WD NASA CR 73477
Date
AVAILABLE TO THE PUBLIC

COMPUTER PROGRAM TO PREDICT SPACECRAFT WINDOW DEFORMATIONS AND COMPUTE WINDOW INDUCED ANGULAR DEVIATIONS OF LIGHT RAYS

Tit -178

By David M. Kelley and Philip A. Diether

Contract Number (Boldface No. 1, 12 Point)

SEPTEMBER 1970

Prepared under Contract No. NAS2-5044 by
PHILCO-FORD CORPORATION
WDL DIVISION
For
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER
MOFFETT FIELD, CALIFORNIA

LOS ANGELES AIR FORCE STATION
LOS ANGELES, CALIFORNIA

NASA CR 73477

COMPUTER PROGRAM TO PREDICT SPACECRAFT WINDOW DEFORMATIONS AND COMPUTE WINDOW INDUCED ANGULAR DEVIATIONS OF LIGHT RAYS

By David M. Kelley and Philip A. Diether

SEPTEMBER 1970

Prepared under Contract No. NAS2-5044 by
PHILCO-FORD CORPORATION
WDL DIVISION

For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER
MOFFETT FIELD, CALIFORNIA

FOREWARD

This report was prepared by Philco-Ford Western Development Laboratory personnel under NASA Contract No. NAS2-5044. Work was administered under the direction of the Manned Systems Research Branch, Ames Research Center, Moffett Field, California. The Technical Monitor for the contract was Mr. Kenneth C. White.

This report covers work conducted between June 1968 and March 1970. The manuscript was released by the authors for publication as a NASA technical report in September 1970.

ABSTRACT

This document describes a computer program (WINDEF) which determines the deviations of light rays passing through deformed windows. Elliptical, rectangular, and trapezoidal window planforms can be analyzed. Rays may enter at any inclination at the points of a specified grid on the undeformed window surface.

Window panes are assumed to be originally flat and of uniform thickness. Ray deviations are computed for windows with elliptical, rectangular, and trapezoidal planforms due to given uniform pressures. Deformations for elliptical and rectangular planforms are calculated in the program. Deformations for trapezoidal planforms must be input from punched cards. Deformations for either clamped or simply supported edge conditions may be considered.

Ray deviations can be developed for windows having one or two panes with any given spacing between panes. Angular and translational deviations are reported for each ray. In addition, mean and root mean square deviations of collinear sets of light rays are listed.

TABLE OF CONTENTS

Section 1

INTRODUCTION

A light ray entering a window system is refracted so that the exiting ray need not be parallel to the entering ray. Thus, corrections must be made to optical measurements performed through the system. The deviations of a set of particular light rays can provide the basis for corrections. These deviations define the difference between the direction of each entering ray and its exiting ray and the changes of coordinates between the point of entry and exit.

The deviations are determined by tracing the path of the ray through the window system. The tracing involves considering ray refractions at the window pane surfaces and the geometrical relationships. Thus, knowing the location and orientation of the entering ray, tracing uses knowledge of pane cross section shape, thickness, and spacing and the indices of refraction of each surface to determine the location and orientation of the exiting ray.

This report describes a computer program which will calculate the shape of thin, originally flat panels of elliptical or rectangular planform, when deformed by uniform pressure, and which will develop ray deviation data for elliptical, rectangular, or trapezoidal planforms.

The technical basis for the calculations is defined. All data needed to prepare input and implement code usage are provided including program details to assist the programmer in diagnosing difficulties and modifying the code.

Section 2

PROGRAM DESCRIPTION

WINDEF is a digital computer program that directs calculation of deformations of window panes of elliptical or rectangular planform. It calculates deviations of light rays passed through deformed elliptical, rectangular or trapezoidal window panes.

The parameters that may be varied are: planform dimensions, pane thickness, number of panes (1 or 2), spacing between panes, pressure load, dimension scaling, ray plane angles, ray inclination angles, and ray location on the window. The spacing, pressure, scaling, plane angles, and inclination angles are each limited to eight values per problem.

Small deflection deformations for the elliptical and rectangular planforms are calculated by exact solutions employing thin plate theory. Approximate solutions are used to calculate large deflections and shear deformations of rectangular plates. Deformations for trapezoidal shapes are found using the Structural Analysis and Matrix Interpretive System (SAMIS) which employs the finite element approach for obtaining solutions. Trapezoidal deformations are read in on punched cards.

The ray trace portion of the program calculates the geometrical changes of rays passing through the window(s). Both coordinate and angular deviations are calculated and presented. In addition, mean and root mean square deviations of collinear sets of light rays are listed. The subroutines used to perform the ray tracing were provided by Ames Research Center.(1)*

---

*Numbers in brackets correspond to references listed at the end of the report.

DEFORMATION EQUATIONS

This section describes the equations used to calculate deformations of elliptical and rectangular plates. Deflections and slopes (about the x and y axes) are calculated. Equations are developed for elliptical plates for both simply supported and clamped edges. The circle with simply supported edges is included as a special case since a simple closed-form solution exists.

The equations for the small deformations of a clamped ellipse are taken from Timoshenko [2] and are expressed in rectangular coordinates. The equations for the small deformations of a simply supported ellipse are taken from B. G. Galerkin [3] and are expressed in elliptic coordinates. The coordinates for the points at which deformations are calculated are rectangular. These are converted to elliptical coordinates to solve for the deformations. In the conversion process a Newton-Rhapson method of succesive approximations [4] was used to determine the relationships between the two sets of coordinates. When the simply supported ellipse degenerates to a circle, another equation in rectangular coordinates from Timoshenko [2] is used. This alleviates the necessity of iterating to find the elliptical coordinates which is required when using Galerkin's elliptic equations.

The equations for both simply supported and clamped edges for the small deformations of rectangular plates are taken from Timoshenko [2] and Evans [5]. The solutions are given by infinite series which are truncated after 16 terms. This truncation will insure the one second of arc accuracy required. [6] The large deflection of rectangular plates is solved by combining small plate deflection theory and membrane theory and requring that the deformations by the two methods be equal at the center of the plate when subjected to the same loads[2]. The small deflections of the plate are predicted as described above. The membrane deflections are predicted exactly by generalizing Timoshenko's results for a square membrane. By combining the equations for the loads to produce the center deflection, w_o, by small deflection theory and the center deflection, w_o, produced by membrane analysis, a cubic equation in w_o results which can be solved to find the large deflection solution. The large deflection solution for points between the center of the plate and the edge is obtained by averaging the deflection for the small deflection plate theory and the membrane theory at each point.

Shear deformations are calculated using a modification of an equation for the deflections of rectangular sandwich plates [7]. The shear deflection is obtained by multiplying the small deflection theory result by a constant of the form $\xi = 1+\alpha$ where α is a function of the lengths of the sides and thickness of the plate.

Details of the development of the above described equations are given in Appendix A. Other miscellaneous equations used in the program are developed and described in Appendix B. These are the trapezoidal boundary, mean and standard deviations, and maximum-minimum slope equations.

INTERPOLATION PROCEDURE

Deformations generated by the above equations or those read in from punched cards are defined only for certain points on a regular grid network. Since the light rays intersecting the window surfaces will generally not fall on points of this regular grid, a method of interpolating between the deformations at the grid points is necessary.

The procedure used for the interpolation is to fit, in a least squares sense, a reduced eight-order polynomial to the deformations of a 6 x 6 grid network (36 points).[19] The form of this polynomial is:

$$
\begin{aligned}
w = {} & A_1 x^4 y^4 + A_2 x^4 y^3 + A_3 x^3 y^2 + A_4 x^4 y + A_5 x^3 y^4 + A_6 x^3 y^3 \\
& + A_7 x^3 y^2 + A_8 x^3 y + A_9 x^2 y^4 + A_{10} x^2 y^3 + A_{11} x^2 y^2 + A_{12} x^2 y \\
& + A_{13} x y^4 + A_{14} x y^3 + A_{15} x y^2 + A_{16} x y + A_{17} y^4 + A_{18} y^3 \\
& + A_{19} y^2 + A_{20} y + A_{21} x^4 + A_{22} x^3 + A_{23} x^2 + A_{24} x + A_{25}
\end{aligned}
\tag{1}
$$

Where the A_i are constants and x and y are coordinates of a rectangular cartesian system. This function is fitted to each of the 36 points of a six by six square array of the grid. The equations expressing deformation can be written in matrix form as:

$$\{w\} = [B]\{A\} \tag{2}$$

Where $\{w\}$ and $\{A\}$ are column vectors and $[B]$ is a 36 x 25 rectangular matrix. To define the deformations at any point, the A_i components must be determined. This is accomplished by first premultiplying the above equation by the transpose of $[B]$ to obtain:

$$[B]^T \{w\} = [B]^T [B] \{A\} \ . \tag{3}$$

Then, the A_i can be found by solving this set of linear homogeneous equations. The solution can be formally expressed by:

$$\{A\} = ([B]^T [B])^{-1} [B]^T \{w\} \ . \tag{4}$$

Knowing $\{A\}$, Equation (1) can be used to evaluate deformations at any point on the window.

Since the eight-order polynomial used is not complete, it is sensitive to where the origin of coordinates is chosen. To minimize this sensitivity, the origin of coordinates should be chosen at the point of maximum deflection of the window. For the elliptical and rectangular planforms the computer program automatically selects the proper region. For the trapezoidal planforms, which are read in on punched cards, the origin of coordinates must be specified by the analyst. In addition, the analyst must specify the center of interpolation (see Figure 1) for the trapezoidal planforms. For the elliptical and rectangular planforms, the center of interpolation is automatically chosen by the computer program.

To obtain adequate accuracy in deformation predictions over the window, it was necessary to use four regions of interpolation as shown in Figure 1. Each region consists of a 6 x 6 grid network as described above. Independent fits are made in each region to determine the interpolation coefficients, A_i. The deformations at any point on the window are then determined by considering within which of the four regions the point lies and using the interpolation coefficients for that region along with Equation (1) to determine the deformations of the point. To avoid discontinuities in the fits the interpolation coefficients are linearly interpolated among fits when the point of interest lies between the centers of the four interpolation regions. For example, in Figure 1, if point P is the point of interest the deformations for P would be predicted using the interpolation coefficients for regions 1 and 2 in proportion to the distance of P from the centers of the regions.

The accuracy of the interpolation is limited by the accuracy of the equation solution process which evaluates the $\{A\}$. This difficulty is eliminated by solving Equation (3) with double precision arithmetic. This results in obtaining at least seven digit accuracy in the equation solving process.

Performing the curve fitting with all points in each of four regions and using double precision arithmetic results in a maximum error in the interpolation of less than one second of arc.

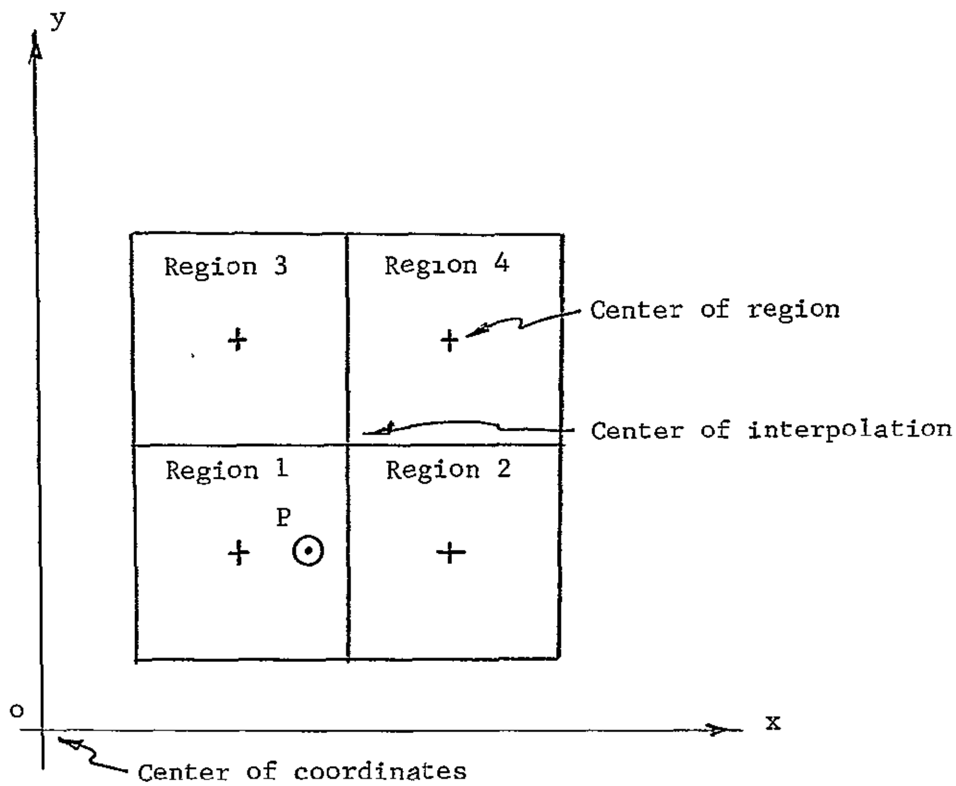


Figure 1. Interpolation Regions

RAY TRACE PROCESS

"Ray tracing" consists of determining the paths of an observed ray as seen from the interior of the spacecraft. Since the mathematical description of the optical phenomenon is reversible, the ray can be considered as emerging from the observer's eye, extending to the window surface, refracting through the window, and then continuing on to the object under observation. This path is shown schematically in Figure 2.

The process by which the ray is traced is to first assume the direction of a ray from the eye of the observer toward the window. The point of intersection of the ray with the deformed window surface is determined by successive improvement of estimates. (This process is used because the deformed surface is defined by tabular data rather than by formulas). At the intersection point the normal to the surface is determined. The refraction of the ray in the medium is determined from the optical incidence rule using the measured value of the index of refraction. In passing through air, the index of refraction is calculated as a function of the air pressure.

The ray is traced through each medium and its refraction calculated at each interface. The position and orientation of the exiting ray is then compared with the position and orientation of the assumed ray at the same distance, measured normal to the undeformed window (reference) surface, if the window system did not exist. (See Figure 2.) The differences in position and angle define the deviation of the light ray being refracted through the set of windows and are a measure of the optical performance of the window system.

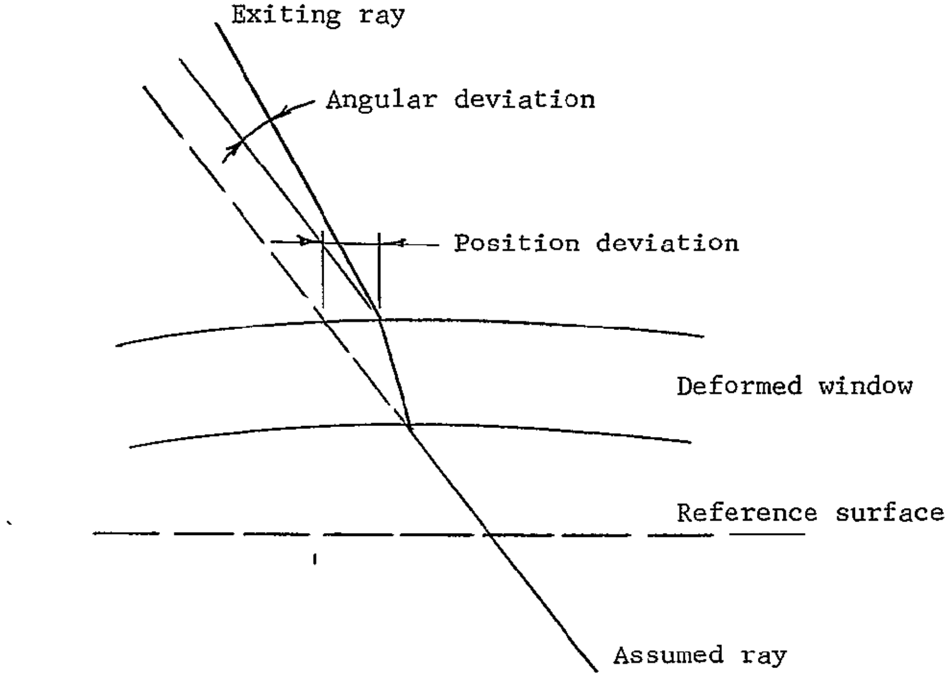


Figure 2. Light Ray Deviations

The equations necessary to determine the path of the refracted light ray are functions of the geometry of the systems and the indices of refraction of the components of the system. Details of these equations are given by White and Gadeberg[8,9].

SUBROUTINE DESCRIPTIONS

Tablê 1 gives descriptions of the subroutines that make up the total program. Also included is the function of each subroutine, the method of solution where pertinent, input and output, and calling statements. All input and output is with the common block in the program unless specified or indicated in the calling statement as otherwise.

Included in Table 2 is a list of constants and variables in the common array and the subroutines of the program in which they appear. The subroutines are referred to by the code values that appear in parenthesis after each subroutine in Table 1.

Table 3 gives a listing of the correspondence between the ray trace results and their variable names and storage locations as used on the ray trace subroutine of the program.

Table 4 provides information concerning the sign convention as used in the development of the equations for the computer code.

FLOW CHARTS

This section contains two flow charts. Figure 3 shows the interrelation between the subroutines of the program. Figure 4 shows the sequence in which subroutines are selected by the driver.

Listings of the routines of the program are given in Appendix D.

Table 1

Subroutine Descriptions

WINDEF (DO)

Apollo window deformation and line-of-sight driver
Controls solution of problems
Input: Physical parameters, program control switches, via cards
Output: Error comments

ELIPSE (D1)

Elliptical plate deformation generator
Solutions by small deflection theory (closed form)
Input: Plate dimensions, physical properties
Output: Plate deflection and slopes about x and y axes
Calling statement: CALL ELIPSE

ELIPIT (D2)

Elliptic coordinate generator
Elliptic coordinates are generated by the Newton-Rhapson method of successive approximations
Calling statement:

CALL ELIPIT (C, X, Y, XI, ET, FXP, FEP, GXP, GEP, DET)

C = focal distance
X = x coordinate rectangular coordinates
Y = y coordinate rectangular coordinates
XI = elliptic elliptical coordinate
ET = hyperbolic elliptical coordinate
FXP = -C sinh (XI) cos (ET)
FEP = C cosh (XI) sin (ET)
GXP = -C cosh (XI) sin (ET)
GEP = -C sinh (XI) cos (ET)
DET = determinant (FXP GEP - FEP GXP)

RECTNG (D3)

Rectangular plate deformation generator
Solution by small deflection theory (infinite series of 16 terms)
Input. Plate dimensions, physical properties
Output: Plate deflection and slopes about x and y axes
Calling statement: CALL RECTNG

SEQS (D4)

Matrix inversion and linear equation solution
Calling statement·

CALL SEQS (A, B, C, N, M)

A = matrix of moments
B = matrix of right hand side
C = solution matrix - returned
N = size of square matrix A
M = number of right hand sides

Table 1 (cont'd)

TRPZOD (D5)

Reads in trapezoidal data from cards generated by SAMIS
Eliminates unnecessary data. Re-formats codes for ray trace routines
Input: Load number desired; number of cards, scale factor via cards
Output: Deflections and slopes about x and y axes
Calling statement: CALL TRPZOD

LRGDEF (D6)

Large deflection generator for rectangles
Solved by energy method described in Timoshenko
Input: Plate dimensions, physical properties, deflections and slopes by small deflection theory (from RECTNG)
Output: Large deflections and slopes about x and y axes
Calling statement. CALL LRGDEF

DEFRES (D7)

Prints plate deformation data on system output tape or tape 7
Input: Problem parameters, physical properties, deflections and slopes
Output: Same as Input
Calling statement:

```
CALL DEFRES (IDT, NØPRT)
IDT   = deformation data retrieval sequence number
NØPRT = output tape selection switch
```

RAYTRA (D8)

Driver for ray trace procedure
Output: Entering and exiting ray coordinates and angles and vector difference between entering and exiting rays
Calling statement:

```
CALL RAYTRA (XS, YS, ZS, ALPHAI, DELTAN)
XS     = x coordinate of entering ray
YS     = y coordinate of entering ray
ZS     = 0.0
ALPHAI = plane angle
DELTAN = ray angle
```

ITERAT (D9)

Iterates to find location of ray on next surface
Stops iteration when error is less than 1.0E-6
Calling statement:

```
CALL ITERATE (XP, YP, K, DELTAP, CI, DELZ, OWX, OWY)
XP     = x coordinate of ray
YP     = y coordinate of ray
K      = index of surface
DELTAP = 1.0
CI     = direction cosines
DELZ = deflection of plate at point ray enters or leaves plate
OWX  = slope about x axis
OWY  = slope about y axis
```

Table 1 (cont'd)

INCOTB (EO)

Determines deformation of plate at intersection with ray
Solution uses an osculating interpolation function
Calling statement:

```
CALL INCOTB (XP, YP, OWF, OWX, OWY, IPG)
XP   = x coordinate of ray
YP   = y coordinate of ray
OWF  = deflection of plate at point ray enters or leaves plate
OWX  = slope about x axis
OWY  = slope about y axis
IPG  = switch associated with MAX-MIN routine
```

NORMAL (E1)

Calculates normal to plate at ray intersection point
Calling statement:

```
CALL NORMAL (OWX, OWY, K, DELTAP, CN)
OWX  = slope about x axis
OWY  = slope about y axis
K    = index of surface
DELTAP = 1.0
CN   = direction cosines
```

REFRI (E2)

Calculates new direction of ray upon entering new medium
Calling statement:

```
CALL REFRI (CI, CN, QRI, CR, ISØ)
CI   = direction cosines, entering
CN   = direction cosines, entering
QRI  = ratio of refractive indexes of two mediums at boundary
CR   = direction cosines, leaving
ISØ  = number of system output tape
```

RESPRT (E3)

Prints ray trace and mean-rms data on system output tape or tapes 7, 8 & 9
Input   Problem parameters, physical properties, ray trace output data
Output. Same as input
Calling statement:

```
CALL RESPRT (IRT, NOPRT)
IRT  = retrieval index
NOPRT = output tape selection switch
```

MENRMS (E4)

Stores data for mean and rms calculations and calculates same
Input·   Vector error between entering and exiting ray for all grid points
Output: Mean and rms of vector error for all plane angles
Calling statement:

```
CALL MENRMS
```

Table 1 (cont'd)

MAXMIN (E5)

Calculates maximum and minimum slopes at each grid point
Calculates slope by means of a small differential
Input: x and y coordinates of point
Output: Problem parameters, physical properties, maximum/minimum output
Calling statement:
CALL MAXMIN

RTVLST (E6)

Prints out the retrieval index list
Input: Problem parameters, physical properties, retrieval data
Output: Same as input
Calling statement:
CALL RTVLST (IRT, LIN, IPV)
IRT = retrieval index
LIN = line number
IPV = page number of retrieval index list

BONDRY (E7)

Tests to see if the location of a ray is outside the plan form boundary
Calling statement:
CALL BONDRY (XP, YP, IBY)
XP = x coordinate of ray
YP = y coordinate of ray
IBY = bypass switch

PACWRD (E8)

Index word packing-unpacking routine
Packs a two word integer into one word or vice versa
Calling statement.
CALL PACWRD (K1, K2, K3)
Packing:
K1 = integer one entering; resulting integer leaving
K2 = integer two entering
K3 = 1, pack integers; = 2 unpack word
Unpacking:
K1 = packed integer entering; integer one leaving
K2 = integer two leaving
K3 = same as above

PAGE (E9)

Prints page number at top of each page
Calling statement:
CALL PAGE (IPN, LINE, ISN, INX)
IPN = page number
LINE = line number
ISN = tape number
INX = retrieval index

Table 1 (cont'd)

SHRDEF (FO)

Calculates shear deflection of a rectangular plate
Calling statement:
CALL SHRDEF

Table 2

Constants and Variables in Common Array

	Subroutine Designation in Which Used												
AMN	DO									E4			
AVH	DO									E4			
AVS	DO									E4			
CHAP	DO					D7			E3	E4	E5	E6	E7
CPRSS	DO						D8						
DEL	DO							EO			E5		
DIMA	DO	D1	D3		D6	D7			E3	E4	E5	E6	E7
DIMB	DO	D1	D3		D6	D7			E3	E4	E5	E6	E7
DIMC	DO					D7			E3	E4		E6	E7
DWX	DO	D1	D3	D5	D6	D7		EO					
DWY	DO	D1	D3	D5	D6	D7		EO					
FR	DO	D1	D3										
GNU	DO	D1											
IBC	DO	D1	D3			D7					E5		
ILRG	DO					D7							
IPB	DO								E3				
PID	DO					D7					E5		
IPR	DO								E3				
IREL	DO									E4			
IRM	DO								E3				
ISCR1	DO					D7							
ISCR2	DO								E3				
ISEC	DO								E3	E4			
ISI	DO			D5									
ISO	DO					D7			E3		E5	E6	
JPN	DO	D1	D3	D5	D6	D7					E5		
LOCP	DO								E3				
LP5	DO											E6	
LP7	DO						D8						
MIPB	DO							EO					
NGP	DO	D1	D3	D5	D6	D7					E5		
NMP	DO									E4			
NPAG	DO								E3	E4			
NPAN	DO					D7	D8		E3		E5	E6	
PLNAi	DO								E3				
PRESi	DO												
PRSS	DO					D7	D8	EO	E3		E5	E6	
RAYA	DO											E6	
RESi	DO						D8		E3	E4			
RIi	DO						D8						
RTV												E6	
SCALi	DO												
SKAL	DO												
SPACi	DO												
SPAD	DO					D7	D8		E3		E5	E6	
STATi	DO								E3	E4			
STD	DO									E4			
THIC	DO				D6	D7	D8		E3		E5	E6	
W	DO	D1	D3	D5	D6	D7		EO					
X	DO	D1	D3	D5	D6	D7		EO			E5		
Y	DO	D1	D3	D5	D6	D7		EO			E5		
YONG	DO				D6								

Table 3

Alternate Names For Printed Ray Trace Itmes

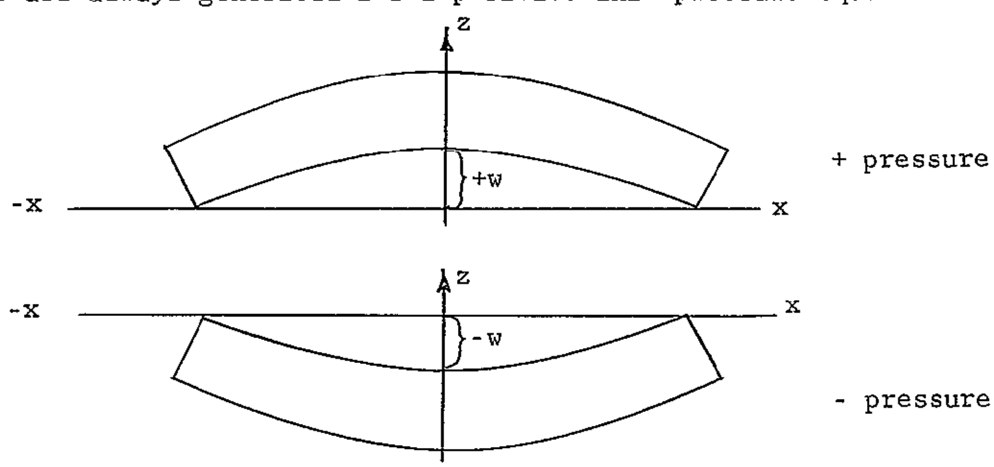
Name in Printouts	Verbal Name	Storage Name and Location	Name in RAYTRA
X	Incident ray x coordinate	RES (1-8)	XS
Y	Incident ray y coordinate	(11-18)	YS
D1	Ray angle entering	(21-28)	DELTAI
A1	Plane angle entering	(31-38)	ALPHAI
Pane Z	Pane deflection	(41-48)	ZP
Pane GX	Slope about x axis	(51-58)	ØWX
Pane GY	Slope about y axis	(61-68)	ØWY
X ØUT	Exiting ray x coordinate	(71-78)	XP
Y ØUT	Exiting ray y coordinate	(81-88)	YP
Z ØUT	Exiting z coordinate	(91-98)	ZP
AZ	Plante angle out	(101-108)	ALPHAR
DZ	Ray angle out	(111-118)	DELTAR
(A1-A2)	Plane angle deviation	(121-128)	DELALP
(D1-D2)	Ray angle deviation	(131-138)	DELDEL
THETA	Incident-exiting ray deviation	(141-148)	DELINC
I(AxB)	i component of cross product	(151-158)	CRPI
J(AxB)	j component of cross product	(161-168)	CRPJ
K(AxB)	k component of cross product	(171-178)	CRPK

Table 4

Sign Convention in Subroutines

Rectangle and Ellipse generate positive deflections in the direction of positive pressure (q).

The pressure (q) is positive in direction of the positive Z-axis. Deflections are always generated for a positive unit pressure (q).



DWX = Slope in x direction (about y axis) is always negative for positive w.

DWY = Slope in y direction (about x axis) is always negative for positive w.

DEFRES changes sign of deflection and both slopes for negative pressure

RAYTRA changes sign of deflection for negative pressures of point under consideration

INCOTB changes sign of deflection and both slopes for negative pressure at 4 corner points

INCOTB returns deflection and slopes with correct signs for any quadrant

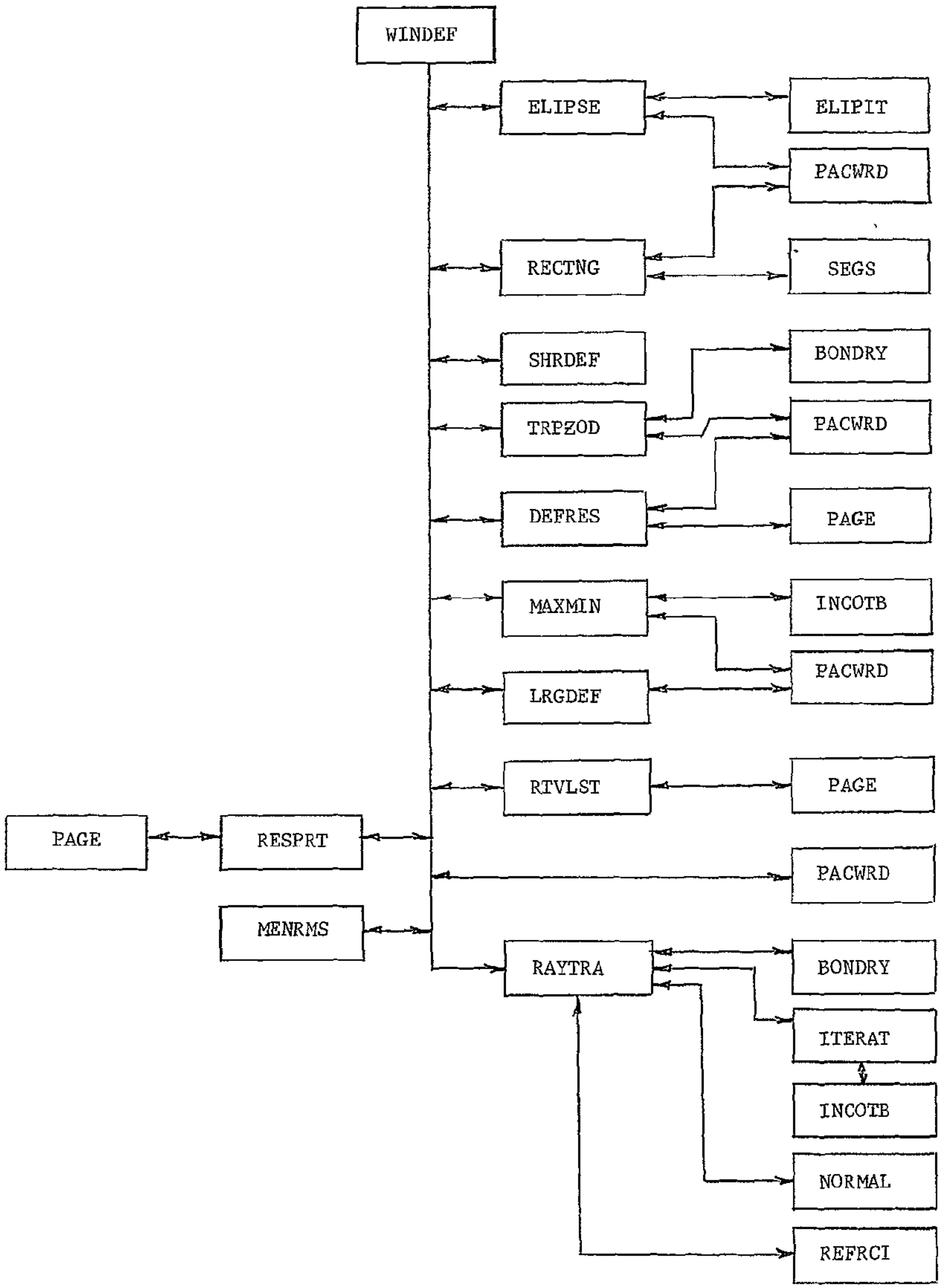


Figure 3. Program Flow Between Subroutines

DRIVER

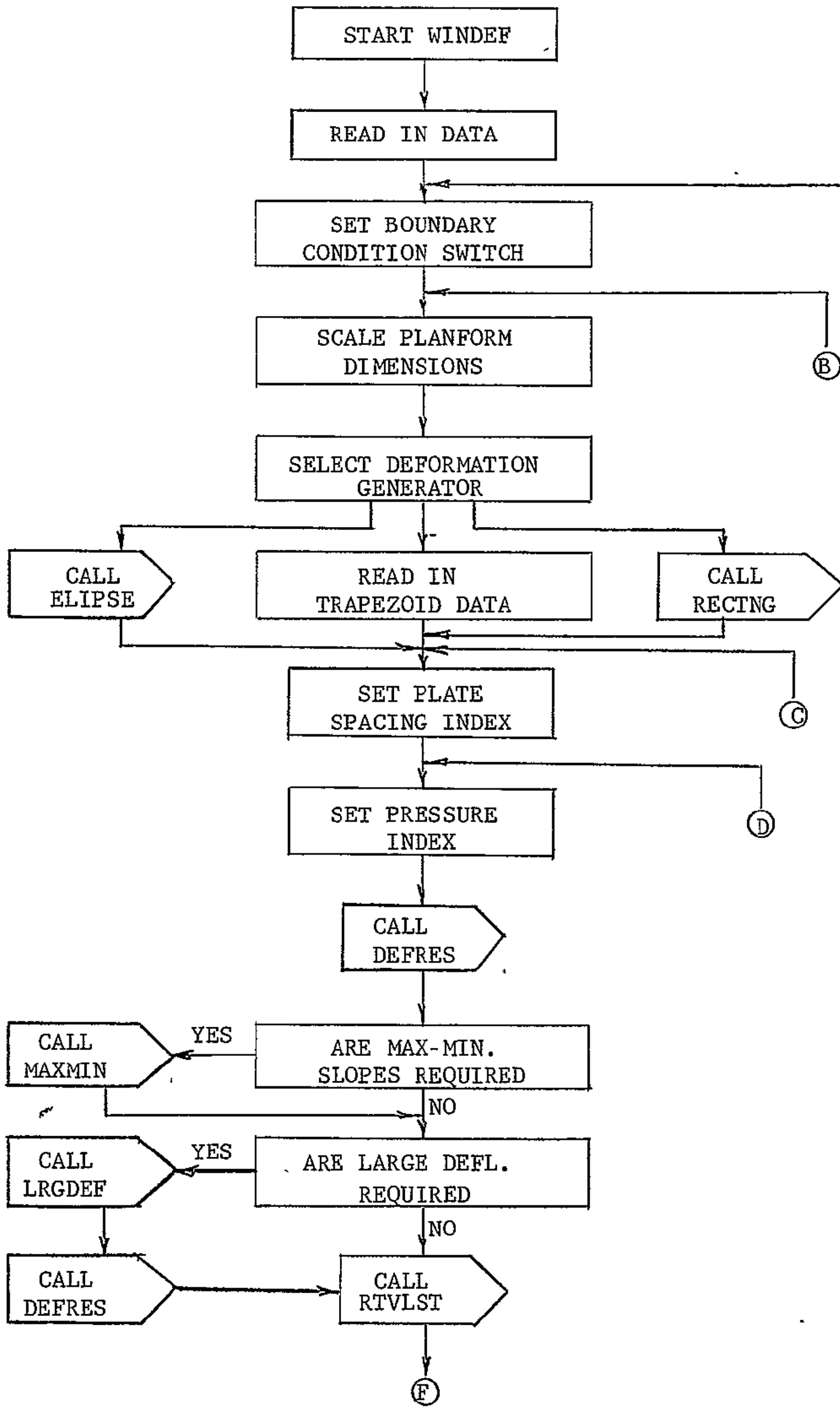


Figure 4a. Driver Flow Chart

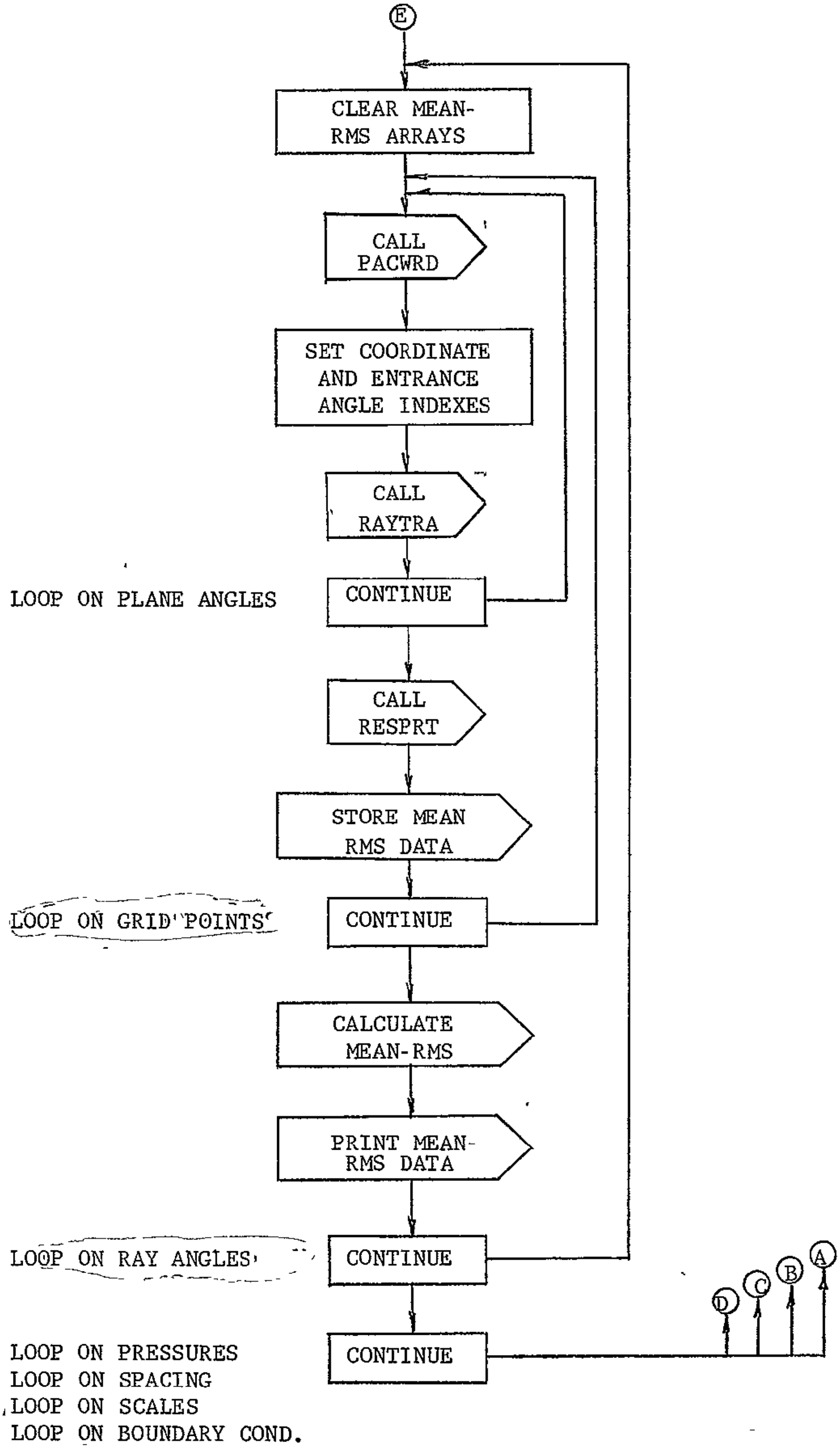


Figure 4b. Driver Flow Chart (cont'd)

Section 3

PROGRAM USAGE

This section presents information to assemble and submit a program deck, prepare a data deck, and interpret the output. The program deck is composed of system control cards,the computer code, and the data deck. The data deck consists of cards containing the information necessary to model the particular windows to be analyzed.

WINDEF is a FORTRAN IV program. It was checked out on the IBM 7094 DCS under version 13 of the IBJOB processor. Elliptical and rectangular parameters are introduced on punched cards. Trapezoidal parameters and deformation data are also read in on punched cards. Deformation output is on tape 7 (IS7) and the ray trace results are output on tapes 8 (IS8) and 9 (IS9). Mean and rms summation data and maximum-minimum slope data is output on the system output tape. The data on IS8 is for off-line printing. The data on IS9 is in binary format and can be read by the data retrieval program.

The following paragraphs provide a general description of the input requirements.

PROGRAM DECK MAKEUP

Figure 5 illustrates the order of the cards which make up the program deck when all the data is to be output on the system output tape (Mode 1).

The format for the control cards in the above deck is:

Columns:	1-7	8-80
	$JOB	(See Manual)
	$IBJOB	blank
	$DATA	blank

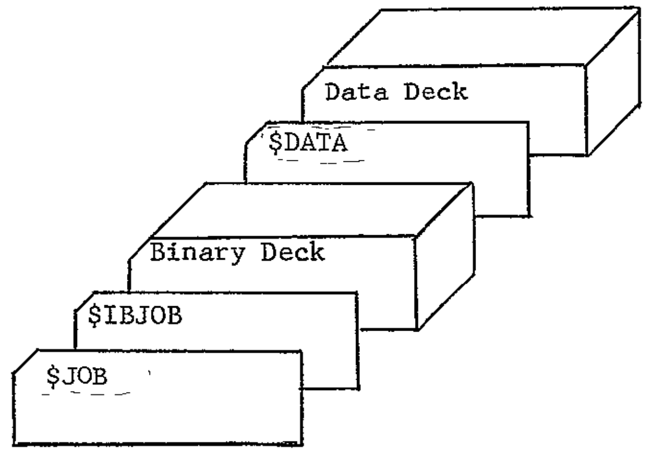


Figure 5. Program Deck-Mode 1

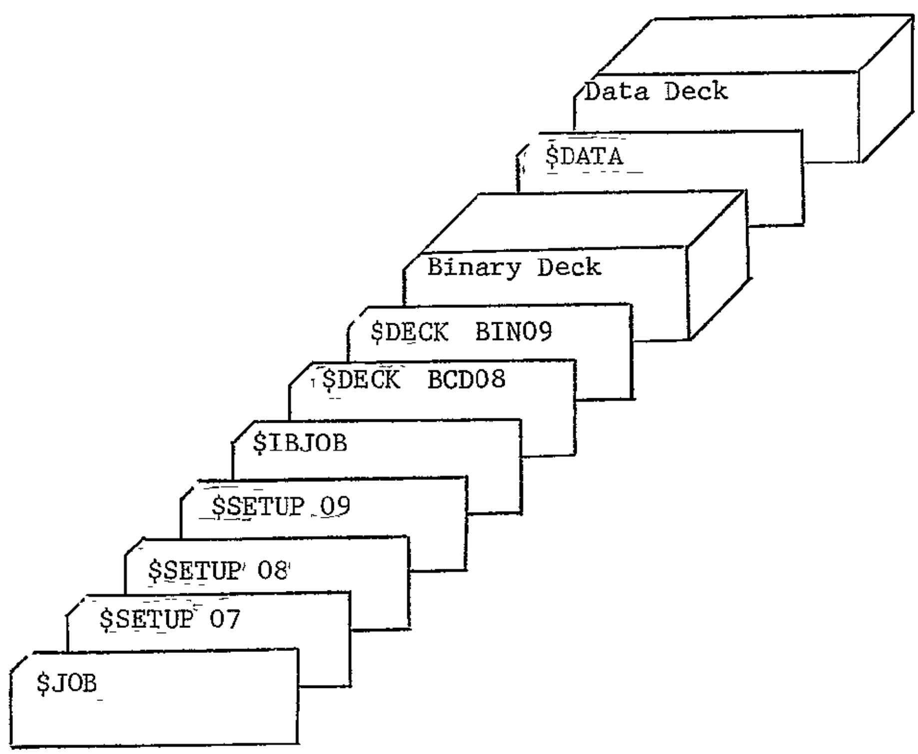


Figure 6. Program Deck-Mode 2

Figure 6 illustrates the order of the cards which make up the program deck when deformation data is output on tape 7, printed ray trace data is output on tape 8 for microfilming, and binary coded ray trace data is stored on tape 9 for later retrieval (Mode 2).

The format for the control cards in the above deck is:

Columns:	1-8	16-80
	$JOB	(See Manual)
	$SETUP 07	ASSIGN
	$SETUP 08	DISK, ASSIGN, 1
	$SETUP 09	ASSIGN
	$IBJOB	blank
	$DECK	BCD08
	$DECK	BIN09
	$DATA	blank

The Ames 7094 Operational Manual should be consulted for other items required on the $JOB cards.

DATA DECK MAKEUP

Figure 7 illustrates the arrangement of the data deck for multiple problems. This deck may include as many problems as desired, stacked one behind the other. The last problem is followed by two (2) blank or zero cards, i.e., column one to eighty are either all blank or filled with zeros.

Figures 8 and 9 illustrate the arrangement of the data cards within a single problem for the Single Ray Trace and Two Ray Trace data decks. The detailed format for each of the sets of cards in Figures 8 and 9 is explained in Tables 5 and 6. The numbers on the cards shown in the Figures 8 and 9 correspond to the numbers of the entries in Tables 5 and 6 respectively.

Note that the figures show the deck arrangement when trapezoidal deformation data are used. If elliptical or rectangular planforms are being analyzed, cards 13 and 14 are not used.

Several problems may be run using the same data by making multiple entries on cards 4 through 8 and entering the corresponding count on card 2. This compacted input format makes it very convenient to run combinations of problems with a minimum of input.

In the tables, three types of formats are indicated. They are:

1) Alphanumeric - Any combination of characters acceptable to the computer, (e.g., 26 letters, numerals 0 to 9, and special characters).

2) Integers - (e.g., 3, 14, -8).

3) Floating Point Numbers - (e.g., 21.7 + 2, 23.5 and 106-1, which are read as 21.7×10^{2}, 23.5, and 106×10^{-1} respectively).

In all instances, the input data <u>must</u> be right justified with respect to their assigned column locations on a card. If a number is to be placed in columns m-n, the rightmost digit (viewer's right) of the number must be in column n. Any consistent set of units for the physical quantities is permissible.

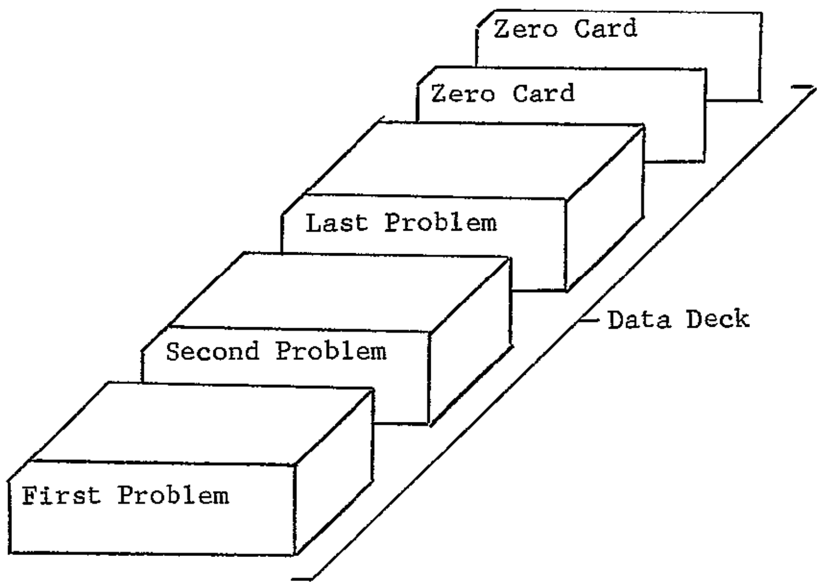


Figure 7. Data Deck

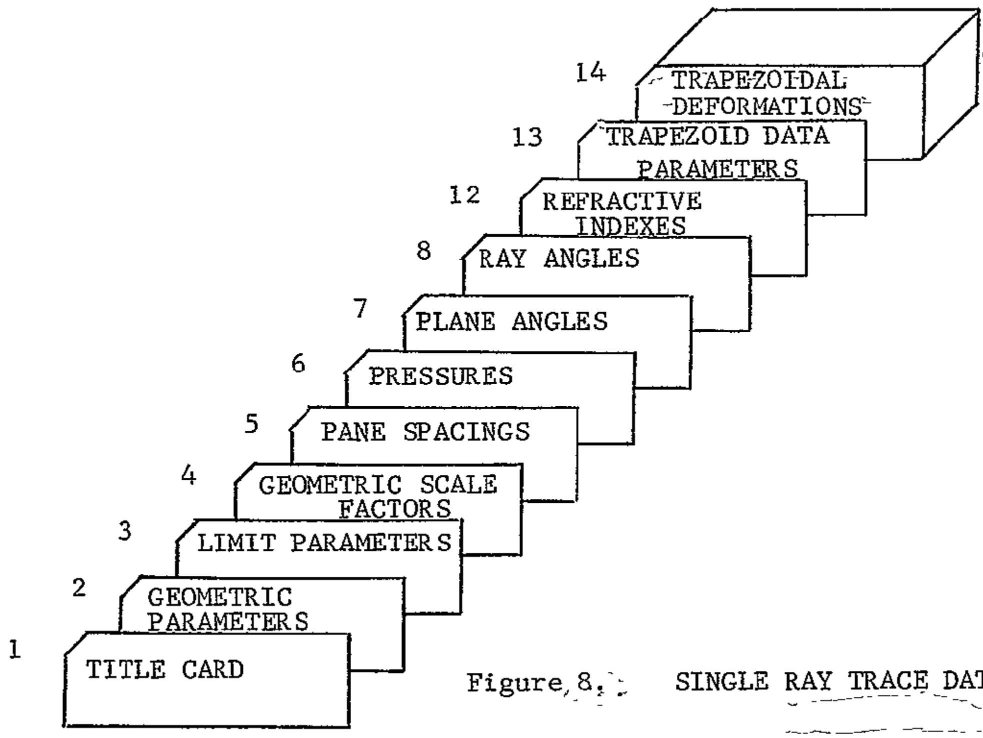


Figure 8. SINGLE RAY TRACE DATA DECK

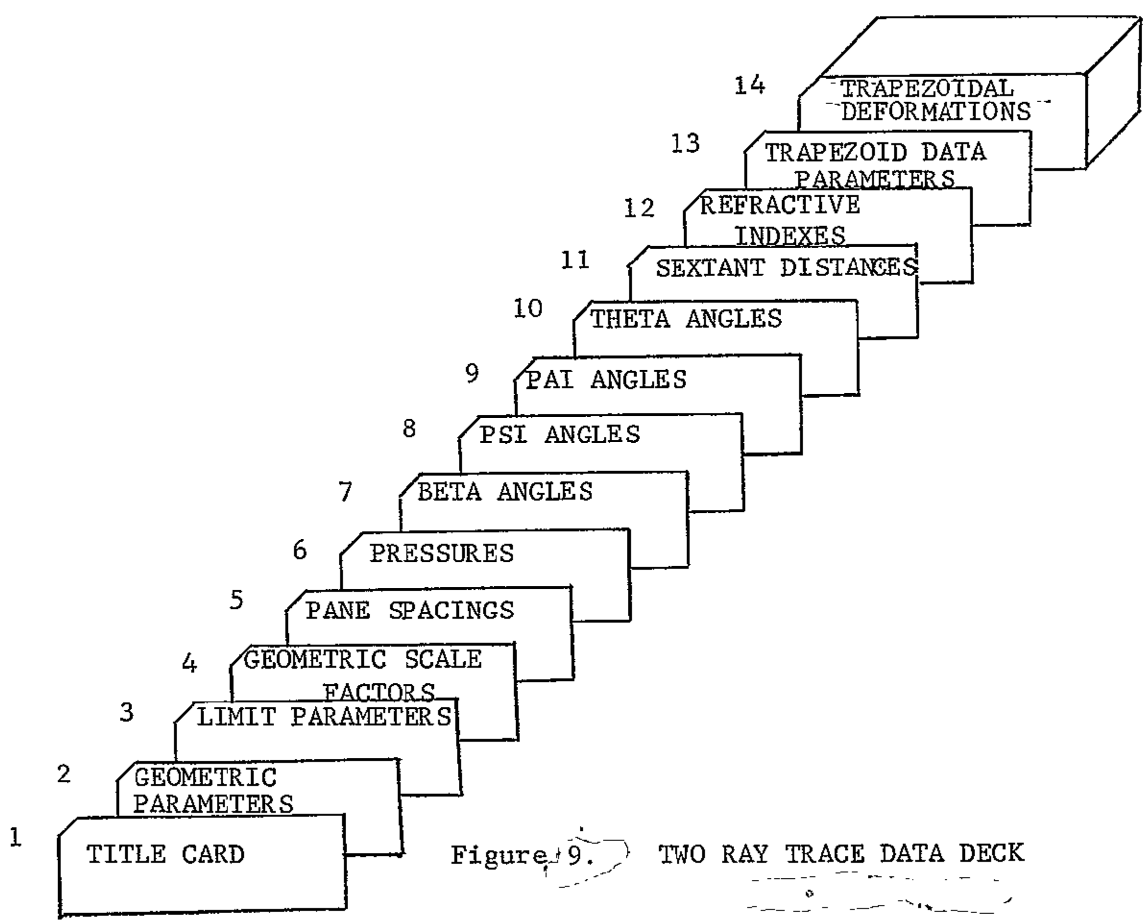


Figure 9. TWO RAY TRACE DATA DECK

Table 5

Single Ray Trace Input Data

1. Title Card

Columns	Symbol	Information	Format
1-5	IRT	Initial retrieval number minus 1	Integer
6-80	WORD(I)	Problem title	Alphanumeric

2. Geometric Parameters

Columns	Symbol	Information	Format
1	-	Leave blank	
2-5	SHAP	Planform shape[a] Enter: ELIP for ellipses[b] RECT for rectangles[b] TRAP for trapezoids[c]	Alphanumeric
6	-	Leave blank	
7-10	BONC	Boundary condition Enter: HING for hinged CLMP for clamped BOTH if both hinged and clamped conditions are to be evaluated	Alphanumeric
11-20	AA	Ellipse: x axis length Rectangle: long side length Trapezoid: base length (longest)	Floating
21-30	BB	Ellipse: y axis length Rectangle: short side length Trapezoid: height	Floating
31-40	CC	Trapezoid. base length (shortest)	Floating
41-50	THIC	Glass thickness	Floating
51-60	YONG	Young's modulus	Floating
61-70	GNU	Poisson's ratio	Floating
71-80	DEL	Coordinate point increment	Floating

---

a See Figure 10.

b A circle is an ellipse with A=B; a square is a rectnagle with A=B.

c Trapezoids must be regular trapezoids.

Table 5 (cont'd)

3. Limit Parameters

Columns	Symbol	Information	Format
1-5	NPAN	Number of panes (max.=2)	Integer
6-10	NSCL	Number of scale values (max.=8)	"
11-15	NSPC	Number of pane spacing values (max.=8)	"
16-20	NPRS	Number of pressure differences (max.=8)	"
21-25	NPAG	Number of plane angles (max.=8)	"
26-30	NRAG	Number of ray angles (max.=8)	"
31-35	IMAN	Set=1 to perform maximum/minimum calculations	"
36-40	ILGD	Set=1 to perform large deflection calculation (rectangles only)	"
41-45	IREL	Set=1 if trapezoidal x-axis boundary is an axis of symmetry	"
46-50	NOPRT	Set=0 to get displacements on tape 7, ray trace data on tapes 8 and 9. Set=1 to get all data on system output tape, ray trace data on tape 9 Set=2 to get rms and deformation data only	"
51-60	CPRSS	Cabin pressure for 2 pane cases	Floating
61-65	ISHR	Set=1 if rectangular shear deformation desired	Integer

4. Geometric Scale Values

Columns	Symbol	Information	Format
1-10	SCAL(I)	Scale value	Floating
11-20			"
.			.
.			.
.			.
71-80			"

Table 5 (cont'd)

5. Pane Spacing Values

Columns	Symbol	Information	Format
1-10	SPAC(I)	Spacing between panes of double pane windows	Floating
11-20			"
.			.
.			.
.			.
71-80			"

6. Pressure Values

Columns	Symbol	Information	Format
1-10	PRES(I)	Absolute (not gage) interstitial pressure	Floating
11-20			"
.			.
.			.
.			.
71-80			"

7. Plane Angles (see Figure 11)

Columns	Symbol	Information	Format
1-10	PLNA(I)	Plane angle measured from positive x-axis	Floating
11-20			"
.			.
.			.
.			.
71-80			"

8. Ray Angles (see Figure 11)

Columns	Symbol	Information	Format
1-10	RAYA(I)	Incidence angle	Floating
11-20			"
.			.
.			.
.			.
71-80			"

Table 5 (cont'd)

12. Refractive Indices (There will be 2 (NPAN) + 1 refractive indices)

Columns	Symbol	Information	Format
1-10	RI(I)	Refractive index	Floating
11-20			"
.			.
.			.
.			.
41-50			"

13. Trapezoid Data Paramters

Columns	Symbol	Information	Format
1-5	JLD[a]	Load no. of data to be accepted by program. JLD is the column code value output by SAMIS to identify different loadings	Integer
6-10	NCRD[b]	No. of cards of data to be read in	"
11-20	SCLFAC	Scaling factor	Floating
21-30	X1	X-coordinate of origin of coordinates	Floating
31-40	Y1	Y-coordinate of origin of coordinates	Floating
41-45	NTX	No. of intervals along x-axis to center of interpolation	Integer
46-50	NTY	No. of intervals along y-axis to center of interpolation	Integer

14. Trapezoidal Data

Columns	Symbol	Information	Format
1-6	LOC(J)	Row/col. code ($J_{max.}$=3)	Integer
7-12	ILD(J)	Load number ($J_{max.}$=3)	"

---

[a] If JLD is negative, data is not to be scaled for pressure.

[b] If NCRD is negative, data for one pane is input and is used for both panes.

Table 5 (cont'd)

14. Trapezoidal Data (continued)

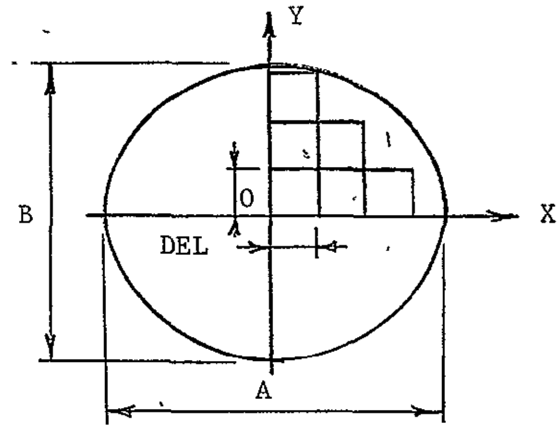
Columns	Symbol	Information	Format
13-24	ELM(J)	Deformation value ($J_{max.}$=3)	Octal
25-48		Same format as 1-24	
49-72		Same format as 1-24	

The rightmost digit it LOC(J) indicates which deformation is stored at ELM(J). The digit-deformation correspondences are:

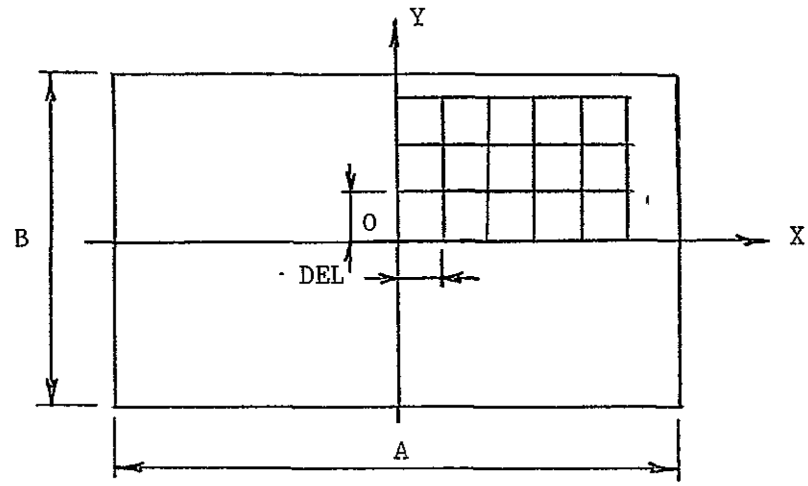
3 = deflection

4 = slope about x-axis

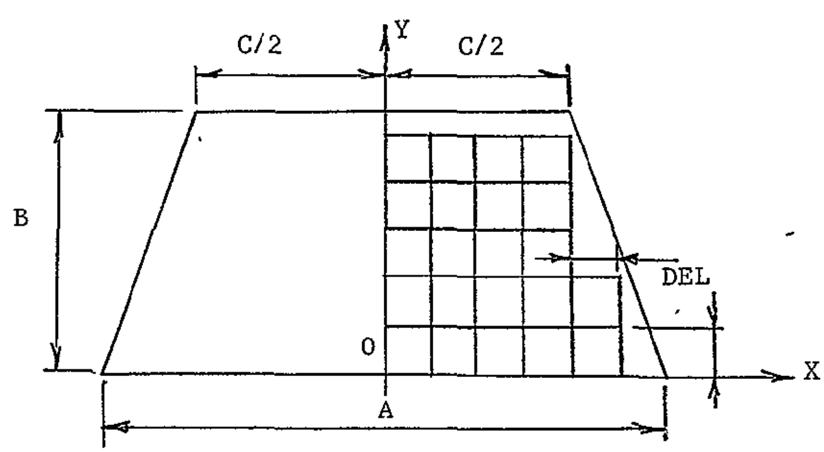
5 = slope about y-axis



(a) Ellipse



(b) Rectangle



(c) Trapezoid

Figure 10. Planform Shapes

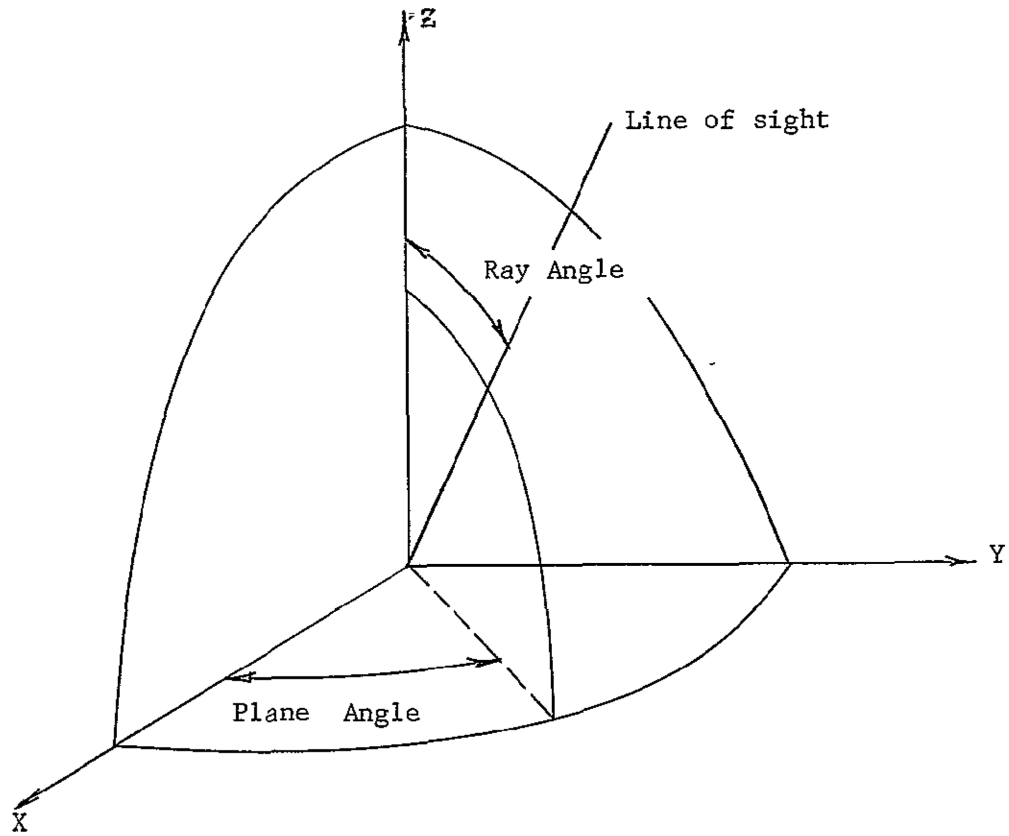


Figure 11. Single Ray Trace Angles

Table 6

Two Ray Trace Input Data

1. Title Card

Columns	Symbol	Information	Format
1-5	IRT	Initial retrieval number minus 1	Integer
6-80	WORD(I)	Problem title	Alphanumeric

2. Geometric Parameters

Columns	Symbol	Information	Format
1	-	Leave blank	
2-5	SHAP	Planform shape[a] Enter. ELIP for ellipses[b] RECT for rectangles[b] TRAP for trapezoids[c]	Alphanumeric
6	-	Leave blank	
7-10	BONC	Boundary condition Enter: HING for hinged CLMP for clamped BOTH if both hinged and clamped conditions are to be evaluated	Alphanumeric
11-20	AA	Ellipse: x axis length Rectangle: long side length Trapezoid: base length (longest)	Floating
21-30	BB	Ellipse: y axis length Rectangle. short side length Trapezoid: height	Floating
31-40	CC	Trapezoid: base length (shortest)	Floating
41-50	THIC	Glass thickness	Floating
51-60	YONG	Young's modulus	Floating
61-70	GNU	Poisson's ratio	Floating
71-80	DEL	Coordinate point increment	Floating

---

a See Figure 10.

b A circle is an ellipse with A=B; a square is a rectangle with A=B.

c Trapezoids must be regular trapezoids.

Table 6 (cont'd)

3. Limit Parameters

Columns	Symbol	Information	Format
1-5	NPAN	Number of panes (max.=2)	Integer
6-10	NSCL	Number of scale values (max.=8)	"
11-15	NSPC	Number of pane spacing values (max.=8)	"
16-20	NPRS	Number of pressure differences (max.=8)	"
21-30	NOPRT	See Table 1 for NOPRT flags	"
31-35	IMAN	Set=1 to perform maximum/minimum calculations	"
36-40	ILGD	Set=1 to perform large deflection calculations (rectangles only)	"
41-45	IREL	Set=1 if trapezoidal x-axis boundary is an axis of symmetry	"
46-50	NBET	Number of Beta angles (max.=8)	"
51-55	NPSI	Number of PSI angles (max.=8)	"
56-60	NPAI	Number of PAI angles (max.=8)	"
61-65	NTHE	Number of THETA angles (max.=8)	"
66-70	NSEX	Number of sextant distances (max.=8)	"
71-80	CPRSS	Cabin pressure for 2 panes cases	Floating

4. Geometric Scale Values

Columns	Symbol	Information	Format
1-10	SCAL(I)	Scale value	Floating
11-20			
.			
.			
.			
71-81			

Table 6 (cont'd)

5. Pane Spacing Values

Columns	Symbol	Information	Format
1-10	SPAC(I)	Spacing between panes of double pane windows	Floating
11-20			"
.			.
.			.
.			.
71-80			"

6. Pressure Values

Columns	Symbol	Information	Format
1-10	PRES(I)	Absolute (not gage) interstitial pressure	Floating
11-20			"
.			.
.			.
.			.
71-80			"

7. Beta Angles (see Figure 12)

Columns	Symbol	Information	Format
1-10	BETA(I)	Plane angle measured from positive x-axis	Floating
11-20			"
.			.
.			.
.			.
71-80			"

8. PSI Angle (see Figure 12)

Columns	Symbol	Information	Format
1-10	PSIA(I)	Z-plane inclination angle	Floating
11-20			"
.			.
.			.
.			.
71-80			"

Table 6 (cont'd)

9. PAI Angle (see Figure 12)

Columns	Symbol	Information	Format
1-10	PAIA(I)	Primary line-of-sight angle	Floating
11-20			"
.			.
. .			.
.			.
71-80			"

10. Theata Angle (see Figure 12)

Columns	Symbol	Information	Format
1-10	THEA(I)	Sextant angle (must be positive)	Floating
11-20			"
.			.
.			.
.			.
71-80			"

11. Sextant Distances

Columns	Symbol	Information	Format
1-10	ZSEXT(I)	Distance of sextant from window	Floating
11-20			"
.			.
.			.
.			.
71-80			"

12. Refractive Indices (There will be 2(NPAN) +1 refractive indices)

Columns	Symbol	Information	Format
1-10	RI(I)	Refractive index	Floating
11-20			"
.			.
.			.
.			.
71-80			"

Table 6 (cont'd)

13. Trapezoid Data Parameters

Columns	Symbol	Information	Format
1-5	JLD[a]	Load no. of data to be accepted by program. JLD is the column code value output by SAMIS to identify different loadings.	Integer
6-10	NCRD[b]	No. of cards of data to be read in	"
11-20	SCLFAC	Scaling factor	Floating
21-30	X1	X-coordinate of origin of coordinates	Floating
31-40	Y1	Y-coordinate of origin of coordinates	Floating
41-45	NTX	No. of intervals along x-axis to center of interpolation	Integer
46-50	NTY	No. of intervals along y-axis to center of interpolation	Integer

14. Trapezoidal Data

Columns	Symbol	Information	Format
1-6	LOC(J)	Row/col. code ($J_{max.}$=3)	Integer
7-12	ILD(J)	Load number ($J_{max.}$=3)	"
13-24	ELM(J)	Deformation value ($J_{max.}$=3)	Octal
25-48		Same format as 1-24	
49-72		Same format as 1-24	

[a]If JLD is negative, data is not to be scaled for pressure.

[b]If NCRD is negative, data for one pane is input and is used for both panes.

Table 6 (cont'd)

The rightmost digit in LOC(J) indicates which deformation is stored at ELM(J). The digit-deformation correspondences are:

3 = deflection

4 = slope about x-axis

5 = slope about y-axis

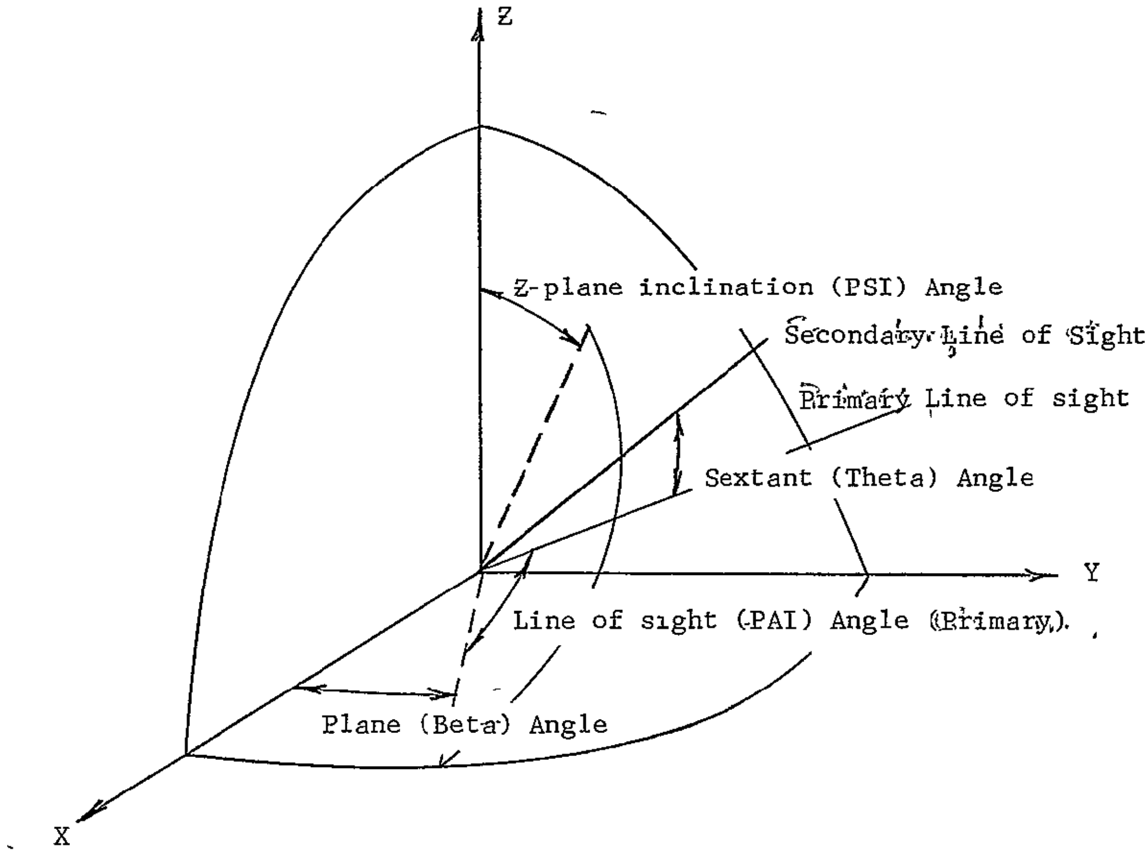


Figure (12) Two Ray Trace Angles

OUTPUT FORMAT

The output for the window deformation data is shown in Figure 13. This output is put on tape 7 (IS7) in a form for printing. The retrieval number is assigned by the analyst to enable retrieval of the data from tape 9. The first line of printout after the title describes the physical parameters of the window being analyzed. The first word denotes the planform shape. A, B, and C are the dimensions of the window. SCALE is the factor by which the dimensions have been multiplied (to study windows of the same shape with different dimensions). The thickness, number of panes, and pane spacing are given. PRESSURE is the interstitial pressure if there are two panes or the cabin pressure if there is only one pane. The edge fixity is given by the last word on the line. The rest of the output consists of a tabulation of the point coordinates (in inches) and the associated deflections for the inner (pane 1) and outer (pane 2) panes. If there is only one pane the deflections of pane 2 are given as zeroes. The deflections are measured in inches.

The output for the ray trace (line of sight) data is shown in Figure 14. This output is put on tape 8 (IS8) in a form for printing and on tape 9 (IS9) in binary format. If the line of sight data is to be retrieved, tape IS9 should be mounted and called by the data retrieval program. The details of the data retrieval program are given in Appendix C. The first line following the title gives the physical parameters of the window being analyzed. The next line gives the coordinates of the point at which the incidence angle strikes the reference surface (see Figure 2). The angle D1 is the incidence angle measured in degrees. The remainder of the output is a tabulation of the ray trace data for each plane angle (A1) requested by the analyst.

RETRIEVAL NUMBER = 1

W I N D O W   D E F O R M A T I O N   D A T A

RECTANGLE A= 9.30 B= 9.30 SCALE=0.75 THICKNESS= 0.30 PANES=2 SPACING=1.0 PRESSURE= 7.5 HINGED

COORDINATES		DEFORMATIONS		COORDINATES		DEFORMATIONS	
X	Y	DEFL. PANE 1	DEFL. PANE 2	X	Y	DEFL. PANE 1	DEFL. PANE 2
0.00	0.00	-0.288272E-02	0.940018E-02	0.50	0.00	-0.284498E-02	0.927711E-02
1.00	0.00	-0.273222E-02	0.890941E-02	1.50	0.00	-0.254587E-02	0.830175E-02
2.00	0.00	-0.228851E-02	0.746254E-02	2.50	0.00	-0.196417E-02	0.640489E-02
3.00	0.00	-0.157870E-02	0.514792E-02	3.50	0.00	-0.114036E-02	0.371857E-02
4.00	0.00	-0.660475E-03	0.215372E-02	4.50	0.00	-0.154197E-03	0.502817E-03
0.00	0.50	-0.284498E-02	0.927711E-02	0.50	0.50	-0.280776E-02	0.915572E-02
1.00	0.50	-0.269653E-02	0.879303E-02	1.50	0.50	-0.251270E-02	0.819360E-02
2.00	0.50	-0.225881E-02	0.736570E-02	2.50	0.50	-0.193880E-02	0.632216E-02
3.00	0.50	-0.155841E-02	0.508179E-02	3.50	0.50	-0.112579E-02	0.367106E-02
4.00	0.50	-0.652079E-03	0.212634E-02	4.50	0.50	-0.152242E-03	0.496443E-03
0.00	1.00	-0.273222E-02	0.890941E-02	0.50	1.00	-0.269653E-02	0.879303E-02
1.00	1.00	-0.258988E-02	0.844525E-02	1.50	1.00	-0.241359E-02	0.787039E-02
2.00	1.00	-0.217004E-02	0.707621E-02	2.50	1.00	-0.186294E-02	0.607482E-02
3.00	1.00	-0.149776E-02	0.488401E-02	3.50	1.00	-0.108222E-02	0.352896E-02
4.00	1.00	-0.626961E-03	0.204444E-02	4.50	1.00	-0.146395E-03	0.477375E-03
0.00	1.50	-0.254587E-02	0.830175E-02	0.50	1.50	-0.251270E-02	0.819360E-02
1.00	1.50	-0.241359E-02	0.787039E-02	1.50	1.50	-0.224970E-02	0.733599E-02
2.00	1.50	-0.202320E-02	0.659738E-02	2.50	1.50	-0.173743E-02	0.566553E-02
3.00	1.50	-0.139736E-02	0.455660E-02	3.50	1.50	-0.101005E-02	0.329364E-02
4.00	1.50	-0.585351E-03	0.190875E-02	4.50	1.50	-0.136707E-03	0.445784E-03
0.00	2.00	-0.228851E-02	0.746254E-02	0.50	2.00	-0.225881E-02	0.736570E-02
1.00	2.00	-0.217004E-02	0.707621E-02	1.50	2.00	-0.202320E-02	0.659738E-02
2.00	2.00	-0.182013E-02	0.593522E-02	2.50	2.00	-0.156374E-02	0.509916E-02
3.00	2.00	-0.125832E-02	0.410321E-02	3.50	2.00	-0.910050E-03	0.296755E-02
4.00	2.00	-0.527665E-03	0.172065E-02	4.50	2.00	-0.123273E-03	0.401977E-03
0.00	2.50	-0.196417E-02	0.640489E-02	0.50	2.50	-0.193880E-02	0.632216E-02
1.00	2.50	-0.186294E-02	0.607482E-02	1.50	2.50	-0.173743E-02	0.566553E-02
2.00	2.50	-0.156374E-02	0.509916E-02	2.50	2.50	-0.134423E-02	0.438337E-02
3.00	2.50	-0.108242E-02	0.352963E-02	3.50	2.50	-0.783420E-03	0.255463E-02
4.00	2.50	-0.454562E-03	0.148227E-02	4.50	2.50	-0.106242E-03	0.346441E-03
0.00	3.00	-0.157870E-02	0.514792E-02	0.50	3.00	-0.155841E-02	0.508178E-02
1.00	3.00	-0.149776E-02	0.488401E-02	1.50	3.00	-0.139736E-02	0.455660E-02
2.00	3.00	-0.125832E-02	0.410321E-02	2.50	3.00	-0.108242E-02	0.352963E-02

Figure 13. Output - Window Deformation Data

FOLDOUT FRAME 1

FOLDOUT FRAME 2

RETRIEVAL NUMBER = 1

RAY TRACE DATA

ELLIPSE A=17.20 B=11.40 SCALE=1.00 THICKNESS= 0.30 PANES=2 SPACING=0.5 PRESSURE= 5.0 HINGED

X = 0.00 Y = 0.00 D1 = 45.00

A1	DEG.	0.000000	45.000000	90.000000	135.000000	180.000000	225.000000	270.000000	315.000000
XOUT	IN.	0.859547	0.607689	0.000000	-0.607689	-0.859547	-0.607689	-0.000000	0.607689
YOUT	IN.	-0.000000	0.607753	0.859348	0.607753	0.000000	-0.607753	-0.859348	-0.607753
ZOUT	IN.	1.126596	1.126410	1.126224	1.126410	1.126596	1.126410	1.126224	1.126410
A2OUT	DEG.	0.000000	44.996014	89.999999	135.003983	179.999996	224.995998	269.999981	315.003967
D2OUT	DEG.	44.997862	44.993917	44.990003	44.993918	44.997862	44.993917	44.990003	44.993919
A1-A2	SEC.	-0.3660E-04	0.1435E 02	0.0000E-38	-0.1434E 02	0.6147E-02	0.1440E 02	0.4918E-01	-0.1430E 02
D1-D2	SEC.	0.7695E 01	0.2189E 02	0.3599E 02	0.2189E 02	0.7695E 01	0.2189E 02	0.3599E 02	0.2189E 02
THETA	SEC.	0.7668E 01	0.2411E 02	0.3597E 02	0.2411E 02	0.7663E 01	0.2411E 02	0.3596E 02	0.2410E 02
ITHE	SEC.	0.000126	20.538464	35.968629	20.536927	0.001099	-20.534622	-35.964019	-20.533854
JTHE	SEC.	-7.667826	-10.393328	-0.000673	10.390254	7.663216	10.391791	0.001394	-10.391023
KTHE	SEC.	-0.000126	-7.173748	0.000672	7.174516	0.001099	-7.172211	0.001392	7.171827

X = 1.00 Y = 0.00 D1 = 45.00

A1	DEG.	0.000000	45.000000	90.000000	135.000000	180.000000	225.000000	270.000000	315.000000
XOUT	IN.	1.858490	1.607128	1.000133	0.392429	0.140355	0.392429	1.000133	1.607128
YOUT	IN.	-0.000000	0.607059	0.858867	0.607768	0.000000	-0.607768	-0.858867	-0.607059
ZOUT	IN.	1.125296	1.125351	1.125745	1.126514	1.126944	1.126514	1.125745	1.125351
A2OUT	DEG.	-0.000000	44.995956	89.999860	135.003986	179.999996	224.995995	270.000118	315.004021
D2OUT	DEG.	44.998249	44.994278	44.990097	44.993809	44.997787	44.993809	44.990097	44.994277
A1-A2	SEC.	0.8726E-04	0.1456E 02	0.5010E 00	-0.1436E 02	0.6147E-02	0.1441E 02	-0.4426E 00	-0.1450E 02
D1-D2	SEC.	0.6301E 01	0.2060E 02	0.3565E 02	0.2229E 02	0.7964E 01	0.2229E 02	0.3565E 02	0.2060E 02
THETA	SEC.	0.6277E 01	0.2301E 02	0.3563E 02	0.2447E 02	0.7938E 01	0.2446E 02	0.3563E 02	0.2301E 02
ITHE	SEC.	0.000188	19.695533	35.632072	20.820465	0.001261	-20.815855	-35.626693	-19.694765
JTHE	SEC.	-6.277029	-9.403634	0.250530	10.659961	7.938302	10.662267	0.252614	-9.405170
KTHE	SEC.	-0.000188	-7.277481	-0.250530	7.183737	0.001261	-7.179895	0.252612	7.275560

Figure 14. Output - Ray Trace Data

When maximum-minimum slopes are required, the deflection and maximum and minimum slopes are printed on the system output tape. The output for this data is shown in Figure 15. The first line following the title gives the physical parameters of the window being analyzed. The remainder of the output consists of a tabulation of the coordinates of the point under investigation along with the deflections at that point and the maximum and minimum slopes (in radians) and orientation angles. The orientation angles are measured relative to the positive x-axis.

The mean and rms summation data for sets of collinear rays also appear on the system output tape. The output for this data is shown in Figure 16. The first line following the title gives the incidence angle. The rest of the output consists of a tabulation of the plane angles and their respective mean and rms values. The "no. points" indicates the total number of points on the window which were used in the calculation of the mean and rms values.

A retrieval list also appears on the system output tape. The list contains the retrieval index number and the parameters associated with each problem for one run on the computer. The output for the retrieval list is shown in Figure 17.

The output for the two ray trace data is shown in Figure 18. This output appears on the system output tape. The first line following the title gives the physical parameters of the window being analyzed. The next lines give the values of other parameters affecting the ray tracing. "ZSEXT" is the distance of the sextant from the window reference surface. "BETA" is the plane angle, "PSI" is the z-plane inclination angle, "THETA" is the sextant angle,

W I N D O W   D E F O R M A T I O N S - D E F L E C T I O N,   M A X I M U M   A N D   M I N I M U M   S L O P E

ELLIPSE A=10.00 B=10.00 SCALE=1.00 THICKNESS= 0.30 PANES=1 SPACING=*** PRESSURE= 10.0 HINGED

(ANGLE IS IN DEGREES MEASURED WITH RESPECT TO THE POSITIVE X-AXIS)

COORDINATES X	Y	DEFLECTION	MAXIMUM SLOPE	SLOPE ANGLE	MINIMUM SLOPE	SLOPE ANGLE
0.50	0.50	0.16436E-01	0.12014E-02	48.	-0.20955E-04	136.
1.50	0.50	0.14785E-01	0.32701E-02	90.	-0.25611E-04	180.
2.50	0.50	0.11647E-01	0.54028E-02	98.	0.31432E-04	8.
3.50	0.50	0.73346E-02	0.69797E-02	100.	-0.10070E-03	10.
4.50	0.50	0.20648E-02	0.83423E-02	98.	-0.61700E-04	8.
5.50	0.50	0.20648E-02	0.83423E-02	98.	-0.61700E-04	8.
0.50	1.50	0.14785E-01	-0.32713E-02	180.	0.24447E-04	90.
1.50	1.50	0.13173E-01	0.33842E-02	46.	-0.59372E-04	136.
2.50	1.50	0.10126E-01	0.46962E-02	72.	-0.66357E-04	162.
3.50	1.50	0.59584E-02	0.59942E-02	84.	-0.90222E-04	174.
4.50	1.50	0.16139E-02	0.50818E-02	86.	-0.61118E-05	176.
0.50	2.50	0.11647E-01	-0.53970E-02	174.	0.30268E-04	82.
1.50	2.50	0.10126E-01	0.46962E-02	20.	0.67521E-04	108.
2.50	2.50	0.72757E-02	0.48988E-02	44.	0.84401E-04	134.
3.50	2.50	0.29470E-02	0.70658E-02	60.	-0.82073E-04	150.
4.50	2.50	0.29470E-02	0.70658E-02	60.	-0.82073E-04	150.
0.50	3.50	0.73346E-02	-0.69803E-02	170.	-0.10012E-03	80.
1.50	3.50	0.59584E-02	0.59948E-02	6.	0.89640E-04	96.
2.50	3.50	0.34088E-02	0.54843E-02	28.	0.86147E-04	116.
3.50	3.50	0.47326E-03	0.29512E-02	40.	0.24265E-04	130.
0.50	4.50	0.20648E-02	-0.83423E-02	172.	-0.61700E-04	82.
1.50	4.50	0.20648E-02	-0.83423E-02	172.	-0.61700E-04	82.
2.50	4.50	0.20648E-02	-0.83423E-02	172.	-0.61700E-04	82.
3.50	4.50	0.20648E-02	-0.83423E-02	172.	-0.61700E-04	82.
0.50	5.50	0.20648E-02	-0.83423E-02	172.	-0.61700E-04	82.

Figure 15. Output - Maximum and Minimum Slopes

FOLDOUT FRAME 1

FOLDOUT FRAME 2

RAY TRACE DATA

MEAN AND RMS SUMMATION

ELLIPSE A=17.20 B=11.40 SCALE=1.00 THICKNESS= 0.30 PANES=2 SPACING=0.5 PRESSURE= 5.0 HINGED

RAY ANGLE (D1) = 45.00 DEG.

PLANE ANGLE	MEAN	RMS	NO. POINTS
0.0	0.7301E 01	0.4958E 01	31
45.0	0.1345E 02	0.5904E 01	28
90.0	0.2329E 02	0.7910E 01	28
135.0	0.1659E 02	0.5921E 01	33
180.0	0.6496E 01	0.3641E 01	36
225.0	0.1644E 02	0.5705E 01	36
270.0	0.2699E 02	0.6800E 01	36
315.0	0.1807E 02	0.3853E 01	33

Figure 16. Output - Mean and RMS Summation

FOLDOUT FRAME 1

FOLDOUT FRAME 2

RETRIEVAL NUMBER	SHAPE	A IN.	B IN.	C IN.	THICKNESS IN.	PANES	SPACING[a] IN.	PRESSURE LB.	FIXITY
1	ELLIPSE	3.60	3.60	0.00	0.30	1	*****	5.0	HINGED
2	ELLIPSE	3.60	3.60	0.00	0.30	1	*****	7.5	HINGED
3	ELLIPSE	3.60	3.60	0.00	0.30	1	*****	10.0	HINGED
4	ELLIPSE	3.60	3.60	0.00	0.30	1	*****	15.0	HINGED
5	ELLIPSE	3.24	3.24	0.00	0.30	1	*****	5.0	HINGED
6	ELLIPSE	3.24	3.24	0.00	0.30	1	*****	7.5	HINGED
7	ELLIPSE	3.24	3.24	0.00	0.30	1	*****	10.0	HINGED
8	ELLIPSE	3.24	3.24	0.00	0.30	1	*****	15.0	HINGED
9	ELLIPSE	4.32	4.32	0.00	0.30	1	*****	5.0	HINGED
10	ELLIPSE	4.32	4.32	0.00	0.30	1	*****	7.5	HINGED
11	ELLIPSE	4.32	4.32	0.00	0.30	1	*****	10.0	HINGED
12	ELLIPSE	4.32	4.32	0.00	0.30	1	*****	15.0	HINGED
13	ELLIPSE	4.68	4.68	0.00	0.30	1	*****	5.0	HINGED
14	ELLIPSE	4.68	4.68	0.00	0.30	1	*****	7.5	HINGED
15	ELLIPSE	4.68	4.68	0.00	0.30	1	*****	10.0	HINGED
16	ELLIPSE	4.68	4.68	0.00	0.30	1	*****	15.0	HINGED
17	ELLIPSE	3.60	3.60	0.00	0.30	1	*****	5.0	CLAMPED
18	ELLIPSE	3.60	3.60	0.00	0.30	1	*****	7.5	CLAMPED
19	ELLIPSE	3.60	3.60	0.00	0.30	1	*****	10.0	CLAMPED
20	ELLIPSE	3.60	3.60	0.00	0.30	1	*****	15.0	CLAMPED
21	ELLIPSE	3.24	3.24	0.00	0.30	1	*****	5.0	CLAMPED
22	ELLIPSE	3.24	3.24	0.00	0.30	1	*****	7.5	CLAMPED
23	ELLIPSE	3.24	3.24	0.00	0.30	1	*****	10.0	CLAMPED
24	ELLIPSE	3.24	3.24	0.00	0.30	1	*****	15.0	CLAMPED
25	ELLIPSE	4.32	4.32	0.00	0.30	1	*****	5.0	CLAMPED
26	ELLIPSE	4.32	4.32	0.00	0.30	1	*****	7.5	CLAMPED
27	ELLIPSE	4.32	4.32	0.00	0.30	1	*****	10.0	CLAMPED
28	ELLIPSE	4.32	4.32	0.00	0.30	1	*****	15.0	CLAMPED
29	ELLIPSE	4.68	4.68	0.00	0.30	1	*****	5.0	CLAMPED
30	ELLIPSE	4.68	4.68	0.00	0.30	1	*****	7.5	CLAMPED
31	ELLIPSE	4.68	4.68	0.00	0.30	1	*****	10.0	CLAMPED
32	ELLIPSE	4.68	4.68	0.00	0.30	1	*****	15.0	CLAMPED
33	RECTANGLE	3.00	3.00	0.00	0.30	1	*****	5.0	HINGED
34	RECTANGLE	3.00	3.00	0.00	0.30	1	*****	7.5	HINGED
35	RECTANGLE	3.00	3.00	0.00	0.30	1	*****	10.0	HINGED
36	RECTANGLE	3.00	3.00	0.00	0.30	1	*****	15.0	HINGED
37	RECTANGLE	2.70	2.70	0.00	0.30	1	*****	5.0	HINGED
38	RECTANGLE	2.70	2.70	0.00	0.30	1	*****	7.5	HINGED
39	RECTANGLE	2.70	2.70	0.00	0.30	1	*****	10.0	HINGED
40	RECTANGLE	2.70	2.70	0.00	0.30	1	*****	15.0	HINGED

a. Pane Spacing Values are not applicable when only one pane is considered and are indicated as "*****."

Figure 17. Output - Retrieval List

FOLDOUT FRAME 1

FOLDOUT FRAME 2

RETRIEVAL NUMBER = 1

TWO RAY TRACE DATA

ELLIPSE A=14.00 B=14.00 SCALE=1.00 THICKNESS= 0.30 PANES=2 SPACING=0.3 PRESSURE= 10.0 HINGED

ZSEXT= 4.000 IN. BETA= 135.00 DEG. PSI= 0.00 DEG. THETA= 0.00 DEG. PAI= 90.00 DEG. SAI= 90.00 DEG.

XP IN	YP IN	XP OUT	YP OUT	XS IN	YS IN	XS OUT	YS OUT	ERROR (SEC)
0.0000	0.0000	-0.0000	0.0000	2.4486	-2.4486	2.4490	-2.4490	1.04848
1.0000	0.0000	1.0002	0.0000	3.4486	-2.4486	3.4491	-2.4490	0.88319
2.0000	0.0000	2.0003	0.0000	4.4486	-2.4486	4.4492	-2.4489	0.67565
3.0000	0.0000	3.0005	0.0000	5.4486	-2.4486	5.4493	-2.4489	0.47786
4.0000	0.0000	4.0006	0.0000	6.4486	-2.4486	6.4493	-2.4489	0.40405
5.0000	0.0000	5.0007	0.0000	7.4486	-2.4486	7.4492	-2.4488	0.51338
6.0000	0.0000	6.0007	0.0000	8.4486	-2.4486	8.4492	-2.4488	0.67047
7.0000	0.0000	7.0007	0.0000	9.4486	-2.4486	9.4490	-2.4487	0.75766
0.0000	1.0000	-0.0000	1.0002	2.4486	-1.4486	2.4490	-1.4488	1.14827
1.0000	1.0000	1.0002	1.0002	3.4486	-1.4486	3.4491	-1.4488	1.01673
2.0000	1.0000	2.0003	1.0002	4.4486	-1.4486	4.4492	-1.4488	0.83633
3.0000	1.0000	3.0005	1.0002	5.4486	-1.4486	5.4493	-1.4488	0.64515
4.0000	1.0000	4.0006	1.0001	6.4486	-1.4486	6.4493	-1.4488	0.51475
5.0000	1.0000	5.0007	1.0001	7.4486	-1.4486	7.4493	-1.4487	0.52127
6.0000	1.0000	6.0007	1.0001	8.4486	-1.4486	8.4492	-1.4487	0.62114
0.0000	2.0000	-0.0000	2.0003	2.4486	-0.4486	2.4490	-0.4487	1.17312
1.0000	2.0000	1.0002	2.0003	3.4486	-0.4486	3.4491	-0.4487	1.07661
2.0000	2.0000	2.0003	2.0003	4.4486	-0.4486	4.4492	-0.4487	0.92533
3.0000	2.0000	3.0004	2.0003	5.4486	-0.4486	5.4493	-0.4487	0.74955
4.0000	2.0000	4.0006	2.0003	6.4486	-0.4486	6.4493	-0.4487	0.60059
5.0000	2.0000	5.0006	2.0003	7.4486	-0.4486	7.4493	-0.4487	0.54315
6.0000	2.0000	6.0007	2.0002	8.4486	-0.4486	8.4492	-0.4486	0.58206
0.0000	3.0000	-0.0000	3.0005	2.4486	0.5514	2.4490	0.5515	1.12325
1.0000	3.0000	1.0002	3.0005	3.4486	0.5514	3.4491	0.5515	1.06157
2.0000	3.0000	2.0003	3.0004	4.4486	0.5514	4.4492	0.5515	0.94077
3.0000	3.0000	3.0004	3.0004	5.4486	0.5514	5.4493	0.5515	0.78530
4.0000	3.0000	4.0005	3.0004	6.4486	0.5514	6.4493	0.5514	0.63573
5.0000	3.0000	5.0006	3.0004	7.4486	0.5514	7.4493	0.5514	0.54513
6.0000	3.0000	6.0006	3.0003	8.4486	0.5514	8.4492	0.5514	0.53690
0.0000	4.0000	-0.0000	4.0006	2.4486	1.5514	2.4490	1.5516	1.00862
1.0000	4.0000	1.0001	4.0006	3.4486	1.5514	3.4491	1.5516	0.97938
2.0000	4.0000	2.0003	4.0006	4.4486	1.5514	4.4492	1.5516	0.88820
3.0000	4.0000	3.0004	4.0005	5.4486	1.5514	5.4493	1.5516	0.75559
4.0000	4.0000	4.0005	4.0005	6.4486	1.5514	6.4493	1.5516	0.61468
5.0000	4.0000	5.0006	4.0004	7.4486	1.5514	7.4493	1.5515	0.51033

Figure 18. Output - Two Ray Trace Data

FOLDOUT FRAME 1

FOLDOUT FRAME 2

"PAI" is the primary line of sight angle, and "SAI" is the secondary line of sight angle. The remainder of the data consists of a tabulation of the coordinates of the entering (XP IN and YP IN) and exiting (XP OUT and YP OUT) primary lines of sight and the entering (XS IN and YS IN) and exiting (XS OUT and YS OUT) secondary lines of sight and the error in the sextant angle (ERROR). If any of the coordinates fall outside the window planform, the error is indicated as "*****".

ERRORS

There are three program generated errors. These are:

1. The boundary condition word used as XXXX which is not acceptable.
2. The plan form word used was XXXX which is not acceptable.
3. ERRØR. There is not a complete grid from which an interpolation can be made.

The first two comments indicate the input data on the parameter card are incorrect. Comment three indicates there are insufficient grid points to form a single grid.

Section 4

CONCLUDING REMARKS

A FORTRAN IV computer program has been described which will generate the deformed shape of elliptical and rectangular windows with single or double panes under pressure loadings. The program also permits tracing of light rays (lines of sight) through the deformed windows. The program computes the angular deviations of the rays passing through the window. The program will also compute the change in the angle between two specified light rays as they pass through the windows. Approximately 2.5 to 4.0 seconds are required to trace a ray through a double pane window.

Extensive use has been made of the computer program to perform ray trace analyses on the Apollo Scientific Side Window and also on generalized windows of various sizes and shapes. This use has resulted in validation of the program for a wide variety of input and output conditions and for extensive run times.

References

1. White, K. C., "A Computer Program for Ray Trace Through Spacecraft Windows," Ames Research Center, NASA TM X-1983, Moffett Field, California, April 1970.

2. Timoshenko, S. and Wainowsky-Krieger, S., Theory of Plates and Shells, McGraw-Hill, New York, 1959.

3. Galerkin, B. G., "Berechnung der frei gelagerten elliptischen Platte and Biegung," Z. Angew Math. Mech, vol 3, 1923, 113-117.

4. U.S. Department of Commerce, Handbook of Mathematical Functions, Applied Mathematical Serves #55, Washington, D.C., 1964, 18.

5. Evans, T. E., "Tables of Moments and Deflections for a Rectangular Plate Fixed on all Edges and Carrying a Uniformly Distributed Load," Journal of Applied Mechanics, vol 6, 1939, 7-10.

6. Kelley, D. M., "Apollo Window Deformation and Ray Trace Analyses" Philco-Ford Corporation, Palo Alto, California, October, 1970

7. Chang, C.C. and Fang, B. T., "Transient and Periodic Response of a Loaded Sandwich Plate," Journal of the Aerospace Sciences, vol 28, May 1961, 382-296.

8. White, K. C. and Gadeberg, B. L., "Methods for Predicting Spacecraft Window-Induced Line of Sight Deviations," Ames Research Center, NASA TN D-5238, Moffett Field, California, July, 1969.

9. Gadeberg, B. L. and White, K. C., "Theory of the Correction of Celestial Observation Made for Space Navigation or Training," Ames Research Center, NASA TN D-5239, Moffett Field, California January, 1970.

Appendix A

Development of Deformation Equations

This appendix contains the details of the development of the deformation equations for the elliptic, circular, and rectangular plates with both simply supported and clamped edges using small deflection theory. In addition, the formulation of the equations for the large deflection and shear deformation of rectangular plates are presented.

Timoshenko[2] gives Equation (1) below as the expression for the deflection, w_o, at the center of a clamped ellipse as a function of the semiaxis dimensions "a" and "b" as shown in Figure A-1. Equation (2) gives the delfection, w, at any point on the ellipse in terms of w_o. Equation 2, when differentiated with respect to x and y, yields the slopes about the x and y axes. Equation (3) and (4) are the resulting expressions.

ELLIPSE

CLAMPED EDGES

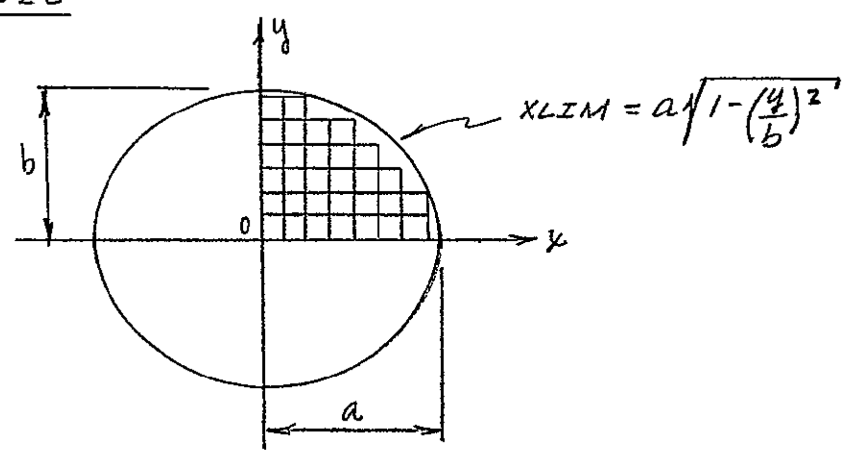


FIGURE A-1

$$w_o = \frac{q}{D\left(\frac{24}{a^4} + \frac{24}{b^4} + \frac{16}{a^2 b^2}\right)} \tag{1}$$

= DEFLECTION AT CENTER OF PLATE

$$w = w_o \left\{ 1 - \frac{x^2}{a^2} - \frac{y^2}{b^2} \right\}^2 \quad \text{pos. in direction of load} \tag{2}$$

$$\frac{\partial w}{\partial x} = - \frac{4 w_o x}{a^2} \left\{ 1 - \frac{x^2}{a^2} - \frac{y^2}{b^2} \right\} \tag{3}$$

$$\frac{\partial w}{\partial y} = - \frac{4 w_o y}{b^2} \left\{ 1 - \frac{x^2}{a^2} - \frac{y^2}{b^2} \right\} \tag{4}$$

w = DEFLECTION AT ANY POINT

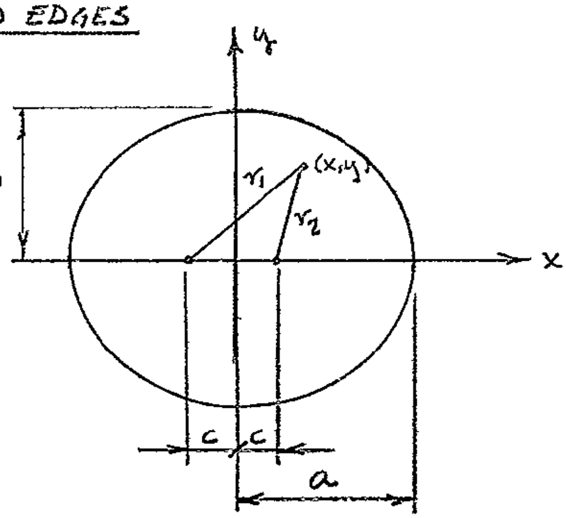
$\partial w/\partial x$ = SLOPE ABOUT X AXIS

$\partial w/\partial y$ = SLOPE ABOUT Y AXIS

The deflection, w, for any point on a simply supported ellipse is given by Galerkin[3] in terms of the center deflection w_o, and the trigonometric and hyperbolic functions of α, ξ and η, where α is a constant and ξ and η are the elliptical coordinates of the ellipse. Equations (5), (6), (7), (8), and (9) give these expressions. The x and y slopes are found by differentiating Equation (4a) with respect to x and y the parameters ξ and η. These differentiations are given in Equations (10) and (11). The resulting differentials of w, ξ, and η are found by differentiating Equation (5) and finding the solution to the two arbitrary functions $F = f(x, \xi, \eta) = 0$ and $G = g(y, \xi, \eta) = 0$. The resulting expressions are given in Equations (12), (13), (14), and (15). These equations are differentiated with respect to x and y (Equations 16 and 17), combined into the matrix equation given as Equation (18), and solved for derivatives of ξ and η as Equation (20). For given values of x and y the values of ξ and η are found using a Newton-Rhapson method of successive approximations[4] which are in terms of the functions F, G, and their derivatives. These expressions are given as Equation (22). The value of ξ and η are substituted into Equations (4a), (10), and (11) to obtain the deflections and slopes.

ELLIPSE

SIMPLY SUPPORTED EDGES



$$\xi = \frac{r_1 + r_2}{2c}$$

$$\eta = \frac{r_1 - r_2}{2c}$$

FIGURE A-2

$$W = f(\xi, \eta) \qquad (4a)$$

$$= W_0 \left[\left(3 \cosh 2\alpha \cosh 4\alpha - 4 \cosh 4\alpha \cosh 2\xi + \cosh 2\alpha \cosh 4\xi \right) \times \left(3 \cosh 2\alpha \cosh 4\alpha - 4 \cosh 4\alpha \cos 2\eta + \cosh 2\alpha \cos 4\eta \right) - W_1 \left(\cosh 2\xi - \cosh 2\alpha \right) \times \left(\cosh 2\alpha - \cos 2\eta \right) \right] \qquad (5)$$

WHERE:
$$W_0 = \frac{8 C^4}{12 \times 128 \times \cosh^2 2\alpha \cosh 4\alpha \times D} \qquad (6)$$

$$\frac{1}{D} = \frac{12(1-\nu^2)}{E H^3} \qquad (7)$$

$$W_1 = \frac{8(1-\nu) \times (3 \cosh^2 2\alpha - 2) \times \sinh^4 2\alpha}{2 \cosh^2 2\alpha - (1-\nu) \sinh^2 2\alpha} \qquad (8)$$

$$X = C \cosh \xi \cos \eta \qquad a = C \cosh \alpha$$
$$Y = C \sinh \xi \sin \eta \qquad b = C \sinh \alpha \qquad (9)$$
$$\alpha = \tanh^{-1}(b/a) \qquad C^2 = a^2 - b^2$$

ELLIPSE - SIMPLY SUPPORTED EDGES

DIFFERENTIATE EQN. 4a TO OBTAIN SLOPES

$$w_x' = \frac{\partial w}{\partial \xi}\frac{\partial \xi}{\partial X} + \frac{\partial w}{\partial \eta}\frac{\partial \eta}{\partial X} \qquad (10)$$

$$w_y' = \frac{\partial w}{\partial \xi}\frac{\partial \xi}{\partial Y} + \frac{\partial w}{\partial \eta}\frac{\partial \eta}{\partial Y} \qquad (11)$$

DIFFERENTIATE EQN. 5 TO OBTAIN $\frac{\partial w}{\partial \xi} = w_\xi'$ AND $\frac{\partial w}{\partial \eta} = w_\eta'$

$$w_\xi' = w_0 \Big[(3 \cosh 2\alpha \cosh 4\alpha - 4 \cosh 4\alpha \cos 2\eta + \cosh 2\alpha \cos 4\eta) \times (-8 \cosh 4\alpha \sinh 2\xi + 4 \cosh 2\alpha \sinh 4\xi) - w_1 (\cosh 2\alpha - \cos 2\eta)(2 \sinh 2\xi)\Big] \qquad (12)$$

$$w_\eta' = w_0 \Big[(3 \cosh 2\alpha \cosh 4\alpha - 4 \cosh 4\alpha \cosh 2\xi + \cosh 2\alpha \cosh 4\xi) \times (8 \cosh 4\alpha \sin 2\eta - 4 \cosh 2\alpha \sin 4\eta) - w_1 (\cosh 2\xi - \cosh 2\alpha)(2 \sin 2\eta)\Big] \qquad (13)$$

TO FIND $\frac{\partial \xi}{\partial x}, \frac{\partial \eta}{\partial x}, \frac{\partial \xi}{\partial y}, \frac{\partial \eta}{\partial y}$ LET

$$F = X - C \cosh\xi \cos\eta = 0 \quad \& \quad G = Y - C \sinh\xi \sin\eta = 0$$

$$F = f(x, \xi, \eta) \quad (14) \qquad G = f(y, \xi, \eta) \quad (15)$$

DIFFERENTIATE WITH RESPECT TO x, y, ξ, η AND SOLVE FOR THE DERIVATIVES.

ELLIPSE – SIMPLY SUPPORTED EDGES

$$\frac{\partial F}{\partial x} = \frac{\partial F}{\partial x}\frac{\partial x}{\partial x} + \frac{\partial F}{\partial \xi}\frac{\partial \xi}{\partial x} + \frac{\partial F}{\partial \eta}\frac{\partial \eta}{\partial x} = 0 \qquad \frac{\partial G}{\partial x} = \frac{\partial G}{\partial y}\frac{\partial y}{\partial x} + \frac{\partial G}{\partial \xi}\frac{\partial \xi}{\partial x} + \frac{\partial G}{\partial \eta}\frac{\partial \eta}{\partial x} = 0$$

$$1 + f'_\xi \xi'_x + f'_\eta \eta'_x = 0 \quad (16) \quad 0 + g'_\xi \xi'_x + g'_\eta \eta'_x = 0$$

$$\frac{\partial F}{\partial y} = \frac{\partial F}{\partial x}\frac{\partial x}{\partial y} + \frac{\partial F}{\partial \xi}\frac{\partial \xi}{\partial y} + \frac{\partial F}{\partial \eta}\frac{\partial \eta}{\partial y} = 0 \qquad \frac{\partial G}{\partial y} = \frac{\partial G}{\partial y}\frac{\partial y}{\partial y} + \frac{\partial G}{\partial \xi}\frac{\partial \xi}{\partial y} + \frac{\partial G}{\partial \eta}\frac{\partial \eta}{\partial y} = 0$$

$$0 + f'_\xi \xi' + f'_\eta \eta'_y = 0 \quad (17) \quad 1 + g'_\xi \xi'_y + g'_\eta \eta'_y = 0$$

EQUATIONS 16 & 17 CAN BE PUT IN MATRIX FORM AS FOLLOWS.

$$\begin{bmatrix} f'_\xi & f'_\eta \\ g'_\xi & g'_\eta \end{bmatrix} \begin{bmatrix} \xi'_x & \xi'_x \\ \eta'_x & \eta'_y \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \qquad (18)$$

$$\begin{bmatrix} \xi'_x & \xi'_y \\ \eta'_x & \eta'_y \end{bmatrix} = \frac{1}{\Delta} \begin{bmatrix} -g'_\eta & f'_\eta \\ g'_\xi & f'_\xi \end{bmatrix} \quad \text{WHERE:} \quad \begin{vmatrix} -g'_\eta & f'_\eta \\ g'_\xi & -f'_\xi \end{vmatrix} = \Delta \qquad (19)$$

THE SOLUTIONS ARE:

$$\begin{aligned} \xi'_x &= g'_\eta / \Delta \\ \eta'_x &= g'_\xi / \Delta \\ \xi'_y &= f'_\eta / \Delta \\ \eta'_y &= f'_\xi / \Delta \end{aligned} \quad (20) \quad \text{WHERE:} \quad \begin{aligned} g'_\eta &= -c \sinh \xi \cos \eta \\ g'_\xi &= -c \cosh \xi \sin \eta \\ f'_\eta &= c \cosh \xi \sin \eta \\ f'_\xi &= -c \sinh \xi \cos \eta \end{aligned} \quad (21)$$

FOR GIVEN VALUES OF X & Y, ξ & η ARE FOUND USING A NEWTON-RHAPSON METHOD OF SUCCESSIVE APPROXIMATIONS. IN GENERAL ξ & η ARE FOUND BY:

$$\xi_{i+1} = \xi_i - \frac{1}{\Delta}\left(g'_\eta f_{\xi,\eta} - f'_\eta g_{\xi,\eta}\right)$$
$$\eta_{i+1} = \eta_i - \frac{1}{\Delta}\left(g'_\xi f_{\xi,\eta} - f'_\xi g_{\xi,\eta}\right) \qquad (22)$$

SEVERAL SPECIAL CASES EXIST IN THE ITERATIONS. THEY ARE:

FOR: $y = 0$ & $0 \leq X \leq C$ $\qquad (X = C \cosh\xi \cos\eta)$

$\xi = 0 \quad \therefore \quad X = C \cos\eta \quad$ or $\quad \eta = \arccos(X/C)$

$y = 0$ & $X > C$

$\eta = 0 \quad \therefore \quad X = C \cosh\xi \quad$ or $\quad \cosh\xi = X/C$

$X = 0$ & $0 \leq y$ $\qquad (y = C \sinh\xi \sin\eta)$

$\eta = 0 \quad \therefore \quad y = C \sinh\xi \quad$ or $\quad \sinh\xi = y/C$

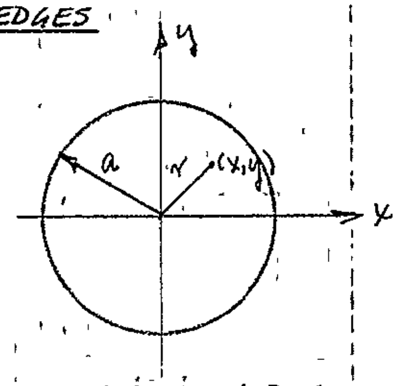
"ξ" IS FOUND BY:

$$\xi_{i+1} = \xi_i - \frac{f(\xi)}{f'(\xi)} \qquad \left(f(\xi) = X - C\cosh\xi\cos\eta\right) \quad \left(\text{or} \quad Y - C\sinh\xi\sin\eta\right)$$

When the ellipse degenerates into a circle another equation given by Timoshenko[2] is used in which the deflection at any point of the circle is given as Equation (23) in terms of the radius and the x and y coordinates of the point. Equation (23) is differentiated with respect to x and y to obtain the slopes about the x and y axes which are given in Equations (24) and (25).

CIRCLE (SPECIAL CASE OF ELLIPSE)

SIMPLY SUPPORTED EDGES



$r^2 = x^2 + y^2$

FIGURE A-3

THE DEFLECTION IS:

$$W = \frac{q}{64D}\left[a^2 - r^2\right]\left[\frac{5+\nu}{1+\nu}a^2 - r^2\right] \qquad \text{LET } C\phi = \frac{5+\nu}{1+\nu}a^2$$

$$r^2 = X^2 + Y^2$$

$$W = \frac{q}{64D}(a^2 - X^2 - Y^2)(C\phi - X^2 - Y^2) \qquad (23)$$

DIFFERENTIATE "W" TO FIND THE SLOPES ABOUT THE X & Y AXES.

$$\frac{\partial W}{\partial X} = -2X\left(\frac{q}{64D}\right)\left[(a^2 - X^2 - Y^2) + (C\phi - X^2 - Y^2)\right] \qquad (24)$$

$$\frac{\partial W}{\partial Y} = -2Y\left(\frac{q}{64D}\right)\left[(a^2 - X^2 - Y^2) + (C\phi - X^2 - Y^2)\right] \qquad (25)$$

Equation (26) is the expression for the deflection of any point on a simply supported rectangular plate given by Timoshenko[2]. The derivative of Equation (26) with respect to x and y gives the slopes in the x and y directions. These appear in Equations (27) and (28).

RECTANGLE

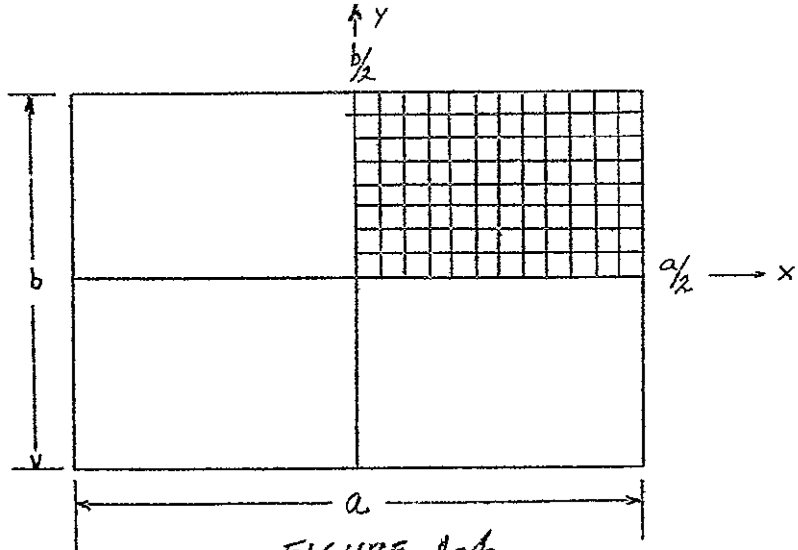


FIGURE A-4

SIMPLY SUPPORTED[1,6]

$$w = \frac{4 q a^4}{\pi^5 D} \sum \frac{(-1)^{\frac{m-1}{2}}}{m^5} \left[1 - \left(\frac{2 + \alpha_m \tanh \alpha_m}{2 \cosh \alpha_m} \right) \cosh \frac{m \pi y}{a} + \frac{m \pi y}{a} \left(\frac{\sinh \frac{m \pi y}{a}}{2 \cosh \alpha_m} \right) \right] \cos \frac{m \pi x}{a} \qquad (26)$$

$$w'_x = - \frac{4 q a^3}{\pi^4 D} \sum \frac{(-1)^{\frac{m-1}{2}}}{m^4} \left[1 - \left(\frac{2 + \alpha_m \tanh \alpha_m}{2 \cosh \alpha_m} \right) \cosh \frac{m \pi y}{a} + \frac{m \pi y}{a} \left(\frac{\sinh \frac{m \pi y}{a}}{2 \cosh \alpha_m} \right) \right] \sin \frac{m \pi x}{a} \qquad (27)$$

$$w'_y = \frac{4 q a^3}{\pi^4 D} \sum \frac{(-1)^{\frac{m-1}{2}}}{m^4} \left[- \left(\frac{2 + \alpha_m \tanh \alpha_m}{2 \cosh \alpha_m} \right) \sinh \frac{m \pi y}{a} + \frac{m \pi y}{a} \left(\frac{\cosh \frac{m \pi y}{a}}{2 \cosh \alpha_m} \right) + \frac{\sinh \frac{m \pi y}{a}}{2 \cosh \alpha_m} \right] \cos \frac{m \pi x}{a}$$

$$\alpha_m = \frac{m \pi b}{2a} \qquad \beta_m = \frac{m \pi a}{2b} \qquad (28)$$

WHERE

w = DEFLECTION

w'_x = SLOPE IN X-DIRECTION

w'_y = SLOPE IN Y-DIRECTION

6. KELLEY, D.M., "APOLLO WINDOW DEFORMATION AND RAY TRACE ANALYSES," PHILCO-FORD CORPORATION, PALO ALTO, CALIFORNIA, AUGUST, 1970.

For clamped rectangular plates the deformations resulting from the moments applied to the boundaries and given in Equations (29) and (32) are added to the simply supported deformations. The resulting Equations (36a) give the deflection and slopes for the clamped plate.

RECTANGLE

CLAMPED EDGES (5,6)

$$\alpha_m = \frac{m\pi b}{a} \qquad \beta_m = \frac{m\pi a}{b}$$

$$w_1 = -\frac{a^2}{2\pi^2 D}\left[\sum \frac{(-1)^{\frac{m-1}{2}}}{m^2} E_m \left(\frac{m\pi Y}{a}\,\frac{\mathrm{SINH}\,\frac{m\pi Y}{a}}{\mathrm{COSH}\,\alpha_m} - \frac{\alpha_m \,\mathrm{TANH}\,\alpha_m}{\mathrm{COSH}\,\alpha_m}\,\mathrm{COSH}\,\frac{m\pi Y}{a}\right)\mathrm{COS}\,\frac{m\pi X}{a}\right] \tag{29}$$

$$w'_{1x} = \frac{a}{2\pi D}\left[\sum \frac{(-1)^{\frac{m-1}{2}}}{m} E_m \left(\frac{m\pi Y}{a}\,\frac{\mathrm{SINH}\,\frac{m\pi Y}{a}}{\mathrm{COSH}\,\alpha_m} - \frac{\alpha_m \,\mathrm{TANH}\,\alpha_m}{\mathrm{COSH}\,\alpha_m}\,\mathrm{COSH}\,\frac{m\pi Y}{a}\right)\mathrm{SIN}\,\frac{m\pi X}{a}\right] \tag{30}$$

$$w'_{1y} = -\frac{a}{2\pi D}\left[\sum \frac{(-1)^{\frac{m-1}{2}}}{m} E_m \left(\frac{m\pi Y}{a}\,\frac{\mathrm{COSH}\,\frac{m\pi Y}{a}}{\mathrm{COSH}\,\alpha_m} + \frac{\mathrm{SINH}\,\frac{m\pi Y}{a}}{\mathrm{COSH}\,\alpha_m} - \frac{\alpha_m \,\mathrm{TANH}\,\alpha_m}{\mathrm{COSH}\,\alpha_m}\,\mathrm{SINH}\,\frac{m\pi Y}{a}\right)\mathrm{COS}\,\frac{m\pi X}{a}\right] \tag{31}$$

$$w_2 = -\frac{b^2}{2\pi^2 D}\left[\sum \frac{(-1)^{\frac{m-1}{2}}}{m^2} F_m \left(\frac{m\pi X}{b}\,\frac{\mathrm{SINH}\,\frac{m\pi X}{b}}{\mathrm{COSH}\,\beta_m} - \frac{\beta_m \,\mathrm{TANH}\,\beta_m}{\mathrm{COSH}\,\beta_m}\,\mathrm{COSH}\,\frac{m\pi X}{b}\right)\mathrm{COS}\,\frac{m\pi Y}{b}\right] \tag{32}$$

$$w'_{2x} = -\frac{b}{2\pi D}\left[\sum \frac{(-1)^{\frac{m-1}{2}}}{m} F_m \left(\frac{m\pi x}{b} \frac{\cosh \frac{m\pi x}{b}}{\cosh \beta_m} + \frac{\sinh \frac{m\pi x}{b}}{\cosh \beta_m} - \frac{\beta_m \tanh \beta_m}{\cosh \beta_m} \sinh \frac{m\pi x}{b}\right) \cos \frac{m\pi y}{b}\right] \quad (33)$$

$$w'_{2y} = \frac{b}{2\pi D}\left[\sum \frac{(-1)^{\frac{m-1}{2}}}{m} F_m \left(\frac{m\pi x}{b} \frac{\sinh \frac{m\pi x}{b}}{\cosh \beta_m} - \frac{\beta_m \tanh \beta_m}{\cosh \beta_m} \cosh \frac{m\pi x}{b}\right) \sin \frac{m\pi y}{b}\right] \quad (34)$$

WHERE E_m & F_m ARE DEFINED BY:

$$\frac{E_n}{n}\left[\tanh \alpha_n + \frac{\alpha_n}{\cosh^2 \alpha_n}\right] + \frac{8na}{\pi b} \sum \frac{F_m}{m^3\left(\frac{n^2}{m^2} + \frac{a^2}{b^2}\right)^2} = \frac{4 q a^2}{\pi^3 n^4}\left[\frac{\alpha_n}{\cosh^2 \alpha_n} - \tanh \alpha_n\right] \quad (35)$$

$$\frac{F_n}{n}\left[\tanh \beta_n + \frac{\beta_n}{\cosh^2 \beta_n}\right] + \frac{8nb}{\pi a} \sum \frac{E_m}{m^3\left(\frac{n^2}{m^2} + \frac{b^2}{a^2}\right)^2} = \frac{4 q b^2}{\pi^3 n^4}\left[\frac{\beta_n}{\cosh^2 \beta_n} - \tanh \beta_n\right] \quad (36)$$

THE DEFLECTION AND SLOPES FOR CLAMPED EDGES ARE:

$$w_c = w_s + w_1 + w_2$$

$$w'_{cx} = w'_{sx} + w'_{1x} + w'_{2x}$$

$$w'_{cy} = w'_{sy} + w'_{1y} + w'_{2y}$$

WHERE: w_s = SIMPLY SUPPORTED DEFLECTION
w_1 = DEFLECTION FOR MOMENT APPLIED TO X BOUNDARY
w_2 = DEFLECTION FOR MOMENT APPLIED TO Y BOUNDARY

The first step in developing a solution for large deflections of a rectangular plate is to generalize Timoshenko's equations for the deformation of a square membrane[2]. Into Equation (37), the general equation for the strain energy in a membrane, are substituted the differentials of the equations for the displacements in a rectangular plate given as Equation (37a). This yields Equation (38) which when simplified by letting $\nu = 0.25$ gives Equation (39). Timoshenko[2] gives two equations resulting from the principle of virtual displacements which can be solved for the constant "c" and the deflection w_o. These are Equations (40) and (41).

LARGE DEFLECTION - RECTANGULAR PLATE

FIRST: SOLVE FOR V IN THE GENERAL CASE $a \neq b$

$$V = \frac{Eh}{2(1-\nu^2)} \iint \left\{ \left(\frac{\partial u}{\partial x}\right)^2 + \frac{\partial u}{\partial x}\left(\frac{\partial w}{\partial x}\right)^2 + \left(\frac{\partial v}{\partial y}\right)^2 + \frac{\partial v}{\partial y}\left(\frac{\partial w}{\partial y}\right)^2 \right. \tag{37}$$

$$+ \frac{1}{4}\left[\left(\frac{\partial w}{\partial x}\right)^2 + \left(\frac{\partial w}{\partial y}\right)^2\right]^2 + 2\nu\left[\frac{\partial u}{\partial x}\frac{\partial v}{\partial y} + \frac{1}{2}\frac{\partial v}{\partial y}\left(\frac{\partial w}{\partial x}\right)^2 + \frac{1}{2}\frac{\partial u}{\partial x}\left(\frac{\partial w}{\partial y}\right)^2\right]$$

$$\left. + \frac{1-\nu}{2}\left[\left(\frac{\partial u}{\partial y}\right)^2 + \frac{\partial u}{\partial y}\frac{\partial v}{\partial x} + \left(\frac{\partial v}{\partial x}\right)^2 + 2\frac{\partial u}{\partial y}\frac{\partial w}{\partial x}\frac{\partial w}{\partial y} + 2\frac{\partial v}{\partial x}\frac{\partial w}{\partial x}\frac{\partial w}{\partial y}\right]\right\} dx\,dy$$

WITH:

$$w = w_o \cos\frac{\pi x}{2a} \cos\frac{\pi y}{2b}$$

$$u = c \sin\frac{\pi x}{a} \cos\frac{\pi y}{2b} \tag{37a}$$

$$v = c \sin\frac{\pi y}{b} \cos\frac{\pi x}{2a}$$

AND:

$$\frac{\partial w}{\partial x} = -\frac{w_o \pi}{2a} \sin\frac{\pi x}{2a} \cos\frac{\pi y}{2b}$$

$$\frac{\partial w}{\partial y} = -\frac{w_o \pi}{2b} \cos\frac{\pi x}{2a} \sin\frac{\pi y}{2b} \tag{37b}$$

$$\frac{\partial u}{\partial x} = \frac{c\pi}{a} \cos\frac{\pi x}{a} \cos\frac{\pi y}{2b}$$

$$\frac{\partial u}{\partial y} = -\frac{C\pi}{2b} \sin\frac{\pi x}{a} \sin\frac{\pi y}{2b}$$

$$\frac{\partial v}{\partial x} = -\frac{C\pi}{2a} \sin\frac{\pi y}{b} \sin\frac{\pi x}{2a} \qquad (37c)$$

$$\frac{\partial v}{\partial y} = \frac{C\pi}{b} \cos\frac{\pi y}{b} \cos\frac{\pi x}{2a}$$

V IS THE STRAIN ENERGY OF A MEMBRANE

SUBSTITUTE, INTEGRATE, AND SIMPLIFY

$$V = \frac{Eh}{2(1-\nu^2)} \int_{-a}^{+a} \int_{-b}^{+b} \Bigg\{ \left(\frac{C^2\pi^2}{a^2} \cos^2\frac{\pi x}{a} \cos^2\frac{\pi y}{2b} \right)$$

$$+ \left(\frac{C W_0^2 \pi^3}{4a^3} \cos\frac{\pi x}{a} \sin^2\frac{\pi x}{2a} \cos^3\frac{\pi y}{2b} \right)$$

$$+ \left(\frac{C^2\pi^2}{b^2} \cos^2\frac{\pi x}{2a} \cos^2\frac{\pi y}{b} \right)$$

$$+ \left(\frac{C W_0^2 \pi^3}{4b^3} \cos^3\frac{\pi x}{2a} \cos\frac{\pi y}{b} \sin^2\frac{\pi y}{2b} \right)$$

$$+ \frac{1}{4} \Bigg[\left(\frac{W_0^4 \pi^4}{16a^4} \sin^4\frac{\pi x}{2a} \cos^4\frac{\pi y}{2b} \right)$$

$$+ 2 \left(\frac{W_0^4 \pi^4}{16a^2b^2} \sin^2\frac{\pi x}{2a} \cos^2\frac{\pi x}{2a} \cos^2\frac{\pi y}{2b} \sin^2\frac{\pi y}{2b} \right)$$

$$+ \left(\frac{W_0^4 \pi^4}{16b^4} \cos^4\frac{\pi x}{2a} \sin^4\frac{\pi y}{2b} \right) \Bigg]$$

$$+2\nu \Bigg[\left(\frac{C^2\pi^2}{ab} \cos\frac{\pi x}{a} \cos\frac{\pi x}{2a} \cos\frac{\pi y}{2b} \cos\frac{\pi y}{b} \right)$$

$$+\frac{1}{2}\left(\frac{C w_0^2 \pi^3}{4a^2 b} \cos\frac{\pi x}{2a} \sin^2\frac{\pi x}{2a} \cos\frac{\pi y}{b} \cos^2\frac{\pi y}{2b}\right)$$

$$+\frac{1}{2}\left(\frac{C w_0^2 \pi^3}{4ab^2} \cos\frac{\pi x}{a} \cos^2\frac{\pi x}{2a} \cos\frac{\pi y}{2b} \sin^2\frac{\pi y}{2b}\right)\Bigg]$$

$$+\frac{1-\nu}{2}\Bigg[\left(\frac{C^2\pi^2}{4b^2} \sin^2\frac{\pi x}{a} \sin^2\frac{\pi y}{2b}\right)$$

$$+\left(\frac{C^2\pi^2}{4ab} \sin\frac{\pi x}{a} \sin\frac{\pi x}{2a} \sin\frac{\pi y}{2b} \sin\frac{\pi y}{b}\right)$$

$$+\left(\frac{C^2\pi^2}{4a^2} \sin^2\frac{\pi x}{2a} \sin^2\frac{\pi y}{b}\right)$$

$$-2\left(\frac{C w_0^2 \pi^3}{8ab^2} \sin\frac{\pi x}{a} \sin\frac{\pi x}{2a} \cos\frac{\pi x}{2a} \sin^2\frac{\pi y}{2b} \cos\frac{\pi y}{2b}\right)$$

$$-2\left(\frac{C w_0^2 \pi^3}{8a^2 b} \sin^2\frac{\pi x}{2a} \cos\frac{\pi x}{2a} \sin\frac{\pi y}{b} \sin\frac{\pi y}{2b} \cos\frac{\pi y}{2b}\right)\Bigg]\Bigg\}dy\,dx$$

$$V = \frac{Eh}{2(1-\nu^2)}\Bigg\{\left(\frac{C^2\pi^2 b}{a}\right) - \left(\frac{C w_0^2 \pi^2 b}{3a^2}\right) + \left(\frac{C^2\pi^2 a}{b}\right) - \left(\frac{C w_0^2 \pi^2 a}{3b^2}\right)$$

$$+\frac{1}{4}\left[\frac{9 w_0^4 \pi^4 b}{256 a^3} + \frac{w_0^4\pi^4}{128ab} + \frac{9 w_0^4 \pi^4 a}{256 b^3}\right]$$

$$+2\nu\left[\frac{16C^2}{9} + \frac{C w_0^2 \pi^2}{12a} + \frac{C w_0^2 \pi^2}{12b}\right]$$

$$+\frac{(1-\nu)}{2}\left[\frac{C^2\pi^2 a}{4b} + \frac{32C^2}{9} + \frac{C^2\pi^2 b}{4a} - \frac{C w_0^2\pi^2}{6b} - \frac{C w_0^2 \pi^2}{6a}\right]\Bigg\}$$

(38)

THIS IS THE STRAIN ENERGY OF A RECTANGULAR MEMBRANE WITH $a \neq b$

CHECK EQUATION BY SETTING $b = a$ AND

CHECK AGAINST TIMOSHENKO SOLUTION, P. 420

$$V = \frac{Eh}{2(1-\nu^2)}\left\{\left(\frac{C^2\pi^2 a}{a}\right) - \left(\frac{C w_0^2 \pi^2 a}{3a^2}\right) + \left(\frac{C^2\pi^2 a}{a}\right) - \left(\frac{C w_0^2\pi^2 a}{3a^2}\right)\right.$$

$$+ \frac{1}{4}\left[\frac{9 w_0^4 \pi^4 a}{256 a^3} + \frac{w_0^4\pi^4}{128 a^2} + \frac{9 w_0^4 \pi^4 a}{256 a^3}\right]$$

$$+ 2\nu\left[\frac{16C^2}{9} + \frac{C w_0^2 \pi^2}{12a} + \frac{C w_0^2 \pi^2}{12a}\right]$$

$$\left. + \frac{(1-\nu)}{2}\left[\frac{C^2\pi^2 a}{4a} + \frac{32C^2}{9} + \frac{C^2\pi^2 a}{4a} - \frac{C w_0^2\pi^2}{6a} - \frac{C w_0^2 \pi^2}{6a}\right]\right.$$

Set $\nu = 0.25$

$$V = \frac{Eh}{1.875}\left\{\frac{5\pi^4 w_0^4}{256 a^2} - \frac{8C\pi^2 w_0^2}{12a} + \frac{C w_0^2\pi^2}{12a} \quad \frac{3C w_0^2 \pi^2}{24a}\right.$$

$$\left. + 2C^2\pi^2 + \frac{3C^2\pi^2}{16} + \frac{8C^2}{9} + \frac{12C^2}{9}\right\}$$

$$V = \frac{Eh}{1.875}\left\{\frac{5\pi^4 w_0^4}{256 a^2} - \frac{17C\pi^2 w_0^2}{24a} + C^2\left\{\frac{35\pi^2}{16} + \frac{80}{36}\right\}\right\}$$

$$V = \frac{Eh}{7.5}\left\{\frac{5\pi^4}{64}\frac{w_0^4}{a^2} - \frac{17\pi^2}{6}\frac{C w_0^2}{a} + C^2\left(\frac{35\pi^2}{4} + \frac{80}{9}\right)\right\}$$

CHECKS

An Equation for w_o is determined by first obtaining Equations (42) and (43) by differentiating Equation (39) with respect to "c" and w_o, then integrating the right hand side of Equation (41), and equating the results. This is the deflection of a membrane due to a uniform load "q". By combining the equations for the loads to produce the center plate deflection w_o and using both small deflection theory and membrane analysis a cubic equation in w_o can be written as Equation (47). The resulting large deflection solution is obtained for points between the center and edge of the rectangular plate by averaging the deflections produced by small deflection theory and membrane theory. This is done in Equation (48). The x and y derivatives of this equation yield the slopes about the x and y axes.

SIMPLIFY EQN. 38 BY COLLECTING TERMS AND SETTING $\nu = 0.25$

$$V = \frac{Eh}{2(1-\nu^2)}\left\{\frac{w_o^4\pi^4}{4\times 256}\left(\frac{9b}{a^3}+\frac{2}{ab}+\frac{9a}{b^3}\right) - \frac{c\,w_o^2\pi^2}{48}\left(\frac{16b}{a^2}+\frac{4-12\nu}{a}+\frac{4-12\nu}{b}+\frac{16a}{b^2}\right) + \frac{c^2}{2}\left(\frac{\pi^2 b}{4a}(9-\nu)+\frac{\pi^2 a}{4b}(9-\nu)+\frac{32}{9}(1-\nu)\right)\right\}$$

LET $\nu = 0.25$

$$V = \frac{Eh}{30}\left\{\frac{w_o^4\pi^4}{64}\left(\frac{9b}{a^3}+\frac{2}{ab}+\frac{9a}{b^3}\right) - \frac{w_o^2\pi^2 c}{3}\left(\frac{16b}{a^2}+\frac{1}{a}+\frac{1}{b}+\frac{16a}{b^2}\right) + c^2\left(\frac{35\pi^2 b}{2a}+\frac{35\pi^2 a}{2b}+\frac{320}{9}\right)\right\} \qquad (39)$$

TIMOSHENKO GIVES TWO EQUATIONS BASED ON THE PRINCIPAL OF VIRTUAL DISPLACEMENTS FROM WHICH THE CONSTANT C AND DEFLECTION W_0 ARE DETERMINED.

$$\frac{\partial V}{\partial C} = 0 \tag{40}$$

$$\frac{\partial V}{\partial w_0}\delta w_0 = \int_{-a}^{a}\int_{-b}^{b} q\,\delta w_0 \cos\frac{\pi x}{2a}\cos\frac{\pi y}{2b}\,dx\,dy \tag{41}$$

DIFFERENTIATING V WITH RESPECT TO w_0 AND C GIVES:

$$\frac{\partial V}{\partial w_0} = \frac{Eh}{30}\left\{\frac{w_0^3\pi^4}{16}\left(\frac{9b}{a^3} + \frac{2}{ab} + \frac{9a}{b^3}\right) - \frac{2w_0\pi^2 C}{3}\left(\frac{16b}{a^2} + \frac{1}{a} + \frac{1}{b} + \frac{16a}{b^2}\right)\right\} \tag{42}$$

$$\frac{\partial V}{\partial C} = \frac{Eh}{30}\left\{-\frac{w_0^2\pi^2}{3}\left(\frac{16b}{a^2} + \frac{1}{a} + \frac{1}{b} + \frac{16a}{b^2}\right) + 2C\left(\frac{35\pi^2 b}{2a} + \frac{35\pi^2 a}{2b} + \frac{320}{9}\right)\right\} \tag{43}$$

$$C = \frac{\frac{w_0^2\pi^2}{3}\left(\frac{16b}{a^2} + \frac{1}{a} + \frac{1}{b} + \frac{16a}{b^2}\right)}{\left(\frac{35\pi^2 b}{a} + \frac{35\pi^2 a}{b} + \frac{640}{9}\right)} \tag{44}$$

LET $a = b$ for CHECK

$$C = \frac{\frac{w_0^2\pi^2}{3}\left(\frac{16}{a} + \frac{1}{a} + \frac{1}{a} + \frac{16}{a}\right)}{\left(35\pi^2 + 35\pi^2 + \frac{640}{9}\right)} = 0.14679\,\frac{w_0^2}{a}$$

CHECKS WITH TIMOSHENKO'S[1] EQUATION # 250, P. 420

INTEGRATE THE RIGHT HAND SIDE OF EQN. 41

$$\frac{\partial V}{\partial w_o}\,\delta w_o = \int_{-a}^{a}\int_{-b}^{b} q\,\delta w_o \cos\frac{\pi x}{2a}\cos\frac{\pi y}{2b}\,dx\,dy$$

$$= q\,\delta w_o \int_{-a}^{a}\cos\frac{\pi x}{2a}\,dx \int_{-b}^{b}\cos\frac{\pi y}{2b}\,dy$$

$$= \frac{4\,\delta w_o\,a\,b}{\pi^2}\left\{\sin\frac{\pi x}{2a}\right\}_{-a}^{a}\left\{\sin\frac{\pi y}{2b}\right\}_{-b}^{b}$$

$$\frac{\partial V}{\partial w_o} = \frac{16\,q\,a\,b}{\pi^2} \tag{45}$$

EQUATE EQUATIONS 42 AND 45, SOLVE FOR w_o

$$\frac{Eh\,\delta w_o^2}{30}\left\{\frac{w_o^2\pi^4}{16}\left(\frac{9b}{a^3}+\frac{2}{ab}+\frac{9a}{b^3}\right)-\frac{2\pi^2 C}{3}\left(\frac{16b}{a^2}+\frac{1}{a}+\frac{1}{b}+\frac{16a}{b^2}\right)\right\}=\frac{16\,q\,\delta w_o\,a\,b}{\pi^2}$$

$$\left\{\frac{w_o^3\pi^2}{16}\left(\frac{9b}{a^3}+\frac{2}{ab}+\frac{9a}{b^3}\right)-\frac{2w_oC}{3}\left(\frac{16b}{a^2}+\frac{1}{a}+\frac{1}{b}+\frac{16a}{b^2}\right)\right\}=\frac{480\,q\,a\,b}{Eh\,\pi^4}$$

$$w_o^3 = \frac{\dfrac{480\,q\,a\,b}{Eh\,\pi^4}}{\dfrac{\pi^2}{16}\left(\dfrac{9b}{a^3}+\dfrac{2}{ab}+\dfrac{9a}{b^3}\right)-\dfrac{2}{3}\left\{\dfrac{\dfrac{\pi^2}{3}\left(\dfrac{16b}{a^2}+\dfrac{1}{a}+\dfrac{1}{b}+\dfrac{16a}{b^2}\right)^2}{\left(\dfrac{35\pi^2 b}{a}+\dfrac{35\pi^2 a}{b}+\dfrac{640}{9}\right)}\right\}}$$

$$w_o^3/q = \frac{\dfrac{480\,a\,b}{Eh\,\pi^6}}{\dfrac{1}{16}\left(\dfrac{9b}{a^3}+\dfrac{2}{ab}+\dfrac{9a}{b^3}\right)-\dfrac{2}{45}\left\{\dfrac{\left(\dfrac{16b}{a^2}+\dfrac{1}{a}+\dfrac{1}{b}+\dfrac{16a}{b^2}\right)^2}{\left(\dfrac{7\pi^2 b}{a}+\dfrac{7\pi^2 a}{b}+\dfrac{128}{9}\right)}\right\}} \tag{46}$$

$w_o^3 = q\,(\text{CONS})$ WHERE CONS = THE RIGHT HAND SIDE OF EQUATION 44 (47)

THE LARGE DEFLECTION SOLUTION IS GIVEN BY SOLVING THE FOLLOWING EQUATION.

$$q1 + q2 = \frac{W_o}{\alpha_{oo}} + \frac{W_o^3}{CON5} = q = PRSS \qquad (48)$$

WHERE: q = UNIT AREA LOAD ON PLATE

$q1$ = LOAD COMPONENT BALANCED BY SMALL DEFLECTION REACTIONS

$q2$ = LOAD COMPONENT BALANCED BY MEMBRANE REACTIONS

$W_o = q1 * \alpha_{oo}$

$W_o^3 = q2 * CON5$

REWRITING:

$$W_o^3\left(\frac{1}{CON5}\right) + W_o\left(\frac{1}{\alpha_{oo}}\right) - PRSS = 0 \qquad (49)$$

THE EQUATION IS NOW IN THE FORM

$W_o^3 A1 + 3W_o^2 B1 + 3W_o C1 + D = 0$

WHERE: $A1 = (1/CON5)$

$B1 = 0$

$C1 = (1/3\alpha_{oo})$ α_{oo} = Defl. @ Plate Center

$D1 = -PRSS$

USING THE CUBIC SOLUTION METHOD

$$Q1 = A1 \times C1 \qquad R = -0.5A1^2 \times D1$$

$$S1 = \left\{ R + \sqrt{Q^3 + R^2} \right\}^{1/3}$$

$$S2 = \left\{ R - \sqrt{Q^3 + R^2} \right\}^{1/3}$$

$$W_o = (S1 + S2)/A1$$

$$q1 = W_o/\alpha_{oo} \qquad q2 = PRSS - q1 \quad \text{or}$$

$$q2 = W_o^3/CON5$$

THE DEFLECTION AND SLOPES OF EACH POINT CAN NOW BE FOUND

$$W_{ij}^L = \left[W_{ij}^S Q1 + W_o \cos\left(\frac{\pi X}{2a}\right) \cos\left(\frac{\pi Y}{2b}\right) \right] 0.5 \tag{50}$$

$$\frac{\partial W_{ij}^L}{\partial X} = \left[\frac{\partial W_{ij}^S}{\partial X} Q1 - \frac{W_o \pi}{2a} \sin\left(\frac{\pi X}{2a}\right) \cos\left(\frac{\pi Y}{2b}\right) \right] 0.5 \tag{51}$$

$$\frac{\partial W_{ij}^L}{\partial Y} = \left[\frac{\partial W_{ij}^S}{\partial Y} Q1 - \frac{W_o \pi}{2b} \cos\left(\frac{\pi X}{2a}\right) \sin\left(\frac{\pi Y}{2b}\right) \right] 0.5 \tag{52}$$

WHERE;

W^L = LARGE DEFLECTION DISPLACEMENT

W^S = SMALL DEFLECTION DISPLACEMENT

W_o = $(CON5 \times Q2)^{1/3}$ MEMBRANE CONTRIBUTION

SHEAR DEFORMATION

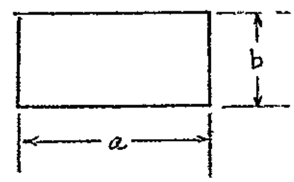
AN APPROXIMATE SOLUTION FOR SHEAR IS GIVEN BY

$$w_s = W \rho$$

$$\rho = 1 + \frac{\pi^2 (1 + \beta^2) t^2}{3 a^2 (1 - \nu)} \qquad (53)$$

W = Deflection by Small defl. Theory

$\beta = a/b$



ρ HAS BEEN SIMPLIFIED FROM AN EQUATION BY C.C. CHANG & B.T. FANG[7] USED FOR SHEAR IN SANDWICH PLATES

---

7. CHANG, C.C, AND FANG, B.T., "TRANSIENT AND PERIODIC RESPONSE OF A LOADED SANDWICH PLATE," JOURNAL OF AEROSPACE SCIENCES, Vol. 28, MAY 1961, 382-396.

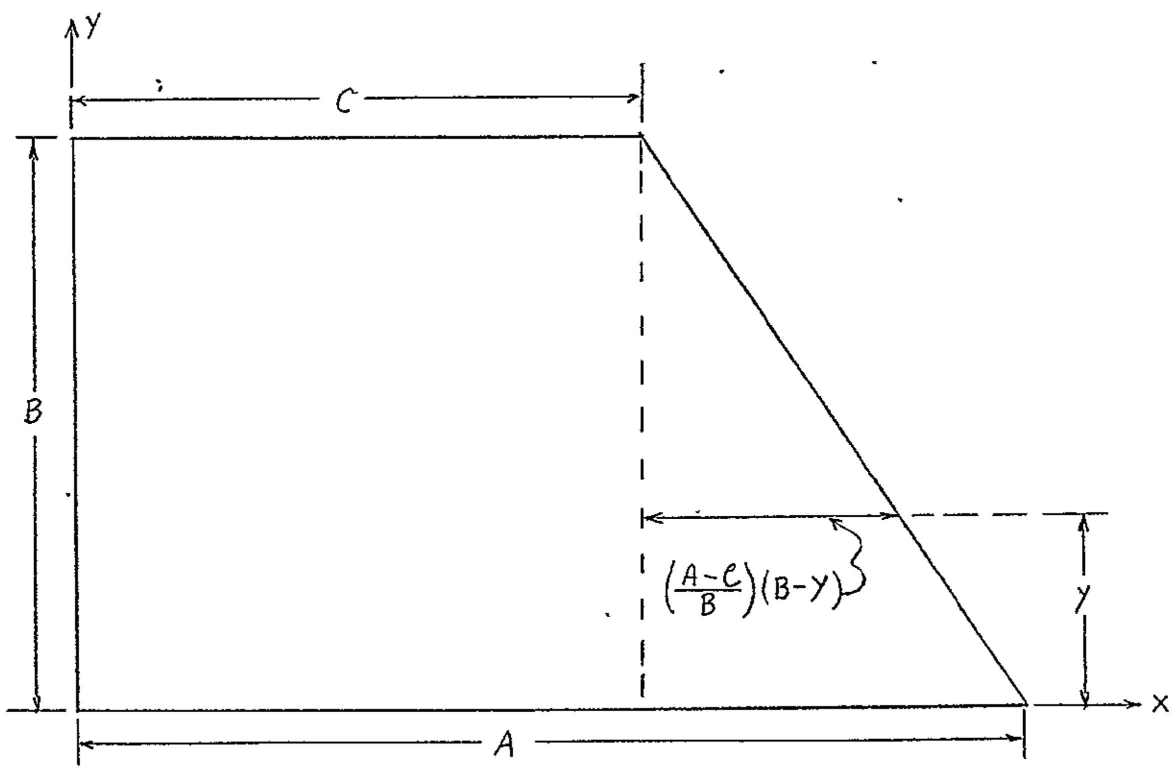
Appendix B

Miscellaneous Equations

This appendix contains equations for defining the boundary of a trapezoid, for finding the mean and rms, and for finding the maximum and minimum slope.

The trapezoid boundary equations are used in the program, BONDRY, which tests for the boundary of a planform shape (ellipse, rectangle, trapezoid).

TRAPEZOIDAL BOUNDARY EQUATIONS



$$XLIM = C + \left(\frac{A-C}{B}\right)(B-Y)$$

$$YLIM_{X=0,C} = B$$

$$YLIM_{X=C,A} = \left(\frac{B}{A-C}\right)(A-X)$$

The equations used for finding the mean and rms are those found in any elementary statistics book..

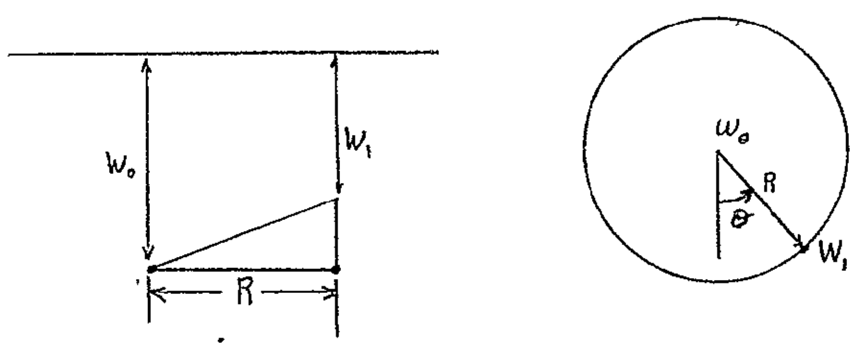
MEAN & STANDARD DEVIATION

$$MEAN = \frac{1}{N}\sum_{i=1}^{N} X_i = \bar{M}$$

$$\sigma = \frac{1}{\sqrt{N-1}}\sqrt{\sum X_i^2 - \frac{1}{N}\left(\sum X_i\right)^2}$$

The equations for the maximum and minimum slope are based on the premise that the slope at a point is approximately equal to the slope between the point and another point a very small distance away.

MAXIMUM-MINIMUM SLOPE EQUATION



THE MAXIMUM AND MINIMUM SLOPES ARE FOUND USING THE Δ EQUATION $S = (W_0 - W_1)/R$ WHERE S IS CALCULATED EVERY 2 DEGREES, BETWEEN 0° AND 180°. THE LIST OF S VALUES IS THEN SEARCHED FOR THE MAX. & MIN. VALUE.

Appendix C

This appendix gives the details of the data retrieval program. This program will search tape 9 (which has been written in binary format by the WINDEF program) and obtain the set(s) of ray trace data required by the user.

Figure C-1 illustrates the order of cards which make up the program deck. The format for the control cards on the above deck is:

Columns:	1-8	16-80
	$JØB	(See Manual)
	$SETUP 09	(Number of tape on which required data is located)
	$IBJOB	blank
	$DECK	BIN09
	$DATA	blank

The AMES 7094 operational manual should be consulted for other items required on the $JOB cards.

Figure C-2 illustrates the arrangement of the data deck for multiple problems. Each problem requires only one card with the following format:

Column	Symbol	Information	Format
1-5	IRTV	Retrieval number desired	Integer

There is no limit on the number of sets of ray trace data which may be retrieved on one run (as long as all the retrieval numbers desired are on the same tape).

A listing of the retrieval program is given in Appendix D.

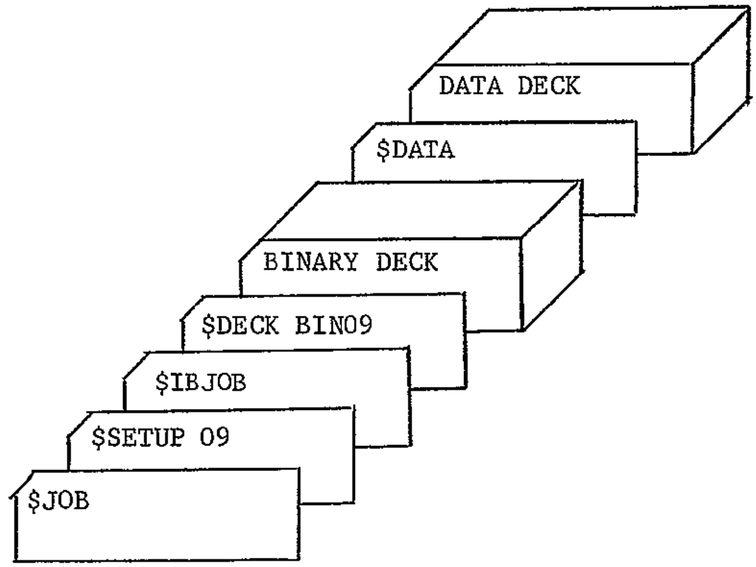


Figure C-1. Program Deck

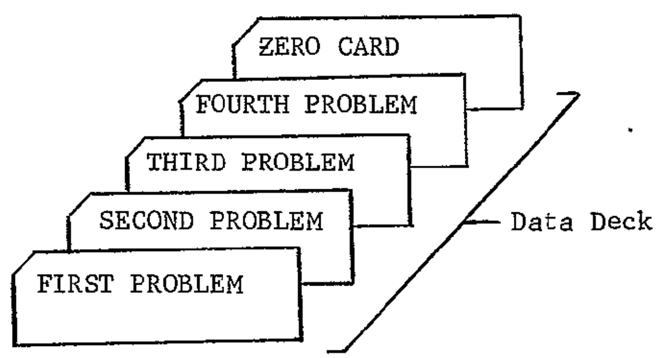


Figure C-2. Data Deck

Appendix D

This appendix contains the listings of the subroutines which comprise the single and two ray trace computer programs and the data retrieval program.

```
$IBFTC MS23D0
CWINDEF
C
C D0   WINDEF - APOLLO WINDOW DEFORMATION AND LINE OF SIGHT DRIVER
C D1   ELIPSE - ELLIPSE DEFORMATION GENERATOR
C D2   ELIPIT - ELLIPTIC COORDINATE GENERATOR
C D3   RECTNG - RECTANGULAR DEFORMATION GENERATOR
C D4   SEQS   - MATRIX INVERSION AND LINEAR EQUATION SOLUTION.
C D5   TRPZOD - READS IN TRAPEZOIDAL DEFORMATION DATA FROM SAMIS
C D6   LRGDEF - LARGE DEFLECTION GENERATOR FOR RECTANGLES
C D7   DEFRES - PRINTS PLATE (WINDOW) DEFORMATION DATA
C D8   RAYTRA - DRIVER FOR RAY TRACE PROCEDURE
C D9   ITERAT - ITERATES TO FIND LOCATION OF RAY ON NEXT SURFACE
C E0   INCOTB - DETERMINES DEFORMATION OF PLATE AT INTERSECTION W/RAY
C E1   NORMAL - CALCULATES NORMAL TO PLATE AT RAY INTERSECTION POINT
C E2   REFRCI - CALCULATES NEW DIRECTION OF RAY UPON ENTERING NEW MEDIUM
C E3   RESPRT - PRINTS RAY TRACE AND MEAN-RMS RESULTS
C E4   MENRMS - STORES DATA FOR MEAN AND RMS CALCULATIONS
C E5   MAXMIN - CALCULATES MAX/MIN SLOPES AT GRID POINTS
C E6   RTVLST - RETRIEVAL LIST
C E7   BONDRY - TEST TO SEE IF POINT OF RAY IS OUTSIDE PLAN FORM BNDRY
C E8   PACWRD - INDEX WORD PACKING-UNPACKING ROUTINE
C E9   PAGE   - PRINTS PAGE NO. AT TOP OF EACH PAGE (AND RETRIEVAL NO.)
C F0   SHRDEF - SHEAR DEFORMATION GENERATOR
C F1   SINH   - CALCULATES HYPERBOLIC SINE
C F2   COSH   - CALCULATES HYPERBOLIC COSINE
C F3   TANH   - CALCULATES HYPERBOLIC TANGENT
C
C      AA     = X DIMENSION OF SHAPE
C             = LENGTH OF ELLIPSE SEMI AXIS
C             = LENGTH OF RECTANGLE
C             = 1/2 BASE LENGTH OF TRAPEZOID
C      AMN    = ARRAY FOR STORING MEANS
C      AVG    = ARRAY FOR STORING MEAN DATA
C      AVS    = ARRAY FOR STORING RMS  DATA
C      BB     = Y DIMENSION OF SHAPE
C             = HEIGHT OF ELLIPSE SEMI AXIS
C             = HEIGHT OF RECTANGLE
C             = HEIGHT OF TRAPEZOID
C      BONC   = BOUNDARY CONDITION
C      CC     = UPPER X DIMENSION OF TRAPEZOID
C      CHAP   = ICHAP = SHAP = GEOMETRIC SHAPE
C      CON    = DUMMY ARRAY FOR CONSTANT AND VARIABLE STORAGE
C      CPRSS  = CABIN PRESSURE
C      DEL    = GRID SPACING
C      DIMA   = AA DIMENSION
C      DIMB   = BB DIMENSION
```

```
C     DIMC  = CC DIMENSION
C     DON   = CONSTANT IN REFRACTIVE INDEX EQUATION
C     DWX   = ARRAY OF GRIDPOINT DEFLECTIONS FOR SECOND PANE
C     EANDF = ARRAY USED IN RECTNG
C     FR    = PLATE STIFFNESS (D)
C     GNU   = POISSONS RATIO
C     IBC   = 1,  INDICATES POINT IS OUTSIDE PLANFORM BOUNDARY
C     ICHAP = SEE CHAP
C     IDT   = DEFORMATION DATA RETRIEVAL SEQUENCE NUMBER
C     ILGD  = 1, FIND DEFORMATIONS BY LARGE DEFORMATION METHOD
C     ILRG  = 1,  LARGE DEFLECTIONS WERE CALCULATED
C     IMAN  = 1, FIND MAX./MIN. SLOPES OF DEFORMED POINTS
C     INDX  = 1,  PRINT RETRIEVAL INDEX AT TOP OF PAGE  =0,NO PRINT
C     IPB   = PAGE NUMBER COUNTER IN RESPRT FOR TAPE 9
C     IPD   = PAGE NUMBER COUNTER IN DEFRES
C     IPR   = PAGE NUMBER COUNTER IN RESPRT FOR TAPE 8
C     IPV   = RETRIEVAL LIST PAGE NUMBER
C     IREL  = 1, REAL WINDOW  INCLUDE OTHER SIDE OF SYMMETRY AXIS
C     IRM   = PAGE NUMBER COUNTER IN RESPRT FOR RMS OUTPUT ON TAPE 6
C     IRT   = LOS         DATA RETRIEVAL SEQUENCE NUMBER
C     ISCR1 = SCRATCH TAPE  UNIT 7  FOR DEFORMATION DATA
C     ISCR2 = SCRATCH TAPE  UNIT 8  FOR LINE OF SIGHT (LOS) DATA
C     ISEC  = 1,  PRINT LOS DATA,    =2, PRINT RMS DATA
C     ISI   = INPUT TAPE NUMBER
C     ISO   = OUTPUT TAPE NUMBER
C     IS9   = SCRATCH TAPE  UNIT 9  FOR LINE OF SIGHT DATA BINARY CODED
C     ISHR  = 1,  CALCULATE SHEAR DEFORMATIONS
C     JPN   = ARRAY OF GRIDPOINT COORDINATE INDEXES
C     LIN   = RETRIEVAL LIST LINE COUNTER
C     LOCP  = KEYS HEADINGS AT TOP OF LOS PRINTED PAGE  LOCP=2,NO HEAD
C     LP1   = INDEX ON NO. OF BOUNDARY CONDITIONS
C     LP2   = INDEX ON NO. OF SCALES
C     LP3   = INDEX ON NO. OF SPACES
C     LP4   = INDEX ON NO. OF PRESSURES
C     LP5   = INDEX ON NO. OF RAY ANGLES
C     LP6   = INDEX ON NO. OF GRID POINTS
C     LP7   = INDEX ON NO. OF PLANE ANGLES
C     MIBP  = 1,  BYPASS GENERATION OF INVERSION MATRIX FOR INTERPOLATION
C     MRT   = BY PASS SWITCH FOR TAPE REWIND STATEMENTS IN WINDEF
C     NBC   = NO. OF BOUNDARY CONDITIONS
C     NGP   = NUMBER OF GRID POINTS
C     NMP   = ARRAY OF NUMBER OF DATA PTS. IN MEAN
C     NOPRT = KEYS TAPES ON WHICH OUTPUT DATA APPEARS
C           = 0,  DEFORMATIONS ON TAPE 7, LOS ON TAPES 8 AND 9
C           = 1,  ALL DATA ON SYSTEM OUTPUT TAPE
C           = 2,  OUTPUT ONLY RMS DATA ON OUTPUT TAPE
C     NPAG = NO. OF PLANE ANGLES
```

```
C       NPAN = NO. OF PANES
C       NPRS = NO. OF PRESSURES
C       NRAG = NO. OF RAY ANGLES
C       NRFI  = NO. OF REFRACTIVE INDEXES TO BE READ IN
C       NSCL = NO. OF SCALES
C       NSPC = NO. OF SPACES
C       OIF  = SUPPLEMENTAL ARRAY
C       PLNA  = ARRAY OF PLANE ANGLES
C       PRES  = ARRAY FOR STORING INTERSTICIAL PRESSURES
C       PRSS = PRES(I) = PRESSURE ON PLATE
C       RAYA  = ARRAY OF RAY ANGLES
C       RES   = ARRAY FOR STORING LOS OUTPUT
C       RI    = ARRAY OF REFRACTIVE INDEXES
C       RIC   = REFRACTIVE INDEX COEFFICIENT
C       RHS   = ARRAY USED IN RECTNG
C       RTV   = ARRAY FOR STORING RETRIEVAL INFORMATION
C       SCAL  = ARRAY FOR STORING GEOMETRIC SCALE FACTORS
C       SHAP  = SEE CHAP
C       SKAL  = SCAL(I) = DIMENSIONAL SCALING FACTOR
C       SPAC  = ARRAY FOR STORING SPACE FACTORS
C       SPAD = SPAC(I) = SPACE BETWEEN PLATES
C       STAT  = ARRAY FOR STORING MEAN AND RMS DATA
C       STD   = ARRAY FOR STORING RMSES
C       THIC = PLATE THICKNESS
C       W    = ARRAY OF GRIDPOINT DEFLECTIONS FOR FIRST PANE
C       WORD  = ARRAY FOR TITLE
C       X    = ARRAY OF X COORDINATES OF GRIDPOINTS IN DEFORMATION TABLE
C       YONG  = YOUNGS MODULUS
C
        DOUBLE PRECISION AVG, AVS
C
        COMMON DUM
C
      0 EQUIVALENCE             (DUM(   1), CON),      (DUM( 501),   X),
      1                         (DUM(1501),   W),      (DUM(2251), DWX),
      2                         (DUM(3001), JPN),      (DUM(3501), RTV)
C
      0 EQUIVALENCE             (CON(  1), DIMA),      (CON(  2), DIMB),
      1 (CON(  3), DIMC),       (CON(  4),  DEL),      (CON(  5),  GNU),
      2 (CON(  6), THIC),       (CON(  7), SPAD),      (CON(  8), PRSS),
      3 (CON(  9), NPAN),       (CON( 10),  ISI),      (CON( 11),  ISO),
      4 (CON( 12),  IBC),       (CON( 13),  NGP),      (CON( 14),  LP7),
      5 (CON( 15),   FR),       (CON( 16), LOCP),      (CON( 17),  IPD),
      6 (CON( 18),  IPR),       (CON( 19), CHAP),      (CON(20), ISCR1),
      7 (CON( 21),ISCR2),       (CON( 22), SKAL),      (CON( 23), ISEC),
      8 (CON( 24), NPAG),       (CON( 25), YONG),      (CON( 26), ILRG),
      9 (CON( 27), IREL),       (CON( 28),  LP5),      (CON( 29),CPRSS)
```

```
      C
        0 EQUIVALENCE          (CON( 30),  IRM),      (CON( 31),  IPB),
        1 (CON( 32), MIBP),
        2 (CON( 53), SCAL),    (CON( 61), SPAC),      (CON( 69), PRES),
        3 (CON( 77), PLNA),    (CON( 85), RAYA),      (CON( 93),   RI),
        4 (CON(101),  RES),    (CON(315), STAT),      (CON(371),  OIF)
        4 ,(OIF(1),IDX),(OIF(2),IDY),(OIF(3),X1),(OIF(4),Y1)
      C
        0 EQUIVALENCE          (RTV(    1), JT1),     (RTV(  41), RT2),
        1 (RTV(  81), RT3),    (RTV( 121), RT4),      (RTV( 161), RT5),
        2 (RTV( 201), RT6),    (RTV( 241), JT7),      (RTV( 281), RT8),
        3 (RTV( 321), RT9),    (RTV( 361),JT10),      (RTV( 401),RT11)
      C
        0 EQUIVALENCE          (STAT( 1),  NMP),      (STAT( 9),  AVG),
        1 (STAT(25),  AVS),    (STAT(41),  AMN),      (STAT(49),  STD)
      C
         EQUIVALENCE (CON(33),ITEST),(OIF(11),N2)
      C
        0 DIMENSION     CON(  500),    X(21,33),                  W(21,33),
        1  DWX(21,33),JPN(500),RTV(500)
      C
        0 DIMENSION    SCAL(    8), SPAC(    8), PRES(    8), PLNA(    8),
        1 RAYA(    8),   RI(    7), WORD(   15)
      C
          DIMENSION  NMP( 8), AVG( 8), AVS( 8), AMN( 8), STD( 8), RES(180)
      C
          DATA  TRAP/4HTRAP/, ELIP/4HELIP/, RECT/4HRECT/
      C
          DATA  HING/4HHING/, CLMP/4HCLMP/, BOTH/4HBOTH/,STAR/5H*****/
      C
      C===== THIS SECTION INITIALIZES INDEXES.
      C
          CALL CLOCK (TIME)
          WRITE (6,9070) TIME
      9070 FORMAT (1H0,25HWINDEF TIME =              ,F10.4)
          ISI = 5
          ISO = 6
          ISCR1 = 7
          ISCR2 = 8
          IS9 = 9
          IDT = 0
          IRT=0
          IRM = 0
          LIN=0
          IPD = 0
          IPR = 0
          IPV = 0
```

```
      IPB = 0
      MRT = 0
      DO 90 I=1,500
   90 RTV(I) = 0.0
  100 NGP = 0
     X1=0.
     Y1=0.
      READ (ISI,499) IRT, (WORD(I),I=1,15)
  499 FORMAT (I5,15A5)
      NBC = 1
      IBC = 0
      CHAP = 0.0
C
C===== READ IN PARAMETER DATA.
C
      READ (ISI,500) SHAP, BONC, AA, BB, CC, THIC, YONG, GNU, DEL
  500 FORMAT (1X,A4,1X,A4,7E10.0)
      IF (AA.EQ. 0.0) GO TO 1000
     0 IF ((THIC .EQ. 0.0) .OR. (YONG .EQ. 0.0) .OR. (DEL .EQ. 0.0))
     1 GO TO 902
      IF (BONC .EQ. HING) IBC = 1
      IF (BONC .EQ. CLMP) IBC = 2
      IF (BONC .EQ. BOTH) IBC = 1
      IF (BONC .EQ. BOTH) NBC = 2
      IF (IBC .EQ. 0) GO TO 900
      IF (SHAP .EQ. ELIP) CHAP = 1.0
      IF (SHAP .EQ. RECT) CHAP = 2.0
      IF (SHAP .EQ. TRAP) CHAP = 3.0
      IF (CHAP .EQ. 0.0) GO TO 901
     0 READ (ISI,501) NPAN, NSCL, NSPC, NPRS, NPAG, NRAG, IMAN, ILGD,
     1 IREL, NOPRT, CPRSS, ISHR
     IF(NPAN.EQ.1) CPRSS=0.
  501 FORMAT (10I5,E10.0,I5)
      READ (ISI,502) (SCAL(I), I=1,NSCL)
      IF (NPAN .LT. 2) GO TO 101
      READ (ISI,502) (SPAC(I), I=1,NSPC)
  502 FORMAT (8E10.0)
  101 READ (ISI,502) (PRES(I), I=1,NPRS)
     DO 299 I=1,8
  299 PLNA(I)=0.0
      READ (ISI,502) (PLNA(I), I=1,NPAG)
      READ (ISI,502) (RAYA(I), I=1,NRAG)
      NRFI = 2*NPAN + 1
      READ (ISI,502) (RI(I),I=1,NRFI)
      FR= (YONG*(THIC**3))/(12.0*(1.0-(GNU**2)))
     ITEST=0
     DO 300 I=1,8
```

```
      EI=I-1
      ANGLE=EI*45.
      IF(PLNA(I).EQ.ANGLE) GO TO 300
      ITEST=1
  300 CONTINUE
       IF (MRT .NE. 0) GO TO 201
       IF (NOPRT .EQ. 0) REWIND ISCR1
       IF (NOPRT .EQ. 0) REWIND ISCR2
       IF (NOPRT .EQ. 0) REWIND IS9
       IF (NOPRT .EQ. 0) MRT = 1
C
C===== MAIN DO-LOOP ON NUMBER OF BOUNDARY CONDITIONS.
C
 201   DO 200 LP1=1,NBC
       IF (LP1 .EQ. 2) IBC=2
       DO 200 LP2=1,NSCL
       MIBP = 0
       SKAL = SCAL(LP2)
       IF (SKAL .EQ. 0.0) GO TO 903
       DIMA = AA*SCAL(LP2)
       DIMB = BB*SCAL(LP2)
       DIMC = CC*SCAL(LP2)
       ICHAP = CHAP
      DO 609 IS=1,33
      DO 609 JS=1,21
      X(IS,JS)=1.E-6
         W(IS,JS) = 0.0
 609   DWX(IS,JS) = 0.0
C
C===== SELECT PLANFORM TO BE SOLVED.
C
       GO TO (301,102,103), ICHAP
 301   CALL ELIPSE
       GO TO 104
 102   CALL RECTNG
       IF (ISHR .EQ. 1) CALL SHRDEF
       GO TO 104
  103  CALL TRPZOD
  104 IF(ICHAP.EQ.3) GO TO 202
      IF((DIMA/2.).GT.(32.*DEL)) GO TO 1060
      IF((DIMB/2.).GT.(20.*DEL)) GO TO 1065
  202  SPAD = STAR
       IF (NSPC .EQ. 0) GO TO 105
       DO 200 LP3=1,NSPC
       SPAD = SPAC(LP3)
 105   DO 200 LP4 = 1,NPRS
       ILRG = 0
```

```
      IRT = IRT + 1
      PRSS = PRES(LP4)
      IF((ICHAP.NE.3).OR. (N2.NE.1)) GO TO 110
      DO 799 K=1,21
      DO 799 L=1,33
      W(K,L)=W(K,L)*(CPRSS-PRSS)
  799 DWX(K,L)=DWX(K,L)*PRSS
C     CALCULATE REFRACTIVE INDEXES FOR PRESSURE USED.
  110 DON = ((2.926E-4)/(1.0 + (3.665E-3)*(21.0)))/14.7
      RIC = 1.0 + DON*ABS(PRSS)
      IF (NPAN .EQ. 1) RI(1) = RIC
      IF (NPAN .EQ. 2) RI(1) = 1.0 + DON*ABS(CPRSS)
      IF (NPAN .EQ. 2) RI(3) = RIC
      WRITE (ISO,1050) IPR,IPB
      WRITE (ISO,123)(PRES(I),I=1,NPRS),CPRSS
      WRITE (ISO,121)(RI(I),I=1,NRFI)
  123 FORMAT (1H , 21HPRESSURE LEVELS ARE  6E15.4)
  121 FORMAT (1H , 23HREFRACTIVE INDICES ARE  6E16.8)
      IDT = IDT + 1
      CALL DEFRES (IRT, NOPRT)
      CALL RTVLST (IRT, LIN, IPV)
      IF (IMAN .EQ. 0) GO TO 184
      CALL MAXMIN (IRT)
  184 IF (ILGD .EQ. 0) GO TO 186
      CALL LRGDEF
      ILRG = 1
      CALL DEFRES (IRT, NOPRT)
C
C===== PERFORM RAY TRACE ON DEFLECTED SHAPE FOUND ABOVE.
C
  186 DO 194 LP5=1,NRAG
      DO 182 I=1,8
      NMP(I) = 0
      AVG(I) = 0.0
      AVS(I) = 0.0
      AMN(I) = 0.0
  182 STD(I) = 0.0
      LOCP = 1
      RAYAN = RAYA(LP5)
      DO 192 LP6 = 1,NGP
      K1 = JPN(LP6)
      CALL PACWRD (K1,K2, 2)
C
C     THIS SECTION BYPASSES ALL POINTS NOT ON A 1 INCH SQUARE GRID
C
      XQ = X(K1,K2)
      EJ=K1-1
```

```
      YQ=DEL*EJ
       ZQ = 0.0
      XQQ=XQ/(2.*DEL)
      IX=XQQ
      XU=IX
      RE=XQQ-XU
      IF(RE.NE.0.) GO TO 192
      YQQ=YQ/(2.*DEL)
      IY=YQQ
      YV=IY
      RE=YQQ-YV
      IF(RE.NE.0.) GO TO 192
       DO 190 LP7 = 1,NPAG
       PLANA = PLNA(LP7)
       CALL RAYTRA (XQ, YQ, ZQ, PLANA, RAYAN)
 190   CONTINUE
C
C      THIS SECTION PRINTS THE RAY TRACE DATA AND STORES THE COMPONENT
C      DATA IN MENRES NEEDED TO CALCULATE THE MEAN AND RMS.
C
       ISEC = 1
       CALL RESPRT (IRT, NOPRT)
       CALL MENRMS
 192   CONTINUE
C
C      THIS SECTION CALCULATES THE MEAN AND RMS AND THEN PRINTS THEM
C
       ISEC = 2
       CALL MENRMS
       CALL RESPRT (IRT, NOPRT)
 194   CONTINUE
      IF((ICHAP.NE.3).OR.(N2.NE.1)) GO TO 200
      DO 199 K=1,21
      DO 199 L=1,33
      W(K,L)=W(K,L)/(CPRSS-PRSS)
  199 DWX(K,L)=DWX(K,L)/PRSS
 200   CONTINUE
       GO TO 100
C
C      THIS SECTION PRINTS THE ERROR COMMENTS.
C
 900   WRITE (ISO,950) BONC
 950 0 FORMAT (1H1/1H0,37HTHE BOUNDARY CONDITION WORD USED WAS ,A4,
     1 25H WHICH IS NOT ACCEPTABLE.)
       GO TO 2000
 901   WRITE (ISO,951) SHAP
 951 0 FORMAT (1H1/1H0/1H0,28HTHE PLANEFORM WORD USED WAS.,A4,
```

```
     1 25H WHICH IS NOT ACCEPTABLE.)
       GO TO 2000
 902   WRITE (ISO,952)
 952 0 FORMAT (1H0,43HTHE THICKNESS, YOUNGS MODULUS, OR THE GRID ,
     1 19HINCREMENT ARE ZERO.)
       GO TO 2000
 903   WRITE (ISO,953) LP2
 953   FORMAT (1H0, 6HSCALE(,I1,10H) IS ZERO.)
       GO TO 2000
1000   LIN = LIN + 100
       CALL RTVLST (IRT, LIN, IPV)
       IF (NOPRT .EQ. 1) GO TO 1010
       WRITE (ISO,1050) IPR, IPB
1050 0 FORMAT (1H1/1H0,9HTHERE ARE,I5,27H PAGES OF RAY TRACE OUTPUT ,
     1 30HON THE MICROFILM TAPE (TAPE 8)/ ,
     2             1H0,9HTHERE ARE,I5,27H PAGES OF RAY TRACE OUTPUT ,
     1 30HON THE RETRIEVAL TAPE (TAPE 9))
       INX = 999
       CALL PAGE (IPB, LIN, IS9, INX)
       GO TO 1020
1010   WRITE (ISO,1051) IPR
1051 0 FORMAT (1H1/1H0,9HTHERE ARE,I5,27HPAGES OF RAY TRACE OUTPUT ,
     1 30HON THE SYSOUTPUT TAPE (TAPE 6))
1020   WRITE (ISO,1052)
1052   FORMAT (1H0/1H0,30X,40H***** THE PROBLEM YOU GAVE ME TO DO WAS ,
     1 20HDONE CORRECTLY *****)
       CALL CLOCK (TIME)
       WRITE (6,9099) TIME
9099   FORMAT (1H0,25HEND WINDEF TIME =         , F10.4)
 1060 WRITE(6,9098) IRT
 9098 FORMAT(1H1,38HTHE PROBLEM DESIGNATED RETRIVAL NUMBER,I4,58H HAS IT
     1S AA DIMENSION GREATER THAN THE PROGRAM CAN HANDLE.)
 1065 WRITE(6,9097) IRT
 9097 FORMAT(1H1,38HTHE PROBLEM DESIGNATED RETRIVAL NUMBER,I4,58H HAS IT
     1S BB DIMENSION GREATER THAN THE PROGRAM CAN HANDLE.)
      GO TO 100
2000   STOP
       END
$IBFTC MS23D1
CELIPSE
       SUBROUTINE ELIPSE
C
C      THIS SUBROUTINE GENERATES THE TABLE OF GRIDPOINT DEFORMATIONS FOR
C      AN ELLIPSE
C
C      A     = ELLIPSE MAJOR SEMI AXIS
C      B     = ELLIPSE MINOR SEMI AXIS
```

```
C       C    = ELLIPTIC FOCAL DISTANCE
C       DWX  = DEFLECTION AT POINT I,J OF SECOND PANE
C       ET   = ELLIPTIC COORDINATE
C       ETX  = PARTIAL OF ET WRT X
C       ETY  = PARTIAL OF ET WRT Y
C       I    = ROW INDEX
C       J    = COLUM INDEX
C       K    = GRIDPOINT COUNTER
C       NGP  = NUMBER OF GRID POINTS
C       W    = DEFLECTION AT POINT I,J OF FIRST PANE
C       W1   = CONSTANT IN DEFLECTION EQUATION
C       WO   = CONSTANT IN DEFLECTION EQUATION
C       WEP  = PARTIAL OF W WRT ET
C       WZP  = PARTIAL OF W WRT ZI
C       X    = X COORDINATE ARRAY
C       XLIM = X VALUE AT ELLIPTIC BOUNDARY ALONG ANY ABSISSA
C       ZI   = ELLIPTIC COORDINATE
C       ZIX  = PARTIAL OF ZI WRT X
C       ZIY  = PARTIAL OF ZI WRT Y
C       ALL OTHER LEFT HAND SIDE VALUES ARE TEMPORARIES
C
        COMMON DUM
C
      0 EQUIVALENCE           (DUM(   1), CON),      (DUM( 501),   X),
      1                       (DUM(1501),   W),      (DUM(2251), DWX),
      2                       (DUM(3001), JPN),      (DUM(3501), RTV)
C
      0 EQUIVALENCE           (CON(   1), DIMA),     (CON(   2), DIMB),
      1 (CON(  3), DIMC),     (CON(   4),  DEL),     (CON(   5),  GNU),
      2 (CON(  6), THIC),     (CON(   7), SPAD),     (CON(   8), PRSS),
      3 (CON(  9), NPAN),     (CON(  10),  ISI),     (CON(  11),  ISO),
      4 (CON( 12),  IBC),     (CON(  13),  NGP),     (CON(  14),  LP7),
      5 (CON( 15),   FR),     (CON(  16), LOCP),     (CON(  17),  IPD),
      6 (CON( 18),  IPR),     (CON(  19), CHAP),     (CON(20), ISCR1),
      7 (CON( 21),ISCR2),     (CON(  22), SKAL),     (CON(  23), ISEC),
      8 (CON( 24), NPAG),     (CON(  25), YONG),     (CON(  26), ILGD),
      9 (CON( 27), IREL),     (CON(  28),  LP5),     (CON( 29),CPRSS)
C
      0 EQUIVALENCE           (CON(  30),  IRM),     (CON(  31),  IPB),
      1 (CON( 53), SCAL),     (CON(  61), SPAC),     (CON(  69), PRES),
      2 (CON( 77), PLNA),     (CON(  85), RAYA),     (CON(  93),   RI),
      3 (CON(101),  RES),     (CON( 315), STAT),     (CON( 371),  OIF),
      4 (CON(401),EANDF),     (CON( 451),  RHS)
C
C
      0 DIMENSION     CON(   500),    X(21,33),              W(21,33),
      1  DWX(21,33),JPN(500),RTV(500)
```

```
C
      A = DIMA/2.0
      B = DIMB/2.0
C
C===== INITIALIZE INDEXES.
C
      IF (A .GT. B) GO TO 201
      TM = B
      B = A
      A = TM
  201 C = SQRT(A*A - B*B)
      XLIM = A
      I = 0
      J = 0
      K = 0
      X(1,1) = 0.0
      GO TO (100,104), IBC
C
C===== THIS SECTION CALCULATES THE GRIDPOINT DEFORMATIONS FOR AN ELLIPSE
C      WITH SIMPLY SUPPORTED EDGES.
C
C      CALCULATE CONSTANTS
C
  100 IF (A .EQ. B) GO TO 102
      X(1,1) = A
      ZI = 1.0
      ET = 1.0
      XC = X(1,1)
     YC=0.
      CALL ELIPIT (C, XC, YC,     ZI, ET, FZP, FEP, GZP, GEP, DET)
C
      A1O = ZI
      A2O = 2.0*ZI
      A4O = 4.0*ZI
      CA2O = COSH(A2O)
      CA4O = COSH(A4O)
      CA2S = (COSH(A2O))**2
      SA2S = (SINH(A2O))**2
      SA2Q = (SINH(A2O))**4
      WO = (C**4)/(12.0*128.0*CA2S*CA4O*FR)
      OMNU = (1.0 - GNU)
      W1 = +(8.0*(OMNU)*(3.0*CA2S-2.0)*SA2Q)/(2.0*CA2S-(OMNU)*SA2S)
      X(1,1) = 0.0
C     CALCULATE GRID POINT DEFORMATIONS.
  203 I = I+1
  101 J = J+1
      K = K+1
```

```
      K1 = I
      K2 = J
      CALL PACWRD (K1,K2,1)
      JPN(K) = K1
      ZI = 1.0
      ET = 1.0
      XC = X(I,J)
     EJ=I-1
     YC=DEL*EJ
      CALL ELIPIT (C, XC, YC,      ZI, ET, FZP, FEP, GZP, GEP, DET)
      ZI2 = 2.0*ZI
      ZI4 = 4.0*ZI
      ET2 = 2.0*ET
      ET4 = 4.0*ET
      TE1 = (3.0*CA20*CA40 - 4.0*CA40*COSH(ZI2) + CA20*COSH(ZI4))
      TE2 = (3.0*CA20*CA40 - 4.0*CA40* COS(ET2) + CA20* COS(ET4))
      TE3 = (COSH(ZI2) - CA20)
      TE4 = (CA20 - COS(ET2))
      W(I,J) = WO*(TE1*TE2 - W1*TE3*TE4)
     IF(NPAN.EQ.2) DWX(I,J)=W(I,J)
    0 WZP  = WO*(TE2*(-8.0*CA40*SINH(ZI2) + 4.0*CA20*SINH(ZI4))
    1       -W1*TE4*(2.0*SINH(ZI2)))
    0 WEP  = WO*(TE1*(+8.0*CA40* SIN(ET2) - 4.0*CA20* SIN(ET4))
    1       -W1*TE3*(2.0* SIN(ET2)))
      ZIX  =-GEP/DET
      ETX  = GZP/DET
      ZIY  = FEP/DET
      ETY  = FZP/DET
      X(I,J+1) = X(I,J) + DEL
      IF (X(I,J+1) .LE. XLIM) GO TO 101
      X(I,J+1) = 0.0
      J = 0
      X(I+1,J+1) = 0.0
     EJ=I
     DWY=DEL*EJ
      IF (DWY        .GT. B) GO TO 800
      XLIM = A*SQRT (1.0 - (DWY        **2/(B*B)))
      IF (DWY        .LE. B) GO TO 203
      GO TO 800
C
C===== THIS SECTION SOLVES THE SIMPLY SUPPORTED EDGE WHEN A = B (CIRCLE)
C
  102 TE1 = 1.0/(64.0*FR)
      TE2 = ((5.0+GNU)/(1.0+GNU))*(A*A)
      I = 0
      J = 0
      X(1,1) = 0.0
```

```
      XLIM = A
205   I = I+1
103   J = J+1
      K = K+1
      K1 = I
      K2 = J
      CALL PACWRD (K1,K2,1)
      JPN(K) = K1
      X2 = X(I,J)*X(I,J)
     EJ=I-1
     Y2=DEL*DEL*EJ*EJ
      TE3 = (A*A - X2 -Y2)
      TE4= (TE2 - X2 - Y2)
      W(I,J) = TE1*TE3*TE4
     IF(NPAN.EQ.2) DWX(I,J)=W(I,J)
      X(I,J+1) = X(I,J) +.DEL
     EJ=I
     DWY=DEL*EJ
      IF (X(I,J+1) .LE. XLIM) GO TO 103
      X(I,J+1) = 0.0
      J = 0
      X(I+1,J+1) = 0.0
     EJ=I
     DWY=DEL*EJ
      IF (DWY        .GT. B) GO TO 800
      XLIM = A*SQRT (1.0 - (DWY        **2/(B*B)))
      IF (DWY        .LE. B) GO TO 205
      GO TO 800
C
C===== THIS SECTION CALCULATES THE GRIDPOINT DEFORMATIONS FOR AN
C      ELLIPSE WITH CLAMPED EDGES.
C
104   TEM = (24.0/(A**4)) + (24.0/(B**4)) + (16.0/(A*A*B*B))
      WO = 1.0/(FR*TEM)
207   I = I+1
105   J = J+1
      K = K+1
      K1 = I
      K2 = J
      CALL PACWRD (K1,K2,1)
      JPN(K) = K1
     EJ=I-1
     DWY=EJ*DEL
      TEM = (1.0 - (X(I,J)*X(I,J)/(A*A)) - (DWY*DWY       /(B*B)))
      W(I,J) = WO*(TEM**2)
     IF(NPAN.EQ.2) DWX(I,J)=W(I,J)
      X(I,J+1) = X(I,J) + DEL
```

```
         IF (X(I,J+1) .LE. XLIM) GO TO 105
         X(I,J+1) = 0.0
         J = 0
         X(I+1,J+1) = 0.0
        EJ=I
        DWY=DEL*EJ
         IF (DWY         .GT. B) GO TO 800
         XLIM = A*SQRT (1.0 - (DWY*DWY      /(B*B)))
         IF (DWY         .LE. B) GO TO 207
  800    NGP = K
         RETURN
         END
$IBFTC MS23D2
CELIPIT
         SUBROUTINE ELIPIT (C, X, Y, XI, ET, FXP, FEP, GXP, GEP, DET)
C
C        THIS SUBROUTINE DETERMINS THE ELLIPTIC COORDINATES XI AND ET,
C        CORRESPONDING TO THE CARTESIAN COORDINATES X AND Y.
C
C        ITERATION IS BY THE NEWTON-RHAPSON METHOD OF SUCCESSIVE APPROX.
C
C        C    = ELLIPTIC FOCAL DISTANCE
C        DET  = DETERMINENT
C        ET   = ET COORDINATE VALUE IN ELLIPTICAL SYSTEM
C        FEP  = PARTIAL OF FIO WRT ET
C        FIO  = FUNCTION F
C        FXP  = PARTIAL OF FIO WRT XI
C        GEP  = PARTIAL OF GIO WRT ET
C        GIO  = FUNCTION G
C        GXP  = PARTIAL OF GIO WRT XI
C        IDON = 1 INDICATES ITERATION IS COMPLETE
C        X     = X COORDINATE VALUE IN RETANGULAR SYSTEM
C        XI    = ZI COORDINATE VALUE IN ELLIPTICAL SYSTEM
C        Y     = Y COORDINATE VALUE IN RETANGULAR SYSTEM
C        ALL OTHER LEFT HAND VALUES ARE TEMPORARIES
C
         IDON = 0
  100    IF (Y .NE. 0.0) GO TO 103
         IF (X .GT. C) GO TO 101
         XI1 = 0.0
         ET1 = ACOS(X/C)
         GO TO 108
  101    XI = 1.0
         ET = 0.0
  102    FIO = X - C*COSH(XI)*COS(ET)
         FXP =   - C*SINH(XI)*COS(ET)
         XI1 = XI - FIO/FXP
```

```
      ET1 = ET
      IF ((ABS(XI1 - XI)) .LE. 0.0000001) GO TO 108
      XI = XI1
      GO TO 102
  103 IF (X .NE. 0.0) GO TO 105
      ET = 90.0*0.017453292519
      XI = 0.0
  104 GIO = Y - C*SINH(XI)*SIN(ET)
      GXP =    - C*COSH(XI)*SIN(ET)
      XI1 = XI - GIO/GXP
      ET1 = ET
      IF ((ABS(XI1 - XI)) .LE. 0.0000001) GO TO 108
      XI = XI1
      GO TO 104
  105 FIO = X - C*COSH(XI)*COS(ET)
      GIO = Y - C*SINH(XI)*SIN(ET)
  106 FXP =    - C*SINH(XI)*COS(ET)
      FEP =    + C*COSH(XI)*SIN(ET)
      GXP =    - C*COSH(XI)*SIN(ET)
      GEP =    - C*SINH(XI)*COS(ET)
      DET = (FXP*GEP - FEP*GXP)
      IF (IDON .EQ. 1) GO TO 800
      XI1 = XI - (1.0/DET)*(GEP*FIO - FEP*GIO)
      ET1 = ET + (1.0/DET)*(GXP*FIO - FXP*GIO)
      IF ((ABS(XI1 - XI)) .LE. 0.0000001) GO TO 107
      XI = XI1
      ET = ET1
      GO TO 105
  107 IF ((ABS(ET1 - ET)) .LE. 0.0000001) GO TO 108
      XI = XI1
      ET = ET1
      GO TO 105
  108 XI = XI1
      ET = ET1
      IDON =1
      GO TO 105
  800 RETURN
      END
$IBFTC MS23D3
CRECTAG
C
      SUBROUTINE RECTNG
C
C     THIS SUBROUTINE GENERATES THE TABLE OF GRIDPOINT DEFORMATIONS
C     FOR A RECTANGULAR PLATE WITH DIMENSIONS A BY  B AND RIGIDITY D
C
C     A       = PLATE LENGTH
```

```
C        ALPHAM = DEFLECTION COEFFICIENT
C        ALPHAN = DEFLECTION COEFFICIENT
C        ASPECT =  SQUARE OF ASPECT RATIO
C        B      = PLATE WIDTH
C        BETAM  = MOMENT COEFFICIENT
C        BETAN  =  MOMENT COEFFICIENT
C        D      = PLATE STIFFNESS
C        DWX    = DEFLECTION AT POINT I,J OF SECOND PANE
C        DWXMOE = SLOPE IN X DIRECTION FOR MOMENTS APPLIED ALONG ONE EDGE
C        DWXMOF = SLOPE IN X DIRECTION FOR MOMENTS APPLIED ALONG OTHER EDGE
C        DWXSIM = SLOPE IN X DIRECTION FOR SIMPLY SUPPORTED EDGE
C        DWYMOE = SLOPE IN Y DIRECTION FOR MOMENTS APPLIED ALONG ONE EDGE
C        DWYMOF = SLOPE IN Y DIRECTION FOR MOMENTS APPLIED ALONG OTHER EDGE
C        DWYSIM = SLOPE IN Y DIRECTION FOR SIMPLY SUPPORTED EDGE
C        EM     =  COUNT ON NUMBER OF TERMS
C        EN     = COUNT ON NUMBER OF TERMS
C        I      = ROW INDEX
C        IBC    = BOUNDARY CONDITION SWITCH
C        ILIM   = NUMBER OF EQUATIONS USED TO DETERMINE REDUNDANT MOMENTS
C        J      = COLUMN INDEX
C        K      = GRIDPOINT COUNTER
C        MN     = NUMBER OF SIMULTANEOUS EQUATIONS
C        MOMENT = COEFFICIENTS OF LHS OF EQUATIONS
C        NGP    = NUMBER OF GRIDPOINTS
C        NM     = COLUMNS IN RHS OF EQUATIONS
C        RHS    =  RHS OF SET OF SIMULTANEOUS EQUATIONS
C        W      = DEFLECTION AT POINT I,J OF FIRST PANE
C        WMOE   = DEFLECTION FOR MOMENTS APPLIED ALONG ONE EDGE
C        WMOF   = DEFLECTION FOR MOMENTS APPLIED ALONG OTHER EDGE
C        WSIM   = DEFLECTION FOR SIMPLY SUPPORTED EDGE
C        X      = X COORDINATE ARRAY
C
         COMMON DUM
C
        DOUBLE PRECISION RHS,EANDF,MOMENT
       0 EQUIVALENCE           (DUM(   1), CON),       (DUM( 501),   X),
       1                       (DUM(1501),   W),       (DUM(2251), DWX),
       2                       (DUM(3001), JPN),       (DUM(3501), RTV),
       3 (DUM(4001),MOMENT)
C
       0 EQUIVALENCE           (CON(   1), DIMA),      (CON(   2), DIMB),
       1 (CON(  3), DIMC),     (CON(   4),  DEL),      (CON(   5),  GNU),
       2 (CON(  6), THIC),     (CON(   7), SPAD),      (CON(   8), PRSS),
       3 (CON(  9), NPAN),     (CON(  10),  ISI),      (CON(  11),  ISO),
       4 (CON( 12),  IBC),     (CON(  13),  NGP),      (CON(  14),  LP7),
       5 (CON( 15),   FR),     (CON(  16), LOCP),      (CON(  17),  IPD),
       6 (CON( 18),  IPR),     (CON(  19), CHAP),      (CON(20), ISCR1),
```

```
     7 (CON( 21),ISCR2),     (CON( 22), SKAL),     (CON( 23), ISEC),
     8 (CON( 24), NPAG),     (CON( 25), YONG),     (CON( 26), ILGD),
     9 (CON( 27), IREL),     (CON( 28),  LP5),     (CON( 29), CPRSS)
C
     0 EQUIVALENCE           (CON( 30),  IRM),     (CON( 31),  IPB),
     1 (CON( 53), SCAL),     (CON( 61), SPAC),     (CON( 69), PRES),
     2 (CON( 77), PLNA),     (CON( 85), RAYA),     (CON( 93),   RI),
     3 (CON(101),  RES),     (CON(315), STAT),     (CON(371),  OIF),
     4 (CON(401),RHS)
C
     0 DIMENSION     CON(  500),    X(21,33),                 W(21,33),
     1  DWX(21,33),JPN(500),RTV(500)
C
      DIMENSION RHS(32),EANDF(32),MOMENT(32,32)
      EQUIVALENCE (RHS,EANDF)
C
C
C===== THIS SECTION SETS UP INITIAL CONSTANTS
C
       D = FR
       A = DIMA
       B = DIMB
       ILIM = 28
       IULIM = ILIM/2
       ILLIM = ILIM/2 + 1
       NTERMS = ILIM - 3
       TERMS = NTERMS
  10   I = 0
       J = 0
       K = 0
       X(1,1) = 0.0
       PI = 3.1415926535
       CNST1 = 4.0*(A**4)/(D*(PI**5))
       CNST2 = 4.0*(A**3)/(D*(PI**4))
       CNST3 = A*A/(2.0*D*PI*PI)
       CNST4 = A/(2.0*D*PI)
       CNST5 = B*B/(2.0*D*PI*PI)
       CNST6 = B/(2.0*D*PI)
       IF (IBC .EQ. 1) GO TO 100
C
C===== THIS SECTION CALCULATES THE MOMENT COEFFICIENTS FOR CLAMPED PLATE
C
 50    DO 55 JK=1,ILIM
       DO 55 L=1,ILIM
 55    MOMENT(JK,L) = 0.0
       EN = -1.0
       DO 60 II=1,IULIM
```

```
      EN = EN + 2.0
      ALPHAN = EN*PI*B/(2.0*A)
      CNST7 = 8.0*EN*A/(PI*B)
      CNST8 = 4.0*A*A/((EN**4)*(PI**3))
      ASPECT = A*A/(B*B)
      III = II
      IF (ALPHAN .LT. 88.0) GO TO 57
       MOMENT(II,III) = 1.0/EN
      RHS(II) = -CNST8
      GO TO 58
 57  0MOMENT(II,III) = (TANH(ALPHAN)+ALPHAN/
     1                  COSH(ALPHAN)/COSH(ALPHAN)) /EN
      RHS(II) = CNST8*(ALPHAN/ COSH(ALPHAN)/COSH(ALPHAN) -TANH(ALPHAN))
 58   EM = -1.0
      DO 60 JJ=ILLIM,ILIM
      EM = EM + 2.0
     0MOMENT(II,JJ) = CNST7*(1.0/((EM**3)*(EN*EN/(EM*EM)+ASPECT)
     1                *(EN*EN/(EM*EM)+ASPECT)))
  60  CONTINUE
  70  EN = -1.0
      DO 80 II=ILLIM,ILIM
      EN = EN +2.0
      BETAN = EN*PI*A/(2.0*B)
      CNST9 = 8.0*B*EN/(PI*A)
      CNST10 = 4.0*B*B/((EN**4)*(PI**3))
      ASPECT = B*B/(A*A)
      III = II
      IF (BETAN .LT. 88.0) GO TO 73
      MOMENT (II,III) = 1.0/EN
      RHS (II) = -CNST10
      GO TO 75
 73  0MOMENT(II,III) = (TANH(BETAN)+BETAN/
     1                  COSH(BETAN)/COSH(BETAN)) /EN
      RHS(II) = CNST10*(BETAN/ COSH(BETAN)/COSH(BETAN) -TANH(BETAN))
 75   EM = -1.0
      DO 80 JJ=1,IULIM
      EM = EM + 2.0
     0MOMENT(II,JJ) = CNST9*(1.0/((EM**3)*(EN*EN/(EM*EM)+ASPECT)
     1                *(EN*EN/(EM*EM)+ASPECT)))
  80  CONTINUE
      MN = ILIM
      NM = 1
     CALL SEQS (MOMENT,RHS,MN,NM)
C
C===== THIS SECTION GENERATES DEFORMATIONS FOR HINGED EDGES
C
 100  I = I + 1
```

```
  105   J = J+1
        K = K+1
        K1 = I
        K2 = J
        CALL PACWRD (K1,K2,1)
        JPN(K) = K1
          W(I,J) = 0.0
       IF(NPAN.EQ.2) DWX(I,J)=W(I,J)
        EM = -1.0
  110   EM = EM + 2.0
       EJ=I-1
       DWY=DEL*EJ
        CNSTA = EM*PI/A
        ALPHAM = CNSTA*B/2.0
        MMM = EM
        CNST11 = -1.0
        IF (((MMM-1)/2-((MMM-1)/4)*2) .EQ. 0) CNST11=1.0
        CNST11 = CNST11/(EM**5)
        CNST12 = EM*CNST11
        CNST13 = COSH(ALPHAM)
        CNST14 = (2.0+ALPHAM*TANH(ALPHAM))/(2.0*CNST13)
      0   WSIM = CNST1*CNST11*(1.0-CNST14*COSH(CNSTA*DWY)
      1          +CNSTA*DWY    *SINH(CNSTA*DWY    )/(2.0*CNST13))*
      2           COS(CNSTA*X(I,J))
        IF (IBC .EQ. 2) GO TO 200
          W(I,J) = W(I,J) + WSIM
       IF(NPAN.EQ.2) DWX(I,J)=W(I,J)
        IF (EM .LE. TERMS) GO TO 110
        X(I,J+1) = X(I,J) + DEL
        IF (X(I,J+1) .LE. (A/2.0)) GO TO 105
        X(I,J+1) = 0.0
        J = 0
        X(I+1,J+1) = 0.0
       EJ=I
       DWY=EJ*DEL
        IF (DWY        .LE. (B/2.0)) GO TO 100
        GO TO 300
C
C===== THIS SECTION GENERATES DEFORMATIONS FOR CLAMPED EDGES
C
C
  200   CNSTB = EM*PI/B
        BETAM = CNSTB*A/2.0
        MMM = EM
        CNST15 = -1.0
        IF (((MMM-1)/2-((MMM-1)/4)*2) .EQ. 0) CNST15=1.0
        CNST15 = CNST15/(EM*EM)
```

```
       CNST16 = EM*CNST15
       CNST17 = COSH(BETAM)
       CNST18 = ALPHAM*TANH(ALPHAM)/CNST13
       CNST19 = BETAM*TANH(BETAM)/CNST17
       EMM = EM/2.0 + 0.5
       M = EMM
      EJ=I-1
      DWY=EJ*DEL
     0   WMOE = -CNST3*CNST15*EANDF(M)*(CNSTA*DWY   *SINH(CNSTA*DWY    )/
     1            CNST13   -CNST18*COSH(CNSTA*DWY    ))*COS(CNSTA*X(I,J))
       EEE = IULIM
       EMM = EM/2.0 + EEE + 0.5
       M = EMM
     0   WMOF = -CNST5*CNST15*EANDF(M)*(CNSTB*X(I,J)*SINH(CNSTB*X(I,J))/
     1            CNST17   -CNST19*COSH(CNSTB*X(I,J)))*COS(CNSTB*DWY    )
         W(I,J) =   W(I,J) +   WSIM +   WMOE +   WMOF
      IF(NPAN.EQ.2) DWX(I,J)=W(I,J)
       IF (EM .LE. TERMS) GO TO 110
       X(I,J+1) = X(I,J) + DEL
       IF (X(I,J+1) .LE. (A/2.0)) GO TO 105
       X(I,J+1) = 0.0
       J = 0
       X(I+1,J+1) = 0.0
      EJ=I
      DWY=DEL*EJ
       IF (DWY         .LE. (B/2.0)) GO TO 100
  300  NGP = K
  800  RETURN
       END
$IBFTC MS23D4
CSEQS
C
      SUBROUTINE SEQS (A,B,N,M)
C
C     MATRIX INVERSION WITH ACCOMPANYING SOLUTION OF LINEAR EQUATIONS
C
C
      COMMON DUM
     0 EQUIVALENCE (DUM(1),CON),(DUM(501),X),(DUM(1001),Y)
     1,(DUM(1501),W),(DUM(2001),DWX), (DUM(2501),DWY),(DUM(3001),JPN)
     2 ,(DUM(3501),RTV)
      DOUBLE PRECISION A,B,AMAX,PIVOT,SWAP,T
      DIMENSION  IPIVOT(32),A(32,32),      INDEX(32,2),PIVOT(32),B(32,2)
       EQUIVALENCE (IROW,JROW),(AMAX,T,SWAP),(ICOLUM,JCOLUM)
C
C
C=====INITIALIZATION
```

```
C
   10 DETERM=1.0
   15 DO 20 J=1,N
   20 IPIVOT(J)=0
   30 DO 550 I=1,N
C
C=====SEARCH FOR PIVOT ELEMENT
C
   40 AMAX=0.0
   45 DO 105 J=1,N
   50 IF (IPIVOT(J)-1) 60, 105, 60
   60 DO 100 K=1,N
   70 IF (IPIVOT(K)-1) 80, 100, 740
  80  IF(DABS(AMAX)-DABS(A(J,K)))85,100,100
   85 IROW=J
   90 ICOLUM=K
   95 AMAX=A(J,K)
  100 CONTINUE
  105 CONTINUE
       IF (AMAX) 128,107,128
 107   PRINT 108
 108   FORMAT (22H MATRIX IS SINGULAR.   )
       NCE = 1
       GO TO 740
 128  IPIVOT(ICOLUM) =IPIVOT(ICOLUM)+1
C
C=====INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL
C
  130 IF (IROW-ICOLUM) 140, 260, 140
  140 DETERM=-DETERM
  150 DO 200 L=1,N
  160 SWAP=A(IROW,L)
  170 A(IROW,L)=A(ICOLUM,L)
  200 A(ICOLUM,L)=SWAP
  205 IF(M) 260, 260, 210
  210 DO 250 L=1, M
  220 SWAP=B(IROW,L)
  230 B(IROW,L)=B(ICOLUM ,L)
  250 B(ICOLUM,L)=SWAP
  260 INDEX(I,1)=IROW
  270 INDEX(I,2)=ICOLUM
  310 PIVOT(I)=A(ICOLUM,ICOLUM)
  320 CONTINUE
C
C=====DIVIDE PIVOT ROW BY PIVOT ELEMEN.
C
  330 A(ICOLUM,ICOLUM)=10.0D-1
```

```
  340 DO 350 L=1,N
  350 A(ICOLUM,L)=A(ICOLUM,L)/PIVOT(I)
  355 IF(M) 380, 380, 360
  360 DO 370 L=1,M
  370 B(ICOLUM,L)=B(ICOLUM,L)/PIVOT(I)
C
C=====REDUCE NON-PIVOT ROWS
C
  380 DO 550 L1=1,N
  390 IF(L1-ICOLUM) 400, 550, 400
  400 T=A(L1,ICOLUM)
  420 A(L1,ICOLUM)=0.0
  430 DO 450 L=1,N
  450 A(L1,L)=A(L1,L)-A(ICOLUM,L)*T
  455 IF(M) 550, 550, 460
  460 DO 500 L=1,M
  500 B(L1,L)=B(L1,L)-B(ICOLUM,L)*T
  550 CONTINUE
C
C=====INTERCHANGE COLUMNS
C
  600 DO 710 I=1,N
  610 L=N+1-I
  620 IF (INDEX(L,1)-INDEX(L,2)) 630, 710, 630
  630 JROW= INDEX(L,1)
  640 JCOLUM=INDEX(L,2)
  650 DO 705 K=1,N
  660 SWAP=A(K,JROW)
  670 A(K,JROW)=A(K,JCOLUM)
  700 A(K,JCOLUM)=SWAP
  705 CONTINUE
  710 CONTINUE
  740 RETURN
      END
$IBFTC MS23D5
CTRPZOD
       SUBROUTINE TRPZOD
C      THIS SUBROUTINE READS IN THE TRAPEZOIDAL DEFORMATION DATA FROM
C      PUNCHED CARDS.  THE CODES ARE BROKEN DOWN AND REASSEMBLED IN THE
C      FORMAT NECESSARY FOR THE RAY TRACE PROGRAMS.
C
C      DWX    = SLOPE IN X DIR. AT POINT LOC
C      DWY    = SLOPE IN Y DIR. AT POINT LOC
C      ELM    = ELEMENT VALVE AT LOC
C      IBY    = =1 INDICATES POINT IS OUTSIDE PLANFORM BOUNDARY
C      ICOL   = COLUMN NUMBER
C      IDIR   = DEGREE OF FREEDOM  1=X, 2=Y, 3=Z, 4=TX, 5= TY, 6=TZ
```

```
C      ILD    = LOAD NUMBER OUTPUT BY SAMIS (COLUMN CODE)
C      IROW   = ROW NUMBER
C      ITEM   = TEMPORARY
C      JLD = LOAD NUMBER DESIRED.  THE LOAD NUMBER IS A PART OF THE
C            ELEMENT CODE GENERATED BY SAMIS.
C      LOC    = COORDINATE LOCATION CODE
C      M      = GRIDPOINT COUNTER
C      NCRD = NO. OF ELEMENT DATA CARDS TO BE READ IN.
C      NGP    = NUMBER OF GRIDPOINTS
C      SCLFAC = SCALE FACTOR TO MULTIPLY DEFLECTIONS BY
C      W      = DEFLECTION AT POINT LOC
C      X      = X COORDINATE ARRAY
C      XS     = X COORDINATE AT POINT LOC
C      YS     = Y COORDINATE AT POINT LOC
C
       COMMON DUM
C
     0 EQUIVALENCE            (DUM(   1), CON),      (DUM( 501),   X),
     1                        (DUM(1501),   W),      (DUM(2251), DWX),
     2                        (DUM(3001), JPN),      (DUM(3501), RTV)
C
     0 EQUIVALENCE            (CON(  1), DIMA),      (CON(  2), DIMB),
     1 (CON(  3), DIMC),      (CON(  4),  DEL),      (CON(  5),  GNU),
     2 (CON(  6), THIC),      (CON(  7), SPAD),      (CON(  8), PRSS),
     3 (CON(  9), NPAN),      (CON( 10),  ISI),      (CON( 11),  ISO),
     4 (CON( 12),  IBC),      (CON( 13),  NGP),      (CON( 14),  LP7),
     5 (CON( 15),   FR),      (CON( 16), LOCP),      (CON( 17),  IPD),
     6 (CON( 18),  IPR),      (CON( 19), CHAP),      (CON(20), ISCR1),
     7 (CON( 21),ISCR2),      (CON( 22), SKAL),      (CON( 23), ISEC),
     8 (CON( 24), NPAG),      (CON( 25), YONG),      (CON( 26), ILGD),
     9 (CON( 27), IREL),      (CON( 28),  LP5),      (CON( 29),CPRSS)
C
     0 EQUIVALENCE            (CON( 30),  IRM),      (CON( 31),  IPB),
     1 (CON( 53), SCAL),      (CON( 61), SPAC),      (CON( 69), PRES),
     2 (CON( 77), PLNA),      (CON( 85), RAYA),      (CON( 93),   RI),
     3 (CON(101),  RES),      (CON(315), STAT),      (CON(371),  OIF)
     4 ,(OIF(1),IDX),(OIF(2),IDY),(OIF(3),X1),(OIF(4),Y1),(OIF(11),N2)
C
     0 DIMENSION     CON(  500),     X(21,33),              W(21,33),
     1  DWX(21,33),JPN(500),OIF(4)
C
       DIMENSION   LOC(3), ILD(3), ELM(3)
C
       READ (ISI,500) JLD, NCRD, SCLFAC,X1,Y1,IDX,IDY
  500  FORMAT (2I5,3E10.0,2I5)
      WRITE (ISO,503)  SCLFAC
  503 FORMAT (1H1,  42HSCALE FACTOR FOR TRAPEZOID DEFLECTIONS IS
```

```
     1    E16.4,1H.)
          WRITE (ISO,505) X1,Y1
      505 FORMAT (1H , 31HINTERPOLATION CENTER IS AT X1=  E12.4, 6H, Y1=
         1  E12.4,1H.)
          WRITE (ISO,507)IDX,IDY
      507 FORMAT (1H , 35HCENTER OF INTERPOLATION SQUARES IS I5,
         1 17H X INTERVALS AND I5, 25H Y INTERVALS FROM ORIGIN.)
C    X1,Y1 - COORDINATES OF TRANSLATED ORIGIN
C    IDX= NO. OF INTERVALS IN X FOR INTERPOLATION CENTER
C    IDY= NO. OF INTERVALS IN Y FOR INTERPOLATION CENTER
C    IF JLD IS MINUS, CARD DATA FOR WINDOW IN ACTUAL CONFIGURATION IS GIVEN.
C    IF NCRD IS MINUS, CARD DATA IS GIVEN FOR ONLY 1 OF 2 PANES AND BOTH
C    ARE THE SAME.
          N1=1
          N2=1
          IF(NCRD)2,6,6
    2     N1=2
          NCRD=-NCRD
     6    IR=21
          IC=33
          IF(JLD) 10,15,15
    10    N2=2
          JLD=-JLD
          IR=20
          IC=20
    15    M=0
           DO 104 I=1,NCRD
           READ (ISI,501) (LOC(J), ILD(J), ELM(J), J=1,3)
   501     FORMAT (3(I6,I6,O12))
C
C===== TEST TO SEE IF DATA IS ACCEPTABLE
           DO 104 J=1,3
           IF (ILD(J) .NE. JLD) GO TO 104
           IF (LOC(J) .LE. 0) GO TO 104
           IROW = LOC(J)/1000
           ITEM = LOC(J) - IROW*1000
           ICOL = ITEM/10
           IDIR = ITEM - ICOL*10
           IF ((IDIR.EQ.1) .OR. (IDIR.EQ.2) .OR. (IDIR.EQ.6)) GO TO 104
          IF((ICOL.GT.IC).OR.(IROW.GT.IR))GO TO 20
           XS = ICOL - 1
           YS = IROW - 1
          GO TO 30
    20    XS=ICOL-1-IC
          YS=IROW-1-IR
    30    IBY=0
          XS=XS*DEL
```

```
      YS=YS*DEL
       CALL BONDRY (XS, YS, IBY)
       IF (IBY .EQ. 1) GO TO 104
       K1 = IROW
       K2 = ICOL
       CALL PACWRD (K1,K2,1)
      IF((IROW.LE.IR).AND.(ICOL.LE.IC))GO TO 32
      IF((IROW.GT.IR).AND.(ICOL.GT.IC))GO TO 40
      GO TO 104
   32 K=IROW
       L = ICOL
       X(K,L) = ICOL - 1
      X(K,L)=X(K,L)*DEL
C
C===== STORE ACCEPTABLE DATA
      IF((IDIR.EQ.3).AND.(N2.EQ.1))   W(K,L)=ELM(J)*SCLFAC
      IF((IDIR.EQ.3).AND.(N2.EQ.2)) DWX(K,L)=ELM(J)*SCLFAC
       IF (IDIR .EQ. 3) M = M+1
       IF (IDIR .EQ. 3) JPN(M) = K1
      GO TO (104,34),N1
   34 DWX(K,L)=W(K,L)
      GO TO 104
   40 IF(NPAN-2)104,44,104
   44 K=IROW-IR
      L=ICOL-IC
      IF((IDIR.EQ.3).AND.(N2.EQ.1)) DWX(K,L)=ELM(J)*SCLFAC
      IF((IDIR.EQ.3).AND.(N2.EQ.2))   W(K,L)=ELM(J)*SCLFAC
  104  CONTINUE
       NGP = M
  800  RETURN
       END
$IBFTC MS23D6
CLRGDEF
       SUBROUTINE LRGDEF
C
C      THIS PROGRAM USES EQUATIONS DERIVED FROM AN ENERGY METHOD
C      DEVELOPED IN TIMOSHENKOS THEORY OF PLATES AND SHELLS, P. 419 TO
C      424 TO FIND THE APPROXIMATE LARGE DEFLECTION SOLUTION FOR A
C      RECTANGULAR PLATE.
C
C      A        = HALF RECTANGLE LENGTH
C      A1       = CONSTANTS IN CUBIC EQUATION
C      B        = HALF RECTANGLE WIDTH
C      C1       = CONSTANTS IN CUBIC EQUATION
C      CON1     = CONSTANTS IN LARGE DEFLECTION EQUATION
C      CON2     = CONSTANTS IN LARGE DEFLECTION EQUATION
C      CON3     = CONSTANTS IN LARGE DEFLECTION EQUATION
```

```
C     CON4   = CONSTANTS IN LARGE DEFLECTION EQUATION
C     CON5   = CONSTANTS IN LARGE DEFLECTION EQUATION
C     D1     = CONSTANTS IN CUBIC EQUATION
C     DUX    = LARGE DEFLECTION THEORY DEFLECTION FOR FIRST PANE
C     Q      = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C     QR     = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C     R      = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C     S1     = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C     S2     = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C     SQR    = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C     TM     = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C     TP     = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C     U      = LARGE DEFLECTION THEORY DEFLECTION FOR SECOND PANE
C     WO     = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C
      DOUBLE PRECISION PI,CON1,CON2,CON3,CON4,CON5,A1,C1,Q,R,QR,SQR,TP,
     1 S1,TM,S2,WO,Q1,Q2,QC
C
      COMMON DUM
C
     0 EQUIVALENCE                (DUM(   1), CON),      (DUM( 501),   X),
     1                            (DUM(1501),   W),      (DUM(2001), DWX),
     2                            (DUM(3001), JPN),      (DUM(3501), RTV),
     3 (DUM(4001),    U),         (DUM(4751), DUX),      (DUM(5501),   R),
     4 (DUM(6001),    S),         (DUM(6501),   T),      (DUM(7251), DTX)
C
     0 EQUIVALENCE                (CON(   1), DIMA),     (CON(   2), DIMB),
     1 (CON(   3), DIMC),         (CON(   4),  DEL),     (CON(   5),  GNU),
     2 (CON(   6), THIC),         (CON(   7), SPAD),     (CON(   8), PRSS),
     3 (CON(   9), NPAN),         (CON(  10),  ISI),     (CON(  11),  ISO),
     4 (CON(  12),  IBC),         (CON(  13),  NGP),     (CON(  14),  LP7),
     5 (CON(  15),   FR),         (CON(  16), LOCP),     (CON(  17),  IPD),
     6 (CON(  18),  IPR),         (CON(  19), CHAP),     (CON(20), ISCR1),
     7 (CON(  21),ISCR2),         (CON(  22), SKAL),     (CON(  23), ISEC),
     8 (CON(  24), NPAG),         (CON(  25), YONG),     (CON(  26), ILGD),
     9 (CON(  27), IREL),         (CON(  28),  LP5),     (CON(  29), CPRSS)
C
     0 EQUIVALENCE                (CON(  30),  IRM),     (CON(  31),  IPB),
     1 (CON(  32), MIBP),         (CON(  33),  IWD),     (CON(  34),  IDS),
     2 (CON(  53), SCAL),         (CON(  61), SPAC),     (CON(  69), PRES),
     3 (CON(  77), PLNA),         (CON(  85), RAYA),     (CON(  93),   RI),
     4 (CON(101),   RES),         (CON(315), STAT),      (CON(371),   OIF),
     5 (CON(401),EANDF),          (CON(451),  RHS)
C
      EQUIVALENCE (RTV,BI),(OIF(1),NDX),(OIF(2),NDY),(X1,OIF(3)),
     1 (Y1,OIF(4)),(OIF(5),CONST1),(OIF(6),CONST2),(OIF(7),CONST3),
     2 (OIF(8),CONST4),(OIF(9),CONST5),(OIF(10),CONST6)
```

```
C
     0 DIMENSION      CON(  500),    X(21,33),    W(21,33),   DWX(21,33),
     1 JPN(500),RTV(500),OIF(10),    U(21,33),   DUX(21,33)
C
      IF (CHAP.NE.2.) GO TO 900
      NTIMES=0
      III=1
      IF(NPAN.EQ.2) III=2
  100 DO 700 II=1,III
      II=II
      NTIMES=NTIMES+1
      PRSSS=PRSS
      IF (NTIMES.EQ.2) PRSSS=-(PRSS-CPRSS)
       DO 102 I=1,21
       DO 102 J=1,33
  102 U(I,J)=W(I,J)*PRSSS
       PI = 3.14159265358979323846
       A = DIMA/2.0
       B = DIMB/2.0
C      CONSTANTS IN LARGE DEFLECTION EQUATION.
       CON1 = 480.0*A*B/(YONG*THIC*PI**4)
       CON2 = (PI**2/16.0)*(9.0*B/(A**3) + 2.0/(A*B) + 9.0*A/(B**3))
     0 CON3 = (PI**2/3.0)*(16.0*B/(A**2) + 1.0/A + 1.0/B + 16.0*A/
     1 (B**2))**2
       CON4 = (35.0*(PI**2)*B/A + 35.0*(PI**2)*A/B + 640.0/9.0)
       CON5 = CON1/(CON2 - (2.0/3.0)*(CON3/CON4))
C      CONSTANTS IN CUBIC EQUATION
       A1 = 1.0/CON5
      C1=    PRSSS/(U(1,1) *3.)
       D1 = -PRSSS
C      SOLUTION OF CUBIC EQUATION.
       Q = A1*C1
       R = -0.5*(A1**2)*D1
       INEG = 0
       QR = Q**3 + R**2
       SQR =DSQRT(QR)
       TP = R + SQR
       IF (TP .GT. 0.0) GO TO 106
       INEG = 1
  106  S1 = ABS(TP)**(1.0/3.0)
       IF (INEG .NE. 1) GO TO 108
       S1 = -S1
       INEG = 0
  108  TM = R - SQR
       IF (TM .GT. 0.0) GO TO 110
       INEG = 1
  110  S2 = ABS(TM)**(1.0/3.0)
```

```
      IF (INEG .NE. 1) GO TO 112
      S2 = -S2
  112 INEG = 0
      WO = (S1 + S2)/A1
C     DETERMINATION OF SMALL DEFLECTION THEORY AND LARGE DEFLECTION
C     THEORY PRESSURES.
      Q2 = (WO**3)/CON5
      Q1 = PRSSS- Q2
C     THIS SECTION DETERMINES THE DEFLECTION AND SLOPES.
  116 IF(NTIMES.EQ.1) GO TO 103
      CONST4=Q1
      CONST5=PRSSS
      CONST6=WO
      GO TO 105
  103 CONST1=Q1
      CONST2=PRSSS
      CONST3=WO
  105 DO 104 I=1,NGP
      K1 = JPN(I)
      CALL PACWRD (K1,K2,2)
      CX = PI*X(K1,K2)/(2.0*A)
      EJ=K1-1
      YY=DEL*EJ
      CY=PI*YY/(2.0*B)
      TE1 = U(K1,K2)*(ABS(Q1/PRSSS))
      TE2 =  WO*COS(CX)*COS(CY)
  104 U(K1,K2) = (TE1 + TE2)/2.0
      IF(NTIMES.EQ.2) GO TO 700
      DO 120 I=1,21
      DO 120 J=1,33
  120 DUX(I,J)=U(I,J)
  700 CONTINUE
  800 RETURN
  900 WRITE(ISO,500)
  500 FORMAT(1H1,99HINPUT ERROR. LARGE DEFLECTION REQUIRED FOR PLANFORM
     1OTHER THAN RECTANGLE.                                          )
      STOP
      END
$IBFTC MS23D7
C     DEFRES
      SUBROUTINE DEFRES (IDT, NOPRT)
C
C     THIS SUBROUTINE PRINTS OUT THE PLATE DEFLECTION DATA.
C
C     CONC    = BOUNDARY CONDITION
C     DTX     = TEMPORARY ARRAY FOR SLOPE IN X DIR.
C     DTY     = TEMPORARY ARRAY FOR SLOPE IN Y DIR.
```

```
C       R       = TEMPORARY ARRAY FOR X COORDINATES
C       S       = TEMPORARY ARRAY FOR Y COORDINATES
C       T       = TEMPORARY ARRAY FOR DEFLECTION
C
        COMMON DUM
C
      0 EQUIVALENCE            (DUM(   1), CON),      (DUM( 501),   X),
      1                        (DUM(1501),   W),      (DUM(2251), DWX),
      2 (DUM(3001),JPN),(DUM(3501),RTV),
      3 (DUM(4001),   U),      (DUM(4751), DUX),
      4 (DUM(5501),   R),      (DUM(6001),   S),
      5 (DUM(6501),   T),      (DUM(7251), DTX)
C
      0 EQUIVALENCE            (CON(  1), DIMA),      (CON(  2), DIMB),
      1 (CON(  3), DIMC),      (CON(  4),  DEL),      (CON(  5),  GNU),
      2 (CON(  6), THIC),      (CON(  7), SPAD),      (CON(  8), PRSS),
      3 (CON(  9), NPAN),      (CON( 10),  ISI),      (CON( 11),  ISO),
      4 (CON( 12),  IBC),      (CON( 13),  NGP),      (CON( 14),  LP7),
      5 (CON( 15),   FR),      (CON( 16), LOCP),      (CON( 17),  IPD),
      6 (CON( 18),  IPR),      (CON( 19), CHAP),      (CON(20), ISCR1),
      7 (CON( 21),ISCR2),      (CON( 22), SKAL),      (CON( 23), ISEC),
      8 (CON( 24), NPAG),      (CON( 25), YONG),      (CON( 26), ILRG),
      9 (CON( 27), IREL),      (CON( 28),  LP5),      (CON( 29),CPRSS)
C
      0 EQUIVALENCE            (CON( 30),  IRM),      (CON( 31),  IPB),
      1 (CON( 53), SCAL),      (CON( 61), SPAC),      (CON( 69), PRES),
      2 (CON( 77), PLNA),      (CON( 85), RAYA),      (CON( 93),   RI),
      3 (CON(101),  RES),      (CON(315), STAT),      (CON(371),  OIF),
      4 (CON(401),EANDF),      (CON(451),  RHS)
C
      0 DIMENSION     CON(  500),    X(21,33),                 W(21,33),
      2    R(  500),    S(  500),    T(  750),   DTX(  750)
      3,    U(21,33),   DUX(21,33)
      3 ,DWX(21,33),JPN(500)
C
      0 DIMENSION RT30(3), RT31(3), RT32(3), RT36(2), RT37(2), RT38(2),
      1 RT39(2)
C
      0 DATA   RT30(1)/13HELLIPSE    A=/, RT31(1)/13HRECTANGLE  A=/,
      1        RT32(1)/13HTRAPEZOID  A=/, RT33/4H  B=/, RT34/4H  C=/,
      2        RT35/6HSCALE=/, RT36(1)/10HTHICKNESS=/,
      3        RT37(1)/9H   PANES=/, RT38(1)/11H   SPACING=/,
      4 RT39(1)/12H   PRESSURE=/
        DATA   HING/6HHINGED/, CH/1H /, CLMP/6HCLAMPE/, CC/1HD/
C
C===== THIS SECTION MULTIPLIES THE UNITIZED DEFORMATIONS BY THE PRESSURE
C       LOAD.
```

```
C
      IS7 = ISO
      IF (NOPRT .EQ. 0) IS7 = ISCR1
      DO 101 I=1,NGP
      K1 = JPN(I)
      CALL PACWRD (K1,K2,2)
     EJ=K1-1
      R(I) = X(K1,K2)
     S(I)=DEL*EJ
     IF(ILRG.EQ.1) GO TO 100
     IF(CHAP.EQ.3.) GO TO 99
        T(I) =   W(K1,K2)*(CPRSS-PRSS)
     DTX(I)=DWX(K1,K2)*PRSS
      GO TO 101
   99 T(I)=W(K1,K2)
     DTX(I)=DWX(K1,K2)
     GO TO 101
  100 T(I)=U(K1,K2)
     DTX(I)=DUX(K1,K2)
     IF(NPAN.EQ.1) DTX(I)=0.
  101 CONTINUE
C
C===== THIS SECTION PRINTS THE TITLE AND HEADING INFORMATION.
C
      CALL PAGE (IPD, LINE, IS7, IDT)
      IF (ILRG .EQ. 0) GO TO 607
      WRITE (IS7,529)
  529 FORMAT (1H0,    38X,38HW I N D O W   D E F O R M A T I O N   ,
     1 7HD A T A/1H ,49X,23H(LARGE DEFLECTION DATA)/1H )
      GO TO 608
  607 WRITE (IS7,500)
  500 FORMAT (1H0/1H ,38X,38HW I N D O W   D E F O R M A T I O N   ,
     1 7HD A T A/1H )
  608 ICHAP = CHAP
      IF ( IBC .NE. 1) GO TO 302
      CONC = HING
      CF = CH
  302 IF (IBC .NE. 2) GO TO 303
      CONC = CLMP
      CF = CC
  303 GO TO (102,103,104), ICHAP
  102 WRITE (IS7,501) (RT30(I),I=1,3), DIMA, RT33, DIMB,
     1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
     2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
  501 FORMAT (1H0,2A6,A1,F5.2,A4,F5.2,14X,A6,F4.2,3X,A6,A4,F5.2,A6,A3,
     1          I1,A6,A5,F3.1,2A6,F5.1,3X,A6,A1)
      GO TO 105
```

```
103 0 WRITE (IS7,501) (RT31(I),I=1,3), DIMA, RT33, DIMB,
    1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
      GO TO 105
104 0 WRITE (IS7,518) (RT32(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
    1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
518 0 FORMAT (1H0,2A6,A1,F5.2,A4,F5.2,A4,F5.2,5X,A6,F4.2,3X,A6,A4,F5.2,
    1 A6,A3,I1,A6,A5,F3.1,2A6,F5.1,3X,A6,A1)
105   WRITE (IS7,505)
505 0 FORMAT (1H0/1H ,1X,11HCOORDINATES,18X,12HDEFORMATIONS,14X,
    1                      11HCOORDINATES,18X,12HDEFORMATIONS/1H0,
    2 44H  X        Y     DEFL. PANE 1   DEFL. PANE 2              ,11X,
    3 44H  X        Y     DEFL. PANE 1   DEFL. PANE 2              )
      LINE = LINE + 11
      JRM = NGP-2*(NGP/2)
      DO 114 K=1,NGP,2
      IF (LINE - 45) 112,107,107
107   CALL PAGE (IPD, LINE, IS7, IDT)
      WRITE (IS7,500)
      GO TO (108,109,110), ICHAP
108 0 WRITE (IS7,501) (RT30(I),I=1,3), DIMA, RT33, DIMB,
    1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
      GO TO 111
109 0 WRITE (IS7,501) (RT31(I),I=1,3), DIMA, RT33, DIMB,
    1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
      GO TO 111
110 0 WRITE (IS7,518) (RT32(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
    1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
111   WRITE (IS7,505)
      LINE = LINE + 11
112   IF ((JRM .EQ. 1) .AND. (K .EQ. NGP)) GO TO 113
      J = K+1
    0 WRITE (IS7,506) R(K), S(K), T(K), DTX(K)
    1  ,                 R(J), S(J), T(J), DTX(J)
506 0 FORMAT (1H ,F5.2,F7.2,2(2X,E13.6),13X
    1  ,           F5.2,F7.2,2(2X,E13.6))
      GO TO 114
113   WRITE (IS7,506) R(K), S(K), T(K), DTX(K)
114   LINE = LINE + 1
800   RETURN
      END
$IBFTC MS23D8
GRAYTRA
```

```
      SUBROUTINE RAYTRA (XQ, YQ, ZQ, PLANA, RAYAN)
C     ALPHAI = PLANE ANGLE  0-360 DEG  MEASURED CCW FROM X TO Y AXIS.
C     DELTAN = RAY ANGLE  0-90 DEG  MEASURER FROM +Z AXIS TO XY PLANE.
C
C     PRSS = FIRST WINDOW PRESSURE FACTOR TO SCALE DEFORMATIONS
C     PRSF =   2ND WINDOW PRESSURE FACTOR TO SCALE DEFORMATIONS
C     RES(IJ+  1) = X COORDINATE OF ENTERING RAY
C     RES(IJ+ 11) = Y COORDINATE OF ENTERING RAY
C     RES(IJ+ 21) = RAY ANGLE    OF ENTERING RAY
C     RES(IJ+ 31) = PLANE ANGLE  OF ENTERING RAY
C     RES(IJ+ 41) = Z COORDINATE OF EXITING RAY
C     RES(IJ+ 51) = PLATE SLOPE ABOUT X-AXIS AT POINT OF ENTERING RAY
C     RES(IJ+ 61) = PLATE SLOPE ABOUT Y-AXIS AT POINT OF ENTERING RAY
C     RES(IJ+ 71) = X COORDINATE OF EXITING RAY
C     RES(IJ+ 81) = Y COORDINATE OF EXITING RAY
C     RES(IJ+ 91) = Z COORDINATE OF EXITING RAY
C     RES(IJ+101) = PLANE ANGLE  OF EXITING RAY
C     RES(IJ+111) = RAY   ANGLE  OF EXITING RAY
C     RES(IJ+121) = PLANE ANGLE DIFFERENCE OF ENTERING-EXITING RAY
C     RES(IJ+131) = RAY   ANGLE DIFFERENCE OF ENTERING-EXITING RAY
C     RES(IJ+141) = VECTOR DIFFERENCE BETWEEN ENTERING-EXITING RAY
C     RES(IJ+151) = X COMPONENT OF ENT-EXT VECTOR DIFFERENCE
C     RES(IJ+161) = Y COMPONENT OF ENT-EXT VECTOR DIFFERENCE
C     RES(IJ+171) = Z COMPONENT OF ENT-EXT VECTOR DIFFERENCE
C
      COMMON  DUM
C
     0 EQUIVALENCE            (DUM(    1), CON),       (DUM( 501),    X),
     1 (DUM(1001),     Y),    (DUM(1501),    W),       (DUM(2001), DWX),
     2 (DUM(2501), DWY),      (DUM(3001), JPN),        (DUM(3501), RTV)
C
     0 EQUIVALENCE            (CON(   1), DIMA),       (CON(   2), DIMB),
     1 (CON(   3), DIMC),     (CON(   4),  DEL),       (CON(   5),  GNU),
     2 (CON(   6), THIC),     (CON(   7), SPAD),       (CON(   8), PRSS),
     3 (CON(   9), NPAN),     (CON(  10),  ISI),       (CON(  11),  ISO),
     4 (CON(  12),   IBC),    (CON(  13),  NGP),       (CON(  14),  LP7),
     5 (CON(  15),    FR),    (CON(  16), LOCP),       (CON(  17),  IPD),
     6 (CON(  18),   IPR),    (CON(  19), CHAP),       (CON(20), ISCR1),
     7 (CON(  21),ISCR2),     (CON(  22), SKAL),       (CON(  23), ISEC),
     8 (CON(  24), NPAG),     (CON(  25), YONG),       (CON(  26), ILGD),
     9 (CON(  27), IREL),     (CON(  28),   LP5),      (CON(  29),CPRSS)
C
     0 EQUIVALENCE            (CON(  30),  IRM),       (CON(  31),  IPB),
     1 (CON(  53), SCAL),     (CON(  61), SPAC),       (CON(  69), PRES),
     2 (CON(  77), PLNA),     (CON(  85), RAYA),       (CON(  93),   RI),
     3 (CON(101),  RES),      (CON(315), STAT),        (CON(371),  OIF),
     4 (CON(401),EANDF),      (CON(451),  RHS)
```

```
C
      DIMENSION    CON(  500),   X(22,22),   Y(22,22),   W(22,22),
     1 DWX(22,22),  DWY(22,22),  JPN(  500),  RTV(  500),  RES(  180)
C
      DIMENSION  CI(3), DELTAP( 6), CN(3), RI(7), CR(3), D(3)
C
      XS = XQ
      YS = YQ
      ZS = ZQ
      ALPHAI = PLANA
      DELTAN = RAYAN
      DELTAI = (90.0-DELTAN)
      IJ = LP7-1
      IF (NPAN .EQ. 2) PRSS = -(PRSS-CPRSS)
      RES(IJ+  1) = XS
      RES(IJ+ 11) = YS
      RES(IJ+ 21) = DELTAN
      RES(IJ+ 31) = ALPHAI
      D(1) = THIC
      D(2) = D(1) + SPAD
      D(3) = D(2) + THIC
      N = NPAN*2
      DO 100 I=1,N
  100 DELTAP(I) = 1.0
      RAD = 0.017453292519
      DEG = 1.0/RAD
      SEC = 206264.8064
      PI = 3.141592653
      K = 1
      ZP = 0.0
      IF (DELTAI .NE. 90.0) GO TO 105
C     COMPLETE COMPONENTS OF INCIDENT RAY
      ALPHAI = ALPHAI*RAD
      DELTAI = DELTAI*RAD
      CI(1) = 0.0
      CI(2) = 0.0
      CI(3) = 1.0
      GO TO 110
  105 ALPHAI = ALPHAI*RAD
      DELTAI = DELTAI*RAD
      CI(1) = COS(DELTAI)*COS(ALPHAI)
      CI(2) = COS(DELTAI)*SIN(ALPHAI)
      CI(3) = SIN(DELTAI)
C     COMPUTE POINT OF INTERSECTION OF INCIDENT RAY WITH XY PLANE.
  110 SIGMAI = (ACOS(CI(1)))
      BETAI  = (ACOS(CI(2)))
      GAMMAI = (1.5707963268-DELTAI)
```

```
      IF (DELTAN .EQ. 0.0) GAMMAI = 0.0
  115 XP = XS - ZS*CI(1)/CI(3)
      YP = YS - ZS*CI(2)/CI(3)
      IBY = 0
      CALL BONDRY (XP, YP, IBY)
      IF (IBY .EQ. 1) GO TO 800
C     CALCULATE INTERSECTION OF RAY WITH WINDOW SURFACE
C
      CALL ITERAT (XP, YP, K, DELTAP, CI, DELZ, OWX, OWY)
C
      ZP = ZP + DELZ
C     CALCULATE NORMAL TO WINDOW SURFACE
C
      CALL NORMAL (OWX, OWY, K, DELTAP, CN)
C
      QRI = RI(K+1)/RI(K)
C     CALCULATE REFRACTED RAY IN NEXT MEDIUM.
C
      CALL REFRCI (CI, CN, QRI,     CR,              ISO)
C
  119 IF (N-K) 130,130,120
  120 XS = XP
      YS = YP
      ZS = ZP - D(K)
      DO 125 I=1,3
  125 CI(I) = CR(I)
      ZP = D(K)
      K = K+1
      IF (K .EQ. 3) PRSS = -(PRSS-CPRSS)
      GO TO 115
  130 CALL BONDRY (XP, YP, IBY)
      IF (IBY .EQ. 1) GO TO 800
      RES(IJ+ 41) = ZP
      RES(IJ+ 51) = OWX
      RES(IJ+ 61) = OWY
      CRPI = COS(BETAI )*CR(3) - COS(GAMMAI)*CR(2)
      CRPJ = COS(GAMMAI)*CR(1) - COS(SIGMAI)*CR(3)
      CRPK = COS(SIGMAI)*CR(2) - COS(BETAI )*CR(1)
      CROSSR = SQRT (CRPI**2 + CRPJ**2 + CRPK**2)
      DELINC =  ASIN(CROSSR)*SEC
      TEM = SQRT (CR(1)**2 + CR(2)**2)
      DELTAR = ACOS(1.0)
      IF (TEM .LT. 1.0) DELTAR = ACOS(TEM)
      DELTAM = (90.0*RAD - DELTAR)
      IF (CR(1) .NE. 0.0) GO TO 361
      ALPHAR = 0.0
      GO TO 362
```

```
 361  ALPHAR = ATAN2(CR(2),CR(1))
 362  IF (ALPHAI) 140,140,505
 505  IF (ALPHAR) 520,140,140
 520  ALPHAR = ALPHAR + 6.283185072
 140  DELDEC = (DELTAN*RAD - DELTAM)*SEC
      DELDEL = (DELTAI - DELTAR)*SEC
      DELALP = (ALPHAI-ALPHAR)*SEC
      DELTAM = DELTAM*DEG
      ALPHAR = ALPHAR*DEG
      DELTAR = DELTAR*DEG
      RES(IJ+ 71) = XP
      RES(IJ+ 81) = YP
      RES(IJ+ 91) = ZP
      RES(IJ+101) = ALPHAR
      RES(IJ+111) = DELTAM
      RES(IJ+121) = DELALP
      RES(IJ+131) = DELDEC
      RES(IJ+141) = DELINC
      RES(IJ+151) = CRPI*SEC
      RES(IJ+161) = CRPJ*SEC
      RES(IJ+171) = CRPK*SEC
  800 IF((K.LT.3).AND.(NPAN.EQ.2)) PRSS=-(PRSS-CPRSS)
      RETURN
      END
$IBFTC MS23D9
CITERAT
      SUBROUTINE ITERAT (XP, YP, K, DELTAP, CI, DELZ, OWX, OWY)
C
C     THIS SUBROUTINE PERFORMS THE ITERATION TO FIND THE POINT XP,YP ON
C     THE DEFORMED SURFACE.
C
      COMMON  DUM
    0 EQUIVALENCE              (DUM(    1), CON)
    0 EQUIVALENCE              (CON(   1), DIMA),        (CON(   2), DIMB)
C
      DIMENSION CI(3), DELTAP( 6)
C
      J = 1
      DELTAA = 0.0
 101  CALL INCOTB (XP, YP, OWF, OWX, OWY, K)
      DELZ = OWF*DELTAP(K)
      A = (DELZ - DELTAA*CI(3))*CI(3)
      IF (ABS(A) - 1.0E-06) 800,800,102
 102  DELTAA = DELTAA + A
      XP = XP + A*CI(1)
      YP = YP + A*CI(2)
      DIMA=2.*DIMA
```

```
      DIMB=2.*DIMB
      IBY=0
      CALL BONDRY  (XP,YP,IBY)
      DIMA=DIMA/2.
      DIMB=DIMB/2.
      IF(IBY.EQ.1) GO TO 800
       J = J+1
       IF (J-25) 101,800,800
  800 RETURN
       END
$IBFTC MS23E0
CINCOTB
       SUBROUTINE INCOTB (XP, YP, OWF, OWX, OWY, L)
C
C      THIS SUBROUTINE GENERATES THE TABLE OF INTERPOLATION COEFFICIENTS
C
      DOUBLE PRECISION A,BR,A1,A2,A3,A4
C
       COMMON  DUM
C
     0 EQUIVALENCE              (DUM(    1), CON),       (DUM( 501),    X),
     1                          (DUM(1501),    W),       (DUM(2251), DWX),
     2                          (DUM(3001), JPN),        (DUM(3501), RTV)
     3 ,(DUM(4001),BR),(DUM(6100),B)
C
     0 EQUIVALENCE              (CON(   1), DIMA),       (CON(   2), DIMB),
     1 (CON(   3), DIMC),       (CON(   4),    DEL),     (CON(   5),   GNU),
     2 (CON(   6), THIC),       (CON(   7), SPAD),       (CON(   8), PRSS),
     3 (CON(   9), NPAN),       (CON( 10),    ISI),      (CON( 11),    ISO),
     4 (CON( 12),    IBC),      (CON( 13),    NGP),      (CON( 14),    LP7),
     5 (CON( 15),     FR),      (CON( 16), LOCP),        (CON( 17),    IPD),
     6 (CON( 18),    IPR),      (CON( 19), CHAP),        (CON( 20),ISCR1),
     7 (CON( 21),ISCR2),        (CON( 22), SKAL),        (CON( 23), ISEC),
     8 (CON( 24), NPAG),        (CON( 25), YONG),        (CON( 26), ILGD),
     9 (CON( 27), IREL),        (CON( 28),    LP5),      (CON( 29),CPRSS)
C
     0 EQUIVALENCE              (CON( 30),    IRM),      (CON( 31),    IPB),
     1 (CON( 32), MIBP),        (CON( 33),    IWD),      (CON( 34),    IDS),
     2 (CON( 53), SCAL),        (CON( 61), SPAC),        (CON( 69), PRES),
     3 (CON( 77), PLNA),        (CON( 85), RAYA),        (CON( 93),     RI),
     4 (CON(101),   RES),       (CON(315), STAT),        (CON(371),    OIF),
     5 (CON(401),EANDF),        (CON(451),    RHS)
C
     0 EQUIVALENCE  (RTV,BI),(OIF(1),NDX),(OIF(2),NDY),(X1,OIF(3)),
     1 (Y1,OIF(4)),(OIF(5),CONST1),(OIF(6),CONST2),(OIF(7),CONST3),
     2 (OIF(8),CONST4),(OIF(9),CONST5),(OIF(10),CONST6)
C
```

```
      DIMENSION     CON(  500),    X(21,33),                   W(21,33),
     1  DWX(21,33),JPN(500),RTV(500),OIF(10)
C
      DIMENSION        A(25),BR(32,32),B(36,25),WC(36,2)
     1,A1(25,2),A2(25,2),A3(25,2),A4(32,2)
C
      DATA PI/3.14159265/
C
      JUMP=5
      IF(MIBP)304,304,400
  304 ICHAP = CHAP
      JUMP=1
      X1P=X1
      Y1P=Y1
      GO TO (20,40,60),ICHAP
   20 IDX=5
      IDY=5
      GO TO 309
   40 IDX=DIMA
      IDX=IDX/2
      IDY=DIMB
      IDY=IDY/2
  305 IF(IDX.LT.5) IDX=5
      IF(IDY.LT.5) IDY=5
      GO TO 309
   60 IDX=NDX
      IDY=NDY
      IF(IDX.LT.5) GO TO 306
      IF(IDY.LT.5) GO TO 306
      GO TO 311
  306 WRITE (ISO,307)
  307 FORMAT (1H0, 78H INTERPOLATION FAILS. GRID HAS LESS THAN SIX NODES
     1 IN THE X OR Y DIRECTION.       )
      STOP
  309 IF(IDX.GT.10) IDX=IDX/2
      IF(IDY.GT.10) IDY=IDY/2
  311 CONTINUE
      DTX=IDX
      DTX=DTX*DEL
      DTY=IDY
      DTY=DTY*DEL
      DO 300 I1=1,4
      GO TO (310,318,314,322),I1
  310 I3=IDY+1
      I2=I3-5
      J3=IDX+1
      J2=J3-5
```

```
      GO TO 308
  314 I2=IDY+1
      I3=I2+5
      J3=IDX+1
      J2=J3-5
      GO TO 308
  318 I3=IDY+1
      I2=I3-5
      J2=IDX+1
      J3=J2+5
      GO TO 308
  322 I2=IDY+1
      I3=I2+5
      J2=IDX+1
      J3=J2+5
  308 CONTINUE
      AA=DIMA/2.
      BB=DIMB/2.
      DO 200 I=1,36
       DO 200 J=1,25
  200  B(I,J) = 0.0
       K = 0
      DO 202 J=J2,J3
      EJ=J
      DO 202 I=I2,I3
       K = K+1
      EI=I
      U=DEL*(EJ-1.)-X1P
      V=DEL*(EI-1.)-Y1P
 8040  B(K, 1) = (U**4)*(V**4)
       B(K, 2) = (U**4)*(V**3)
       B(K, 3) = (U**3)*(V**4)
       B(K, 4) = (U**4)*(V**2)
       B(K, 5) = (U**3)*(V**3)
       B(K, 6) = (U**2)*(V**4)
       B(K, 7) = (U**4)*(V   )
       B(K, 8) = (U**3)*(V**2)
       B(K, 9) = (U**2)*(V**3)
       B(K,10) = (U   )*(V**4)
       B(K,11) = (U**4)
       B(K,12) = (U**3)*(V   )
       B(K,13) = (U**2)*(V**2)
       B(K,14) = (U   )*(V**3)
       B(K,15) =         (V**4)
       B(K,16) = (U**3)
       B(K,17) = (U**2)*(V   )
       B(K,18) = (U   )*(V**2)
```

```
      B(K,19) =         (V**3)
      B(K,20) = (U**2)
      B(K,21) = (U    )*(V    )
      B(K,22) =         (V**2)
      B(K,23) = (U    )
      B(K,24) =         (V    )
      B(K,25) = 1.0
     WC(K,1)=W(I,J)
     WC(K,2)=DWX(I,J)
     IF(ILRG.NE.1) GO TO 201
     WC(K,1)=0.5*(W(I,J)*CONST2*(ABS(CONST1/CONST2))+CONST3*COS(PI*U/
    1 (AA*2.))*COS(PI*V/(BB*2.)))
     IF(NPAN.NE.2) GO TO 201
                   WC(K,1)=0.5*(W(I,J)*CONST5*(ABS(CONST4/CONST5))+
    1 CONST6*COS(PI*U/(AA*2.))*COS(PI*V/(BB*2.)))
     WC(K,2)=0.5*(W(I,J)*CONST2*(ABS(CONST1/CONST2))+CONST3*COS(PI*U/
    1 (AA*2.))*COS(PI*V/(BB*2.)))
 201  IF(ABS(X(I,J)-X1P-U)-1.0E-7)202,202,206
  206 DO 210 LM=1,25
  210 B(K,LM)=0.
  202 CONTINUE
      DO 240 K=1,2
      DO 240 I=1,25
      A4(I,K)=0.
      DO 240 J=1,36
  240 A4(I,K)=A4(I,K)+B(J,I)*WC(J,K)
C
C===== THIS SECTION MULTIPLIES THE COEFFICIENT MATRIX BY ITS TRANSPOSE
C
       DO 124 I=1,25
       DO 124 J=1,25
 122   BR(I,J) = 0.0
      DO 124 K=1,36
 124   BR(I,J) = BR(I,J) + B(K,I)*B(K,J)
C
C===== THIS SECTION INVERTS THE INTERMEDIATE MATRIX.
C===== THIS SECTION CALCULATES THE COEFFICIENTS.
C
       NR = 25
      NC=2
      CALL SEQS (BR,A4,NR,NC)
      DO 280 I=1,25
      GO TO (260,264,268,300),I1
  260 A1(I,1)=A4(I,1)
      A1(I,2)=A4(I,2)
      GO TO 280
  264 A2(I,1)=A4(I,1)
```

```
      A2(I,2)=A4(I,2)
      GO TO 280
  268 A3(I,1)=A4(I,1)
      A3(I,2)=A4(I,2)
  280 CONTINUE
  300 CONTINUE
C
C===== THIS SECTION INTERPOLATES TO OBTAIN THE DEFLECTION AND SLOPES AT
C      THE POINT XP, YP.
C
  400 J=1
      IF(L.GE.3)  J=2
      IF(JUMP.EQ.5) GO TO 504
  410 GO TO (420,522,526,534,504),JUMP
  420 SXP=XP
      SYP=YP
      XP=DTX
      YP=DTY
      GO TO 512
  504 IF(ABS(XP)-DTX)510,510,518
  510 IF(ABS(YP)-DTY)512,512,526
  512 DO 514 K=1,25
  514 A(K)=A1(K,J)
      GO TO 540
  518 IF(ABS(YP)-DTY)522,522,534
  522 DO 524 K=1,25
  524 A(K)=A2(K,J)
      GO TO 540
  526 DO 530 K=1,25
  530 A(K)=A3(K,J)
      GO TO 540
  534 DO 538 K=1,25
  538 A(K)=A4(K,J)
  540 CONTINUE
      XP=XP-X1P
      YP=YP-Y1P
     0 OWA = A( 1)*(XP**4)*(YP**4) + A( 2)*(XP**4)*(YP**3)
     1       + A( 3)*(XP**3)*(YP**4) + A( 4)*(XP**4)*(YP**2)
     2       + A( 5)*(XP**3)*(YP**3) + A( 6)*(XP**2)*(YP**4)
     3       + A( 7)*(XP**4)*(YP   ) + A( 8)*(XP**3)*(YP**2)
     4       + A( 9)*(XP**2)*(YP**3) + A(10)*(XP   )*(YP**4)
     5       + A(11)*(XP**4)         + A(12)*(XP**3)*(YP   )
     6       + A(13)*(XP**2)*(YP**2) + A(14)*(XP   )*(YP**3)
     7       + A(15)*        (YP**4) + A(16)*(XP**3)
     8       + A(17)*(XP**2)*(YP   ) + A(18)*(XP   )*(YP**2)
     9       + A(19)*        (YP**3) + A(20)*(XP**2)
     0 OWB = A(21)*(XP   )*(YP   ) + A(22)*         (YP**2)
```

```
     1      + A(23)*(XP    )           + A(24)*        (YP    )
     2      + A(25)
       OWF = OWA + OWB
     0 OWX = 4.0*A( 1)*(XP**3)*(YP**4) + 4.0*A( 2)*(XP**3)*(YP**3)
     1      + 3.0*A( 3)*(XP**2)*(YP**4) + 4.0*A( 4)*(XP**3)*(YP**2)
     2      + 3.0*A( 5)*(XP**2)*(YP**3) + 2.0*A( 6)*(XP    )*(YP**4)
     3      + 4.0*A( 7)*(XP**3)*(YP    ) + 3.0*A( 8)*(XP**2)*(YP**2)
     4      + 2.0*A( 9)*(XP    )*(YP**3) +       A(10)*        (YP**4)
     5      + 4.0*A(11)*(XP**3)          + 3.0*A(12)*(XP**2)*(YP    )
     6      + 2.0*A(13)*(XP    )*(YP**2) +       A(14)*        (YP**3)
     7      + 3.0*A(16)*(XP**2)          + 2.0*A(17)*(XP    )*(YP    )
     8      +       A(18)*        (YP**2) + 2.0*A(20)*(XP    )
     9      +       A(21)*        (YP    ) +       A(23)
     0 OWY = 4.0*A( 1)*(XP**4)*(YP**3) + 3.0*A( 2)*(XP**4)*(YP**2)
     1      + 4.0*A( 3)*(XP**3)*(YP**3) + 2.0*A( 4)*(XP**4)*(YP    )
     2      + 3.0*A( 5)*(XP**3)*(YP**2) + 4.0*A( 6)*(XP**2)*(YP**3)
     3      +       A( 7)*(XP**4)          + 2.0*A( 8)*(XP**3)*(YP    )
     4      + 3.0*A( 9)*(XP**2)*(YP**2) + 4.0*A(10)*(XP    )*(YP**3)
     5      +       A(12)*(XP**3)          + 2.0*A(13)*(XP**2)*(YP    )
     6      + 3.0*A(14)*(XP    )*(YP**2) + 4.0*A(15)*        (YP**3)
     7      +       A(17)*(XP**2)          + 2.0*A(18)*(XP    )*(YP    )
     8      + 3.0*A(19)*        (YP**2) +       A(21)*(XP    )
     9      + 2.0*A(22)*        (YP    ) +       A(24)
      XP=XP+X1P
      YP=YP+Y1P
      JUMP=JUMP+1
      GO TO(580,574,580,580,576,600),JUMP
  574 WRITE (ISO,575)
  575 FORMAT (1H1)
      GO TO 580
  576 XP=SXP
      YP=SYP
  580 WRITE (ISO,581) OWF,OWX,OWY
  581 FORMAT (1H , 39H TEST INTERPOLATION VALUES AT CENTER = ,E16.6,
     1  1H,, E16.6,1H,, E16.6)
      GO TO 410
  600 MIBP=1
      IF((ICHAP.EQ.3).OR.(ILRG.EQ.1)) GO TO 800
      OWF=OWF*PRSS
      OWX=OWX*PRSS
      OWY=OWY*PRSS
 800   RETURN
       END
$IBFTC MS23E1
CNORMAL
       SUBROUTINE NORMAL (OWX, OWY, K, DELTAP, CN)
C
```

```
C        THIS SUBROUTINE FINDS THE NORMAL TO THE SURFACE.
C
         DIMENSION CN(3), DELTAP( 6)
C
         AMAG = SQRT ((OWX**2 + OWY**2)*(DELTAP(K)**2) + 1.0)
         CN(1) = (-DELTAP(K)*OWX)/AMAG
         CN(2) = (-DELTAP(K)*OWY)/AMAG
         CN(3) = 1.0/AMAG
  800    RETURN
         END
$IBFTC MS23E2
CREFRCI
         SUBROUTINE REFRCI (CI, CN, QRI,     CR,              ISO)
C
C        THIS SUBROUTINE CALCULATES NEW DIRECTION OF RAY UPON ENTERING
C        NEW MEDIA.
C
         DIMENSION  CI(3), CN(3), CR(3)
         DOTP = 0.0
         DO 101 I=1,3
  101    DOTP = DOTP + CI(I)*CN(I)
         ROOT = QRI**2 -1.0 + DOTP**2
         IF (ROOT) 103,105,105
  103    ROUT = 0.0
         WRITE (ISO,500) ROOT
  500    FORMAT (1H0,6HROOT=  ,E16.8/)
         GO TO 107
  105    ROUT = SQRT (ROOT)
  107    DO 109 I=1,3
  109    CR(I) = (CI(I) + (ROUT-DOTP)*CN(I))/QRI
  800    RETURN
         END
$IBFTC MS23E3
CRESPRT
         SUBROUTINE RESPRT (IRT, NOPRT)
C
C        THIS SUBROUTINE PRINTS THE RESULTS OBTAINED BY THE RAYTRA PROG.
C
         COMMON DUM
C
       0 EQUIVALENCE           (DUM(   1), CON),      (DUM( 501),    X),
       1 (DUM(1001),    Y),    (DUM(1501),    W),      (DUM(2001), DWX),
       2 (DUM(2501), DWY),     (DUM(3001), JPN),      (DUM(3501), RTV)
C
       0 EQUIVALENCE           (CON(   1), DIMA),     (CON(   2), DIMB),
       1 (CON(   3), DIMC),    (CON(   4),  DEL),     (CON(   5),  GNU),
       2 (CON(   6), THIC),    (CON(   7), SPAD),     (CON(   8), PRSS),
```

```
     3 (CON(  9), NPAN),      (CON( 10),  ISI),      (CON( 11),  ISO),
     4 (CON( 12),  IBC),      (CON( 13),  NGP),      (CON( 14),  LP7),
     5 (CON( 15),   FR),      (CON( 16), LOCP),      (CON( 17),  IPD),
     6 (CON( 18),  IPR),      (CON( 19), CHAP),      (CON( 20),ISCR1),
     7 (CON( 21),ISCR2),      (CON( 22), SKAL),      (CON( 23), ISEC),
     8 (CON( 24), NPAG),      (CON( 25), YONG),      (CON( 26), ILGD),
     9 (CON( 27), IREL),      (CON( 28),  LP5),      (CON( 29),CPRSS)
C
     0 EQUIVALENCE            (CON( 30),  IRM),      (CON( 31),  IPB),
     1 (CON( 53), SCAL),      (CON( 61), SPAC),      (CON( 69), PRES),
     2 (CON( 77), PLNA),      (CON( 85), RAYA),      (CON( 93),   RI),
     3 (CON(101),  RES),      (CON(315), STAT),      (CON(371),  OIF),
     4 (CON(401),EANDF),      (CON(451),  RHS)
C
     0 EQUIVALENCE            (STAT( 1),  NMP),      (STAT( 9),  AVG),
     1 (STAT(25),  AVS),      (STAT(41),  AMN),      (STAT(49),  STD)
C
      EQUIVALENCE (CON(33),ITEST)
C
     0 DIMENSION  RT10(3), RT20(5), RT30(3), RT36(2), RT37(2),
     1 RT38(2), RT39(2), RT31(3), RT32(3), RES(200), PLNA( 8), AMN( 8),
     2 STD( 8), NMP( 8)
C
       DATA  RT20(1)/27HR A Y   T R A C E   D A T A/
C
     0 DATA  RT30(1)/13HELLIPSE    A=/, RT31(1)/13HRECTANGLE  A=/,
     1       RT32(1)/13HTRAPEZOID  A=/, RT33/4H  B=/, RT34/4H  C=/,
     2       RT35/6HSCALE=/, RT36(1)/10HTHICKNESS=/,
     3       RT37(1)/9H   PANES=/, RT38(1)/11H   SPACING=/,
     4 RT39(1)/12H   PRESSURE=/
C
       DATA  HING/6HHINGED/, CH/1H /, CLMP/6HCLAMPE/, CC/1HD/
C
       DATA  RT40/4HX = /, RT41/4HY = /, RT42/4HD1 =/
C
     0 DATA  RT50/6HA1    /, RT51/4HDEG./, RT52/6HXOUT  /, RT53/4H IN./,
     1       RT54/6HYOUT  /, RT55/4H IN./, RT56/6HZOUT  /, RT57/4H IN./,
     2       RT58/6HA2OUT /, RT59/4HDEG./, RT60/6HD2OUT /, RT61/4HDEG./,

     3       RT62/6HA1-A2 /, RT63/4HSEC./, RT64/6HD1-D2 /, RT65/4HSEC./,
     4       RT66/6HTHETA /, RT67/4HSEC./, RT68/6HITHE  /, RT69/4HSEC./,
     5       RT70/6HJTHE  /, RT71/4HSEC./, RT72/6HKTHE  /, RT73/4HSEC./
C
C      INITIALIZE INDEXES.
C
      IS10=10
       IS8 = ISO
```

```
      IS9=ISCR2+1
      IF (NOPRT .EQ. 0) IS8 = ISCR2
      IF (NOPRT .EQ. 0) IS9 = IS8 + 1
      ICHAP = CHAP
      IF (IBC .NE. 1) GO TO 102
      CONC = HING
      CF = CH
  102 IF (IBC .NE. 2) GO TO 104
      CONC = CLMP
      CF = CC
  104 GO TO (106,140), ISEC
  106 MPRT = NOPRT + 1
      GO TO (108,128,800), MPRT
  108 GO TO (110, 116, 116, 116), LOCP
  110 LOCP = 2
C
C     THIS SECTION PRINTS THE RAY TRACE RESULTS ON TAPE 8
C
      CALL PAGE (IPR, LINE, IS8, IRT)
      WRITE (IS8,500) RT20
  500 FORMAT (1H ,46X,4A6,A3)
      GO TO (112, 113, 114), ICHAP
  112 0 WRITE (IS8,501) (RT30(I),I=1,3), DIMA, RT33, DIMB,
    1         RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2         (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
  501 0 FORMAT (1H0,2A6,A1,F5.2,A4,F5.2,14X,A6,F4.2,3X,A6,A4,F5.2,A6,A3,
    1           I1,A6,A5,F3.1,2A6,F5.1,3X,A6,A1)
      GO TO 115
  113 0 WRITE (IS8,501) (RT31(I),I=1,3), DIMA, RT33, DIMB,
    1         RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2         (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
      GO TO 115
  114 0 WRITE (IS8,502) (RT32(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
    1         RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2         (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
  502 0 FORMAT (1H0,2A6,A1,F5.2,A4,F5.2,A4,F5.2,5X,A6,F4.2,3X,A6,A4,F5.2,
    1 A6,A3,I1,A6,A5,F3.1,2A6,F5.1,3X,A6,A1)
  115 WRITE (IS8,503) RT40, RES(1), RT41, RES(11), RT42, RES(21)
  503 FORMAT (1H0,    40X,A4,F5.2,5X,A4,F5.2,5X,A5,F6.2)
      GO TO 117
  116 LOCP = LOCP + 1
      WRITE (IS8,503) RT40, RES(1), RT41, RES(11), RT42, RES(21)
  117 0 WRITE (IS8,504)
    1 RT50,RT51, (RES(I),I= 31, 38), RT52,RT53, (RES(I),I= 71, 78),
    2 RT54,RT55, (RES(I),I= 81, 88), RT56,RT57, (RES(I),I= 91, 98),
    3 RT58,RT59, (RES(I),I=101,108), RT60,RT61, (RES(I),I=111,118),
    4 RT62,RT63, (RES(I),I=121,128), RT64,RT65, (RES(I),I=131,138),
```

```
     5 RT66,RT67, (RES(I),I=141,148), RT68,RT69, (RES(I),I=151,158),
     6 RT70,RT71, (RES(I),I=161,168), RT72,RT73, (RES(I),I=171,178)
 504 0 FORMAT (1H ,A6,A4,8F13.6/1H ,A6,A4,8F13.6/1H ,A6,A4,8F13.6/
     1           1H ,A6,A4,8F13.6/1H ,A6,A4,8F13.6/1H ,A6,A4,8F13.6/
     2           1H ,A6,A4,8E13.4/1H ,A6,A4,8E13.4/1H ,A6,A4,8E13.4/
     3           1H ,A6,A4,8F13.6/1H ,A6,A4,8F13.6/1H ,A6,A4,8F13.6)
C
C       THIS SECTION PRINTS THE RAY TRACE RESULTS ON TAPE 9
C
        MOCP = LOCP - 1
        IF (MOCP .EQ. 1) NOCP = 1
        IF (MOCP .EQ. 2) NOCP = 2
        IF (MOCP .EQ. 3) NOCP = 1
        IF (MOCP .EQ. 4) NOCP = 2
 119    GO TO (120,125), NOCP
 120    CALL PAGE (IPB, LIME, IS9, IRT)
        WRITE (IS9) (RT20(I), I=1,5)
        GO TO (122,123,124), ICHAP
 122 0  WRITE (IS9)      (RT30(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
     1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
     2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
        GO TO 125
 123 0  WRITE (IS9)      (RT31(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
     1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
     2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
        GO TO 125
 124 0  WRITE (IS9)      (RT32(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
     1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
     2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
 125    WRITE (IS9)      RT40, RES(1), RT41, RES(11), RT42, RES(21)
 127 0  WRITE (IS9)
     1 RT50,RT51, (RES(I),I= 31, 38), RT52,RT53, (RES(I),I= 71, 78),
     2 RT54,RT55, (RES(I),I= 81, 88), RT56,RT57, (RES(I),I= 91, 98),
     3 RT58,RT59, (RES(I),I=101,108), RT60,RT61, (RES(I),I=111,118),
     4 RT62,RT63, (RES(I),I=121,128), RT64,RT65, (RES(I),I=131,138),
     5 RT66,RT67, (RES(I),I=141,148), RT68,RT69, (RES(I),I=151,158),
     6 RT70,RT71, (RES(I),I=161,168), RT72,RT73, (RES(I),I=171,178)
        IF (LOCP .EQ. 5) LOCP = 1
        GO TO 800
C
C       THIS SECTION PRINTS THE RAY TRACE RESULTS ON TAPE 6
C
 128    GO TO (130,136), LOCP
 130   NOCP=LOCP
        LOCP = 2
        CALL PAGE (IPR, LINE, IS8, IRT)
        WRITE (IS8,510) RT20
```

```
  510    FORMAT (1H0,46X,4A6,A3)
         GO TO (132, 133, 134), ICHAP
  132 0  WRITE (IS8,501) (RT30(I),I=1,3), DIMA, RT33, DIMB,
      1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
      2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
         GO TO 135
  133 0  WRITE (IS8,501) (RT31(I),I=1,3), DIMA, RT33, DIMB,
      1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
      2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
         GO TO 135
  134 0  WRITE (IS8,502) (RT32(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
      1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
      2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
  135    WRITE (IS8,512) RT40, RES(1), RT41, RES(11), RT42, RES(21)
         GO TO 137
  136   NOCP=LOCP
         LOCP = 1
         WRITE (IS8,512) RT40, RES(1), RT41, RES(11), RT42, RES(21)
  512    FORMAT (1H0/1H ,40X,A4,F5.2,5X,A4,F5.2,5X,A5,F6.2)
  137 0  WRITE (IS8,514)
      1  RT50,RT51, (RES(I),I= 31, 38), RT52,RT53, (RES(I),I= 71, 78),
      2  RT54,RT55, (RES(I),I= 81, 88), RT56,RT57, (RES(I),I= 91, 98),
      3  RT58,RT59, (RES(I),I=101,108), RT60,RT61, (RES(I),I=111,118),
      4  RT62,RT63, (RES(I),I=121,128), RT64,RT65, (RES(I),I=131,138),
      5  RT66,RT67, (RES(I),I=141,148), RT68,RT69, (RES(I),I=151,158),
      6  RT70,RT71, (RES(I),I=161,168), RT72,RT73, (RES(I),I=171,178)
  514 0  FORMAT (1H0,A6,A4,8F13.6/1H0,A6,A4,8F13.6/1H ,A6,A4,8F13.6/
      1          1H ,A6,A4,8F13.6/1H ,A6,A4,8F13.6/1H ,A6,A4,8F13.6/
      2          1H0,A6,A4,8E13.4/1H ,A6,A4,8E13.4/1H ,A6,A4,8E13.4/
      3          1H0,A6,A4,8F13.6/1H ,A6,A4,8F13.6/1H ,A6,A4,8F13.6)
         GO TO 119
C
C        THIS SECTION PRINTS OUT THE MEAN AND RMS SUMMATION DATA.
C
   140 ISQ=ISO
         CALL PAGE (IRM, LYN, ISQ, IRT)
         WRITE (ISQ,500) RT20
         WRITE (ISQ,546)
  546    FORMAT (1H0,39X,43HM E A N   A N D   R M S   S U M M A T I O N)
         GO TO (142,144,146), ICHAP
  142 0  WRITE (ISQ,501) (RT30(I),I=1,3), DIMA, RT33, DIMB,
      1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
      2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
         GO TO 148
  144 0  WRITE (ISQ,501) (RT31(I),I=1,3), DIMA, RT33, DIMB,
      1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
      2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
```

```
      GO TO 148
  146 0 WRITE (ISQ,502) (RT32(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
     1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
     2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
  148 WRITE (ISQ,548) RES(21)
  548 FORMAT (1H0,48X,17HRAY ANGLE (D1) = ,F6.2,5H DEG.)
      WRITE (ISQ, 549)
  549 FORMAT (1H0,47HPLANE ANGLE      MEAN          RMS     NO. POINTS)
     0 WRITE (ISQ,550) (PLNA(I), AMN(I), STD(I), NMP(I), I=1,NPAG)
  550 FORMAT (1H0,F7.1,6X,E11.4,2X,E11.4,6X,I3)
      IF(ITEST.EQ.0) GO TO 800
      WRITE(ISQ,551)
  551 FORMAT(1H0,60HNOTE - THE ABOVE SUMMATION DATA WAS CALCULATED BASED
     1 ONLY ON/8X,54HPOINTS IN THE FIRST QUADRANT OF ELLIPSES OR RECTANG
     2LES/8X,45HOR ON POINTS IN THE FIRST HALF OF TRAPEZOIDS.)
  800 RETURN
      END
$IBFTC MS23E4
CMENRMS
      SUBROUTINE MENRMS
C
      DOUBLE PRECISION AVG, AVS, VAL, CON2
C
      COMMON DUM
C
     0 EQUIVALENCE              (DUM(    1), CON),       (DUM( 501),    X),
     1 (DUM(1001),    Y),       (DUM(1501),    W),       (DUM(2001), DWX),
     2 (DUM(2501), DWY),        (DUM(3001), JPN),        (DUM(3501), RTV)
C
     0 EQUIVALENCE              (CON(   1), DIMA),       (CON(   2), DIMB),
     1 (CON(   3), DIMC),       (CON(   4),  DEL),       (CON(   5),  GNU),
     2 (CON(   6), THIC),       (CON(   7), SPAD),       (CON(   8), PRSS),
     3 (CON(   9), NPAN),       (CON( 10),   ISI),       (CON( 11),   ISO),
     4 (CON( 12),   IBC),       (CON( 13),   NGP),       (CON( 14),   LP7),
     5 (CON( 15),    FR),       (CON( 16), LOCP),        (CON( 17),   IPD),
     6 (CON( 18),   IPR),       (CON( 19), CHAP),        (CON( 20),ISCR1),
     7 (CON( 21),ISCR2),        (CON( 22), SKAL),        (CON( 23), ISEC),
     8 (CON( 24), NPAG),        (CON( 25), YONG),        (CON( 26), ILGD),
     9 (CON( 27), IREL),        (CON( 28),   LP5),       (CON( 29),CPRSS)
C
     0 EQUIVALENCE              (CON( 30),   IRM),       (CON( 31),   IPB),
     1 (CON( 53), SCAL),        (CON( 61), SPAC),        (CON( 69), PRES),
     2 (CON( 77), PLNA),        (CON( 85), RAYA),        (CON( 93),    RI),
     3 (CON(101),   RES),       (CON(315), STAT),        (CON(371),   OIF),
     4 (CON(401),EANDF),        (CON(451),   RHS)
C
     0 EQUIVALENCE              (STAT(  1),  NMP),       (STAT(  9),  AVG),
```

```
     1 (STAT(25), AVS),     (STAT(41), AMN),     (STAT(49), STD)
C
      EQUIVALENCE (CON(33),ITEST),(OIF(11),N2)
C
      DIMENSION  NMP( 8), AVG( 8), AVS( 8), AMN( 8), STD( 8), RES(180)
C
C     XS = XIN
C     YS = YIN
C     XP = XOUT
C     YP = YOUT
C
      XXX=1.
      IF(N2.EQ.2) XXX=0.
      GO TO (101,110), ISEC
 101  DO 109 I=1,NPAG
      IJ = I-1
      XS = RES(IJ+  1)
      YS = RES(IJ+ 11)
      XP = RES(IJ+ 71)
      YP = RES(IJ+ 81)
      ICHAP = CHAP
      GO TO (102,103,104), ICHAP
C
C===== IS POINT MORE THAN 1 INCH INSIDE ELLIPSE BOUNDARY
 102  A = DIMA/2.0
      B = DIMB/2.0
      IF (XS .GT. A) GO TO 109
      IF (YS .GT. B) GO TO 109
      XLIM = A*SQRT(1.0-(YS**2/(B*B)))
      YLIM = B*SQRT(1.0-(XS**2/(A*A)))
      IF (XS .GT. (XLIM-1.0)) GO TO 109
      IF (YS .GT. (YLIM-1.0)) GO TO 109
      IF (XP .GT. A) GO TO 109
      IF (YP .GT. B) GO TO 109
      XLIM = A*SQRT(1.0-(YP**2/(B*B)))
      YLIM = B*SQRT(1.0-(XP**2/(A*A)))
      IF (XP .GT. (XLIM-1.0)) GO TO 109
      IF (YP .GT. (YLIM-1.0)) GO TO 109
      GO TO 108
C
C===== IS POINT MORE THAN 1 INCH INSIDE RECTANGLE BOUNDARY
 103  A = DIMA/2.0
      B = DIMB/2.0
      IF (XS .GT. (A-1.0)) GO TO 109
      IF (YS .GT. (B-1.0)) GO TO 109
      IF (XP .GT. (A-1.0)) GO TO 109
      IF (YP .GT. (B-1.0)) GO TO 109
```

```
      GO TO 108
C
C===== IS POINT MORE THAN 1 INCH INSIDE TRAPEZOID BOUNDARY
 104  A = DIMA/2.0
      B = DIMB
      C = DIMC/2.0
     IF((N2.EQ.2) .AND. (XP.LT.0.)) GO TO 109
     IF((N2.EQ.2) .AND. (YP.LT.0.)) GO TO 109
      IF (YS .GT. B) GO TO 109
      XLIM = C + ((A-C)/B)*(B-YS)
      YLIM = B
      IF (XS .LE. C) GO TO 105
      IF (XS .GT. A) GO TO 109
      IF ((A-C) .NE. 0.0) GO TO 114
      YLIM = B
      GO TO 105
 114  YLIM = (B/(A-C))*(A-XS)
 105  IF (XS .GT. (XLIM-XXX)) GO TO 109
      IF (YS .GT. (YLIM-XXX)) GO TO 109
      IF (IREL .EQ. 1) GO TO 106
      IF (YS .LT. XXX) GO TO 109
      IF (YP .GT. B) GO TO 109
 106  XLIM = C + ((A-C)/B)*(B-YP)
      YLIM = B
      IF (XP .LE. C) GO TO 107
      IF (XP .GT. A) GO TO 109
      IF ((A-C) .NE. 0.0) GO TO 115
      YLIM = B
      GO TO 107
 115  YLIM = (B/(A-C))*(A-XP)
 107  IF (XP .GT. (XLIM-XXX)) GO TO 109
      IF (YP .GT. (YLIM-XXX)) GO TO 109
      IF (IREL .EQ. 1) GO TO 108
      IF (YP .LT. XXX) GO TO 109
C
C===== STORE COMPONENTS NEEDED FOR MEAN AND RMS
C
 108  NMP(I) = NMP(I) + 1
      RES1 = RES(IJ+141)
      RES2 = RES1*RES1
      AVG(I) = AVG(I) + RES1
      AVS(I) = AVS(I) + RES2
     IF(N2.EQ.2) GO TO 109
     IF(ITEST.EQ.1) GO TO 109
     IF((XS.EQ.0.).AND.(YS.EQ.0.)) GO TO 109
     IF(XS.EQ.0.) GO TO 116
     IF(I.EQ.1) J=5
```

```
      IF(I.EQ.2) J=4
      IF(I.EQ.3) J=3
      IF(I.EQ.4) J=2
      IF(I.EQ.5) J=1
      IF(I.EQ.6) J=8
      IF(I.EQ.7) J=7
      IF(I.EQ.8) J=6
      NMP(J)=NMP(J)+1
      AVG(J)=AVG(J)+RES1
      AVS(J)=AVS(J)+RES2
  116 IF(ICHAP.EQ.3) GO TO 109
      IF(YS.EQ.0.) GO TO 109
      IF(I.EQ.1) J=5
      IF(I.EQ.2) J=6
      IF(I.EQ.3) J=7
      IF(I.EQ.4) J=8
      IF(I.EQ.5) J=1
      IF(I.EQ.6) J=2
      IF(I.EQ.7) J=3
      IF(I.EQ.8) J=4
      NMP(J)=NMP(J)+1
      AVG(J)=AVG(J)+RES1
      AVS(J)=AVS(J)+RES2
  117 IF(XS.EQ.0.) GO TO 109
      IF(I.EQ.1) J=1
      IF(I.EQ.2) J=8
      IF(I.EQ.3) J=7
      IF(I.EQ.4) J=6
      IF(I.EQ.5) J=5
      IF(I.EQ.6) J=4
      IF(I.EQ.7) J=3
      IF(I.EQ.8) J=2
      NMP(J)=NMP(J)+1
      AVG(J)=AVG(J)+RES1
      AVS(J)=AVS(J)+RES2
 109   CONTINUE
       GO TO 800
C
C===== THIS SECTION CALCULATES THE MEAN (AMN) AND RMS (STD).
C
 110   DO 112 I=1,NPAG
       AMP = 0.0
       AMP = NMP(I)
       IF (AMP .EQ. 0.0) GO TO 113
       AMN(I) = AVG(I)/AMP
       VAL = (AVS(I) - AVG(I)*AVG(I)/AMP)
       IF (VAL .GT. 0.0) GO TO 111
```

```
      VAL = ABS(VAL)
  111 STD(I) = SQRT(VAL)/(SQRT(AMP-1.0))
      SMN = AMN(I)*(1.0E-6)
      IF (STD(I) .LT. SMN) STD(I) = 0.0
      GO TO 112
  113 AMN(I) = 0.0
      STD(I) = 0.0
  112 CONTINUE
  800 RETURN
      END
$IBFTC MS23E5
CMAXMIN
      SUBROUTINE MAXMIN(IRT)
C
C     THIS SUBROUTINE CALCULATES THE MAXIMUM AND MINIMUM SLOPES AT A
C     POINT.
C
      COMMON  DUM
C
     0 EQUIVALENCE              (DUM(   1), CON),      (DUM( 501),    X),
     1                          (DUM(1501),   W),      (DUM(2251), DWX),
     2                          (DUM(3001), JPN),      (DUM(3501), RTV)
C
     0 EQUIVALENCE              (CON(   1), DIMA),     (CON(   2), DIMB),
     1 (CON(  3), DIMC),        (CON(   4),  DEL),     (CON(   5),  GNU),
     2 (CON(  6), THIC),        (CON(   7), SPAD),     (CON(   8), PRSS),
     3 (CON(  9), NPAN),        (CON(  10),  ISI),     (CON(  11),  ISO),
     4 (CON( 12),  IBC),        (CON(  13),  NGP),     (CON(  14),  LP7),
     5 (CON( 15),   FR),        (CON(  16), LOCP),     (CON(  17),  IPD),
     6 (CON( 18),  IPR),        (CON(  19), CHAP),     (CON(  20),ISCR1),
     7 (CON( 21),ISCR2),        (CON(  22), SKAL),     (CON(  23), ISEC),
     8 (CON( 24), NPAG),        (CON(  25), YONG),     (CON(  26), ILGD),
     9 (CON( 27), IREL),        (CON(  28),  LP5),     (CON(  29),CPRSS)
C
     0 EQUIVALENCE              (CON(  30),  IRM),     (CON(  31),  IPB),
     1 (CON( 53), SCAL),        (CON(  61), SPAC),     (CON(  69), PRES),
     2 (CON( 77), PLNA),        (CON(  85), RAYA),     (CON(  93),   RI),
     3 (CON(101),  RES),        (CON(315), STAT),      (CON(371),  OIF),
     4 (CON(401),EANDF),        (CON(451),  RHS)
C
     0 DIMENSION      CON(  500),     X(21,33),                W(21,33),
     1  DWX(21,33),JPN(500),RTV(500),OIF(12)
C
     0 DIMENSION RT30(3), RT31(3), RT32(3), RT36(2), RT37(2), RT38(2),
     1 RT39(2)
C
     0 DATA  RT30(1)/13HELLIPSE    A=/, RT31(1)/13HRECTANGLE  A=/,
```

```
     1      RT32(1)/13HTRAPEZOID  A=/, RT33/4H  B=/, RT34/4H  C=/,
     2      RT35/6HSCALE=/, RT36(1)/10HTHICKNESS=/,
     3      RT37(1)/9H   PANES=/, RT38(1)/11H   SPACING=/,
     4 RT39(1)/12H   PRESSURE=/
C
      DATA  HING/6HHINGED/, CH/1H /, CLMP/6HCLAMPE/, CC/1HD/
      RAD = 0.017453292519
      IDT = IRT
      LINE=0
C
C===== THIS SECTION GENERATES A POINT IN THE MIDDLE OF A GRID AND THEN
C      DETERMINES IF THE GRID EXISTS.
C
      DO 120 K=1,NGP
      IPG = 2
      K1 = JPN(K)
      CALL PACWRD (K1, K2, 2)
      XP = X(K1,K2) + DEL/2.0
     EJ=K1-1
      YP=EJ*DEL + DEL/2.0
      CALL INCOTB (XP, YP, OWF, OWX, OWY, IPG)
      IF (IPG .EQ. 1) GO TO 120
      R = 0.0001
      SMX = 0.0
      DO 114 J=1,181,2
      RJ = J-1
      THE = RJ*RAD
      XL =  XP + R*COS(THE)
      YL =  YP + R*SIN(THE)
     CALL INCOTB(XL,YL,OWG,OWX,OWY,IPG)
      OWR = (ABS(OWF) - ABS(OWG))/R
      OWS = ABS(OWR)
      IF (J .EQ. 1) SMN = OWR
      IF (J .EQ. 1) SMX = OWR
      THF = THE/RAD
      IF (OWS .LT. ABS(SMX)) GO TO 112
      SMX = OWR
      AMX = THE/RAD
  112 IF (OWS .GT. ABS(SMN)) GO TO 114
      SMN = OWR
      AMN = THE/RAD
  114 CONTINUE
      IF(K.EQ.1) GO TO 115
      IF(LINE-45) 116,115,115
  115 CALL PAGE (IPD, LINE, ISO, IDT)
      WRITE (ISO,500)
  500 0 FORMAT (1H0/1H ,3X,40HW I N D O W   D E F O R M A T I O N S  -,
     1 49H  D E F L E C T I O N,  M A X I M U M   A N D  ,
```

```
     2 25HM I N I M U M   S L O P E/1H )
       ICHAP = CHAP
       IF ( IBC .NE. 1) GO TO 302
       CONC = HING
       CF = CH
 302   IF (IBC .NE. 2) GO TO 303
       CONC = CLMP
       CF = CC
 303   GO TO (102,103,104), ICHAP
 102 0 WRITE (ISO,501) (RT30(I),I=1,3), DIMA, RT33, DIMB,
     1         RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
     2         (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
 501 0 FORMAT (1H0,2A6,A1,F5.2,A4,F5.2,14X,A6,F4.2,3X,A6,A4,F5.2,A6,A3,
     1            I1,A6,A5,F3.1,2A6,F5.1,3X,A6,A1)
       GO TO 105
 103 0 WRITE (ISO,501) (RT31(I),I=1,3), DIMA, RT33, DIMB,
     1         RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
     2         (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
       GO TO 105
 104 0 WRITE (ISO,518) (RT32(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
     1         RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
     2         (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
 518 0 FORMAT (1H0,2A6,A1,F5.2,A4,F5.2,A4,F5.2,5X,A6,F4.2,3X,A6,A4,F5.2,
     1 A6,A3,I1,A6,A5,F3.1,2A6,F5.1,3X,A6,A1)
 105   WRITE (ISO,505)
 505 0 FORMAT (1H0/1H ,43H(ANGLE IS IN DEGREES MEASURED WITH RESPECT ,
     1 23HTO THE POSITIVE X-AXIS)/1H0,12H COORDINATES,26X,8HMAXIMUM ,
     2 5HSLOPE,10X,14HMINIMUM  SLOPE/1H ,3H  X,7X,1HY,8X,10HDEFLECTION,
     3 8X,15HSLOPE     ANGLE,8X,15HSLOPE     ANGLE)
  116  WRITE (ISO,506) XP, YP, OWF, SMX, AMX, SMN, AMN
 506   FORMAT (1H ,F5.2,3X,F5.2,4X,E12.5,2(4X,E12.5,3X,F4.0))
 120   CONTINUE
 800   RETURN
       END
$IBFTC MS23E6
CRTVLST
       SUBROUTINE RTVLST (IRT, LIN, IPV)
C
C      III = SWITCH TO BYPASS RETRIEVAL PAGING PRINTOUT
C      IPV = PAGE COUNTER FOR RETRIEVAL INDEX PRINTOUT
C      ISO = SYSTEM OUTPUT TAPE
C      JT1 = RETRIEVAL NUMBER
C      JT7 = NUMBER OF PANES
C      JT10 = BOUNDARY COORDINATE SWITCH
C      LIN = RETRIEVAL INDEX OUTPUT LINE COUNTER
C      RT2 = PLANFORM SELECTION SWITCH
C      RT3 = BASE LENGTH OF PLANFORM
C      RT4 = WIDTH OF PLANFORM
C      RT5 = UPPER X DIMENSION OF TRAPEZOID
```

```
C          RT6 = GLASS THICKNESS
C          RT8 = SPACING BETWEEN PANES
C          RT9 = INTERSTICIAL PRESSURE
C
           COMMON DUM
C
         0 EQUIVALENCE            (DUM(   1), CON),      (DUM( 501),   X),
         1 (DUM(1001),   Y),      (DUM(1501),   W),      (DUM(2001), DWX),
         2 (DUM(2501), DWY),      (DUM(3001), JPN),      (DUM(3501), RTV)
C
         0 EQUIVALENCE            (CON(   1), DIMA),     (CON(   2), DIMB),
         1 (CON(   3), DIMC),     (CON(   4),  DEL),     (CON(   5),  GNU),
         2 (CON(   6), THIC),     (CON(   7), SPAD),     (CON(   8), PRSS),
         3 (CON(   9), NPAN),     (CON(  10),  ISI),     (CON(  11),  ISO),
         4 (CON(  12),  IBC),     (CON(  13),  NGP),     (CON(  14),  LP7),
         5 (CON(  15),   FR),     (CON(  16), LOCP),     (CON(  17),  IPD),
         6 (CON(  18),  IPR),     (CON(  19), CHAP),     (CON(20), ISCR1),
         7 (CON(  21),ISCR2),     (CON(  22), SKAL),     (CON(  23), ISEC),
         8 (CON(  24), NPAG),     (CON(  25), YONG),     (CON(  26), ILGD),
         9 (CON(  27), IREL),     (CON(  28),  LP5),     (CON(  29),CPRSS)
C
         0 EQUIVALENCE            (CON(  30),  IRM),     (CON(  31),  IPB),
         1 (CON(  53), SCAL),     (CON(  61), SPAC),     (CON(  69), PRES),
         2 (CON(  77), PLNA),     (CON(  85), RAYA),     (CON(  93),   RI),
         3 (CON(101),   RES),     (CON(315), STAT),      (CON(371),   OIF),
         4 (CON(401),EANDF),      (CON(451),  RHS)
C
         0 EQUIVALENCE            (RTV(   1), JT1),      (RTV(  41), RT2),
         1 (RTV(  81), RT3),      (RTV( 121), RT4),      (RTV( 161), RT5),
         2 (RTV( 201), RT6),      (RTV( 241), JT7),      (RTV( 281), RT8),
         3 (RTV( 321), RT9),      (RTV( 361),JT10),      (RTV( 401),RT11)
C
         0 DIMENSION     CON(  500),    X(22,22),    Y(22,22),    W(22,22),
         1  DWX(22,22),  DWY(22,22),  JPN(  500),  RTV(  500)
C
         0 DIMENSION    SCAL(    8), SPAC(    8), PRES(    8), PLNA(    8),
         1 RAYA(    8),    RI(    7),   RES(  180),
         2 RT30(2), RT31(2), RT32(2), RT33(2), RT34(2), SHAP(2), CONC(2)
C
         0 DIMENSION  JT1(50), RT2(50), RT3(50), RT4(50), RT5(50), RT6(50),
         1 JT7(50), RT8(50), RT9(50), JT10(50)
C
         0 DATA  RT30(1)/9HELLIPSE  /, RT31(1)/9HRECTANGLE/,
         1       RT32(1)/9HTRAPEZOID/, RT33(1)/7HHINGED /,
         2       RT34(1)/7HCLAMPED/,STAR/5H*****/
C
           LIN = LIN + 1
```

```
      IF (LIN .LT. 100) GO TO 100
      LIN = LIN - 101
      GO TO 101
100   JT1(LIN)  = IRT
      RT2(LIN)  = CHAP
      RT3(LIN)  = DIMA
      RT4(LIN)  = DIMB
      RT5(LIN)  = DIMC
      RT6(LIN)  = THIC
      JT7(LIN)  = NPAN
      RT8(LIN)  = SPAD
      IF (NPAN .EQ. 1) RT8(LIN) = STAR
      RT9(LIN)  = PRSS
      JT10(LIN) = IBC
      IF (LIN .LT. 40) GO TO 800
101   III = 0
      CALL PAGE (IPV, LIN,  ISO, III)
      WRITE (ISO, 500)
500 0 FORMAT (1H0,42HRETRIEVAL   SHAPE      A      B      C    ,
    1 59HTHICKNESS   PANES   SPACING   PRESSURE   FIXITY          /
    2 7H NUMBER,16X,17HIN.    IN.    IN.,6X,3HIN.,16X,3HIN.,8X,3HLB.,
    3 16X/1H )
      DO 114 I=1,LIN
      IF (RT2(I) .NE. 1.0) GO TO 102
      SHAP(1) = RT30(1)
      SHAP(2) = RT30(2)
102   IF (RT2(I) .NE. 2.0) GO TO 104
      SHAP(1) = RT31(1)
      SHAP(2) = RT31(2)
104   IF (RT2(I) .NE. 3.0) GO TO 106
      SHAP(1) = RT32(1)
      SHAP(2) = RT32(2)
106   IF (JT10(I) .NE. 1) GO TO 108
      CONC(1) = RT33(1)
      CONC(2) = RT33(2)
108   IF (JT10(I) .NE. 2) GO TO 112
      CONC(1) = RT34(1)
      CONC(2) = RT34(2)
112   IF (NPAN .EQ. 2) GO TO 113
    0 WRITE (ISO,502) JT1(I), (SHAP(J),J=1,2), RT3(I), RT4(I), RT5(I),
    1 RT6(I), JT7(I), RT8(I), RT9(I), (CONC(J),J=1,2)
502 0 FORMAT (1H ,3X,I3,4X,A6,A3,2X,F5.2,2X,F5.2,2X,F5.2,4X,F5.2,7X,I1,
    1 6X,A5,  5X,F5.1,5X,A6,A1,4X)
      GO TO 114
113 0 WRITE (ISO,503) JT1(I), (SHAP(J),J=1,2), RT3(I), RT4(I), RT5(I),
    1 RT6(I), JT7(I), RT8(I), RT9(I), (CONC(J),J=1,2)
503 0 FORMAT (1H ,3X,I3,4X,A6,A3,2X,F5.2,2X,F5.2,2X,F5.2,4X,F5.2,7X,I1,
```

```
     1 6X,F5.2,5X,F5.1,5X,A6,A1)
 114  CONTINUE
      LIN = 0
 800  RETURN
      END
$IBFTC MS23E7
CBONDRY
      SUBROUTINE BONDRY (XP, YP, IBY)
C
C     THIS SUBROUTINE TESTS THE X AND Y COORDINATES OF A POINT TO BE
C     SURE THEY ARE INSIDE THE BOUNDARY.
C
C     A    = DEFINED BELOW
C     B    = DEFINED BELOW
C     C    = DEFINED BELOW
C     CHAP = ICHAP = PLANFORM SELECTION SWTICH
C     DIMA = LOWER LENGTH OF PLANFORM
C     DIMB = HEIGHT OF PLANFORM
C     DIMC = UPPER X DIMENSION OF TRAPEZOID
C     IBY  = 1  INDICATES POINT IS OUTSIDE PLANFORM BOUNDARY
C     XLIM = X VALUE AT PLANFORM BOUNDARY CORRESPONDING TO YP
C     XP   = X COORDINATE OF POINT BEING CHECKED
C     YP   = Y COORDINATE OF POINT BEING CHECKED
C
      COMMON DUM
C
     0 EQUIVALENCE              (DUM(   1), CON),      (DUM( 501),   X),
     1 (DUM(1001),    Y),       (DUM(1501),    W),     (DUM(2001), DWX),
     2 (DUM(2501), DWY),        (DUM(3001), JPN),      (DUM(3501), RTV)
C
     0 EQUIVALENCE              (CON(   1), DIMA),     (CON(   2), DIMB),
     1 (CON(   3), DIMC),       (CON(   4),  DEL),     (CON(   5),  GNU),
     2 (CON(   6), THIC),       (CON(   7), SPAD),     (CON(   8), PRSS),
     3 (CON(   9), NPAN),       (CON( 10),   ISI),     (CON( 11),   ISO),
     4 (CON( 12),   IBC),       (CON( 13),   NGP),     (CON( 14),   LP7),
     5 (CON( 15),    FR),       (CON( 16), LOCP),      (CON( 17),   IPD),
     6 (CON( 18),   IPR),       (CON( 19), CHAP),      (CON(20), ISCR1),
     7 (CON( 21),ISCR2),        (CON( 22), SKAL),      (CON( 23), ISEC),
     8 (CON( 24), NPAG),        (CON( 25), YONG),      (CON( 26), ILGD),
     9 (CON( 27), IREL),        (CON( 28),   LP5),     (CON( 29),CPRSS)
C
     0 EQUIVALENCE              (CON( 30),   IRM),     (CON( 31),   IPB),
     1 (CON( 53), SCAL),        (CON( 61), SPAC),      (CON( 69), PRES),
     2 (CON( 77), PLNA),        (CON( 85), RAYA),      (CON( 93),    RI),
     3 (CON(101),   RES),       (CON(315), STAT),      (CON(371),   OIF),
     4 (CON(401),EANDF),        (CON(451),   RHS)
C
```

```
    0 DIMENSION    CON(  500),    X(22,22),    Y(22,22),    W(22,22),
    1  DWX(22,22),  DWY(22,22),  JPN(  500),  RTV(  500)
C
      ICHAP = CHAP
      GO TO (101,102,103), ICHAP
  101 A = DIMA/2.0
      B = DIMB/2.0
      IF (ABS(YP) .GT. B) GO TO 104
      XLIM = A*SQRT(1.0-(YP**2/(B*B)))
      IF (ABS(XP) .GT. XLIM) GO TO 104
      GO TO 800
  102 A = DIMA/2.0
      B = DIMB/2.0
      IF (ABS(YP) .GT. B) GO TO 104
      IF (ABS(XP) .GT. A) GO TO 104
      GO TO 800
  103 A = DIMA/2.0
      B = DIMB
      C = DIMC/2.0
      IF (ABS(YP) .GT. B) GO TO 104
      XLIM = C + ((A-C)/B)*(B-YP)
      IF (ABS(XP) .GT. XLIM) GO TO 104
      GO TO 800
  104 IBY = 1
  800 RETURN
      END
$IBFTC MS23E8
CPACWRD
      SUBROUTINE PACWRD (K1, K2, K3)
C
C     THIS SUBROUTINE PACKS AND UNPACKS TWO INTEGER WORDS.
C
C       PACKING  K1 = FIRST INTEGER AND RETURNED PACKED WORD
C                K2 = SECOND INTEGER INPUT
C                K3 = 1
C
C     UNPACKING  K1 = PACKED WORD AND RETURNED FIRST INTEGER
C                K2 = SECOND INTEGER RETURNED
C                K3 = 2
C
      GO TO (100, 102), K3
  100 K1 = K1*32768 + K2
      GO TO 800
  102 K4 = K1/32768
      K2 = K1 - K4*32768
      K1 = K4
  800 RETURN
```

```
      END
$IBFTC MS23E9
CPAGE
      SUBROUTINE PAGE (IPN, LINE, ISN, INX)
C     THIS SUBROUTINE PRINTS THE TIME AND PAGE NUMBER AT THE PAGE TOP
C
C     INX  = RETRIEVAL NUMBER
C     IPN  = PAGE NUMBER
C     ISN  = TAPE NUMBER
C     LINE = LINE NUMBER
C
      DIMENSION RT10(3)
C
      DATA  RT10(1)/18HRETRIEVAL NUMBER =/, RT11/4HPAGE/
C
      IPN = IPN + 1
      IF (INX .EQ. 0) GO TO 100
      IF (ISN .EQ. 9) GO TO 102
      WRITE (ISN,500) (RT10(I), I=1,3), INX,        RT11, IPN
  500 FORMAT (1H1,3A6,I5,89X,A4,I4)
      GO TO 800
  102 WRITE (ISN)      (RT10(I), I=1,3), INX,        RT11, IPN
      GO TO 800
  100 WRITE (ISN, 501) RT11, IPN
  501 FORMAT (1H1,112X,A4,I4)
  800 LINE = 1
      RETURN
      END
$IBFTC MS23F0
CSHRDEF
      SUBROUTINE SHRDEF
C
C     ETA = FACTOR TO MODIFY DEFLECTION BY TO OBTAIN SHEAR DEFORMATION
C
      COMMON DUM
C
     0 EQUIVALENCE             (DUM(    1), CON),      (DUM( 501),    X),
     1 (DUM(1001),     Y),     (DUM(1501),    W),      (DUM(2001), DWX),
     2 (DUM(2501), DWY),       (DUM(3001), JPN),       (DUM(3501), RTV)
C
     0 EQUIVALENCE             (CON(    1), DIMA),     (CON(   2), DIMB),
     1 (CON(   3), DIMC),      (CON(   4),  DEL),      (CON(   5),  GNU),
     2 (CON(   6), THIC),      (CON(   7), SPAD),      (CON(   8), PRSS),
     3 (CON(   9), NPAN),      (CON(  10),  ISI),      (CON(  11),  ISO),
     4 (CON(  12),   IBC),     (CON(  13),  NGP),      (CON(  14),  LP7),
     5 (CON(  15),    FR),     (CON(  16), LOCP),      (CON(  17),  IPD),
     6 (CON(  18),   IPR),     (CON(  19), CHAP),      (CON(20), ISCR1),
```

```
     7 (CON( 21),ISCR2),      (CON( 22), SKAL),      (CON( 23), ISEC),
     8 (CON( 24), NPAG),      (CON( 25), YONG),      (CON( 26), ILRG),
     9 (CON( 27), IREL),      (CON( 28),  LP5),      (CON( 29),CPRSS)
C
     0 EQUIVALENCE            (CON( 30),  IRM),      (CON( 31),  IPB),
     1 (CON( 53), SCAL),      (CON( 61), SPAC),      (CON( 69), PRES),
     2 (CON( 77), PLNA),      (CON( 85), RAYA),      (CON( 93),   RI),
     3 (CON(101),  RES),      (CON(315), STAT),      (CON(371),  OIF),
     4 (CON(401),EANDF),      (CON(451),  RHS)
C
     0 DIMENSION     CON(  500),     X(22,22),     Y(22,22),     W(22,22),
     1  DWX(22,22),  DWY(22,22),  JPN(  500),  RTV(  500)
C
       PI2 = 3.141592653*3.141592653
       BET2 = (DIMA/DIMB)**2
       ETA = PI2*(1.0 + BETA)*(THIC**2)/((DIMA**2)*(1.0 - GNU)*3.0)
       DO 100 I=1,22
       DO 100 J = 1,22
  100  W(I,J) = W(I,J)*ETA
  800  RETURN
       END
$IBFTC MS23F1
       FUNCTION  SINH(ARC)
C
C      THIS FUNCTION CALCULATES THE DOUBLE PRECISION HYPERBOLIC SINE
C      BUT RETURNS THE SINGLE PRECISION HYPERBOLIC SINE.
C
       DOUBLE PRECISION ARG,DSINH
C
       ARG = ARC
       IF(ARC .GT. 88.0) ARG=88.0
       DSINH = 5.0D-1*(DEXP(ARG)-DEXP(-ARG))
       SINH = DSINH
       RETURN
       END
$IBFTC MS23F2
       FUNCTION  COSH(ARC)
C
C      THIS FUNCTION CALCULATES THE DOUBLE PRECISION HYPERBOLIC COSINE
C      BUT RETURNS THE SINGLE PRECISION HYPERBOLIC COSINE.
C
       DOUBLE PRECISION ARG,DCOSH
C
       ARG = ARC
       IF(ARC .GT. 88.0) ARG=88.0
       DCOSH = 5.0D-1*(DEXP(ARG)+DEXP(-ARG))
       COSH = DCOSH
```

```
      RETURN
      END
$IBFTC MS23F3
      FUNCTION  TANH(ARC)
C
C     THIS FUNCTION CALCULATES THE DOUBLE PRECISION HYPERBOLIC TANGENT
C     BUT RETURNS THE SINGLE PRECISION HYPERBOLIC TANGENT.
C
      DOUBLE PRECISION ARG,DTANH
C
      ARG = ARC
      IF(ARC .GT. 88.0) ARG=88.0
      DTANH = (DEXP(ARG)-DEXP(-ARG))/(DEXP(ARG)+DEXP(-ARG))
      TANH = DTANH
      RETURN
      END
```

```
$IBFTC MS23G0
CWINTWO
C
C     * STARED PROGRAMS CONTAIN DIFFERENT FLOW LOGIC THAN SINGLE RAY
C       PROGRAMS OF THE SAME NAME.  THE CON EQUIVALENCE IS DIFFERENT FROM
C       SINGLE RAY TRACE PROGRAMS IN ALL TWO RAY TRACE PROGRAMS.
C G0 *  WINTWO - APOLLO WINDOW DEFORMATION AND LINE OF SIGHT DRIVER
C G1    ELIPSE - ELLIPSE DEFORMATION GENERATOR
C G2    ELIPIT - ELLIPTIC COORDINATE GENERATOR
C G3    RECTAG - RECTANGULAR DEFORMATION GENERATOR
C G4    SEQS   - MATRIX INVERSION AND LINEAR EQUATION SOLUTION
C G5    TRPZOD - READS IN TRAPEZOIDAL DEFORMATION DATA FROM SAMIS
C G6    LRGDEF - LARGE DEFLECTION GENERATOR FOR RECTANGLES
C G7    DEFRES - PRINTS PLATE (WINDOW) DEFORMATION DATA
C G8 *  RAYTWO - DRIVER FOR RAY TRACE PROCEDURE
C G9 *  TRACE  - TRACES RAY THRU WINDOW
C H0    ITERAT - ITERATES TO FIND LOCATION OF RAY ON NEXT SURFACE
C H1    INCOTB - DETERMINES DEFORMATION OF PLATE AT INTERSECTION W/RAY
C H2    NORMAL - CALCULATES NORMAL TO PLATE AT RAY INTERSECTION POINT
C H3    REFRCI - CALCULATES NEW DIRECTION OF RAY UPON ENTERING NEW MEDIUM
C H4    CROPOD - FINDS CROSS PRODUCT OF 2 VECTORS
C H5 *  RESTWO - PRINTS RAY TRACE AND MEAN-RMS RESULTS
C H6 *  MENRMS - STORES DATA FOR MEAN AND RMS CALCULATIONS
C H7    MAXMIN - CALCULATES MAX/MIN SLOPES AT GRID POINTS
C H8    RTVLST - RETRIEVAL LIST
C H9    BONDRY - TEST TO SEE IF POINT OF RAY IS OUTSIDE PLAN FORM BNDRY
C J0    PACWRD - INDEX WORD PACKING-UNPACKING ROUTINE
C J1    PAGE   - PRINTS PAGE NO. AT TOP OF EACH PAGE (AND RETRIEVAL NO.)
C J2    SHRDEF - SHEAR DEFORMATION GENERATOR
C J3    SINH   - CALCULATES HYPERBOLIC SINE
C J4    COSH   - CALCULATES HYPERBOLIC COSINE
C J5    TANH   - CALCULATES HYPERBOLIC TANGENT
C
C       AA     = X DIMENSION OF SHAPE
C              = LENGTH OF ELLIPSE SEMI AXIS
C              = LENGTH OF RECTANGLE
C              = 1/2 BASE LENGTH OF TRAPEZOID
C       AMN    = ARRAY FOR STORING MEANS
C       AVG    = ARRAY FOR STORING MEAN DATA
C       AVS    = ARRAY FOR STORING RMS  DATA
C       BB     = Y DIMENSION OF SHAPE
C              = HEIGHT OF ELLIPSE SEMI AXIS
C              = HEIGHT OF RECTANGLE
C              = HEIGHT OF TRAPEZOID
C       BONC   = BOUNDARY CONDITION
C       CC     = UPPER X DIMENSION OF TRAPEZOID
C       CHAP = ICHAP = SHAP = GEOMETRIC SHAPE
```

```
C      CON    = DUMMY ARRAY FOR CONSTANT AND VARIABLE STORAGE
C      CPRSS = CABIN PRESSURE
C      DEL    = GRID SPACING
C      DIMA = A DIMENSION
C      DIMB = B DIMENSION
C      DIMC = C DIMENSION
C      DON    = CONSTANT IN REFRACTIVE INDEX EQUATION
C      DWX   = ARRAY OF GRIDPOINT DEFLECTIONS FOR SECOND PANE
C      EANDF = ARRAY USED IN RECTNG
C      FR    = PLATE STIFFNESS (D)
C      GNU    = POISSONS RATIO
C      IBC   = BOUNDARY CONDITION SWITCH
C      ICHAP = SEE CHAP
C      IDT    = DEFORMATION DATA RETRIEVAL SEQUENCE NUMBER
C      ILGD   = 1, FIND DEFORMATIONS BY LARGE DEFORMATION METHOD
C      ILRG   = 1, LARGE DEFLECTIONS WERE CALCULATED
C      IMAN   = 1, FIND MAX./MIN. SLOPES OF DEFORMED POINTS
C      INDX   = 1,  PRINT RETRIEVAL INDEX AT TOP OF PAGE  =0,NO PRINT
C      IPB    = PAGE NUMBER COUNTER IN RESPRT FOR TAPE 9
C      IPD = PAGE NUMBER COUNTER IN DEFRES
C      IPR = PAGE NUMBER COUNTER IN RESPRT
C      IPV    = RETRIEVAL LIST PAGE NUMBER
C      IREL   = 1, REAL WINDOW  INCLUDE OTHER SIDE OF SYMMETRY AXIS
C      IRM    = PAGE NUMBER COUNTER IN RESPRT FOR RMS OUTPUT ON TAPE 6
C      IRT    = LOS        DATA RETRIEVAL SEQUENCE NUMBER
C      ISCR1 = SCRATCH TAPE  UNIT 7  FOR DEFORMATION DATA
C      ISCR2 = SCRATCH TAPE  UNIT 8  FOR LINE OF SIGHT (LOS) DATA
C      ISEC   = 1,  PRINT LOS DATA,   =2, PRINT RMS DATA
C      ISI   = INPUT TAPE NUMBER
C      ISO   = OUTPUT TAPE NUMBER
C      IS9    = SCRATCH TAPE  UNIT 9  FOR LINE OF SIGHT DATA BINARY CODED
C      ISHR   = 1,  CALCULATE SHEAR DEFORMATIONS
C      JPN   = ARRAY OF GRIDPOINT COORDINATE INDEXES
C      LIN    = RETRIEVAL LIST LINE COUNTER
C      LOCP   = KEYS HEADINGS AT TOP OF LOS PRINTED PAGE  LOCP=2,NO HEAD
C      LP1    = INDEX ON NO. OF BOUNDARY CONDITIONS
C      LP2    = INDEX ON NO. OF SCALES
C      LP3    = INDEX ON NO. OF SPACES
C      LP4    = INDEX ON NO. OF PRESSURES
C      LP5    = INDEX ON NO. OF RAY ANGLES
C      LP6    = INDEX ON NO. OF GRID POINTS
C      LP7    = INDEX ON NO. OF PLANE ANGLES
C      MIBP   = 1,  BYPASS GENERATION OF INVERSION MATRIX FOR INTERPOLATION
C      MRT    = BY PASS SWITCH FOR TAPE REWIND STATEMENTS IN WINTWO
C      NBC    = NO. OF BOUNDARY CONDITIONS
C      NGP   = NO. OF GRID POINTS
C      NMP    = ARRAY OF NUMBER OF DATA PTS. IN MEAN
```

```
C       NOPRT = KEYS TAPES ON WHICH OUTPUT DATA APPEARS
C             = 0,  DEFORMATIONS ON TAPE 7, LOS ON TAPES 8 AND 9
C             = 1,  ALL DATA ON SYSTEM OUTPUT TAPE
C             = 2,  OUTPUT ONLY RMS DATA ON OUTPUT TAPE
C       NPAG = NO. OF PLANE ANGLES
C       NPAN = NO. OF PANES
C       NPRS = NO. OF PRESSURES
C       NRAG = NO. OF RAY ANGLES
C       NRFI  = NO. OF REFRACTIVE INDEXES TO BE READ IN
C       NSCL = NO. OF SCALES
C       NSPC = NO. OF SPACES
C       OIF  = SUPPLEMENTAL ARRAY
C       PLNA  = ARRAY OF PLANE ANGLES
C       PRES  = ARRAY FOR STORING INTERSTICIAL PRESSURES
C       PRSS = PRES(I) = PRESSURE ON PLATE
C       RAYA  = ARRAY OF RAY ANGLES
C       RES   = ARRAY FOR STORING LOS OUTPUT
C       RI    = ARRAY OF REFRACTIVE INDEXES
C       RIC   = REFRACTIVE INDEX COEFFICIENT
C       RHS   = ARRAY USED IN RECTNG
C       RTV   = ARRAY FOR STORING RETRIEVAL INFORMATION
C       SCAL  = ARRAY FOR STORING GEOMETRIC SCALE FACTORS
C       SHAP  = SEE CHAP
C       SKAL  = SCAL(I) = DIMENSIONAL SCALING FACTOR
C       SPAC  = ARRAY FOR STORING SPACE FACTORS
C       SPAD = SPAC(I) = SPACE BETWEEN PLATES
C       STAT  = ARRAY FOR STORING MEAN AND RMS DATA
C       STD   = ARRAY FOR STORING RMSES
C       THIC = PLATE THICKNESS
C       W    = ARRAY OF GRIDPOINT DEFLECTIONS FOR FIRST PANE
C       WORD  = ARRAY FOR TITLE
C       X    = ARRAY OF X COORDINATES OF GRIDPOINTS IN DEFORMATION TABLE
C       YONG  = YOUNGS MODULUS
C
      DOUBLE PRECISION AVG,AVS
C
       COMMON DUM
C
     0 EQUIVALENCE            (DUM(   1), CON),       (DUM( 501),    X),
     1                        (DUM(1501),    W),      (DUM(2251), DWX),
     2                        (DUM(3001), JPN),       (DUM(3501), RTV)
C
     0 EQUIVALENCE            (CON(  1), DIMA),       (CON(  2), DIMB),
     1 (CON(  3), DIMC),      (CON(  4),  DEL),       (CON(  5),  GNU),
     2 (CON(  6), THIC),      (CON(  7), SPAD),       (CON(  8), PRSS),
     3 (CON(  9), NPAN),      (CON( 10),  ISI),       (CON( 11),  ISO),
     4 (CON( 12),   IBC),     (CON( 13),  NGP),       (CON( 14),  LP7),
```

```
     5 (CON( 15),    FR),      (CON( 16), LOCP),      (CON( 17),  IPD),
     6 (CON( 18),   IPR),      (CON( 19), CHAP),      (CON(20), ISCR1),
     7 (CON( 21),ISCR2),       (CON( 22), SKAL),      (CON( 23), ISEC),
     8 (CON( 24), NPAG),       (CON( 25), YONG),      (CON( 26), ILRG),
     9 (CON( 27), IREL),       (CON( 28),  LP5),      (CON( 29), CPRSS)
C
     0 EQUIVALENCE             (CON( 31), SCAL),      (CON( 41), SPAC),
     1 (CON( 51), PRES),       (CON( 61), PLNA),      (CON( 71), RAYA),
     2 (CON( 81), PAIA),       (CON( 91), THEA),      (CON(101),    RI),
     3 (CON(111),   RES),      (CON(291), STAT),      (CON(351),   OIF),
     4 (CON( 30),   IRM),      (OIF(  1),  IDX),
     5 (OIF(  2),   IDY),      (OIF(  3),   X1),      (OIF(  4),    Y1)
C
     0 EQUIVALENCE             (STAT( 1),  NMP),      (STAT( 9),   AVG),
     1 (STAT(25),   AVS),      (STAT(41),  AMN),      (STAT(49),   STD)
C
     0 EQUIVALENCE             (RTV(   1), JT1),      (RTV(  51), RT2),
     1 (RTV( 101), RT3),       (RTV( 151), RT4),      (RTV( 201), RT5),
     2 (RTV( 251), RT6),       (RTV( 301), JT7),      (RTV( 351), RT8),
     3 (RTV( 401), RT9),       (RTV( 451),JT10),      (RTV( 501),RT11)
C
       EQUIVALENCE   (PLNA,BETA),(RAYA,PSIA),(OIF(11),N2),(OIF(12),MIBP)
C
     0 DIMENSION      CON(  500),    X(21,33),                W(21,33),
     1  DWX(21,33),                SCAL(    8), SPAC(    8), PRES(    8),
     2 PLNA(    8), RAYA(    8),    RI(    7),  JPN(  500),  KOD(    5),
     3  RES(  180),  NMP(    8),   AVG(    8),  AVS(    8),  AMN(    8),
     4  STD(    8), BETA(    8),  PSIA(    8), PAIA(    8), THEA(    8),
     5 ZSEXT(    8), RTV(500), WORD(15)
C
       DATA  TRAP/4HTRAP/, ELIP/4HELIP/, RECT/4HRECT/
       DATA  HING/4HHING/, CLMP/4HCLMP/, BOTH/4HBOTH/, STAR/5H*****/
C
C===== THIS SECTION INITIALIZES INDEXES.
C
       CALL CLOCK (TIME)
       WRITE (6,600) TIME
  600  FORMAT (1H0,25HWINTWO TIME =            ,F10.4)
       ISI = 5
       ISO = 6
       ISCR1 = 7
       ISCR2 = 8
       IDT = 0
       IRT=0
       IRM = 0
       LIN=0
       IPD = 0
```

```
      IPR = 0
      IPV = 0
     IPB=0
     MRT=0
      DO 90 I=1,500
 90   RTV(I) = 0.0
 100  NGP = 0
     X1=0.
     Y1=0.
     READ(ISI,499) IRT,(WORD(I),I=1,15)
 499 FORMAT(I5,15A5)
      NBC = 1
      IBC = 0
      CHAP = 0.0
C
C===== READ IN PARAMETER DATA.
C
      READ (ISI,500) SHAP, BONC, AA, BB, CC, THIC, YONG, GNU, DEL
 500  FORMAT (1X,A4,1X,A4,7E10.0)
      IF (AA.EQ. 0.0) GO TO 1000
     IF((THIC.EQ.0.).OR.(YONG.EQ.0.).OR.(DEL.EQ.0.)) GO TO 902
      IF (BONC .EQ. HING) IBC = 1
      IF (BONC .EQ. CLMP) IBC = 2
      IF (BONC .EQ. BOTH) IBC = 1
      IF (BONC .EQ. BOTH) NBC = 2
      IF (IBC .EQ. 0) GO TO 900
      IF (SHAP .EQ. ELIP) CHAP = 1.0
      IF (SHAP .EQ. RECT) CHAP = 2.0
      IF (SHAP .EQ. TRAP) CHAP = 3.0
      IF (CHAP .EQ. 0.0) GO TO 901
     0 READ (ISI,501) NPAN, NSCL, NSPC, NPRS,NOPRT,       IMAN, ILGD,
     1 IREL, NBET, NPSI, NPAI, NTHE, NSEX, CPRSS
 501  FORMAT (4I5, 5X,9I5,E10.0)
     IF(NPAN.EQ.1) CPRSS=0.
      READ (ISI,502) (SCAL(I), I=1,NSCL)
      IF (NPAN .LT. 2) GO TO 102
      READ (ISI,502) (SPAC(I), I=1,NSPC)
 502  FORMAT (8E10.0)
 102  READ (ISI,502) (PRES(I), I=1,NPRS)
      READ (ISI,502) (BETA(I), I=1,NBET)
      READ (ISI,502) (PSIA(I), I=1,NPSI)
      READ (ISI,502) (PAIA(I), I=1,NPAI)
      READ (ISI,502) (THEA(I), I=1,NTHE)
      READ (ISI,502) (ZSEXT(I), I=1,NSEX)
      NRFI = 2*NPAN + 1
      READ (ISI,502) (RI(I),I=1,NRFI)
      FR= (YONG*(THIC**3))/(12.0*(1.0-(GNU**2)))
```

```
      IF(MRT.NE.0) GO TO 103
      IF(NOPRT.EQ.0) REWIND ISCR1
      IF(NOPRT.EQ.0) REWIND ISCR2
      IF(NOPRT.EQ.0) REWIND IS9
      IF(NOPRT.EQ.0) MRT=1
C
C===== MAIN DO-LOOP ON NUMBER OF BOUNDARY CONDITIONS.
C
  103  DO 126 LP1=1,NBC
       IF (LP1 .EQ. 2) IBC=2
       DO 126 LP2=1,NSCL
      MIBP=0
       SKAL = SCAL(LP2)
      IF(SKAL.EQ.0.) GO TO 903
       DIMA = AA*SCAL(LP2)
       DIMB = BB*SCAL(LP2)
       DIMC = CC*SCAL(LP2)
       ICHAP = CHAP
       DO 104 IS = 1,33
       DO 104 JS = 1,21
         X(IS,JS) = 1.E-6
         W(IS,JS) = 0.0
  104  DWX(IS,JS) = 0.0
C
C===== SELECT PLANFORM TO BE SOLVED.
C
       GO TO (106,108,110), ICHAP
 106   CALL ELIPSE
       GO TO 112
 108   CALL RECTNG
      IF(ISHR.EQ.1) CALL SHRDEF
       GO TO 112
 110   CALL TRPZOD
  112 IF(ICHAP.EQ.3) GO TO 202
      IF((DIMA/2.).GT.(32.*DEL)) GO TO 1060
      IF((DIMB/2.).GT.(20.*DEL)) GO TO 1065
  202 IF(NSPC.EQ.0) SPAC(1)=STAR
      IF(NSPC.EQ.0) NSPC=1
       DO 126 LP3=1,NSPC
       SPAD = SPAC(LP3)
 113   DO 126 LP4 = 1,NPRS
       LP5 = LP4
       ILRG = 0
       IRT = IRT + 1
       PRSS = PRES(LP4)
      IF((ICHAP.NE.3).OR. (N2.NE.1)) GO TO 111
      DO 799 K=1,21
```

```
      DO 799 L=1,33
      W(K,L)=W(K,L)*(CPRSS-PRSS)
  799 DWX(K,L)=DWX(K,L)*PRSS
C       CALCULATE REFRACTIVE INDEXES FOR PRESSURE USED.
  111  DON = ((2.926E-4)/(1.0 + (3.665E-3)*(21.0)))/14.7
       RIC = 1.0 + DON*ABS(PRSS)
       IF (NPAN .EQ. 1) RI(1) = RIC
       IF (NPAN .EQ. 2) RI(1) = 1.0 + DON*ABS(CPRSS)
       IF (NPAN .EQ. 2) RI(3) = RIC
      WRITE(ISO,1050) IPR,IPB
      WRITE(ISO,123) (PRES(I),I=1,NPRS),CPRSS
      WRITE(ISO,121) (RI(I),I=1,NRFI)
  123 FORMAT(1H , 21HPRESSURE LEVELS ARE  6E15.4)
  121 FORMAT(1H , 23HREFRACTIVE INDICES ARE  6E16.8)
       IDT = IDT + 1
       CALL DEFRES (IRT, NOPRT)
       CALL RTVLST (IRT, LIN, IPV)
       IF (IMAN .EQ. 0) GO TO 114
       CALL MAXMIN (IRT)
  114  IF (ILGD .EQ. 0) GO TO 116
       CALL LRGDEF
       ILRG = 1
       CALL DEFRES (IRT, NOPRT)
C
C===== PERFORM RAY TRACE ON DEFLECTED SHAPE FOUND ABOVE.
C
  116  DO 125 LQ1 = 1,NSEX
       DO 125 LQ2 = 1, NBET
       DO 125 LQ3 = 1, NPSI
       DO 125 LQ4 = 1, NPAI
       DO 125 LP6 = 1,NTHE
       DO 118 I=1,8
       NMP(I) = 0
       AVG(I) = 0.0
       AVS(I) = 0.0
       AMN(I) = 0.0
  118  STD(I) = 0.0
       LOCP = 1
       DO 120 I=1,180
  120  RES(I) = 0.0
       DO 124 LP7 = 1,NGP
       K1 = JPN(LP7)
       CALL PACWRD (K1,K2, 2)
       XS = X(K1,K2)
      EJ=K1-1
      YS=DEL*EJ
       ZS = 0.0
```

```
      XQQ=XS/(2.*DEL)
      IX=XQQ
      XU=IX
      RE=XQQ-XU
      IF(RE.NE.0.) GO TO 124
      YQQ=YS/(2.*DEL)
      IY=YQQ
      YV=IY
      RE=YQQ-YV
      IF(RE.NE.0.) GO TO 124
       ZSEX  = ZSEXT(LQ1)
       PLANA = BETA(LQ2)
       RAYAN = PSIA(LQ3)
       PAIAN = PAIA(LQ4)
       THEAN = THEA(LP6)
       CALL RAYTWO (XS, YS, ZS, PLANA, RAYAN, PAIAN, THEAN, ZSEX)
  122  CONTINUE
C
C      THIS SECTION PRINTS THE RAY TRACE DATA AND STORES THE COMPONENT
C      DATA IN MENRES NEEDED TO CALCULATE THE MEAN AND RMS.
C
       ISEC = 1
       CALL MENRMS
       CALL RESTWO (IRT, NOPRT)
  124  CONTINUE
C
C      THIS SECTION CALCULATES THE MEAN AND RMS AND THEN PRINTS THEM
C
       ISEC = 2
       CALL MENRMS
       CALL RESTWO (IRT, NOPRT)
  125 CONTINUE
      IF((ICHAP.NE.3).OR.(N2.NE.1)) GO TO 126
      DO 199 K=1,21
      DO 199 L=1,33
      W(K,L)=W(K,L)/(CPRSS-PRSS)
  199 DWX(K,L)=DWX(K,L)/PRSS
  126  CONTINUE
       GO TO 100
C
C      THIS SECTION PRINTS THE ERROR COMMENTS.
C
  900  WRITE (ISO,950) BONC
  950 0 FORMAT (1H1/1H0,37HTHE BOUNDARY CONDITION WORD USED WAS ,A4,
     1 25H WHICH IS NOT ACCEPTABLE.)
       GO TO 2000
  901  WRITE (ISO,951) SHAP
```

```
  951 0 FORMAT (1H1/1H0/1H0,28HTHE PLANEFORM WORD USED WAS ,A4,
      1 25H WHICH IS NOT ACCEPTABLE.)
        GO TO 2000
  902   WRITE (ISO,952)
  952 0 FORMAT (1H0,43HTHE THICKNESS, YOUNGS MODULUS, OR THE GRID ,
      1 19HINCREMENT ARE ZERO.)
        GO TO 2000
  903   WRITE (ISO,953) LP2
  953   FORMAT (1H0, 6HSCALE(,I1,10H) IS ZERO.)
        GO TO 2000
 1000   LIN = LIN + 100
        CALL RTVLST (IRT, LIN, IPV)
       IF(NOPRT.EQ.1) GO TO 1010
        WRITE (ISO,1050) IPR,IPB
 1050 0 FORMAT (1H1/1H0,9HTHERE ARE,I5,27H PAGES OF RAY TRACE OUTPUT ,
      1 30HON THE MICROFILM TAPE (TAPE 8)/
      2             1H0,9HTHERE ARE,I5,27H PAGES OF RAY TRACE OUTPUT ,
      1 30HON THE RETRIEVAL TAPE (TAPE 9))
        INX = 999
        CALL PAGE (IPB, LIN, IS9, INX)
        GO TO 1020
 1010   WRITE (ISO,1051) IPR
 1051 0 FORMAT (1H1/1H0,9HTHERE ARE,I5,27HPAGES OF RAY TRACE OUTPUT ,
      1 30HON THE SYSOUTPUT TAPE (TAPE 6))
 1020   WRITE (ISO,1052)
 1052   FORMAT (1H0/1H0,30X,40H***** THE PROBLEM YOU GAVE ME TO DO WAS ,
      1 20HDONE CORRECTLY *****)
        CALL CLOCK (TIME)
        WRITE (6,9099) TIME
 9099   FORMAT (1H0,25HEND WINDEF TIME =         , F10.4)
  1060 WRITE(6,9098) IRT
  9098 FORMAT(1H1,38HTHE PROBLEM DESIGNATED RETRIVAL NUMBER,I4,58H HAS IT
      1S AA DIMENSION GREATER THAN THE PROGRAM CAN HANDLE.)
  1065 WRITE(6,9097) IRT
  9097 FORMAT(1H1,38HTHE PROBLEM DESIGNATED RETRIVAL NUMBER,I4,58H HAS IT
      1S BB DIMENSION GREATER THAN THE PROGRAM CAN HANDLE.)
       GO TO 100
 2000   STOP
        END
$IBFTC MS23G1
CELIPSE
        SUBROUTINE ELIPSE
C
C       THIS SUBROUTINE GENERATES THE TABLE OF GRIDPOINT DEFORMATIONS FOR
C       AN ELLIPSE
C
C       A    = ELLIPSE MAJOR SEMI AXIS
```

```
C     B    = ELLIPSE MINOR SEMI AXIS
C     C    = ELLIPTIC FOCAL DISTANCE
C     DWX  = DEFLECTION AT POINT I,J OF SECOND PANE
C     ET   = ELLIPTIC COORDINATE
C     ETX  = PARTIAL OF ET WRT X
C     ETY  = PARTIAL OF ET WRT Y
C     I    = ROW INDEX
C     J    = COLUM INDEX
C     K    = GRIDPOINT COUNTER
C     NGP  = NUMBER OF GRID POINTS
C     W    = DEFLECTION AT POINT I,J OF FIRST PANE
C     W1   = CONSTANT IN DEFLECTION EQUATION
C     WO   = CONSTANT IN DEFLECTION EQUATION
C     WEP  = PARTIAL OF W WRT ET
C     WZP  = PARTIAL OF W WRT ZI
C     X    = X COORDINATE ARRAY
C     XLIM = X VALUE AT ELLIPTIC BOUNDARY ALONG ANY ABSISSA
C     ZI   = ELLIPTIC COORDINATE
C     ZIX  = PARTIAL OF ZI WRT X
C     ZIY  = PARTIAL OF ZI WRT Y
C     ALL OTHER LEFT HAND SIDE VALUES ARE TEMPORARIES
C
      COMMON DUM
C
     0 EQUIVALENCE             (DUM(   1), CON),       (DUM( 501),   X),
     1                         (DUM(1501),   W),       (DUM(2251), DWX),
     2                         (DUM(3001), JPN),       (DUM(3501), RTV)
C
     0 EQUIVALENCE             (CON(   1), DIMA),      (CON(   2), DIMB),
     1 (CON(  3), DIMC),       (CON(   4),  DEL),      (CON(   5),  GNU),
     2 (CON(  6), THIC),       (CON(   7), SPAD),      (CON(   8), PRSS),
     3 (CON(  9), NPAN),       (CON(  10),  ISI),      (CON(  11),  ISO),
     4 (CON( 12),  IBC),       (CON(  13),  NGP),      (CON(  14),  LP7),
     5 (CON( 15),   FR),       (CON(  16), LOCP),      (CON(  17),  IPD),
     6 (CON( 18),  IPR),       (CON(  19), CHAP),      (CON(20), ISCR1),
     7 (CON( 21),ISCR2),       (CON(  22), SKAL),      (CON(  23), ISEC),
     8 (CON( 24), NPAG),       (CON(  25), YONG),      (CON(  26), ILGD),
     9 (CON( 27), IREL),       (CON(  28),  LP5),      (CON(  29), CPRSS)
C
     0 EQUIVALENCE             (CON(  31), SCAL),      (CON(  41), SPAC),
     1 (CON( 51), PRES),       (CON(  61), PLNA),      (CON(  71), RAYA),
     2 (CON( 81), PAIA),       (CON(  91), THEA),      (CON(101),    RI),
     3 (CON(111),  RES),       (CON(301), STAT),       (CON(351),   OIF),
     4 (CON(401),EANDF),       (CON(451),  RHS)
C
     0 DIMENSION     CON(   500),     X(21,33),                  W(21,33),
     1  DWX(21,33),              JPN(   500),  RTV(   500)
```

```
C
      A = DIMA/2.0
      B = DIMB/2.0
C
C===== INITIALIZE INDEXES.
C
      IF (A .GT. B) GO TO 201
      TM = B
      B = A
      A = TM
  201 C = SQRT(A*A - B*B)
      XLIM = A
      I = 0
      J = 0
      K = 0
      X(1,1) = 0.0
      GO TO (100,104), IBC
C
C===== THIS SECTION CALCULATES THE GRIDPOINT DEFORMATIONS FOR AN ELLIPSE
C      WITH SIMPLY SUPPORTED EDGES.
C
C      CALCULATE CONSTANTS
C
  100 IF (A .EQ. B) GO TO 102
      X(1,1) = A
      ZI = 1.0
      ET = 1.0
      XC = X(1,1)
      YC = 0.
      CALL ELIPIT (C, XC, YC,     ZI, ET, FZP, FEP, GZP, GEP, DET)
      A10 = ZI
      A20 = 2.0*ZI
      A40 = 4.0*ZI
      CA20 = COSH(A20)
      CA40 = COSH(A40)
      CA2S = (COSH(A20))**2
      SA2S = (SINH(A20))**2
      SA2Q = (SINH(A20))**4
      WO = (C**4)/(12.0*128.0*CA2S*CA40*FR)
      OMNU = (1.0 - GNU)
      W1 = +(8.0*(OMNU)*(3.0*CA2S-2.0)*SA2Q)/(2.0*CA2S-(OMNU)*SA2S)
      X(1,1) = 0.0
C     CALCULATE GRIDPOINT DEFORMATIONS.
  203 I = I+1
  101 J = J+1
      K = K+1
      K1 = I
```

```
      K2 = J
      CALL PACWRD (K1,K2,1)
      JPN(K) = K1
      ZI = 1.0
      ET = 1.0
      XC = X(I,J)
     EJ=I-1
     YC=DEL*EJ
      CALL ELIPIT (C, XC, YC,      ZI, ET, FZP, FEP, GZP, GEP, DET)
      ZI2 = 2.0*ZI
      ZI4 = 4.0*ZI
      ET2 = 2.0*ET
      ET4 = 4.0*ET
      TE1 = (3.0*CA20*CA40 - 4.0*CA40*COSH(ZI2) + CA20*COSH(ZI4))
      TE2 = (3.0*CA20*CA40 - 4.0*CA40* COS(ET2) + CA20* COS(ET4))
      TE3 = (COSH(ZI2) - CA20)
      TE4 = (CA20 - COS(ET2))
      W(I,J) = WO*(TE1*TE2 - W1*TE3*TE4)
     IF(NPAN.EQ.2) DWX(I,J)=W(I,J)
    0 WZP  = WO*(TE2*(-8.0*CA40*SINH(ZI2) + 4.0*CA20*SINH(ZI4))
    1        -W1*TE4*(2.0*SINH(ZI2)))
    0 WEP  = WO*(TE1*(+8.0*CA40* SIN(ET2) - 4.0*CA20* SIN(ET4))
    1        -W1*TE3*(2.0* SIN(ET2)))
      ZIX  =-GEP/DET
      ETX  = GZP/DET
      ZIY  = FEP/DET
      ETY  = FZP/DET
      X(I,J+1) = X(I,J) + DEL
      IF (X(I,J+1) .LE. XLIM) GO TO 101
      X(I,J+1) = 0.0
      J = 0
      X(I+1,J+1) = 0.0
     EJ=I
     DWY=DEL*EJ
             IF (DWY .GT. B) GO TO 800
      XLIM = A*SQRT (1.0 -        (DWY**2/(B*B)))
             IF (DWY .LE. B) GO TO 203
      GO TO 800
C
C===== THIS SECTION SOLVES THE SIMPLY SUPPORTED EDGE WHEN A = B (CIRCLE)
C
 102  TE1 = 1.0/(64.0*FR)
      TE2 = ((5.0+GNU)/(1.0+GNU))*(A*A)
      I = 0
      J = 0
      X(1,1) = 0.0
      XLIM = A
```

```
  205 I = I+1
  103 J = J+1
      K = K+1
      K1 = I
      K2 = J
      CALL PACWRD (K1,K2,1)
      JPN(K) = K1
      X2 = X(I,J)*X(I,J)
     EJ=I-1
     Y2=DEL*DEL*EJ*EJ
      TE3 = (A*A - X2 -Y2)
      TE4= (TE2 - X2 - Y2)
      W(I,J) = TE1*TE3*TE4
     IF(NPAN.EQ.2) DWX(I,J)=W(I,J)
      X(I,J+1) = X(I,J) + DEL
     EJ=I
     DWY=DEL*EJ
      IF (X(I,J+1) .LE. XLIM) GO TO 103
      X(I,J+1) = 0.0
      J = 0
      X(I+1,J+1) = 0.0
     EJ=I
     DWY=DEL*EJ
              IF (DWY .GT. B) GO TO 800
      XLIM = A*SQRT (1.0 -         (DWY**2/(B*B)))
              IF (DWY .LE. B) GO TO 205
      GO TO 800
C
C===== THIS SECTION CALCULATES THE GRIDPOINT DEFORMATIONS FOR AN
C      ELLIPSE WITH CLAMPED EDGES.
C
  104 TEM = (24.0/(A**4)) + (24.0/(B**4)) + (16.0/(A*A*B*B))
      WO = 1.0/(FR*TEM)
  207 I = I+1
  105 J = J+1
      K = K+1
      K1 = I
      K2 = J
      CALL PACWRD (K1,K2,1)
      JPN(K) = K1
     EJ=I-1
     DWY=DEL*EJ
      TEM = (1.0 - (X(I,J)*X(I,J)/(A*A)) -        (DWY*DWY/(B*B)))
      W(I,J) = WO*(TEM**2)
     IF(NPAN.EQ.2) DWX(I,J)=W(I,J)
      X(I,J+1) = X(I,J) + DEL
      IF (X(I,J+1) .LE. XLIM) GO TO 105
```

```
      X(I,J+1) = 0.0
      J = 0
      X(I+1,J+1) = 0.0
     EJ=I
     DWY=DEL*EJ
             IF (DWY .GT. B) GO TO 800
      XLIM = A*SQRT (1.0 -          (DWY**2/(B*B)))
             IF (DWY .LE. B) GO TO 207
  800 NGP = K
      RETURN
      END
$IBFTC MS23G2
CELIPIT
      SUBROUTINE ELIPIT (C, X, Y, XI, ET, FXP, FEP, GXP, GEP, DET)
C
C     THIS SUBROUTINE DETERMINS THE ELLIPTIC COORDINATES XI AND ET,
C     CORRESPONDING TO THE CARTESIAN COORDINATES X AND Y.
C
C     ITERATION IS BY THE NEWTON-RHAPSON METHOD OF SUCCESSIVE APPROX.
C
C     C     = ELLIPTIC FOCAL DISTANCE
C     DET   = DETERMINENT
C     ET    = ET COORDINATE VALUE IN ELLIPTICAL SYSTEM
C     FEP   = PARTIAL OF FIO WRT ET
C     FIO   = FUNCTION F
C     FXP   = PARTIAL OF FIO WRT XI
C     GEP   = PARTIAL OF GIO WRT ET
C     GIO   = FUNCTION G
C     GXP   = PARTIAL OF GIO WRT XI
C     IDON = 1 INDICATES ITERATION IS COMPLETE
C     X     = X COORDINATE VALUE IN RETANGULAR SYSTEM
C     XI    = ZI COORDINATE VALUE IN ELLIPTICAL SYSTEM
C     Y     = Y COORDINATE VALUE IN RETANGULAR SYSTEM
C     ALL OTHER LEFT HAND VALUES ARE TEMPORARIES
C
      IDON = 0
  100 IF (Y .NE. 0.0) GO TO 103
      IF (X .GT. C) GO TO 101
      XI1 = 0.0
      ET1 = ACOS(X/C)
      GO TO 108
  101 XI = 1.0
      ET = 0.0
  102 FIO = X - C*COSH(XI)*COS(ET)
      FXP =    - C*SINH(XI)*COS(ET)
      XI1 = XI - FIO/FXP
      ET1 = ET
```

```
      IF ((ABS(XI1 - XI)) .LE. 0.0000001) GO TO 108
      XI = XI1
      GO TO 102
  103 IF (X .NE. 0.0) GO TO 105
      ET = 90.0*0.017453292519
      XI = 0.0
  104 GIO = Y - C*SINH(XI)*SIN(ET)
      GXP =   - C*COSH(XI)*SIN(ET)
      XI1 = XI - GIO/GXP
      ET1 = ET
      IF ((ABS(XI1 - XI)) .LE. 0.0000001) GO TO 108
      XI = XI1
      GO TO 104
  105 FIO = X - C*COSH(XI)*COS(ET)
      GIO = Y - C*SINH(XI)*SIN(ET)
  106 FXP =   - C*SINH(XI)*COS(ET)
      FEP =   + C*COSH(XI)*SIN(ET)
      GXP =   - C*COSH(XI)*SIN(ET)
      GEP =   - C*SINH(XI)*COS(ET)
      DET = (FXP*GEP - FEP*GXP)
      IF (IDON .EQ. 1) GO TO 800
      XI1 = XI - (1.0/DET)*(GEP*FIO - FEP*GIO)
      ET1 = ET + (1.0/DET)*(GXP*FIO - FXP*GIO)
      IF ((ABS(XI1 - XI)) .LE. 0.0000001) GO TO 107
      XI = XI1
      ET = ET1
      GO TO 105
  107 IF ((ABS(ET1 - ET)) .LE. 0.0000001) GO TO 108
      XI = XI1
      ET = ET1
      GO TO 105
  108 XI = XI1
      ET = ET1
      IDON =1
      GO TO 105
  800 RETURN
      END
$IBFTC MS23G3
CRECTAG
C
      SUBROUTINE RECTNG
C
C     THIS SUBROUTINE GENERATES THE TABLE OF GRIDPOINT DEFORMATIONS
C     FOR A RECTANGULAR PLATE WITH DIMENSIONS A BY  B AND RIGIDITY D
C
C     A      = PLATE LENGTH
C     ALPHAM = DEFLECTION COEFFICIENT
```

```
C     ALPHAN = DEFLECTION COEFFICIENT
C     ASPECT =  SQUARE OF ASPECT RATIO
C     B      = PLATE WIDTH
C     BETAM  = MOMENT COEFFICIENT
C     BETAN  =  MOMENT COEFFICIENT
C     D      = PLATE STIFFNESS
C     DWX    = DEFLECTION AT POINT I,J OF SECOND PANE
C     DWXMOE = SLOPE IN X DIRECTION FOR MOMENTS APPLIED ALONG ONE EDGE
C     DWXMOF = SLOPE IN X DIRECTION FOR MOMENTS APPLIED ALONG OTHER EDGE
C     DWXSIM = SLOPE IN X DIRECTION FOR SIMPLY SUPPORTED EDGE
C     DWYMOE = SLOPE IN Y DIRECTION FOR MOMENTS APPLIED ALONG ONE EDGE
C     DWYMOF = SLOPE IN Y DIRECTION FOR MOMENTS APPLIED ALONG OTHER EDGE
C     DWYSIM = SLOPE IN Y DIRECTION FOR SIMPLY SUPPORTED EDGE
C     EM     =  COUNT ON NUMBER OF TERMS
C     EN     = COUNT ON NUMBER OF TERMS
C     I      = ROW INDEX
C     IBC    = BOUNDARY CONDITION SWITCH
C     ILIM   = NUMBER OF EQUATIONS USED TO DETERMINE REDUNDANT MOMENTS
C     J      = COLUMN INDEX
C     K      = GRIDPOINT COUNTER
C     MN     = NUMBER OF SIMULTANEOUS EQUATIONS
C     MOMENT = COEFFICIENTS OF LHS OF EQUATIONS
C     NGP    = NUMBER OF GRIDPOINTS
C     NM     = COLUMNS IN RHS OF EQUATIONS
C     RHS    =  RHS OF SET OF SIMULTANEOUS EQUATIONS
C     W      = DEFLECTION AT POINT I,J OF FIRST PANE
C     WMOE   = DEFLECTION FOR MOMENTS APPLIED ALONG ONE EDGE
C     WMOF   = DEFLECTION FOR MOMENTS APPLIED ALONG OTHER EDGE
C     WSIM   = DEFLECTION FOR SIMPLY SUPPORTED EDGE
C     X      = X COORDINATE ARRAY
C
      COMMON DUM
C
      DOUBLE PRECISION RHS,EANDF,MOMENT
C
     0 EQUIVALENCE             (DUM(   1), CON),      (DUM( 501),    X),
     1                         (DUM(1501),    W),     (DUM(2251),  DWX),
     2                         (DUM(3001),  JPN),     (DUM(3501),  RTV),
     3 (DUM(4001),MOMENT)
C
     0 EQUIVALENCE             (CON(   1), DIMA),     (CON(   2), DIMB),
     1 (CON(  3), DIMC),       (CON(   4),  DEL),     (CON(   5),  GNU),
     2 (CON(  6), THIC),       (CON(   7), SPAD),     (CON(   8), PRSS),
     3 (CON(  9), NPAN),       (CON(  10),  ISI),     (CON(  11),  ISO),
     4 (CON( 12),  IBC),       (CON(  13),  NGP),     (CON(  14),  LP7),
     5 (CON( 15),   FR),       (CON(  16), LOCP),     (CON(  17),  IPD),
     6 (CON( 18),  IPR),       (CON(  19), CHAP),     (CON(20), ISCR1),
```

```
     7 (CON( 21),ISCR2),      (CON( 22), SKAL),      (CON( 23), ISEC),
     8 (CON( 24), NPAG),      (CON( 25), YONG),      (CON( 26), ILGD),
     9 (CON( 27), IREL),      (CON( 28),  LP5),      (CON( 29), CPRSS)
C
     0 EQUIVALENCE            (CON( 31), SCAL),      (CON( 41), SPAC),
     1 (CON( 51), PRES),      (CON( 61), PLNA),      (CON( 71), RAYA),
     2 (CON( 81), PAIA),      (CON( 91), THEA),      (CON(101),   RI),
     3 (CON(111),  RES),      (CON(301), STAT),      (CON(351),  OIF),
     4 (CON(401),  RHS)
C
     0 DIMENSION     CON(  500),    X(21,33),                 W(21,33),
     1  DWX(21,33),               JPN(  500),  RTV(  500)
C
       DIMENSION EANDF(32),MOMENT(32,32),RHS(32)
C
       EQUIVALENCE (RHS,EANDF)
C
C===== THIS SECTION SETS UP INITIAL CONSTANTS
C
       D = FR
       A = DIMA
       B = DIMB
       ILIM = 28
       IULIM = ILIM/2
       ILLIM = ILIM/2 + 1
       NTERMS = ILIM - 3
       TERMS = NTERMS
  10   I = 0
       J = 0
       K = 0
       X(1,1) = 0.0
       PI = 3.1415926535
       CNST1 = 4.0*(A**4)/(D*(PI**5))
       CNST2 = 4.0*(A**3)/(D*(PI**4))
       CNST3 = A*A/(2.0*D*PI*PI)
       CNST4 = A/(2.0*D*PI)
       CNST5 = B*B/(2.0*D*PI*PI)
       CNST6 = B/(2.0*D*PI)
       IF (IBC .EQ. 1) GO TO 100
C
C===== THIS SECTION CALCULATES THE MOMENT COEFFICIENTS FOR CLAMPED PLATE
C
 50    DO 55 JK=1,ILIM
       DO 55 L=1,ILIM
 55    MOMENT (JK,L) = 0.0
       EN = -1.0
       DO 60 II=1,IULIM
```

```
      EN = EN + 2.0
      ALPHAN = EN*PI*B/(2.0*A)
      CNST7 = 8.0*EN*A/(PI*B)
      CNST8 = 4.0*A*A/((EN**4)*(PI**3))
      ASPECT = A*A/(B*B)
      III = II
      IF (ALPHAN .LT. 88.0) GO TO 57
       MOMENT(II,III) = 1.0/EN
      RHS(II) = -CNST8
      GO TO 58
   57 0 MOMENT(II,III) = (TANH(ALPHAN)+ALPHAN/
     1                  COSH(ALPHAN)/COSH(ALPHAN)) /EN
      RHS(II) = CNST8*(ALPHAN/ COSH(ALPHAN)/COSH(ALPHAN) -TANH(ALPHAN))
   58 EM = -1.0
      DO 60 JJ=ILLIM,ILIM
      EM = EM + 2.0
     0 MOMENT(II,JJ) = CNST7*(1.0/((EM**3)*(EN*EN/(EM*EM)+ASPECT)
     1                *(EN*EN/(EM*EM)+ASPECT)))
   60 CONTINUE
   70 EN = -1.0
      DO 80 II=ILLIM,ILIM
      EN = EN +2.0
      BETAN = EN*PI*A/(2.0*B)
      CNST9 = 8.0*B*EN/(PI*A)
      CNST10 = 4.0*B*B/((EN**4)*(PI**3))
      ASPECT = B*B/(A*A)
      III = II
      IF (BETAN .LT. 88.0) GO TO 73
      MOMENT (II,III) = 1.0/EN
      RHS (II) = -CNST10
      GO TO 75
   73 0 MOMENT(II,III) = (TANH(BETAN)+BETAN/
     1                  COSH(BETAN)/COSH(BETAN)) /EN
      RHS(II) = CNST10*(BETAN/ COSH(BETAN)/COSH(BETAN) -TANH(BETAN))
   75 EM = -1.0
      DO 80 JJ=1,IULIM
      EM = EM + 2.0
     0 MOMENT(II,JJ) = CNST9*(1.0/((EM**3)*(EN*EN/(EM*EM)+ASPECT)
     1                *(EN*EN/(EM*EM)+ASPECT)))
   80 CONTINUE
      MN = ILIM
      NM = 1
      CALL SEQS (MOMENT,RHS,MN,NM)
C
C===== THIS SECTION GENERATES DEFORMATIONS FOR HINGED EDGES
C
  100 I = I + 1
```

```
  105   J = J+1
        K = K+1
        K1 = I
        K2 = J
        CALL PACWRD (K1,K2,1)
        JPN(K) = K1
          W(I,J) = 0.0
       IF(NPAN.EQ.2) DWX(I,J)=W(I,J)
        EM = -1.0
  110   EM = EM + 2.0
       EJ=I-1
       DWY=DEL*EJ
        CNSTA = EM*PI/A
        ALPHAM = CNSTA*B/2.0
        MMM = EM
        CNST11 = -1.0
        IF (((MMM-1)/2-((MMM-1)/4)*2) .EQ. 0) CNST11=1.0
        CNST11 = CNST11/(EM**5)
        CNST12 = EM*CNST11
        CNST13 = COSH(ALPHAM)
        CNST14 = (2.0+ALPHAM*TANH(ALPHAM))/(2.0*CNST13)
     0    WSIM = CNST1*CNST11*(1.0-CNST14*COSH(CNSTA*DWY)
     1          +CNSTA*DWY    *SINH(CNSTA*DWY)   /(2.0*CNST13))*
     2           COS(CNSTA*X(I,J))
        IF (IBC .EQ. 2) GO TO 200
          W(I,J) = W(I,J) + WSIM
       IF(NPAN.EQ.2) DWX(I,J)=W(I,J)
        IF (EM .LE. TERMS) GO TO 110
        X(I,J+1) = X(I,J) + DEL
        IF (X(I,J+1) .LE. (A/2.0)) GO TO 105
        X(I,J+1) = 0.0
        J = 0
        X(I+1,J+1) = 0.0
       EJ=I
       DWY=DEL*EJ
               IF (DWY .LE. (B/2.0)) GO TO 100
        GO TO 300
C
C===== THIS SECTION GENERATES DEFORMATIONS FOR CLAMPED EDGES
C
C
  200   CNSTB = EM*PI/B
        BETAM = CNSTB*A/2.0
        MMM = EM
        CNST15 = -1.0
        IF (((MMM-1)/2-((MMM-1)/4)*2) .EQ. 0) CNST15=1.0
        CNST15 = CNST15/(EM*EM)
```

```
      CNST16 = EM*CNST15
      CNST17 = COSH(BETAM)
      CNST18 = ALPHAM*TANH(ALPHAM)/CNST13
      CNST19 = BETAM*TANH(BETAM)/CNST17
      EMM = EM/2.0 + 0.5
      M = EMM
     EJ=I-1
     DWY=DEL*EJ
    0   WMOE = -CNST3*CNST15*EANDF(M)*(CNSTA*DWY   *SINH(CNSTA*DWY)/
    1           CNST13   -CNST18*COSH(CNSTA*DWY))   *COS(CNSTA*X(I,J))
      EEE = IULIM
      EMM = EM/2.0 + EEE + 0.5
      M = EMM
    0   WMOF = -CNST5*CNST15*EANDF(M)*(CNSTB*X(I,J)*SINH(CNSTB*X(I,J))/
    1           CNST17   -CNST19*COSH(CNSTB*X(I,J)))*COS(CNSTB*DWY)
        W(I,J) =   W(I,J) +   WSIM +   WMOE +   WMOF
     IF(NPAN.EQ.2) DWX(I,J)=W(I,J)
      IF (EM .LE. TERMS) GO TO 110
      X(I,J+1) = X(I,J) + DEL
      IF (X(I,J+1) .LE. (A/2.0)) GO TO 105
      X(I,J+1) = 0.0
      J = 0
      X(I+1,J+1) = 0.0
     DWY=DEL*EJ
           IF (DWY .LE. (B/2.0)) GO TO 100
  300 NGP = K
  800 RETURN
      END
$IBFTC MS23G4
CSEQS
C
      SUBROUTINE SEQS (A,B,N,M)
C
C     MATRIX INVERSION WITH ACCOMPANYING SOLUTION OF LINEAR EQUATIONS
C
C
      COMMON DUM
     0 EQUIVALENCE (DUM(1),CON),(DUM(501),X),(DUM(1001),Y)
     1,(DUM(1501),W),(DUM(2001),DWX), (DUM(2501),DWY),(DUM(3001),JPN)
     2 ,(DUM(3501),RTV)
      DOUBLE PRECISION A,B,AMAX,PIVOT,SWAP,T
      DIMENSION  IPIVOT(32),A(32,32),      INDEX(32,2),PIVOT(32),B(32,2)
      EQUIVALENCE (IROW,JROW),(AMAX,T,SWAP),(ICOLUM,JCOLUM)
C
C=====INITIALIZATION
C
   10 DETERM=1.0
```

```
   15 DO 20 J=1,N
   20 IPIVOT(J)=0
   30 DO 550 I=1,N
C
C=====SEARCH FOR PIVOT ELEMENT
C
   40 AMAX=0.0
   45 DO 105 J=1,N
   50 IF (IPIVOT(J)-1) 60, 105, 60
   60 DO 100 K=1,N
   70 IF (IPIVOT(K)-1) 80, 100, 740
  80  IF(DABS(AMAX)-DABS(A(J,K)))85,100,100
   85 IROW=J
   90 ICOLUM=K
   95 AMAX=A(J,K)
  100 CONTINUE
  105 CONTINUE
       IF (AMAX) 128,107,128
 107   PRINT 108
 108   FORMAT (22H MATRIX IS SINGULAR.   )
       NCE = 1
       GO TO 740
 128  IPIVOT(ICOLUM) =IPIVOT(ICOLUM)+1
C
C=====INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL
C
  130 IF (IROW-ICOLUM) 140, 260, 140
  140 DETERM=-DETERM
  150 DO 200 L=1,N
  160 SWAP=A(IROW,L)
  170 A(IROW,L)=A(ICOLUM,L)
  200 A(ICOLUM,L)=SWAP
  205 IF(M) 260, 260, 210
  210 DO 250 L=1, M
  220 SWAP=B(IROW,L)
  230 B(IROW,L)=B(ICOLUM ,L)
  250 B(ICOLUM,L)=SWAP
  260 INDEX(I,1)=IROW
  270 INDEX(I,2)=ICOLUM
  310 PIVOT(I)=A(ICOLUM,ICOLUM)
  320 CONTINUE
C
C=====DIVIDE PIVOT ROW BY PIVOT ELEMEN.
C
  330 A(ICOLUM,ICOLUM)=10.0D-1
  340 DO 350 L=1,N
  350 A(ICOLUM,L)=A(ICOLUM,L)/PIVOT(I)
```

```
  355 IF(M) 380, 380, 360
  360 DO 370 L=1,M
  370 B(ICOLUM,L)=B(ICOLUM,L)/PIVOT(I)
C
C=====REDUCE NON-PIVOT ROWS
C
  380 DO 550 L1=1,N
  390 IF(L1-ICOLUM) 400, 550, 400
  400 T=A(L1,ICOLUM)
  420 A(L1,ICOLUM)=0.0
  430 DO 450 L=1,N
  450 A(L1,L)=A(L1,L)-A(ICOLUM,L)*T
  455 IF(M) 550, 550, 460
  460 DO 500 L=1,M
  500 B(L1,L)=B(L1,L)-B(ICOLUM,L)*T
  550 CONTINUE
C
C=====INTERCHANGE COLUMNS
C
  600 DO 710 I=1,N
  610 L=N+1-I
  620 IF (INDEX(L,1)-INDEX(L,2)) 630, 710, 630
  630 JROW= INDEX(L,1)
  640 JCOLUM=INDEX(L,2)
  650 DO 705 K=1,N
  660 SWAP=A(K,JROW)
  670 A(K,JROW)=A(K,JCOLUM)
  700 A(K,JCOLUM)=SWAP
  705 CONTINUE
  710 CONTINUE
  740 RETURN
      END
$IBFTC MS23G5
CTRPZOD
      SUBROUTINE TRPZOD
C     THIS SUBROUTINE READS IN THE TRAPEZOIDAL DEFORMATION DATA FROM
C     PUNCHED CARDS.  THE CODES ARE BROKEN DOWN AND REASSEMBLED IN THE
C     FORMAT NECESSARY FOR THE RAY TRACE PROGRAMS.
C
C     DWX    = SLOPE IN X DIR. AT POINT LOC
C     DWY    = SLOPE IN Y DIR. AT POINT LOC
C     ELM    = ELEMENT VALVE AT LOC
C     IBY    = =1 INDICATES POINT IS OUTSIDE PLANFORM BOUNDARY
C     ICOL   = COLUMN NUMBER
C     IDIR   = DEGREE OF FREEDOM  1=X, 2=Y, 3=Z, 4=TX, 5= TY, 6=TZ
C     ILD    = LOAD NUMBER OUTPUT BY SAMIS (COLUMN CODE)
C     IROW   = ROW NUMBER
```

```
C        ITEM   = TEMPORARY
C        JLD = LOAD NUMBER DESIRED.  THE LOAD NUMBER IS A PART OF THE
C              ELEMENT CODE GENERATED BY SAMIS.
C        LOC    = COORDINATE LOCATION CODE
C        M      = GRIDPOINT COUNTER
C        NCRD = NO. OF ELEMENT DATA CARDS TO BE READ IN.
C        NGP    = NUMBER OF GRIDPOINTS
C        SCLFAC = SCALE FACTOR TO MULTIPLY DEFLECTIONS BY
C        W      = DEFLECTION AT POINT LOC
C        X      = X COORDINATE ARRAY
C        XS     = X COORDINATE AT POINT LOC
C        YS     = Y COORDINATE AT POINT LOC
C
         COMMON DUM
C
       0 EQUIVALENCE            (DUM(    1), CON),      (DUM( 501),    X),
       1                        (DUM(1501),    W),      (DUM(2251), DWX),
       2                        (DUM(3001), JPN),       (DUM(3501), RTV)
C
       0 EQUIVALENCE            (CON(   1), DIMA),      (CON(   2), DIMB),
       1 (CON(   3), DIMC),     (CON(   4),  DEL),      (CON(   5),  GNU),
       2 (CON(   6), THIC),     (CON(   7), SPAD),      (CON(   8), PRSS),
       3 (CON(   9), NPAN),     (CON(  10),  ISI),      (CON(  11),  ISO),
       4 (CON(  12),  IBC),     (CON(  13),  NGP),      (CON(  14),  LP7),
       5 (CON(  15),   FR),     (CON(  16), LOCP),      (CON(  17),  IPD),
       6 (CON(  18),  IPR),     (CON(  19), CHAP),      (CON(20), ISCR1),
       7 (CON(  21),ISCR2),     (CON(  22), SKAL),      (CON(  23), ISEC),
       8 (CON(  24), NPAG),     (CON(  25), YONG),      (CON(  26), ILGD),
       9 (CON(  27), IREL),     (CON(  28),  LP5),      (CON(  29), CPRSS)
C
       0 EQUIVALENCE            (CON(  31), SCAL),      (CON(  41), SPAC),
       1 (CON(  51), PRES),     (CON(  61), PLNA),      (CON(  71), RAYA),
       2 (CON(  81), PAIA),     (CON(  91), THEA),      (CON(101),    RI),
       3 (CON(111),   RES),     (CON(291), STAT),       (CON(351),   OIF),
       4  (OIF(1),IDX),(OIF(2),IDY),(OIF(3),X1),(OIF(4),Y1),(OIF(11),N2)
C
       0 DIMENSION     CON(  500),     X(21,33),                 W(21,33),
       1  DWX(21,33),                JPN(  500), OIF(12)
C
         DIMENSION   LOC(3), ILD(3), ELM(3)
C
         READ (ISI,500) JLD,NCRD,SCLFAC,X1,Y1,IDX,IDY
     500 FORMAT (2I5,3E10.0,2I5)
        WRITE (ISO,503)  SCLFAC
     503 FORMAT (1H1,  42HSCALE FACTOR FOR TRAPEZOID DEFLECTIONS IS
       1     E16.4,1H.)
        WRITE (ISO,505) X1,Y1
```

```
  505 FORMAT (1H , 31HINTERPOLATION CENTER IS AT X1=  E12.4, 6H, Y1=
     1  E12.4,1H.)
      WRITE (ISO,507)IDX,IDY
  507 FORMAT (1H , 35HCENTER OF INTERPOLATION SQUARES IS I5,
     1 17H X INTERVALS AND I5, 25H Y INTERVALS FROM ORIGIN.)
C     X1,Y1 - COORDINATES OF TRANSLATED ORIGIN
C     IDX= NO. OF INTERVALS IN X FOR INTERPOLATION CENTER
C     IDY= NO. OF INTERVALS IN Y FOR INTERPOLATION CENTER
C     IF JLD IS MINUS, CARD DATA FOR WINDOW IN ACTUAL CONFIGURATION IS GIVEN.
C     IF NCRD IS MINUS, CARD DATA IS GIVEN FOR ONLY 1 OF 2 PANES AND BOTH
C     ARE THE SAME.
      N1=1
      N2=1
      IF(NCRD)2,6,6
    2 N1=2
      NCRD=-NCRD
    6 IR=21
      IC=33
      IF(JLD) 10,15,15
   10 N2=2
      JLD=-JLD
      IR=20
      IC=20
   15 M=0
       DO 104 I=1,NCRD
       READ (ISI,501) (LOC(J), ILD(J), ELM(J), J=1,3)
  501  FORMAT (3(I6,I6,O12))
C
C===== TEST TO SEE IF DATA IS ACCEPTABLE
       DO 104 J=1,3
       IF (ILD(J) .NE. JLD) GO TO 104
       IF (LOC(J) .LE. 0) GO TO 104
       IROW = LOC(J)/1000
       ITEM = LOC(J) - IROW*1000
       ICOL = ITEM/10
       IDIR = ITEM - ICOL*10
       IF ((IDIR.EQ.1) .OR. (IDIR.EQ.2) .OR. (IDIR.EQ.6)) GO TO 104
      IF((ICOL.GT.IC).OR.(IROW.GT.IR)) GO TO 20
       XS = ICOL - 1
       YS = IROW - 1
      GO TO 30
   20 XS=ICOL-1-IC
      YS=IROW-1-IR
   30  IBY = 0
      XS=XS*DEL
      YS=YS*DEL
       CALL BONDRY (XS, YS, IBY)
```

```
      IF (IBY .EQ. 1) GO TO 104
      K1 = IROW
      K2 = ICOL
      CALL PACWRD (K1,K2,1)
     IF((IROW.LE.IR).AND.(ICOL.LE.IG)) GO TO 32
     IF((IROW.GT.IR).AND.(ICOL.GT.IC)) GO TO 40
     GO TO 104
   32 K = IROW
      L = ICOL
      X(K,L) = ICOL - 1
     X(K,L)=X(K,L)*DEL
C
C===== STORE ACCEPTABLE DATA
     IF((IDIR.EQ.3).AND.(N2.EQ.1))   W(K,L)=ELM(J)*SCLFAC
     IF((IDIR.EQ.3).AND.(N2.EQ.2)) DWX(K,L)=ELM(J)*SCLFAC
      IF (IDIR .EQ. 3) M = M+1
      IF (IDIR .EQ. 3) JPN(M) = K1
     GO TO (104,34),N1
   34 DWX(K,L)=W(K,L)
     GO TO 104
   40 IF(NPAN-2)104,44,104
   44 K=IROW-IR
     L=ICOL-IC
     IF((IDIR.EQ.3).AND.(N2.EQ.1)) DWX(K,L)=ELM(J)*SCLFAC
     IF((IDIR.EQ.3).AND.(N2.EQ.2))   W(K,L)=ELM(J)*SCLFAC
  104 CONTINUE
      NGP = M
  800 RETURN
      END
$IBFTC MS23G6
CLRGDEF
      SUBROUTINE LRGDEF
C
C     THIS PROGRAM USES EQUATIONS DERIVED FROM AN ENERGY METHOD
C     DEVELOPED IN TIMOSHENKOS THEORY OF PLATES AND SHELLS, P. 419 TO
C     424 TO FIND THE APPROXIMATE LARGE DEFLECTION SOLUTION FOR A
C     RECTANGULAR PLATE.
C
C     A       = HALF RECTANGLE LENGTH
C     A1      = CONSTANTS IN CUBIC EQUATION
C     B       = HALF RECTANGLE WIDTH
C     C1      = CONSTANTS IN CUBIC EQUATION
C     CON1    = CONSTANTS IN LARGE DEFLECTION EQUATION
C     CON2    = CONSTANTS IN LARGE DEFLECTION EQUATION
C     CON3    = CONSTANTS IN LARGE DEFLECTION EQUATION
C     CON4    = CONSTANTS IN LARGE DEFLECTION EQUATION
C     CON5    = CONSTANTS IN LARGE DEFLECTION EQUATION
```

```
C      D1     = CONSTANTS IN CUBIC EQUATION
C      DUX    = LARGE DEFLECTION THEORY DEFLECTION FOR FIRST PANE
C      Q      = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C      QR     = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C      R      = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C      S1     = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C      S2     = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C      SQR    = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C      TM     = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C      TP     = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C      U      = LARGE DEFLECTION THEORY DEFLECTION FOR SECOND PANE
C      WO     = CONSTANTS IN SOLUTION OF CUBIC EQUATION
C
       DOUBLE PRECISION PI,CON1,CON2,CON3,CON4,CON5,A1,C1,Q,R,QR,SQR,TP,
     1 S1,TM,S2,WO,Q1,Q2,QC
C
       COMMON DUM
C
     0 EQUIVALENCE                (DUM(   1), CON),        (DUM( 501),   X),
     1                            (DUM(1501),   W),        (DUM(2001), DWX),
     2                            (DUM(3001), JPN),        (DUM(3501), RTV),
     3 (DUM(4001),    U),         (DUM(4751), DUX),        (DUM(6501),   T),
     4 (DUM(5501),    R),         (DUM(6001),   S),        (DUM(7251), DTX)
C
     0 EQUIVALENCE                (CON(  1), DIMA),        (CON(  2), DIMB),
     1 (CON(  3), DIMC),          (CON(  4),  DEL),        (CON(  5),  GNU),
     2 (CON(  6), THIC),          (CON(  7), SPAD),        (CON(  8), PRSS),
     3 (CON(  9), NPAN),          (CON( 10),  ISI),        (CON( 11),  ISO),
     4 (CON( 12),  IBC),          (CON( 13),  NGP),        (CON( 14),  LP7),
     5 (CON( 15),   FR),          (CON( 16), LOCP),        (CON( 17),  IPD),
     6 (CON( 18),  IPR),          (CON( 19), CHAP),        (CON(20), ISCR1),
     7 (CON( 21),ISCR2),          (CON( 22), SKAL),        (CON( 23), ISEC),
     8 (CON( 24), NPAG),          (CON( 25), YONG),        (CON( 26), ILGD),
     9 (CON( 27), IREL),          (CON( 28),  LP5),        (CON( 29), CPRSS)
C
     0 EQUIVALENCE                (CON( 31), SCAL),        (CON( 41), SPAC),
     1 (CON( 51), PRES),          (CON( 61), PLNA),        (CON( 71), RAYA),
     2 (CON( 81), PAIA),          (CON( 91), THEA),        (CON(101),   RI),
     3 (CON(111),  RES),          (CON(291), STAT),        (CON(351),  OIF),
     4 (CON(401),EANDF),          (CON(451),  RHS)
C
      EQUIVALENCE (RTV,BI),(OIF(1),NDX),(OIF(2),NDY),(X1,OIF(3)),
     1 (Y1,OIF(4)),(OIF(5),CONST1),(OIF(6),CONST2),(OIF(7),CONST3),
     2 (OIF(8),CONST4),(OIF(9),CONST5),(OIF(10),CONST6)
C
     0 DIMENSION     CON(  500),    X(21,33),    U(21,33),    W(21,33),
     1  DWX(21,33),  DUX(21,33),  JPN(  500), RTV(500), OIF(12)
```

```
C
      IF (CHAP.NE.2.) GO TO 900
      NTIMES=0
      III=1
      IF(NPAN.EQ.2) III=2
  100 DO 700 II=1,III
      II=II
      NTIMES=NTIMES+1
      PRSSS=PRSS
      IF (NTIMES.EQ.2) PRSSS=-(PRSS-CPRSS)
       DO 102 I=1,21
       DO 102 J=1,33
  102 U(I,J)=W(I,J)*PRSSS
       PI = 3.14159265358979323846
       A = DIMA/2.0
       B = DIMB/2.0
C      CONSTANTS IN LARGE DEFLECTION EQUATION.
       CON1 = 480.0*A*B/(YONG*THIC*PI**4)
       CON2 = (PI**2/16.0)*(9.0*B/(A**3) + 2.0/(A*B) + 9.0*A/(B**3))
     0 CON3 = (PI**2/3.0)*(16.0*B/(A**2) + 1.0/A + 1.0/B + 16.0*A/
     1 (B**2))**2
       CON4 = (35.0*(PI**2)*B/A + 35.0*(PI**2)*A/B + 640.0/9.0)
       CON5 = CON1/(CON2 - (2.0/3.0)*(CON3/CON4))
C      CONSTANTS IN CUBIC EQUATION
       A1 = 1.0/CON5
      C1=PRSSS/(ABS(U(1,1))*3.)
       D1 = -PRSSS
C      SOLUTION OF CUBIC EQUATION.
       Q = A1*C1
       R = -0.5*(A1**2)*D1
       INEG = 0
       QR = Q**3 + R**2
       SQR =DSQRT(QR)
       TP = R + SQR
       IF (TP .GT. 0.0) GO TO 106
       INEG = 1
  106  S1 = ABS(TP)**(1.0/3.0)
       IF (INEG .NE. 1) GO TO 108
       S1 = -S1
       INEG = 0
  108  TM = R - SQR
       IF (TM .GT. 0.0) GO TO 110
       INEG = 1
  110  S2 = ABS(TM)**(1.0/3.0)
       IF (INEG .NE. 1) GO TO 112
       S2 = -S2
  112  INEG = 0
```

```
      WO = (S1 + S2)/A1
C     DETERMINATION OF SMALL DEFLECTION THEORY AND LARGE DEFLECTION
C     THEORY PRESSURES.
      Q2 = (WO**3)/CON5
      Q1 = PRSSS- Q2
      QC = Q2*CON5
      IF (QC .GT. 0.0) GO TO 114
      INEG = 1
  114 CQC = ABS(QC)**(1.0/3.0)
      IF (INEG .NE. 1) GO TO 116
      CQC = -CQC
C     THIS SECTION DETERMINES THE DEFLECTION AND SLOPES.
  116 IF(NTIMES.EQ.1) GO TO 103
      CONST4=Q1
      CONST5=PRSSS
      CONST6=CQC
      GO TO 105
  103 CONST1=Q1
      CONST2=PRSSS
      CONST3=CQC
  105 DO 104 I=1,NGP
      K1 = JPN(I)
      CALL PACWRD (K1,K2,2)
      CX = PI*X(K1,K2)/(2.0*A)
      EJ=K1-1
      YY=DEL*EJ
      GY=PI*YY/(2.*B)
      TE1 = U(K1,K2)*(ABS(Q1/PRSSS))
      TE2 = CQC*COS(CX)*COS(CY)
  104 U(K1,K2) = (TE1 + TE2)/2.0
      IF(NTIMES.EQ.2) GO TO 700
      DO 120 I=1,21
      DO 120 J=1,33
  120 DUX(I,J)=U(I,J)
  700 CONTINUE
  800 RETURN
  900 WRITE(ISO,500)
  500 FORMAT(1H1,99HINPUT ERROR. LARGE DEFLECTION REQUIRED FOR PLANFORM
     1OTHER THAN RECTANGLE.                         )
      STOP
      END
$IBFTC MS23G7
C     DEFRES
      SUBROUTINE DEFRES (IDT,NOPRT)
C
C     THIS SUBROUTINE PRINTS OUT THE PLATE DEFLECTION DATA.
C
```

```
C        CONC    = BOUNDARY CONDITION
C        DTX     = TEMPORARY ARRAY FOR SLOPE IN X DIR.
C        DTY     = TEMPORARY ARRAY FOR SLOPE IN Y DIR.
C        R       = TEMPORARY ARRAY FOR X COORDINATES
C        S       = TEMPORARY ARRAY FOR Y COORDINATES
C        T       = TEMPORARY ARRAY FOR DEFLECTION
C
         COMMON DUM
C
       0 EQUIVALENCE          (DUM(   1), CON),     (DUM( 501),   X),
       1                      (DUM(1501),   W),     (DUM(2251), DWX),
       2                      (DUM(3001), JPN),     (DUM(3501), RTV),
       3 (DUM(4001),    U),   (DUM(4751), DUX),
       4 (DUM(5501),    R),   (DUM(6001),   S),
       5 (DUM(6501),    T),   (DUM(7251), DTX)
C
       0 EQUIVALENCE          (CON(  1), DIMA),     (CON(  2), DIMB),
       1 (CON(  3), DIMC),    (CON(  4),  DEL),     (CON(  5),  GNU),
       2 (CON(  6), THIC),    (CON(  7), SPAD),     (CON(  8), PRSS),
       3 (CON(  9), NPAN),    (CON( 10),  ISI),     (CON( 11),  ISO),
       4 (CON( 12),  IBC),    (CON( 13),  NGP),     (CON( 14),  LP7),
       5 (CON( 15),   FR),    (CON( 16), LOCP),     (CON( 17),  IPD),
       6 (CON( 18),  IPR),    (CON( 19), CHAP),     (CON(20), ISCR1),
       7 (CON( 21),ISCR2),    (CON( 22), SKAL),     (CON( 23), ISEC),
       8 (CON( 24), NPAG),    (CON( 25), YONG),     (CON( 26), ILRG),
       9 (CON( 27), IREL),    (CON( 28),  LP5),     (CON( 29), CPRSS)
C
       0 EQUIVALENCE          (CON( 31), SCAL),     (CON( 41), SPAC),
       1 (CON( 51), PRES),    (CON( 61), PLNA),     (CON( 71), RAYA),
       2 (CON( 81), PAIA),    (CON( 91), THEA),     (CON(101),   RI),
       3 (CON(111),  RES),    (CON(301), STAT),     (CON(351),  OIF),
       4 (CON(401),EANDF),    (CON(451),  RHS)
C
C
       0 DIMENSION  CON(500), X(21,33),         W(21,33), DWX(21,33),
       1              JPN(500), R(500), S(500), T(500), DTX(750),
       3 RTV( 500),U(21,33), DUX(21,33)
C
       0 DIMENSION RT30(3), RT31(3), RT32(3), RT36(2), RT37(2), RT38(2),
       1 RT39(2)
C
       0 DATA  RT30(1)/13HELLIPSE    A=/, RT31(1)/13HRECTANGLE  A=/,
       1         RT32(1)/13HTRAPEZOID  A=/, RT33/4H  B=/, RT34/4H  C=/,
       2         RT35/6HSCALE=/, RT36(1)/10HTHICKNESS=/,
       3         RT37(1)/9H   PANES=/, RT38(1)/11H   SPACING=/,
       4 RT39(1)/12H   PRESSURE=/
C
```

```
      DATA  HING/6HHINGED/, CH/1H /, CLMP/6HCLAMPE/, CC/1HD/
C
C===== THIS SECTION MULTIPLIES THE UNITIZED DEFORMATIONS BY THE PRESSURE
C      LOAD.
C
      IS7 = ISO
      IF (NOPRT .EQ. 0) IS7 = ISCR1
      DO 101 I=1,NGP
      K1 = JPN(I)
      CALL PACWRD (K1,K2,2)
     EJ=K1-1
      R(I) = X(K1,K2)
      S(I) = DEL*EJ
     IF(ILRG.EQ.1) GO TO 100
     IF(CHAP.EQ.3.) GO TO 99
        T(I) =   W(K1,K2)*(CPRSS-PRSS)
      DTX(I) = DWX(K1,K2)*PRSS
      GO TO 101
   99 T(I)=W(K1,K2)
     DTX(I)=DWX(K1,K2)
     GO TO 101
  100   T(I) = DUX(K1,K2)
      DTX(I) =   U(K1,K2)
  101 CONTINUE
C
C===== THIS SECTION PRINTS THE TITLE AND HEADING INFORMATION.
C
      CALL PAGE (IPD, LINE, IS7, IDT)
      IF (ILRG .EQ. 0) GO TO 607
      WRITE (IS7,529)
  529 0 FORMAT (1H0,    38X,38HW I N D O W   D E F O R M A T I O N   ,
     1 7HD A T A/1H ,49X,23H(LARGE DEFLECTION DATA)/1H )
      GO TO 608
  607 WRITE (IS7,500)
  500 0 FORMAT (1H0/1H ,38X,38HW I N D O W   D E F O R M A T I O N   ,
     1 7HD A T A/1H )
  608 ICHAP = CHAP
      IF ( IBC .NE. 1) GO TO 302
      CONC = HING
      CF = CH
  302 IF (IBC .NE. 2) GO TO 303
      CONC = CLMP
      CF = CC
  303 GO TO (102,103,104), ICHAP
  102 0 WRITE (IS7,501) (RT30(I),I=1,3), DIMA, RT33, DIMB,
     1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
     2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
```

```
501 0 FORMAT (1H0,2A6,A1,F5.2,A4,F5.2,14X,A6,F4.2,3X,A6,A4,F5.2,A6,A3,
    1         I1,A6,A5,F3.1,2A6,F5.1,3X,A6,A1)
      GO TO 105
103 0 WRITE (IS7,501) (RT31(I),I=1,3), DIMA, RT33, DIMB,
    1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
      GO TO 105
104 0 WRITE (IS7,518) (RT32(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
    1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
518 0 FORMAT (1H0,2A6,A1,F5.2,A4,F5.2,A4,F5.2,5X,A6,F4.2,3X,A6,A4,F5.2,
    1 A6,A3,I1,A6,A5,F3.1,2A6,F5.1,3X,A6,A1)
105   WRITE (IS7,505)
505 0 FORMAT (1H0/1H ,1X,11HCOORDINATES,18X,12HDEFORMATIONS,14X,
    1                   11HCOORDINATES,18X,12HDEFORMATIONS/1H0,
    2 44H  X       Y     DEFL. PANE 1   DEFL. PANE 2             ,11X,
    3 44H  X       Y     DEFL. PANE 1   DEFL. PANE 2             )
      LINE = LINE + 11
      JRM = NGP-2*(NGP/2)
      DO 114 K=1,NGP,2
      IF (LINE - 45) 112,107,107
107   CALL PAGE (IPD, LINE, IS7, IDT)
      WRITE (IS7,500)
      GO TO (108,109,110), ICHAP
108 0 WRITE (IS7,501) (RT30(I),I=1,3), DIMA, RT33, DIMB,
    1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
      GO TO 111
109 0 WRITE (IS7,501) (RT31(I),I=1,3), DIMA, RT33, DIMB,
    1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
      GO TO 111
110 0 WRITE (IS7,518) (RT32(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
    1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
111   WRITE (IS7,505)
      LINE = LINE + 11
112   IF ((JRM .EQ. 1) .AND. (K .EQ. NGP)) GO TO 113
      J = K+1
    0 WRITE (IS7,506) R(K), S(K), T(K), DTX(K),
    1                 R(J), S(J), T(J), DTX(J)
506 0 FORMAT (1H ,F5.2,F7.2,2(2X,E13.6),13X,
    1             F5.2,F7.2,2(2X,E13.6))
      GO TO 114
113   WRITE (IS7,506) R(K), S(K), T(K), DTX(K)
114   LINE = LINE + 1
800   RETURN
```

```
      END
$IBFTC MS23G8
CRAYTWO
      SUBROUTINE RAYTWO (XP, YP, ZS, BETA, PSI, PAI, THETA, ZSEXT)
C
C     PRSS = FIRST WINDOW PRESSURE FACTOR TO SCALE DEFORMATIONS
C     PRSF =   2ND WINDOW PRESSURE FACTOR TO SCALE DEFORMATIONS
C     BETA  = ANGLE IN XY PLANE BETWEEN Y AXIS AND PLANE OF TWO RAYS
C     PSI   = ANGLE BETWEEN Z AXIS AND PLANE CONTAINING 2 RAYS
C     PAI   = ANGLE IN RAY PLANE BETWEEN XY PLANE AND PRIMARY RAY
C     THETA = ANGLE IN THE RAY PLANE BETWEEN PRIMARY AND SECONDARY RAY
C     ZSEXT = DISTANCE OF SEXTANT FROM INSIDE OF WINDOW
C     RES(IJ+  1) = XP  X COORD. OF PRIMARY ENTERING RAY
C     RES(IJ+ 11) = YP  Y COORD. OF PRIMARY ENTERING RAY
C     RES(IJ+ 21) = XP  X COORD. OF PRIMARY LEAVING RAY
C     RES(IJ+ 31) = YP  Y COORD. OF PRIMARY LEAVING RAY
C     RES(IJ+ 41) = XS  X COORD. OF SECONDARY ENTERING RAY
C     RES(IJ+ 51) = YS  Y COORD. OF SECONDARY ENTERING RAY
C     RES(IJ+ 61) = XS  X COORD. OF SECONDARY LEAVING RAY
C     RES(IJ+ 71) = YS  Y COORD. OF SECONDARY LEAVING RAY
C     RES(IJ+ 81) = ZSEXT
C     RES(IJ+ 91) = BETA
C     RES(IJ+101) = PSI
C     RES(IJ+111) = PAI
C     RES(IJ+121) = THETA
C     RES(IJ+131) = SAI
C     RES(IJ+141) = ERROR
C     RES(IJ+151) = BLANK
C     RES(IJ+161) = BLANK
C     RES(IJ+171) = BLANK
C
      COMMON  DUM
C
     0 EQUIVALENCE          (DUM(   1), CON),     (DUM( 501),    X),
     1 (DUM(1001),    Y),   (DUM(1501),    W),    (DUM(2001), DWX),
     2 (DUM(2501), DWY),    (DUM(3001), JPN),     (DUM(3501), RTV)
C
     0 EQUIVALENCE          (CON(   1), DIMA),    (CON(   2), DIMB),
     1 (CON(  3), DIMC),    (CON(   4),  DEL),    (CON(   5),  GNU),
     2 (CON(  6), THIC),    (CON(   7), SPAD),    (CON(   8), PRSS),
     3 (CON(  9), NPAN),    (CON(  10),  ISI),    (CON(  11),  ISO),
     4 (CON( 12),  IBC),    (CON(  13),  NGP),    (CON(  14),  LP7),
     5 (CON( 15),   FR),    (CON(  16), LOCP),    (CON(  17),  IPD),
     6 (CON( 18),  IPR),    (CON(  19), CHAP),    (CON(20), ISCR1),
     7 (CON( 21),ISCR2),    (CON(  22), SKAL),    (CON(  23), ISEC),
     8 (CON( 24), NPAG),    (CON(  25), YONG),    (CON(  26), ILGD),
     9 (CON( 27), IREL),    (CON(  28),  LP5),    (CON(  29), CPRSS)
```

```
C
      EQUIVALENCE         (CON( 31), SCAL),       (CON( 41), SPAC),
     1 (CON( 51), PRES),   (CON( 61), PLNA),       (CON( 71), RAYA),
     2 (CON( 81), PAIA),   (CON( 91), THEA),       (CON(101),   RI),
     3 (CON(111),  RES),   (CON(301), STAT),       (CON(351),  OIF),
     4 (CON(401),EANDF),   (CON(451),  RHS)
C
      DIMENSION  CON(500), X(22,22), Y(22,22), W(22,22), DWX(22,22),
     1 DWY(22,22), RES(180)
C
      DIMENSION  CI(3), DELTAP( 4), CN(3), RI(5), CR(3), D(3), EE(3)
C
      DIMENSION E(3), SN1(3), SN2(3), S1(3), S2(3), PNS(3), V(3)
C
      IJ = LP7-1
      IF (NPAN .EQ. 2) PRSS = -(PRSS-CPRSS)
      RES(     1) = XP
      RES(     2) = YP
      D(1) = THIC
      D(2) = D(1) + SPAD
      D(3) = D(2) + THIC
      N = NPAN*2
      DO 100 I=1,N
  100 DELTAP(I) = 1.0
      RAD = 0.017453292519
      DEG = 1.0/RAD
      SEC = 206264.8064
      PI = 3.141592653
      RES(     9) = ZSEXT
      RES(    10) = BETA
      RES(    11) = PSI
      RES(    12) = THETA
      RES(    13) = PAI
     RES(14)=PAI+THETA
      BETA = BETA*RAD
      PSI  = PSI *RAD
      PAI  = PAI * RAD
      THETA= THETA*RAD
      S1(1) = COS(BETA)*COS(PAI) - SIN(BETA)*SIN(PSI)*SIN(PAI)
      S1(2) = SIN(BETA)*COS(PAI) + COS(BETA)*SIN(PSI)*SIN(PAI)
      S1(3) = COS(PSI) *SIN(PAI)
      G = -ZSEXT -0.716
  310 A = (0.1703 + 0.335/COS(64.0*RAD + ABS(THETA/2.0)))/
     1        (TAN(64.0*RAD + ABS(THETA/2.0)) - TAN(-52.0*RAD))
      B = A*TAN(-52.0*RAD) + 0.1703
     IF(THETA.EQ.0.) GO TO 20
      C = (-3.274 - B + A*TAN(ABS(THETA)))/TAN(ABS(THETA))
```

```
      G = C-ZSEXT - 3.407
 20   E(1) = XP + G*S1(1)
      E(2) = YP + G*S1(2)
      E(3) = G*S1(3)
      DO 304 I=1,3
 304  V(I) = E(I)
      IBY = 0
      CALL BONDRY (XP, YP, IBY)
     IF(IBY.EQ.1) GO TO 800
      CALL TRACE (S1,V,XP,YP,RI,N,D,DELTAP,SN1,ISO,PRSS,CPRSS)
      RES(     3) = XP
      RES(     4) = YP
      CALL BONDRY (XP, YP, IBY)
      IF (IBY .EQ. 1) GO TO 801
      SAI = PAI + THETA
      S2(1) = COS(BETA)*COS(SAI) - SIN(BETA)*SIN(PSI)*SIN(SAI)
      S2(2) = SIN(BETA)*COS(SAI) + COS(BETA)*SIN(PSI)*SIN(SAI)
      S2(3) = COS(PSI) *SIN(SAI)
      IF (THETA .NE. 0.0) GO TO 330
      AA = A - 4.123
      BB = 3.274 - B
     0 DX = S1(1)*AA - BB*(COS(BETA)*SIN(PAI) + SIN(BETA)*SIN(PSI)*
     1 COS(PAI))
     0 DY = S1(2)*AA + BB*(COS(BETA)*SIN(PSI)*COS(PAI) - SIN(BETA)*
     1 SIN(PAI))
      DZ = S1(3)*AA + COS(PSI)*COS(PAI)*BB
      EE(1) = E(1) + DX
      EE(2) = E(2) + DY
      EE(3) = E(3) + DZ
      DO 350 I=1,3
 350  E(I) = EE(I)
 330  XS = E(1) - E(3)*S2(1)/S2(3)
      YS = E(2) - E(3)*S2(2)/S2(3)
      RES(     5) = XS
      RES(     6) = YS
      CALL BONDRY (XS, YS, IBY)
      IF (IBY .EQ. 1) GO TO 802
      IF (NPAN .EQ. 2) PRSS = -(PRSS-CPRSS)
      CALL TRACE (S2,E,XS,YS,RI,N,D,DELTAP,SN2,ISO,PRSS,CPRSS)
      RES(     7) = XS
      RES(     8) = YS
      CALL BONDRY (XS, YS, IBY)
      IF (IBY .EQ. 1) GO TO 803
      CALL CROPOD (SN1, SN2, PNS, APNS)
      THETAN = ASIN(APNS)
      ERROR = (THETAN - THETA)*SEC
      SAI = SAI/RAD
```

```
      RES(    15) = ERROR
      GO TO 900
  800 RES(3)=1.E+9
      RES(4)=1.E+9
  801 RES(5)=1.E+9
      RES(6)=1.E+9
  802 RES(7)=1.E+9
      RES(8)=1.E+9
      IF(NPAN.EQ.2) PRSS=-(PRSS-CPRSS)
  803 RES(15)=1.E+13
  900 RETURN
      END
$IBFTC MS23G9
CTRACE
       SUBROUTINE TRACE (CS,E,X,Y,RI,N,D,DELTAP,CR,ISO,PRSS,CPRSS)
C
C      THIS SUBROUTINE TRACES THE RAY THRU THE WINDOW
C
      0 DIMENSION CS(3), E(3), CI(3), CN(3), CR(3), DELTAP( 4), RI( 5),
      1 D(3)
C
       ZP = 0.0
       K = 1
       DO 110 I=1,3
 110   CI(I) = CS(I)
 115   CALL ITERAT (X, Y, K, DELTAP, CI, DELZ, OWX, OWY)
       ZP = ZP + DELZ
       CALL NORMAL (OWX, OWY, K, DELTAP, CN)
       QRI = RI(K+1)/RI(K)
       CALL REFRCI (CI, CN, QRI,     CR,              ISO)
       IF (N-K) 800,800,120
 120   E(1) = X
       E(2) = Y
       E(3) = ZP - D(K)
       DO 125 I=1,3
 125   CI(I) = CR(I)
       X = E(1) - E(3)*CI(1)/CI(3)
       Y = E(2) - E(3)*CI(2)/CI(3)
       ZP = D(K)
       K = K+1
       IF (K .EQ. 3) PRSS = -(PRSS-CPRSS)
       GO TO 115
 800   RETURN
       END
$IBFTC MS23H0
CITERAT
       SUBROUTINE ITERAT (XP, YP, K, DELTAP, CI, DELZ, OWX, OWY)
```

```
      C
      C     THIS SUBROUTINE PERFORMS THE ITERATION TO FIND THE POINT XP,YP ON
      C     THE DEFORMED SURFACE.
      C
           COMMON DUM
           EQUIVALENCE (DUM(1),CON),(CON(1),DIMA),(CON(2),DIMB)
      C
            DIMENSION CI(3), DELTAP(10)
      C
            J = 1
            DELTAA = 0.0
        101 CALL INCOTB (XP, YP, OWF, OWX, OWY,K)
            DELZ = OWF*DELTAP(K)
            A = (DELZ - DELTAA*CI(3))*CI(3)
            IF (ABS(A) - 1.0E-06) 800,800,102
        102 DELTAA = DELTAA + A
            XP = XP + A*CI(1)
            YP = YP + A*CI(2)
           DIMA=2.*DIMA
           DIMB=2.*DIMB
           IBY=0
           CALL BONDRY(XP,YP,IBY)
           DIMA=DIMA/2.
           DIMB=DIMB/2.
           IF(IBY.EQ.1) GO TO 800
            J = J+1
            IF (J-25) 101,800,800
        800 RETURN
            END
      $IBFTC MS23H1
      CINCOTB
            SUBROUTINE INCOTB (XP, YP, OWF, OWX, OWY, IPG)
      C
      C     THIS SUBROUTINE GENERATES THE TABLE OF INTERPOLATION COEFFICIENTS
      C
            DOUBLE PRECISION A,BR,A1,A2,A3,A4
      C
            COMMON  DUM
      C
          0 EQUIVALENCE            (DUM(   1), CON),      (DUM( 501),    X),
          1                        (DUM(1501),    W),     (DUM(2251), DWX),
          2                        (DUM(3001), JPN),      (DUM(3501), RTV),
          3 (DUM(4001), BR),       (DUM(6100),    B)
      C
          0 EQUIVALENCE            (CON(   1), DIMA),     (CON(   2), DIMB),
          1 (CON(   3), DIMC),     (CON(   4),  DEL),     (CON(   5),  GNU),
          2 (CON(   6), THIC),     (CON(   7), SPAD),     (CON(   8), PRSS),
```

```
     3 (CON(  9), NPAN),      (CON( 10),  ISI),      (CON( 11),  ISO),
     4 (CON( 12),  IBC),      (CON( 13),  NGP),      (CON( 14),  LP7),
     5 (CON( 15),   FR),      (CON( 16), LOCP),      (CON( 17),  IPD),
     6 (CON( 18),  IPR),      (CON( 19), CHAP),      (CON( 20),ISCR1),
     7 (CON( 21),ISCR2),      (CON( 22), SKAL),      (CON( 23), ISEC),
     8 (CON( 24), NPAG),      (CON( 25), YONG),      (CON( 26), ILGD),
     9 (CON( 27), IREL),      (CON( 28),  LP5),      (CON( 29), CPRSS)
C
     0 EQUIVALENCE            (CON( 31), SCAL),      (CON( 41), SPAC),
     1 (CON( 51), PRES),      (CON( 61), PLNA),      (CON( 71), RAYA),
     2 (CON( 81), PAIA),      (CON( 91), THEA),      (CON(101),   RI),
     3 (CON(111),  RES),      (CON(301), STAT),      (CON(351),  OIF),
     4 (CON(401),EANDF),      (CON(451),  RHS)
C
     0 EQUIVALENCE  (RTV,BI),(OIF(1),NDX),(OIF(2),NDY),(X1,OIF(3)),
     1 (Y1,OIF(4)),(OIF(5),CONST1),(OIF(6),CONST2),(OIF(7),CONST3),
     2 (OIF(8),CONST4),(OIF(9),CONST5),(OIF(10),CONST6),(OIF(12),MIBP)
C
      DIMENSION  CON(500), X(21,33), OIF(10),  W(21,33), DWX(21,33),
C
      DIMENSION        A(25),BR(32,32),B(36,25),A1(25,2),A2(25,2),
     1        JPN(500),RTV(500),A3(25,2),A4(32,2),WC(36,2)
C
      DATA PI/3.14159265/
C
      JUMP=5
      IF(MIBP)304,304,400
  304 ICHAP = CHAP
      JUMP=1
      X1P=X1
      Y1P=Y1
      GO TO (20,40,60),ICHAP
   20 IDX=5
      IDY=5
      GO TO 309
   40 IDX=DIMA
      IDX=IDX/2
      IDY=DIMB
      IDY=IDY/2
  305 IF(IDX.LT.5) IDX=5
      IF(IDY.LT.5) IDY=5
      GO TO 309
   60 IDX=NDX
      IDY=NDY
      IF(IDX.LT.5) GO TO 306
      IF(IDY.LT.5) GO TO 306
      GO TO 311
```

```
  306 WRITE (ISO,307) IDX,IDY
  307 FORMAT (1H0, 80H INTERPOLATION FAILS. GRID HAS LESS THAN SIX NODES
     1 IN THE X OR Y DIRECTION. IDX=,I2,6H. IDY=,I2,1H.)
      STOP
  309 IF(IDX.GT.10) IDX=IDX/2
      IF(IDY.GT.10) IDY=IDY/2
  311 CONTINUE
      DTX=IDX
      DTX=DTX*DEL
      DTY=IDY
      DTY=DTY*DEL
      DO 300 I1=1,4
      GO TO (310,318,314,322),I1
  310 I3=IDY+1
      I2=I3-5
      J3=IDX+1
      J2=J3-5
      GO TO 308
  314 I2=IDY+1
      I3=I2+5
      J3=IDX+1
      J2=J3-5
      GO TO 308
  318 I3=IDY+1
      I2=I3-5
      J2=IDX+1
      J3=J2+5
      GO TO 308
  322 I2=IDY+1
      I3=I2+5
      J2=IDX+1
      J3=J2+5
  308 CONTINUE
      AA=DIMA/2.
      BB=DIMB/2.
      DO 200 I=1,36
       DO 200 J=1,25
 200   B(I,J) = 0.0
       K = 0
      DO 202 J=J2,J3
      EJ=J
      DO 202 I=I2,I3
       K = K+1
      EI=I
      U=DEL*(EJ-1.)-X1P
      V=DEL*(EI-1.)-Y1P
 8040  B(K, 1) = (U**4)*(V**4)
```

```
      B(K, 2) = (U**4)*(V**3)
      B(K, 3) = (U**3)*(V**4)
      B(K, 4) = (U**4)*(V**2)
      B(K, 5) = (U**3)*(V**3)
      B(K, 6) = (U**2)*(V**4)
      B(K, 7) = (U**4)*(V    )
      B(K, 8) = (U**3)*(V**2)
      B(K, 9) = (U**2)*(V**3)
      B(K,10) = (U    )*(V**4)
      B(K,11) = (U**4)
      B(K,12) = (U**3)*(V    )
      B(K,13) = (U**2)*(V**2)
      B(K,14) = (U    )*(V**3)
      B(K,15) =          (V**4)
      B(K,16) = (U**3)
      B(K,17) = (U**2)*(V    )
      B(K,18) = (U    )*(V**2)
      B(K,19) =          (V**3)
      B(K,20) = (U**2)
      B(K,21) = (U    )*(V    )
      B(K,22) =          (V**2)
      B(K,23) = (U    )
      B(K,24) =          (V    )
      B(K,25) = 1.0
     WC(K,1)=W(I,J)
     WC(K,2)=DWX(I,J)
     IF(ILRG.NE.1) GO TO 201
     WC(K,1)=0.5*(W(I,J)*CONST2*(ABS(CONST1/CONST2))+CONST3*COS(PI*U/
    1 (AA*2.))*COS(PI*V/(BB*2.)))
     IF(NPAN.EQ.2) WC(K,2)=0.5*(W(I,J)*CONST5*(ABS(CONST4/CONST5))+
    1 CONST6*COS(PI*U/(AA*2.))*COS(PI*V/(BB*2.)))
201  IF(ABS(X(I,J)-X1P-U)-1.0E-7)202,202,206
 206 DO 210 LM=1,25
 210 B(K,LM)=0.
 202 CONTINUE
     DO 240 K=1,2
     DO 240 I=1,25
     A4(I,K)=0.
     DO 240 J=1,36
 240 A4(I,K)=A4(I,K)+B(J,I)*WC(J,K)
C
C===== THIS SECTION MULTIPLIES THE COEFFICIENT MATRIX BY ITS TRANSPOSE
C
      DO 124 I=1,25
      DO 124 J=1,25
122   BR(I,J) = 0.0
     DO 124 K=1,36
```

```
  124 BR(I,J) = BR(I,J) + B(K,I)*B(K,J)
C
C===== THIS SECTION INVERTS THE INTERMEDIATE MATRIX.
C===== THIS SECTION CALCULATES THE COEFFICIENTS.
C
       NR = 25
       NC = 2
      CALL SEQS (BR,A4,NR,NC)
      DO 280 I=1,25
      GO TO (260,264,268,300),I1
  260 A1(I,1)=A4(I,1)
      A1(I,2)=A4(I,2)
      GO TO 280
  264 A2(I,1)=A4(I,1)
      A2(I,2)=A4(I,2)
      GO TO 280
  268 A3(I,1)=A4(I,1)
      A3(I,2)=A4(I,2)
      GO TO 280
  280 CONTINUE
  300 CONTINUE
C
C===== THIS SECTION INTERPOLATES TO OBTAIN THE DEFLECTION AND SLOPES AT
C       THE POINT XP, YP.
C
  400 J=1
      IF(L.GE.3)  J=2
      IF(JUMP.EQ.5) GO TO 504
  410 GO TO (420,522,526,534,504),JUMP
  420 SXP=XP
      SYP=YP
      XP=DTX
      YP=DTY
      GO TO 512
  504 IF(ABS(XP)-DTX)510,510,518
  510 IF(ABS(YP)-DTY)512,512,526
  512 DO 514 K=1,25
  514 A(K)=A1(K,J)
      GO TO 540
  518 IF(ABS(YP)-DTY)   522,522,534
  522 DO 524 K=1,25
  524 A(K)=A2(K,J)
      GO TO 540
  526 DO 530 K=1,25
  530 A(K)=A3(K,J)
      GO TO 540
  534 DO 538 K=1,25
```

```
  538 A(K)=A4(K,J)
  540 CONTINUE
      XP=XP-X1P
      YP=YP-Y1P
     0 OWA = A( 1)*(XP**4)*(YP**4) + A( 2)*(XP**4)*(YP**3)
     1      + A( 3)*(XP**3)*(YP**4) + A( 4)*(XP**4)*(YP**2)
     2      + A( 5)*(XP**3)*(YP**3) + A( 6)*(XP**2)*(YP**4)
     3      + A( 7)*(XP**4)*(YP   ) + A( 8)*(XP**3)*(YP**2)
     4      + A( 9)*(XP**2)*(YP**3) + A(10)*(XP   )*(YP**4)
     5      + A(11)*(XP**4)         + A(12)*(XP**3)*(YP   )
     6      + A(13)*(XP**2)*(YP**2) + A(14)*(XP   )*(YP**3)
     7      + A(15)*        (YP**4) + A(16)*(XP**3)
     8      + A(17)*(XP**2)*(YP   ) + A(18)*(XP   )*(YP**2)
     9      + A(19)*        (YP**3) + A(20)*(XP**2)
     0 OWB = A(21)*(XP   )*(YP   ) + A(22)*        (YP**2)
     1      + A(23)*(XP   )         + A(24)*        (YP   )
     2      + A(25)
       OWF = OWA + OWB
     0 OWX = 4.0*A( 1)*(XP**3)*(YP**4) + 4.0*A( 2)*(XP**3)*(YP**3)
     1      + 3.0*A( 3)*(XP**2)*(YP**4) + 4.0*A( 4)*(XP**3)*(YP**2)
     2      + 3.0*A( 5)*(XP**2)*(YP**3) + 2.0*A( 6)*(XP   )*(YP**4)
     3      + 4.0*A( 7)*(XP**3)*(YP   ) + 3.0*A( 8)*(XP**2)*(YP**2)
     4      + 2.0*A( 9)*(XP   )*(YP**3) +     A(10)*        (YP**4)
     5      + 4.0*A(11)*(XP**3)         + 3.0*A(12)*(XP**2)*(YP   )
     6      + 2.0*A(13)*(XP   )*(YP**2) +     A(14)*        (YP**3)
     7      + 3.0*A(16)*(XP**2)         + 2.0*A(17)*(XP   )*(YP   )
     8      +     A(18)*        (YP**2) + 2.0*A(20)*(XP   )
     9      +     A(21)*        (YP   ) +     A(23)
     0 OWY = 4.0*A( 1)*(XP**4)*(YP**3) + 3.0*A( 2)*(XP**4)*(YP**2)
     1      + 4.0*A( 3)*(XP**3)*(YP**3) + 2.0*A( 4)*(XP**4)*(YP   )
     2      + 3.0*A( 5)*(XP**3)*(YP**2) + 4.0*A( 6)*(XP**2)*(YP**3)
     3      +     A( 7)*(XP**4)         + 2.0*A( 8)*(XP**3)*(YP   )
     4      + 3.0*A( 9)*(XP**2)*(YP**2) + 4.0*A(10)*(XP   )*(YP**3)
     5      +     A(12)*(XP**3)         + 2.0*A(13)*(XP**2)*(YP   )
     6      + 3.0*A(14)*(XP   )*(YP**2) + 4.0*A(15)*        (YP**3)
     7      +     A(17)*(XP**2)         + 2.0*A(18)*(XP   )*(YP   )
     8      + 3.0*A(19)*        (YP**2) +     A(21)*(XP   )
     9      + 2.0*A(22)*        (YP   ) +     A(24)
      XP=XP+X1P
      YP=YP+Y1P
      JUMP=JUMP+1
      GO TO(580,574,580,580,576,600),JUMP
  574 WRITE (ISO,575)
  575 FORMAT (1H1)
      GO TO 580
  576 XP=SXP
      YP=SYP
```

```
  580 WRITE (ISO,581) OWE,OWX,OWY
  581 FORMAT (1H , 39H TEST INTERPOLATION VALUES AT CENTER = ,E16.6,
     1  1H,, E16.6,1H,, E16.6)
      GO TO 410
  600 MIBP=1
      IF((ICHAP.EQ.3).OR.(ILRG.EQ.1)) GO TO 800
      OWF=OWF*PRSS
      OWX=OWX*PRSS
      OWY=OWY*PRSS
 800   RETURN
       END
$IBFTC MS23H2
CNORMAL
       SUBROUTINE NORMAL (OWX, OWY, K, DELTAP, CN)
C
C      THIS SUBROUTINE FINDS THE NORMAL TO THE SURFACE.
C
       DIMENSION CN(3), DELTAP( 6)
C
       AMAG = SQRT ((OWX**2 + OWY**2)*(DELTAP(K)**2) + 1.0)
       CN(1) = (-DELTAP(K)*OWX)/AMAG
       CN(2) = (-DELTAP(K)*OWY)/AMAG
       CN(3) = 1.0/AMAG
 800   RETURN
       END
$IBFTC MS23H3
CREFRCI
       SUBROUTINE REFRCI (CI, CN, QRI,     CR,               ISO)
C
C      THIS SUBROUTINE CALCULATES NEW DIRECTION OF RAY UPON ENTERING
C      NEW MEDIA.
C
       DIMENSION  CI(3), CN(3), CR(3)
C
       DOTP = 0.0
       DO 101 I=1,3
 101   DOTP = DOTP + CI(I)*CN(I)
       ROOT = QRI**2 -1.0 + DOTP**2
       IF (ROOT) 103,105,105
 103   ROUT = 0.0
       WRITE (ISO,500) ROOT
 500   FORMAT (1H0,6HROOT= ,E16.8/)
       GO TO 107
 105   ROUT = SQRT (ROOT)
 107   DO 109 I=1,3
 109   CR(I) = (CI(I) + (ROUT-DOTP)*CN(I))/QRI
 800   RETURN
```

```
      END
$IBFTC MS23H4
CCROPOD
      SUBROUTINE CROPOD (VA, VB, VPROD, AVPROD)
C
C     THIS SUBROUTINE FIND THE CROSS PRODUCT OF TWO VECTORS
C
      DIMENSION VA(3), VB(3), VPROD(3)
C
      VPROD(1) = VA(2)*VB(3) - VA(3)*VB(2)
      VPROD(2) = VA(3)*VB(1) - VA(1)*VB(3)
      VPROD(3) = VA(1)*VB(2) - VA(2)*VB(1)
      AVPROD  = SQRT(VPROD(1)**2 + VPROD(2)**2 + VPROD(3)**2)
  800 RETURN
      END
$IBFTC MS23H5
CRESTWO
      SUBROUTINE RESTWO (IRT,NOPRT)
C
C     THIS SUBROUTINE PRINTS THE RESULTS OBTAINED BY THE RAYTRA PROG.
C
      COMMON DUM
C
     0 EQUIVALENCE          (DUM(   1), CON),      (DUM( 501),   X),
     1 (DUM(1001),    Y),   (DUM(1501),    W),     (DUM(2001), DWX),
     2 (DUM(2501), DWY),    (DUM(3001), JPN),      (DUM(3501), RTV)
C
     0 EQUIVALENCE          (CON(  1), DIMA),      (CON(  2), DIMB),
     1 (CON(  3), DIMC),    (CON(  4),  DEL),      (CON(  5),  GNU),
     2 (CON(  6), THIC),    (CON(  7), SPAD),      (CON(  8), PRSS),
     3 (CON(  9), NPAN),    (CON( 10),  ISI),      (CON( 11),  ISO),
     4 (CON( 12),  IBC),    (CON( 13),  NGP),      (CON( 14),  LP7),
     5 (CON( 15),   FR),    (CON( 16), LOCP),      (CON( 17),  IPD),
     6 (CON( 18),  IPR),    (CON( 19), CHAP),      (CON( 20),ISCR1),
     7 (CON( 21),ISCR2),    (CON( 22), SKAL),      (CON( 23), ISEC),
     8 (CON( 24), NPAG),    (CON( 25), YONG),      (CON( 26), ILGD),
     9 (CON( 27), IREL),    (CON( 28),  LP5),      (CON( 29), CPRSS)
C
     0 EQUIVALENCE          (CON( 31), SCAL),      (CON( 41), SPAC),
     1 (CON( 51), PRES),    (CON( 61), PLNA),      (CON( 71), RAYA),
     2 (CON( 81), PAIA),    (CON( 91), THEA),      (CON(101),   RI),
     3 (CON(111),  RES),    (CON(291), STAT),      (CON(351),  OIF),
     4 (CON(401),EANDF),    (CON(451),  RHS),      (CON( 30),  IRM)
C
     0 EQUIVALENCE          (STAT( 1),  NMP),      (STAT( 9),  AVG),
     1 (STAT(25),  AVS),    (STAT(41),  AMN),      (STAT(49),  STD)
C
```

```
      0 DIMENSION  RT10(3), RT20(6), RT30(3), RT36(2), RT37(2),
      1 RT38(2), RT39(2), RT31(3), RT32(3), RES(180), PLNA( 8), AMN( 8),
      2 STD( 8), NMP( 8)
C
        DATA  RT20(1)/36HT W O   R A Y   T R A C E   D A T A /
      0 DATA  RT30(1)/13HELLIPSE    A=/, RT31(1)/13HRECTANGLE  A=/,
      1       RT32(1)/13HTRAPEZOID  A=/, RT33/4H  B=/, RT34/4H  C=/,
      2       RT35/6HSCALE=/, RT36(1)/10HTHICKNESS=/,
      3       RT37(1)/9H    PANES=/, RT38(1)/11H    SPACING=/,
      4 RT39(1)/12H   PRESSURE=/
      0 DATA  RT40/6HZSEXT=/,  RT41/4H IN./,
      1       RT42/5HBETA=/,   RT43/5H DEG./,
      2       RT44/4HPSI=/,    RT45/5H DEG./,
      3       RT46/6HTHETA=/,  RT47/5H DEG./,
      4       RT48/4HPAI=/,    RT49/5H DEG./,
      5       RT50/4HSAI=/,    RT51/5H DEG./
        DATA  HING/6HHINGED/, CH/1H /, CLMP/6HCLAMPE/, CC/1HD/
      0 DATA                      RT60/6HXP IN /, RT61/6HYP IN /,
      1 RT62/6HXP OUT/, RT63/6HYP OUT/, RT64/6HXS IN /, RT65/6HYS IN /,
      2 RT66/6HXS OUT/, RT67/6HYS OUT/, RT68/6HERROR /, RT69/6H(SEC) /
C
C       INITIALIZE INDEXES.
C
       IS10=10
        IS8 = ISO
       IS9=ISCR2+1
       IF(NOPRT.EQ.0) IS8=ISCR2
       IF(NOPRT.EQ.0) IS9=IS8+1
        ICHAP = CHAP
        GO TO (100,110), ISEC
  100   GO TO (101,106), LOCP
  101   LOCP = 2
C
C       THIS SECTION PRINTS THE RAY TRACE RESULTS
C
        CALL PAGE (IPR, LINE, IS8, IRT)
        WRITE (IS8,500) RT20
  500   FORMAT (1H0,46X,6A6)
        IF (IBC .NE. 1) GO TO 302
        CONC = HING
        CF = CH
  302   IF (IBC .NE. 2) GO TO 303
        CONC = CLMP
        CF = CC
  303   GO TO (102, 103, 104), ICHAP
  102 0 WRITE (IS8,501) (RT30(I),I=1,3), DIMA, RT33, DIMB,
      1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
```

```
    2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
501 0 FORMAT (1H0,2A6,A1,F5.2,A4,F5.2,14X,A6,F4.2,3X,A6,A4,F5.2,A6,A3,
    1            I1,A6,A5,F3.1,2A6,F5.1,3X,A6,A1)
      GO TO 105
103 0 WRITE (IS8,501) (RT31(I),I=1,3), DIMA, RT33, DIMB,
    1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
      GO TO 105
104 0 WRITE (IS8,518) (RT32(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
    1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
518 0 FORMAT (1H0,2A6,A1,F5.2,A4,F5.2,A4,F5.2,5X,A6,F4.2,3X,A6,A4,F5.2,
    1 A6,A3,I1,A6,A5,F3.1,2A6,F5.1,3X,A6,A1)
105 0 WRITE (IS8,502)        RT40, RES(  9), RT41, RT42, RES( 10), RT43,
    1 RT44, RES( 11), RT45, RT46, RES( 12), RT47, RT48, RES( 13), RT49,
    2 RT50, RES( 14), RT51
502 0 FORMAT (1H0/1H ,A6,F7.3,A4,3X,A5,F8.2,A5,3X,A4,F8.2,A5,3X,
    1                A6,F8.2,A5,3X,A4,F8.2,A5,3X,A4,F8.2,A5)
    0 WRITE (IS8,503) RT60, RT61, RT62, RT63, RT64, RT65, RT66, RT67,
    1 RT68, RT69
503   FORMAT (1H0,2X,A6,5X,A6,5X,A6,5X,A6,7X,A6,5X,A6,5X,A6,5X,A6,5X,
    1               A6,1X,A5)
106  IF(LINE.EQ.35) LOCP=1
108 0 WRITE (IS8,504)   RES( 1), RES( 2), RES( 3), RES( 4), RES( 5),
    1 RES( 6), RES( 7), RES( 8), RES(   15)
504 0 FORMAT (1H ,F8.4,3X,F8.4,3X,F8.4,3X,F8.4,5X,F8.4,3X,F8.4,3X,
    1            F8.4,3X,F8.4,5X,F12.5)
      LINE = LINE + 1
      GO TO 800
C
C     THIS SECTION PRINTS OUT THE MEAN AND RMS SUMMATION DATA.
C
110   III = 0
      CALL PAGE (IRM, LYN, ISO, IRT)
      WRITE (ISO,500) RT20
      WRITE (ISO,510)
510   FORMAT (1H0,39X,43HM E A N   A N D   R M S   S U M M A T I O N)
      GO TO (112,114,116), ICHAP
112 0 WRITE (IS8,501) (RT30(I),I=1,3), DIMA, RT33, DIMB,
    1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
      GO TO 118
114 0 WRITE (IS8,501) (RT31(I),I=1,3), DIMA, RT33, DIMB,
    1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
    2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
      GO TO 118
116 0 WRITE (IS8,518) (RT32(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
```

```
     1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
     2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
 118 0 WRITE (IS8,502)        RT40, RES(  9), RT41, RT42, RES( 10), RT43,
     1 RT44, RES( 11), RT45, RT46, RES( 12), RT47, RT48, RES( 13), RT49,
     2 RT50, RES( 14), RT51
       WRITE (ISO, 513)
 513   FORMAT (1H0,47H                         MEAN            RMS     NO. POINTS)
     0 WRITE (ISO,512) (           AMN(I), STD(I), NMP(I), I=1,NPAG)
 512   FORMAT (1H0,     13X,E11.4,2X,E11.4,6X,I3)
 800   RETURN
       END
$IBFTC MS23H6
CMENRMS
       SUBROUTINE MENRMS
C
       DOUBLE PRECISION AVG, AVS, VAL, CON2
C
       COMMON DUM
C
     0 EQUIVALENCE           (DUM(    1), CON),        (DUM( 501),    X),
     1 (DUM(1001),    Y),    (DUM(1501),    W),        (DUM(2001), DWX),
     2 (DUM(2501), DWY),     (DUM(3001), JPN),         (DUM(3501), RTV)
C
     0 EQUIVALENCE           (CON(  1), DIMA),         (CON(  2), DIMB),
     1 (CON(  3), DIMC),     (CON(  4),  DEL),         (CON(  5),  GNU),
     2 (CON(  6), THIC),     (CON(  7), SPAD),         (CON(  8), PRSS),
     3 (CON(  9), NPAN),     (CON( 10),  ISI),         (CON( 11),  ISO),
     4 (CON( 12),  IBC),     (CON( 13),  NGP),         (CON( 14),  LP7),
     5 (CON( 15),   FR),     (CON( 16), LOCP),         (CON( 17),  IPD),
     6 (CON( 18),  IPR),     (CON( 19), CHAP),         (CON( 20),ISCR1),
     7 (CON( 21),ISCR2),     (CON( 22), SKAL),         (CON( 23), ISEC),
     8 (CON( 24), NPAG),     (CON( 25), YONG),         (CON( 26), ILGD),
     9 (CON( 27), IREL),     (CON( 28),  LP5),         (CON( 29), CPRSS)
C
     0 EQUIVALENCE           (CON( 31), SCAL),         (CON( 41), SPAC),
     1 (CON( 51), PRES),     (CON( 61), PLNA),         (CON( 71), RAYA),
     2 (CON( 81), PAIA),     (CON( 91), THEA),         (CON(101),   RI),
     3 (CON(111),  RES),     (CON(291), STAT),         (CON(351),  OIF),
     4 (CON(401),EANDF),     (CON(451),  RHS)
C
     0 EQUIVALENCE           (STAT( 1),  NMP),         (STAT( 9),  AVG),
     1 (STAT(25),  AVS),     (STAT(41),  AMN),         (STAT(49),  STD),
     2 (OIF(11),N2)
C
       DIMENSION  NMP( 8), AVG( 8), AVS( 8), AMN( 8), STD( 8),RES(180)
C
C      XS = XIN
```

```
C       YS = YIN
C       XP = XOUT
C       YP = YOUT
C
      XXX=1.
      IF(N2.EQ.2) XXX=0.
       ISW = 1
       GO TO (100,111), ISEC
  100  IJ = LP7 - 1
       I = 1
       XS = RES( 1)
       YS = RES( 2)
       XP = RES( 3)
       YP = RES( 4)
       ICHAP = CHAP
  101  GO TO (102,103,104), ICHAP
C
C===== IS POINT MORE THAN 1 INCH INSIDE ELLIPSE BOUNDARY
  102  A = DIMA/2.0
       B = DIMB/2.0
       IF (XS .GT. A) GO TO 109
       IF (YS .GT. B) GO TO 109
       XLIM = A*SQRT(1.0-(YS**2/(B*B)))
       YLIM = B*SQRT(1.0-(XS**2/(A*A)))
       IF (XS .GT. (XLIM-1.0)) GO TO 109
       IF (YS .GT. (YLIM-1.0)) GO TO 109
       IF (XP .GT. A) GO TO 109
       IF (YP .GT. B) GO TO 109
       XLIM = A*SQRT(1.0-(YP**2/(B*B)))
       YLIM = B*SQRT(1.0-(XP**2/(A*A)))
       IF (XP .GT. (XLIM-1.0)) GO TO 109
       IF (YP .GT. (YLIM-1.0)) GO TO 109
       GO TO 108
C
C===== IS POINT MORE THAN 1 INCH INSIDE RECTANGLE BOUNDARY
  103  A = DIMA/2.0
       B = DIMB/2.0
       IF (XS .GT. (A-1.0)) GO TO 109
       IF (YS .GT. (B-1.0)) GO TO 109
       IF (XP .GT. (A-1.0)) GO TO 109
       IF (YP .GT. (B-1.0)) GO TO 109
       GO TO 108
C
C===== IS POINT MORE THAN 1 INCH INSIDE TRAPEZOID BOUNDARY
  104  A = DIMA/2.0
       B = DIMB
       C = DIMC/2.0
```

```
      IF(N2.EQ.1) GO TO 117
      IF((XS.LT.0.) .OR. (YS.LT.0.)) GO TO 109
      IF((XP.LT.0.) .OR. (YP.LT.0.)) GO TO 109
  117 IF (YS .GT. B) GO TO 109
      XLIM = C + ((A-C)/B)*(B-YS)
      YLIM = B
      IF (XS .LE. C) GO TO 105
      IF (XS .GT. A) GO TO 109
      IF ((A-C) .NE. 0.0) GO TO 115
      YLIM = B
      GO TO 105
  115 YLIM = (B/(A-C))*(A-XS)
  105 IF (XS .GT. (XLIM-XXX)) GO TO 109
      IF (YS .GT. (YLIM-XXX)) GO TO 109
      IF (IREL .EQ. 1) GO TO 106
      IF (YS .LT. XXX) GO TO 109
      IF (YP .GT. B) GO TO 109
  106 XLIM = C + ((A-C)/B)*(B-YP)
      YLIM = B
      IF (XP .LE. C) GO TO 107
      IF (XP .GT. A) GO TO 109
      IF ((A-C) .NE. 0.0) GO TO 116
      YLIM = B
      GO TO 107
  116 YLIM = (B/(A-C))*(A-XP)
  107 IF (XP .GT. (XLIM-XXX)) GO TO 109
      IF (YP .GT. (YLIM-XXX)) GO TO 109
      IF (IREL .EQ. 1) GO TO 108
      IF (YP .LT. XXX) GO TO 109
  108 IF (ISW .EQ. 2) GO TO 110
      XS = RES( 5)
      YS = RES( 6)
      XP = RES( 7)
      YP = RES( 8)
      ISW = 2
      GO TO 101
  109 GO TO 799
C
C===== STORE COMPONENTS NEEDED FOR MEAN AND RMS
  110 NMP(I) = NMP(I) + 1
      RES1 = RES(15)
      RES2 = RES1*RES1
      AVG(I) = AVG(I) + RES1
      AVS(I) = AVS(I) + RES2
      GO TO 800
C
C===== THIS SECTION CALCULATES THE MEAN (AMN) AND RMS (STD).
```

```
  111   AMP = NMP(I)
        IF (AMP .EQ. 0.0) GO TO 114
        AMN(I) = AVG(I)/AMP
        VAL = (AVS(I) - AVG(I)*AVG(I)/AMP)
        IF (VAL .GT. 0.0) GO TO 112
        VAL = ABS(VAL)
  112   STD(I) = SQRT(VAL)/(SQRT(AMP-1.0))
        SMN = AMN(I)*(1.0E-6)
        IF (STD(I) .LT. SMN) STD(I) = 0.0
        GO TO 800
  114   STD(I) = 0.0
        AMN(I) = 0.0
       GO TO 800
   799 RES(15)=1.E+13
  800   RETURN
        END
$IBFTC MS23H7
CMAXMIN
        SUBROUTINE MAXMIN(IRT)
C
C       THIS SUBROUTINE CALCULATES THE MAXIMUM AND MINIMUM SLOPES AT A
C       POINT.
C
        COMMON  DUM
C
     0 EQUIVALENCE             (DUM(   1), CON),      (DUM( 501),    X),
     1                         (DUM(1501),   W),      (DUM(2251), DWX),
     2                         (DUM(3001), JPN),      (DUM(3501), RTV)
C
     0 EQUIVALENCE             (CON(   1), DIMA),     (CON(   2), DIMB),
     1 (CON(   3), DIMC),      (CON(   4),  DEL),     (CON(   5),  GNU),
     2 (CON(   6), THIC),      (CON(   7), SPAD),     (CON(   8), PRSS),
     3 (CON(   9), NPAN),      (CON(  10),  ISI),     (CON(  11),  ISO),
     4 (CON(  12),  IBC),      (CON(  13),  NGP),     (CON(  14),  LP7),
     5 (CON(  15),   FR),      (CON(  16), LOCP),     (CON(  17),  IPD),
     6 (CON(  18),  IPR),      (CON(  19), CHAP),     (CON(  20),ISCR1),
     7 (CON(  21),ISCR2),      (CON(  22), SKAL),     (CON(  23), ISEC),
     8 (CON(  24), NPAG),      (CON(  25), YONG),     (CON(  26), ILGD),
     9 (CON(  27), IREL),      (CON(  28),  LP5),     (CON(  29), CPRSS)
C
     0 EQUIVALENCE             (CON(  31), SCAL),     (CON(  41), SPAC),
     1 (CON(  51), PRES),      (CON(  61), PLNA),     (CON(  71), RAYA),
     2 (CON(  81), PAIA),      (CON(  91), THEA),     (CON( 101),   RI),
     3 (CON( 111),  RES),      (CON( 301), STAT),     (CON( 351),  OIF),
     4 (CON( 401),EANDF),      (CON( 451),  RHS)
C
        DIMENSION  CON(500), X(21,33),           W(21,33), DWX(21,33),
```

```
     1            JPN(500),RTV(500),OIF(12)
C
     0 DIMENSION RT30(3), RT31(3), RT32(3), RT36(2), RT37(2), RT38(2),
     1 RT39(2)
C
     0 DATA  RT30(1)/13HELLIPSE     A=/, RT31(1)/13HRECTANGLE  A=/,
     1         RT32(1)/13HTRAPEZOID  A=/, RT33/4H   B=/, RT34/4H   C=/,
     2         RT35/6HSCALE=/, RT36(1)/10HTHICKNESS=/,
     3         RT37(1)/9H   PANES=/, RT38(1)/11H   SPACING=/,
     4 RT39(1)/12H   PRESSURE=/
       DATA  HING/6HHINGED/, CH/1H /, CLMP/6HCLAMPE/, CC/1HD/
C
       RAD = 0.017453292519
      IDT=IRT
      LINE=0
C
C===== THIS SECTION GENERATES A POINT IN THE MIDDLE OF A GRID AND THEN
C      DETERMINES IF THE GRID EXISTS.
C
       DO 120 K=1,NGP
      IPG=2
       K1 = JPN(K)
       CALL PACWRD (K1, K2, 2)
       XP = X(K1,K2) + DEL/2.0
      EJ=K1-1
      YP=DEL*EJ+DEL/2.0
       CALL INCOTB (XP, YP, OWF, OWX, OWY, IPG)
      IF(IPG.EQ.1) GO TO 120
       R = 0.0001
       SMX = 0.0
       DO 114 J=1,181,2
       RJ = J-1
       THE = RJ*RAD
       XL =  XP + R*COS(THE)
       YL =  YP + R*SIN(THE)
      CALL INCOTB(XL,YL,OWG,OWX,OWY,IPG)
       OWR = (ABS(OWF) - ABS(OWG))/R
       OWS = ABS(OWR)
      IF(J.EQ.1) SMN=OWR
      IF(J.EQ.1) SMX=OWR
       THF = THE/RAD
       IF (OWS .LT. ABS(SMX)) GO TO 112
       SMX = OWR
       AMX = THE/RAD
 112   IF (OWS .GT. ABS(SMN)) GO TO 114
       SMN = OWR
       AMN = THE/RAD
 114   CONTINUE
      IF(K.EQ.1) GO TO 115
```

```
      IF(LINE-45) 116,115,115
  115 CALL PAGE (IPD, LINE, ISO, IDT)
      WRITE (ISO,500)
  500 0 FORMAT (1H0/1H ,3X,40HW I N D O W   D E F O R M A T I O N S  -,
      1 49H  D E F L E C T I O N,   M A X I M U M   A N D    ,
      2 25HM I N I M U M   S L O P E/1H )
      ICHAP = CHAP
      IF ( IBC .NE. 1) GO TO 302
      CONC = HING
      CF = CH
  302 IF (IBC .NE. 2) GO TO 303
      CONC = CLMP
      CF = CC
  303 GO TO (102,103,104), ICHAP
  102 0 WRITE (ISO,501) (RT30(I),I=1,3), DIMA, RT33, DIMB,
      1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
      2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
  501 0 FORMAT (1H0,2A6,A1,F5.2,A4,F5.2,14X,A6,F4.2,3X,A6,A4,F5.2,A6,A3,
      1        I1,A6,A5,F3.1,2A6,F5.1,3X,A6,A1)
      GO TO 105
  103 0 WRITE (ISO,501) (RT31(I),I=1,3), DIMA, RT33, DIMB,
      1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
      2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
      GO TO 105
  104 0 WRITE (ISO,518) (RT32(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
      1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
      2       (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC, CF
  518 0 FORMAT (1H0,2A6,A1,F5.2,A4,F5.2,A4,F5.2,5X,A6,F4.2,3X,A6,A4,F5.2,
      1 A6,A3,I1,A6,A5,F3.1,2A6,F5.1,3X,A6,A1)
  105 WRITE (ISO,505)
  505 0 FORMAT (1H0/1H ,43H(ANGLE IS IN DEGREES MEASURED WITH RESPECT ,
      1 23HTO THE POSITIVE X-AXIS)/1H0,12H COORDINATES,26X,8HMAXIMUM ,
      2 5HSLOPE,10X,14HMINIMUM  SLOPE/1H ,3H  X,7X,1HY,8X,10HDEFLECTION,
      3 8X,15HSLOPE      ANGLE,8X,15HSLOPE      ANGLE)
  116 WRITE (ISO,506) XP, YP, OWF, SMX, AMX, SMN, AMN
  506 FORMAT (1H ,F5.2,3X,F5.2,4X,E12.5,2(4X,E12.5,3X,F4.0))
  120 CONTINUE
  800 RETURN
      END
$IBFTC MS23H8
CRTVLST
      SUBROUTINE RTVLST (IRT, LIN, IPV)
C
C     III = SWITCH TO BYPASS RETRIEVAL PAGING PRINTOUT
C     IPV = PAGE COUNTER FOR RETRIEVAL INDEX PRINTOUT
C     ISO = SYSTEM OUTPUT TAPE
C     JT1 = RETRIEVAL NUMBER
```

```
C         JT7 = NUMBER OF PANES
C         JT10 = BOUNDARY COORDINATE SWITCH
C         LIN = RETRIEVAL INDEX OUTPUT LINE COUNTER
C         RT2 = PLANFORM SELECTION SWITCH
C         RT3 = BASE LENGTH OF PLANFORM
C         RT4 = WIDTH OF PLANFORM
C         RT5 = UPPER X DIMENSION OF TRAPEZOID
C         RT6 = GLASS THICKNESS
C         RT8 = SPACING BETWEEN PANES
C         RT9 = INTERSTICIAL PRESSURE
C
          COMMON DUM
C
        0 EQUIVALENCE              (DUM(    1), CON),      (DUM( 501),    X),
        1 (DUM(1001),    Y),       (DUM(1501),    W),      (DUM(2001), DWX),
        2 (DUM(2501), DWY),        (DUM(3001), JPN),       (DUM(3501), RTV)
C
        0 EQUIVALENCE              (CON(   1), DIMA),      (CON(   2), DIMB),
        1 (CON(  3), DIMC),        (CON(   4),  DEL),      (CON(   5),  GNU),
        2 (CON(  6), THIC),        (CON(   7), SPAD),      (CON(   8), PRSS),
        3 (CON(  9), NPAN),        (CON(  10),  ISI),      (CON(  11),  ISO),
        4 (CON( 12),  IBC),        (CON(  13),  NGP),      (CON(  14),  LP7),
        5 (CON( 15),   FR),        (CON(  16), LOCP),      (CON(  17),  IPD),
        6 (CON( 18),  IPR),        (CON(  19), CHAP),      (CON(20), ISCR1),
        7 (CON( 21),ISCR2),        (CON(  22), SKAL),      (CON(  23), ISEC),
        8 (CON( 24), NPAG),        (CON(  25), YONG),      (CON(  26), ILGD),
        9 (CON( 27), IREL),        (CON(  28),  LP5),      (CON(  29), CPRSS)
C
        0 EQUIVALENCE              (CON(  31), SCAL),      (CON(  41), SPAC),
        1 (CON( 51), PRES),        (CON(  61), PLNA),      (CON(  71), RAYA),
        2 (CON( 81), PAIA),        (CON(  91), THEA),      (CON(101),    RI),
        3 (CON(111),  RES),        (CON(301), STAT),       (CON(351),   OIF),
        4 (CON(401),EANDF),        (CON(451),  RHS)
C
        0 EQUIVALENCE              (RTV(    1), JT1),      (RTV(   51), RT2),
        1 (RTV( 101), RT3),        (RTV( 151), RT4),       (RTV( 201), RT5),
        2 (RTV( 251), RT6),        (RTV( 301), JT7),       (RTV( 351), RT8),
        3 (RTV( 401), RT9),        (RTV( 451),JT10),       (RTV( 501),RTI1)
C
        0 DIMENSION     CON(  500),    X(22,22),    Y(22,22),    W(22,22),
        1  DWX(22,22),  DWY(22,22),     JPN(500),  RTV(  500),
        3  RES(  180), RT30(2), RT31(2), RT32(2), RT33(2), RT34(2), RI(7),
        4 SHAP(2), CONC(2), SCAL(8), SPAC(8), PRES(8), PLNA(8), RAYA(8)
C
        0 DIMENSION  JT1(50), RT2(50), RT3(50), RT4(50), RT5(50), RT6(50),
        1 JT7(50), RT8(50), RT9(50), JT10(50)
C
```

```
      0 DATA  RT30(1)/9HELLIPSE  /, RT31(1)/9HRECTANGLE/,
      1        RT32(1)/9HTRAPEZOID/, RT33(1)/7HHINGED /,
      2        RT34(1)/7HCLAMPED/,STAR/5H*****/
C
        LIN = LIN + 1
        IF (LIN .LT. 100) GO TO 100
        LIN = LIN-101
        GO TO 101
  100   JT1(LIN)  = IRT
        RT2(LIN)  = CHAP
        RT3(LIN)  = DIMA
        RT4(LIN)  = DIMB
        RT5(LIN)  = DIMC
        RT6(LIN)  = THIC
        JT7(LIN)  = NPAN
        RT8(LIN)  = SPAD
        IF (NPAN .EQ. 1) RT8(LIN) = STAR
        RT9(LIN)  = PRSS
        JT10(LIN) = IBC
        IF (LIN .LT. 40) GO TO 800
  101   III = 0
        CALL PAGE (IPV, LINE, ISO, III)
        WRITE (ISO, 500)
  500 0 FORMAT (1H0,42HRETRIEVAL   SHAPE      A      B      C    ,
      1 59HTHICKNESS   PANES   SPACING   PRESSURE   FIXITY          /
      2 7H NUMBER,16X,17HIN.     IN.    IN.,6X,3HIN.,16X,3HIN.,8X,3HLB.,
      3 16X/1H )
        DO 114 I=1,LIN
        IF (RT2(I) .NE. 1.0) GO TO 102
        SHAP(1) = RT30(1)
        SHAP(2) = RT30(2)
  102   IF (RT2(I) .NE. 2.0) GO TO 104
        SHAP(1) = RT31(1)
        SHAP(2) = RT31(2)
  104   IF (RT2(I) .NE. 3.0) GO TO 106
        SHAP(1) = RT32(1)
        SHAP(2) = RT32(2)
  106   IF (JT10(I) .NE. 1) GO TO 108
        CONC(1) = RT33(1)
        CONC(2) = RT33(2)
  108   IF (JT10(I) .NE. 2) GO TO 112
        CONC(1) = RT34(1)
        CONC(2) = RT34(2)
  112   IF (NPAN .EQ. 2) GO TO 113
      0 WRITE (ISO,502) JT1(I), (SHAP(J),J=1,2), RT3(I), RT4(I), RT5(I),
      1 RT6(I), JT7(I), RT8(I), RT9(I), (CONC(J),J=1,2)
  502 0 FORMAT (1H ,3X,I3,4X,A6,A3,2X,F5.2,2X,F5.2,2X,F5.2,4X,F5.2,7X,I1,
```

```
     1 6X,A5,  5X,F5.1,5X,A6,A1,4X)
       GO TO 114
  113 0 WRITE (ISO,503) JT1(I), (SHAP(J),J=1,2), RT3(I), RT4(I), RT5(I),
     1 RT6(I), JT7(I), RT8(I), RT9(I), (CONC(J),J=1,2)
  503 0 FORMAT (1H ,3X,I3,4X,A6,A3,2X,F5.2,2X,F5.2,2X,F5.2,4X,F5.2,7X,I1,
     1 6X,F5.2,5X,F5.1,5X,A6,A1)
  114   CONTINUE
        LIN = 0
  800   RETURN
        END
$IBFTC MS23H9
CBONDRY
      SUBROUTINE BONDRY (XP, YP, IBY)
C
C     THIS SUBROUTINE TESTS THE X AND Y COORDINATES TO BE SURE THEY
C     ARE INSIDE THE BOUNDARY.
C
C     A    = DEFINED BELOW
C     B    = DEFINED BELOW
C     C    = DEFINED BELOW
C     CHAP = ICHAP = PLANFORM SELECTION SWITCH
C     DIMA = LOWER LENGTH OF PLANFORM
C     DIMB = HEIGHT OF PLANFORM
C     DIMC = UPPER X DIMENSION OF TRAPEZOID
C     IBY  = 1  INDICATES POINT IS OUTSIDE PLANFORM BOUNDARY
C     XLIM = X VALUE AT PLANFORM BOUNDARY CORRESPONDING TO YP
C     XP   = X COORDINATE OF POINT BEING CHECKED
C     YP   = Y COORDINATE OF POINT BEING CHECKED
C
      COMMON DUM
C
     0 EQUIVALENCE           (DUM(   1), CON),     (DUM( 501),    X),
     1 (DUM(1001),    Y),    (DUM(1501),    W),    (DUM(2001), DWX),
     2 (DUM(2501), DWY),     (DUM(3001), JPN),     (DUM(3501), RTV)
C
     0 EQUIVALENCE           (CON(  1), DIMA),     (CON(  2), DIMB),
     1 (CON(  3), DIMC),     (CON(  4),  DEL),     (CON(  5),  GNU),
     2 (CON(  6), THIC),     (CON(  7), SPAD),     (CON(  8), PRSS),
     3 (CON(  9), NPAN),     (CON( 10),  ISI),     (CON( 11),  ISO),
     4 (CON( 12),  IBC),     (CON( 13),  NGP),     (CON( 14),  LP7),
     5 (CON( 15),   FR),     (CON( 16), LOCP),     (CON( 17),  IPD),
     6 (CON( 18),  IPR),     (CON( 19), CHAP),     (CON(20), ISCR1),
     7 (CON( 21),ISCR2),     (CON( 22), SKAL),     (CON( 23), ISEC),
     8 (CON( 24), NPAG),     (CON( 25), YONG),     (CON( 26), ILGD),
     9 (CON( 27), IREL),     (CON( 28),  LP5),     (CON( 29), CPRSS)
C
     0 EQUIVALENCE           (CON( 31), SCAL),     (CON( 41), SPAC),
```

```
     1 (CON( 51), PRES),       (CON( 61), PLNA),       (CON( 71), RAYA),
     2 (CON( 81), PAIA),       (CON( 91), THEA),       (CON(101),   RI),
     3 (CON(111),  RES),       (CON(301), STAT),       (CON(351),  OIF),
     4 (CON(401),EANDF),       (CON(451),  RHS)
C
     0 DIMENSION  CON(500), X(22,22), Y(22,22), W(22,22), DWX(22,22),
     1 DWY(22,22), JPN(500),RTV(500)
C
      ICHAP = CHAP
      GO TO (101,102,103), ICHAP
  101 A = DIMA/2.0
      B = DIMB/2.0
      IF (ABS(YP) .GT. B) GO TO 104
      XLIM = A*SQRT(1.0-(YP**2/(B*B)))
      IF (ABS(XP) .GT. XLIM) GO TO 104
      GO TO 800
  102 A = DIMA/2.0
      B = DIMB/2.0
      IF (ABS(YP) .GT. B) GO TO 104
      IF (ABS(XP) .GT. A) GO TO 104
      GO TO 800
  103 A = DIMA/2.0
      B = DIMB
      C = DIMC/2.0
      IF (ABS(YP) .GT. B) GO TO 104
      XLIM = C + ((A-C)/B)*(B-YP)
      IF (ABS(XP) .GT. XLIM) GO TO 104
      GO TO 800
  104 IBY = 1
  800 RETURN
      END
$IBFTC MS23J0
CPACWRD
      SUBROUTINE PACWRD (K1, K2, K3)
C
C     THIS SUBROUTINE PACKS AND UNPACKS TWO INTEGER WORDS.
C
C       PACKING  K1 = FIRST INTEGER AND RETURNED PACKED WORD
C                K2 = SECOND INTEGER
C                K3 = 1
C
C     UNPACKING  K1 = PACKED WORD AND RETURNED FIRST INTEGER
C                K2 = SECOND INTEGER
C                K3 = 2
C
      GO TO (100, 102), K3
  100 K1 = K1*32768 + K2
```

```
      GO TO 800
  102 K4 = K1/32768
      K2 = K1 - K4*32768
      K1 = K4
  800 RETURN
      END
$IBFTC MS23J1
CPAGE
      SUBROUTINE PAGE (IPN, LINE, ISN, INX)
C     THIS SUBROUTINE PRINTS THE TIME AND PAGE NUMBER AT THE PAGE TOP
C     INX  = RETRIEVAL NUMBER
C     IPN  = PAGE NUMBER
C     ISN  = TAPE NUMBER
C     LINE = LINE NUMBER
C
      DIMENSION RT10(3)
C
      DATA  RT10(1)/18HRETRIEVAL NUMBER =/, RT11/4HPAGE/
C
      IPN = IPN + 1
      IF (INX .EQ. 0) GO TO 100
      IF (ISN .EQ. 9) GO TO 102
      WRITE (ISN,500) (RT10(I), I=1,3), INX,       RT11, IPN
  500 FORMAT (1H1,3A6,I5,89X,A4,I4)
      GO TO 800
  102 WRITE (ISN) (RT10(I), I=1,3), INX, RT11, IPN
      GO TO 800
  100 WRITE (ISN, 501) RT11, IPN
  501 FORMAT (1H1,112X,A4,I4)
  800 LINE = 1
      RETURN
      END
$IBFTC MS23J2
CSHRDEF
      SUBROUTINE SHRDEF
C
C     ETA = FACTOR TO MODIFY DEFLECTION BY TO OBTAIN SHEAR DEFORMATION
C
      COMMON DUM
C
     0 EQUIVALENCE             (DUM(   1), CON),        (DUM( 501),    X),
     1 (DUM(1001),    Y),      (DUM(1501),    W),       (DUM(2001), DWX),
     2 (DUM(2501), DWY),       (DUM(3001), JPN),        (DUM(3501), RTV)
C
     0 EQUIVALENCE             (CON(  1), DIMA),        (CON(  2), DIMB),
     1 (CON(  3), DIMC),       (CON(  4),  DEL),        (CON(  5),  GNU),
     2 (CON(  6), THIC),       (CON(  7), SPAD),        (CON(  8), PRSS),
```

```
     3 (CON(  9), NPAN),       (CON( 10),  ISI),        (CON( 11),  ISO),
     4 (CON( 12),  IBC),       (CON( 13),  NGP),        (CON( 14),  LP7),
     5 (CON( 15),   FR),       (CON( 16), LOCP),        (CON( 17),  IPD),
     6 (CON( 18),  IPR),       (CON( 19), CHAP),        (CON(20), ISCR1),
     7 (CON( 21),ISCR2),       (CON( 22), SKAL),        (CON( 23), ISEC),
     8 (CON( 24), NPAG),       (CON( 25), YONG),        (CON( 26), ILRG),
     9 (CON( 27), IREL),       (CON( 28),  LP5),        (CON( 29),CPRSS)
C
     0 EQUIVALENCE             (CON( 30),  IRM),        (CON( 31),  IPB),
     1 (CON( 53), SCAL),       (CON( 61), SPAC),        (CON( 69), PRES),
     2 (CON( 77), PLNA),       (CON( 85), RAYA),        (CON( 93),   RI),
     3 (CON(101),  RES),       (CON(315), STAT),        (CON(371),  OIF),
     4 (CON(401),EANDF),       (CON(451),  RHS)
C
     0 DIMENSION     CON(  500),    X(22,22),     Y(22,22),     W(22,22),
     1  DWX(22,22),  DWY(22,22),  JPN(  500),  RTV(  500)
C
      PI2 = 3.141592653*3.141592653
      BET2 = (DIMA/DIMB)**2
      ETA = PI2*(1.0 + BETA)*(THIC**2)/((DIMA**2)*(1.0 - GNU)*3.0)
      DO 100 I=1,22
      DO 100 J = 1,22
  100 W(I,J) = W(I,J)*ETA
  800 RETURN
      END
$IBFTC MS23J3
      FUNCTION  SINH(ARC)
C
C     THIS FUNCTION CALCULATES THE DOUBLE PRECISION HYPERBOLIC SINE
C     BUT RETURNS THE SINGLE PRECISION HYPERBOLIC SINE.
C
      DOUBLE PRECISION ARG,DSINH
C
      ARG = ARC
      IF(ARC .GT. 88.0) ARG=88.0
      DSINH = 5.0D-1*(DEXP(ARG)-DEXP(-ARG))
      SINH = DSINH
      RETURN
      END
$IBFTC MS23J4
      FUNCTION  COSH(ARC)
C
C     THIS FUNCTION CALCULATES THE DOUBLE PRECISION HYPERBOLIC COSINE
C     BUT RETURNS THE SINGLE PRECISION HYPERBOLIC COSINE.
C
      DOUBLE PRECISION ARG,DCOSH
C
```

```
      ARG = ARC
      IF(ARC .GT. 88.0) ARG=88.0
      DCOSH = 5.0D-1*(DEXP(ARG)+DEXP(-ARG))
      COSH = DCOSH
      RETURN
      END
$IBFTC MS23J5
      FUNCTION  TANH(ARC)
C
C     THIS FUNCTION CALCULATES THE DOUBLE PRECISION HYPERBOLIC TANGENT
C     BUT RETURNS THE SINGLE PRECISION HYPERBOLIC TANGENT.
C
      DOUBLE PRECISION ARG,DTANH
C
      ARG = ARC
      IF(ARC .GT. 88.0) ARG=88.0
      DTANH = (DEXP(ARG)-DEXP(-ARG))/(DEXP(ARG)+DEXP(-ARG))
      TANH = DTANH
      RETURN
      END
$IBFTC MS23H1
CINCOTB
      SUBROUTINE INCOTB (XP, YP, OWF, OWX, OWY, IPG)
C
C     THIS SUBROUTINE GENERATES THE TABLE OF INTERPOLATION COEFFICIENTS
C
      COMMON  DUM
C
    0 EQUIVALENCE            (DUM(   1), CON),      (DUM( 501),   X),
    1 (DUM(1001),   Y),      (DUM(1501),   W),      (DUM(2001), DWX),
    2 (DUM(2501), DWY),      (DUM(3001), JPN),      (DUM(3501), RTV)
C
    0 EQUIVALENCE            (CON(  1), DIMA),      (CON(  2), DIMB),
    1 (CON(  3), DIMC),      (CON(  4),  DEL),      (CON(  5),  GNU),
    2 (CON(  6), THIC),      (CON(  7), SPAD),      (CON(  8), PRSS),
    3 (CON(  9), NPAN),      (CON( 10),  ISI),      (CON( 11),  ISO),
    4 (CON( 12),  IBC),      (CON( 13),  NGP),      (CON( 14),  LP7),
    5 (CON( 15),   FR),      (CON( 16), LOCP),      (CON( 17),  IPD),
    6 (CON( 18),  IPR),      (CON( 19), CHAP),      (CON( 20),ISCR1),
    7 (CON( 21),ISCR2),      (CON( 22), SKAL),      (CON( 23), ISEC),
    8 (CON( 24), NPAG),      (CON( 25), YONG),      (CON( 26), ILGD),
    9 (CON( 27), IREL),      (CON( 28),  LP5),      (CON( 29), CPRSS)
C
    0 EQUIVALENCE            (CON( 31), SCAL),      (CON( 41), SPAC),
    1 (CON( 51), PRES),      (CON( 61), PLNA),      (CON( 71), RAYA),
    2 (CON( 81), PAIA),      (CON( 91), THEA),      (CON(101),   RI),
    3 (CON(111),  RES),      (CON(301), STAT),      (CON(351),  OIF),
```

```
     4 (CON(401),EANDF),      (CON(451),  RHS)
C
      DIMENSION  CON(500), X(22,22), Y(22,22), W(22,22), DWX(22,22),
     1 DWY(22,22), JPN(500), RTV(500)
C
  100 A = DIMA/2.0
      B = DIMB/2.0
      GO TO (102, 104), IBC
  102 TE1 = 1.0/(64.0*FR)
      TE2 = ((5.0+GNU)/(1.0+GNU))*(A*A)
      X2 = XP*XP
      Y2 = YP*YP
      TE3 = (A*A - X2 -Y2)
      TE4= (TE2 - X2 - Y2)
      OWF = TE1*TE3*TE4*PRSS
      OWX = -2.0*XP*TE1*(TE3 + TE4)*PRSS
      OWY = -2.0*YP*TE1*(TE3 + TE4)*PRSS
      GO TO 800
  104 TEM = (24.0/(A**4)) + (24.0/(B**4)) + (16.0/(A*A*B*B))
      WO = 1.0/(FR*TEM)
      TEM = (1.0 - (XP*XP/(A*A)) - (YP*YP/(B*B)))
      OWF = WO*(TEM**2)*PRSS
      OWX =(-4.0*WO*XP*TEM/(A*A))*PRSS
      OWY =(-4.0*WO*YP*TEM/(B*B))*PRSS
  800 RETURN
      END
```

2752

```
$IBFTC MS23R0
CDATRTV
C
C        THIS IS A DATA RETRIEVAL PROGRAM TO RETRIEVE LINE OF SIGHT DATA
C        FROM SYMBOLIC TAPE IS9.
C
C
      0 DIMENSION  RT10(3), RT20(5), RT30(3), RT36(2), RT37(2),
      1 RT38(2),    RT39(2), RES(200)
C
        DATA DUM1/4HX = /
C
C===== INITIALIZE INDEXES, READ RETRIEVAL NUMBER, AND FIRST BLOCKS DATA.
C
        ISI = 5
        ISO = 6
        IS9 = 9
        REWIND IS9
        READ  (IS9) (RT10(I),I=1,3), INX, RT11, IPN
        IINX = INX
  100   READ (ISI,500) IRTV
  500   FORMAT (I5)
        IF (IRTV .EQ. 0) GO TO 1000
        IF (INX .GT. IRTV) GO TO 900
        IF (INX .EQ. IRTV) GO TO 108
        IF (INX .EQ. 999) GO TO 902
        LINX = INX
C
C===== THIS SECTION READS IN THE DATA TO BE BY-PASSED.
C
  102   READ  (IS9) (RT10(I),I=1,3), INX
        IF (INX .EQ. IRTV) GO TO 105
        GO TO 102
  105   BACKSPACE IS9
        READ (IS9) (RT10(I),I=1,3),INX,RT11,IPN
        GO TO 108
C
C===== THIS SECTION READS IN THE TOP SECTION OF DATA TO BE PRINTED.
C
  106   READ  (IS9) (RT10(I),I=1,3), INX, RT11, IPN
        IF (INX .EQ. 999) GO TO 1000
        LINX = INX
        IF (INX .NE. IRTV) GO TO 100
  108   READ  (IS9) (RT20(I),I=1,5)
      0 READ  (IS9) (RT30(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
      1       RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
      2       (RT38(I),I=1,2), SPAD, (RT39(I), I=1,2), PRSS, CONC, CF
```

```
      READ  (IS9) RT40, RES(1), RT41, RES(11), RT42, RES(21)
     0 READ  (IS9)
     1 RT50,RT51, (RES(I),I= 31, 38), RT52,RT53, (RES(I),I= 71, 78),
     2 RT54,RT55, (RES(I),I= 81, 88), RT56,RT57, (RES(I),I= 91, 98),
     3 RT58,RT59, (RES(I),I=101,108), RT60,RT61, (RES(I),I=111,118),
     4 RT62,RT63, (RES(I),I=121,128), RT64,RT65, (RES(I),I=131,138),
     5 RT66,RT67, (RES(I),I=141,148), RT68,RT69, (RES(I),I=151,158),
     6 RT70,RT71, (RES(I),I=161,168), RT72,RT73, (RES(I),I=171,178)
C
C===== THIS SECTION PRINTS THE TOP SECTION OF DATA.
C
      WRITE (IS0,501) (RT10(I), I=1,3), INX, RT11, IPN
  501 FORMAT (1H1,3A6,I5,74X,A4,I4)
      WRITE (IS0,502) (RT20(I), I=1,5)
  502 FORMAT (1H0,46X,4A6,A3)
     0 WRITE (IS0,503) (RT30(I),I=1,3), DIMA, RT33, DIMB, RT34, DIMC,
     1        RT35, SKAL, (RT36(I),I=1,2), THIC, (RT37(I),I=1,2), NPAN,
     2        (RT38(I),I=1,2), SPAD, (RT39(I),I=1,2), PRSS, CONC , CF
  503 0 FORMAT (1H0,2A6,A1,F5.2,A4,F5.2,A4,F5.2,5X,A6,F4.2,3X,A6,A4,F5.2,
     1 A6,A3,I1,A6,A5,F3.1,2A6,F5.1,3X,A6,A1)
      WRITE (IS0,504) RT40, RES(1), RT41, RES(11), RT42, RES(21)
  504 FORMAT (1H0,40X,A4,F5.2,5X,A4,F5.2,5X,A5,F6.2)
     0 WRITE (IS0,505)
     1 RT50,RT51, (RES(I),I= 31, 38), RT52,RT53, (RES(I),I= 71, 78),
     2 RT54,RT55, (RES(I),I= 81, 88), RT56,RT57, (RES(I),I= 91, 98),
     3 RT58,RT59, (RES(I),I=101,108), RT60,RT61, (RES(I),I=111,118),
     4 RT62,RT63, (RES(I),I=121,128), RT64,RT65, (RES(I),I=131,138),
     5 RT66,RT67, (RES(I),I=141,148), RT68,RT69, (RES(I),I=151,158),
     6 RT70,RT71, (RES(I),I=161,168), RT72,RT73, (RES(I),I=171,178)
  505 0 FORMAT (1H0,A6,A4,8F13.6/1H0,A6,A4,8F13.6/1H ,A6,A4,8F13.6/
     1            1H0,A6,A4,8F13.6/1H ,A6,A4,8F13.6/1H ,A6,A4,8F13.6/
     2            1H0,A6,A4,8E13.6/1H ,A6,A4,8E13.6/1H ,A6,A4,8E13.6/
     3            1H0,A6,A4,8F13.6/1H ,A6,A4,8F13.6/1H ,A6,A4,8F13.6)
C
C===== THIS SECTION READS IN THE BOTTOM SECTION OF DATA TO BE PRINTED.
C
      READ (IS9) DUM2
      BACKSPACE  IS9
      IF (DUM2 .EQ. DUM1) GO TO 800
      GO TO 106
  800 READ  (IS9) RT40, RES(1), RT41, RES(11), RT42, RES(21)
     0 READ  (IS9)
     1 RT50,RT51, (RES(I),I= 31, 38), RT52,RT53, (RES(I),I= 71, 78),
     2 RT54,RT55, (RES(I),I= 81, 88), RT56,RT57, (RES(I),I= 91, 98),
     3 RT58,RT59, (RES(I),I=101,108), RT60,RT61, (RES(I),I=111,118),
     4 RT62,RT63, (RES(I),I=121,128), RT64,RT65, (RES(I),I=131,138),
     5 RT66,RT67, (RES(I),I=141,148), RT68,RT69, (RES(I),I=151,158),
```

```
     6 RT70,RT71, (RES(I),I=161,168), RT72,RT73, (RES(I),I=171,178)
C
C===== THIS SECTION PRINTS THE BOTTOM DATA.
C
       WRITE (ISO,504) RT40, RES(1), RT41, RES(11), RT42, RES(21)
     0 WRITE (ISO,505)
     1 RT50,RT51, (RES(I),I= 31, 38), RT52,RT53, (RES(I),I= 71, 78),
     2 RT54,RT55, (RES(I),I= 81, 88), RT56,RT57, (RES(I),I= 91, 98),
     3 RT58,RT59, (RES(I),I=101,108), RT60,RT61, (RES(I),I=111,118),
     4 RT62,RT63, (RES(I),I=121,128), RT64,RT65, (RES(I),I=131,138),
     5 RT66,RT67, (RES(I),I=141,148), RT68,RT69, (RES(I),I=151,158),
     6 RT70,RT71, (RES(I),I=161,168), RT72,RT73, (RES(I),I=171,178)
       GO TO 106
  900  WRITE (ISO,950) IINX, IRTV, INX
  950 0 FORMAT (1H1/1H0,37HYOU HAVE ONE OF THE FOLLOWING ERRORS./1H0,
     1 5X,55HYOUR RETRIEVAL INDEX VALUES ARE NOT IN ASCENDING ORDER./
     2 1H0,5X,48HYOUR RETRIEVAL INDEX NUMBER IS SMALLER THAN THE ,
     3 38HSMALLEST RETRIEVAL NUMBER ON THE TAPE./1H0/1H0,
     4 44HTHE LOWEST RETRIEVAL NUMBER ON THIS TAPE IS ,I3/1H0,
     5 31HYOUR RETRIEVAL INDEX NUMBER IS ,I3/1H0,
     6 55HTHE RETRIEVAL NUMBER OF THE DATA CAUSING THIS ERROR IS ,I3)
       GO TO 1000
  902  WRITE (ISO,952) LINX
  952 0 FORMAT (1H1/1H0,37HYOU HAVE READ TO THE END OF THE DATA./1H0,
     1 45HTHE HIGHEST RETRIEVAL NUMBER ON THIS TAPE IS ,I3/1H0
     2 31HYOUR RETRIEVAL INDEX NUMBER IS ,I3)
 1000  STOP
       END
```