THE NASTRAN CONTOUR PLOTTER

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SUMMARY

The NASTRAN Contour Plotter, a group of subroutines and modifications to the NASTRAN Plot Module, enables contour lines to be superimposed on the plot of the structural model or on an outline of the structural model. The NASTRAN Contour Plotter can be incorporated into NASTRAN Version 12. Consistent with the NASTRAN computer program, it is operational on the IBM 360, the CDC 6000, and the UNIVAC 1108 computers on a variety of plotter hardware.

INTRODUCTION

NASTRAN (NAsa STRuctural ANalysis)program is a general purpose digital computer program for the analysis of large complex structures. NASTRAN uses the finite element structural analysis approach which involves replacing the actual, continuous structure by an idealization composed of small elements.

NASTRAN currently provides a plotting capability to aid in the preparation of the structural model and in the interpretation of the computed results. This structure plotting capability produces both deformed and undeformed geometric projections of the structural model with or without displacement vectors at the nodal points. The X-Y plotting capability produces graphs of transient response and frequency response, and the matrix plotting capability generates topological displays of matrices.

The contour plotting capability, an enhancement to the structure plotter, will plot lines representing equal values on any deformed or undeformed geometric projection of the structural model. It was developed to aid in the interpretation of various stress and displacement results.

The contour plotting capabilities are described in terms of the data card specifications which indicate the type of contour plot and direct the contour plotter to superimpose contour lines on the structural model. These data cards are an addition to the structure plot request packet used to define and control the execution of the structural model plot (ref. 1).

Adding the contour plotting capability to the structure plot module necessitated certain modifications to existing subroutines within the module and to the plot DMAP (Direct Matrix Abstraction Program) statement in the all rigid formats. These modifications and additions are described in the format of The NASTRAN Programmer's Manual (ref. 2).

USING THE CONTOUR PLOTTING CAPABILITY

The Contour Plot Definition Card

The contour plot definition card (fig. 1) is used to specify the type of contour plot and the contour values to be plotted. The card is optional since all parameters may be defaulted. The card follows the format of a free-field plot request card (ref. 3).
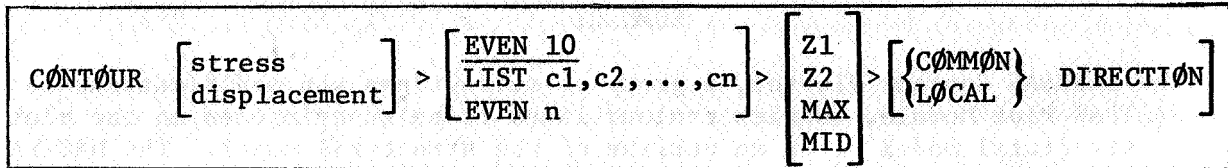
$$\text{CØNTØUR} \begin{bmatrix} \text{stress} \\ \text{displacement} \end{bmatrix} > \begin{bmatrix} \underline{\text{EVEN } 10} \\ \text{LIST c1,c2,...,cn} \\ \text{EVEN n} \end{bmatrix} > \begin{bmatrix} \text{Z1} \\ \text{Z2} \\ \text{MAX} \\ \text{MID} \end{bmatrix} > \begin{bmatrix} \begin{Bmatrix} \text{CØMMØN} \\ \text{LØCAL} \end{Bmatrix} \text{DIRECTIØN} \end{bmatrix}$$

Figure 1.

Nine types of stress contour plots are available:

$$\text{stress} = \begin{cases} \begin{matrix} \underline{\text{MAJPRIN}} \\ \text{MINPRIN} \end{matrix} & \text{- Major and Minor Principal Stress} \\ \text{MAXSHEAR} & \text{- Maximum Shear Stress} \\ \begin{matrix} \text{XNØRMAL} \\ \text{YNØRMAL} \\ \text{ZNØRMAL} \end{matrix} & \text{- X,Y,Z Normal Stresses} \\ \begin{matrix} \text{XYSHEAR} \\ \text{XZSHEAR} \\ \text{YZSHEAR} \end{matrix} & \text{- Shear-XY, -XZ, -YZ .} \end{cases}$$

Four types of displacement contour plots are available:

$$\text{displacement} = \begin{cases} \begin{matrix} \text{XDISPLAC} \\ \text{YDISPLAC} \\ \text{ZDISPLAC} \end{matrix} & \begin{matrix} \text{- the X,Y,Z components of the} \\ \text{displacement vector} \end{matrix} \\ \text{MAGNITUD} & \text{- the magnitude of the displacement vector} \end{cases}$$

Default for this parameter is MAJPRIN, Major Principal Stress.

The contour values to be plotted may be specified by supplying the parameter EVEN and the number, n, of contour values, or by supplying LIST and a list of real number contour values. If EVEN is specified, the contour plotter will calculate n contour values at (n-1) equal intervals over the range of values specified by the user. The first contour value will be the minimum and the n-th contour value the maximum of the values for the current set of elements. The number of contour values, n, must be less than or equal to 50. Default for this parameter is "EVEN 10", i.e., contour values at 10 even (i.e., equal) intervals.

Since stress may be calculated at two Fibre Distances, the Fibre Distance may be specified by designating Z1 (Fibre Distance 1) or Z2 (Fibre Distance 2). In addition, MAX, the maximum of Z1 and Z2, or MID, the average of Z1 and Z2,

may be selected. In the set of elements for which a contour plot can be executed (see The PLOT Execution Card), the average of Z1 and Z2, MID, is applicable only to the CTR1A2 and CQUAD2 elements. The default is Z1.

The Normal Stresses are directional and are calculated in the elements local coordinate system. If COMMON DIRECTION is specified, the contour plotter will transform the Normal Stresses and the Shear Stresses to a common (currently the basic) coordinate system. If LOCAL DIRECTION is specified, the contour plotter will leave these stresses in the global coordinate system. Note that the Normal Z Stress, and the Shear-XZ and Shear-YZ are assumed to be zero in the element's local coordinate system. Default for this parameter is the COMMON DIRECTION.

<center>The PLOT Execution Card</center>

The PLOT Execution Card (figure 2) has been altered to include the CONTOUR and OUTLINE execution commands (ref. 4).

$$
\text{PLOT} \begin{bmatrix} \begin{Bmatrix} \text{STATIC} \\ \text{MODAL} \\ \text{TRANSIENT} \end{Bmatrix} \text{DEFORMATION } i1,i2,\text{THRU } i3,i4, \text{ etc.} \end{bmatrix} >
$$

$$
\begin{bmatrix} \begin{Bmatrix} \text{RANGE } \lambda1, \ \lambda2 \\ \text{TIME } \ +1, \ +2 \end{Bmatrix} \end{bmatrix} >
$$

$$
[\text{CONTOUR } i1,i2 \text{ THRU } i3,i4, \text{ etc.}] > \begin{bmatrix} \begin{Bmatrix} \text{RANGE } \lambda1, \ \lambda2 \\ \text{TIME } t1, \ t2 \end{Bmatrix} \end{bmatrix} >
$$

$$
[\text{MAXIMUM DEFORMATION } d] > [\text{SET } j] > [\text{ORIGIN } k] > \begin{bmatrix} \begin{Bmatrix} \text{SYMMETRY} \\ \text{ANTISYMMETRY} \end{Bmatrix} w \end{bmatrix} >
$$

$$
\begin{bmatrix} \begin{Bmatrix} \text{PEN} \\ \text{DENSITY} \end{Bmatrix} p \end{bmatrix} > \begin{bmatrix} \text{SYMBOLS } m[,n] \end{bmatrix} > \begin{bmatrix} \text{LABEL} \begin{Bmatrix} \text{GRID POINTS} \\ \text{ELEMENTS} \\ \text{BOTH} \end{Bmatrix} \end{bmatrix} >
$$

$$
\begin{bmatrix} \underline{\text{SHAPE}} \\ \text{OUTLINE} \\ \text{VECTOR } v \\ \text{SHAPE, VECTOR } v \end{bmatrix}
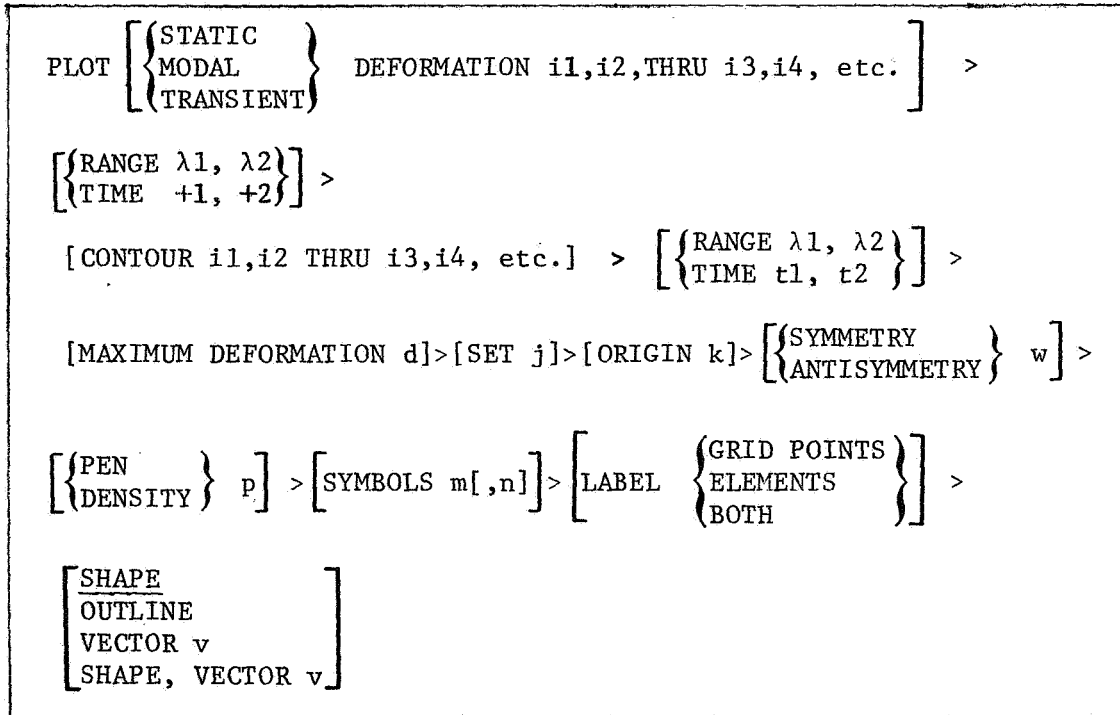$$

<center>Figure 2.</center>

The CONTOUR command will superimpose lines representing equal value on the structural model or on the outline of the structural model. The nonzero integers following the CONTOUR command refer to subcases to be plotted. Default is the subcase following the DEFORMATION parameter or, if that parameter is not specified, all subcases. In addition, the RANGE or TIME may be specified. If both DEFORMATION and CONTOUR are specified, the contour plotter will take the subcase, range, or time parameters following

DEFORMATION as applicable to the contour plot as well as to the deformed plot.

If a stress contour plot is requested, contour lines will be plotted on the following elements in SET j appropriate to the type of stress contour plot requested (ref. 5): CSHEAR, CTR1A1, CTR1A2, CQUAD1, CQUAD2, CTRMEM, CQDMEM.

If a displacement contour plot is requested, contour lines will be plotted on all two-dimensional elements plotted by the structure plotter. The type of deformation must be specified for a displacement contour plot.

The contour lines are labeled with integers indicating the contour value. The integers are listed with their associated contour values in the form of a key in the Plot Module Message section of the printed output.

The OUTLINE command has been added as an alternative to the SHAPE command. OUTLINE will plot connecting lines between those grid points which lie on the boundary of the structural model.

If DEFORMATION is specified in an addition to OUTLINE, the OUTLINE will reflect the deformed structure. If a "0" is added to the deformation subcase string, the undeformed outline will be plotted.

The OUTLINE command may be specified only in addition to the CONTOUR command.

CONTOUR PLOT PROGRAM FUNDAMENTALS

Modifications and Additions to the Functional Module Plot

The addition of the contour plotter enlarges the capabilities of the Functional Module Plot (ref. 6) to include the capability of superimposing contour lines on structural shapes using a variety of different plotters. In order to incorporate the contour plotter, two data blocks were added to the input string of data blocks brought into the Plot Module and modifications were made to the existing subroutines in order to add the new subroutines to the Plot Module. A page of printed output was also devised to give information on the contour plot.

The data blocks ECPT and ØES1 were added as additional input blocks to the DMAP calling sequence. The DMAP calling sequence (ref. 7) becomes:

```
PLØT   PLTPAR, GPSETS, ELSETS, CASECC, BGPDT, EQEXIN, SIL, ECPT,
       PLTDSP1, PLTDSP2, ØES1/PLØTX/V,N,NGP/V,N,LSIL/V,N,PLTFLG/
       V,N,PLTNUM    $
```

ECPT is the Element Connection and Properties Table and ØES1 is the Output Element Stress Table. If the ECPT data block is purged, contour plots will not be drawn. If the ØES1 data block is purged, the stress contour plots will not be drawn.

Modifications were made to existing plot module subroutines so that the contour plot definition card could be detected and so that the CONTOUR and OUTLINE commands could be executed. When the plot module is ready to generate the plot (subroutine DRAW), all the necessary parameters have been set and any necessary rotations have been made to generate the contour plot.

The subroutine CONTOR is called by the subroutine DRAW to plot contour lines. If a stress contour plot was requested, CONTOR requests that the plot set be ordered and that contour values be found for each element. The contour lines are then located on the structural model, drawn and labeled. If a displacement contour plot was requested, the contour lines are drawn by the subroutine DISPLA which returns to the subroutine CONTOR to plot the labels.

If an OUTLINE of the structural model was requested, the subroutine DRAW calls the subroutine BORDER to generate this part of the plot.

The subroutine DRAW, then, (ref. 8), has been altered so that subroutines CONTOR and BORDER can be called to generate contour lines and the structural outline. The subroutine PLOT (ref. 9) has also been altered so that a call to ROTATE can be made to transform certain stresses to a common coordinate system.

The seven subroutines comprising the contour plotting capability are described below.

(1) Subroutine Name: RØTATE

Purpose: to transform the Normal Stresses and the Shear Stresses to a common coordinate system.

Calling Sequence: CALL RØTATE(ELSETS, GPLST, X)
where   ELSETS is the data block containing element connection data,
        GPLST is a list of indices defining the set of grid points associated
               with the elements, and
        X   contains the corresponding coordinates of the grid points.

Common Blocks:
                /XXPARM/ (ref. 10) (see also Additions to NASTRAN Tables,
                                    page 10).

Method: The subroutine transforms the Normal Stresses and Shear Stresses from the local coordinate system to a common coordinate system using the following expression:

$$[T] = [\theta] [T'] [\theta]^T$$

where $[T] = \begin{bmatrix} \sigma_x & \tau_{xy} & \tau_{xz} \\ \tau_{yx} & \sigma_y & \tau_{yz} \\ \tau_{zx} & \tau_{zy} & \sigma_z \end{bmatrix}$ is a symmetric matrix,

σ_x, σ_y, σ_z are the Normal X,Y, and Z Stresses respectively,

τ_{xy}, τ_{xz}, τ_{yz} are the Shear-XY, -XZ, and -YZ Stresses respectively, and

[θ] is the rotation matrix which has as its components the direction cosines between the local and common coordinate systems.

Since all elements considered by the contour plotter are plate elements, the elements are all assumed to lie in the local X,Y plane with the X-axis passing from grid point one to grid point two (ref. 11). The subroutine makes use of the assumption that $\sigma_z = \tau_{xz} = \tau_{yz} = 0$ in the local coordinate system.

A new local element stress table (NEWOES) is compiled by the subroutine ROTATE to communicate the transformed stresses to the subroutine CONTOR.

Additional Subroutines Required: None.

(2) Subroutine Name: CØNTØR

Purpose: to plot and label contour lines.

Calling Sequence: CALL CØNTØR(GPLST,X,S,U,PEN,DEFØRM)
where GPLST is a list of indices defining the set of grid points,
X contains the corresponding coordinates of the undeformed points,
S contains the corresponding coordinates of the deformed points,
U contains the displacement coordinates,
PEN is the line density or pen number, and

$$\text{DEFORM} = \begin{cases} 0 \text{ if an undeformed structural model was requested} \\ 1 \text{ if a deformed structural model was requested} \end{cases}$$

Common Blocks:
/XXPARM/ (ref.12) (see also Additions to NASTRAN Tables, page 10).

/PLTDAT/ (ref.13)

/DRWDAT/ (ref.12) (see also Additions to NASTRAN Tables, page 10).

Method: If the contour plot is to be a displacement contour plot, CONTOR calls the subroutine DISPLA to plot the contour lines. If a stress contour plot was requested, CONTOR calls the subroutine CREATE to prepare a table containing the contour value and the centroid for each element in the plot set. The subroutine ORDER is then called, if necessary, to provide a table of all grid points internal to the structural shape and all elements that share a common grid point in the current plot set.

Once these tables are available, CONTOR estimates a contour value for each internal grid point using a weighted average of distance from the centroids and contour values of surrounding elements. Contour lines are found within a triangle formed by connecting an internal grid point and two

390

adjacent elements' centroids. Contour lines are plotted with the assumption that the contour values vary linearly between vertices of this triangle.

Labels are placed on the completed contour plot and the subroutine PLTOPR is called to print the contour plot key as part of the plot messages.

Additional Subroutines Required: ORDER, CREATE, DISPLA.

(3) Subroutine Name: CREATE

Purpose: to extract the stress contour values from the appropriate data block and calculate the centroid of each element in the plot set.

Calling Sequence: CALL CREATE(GPLST,X,U,DEFØRM,CØNMIN,CØNMAX,ELMTID,STØRE)
where   GPLST is a list of indices defining the set of grid points,

X,U   contain the corresponding undeformed and deformed coordinates respectively, of the grid points,

$$DEFORM = \begin{cases} 0 & \text{if an undeformed structural shape was requested,} \\ 1 & \text{if a deformed structural shape was requested} \end{cases}$$

CONMIN,CONMAX   are the minimum and maximum of the contour values, and
ELMTID,STORE   are temporary storage areas for the element identification number and the contour value found on the stress data block.

Common Block:
    /XXPARM/ (ref.14) (see also Additions to NASTRAN Tables, page 10).

Method: After determining which stress data block contains the contour values for this contour plot, the appropriate data block is opened and the temporary storage area is filled. The contour values are selected from the information on Fibre Distance, direction, subcase, and if applicable, range or time specified by the user. Then the ELSETS data block is read to supply information on element types, elements identification numbers, and internal grid point numbers of elements contained in the current set.

The subroutine makes two assumptions concerning the stress data block and the ELSETS data block. It assumes that element types are ordered in the same sequence and that for each element type, element information is ordered by increasing element identification number. Element types for which contour lines cannot be drawn are ignored as are elements not included in the current plot set.

Finally, the centroid is calculated for each element in the plot set and a temporary table is made containing the element identification number, the contour value, and the centroid.

Additional Subroutines Required: CENTRE .

(4) Subroutine Name: ØRDER

Purpose: to find for each grid point in the plot set, all elements which contain that grid point and to order those elements surrounding interior grid points.

Calling Sequence: CALL ØRDER(GPLST, ID, REST)
where   GPLST is a list of indices defining the set of grid points and
         ID,REST are temporary storage areas for element and grid point information.

Common Blocks: None.

Method: The subroutine ORDER extracts from the ECPT (Element Connections and Properties Table) data block the list of elements connected to each grid point for each grid point in the plot set. Since the grid point numbers given in the ECPT data block are in SIL (Scalar Index List) form, ORDER uses the SIL table to find the internal grid point numbers associated with each element. For each grid point in the plot set, ORDER finds all two dimensional elements in the plot set containing that (pivot) grid point. The elements are then ordered so that adjacent elements contain a second common grid point. A flag is set indicating whether the pivot grid point is interior to the structural shape or on the boundary of the structural shape.

A temporary table is compiled containing one record for each grid point in the current plot set. Each record contains a flag indicating whether the grid point is interior to the structural model or on the boundary of the structural model, and a list of elements connected to the grid point. For boundary grid points, the table contains two grid points for each element that are connected by element boundary lines to that grid point.

Additional Subroutines Required: None.

(5) Subroutine Name: CENTRE

Purpose: to find the intersection of two lines.

Calling Sequence: CALL CENTRE(X1,Y1,X2,Y2,X3,Y3,X4,Y4,CENTER),
                              RETURNS(RETURN1)
where   X1,Y1 and X3,Y3 are the end points of one line,
         X2,Y2 and X4,Y4 are the end points of the second line, and
         CENTER is returned as the point of intersection.

Common Blocks: None.

Method: The subroutine CENTRE is used in the calculation of the centroid of an element. The nonstandard return is taken in the event that either of the lines has infinite slope. It is assumed that the two lines are not parallel.

Additional Subroutines Required: None.

(6) Subroutine Name: DISPLA

Purpose: to draw displacement contour lines.

Calling Sequence: CALL DISPLA(GPLST,X,S,U,PEN,DEFORM,LABEL,PT)
where   GPLST is a list of indices defining the set of grid points,
         X,S   contain the corresponding undeformed and deformed
                coordinates, respectively, of the grid points.
         U   contains the grid point displacement coordinates,
         PEN   is the line density or pen number,

$$\text{DEFORM} = \begin{cases} 0 & \text{if an undeformed structural shape was requested} \\ 1 & \text{if a deformed structural shape was requested} \end{cases},$$

         LABEL contains the contour line labeling information, and
         PT   contains the coordinates of the triangle formed to calculate
                contour lines.

Common Blocks:
    /XXPARM/ (ref.15) (see also Additions to NASTRAN Tables, page 10).

    /PLTDAT/ (ref.15) (see also Additions to NASTRAN Tables, page 10).

Method: The subroutine DISPLA uses the ELSETS data block to extract
the two dimensional elements in the plot set. Each element is then broken
down to one or more triangles and contour lines are drawn within the
triangles with the assumption that the contour values vary linearly between
grid points.

.It is assumed in the DISPLA subroutine that the user's coordinate
system is a right-handed coordinate system with coordinate axes X,Y,Z. If
the AXES card (ref. 16) is used to change the orientation of the structural
model, it will have no effect on the component of displacement used to draw
the contour plot.

Labeling information is maintained on a temporary file to be added
to the plot by the subroutine CONTOR.

Additional Subroutines Requested: None.

(7) Subroutine Name: BØRDER

Purpose: to draw the structural outline.

Calling Sequence: CALL BØRDER(GPLST, X, U, DEFØRM)
where   GPLST is a list of indices defining the set of grid points,
         X,U   contain the corresponding undeformed and deformed coordinates,
                respectively, of the grid points, and

$$\text{DEFORM} = \begin{cases} 0 & \text{if an undeformed structural shape was requested} \\ 1 & \text{if a deformed structural shape was requested.} \end{cases}$$

Common Blocks: None.

Method: The subroutine BØRDER uses the table created by the subroutine
ØRDER. BORDER extracts from the table those grid points that lie on the plot
sets boundary. All grid points connected to this grid point by element

boundary lines are sorted to find the two element boundary lines which form the structural boundary. The BORDER subroutine then draws two connecting lines for each grid point so that the structural outline will be of density two.

Additional Subroutines Required: None.

Additions to the NASTRAN Tables

The NASTRAN Functional Module Plot uses labeled common to communicate information concerning plot requests, plot calculation parameters, and plotter hardware characteristics among subroutines. Additional parameters have been added to two of the labeled common blocks to pass contour plotter information. These additional parameters are described here (ref. 17).

(1) CØMMØN/DRWDAT/SET,...,VECTØR,CØN,EDGE

where   CØN   is an integer indicating the contour plot option, and

             EDGE   is an integer indicating the outline option.

(2) CØMMØN/XXPARM/PBUFSZ,...,XY(11,3),NCNTR,CNTR(50),ICNTVL,WHERE,DIRECT,
         SUBCAS,FLAG,VALUE,SET

In the following descriptions, the value in parenthesis to the right of the variable name is the default value, and the letter in parenthesis to the right of the explanation pertains to the type of variable (I is integer, and R is real).

Contour Plotting Data

NCNTR(10)	–	Number of contour values to be plotted (I)
CNTR	–	Contour values (R)
ICNTVL(3)	–	Type of contour plot (I)
WHERE(1)	–	Fibre Distance of stress contour value (I)
DIRECT(2)	–	Stress vector direction option (I)
SUBCAS	–	Current subcase (I)
FLAG(0.0)	–	Data identification indicator (R)
VALUE	–	Current eigenvalue or time step (R)
SET	–	Last plot set processed by contour plotter (I)

Local Table Descriptions

Three tables are formed for the use of the contour plot subroutines. The tables are compiled and used within the structure plot module. The description of each table follows the file name.

1. SCR1, scratch file 1 – compiled by the subroutine CREATE to be used by the subroutine CONTOR. The header record is written by the subroutine GOPEN. The table is compiled from information contained in the ELSETS data block (ref. 18) and the OES1 data block (ref. 19) or the NEWOES table (see below).

Table Format:

Record	Word	Type	Item
0			Header Record
1	1	I	Element Type
	2	I	Element Identification Number
	3	R	Stress Value
	4,5	R	Element Centroid
	⋮		⋮
	(4m+2)	I	0
2			End-of-File

Note: m = the number of elements of current type in the plot set.

2. SCR2, scratch file 2 – compiled by the subroutine ORDER to be used by the subroutines CONTOR and BORDER. The header record is written by the subroutine GOPEN. The table is compiled from information contained in the ECPT data block (ref. 20) and the SIL table (ref. 21).

Table Format:

Record	Word	Type	Item
0			Header Record
1	1	I	Flag
	2	I	Number of elements, m.
	3	I	Grid point internal number
	4	I	repeated for each element containing the grid point. Contents dependent on Flag.
	⋮		

Notes:
1) n = the number of grid points in the plot set.
2) m = the number of elements in current record.
3) Flag = -1:

Word	Type	Item
4	I	Element identification number
⋮	⋮	⋮
(3+m)	I	⋮

4) Flag = -2:

Word	Type	Item
4	I	Element identification number
5	I	Grid point internal number
6	I	Grid point internal number
$\vdots$		$\vdots$
(3m+1)	I	Element identification number
(3m+2)	I	Grid point internal number
(3m+3)	I	Grid point internal number

3. NEWOES - compiled by the subroutine ROTATE to be used by the subroutine CREATE. There is no header record. The table is compiled using stress values contained in the OES1 data block (ref. 22).

The first record in each set of two records on NEWOES is a copy of the corresponding record of the OES1 data block. The second record of each set contains changes in content for the following element types:

Element types CTRIA1, CQUAD1, CTRIA2, CQUAD2

Word	Contents
2	Z1
3	Normal X Stress at Z1
4	Normal Y Stress at Z1
5	Normal Z Stress at Z1
6	Shear XY at Z1
7	Shear XZ at Z1
8	Shear YZ at Z1
9	Maximum Shear at Z1
10	Z2
11	Normal X Stress at Z2
12	Normal Y Stress at Z2
13	Normal Z Stress at Z2
14	Shear XY at Z2
15	Shear XZ at Z2
16	Shear YZ at Z2
17	Maximum Shear at Z2

Element types CTRMEM, CQDMEM

Word	Contents
2	Normal X Stress
3	Normal Y Stress
4	Normal Z Stress
5	Shear XY
6	Shear XZ
7	Shear YZ
8	Maximum Shear

396

REFERENCES

1. "The NASTRAN User's Manual," edited by Caleb W. McCormick, Office of Technology Utilization, National Aeronautics and Space Administration, Washington, D.C. (1970), Section 4.2.

2. "The NASTRAN Programmer's Manual," edited by Frank J. Douglas, Office of Technology Utilization, National Aeronautics and Space Administration, Washington, D.C. (1970), Section 4.24.

3. "The NASTRAN User's Manual," Section 4.2.1.

4. "The NASTRAN User's Manual," Section 4.2.2.3.

5. "The NASTRAN User's Manual," pages 4.3-12 through 4.3-14.

6. "The NASTRAN Programmer's Manual," Section 4.24.

7. "The NASTRAN Programmer's Manual," Section 4.24.3.

8. "The NASTRAN Programmer's Manual," Section 4.24.8.6.

9. "The NASTRAN Programmer's Manual," Section 4.24.8.3.

10. "The NASTRAN Programmer's Manual," Section 4.24.9.2.

11. "The NASTRAN User's Manual," Section 1.3.5.

12. "The NASTRAN Programmer's Manual," Section 4.24.9.2.

13. "The NASTRAN Programmer's Manual," Section 2.5.

14. "The NASTRAN Programmer's Manual," Section 4.24.9.2.

15. "The NASTRAN Programmer's Manual," Section 4.24.9.2.

16. "The NASTRAN User's Manual," Section 4.2.2.2.

17. "The NASTRAN Programmer's Manual," Section 4.24.9.2.

18. "The NASTRAN Programmer's Manual," Section 2.3.5.4.

19. "The NASTRAN Programmer's Manual," Section 2.3.28.15.

20. "The NASTRAN Programmer's Manual," Section 2.3.8.3.

21. "The NASTRAN Programmer's Manual," Section 2.3.3.6.

22. "The NASTRAN Programmer's Manual," Section 2.3.28.15.