION

SEGMENT NUMBER 1   SEGMENT CODE 21   NO. OF LAYERS 20

TABLE ORDER PHI OR S VS. CROSSECTION PROPERTIES

.1875000+00	.6100000+00
.1283000+00	.1283000+00

PHI (RAD. OR IN.)	DEGRES	R ZERO	BASE THICKNESS	STEP	EPSILON THETA IN
EPSILON THETA	EPSILON PHI	GAMMA PHI THETA	K PHI	K THETA	EPSILON THETA OUT
U	K PHI THETA	N THETA	N PHI	N PHI THETA	EPSILON PHI IN
V	J PHI STAR	M THETA	M PHI	M PHI THETA	EPSILON PHI OUT
W	T PHI THETA	SIGMA THETA IN	SIGMA PHI IN	TAU PHI THETA IN	GAMMA PHI THETA IN
OMEGA THETA	OMEGA PHI	SIGMA THETA OUT	SIGMA PHI OUT	TAU PHI THETA OUT	GAMMA PHI THETA OUT

CYCLE 1.

1.8750000-01	0.0000000	1.8750000-01	1.2830000-01	4.2250000-02	-8.5076888-05
0.0000000	0.0000000	0.0000000	-1.1150763-03	-1.3262181-03	8.5076888-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-7.1532083-05
0.0000000	-9.3592367+00	3.5133744+00	3.2200066+00	0.0000000	7.1532083-05
1.7647629-03	0.0000000	1.2806262+03	1.1736935+03	0.0000000	0.0000000
-2.4866589-04	0.0000000	-1.2806262+03	-1.1736935+03	0.0000000	0.0000000
4.8325000-01	0.0000000	4.8325000-01	1.2830000-01	4.2250000-02	-6.5154721-05
0.0000000	0.0000000	0.0000000	-6.2448315-04	-1.0156621-03	6.5154721-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-4.0060594-05
0.0000000	-3.6313645+00	2.5336166+00	1.9901013+00	0.0000000	4.0060594-05
1.6520246-03	0.0000000	9.2350411+02	7.2539259+02	0.0000000	0.0000000
-4.9081869-04	0.0000000	-9.2350411+02	-7.2539259+02	0.0000000	0.0000000
5.6774998-01	0.0000000	5.6774998-01	1.2830000-01	4.2250000-02	-6.1062959-05
0.0000000	0.0000000	0.0000000	-5.5190275-04	-9.5187777-04	6.1062959-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-3.5404561-05

0.0000000	-3.0908972+00	2.3516723+00	1.7959363+00	0.0000000	3.5404561-05
1.6084112-03	0.0000000	8.5718534+02	6.5461905+02	0.0000000	0.0000000
-5.4042858-04	0.0000000	-8.5718534+02	-6.5461905+02	0.0000000	0.0000000

6.0999998-01	0.0000000	6.0999998-01	1.2830000-01	4.2250000-02	-5.9213960-05
0.0000000	0.0000000	0.0000000	-5.1998649-04	-9.2305472-04	5.9213960-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-3.3357133-05
0.0000000	-2.8768146+00	2.2700580+00	1.7100233+00	0.0000000	3.3357133-05
1.5850951-03	0.0000000	8.2743692+02	6.2330407+02	0.0000000	0.0000000
-5.6306336-04	0.0000000	-8.2743692+02	-6.2330407+02	0.0000000	0.0000000

REGION NUMBER 4

THERE ARE 1 SEGMENTS AND 0 KINEMATIC LINKS WITHIN THIS REGION

SEGMENT NUMBER 1 SEGMENT CODE 21 NO. OF LAYERS 20

TABLE ORDER PHI OR S VS. CROSSECTION PROPERTIES

.6100000+00	.2610000+01
.1283000+00	.1283000+00

PHI (RAD. OR IN.)	DEGRES	R ZERO	BASE THICKNESS	STEP	EPSILON THETA IN
EPSILON THETA	EPSILON PHI	GAMMA PHI THETA	K PHI	K THETA	EPSILON THETA OUT
U	K PHI THETA	N THETA	N PHI	N PHI THETA	EPSILON PHI IN
V	J PHI STAR	M THETA	M PHI	M PHI THETA	EPSILON PHI OUT
W	T PHI THETA	SIGMA THETA IN	SIGMA PHI IN	TAU PHI THETA IN	GAMMA PHI THETA IN
OMEGA THETA	OMEGA PHI	SIGMA THETA OUT	SIGMA PHI OUT	TAU PHI THETA OUT	GAMMA PHI THETA OUT

CYCLE 1.

6.1000000-01	0.0000000	6.1000000-01	1.2830000-01	2.0000000-01	-5.9213930-05
0.0000000	0.0000000	0.0000000	-5.1977231-04	-9.2305426-04	5.9213930-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-3.3343393-05
0.0000000	-2.8770580+00	2.2699105+00	1.7095788+00	0.0000000	3.3343393-05
1.5850952-03	0.0000000	8.2738313+02	6.2314206+02	0.0000000	0.0000000
-5.6306310-04	0.0000000	-8.2738313+02	-6.2314206+02	0.0000000	0.0000000

2.0099999+00	0.0000000	2.0099999+00	1.2830000-01	2.0000000-01	-2.7424734-05
0.0000000	0.0000000	0.0000000	-6.2507572-06	-4.2750950-04	2.7424734-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-4.0098607-07
0.0000000	-8.7313700-01	8.9083607-01	3.0552693-01	0.0000000	4.0098607-07
5.0960379-04	0.0000000	3.2471004+02	1.1136467+02	0.0000000	0.0000000
-8.5929406-04	0.0000000	-3.2471004+02	-1.1136467+02	0.0000000	0.0000000

2.4099999+00	0.0000000	2.4099999+00	1.2830000-01	2.0000000-01	-2.2516578-05
0.0000000	0.0000000	0.0000000	7.0832355-05	-3.5099887-04	2.2516578-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	4.5438956-06

0.0000000	-7.2821799-01	6.7941877-01	9.3314203-02	0.0000000	-4.5438956-06
1.6753523-04	0.0000000	2.4764837+02	3.4013059+01	0.0000000	0.0000000
-8.4590725-04	0.0000000	-2.4764837+02	-3.4013059+01	0.0000000	0.0000000

2.6099999+00	0.0000000	2.6099999+00	1.2830000-01	2.0000000-01	-2.0358709-05
0.0000000	0.0000000	0.0000000	1.0466323-04	-3.1736101-04	2.0358709-05
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	6.7141461-06
0.0000000	-6.7241584-01	5.8650941-01	1.3667286-04	0.0000000	-6.7141461-06
-1.8348252-11	0.0000000	2.1378288+02	4.9817085-02	0.0000000	0.0000000
-8.2831220-04	0.0000000	-2.1378288+02	-4.9817085-02	0.0000000	0.0000000

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CYCLE    1,    1 IS COMPLETE.
CYCLE    2,    2 IS COMPLETE.
CYCLE    3,    3 IS COMPLETE.
CYCLE    4,    4 IS COMPLETE.
CYCLE    5,    5 IS COMPLETE.
CYCLE    6,    6 IS COMPLETE.
CYCLE    7,    7 IS COMPLETE.
CYCLE    8,    8 IS COMPLETE.
CYCLE    9,    9 IS COMPLETE.
CYCLE   10,   10 IS COMPLETE.
CYCLE   11,   11 IS COMPLETE.
CYCLE   12,   12 IS COMPLETE.
CYCLE   13,   13 IS COMPLETE.
CYCLE   14,   14 IS COMPLETE.
CYCLE   15,   15 IS COMPLETE.
CYCLE   16,   16 IS COMPLETE.
CYCLE   17,   17 IS COMPLETE.
CYCLE   18,   18 IS COMPLETE.
CYCLE   19,   19 IS COMPLETE.
CYCLE   20,   20 IS COMPLETE.
CYCLE   21,   21 IS COMPLETE.
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CYCLE   22.   22 IS COMPLETE.
CYCLE   23.   23 IS COMPLETE.
CYCLE   24.   24 IS COMPLETE.
CYCLE   25.   25 IS COMPLETE.
CYCLE   26.   26 IS COMPLETE.
CYCLE   27.   27 IS COMPLETE.
CYCLE   28.   28 IS COMPLETE.
CYCLE   29.   29 IS COMPLETE.
CYCLE   30.   30 IS COMPLETE.
CYCLE   31.   31 IS COMPLETE.
CYCLE   32.   32 IS COMPLETE.
CYCLE   33.   33 IS COMPLETE.
CYCLE   34.   34 IS COMPLETE.
CYCLE   35.   35 IS COMPLETE.
CYCLE   36.   36 IS COMPLETE.
CYCLE   37.   37 IS COMPLETE.
CYCLE   38.   38 IS COMPLETE.
CYCLE   39.   39 IS COMPLETE.
CYCLE   40.   40 IS COMPLETE.
CYCLE   41.   41 IS COMPLETE.
CYCLE   42.   42 IS COMPLETE.
CYCLE   43.   43 IS COMPLETE.
CYCLE   44.   44 IS COMPLETE.
CYCLE   45.   45 IS COMPLETE.
CYCLE   46.   46 IS COMPLETE.
CYCLE   47.   47 IS COMPLETE.
CYCLE   48.   48 IS COMPLETE.
CYCLE   49.   49 IS COMPLETE.
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REGION NUMBER 1

THERE ARE 1 SEGMENTS AND 0 KINEMATIC LINKS WITHIN THIS REGION

SEGMENT NUMBER 1 SEGMENT CODE 21 NO. OF LAYERS 20

TABLE ORDER PHI OR S VS. CROSSECTION PROPERTIES

.2000000-02	.2000000-01
.1283000+00	.1283000+00

TABLE ORDER PHI OR S VS. DISTRIBUTED LOADS (F THETA, F PHI, F ZETA, M THETA, M PHI)

LOAD IDENTIFICATION CLUES 000100

.5000000+04	.5000000+04

PHI (RAD. OR IN.)	DEGRES	R ZERO	BASE THICKNESS	STEP	EPSILON THETA IN
EPSILON THETA	EPSILON PHI	GAMMA PHI THETA	K PHI	K THETA	EPSILON THETA OUT
U	K PHI THETA	N THETA	N PHI	N PHI THETA	EPSILON PHI IN
V	J PHI STAR	M THETA	M PHI	M PHI THETA	EPSILON PHI OUT
W	T PHI THETA	SIGMA THETA IN	SIGMA PHI IN	TAU PHI THETA IN	GAMMA PHI THETA IN
OMEGA THETA	OMEGA PHI	SIGMA THETA OUT	SIGMA PHI OUT	TAU PHI THETA OUT	GAMMA PHI THETA OUT

CYCLE 50.

2.0000000-03	0.0000000	2.0000000-03	1.2830000-01	6.0000000-04	0.0000000
0.0000000	2.0819583-03	0.0000000	-8.6754989-02	0.0000000	0.0000000
0.0000000	0.0000000	1.0386649+03	3.1474695+03	0.0000000	-3.4833742-03
0.0000000	8.0956860+02	5.9370400+01	1.7991030+02	0.0000000	7.6472908-03
1.9438292-01	0.0000000	2.9736126+04	9.0109475+04	0.0000000	0.0000000
0.0000000	0.0000000	-1.3544935+04	-4.1045259+04	0.0000000	0.0000000

4.9999998-03	0.0000000	4.9999998-03	1.2830000-01	6.0000000-04	-1.4751544-03
8.7429638-04	1.2074396-03	0.0000000	-5.0829503-02	-3.6624330-02	3.2237471-03
0.0000000	0.0000000	1.9241305+03	2.2615825+03	0.0000000	-2.0532729-03
4.3714814-06	3.1330577+02	1.1073555+02	1.3047264+02	0.0000000	4.4681522-03
1.9438262-01	0.0000000	5.5360219+04	6.5184471+04	0.0000000	0.0000000
-1.8312162-04	0.0000000	-2.5366077+04	-2.9930172+04	0.0000000	0.0000000

7.3999994-03	0.0000000	7.3999994-03	1.2830000-01	6.0000000-04	-1.6351318-03
9.6481578-04	1.1168894-03	0.0000000	-4.7215202-02	-4.0529191-02	3.5647633-03
0.0000000	0.0000000	2.0158122+03	2.1698812+03	0.0000000	-1.9119658-03
7.1396356-06	2.0161826+02	1.1635992+02	1.2564966+02	0.0000000	4.1457446-03
1.9438204-01	0.0000000	5.8124812+04	6.2711506+04	0.0000000	0.0000000
-2.9991596-04	0.0000000	-2.6701655+04	-2.8887186+04	0.0000000	0.0000000
9.7999991-03	0.0000000	9.7999991-03	1.2830000-01	6.0000000-04	-1.6961306-03
9.9749051-04	1.0841709-03	0.0000000	-4.5951565-02	-4.1989417-02	3.6911116-03
0.0000000	0.0000000	2.0489012+03	2.1367638+03	0.0000000	-1.8636220-03
9.7764054-06	1.4168997+02	1.1852333+02	1.2402847+02	0.0000000	4.0319638-03
1.9438118-01	0.0000000	5.9171166+04	6.1862104+04	0.0000000	0.0000000
-4.1149619-04	0.0000000	-2.7232432+04	-2.8554733+04	0.0000000	0.0000000
1.2199999-02	0.0000000	1.2199999-02	1.2830000-01	6.0000000-04	-1.7267232-03
1.0128560-03	1.0687485-03	0.0000000	-4.5376451-02	-4.2705833-02	3.7524352-03
0.0000000	0.0000000	2.0644554+03	2.1211716+03	0.0000000	-1.8421508-03
1.2356840-05	1.0297448+02	1.1961544+02	1.2332608+02	0.0000000	3.9796478-03
1.9438007-01	0.0000000	5.9690323+04	6.1484108+04	0.0000000	0.0000000
-5.2101104-04	0.0000000	-2.7609421+04	-2.8420691+04	0.0000000	0.0000000
1.4599998-02	0.0000000	1.4599998-02	1.2830000-01	6.0000000-04	-1.7446910-03
1.0212778-03	1.0602566-03	0.0000000	-4.5068673-02	-4.3117207-02	3.7872466-03
0.0000000	0.0000000	2.0729740+03	2.1126053+03	0.0000000	-1.8308988-03
1.4910653-05	7.5010674+01	1.2025791+02	1.2296935+02	0.0000000	3.9514119-03
1.9437869-01	0.0000000	5.9990721+04	6.1286764+04	0.0000000	0.0000000
-6.2951107-04	0.0000000	-2.7677385+04	-2.8357975+04	0.0000000	0.0000000
1.6999998-02	0.0000000	1.6999998-02	1.2830000-01	6.0000000-04	-1.7563577-03
1.0263798-03	1.0550715-03	0.0000000	-4.4882651-02	-4.3378606-02	3.8091173-03
0.0000000	0.0000000	2.0781276+03	2.1073944+03	0.0000000	-1.8241506-03
1.7448454-05	5.3244901+01	1.2067269+02	1.2276246+02	0.0000000	3.9342935-03
1.9437704-01	0.0000000	6.0181863+04	6.1170097+04	0.0000000	0.0000000
-7.3743609-04	0.0000000	-2.7788617+04	-2.8323825+04	0.0000000	0.0000000
1.9399998-02	0.0000000	1.9399998-02	1.2830000-01	6.0000000-04	-1.7644534-03
1.0296957-03	1.0514594-03	0.0000000	-4.4757617-02	-4.3556495-02	3.8238449-03
0.0000000	0.0000000	2.0814697+03	2.1039855+03	0.0000000	-1.8195418-03

1.9976093-05	3.5376860+01	1.2095603+02	1.2262491+02	0.0000000	3.9228605-03
1.9437515-01	0.0000000	6.0310943+04	6.1092647+04	0.0000000	0.0000000
-8.4499580-04	0.0000000	-2.7866091+04	-2.8300998+04	0.0000000	0.0000000
1.9999997-02	0.0000000	1.9999997-02	1.2830000-01	6.0000000-04	-1.7660941-03
1.0303418-03	1.0509872-03	0.0000000	-4.4732130-02	-4.3592142-02	3.8267777-03
0.0000000	0.0000000	2.0821196+03	2.1033175+03	0.0000000	-1.8185789-03
2.0606833-05	3.1354434+01	1.2101251+02	1.2259645+02	0.0000000	3.9205534-03
1.9437463-01	0.0000000	6.0336532+04	6.1076865+04	0.0000000	0.0000000
-8.7184265-04	0.0000000	-2.7881679+04	-2.8296032+04	0.0000000	0.0000000

REGION NUMBER 2

THERE ARE 1 SEGMENTS AND 0 KINEMATIC LINKS WITHIN THIS REGION

SEGMENT NUMBER 1   SEGMENT CODE 21   NO. OF LAYERS 20

TABLE ORDER PHI OR S VS. CROSSECTION PROPERTIES

.2000000-01   .1875000+00
.1283000+00   .1283000+00

TABLE ORDER PHI OR S VS. DISTRIBUTED LOADS (F THETA, F PHI, F ZETA, M THETA, M PHI)

LOAD IDENTIFICATION CLUES 000100

.5000000+04   .5000000+04

PHI (RAD. OR IN.)	DEGRES	R ZERO	BASE THICKNESS	STEP	EPSILON THETA IN
EPSILON THETA	EPSILON PHI	GAMMA PHI THETA	K PHI	K THETA	EPSILON THETA OUT
U	K PHI THETA	N THETA	N PHI	N PHI THETA	EPSILON PHI IN
V	J PHI STAR	M THETA	M PHI	M PHI THETA	EPSILON PHI OUT
W	T PHI THETA	SIGMA THETA IN	SIGMA PHI IN	TAU PHI THETA IN	GAMMA PHI THETA IN
OMEGA THETA	OMEGA PHI	SIGMA THETA OUT	SIGMA PHI OUT	TAU PHI THETA OUT	GAMMA PHI THETA OUT

CYCLE 50.

2.0000000-02	0.0000000	2.0000000-02	1.2830000-01	5.9330000-03	-1.7657655-03
1.0303418-03	5.3573559-03	0.0000000	-2.9431634-01	-4.3587019-02	3.8264490-03
0.0000000	0.0000000	1.2385903+03	2.1021231+03	0.0000000	-1.3523037-02
2.0604834-05	-6.0325635+01	7.0103066+01	1.2223504+02	0.0000000	2.4237749-02
1.9437463-01	0.0000000	3.2185439+04	4.9888050+04	0.0000000	0.0000000
-8.7174028-04	0.0000000	-1.7721792+04	-3.0083850+04	0.0000000	0.0000000

NPLA = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 -17 18 19 20 21

SIGMA =	4.98881+04	3.21854+04	0.00000	4.70497+04	3.02495+04	0.00000	4.43587+04	2.85768+04	0.00000
	4.16107+04	2.68351+04	0.00000	3.86094+04	2.48307+04	0.00000	3.54446+04	2.27137+04	0.00000
	3.22512+04	2.05910+04	0.00000	2.90864+04	1.84937+04	0.00000	2.58598+04	1.63033+04	0.00000
	2.25144+04	1.40534+04	0.00000	1.89792+04	1.17715+04	0.00000	1.55279+04	9.92321+03	0.00000
	1.17410+04	7.39991+03	0.00000	8.78204+03	5.72058+03	0.00000	8.86413+02	9.07626+02	0.00000
	-7.51841+03	-3.37078+03	0.00000	-1.49424+04	-7.54983+03	0.00000	-2.02028+04	-1.06983+04	0.00000
	-2.36625+04	-1.32996+04	0.00000	-2.69352+04	-1.55018+04	0.00000	-3.00839+04	-1.77218+04	0.00000

EPSILON PLAS =	2.04980-02	2.32907-03	0.00000	1.88195-02	2.14463-03	0.00000	1.71352-02	1.93975-03	0.00000
	1.54541-02	1.73965-03	0.00000	1.37892-02	1.55576-03	0.00000	1.21357-02	1.37916-03	0.00000
	1.04851-02	1.20134-03	0.00000	8.83257-03	1.02201-03	0.00000	7.18299-03	8.49603-04	0.00000
	5.54285-03	6.79125-04	0.00000	3.91978-03	5.05732-04	0.00000	2.30234-03	2.93682-04	0.00000
	6.95659-04	1.35369-04	0.00000	-9.63357-04	-7.73007-05	0.00000	-2.25070-03	-1.46683-04	0.00000
	-3.47274-03	-2.82978-04	0.00000	-4.78508-03	-3.97910-04	0.00000	-6.27107-03	-5.42991-04	0.00000
	-7.91137-03	-6.83592-04	0.00000	-9.55694-03	-8.56330-04	0.00000	-1.12149-02	-1.02347-03	0.00000

4.9664999-02	0.0000000	4.9664999-02	1.2830000-01	5.9330000-03	-8.9874523-03
4.0248667-03	7.3419606-03	0.0000000	-3.5812223-01	-2.0284207-01	1.7037185-02
0.0000000	0.0000000	1.5748820+03	1.9000411+03	0.0000000	-1.5631581-02
1.9989499-04	-1.2927106+02	9.3693265+01	1.1172279+02	0.0000000	3.0315502-02
1.9421613-01	0.0000000	3.7630761+04	4.2362781+04	0.0000000	0.0000000
-1.0074151-02	0.0000000	-2.3465455+04	-2.7251796+04	0.0000000	0.0000000

NPLA = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 -16 -17 18 19 20 21

SIGMA =	4.23628+04	3.75308+04	0.00000	4.00973+04	3.56027+04	0.00000	3.79102+04	3.37207+04	0.00000
	3.58273+04	3.18707+04	0.00000	3.37744+04	3.00124+04	0.00000	3.17039+04	2.81337+04	0.00000
	2.95723+04	2.62070+04	0.00000	2.73338+04	2.41858+04	0.00000	2.49321+04	2.19949+04	0.00000
	2.23804+04	1.96428+04	0.00000	1.97210+04	1.71045+04	0.00000	1.70162+04	1.42017+04	0.00000
	1.42269+04	1.09958+04	0.00000	1.05829+04	8.49566+03	0.00000	-1.76008+03	-7.15158+02	0.00000
	-1.07682+04	-8.04022+03	0.00000	-1.75318+04	-1.37788+04	0.00000	-2.07146+04	-1.70994+04	0.00000
	-2.27267+04	-1.92859+04	0.00000	-2.48633+04	-2.12954+04	0.00000	-2.72518+04	-2.34655+04	0.00000
EPSILON PLAS =	2.74605-02	1.47942-02	0.00000	2.53183-02	1.36054-02	0.00000	2.31701-02	1.24147-02	0.00000
	2.10130-02	1.12242-02	0.00000	1.88527-02	1.00354-02	0.00000	1.66935-02	8.84804-03	0.00000
	1.45386-02	7.66330-03	0.00000	1.23909-02	6.48421-03	0.00000	1.02535-02	5.31616-03	0.00000
	8.12519-03	4.15874-03	0.00000	6.00134-03	3.01567-03	0.00000	3.87036-03	1.90588-03	0.00000
	1.73789-03	8.22319-04	0.00000	-2.90990-04	-3.55326-04	0.00000	-1.70231-03	-1.16727-03	0.00000
	-3.37196-03	-2.05399-03	0.00000	-5.20551-03	-3.02126-03	0.00000	-7.30411-03	-4.10628-03	0.00000
	-9.47856-03	-5.26250-03	0.00000	-1.16356-02	-6.43961-03	0.00000	-1.37737-02	-7.60913-03	0.00000

7.3396998-02	0.0000000	7.3396998-02	1.2830000-01	5.9330000-03	-1.1234215-02
5.1782578-03	7.9162829-03	0.0000000	-3.6734302-01	-2.5584526-01	2.1590731-02
0.0000000	0.0000000	1.5444354+03	1.8307066+03	0.0000000	-1.5648772+02
3.8006857-04	-1.8817653+02	9.3342000+01	1.0585450+02	0.0000000	3.1481337+02
1.9387452-01	0.0000000	3.6282790+04	3.8918227+04	0.0000000	0.0000000
-1.8778274-02	0.0000000	-2.3672555+04	-2.5956944+04	0.0000000	0.0000000

NPLA = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 -16 -17 18 19 20 21

SIGMA =	3.89182+04	3.62828+04	0.00000	3.71430+04	3.46508+04	0.00000	3.54319+04	3.30683+04	0.00000
	3.36777+04	3.14444+04	0.00000	3.19889+04	2.98957+04	0.00000	3.02477+04	2.82740+04	0.00000
	2.84072+04	2.65529+04	0.00000	2.63934+04	2.46818+04	0.00000	2.41682+04	2.26191+04	0.00000
	2.18191+04	2.04269+04	0.00000	1.94711+04	1.80739+04	0.00000	1.73454+04	1.56032+04	0.00000
	1.49594+04	1.23384+04	0.00000	1.15827+04	9.23289+03	0.00000	2.71993+02	-1.36192+02	0.00000

	-1.06549+04	-9.19506+03	0.00000	-1.78964+04	-1.53036+04	0.00000	-2.02676+04	-1.80697+04	0.00000
	-2.20422+04	-1.99783+04	0.00000	-2.38938+04	-2.17617+04	0.00000	-2.59569+04	-2.36726+04	0.00000
EPSILON PLAS =	2.89151-02	1.93584-02	0.00000	2.66764-02	1.78167-02	0.00000	2.44331-02	1.62724-02	0.00000
	2.21927-02	1.47307-02	0.00000	1.99483-02	1.31839-02	0.00000	1.77067-02	1.16424-02	0.00000
	1.54714-02	1.01072-02	0.00000	1.32479-02	8.58086-03	0.00000	1.10384-02	7.06612-03	0.00000
	8.83677-03	5.55983-03	0.00000	6.62993-03	4.06888-03	0.00000	4.39508-03	2.60565-03	0.00000
	2.16634-03	1.19083-03	0.00000	3.38287-05	-2.60779-04	0.00000	-1.53992-03	-1.36521-03	0.00000
	-3.14048-03	-2.48713-03	0.00000	-4.99930-03	-3.77420-03	0.00000	-7.21691-03	-5.22653-03	0.00000
	-9.46439-03	-6.74178-03	0.00000	-1.17006-02	-8.27138-03	0.00000	-1.39207-02	-9.79548-03	0.00000

9.7128997-02	0.0000000	9.7128997-02	1.2830000-01	5.9330000-03	-1.2247601-02
5.7556266-03	7.4772922-03	0.0000000	-3.3557214-01	-2.8064268-01	2.3758854-02
0.0000000	0.0000000	1.5587908+03	1.7753294+03	0.0000000	-1.4049640-02
5.5903824-04	-2.4774274+02	9.3777378+01	1.0006131+02	0.0000000	2.9004245-02
1.9332681-01	0.0000000	3.5798191+04	3.6761547+04	0.0000000	0.0000000
-2.7258541-02	0.0000000	-2.3734440+04	-2.4540983+04	0.0000000	0.0000000

NPLA = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 -16 -17 18 19 20 21

SIGMA =	3.67615+04	3.57982+04	0.00000	3.51249+04	3.42156+04	0.00000	3.34535+04	3.26598+04	0.00000
	3.18340+04	3.11467+04	0.00000	3.04709+04	2.98280+04	0.00000	2.91545+04	2.85043+04	0.00000
	2.75694+04	2.69449+04	0.00000	2.56352+04	2.50930+04	0.00000	2.34440+04	2.30131+04	0.00000
	2.11506+04	2.08316+04	0.00000	1.89428+04	1.85857+04	0.00000	1.69395+04	1.62530+04	0.00000
	1.47519+04	1.32540+04	0.00000	1.18868+04	9.51036+03	0.00000	1.94396+03	1.55833+02	0.00000
	-9.65828+03	-9.32122+03	0.00000	-1.68157+04	-1.56981+04	0.00000	-1.93914+04	-1.86647+04	0.00000
	-2.10226+04	-2.03501+04	0.00000	-2.26628+04	-2.19383+04	0.00000	-2.45410+04	-2.37344+04	0.00000
EPSILON PLAS =	2.66282-02	2.15049-02	0.00000	2.45817-02	1.98038-02	0.00000	2.25393-02	1.80991-02	0.00000
	2.04932-02	1.63920-02	0.00000	1.84289-02	1.46745-02	0.00000	1.63600-02	1.29588-02	0.00000
	1.43093-02	1.12572-02	0.00000	1.22826-02	9.57247-03	0.00000	1.02732-02	7.90136-03	0.00000
	8.27036-03	6.23672-03	0.00000	6.25734-03	4.58091-03	0.00000	4.22212-03	2.93978-03	0.00000
	2.18351-03	1.35633-03	0.00000	1.86024-04	-1.77504-04	0.00000	-1.21373-03	-1.39941-03	0.00000
	-2.65930-03	-2.66180-03	0.00000	-4.33076-03	-4.07975-03	0.00000	-6.33138-03	-5.67849-03	0.00000
	-8.38169-03	-7.36956-03	0.00000	-1.04281-02	-9.07017-03	0.00000	-1.24584-02	-1.07585-02	0.00000

1.2086100-01	0.0000000	1.2086100-01	1.2830000-01	5.9330000-03	-1.2832238-02
6.1008128-03	8.0542503-03	0.0000000	-3.4800652-01	-2.9512783-01	2.5032663-02
0.0000000	0.0000000	1.3881096+03	1.7184693+03	0.0000000	-1.4270368-02
7.3727781-04	-3.0759372+02	8.8665590+01	9.3925161+01	0.0000000	3.0378869-02
1.9268063-01	0.0000000	3.4398929+04	3.3528554+04	0.0000000	0.0000000
-3.5669443-02	0.0000000	-2.3396246+04	-2.3729577+04	0.0000000	0.0000000

NPLA = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 -16 -17 18 19 20 21

SIGMA =	3.35286+04	3.43989+04	0.00000	3.22986+04	3.32611+04	0.00000	3.13256+04	3.21894+04	0.00000
	3.00691+04	3.08741+04	0.00000	2.86644+04	2.94832+04	0.00000	2.71549+04	2.80112+04	0.00000
	2.55982+04	2.65030+04	0.00000	2.40422+04	2.49747+04	0.00000	2.24793+04	2.33724+04	0.00000

	2.08883+04	2.15455+04	0.00000	1.92801+04	1.92648+04	0.00000	1.76197+04	1.62955+04	0.00000
	1.55117+04	1.29377+04	0.00000	1.29178+04	9.99827+03	0.00000	9.89971+03	1.85293+03	0.00000
	-7.67856+03	-1.07830+04	0.00000	-1.64852+04	-1.71366+04	0.00000	-1.92703+04	-1.89022+04	0.00000
	-2.08918+04	-2.09784+04	0.00000	-2.22683+04	-2.19177+04	0.00000	-2.37396+04	-2.33962+04	0.00000
EPSILON PLAS =	2.52660-02	2.28103-02	0.00000	2.61157-02	2.07868-02	0.00000	2.37982-02	1.91660-02	0.00000
	2.17881-02	1.73576-02	0.00000	1.94957-02	1.55526-02	0.00000	1.75107-02	1.37621-02	0.00000
	1.53791-02	1.19536-02	0.00000	1.32968-02	1.01670-02	0.00000	1.11129-02	8.36726-03	0.00000
	8.97460-03	6.59799-03	0.00000	6.82352-03	4.87142-03	0.00000	4.65586-03	3.20878-03	0.00000
	2.51869-03	1.56889-03	0.00000	9.71069-04	-8.87986-05	0.00000	-1.28391-03	-1.49628-03	0.00000
	-3.71664-03	-2.50838-03	0.00000	-4.29003-03	-4.15169-03	0.00000	-6.33176-03	-5.96793-03	0.00000
	-8.96412-03	-7.75045-03	0.00000	-1.04060-02	-9.56146-03	0.00000	-1.27487-02	-1.12498-02	0.00000

1.4967299-01	0.0000000	1.4967299-01	1.2830000-01	5.9330000-03	-1.2992801-02
6.1975312-03	7.0066071-03	0.0000000	-2.8997531-01	-2.9834839-01	2.5337863-02
0.0000000	0.0000000	1.9458862-03	1.6684657-03	0.0000000	-1.1863239-02
8.9411956-04	-3.4760955+02	9.0982062-01	8.7467924-01	0.0000000	2.5576468-02
1.9169266-01	0.0000000	3.3499999+04	3.2058380+04	0.0000000	0.0000000
-4.3141977-02	0.0000000	-2.3294197+04	-2.2101963+04	0.0000000	0.0000000

NPLA = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 -16 -17 18 19 20 21

SIGMA =	3.20589+04	3.36996+04	0.00000	3.09169+04	3.29635+04	0.00000	2.97332+04	3.11982+04	0.00000
	2.86679+04	2.99390+04	0.00000	2.73864+04	2.86659+04	0.00000	2.61383+04	2.73180+04	0.00000
	2.46960+04	2.58810+04	0.00000	2.30701+04	2.41199+04	0.00000	2.13965+04	2.23876+04	0.00000
	1.96309+04	2.06159+04	0.00000	1.89257+04	1.86083+04	0.00000	1.70992+04	1.60011+04	0.00000
	1.62279+04	1.26959+04	0.00000	1.22793+04	8.46010+03	0.00000	9.86589+03	1.19551+03	0.00000
	-6.03560+03	-1.09315+04	0.00000	-1.41390+04	-1.70121+04	0.00000	-1.79662+04	-1.92059+04	0.00000
	-1.93380+04	-2.05709+04	0.00000	-2.07560+04	-2.18966+04	0.00000	-2.21020+04	-2.32291+04	0.00000
EPSILON PLAS =	2.35829-02	2.31369-02	0.00000	2.17953-02	2.13027-02	0.00000	2.00113-02	1.99730-02	0.00000
	1.82257-02	1.76423-02	0.00000	1.69910-02	1.58133-02	0.00000	1.46407-02	1.39875-02	0.00000
	1.28735-02	1.21725-02	0.00000	1.11305-02	1.03676-02	0.00000	9.38692-03	8.56571-03	0.00000
	7.82290-03	6.77193-03	0.00000	5.83652-03	5.00967-03	0.00000	4.02878-03	3.27591-03	0.00000
	2.23903-03	1.64372-03	0.00000	5.38369-04	1.45820-05	0.00000	-6.47169-04	-1.41953-03	0.00000
	-2.03135-03	-2.66089-03	0.00000	-3.32343-03	-4.11079-03	0.00000	-4.92300-03	-5.92366-03	0.00000
	-6.46468-03	-7.76181-03	0.00000	-8.41769-03	-9.59596-03	0.00000	-1.01882-02	-1.19256-02	0.00000

1.6832996-01	0.0000000	1.6832996-01	1.2830000-01	5.9330000-03	-1.2669785-02
6.2117170-02	7.0478829-03	0.0000000	-2.6902677-01	-2.9737136-01	2.5288217-02
0.0000000	0.0000000	1.2769997-03	1.6210166-03	0.0000000	-1.0170186-02
1.0956872-03	-4.3790417+02	8.9000532-01	8.0392523-01	0.0000000	2.9325950-02
1.9053672-01	0.0000000	3.6389660+04	3.0144708+04	0.0000000	0.0000000
-6.0056367-02	0.0000000	-2.3356623+04	-2.0701348+04	0.0000000	0.0000000

NPLA = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 -17 18 19 20 21

SIGMA =	3.01697+04	3.53897+04	0.00000	2.90813+04	3.41661+04	0.00000	2.81229+04	3.30017+04	0.00000

	2.71971+04	3.17899+04	0.00000	2.62329+04	3.09668+04	0.00000	2.52292+04	2.90890+04	0.00000
	2.40728+04	2.74090+04	0.00000	2.27770+04	2.40169+04	0.00000	2.14592+04	2.43395+04	0.00000
	2.00342+04	2.23623+04	0.00000	1.84644+04	1.98668+04	0.00000	1.70229+04	1.68442+04	0.00000
	1.53213+04	1.32601+04	0.00000	1.27307+04	8.12032+03	0.00000	6.11693+03	1.99634+03	0.00000
	-9.61992+03	-1.03161+04	0.00000	-1.35599+04	-1.67746+04	0.00000	-1.65351+04	-1.92786+04	0.00000
	-1.41724+04	-2.07509+04	0.00000	-1.99966+04	-2.20569+04	0.00000	-2.07013+04	-2.33666+04	0.00000
EPSILON PLAS =	2.26652-02	2.28663-02	0.00000	2.07039-02	2.10917-02	0.00000	1.92331-02	1.92138-02	0.00000
	1.76679-02	1.72929-02	0.00000	1.58818-02	1.55809-02	0.00000	1.42089-02	1.37725-02	0.00000
	1.26460-02	1.19699-02	0.00000	1.08937-02	1.01727-02	0.00000	9.24109-03	8.38372-03	0.00000
	7.56849-03	6.61927-03	0.00000	5.93382-03	4.89976-03	0.00000	4.25028-03	3.23905-03	0.00000
	2.57389-03	1.61508-03	0.00000	9.33222-04	1.15511-04	0.00000	-3.72936-04	-1.36930-03	0.00000
	-1.96999-03	-2.98607-03	0.00000	-2.52279-03	-4.06276-03	0.00000	-4.04389-03	-5.82695-03	0.00000
	-6.66001-03	-7.69939-03	0.00000	-7.30076-03	-8.96927-03	0.00000	-8.95269-03	-1.12910-02	0.00000

1.8412397-01	0.0000000	1.8412397-01	1.2830000-01	5.9330000-03	-1.2649046-02
6.1376484-03	5.8797607-03	0.0000000	-2.1630505-01	-2.9314799-01	2.9994343-02
0.0000000	0.0000000	1.3286982+03	1.5827118+03	0.0000000	-7.9962079-03
1.1923635-03	-4.7249019+02	6.5458736+01	7.4352965+01	0.0000000	1.9756729-02
1.8960381-01	0.0000000	3.2477321+04	2.8216283+04	0.0000000	0.0000000
-5.4565499-02	0.0000000	-2.2902638+04	-1.9417507+04	0.0000000	0.0000000

NPLA = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

SIGMA =	2.82163+04	3.24773+04	0.00000	2.73369+04	3.14498+04	0.00000	2.65892+04	3.09687+04	0.00000
	2.50491+04	2.94626+04	0.00000	2.40779+04	2.82532+04	0.00000	2.36989+04	2.68678+04	0.00000
	2.23728+04	2.53685+04	0.00000	2.07944+04	2.38319+04	0.00000	1.96835+04	2.22695+04	0.00000
	1.94861+04	2.05290+04	0.00000	1.74276+04	1.85566+04	0.00000	1.63592+04	1.60061+04	0.00000
	1.60232+04	1.21029+04	0.00000	1.21917+04	7.86431+03	0.00000	5.71055+03	7.59560+02	0.00000
	-3.19938+03	-9.91928+03	0.00000	-9.69825+03	-1.42775+04	0.00000	-1.41961+04	-1.90653+04	0.00000
	-1.65879+04	-2.09885+04	0.00000	-1.81819+04	-2.17387+04	0.00000	-1.95179+04	-2.29026+04	0.00000
EPSILON PLAS =	1.80093-02	2.27381-02	0.00000	1.67531-02	2.09296-02	0.00000	1.59063-02	1.91167-02	0.00000
	1.40571-02	1.73088-02	0.00000	1.27240-02	1.55128-02	0.00000	1.19052-02	1.37270-02	0.00000
	1.00967-02	1.19479-02	0.00000	8.79188-03	1.01608-02	0.00000	7.48021-03	8.29680-03	0.00000
	6.15207-03	6.69906-03	0.00000	4.90319-03	4.91808-03	0.00000	3.43767-03	3.29658-03	0.00000
	2.06815-03	1.69586-03	0.00000	8.03022-04	1.29825-04	0.00000	-1.90617-04	-1.27789-03	0.00000
	-1.84987-03	-2.46950-03	0.00000	-2.03862-03	-3.89936-03	0.00000	-3.08061-03	-6.65796-03	0.00000
	-4.28613-03	-7.67777-03	0.00000	-5.56022-03	-9.28945-03	0.00000	-6.86672-03	-1.10781-02	0.00000

1.8760000-01	0.0000000	1.8760000-01	1.2830000-01	5.9330000-03	-1.2645309-02
6.1260119-03	5.9908930-03	0.0000000	-2.1390345-01	-2.9260090-01	2.9875327-02
0.0000000	0.0000000	1.3251638+03	1.5804264+03	0.0000000	-7.8810762-03
1.1989397-03	-4.7571032+02	6.5902778+01	7.3878969+01	0.0000000	1.9562762-02
1.8952822-01	0.0000000	3.2439898+04	2.8082657+04	0.0000000	0.0000000
-5.4862574-02	0.0000000	-2.2890189+04	-1.9325516+04	0.0000000	0.0000000

NPLA = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

SIGMA =	2.80827+04	3.24348+04	0.00000	2.72244+04	3.14192+04	0.00000	2.64852+04	3.04398+04	0.00000
	2.57357+04	2.94172+04	0.00000	2.47491+04	2.81936+04	0.00000	2.35692+04	2.68080+04	0.00000
	2.22566+04	2.53204+04	0.00000	2.09010+04	2.38009+04	0.00000	1.96128+04	2.22508+04	0.00000
	1.84367+04	2.05129+04	0.00000	1.73952+04	1.85368+04	0.00000	1.63394+04	1.59767+04	0.00000
	1.49994+04	1.20878+04	0.00000	1.21845+04	7.84395+03	0.00000	5.74297+03	7.39512+02	0.00000
	-3.08667+03	-9.27673+03	0.00000	-9.44908+03	-1.61709+04	0.00000	-1.40591+04	-1.90397+04	0.00000
	-1.64854+04	-2.04779+04	0.00000	-1.80891+04	-2.17288+04	0.00000	-1.93255+04	-2.28902+04	0.00000
EPSILON PLAS =	1.79076-02	2.26889-02	0.00000	1.65852-02	2.08816-02	0.00000	1.52527-02	1.90746-02	0.00000
	1.39197-02	1.72714-02	0.00000	1.26030-02	1.54799-02	0.00000	1.12997-02	1.36978-02	0.00000
	1.00057-02	1.19212-02	0.00000	8.71488-03	1.01462-02	0.00000	7.41665-03	8.37636-03	0.00000
	6.10185-03	6.62788-03	0.00000	4.76475-03	4.90630-03	0.00000	3.41465-03	3.23991-03	0.00000
	2.04784-03	1.69114-03	0.00000	8.10360-04	1.29816-04	0.00000	-1.71632-04	-1.27305-03	0.00000
	-1.01770-03	-2.47366-03	0.00000	-2.00062-03	-3.89407-03	0.00000	-3.02393-03	-5.64276-03	0.00000
	-4.21024-03	-7.45908-03	0.00000	-5.46902-03	-9.26738-03	0.00000	-6.75996-03	-1.10727-02	0.00000

REGION NUMBER 3

THERE ARE 1 SEGMENTS AND 0 KINEMATIC LINKS WITHIN THIS REGION

SEGMENT NUMBER 1 SEGMENT CODE 21 NO. OF LAYERS 20

TABLE ORDER PHI OR S VS. CROSSECTION PROPERTIES

.1875000+00	.6100000+00
.1283000+00	.1283000+00

PHI (RAD. OR IN.)	DEGRES	R ZERO	BASE THICKNESS	STEP	EPSILON THETA IN
EPSILON THETA	EPSILON PHI	GAMMA PHI THETA	K PHI	K THETA	EPSILON THETA OUT
U	K PHI THETA	N THETA	N PHI	N PHI THETA	EPSILON PHI IN
V	J PHI STAR	M THETA	M PHI	M PHI THETA	EPSILON PHI OUT
W	T PHI THETA	SIGMA THETA IN	SIGMA PHI IN	TAU PHI THETA IN	GAMMA PHI THETA IN
OMEGA THETA	OMEGA PHI	SIGMA THETA OUT	SIGMA PHI OUT	TAU PHI THETA OUT	GAMMA PHI THETA OUT

CYCLE 50.

1.8750000-01	0.0000000	1.8750000-01	1.2830000-01	4.2250000-02	-1.2645309-02
6.1260114-03	4.3893477-03	0.0000000	-1.9325211-01	-2.9260047-01	2.4895331-02
0.0000000	0.0000000	1.3316176+03	1.3220654+03	0.0000000	-8.0077754-03
1.1484396-03	-4.7124183+02	8.6768125+01	7.3677046+01	0.0000000	1.6786471-02
1.8952822-01	0.0000000	3.2697969+04	2.6634838+04	0.0000000	0.0000000
-6.4862590-02	0.0000000	-2.3055371+04	-1.9203840+04	0.0000000	0.0000000

NPLA = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 -16 -17 18 19 20 21

SIGMA =	2.66348+04	3.25980+04	0.00000	2.58131+04	3.15222+04	0.00000	2.50110+04	3.04469+04	0.00000
	2.41657+04	2.93118+04	0.00000	2.31528+04	2.80231+04	0.00000	2.20193+04	2.66144+04	0.00000
	2.07908+04	2.51147+04	0.00000	1.95131+04	2.35633+04	0.00000	1.82358+04	2.19670+04	0.00000
	1.69806+04	2.02713+04	0.00000	1.57232+04	1.84099+04	0.00000	1.43436+04	1.60874+04	0.00000
	1.26437+04	1.28805+04	0.00000	9.53637+03	9.15108+03	0.00000	1.29217+03	-4.04172+02	0.00000
	-7.73449+03	-1.15775+04	0.00000	-1.25880+04	-1.71422+04	0.00000	-1.62024+04	-1.91397+04	0.00000
	-1.68175+04	-2.05381+04	0.00000	-1.81161+04	-2.18432+04	0.00000	-1.92038+04	-2.30554+04	0.00000
EPSILON PLAS =	1.52743-02	2.26279-02	0.00000	1.40791-02	2.08274-02	0.00000	1.28819-02	1.90276-02	0.00000
	1.16871-02	1.72321-02	0.00000	1.05033-02	1.54460-02	0.00000	9.32729-03	1.36675-02	0.00000
	8.15744-03	1.18947-02	0.00000	6.99065-03	1.01253-02	0.00000	5.82242-03	8.36011-03	0.00000
	4.64896-03	4.60512-03	0.00000	3.47050-03	4.86585-03	0.00000	2.28918-03	3.16664-03	0.00000
	1.11058-03	1.54161-03	0.00000	4.95901-05	-7.79017-05	0.00000	-7.05268-04	-1.30401-03	0.00000

-1.43646-03	-2.40062-03	0.00000	-2.38882-03	-3.90022-03	0.00000	-3.44233-03	-5.66917-03	0.00000
-4.57217-03	-7.46378-03	0.00000	-5.72922-03	-9.25734-03	0.00000	-6.90344-03	-1.10531-02	0.00000

4.8325000-01	0.0000000	4.8325000-01	1.2830000-01	4.2250000-02	-7.8504867-03
2.5450693-03	1.7395115-03	0.0000000	-2.2027665-02	-1.6205076-01	1.2940625-02
0.0000000	0.0000000	9.3268307+02	1.0705541+03	0.0000000	3.2643683-04
1.2299047-03	-1.8284084+02	6.5028218+01	3.0350027+01	0.0000000	3.1525863-03
1.6861438-01	0.0000000	2.2734475+04	1.4457980+04	0.0000000	0.0000000
-7.8311028-02	0.0000000	-1.7778336+04	-7.1427858+03	0.0000000	0.0000000

NPLA = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

SIGMA =	1.44680+04	2.27345+04	0.00000	1.41362+04	2.21605+04	0.00000	1.38609+04	2.15874+04	0.00000
	1.35375+04	2.09500+04	0.00000	1.32110+04	2.02624+04	0.00000	1.28850+04	1.95184+04	0.00000
	1.25310+04	1.86634+04	0.00000	1.22249+04	1.77577+04	0.00000	1.18991+04	1.66442+04	0.00000
	1.16200+04	1.52842+04	0.00000	1.14244+04	1.36095+04	0.00000	1.12161+04	1.09564+04	0.00000
	1.03039+04	6.79313+03	0.00000	7.65147+03	9.32593+02	0.00000	4.13535+03	-4.17910+03	0.00000
	1.31017+03	-8.07316+03	0.00000	-1.14643+03	-1.11910+04	0.00000	-3.12656+03	-1.34980+04	0.00000
	-4.75329+03	-1.52636+04	0.00000	-6.01739+03	-1.66169+04	0.00000	-7.14279+03	-1.77783+04	0.00000
EPSILON PLAS =	2.49015-03	1.12298-02	0.00000	2.36145-03	1.02348-02	0.00000	2.22835-03	9.24120-03	0.00000
	2.09780-03	8.25219-03	0.00000	1.96599-03	7.26785-03	0.00000	1.83234-03	6.28891-03	0.00000
	1.69788-03	5.31966-03	0.00000	1.55725-03	4.35674-03	0.00000	1.41198-03	3.41299-03	0.00000
	1.25451-03	2.49419-03	0.00000	1.07605-03	1.61750-03	0.00000	8.74350-04	8.14550-04	0.00000
	6.89073-04	1.42830-04	0.00000	6.16188-04	-4.21941-04	0.00000	6.49096-04	-1.08518-03	0.00000
	6.54468-04	-1.84266-03	0.00000	6.49133-04	-2.66248-03	0.00000	6.23904-04	-3.54456-03	0.00000
	5.82032-04	-4.46709-03	0.00000	5.18584-04	-5.41749-03	0.00000	4.47954-04	-6.38180-03	0.00000

5.6774998-01	0.0000000	5.6774998-01	1.2830000-01	4.2250000-02	-7.0753662-03
1.9631285-03	1.5136510-03	0.0000000	-1.3701320-02	-1.4089626-01	1.1001623-02
0.0000000	0.0000000	8.3038660+02	1.0246568+03	0.0000000	6.3471137-04
1.1145662-03	-1.5562807+02	6.2391844+01	2.7680486+01	0.0000000	2.3925907-03
1.6192056-01	0.0000000	2.1517579+04	1.3352818+04	0.0000000	0.0000000
-7.9993846-02	0.0000000	-1.6983962+04	-6.1285358+03	0.0000000	0.0000000

NPLA = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

SIGMA =	1.33520+04	2.15176+04	0.00000	1.31258+04	2.10072+04	0.00000	1.28457+04	2.04281+04	0.00000
	1.25636+04	1.98024+04	0.00000	1.22857+04	1.91285+04	0.00000	1.20136+04	1.83947+04	0.00000
	1.17493+04	1.75846+04	0.00000	1.14768+04	1.66341+04	0.00000	1.12246+04	1.55007+04	0.00000
	1.10285+04	1.41002+04	0.00000	1.09168+04	1.22476+04	0.00000	1.06924+04	9.49389+03	0.00000
	9.60910+03	5.02508+03	0.00000	6.90113+03	-4.80105+02	0.00000	3.87834+03	-4.95289+03	0.00000
	1.32963+03	-8.40764+03	0.00000	-7.51354+02	-1.10270+04	0.00000	-2.49872+03	-1.30540+04	0.00000
	-3.95944+03	-1.46557+04	0.00000	-5.17699+03	-1.59512+04	0.00000	-6.12854+03	-1.69840+04	0.00000
EPSILON PLAS =	1.79716-03	9.37199-03	0.00000	1.71484-03	8.50962-03	0.00000	1.63542-03	7.65212-03	0.00000
	1.55474-03	6.79898-03	0.00000	1.47212-03	5.95069-03	0.00000	1.38709-03	5.10807-03	0.00000
	1.29891-03	4.27307-03	0.00000	1.20709-03	3.45118-03	0.00000	1.10760-03	2.64734-03	0.00000

9.94360-04	1.87072-03	0.00000	8.58881-04	1.13979-03	0.00000	7.05816-04	4.91145-04	0.00000
5.80642-04	-2.11496-05	0.00000	5.77630-04	-4.85803-04	0.00000	6.37047-04	-1.05867-03	0.00000
6.83320-04	-1.71361-03	0.00000	7.11283-04	-2.43339-03	0.00000	7.26098-04	-3.17911-03	0.00000
7.26980-04	-3.99632-03	0.00000	7.14329-04	-4.81506-03	0.00000	6.84600-04	-5.65046-03	0.00000

6.0999998-01	0.0000000	6.0999998-01	1.2830000-01	4.2250000-02	-6.7600276-03
1.7153106-03	1.4333389-03	0.0000000	-1.1244009-02	-1.3211751-01	1.0190649-02
0.0000000	0.0000000	7.7967858+02	1.0025368+03	0.0000000	7.1203567-04
1.0463394-03	-1.4484891+02	6.1409588+01	2.6882354+01	0.0000000	2.1546421-03
1.5862780-01	0.0000000	2.1017394+04	1.2980834+04	0.0000000	0.0000000
-8.0591677-02	0.0000000	-1.6743491+04	-5.8628776+03	0.0000000	0.0000000

NPLA = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

SIGMA =	1.29808+04	2.10174+04	0.00000	1.27608+04	2.05082+04	0.00000	1.24930+04	1.99318+04	0.00000
	1.22242+04	1.93088+04	0.00000	1.19602+04	1.86356+04	0.00000	1.17027+04	1.79003+04	0.00000
	1.14262+04	1.70422+04	0.00000	1.11794+04	1.60831+04	0.00000	1.09540+04	1.49277+04	0.00000
	1.07834+04	1.34911+04	0.00000	1.06878+04	1.15895+04	0.00000	1.04019+04	8.73280+03	0.00000
	9.24210+03	4.16687+03	0.00000	6.57359+03	-1.10428+03	0.00000	3.74979+03	-5.30443+03	0.00000
	1.34106+03	-8.54400+03	0.00000	-7.24744+02	-1.10761+04	0.00000	-2.38490+03	-1.29842+04	0.00000
	-3.77639+03	-1.45046+04	0.00000	-4.94266+03	-1.57454+04	0.00000	-5.86288+03	-1.67435+04	0.00000
EPSILON PLAS =	1.57892-03	8.59696-03	0.00000	1.51174-03	7.79101-03	0.00000	1.44700-03	6.98995-03	0.00000
	1.38089-03	6.19331-03	0.00000	1.31275-03	5.40158-03	0.00000	1.24203-03	4.61599-03	0.00000
	1.16926-03	3.84149-03	0.00000	1.09049-03	3.07755-03	0.00000	1.00352-03	2.33296-03	0.00000
	9.02484-04	1.61689-03	0.00000	7.79689-04	9.47466-04	0.00000	6.45015-04	3.62997-04	0.00000
	5.39837-04	-8.61361-05	0.00000	5.56186-04	-5.15523-04	0.00000	6.20985-04	-1.05179-03	0.00000
	6.76441-04	-1.66650-03	0.00000	7.21474-04	-2.33780-03	0.00000	7.47486-04	-3.05579-03	0.00000
	7.60093-04	-3.80225-03	0.00000	7.60040-04	-4.56827-03	0.00000	7.44181-04	-5.34967-03	0.00000

REGION NUMBER 4

THERE ARE 1 SEGMENTS AND 0 KINEMATIC LINKS WITHIN THIS REGION

SEGMENT NUMBER 1   SEGMENT CODE 21   NO. OF LAYERS 20

TABLE ORDER PHI OR S VS. CROSSECTION PROPERTIES

.6100000+00	.2610000+01
.1283000+00	.1283000+00

PHI (RAD. OR IN.)	DEGRES	R ZERO	BASE THICKNESS	STEP	EPSILON THETA IN
EPSILON THETA	EPSILON PHI	GAMMA PHI THETA	K PHI	K THETA	EPSILON THETA OUT
U	K PHI THETA	N THETA	N PHI	N PHI THETA	EPSILON PHI IN
V	J PHI STAR	M THETA	M PHI	M PHI THETA	EPSILON PHI OUT
W	T PHI THETA	SIGMA THETA IN	SIGMA PHI IN	TAU PHI THETA IN	GAMMA PHI THETA IN
OMEGA THETA	OMEGA PHI	SIGMA THETA OUT	SIGMA PHI OUT	TAU PHI THETA OUT	GAMMA PHI THETA OUT

CYCLE 50.

6.1000000-01	0.0000000	6.1000000-01	1.2830000-01	2.0000000+01	-6.7600262-03
1.7153106-03	1.4340637-03	0.0000000	-1.1182921-02	-1.3211749-01	1.0190647-02
0.0000000	0.0000000	7.7998949+02	1.0030501+03	0.0000000	7.1667929-04
1.0463395-03	-1.4491372+02	6.1396209+01	2.6855199+01	0.0000000	2.1514481-03
1.5852781-01	0.0000000	2.1016908+04	1.2977403+04	0.0000000	0.0000000
-8.0591668-02	0.0000000	-1.6738654+04	-5.8514255+03	0.0000000	0.0000000

NPLA = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

SIGMA =	1.29774+04	2.10169+04	0.00000	1.27576+04	2.05077+04	0.00000	1.24901+04	1.99313+04	0.00000
	1.22216+04	1.93084+04	0.00000	1.19580+04	1.86363+04	0.00000	1.17010+04	1.79000+04	0.00000
	1.14250+04	1.70419+04	0.00000	1.11788+04	1.60828+04	0.00000	1.09542+04	1.49276+04	0.00000
	1.07845+04	1.34910+04	0.00000	1.06902+04	1.15894+04	0.00000	1.04052+04	8.73270+03	0.00000
	9.24724+03	4.16845+03	0.00000	6.58122+03	-1.09928+03	0.00000	3.75934+03	-5.29733+03	0.00000
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0.0000000	0.0000000	-5.6494872+02	2.2753049+02	0.0000000	9.7355239-04
-2.3043819-03	-4.3978788+01	3.4499357+01	1.2572641+01	0.0000000	7.7866229-05
4.5184420-02	0.0000000	9.6064626+03	4.9053897+03	0.0000000	0.0000000
-7.7657207-02	0.0000000	-1.3410280+04	-2.7818209+03	0.0000000	0.0000000

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	4.55817+03	6.40849+03	0.00000	4.30118+03	4.64386+03	0.00000	3.91676+03	2.26665+03	0.00000
	3.48073+03	-4.79633+02	0.00000	2.74465+03	-2.94115+03	0.00000	1.90836+03	-4.81441+03	0.00000
	1.18337+03	-6.26099+03	0.00000	5.68418+02	-7.41545+03	0.00000	4.56793+01	-8.39399+03	0.00000
	-4.12645+02	-9.23272+03	0.00000	-8.18671+02	-9.94156+03	0.00000	-1.18221+03	-1.05912+04	0.00000
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-7.2531296-02	0.0000000	-1.2078569+04	-8.1184282+02	0.0000000	0.0000000

NPLA = -1 -2 0 0 0 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

SIGMA =	-1.02422+03	2.84625+03	0.00000	-9.71920+02	1.45112+03	0.00000	-8.83071+02	-1.12249+02	0.00000
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	-4.25661+02	-6.11293+03	0.00000	-4.33132+02	-6.90145+03	0.00000	-4.54680+02	-7.60519+03	0.00000
	-4.86722+02	-8.19737+03	0.00000	-5.24241+02	-8.67890+03	0.00000	-5.55337+02	-9.17927+03	0.00000
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JOB NO 451026 PAGE 1

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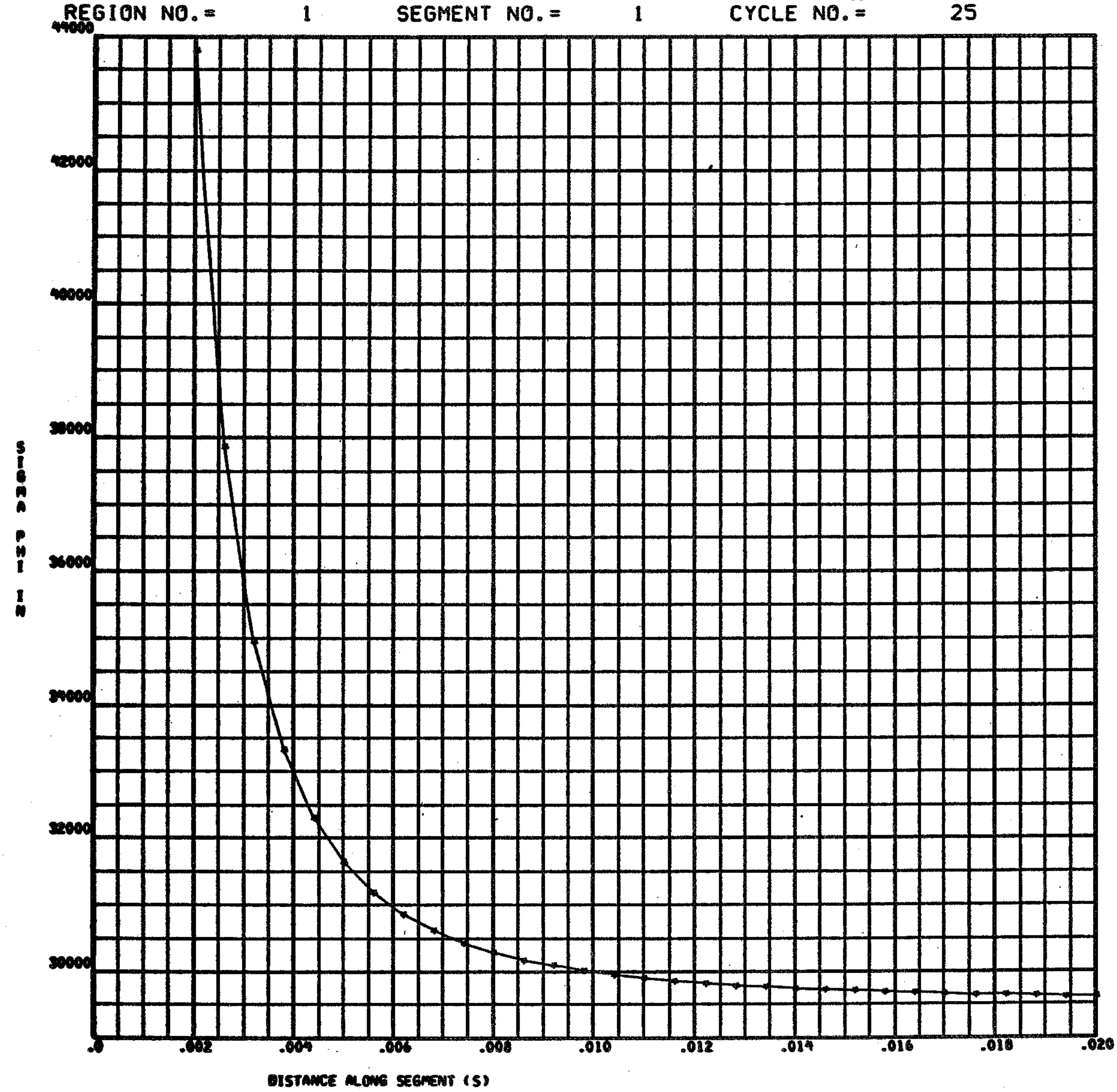

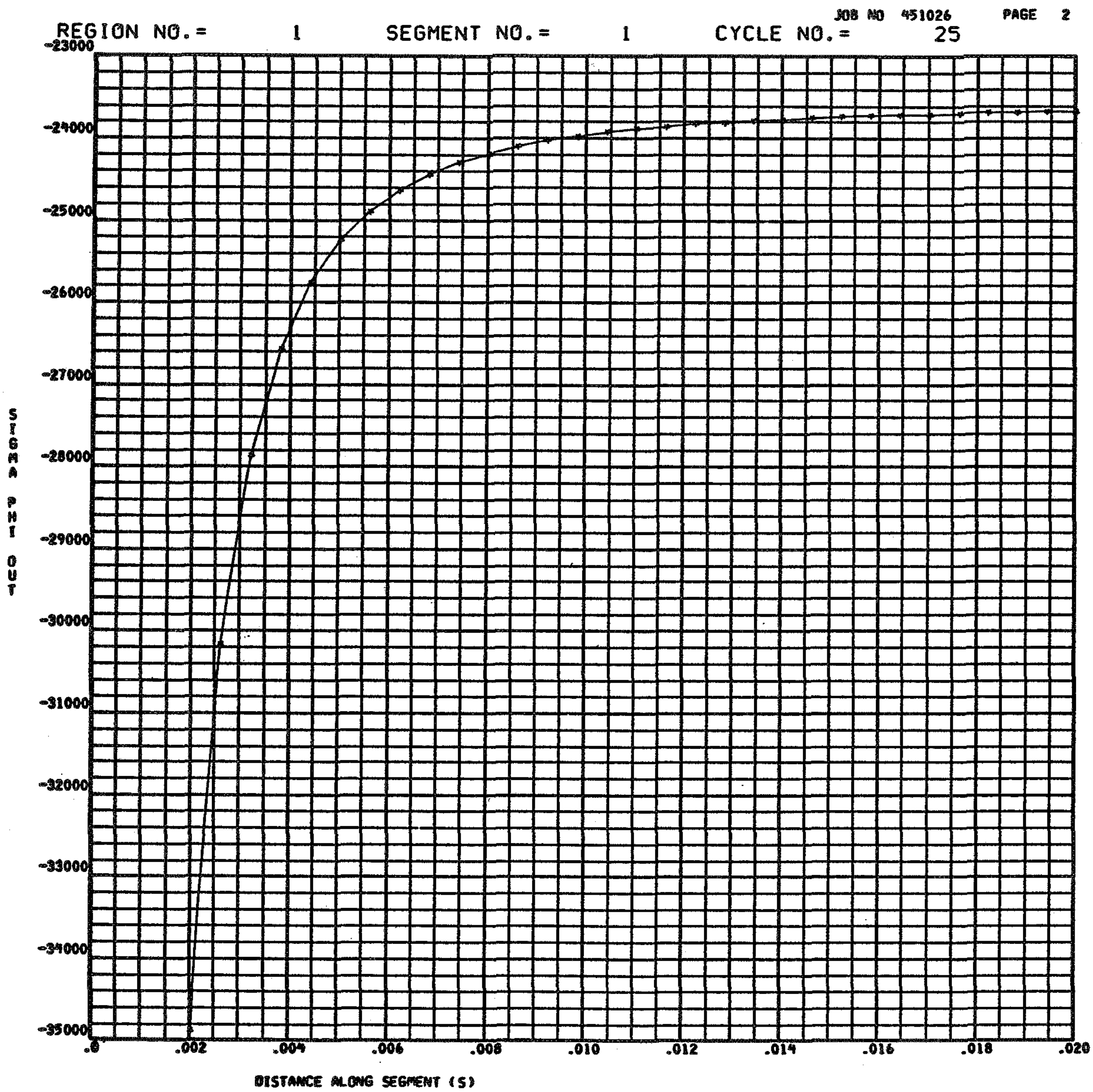
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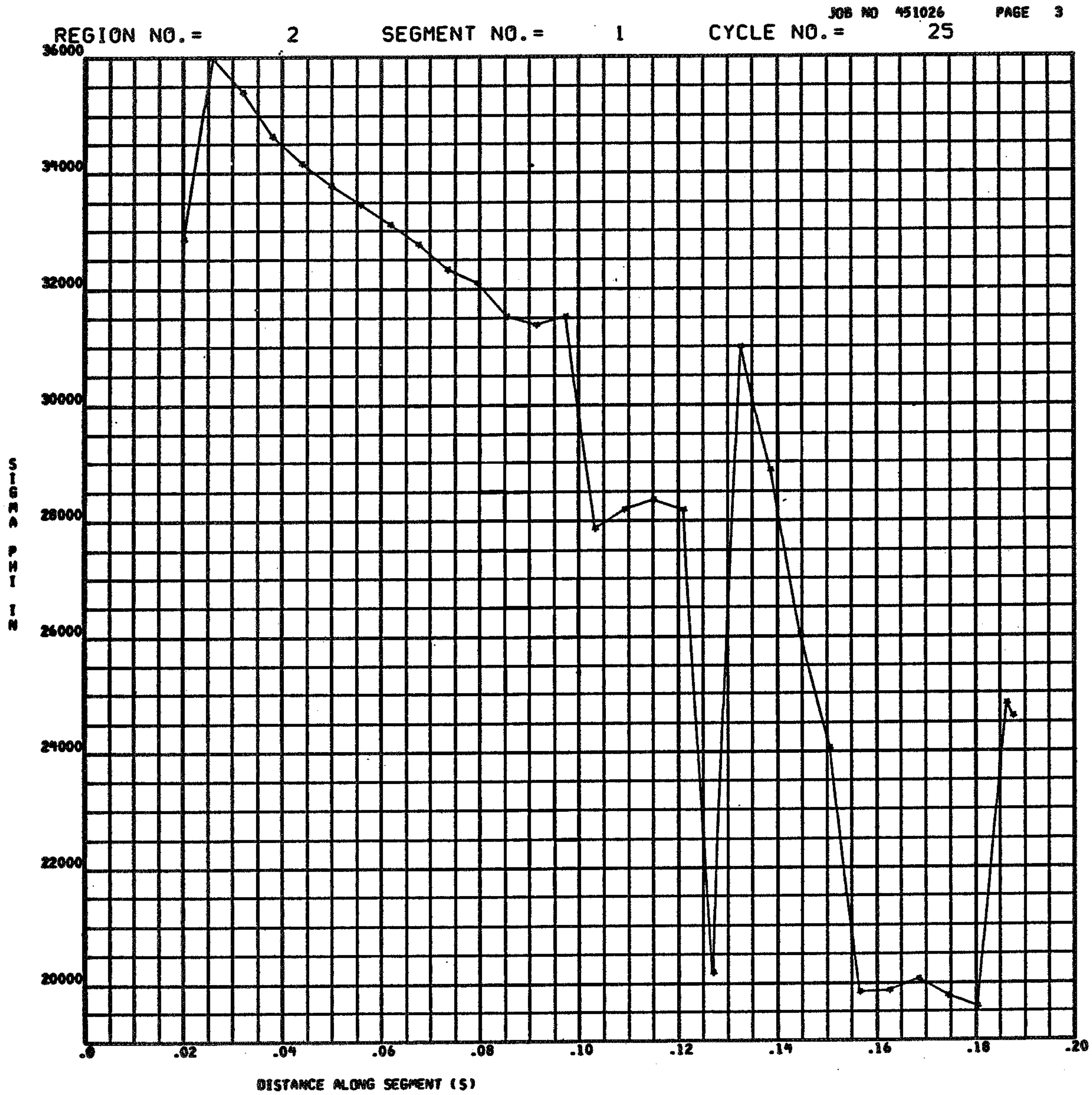

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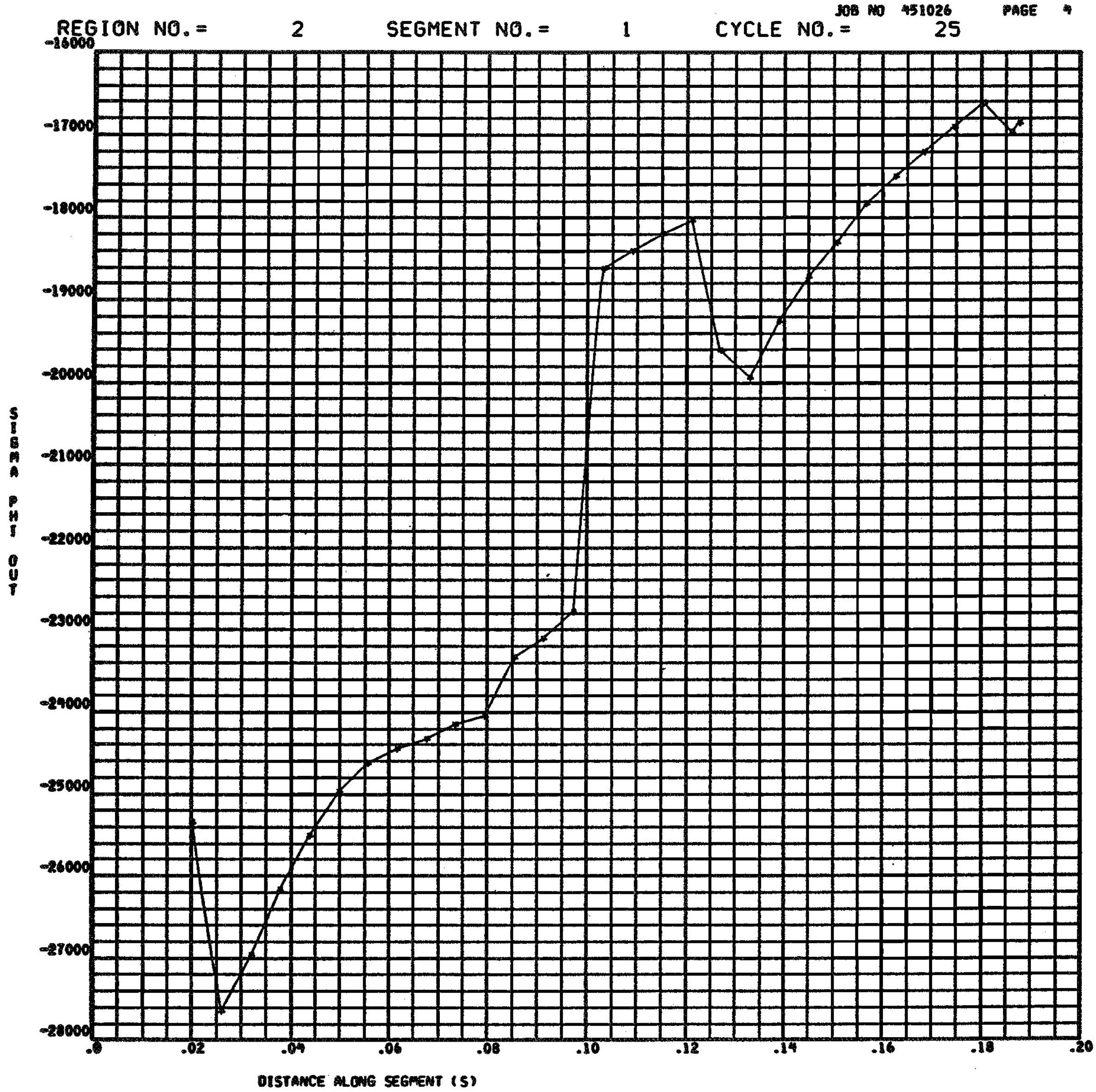
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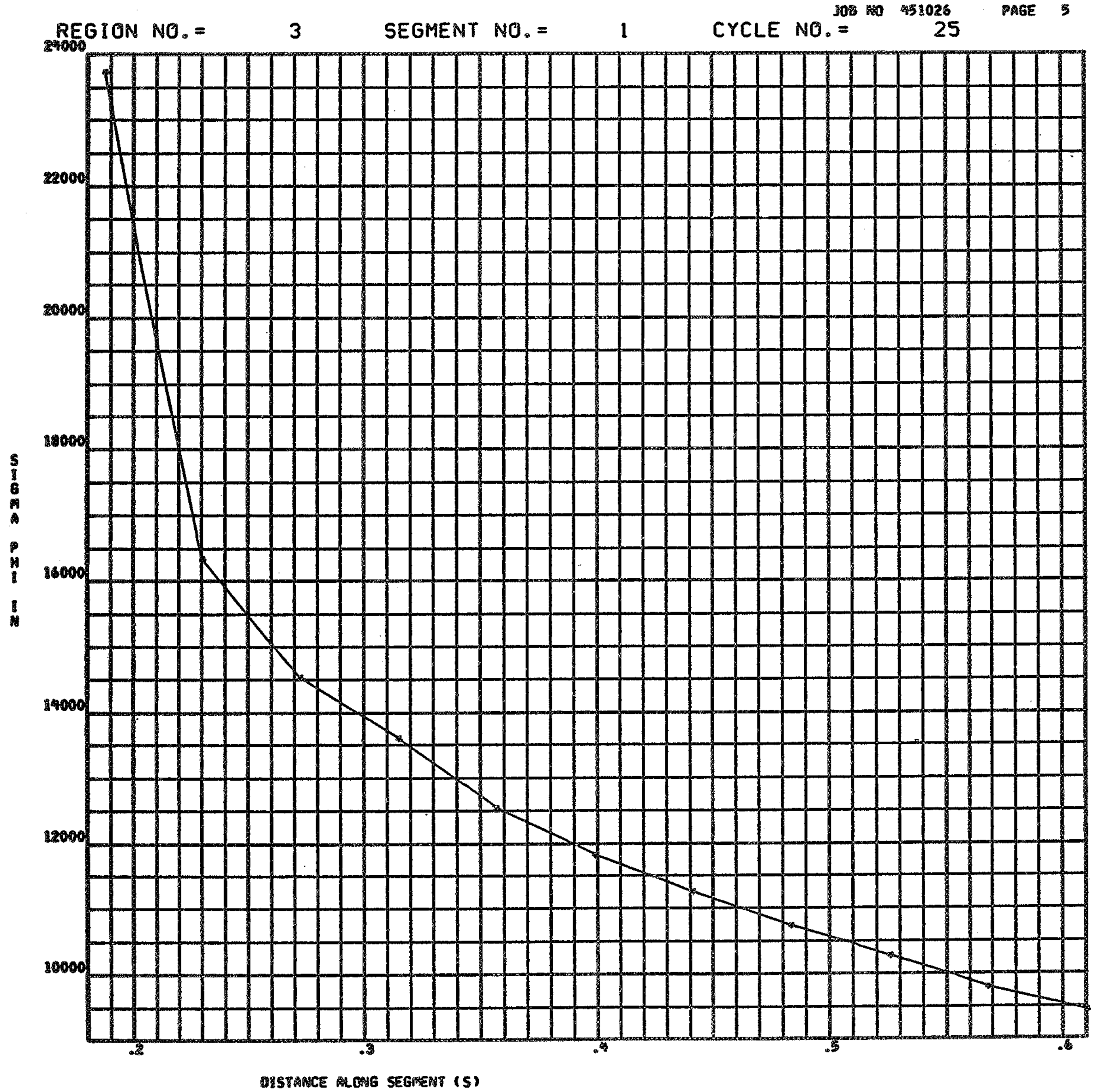
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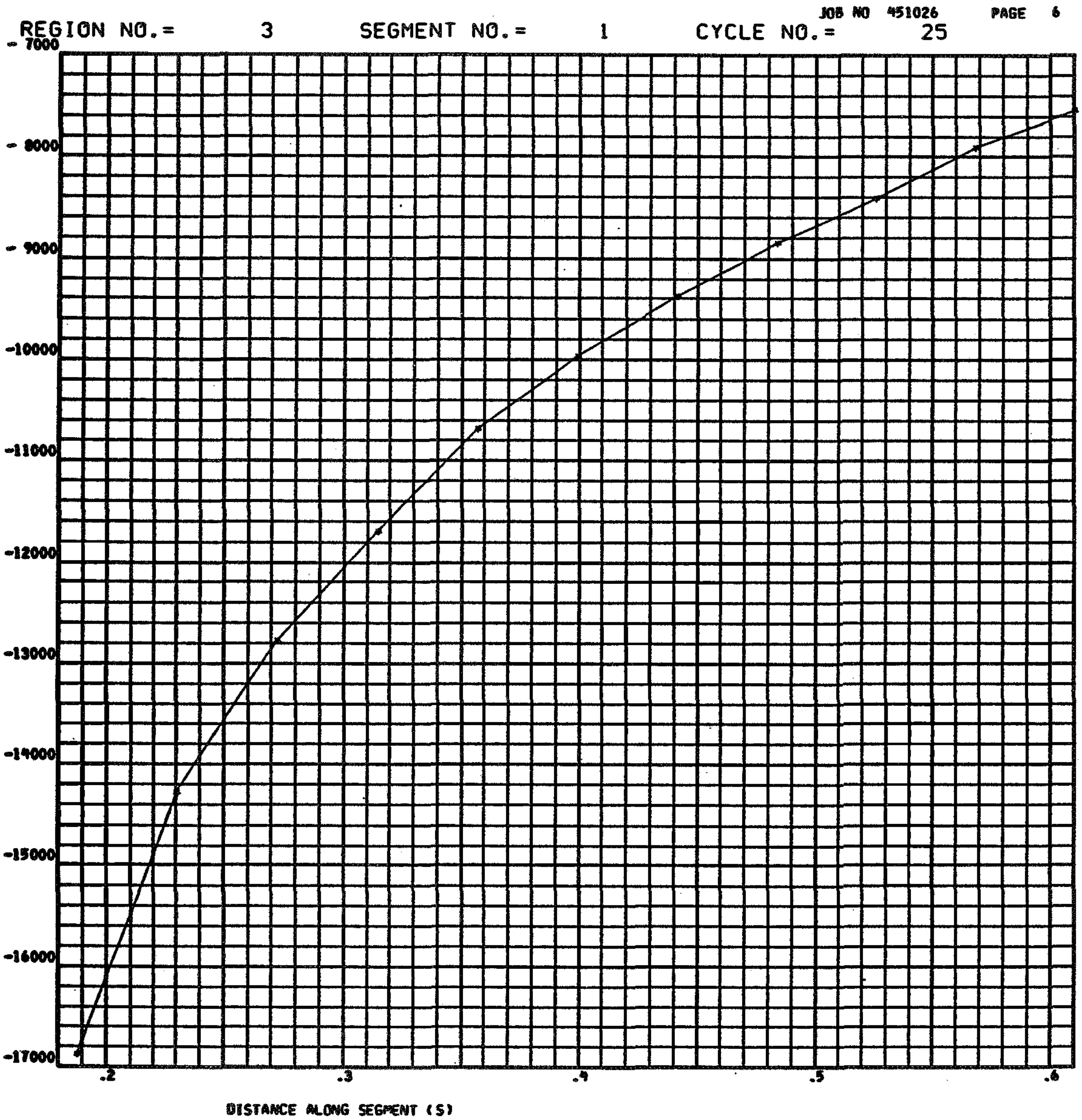

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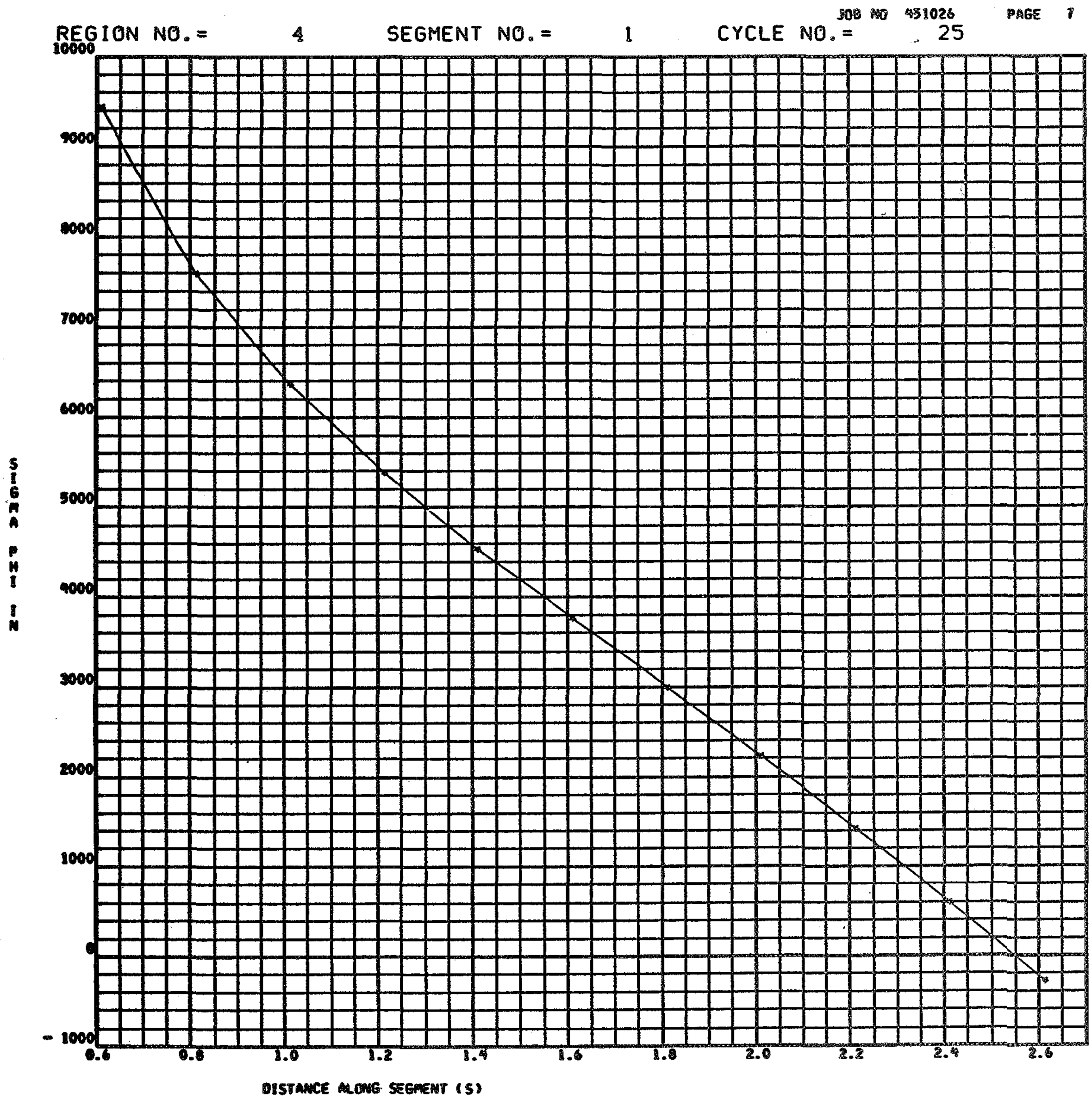

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6000
5000
4000
3000
2000
1000
0
- 1000
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2.4
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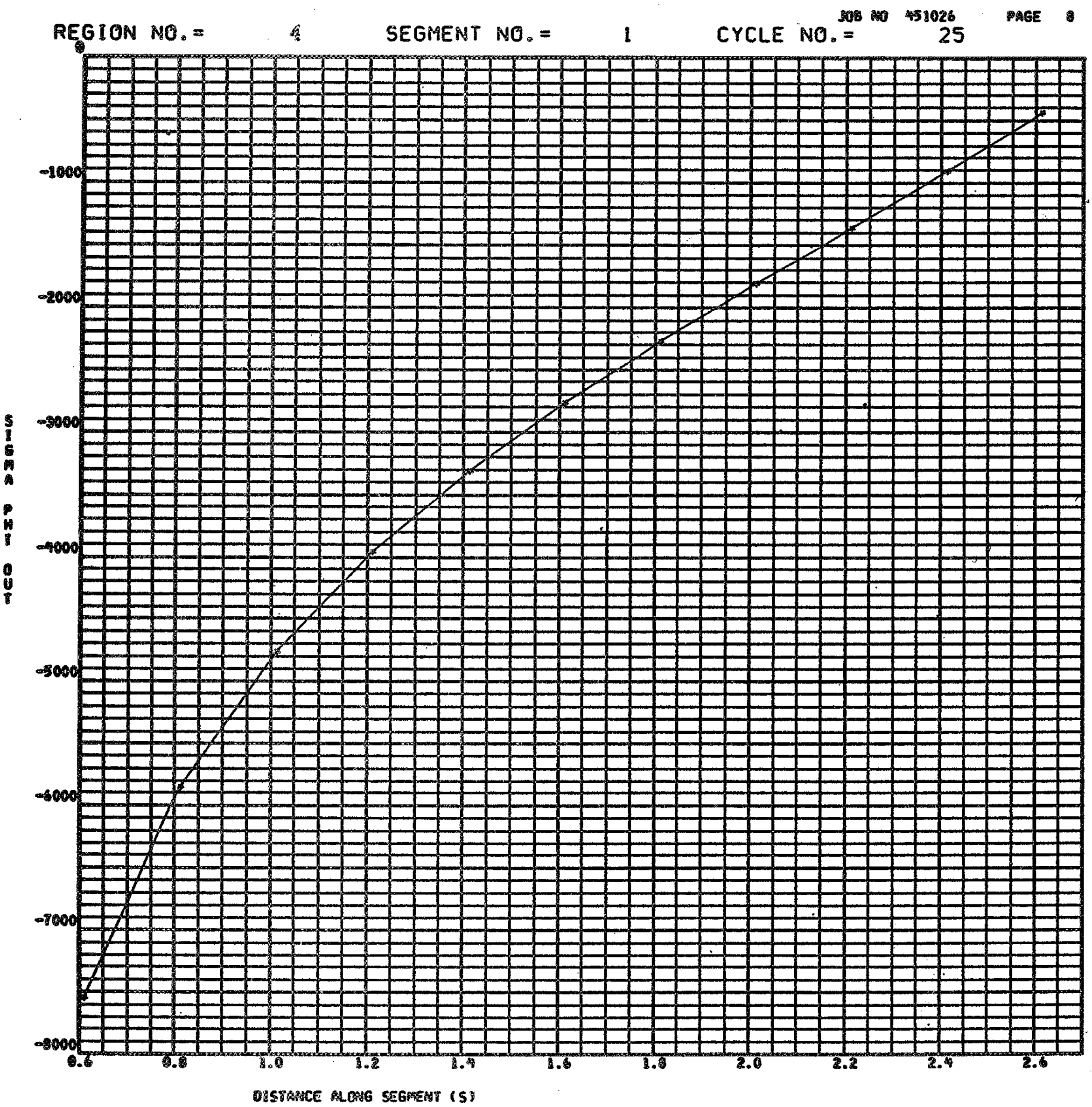

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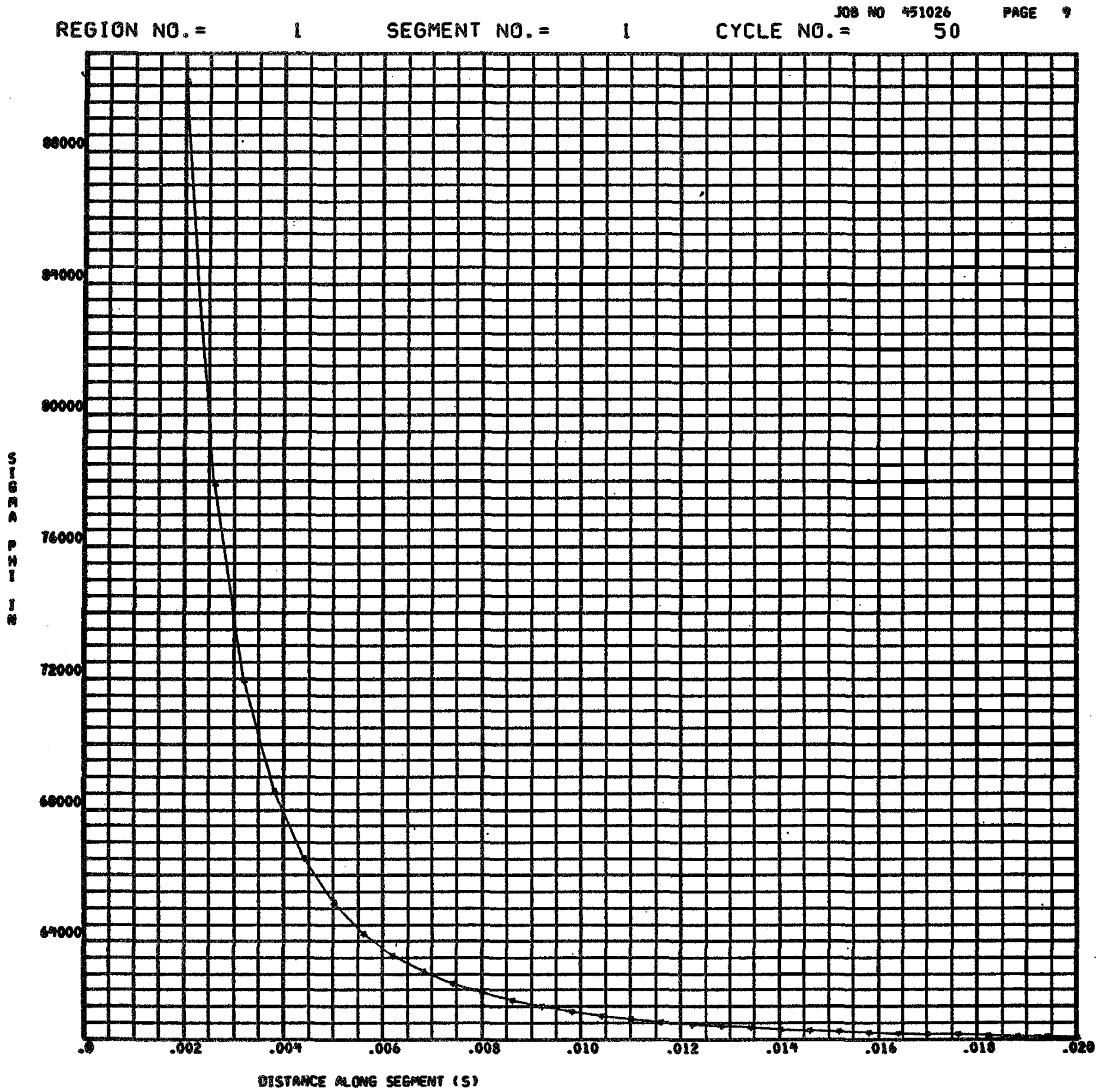
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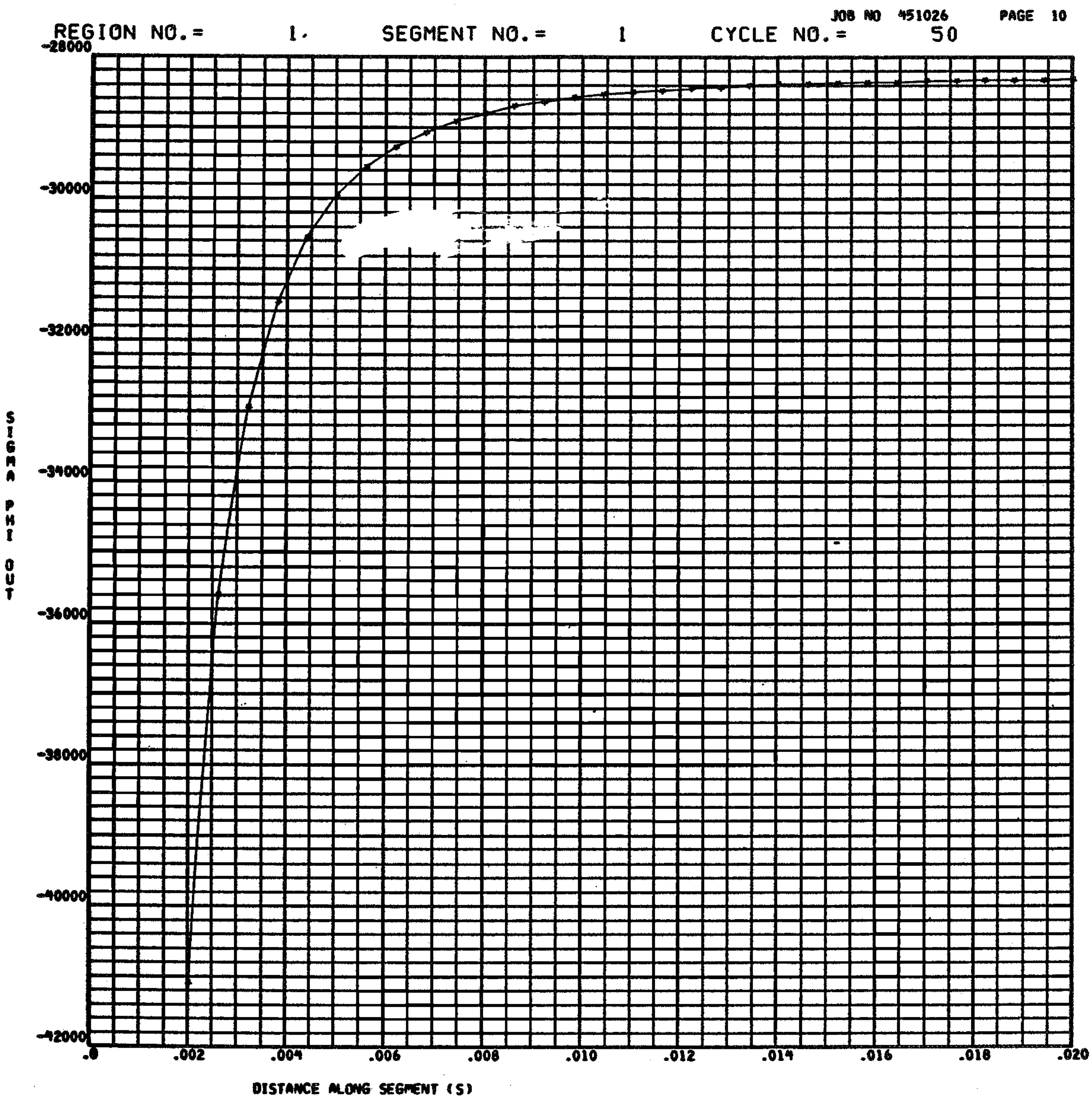
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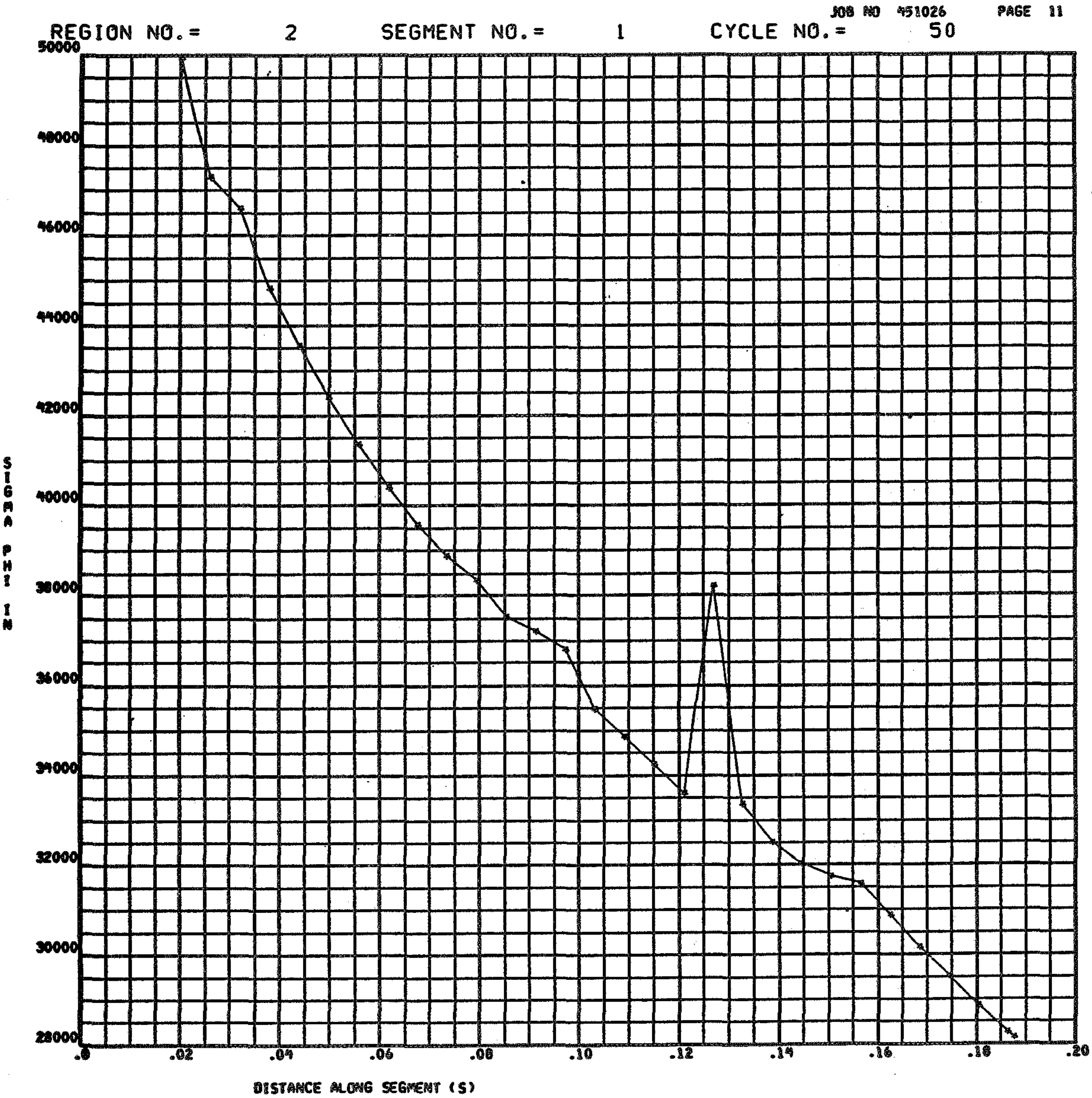

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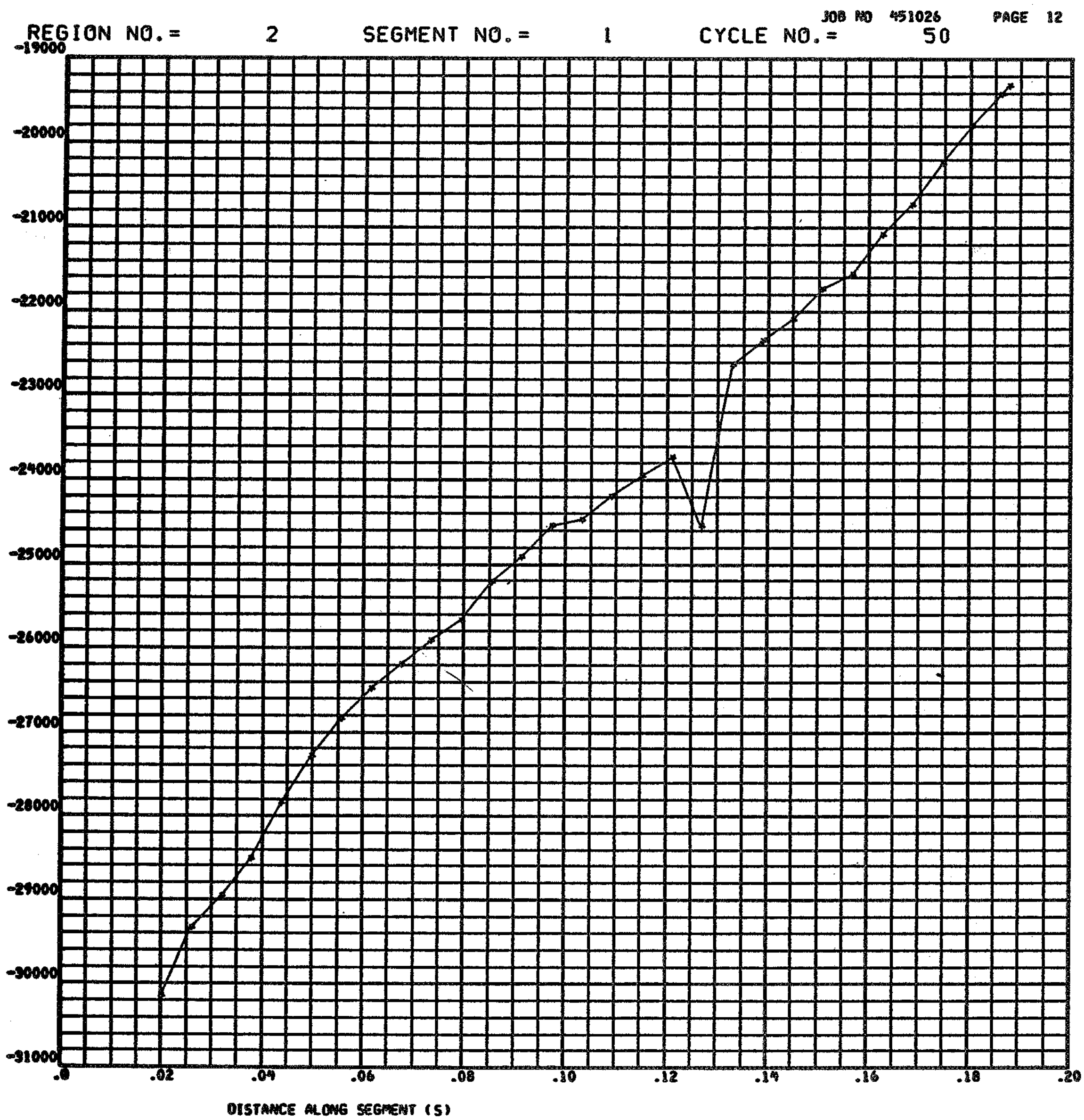

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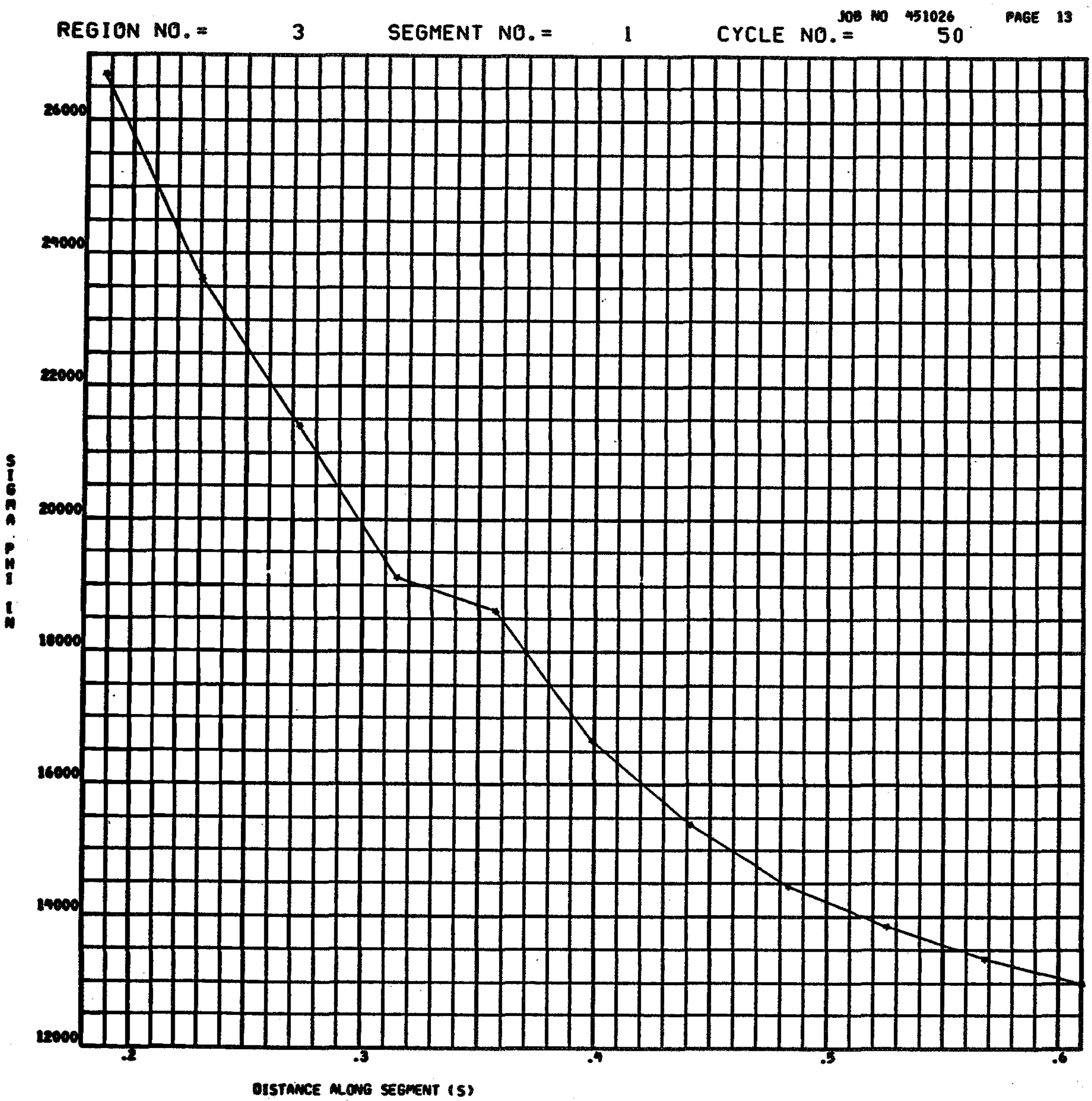

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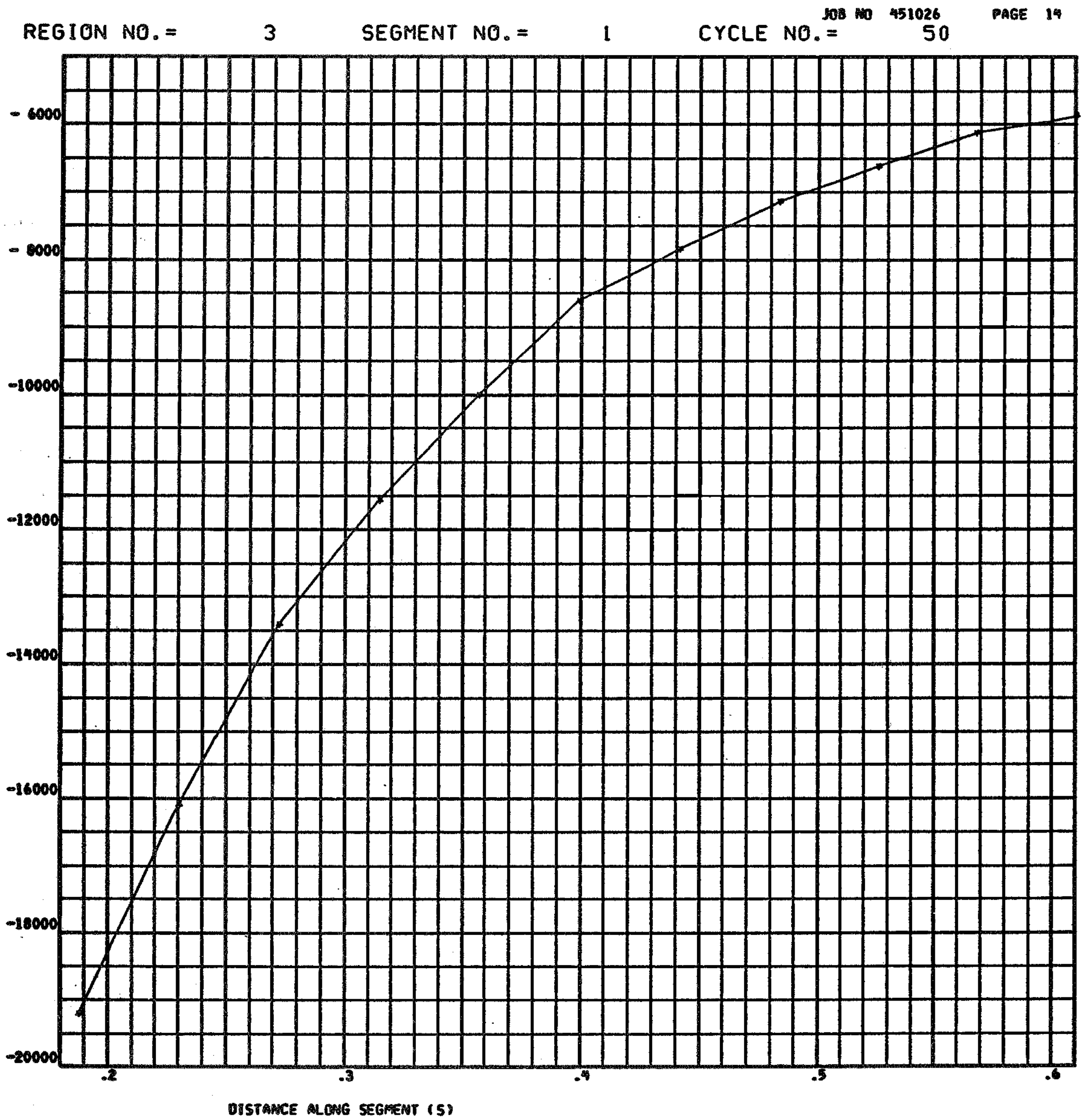
DISTANCE ALONG SEGMENT (S)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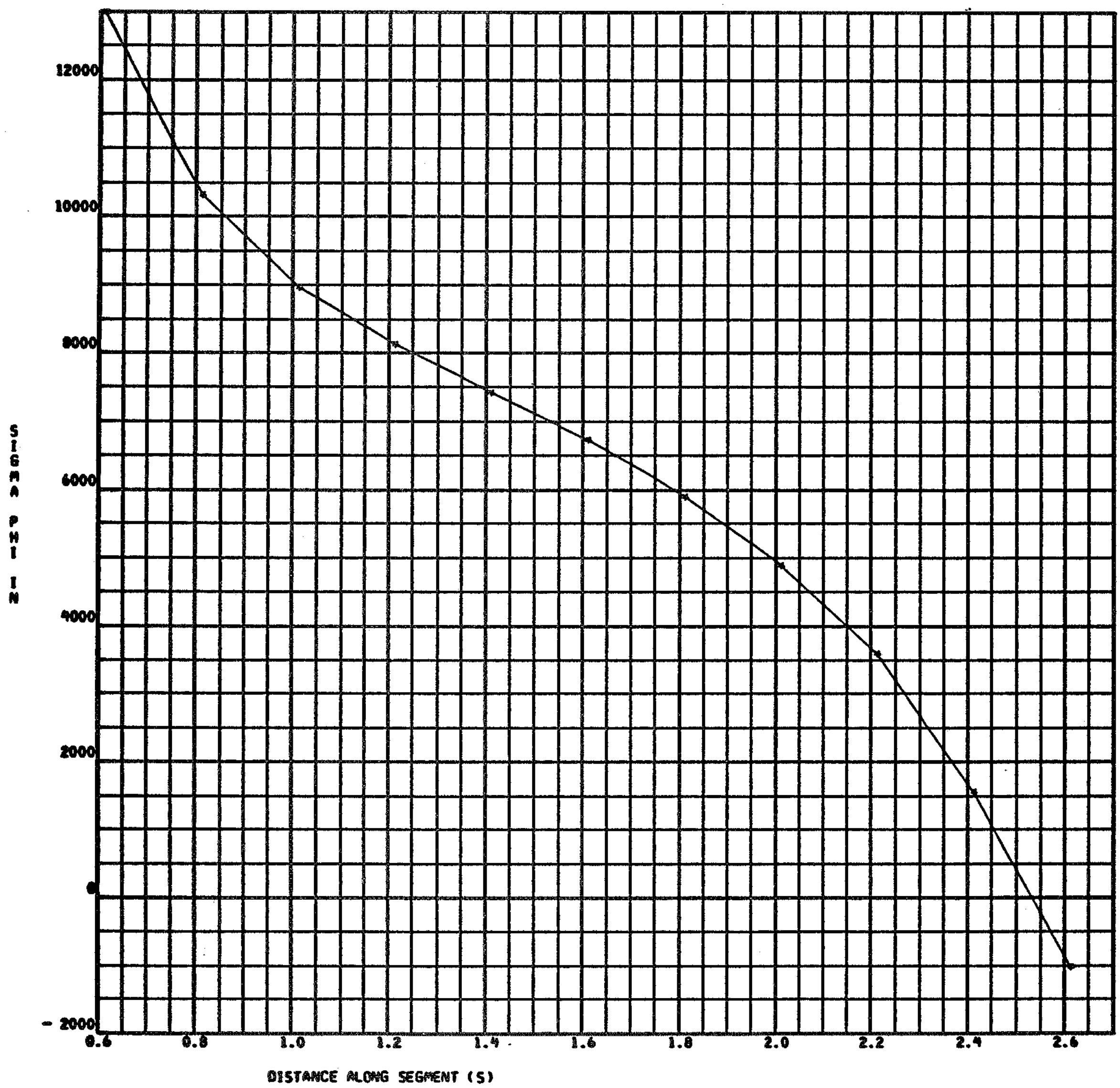
DISTANCE ALONG SEGMENT (S)

REGION NO.= 4 SEGMENT NO.= 1 CYCLE NO.= 50



JOB NO 451026 PAGE 16

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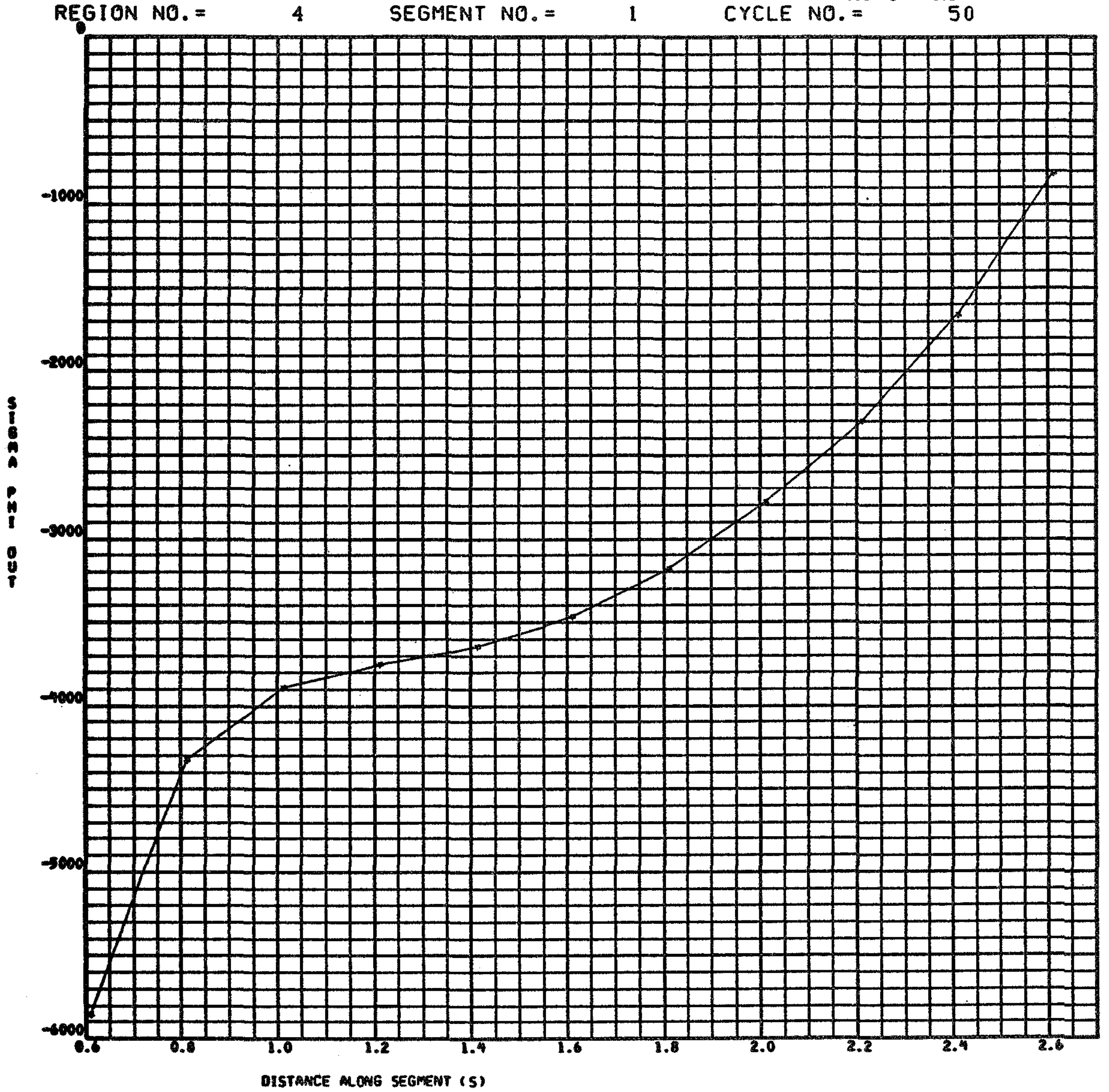

SECTION 5

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1. Svalbonas, V., and Levine, H. "Numerical Nonlinear Inelastic Analysis of Stiffened Shells of Revolution, Vol. I: Theory Manual", NASA CR-2559

2. Turing, A. M., "Rounding Off Errors in Matrix Processes", Quarterly Journal of Mechanics and Physics, Sept. 1948, pp. 287-308.

3. Svalbonas, V., and Ogilvie, P., "'SATELLITE' Program for the 'STARS-2P'", NASA CR-2559

4. Svalbonas, V., "Numerical Analysis of Stiffened Shells of Revolution, Vol. I: Theory Manual", NASA CR-2273, Sept. 1973.

5. Foster, B., and Thomas, J., "Automated Shell Theory for Rotating Structures (ASTROS)", NASA TN D-6485, Nov. 1971.

APPENDIX A

CONVERSION OF U.S. CUSTOMARY UNITS TO SI UNITS

The International System of Units (SI) was adopted by the Eleventh General Conference on Weights and Measures in 1960. Conversion factors for the units used in this report are given in the following table:

Physical Quantity	U.S. Customary Unit	Conversion factor (*)	SI Unit (**)
Length	in.	0.0254	meters (m)
Stress modulus	ksi	6.895×10^6	newtons/meter^2 (N/m^2)
Stress resultant	lbf/in.	175.1	newtons/meter (N/m)
Temperature change	$^\circ$F	5/9	Kelvin (K)

* Multiply value given in U.S. Customary Unit by conversion factor to obtain equivalent value in SI Units.

** Prefixes to indicate multiple of units are as follows:

Prefix	Multiple
giga (G)	10^9
mega (M)	10^6
kilo (k)	10^3
deci (d)	10^{-1}
centi (c)	10^{-2}
milli (m)	10^{-3}

*U.S. GOVERNMENT PRINTING OFFICE: 1975 - 635-275/1