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THE NASTRAN USER'S MANUAL

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INTRODUCTION

The User's Manual is one of four manuals that constitute the documentation for NASTRAN, the other three being the Theoretical Manual, the Programmer's Manual and the Demonstration Problem Manual. Although the User's Manual contains all of the information that is directly associated with the solution of problems with NASTRAN, the user will find it desirable to refer to the other manuals for assistance in the solution of specific user problems.

The Theoretical Manual is an excellent introduction to NASTRAN for those who are using NASTRAN for the first time. The User's Manual is restricted to those items related to the use of NASTRAN that are independent of the computing system being used. Computer dependent matters, such as operating system control cards, are treated in Section 5 of the Programmer's Manual. The Demonstration Problem Manual presents a discussion of the sample problems contained on the NASTRAN delivered User Master File (UMF).

NASTRAN uses a finite element structural model, wherein the distributed physical properties of a structure are represented by a finite number of structural elements which are interconnected at a finite number of grid points, to which loads are applied and for which displacements are calculated. The procedures for defining and loading a structural model are described in Section 1. This section contains a functional reference for every card that is used for structural modeling.

The NASTRAN Data Deck, including the details for each of the data cards, is described in Section 2. This section also discusses the NASTRAN control cards that are associated with the use of the program.

NASTRAN contains problem solution sequences, called rigid formats. Each of these rigid formats is associated with the solution of problems for a particular type of static or dynamic analysis. Section 3 contains a general description of rigid format procedures, along with specific instructions for the use of each rigid format.

The procedures for using the NASTRAN plotting capability are described in Section 4. Both deformed and undeformed plots of the structural model are available. Response curves are also available for transient response and frequency response analyses.

In addition to the rigid format procedures, the user may choose to write his own Direct Matrix Abstraction Program (DMAP). This procedure permits the user to execute a series of matrix operations of his choice along with any utility modules or executive operations that he may need. The rules governing the creation of DMAP programs are described in Section 5.

The NASTRAN diagnostic messages are documented and explained in Section 6. The NASTRAN Dictionary, in Section 7, contains descriptions of mnemonics, acronyms, phrases, and other commonly used NASTRAN terms.

There is a limited number of sample problems included in the User's Manual. However, a more comprehensive set of demonstration problems, at least one for each of the rigid formats, are described in the NASTRAN Demonstration Problem Manual. The data decks are available on tape, in the form of a User's Master file, for each of the computers on which NASTRAN has been implemented. Samples of the printer output and of structure plots and response plots can be obtained by executing these demonstration problems.

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1.1 INTRODUCTION

NASTRAN embodies a lumped element approach, wherein the distributed physical properties of a structure are represented by a model consisting of a finite number of idealized substructures or elements that are interconnected at a finite number of grid points, to which loads are applied. All input and output data pertain to the idealized structural model. The major steps in the definition and loading of a structural model are indicated in Figure 1.

As indicated in Figure 1, the grid point definition forms the basic framework for the structural model. All other parts of the structural model are referenced either directly or indirectly to the grid points.

Two general types of grid points are used in defining the structural model. They are:

1. Geometric grid point - a point in three-dimensional space at which three components of translation and three components of rotation are defined. The coordinates of each grid point are specified by the user.

2. Scalar point - a point in vector space at which one degree of freedom is defined. Scalar points can be coupled to geometric grid points by means of scalar elements and by constraint relationships.

The structural element is a convenient means for specifying many of the properties of the structure, including material properties, mass distribution and some types of applied loads. In static analysis by the displacement method, stiffness properties are input exclusively by means of structural elements. Mass properties (used in the generation of gravity and inertia loads) are input either as properties of structural elements or as properties of grid points. In dynamic analysis, mass, damping, and stiffness properties may be input either as the properties of structural elements or as the properties of grid points (direct input matrices).

Structural elements are defined on connection cards by referencing grid points, as indicated on Figure 1. In a few cases, all of the information required to generate the structural matrices for the element is given on the connection card. In most cases the connection card refers to a property card, on which the cross-sectional properties of the element are given. The property card in turn refers to a material card which gives the material properties. If some of the material properties are stress dependent or temperature dependent, a further reference is made to tables for this information.

Various kinds of constraints can be applied to the grid points. Single-point constraints are used to specify boundary conditions, including enforced displacements of grid points.

Multipoint constraints are used to specify a linear relationship among selected degrees of freedom, including the definition of infinitely rigid elements. Omitted points are used as a tool in matrix partitioning and for reducing the number of degrees of freedom used in dynamic analysis. Free-body supports are used to remove stress-free motions in static analysis and to evaluate the free-body inertia properties of the structural model.

Static loads may be applied to the structural model by concentrated loads at grid points, pressure loads on surfaces, or indirectly, by means of the mass and thermal expansion properties of structural elements are enforced deformations of one-dimensional structural elements. Due to the great variety of possible sources for dynamic loading, only general forms of loads are provided to the user in dynamic analysis.

The following sections describe the general procedures for defining structural models. Detailed instructions for each of the bulk data cards and case control cards are given in Section 2. Additional information on the case control cards and use of parameters is given for each rigid format in Section 3.

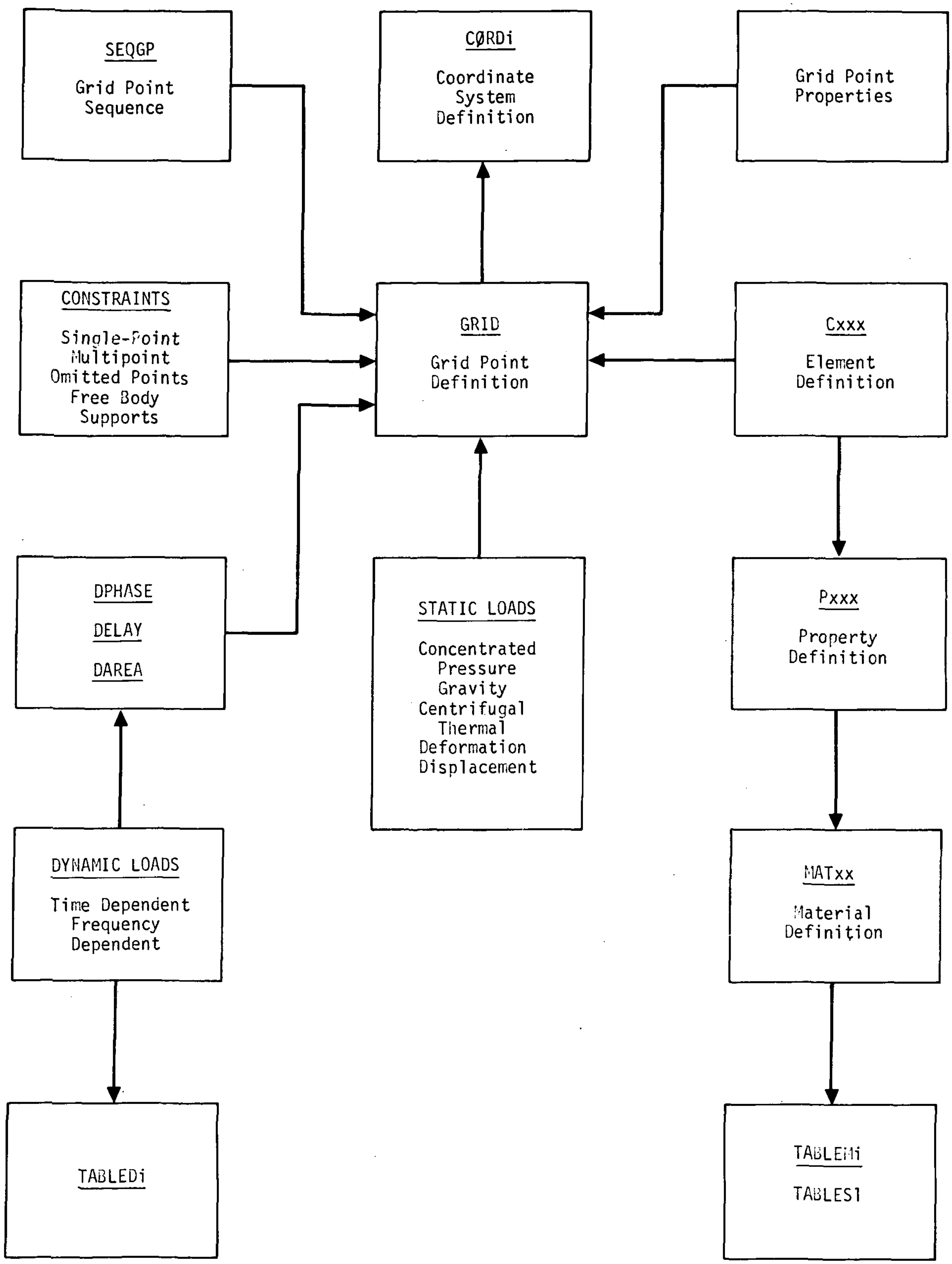

Figure 1. Structural model.

1.2 GRID POINTS

1.2.1 Grid Point Definition

Geometric grid points are defined on GRID bulk data cards by specifying their coordinates in either the basic or a local coordinate system. The implicitly defined basic coordinate system is rectangular, except when using axisymmetric elements. Local coordinate systems may be rectangular, cylindrical, or spherical. Each local system must be related directly or indirectly to the basic coordinate system. The CØRD1C, CØRD1R and CØRD1S cards are used to define cylindrical, rectangular and spherical local coordinate systems, respectively, in terms of three geometric grid points which have been previously defined. The CØRD2C, CØRD2R and CØRD2S cards are used to define cylindrical, rectangular and spherical local coordinate systems, respectively, in terms of the coordinates of three points in a previously defined coordinate system.

Six rectangular displacement components (3 translations and 3 rotations) are defined at each grid point. The local coordinate system used to define the directions of motion may be different from the local coordinate system used to locate the grid point. Both the location coordinate system and the displacement coordinate system are specified on the GRID card for each geometric grid point. The orientation of displacement components depends on the type of local coordinate system used to define the displacement components. If the defining local system is rectangular, the displacement system is parallel to the local system and is independent of the grid point location as indicated in Figure 1a. If the local system is cylindrical, the displacement components are in the radial, tangential and axial directions as indicated in Figure 1b. If the local system is spherical, the displacement components are in the radial, meridional, and azimuthal directions as indicated in Figure 1c. Each geometric grid point may have a unique displacement coordinate system associated with it. The collection of all displacement coordinate systems is known as the global coordinate system. All matrices are formed and all displacements are output in the global coordinate system. The symbols T1, T2 and T3 on the printed output indicate translations in the 1, 2 and 3-directions, respectively, for each grid point. The symbols R1, R2 and R3 indicate rotations about the three axes.

Provision is also made on the GRID card to apply single-point constraints to any of the displacement components. Any constraints specified on the GRID card will be automatically used for all solutions. Constraints specified on the GRID card are usually restricted to those degrees of freedom that will not be elastically constrained and hence must be removed from the model in order to avoid singularities in the stiffness matrix.

The GRDSET card is provided to avoid the necessity of repeating the specification of location coordinate systems, displacement coordinate systems, and single-point constraints, when all, or many, of the GRID cards have the same entries for these items. When any of the 3 items are specified on the GRDSET card, the entries are used to replace blank fields on the GRID card for these items. This feature is useful in the case of such problems as space trusses where one wishes to remove all of the rotational degrees of freedom or in the case of plane structures where one wishes to remove all of the out-of-plane or all of the in-plane motions.

Scalar points are defined either on an SPØINT card or by reference on a connection card for a scalar element. SPØINT cards are used primarily to define scalar points appearing in constraint equations, but to which no structural elements are connected. A scalar point is implicitly defined if it is used as a connection point for any scalar element. Special scalar points, called "extra points", may be introduced for dynamic analyses. Extra points are used in connection with transfer functions and other forms of direct matrix input used in dynamic analyses and are defined on EPØINT cards.

GRIDB is a variation of the GRID card that is used to define a point on a fluid-structure interface (see Section 1.7).

1.2.2 Grid Point Sequencing

The best decomposition and equation solution times are obtained if the grid points can be sequenced in such a manner as to create matrices having small numbers of active columns (see Section 2.2 of the Theoretical Manual for a discussion of active columns and the decomposition algorithm). The decomposition time is proportional to the sum of the squares of the number of active columns in each row of the triangular factor. The equation solution time (forward/backward substitution) is proportional to the number of nonzero terms in the triangular factor.

In selecting the grid point sequencing it is not important to find the best sequence, rather it is usually quite satisfactory to find a good sequence, and to avoid bad sequences that create unreasonably large numbers of active columns. For many problems a sequence which will result in a band matrix is a reasonably good choice, but not necessarily the best. Also, sequences which result in small numbers of columns with nonzero terms are usually good but not necessarily the best.

A sequence with a larger number of nonzero columns will frequently have a smaller number of nonzero operations in the decomposition when significant passive regions exist within the active columns (see Section 2.2 of the Theoretical Manual).

Examples of proper grid point sequencing for one-dimensional systems are shown in Figure 2. For open loops a consecutive numbering system should be used as shown in Figure 2a. This sequencing will result in a narrow band matrix with no new nonzero terms created during the triangular decomposition. Generally, there is an improvement in the accumulated round off error if the grid points are sequenced from the flexible end to the stiff end.

For closed loops the grid points may be sequenced either as shown in Figure 2b or as shown in Figure 2c. If the sequencing is as shown in Figure 2b, the semiband will be twice that of the model shown in Figure 2a. The matrix will initially contain a number of zeroes within the band which will become nonzero as the decomposition proceeds. If the sequencing is as shown in Figure 2c, the band portion of the matrix will be the same as that for Figure 2a. However, the connection between grid points 1 and 8 will create a number of active columns on the right hand side of the matrix. The solution times will be the same for the sequence shown in Figure 2b or 2c, because the number of active columns in each sequence is the same.

Examples of grid point sequencing for surfaces are shown in Figure 3. For plain or curved surfaces with a pattern of grid points that tends to be rectangular, the sequencing shown in Figure 3a will result in a band matrix having good solution times. The semiband will be proportional to the number of grid points along the short direction of the pattern. If the pattern of grid points shown in Figure 3a is made into a closed surface by connecting grid points 1 and 17, 2 and 18, etc., a number of active columns equal to the semiband will be created. If the number of grid points in the circumferential direction is greater than twice the number in the axial direction, the sequencing indicated in Figure 3a is a good one. However, if the number of grid points in the circumferential direction is less than twice the number in the axial direction, the use of consecutive numbering in the circumferential direction is more efficient. An alternate sequencing for a closed loop is shown in Figure 3b, where the semiband is proportional to twice the number of grid points in a row. For cylindrical or similar closed surfaces, the sequencing shown in Figure 3b has no advantage over that shown in Figure 3a, as the total number of active columns will be the same in either case.

With the exception of the central point, sequencing considerations for the radial pattern shown in Figure 3c are similar to those for the rectangular patterns shown in Figures 3a and 3b. The central point must be sequenced last in order to limit the number of active columns associated with this point to the number of degrees of freedom at the central point. If the central point is sequenced first, the number of active columns associated with the central point will be proportional to the number of radial lines. If there are more grid points on a radial line than on a circumferential line, the consecutive numbering should extend in the circumferential direction beginning with the outermost circumferential ring. In this case, the semiband is proportional to the number of grid points on a circumferential line and there will be no active columns on the right hand side of the matrix. If the grid points form a full circular pattern, the closure will create a number of active columns proportional to the number of grid points on a radial line if the grid points are numbered as shown in Figure 3c. Proper sequencing for a full circular pattern is similar to that discussed for the rectangular arrays shown in Figures 3a and 3b for closed surfaces.

Sequencing problems for actual structural models can frequently be handled by considering the model as consisting of several substructures. Each substructure is first numbered in the most efficient manner. The substructures are then connected so as to create the minimum number of active columns. The grid points at the interface between two substructures are usually given numbers near the end of the sequence for the first substructure and as near the beginning of the sequence for the second substructure as is convenient.

Figure 4 shows a good sequence for the substructure approach. Grid points 1 thru 9 are associated with the first substructure, and grid points 10 thru 30 are associated with the second substructure. In the example, each of the substructures was sequenced for band matrices. However, other schemes could also be considered for sequencing the individual substructures. Figure 5 shows the nonzero terms in the triangular factor. The X's indicate terms which are nonzero in the original matrix. The zeros indicate nonzero terms created during the decomposition. The mazimum number of active columns for any pivotal row is only five, and this occurs in only three rows near the middle of the matrix for the second substructure. All other pivotal rows have four or less active columns.

Figure 6 indicates the grid point sequencing using substructuring techniques for a square model, and Figure 7 shows the nonzero terms in the triangular factor. If the square model were sequenced for a band matrix, the number of nonzero terms in the triangular factor would be 129, whereas Figure 7 contains only 102 nonzero terms. The time for the forward/backward substitution operation is directly proportional to the number of nonzero terms in the triangular factor. Consequently, the time for the forward/backward substitution operation when the square array is ordered as shown in Figure 7 is only about 80% of that when the array is ordered for a band matrix. The number of multiplications for a decomposition when ordered for a band is 294, whereas the number indicated in Figure 7 is only 177. This indicates that the time for the decomposition when ordered as shown in Figure 6 is only 60% of that when ordered for a band.

Although scalar points are defined only in vector space, the pattern of the connections is used in a manner similar to that of geometric grid points for sequencing scalar points among themselves or with geometric grid points. Since scalar points introduced for dynamic analysis (extra points) are defined in connection with direct input matrices, the sequencing of these points is determined by direct reference to the positions of the added terms in the dynamic matrices.

The external identification numbers used for grid points may be selected in any manner the user desires. However, in order to reduce the number of active columns, and, hence, to substantially reduce computing times when using the displacement method, the internal sequencing of the grid points must not be arbitrary. In order to allow arbitrary grid point numbers and still preserve sparsity in the triangular decomposition factor to the greatest extent possible, provision is made for the user to resequence the grid point numbers for internal operations. This feature also makes it possible to easily change the sequence if a poor initial choice is made. All output associated with grid points is identified with the external grid point numbers. The SEQGP card is used to resequence geometric grid points and scalar points. The SEQEP card is used to sequence the extra points in with the previously sequenced grid points and scalar points.

1.2.3 Grid Point Properties

Some of the characteristics of the structural model are introduced as properties of grid points, rather than as properties of structural elements. Any of the various forms of direct matrix input are considered as describing the structural model in terms of properties of grid points.

Thermal fields are defined by specifying the temperatures at grid points. The TEMP card is used to specify the temperature at grid points for use in connection with thermal loading and temperature dependent material properties. The TEMPD card is used to specify a default temperature, in order to avoid a large number of duplicate entries on a TEMP card when the temperature is uniform over a large portion of the structure. The TEMPAX card is used for conical shell problems.

Mass properties may be input as properties of grid points by using the concentrated mass element (see Section 5.5 of the Theoretical Manual). The CØNM1 card is used to define a 6x6 matrix of mass coefficients at a geometric grid point in any selected coordinate system. The CØNM2 card is used to define a concentrated mass at a geometric grid point in terms of its mass, the three coordinates of its center of gravity, the three moments of inertia about its center of gravity, and its three products of inertia, referred to any selected coordinate system.

In dynamic analysis, mass, damping, and stiffness properties may be provided, in part or entirely, as properties of grid points through the use of direct input matrices. The DMIG card is used to define direct input matrices for use in dynamic analysis. These matrices may be associated with components of geometric grid points, scalar points, or extra points introduced for dynamic analysis. The TF card is used to define transfer functions that are internally converted to direct matrix input. The DMIAX card is an alternate form of direct matrix input that is used for hydroelastic problems (see Section 1.7).

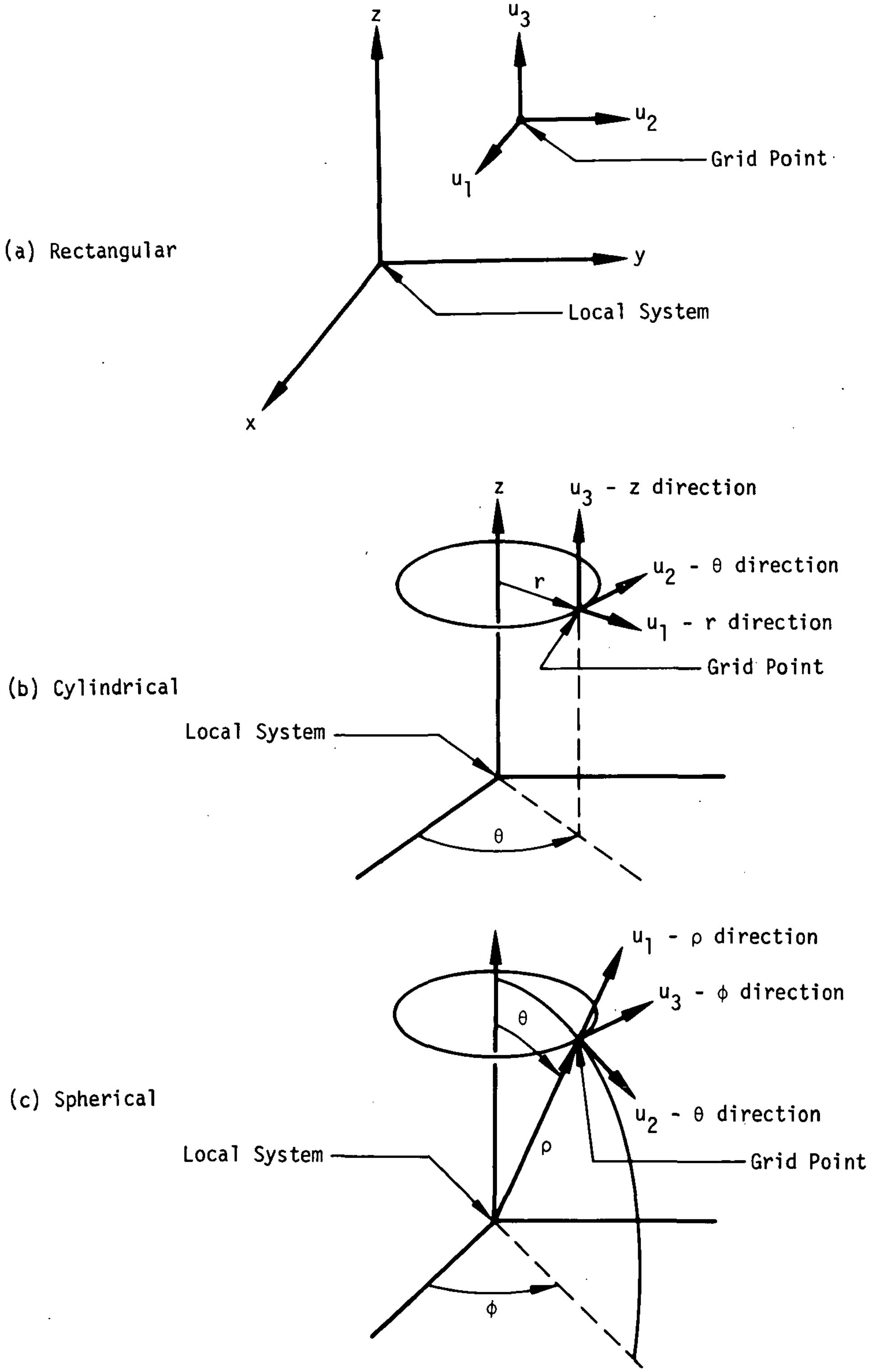

Figure 1. Displacement coordinate systems.

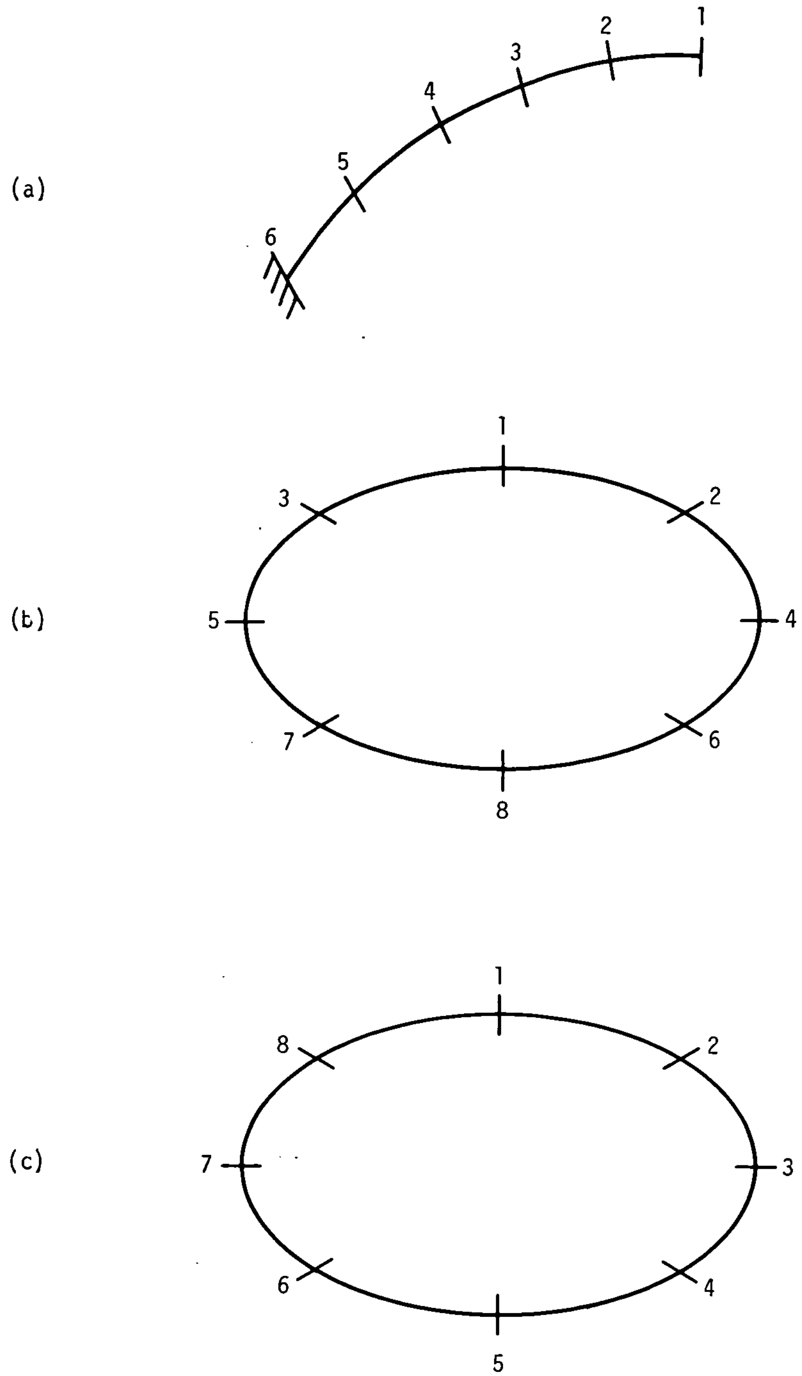

Figure 2. Grid point sequencing for one-dimensional systems.

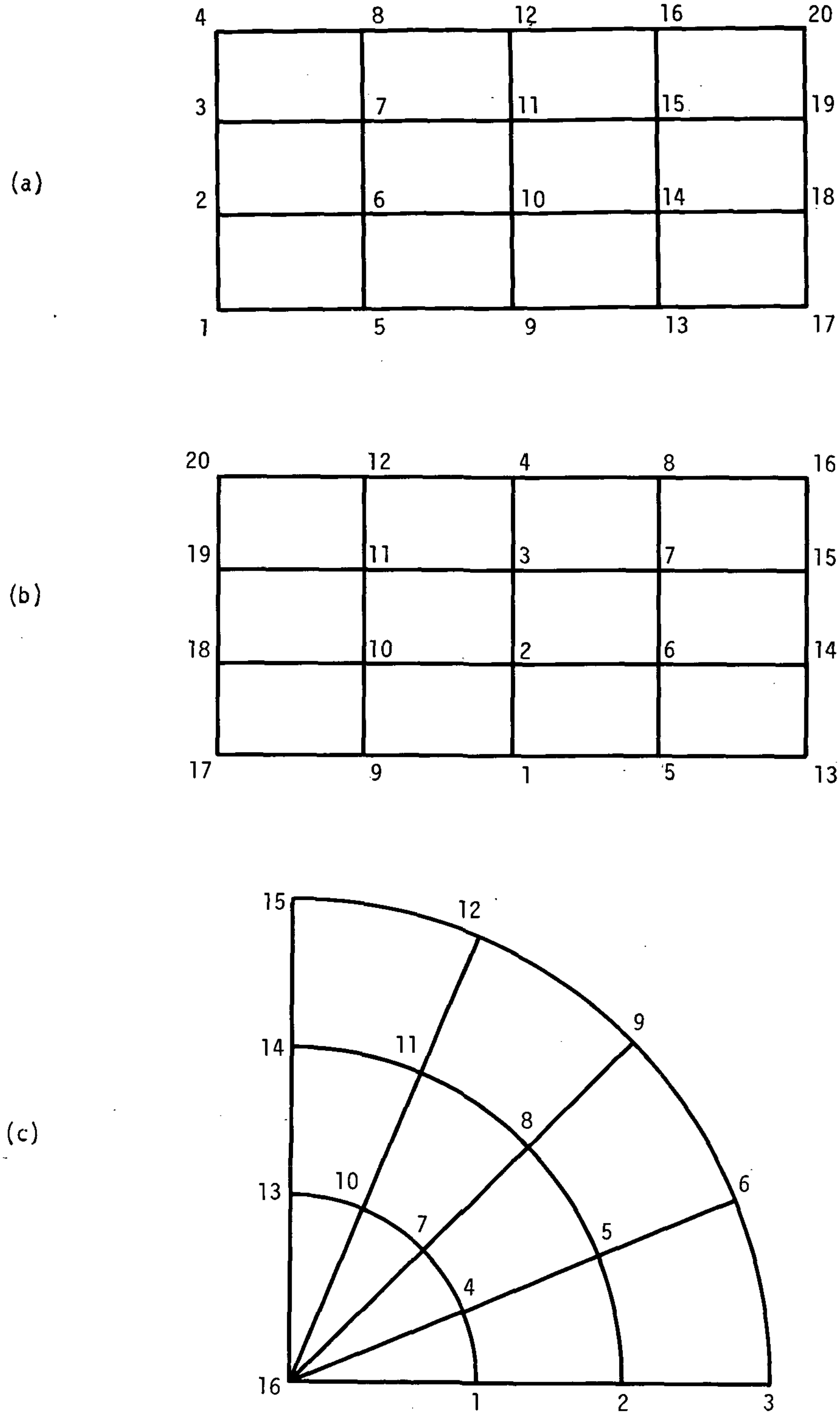

Figure 3. Grid point sequencing for surfaces.

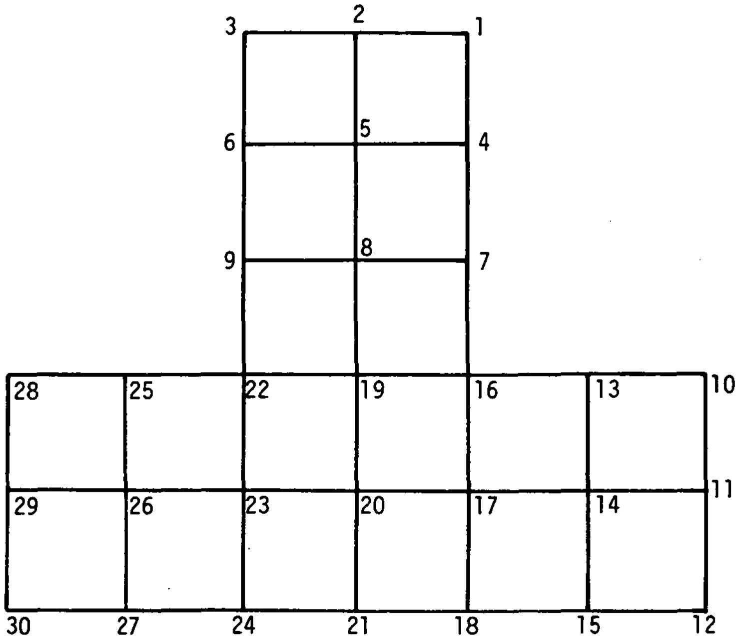

Figure 4. Grid point sequencing for substructures

X	X		X																										
	X	X	0	X																									
		X	0	0	X																								
			X	X	0	X																							
				X	X	0	X																						
					X	0	0	X																					
						X	X	0							X														
							X	X							0			X											
								X							0			0			X								
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																				X	0	0	X						
																					X	X	0	X					
																						X	X	0	X				
																							X	0	0	X			
						(Symmetric)																		X	X	0	X		
																									X	X	0	X	
																										X	0	0	X
																											X	X	0
																												X	X
																													X

Figure 5. Matrix for substructure example

GRID POINTS

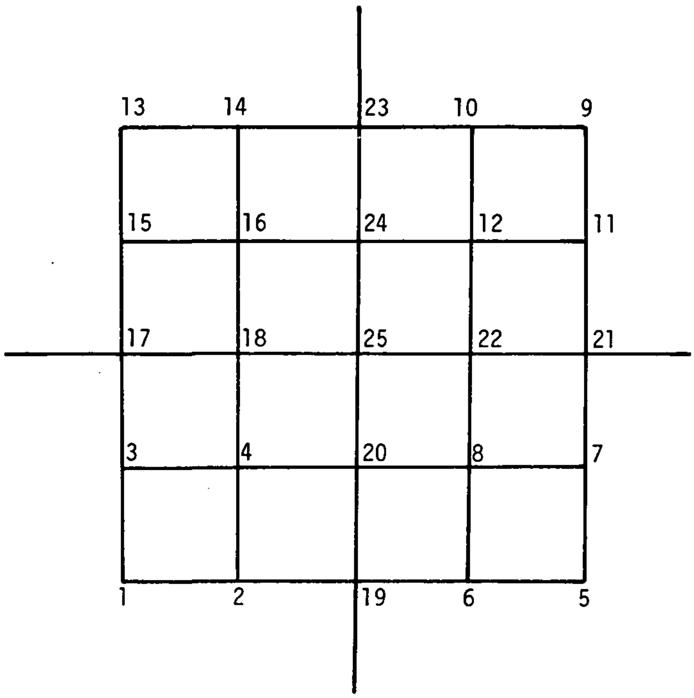

Figure 6. Grid point sequencing for square model

GRID POINTS

```
X X X
  X 0 X                            X
    X X                        X   0
      X                        0 X 0 X
        X X X
          X 0 X                    X
            X X                    0   X
              X                    0 X 0 X
                X X X
                  X 0 X                    X
                    X X                 X  0
                      X                 0 X 0 X
                        X X X
                          X 0 X             X
                            X X X           0
                              X 0 X         0 X
                                X X 0 0
                                  X 0 0     0 0 X
                                    X X 0 0 0 0 0
                                      X 0 0 0 0 X
                                        X X 0 0 0
                                          X 0 0 X
                                            X X 0
        (Symmetric)                           X X
                                                X
```

Figure 7. Matrix for square model example

1.3 STRUCTURAL ELEMENTS

1.3.1 Element Definition

Structural elements are defined on connection cards that identify the grid points to which the element is connected. The mnemonics for all such cards have a prefix of the letter "C", followed by an indication of the type of element, such as CBAR and CRØD. The order of the grid point identification defines the positive direction of the axis of a one-dimensional element and the positive surface of a plate element. The connection cards include additional orientation information when required. Except for the simplest elements, each connection card references a property definition card. If many elements have the same properties, this system of referencing eliminates a large number of duplicate entries.

The property definition cards define geometric properties such as thicknesses, cross-sectional areas, and moments of inertia. The mnemonics for all such cards have a prefix of the letter "P", followed by some, or all of the characters used on the associated connection card, such as PBAR and PRØD. Other included items are the nonstructural mass and the location of points where stresses will be calculated. Except for the simplest elements, each property definition card will reference a material property card.

In some cases, the same finite element can be defined by using different bulk data cards. These alternate cards have been provided for user convenience. In the case of a rod element, the normal definition is accomplished with a connection card (CRØD) which references a property card (PRØD). However, an alternate definition uses a CØNRØD card which combines connection and property information on a single card. This is more convenient if a large number of rod elements all have different properties.

In the case of plate elements, a different property card is provided for each type of element, such as membrane or sandwich plates. Thus, each property card contains only the information required for a single type of plate element, and in most cases, a single card has sufficient space for all of the property information. In order to maintain uniformity in the relationship between connection cards and property cards, a number of connection card types contain the same information, such as the connection cards for the various types of triangular elements. Also, the property cards for triangular and quadrilateral elements of the same type contain the same information.

The material property definition cards are used to define the properties for each of the materials used in the structural model. The MAT1 card is used to define the properties for isotropic materials. The MAT1 card may be referenced by any of the structural elements. The MATS1 card specifies table references for isotropic material properties that are stress dependent. The TABLES1 card defines a tabular stress-strain function for use in Piecewise Linear Analysis. The MATT1 card specifies table references for isotropic material properties that are temperature dependent. The TABLEM1, TABLEM2, TABLEM3, and TABLEM4 cards define four different types of tabular functions for use in generating temperature-dependent material properties.

The MAT2 card is used to define the properties for anisotropic materials. The MAT2 card may only be referenced by triangular or quadrilateral membrane and bending elements. The MAT2 card specifies the relationship between the inplane stresses and strains. The material is assumed to be infinitely rigid in transverse shear. The angle between the material coordinate system and the element coordinate system is specified on the connection cards. The MATT2 card specifies table references for anisotropic material properties that are temperature dependent. This card may reference any of the TABLEM1, TABLEM2, TABLEM3, or TABLEM4 cards.

The MAT3 card is used to define the properties for orthotropic materials used in the modeling of axisymmetric shells. This card may only be referenced by CTRIARG, CTRIAAX, CTRAPRG, CTRAPAX and PTØRDRG cards. The MATT3 card specifies table references for use in generating temperature-dependent properties for this type of material.

The GENEL card is used to define general elements whose properties are defined in terms of deflection influence coefficients or stiffness matrices, and which can be connected between any number of grid points. One of the important uses of the general element is the representation of part of a structure by means of experimentally measured data. No output data is prepared for the general element. Detail information on the general element is given in Section 5.7 of the Theoretical Manual.

Dummy elements are provided in order to allow the user to investigate new structural elements with a minimum expenditure of time and money. A dummy element is defined with a CDUMi (i = index of element type, $1 \le i \le 9$) card and its properties are defined with the PDUMi card. The ADUMi card is used to define the items on the connection and property cards. Detail instructions for coding dummy element routines are given in Section 6.8.5 of the Programmer's Manual.

1.3.2 Bar Element

The bar element is defined with a CBAR card and its properties (constant over the length) are defined with a PBAR card. The bar element includes extension, torsion, bending in two perpendicular planes, and the associated shears. The shear center is assumed to coincide with the elastic axis. Any five of the six forces at either end of the element may be set equal to zero by using the pin flags on the CBAR card. The integers 1 to 6 represent the axial force, shearing force in Plane 1, shearing force in Plane 2, axial torque, moment in Plane 2, and moment in Plane 1, respectively. The structural and nonstructural mass of the bar are lumped at the ends of the elements, unless coupled mass is requested with the PARAM card CØUPMASS (see PARAM bulk data card). Theoretical aspects of the bar element are treated in Section 5.2 of the Theoretical Manual.

STRUCTURAL ELEMENTS

The element coordinate system is shown in Figure 1a. End a is offset from grid point a an amount measured by vector $\vec{w}_a$ and end b is offset from grid point b an amount measured by vector $\vec{w}_b$. The vectors $\vec{w}_a$ and $\vec{w}_b$ are measured in the global coordinates of the connected grid point. The x-axis of the element coordinate system is defined by a line connecting end a to end b of the bar element. The orientation of the bar element is described in terms of two reference planes. The reference planes are defined with the aid of vector $\vec{v}$. This vector may be defined directly with three components in the global system at end a of the bar or by a line drawn from end a to a third referenced grid point. The first reference plane (Plane 1) is defined by the x-axis and the vector $\vec{v}$. The second reference plane (Plane 2) is defined by the vector cross product $(\vec{x} \times \vec{v})$ and the x-axis. The subscripts 1 and 2 refer to forces and geometric properties associated with bending in planes 1 and 2 respectively. The reference planes are not necessarily principal planes. The coincidence of the reference planes and the principal planes is indicated by a zero product of inertia (I_{12}) on the PBAR card. If shearing deformations are included, the reference axes and the principal axes must coincide. When pin flags and offsets are used, the effect of the pin is to free the force at the end of the element x-axis of the beam, not at the grid point. The positive directions for element forces are shown in Figure 1b. The following element forces, either real or complex (depending on the rigid format), are output on request:

1. Bending moments at both ends in the two reference planes.
2. Shears in the two reference planes.
3. Average axial force.
4. Torque about the bar axis.

The following real element stresses are output on request:

1. Average axial stress.
2. Extensional stress due to bending at four points on the cross-section at both ends. (Optional, calculated only if user enters stress recovery points on PBAR card.)
3. Maximum and minimum extensional stresses at both ends.
4. Margins of safety in tension and compression for the whole element. (Optional, calculated only if user enters stress limits on MAT1 card.)

Tensile stresses are given a positive sign and compressive stresses a negative sign. Only the average axial stress and the extensional stresses due to bending are available as complex stresses. The stress recovery coefficients on the PBAR card are used to locate points on the cross-section for stress recovery. The subscript 1 is associated with the distance of a stress recovery point from plane 2. The subscript 2 is associated with the distance from plane 1.

The use of the BARØR card avoids unnecessary repetition of input when a large number of bar elements either have the same property identification number or have their reference axes oriented in the same manner. This card is used to define default values on the CBAR card for the property identification number and the orientation vector for the reference axes. The default values are used only when the corresponding fields on the CBAR card are blank.

1.3.3 Rod Element

The rod element is defined with a CRØD card and its properties with a PRØD card. The rod element includes extensional and torsional properties. The CØNRØD card is an alternate form that includes both the connection and property information on a single card. The tube element is a specialized form that is assumed to have a circular cross-section. The tube element is defined with a CTUBE card and its properties with a PTUBE card. The structural and nonstructural mass of the rod are lumped at the adjacent grid points unless coupled mass is requested with the PARAM card CØUPMASS (see PARAM bulk data card). Theoretical aspects of the rod element are treated in Section 5.2 of the Theoretical Manual).

The x-axis, of the element coordinate system, is defined by a line connecting end a to end b as shown in Figure 2. The axial force and torque are output on request in either the real or complex form. The positive directions for these forces are indicated in Figure 2. The following real element stresses are output on request:

1. Axial stress
2. Torsional stress
3. Margin of safety for axial stress
4. Margin of safety for torsional stress.

Positive directions are the same as those indicated in Figure 2 for element forces. Only the axial stress and the torsional stress are available as complex stresses.

Another kind of rod element is the viscous damper, that has extensional and torsional viscous damping properties rather than stiffness properties. The viscous damper element is defined with a CVISC card and its properties with a PVISC card. This element is used in the direct formulation of dynamic matrices.

1.3.4 Shear Panels and Twist Panels

The shear panel is defined with a CSHEAR card and its properties with a PSHEAR card. A shear panel is a two-dimensional structural element that resists the action of tangential forces applied to its edges, but does not resist the action of normal forces. The structural and nonstructural mass of the shear panel are lumped at the connected grid points. Details of the shear panel element are discussed in Section 5.3 of the Theoretical Manual.

The element coordinate system for a shear panel is shown in Figure 3a. The integers 1, 2,3, and 4 refer to the order of the connected grid points on the CSHEAR card. The element forces are output on request in either the real or complex form. The positive directions for these forces are indicated in Figure 3b. These forces consist of the forces applied to the element at the corners in the direction of the sides, kick forces at the corners in a direction normal to the plane formed by the two adjacent edges, and "shear flows" (force per unit length) along the four edges. The shear stresses are calculated at the corners in skewed coordinates parallel to the exterior edges. The average of the four corner stresses and the maximum stress are output on request in either the real or complex form. A margin of safety is also output when the stresses are real.

The twist panel performs the same function for bending action that the shear panel performs for membrane action. The twist panel is defined with a CTWIST card and its properties with a PTWIST card. In calculating the stiffness matrix, a twist panel is assumed to be solid. For built-up panels, the thickness in the PTWIST card must be adjusted to give the correct moment of inertia of the cross-section. If mass calculations are being made, the density will also have to be adjusted on a MAT1 card. The element coordinate system and directions for positive forces are shown in Figure 4. Stress recovery is similar to that for shear panels.

1.3.5 Plate Elements

NASTRAN includes two different shapes of plate elements (triangular and quadrilateral) and two different stress systems (membrane and bending) which are uncoupled. There are in all a total of eleven different forms of plate elements that are defined by connection cards as follows:

1. CTRMEM - triangular element with finite inplane stiffness and zero bending stiffness.
2. CTRBSC - basic unit from which the bending properties of the other plate elements are formed.
3. CTRPLT - triangular element with zero inplane stiffness and finite bending stiffness.
4. CTRIA1 - triangular element with both inplane and bending stiffness. It is designed for sandwich plates which can have different materials referenced for membrane, bending and transverse shear properties.

5. CTRIA2 - triangular element with both inplane and bending stiffness that assumes a solid homogeneous cross section.

6. CQDMEM - quadrilateral element consisting of four overlapping CTRMEM elements.

7. CQDMEM1 - an isoparametric quadrilateral membrane element.

8. CQDMEM2 - a quadrilateral membrane element consisting of four nonoverlapping CTRMEM elements.

9. CQDPLT - quadrilateral element with zero inplane stiffness and finite bending stiffness.

10. CQUAD1 - quadrilateral element with both inplane and bending stiffness. It is designed for sandwich plates which can have different materials referenced for membrane, bending and transverse shear properties.

11. CQUAD2 - quadrilateral element with both inplane and bending stiffness that assumes a solid homogeneous cross section.

Theoretical aspects of the plate elements are treated in Section 5.8 of the Theoretical Manual.

The properties for the above elements are defined on the PTRMEM, PTRBSC, PTRPLT, PTRIA1, PTRIA2, PQDMEM, PQDMEM1, PQDMEM2, PQDPLT, PQUAD1, and PQUAD2 cards respectively. Anisotropic material may be specified for all plate elements. Transverse shear flexibility may be included for all bending elements on an optional basis, except for homogeneous plates (CTRIA2 and CQUAD2), where this effect is automatically included. Structural mass is calculated only for elements that specify a membrane thickness and is based only on the membrane thickness. Nonstructural mass can be specified for all plate elements, except the basic bending triangle. Only lumped mass procedures are used for membrane elements. Coupled mass procedures may be requested for elements that include bending stiffness with the PARAM card CØUPMASS (see PARAM bulk data card). Differential stiffness matrices are generated for the following plate elements: CTRMEM, CTRIA1, CTRIA2, CQDMEM, CQUAD1, CQUAD2. The following plate elements may have nonlinear material characteristics in Piecewise Linear Analysis: CTRMEM, CTRIA1, CTRIA2, CQDMEM, CQUAD1, CQUAD2.

The element coordinate systems for triangular and quadrilateral plate elements are shown in Figure 5. The integers 1, 2, 3, and 4 refer to the order of the connected grid points on the connection cards defining the elements. The angle θ is the orientation angle for anisotropic materials.

Average values of element forces are calculated for all plate elements having a finite bending stiffness. The positive directions for plate element forces in the element coordinate system are shown in Figure 6a. The following element forces per unit of length, either real or complex, are output on request:

1. Bending moments on the x and y faces.

2. Twisting moment.

3. Shear forces on the x and y faces.

The CQDMEM2 is the only membrane element for which element forces are calculated. The positive directions for these forces are shown in Figure 3b, and the force output has the same interpretation as the force output for the shear panel discussed previously.

Average values of the membrane stresses are calculated for the triangular and quadrilateral membrane elements, with the exception of the CQDMEM1 element. For the CQDMEM1 element, in which the stress field varies, the stresses are evaluated at the intersection of diagonals (in a mean plane if the element is warped). The positive directions for the membrane stresses are shown in Figure 6b. The stresses for the CQDMEM2 element are calculated in the material coordinate system. The material coordinate system is defined by the material orientation angle on the CQDMEM2 card. The stresses for all other membrane elements are calculated in the element coordinate system.

The following real membrane stresses are output on request:

1. Normal stresses in the x and y directions
2. Shear stress on the x face in the y direction
3. Angle between the x-axis and the major principal axis
4. Major and minor principal stresses
5. Maximum shear stress

Only the normal stresses and shearing stress are available in the complex form.

If the plate element has bending stiffness the average stresses are calculated on the two faces of the plate for homogeneous plates and at two specified points on the cross-section for other plate elements. The distances to the specified points are given on the property cards. The positive directions for these fiber distances are defined according to the right-hand sequence of the grid points specified on the connection card. These distances must be nonzero in order to obtain nonzero stress output. The same stresses are calculated for each of the faces as are calculated for membrane elements.

The quadrilateral plate elements are intended for use when the surfaces are reasonably flat and the geometry is nearly rectangular. For these conditions the quadrilateral elements eliminate the modeling bias associated with the use of triangular elements, and quadrilaterals give more accurate results for the same mesh size. If the surfaces are highly warped, curved or swept, triangular elements should be used. Under extreme conditions quadrilateral elements will give results that are considerably less accurate than triangular elements for the same mesh size. Quadrilateral elements should be kept as nearly square as practicable, as the accuracy tends to deteriorate as the aspect ratio of the quadrilateral increases. Triangular elements should be kept as nearly equilateral as practicable, as the accuracy tends to deteriorate as the triangles become obtuse and as the ratio of the longest to the shortest side increases.

1.3.6 Axisymmetric Shell Elements

The properties of axisymmetric shells can be specified with either of two elements, the conical shell (CØNEAX) or the toroidal ring (TØRDRG). However, these cannot be used together in the same model. Also available for thick shells of revolution are the axisymmetric solid elements which are described in the next section.

The properties of the conical shell element are assumed to be symmetrical with respect to the axis of the shell. However, the loads and deflections need not be axisymmetric, as they are expanded in Fourier series with respect to the aximuthal coordinate. Due to symmetry, the resulting load and deformation systems for different harmonic orders are independent, a fact that results in a large time saving when the use of the conical shell element is compared with an equivalent model constructed from plate elements. Theoretical aspects of the conical shell element are treated in Section 5.9 of the Theoretical Manual.

At present the conical shell element cannot be combined with other types of elements. The existence of a conical shell problem is defined by the AXIC card. This card also indicates the number of harmonics desired in the problem formulation. Only a limited number of bulk data cards are allowed when using conical shell elements. The list of allowable cards is given on the AXIC card description in Section 2.4.2.

The geometry of a problem using the conical shell element is described with RINGAX cards instead of GRID cards. The RINGAX cards describe concentric circles about the basic z-axis, with their locations given by radii and z-coordinates as shown in Figure 7. The degrees of freedom defined by each RINGAX card are the fourier coefficients of the motion with respect to angular position around the circle. For example the radial motion, u_r, at any angle, ϕ, is described by the equation:

$$u_r\,(\phi) = \sum_{n=0}^{N} u_r^n \cos n\phi + \sum_{n=0}^{N} u_r^{n*} \sin n\phi \;, \tag{1}$$

where u_r^n and u_r^{n*} are the fourier coefficients of radial motion for the n-harmonic. For calculation purposes the series is limited to N harmonics as defined by the AXIC card. The first sum in the above equation describes symmetric motion with respect to the $\phi = 0$ plane. The second sum with the "starred" (*) superscripts describes the antisymmetric motion. Thus each RINGAX data card will produce six times (N+1) degrees of freedom for each series.

The selection of symmetric or antisymmetric solutions is controlled by the AXISYM card in the Case Control Deck. For general loading conditions, a combination of the symmetric and antisymmetric solutions must be made, using the SYMCØM card in the Case Control Deck (Section 2.3 of the User's Manual).

Since the user is rarely interested in applying his loads in terms of Fourier harmonics and interpreting his data by manually performing the above summations, NASTRAN is provided with special cards which automatically perform these operations. The PØINTAX card is used like a GRID card to define physical points on the structure for loading and output. Sections of the circle may be defined by a SECTAX card which defines a sector with two angles and a referenced RINGAX card. The PØINTAX and SECTAX cards define six degrees of freedom each. The basic coordinate system for these points is a cylindrical system (r, ϕ, z) and their applied loads must be described in this coordinate system. Since the displacements of these points are dependent on the harmonic motions, they may not be constrained in any manner.

The conical shell element is connected to two RINGAX points with a CCØNEAX card. The properties of the conical shell element are described on the PCØNEAX card. The RINGAX points must be placed on the neutral surface of the element and the points for stress calculation must be given on the PCØNEAX card relative to the neutral surface. Up to fourteen angular positions around the element may be specified for stress and force output. These values will be calculated midway between the two connected rings.

The structure defined with RINGAX and CCØNEAX cards must be constrained in a special manner. All harmonics may be constrained for a particular degree of freedom on a ring by using permanent single-point constraints on the RINGAX cards. Specified harmonics of each degree of freedom on a ring may be constrained with a SPCAX card. This card is the same as the SPC card except that a harmonic must be specified. The MPCAX, ØMITAX, and SUPAX data cards correspond the the MPC, ØMIT, and SUPØRT data except that harmonics must be specified. SPCADD and MPCADD cards may be used to combine constraint sets in the usual manner.

The stiffness matrix includes five degrees of freedom per grid circle per harmonic when transverse shear flexibility is included. Since the rotation about the normal to the surface is not included, either the fourth or the sixth degree of freedom (depending upon the situation) must be constrained to zero when the angle between the meridional generators of two adjacent elements is zero. When the transverse shear flexibility is not included, only four independent degrees of freedom are used and the fourth and sixth degrees of freedom must be constrained to zero for all rings. These constraints can be conveniently specified on the RINGAX card.

The conical shell structure may be loaded in various ways. Concentrated forces may be described by FØRCE and MØMENT cards applied to PØINTAX points. Pressure loads may be input in the PRESAX data card which defines an area bounded by two rings and two angles. Temperature fields are described by a paired list of angles and temperatures around a ring as required by the TEMPAX card. Direct loads on the harmonics of a RINGAX point are given by the FORCEAX and MØMAX card. Since the basic coordinate system is cylindrical the loads are given in the r, ϕ, and z directions. The value of a harmonic load F_n is the total load on the whole ring of radius r. If a sinusoidal load per unit length of maximum value a_n is given, the value on the FØRCEAX card must be

$$F_n = 2\pi \; r \, a_n \qquad n = 0 , \tag{2}$$

$$F_n = \pi \, r \; a_n \qquad n > 0 . \tag{3}$$

Displacements of rings and forces in conical shell elements can be requested in two ways:

1. The harmonic coefficients of displacements on a ring or forces in a conical element.
2. The displacements at specified points or the average value over a specified sector of a ring. The forces in the element at specified azimuths or average values over specified sectors of a conical element.

Harmonic output is requested by ring number for displacements and conical shell element number for element forces. The number of harmonics that will be output for any request is a constant for any single execution. This number is controlled by the HARMØNICS card in the Case Control Deck (see Section 2.3).

The following element forces per unit of width are output either as harmonic coefficients or at specified locations on request:

1. Bending moments on the u and v faces
2. Twisting moments
3. Shearing forces on the u and v faces

The following element stresses are calculated at two specified points on the cross-section of the element and output either as harmonic coefficients or at specified locations on request:

1. Normal stresses in u and v directions
2. Shearing stress on the u face in the v direction

3. Angle between the u-axis and the major principal axis
4. Major and minor principal stresses
5. Maximum shear stress

The coordinate system for the toroidal ring is shown in Figure 8. This cylindrical coordinate system is implied by the use of the toroidal element, and hence, no explicit definition is required. The toroidal element may use orthotropic materials. The axes of orthotropy are assumed to coincide with the element coordinate axes.

Deformation behavior of the toroidal element is described by five degrees of freedom for each of the two grid rings which it connects. The degrees of freedom in the implicit coordinate system are:

1. $\bar{u}$ - radial displacement
2. Not defined for toroidal element (must be constrained)
3. $\bar{w}$ - axial displacement
4. $w' = \frac{\partial w}{\partial \xi}$ slope in ξ-direction
5. $u' = \frac{\partial u}{\partial \xi}$ strain in ξ-direction
6. $w'' = \frac{\partial^2 w}{\partial \xi^2}$ curvature in $z\xi$-plane

The displacements $\bar{u}$ and $\bar{w}$ are in the basic coordinate system, and hence can be expressed in other local coordinate systems if desired. However, the quantities u', w' and w" are always in the element coordinate system.

The toroidal ring element connectivity is defined with a CTØRDRG card and its properties with a PTØRDRG card and, in the limit, this element becomes a cap element (see Section 5.10 of the Theoretical Manual). The integers 1 and 2 on Figure 8 refer to the order of the connected grid points on the CTØRDRG card. The grid points must lie in the r-$\bar{z}$ plane of the basic coordinate system and they must lie to the right of the axis of symmetry. The angles α_1 and α_2 in Figure 8 are the angles of curvature and are defined as the angle measured in degrees from the axis of symmetry to a line which is perpendicular to the tangent to the surface at grid points 1 and 2 respectively. For conic rings $\alpha_1 = \alpha_2$ and for cylindrical rings $\alpha_1 = \alpha_2 = 90$ degrees. Toroidal elements may be connected to form closed figures in the r-$\bar{z}$ plane, but slope discontinuities are not permitted at connection points.

The following forces, evaluated at each end of the toroidal element, are output on request:

1. Radial force
2. Axial force
3. Meridional moment
4. A generalized force which corresponds to the w' degree of freedom.
5. A generalized force which corresponds to the w" degree of freedom.

The first three forces are referenced to the global coordinate system and the two generalized forces are referenced to the element coordinate system. For a definition of the generalized forces see Section 5.10 of the Theoretical Manual.

The following stresses, evaluated at both ends and the midspan of each element, are output on request:

1. Tangential membrane stress (Force per unit length)
2. Circumferential membrane stress (Force per unit length)
3. Tangential bending stress (Moment per unit length)
4. Circumferential bending stress (Moment per unit length)
5. Shearing stress (Force per unit length)

The positive directions for these stresses are indicated in Figure 9.

1.3.7 Axisymmetric Solid Elements

Two sets of elements are provided for representing thick axisymmetric shell and/or solid structures (see Section 5.11 of the Theoretical Manual). The first set, the triangular ring TRIARG and trapezoidal ring TRAPRG, is restricted to axisymmetric applied loadings only. The second set is not restricted to axisymmetric loadings and, like the conical shell element, their displacements and loads are represented by coefficients of a Fourier series about the circumference. These elements, the TRIAAX and the TRAPAX, also define a triangular and a trapezoidal cross section respectively. The elements of one set may not be used together with elements of the other set nor with any other elements in NASTRAN.

The triangular and trapezoidal ring elements may be used for modeling axisymmetric thick-walled structures of arbitrary profile. In the limiting case only the TRAPRG element may become a solid core element.

The coordinate system for the triangular ring element is shown on Figure 10. The cylindrical system is implied by the use of the triangular ring element. Hence, no explicit definition of the basic cylindrical coordinate system is required. Cylindrical anisotropy is optional for the material properties in the ring element. Orientation of the orthotropic axes in the (r,z) plane is specified by the angle θ. Deformation behavior of the element is described in terms of translations in the r and z directions at each of the 3 connected grid points. All other degrees of freedom must be constrained.

The triangular ring element is defined with a CTRIARG card. No property card is used for this element. The material property reference is given on the connection card. The integers 1, 2 and 3 on Figure 10 refer to the order of the connected grid points on the CTRIARG card. This order must be counter-clockwise around the element. The grid points must lie in the r-z plane of the basic cylindrical coordinate system, and they must lie to the right of the axis of symmetry.

The radial and axial forces at each connected grid point are output on request. The positive directions for these forces are shown in Figure 10. These are apparent element forces and they include any equivalent thermal loads. The stresses at the centroid of an element are output on request. The available quantities are the normal stresses in the radial, circumferential and axial directions, and the shear stress on the radial face in the axial direction. Positive stresses are in the positive direction on the positive face.

The coordinate system for the trapezoidal ring element is shown in Figure 11. This element is similar to the triangular ring element. This element has the additional restriction that the element numbering must begin at the lower left hand corner of the element. Also, the parallel faces of the trapezoid must be perpendicular to the axis of symmetry. This element can be used in the limiting case where the r coordinates associated with grid points 1 and 4 are zero. In this special case the element is referred to as a core element.

The trapezoidal ring element is defined with a CTRAPRG card in a manner similar to that for a triangular element. The forces at the four connected grid points are provided on request in a manner similar to that for a triangular element. In addition to providing the stresses at the four connected grid points of the trapezoid, similar stresses are provided at a point of average radius and average z-distance from the four points.

The two solid of revolution elements which are provided for representing nonaxisymmetric loadings on axisymmetric structures with thick or solid cross sections are the TRIAAX and TRAPAX elements. These define a triangle and a trapezoidal cross section of the structure. They are functionally similar to the conical shell element (see Section 1.3.6) and physically similar to the axisymmetric ring elements CTRAPRG and CTRIARG described above (see Figures 10 and 11).

The elements are connected to RINGAX points which define displacement degrees of freedom represented by coefficients of a Fourier series about the circumference. Due to symmetry, the resulting load and deformation systems for the different harmonic orders are uncoupled, resulting in large time savings compared to a general three-dimensional model. Theoretical aspects of the solid of revolution elements are treated in Section 5.11 of the Theoretical Manual. Definitions of the Fourier series representation of the structural displacements and loads are given in Section 5.9 of the Theoretical Manual. As in the conical shell formulation, no other element types may be combined with these elements.

The following special case control cards, used also with the conical shell problem, are used with the solid of revolution elements:

AXISYM - Defines whether the cosine series, sine series or combination of displacements are to be calculated.

HARMØNICS - Limits the output to all harmonics up to and including the n^{th} harmonic, default is 0.

The geometry of a problem using these elements is defined by the RINGAX cards. The harmonic limit in the Fourier expansion is defined by the <u>required</u> AXIC card. The RINGAX card does not allow a zero radius. However, a small "hole" may be defined around the axis of revultion. To avoid inaccuracies, a warning is issued for each element whose inner radius is less than one-tenth its outer radius. Property cards PTRAPAX and PTRIAAX are used to identify the material and the circumferential locations for stress output. The material type is limited to MAT1 and MAT3 definitions. The following bulk data cards, also used with the conical shell elements, are available with the solid of revolution elements:

AXIC - Defines limit of displacement Fourier series.

SPCAX - Defines single point constraints and enforced displacements on specified degrees of freedom.

MPCAX - Defines multipoint constraints connecting specified degrees of freedom.

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ØMITAX - Defines degrees of freedom to be removed by structural partitioning.

SUPAX - Defines free-body support points.

PØINTAX - Defines circumferential location on a RINGAX station for applied loading and/or output.

SECTAX - Defines a circumferential sector on a RINGAX station for distributed applied forces.

FØRCE - Defines a concentrated force at a PØINTAX or load per length at a SECTAX location on the structure.

FØRCEAX - Defines a generalized force directly on a specified harmonic of a RINGAX station.

PRESAX - Defines a pressure load.

TEMPAX - Defines a temperature distribution at a RINGAX point for thermal loading and temperature-dependent matrices.

The basic coordinate system for the solid of revolution elements is a cylindrical coordinate system (r, ϕ, z). The rotational degrees of freedom (components 4, 5 and 6) must be constrained.

The output quantities for the RINGAX points are the displacement coefficients for each harmonic. The output for the PØINTAX degrees of freedom are the sum of the harmonics giving the physical displacements at the point while output for SECTAX points are the average displacements over the circumferential sector. These quantities are available only in SØRT1 format.

The stress output for these elements is similar to that for the TRIARG and TRARPRG elements described above. However, since the stresses vary around the circumference, each element output includes the Fourier coefficients of stress for each harmonic followed by the stresses at the angular locations specified on the property card. Stresses are calculated at the centroid of the cross section on the TRIAAX element. Stresses are calculated at the four corners as well as at a fifth "grid point" on the TRAPAX element, which is located an average radius and average length from the four corner points.

1.3.8 Scalar Elements

Scalar elements are connected between pairs of degrees of freedom (at either scalar or geometric grid points) or between one degree of freedom and ground. Scalar elements are available as springs, masses and viscous dampers. Scalar spring elements are useful for representing elastic properties that cannot be conveniently modeled with the usual metric structural elements. Scalar masses are useful for the selective representation of inertia properties, such as occurs when a concentrated mass is effectively isolated for motion in one direction only. The scalar damper is used to provide viscous damping between two selected degrees of freedom or between one degree of freedom and ground. It is possible, using only scalar elements and constraints, to construct a model for the linear behavior of any structure. However it is expected that these elements will be used only when the usual metric elements are not satisfactory. Scalar elements are useful for modeling part of a structure with its vibration modes or when trying to consider electrical or heat transfer properties as part of an overall structural analysis. The reader is referred to Sections 5.5 and 5.6 of the Theoretical Manual for further discussions on the use of scalar elements.

The most general definition of a scalar spring is given with a CELAS1 card. The associated properties are given on the PELAS card. The properties include the magnitude of the elastic spring, a damping coefficient, and a stress coefficient to be used in stress recovery. The CELAS2 defines a scalar spring without reference to a property card. The CELAS3 card defines a scalar spring that is connected only to scalar points and the properties are given on a PELAS card. The CELAS4 card defines a scalar spring that is connected only to scalar points and without reference to a property card. No damping coefficient or stress coefficient is available with the CELAS4 card.

Scalar elements may be connected to ground without the use of constraint cards. Grounded connections are indicated on the connection card by leaving the appropriate scalar identification number blank. Since the values for scalar elements are not functions of material properties, no references to such cards are needed.

The CDAMP1, CDAMP2, CDAMP3 and CDAMP4 cards define scalar dampers in a manner similar to the scalar spring definitions. The associated PDAMP card contains only a value for the scalar damper.

1.3.9 Mass

Inertia properties are specified directly as mass elements attached to grid points and indirectly as the properties of matrix structural elements. In addition, dynamic analysis mass matrix coefficients may be specified that are directly referred to the global coordinate system. Some portions of the mass matrix are generated automatically while other portions are not. Mass data may be assembled according to two different kinds of relationships: lumped mass assumptions or coupled mass considerations. Additional information on treatment of inertia properties is given in Section 5.5 of the Theoretical Manual.

1.3.9.1 Lumped Mass

The partitions of the lumped mass matrix are explained in Section 5.5.3 of the Theoretical Manual, but to aid the user the form is repeated here in Equation 1.

$$M = \left[\begin{array}{c|c} \text{Scalar} & \begin{array}{c}\text{1st}\\ \text{Moment}\end{array} \\ \hline \begin{array}{c}\text{1st}\\ \text{Moment}\end{array} & \begin{array}{c}\text{2nd}\\ \text{Moment}\end{array} \end{array}\right] = \left[\begin{array}{c:c} m_{ij} & N_{ij} \\ \hdashline N_{ij}^{T} & I_{ij} \end{array}\right] \qquad (1)$$

The only portion of the lumped mass matrix that is automatically generated is the scalar partition. This implies that no first moment and second moment terms for the lumped mass matrix are automatically generated. In this context, automatic generation means the calculation of the mass from the structural elements that are connected to a given grid point, solely from the information provided on the element connection and property card. All of the metric structural elements (rods, bars, shear panels, twist panels, plates, and shell elements) may have uniformly distributed structural and nonstructural mass. Structural mass is calculated from material and goemetric properties. The mass is assumed to be concentrated in the middle surface or along the neutral axis in the case of rods and bars, so that rotary inertia effects, including the torsional inertia of beams, are absent.

In the lumped mass method, the mass of an element is simply divided into equal portions and each portion is assigned to only one of the surrounding grid points. Thus, for uniform rods and bars, one-half of the mass is placed at each end; for uniform triangles, one-third of the mass is placed at each corner; quadrilaterals are treated as two pairs of overlapping triangles (see the Theoretical Manual Sections 5.3 and 5.8). The lumped mass matrix is independent of the elastic properties of elements. There are no other automatic routines for providing mass terms for the lumped mass approach.

1.3.9.2 Coupled Mass

In the coupled mass approach, properties of mass pertaining to a single structural element include off-diagonal coefficients that couple action at adjacent grid points. For further amplification of the techniques used in the coupled mass approach see Section 5.5.3 of the Theoretical Manual. To invoke the automatic generation of the coupled mass matrix, the parameter CØUPMASS is indicated on the PARAM card. If selected coupled mass properties are desired only for certain element types, this is obtained by a second parameter call specifying the element. For further details see the PARAM bulk data card. When using CØUPMASS, the nonzero terms are generated in off-diagonal positions of the mass matrix corresponding generally to nonzero terms of the stiffness matrix. This implies that a mass matrix generated by the coupled mass approach will generally have a density and topology equivalent to that of the stiffness matrix.

Off-diagonal mass terms may also be created during Guyan reduction when the ØMIT or ASET bulk data cards are used to condense the stiffness and mass matrices. Any mass associated with the omitted degrees of freedom will be redistributed to the remaining degrees of freedom forming a coupled mass matrix. The use of multipoint constraints (MPC cards) with mass terms on the dependent degrees of freedom produces a similar effect. The mass on the dependent coordinate will be transformed to the connected independent coordinates, thereby coupling them together. Mathematically, these operations and the element coupled mass formulations described above are closely related.

1.3.9.3 Mass Input

In many cases it may be desired to add mass terms to the structure in addition to those generated by the structural elements. For instance, in a lumped mass formulation any additional masses involving rotational degrees of freedom must be independently calculated and input manually via bulk data cards.

The concentrated mass elements CØNM1 and CØNM2 may be used to add mass terms directly to a single grid point. The CØNM2 element is used to specify a rigid body with mass and inertia properties that is connected to a single grid point (offsets are allowed). The CONM1 element has a more general input format to allow directional mass terms.

The notation on the CONM1 card is explicit, that is, subscripting of each term spans the degree of freedom range from 1 through 6. On the CØNM2 card, double subscripting is used only for the second moment partition. Therefore, the correspondence for symbols between CØNM1 entries and CØNM2 entries for the second moment partition is as follows: I_{11}, I_{21}, I_{22}, I_{31}, I_{32} and I_{33} on the CØNM2 card (defined in Theoretical Manual section 5.5.2.2 by the integrals of Equations 13, 14 and 15) correspond to M_{44}, M_{54}, M_{55}, M_{64}, M_{65} and M_{66} on CØNM1 ($M_{54} = -I_{xy}$, $M_{64} = -I_{xz}$, $M_{65} = -I_{yz}$) with sign changes on the off-diagonal terms as shown in Equation 10 of the referenced section. The program multiplies each cross product of inertia term from CØNM2 user data by (-1) before assembling this data into the mass matrix, to make it correspond to the requirements of Equation 10.

An alternative to specifying mass information for the lumped mass method is to use the CMASSi and the PMASSi cards. This allows the option of treating mass as finite elements, one degree of freedom at a time. A particularly advantageous feature of the CMASSi card is the ability to couple mass terms between grid points and/or scalar points. When dynamic rigid formats are used, the direct matrix input (DMIG) may be used to supply grid point mass data. When mass information is entered via DMIG cards, it will remain dormant until activated by a call from Case Control via the M2PP card.

When a DMAP sequence is used or a rigid format is ALTERed, another form is available for presenting mass information via the DMI card. The DMI card is not recognized as a ligitimate source of bulk data for the rigid formats, unless an ALTER is used.

In all cases a combination of mass input can be used. For instance, the translational inertias can be generated automatically by the element routines, while the first and second moment properties can be provided through CØNM2 cards. Some elements can be used to provide coupled mass properties through the CØUPMASS parameter, while other contributions to the same grid points can be made by direct matrix input through DMIG cards. The information from these several sources will be summed in the formation of the final mass matrix.

1.3.9.4 Output from the Grid Point Weight Generator

The Grid Point Weight Generator (GPWG) module computes the rigid body mass properties of an entire structure with respect to a user specified point and with respect to the center of mass.

Output from the module is requested by a PARAM card in the Bulk Data Deck which specifies from which grid point mass computations are to be referenced. Optionally, the absence of a specific grid point automatically causes the origin of the basic coordinate system to be utilized as a reference. The mass properties are initially defined in the basic coordinate system. Subsequently, the mass properties are transformed to principal mass axes and to principal inertia axes. The actual printout is composed of several elements. These are

1. Title MØ

   This is the rigid body mass matrix of the entire structure in the basic coordinate system with respect to a reference point chosen by the analyst.

2. Title S

   S is the transformation from the basic coordinate system to the set of principal axes for the 3 x 3 scalar mass partition of the 6 x 6 mass matrix. The principal axes for just the scalar partition are known as the principal mass axes.

3. Title X-C.G. Y-C.G. Z-C.G.

   It is possible in NASTRAN to assemble a structural model having different values of mass in each coordinate direction at a grid point. This can arise for example assembling scalar mass components or from omitting some components by means of bar element pin flags. Consequently three distinct mass systems are assembled one in each of the three directions of the principal mass axes (the S system). This third tabulation has five columns. The first column lists the axis direction in the S coordinates. The second column lists the mass associated with the appropriate axis direction. The final three columns list the x, y, and z coordinate distances from the reference point to the center of mass for each of the three mass systems.

4. Title I(S)

   This is the 3 x 3 mass moment of inertia partition with respect to the center of gravity referred to the principal mass axes (the S system). This is not necessarily a diagonal matrix because the determination of the S system does not involve second moments. The values of inertias at the center of gravity are found from the values at the reference point by employing the parallel axes rule.

5. Title I(Q)

The principal moments of inertia at the center of gravity are displayed in matrix form with reference to the Q system of axes. The Q system is obtained from an eigenvalue analysis of the I(s) matrix.

6. Title Q

Q is the coordinate transformation between the S axes and the Q axes.

1.3.9.5 Bulk Data Cards for Mass

A summary chart is given in Table 1 to help in the selection of the method of input for a given type of mass information. Descriptions of individual cards for the entering of mass information into the bulk data are listed here:

1. Element data from the combined sources of C(-), P(-), and MATi cards will automatically cause the translational mass (scalar) terms of the mass matrix to be generated, provided a density value and/or a nonstructural density factor is entered.
2. The MASSi cards define scalar masses. CMASSi cards define connections between a pair of degrees of freedom (at either scalar or geometric grid points) or between one degree of freedom and ground. Thus, $f_1 = m(x_1 - x_2)$ where x_2 may be absent. The CMASS1 cards (i = 1 through 4) are necessary whenever scalar points are used. PMASSi cards define mass property magnitudes. Other applications include selective representations of inertia properties, such as occur in shell theory where in-plane inertia forces are often ignored.
3. The CØNM2 card defines the properties of a solid body: m, its mass, x_1, x_2, x_3, the three coordinates of its center of gravity offset with respect to the grid point, I_{11}, I_{22}, I_{33}, its three moments of inertia and I_{12}, I_{13}, I_{23}, and its three products of inertia, all with respect to any (selected) coordinate system. If a local cylindrical or a sphrical coordinate system is chosen to define the mass properties, the offset distances of the mass c.g. from the grid point are measured along the axes(r,θ,z or ρ,θ,Φ) defined at the grid point in that local system. Also note, that the mass properties of inertia are computed relative to a set axes at the mass c.g. which are <u>parallel</u> to those r,θ,z or ρ,θ,ϕ axes at that grid point. The CØNM2 element routine uses the parallel axis theorem to

transform inertias with respect to the center of gravity to inertias with respect to the grid point. Section 5.5.2.1 of the Theoretical Manual describes how to treat the signs of cross products of inertia terms on CØNM2 cards.

4. The CØNM1 card defines a 6 x 6 matrix of mass coefficients at a geometric grid point in any selected coordinate system. Since the only restrictions are that the matrix be real and symmetric, there are 21 possible independent coefficients. The CØNM1 card therefore permits somewhat more general inertia relationships than those of a solid body which has only 10 independent inertia properties. This should be remembered in applications requiring unique centers of gravity, such as in the calculation of centrifugal forces. See Section 5.5.2.5 of the Theoretical Manual for a discussion of inertia properties resulting from CØNM1 card input.
5. The DMIG (or DMIGAX for axisymmetric structures) card accomodates matrix entries by grid point and component. This is a general card that can be used for mass, stiffness, or damping matrices. It becomes particularized to mass when the name given to the matrix is called by an M2PP card in Case Control. Data defined by this card will be recognized as admissible only when used with dynamic rigid formats 7 through 12.
6. The DMI card is used to assign values according to row-column positions in a matrix. This is a general card for any kind of matrix which becomes particularlized to mass when the name given to the matrix is called from a DMAP statement. Data defined by this card will be recognized as admissible only when used in a DMAP sequence or in an ALTER to a rigid format.
7. The COUPMASS entry on the PARAM card will activate the "consistent" mass matrix algorithms in the element routines which generate mass coupling properties between grid points. There are three options available to regulate whether the coupling properties are generated for all or some types of elements (see PARAM bulk data card). A set of entries for a second PARAM card of the form CP(element name) are available for use in connection with CØUPMASS for selecting the element types for which coupling terms will be computed.
8. The ØMIT (or ØMIT1, or ØMITAX for axisymmetric structures, or ASET for obverse operations) card will cause the initially-generated mass matrix to be condensed from the omitted degrees of freedom to the remaining degrees of freedom. The condensing process generally produces a mass term in every matrix position in which there is a nonzero stiffness term in the corresponding reduced stiffness matrix.

9. The GRDPNT entry on the PARAM card will activate the Grid Point Weight Generator (GPWG) module previously discussed. It will treat the mass properties of the entire structure as though the structure were rigid and it will determine the translational (scalar) mass properties, the first and second moment properties of the rigid body structure and the center of gravity distances with respect to the user specified reference grid points. It also computes the 6 x 6 matrix of mass properties with respect to the center of mass and the orientation of the principal mass axes.

Table 1. Bulk Data Card Choices for Mass Properties Versus Method of Mass Representation.

Representation Method / Mass Property	Lumped				Coupled		Grid Point Weight Generator (Total Structure)
	Automatic	Manual			Automatic	Manual	
		All R.F.'s	R.F.'s 7, 8, 9	DMAP or R.F. ALTER			
Translational Mass (Scalar)	Element Routines C (element) + P (element) + MATi for structural and nonstructural contributions	MASSi CØNM1 CØNM2	MASSi CØNM1 CØNM2 DMIG DMIGAX	DMI	PARAM COUPMASS + PARAM CP (element) ØMIT ØMIT1 ØMITAX ASET	DMIG DMIGAX	PARAM GRDPNT
First Moment		MASSi CØNM1 CØNM2	MASSi CØNM1 CØNM2 DMIG DMIGAX	DMI			
Second Moment		MASSi CØNM1 CØNM2	MASSi CØNM1 CØNM2 DMIG DMIGAX	DMI			
All Order Moments and Off-Diagonal Properties Between Grid Points					PARAM COUPMASS + PARAM CP (element) ØMIT ØMIT1 ØMITAX ASET	DMIG DMIGAX	

1.3.10 Solid Polyhedron Elements

Three types of solid polyhedron elements are provided for the general solid structures (see Section 1.3.7 for axisymmetric structures with axisymmetric loads). These elements (see Figure 12) are a tetrahedron, a wedge and a hexahedron. The theory is given in Section 5.12 of the Theoretical Manual. These elements can be used with all other NASTRAN elements, except the axisymmetric elements. Connections are made only to displacement degrees of freedom at the grid points.

The elements are defined by CTETRA, CWEDGE, CHEXA1, and CHEXA2 connection cards. The user should specify grid locations such that the quadrilateral faces are nearly planar. No special element coordinate system is required. The only properties required are material properties, thus no PID card is referenced; direct reference is made to a MID card. For thermal stress problems, the temperature is assumed to be the average of the connected grid points. Differential stiffness, buckling, and piecewise linear analyses have not been implemented.

The output stresses are given in the basic coordinate system. In addition to the six normal and shear stresses, output also includes the pressure

$$p_o = -\frac{1}{3}(\sigma_x + \sigma_y + \sigma_z)$$

and the octahedral stress

$$\sigma_o = \frac{1}{3}\left[(\sigma_x - \sigma_y)^2 + (\sigma_y - \sigma_z)^2 + (\sigma_z - \sigma_x)^2 + 6\tau_{yz}^2 + 6\tau_{zx}^2 + 6\tau_{xy}^2\right]^{1/2}$$

The stresses in the tetrahedra are constant. The stresses in the wedge and the hexahedron are obtained as the weighted average of the stresses in the subtetrahedra. The weighting factor for each tetrahedra is proportional to its volume.

1.3.11 Isoparametric Solid Hexahedron Elements

Three types of isoparametric solid hexahedron elements are provided for general solid structures. These elements (see Figure 13) are a linear, a quadratic, and a cubic isoparametric hexahedron. The theory is given in Section 5.13 of the Theoretical Manual. These elements can be used with all other NASTRAN elements, except the axisymmetric elements. Connections are made only to the translational degrees of freedom at the grid points. The elements are defined by CIHEX1, CIHEX2, and CIHEX3 connection cards. All three of these cards reference the PIHEX property card.

The isoparametric solid hexahedron elements allow the user to accurately define a structure with fewer elements and grid points than might otherwise be necessary with simple constant strain solid elements. The linear element generally gives best results for problems involving mostly shear deformations, and the higher order elements give good results for problems involving both shearing and bending deformations. Only a coupled mass matrix is generated to retain the inherent accuracy of the elements. Temperature, temperature-dependent material properties, displacements, and stresses may vary through the volume of the elements. The values at interior points of the element are interpolated using the isoparametric shape function. For best results, the applied grid point temperatures should not have more than a "gentle" quadratic variation in each of the three dimensions of the element. If the element has non-uniform applied temperatures, or if it is not a rectangular parallelopiped, three or more integration points should be specified on the PIHEX card. Severely distorted element shapes should be avoided.

Stiffness, mass, differential stiffness, structural damping, conductance, and capacitance matrices may be generated with these elements. Piecewise linear analysis has not been implemented.

The output stresses are given in the basic coordinate system. The stresses are assumed to vary through the element. Therefore, stresses are computed at the center and at each corner grid point of these elements. For the quadratic and cubic elements, they are also computed at the midpoint of each edge of the element. In addition to the six normal and shear stresses, output also includes the principal stresses (S_x, S_y, and S_z), the direction cosines of the principal planes, the mean stress

$$\sigma_n = -\frac{1}{3}(\sigma_x + \sigma_y + \sigma_z) \quad ,$$

and the octahedral shear stress

$$\sigma_o = \left\{\frac{1}{3}\left[(S_x + \sigma_n)^2 + (S_y + \sigma_n)^2 + (S_z + \sigma_n)^2\right]\right\}^{1/2} \quad .$$

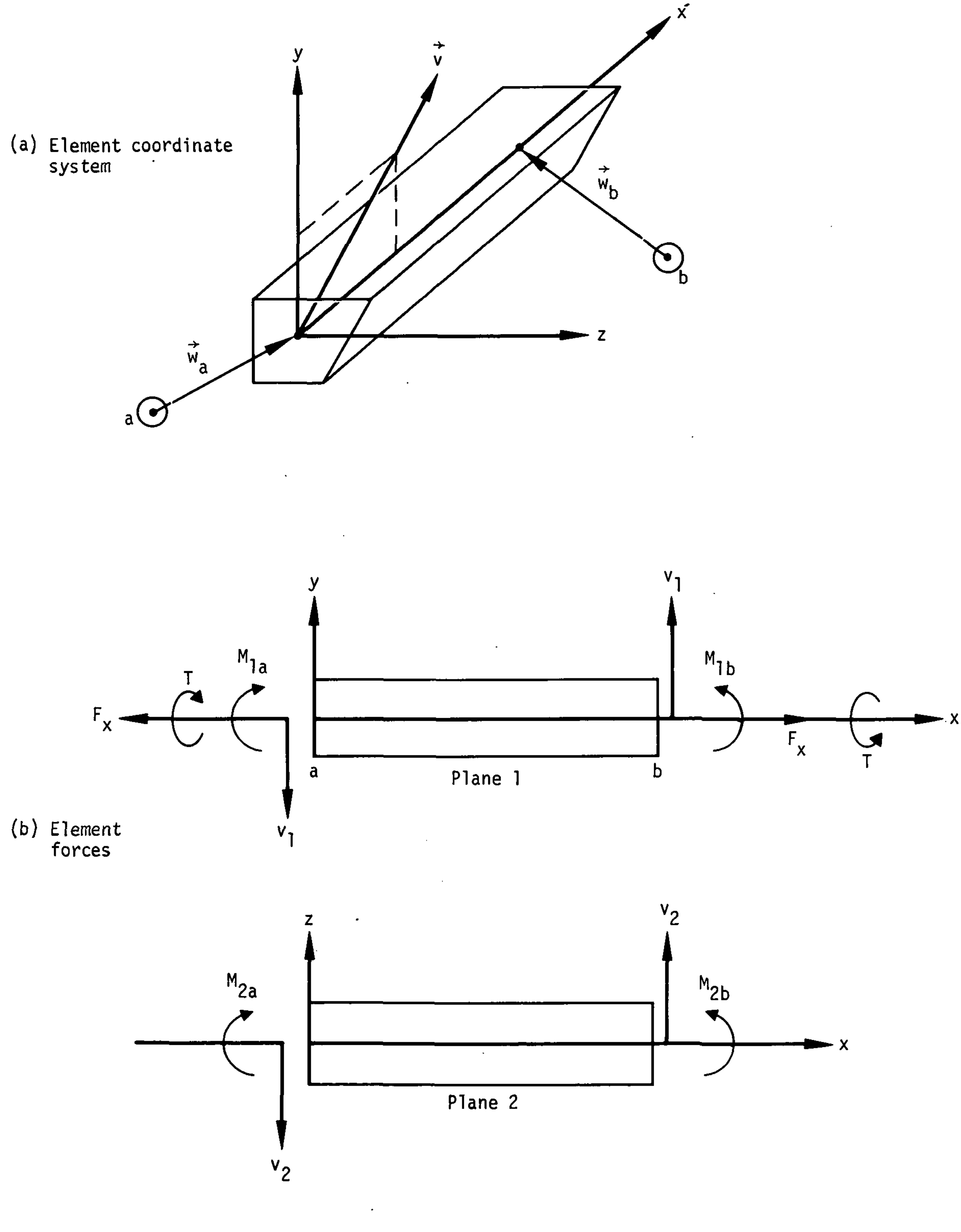


Figure 1. Bar element coordinate system and element forces.

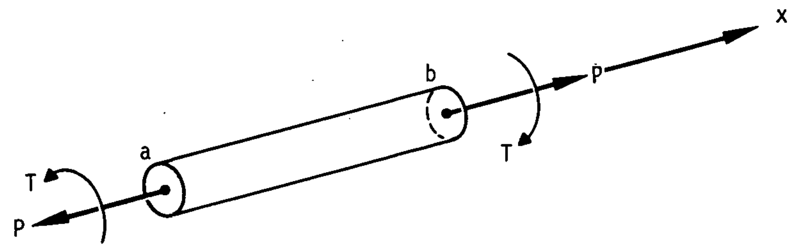
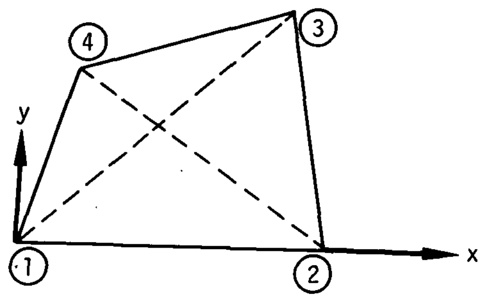
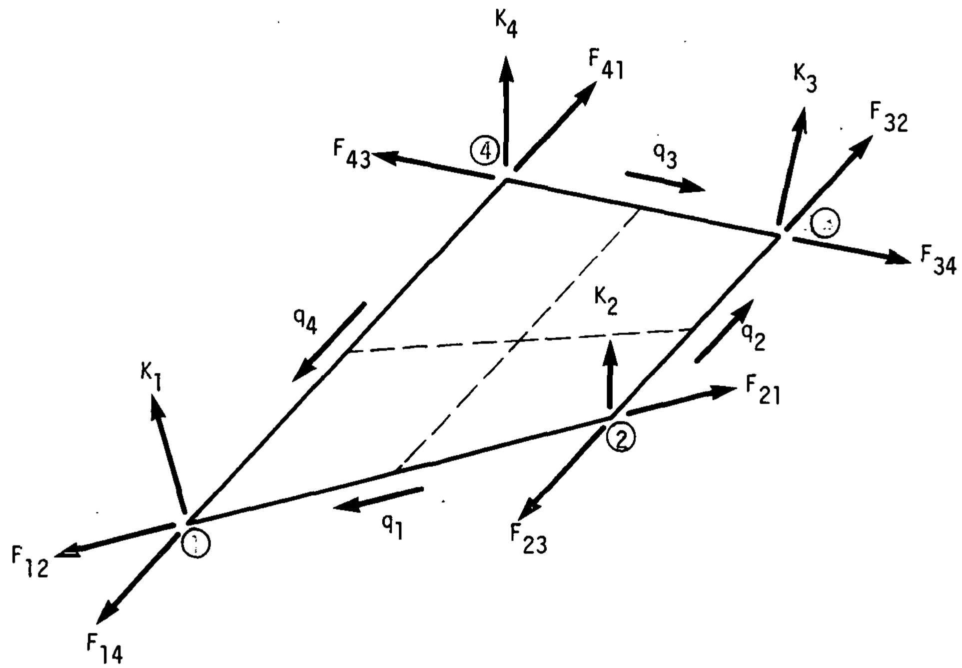


Figure 2. Rod element coordinate system and element forces.



(a) Coordinate System.



(b) Corner forces and shear flows.

Figure 3. Coordinate system and element forces for shear panel and CQDMEM2 elements.

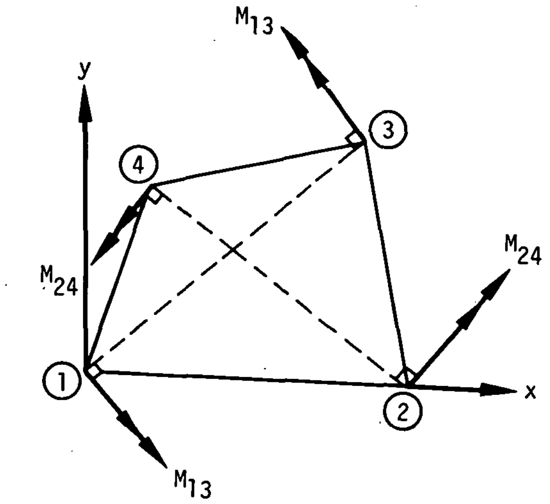
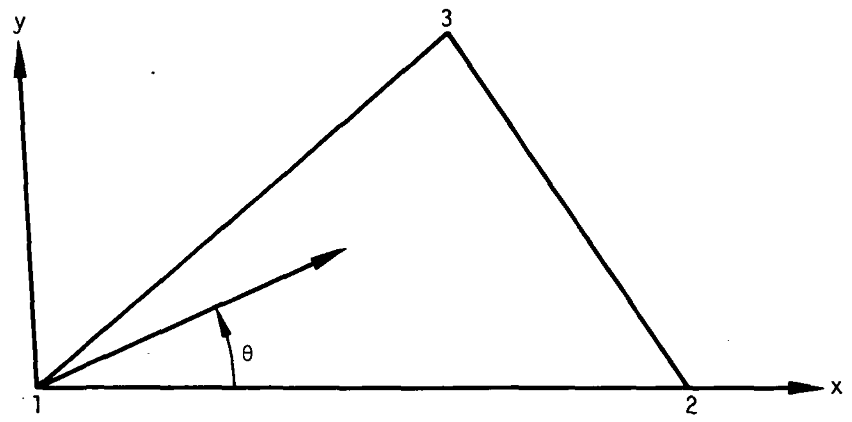
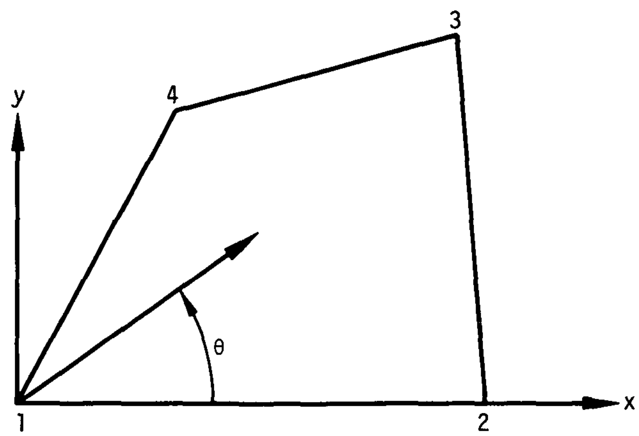


Figure 4. Twist panel coordinate system and element forces.



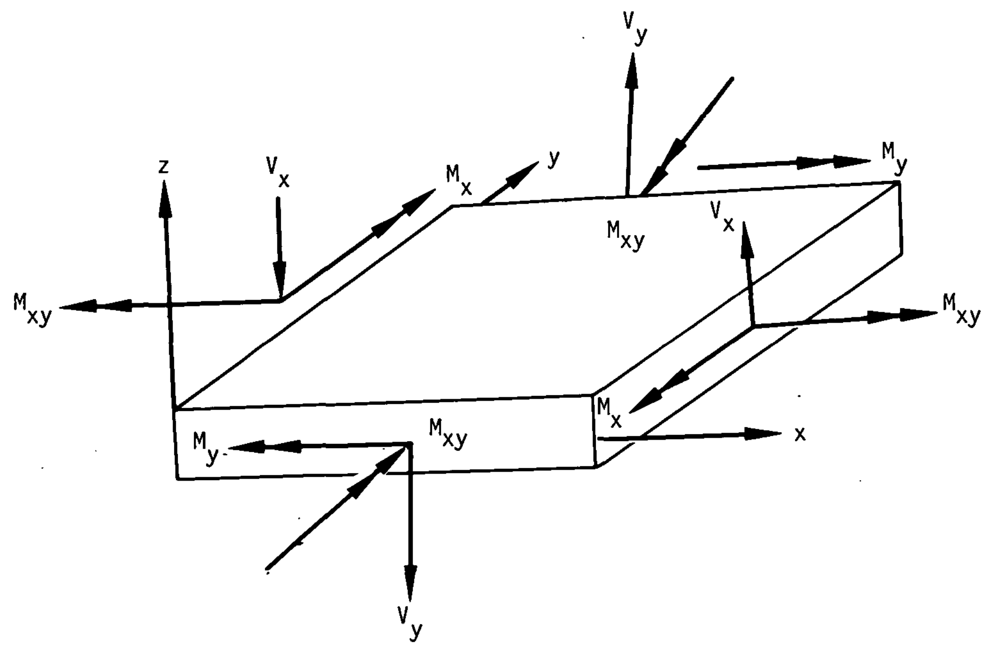
(a)



(b)

Figure 5. Plate element coordinate systems.

(a)



(b)

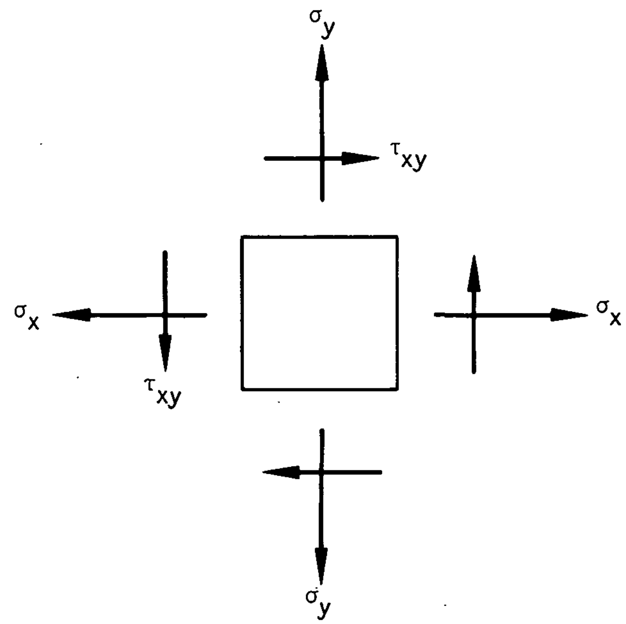


Figure 6. Forces and stresses in plate elements.

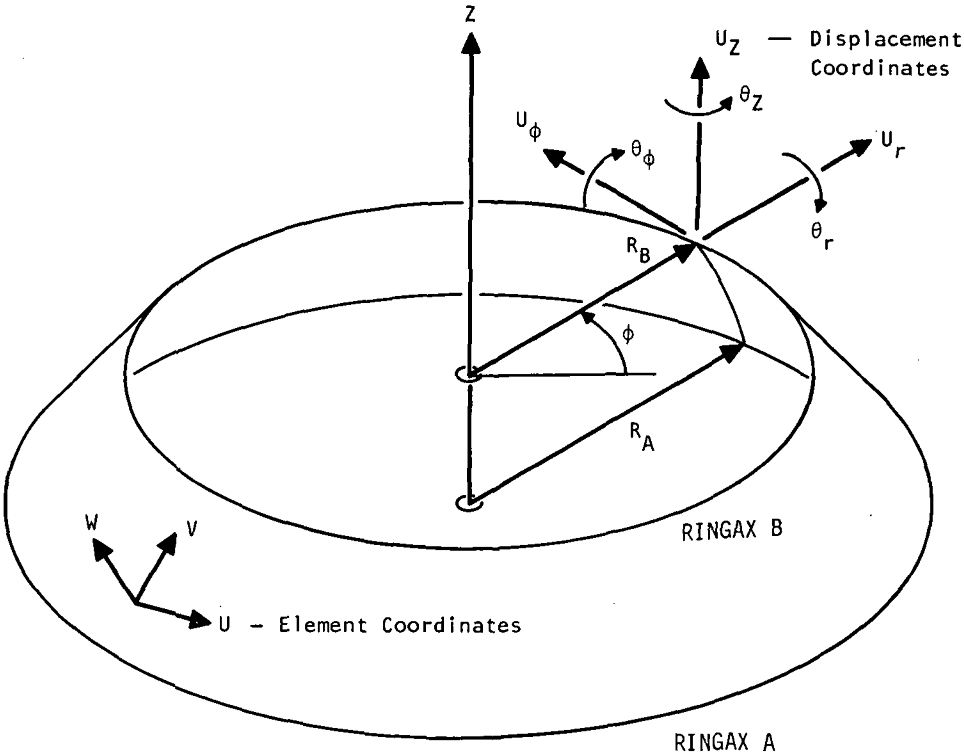


Figure 7. Geometry for conical shell element.

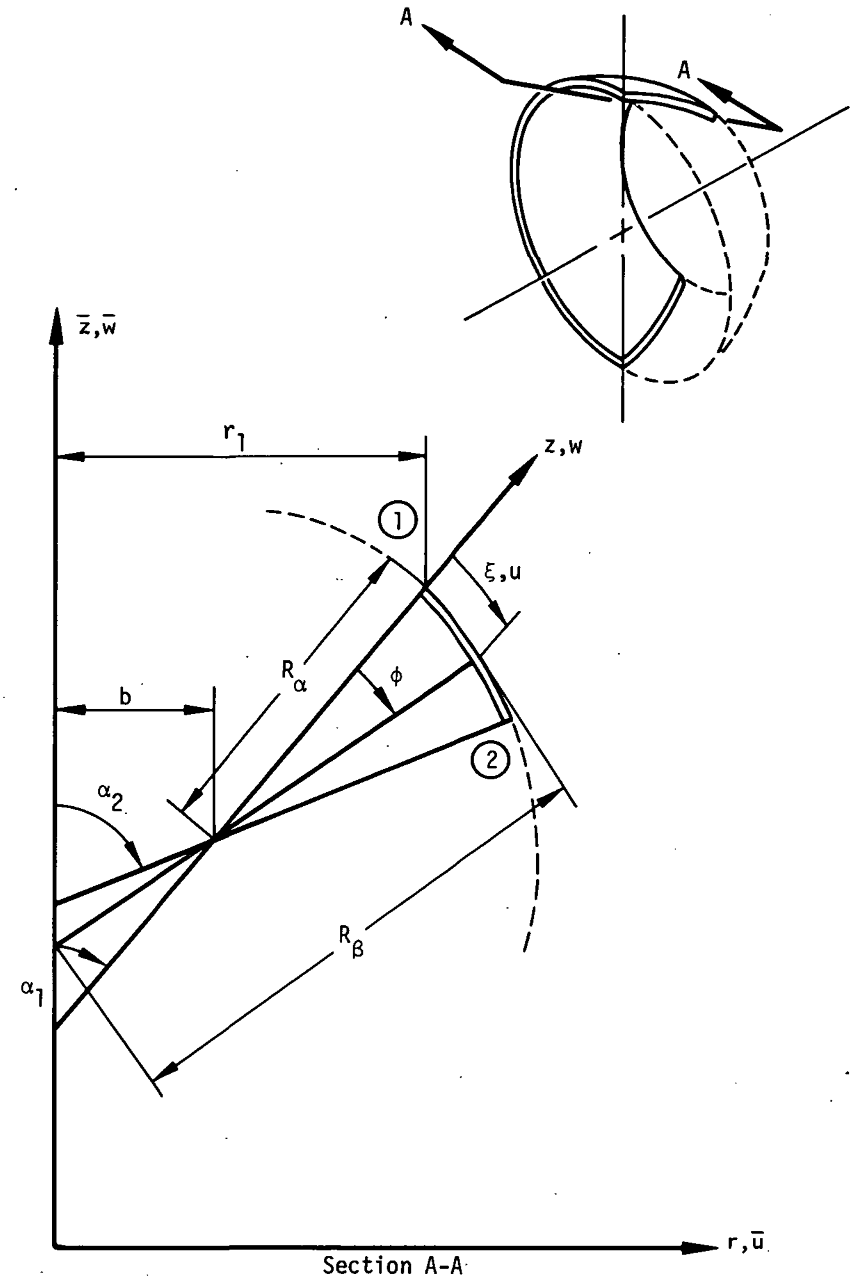


Figure 8. Toroidal ring element coordinate system.

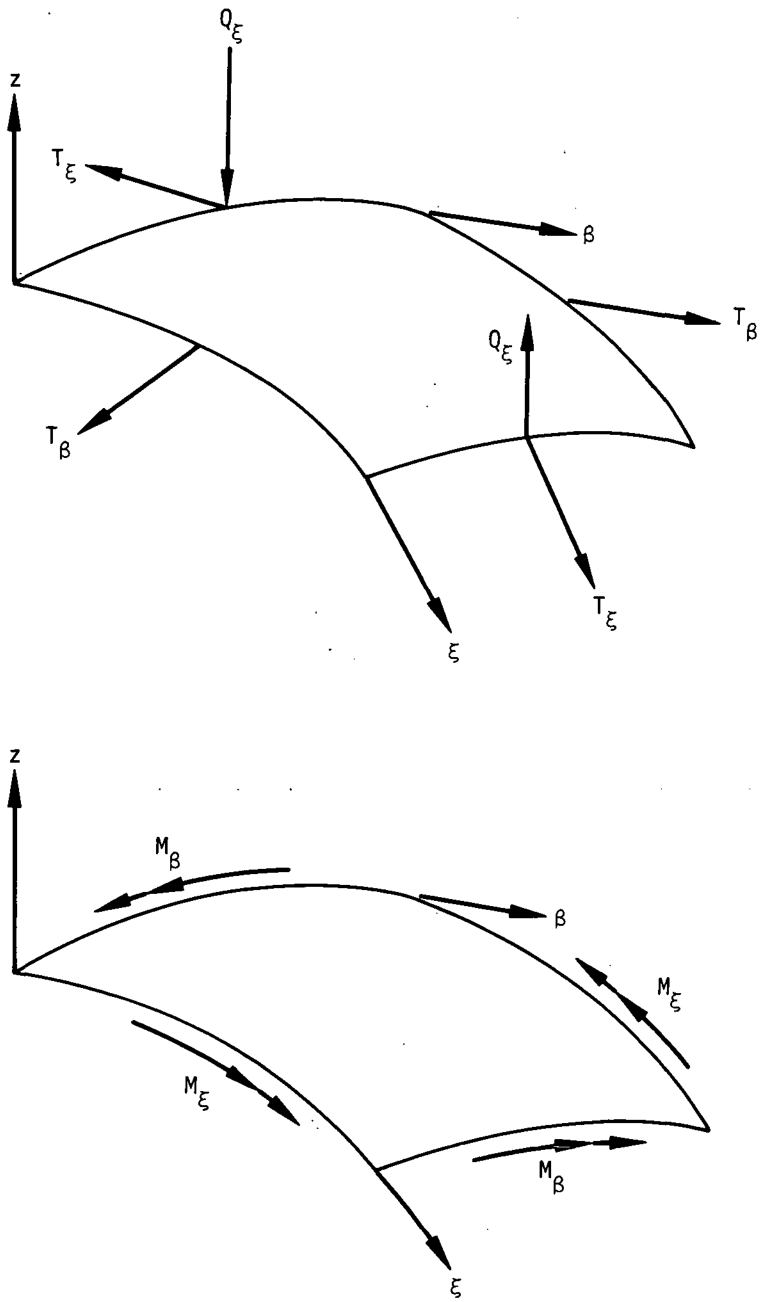


Figure 9. Stresses for toroidal element.

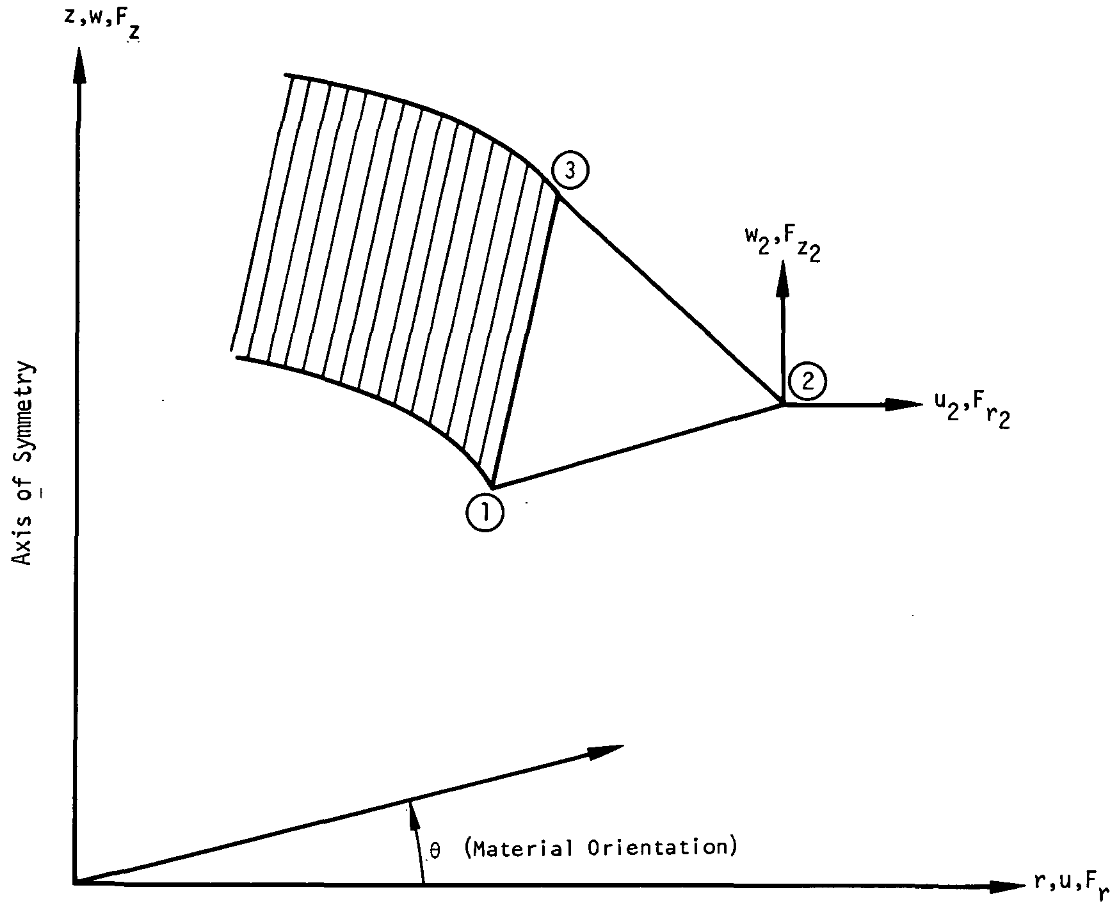


Figure 10. Triangular ring element coordinate system.

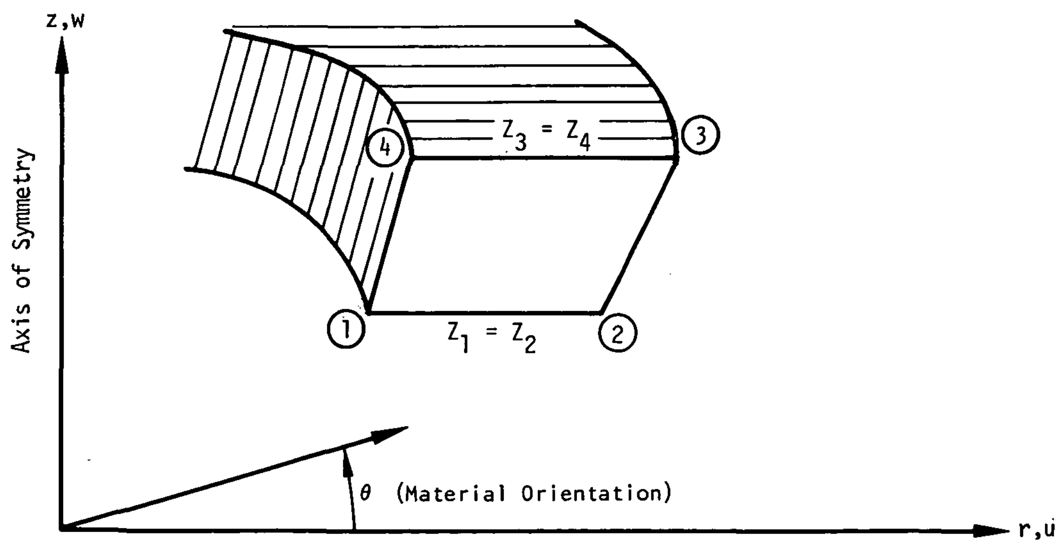
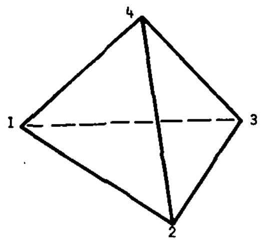
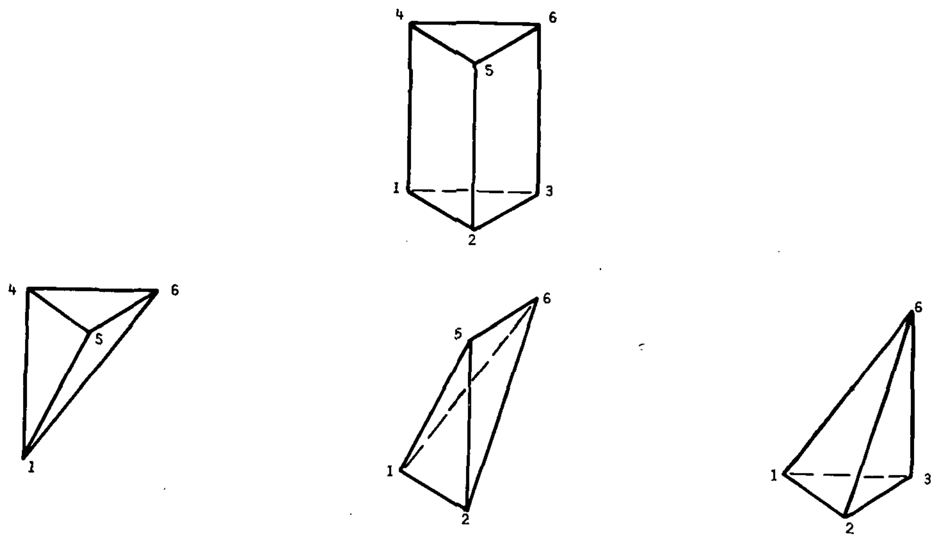


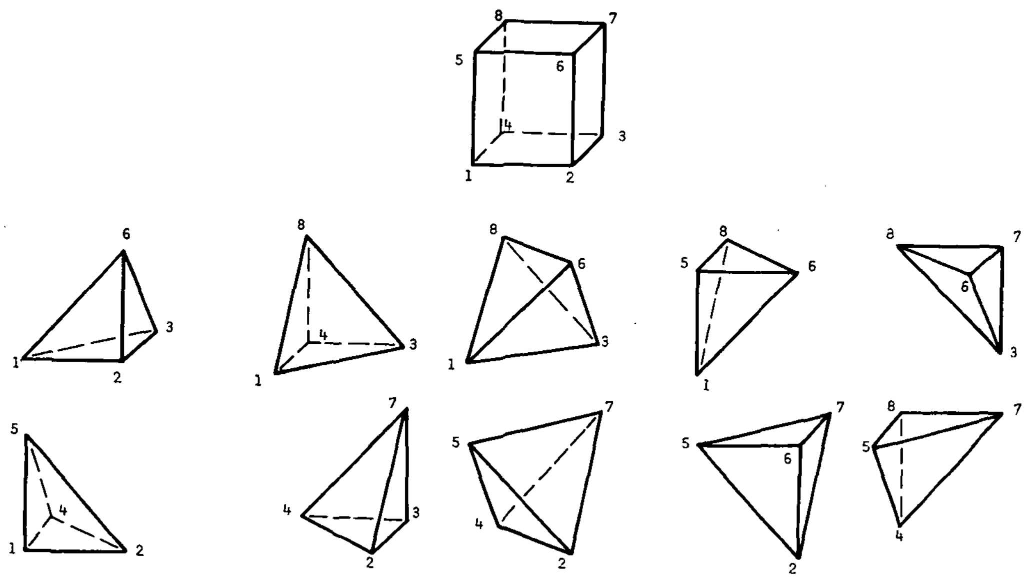
Figure 11. Trapezoidal ring element coordinate system.



(a) Tetrahedron.

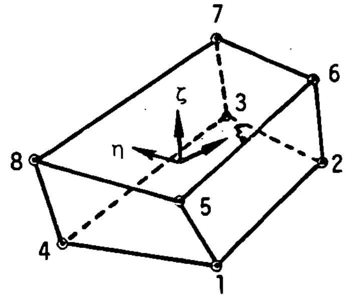


(b) Wedge and One of its Six Decompositions.

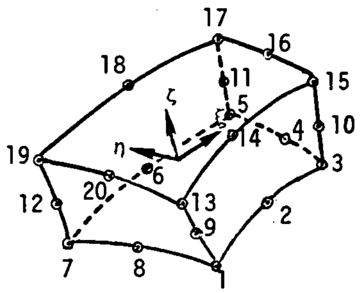


(c) Hexahedron and its Two Decompositions.

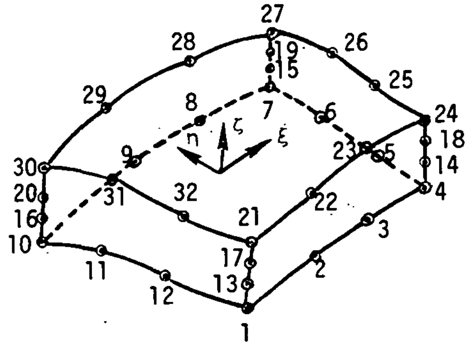
Figure 12. - Polyhedron elements and their subtetrahedra.



(a) Linear



(b) Quadratic



(c) Cubic

Figure 13. Isoparametric solid hexahedron elements

1.4 CONSTRAINTS AND PARTITIONING

Structural matrices are initially assembled in terms of all structural grid points, which excludes only the extra scalar points introduced for dynamic analysis. These matrices are generated with six degrees of freedom for each geometric grid point and a single degree of freedom for each scalar point. Various constraints are applied to these matrices in order to remove undesired singularities, provide boundary conditions, define rigid elements, and provide other desired characteristics for the structural model.

There are two basic kinds of constraints. Single-point constraints are used to constrain a degree of freedom to zero or to a prescribed value, and multipoint constraints are used to constrain a degree of freedom to be equal to a linear combination of the values of other degrees of freedom. The following four types of bulk data cards are provided for the definition of constraints:

1. Single-point constraint cards
2. Multipoint constraint cards
3. Cards to define reaction points on free bodies
4. Cards to define the omitted coordinates in matrix partitioning

The latter type does not produce constraint forces in static analysis.

1.4.1 Single-Point Constraints

A single-point constraint applies a fixed value to a translational or rotational component at a geometric grid point or to a scalar point. One of the most common uses of single-point constraints is to specify the boundary conditions of a structural model by fixing the appropriate degrees of freedom. Multiple sets of single-point constraints can be provided in the Bulk Data Deck, with selections made at execution time by using the subcase structure in the Case Control Deck as explained in Section 2.3.3. This procedure is particularly useful in the solution of problems having one or more planes of symmetry.

The elements connected to a grid point may not provide resistance to motion in certain directions, causing the stiffness matrix to be singular. Single-point constraints are used to remove these degrees of freedom from the stiffness matrix. A typical example is a planar structure composed of membrane and extensional elements. The translations normal to the plane and all three rotational degrees of freedom must be constrained since the corresponding stiffness matrix terms are all zero. If a grid point has a direction of zero stiffness, the single-point constraint need not be exactly in that direction, but only needs to have a component in that direction. This allows the use of single-point constraints for the removal of such singularities regardless of the orientation of the global coordinate system. Although the displacements will depend on the direction of the constraint, the internal forces will be unaffected.

One of the tasks performed by the Structural Matrix Assembler (Section 4.27 of the Programmer's Manual) is to examine the stiffness matrix for singularities at the grid point level. Singularities remaining at this level, following the application of the single-point constraints, are listed in the Grid Point Singularity Table (GPST). This table is automatically printed following the comparison of the possible singularities tabulated by the Structural Matrix Assembler with the single-point constraints and the dependent coordinates of the multipoint constraint equations provided by the user. The GPST contains all possible combinations of single-point constraints, in the global coordinate system, that can be used to remove the singularities. These remaining singularities are treated only as warnings, because it cannot be determined at the grid point level whether or not the singularities are removed by other means, such as general elements or multipoint constraints in which these singularities are associated with independent coordinates.

Single-point constraints are defined on SPC, SPC1, SPCADD and SPCAX cards. The SPC card is the most general way of specifying single-point constraints. The SPC1 card is a less general card that is more convenient when a number of grid points have the same components constrained to a zero displacement. The SPCADD card defines a union of single-point constraint sets specified with SPC or SPC1 cards. The SPCAX card is used only for specifying single-point constraints in problems using conical shell elements.

Single-point constraints can also be defined on the GRID card. In this case, however, the constraints are part of the model and modifications cannot be made at the subcase level. Also, only zero displacements can be specified on the GRID card.

1.4.2 Multipoint Constraints

Each multipoint constraint is described by a single equation that specifies a linear relationship for two or more degrees of freedom. Multiple sets of multipoint constraints can be provided in the Bulk Data Deck, with selections made at execution time by using the subcase structure in the Case Control Deck as explained in Section 2.3.3. Multipoint constraints are discussed in Sections 3.5.1 and 5.4 of the Theoretical Manual.

Multipoint constraints are defined on MPC, MPCADD and MPCAX cards. The MPC card is the basic card for defining multipoint constraints. The first coordinate mentioned on the card is taken as the dependent degree of freedom, i.e. that degree of freedom that is removed from the equations of motion. Dependent degrees of freedom may appear as independent terms in other equations of the set, however, they may appear as dependent terms in only a single equation. The MPCADD card defines a union of multipoint constraint sets specified with MPC cards. The MPCAX card is used only for specifying multipoint constraints in problems using conical shell elements. Some uses of multipoint constraints are:

1. To enforce zero motion in directions other than those corresponding with components of the global coordinate system. In this case, the multipoint constraint will involve only the degrees of freedom at a single grid point. The constraint equation relates the displacement in the direction of zero motion to the displacement components in the global system at the grid point.
2. To describe rigid elements and mechanisms such as levers, pulleys and gear trains. In this application, the degrees of freedom associated with the rigid element that are in excess of those needed to describe rigid body motion are eliminated with multipoint constraint equations. Treatment of very stiff members as being rigid elements eliminates the ill-conditioning associated with their treatment as ordinary elastic elements.
3. To be used with scalar elements to generate nonstandard structural elements and other special effects.
4. To describe parts of a structure by local vibration modes. This application is treated in section 14.1 of the Theoretical Manual. The general idea is that the matrix of local eigenvectors represents a set of constraints relating physical coordinates to modal coordinates.

At present, the user provides the coefficients in the multipoint constraint equations.

1.4.3 Free Body Supports

In the following discussion, a free body is defined as a structure that is capable of motion without internal stress, i.e. it has one or more rigid body degrees of freedom. The stiffness matrix for a free body is singular with the defect equal to the number of stress-free, or rigid body modes. A solid three-dimensional body has up to six rigid body modes. Linkages and mechanisms can have a greater number. No restriction is placed in the program on the number of stress-free modes, in order to permit the analysis of mechanisms.

Free-body supports are defined with a SUPØRT card. In the case of problems using conical shell elements, the SUPAX card is used. In either case, only a single set can be specified, and if such cards appear in the Bulk Data Deck, they are automatically used in the solution. Free-body supports must be defined in the global coordinate system.

In static analysis by the displacement method, the rigid body modes must be restrained in order to remove the singularity of the stiffness matrix. The required constraints may be supplied with single-point constraints, multipoint constraints, or free-body supports. If free-body supports are used, the rigid body characteristics will be calculated and a check will be made on the sufficiency of the supports. Such a check is obtained by calculating the rigid body error ratio as defined in the Rigid Body Matrix Generator operation in Section 3.2.2. This error ratio is automatically printed following the execution of the Rigid Body Matrix Generator. The error ratio should be zero, but may be nonzero for any of the following reasons:

1. Round-off error accumulation
2. Insufficient free-body supports have been provided
3. Redundant free-body supports have been provided

The redundancy of the supports may be caused by improper use of the free-body supports themselves, or by the presence of single-point or multipoint constraints that constrain the rigid body motions.

Static analysis with inertia relief is necessarily made on a model having at least one rigid body motion. Such rigid body motion must be constrained by the use of free-body supports. These supported degrees of freedom define a reference system, and the elastic displacements are calculated relative to the motion of the support points. The element stresses and forces will be independent of any valid set of supports.

Rigid body vibration modes are calculated by a separate procedure provided that a set of free-body supports are supplied by the user. This is done to improve efficiency and, in some cases, reliability. The determinant method, for example, has difficulty extracting zero frequency roots of high multiplicity, whereas the alternate procedure of extracting rigid body modes is both efficient and reliable. If the user does not specify free-body supports (or he specifies an insufficient number of them) the (remaining) rigid body modes will be calculated by the method selected for the finite frequency modes, provided zero frequency is included in the range of interest. If the user does not provide free-body supports, and if zero frequency is not included in the range of interest, the rigid body modes will not be calculated.

Free-body supports must be specified if the mode acceleration method of solution improvement is used for dynamics problems having rigid body degrees of freedom (see Section 9.4 of the Theoretical Manual). This solution improvement technique involves a static solution, and although the dynamic solution can be made on a free-body, the static solution cannot be performed without removing the singularities in the stiffness matrix associated with the rigid body motions.

1.4.4 Partitioning

A two-way partitioning scheme is provided as an optional feature for the NASTRAN model. The partitions are defined by listing the degrees of freedom for one of the partitions on the ØMIT card. These degrees of freedom are referred to as the omitted set. The remaining degrees of freedom are referred to as the analysis set. The ØMIT1 Card is easier to use if a large number of grid points have the same degrees of freedom in the omitted set. The ASET or ASET1 cards can be used to place degrees of freedom in the analysis set with the remaining degrees of freedom being placed in the omitted set. This is easier if the omitted set is large. In the case of problems using conical shell elements, the ØMITAX card is used.

Partitioning can be used to improve the efficiency in the solution or ordinary statics problems where the bandwidth of the unpartitioned stiffness matrix is large enough to cause excessive use of secondary storage devices during the triangular decomposition of the stiffness matrix. In this application, the analysis set should be relatively small and should be selected so that the omitted set will consist of uncoupled partitions, each having a bandwidth of approximately the same size and smaller than the original matrix. The omitted set might be thought of as consisting of several substructures which are coupled to the analysis set.

Matrix partitioning also improves efficiency when solving a number of similar cases with stiffness changes in local regions of the structure. In this application, the omitted set is relatively large, and should be selected so that the structural elements that will be changed are connected only to points in the analysis set. The stiffness matrix for the omitted set is then unaffected by the structural changes, and only the smaller stiffness matrix for the analysis set need be decomposed for each case. In order to avoid repeating the decomposition of the stiffness matrix for the omitted set, the alter feature must be used to replace the functional module SMP1 with SMP2. The alter feature is described in section 2.2, and a similar use of SMP2 occurs near the end of the DMAP sequence used in the rigid format for Static Analysis with Differential Stiffness.

One of the more important applications of partitioning is the Guyan Reduction, described in Section 3.5.4 of the Theoretical Manual. This technique is a means for reducing the number of degrees of freedom used in dynamic analysis with minimum loss of accuracy. Its basis is that many fewer grid points are needed to describe the inertia of a structure than are needed to describe its elasticity with comparable accuracy. The error in the approximation is small provided that the set of displacements used for dynamic analysis is judiciously chosen. Its members should be uniformly dispersed throughout the structure and all large mass items should be connected to grid points that are members of the analysis set.

The user is cautioned to consider the fact that the matrix operations associated with this partitioning procedure tend to create nonzero terms and to fill what were previously very sparse matrices. The partitioning option is most effectively used if the members of the omitted set are either a very large fraction or a very small fraction of the total set. In most of the applications the omitted set is a large fraction of the total and the matrices used for analysis, while small, are usually full. If the analysis set is not a small fraction of the total, a solution using the larger, but sparser matrices, may well be more efficient. The partitioning option can also be used to make modest reductions in the order of the problem by placing a few scattered grid points in the omitted set. If the points in the omitted set are uncoupled, the sparseness in the matrices will be well preserved.

1.5 APPLIED LOADS

1.5.1 Static Loads

In NASTRAN, static loads are applied to geometric and scalar grid points in a variety of ways, including:

1. Loads applied directly to grid points.
2. Pressure on surfaces.
3. Gravity loads (internally generated).
4. Centrifugal forces due to steady rotation.
5. Equivalent loads resulting from thermal expansion
6. Equivalent loads resulting from enforced deformations of structural elements.
7. Equivalent loads resulting from enforced displacements of grid points.

Additional information on static loads is given in Section 3.6 of the Theoretical Manual. Any number of load sets can be defined in the Bulk Data Deck. However, only those sets selected in the Case Control Deck, as described in Section 2.3, will be used in the problem solution. The manner of selecting each type of load is specified on the associated bulk data card description in Section 2.4.

The FØRCE card is used to define a static load applied to a geometric grid point in terms of components defined by a local coordinate system. The orientation of the load components depends on the type of local coordinate system used to define the load. The directions of the load components are the same as those indicated on Figure 1 of Section 1.2 for displacement components. The FØRCE1 card is used if the direction is determined by a vector connecting two grid points, and a FØRCE2 card is used if the direction is specified by the cross product of two such vectors. The MØMENT, MØMENT1 and MØMENT2 cards are used in a similar fashion to define the application of a concentrated moment at a geometric grid point. The SLØAD card is used to define a load at a scalar point. In this case, only the magnitude is specified, as only one component of motion exists at a scalar point.

The FØRCEAX and MØMAX cards are used to define the loading of specified harmonics on rings of conical shell elements. FØRCE and MØMENT cards may be used to apply concentrated loads or moments to conical shell elements, providing that such points have been defined with a PØINTAX card.

Pressure loads on triangular and quadrilateral elements are defined with a PLØAD2 card. The positive direction of the loading is determined by the order of the grid points on the element connection card, using the right hand rule. The magnitude and direction of the load is automatically computed from the value of the pressure and the coordinates of the connected grid points. The load is applied to the connected grid points. The PLØAD card is used in a similar fashion to define the loading of any three or four grid points regardless of whether they are connected with two-dimensional elements. The PRESAX card is used to define a pressure loading on a conical shell element.

Pressure loads on the isoparametric solid elements are defined with the PLØAD3 card. The pressure is defined positive outward from the element. The magnitude and direction of the equivalent grid point forces are automatically computed using the isoparametric shape functions of the element to which the load has been applied.

The GRAV card is used to specify a gravity load by providing the components of the gravity vector in any defined coordinate system. The gravity load is obtained from the gravity vector and the mass matrix assembled by the Structural Matrix Assembler (see Section 4.28 of the Programmer's Manual). The gravitational acceleration is not calculated at scalar points. The user is required to introduce gravity loads at scalar points directly.

The RFØRCE card is used to define a static loading condition due to a centrifugal force field. A centrifugal force load is specified by the designation of a grid point that lies on the axis of rotation and by the components of rotational velocity in any defined coordinate system. In the calculation of the centrifugal force, the mass matrix is regarded as pertaining to a set of distinct rigid bodies connected to grid points. Deviations from this viewpoint, such as the use of scalar points or the use of mass coupling between grid points, can result in errors.

Temperatures may be specified for selected elements. The temperatures for a RØD, BAR, CØNRØD or TUBE element are specified on the TEMPRB data card. This card specifies the average temperature on both ends and, in the case of the BAR element, is used to define temperature gradients over the cross section. Temperatures for two dimensional plate and membrane elements are specified on a TEMPP1, TEMPP2, or TEMPP3 data card. The user defined average temperature over the volume is used to produce in-plane loads and stresses. Thermal gradients over the depth of the bending elements, or the resulting moments, may be used to produce bending loads and stresses.

If no thermal element data is given for an element, the temperatures of the connected grid points given on the TEMP, TEMPD or TEMPAX cards are simply averaged to produce an average temperature for the element. The thermal expansion coefficients are defined on the material definition cards. Regardless of the type of thermal data, if the material coefficients for an element are temperature-dependent by use of the MATTi card, they are always calculated from the "average" temperature of the element. The mere presence of a thermal field does not imply the application of a thermal load. A thermal load will not be applied unless the user makes a specific request in the Case Control Deck.

Enforced axial deformations can be applied to rod and bar elements. They are useful in the simulation of misfit and misalignment in engineering structures. As in the case of thermal expansion, the equivalent loads are calculated by separate subroutines for each type of structural element, and are applied to the connected grid points. The magnitude of the axial deformation is specified on a DEFØRM card.

Zero enforced displacements may be specified on GRID, SPC or SPC1 cards. Zero displacements which result in nonzero forces of constraint are usually specified on SPC or SPC1 cards. If GRID cards are used, the constraints become part of the structural model and modifications cannot be made at the subcase level.

Nonzero enforced displacements may be specified on SPC or SPCD cards. The SPC card specifies both the component to be constrained and the magnitude of the enforced displacement. The SPCD card specifies only the magnitude of the enforced displacement. When an SPCD card is used, the component to be constrained must be specified on either an SPC or SPC1 card. The use of the SPCD card avoids the decomposition of the stiffness matrix when changes are only made in the magnitudes of the enforced displacements.

The equivalent loads resulting from enforced displacments of grid points are calculated by the program and added to the other applied loads. The magnitudes of the enforced displacements are specified on SPC cards (SPCAX in the case of conical shell problems) in the global coordinate system. The application of the load is automatic when the user selects the associated SPC set in the Case Control Deck.

The LØAD card in the Bulk Data Deck defines a static loading condition that is a linear combination of load sets consisting of loads applied directly to grid points, pressure loads, gravity loads and centrifugal forces. This card must be used if gravity loads are to be used in combination with loads applied directly to grid points, pressure loads or centrifugal forces. The application of the combined loading condition is requested in the Case Control Deck by selecting the set number of the LØAD combination.

It should be noted that the equivalent loads (thermal, enforced deformation and enforced displacement) must have unique set identification numbers and be separately selected in the Case Control Deck. For any particular solution, the total static load will be the sum of the applied loads (grid point loading, pressure loading, gravity loading and centrifugal forces) and the equivalent loads.

1.5.2 Frequency Dependent Loads

A discussion of frequency response calculations is given in Section 12.1 of the Theoretical Manual. The DLØAD card is used to define linear combinations of frequency dependent loads that are defined on RLØAD1 or RLØAD2 cards. The RLØAD1 card defines a frequency dependent load of the form

$$\{P(f)\} = \left\{A[C(f) + iD(f)]e^{i(\theta - 2\pi f\tau)}\right\}, \tag{1}$$

where A is defined on a DAREA card, C(f) and D(f) are defined on TABLEDi cards, θ is defined on a DPHASE card and τ is defined on a DELAY card. The RLØAD2 card defines a frequency dependent load of the form

$$\{P(f)\} = \left\{AB(f)e^{i\{\phi(f)+\theta-2\pi f\tau\}}\right\}, \tag{2}$$

where A is defined on a DAREA card, B(f) and $\phi(f)$ are defined on TABLEDi cards, θ is defined on a

DPHASE card, and τ is defined on a DELAY card. The coefficients on the DAREA, DELAY and DPHASE cards may be different for each loaded degree of freedom. The loads are applied to the specified components in the global coordinate system.

A discussion of random response calculations is given in Section 12.2 of the Theoretical Manual. The RANDPS card defines load set power spectral density factors for use in random analysis of the form

$$S_{jk}(f) = (X + iY)G(f) \quad , \tag{3}$$

where G(f) is defined on a TABRNDi card. The subscripts j and k define the subcase numbers of the load definitions. If the applied loads are independent, only the diagonal terms (j=k) need be defined. The RANDT1 card is used to specify the time lag constants for use in the computation of the autocorrelation functions.

1.5.3 Time Dependent Loads

A discussion of transient response calculations is given in Section 11 of the Theoretical Manual. The DLØAD card is used to define linear combinations of time dependent loads that are defined on TLØAD1 and TLØAD2 cards. The TLØAD1 card defines a time dependent load of the form

$$\{P(t)\} = \{AF(t - \tau)\} \quad , \tag{4}$$

where A is defined on a DAREA card, τ is defined on a DELAY card, and $F(t-\tau)$ is defined on a TABLEDi card. The TLØAD2 card defines a time dependent load of the form

$$\{P(t)\} = \begin{cases} \{0\} \ , & \tilde{t} < 0 \ \text{ or } \ \tilde{t} > T_2 - T_1 \\ \left\{A\tilde{t}^B \, e^{C\tilde{t}} \cos(2\pi f\tilde{t}+P)\right\}, & 0 < \tilde{t} < T_2 - T_1 \end{cases} \quad , \tag{5}$$

where $\tilde{t} = t - T_1 - \tau$ and A and τ are defined as above. The coefficients on the DAREA and DELAY cards may be different for each loaded degree of freedom. The loads are applied to the specified components in the global coordinate system.

Nonlinear effects are treated as an additional applied load vector, for which the components are functions of the degrees of freedom. This additional load vector is added to the right side of the equations of motion and treated along with the applied load vector during numerical integration. It is required that the points to which the nonlinear loads are applied and the degrees of freedom on which they depend be members of the solution set, i.e., that they cannot be degrees of freedom eliminated by constraints. It is further required, that if a modal formulation is use the points referenced by the nonlinear loads be members of the set of extra scalar points introduced for dynamic analysis.

At present, NASTRAN includes four different types of nonlinear elements. For a discussion o nonlinear elements see Section 11.2 of the Theoretical Manual. The NØLIN1 card defines a nonline load of the form

$$P_i(t) = S_i T(u_j) \tag{6}$$

where P_i is the load applied to u_i, S_i is a scale factor, $T(u_j)$ is a tabulated function defined with a TABLEDi card, and u_j is any permissible displacement component. The NØLIN2 card defines a nonlinear load of the form

$$P_i(t) = S_i\, u_j\, u_k \tag{7}$$

where u_j and u_k are any permissible pair of displacement components. They may be the same. The NØLIN3 card defines a nonlinear load of the form

$$P_i(t) = \begin{cases} S_i(u_j)^A & , \quad u_j > 0 \\ 0 & , \quad u_j \le 0 \end{cases} , \tag{8}$$

where A is an exponent. The NØLIN4 card defines a nonlinear load of the form

$$P_i(t) = \begin{cases} -S_i(-u_j)^A & , \quad u_j < 0 \\ 0 & , \quad u_j \ge 0 \end{cases} \tag{9}$$

Nonlinear loads applied to a massless system without damping will not converge to a steady state solution. Use of DIAG 10 (Section 2.2.1) will cause the nonlinear term $\{N_{n+1}\}$ to be replac by 1/3 $\{N_{n+1} + N_n + N_{n-1}\}$ where N_{n+1}, N_n and N_{n-1} are the values of the nonlinear loads at time steps preceding the solution time step. Section 11.3 of the Theoretical Manual discusses the integration equations.

1.6 DYNAMIC MATRICES

The dynamic matrices are defined as the stiffness, mass and damping matrices used in either the direct or modal formulation of dynamics problems. The assembly of dynamics matrices is discussed in Section 9.3 of the Theoretical Manual. There are three general sources for the elements of the dynamic matrices.

1. Matrices generated by the Structural Matrix Assembler.
2. Direct input matrices.
3. Modal matrices obtained from real eigenvalue analysis.

The Structural Matrix Assembler generates stiffness terms from the following sources:

1. Structural elements defined on connection cards, e.g., CBAR and CRØD.
2. General elements defined on GENEL cards.
3. Scalar springs defined on CELASi cards.

The Structural Matrix Assembler generates mass terms from the following sources:

1. A 6x6 matrix of mass coefficients at a grid point defined on a CØNM1 card.
2. A concentrated mass element defined on a CØNM2 card in terms of its mass and moments of inertia about its center of gravity.
3. Structural mass for all elements, except plate elements without membrane stiffness, using the mass density on the material definition card.
4. Nonstructural mass for all elements specifying a value on the property card.
5. Scalar masses defined on CMASSi cards.

A discussion of inertia properties, including the Lumped Mass method and the Coupled Mass method are given in Section 5.5 of the Theoretical Manual. The Structural Matrix Assembler will use the Lumped Mass method for bars, rods and plates unless the PARAM card CØUPMASS (see PARAM bulk data card) used to request the Coupled Mass method.

The Structural Matrix Assembler generates damping terms from the following sources:

1. Viscous rod elements defined on CVISC cards.
2. Scalar viscous dampers defined on CDAMPi cards.
3. Element structural damping by multiplying the stiffness matrix of an individual structural element by a damping factor obtained from the material properties (MATi) card for the element.

In addition, uniform structural damping is provided by multiplying the stiffness matrix generated in Structural Matrix Assembler by a damping factor that is specified by the user on the PARAM card G (see PARAM bulk data card). This form of damping is not recommended for hydroelastic problems.

The direct input matrices are generated by transfer functions (TF cards) or they are supplied directly by the user (DMIG or DMIAX cards). The terms of the direct input matrices may be associated either with grid points or with extra points introduced for dynamic analysis.

The modal matrices are obtained from real eigenvalue analysis using the stiffness and mass matrices generated by the Structural Matrix Assembler.

1.6.1 Direct Formulation

In the direct method of dynamic problem formulation, the degrees of freedom are simply the displacements at grid points. The dynamic matrices are assembled from the direct input matrices and the stiffness, mass and damping matrices generated by the Structural Matrix Assembler. The direct input matrices are generated by transfer functions (TF cards) or they are supplied directly by the user (DMIG or DMIAX cards).

For frequency response analysis and complex eigenvalue analysis the complete dynamic matrices are:

$$[K_{dd}] = (1 + ig)[K^1_{dd}] + [K^2_{dd}] + i[K^4_{dd}], \tag{1}$$

$$[B_{dd}] = [B^1_{dd}] + [B^2_{dd}] \quad , \tag{2}$$

$$[M_{dd}] = [M^1_{dd}] + [M^2_{dd}] \quad , \tag{3}$$

where the subscripts dd indicate the solution set composed of the degrees of freedom remaining after all constraints have been applied and the extra scalar points introduced for dynamic analysis. The matrices K, B and M are the stiffness, damping and mass matrices respectively. The superscript 1 indicates the matrices generated by the Structural Matrix Assembler. The superscript 2 indicates the direct input matrices. The matrix $[K^4_{dd}]$ is a structural damping matrix obtained by multiplying the stiffness matrix of an individual structural element by a damping factor obtained from the material properties (MATi) card for the element. The matrix $[K^1_{dd}]$ is multiplied by the damping factor (g) to provide for uniform structural damping in cases where it is appropriate. The constant g is specified by the user on a PARAM card (see PARAM bulk data card).

For transient response analysis the complete dynamic matrices are:

$$[K_{dd}] = [K^1_{dd}] + [K^2_{dd}] \quad , \tag{4}$$

$$[B_{dd}] = [B^1_{dd}] + [B^2_{dd}] + \frac{g}{\omega_3}[K^1_{dd}] + \frac{1}{\omega_4}[K^4_{dd}] \quad , \tag{5}$$

$$[M_{dd}] = [M^1_{dd}] + [M^2_{dd}] \quad , \tag{6}$$

where ω_3 is the radian frequency at which the term $\frac{g}{\omega_3}[K^1_{dd}]$ produces the same magnitude of damping as the term $ig[K^1_{dd}]$ in frequency response analysis, and ω_4 is the radian frequency at which the term $\frac{1}{\omega_4}[K^4_{dd}]$ produces the same magnitude of damping as the term $i[K^4_{dd}]$ in frequency response analysis. The equivalent viscous damping is only an approximation to the structural damping as the viscous damping forces are larger at higher frequencies and smaller at lower frequencies. Therefore, the quantities ω_3 and ω_4 are frequently selected by the user to be at the center of the frequency range of interest. A small value of g/ω_3 is frequently useful to insure stability of higher modes in nonlinear transient analysis. The user specifies the values of ω_3 and ω_4 on PARAM cards W3 and W4 (see PARAM bulk data card). If ω_3 and ω_4 are omitted, the corresponding terms are ignored.

1.6.2 Modal Formulation

In the modal method of dynamic problem formulation, the vibration modes of the structure in a selected frequency range are used as degrees of freedom, thereby reducing the number of degrees of freedom while maintaining accuracy in the selected frequency range. The frequency range is specified on PARAM cards by either selecting the number of lowest modes obtained from a real eigenvalue analysis or selecting all of the modes in a given frequency range (see PARAM bulk data card).

It is important to have both direct and modal methods of dynamic problem formulation, in order to maximize efficiency in different situations. The modal method will usually be more efficient in problems where a small fraction of all of the modes are sufficient to produce the desired accuracy, provided that the bandwidth of the direct stiffness matrix is large. The bandwidth may be large due either to a compact structural arrangement or to dynamic coupling effects. The direct method will usually be more efficient for problems in which the bandwidth of the direct stiffness matrix is small and for problems with dynamic coupling in which a large fraction of the vibration modes are required to produce the desired accuracy. For problems without dynamic coupling, i.e., for problems in which the matrices of the modal formulation are diagonal, the modal method will frequently be more efficient, even though a large fraction of the modes are needed.

The complete dynamic matrices used in dynamic analysis by the modal method include the direct input mass, damping and stiffness matrices $[M^2_{dd}]$, $[B^2_{dd}]$, $[K^2_{dd}]$, and the modal matrices $[m_i]$, $[b_i]$ and $[k_i]$, obtained from real eigenvalue analysis. The matrix $[m_i]$ is the modal mass matrix with off-diagonal terms (which should be zero) omitted. The modal damping matrix $[b_i]$ and stiffness matrix $[k_i]$ are obtained from $[m_i]$ by:

$$[b_i] = [2\pi f_i \; g(f_i) \; m_i] \quad , \tag{7}$$

$$[k_i] = [4\pi^2 \; f_i^2 \; m_i] \quad , \tag{8}$$

where f_i is the frequency of the i^{th} normal mode and $g(f_i)$ is obtained by interpolation of a table supplied by the user to represent the variation of structural damping with frequency. This table is defined with a TABDMP1 card. Structural damping will not be used in the modal formulation unless an SDAMPING card is used in the Case Control Deck to select a particular TABDMP1 card. The specification of damping properties for the modal method is somewhat less general than it is for the direct method, in that viscous dampers and nonuniform structural damping are not used.

The mode acceleration method of data recovery is optional when using the modal formulation for transient response and frequency response problems, see Section 9.4 of the Theoretical Manual for details. In this procedure, the inertia and damping forces are computed from the modal solution. These forces are then added to the applied forces and the combination is used to obtain a more accurate displacement vector for the structure by static analysis. This improved displacement vector is used in the stress recovery operation. The mode acceleration method is selected with the PARAM card MØDACC (see PARAM bulk data card).

1.7 HYDROELASTIC MODELING

1.7.1 Solution of the NASTRAN Fluid Model

The NASTRAN hydroelastic option allows the user to solve a wide variety of fluid problems having structural interfaces, compressibility, and gravity effects. A complete derivation of the NASTRAN model and an explanation of the assumptions are given in the Theoretical Manual, Section 16.1. The input data and the solution logic have many similarities to a structural model. The standard normal modes analysis, transient analysis, complex eigenvalue analysis, and frequency response solutions are available with minor restrictions. The differences between a NASTRAN fluid model and an ordinary structural problem are due to the physical properties of a fluid, and are:

1. The independent degrees of freedom for a fluid are the Fourier coefficients of the pressure function (i.e. "harmonic pressures") in an axisymmetric coordinate system. The independent degrees of freedom for a structure are typically displacements and rotations at a physical point in space.

2. Much like the structural model, the fluid data will produce "stiffness" and "mass" matrices. Because they now relate pressures and flow instead of displacement and force, their physical meaning is quite different. The user may not apply loads, constraints, sequencing, or omitted coordinates "directly" on the fluid points involved. Instead, the user supplies information related to the boundaries and NASTRAN internally generates the correct constraints, sequencing, and matrix terms. Indirect methods, however, are available to the user for utilizing the internally generated points as normal grid or scalar points. See Section 1.7.4 for the identification code.

3. When a physical structure is to be connected to the fluid, the user supplies a list of fluid points and a related list of special structural grid points. NASTRAN will produce unsymmetric matrix terms which define the actual physical relations. A special provision is included in NASTRAN in the event that the structure has planes of symmetry. The user may, if he wishes, define only a section of the boundary and solve his problem with symmetric or antisymmetric constraints. The fluid-structure interface will take the missing sections of structural boundary into account.

4. Because of the special nature of the fluid problems, various user convenience options are absent. The fluid elements and harmonic pressures may not be included in the structural plots at present. Plotting the harmonic pressures versus frequency or time may not be "directly" requested. Because mass matrix terms are automatically generated if compressibility or free surface effects are present, the weight and C.G. calculations with fluid elements present may not be correct and should be avoided. Also, the inertia relief rigid format uses the mass matrix to produce internal loads and if fluids are included, these special fluid terms in the mass matrix may produce erroneous results.

In spite of the numerous differences between a NASTRAN structural model and a NASTRAN fluid model, the similarities allow the user to formulate a model with a minimum of data preparation and obtain efficient solutions to large order problems. The similarities of the fluid model to the NASTRAN structural model are:

1. The fluid is described by points in space and finite element connections. The locations of the axisymmetric fluid points are described by rings (RINGFL) about a polar axis, much like the axisymmetric conical shell. The rings are connected by elements (CFLUIDi) which have the properties of density and bulk modulus of compressibility. Each fluid ring produces, internally, a series of NASTRAN scalar points, P^n and P^{n*} (i.e. "harmonic pressures"), describing the pressure function, $P(\phi)$, in the following equation:

$$P(\phi) = P^o + \sum_{n=1}^{N} P^n \cos n\phi + \sum_{n=1}^{N} P^{n*} \sin n\phi \qquad 0 < N < 100$$

   where the set of harmonics 0, n and n* are selected by the user. If the user desires the output of pressure at specific points on the circular ring, he may specify them as "pressure points" (PRESPT) by giving a point number and an angle on a specified fluid ring. The output data will have the values of pressure at the angle, ϕ, given in the above equation. The output of free surface displacements normal to the surface (FREEPT) are also available at specified angles, ϕ. The case control card option "AXISYM=FLUID" is necessary when any harmonic fluid degrees of freedom are included.

2. The input data to NASTRAN may include all of the existing options except the axisymmetric structural element data. All of the existing case control options may be included with some additional fluid case control requests. All of the structural element and constraint

data may be used (but not connected to RINGFL, PRESPT, or FREEPT fluid points). The structure-fluid boundary is defined with the aid of special grid points (GRIDB) which may be used for any purpose that a structural grid point is presently used.

3. The output data options for the structural part of a hydroelastic model are unchanged from the existing NASTRAN options. The output values for the fluid will be produced in the same form as the displacement vectors but with format modifications for the harmonic data. Printed values for the fluid may include both real and complex values. Pressures and free surface displacements, and their velocities and accelerations, may be printed with the same request (the case control request PRESSURE=SET is equivalent to DISP=SET) as structural displacements, velocities and accelerations. Structural plots are restricted to GRID and GRIDB points and any elements connected to them. X-Y plot and Random Analysis capability are available for FREEPT and PRESPT points if they are treated as scalar points. The RINGFL point identification numbers may not be used in any plot request, instead the special internally generated points used for harmonics may be requested in X-Y plots and Random Analysis. See Section 1.7.4 for the identification number code. No element stress or force data is produced for the fluid elements. As in the axisymmetric conical shell problem the case control request HARMØNICS=N is used to select up to the Nth harmonic for output.

1.7.2 Hydroelastic Input Data

A number of special NASTRAN data cards are required for fluid analysis problems. These cards are compatible with structural NASTRAN data. The NASTRAN RESTART feature will be available in Rigid Format Series M for changes in these data cards. A brief description of the uses for each bulk data card follows.

AXIF

This card controls the formulation of the axisymmetric fluid problem. It is a required card if any of the subsequent fluid related cards are present. The data references a fluid related coordinate system to define the axis of symmetry. The gravity parameter is included on the card rather than on the GRAV card because the direction of gravity must be parallel to the axis of symmetry. The values of density and bulk elastic modulus are conveniences in the event that these properties are constant throughout the fluid. A list of harmonics and the request for the nonsymmetric (sine) coefficients are included on this card to allow the user to select any of the harmonics without producing extra matrix terms for the missing harmonics. A change in this list, however, will require a RESTART at the beginning of the problem.

RINGFL

The geometry of the fluid model about the axis of symmetry is defined with the aid of these data cards. The RINGFL data cards serve somewhat the same function for the fluid as the GRID cards serve in the structural model. In fact, each RINGFL card will produce, internally, a special grid point for each of the various harmonics selected on the AXIF data card. They may not, however, be connected directly to normal NASTRAN structural elements (see GRIDB and BDYLIST data cards). No constraints may be applied directly to RINGFL fluid points.

CFLUIDi

The data on these cards are used to define a volume of fluid bounded by the referenced RINGFL points. The volume is called an element and logically serves the same purpose as a structural finite element. The physical properties (density and bulk modulus) of the fluid element may be defined on this card if they are variables with respect to the geometry. If a property is not defined, the default value on the AXIF card is assumed. Two connected circles (RINGFL) must be used to define fluid elements adjacent to the axis of symmetry. A choice of three or four points is available in the remainder of the fluid.

GRIDB

This card provides an alternate to the GRID card for the definition of structural grid points. It also identifies the structural grid point with a particular RINGFL fluid point for hydroelastic problems. The particular purpose for this card is to force the user to place structural boundary points in exactly the same locations as the fluid points on the boundary. The format of the GRIDB card is identical to the format of the GRID card except that one additional field is used to identify the RINGFL point. The GRDSET card, however, is not used for GRIDB data.

If the user desires, he may use GRIDB cards without a fluid model. This is convenient in case the user wished to solve his structural problem first and to add the fluid effects later without converting GRID cards to GRIDB cards. The referenced RINGFL point must still be included in a boundary list (BDYLIST), see below, and the AXIF card must always be present when GRIDB cards are used. (The fluid effects are eliminated by specifying no harmonics.)

FREEPT, PRESPT

These cards are used to define points on a free surface for surface displacement output and points in the fluid for pressure output. No constraints may be applied to these points. Scalar elements and direct matrix data may be connected to these points, but the physical meaning of the elements will be different than in the structural sense.

FSLIST, BDYLIST

The purpose for these cards is to allow the user to define the boundaries of the fluid with a complete freedom of choice. The FSLIST card defines a list of fluid points which lie on a free surface. The BDYLIST data is a list of fluid points to which structural GRIDB points are connected. Points on the boundary of the fluid for which BDYLIST or FSLIST data are not defined are assumed to be rigidly restrained from motion in a direction normal to the surface.

With both of these lists the sequence of the listed points determines the nature of the boundary. The following directions will aid the user in producing a list.

1. Draw the z axis upward and the r axis to the right. Plot the locations of the fluid points on the right hand side of z.

2. If one imagines himself traveling along the free surface or boundary with the fluid on his right side the sequence of points encountered is used for the list. If the surface or boundary touches the axis, the word "AXIS" is placed in the list. "AXIS" may be used only for the first and/or last point in the list.

3. The free surface must be consistent with static equilibrium. With no gravity field, any free surface consistent with axial symmetry is allowed. With gravity, the free surface must be a plane perpendicular to the z axis of the fluid coordinate system.

4. Multiple free surface lists and boundary lists are allowed. A fluid point may be included in any number of lists.

Figure 1.7-1 illustrates a typical application of the free surface and structural boundary lists.

FLSYM

This card allows the user to optionally model a portion of the structure with planes of symmetry containing the polar axis of the fluid. The first plane of symmetry is assumed at

ϕ = 0.0 and the second plane of symmetry is assumed at ϕ = 360°/M where M is an integer specified on the card. Also specified are the types of symmetry for each plane, symmetric (S) or antisymmetric (A). The user must also supply the relevant constraint data for the structure. The solution is performed correctly only for those harmonic coefficients that are compatible with the symmetry conditions as illustrated in the following example for quarter symmetry, M = 4.

Series	Plane 1	Plane 2	
		S	A
Cosine	S A	0,2,4,... none	1,3,5,... none
Sine (*)	S A	none 1,3,5,...	none 2,4,6,...

DMIAX

These cards are used for Direct Matrix Input for special purposes such as surface friction effects. They are equivalent to the DMIG cards, the only difference being the capability to specify the harmonic numbers for the degrees of freedom. A matrix may be defined with either DMIG or DMIAX cards, but not with both.

1.7.3 Rigid Formats

The characteristics of the fluid analysis problems which cause restrictions on the type of solution are:

1. The fluid-structure interface is mathematically described by a set of unsymmetric matrices. Since the first six Rigid Formats are restricted to the use of symmetric matrices, the fluid-structure boundary is ignored. Thus, for any of these Rigid Formats the program solves the problem for a fluid in a rigid container with an optional free surface and an uncoupled elastic structure with no fluid present.

2. No means are provided for the direct input of applied loads on the fluid. The only direct means of exciting the fluid is through the structure-fluid boundary. The fluid problem may be formulated in any rigid format. However, only some will provide nontrivial solutions.

The suggested Rigid Formats for the axisymmetric fluid and the restrictions on each are described below:

Rigid Format No. 3 - Normal Modes Analysis

The modes of a fluid in a rigid container may be extracted with a conventional solution request. Free surface effects with or without gravity may be accounted for. Any structure data in the deck will be treated as a disjoint problem. (The structure may also produce normal modes.) Normalization of the eigenvectors using the PØINT option will cause a fatal error.

Rigid Format No. 7 - Direct Complex Eigenvalue Analysis

The coupled modes of the fluid and structure must be solved with this rigid format. If no damping or direct input matrices are added, the resulting complex roots will be purely imaginary numbers, whose values are the natural frequencies of the system. The mode shape of the combination may be normalized to the maximum quantity (harmonic pressure or structural displacement) or to a specified structural point displacement.

Rigid Format No. 8 - Direct Frequency and Random Response

This solution may be used directly if the loads are applied only to the structural points. The use of overall structural damping (parameter g) is not recommended since the fluid matrices will be affected incorrectly. Output restrictions are listed on page 1.7-3.

Rigid Format No. 9 - Direct Transient Response

Transient analysis may be performed directly on the fluid-structure system if the following rules apply.

1. Applied loads and initial conditions are only given to the structural points.
2. All quantities are measured relative to static equilibrium. The initial values of the pressures are assumed to be at equilibrium.
3. Overall structural damping (parameters ω_3 and g) must not be used.
4. Output restrictions are listed on page 1.7-3.

Rigid Formats 10, 11, and 12 - Modal Formulations

Although these rigid formats may be used in a fluid dynamics problem, their practicality is limited. The modal coordinates used to formulate the dynamic matrices will be the normal modes of both the fluid and the structure solved as uncoupled systems. Even though the range of natural frequencies would be typically very different for the fluid than for the structure, NASTRAN will select both sets of modes from a given fixed frequency range. The safest method with the present system is the extraction of all modes for both systems with the Tridiagonalization Method. This procedure, however, results in a dynamic system with large full matrices. The Direct Formulation would be more efficient in that case. At present, the capability for fluid-structure boundary coupling is not provided with Rigid Formats 10, 11 and 12. However the capability may be provided by means of an ALTER using the same logic as in the direct formulations.

1.7.4 Hydroelastic Data Processing

The fluid related data cards submitted by the user are processed by the NASTRAN preface module to produce equivalent grid point, scalar point, element connection, and constraint data card images. Each specified harmonic, N, of the Fourier series solution produces a complete set of special grid and connection card images. In order to retain unique identification numbers the user identification numbers are encoded by the algorithm below:

RINGFL points:

NASTRAN grid Id. = User ring Id. + 1,000,000 x I_N

where

I_N = N + 1 cosine series

I_N = N + 1/2 sine series

CFLUIDi connection cards:

NASTRAN element Id. = User element Id. x 1000 + I_N

where I_N is defined above for each harmonic N.

For example, if the user requested all harmonics from zero to two, including the sine(*) series, each RINGFL card will produce five special grid cards internally. If the user's Identification number (in field 2 of the RINGFL data card) were 37, the internally generated grid points would have the following identification numbers:

Harmonic	Id.
0	1,000,037
1*	1,500,037
1	2,000,037
2*	2,500,037
2	3,000,037

These equivalent grid points are resequenced automatically by NASTRAN to be adjacent to the original RINGFL identification number. A RINGFL point may not be resequenced by the user.

The output from matrix printout, table printout, and error messages will have the fluid points labeled in this form. If the user wishes, he may use these numbers as scalar points for Random Analysis, X-Y plotting, or for any other purpose.

In addition to the multiple sets of points and connection cards, the NASTRAN preface also may generate constraint sets. For example if a free surface (FSLIST) is specified in a zero-gravity field, the pressures are constrained by NASTRAN to zero. For this case the internally generated set of single point constraints are internally combined with any user defined structural constraints and will always be automatically selected.

If pressures at points in the fluid (PRESPT) or gravity dependent normal displacements on the free surface (FREEPT) are requested, the program will convert them to scalar points and create a set of multipoint constraints with the scalar points as dependent variables. The constraint set will be internally combined with any user defined sets and will be selected automatically.

The PRESPT and FREEPT scalar points may be used as normal scalar points for purposes such as plotting versus frequency or time. Although the FREEPT values are displacements, scalar elements connected to them will have a different meaning than in the structural sense.

1.7.5 Sample Hydroelastic Model

Table 1.7-1 contains a list of the data deck for a sample hydroelastic problem. Figure 1.7-2 describes the problem and lists the parameters. The relatively small number of grid points were chosen for purposes of simplicity, and not accuracy. The special cards for hydroelastic analysis are flagged with the symbol (†). The symbols for the fields in the hydroelastic data cards are placed above each group. Structural data cards are included in their standard formats. The explanations for the data are given in the following notes:

1. The "AXISYM=FLUID" card is necessary to control the constraint set selections and the output formats for a fluid problem. It must appear above the subcase level.

2. "DISPLACEMENT=" and "PRESSURE=" case control cards are pseudonyms. "DISP=ALL" will produce all structure displacements, free surface displacements, and all fluid pressure values in the output. The "HARMØNICS=" control is a limit on the harmonic data and has the same function as in an axisymmetrical conical shell problem.

3. The AXIF card defines the existence of a hydroelastic problem. It is used to define overall parameters and control the harmonic degrees of freedom.

4. The RINGFL cards included will define the five points on the fluid cross section.

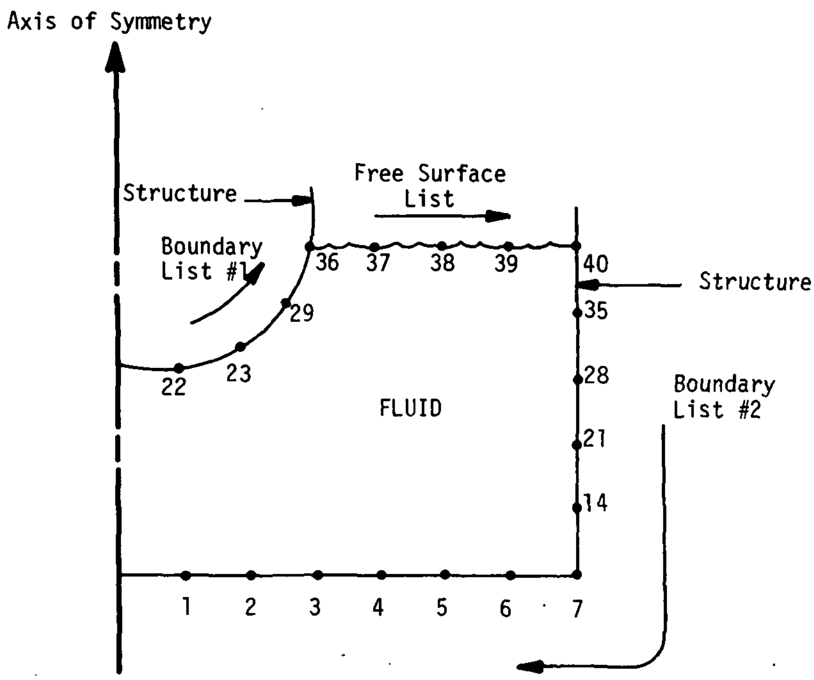
5. The CFLUIDi cards are used to define the volume of the fluid as finite elements connected by the RINGFL points. Since parameters ρ and B are missing, the default values on the AXIF card will be used.

6. The FSLIST card is used to define the free surface at z = 10.0. The density factor, ρ, is placed on the card in this case. If blank, the default value on the AXIF card is used.

7. The fluid-structure boundary is defined on the BDYLIST card. The AXIF default density is used.

8. The GRIDB cards define the structure points on the fluid boundary. Points #3 through #6 are connected to the #2 fluid ring. The rotation in the r direction ("4" in field 8) is constrained.

9. The fact that one-quarter symmetry was used for the structure requires the use of the FLSYM card. Symmetric-Antisymmetric boundaries indicate that only the cosine terms for the odd harmonics will interact with the structure. If Symmetric-Symmetric boundary conditions were chosen on the FLSYM data card, only the even harmonics of the cosine series would interact with the structure.

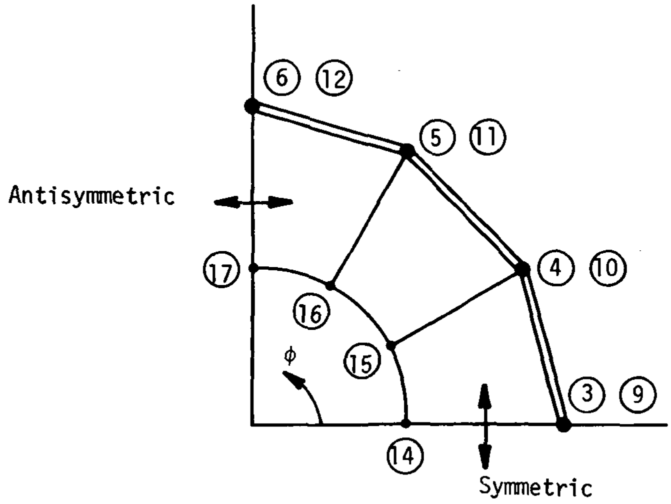


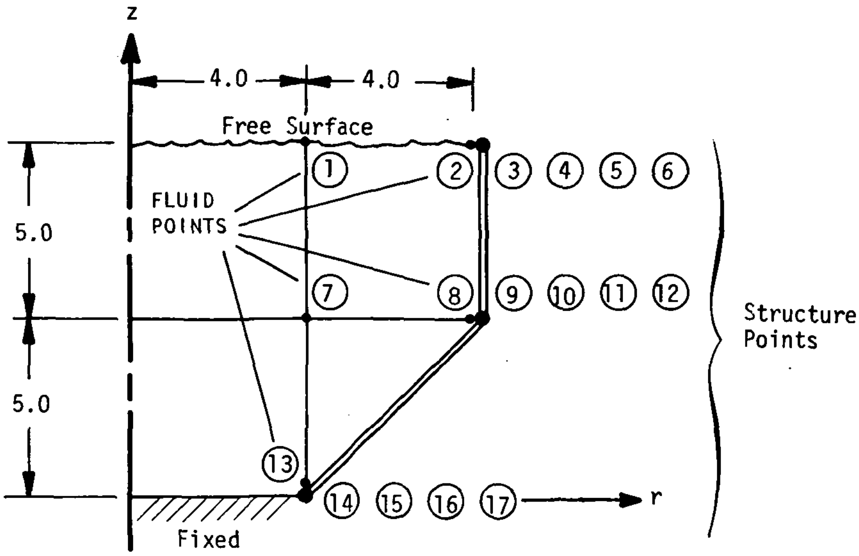
FSLIST: 36, 37, 38, 39, 40

BDYLIST #1: AXIS, 22, 23, 29, 36

BDYLIST #2: 40, 35, 28, 21, 14, 7, 6, 5, 4, 3, 2, 1, AXIS

Figure 1.7-1 Examples of boundary lists.





Fluid: Density, $\rho = 0.03$

Bulk Modulus, $B = \infty$

Gravity, $g = 32.2$

Structure: Thickness, $t = 0.5$

Density, $\rho = 0.05$

Figure 1.7-2 Sample hydroelastic problem.

Table 1.7-1 Sample hydroelastic problem.

```
   ID    HYDRØ, USER
   APP   DISP
   SØL   7,0
   TIME  2
   CEND
   TITLE = SAMPLE HYDRØELASTIC PRØBLEM.
   SUBTITLE = EIGENVALUE ANALYSIS WITH FLEXIBLE BØUNDARY.
(†)AXISYM=FLUID                                              (1)
   SPC = 3
   CMETHØD = 1
   ØUTPUT
          DISP = ALL
          HARMØNICS = ALL                                    (2)
          ELFØRCE = ALL
   BEGIN BULK
```

BULK DATA FIELD

	1	2	3	4	5	6	7	8	9	10	
		(CID)	(g)	(ρ)	(B)	(*SERIES?)					
(†)	AXIF	2	32.2	0.03		NØ				+AX	(3)
		(N_1)	(N_2)								
	+AX	1	3								
	CØRD2C	2		0.	0.	0.	0.	0.	1.0	+CØ	
	+CØ	1.0	0.	0.							
		(Id)	(r)		(z)	(Id)	(r)		(z)		
(†)	RINGFL	1	4.0		10.0	2	8.0		10.0		(4)
(†)	RINGFL	7	4.0		5.0	8	8.0		5.0		
(†)	RINGFL	13	4.0		0.0						
		(Id)	(f_1)	(f_2)	(f_3)	(f_4)	(ρ)	(B)			
(†)	CFLUID2	101	1	7							(5)
(†)	CFLUID2	102	7	13							
(†)	CFLUID3	103	7	8	13						
(†)	CFLUID4	104	1	2	7	8					
		(ρ)	(Id_1)	(Id_2)	(Id_3)						
(†)	FSLIST	0.03	AXIS	1	2						(6)
		(ρ)	(Id_1)	(Id_2)	(Id_3)						
(†)	BDYLIST		2	8	13						(7)

(Continued)

	1	2	3	4	5	6	7	8	9	10
		(Id)			(φ)		(CID)	(P-SPC)	(IDF)	
(†)	GRIDB	3			0.0		2	4	2	
	GRIDB	4			30.0		2	4	2	
	GRIDB	5			60.0		2	4	2	
	GRIDB	6			90.0		2	4	2	
	GRIDB	9			0.		2		8	
	GRIDB	10			30.		2		8	
	GRIDB	11			60.		2		8	
	GRIDB	12			90.		2		8	
	GRIDB	14			0.		2		13	
	GRIDB	15			30.		2		13	
	GRIDB	16			60.		2		13	
	GRIDB	17			90.		2		13	
	CQUAD2	10	11	3	9	10	4			
	CQUAD2	11	11	4	10	11	5			
	CQUAD2	12	11	5	11	12	6			
	CQUAD2	13	11	9	14	15	10			
	CQUAD2	14	11	10	15	16	11			
	CQUAD2	15	11	11	16	17	12			
	PQUAD2	11	12	0.5						
	MAT1	12	10.6+6		0.3	0.05				
	SPC1	3	246	3	9	14				
	SPC1	3	135	6	12	17				
	SPC1	3	135	14	15	16				
		(M)	(S1)	(S2)						
(†)	FLSYM	4	S	A						
	EIGC	1	INV	MAX						+EI
	+EI	0.	0.	0.	5.	3.	2	2		
	ENDDATA									

(†) Hydroelastic cards

1.8 HEAT TRANSFER PROBLEMS

1.8.1 Introduction to NASTRAN Heat Transfer

NASTRAN heat flow capability may be used either as a separate analysis to determine temperatures and fluxes, or to determine temperature inputs for structural problems. Steady and transient problems can be solved, including heat conduction (with variable conductivity for static analysis), film heat transfer, and nonlinear (fourth power law) radiation.

The heat flow problem is similar, in many ways, to structural analysis. The same grid points, coordinate systems, elements, constraints, and sequencing can be used for both problems. There are several differences, such as the number of degrees of freedom per grid point, the methods of specifying loads, boundary film heat conduction, and the nonlinear elements. For heat flow problems, the only unknown at a grid point is the temperature (cf. structural analysis with three translations and three rotations), and hence, there is one degree of freedom per grid point. Additional grid or scalar points are introduced for ambient temperatures in film heat transfer. If the conductivity of an element is temperature dependent, the problem becomes nonlinear (cf. structural analysis with temperature dependent materials which only requires looking up material properties and computing thermal loads).

The heat conduction analysis of NASTRAN is compatible with structural analysis. If the same finite elements are appropriate, then the same grid and connection cards can be used for both problems. As in structural analysis, the choice of a finite element model is left to the analyst. Temperature distributions can be output in a format which can be input into structural problems. Heat flow analysis uses many structural NASTRAN bulk data cards. These include (where i means there is more than one type): CBAR, CDAMPi, CELASi, CHEXAi, CØNRØD, CØRDii, CQDMEM, CQDPLT, CQUADi, CRØD, CTETRA, CTRAPRG, CTRIAi, CTRIARG, CTRMEM, CTUBE, CVISC, CWEDGE, DAREA, DELAY, DLØAD, DMI, DMIG, EPØINT, GRDSET, GRID, LØAD, MPC, MPCADD, NØLINi, ØMITi, PARAM, Piii (for elements requiring properties), PLØTEL, SEQiP, SLØAD, SPCi, SPCADD,SPØINT, TABLEDi, TABLEMi, TEMPii, TF, TLØADi, and TSTEP.

1.8.2 Heat Transfer Elements

The basic heat conduction elements are the same as NASTRAN structural elements. These elements are shown in the following table:

Heat Conduction Elements	
Type	Elements
Linear	BAR, RØD, CØNRØD, TUBE
Membrane	TRMEM, TRIA1, TRIA2, QDMEM, QUAD1, QUAD2
Solid of Revolution	TRIARG, TRAPRG
Solid	TETRA, WEDGE, HEXA1, HEXA2

A connection card (Cxxx) and, if applicable, a property card (Pxxx) is defined for each of these elements. Linear elements have a constant cross-sectional area. The offset on the BAR is treated as a perfect conductor (no temperature drop). For the membrane elements, the heat conduction thickness is the membrane thickness. The bending characteristics of the elements do not enter into heat conduction problems. The solid of revolution element, TRAPRG, has been generalized to accept general quadrilateral rings (i.e., the top and bottom need not be perpendicular to the z-axis for heat conduction). These heat conduction elements are composed of constant gradient lines, triangles, and tetrahedra. The quadrilaterals are composed of overlapping triangles, and the wedges and hexahedra from subtetrahedra. Gradients and fluxes may be output by requesting ELFØRCE.

Thermal material conductivities and heat capacities are given on MAT4 (isotropic) and MAT5 (anisotropic) bulk data cards. Temperature dependent conductivities are given on MATT4 and MATT5 bulk data cards, which can only be used for nonlinear static analysis. The heat capacity per unit volume is specified, which is the product of density and heat capacity per unit mass (ρC_p).

A special element (HBDY) defines an area for boundary conditions. There are five basic types, called PØINT, LINE, REV, AREA3, and AREA4 (the sixth type, ELCYL, is for use only with QVECT radiation). The HBDY is considered an element, since it can add terms to the conduction and heat capacity matrices. There is a CHBDY connection and PHBDY property card. When a film heat transfer condition is desired, film conductivity and heat capacity per unit area are specified on MAT4 data cards. The ambient temperature is specified with additional points (GRID or SPØINT) listed on the CHBDY connection card. See Figure 1 for geometry.

Radiation heat exchange may be included between HBDY elements. A list of HBDY elements must be specified on a RADLST bulk data card. The emissivities are specified on the PHBDY cards. The Stefan-Boltzmann constant (SIGMA) and absolute reference temperature (TABS) are specified on PARAM bulk data cards. Radiation exchange coefficients (default is zero) are specified on RADMTX bulk data cards.

The several types of power input to the HBDY elements can be output by requesting "ELFØRCE".

1.8.3 Constraints and Partitioning

Constraints are applied to provide boundary conditions, represent "perfect" conductors, and provide other desired characteristics for the heat transfer model.

Single point constraints are used to specify the temperature at a point. The grid or scalar points are listed on SPC or SPC1 bulk data cards. The component on the data card can be "0" or "1". This declares the degree of freedom to be in the u_s set. The method of specifying temperature is dependent upon the problem type.

Algorithm	Value of u_s Used
Linear statics	Values defined on selected SPC cards.
Nonlinear statics	Values of the selected TEMP (MATERIAL) set.
Transient	u_s = 0.0 (special modeling techniques, such as a good conductor with a large power specified, can be used to enforce u(t)).

Multipoint constraints are linear relationships between temperatures at several grid points, and are specified on MPC cards. The first entry on an MPC card will be in the u_m set. The type of constraint is limited if nonlinear elements are present. If a member of set u_m touches a nonlinear (conduction or radiation) element, the constraint relationship is restricted to be an "equivalence". The term "equivalence" means that the value of the member of the u_m set will be equal to one of the members of the u_n set (a point not multipoint constrained). Those points not touching nonlinear elements are not so limited. The user will be responsible to satisfy the equivalence requirement, by having only two entries on the MPC data card, with equal (but opposite in sign) coefficients.

1.8.4 Thermal Loads

Thermal "loads" may be boundary heat fluxes or volume heat addition. As in the case of structural analysis, the method of specifying loads is different for static and transient analysis. The HBDY element is used for boundaries of conducting regions. Surface heat flux input can be specified for HBDY elements with QBDY1 and QBDY2 data cards. These two cards are for constant and (spatially) variable flux, respectively. Flux can be specified without reference to an HBDY element with the QHBDY data card. Vector flux, such as solar radiation, depends upon the angle between the flux and the element normal, and is specified for HBDY elements with the QVECT data card. This requires that the orientation of the HBDY element be defined. Volume heat addition into a conduction element is specified on a QVØL data card.

Static thermal loads are requested in case control with "LØAD" card. All of the above load types plus SLØAD's can be requested. Transient loads are requested in case control with a "DLØAD" card, which selects TLØAD time functions. Transient thermal loads may use DAREA (as in structural transient), and the QBDY1, QBDY2, QHBDY, QVECT, QVØL, and SLØAD cards.

1.8.5 Linear Static Analysis

Linear static analysis uses APProach HEAT, SØLution 1. The rigid format is the same as that used for static structural analysis. This implies that several loading conditions and constraint sets can be solved in one job, by using subcases in the Case Control Deck.

1.8.6 Nonlinear Static Analysis

Nonlinear static analysis uses APProach HEAT, SØLution 3. This rigid format will allow temperature dependent conductivities of the elements, nonlinear radiation exchange, and a limited use of multipoint constraints. There is no looping for load and constraints. The solution is iterative. The user can supply values on PARAM bulk data cards for:

MAXIT (integer)	Maximum number of iterations (default 4).
EPSHT (real)	ε convergence parameter (default .001).
TABS (real)	Absolute reference temperature (default 0.0).
SIGMA (real)	Stefan-Boltzmann radiation constant (default 0.0).
IRES (integer)	Request residual vector output if positive (default -1).

The user must supply an estimate of the temperature distribution vector $\{u^1\}$. This estimate is used to calculate the reference conductivity plus radiation matrix needed for the iteration. $\{u^1\}$ is also used at all points in the u_s set to specify a boundary temperature. The values of $\{u^1\}$ are given on TEMP bulk data cards, and they are selected by TEMP(MATERIAL) in case control.

Iteration may stop for the following reasons:

1. Normal convergency: ε_T < EPSHT, where ε_T is the per unit error estimate of the temperatures calculated.
2. Number of iterations > MAXIT.
3. Unstable: $|\lambda_1| < 1$ and the number of iterations > 3, where λ_1 is a stability estimator.
4. Insufficient time to perform another iteration and output data.

The precise definitions are given in the NASTRAN Theoretical Manual, Section 8.4. Error estimates ε_p, λ_1, and ε_T for all iterations may be output with the Executive Control Card DIAG 18, where ε_p is the ratio of the Euclidian norms of the residual (error) loads to the applied loads on the unconstrained degrees of freedom.

1.8.7 Transient Analysis

Transient analysis uses APProach HEAT, SØLution 9. This rigid format may include conduction, film heat transfer, nonlinear radiation, and NASTRAN nonlinear elements. Extra points are used as in structural transient analysis. All points associated with nonlinear loads must be in the solution set. Loads may be applied with TLØAD and DAREA cards as in structural analysis. Also, the thermal static load cards can be modified by a function of time for use in transient analysis. Loads are requested in case control with DLØAD. Initial temperatures are specified on TEMP bulk data cards and are requested by IC. Previous static or transient solutions can be easily used as initial conditions, since they can be punched in the correct format. An estimate of the temperature $\{u^1\}$ is specified on TEMP bulk data cards for transient with radiation, and is requested by TEMP(MATERIAL). The parameters available are:

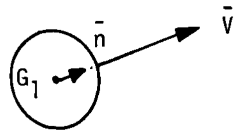
TABS (real)	Absolute reference temperature (default 0.0).
SIGMA (real)	Stefan-Boltzmann radiation constant (default 0.0).
BETA (real)	Foreward difference integration factor (default .55).
RADLIN (integer)	Radiation is linearized if positive (default -1).

Time steps are specified on TSTEP data cards.

1.8.8 Compatibility with Structural Analysis

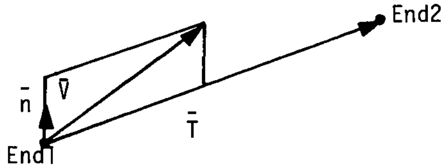
Grid point temperatures for thermal stress analysis (static structural analysis) are specified on TEMP bulk data cards. If punched output is requested in a heat conduction analysis, the format of the punched card is exactly that of a double field TEMP* data card. Thus, if the heat conduction model is the same as the structural model, the same grid, connection, and property cards can be used for both, and the temperature cards for the structural analysis are produced by the heat conduction analysis. The output request in case control is THERMAL(PUNCH).

Type = PØINT



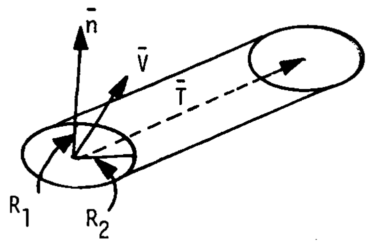
The unit normal vector is given by $\bar{n} = \bar{V}/|\bar{V}|$, where $\bar{V}$ is given in the basic system at the referenced grid point (see CHBDY data card, fields 16-18).

Type = LINE



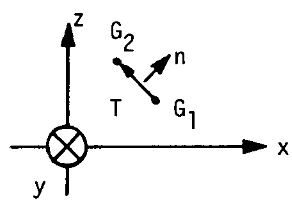
The unit normal lies in the plane of $\bar{V}$ and $\bar{T}$, is perpendicular to $\bar{T}$, and is given by $\bar{n} = (\bar{T} \times (\bar{V} \times \bar{T}))/|\bar{T} \times (\bar{V} \times \bar{T})|$.

Type = ELCYL



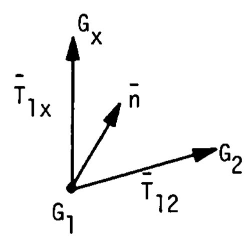
The same logic is used to determine $\bar{n}$ as for type = LINE. The "radius" R_1 is in the $\bar{n}$ direction, and R_2 is perpendicular to $\bar{n}$ and $\bar{T}$ (see fields 7 and 8 of PHBDY card).

Type = REV



The unit normal lies in the x-z plane, and is given by $\bar{n} = (\bar{e}_y \times \bar{T})/|\bar{e}_y \times \bar{T}|$. $\bar{e}_y$ is the unit vector in the y direction.

Type = AREA3 or AREA4



The unit normal vector is given by $\bar{n} = (\bar{T}_{12} \times \bar{T}_{1x})/|\bar{T}_{12} \times \bar{T}_{1x}|$, where x = 3 for triangles and x = 4 for quadrilaterals.

Figure 1. HBDY Element Orientation (for QVECT flux).

1.9 ACOUSTIC CAVITY MODELING

1.9.1 Data Card Functions

The NASTRAN structural analysis system is used as the basis for acoustic cavity analysis. Many of the structural analysis options such as selecting boundary conditions, applying loading conditions, and selecting output data are also available for acoustics.

The data cards specifically used for acoustic cavity analysis are described below. The card formats are exhibited in Section 2.4. Their purposes are analogous to the use of structural data cards. A gridwork of points is distributed over the longitudinal cross section of an acoustic cavity and finite elements are connected between these points to define the enclosed volume.

The points are defined by GRIDF data cards for the axisymmetric central fluid cavity and by GRIDS data cards for the radial slots. The GRIDF points are interconnected by finite elements via the CAXIF2, CAXIF3, and CAXIF4 data cards to define a cross sectional area of the body of rotation. The CAXIF2 element data card defines the area of the cross section between the axis and two points off the axis (the GRIDF points may not have a zero radius). The CAXIF3 and CAXIF4 data cards define triangular or quadrilateral cross sections and connect three or four GRIDF points respectively. The density and/or bulk modulus at each location of the enclosed fluid may also be defined on these cards.

The GRIDS points in the slot region are interconnected by finite elements via the CSLØT3 and CSLØT4 data cards. These define finite elements with triangular and quadrilateral cross-sectional shapes respectively. The width of the slot and the number of slots may be defined by default values on the AXSLØT data card. If the width of the slots is a variable, the value is specified on the GRIDS cards at each point. The number of slots, the density, and/or the bulk modulus of the fluid may also be defined individually, for each element on the CSLØT3 and CSLØT4 cards.

The AXSLØT data card is used to define the overall parameters for the system. Some of these parameters are called the "default" values and may be selectively changed at particular cross sections of the structure. The values given on the AXSLØT card will be used if a corresponding value on the GRIDS, CAXIFi, or CSLØTi is left blank. The parameters ρ (density) and B (bulk modulus) are properties of the fluid. If the value given for Bulk Modulus is zero the fluid is considered incompressible to the program. The parameters M (Number of slots) and W (slot width) are properties of the geometry. The parameter M defines the number of equally spaced slots around the circumference with the first slot located at $\phi = 0°$. The parameter N (harmonic number) is selected by the user to analyze a particular set of acoustic modes. The pressure is assumed to have the following distribution

$$p(r,z,\phi) = p(r,z) \cos N\phi$$

If N = 0 the breathing and longitudinal modes will result. If N = 1 the pressure at $\phi = 180°$ will be the negative of the pressure at $\phi = 0°$. If N = 2, the pressures at $\phi = 90°$ and $\phi = 270°$ will be the negative of that at $\phi = 0°$. Values of N larger than M/2 have no significance.

The interface between the central cavity and the slots is defined with the SLBDY data cards. The data for each card consists of the density of the fluid at the interface, the number of radial slots around the circumference, and a list of GRIDS points that are listed in the sequence in which they occur as the boundary is traversed. In order to ensure continuity between GRIDF and GRIDS points at the interface, the GRIDF points on the boundary between the cylindrical cavity and the slots are identified on the corresponding GRIDS data cards rather than on GRIDF cards. Thus, the locations of the GRIDF points will be exactly the same as the locations of the corresponding GRIDS points.

Various standard NASTRAN data cards may be used for special purposes in acoustic analysis. The SPC1 data card may be used to constrain the pressures to zero at specified points such as at a free boundary. The formats for these cards are included in Section 2.4. Dynamic load cards, direct input matrices, and scalar elements may be introduced to account for special effects. The reader is referred to Sections 1.4 and 1.5 for instruction in the use of these cards.

1.9.2 Assumptions and Limitations

The accuracy of the acoustic model will be dependent on the selection of the mesh of finite elements. The assumption for each element is that the pressure field has a linear variation over the cross section and a sinusoidal variation around the axis in the circumferential direction. In areas where the pressure gradient changes are large, such as near a sharp corner, the points in the mesh should be placed closer together so that large changes in flow may be defined accurately by the finite elements.

The shape of the finite elements play an important part in the accuracy of the results. It has been observed that long narrow elements produce disproportionate errors. Cutting a large square into two rectangles will not improve the results whereas dividing the square into four smaller squares may decrease the local error by as much as a factor of ten.

The slot portion of the cavity is limited to certain shapes because of basic assumptions in the algorithms. The cross section of the cavity normal to the axis must have a shape that is reasonably well defined by a central circular cavity having equally spaced, narrow slots. Various shapes are shown in Figure 1 in the order of increasing expected error.

It is recommended that shapes such as the cloverleaf and square cross section be analyzed with a full three dimensional technique. The assumption of negligible pressure gradient in the circumferential direction within a slot is not valid in these cases.

The harmonic orders of the solutions are also limited by the width of the slots. The harmonic number, N, should be no greater than the number of slots divided by two. The response of the higher harmonics is approximated by the slot width correction terms discussed in the NASTRAN Theoretical Manual, Section 17.1.

The output data for the acoustic analysis consists of the values of pressure in the displacement vector selected via the case control card "PRESSURE = i". The velocity vector components corresponding to each mode may be optionally requested by the case control card "STRESS = i", where i is the set number indicating the element numbers to be used for output, or by the words "STRESS = ALL". The "SET =" card lists the element or point numbers to be output.

Plots of the finite element model and/or of the pressure field may be requested with the NASTRAN plot request data cards. The central cavity cross section will be positioned in the XY plane of the Basic Coordinate System of NASTRAN. The slot elements are offset from the XY plane by the width of the slot in the +Z direction. The radial direction corresponds to X and the axial direction corresponds to the Y direction. Pressures will be plotted in the Z direction for both the slot points and the central cavity points. The case control data cards for plotting are documented in the User's Manual. The PLØTEL elements are used for plotting the acoustic cavity shape. The plot request card "SET n INCLUDE PLØTEL" must be used where n is a set number.

1.9.3 Acoustic Cavity Example Problem

Table 1 contains a listing of the data cards used as a simple example of acoustic cavity analysis. The problem to be solved is illustrated in Figure 2. The model was subdivided into only ten finite elements in order to limit the number of data cards. For reasonable engineering accuracy, this model should be subdivided into at least four times that number of elements.

Each data card in Table 1 is given a number on the left side. The format for each type of bulk data card is given in parentheses above the group of that type. The following is a brief description of each card:

Card(s)

1-5 Each data card in the Executive Control deck has the format of a request word and a selection separated by blanks or a comma. The ID card is first, the CEND card is last, but the intermediate cards may appear in any order. The user may put any pair of words on the ID card for identification purposes. In this particular case Rigid Format number 3 (SØL 3,0) was chosen which is Normal Modes analysis. A limit of 2 minutes CPU time was set (TIME 2).

6-7 The TITLE= and SUBTITLE= cards may contain any list of letters and numbers following the (=) sign. This list will appear on the first two lines of each output page.

8 The method of eigenvalue extraction is selected with the METHØD= data card. The number 11 refers to the identification number of an EIGR bulk data card which appears below as card 32 and 33.

9-11 A simple output request is illustrated with these cards. PRES=ALL will result in printout of all pressures at the GRIDF and GRIDS points. STRESS=ALL will result in the printout of all velocities in the elements. This printout will occur for all extracted eigenvectors. Selected points or elements can be printed via the SET card described in the User's Manual.

12 The BEGIN BULK card denotes the beginning of the bulk data deck. The Bulk Data Deck cards may occur in any order. Putting these cards in alphabetic sort will save NASTRAN sorting time in large problems, however.

13 In this problem all the parameters except slot width w_d are constant throughout the volume. The data values on the AXSLØT card will be used whenever a corresponding entry in the following cards is blank.

14-20 The location of points on the slot are defined with these cards. Cards 14, 16, 18 and 20 serve a dual purpose by defining a GRIDS point identification number in field 2 and a GRIDF point identification number in field 6. The two types of points thereby are forced to have the same locations at the interface.

21,22 The location of points within the axisymmetric fluid cavity are described by the GRIDF card. No points are allowed to have a zero or negative radius.

23-31 These cards describe the elements shown in Figure 2. Each element is given a unique identification number and a list of the connected GRIDS or GRIDF points. Since the parameters ρ and B are constants, these fields are left blank so the values on the AXSLØT card will be used.

32,33 The EIGR card is used to define parameters for eigenvalue extraction (resonant frequencies). More than one of these cards may appear. The method to be used is selected with the METHØD= data card in the Case Control Deck (card 8). With this particular card we selected the Givens Tridiagonalization method (GIV) with a desired number of three (Nd = 3) output mode shapes. The modes will be normalized such that the maximum pressure is 1.0 (NØRM=MAX). These two cards illustrate a continuation card.

34 The SLBDY card defines the boundary between the slot and the central cavity. Both the density (ρ) and the number of radial slots (M) are blank so the AXSLØT defaults are used, i.e. $\rho = 1.2 \times 10^{-7}$ and M = 4. Only four GRIDS points are on the boundary so a continuation card is not necessary. Field 8 being blank signifies the last entry.

35. The ENDDATA card is required to denote the end of the bulk data. Any following cards will be ignored by NASTRAN.

Table 1. Example problem data cards.

Card No.		
1	ID ACØUS, MSC	Executive Control Cards
2	APP DISP	
3	SØL 3,0	
4	TIME 2	
5	CEND	
6	TITLE = ACØUSTIC CAVITY EXAMPLE PRØBLEM	Case Control Data Cards
7	SUBTITLE = FIRST HARMØNIC	
8	METHØD = 11	
9	ØUTPUT	
10	PRES = ALL	
11	STRESS = ALL	
12	BEGIN BULK	

Card No.	1	2	3	4	5	6	7	8	9	10
	(AXSLØT	ρ_d	B_d	N	w_d	M_d)				
13	AXSLØT	1.2-7	21.0	1		4				
	(GRIDS	Id	r	z	w	Id_f)				
14	GRIDS	2	4.0	0.0	0.2E 01	1				
15	GRIDS	3	8.0	.0	1.0					
16	GRIDS	5	4.0	4.0	2.0	4				
17	GRIDS	6	8.0	4.0	1.0					
18	GRIDS	8	4.0	8.0	2.0	7				
19	GRIDS	9	8.0	8.0	1.0					
20	GRIDS	12	4.0	1.2+1	2.0	11				
	(GRIDF	Id	r	z)						
21	GRIDF	10	2.0	12.0						
22	GRIDF	13	2.0	1.4E1						
	(CSLØT4	Id	P_1	P_2	P_3	P_4	ρ	B	M)	
23	CSLØT4	1	2	3	6	5				
24	CSLØT4	2	5	6	9	8				
	(CSLØT3	Id	P_1	P_2	P_3		ρ	B	M)	
25	CSLØT3	3	8	9	12					
	(CAXIF2	ID	P_1	P_2			ρ	B)		
26	CAXIF2	4	1	4						
27	CAXIF2	5	4	7						
28	CAXIF2	6	7	10						
29	CAXIF2	9	10	13						

(Continued)

Card No.	1	2	3	4	5	6	7	8	9	10
	(CAXIF3	Id	P_1	P_2	P_3		ρ	B)		
30	CAXIF3	7	7	10	11					
31	CAXIF3	8	10	11	13					
	(EIGR	Id	Method	f_1	f_2	Ne	Nd	Nz		+XYZ
	(+XYZ	NØRM)								
32	EIGR	11	GIV				3			+AB
33	+AB	MAX								
	(SLBDY	ρ	M	ID1	ID2	ID3	ID4	etc.)		
34	SLBDY			12	8	5	2			
35	ENDDATA									

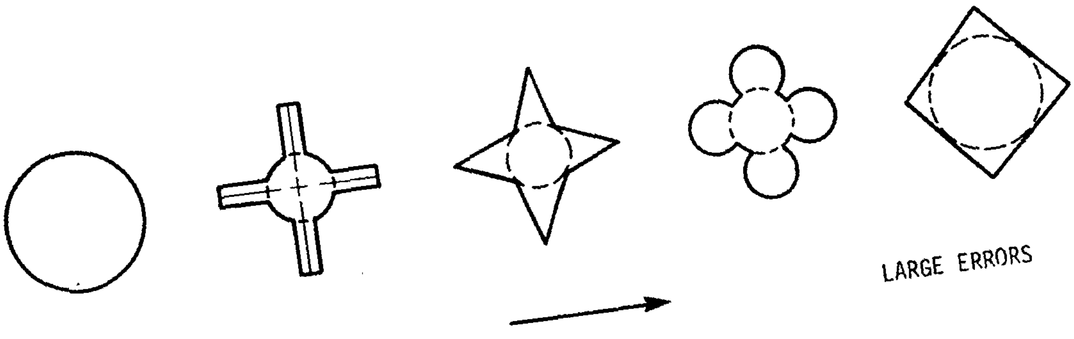
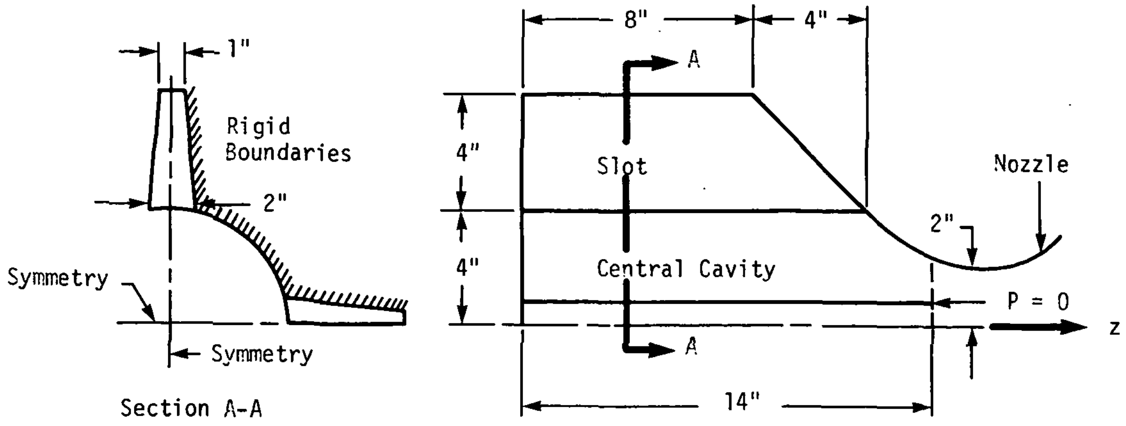


Figure 1. Modeling errors for various shapes.



Parameters:

Density: $\rho = 1.1463 \times 10^{-7}$ lb-sec^2/in^4

Bulk Modulus: $B = \rho a^2 = \gamma RT = 20.59$ lb/in^2

Harmonic: N = 1

Number of slots: M = 4

Note: Consistent Dimensional Units must be used.

FINITE ELEMENT MODEL:

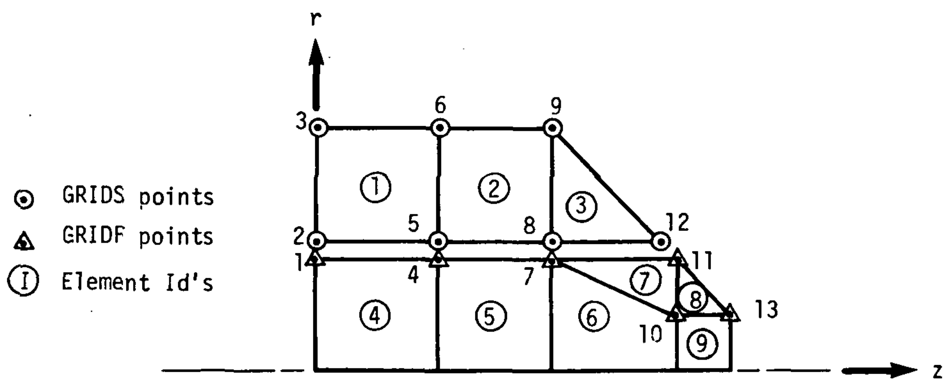


Figure 2. Description of example problem.

1.10 MANUAL SINGLE-STAGE SUBSTRUCTURING

The theoretical basis for NASTRAN manual substructuring is given in Section 4.3 of the Theoretical Manual. The NASTRAN Substructuring technique may be used with any of the rigid formats, except Piecewise Linear Analysis. The following sections present instructions, including suggested Series N DMAP alters; for use with the rigid formats for Static Analysis and Normal Modes Analysis.

Substructure analysis, as here defined, is a procedure in which the structural model is divided into separate parts which are then processed in separate computer executions to the point where the data blocks required to join each part to the whole are generated. The subsequent operations of merging the data for the substructures and of obtaining solutions for the combined problem are performed in one or more subsequent executions, after which detailed information for each substructure is obtained by additional separate executions.

Substructure analysis by the manual substructuring technique is logically performed in at least three phases as follows:

<u>Phase I</u> - Analysis of each individual substructure by NASTRAN to produce a description, in matrix terms, of its properties as seen at the boundary degrees of freedom, u_a.

<u>Phase II</u> - Combination of the matrix properties from Phase I and the inclusion, if desired, of additional terms to form a "pseudostructure," which is then analyzed by NASTRAN.

<u>Phase III</u> - Completion of the analysis of individual substructures using the $\{u_a\}$ vector produced in Phase II.

The NASTRAN Data Deck for each of the substructures is constructed in the same manner as for a NASTRAN analysis without substructuring. The following restrictions must be considered when forming the NASTRAN Data Deck for each of the substructures:

1. All points on boundaries between substructures which are to be joined must have their free degrees of freedom placed in the a-set.

2. The sequence of internal grid point identification numbers along the boundary between any two substructures must be the same. The internal sequence is the external sequence modified by any SEQGP cards. For example, if one substructure had boundary grid point internal identification numbers of 3, 4, 9, 27, and 31, the adjoining substructure could have a corresponding set of internal grid point identification numbers of 7, 11, 21, 22, and 41, but not 7, 11, 22, 21, and 41. This restriction is automatically satisfied if the same grid point numbers, without SEQGP cards, are used on the boundaries for connected substructures.

3. The displacement coordinate system for each group of connected grid points on the boundaries between substructures must be the same.

4. Elements located on the boundary may be placed in either adjacent substructure.

5. The loads applied to boundary points may be arbitrarily distributed between the adjoining substructures. Care should be exercised not to duplicate the loads by placing the entire load on each substructure.

6. The constrained stiffness matrix, $[K_{oo}]$, for each substructure must be nonsingular. This requirement is automatically satisfied in most cases, since usually there are enough degrees of freedom on the boundary of the substructure to account for its rigid body motions. In exceptional cases, such as when the substructure is a hinged appendage, it may be necessary for the user to assign additional degrees of freedom to u_a, rather than u_o.

Although the following discussion is limited to single-stage substructuring, there is no inherent restriction on the use of multi-stage substructures in NASTRAN. In multi-stage substructuring, some of the substructures are precombined in Phase II to form intermediate substructures. The final combination in Phase II then consists of joining two or more intermediate substructures. This procedure will be useful if there are several substructures in the model, and changes are made in only one or a few substructures. In this case, the amount of effort and computer time required for changes in the model can be substantially reduced if the unchanged substructures are initially combined into a single intermediate substructure.

1.10.1 Basic Manual Substructure Analysis

Basic manual substructure analysis will be described with reference to the simple beam structure shown in Figure 1. The beam is arbitrarily separated into two substructures, referred to as substructure 1 and substructure 2, with a single boundary point being located at grid point 3. The beam is supported at grid points 1 and 6. No loads are applied to substructure 1. A single load is applied to substructure 2 at grid point 4, and a single load is applied at the boundary to grid point 3.

The complete NASTRAN Data Decks for all three phases of a substructure analysis for the beam shown in Figure 1 will be presented with comments for each card. The integers in the left-hand column will be used to relate the discussion to the cards in the NASTRAN Data Deck.

The following data deck is used for the Phase I of substructure 1:

```
ID        PHASE ØNE $ SUBSTRUCTURE 1
TIME      2
CHKPNT    YES
APP       DISP
SØL       1,9
ALTER     100
JUMP      LBL7 $
ALTER     118
FBS       LØØ,UØØ,PØ/UØØV $
CHKPNT    UØØV $
ØUTPUT1   E1,KLL,PL,,//C,N,-1/C,N,0/C,N,USERTP1 $
ALTER     119, 164
ENDALTER
CEND
TITLE = PHASE ØNE - SUBSTRUCTURE 1
SPC = 101
BEGIN BULK
ASET      3       126
CBAR      1       10      1       2               1.0             1
CBAR      2       10      2       3               1.0             1
DMI       E1      0       2       1       1               3       1
DMI       E1      1       1       1.0     1.0     1.0
GRID      1                                               345
GRID      2               240.                            345
GRID      3               480.                            345
MAT1      11      30.+6
PBAR      10      11      60.     500.
SPC       101     1       12
ENDDATA
```

Comments are as follows:

101 ID card is first card of NASTRAN Data Deck.

102 TIME card is required in Executive Control Deck.

103 This run will be checkpointed, so that a restart can be made for Phase III. The user must arrange to have a physical tape mounted for the New Problem Tape (NPTP).

104 One of the rigid formats will be used for this problem.

105 Rigid Format 1 (Series N), Static Analysis, will be used for this problem without property optimization.

106 Insert the following statement after DMAP statement No. 100.

107 Jump around the Rigid Body Matrix Generator modules. The solution for $\{u_a\}$ will be performed in Phase II.

108 Insert the following three statements after DMAP statement No. 118.

109 Use the module FBS to solve for $\{u_o^o\}$ the displacement of the o-set points relative to the a-set points.

110 Write displacement vector UØØV on the New Problem Tape.

111 Use the module ØUTPUT1 to write the DMI matrix given on cards 121 and 122, along with the stiffness matrix KLL, and the load vector PL on User Tape 1 (USERTP1). The user must arrange to have a physical tape mounted for User Tape 1 (INPT). The details of the call for DMAP module ØUTPUT1 and other DMAP information are given in Section 5.

112 Delete the data recovery modules.

113 End of the ALTER package.

114 Last card of Executive Control Deck.

115 Title information for Phase I substructure 1 printed output.

116 Select single-point constraint set 101.

117 Indicates the beginning of the Bulk Data Deck.

118 Defines grid point 3 as a boundary point between substructures.

119, 120 Connection cards defining bar elements in substructure 1.

121, 122 Direct Matrix Input cards that define the partitioning vector for use in Phase II. The entries on these cards are discussed below.

123, 124, 125 These cards define the grid points in substructure 1.

126 Defines the material for the elements in substructure 1.

127 Defines the properties of the elements in substructure 1.

128 Defines single-point constraint set 101. Components 1 and 2 are constrained at grid point 1 in substructure 1.

129 End of NASTRAN Data Deck.

It should be noted that no output has been requested in the Case Control Deck for substructure 1. If the user wishes to have a plot of the undeformed structure for checking the model, a Plot Package can be inserted in the Case Control Deck in the usual way, as described in Section 4.2.

The partitioning matrix gives the relationship between the internal indices associated with the a-set matrices generated in Phase I and the external grid point component definition given on the grid cards that are input to Phase I as modified by any SEQGP cards. The same internal indices in Phase I for the a-set are redefined in Phase II as the indices for the g-set. The word pseudostructure is associated with the g-size matrices used in Phase II.

The partitioning matrix for the problem under consideration is given as follows:

PARTITIONING MATRIX

	External Grid-Component	
Internal Index	Substructure 1	Substructure 2
1	3-1	3-1
2	3-2	3-2
3	3-6	3-6

The procedure for constructing a partitioning matrix is as follows:

1. Select any one of the substructures and list the components of the a-set in sequence by grid point and component number as modified by any SEQGP cards (internal sequence). These are the nonzero entries in the partitioning vector for the first substructure.

2. Build the second column of the partitioning matrix by selecting any connected substructure and entering the connected components in the same row as the associated components in the first substructure.

3. Enter all unconnected a-set components in unoccupied rows of the partitioning matrix according to their internal sequence numbers. Unconnected members of the a-set having

internal sequence numbers in the range of the connected components will create new intermediate rows in the previously formed columns of the matrix.

4. Build the remaining columns of the partitioning matrix, one for each substructure, by following a similar procedure for all remaining substructures. In each case, first enter all components that are connected to the previously selected substructure or substructures, followed by the remaining unconnected components in their internal sequence.

5. The rows of the partitioning matrix are associated with the sequence of the internal indices for the scalar points in the pseudostructure. Any sequential set of integers may be used to identify these scalar points in Phase II.

6. The columns of the partitioning matrix (one vector for each substructure) are input with Direct Matrix Input (DMI) cards. The input matrix contains real 1's in all locations in the partitioning matrix having grid point-component entries. See Section 2.4 for DMI card format.

The DMI cards (121 and 122) in the sample problem give the name E1 to the partitioning vector for substructure 1. The first card defines the partitioning vector as being rectangular and consisting of real single-precision entries. The next to the last entry on the first card indicates there are three rows in the g-set matrices input to Phase II. The second integer 1 on the second card indicates that the first internal index is associated with one of the components in substructure 1; in this case, grid point 3, component 1. The three real 1.0's indicate the first three internal indices are associated with components in substructure 1; in this case, grid point 3, components 1, 2, and 6. In this particular case, only the initial two steps are required to construct the partitioning matrix and the partitioning vector for substructure 2 will be identical to that for substructure 1. This results from the fact that the single boundary point in this problem is a part of both substructures.

The partitioning vectors are not needed until Phase II. They were arbitrarily input to Phase I so they could be included on the User Tape, along with the output matrices from Phase I.

The NASTRAN Data Deck for substructure 2 is given below. For identification purposes, the cards are arbitrarily numbered beginning with 150.

```
ID        PHASE ØNE $ SUBSTRUCTURE 2
TIME      2
CHKPNT    YES
APP       DISP
SØL       1, 9
ALTER     100
JUMP      LBL7 $
ALTER     118
FBS       LØØ,UØØ,PØ/UØØV $
CHKPNT    UØØV $
ØUTPUT1   E2,KLL,PL,,//C,N,-1/C,N,0/C,N,USERTP2 $
ALTER     119, 164
ENDALTER
CEND
TITLE = PHASE ØNE - SUBSTRUCTURE 2
SPC = 201
LØAD = 202
BEGIN BULK
ASET      3       126
CBAR      3       10      3       4               1.0             1
CBAR      4       10      4       5               1.0             1
CBAR      5       10      5       6               1.0             1
DMI       E2      0       2       1       1               3       1
DMI       E2      1       1       1.0     1.0     1.0
FORCE     202     3               1000.           -1.0
FORCE     202     4               1000.           -1.0
GRID      3               480.                            345
GRID      4               720.                            345
GRID      5               960.                            345
GRID      6               1200.                           345
MAT1      11      30.+6
PBAR      10      11      60.     500.
```

```
182  SPC      201            6          2
183  ENDDATA
```

Comments are given only for those cards which are different from those given in substructure 1.

150 The ID card contains the comment following the dollar sign indicating the deck is for substructure 2.

160 The partitioning vector for substructure 2 is written on User Tape 2 and is named E2. The user must arrange to mount a second physical tape for INPT. It is possible to change the ØUTPUT1 statement and write the results for substructure 2 on the same tape as for substructure 1, if desired.

164 The printed output will indicate this run is for substructure 2.

165 Selects single-point constraint set 201.

166 Selects load set 202.

172–173 Other than the name E2, the partitioning vector is identical to that for substructure 1.

174–175 Defines the external loads in load set 202. The load applied to grid point 3 has arbitrarily been placed in substructure 2.

182 Defines single-point constraint set 201 at grid point 6, component 2.

The Phase II operations are concerned with merging the a-set matrices generated in Phase I which define the g-size pseudostructure in Phase II. The NASTRAN Data Deck for Phase II is given below. The cards are arbitrarily numbered beginning with 201.

```
201  ID        PHASE TWØ
202  TIME      2
203  APP       DISP
204  SØL       1,9
205  ALTER     1
206  PARAM     //C,N,NØP/V,N,TRUE=-1 $
207  ALTER     7,22
208  ALTER     25,64
209  INPUTT1   /E01,KGG01,PG01,,/C,N,-1/C,N,1/C,N,USERTP1 $
210  MERGE,    ,,,KGG01,E01,/KGGT01 $
```

```
211  ADD        KGG,KGGT01/KT01 $
212  EQUIV      KT01,KGG/TRUE $
213  MERGE,     ,PG01,,,,E01/PGT01/C,N,1 $
214  ADD        PGT,PGT01/PT01 $
215  EQUIV      PT01,PGT/TRUE $
216  INPUTT1    /E02,KGG02,PG02,,/C,N,-1/C,N,2/C,N,USERTP2 $
217  MERGE,     ,,,KGG02,E02,/KGGT02 $
218  ADD        KGG,KGGT02/KT02 $
219  EQUIV      KT02,KGG/TRUE $
220  MERGE,     ,PG02,,,,E02/PGT02/C,N,1 $
221  ADD        PGT,PGT02/PT02 $
222  EQUIV      PT02,PGT/TRUE $
223  ALTER      73,78
224  ALTER      111,111
225  SSG1       SLT,BGPDT,CSTM,SIL,,MPT,,EDT,,CASECC,DIT/PG/V,N,LUSET/V,N,NSKIP $
226  ADD        PGT,PG/PGX $
227  EQUIV      PGX,PG/TRUE $
228  ALTER      137,141
229  ØUTPUT1,   ,,,,//C,N,-1/C,N,0/C,N,USERTP3 $
230  PARTN      UGV,,E01/,ULV01,,/C,N,1 $
231  ØUTPUT1    ULV01,,,,//C,N,0/C,N,0/C,N,USERTP3 $
232  PARTN      UGV,,E02/,ULV02,,/C,N,1 $
233  ØUTPUT1    ULV02,,,,//C,N,0/C,N,0/C,N,USERTP3 $
234  SDR2       CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,PGG,QG,UGV,,/ØPG1,ØQG1,ØUGV1,,,/C,N,STATICS $
235  ØFP        ØUGV1,ØPG1,ØQG1,,,//V,N,CARDNØ $
236  ALTER      154,156
237  ALTER      158,164
238  ALTER      168,169
     ALTER      172,173
239  ENDALTER
240  CEND
241  TITLE = PHASE TWØ
242  BEGIN BULK
```

243	DMI	KGG	0	6	1	2		3	3
244	DMI	KGG	1	1	0.0				
245	DMI	PGT	0	2	1	2		3	1
246	DMI	PGT	1	1	0.0				
247	SPØINT	1	THRU	3					
248	ENDDATA								

Comments for each of the cards are as follows:

201 The ID card is the first card of the NASTRAN Data Deck.

202 The TIME card is required in the Executive Control Deck.

203 One of the rigid formats will be used to solve this problem.

204 Rigid Format 1 (Series N), Static Analysis, will be used for this problem.

205 Insert the following statement after DMAP statement No. 1.

206 Define the parameter TRUE = -1.

207 Delete the DMAP statements associated with the preparation of the Element Connection Table and structure plots.

208 Delete the DMAP statements associated with matrix assembly.

209 Insert the DMAP module INPUTT1 to read the partitioning vector, the stiffness matrix, and the load vector from User Tape 1. These matrices have been renamed E01, KGG01, and PG01, respectively. The user must arrange to have the tape mounted that was prepared during the Phase I run of substructure 1. This tape should be designated as INP1.

210 Insert the module MERGE to change the a-set size of the stiffness matrix from Phase I to g-size for Phase II, and designate the output as KGGT01. In this particular case, no change will take place, since the a-size from Phase I is the same as the g-size in Phase II.

211 Insert the module ADD to add the null matrix KGG, defined in the Bulk Data Deck, to KGGT01, and designate the output as KT01.

212 Insert the module EQUIV to equivalence KT01 to KGG.

213 Insert the module MERGE to change the a-size of the load vector from Phase I to g size for Phase II, and designate the output as PGT01. In this case, no change in size will take place.

214 Insert the module ADD to add the null matrix PGT, defined in the Bulk Data Deck, to PGT01, and designate the output as PT01.

215 Insert the module EQUIV to equivalence PT01 to PGT.

216 Insert the module INPUTT1 to read the partitioning vector, the stiffness matrix, and the load vector from User Tape 2. These matrices which were generated for substructure 2 in Phase I are redesignated as E02, KGG02, and PG02, respectively.

217 Insert the module MERGE to change the stiffness matrix for substructure 2 from a-size in Phase I to g-size in Phase II and designate the output as KGGT02.

218 Insert the module ADD to add the stiffness matrix for substructure 2 to the stiffness matrix for substructure 1, and designate the output as KT02.

219 Insert module EQUIV to equivalence KT02 to KGG. The matrix KGG now represents the stiffness matrix for the pseudostructure, and will be used for input to Phase II.

220 Insert the module MERGE to change the load vector from a-size in Phase I to g-size in Phase II.

221 Insert the module ADD to add the loads applied to substructure 2 to the load vector for substructure 1, and designate the output as PT02.

222 Insert the module EQUIV to equivalence PT02 to PGT.

223 Delete the DMAP statements associated with the Grid Point Singularity Processor.

224 Delete the module SSG1 as given in Rigid Format 1.

225 Insert the module SSG1 with the calling sequence modified to remove parts not associated with directly applied loads. Since, for this particular problem, all loads were applied in Phase I, there will be no output from SSG1.

226 Insert the module ADD to combine the load vector from Phase II with the load vectors generated in Phase I, and designate the output as PGX.

227 Insert the module EQUIV to equivalence PGX to PG. The data block PG now includes all loads from both Phase I and Phase II, and will be used as input to Phase III.

228 Remove SDR2 and ØFP as given in Rigid Format 1.

229 Insert the module ØUTPUT1 to rewind User Tape 3 and place the label USERTP3 on this tape. The user must arrange to have a physical tape mounted and designated as INPT.

230 Insert the module PARTN to separate that part of the solution vector UGV associated with substructure 1, and designate the output as ULV01.

231 Insert the module ØUTPUT1 to write the partition of the solution vector associated with substructure 1 on User Tape 3.

232 Insert the module PARTN to separate that part of the solution vector associated with substructure 2, and designate the output as ULV02.

233 Insert the module ØUTPUT1 to write that part of the solution vector associated with substructure 2 on User Tape 3. This will place the solution vectors for both substructures on User Tape 3. A second tape could be used for the solution vector for substructure 2 by changing the DMAP statement for ØUTPUT1.

234 Insert the module SDR2 with the calling sequence modified to remove those parts associated with element output.

235 Insert the module ØFP with the calling sequence modified to remove those parts associated with element output.

236 Remove ØFP as given in Rigid Format 1.

237 Remove the DMAP statements associated with the preparation of the deformed structure plots.

238 Remove the statements associated with ERRØR2 and ERRØR4.

239 End of ALTER package.

240 End of Executive Control Deck.

241 Title information for Phase II printed output.

242 Beginning of the Bulk Data Deck.

243-244 } DMI cards used to define the null matrix KGG.

245-246 } DMI cards used to define the null matrix PGT.

247 Definition of the three scalar points for the pseudostructure.

248 End of NASTRAN Data Deck.

Although the data deck shown above is prepared for two substructures, it was constructed in such a manner that it could be easily extended to more than two substructures. If there are more than two substructures, cards similar to 216 to 222, 232, and 233 need to be added to the NASTRAN data deck for each additional substructure.

The final part of a substructure analysis is to perform data recovery for each substructure of interest. These runs are made as a restart of the Phase I runs. Any of the normal rigid format output can be requested, including both undeformed and deformed structure plots. All of the output will be in terms of the elements and grid points defined in the Phase I Bulk Data Decks. The NASTRAN Data Deck for the Phase III analysis of substructure 1 is given as follows:

```
301 ID        PHASE THREE $ SUBSTRUCTURE 1
```

```
302  TIME      2
303  APP       DISP
304  SØL       1,9
305  ALTER     23,125
306  INPUTT1   /,,,,/C,N,-1/C,N,0/C,N,USERTP3 $
307  INPUTT1   /ULV,,,,/C,N,0 $
308  ALTER     128,133
309  ALTER     165,176
310  ENDALTER
311     (Include Restart Dictionary from Phase I)
312  CEND
313  TITLE = PHASE THREE - SUBSTRUCTURE 1
314  DISP = ALL
315  ELFØRCE = ALL
316  ØLØAD = ALL
317  SPCFØRCE = ALL
318  BEGIN BULK
319     (No Bulk Data)
320  ENDDATA
```

Comments for each of the cards are as follows:

301 ID card is first card of the NASTRAN Data Deck.

302 TIME card is required in the Executive Control Deck.

303 One of the rigid formats will be used for this problem.

304 Rigid Format 1 (Series N), Static Analysis, will be used for this problem.

305 Delete all parts of the rigid format, except the data recovery modules.

306 Insert module INPUTT1 to rewind and check the label on User Tape 3. The user must arrange to have User Tape 3 mounted and designated as INPT.

307 Insert module INPUTT1 to read the solution vector for substructure 1 from User Tape 3. The solution vector is designated as ULV for input to module SDR1.

308, 309 Remove additional DMAP statements not associated with data recovery operations.

310 End of ALTER package.

311 Insert the Restart Dictionary punched during the Phase I run of substructure 1.

312 End of Executive Control Deck.

313 Title information for printed output for Phase III.

314 Request printed output for all displacements of substructure 1.

315 Request printed output of forces for all elements in substructure 1.

316 Request printed output of the load vector for substructure 1. In this particular case, no output will result because no loads were applied to substructure 1.

317 Request printed output for all nonzero single-point forces of constraint on substructure 1.

318 Beginning of Bulk Data Deck.

319 No bulk data cards should be included in the Phase III run. However, the BEGIN BULK and ENDDATA cards must be present.

320 End of NASTRAN Data Deck.

The NASTRAN data deck for the Phase III analysis of substructure 2 is given below. Comments are restricted to cards that are different from those presented for the Phase III run of substructure 1.

```
350  ID         PHASE THREE $ SUBSTRUCTURE 2
351  TIME       2
352  APP        DISP
353  SØL        1,9
354  ALTER      23,125
355  INPUTT1    /,,,,/C,N,-1/C,N,0/C,N,USERTP3 $
356  INPUTT1    /ULV,,,,/C,N,1 $
357  ALTER      128,133
358  ALTER      165,176
359  ENDALTER
360     (Include Restart Dictionary from Phase I)
361  CEND
362  TITLE = PHASE THREE - SUBSTRUCTURE 2
363  DISP = ALL
364  ELFØRCE = ALL
```

365 ØLØAD = ALL

366 SPCFØRCE = ALL

367 BEGIN BULK

368 (No Bulk Data)

369 ENDDATA

Comments are as follows:

350 The comment following the dollar sign indicates this analysis is for substructure 2.

355 Insert module INPUTT1 to rewind User Tape 3. The user must arrange to mount User Tape 3, if it is not already mounted as a result of the previous run on substructure 1.

356 Insert module INPUTT1 to skip over the solution vector for substructure 1 on User Tape 3, and read the solution vector for substructure 2.

365 The request for printed output of the load vectors will show nonzero loads applied to grid points 3 and 4.

1.10.2 Loads and Boundary Conditions

The single load and the single boundary condition for the sample problem in Section 1.10.1 were introduced in Phase I. It is also possible to introduce loads and boundary conditions in Phase II. In this case, the loaded and/or constrained degrees of freedom must be included in the a-set for Phase I, so they will be a part of the pseudostructure in Phase II. Loads are applied to the pseudostructure in Phase II with the SLØAD card. This limits the type of load that can be applied in Phase II to directly applied loads. Other loading conditions depending on element properties or connection data, such as thermal loads, gravity loads, and pressure loads, must be applied in Phase I. Loads may be introduced in both Phases I and II, as the suggested DMAP sequence will add contributions to the load vector from both phases. The lack of generality for the application of loads in Phase II will often dictate that static loads be applied in Phase I.

The loads and boundary conditions for the sample problem can be applied in Phase II if the following modifications are made to the NASTRAN Data Decks presented in Section 1.10.1.

1. Remove card 116, SPC set selection for Phase I substructure 1.
2. Replace card 118 as shown below to redefine the a-set for substructure 1.

3. Replace cards 121 and 122 with cards 121, 122, and 122a shown below to redefine the partitioning vectors for substructure 1.

4. Card 128 is not required, SPC set definition for substructure 1.

5. Remove cards 165 and 166, SPC and load set selection for Phase I, substructure 2.

6. Replace card 168 as shown below to redefine the a-set for substructure 2.

7. Replace cards 172 and 173 with cards 172, 173, and 173a shown below to redefine the partitioning vectors for substructure 2.

8. Cards 174, 175, and 182 are not required, load definition and SPC definition for substructure 2.

9. Insert cards 241a and 241b as shown below after card 241 in the Case Control Deck for Phase II for the selection of the boundary conditions and loading condition.

10. Replace cards 243 and 245 as shown below to conform to new size for pseudostructure.

11. Insert the cards 246a and 246b as shown below in the Bulk Data Deck for Phase II for definition of the loading condition and boundary condition.

12. Replace card 247 as shown below to modify the definition of the pseudostructure to contain 12 scalar points.

118	ASET1	126	1	3						
121	DMI	E1	0	2	1	1		12	1	
122	DMI	E1	1	1	1.0	1.0	1.0	1.0	1.0	+E11
122a	+E11	E1	1.0							
168	ASET1	126	3	4	6					
172	DMI	E2	0	2	1	1		12	1	
173	DMI	E2	1	4	1.0	1.0	1.0	1.0	1.0	+E21
173a	+E21	E2	1.0	1.0	1.0	1.0				
241a	SPC = 201									
241b	LØAD = 202									
243	DMI	KGG	0	6	1	2		12	12	
245	DMI	PGT	0	2	1	2		12	1	
246a	SLØAD	202	5	1000.	8	1000.				
246b	SPC1	201		1	2	11				
247	SPØINT	1	THRU	12						

The modified partitioning matrix with grid points 1, 3, 4, and 6 in the a-set is shown below.

PARTITIONING MATRIX

Internal Index	External Grid-Component Substructure 1	External Grid-Component Substructure 2
1	1-1	
2	1-2	
3	1-6	
4	3-1	3-1
5	3-2	3-2
6	3-6	3-6
7		4-1
8		4-2
9		4-6
10		6-1
11		6-2
12		6-6

The modified partitioning matrix contains twelve scalar points, with six in substructure 1, nine in substructure 2, and three common to both substructures. The loads are now located at scalar points 5 and 8, as indicated on card 246a. The single-point constraints are located at scalar points 1, 2, and 11, as indicated on card 246b. The modified partitioning vector for substructure 1 indicates there are twelve degrees of freedom in the pseudostructure, and that, beginning with the first scalar point, there are six scalar points associated with substructure 1. The modified partitioning vector for substructure 2 indicates the first entry is associated with scalar point 4, and that there are a total of nine scalar points associated with substructure 2.

If multiple loading conditions are used in the solution, the subcase structure must be established in Phase I. In order to perform the matrix operations in Phase II, the same case control structure must be used for all substructures. This means that the same number of subcases must be defined for each substructure, even though some of the subcases will not contain a load selection or any other entries. NASTRAN will generate a null column in the load matrix for all subcases for which no load set is selected. If any loads are applied in Phase II, the same subcase structure must be used in Phase II. In any event, the subcase structure established in Phase I must be used in Phase III. The contents of each subcase in Phase III will relate to output selections, rather than load and boundary condition selections.

Consider adding two additional loading conditions to the sample problem in Section 1.10.1. If one additional loading condition were applied to substructure 1, identified as 202, and one additional loading to substructure 2, identified as 203, the subcase structure established in Phase I would appear as follows:

Substructure 1	Substructure 2
SPC = 101	SPC = 201
SUBCASE 1	SUBCASE 1
	LØAD = 201
SUBCASE 2	SUBCASE 2
LØAD = 202	
SUBCASE 3	SUBCASE 3
	LØAD = 203

Load case 202 would have to be defined with some form of static loading in the Bulk Data Deck for Phase I of substructure 1. In addition, load set 203 would have to be defined with some form of static loading in the Bulk Data Deck for Phase I of substructure 2.

The suggested DMAP sequence for the sample problem in Section 1.10.1 will not support multiple boundary conditions in Phase I. If multiple boundary conditions are introduced in Phase I, it is necessary to generate a separate partitioning vector for use in Phase II for each of the unique boundary conditions. In some sense, this results in the definition of a number of separate problems equal to the number of unique boundary conditions. Although a DMAP sequence could be developed to support multiple boundary conditions in Phase I, it is not recommended that multiple boundary conditions be introduced into Phase I.

Multiple boundary conditions may be introduced in Phase II without any difficulty. However, in order to handle the internal looping for each boundary condition, it is more convenient if the loads are also introduced in Phase II. As indicated earlier, the introduction of loads in Phase II does limit the manner in which the static loads can be defined. If the loads and boundary conditions are introduced in Phase II, all of the case control options for combining subcases, including symmetry combinations, may be used in the usual manner.

It is possible to introduce the loads in Phase I and multiple boundary conditions in Phase II. However, provision must be made to generate all loading conditions in Phase I, which will automatically take place if one subcase is defined for each loading condition and no boundary conditions are mentioned in the Phase I Case Control Deck. It is then necessary in Phase II to partition out the proper columns of the loading matrix for each loop or boundary condition in Phase II. This requires that the user construct the proper partitioning vector for each boundary condition. Also, appropriate modifications would have to be made to the suggested DMAP sequence for Phase II.

1.10.3 Dynamic Analysis

Substructuring for dynamic analysis is performed in much the same way as that for static analysis. A suggested NASTRAN Data Deck for use in Phase I of a Normal Modes Analysis (Rigid Format 3) is shown below:

```
ID        PHASE ØNE $ NØRMAL MØDES
TIME      2
CHKPNT    YES
APP       DISP
SØL       3,0
ALTER     86,126
ØUTPUT1   E10,KAA,MAA,,//C,N,-1/C,N,0/C,N,USERTP1 $
ENDALTER
CEND
   (Case Control Deck)
BEGIN BULK
   (Bulk Data Deck)
ENDDATA
```

Note that the ØUTPUT1 module writes the mass matrix, as well as the stiffness matrix and partitioning vector on User Tape 1. The Case Control Deck is similar to the Phase I deck for static analysis. It must include a constraint selection if the boundary conditions are applied in Phase I. The Bulk Data Deck is also similar to that used in Phase I for static analysis. In general, it includes all the cards associated with the definition of the model and the DMI cards for the definition of the partitioning vector. It will also include cards for the definition of the a-set and other constraint cards if the boundary conditions are applied in Phase I. As in static analysis, one such deck must be prepared for each substructure.

The suggested NASTRAN Data Deck for Phase II of Normal Modes Analysis with two substructures is shown below:

```
ID        PHASE TWØ $ NØRMAL MØDES
TIME      2
APP       DISP
SØL       3,0
ALTER     1
PARAM     //C,N,NØP/V,N,TRUE=-1 $
ALTER     6,49
INPUTT1   /E01,KGG01,MGG01,,/C,N,-1/C,N,1/C,N,USERTP1 $
MERGE,    ,,,KGG01,E01,/KGGT01 $
ADD       KGG,KGGT01/KT01 $
EQUIV     KT01,KGG/TRUE $
MERGE,    ,,,MGG01,E01,/MGGT01 $
ADD       MGG,MGGT01/MT01 $
EQUIV     MT01,MGG/TRUE $
INPUTT1   /E02,KGG02,MGG02,,/C,N,-1/C,N,2/C,N,USERTP2 $
MERGE,    ,,,KGG02,E02,/KGGT02 $
ADD       KGG,KGGT02/KT02 $
EQUIV     KT02,KGG/TRUE $
MERGE,    ,,,MGG02,E02,/MGGT02 $
ADD       MGG,MGGT02/MT02 $
EQUIV     MT02,MGG/TRUE $
ALTER     57,62
ALTER     119,120
ØUTPUT1   LAMA,,,,//C,N,-1/C,N,0/C,N,USERTP3 $
PARTN     PHIG,,E01/,PHIA01,,/C,N,1 $
ØUTPUT1   PHIA01,,,,//C,N,0/C,N,0/C,N,USERTP3 $
PARTN     PHIG,,E02/,PHIA02,,/C,N,1 $
```

```
ØUTPUT1   PHIA02,,,,//C,N,0/C,N,0/C,N,USERTP3 $
SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,QG,PHIG,,/,ØQG1,ØPHIG,,,/C,N,REIG $
ØFP       ØPHIG,ØQG1,,,,//V,N,CARDNØ $
ALTER     122,126
ALTER     128,129
ENDALTER
CEND
   (Case Control Deck)
BEGIN BULK
   (Bulk Data Deck)
ENDDATA
```

The Phase II NASTRAN Data Deck for Normal Modes Analysis is similar to that used for Static Analysis. The following comments are related to differences in the two decks:

1. Since there are no loads associated with a normal modes analysis, the module GP3 is not executed.
2. The same operations are performed on the mass matrix as are performed for the stiffness matrix.
3. The data block LAMA (Eigenvalue Summary) is written as the first data block on User Tape 3. This is followed by the appropriate partitions of the eigenvectors for each of the substructures.
4. The Case Control Deck must include a method selection for eigenvalue extraction.
5. The Bulk Data Deck is similar to that used in static analysis, except that a null matrix must be defined for the mass matrix, instead of the load matrix, and an EIGR card must be included.

In dynamic analysis, the a-set will include, in addition to all points on the boundary of the substructure, a number of points within each substructure sufficient to define the dynamic response. Since all active degrees of freedom along interior boundaries must be included in u_a, the a-set will contain more degrees of freedom than are needed in dynamic analysis, with a large resulting inefficiency for a very small gain in accuracy. This is a serious consideration because, due to the high density of K_{aa}, the time to perform most of the significant matrix operations in Phase II increases nearly as the cube of the number of degrees of freedom in u_a. The situation can be greatly improved by a second stiffness reduction in Phase II, in which u_a is partitioned into a set, u_c, that will be retained in dynamic analysis, and a set, u_b, that will be eliminated. The u_b set includes the excess degrees of freedom on the interior boundaries.

The second stiffness reduction in Phase II is defined by listing the members of the u_b set that will be eliminated on ØMIT cards. These omitted degrees of freedom must reference the scalar points associated with the pseudostructure.

In Phase III for dynamics, each NASTRAN substructure is restarted with the partition of the Phase II solution vector, or eigenvector, for each substructure. All normal data reduction procedures may then be applied. In dynamic analysis, Phase III can be omitted if output requests are restricted to the response quantities for the scalar points of the pseudostructure. In this case, the output and partition modules can be omitted from the Phase II runs, as their only purpose is to serve as input for the Phase III runs.

If output is desired for dependent response quantities or element stresses and forces, a Phase III run must be made for each substructure of interest. The suggested NASTRAN Data Deck is given below for a Phase III dynamics run:

```
ID        PHASE THREE $ NØRMAL MØDES
TIME      2
APP       DISP
SØL       3,0
ALTER     22,107
INPUTT1   /LAMA,,,,/C,N,-1/C,N,0/C,N,USERTP3 $
INPUTT1   /PHIA,,,,/C,N,0 $
ALTER     127,134
ENDALTER
   (Include Restart Dictionary from Phase I)
CEND
   (Case Control Deck)
BEGIN BULK
   (No Bulk Data)
ENDDATA
```

The Phase III data deck for Normal Modes Analysis is similar to that used for Static Analysis. The first reference to module INPUTT1 is to read the data block LAMA, which is the first data block on User Tape 3. The second reference to INPUTT1 is to read the proper partition of the eigenvectors. The zero parameter at the end of the statement should be incremented one for each substructure in order to point to the proper eigenvector partition.

Substructuring may be used with any of the other dynamics rigid formats. The NASTRAN Data Decks will be similar to those used for Normal Modes Analysis. All dynamic loads must be applied in Phase II. If the SUPØRT card is needed to define free body motions for the structure as a whole, it must be included in Phase II.

1.10.4 DMAP Loops for Phase II

The suggested DMAP sequences for the substructure example in Section 1.10.1 uses repeated blocks of code for each substructure. Cards 209 through 215 are associated with input for substructure 1. Cards 216 through 222 perform the same operations for substructure 2. Likewise, cards 230 and 231 are associated with output for substructure 1, and cards 232 and 233 are associated with output for substructure 2. If a large number of substructures are used, it is more convenient to use a DMAP loop, rather than repeating blocks of code. DMAP loops are constructed by placing a LABEL statement at the beginning of the loop and an REPT statement at the end of the loop. The number of times the REPT statement must be executed is set by an integer constant.

The series of statements represented by cards 209 through 222 can be replaced with the following sequence of DMAP operations:

```
PARAM     // C,N,NØP / V,N,INP=1 $
LABEL     BLØCK1 $
INPUTT1   / E,KGGA,PGA,, / C,N,-3 / V,N,INP $
MERGE,    ,,,KGGA,E, / KGGTA $
ADD       KGG,KGGTA / KTA $
EQUIV     KTA,KGG / TRUE $
MERGE,    ,PGA,,,,E / PGTA / C,N,1 $
ADD       PGT,PGTA / PTA $
EQUIV     PTA,PGT / TRUE $
PARAM     // C,N,ADD / V,N,INP / V,N,INP / C,N,1 $
REPT      BLØCK1,1 $
```

The LABEL, BLØCK1, is shown at the beginning of the loop, and the REPT statement is shown at the end. The integer in the REPT statement is set to one less than the number of substructures, which in this case is one. The PARAM statement preceding the REPT statement is used to increment the second parameter of INPUTT1 by one each time through the loop. This causes the information to be read from a different tape each time through the loop. This DMAP loop does not check the label before reading the information on the input tape. The fact that the same names are used for the matrices each time through the loop does not cause any difficulty, as the matrices are located by their position on the tape, rather than by name.

If a DMAP loop is used for the input sequence, consideration must be given to its effect on the output sequence. Since the partitioning vectors were not saved on each pass through the DMAP loop for the input sequence, it is necessary to recover this information for use in the output sequence. This might be done by rerunning INPUTT1 to reread the partitioning vectors as needed, or perhaps by inserting the DMI cards for the partitioning vectors in the Bulk Data Deck for Phase II. If Phase III runs are not required, no output sequence is necessary.

1.10.5 Identical Substructures

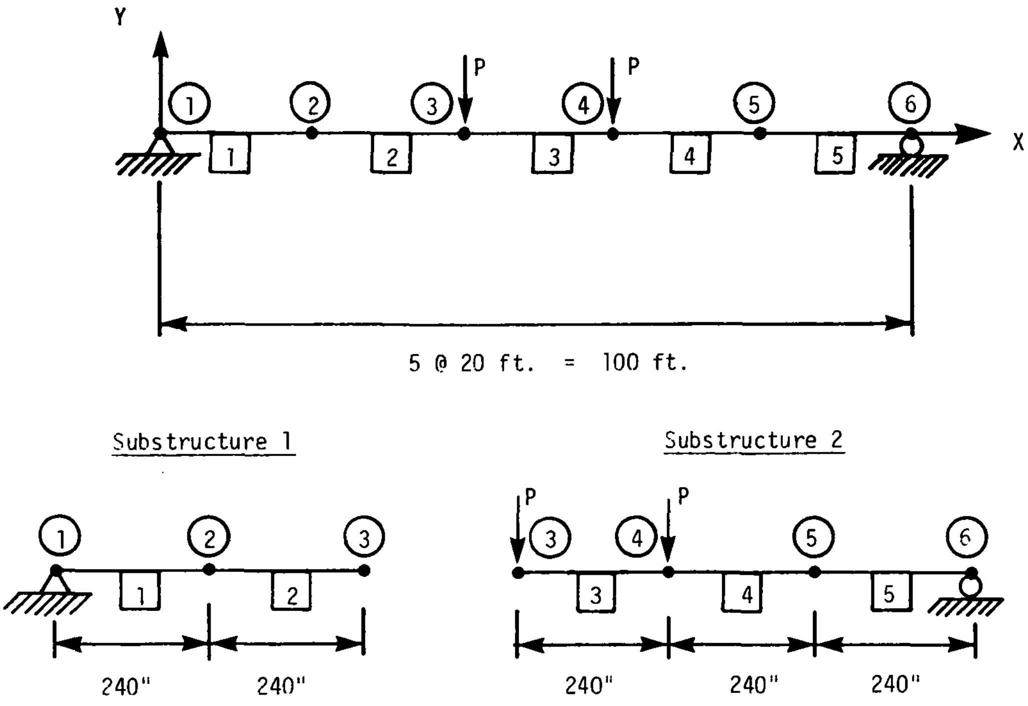
In the case of identical substructures, the substructuring procedures can be organized to take full advantage of the repetitive parts. The substructures only have to appear identical in Phase I. The loading conditions and boundary conditions used in Phase II may be quite different for the otherwise identical substructures. The Phase I substructures must have identical geometry, including the global coordinate systems used on the boundary grid points.

Only a single Phase I run is made for each group of identical substructures. Since the identical substructures will be coupled in different ways during Phase II, a different partitioning vector must be generated for each use of the identical substructures in Phase II. These multiple partitioning vectors can be placed on the same output tape from Phase I, which also contains the single set of structural and loading matrices for the group of identical substructures.

The user may choose to make one or more Phase III runs for the members of a group of identical substructures. If the loading conditions and boundary conditions are also identical for the group of identical substructures, a single Phase III run will give all information of interest. However, if the boundary conditions and/or loading conditions are different for the various members of the group of identical substructures, it will probably be desirable to make a separate Phase III run for each of the substructures used in the complete structural model.

MANUAL SINGLE-STAGE SUBSTRUCTURING

The use of identical substructures not only saves time in computer runs for Phase I and perhaps for Phase III, but also substantially reduces the effort associated with the preparation of the structural model in the Bulk Data Deck. In some sense, substructuring procedures with identical substructures can be thought of as being a form of data generation. Although substructuring is usually used because of problem size, it may be desirable, in some cases, to use substructuring because of the repetitive nature of the structure, and a consequent saving in data generation effort.



2 Grid Point Numbers

3 Element Numbers

$E = 30 \times 10^6$ psi

$I = 500$ in^4

$P = 1000$ lbs

FIGURE 1. Substructure Problem

1.11 AEROELASTIC MODELING

1.11.1 Introduction

The NASTRAN aeroelastic capability is compatible with the general structural capability. It is not designed for use with other special capabilities such as conical shell elements, hydroelastic option, and acoustic cavity analysis. The structural part of the problem will be modeled as described in other sections of this manual. This section deals with the new data, which is entirely aerodynamic, and with the connection between structural and aerodynamic elements.

Section 1.11.2 deals with the aerodynamic data. The selection of a good aerodynamic model will depend upon a knowledge of the theory (see Section 17 of the Theoretical Manual). At the present time, only the Doublet Lattice method has been implemented. This method can be used for small sinusoidal motions of subsonic lifting surfaces of general configurations.

Section 1.11.3 deals with the interconnection between aerodynamic and structural degrees of freedom. The interpolation methods include both linear and surface splines. These methods are superior to high order polynomials since they tend to give smooth interpolation. They are based upon the theory of uniform beams and plates of infinite extent (see Section 17.2 of the Theoretical Manual).

Section 1.11.4 explains how to do modal flutter analysis by the k-method. Further details are given in the Rigid Format description (Section 3.20.).

Section 1.11.5 is a sample problem which shows how to analyze a simple structure for flutter using the Doublet Lattice theory and the k-method of flutter analysis.

1.11.2 Aerodynamic Modeling

The lifting surfaces must be idealized as planes parallel to the flow. The configuration is divided into plane panels, each of constant dihedral. These panels are further subdivided into "boxes" (see Figure 1), which are really trapezoids with parallel sides in the airflow direction. If an airfoil lies in (or nearly in) the wake of another, then the spanwise divisions should lie along the same streamline. The boxes should be arranged so that any fold or hinge lines lie along the box boundaries. The aspect ratio of the boxes should be roughly one or less. The size of the boxes will depend upon the basic wavelength. An approximate rule is that the number of boxes per reference chord is greater than eight times the reduced frequency.

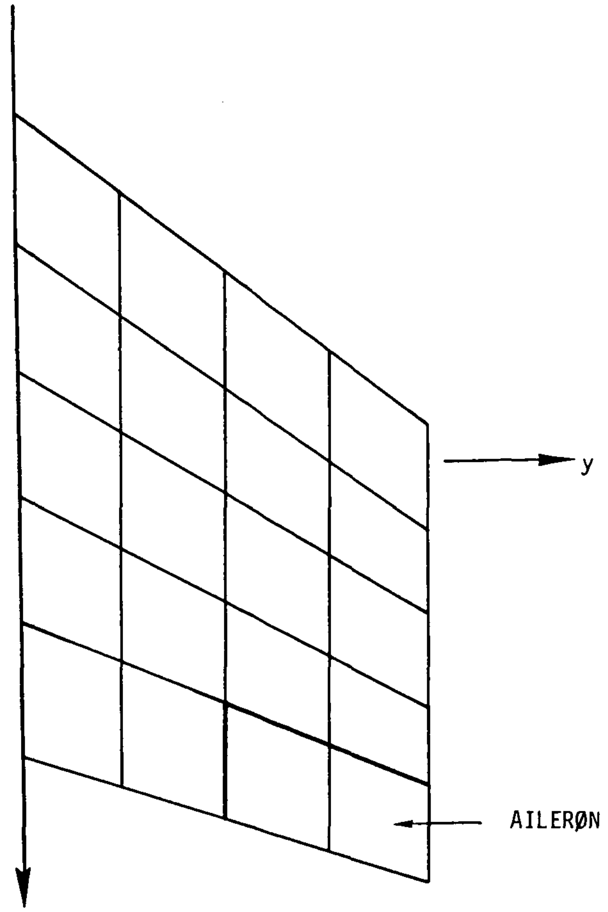


Figure 1. An aerodynamic panel subdivided into boxes.

Boxes should be concentrated near wing edges and hinge lines or any other place where downwash is discontinuous. A further discussion of the choice of models is found in Reference 1. Aerodynamic panels are assigned to groups. All panels within a group have aerodynamic interaction. The purpose of the groups is to reduce the time to compute aerodynamic matrices when it is known that aerodynamic coupling is unimportant, or to allow the analyst to investigate the effects of aerodynamic coupling.

The basic aerodynamic parameters are given on the AERØ bulk data card. A rectangular aerodynamic coordinate must be identified. The flow is in the +x direction of this system. The use of symmetry (or antisymmetry) is recommended to analyze symmetric structures, simulate ground effects, or simulate wind tunnel walls. Any consistent set of units can be used for the dimensional quantities.

The panel is described by a bulk data CAERØ1 card. A property card PAERØ1 may be used to move the center of pressure, a procedure not generally recommended. The box divisions along the span can be determined either by specifying the number of equal boxes (NSPAN) or the identity (LSPAN) of an AEFACT data card which gives a list of division points in terms of percent span. A similar arrangement can be used in the chord direction. The locations of the two leading edge points may be specified in any coordinate system (CP) defined by the user (including BASIC). The lengths of the sides are specified by the user, and they are in the airstream direction, assuring that the panel is parallel to the flow. Every panel must be assigned to some group (IGID), which is usually 1 if all panels interact.

There will be many degrees of freedom associated with each aerodynamic panel. There is an aerodynamic grid point associated with each box within a given panel. These points are located at the center of each box, and are automatically numbered and sequenced by the program. The lowest aerodynamic grid point number for a given panel is assigned the same number the program user specifies for the panel designation. The grid point numbers increase in increments of 1 (see CAERØ data card figure) over all boxes in the panel. The user must be aware of these internally generated grids and ensure that their numbers are distinct from structural grids. These aerodynamic points will be used for output including displacements, plotting, matrix prints, etc. The local displacement coordinate system will have component T1 in the flow direction, and component T3 in the direction normal to the panel (the element coordinate system of CAERØ1).

1.11.3 The Interconnection Between Structure and Aerodynamic Models

The basis for interpolation to the aerodynamic degrees of freedom is based upon the theory of splines (Figure 2). High aspect ratio wings, or other beamlike structures, should use linear splines. Low aspect ratio wings, where the structural grid points are spread over an area, should use surface splines. Several splines can be used to interpolate the boxes on a panel; however, each box can refer to only one spline. Any box not referenced by a spline will be "fixed" and have no motion.

For both types of splines, the user must specify the structural degrees of freedom and the aerodynamic boxes involved. The structural points, called the g-set, can be specified by a list or by specifying a volume in space and determining all the grid points in the volume. The degrees

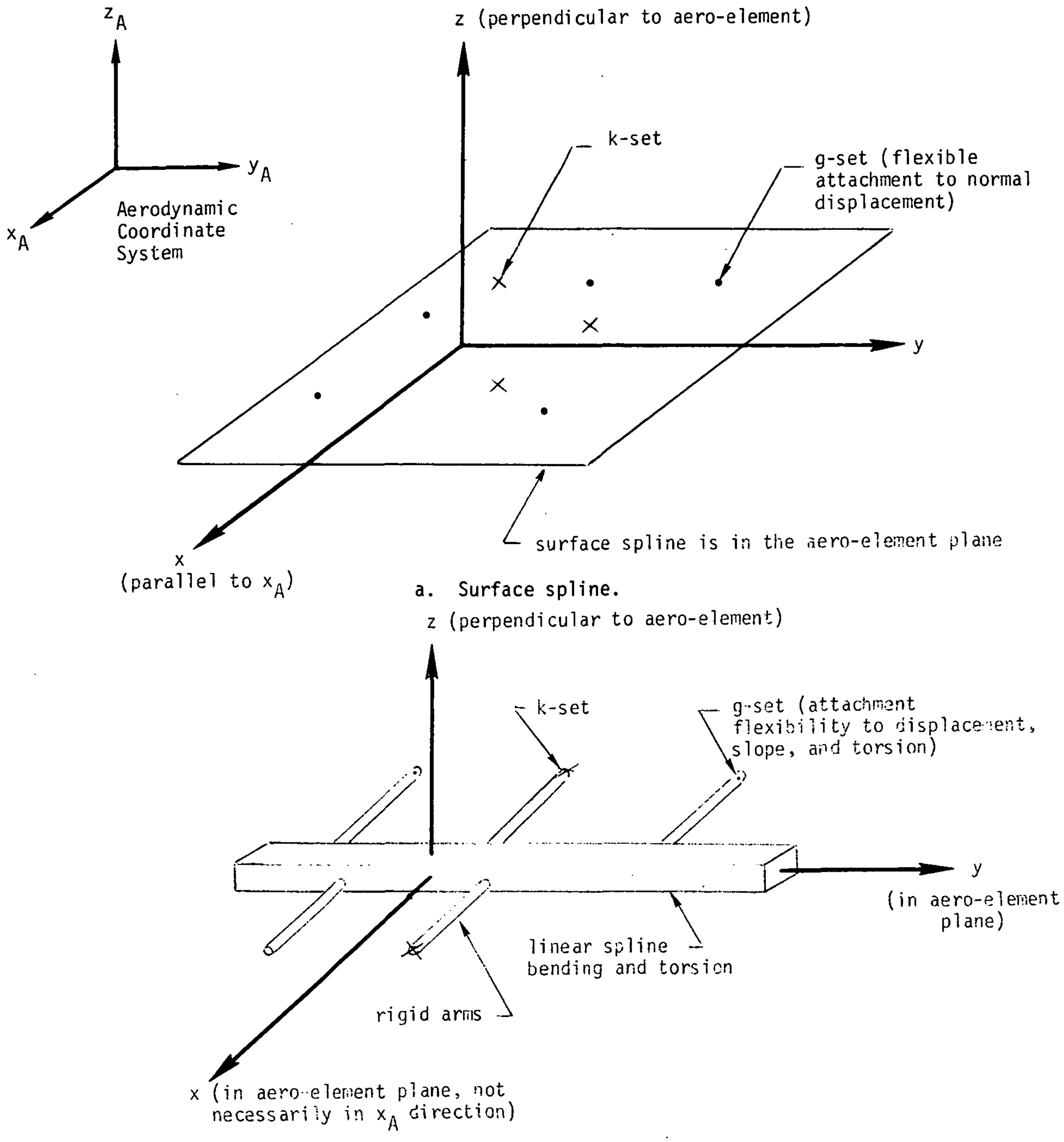


Figure 2. Splines and their coordinate systems.

of freedom at the grid points include only the normal displacements for surface splines. For linear splines, the normal displacement is always used and, by user option, rotations in torsion or slopes may be included.

The SPLINE1 data card defines a surface spline. This can interpolate for any "rectangular" subarray of boxes on a panel. For example, one spline can be used for the inboard end of a panel and another for the outboard end. The interpolated grid points (set k) are specified by naming the lowest and highest elements in the area to be splined. The two methods for specifying the grid points use SET1 and SET2 data cards. A parameter DZ is used to allow some smoothing of the spline fit. If DZ=0 (the usual value), the spline will pass through all deflected grid points. If DZ>0, then the spline (a plate) is attached to the grid deflections via springs, which produce a smoother interpolation that does not necessarily pass exactly through all points.

The SPLINE2 data card defines a linear spline. As can be seen from Figure 2, this is really a generalization of a simple spline to allow for interpolation over an area. It is similar to the method often used by aeronautical engineers who assume that there is no curvature perpendicular to the elastic axis. The portion of a panel to be interpolated and the set of structural points are determined in the same manner as a SPLINE1. A NASTRAN coordinate system must be supplied to determine the axis of the spline. Since the spline has torsion as well as bending flexibility, the user may specify the ratio; the usual value is 1.0. The attachment flexibilities, D_z, $D_{\theta x}$, and $D_{\theta y}$ allow for smoothing, where usually all are taken to be zero. An exception would occur if the structural model does not have slopes defined, in which case the flexibility DTHX must be infinite.

1.11.4 Modal Flutter Analysis

A prerequisite to modal flutter analysis is the calculation of an aerodynamic matrix and the transformation to modal coordinates. This operation is often very costly and care should be taken to avoid unnecessary work. One method is to compute the modal aerodynamic matrix at a few Mach numbers and reduced frequencies and interpolate to others. Matrix interpolation is an automatic feature of Rigid Format 10. The MKAERØ1 and MKAERØ2 data cards allow the selection of parameters for matrix calculation. On restart, additional MKAERØi cards will cause the new matrix terms to be appended (if no other data cards are added to invalidate previously computed matrices).

The method of flutter analysis is specified on the FLUTTER bulk data card. The FLUTTER card is selected in case control by an FMETHØD card. At the present time, only the k-method of flutter analysis is available. This allows looping through three sets of parameters: density ratio (ρ/ρ_{ref}, ρ_{ref} is given on an AERØ data card); Mach number(m); and reduced frequency, k. For example, if the user specifies two values of each, there will be eight loops in the following order.

LØØP	DENS	MACH	RFREQ
1	1	1	1
2	2	1	1
3	1	1	2
4	2	1	2
5	1	2	1
6	2	2	1
7	1	2	2
8	2	2	2

Values for the parameters are listed on FLFACT bulk data cards. Usually, one or two of the parameters will have only a single value.

A parameter VREF may be used to scale the output velocity. This can be used to convert from consistent units (e.g., in/sec) to any units the user may desire (e.g., mph), determined from $V_{out} = V/V_{REF}$. Another use of this parameter is to compute flutter index, by choosing $V_{REF} = b\omega_\theta \sqrt{\mu}$.

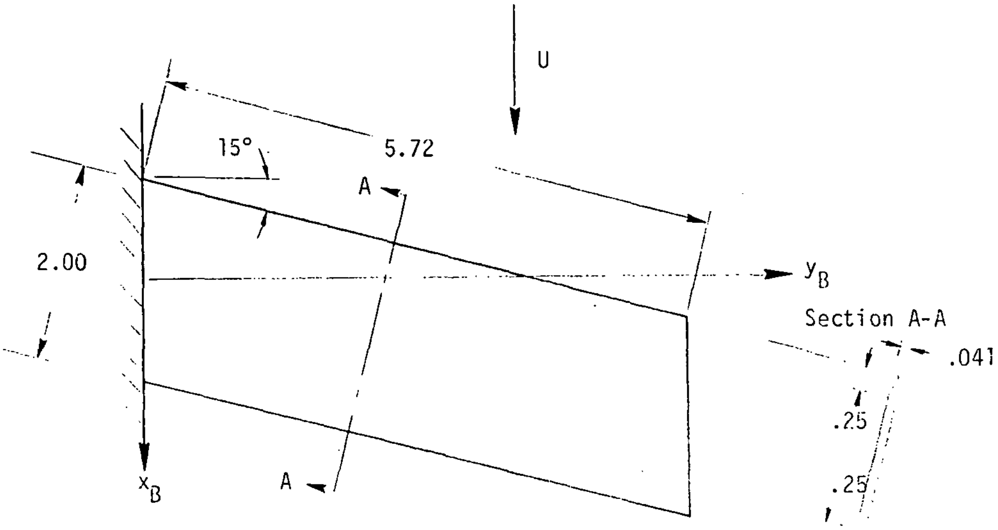
If physical output (grid point deflections or element forces, plots, etc.) is desired rather than modal amplitudes, this data recovery can be made upon a user selected subset of the cases. The selection is based upon the velocity; the method is discussed in Section 3.20.3.

Subsets of flutter analysis for checking data are discussed in Section 3.20.5.

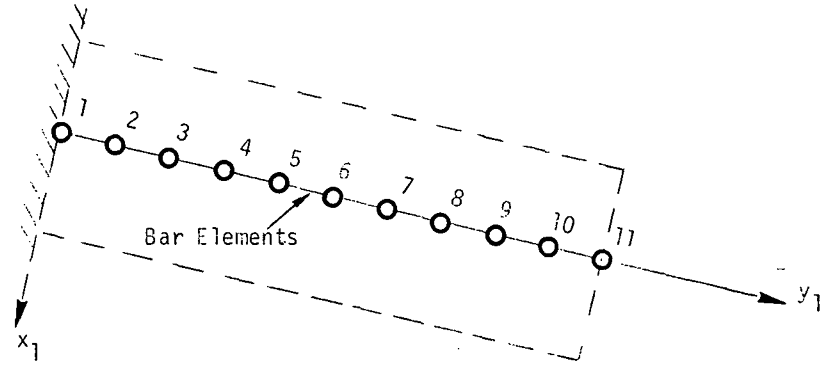
1.11.5 Sample Problem

A sample problem (see Figure 3) has been chosen to illustrate flutter analysis. This model has been tested in a wind tunnel and analyzed using strip theory aerodynamics (see Reference 2). The analysis showed that "uncoupled" modes fortuitously provide a good result. This analysis has not included the bending-torsion elastic coupling at the root or the mass coupling at the tip. The NASTRAN deck (Figure 4) will be discussed to illustrate how to solve for flutter conditions using the k-method.

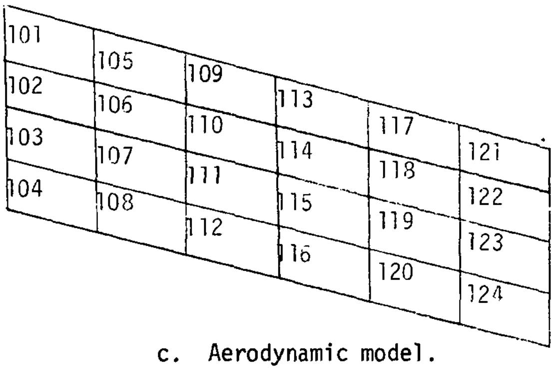
The structure will be modeled as a ten cell beam. A swept back coordinate system will be introduced to make it easier to model this beam. The global (i.e., local displacement) coordinate



a. Planform.



b. Structural model.



c. Aerodynamic model.

Figure 3. Fifteen degree sweep model.

```
ID   DEMO,AERO
APP   AERO
SOL   10,0
TIME   10
ALTER  87  $
MATGPR   GPL,USET,SIL,PHIA//C,N,FE/C,N,A $
ENDALTER $
CEND
TITLE = AEROELASTIC MODAL FLUTTER ANALYSIS DEMONSTRATION PROBLEM
SUBTITLE = SEE NASTRAN DEMONSTRATION PROBLEMS MANUAL FOR RESULTS
LABEL=K VALUES .200(*) .167(0) .143(1) .125(2) .111(3) .100(4)
SPC=1
METHOD=10
CMETHOD=20
FMETHOD=30
OUTPUT(XYOUT)
CURVELINESYMBOL=-1
XYPAPERPLOT VG / 1(G,F) 2(G,F) 3(G,F) 4(G,F) 5(G,F) 6(G,F)
BEGIN BULK
$
$   1   .   2   .   3   .   4   .   5   .   6   .   7   .   8   .   9   .   10
$
$ GEOMETRY AND CONSTRAINTS
CORD2R  1               0.      0.      0.      0.      0.      1.      +C1
+C1     .96593  -.25882 0.
GRDSET          1                               1       126
GRID    1               0.      .0      0.
GRID    2               0.      .572    0.
GRID    3               0.      1.144   0.
GRID    4               0.      1.716   0.
GRID    5               0.      2.288   0.
GRID    6               0.      2.86    0.
GRID    7               0.      3.432   0.
GRID    8               0.      4.004   0.
GRID    9               0.      4.576   0.
GRID    10              0.      5.148   0.
GRID    11              0.      5.72    0.
SPC1    1       345     1
$
$ STRUCTURAL ELEMENTS
CBAR    1       1       1       2       0.      0.      1.      1
CBAR    2       1       2       3       0.      0.      1.      1
CBAR    3       1       3       4       0.      0.      1.      1
CBAR    4       1       4       5       0.      0.      1.      1
CBAR    5       1       5       6       0.      0.      1.      1
CBAR    6       1       6       7       0.      0.      1.      1
CBAR    7       1       7       8       0.      0.      1.      1
CBAR    8       1       8       9       0.      0.      1.      1
CBAR    9       1       9       10      0.      0.      1.      1
CBAR    10      1       10      11      0.      0.      1.      1
PBAR    1       1       7.175-2 9.83-6          36.8-6
MAT1    1       10.4+6  3.9+6           2.61-4
PARAM   COUPMASS1
CMASS2  12      2.8-6   2       5
CMASS2  13      2.8-6   3       5
CMASS2  14      2.8-6   4       5
CMASS2  15      2.8-6   5       5
CMASS2  16      2.8-6   6       5
CMASS2  17      2.8-6   7       5
CMASS2  18      2.8-6   8       5
CMASS2  19      2.8-6   9       5
CMASS2  20      2.8-6   10      5
CMASS2  21      1.4-6   11      5
$
```

Figure 4. NASTRAN deck for fifteen degree sweep model.

```
$ AERODYNAMIC ELEMENTS
CAERO1  101     1       1       6       4                       1       +CA101
+CA101  -1.     -.26795 0.      2.0706  -1.     5.45205 0.      2.0706
PAERO1  1
SPLINE2 100     101     101     124     100     0.      1.      1       +SP
+SP     0.      0.
SET1    100     1       THRU    11
$
$ CONTROL DATA
EIGR    10      GIV     .3      .1              6                       +ER
+ER     MAX
PARAM   LMODES  3
AERO    0       1.3+4   2.0706  1.145-7
MKAERO1 .45                                                             +MK
+MK     0.      .1      .2
FLUTTER 30      K       1       2       3       L       3
FLFACT  1       .967
FLFACT  2       .45
FLFACT  3       .2      .16667  .14286  .125    .11111  .1
EIGC    20      HESS    MAX                                             +EC
+EC                                                     3
ENDDATA
```

Figure 4. NASTRAN deck for fifteen degree sweep model (continued).

system for the grid points will be in the swept back system. Twenty-four aerodynamic boxes will be used. The deflections of the aerodynamic boxes will be interpolated using a linear spline.

The Executive Control Deck (from ID to CEND) selects the modal flutter analysis, e.g., APP and SØL cards. A time estimate (CPU min.) is required. The three card ALTER package (not required) will print the nonzero components of the mode shapes of the structure; the mode frequencies are an automatic output of this Rigid Format. If desired, the problem can be checkpointed using modal analysis (Rigid Format 3), and then restarted in flutter analysis (Rigid Format 10), allowing better output format of mode shapes.

The Case Control Deck is used to select constraints, methods, and output. In this problem, SPC set 1 is used to cantilever the root of the beam, and no MPC's are used. A METHØD card must be used to select an EIGR data card for real eigenvalue extraction. An FMETHØD card must select a FLUTTER data card for flutter analysis. A CMETHØD card must select an EIGC control for complex eigenvalue analysis. If desired solution set (SDISP gives modal quantities) or physical set (DISP, STRESS, etc.) output may be requested, but this is not usually done. An automatic flutter summary is printed unless parameter PRINT is set to NØ. The XYØUT request shown will plot V-g and V-f split frame "plots" on the printer output. To produce plots, it is necessary to specify a plotter, request a plot tape, and specify XYPLØT VG. The "curves" (e.g., 1 through 6 in the example) refer to the loops of flutter analysis.

The geometry and constraint bulk data is discussed in previous sections of this manual, and there are no special rules for aeroelastic problems. The structural elements are BAR elements with MASS2 used for torsional inertia. The CØUPMASS option is used to provide a nonsingular mass matrix so that the Given's method of eigenvalue extraction can be used. The bending moment of inertia and torsional rigidity (on the PBAR data card) have been adjusted to match experimental mode frequencies.

The aerodynamic boxes are defined by the CAERØ1 data card. The element number (e.g., 101) becomes the ID of the lowest numbered box. Other boxes are numbered as shown in Figure 3. A property card must be referenced. The leading edge corners of the panel will be specified in coordinate system 1 for this example; however, any defined system may be used. Since equal box sizes are desired, the NSPAN and NCHØRD options are used to specify the numbers. If unequal divisions were desired, LSPAN and LCHØRD would be used to specify lists referenced on AEFACT data cards.

The interpolation is specified by a SPLINE2 (linear spline) data card. This must have an element number. For aerodynamic boxes, the lowest and highest numbered boxes in a rectangular array must be specified. In this case, all are desired from 101 through 124. In order to provide data for the spline, the user must determine which box numbers will be assigned to the boxes. All grid points are used in this example, as specified in SET 100.

An EIGR data card will usually use either the INV or GIV method of eigenvalue extraction. In the example, six mode shapes are found, and a parameter LMØDES is used to limit the modal formulation to three. Usually, these numbers agree unless one is interested in checkpointing more modes for possible use in restart, examining shapes of neglected modes, or some other special reason. The AERØ data card specifies aerodynamic coordinate system (for this example, BASIC), velocity of sound (not used), reference length, and density. The MKAERØ1 data card will cause the aerodynamic matrix to be computed for Mach number 0.45 and reduced frequencies of 0.0, 0.1, and 0.2.

The FLUTTER data card requests the k-method (the only one now implemented) and selects FLFACT cards specifying density ratios, Mach numbers, and reduced frequencies. The analysis will loop through all combinations, with density on the inner loop and Mach number on the outermost loop. This arrangement also allows, for example, plots of V-g versus density. In the example given, probably typical, only one density and Mach number were specified. Both linear and surface splines are available for interpolation of aerodynamic matrices to intermediate values of M (Mach number) and k (reduced frequency). The linear, L, method is used when the matrix has been computed at the desired Mach numbers. The EIGC data card is required, and the HESS method is recommended. The number of vectors must be specified and will usually agree with the number of modes saved for output specified on the FLUTTER data card.

Results are presented in the Demonstration Problems Manual.

REFERENCES

1. Giesing, J. P., T. P. Kalman and W. P. Rodden, "Subsonic Unsteady Aerodynamics for General Configurations," Part II; Volume I, Application of the Doublet-Lattice Method and the Method of Images to Lifting-Surface/Body Interference; AFFDL-TR-71-5; April 1972.

2. Yates, E. C. and R. M. Bennett, "Use of Aerodynamic Parameters From Nonlinear Theory in Modified-Strip-Analysis Flutter Calculations for Finite-Span Wings at Supersonic Speeds; NASA TN D-1824, July 1963.

1.12 CYCLIC SYMMETRY

Many structures, including pressure vessels, rotating machines and antennae for space communications, are made up of virtually identical segments that are symmetrically arranged with respect to an axis. There are two types of cyclic symmetry as shown in Figures 1 and 2: simple rotational symmetry, in which the segments do not have planes of reflective symmetry and the boundaries between segments may be general doubly-curved surfaces; and dihedral symmetry, in which each segment has a plane of reflective symmetry and the boundaries between segments are planar. The use of cyclic symmetry allows the user to model only one of the identical substructures. There will also be a large saving of computer time for most problems. The theoretical treatment for cyclic symmetry is given in Section 4.5 of the Theoretical Manual.

The total model consists of N identical segments which are numbered consecutively from 1 to N. The user supplies a NASTRAN model for one segment, using regular elements and standard modeling techniques, except grid points are not permitted on the polar axis. All other segments and their coordinate systems are automatically rotated to equally spaced positions about the polar axis by the program. The boundaries must be conformable, i.e., the segments must coincide. This is easiest to insure if a cylindrical or spherical coordinate system is used, but such is not required. The PARAM card, CTYPE, is used to specify either rotational symmetry or dihedral symmetry and the number of segments, N, in the structural model is specified on the PARAM card, NSEGS. As indicated in Figure 2, dihedral symmetry provides solutions for each segment and its reflected image. This requires application of both symmetric and antisymmetric boundary conditions.

In rotational symmetry the basic transformation equation between the structure segments n = 1, 2, etc. and the harmonic indices k = 0, 1, 2, etc. is

$$u^n = \bar{u}^o + \sum_{k=1}^{KMAX} [\bar{u}^{kc}\cos(n-1)ka + \bar{u}^{ks}\sin(n-1)ka] \qquad (1)$$

where

u^n is any displacement, load, stress, etc., on the n^{th} segment (n = 1, 2...NSEGS),

$\bar{u}^o$, $\bar{u}^{kc}$, $\bar{u}^{ks}$ are the corresponding cyclic coefficients used in the solution which define the entire structure,

k is the cyclic index (i.e., KINDEX),

KMAX is the limit (KMAX $\le \frac{N}{2}$) of k. (If all values of k are used, the transformation is exact),

and

$a = \frac{2\bar{u}}{NSEGS}$ is the circumferential angle for each segment.

In dihedral symmetry the repeated request may be divided into two half segments divided by a plane of symmetry. The solution is obtained for symmetric motions (S) and antisymmetric motions (A) of the right half segment modeled by the user. Thus, for each cyclic index, K, four coefficients are obtained defining the variable, n, i.e., $\bar{u}^{ks,S}$, $\bar{u}^{kc,S}$, $\bar{u}^{ks,A}$ and $\bar{u}^{kc,A}$. In the right hand segment the terms are added

Right side: $$\bar{u}^{ks} = \bar{u}^{ks,S} + \bar{u}^{ks,A} \tag{2}$$

In the left hand mirror image the antisymmetric solution is subtracted.

Left Side: $$\bar{u}^{ks} = \bar{u}^{ks,S} - \bar{u}^{ks,A} \tag{3}$$

The reason for using dihedral symmetry is to reduce the size of the model by one half. However in static analysis, this procedure requires twice as many solutions as in rotational cyclic symmetry. In normal modes analysis only the modes for the symmetrical components $\bar{u}^{kc,S}$ and $\bar{u}^{ks,A}$ are obtained. The modes for the other two terms are identical and correspond to a one segment rotation of the structure.

The two boundaries are called sides 1 and 2. In the case of rotational symmetry, side 2 of segment n is connected to side 1 of segment n+1, as shown in Figure 1. In the case of dihedral symmetry, side 1 is on the boundary of the segment and side 2 is on the plane of symmetry for the segment, as shown in Figure 2. In either case the grid point numbers on sides 1 and 2 must be specified on the bulk data card, CYJØIN.

As indicated in the Theoretical Manual Section 4.5, the cyclic symmetry analysis uses a finite Fourier transformation. Hence, the use of cyclic symmetry procedures does not introduce any additional approximations beyond those normally associated with finite element analysis. In the case of static analysis, a shortened approximate method may be used where the maximum value of the harmonic index is specified on the PARAM card, KMAX. The default procedure is to include all harmonic indices. The use of a smaller number of harmonic indices is similar to truncating a Fourier series. The stiffness associated with the higher harmonic indices tends to be large, so that these components of displacements tend to be small. In the case of vibration analysis, the solutions are performed separately for each harmonic index. The harmonic index for each solution is specified on the PARAM card, KINDEX. The standard restart procedures can be used to calculate vibration modes for additional harmonic indices.

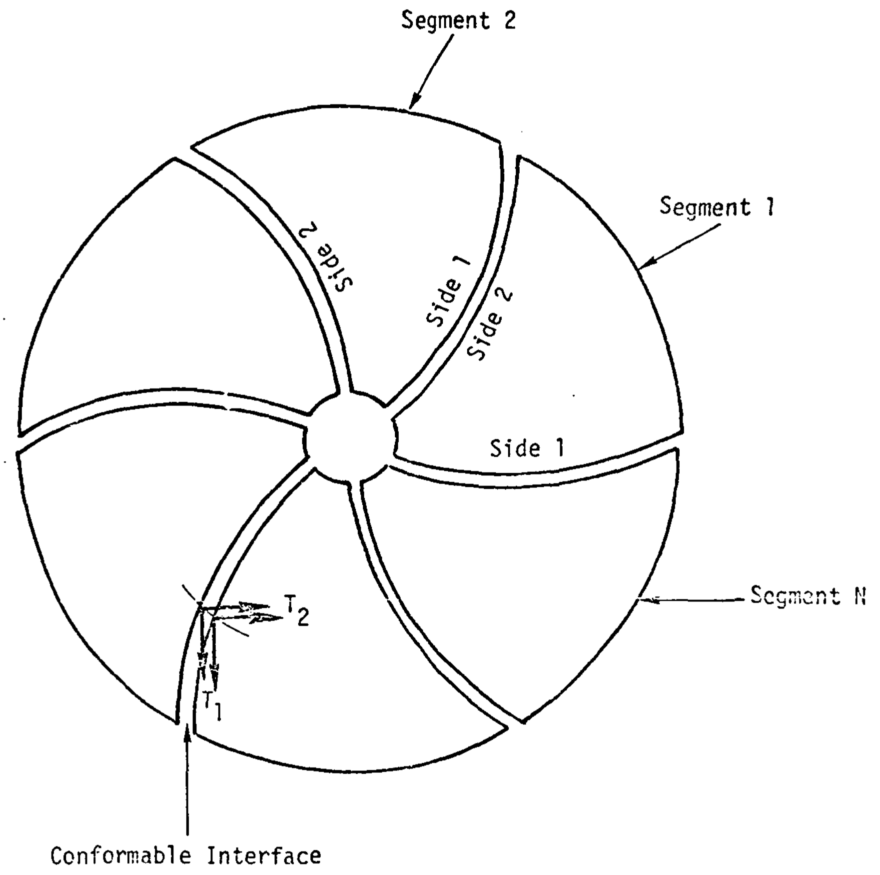
No restrictions are placed on the use of the single point constraint, the multipoint constraint, or the ØMIT feature of NASTRAN, other than that the constraints must be the same for each segment. Constraints between segments are automatically applied to the degrees of freedom at grid points specified on CYJØIN bulk data cards which are not otherwise constrained. The SPCD bulk data card may be used to vary the magnitude of enforced displacements for each of the segments. In the case of static analysis, the ØMIT feature may be used to remove all degrees of freedom at internal grid points without any loss of accuracy. Since this reduction is applied to a single segment prior to the symmetry transformations, it can greatly reduce the amount of subsequent calculation. In the case of vibration analysis, the ØMIT feature is used in the usual way to reduce the size of the analysis set and involves the usual approximations. The SUPØRT card for free bodies cannot be used with cyclic symmetry.

Static loads are applied to the structural model in the usual way. A separate subcase is defined for each segment (half segment for dihedral symmetry) and loading condition. The subcases for static loading must be ordered sequentially, according to the segment numbers. Multiple loading conditions for each segment must be in consecutive subcases. In the case of rotational symmetry, there will be a number of subcases equal to the number of segments in the structural model for each loading condition. In the case of dihedral symmetry, there will be twice as many subcases as for rotational symmetry because of the two symmetric components. If there is more than a single loading condition, the number of loading conditions must be specified on the PARAM card, NLØAD.

An alternate procedure for specifying the static loads may be used if the transform values of the forcing functions are known. In this case, the transform values of the loads are specified directly on the usual loading cards. The PARAM card, CYCIØ, must be included in the Bulk Data Deck to indicate that cyclic transform representation rather than physical segment representation is being used for the static loads. If this option is used, the subcases must be ordered according to the symmetrical components with the cosine cases preceding the sine cases for each symmetrical component. The output quantities will also be prepared in terms of the symmetric components.

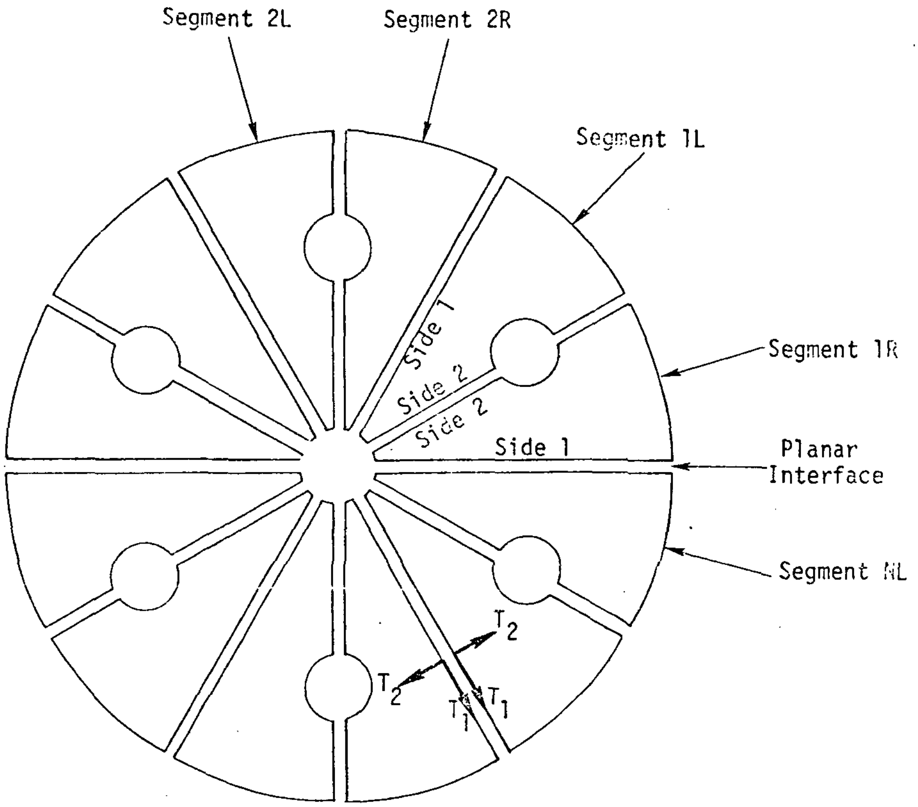
If the loading is specified in terms of the physical segments, the data reduction will also be done in terms of the physical variables. All of the normal output, including structure plots, are available. No provision is made to recover physical segment data in vibration analysis. The available output data does, however, include the symmetrical components of dependent displacements, internal forces and stresses.

For purposes of minimizing matrix bandwidth, the equations of the solution set are normally sequenced with the cosine terms alternating with the sine terms. The user may request an alternate sequence on the PARAM card, CYCSEQ, which orders all cosine terms before all sine terms. The latter may improve efficiency when all of the interior points have been omitted.



1. The user models one segment.
2. Each segment has its own coordinate system which rotates with the segment.
3. Segment boundaries may be curved surfaces. The local displacement coordinate systems must conform at the joining points. The user gives a paired list of points on Side 1 and Side 2 which are to be joined.

Figure 1. Rotational symmetry



1. The user models one-half segment (an R segment). The L half segments are mirror images of the R half segments.
2. Each half segment has its own coordinate system which rotates with the segment. The L half segments use left hand coordinate systems.
3. Segment boundaries must be planar. Local displacement systems axes, associated with inter-segment boundaries, must be in the plane or normal to the plane. The user lists the points on Side 1 and Side 2 which are to be joined.

Figure 2. Dihedral symmetry

1.13 FULLY STRESSED DESIGN

The fully stressed design option is part of the static analysis rigid format for structural analysis. Functional modules (ØPTPR1 and ØPTPR2) are provided to automatically adjust the properties based on maximum stress levels, and to control the number of design iterations based on user-supplied convergence criteria. All elements using a common property are sized together, i.e., a plate with uniform thickness remains uniform. If the user wishes to scale the properties for each element separately, each element must have its own property card. After a sufficient number of iterations, the element properties will be adjusted to the minimum values necessary to carry the prescribed loads.

The process begins by performing a static analysis for all loading conditions using the initial values for all element properties. A new property, P_2, will be scaled such that

$$P_2 = P_1 \left[\frac{\alpha}{\alpha + (1-\alpha)\gamma} \right] \quad , \qquad (1)$$

where P_1 is the current property value and γ is an iteration factor with a default value of unity. The scale factor, α, is defined as follows:

$$\alpha = \mathrm{Max} \left(\frac{\sigma}{\sigma_\ell} \right) \quad , \qquad (2)$$

where σ is a stress value and σ_ℓ is a stress limit. The maximum value of α is taken for all loading conditions. Values of γ smaller than unity limit the property change in a single iteration, and thereby tend to improve the stability of the process. The maximum change in any property is limited by

$$K_{min} < \frac{P_2}{P_i} < K_{max} \quad , \qquad (3)$$

where P_i is the initial value of the property and K_{min} and K_{max} are user-supplied limits.

Convergence is achieved by completing the user-specified number of iterations, by having all selected element properties reach the user-specified limits, or by satisfying the following convergence criteria:

$$\frac{|\sigma - \sigma_\ell|}{\sigma_\ell} < \varepsilon \quad , \qquad (4)$$

where ε is a user-supplied convergence limit.

The following actions are required by the user in order to utilize the fully stressed design capability:

1. The user must select stress output in the Case Control Deck for all elements that will participate in the fully stressed design.

2. All required stress limits must be specified on the structural material cards associated with element properties that will participate in the fully stressed design.

3. The property optimization parameters must be specified on the bulk data card PØPT. This card contains user-specified values for the maximum number of iterations, the convergence criteria (ε), the iteration factor (γ), and output options to print and/or punch the calculated values of the element properties.

4. The property optimization limits (K_{min} and K_{max}) must be specified on the PLIMIT bulk data card if the user wishes to limit the maximum and minimum values of the element properties.

The detailed definitions of the scale factors for each of the element types are given in Table 1. The symbols σ_t, σ_c and σ_s represent the limiting stress values in tension, compression and shear, given on the structural material cards. All of the properties listed for each element are scaled in the same way, i.e., both the area and torsional constant for the RØD are modified using the same scale factor.

Table 1. Scale Factors for Fully Stressed Design

Element	Stress Value Used	Scale Factor (α)	Properties Changed
RØD TUBE	Axial Tension (σ_1) Axial Compression (σ_2) Torsion (τ)	$\mathrm{Max}\left(\frac{\sigma_1}{\sigma_t}, \frac{\sigma_2}{\sigma_c}, \frac{\tau}{\sigma_s}\right)$	Area (A) Torsional Constant (J)
BAR	Fiber Stress Tension $\left\{\begin{array}{l}\text{End a } (\sigma_{a1}) \\ \text{End b } (\sigma_{b1})\end{array}\right.$ Fiber Stress Compression $\left\{\begin{array}{l}\text{End a } (\sigma_{a2}) \\ \text{End b } (\sigma_{b2})\end{array}\right.$	$\mathrm{Max}\left(\frac{\sigma_{a1}}{\sigma_t}, \frac{\sigma_{b1}}{\sigma_t}, \frac{\sigma_{a2}}{\sigma_c}, \frac{\sigma_{b2}}{\sigma_c}\right)$	Area (A) Torsional Constant (J) Moments of Inertia (I_1, I_2, I_{12})
TRMEM QDMEM	Principal Tension (σ_1) Principal Compression (σ_2) Maximum Shear (τ_m)	$\mathrm{Max}\left(\frac{\sigma_1}{\sigma_t}, \frac{\sigma_2}{\sigma_c}, \frac{\tau_m}{\sigma_s}\right)$	Thickness (t)
TRPLT QDPLT TRBSC	Same as Above (Fiber Distances z_1 & z_2)	Same as Above	Moment of Inertia (I)
TRIA1 QUAD1	Same as Above	Same as Above	Moment of Inertia (I) Membrane Thickness (t_1)
TRIA2 QUAD2	Same as Above	Same as Above	Thickness (t)
SHEAR	Maximum Shear (τ_m)	$\frac{\tau_m}{\sigma_s}$	Thickness (t)

1.14 AUTOMATED MULTI-STAGE SUBSTRUCTURING

Large and complex structural analysis problems can be solved for static and/or normal modes response using the automated multi-stage substructuring features of NASTRAN. The user subdivides the intended model into a set of smaller more elementary partitions called basic substructures. These components of the whole structure can be modeled independently, checked for accuracy and then assembled automatically to form a composite model representing the whole structure for final solution. This approach offers the following advantages:

1. Each component model of the overall structure (e.g., wing, fuselage, engine nacelles, landing gear, etc.) may be developed independently.
2. Larger component substructures may themselves be assembled from yet smaller component substructures for multi-stage substructure analyses.
3. Each component substructure may be validated independently, plotted and analyzed prior to assembly and solution of the integrated whole model.
4. Changes due to errors, model modifications, and/or design alterations may be effected for any basic substructure and reintegrated into the overall structure at a minimum cost.
5. Via matrix reduction of the stiffness and mass matrices of neighboring substructures (see Theoretical Manual, Section 4.6), their interaction effects on any given component can be economically included in the separate analysis of that particular component.

In effect, the concept of multi-stage substructuring is analogous to the elementary finite element theory whereby simple beam, plate, and solid elements are replaced by more complex elements each of which, in turn, may represent an assemblage of simple or complex elements.

In order to effectively employ this automated substructuring capability of NASTRAN for static and normal modes analyses, the user should gain an overall understanding of the basic program design concepts, the data base on which it operates, and the control functions provided. These are outlined in the next section which is then followed by a more detailed description of how to use the features of the program including examples of the input data flow. A detail description of each substructuring control card and a summary of the associated bulk data cards is provided in Section 2.7. The detailed definition of each of these bulk data cards is included with the alphabetical listing of all the other bulk data cards in Section 2.3.

1.14.1 Substructuring Terminology

This section summarizes the basic concepts of operation provided in NASTRAN for executing an automated multi-stage substructure analysis. Definitions are given in Table 1 for the specialized terminology used in describing the operation and control of each execution step.

A static or normal modes analysis using substructuring techniques can be divided into three basic phases of operation:

Phase 1: Initial generation of individual basic substructure matrices.

Phase 2: Substructure matrix reduction and assembly, solution of the assembled substructure, and recovery of substructure displacements and reaction forces.

Phase 3: Completion of the analysis with conventional selective output for each individual basic substructure.

Each of these three phases of operation can be performed using Rigid Formats 1, 2, or 3 of NASTRAN according to the results desired. Control of the individual execution steps is provided via the Substructure Control Deck. Section 2.7 presents detailed descriptions of each command and summarizes the special Bulk Data cards provided for substructuring. The Substructure Control Deck is input as shown in Figure 1 between the standard Executive Control and Case Control Decks now used by NASTRAN. Each substructure control command is automatically translated into appropriate DMAP ALTER cards to augment the specified Rigid Format sequence. The user may also include his own DMAP ALTER commands or he may modify a previously defined DMAP sequence as described in Section 2.7.2.

1.14.1.1 Storage of Substructure Data

The data required for each basic substructure and for subsequent combinations of substructures is stored on a Substructure Operating File (SØF). The SØF data are stored in direct access format on disk or drum during a NASTRAN execution. These data may also be stored on tape between runs for backup storage or for subsequent input to other computers. A schematic diagram of data flow is given in Figure 2.

The SØF file which contains the data items listed in Table 2 is used to communicate between each phase of operation and between each step of the Phase 2 operation. Thus, the user is allowed to develop his analysis in separate steps as he builds his final solution structure without use of the checkpoint/restart feature of NASTRAN. He may execute a series of Phase 1 runs to build

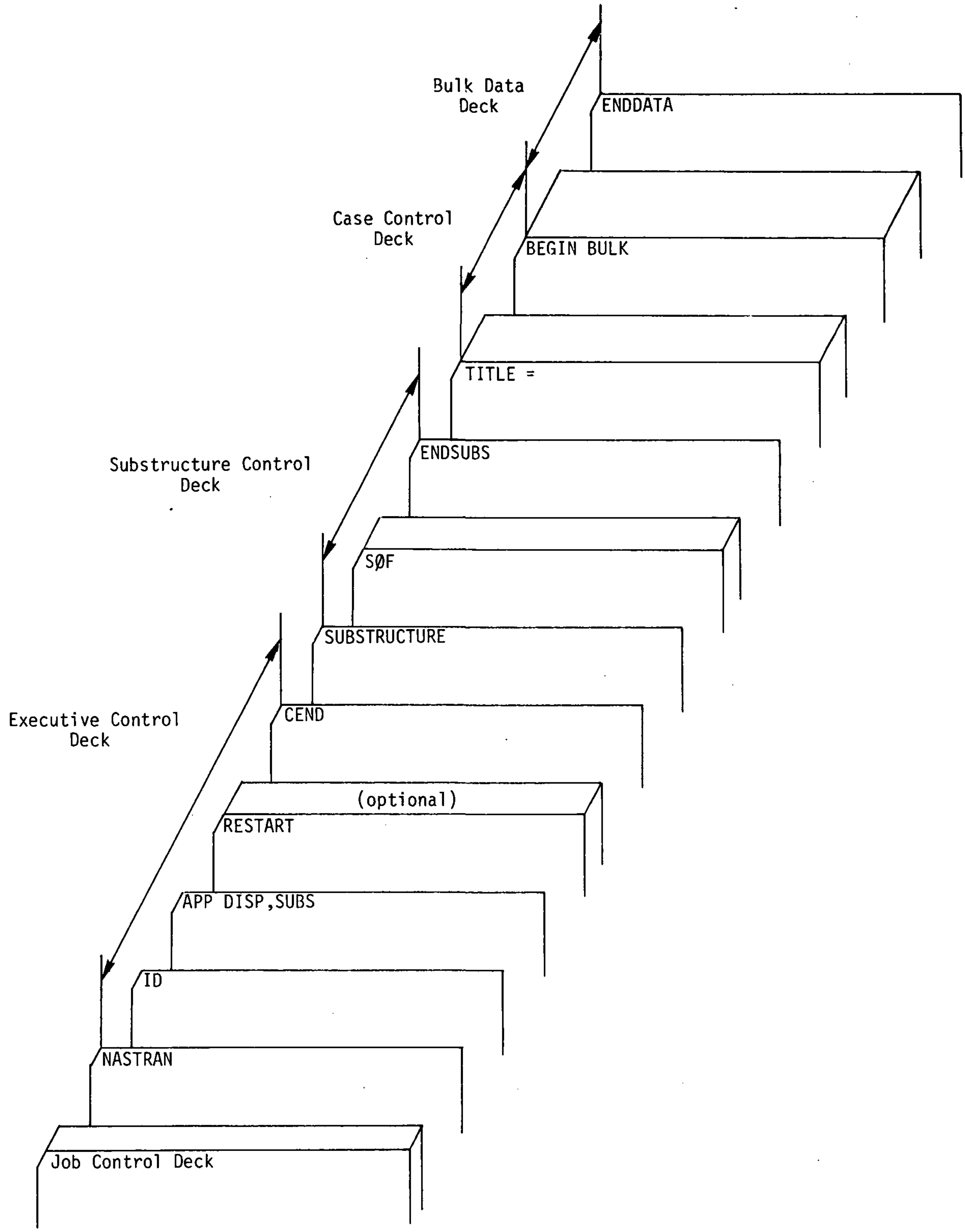
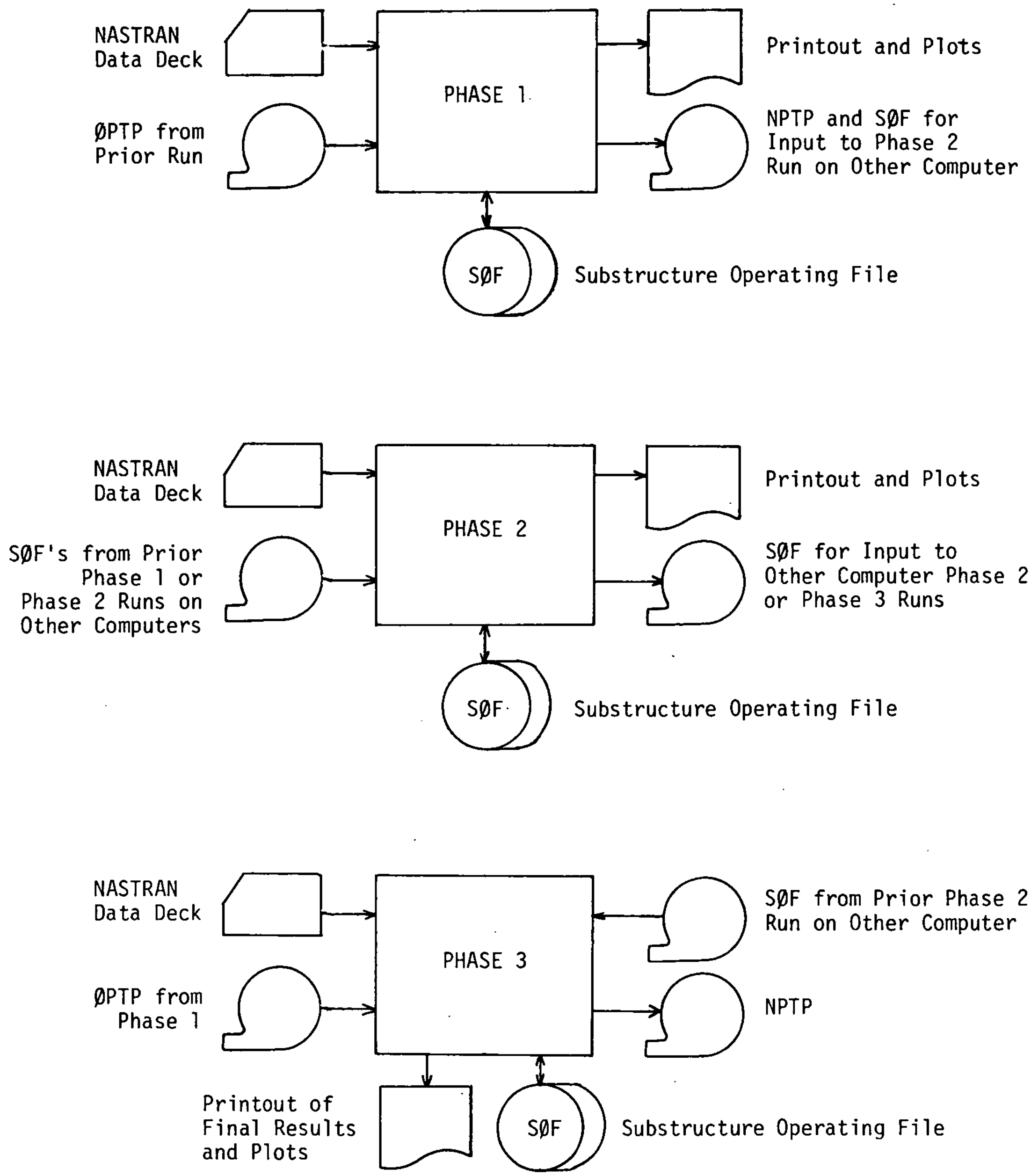


Figure 1. Substructuring input data deck.

STRUCTURAL MODELING



Note: If all processing is performed on the same computer, SØF tape output is not required. All communication may be carried out using the same SØF disk/drum throughout.

Figure 2. Data file organization for NASTRAN multi-stage substructuring.

Table 1. Definitions of Substructure Terminology.

Basic Substructure	- A structure formulated from finite elements in Phase 1.
Boundary Set	- Set of degrees of freedom to be retained in a Phase 2 reduce operation.
Combine Operation	- Merge two or more structures by connecting related degrees of freedom. The matrix elements for connected degrees of freedom are added to produce the combined structure matrices, and the substructure load vectors are processed and stored for subsequent combination at solution time.
Component Substructure	- Any basic or pseudostructure comprising a part of an assembled substructure.
Connection Set	- Set of grid points and their component degrees of freedom to be connected in adjoining structures.
Equivalence Operation	- The creation of an image substructure equivalent to a primary substructure.
Phase (1, 2, or 3)	- Basic steps required for multi-stage substructure processing with NASTRAN - creation, combination, reduction, solution and recovery, and detail data recovery.
Primary Substructure	- Any basic substructure or any substructure resulting from a combine or reduce operation.
Pseudostructure	- A combination of component substructures.
Reduce Operation	- Structural matrix and load vector reduction process to obtain smaller matrices.
Secondary Substructure	- An image substructure created from an equivalence operation.
SØF	- Substructure Operating File. Contains all data necessary to define a structure at any stage, including solutions.
Solution Structure	- The resulting substructure to be used in the solve operation.
Solve Operation	- To obtain solutions using the present structural matrices and user-defined input data.

Table 2. Substructure Item Descriptions.

Item Name	Description
EQSS	External grid point and internal point equivalence data
BGSS	Basic grid point coordinates
CSTM	Local coordinate system transformation matrices
LØDS	Load set identification numbers
LØAP	Load set identification numbers for appended load vectors
PLTS	Plot sets and other data required for Phase 2 plotting
KMTX	Stiffness matrix
LMTX	Decomposition product of REDUCE operation
MMTX	Mass matrix
PAPP	Appended load vectors
PVEC	Load vectors
PØAP	Appended load vectors on omitted points
PØVE	Load vectors on points omitted during matrix reduction
UPRT	Partitioning vector used in matrix reduction
HØRG	H or G transformation matrix
UVEC	Displacement vectors or eigenvectors
QVEC	Reaction force vectors
SØLN	Load vectors or eigenvalues used in a solution

all basic substructures prior to any reduction or combination in Phase 2, or he may build component pseudostructures from a few basic substructures and return later to add other basic substructures to his SØF file as required.

Once the final solution model is established, the user may solve his problem and recover results for any level of component pseudo- or basic substructure. Detail element stresses and element forces or support reactions specified with the basic substructure can be recovered in Phase 3. These results in Phase 3 may be recovered using the original data deck or by restarting from a checkpointed Phase 1 execution.

The physical characteristics of the SØF and the procedures for managing the data on the SØF are described in Section 1.14.2.

1.14.1.2 Identification of Substructure Data

The user controls each step in the analysis by specifying the substructure commands to be executed and the names, such as HUB, WING, RØØT, etc., of each substructure to be used in that step. Automatically the program retrieves all the relevant data for the named substructures from the SØF, performs the matrix operations requested, and stores the results on the SØF. Thus, the user is freed from the tedious task of bookkeeping. Additional commands have also been provided to facilitate the examination of any data item stored on the SØF and to eliminate any data no longer needed or incorrectly specified due to input data errors.

All specific references to grid points for connection or boundary sets, releases, and loads, etc. are made with respect to the basic substructure name. The names of any component substructure can be used for the combine, reduce, equivalence, solve, and recover operations. However, no component substructure name may be used more than once while building the solution structure. If the same component substructure is to be used more than once, e.g., identical components are to be used to create the full model, the equivalence operation should be used to assign unique names for all substructures comprising that component. The data for the equivalent or secondary image substructures will be automatically stored on the SØF for future reference. New names will be created for each lower level component of the equivalenced substructure simply by adding a user specified prefix to the old names. The user can then reference the prefixed name to obtain results for the secondary structure during the recovery operations in Phase 2 or in Phase 3.

1.14.1.3 Input Data Checking

Several features have been provided for input data checking. Principal among these is the DRY run option. This option allows the user to submit his run to have the program validate the consistency of his command structure and his data without actually performing the more time consuming matrix operations. Assuming his input is found to be consistent, the run may be resubmitted with the GØ option to complete the matrix processing.

Also available is a STEP option which first checks the data and then executes the matrix operations one step at a time. If errors are detected in the data, the matrix operations are skipped and the remainder of the processing sequence is executed as a DRY run only.

A second feature is also provided which allows the user to process only selected matrix data. For example, if the user finds that after having assembled his solution structure he wishes to add new loading conditions, or he wishes to obtain normal modes but did not have the mass matrix, he may re-execute the sequence of matrix operations to process only the load or mass matrix. First, however, the user must remove (EDIT or DELETE) the old loading data from the SØF to free that space for the new matrix data to be stored.

A third feature is available for displaying all the relevant substructuring data generated by the program. A description of the SØF data items for each substructure is given in Section 1.14.2, Table 2. Both the combine and reduce operations involve specification of grid point and degree of freedom data related to the basic substructures involved. The automatic generated or manually specified connectivities are critical to the combine operation. Using the output options provided, the user can verify explicitly each and every connectivity. The reduce operation requires the user specify the degrees of freedom to be retained. These are also identified by basic substructure grid point numbers. If desired, the user may also obtain lists of all the retained degrees of freedom of the resulting pseudostructure to verify the completeness and accuracy of his input.

Examples of the output generated are given in Figure 3. Two items in these examples require explanation to assist in their interpretation. The columns labeled "DEGREES ØF FREEDØM" and "CØMPONENT DØF" show entries containing six digit integers of "1" through "6". These represent the components of displacement and rotation at the grid point in question. These are read from right to left in the usual convention of NASTRAN such that the integer "23" represents displacement components 2 and 3 or y and z displacements, respectively.

SUMMARY OF PSEUDOSTRUCTURE CONNECTIVITIES

INTERNAL POINT NO	DEGREES OF FREEDOM	PSEUDOSTRUCTURE NAMES WING001	WING002
1	123	WING001 13	WING002 13
2	123	WING001 27	WING002 27
3	23	WING001 14	WING002 14
4	23	WING001 28	WING002 28

EQSS ITEM FOR PSEUDOSTRUCTURE WING   COMPONENT WING001

GRID POINT ID	INTERNAL POINT ID	COMPONENT DOF
13	1	123
14	3	23
27	2	123
28	4	23

BGSS ITEM FOR PSEUDOSTRUCTURE WING

INTERNAL POINT ID	CSTM ID NO.	COORDINATES X1	X2	X3
1	0	-0.433013E+01	0.375000E+02	0.500000E+01
2	0	-0.433013E+01	0.375000E+02	-0.500000E+01
3	0	0.600000E+02	0.375000E+02	0.500000E+01
4	0	0.600000E+02	0.375000E+02	-0.500000E+01

Figure 3. Sample of output options for reduce and combine operations.

The column heading "INTERNAL PØINT NØ" references the internally generated "grid points" of the resulting pseudostructure. In the example showing pseudostructure connectivities, the internal point number 4 represents the connectivity of components 2 and 3 at grid point 28 in basic substructure WINGOO1 to components 2 and 3 at grid point 28 in basic substructure WINGOO2.

The printout of the EQSS item in Figure 3 for pseudostructure WING (which comprises the two basic substructures WINGOO1 and WINGOO2) shows again which degrees of freedom are retained in the substructure from the basic substructure WINGOO1. Note that these degrees of freedom correlate exactly to the connectivities already discussed. That correlation can be found by looking up the internal point number.

The BGSS item displays all the internal point numbers for the pseudostructure WING along with its coordinates in that pseudostructure basic system. The "CSTM ID NØ." column indicates the existence (if any) of local coordinate systems associated with those internal points. If the entry is "0", the displacement components will be in that pseudostructure basic system. Otherwise, they will be in a local system which may be checked by requesting the optional printout of the "CSTM" item from the SØF for that pseudostructure.

1.14.2 The Substructure Operating File (SØF)

The Substructure Operating File (SØF) is a single logical file used to store all data necessary for a complete multi-level substructuring analysis. The SØF may actually reside on one to ten physical files. However, these physical files are chained together to form a single logical file for use in the analysis of larger problems. See Figure 4 showing the basic arrangement of the SØF of disk or drum.

Each physical file comprising the SØF is a direct access disk file. These disk files are not used by NASTRAN GINØ operations. NASTRAN treats them as external user files. In a substructure analysis, NASTRAN stores data on the SØF which must be saved from run to run. Therefore, it is the user's responsibility to maintain the physical disk files comprising the SØF from one execution to the next.

The SØF declaration in the Substructure Control Deck is used to define the physical files which make up the SØF. See Section 2.7 for a complete description of the SØF declaration. An SØF composed of only one physical file which already exists, might be declared as follows:

SØF(1)=SØF1,200,ØLD

A new SØF composed of five physical files would be declared as follows:

```
SØF(1)=SØF1,200,NEW
SØF(2)=SØF2,200
SØF(3)=SØF3,400
SØF(4)=SØF4,600
SØF(5)=SØF5,700
```

All data stored on the SØF is accessed via the substructure name. For each substructure, various types of SØF data may be stored. These types of data are called items and are accessed via their item names. Thus, the substructure name and item name are all that is required to access any block of data on the SØF. The items which can be stored for any substructure are described in Table 2. The program automatically keeps track of the data, stores the data as it is created, and retrieves these data when required. The user's only responsibility is to maintain the file. It must be accessible by the system when needed. The user must remove items already created in the event input errors were detected during processing or if that data is no longer needed for subsequent analyses.

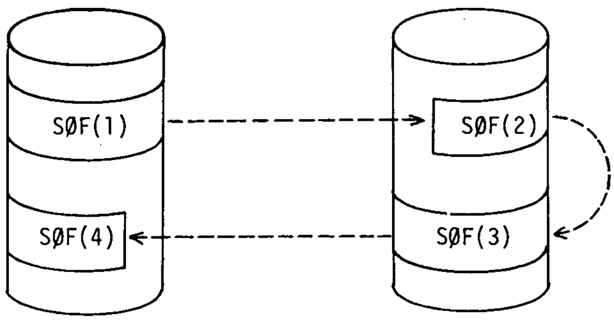


Figure 4. Substructure Operating File (SØF).

1.14.3 The Case Control Deck for Substructuring Analyses

The Case Control Deck controls loading conditions, constraint set selection, output requests, and so forth in a substructuring analysis just as in a non-substructuring analysis. However, in a substructuring analysis, there are very important relationships among the Case Control Decks to be input for the three Phases of a substructuring analysis. Compatibility among the substructuring Phases must be maintained for load sets, constraint sets, and subcase definitions. This section will describe how the Case Control Deck should be used for each of the three Phases.

1.14.3.1 Phase 1

The following requirements must be satisfied by the Case Control Deck in Phase 1:

1. Constraint set selections (MPC, SPC) must be above the subcase level. That is, only one set of constraints is allowed in Phase 1 for all loading conditions.

2. One subcase must be defined for each loading condition which is to be saved on the SØF. The loading condition may consist of any combination of external static loads, thermal loads, element deformation loads, or enforced displacements. Loading conditions which are not saved on the SØF in Phase 1 cannot be used in any solution in Phase 2.

1.14.3.2 Phase 2

The Phase 2 Case Control Deck is exactly like the Case Control used in a non-substructuring analysis. It is only needed, however, if plots are requested or when there is a SØLVE command in the Substructure Control Deck. In this latter case, the subcase definitions, load and constraint set selections, etc. are used in the usual fashion to control the solution process.

Case Control output requests are honored only if there is a PRINT or SAVE subcommand under the RECØVER command in the Substructure Control Deck. If a RECØVER command with a PRINT or SAVE subcommand is used for a solution obtained in a previous execution, the Case Control should be identical (except for output requests) to that used to obtain that solution.

1.14.3.3 Phase 3

The following requirements must be satisfied by the Case Control Deck in Phase 3:

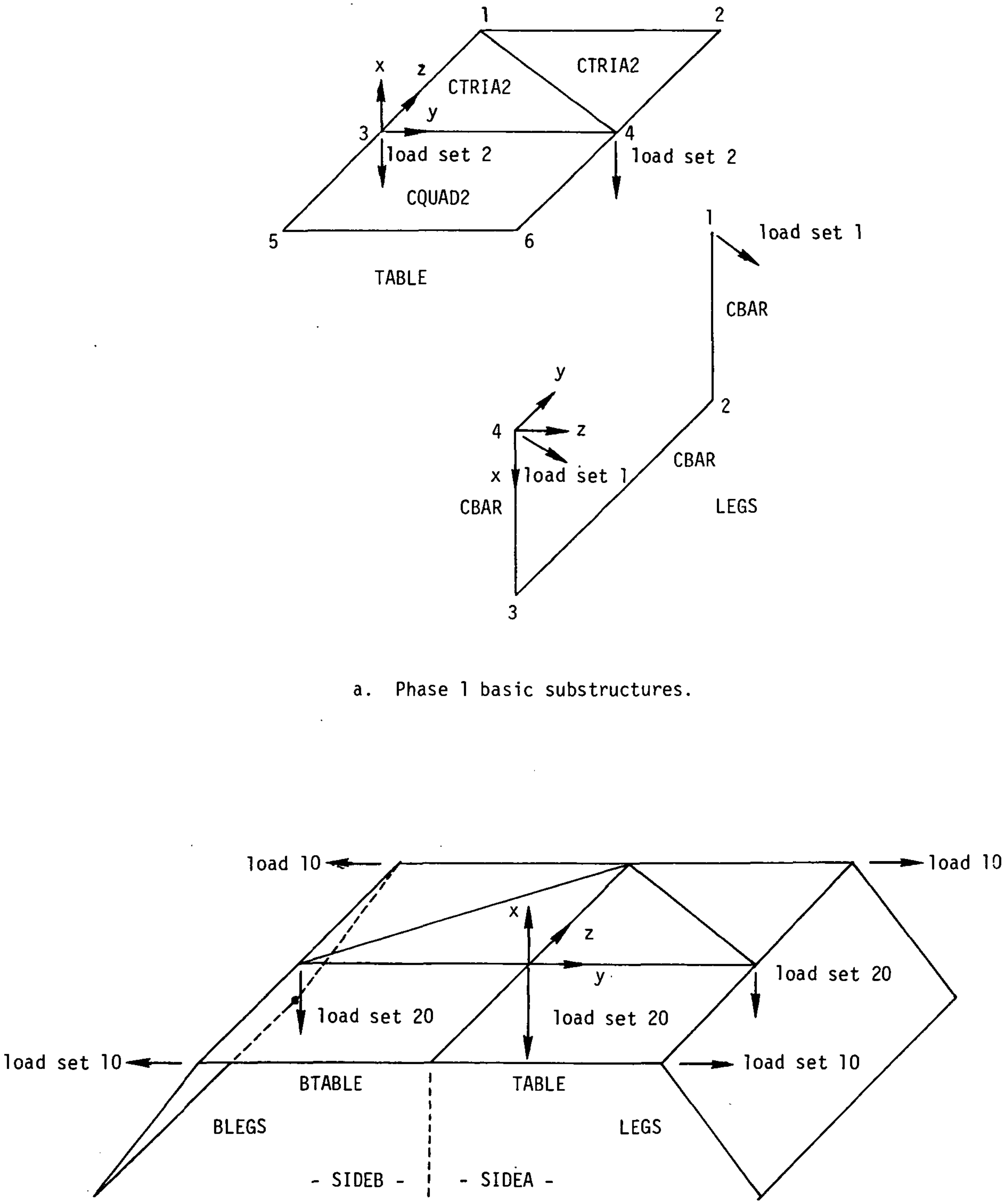
1. Constraint sets (MPC, SPC) must be identical to those used in Phase 1 for this substructure.

2. The subcase definitions must be identical to those used in Phase 2 for the Phase 2 SØLVE operation. That is, they must conform in number.

Load set selections are not required in Phase 3 unless there is an ØLØAD output request and the problem is not a Phase 1 restart. If there is such a request, the load set selected for each subcase should be the component of the load used in the Phase 2 solution which originated in this substructure. Note that if the load was scaled in Phase 2, it should be scaled again in Phase 3 (use the 'LØAD' Bulk Data card). Temperature loads should not be scaled in any event, due to limitations in the stress calculation logic.

1.14.4 Example of Substructure Analysis

This example illustrates a simple substructuring analysis. Figure 5a shows two basic substructures, TABLE and LEGS. Note that these structures have different basic coordinate systems as shown in the figure. Figure 5b shows a combined structure which is assembled from the basic substructures. The entire data decks to generate and analyze this structure are listed in Tables 3 - 6. These include the data for the generating of the basic substructures in Phase 1, the assembly of the complete structure, solution, and data recovery in Phase 2, and the data recovery in Phase 3. The remainder of this section is devoted to a detailed description of each of the data decks used in this analysis.



a. Phase 1 basic substructures.

b. Phase 2 combined substructure.

Figure 5. Substructure example problem.

Table 3. Phase 1 Data Deck for Substructure TABLE.

Card No.

1 ID TABLE,BASIC
2 APP DISP,SUBS
3 SØL 2,0
4 TIME 1
5 CHKPNT YES
6 CEND

7 SUBSTRUCTURE PHASE1
8 PASSWØRD=PRØJECTX
9 SØF(1)=SØF1,250,NEW
10 NAME=TABLE
11 SAVEPLØT=1
12 SØFPRINT TØC
13 ENDSUBS

14 TITLE=TABLE, PHASE ØNE
15 LØAD=2
16 ØUTPUT(PLØT)
17 SET 1=ALL
18 PLØT
19 BEGIN BULK

	1	2	3	4	5	6	7	8	9	10
20	CQUAD2	3	2	5	6	4	3			
21	CTRIA2	1	1	1	2	4				
22	CTRIA2	2	1	3	4	1				
23	FØRCE	2	3		10.0	-1.0				
24	FØRCE	2	4		10.0	-1.0				
25	GRID	1		0.0	0.0	5.				
26	GRID	2		0.0	7.	5.				
27	GRID	3		0.0	0.0	0.0				
28	GRID	4		0.0	7.	0.0				
29	GRID	5		0.0	0.0	-5.				
30	GRID	6		0.0	7.	-5.				
31	GRID	7						123456		
32	MAT1	1	3.+7		.3	4.3				
33	PQUAD2	2	1	.1						
34	PTRIA2	1	1	.1						
35	ENDDATA									

Table 4. Phase 1 Data Deck for Substructure LEGS.

```
Card
 No.

  1  ID LEGS,BASIC
  2  APP DISP,SUBS
  3  SØL 2,0
  4  TIME 1
  5  CHKPNT YES
  6  CEND

  7  SUBSTRUCTURE PHASE1
  8  PASSWØRD=PRØJECTY
  9  SØF(1)=SØF4,7500
 10  NAME=LEGS
 11  SAVEPLØT=1
 12  SØFØUT INP3
 13     PØSITIØN=REWIND
 14     NAME=LEGS
 15  EDIT(32) LEGS
 16  ENDSUBS

 17  TITLE=LEGS PHASE ØNE
 18  LØAD=1
 19  ØUTPUT(PLØT)
 20     SET 1=ALL
 21     PLØT
 22  BEGIN BULK
```

Card No.	1	2	3	4	5	6	7	8	9	10
23	CBAR	1	1	1	2	5			2	
24	CBAR	2	1	3	2	5			2	
25	CBAR	3	1	4	3	5			2	
26	FØRCE	1	1		2.0	3.0	.0	4.0		
27	FØRCE	1	4		2.0	3.0	.0	4.0		
28	GRID	1		0.0	10.	0.0				
29	GRID	2		5.	10.	0.0				
30	GRID	3		5.	0.0	0.0				
31	GRID	4		0.0	0.0	0.0				
32	GRID	5		100.	100.	0.0		123456		
33	MAT1	1	3.+7		.3	4.3				
34	PBAR	1	1	1.0	50.	100.	10.			
35	ENDDATA									

Table 5. Phase 2 Data Deck.

```
Card
 No.

  1  ID SUBSTR,PHASE2
  2  APP DISP,SUBS
  3  SØL 1,0
  4  TIME 1
  5  DIAG 23
  6  CEND

  7  SUBSTRUCTURE PHASE2
  8  PASSWØRD=PRØJECTX
  9  SØF(1)=SØF1,250
 10  ØPTIØNS=K,M,P
 11  SØFIN INP3,TAPE
 12     PØSITION=REWIND
 13     NAME=LEGS
 14  SØFPRINT TØC
 15  CØMBINE LEGS,TABLE
 16     NAME=SIDEA
 17     TØLER=0.001
 18     ØUTPUT=1,2,7,11,12,13,14,15,16,17
 19     CØMPØNENT LEGS
 20        TRANS=10
 21  EQUIV SIDEA,SIDEB
 22     PREFIX=B
 23  CØMBINE SIDEA,SIDEB
 24     NAME=BIGTABLE
 25     TØLER=0.001
 26     ØUTPUT=1,2,7,11,12,13,14,15,16,17
 27     CØMPØNENT SIDEB
 28        SYMT=Y
 29  REDUCE BIGTABLE
 30     NAME=SMALTABL
 31     BØUNDARY=100
 32     ØUTPUT=1,2,3,4,5,6,7,8
 33  SØFPRINT TØC
 34  PLØT SMALTABL
 35  SØLVE SMALTABL
 36  RECØVER SMALTABL
 37     PRINT BIGTABLE
 38     SAVE BTABLE
 39  SØFPRINT TØC
 40  ENDSUBS

 41  TITLE=PHASE TWØ SUBSTRUCTURE
 42  DISP=ALL
 43  SPCF=ALL
 44  ØLØAD=ALL
 45  SPC=10
 46  SUBCASE 1
 47     LØAD=10
 48  SUBCASE 2
 49     LØAD=20
 50  ØUTPUT(PLØT)
 51     SET 1=ALL
 52     PLØT
 53  BEGIN BULK
```

Table 5. Phase 2 Data Deck (continued)

Card No.	1	2	3	4	5	6	7	8	9	10
54	BDYC	100	LEGS	20	BLEGS	20				+A
55	+A		TABLE	10	BTABLE	10				
56	BDYS1	1C	4	1	3	4	5			
57	BDYS1	1C	123456	2	6					
58	BDYS1	20	123456	2	3					
59	LOADC	10	1.0	LEGS	1	1.0	BLEGS	1	1.0	
60	LOADC	20	1.0	TABLE	2	1.0	BTABLE	2	1.0	
61	SPCS1	10	BLEGS	123456	2	3				
62	SPCS1	10	BTABLE	4	1	3	4	5		
63	SPCS1	10	LEGS	123456	2	3				
64	SPCS1	10	TABLE	4	1	3	4	5		
65	TRANS	10		.0	7.0	-5.0	3.0	11.0	-5.0	+B
66	+B	0.0	8.0	-5.0						
67	ENDDATA									

Table 6. Phase 3 Data Deck.

Card No.	
1	ID TABLE,BASIC
2	APP DISP,SUBS
3	SØL 1,0
4	TIME 1
5	RESTART TABLE,BASIC (Restart deck)
6	CEND
7	SUBSTRUCTURE PHASE3
8	PASSWØRD=PRØJECTX
9	SØF(1)=SØF1,250
10	BRECØVER BTABLE
11	ENDSUBS
12	TITLE=PHASE THREE FØR REFLECTED TABLE
13	DISP=ALL
14	ØLØAD=ALL
15	SPCF=ALL
16	STRESS=ALL
17	SUBCASE 1
18	SUBCASE 2
19	LØAD=2
20	BEGIN BULK
21	ENDDATA

Phase 1 Data Deck for Substructure TABLE

Card No.	Refer to Table 3 for input cards described below.
1-6	Standard NASTRAN Executive Control Deck except the 'SUBS' option is selected on the APP card.
7	First card of Substructure Control Deck. Phase 1 is selected.
8	Password protection on the SØF is 'PRØJECTX'.
9	The SØF consists of one physical file with an index of one. (Indices must begin with one and increase sequentially.) The name of the file is 'SØF1' and it has a maximum size of 250,000 words. The file is to be initialized. (Internal pointers will be set to indicate that the SØF contains no data.)
10	The basic substructure to be generated will be identified by the name TABLE.
11	Plot set 1 will be saved on the SØF for performing plots of the combined structure in Phase 2.
12	Print a table of contents for the SØF. This includes a list of all substructures and their data items.
13	End of Substructure Control Deck
15	Selects the load to be saved on the SØF for use in Phase 2. Note that multiple loads may be saved by using multiple subcases. In addition to external static loads, thermal loads and element deformation loads may be selected.
16-18	Plot control cards are required if the SAVEPLØT subcommand is used in the Substructure Control Deck. These cards are used to define the plot sets for Phase 2 plotting. It is not necessary that a plot tape be set up in Phase 1.
19-35	Standard NASTRAN Bulk Data Deck. These cards define the mathematical model of the basic substructure.

Phase 1 Data Deck for Substructure LEGS

Card No.	Refer to Table 4 for input cards described below.
1-6	Standard NASTRAN Executive Control Deck except the 'SUBS' option is selected on the APP card.
7	First card of the Substructure Control Deck. Phase 1 is selected.
8	Password protection on the SØF is 'PRØJECTY'.
9	The SØF consists of one physical file with an index of one. (Indices must begin with one and increase sequentially.) The name of the file is 'SØF4' and it has a maximum size of 7,500,000 words. The file has been used previously as an SØF.
10	The basic substructure to be generated will be identified by the name LEGS.
11	Plot set 1 will be saved on the SØF for performing plots of the combined structure in Phase 2.
12-14	After substructure LEGS has been generated and saved on the SØF, it is copied out to user tape INP3.

Card No.	
15	All data items for substructure LEGS are removed from the SØF. (The substructure name remains in the SØF directory, however.)
16	End of Substructure Control Deck
18	Selects the load to be saved on the SØF for use in Phase 2. Note that multiple loads may be saved by using multiple subcases. In addition to external static loads, thermal loads, and element deformation loads may be selected.
19-21	Plot control cards are required if the SAVEPLØT subcommand is used in the Substructure Control Deck. These cards are used to define the plot sets for Phase 2 plotting. It is not necessary that a plot tape be set up in Phase 1.
22-35	Standard NASTRAN Bulk Data Deck. These cards define the mathematical model of the basic substructure.

Phase 2 Data Deck

Card No.	Refer to Table 5 for input cards described below.
1-6	Standard NASTRAN Executive Control Deck except the 'SUBS' option is selected on the APP card. DIAG 23 requests an echo of the automatic DMAP alters generated.
7	First card of the Substructure Control Deck. Phase 2 is selected.
8,9	These cards specify the same SØF used in Phase 1 for substructure TABLE.
10	The card causes matrix operations to be performed on stiffness, mass, and load matrices. The default for Rigid Format 1 is stiffness and loads only. However, Rigid Format 2 was selected in the Phase 1 decks. This caused all three matrix types to be generated in Phase 1.
11-13	Basic substructure LEGS is copied to the SØF from user tape INP3.
14	Print the SØF table of contents.
15-20	Perform an automatic combination of substructures TABLE and LEGS. The resultant combined pseudostructure will be named SIDEA. The tolerance for conenctions is 0.001 units. Detailed output is requested (see Substructure Command CØMBINE). The basic coordinate system for substructure LEGS is transformed according to transformation set 10 in the Bulk Data.
21,22	Create a new secondary substructure SIDEB which is equivalent to SIDEA. This operation causes image substructures BLEGS and BTABLE to be generated.
23-28	Perform an automatic combination of substructures SIDEA and SIDEB. The resultant combined pseudostructure will be named BIGTABLE. The tolerance for connections is 0.001 units. Detailed output is requested. The basic coordinate system for pseudostructure SIDEB is symmetrically transformed about the XZ plane, identified by Y, the axis normal to the plane (sign change for all 'Y' degrees of freedom).
29-32	Perform a matrix reduction on the matrices of substructure BIGTABLE. The resultant reduced pseudostructure will be named SMALTABL. The retained degrees of freedom are selected in boundary set 100 in the Bulk Data. Detailed output is requested.
33	Print the SØF table of contents.
34	Plot pseudostructure SMALTABL. The plot control cards in the Case Control Deck are referenced.

No.	
35	Perform a static solution of pseudostructure SMALTABL. The constraint sets anل selected in the Case Control Deck are used.
36-38	Recover the displacements of substructures BIGTABLE and BTABLE from the solution of SMALTABL and save then on the SØF. Also, print the results for substructure BIGTABL The output requests in the Case Control Deck are referenced when the PRINT subcomman invoked.
39	Print the SØF table of contents.
40	End of the Substructure Control Deck
42-44	Case Control output requests. Referenced by the PRINT subcommand of the RECØVER comm
45-49	Constraint and load set selections are referenced by the SØLVE command.
50-52	Plot control cards are referenced by the PLØT command.
54-58	These Bulk Data cards define the boundary set of retained degrees of freedom which was selected in the REDUCE operation (cards 29-32).
59-64	These cards define the loads and constraints selected in the Case Control Deck for the substructure SØLVE operation.
65,66	These cards define the transformation which is applied to the basic coordinate system substructure LEGS in the first CØMBINE operation (cards 15-20).

Phase 3 Data Deck for Substructure BTABLE

Card No.	Refer to Table 6 for input cards described below.
1-6	Standard NASTRAN Executive Control Deck except the 'SUBS' option is selected on the AP card. "Card" 5 is actually the Restart deck punched out in Phase 1 for substructure T
7	First card of the Substructure Control Deck. Phase 3 is selected.
8,9	These cards specify the same SØF used in Phase 2.
10	This card causes the data for the image basic substructure BTABLE to be copied from tl SØF to GINØ data blocks. The data can then be used for data recovery operations, i.e deformed structure plots, stresses, etc.
11	End of Substructure Control Deck.
13-16	Output requests for Phase 3 data recovery.
17-19	The subcase definitions in Phase 3 must be identical to those used in the SØLVE opera in Phase 2. SPC and MPC constraints in Phase 3 must be the same as those used in Pha Load sets selected in Phase 3 must correspond to those selected in Phase 2 for each case. However, load sets selected in Phase 2 which do not exist for this particular basic substructure can not be selected in Phase 3. See Section 1.14.4 for a more de discussion of the Phase 3 Case Control Deck.

NASTRAN DATA DECK

2.1 GENERAL DESCRIPTION OF DATA DECK

The input deck begins with the required resident operating system control cards. The type and number of these cards will vary with the installation. Instructions for the preparation of these control cards should be obtained from the programming staff at each installation.

The operating system control cards are followed by the NASTRAN Data Deck (see Figure 1), which is constructed in the following order (depending on the particular job requirements):

1. The NASTRAN Card
2. The Executive Control Deck
3. The Substructure Control Deck
4. The Case Control Deck
5. The Bulk Data Deck
6. The INPUT Module Data Card(s)

The NASTRAN card is used to change the default values for certain operational parameters, such as buffer size and machine model number. The NASTRAN card is optional, but, if present, it must be the first card of the NASTRAN Data Deck. The NASTRAN card is a free-field card (similar to cards in the Executive Control Deck). Its format is as follows:

$$\text{NASTRAN keyword}_1 = \text{value, keyword}_2 = \text{value, . . .}$$

The most frequently used keywords are as follows:

1. BUFFSIZE - Defines the number of words in a GINØ buffer. Usually this value is standardized at any particular installation. However, the desired value may be different from the default value of 1803 (IBM), 1183 (CDC) and 871 (UNIVAC). In any event, related runs, such as restarts and User Master File runs, must use the same BUFFSIZE for all parts of the runs.

2. CØNFIG - Defines the model number of the configuration for use in timing equations for matrix operations. Entries exist for the following configurations:

MACHINE	CØNFIG	MØDEL NØ.
IBM 360/370	0 (default)	91, 95
	3	50
	4	65
	5	75
	6	85
	7	195
	9	155

MACHINE	CØNFIG	MØDEL NØ.
CDC 6000	0 (default)	6600
	6	6400
UNIVAC 1100	0 (default)	1108

The machine type is automatically determined by NASTRAN. If the model number is the default, the CØNFIG keyword is not needed on the NASTRAN card. It is important to indicate the proper configuration; otherwise, all time-dependent matrix decisions will be incorrect

3. KØN360 - Defines the number of 32-bit words to release for IBM 360 ØS routines and FØRTRAN buffers. The default is 4096.

4. MØDCØM(i) - Defines a nine-word array for module communications. Currently, only MØDCØM(1) is supported. When MØDCØM(1) = 999999, optimization of passive columns in the symmetric decomposition routine is not used. If MØDCØM(1) = 1, diagnostic statistics from subroutine SDCØMP are printed.

5. HICØRE - Defines the amount of open core available to the user on the UNIVAC 1100 series machines. The user area default is nominally 65K decimal words. The ability to increase this value may be installation limited.

6. FILES - Establishes NASTRAN permanent files as being disk files rather than tape files. The FILES are PØØL, ØPTP, NPTP, UMF, NUMF, PLT1, PLT2, INPT, INP1, ... INP9. Multiple file names must be enclosed with parentheses such as FILES = (UMF,NPTP).

Additional information for all NASTRAN card options is given in Section 6.3.1 of the Programmer's Manual.

The Executive Control Deck begins with the NASTRAN ID card and ends with the CEND card, as indicated in Figure 1. It identifies the job and the type of solution to be performed. It also declares the general conditions under which the job is to be executed, such as, maximum time allowed, type of system diagnostics desired, restart conditions, and whether or not the job is to be checkpointed. If the job is to be executed with a rigid format, the number of the rigid format is declared along with any alterations to the rigid format that may be desired. If Direct Matrix Abstraction is used, the complete DMAP sequence must appear in the Executive Control Deck. The executive control cards and examples of their use are described in Section 2.2.

GENERAL DESCRIPTION OF DATA DECK

The Substructure Control Deck begins with the SUBSTRUCTURE card and terminates with the ENDSUBS card. It defines the general attributes of the Automated Multi-stage Substructuring capability and establishes the control of the Substructure Operating File (SØF). The command cards are illustrated in Section 2.7.

When Automated Multi-stage Substructuring is not included, then the Case Control Deck begins with the first card following CEND and ends with the card, BEGIN BULK. It defines the subcase structure for the problem, makes selections from the Bulk Data Deck, and makes output requests for printing, punching and plotting. A general discussion of the functions of the Case Control Deck and a detailed description of the cards used in this deck are given in Section 2.3. The special requirements of the Case Control Deck for each rigid format are discussed in Section 3.

The Bulk Data Deck begins with the card following BEGIN BULK and ends with the card preceeding ENDDATA. It contains all of the details of the structural model and the conditions for the solution. The BEGIN BULK and ENDDATA cards must be present even though no new bulk data is being introduced into the problem or all of the bulk data is coming from an alternate source, such as User's Master File or user generated input. The format of the BEGIN BULK card is free field. The ENDDATA card must begin in column 1 or 2. Generally speaking, only one structural model can be defined in the Bulk Data Deck. However, some of the bulk data, such as cards associated with loading conditions, constraints, direct input matrices, transfer functions and thermal fields may exist in multiple sets. All types of data that are available in multiple sets are discussed in Section 2.3.1. Only sets selected in the Case Control Deck will be used in any particular solution.

If the INPUT module is employed, one or two additional FØRTRAN data cards are required following the ENDDATA card. For specific cases, see Section 2.6.

Comment cards may be inserted in any of the parts of the NASTRAN Data Deck. These cards are identified by a $ in column one. Columns 2-72 may contain any desired text.

Except for the IBM 360/370 series, all NASTRAN data cards must be punched using the character set shown in the table below. The EBCDIC character set may be used on the IBM 360/370 series. Any EBCDIC characters are automatically translated into the character set shown in the table below. The EBCDIC character card punch configurations are shown in parenthesis for the five characters that differ from the standard character set.

Character	Card Punch(s)	Character	Card Punch(s)	EBCDIC Punch(s)
blank	blank	N	11-5	
0	0	Ø	11-6	
1	1	P	11-7	
2	2	Q	11-8	
3	3	R	11-9	
4	4	S	0-2	
5	5	T	0-3	
6	6	U	0-4	
7	7	V	0-5	
8	8	W	0-6	
9	9	X	0-7	
A	12-1	Y	0-8	
B	12-2	Z	0-9	
C	12-3	$	11-3-8	
D	12-4	/	0-1	
E	12-5	+	12	(12-6-8)*
F	12-6	-	11	
G	12-7	(	0-4-8	(12-5-8)*
H	12-8	)	12-4-8	(11-5-8)*
I	12-9	'	4-8	(5-8)*
J	11-1	=	3-8	(6-8)*
K	11-2	,	0-3-8	
L	11-3	.	12-3-8	
M	11-4	*	11-4-8	

*IBM 360,370 only.

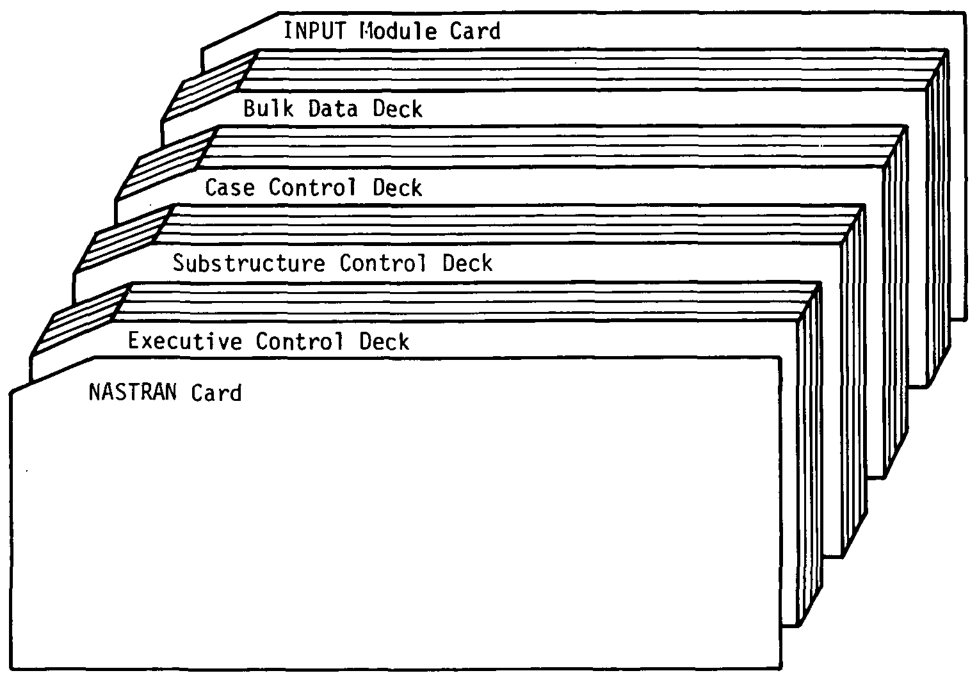


Figure 1. General construction of NASTRAN data deck.

2.2 EXECUTIVE CONTROL DECK

The format of the Executive control cards is free field. The name of the operation (e.g., CHKPNT) is separated from the operand by one or more blanks. The fields in the operand are separated by commas, and may be up to 8 integers (Ki) or alphanumeric (Ai) as indicated in the following control card descriptions. The first character of an alphanumeric field must be alphabetic followed by up to 7 additional alphanumeric characters. Blank characters may be placed adjacent to separating commas if desired. The individual cards are described in Section 2.2.1 and examples follow in Section 2.2.2.

2.2.1 Executive Control Card Descriptions

ID A1, A2 Required.

A1, A2 -- Any legal alphanumeric fields chosen by the user for problem identification.

RESTART A1, A2, K1/K2/K3, K4, Required for Restart.

A1, A2 -- Fields taken from ID card of previously checkpointed problem.

K1/K2/K3 -- Month/Day/Year that Problem Tape was generated.

K4 -- Number of seconds after midnight at which XCSA begins execution.

The complete restart dictionary consists of this card followed by one card for each file checkpointed. The restart dictionary is automatically punched when operating in the checkpoint mode. All subsequent cards are continuations of this logical card.

Each continuation card begins with a sequence number. Each type of continuation card will be documented separately.

1. Basic continuation card

   NO,DATABLØCK,FLAG=Y,REEL=Z,FILE=W

where: NO is the sequence number of the card. The entire dictionary must be in sequence by this number.

DATABLØCK is the name of the data block referenced by this card.

FLAG=Y defines the status of the data block where Y = 0 is the normal case and Y = 4 implies this data block is equivalenced to another data block. In this case (FLAG=4) the file number points to a previous data block which is the "actual" copy of the data.

REEL=Z specifies the reel number as the Problem Tape can be a multi-reel tape. Z = 1 is the normal case.

FILE=W specifies the GINØ (internal) file number of the data block on the Problem Tape. A zero value indicates the data block is purged. For example:

1,GPL,FLAGS=0,REEL=1,FILE=7 says data block GPL occupies file 7 of reel 1.

2,KGG,FLAGS=4,REEL=1,FILE=20 says KGG is equivalenced to the data block which occupies file 20. (Note that FLAGS=4 cards usually occur in at least pairs as the equivalenced operation is at least binary).

3,USETD,FLAGS=0,REEL=1,FILE=0 implies USETD is purged.

2. Reentry point card:

NO,REENTER AT DMAP SEQUENCE NUMBER N

where: NO is the sequence number of the card.

N is the sequence number associated with the DMAP instruction at which the problem will restart. This value may be changed by adding a final such card (i.e., only the last such card is operative). This may be necessary when restarting from a Rigid Format to a DMAP sequence (to print a matrix for example).

There are four types of restarts Unmodified Restart, Modified Restart, Rigid Format Switch and Pseudo Modified Restart. The function of the reentry point is different in each case. On an unmodified restart the program continues from the reentry point. On a modified restart modules which must be run to process the modified data but which are ahead of the reentry point are executed first. The program then continues from the reentry point. On a Rigid Format Switch (going from a Rigid Format to another) the reentry point is meaningless in that it was determined for another DMAP sequence. In this case the data blocks available are consulted to determine the proper sequence of modules to run. A Pseudo modified restart (defined by the existence of only changes to output producing data such as plotter requests) is treated like a modified restart. The type of restart is implied by the changes made in the NASTRAN Data Deck. No explicit request for a particular kind of restart is required. See Section 3.1 for additional information.

3. End of dictionary card

$ END ØF CHECKPØINT DICTIØNARY

This card is simply a comment card but is punched to signal the end of the dictionary for user convenience. The program does not need such a card. Terminations associated with non-NASTRAN failures (operator intervention, maximum time etc.) will not have such a card punched.

NUMF K1, K2 Required when creating a User's Master File.

K1 -- User specified tape identification number assigned during the creation of a User's Master File.

K2 -- User specified problem identification number assigned during the creation of a User's Master File.

UMF K1, K2 Required when using a User's Master File.

K1 -- Previously assigned tape identification number to access a Bulk Data Deck when using a User's Master File.

K2 -- Previously assigned problem identification number to access a Bulk Data Deck when using a User's Master File.

CHKPNT A1 or CHKPNT A1, A2 Optional.

A1 -- YES if problem is to be checkpointed, NØ if problem is not to be checkpointed - default is NØ.

A2 -- DISK if checkpoint file is on direct access device. If the DISK option is used, the user must instruct the resident operating system to permanently catalog the checkpoint file.

APP A Required.

A -- DISPLACEMENT indicates one of the Displacement Approach rigid formats.

A -- HEAT indicates one of the Heat Transfer Approach rigid formats.

A -- AERØ indicates the Aeroelastic Approach rigid formats.

A -- DMAP indicates Direct Matrix Abstraction Approach (DMAP).

ALTER K1, K2 Optional.

K1, K2 -- First and last DMAP instructions of series to be deleted and replaced with any following DMAP instructions.

ALTER K Optional.

K -- Input any following DMAP instructions after statement K.

ENDALTER Required when using ALTER.

Indicates end of DMAP alterations.

TIME K Required.

K -- Maximum allowable execution time in minutes.

SØL K1 [,Ki] or SØL An [,Ki] Required when using a rigid format (see Section 3.1 for available options).

K1 -- Solution number of Rigid Format (see table below and Section 3.1).

Ki -- Subset numbers for solution K1, default value = 0. Multiple subsets may be selected by using multiple integers separated by commas.

An -- Name of Rigid Format (see table below)

Displacement Approach Rigid Formats

K1	An
1	STATICS
2	INERTIA RELIEF
3	MØDES or NØRMAL MØDES or REAL EIGENVALUES
4	DIFFERENTIAL STIFFNESS
5	BUCKLING
6	PIECEWISE LINEAR
7	DIRECT CØMPLEX EIGENVALUES
8	DIRECT FREQUENCY RESPØNSE
9	DIRECT TRANSIENT RESPØNSE
10	MØDAL CØMPLEX EIGENVALUES
11	MØDAL FREQUENCY RESPØNSE
12	MØDAL TRANSIENT RESPØNSE
13	NØRMAL MØDES ANALYSIS WITH DIFFERENTIAL STIFFNESS
14	STATICS CYCLIC SYMMETRY
15	MØDES CYCLIC SYMMETRY

Heat Transfer Approach Rigid Formats

K1	An
1	STATICS
3	STEADY STATE
9	TRANSIENT

Aeroelastic Approach Rigid Format

K1	An
10	MØDAL FLUTTER ANALYSIS

Subset Numbers

1. Delete loop control.
2. Delete mode acceleration method of data recovery (modal transient and modal frequency response).
3. Combine subsets 1 and 2.
4. Check all structural and aerodynamic data without execution of the aeroelastic problem.
5. Check only the aerodynamic data without execution of the aeroelastic problem.
6. Delete checkpoint instructions.
7. Delete structure plotting and X-Y plotting.
8. Delete Grid Point Weight Generator.
9. Delete fully stressed design (static analysis).

DIAG K Optional request for diagnostic output.

K = 1	Dump memory when fatal message is generated.
K = 2	Print File Allocation Table (FIAT) following each call to the File Allocator.
K = 3	Print status of the Data Pool Dictionary (DPD) following each call to the Data Pool Housekeeper.
K = 4	Print the Operation Sequence Control Array (ØSCAR).
K = 5	Print BEGIN time on-line for each functional module.
K = 6	Print END time on-line for each functional module.
K = 7	Print eigenvalue extraction diagnostics for real and complex determinant methods.
K = 8	Print matrix and table data block trailers as they are generated.
K = 9	Suppress echo of checkpoint dictionary.
K = 10	Use alternate nonlinear loading in TRD. (Replace $\{N_{n+1}\}$ by $\frac{1}{3}\{N_{n+1} + N_n + N_{n-1}\}$)
K = 11	Print all active row and column possibilities for decomposition algorithms.
K = 12	Print eigenvalue extraction diagnostics for complex inverse power.
K = 13	Print open core length.
K = 14	Print the Rigid Format (NASTRAN SØURCE PRØGRAM CØMPILATIØN)
K = 15	Trace GINØ ØPEN/CLØSE operations.
K = 16	Trace real inverse power eigenvalue extraction operations.
K = 17	Punch the DMAP sequence that is compiled.
K = 18	Trace Heat Transfer iterations (APP HEAT) or print grid point ID conversions from SET card (APP AERØ).
K = 19	Print data for MPYAD method selection.
K = 20	Generate de-bug printout (For NASTRAN programmers who include CALL BUG in their subroutines).
K = 21	Print GP4 set definition.
K = 22	Print GP4 degree of freedom definition.
K = 23	Print the DMAP alters generated during Automated Multi-stage Substructuring.
K = 24	Punch the DMAP alters generated during Automated Multi-stage Substructuring.
K = 25	
K = 26	
K = 27	Input File Processor (IFP) table dump.
K = 28	Punch the link specification table (Deck XBSBD).
K = 29	Process link specification table update deck.

K = 30 Punch alters to the XSEMi decks (i set via DIAG 1-15).

K = 31 Print link specification table and module properties list data.

Multiple options may be selected by using multiple integers separated by commas. Other options and other rules associated with the DIAG card which primarily concern the programmer can be found in Section 6.11.3 of the Programmer's Manual.

BEGIN$ Required when using DMAP approach.

Indicates beginning of DMAP sequence. This card is supplied as part of a Rigid Format.

END$ Required when using DMAP approach.

Indicates end of DMAP sequence. This card is supplied as part of a Rigid Format.

UMFEDIT Required when using User's Master File Editor (see Section 2.5)

$ Comment flag in column 1. Commentary text may appear in columns 2-80.

CEND Required

Indicates end of Executive control cards.

The ID card must appear first and CEND must be the last card of the Executive Control Deck. Otherwise the Executive Control card groups (RESTART dictionary, DMAP sequence, ALTER packet) can be in any order.

2.2.2 Executive Control Deck Examples

1. Cold start, no checkpoint, rigid format, diagnostic output.

```
ID          MYNAME, BRIDGE23
APP         DISPLACEMENT
SØL         2,0
TIME        5
DIAG        1,2
CEND
```

2. Cold start, checkpoint, rigid format.

```
ID          PERSØNZZ, SPACECFT
CHKPNT      YES
APP         DISPLACEMENT
SØL         1,3
TIME        15
CEND
```

3. Restart, no checkpoint, rigid format. The restart dictionary indicated by the brace is automatically punched on previous run in which the CHKPNT option was selected by the user.

```
ID JØESHMØE, PRØJECTX
RESTART  PERSØNZZ, SPACECFT, 05/13/67,
     1, XVPS, FLAGS=0, REEL=1, FILE=6
     2, REENTER AT DMAP SEQUENCE NUMBER 7
     3, GPL, FLAGS=0 REEL=1, FILE=7
                    .
                    .
                    .
$ END OF CHECKPØINT DICTIØNARY
APP           DISPLACEMENT
SØL           3,3
TIME          10
CEND
```

4. Cold start, no checkpoint, DMAP. User-written DMAP program is indicated by braces.

```
ID          IAM007, TRYIT
APP         DMAP
BEGIN $

{DMAP statements go here}

END $
TIME        8
CEND
```

5. Restart, checkpoint, altered rigid format, diagnostic output.

```
ID GØØDGUY, NEATDEAL
RESTART BADGUY, NØSHØW, 05/09/68,
     1, XVPS, FLAGS=0, REEL=1, FILE=6
     2, REENTER AT DMAP SEQUENCE NUMBER 7
     3, GPL, FLAGS=0, REEL=1, FILE=7
                 .
                 .
                 .
$ END ØF CHECKPØINT DICTIØNARY
CHKPNT        YES
DIAG          2,4
APP           DISPLACEMENT
SØL           3,3
TIME          15
ALTER         20
MATPRN        KGGX,,,,// $
TABPT         GPST,,,,// $
ENDALTER
CEND
```

2.3 CASE CONTROL DECK

2.3.1 Data Selection

The case control cards that are used for selecting items from the Bulk Data Deck are listed below in functional groups. A detailed description of each card is given in Section 2.3.4. The first four characters of the mnemonic are sufficient if unique.

The following case control cards are associated with the selection of applied loads for both static and dynamic analysis:

1. DEFØRM - selects element deformation set.
2. DLØAD - selects dynamic loading condition.
3. DSCØEFFICIENT - selects loading increments for static analysis with differential stiffness.
4. LØAD - selects static loading condition.
5. NØNLINEAR - selects nonlinear loading condition for transient response.
6. PLCØEFFICIENT - selects loading increments for piecewise linear analysis.

The following case control cards are used for the selection of constraints:

1. AXISYMMETRIC - selects boundary conditions for conical shell and axisymetric solid elements or specifies the existence of fluid harmonics for a hydroelastic problem.
2. MPC - selects set of multipoint constraints.
3. SPC - selects set of single-point constraints.

The following case control cards are used for the selection of direct input matrices:

1. B2PP - selects direct input damping matrices.
2. K2PP - selects direct input stiffness matrices.
3. M2PP - selects direct input mass matrices.
4. TFL - selects transfer functions.

The following case control cards specify the conditions for dynamic analyses:

1. CMETHØD - selects the conditions for complex eigenvalue extraction.
2. FREQUENCY - selects the frequencies to be used for frequency and random response calculations.
3. IC - selects the initial conditions for direct transient response.
4. METHØD - selects the conditions for real eigenvalue analysis.
5. RANDØM - selects the power spectral density functions to be used in random analysis.

6. SDAMPING - selects table to be used for determination of modal damping.

7. TSTEP- selects time steps to be used for integration in transient response problems.

8. FMETHØD - selects method to be used in aerooelastic flutter analysis.

The following case control cards are associated with the use of thermal fields:

1. TEMPERATURE(LØAD) - selects thermal field to be used for determining equivalent static loads.

2. TEMPERATURE(MATERIAL) - selects thermal field to be used for determining material properties.

3. TEMPERATURE - selects thermal field for determining both equivalent static loads and material properties.

2.3.2 Output Selection

Printer output requests may be grouped in packets following ØUTPUT cards or the individual requests may be placed anywhere in the Case Control Deck ahead of any structure plotter or curve plotter requests. Plotter requests are described in Section 4. The case control cards that are used for output selection are listed below in functional groups. A detailed description of each card is given in Section 2.3.4.

The following cards are associated with output control, titling and bulk data echoes:

1. TITLE - defines a text to be printed on first line of each page of output.

2. SUBTITLE - defines a text to be printed on second line of each page of output.

3. LABEL - defines a text to be printed on third line of each page of output.

4. LINE - sets the number of data lines per printed page, default is 50 for 11-inch paper.

5. MAXLINES - sets the maximum number of output lines, default is 20,000.

6. ECHØ - selects echo options for Bulk Data Deck, default is a sorted bulk data echo.

The following cards are used in connection with some of the specific output requests for calculated quantities:

1. SET - defines lists of point numbers, elements numbers, or frequencies for use in output requests.

2. ØFREQUENCY - selects a set of frequencies to be used for output requests in frequency response problems; default is all frequencies used in the calculations.

3. TSTEP - selects a set of time steps to be used for output requests in transient response problems.

The following cards are used to make output requests for the calculated response of components in the SØLUTIØN set (components in the direct or modal formulation of the general K system) for dynamics problems:

1. SACCELERATIØN - requests the acceleration of the independent components for a selected set of points or modal coordinates.

2. SDISPLACEMENT - requests the displacements of the independent components for a selected set of points or modal coordinates or the temperatures of the independent components for a selected set of points in heat transfer.

3. SVELØCITY - requests the velocities of the independent components for a selected set of points or modal coordinates or the change in temperature with respect to time of the independent components for a selected set of points in heat transfer.

4. NLLØAD - requests the nonlinear loads for a selected set of physical points (grid points and extra points introduced for dynamic analysis) intransient response problems.

The following cards are used to make output requests for stresses and forces, as well as the calculated response of degrees of freedom used in the model:

1. ELFØRCE - requests the forces in a set of structural elements or the temperature gradients and fluxes in a set of structural or heat elements in heat transfer.

2. STRESS - requests the stresses in a set of structural elements or the velocity components in a fluid element in acoustic cavity analysis.

3. SPCFØRCES - requests the single-point forces of constraint at a set of points or the thermal power transmitted at a selected set of points in heat transfer.

4. ØLØAD - selects a set of applied loads for output.

5. ACCELERATIØN - requests the accelerations for a selected set of PHYSICAL points (grid, scalar and fluid points plus extra points introduced for dynamic analysis).

6. DISPLACEMENT - requests the displacements for a selected set of PHYSICAL points or the temperatures for a selected set of PHYSICAL points in heat transfer or the pressures for a selected set of PHYSICAL points in hydroelasticity.

7. VELØCITY - requests the velocities for a selected set of PHYSICAL points or the change in temperatures with respect to time for a selected set of PHYSICAL points in heat transfer.

8. HARMØNICS - controls the number of harmonics that will be output for requests associated with the conical shell, axisymmetric solids and hydroelastic problems.

9. ESE - requests structural element strain energies in Rigid Format 1.

10. GPFØRCE - requests grid point force balance due to element forces, forces of single point constraint, and applied loads in Rigid Format 1.

11. THERMAL - requests temperatures for a set of PHYSICAL points in heat transfer.

12. PRESSURE - requests pressures for a set of PHYSICAL points in hydroelasticity.

2.3.3 Subcase Definition

In general, a separate subcase is defined for each loading condition. In statics problems separate subcases are also defined for each set of constraints. In complex eigenvalue analysis and frequency response separate subcases are defined for each unique set of direct input matrices. Subcases may be used in connection with output requests, such as in requesting different output for each mode in a real eigenvalue problem.

The Case Control Deck is structured so that a minimum amount of repetition is required. Only one level of subcase definition is provided. All items placed above the subcase level (ahead of the first subcase) will be used for all following subcases, unless overridden within the individual subcase.

In static problems, provision has been made for the combination of the results of several subcases. This is convenient for studying various combinations of individual loading conditions and for the superposition of solutions for symmetrical and antisymmetrical boundaries.

Typical examples of subcase definition are given following a brief description of the cards used in subcase definitions.

The following case control cards are associated with subcase definition:

1. SUBCASE - defines the beginning of a subcase that is terminated by the next subcase delimiters encountered.

2. SUBCØM - defines a combination of two or more immediately preceeding subcases in statics problems. Output requests above the subcase level are used.

3. SUBSEQ - must appear in a subcase defined by SUBCØM to give the coefficients for making the linear combination of the preceeding subcases.

4. SYM - defines a subcase in statics problems for which only output requests within the subcase will be honored. Primarily for use with symmetry problems where the individual parts of the solution may not be of interest.

5. SYMCØM - defines a combination of two or more immediately preceeding SYM subcases in static problems. Output requests above the subcase level are used.

6. SYMSEQ - may appear in a subcase defined by SYMCØM to give the coefficient for making the linear combination of the preceeding SYM subcases. A default value of 1.0 is used if no SYMSEQ card appears.

7. REPCASE - defines a subcase in statics problems that is used to make additional output requests for the previous real subcase. This card is required because multiple output requests for the same item are not permitted in the same subcase. Output requests above the subcase level are still used.

8. MØDES - repeats the subcase in which it appears MØDES times for eigenvalue problems. Used to repeat the same output request for several consecutive modes.

The following examples of Case Control Decks indicate typical ways of defining subcases:

1. Static analysis with multiple loads.

```
ØUTPUT
    DISPLACEMENT = ALL
MPC = 3
    SUBCASE 1
        SPC = 2
        TEMPERATURE(LØAD) = 101
        LØAD = 11
    SUBCASE 2
        SPC = 2
        DEFØRM = 52
        LØAD = 12
    SUBCASE 3
        SPC = 4
        LØAD = 12
    SUBCASE 4
        MPC = 4
        SPC = 4
```

Four subcases are defined in this example. The displacements at all grid points will be printed for all four subcases. MPC = 3 will be used for the first three subcases and will be overridden by MPC = 4 in the last subcase. Since the constraints are the same for subcases 1 and 2 and the subcases are contiguous, the static solutions will be performed simultaneously. In subcase 1, thermal load 101 and external load 11 are internally superimposed, as are the external and deformation loads in subcase 2. In subcase 4 the static loading will result entirely from enforced displacements of grid points.

2. Linear combination of subcases.

```
SPC = 2
ØUTPUT
    SET 1 = 1 THRU 10,20,30
    DISPLACEMENT = ALL
    STRESS = 1
SUBCASE 1
    LØAD = 101
    ØLØAD = ALL
SUBCASE 2
    LØAD = 201
    ØLØAD = ALL
SUBCØM 51
    SUBSEQ = 1.0,1.0
SUBCØM 52
    SUBSEQ = 2.5,1.5
```

Two static loading conditions are defined in subcases 1 and 2. SUBCØM 51 defines the sum of subcases 1 and 2. SUBCØM 52 defines a linear combination consisting of 2.5 times subcase 1 plus 1.5 times subcase 2. The displacements at all grid points and the stresses for the elements numbers in SET will be printed for all four subcases. In addition, the nonzero components of the static load vectors will be printed for subcases 1 and 2.

3. Statics problem with one plane of symmetry.

```
ØUTPUT
    SET 1 = 1,11,21,31,51
    SET 2 = 1 THRU 10, 101 THRU 110
    DISPLACEMENT = 1
    ELFØRCE = 2
SYM 1
    SPC = 11
    LØAD = 21
    ØLØAD = ALL
SYM 2
    SPC = 12
    LØAD = 22
SYMCØM 3
SYMCØM 4
    SYMSEQ 1.0,-1.0
```

Two SYM subcases are defined in subcases 1 and 2. SYMCØM 3 defines the sum and SYMCØM 4 the difference of the two SYM subcases. The nonzero components of the static load will be printed for subcase 1 and no output is requested for subcase 2. The displacements for the grid point numbers in set 1 and the forces for elements in set 2 will be printed for subcases 3 and 4.

4. Use of REPCASE in statics problems.

```
SET 1 = 1 THRU 10, 101 THRU 110, 201 THRU 210
SET 2 = 21 THRU 30, 121 THRU 130, 221 THRU 230
SET 3 = 31 THRU 40, 131 THRU 140, 231 THRU 240
    SUBCASE 1
        LØAD =10
        SPC = 11
        DISPLACEMENT = ALL
        SPCFØRCE = 1
        ELFØRCE = 1
    REPCASE 2
        ELFØRCE = 2
    REPCASE 3
        ELFØRCE = 3
```

This example defines one subcase for solution and two subcases for output control. The displacements at all grid points and the nonzero components of the single-point forces of constraint along with forces for the elements in SET 1 will be printed for SUBCASE 1. The forces for elements in SET 2 will be printed for REPCASE 2 and the forces for elements in SET 3 will be printed for REPCASE 3.

5. Use of MØDES in eigenvalue problems

```
    METHØD = 2
    SPC = 10
SUBCASE 1
    DISPLACEMENT = ALL
    STRESS = ALL
    MØDES = 2
SUBCASE 3
    DISPLACEMENT = ALL
```

In this example the displacements at all grid points will be printed for all modes. The stresses in all elements will be printed for the first two modes.

2.3.4 Case Control Card Descriptions

The format of the case control cards is free-field. In presenting general formats for each card embodying all options, the following conventions are used:

1. Upper-case letters and parentheses must be punched as shown.
2. Lower-case letters indicate that a substitution must be made.
3. Braces { } indicate that a choice of contents is mandatory.

4. Brackets [ ] contain an option that may be omitted or included by the user.

5. Underlined options or values are the default values.

6. Physical card consists of information punched in columns 1 thru 72 of a card. Most case control cards are limited to a single physical card.

7. Logical card may have more than 72 columns with the use of continuation cards. A continuation card is honored by ending the preceeding card with a comma.

The structure plotter output request packet and the x-y output request packet, while part of the Case Control Deck, are treated separately in Sections 4.2 and 4.3, respectively.

Case Control Data Card - ACCELERATIØN - Acceleration Output Request.

Description: Requests form and type of acceleration vector output.

Format and Example(s):

$$\text{ACCELERATIØN}\left[\left(\frac{\text{SØRT1}}{\text{SØRT2}},\ \frac{\text{PRINT}}{\text{PUNCH}},\ \frac{\text{REAL}}{\substack{\text{IMAG}\\ \text{PHASE}}}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{matrix}\right\}$$

ACCELERATIØN = 5

ACCELERATIØN(SØRT2, PHASE) = ALL

ACCELERATIØN(SØRT1, PRINT, PUNCH, PHASE) = 17

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Frequency Response problems.
ALL	Accelerations for all points will be output.
n	Set identification of a previously appearing SET card. Only accelerations of points whose identification numbers appear on this SET card will be output (Integer > 0).
NØNE	Accelerations for no points will be output.

Remarks:
1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. Acceleration output is only available for Transient and Frequency Response problems.
4. In a frequency Response problem any request for SORT2 output causes all output to be SØRT2.
5. ACCELERATIØN = NØNE allows overriding an overall output request.

Case Control Data Card AXISYMMETRIC - Boundary Conditions or Hydroelastic Harmonics.

Description: Selects boundary conditons for problems containing CCØNEAX, CTRAPAX or CTRIAAX elements or specifies the existence of fluid harmonics for hydroelastic problems.

Format and Example(s):

$$\text{AXISYMMETRIC} = \begin{Bmatrix} \text{SINE} \\ \text{CØSINE} \\ \text{FLUID} \end{Bmatrix}$$

AXISYMMETRIC = CØSINE

Option	Meaning
SINE	Sine boundary conditions will be used.
CØSINE	Cosine boundary conditions will be used.
FLUID	Existence of fluid harmonics.

Remarks:

1. This card is required for problems containing the elements named above.
2. If this card is used for hydroelastic problems, at least one harmonic must be specified on the AXIF card.
3. See Section 1.3.6 of User's Manual for a discussion of the conical shell problem.
4. See Section 1.3.7 of User's Manual for a discussion of the axisymmetric solid problem.
5. See Section 1.7.1 of User's Manual for a discussion of the hydroelastic formulation.
6. The sine boundary condition will constrain components 1, 3 and 5 at every ring for the zero harmonic.
7. The consine boundary condition will constrain components 2, 4 and 6 at every ring for for the zero harmonic.
8. SPC and MPC case control cards may also be used to effect additional constraints.

Case Control Data Card B2PP - Direct Input Damping Matrix Selection.

Description: Selects a direct input damping matrix.

Format and Example(s):

B2PP = name

B2PP = BDMIG

B2PP = B2PP

Option	Meaning
name	BCD name of $[B^2_{pp}]$ matrix that is input on the DMIG or DMIAX bulk data card.

Remarks: 1. B2PP is used only in dynamics problems.

2. DMIG and DMIAX matrices will not be used unless selected.

Case Control Data Card CMETHØD - Complex Eigenvalue Extraction Method Selection.

Description: Selects complex eigenvalue extraction data to be used by module CEAD.

Format and Example(s):

CMETHØD = n

CMETHØD = 77

Option	Meaning
n	Set identification of EIGC (and EIGP) card (Integer > 0).

Remarks: Eigenvalue extraction data must be selected when extracting complex eigenvalues using Functional Module CEAD.

Case Control Data Card DEFØRM - Element Deformation Static Load.

Description: Selects the Element Deformation Set to be applied to the structural model.

Format and Example(s):

DEFØRM = n

DEFØRM = 27

Option	Meaning
n	Set identification of DEFØRM cards (Integer > 0).

Remarks:

1. DEFØRM bulk data cards will not be used unless selected in the Case Control Deck.
2. DEFØRM is only applicable in statics, inertia relief, differential stiffness, and buckling problems.
3. The total load applied will be the sum of external, (LØAD), thermal (TEMP(LØAD)), element deformation (DEFØRM) and constrained displacement loads (SPC).
4. Static, thermal and element deformation loads should have unique identification numbers.

Case Control Data Card DISPLACEMENT - Displacement Output Request.

Description: Requests form and type of displacement vector output.

Format and Example(s):

$$\text{DISPLACEMENT} \left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \frac{\text{REAL}}{\begin{matrix}\text{IMAG} \\ \text{PHASE}\end{matrix}} \right) \right] = \begin{Bmatrix} \text{ALL} \\ \text{n} \\ \text{NØNE} \end{Bmatrix}$$

DISPLACEMENT = 5

DISPLACEMENT(REAL) = ALL

DISPLACEMENT(SØRT2, PUNCH, REAL) = ALL

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each grid point. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° $\leq$ phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements for all points will be output.
NØNE	Displacements for no points will be output.
n	Set identification of previously appearing SET card. Only displacements of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT AND PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 causes all output to be SØRT2.
4. VECTØR, PRESSURE and THERMAL are alternate forms and are entirely equivalent to DISPLACEMENT.
5. DISPLACEMENT = NØNE allows overriding an overall output request.

Case Control Data Card DLØAD - Dynamic Load Set Selection.

Description: Selects the dynamic load to be applied in a Transient or Frequency Response problem.

Format and Example(s):

DLØAD = n

DLØAD = 73

Option	Meaning
n	Set identification of a DLØAD, RLØAD1, RLØAD2, TLØAD1, or TLØAD2 card (Integer > 0).

Remarks:
1. The above loads will not be used by NASTRAN unless selected in Case Control.
2. RLØAD1 and RLØAD2 may only be selected in a Frequency Response problem.
3. TLØAD1 and TLØAD2 may only be selected in a Transient Response problem.

Case Control Data Card DSCØEFFICIENT - Differential Stiffness Coefficient Set.

Description: Selects the coefficient set for a Differential Stiffness problem.

Format and Example(s):

DSCØEFFICIENT = $\left\{ \begin{matrix} \text{DEFAULT} \\ \text{n} \end{matrix} \right\}$

DSCØEF = 15

DSCØEF = DEFAULT

Option	Meaning
DEFAULT	A single default coefficient of value 1.0.
n	Set identification of DSFACT card (Integer > 0).

Remarks: 1. DSFACT cards will not be used unless selected.

2. DSCØEFFICIENT must appear in the 2nd Subcase of a differential stiffness problem.

Case Control Data Card ECHØ - Bulk Data Echo Request.

Description: Requests echo of bulk data deck.

Format and Example(s):

$$\text{ECHØ} = \begin{bmatrix} \underline{\text{SØRT}} \\ \text{UNSØRT} \\ \text{BØTH} \\ \text{NØNE} \\ \text{PUNCH} \end{bmatrix}$$

ECHØ = BØTH

ECHØ = PUNCH, SØRT

Option	Meaning
SØRT	Sorted echo will be printed.
UNSØRT	Unsorted echo will be printed.
BØTH	Both sorted and unsorted echo will be printed.
NØNE	No echo will be printed.
PUNCH	The sorted bulk data deck will be punched onto cards.

REMARKS:
1. If no ECHØ card appears a sorted echo will be printed.
2. If CHKPNT YES a sorted echo will be printed unless ECHØ = NØNE.
3. Unrecognizable options will be treated as SØRT.
4. Any option overrides the default. Thus, for example, if both print and punch are desired, both SØRT and PUNCH must be requested on the same card.

Case Control Data Card ELFØRCE - Element Force Output Request.

Description: Requests form and type of element force output.

Format and Example(s):

$$\text{ELFØRCE}\quad\left[\left(\frac{\text{SØRT1}}{\text{SØRT2}},\ \frac{\text{PRINT}}{\text{PUNCH}},\ \frac{\text{REAL}}{\begin{matrix}\text{IMAG}\\ \text{PHASE}\end{matrix}}\right)\right] = \begin{Bmatrix}\text{ALL}\\ n\\ \text{NØNE}\end{Bmatrix}$$

ELFØRCE = ALL

ELFØRCE(REAL, PUNCH, PRINT) = 17

ELFØRCE = 25

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Forces for all elements will be output.
NØNE	Forces for no elements will be output.
n	Set identification of a previously appearing SET card. Only forces of elements whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. FØRCE is an alternate form and is entirely equivalent to ELFØRCE.
5. ELFØRCE = NØNE allows overriding an overall request.

Case Control Data Card ELSTRESS - Element Stress Output Request.

Description: Requests form and type of element stress output.

Format and Example(s):

$$\text{ELSTRESS} \left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \frac{\text{REAL}}{\substack{\text{IMAG} \\ \text{PHASE}}} \right) \right] = \left\{ \begin{matrix} \text{ALL} \\ \text{n} \\ \text{NØNE} \end{matrix} \right\}$$

ELSTRESS = 5

ELSTRESS = ALL

ELSTRESS(SØRT1, PRINT, PUNCH, PHASE) = 15

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary printout on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Stresses for all elements will be output.
n	Set identification of a previously appearing SET card (Integer > 0). Only stresses for elements whose identification numbers appear on this SET card will be output.
NØNE	Stress for no elements will be output.

Remarks:
1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. STRESS is an alternate form and is entirely equivalent to ELSTRESS.
5. ELSTRESS = NØNE allows overriding an overall output request.

Case Control Data Card ESE - Element Strain Energy Output Request

Description: Requests strain energy output and per cent of total strain energy with respect to all elements.

Format and Example(s):

$$\text{ESE} \left[\left(\begin{array}{c}\text{PRINT} \\ \hline \text{PUNCH}\end{array}\right)\right] = \left\{\begin{array}{c}\text{ALL} \\ \text{n} \\ \text{NØNE}\end{array}\right\}$$

ESE (PUNCH) = 5

ESE (PRINT,PUNCH) = ALL

Option	Meaning
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Strain energies will be output for all elements for which stiffness matrices exist.
NØNE	Strain energies for no elements will be output.
n	Set identification of previously appearing SET card (Integer >0). Only strain energies for elements whose identification numbers appear on this SET card will be output.

Remarks:
1. Element strain energies are output from Static Analysis (Rigid Format 1) only.
2. The output will be in SØRT 1 format.
3. Both PRINT and PUNCH may be requested.
4. ESE = NØNE allows overriding an overall output request.

Case Control Data Card   FMETHØD -Flutter Analysis Method

Description: Selects the FLUTTER parameters to be used by the flutter module (FA1).

Format and Example(s):

FMETHØD = n
FMETHØD = 72

Option	Meaning
n	Set identification number of a FLUTTER card (integer > 0).

Remarks:

A FMETHØD card is required for flutter analysis.

Case Control Data Card FØRCE - Element Force Output Request.

Description: Requests form and type of element force output.

Format and Example(s):

$$\text{FØRCE} \quad \left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \frac{\text{REAL}}{\begin{array}{c}\text{IMAG}\\ \text{PHASE}\end{array}}\right)\right] = \left\{\begin{array}{c}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{array}\right\}$$

FØRCE = ALL

FØRCE(REAL, PUNCH, PRINT) = 17

FØRCE = 25

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary printout on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Forces for ALL elements will be output.
n	Set identification of a previously appearing SET card. Only forces whose element identification numbers appear on this SET card will be output (Integer > 0).
NØNE	Forces for no elements will be output.

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. ELFØRCE is an alternate form and is entirely equivalent to FØRCE.
5. FØRCE = NØNE allows overriding an overall request.

Case Control Data Card FREQUENCY - Frequency Set Selection

Description: Selects the set of frequencies to be solved in Frequency Response problems.

Format and Example(s):

FREQUENCY = n
FREQUENCY = 17

Option	Meaning
n	Set identification of a FREQ, FREQ1 or FREQ2 type card (Integer > 0).

Remarks:
1. The FREQ, FREQ1 or FREQ2 cards will not be used unless selected in Case Control.
2. A frequency set selection is required for a Frequency Response problem.

Case Control Data Card GPFØRCE - Grid Point Force Balance Output Request

Description: Requests grid point force balance output from applied loads, single-point constraints, and element contraints.

Format and Example (s):

$$\text{GPF\O} = \left[\begin{pmatrix}\underline{\text{PRINT}} \\ \text{PUNCH}\end{pmatrix}\right] = \begin{Bmatrix}\text{ALL} \\ \text{n} \\ \text{N\O NE}\end{Bmatrix}$$

Option	Meaning
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Force balance will be output for all elements connected to grid points or scalar points.
NØNE	Force balance for no grid points will be output.
n	Set identification of previously appearing SET card (Integer >0). Only force balance for points whose identification numbers appear on this SET card will be output.

Remarks:

1. Grid point force balance is output from Statics Analysis (Rigid Format 1) only.
2. The output will be in SØRT 1 format.
3. Both PRINT and PUNCH may be requested.
4. GPFØ = NØNE allows overriding an overall output request.

Case Control Data Card HARMØNICS - Harmonic Printout Control.

Description: Controls number of harmonics output for problems containing CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example(s):

$$\text{HARMONICS} = \left\{\begin{array}{c}\text{ALL}\\ \text{NØNE}\\ n\\ \underline{0}\end{array}\right\}$$

Option	Meaning
ALL	All Harmonics will be output.
NØNE	No Harmonics will be output.
n	Available harmonics up to and including n will be output (Integer $\geq$ 0).

Remarks: If no HARMØNICS card appears in Case Control, only 0 harmonic output will be printed.

Case Control Data Card <u>IC</u> - Transient Initial Condition Set Selection.

Description: To select the initial conditions for Direct Transient problems.

Format and Example(s):

IC = n

IC = 17

Option	Meaning
n	Set identification of TIC card (Integer > 0).

Remarks:

1. TIC cards will not be used (hence no initial conditions) unless selected in Case Control.
2. Initial conditions are not allowed in a Modal Transient problem.

Case Control Data Card K2PP - Direct Input Stiffness Matrix Selection.

Description: Selects a direct input stiffness matrix.

Format and Example(s):

K2PP = name

K2PP = KDMIG

K2PP = K2PP

Option	Meaning
name	BCD name of a $[K^{2d}_{pp}]$ matrix that is input on the DMIG or DMIAX bulk data card.

Remarks: 1. K2PP is used only in dynamics problems.

2. DMIG and DMIAX matrices will not be used unless selected.

Case Control Data Card LABEL - Output Label.

Description: Defines a BCD label which will appear on the third heading line of each page of NASTRAN printer output.

Format and Example(s):

LABEL = { Any BCD data }

LABEL = STEVEN E. WALL'S PRØBLEM

Remarks:

1. LABEL appearing at the subcase level will label output for that subcase only.
2. LABEL appearing before all subcases will label any outputs which are not subcase dependent.
3. If no LABEL card is supplied, the label line will be blank.
4. LABEL information is also placed on NASTRAN plotter output as applicable.

Case Control Data Card LINE - Data Lines Per Page.

Description: Defines the number of data lines per printed page.

Format and Example(s):

LINE = $\begin{Bmatrix} 50 \\ n \end{Bmatrix}$ IBM or CDC

LINE = $\begin{Bmatrix} 45 \\ n \end{Bmatrix}$ UNIVAC

LINE = 35

Option	Meaning
n	Number of data lines per page (Integer > 0).

Remarks: 1. If no LINE card appears, the appropriate default is used.

2. For 11 inch paper, 50 is the recommended number; for 8-1/2 paper, 35 is the recommended number.

Case Control Data Card LØAD - External Static Load Set Selection.

Description: Selects the external static load set to be applied to the structural model.

Format and Example(s):

LØAD = n

LØAD = 15

Option	Meaning
n	Set identification of at least one external load card and hence must appear on at least one FØRCE, FØRCE1, FØRCE2, MØMENT, MØMENT1, MØMENT2, GRAV, PLØAD, PLØAD2, PLØAD3, RFØRCE, PRESAX, FØRCEAX, MØMAX, SLØAD, or LØAD card (Integer > 0).

Remarks:

1. The above static load cards will not be used by NASTRAN unless selected in Case Control.

2. A GRAV card cannot have the same set identification number as any of the other loading card types. If it is desired to apply a gravity load along with other static loads, a LØAD bulk data card must be used.

3. LØAD is only applicable in statics, inertia relief, differential stiffness, buckling, and piecewise linear problems.

4. The total load applied will be the sum of external (LØAD), thermal (TEMP(LØAD)), element deformation (DEFØRM) and constrained displacement (SPC) Loads.

5. Static, thermal and element deformation loads should have unique set identification numbers.

Case Control Data Card M2PP - Direct Input Mass Matrix Selection.

Description: Selects a direct input mass matrix.

Format and Example(s):

M2PP = name
M2PP = MDMIG
M2PP = M2PP

Option	Meaning
name	BCD name of a $[M_{pp}^{2d}]$ matrix that is input on the DMIG or DMIAX bulk data card.

Remarks: 1. M2PP is supported only in dynamics problems.

2. DMIG and DMIAX matrices will not be used unless selected.

Case Control Data Card MAXLINES - Maximum Number of Output Lines.

Description: Sets the maximum number of output lines to a given value.

Format and Example(s):

$$\text{MAXLINES} = \left\{ \begin{array}{c} \underline{20000} \\ n \end{array} \right\}$$

MAXLINES = 50000

Option	Meaning
n	Maximum number of output lines which the user wishes to allow (Integer > 0).

Remarks:

1. Any time this number is exceeded, NASTRAN will terminate thru PEXIT.
2. This card may or may not override system operating control cards. Users should check with the local operations staff.

Case Control Data Card METHØD - Real Eigenvalue Extraction Method Selection.

Description: Selects the Real Eigenvalue Parameters to be used by the READ module.

Format and Example(s):

METHØD = n

METHØD = 33

Option	Meaning
n	Set identification number of an EIGR card (normal modes or modal formulation) or an EIGB card (buckling). (Integer > 0)

Remarks: An eigenvalue extraction method must be selected when extracting real eigenvalues using Functional Module READ.

Case Control Data Card MØDES - Duplicate Case Control.

Description: Repeats case control MØDES times - to allow control of output in eigenvalue problems.

Format and Example(s):

MØDES = n

MØDES = 1

Option	Meaning
n	Number of modes, starting with the first and proceeding sequentially upward, for which the case control or subcase control is to apply. (Integer > 0).

Remarks: 1. This card can be illustrated by an example. Suppose stress output is desired for the first five modes only and Displacements only thereafter. The following example would accomplish this:

```
SUBCASE 1
MØDES = 5
ØUTPUT
STRESS = ALL
SUBCASE 6
ØUTPUT
DISPLACEMENTS = ALL
BEGIN BULK
```

2. The MØDES card causes the results for each eigenvalue to be considered as a separate, successively numbered subcase, beginning with the subcase number containing the MØDES card.

3. If the MØDES card is not used, eigenvalue results are considered to be a part of a single subcase. Hence, any output requests for the single subcase will apply for all eigenvalues.

4. All eigenvectors with mode numbers greater than the number of records in Case Control are printed with the descriptors of the last Case Control record. For example, to suppress all printout for modes beyond the first three, the following Case Control deck could be used:

```
SUBCASE 1
MØDES = 3
DISPLACEMENTS = ALL
SUBCASE 4
DISPLACEMENTS = NØNE
BEGIN BULK
```

Case Control Data Card MPC - Multipoint Constraint Set Selection.

Description: Selects the multipoint constraint set to be applied to the structural model.

Format and Example(s):

MPC = n

MPC = 17

Option	Meaning
n	"n" is the set identification of a Multipoint-Constraint Set and hence must appear on at least one MPC or MPCADD card. (Integer > 0).

Remarks: MPC or MPCADD cards will not be used by NASTRAN unless selected in Case Control.

Case Control Data Card NLLØAD - Nonlinear Load Output Request.

Description: Requests form and type of nonlinear load output for Transient problems.

Format and Example(s):

$$\text{NLLØAD } [(\frac{\text{PRINT}}{\text{PUNCH}})] = \begin{Bmatrix} \text{ALL} \\ \text{n} \\ \text{NØNE} \end{Bmatrix}$$

NLLØAD = ALL

Option	Meaning
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Nonlinear loads for all solution points will be output.
NØNE	Nonlinear loads will not be output.
n	Set identification of previously appearing SET card. (Integer > 0). Only nonlinear loads for points whose identification numbers appear on this SET card will be output.

Remarks:
1. Both PRINT and PUNCH may be used.
2. Nonlinear loads are output only in the solution (D or H) set.
3. The output format will be SØRT2.
4. An output request for ALL in Transient response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
5. THERMAL = NØNE allows overriding an overall output request.

Case Control Data Card NØNLINEAR - Nonlinear Load Set Selection.

Description: Selects nonlinear load for transient problems.

Format and Example(s):

NØNLINEAR = n

NØNLINEAR LØAD SET = 75

Option	Meaning
n	Set identification of NØLINi cards (Integer > 0).

Remarks: NØLINi cards will not be used unless selected in Case Control.

Case Control Data Card ØFREQUENCY - Output Frequency Set.

Description: Selects from the solution set of frequencies a subset for output requests. In flutter analysis, it selects a subset of velocities.

Format and Example(s):

ØFREQUENCY = $\left\{\frac{\text{ALL}}{\text{n}}\right\}$

ØFREQUENCY = ALL

ØFREQUENCY SET = 15

Option	Meaning
ALL	Output for all frequencies will be printed out.
n	Set identification of previously appearing SET card. (Integer > 0). Output for frequencies closest to those given on this SET card will be output.

Remarks:

1. ØFREQUENCY is defaulted to ALL if it is not supplied.
2. In flutter analysis, the selected set lists velocities in input units. If there are n velocities in the list, the n points with velocities closest to those in the list will be selected for output.

Case Control Data Card ØLØAD - Applied Load Output Request

Description: Requests form and type of applied load vector output.

Format and Example(s):

$$\text{ØLØAD} \quad \left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \frac{\text{REAL}}{\frac{\text{IMAG}}{\text{PHASE}}}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{matrix}\right\}$$

ØLØAD = ALL

ØLØAD(SØRT1, PHASE) = 5

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each grid point. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Applied loads for all points will be output. (SØRT1 will only output nonzero values).
NØNE	Applied loads for no points will be output.
n	Set identification of previously appearing SET card. Only loads on points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. A request for SØRT2 causes loads (zero and nonzero) to be output.
5. ØLØAD = NØNE allows overriding an overall output request.

Case Control Data Card ØUTPUT - Output Packet Delimiter.

Description: Delimits the various output packets, structure plotter, curve plotter, and printer/punch.

Format and Example(s):

$$\text{ØUTPUT}\left[\begin{pmatrix}\text{PLØT}\\ \text{XYØUT}\\ \text{XYPLØT}\end{pmatrix}\right]$$

ØUTPUT

ØUTPUT(PLØT)

ØUTPUT(XYØUT)

Option	Meaning
No qualifier	Beginning of printer output packet - this is not a required card.
PLØT	Beginning of structure plotter packet. This card must preceed all structure plotter control cards.
XYØUT or XYPLØT	Beginning of curve plotter packet. This card must precede all curve plotter control cards. XYPLØT and XYØUT are entirely equivalent.

Remarks:

1. The structure plotter packet and the curve plotter packet must be at the end of the Case Control Deck. Either may come first.

2. The delimiting of a printer packet is completely optional.

Case Control Data Card PLCØEFFICIENT - Piecewise Linear Coefficient Set.

Description: Selects the coefficient set for Piecewise Linear problems.

Format and Example(s):

$$\text{PLCØEFFICIENT} = \begin{Bmatrix} \text{DEFAULT} \\ n \end{Bmatrix}$$

PLCØEFFICIENT = DEFAULT

PLCØEFFICIENT = 25

Option	Meaning
DEFAULT	A single default coefficient of value 1.0.
n	Set identification of PLFACT card (Integer > 0).

Remarks: PLFACT cards will not be used unless selected.

Case Control Data Card PLØTID - Plotter Identification.

Description: Defines BCD identification which will appear on the first frame of any NASTRAN plotter output.

Format and Example(s):

PLØTID = { Any BCD data }

PLØTID = MSC - BLDG. 125 BØX 91 - - RETURN TØ MACNEAL-SCHWENDLER CØRP.

Remarks:

1. PLØTID must appear before the ØUTPUT(PLØT) or ØUTPUT(XYØUT) cards.
2. The presence of PLØTID causes a special header frame to be plotted with the supplied identification plotted several times. This allows easy identification of NASTRAN plotter output.
3. If no PLØTID card appears, no ID frame will be plotted.
4. The PLØTID header frame will not be generated for the table plotters.

Case Control Data Card PRESSURE - Hydroelastic Pressure Output Request.

Description: Requests form and type of displacement and hydroelastic pressure vector output.

Format and Example(s):

$$\text{PRESSURE}\left[\left(\frac{\text{SØRT1}}{\text{SØRT2}},\ \frac{\text{PRINT}}{\text{PUNCH}},\ \begin{matrix}\underline{\text{REAL}}\\ \text{IMAG}\\ \text{PHASE}\end{matrix}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ n\\ \text{NØNE}\end{matrix}\right\}$$

PRESSURE = 5

PRESSURE(IMAG) = ALL

PRESSURE(SØRT2, PUNCH, REAL) = ALL

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° ≤ phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements and pressures for all points will be output.
NØNE	Displacements and pressures for no points will be output.
n	Set identification of previously appearing SET card. Only displacements and pressures of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
4. DISPLACEMENT and VECTØR are alternate forms and are entirely equivelent to PRESSURE.
5. PRESSURE = NØNE allows overriding an overall output request.

Case Control Data Card RANDØM - Random Analysis Set Selection

Description: Selects the RANDPS and RANDTi cards to be used in Random Analysis.

Format and Example(s):

RANDØM = n
RANDØM = 177

Option	Meaning
n	Set identification of RANDPS and RANDTi cards to be used in RANDØM analysis (Integer > 0).

Remarks:

1. RANDPS cards must be selected to do Random Analysis.
2. RANDPS must be selected in the first subcase of the current loop. RANDPS may not reference subcases in a different loop.

Case Control Data Card REPCASE - Repeat Case Subcase Delimiter.

Description: Delimits and identifies a repeated subcase.

Format and Example(s):

REPCASE n

REPCASE 137

Option	Meaning
n	Subcase number (Integer > 1).

Remarks:

1. "n" must be strictly increasing (i.e. greater than all previous subcase set identification numbers).
2. This case will only re-output the previous real case. This allows additional set specification.
3. REPCASE may only be used in Statics or Inertia Relief.
4. One or more repeated subcases (REPCASEs) must immediately follow the subcase (SUBCASE) to which they refer. (See example 4 in Section 2.3.3).

Case Control Data Card SACCELERATIØN - Solution Set Acceleration Output Request

Description: Requests form and type of solution set acceleration output.

Format and Example(s):

$$\text{SACCELERATIØN}\left[\left(\begin{matrix}\text{SØRT1}\\ \text{SØRT2}\end{matrix}, \begin{matrix}\text{PRINT}\\ \text{PUNCH}\end{matrix}, \begin{matrix}\text{REAL}\\ \text{IMAG}\\ \text{PHASE}\end{matrix}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ n\\ \text{NØNE}\end{matrix}\right\}$$

SACCELERATIØN = ALL

SACCELERATIØN(PUNCH, IMAG) = 142

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point (or mode number). SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Frequency Response problems.
ALL	Acceleration for all solution points (modes) will be output.
NØNE	Acceleration for no solution points (modes) will be output.
n	Set identification of a previously appearing SET card. Only accelerations of points whose identification numbers appear on this SET card will be output (Integer > 0)

Remarks:
1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. Acceleration output is only available for Transient and Frequency Response problems.
4. In a Frequency Response problem any request for SØRT2 output causes all output to be SØRT2.
5. SACCELERATION = NØNE allows overriding an overall output request.

Case Control Data Card SDAMPING - Structural Damping.

Description: Selects table which defines damping as a function of frequency in Modal Formulation problems.

Format and Example(s):

SDAMPING = n

SDAMPING = 77

Option	Meaning
n	Set identification of a TABDMP1 table (Integer > 0).

Remarks: If SDAMPING is not used BHH = [0].

Case Control Data Card SDISPLACEMENT - Solution Set Displacement Output Request.

Description: Requests form and type of solution set displacement output.

Format and Example(s):

$$\text{SDISPLACEMENT} \left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \frac{\text{REAL}}{\text{IMAG}} \atop \text{PHASE} \right) \right] = \left\{ \begin{matrix} \text{ALL} \\ \text{n} \\ \text{NØNE} \end{matrix} \right\}$$

SDISPLACEMENT = ALL

SDISPLACEMENT(SØRT2, PUNCH, PHASE) = NØNE

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point (or mode number). SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements for all points (modes) will be output.
NØNE	Displacements for no points (modes) will be output.
n	Set identification of previously appearing SET card. Only displacements of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
4. SVECTØR is an alternate form which is entirely equivalent to SDISPLACEMENT.
5. SDISPLACEMENT = NØNE allows overriding an overall output request.

Case Control Data Card SET - Set Definition Card.

Description: 1) Lists identification numbers (point or element) for output requests.
2) Lists the frequencies for which output will be printed in Frequency Response Problems.

Format and Example(s):

1) SET n = $\{i_1[,i_2, i_3$ THRU i_4 EXCEPT i_5, i_6, i_7, i_8 THRU $i_9]\}$

SET 77 = 5

SET 88 = 5, 6, 7, 8, 9, 10 THRU 55 EXCEPT 15, 16, 77,
78, 79, 100 THRU 300

SET 99 = 1 THRU 100000

2) SET n = $\{r_1 [, r_2, r_3, r_4]\}$

SET 101 = 1.0, 2.0, 3.0

SET 105 = 1.009, 10.2, 13.4,
14.0, 15.0

Option	Meaning
n	Set identification (Integer > 0). Any set may be redefined by reassigning its identification number. Sets inside SUBCASE delimiters are local to the SUBCASE.
i_1, i_2 etc.	Element or point identification number at which output is requested. (Integer > 0) If no such identification number exists, the request is ignored.
i_3 THRU i_4	Output at set identification numbers i_3 thru i_4 $(i_4 > i_3)$.
EXCEPT	Set identification numbers following EXCEPT will be deleted from output list as long as they are in the range of the set defined by the immediately preceding THRU.
r_1, r_2 etc.	Frequencies for output (Real > 0.0). The nearest solution frequency will be output. EXCEPT and THRU cannot be used.

Remarks:

1. A SET card may be more than one physical card. A comma (,) at the end of a physical card signifies a continuation card. Commas may not end a set.

2. Set identification numbers following EXCEPT within the range of the THRU must be in ascending order.

Case Control Data Card SPC - Single-Point Constraint Set Selection.

Description : Selects the single-point constraint set to be applied to the structural model.

Format and Example(s):

SPC = n

SPC = 10

Option	Meaning
n	Set identification of a single-point constraint set and hence must appear on a SPC, SPC1 or SPCADD card (Integer > 0).

Remarks: SPC, SPC1 or SPCADD cards will not be used by NASTRAN unless selected in Case Control.

Case Control Data Card SPCFØRCES - Single-Point Forces of Constraint Output Request.

Description: Requests form and type of Single-Point Force of constraint vector output.

Format and Example(s):

$$\text{SPCFØRCES} \quad \left[\left(\begin{matrix}\underline{\text{SØRT1}}\\ \text{SØRT2}\end{matrix}, \begin{matrix}\underline{\text{PRINT}}\\ \text{PUNCH}\end{matrix}, \begin{matrix}\underline{\text{REAL}}\\ \text{IMAG}\\ \text{PHASE}\end{matrix}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{matrix}\right\}$$

SPCFØRCES = 5

SPCFØRCES(SØRT2, PUNCH, PRINT, IMAG) = ALL

SPCFØRCES(PHASE) = NØNE

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each grid point. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° < \text{phase} < 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Single-Point forces of constraint for all points will be output. (SØRT1 will only output nonzero values.)
NØNE	Single point forces of constraint for no points will be output.
n	Set identification of previously appearing SET card. Only single-point forces constraint for points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. A request for SØRT2 causes loads (zero and nonzero) to be output.
5. SPCFØRCES = NØNE allows overriding an overall output request.

Case Control Data Card STRESS - Element Stress Output Request.

Description: Requests form and type of element stress output.

Format and Example(s):

$$\text{STRESS} \quad \left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \frac{\text{REAL}}{\substack{\text{IMAG}\\ \text{PHASE}}}\right)\right] = \begin{Bmatrix} \text{ALL} \\ n \\ \text{NØNE} \end{Bmatrix}$$

STRESS = 5

STRESS = ALL

STRESS(SØRT1, PRINT, PUNCH, PHASE) = 15

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary printout on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Stresses for all elements will be output.
n	Set identification of a previously appearing SET card (Integer > 0). Only stresses for elements whose identification numbers appear on this SET card will be output.
NØNE	Stresses for no points will be output.

Remarks:
1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any recuest for SØRT2 output causes all output to be SØRT2.
4. ELSTRESS is an alternate form and is entirely equivalent to STRESS.
5. STRESS = NØNE allows overriding an overall output request.

Case Control Data Card SUBCASE - Subcase Delimiter.

Description: Delimits and identifies a subcase.

Format and Example(s):

SUBCASE n

SUBCASE 101

Option	Meaning
n	Subcase identification number (Integer > 0).

Remarks:

1. The subcase identification number, n, must be strictly increasing (i.e., greater than all previous subcase identification numbers).
2. Plot requests and RANDØM requests refer to n.

Case Control Data Card SUBCØM - Combination Subcase Delimiter.

Description: Delimits and identifies a combination subcase.

Format and Example(s):

SUBCØM n

SUBCØM 125

Option	Meaning
n	Subcase identification number (Integer > 2).

Remarks:
1. The subcase identification number, n, must be strictly increasing (i.e., greater than all previous subcase identification numbers).
2. A SUBSEQ card must appear in this subcase.
3. SUBCØM may only be used in Statics or Inertia Relief problems.
4. Output requests above the subcase level will be utilized.

Case Control Data Card SUBSEQ - Subcase Sequence Coefficients.

Description: Gives the coefficients for forming a linear combination of the previous subcases.

Format and Example(s):

SUBSEQ = R_1 [, R_2, R_3, . . ., R_N]

SUBSEQ = 1.0, -1.0, 0.0, 2.0

Option	Meaning
R_1 to R_N	Coefficients of the previously occuring subcases (Real).

Remarks:

1. A SUBSEQ card must only appear in a SUBCØM subcase.
2. A SUBSEQ card may be more than one physical card. A comma at the end signifies a continuation card.
3. SUBSEQ may only be used in Statics or Inertia Relief problems.

Case Control Data Card SUBTITLE - Output Subtitle.

Description: Defines a BCD subtitle which will appear on the second heading line of each page of NASTRAN printer output.

Format and Example(s):

SUBTITLE = { Any BCD data }

SUBTITLE = NASTRAN PRØBLEM NØ. 5-1A

Remarks:

1. SUBTITLE appearing at the subcase level will title output for that subcase only.
2. SUBTITLE appearing before all subcases will title any outputs which are not subcase dependent.
3. If no SUBTITLE card is supplied, the subtitle line will be blank.
4. SUBTITLE information is also placed on NASTRAN plotter output as applicable.

Case Control Data Card SVECTØR - Solution Set Displacement Output Request.

Description: Requests form and type of solution set displacement output.

Format and Example(s):

$$\text{SVECTØR} \quad \left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \begin{array}{c}\text{REAL}\\ \hline \text{IMAG}\\ \text{PHASE}\end{array}\right)\right] = \left\{\begin{array}{c}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{array}\right\}$$

SVECTØR = ALL

SVECTØR(SØRT2, PUNCH, PHASE) = NØNE

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point (or mode number). SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements for all points (modes) will be output.
NØNE	Displacements for no points (modes) will be output.
n	Set identification of previously appearing SET card. Only displacements of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In a frequency response problem any request for SØRT2 causes all output to be SØRT2.
4. SDISPLACEMENT is an alternate form and is entirely equivalent to SVECTØR.
5. SVECTØR = NØNE allows overriding an overall output request.

Case Control Data Card SVELØCITY - Solution Set Velocity Output Request

Description: Requests form and type of solution set velocity output.

Format and Example(s):

$$\text{SVELØCITY}\left[\left(\frac{\text{SØRT1}}{\text{SØRT2}},\ \frac{\text{PRINT}}{\text{PUNCH}},\ \begin{matrix}\underline{\text{REAL}}\\ \underline{\text{IMAG}}\\ \text{PHASE}\end{matrix}\right)\right] = \begin{Bmatrix}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{Bmatrix}$$

SVELØCITY = 5

SVELØCITY(SØRT2, PUNCH, PRINT, PHASE) = ALL

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point (or mode number). SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Frequency Response problems.
ALL	Velocity for all solution points (modes) will be output.
NØNE	Velocity for no solution points (modes) will be output.
n	Set identification of a previously appearing SET card. Only velocities of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks: 1. Both PRINT and PUNCH may be requested.

2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.

3. Velocity output is only available for Transient and Frequency Response problems.

4. In a Frequency Response problem any request for SØRT2 output causes all output to be SØRT2.

5. SVELØCITY = NØNE allows overriding an overall output request.

Case Control Data Card SYM - Symmetry Subcase Delimiter.

Description: Delimits and identifies a symmetry subcase.

Format and Example(s):

SYM n

SYM 123

Option	Meaning
n	Subcase identification number (Integer > 0).

Remarks:

1. The subcase identification number, n, must be strictly increasing (i.e., greater than all previous subcase identification numbers).
2. Plot requests and RANDØM requests should refer to n.
3. Overall output requests will not propagate into a SYM subcase (i.e. any output desired must be requested within the subcase).
4. SYM may only be used in Statics or Inertia Relief.

Case Control Data Card SYMCØM - Symmetry Combination Subcase Delimiter.

Description: Delimits and identifies a symmetry combination subcase.

Format and Example(s):

SYMCØM n

SYMCØM 123

Option	Meaning
n	Subcase identification number (Integer > 2).

Remarks: 1. The subcase identification number, n, must be strictly increasing (i.e., greater than all previous subcase identification numbers).

2. SYMCØM may only be used in Statics or Inertia Relief problems.

Case Control Data Card SYMSEQ - Symmetry Sequence Coefficients.

Description: Gives the coefficients for combining the symmetry subcases into the total structure.

Format and Example(s):

SYMSEQ = R_1[, R_2, R_3 --- R_n]
SYMSEQ = 1.0, -2.0, 3.0, 4.0

Option	Meaning
R_1 to R_N	Coefficients of the previously occurring N SYM subcases (Real).

Remarks:
1. A SYMSEQ card may only appear in a SYMCØM subcase.
2. The default value for the coefficients is 1.0 if no SYMSEQ card appears.
3. A SYMSEQ card may consist of more than one physical card.
4. SYMSEQ may only be used in Statics or Inertia Relief.

Case Control Data Card TEMPERATURE - Thermal Properties Set Selection.

Description: Selects the temperature set to be used in either material property calculation or thermal loading.

Format and Example(s):

$$\text{TEMPERATURE}\left[\begin{pmatrix}\text{MATERIAL}\\ \text{LØAD}\\ \underline{\text{BØTH}}\end{pmatrix}\right] = n$$

TEMPERATURE(LØAD) = 15

TEMPERATURE(MATERIAL) = 7

TEMPERATURE = 7

Option	Meaning
MATERIAL	The selected temperature table will be used to determine temperature-dependent material properties indicated on the MATi type cards.
LØAD	The selected temperature table will be used to determine an equivalent static load.
BØTH	Both options, MATERIAL and LØAD will use the same temperature table.
n	Set identification number of TEMP, TEMPD, TEMPP1, TEMPP2, TEMPP3, TEMPRB, or TEMPAX cards (Integer > 0).

Remarks:

1. Only one temperature-dependent material request may be made in any problem and must be above the subcase level.
2. Thermal loading may only be used in Statics, Inertia Relief, Differential Stiffness, and Buckling problems.
3. Temperature-dependent materials may not be used in Piecewise Linear problems.
4. The total load applied will be the sum of external (LØAD), thermal (TEMP(LØAD)), element deformation (DEFØRM) and constrained displacement (SPC) loads.
5. Static, thermal and element deformation loads should have unique set identification numbers.

Case Control Data Card TFL - Transfer Function Set Selection.

Description: Selects the Transfer function set to be added to the direct input matrices.

Format and Example(s):

TFL = n

TFL = 77

Option	Meaning
n	Set identification of a TF card (Integer > 0).

Remarks:
1. Transfer functions will not be used unless selected in the Case Control Deck.
2. Transfer functions are supported on dynamics problems only.
3. Transfer functions are simply another form of direct matrix input.

Case Control Data Card THERMAL - Temperature Output Request.

Description: Requests form and type of temperature vector output.

Format and Example(s):

$$\text{THERMAL} \quad \left[\begin{pmatrix}\text{PRINT}\\ \text{PUNCH}\end{pmatrix}\right] = \begin{Bmatrix}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{Bmatrix}$$

THERMAL = 5

THER(PRINT,PUNCH) = ALL

Option	Meaning
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Temperatures for all points will be output.
NØNE	Temperatures for no points will be output.
n	Set identification of previously appearing SET card. Only temperatures of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. THERMAL output request is designed for use with the Heat Transfer option. The printed output will have temperature headings and the punched output will be TEMP bulk data cards. The SID on a bulk data card will be the subcase number (= 1 if no defined subcases). The output format will be SØRT1 for Static problems and SØRT2 for Transient problems.
3. An output request for ALL in Transient response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
4. DISPLACEMENT and VECTOR are alternate forms and are entirely equivalent to THERMAL.
5. THERMAL = NØNE allows overriding an overall output request.

Case Control Data Card TITLE - Output Title.

Description: Defines a BCD title which will appear on the first heading line of each page of NASTRAN printer output.

Format and Example(s):

TITLE = { Any BCD data }

TITLE = **$// ABCDEFGHI .... $

Remarks:

1. TITLE appearing at the subcase level will title output for that subcase only.
2. TITLE appearing before all subcases will title any outputs which are not subcase dependent.
3. If no TITLE card is supplied, the title line will contain data and page numbers only.
4. TITLE information is also placed on NASTRAN plotter output as applicable.

Case Control Data Card TSTEP - Transient Time Step Set Selection.

Description: Selects integration and output time steps for Transient problems.

Format and Example(s):

TSTEP = n
TSTEP = 731

Option	Meaning
n	Set identification of a selected TSTEP bulk data card (Integer > 0).

Remarks:
1. A TSTEP card must be selected to execute a Transient problem.
2. Only one TSTEP card may have this value of n.

Case Control Data Card VECTØR - Displacement Output Request.

Description: Requests form and type of displacement vector output.

Format and Example(s):

$$\text{VECTØR} \quad \left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \frac{\text{REAL}}{\frac{\text{IMAG}}{\text{PHASE}}} \right) \right] = \left\{ \begin{matrix} \text{ALL} \\ n \\ \text{NØNE} \end{matrix} \right\}$$

VECTØR = 5

VECTØR(REAL) = ALL

VECTØR(SØRT2, PUNCH, REAL) = ALL

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \leq$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements for all points will be output.
NØNE	Displacements for no points will be output.
n	Set identification of a previously appearing SET card. Only displacements of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:
1. Both PRINT and PUNCH may be requested.
2. On a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
3. DISPLACEMENT and PRESSURE are alternate forms and are entirely equivalent to VECTØR.
4. VECTØR = NØNE allows overriding an overall output request.

Case Control Data Card VELØCITY - Velocity Output Request.

Description: Requests form and type of velocity vector output.

Format and Example(s):

$$\text{VEL\O CITY} \quad \left[\left(\frac{\text{S\O RT1}}{\text{S\O RT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \frac{\text{REAL}}{\substack{\text{IMAG}\\ \text{PHASE}}}\right)\right] = \begin{Bmatrix} \text{ALL} \\ \text{n} \\ \text{N\O NE} \end{Bmatrix}$$

VELØCITY = 5

VELØCITY(SØRT2, PHASE, PUNCH) = ALL

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° < \text{phase} < 360.0°$) on Frequency Response problems.
ALL	Velocity for all solution points will be ouptut.
NØNE	Velocity for no solution points will be output.
n	Set identification of a previously appearing SET card. Only velocities of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. Velocity output is only available for Transient and Frequency Response problems.
4. In a Frequency Response problem any request for SØRT2 output causes all output to be SØRT2.
5. VELØCITY = NØNE allows overriding an overall output request.

Case Control Data Card $ - Comment Card.

Description: Defines a comment card by specifying a $ in column one with commentary text appearing in columns 2-80.

Format and Example(s):

$ {Any BCD data}
$---THIS IS AN EXAMPLE OF A COMMENT CARD.

Remarks: Unlike other Case Control cards which are free field, the comment card must have the $ in column 1.

2.4 BULK DATA DECK

The primary NASTRAN input medium is the Bulk Data card. These cards are used to define the structural model and various pools of data which may be selected by Case Control at execution time.

For large problems the Bulk Data Deck may consist of several thousand cards. In order to minimize the handling of large numbers of cards, provision has been made in NASTRAN to store the bulk data on the Problem Tape, from which it may be modified on subsequent runs. A User's Master File (Section 2.5) is also provided for the storage of Bulk Data Decks.

For any cold start, the entire Bulk Data Deck must be submitted. Thereafter, if the original run was checkpointed, the Bulk Data Deck exists on the Problem Tape in sorted form where it may be modified and reused on restart. On restart the bulk data cards contained in the Bulk Data Deck are <u>added</u> to the bulk data contained on the Old Problem Tape. Cards are removed from the Old Problem Tape (or the User's Master File) by the use of a delete card. Cards to be deleted are indicated by inserting a bulk data card with a / in column one and the sorted bulk data sequence numbers in fields two and three. All bulk data cards in the range of the sequence numbers in fields two and three will be deleted. In the case where only a single card is deleted, field three may be left blank.

The Bulk Data Deck may be submitted with the cards in any order as a sort is performed prior to the execution of the Input File Processor. It should be noted that the machine time to perform this is minimized for a deck that is already sorted. The sort time for a badly sorted deck will become significant for large decks. The user may obtain a printed copy of either the unsorted or sorted bulk data by selection in the Case Control Deck. A sorted echo is necessary in order to make modifications on a secondary execution using the Problem Tape. This echo is automatically provided unless specifically suppressed by the user.

2.4.1 <u>Format of Bulk Data Cards</u>

The bulk data card format is variable to the extent that any quantity except the mnemonic can be punched anywhere within a specified 8 or 16-column field. The normal card uses an 8-column field as indicated in the following diagram:

Small Field Bulk Data Card

1a	2	3	4	5	6	7	8	9	10a
8	8	8	8	8	8	8	8	8	8

The mnemonic is punched in field 1 beginning in column 1. Fields 2-9 are for data items. The only limitations in data items are that they must lie completely within the designated field, have no imbedded blanks, and must be of the proper type, i.e., blank, integer, real, double precision, or BCD*. All real numbers, including zero, must contain a decimal point. A blank will be interpreted as a real zero or integer zero as required. Real numbers may be encoded in various ways. For example, the real number 7.0 may be encoded as 7.0, .7E1, 0.7+1, 70.-1, .70+1, etc. A double precision number must contain both a decimal point and an exponent with the character D such as 7.0D0. Double precision data values are only allowed in a few situations, such as on the PARAM card. BCD data values consist of one to eight alphanumeric characters, the first of which must be alphabetic.

Normally field 10 is reserved for optional user identification. However, in the case of continuation cards field 10 (except column 73 which is not referenced) is used in conjunction with field 1 of the continuation card as an identifier and hence must contain a unique entry. The continuation card contains the symbol + in column 1 followed by the same seven characters that appeared in columns 74-80 of field 10 of the card that is being continued. This allows the data to be submitted as an unsorted deck.

The small field data card should be more than adequate for the kinds of data normally associated with structural engineering problems. Since abbreviated forms of floating point numbers are allowed, up to seven significant decimal digits may be used in an eight-character field. Occasionally, however, the input is generated by another computer program or is available in a form where a wider field would be desirable. For this case, the larger field format with a 16-character data field is provided. Each logical card consists of two physical cards as indicated in the following diagram:

*See SEQGP and SEQEP for exceptions.

Large Field Bulk Data Card

1a	2	3	4	5	10a
8	16	16	16	16	8

1b	6	7	8	9	10b
8	16	16	16	16	8

The large field card is denoted by placing the symbol * after the mnemonic in field 1a and some unique character configuation in the last 7 columns of field 10a. The second physical card contains the symbol * in column 1 followed by the same seven characters that appeared after column 73 in field 10a of the first card. The second card may in turn be used to point to a large or small field continuation card, depending on whether the continuation card contains the symbol * or the symbol + in column 1. The use of multiple and large field cards are illustrated in the following examples:

Small Field Card with Small Field Continuation Card.

TYPE									QED123
+ED123									

Large Field Card

TYPE*					QED124
*ED124					

Large Field Card with Large Field Continuation Card

TYPE*					QED301
*ED301					QED302
*ED302					QED305
*ED305					

Large Field Card Followed by a Small Field Continuation Card and a Large Field Continuation Card

<table>
<tr><td>TYPE*</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td>QED462</td></tr>
<tr><td>*ED462</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td>QED421</td></tr>
<tr><td>+ED421</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>QED361</td></tr>
<tr><td>*ED361</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td>QED291</td></tr>
<tr><td>*ED291</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
</table>

Small Field Card with Large Field Continuation Card

TYPE									QED632
*ED632									QED204
*ED204									

In the above examples column 73 arbitrarily contains the symbol Q in all cases where field 10 is used as a pointer. However, column 73 could have been left blank or the same symbol used in column 1 of the following card could have been used (i.e., the symbols * or +).

2.4.2 Bulk Data Card Descriptions

The detailed descriptions of the bulk data cards are contained in this section in alphabetical order. For details pertaining to the use of each card and for a discussion of the cards in functional groups, the user is referred to Section 1 - Structural Modeling. Small field examples are given for each card along with a description of the contents of each field. In the Format and Example section of each card description, both a symbolic card format description and an example of an actual card are shown. Literal constants are shown in the card format section enclosed in quotes (e.g., "0"). Fields that are required to be blank are indicated in the card format section by whenever they are followed by nonblank fields or whenever such notation will clarify the card description.

The Input File Processor will produce error messages for any cards that do not have the proper format or which contain illegal data.

Continuation cards need not be present unless they contain required data. In the case of multiple continuation cards, the intermediate cards must be present (even though fields 2-9 are blank) if one of the following cards contains data in fields 2-9. In addition, a double field format requires at least two cards (or subsequent multiples of two) so that 10 data fields are included. Thus one or more double field cards may contain no data.

Input Data Card <u>$</u> Comment

<u>Description:</u> For user convenience in inserting commentary material into the unsorted echo of his input Bulk Data Deck. The $ card is otherwise ignored by the program. These cards will not appear in a sorted echo nor will they exist on the New Problem Tape.

<u>Format and Example:</u>

1	2	3	4	5	6	7	8	9	10
$	followed	by any	legitimate	characters	in card	columns	2-80		
$	THIS IS	A REMARK	(*,'$$)-+/						

Input Data Card /   Delete

Description: Delete cards are used to remove cards from either the Old Problem Tape on restart or the User's Master File.

Format and Example:

1	2	3	4	5	6	7	8	9	10
/	K1	K2							
/	4								

Field	Contents
K1	Sorted sequence number of first card in sequence to be removed
K2	Sorted sequence number of last card in sequence to be removed

Remarks:
1. The delete card causes bulk data cards having sort sequence numbers K1 thru K2 to be removed from the Bulk Data Deck.
2. If K2 is blank, only card K1 is removed from the Bulk Data Deck.
3. If neither an Old Problem Tape nor a User's Master File are used in the current execution, the delete cards are ignored.

Input Data Card ADUMi Dummy Element Attributes

Description: Defines attributes of the dummy elements ($1 \leq i \leq 9$).

Format and Example:

1	2	3	4	5	6	7	8	9	10
ADUMi	NG	NC	NP	ND					
ADUM2	8	2	1	3					

Field

NG Number of grid points connected by DUMi dummy element (Integer > 0)

NC Number of additional entries on CDUMi connection card (Integer $\geq$ 0)

NP Number of additional entries on PDUMi property card (Integer $\geq$ 0)

ND Number of displacement components at each grid point used in generation of differential stiffness matrix (Integer 3 or 6)

Input Data Card AEFACT Aerodynamic Spanwise Divisions

Description: Used to specify box division points for flutter analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
AEFACT	SID	D1	D2	D3	D4	D5	D6	D7	ABC
AEFACT	97	.3	.7	1.0					
+BC	D8	D9	--etc.-						

Field	Contents
SID	Set identification number (unique Integer > 0).
Di	Division point (Real).

Remarks:

1. These factors must be selected by a CAERØ data card to be used by NASTRAN.
2. Imbedded blank fields are forbidden.
3. There is one more division point than the number of boxes.

Input Data Card AERØ Aerodynamic Physical Data

Description: Gives basic aerodynamic parameters.

Format and Examples:

1	2	3	4	5	6	7	8	9	10
AERØ	ACSID	VSØUND	REFC	RHØREF	SYMXZ	SYMXY			
AERØ	3	1.3+4	100.	1.-5		1			

Field	Contents
ACSID	Aerodynamic coordinate system identification (Integer $\geq$ 0). See Remark 2.
VSØUND	Speed of sound (Real).
REFC	Reference length (for reduced frequency) (Real).
RHØREF	Reference density (Real).
SYMXZ	Symmetry key for aero coordinate X-Z plane (Integer) (+1 for sym, =0 for no sym, -1 for anti-sym).
SYMXY	Symmetry key for aero coordinate X-Y plane can be used to simulate ground effects (Integer), same code as SYMXZ.

Remarks:

1. This card is required for aerodynamic problems. Only one AERØ card is allowed.
2. The ACSID must be a rectangular coordinate system. Flow is in the positive x direction.

Input Data Card ASET Selected Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to place in the analysis set. Used to define the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ASET	ID	C	ID	C	ID	C	ID	C	
ASET	16	2	23	3516			1	4	

Field	Contents
ID	Grid or scalar point identification number (Integer > 0)
C	Component number, zero or blank for scalar points, any unique combination of the digits 1-6 for grid points

Remarks:

1. Coordinates specified on ASET cards may not be specified on ØMIT, ØMIT1, ASET1, SUPØRT, SPC or SPC1 cards nor may they appear as dependent coordinates in multipoint constraint relations (MPC) or as permanent single-point constraints on a GRID card.
2. As many as 24 coordinates may be placed in the analysis set by a single card.
3. When ASET and/or ASET1 cards are present, all degrees of freedom not otherwise constrained will be placed in the Ø-set.

Input Data Card ASET1 Selected Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to place in the analysis set. Used to define the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ASET1	C	G	G	G	G	G	G	G	abc
ASET1	345	2	1	3	10	9	6	5	ABC

+bc	G	G	G	-etc.-					
+BC	7	8							

-etc.-

Alternate Form

ASET1	C	ID1	"THRU"	ID2					
ASET1	123456	7	THRU	109					

Field	Contents
C	Component number (any unique combination of the digits 1-6 [with no imbedded blanks] when point identification numbers are grid points; must be null or zero if point identification numbers are scalar points).
G,ID1,ID2	Grid or scalar point identification numbers (Integer > 0, ID1 < ID2)

Remarks:

1. A coordinate referenced on this card may not appear as a dependent coordinate in a multi-point constraint relation (MPC card), nor may it be referenced on an SPC, SPC1, ØMIT, ØMIT1, ASET, or SUPØRT card or on a GRID card as permanent single-point constraints.

2. When ASET and/or ASET1 cards are present, all degrees of freedom not otherwise constrained will be placed in the Ø-set.

3. If the alternate form is used, all of the grid (or scalar) points ID1 thru ID2 are assumed.

Input Data Card AXIC Axisymmetric Problem "Flag"

Description: Defines the existence of a model containing CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
AXIC	H								
AXIC	15								

Field Contents

H Highest harmonic defined for the problem ($0 \leq$ Integer ≤ 998)

Remarks: 1. Only one (1) AXIC card is allowed. When the AXIC card is present, most other cards are not allowed. The types which are allowed with the AXIC card are listed below.

CCØNEAX	GRAV	RLØAD1
CTRAPAX	LØAD	RLØAD2
CTRIAAX	MAT1	SECTAX
DAREA	MATT1	SPCADD
DELAY	MØMAX	SPCAX
DLØAD	MØMENT	SUPAX
DMI	MPCADD	TABDMP1
DMIG	MPCAX	TABLED1
DPHASE	NØLIN1	TABLED2
DSFACT	NØLIN2	TABLED3
EIGB	NØLIN3	TABLED4
EIGC	NØLIN4	TABLEM1
EIGP	ØMITAX	TABLEM2
EIGR	PARAM	TABLEM3
EPØINT	PCØNEAX	TABLEM4
FØRCE	PØINTAX	TEMPAX
FØRCEAX	PRESAX	TF
FREQ	PTRAPAX	TIC
FREQ1	PTRIAAX	TLØAD1
FREQ2	RINGAX	TLØAD2
		TSTEP

2. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

3. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

Input Data Card AXIF   Fluid Related Axisymmetric Parameters

Description: Defines basic parameters and the existence of an axisymmetric fluid analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
AXIF	CID	G	DRHØ	DB	NØSYM	F			abc
AXIF	2	32.2	0.12	2.5+5	YES				CARD-1

+bc	N1	N2	N3	N4	N5	N6	N7	N8	def
+ARD-1	1	2	3		4		7	10	

-etc.-

Alternate form of continuation card:

+bc	N1	"THRU"	Ni						def
+ARD-1	0	THRU	10						

-etc.-

Alternate form of continuation card:

+bc	N1	"THRU"	Ni	"STEP"	NS				def
+ARD-1	0	THRU	9	STEP	3				

-etc.-

Field	Contents
CID	Fluid Coordinate System identification number (Integer > 0)
G	Value of gravity for fluid elements in axial direction (Real)
DRHØ	Default mass density for fluid elements (Real > 0.0 or blank)
DB	Default bulk modulus for fluid elements (Real)
NØSYM	Request for nonsymmetric (sine) terms of series (BCD: "YES" or "NO")
F	Flag specifing harmonics (Blank - harmonic specified, or BCD - "NØNE")
Nn	Harmonic numbers for solution, an increasing sequence of integers. On the standard continuation card blanks are ignored. On the alternate form continuation cards, "THRU" implies all numbers including upper and lower integer (Blank, or integer, $0 \leq Nn < 100$, or BCD: "THRU" or "STEP")
NS	Every NSth step of the harmonic numbers specified in the "THRU" range is used for solution (Integer if field 5 is "STEP", $Ni = I \cdot NS + N1$ where I is an integer)

Remarks:

1. Only one (1) AXIF card is allowed.
2. CID must reference a cylindrical or spherical coordinate system.
3. Positive gravity (+G) implies that the direction of free fall is in the -Z direction of the Fluid Coordinate System.
4. The DRHØ value replaces blank values of RHØ on the FSLIST, BDYLIST and CFLUIDi cards.
5. The DB value replaces blank values of B on the CFLUIDi cards. If the CFLUIDi entry is blank and DB is zero or blank, the fluid is incompressible.
6. If NØSYM=YES, both sine and cosine terms are specified. If NØSYM=NØ, only cosine terms are specified.

(Continued)

AXIF (cont.)

7. If F = NØNE, no harmonics are specified, no fluid elements are necessary, and no continuation cards may be present.

Example:

1	2	3	4	5	6	7	8	9	10
AXIF	100	-386.0		0.0	NØ				+1
+1	0	THRU	50	STEP	5				+2
+2	52								+3
+3	54	THRU	57						+4
+4	61	THRU	65						+5
+5	68		71		72	75			+6
+6	81	92							END

Input Data Card AXSLØT   Axisymmetric slot analysis parameter

Description: Defines the harmonic index and the default values for acoustic analysis cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
AXSLØT	RHØD	BD	N	WD	MD				
AXSLØT	0.003	1.5+2	3	0.75	6				

Field	Contents
RHØD	Default density of fluid-mass/volume (Real ≠ 0.0 or blank)
BD	Default bulk modulus of fluid = (force/volume ratio change) (Real ≥ 0.0 or blank)
N	Harmonic index number (Integer ≥ 0)
WD	Default slot width (Real ≥ 0.0 or blank)
MD	Default number of slots (Integer ≥ 0 or blank)

Remarks:

1. No more than one AXSLØT card is permitted.
2. The default values are used on the GRIDS, SLBDY, CAXIFi, and CSLØTi data cards and must be nonzero as noted if these cards use the default.
3. The harmonic index number N must be entered on this card.
4. If the number of slots, M, is different in different regions or the cavity, this fact may be indicated on the CSLØTi and SLBDY cards. If the number of slots is zero, no matrices for CSLØTi elements are generated.
5. A zero entry for bulk modulus is treated as if the fluid was incompressible.

Input Data Card BARØR   Simple Beam Orientation Default

Description: Defines default values for fields 3 and 6-9 of the CBAR card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
BARØR		PID			X1,GO	X2	X3	F	
BARØR		39			0.6	2.9	-5.87	1	

Field	Contents
PID	Identification number of PBAR property card (Integer > 0 or blank)
X1, X2, X3	Vector components measured in displacement coordinate system at GA to determine (with the vector from end A to end B) the orientation of the element coordinate system for the bar element (Real or blank; see below)
GO	Grid point identification number (Integer > 0; see below)
F	Flag to specify the nature of fields 6-8 as follows:

	6	7	8
F = 1	X1	X2	X3
F = 2	GO	blank	blank

Remarks:

1. The contents of fields on this card will be assumed for any CBAR card whose corresponding fields are blank.
2. Only one BARØR card may appear in the user's Bulk Data Deck.
3. For an explanation of bar element geometry, see Section 1.3.2.

Input Data Card BDYC Combination of Substructure Boundary Sets

Description: Defines a combination of boundary sets by basic substructure to define a set of grid points and components which may be used in a REDUCE operation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
BDYC	ID	NAME1	SID1	NAME2	SID2	NAME3	SID3		ghi
BDYC	157	WINGRT	7	MIDWG	15	FUSELAGE	32		GHI

+hi		NAMEi	SIDi	etc.					jkl
+HI		PØD1	175	WINGRT	15	CABIN	16		

Field	Contents
ID	Identification number of combination boundary set (Integer > 0)
NAMEi	Name of basic substructure which contains the grid points defined by boundary set SIDi (BCD)
SIDi	Identification number of the boundary set associated with basic substructure NAMEi (Integer > 0)

Remarks:

1. Boundary sets must be selected in the Substructure Control Deck (BØUNDARY=ID) to be used by NASTRAN. Note that 'BØUNDARY' is a subcommand of the substructure REDUCE command.

2. The same substructure name may appear more than once per set.

3. The SIDi numbers need not be unique. The same number could appear for different component structures.

4. The SIDi numbers reference the set ID's of BDYS and BDYS1 cards.

5. The ID number must be unique with respect to all other BDYC data cards.

6. After two or more basic substructures are combined, the connected degrees of freedom are actually the same and may be referenced with any one of the substructure names. Redundant specification is allowed.

NASTRAN DATA DECK

Input Data Card BDYLIST   Fluid Boundary List

Description: Defines the boundary between a fluid and a structure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
BDYLIST	RHØ	IDF1	IDF2	IDF3	IDF4	IDF5	IDF6	IDF7	abc
BDYLIST	.037	432	325	416	203	256	175	153	345A

+bc	IDF8	etc.							def
+45A	101	105	AXIS						

-etc.-

Field	Contents
RHØ	Fluid mass density at boundary (Real $\geq$ 0.0 or blank. Default on AXIF card is used if blank)
IDFi	Identification number of a RINGFL point (Integer > 0 or BCD. "AXIS" may be first and/or last entry on the logical card)

Remarks:

1. This card is allowed only if an AXIF card is also present.
2. Each logical card defines a boundary if RHØ $\neq$ 0.0. The order of the points must be sequential with the fluid on the right with respect to the direction of travel.
3. The BCD word, AXIS, defines an intersection with the polar axis of the fluid coordinate system.
4. There may be as many BDYLIST cards as the user requires. If the fluid density varies along the boundary there must be one BDYLIST card for each interval between fluid points.
5. The BDYLIST card is not required and should not be used to specify a rigid boundary where structural points are not defined. Such a boundary is automatically implied by the omission of a BDYLIST.
6. If RHØ is 0.0, no boundary matrix terms will be generated to connect the GRIDB points to the fluid. This option is a convenience for structural plotting purposes. GRIDB points may be located on a fluid ring (RINGFL) only if the rings are included in a BDYLIST.

Input Data Card BDYS   Boundary Set Definition

Description: This card is used to define a boundary set of grid points and degrees of freedom for a basic substructure. The boundary set is used in the substructure REDUCE operation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
BDYS	SID	G1	C1	G2	C2	G3	C3		
BDYS	7	13	123456	15	123	17	123456		

Field	Contents
SID	Identification number of BDYS set (Integer > 0)
Gi	Grid or scalar point identification number of a basic substructure (Integer > 0)
Ci	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.

Remarks:
1. The set of boundary points defines the degrees of freedom which are to be retained in the matrices after the substructure REDUCE operation has been performed. An alternate input format is provided by the BDYS1 card.
2. The SID need not be unique.
3. The BDYS card must be referenced by the BDYC card in order to attach the basic substructure name to the boundary set specified on the BDYS card. Note that the same BDYS boundary set may be attached to more than one basic substructure name.

Input Data Card BDYS1 Boundary Set Definition

Description: This card is used to define a boundary set of grid points and degrees of freedom for a basic substructure. The boundary set is used in the substructure REDUCE operation.

Format and Examples:

1	2	3	4	5	6	7	8	9	10
BDYS1	SID	C	G1	G2	G3	G4	G5	G6	abc
BDYS1	15	123456	275	276	THRU	457	589	102	ABC
+bc	G7	G8	etc.		GN				
+BC	103	105			1275				

Field	Contents
SID	Identification number of BDYS1 set (Integer > 0)
Ci	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.
Gi	Grid or scalar point identification number of a basic substructure (Integer > 0)

Remarks:

1. The set of boundary points defines the degrees of freedom which are to be retained in the matrices after the substructure REDUCE operation has been performed. An alternate format is provided by the BDYS card.
2. The "THRU" may appear in any field other than 2 and 9.
3. The SID need not be unique.
4. The BDYS1 card must be referenced by the BDYC card in order to attach the basic substructure name to the boundary set specified on the BDYS card. Note that the same BDYS boundary set may be attached to more than one basic substructure name.

Input Data Card CAERØ1 Aerodynamic Panel Element Connection

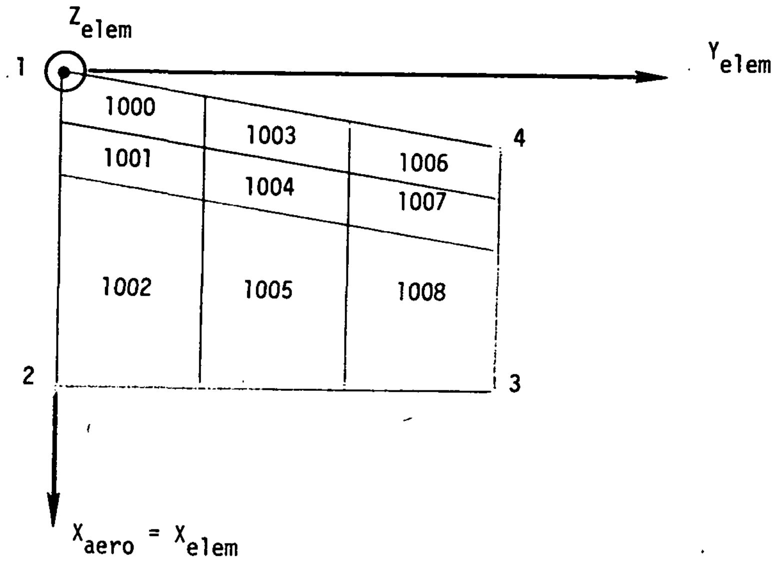
Description: Defines an aerodynamic macro element (panel) in terms of two leading edge locations and side chords.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CAERØ1	EID	PID	CP	NSPAN	NCHØRD	LSPAN	LCHØRD	IGID	ABC
CAERØ1	1000	1		3			2	1	ABC
+BC	X1	Y1	Z1	X12	X4	Y4	Z4	X43	
+BC	0.0	0.0	0.0	1.0	0.2	1.0	0.0	0.8	

Field	Contents
EID	Element identification number (unique Integer > 0).
PID	Identification number of property card (Integer > 0).
CP	Coordinate system for locating points 1 and 4 (Integer ≥ 0).
NSPAN	Number of spanwise boxes; if a positive value is given, equal divisions are assumed; if zero or blank, a list of division points follows (Integer ≥ 0).
NCHØRD	Number of chordwise boxes (same rule as for NSPAN).
LSPAN	ID of an AEFACT data card containing a list of division points for spanwise boxes. Used only if field 5 is zero or blank (Integer > 0 if NSPAN is zero or blank).
LCHØRD	ID of an AEFACT data card containing a list of division points for chordwise boxes. Used only if field 6 is zero or blank (Integer > 0 if NCHØRD is zero or blank).
IGID	Interference group identification (aerodynamic elements with different IGID's are uncoupled) (Integer > 0).
X1,Y1,Z1;X4,Y4,Z4	Location of points 1 and 4, in coordinate system CP (Real).
X12; X43	Edge chord (in aerodynamic coordinate system) (Real ≥ 0, and not both zero).

Remarks:



1. The boxes are numbered sequentially, beginning with EID. The user should be careful to ensure that all box numbers are unique, and different from structural grid ID's.

2. The number of division points is one greater than the number of boxes. Thus, if NSPAN = 3, the division points are 0.0, 0.333, 0.667, 1.000. If the user supplies division points, the first and last points need not be 0. and 1. (in which the corners of the panel would not be at the reference points).

3. A triangular element is formed if X12 <u>or</u> X43 = 0.

4. The element coordinate system (right-handed) is shown in the sketch.

5. The continuation card is required.

Input Data Card CAXIFi Fluid Element Connections

Description: Defines an axisymmetric fluid element which connects i = 2, i = 3, or i = 4 fluid points.

Formats and Examples:

1	2	3	4	5	6	7	8	9	10
CAXIF2	EID	IDF1	IDF2			RHØ	B		
CAXIF2	11	23	25			.25E-03			
CAXIF3	EID	IDF1	IDF2	IDF3		RHØ	B		
CAXIF3	105	31	32	33			6.7E4		
CAXIF4	EID	IDF1	IDF2	IDF3	IDF4	RHØ	B		
CAXIF4	524	421	425	424	422	.5-3	2.5+3		

Field	Contents
EID	Element identification number (Integer > 0)
IDFj	Identification numbers of connected GRIDF points, j = 1,2,...i (Integer > 0)
RHØ	Fluid density in mass units (Real > 0.0 or blank)
B	Fluid bulk modulus (Real ≥ 0.0 or blank)

Remarks:

1. This card is allowed only if an AXSLØT card is also present.
2. The element identification number (EID) must be unique with respect to all other fluid or structural elements.
3. If RHØ, or B are "blank" the corresponding values on the AXSLØT data card are used, in which case the default must not be blank (undefined).
4. Plot elements are generated for these elements. Because each plot element connects two points, one is generated for the CAXIF2 element, three are generated for the CAXIF3 element, and four plot elements are generated for the CAXIF4 element. In the last case the elements connect the pairs of points (1-2), (2-3), (3-4) and (4-1).
5. If B = 0.0, the fluid is considered to be incompressible.

Input Data Card CBAR Simple Beam Element Connection

Description: Defines a simple beam element (BAR) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CBAR	EID	PID	GA	GB	X1,G0	X2	X3	F	abc
CBAR	2	39	7	3	13			2	123
+bc	PA	PB	Z1A	Z2A	Z3A	Z1B	Z2B	Z3B	
+23		513							

Field Contents

EID Unique element identification number (Integer > 0)

PID Identification number of a PBAR property card (Default is EID unless BARØR card has nonzero entry in field 3) (Integer > 0 or blank*)

GA,GB Grid point identification numbers of connection points (Integer > 0; GA $\neq$ GB)

X1,X2,X3 Components of vector $\vec{v}$, at end a, (figure 1(a) on page 1.3-15) measured at end a, parallel to the components of the displacement coordinate system for GA, to determine (with the vector from end a to end b) the orientation of the element coordinate system for the bar element (Real, $X1^2 + X2^2 + X3^2 > 0$ or blank*, see below).

G0 Grid point identification number to optionally supply X1, X2, X3 (integer > 0 or blank*) (see below)

F Flag to specify the nature of fields 6-8 as follows:

	6	7	8
F = blank*			
F = 1	X1	X2	X3
F = 2	G0	blank/0	blank/0

PA,PB Pin flags for bar ends a and b, respectively, that are used to insure that the bar cannot resist a force or moment corresponding to the pin flag at that respective end of the bar. (Up to 5 of the unique digits 1-6 anywhere in the field with no imbedded blanks; integer > 0) (These degree of freedom codes refer to the element forces and not global forces. The bar must have stiffness associated with the pin flag. For example, if pin flag 4 is specified, the bar must have a value for J, the torsional constant.)

Z1A,Z2A,Z3A
Z1B,Z2B,Z3B Components of offset vectors $\vec{w}_a$ and $\vec{w}_b$, respectively, (see figure 1(a), page 1.3-15) in displacement coordinate systems at points GA and GB, respectively. (Real or blank)

*See the BARØR card for default options for fields 3, 6, 7, 8 and 9.

Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. For an explanation of bar element geometry, see Section 1.3.2.

3. Zero (0) must be used in fields 7 and 8 in order to override entries in these fields associated with F = 1 in field 9 on a BARØR card.

4. If there are no pin flags or offsets, the continuation card may be omitted.

Input Data Card <u>CCØNEAX</u> Axisymmetric Shell Element Connection

<u>Description</u>: Defines the connection of a conical shell element.

<u>Format and Example</u>:

1	2	3	4	5	6	7	8	9	10
CCØNEAX	ID	PID	RA	RB					
CCØNEAX	1	2	3	4					

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PCØNEAX card (Default is EID) (Integer > 0)
RA	Identification number of a RINGAX card (Integer > 0; RA ≠ RB)
RB	Identification number of a RINGAX card (Integer > 0; RA ≠ RB)

<u>Remarks</u>: 1. This card is allowed if and only if an AXIC card is also present.

2. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

Input Data Card CDAMP1 Scalar Damper Connection

Description: Defines a scalar damper element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP1	EID	PID	G1	C1	G2	C2			
CDAMP1	19	6	0		23	2			

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PDAMP property card (Default is EID) (Integer > 0)
G1, G2	Geometric grid point identification number (Integer $\geq$ 0)
C1, C2	Component number (6 $\geq$ Integer $\geq$ 0)

Remarks:

1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CDAMP3 card.

2. Element identification numbers must be unique with respect to all other element identification numbers.

3. The two connection points, (G1, C1) and (G2, C2), must be distinct.

4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

Input Data Card CDAMP2 Scalar Damper Property and Connection

Description: Defines a scalar damper element of the structural model without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP2	EID	B	G1	C1	G2	C2			
CDAMP2	16	-2.98	32	1					

Field	Contents
EID	Unique element identification number (Integer > 0)
B	The value of the scalar damper (Real)
G1, G2	Geometric grid point identification number (Integer ≥ 0)
C1, C2	Component number (6 ≥ Integer ≥ 0)

Remarks:

1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CDAMP4 card.

2. Element identification numbers must be unique with respect to all other element identification numbers.

3. This single card completely defines the element since no material or geometric properties are required.

4. The two connection points, (G1, C1) and (G2, C2), must be distinct.

5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

Input Data Card CDAMP3 Scalar Damper Connection

Description: Defines a scalar damper element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP3	EID	PID	S1	S2	EID	PID	S1	S2	
CDAMP3	16	978	24	36	17	978	24	37	

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PDAMP property card (Default is EID) (Integer > 0)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:
1. S1 or S2 may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. One or two scalar damper elements may be defined on a single card.
4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card CDAMP4 Scalar Damper Property and Connection

Description: Defines a scalar damper element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP4	EID	B	S1	S2	EID	B	S1	S2	
CDAMP4	16	-2.6	4	9	17	+8.6	3	7	

Field	Contents
EID	Unique element identification number (Integer > 0)
B	The scalar damper value (Real)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:

1. S1 or S2 may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. This card completely defines the element since no material or geometric properties are required.
4. One or two scalar damper elements may be defined on a single card.
5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card CDUMi Dummy Element Connection

Description: Defines a dummy element ($1 \leq i \leq 9$).

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDUMi	EID	PID	G1	G2	G3	G4	-etc.-	GN	abc
CDUM2	114	108	2	5	6	8		11	ABC
+bc	A1	A2	-etc.-			AN			
+BC	2.4		3.E4	2		50			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PDUMi property card (Integer > 0)
G1...GN	Grid point identification numbers of connection points (Integer > 0, G1 ≠ G2 ... ≠ GN)
A1...AN	Additional entries (Real or Integer)

Remarks:

1. The user must code the associated element routines for matrix generation, stress recovery, etc., and perform a link edit to replace the dummy routines.
2. If no property card is required, field 3 may contain the material identification number.
3. Additional entries are defined in the user written element routines.

Input Data Card CELAS1 Scalar Spring Connection

Description: Defines a scalar spring element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS1	EID	PID	G1	C1	G2	C2			
CELAS1	2	6			8	1			

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PELAS property card (Default is EID) (Integer > 0)
G1, G2	Geometric grid point identification number (Integer > 0)
C1, C2	Component number (6 ≥ Integer ≥ 0)

Remarks:
1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CELAS3 card.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. The two connection points, (G1, C1) and (G2, C2), must be distinct.
4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

Input Data Card CELAS2 Scalar Spring Property and Connection

Description: Defines a scalar spring element of the structural model without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS2	EID	K	G1	C1	G2	C2	GE	S	
CELAS2	28	6.2+3	32		19	4			

Field	Contents
EID	Unique element identification number (Integer > 0)
K	The value of the scalar spring (Real)
G1, G2	Geometric grid point identification number (Integer $\geq$ 0)
C1, C2	Components number (6 $\geq$ Integer $\geq$ 0)
GE	Damping coefficient (Real)
S	Stress coefficient (Real)

Remarks:

1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CELAS4 card.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. This single card completely defines the element since no material or geometric properties are required.
4. The two connection points, (G1, C1) and (G2, C2), must be distinct.
5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

Input Data Card CELAS3 Scalar Spring Connection

Description: Defines a scalar spring element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS3	EID	PID	S1	S2	EID	PID	S1	S2	
CELAS3	19	2	14	15	2	3	0	28	

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PELAS property card (Default is EID) (Integer > 0)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:

1. S1 or S2 may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. One or two scalar springs may be defined on a single card.
4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card CELAS4 Scalar Spring Property and Connection

Description: Defines a scalar element of the structural model which is connected only to scalar points without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS4	EID	K	S1	S2	EID	K	S1	S2	
CELAS4	42	6.2-3	2		13	6.2-3	0	2	

Field	Contents
EID	Unique element identification number (Integer > 0)
K	The scalar spring value (Real)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:

1. S1 or S2 but not both may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. This card completely defines the element since no material or geometric properties are required.
4. No damping coefficient is available with this form. (Assumed to be 0.0)
5. No stress coefficient is available with this form.
6. One or two scalar springs may be defined on a single card.
7. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card CFLUIDi Fluid Element Connections

Description: Defines three types of fluid elements for axisymmetric fluid model.

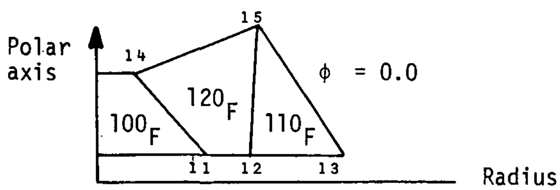
Format and Example:

1	2	3	4	5	6	7	8	9	10
CFLUID2	EID	IDF1	IDF2			RHØ	B		
CFLUID2	100	11	14			.025	0.0		
CFLUID3	EID	IDF1	IDF2	IDF3		RHØ	B		
CFLUID3	110	15	13	12		1.2			
CFLUID4	EID	IDF1	IDF2	IDF3	IDF4	RHØ	B		
CFLUID4	120	11	15	12	14				

Field	Contents
EID	Element identification number (Integer, $0 < Id_c < 10^5$)
IDFi	Identification number of RINGFL card (Integer > 0; IDF1 ≠ IDF2 ≠ IDF3 ≠ IDF4)
RHØ	Mass density (Real > 0.0 or blank; If blank, the AXIF default value is used)
B	Bulk modulus, pressure per volume ratio (Real or blank. Default value on AXIF card is used if blank)

Remarks:

1. This card is allowed only if an AXIF card is also present.
2. Element identification number must be unique with respect to all other fluid, scalar and structural elements.
3. The volume defined by IDFi is a body of revolution about the polar axis of the Fluid Coordinate System defined by AXIF. CFLUID2 defines a thick disk with IDF1 and IDF2 defining the outer corners as in the sketch.



4. All interior angles must be less than 180°.
5. The order of connected RINGFL points is arbitrary.
6. If the bulk modulus value is zero the fluid is assumed incompressible.

Input Data Card CHBDY   Heat Boundary Element

Description: Defines a boundary element for heat transfer analysis which is used for heat flux, thermal vector flux, convection and/or radiation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CHBDY	EID	PID	TYPE	G1	G2	G3	G4		
CHBDY	721	100	LINE	101	98				+BD721

+abc	GA1	GA2	GA3	GA4	V1	V2	V3		
+BD721	102	102			1.00	0.0	0.0		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Property identification number (Integer > 0)
TYPE	Type of area involved (must be one of "PØINT", "LINE", "REV", "AREA3", "AREA4" or "ELCYL")
G1,G2,G3,G4	Grid point identification numbers of primary connected points (Integer > 0 or blank)
GA1,GA2,GA3,GA4	Grid or scalar point identification numbers of associated ambient points (Integer > 0 or blank)
V1,V2,V3	Vector (in the basic coordinate system) used for element orientation (real or blank)

Remarks:

1. The continuation card is not required.
2. The six types have the following characteristics:
   a. The "PØINT" type has one primary grid point, requires a property card, and the normal vector {V1,V2,V3} must be given if thermal vector flux is to be used.
   b. The "LINE" type has two primary grid points, requires a property card, and the vector is required if thermal vector flux is to be used.
   c. The "REV" type has two primary grid points which must lie in the x-z plane of the basic coordinate system with x > 0. The defined area is a conical section with z as the axis of symmetry. A property card is required for convection, radiation, or thermal vector flux.
   d. The "AREA3" and "AREA4" types have three and four primary grid points, respectively. These points define a triangular or quadrilateral surface and must be ordered to go around the boundary. A property card is required for convection, radiation, or thermal vector flux.
   e. The "ELCYL" type (elliptic cylinder) has two connected primary grid points, it requires a property card, and if thermal vector flux is used, the vector must be nonzero.

CHBDY (Cont.)

3. A property card, PHBDY, is used to define the associated area factors, the emissivity, the absorbtivity, and the principal radii of the elliptic cylinder. The material coefficients used for convection and thermal capacity are referenced by the PHBDY card. See this card description for details.

4. The associated points, GA1, GA2, etc., may be either grid or scalar points, and are used to define the ambient temperature for a convection field. These points correspond to the primary points G1, G2, etc., and the number of them depends on the TYPE option, but they need not be unique. Their values may be set in statics with an SPC card, or they may be connected to other elements. If any field is blank, the ambient temperature associated with that grid point is assumed to be zero.

5. Heat flux may be applied to this element with QBDY1 or QBDY2 cards.

6. Thermal vector flux from a directional source may be applied to this element with a QVECT card. See Figure 1 on page 1.8-7 for the definition of the normal vector for each element type.

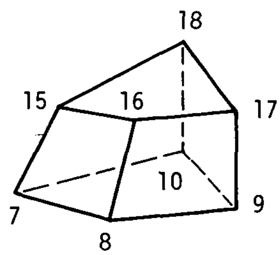
Input Data Card CHEXAi Hexahedron Element Connection

Description: Defines two types of hexahedron elements (3 dimensional solid with 8 vertices and 6 quadrilateral faces, HEXAi) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CHEXAi	EID	MID	G1	G2	G3	G4	G5	G6	abc
CHEXA2	15	2	7	8	9	10	15	16	ABC
+bc	G7	G8							
+BC	17	18							

Field	Contents
CHEXAi	CHEXA1 or CHEXA2 (see Remark 7)
EID	Element identification number (Integer > 0)
MID	Material identification number (Integer > 0)
G1,...,G8	Grid point identification numbers of connection points (Integers > 0, G1 ≠ G2 ≠ ... ≠ G8)



Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.

2. The order at the grid points is: G1, G2, G3, G4 in order around one quadrilateral face. G5, G6, G7, G8 are in order in the same direction around the opposite quadrilateral, with G1 and G5 along the same edge.

3. The quadrilateral faces must be nearly planar.

4. There is no nonstructural mass.

5. For structural problems, material must be defined by MAT1 card.

6. Stresses are given in the basic coordinate system.

7. CHEXA1 represents the element as 5 tetrahedra, CHEXA2 represents the element as 10 overlapping tetrahedra.

8. For heat transfer problems, material may be defined with either a MAT4 or MAT5 card.

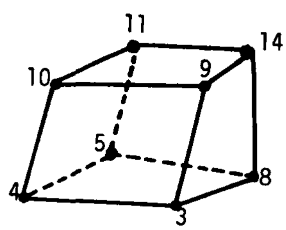
Input Data Card CIHEX1 Linear Isoparametric Hexahedron Element Connection

Description: Defines a linear isoparametric hexahedron element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CIHEX1	EID	PID	G1	G2	G3	G4	G5	G6	abc
CIHEX1	137	5	3	8	5	4	9	14	ABC
+bc	G7	G8							
+BC	11	10							

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PIHEX property card (Integer > 0)
G1,...,G8	Grid point identification numbers of connection points (Integer > 0, G1 ≠ G2 ≠ ... ≠ G8)



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Grid points G1, G2, G3, G4 must be given in counter-clockwise order about one quadrilateral face when viewed from inside the element. G5, G6, G7, G8 are in order in the same direction around the opposite quadrilateral, with G1 and G5 along the same edge.

3. There is no non-structural mass.

4. The quadrilateral faces need not be planar.

5. Stresses are given in the basic coordinate system.

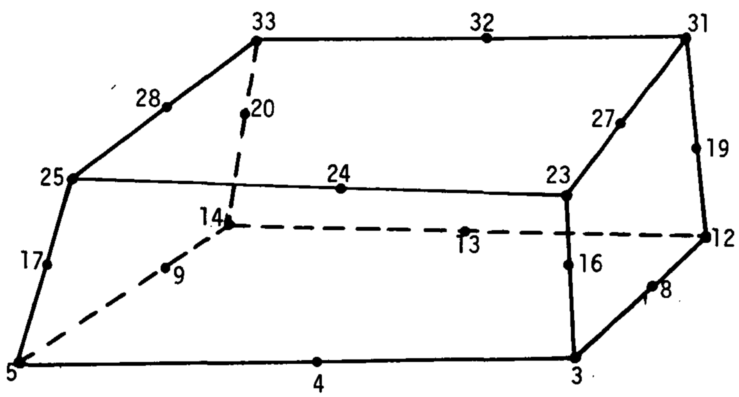
Input Data Card CIHEX2 Quadratic Isoparametric Hexahedron Element Connection

Description: Defines a quadratic isoparametric hexahedron element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CIHEX2	EID	PID	G1	G2	G3	G4	G5	G6	abc
CIHEX2	110	7	3	8	12	13	14	9	ABC
+bc	G7	G8	G9	G10	G11	G12	G13	G14	def
+BC	5	4	16	19	20	17	23	27	DEF
+ef	G15	G16	G17	G18	G19	G20			
+EF	31	32	33	28	25	24			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PIHEX property card (Integer > 0)
G1,...,G20	Grid point identification numbers of connection points (Integer > 0, G1 ≠ G2 ≠ ... ≠ G20)



Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Grid points G1,...,G8 must be given in counter-clockwise order about one quadrilateral face when viewed from inside the element. G9,...,G12 and G13,...,G20 are in the same direction with G1, G9 and G13 along the same edge.

3. There is no nonstructural mass.

4. The quadrilateral faces need not be planar.

5. Stresses are given in the basic coordinate system.

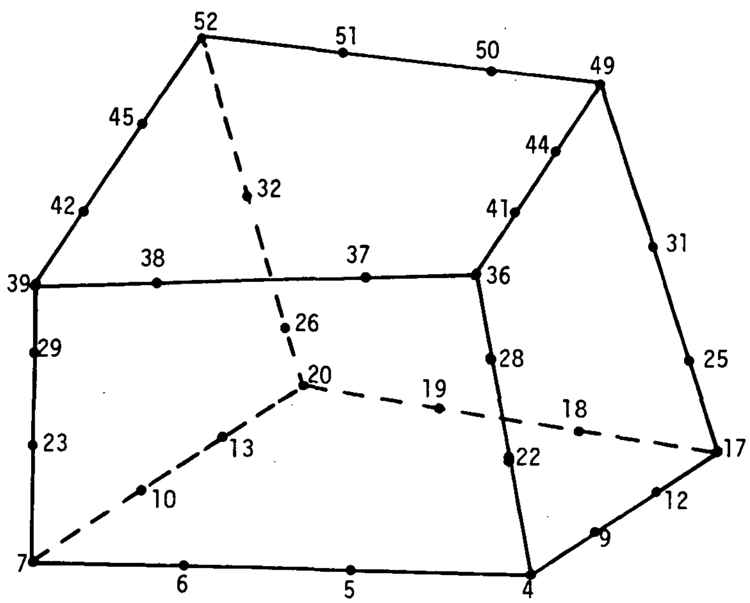
Input Data Card CIHEX3 Cubic Isoparametric Hexahedron Element Connection

Description: Defines a cubic isoparametric hexahedron element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CIHEX3	EID	PID	G1	G2	G3	G4	G5	G6	abc
CIHEX3	15	3	4	9	12	17	18	19	ABC
+bc	G7	G8	G9	G10	G11	G12	G13	G14	def
+BC	20	13	10	7	6	5	22	25	DEF
+ef	G15	G16	G17	G18	G19	G20	G21	G22	ghi
+EF	26	23	28	31	32	29	36	41	GHI
+hi	G23	G24	G25	G26	G27	G28	G29	G30	jkl
+HI	44	49	50	51	52	45	42	39	JKL
+kl	G31	G32							
+KL	38	37							

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PIHEX property card (Integer > 0)
G1,...,G32	Grid point identification number of connection points (Integer > 0, G1 $\neq$ G2 $\neq$ ... $\neq$ G32)



Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Grid points G1,...,G12 must be given in counter-clockwise order about one quadrilateral face when viewed from inside the element. G13,...,G16; G17,...,G20; and G21,...,G32 are in the same direction with G1, G13, G17, G21 along the same edge.

3. There is no nonstructural mass.

4. The quadrilateral faces need not be planar.

5. Stresses are given in the basic coordinate system.

Input Data Card CMASS1 Scalar Mass Connection

Description: Defines a scalar mass element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CMASS1	EID	PID	G1	C1	G2	C2			
CMASS1	32	6	2	1	2	3			

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PMASS property card (Default is EID) (Integer > 0)
G1, G2	Geometric grid point identification number (Integer $\geq$ 0)
C1, C2	Component number (6 $\geq$ Integer $\geq$ 0)

Remarks:

1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CMASS3 card.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. The two connection points, (G1, C1) and (G2, C2), must be distinct.
4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

BULK DATA DECK

Input Data Card CMASS2 Scalar Mass Property and Connection

Description: Defines a scalar mass element of the structural model without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CMASS2	EID	M	G1	C1	G2	C2			
CMASS2	32	9.25	6	1	7				

Field	Contents
EID	Unique element identification number (Integer > 0)
M	The value of the scalar mass (Real)
G1, G2	Geometric grid point identification number (Integer ≥ 0)
C1, C2	Component number (6 ≥ Integer ≥ 0)

Remarks: 1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CMASS4 card.

2. Element identification numbers must be unique with respect to all other element identification numbers.

3. This card completely defines the element since no material or geometric properties are required.

4. The two connection points, (G1, C1) and (G2, C2), must be distinct.

5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

Input Data Card CMASS3 Scalar Mass Connection

Description: Defines a scalar mass element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CMASS3	EID	PID	S1	S2	EID	PID	S1	S2	
CMASS3	13	42	62	1					

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PMASS property card (Default is EID) (Integer > 0)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:
1. S1 or S2 may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. One or two scalar masses may be defined on a single card.
4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card CMASS4 Scalar Mass Property and Connection

Description: Defines a scalar mass element of the structural model which is connected only to scalar points without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CMASS4	EID	M	S1	S2	EID	M	S1	S2	
CMASS4	23	14.92	6	23	2	-16.3	0	29	

Field	Contents
EID	Unique element identification number (Integer > 0)
M	The scalar mass value (Real)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:
1. S1 or S2 may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. This card completely defines the element since no material or geometric properties are required.
4. One or two scalar masses may be defined on a single card.
5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card CNGRNT Identical Elements Indicator

Description: Designates secondary element(s) identical to a primary element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CNGRNT	PRID	SECID1	SECID2	SECID3	SECID4	SECID5	SECID6	SECID7	abc
CNGRNT	11	2	17	34	35	36			

+bc	SECID8	SECID9		-etc.-					

Alternate Form

CNGRNT	PRID	SECID1	"THRU"	SECID2					
CNGRNT	7	2	THRU	55					

Field	Contents
PRID	Identification number of the primary element (not necessarily the lowest number) for which the stiffness, mass and damping matrices will be calculated.
SECIDi	Identification number(s) of secondary element(s) whose matrices will be identical to the primary element.

Remarks:

1. Orientation, geometry, etc. must be truly identical such that the same stiffness, mass and damping matrices are generated in the global coordinate system.
2. This feature is automatically used by the INPUT module.
3. An element that has been listed as a primary element on any CNGRNT card cannot be listed as a secondary element either on that card or on any other CNGRNT card.
4. The CNGRNT feature cannot be used when an AXIC card is present in the bulk data deck.

Input Data Card CØNCT   Substructure Connectivity

Description: Defines the grid point and degree of freedom connectivities between two substructures for a manual CØMBINE operation.

Format and Example:

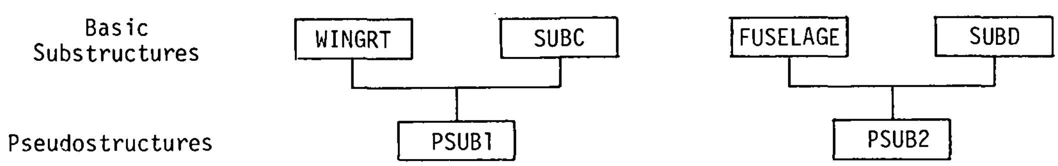
1	2	3	4	5	6	7	8	9	10
CØNCT	SID	C	SUBA	SUBB					def
CØNCT	307	1236	WINGRT	FUSELAGE					DEF
+ef	GA1	GB1	GA2	GB2	GA3	GB3	GA4	GB4	hij
+EF	201	207	958	214	971	216	982		HIJ

Field	Contents
SID	Identification number of connectivity set (Integer > 0)
C	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.
SUBA, SUBB	Names of basic substructures being connected (BCD).
GAi, GBi	Grid or scalar point identification numbers GAi from SUBA connects to GBi from SUBB by the degrees of freedom specified in C (Integer > 0)

Remarks:

1. At least one continuation card must be present.
2. Components specified on a CØNCT card will be overridden by RELES cards.
3. Several CØNCT and CØNCT1 cards may be input with the same value of SID.
4. An alternate format is given by the CØNCT1 data card.
5. Connectivity sets must be selected in the Substructure Control Deck (CØNNECT=SID) to be used by NASTRAN. Note that 'CØNNECT' is a subcommand of the substructure CØMBINE command.
6. SUBA and SUBB must be component basic substructures of the pseudostructures being combined as specified on the substructure CØMBINE command card. SUBA and SUBB must not be components of the same pseudostructure.

   In the figure below, a substructure "tree" and a set of substructure command cards are shown. The CØNNECT subcommand references the example CØNCT card above. In this example, pseudostructure PSUB1 and PSUB2 are combined and connected only at points in their respective basic component substructures WINGRT and FUSELAGE.



CØNCT (Cont'd)

```
COMBINE(MANUAL) PSUB1,PSUB2
    NAME = PPSUB
    TØLER = 0.01
    CØNNECT = 307
```

Input Data Card CØNCT1 Substructure Connectivity

Description: Defines the grid point and degree of freedom connectivities between two or more substructures for a manual CØMBINE operation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CØNCT1	SID	NAME1	NAME2	NAME3	NAME4	NAME5	NAME6	NAME7	def
CØNCT1	805	WINGRT	FUSELAGE	MIDWG	PØD				DEF
+ef	C1	G11	G12	G13	G14	G15	G16	G17	hij
+EF	123	528	17	32	106				HIJ
+ij	C2	G21	G22	G23	G24	G25	G26	G27	
+IJ	46	518							etc.

Field	Contents
SID	Identification number of connectivity set (Integer > 0)
NAMEi	Basic substructure name (BCD)
Ci	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.
Gij	Grid or scalar point identification number in substructure namei with components Ci (Integer > 0)

Remarks:

1. As least one continuation card must be present.
2. Components specified on CØNCT1 card will not be overridden by RELES cards.
3. Several CØNCT and CØNCT1 cards may be input with the same value of SID.
4. An alternate format is given by the CØNCT card.
5. Connectivity sets must be selected in the Substructure Control Deck (CØNNECT=SID) to be used by NASTRAN. Note that 'CØNNECT' is a subcommand of the substructure CØMBINE command.
6. The NAMEi's must be the names of basic substructure components of the pseudostructures named on the CØMBINE card in the Substructure Control Deck. See the CØNCT card for a more complete discussion related to the combination of two substructures.

Input Data Card C∅NM1 Concentrated Mass Element Connection

Description: Defines a 6x6 symmetric mass matrix at a geometric grid point of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
C∅NM1	EID	G	CID	M11	M21	M22	M31	M32	abc
C∅NM1	2	22	2	2.9		6.3			+1
+bc	M33	M41	M42	M43	M44	M51	M52	M53	def
+1	4.8				28.6				+2
+ef	M54	M55	M61	M62	M63	M64	M65	M66	
+2		28.6						28.6	

Field	Contents
EID	Unique element identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
CID	Coordinate system identification number for the mass matrix (Integer ≥ 0)
Mij	Mass matrix values (Real)

Remarks:
1. For a less general means of defining concentrated mass at grid points, see C∅NM2.
2. Element identification numbers must be unique with respect to all other element identification numbers.

Input Data Card CØNM2 Concentrated Mass Element Connection

Description: Defines a concentrated mass at a grid point of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CØNM2	EID	G	CID	M	X1	X2	X3		abc
CØNM2	2	15	6	49.7					123
+bc	I11	I21	I22	I31	I32	I33			
+23	16.2		16.2			7.8			

Field	Contents
EID	Element identification number (Integer > 0)
G	Grid point identification number (Integer >0)
CID	Coordinate system identification number (Integer $\geq$ 0)
M	Mass Value (Real)
X1,X2,X3	Offset distances for the mass in the coordinate system defined in field 4 (Real)
Iij	Mass moments of inertia measured at the mass c.g. in coordinate system defined by field 4 (Real)

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. For a more general means of defining concentrated mass at grid points, see CØNM1.
3. The continuation card may be omitted.
4. The form of the inertia matrix about its c.g. is taken as:

$$\begin{bmatrix} M & & & 0 & zM & -yM \\ & M & & -zM & 0 & xM \\ & & M & yM & -xM & 0 \\ & & & I11 & -I21 & -I31 \\ & \text{SYM.} & & & I22 & -I32 \\ & & & & & I33 \end{bmatrix}$$

Input Data Card CØNRØD   Rod Element Property and Connection

Description: Defines a rod element of the structural model without reference to a property card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CØNRØD	EID	G1	G2	MID	A	J	C	NSM	
CØNRØD	2	16	17	23	2.69				

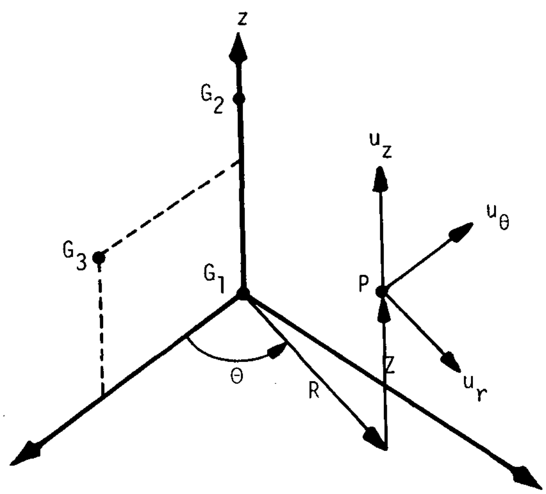
Field	Contents
EID	Unique element identification number (Integer > 0)
G1, G2	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2)
MID	Material identification number (Integer > 0)
A	Area of rod (Real)
J	Torsional constant (Real)
C	Coefficient for torsional stress determination (Real)
NSM	Nonstructural mass per unit length (Real)

Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
2. For structural problems, CØNRØD cards may only reference MAT1 material cards.
3. For heat transfer problems, CØNRØD cards may only reference MAT4 or MAT5 material cards.

NASTRAN DATA DECK

Input Data Card CØRD1C   Cylindrical Coordinate System Definition

Description: Defines a cylindrical coordinate system by reference to three grid points. These points must be defined in coordinate systems whose definition does not involve the coordinate system being defined. The first point is the origin, the second lies on the z-axis, and the third lies in the plane of the azimuthal origin.



Format and Example:

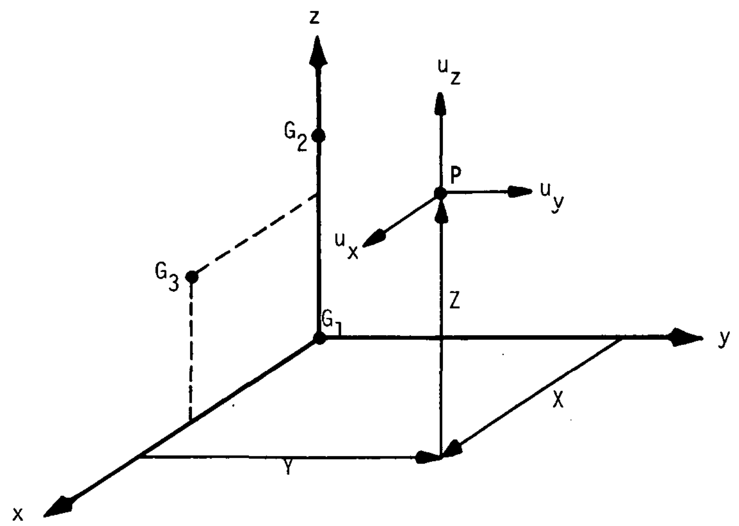
1	2	3	4	5	6	7	8	9	10
CØRD1C	CID	G1	G2	G3	CID	G1	G2	G3	
CØRD1C	3	16	32	19					

Field	Contents
CID	Coordinate system identification number (Integer > 0)
G1, G2, G3	Grid point identification numbers (Integer > 0; G1 $\neq$ G2 $\neq$ G3)

Remarks:
1. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.
2. The three points G1, G2, G3 must be noncollinear.
3. The location of a grid point (P in the sketch) in this coordinate system is given by (R, Θ, Z) where Θ is measured in degrees.
4. The displacement coordinate directions at P are dependent on the location of P as shown above by (u_r, u_θ, u_z).
5. Points on the z-axis may not have their displacement directions defined in this coordinate system since an ambiguity results.
6. One or two coordinate systems may be defined on a single card.

Input Data Card CØRD1R   Rectangular Coordinate System Definition

Description: Defines a rectangular coordinate system by reference to three grid points. These points must be defined in coordinate systems whose definition does not involve the coordinate system being defined. The first point is the origin, the second lies on the z-axis, and the third lies in the x-z plane.



Format and Example:

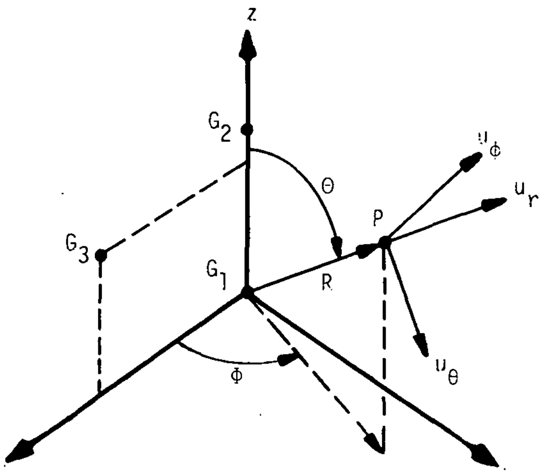
1	2	3	4	5	6	7	8	9	10
CØRD1R	CID	G1	G2	G3	CID	G1	G2	G3	
CØRD1R	3	16	32	19					

Field	Contents
CID	Coordinate system identification number (Integer > 0)
G1, G2, G3	Grid point identification numbers (Integer > 0; G1 ≠ G2 ≠ G3)

Remarks:
1. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.
2. The three points G1, G2, G3 must be noncollinear.
3. The location of a grid point (P in the sketch) in this coordinate system is given by (X, Y, Z).
4. The displacement coordinate directions at P are shown above by (u_x, u_y, u_z).
5. One or two coordinate systems may be defined on a single card.

Input Data Card CØRD1S   Spherical Coordinate System Definition

Description: Defines a spherical coordinate system by reference to three grid points. These points must be defined in coordinate systems whose definition does not involve the coordinate system being defined. The first point is the origin, the second lies on the z-axis, and the third lies in the plane of the azimuthal origin.



Format and Example:

1	2	3	4	5	6	7	8	9	10
CØRD1S	CID	G1	G2	G3	CID	G1	G2	G3	
CØRD1S	3	16	32	19					

Field	Contents
CID	Coordinate system identification number (Integer > 0)
G1, G2, G3	Grid point identification numbers (Integer > 0; G1 $\neq$ G2 $\neq$ G3)

Remarks: 1. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.

2. The three points G1, G2, G3 must be noncollinear.

3. The location of a grid point (P in the sketch) in this coordinate system is given by (R, Θ, Φ) where Θ and Φ are measured in degrees.

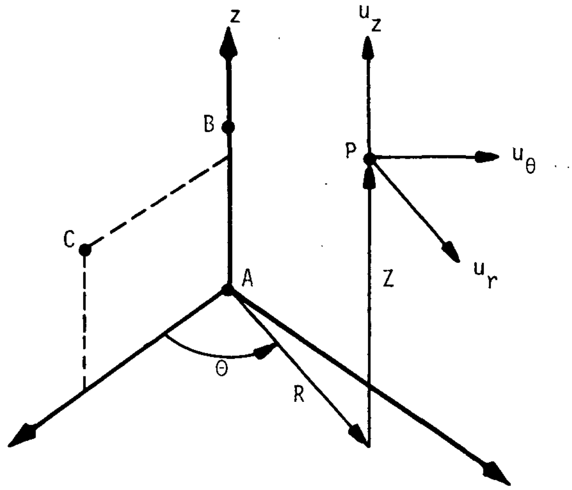
4. The displacement coordinate directions at P are dependent on the location of P as shown above by (u_r, u_θ, u_ϕ).

5. Points on the polar axis may not have their displacement directions defined in this coordinate system since an ambiguity results.

6. One or two coordinate systems may be defined on a single card.

Input Data Card CØRD2C Cylindrical Coordinate System Definition

Description: Defines a cylindrical coordinate system by reference to the coordinates of three points. The first point defines the origin. The second point defines the direction of the z-axis. The third lies in the plane of the azimuthal origin. The reference coordinate must be independently defined.



Format and Example:

1	2	3	4	5	6	7	8	9	10
CØRD2C	CID	RID	A1	A2	A3	B1	B2	B3	ABC
CØRD2C	3	17	-2.9	1.0	0.0	3.6	0.0	1.0	123
+BC	C1	C2	C3						
+23	5.2	1.0	-2.9						

Field	Contents
CID	Coordinate system identification number (Integer > 0)
RID	Reference to a coordinate system which is defined independently of new coordinate system (Integer ≥ 0 or blank)
A1,A2,A3 B1,B2,B3 C1,C2,C3	Coordinates of three points in coordinate system defined in field 3 (Real)

(continued)

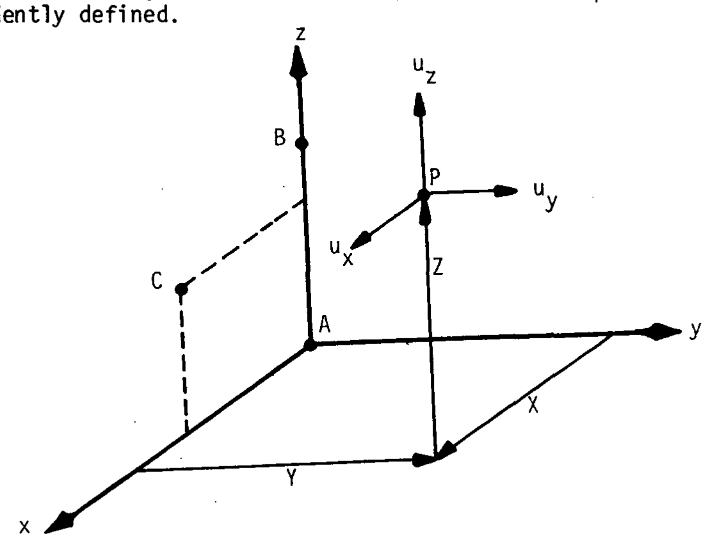
CØRD2C (Cont.)

Remarks:

1. Continuation card must be present.
2. The three points (A1, A2, A3), (B1, B2, B3), (C1, C2, C3) must be unique and noncollinear. Noncollinearity is checked by the geometry processor.
3. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.
4. An RID of zero references the basic coordinate system.
5. The location of a grid point (P in the sketch) in this coordinate system is given by (R, Θ, Z) where Θ is measured in degrees.
6. The displacement coordinate directions at P are dependent on the location of P as shown above by (u_r, u_θ, u_z).
7. Points on the z-axis may not have their displacement direction defined in this coordinate system since an ambiguity results.

Input Data Card CØRD2R Rectangular Coordinate System Definition

Description: Defines a rectangular coordinate system by reference to the coordinates of three points. The first point defines the origin. The second point defines the direction of the z-axis. The third point defines a vector which, with the z-axis, defines the x-z plane. The reference coordinate must be independently defined.



Format and Example:

1	2	3	4	5	6	7	8	9	10
CØRD2R	CID	RID	A1	A2	A3	B1	B2	B3	ABC
CØRD2R	3	17	-2.9	1.0	0.0	3.6	0.0	1.0	123
+BC	C1	C2	C3						
+23	5.2	1.0	-2.9						

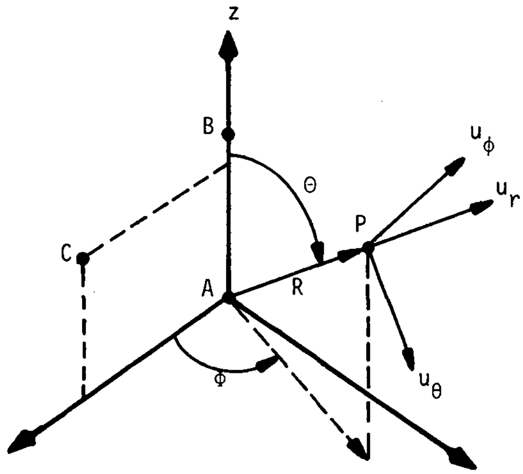
Field	Contents
CID	Coordinate system identification number (Integer > 0)
RID	Reference to a coordinate system which is defined independently of new coordinate system (Integer $\geq$ 0 or blank)
A1,A2,A3 B1,B2,B3 C1,C2,C3	Coordinates of three points in coordinate system defined in field 3 (Real)

Remarks:

1. Continuation card must be present.
2. The three points (A1, A2, A3), (B1, B2, B3), (C1, C2, C3) must be unique and noncollinear. Noncollinearity is checked by the geometry processor.
3. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.
4. An RID of zero references the basic coordinate system.
5. The location of a grid point (P in the sketch) in this coordinate system is given by (X, Y, Z).
6. The displacement coordinate directions at P are shown by (u_x, u_y, u_z).

Input Data Card CØRD2S Spherical Coordinate System Definition

Description: Defines a spherical coordinate system by reference to the coordinates of three points. The first point defines the origin. The second point defines the direction of the z-axis. The third lies in the plane of the azimuthal origin. The reference coordinate must be independently defined.



Format and Example:

1	2	3	4	5	6	7	8	9	10
CØRD2S	CID	RID	A1	A2	A3	B1	B2	B3	ABC
CØRD2S	3	17	-2.9	1.0	0.0	3.6	0.0	1.0	123
+BC	C1	C2	C3						
+23	5.2	1.0	-2.9						

Field	Contents
CID	Coordinate system identification number (Integer > 0)
RID	Reference to a coordinate system which is defined independently of new coordinate system (Integer ≥ 0 or blank)
A1,A2,A3 B1,B2,B3 C1,C2,C3	Coordinates of three points in coordinate system defined in field 3 (Real)

(Continued)

CØRD2S (Cont.)

Remarks: 1. Continuation card must be present.

2. The three points (A1, A2, A3), (B1, B2, B3), (C1, C2, C3) must be unique and non-collinear. Noncollinearity is checked by the geometry processor.

3. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.

4. An RID of zero references the basic coordinate system.

5. The location of a grid point (P in the sketch) in this coordinate system is given by (R, Θ, Φ) where Θ and Φ are measured in degrees.

6. The displacement coordinate directions at P are shown above by (u_r, u_θ, u_ϕ).

7. Points on the polar axis may not have their displacement directions defined in this coordinate system since an ambiguity results.

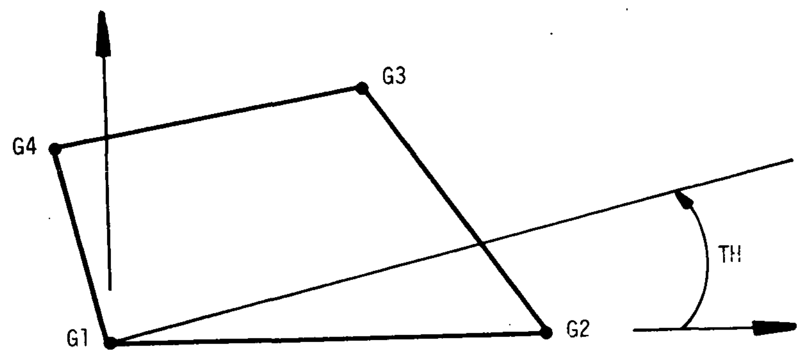
Input Data Card <u>CQDMEM</u> Quadrilateral Element Connection

<u>Description</u>: Defines a quadrilateral membrane element (QDMEM) of the structural model consisting of four overlapping TRMEM elements.

<u>Format and Example</u>:

1	2	3	4	5	6	7	8	9	10
CQDMEM	EID	PID	G1	G2	G3	G4	TH		
CQDMEM	72	13	13	14	15	16	29.2		

<u>Field</u>	<u>Contents</u>
EID	Element identification number (Integer > 0)
PID	Identification number of a PQDMEM property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3 ≠ G4)
TH	Material property orientation angle in degrees (Real) The sketch below gives the sign convention for TH.



<u>Remarks</u>: 1. Element identification numbers must be unique with respect to <u>all</u> other element identification numbers.

2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.

3. All interior angles must be less than 180°.

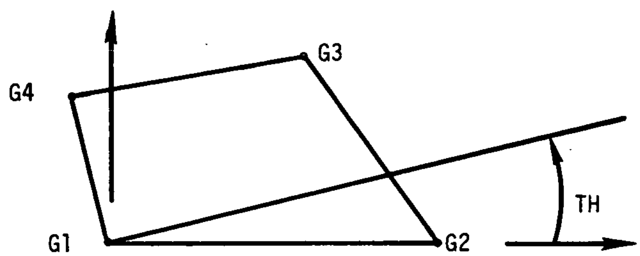
Input Data Card CQDMEM1 Isoparametric Quadrilateral Element Connection

Description: Defines an isoparametric quadrilateral membrane element (QDMEM1) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQDMEM1	EID	PID	G1	G2	G3	G4	TH		
CQDMEM1	72	13	13	14	15	16	29.2		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PQDMEM1 property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3 ≠ G4)
TH	Material property orientation angle in degrees (Real) The sketch below gives the sign convention for TH



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Grid points G1 through G4 must be ordered consecutively around the perimeter of the element.

3. All interior angles must be less than 180 degrees.

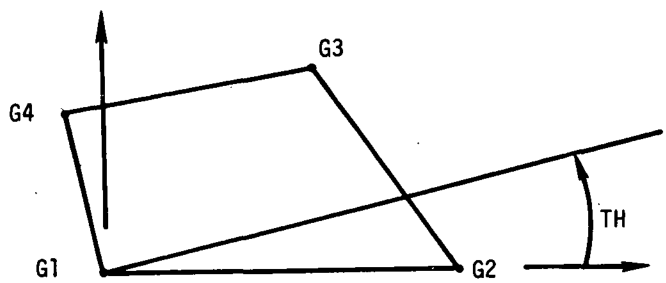
Input Data Card <u>CQDMEM2</u> Quadrilateral Element Connection

Description: Defines a quadrilateral membrane element (QDMEM2) of the structural model consisting of four nonoverlapping TRMEM elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQDMEM2	EID	PID	G1	G2	G3	G4	TH		
CQDMEM2	72	13	13	14	15	16	29.2		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PQDMEM2 property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3 ≠ G4)
TH	Material property orientation angle in degrees (Real) The sketch below gives the sign convention for TH



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Grid points G1 through G4 must be ordered consecutively around the perimeter of the element.

3. All interior angles must be less than 180 degrees.

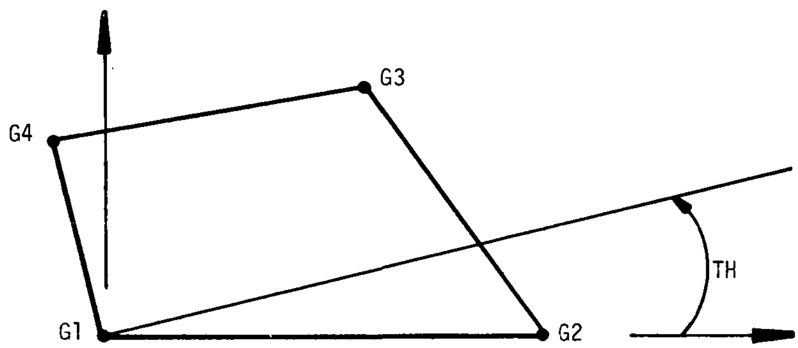
Input Data Card CQDPLT Quadrilateral Element Connection

Description: Defines a quadrilateral bending element (QDPLT) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQDPLT	EID	PID	G1	G2	G3	G4	TH		
CQDPLT	72	13	13	14	15	16	29.2		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PQDPLT property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3 ≠ G4)
TH	Material property orientation angle in degrees (Real) The sketch below gives the sign convention for TH.



Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.
3. All interior angles must be less than 180°.
4. No structural mass is generated by this element.

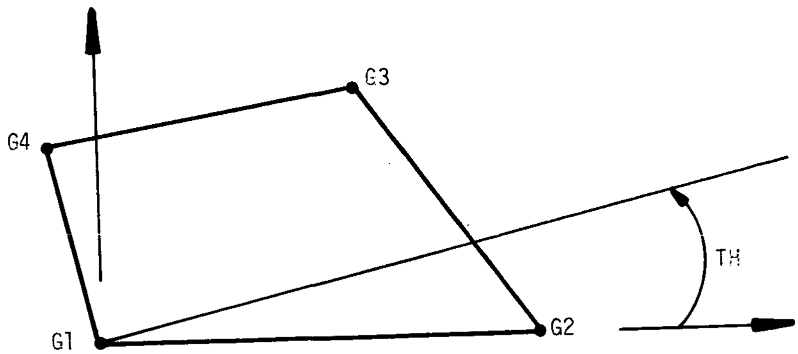
Input Data Card <u>CQUAD1</u> Quadrilateral Element Connection

Description: Defines a quadrilateral membrane and bending element (QUAD1) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQUAD1	EID	PID	G1	G2	G3	G4	TH		
CQUAD1	72	13	13	14	15	16	29.2		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PQUAD1 property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3 ≠ G4)
TH	Material property orientation angle in degrees (Real) The sketch below gives the sign convention for TH.



Remarks: 1. Element identification numbers must be unique with respect to <u>all</u> other element identification numbers.

2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.

3. All interior angles must be less than 180°.

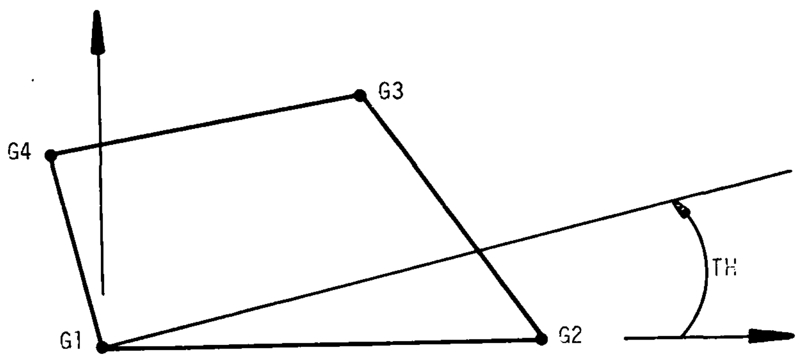
Input Data Card CQUAD2 Quadrilateral Element Connection

Description: Defines a homogeneous quadrilateral membrane and bending element (QUAD2) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQUAD2	EID	PID	G1	G2	G3	G4	TH		
CQUAD2	72	13	13	14	15	16	29.2		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PQUAD2 property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3 ≠ G4)
TH	Material property orientation angle in degrees (Real) The sketch below gives the sign convention for TH.



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.

3. All interior angles must be less than 180°.

Input Data Card CRIGD1 Rigid Element Connection

Description: Defines a rigid element where all degrees of freedom of the selected dependent grid points are coupled to the degrees of freedom of the reference grid point.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CRIGD1	EID		IG	G1	G2	G3	G4	G5	abc
CRIGD1	101		18	43	9	26	35	41	123

+bc	G6	G7	etc.						
+23	8	63							

Field	Contents
EID	Unique element identification number (Integer > 0)
IG	Identification number of the reference grid point.
G1, G2, etc.	Identification numbers of the dependent grid points.

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. The reference grid point must appear before any of the dependent grid points.
3. Any number of dependent grid points may be associated with a rigid element but only one reference grid point is allowed per rigid element.
4. Dependent degrees of freedom defined in a rigid element may not appear on MPC, ØMIT, ØMIT1 or SUPØRT cards.
5. In order to use this element, a Rigid Format ALTER must be made to replace GP4 and MCE1 with ZGP4 and ZMCE1 respectively. The input and output data blocks and parameters remain the same.

Input Data Card CRIGD2 Rigid Element Connection

Description: Defines a rigid element where selected degrees of freedom of the dependent grid points are coupled to the degrees of freedom of the reference grid point.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CRIGD2	EID		IG		G1	IC1	G2	IC2	abc
CRIGD2	102		9		45	123	53	135	123

+bc	G3	IC3	etc.						
+23	27	456							

Field	Contents
EID	Unique element identification number (Integer > 0).
IG	Identification number of the reference grid point.
G1, G2, etc.	Identification numbers of the dependent grid points.
IC1, IC2, etc.	List of dependent degrees of freedom associated with the preceeding dependent grid point (any of the digits 1-6 with no imbedded blanks).

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.

2. The reference grid point must appear before any of the dependent grid points. If any grid point of a rigid element has less than six coupled degrees of freedom, the reference grid point may not be connected to any other structural elements or rigid elements. Multiple numbering of a grid point may be used for this purpose.

3. Any number of dependent grid points may be associated with a rigid element but only one reference grid point is allowed per rigid element.

4. Dependent degrees of freedom defined in a rigid element may not appear on MPC, ØMIT, ØMIT1 or SUPØRT cards.

5. In order to use this element, a Rigid Format ALTER must be made to replace GP4 and MCE1 with ZGP4 and ZMCE1 respectively. The input and output data blocks and parameters remain the same.

Input Data Card CRØD Rod Element Connection

Description: Defines a tension-compression-torsion element (RØD) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CRØD	EID	PID	G1	G2	EID	PID	G1	G2	
CRØD	12	13	21	23	3	12	24	5	

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PRØD property card (Default is EID) (Integer > 0)
G1, G2	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2)

Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
2. See CØNRØD for alternative method of rod definition.
3. One or two RØD elements may be defined on a single card.

Input Data Card CSHEAR Shear Panel Element Connection

Description: Defines a shear panel element (SHEAR) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CSHEAR	EID	PID	G1	G2	G3	G4			
CSHEAR	3	6	1	5	3	7			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PSHEAR property card (Default is EID) (Integer > 0)
G1, G2, G3, G4	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3 ≠ G4)

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.

3. All interior angles must be less than 180°.

Input Data Card CSLØTi Slot Element Connections

Description: Defines an element connecting i = 3 or i = 4 points which solves the wave equation in two dimensions. Used in the acoustic cavity analysis for the definition of evenly spaced radial slots.

Formats and Examples:

1	2	3	4	5	6	7	8	9	10
CSLØT3	EID	IDS1	IDS2	IDS3		RHØ	B	M	
CSLØT3	100	1	3	2		3.E-3		6	

1	2	3	4	5	6	7	8	9	10
CSLØT4	EID	IDS1	IDS2	IDS3	IDS4	RHØ	B	M	
CSLØT4	101	1	3	2	4		6.2+4	3	

Field	Contents
EID	Element identification number (Integer > 0)
IDSj	Identification number of connected GRIDS points, j = 1,2,...J (Integer > 0)
RHØ	Fluid density in mass units (Real > 0.0 or "blank")
B	Fluid bulk modulus (Real ≥ 0.0 or blank)
M	Number of slots in circumferential direction (Integer ≥ 0, or "blank")

Remarks:

1. This card is allowed only if an AXSLØT card is also present.
2. The element identification number (IDF) must be unique with respect to all other fluid or structural elements.
3. If RHØ, B, or M are blank, the corresponding values on the AXSLØT data card are used, in which case the default value must not be blank (undefined).
4. Plot elements connecting two points at a time are generated for these elements. The CSLØT3 element generates 3 plot elements. The CSLØT4 element generates four plot elements, connecting points 1-2, 2-3, 3-4, and 4-1.
5. If B = 0.0, the slot is considered to be an incompressible fluid.
6. If M = 0 no matrices for CSLØTi elements are generated.

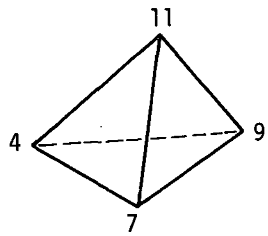
Input Data Card CTETRA Tetrahedron Element Connection

Description: Defines a tetrahedron element (3 dimensional solid with 4 vertices and 4 triangular faces, TETRA) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTETRA	EID	MID	G1	G2	G3	G4			
CTETRA	15	2	4	7	9	11			

Field	Contents
EID	Element identification number (Integer > 0)
MID	Material identification number (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integers > 0, G1 $\neq$ G2 $\neq$ G3 $\neq$ G4)



Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
2. There is no nonstructural mass.
3. For structural problems, material must be defined by MAT1 card.
4. Output stresses are given in basic coordinate system.
5. For heat transfer problems, material may be defined with either a MAT4 or MAT5 card.

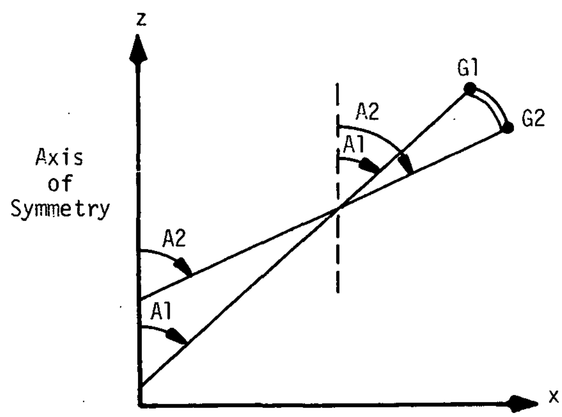
Input Data Card <u>CTØRDRG</u> Toroidal Ring Element Connection

<u>Description</u>: Defines an axisymmetric toroidal cross-section ring element (TØRDRG) of the structural model.

<u>Format and Example</u>:

1	2	3	4	5	6	7	8	9	10
CTØRDRG	EID	PID	G1	G2	A1	A2			
CTØRDRG	25	2	47	48	30.0	60.0			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Property identification number (Default is EID) (Integer > 0)
G1, G2	Grid Point identification numbers of connection points (Integer > 0; G1 ≠ G2)
A1	Angle of curvature at grid point 1 in degrees (Real; 0° ≤ A1 ≤ 180°; A2 ≥ A1)
A2	Angle of curvature at grid point 2 in degrees (Real; 0° ≤ A2 ≤ 180°; A2 ≥ A1)



<u>Remarks</u>:

1. Element identification numbers must be unique with respect to <u>all</u> other element identification numbers.

2. Grid points G1 and G2 must lie in the x-z plane of the basic coordinate system and to the right of the axis of symmetry (the z-axis).

3. If A1 = 0, the element is assumed to be a shell cap.

4. Only elements of zero or positive Gaussian curvature may be used.

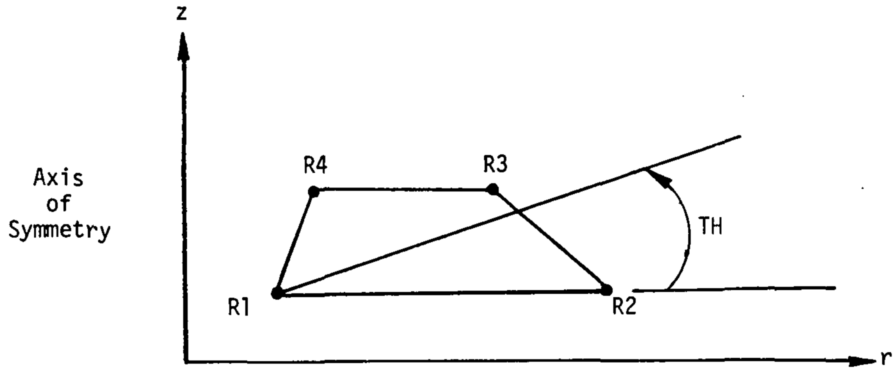
Input Data Card CTRAPAX Trapezoidal Ring Element Connection

Description: Defines an axisymmetric trapezoidal cross-section ring element with non-axisymmetric deformation of the structural model with reference to property card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRAPAX	EID	PID	R1	R2	R3	R4	TH		
CTRAPAX	15	5	10	11	12	13	30.0		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PTRAPAX card (Integer > 0)
R1,R2,R3,R4	Identification numbers of RINGAX cards (Integer > 0; R1 ≠ R2 ≠ R3 ≠ R4)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



Remarks:

1. CTRAPAX card is allowed if and only if an AXIC card is also present.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. RINGAX identification numbers R1, R2, R3 and R4 must be ordered counterclockwise around the perimeter.
4. For a discussion of the axisymmetric ring problem, see Section 5.11 of the Theoretical Manual.
5. The lines connecting R1 to R2 and R4 to R3 must be parallel to the r axis.
6. This element cannot be modeled with a grid point on the axis of symmetry.

NASTRAN DATA DECK

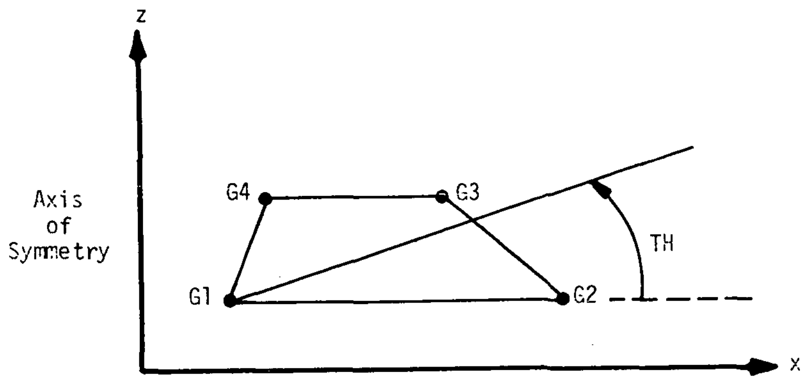
Input Data Card CTRAPRG Trapezoidal Ring Element Connection

Description: Defines an axisymmetric trapezoidal cross-section ring element (TRAPRG) of the structural model without reference to a property card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRAPRG	EID	G1	G2	G3	G4	TH	MID		
CTRAPRG	72	13	14	15	16	29.2	13		

Field	Contents
EID	Element identification number (Integer > 0)
G1,G2,G3,G4	Grid point identification number of connection points (Integers > 0; G1 ≠ G2 ≠ G3 ≠ G4)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.
MID	Material property identification number (Integer > 0)



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. The four grid points must lie in the x-z plane of both the basic and any local coordinate systems and to the right of the axis of symmetry (the z-axis).

3. Grid points G1, G2, G3 and G4 must be ordered counterclockwise around the perimeter of the element as in the above sketch.

4. The line connecting grid points G1 and G2 and the line connecting grid points G3 and G4 must both be parallel to the x-axis.

5. All interior angles must be less than 180°.

6. For structural problems, the material property identification number must reference only a MAT1 or MAT3 card.

7. For heat transfer problems, the material property identification number must reference only a MAT4 or MAT5 card.

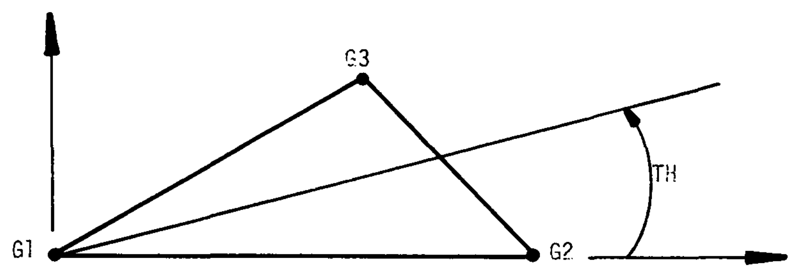
Input Data Card CTRBSC Triangular Element Connection

Description: Defines a basic triangular bending element (TRBSC) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRBSC	EID	PID	G1	G2	G3	TH			
CTRBSC	16	2	12	1	3	16.2			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PTRBSC property card (Default is EID) (Integer > 0)
G1,G2,G3	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Interior angles must be less than 180°.
3. No structural mass is generated by this element.

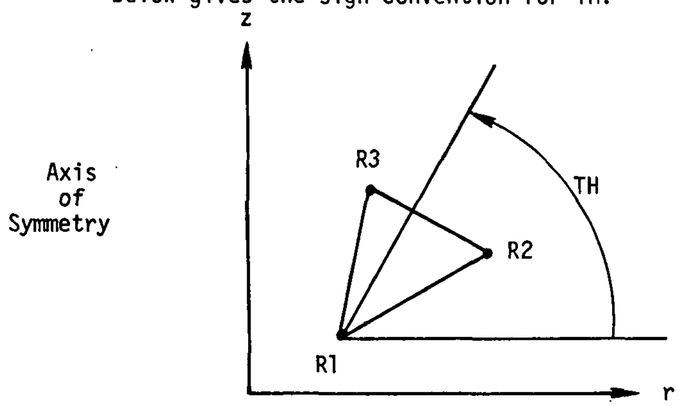
Input Data Card CTRIAAX Triangular Ring Element Connection

Description: Defines an axisymmetric triangular cross-section ring element with non-axisymmetric deformation of the structural model with reference to property card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRIAAX	EID	PID	R1	R2	R3	TH			
CTRIAAX	20	15	42	43	52	60.0			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PTRIAAX card (Integer > 0)
R1,R2,R3	Identification numbers of RINGAX cards (Integer > 0; R1 ≠ R2 ≠ R3)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



Remarks:
1. CTRIAAX card is allowed if and only if an AXIC card is also present.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. RINGAX identification numbers R1,R2 and R3 must be ordered counterclockwise around the perimeter.
4. For a discussion of the axisymmetric ring problem, see Section 5.11 of the Theoretical Manual.

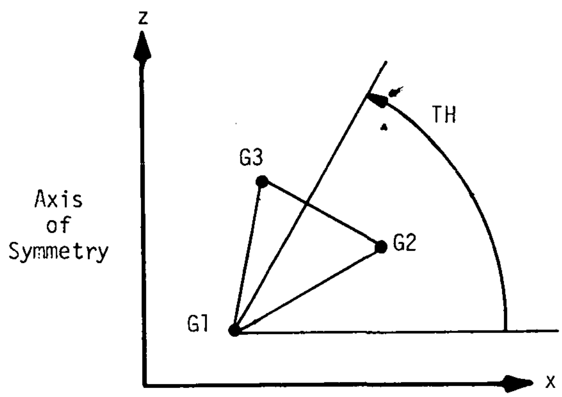
Input Data Card CTRIARG Triangular Ring Element Connection

Description: Defines an axisymmetric triangular cross section ring element (TRIARG) of the structural model without reference to a property card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRIARG	EID	G1	G2	G3	TH	MID			
CTRIARG	16	12	13	14	29.2	17			

Field	Contents
EID	Element identification number (Integer > 0)
G1, G2, G3	Grid point identification numbers of connection points (Integers > 0; G1 ≠ G2 ≠ G3)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for the TH.
MID	Material identification number (Integer > 0)



Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.

2. The grid points must lie in the x-z plane of both the basic and any local coordinate systems and to the right of the axis of symmetry (the z-axis).

3. Grid points G1, G2 and G3 must be ordered counterclockwise around the perimeter of the element as shown in the above sketch.

4. For structural problems, the material property identification number must reference only a MAT1 or MAT3 card.

5. For heat transfer problems, the material property identification number must reference only a MAT4 or MAT5 card.

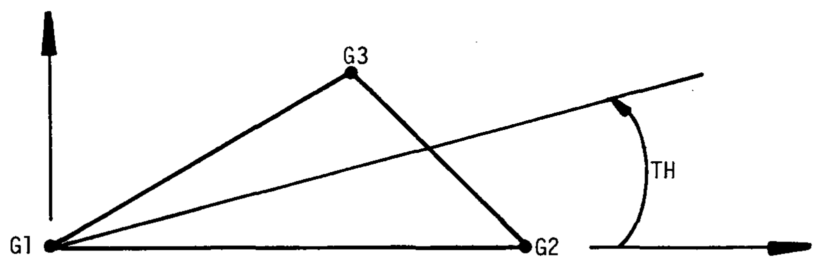
Input Data Card <u>CTRIA1</u> Triangular Element Connection

<u>Description</u>: Defines a triangular membrane and bending element (TRIA1) of the structural model.

<u>Format and Example</u>:

1	2	3	4	5	6	7	8	9	10
CTRIA1	EID	PID	G1	G2	G3	TH			
CTRIA1	16	2	12	1	3	16.2			

<u>Field</u>	<u>Contents</u>
EID	Element identification number (Integer > 0)
PID	Identification number of a PTRIA1 property card (Default is EID) (Integer > 0)
G1,G2,G3	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



<u>Remarks</u>: 1. Element identification numbers must be unique with respect to <u>all</u> other element identification numbers.

2. Interior angles must be less than 180°.

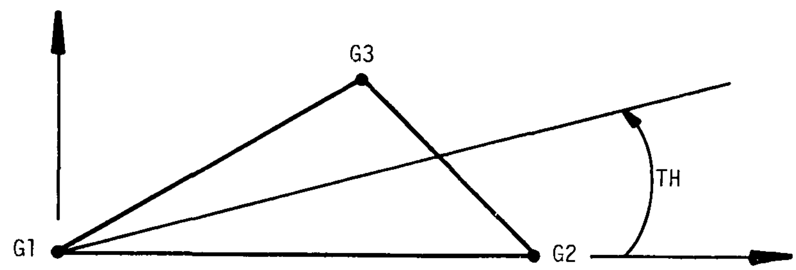
Input Data Card <u>CTRIA2</u> Triangular Element Connection

<u>Description</u>: Defines a triangular membrane and bending element (TRIA2) of the structural model.

<u>Format and Example</u>:

1	2	3	4	5	6	7	8	9	10
CTRIA2	EID	PID	G1	G2	G3	TH			
CTRIA2	16	2	12	1	3	16.2			

<u>Field</u>	<u>Contents</u>
EID	Element identification number (Integer > 0)
PID	Identification number of a PTRIA2 property card (Default is EID) (Integer > 0)
G1,G2,G3	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



<u>Remarks</u>: 1. Element identification numbers must be unique with respect to <u>all</u> other element identification numbers.

2. Interior angles must be less than 180°.

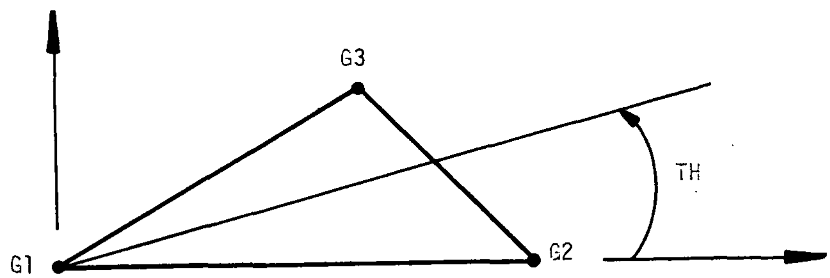
Input Data Card <u>CTRMEM</u> Triangular Element Connection

Description: Defines a triangular membrane element (TRMEM) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRMEM	EID	PID	G1	G2	G3	TH			
CTRMEM	16	2	12	1	3	16.3			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PTRMEM property card (Default is EID) (Integer > 0)
G1,G2,G3	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Interior angles must be less than 180°.

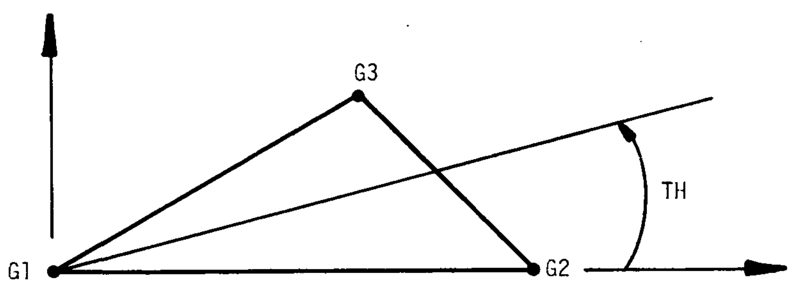
Input Data Card CTRPLT Triangular Element Connection

Description: Defines a triangular bending element (TRPLT) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRPLT	EID	PID	G1	G2	G3	TH			
CTRPLT	16	2	12	1	3	16.2			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PTRPLT property card (Default is EID) (Integer > 0)
G1,G2,G3	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



Remarks: 1. *Element identification numbers must be unique with respect to all other element identification numbers.*

2. Interior angles must be less than 180°.

3. No structural mass is generated by this element.

Input Data Card CTUBE Tube Element Connection

Description: Defines a tension-compression-torsion element (TUBE) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTUBE	EID	PID	G1	G2	EID	PID	G1	G2	
CTUBE	12	13	21	23	3	12	24	5	

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PTUBE property card (Default is EID) (Integer > 0)
G1, G2	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2)

Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. One or two TUBE elements may be defined on a single card.

Input Data Card CTWIST Twist Panel Element Connection

Description: Defines a twist panel element (TWIST) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTWIST	EID	PID	G1	G2	G3	G4			
CTWIST	2	6	1	5	3	7			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PTWIST property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0; G1 $\neq$ G2 $\neq$ G3 $\neq$ G4)

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.
3. All interior angles must be less than 180°.

Input Data Card CVISC Viscous Damper Connection

Description: Defines a viscous damper element (VISC) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CVISC	EID	PID	G1	G2	EID	PID	G1	G2	
CVISC	21	6327	29	31	22	6527	35	33	

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of PVISC property card (Default is EID) (Integer > 0)
G1, G2	Grid point identification numbers of connection points (Integer > 0; G1 $\neq$ G2)

Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. One or two VISC elements may be defined on a single card.

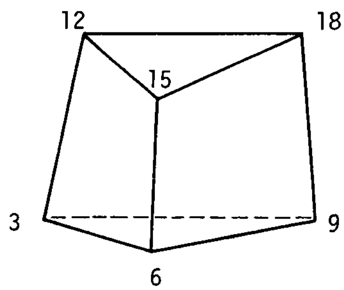
Input Data Card CWEDGE Wedge Element Connection

Description: Defines a wedge element (3 dimensional solid, with three quadrilateral faces and two opposing triangular faces, WEDGE) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CWEDGE	EID	MID	G1	G2	G3	G4	G5	G6	
CWEDGE	15	2	3	6	9	12	15	18	

Field	Contents
EID	Element identification number (Integer > 0)
MID	Material identification number (Integer > 0)
G1,...,G6	Grid point identification numbers of connection points (Integers > 0, G1 ≠ G2 ≠ ... ≠ G6)



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. The order of the grid points is: G1, G2, G3 on one triangular face, G4, G5, G6 at the other triangular face. G1, G4 on a common edge, G2, G5 on a common edge.

3. The quadrilateral faces must be nearly planar.

4. There is no nonstructural mass.

5. For structural problems, material must be defined by MAT1 card.

6. Output stresses are given in the basic coordinate system.

7. For heat transfer problems, material may be defined with either a MAT4 or MAT5 card.

Input Data Card CYJØIN

Description: Defines the boundary points of a segment for cyclic symmetry structural molds.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CYJØIN	SIDE	C	G1	G2	G3	G4	G5	G6	abc
CYJØIN	1		7	9	16	25	33	64	ABC

+bc	G7	G8	G9	-etc.-					
+BC	72								

Alternate Form

CYJØIN	SIDE	C	GID1	"THRU"	GID2				
CYJØIN	2	S	6	THRU	32				

Field	Contents
SIDE	Side identification (Integer 1 or 2)
C	Coordinate System (BCD value R,C or S or blank)
Gi,GIDi	Grid or scalar point identification numbers (Integer > 0)

Remarks:

1. CYJØIN bulk data cards are only used for cyclic symmetry problems. A parameter (CTYPE) must specify rotational or dihedral symmetry.

2. For rotational symmetry problems there must be one logical card for side 1 and one for side 2. The two lists specify grid points to be connected, hence both lists must have the same length.

3. For dihedral symmetry problems, side 1 refers to the boundary between segments and side 2 refers to the middle of a segment. A coordinate system must be referenced in field 3, where R = rectangular C = cylindrical and S = spherical.

4. All components of displacement at boundary points are connected to adjacent segments, except those constrained by SPC, MPC or ØMIT.

NASTRAN DATA DECK

Input Data Card DAREA Dynamic Load Scale Factor

Description: This card is used in conjunction with the RLØAD1, RLØAD2, TLØAD1, and TLØAD2 data cards and defines the point where the dynamic load is to be applied with the scale (area) factor A.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DAREA	SID	P	C	A	P	C	A		
DAREA	3	6	2	8.2	15	1	10.1		

Field	Contents
SID	Identification number of DAREA set (Integer > 0)
P	Grid or scalar point identification number (Integer > 0)
C	Component number (1-6 for grid point; blank or 0 for scalar point)
A	Scale (area) factor A for the designated coordinate (Real)

Remarks: One or two scale factors may be defined on a single card.

Input Data Card DEFØRM Element Deformation

Description: Defines enforced axial deformation for one-dimensional elements for use in statics problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DEFØRM	SID	EID	D	EID	D	EID	D		
DEFØRM	1	535	.05	536	-.10				

Field	Contents
SID	Deformation set identification number (Integer > 0)
EID	Element number (Integer > 0)
D	Deformation (+ = elongation) (Real)

Remarks:

1. The referenced element must be one-dimensional (i.e., a RØD (including CØNRØD), TUBE or BAR).
2. Deformation sets must be selected in the Case Control Deck (DEFØRM=SID) to be used by NASTRAN.
3. From one to three enforced element deformations may be defined on a single card.

Input Data Card DELAY Dynamic Load Time Delay

Description: This card is used in conjunction with the RLØAD1, RLØAD2, TLØAD1 and TLØAD2 data cards and defines the time delay term τ in the equations of the loading function.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DELAY	SID	P	C	T	P	C	T		
DELAY	5	21	6	4.25	7	6	8.1		

Field Contents

SID Identification number of DELAY set (Integer > 0)

P Grid or scalar point identification number (Integer > 0)

C Component number (1-6 for grid point, blank or 0 for scalar point)

T Time delay τ for designated coordinate (Real)

Remarks: One or two dynamic load time delays may be defined on a single card.

Input Data Card DLØAD Dynamic Load Combination (Superposition)

Description: Defines a dynamic loading condition for frequency response or transient response problems as a linear combination of load sets defined via RLØAD1 or RLØAD2 cards (for frequency response) or TLØAD1 or TLØAD2 cards (for transient response).

Format and Example:

1	2	3	4	5	6	7	8	9	10
DLØAD	SID	S	S1	L1	S2	L2	S3	L3	+abc
DLØAD	17	1.0	2.0	6	-2.0	7	2.0	8	+A
+abc	S4	L4		-etc.-					
+A	-2.0	9							

-etc.-

Field	Contents
SID	Load set identification number (Integer > 0)
S	Scale Factor (Real)
Si	Scale Factors (Real)
Li	Load set identification numbers defined via card types enumerated above (Integer > 0)

Remarks: 1. The load vector being defined by this card is given by

$$\{P\} = S \sum_i Si\{P_{Li}\}.$$

2. The Li must be unique.
3. SID must be unique from all Li.
4. Nonlinear transient loads may not be included; they are selected separately in the Case Control Deck.
5. Linear load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
6. A DLØAD card may not reference a set identification number defined by another DLØAD card.
7. TLØAD1 and TLØAD2 loads may be combined only thru the use of the DLØAD card.
8. RLØAD1 and RLØAD2 loads may be combined only thru the use of the DLØAD card.
9. SID must be unique for all TLØAD1, TLØAD2, RLØAD1, and RLØAD2 cards.

Input Data Card DMI Direct Matrix Input

Description: Used to define matrix data blocks directly. Generates a matrix of the form

$$[A] = \begin{bmatrix} A_{11} & A_{12} & \cdots\cdots & A_{1n} \\ A_{21} & A_{22} & \cdots\cdots & A_{2n} \\ \vdots & \vdots & & \vdots \\ A_{m1} & \cdots\cdots & & A_{mn} \end{bmatrix}$$

where the elements A_{ij} may be real or complex single-precision or double precision numbers.

Formats and Example: (The first logical card is a header card.)

1	2	3	4	5	6	7	8	9	10
DMI	NAME	"0"	FØRM	TIN	TØUT		M	N	
DMI	QQQ	0	2	3	3		4	2	

1	2	3	4	5	6	7	8	9	10
DMI	NAME	J	I1	A(I1,J)	A(I1+1,J)		etc.	I2	+abc
DMI	QQQ	1	1	1.0	2.0	3.0	4.0	3	+1
+abc	A(I2,J)		etc.						
+1	5.0	6.0							

1	2	3	4	5	6	7	8	9	10
DMI	QQQ	2	2	6.0	7.0	4	8.0	9.0	

(etc. for each nonnull column)

Field	Contents
NAME	Any NASTRAN BCD value (1-8 alphnumeric characters, the first of which must be alphabetic) which will be used in the DMAP sequence to reference the data block
FØRM	1 Square matrix (not symmetric) 2 General rectangular matrix 6 Symmetric matrix
TIN	Type of matrix being input as follows: 1 Real, single-precision (One field is used per element) 2 Real, double-precision (One field is used per element) 3 Complex, single-precision (Two fields are used per element) 4 Complex, double-precision (Two fields are used per element)
TØUT	Type of matrix which will be created 1 Real, single-precision 3 Complex, single-precision 2 Real, double-precision 4 Complex, double-precision
M	Number of rows in A (Integer > 0)
N	Number of columns in A (Integer > 0)
J	Column number of A (Integer > 0)
I1,I2,etc.	Row number of A (Integer > 0)
A(Ix,J)	Element of A (See TIN) (Real)

(Continued)

DMI (Cont.)

Remarks: 1. The user must write a DMAP (or make alterations to a rigid format) in order to use the DMI feature since he is defining a data block. All of the rules governing the use of data blocks in DMAP sequences apply. In the example shown above, the data block QQQ is defined to be the complex, single-precision rectangular 4x2 matrix

$$[QQQ] = \begin{bmatrix} (1.0,\ 2.0) & (0.0,\ 0.0) \\ (3.0,\ 4.0) & (6.0,\ 7.0) \\ (5.0,\ 6.0) & (0.0,\ 0.0) \\ (0.0,\ 0.0) & (8.0,\ 9.0) \end{bmatrix}$$

The DMAP data block NAME (QQQ in the example) will appear in the initial FIAT and the data block will initially appear on the Data Pool File (PØØL).

2. A limit to the number of DMI's which may be defined is set by the size of the Data Pool Dictionary. The total number of DMI's may not exceed this size.

3. There are a number of reserved words which may not be used for DMI names. Among these are PØØL, NPTP, ØPTP, UMF, NUMF, PLT1, PLT2, INPT, GEØM1, GEØM2, GEØM3, GEØM4 GEØM5, EDT, MPT, EPT, DIT, DYNAMICS, IFPFILE, AXIC, FØRCE, MATPØØL, PCDB, XYCDB, CASECC, any DTI names, and SCRATCH1 thru SCRATCH9.

4. Field 3 of the header card must contain an integer 0.

5. For symmetric matrices, the entire matrix must be input.

6. Only nonzero terms need be entered.

7. A blank field on this card is not equivalent to a zero. If zero input is desired, the appropriate type zero must be punched (i.e., 0.0 or 0.0D0).

8. Complex input must have both the real and imaginary parts punched if either part is nonzero.

9. A new column requires a new card be started.

Input Data Card DMIAX Direct Axisymmetric Matrix Input

Description: Defines axisymmetric (fluid or structure) related direct input matrix terms.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DMIAX	NAME	"0"	IFØ	TIN	TØUT				
DMIAX	B2PP	0	1	3	4				

1	2	3	4	5	6	7	8	9	10
DMIAX	NAME	GJ	CJ	NJ					+abc
DMIAX	B2PP	32							+BG27

1	2	3	4	5	6	7	8	9	10
+abc	GI	CI	NI	X_{ij}	Y_{ij}				+def
+BG27	1027	3		4.35+6	2.27+3				

-etc. for each column and row containing nonzero terms-

Field	Contents
NAME	BCD name of matrix (one to eight alphanumeric characters the first of which is alphabetic)
IFØ	1 Square matrix 2 General rectangular matrix 6 Symmetric matrix } Identification of Matrix Form
TIN	Type of matrix being input as follows: 1 Real, single-precision (One field is used per element) 3 Complex, single-precision (Two fields are used per element)
TØUT	Type of matrix which will be created 1 Real, single-precision 3 Complex, single-precision 2 Real, double precision 4 Complex, double-precision
GJ, GI	Grid, scalar, RINGFL fluid point, PRESPT pressure point, FREEPT free surface displacement, or extra point identification number (Integer > 0)
CJ, CI	Component number for GJ or GI grid point ($0 \leq$ Integer ≤ 6; Blank or zero if GJ or GI is a scalar, fluid, or extra point)
NJ, NI	Harmonic number of RINGFL point. Must be blank if a point type other than RINGFL is used. Negative number implies the "sine" series, positive implies the "cosine" series. (Integer)
X_{ij}, Y_{ij}	Real and Imaginary parts of matrix element; row (GI, CI, NI) column (GJ,CJ,NJ)

(Continued)

Remarks:

1. This card is allowed only if an AXIF card is also present.
2. Matrices defined on this card may be used in dynamics by selection in the Case Control Deck by K2PP=NAME, B2PP=NAME, or M2PP=NAME for $[K^2_{pp}]$, $[B^2_{pp}]$, or $[M^2_{pp}]$ respectively.
3. In addition to the header card containing IFØ, TIN and TØUT, a logical card consisting of two or more physical cards is needed for each nonnull column of the matrix.
4. If TIN = 1, Y_{ij} must be blank.
5. Field 3 of the header card must contain an integer 0.
6. For symmetric matrices, the entire matrix must be input.
7. Only nonzero terms need be entered.

Input Data Card DMIG   Direct Matrix Input at Grid Points

Description: Defines structure-related direct input matrices.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DMIG	NAME	"0"	IFØ	TIN	TØUT				
DMIG	STIF	0	1	3	4				
DMIG	NAME	GJ	CJ		GI	CI	X_{ij}	Y_{ij}	Xabc
DMIG	STIF	27	1		2	3	3.+5	3.+3	EKG1
+abc	GI	CI	X_{ij}	Y_{ij}	GI	CI	X_{ij}	Y_{ij}	Xcef
+KG1	2	4	2.5+10	0.	50		1.0	0.	

etc. for each column containing nonzero terms

Field	Contents
NAME	BCD name of matrix (one to eight alphanumeric characters the first of which is alphabetic)
IFØ	1 Square matrix 2 General rectangular matrix 6 Symmetric matrix
TIN	Type of matrix being input as follows: 1 Real, single-precision (One field is used per element) 3 Complex, single-precision (Two fields are used per element)
TØUT	Type of matrix which will be created 1 Real, single-precision 3 Complex, single-precision 2 Real, double-precision 4 Complex, double-precision
GJ, GI	Grid or scalar or extra point identification number (Integer > 0)
CJ, CI	Component number for GJ a grid point ($0 < CJ \le 6$); blank or zero for GJ a scalar or extra point
X_{ij}, Y_{ij}	Real and imaginary parts of matrix element

Remarks:

1. Matrices defined on this card may be used in dynamics by selection in the Case Control Deck by K2PP=NAME, B2PP=NAME, or M2PP=NAME for $[K^2_{pp}]$, $[B^2_{pp}]$, or $[M^2_{pp}]$, respectively.
2. In addition to the header card containing IFØ, TIN and TØUT, a logical card consisting of one or more physical cards is needed for each nonnull column of the matrix.
3. If TIN = 1, Y_{ij} must be blank.
4. Field 3 of the header card must contain an integer 0.
5. For symmetric matrices, the entire matrix must be input.
6. Only nonzero terms need be entered.
7. The matrix names must be unique among all DMIG's.

Input Data Card DPHASE Dynamic Load Phase Lead

Description: This card is used in conjunction with the RLØAD1 and RLØAD2 data cards to define the phase lead term θ in the equation of the loading function.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DPHASE	SID	P	C	TH	P	C	TH		
DPHASE	4	21	6	2.1	8	6	7.2		

Field	Contents
SID	Identification number of DPHASE set (Integer > 0)
P	Grid or scalar point identification number (Integer > 0)
C	Component number (1-6 for grid point, 0 or blank for scalar point)
TH	Phase lead θ (in degrees) for designated coordinate (Real)

Remarks: One or two dynamic load phase lead terms may be defined on a single card.

Input Data Card DSFACT Differential Stiffness Factors

Description: Used to define scale factors for applied loads and stiffness matrices in a Differential Stiffness Analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DSFACT	SID	B1	B2	B3	B4	B5	B6	B7	abc
DSFACT	97	-1.0	-2.0	-4.0					

+bc	B8	B9	-etc.-						

-etc.-

Field	Contents
SID	Set identification number (Unique Integer > 0)
Bi	Scale factor (Real)

Remarks:
1. Load sets must be selected in the Case Control Deck (DSCØ=SID) to be used by NASTRAN.
2. All fields following the last entry must be blank.
3. An error is detected if any continuation cards follow the last entry.

Input Data Card DTI Direct Table Input

Description: Used to define table data blocks directly.

Format and Example: (The first logical card is a header card)

1	2	3	4	5	6	7	8	9	10
DTI	NAME	"0"	T1	T2	T3	T4	T5	T6	+00
DTI	XXX	0	3	4	4096	32768	1	0	

+00	V	V		-etc.-	ENDREC				+01

-etc.-

DTI	NAME	IREC	V	V	V	V	V	V	+11
DTI	XXX	1	2.0	-6	ABC	6.0D0	-1	2	+11

+11	V	V	V	V	-etc.-		ENDREC		+12
+11	4	-6.2	2.9	1	DEF	-1	ENDREC		

-etc.-

Field	Contents
NAME	Any NASTRAN BCD value (1-8 alphanumeric characters, the first of which must be alphabetic) which will be used in the DMAP sequence to reference the data block
Ti	Trailer values ($65535 \geq$ Integer ≥ 0)
IREC	Record Number (sequential integer beginning with 1)
V	Value (blank, integer, real, BCD (except "ENDREC"), double precision)
ENDREC	The BCD value ENDREC which flags the end of the string of values that constitute logical record IREC

Remarks:

1. Records may be made as long as desired via continuation cards.

2. Values may be of any type (blank, integer, real, BCD, double precision) with the exception that a BCD value may not be "ENDREC".

3. All fields following ENDREC must be blank.

4. The user must write a DMAP (or make alterations to a rigid format) in order to use the DTI feature since he is defining a data block. All of the rules governing the use of data blocks in DMAP sequences apply.

5. The DMAP data block NAME (XXX in the example) will appear in the initial FIAT and the data block will initially appear on the PØØL.

6. If trailer is not specified, T1 = number of records, T2 thru T6 = 0.

7. In addition to the header card, there must be one logical card for each record in the table.

Input Data Card EIGB Buckling Analysis Data

Description: Defines data needed to perform buckling analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
EIGB	SID	METHØD	L1	L2	NEP	NDP	NDN	E	+abc
EIGB	13	DET	0.1	2.5	2	1	1	0.0	ABC
+abc	NØRM	G	C						
+BC	MAX								

Field	Contents
SID	Set identification number (Unique integer > 0)
METHØD	Method of eigenvalue extraction, one of the BCD values "INV", "DET", "UINV", or "UDET" INV - Inverse power method, symmetric matrix operations DET - Determinant method, symmetric matrix operations UINV - Inverse power method, unsymmetric matrix operations UDET - Determinant method, unsymmetric matrix operations
L1,L2	Eigenvalue range of interest (Real; L1 < L2 > 0.0)
NEP	Estimate of number of roots in positive range (Integer > 0)
NDP, NDN	Desired number of positive and negative roots (Default = 3 NEP) (Integer > 0)
E	Convergence criteria (optional) (Real $\geq$ 0.0)
NØRM	Method for normalizing eigenvectors, one of the BCD values "MAX" or "PØINT" MAX - Normalize to unit value of the largest component in the analysis set PØINT - Normalize to unit value of the component defined in fields 3 and 4 defaults to "MAX" if defined component is zero.
G	Grid or scalar point identification number (Integer > 0) (Required if and only if NØRM = "PØINT")
C	Component number (One of the integers 1-6) (Required if and only if NØRM = "PØINT" and G is a geometric grid point)

Remarks:

1. Buckling analysis root extraction data sets must be selected in the Case Control Deck (METHØD = SID) to be used by NASTRAN.

2. The quantities L1 and L2 are dimensionless and specify a range in which the eigenvalues are to be found. An eigenvalue is a factor by which the prebuckling state of stress (first subcase) is multiplied to produce buckling.

3. The continuation card is required.

4. See Sections 10.3.6 and 10.4.2.2 of the Theoretical Manual for a discussion of convergence criteria.

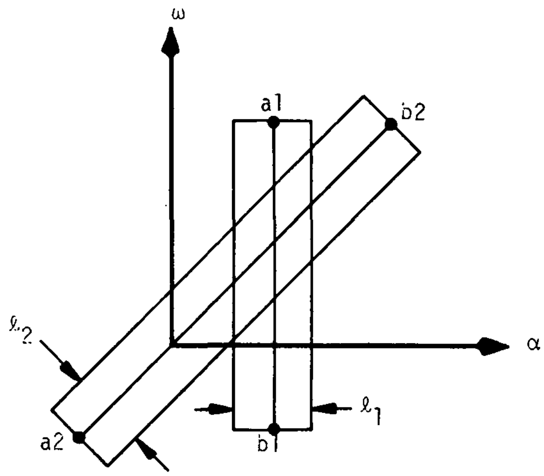
5. If METHØD = DET, L1 must be greater than or equal to 0.0.

6. If NØRM = MAX, components that are not in the analysis set may have values larger than unity.

7. If NØRM = PØINT, the selected component must be in the analysis set.

Input Data Card EIGC Complex Eigenvalue Extraction Data

Description: Defines data needed to perform complex eigenvalue analysis.



Format and Example:

1	2	3	4	5	6	7	8	9	10
EIGC	SID	METHØD	NØRM	G	C	E			+abc
EIGC	14	DET	PØINT	27		1.-8			ABC
+abc	α_{a1}	ω_{a1}	α_{b1}	ω_{b1}	ℓ_1	N_{e1}	N_{d1}		+def
+BC	2.0	5.6	2.0	-3.4	2.0	4	4		DEF
+def	α_{a2}	ω_{a2}	α_{b2}	ω_{b2}	ℓ_2	N_{e2}	N_{d2}		
+EF	-5.5	-5.5	5.6	5.6	1.5	6	3		

(etc.)

Field	Contents
SID	Set identification number (Unique integer > 0)
METHØD	Method of complex eigenvalue extraction, one of the BCD values, "INV" "DET" or "HESS" INV - Inverse power method DET - Determinant method HESS - Upper Hessenburg method

NØRM	Method for normalizing eigenvectors, one of the BCD values "MAX" or "PØINT" MAX - Normalize to a unit value for the real part and a zero value for the imaginary part, the component having the largest magnitude PØINT - Normalize to a unit value for the real part and a zero value for the imaginary part the component defined in fields 5 and 6 - defaults to "MAX" if the magnitude of the defined component is zero.
G	Grid or scalar point identification number (Required if and only if NØRM=PØINT) (Integer > 0)
C	Component number (Required if and only if NØRM="PØINT" and G is a geometric grid point) ($0 \leq$ integer ≥ 6)
E	Convergence criterion (optional) (Real ≥ 0.0)
$(\alpha_{aj}, \omega_{aj})$, $(\alpha_{bj}, \omega_{bj})$	Two complex points defining a line in the complex plane (Real)
ℓj	Width of region in complex plane (Real > 0.0)
N_{ej}	Estimated number of roots in each region (Integer > 0)
N_{dj}	Desired number of roots in each region (Default is $3N_{ej}$) (Integer > 0)

Remarks:

1. Each continuation card defines a rectangular search region. Any number of regions may be used and they may overlap. Roots in overlapping regions will not be extracted more than once.

2. Complex eigenvalue extraction data sets must be selected in the Case Control Deck (CMETHØD=SID) to be used by NASTRAN.

3. The units of α, ω and ℓ are radians per unit time.

4. At least one continuation card is required.

5. For the determinant method with no damping matrix, complex conjugates of the roots found are not printed.

6. See Section 10.4.4.5 of the Theoretical Manual for a discussion of convergence criteria.

7. For the Upper Hessenberg method, N_{d1} controls the number of vectors computed. Only one continuation card is considered and the (α,ω) pairs, along with the parameters ℓ_1 and N_{e1}, are ignored. Insufficient storage for HESS will cause the program to switch to INV.

Input Data Card EIGP Poles in Complex Plane

Description: Defines poles that are used in complex eigenvalue extraction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
EIGP	SID	α	ω	M	α	ω	M		
EIGP	15	-5.2	0.0	2	6.3	5.5	3		

Field	Contents
SID	Set identification number (Integer > 0)
(α,ω)	Coordinates of point in complex plane (Real)
M	Multiplicity of complex root at pole defined by (α,ω) (Integer > 0)

Remarks:

1. Defines poles in complex plane that are used with associated EIGC card having same set number.
2. The units of α,ω are radians per unit time.
3. Poles are used only in the Determinant Method.
4. One or two poles may be defined on a single card.

Input Data Card EIGR Real Eigenvalue Extraction Data

Description: Defines data needed to perform real eigenvalue analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
EIGR	SID	METHØD	F1	F2	NE	ND	NZ	E	+abc
EIGR	13	DET	1.9	15.6	10	12	0	1.-3	ABC
+abc	NØRM	G	C						
+BC	PØINT	32	4						

Field

SID — Set identification number (Unique integer > 0)

METHØD — Method of eigenvalue extraction, one of the BCD values "INV", "DET", "GIV", "UINV", or "UDET".

- INV - Inverse power method, symmetric matrix operations.
- DET - Determinant method, symmetric matrix operations.
- GIV - Givens method of tridiagonalization.
- UINV - Inverse power method, unsymmetric matrix operations.
- UDET - Determinant method, unsymmetric matrix operations.

F1,F2 — Frequency range of interest (Required for METHØD = "DET", "INV", "UDET", or "UINV") (Real $\geq$ 0.0; F1 < F2). Frequency range over which eigenvectors are desired for METHØD = "GIV". The frequency range is ignored if ND > 0, in which case the eigenvectors for the first ND positive roots are found. (Real, F1 < F2).

NE — Estimate of number of roots in range (Required for METHØD = "DET", "INV", "UDET", or "UINV") (Integer > 0)

ND — Desired number of roots for METHØD = "DET", "INV", "UDET", or "UINV" (Default is 3 NE) (Integer > 0). Desired number of eigenvectors for METHØD = "GIV" (Default is zero) (Integer $\geq$ 0)

NZ — Number of free body modes (Optional - used only if METHØD = "DET" or "UDET") (Integer $\geq$ 0)

E — Mass orthogonality test parameter (Default is 0.0 which means no test will be made) (Real $\geq$ 0.0)

NØRM — Method for normalizing eigenvectors, one of the BCD values "MASS", "MAX" or "PØINT"

- MASS - Normalize to unit value of the generalized mass
- MAX - Normalize to unit value of the largest component in the analysis set
- PØINT - Normalize to unit value of the component defined in fields 3 and 4 - defaults to "MAX" if defined component is zero

G	Grid or scalar point identification number (Required if and only if NØRM="PØINT") (Integer $\geq$ 0)
C	*Component number (One of the integers 1-6) (Required if and only if* NØRM="PØINT" and G is a geometric grid point)

Remarks:

1. Real eigenvalue extraction data sets must be selected in the Case Control Deck (METHØD = SID) to be used by NASTRAN.
2. The units of F1 and F2 are cycles per unit time.
3. The continuation card is required.
4. If METHØD = "GIV", all eigenvalues are found.
5. If METHØD = "GIV", the mass matrix for the analysis set must be positive definite. This means that all degrees of freedom, including rotations, must have mass properties. ØMIT cards may be used to remove massless degrees of freedom.
6. A nonzero value of E in field 9 also modifies the convergence criteria. See Sections 10.3.6 and 10.4.2.2 of the Theoretical Manual for a discussion of convergence criteria.
7. If NØRM = MAX, components that are not in the analysis set may have values larger than unity.
8. If NØRM = PØINT, the selected component must be in the analysis set.
9. If METHØD = "GIV" and rigid body modes are present, F1 should be set to zero if the rigid body eigenvectors are desired.
10. The desired number of roots (ND) includes all roots previously found, such as rigid body modes determined with the use of the SUPØRT card, or the number of roots found on the previous run when restarting and APPENDing the eigenvector file.

Input Data Card EPØINT Extra Point

Description: Defines extra points of the structural model for use in dynamics problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
EPØINT	ID	ID	ID	ID	ID	ID	ID	ID	
EPØINT	3	18	1	4	16	2			

Alternate Form

EPØINT	ID1	"THRU"	ID2						
EPØINT	17	THRU	43						

Field	Contents
ID,ID1,ID2	Extra point identification number (Integer > 0; ID1 < ID2)

Remarks:
1. All extra point identification numbers must be unique with respect to all other structural, scalar, and fluid points.
2. This card is used to define coordinates used in transfer function definitions (see TF card).
3. If the alternate form is used, extra points ID1 thru ID2 are defined.

Input Data Card FLFACT Aerodynamic Physical Data

Description: Used to specify densities, Mach numbers, and reduced frequencies for flutter analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FLFACT	SID	F1	F2	F3	F4	F5	F6	F7	ABC
FLFACT	97	.3	.7	3.5					
+BC	F8	F9	--etc.-						

Field	Contents
SID	Set identification number (unique integer > 0).
Fi	Aerodynamic factor (real).

Remarks:

1. These factors must be selected by a FLUTTER data card to be used by NASTRAN.
2. Imbedded blank fields are forbidden.
3. Parameters must be listed in the order in which they are to be used within the looping of flutter analysis.

NASTRAN DATA DECK

Input Data Card FLSYM Axisymmetric Symmetry Control

Description: Defines the relationship between the axisymmetric fluid and a structural boundary having symmetric constraints. The purpose is to allow fluid boundary matrices to conform to structural symmetry definitions.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FLSYM	M	S1	S2						
FLSYM	12	S	A						

Field	Contents
M	Number of symmetric sections of structural boundary around circumference of fluid being modeled by the set of structural elements (Integer $\geq$ 2, even)
S1, S2	Description of boundary constraints used on structure at first and second planes of symmetry. (BCD: "S" $\Rightarrow$ symmetric, "A" $\Rightarrow$ antisymmetric)

Remarks:

1. This card is allowed only if an AXIF card is also present.
2. Only one (1) FLSYM card is allowed.
3. The card is not required if no planes of symmetry are involved.
4. First plane of symmetry is assumed to be at $\phi = 0$. Second plane of symmetry is assumed to be at $\phi = 360°/M$.
5. Symmetric and antisymmetric constraints for the structure must, in addition, be provided by the user.
6. The solution is performed for those harmonic indices listed on the AXIF card that are compatible with the symmetry conditions.

Example: If a quarter section of structure is used to model the boundary, M = 4. If the boundary constraints are S-S, the compatible cosine harmonics are: 0, 2, 4, etc. If S-A is used the compatible cosine harmonics are 1, 3, 5, ..., etc.

NASTRAN DATA DECK

Input Data Card FLUTTER Aerodynamic Flutter Data

Description: Defines data needed to perform flutter analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FLUTTER	SID	METHØD	DENS	MACH	RFREQ	IMETH	NVALUE		
FLUTTER	19	K	119	219	319	S	5		

Field	Contents
SID	Set identification number (unique integer > 0).
METHØD	Flutter analysis method, "K" for k-method (BCD).
DENS	Identification number of an FLFACT data card specifying density ratios to be used in flutter analysis (integer ≥ 0).
MACH	Identification number of an FLFACT data card specifying Mach numbers (m) to be used in flutter analysis (integer ≥ 0).
RFREQ	Identification number of an FLFACT data card specifying reduced frequencies (k) to be used in flutter analysis (integer ≥ 0).
IMETH	Choice of interpolation method for matrix interpolation (BCD: L = linear, S = surface, default is S).
NVALUE	Number of eigenvalues for output and plots (integer > 0).

Remarks:

1. The FLUTTER data card must be selected in Case Control Deck (FMETHØD = SID).
2. The density is given by $\rho \cdot$ RHØREF where ρ is the density ratio given on the FLFACT data card and RHØREF is the reference density given on the AERØ data card.
3. The reduced frequency is given by $k = (REFC \cdot \omega / 2 \cdot V)$, where REFC is given on the AERØ data card, ω is the circular frequency and V is the velocity.

NASTRAN DATA DECK

Input Data Card FØRCE Static Load

Description: Defines a static load at a grid point by specifying a vector.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FØRCE	SID	G	CID	F	N1	N2	N3		
FØRCE	2	5	6	2.9	0.0	1.0	0.0		

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
CID	Coordinate system identification number (Integer ≥ 0)
F	Scale factor (Real)
N1,N2,N3	Components of Vector measured in coordinate system defined by CID (Real; $N1^2 + N2^2 + N3^2 > 0.0$)

Remarks: 1. The static load applied to grid point G is given by

$$\vec{f} = F\vec{N}$$

where $\vec{N}$ is the vector defined in fields 6, 7 and 8.

2. Load sets must be selected in the Case Control Deck (LOAD=SID) to be used by NASTRAN.

3. A CID of zero references the basic coordinate system.

Input Data Card FØRCE1 Static Load

Description: Used to define a static load by specification of a value and two grid points which determine the direction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FØRCE1	SID	G	F	G1	G2				
FØRCE1	6	13	-2.93	16	13				

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
F	Value of load (Real)
G1, G2	Grid point identification numbers (Integer > 0; G1 ≠ G2)

Remarks:
1. The direction of the force is determined by the vector from G1 to G2.
2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

Input Data Card FØRCE2 Static Load

Description: Used to define a static load by specification of a value and four grid points which determine the direction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FØRCE2	SID	G	F	G1	G2	G3	G4		
FØRCE2	6	13	-2.93	16	13	17	13		

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
F	Value of load (Real)
G1,G2,G3,G4	Grid point identification numbers (Integer > 0; G1 $\neq$ G2; G3 $\neq$ G4)

Remarks: 1. The direction of the force is determined by the vector product whose factors are vectors from G1 to G2 and G3 to G4 respectively.

2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

Input Data Card FØRCEAX Axisymmetric Static Load

Description: Defines a static loading for a model containing CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FØRCEAX	SID	RID	HID	S	FR	FP	FZ		
FØRCEAX	1	2	3	2.0	0.1	0.2	0.3		

Field	Contents
SID	Load set identification number (Integer > 0)
RID	Ring identification number (see RINGAX) (Integer > 0)
HID	Harmonic identification number (Integer ≥ 0 or a sequence of harmonics, see note 5)
S	Scale factor for load (Real)
FR, FP, FZ	Load components in r, ϕ, z directions (Real)

Remarks:

1. This card is allowed if and only if an AXIC card is also present.
2. Axisymmetric loads must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
3. A separate card is needed for the definition of the force associated with each harmonic.
4. If a sequence of harmonics is to be placed in HID the form is as follows: "SnlTn2" where nl is the start of the sequence and n2 is the end of the sequence, i.e., harmonics 0 through 10, the field would contain "S0T10".
5. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
6. For a discussion of the axisymmetric solid problem see Section 5.11 of the Theoretical Manual.

Input Data Card FREEPT Fluid Free Surface Point

Description: Defines the location of points on the surface of a fluid for recovery of surface displacements in a gravity field.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FREEPT	IDF		IDP	ϕ	IDP	ϕ	IDP	ϕ	
FREEPT	3		301	22.5	302	90.0	303	370.0	

Field	Contents
IDF	Fluid point (RINGFL) identification number (Integer > 0)
IDP	Free surface point identification number (Integer > 0)
ϕ	Azimuthal position of FREEPT on fluid point (RINGFL), in Fluid Coordinate System (Real)

Remarks:
1. This card is allowed only if an AXIF card is also present.
2. All free surface point identification numbers must be unique with respect to other scalar, structural and fluid points.
3. The free surface points are used for the identification of output data only.
4. Three points may be defined on a single card.
5. The referenced fluid point (IDF) must be included in a free surface list (FSLIST).
6. Output requests for velocity and acceleration can be made at these points.

Input Data Card FREQ Frequency List

Description: Defines a set of frequencies to be used in the solution of frequency response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FREQ	SID	F	F	F	F	F	F	F	abc
FREQ	3	2.98	3.05	17.9	21.3	25.6	28.8	31.2	ABC

+bc	F	F	F	F	F	F	F	F	
+BC	29.2	22.4	19.3						

-etc.-

Field	Contents
SID	Frequency set identification number (Integer > 0)
F	Frequency value (Real > 0.0)

Remarks:
1. The units for the frequencies are cycles per unit time.
2. Frequency sets must be selected in the Case Control Deck (FREQ=SID) to be used by NASTRAN.
3. All FREQ, FREQ1 and FREQ2 cards must have unique frequency set identification numbers.

Input Data Card FREQ1 Frequency List

Description: Defines a set of frequencies to be used in the solution of frequency response problems by specification of a starting frequency, frequency increment, and number of increments desired.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FREQ1	SID	F1	DF	NDF					
FREQ1	6	2.9	0.5	13					

Field	Contents
SID	Frequency set identification number (Integer > 0)
F1	First frequency in set (Real ≥ 0.0)
DF	Frequency increment (Real > 0.0)
NDF	Number of frequency increments (Integer > 0)

Remarks:

1. The units for the frequency F1 and the frequency increment DF are cycles per unit time.
2. The frequencies defined by this card are given by

$$f_i = F1 + (i - 1)\,DF, \quad i = 1, NDF + 1$$

3. Frequency sets must be selected in the Case Control Deck (FREQ=SID) to be used by NASTRAN.
4. All FREQ, FREQ1 and FREQ2 cards must have unique frequency set identification numbers.

Input Data Card FREQ2 Frequency List

Description: Defines a set of frequencies to be used in the solution of frequency response problems by specification of a starting frequency, final frequency, and number of logarithmic increments desired.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FREQ2	SID	F1	F2	NF					
FREQ2	6	1.0	1.E5	5					

Field	Contents
SID	Frequency set identification number (Integer > 0)
F1	First frequency (Real > 0.0)
F2	Last frequency (Real > 0.0; F2 > F1)
NF	Number of logarithmic intervals (Integer > 0)

Remarks:
1. The units for the frequencies F1 and F2 are cycles per unit time.
2. The frequencies defined by this card are given by

$$f_i = F1 \cdot e^{(i-1)d}, \qquad i = 1,2,\ldots,NF+1$$

where

$$d = \frac{1}{NF} \log_e \frac{F2}{F1}$$

For the example shown, the list of frequencies will be 1.0, 10.0, 100.0, 1000.0, 10000.0, and 100000.0 cycles per unit time.

3. Frequency sets must be selected in the Case Control Deck (FREQ=SID) to be used by NASTRAN.
4. All FREQ, FREQ1 and FREQ2 cards must have unique frequency set identification numbers.

Input Data Card FSLIST Free Surface List

Description: Declares the fluid points (RINGFL) which lie on a free surface boundary.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FSLIST	RHØ	IDF1	IDF2	IDF3	IDF4	IDF5	IDF6	IDF7	abc
FSLIST	1.0-4	1	3	5	4	2	7	6	+12FS
+bc	IDF8	IDF9	-etc.-						def
+12FS	8	9	10	11	AXIS				

-etc.-

Field	Contents
RHØ	Mass density at the surface (Real > 0.0 or blank; if blank the AXIF default value must not be blank)
IDFi	Identification number of RINGFL point (Integer > 0 or BCD, "AXIS." The first and/or last entry may be AXIS)

Remarks:

1. This card is allowed only if an AXIF card is also present.
2. Each logical card defines a surface. The order of the points must be sequential with the fluid on the right with respect to the direction of travel.
3. The BCD word, AXIS, defines an intersection with the polar axis of the Fluid Coordinate System.
4. There may be as many FSLIST cards as the user requires. If the fluid density varies along the boundary there must be one FSLIST card for each interval between fluid points.

Input Data Card <u>GENEL</u>   General Element

<u>Description</u>: Defines a general element using either:

1. The stiffness approach:

$$\begin{Bmatrix} f_i \\ -- \\ f_d \end{Bmatrix} = \left[\begin{array}{c|c} K & -KS \\ \hline -S^TK & S^TKS \end{array}\right] \begin{Bmatrix} u_i \\ -- \\ u_d \end{Bmatrix} \quad , \text{ or}$$

2. The flexibility approach:

$$\begin{Bmatrix} u_i \\ -- \\ f_d \end{Bmatrix} = \left[\begin{array}{c|c} Z & S \\ \hline -S^T & 0 \end{array}\right] \begin{Bmatrix} f_i \\ -- \\ u_d \end{Bmatrix} \quad , \text{ where}$$

$$\{u_i\} = [u_{i1}, u_{i2}, \ldots, u_{im}]^T \ ,$$

$$\{u_d\} = [u_{d1}, u_{d2}, \ldots, u_{dn}]^T \ ,$$

$$[KZ] = [K] \text{ or } [Z] = \begin{bmatrix} KZ_{11} & KZ_{12} & \cdots & KZ_{1m} \\ \vdots & KZ_{22} & \cdots & \vdots \\ \vdots & \vdots & & \vdots \\ KZ_{m1} & \cdots & \cdots & KZ_{mm} \end{bmatrix} \text{ and } [KZ]^T = [KZ] \ ,$$

$$[S] = \begin{bmatrix} S_{11} & \cdots & S_{1n} \\ \vdots & & \vdots \\ S_{m1} & \cdots & S_{mn} \end{bmatrix} .$$

The required input is the $\{u_i\}$ list and the lower triangular portion of [K] or [Z]. Additional input may include the $\{u_d\}$ list and [S]. If [S] is input, $\{u_d\}$ must also be input. If $\{u_d\}$ is input but [S] is omitted, [S] is internally calculated. In this case, $\{u_d\}$ must have six and only six degrees of freedom. If [S] is not required, both $\{u_d\}$ and [S] are omitted.

Format: (An example is given on the following page.)

1	2	3	4	5	6	7	8	9	10
GENEL	EID		UI1	CI1	UI2	CI2	UI3	CI3	X1
+1	UI4	CI4	UI5	CI5	UI6	CI6	UI7	CI7	X2
+2				Etc.					X3
+3	UI_m - The last item in the UI-list will appear in one of fields 2, 4, 6, or 8.								X4
+4	"UD"		UD1	CD1	UD2	CD2	UD3	CD3	X5
+5				Etc.					X6
+6	UD_n - The last item in the UD list will appear in one of fields 2, 4, 6, or 8.								X7
+7	"K" or "Z"	KZ11	KZ21	KZ31	Etc.		KZ22	KZ32	X8
+8	Etc.		KZ33	KZ43	Etc.				X9
+9				Etc.					X10
+10	KZ_{mm} - The last item in the K or Z matrix, will appear in one of fields 2 through 9.								X11
+11	"S"	S11	S12	Etc.		S21	Etc.		X12
+12	S_{mn} - The last item in the S matrix will appear in one of fields 2 through 9.								

Field	Contents
EID	Unique element identification number, a positive integer.
UI1, CI1 Etc. UD1, ED1 Etc.	Identification numbers of coordinates in the UI or UD list, in sequence corresponding to the [K], [Z], and [S] matrices. U_i and UD_i are grid point numbers, and CI_i and CD_i are the component numbers. If a scalar point is given, the component number is zero.
KZ_{ij}	Values of the [K] or [Z] matrix ordered by columns from the diagonal, according to the UI list.
S_{ij}	Values of the [S] matrix ordered by rows, according to the UD list.
"UD", "K", "Z", and "S"	BCD data words which indicate the start of data belonging to UD, [K], [Z], or [S].

Remarks:

1. When the stiffness matrix, K, is input, the number of significant digits should be the same for all terms.

2. Double-field format may be used for input of K or Z.

Example: Let element 629 be defined by

$$\{u_i\} = [1\text{-}1,13\text{-}4,42,24\text{-}2]^T ,$$

$$\{u_d\} = [6\text{-}2,33]^T ,$$

where i-j means the j^{th} component of grid point i. Points 42 and 33 are scalar points.

$$[K] = \begin{bmatrix} 1.0 & 2.0 & 3.0 & 4.0 \\ 2.0 & 5.0 & 6.0 & 7.0 \\ 3.0 & 6.0 & 8.0 & 9.0 \\ 4.0 & 7.0 & 9.0 & 0.0 \end{bmatrix} , \qquad [S] = \begin{bmatrix} 1.5 & 2.5 \\ 3.5 & 4.5 \\ 5.5 & 6.5 \\ 7.5 & 8.5 \end{bmatrix}$$

The data cards necessary to input this general element are shown below:

1	2	3	4	5	6	7	8	9	10
GENEL	629		1	1	13	4	42	0	X1
+1	24	2							X2
+2	UD		6	2	33	0			X3
+3	Z	1.0	2.0	3.0	4.0	5.0	6.0	7.0	X4
+4	8.0	9.0	0.0						X5
+5	S	1.5	2.5	3.5	4.5	5.5	6.5	7.5	X6
+6	8.5								

Input Data Card GRAV Gravity Vector

Description: Used to define gravity vectors for use in determining gravity loading for the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRAV	SID	CID	G	N1	N2	N3			
GRAV	1	3	32.2	0.0	0.0	-1.0			

Field	Contents
SID	Set identification number (Integer > 0)
CID	Coordinate system identification number (Integer $\geq$ 0)
G	Gravity vector scale factor (Real)
N1, N2, N3	Gravity vector components (Real; $N1^2 + N2^2 + N3^2 > 0.0$)

Remarks: 1. The gravity vector is defined by

$$\vec{g} = G \cdot (N1, N2, N3).$$

2. A CID of zero references the basic coordinate system.
3. Gravity loads may be combined with "simple loads" (e.g., FØRCE, MØMENT) only by specification on a LØAD card. That is, the SID on a GRAV card may not be the same as that on a simple load card.
4. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

Input Data Card GRDSET Grid Point Default

Description: Defines default options for fields 3, 7 and 8 of all GRID cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRDSET		CP				CD	PS		
GRDSET		16				32	3456		

Field	Contents
CP	Identification number of coordinate system in which the location of the grid point is defined (Integer ≥ 0)
CD	Identification number of coordinate system in which displacements are measured at grid point (Integer ≥ 0)
PS	Permanent single-point constraints associated with grid point (any of the digits 1-6 with no imbedded blanks) (Integer ≥ 0)

Remarks:

1. The contents of fields 3, 7 or 8 of this card are assumed for the corresponding fields of any GRID card whose fields 3, 7 and 8 are blank. If any of these fields on the GRID card are blank, the default option defined by this card occurs for that field. If no permanent single-point constraints are desired or one of the coordinate systems is basic, the default may be overridden on the GRID card by making one of fields 3, 7 or 8 zero (rather than blank). Only one GRDSET card may appear in the user's Bulk Data Deck.
2. The primary purpose of this card is to minimize the burden of preparing data for problems with a large amount of repetition (e.g., two-dimensional pinned-joint problems).
3. At least one of the entries CP, CD, or PS must be nonzero.

Input Data Card GRID   Grid Point

Description: Defines the location of a geometric grid point of the structural model, the directions of its displacement, and its permanent single-point constraints.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRID	ID	CP	X1	X2	X3	CD	PS		
GRID	2	3	1.0	2.0	3.0		316		

Field	Contents
ID	Grid point identification number (0<Integer<999999)
CP	Identification number of coordinate system in which the location of the grid point is defined (Integer ≥ 0 or blank*).
X1,X2,X3	Location of the grid point in coordinate system CP (Real)
CD	Identification number of coordinate system in which displacements, degrees of freedom, constraints, and solution vectors are defined at the grid point (Integer ≥ 0 or blank*)
PS	Permanent single-point constraints associated with grid point (any of the digits 1-6 with no imbedded blanks) (Integer ≥ 0 or blank*)

Remarks:

1. All grid point identification numbers must be unique with respect to all other structural, scalar, and fluid points.

2. The meaning of X1, X2 and X3 depend on the type of coordinate system, CP, as follows: (see CØRD__ card descriptions)

Type	X1	X2	X3
Rectangular	X	Y	Z
Cylindrical	R	Θ(degrees)	Z
Spherical	R	Θ(degrees)	Φ(degrees)

3. The collection of all CD coordinate systems defined on all GRID cards is called the Global Coordinate System. All degrees-of-freedom, constraints, and solution vectors are expressed in the Global Coordinate System.

* See the GRDSET card for default options for fields 3, 7 and 8.

Input Data Card GRIDB Axisymmetric Problem Grid Point

Description: Defines the location of a geometric grid point on a RINGFL for an axisymmetric fluid model and/or axisymmetric structure. Used to define the boundary of the fluid.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRIDB	ID			ϕ		CD	PS	IDF	
GRIDB	30			30.0		3	345	20	

Field	Contents
ID	Grid point identification number (Integer > 0)
ϕ	Azimuthal position in the fluid in degrees (Real)
CD	Identification number of the coordinate system in which displacements are defined at the grid point (Integer $\geq$ 0)
PS	Permanent single-point constraints associated with the grid point (any combination of the digits 1-6 with no embedded blanks) (Integer $\geq$ 0)
IDF	Identification number of a RINGFL (Integer > 0)

Remarks:

1. This card is allowed only if an AXIF card is also present.
2. All GRIDB identification numbers must be unique with respect to other scalar, structural and fluid points.
3. An AXIF card must define a Fluid Coordinate System.
4. The RINGFL referenced must be present.
5. If no harmonic numbers on the AXIF card are specified, no fluid elements are necessary.
6. The collection of all CD coordinate systems defined on all GRID and GRIDB cards is called the Global Coordinate System.
7. Fields 3, 4, and 6 are ignored. This will facilitate the user's conversion of GRID cards to GRIDB cards. Note that the fields are the same except for fields 1 and 9 if a cylindrical coordinate system is used.
8. The referenced RINGFL point must be included in a boundary list (BDYLIST data card).

Input Data Card GRIDF Fluid Point

Description: Defines a scalar degree of freedom for harmonic analysis of a fluid.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRIDF	ID	R	Z						
GRIDF	23	2.5	-7.3						

Field	Contents
ID	Identification number of axisymmetric fluid point (Integer > 0)
R	Radial location of point in basic coordinate system (Real > 0.0)
Z	Axial location of point in basic coordinate system (Real)

Remarks:

1. This card is allowed only if an AXSLØT card is also present.
2. The identification number (ID) must be unique with respect to all other scalar, structural and fluid points.
3. Grid points on slot boundaries are defined on GRIDS cards. Do not also define them on GRIDF cards.
4. For plotting purposes the R location corresponds to the basic X coordinate. The Z location corresponds to the basic Y coordinate. Pressures will be plotted as displacement in the basic Z direction.
5. Load and constraint conditions are applied as if the GRIDF is a scalar point. Positive loads correspond to inward flow and a single point constraint causes zero pressure at the point.

NASTRAN DATA DECK

Input Data Card GRIDS Slot Surface Point

Description: Defines a scalar degree of freedom with a two dimensional location. Used in defining pressure in slotted acoustic cavities.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRIDS	ID	R	Z	W	IDF				
GRIDS	25	2.5	-7.3	0.5					

Field	Contents
ID	Identification number of slot point (Integer > 0)
R	Radial location of point in basic coordinate system (Real $\neq$ 0.0)
Z	Axial location of point in basic coordinate system (Real)
W	Slot width or thickness at the GRIDS point (Real $\geq$ 0.0, or blank)
IDF	Identification number to define a GRIDF point (Integer > 0, or blank)

Remarks:

1. This card is allowed only if an AXSLØT card is also present.
2. The identification numbers (ID and IDF if present) must be unique with respect to all other scalar, structural and fluid points.
3. If W is "blank", the default value on the AXSLØT card will be used.
4. The IDF number is referenced on the CAXIFi card for central cavity fluid elements next to the interface. The IDF number is entered only if the grid point is on an interface. In this case it should not also be defined on a GRIDF card.
5. If IDF is nonzero then R must be greater than zero.
6. For plotting purposes the R location corresponds to the basic X coordinate. The Z location corresponds to the basic Y coordinate. The slot width, W, corresponds to the basic Z coordinate. The pressure will be plotted in the basic Z direction.
7. Load and constraint conditions are applied as if the GRIDS is a scalar point. Positive loads correspond to inward flow and a single point constraint causes zero pressure at the point.

Input Data Card GTRAN Grid Point Transformation

Description: This card defines the output coordinate system transformation to be applied to the displacement set of a selected grid point.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GTRAN	SID	NAME	GID	TRAN					
GTRAN	44	GIMBAL	1067	45					

Field	Contents
SID	Identification number of the transformation set (Integer > 0)
NAME	Basic substructure name (BCD)
GID	Grid point identification (Integer > 0)
TRAN	Identification number of a TRANS bulk data card (Integer ≥ 0)

Remarks:
1. If TRAN = 0, the displacement set at the grid point will be transformed to the overall basic coordinate system.
2. If TRAN = SID, the point will remain fixed to the substructure (i.e., no transformation occurs).
3. Otherwise, the displacement set at the grid point will be transformed to the coordinate system directions defined by the selected TRANS card.
4. Transformation sets must be selected in the Substructure Control Deck (TRANS=SID) to be used by NASTRAN. Note that 'TRANS' is a subcommand of the substructure CØMBINE command.

NASTRAN DATA DECK

Input Data Card LØAD   Static Load Combination (Superposition)

Description: Defines a static load as a linear combination of load sets defined via FØRCE, MØMENT, FØRCE1, MØMENT1, FØRCE2, MØMENT2, PLØAD, PLØAD2, PLØAD3, FØRCEAX, PRESAX, MØMAX, SLØAD, RFØRCE and GRAV cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
LØAD	SID	S	S1	L1	S2	L2	S3	L3	abc
LØAD	101	-0.5	1.0	3	6.2	4			

+bc	S4	L4		-etc.-					

(etc.)

Field	Contents
SID	Load set identification number (Integer > 0)
S	Scale factor (Real)
Si	Scale factors (Real)
Li	Load set identification numbers defined via card types enumerated above (Integer > 0)

Remarks: 1. The load vector defined is given by

$$\{P\} = S\sum_i S_i \{P_{Li}\}$$

2. The Li must be unique. The remainder of the physical card containing the last entry must be blank.

3. This card must be used if gravity loads (GRAV) are to be used with any of the other types.

4. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

5. A LØAD card may not reference a set identification number defined by another LØAD card.

BULK DATA DECK

Input Data Card LØADC Substructure Static Loading Combination

Description: Defines the static load for a substructuring analysis as a linear combination of load sets defined for each component substructure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
LØADC	SID	S	NAME1	ID1	S1	NAME2	ID2	S2	abc
LØADC	27	1.0	WINGRT	5	0.5	FUSELAGE	966	2.5	ABC
+bc			NAME3	ID3	S3	NAME4	ID4	S4	def
+BC			MIDWG	27	1.75	etc.			

Field	Contents
SID	Load set identification number (Integer > 0)
S	Scale factor applied to final load vector (Real)
NAMEi	Basic substructure name (BCD)
IDi	Load set identification number of substructure NAMEi (Integer > 0)
Si	Scale factor (Real)

Remarks: 1. The load vector is combined by:

$$\{P\} = S\sum_{i} Si\ \{P\}_{IDi}$$

2. The load set identification numbers (IDi) reference the load sets used in Phase 1 to generate the load vectors on the basic substructures.

3. The NAMEi and IDi need not be unique.

4. The LØADC card is the means of specifying a static loading condition in a Phase 2 substructure analysis. The IDi may actually reference temperature loads or element deformation loads defined in Phase 1.

5. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

NASTRAN DATA DECK

Input Data Card MAT1   Material Property Definition

Description: Defines the material properties for linear, temperature-independent, isotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT1	MID	E	G	NU	RHØ	A	TREF	GE	+abc
MAT1	17	3.+7	1.9+7		4.28	0.19	5.37+2	0.23	ABC
+abc	ST	SC	SS						
+BC	20.+4	15.+4	12.+4						

Field	Contents
MID	Material identification number (Integer > 0)
E	Young's modulus (Real ≥ 0.0 or blank)
G	Shear modulus (Real ≥ 0.0 or blank)
NU	Poisson's ratio (-1.0 < Real ≤ 0.5 or blank)
RHØ	Mass density (Real)
A	Thermal expansion coefficient (Real)
TREF	Thermal expansion reference temperature (Real)
GE	Structural element damping coefficient (Real)
ST, SC, SS	Stress limits for tension, compression and shear (Real) (Required for Property Optimization calculations; otherwise optional if margins of safety are desired.)

Remarks:

1. One of E or G must be positive (i.e., either E > 0.0 or G > 0.0 or both E and G may be > 0.0).
2. If any one of E, G or NU is blank, it will be computed to satisfy the identity E = 2(1+NU)G; otherwise, values supplied by the user will be used.
3. The material identification number must be unique for all MAT1, MAT2 and MAT3 cards.
4. MAT1 materials may be made temperature dependent by use of the MATT1 card.
5. The mass density, RHØ, will be used to automatically compute mass for all structural elements except the two-dimensional bending only elements TRBSC, TRPLT and QDPLT.
6. If E and NU or G and NU are both blank they will be both given the value 0.0.
7. Weight density may be used in field 6 if the value $\frac{1}{g}$ is entered on the PARAM card WTMASS, where g is the acceleration of gravity.
8. Solid elements must not have NU equal to 0.5.

Input Data Card MAT2 Material Property Definition

Description: Defines the material properties for linear, temperature-independent, anisotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT2	MID	G11	G12	G13	G22	G23	G33	RHØ	+abc
MAT2	13	6.2+3			6.2+3		5.1+3	0.056	ABC
+abc	A1	A2	A12	T0	GE	ST	SC	SS	
+BC	0.15			-500.0	0.002	20.+5			

Field	Contents
MID	Material identification number (Integer > 0)
Gij	The material property matrix (Real)
RHØ	Mass density (Real)
Ai	Thermal expansion coefficient vector (Real)
T0	Thermal expansion reference temperature (Real)
GE	Structural element damping coefficient (Real)
ST, SC, SS	Stress limits for tension, compression and shear (Real) (Used only to compute margins of safety in certain elements; they have no effect on the computational procedures)

Remarks:

1. The material identification numbers must be unique for all MAT1, MAT2 and MAT3 cards.

2. MAT2 materials may be made temperature dependent by use of the MATT2 card.

3. The mass density, RHØ, will be used to automatically compute mass for all structural elements except the two-dimensional bending only elements TRBSC, TRPLT and QDPLT.

4. The convention for the G_{ij} in fields 3 through 8 is represented by the matrix relationship.

$$\begin{Bmatrix} \sigma_1 \\ \sigma_2 \\ \tau_{12} \end{Bmatrix} = \begin{bmatrix} G_{11} & G_{12} & G_{13} \\ G_{12} & G_{22} & G_{23} \\ G_{13} & G_{23} & G_{33} \end{bmatrix} \begin{Bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \gamma_{12} \end{Bmatrix}$$

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MAT3 Material Property Definition

Description: Defines the material properties for linear, temperature-independent, orthotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT3	MID	EX	EY	EZ	NUXY	NUYZ	NUZX	RHØ	+abc
MAT3	23	1.0+7	1.1+7	1.2+7	.3	.25	.27	1.0-5	ABC
+abc	GXY	GYZ	GZX	AX	AY	AZ	TREF	GE	
+BC	2.5+6	3.0+6	2.5+6	1.0-4	1.0-4	1.1-4	68.5	.23	

Field	Contents
MID	Material identification number (Integer > 0)
EX, EY, EZ	Young's moduli in the x, y and z directions respectively (Real ≥ 0.0)
NUXY,NUYZ,NUZX	Poisson's Ratios (Coupled strain ratios in the xy, yz and zx directions respectively) (Real)
RHØ	Mass density (Real)
GXY, GYZ, GZX	Shear moduli for xy, yz and zx (Real ≥ 0.0)
AX, AY, AZ	Thermal expansion coefficients (Real)
TREF	Thermal expansion reference temperature (Real)
GE	Structural element damping coefficient (Real)

Remarks:

1. The material identification number must be unique with respect to the collection of all MATi cards.
2. MAT3 materials may be made temperature-dependent by use of the MATT3 card.
3. All nine of the numbers EX, EY, EZ, NUXY, NUYZ, NUZX, GXY, GYZ and GZX must be present.
4. A nonfatal warning diagnostic will occur if any of NUXY or NUYZ has an absolute value greater than 1.0.
5. MAT3 materials may only be referenced by CTRIARG, CTRAPRG, CTRIAAX, CTRAPAX, and PTØRDRG cards.
6. The mass density, RHØ, will be used to automatically compute mass for the TRIARG, TRAPRG, CTRIAAX, CTRAPAX and TØRDRG elements.

Input Data Card MAT4 Thermal Material Property Definition

Description: Defines the thermal material properties for temperature-independent, isotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT4	MID	K	CP						
MAT4	103	.6	.2						

Field	Contents
MID	Material identification number (Integer > 0)
K	Thermal conductivity (Real > 0.0), or convective film coefficient
CP	Thermal capacity per unit volume (Real > 0.0 or blank), or film capacity per unit area

Remarks:

1. The material identification number may be the same as a MAT1, MAT2, or MAT3 card, but must be unique with respect to other MAT4 or MAT5 cards.
2. If a HBDY element references this card, K is the convective film coefficient and CP is the thermal capacity per unit area.
3. MAT4 materials may be made temperature dependent by use of the MATT4 card.

Input Data Card MAT5 Thermal Material Property Definition

Description: Defines the thermal material properties for temperature-independent, anisotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT5	MID	KXX	KXY	KXZ	KYY	KYZ	KZZ	CP	
MAT5	24	.092			.083		.020	0.2	

Field	Contents
MID	Material identification number (Integer > 0)
KXX,KXY,KXZ, KYY,KYZ,KZZ	Thermal conductivity (Real)
CP	Thermal capacity per unit volume (Real $\geq$ 0.0 or blank)

Remarks:

1. The thermal conductivity matrix has the form:

$$K = \begin{bmatrix} KXX & KXY & KXZ \\ KXY & KYY & KYZ \\ KXZ & KYZ & KZZ \end{bmatrix}$$

2. The material number may be the same as a MAT1, MAT2, or MAT3 card, but must be unique with respect to the MAT4 or MAT5 cards.

3. MAT5 materials may be made temperature dependent by use of the MATT5 card.

Input Data Card MATS1 Material Stress Dependence

Description: Specifies table references for material properties which are stress-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATS1	MID	R1							+abc
MATS1	17	28							ABC

Field	Contents
MID	Material property identification number which matches the identification number on some basic MAT1 card (Integer > 0)
R1	Reference to table identification number (Integer $\geq$ 0)

Remarks: 1. Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT1 card.

2. TABLES1 type tables must be used.

Input Data Card MATT1 Material Temperature Dependence

Description: Specifies table references for material properties which are temperature-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT1	MID	R1	R2	R3	R4	R5	R6	R7	+abc
MATT1	17	32				15			ABC
+abc	R8	R9	R10						
+BC	62								

Field	Contents
MID	Material property identification number which matches the identification number on some basic MAT1 card (Integer > 0)
Ri	References to table identification numbers (Integer $\geq$ 0)

Remarks:

1. Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT1 card.
2. TABLEM1, TABLEM2, TABLEM3 or TABLEM4 type tables may be used.

Input Data Card MATT2 Material Temperature Dependence

Description: Specifies table references for material properties which are temperature-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT2	MID	R1	R2	R3	R4	R5	R6	R7	+abc
MATT2	17	32				15			ABC
+abc	R8	R9	R10	R11	R12	R13	R14	R15	
+BC	62								

Field	Contents
MID	Material property identification number which matches the identification number on some basic MAT2 card (Integer > 0)
Ri	References to table identification numbers (Integer $\geq$ 0)

Remarks: 1. Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT2 card.

2. TABLEM1, TABLEM2, TABLEM3 or TABLEM4 type tables may be used.

Input Data Card MATT3 Material Temperature Dependence

Description: Specifies table references for orthotropic, "MAT3", material properties which are temperature-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT3	MID	R1	R2	R3	R4	R5	R6	R7	+abc
MATT3	23	48			54				ABC

+abc	R8	R9	R10	R11	R12	R13	R14	R15	
+BC	74								

Field	Contents
MID	Material property identification number which matches the identification number on some basic MAT3 card (Integer > 0)
Ri	References to table identification numbers (Integer $\geq$ 0)

Remarks:
1. Blank or zero entries imply no table dependence of the referenced quantity on the basic MAT3 card.
2. TABLEM1, TABLEM2, TABLEM3 or TABLEM4 type tables may be used.

Input Data Card MATT4 Thermal Material Temperature Dependence

Description: Specifies table reference for temperature dependent thermal conductivity or convective film coefficient.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT4	MID	T(K)	X	X	X	X	X	X	
MATT4	103	73							

Field	Contents
MID	ID of a MAT4 which is to be temperature dependent (Integer > 0)
T(K)	Identification number of a TABLEMi card which gives temperature dependence of the thermal conductivity or convective film coefficient (Integer > 0 or blank)

Remarks:

1. The thermal capacity may not be temperature dependent; field 4 must be blank.
2. TABLEM1, TABLEM2, TABLEM3, or TABLEM4 type tables may be used. The basic quantities on the MAT4 card is always multiplied by the tabular function. Note that this is different from structural applications.
3. Blank or zero entries means no table dependence of the referenced quantity on the basic MAT4 card.

NASTRAN DATA DECK

Input Data Card MATT5 Thermal Material Temperature Dependence

Description: Specifies table references for temperature dependent conductivity matrix.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT5	MID	T(KXX)	T(KXY)	T(KXZ)	T(KYY)	T(KYZ)	T(KZZ)		
MATT5	24	73							

Field	Contents
MID	Identification number of a MAT5, which is to be temperature dependent (Integer > 0)
T(K--)	Identification number of a TABLEMi card which gives temperature dependence of the matrix term (Integer > 0 or blank)

Remarks:

1. The thermal capacity may not be temperature dependent. Field 9 must be blank.

2. TABLEM1, TABLEM2, TABLEM3, or TABLEM4 type tables may be used. The basic quantities on the MAT5 card are always multiplied by the tabular function. Note that this is different from the structural applications.

3. Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT5 card.

NASTRAN DATA DECK

Input Data Card MKAERØ1 Mach Number - Frequency Table

Description: Provides a table of Mach numbers (m) and reduced frequencies (k) for aerodynamic matrix calculation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MKAERØ1	m_1	m_2	m_3	m_4	m_5	m_6	m_7	m_8	ABC
MKAERØ1	.1	.7							+ABC
+BC	k_1	k_2	k_3	k_4	k_5	k_6	k_7	k_8	
+BC	.3	.6	1.0						

Field	Contents
m_i	List of Mach numbers (Real, $1 \leq i \leq 8$).
k_j	List of reduced frequencies (Real, $1 \leq j \leq 8$).

Remarks:

1. Blank fields end the list, and thus cannot be used for 0.0.
2. All combinations of (m,k) will be used.
3. The continuation card is required.

NASTRAN DATA DECK

Input Data Card MKAERØ2 Mach Number - Frequency Table

Description: Provides a list of Mach numbers (m) and reduced frequencies (k) for aerodynamic matrix calculation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MKAERØ2	m_1	k_1	m_2	k_2	m_3	k_3	m_4	k_4	
MKAERØ2	.10	.30	.10	.60	.70	.30	.70	1.0	

Field	Contents
m_i, k_i	List of pairs of Mach numbers (Real) and reduced frequencies (Real) (imbedded blank pairs are skipped).

Remarks:

1. This card will cause the aerodynamic matrices to be computed for a set of parameter pairs.
2. Several MKAERØ2 cards may be in the deck.

NASTRAN DATA DECK

Input Data Card MØMAX Conical Shell Static Moment

Description: Defines a static moment loading of a conical shell coordinate.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MØMAX	SID	RID	HID	S	MR	MP	MZ		
MØMAX	1	2	3	1.0	0.1	0.2	0.3		

Field	Contents
SID	Load set identification number (Integer > 0)
RID	Ring identification number (see RINGAX)(Integer > 0)
HID	Harmonic identification number (Integer $\geq$ 0 or a sequence of harmonics,see note 5)
S	Scale factor (Real)
MR, MP, MZ	Moment components in the r, ϕ, z directions (Real)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
3. A separate card is needed for the definition of the moment associated with each harmonic.
4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
5. If a sequence of harmonics is to be placed in HID the form is as follows: "Sn1Tn2" where n1 is the start of the sequence and n2 is the end of the sequence i.e., for harmonics 0 through 10, the field would contain "S0T10".

NASTRAN DATA DECK

Input Data Card MØMENT Static Moment

Description: Defines a static moment at a grid point by specifying a vector.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MØMENT	SID	G	CID	M	N1	N2	N3		
MØMENT	2	5	6	2.9	0.0	1.0	0.0		

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
CID	Coordinate system identification number (Integer ≥ 0)
M	Scale factor (Real)
N1,N2,N3	Components of Vector measured in coordinate system defined by CID (Real; $N1^2 + N2^2 + N3^2 > 0.0$)

Remarks: 1. The static moment applied to grid point G is given by

$$\vec{m} = M \cdot (N1, N2, N3)$$

2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

3. A CID of zero references the basic coordinate system.

NASTRAN DATA DECK

Input Data Card MØMENT1 Static Moment

Description: Used to define a static moment by specification of a value and two grid points which determine the direction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MØMENT1	SID	G	M	G1	G2				
MØMENT1	6	13	-2.93	16	13				

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
M	Value of moment (Real)
G1, G2	Grid point identification numbers (Integer > 0; G1 $\neq$ G2)

Remarks:

1. The direction of the moment is determined by the vector from G1 to G2.
2. Load sets must be selected in the Case Control Deck (LØAD-SID) to be used by NASTRAN.

Input Data Card MØMENT2 Static Moment

Description: Used to define a static moment by specification of a value and four grid points which determine the direction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MØMENT2	SID	G	M	G1	G2	G3	G4		
MØMENT2	6	13	-2.93	16	13	17	13		

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
M	Value of moment (Real)
G1,G2,G3,G4	Grid point identification numbers (Integer > 0; G1 ≠ G2; G3 ≠ G4)

Remarks: 1. The direction of the force is determined by the vector product whose factors are vectors from G1 to G2 and G3 to G4 respectively.

2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

Input Data Card MPC Multipoint Constraint

Description: Defines a multipoint constraint equation of the form

$$\sum_j A_j u_j = 0$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
MPC	SID	G	C	A	G	C	A		abc
MPC	3	28	3	6.2	2		4.29		+B
+bc		G	C	A	-etc.-				
+B		1	4	-2.91					

Field	Contents
SID	Set identification number (Integer > 0)
G	Identification number of grid or scalar point (Integer > 0)
C	Component number - any one of the digits 1-6 in the case of geometric grid points; blank or zero in the case of scalar points (Integer)
A	Coefficient (Real; the first A must be nonzero)

Remarks:

1. The first coordinate in the sequence is assumed to be the dependent coordinate and must be unique for all equations of the set.
2. Forces of multipoint constraint are not recovered.
3. Multipoint constraint sets must be selected in the Case Control Deck (MPC=SID) to be used by NASTRAN.
4. Dependent coordinates on MPC cards may not appear on ØMIT, ØMIT1, SUPØRT, SPC or SPC1 cards; nor may the dependent coordinates be redundantly implied on ASET, ASET1, or MPCADD cards.

Input Data Card MPCADD   Multipoint Constraint Set Definition

Description: Defines a multipoint constraint set as a union of multipoint constraint sets defined via MPC cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MPCADD	SID	S1	S2	S3	S4	S5	S6	S7	abc
MPCADD	101	2	3	1	6	4			
+bc	S8	S9	-etc.-						

Field	Contents
SID	Set identification number (Integer > 0)
Sj	Set identification numbers of multipoint constraint sets defined via MPC cards (Integer > 0)

Remarks: 1. The Sj must be unique.

2. Multipoint constraint sets must be selected in the Case Control Deck (MPC=SID) to be used by NASTRAN.

3. Sj may not be the identification number of a multipoint constraint set defined by another MPCADD card.

NASTRAN DATA DECK

Input Data Card MPCAX Axisymmetric Multipoint Constraint

Description: Defines a multipoint constraint equation of the form

$$\sum_j A_j u_j = 0$$

for a model containing CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MPCAX	SID				RID	HID	C	A	+abc
MPCAX	32				17	6	1	1.0	+1
+abc	RID	HID	C	A	RID	HID	C	A	+def
+1	23	4	2	-6.8					

-etc.-

Field	Contents
SID	Set identification number (Integer > 0)
RID	Ring identification number (Integer > 0)
HID	Harmonic identification number (Integer > 0)
C	Component number ($1 \leq$ Integer ≤ 6)
A	Coefficient (Real; the first A must be nonzero)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. The first coordinate in the sequence is assumed to be the dependent coordinate and must be unique for all equations of the set.
3. Multipoint constraint sets must be selected in the Case Control Deck (MPC=SID) to be used by NASTRAN.
4. Dependent coordinates appearing on MPCAX cards may not appear on ØMITAX, SPCAX, or SUPAX cards.
5. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
6. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

Input Data Card MPCS   Substructure Multipoint Constraints

Description: Defines multipoint constraints within or between substructures.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MPCS	SID	NAME1	G1	C1	A1				abc
MPCS	171	WINGRT	966	1	1.0				ABC
+bc		NAME2	G21	C21	A21	G22	C22	A32	def
+BC		FUSELAGE	1036	1	.031	1036	6	32.7	DEF
+ef		NAME3	G31	C31	A31	G32	C32	A32	ghi
+EF		CABIN	39	2	.076				

Field	Contents
SID	Set identification number (Integer > 0)
NAMEi	Basic substructure name (BCD)
Gi	Grid or scalar point identification number in basic substructure NAME or NAMEi (Integer > 0)
Ci	Component number - Any one of the digits 1 - 6 in the case of geometric grid points; blank or zero in the case of scalar points (Integer > 0)
Ai	Coefficient (Real; A must be non-zero)

Remarks:
1. The first degree of freedom in the sequence is the dependent degree of freedom and must be unique for all equations of the set.
2. MPCS constraints may be imposed only at the SØLVE step of substructuring in Phase 2. Therefore, referenced grid point components must exist in the final solution substructure.
3. The operation will constrain the degrees of freedom by the equation:

$$\sum A_i u_i = 0$$

where u_i is the displacement defined by NAMEi, Gi, and Ci.

4. Components may be connected within substructures and/or to separate substructures.
5. The dependent degree of freedom may not also be referenced on any SPCS, SPCS1, SPCSD, SPC, SPC1, ØMIT, ØMIT1 or SUPØRT cards.
6. Multipoint constraint sets must be selected in the Case Control Deck (MPC=SID) to be used by NASTRAN.
7. MPCS cards may be referenced by an MPCADD card.

NASTRAN DATA DECK

Input Data Card NØLIN1 Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = S\ T(u_j(t))$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN1	SID	GI	CI	S	GJ	CJ	T		
NØLIN1	21	3	4	2.1	3	1	6		

Field	Contents
SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number for GI a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number for GJ a grid point (0 < Integer ≤ 6); blank or zero if GJ is a scalar or extra point
T	Identification number of a TABLEDi card (Integer > 0)

Remarks:
1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
2. Nonlinear loads may not be referenced on a DLØAD card.
3. All coordinates referenced on NØLIN1 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.

Input Data Card NØLIN2 Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = S\, u_j(t) u_k(t)$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN2	SID	GI	CI	S	GJ	CJ	GK	CK	
NØLIN2	14	2	1	2.9	2	1	2	1	

Field	Contents
SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number GI a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number for GJ a grid point (0 < Integer ≤ 6); blank or zero if GJ is a scalar or extra point
GK	Grid or scalar or extra point identification number (Integer > 0)
CK	Component number of GK a grid point (0 < Integer ≤ 6); blank or zero if GK is a scalar or extra point

Remarks:
1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
2. Nonlinear loads may not be referenced on a DLØAD card.
3. All coordinates referenced on NØLIN2 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.

Input Data Card NØLIN3 Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = \begin{cases} S(u_j(t))^A, & u_j(t) > 0 \\ 0 & , \ u_j(t) \le 0 \end{cases}$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN3	SID	GI	CI	S	GJ	CJ	A		
NØLIN3	4	102		-6.1	2	5	-3.5		

Field	Contents
SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number for GI a grid point (0 < Integer $\le$ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number for GJ a grid point (0 < Integer $\le$ 6); blank or zero if GJ is a scalar or extra point
A	Amplification factor (Real)

Remarks:
1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
2. Nonlinear loads may not be referenced on a DLØAD card.
3. All coordinates referenced on NØLIN3 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.

Input Data Card NØLIN4 Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = \begin{cases} -S(-u_j(t))^A, & u_j(t) < 0 \\ 0, & u_j(t) \geq 0 \end{cases}$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN4	SID	GI	CI	S	GJ	CJ	A		
NØLIN4	2	4	6	2.0	101		16.3		

Field	Contents
SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number for GI a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number for GJ a grid point (0 < Integer ≤ 6); blank or zero if GJ is a scalar or extra point
A	Amplification factor (Real)

Remarks:

1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
2. Nonlinear loads may not be referenced on a DLØAD card.
3. All coordinates referenced on NØLIN4 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.

Input Data Card ØMIT Omitted Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to omit from the problem through matrix partitioning. Used to reduce the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ØMIT	ID	C	ID	C	ID	C	ID	C	
ØMIT	16	2	23	3516			1	4	

Field	Contents
ID	Grid or scalar point identification number (Integer > 0)
C	Component number, zero or blank for scalar points, any unique combination of the digits 1-6 for grid points

Remarks: 1. Coordinates specified on ØMIT cards may not be specified on ØMIT1, ASET, ASET1, SUPØRT, SPC or SPC1 cards nor may they appear as dependent coordinates in multi-point constraint relations (MPC) or as permanent single-point constraints on GRID card.

2. As many as 24 coordinates may be omitted by a single card.

Input Data Card ØMIT1   Omitted Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to omit from the problem through matrix partitioning. Used to reduce the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ØMIT1	C	G	G	G	G	G	G	G	abc
ØMIT1	3	2	1	3	10	9	6	5	ABC
+bc	G	G	G	-etc.-					
+BC	7	8							

-etc.-

Alternate Form

ØMIT1	C	ID1	"THRU"	ID2					
ØMIT1	0	17	THRU	109					

Field	Contents
C	Component number (Any unique combination of the digits 1-6 (with no imbedded blanks) when point identification numbers are grid points; must be null or zero if point identification numbers are scalar points)
G,ID1,ID2	Grid or scalar point identification number (Integer > 0; ID1 < ID2)

Remarks: 1. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation (MPC card), nor may it be referenced on a SPC, SPC1, ØMIT, ASET, ASET1, or SUPØRT card or on a GRID card as permanent single-point constraints.

2. If the alternate form is used, all of the grid (or scalar) points ID1 thru ID2 are assumed.

Input Data Card ØMITAX   Axisymmetric Omitted Coordinate

Description: Defines coordinates that the user desires to omit from a model containing CCØNEAX, CTRAPAX or CTRIAAX elements through matrix partitioning. Used to reduce the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ØMITAX	RID	HID	C	RID	HID	C			
ØMITAX	2	6	3	4	7	1			

Field	Contents
RID	Ring identification number (Integer > 0)
HID	Harmonic identification number (Integer ≥ 0)
C	Component number (any unique combination of the digits 1-6)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. Up to 12 coordinates may be omitted via this card.
3. Coordinates appearing on ØMITAX cards may not appear on MPCAX, SUPAX or SPCAX cards.
4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
5. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

Input Data Card PAERØ1 Aerodynamic Panel Property

Description: Gives properties for DOUBLET LATTICE method.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PAERØ1	PID		X0	X1					
PAERØ1	1		.45	.95					

Field	Contents
PID	Property identification number (referenced by CAERØ), (unique Integer > 0).
X0	Center of pressure in fraction of box chord (Real), default X0 = 0.25.
X1	Downwash center in fraction of box chord (Real), default X1 = 0.75.

NASTRAN DATA DECK

Input Data Card PARAM Parameter

Description: Specifies values for parameters used in DMAP sequences (including rigid formats).

Format and Example :

1	2	3	4	5	6	7	8	9	10
PARAM	N	V1	V2						
PARAM	IRES	1							

Field	Contents
N	Parameter name (one to eight alphanumeric characters, the first of which is alphabetic)
V1, V2	Parameter value based on parameter type as follows:

Type	V1	V2
Integer	Integer	Blank
Real, single-precision	Real	Blank
BCD	BCD	Blank
Real, double-precision	Double-precision	Blank
Complex, single-precision	Real	Real
Complex, double-precision	Double-precision	Double-precision

Remarks: 1. Only parameters for which assigned values are allowed may be given values via the PARAM card. Section 5 describes parameters as used in DMAP.

2. The following is a list of the parameters:

a. GRDPNT - optional in all DISPLACEMENT and AERØ rigid formats. A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed. The value of the integer indicates the grid point to be used as a reference point. If the integer is zero (blank is not equivalent) or is not a defined grid point, the reference point is taken as the origin of the basic coordinate system. All fluid related masses are ignored. Additional details for the Grid Point Weight Generator are given in Section 5.5 of the Theoretical Manual. The following weight and balance information is automatically printed following the execution of the Grid Point Weight Generator.

(1) Reference point.

(2) Rigid body mass matrix [MØ] relative to the reference point in the basic coordinate system.

(3) Transformation matrix [S] from basic coordinate system to principal mass axes.

(4) Principal masses (mass) and associated centers of gravity (X-C.G.,Y-C.G., Z-C.G.).

(5) Inertia matrix I(S) about the center of gravity relative to the principal mass axes.

(6) Inertia matrix I(Q) about the center of gravity relative to the principal inertia axes.

(7) Transformation matrix [Q] between S-axes and Q-axes.

b. WTMASS - optional in all DISPLACEMENT and AERØ rigid formats. The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

c. IRES - optional in all DISPLACEMENT and HEAT statics problems (rigid formats 1, 2, 4, 5 and 6). A positive integer value of this parameter will cause the printing of the residual vectors following each execution of SSG3.

d. LFREQ and HFREQ - required in all modal formulations of DISPLACEMENT and AERØ dynamics problems (rigid formats 10, 11 and 12) unless LMØDES is used. The real values of these parameters give the cyclic frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.

e. LMØDES - required in all modal formulations of DISPLACEMENT and AERØ dynamics problems (rigid formats 10, 11 and 12) unless LFREQ and HRFEQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

f. G - optional in the direct formulation of all DISPLACEMENT dynamics problems (rigid formats 7, 8 and 9). The real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems (See Section 9.3.3 of the Theoretical Manual). Not recommended for use in hydroelastic problems.

g. W3 and W4 - optional in the direct formulation of DISPLACEMENT transient response problems (rigid format 9). The real values (radians/unit time) of these parameters are used as pivotal frequencies for uniform structural damping and element structural damping, respectively (See Section 9.3.3 of the Theoretical Manual). The parameter W3 should not be used for hydroelastic problems.

h. MØDACC - optional in the modal formulation of frequency response (rigid format 11) and transient response (rigid format 12) problems. A positive integer value of this parameter causes the Dynamic Data Recovery module to use the mode acceleration method. Not recommended for use in hydroelastic problems.

i. CØUPMASS - optional in all DISPLACEMENT and AERØ rigid formats. A positive integer value of this parameter will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness. This option applies to both structural and nonstructural mass for the following elements: BAR, CØNRØD, QUAD1, QUAD2, RØD, TRIA1, TRIA2, TUBE. Since structural mass is not defined for the following list of elements, the option applies only to the nonstructural mass: QDPLT, TRBSC, TRPLT. A negative value causes the generation of lumped mass matrices (translational components only) for all the above elements. (This is the default). A zero value activates the following parameters described under j.

j. CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional in all DISPLACEMENT and AERØ rigid formats. These parameters are active only if CØUPMASS=0. A positive value will cause the generation of coupled mass matrices for all elements of that particular type as shown by the following table:

Parameter	Element Types
CPBAR	BAR
CPRØD	RØD, CONRØD
CPQUAD1	QUAD1
CPQUAD2	QUAD2
CPTRIA1	TRIA1
CPTRIA2	TRIA2
CPTUBE	TUBE
CPQDPLT	QDPLT
CPTRPLT	TRPLT
CPTRBSC	TRBSC

A negative value (the default) for these parameters will cause the generation of the lumped mass matrices (translational components only) for these element types.

PARAM (Cont.)

k. MAXIT - optional in nonlinear static HEAT transfer analysis (rigid format 3). The integer value of this parameter limits the maximum number of iterations. The default value is 4 iterations.

l. EPSHT - optional in nonlinear static HEAT transfer analysis (rigid format 3). The real value of this parameter is used to test the convergence of the nonlinear heat transfer solution (see Section 8.4.1 of the Theoretical Manual). The default value is .001.

m. TABS - optional in nonlinear static (rigid format 3) and transient (rigid format 9) HEAT transfer analysis. The real value of this parameter is the absolute reference temperature. The default value is 0.0.

n. SIGMA - optional in nonlinear static (rigid format 3) and transient (rigid format 9) HEAT transfer analysis. The real value of this parameter is the Stefan-Boltzman constant. The default value is 0.0.

o. BETA - optional in transient HEAT transfer analysis (rigid format 9). The real value of this parameter is used as a factor in the integration algorithm (see Section 8.4.2 of the Theoretical Manual). The default value is 0.55.

p. RADLIN - optional in transient HEAT transfer analysis (rigid format 9). A positive integer value of this parameter causes some of the radiation effects to be linearized (see Equation 2, Section 8.4.2 of the Theoretical Manual). The default value is -1.

q. BETAD - optional in static analysis with differential stiffness (rigid format 4). The integer value of this parameter is the number of iterations allowed for computing the load correction in the inner (load) loop before shifting to the outer (stiffness) loop which adjusts the differential stiffness. The default value is 4 iterations.

r. NT - optional in static analysis with differential stiffness (rigid format 4). The integer value of this parameter limits the cumulative number of iterations in both loops. The default value is 10 iterations.

s. EPSIØ - optional in static analysis with differential stiffness (rigid format 4). The real value of this parameter is used to test the convergence of iterated differential stiffness. The default value is 10^{-5}.

t. CTYPE - required in cyclic symmetry analysis (rigid formats 14 and 15). The BCD value of this parameter defines the type of cyclic symmetry as follows:

(1) RØT - rotational symmetry
(2) DRL - dihedral symmetry, using right and left halves
(3) DSA - dihedral symmetry, using symmetric and antisymmetric components.

u. NESGS - required in cyclic symmetry analysis (rigid formats 14 and 15). The integer value of this parameter is the number of identical segments in the structural model.

v. NLØAD - optional in static analysis with cyclic symmetry (rigid format 14). The integer value of this parameter is the number of static loading conditions. The default value is 1.

w. CYCIØ - optional in static analysis with cyclic symmetry (rigid format 14). The integer value of this parameter specifies the form of the input and output data. A value of +1 is used to specify physical segment representation, and a value of -1 for cyclic transform representation. The default value is +1.

x. CYCSEQ - optional in cyclic symmetry analysis (rigid formats 14 and 15). The integer value of this parameter specifies the procedure for sequencing the equations in the solution set. A value of +1 specifies that all cosine terms should be sequenced before all sine terms, and a value of -1 for alternating the cosine and sine terms. The default value is -1.

y. KMAX - optional in static analysis with cyclic symmetry (rigid format 14). The integer value of this parameter specifies the maximum value of the harmonic index. The default value is ALL which is NSEGS/2 for NSEGS even and (NSEGS-1)/2 for NSEGS odd.

z. KINDEX - required in normal modes with cyclic symmetry (rigid format 15). The integer value of this parameter specifies a single value of the harmonic index.

aa. NØDJE - optional in modal flutter analysis. A positive integer of this parameter indicates user supplied downwash matrices due to extra points are to be read from tape via the INPUTT2 module in the rigid format. The default value is -1.

ab. P1,P2 and P3 - required in modal flutter analysis when using NØDJE parameter. See Section 5.3.2 for tape operation parameters required by INPUTT2 module. The defaults for P1,P2 and P3 are -1,11 and TAPEID, respectively.

ac. VREF - optional in modal flutter analysis. Velocities are divided by the real value of this parameter to convert units or to compute flutter indices. The default value is 1.0.

ad. PRINT - optional in modal flutter analysis. The BCD value, NØ, of this parameter will suppress the automatic printing of the flutter summary for the K method. The default value is YES.

Input Data Card PBAR Simple Beam Property

Description: Defines the properties of a simple beam (bar) which is used to create bar elements via the CBAR card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PBAR	PID	MID	A	I1	I2	J	NSM		abc
PBAR	39	6	2.9		5.97				123
+bc	C1	C2	D1	D2	E1	E2	F1	F2	def
+23			2.0	4.0					
+ef	K1	K2	I12						

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
A	Area of bar cross-section (Real)
I1, I2, I12	Area moments of inertia (Real, $I_1 I_2 \geq I_{12}^2$)
J	Torsional constant (Real)
NSM	Nonstructural mass per unit length (Real)
K1, K2	Area factor for shear (Real)
Ci, Di, Ei, Fi	Stress recovery coefficients (Real)

Remarks:

1. For structural problems, PBAR cards may only reference MAT1 material cards.
2. See Section 1.3.2 for a discussion of bar element geometry.
3. For heat transfer problems, PBAR cards may only reference MAT4 or MAT5 material cards.

Input Data Card PCØNEAX Conical Shell Element Property

Description: Defines the properties of a conical shell element described on a CCØNEAX card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PCØNEAX	ID	MID1	T1	MID2	I	MID3	T2	NSM	+abc
PCØNEAX	2	4	1.0	6	16.3	8	2.1	0.5	+1
+abc	Z1	Z2	PHI1	PHI2	PHI3	PHI4	PHI5	PHI6	+def
+1	0.001	-0.002	23.6	42.9					+2
+def	PHI7	PHI8	PHI9	PHI10	PHI11	PHI12	PHI13	PHI14	
+2									

Field	Contents
ID	Property identification number (Unique Integer > 0)
MIDi	Material identification number for membrane, bending, and transverse shear (Integer $\geq$ 0)
T1,T2	Membrane thickness and transverse shear thickness (Real > 0.0 if MIDi $\neq$ 0)
I	Moment of Inertia per unit width (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for stress recovery (Real)
PHIi	Azimuthal coordinates (in degrees) for stress recovery (Real)

Remarks:

1. This card is allowed if and only if a AXIC card is also present.
2. PCØNEAX cards may only reference MAT1 material cards.
3. If either MID1 = 0 or blank or T1 = 0.0 or blank, then both must be zero or blank.
4. If either MID2 = 0 or blank or I = 0.0 or blank, then both must be zero or blank.
5. If either MID3 = 0 or blank or T2 = 0.0 or blank, then both must be zero or blank.
6. A maximum of 14 azimuthal coordinates for stress recovery may be specified. An error will be detected if more than two (2) continuation cards appear.
7. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

Input Data Card PDAMP Scalar Damper Property

Description: Used to define the damping value of a scalar damper element which is defined by means of the CDAMP1 or CDAMP3 cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PDAMP	PID	B	PID	B	PID	B	PID	B	
PDAMP	14	-2.3	2	6.1					

Field	Contents
PID	Property identification number (Integer > 0)
B	Value of scalar damper (Real)

Remarks:

1. This card defines a damper value. The user is cautioned to be careful when using negative damper values. Damper values are defined directly on the CDAMP2 and CDAMP4 cards. A structural viscous damper, CVISC, may also be used for geometric grid points.

2. Up to four damper properties may be defined on a single card.

3. For a discussion of scalar elements, see Section 5.6 of the Theoretical Manual.

BULK DATA DECK

Input Data Card PDUMi   Dummy Element Property

Description: Defines the properties of a dummy element ($1 \leq i \leq 9$). Referenced by the CDUMi card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PDUMi	PID	MID	A1	A2			-etc.-		abc
PDUM3	108	2	2.4	9.6	1.E4	15.		3.5	ABC

+bc		-etc.-	AN						
+BC	5		2						

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
A1...AN	Additional entries (Real or Integer)

Remarks: The additional entries are defined in the user written element routines.

Input Data Card PELAS Scalar Elastic Property

Description: Used to define the stiffness, damping coefficient, and stress coefficient of a scalar elastic element (spring) by means of the CELAS1 or CELAS3 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PELAS	PID	K	GE	S	PID	K	GE	S	
PELAS	7	4.29	0.06	7.92	27	2.17	0.0032		

Field	Contents
PID	Property identification number (Integer > 0)
K	Elastic property value (Real)
GE	Damping coefficient, g_e (Real)
S	Stress coefficient (Real)

Remarks:

1. The user is cautioned to be careful using negative spring values. (Values are defined directly on some of the CELASi card types.)
2. One or two elastic spring properties may be defined on a single card.
3. For a discussion of scalar elements, see Section 5.6 of the Theoretical Manual.

NASTRAN DATA DECK

Input Data Card PHBDY Property of Heat Boundary Element

Description: Defines the properties of the HBDY element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PHBDY	PID	MID	AF	E	ALPHA	R1	R2		
PHBDY	100	103	300.	.79					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer $\geq$ 0 or blank), used for convective film coefficient and thermal capacity.
AF	Area factor (Real $\geq$ 0.0 or blank). Used only for HBDY types PØINT, LINE, and ELCYL.
E	Emissivity (0.0 $\leq$ Real $\leq$ 1.0 or blank). Used only for radiation calculations.
ALPHA	Absorbtivity (0.0 $\leq$ Real $\leq$ 1.0 or blank). Used only for thermal vector flux calculations, default value is E.
R1,R2	"Radii" of elliptic cylinder. Used for HBDY type "ELCYL". See the HBDY element description. (Real)

Remarks:

1. The referenced material Id must be on a MAT4 card. The card defines the convective film coefficient and thermal capacity per unit area. If no material is referenced the element convection and heat capacity are zero.

2. The area factor AF is used to determine the effective area. For a "PØINT", AF = area; for "LINE" or "ELCYL", AF = effective width where area = AF·length. The effective area is automatically calculated for other HBDY types.

Input Data Card PIHEX   Isoparametric Hexahedron Property

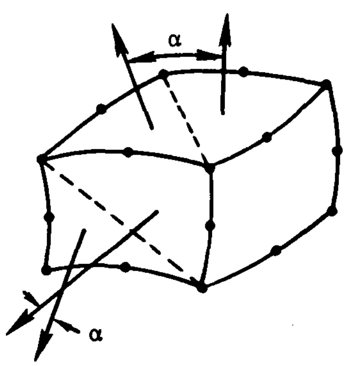
Description: Defines the properties of an isoparametric solid element, including a material reference and the number of integration points. Referenced by the CIHEX1, CIHEX2, and CIHEX3 cards.

Format and Example:

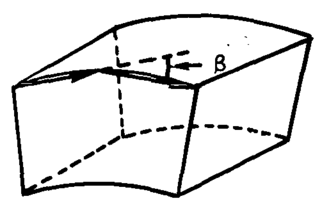
1	2	3	4	5	6	7	8	9	10
PIHEX	PID	MID	CID	NIP	AR	ALFA	BETA		
PIHEX	15	3		3			5.0		

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
CID	Identification number of the coordinate system in which the material referenced by MID is defined (Integer ≥ 0 or blank)
NIP	Number of integration points along each edge of the element (Integer = 2, 3, 4 or blank)
AR	Maximum aspect ratio (ratio of longest to shortest edge) of the element (Real > 1.0 or blank)
ALFA	Maximum angle in degrees between the normals of two subtriangles comprising a quadrilateral face (Real, 0.0 ≤ ALFA ≤ 180.0, or blank)
BETA	Maximum angle in degrees between the vector connecting a corner point to an adjacent midside point and the vector connecting that midside point and the other midside or corner point (Real, 0.0 ≤ BETA ≤ 180.0, or blank)

Examples of Field Definitions:



Example of ALFA



Example of BETA

Remarks:

1. All PIHEX cards must have unique identification numbers.
2. CID is not used for isotropic materials.
3. The default for CID is the basic coordinate system.
4. The default for NIP is 2 for IHEX1 and 3 for IHEX2 and IEHX3.
5. AR, ALFA, and BETA are used for checking the geometry of the element. The defaults are:

	AR	ALFA (degrees)	BETA (degrees)
CIHEX1	5.0	45.0	--
CIHEX2	10.0	45.0	45.0
CIHEX3	15.0	45.0	45.0

Input Data Card PLFACT Piecewise Linear Analysis Factor Definition Card

Description: Defines scale factors for Piecewise Linear Analysis loading.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLFACT	SID	B1	B2	B3	B4	B5	B6	B7	+abc
PLFACT	6	0.2	0.3	0.4	0.5	0.6	0.7	0.8	ABC
+abc	B8	B9	-etc.-						
+BC	0.9	1.0							

Field	Contents
SID	Unique set identification number (Integer > 0)
Bi	Loading factor (Real)

Remarks:
1. The remainder of the physical card containing the last entry must be null.
2. At any stage of the Piecewise Linear Analysis, the accumulated load is given by

   $$\{P_i\} = B_i\{P\}$$

   where {P} is the total load defined in the usual way.

   Example: If it were desired to load the structure in ten equally spaced load increments then set

   $$B_i = 0.1 \cdot i \quad ; \quad i = 1, 10$$

3. Normally, the B_i form a monotonically increasing sequence. A singular stiffness matrix will result if $B_i = B_{i-1}$.
4. At least two factors must be defined.
5. Piecewise Linear Analysis factor sets must be selected in the Case Control Deck (PLCØEFF=SID) to be used by NASTRAN.

Input Data Card PLIMIT Property Optimization Limits

Description: Defines the maximum and minimum limits for ratio of new property to original property.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLIMIT	ELTYP	KMIN	KMAX	PID1	PID2	PID3	PID4	PID5	+abc
PLIMIT	RØD	.01	1.5	1	3	5	4	2	+ABC

+bc	PID6	-etc.-							
+BC		-etc.-							

Alternate form:

PLIMIT	ELTYP	KMIN	KMAX	PID1	"THRU"	PIDi			
PLIMIT	ALL	.001	0.05	30	"THRU"	36			

Field	Contents
ELTYP	One of the following element types: RØD, TUBE, BAR, TRMEM, QDMEM, TRPLT, QDPLT, TRBSC, TRIA1, QUAD1, TRIA2, QUAD2, SHEAR, or ALL or blank.
KMIN	Minimum property ratio (Real > 0.0)
KMAX	Maximum property ratio (Real > KMIN or = 0.0)
PIDn	List of property identification numbers associated with KMIN and/or KMAX (Integer > 0)

Remarks:

1. This card is not required (Default KMIN = KMAX = 0.0 for ALL elements).
2. All PID values must be unique for each element type.
3. All elements with the same property identification number in the output stress data block, ØES1, have these limits applied if ALL is specified.
4. Property entries optimized depend on the element type and material stress limits. Only nonzero properties with nonzero stress limits are optimized.
5. If KMAX = 0.0, no limit is placed on the maximum change.
6. If ELTYP is blank, ALL is assumed.

NASTRAN DATA DECK

Input Data Card PLØAD Static Pressure Load

Description: Defines a static pressure load.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLØAD	SID	P	G1	G2	G3	G4			
PLØAD	1	-4.0	16	32	11				

Field	Contents
SID	Load set identification number (Integer > 0)
P	Pressure (Real)
G1,G2,G3,G4	Grid point identification numbers (Integer > 0; G4 may be zero)

Remarks:

1. Grid points must be unique and noncollinear.
2. If four grid points are given, four triangles are formed and half of P is applied to each one. For each triangle the direction is defined by

$$+(\vec{r}_{12} \times \vec{r}_{13})$$

where $\vec{r}_{ij}$ is the vector from Gi to Gj.

3. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

Input Data Card PLØAD2 Pressure Load

Description: Defines a uniform static pressure load applied to two-dimensional elements. Only QUAD1, QUAD2, QDMEM, QDMEM1, QDMEM2, QDPLT, SHEAR, TRBSC, TRIA1, TRIA2, TRMEM, TRPLT or TWIST elements may have a pressure load applied to them via this card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLØAD2	SID	P	EID	EID	EID	EID	EID	EID	
PLØAD2	21	-3.6		4	16		2		

Alternate Form

1	2	3	4	5	6	7	8	9	10
PLØAD2	SID	P	EID1	"THRU"	EID2				
PLØAD2	1	30.4	16	THRU	48				

Field	Contents
SID	Load set identification number (Integer > 0)
P	Pressure value (Real)
EID, EID1, EID2	Element identification number (Integer > 0; EID1 < EID2)

Remarks:

1. EID must be 0 or blank for omitted entrys.
2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
3. At least one positive EID must be present on each PLØAD2 card.
4. If the alternate form is used, all elements EID1 thru EID2 must be two-dimensional.
5. The pressure load is computed for each element as if the grid points to which the element is connected were specified on a PLØAD card. The grid point sequence specified on the element connection card is assumed for the purpose of computing pressure loads.
6. All elements referenced must exist.

Input Data Card PLØAD3 Pressure Load on a Face of an Isoparametric Element

Description: Defines a uniform static pressure load applied to a surface of an isoparametric hexahedron element only.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLØAD3	SID	P	EID1	G11	G12	EID2	G21	G22	
PLØAD3	3	-15.1	15	7	25	16	117	135	

Field	Contents
SID	Load set identification number (Integer > 0)
P	Pressure value (Real, force per unit area)
EID1, EID2	Element identification number (Integer > 0)
G11, G12, G21, G22	Grid point identification number of two grid points at diagonally opposite corners of the face on which the pressure acts (Integers > 0)

Remarks:
1. Load sets must be selected in the Case Control Deck (LØAD = SID) to be used by NASTRAN.
2. At least one EID must be present on each PLØAD3 card.
3. All elements referenced must exist.
4. Computations consider the pressure to act positive outward on specified face of element.

Input Data Card PLØTEL Dummy Element Definition

Description: Defines a dummy one-dimensional element for use in plotting. This element is not used in the model during any of the solution phases of a problem. It is used to simplify plotting of structures with large numbers of collinear grid points where the plotting of each one along with the elements connecting them would result in a confusing plot. The use of this "element" is entirely the responsibility of the user.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLØTEL	EID	G1	G2		EID	G1	G2		
PLØTEL	29	35	16						

Field	Contents
EID	Element identification number (Integer > 0)
G1, G2	Grid point identification numbers of connection points (Integer > 0; G1 $\neq$ G2)

Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. One or two PLØTEL elements may be defined on a single card.

Input Data Card PMASS Scalar Mass Property

Description: Used to define the mass value of a scalar mass element which is defined by means of the CMASS1 or CMASS3 cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PMASS	PID	M	PID	M	PID	M	PID	M	
PMASS	7	4.29	6	13.2					

Field	Contents
PID	Property identification number (Integer > 0)
M	Value of scalar mass (Real)

Remarks:

1. This card defines a mass value. The user is cautioned to be careful when using negative mass values. (Values are defined directly on some of the CMASSi card types.)
2. Up to four mass properties may be defined by this card.
3. For a discussion of scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card PØINTAX   Axisymmetric Point

Description: Defines the location of a point on an axisymmetric ring at which loads may be applied via the FØRCE, FØRCEAX, MØMENT or MØMAX cards and at which displacements may be requested. These points are not subject to constraints via MPCAX, SPCAX, or ØMITAX cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PØINTAX	ID	RID	PHI						
PØINTAX	2	3	30.0						

Field	Contents
ID	Point identification number (Unique Integer > 0)
RID	Identification number of a RINGAX card (Integer > 0)
PHI	Azimuthal angle in degrees (Real)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. PØINTAX identification numbers must be unique with respect to all other PØINTAX, RINGAX and SECTAX identification numbers.
3. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
4. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

Input Data Card PØPT Property Optimization Parameter

Description: Defines the basic parameters and existence of a property optimization analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PØPT	MAX	EPS	GAMA	PRINT	PUNCH				
PØPT	2	1.0E-3	0.9	2	NØ				

Field	Contents
MAX	Maximum number of iterations on property values (Integer > 0)
EPS	Convergence criteria for property value. If zero, no convergence check (Real ≥ 0.0)
GAMA	Iteration factor (Default = 1.0) (Real > 0.0)
PRINT	Print control for property parameters and ØFP. Printout occurs every Ith loop. The first and last loops are always printed (Integer > 0)
PUNCH	Property card punch option. If YES, properties that were optimized are punched (BCD, "YES" or "NO")

Remarks:

1. Only one PØPT card is allowed.
2. All subcases will be analyzed MAX+1 times unless all properties converge.
3. Property convergence is defined by

$$\frac{|\sigma-\sigma_\ell|}{\sigma_\ell} < \mathrm{EPS}$$

where σ is the maximum stress and σ_ℓ is the appropriate stress limit on the material card.

4. Stress recovery must be requested for one of the following elements: RØD, TUBE, BAR, TRMEM, QDMEM, TRPLT, QDPLT, TRBSC, TRIA1, QUAD1, TRIA2, QUAD2, or SHEAR. In addition, the material card must have stress limits defined.
5. Property cards are always printed for the last iteration.
6. The property entry optimized depends on the element type and the material stress limits (see Section 1.13).

BULK DATA DECK

Input Data Card PQDMEM Quadrilateral Membrane Property

Description: Used to define the properties of a quadrilateral membrane. Referenced by the CQDMEM card. No bending properties are included.

Foramt and Example:

1	2	3	4	5	6	7	8	9	10
PQDMEM	PID	MID	T	NSM	PID	MID	T	NSM	
PQDMEM	235	2	0.5	0.0					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness of membrane (Real > 0.0)
NSM	Nonstructural mass per unit area (Real)

Remarks: 1. All PQDMEM cards must have unique property identification numbers.

2. One or two quadrilateral membrane properties may be defined on a single card.

Input Data Card PQDMEM1 Isoparametric Quadrilateral Membrane Property

Description: Used to define the properties of an isoparametric quadrilateral membrane. Referenced by the CQDMEM1 card. No bending properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQDMEM1	PID	MID	T	NSM	PID	MID	T	NSM	
PQDMEM1	235	2	0.5	0.0					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness of membrane (Real > 0.0)
NSM	Nonstructural mass per unit area (Real)

Remarks:

1. All PQDMEM1 cards must have unique property identification numbers.
2. One or two isoparametric quadrilateral membrane properties may be defined on a single card.

Input Data Card PQDMEM2 Quadrilateral Membrane Property

Description: Used to define the properties of a quadrilateral membrane. Referenced by the CQDMEM2 card. No bending properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQDMEM2	PID	MID	T	NSM	PID	MID	T	NSM	
PQDMEM2	235	2	0.5	0.0					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness of membrane (Real > 0.0)
NSM	Nonstructural mass per unit area (Real)

Remarks: 1. All PQDMEM2 cards must have unique property identification numbers.

2. One or two quadrilateral membrane properties may be defined on a single card.

Input Data Card PQDPLT Quadrilateral Plate Property

Description: Used to define the bending properties of a quadrilateral plate element. Referenced by the CQDPLT card. No membrane properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQDPLT	PID	MID1	I	MID2	T	NSM	Z1	Z2	
PQDPLT	16	23	4.29	16	2.63	1.982	0.05	-0.05	

Field	Contents
PID	Property identification number (Integer > 0)
MID1	Material identification number for bending (Integer > 0)
I	Bending area moment of inertia per unit width (Real)
MID2	Material identification number for transverse shear (Integer ≥ 0)
T	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for stress computation, positive according to the right-hand sequences defined on the CQDPLT card (Real)

Remarks:
1. All PQDPLT cards must have unique property identification numbers.
2. If T is zero, the element is assumed to be rigid in transverse shear.
3. No structural mass is generated for this element.

NASTRAN DATA DECK

Input Data Card PQUAD1 General Quadrilateral Element Property

Description: Defines the properties of a general quadrilateral element of the structural model, including bending, membrane, and transverse shear effects. Referenced by the CQUAD1 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQUAD1	PID	MID1	T1	MID2	I	MID3	T3	NSM	abc
PQUAD1	32	16	2.98	9	6.45	16	5.29	6.32	WXYZ1
+bc	Z1	Z2							
+XYZ1	0.09	-0.06							

Field	Contents
PID	Property identification number (Integer > 0)
MID1	Material identification number for membrane (Integer $\geq$ 0)
T1	Membrane thickness (Real)
MID2	Material identification number for bending (Integer $\geq$ 0)
I	Area moment of inertia per unit width (Real)
MID3	Material identification number for transverse shear (Integer $\geq$ 0)
T3	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for stress computation, positive according to the right-hand sequence defined on the CQUAD1 card (Real)

Remarks:
1. All PQUAD1 cards must have unique property identification numbers.
2. If T3 is zero, the element is assumed to be rigid in transverse shear.
3. The membrane thickness, T1, is used to compute the structural mass for this element.

Input Data Card PQUAD2 Homogeneous Quadrilateral Property

Decription : Defines the properties of a homogeneous quadrilateral element of the structural model, including bending, membrane and transverse shear effects. Referenced by the CQUAD2 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQUAD2	PID	MID	T	NSM	PID	MID	T	NSM	
PQUAD2	32	16	2.98	9.0	45	16	5.29	6.32	

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness (Real> 0.0)
NSM	Nonstructual mass per unit area (Real)

Remarks:
1. All PQUAD2 cards must have unique identification numbers.
2. The thickness used to compute membrane and transverse shear properties is T.
3. The area moment of inertia per unit width used to compute the bending stiffness is $T^3/12$.
4. Outer fiber distances of ±T/2 are assumed.
5. One or two homogeneous quadrilateral properties may be defined on a single card.

Input Data Card PRESAX Axisymmetric Pressure Load

Description: Defines the static pressure loading for a model containing CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PRESAX	SID	P	RID1	RID2	PHI1	PHI2			
PRESAX	3	7.92	4	3	20.6	31.4			

Field	Contents
SID	Load set identification number (Integer > 0)
P	Pressure value (Real)
RID1, RID2	Ring identification numbers (see RINGAX card) (Integer > 0)
PHI1, PHI2	Azimuthal angles in degrees (Real)

Remarks: 1. This card is allowed if and only if an AXIC card is also present.

2. Load sets must be selected in the Case Control Deck (LØAD=SID) in order to be used by NASTRAN.

3. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

4. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

NASTRAN DATA DECK

Input Data Card PRESPT Fluid Pressure Point

Description: Defines the location of pressure points in the fluid for recovery of pressure data.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PRESPT	IDF		IDP	ϕ	IDP	ϕ	IDP	ϕ	
PRESPT	14		141	0.0			142	90.0	

Field	Contents
IDF	Fluid point (RINGFL) identification number (Integer > 0)
IDP	Unique pressure point identification number (Integer > 0)
ϕ	Azimuthal position on fluid point, referenced by IDF, in Fluid Coordinate System (Real)

Remarks:
1. This card is allowed only if an AXIF card is also present.
2. All pressure point identification numbers must be unique with respect to other scalar, structural and fluid points.
3. The pressure points are used primarily for the identification of output data. They may also be used as points at which to measure pressure for input to control devices (see User's Manual, Section 1.7).
4. One, two or three pressure points may be defined per card.
5. Output requests for velocity and acceleration of these degrees of freedom will result in derivatives of pressure with respect to time.

Input Data Card PRØD Rod Property

Description: Defines the properties of a rod which is referenced by the CRØD card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PRØD	PID	MID	A	J	C	NSM			
PRØD	17	23	42.6	17.92	4.236	0.5			

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
A	Area of rod (Real)
J	Torsional constant (Real)
C	Coefficient to determine torsional stress (Real)
NSM	Nonstructual mass per unit length (Real)

Remarks:

1. PRØD cards must all have unique property identification numbers.
2. For structural problems, PRØD cards may only reference MAT1 material cards.
3. For heat transfer problems, PRØD cards may only reference MAT4 or MAT5 cards.

Input Data Card PSHEAR Shear Panel Property

Description: Defines the elastic properties of a shear panel. Referenced by the CSHEAR card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PSHEAR	PID	MID	T	NSM	PID	MID	T	NSM	
PSHEAR	13	2	4.9	16.2	14	6	4.9	14.7	

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness of shear panel (Real $\neq$ 0.0)
NSM	Nonstructural mass per unit area (Real)

Remarks:
1. All PSHEAR cards must have unique identification numbers.
2. PSHEAR cards may only reference MAT1 material cards.
3. One or two shear panel properties may be defined on a single card.

NASTRAN DATA DECK

Input Data Card PTØRDRG Toroidal Ring Property

Description: Used to define membrane and flexure (bending) properties of a toroidal ring element. Referenced by the CTØRDRG card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTØRDRG	PID	MID	TM	TF	PID	MID	TM	TF	
PTØRDRG	2	4	0.1	0.15					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
TM	Thickness for membrane (Real > 0.0)
TF	Thickness for flexure (Real)

Remarks:
1. All PTØRDRG cards must have unique property identification numbers.
2. The material identification number MID must reference only a MAT1 or MAT3 card.
3. One or two toroidal ring properties may be defined on a single card.

NASTRAN DATA DECK

Input Data Card PTRAPAX Triangular Ring Element Property

Description: Defines the properties of an axisymmetric trapezoidal cross-section ring element referenced by the CTRAPAX card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRAPAX	PID		MID	PHI1	PHI2	PHI3	PHI4	PHI5	+abc
PTRAPAX	5		15	0.0	5.0	6.0	7.0	8.0	+N1
+abc	PHI6	PHI7	PHI8	PHI9	PHI10	PHI11	PHI12	PHI13	+def
+N1	9.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	+2
+def	PHI14								
+N2	45.0								

Field	Contents
PID	Property identification number (Integer > 0).
MID	Material identification number (Integer > 0).
PHIi	Azimuthal coordinates (in degrees) for stress recovery (Real).

Remarks:

1. All PTRAPAX cards must have unique property identification numbers.
2. This card is allowed if and only if an AXIC card is also present.
3. PTRAPAX card may reference MAT1 or MAT3 material cards.
4. A maximum of 14 azimuthal coordinates for stress recovery may be specified.

Input Data Card PTRBSC Basic Bending Triangle Property

Description: Defines basic bending triangle (TRBSC) properties. Referenced by the CTRBSC card. No membrane properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRBSC	PID	MID1	I	MID2	T	NSM	Z1	Z2	
PTRBSC	3	17	6.29	4	16.	1.982	0.05	-0.05	

Field	Contents
PID	Property identification number (Integer > 0)
MID1	Material identification number for bending (Integer > 0)
I	Bending area moment of inertia per unit width (Real)
MID2	Material identification number for transverse shear (Integer ≥ 0)
T	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for shear computation, positive according to the right-hand sequence defined in the CTRBSC card (Real)

Remarks:
1. All PTRBSC cards must have unique property identification numbers.
2. If T is zero, the element is assumed to be rigid in transverse shear.
3. No structural mass is generated by this element.

BULK DATA DECK

Input Data Card PTRIAAX Triangular Ring Element Property

Description: Defines the properties of an axisymmetric triangular cross-section ring element referenced by the CTRIAAX card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRIAAX	PID		MID	PHI1	PHI2	PHI3	PHI4	PHI5	+abc
PTRIAAX	5		15	0.0	5.0	6.0	7.0	8.0	+N1
+abc	PHI6	PHI7	PHI8	PHI9	PHI10	PHI11	PHI12	PHI13	+def
+N1	9.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	+N2
+def	PHI14								
+N2	45.0								

Field	Contents
PID	Property identification number (Integer > 0).
MID	Material identification number (Integer > 0).
PHIi	Azimuthal coordinates (in degrees) for stress recovery (Real).

Remarks:

1. All PTRIAAX cards must have unique property identification numbers.
2. This card is allowed if and only if an AXIC card is also present.
3. PTRIAAX card may reference MAT1 or MAT3 material cards.
4. A maximum of 14 azimuthal coordinates for stress recovery may be specified.

Input Data Card PTRIA1 General Triangular Element Property

Description: Defines the properties of a general triangular element of the structural model, including bending, membrane and transverse shear effects. Referenced by the CTRIA1 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRIA1	PID	MID1	T1	MID2	I	MID3	T3	NSM	abc
PTRIA1	32	16	2.98	9	6.45	16	5.29	6.32	QED
+bc	Z1	Z2							
+ED									

Field	Contents
PID	Property identification number (Integer > 0)
MID1	Material identification number for membrane (Integer ≥ 0)
T1	Membrane thickness (Real)
MID2	Material identification number for bending (Integer ≥ 0)
I	Area of moment of inertia per unit width (Real)
MID3	Bending material identification number for transverse shear (Integer ≥ 0)
T3	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for stress calculations, positive according to the right-hand sequence defined on the CTRIA1 card (Real)

Remarks:

1. All PTRIA1 cards must have unique property identification numbers.
2. If T3 is zero, the element is assumed to be rigid in transverse shear.
3. The membrane thickness, T1, is used to compute the structural mass for this element.

Input Data Card PTRIA2 Homogeneous Triangular Element Property

Description: Defines the properties of a homogeneous triangular element of the structural model, including membrane, bending and transverse shear effects. Referenced by the CTRIA2 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRIA2	PID	MID	T	NSM	PID	MID	T	NSM	
PTRIA2	2	16	3.92	14.7	6	16	2.96		

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness (Real > 0.0)
NSM	Nonstructural mass per unit area (Real)

Remarks:

1. All PTRIA2 cards must have unique identification numbers.
2. The thickness used to compute the membrane and transverse shear properties is T.
3. The area moment of inertia per unit width used to compute the bending stiffness is $T^3/12$.
4. Outer fiber distances of $\pm T/2$ are assumed.
5. One or two homogeneous triangular element properties may be defined on a single card.

Input Data Card PTRMEM Triangular Membrane Property

Description: Used to define the properties of a triangular membrane element. Referenced by the CTRMEM card. No bending properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRMEM	PID	MID	T	NSM	PID	MID	T	NSM	
PTRMEM	17	23	4.25	0.2					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Membrane thickness (Real > 0.0)
NSM	Nonstructural mass per unit area (Real)

Remarks: 1. All PTRMEM cards must have unique property identification numbers.

2. One or two triangular membrane properties may be defined on a single card.

Input Data Card PTRPLT Triangular Plate Property

Description: Used to define the bending properties of a triangular plate element. Referenced by the CTRPLT card. No membrane properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRPLT	PID	MID1	I	MID2	T	NSM	Z1	Z2	
PTRPLT	17	26	4.29	16	3.9-4	2.634			

Field	Contents
PID	Property identification number (Integer > 0)
MID1	Material identification number for bending (Integer > 0)
I	Bending area moment of inertia per unit width (Real)
MID2	Material identification number for transverse shear (Integer ≥ 0)
T	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for stress computation, positive according to the right-hand sequence defined on the CTRPLT card (Real)

Remarks:
1. All PTRPLT cards must have unique property identification numbers.
2. If T is zero, the element is assumed to be rigid in transverse shear.
3. No structural mass is generated by this element.

Input Data Card PTUBE Tube Property

Description: Defines the properties of a thin-walled cylindrical tube element. Referenced by the CTUBE card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTUBE	PID	MID	ØD	T	NSM				
PTUBE	2	6	6.29	0.25					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
ØD	Outside diameter of tube (Real > 0.0)
T	Thickness of tube (Real; T $\leq$ 1/2 ØD)
NSM	Nonstructural mass per unit length (Real)

Remarks:
1. If T is zero, a solid circular rod is assumed.
2. PTUBE cards must all have unique property identification numbers.
3. For structural problems, PTUBE cards may only reference MAT1 material cards.
4. For heat transfer problems, PTUBE cards may only reference MAT4 or MAT5 material cards.

Input Data Card PTWIST Twist Panel Property

Description: Defines the elastic properties of a twist panel element. Referenced by the CTWIST card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTWIST	PID	MID	T	NSM	PID	MID	T	NSM	
PTWIST	4	6	2.3	9.4	5	6	1.6		

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness of twist panel (Real $\neq$ 0.0)
NSM	Nonstructural mass per unit area (Real)

Remarks:
1. All PTWIST cards must have unique identification numbers.
2. PTWIST cards may only reference MAT1 material cards.
3. One or two twist panel properties may be defined on a single card.

Input Data Card PVISC Viscous Element Property

Description: Defines the viscous properties of a one-dimensional viscous element which is used to create viscous elements by means of the CVISC card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PVISC	PID	C1	C2		PID	C1	C2		
PVISC	3	6.2	3.94						

Field	Contents
PID	Property identification number (Integer > 0)
C1, C2	Viscous coefficients for extension and rotation (Real)

Remarks:
1. Used for both extensional and rotational viscous elements.
2. Has meaning for dynamics problems only.
3. Viscous properties are material independent; in particular, they are temperature-independent.
4. One or two viscous element properties may be defined on a single card.

Input Data Card QBDY1 Boundary Heat Flux Load

Description: Defines a uniform heat flux into HBDY elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QBDY1	SID	Q0	EID1	EID2	EID3	EID4	EID5	EID6	abc
QBDY1	109	1.-5	721						ABC
+bc	EID7	-etc.-							def
+BC									

-etc.-

Field	Contents
SID	Load set identification number (Integer > 0)
Q0	Heat flux into element (Real)
EIDi	HBDY elements (Integer > 0 or "THRU")

Remarks:

1. QBDY1 cards must be selected in Case Control (LØAD = SID) to be used in statics. The total power into an element is given by the equation:

$$P_{in} = (\text{Effective area}) \cdot Q0.$$

2. QBDY1 cards must be referenced on a TLØAD card for use in transient. The total power into an element is given by the equation:

$$P_{in(t)} = (\text{Effective area}) \cdot Q0 \cdot F(t-\tau),$$

where the function of time, $F(t-\tau)$, is specified on a TLØAD1 or TLØAD2 card.

3. Q0 is positive for heat input.

4. If a sequential list of elements is desired, fields 4, 5, and 6 may specify the first element, the BCD string "THRU", and the last element. No subsequent data is allowed with this option.

Input Data Card QBDY2 Boundary Heat Flux Load

Description: Defines grid point heat flux into an HBDY element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QBDY2	SID	EID	Q01	Q02	Q03	Q04			
QBDY2	109	721	1.-5	1.-5	2.-5	2.-5			

Field	Contents
SID	Load set identification number (Integer > 0)
EID	Identification number of an HBDY element (Integer > 0)
Q0i	Heat flux at the i^{th} grid point on the referenced HBDY element (Real or blank)

Remarks:

1. QBDY2 cards must be selected in Case Control (LØAD = SID) to be used in statics. The total power into each point, i, on an element is given by

$$P_i = AREA_i \cdot Q0_i .$$

2. QBDY2 cards must be referenced on a TLØAD card for use in transient. All connected grid points will have the same time function, but may have individual delays. The total power into each point, i, on an element is given by

$$P_{i(t)} = AREA_i \cdot Q0_i \cdot F(t-\tau_i),$$

where $F(t-\tau_i)$ is a function of time specified on a TLØAD1 or TLØAD2 card.

3. $Q0_i$ is positive for heat flux input to the element.

Input Data Card QHBDY   Boundary Heat Flux Load

Description: Defines a uniform heat flux into a set of grid points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QHBDY	SID	FLAG	Q0	AF	G1	G2	G3	G4	
QHBDY	120	LINE	1.5+3	.75	13	15			

Field	Contents
SID	Load set identification number (Integer > 0)
FLAG	Type of area involved (must be one of the following "PØINT," "LINE," "REV," "AREA3," "AREA4")
Q0	Heat flux into an area (Real)
AF	Area factor depends on type (Real > 0.0 or blank)
G1,G2,G3,G4	Grid point identification of connected points (Integer > 0 or blank)

Remarks:

1. The heat flux applied to the area is transformed to loads on the points. These points need not correspond to an HBDY element.

2. The flux is applied to each point, i, by the equation

   $$P_i = AREA_i \cdot Q0,$$

   where Q0 is positive for heat input, and $AREA_i$ is the portion of the total area associated with point i.

3. In statics, the load is applied with the Case Control request: LØAD = SID. In dynamics, the load is applied by reference on a TLØADi data card. The load at each point will be multiplied by the function of time $F(t-\tau_i)$ defined on the TLØADi card. τ_i is the delay factor for each point.

4. The number of connected points for the five types are 1(PØINT), 2(LINE,REV), 3(AREA3), 4(AREA4). Any unused Gi entries must be on the right.

5. The area factor AF is used to determine the effective area for the PØINT and LINE types. It equals the area and the effective width, respectively. It is ignored for the other types, which have their area defined implicitly.

6. The type flag defines a surface in the same manner as the CHBDY data card. For physical descriptions of the geometry involved, see the CHBDY description.

Input Data Card QVECT Thermal Vector Flux Load

Description: Defines thermal vector flux from a distant source into HBDY elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QVECT	SID	Q0	E1	E2	E3	EID1	EID2	EID3	abc
QVECT	333	1.-2	-1.0	0.0	0.0	721	722	723	ABC
+bc	EID4	EID5	-etc.-						def
+BC	724								

-etc.-

Field	Contents
SID	Load set identification number (Integer > 0)
Q0	Magnitude of thermal flux vector (Real)
E1,E2,E3	Vector components (in basic coordinate system) of the thermal vector flux (Real or Integer > 0). The total flux is given by Q = Q0{E1,E2,E3}
EID_i	Element identification numbers of HBDY elements irradiated by the distant source (Integer > 0)

Remarks:

1. For statics, the load set is selected in the Case Control Deck (LØAD = SID). The total power into an element is given by

$$P_{in} = -\alpha A(\bar{e}\cdot\bar{n})^* Q0,$$

where:

α = absorbtivity
A = area of HBDY element
$\bar{e}$ = vector of real numbers E1, E2, E3
$\bar{n}$ = positive normal vector of element, see CHBDY data card description
$(\bar{e}\cdot\bar{n})^*$ = 0 if the vector product is positive (i.e., the flux is coming from behind the element)

2. For transient analysis, the load set (SID) is selected by a TLØADi card which defines a load function of time. The total power into the element is given by

$$P_\ell(t) = -\alpha A(\bar{e}(t)\cdot\bar{n})^* Q0\ F(t-\tau),$$

where:

α,A, and $\bar{n}$ are the same as the statics case
$\bar{e}(t)$ = vector of three functions of time, which may be given on TABLEDi data cards. If E1, E2, or E3 is an integer, it is the table identification number. If E1, E2, or E3 is a real number, its value is used directly; if Ei is blank, its value is zero.
$F(t-\tau)$ is a function of time specified or referenced by the parent TLØAD1 or TLØAD2 card. The value τ is calculated for each loaded point.

QVECT (Cont.)

3. If the referenced HBDY element is of TYPE = ELCYL, the power input is an exact integration over the area exposed to the thermal flux vector.

4. If the referenced HBDY element is of TYPE = REV, the vector should be parallel to the basic z axis.

5. If a sequential list of elements is desired, fields 4, 5, and 6 may specify the first element, the BCD string "THRU", and the last element. No subsequent data is allowed with this option.

Input Data Card QVØL Volume Heat Addition

Description: Defines a rate of internal heat generation in an element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QVØL	SID	QV	EID1	EID2	EID3	EID4	EID5	EID6	abc
QVØL	333	1.+2	301	302	303	317	345	416	ABC
+bc	EID7	-etc.-							def
+BC	127								

-etc.-

Field	Contents
SID	Load set identification (Integer > 0)
QV	Power input per unit volume produced by a heat conduction element (Real)
EIDi	A list of heat conduction elements (Integer > 0 or BCD "THRU")

Remarks:

1. In statics, the load is applied with the case control request, LØAD = SID. The equivalent power into each grid point, i, connected to each element, is given by

$$P_i = QV \cdot VØL_i ,$$

where $VØL_i$ is the portion of the volume associated with point i and QV is positive for heat generation.

2. In dynamics, the load is requested by reference on a TLØADi data card. The equivalent power into each grid point i is

$$P_i = QV \cdot VØL_i \cdot F(t-\tau_i) ,$$

where $VØL_i$ is the portion of the volume associated with point i and $F(t-\tau_i)$ is the function of time defined by a TLØADi card. τ_i is the delay for each point i.

3. If a sequential list of elements is desired, fields 4, 5, and 6 may specify the first element identification number, the BCD string "THRU" and the last element identification number. No subsequent data is allowed with this option.

Input Data Card RADLST List of Radiation Areas

Description: A list of HBDY identification numbers given in the same order as the columns of the RADMTX matrix.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RADLST	EID1	EID2	EID3	EID4	EID5	EID6	EID7	EID8	abc
RADLST	10	20	30	50	31	41	THRU	61	ABC
+bc	EID9	-etc.-							def
+BC	71								

-etc.-

Field	Contents
EIDi	The element identification numbers of the HBDY elements, given in the order that they appear in the RADMTX matrix (Integer > 0 or BCD "THRU")

Remarks:

1. This card is required if a RADMTX is defined.
2. Only one RADLST card string is allowed in a data deck.
3. If a group of the elements are sequential, any field except 2 and 9 may contain the BCD word "THRU". Element Id numbers will be generated for every integer between the value of the previous field and the value of the subsequent field. The values must increase, however.
4. Any element may be listed more than once. For instance, if both sides of a panel are radiating, each side may participate in a different part of the view factor matrix.

Input Data Card RADMTX Radiation Matrix

Description: Matrix of radiation exchange coefficients for nonlinear heat transfer analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RADMTX	INDEX	Fi,i	Fi+1,i	Fi+2,i	Fi+3,i	Fi+4,i	Fi+5,i	Fi+6,i	abc
RADMTX	3	0.	9.3	17.2	16.1	.1	0.	6.2	ABC

+bc	Fi+7,i	-etc.-							def
+BC	6.2								

-etc.-

Field	Contents
INDEX	The column number of the matrix (Integer > 0)
Fi+k,i	The matrix values (Real), starting on the diagonal, continuing down the column. A group of zero's at the bottom of the column may be omitted. A blank field will end the column, which disallows imbedded blank fields.

Remarks:

1. The INDEX numbers go from 1 thru NA, where NA is the number of radiating areas.

2. The radiation exchange coefficient matrix is symmetric, and only the lower triangle is input. Column 1 is associated with the HBDY element first listed on the RADLST card, Column 2 for the next, etc. Null columns need not be entered.

3. $$P_i = \sum_{j=1}^{NA} F_{ij} q_j$$

   P_i = total irradiation into element i

   q_j = radiosity (per unit area) at j

   F_{ij} = radiation matrix (units of area)

4. A column may only be specified once.

Input Data Card RANDPS Power Spectral Density Specification

Description: Defines load set power spectral density factors for use in Random Analysis having the frequency dependent form

$$S_{jk}(F) = (X + iY)\, G(F)$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
RANDPS	SID	J	K	X	Y	TID			
RANDPS	5	3	7	2.0	2.5	4			

Field	Contents
SID	Random analysis set identification number (Integer > 0)
J	Subcase identification number of excited load set (Integer > 0)
K	Subcase identification number of applied load set (Integer $\geq$ 0; K $\geq$ J)
X,Y	Components of complex number (Real)
TID	Identification number of a TABRNDi card which defines G(F) (Integer $\geq$ 0)

Remarks:

1. If J = K, then Y must be 0.0.
2. For TID = 0, G(F) = 1.0.
3. Set identification numbers must be selected in the Case Control Deck (RANDØM=SID) to be used by NASTRAN.
4. Only 20 unique sets may be defined. As many RANDPS cards as desired with the same SID may be input, however.
5. RANDPS can only reference subcases included within a single loop (change in direct matrix input is not allowed).

Input Data Card RANDT1 Autocorrelation Function Time Lag

Description: Defines time lag constants for use in random analysis autocorrelation function computation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RANDT1	SID	N	TO	TMAX					
RANDT1	5	10	3.2	9.6					

Field	Contents
SID	Random analysis set identification number (Integer > 0)
N	Number of time lag intervals (Integer > 0)
TO	Starting time lag (Real $\geq$ 0.0)
TMAX	Maximum time lag (Real > TO)

Remarks: 1. At least one RANDPS card must be present with the same set identification number.

2. The time lags defined on this card are given by

$$T_i = T_o + \frac{T_{max} - T_o}{N}(i - 1), \qquad i = 1, N + 1$$

3. Time lag sets must be selected in the Case Control Deck (RANDØM=SID) to be used by NASTRAN.

BULK DATA DECK

Input Data Card RELES Release Substructure Connectivities

Description: Defines sets of component degrees of freedom at substructure grid points which are not to be connected.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RELES	SID	NAME	G1	C1	G2	C2	G3	C3	def
RELES	6	WINGRT	17	456	18	456	21	123	DEF
+ef	G4	C4	etc.		GN	CN			
+EF	25	456							

Field	Contents
SID	Set identification number (Integer > 0)
NAME	Name of basic substructure (BCD)
Gi	Grid or scalar point identification number (Integer > 0)
Ci	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.

Remarks:

1. The RELES data will override any connections generated automatically from geometry and any connections defined on CØNCT data cards.
2. The RELES data will not override connections defined on the CØNCT1 data card.
3. Connectivity sets must be selected in the Substructure Control Deck (CØNNECT=SID) to be used by NASTRAN. Note that 'CØNNECT' is a subcommand of the substructure CØMBINE command.
4. Connectivities defined during previously executed CØMBINE operations will be retained and may be referenced by the grid point ID and component of any one of the basic substructures associated with that connectivity.

Input Data Card RFØRCE Rotational Force

Description: Defines a static loading condition due to a centrifugal force field.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RFØRCE	SID	G	CID	A	N1	N2	N3		
RFØRCE	2	5		-6.4	0.0	0.0	1.0		

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer $\geq$ 0)
CID	Coordinate system defining rotation direction (Integer $\geq$ 0)
A	Scale factor for rotational velocity in revolutions per unit time (Real)
N1, N2, N3	Rectangular components of rotation direction vector (Real; $N1^2 + N2^2 + N3^2 > 0.0$) The vector defined will act at point G.

Remarks:

1. G = 0 means the basic coordinate system origin.
2. CID = 0 means the basic coordinate system.
3. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
4. Rotational force sets can be combined with other static loads only by using the LØAD bulk data card.
5. The load vector generated by this card can be printed with an ØLØAD request in the Case Control Deck.

Input Data Card RINGAX Axisymmetric Ring

Description: Defines a ring for a model containing CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RINGAX	ID		R	Z			PS		
RINGAX	3		2.0	-10.0			162		

Field	Contents
ID	Ring identification number (Integer > 0)
R	Ring radius (Real > 0.0)
Z	Ring axial location (Real)
PS	Permanent single-point constraints (any unique combination of the digits 1-6)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. The number of degrees of freedom defined is (6-PS)·H where H is the harmonic count and PS is the number of digits in field 8. (See AXIC card.)
3. RINGAX identification numbers must be unique with respect to all other PØINTAX, RINGAX and SECTAX identification numbers.
4. The fourth and sixth degrees of freedom must be constrained when transverse shear flexibility is not included for the conical shell.
5. For a discussion of the conical shell problem see Section 5.9 of the Theoretical Manual.
6. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

Input Data Card RINGFL Axisymmetric Fluid Point

Description: Defines a circle (fluid point) in an axisymmetric fluid model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RINGFL	IDF	X1	X2	X3	IDF	X1	X2	X3	
RINGFL	3	1.0		30.0					

Field	Contents
IDF	Unique identification number of the fluid point (Integer, $0 < IDF < 10^5$)
X1,X2,X3	Coordinates of point in fluid coordinate system defined on AXIF card (Real; X1 > 0.0)

Remarks:
1. This card is allowed only if an AXIF card is also present.
2. All fluid point identification numbers must be unique with respect to other scalar, structural and fluid points.
3. X1, X2, X3 are (r, ϕ, z) for a cylindrical coordinate system and (ρ, θ, ϕ) for a spherical coordinate system. θ is in degrees. The value of ϕ must be blank or zero.
4. One or two fluid points may be defined per card.

NASTRAN DATA DECK

Input Data Card RLØAD1   Frequency Response Dynamic Load

Description: Defines a frequency dependent dynamic load of the form

$$\left\{P(f)\right\} = \left\{A[C(f) + iD(f)]\ e^{i\{\theta - 2\pi f\tau\}}\right\}$$

for use in frequency response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RLØAD1	SID	L	M	N	TC	TD			
RLØAD1	5	3	6	9	1	2			

Field	Contents
SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set which defines A (Integer > 0)
M	Identification number of DELAY card set which defines τ (Integer $\geq$ 0)
N	Identification number of DPHASE card set which defines θ (Integer $\geq$ 0)
TC	Set identification number of TABLEDi card which gives C(f) (Integer $\geq$ 0; TC + TD > 0)
TD	Set identification number of TABLEDi card which gives D(f) (Integer $\geq$ 0; TC + TD > 0)

Remarks:

1. If any of M, N, TC or TD are blank or zero, the corresponding τ, θ, C(f), or D(f) will be zero.
2. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
3. RLØAD1 loads may be combined with RLØAD2 loads only by specification on a DLØAD card. That is, the SID on a RLØAD1 card may not be the same as that on a RLØAD2 card.
4. SID must be unique for all RLØAD1, RLØAD2, TLØAD1 and TLØAD2 cards.

Input Data Card RLØAD2 Frequency Response Dynamic Load

Description: Defines a frequency dependent dynamic load of the form

$$\left\{P(f)\right\} = \left\{AB(f)e^{i\{\phi(f) + \theta - 2\pi f\tau\}}\right\}$$

for use in frequency response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RLØAD2	SID	L	M	N	TB	TP			
RLØAD2	5	3	6	21	7	2			

Field	Contents
SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set which defines A (Integer > 0)
M	Identification number of DELAY card set which defines τ (Integer $\geq$ 0)
N	Identification number of DPHASE card set which defines θ in degrees (Integer $\geq$ 0)
TB	Set identification number of TABLEDi card which gives B(f) (Integer > 0)
TP	Set identification number of TABLEDi card which gives $\phi(f)$ in degrees (Integer $\geq$ 0)

Remarks:
1. If any of M, N or TP are zero, the corresponding τ, θ or $\phi(f)$ will be zero.
2. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
3. RLØAD2 loads may be combined with RLØAD1 loads only by specification on a DLØAD card. That is, the SID on a RLØAD2 card may not be the same as that on a RLØAD1 card.
4. SID must be unique for all RLØAD1, RLØAD2, TLØAD1 and TLØAD2 cards.

Input Data Card SECTAX Axisymmetric Sector

Description: Defines a sector of a model containing CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SECTAX	ID	RID	R	PHI1	PHI2				
SECTAX	1	2	3.0	30.0	40.0				

Field	Contents
ID	Sector identification number (Unique Integer > 0)
RID	Ring identification number (see RINGAX)(Integer > 0)
R	Effective radius (Real)
PHI1, PHI2	Azimuthal limits of sector in degrees (Real)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. SECTAX identification numbers must be unique with respect to all other PØINTAX, RINGAX and SECTAX identification numbers.
3. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
4. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

Input Data Card SEQEP Extra Point Resequencing

Description: The purpose of this card is to allow the user to reidentify the formation sequence of the extra points of his structural model in such a way as to optimize bandwidth which is essential for efficient solutions by the displacement method.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SEQEP	ID	SEQID	ID	SEQID	ID	SEQID	ID	SEQID	
SEQEP	5392	15.6			2	1.9.2.6	3	2	

Field	Contents
ID	Extra point identification number (Integer > 0)
SEQID	Sequenced identification number (a special number described below)

Remarks:

1. ID is any extra point identification number which is to be reidentified for sequencing purposes. The sequence number is a special number which may have any of the following forms where X is a decimal integer digit - XXXX.X.X.X, XXXX.X.X, XXXX.X or XXXX where any of the leading X's may be omitted. This number must contain no imbedded blanks.
2. If the user wishes to insert an extra point between two already existing grid, scalar and/or extra points, such as 15 and 16, for example, he would define it as, say 5392, and then use this card to insert extra point number 5392 between them by equivalencing it to, say, 15.6. All output referencing this point will refer to 5392.
3. The SEQID numbers must be unique and may not be the same as a point ID which is not being changed. No extra point ID may be referenced more than once.
4. No continuation cards (small field or large field) are allowed with either the SEQGP or the SEQEP card.
5. From one to four extra points may be resequenced on a single card.

Input Data Card SEQGP   Grid and Scalar Point Resequencing

Description: Used to order the grid points and user-supplied scalar points of the problem. The purpose of this card is to allow the user to reidentify the formation sequence of the grid and scalar points of his structural model in such a way as to optimize bandwidth which is essential for efficient solutions by the displacement method.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SEQGP	ID	SEQID	ID	SEQID	ID	SEQID	ID	SEQID	
SEQGP	5392	15.6			2	1.9.2.6	3	2	

Field	Contents
ID	Grid or scalar point identification number (Integer > 0)
SEQID	Sequenced identification number (a specical number described below)

Remarks:

1. ID is any grid or scalar point identification number which is to be reidentified for sequencing purposes. The grid point sequence number (SEQID) is a special number which may have any of the following forms where X is a decimal integer digit - XXXX.X.X.X, XXXX.X.X, XXXX.X or XXXX where any of the leading X's may be omitted. This number must contain no imbedded blanks.
2. If the user wishes to insert a grid point between two already existing grid points, such as 15 and 16, for example, he would define it as, say 5392, and then use this card to insert grid point number 5392 between them by equivalencing it to, say 15.6. All output referencing this point will refer to 5392.
3. The SEQID numbers must be unique and may not be the same as a point ID which is not being changed. No grid point ID may be referenced more than once.
4. No continuation cards (small field or large field) are allowed with either the SEQGP or the SEQEP card.
5. From one to four grid or scalar points may be resequenced on a single card.

BULK DATA DECK

Input Data Card SET1 Grid Point List

Description: Defines a set of structural grid points by a list.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SET1	SID	G1	G2	G3	G4	G5	G6	G7	ABC
SET1	3	31	62	93	124	16	17	18	ABC
+BC	G8	--etc.-							
+BC	19								

Field	Contents
SID	Set of identification numbers (Integer > 0).
G1,G2, etc.	List of structural grid points (Integer > 0 or "THRU").

Remarks:

1. These cards are referenced by the SPLINE data cards.
2. When using the "THRU" option, all intermediate grid points must exist. The word "THRU" may not appear in field 3 or 9 (2 or 9 for continuation cards).

NASTRAN DATA DECK

Input Data Card SET2 Grid Point List

Description: Defines a set of structural grid points in terms of aerodynamic macro elements.

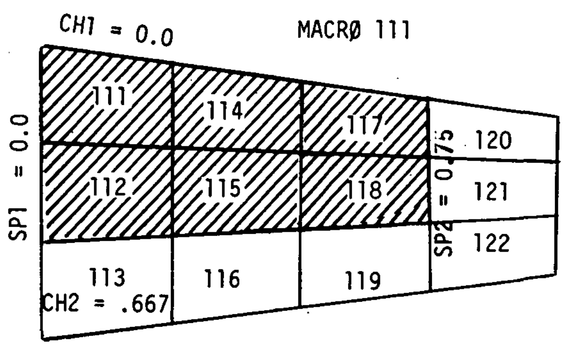
Format and Example:

1	2	3	4	5	6	7	8	9	10
SET2	SID	MACRØ	SP1	SP2	CH1	CH2	ZMAX	ZMIN	
SET2	3	111	.0	.75	0.	.667	1.0	-3.51	

Field	Contents
SID	Set identification number (Integer > 0).
MACRØ	Element identification number of an aero macro element (Integer > 0).
SP1,SP2	Lower and higher span division points defining prism containing set (Real).
CH1,CH2	Lower and higher chord division points defining prism containing set (Real).
ZMAX,ZMIN	Top and bottom (using right-hand rule with the order the corners as listed on a CAERØ card) of the prism containing set (Real). Usually ZMAX ≥ 0, ZMIN ≤ 0.

Remarks:

1. These cards are referenced by the SPLINEi data cards.
2. Every grid point, within the defined prism and within the height range, will be in the set. For example,



The shaded area in the figure defines the cross-section of the prism for the sample data given above. Points exactly on the boundary may be missed, hence, to get the area of the macro element, use SP1 = -.01, SP2 = 1.01, etc.

3. A zero value for ZMAX or ZMIN implies infinity is to be used.
4. To find the (internal) grid ID's found, use DIAG 18.

NASTRAN DATA DECK

Input Data Card SLBDY Slot Boundary List

Description: Defines a list of slot points which lie on an interface between an axisymmetric fluid and a set of evenly spaced radial slots.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SLBDY	RHØ	M	ID1	ID2	ID3	ID4	ID5	ID6	abc
SLBDY	0.002	6	16	17	18	25	20	21	+BDY

+bc	ID7	-etc.-							+def
+BDY	22								

- etc. -

Field	Contents
RHØ	Density of fluid at boundary (Real > 0.0, or blank)
M	Number of slots (Integer ≥ 0, or blank)
IDj	Identification numbers of GRIDS slot points at boundary with axisymmetric fluid cavity, j = 1,2,...,J (Integer > 0)

Remarks:

1. This card is allowed only if an AXSLØT card is also present.
2. If RHØ or M is "blank" the default value on the AXSLØT card is used. The effective value must not be zero for RHØ. If the effective value of M is zero, no matrices at the boundary will be generated.
3. The order of the list of points determines the topology of the boundary. The points are listed sequentially as one travels along the boundary in either direction. At least two points must be defined.
4. More than one logical boundary card may be used.

NASTRAN DATA DECK

Input Data Card SLØAD Static Scalar Load

Description: Used to apply static loads to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SLØAD	SID	S	F	S	F	S	F		
SLØAD	16	2	5.9	17	-6.3	14	-2.93		

Field	Contents
SID	Load set identification number (Integer > 0)
S	Scalar point identification number (Integer > 0)
F	Load value (Real)

Remarks:
1. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
2. Up to three scalar loads may be defined on a single card.

BULK DATA DECK

Input Data Card SPC   Single-Point Constraint

Description: Defines sets of single-point constraints and enforced displacements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPC	SID	G	C	D	G	C	D		
SPC	2	32	436	-2.6	5		+2.9		

Field	Contents
SID	Identification number of single-point constraint set (Integer > 0)
G	Grid or scalar point identification number (Integer > 0)
C	Component number (6 ≥ Integer ≥ 0; up to six unique such digits may be placed in the field with no imbedded blanks)
D	Value of enforced displacement for all coordinates designated by G and C (Real)

Remarks:

1. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation (MPC card), nor may it be referenced on a SPC1, ØMIT, ØMIT1 or SUPØRT card. D must be 0.0 for dynamics problems.
2. Single-point forces of constraint are recovered during stress data recovery.
3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
4. From one to twelve single-point constraints may be defined on a single card.
5. SPC degrees of freedom may be redundantly specified as permanent constraints on the GRID card.

Input Data Card SPC1 Single-Point Constraint

Description: Defines sets of single-point constraints.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPC1	SID	C	G1	G2	G3	G4	G5	G6	abc
SPC1	3	2	1	3	10	9	6	5	ABC

+bc	G7	G8	G9	-etc.-					
+BC	2	8							

Alternate Form

SPC1	SID	C	GID1	"THRU"	GID2				
SPC1	313	12456	6	THRU	32				

Field	Contents
SID	Identification number of single-point constraint set (Integer > 0)
C	Component number (Any unique combination of the digits 1-6 (with no imbedded blanks) when point identification numbers are grid points; must be null if point identification numbers are scalar points)
Gi, GIDi	Grid or scalar point identification numbers (Integer > 0)

Remarks:

1. Note that enforced displacements are not available via this card. As many continuation cards as desired may appear when "THRU" is not used.
2. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation, nor may it be referenced on a SPC, ØMIT, ØMIT1, SUPØRT card.
3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
4. SPC degrees of freedom may be redundantly specified as permanent constraints on the GRID card.
5. All grid points referenced by GID1 thru GID2 must exist.

Input Data Card SPCADD Single-Point Constraint

Description: Defines a single-point constraint set as a union of single-point constraint sets defined via SPC or SPC1 cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCADD	SID	S1	S2	S3	S4	S5	S6	S7	abc
SPCADD	101	3	2	9	1				

+bc	S8	S9	-etc.-						

-etc.-

Field	Contents
SID	Identification number for new single-point constraint set (Integer > 0)
Si	Identification numbers of single-point constraint sets defined via SPC or SPC1 cards (Integer > 0; SID ≠ Si)

Remarks:
1. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
2. No Si may be the identification number of a single-point constraint set defined by another SPCADD card.
3. The Si values must be unique.

Input Data Card SPCAX Axisymmetric Single-Point Constraint

Description: Defines sets of single-point constraints for a model containing CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCAX	SID	RID	HID	C	V				
SPCAX	2	3	4	13	6.0				

Field	Contents
SID	Identification number of single-point constraint set (Integer > 0)
RID	Ring identification number (see RINGAX) (Integer ≥ 0)
HID	Harmonic identification number (Integer ≥ 0)
C	Component identification number (any unique combination of the digits 1-6)
V	Enforced displacement value (Real)

Remarks:

1. This card is allowed if and only if an AXIC card is also present.
2. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
3. Coordinates appearing on SPCAX cards may not appear on MPCAX, SUPAX or ØMITAX cards.
4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
5. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

Input Data Card SPCD Enforced Displacement Value

Description: Defines an enforced displacement value for static analysis, which is requested as a LØAD.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCD	SID	G	C	D	G	C	D		
SPCD	100	32	436	-2.6	5		+2.9		

Field	Contents
SID	Identification number of a static load set (Integer > 0)
G	Grid or scalar point identification number (Integer > 0)
C	Component number (6 ≥ Integer ≥ 0; up to six unique such digits may be placed in the field with no imbedded blanks.)
D	Value of enforced displacement for all coordinates designated by G and C (Real)

Remarks:

1. A coordinate referenced on this card must be referenced by a selected SPC or SPC1 data card.
2. Values of D will override the values specified on an SPC bulk data card, if the LØAD set is requested.
3. The bulk data LØAD combination card will not request an SPCD.
4. At least one bulk data LØAD card (FØRCE, SLØAD, etc.) is required in the LØAD set selected in case control.

NASTRAN DATA DECK

Input Data Card SPCS Substructure Single Point Constraints

Description: Defines a set of single point constraints on a specified basic substructure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCS	SID	NAME	G1	C1	G2	C2	G3	C3	abc
SPCS	61	MIDWG	9	45	18	124	36	456	ABC
+bc	G4	C4	G5	C5	G6	C6	G7	C7	def
+BC	88	136	etc.						

Field	Contents
SID	Set identification number (Integer > 0)
NAME	Basic substructure name (BCD)
Gi	Grid or scalar point identification number in substructure (Integer > 0)
Ci	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.

Remarks:

1. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation, nor may it be referenced on a SPCS1, SPCSD, SPC, SPC1, ØMIT, ØMIT1 or SUPØRT card.
2. Single-point forces of constraint are recovered during stress data recovery.
3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
4. A single G, C pair may not specify all component degrees of freedom for a connected grid point where only some of the degrees of freedom of the grid point have been connected or when some have been disconnected via the RELES card. The degrees of freedom which were connected and those that were not connected must be referenced separately.

Input Data Card SPCS1 Substructure Single Point Constraints

Description: Defines a set of single point constraints on a specified basic substructure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCS1	SID	NAME	C	G1	G2	G3	G4	G5	abc
SPCS1	15	FUSELAGE	1236	1101	1102	1105	THRU	1110	ABC

+bc	G6	G7	G8	G9	G10	G11	G12	G13	def
+BC	1121	1130	THRU	1140	1143	1150	etc.		

Field	Contents
SID	Set identification number (Integer > 0)
NAME	Basic substructure name (BCD)
C	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points
Gi	Grid or scalar point identification numbers (Integer > 0)

Remarks:

1. THRU may appear in fields 6, 7, or 8 of the first card and anywhere in fields 3 - 8 on a continuation card.

2. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation, nor may it be referenced on a SPCS, SPCSD, SPC, SPC1, ØMIT, ØMIT1, or SUPØRT card.

3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.

4. All grid points referenced by Gi through Gj must exist.

5. A single G, C pair may not specify all component degrees of freedom for a connected grid point where only some of the degrees of freedom of the grid point have been connected or when some have been disconnected via the RELES card. The degrees of freedom which were connected and those that were not connected must be referenced separately.

NASTRAN DATA DECK

Input Data Card SPCSD   Substructure Single Point Constraints

Description: Defines a set of single point constraints and enforced displacements for a given substructure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCSD	SID	NAME	G1	C1	D1	G2	C2	D2	
SPCSD	27	LWINGRT	965	3	3.6				

Field	Contents
SID	Set identification number (Integer > 0)
NAME	Basic substructure name (BCD)
Gi	Grid or scalar point identification number (Integer > 0)
Ci	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.
Di	Value of enforced displacement for all coordinates designated by Gi and Ci (Real)

Remarks

1. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation, nor may it be referenced on a SPCS, SPCS1, SPC, SPC1, ØMIT, ØMIT1, or SUPØRT card. The Di values are ignored in dynamics problems.

2. Single-point forces of constraint are recovered during stress data recovery.

3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.

4. From one to twelve single-point constraints may be defined on a single card.

5. A single G, C pair may not specify all component degrees of freedom for a connected grid point where only some of the degrees of freedom of the grid point have been connected or when some have been disconnected via the RELES card. The degrees of freedom which were connected and those that were not connected must be referenced separately.

Input Data Card SPLINE1 Surface Spline

Description: Defines a surface spline for interpolating out-of-plane motion for aeroelastic problems.

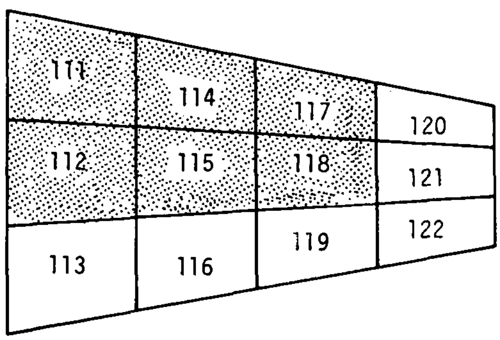
Format and Example:

1	2	3	4	5	6	7	8	9	10
SPLINE1	EID	CAERØ	BØX1	BØX2	SETG	DZ			
SPLINE1	3	111	111	118	14				

Field	Contents
EID	Element identification number (unique Integer > 0).
CAERØ	Aero element ID which defines plane of spline (Integer > 0).
BØX1,BØX2	First and last box whose motions are interpolated using this spline (Integer > 0).
SETG	Refers to a SETi card which lists the structural grid points to which the spline is attached (Integer > 0).
DZ	Linear attachment flexibility (Real ≥ 0).

Remarks:

1. The interpolated points (k-set) will be defined by aero-cells. The sketch shows the cells for which u_k is interpolated if BØX1 = 111 and BØX2 = 118.



2. The attachment flexibility (units of area) is used for smoothing the interpolation. If DZ = 0, the spline will pass thru all deflected grid points. If DZ >> (area of spline), a least squares plane fit will occur. Intermediate values will provide smoothing.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card <u>SPLINE2</u> Linear Spline

<u>Description</u>: Defines a beam spline for interpolating out-of-plane motion for aeroelastic problems.

<u>Format and Example</u>:

1	2	3	4	5	6	7	8	9	10
SPLINE2	EID	CAERØ	BØX1	BØX2	SETG	DZ	DTØR	CID	ABC
SPLINE2	5	8	12	24	60		1.0	3	
+BC	DTHX	DTHY							
	-1.								

Field	Contents
EID	Element identification number (unique Integer > 0).
CAERØ	Aero element which defines plane of spline (Integer > 0).
BØX1,BØX2	First and last box whose motions are interpolated using this spline (Integer > 0).
SETG	Refers to a SETi card which lists the structural "g"-set to which the spline is attached (Integer > 0).
DZ	Linear attachment flexibility (Real > 0).
DTØR	Torsional flexibility (EI/GJ) (Real > 0).
CID	Rectangular coordinate system which defines y-axis of spline (Integer ≥ 0).
DTHX,DTHY	Torsional attachment flexibility (Real).

<u>Remarks</u>:

1. The interpolated points (k-set) will be defined by aero cells.
2. The y-axis of the spline is the projection of the y-axis of the coordinate system CID, projected onto the plane of the spline.
3. The flexibilities are used for smoothing. Zero attachment flexibility values will imply rigid attachment, i.e., no smoothing. (Negative values in fields 12 and 13 will imply infinity, hence no attachment. Do not use negative value for DTHY if grid points are on a straight line.)
4. A continuation card is required.

Input Data Card SPØINT Scalar Point

Description: Defines scalar points of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPØINT	ID	ID	ID	ID	ID	ID	ID	ID	
SPØINT	3	18	1	4	16	2			

Alternate Form

1	2	3	4	5	6	7	8	9	10
SPØINT	ID1	"THRU"	ID2						
SPØINT	5	THRU	649						

Field	Contents
ID,ID1,ID2	Scalar point identification number (Integer > 0; ID1 < ID2)

Remarks:

1. Scalar point defined by their appearance on a scalar connection card need not appear on a SPØINT card.
2. All scalar point identification numbers must be unique with respect to all other structural, scalar, and fluid points.
3. This card is used primarily to define scalar points appearing in single or multipoint constraint equations but to which no scalar elements are connected.
4. If the alternate form is used, scalar points ID1 thru ID2 are defined.
5. For a discussion of scalar points, see Section 5.6 of the Theoretical Manual.

Input Data Card SUPAX Axisymmetric Fictitious Support

Description: Defines coordinates at which the user desires determinate reactions to be applied during the analysis of a free body modeled with CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SUPAX	RID	HID	C	RID	HID	C			
SUPAX				4	3	2			

Field	Contents
RID	Ring identification number (Integer > 0)
HID	Harmonic identification number (Integer ≥ 0)
C	Component number (any unique combination of the digits 1-6)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. Up to 12 coordinates may appear on a single card.
3. Coordinates appearing on SUPAX cards may not appear on MPCAX, SPCAX or ØMITAX cards.
4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
5. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

Input Data Card SUPØRT Fictitious Support

Description: Defines coordinates at which the user desires determinate reactions to be applied to a free body during analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SUPØRT	ID	C	ID	C	ID	C	ID	C	
SUPØRT	16	215							

Field	Contents
ID	Grid or scalar point identification number (Integer > 0)
C	Component number (Zero or blank for scalar points; any unique combination of the digits 1-6 for grid points)

Remarks:
1. Coordinates defined on this card may not appear on single-point constraint cards (SPC, SPC1), on omit cards (ØMIT, ØMIT1) or in multipoint constraint equations as dependent coordinates (MPC).
2. From one to twenty-four support coordinates may be defined on a single card.

NASTRAN DATA DECK

Input Data Card TABDMP1 Structural Damping Table

Description: Defines structural damping as a tabular function of frequency.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABDMP1	ID								abc
TABDMP1	3								ABC
+bc	f_1	g_1	f_2	g_2	f_3	g_3	f_4	g_4	
+BC	2.5	.01057	2.6	.01362	ENDT				

(etc.)

Field	Contents
ID	Table identification number (Integer > 0)
f_i	Frequency value in cycles per unit time (Real $\geq$ 0.0)
g_i	Damping value (Real)

Remarks:

1. The f_i must be in either ascending or descending order but not both.
2. Jumps ($f_i = f_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any f_i, g_i entry may be ignored by placing the BCD string "SKIP" in either of two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. The TABDMP1 mnemonic infers the use of the algorithm

$$\boxed{G = g_T(F)}$$

where F is input to the table and G is returned. The table look-up $g_T(F)$ is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $g_T(F)$ is used. There are no error returns from this table look-up procedure.

7. Structural damping tables must be selected in the Case Control Deck (SDAMP=ID) to be used by NASTRAN.
8. Structural damping is used only in modal formulations of complex eigenvalue analysis, frequency response analysis, or transient response analysis.

Input Data Card TABLED1 Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED1	ID								+abc
TABLED1	32								ABC
+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	-3.0	6.9	2.0	5.6	3.0	5.6	ENDT		

-etc.-

Field	Contents
ID	Table identification number (Integer > 0)
x_i, y_i	Tabular entries (Real)

Remarks:

1. The x_i must be in either ascending or decending order but not both.
2. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED1 type tables, this algorithm is

$$\boxed{Y = y_T(X)}$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = X$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

NASTRAN DATA DECK

Input Data Card TABLED2 Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED2	ID	X1							+abc
TABLED2	15	-10.5							ABC
+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	1.0	-4.5	2.0	-4.2	2.0	2.8	7.0	6.5	DEF
+def	x_5	y_5	x_6	y_6	x_7	y_7	x_8	y_8	+ghi
+EF	SKIP	SKIP	9.0	6.5	ENDT				

(etc.)

Field	Contents
ID	Table identification number (Integer > 0)
X1	Table parameter (Real)
x_i, y_i	Tabular entries (Real)

Remarks:

1. The x_i must be in either ascending or decending order but not both.
2. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED2 type tables, this algorithm is

$$\boxed{Y = y_T(X - X1)}$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = X-X1$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

Input Data Card TABLED3 Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED3	ID	X1	X2						+abc
TABLED3	62	126.9	30.0						ABC
+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	2.9	2.9	3.6	4.7	5.2	5.7	ENDT		

-etc.-

Field	Contents
ID	Table identification number (Integer > 0)
X1, X2	Table parameters (Real; X2 $\neq$ 0.0)
x_i, y_i	Tabular entries (Real)

Remarks:

1. The x_i must be in either ascending or descending order but not both.
2. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED3 type tables, this algorithm is

$$\boxed{Y = y_T\left(\frac{X - X1}{X2}\right)}$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = \frac{X - X1}{X2}$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

Input Data Card TABLED4 Dynamic Load Tabular Function

Description: Defines coefficients of a power series for use in generating frequency-dependent and time-dependent dynamic loads. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED4	ID	X1	X2	X3	X4				+abc
TABLED4	28	0.0	1.0	0.0	100.				ABC
+abc	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	+def
+BC	2.91	-0.0329	6.51-5	0.0	-3.4-7	ENDT			

etc.

Field	Contents
ID	Table identification number (Integer > 0)
X1,X2,X3,X4	Table parameters (Real; X2 $\neq$ 0.0; X3 < X4)
A_i	Coefficient entries (Real)

Remarks:
1. At least one entry must be present.
2. The end of the table is indicated by the existence of the BCD string "ENDT" in the field following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
3. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED4 type tables, this algorithm is

$$\boxed{Y = \sum_{i=0}^{N} A_i \left(\frac{X - X1}{X2}\right)^i}$$

where X is input to the table and Y is returned. Whenever X < X3, use X3 for X; whenever X > X4, use X4 for X. There are N + 1 entries in the table. There are no error returns from this table look-up procedure.

NASTRAN DATA DECK

Input Data Card TABLEM1 Material Property Table

Description: Defines a tabular function for use in generating temperature dependent material properties.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLEM1	ID								+abc
TABLEM1	32								ABC
+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	-3.0	6.9	2.0	5.6	3.0	5.6	ENDT		

(etc.)

Field	Contents
ID	Table identification number (Integer > 0)
x_i, y_i	Tabular entries (Real)

Remarks:

1. The x_i must be in either ascending or descending order but not both.
2. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEMi mnemonic infers the use of a specific algorithm. For TABLEM1 type tables, this algorithm is

$$\boxed{Y = y_T(X)}$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = X$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

Input Data Card TABLEM2 Material Property Table

Description: Defines a tabular function for use in generating temperature dependent material properties. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLEM2	ID	X1							+abc
TABLEM2	15	-10.5							ABC
+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	1.0	-4.5	2.0	-4.5	2.0	2.8	7.0	6.5	DEF
+def	x_5	y_5	x_6	y_6	x_7	y_7	x_8	y_8	+ghi
+EF	SKIP	SKIP	9.0	6.5	ENDT				

(etc.)

Field	Contents
ID	Table identification number (Integer > 0)
X1	Table parameter (Real)
x_i, y_i	Tabular entries (Real)

Remarks:

1. The x_i must be in either ascending or descending order but not both.
2. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEMi mnemonic infers the use of a specific algorithm. For TABLEM2 type tables, this algorithm is

$$\boxed{Y = Z\, y_T(X - X1)}$$

where X is input to the table, Y is returned and Z is supplied from the basic MATi card. The table look-up $y_T(x)$, $x = X - X1$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

Input Data Card TABLEM3 Material Property Table

Description: Defines a tabular function for use in generating temperature dependent material properties. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLEM3	ID	X1	X2						+abc
TABLEM3	62	126.9	30.0						ABC
+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	2.9	2.9	3.6	4.7	5.2	5.7	ENDT		

(etc.)

Field	Contents
ID	Table identification number (Integer > 0)
X1, X2	Table parameters (Real; X2 $\neq$ 0.0)
x_i, y_i	Tabular entries (Real)

Remarks:

1. The x_i must be in either ascending or descending order but not both.
2. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEMi mnemonic infers the use of a specific algorithm. For TABLEM3 type tables, this algorithm is

$$\boxed{Y = Z\, y_T\left(\frac{X - X1}{X2}\right)}$$

where X is input to the table, Y is returned and Z is supplied from basic MATi card. The table look-up $y_T(x)$, $x = \frac{X - X1}{X2}$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

Input Data Card TABLEM4 Material Property Table

Description: Defines coefficients of a power series for use in generating temperature dependent material properties. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLEM4	ID	X1	X2	X3	X4				+abc
TABLEM4	28	0.0	1.0	0.0	100.				ABC
+abc	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	+def
+BC	2.91	-0.0329	6.51-5	0.0	-3.4-7	ENDT			

etc.

Field	Contents
ID	Table identification number (Integer > 0)
X1,X2,X3,X4	Table parameters (Real; X2 $\neq$ 0.0; X3 < X4)
A_i	Coefficient entries (Real)

Remarks:
1. At least one entry must be present.
2. The end of the table is indicated by the existence of the BCD string "ENDT" in the field following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
3. Each TABLEMi mnemonic infers the use of a specific algorithm. For TABLEM4 type tables, this algorithm is

$$\boxed{Y = Z \sum_{i=0}^{N} A_i\left(\frac{X - X1}{X2}\right)^i}$$

where X is input to the table, Y is returned and Z is supplied from the basic MATi card. Whenever X < X3, use X3 for X; whenever X > X4, use X4 for X. There are N +1 entries in the table. There are no error returns from this table look-up procedure.

Input Data Card TABLES1 Tabular Stress-Strain Function

Description: Defines a tabular stress-strain function for use in Piecewise Linear Analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLES1	ID								+abc
TABLES1	32								ABC
+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	-3.0	6.9	2.0	5.6	3.0	5.6	ENDT		

-etc.-

Field	Contents
ID	Table identification number (Integer > 0)
x_i, y_i	Tabular entries (Real)

Remarks:

1. The x_i must be in either ascending or descending order but not both.
2. For Piecewise Linear Analysis, the y_i numbers must form a nondecreasing sequence for an ascending x_i sequence and vice versa.
3. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.
4. At least two entries must be present.
5. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
6. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
7. Each TABLESi mnemonic infers the use of a specific algorithm. For TABLES1 type tables, this algorithm is

$$\boxed{Y = y_T(X)}$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = X$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

8. The table may have a zero slope only at its end.

Input Data Card TABRND1 Power Spectral Density Table

Description: Defines Power Spectral density as a tabular function of frequency for use in Random Analysis. Referenced on the RANDPS card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABRND1	ID								abc
TABRND1	3								ABC
+bc	f_1	g_1	f_2	g_2	f_3	g_3	f_4	g_4	def
+BC	2.5	.01057	2.6	.01362	ENDT				

-etc.-

Field	Contents
ID	Table identification number (Integer > 0)
f_i	Frequency value in cycles per unit time (Real $\geq$ 0.0)
g_i	Power Spectral Density (Real)

Remarks:
1. The f_i must be in either ascending or descending order but not both.
2. Jumps between two points ($f_i = f_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any f-g entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. The TABRND1 mnemonic infers the use of the algorithm

$$\boxed{G = g_T(F)}$$

where F is input to the table and G is returned. The table look-up $g_T(F)$ is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $g_T(F)$ is used. There are no error returns from this table look-up procedure.

Input Data Card TEMP Grid Point Temperature Field

Description: Defines temperature at grid points for determination of:

1) Thermal loading
2) Temperature-dependent material properties
3) Stress recovery

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMP	SID	G	T	G	T	G	T		
TEMP	3	94	316.2	49	219.8				

Field	Contents
SID	Temperature set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
T	Temperature (Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.

2. From one to three grid point temperatures may be defined on a single card.

3. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

4. If the element material is temperature dependent, its properties are evaluated at the average temperature. In the case of isoparametric hexahedron elements, their properties are evaluated at the temperature computed by interpolating the grid point temperatures.

5. Average element temperatures are obtained as a simple average of the connecting grid point temperatures when no element temperature data are defined.

6. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.

Input Data Card TEMPAX Axisymmetric Temperature

Description: Defines temperature sets for a model containing CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPAX	SID	RID	PHI	TEMP	SID	RID	PHI	TEMP	
TEMPAX	4	7	30.0	105.3					

Field	Contents
SID	Temperature set identification number (Integer > 0)
RID	Ring identification number (see RINGAX card) (Integer > 0)
PHI	Azimuthal angle in degrees (Real)
TEMP	Temperature (Real)

Remarks:

1. This card is allowed if and only if an AXIC card is also present.
2. One or two temperatures may be defined on each card.
3. Temperature sets must be selected in the case Control Deck (TEMP=SID) to be used by NASTRAN.
4. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.
5. At least two different angles are required for each RID and temperature set to specify the subtended angle $[\phi_b - \phi_a]$ over which the temperature applies.
6. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
7. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

NASTRAN DATA DECK

Input Data Card TEMPD   Grid Point Temperature Field Default

Description: Defines a temperature default for all grid points of the structural model which have not been given a temperature on a TEMP card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPD	SID	T	SID	T	SID	T	SID	T	
TEMPD	1	216.3							

Field	Contents
SID	Temperature set identification number (Integer > 0)
T	Default temperature (Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.

2. From one to four default temperatures may be defined on a single card.

3. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

4. If the element material is temperature dependent its properties are evaluated at the average temperature. In the case of isoparametric hexahedron elements, their properties are evaluated at the temperature computed by interpolating the grid point temperatures.

5. Average element temperatures are obtained as a simple average of the connecting grid point temperatures when no element temperature data are defined.

6. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.

Input Data Card TEMPP1 Plate Element Temperature Field

Description: Defines a temperature field for plate, membrane and combination elements (by an average temperature and a thermal gradient over the cross-section) for determination of:

1) Thermal loading
2) Temperature-dependent material properties
3) Stress recovery

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPP1	SID	EID1	$\bar{T}$	T'	T1	T2			+abc
TEMPP1	2	24	62.0	10.0	57.0	67.0			A1A

+abc	EID2	EID3	EID4	EID5	EID6	EID7	EID8	EID9	+def
+1A	26	21	19	30					

-etc.-

Alternate Form of Continuation Card

+abc	EID2	"THRU"	EIDi	EIDj	"THRU"	EIDk			+def
+1A	1	THRU	10	30	THRU	61			

-etc.-

Field	Contents
SID	Temperature set identification number (Integer > 0)
EIDn	Unique element identification number(s) (Integer > 0 or BCD: the continuation card may have THRU in fields 3 and/or 6, in which case EID2 < EIDi, EIDj < EIDk)
$\bar{T}$	Average temperature over the cross-section. Assumed constant over area (Real)
T'	Effective linear thermal gradient. Not used for membranes (Real)
T1, T2	Temperatures for stress calculation at points defined on the element property card. (Z1 and Z2 are given on PTRBSC, PQDPLT, PTRPLT, PTRIA1, and PQUAD1 cards. T1 may be specified on the lower surface and T2 on the upper surface for the QUAD2 and TRIA2 elements. These data are not used for membrane elements (Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.

2. If continuation cards are present, EID1 and elements specified on the continuation card(s) are used. Elements must not be specified more than once.

3. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

4. For a temperature field other than a constant gradient the "effective gradient" for a homogeneous plate is:

$$T' = \frac{1}{I}\int_z T(z)z\,dz$$

where I is the bending inertia, and z is the distance from the neutral surface in the positive normal direction.

(Continued)

TEMPP1 (Cont.)

5. The "average" temperature for a homogeneous plate is

$$\bar{\bar{T}} = \frac{1}{\text{Volume}} \int_{\text{Volume}} T \, d\text{Volume}$$

6. If the element material is temperature dependent, its properties are evaluated at the average temperature $\bar{T}$.

7. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.

Input Data Card TEMPP2 Plate Element Temperature Field

Description: Defines a temperature field for plate, membrane, and combination elements by an average temperature and thermal moments for determination of:

1) Thermal loading
2) Temperature-dependent material properties
3) Stress recovery

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPP2	SID	EID1	$\bar{T}$	MX	MY	MXY	T1	T2	+abc
TEMPP2	2	36	68.8						XYZ
+abc	EID2	EID3	EID4	EID5	EID6	EID7	EID8	EID9	+def
+YZ	400	1	2	5					

-etc.-

Alternate Form of Continuation Card

+abc	EID2	"THRU"	EIDi	EIDj	"THRU"	EIDk			+def
+YZ	37	THRU	312	315	THRU	320			

-etc.-

Field	Contents
SID	Temperature set identification number (Integer > 0)
EIDn	Unique element identification number(s) (Integer > 0 or BCD: a continuation card may have THRU in field 3 and/or 6 in which case EID2 < EIDi, EIDj < EIDk)
$\bar{T}$	Average temperature over cross-section. Assumed constant over area (Real)
MX, MY, MXY	Resultant thermal moments per unit width in element coordinate system. Not used for membrane elements (Real)
T1, T2	Temperature for stress calculation at points defined on the element property card. (Z1 and Z2 are given on PTRBSC, PQDPLT, PTRPLT, PTRIA1, and PQUAD1 cards. T1 may be specified on the lower surface and T2 on the upper surface for the QUAD2 and TRIA2 elements. These data are not used for membrane elements (Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.

2. If continuation cards are present, EID1 and elements specified on the continuation card(s) are used. Elements must not be specified more than once.

3. If thermal effects are requested all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

(Continued)

TEMPP2 (Cont.)

4. The thermal moments in the element coordinate system may be calculated from the formula:

$$\begin{Bmatrix} M_x \\ M_y \\ M_{xy} \end{Bmatrix} = -\int [G_e]\{\alpha_e\}T(z)z\ dz$$

where the integration is performed over the bending material properties in the element coordinate system.

$[G_e]$ - 3x3 elastic coefficient matrix

$\{\alpha_e\}$ - 3x1 material thermal expansion coefficients

$T(z)$ - temperature at z

z - distance from the neutral surface in the element coordinate system.

5. The temperature dependent material properties are evaluated at the average temperature T. If a property varies with depth, an effective value must be used which satisfies the desired elastic and stress relationships. The temperatures at the fibre distances may be changed to compensate for local differences in α_e and produce correct stresses.

6. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.

Input Data Card TEMPP3 Plate Element Temperature Field

Description: Defines a temperature field for homogeneous plate, membrane and combination elements (by a tabular description of the thermal field over the cross-section) for determination of:
1) Thermal loading
2) Temperature-dependent material properties
3) Stress recovery.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPP3	SID	EID1	Z0	T0	Z1	T1	Z2	T2	+abc
TEMPP3	17	39	0.0	32.9	2.0	43.4	2.5	45.0	XY1
+abc	Z3	T3	Z4	T4	Z5	T5	Z6	T6	+def
+Y1	3.0	60.0	4.0	90.0					XY2
+def	Z7	T7	Z8	T8	Z9	T9	Z10	T10	+ghi
+Y2									XY3
+ghi	EID2	EID3	EID4	EID5	EID6	EID7	EID8	EID9	+jkl
+Y3	1	2	3	4	5	6	8	10	

-etc.-

Alternate Form of Continuation Card Number 3

+ghi	EID2	"THRU"	EIDi	EIDj	"THRU"	EIDk			+jkl
+Y3				1	THRU	10			

-etc.-

Field	Contents
SID	Temperature set identification number (Integer > 0)
EIDn	Unique element identification number(s) (Integer > 0 or BCD: the continuation card may have THRU in fields 3 and/or 6 in which case EID2 < EIDi, EIDj < EIDk)
Z0	Position of the bottom surface with respect to an arbitrary reference plane (Real)
Zi	Positions on cross-section from bottom to top of cross-section relative to the arbitrary reference plane. There must be an increasing sequence with the last nonzero value corresponding to the top surface (Real)
T0	Temperature at the bottom surface (Real)
Zi	Temperature at position Zi (Real)

Remarks:
1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.
2. If the third (and succeeding) continuation card is present, EID1 and elements specified on the third (and succeeding) continuation cards are used. Elements must not be specified more than once.
3. The first and second continuation card must be present if a list of elements is to be used.

(Continued)

TEMPP3 (Cont.)

4. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

5. If the element material is temperature dependent, its properties are evaluated at the average temperature over the depth which is calculated by the program using a linear distribution between points.

6. For stress recovery, the temperatures at the extreme points z_0 and z_N are assigned to the bottom surface and the top surface of the elements specified on either PTRIA2 or QUAD2 data card.

7. The data is limited to a maximum of eleven points on the temperature-depth profile.

8. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.

Input Data Card TEMPRB One-Dimensional Element Temperature Field

Description: Defines a temperature field for the BAR, RØD, TUBE, and CØNRØD elements for determination of:

1) Thermal loading
2) Temperature-dependent material properties
3) Stress recovery

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPRB	SID	EID1	$\bar{T}A$	$\bar{T}B$	T'1a	T'1b	T'2a	T'2b	+abc
TEMPRB	200	1	68.0	23.0	0.0	28.0		2.5	AXY10

+abc	TCa	TDa	TEa	TFa	TCb	TDb	TEb	TFb	+def
+XY10	68.0	91.0	45.0		48.0	80.0	20.0		AXY20

+def	EID2	EID3	EID4	EID5	EID6	EID7	EID8	EID9	+ghi
+XY20	9	10							

-etc.-

Alternate Form for Continuation Card Number 2

+def	EID2	"THRU"	EIDi	EIDj	"THRU"	EIDk			+ghi
+XY20	2	THRU	4	10	THRU	14			

-etc.-

Field	Contents
SID	Temperature set identification number (Integer > 0)
EIDn	Unique element identification number(s) (Integer > 0 or BCD: the second continuation card may have THRU in fields 3 and/or 6 in which case EID2 < EIDi, EIDj < EIDk)
$\bar{T}A$, $\bar{T}B$	Average temperature over the area at end "a" and end"b" (Real)
T'ij	Effective linear gradient in direction i on end j (BAR only, Real)
Tij	Temperatures at point i as defined on the PBAR card(s) at end j. These data are used for stress recovery only (BAR only, Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.

2. If at least one nonzero or nonblank Tij is present, the point temperatures given are used for stress recovery. If no Tij values are given, linear temperature gradients are assumed for stresses.

3. If the second (and succeeding) continuation card is present, EID1 <u>and</u> elements specified on the second (and succeeding) continuation cards are used. Elements must not be specified more than once.

4. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

(Continued)

TEMPRB (Cont.)

5. The effective thermal gradients in the element coordinate system for the BAR element are defined by the following integrals over the cross-section. For end "a" (end "b" is similar):

$$T'_{1a} = \frac{1}{I_1} \int_A T_a(y,z)y \, dA$$

$$T'_{2a} = \frac{1}{I_2} \int_A T_a(y,z)z \, dA$$

where $T_a(y,z)$ is the temperature at point y,z (in the element coordinate system) at end "a" of the BAR. See Section 1.3, Figure 1 for the element coordinate system: I_1 and I_2 are the moment of inertia about the z and y axis respectively. The temperatures are assumed to vary linearly along the length (x-axis). Note that if the temperature varies linearly over the cross-section then T'_{1a}, T'_{1b}, T'_{2a}, and T'_{2b} are the actual gradients.

6. If the element material is temperature dependent, the material properties are evaluated at the average temperature

$$\bar{T} = \frac{\bar{T}_A + \bar{T}_B}{2}$$

7. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.

Input Data Card TF • Dynamic Transfer Function

Description: 1. May be used to define a transfer function of the form

$$(B0 + B1p + B2p^2)u_d + \sum_i (A0(i) + A1(i)p + A2(i)p^2)u_i = 0$$

2. May be used as a means of direct matrix input.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TF	SID	GD	CD	B0	B1	B2			+abc
TF	1	2	3	4.0	5.0	6.0			+ABC
+abc	G(1)	C(1)	A0(1)	A1(1)	A2(1)				+def
+ABC	3	4	5.0	6.0	7.0				+DEF

(etc.)

Field	Contents
SID	Set identification number (Integer > 0)
GD,G(i)	Grid, scalar or extra point identification numbers (Integer > 0)
CD,C(i)	Component numbers (Null or zero for scalar or extra points, any one of the digits 1-6 for a grid point)
B0,B1,B2 A0(i),A1(i), A2(i)	Transfer function coefficients (Real)

Remarks: 1. The matrix elements defined by this card are added to the dynamic matrices for the problem.

2. Transfer Function sets must be selected in the Case Control Deck (TFL=SID) to be used by NASTRAN.

3. The constraint relation given above will hold only if no elements are connected to the dependent coordinate.

Input Data Card TIC Transient Initial Condition

Description: Defines values for the initial conditions of coordinates used in Transient analysis. Both displacement and velocity values may be specified at independent coordinates of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TIC	SID	G	C	U0	V0				
TIC	1	3	2	5.0	-6.0				

Field	Contents
SID	Set identification number (Integer > 0)
G	Grid or scalar or extra point identification number (Integer > 0)
C	Component number (Null or zero for scalar or extra points, any one of the digits 1-6 for a grid point)
U0	Initial displacement value (Real)
V0	Initial velocity value (Real)

Remarks:

1. Transient initial condition sets must be selected in the Case Control Deck (IC=SID) to be used by NASTRAN.
2. If no TIC set is selected in Case Control Deck, all initial conditions are assumed zero.
3. Initial conditions for coordinates not specified on TIC cards will be assumed zero.
4. Initial conditions may be used only in direct formulation.

Input Data Card TLØAD1 Transient Response Dynamic Load

Description: Defines a time-dependent dynamic load of the form

$$\{P(t)\} = \{A\ F(t - \tau)\}$$

for use in transient response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TLØAD1	SID	L	M		TF				
TLØAD1	5	7	9		13				

Field	Contents
SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set or a thermal load set which defines A (Integer > 0)
M	Identification number of DELAY card set which defines τ (Integer $\geq$ 0)
TF	Identification number of TABLEDi card which gives $F(t - \tau)$ (Integer > 0)

Remarks:

1. If M is zero, τ will be zero.
2. Field 5 must be blank.
3. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
4. TLØAD1 loads may be combined with TLØAD2 loads only by specification on a DLØAD card. That is, the SID on a TLØAD1 card may not be the same as that on a TLØAD2 card.
5. SID must be unique for all TLØAD1, TLØAD2, RLØAD1 and RLØAD2 cards.
6. Field 3 may reference sets containing QHBDY, QBDY1, QBDY2, QVECT, and QVØL cards when using the heat transfer option.
7. If the heat transfer option is used, the referenced QVECT data card may also contain references to functions of time, and therefore A may be a function of time.

NASTRAN DATA DECK

Input Data Card TLØAD2 Transient Response Dynamic Load

Description: Defines a time-dependent dynamic load of the form

$$\{P(t)\} = \begin{cases} \{0\}, & \tilde{t} < 0 \text{ or } \tilde{t} > T2 - T1 \\ \left\{A\ \tilde{t}^{B}\ e^{C\tilde{t}} \cos(2\pi F\tilde{t} + P)\right\}, & 0 \le \tilde{t} \le T2 - T1 \end{cases}$$

for use in transient response problems where $\tilde{t} = t - T1 - \tau$.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TLØAD2	SID	L	M		T1	T2	F	P	abc
TLØAD2	4	10	7		2.1	4.7	12.0	30.0	+12
+bc	C	B							
+12	2.0	3.0							

Field	Contents
SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set or a thermal load set which defines A (Integer > 0)
M	Identification number of DELAY card set which defines τ (Integer $\geq$ 0)
T1	Time constant (Real $\geq$ 0.0)
T2	Time constant (Real, T2 > T1)
F	Frequency in cycles per unit time (Real $\geq$ 0.0)
P	Phase angle in degrees (Real)
C	Exponential coefficient (Real)
B	Growth coefficient (Real)

Remarks:

1. If M is zero, τ will be zero.

2. Field 5 must be blank.

3. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.

4. TLØAD2 loads may be combined with TLØAD1 loads only by specification on a DLØAD card. That is, the SID on a TLØAD2 card may not be the same as that on a TLØAD1 card.

5. SID must be unique for all TLØAD1, TLØAD2, RLØAD1 and RLØAD2 cards.

TLØAD2 (Cont.)

6. Field 3 may reference load sets containing QHBDY, QBDY1, QBDY2, QVECT, and QVØL cards when using the heat transfer option.

7. If the heat transfer option is being used, the referenced QVECT load card may also contain references to functions of time, and therefore A may be a function of time.

Input Data Card TRANS Component Substructure Transformation Definition

Description: Defines the location and orientation of the component substructure basic coordinate system axes relative to the basic coordinate system of the substructure formed as a result of the substructure CØMBINE operation. The translation and rotation matrices are defined by specifying the coordinates of three points A, B, C. The coordinates of points A, B, C must be expressed on this card in the basic coordinate system of the resultant combined substructure as follows:

A - defines the location of the origin of the basic coordinate system of the component substructure.

B - defines the location of a point on the z axis of the basic coordinate system of the component substructure.

C - defines the location of a point in the positive x side of the xz plane of the basic coordinate system of the component substructure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TRANS	CID		A1	A2	A3	B1	B2	B3	abc
TRANS	1		0.0	0.0	0.0	0.0	-0.5	10.0	ABC
+bc	C1	C2	C3						
+BC	0.0	10.0	0.5						

Field	Contents
CID	Set identification number (Integer > 0)
A1, A2, A3 B1, B2, B3 C1, C2, C3	Coordinates of the points defining system as described above.

Remarks:

1. Continuation card must be present.
2. Coordinates A, B, C are given in BASIC coordinate system of the result substructure.
3. The value of CID must be unique with respect to all other TRANS data cards.
4. Transformation sets for a whole substructure must be selected in the Substructure Control Deck (TRANS=SID) to be used by NASTRAN. Note that 'TRANS' is a subcommand of the substructure CØMBINE command.
5. Transformation of individual grid points in a substructure prior to combining them is requested by the GTRAN Bulk Data card which references the TRANS information.

NASTRAN DATA DECK

Input Data Card TSTEP · Transient Time Step

Description: Defines time step intervals at which solution will be generated and output in Transient Analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TSTEP	SID	N(1)	DT(1)	NØ(1)					+abc
TSTEP	2	10	.001	5					+ABC
+abc		N(2)	DT(2)	NØ(2)					+def
+ABC		9	0.01	1					+DEF

(etc.)

Field	Contents
SID	Set identification number (Integer > 0)
N(i)	Number of time steps of value DT(i) (Integer ≥ 2)
DT(i)	Time increment (Real > 0.0)
NØ(i)	Skip factor for output (Every NØ(i)$^{\underline{th}}$ step will be saved for output) (Integer > 0)

Remarks: TSTEP cards must be selected in the Case Control Deck (TSTEP=SID) in order to be used by NASTRAN.

2.5 USER'S MASTER FILE

As a means of aiding the user in handling the large (several boxes of cards) Bulk Data Decks which are typical of NASTRAN problems, the User's Master File is provided for storage of many Bulk Data Decks on a single tape. There are many advantages to using a Master File. For a problem that several investigators are concurrently studying, the User's Master File provides a convenient common source of data. Standardization is easy to impose since there can be only one legitimate structural model deck for any given problem. When various parts of a structure are being analyzed separately, they may all be placed on the same User's Master File for ease of use. Errors due to card handling equipment (and people!) are sharply reduced since a several box input deck is reduced to a few cards. Finally, the convenience to the user in submitting jobs should be emphasized (run decks can be hand-carried!).

2.5.1 Use of User's Master File

Functionally, the User's Master File exhibits all of the properties of an Old Problem Tape (ØPTP) which would result if a job were terminated after the NASTRAN preface; only the control cards used are different. Thus the User's Master File (UMF) becomes an alternate source of bulk data input to NASTRAN which may be modified in identically the same way as bulk data is changed during a modified restart. Since the UMF is used as an alternate ØPTP functionally, only one or the other may appear in a run. The UMF, then, is used only for an initial run and may not be used in conjunction with a restart. The checkpoint feature may be used with a UMF run, however, and the resulting New Problem Tape (NPTP) may be used as an ØPTP in a subsequent restart.

In describing the use of the User's Master File, the UMF control cards will be contrasted with their ØPTP counterparts. In place of the setup card for the ØPTP tape (see Chapter 5 of the Programmer's Manual for a discussion of these machine and installation dependent NASTRAN driver control cards), use a setup card for the selected UMF tape. In place of the restart dictionary in the Executive Control Deck, use the card

$$\text{UMF} \quad k_1, k_2$$

described in Section 2.2.1, which selects Bulk Data Deck k_2 from UMF tape k_1 to use in the current execution.

2.5.2 Using the User's Master File Editor

To assist the NASTRAN user in creating and maintaining User's Master Files, an auxiliary NASTRAN preface module, the User's Master File Editor, is provided. The functions performed by the Editor are:

1. Create a New User's Master File (NUMF) from Bulk Data Decks supplied by the user.
2. List and/or punch Bulk Data Decks from an already existing UMF.
3. Edit Bulk Data Decks (which may be modified) from an old UMF onto a NUMF.

Bulk Data Decks must be acceptable to the NASTRAN preface (XSØRT and IFP) to be accepted by the Editor.

The executive control card that causes NASTRAN to execute as the User's Master File Editor is UMFEDIT. When in the Editor mode, NASTRAN executes only the preface. A separate run is required to use a User's Master File generated by the Editor. Preface module UMFEDT, which is where the User's Master File Editor actions occur, reads data cards from the System Input Stream which are used to control Editor activity. Some of these data cards precede the Bulk Data Deck being processed while others follow. The remainder of this section will be devoted to describing these cards and the action caused by them. Section 2.5.3 gives some rules to be followed when making up data cards for the Editor. Several examples will then be given in Section 2.5.4 to illustrate the functions performed by the User's Master File Editor.

Table 1 shows the Editor data cards and describes the action taken for each one. Three classes are described, depending on the tapes used. The cards are free-field format as are the executive control cards and case control cards previously described. The symbolic quantities tid and pid are each up to 8 arbitrarily selected integers chosen by the user who causes the User's Master File to be created. Table 2 shows a summary of Editor control cards.

When a New User's Master File (NUMF) is created, the User's Master File Editor (UMFEDIT) punches the Executive Control cards that are needed to read the decks from the newly created master file. The UMFEDIT automatically punches one UMF Executive Control card for each Bulk Data Deck that is written on the NUMF and lists it in a table of contents.

2.5.3 Rules for the User's Master File Editor

1. The tape identification number, tid, and the problem identification number, pid, are positive integers selected by the user. The only exception to this is that pid may be zero if the UMF card is being used only to specify a value for tid or to indicate a new deck rather than an alter set.

2. The tape identification number, tid, must be the same for all decks on a single UMF.

3. Only one pass is made while either reading the UMF or writing the NUMF. Sequential processing requests are thereby required. This means that the problem identification numbers must form an increasing sequence corresponding to the order of the decks.

4. A corollary to 2 is that a deck to be inserted between two decks on an existing UMF must be given a problem identification number whose value "lies between" the values of the problem identification numbers for the two UMF decks. Thus, an initial numbering sequence such as 10, 20, 30, ... is recommended.

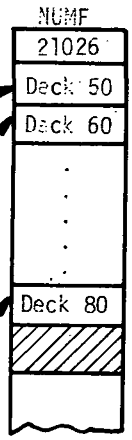
5. Most NASTRAN users develop the habit of "storing" data cards not needed for a given run behind the ENDDATA card where they are normally ignored. This must not be done when using the Editor since it reads data from this position. Data cards following the FINIS card are ignored, however.

2.5.4 Examples of User's Master File Editor Usage

Several examples of User's Master File Editor usage are given in this section. The user is well-advised to study these examples both from the standpoint of understanding the functioning of the Editor and from the standpoint of learning how to use this NASTRAN feature. A symbolic representation of the contents of the UMF and/or NUMF used in each example is given along with an explanation of specific items of interest. These examples illustrate all of the capability of the User's Master File Editor.

Example 1. Create a User's Master File

```
ID  A,B
TIME 1
APP DMAP
BEGIN
END
UMFEDIT
CEND
TITLE = USER'S MASTER FILE CØNTAINS
LABEL = PRØBLEMS 50, 60, ..., 80
ECHØ = BØTH
MAXLINES=50000
BEGIN BULK )
     .     }
     .     }   1st Bulk Data Deck
     .     }
ENDDATA    )
NUMF  21026, 50
BEGIN BULK )
     .     }
     .     }   2nd Bulk Data Deck
     .     }
ENDDATA    )
NUMF  21026, 60
     .
     .
     .
     .
     .
BEGIN BULK )
     .     }
     .     }   Last Bulk Data Deck
     .     }
ENDDATA    )
NUMF  21026, 80
FINIS
```



Notes: 1. A tape must be set up for NASTRAN file NUMF.

2. A tape must not be set up for NASTRAN file UMF.

3. The DMAP sequence will not be used but must appear in the Executive Control Deck.

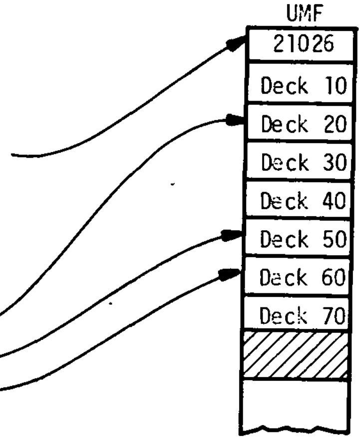
4. ECHØ = BØTH is recommended since the unsorted Bulk Data Deck is available only during the run used to create the User's Master File. The sorted echo is needed in order to make alterations to the bulk data when using the User's Master File in a NASTRAN run.

5. Note that the tape identification number, tid, is the same on all of the NUMF cards.

6. Note that the problem identification numbers, pid, are increasing according to the data deck order.

Example 2. <u>List and/or punch selected decks from a User's Master File</u>

```
ID  A,B
TIME 1
APP DMAP
BEGIN
END
UMF  21026, 0
UMFEDIT
CEND
ECHØ=NØNE
BEGIN BULK
  {blank card}
ENDDATA
LIST  20
PUNCH  50
PUNPRT  60
FINIS
```



Notes: 1. A tape containing the proper User's Master File <u>must</u> be set up on NASTRAN file UMF.

2. A tape <u>must not</u> be set up for NASTRAN file NUMF.

3. The DMAP sequence will not be used but <u>must appear</u> in the Executive Control Deck.

4. The dummy Bulk Data Deck consisting of a single blank card will not be used but <u>must appear</u>.

5. ECHØ = NØNE is recommended to suppress printout of the dummy Bulk Data Deck. This has no effect on the User's Master File Editor.

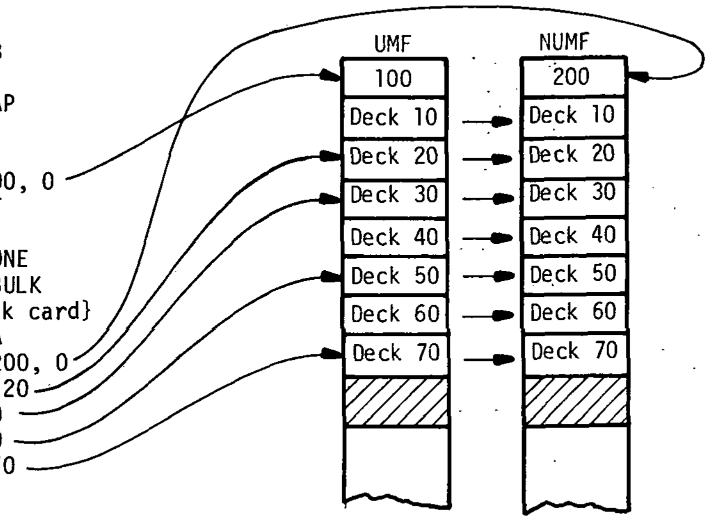
6. The zero value of pid on the UMF card is required since only tid is being used in this application.

7. The LIST, PUNCH, and PUNPRT cards must be sequenced such that the pid values form an increasing sequence.

8. The above requests will cause a sorted Bulk Data Deck echo to be made for decks 20 and 60; decks 50 and 60 will be punched.

Example 3. Copy a User's Master File while listing and/or punching selected decks.

```
ID  A,B
TIME 5
APP DMAP
BEGIN
END
UMF  100, 0
UMFEDIT
CEND
ECHØ=NØNE
BEGIN BULK
  {blank card}
ENDDATA
NUMF  200, 0
PUNPRT 20
LIST 30
LIST 50
PUNCH 70
FINIS
```

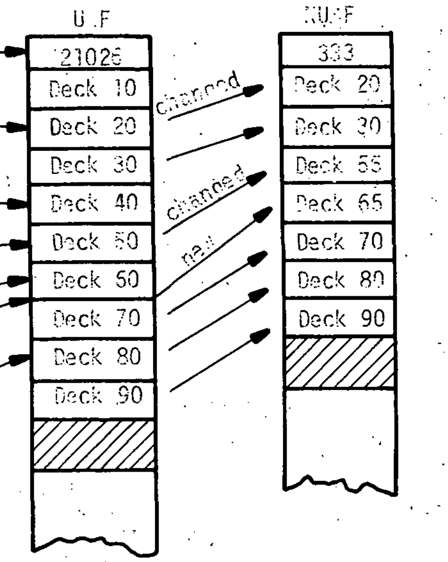


Notes:

1. A tape containing the User's Master File to be copied must be set up on NASTRAN file UMF.
2. A tape must be set up on NASTRAN file NUMF.
3. The DMAP sequence is not used but must appear in the Executive Control Deck.
4. The dummy Bulk Data Deck consisting of a single blank card will not be used but must appear.
5. ECHØ = NØNE is recommended to suppress printout of the dummy Bulk Data Deck. This has no effect on the User's Master File Editor.
6. The zero value of pid on the UMF card is required since only tid is being used in this application.
7. The zero value of pid on the NUMF card is not used. This card is used to specify tid for the NUMF. If the NUMF card were absent, the same tid would be put on the NUMF as existed on the UMF.
8. The LIST, PUNCH, and PUNPRT cards must be sequenced such that the pid values form an increasing sequence.
9. The above requests will cause a sorted Bulk Data Deck echo to be made for decks 20, 30, and 50; decks 20 and 70 will be punched.
10. All of the decks contained on the UMF will be copied onto the NUMF tape. The tape identification number will be different as explained in note 7.

Example 4. Edit a User's Master File

```
ID A,B
TIME 5
APP DMAP
BEGIN
END
UMF  21026, 20
UMFEDIT
CEND
TITLE = MØDIFICATIØN ØF
SUBTITLE = DECKS 20 AND 50
ECHØ = BØTH
BEGIN BULK
  {alter cards for Deck 20}
ENDDATA
NUMF  333, 20
REMØVE 40
UMF  21026, 50
BEGIN BULK
  {alter cards for Deck 50}
ENDDATA
NUMF  333, 55
REMØVE 60
UMF  21026, 0
BEGIN BULK
  {Deck 65}
ENDDATA
NUMF 333, 65
LIST 80
FINIS
```



Notes: 1. A tape containing the User's Master File to be edited must be set up on NASTRAN file UMF.

2. A tape must be set up on NASTRAN file NUMF.

3. The DMAP sequence is not used but must appear in the Executive Control Deck.

4. ECHØ = BØTH is recommended since the alter cards are available only during the run used to perform the edit. The sorted echo is needed for those decks being altered in order to make further alterations to the bulk data when using the newly created User's Master File in a NASTRAN run. Decks not being altered will not be echoed as a result of the ECHØ = BØTH card. Such decks may be echoed as they are copied as shown in the example for Deck 80.

5. The pid values must form an increasing sequence.

6. The requests in the above example will cause listings to be generated for deck 80; no decks will be punched.

7. Decks 30, 70, 80, and 90 will be copied onto the NUMF with no changes.

8. Decks 10, 40, and 60 will be removed (i.e., not copied onto the NUMF).

9. Decks 20 and 50 will be modified. In addition the problem identification number of Deck 50 will be changed to 55.

10. Deck 65 will be added.

11. Deck 10 is removed because it appears prior to the first call to the Editor. This may be avoided by using a pid of zero and a dummy Bulk Data Deck as shown in Example 3.

Table 1. User's Master File Editor Control Card Actions.

I. UMF Only is Present

- A. FINIS
  1. Terminate run.
- B. BEGIN BULK (Not Allowed)
- C. REMØVE pid (Not Allowed)
- D. LIST pid
  1. Skip UMF forward to pid and list the Bulk Data Deck on the printer.
- E. PUNCH pid
  1. Skip UMF forward to pid and punch the Bulk Data Deck on the punch.
- F. UMF tid, pid (Not Allowed)
- G. NUMF tid, pid (Not Allowed)
- H. PUNPRT pid
  1. Skip UMF forward to pid and then list and punch the Bulk Data Deck.

II. NUMF Only is Present

- A. FINIS
  1. Write end-of-file on NUMF.
  2. Terminate run.
- B. BEGIN BULK
  1. Process the next Bulk Data Deck.
- C. REMØVE pid (Not Allowed)
- D. LIST pid (Not Allowed)
- E. PUNCH pid (Not Allowed)
- F. UMF tid, pid (Not Allowed)
- G. NUMF tid, pid
  1. If first entry to Editor, write tape identification file on NUMF.
  2. Add preceding Bulk Data Deck to NUMF and automatically punch and list the UMF card for use with UMF.
- H. PUNPRT pid (Not Allowed)

III. Both UMF and NUMF are Present

- A. FINIS
  1. Copy any remaining Bulk Data Decks from UMF to NUMF.
  2. Write end-of-file on NUMF.
  3. Terminate run.
- B. BEGIN BULK
  1. Process the next Bulk Data Deck which may be a new deck or a modified deck from the UMF.
- C. REMØVE pid
  1. Copy UMF onto NUMF up to indicated deck.
  2. Skip indicated deck on UMF.
- D. LIST pid
  1. Copy UMF onto NUMF through indicated deck.
  2. List indicated Bulk Data Deck on printer.
- E. PUNCH pid
  1. Copy UMF onto NUMF through indicated deck.
  2. Punch indicated Bulk Data Deck on printer.
- F. UMF tid, pid
  1. Copy UMF onto NUMF up to indicated deck. (Must be immediately followed by BEGIN BULK card.)
- G. NUMF tid, pid
  1. If first entry to Editor, write tape identification file on NUMF.
  2. Copy UMF onto NUMF up to deck with identification greater than pid.
  3. Add preceding Bulk Data Deck to NUMF and automatically punch and list the UMF card for use with UMF.
- H. PUNPRT pid
  1. Copy UMF onto NUMF through indicated deck.
  2. List indicated Bulk Data Deck on printer.
  3. Punch indicated Bulk Data Deck on punch.

Table 2. Summary of User's Master File Editor Control Cards.

LIST pid	List the problem deck from UMF or copy the problem deck from UMF onto NUMF and list it.
NUMF tid, pid	Add problem deck to NUMF, list it and punch UMF card.
PUNCH pid	Punch the problem deck from UMF or copy the problem deck from UMF onto NUMF and punch it.
PUNPRT pid	Punch and print the problem deck from UMF or copy the problem deck from UMF onto NUMF and punch and print it.
REMØVE pid	Copy problem decks from UMF onto NUMF up to pid and skip over problem pid.
UMF tid, pid	Copy UMF problem deck onto NUMF, list it and punch UMF card.

2.5.5 NASTRAN Demonstration Problems

The standard set of NASTRAN Demonstration Problems are each identified by a UMF tid, pid card. Thus, to run a demonstration problem, either use the Executive and Case Control driver decks provided or alter them and then add the bulk data deck from the UMF. Bulk data cards can be deleted with the / card or others can be added by referring to the sorted Bulk Data Deck Card number. See the NASTRAN Demonstration Problems Manual for the appropriate UMF number.

2.6 USER GENERATED INPUT

It may happen that a user will want to take a problem previously run on another program and run it using NASTRAN. In many instances, this provides the user with the quickest means of familiarizing himself with NASTRAN since he is running a problem which he understands intimately. Also, he may wish to extend his analysis of some previously analyzed problem into regions which previous programs would not allow. In either event, he is faced with the problem of Input Data conversion.

The simplest way to convert structural model data is to write a small FØRTRAN (or other language) program to read in the data cards composing the input data deck for the previous program and punch a new NASTRAN Bulk Data Deck. Usually, the information is in a one to one correspondence, and this procedure is quite straight forward, requiring only a minimal knowledge of programing. While a large deck of cards may result, by using the User's Master File feature described in Section 2.5, the amount of large deck handling may be minimized.

2.6.1 Utility Module INPUT Usage

NASTRAN has implemented one data generating utility module within its existing structure for specific cases. General characteristics of the INPUT module are as follows:

1. INPUT allows the user of NASTRAN to generate the majority of the bulk data cards for a number of selected test problems without having to actually input the physical cards into the Bulk Data Deck.

2. The test problems for which partial data are generated by INPUT are:

   a. N x N Laplace Network from scalar elements

   b. W x L Rectangular Frame from BAR elements or RØD elements

   c. W x L Rectangular Array of QUAD1 elements

   d. W x L Rectangular Array of TRIA1 elements

   e. N - segment string from scalar elements

   f. N - cell beam made from BAR elements

   g. N - scalar point full matrix with optional unit loading

These problem types are described separately in the following sections.

3. To use INPUT variations of the following alter deck must be used:

```
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT,    ,,,,/G1,G2,----,G5/C,N,a/C,N,b/C,N,b $
EQUIV G1,GEØM1/TRUE  /  G2,GEØM2/TRUE----/ G5,GEØM5/TRUE $
ENDALTER
```

The specific data blocks that need be included depend on the particular problem as do the parameter values. Examples for each problem type will be given.

4. Data cards are read by INPUT from the System Input File using FØRTRAN I/Ø, each card containing up to 10 eight column fields. Remember to right-justify this data. The required data are described in each problem type description.

5. The INPUT data card(s) follow the ENDDATA card. Do not "store" other data that is not intended to be used by the INPUT module. Note that if the Univac 1108 is used, a system control card @XQT *NASTRAN.LINK2 must be inserted between the ENDDATA and INPUT data card(s).

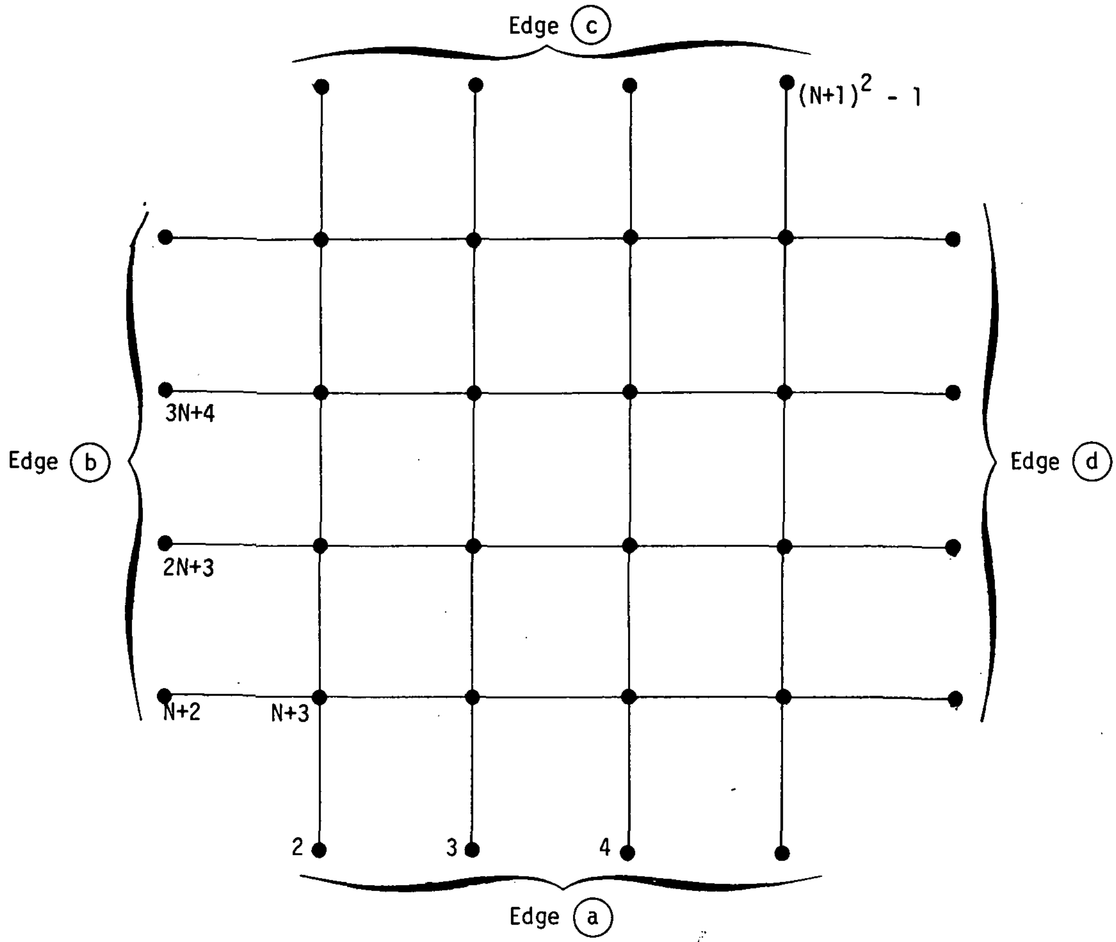
6. Several sample problems were run as part of checkout. The input for these runs are available as examples of INPUT usage.

7. Restart tables are not effective with respect to "cards" generated by INPUT since the preface is unaware of their existance.

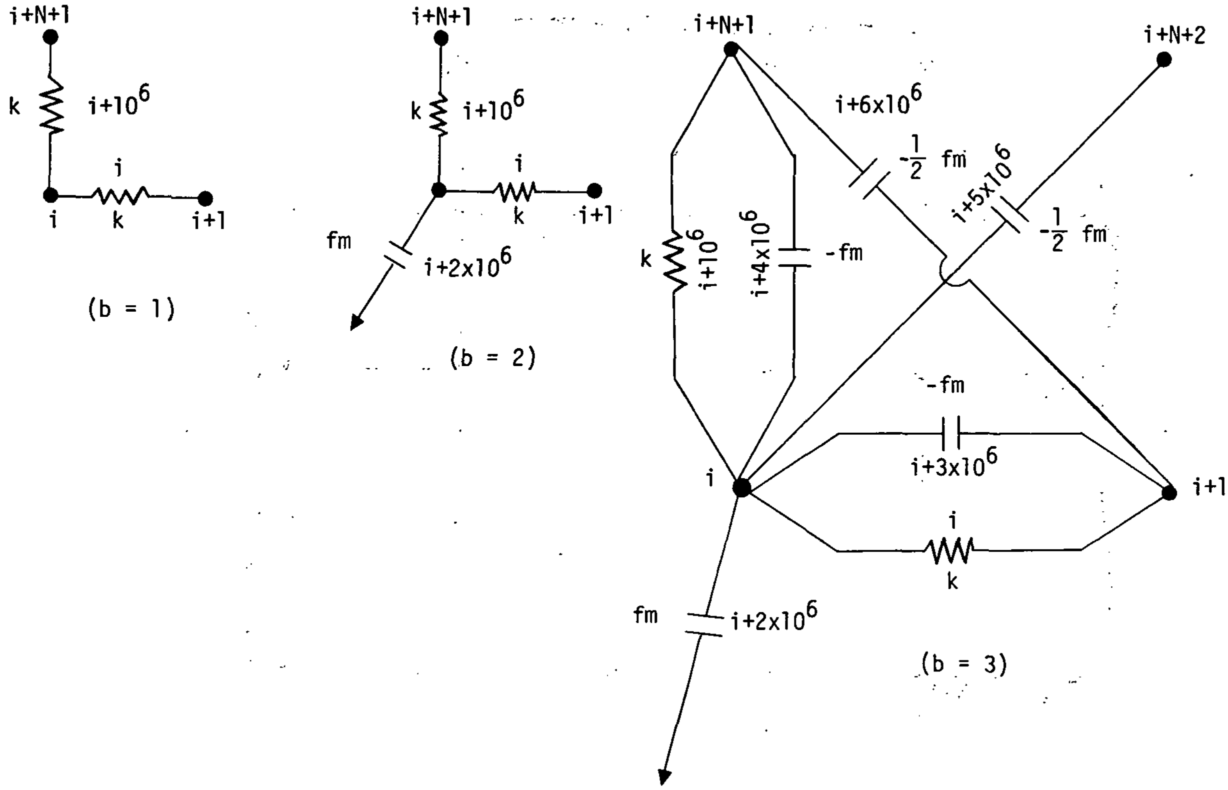
8. The INPUT data generator feature is restrictive. It can only be used in the circumstances illustrated. The user may employ the INPUT module as described but merging of user data with INPUT data is not supported. As an example, single point constraints may be defined either in the bulk data deck or in the INPUT module data deck but not both places in an attempt to combine them. Thus if SPC cards are defined in the bulk data deck, then the G4 data block will not be generated and GEØM4 must not be equivalenced to G4.

2.6.1.1 Laplace Circuit (a=1, b=1,2 or 3, c is not used)

INPUT generates CELAS4, SPC (for b=1), and CMASS (for b=2,3) cards for the circuit shown.



The scalar point id's are 1 through $(N+1)^2$ except for 1, N+1, N(N+1)+1, and $(N+1)^2$. For b = 2 or 3, all edge points are replaced with ground. The scalar elements generated are shown below for each value of b for a typical cell. Elements between edge points are not generated.



a. Data Card

1	N	(I8)	N^2 = no. of cells
2	k	(E8.0)	Spring stiffness
3	U	(E8.0)	Enforced displacement along edge b (b = 1)
3	m	(E8.0)	Mass (b = 2,3)
4	f	(E8.0)	Coupling fraction (b = 3 only)

b. Options

b

= 1, statics. Use statics (Rigid Format D-1) to solve $\nabla^2 u = 0$ with boundary conditions u = 0 along (a), (c) and (d), u = U along (b). G2 and G4 are both used. No masses are generated.

= 2, no mass coupling. Use real eigenvalue analysis (Rigid Format D-3) to obtain the eigenvalues of a square membrane ($\nabla^2 u = \frac{\partial^2 u}{\partial t^2}$) where the theoretical solutions for $N \to \infty$ are given by

$$f_{ij} = \frac{1}{N}\{i^2 + j^2\}^{1/2} \; ; \quad i,j = 1,2,---$$

U is ignored. **Only** G2 is used. Diagonal masses only are generated.

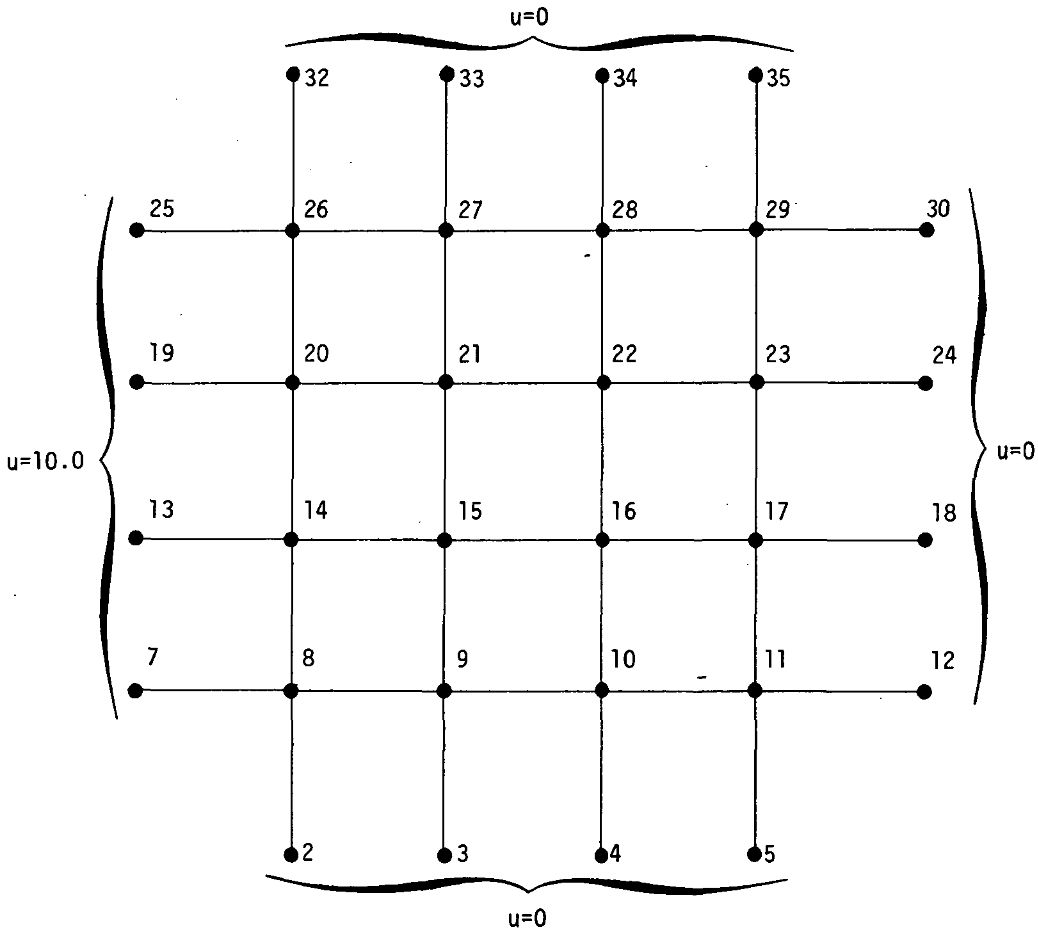
= 3, mass coupling. Same as where the diagonal masses are m. The horizontal and vertical masses are -fm; the cross diagonal masses are $-\frac{1}{2}$ fm.

c. Notes

(1) For b = 1, SPR = 1000+N must be selected in Case Control Deck.

NASTRAN DATA DECK

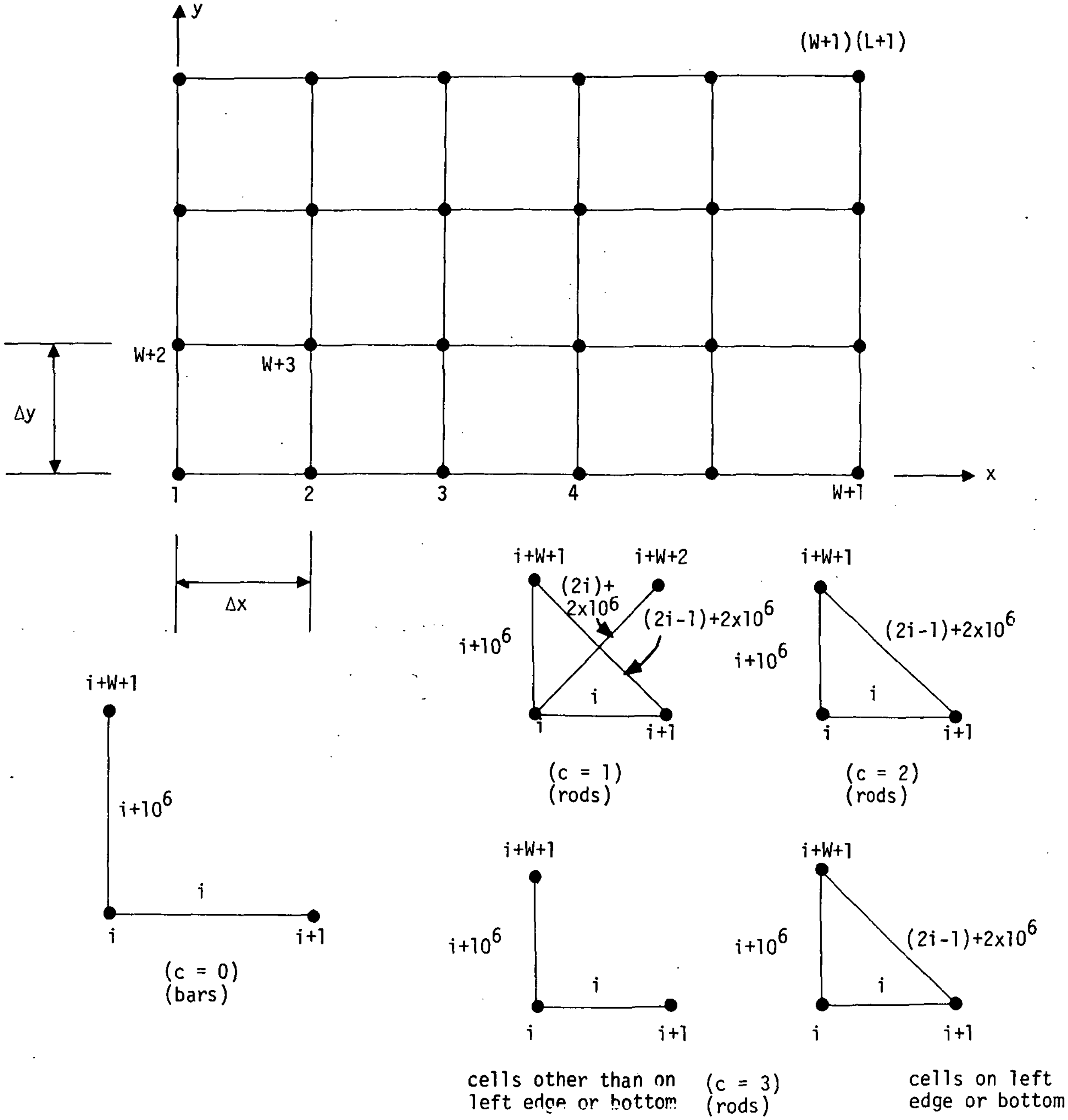
```
ID INPUT,CASE1
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/,G2,,G4,/C,N,1/C,N,1 $
EQUIV G2,GEØM2/TRUE  /  G4,GEØM4/TRUE $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=LAPLACE CIRCUIT
LABEL=STATICS
SPC=1005
ØUTPUT
DISP=ALL
BEGIN BULK
{blank card}
ENDDATA
      5        1.0       10.0
```



Lines indicate scalar springs

2.6.1.2 Rectangular Frame made from BAR's or RØD's (a=2, b=1,2,3 or 4, c=0,1,2 or 3)

INPUT generates GRID, CBAR or CRØD and SEQGP cards for the rectangular frame shown.



a. Data Card

1	W	(I8)	No. cells in x-direction
2	L	(I8)	No. cells in y-direction
3	Δx	(E8.0)	Length of cell in x-direction
4	Δy	(E8.0)	Length of cell in y-direction
5	P	(I8)	Permanent single-point constraints

b. Options (SEQGP cards)

$$b \begin{cases} =1, \text{ Regular Banding (no SEQGP cards)} \\ =2, \text{ Double Banding} \\ =3, \text{ Active Columns} \\ =4, \text{ Reverse Double Banding} \end{cases}$$

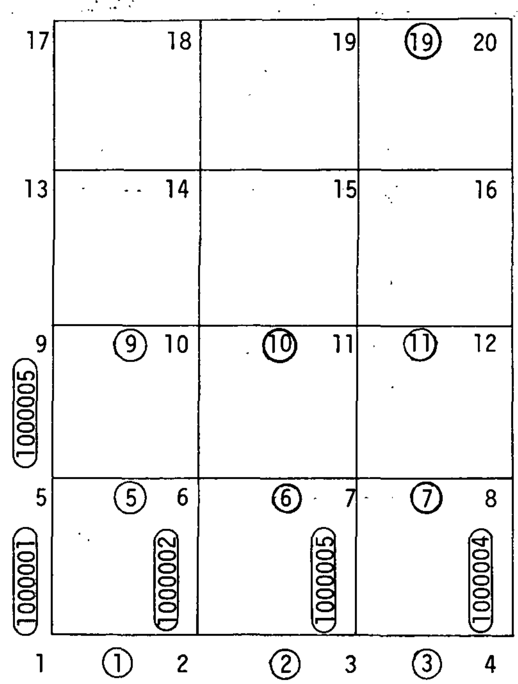
$$c \begin{cases} =0, \text{ Bars} \\ =1, \text{ Rods with both diagonals} \\ =2, \text{ Rods with UL - LR diagonals} \\ =3, \text{ Rods - statically determinate} \end{cases}$$

c. Notes

(1) A PBAR card with PID of 101 must be supplied as part of the bulk data for c = 0; for c ≠ 0, this is a PRØD card.

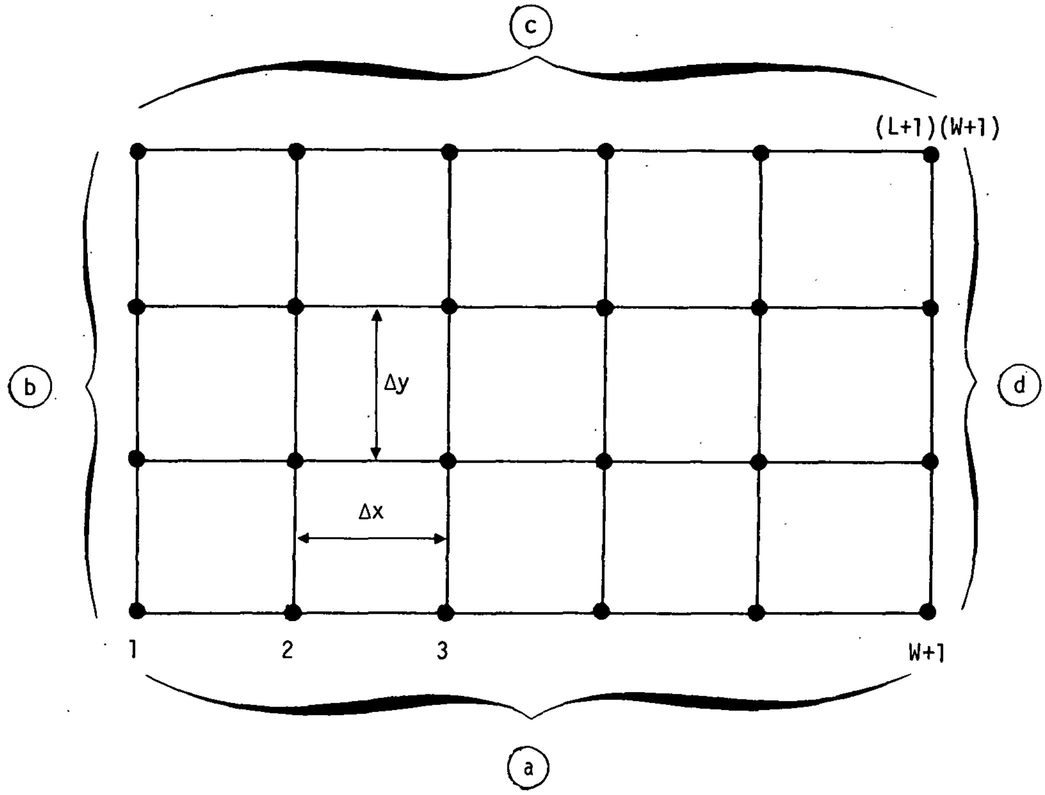
USER GENERATED INPUT

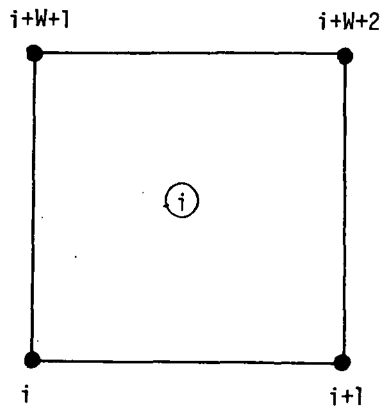
```
ID INPUT, CASE2
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/G1,G2,,,/C,N,2/C,N,1 $
EQUIV G1,GEØM1/TRUE  /  G2,GEØM2/TRUE  $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=RECTANGULAR FRAME FRØM BARS
LABEL=REGULAR BANDING
SPC=1
LØAD=1
ØUTPUT
SET 101 = 1,4,17,20
DISP=101
BEGIN BULK
FØRCE          1      20       0     1.0     1.0     0.0     0.0
MAT1           7     1.0     1.0
PBAR         101       7     1.0     2.0     4.0     8.0
SPC            1       1    1234     0.0       4      23     0.0
ENDDATA
       3       4     1.0     2.0     345
```



2.6.1.3 Rectangular Plate made from QUAD1's (a=3, b=1,2,3 or 4, c is not used)

INPUT generates GRID, CQUAD1, SEQGP and SPC (if requested) cards for the rectangular grid work shown.





USER GENERATED INPUT

a. Data Deck (2 cards required)

First Card

1	W	(I8)	No. cells in x-direction
2	L	(I8)	No. cells in y-direction
3	ΔX	(E8.0)	Length of cell in x-direction
4	Δy	(E8.0)	Length of cell in y-direction
5	IP	(I8)	Permanent constraints
6	θ	(E8.0)	Material orientation angle in degrees

Second Card

1	IYO	(I8)	SPC's on y = 0
2	IXO	(I8)	SPC's on x = 0
3	IYL	(I8)	SPC's on $y = L \cdot \Delta y$
4	IXW	(I8)	SPC's on $x = W \cdot \Delta x$
5	IØX	(I8)	ØMIT's in x-direction
6	IØY	(I8)	ØMIT's in y-direction

b. Options (SEQGP cards)

$$b \begin{cases} =1, \text{ Regular banding (no SEQGP cards)} \\ =2, \text{ Double banding} \\ =3, \text{ Active banding} \\ =4, \text{ Reverse double banding} \end{cases}$$

c. Notes

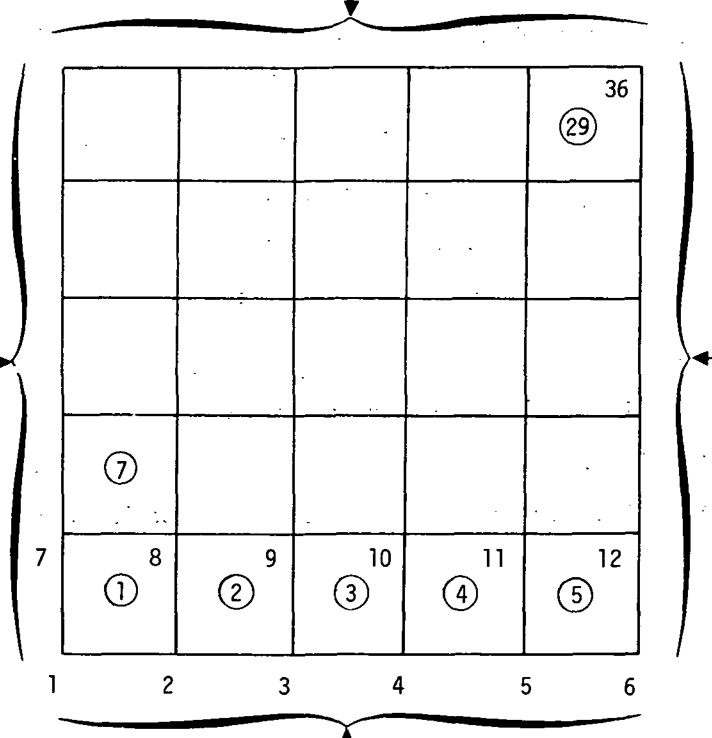
(1) If IP, IYO, IXO, IYL and IXW are all zero, G4 will be purged.

(2) A PQUAD1 card with PID = 101 must be included in the Bulk Data.

(3) If SPC's are generated the set ID will be 1000NX + NY.

```
ID INPUT, CASE3
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/G1,G2,,G4,/C,N,3/C,N,1 $
EQUIV G1,GEØM1/TRUE  /  G2,GEØM2/TRUE  /  G4,GEØM4/TRUE  $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=RECTANGULAR PLATE MADE FRØM CQUAD1'S
LABEL=STATICS              SIMPLE SUPPØRTS        REGULAR BAND
SPC=5005
LØAD=1
ØUTPUT
DISP=ALL
BEGIN BULK
FØRCE   1       1       0       1.0     0.0     0.0     1.0
MAT1    7       1.0     1.0
PQUAD1  101     7       1.0     7       2.0     7       4.0
ENDDATA
     5       5      10.0    10.0     126     0.0
    246     156    12356   12346     0       0
```

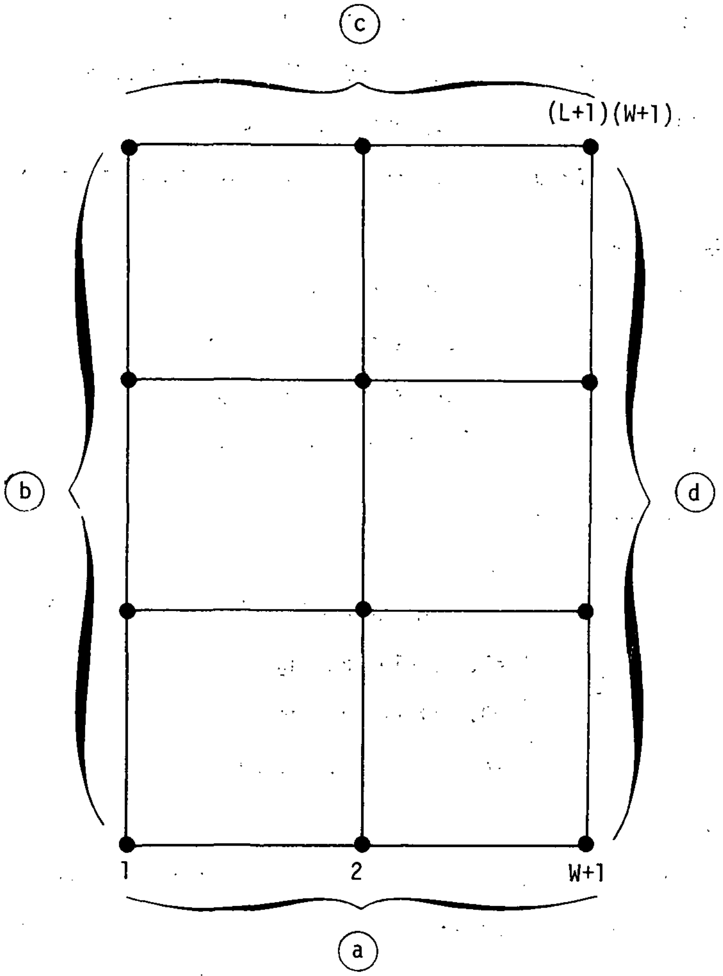
NØ ØMIT'S

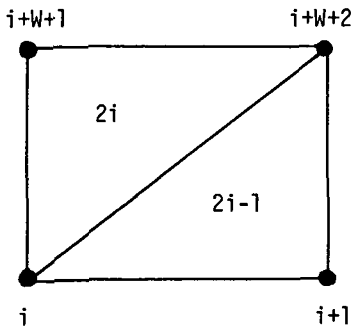


SPC SET ID IS GIVEN BY 1000 · W + L

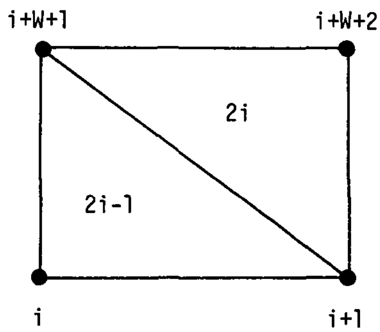
2.6.1.4 Rectangular Plate made from TRIA1's (a=4, b=1,2,3 or 4, c is not used)

INPUT generates GRID, CTRIA1 and SPC (if requested) cards for the rectangular grid work shown.





(c = 1)



(c = 2)

NASTRAN DATA DECK

a. Data Deck (2 cards required)

First Card

1	W	(I8)	No. cells in x-direction
2	L	(I8)	No. cells in y-direction
3	ΔX	(E8.0)	Length of cell in x-direction
4	Δy	(E8.0)	Length of cell in y-direction
5	IP	(I8)	Permanent constraints
6	θ	(E8.0)	Material orientation angle in degress

Second Card

1	IYO	(I8)	SPC's on $y = 0$
2	IXO	(I8)	SPC's on $x = 0$
3	IYL	(I8)	SPC's on $y = L \cdot \Delta y$
4	IXW	(I8)	SPC's on $x = W \cdot \Delta x$

b. Options (SEQGP cards)

b { =1, Regular banding (no SEQGP cards)
=2, Double banding
=3, Active banding
=4, Reverse double banding

c. Notes

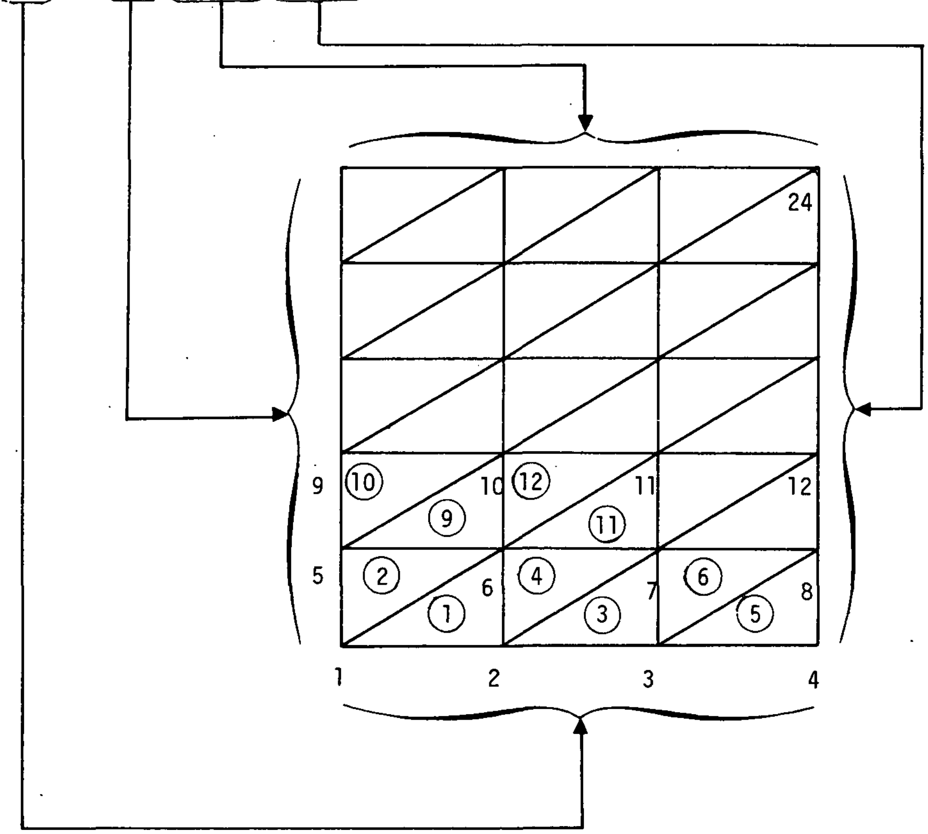
(1) If IP, IYO, IXO, IYL and IXW are all zero, G4 will be purged.

(2) A PTRIA1 card with PID=101 must be included in the Bulk Data.

(3) If SPC's are generated the set ID will be 1000NX + NY.

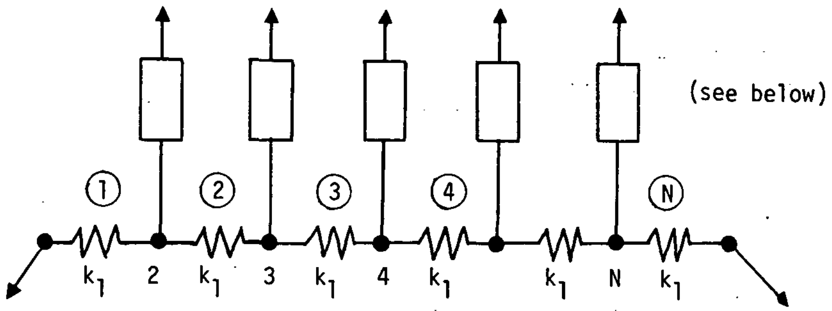
USER GENERATED INPUT

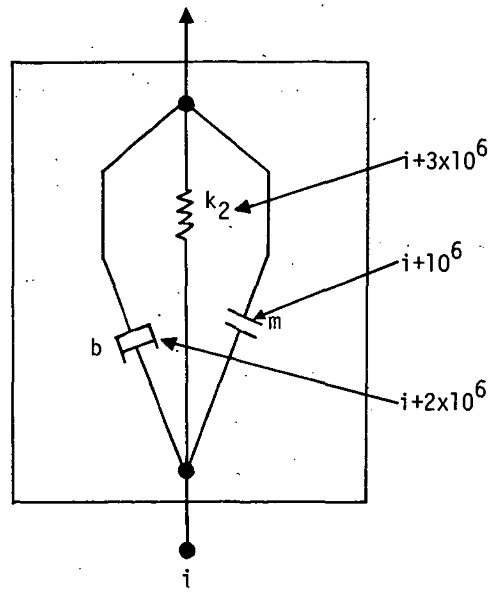
```
ID INPUT, CASE 4
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/G1,G2,,G4,/C,N,4/C,N,1/C,N,1 $
EQUIV G1,GEØM1/TRUE  /  G2,GEØM2/TRUE  /  G4,GEØM4/TRUE  $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=RECTANGULAR PLATE MADE FRØM CTRIA1'S
LABEL=ØPTIØN 1                  WITH CLAMPED SUPPØRTS
SPC=3005
LØAD=1
ØUTPUT
DISP=ALL
BEGIN BULK
FØRCE   1       1       0       1.0     0.0     0.0     1.0
MAT1    7       1.0     1.0
PTRIA1  101     7       1.0     7       2.0     7       4.0
ENDDATA
      3       5     2.0     1.0     126     0.0
    246     156  412356  512346
```



2.6.1.5 N-segment string (a=5, b and c are not used)

INPUT generates CELAS4, CMASS4 and CDAMP4 cards for an N-segment string grounded at both ends.





USER GENERATED INPUT

a. Data Card

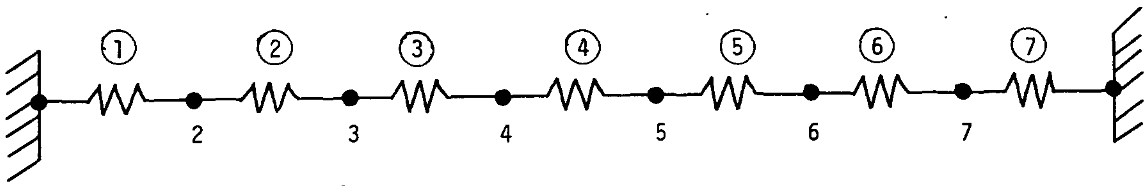
1	N	(I8)	No. of segments
2	k_1	(E8.0)	Spring value
3	k_2	(E8.0)	Spring value (if zero, none of these elements are generated)
4	m	(E8.0)	Mass value (if zero, none of these elements are generated)
5	b	(E8.0)	Damper values (if zero, none of these elements are generated)

b. Notes

(1) If any of k_2, m, or b are zero, those elements will not be generated.

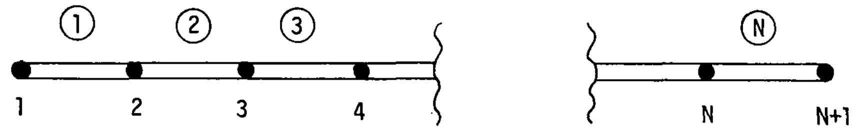
NASTRAN DATA DECK

```
ID INPUT, CASE 5
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/,G2,,,/C,N,5 $
EQUIV G2,GEØM2/TRUE $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=N-SEGMENT STRING
LABEL=STATICS
LØAD=1
ØUTPUT
DISP=ALL
BEGIN BULK
LØAD           1       3      1.0      6      1.0
ENDDATA
       7     1.0     0.0     0.0    0.0
```



2.6.1.6 N-cell Bar (a=6, b and c are not used)

INPUT generates GRID and CBAR cards for an N-cell bar. ØMIT cards will also be created if requested.



a. Data deck

First Card

1	N	(I8)	No. of cells
2	L	(E8.0)	Length of bar
3	IP	(I8)	Permanent constraints
4	IFLG	(I8)	Orientation vector flag
5	IGO	(I8)	GO (used only if IFLG = 2)
6	M	(I8)	No. of right-most grid points to be connected to GP2 via bars with PID = 102
7	IØX	(I8)	ØMIT card count

Second Card (Read only if IFLG = 1)

1	X1	(E8.0)	Orientation vector X1 component
2	X2	(E8.0)	Orientation vector X2 component
3	X3	(E8.0)	Orientation vector X3 component

b. Notes

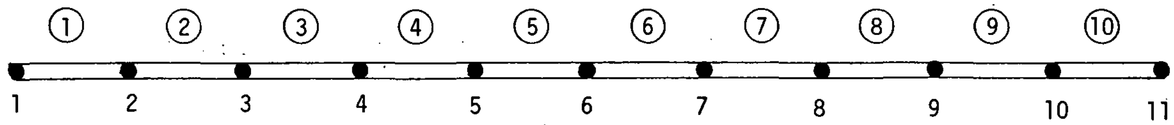
(1) A PBAR card with PID = 101 is required. If M ≠ 0, a PBAR card with PID = 102 is required.

(2) IFLG = 2 option is not allowed for this case.

(3) Do not include G4 in alter packet unless IØX is greater than 0.

NASTRAN DATA DECK

```
ID INPUT, CASE 6
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/G1,G2,,,/C,N,6 $
EQUIV G1,GEØM1/TRUE  /  G2,GEØM2/TRUE  $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=N-CELL BAR
LABEL=STATICS
SPC=1
LØAD=1
ØUTPUT
SET 101=11
DISP=101
BEGIN BULK
FØRCE          1      11       0     1.0     0.0     1.0     1.0
MAT1           7     1.0     1.0
PBAR         101       7     1.0     2.0     4.0     8.0
SPC            1       1  123456     0.0
PARAM  GRDPNT  6
ENDDATA
       10   100.0       0       1       0       0       0
      0.0     0.0     1.0
```



2.6.1.7 Full matrix with optional unit load (a=7, b and c are not used)

INPUT generates N scalar points, all of which are interconnected giving N(N+1)/2 elements. On option, SLØAD cards are generated for each CELAS4 scalar point.

a. Data Card

1	N	(I8)	Order of problem	
2	NSLØAD	(I8)	Uniform load flag	=0, will not generate SLØAD cards ≠0, will generate SLØAD cards

b. Notes

(a) GP1 is altered as shown in the example in order to run efficiently.

(b) If SLØAD cards are generated the load set ID is N.

NASTRAN DATA DECK

```
ID INPUT, CASE 7
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/,G2,G3,,G5/C,N,7 $
EQUIV G2,GEØM2/TRUE  /  G3,GEØM3/TRUE  $
ALTER 4,4
GP1 GEØM1,G5/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/C,N,0/V,N,NØGPDT $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=FULL MATRIX WITH ØPTIØNAL UNIT LØAD
LABEL=ØRDER = 10
LØAD=10
ØUTPUT
DISP=ALL
SPCF=ALL
ØLØAD=ALL
ELFØ=ALL
BEGIN BULK
{blank card}
ENDDATA
     10    1
```

2.7 SUBSTRUCTURE CONTROL DECK

The Substructure Control Deck options provide the user commands needed to control the execution of NASTRAN for automated multi-stage substructure analyses. These commands are input on cards with the same format conventions as are used for the normal NASTRAN Case Control Deck.

Initiation of a substructure analysis is achieved via the Executive Control Deck command (see Section 2.1):

APP DISPLACEMENT,SUBS

This command directs NASTRAN to automatically generate the required DMAP sequence of alters to the specified Rigid Format necessary to perform the operations requested in the Substructure Control Deck. Following the Substructure Control Deck in the NASTRAN input data stream comes the standard Case Control Deck which specifies the loading conditions, omit sets, method of eigenvalue extraction, element sets for plotting, plot control, and output requests, etc.

The Substructure Control Deck commands are summarized in Table 1 where they are listed under one of three categories according to whether they:

1. Specify the phase and mode of execution
2. Specify the substructuring matrix operations
3. Define and control the substructure operating file (SØF)

Several commands have associated with them a set of subcommands used to specify additional control information appropriate to the processing requested by the primary command. These subcommands are defined together with the alphabetically sorted descriptions of their primary commands in Section 2.7.3. Examples utilizing these commands are presented in Section 1.

The sections that follow discuss the interaction between the substructure commands and the standard case control commands, the translation of substructure commands into DMAP ALTER sequences, and the format conventions to be used. The bulk data cards provided for substructure analyses are included with the standard bulk data descriptions in Section 2.3 and they are summarized for convenient reference in Table 2.

Table 1. Summary of substructure commands.

A.	Phase and Mode Control	
	SUBSTRUCTURE #	- Defines execution phase (1, 2, or 3) (Required)
	ØPTIØNS	- Defines matrix options (K, M, P, or PA)
	RUN	- Limits mode of execution (DRY, GØ, DRYGØ, STEP)
	ENDSUBS #	- Terminates Substructure Control Deck (Required)
B.	Substructure Operations	
	CØMBINE	- Combines sets of substructures
	NAME	- Names the resulting substructure
	TØLERANCE*	- Limits distance between automatically connected grids
	CØNNECT	- Defines sets for manually connected grids and releases
	ØUTPUT	- Specifies optional output results
	CØMPØNENT	- Identifies component substructure for special processing
	TRANSFØRM	- Defines transformations for named component substructures
	SYMTRANSFØRM	- Specifies symmetry transformation
	SEARCH	- Limits search for automatic connects
	EQUIV	- Creates a new equivalent substructure
	PREFIX*	- Prefix to rename equivalenced lower level substructures
	REDUCE	- Reduces substructure matrices
	NAME*	- Names the resulting substructure
	BØUNDARY*	- Defines set of retained degrees of freedom
	ØUTPUT*	- Specifies optional output requests
	RSAVE	- Save REDUCE decomposition produce
	SØLVE	- Initiates substructure solution (statics or normal modes)
	RECØVER	- Recovers Phase 2 solution data
	SAVE	- Stores solution data on SØF
	PRINT	- Stores solution and prints data requested
	BRECØVER	- Basic substructure data recovery, Phase 3
	PLØT	- Initiates substructure undeformed plots
C.	SØF Controls	
	SØF #	- Assigns physical files for storage of the SØF (Required)
	PASSWØRD	- Protects and insures access to correct file
	SØFØUT or SØFIN	- Copies SØF data to or from an external file
	PØSITIØN	- Specifies initial position of input file
	NAMES	- Specifies substructure name used for input
	ITEMS	- Specifies data items to be copied in
	SØFPRINT	- Prints selected items from the SØF
	DUMP	- Dumps entire SØF to a backup file
	RESTØRE	- Restores entire SØF from a previous DUMP operation
	CHECK	- Checks contents of external file created by SØFØUT
	DELETE	- Edits out selected groups of items from the SØF
	EDIT	- Edits out selected groups of items from the SØF
	DESTRØY	- Destroys all data for a named substructure and all the substructures of which it is a component

Mandatory Control Cards   * Required Subcommand

Table 2. Substructure Bulk Data Card Summary.

A. Bulk Data Used for Processing Substructure Command REDUCE

BDYC	- Combination of substructure boundary sets of retained degrees of freedom
BDYS	- Boundary set definition
BDYS1	- Alternate boundary set definition

B. Bulk Data Used for Processing Substructure Command CØMBINE

CØNCT	- Specifies grid points and degrees of freedom for manually specified connectivities - will be overridden by RELES data
CØNCT1	- Alternate specification of connectivities
RELES	- Specifies grid point degrees of freedom to be disconnected - overrides CØNCT and automatic connectivities
GTRAN	- Redefines the output coordinate system grid point displacement sets
TRANS	- Specifies coordinate systems for substructure and gird point transformations

C. Bulk Data Used for Processing Substructure Command SØLVE

LØADC	- Defines loading conditions for static analysis
MPCS	- Specifies multipoint constraints
SPCS	- Specifies single point constraints
SPCS1	- Alternate specification of single point constraints
SPCSD	- Specifies enforced displacements for single point constraints

2.7.1 Commands and Their Execution

The sequence of operations is controlled by the order in which NASTRAN encounters the substructure commands. A few special data cards are required in any Substructure Command Deck. These are:

SUBSTRUCTURE $\left\{\begin{array}{l}\text{PHASE1}\\ \text{PHASE2}\\ \text{PHASE3}\end{array}\right\}$ - The first card of the Substructure Command Deck and it follows the CEND card of the Executive Control Deck.

SØF
PASSWØRD } - Required to define the substructure operating file to be used for this execution.

ENDSUBS - Signals the end of the Substructure Command Deck.

The first step of any substructuring analysis is to define the basic substructures to be used. These are prepared by executing one Phase 1 run for each substructure. Checkpoints may be taken for each Phase 1 execution to save the files to be used during the Phase 3 data recovery runs. Alternately, the user may resubmit his entire original data deck for a Phase 3 run, thereby avoiding a proliferation of checkpoint tapes. During a Phase 2 execution, a long list of instructions may be specified. This list may be split up and run in several separate smaller steps. No checkpointing is required during a Phase 2 run in that all pertinent substructure data will be retained on the substructure operating file (SØF).

The Case Control Deck submitted following the ENDSUBS card will be used to direct the processing appropriate to the particular Phase being executed. During a Phase 1 run, the Case Control will be used to define the loading conditions, single and multipoint constraints (only one set may be used per basic substructure), omits, and desired plot sets. During a Phase 2 run, the Case Control will be used to specify the loads and constraint data for the SØLVE operation, outputting of results, or any plot requests. Finally, for a Phase 3 execution, the Case Control Deck is used to define the detail output and plot requests for each basic substructure.

Normal substructuring analyses will require many steps to be executed under Phase 2 processing. They may all be submitted for processing at once, or they may be divided into several shorter sequences and executed separately. In the event of an abnormal termination, several steps may have been successfully executed. To recover requires simply removing those completed steps from the Substructure Control Deck and resubmitting the remaining commands. The SØF will act as the checkpoint/restart file independently of the normal NASTRAN checkpointing procedures.

If the solution structure is large, a NASTRAN checkpoint would be recommended to save intermediate results during the SØLVE operation. If this is done, however, care must be exercised on restart to insure correct re-entry into the DMAP sequence. This may be accomplished by removing all substructure control commands preceding the SØLVE, modifying the Case Control Deck and Bulk Data Deck to change set identifiers only if any new loads or constraint sets are to be specified and resubmitting the job. If no changes are to be made which would affect the SØLVE operations, a regular restart can be executed without changing the original Case Control and Bulk Data Decks.

The user may wish to add to or modify the DMAP sequence generated automatically from the Substructure Control Deck commands. This user interaction with the DMAP operations is explained in the following section.

2.7.2 Interface with NASTRAN DMAP

Each substructure command card produces a set of DMAP ALTER cards which are automatically inserted into the Rigid Format called for execution on the SØL card of the Execution Control Deck (Section 2.1). These automatically generated alters require no user interfacing unless the user wishes to exercise the following options:

1. The user may insert ALTER cards in the Executive Control Deck. However, they may not overlap any DMAP cards affected by the substructure ALTERs. The DMAP card numbers, modified for each Rigid Format, are given in Chapter 3.

2. The user may suppress the DMAP generated by the substructure deck and run with either ALTER cards or with approach DMAP. To suppress the automatic DMAP, the following forms of the executive control card APP are provided

   APP DISP,SUBS,1 (Retains execution of the substructuring preface operations)

   or APP DMAP (Standard NASTRAN is executed)

3. For user information and convenience, the substructure ALTER packages may be printed and/or punched on cards. The executive control card, DIAG 23, will produce the printout. DIAG 24 will produce the punched deck. The punched deck may then be altered by the user and resubmitted as described in (2) above. However, the order of the associated substructure command deck must not be changed to insure proper sequencing of the requested operations.

2.7.3 Substructure Control Card Descriptions

The format of the substructure control cards is free-field. In presenting general formats for each card embodying all options, the following conventions are used:

1. Upper-case letters must be punched as shown.
2. Lower-case letters indicate that a substitution must be made.
3. Braces { } indicate that a choice of contents is mandatory.
4. Brackets [ ] contain an option that may be omitted or included by the user.
5. Underlined options or values are the default values.
6. Physical card consists of information punched in columns 1 thru 72 of a card. All Substructure Control Cards are limited to a single physical card.

The Case Control Deck, which follows the ENDSUBS card of the Substructure Control Deck is described in Section 2.3.

Substructure Command <u>BRECØVER</u> - Basic Substructure Data Recovery

<u>Purpose</u>: This operation is performed in Phase 3 to recover datailed output data for a basic substructure used in Phase 1.

<u>Request Format</u>:

BRECØVER   name

<u>Subcommands</u>: None

<u>Definitions</u>:

name   - Name of structure defined in Phase 1 or structure equivalenced to the Phase 1 structure.

<u>Notes</u>:
1. Use of the RECØVER command in Phase 3 has the same effect as BRECØVER. That is, RECØVER is an alias for BRECØVER in Phase 3.
2. Phase 3 may be a RESTART of the original Phase 1 run or it may be executed from the original input data.

Substructure Command <u>CHECK</u> - Check Contents of External File

<u>Purpose</u>: To list all substructure items on an external file which was generated with SØFØUT.

<u>Request Format</u>:

CHECK   filename $\left\{ \begin{array}{l} \text{DISK} \\ ,\underline{\text{TAPE}} \end{array} \right\}$

<u>Subcommands</u>: None

<u>Definitions</u>:

filename - Name of the external file. One of the following: INPT, INP1,..., INP9.

DISK - File resides on a direct access device.

TAPE - File resides on tape.

<u>Notes</u>: 1. The substructure name, item name, and the date and time the item was written are listed for each item on the file.

Substructure Command <u>CØMBINE</u> - Combine Sets of Substructures

<u>Purpose</u>: This operation will perform the operations to combine the matrices and loads up to seven substructures into matrices and loads representing a new pseudostructure. Each component structure may be translated, rotated, and reflected before it is connected. The user may manually select the points to be connected or direct the program to connect them automatically.

<u>Request Format</u>:

$$\text{CØMBINE} \left(\left\{ \frac{\text{AUTØ}}{\text{MAN}} \right\}, \left\{ \begin{matrix} X \\ Y \\ Z \end{matrix} \right\} \right) \quad \text{name1, name2, etc.}$$

<u>Subcommands</u>:

NAME	= new name (required)
TØLERANCE	= ε (required)
CØNNECT	= n
ØUTPUT	= m_1, m_2,...

Each individual component substructure may have the following added commands:

CØMPØNENT	= name	repeat for each component
TRANSFØRM	= m	
SYMTRANSFØRM	= $\left\{ \begin{matrix} X \\ Y \\ Z \\ XY \\ XZ \\ YZ \\ XYZ \end{matrix} \right\}$	
SEARCH	= namej, namek, etc.	

<u>Definitions</u>:

AUTØ/MAN - Defines method of connecting points. If AUTØ is chosen, the physical location of grid points is used to determine connections. If MAN, all connections are defined on CØNCT or CØNCT1 bulk data.

X, Y, Z - Are used on CØMBINE card for searching geometry data for AUTØ connections. Denotes preferred search direction for processing efficiency.

name1, name2, etc. - Unique names of substructures to be combined. Limits are from one to seven component structures.

new name - Defines name of combination structure (required).

ε - Defines limit of distance between points which will be automatically connected (real > 0).

n - Defines set number of manual connections and releases specified on bulk data cards, CØNCT, CØNCT1, and RELES.

name - On CØMPØNENT card defines which substructure (name1, etc.) to which the following data is applied.

m - Set identification number of TRANS and GTRAN bulk data cards which define the orientation of the substructure and/or selected grid points relative to new basic coordinates.

X, Y,...XY,...XYZ - Defines axis (or set of axes) normal to the plane(s) of symmetry in the new basic coordinate system. The displacement and location coordinates in these directions will be reversed in sign.

namej, namek, etc. - Limits the automatic connection process such that only connections between component "name" and these structures are produced.

m_1, m_2, etc. - Optional output requests (see Note 4).

Notes: 1. The automatic connections are produced by first sorting the grid point coordinates in the specified coordinate direction and then searching within limited groups of coordinates. If the boundary of a substructure to be connected is aligned primarily along one of the coordinate axes, this axis should be used as the preferred search direction. If the boundary is parallel with, say, the yz plane and all boundary coordinates have a constant x value, then the search should be specified along either the y or the z axis.

2. The transformation (TRANS) data defines the orientation of the component substructure (old basic) in terms of the new basic coordinate system. All grid points originally defined in the old basic system will be transformed to the new basic system. Points defined in local coordinate systems will not be transformed unless otherwise specified on a GTRAN card, and their directions will rotate with the substructure.

3. The SYMTRANFØRM (or SYMT) request is primarily used to produce symmetric reflections of a structure. This is usually preceded by an EQUIV command to produce a new, unique substructure name. Note that the results for the new reflected substructure may reference a left-handed coordinate system wherever local coordinate systems are retained during the transformation. However, those coordinates which are originally in the old basic or are newly specified via a GTRAN card are automatically transformed to a right-handed coordinate system of the combined structure during the combination process.

4. The following output requests are available for the CØMBINE operation:

CODE	OUTPUT	
2*	SØF table of contents	
3	CØNCT1 bulk data summary	
4	CØNCT bulk data summary	
6	GTRAN bulk data summary	
7*	TRANS bulk data summary	
9	RELES bulk data summary	
11	Summary of automatically generated connections (in terms of internal point numbers)	
12	Complete connectivity map of final combined pseudostructure defining each internal point in terms of the gird point ID and component substructure it represents	
13	The EQSS item	Output printed is formatted SØF data for the newly created pseudostructure (See Section 1.14 for definitions)
14	The BGSS item	
15	The CSTM item	
16	The PLTS item	
17	The LØDS item	

*recommended output items

Examples:

1. CØMBINE PANEL SPAR

```
TØLE = .0001
NAME = SECTA
```

2. CØMBINE (AUTØ,Z) TANK1, TANK2, BULKHD

```
NAME = TANKS
TØLE = .01
CØMPØNENT TANK1
TRAN = 4
SEARCH = BULKHD
CØMPØNENT TANK2
SEARCH = BULKHD
```

3. CØMBINE (MAN) LWING, RWING

```
TØLE = 1.0
NAME = WING
CØMPØNENT LWING
SYMT = Y
```

Substructure Command DELETE

Purpose: To delete individual substructure items from the SØF.

Request Format:

DELETE   name, item1, item2, item3, item4, item5

Subcommands: None

Definitions:

name - Substructure name

item1, item2,... - Item names (HØRG, KMTR, LØDS, SØLN, etc.)

Notes:

1. DELETE may be used to remove from one to five items of any single substructure.

2. For primary substructures, items of related secondary substructures are removed only if the later point to the same data (KMTX, MMTX, etc.).

3. For secondary and image substructures, no action is taken on items of related substructures, i.e., items of equivalenced substructures or higher or lower level substructures.

4. See the EDIT and DESTRØY commands for other means of removing substructure data.

Substructure Command DESTRØY - Removes All Data Referencing a Component Substructure

Purpose: To remove data for a substructure and all substructures of which it is a component from the SØF. In addition to the substructure being DESTRØY'ed ("name"), data for substructures which satisfy one or more of the following conditions are also removed from the SØF:

1. All substructures of which "name" is a component

2. All secondary (or equivalenced) substructures for which "name" is the primary substructure

3. All image substructures which are components of a substructure that is destroyed

Request Format:

DESTRØY name

Subcommands: None

Definition:

name - Name of substructure

Notes: 1. No action is taken if "name" is an image substructure.

2. See related commands EDIT and DELETE for additional means of removing substructure data.

Substructure Command DUMP

Purpose: To copy the entire SØF to an external file.

Request Format:

DUMP filename $\left\{\begin{array}{l} \text{DISK} \\ \text{,}\underline{\text{TAPE}} \end{array}\right\}$

Subcommands: None

Definitions:

Filename - Name of the external file. Any one of the following: INPT, INP1,..., INP9.

DISK - File resides on a direct access device.

TAPE - File resides on tape.

Notes:
1. DUMP may be used to create a backup copy of the SØF.
2. All system information on the SØF is saved.
3. The RESTØRE command will reload a DUMPed SØF.

Substructure Command EDIT - Selectively Removes Data from SØF File

Purpose: To permanently remove selected substructure data from the SØF.

Request Format:

EDIT (opt) name

Subcommands: None

Definitions:

name - Name of substructure.

opt - Integer value reflecting combinations of requests. The sum of the following integers defines the combination of data items to be removed from the SØF.

ØPT	Items Removed
1	Stiffness Matrix (KMTX)
2	Mass Matrix
4	Load Data
8	Solution Data
16	Transformation Matrices defining next level (HØRG)
32	All items for the substructure

Notes:
1. The user is cautioned on the removal of the HØRG matrix data. These matrices are required for the recovery of the solution results.
2. If the EDIT feature is to be employed, the user should consider also using SØFØUT to insure the existence of backup data in the event of an error.

Substructure Command EQUIV - Create a New Equivalent Substructure

Purpose: To assign an alias to an existing substructure and thereby create a new equivalent substructure. The new secondary substructure may be referenced independently of the original primary substructure in subsequent substructure commands. However, the data actually used in substructuring operations is that of the primary substructure.

Request Format:

EQUIV *name1, name2*

Subcommands:

PREFIX = p

Definitions:

p - Single BCD character.

name1 - Existing primary substructure name.

name2 - New equivalent substructure name.

Notes:
1. A substructure created by this command is referred to as a secondary substructure.
2. All substructures which were used to produce the primary substructure will produce equivalent image substructures. The new image substructure names will have the prefix p.
3. A DESTRØY operation on the primary substructure data will also destroy the secondary substructure data and all image substructures.
4. An EDIT or DELETE opeartion on the primary substructure will not remove data of the secondary substructure and vice versa.

Substructure Mode Control ØPTIØNS - Defines Matrix Types

Purpose: This allows the user to selectively control the type of matrices being processed.

Request Format:

ØPTIØNS m1,m2,m3

Subcommands: None

Definition:

m1,m2,m3 - Any combination of the characters K, M, and either P or PA, where:

K = Stiffness Matrices
M = Mass Matrices
P = Load Matrices
PA = Appended Load Vectors

Notes: 1. The default depends on the NASTRAN rigid format:

Rigid Format	Default
1 - Statics	K,P
2 - Inertia Relief	K,M,P
3 - Normal Modes	K,M

2. In a Phase 1 execution, Rigid Formats 1 and 3 will provide only two of the matrices, as shown above. In Rigid Format 1, the mass matrix is not generated. In Rigid Format 3, the loads matrix is not generated. An error condition will result unless the user adds the required DMAP alters to provide the requested data.

3. Stiffness, mass, or load matrices must exist if the corresponding K, M, P, or PA option is requested in the subsequent Phase 2 run.

4. Matrices or loads may be modified by rerunning the substructure sequence for only the desired type. However, the old data must be deleted first with the EDIT or DELETE command. See Section 1.11 for the actual item names.

5. The append load option, PA, is used when additional load sets are required for solution, and it is not desired to regenerate existing loads. To generate these new load vectors, re-execute all required Phase 1 runs with the new load sets and ØPTIØN = PA. Then, repeat the Phase 2 operations with ØPTIØN = PA. At each step, the new vectors are appended to the existing loads so that all load vectors will be available in the SØLVE stage.

6. Each ØPTIØN command overrides the preceding command to control subsequent steps of the substructure process.

Substructure Operating File Declaration PASSWØRD

Purpose: This declaration is required in the substructure command deck. The password is written on the SØF file and is used to protect the file and insure that the correct file is assigned for the current run.

Request Format:

PASSWØRD   password

Subcommands: None

Definition:

password - BCD password for the SØF (8 characters maximum). See the SØF file declaration card description.

Substructure Command PLØT - Substructure Plot Command

Purpose: This operation is used to plot the undeformed shape of a substructure which may be composed of several component substructures. This command initiates the execution of a plot at any stage of the substructure process. The actual plot commands; origin data, etc., must be included in the normal case control data.

Request Format:

PLØT   name

Subcommands: None

Definitions:

name   - Name of component substructure to be plotted.

Notes: 1. The set of elements to be plotted will consist of all the elements and grid points saved in Phase 1 for each basic substructure comprising the substructures named in the PLØT command. (Only one plot set from each basic substructure is saved in Phase 1.)

2. The structure plotter output request packet, while part of the standard Case Control Deck, are treated separately in Sections 4.2 and 4.3, respectively.

Substructure Command RECØVER - Phase 2 Solution Data Recovery

Purpose: This operation recovers displacements and boundary forces on specified substructures in the Phase 2 execution. The results are saved on the SØF file and they may be printed upon user request. This command should be input after the SØLVE command to store the solution results on the SØF file.

Request Format:

RECØVER   s-name

Subcommands:

SAVE = name

PRINT = name

Definitions:

s-name - Name of the substructure named in a prior SØLVE command from which the solution results are to be recovered.

name   - Name of the component structure for which results are to be recovered. May be the same as "s-name".

Notes:

1. SAVE will save the solution for substructure "name" on the SØF. PRINT will save and print the solution.

2. The actual printout is controlled by the output requests specified in the Case Control Deck (DISP, SPCF, and ØLØAD). If there are no output requests in Case Control, PRINT is equivalent to SAVE and nothing will be printed.

3. For efficiency, the user should order multiple SAVE and/or PRINT commands so as to trace one branch at a time starting from his solution structure.

4. Reaction forces are computed for a substructure only if (1) the substructure is named on a PRINT subcommand and, (2) an output request for SPCFØRCE exists in the Case Control.

Substructure Command REDUCE - Phase 2 Reduction to Retained Degrees of Freedom

Purpose: This operation performs a Guyan matrix reduction process for a specified component substructure, otherwise known as matrix condensation. It produces the same result as obtained by the specification of NASTRAN ØMIT or ASET data. The purpose is to reduce the size of the matrices. In static analysis only points on the boundary need be retained. In dynamics, the boundary points and selected interior points are retained.

Request Format:

REDUCE name

Subcommands:

NAME - new name

BØUNDARY - n

ØUTPUT - m_1, m_2,...

RSAVE

Definitions:

name - Name of substructure to be reduced.

new name - Name of resulting substructure.

n - Set identification number of BDYC bulk data cards which define sets of retained degrees of freedom for the resulting reduced substructure matrices.

m_1, m_2, etc. - Optional output requests (see Note 3).

Notes:

1. All references to the grid points and components not defined in the "boundary set" will be reduced out of the new substructure. Any subsequent reference to these omitted degrees of freedom in CØMBINE, REDUCE, or SØLVE operations generated an error condition.

2. The same transformations will be applied to the reduced mass matrix for the new substructure. See the NASTRAN Theoretical Manual for a discussion of this effect.

3. The following output requests are available for the REDUCE operation (* marks recommended output options):

CODE	OUTPUT	
1*	Current problem summary	
2	Boundary set summary	
3	Summary of grid point ID numbers in each boundary set	
4	The EQSS item for the structure being reduced	
5*	The EQSS item	These requests write formatted SØF items for the new reduced pseudostructure
6*	The BGSS item	
7	The CSTM item	
8	The PLTS item	
9*	The LØDS item	

4. If the RSAVE card is included, the decomposition product of the interior point stiffness matrix (LMTX item) is saved on the SØF file. This matrix will be used in the data recovery for the omitted points. If it is not saved it will be regenerated when needed.

Substructure Command RESTØRE

Purpose: To reload the SØF from an external file created with the DUMP command.

Request Format:

RESTØRE filename $\left\{ \begin{matrix} \text{DISK} \\ \underline{\text{TAPE}} \end{matrix} \right\}$

Subcommands: None

Definitions:

Filename - Name of the external file. Any one of the following: INPT, INP1,..., INP9.

DISK - File resides on a direct access device.

TAPE - File resides on tape.

Notes:

1. The external file must have been created with the DUMP command.
2. The SØF must be declared as 'NEW' on the SØF command.
3. RESTØRE must be the very first substructure command following the SØF and PASSWØRD declarations.

Substructure Mode Control RUN - Specifies Run Options

Purpose: This command is used to limit the substructure execution for the purpose of checking the validity of the input data. It allows for the processing of input data separately from the actual execution of the matrix operations.

Request Format:

$$\text{RUN} \quad \left\{ \begin{matrix} \text{DRY} \\ \text{GØ} \\ \text{DRYGØ} \\ \underline{\text{STEP}} \end{matrix} \right\}$$

Subcommands: None

Definitions:

DRY - Limits the execution to table and transformation matrix generation. Matrix operations are skipped.

GØ - Limits the execution to matrix generation only. This mode must have been preceded by a successful RUN=DRY execution.

DRYGØ - Will cause execution of a complete dry run for the entire job, followed by a RUN=GØ execution if no fatal errors were detected.

STEP - Will cause the execution of both DRY and GØ operations one step at a time.

Notes:

1. The DRY, GØ and STEP options may be changed at any step in the input substructure command sequence. If the DRYGØ option is used, the RUN card must appear only once at the beginning.

2. If a fatal error occurs during the first pass of the DRYGØ option, the program exits at the completion of all DRY operations.

Substructure Operation File Declaration SØF - Assigns Physical Files for Storage of the SØF

Purpose: This declaration defines the names and sizes of the physical NASTRAN files the user assigns for storage of the SØF file. At least one of these declarations must be present in each substructure command deck. As many SØF declarations are required in the substructure command deck on each run as there are physical files assigned for ths storage of the SØF file.

Request Format:

SØF(no.) = filename, filesize, $\left\{\begin{matrix}\underline{\text{OLD}}\\ \text{NEW}\end{matrix}\right\}$

Subcommands:

PASSWØRD = password

Definitions:

no. - Integer index of SØF file (1, 2, etc.) in ascending order of files required for storage of the SØF. The maximum index is 10.

filename - User name for an SØF physical file.

filesize - Size of allocated file space in kilowords, default = 100.

ØLD - SØF data is assumed to already exist on the file.

NEW - The SØF is new. In this case, the SØF will be initialized.

password - BCD password for the SØF (8 characters maximum) used to protect the file and insure that the correct file is assigned for the current run (see the PASSWØRD card description).

Notes:

1. If more space is required for storage of the SØF file, additional physical files may be declared. Alternately, the file size parameter on a previously declared file may be increased, but only on the last physical file if more than one is used (on IBM the size of an existing file may not be increased.

2. Once an SØF declaration is made, the index of the SØF file must always be associated with the same file name. File names may not be changed from run to run.

3. The file names of each physical SØF file must be unique.

4. The declared size of the SØF may be reduced by the amount of contiguous free-space at the end of the logical SØF file. This may be accomplished by removing the physical file declaration for those unused files which have the highest sequence numbers. And, the size of the physical file with the highest sequence number of those remaining may be reduced. An attempt to eliminate a portion of the SØF which contains valid data will result in a fatal error.

5. If the NEW parameter is present on any one of the SØF declarations, the entire logical SØF is considered new. Therefore, if an additional physical file is added to an existing SØF, the NEW parameter should not be included on any declarations.

6. The following conventions should be used for the file name declarations on each of the three NASTRAN computers:

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   Any 4-character alphanumeric name is acceptable. No special characters or blanks may be used. The file name used on the SØF declaration must correspond to ones used on the system REQUEST or ATTACH card. Note that after a NASTRAN execution, the SØF files should be catalogued or extended.

Examples:

1. Create a new SØF file with a filename of SØF1 and catalogue it.

```
REQUEST(SØF1,*PF)
NASTRAN.
CATALØG(SØF1,username)
789
 .
 .
 .
  NASTRAN data cards including the SØF declaration --
  SØF(1)=SØF1,1000,NEW
 .
 .
 .
6789
```

2. Use of an existing SØF file with a filename of ABCD.

```
ATTACH(ABCD,username)
NASTRAN.
EXTEND(ABCD)
789
 .
 .
 .
  NASTRAN data cards including the SØF declaration --
  SØF(1)=ABCD,1000
 .
 .
 .
6789
```

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The filename used on the SØF declaration must specify one of the NASTRAN user files INPT, INP1,..., INP9.

Examples:

1. Create a new SØF file named INPT.

```
@ASG,U INPT.F///1000
@HDG,N
@XQT *NASTRAN.LINK1
 .
 .
  NASTRAN data cards including the SØF declaration --
  SØF(1)=INPT,400,NEW
 .
 .
 .
@ADD,P *NASTRAN.CØNTRL
@FIN
```

2. Use of an existing SØF file with a filename of INP7.

```
@ASG,AX INP7.
@HDG,N
@XQT, *NASTRAN.LINK1
 .
 .
  NASTRAN data cards including the SØF declaration --
  SØF(1)=INP7,250
 .
 .
 .
@ADD,P *NASTRAN.CØNTRL
@FIN
```

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The file name used on the SØF declaration must specify one of the following ten file names: SØFØ, SØF1, SØF2, ... , SØF9.

The JCL (Job Control Language) DD (data definition) card, not the NASTRAN SØF declaration, is used by the IBM operating system to allocate units to NASTRAN for use as SØF datasets. There must be one DD card corresponding to each NASTRAN SØF declaration; the DD card DDNAME parameter must exactly correspond to the four-character file name of the SØF declaration of the Substructure Control Deck. The physical unit specified on the DD card must be a direct access device. On IBM, the SØF declaration file size parameter is ignored and the actual size of the SØF file is obtained from the SPACE parameter of the DD card.

Examples:

1. Create a new SØF dataset with a filename SØF1 and 1000 blocks.

```
//NSGØ EXEC NASTRAN
//NS.SØF1, DD DSN=username,UNIT=2314,VØL=SER=userno,DISP=(NEW,KEEP)
// SPACE=(7200,(1000)),DCB=BLKSIZE=7200
//NS.SYSIN DD *
   .
   .
   .
NASTRAN data cards including the SØF declaration --
SØF(1)=SOF1,,NEW
   .
   .
   .
/*
```

Note: The dataset disposition must be DISP=(NEW,KEEP) when the SØF dataset is created. However, an existing SØF dataset may be re-initialized by coding NEW on the SØF declaration in the NASTRAN data deck. In this case, the disposition on the DD card should be coded DISP=ØLD.

2. Use of an existing SØF dataset with a filename of SØF7.

```
//NSGØ EXEC NASTRAN
//NS.SØF7 DD DSN=username,UNIT=3330,VØL=SER=userno,DISP=ØLD,
//NS.SYSIN DD *
   .
   .
   .
NASTRAN data cards including the SØF declaration --
SØF(1)=SØF7
   .
   .
   .
/*
```

Substructure Command <u>SØFIN</u>

<u>Purpose</u>: To copy substructure items from an external file to the SØF.

<u>Request Format</u>:

$$\text{SØFIN} \quad \left\{\begin{pmatrix}\text{EXTERNAL}\\ \underline{\text{INTERNAL}}\end{pmatrix}\right\} \quad \text{filename} \quad \left\{\begin{matrix},\text{DISK}\\ ,\underline{\text{TAPE}}\end{matrix}\right\}$$

<u>Subcommands</u>:

$$\text{POSITION} = \left\{\begin{matrix}\text{REWIND}\\ \underline{\text{NØREWIND}}\end{matrix}\right\}$$

$$\text{NAMES} = \left\{\begin{matrix}\text{substructure name}\\ \underline{\text{WHØLESØF}}\end{matrix}\right\}$$

$$\text{ITEMS} = \left\{\begin{matrix}\underline{\text{ALL}}\\ \text{MATRICES}\\ \text{PHASE3}\\ \text{TABLES}\\ \text{item name}\end{matrix}\right\}$$

<u>Definitions</u>:

EXTERNAL - File was written on a different computer type.

INTERNAL - File was written with GINØ on the same computer type.

Filename - Name of the external file. If the file is in INTERNAL format, filename must specify INPT, INP1,...,INP9. If the file is in EXTERNAL format, filename must specify a FØRTRAN unit by using the form FØRT1, FØRT2,...,FØRT32.

DISK - File is located on a direct access device.

TAPE - File is located on a tape.

PØSITION - Specifies initial file position.

REWIND: file is rewound
NØREWIND: input begins at the current position

NAMES - Identifies a substructure for which data will be read. If NAMES=WHØLESØF is coded, and no other NAMES subcommands appear for the current SØFIN command, all substructure items found on the external file from the point specified by the PØSITIØN subcommand to the end-of-file are copied to the SØF.

ITEMS - Identifies the data items which are to be copied to the SØF for each substructure specified by the NAMES subcommands.

ALL: all items
MATRICES: all matrix items
PHASE3: the UVEC, QVEC, and SØLN items
TABLES: all table items
item name: name of an individual item

<u>Notes</u>: 1. Filename is required. The other SØFIN operands are optional.

2. All subcommands are optional.

3. The NAMES subcommand may appear up to five times for each SØFIN command.

4. If a substructure name of an item which is to be copied to the SØF does not exist on the SØF, it is added to the SØF. MDI(Master Data Index) pointers for higher level, combined structures and lower level are restored.

5. The PØSITIØN subcommand must be specified as REWIND for the EXTERNAL form of this command. All items on the external file are then read in. (User specifications for other subcommands are ignored.)

6. SØFØUT is the companion substructure command.

7. On IBM computers and for the EXTERNAL form of this command, the following DD card should be used:

```
//NS.FTxxF001 DD DSN=username,UNIT=2400-1,DISP=(,KEEP),
//     LABEL=(,NL),DCB=(RECFM=FB,LRECL=132,BLKSIZE=3960,
//     TRTCH=T,DEN=2)
```

Substructure Command SØFØUT

Purpose: To copy substructure items from the SØF to an external file.

Request Format:

$$\text{SØFØUT} \quad \left\{ \begin{pmatrix} \text{EXTERNAL} \\ \underline{\text{INTERNAL}} \end{pmatrix} \right\} \quad \text{filename} \quad \left\{ \begin{matrix} \text{,DISK} \\ \underline{\text{TAPE}} \end{matrix} \right\}$$

Subcommands:

$$\text{PØSITIØN} = \left\{ \begin{matrix} \text{REWIND} \\ \underline{\text{NØREWIND}} \\ \text{EØF} \end{matrix} \right\}$$

$$\text{NAMES} = \left\{ \begin{matrix} \text{substructure name} \\ \underline{\text{WHØLESØF}} \end{matrix} \right\}$$

$$\text{ITEMS} = \left\{ \begin{matrix} \underline{\text{ALL}} \\ \text{MATRICES} \\ \text{PHASE3} \\ \text{TABLES} \\ \text{item name} \end{matrix} \right\}$$

Definitions:

EXTERNAL - File will be written so that it may be read on a different computer type.

INTERNAL - File will be written with GINØ.

Filename - Name of the external file. If the file is in INTERNAL format, filename must specify INPT, INP1,...,INP9. If the file is in EXTERNAL format, filename must specify a FØRTRAN unit by using the form FØRT1, FØRT2,...,FØRT32.

DISK - File is located on a direct access device.

TAPE - File is located on a tape.

PØSITIØN - Specifies initial file position.

REWIND: file is rewound
NØREWIND: output begins at the current position
EØF: file is positioned to the point immediately preceding the end-of-file mark.

NAMES - Identifies a substructure for which data will be written. If NAMES=WHØLESØF is coded and no other NAMES subcommands appear for the current SØFØUT command, all substructure items found on the SØF are copied to the external file.

ITEMS - Identifies the data items which are to be copied to the external file for each substructure specified by the NAMES subcommands.

ALL: all items
MATRICES: all matrix items
PHASE3: the UVEC, QVEC, and SØLN items
TABLES: all table items
item names: name of an individual item

Notes: 1. Filename is required. The other SØFØUT operands are optional.

2. All subcommands are optional.

3. The NAMES subcommand may appear up to five times for each SØFØUT command.

4. PLTS items of pseudostructures reference the PLTS items of the component basic substructures. Therefore, in order to save all data necessary to plot a pseudostructure, the PLTS items of its component basic substructures must be saved as well as the PLTS item of the pseudostructure.

5. For the external form of this command, PØSITIØN=NØREWIND has the effect of positioning the file to the end-of-file.

6. PØSITIØN=REWIND should be coded for the first write to a new file.

7. SØFIN is the companion substructure command.

8. On IBM computers and for the EXTERNAL form of this command, the following DD card should be used:

```
//NS.FTxxF001 DD DSN=username,UNIT=2400-1,DISP=(,KEEP),
//     LABEL=(,NL),DCB=(RECFM=FB,LRECL=132,BLKSIZE=3960,
//     TRTCH=T,DEN=2)
```

Substructure Command SØFPRINT

Purpose: To print selected contents of the SØF file for data checking purposes.

Request Format:

SØFPRINT(opt)   name, item1, item2, etc.

Subcommands: None

Definitions:

opt - integer, control option, default = 0.

opt = 1: prints data items only
opt = 0: prints table of contents
opt = -1: prints both

name - Name of substructure for which data is to be printed.

item1, item2 - SØF item name, used only when opt ≠ 0, limit = 5 (See Table 2.7-1).

Notes: 1. If only the table of contents is desired (opt = 0), this command may be coded:

SØFPRINT TØC

On the page heading for the table of contents, the labels are defined as follows:

IS - Image substructure flag. 0 - not an image substructure
1 - image substructure

SS - Secondary substructure number (successor)

PS - Primary substructure number (predecessor)

LL - Lower level substructure number

CS - Combined substructure number

HL - Higher level substructure number

Substructure Command SØLVE - Substructure Solution

Purpose: This command initiates the substructure solution phase. The tables and matrices for the pseudostructure are converted to their equivalent NASTRAN data blocks. The substructure grid points referenced on bulk data cards SPCS, MPC, etc., are converted to pseudostructure scalar point identification numbers. The NASTRAN execution then proceeds as though a normal structure were being processed.

Request Format:

SØLVE   name

Subcommands: None (Case Control and Bulk Data decks control the operations.)

Definition:

name - Name of pseudostructure to be analyzed with NASTRAN.

Notes: 1. Before requesting a SØLVE, the user should check to be sure that all necessary matrices are available on the SØF file. For instance, loads and stiffness matrices are necessary in statics analysis. Mass and stiffness matrices are necessary in eigenvalue analysis, etc.

Substructure Command SUBSTRUCTURE - Initiates the Substructure Control Data Deck

Purpose: This command initiates the processing for automated substructuring and defines the phase of the analysis. It must be the first card in the Substructure Control Deck.

Request Format:

$$\text{SUBSTRUCTURE} \quad \left\{ \begin{array}{l} \text{PHASE1} \\ \text{PHASE2} \\ \text{PHASE3} \end{array} \right\}$$

Subcommands:

NAME = name (required for PHASE1 only)

SAVEPLØT = n (used only in PHASE1)

RECØVER = name (used only in PHASE3)

BRECØVER = name (used only in PHASE3)

Definitions:

name - The name assigned to the basic substructure which is being created in PHASE1 or for which results are to be computed in PHASE3.

n - The plot set identification used to define the one set of elements and grid points to be saved in PHASE1 for subsequent plotting in PHASE2.

Notes:

1. The mode command RUN=STEP is assumed initially if the explicit command is not given immediately following the SUBSTRUCTURE command.
2. No further substructure commands are required for PHASE1 and PHASE3.
3. Additional substructure commands are required for PHASE2.
4. For PHASE3 operations, RECØVER and BRECØVER are equivalent and one of them must be present.

3.1 GENERAL DESCRIPTION OF RIGID FORMATS

The most general way of using NASTRAN is with a user written Direct Matrix Abstraction Program (DMAP). This procedure permits the user to execute a series of matrix operations of his choice along with any utility modules or executive operations that he may need. The user may even choose to write a module of his own. The rules governing all of these operations are described in Section 5.

In order to relieve the user from the necessity of constructing a DMAP sequence for each of his problems, a number of such sequences have been included in NASTRAN as rigid formats. A rigid format consists of two parts. The first part is a DMAP sequence that is stored in NASTRAN and available to the user by specifying the number of the rigid format on the SØL card in the Executive Control Deck. The second part of a rigid format is a set of restart tables that automatically modify the series of DMAP operations to account for any changes that are made in any part of the Data Deck when making a restart, after having previously run all, or a part of the problem. Without such tables, the user would have to carefully modify his DMAP sequence to account for the conditions surrounding each restart. The chances for error in making these modifications for restart are very great. The restart tables not only relieve the user of the burden of modifying his DMAP sequence, but also assures him of a correct and efficient program execution.

In addition to the DMAP sequence provided with each rigid format, a number of options are available, which are subsets of each complete DMAP sequence. Subsets are selected by specifying the subset numbers (zero for the complete DMAP sequence) along with the rigid format number on the SØL card in the Executive Control Deck. See Section 2.2.1 for list of available subsets.

If the user wishes to modify the DMAP sequence of a rigid format in some manner not provided for in the available subsets, he can use the ALTER feature described in Section 2. Typical uses are to schedule an EXIT prior to completion, in order to check intermediate output, schedule the printing of a table or matrix for diagnostic purposes, and to delete, or add a functional module to the DMAP sequence. Any DMAP instructions that are added to a rigid format are automatically executed when a restart is performed. The user should be familiar with the rules for DMAP programming, as described in Section 5, prior to making alterations to a rigid format.

The following rigid formats for structural analysis are currently included in NASTRAN:

1. Static Analysis
2. Static Analysis with Inertia Relief
3. Normal Mode Analysis
4. Static Analysis with Differential Stiffness
5. Buckling Analysis
6. Piecewise Linear Analysis
7. Direct Complex Eigenvalue Analysis
8. Direct Frequency and Random Reponse
9. Direct Transient Response
10. Modal Complex Eigenvalue Analysis
11. Modal Frequency and Random Response
12. Modal Transient Response
13. Normal Modes Analysis with Differential Stiffness
14. Static Analysis with Cyclic Symmetry
15. Normal Modes Analysis with Cyclic Symmetry

The following rigid formats for heat transfer analysis are included in NASTRAN:

1. Linear Static Heat Transfer Analysis
3. Nonlinear Static Heat Transfer Analysis
9. Transient Heat Transfer Analysis

The following rigid format for subsonic aeroelastic analysis is included in NASTRAN:

10. Modal Flutter Analysis

3.1.1 Input File Processor

The Input File Processor operates in the Preface prior to the execution of the DMAP operations in the rigid format. A complete description of the operations in the Preface is given in the Programmer's Manual. The main interest here is to indicate the source of data blocks that are created in the Preface and hence appear only as inputs in the DMAP sequences of the rigid formats. None of the data blocks created by the Input File Processor are checkpointed, as they are always regenerated on restart. The Input File Processor is divided into five parts. The first part (IFP1) processes the Case Control Deck, the second part (IFP) processes the Bulk Data

Deck, the third part (IFP3) performs additional processing of the bulk data cards associated with the conical shell element, and the fourth part (IFP4) performs additional processing of the bulk data cards associated with the fluid element. The fifth section (IFP5) processes data related to acoustic cavity analysis.

IFP1 processes the Case Control Deck and creates the Case Control Data Block (CASECC), the Plot Control Data Block (PCDB), and the XY-Plot Control Data Block (XYCDB). IFP1 also examines all of the cards, except those associated with plotting, for errors in format or use. If errors are detected, they are classed as either fatal or warning, and suitable error messages are provided. Reference to Section 2.3 will assist the user in correcting errors in the Case Control Deck. If the error is fatal, the Executive System will not allow the execution to continue beyond the completion of the Preface.

The Bulk Data Deck is sorted in the Preface, if necessary, before the execution of the second part of the Input File Processor. IFP checks all of the bulk data cards for errors according to the rules given for each card in Section 2.4. If errors are detected, suitable messages are provided to the user. If the error is classed as fatal, the Executive System will not allow the execution to continue beyond the completion of the Preface. IFP creates the data blocks that are input to the various parts of the Geometry Processor (GEØM1, GEØM2, GEØM3 and GEØM4), the Element Properties Table (EPT), the Material Properties Table (MPT), the Element Deformation Table (EDT), and the Direct Input Table (DIT).

The third part of the Input File Processor (IFP3) converts the information on the special conical shell cards (CCØNEAX, CTRAPAX, CTRIAAX, FØRCEAX, MØMAX, MPCAX, ØMITAX, PCØNEAX, PØINTAX, PRESAX, PTRAPAX, PTRIAAX, RINGAX, SECTAX, SPCAX, SUPAX, AND TEMPAX) to reflect the number of harmonics specified by the user on the AXIC card. This converted information is added to any existing information on data blocks GEØM1, GEØM2, GEØM3 and GEØM4.

The fourth part of the input file processor (IFP4) converts the information on the fluid related cards (AXIF, BDYLIST, CFLUID2, CFLUID3, CFLUID4, DMIAX, FLSYM, FREEPT, FSLIST, GRIDB, PRESPT, and RINGFL) to reflect the desired harmonics, boundaries, and matrix input. This converted information is added to GEØM1, GEØM2, GEØM4, and MATPØØL.

The fifth part of the input file processor (IFP5) converts the information on the acoustic cavity related cards (AXSLØT, CAXIF2, CAXIF3, CAXIF4, CSLØT3, CSLØT4, GRIDF, GRIDS, and SLBDY) to equivalent structural scalar points, elements, scalar springs and plotting elements. This converted information is added to the GEØM1 and GEØM2 data blocks.

3.1.2 Functional Modules and Supporting DMAP Operations

The DMAP listings for the rigid formats currently included in NASTRAN are presented in the following sections. The mnemonics for the major functional modules are circled on the DMAP listings for ease of identification. Each major functional module is usually preceded and/or succeeded by several supporting DMAP operations. Brief descriptions of the operations in the functional modules are given for each of the rigid formats. The complete details for each functional module are given in the Programmer's Manual. Additional information is also given in the Theoretical Manual. The format of a functional module DMAP instruction is given in Section 5.

Many of the executive modules in the following list appear repeatedly in the rigid formats. Since the purpose of many of these operations in a rigid format is obvious, they are frequently omitted from the descriptions of the DMAP operations in the following sections. More complete descriptions of the executive modules are given in Section 5.

1. BEGIN indicates the beginning of the DMAP sequence constituting the rigid format.

2. FILE makes declarations relative to a particular file.

   ABC = TAPE states that file ABC will be assigned to a physical tape if one is available.

   DEF = APPEND states that file DEF may be extended as the result of an internal loop in the rigid format.

   GHI = SAVE states that file GHI should not be dropped after use as it may be needed for subsequent executions of an internal loop.

3. CHKPNT specifies a list of files to be written on the new problem tape, including files that may have been purged, either because they were not generated in this particular execution or were explicitly purged with a PURGE statement.

4. LABEL specifies a labeled point in the sequence of DMAP instructions. Labels are referenced by REPT, JUMP and CØND instructions.

5. REPT specifies the end of a loop. The variable field contains the label name for the beginning of the loop and the number of times the loop is to be repeated.

6. JUMP specifies an unconditional transfer to the label indicated.

7. CØND specifies a conditional tranfer to the label indicated based on the value of the parameter named. The transfer occurs if the parameter value is negative.

8. SAVE specifies variable parameter values that are to be saved for future use.

9. PURGE specifies the names of files that are conditionally dropped based on the parameter named.

10. EQUIV specifies the names of files that are conditionally equivalenced based on the parameter named.

11. END indicates the end of the DMAP sequence constituting the rigid format and causes a normal termination when executed.

3.1.3 Restart Procedures

Scheduled exits can be requested at any point in a rigid format by means of the ALTER feature. An exit is scheduled by inserting the following cards in the Executive Control Deck:

```
ALTER     K1
EXIT      K2

ENDALTER
```

K1 = DMAP statement number after which exit will take place.

K2 = Number of times EXIT instruction will be skipped before being executed - default is zero. For use with loops, where user wishes to execute the loop K2 times before scheduling the exit.

If the user chooses to restart the problem without making any changes, the Executive System will execute an unmodified restart following the last completed checkpoint.

Unscheduled exits are usually caused by errors on input cards or errors in the structural model resulting from missing or inconsistent input data. When such errors are detected, an unscheduled exit is performed accompanied with the output of the applicable user error messages. Following the correction of the input data errors, a modified restart can be performed.

Unscheduled exits may also occur because of machine failure or insufficient time allowance. In these cases, an unmodified restart is usually made following the last completed checkpoint. In some cases, where a portion of the problem has been completed, including the output for the completed portion, a modified restart must be made following an unscheduled exit due to insufficient time allowance. These situations are discussed under case control requirements in the sections dealing with the individual rigid formats.

The initial execution of any problem must be made with a complete NASTRAN Data Deck, including all of the bulk data. However, all or part of the bulk data may be assembled from alternate input sources, such as the User's Master File or a module written by the user to generate input. The User's Master File is described in Section 2.5 and user generated input is discussed in Section 2.6.

A New Problem Tape is constructed only when checkpointing (CHKPNT) is requested in the Executive Control Deck. The New Problem Tape should be assigned to a physical tape or other storage device that can be dismounted and saved at the conclusion of the execution. At the completion of an initial execution, the New Problem Tape contains the input deck, with the bulk data in sorted form, and all of the files that were checkpointed during the execution.

For restarts, the Old Problem Tape is defined as the Problem Tape that was written during the previous execution. The New Problem Tape is defined as the Problem Tape written during the current execution, beginning with the restart. At the completion of an unmodified restart the New Problem Tape contains the input deck, with the bulk data in sorted form, all files from the Old Problem Tape that are necessary to complete the solution, and all of the files checkpointed during the current execution. At the completion of a modified restart, the New Problem Tape is similar, except the input deck is modified according to the information submitted for the restart.

For restarts, the Bulk Data Deck consists only of delete cards (see Section 2.4) and new cards which the user wishes to add. The previous Bulk Data Deck is read from the Old Problem Tape. All other parts of the NASTRAN Data Deck, including the Executive Control Deck, the Case Control Deck, the BEGIN BULK card and the ENDDATA card must be resubmitted even though no changes are made in the control decks and no new bulk data is added. In addition, the RESTART cards punched during the previous execution must be included in the Executive Control Deck. When changing rigid formats, the solution number (SØL) must be changed to the number of the new rigid format.

Any changes in the Case Control Deck associated with bulk data selection or subcase definition, or changes in the Bulk Data Deck, in the form of deletions or additions, mark the restart as being modified. If no such changes are made, the Executive System performs an unmodified restart at the last completed checkpoint. If only changes have been made in the output requests, the restart is considered unmodified. However, some modules preceeding the last completed checkpoint may have to be executed in order to prepare the output.

For modified restarts, a number of previously executed DMAP instructions may have to be re-executed, depending on the nature of the modifications made by the user. The DMAP instructions that need to be executed in a modified restart are automatically determined within the program by comparing all changes made in Case Control cards and Bulk Data cards with the restart tables that are part of each rigid format (see Section 10 of the Programmer's Manual). In addition, if the previous execution terminated prior to completion on the same rigid format, all DMAP instructions beyond the last completed checkpoint are executed on restart.

3.1.4 Rigid Format Output

Although most of the rigid format output is optional, some of the printer output is automatic.

The printer output is designed for 132 characters per line, with the lines per page controlled by the LINE card in the Case Control Deck. The LINE default is set to fit on 11-inch paper. Optional titles are printed at the top of each page from information in the Case Control Deck. These titles may be defined at the subcase level. The pages are automatically dated and numbered.

The output from data recovery and plot modules is all optional, and its selection is controlled by cards in the Case Control Deck. The details of making selections in the Case Control Deck are described in Section 2.3 for printer and punch output, and in Section 4 for plotter output. Since the outputs from the data recovery and plot modules vary considerably with the rigid format, a list of available output is included in the section on the Case Control Deck for each rigid format. Information on the force and stress output available for each element type is given in Section 1.3.

The first part of the output for a NASTRAN run is prepared during the execution of the Preface, prior to the beginning of the DMAP sequence of the rigid format. The following output is either automatically or optionally provided during the execution of the Preface:

1. NASTRAN title page - one full page automatic unless changed with the TITLEØPT parameter on the NASTRAN card before the Executive Control Deck.

2. Executive Control Deck echo - automatic.

3. Case Control Deck echo - automatic.

4. Unsorted Bulk Data Deck echo - optional, selected in Case Control Deck with the ECHØ Card.

5. Sorted Bulk Data Deck echo - automatic, unless suppressed in the Case Control Deck with the ECHØ Card.

6. DMAP listing - Selected with DIAG 14 in the Executive Control Deck. Provides the list of DMAP instructions, including alters, for the subset of the rigid format being executed.

7. Checkpoint Dictionary - automatic, when operating in the checkpoint mode. A printed echo (unless suppressed with the DIAG 9 card in the Executive Control Deck) and the punched cards are prepared for additions to the checkpoint dictionary after the execution of each checkpoint.

When making restarts, the following additional output is automatically prepared during the execution of the Preface:

1. Asterisks are placed beside the DMAP statement numbers of all instructions marked for execution by the Card Name Table in the case of modified restarts, and by the Rigid Format Change Table in the case of restarts on different rigid formats.

2. Message indicating the bit position activated by a rigid format change.

3. Table indicating, among other things, the card names and the associated "packed bit positions" activated by modifications in the NASTRAN Data Deck. The reader is referred to the Programmer's Manual for the interpretation of the rest of this table.

4. A list of files, along with the DMAP instructions that were marked for execution by the File Name Table.

5. List of files from the Old Problem Tape, including purged files, used to initiate the restart.

A number of fatal errors are detected by DMAP statements in the various rigid formats. The messages associated with these errors are documented in Section 6.1. These messages indicate the presence of fatal user errors that, either cannot be determined by the functional modules, or they can be more effectively detected by DMAP statements in the rigid format.

NASTRAN diagnostic messages are usually identified by number and documented in Section 6.2. These messages may be either program diagnostics or user diagnostics, and they may contain information, warnings, or an indication of a fatal error. There are also a few unnumbered, self-explanatory messages, for example, the time that the execution of each functional module begins and ends.

The Grid Point Singularity Table (GPST) is automatically output following the execution of the Grid Point Singularity Processor (GPSP) if singularities remain in the stiffness matrix at the grid point level. This table contains all possible combinations of single-point constraints, in the global coordinate system, that can be used to remove the singularities. Entries in this table should only be treated as warnings, because it cannot be determined at the grid point level whether or not the singularities are removed by other means, such as general elements or multipoint constraints. Further information on this matter is given in the Theoretical Manual.

Several items of output are discussed in other sections. Automatic output that is not associated with all of the rigid formats is discussed in the sections treating the individual rigid formats. Some output is under the control of PARAM cards. These itmes are discussed in Section 2.4 (PARAM card). The DIAG card is used to control the printing of some output. A list of the available output under DIAG control is given in the description of the executive control cards in Section 2.2.1.

Any of the matrices or tables that are prepared by the functional modules can be printed by using selected utility modules described in Section 5.5. These utility modules can be scheduled at any point in the rigid format by using the ALTER feature. In general, they should be scheduled immediately after the functional module that generates the table or matrix to be printed. Note that functional modules cannot be seperated from a SAVE instruction. However, the user is cautioned to check the calling sequence for the utility module, in order to be certain that all required inputs have been generated prior to this point.

3.2 STATIC ANALYSIS

3.2.1 DMAP Sequence for Static Analysis

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 1

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 1  BEGIN    NO.1 STATIC ANALYSIS - SERIES N $

 2  FILE     OPTP2=SAVE/EST1=SAVE $

 3  FILE     QG=APPEND/PGG=APPEND/UGV=APPEND/GM=SAVE/KNN=SAVE $

 4  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
             NOGPDT/V,N,ALWAYS=-1 $

 5  SAVE     LUSET $

 6  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

 7  GP2      GEOM2,EQEXIN/ECT $

 8  CHKPNT   ECT $

 9  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

10  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

11  COND     P1,NOPCDB $

12  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
             JUMPPLOT=-1 $

13  SAVE     NSIL,JUMPPLOT $

14  PRTMSG   PLTSETX// $

15  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

16  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

17  COND     P1,JUMPPLOT $

18  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/   V,N,
             NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

19  SAVE     JUMPPLOT,PLTFLG,PFILE $

20  PRTMSG   PLOTX1// $

21  LABEL    P1 $

22  CHKPNT   PLTPAR,GPSETS,ELSETS $

23  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV/V,N,NEVER=1 $

24  SAVE     NOGRAV $

25  PARAM    //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRDPNT=-1 $

26  CHKPNT   SLT,GPTT $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 1

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.
27  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

28  SAVE      NOSIMP,NOGENL,GENEL $

29  PARAM     //C,N,AND/V,N,NOELMT/V,N,NOGENL/V,N,NOSIMP $

30  COND      ERROR4,NOELMT $

31  PURGE     KGGX,GPST/NOSIMP/OGPST/GENEL $

32  CHKPNT    EST,GPECT,GEI,GPST,OGPST $

33  OPTPR1    MPT,EPT,ECT,DIT,EST/OPTP1/V,N,PRINT/V,N,TSTART/V,N,COUNT $

34  SAVE      PRINT,TSTART,COUNT $

35  CHKPNT    OPTP1 $

36  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

37  JUMP      LOOPTOP $
--------------------------------------------------------- Top of Optimization Loop
38  LABEL     LOOPTOP $

39  COND      LBL1,NOSIMP $

40  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

41  EQUIV     OPTP1,OPTP2/NEVER/EST,EST1/NEVER $

42  EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
              N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
              CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
              CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

43  SAVE      NOKGGX,NOMGG $

44  CHKPNT    KELM,KDICT,MELM,MDICT $

45  COND      JMPKGG,NOKGGX $

46  EMA       GPECT,KDICT,KELM/KGGX,GPST $

47  CHKPNT    KGGX,GPST $

48  LABEL     JMPKGG $

49  COND      JMPMGG,NOMGG $

50  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

51  CHKPNT    MGG $

52  LABEL     JMPMGG $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 1

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.
53  COND     LBL1,GRDPNT $
54  COND     ERROR2,NOMGG $
55  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $
56  OFP      OGPWG,,,,,// $
57  LABEL    LBL1 $
58  EQUIV    KGGX,KGG/NOGENL $
59  CHKPNT   KGG $
60  COND     LBL11A,NOGENL $
61  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
62  CHKPNT   KGG $
63  LABEL    LBL11A $
64  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
65  JUMP     LBL11 $
------------------------------------------------------------ Top of DMAP Loop
66  LABEL    LBL11 $
67  GP4      CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,
             LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
             NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
68  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $
69  COND     ERROR3,NOL $
70  PARAM    //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $
71  PURGE    KRR,KLR,QR,DM/REACT/GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,
             KFS,KSS/SINGLE/QG/NOSR $
72  CHKPNT   KRR,KLR,QR,DM,GM,GO,KOO,LOO,PO,UOOV,RUOV,PS,KFS,KSS,QG,USET,RG,
             YS,ASET $
73  COND     LBL4,GENEL $
74  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
75  SAVE     NOGPST $
76  COND     LBL4,NOGPST $
77  OFP      OGPST,,,,,// $
78  LABEL    LBL4 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 1

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 79  EQUIV    KGG,KNN/MPCF1 $
 80  CHKPNT   KNN $
 81  COND     LBL2,MPCF2 $
 82  MCE1     USET,RG/GM $
 83  CHKPNT   GM $
 84  MCE2     USET,GM,KGG,,,/KNN,,, $
 85  CHKPNT   KNN $
 86  LABEL    LBL2 $
 87  EQUIV    KNN,KFF/SINGLE $
 88  CHKPNT   KFF $
 89  COND     LBL3,SINGLE $
 90  SCE1     USET,KNN,,,/KFF,KFS,KSS,,, $
 91  CHKPNT   KFS,KSS,KFF $
 92  LABEL    LBL3 $
 93  EQUIV    KFF,KAA/OMIT $
 94  CHKPNT   KAA $
 95  COND     LBL5,OMIT $
 96  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $
 97  CHKPNT   GO,KAA,KOO,LOO $
 98  LABEL    LBL5 $
 99  EQUIV    KAA,KLL/REACT $
100  CHKPNT   KLL $
101  COND     LBL6,REACT $
102  RBMG1    USET,KAA,/KLL,KLR,KRR,,, $
103  CHKPNT   KLL,KLR,KRR $
104  LABEL    LBL6 $
105  RBMG2    KLL/LLL $
106  CHKPNT   LLL $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 1

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

107  COND      LBL7,REACT $

108  RBMG3     LLL,KLR,KRR/DM $

109  CHKPNT    DM $

110  LABEL     LBL7 $

111  SSG1      SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N,
               LUSET/V,N,NSKIP $

112  CHKPNT    PG $

113  EQUIV     PG,PL/NOSET $

114  CHKPNT    PL $

115  COND      LBL10,NOSET $

116  SSG2      USET,GM,YS,KFS,GO,DM,PG/QR,PO,PS,PL $

117  CHKPNT    QR,PO,PS,PL $

118  LABEL     LBL10 $

119  SSG3      LLL,KLL,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
               V,N,NSKIP/V,N,EPSI $

120  SAVE      EPSI $

121  CHKPNT    ULV,UOOV,RULV,RUOV $

122  COND      LBL9,IRES $

123  MATGPR    GPL,USET,SIL,RULV//C,N,L $

124  MATGPR    GPL,USET,SIL,RUOV//C,N,O $

125  LABEL     LBL9 $

126  SDR1      USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,QR/UGV,PGG,QG/V,N,NSKIP/
               C,N,STATICS $

127  CHKPNT    UGV,PGG,QG $

128  COND      LBL8,REPEAT $

129  REPT      LBL11,100 $
                                                         Bottom of DMAP Loop
130  JUMP      ERROR1 $

131  PARAM     //C,N,NOT/V,N,TEST/V,N,REPEAT $

132  COND      ERROR5,TEST $

133  LABEL     LBL8 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 1

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

134   CHKPNT    CSTM $

135   GPFDR     CASECC,UGV,KELM,KDICT,ECT,EQEXIN,GPECT,PGG,QG/ONRGY1,OGPFB1/
                C,N,STATICS $

136   OFP       ONRGY1,OGPFB1,,,,// $

137   SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,,PGG/
                OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,STATICS/V,N,NOSORT2=-1 $

138   SAVE      NOSORT2 $

139   COND      LBL17,NOSORT2 $

140   SDR3      OUGV1,OPG1,OQG1,OEF1,OES1,/OUGV2,OPG2,OQG2,OEF2,OES2, $

141   OFP       OUGV2,OPG2,OQG2,OEF2,OES2,//V,N,CARDNO $

142   SAVE      CARDNO $

143   XYTRAN    XYCDB,OPG2,OQG2,OUGV2,OES2,OEF2/XYPLTT/C,N,TRAN/C,N,PSET/V,N,
                PFILE/V,N,CARDNO $

144   SAVE      PFILE,CARDNO $

145   XYPLOT    XYPLTT// $

146   JUMP      DPLOT $

147   LABEL     LBL17 $

148   COND      LBLOFP,COUNT $

149   OPTPR2    OPTP1,OES1,EST/OPTP2,EST1/V,N,PRINT/V,N,TSTART/V,N,COUNT/V,N,
                CARDNO $

150   SAVE      CARDNO,COUNT,PRINT $

151   EQUIV     EST1,EST/ALWAYS/OPTP2,OPTP1/ALWAYS $

152   COND      LOOPEND,PRINT $

153   LABEL     LBLOFP $

154   OFP       OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

155   SAVE      CARDNO $

156   COND      P2,JUMPPLOT $

157   LABEL     DPLOT $

158   PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
                PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

159   SAVE      PFILE $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 1

```
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

160  PRTMSG    PLOTX2// $

161  LABEL     P2 $

162  LABEL     LOOPEND $

163  COND      FINIS,COUNT $

164  REPT      LOOPTOP,100 $                                   Bottom of
                                                         Optimization Loop
165  JUMP      FINIS $

166  LABEL     ERROR1 $

167  PRTPARM   //C,N,-1/C,N,STATICS $

168  LABEL     ERROR2 $

169  PRTPARM   //C,N,-2/C,N,STATICS $

170  LABEL     ERROR3 $

171  PRTPARM   //C,N,-3/C,N,STATICS $

172  LABEL     ERROR4 $

173  PRTPARM   //C,N,-4/C,N,STATICS $

174  LABEL     ERROR5 $

175  PRTPARM   //C,N,-5/C,N,STATICS $

176  LABEL     FINIS $

177  END       $
```

3.2.2 Description of DMAP Operations for Static Analysis

4. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

7. GP2 generates Element Connection Table with internal indices.

11. Go to DMAP No. 21 if no plot package is present.

12. PLTSET transforms user input into a form used to drive structure plotter.

14. PRTMSG prints error messages associated with structure plotter.

17. Go to DMAP No. 21 if no undeformed structure plot request.

18. PLØT generates all requested undeformed structure plots.

20. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

23. GP3 generates Static Loads Table and Grid Point Temperature Table.

27. TA1 generates element tables for use in matrix assembly and stress recovery.

30. Go to DMAP No. 172 and print error message if no elements have been defined.

33. ØPTPR1 performs phase one property optimization and initialization check.

37. Go to next DMAP instruction if cold start or modified restart. LØØPTØP will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

38. Beginning of Loop for property optimization.

39. Go to DMAP No. 57 if there are no structural elements.

42. EMG generates structural element matrix tables and dictionaries for later assembly.

45. Go to DMAP No. 48 if no stiffness matrix is to be assembled.

46. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

49. Go to DMAP No. 52 if no mass matrix is to be assembled.

50. EMA assembles mass matrix $[M_{gg}]$.

53. Go to DMAP No. 57 if no weight and balance request.

54. Go to DMAP No. 168 and print error message if no mass matrix exists.

55. GPWG generates weight and balance information.

56. ØFP formats weight and balance information and places it on the system output file for printing.

58. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

60. Go to DMAP No. 63 if no general elements.

61. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

65. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

66. Beginning of Loop for additional constraint sets

67. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

69. Go to DMAP No. 170 and print error message if no independent degrees of freedom are defined.

73. Go to DMAP No. 78 if general elements present.

74. GPSP determines if possible grid point singularities remain.

76. Go to DMAP No. 78 if no grid point singularities remain.

77. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

79. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

81. Go to DMAP No. 86 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

82. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

84. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] .$$

87. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

89. Go to DMAP No. 92 if no single-point constraints.

90. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right].$$

93. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

95. Go to DMAP No. 98 if no omitted coordinates.

96. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right] ,$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

99. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

101. Go to DMAP No. 104 if no free-body supports.

102. RBMG1 partitions out-free body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] .$$

105. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

107. Go to DMAP No. 110 if no free-body supports.

108. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}] \quad ,$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] \quad ,$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||} .$$

111. SSG1 generates static load vectors $\{P_g\}$.

113. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

116. SSG2 applies constraints to static load vectors

$$\{P_g\} = \left\{\begin{array}{c} \bar{P}_n \\ \hline P_m \end{array}\right\} , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} \quad ,$$

$$\{P_n\} = \left\{\begin{array}{c} \bar{P}_f \\ \hline P_s \end{array}\right\} , \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\} \quad ,$$

$$\{P_f\} = \left\{\begin{array}{c} \bar{P}_a \\ \hline P_o \end{array}\right\} , \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\} \quad ,$$

$$\{P_a\} = \left\{\begin{array}{c} P_\ell \\ \hline P_r \end{array}\right\}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

119. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\} ,$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\} ,$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\} ,$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}}$$

122. Go to DMAP No. 125 if residual vectors are not to be printed.

123. MATGPR prints the residual vector for independent coordinates (RULV)

124. MATGPR prints the residual vector for omitted coordinates (RUØV).

126. SDR1 recovers dependent displacements

$$\left\{\begin{array}{c} u_\ell \\ \hline u_r \end{array}\right\} = \{u_a\} , \qquad \{u_o\} = [G_o]\{u_a\} + \{u_o^o\} ,$$

$$\left\{\begin{array}{c} u_a \\ \hline u_o \end{array}\right\} = \{u_f\} , \qquad \left\{\begin{array}{c} u_f \\ \hline Y_s \end{array}\right\} = \{u_n\} ,$$

$$\{u_m\} = [G_m]\{u_n\} , \qquad \left\{\begin{array}{c} u_n \\ \hline u_m \end{array}\right\} = \{u_g\} ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\}.$$

128. Go to DMAP No. 133 if all constraint sets have been processed.

129. Go to DMAP No. 66 if additional sets of constraints need to be progessed.

130. Go to DMAP No. 166 and print error message if number of loops exceeds 100.

132. Go to DMAP No. 174 and print error message if multiple boundary conditions are attempted with improper subset.

135. GPFDR calculates for requested sets the grid point force balance and element strain energy for output.

136. ØFP formats the tables prepared by GPFDR and places them on the system output file for printing

137. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).

139. Go to DMAP No. 147 if no output requests for grid point number or element number sort.

140. SDR3 prepares requested output sorted by grid point number or element number.

141. ØFP formats requested output sorted by grid point number or element number and places it on the system output file for printing.

143. XYTRAN prepares the input for requested X-Y plots.

145. XYPLØT prepares requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. subcase.

146. Go to DMAP No. 157.

148. Go to DMAP No. 153 if no phase two property optimization.

149. ØPTPR2 performs phase two property optimization.

151. Equivalence EST1 to EST and ØPTP2 to ØPTP1 everytime this instruction is executed.

152. Go to DMAP No. 162 if no additional output is to be printed for this loop.

154. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

156. Go to DMAP No. 161 if no deformed structure plots are requested.

158. PLØT generates all requested deformed structure plots.

160. PRTMSG prints plotter data and engineering data for each deformed plot generated.

163. Go to DMAP No. 176 and make a normal exit if property optimization is complete.

164. Go to DMAP No. 38 if additional loops for property optimization are needed.

165. Go to DMAP No. 176 and make normal exit.

167. STATIC ANALYSIS ERRØR MESSAGE NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

169. STATIC ANALYSIS ERRØR MESSAGE NØ. 2 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

171. STATIC ANALYSIS ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

173. STATIC ANALYSIS ERRØR MESSAGE NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

175. STATIC ANALYSIS ERRØR MESSAGE NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

3.2.3 Case Control Deck and Parameters for Static Analysis

The following items relate to subcase definition and data selection for Static Analysis:

1. A separate subcase must be defined for each unique combination of constraints and static loads.

2. A static loading condition must be defined for (not necessarily within) each subcase with a LØAD, TEMPERATURE(LØAD), or DEFØRM selection unless all loading is specified with grid point displacements on SPC cards.

3. An SPC set must be selected for (not necessarily within) each subcase, unless the model is a properly supported free body, or all constraints are specified on GRID cards, Scalar Connection cards, or with General Elements.

4. Loading conditions associated with the same sets of constraints should be in contiguous subcases in order to avoid unnecessary looping.

5. REPCASE may be used to repeat subcases in order to allow multiple sets of the same output item.

The following printed output, sorted by loads (SØRT1) or by grid point number or element number (SØRT2), may be requested for Static Analysis solutions:

1. Displacements and components of static loads and single-point forces of constraint at selected grid points or scalar points.

2. Forces and stresses in selected elements.

The following plotter output may be requested for Static Analysis solutions:

1. Undeformed and deformed plots of the structural model.

2. X-Y plot of any component of displacement, static load, or single-point force of constraint for a grid point or scalar point versus subcase.

3. X-Y plot of any stress or force component for an element versus subcase.

The following parameters are used in Static Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in EMG.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices, rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.2.4 Automatic Alters for Automated Multi-stage Substructuring

The following lines of the Static Analysis, Rigid Format 1, are altered for automatic substructure analyses.

Phase 1: 69, 100-110, 115-161

Phase 2: 4-5, 9-22, 29-30, 41, 58-61, 73-78, 134-164

Phase 3: 100-110, 115-125, 127

If APP DISP,SUBS is used, the user may also specify ALTER's. However, these must not interfere with the automatically generated DMAP statement ALTER's listed above. See Section 5.9 for a description and listing of the ALTER's which are automatically generated for substructuring.

3.3 STATIC ANALYSIS WITH INERTIA RELIEF

3.3.1 DMAP Sequence for Static Analysis with Inertia Relief

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 2

    N A S T R A N  S O U R C E  P R O G R A M  C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN    NO.2 STATIC ANALYSIS WITH INERTIA RELIEF - SERIES N $

  2  FILE     QG=APPEND/PGG=APPEND/UGV=APPEND/GM=SAVE/KNN=SAVE/MNN=SAVE $

  3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
              NOGPDT $

  4  SAVE     LUSET $

  5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  6  GP2      GEOM2,EQEXIN/ECT $

  7  CHKPNT   ECT $

  8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

 10  COND     P1,NOPCDB $

 11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
              JUMPPLOT=-1 $

 12  SAVE     NSIL,JUMPPLOT $

 13  PRTMSG   PLTSETX// $

 14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 16  COND     P1,JUMPPLOT $

 17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/   V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 18  SAVE     JUMPPLOT,PLTFLG,PFILE $

 19  PRTMSG   PLOTX1// $

 20  LABEL    P1 $

 21  CHKPNT   PLTPAR,GPSETS,ELSETS $

 22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

 23  CHKPNT   SLT,GPTT $

 24  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 2

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.
                NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

 25   SAVE      NOSIMP,NOGENL,GENEL $

 26   COND      ERROR1,NOSIMP $

 27   PURGE     OGPST/GENEL $

 28   CHKPNT    EST,GPECT,GEI,OGPST $

 29   PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

 30   PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

 31   EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
                N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
                CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
                CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

 32   SAVE      NOKGGX,NOMGG $

 33   CHKPNT    KELM,KDICT,MELM,MDICT $

 34   COND      JMPKGG,NOKGGX $

 35   EMA       GPECT,KDICT,KELM/KGGX,GPST $

 36   CHKPNT    KGGX,GPST $

 37   LABEL     JMPKGG $

 38   COND      ERROR1,NOMGG $

 39   EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

 40   CHKPNT    MGG $

 41   COND      LGPWG,GRDPNT $

 42   GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

 43   OFP       OGPWG,,,,,// $

 44   LABEL     LGPWG $

 45   EQUIV     KGGX,KGG/NOGENL $

 46   CHKPNT    KGG $

 47   COND      LBL11A,NOGENL $

 48   SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
```

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 2

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 49  CHKPNT   KGG $

 50  LABEL    LBL11A $

 51  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 52  JUMP     LBL11 $
-------------------------------------------------- Top of DMAP Loop
 53  LABEL    LBL11 $

 54  GP4      CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,
              LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
              NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 55  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

 56  COND     ERROR3,NOL $

 57  COND     ERROR4,REACT $

 58  PURGE    GM/MPCF1/GO,KOO,LOO,MOO,MOA,PO,UOOV,RUOV/OMIT/KSS,KFS,PS/
              SINGLE $

 59  CHKPNT   GM,RG,GO,KOO,LOO,MOO,MOA,PO,KSS,KFS,YS,PS,USET,ASET,RUOV $

 60  COND     LBL4,GENEL $

 61  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 62  SAVE     NOGPST $

 63  COND     LBL4,NOGPST $

 64  OFP      OGPST,,,,,// $

 65  LABEL    LBL4 $

 66  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

 67  CHKPNT   KNN,MNN $

 68  COND     LBL2,MPCF2 $

 69  MCE1     USET,RG/GM $

 70  CHKPNT   GM $

 71  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $

 72  CHKPNT   KNN,MNN $

 73  LABEL    LBL2 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 2

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 74  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE $

 75  CHKPNT   KFF,MFF $

 76  COND     LBL3,SINGLE $

 77  SCE1     USET,KNN,MNN,,/KFF,KFS,KSS,MFF,, $

 78  CHKPNT   KFS,KSS,KFF,MFF $

 79  LABEL    LBL3 $

 80  EQUIV    KFF,KAA/OMIT/ MFF,MAA/OMIT $

 81  CHKPNT   KAA,MAA $

 82  COND     LBL5,OMIT $

 83  SMP1     USET,KFF,MFF,,/GO,KAA,KOO,LOO,MAA,MOO,MOA,, $

 84  CHKPNT   GO,KAA,KOO,LOO,MAA,MOO,MOA $

 85  LABEL    LBL5 $

 86  RBMG1    USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

 87  CHKPNT   KLL,KLR,KRR,MLL,MLR,MRR $

 88  RBMG2    KLL/LLL $

 89  CHKPNT   LLL $

 90  RBMG3    LLL,KLR,KRR/DM $

 91  CHKPNT   DM $

 92  RBMG4    DM,MLL,MLR,MRR/MR $

 93  CHKPNT   MR $

 94  SSG1     SLT,BGPDT,CSTM,SIL,EST ,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N,
              LUSET/V,N,NSKIP $

 95  CHKPNT   PG $

 96  SSG2     USET,GM,YS,KFS,GO,DM,PG/QR,PO,PS,PL $

 97  CHKPNT   QR,PO,PS,PL $

 98  SSG4     PL,QR,PO,MR,MLR,DM,MLL,MOO,MOA,GO,USET/PLI,POI/V,N,OMIT $

 99  CHKPNT   PLI,POI $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 2

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

100  SSG3     LLL,KLL,PLI,LOO,KOO,POI/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,
              IRES=-1/V,N,NSKIP/V,N,EPSI $

101  SAVE     EPSI $

102  CHKPNT   ULV,UOOV,RULV,RUOV $

103  COND     LBL9,IRES $

104  MATGPR   GPL,USET,SIL,RULV//C,N,L $

105  MATGPR   GPL,USET,SIL,RUOV//C,N,O $

106  LABEL    LBL9 $

107  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,QR/UGV,PGG,QG/V,N,NSKIP/
              C,N,STATICS $

108  CHKPNT   UGV,QG,PGG $

109  COND     LBL8,REPEAT $

110  REPT     LBL11,100 $
------------------------------------------------  Bottom of DMAP Loop
111  JUMP     ERROR2 $

112  PARAM    //C,N,NOT/V,N,TEST/V,N,REPEAT $

113  COND     ERROR5,TEST $

114  LABEL    LBL8 $

115  CHKPNT   CSTM $

116  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,,PGG/
              OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,STATICS $

117  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

118  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

119  SAVE     CARDNO $

120  COND     P2,JUMPPLOT $

121  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

122  SAVE     PFILE $

123  PRTMSG   PLOTX2// $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 2

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

124  LABEL    P2 $

125  JUMP     FINIS $

126  LABEL    ERROR1 $

127  PRTPARM  //C,N,-1/C,N,INERTIA $

128  LABEL    ERROR2 $

129  PRTPARM  //C,N,-2/C,N,INERTIA $

130  LABEL    ERROR3 $

131  PRTPARM  //C,N,-3/C,N,INERTIA $

132  LABEL    ERROR4 $

133  PRTPARM  //C,N,-4/C,N,INERTIA $

134  LABEL    ERROR5 $

135  PRTPARM  //C,N,-5/C,N,INERTIA $

136  LABEL    FINIS $

137  END      $
```

3.3.2 Description of DMAP Operations for Static Analysis with Inertia Relief

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot package is present.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plot request.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 126 and print error message if there are no structure elements.

31. EMG generates structural element matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 126 and print error message if no mass matrix exists.

39. EMA assembles mass matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance request.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information and places it on the system output file for printing.

45. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

52. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

53. Beginning of Loop for additional constraint sets.

54. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

56. Go to DMAP No. 130 and print error message if no independent degrees of freedom are defined.

57. Go to DMAP No. 132 and print error message if no free-body supports.

60. Go to DMAP No. 65 if general elements present.

61. GPSP determines if possible grid point singularities remain.

63. Go to DMAP No. 65 if grid point singularities remain.

64. ØFP Formats table of possible grid point singularities and places it on the system output file for printing.

66. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

68. Go to DMAP No. 73 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

69. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

71. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

74. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

76. Go to DMAP No. 79 if no single-point constraints.

77. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right].$$

80. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

82. Go to DMAP No. 85 if no omitted coordinates.

83. SMP1 partitions constrained stiffness and mass matrices

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right] \quad \text{and} \quad [M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right],$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reductions $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

and $[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o]$.

86. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right] .$$

88. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

90. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

92. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

94. SSG1 generates static load vectors $\{P_g\}$.

96. SSG2 applies constraints to static load vectors

$$\{P_g\} = \left\{\begin{array}{c} \bar{P}_n \\ \hline P_m \end{array}\right\}, \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \left\{\begin{array}{c} \bar{P}_f \\ \hline P_s \end{array}\right\}, \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \left\{\begin{array}{c} \bar{P}_a \\ \hline P_o \end{array}\right\}, \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\},$$

$$\{P_a\} = \left\{\begin{array}{c} P_\ell \\ \hline P_r \end{array}\right\}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

98. SSG4 calculates inertia loads and combines them with static loads

$$\{P_\ell^i\} = \{P_\ell\} + \Big([M_{\ell\ell}][D] + [M_{\ell r}]\Big)[m_r]^{-1}\{q_r\} \qquad \text{and}$$

$$\{P_o^i\} = \{P_o\} + \Big([M_{oo}][G_o] + [M_{ao}^T]\Big)\left[\frac{D}{I}\right][m_r]^{-1}\{q_r\} .$$

100. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell^i\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o^i\} ,$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell^i\} = \{P_\ell^i\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell^i\}}{\{P_\ell^i\}^T\{u_\ell\}} .$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o^i\} = \{P_o^i\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o^i\}}{\{P_o^i\}^T\{u_o^o\}} .$$

103. Go to DMAP No. 106 if residual vectors are not to be printed.

104. Print residual vector for independent coordinates (RULV)

105. Print residual vector for omitted coordinates (RUØV).

107. SDR1 recovers dependent displacements

$$\begin{Bmatrix} u_\ell \\ \hline u_r \end{Bmatrix} = \{u_a\}, \qquad \{u_o\} = [G_o]\{u_a\} + \{u_o^o\} ,$$

$$\begin{Bmatrix} u_a \\ \hline u_o \end{Bmatrix} = \{u_f\} , \qquad \begin{Bmatrix} u_f \\ \hline Y_s \end{Bmatrix} = \{u_n\},$$

$$\{u_m\} = [G_m]\{u_n\} , \qquad \begin{Bmatrix} u_n \\ \hline u_m \end{Bmatrix} = \{u_g\}$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} .$$

109. Go to DMAP No. 114 if all constraint sets have been processed.

110. Go to DMAP No. 53 if additional sets of constraints need to be processed.

111. Go to DMAP No. 128 and print error message if number of loops exceeds 100.

STATIC ANALYSIS WITH INERTIA RELIEF

113. Go to DMAP No. 134 and print error message if multiple boundary conditions are attempted with improper subset.

116. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).

118. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

120. Go to DMAP No. 124 if no deformed structure plots are requested.

121. PLØT generates all requested deformed structure plots.

123. PRTMSG prints plotter data and engineering data for each deformed plot generated.

125. Go to DMAP No. 136 and make normal exit.

127. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR CALCULATIØN ØF INERTIA LØADS.

129. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

131. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

133. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 4 - FREE-BØDY SUPPØRTS ARE REQUIRED.

135. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 5 - A LØØPING PRØBLEM RUN ØN A NØN-LØØPING SUBSET.

3.3.3 Case Control Deck and Parameters for Static Analysis with Inertia Relief

The following items relate to subcase definition and data selection for Static Analysis with Inertia Relief:

1. A separate subcase must be defined for each unique combination of constraints and static loads.
2. A static loading condition must be defined for (not necessarily within) each subcase with a LØAD selection.
3. An SPC set may be selected only if used to remove grid point singularities or some, but not all, of the free body motions. At least one free body support must be provided with a SUPØRT card in the Bulk Data Deck.
4. Loading conditions associated with the same sets of constraints should be in contiguous subcases in order to avoid unnecessary looping.
5. REPCASE may be used to repeat subcases in order to allow multiple sets for the same output item.

The following output may be requested for Static Analysis with Inertia Relief:

1. Displacements at selected grid points due to the sum of the applied loads and the inertia loads.
2. Nonzero components of the applied static loads at selected grid points.
3. Reactions on free-body supports due to applied loads (single-point forces of constraint).
4. Forces and stresses in selected elements due to the sum of the applied loads and inertia loads.
5. Undeformed and deformed plots of the structural model.

The following parameters are used in Static Analysis with Inertia Relief:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.
2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.3.4 Automatic Alters for Automated Multi-stage Substructuring

The following lines of the Static Analysis with Inertia Relief, Rigid Format 2, are altered in automatic substructure analyses.

Phase 1: 57, 86-93, 96-124

Phase 2: 3-4, 8-21, 26, 38, 45-48, 60-65, 116-124

Phase 3: 86-93, 96-106, 108

If APP DISP,SUBS is used, the user may also specify ALTER's. However, these must not interfere with the automatically generated DMAP statement ALTER's listed above. See Section 5.9 for a description and listing of the ALTER's which are automatically generated for substructuring.

3.4 NORMAL MODE ANALYSIS

3.4.1 DMAP Sequence for Normal Mode Analysis

```
 RIGID FORMAT DMAP LISTING
 SERIES N

 RIGID FORMAT 3

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN    NO.3 NORMAL MODES ANALYSIS - SERIES N $

  2  FILE     LAMA=APPEND/PHIA=APPEND $

  3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
              NOGPDT $

  4  SAVE     LUSET $

  5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  6  GP2      GEOM2,EQEXIN/ECT $

  7  CHKPNT   ECT $

  8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

 10  COND     P1,NOPCDB $

 11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
              JUMPPLOT=-1 $

 12  SAVE     NSIL,JUMPPLOT $

 13  PRTMSG   PLTSETX// $

 14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 16  COND     P1,JUMPPLOT $

 17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/   V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 18  SAVE     JUMPPLOT,PLTFLG,PFILE $

 19  PRTMSG   PLOTX1//$

 20  LABEL    P1 $

 21  CHKPNT   PLTPAR,GPSETS,ELSETS $

 22  GP3      GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

 23  CHKPNT   GPTT $

 24  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 3

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.
                NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

 25   SAVE      NOGENL,NOSIMP,GENEL $

 26   COND      ERROR1,NOSIMP $

 27   PURGE     OGPST/GENEL $

 28   CHKPNT    EST,GPECT,GEI,OGPST $

 29   PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

 30   PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

 31   EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
                N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
                CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
                CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

 32   SAVE      NOKGGX,NOMGG $

 33   CHKPNT    KELM,KDICT,MELM,MDICT $

 34   COND      JMPKGG,NOKGGX $

 35   EMA       GPECT,KDICT,KELM/KGGX,GPST $

 36   CHKPNT    KGGX,GPST $

 37   LABEL     JMPKGG $

 38   COND      ERROR1,NOMGG $

 39   EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

 40   CHKPNT    MGG $

 41   COND      LGPWG,GRDPNT $

 42   GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

 43   OFP       OGPWG,,,,,// $

 44   LABEL     LGPWG $

 45   EQUIV     KGGX,KGG/NOGENL $

 46   CHKPNT    KGG $

 47   COND      LBL11,NOGENL $

 48   SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 3

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 49  CHKPNT   KGG $

 50  LABEL    LBL11 $

 51  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 52  GP4      CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,
              LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
              NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 53  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

 54  COND     ERROR3,NOL $

 55  PURGE    KRR,KLR,DM,MLR,MR/REACT/GM/MPCF1/GO/OMIT/KFS/SINGLE/QG/NOSET $

 56  CHKPNT   KRR,KLR,DM,MLR,MR,GM,RG,GO,KFS,QG,USET,ASET $

 57  COND     LBL4,GENEL $

 58  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 59  SAVE     NOGPST $

 60  COND     LBL4,NOGPST $

 61  OFP      OGPST,,,,,// $

 62  LABEL    LBL4 $

 63  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

 64  CHKPNT   KNN,MNN $

 65  COND     LBL2,MPCF2 $

 66  MCE1     USET,RG/GM $

 67  CHKPNT   GM $

 68  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $

 69  CHKPNT   KNN,MNN $

 70  LABEL    LBL2 $

 71  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE $

 72  CHKPNT   KFF,MFF $

 73  COND     LBL3,SINGLE $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 3

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 74  SCE1      USET,KNN,MNN,,/KFF,KFS,,MFF,, $

 75  CHKPNT    KFS,KFF,MFF $

 76  LABEL     LBL3 $

 77  EQUIV     KFF,KAA/OMIT $

 78  EQUIV     MFF,MAA/OMIT $

 79  CHKPNT    KAA,MAA $

 80  COND      LBL5,OMIT $

 81  SMP1      USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

 82  CHKPNT    GO,KAA $

 83  SMP2      USET,GO,MFF/MAA $

 84  CHKPNT    MAA $

 85  LABEL     LBL5 $

 86  COND      LBL6,REACT $

 87  RBMG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

 88  CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $

 89  RBMG2     KLL/LLL $

 90  CHKPNT    LLL $

 91  RBMG3     LLL,KLR,KRR/DM $

 92  CHKPNT    DM $

 93  RBMG4     DM,MLL,MLR,MRR/MR $

 94  CHKPNT    MR $

 95  LABEL     LBL6 $

 96  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,,,EED,EQDYN/V,N,
               LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/  V,
               N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

 97  SAVE      NOEED $

 98  COND      ERROR2,NOEED $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 3

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 99  CHKPNT   EED $

100  PARAM    //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $

101  READ     KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
              NEIGV $

102  SAVE     NEIGV $

103  CHKPNT   LAMA,PHIA,MI,OEIGS $

104  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

105  OFP      LAMA,OEIGS,,,,//V,N,CARDNO $

106  SAVE     CARDNO $

107  COND     FINIS,NEIGV $

108  SDR1     USET,,PHIA,,,GO,GM,,KFS,,/PHIG,,QG/C,N,1/C,N,REIG $

109  CHKPNT   PHIG,QG $

110  PARAM    //C,N,MPY/V,N,SIXSIL/V,N,NSIL/C,N,6 $

111  PARAM    //C,N,EQ /V,N,SCALAR/V,N,SIXSIL/V,N,LUSET $

112  EQUIV    SIL,SIP/SCALAR/BGPDT,BGPDP/SCALAR $

113  CHKPNT   SIP,BGPDP $

114  COND     LBL7,SCALAR $

115  PLTTRAN  BGPDT,SIL/BGPDP,SIP/V,N,LUSET/V,N,LUSEP $

116  SAVE     LUSEP $

117  CHKPNT   BGPDP,SIP $

118  LABEL    LBL7 $

119  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDP,LAMA,QG,PHIG,EST,,/ ,
              OQG1,OPHIG,OES1,OEF1,PPHIG/C,N,REIG $

120  OFP      OPHIG,OQG1,OEF1,OES1,,//V,N,CARDNO $

121  SAVE     CARDNO $

122  COND     P2,JUMPPLOT $

123  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIP,,PPHIG,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 3

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

124  SAVE      PFILE $

125  PRTMSG    PLOTX2// $

126  LABEL     P2 $

127  JUMP      FINIS $

128  LABEL     ERROR1 $

129  PRTPARM   //C,N,-1/C,N,MODES $

130  LABEL     ERROR2 $

131  PRTPARM   //C,N,-2/C,N,MODES $

132  LABEL     ERROR3 $

133  PRTPARM   //C,N,-3/C,N,MODES $

134  LABEL     FINIS $

135  END       $
```

3.4.2 Description of DMAP Operations for Normal Mode Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot package is present.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plot request.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 128 and print error message if there are no structural elements.

31. EMG generates structural element matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 128 and print error message if no mass matrix exists.

39. EMA assembles mass matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance request.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information and places it on the system output file for printing.

45. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to stiffness matrix $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

52. GP4 generates flags defining numbers of various displacement sets (USET) and forms multi-point constraint equations $[R_g]\{u_g\} = 0$.

54. Go to DMAP No. 132 and print error message if no independent degrees of freedom are defined.

57. Go to DMAP No. 62 if general elements present.

58. GPSP determines if possible grid point singularities remain.

60. Go to DMAP No. 62 if no Grid Point Singularity Table.

61. ØFP formats table of possible grid point singularities and places it on the system output file for printing.

63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

65. Go to DMAP No. 70 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \;\; R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right].$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

80. Go to DMAP No. 85 if no omitted coordinates.

81. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

83. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o].$$

86. Go to DMAP No. 95 if no free-body supports.

87. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right] .$$

89. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

91. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||} .$$

93. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

96. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

98 Go to DMAP No. 130 and print error message if no Eigenvalue Extraction Data.

101. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 \quad ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized, computes rigid body eigenvectors

$$[\phi_{ao}] = \left[\begin{array}{c} D\,\phi_{ro} \\ \hline \phi_{ro} \end{array}\right] \quad ,$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

105. ØFP formats eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

107. Go to DMAP No. 134 and exit if no eigenvalues found.

108. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} , \qquad \begin{Bmatrix} \phi_a \\ \hline \phi_o \end{Bmatrix} = \{\phi_f\} ,$$

$$\begin{Bmatrix} \phi_f \\ \hline \phi_s \end{Bmatrix} = \{\phi_n\} , \qquad \{\phi_m\} = [G_m]\{\phi_n\} ,$$

$$\begin{Bmatrix} \phi_n \\ \hline \phi_m \end{Bmatrix} = \{\phi_g\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}]^T\{\phi_f\}$.

112. Equivalence SIL to SIP and BGPDT to BGPDP when one or more geometric grid points exist.

114. Go to DMAP No. 118 if

115. PLTTRAN modifies BGPDT and SIL for functional modules SDR2 and PLØT.

119. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares eigenvectors and single-point forces of constraint for output (ØPHIG, PPHIG, ØQG1).

120. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

122. Go to DMAP No. 126 if no deformed structure plots are requested.

123. PLØT generates all requested deformed structure plots.

125. PRTMSG prints plotter data and engineering data for each deformed plot generated.

127. Go to DMAP No. 134 and make normal exit.

129. NØRMAL MØDE ANALYSIS ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

131. NØRMAL MØDE ANALYSIS ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

133. NØRMAL MØDE ANALYSIS ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

3.4.3 Automatic Output for Normal Mode Analysis

Each eigenvalue is identified with a mode number determined by sorting the eigenvalues by their magnitude. The following summary of the eigenvalues extracted is automatically printed:

1. Mode Number
2. Extraction Order
3. Eigenvalue
4. Radian Frequency
5. Cyclic Frequency
6. Generalized Mass
7. Generalized Stiffness

The following summary of the eigenvalue analysis performed, using the Inverse Power method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of starting points used.
3. Number of starting point moves.
4. Number of triangular decompositions.
5. Number of vector iterations.
6. Reason for termination.
   (1) Two consecutive singularities encountered while performing triangular decomposition.
   (2) Four shift points while tracking a single root.
   (3) All eigenvalues found in the frequency range specified.
   (4) Three times the number of roots estimated in the frequency range have been extracted.
   (5) All eigenvalues that exist in the problem have been found.
   (6) The number of roots desired have been found.
   (7) One or more eigenvalues have been found outside the frequency range specified.
   (8) Insufficient time to find another root.
   (9) Unable to converge
7. Largest off-diagonal modal mass term and the number failing the criteria.

The following summary of the eigenvalue analysis performed, using the Determinant method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of passes through starting points.
3. Number of criteria changes.
4. Number of starting point moves.
5. Number of triangular decompositions.
6. Number of failures to iterate to a root.
7. Reason for termination.
   (1) The number of roots desired have been found.
   (2) All predictions for eigenvalues are outside the frequency range specified.
   (3) Insufficient time to find another root.
   (4) Matrix is singular at first three starting points.
8. Largest off-diagonal modal mass term and the number failing the criterion.
9. Swept determinant function for each starting point.

The following summary of the eigenvalue analysis performed using the Givens method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of eigenvectors computed.
3. Number of eigenvalue convergence failures.
4. Number of eigenvector convergence failures.
5. Reason for termination.
   (1) Normal termination.
   (2) Insufficient time to calculate eigenvalues and number of eigenvectors requested.
   (3) Insufficient time to find additional eigenvectors.
6. Largest off-diagonal modal mass term and the number failing the criterion.

3.4.4 Case Control Deck and Parameters for Normal Mode Analysis

The following items relate to subcase definition and data selection for Normal Modes:

1. METHØD must be used to select an EIGR card that exists in the Bulk Data Deck.
2. On restart, the current EIGR card controls the eigenvalue extraction, regardless of what calculations were made in the previous execution. Consequently, when making restarts with either the Determinant method or the Inverse Power method, METHØD should be changed

to select an EIGR card that avoids the extraction of previously found eigenvalues. This is particularly important following unscheduled exits due to insufficient time to find all eigenvalues in the range of interest.

3. An SPC set must be selected unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.

4. Multiple subcases are used only to control output requests. A single subcase is sufficient if the same output is desired for all modes. If multiple subcases are present, the output requests will be honored in succession for increasing mode numbers. MØDES may be used to repeat subcases in order to make the same output request for several consecutive modes.

The following output may be requested for Normal Mode Analysis:

1. Eigenvectors along with the associated eigenvalue for each mode.

2. Nonzero components of the single-point forces of constraint for selected modes at selected grid points.

3. Forces and stresses in selected elements for selected modes.

4. Undeformed plot of the structural model and mode shapes for selected modes.

The following parameters are used in Normal Mode Analysis:

1. <u>GRDPNT</u> - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. <u>WTMASS</u> - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.

3. <u>CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC</u> - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.4.5 Automatic Alters for Automated Multi-stage Substructuring

The following lines of the Normal Modes Analysis, Rigid Format 3, are altered in automatic substructure analyses.

Phase 1: 53, 86-95, 96-126

Phase 2: 3-4, 10-21, 26, 38, 45-48, 57-62, 119-126

Phase 3: 86-95, 100-107, 108

If APP DISP,SUBS is used, the user may also specify ALTER's. However, these must not interfere with the automatically generated DMAP statement ALTER's listed above. See Section 5.9 for a description and listing of the ALTER's which are automatically generated for substructuring.

3.5 STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

3.5.1 DMAP Sequence for Static Analysis with Differential Stiffness

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 4

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP  INSTRUCTION
 NO.

  1  BEGIN    NO.4 DIFFERENTIAL STIFFNESS ANALYSIS - SERIES N $

  2  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
              NOGPDT $

  3  SAVE     LUSET,NOGPDT $

  4  COND     ERROR1,NOGPDT $

  5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  6  GP2      GEOM2,EQEXIN/ECT $

  7  CHKPNT   ECT $

  8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

 10  COND     P1,NOPCDB $

 11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
              JUMPPLOT=-1 $

 12  SAVE     NSIL,JUMPPLOT $

 13  PRTMSG   PLTSETX// $

 14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 16  COND     P1,JUMPPLOT $

 17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/   V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 18  SAVE     JUMPPLOT,PLTFLG,PFILE $

 19  PRTMSG   PLOTX1// $

 20  LABEL    P1 $

 21  CHKPNT   PLTPAR,GPSETS,ELSETS $

 22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

 23  SAVE     NOGRAV $

 24  PARAM    //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRDPNT=-1 $

 25  CHKPNT   SLT,GPTT $

 26  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 4

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.
                 NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

 27   SAVE       NOSIMP,NOGENL,GENEL $

 28   COND       ERROR1,NOSIMP $

 29   PURGE      OGPST/GENEL $

 30   CHKPNT     EST,GPECT,GEI,OGPST $

 31   PARAM      //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

 32   EMG        EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
                 N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
                 CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
                 CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

 33   SAVE       NOKGGX,NOMGG $

 34   CHKPNT     KELM,KDICT,MELM,MDICT $

 35   COND       JMPKGG,NOKGGX $

 36   EMA        GPECT,KDICT,KELM/KGGX,GPST $

 37   CHKPNT     KGGX,GPST $

 38   LABEL      JMPKGG $

 39   COND       JMPMGG,NOMGG $

 40   EMA        GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

 41   CHKPNT     MGG $

 42   LABEL      JMPMGG $

 43   COND       LBL1,GRDPNT $

 44   COND       ERROR4,NOMGG $

 45   GPWG       BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $

 46   OFP        OGPWG,,,,,// $

 47   LABEL      LBL1 $

 48   EQUIV      KGGX,KGG/NOGENL $

 49   CHKPNT     KGG $

 50   COND       LBL11,NOGENL $

 51   SMA3       GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 52   CHKPNT     KGG $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 4

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 53  LABEL    LBL11 $

 54  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 55  GP4      CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,
              LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
              NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 56  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

 57  COND     ERROR5,NOL $

 58  PURGE    GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS,QG/SINGLE/
              UBOOV/OMIT/YBS,PBS,KBFS,KBSS,KDFS,KDSS/SINGLE $

 59  CHKPNT   GM,RG,GO,KOO,LOO,PO,UOOV,RUOV,YS,PS,KFS,KSS,USET,ASET,   UBOOV,
              YBS,PBS,KBFS,KBSS,KDFS,KDSS,QG $

 60  COND     LBL4D,REACT $

 61  JUMP     ERROR2 $

 62  LABEL    LBL4D $

 63  COND     LBL4,GENEL$

 64  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 65  SAVE     NOGPST $

 66  COND     LBL4,NOGPST $

 67  OFP      OGPST,,,,,// $

 68  LABEL    LBL4 $

 69  EQUIV    KGG,KNN/MPCF1 $

 70  CHKPNT   KNN $

 71  COND     LBL2,MPCF2 $

 72  MCE1     USET,RG/GM $

 73  CHKPNT   GM $

 74  MCE2     USET,GM,KGG,,,/KNN,,, $

 75  CHKPNT   KNN $

 76  LABEL    LBL2 $

 77  EQUIV    KNN,KFF/SINGLE $

 78  CHKPNT   KFF $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 4

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 79   COND       LBL3,SINGLE $
 80   SCE1       USET,KNN,,,/KFF,KFS,KSS,,, $
 81   CHKPNT     KFS,KSS,KFF $
 82   LABEL      LBL3 $
 83   EQUIV      KFF,KAA/OMIT $
 84   CHKPNT     KAA $
 85   COND       LBL5,OMIT $
 86   SMP1       USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $
 87   CHKPNT     GO,KAA,KOO,LOO $
 88   LABEL      LBL5 $
 89   RBMG2      KAA/LLL $
 90   CHKPNT     LLL $
 91   SSG1       SLT,BGPDT,CSTM,SIL,EST ,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N,
                 LUSET/C,N,1 $
 92   CHKPNT     PG $
 93   EQUIV      PG,PL/NOSET $
 94   CHKPNT     PL $
 95   COND       LBL10,NOSET $
 96   SSG2       USET,GM,YS,KFS,GO,,PG/,PO,PS,PL $
 97   CHKPNT     PO,PS,PL $
 98   LABEL      LBL10 $
 99   SSG3       LLL,KAA,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
                 C,N,1/V,N,EPSI $
100   SAVE       EPSI $
101   CHKPNT     ULV,UOOV,RULV,RUOV $
102   COND       LBL9,IRES $
103   MATGPR     GPL,USET,SIL,RULV//C,N,L $
104   MATGPR     GPL,USET,SIL,RUOV//C,N,O $
105   LABEL      LBL9 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 4

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

106  SDR1     USET,,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PG1,QG/C,N,1/C,N,DSO $

107  CHKPNT   UGV,QG $

108  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,ECT,BGPDT,,QG,UGV,EST,,PG/
              OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,DSO $

109  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

110  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

111  SAVE     CARDNO $

112  COND     P2,JUMPPLOT $

113  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

114  SAVE     PFILE $

115  PRTMSG   PLOTX2// $

116  LABEL    P2 $

117  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/X1,X2,ECPT,GPCT/V,N,LUSET/  V,N,
              NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

118  DSMG1    CASECC,GPTT,SIL,EDT,UGV,CSTM,MPT,ECPT,GPCT,DIT/KDGG/  V,N,
              DSCOSET $

119  CHKPNT   KDGG $

120  PARAM    //C,N,ADD/V,N,SHIFT/C,N,-1/C,N,0 $

121  PARAM    //C,N,ADD/V,N,COUNT/V,N,ALWAYS=-1/V,N,NEVER= 1 $

122  PARAMR   //C,N,ADD/V,N,DSEPSI/C,N,0.0/C,N,0.0 $

123  PARAML   YS//C,N,NULL/C,N,/C,N,/C,N,/V,N,NOYS $

124  JUMP     OUTLPTOP $
                                                   Top of Stiffness
                                                   Adjustment Loop
125  LABEL    OUTLPTOP $

126  EQUIV    PG,PG1/NOYS $

127. CHKPNT   PG1 $

128  PARAM    //C,N,KLOCK/V,N,TO $

129  EQUIV    KDGG,KDNN/MPCF2 $

130  CHKPNT   KDNN $

131  COND     LBL2D,MPCF2 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 4

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

132  MCE2     USET,GM,KDGG,,,/KDNN,,, $

133  CHKPNT   KDNN $

134  LABEL    LBL2D $

135  EQUIV    KDNN,KDFF/SINGLE $

136  CHKPNT   KDFF $

137  COND     LBL3D,SINGLE $

138  SCE1     USET,KDNN,,,/KDFF,KDFS,KDSS,,, $

139  CHKPNT   KDFF,KDFS,KDSS $

140  LABEL    LBL3D $

141  EQUIV    KDFF,KDAA/OMIT $

142  CHKPNT   KDAA $

143  COND     LBL5D,OMIT $

144  SMP2     USET,GO,KDFF/KDAA $

145  CHKPNT   KDAA $

146  LABEL    LBL5D $

147  ADD      KAA,KDAA/KBLL $

148  ADD      KFS,KDFS/KBFS $

149  ADD      KSS,KDSS/KBSS $

150  COND     PGOK,NOYS $

151  MPYAD    KBSS,YS,/PSS/C,N,0/C,N,1/C,N,1/C,N,1 $

152  MPYAD    KBFS,YS,/PFS/C,N,0/C,N,1/C,N,1/C,N,1 $

153  UMERGE   USET,PFS,PSS/PN/C,N,N/C,N,F/C,N,S $

154  EQUIV    PN,PGX/MPCF2 $

155  COND     LBL6D,MPCF2 $

156  UMERGE   USET,PN,/PGX/C,N,G/C,N,N/C,N,M $

157  LABEL    LBL6D $

158  ADD      PGX,PG/PGG/C,N,(-1.0,0.0) $

159  EQUIV    PGG,PG1/ALWAYS $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 4

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

160  LABEL     PGOK $

161  ADD       PG1,/PGO/ $

162  RBMG2     KBLL/LBLL/V,N,POWER/V,N,DET $

163  SAVE      DET,POWER $

164  CHKPNT    LBLL $

165  PRTPARM   //C,N,0/C,N,DET $

166  PRTPARM   //C,N,0/C,N,POWER $

167  JUMP      INLPTOP $
                                                        Top of Load
-------------------------------------------------------  Correction Loop
168  LABEL     INLPTOP $

169  PARAM     //C,N,KLOCK/V,N,TI $

170  SSG2      USET,GM,YS,KDFS,GO,,PG1/,PBO,PBS,PBL $

171  SSG3      LBLL,KBLL,PBL,,,/UBLV,,RUBLV,/C,N,-1/V,Y,IRES/V,N,NDSKIP/V,N,
               EPSI $

172  SAVE      EPSI $

173  CHKPNT    UBLV,RUBLV $

174  COND      LBL9D,IRES $

175  MATGPR    GPL,USET,SIL,RUBLV//C,N,L $

176  LABEL     LBL9D $

177  SDR1      USET,,UBLV,,YS,GO,GM,PBS,KBFS,KBSS,/UBGV,,QBG/C,N,1/C,N,DS1 $

178  CHKPNT    UBGV,QBG $

179  ADD       UBGV,UGV/DUGV/C,N,(-1.0,0.0) $

180  DSMG1     CASECC,GPTT,SIL,EDT,DUGV,CSTM,MPT,ECPT,GPCT,DIT/DKDGG/V,N,
               DSCOSET $

181  CHKPNT    DKDGG $

182  MPYAD     DKDGG,UBGV,PGO/PGI1/C,N,0/C,N,1/C,N,1/C,N,1 $

183  DSCHK     PG1,PGI1,UBGV//C,Y,EPSIO=1.E-5/V,N,DSEPSI/C,Y,NT=10/V,N,TO/V,N,
               TI/V,N,DONE/V,N,SHIFT/V,N,COUNT/C,Y,BETAD=4 $

184  SAVE      DSEPSI,DONE,SHIFT,COUNT $

185  COND      DONE,DONE $

186  COND      SHIFT,SHIFT $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 4

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

187  EQUIV    PG,PG1/NEVER $

188  EQUIV    PGI1,PG1/ALWAYS $

189  EQUIV    PG1,PGI1/NEVER $

190  REPT     INLPTOP,1000 $                    Bottom of Load
                                                 Correction Loop
191  TABPT    PGI1,PG1,PG,,// $

192  LABEL    SHIFT $

193  ADD      DKDGG,KDGG/KDGG1/C,N,(-1.0,0.0) $

194  CHKPNT   KDGG1 $

195  EQUIV    UBGV,UGV/ALWAYS/KDGG1,KDGG/ALWAYS $

196  CHKPNT   KDGG $

197  EQUIV    KDGG,KDGG1/NEVER/UGV,UBGV/NEVER $

198  REPT     OUTLPTOP,1000 $                   Bottom of Stiffness
                                                 Adjustment Loop
199  TABPT    KDGG1,KDGG,UGV,,// $

200  LABEL    DONE $

201  CHKPNT   CSTM $

202  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QBG,UBGV,EST,,/
              ,OQBG1,OUBGV1,OESB1,OEFB1,PUBGV1/C,N,DS1 $

203  OFP      OUBGV1,OQBG1,OEFB1,OESB1,,//V,N,CARDNO $

204  SAVE     CARDNO $

205  COND     P3,JUMPPLOT $

206  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUBGV1,,GPECT,
              OESB1/PLOTX3/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,
              PFILE $

207  SAVE     PFILE $

208  PRTMSG   PLOTX3// $

209  LABEL    P3 $

210  JUMP     FINIS $

211  LABEL    ERROR1 $

212  PRTPARM  //C,N,-1/C,N,DIFFSTIF $

213  LABEL    ERROR2 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 4

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

214  PRTPARM   //C,N,-2/C,N,DIFFSTIF $

215  LABEL     ERROR4 $

216  PRTPARM   //C,N,-4/C,N,DIFFSTIF $

217  LABEL     ERROR5 $

218  PRTPARM   //C,N,-5/C,N,DIFFSTIF $

219  LABEL     FINIS $

220  END       $
```

3.5.2 Description of DMAP Operations for Static Analysis with Differential Stiffness

2. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

4. Go to DMAP No. 211 if no grid point definition table.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot package is present.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plot request.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

28. Go to DMAP No. 211 and print error message if no structural elements

32. EMG generates structural element matrix tables and dictionaries for later assembly.

35. Go to DMAP No. 38 if no stiffness matrix is to be assembled.

36. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

39. Go to DMAP No. 42 if no mass matrix is to be assembled.

40. EMA assembles mass matrix $[M_{gg}]$.

43. Go to DMAP No. 47 if no weight and balance request.

44. Go to DMAP No. 215 and print error message if no mass matrix exists.

45. GPWG generates weight and balance information.

46. ØFP formats weight and balance information and places it on the system output file for printing.

48. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

50. Go to DMAP No. 53 if no general elements.

51. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

55. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

57. Go to DMAP No. 217 and print error message if no independent degrees of freedom are defined.

60. Go to DMAP No. 62 if no free-body supports supplied.

63. Go to DMAP No. 68 if general elements present.

64. GPSP determines if possible grid point singularities remain.

66. Go to DMAP No. 68 if no Grid Point Singularity Table.

67. ØFP formats table of possible grid point singularities and places it on the system output file for printing.

69. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

71. Go to DMAP No. 76 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

72. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

74. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

77. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

79. Go to DMAP No. 82 if no single-point constraints.

80. SCE1 partitions out single-point constraints.

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right].$$

83. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

85. Go to DMAP No. 88 if no omitted coordinates.

86. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

89. RMBG2 decomposes constrained stiffness matrix $[K_{aa}] = [L_{\ell\ell}][U_{\ell\ell}]$

91. SSG1 generates static load vectors $\{P_g\}$.

93. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

95. Go to DMAP No. 98 if no constraints applied.

96. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ \hline P_m \end{Bmatrix} \quad , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} \quad ,$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ \hline P_s \end{Bmatrix} \quad , \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\} \quad ,$$

$$\{P_f\} = \begin{Bmatrix} P_a \\ \hline P_o \end{Bmatrix} \quad \text{and} \qquad \{P_\ell\} = \{P_a\} + [G_o^T]\{P_o\} \quad .$$

99. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{aa}]^{-1}\{P_\ell\} \quad ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{aa}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}} \quad .$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}} \quad .$$

102. Go to DMAP No. 105 if residual vectors are not to be printed.

103. Print residual vector for independent coordinates (RULV).

104. Print residual vector for omitted coordinates (RUØV).

106. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_\ell\} + \{u_o^o\} ,$$

$$\begin{Bmatrix} u_a \\ \hline u_o \end{Bmatrix} = \{u_f\} , \qquad \begin{Bmatrix} u_f \\ \hline Y_s \end{Bmatrix} = \{u_n\} ,$$

$$\{u_m\} = [G_m]\{u_n\}, \qquad \begin{Bmatrix} u_n \\ \hline u_m \end{Bmatrix} = \{u_g\} ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} .$$

108. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).

110. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

112. Go to DMAP No. 116 if no static deformed structure plots are requested.

113. PLØT generates all requested static deformed structure plots.

115. PRTMSG prints plotter data and engineering data for each deformed plot generated.

117. TA1 generates element tables for use in differential stiffness matrix assembly.

118. DSMG1 generates differential stiffness matrix $[K_{gg}^d]$.

124. Go to next DMAP instruction if cold start or modified restart. ØUTLPTØP will be altered by the Executive System to the proper location inside the loop for unmodified restarts wtihin the loop.

125. Beginning of outer loop for differential stiffness iteration.

126. Equivalence $\{P_g\}$ to $\{P_{g1}\}$ if no enforced displacements.

129. Equivalence $[K_{gg}^d]$ to $[K_{nn}^d]$ if no multipoint constraints.

131. Go to DMAP No. 134 if no multipoint constraints.

132. MCE2 partitions differential stiffness matrix

$$[K_{gg}^d] = \left[\begin{array}{c|c} \bar{K}_{nn}^d & K_{nm}^d \\ \hline K_{mn}^d & K_{mm}^d \end{array}\right]$$

and performs matrix reduction $[K_{nn}^d] = [\bar{K}_{nn}^d] + [G_m^T][K_{mn}^d] + [K_{mn}^d][G_m] + [G_m^T][K_{mm}^d][G_m]$.

135. Equivalence $[K^d_{nn}]$ to $[K^d_{ff}]$ if no single-point constraints.

137. Go to DMAP No. 140 if no single-point constraints.

138. SCE1 partitions out single-point constraints

$$[K^d_{nn}] = \left[\begin{array}{c|c} K^d_{ff} & K^d_{fs} \\ \hline K^d_{sf} & K^d_{ss} \end{array}\right] .$$

141. Equivalence $[K^d_{ff}]$ to $[K^d_{aa}]$ if no omitted coordinates.

143. Go to DMAP No. 146 if no omitted coordinates.

144. SMP2 partitions constrained differential stiffness matrix

$$[K^d_{ff}] = \left[\begin{array}{c|c} \bar{K}^d_{aa} & K^d_{ao} \\ \hline K^d_{oa} & K^d_{oo} \end{array}\right]$$

and performs matrix reduction $[K^d_{aa}] = [\bar{K}^d_{aa}] + [K^d_{oa}]^T[G_o] + [G_o]^T[K^d_{oa}] + [G_o]^T[K^d_{oo}][G_o]$.

147. ADD $[K_{aa}]$ and $[K^d_{aa}]$ to form $[K^b_{\ell\ell}]$.

148. ADD $[K_{fs}]$ and $[K^d_{fs}]$ to form $[K^b_{fs}]$.

149. ADD $[K_{ss}]$ and $[K^d_{ss}]$ to form $[K^b_{ss}]$.

150. Go to DMAP No. 160 if no enforced displacements.

151. MPYAD multiply $[K^b_{ss}]$ and $\{Y_s\}$ to form $\{P_{ss}\}$.

152. MPYAD multiply $[K^b_{fs}]$ and $\{Y_s\}$ to form $\{P_{fs}\}$.

153. UMERGE expand $\{P_n\}$ to form $\{P^x_g\}$.

158. ADD $-\{P^x_g\}$ and $\{P_g\}$ to form $\{P_{gg}\}$.

159. Equivalence $\{P_{gg}\}$ to $\{P_{gl}\}$.

161. ADD $\{P_{gl}\}$ and nothing to create $\{P_{go}\}$.

162. RBMG2 decomposes the combined differential stiffness matrix and elastic stiffness matrix.

$$[K^b_{\ell\ell}] = [L^b_{\ell\ell}][U^b_{\ell\ell}].$$

165. PRTPARM prints the scaled value of the determinant of the combined differential stiffness matrix and elastic stiffness matrix.

166. PRTPARM prints the scale factor (power of ten) of the determinant of the combined differential stiffness matrix and the elastic stiffness matrix.

167. Go to next DMAP instruction if cold start or modified restart. INLPTØP will be altered by the executive system to the proper location inside the loop for unmodified restarts within the loop.

168. Beginning of inner loop for differential stiffness iteration.

170. SSG2 applies constraints to static load vectors

$$\{P_{gl}\} = \begin{Bmatrix} \bar{P}^b_n \\ -- \\ P^b_m \end{Bmatrix} , \qquad \{P^b_n\} = \{\bar{P}^b_n\} + [G^T_m]\{P^b_m\} ,$$

$$\{P^b_n\} = \begin{Bmatrix} \bar{P}^b_f \\ -- \\ P^b_s \end{Bmatrix} , \qquad \{P_f\} = \{\bar{P}^b_f\} - [K^d_{fs}]\{Y_s\} ,$$

$$\{P^b_f\} = \begin{Bmatrix} P^b_a \\ -- \\ P^b_o \end{Bmatrix} \quad \text{and} \quad \{P^b_\ell\} = \{P^b_a\} + [G^T_o]\{P^b_o\} .$$

171. SSG3 solves for displacements of independent coordinates for current differential stiffness load vector

$$\{u^b_\ell\} = [K^b_{\ell\ell}]^{-1}\{P^b_\ell\}$$

and calculates residual vector (RBULV) and residual vector error ratio for current differential stiffness load vector

$$\{\delta P^b_\ell\} = \{P^b_\ell\} - [K^b_{\ell\ell}]\{u^b_\ell\} ,$$

$$\varepsilon^b_\ell = \frac{\{u^b_\ell\}^T\{\delta P^b_\ell\}}{\{P^b_\ell\}^T\{u^b_\ell\}} .$$

174. Go to DMAP No. 176 if residual vector for current differential stiffness solution is not to be printed.

175. Print residual vector for current differential stiffness solution.

177. SDR1 recovers dependent displacements for current differential stiffness solution

$$\{u_o^b\} = [G_o]\{u_\ell^b\} + \{u_o^{ob}\} , \qquad \left\{\begin{array}{c} u_\ell^b \\ \hline u_o^b \end{array}\right\} = \{u_f^b\} ,$$

$$\left\{\begin{array}{c} u_f^b \\ \hline Y_s^b \end{array}\right\} = \{u_n^b\} , \qquad \{u_m^b\} = [G_m]\{u_n^b\} ,$$

$$\left\{\begin{array}{c} u_n^b \\ \hline u_m^b \end{array}\right\} = \{u_g^b\}$$

and recovers single-point forces of constraint for current differential stiffness solution

$$\{q_s^b\} = -\{P_s^b\} + [K_{sf}^b]\{u_f^b\} + [K_{ff}^b]\{Y_s^b\} .$$

179. ADD $-\{U_g^b\}$ and $\{U_g\}$ to form $\{U_g^d\}$.

180. DSMG1 generates differential stiffness matrix $[\delta K_{gg}^d]$

182. MPYAD form load vector for inner loop iteration.

$$\{P_{g_{I1}}\} = [\delta K_{gg}^d]\{U_g^b\} + \{P_{go}\}$$

183. DSCHK performs differential stiffness convergence checks.

185. Go to DMAP No. 200 if differential stiffness iteration is complete.

186. Go to DMAP No. 192 if additional differential stiffness matrix changes are necessary for further iteration.

187. Equivalence breaks previous equivalence of $\{P_g\}$ to $\{P_{g1}\}$.

188. Equivalence $\{P_{g_{I1}}\}$ to $\{P_{g1}\}$

189. Equivalence breaks previous equivalence of $\{P_{g1}\}$ to $\{P_{g_{I1}}\}$.

190. Go to DMAP No. 168 for additional inner loop differential stiffness iteration.

191. TABPT table prints vectors $\{P_{g_{I1}}\}$, $\{P_{g1}\}$, and $\{P_g\}$.

193. ADD $-[\delta K_{gg}^d]$ and $[K_{gg}^d]$ to form $[K_{gg1}^d]$.

195. Equivalence $\{U_g^b\}$ to $\{U_g\}$ and $[K_{gg1}^d]$ to $[K_{gg}^d]$.

197. Equivalence breaks previous equivalence of $[K^d_{gg}]$ to $[K^d_{gg1}]$ and $\{U_g\}$ to $\{U^b_g\}$.

198. Go to DMAP No. 125 for additional outer loop differential stiffness iteration.

199. TABPT table prints $[K^d_{gg1}]$, $[K^d_{gg}]$ and $\{U_g\}$.

202. SDR2 calculates element forces and stresses (ØEFB1, ØESB1) and prepares displacement vectors and single-point forces of constraint for output (ØUBGV1, PUBGV1, ØQBG1) for all differential stiffness solutions.

203. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

205. Go to DMAP No. 209 if no deformed differential stiffness structure plots are requested.

206. PLØT generates all requested deformed differential stiffness structure plots.

208. PRTMSG prints plotter data and engineering data for each deformed plot generated.

210. Go to DMAP No. 219 and make normal exit.

212. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

214. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 2 - FREE BØDY-SUPPØRTS NØT ALLØWED.

216. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 4 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIONS.

218. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 5 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

3.5.3 Automatic Output for Static Analysis with Differential Stiffness

The value of the determinant of the sum of the elastic stiffness and the differential stiffness is automatically printed for each differential stiffness loading condition.

Iterative differential stiffness computations are terminated for one of five reasons. Iteration termination reasons are automatically printed in an information message. These reasons have the following meanings:

1. REASON 0 means the iteration procedure was incomplete at the time of exit. This is caused by an unexpected interruption of the iteration procedure prior to the time the subroutine has had a chance to perform necessary checks and tests. Not much more has happened other than to initialize the exit mode to REASON 0.

2. REASON 1 means the iteration procedure converged to the EPSIØ value supplied by the user on a PARAM bulk data card. (The default value of EPSIØ is 1.0E-5.)

3. REASON 2 means iteration procedure is diverging from the EPSIØ value supplied by the user on a PARAM bulk data card. (The default value of EPSIØ is 1.0E-5.)

4. REASON 3 means insufficient time remaining to achieve convergence to the EPSIØ value supplied by the user on a PARAM bulk data card. (The default value of EPSIØ is 1.0E-5.)

5. REASON 4 means the number of iterations supplied by the user on a PARAM bulk data card has been met. (The default number of iterations is 10.)

Parameter values at the time of exit are automatically output as follows:

1. Parameter DØNE: -1 is normal; + N is the estimate of the number of iterations required to achieve convergence.

2. Parameter SHIFT: +1 indicates a return to the top of the inner loop was scheduled; -1 indicates a return to top of the outer loop was scheduled following the current iteration.

3. Parameter DSEPSI: the value of the ratio of energy error to total energy at the time of exit.

3.5.4 Case Control Deck and Parameters for Static Analysis with Differential Stiffness

The following items relate to subcase definition and data selection for Static Analysis with Differential Stiffness:

1. The Case Control Deck must contain at least two subcases. Other than DSCØEFFICIENT in the second subcase, all subcases are used only for output selection.
2. DSCØEFFICIENT must appear in the second subcase, either to select a DSFACT set from the Bulk Data Deck, or to explicitly select the default value of unity.
3. A static loading condition must be defined above the subcase level with a LØAD, TEMPERATURE(LØAD), or DEFØRM selection, unless all loading is specified by grid point displacements on SPC cards.
4. An SPC set must be selected above the subcase level unless all constraints are specified on GRID cards.
5. Output requests that apply only to the linear solution must appear in the first subcase.
6. Output requests that apply only to the solution with differential stiffness must be placed in the second and succeeding subcases. If only two subcases exist, the output requests in the second subcase will be honored for all differential stiffness loading conditions.
7. Output requests that apply to all solutions, both with and without differential stiffness may be placed above the subcase level.

The following output may be requested for Static Analysis with Differential Stiffness:

1. Nonzero Components of the applied static load for the linear solution at selected grid points.
2. Displacement and nonzero components of the single-point forces of constraint, with and without differential stiffness, at selected grid points.
3. Forces and stresses in selected elements, with and without differential stiffness.
4. Undeformed and deformed plots of the structural model.

The following parameters are used in Static Analysis with Differential Stiffness:

RIGID FORMATS

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in EMG.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

5. BETAD - optional - the integer value of this parameter is the assumed number of iterations for the inner loop in shift decisions for iterated differential stiffness. The default value is 4 iterations.

6. NT - optional - the integer value of this parameter limits the maximum number of iterations. The default value is 10 iterations.

7. EPSIØ - optional - the real value of this parameter is used to test the convergence of iterated differential stiffness. The default value is 10^{-5}.

3.6 BUCKLING ANALYSIS

3.6.1 DMAP Sequence for Buckling Analysis

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 5

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

   1  BEGIN    NO.5 BUCKLING ANALYSIS - SERIES N $

   2  FILE     LAMA=APPEND/PHIA=APPEND $

   3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

   4  SAVE     LUSET $

   5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

   6  GP2      GEOM2,EQEXIN/ECT $

   7  CHKPNT   ECT $

   8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

  10  COND     P1,NOPCDB $

  11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT=-1 $

  12  SAVE     NSIL,JUMPPLOT $

  13  PRTMSG   PLTSETX// $

  14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

  15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

  16  COND     P1,JUMPPLOT $

  17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/   V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

  18  SAVE     JUMPPLOT,PLTFLG,PFILE $

  19  PRTMSG   PLOTX1// $

  20  LABEL    P1 $

  21  CHKPNT   PLTPAR,GPSETS,ELSETS $

  22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

  23  SAVE     NOGRAV $

  24  PARAM    //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRDPNT=-1 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 5

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 25  CHKPNT    SLT,GPTT $

 26  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
               NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

 27  SAVE      NOSIMP,NOGENL,GENEL $

 28  COND      ERROR1,NOSIMP $

 29  PURGE     OGPST/GENEL $

 30  CHKPNT    EST,GPECT,GEI,OGPST $

 31  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

 32  EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
               N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
               CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
               CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

 33  SAVE      NOKGGX,NOMGG $

 34  CHKPNT    KELM,KDICT,MELM,MDICT $

 35  COND      JMPKGG,NOKGGX $

 36  EMA       GPECT,KDICT,KELM/KGGX,GPST $

 37  CHKPNT    KGGX,GPST $

 38  LABEL     JMPKGG $

 39  COND      JMPMGG,NOMGG $

 40  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

 41  CHKPNT    MGG $

 42  LABEL     JMPMGG $

 43  COND      LBL1,GRDPNT $

 44  COND      ERROR5,NOMGG $

 45  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $

 46  OFP       OGPWG,,,,,// $

 47  LABEL     LBL1 $

 48  EQUIV     KGGX,KGG/NOGENL $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 5

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 49  CHKPNT   KGG $

 50  COND     LBL11,NOGENL $

 51  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 52  CHKPNT   KGG $

 53  LABEL    LBL11 $

 54  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 55  GP4      CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,
              LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
              NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 56  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

 57  COND     ERROR6,NOL $

 58  PARAM    //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $

 59  PURGE    GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS/SINGLE/  QG/
              NOSR $

 60  CHKPNT   GM,RG,GO,KOO,LOO,PO,UOOV,RUOV,YS,PS,KFS,KSS,USET,ASET,QG $

 61  COND     LBL4D,REACT $

 62  JUMP     ERROR2 $

 63  LABEL    LBL4D $

 64  COND     LBL4,GENEL $

 65  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 66  SAVE     NOGPST $

 67  COND     LBL4,NOGPST $

 68  OFP      OGPST,,,,,// $

 69  LABEL    LBL4 $

 70  EQUIV    KGG,KNN/MPCF1 $

 71  CHKPNT   KNN $

 72  COND     LBL2,MPCF2 $

 73  MCE1     USET,RG/GM $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 5

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 74  CHKPNT   GM $

 75  MCE2     USET,GM,KGG,,,/KNN,,, $

 76  CHKPNT   KNN $

 77  LABEL    LBL2 $

 78  EQUIV    KNN,KFF/SINGLE $

 79  CHKPNT   KFF $

 80  COND     LBL3,SINGLE $

 81  SCE1     USET,KNN,,,/KFF,KFS,KSS,,, $

 82  CHKPNT   KFS,KSS,KFF $

 83  LABEL    LBL3 $

 84  EQUIV    KFF,KAA/OMIT $

 85  CHKPNT   KAA $

 86  COND     LBL5,OMIT $

 87  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

 88  CHKPNT   GO,KAA,KOO,LOO $

 89  LABEL    LBL5 $

 90  RBMG2    KAA/LLL $

 91  CHKPNT   LLL $

 92  SSG1     SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/ V,N,
              LUSET/C,N,1 $

 93  CHKPNT   PG $

 94  EQUIV    PG,PL/NOSET $

 95  CHKPNT   PL $

 96  COND     LBL10,NOSET $

 97  SSG2     USET,GM,YS,KFS,GO,,PG/,PO,PS,PL $

 98  CHKPNT   PO,PS,PL $

 99  LABEL    LBL10 $
```

RIGID FORMAT DMAP LISTING
SERIES N .

RIGID FORMAT 5

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

100  SSG3     LLL,KAA,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
              C,N,1/V,N,EPSI $

101  SAVE     EPSI $

102  CHKPNT   ULV,UOOV,RULV,RUOV $

103  COND     LBL9,IRES $

104  MATGPR   GPL,USET,SIL,RULV//C,N,L $

105  MATGPR   GPL,USET,SIL,RUOV//C,N,O $

106  LABEL    LBL9 $

107  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PGG,QG/C,N,1/C,N,
              BKLO $

108  CHKPNT   UGV,QG,PGG $

109  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,,PGG/
              OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,BKLO $

111  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

112  SAVE     CARDNO $

113  COND     P2,JUMPPLOT $

114  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

115  SAVE     PFILE $

116  PRTMSG   PLOTX2// $

117  LABEL    P2 $

118  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/X1,X2,ECPT,GPCT/V,N,LUSET/  V,N,
              NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

119  DSMG1    CASECC,GPTT,SIL,EDT,UGV,CSTM,MPT,ECPT,GPCT,DIT/KDGG/  V,N,
              DSCOSET $

120  CHKPNT   KDGG $

121  EQUIV    KDGG,KDNN/MPCF2 $

122  CHKPNT   KDNN $

123  COND     LBL2D,MPCF2 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 5

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP  INSTRUCTION
 NO.

124  MCE2     USET,GM,KDGG,,,/KDNN,,, $

125  CHKPNT   KDNN $

126  LABEL    LBL2D $

127  EQUIV    KDNN,KDFF/SINGLE $

128  CHKPNT   KDFF $

129  COND     LBL3D,SINGLE $

130  SCE1     USET,KDNN,,,/KDFF,KDFS,,,, $

131  CHKPNT   KDFF,KDFS $

132  LABEL    LBL3D $

133  EQUIV    KDFF,KDAA/OMIT $

134  CHKPNT   KDAA $

135  COND     LBL5D,OMIT $

136  SMP2     USET,GO,KDFF/KDAA $

137  CHKPNT   KDAA $

138  LABEL    LBL5D $

139  ADD      KDAA,/KDAAM/C,N,(-1.0,0.0)/C,N,(0.0,0.0) $

140  CHKPNT   KDAAM $

141  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,,,EED,EQDYN/V,N,
              LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/   V,
              N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

142  SAVE     NOEED $

143  COND     ERROR3,NOEED $

144  CHKPNT   EED $

145  PARAM    //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $

146  READ     KAA,KDAAM,,,EED,USET,CASECC/LAMA,PHIA,,OEIGS/C,N,BUCKLING/ V,N,
              NEIGV/C,N,2 $

147  SAVE     NEIGV $

148  CHKPNT   LAMA,PHIA,OEIGS $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 5

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

149  OFP      OEIGS,LAMA,,,,//V,N,CARDNO $

150  SAVE     CARDNO $

151  COND     ERROR4,NEIGV $

152  SDR1     USET,,PHIA,,,GO,GM,,KFS,,/PHIG,,BQG/C,N,1/C,N,BKL1 $

153  CHKPNT   PHIG,BQG $

154  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,BQG,PHIG,EST,,/,
              OBQG1,OPHIG,OBES1,OBEF1,PPHIG/C,N,BKL1 $

155  OFP      OPHIG,OBQG1,OBEF1,OBES1,,//V,N,CARDNO $

156  SAVE     CARDNO $

157  COND     P3,JUMPPLOT $

158  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,PPHIG,GPECT,
              OBES1/PLOTX3/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,
              PFILE $

159  SAVE     PFILE $

160  PRTMSG   PLOTX3// $

161  LABEL    P3 $

162  JUMP     FINIS $

163  LABEL    ERROR1 $

164  PRTPARM  //C,N,-1/C,N,BUCKLING $

165  LABEL    ERROR2 $

166  PRTPARM  //C,N,-2/C,N,BUCKLING $

167  LABEL    ERROR3 $

168  PRTPARM  //C,N,-3/C,N,BUCKLING $

169  LABEL    ERROR4 $

170  PRTPARM  //C,N,-4/C,N,BUCKLING $

171  LABEL    ERROR5 $

172  PRTPARM  //C,N,-5/C,N,BUCKLING $

173  LABEL    ERROR6 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 5

```
   N A S T R A N  S O U R C E  P R O G R A M  C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

174  PRTPARM  //C,N,-6/C,N,BUCKLING $

175  LABEL    FINIS $

176  END      $
```

3.6.2 Description of DMAP Operations for Buckling Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations and tables for relating internal and external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot package is present.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plot request.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

28. Go to DMAP No. 163 and print error message if no structural elements.

32. EMG generates structural element matrix tables and dictionaries for later assembly.

35. Go to DMAP No. 38 if no stiffness matrix is to be assembled.

36. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

39. Go to DMAP No. 42 if no mass matrix is to be assembled.

40. EMA assembles mass matrix $[M_{gg}]$.

43. Go to DMAP No. 47 if no gravity loads and no weight and balance request.

44. Go to DMAP No. 171 and print error message if no mass matrix exists.

45. GPWG generates weight and balance information.

46. ØFP formats weight and balance information and places it on the system output file for printing.

48. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

50. Go to DMAP No. 53 if no general elements.

51. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

55. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

57. Go to DMAP No. 173 and print error message if no independent degrees of freedom are defined.

61. Go to DMAP No. 63 if no free-body supports supplied.

62. Go to DMAP No. 165 and print error message if free-body supports are present.

64. Go to DMAP No. 69 if general elements present.

65. GPSP determines if possible grid point singularities remain.

67. Go to DMAP No. 69 if no Grid Point Singuarity Table.

68. ØFP formats table of possible grid point singularities and places it on the system output file for printing.

70. Equivalence $[K_{aa}]$ to $[K_{nn}]$ if no multipoint constraints.

72. Go to DMAP No. 77 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

73. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

75. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

78. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

80. Go to DMAP No. 88 if no single-point constraints.

81. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right].$$

84. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

86. Go to DMAP No. 89 if no omitted coordinates.

87. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right],$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

90. RBMG2 decomposes constrained stiffness matrix $[K_{aa}] = [L_{\ell\ell}][U_{\ell\ell}]$.

92. SSG1 generates static load vectors $\{P_g\}$.

94. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

96. Go to DMAP No. 99 if no constraints applied.

97. SSG2 applies constraints to static load vectors

$$\{P_g\} = \left\{\begin{array}{c}\bar{P}_n \\ \hline P_m\end{array}\right\}, \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \left\{\begin{array}{c}\bar{P}_f \\ \hline P_s\end{array}\right\}, \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \left\{\begin{array}{c}P_a \\ \hline P_o\end{array}\right\} \text{ and } \{P_\ell\} = \{P_a\} + [G_o^T]\{P_o\} \quad .$$

100. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o\}}$$

103. Go to DMAP No. 106 if residual vectors are not to be printed.

104. Print residual vector for independent coordinates (RULV)

105. Print residual vector for omitted coordinates (RUØV).

107. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_\ell\} + \{u_o^o\} ,$$

$$\begin{Bmatrix} u_a \\ \hline u_o \end{Bmatrix} = \{u_f\} \quad , \qquad \begin{Bmatrix} u_f \\ \hline Y_s \end{Bmatrix} = \{u_n\},$$

$$\{u_m\} = [G_m]\{u_n\} \quad , \qquad \begin{Bmatrix} u_n \\ \hline u_m \end{Bmatrix} = \{u_g\},$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\}.$$

109. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).

111. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

113. Go to DMAP No. 117 if no static deformed structure plots are requested.

114. PLØT generates all requested static deformed structure plots.

116. PRTMSG prints plotter data and engineering data for each deformed plot generated.

118. TA1 generates element tables for use in differential stiffness matrix assembly.

119. DSMG1 generates differential stiffness matrix $[K_{gg}^d]$.

121. Equivalence $[K_{gg}^d]$ to $[K_{nn}^d]$ if no multipoint constraints.

123. Go to DMAP No. 126 if no multipoint constraints.

124. MCE2 partitions differential stiffness matrix

$$[K_{gg}^d] = \left[\begin{array}{c|c} \bar{K}_{nn}^d & K_{nm}^d \\ \hline K_{mn}^d & K_{mm}^d \end{array}\right]$$

and performs matrix reduction $[K_{nn}^d] = [\bar{K}_{nn}^d] + [G_m^T][K_{mn}^d] + [K_{mn}^d][G_m] + [G_m^T][K_{mm}^d][G_m]$.

127. Equivalence $[K_{nn}^d]$ to $[\bar{K}_{ff}^d]$ if no single-point constraints.

129. Go to DMAP No. 132 if no single-point constraints.

130. SCE1 partitions out single-point constraints

$$[K_{nn}^d] = \left[\begin{array}{c|c} K_{ff}^d & K_{fs}^d \\ \hline K_{sf}^d & K_{ss}^d \end{array}\right].$$

133. Equivalence $[K_{ff}^d]$ to $[K_{aa}^d]$ if no omitted coordinates.

135. Go to DMAP No. 138 if no omitted coordinates.

136. SMP2 partitions constrained differential stiffness matrix

$$[K^d_{ff}] = \left[\begin{array}{c|c} \bar{K}^d_{aa} & K^d_{ao} \\ \hline K^d_{oa} & K^d_{oo} \end{array}\right]$$

and performs matrix reduction $[K^d_{aa}] = [\bar{K}^d_{aa}] + [K^d_{oa}]^T[G_o] + [G_o]^T[K^d_{oa}] + [G_o]^T[K^d_{oo}][G_o]$.

141. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

143. Go to DMAP No. 167 and print error message if no Eigenvalue Extraction Data.

146. READ extracts real eigenvalues from the equation

$$[K_{\ell\ell} + \lambda K^d_{\ell\ell}]\{u_\ell\} = 0$$

and normalizes eigenvectors according to one of the following user requests:
1) Unit value of selected coordinate
2) Unit value of largest component

149. ØFP formats eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

151. Go to DMAP No.169 and print error message if no eigenvalues found.

152. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} , \qquad \left\{\begin{array}{c} \phi_a \\ \hline \phi_o \end{array}\right\} = \{\phi_f\} ,$$

$$\left\{\begin{array}{c} \phi_f \\ \hline \phi_s \end{array}\right\} = \{\phi_n\} , \qquad \{\phi_m\} = [G_m]\{\phi_n\} ,$$

$$\left\{\begin{array}{c} \phi_n \\ \hline \phi_m \end{array}\right\} = \{\phi_g\}$$

and recovers single point forces of constraint $\{q_s\} = [K^T_{fs}]\{\phi_f\}$.

154. SDR2 calculates element forces and stresses (ØBEF1, ØBES1) and prepares eigenvectors and single-point forces of constraint for output (ØPHIG, PPHIG, ØBQG1).

155. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

157. Go to DMAP No. 161 if no deformed (buckling) structure plots are requested.

158. PLØT generates all requested deformed (buckling) structure plots.

160. PRTMSG prints plotter data and engineering data for each deformed plot generated.

162. Go to DMAP No. 175 and make normal exit.

164 BUCKLING ANALYSIS ERRØR MESSAGE NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

166. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 2 - FREE BØDY-SUPPØRTS NØT ALLØWED.

168. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 3 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

170. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 4 - NØ EIGENVALUES FØUND.

172. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 5 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

174. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 6 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

3.6.3 Automatic Output for Buckling Analysis

The summary of the eigenvalues associated with the buckling modes and the summary of the eigenvalue analysis performed, as described in the Normal Mode Analysis rigid format, are automatically printed.

3.6.4 Case Control Deck and Parameters for Buckling Analysis

The following items relate to subcase definition and data selection for Buckling Analysis:

1. The Case Control Deck must contain at least two subcases. Subcases beyond the second are used only for output selection.
2. METHØD must appear in the second subcase to select an EIGB card from the Bulk Data Deck.
3. A static loading condition must be defined in the first subcase with a LØAD, TEMPERATURE(LØAD), or DEFØRM selection, unless all loading is specified by grid point displacements on SPC cards.
4. An SPC set must be selected above the subcase level, unless all constraints are specified on GRID cards.
5. Output requests that apply only to the solution under static load must be placed in the first subcase.
6. Output requests that apply to the buckling solution only must be placed in the second and succeeding subcases. If only two subcases exist, the output requests in the second subcase will be honored for all buckling modes.
7. Output requests that apply to both the static solution and the buckling modes may be placed above the subcase level.

The following output may be requested for Buckling Analysis:

1. Displacements and nonzero components of the static loads and single-point forces of constraint at selected grid points for the static analysis.
2. Forces and stresses in selected elements for the static loading condition.
3. Mode shapes and nonzero components of the single-point forces of constraint at selected grid points for selected modes.
4. Undeformed plot of the structural model and mode shapes for selected buckling modes.

The following parameters are used in Buckling Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.7 PIECEWISE LINEAR ANALYSIS

3.7.1 DMAP Sequence for Piecewise Linear Analysis

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 6

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

  1  BEGIN    NO.6 PIECEWISE LINEAR STATIC ANALYSIS - SERIES N $

  2  FILE     QG1=APPEND/UGV1=APPEND/KGGSUM=SAVE/PGV1=APPEND $

  3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
              NOGPDT $

  4  SAVE     LUSET $

  5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  6  GP2      GEOM2,EQEXIN/ECT $

  7  CHKPNT   ECT $

  8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

 10  COND     P1,NOPCDB $

 11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
              JUMPPLOT=-1 $

 12  SAVE     NSIL,JUMPPLOT $

 13  PRTMSG   PLTSETX// $

 14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 16  COND     P1,JUMPPLOT $

 17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/   V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 18  SAVE     JUMPPLOT,PLTFLG,PFILE $

 19  PRTMSG   PLOTX1// $

 20  LABEL    P1 $

 21  CHKPNT   PLTPAR,GPSETS,ELSETS $

 22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

 23  SAVE     NOGRAV $

 24  PARAM    //C,N,AND/V,N,SKPMGG/V,N,NOGRAV/V,Y,GRDPNT $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FCRMAT 6

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 25  CHKPNT    SLT,GPTT $

 26  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,ECPT ,GPCT/V,N,LUSET/   V,
               N,NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

 27  SAVE      NOSIMP,NOGENL,GENEL $

 28  PARAM     //C,N,AND/V,N,NOELMT/V,N,NOGENL/V,N,NOSIMP $

 29  COND      ERROR4,NOELMT $

 30  PURGE     GPST/NOSIMP/OGPST/GENEL $

 31  CHKPNT    EST,ECPT,GPCT,GEI,GPST,OGPST $

 32  COND      LBL1,NOSIMP $

 33  SMA1      CSTM,MPT,ECPT,GPCT,DIT/KGGX,,GPST/V,N,NOGENL/V,N,NOK4GG $

 34  CHKPNT    GPST,KGGX $

 35  COND      LBL1,SKPMGG $

 36  SMA2      CSTM,MPT,ECPT,GPCT,DIT/MGG,/V,Y,WTMASS=1.0/V,N,NOMGG/V,N,NOBGG/
               C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,
               CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/C,Y,CPQDPLT/C,Y,CPTRPLT/C,Y,
               CPTRBSC $

 37  SAVE      NOMGG $

 38  CHKPNT    MGG $

 39  COND      LBL1,GRDPNT $

 40  COND      ERROR3,NOMGG $

 41  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $

 42  OFP       OGPWG,,,,,// $

 43  LABEL     LBL1 $

 44  PLA1      CSTM,MPT,ECPT,GPCT,DIT,CASECC,EST/KGGXL,ECPTNL,ESTL,ESTNL/V,N,
               KGGLPG/V,N,NPLALIM/V,N,ECPTNLPG/V,N,PLSETNO/V,N,NONLSTR/V,N,
               PLFACT $

 45  SAVE      KGGLPG,NPLALIM,ECPTNLPG,PLSETNO,NONLSTR,PLFACT $

 46  COND      ERROR1,ECPTNLPG $

 47  PURGE     ONLES,ESTNL1/NONLSTR $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 6

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 48   CHKPNT    KGGXL,ECPTNL,ESTL,ESTNL,ESTNL1 $

 49   PARAM     //C,N,ADD/V,N,ALWAYS/C,N,-1/C,N,0 $

 50   PARAM     //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

 51   EQUIV     KGGX,KGG/NOGENL/KGGXL,KGGL/NOGENL $

 52   CHKPNT    KGG,KGGL $

 53   COND      LBL11,NOGENL $

 54   SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 55   CHKPNT    KGG $

 56   SMA3      GEI,KGGXL/KGGL/V,N,LUSET/V,N,NOGENL/V,N,KGGLPG $

 57   CHKPNT    KGGL $

 58   LABEL     LBL11 $

 59   PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 60   GP4       CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,
                LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
                NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 61   SAVE      MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

 62   PARAM     //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $

 63   PURGE     KRR,KLR,QR,DM/REACT/GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,
                KFS,KSS/SINGLE/QG/NOSR $

 64   CHKPNT    KRR,KLR,QR,DM,GM,GO,KOO,LOO,PO,UOOV,QG,PS,KFS,KSS,USET,RG,YS,
                RUOV $

 65   SSG1      SLT,BGPDT,CSTM,SIL,EST,MPT,,,MGG,CASECC,DIT/PG1/V,N,    LUSET/C,
                N,1 $

 66   CHKPNT    PG1 $

 67   EQUIV     PG1,PL/NOSET $

 68   CHKPNT    PL $

 69   COND      LBL4,GENEL $

 70   GPSP      GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 71   SAVE      NOGPST $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 6

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 72  COND      LBL4,NOGPST $
 73  OFP       OGPST,,,,,// $
 74  LABEL     LBL4 $
 75  PARAM     //C,N,ADD/V,N,PLACOUNT/C,N,1/C,N,0 $
 76  EQUIV     KGG,KNN/MPCF1 $
 77  CHKPNT    KNN $
 78  COND      LBL2,MPCF2 $
 79  MCE1      USET,RG/GM $
 80  CHKPNT    GM $
 81  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
 82  JUMP      LOOPBGN $
--------------------------------------------------- Top of DMAP Loop
 83  LABEL     LOOPBGN $
 84  EQUIV     KGG,KNN/MPCF2 $
 85  CHKPNT    KNN $
 86  COND      LBL2,MPCF2 $
 87  MCE2      USET,GM,KGG,,,/KNN,,, $
 88  CHKPNT    KNN $
 89  LABEL     LBL2 $
 90  EQUIV     KNN,KFF/SINGLE $
 91  CHKPNT    KFF $
 92  COND      LBL3,SINGLE $
 93  SCE1      USET,KNN,,,/KFF,KFS,KSS,,, $
 94  CHKPNT    KFS,KSS,KFF $
 95  LABEL     LBL3 $
 96  EQUIV     KFF,KAA/OMIT $
 97  CHKPNT    KAA $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 6

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 98  COND     LBL5,OMIT $

 99  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

100  CHKPNT   GO,KAA,KOO,LOO $

101  LABEL    LBL5 $

102  EQUIV    KAA,KLL/REACT $

103  CHKPNT   KLL $

104  COND     LBL6,REACT $

105  RBMG1    USET,KAA,/KLL,KLR,KRR,,, $

106  CHKPNT   KLL,KLR,KRR $

107  LABEL    LBL6 $

108  DECOMP   KLL/LLL,/C,N,1/C,N,0/V,N,MINDIAGK/V,N,DETKLLXX/V,N,IDETKLLX/ V,
              N,SINGKLLX $

109  SAVE     SINGKLLX $

110  COND     LOOPENDA,SINGKLLX $

111  CHKPNT   LLL $

112  COND     LBL7,REACT $

113  RBMG3    LLL,KLR,KRR/DM $

114  CHKPNT   DM $

115  LABEL    LBL7 $

116  ADD      PG1,/PG/V,N,PLFACT $

117  CHKPNT   PG $

118  COND     LBL10,NOSET $

119  SSG2     USET,GM,YS,KFS,GO,DM,PG/QR,PO,PS,PL $

120  CHKPNT   QR,PO,PS,PL $

121  LABEL    LBL10 $

122  SSG3     LLL,KLL,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
              V,N,PLACOUNT/V,N,EPSI $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 6

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

123  SAVE     EPSI $

124  CHKPNT   ULV,UOOV,RULV,RUOV $

125  COND     LBL9,IRES $

126  MATGPR   GPL,USET,SIL,RULV//C,N,L $

127  MATGPR   GPL,USET,SIL,RUOV//C,N,O $

128  LABEL    LBL9 $

129  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,QR/DELTAUGV,DELTAPG,
              DELTAQG/C,N,1/C,N,STATICS $

130  CHKPNT   DELTAUGV,DELTAPG,DELTAQG $

131  PLA2     DELTAUGV,DELTAPG,DELTAQG/UGV1,PGV1,QG1/V,N,PLACOUNT $

132  SAVE     PLACOUNT $

133  CHKPNT   UGV1,QG1,PGV1 $

134  EQUIV    ESTNL,ESTNL1/NEVER/ECPTNL,ECPTNL1/NEVER $

135  COND     PLALBL2A,NONLSTR $

136  PLA3     CSTM,MPT,DIT,DELTAUGV,ESTNL,CASECC/ONLES,ESTNL1/V,N,PLACOUNT/
              V,N,PLSETNO $

137  CHKPNT   ESTNL1 $

138  OFP      ONLES,,,,,//V,N,CARDNO $

139  SAVE     CARDNO $

140  LABEL    PLALBL2A $

141  PARAM    //C,N,SUB/V,N,DIFF/V,N,NPLALIM/V,N,PLACOUNT $

142  COND     LOOPEND,DIFF $

143  PLA4     CSTM,MPT,ECPTNL,GPCT,DIT,DELTAUGV/KGGNL,ECPTNL1/V,N,PLACOUNT/V,
              N,PLSETNO/V,N,PLFACT $

144  SAVE     PLACOUNT,PLSETNO,PLFACT $

145  CHKPNT   KGGNL,ECPTNL1 $

146  EQUIV    KGGNL,KGGSUM/KGGLPG $

147  CHKPNT   KGGSUM $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 6

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

148  COND      PLALBL3,KGGLPG $

149  ADD       KGGNL,KGGL/KGGSUM $

150  CHKPNT    KGGSUM $

151  LABEL     PLALBL3 $

152  EQUIV     KGGSUM,KGG/ALWAYS $

153  CHKPNT    KGG $

154  EQUIV     ESTNL1,ESTNL/ALWAYS/ECPTNL1,ECPTNL/ALWAYS $

155  CHKPNT    ESTNL,ECPTNL $

156  COND      PLALBL4,ALWAYS $

157  PLA2      KGGSUM,KGG,/,,/C,N,0 $

158  PLA2      ESTNL1,ECPTNL1,/,,/C,N,0 $

159  LABEL     PLALBL4 $

160  REPT      LOOPBGN,100 $
------------------------------------------------  Bottom of DMAP Loop
161  JUMP      ERROR2 $

162  LABEL     LOOPENDA $

163  PRTPARM   //C,N,+5/C,N,PLA $

164  LABEL     LOOPEND $

165  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG1,UGV1,ESTL,,
               PGV1/OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,PLA $

166  OFP       OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

167  SAVE      CARDNO $

168  COND      P2,JUMPPLOT $

169  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,ECPT,OES1/
               PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

170  SAVE      PFILE $

171  PRTMSG    PLOTX2// $

172  LABEL     P2 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 6

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

173  JUMP     FINIS $

174  LABEL    ERROR1 $

175  PRTPARM  //C,N,-1/C,N,PLA $

176  LABEL    ERROR2 $

177  PRTPARM  //C,N,-2/C,N,PLA $

178  LABEL    ERROR3 $

179  PRTPARM  //C,N,-3/C,N,PLA $

180  LABEL    ERROR4 $

181  PRTPARM  //C,N,-4/C,N,PLA $

182  LABEL    FINIS $

183  END      $
```

3.7.2 Description of DMAP Operations for Piecewise Linear Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot package is present.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plot request.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

29. Go to DMAP No. 180 and print error message if no elements have been defined.

32. Go to DMAP No. 43 if there are no structural elements.

33. SMA1 generates stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

35. Go to DMAP No. 43 if no gravity loads and no weight and balance request.

36. SMA2 generates mass matrix $[M_{gg}]$.

39. Go to DMAP No. 43 if no weight and balance request.

40. Go to DMAP No. 178 and print error message if no mass matrix exists.

41. GPWG generates weight and balance information.

42. ØFP formats weight and balance information and places it on the system output file for printing.

44. PLA1 extracts the linear terms from $[K^x_{gg}]$ to give $[K^{x\ell}_{gg}]$, extracts the nonlinear entries from the Element Connection and Properties Table to give ECPTNL, and separates the linear and nonlinear entries in the Element Summary Table to give ESTL and ESTNL.

46. Go to DMAP No. 174 and print error message if no elements have a stress dependent modulus of elasticity.

51. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ and $[K^{x\ell}_{gg}]$ to $[K^\ell_{gg}]$ if no general elements.

53. Go to DMAP No. 58 if no general elements.

54. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

56. SMA3 adds general elements to $[K^{x\ell}_{gg}]$ to obtain stiffness matrix of linear elements $[K^\ell_{gg}]$.

60. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

65. SSG1 generates total static load vector $\{P_g^1\}$.

67. Equivalence $\{P_g^1\}$ to $\{P_\ell\}$ if no constraints applied.

69. Go to DMAP No. 74 if general elements present.

70. GPSP determines if possible grid point singularities remain.

72. Go to DMAP No. 74 if no Grid Point Singularity Table.

73. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

76. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

78. Go to DMAP No. 89 if no multipoint constraints.

79. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

82. Beginning of loop for Piecewise Linear Analysis.

84. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

86. Go to DMAP No. 91 if no multipoint constraints.

87. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

90. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

92. Go to DMAP No. 95 if no single-point constraints.

93. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right].$$

96. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

98. Go to DMAP No. 101 if no omitted coordinates.

99. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right],$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$ and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

102. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

104. Go to DMAP No. 107 if no free-body supports.

105. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right]$$

108. DECØMP decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

110. Go to DMAP No. 166 if stiffness matrix $[K_{\ell\ell}]$ is singular (i.e., local plasticity).

112. Go to DMAP No. 117 if no free-body supports.

113. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

116. Multiply total load vector $\{P_g^1\}$ by factor to obtain applied load vector $\{P_g\}$ for current loop.

118. Go to DMAP No. 121 if no constraints applied.

119. SSG2 applies constraints to static load vector for current loop.

$$\{P_g\} = \left\{\begin{array}{c} \bar{P}_n \\ \hline P_m \end{array}\right\}, \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \left\{\begin{array}{c} \bar{P}_f \\ \hline P_s \end{array}\right\}, \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \left\{\begin{array}{c} \bar{P}_a \\ \hline P_o \end{array}\right\}, \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\},$$

$$\{P_a\} = \left\{\begin{array}{c} P_\ell \\ \hline P_r \end{array}\right\}$$

and calculates incremental determinate forces of reaction for current loop

$$\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}.$$

122. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\} .$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}} .$$

125. Go to DMAP No. 128 if residual vectors are not to be printed.

126. Print residual vector for independent coordinates (RULV)

127. Print residual vector for omitted coordinates (RUØV).

129. SDR1 recovers dependent incremental displacements for current loop

$$\begin{Bmatrix} u_\ell \\ \hline u_r \end{Bmatrix} = \{u_a\}, \qquad \{u_o\} = [G_o]\{u_a\} + \{u_o^o\},$$

$$\begin{Bmatrix} u_a \\ \hline u_o \end{Bmatrix} = \{u_f\} , \qquad \begin{Bmatrix} u_f \\ \hline Y_s \end{Bmatrix} = \{u_n\} ,$$

$$\{u_m\} = [G_m]\{u_n\}, \qquad \begin{Bmatrix} u_n \\ \hline u_m \end{Bmatrix} = \{u_g\},$$

and recovers incremental single-point forces of constraint for current loop

$$\{\delta q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} .$$

131. PLA2 adds the incremental displacement vector and the incremental single-point forces of constraint vector for the current loop to the accumulated sum of these vectors.

$$\{u_{g_{i+1}}\} = \{\delta u_{g_i}\} + \{u_{g_i}\} \quad \text{and}$$

$$\{q_{g_{i+1}}\} = \{\delta q_{g_i}\} + \{q_{g_i}\} .$$

PIECEWISE LINEAR ANALYSIS

134. Allocate separate files for ESTNL and ESTNL1 and for ECPTNL and ECPTNL1.

135. Go to DMAP No. 140 if no stress output requested for nonlinear elements.

136. PLA3 calculates incremental stresses in nonlinear elements for which an output request has been made and updates the accumulated stresses in these elements.

138. ØFP formats the accumulated stresses in nonlinear elements and places them on the system output file for printing.

142. Go to DMAP No. 164 if all loading increments have been completed.

143. PLA4 generates stiffness matrix for nonlinear elements and updates stress information in ECPTNL.

146. Equivalence $[K_{gg}^{n\ell}]$ to $[K_{gg}]$ if all elements are nonlinear.

148. Go to DMAP No. 151 if all elements are nonlinear.

149. Add stiffness matrix for nonlinear elements to stiffness matrix for linear elements

$$[K_{gg}^{n\ell}] + [K_{gg}^{\ell}] = \text{KGGSUM}$$

152. Equivalence KGGSUM to $[K_{gg}]$ for next pass through loop.

154. Equivalence existing element tables to updated tables for next pass through loop.

156. Go to DMAP No. 159 - next two instructions are never executed.

157. PLA2 is used to define KGGSUM.

158. PLA2 is used to define ESTNL1 and ECPTNL1.

160. Go to DMAP No. 83 if additional load increments need to be processed.

161. Go to DMAP No. 176 and print error message if more than 100 loops.

162. End of loop for Piecewise Linear Analysis when local plasticity occurs in $K_{\ell\ell}$.

163. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 5 - STIFFNESS MATRIX SINGULAR DUE TØ MATERIAL PLASTICITY.

164. End of loop for Piecewise Linear Analysis.

165. SDR2 calculates element forces and stresses for linear elements (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).

166. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

168. Go to DMAP No. 172 if no deformed structure plots are requested.

169. PLØT generates all requested deformed structure plots.

171. PRTMSG prints plotter data and engineering data for each deformed plot generated.

173. Go to DMAP No. 182 and make normal exit.

175. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 1 - NØ NØNLINEAR ELEMENTS HAVE BEEN DEFINED.

177. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

179. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

181. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

3.7.3 Case Control Deck and Parameters for Piecewise Linear Analysis

The following items relate to subcase definition and data selection for Piecewise Linear Analysis:

1. The Case Control Deck must contain one and only one subcase.

2. A static loading condition must be defined with a LØAD selection.

3. An SPC set must be selected unless all constraints are specified on GRID cards.

4. PLCØEFFICIENT must appear either to select a PLFACT set from the Bulk Data Deck or to explicitly select the default value of unity.

The following output may be requested for Piecewise Linear Analysis:

1. Accumulated sums of displacements and nonzero components of the static loads and single-point forces of constraint at selected grid points for each load increment.

2. Stresses in selected elements. If an element is composed of a nonlinear material the accumulated stress will be output for each load increment. Stresses in linear elements are only calculated for the total load.

3. Undeformed plot of the structural model and deformed plots for each load increment.

The following parameters are used in Piecewise Linear Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.8 DIRECT COMPLEX EIGENVALUE ANALYSIS

3.8.1 DMAP Sequence for Direct Complex Eigenvalue Analysis

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 7

   N A S T R A N  S O U R C E  P R O G R A M  C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.7 DIRECT COMPLEX EIGENVALUE ANALYSIS - SERIES N $

  2  FILE      KGGX=TAPE/ KGG=TAPE/ GOD=SAVE/ GMD=SAVE $

  3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

  4  SAVE      LUSET,NOGPDT $

  5  PURGE     USET,GM,GO,KAA,BAA,MAA,K4AA,KFS,EST,ECT,PLTSETX,PLTPAR,GPSETS,
               ELSETS/NOGPDT $

  6  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,EST,
               ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $

  7  COND      LBL5,NOGPDT $

  8  GP2       GEOM2,EQEXIN/ECT $

  9  CHKPNT    ECT $

 10  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

 11  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

 12  COND      P1,NOPCDB $

 13  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT=-1 $

 14  SAVE      NSIL,JUMPPLOT $

 15  PRTMSG    PLTSETX// $

 16  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 17  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 18  COND      P1,JUMPPLOT $

 19  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/   V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 20  SAVE      PFILE $

 21  PRTMSG    PLOTX1// $

 22  LABEL     P1 $

 23  CHKPNT    PLTPAR,GPSETS,ELSETS $

 24  GP3       GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

 25  CHKPNT    GPTT $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 7

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 26  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
              NOSIMP=-1/C,N,1/V,N,NOGENL=-1/V,N,GENEL $

 27  SAVE     NOSIMP,NOGENL,GENEL $

 28  PURGE    K4GG,GPST,OGPST,MGG,BGG,K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF,BAA,
              KGGX/NOSIMP / OGPST/GENEL $

 29  CHKPNT   EST,GPECT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST,  K4NN,K4FF,K4AA,
              MNN,MFF,MAA,BNN,BFF,BAA $

 30  COND     LBL1,NOSIMP $

 31  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

 32  PARAM    //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

 33  PARAM    //C,N,ADD/V,N,NOBGG=-1/C,N,1/C,N,0 $

 34  PARAM    //C,N,ADD/V,N,NOK4GG/C,N,1/C,N,0 $

 35  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,BELM,BDICT/V,N,
              NOKGGX/V,N,NOMGG/V,N,NOBGG/V,N,NOK4GG/C,N,/C,Y,COUPMASS/C,Y,
              CPBAR/C,Y,CPROD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,
              CPTRIA2/C,Y,CPTUBE/C,Y,CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

 36  SAVE     NOKGGX,NOMGG,NOBGG,NOK4GG $

 37  CHKPNT   KELM,KDICT,MELM,MDICT,BELM,BDICT $

 38  COND     LBLKGGX,NOKGGX $

 39  EMA      GPECT,KDICT,KELM/KGGX,GPST $

 40  CHKPNT   KGGX,GPST $

 41  LABEL    LBLKGGX $

 42  COND     LBLMGG,NOMGG $

 43  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

 44  CHKPNT   MGG $

 45  LABEL    LBLMGG $

 46  COND     LBLBGG,NOBGG $

 47  EMA      GPECT,BDICT,BELM/BGG, $

 48  CHKPNT   BGG $

 49  LABEL    LBLBGG $

 50  COND     LBLK4GG,NOK4GG $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 7

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 51  EMA      GPECT,KDICT,KELM/K4GG,/V,N,NOK4GG $

 52  CHKPNT   K4GG $

 53  LABEL    LBLK4GG $

 54  PURGE    MNN,MFF,MAA/NOMGG $

 55  PURGE    BNN,BFF,BAA/NOBGG $

 56  CHKPNT   MGG,MNN,MFF,MAA,BGG,BNN,BFF,BAA $

 57  COND     LBL1,GRDPNT $

 58  COND     ERROR3,NOMGG $

 59  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $

 60  OFP      OGPWG,,,,,// $

 61  LABEL    LBL1 $

 62  EQUIV    KGGX,KGG/NOGENL $

 63  CHKPNT   KGG $

 64  COND     LBL11,NOGENL $

 65  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 66  CHKPNT   KGG $

 67  LABEL    LBL11 $

 68  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 69  GP4      CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,
              LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
              NSKIP/V,N,REPEAT/V,N,NOSET=-1/V,N,NOL/V,N,NOA=-1/   C,Y,SUBID $

 70  SAVE     MPCF1,MPCF2,SINGLE,OMIT,NSKIP,NOSET,REACT,REPEAT,NOL,NOA $

 71  PURGE    GM,GMD/MPCF1/GO,GOD/OMIT/KFS,QPC/SINGLE $

 72  CHKPNT   GM,GMD,RG,GO,GOD,KFS,QPC $

 73  COND     LBL4,GENEL $

 74  COND     LBL4,NOSIMP $

 75  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 76  SAVE     NOGPST $

 77  COND     LBL4,NOGPST $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 7

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 78   OFP      OGPST,,,,,// $

 79   LABEL    LBL4 $

 80   EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 $

 81   CHKPNT   KNN,MNN,BNN,K4NN $

 82   COND     LBL2,MPCF2 $

 83   MCE1     USET,RG/GM $

 84   CHKPNT   GM $

 85   MCE2     USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN $

 86   CHKPNT   KNN,MNN,BNN,K4NN $

 87   LABEL    LBL2 $

 88   EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE $

 89   CHKPNT   KFF,MFF,BFF,K4FF $

 90   COND     LBL3,SINGLE $

 91   SCE1     USET,KNN,MNN,BNN,K4NN/KFF,KFS,,MFF,BFF,K4FF $

 92   CHKPNT   KFS,KFF,MFF,BFF,K4FF $

 93   LABEL    LBL3 $

 94   EQUIV    KFF,KAA/OMIT/ MFF,MAA/OMIT/BFF,BAA/OMIT/K4FF,K4AA/OMIT $

 95   CHKPNT   KAA,MAA,BAA,K4AA $

 96   COND     LBL5,OMIT $

 97   SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

 98   CHKPNT   GO,KAA $

 99   COND     LBLM,NOMGG $

100   SMP2     USET,GO,MFF/MAA $

101   CHKPNT   MAA $

102   LABEL    LBLM $

103   COND     LBLB,NOBGG $

104   SMP2     USET,GO,BFF/BAA $

105   CHKPNT   BAA $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 7

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

106  LABEL    LBLB $

107  COND     LBL5,NOK4GG $

108  SMP2     USET,GO,K4FF/K4AA $

109  CHKPNT   K4AA $

110  LABEL    LBL5 $

111  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,,EED,EQDYN/V,
              N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/
              V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE $

112  SAVE     LUSETD,NOUE $

113  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $

114  CHKPNT   USETD,EED,EQDYN,TFPOOL,GOD,GMD,SILD,GPLD $

115  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

116  PARAM    //C,N,MPY/V,N,REPEATE/C,N,1/C,N,-1 $

117  BMG      MATPOOL,BGPDT,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/ V,N,
              MFACT $

118  SAVE     MFACT,NOKBFL,NOABFL $

119  PARAM    //C,N,AND/V,N,NOFL/V,N,NOABFL/V,N,NOKBFL $

120  PURGE    KBFL/NOKBFL/ ABFL/NOABFL $

121  COND     LBLFL3,NOFL $

122  MTRXIN,  ,BDPOOL,EQDYN,,/ABFL,KBFL,/V,N,LUSETD/V,N,NOABFL/V,N,NOKBFL/C,
              N,0 $

123  SAVE     NOABFL,NOKBFL $

124  LABEL    LBLFL3 $

125  CHKPNT   ABFL,KBFL $

126  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

127  JUMP     LBL13 $
-------------------------------------------------- Top of DMAP Loop
128  LABEL    LBL13 $

129  PURGE    PHID,CLAMA,OPHID,OQPC1,OCPHIP,OESC1,OEFC1,CPHIP,QPC,  K2PP,
              M2PP,B2PP,K2DD,M2DD,B2DD/NEVER $

130  CASE     CASECC,/CASEXX/C,N,CEIGN/V,N,REPEATE/V,N,NOLOOP $

131  SAVE     REPEATE,NOLOOP $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 7

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

132  CHKPNT   CASEXX $

133  MTRXIN   CASEXX,MATPOOL,EQDYN,,TFPOOL/K2DPP,M2DPP,B2PP/V,N,LUSETD/V,N,
              NOK2DPP/V,N,NOM2DPP/V,N,NOB2PP $

134  SAVE     NOK2DPP,NOM2DPP,NOB2PP $

135  PARAM    //C,N,AND/V,N,NOM2PP/V,N,NOABFL/V,N,NOM2DPP $

136  PARAM    //C,N,AND/V,N,NOK2PP/V,N,NOFL /V,N,NOK2DPP $

137  EQUIV    M2DPP,M2PP/NOABFL $

138  ADD5     ABFL,KBFL,K2DPP,,/K2PP/C,N,(-1.0,0.0) $

139  COND     LBLFL2,NOABFL $

140  TRNSP    ABFL/ABFLT $

141  ADD      ABFLT,M2DPP/M2PP/V,N,MFACT $

142  LABEL    LBLFL2 $

143  PARAM    //C,N,AND/V,N,BDEBA/V,N,NOUE/V,N,NOB2PP $

144  PARAM    //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

145  PARAM    //C,N,AND/V,N,KDEK2/V,N,NOGENL/V,N,NOSIMP $

146  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

147  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA/BAA,
              BDD/BDEBA $

148  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,BDD,MDD $

149  COND     LBL18,NOGPDT $

150  GKAD     USETD,GM,GO,KAA,BAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDD,MDD,GMD,
              GOD,K2DD,M2DD,B2DD/C,N,CMPLEV/C,N,DISP/C,N,DIRECT/C,Y,G=0.0/C,
              N,0.0/C,N,0.0/V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/V,
              N,SINGLE/V,N,OMIT/V,N,NOUE/V,N,NOK4GG/V,N,NOBGG/V,N,KDEK2/C,N,
              -1 $

151  LABEL    LBL18 $

152  EQUIV    B2DD,BDD/NOBGG/ M2DD,MDD/NOSIMP/ K2DD,KDD/KDEK2 $

153  CHKPNT   KDD,BDD,MDD,GOD,GMD $

154  COND     ERROR1,NOEED $

155  CEAD     KDD,BDD,MDD,EED,CASEXX/PHID,CLAMA,OCEIGS/V,N,EIGVS $

156  SAVE     EIGVS $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 7

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

157  CHKPNT   PHID,CLAMA,OCEIGS $

158  OFP      OCEIGS,CLAMA,,,,//V,N,CARDNO $

159  SAVE     CARDNO $

160  COND     LBL16,EIGVS $

161  VDR      CASEXX,EQDYN,USETD,PHID,CLAMA,,/OPHID,/C,N,CEIGN/C,N,DIRECT/C,
              N,0/V,N,NOD/V,N,NOP/C,N,0 $

162  SAVE     NOD,NOP $

163  COND     LBL15,NOD $

164  OFP      OPHID,,,,,//V,N,CARDNO $

165  SAVE     CARDNO $

166  LABEL    LBL15 $

167  COND     LBL16,NOP $

168  EQUIV    PHID,CPHIP/NOA $

169  COND     LBL17,NOA $

170  SDR1     USETD,, PHID,,,GOD,GMD,,KFS,,/CPHIP,,QPC/C,N,1/C,N,DYNAMICS $

171  LABEL    LBL17 $

172  CHKPNT   CPHIP,QPC $

173  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,CLAMA,QPC,CPHIP,EST,,/,OQPC1,
              OCPHIP,OESC1,OEFC1,/C,N,CEIG $

174  OFP      OCPHIP,OQPC1,OEFC1,OESC1,,//V,N,CARDNO $

175  SAVE     CARDNO $

176  LABEL    LBL16 $

177  COND     FINIS,REPEATE $

178  REPT     LBL13,100 $
------------------------------------------------------------  Bottom of DMAP Loop
179  JUMP     ERROR2 $

180  JUMP     FINIS $

181  LABEL    ERROR2 $

182  PRTPARM  //C,N,-2/C,N,DIRCEAD $

183  LABEL    ERROR1 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 7

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

184  PRTPARM  //C,N,-1/C,N,DIRCEAD $

185  LABEL    ERROR3 $

186  PRTPARM  //C,N,-3/C,N,DIRCEAD $

187  LABEL    FINIS $

188  END      $
```

3.8.2 Description of DMAP Operations for Direct Complex Eigenvalue Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

7. Go to DMAP No. 110 if only Direct Matrix Input.

8. GP2 generates Element Connection Table with internal indices.

12. Go to DMAP No. 22 if no plot package is present.

13. PLTSET transforms user input into a form used to drive structure plotter.

15. PRTMSG prints error messages associated with structure plotter.

18. Go to DMAP No. 22 if no undeformed structure plot request.

19. PLØT generates all requested undeformed structure plots.

21. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

24. GP3 generates Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

30. Go to DMAP No. 61 if there are no structural elements.

35. EMG generates structural element matrix tables and dictionaries for later assembly.

38. Go to DMAP No. 41 if no stiffness matrix is to be assembled.

39. EMA assembles stiffness matrix $[K_{gg}^{x}]$ and Grid Point Singularity Table.

42. Go to DMAP No. 45 if no mass matrix is to be assembled.

43. EMA assembles mass matrix $[M_{gg}]$.

46. Go to DMAP No. 49 if no viscous damping matrix.

47. EMA assembles viscous damping matrix $[B_{gg}]$.

50. Go to DMAP No. 53 if no structural damping matrix.

51. EMA assembles structural damping matrix $[K_{gg}^{4}]$.

57. Go to DMAP No. 61 if no weight and balance request.

58. Go to DMAP No. 185 and print error message if no mass matrix exists.

59. GPWG generates weight and balance information.

60. ØFP formats the weight and balance information and places it on the system output file for printing.

62. Equivalence $[K_{gg}^{x}]$ to $[K_{gg}]$ if no general elements.

64. Go to DMAP No. 67 if no general elements.

65. SMA3 adds general elements to $[K_{gg}^{x}]$ to obtain stiffness matrix $[K_{gg}]$.

69. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

73. Go to DMAP No. 79 if general elements present.

74. Go to DMAP No. 79 if no structural elements.

75. GPSP determines if possible grid point singularities remain.

77. Go to DMAP No. 79 if no structural elements.

78. ØFP formats table of possible grid point singularities and places it on the system output file for printing.

80. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[M_{gg}]$ to $[M_{nn}]$, $[B_{gg}]$ to $[B_{nn}]$ and $[K^4_{gg}]$ to $[K^4_{nn}]$ if no multipoint constraints.

82. Go to DMAP No. 87 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

83. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \,\vdots\, R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

85. MCE2 partitions stiffness, mass and damping matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] , \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right] ,$$

$$[B_{gg}] = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array}\right] \quad \text{and} \quad [K^4_{gg}] = \left[\begin{array}{c|c} \bar{K}^4_{nn} & K^4_{nm} \\ \hline K^4_{mn} & K^4_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G^T_m][K_{mn}] + [K^T_{mn}][G_m] + [G^T_m][K_{mm}][G_m],$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G^T_m][M_{mn}] + [M^T_{mn}][G_m] + [G^T_m][M_{mm}][G_m],$$

$$[B_{nn}] = [\bar{B}_{nn}] + [G^T_m][B_{mn}] + [B^T_{mn}][G_m] + [G^T_m][B_{mm}][G_m],$$

$$[K^4_{nn}] = [\bar{K}^4_{nn}] + [G^T_m][K^4_{mn}] + [K^4_{mn}]^T[G_m] + [G^T_m][K^4_{mm}][G_m].$$

88. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K^4_{nn}]$ to $[K^4_{ff}]$ if no single-point constraints.

90. Go to DMAP No. 93 if no single-point constraints.

91. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] , \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right] ,$$

$$[B_{nn}] = \left[\begin{array}{c|c} B_{ff} & B_{fs} \\ \hline B_{sf} & B_{ss} \end{array}\right] \quad \text{and} \quad [K^4_{nn}] = \left[\begin{array}{c|c} K^4_{ff} & K^4_{fs} \\ \hline K^4_{sf} & K^4_{ss} \end{array}\right] .$$

94. Equivalence $[K_{ff}]$ to $[K_{aa}]$, $[M_{ff}]$ to $[M_{aa}]$, $[B_{ff}]$ to $[B_{aa}]$ and $[K^4_{ff}]$ to $[K^4_{aa}]$ if no omitted coordinates.

96. Go to DMAP No. 110 if no omitted coordinates.

97. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} K_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1} [K_{oa}]$
and performs matrix reduction

$$[K^1_{aa}] = [K_{aa}] + [K_{ao}][G_o]$$

99. Go to DMAP No. 102 if no mass matrix.

100. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} M_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M^1_{aa}] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G^T_o][M_{oo}][G_o]$$

103. Go to DMAP No. 106 if no viscous damping matrix.

104. SMP2 partitions constrained viscous damping matrix

$$[B_{ff}] = \left[\begin{array}{c|c} B_{aa} & B_{ao} \\ \hline B_{oa} & B_{oo} \end{array}\right]$$

and performs matrix reduction

$$[B^1_{aa}] = [B_{aa}] + [B_{ao}][G_o] + [B_{ao}G_o]^T + [G_o^T][B_{oo}][G_o]$$

107. Go to DMAP No.110 if no structural damping matrix.

108. SMP2 partitions constrained structural damping matrix

$$[K^4_{ff}] = \left[\begin{array}{c|c} K^4_{aa} & K^4_{ao} \\ \hline K^4_{oa} & K^4_{oo} \end{array}\right]$$

and performs matrix reduction

$$[K^4_{aa}] = [K^4_{aa}] + [K^4_{ao}][G_o] + [K^4_{ao}G_o]^T + [G_o^T][K^4_{oo}][G_o]$$

111. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool and Eigenvalue Extraction Data.

113. Equivalence $[G_o]$ to $[G^d_o]$ and $[G_m]$ to $[G^d_m]$ if no extra points introduced for dynamic analysis.

117. BMG generates DMIG card images describing the interconnection of the fluid and the structure.

121. Go to DMAP No. 124 if no fluid structure interface is defined.

122. MTRXIN generates fluid boundary matrices $[A_{b,f\ell}]$ and $[K_{b,f\ell}]$ if a fluid structure interface is defined. The matrix $[K_{b,f\ell}]$ is generated only for a nonzero gravity in the fluid.

127. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

128. Beginning of loop for additional sets of direct input matrices.

130. CASE extracts user requests from CASECC for current loop.

133. MTRXIN selects the direct input matrices for the current loop, $[K^{2d}_{pp}]$, $[M^{2d}_{pp}]$ and $[B^2_{pp}]$.

137. Equivalence $[M^{2d}_{pp}]$ to $[M^2_{pp}]$ if no $[A_{b,f\ell}]$.

138. Add5 adds $[K_{b,f\ell}]$ and $[K^{2d}_{pp}]$ and subtracts $[A_{b,f\ell}]$ from them to form $[K^2_{pp}]$.

139. Go to DMAP No. 142 if no $[A_{b,f\ell}]$.

140. Transpose $[A_{b,f\ell}]$ to obtain $[A_{b,f\ell}]^T$.

141. ADD assembles input matrix $[M^2_{pp}]$ = MFACT $[A_{b,f\ell}]^T + [M^{2d}_{pp}]$.

147. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied, $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points, and $[B_{aa}]$ to $[B_{dd}]$ if no direct input damping matrices and no extra points.

149. Go to DMAP No. 151 if only extra points defined.

150. GKAD assembles stiffness, mass, and damping matrices for use in Direct Complex Eigenvalue Analysis

$$[K_{dd}] = (1 + ig)[K^1_{dd}] + [K^2_{dd}] + i[K^4_{dd}],$$

$$[M_{dd}] = [M^1_{dd}] + [M^2_{dd}] \text{ and}$$

$$[B_{dd}] = [B^1_{dd}] + [B^2_{dd}].$$

Direct input matrices may be complex.

152. Equivalence $[K^2_{dd}]$ to $[K_{dd}]$ if all stiffness is Direct Matrix Input, $[M^2_{dd}]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[B^2_{dd}]$ to $[B_{dd}]$ if all damping is Direct Matrix Input.

154. Go to DMAP No. 183 and print error message if no Eigenvalue Extraction Data.

155. CEAD extracts complex eigenvalues from the equation

$$[M_{dd}p^2 + B_{dd}p + K_{dd}]\{u_d\} = 0$$

and normalizes eigenvectors according to one of the following user requests:
   (1) Unit magnitude of selected coordinate
   (2) Unit magnitude of largest component.

158. ØFP formats the summary of complex eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

160. Go to DMAP No. 176 if no eigenvalues found.

161. VDR prepares eigenvectors for output, using only the independent degrees of freedom.

163. Go to DMAP No. 166 if no output request for the independent degrees of freedom.

164. ØFP formats the eigenvectors for independent degrees of freedom and places them on the system output file for printing.

167. Go to DMAP No. 176 if no output request involving dependent degrees of freedom or forces and stresses.

168. Equivalence $\{\phi_d\}$ to $\{\phi_p\}$ if no constraints applied.

169. Go to DMAP No. 171 if no constraints applied.

170. SDR1 recovers dependent components of eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_d\} \quad , \qquad \left\{\begin{array}{c}\phi_d \\ \hline \phi_o\end{array}\right\} = \{\phi_f + \phi_e\} \quad ,$$

$$\left\{\begin{array}{c}\phi_f + \phi_e \\ \hline \phi_s\end{array}\right\} = \{\phi_n + \phi_e\} \quad , \qquad \{\phi_m\} = [G_m^d]\{\phi_n + \phi_e\} \quad ,$$

$$\left\{\begin{array}{c}\phi_n + \phi_e \\ \hline d_m\end{array}\right\} = \{\phi_p\}$$

and recovers single-point forces of constraint

$$\{q_s\} = [K_{fs}^T]\{\phi_f\} \ .$$

173. SDR2 calculates element forces and stresses (ØEFC1, ØESC1) and prepares eigenvectors and single-point forces of constraint for output (ØCPHIP, ØQPC1).

174. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

177. Go to DMAP No. 187 if no additional sets of direct input matrices need to be processed.

178. Go to DMAP No. 128 if additional sets of direct input matrices need to be processed.

179. Go to DMAP No. 181 and print error message if more than 100 loops.

180. Go to DMAP No. 187 and make normal exit.

182. DIRECT CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

184. DIRECT CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 1 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR CØMPLEX EIGENVALUE ANALYSIS.

186. DIRECT CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

3.8.3 Automatic Output for Direct Complex Eigenvalue Analysis

Each complex eigenvalue is identified with a root number determined by sorting the complex eigenvalues according to the magnitude of the imaginary part, with positive values considered as a group ahead of all negative values. The following summary of the complex eigenvalues extracted is automatically printed for each set of direct input matrices:

1. Root Number

2. Extraction Order

3. Real and Imaginary Parts of the Eigenvalue

4. The coefficients f_j (frequency) and g_j (damping coefficient) in the following representation of the eigenvalue

$$P_j = 2\pi f_j(i - \frac{1}{2} g_j)$$

The following summary of the eigenvalue analysis performed using the Determinant method is automatically printed for each set of direct input matrices:

1. Number of eigenvalues extracted

2. Number of passes through starting points.

3. Number of criteria changes.

4. Number of starting point moves.

5. Number of triangular decompositions.

6. Number of failures to iterate to a root.

7. Number of predictions outside region.

8. Reason for termination:

   (1) The number of roots desired have been found.

   (2) All predictions for eigenvalues are outside the regions specified.

   (3) Insufficient time to find another root.

   (4) Matrix is singular at first three starting points.

9. Swept determinant functions for each starting point.

The following summary of the eigenvalue analysis performed, using the Inverse Power method, is automatically printed for each region specified:

1. Number of eigenvalues extracted.

2. Number of starting points used.

3. Number of starting point moves.

4. Number of triangular decompositions.

5. Number of vector iterations.

6. Reason for termination.

   (1) Two consecutive singularities encountered while performing triangular decomposition.
   (2) Four starting point moves while tracking a single root.
   (3) All eigenvalues found in the region specified.
   (4) Three times the number of roots estimated in the region have been extracted.
   (5) All eigenvalues that exist in the problem have been found.
   (6) The number of roots desired have been found.
   (7) One or more eigenvalues have been found outside the region specified.
   (8) Insufficient time to find another root.
   (9) Unable to converge.

3.8.4 <u>Case Control Deck and Parameters for Direct Complex Eigenvalue Analysis</u>

The following items relate to subcase definition and data selections for Direct Complex Eigenvalue Analysis.

1. At least one subcase must be defined for each unique set of direct input matrices (K2PP, M2PP, B2PP).

2. Multiple subcases for each set of direct input matrices are used only to control output requests. A single subcase for each set of direct input matrices is sufficient if the same output is desired for all modes. If consecutive multiple subcases are present for a single set of direct input matrices, the output requests will be honored in succession for increasing mode numbers. MØDES may be used to repeat subcases in order to make the same output request for several consecutive modes.

3. CMETHØD must be used to select an EIGC card from the Bulk Data Deck for each set of direct input matrices.

4. On restart following an unscheduled exit due to insufficient time, the subcase structure must be changed to reflect the sets of direct input matrices that were completed, and either CMETHØD must be changed to select an EIGC card that reflects any complex eigenvalues found in the previous execution or EIGP cards must be used to insert poles for previously found eigenvalues. Otherwise, the previously found eigenvalues will be extracted again.

5. Constraints must be defined above the subcase level.

The following printed output, sorted by complex eigenvalue root number (SØRT1), may be requested for any complex eigenvalue extracted, as either real and imaginary parts or magnitude and phase angle (0° - 360° lead):

1. The eigenvector for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SØLUTIØN points (points used in formulation of the general K system).

2. Nonzero components of the single-point forces of constraint for a list of PHYSICAL points.

3. Stresses and forces in selected elements.

In addition an undeformed plot of the structural model may be requested.

The following parameters are used in Direct Complex Eigenvalue Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. G - optional - the real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.9 DIRECT FREQUENCY AND RANDOM RESPONSE

3.9.1 DMAP Sequence for Direct Frequency and Random Response

```
 RIGID FORMAT DMAP LISTING
 SERIES N

 RIGID FORMAT 8
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

   1  BEGIN     NO.8 DIRECT FREQUENCY RESPONSE ANALYSIS - SERIES N $

   2  FILE      KGGX=TAPE/ KGG=TAPE/ GOD=SAVE/ GMD=SAVE $

   3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

   4  SAVE      LUSET,NOGPDT $

   5  PURGE     USET,GM,GO,KAA,BAA,MAA,K4AA,KFS,PSF,QPC,EST,ECT,PLTSETX,PLTPAR,
                GPSETS,ELSETS/NOGPDT $

   6  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,
                KFS,PSF,QPC,EST,ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $

   7  COND      LBL5,NOGPDT $

   8  GP2       GEOM2,EQEXIN/ECT $

   9  CHKPNT    ECT $

  10  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  11  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

  12  COND      P1,NOPCDB $

  13  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

  14  SAVE      NSIL,JUMPPLOT $

  15  PRTMSG    PLTSETX// $

  16  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

  17  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

  18  COND      P1,JUMPPLOT $

  19  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/   V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

  20  SAVE      PFILE $

  21  PRTMSG    PLOTX1//$

  22  LABEL     P1 $

  23  CHKPNT    PLTPAR,GPSETS,ELSETS $

  24  GP3       GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

  25  CHKPNT    GPTT $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 8

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 26  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
               NOSIMP=-1/C,N,1/V,N,NOGENL=-1/V,N,GENEL $

 27  SAVE      NOSIMP,NOGENL,GENEL $

 28  PURGE     K4GG,GPST,OGPST,MGG,BGG,K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF,BAA,
               KGGX/NOSIMP/OGPST/GENEL $

 29  CHKPNT    EST,GPECT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST,  K4NN,K4FF,K4AA,
               MNN,MFF,MAA,BNN,BFF,BAA $

 30  COND      LBL1,NOSIMP $

*31  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

 32  PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

 33  PARAM     //C,N,ADD/V,N,NOBGG=-1/C,N,1/C,N,0 $

 34  PARAM     //C,N,ADD/V,N,NOK4GG/C,N,1/C,N,0 $

 35  EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,BELM,BDICT/   V,
               N,NOKGGX/V,N,NOMGG/V,N,NOBGG/V,N,NOK4GG/C,N,/C,Y,COUPMASS/C,Y,
               CPBAR/C,Y,CPROD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,
               CPTRIA2/C,Y,CPTUBE/C,Y,CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

 36  SAVE      NOKGGX,NOMGG,NOBGG,NOK4GG $

 37  CHKPNT    KELM,KDICT,MELM,MDICT,BELM,BDICT $

 38  COND      LBLKGGX,NOKGGX $

 39  EMA       GPECT,KDICT,KELM/KGGX,GPST $

 40  CHKPNT    KGGX,GPST $

 41  LABEL     LBLKGGX $

 42  COND      LBLMGG,NOMGG $

 43  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

 44  CHKPNT    MGG $

 45  LABEL     LBLMGG $

 46  COND      LBLBGG,NOBGG $

 47  EMA       GPECT,BDICT,BELM/BGG, $

 48  CHKPNT    BGG $

 49  LABEL     LBLBGG $

 50  COND      LBLK4GG,NOK4GG $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 8

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 51  EMA      GPECT,KDICT,KELM/K4GG,/V,N,NOK4GG $

 52  CHKPNT   K4GG $

 53  LABEL    LBLK4GG $

 54  PURGE    MNN,MFF,MAA/NOMGG $

 55  PURGE    BNN,BFF,BAA/NOBGG $

 56  CHKPNT   MGG,MNN,MFF,MAA,BGG,BNN,BFF,BAA $

 57  COND     LBL1,GRDPNT $

 58  COND     ERROR4,NOMGG $

 59  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

 60  OFP      OGPWG,,,,,// $

 61  LABEL    LBL1 $

 62  EQUIV    KGGX,KGG/NOGENL $

 63  CHKPNT   KGG $

 64  COND     LBL11,NOGENL $

 65  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 66  CHKPNT   KGG $

 67  LABEL    LBL11 $

 68  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 69  GP4      CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,
              LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
              NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 70  SAVE     MPCF1,SINGLE,OMIT,NOSET,REACT,MPCF2,NSKIP,REPEAT,NOL,NOA $

 71  PURGE    GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PSF,QPC/SINGLE $

 72  CHKPNT   GM,GMD,RG,GO,GOD,KFS,PSF,QPC,USET $

 73  COND     LBL4,GENEL $

 74  COND     LBL4,NOSIMP $

 75  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 76  SAVE     NOGPST $

 77  COND     LBL4,NOGPST $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 8

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  78  OFP      OGPST,,,,,// $

  79  LABEL    LBL4 $

  80  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 $

  81  CHKPNT   KNN,MNN,BNN,K4NN $

  82  COND     LBL2,MPCF1 $

  83  MCE1     USET,RG/GM $

  84  CHKPNT   GM $

  85  MCE2     USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN $

  86  CHKPNT   KNN,MNN,BNN,K4NN $

  87  LABEL    LBL2 $

  88  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE $

  89  CHKPNT   KFF,MFF,BFF,K4FF $

  90  COND     LBL3,SINGLE $

  91  SCE1     USET,KNN,MNN,BNN,K4NN/KFF,KFS,,MFF,BFF,K4FF $

  92  CHKPNT   KFS,KFF,MFF,BFF,K4FF $

  93  LABEL    LBL3 $

  94  EQUIV    KFF,KAA/OMIT $

  95  EQUIV    MFF,MAA/OMIT $

  96  EQUIV    BFF,BAA/OMIT $

  97  EQUIV    K4FF,K4AA/OMIT $

  98  CHKPNT   KAA,MAA,BAA,K4AA $

  99  COND     LBL5,OMIT $

 100  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

 101  CHKPNT   GO,KAA $

 102  COND     LBLM,NOMGG $

 103  SMP2     USET,GO,MFF/MAA $

 104  CHKPNT   MAA $

 105  LABEL    LBLM $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 8

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

DMAP-NO.	DMAP INSTRUCTION	
106	COND	LBLB,NOBGG $
107	SMP2	USET,GO,BFF/BAA $
108	CHKPNT	BAA $
109	LABEL	LBLB $
110	COND	LBL5,NOK4GG $
111	SMP2	USET,GO,K4FF/K4AA $
112	CHKPNT	K4AA $
113	LABEL	LBL5 $
114	DPD	DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,PSDL,FRL,,,,EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $
115	SAVE	LUSETD,NOUE,NODLT,NOFRL,NOPSDL $
116	EQUIV	GO,GOD/NOUE/GM,GMD/NOUE $
117	CHKPNT	USETD,EQDYN,TFPOOL,DLT,FRL,GOD,GMD,SILD,PSDL,GPLD $
118	PARAM	//C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $
119	PARAM	//C,N,MPY/V,N,REPEATF/C,N,-1/C,N,1 $
120	BMG	MATPOOL,BGPDT,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/ V,N,MFACT $
121	SAVE	MFACT,NOKBFL,NOABFL $
122	PARAM	//C,N,AND/V,N,NOFL/V,N,NOABFL/V,N,NOKBFL $
123	PURGE	KBFL/NOKBFL/ ABFL/NOABFL $
124	COND	LBLFL3,NOFL $
125	MTRXIN	,BDPOOL,EQDYN,,/ABFL,KBFL,/V,N,LUSETD/V,N,NOABFL/V,N,NOKBFL/C,N,0 $
126	SAVE	NOABFL,NOKBFL $
127	LABEL	LBLFL3 $
128	CHKPNT	ABFL,KBFL $
129	PARAM	//C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
130	JUMP	LBL13 $
131	LABEL	LBL13 $

Top of DMAP Loop

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 8

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

132  PURGE    OUDVC1,OUDVC2,XYPLTFA,OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,OPPC2,
              OQPC2,OUPVC2,OESC2,OEFC2,XYPLTF,PSDF,AUTO,XYPLTR,   K2PP,M2PP,
              B2PP,K2DD,M2DD,B2DD/NEVER $

133  CASE     CASECC,PSDL/CASEXX/C,N,FREQ/V,N,REPEATF/V,N,NOLOOP $

134  SAVE     REPEATF,NOLOOP $

135  CHKPNT   CASEXX $

136  MTRXIN   CASEXX,MATPOOL,EQDYN,,TFPOOL/K2DPP,M2DPP,B2PP/V,N,LUSETD/V,N,
              NOK2DPP/V,N,NOM2DPP/V,N,NOB2PP $

137  SAVE     NOK2DPP,NOM2DPP,NOB2PP $

138  PARAM    //C,N,AND/V,N,NOM2PP/V,N,NOABFL/V,N,NOM2DPP $

139  PARAM    //C,N,AND/V,N,NOK2PP/V,N,NOFL /V,N,NOK2DPP $

140  EQUIV    M2DPP,M2PP/NOABFL $

141  ADD5     ABFL,KBFL,K2DPP,,/K2PP/C,N,(-1.0,0.0) $

142  COND     LBLFL2,NOABFL $

143  TRNSP    ABFL/ABFLT $

144  ADD      ABFLT,M2DPP/M2PP/V,N,MFACT $

145  LABEL    LBLFL2 $

146  PARAM    //C,N,AND/V,N,BDEBA/V,N,NOUE/V,N,NOB2PP $

147  PARAM    //C,N,AND/V,N,KDEK2/V,N,NOGENL/V,N,NOSIMP $

148  PARAM    //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

149  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

150  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA/BAA,
              BDD/BDEBA $

151  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,BDD,MDD $

152  COND     LBL18,NOGPDT $

153  GKAD     USETD,GM,GO,KAA,BAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDD,MDD,GMD,
              GOD,K2DD,M2DD,B2DD/C,N,FREQRESP/C,N,DISP/C,N,DIRECT/C,Y,G=0.0/
              C,N,0.0/C,N,0.0/V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/
              V,N,SINGLE/V,N,OMIT/V,N,NOUE/V,N,NOK4GG/V,N,NOBGG/V,N,KDEK2/C,
              N,-1 $

154  LABEL    LBL18 $

155  EQUIV    B2DD,BDD/NOBGG/ M2DD,MDD/NOSIMP/ K2DD,KDD/KDEK2 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 8

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

156  CHKPNT   KDD,BDD,MDD,GMD,GOD $

157  COND     ERROR1,NOFRL $

158  COND     ERROR2,NODLT $

159  FRRD     CASEXX,USETD,DLT,FRL,GMD,GOD,KDD,BDD,MDD,,DIT/UDVF,PSF,PDF,PPF/
              C,N,DISP/C,N,DIRECT/V,N,LUSETD/V,N,MPCF1/V,N,SINGLE/V,N,OMIT/
              V,N,NONCUP/V,N,FRQSET $

160  EQUIV    PPF,PDF/NOSET $

161  CHKPNT   PSF,PPF,UDVF,PDF $

162  VDR      CASEXX,EQDYN,USETD,UDVF,PPF,XYCDB,/OUDVC1,/C,N,FREQRESP/C,N,
              DIRECT/V,N,NOSORT2/V,N,NOD/V,N,NOP/C,N,0 $

163  SAVE     NOD,NOP,NOSORT2 $

164  COND     LBL15,NOD $

165  COND     LBL15A,NOSORT2 $

166  CHKPNT   OUDVC1 $

167  SDR3     OUDVC1,,,,,/OUDVC2,,,,, $

168  OFP      OUDVC2,,,,,//V,N,CARDNO $

169  SAVE     CARDNO $

170  CHKPNT   OUDVC2 $

171  XYTRAN   XYCDB,OUDVC2,,,,/XYPLTFA/C,N,FREQ/C,N,DSET/V,N,PFILE/V,N,
              CARDNO $

172  SAVE     PFILE,CARDNO $

173  XYPLOT   XYPLTFA// $

174  JUMP     LBL15 $

175  LABEL    LBL15A $

176  OFP      OUDVC1,,,,,//V,N,CARDNO $

177  SAVE     CARDNO $

178  LABEL    LBL15 $

179  COND     LBL16,NOP $

180  EQUIV    UDVF,UPVC/NOA $

181  COND     LBL19,NOA $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 8

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

182  SDR1     USETD,,UDVF,,,GOD,GMD,PSF,KFS,,/UPVC,,QPC/C,N,1/C,N,DYNAMICS $

183  LABEL    LBL19 $

184  CHKPNT   UPVC,QPC $

185  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,PPF,QPC,UPVC,EST,XYCDB,PPF/
              OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,/C,N,FREQRESP/V,N,NOSORT2 $

186  SAVE     NOSORT2 $

187  COND     LBL17,NOSORT2 $

188  SDR3     OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,/OPPC2,OQPC2,OUPVC2,OESC2,
              OEFC2, $

189  CHKPNT   OPPC2,OQPC2,OUPVC2,OESC2,OEFC2 $

190  OFP      OPPC2,OQPC2,OUPVC2,OEFC2,OESC2,//V,N,CARDNO $

191  SAVE     CARDNO $

192  XYTRAN   XYCDB,OPPC2,OQPC2,OUPVC2,OESC2,OEFC2/XYPLTF/C,N,FREQ/C,N,PSET/
              V,N,PFILE/V,N,CARDNO $

193  SAVE     PFILE,CARDNO $

194  XYPLOT   XYPLTF// $

195  COND     LBL16,NOPSDL $

196  RANDOM   XYCDB,DIT,PSDL,OUPVC2,OPPC2,OQPC2,OESC2,OEFC2,CASEXX/PSDF,AUTO/
              V,N,NORD $

197  SAVE     NORD $

198  CHKPNT   PSDF,AUTO $

199  COND     LBL16,NORD $

200  XYTRAN   XYCDB,PSDF,AUTO,,,/XYPLTR/C,N,RAND/C,N,PSET/V,N,PFILE/   V,N,
              CARDNO $

201  SAVE     PFILE,CARDNO $

202  XYPLOT   XYPLTR// $

203  JUMP     LBL16 $

204  LABEL    LBL17 $

205  OFP      OUPVC1,OPPC1,OQPC1,OEFC1,OESC1,//V,N,CARDNO $

206  SAVE     CARDNO $

207  LABEL    LBL16 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 8

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

208  COND      FINIS,REPEATF $

209  REPT      LBL13,100 $
--------------------------------------------- Bottom of DMAP Loop
210  JUMP      ERROR3 $

211  JUMP      FINIS $

212  LABEL     ERROR3 $

213  PRTPARM   //C,N,-3/C,N,DIRFRRD $

214  LABEL     ERROR2 $

215  PRTPARM   //C,N,-2/C,N,DIRFRRD $

216  LABEL     ERROR1 $

217  PRTPARM   //C,N,-1/C,N,DIRFRRD $

218  LABEL     ERROR4 $

219  PRTPARM   //C,N,-4/C,N,DIRFRRD $

220  LABEL     FINIS $

221  END       $
```

3.9.2 Description of DMAP Operations for Direct Frequency and Random Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

7. Go to DMAP No. 113 if only Direct Matrix Input.

8. GP2 generates Element Connection Table with internal indices.

12. Go to DMAP No. 22 if no plot package is present.

13. PLTSET transforms user input into a form used to drive structure plotter.

15. PRTMSG prints error messages associated with structure plotter.

18. Go to DMAP No. 22 if no undeformed structure plot request.

19. PLØT generates all requested undeformed structure plots.

21. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

24. GP3 generates Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

30. Go to DMAP No. 61 if there are no structural elements.

35. EMG generates structural element matrix tables and dictionaries for later assembly.

38. Go to DMAP No. 41 if no stiffness matrix is to be assembled.

39. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

42. Go to DMAP No. 45 if no mass matrix is to be assembled.

43. EMA assembles mass matrix $[M_{gg}]$.

46. Go to DMAP No. 49 if no viscous damping matrix.

47. EMA assembles viscous damping matrix $[B_{gg}]$.

50. Go to DMAP No. 53 if no structural damping matrix is to be assembled.

51. EMA assembles structural damping matrix $[K^4_{gg}]$.

57. Go to DMAP No. 61 if no weight and balance request.

58. Go to DMAP No. 218 and print error message if no mass matrix exists.

59. GPWG generates weight and balance information.

60. ØFP formats weight and balance information and places it on the system output file for printing.

62. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

64. Go to DMAP No. 67 if no general elements.

65. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

69. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

73. Go to DMAP No. 79 if general elements present.

74. Go to DMAP No. 79 if no structural elements.

75. GPSP determines if possible grid point singularities remain.

77. Go to DMAP No. 79 if no grid point singularities exist.

78. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

80. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[M_{gg}]$ to $[M_{nn}]$, $[B_{gg}]$ to $[B_{nn}]$ and $[K^4_{gg}]$ to $[K^4_{nn}]$ if no multipoint constraints.

82. Go to DMAP No. 87 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

83. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

85. MCE2 partitions stiffness, mass and damping matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] , \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right] ,$$

$$[B_{gg}] = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array}\right] \quad \text{and} \quad [K^4_{gg}] = \left[\begin{array}{c|c} \bar{K}^4_{nn} & K^4_{nm} \\ \hline K^4_{mn} & K^4_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m],$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m],$$

$$[B_{nn}] = [\bar{B}_{nn}] + [G_m^T][B_{mn}] + [B_{mn}^T][G_m] + [G_m^T][B_{mm}][G_m],$$

$$[K^4_{nn}] = [\bar{K}^4_{nn}] + [G_m^T][K^4_{mn}] + [K^4_{mn}]^T[G_m] + [G_m^T][K^4_{mm}][G_m].$$

88. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K^4_{nn}]$ to $[K^4_{ff}]$ if no single-point constraints.

90. Go to DMAP No. 93 if no single-point constraints.

91. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] , \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right] ,$$

$$[B_{nn}] = \left[\begin{array}{c|c} B_{ff} & B_{fs} \\ \hline B_{sf} & B_{ss} \end{array}\right] \quad \text{and} \quad [K^4_{nn}] = \left[\begin{array}{c|c} K^4_{ff} & K^4_{fs} \\ \hline K^4_{sf} & K^4_{ss} \end{array}\right] .$$

94. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

95. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

96. Equivalence $[B_{ff}]$ to $[B_{aa}]$ if no omitted coordinates.

97. Equivalence $[K^4_{ff}]$ to $[K^4_{aa}]$ if no omitted coordinates.

99. Go to DMAP No. 113 if no omitted coordinates.

100. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} K_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction

$$[K^1_{aa}] = [K_{aa}] + [K_{ao}][G_o].$$

102. Go to DMAP No. 105 if no mass matrix.

103. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} M_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M^1_{aa}] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G_o^T][M_{oo}][G_o]$$

106. Go to DMAP No. 109 if no viscous damping matrix.

107. SMP2 partitions constrained viscous damping matrix

$$[B_{ff}] = \left[\begin{array}{c|c} B_{aa} & B_{ao} \\ \hline B_{oa} & B_{oo} \end{array}\right]$$

and performs matrix reduction

$$[B^1_{aa}] = [B_{aa}] + [B_{ao}][G_o] + [B_{ao}G_o]^T + [G_o^T][B_{oo}][G_o]$$

110. Go to DMAP No. 113 if no structural damping matrix.

111. SMP2 partitions constrained structural damping matrix

$$[K^4_{ff}] = \left[\begin{array}{c|c} K^4_{aa} & K^4_{ao} \\ \hline K^4_{oa} & K^4_{oo} \end{array}\right]$$

and performs matrix reduction

$$[K^4_{aa}] = [K^4_{aa}] + [K^4_{ao}][G_o] + [K^4_{ao}G_o]^T + [G^T_o][K^4_{oo}][G_o]$$

114. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Dynamics Load Table, Power Spectral Density List and Frequency Response List.

116. Equivalence $[G_o]$ to $[G^d_o]$ and $[G_m]$ to $[G^d_m]$ if no extra points introduced for dynamic analysis.

120. BMG generates DMIG card images describing the interconnection of the fluid and the structure.

124. Go to DMAP No. 127 if no fluid structure interface is defined.

125. MTRXIN generates fluid boundary matrices $[A_{b,f\ell}]$ and $[K_{b,f\ell}]$ if a fluid structure interface is defined. The matrix $[K_{b,f\ell}]$ is generated only for a nonzero gravity in the fluid.

130. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

131. Beginning of loop for additional sets of direct input matrices.

133. CASE extracts user requests from CASECC for current loop.

136. MTRXIN selects the direct input matrices for the current loop, $[K^{2d}_{pp}]$, $[M^{2d}_{pp}]$ and $[B^2_{pp}]$.

140. Equivalence $[M^{2d}_{pp}]$ to $[M^2_{pp}]$ if no $[A_{b,f\ell}]$.

141. ADD5 adds $[K_{b,f\ell}]$ and $[K^{2d}_{pp}]$ and subtracts $[A_{b,f\ell}]$ from them to form $[K^2_{pp}]$.

142. Go to DMAP No. 145 if no $[A_{b,f\ell}]$.

143. Transpose $[A_{b,f\ell}]$ to obtain $[A_{b,f\ell}]^T$.

144. ADD assembles input matrix $[M^2_{pp}]$ = MFACT $[A_{b,f\ell}]^T + [M^{2d}_{pp}]$.

150. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied, $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points and $[B_{aa}]$ to $[B_{dd}]$ if no direct input damping matrices and no extra points.

152. Go to DMAP No. 154 if only extra points defined.

153. GKAD assembles stiffness, mass, and damping matrices for use in Direct Frequency Response

$$[K_{dd}] = (1 + ig)[K^1_{dd}] + [K^2_{dd}] + i[K^4_{dd}],$$

$$[M_{dd}] = [M^1_{dd}] + [M^2_{dd}] \text{ and}$$

$$[B_{dd}] = [B^1_{dd}] + [B^2_{dd}] \ .$$

Direct input matrices may be complex.

155. Equivalence $[K^2_{dd}]$ to $[K_{dd}]$ if all stiffness is Direct Matrix Input, $[M^2_{dd}]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[B^2_{dd}]$ to $[B_{dd}]$ if all damping is Direct Matrix Input.

157. Go to DMAP No. 216 and print error message if no Frequency Response List.

158. Go to DMAP No. 214 and print error message if no Dynamics Load Table.

159. FRRD forms the dynamic load vectors $\{P_d\}$ and solves for the displacements using the following equation

$$[-M_{dd}\omega^2 + iB_{dd}\omega + K_{dd}]\{u_d\} = \{P_d\} \ .$$

160. Equivalence $\{P_p\}$ to $\{P_d\}$ if no constraints applied.

162. VDR prepares displacements, sorted by frequency, for output using only the independent degrees of freedom.

164. Go to DMAP No. 178 if no output request for the independent degrees of freedom.

165. Go to DMAP No. 175 if no output request for independent displacements sorted by point number.

167. SDR3 sorts the independent displacements by point number.

168. ØFP formats the requested independent displacements sorted by point number and places them on the system output file for printing.

171. XYTRAN prepares the input for X-Y plotting of the independent displacements vs. frequency.

173. XYPLØT prepares the requested X-Y plots of the independent displacements vs. frequency.

176. ØFP formats the requested independent displacements sorted by frequency and places them on the system output file for printing.

179. Go to DMAP No. 207 if no output request involving dependent degrees of freedom or forces and stresses.

180. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.

181. Go to DMAP No. 183 if no constraints applied.

182. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\} \quad , \qquad \left\{\begin{array}{c} u_d \\ \hline u_o \end{array}\right\} = \{u_f + u_e\} \quad ,$$

$$\left\{\begin{array}{c} u_f + u_e \\ \hline u_s \end{array}\right\} = \{u_n + u_e\} \quad , \qquad \{u_m\} = [G_m^d]\{u_f + u_e\} \quad ,$$

$$\left\{\begin{array}{c} u_n + u_e \\ \hline u_m \end{array}\right\} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

185. SDR2 calculates element forces and stresses (ØEFC1, ØESC1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPPC1, ØUPVC1, ØQPC1) - all sorted by frequency.

187. Go to DMAP No. 204 if no output requests sorted by point number or element number.

188. SDR3 prepares requested output sorted by point number or element number.

190. ØFP formats the requested output sorted by point number or element number and places it on the system output file for printing.

192. XYTRAN prepares the input for requested X-Y plots.

194. XYPLØT prepares the requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. frequency.

195. Go to DMAP No. 207 if no Power Spectral Density List.

196. RANDØM calculates power spectral density functions and autocorrelation functions using the previously calculated frequency response.

199. Go to DMAP No. 207 if no RANDØM calculations requested.

200. XYTRAN prepares the input for requested X-Y plots of the RANDØM output.

202. XYPLØT prepares the requested X-Y plots of autocorrelation functions and power spectral density functions.

203. Go to DMAP No. 207 if no frequency response output requests sorted by frequency.

205. ØFP formats frequency response output requests sorted by frequency and places them on the system output file for printing.

208. Go to DMAP No. 220 if no additional sets of direct input matrices need to be processed.

209. Go to DMAP No. 131 if additional sets of direct input matrices need to be processed.

210. Go to DMAP No. 212 and print error message if more than 100 loops.

211. Go to DMAP No. 220 and make normal exit.

213. DIRECT FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

215. DIRECT FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 2 - DYNAMIC LØADS TABLE REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

217. DIRECT FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 1 - FREQUENCY RESPØNSE LIST REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

219. DIRECT FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 4 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

3.9.3 Case Control Deck and Parameters for Direct Frequency and Random Response

The following items relate to subcase definition and data selection for Direct Frequency and Random Response:

1. At least one subcase must be defined for each unique set of direct input matrices (K2PP, M2PP, B2PP) or frequencies.

2. Consecutive subcases for each set of direct input matrices or frequencies are used to define the loading conditions - one subcase for each dynamic loading condition.

3. Constraints must be defined above the subcase level.

4. DLØAD must be used to define a frequency-dependent loading condition for each subcase.

5. FREQUENCY must be used to select one, and only one, FREQ, FREQ1, or FREQ2 card from the Bulk Data Deck for each unique set of direct input matrices.

6. On restart following an unscheduled exit due to insufficient time, the subcase structure must be changed to reflect the sets of direct input matrices that were completed, and FREQUENCY must be changed to select a FREQ, FREQ1, or FREQ2 card that reflects any frequencies for which the response has already been determined. Otherwise the previous calculations will be repeated.

7. ØFREQUENCY may be used above the subcase level or within each subcase to select a subset of the solution frequencies for output requests. The default is to use all solution frequencies.

8. If Random Response calculations are desired, RANDØM must be used to select RANDPS and RANDTi cards from the Bulk Data Deck. Only one ØFREQUENCY and FREQUENCY card can be used for each set of direct input matrices.

The following printed output, sorted by frequency (SØRT1) or by point number or element number (SØRT2), is available, either as real and imaginary parts or magnitude and phase angle (0° - 360° lead), for the list of frequencies specified by ØFREQUENCY:

1. Displacements, velocities, and accelerations for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SØLUTIØN points (points used in formulation of the general K system).

2. Nonzero components of the applied load vector and single-point forces of constraint for a list of PHYSICAL points.

3. Stresses and forces in selected elements (ALL available only for SØRT1).

The following plotter output is available for Frequency Response calculations:

1. Undeformed plot of the structural model.

2. X-Y plot of any component of displacement, velocity, or acceleration of a PHYSICAL point or SØLUTIØN point.

3. X-Y plot of any component of the applied load vector or single-point force of constraint.

4. X-Y plot of any stress or force component for an element.

The following plotter output is available for Random Response calculations:

1. X-Y plot of the power spectral density versus frequency for the response of selected components for points or elements.

2. X-Y plot of the autocorrelation versus time lag for the response of selected components for points or elements.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.3). This is the only form of printed output that is available for Random Response. Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Frequency Response calculations:

1. <u>GRDPNT</u> - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. <u>WTMASS</u> - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.

3. G - optional - the real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.10 DIRECT TRANSIENT RESPONSE

3.10.1 DMAP Sequence for Direct Transient Response

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.9 DIRECT TRANSIENT RESPONSE ANALYSIS - SERIES N $

  2  FILE      KGGX=TAPE/ KGG=TAPE/ UDVT=APPEND $

  3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

  4  SAVE      LUSET,NOGPDT $

  5  PURGE     USET,GM,GO,KAA,BAA,MAA,K4AA,PST,KFS,QP,EST,ECT,PLTSETX,PLTPAR,
               GPSETS,ELSETS/NOGPDT $

  6  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,
               PST,KFS,QP,EST,ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $

  7  COND      LBL5,NOGPDT $

  8  GP2       GEOM2,EQEXIN/ECT $

  9  CHKPNT    ECT $

 10  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

 11  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

 12  COND      P1,NOPCDB $

 13  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT=-1 $

 14  SAVE      NSIL,JUMPPLOT $

 15  PRTMSG    PLTSETX// $

 16  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 17  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 18  COND      P1,JUMPPLOT $

 19  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/   V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 20  SAVE      JUMPPLOT,PLTFLG,PFILE $

 21  PRTMSG    PLOTX1// $

 22  LABEL     P1 $

 23  CHKPNT    PLTPAR,GPSETS,ELSETS $

 24  GP3       GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

 25  CHKPNT    SLT,GPTT $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 26  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
               NOSIMP=-1/C,N,1/V,N,NOGENL=-1/V,N,GENEL $

 27  SAVE      NOSIMP,NOGENL,GENEL $

 28  PURGE     K4GG,GPST,OGPST,MGG,BGG,  K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF,
               BAA,KGGX/NOSIMP/ OGPST/GENEL $

 29  CHKPNT    EST,GPECT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST,   K4NN,K4FF,K4AA,
               MNN,MFF,MAA,BNN,BFF,BAA $

 30  COND      LBL1,NOSIMP $

 31  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

 32  PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

 33  PARAM     //C,N,ADD/V,N,NOBGG=-1/C,N,1/C,N,0 $

 34  PARAM     //C,N,ADD/V,N,NOK4GG/C,N,1/C,N,0 $

 35  EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,BELM,BDICT/   V,
               N,NOKGGX/V,N,NOMGG/V,N,NOBGG/V,N,NOK4GG/C,N,/C,Y,COUPMASS/C,Y,
               CPBAR/C,Y,CPROD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,
               CPTRIA2/C,Y,CPTUBE/C,Y,CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

 36  SAVE      NOKGGX,NOMGG,NOBGG,NOK4GG $

 37  CHKPNT    KELM,KDICT,MELM,MDICT,BELM,BDICT $

 38  COND      LBLKGGX,NOKGGX $

 39  EMA       GPECT,KDICT,KELM/KGGX,GPST $

 40  CHKPNT    KGGX,GPST $

 41  LABEL     LBLKGGX $

 42  COND      LBLMGG,NOMGG $

 43  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

 44  CHKPNT    MGG $

 45  LABEL     LBLMGG $

 46  COND      LBLBGG,NOBGG $

 47  EMA       GPECT,BDICT,BELM/BGG, $

 48  CHKPNT    BGG $

 49  LABEL     LBLBGG $

 50  COND      LBLK4GG,NOK4GG $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 51  EMA       GPECT,KDICT,KELM/K4GG,/V,N,NOK4GG $

 52  CHKPNT    K4GG $

 53  LABEL     LBLK4GG $

 54  PURGE     MNN,MFF,MAA/NOMGG $

 55  PURGE     BNN,BFF,BAA/NOBGG $

 56  CHKPNT    MGG,MNN,MFF,MAA,BGG,BNN,BFF,BAA $

 57  COND      LBL1,GRDPNT $

 58  COND      ERROR3,NOMGG $

 59  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

 60  OFP       OGPWG,,,,,// $

 61  LABEL     LBL1 $

 62  EQUIV     KGGX,KGG/NOGENL $

 63  CHKPNT    KGG $

 64  COND      LBL11,NOGENL $

 65  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 66  CHKPNT    KGG $

 67  LABEL     LBL11 $

 68  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 69  GP4       CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,
               LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
               NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 70  SAVE      MPCF1,SINGLE,OMIT,NOSET,REACT,MPCF2,NSKIP,REPEAT,NOL,NOA $

 71  PURGE     GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PST,QP/SINGLE $

 72  CHKPNT    GM,GMD,RG,GO,GOD,KFS,PST,QP,USET $

 73  COND      LBL4,GENEL $

 74  COND      LBL4,NOSIMP $

 75  GPSP      GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 76  SAVE      NOGPST $

 77  COND      LBL4,NOGPST $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9

```
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 78  OFP      OGPST,,,,,// $

 79  LABEL    LBL4 $

 80  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 $

 81  CHKPNT   KNN,MNN,BNN,K4NN $

 82  COND     LBL2,MPCF1 $

 83  MCE1     USET,RG/GM $

 84  CHKPNT   GM $

 85  MCE2     USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN $

 86  CHKPNT   KNN,MNN,BNN,K4NN $

 87  LABEL    LBL2 $

 88  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE $

 89  CHKPNT   KFF,MFF,BFF,K4FF $

 90  COND     LBL3,SINGLE $

 91  SCE1     USET,KNN,MNN,BNN,K4NN/KFF,KFS, ,MFF,BFF,K4FF $

 92  CHKPNT   KFS,KFF,MFF,BFF,K4FF $

 93  LABEL    LBL3 $

 94  EQUIV    KFF,KAA/OMIT $

 95  EQUIV    MFF,MAA/OMIT $

 96  EQUIV    BFF,BAA/OMIT $

 97  EQUIV    K4FF,K4AA/OMIT $

 98  CHKPNT   KAA,MAA,BAA,K4AA $

 99  COND     LBL5,OMIT $

100  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

101  CHKPNT   GO,KAA $

102  COND     LBLM,NUMGG $

103  SMP2     USET,GO,MFF/MAA $

104  CHKPNT   MAA $

105  LABEL    LBLM $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

106   COND      LBLB,NOBGG $

107   SMP2      USET,GO,BFF/BAA $

108   CHKPNT    BAA $

109   LABEL     LBLB $

110   COND      LBL5,NOK4GG $

111   SMP2      USET,GO,K4FF/K4AA $

112   CHKPNT    K4AA $

113   LABEL     LBL5 $

114   DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,,,NLFT,TRL,,
                EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/  V,
                N,NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

115   SAVE      LUSETD,NODLT,NONLFT,NOTRL,NOUE $

116   PURGE     PNLD/NONLFT$

117   EQUIV     GO,GOD/NOUE/GM,GMD/NOUE $

118   CHKPNT    USETD,EQDYN,TFPOOL,DLT,TRL,GOD,GMD,NLFT,PNLD,SILD,GPLD $

119   BMG       MATPOOL,BGPDT,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/ V,N,
                MFACT $

120   SAVE      MFACT,NOKBFL,NOABFL $

121   PARAM     //C,N,AND/V,N,NOFL/V,N,NOABFL/V,N,NOKBFL $

122   PURGE     KBFL/NOKBFL/ ABFL/NOABFL $

123   COND      LBLFL3,NOFL $

124   MTRXIN,   ,BDPOOL,EQDYN,,/ABFL,KBFL,/V,N,LUSETD/V,N,NOABFL/V,N,NOKBFL/C,
                N,0 $

125   SAVE      NOABFL,NOKBFL $

126   LABEL     LBLFL3 $

127   CHKPNT    ABFL,KBFL $

128   MTRXIN    CASECC,MATPOOL,EQDYN,,TFPOOL/K2DPP,M2DPP,B2PP/V,N,LUSETD/V,N,
                NOK2DPP/V,N,NOM2DPP/V,N,NOB2PP $

129   SAVE      NOK2DPP,NOM2DPP,NOB2PP $

130   PARAM     //C,N,AND/V,N,NOM2PP/V,N,NOABFL/V,N,NOM2DPP $

131   PARAM     //C,N,AND/V,N,NOK2PP/V,N,NOFL /V,N,NOK2DPP $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

132  EQUIV    M2DPP,M2PP/NOABFL $

133  ADD5     ABFL,KBFL,K2DPP,,/K2PP/C,N,(-1.0,0.0) $

134  COND     LBLFL2,NOABFL $

135  TRNSP    ABFL/ABFLT $

136  ADD      ABFLT,M2DPP/M2PP/V,N,MFACT $

137  LABEL    LBLFL2 $

138  PARAM    //C,N,AND/V,N,KDEKA/V,N,NOUE/V,N,NOK2PP $

139  PARAM    //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

140  PARAM    //C,N,AND/V,N,KDEK2/V,N,NOGENL/V,N,NOSIMP $

141  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

142  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA/  KAA,
              KDD/KDEKA $

143  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MDD,KDD $

144  COND     LBL16,NOGPDT $

145  GKAD     USETD,GM,GO,KAA,BAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDD,MDD,GMD,
              GOD,K2DD,M2DD,B2DD/C,N,TRANRESP/C,N,DISP/C,N,DIRECT/C,Y,G=0.0/
              C,Y,W3=0.0/C,Y,W4=0.0/V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/ V,N,
              MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/V,N,NOK4GG/V,N,NOBGG/V,N,
              KDEK2/C,N,-1 $

146  LABEL    LBL16 $

147  EQUIV    M2DD,MDD/NOSIMP/B2DD,BDD/NOGPDT/K2DD,KDD/KDEK2 $

148  CHKPNT   KDD,BDD,MDD,GMD,GOD $

149  COND     ERROR1,NOTRL $

150  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

151  PARAM    //C,N,MPY/V,N,REPEATT/C,N,1/C,N,-1 $

152  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

153  JUMP     LBL13 $
-------------------------------------------------  Top of DMAP Loop
154  LABEL    LBL13 $

155  PURGE    PNLD,OUDV1,OPNL1,OUDV2,OPNL2,XYPLTTA,OPP1,OQP1,OUPV1,OES1,OEF1,
              OPP2,OQP2,OUPV2,OES2,OEF2,PLOTX2,XYPLTT/NEVER $

156  CASE     CASECC,/CASEXX/C,N,TRAN/V,N,REPEATT/V,N,NOLOOP $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9

```
        N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

157  SAVE     REPEATT,NOLOOP $

158  CHKPNT   CASEXX $

159  PARAM    //C,N,MPY/V,N,NCOL/C,N,0/C,N,1 $

160  TRLG     CASEXX,USETD,DLT,SLT,BGPDT,SIL,CSTM,TRL,DIT,GMD,GOD,,EST,MGG/
              PPT,PST,PDT,PD,,TOL/V,N,NOSET/V,N,PDEPDO/V,N,NCOL $

161  SAVE     PDEPDO,NOSET $

162  CHKPNT   PPT,PST,PDT,PD,TOL $

163  EQUIV    PD,PDT/PDEPDO/PPT,PDT/NOSET $

164  CHKPNT   PDT $

165  TRD      CASEXX,TRL,NLFT,DIT,KDD,BDD,MDD,PD/UDVT,PNLD/C,N,DIRECT/V,N,
              NOUE/V,N,NONCUP/V,N,NCOL $

166  SAVE     NCOL $

167  CHKPNT   UDVT,PNLD $

168  VDR      CASEXX,EQDYN,USETD,UDVT,TOL,XYCDB,PNLD/OUDV1,OPNL1/ C,N,
              TRANRESP/C,N,DIRECT/C,N,0/V,N,NOD/V,N,NOP/C,N,0 $

169  SAVE     NOD,NOP $

170  CHKPNT   OUDV1,OPNL1 $

171  COND     LBL15,NOD $

172  SDR3     OUDV1,OPNL1,,,,/OUDV2,OPNL2,,,, $

173  OFP      OUDV2,OPNL2,,,,//V,N,CARDNO $

174  SAVE     CARDNO $

175  CHKPNT   OPNL2,OUDV2 $

176  XYTRAN   XYCDB,OUDV2,OPNL2,,,/XYPLTTA/C,N,TRAN/C,N,DSET/V,N,PFILE/V,N,
              CARDNO $

177  SAVE     PFILE,CARDNO $

178  XYPLOT   XYPLTTA// $

179  LABEL    LBL15 $

180  PARAM    //C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT $

181  COND     LBL18,PJUMP $

182  EQUIV    UDVT,UPV/NOA $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

183  COND      LBL17,NOA $

184  SDR1      USETD,,UDVT,,,GOD,GMD,PST,KFS,,/UPV,,QP/C,N,1/C,N,DYNAMICS $

185  LABEL     LBL17 $

186  CHKPNT    UPV,QP $

187  SDR2      CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDT,TOL,QP,UPV,EST,XYCDB,
               PPT/OPP1,OQP1,OUPV1,OES1,OEF1,PUGV/C,N,TRANRESP $

188  SDR3      OPP1,OQP1,OUPV1,OES1,OEF1,/OPP2,OQP2,OUPV2,OES2,OEF2, $

189  CHKPNT    OPP2,OQP2,OUPV2,OES2,OEF2 $

190  OFP       OPP2,OQP2,OUPV2,OEF2,OES2,//V,N,CARDNO $

191  SAVE      CARDNO $

192  COND      P2,JUMPPLOT $

193  PLOT      PLTPAR,GPSETS,ELSETS,CASEXX,BGPDT,EQEXIN,SIL,,PUGV,GPECT,OES1/
               PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

194  SAVE      PFILE $

195  PRTMSG    PLOTX2// $

196  LABEL     P2 $

197  XYTRAN    XYCDB,OPP2,OQP2,OUPV2,OES2,OEF2/XYPLTT/C,N,TRAN/C,N,PSET/V,N,
               PFILE/V,N,CARDNO $

198  SAVE      PFILE,CARDNO $

199  XYPLOT    XYPLTT// $

200  LABEL     LBL18 $

201  COND      FINIS,REPEATT $

202  REPT      LBL13,100 $
----------------------------------------------------------  Bottom of DMAP Loop
203  JUMP      ERROR2 $

204  JUMP      FINIS $

205  LABEL     ERROR2 $

206  PRTPARM   //C,N,-2/C,N,DIRTRD $

207  LABEL     ERROR1 $

208  PRTPARM   //C,N,-1/C,N,DIRTRD $

209  LABEL     ERROR3 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

210   PRTPARM   //C,N,-3/C,N,DIRTRD $

211   LABEL     FINIS $

212   END       $
```

3.10.2 Description of DMAP Operations for Direct Transient Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

7. Go to DMAP No. 113 if only Direct Matrix Input.

8. GP2 generates Element Connection Table with internal indices.

12. Go to DMAP No. 22 if no plot package is present.

13. PLTSET transforms user input into a form used to drive structure plotter.

15. PRTMSG prints error messages associated with structure plotter.

18. Go to DMAP No. 22 if no undeformed structure plot request.

19. PLØT generates all requested undeformed structure plots.

21. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

24. GP3 generates Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

30. Go to DMAP No. 61 if there are no structural elements.

35. EMG generates structural element matrix tables and dictionaries for later assembly.

38. Go to DMAP No. 41 if no stiffness matrix is to be assembled.

39. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

42. Go to DMAP No. 45 if no mass matrix is to be assembled.

43. EMA assembles mass matrix $[M_{gg}]$.

46. Go to DMAP No. 49 if no viscous damping matrix.

47. EMA assembles viscous damping matrix $[B_{gg}]$.

50. Go to DMAP No. 53 if no structural damping matrix.

51. EMA assembles structural damping matrix $[K^4_{gg}]$.

57. Go to DMAP No. 61 if no weight and balance request.

58. Go to DMAP No. 209 and print error message if no mass matrix exists.

59. GPWG generates weight and balance information.

60. ØFP formats weight and balance information and places it on the system output file for printing.

62. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

64. Go to DMAP No. 67 if no general elements.

65. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

69. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

73. Go to DMAP No. 79 if general elements present.

74. Go to DMAP No. 79 if no structural elements.

75. GPSP determines if possible grid point singularities remain.

77. Go to DMAP No. 79 if no grid point singularities exist.

78. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

80. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[M_{gg}]$ to $[M_{nn}]$, $[B_{gg}]$ to $[B_{nn}]$ and $[K^4_{gg}]$ to $[K^4_{nn}]$ if no multipoint constraints.

82. Go to DMAP No. 87 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

83. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

85. MCE2 partitions stiffness, mass and damping matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] , \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right] ,$$

$$[B_{gg}] = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array}\right] \quad \text{and} \quad [K^4_{gg}] = \left[\begin{array}{c|c} \bar{K}^4_{nn} & K^4_{nm} \\ \hline K^4_{mn} & K^4_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G^T_m][K_{mn}] + [K^T_{mn}][G_m] + [G^T_m][K_{mm}][G_m],$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G^T_m][M_{mn}] + [M^T_{mn}][G_m] + [G^T_m][M_{mm}][G_m],$$

$$[B_{nn}] = [\bar{B}_{nn}] + [G^T_m][B_{mn}] + [B^T_{mn}][G_m] + [G^T_m][B_{mm}][G_m],$$

$$[K^4_{nn}] = [\bar{K}^4_{nn}] + [G^T_m][K^4_{mn}] + [K^4_{mn}]^T[G_m] + [G^T_m][K^4_{mm}][G_m].$$

88. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K^4_{nn}]$ to $[K^4_{ff}]$ if no single-point constraints.

90. Go to DMAP No. 93 if no single-point constraints.

91. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] , \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right] ,$$

$$[B_{nn}] = \left[\begin{array}{c|c} B_{ff} & B_{fs} \\ \hline B_{sf} & B_{ss} \end{array}\right] \quad \text{and} \quad [K^4_{nn}] = \left[\begin{array}{c|c} K^4_{ff} & K^4_{fs} \\ \hline K^4_{sf} & K^4_{ss} \end{array}\right] .$$

94. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

95. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

96. Equivalence $[B_{ff}]$ to $[B_{aa}]$ if no omitted coordinates.

97. Equivalence $[K^4_{ff}]$ to $[K^4_{aa}]$ if no omitted coordinates.

99. Go to DMAP No. 113 if no omitted coordinates.

100. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} K_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = [K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction

$$[K^1_{aa}] = [K_{aa}] + [K_{ao}][G_o]$$

102. Go to DMAP No. 105 if no mass matrix.

103. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} M_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M^1_{aa}] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G_o^T][M_{oo}][G_o]$$

106. Go to DMAP No. 109 if no viscous damping matrix.

107. SMP2 partitions constrained viscous damping matrix

$$[B_{ff}] = \left[\begin{array}{c|c} B_{aa} & B_{ao} \\ \hline B_{oa} & B_{oo} \end{array}\right]$$

and performs matrix reduction

$$[B^1_{aa}] = [B_{aa}] + [B_{ao}][G_o] + [B_{ao}G_o]^T + [G_o^T][B_{oo}][G_o]$$

110. Go to DMAP No. 113 if no structural damping matrix.

111. SMP2 partitions constrained structural damping matrix

$$[K^4_{ff}] = \left[\begin{array}{c|c} K^4_{aa} & K^4_{ao} \\ \hline K^4_{oa} & K^4_{oo} \end{array}\right]$$

and performs matrix reduction

$$[K^4_{aa}] = [K^4_{aa}] + [K^4_{ao}][G_o] + [K^4_{ao}G_o]^T + [G_o^T][K^4_{oo}][G_o]$$

114. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Dynamics Load Table, Nonlinear Function Table and Transient Response List.

117. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

119. BMG generates DMIG card images describing the interconnection of the fluid and the structure.

123. Go to DMAP No. 126 if no fluid structure interface is defined.

124. MTRXIN generates fluid boundary matrices $[A_{b,f\ell}]$ and $[K_{b,f\ell}]$ if a fluid structure interface is defined. The matrix $[K_{b,f\ell}]$ is generated only for a nonzero gravity in the field.

128. MTRXIN selects the direct input matrices $[K_{pp}^{2d}]$, $[M_{pp}^{2d}]$ and $[B_{pp}^2]$.

132. Equivalence $[M_{pp}^{2d}]$ to $[M_{pp}^2]$ if no $[A_{b,f\ell}]$.

133. ADD5 adds $[K_{b,f\ell}]$ and $[K_{pp}^{2d}]$ and subtracts $[A_{b,f\ell}]$ from them to form $[K_{pp}^2]$.

134. Go to DMAP No. 137 if no $[A_{b,f\ell}]$.

135. Transpose $[A_{b,f\ell}]$ to obtain $[A_{b,f\ell}]^T$.

136. ADD assembles input matrix $[M_{pp}^2] = \text{MFACT } [A_{b,f\ell}]^T + [M_{pp}^{2d}]$.

142. Equivalence $[M_{pp}^2]$ to $[M_{dd}^2]$, $[B_{pp}^2]$ to $[B_{dd}^2]$ and $[K_{pp}^2]$ to $[K_{dd}^2]$ if no constraints applied, $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points, and $[K_{aa}]$ to $[K_{dd}]$ if no direct input stiffness matrices and no extra points.

144. Go to DMAP No. 146 if only extra points defined.

145. GKAD assembles stiffness, mass, and damping matrices for use in Direct Transient Response

$$[K_{dd}] = [K_{dd}^1] + [K_{dd}^2],$$

$$[M_{dd}] = [M_{dd}^1] + [M_{dd}^2] \text{ and}$$

$$[B_{dd}] = [B_{dd}^1] + [B_{dd}^2] + \frac{g}{\omega_3}[K_{dd}^1] + \frac{1}{\omega_4}[K_{dd}^4].$$

All matrices are real.

147. Equivalence $[B_{dd}^2]$ to $[B_{dd}]$ if all damping is Direct Matrix Input, $[M_{dd}^2]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[K_{dd}^2]$ to $[K_{dd}]$ if all stiffness is Direct Matrix Input.

149. Go to DMAP No. 207 and print error message if no Transient Response List.

153. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

154. Beginning of loop for additional dynamic load sets.

156. CASE extracts user requests from CASECC for current loop.

160. TRLG generates matrices of loads versus time. $\{P_p^t\}$, $\{P_s^t\}$, and $\{P_d^t\}$ are generated with one column per output time step. $\{P_d\}$ is generated with one column per solution time step, and the Transient Output List (TØL) is a list of output time steps.

163. Equivalence $\{P_d\}$ to $\{P_d^t\}$ if the output times are the same as the solution times and $\{P_p^t\}$ to $\{P_d^t\}$ if the d and p sets are the same.

165. TRD forms the linear and nonlinear dynamic load vectors $\{P_d\}$ and $\{P_d^{n\ell}\}$ and integrates the equations of motion over specified time periods to solve for the displacements, velocities, and accelerations, using the following equation

$$[M_{dd}p^2 + B_{dd}p + K_{dd}]\{u_d\} = \{P_d\} + \{P_d^{n\ell}\} .$$

168. VDR prepares displacements, velocities and accelerations, sorted by time step, for output using only the independent degrees of freedom.

171. Go to DMAP No. 179 if no output request for the independent degrees of freedom.

172. SDR3 sorts the independent displacements, velocities, accelerations and nonlinear load vectors by point number.

173. ØFP formats the requested independent displacements, velocities, accelerations and nonlinear load vectors sorted by point number and places them on the system output file for printing.

176. XYTRAN prepares the input for X-Y plotting of the independent displacements, velocities, accelerations and nonlinear load vectors vs. time.

178. XYPLØT prepares requested X-Y plots of the independent displacements, velocities, accelerations and nonlinear load vectors vs. time.

181. Go to DMAP No. 200 if no output request involving dependent degrees of freedom or forces and stresses.

182. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.

183. Go to DMAP No. 185 if no constraints applied.

184. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\} \quad , \qquad \left\{\begin{array}{c} u_d \\ \hline u_o \end{array}\right\} = \{u_f + u_e\} \quad ,$$

$$\left\{\begin{array}{c} u_f + u_e \\ \hline u_s \end{array}\right\} = \{u_n + u_e\} \quad , \qquad \{u_m\} = [G_m^d]\{u_f + u_e\} \quad ,$$

$$\left\{\begin{array}{c} u_n + u_e \\ \hline u_m \end{array}\right\} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

187. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement, velocity and acceleration vectors and single-point forces of constraint for output (ØPP1, ØUPV1, PUGV, ØQP1) - all sorted by time step.

188. SDR3 prepares requested output sorted by point number or element number.

190. ØFP formats requested output sorted by point number or element number and places it on the system output file for printing.

192. Go to DMAP No. 196 if no deformed structure plots requested.

193. PLØT prepares all requested deformed structure plots.

195. PRTMSG prints plotter data and engineering data for each deformed plot generated.

197. XYTRAN prepares the input for requested X-Y plots.

199. XYPLØT prepares requested X-Y plots of displacements, velocities, accelerations, forces, stresses, loads or single-point forces of constraint vs. time.

201. Go to DMAP No. 211 if no additional dynamic load sets need to be processed.

202. Go to DMAP No. 154 if additional dynamic load sets need to be processed.

203. Go to DMAP No. 205 and print error message if more than 100 loops.

204. Go to DMAP No. 211 and make normal exit.

206. DIRECT TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

208. DIRECT TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 1 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

210. DIRECT TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

3.10.3 Case Control Deck and Parameters for Direct Transient Response

The following items relate to subcase definition and data selection for Direct Transient Response:

1. One subcase must be defined for each dynamic loading condition.

2. DLØAD or NØNLINEAR must be used to define a time-dependent loading condition for each subcase.

3. Constraints must be defined above the subcase level.

4. TSTEP must be used to select the time-step intervals to be used for integration and output in each subcase.

5. If nonzero initial conditions are desired, IC must be used to select a TIC card in the Bulk Data Deck.

6. On restart following an unscheduled exit due to insufficient time, the subcase structure should be changed to reflect any completed loading conditions. The TSTEP selections must be changed if it is desired to resume the integration at the point terminated.

The following printed output, sorted by point number or element number (SØRT2) is available at selected multiples of the integration time step:

1. Displacements, velocities, and accelerations for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SØLUTIØN points (points used in formulation of the general K system).

2. Nonzero components of the applied load vector and single point forces of constraint for a list of PHYSICAL points.

3. Nonlinear force vector for a list of SØLUTIØN points.

4. Stresses and forces in selected elements (All not allowed).

The following plotter output is available for Transient Response:

1. Undeformed plot of the structural model.

2. Deformed shapes of the structural model for selected time intervals.

3. X-Y plot of any component of displacement, velocity, or acceleration of a PHYSICAL point or SØLUTIØN point.

4. X-Y plot of any component of the applied load vector, nonlinear force vector, or single-point force of constraint.

5. X-Y plot of any stress or force component for an element.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.2). Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Direct Transient Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. G - optional - The real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.

4. W3 and W4 - optional - The values of these parameters are used as pivotal frequencies for uniform structural damping and element structural damping respectively. W3 is required if uniform structural damping is desired. W4 is required if structural damping is desired for any of the structural elements. See page 9.3-8 of the NASTRAN Theoretical Manual.

5. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - These parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.11 MODAL COMPLEX EIGENVALUE ANALYSIS

3.11.1 DMAP Sequence for Modal Complex Eigenvalue Analysis

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.10 MODAL COMPLEX EIGENVALUE ANALYSIS - SERIES N $

  2  FILE      GOD=SAVE/ GMD=SAVE/ LAMA=APPEND/ PHIA=APPEND $

  3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

  4  SAVE      LUSET $

  5  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  6  GP2       GEOM2,EQEXIN/ECT $

  7  CHKPNT    ECT $

  8  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  9  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

 10  COND      P1,NOPCDB $

 11  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT=-1 $

 12  SAVE      NSIL,JUMPPLOT $

 13  PRTMSG    PLTSETX// $

 14  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 15  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 16  COND      P1,JUMPPLOT $

 17  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/   V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 18  SAVE      PFILE $

 19  PRTMSG    PLOTX1// $

 20  LABEL     P1 $

 21  CHKPNT    PLTPAR,GPSETS,ELSETS $

 22  GP3       GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

 23  CHKPNT    GPTT $

 24  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
               NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

 25  SAVE      NOGENL,NOSIMP,GENEL $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 26  COND      ERROR1,NOSIMP $

 27  PURGE     OGPST/GENEL $

 28  CHKPNT    EST,GPECT,GEI,OGPST $

 29  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

 30  PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

 31  EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
               N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
               CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
               CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

 32  SAVE      NOKGGX,NOMGG $

 33  CHKPNT    KELM,KDICT,MELM,MDICT $

 34  COND      JMPKGGX,NOKGGX $

 35  EMA       GPECT,KDICT,KELM/KGGX,GPST $

 36  CHKPNT    KGGX,GPST $

 37  LABEL     JMPKGGX $

 38  COND      ERROR1,NOMGG $

 39  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

 40  CHKPNT    MGG $

 41  COND      LGPWG,GRDPNT $

 42  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

 43  OFP       OGPWG,,,,,// $

 44  LABEL     LGPWG $

 45  EQUIV     KGGX,KGG/NOGENL $

 46  CHKPNT    KGG $

 47  COND      LBL11,NOGENL $

 48  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 49  CHKPNT    KGG $

 50  LABEL     LBL11 $

 51  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 52  GP4       CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.
               LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
               NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 53  SAVE      MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,NSKIP,REPEAT,NOL,NOA $

 54  PARAM     //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $

 55  PURGE     GM,GMD/MPCF1/GO,GOD/OMIT/KFS/SINGLE/QPC/NOSR/KLR,KRR,MLR,MRR,
               DM,MR/REACT $

 56  CHKPNT    KRR,KLR,DM,MLR,MRR,MR,GM,RG,GO,KFS,QPC,USET,GMD,GOD,ASET $

 57  COND      LBL4,GENEL $

 58  GPSP      GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 59  SAVE      NOGPST $

 60  COND      LBL4,NOGPST $

 61  OFP       OGPST,,,,,// $

 62  LABEL     LBL4 $

 63  EQUIV     KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

 64  CHKPNT    KNN,MNN $

 65  COND      LBL2,MPCF1 $

 66  MCE1      USET,RG/GM $

 67  CHKPNT    GM $

 68  MCE2      USET,GM,KGG,MGG,,/KNN,MNN,, $

 69  CHKPNT    KNN,MNN $

 70  LABEL     LBL2 $

 71  EQUIV     KNN,KFF/SINGLE/MNN,MFF/SINGLE $

 72  CHKPNT    KFF,MFF $

 73  COND      LBL3,SINGLE $

 74  SCE1      USET,KNN,MNN,,/KFF,KFS,,MFF,, $

 75  CHKPNT    KFS,KFF,MFF $

 76  LABEL     LBL3 $

 77  EQUIV     KFF,KAA/OMIT $

 78  EQUIV     MFF,MAA/OMIT $
```

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RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 79   CHKPNT    KAA,MAA $

 80   COND      LBL5,OMIT $

 81   SMP1      USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

 82   CHKPNT    GO,KAA $

 83   SMP2      USET,GO,MFF/MAA $

 84   CHKPNT    MAA $

 85   LABEL     LBL5 $

 86   COND      LBL6,REACT $

 87   RBMG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

 88   CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $

 89   RBMG2     KLL/LLL $

 90   CHKPNT    LLL $

 91   RBMG3     LLL,KLR,KRR/DM $

 92   CHKPNT    DM $

 93   RBMG4     DM,MLL,MLR,MRR/MR $

 94   CHKPNT    MR $

 95   LABEL     LBL6 $

 96   DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,,EED,EQDYN/V,
                N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/V,
                N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

 97   SAVE      LUSETD,NOUE,NOEED $

 98   COND      ERROR2,NOEED $

 99   EQUIV     GO,GOD/NOUE/GM,GMD/NOUE $

100   CHKPNT    USETD,EED,EQDYN,TFPOOL,GOD,GMD,SILD,GPLD $

101   PARAM     //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $

102   READ      KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
                NEIGV $

103   SAVE      NEIGV $

104   CHKPNT    LAMA,PHIA,MI,OEIGS $

105   PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
```

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

106   OFP      OEIGS,LAMA,,,,//V,N,CARDNO $

107   SAVE     CARDNO $

108   COND     ERROR4,NEIGV $

109   PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

110   PARAM    //C,N,MPY/V,N,REPEATE/C,N,1/C,N,-1 $

111   JUMP     LBL13 $
                                                    Top of DMAP Loop
112   LABEL    LBL13 $

113   PURGE    PHIH,CLAMA,OPHIH,CPHID,CPHIP,QPC,OQPC1,OCPHIP,OESC1,OEFC1,K2PP,
               M2PP,B2PP,K2DD,M2DD,B2DD/NEVER $

114   CASE     CASECC,/CASEXX/C,N,CEIGN/V,N,REPEATE/V,N,NOLOOP $

115   SAVE     REPEATE,NOLOOP $

116   CHKPNT   CASEXX $

117   MTRXIN   CASEXX,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
               NOK2PP/V,N,NOM2PP/V,N,NOB2PP $

118   SAVE     NOK2PP,NOM2PP,NOB2PP $

119   PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

120   EQUIV    M2PP,M2DD/NOSET/B2PP,B2DD/NOSET/K2PP,K2DD/NOSET $

121   CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD $

122   GKAD     USETD,GM,GO,,,,,K2PP,M2PP,B2PP/,,,GMD,GOD,K2DD,M2DD,B2DD/C,N,
               CMPLEV/C,N,DISP/C,N,MODAL/C,N,0.0/C,N,0.0/C,N,0.0/V,N,NOK2PP/V,
               N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/
               C,N,-1/C,N,-1/   C,N,-1/C,N,-1 $

123   CHKPNT   K2DD,M2DD,B2DD,GOD,GMD $

124   GKAM     USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASEXX/MHH,BHH,KHH,PHIDH/
               V,N,NOUE/C,Y,LMODES=999999/C,Y,LFREQ=0.0/C,Y,HFREQ=0.0/V,N,
               NOM2PP/V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE $

125   SAVE     NONCUP,FMODE $

126   CHKPNT   MHH,BHH,KHH,PHIDH $

127   CEAD     KHH,BHH,MHH,EED,CASEXX/PHIH,CLAMA,OCEIGS/V,N,EIGVS $

128   SAVE     EIGVS $

129   CHKPNT   PHIH,CLAMA,OCEIGS $

130   OFP      OCEIGS,CLAMA,,,,//V,N,CARDNO $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

131  SAVE     CARDNO $

132  COND     LBL17,EIGVS $

133  VDR      CASEXX,EQDYN,USETD,PHIH,CLAMA,,/OPHIH,/C,N,CEIGEN/C,N,MODAL/V,
              N,NOSORT2/V,N,NOH/V,N,NOP/V,N,FMODE $

134  SAVE     NOH,NOP $

135  COND     LBL16,NOH $

136  OFP      OPHIH,,,,,//V,N,CARDNO $

137  SAVE     CARDNO $

138  LABEL    LBL16 $

139  COND     LBL17,NOP $

140  DDR1     PHIH,PHIDH/CPHID $

141  CHKPNT   CPHID $

142  EQUIV    CPHID,CPHIP/NOA $

143  COND     LBLNOA,NOA $

144  SDR1     USETD,,CPHID,,,GOD,GMD,,KFS,,/CPHIP,,QPC/C,N,1 /C,N,DYNAMICS $

145  LABEL    LBLNOA $

146  CHKPNT   CPHIP,QPC $

147  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,CLAMA,QPC,CPHIP,EST,,/    ,
              OQPC1,OCPHIP,OESC1,OEFC1, /C,N,CEIGEN $

148  OFP      OCPHIP,OQPC1,OEFC1,OESC1,,//V,N,CARDNO $

149  SAVE     CARDNO $

150  LABEL    LBL17 $

151  COND     FINIS,REPEATE $

152  REPT     LBL13,100 $
-------------------------------------------------   Bottom of DMAP Loop
153  JUMP     ERROR3 $

154  JUMP     FINIS $

155  LABEL    ERROR3 $

156  PRTPARM  //C,N,-3/C,N,MDLCEAD $

157  LABEL    ERROR2 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

158  PRTPARM  //C,N,-2/C,N,MDLCEAD $

159  LABEL    ERROR1 $

160  PRTPARM  //C,N,-1/C,N,MDLCEAD $

161  LABEL    ERROR4 $

162  PRTPARM  //C,N,-4/C,N,MDLCEAD $

163  LABEL    FINIS $

164  END      $
```

3.11.2 Description of DMAP Operations for Modal Complex Eigenvalue Analysis

3. GP1 generates coordinate system transformation matrices, table of grid point locations, and tables for relating internal and external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot package is present.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plot request.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 159 and print error message if there are no structural elements.

31. EMG generates structural element matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K_{gg}^{x}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 159 if no mass matrix is to be assembled.

39. EMA assembles mass matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance request.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information and places it on the system output file for printing.

45. Equivalence $[K_{gg}^{x}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to stiffness matrix $[K_{gg}^{x}]$ to obtain stiffness matrix $[K_{gg}]$.

52. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

57. Go to DMAP No. 62 if general elements present.

58. GPSP determines if possible grid point singularities remain.

60. Go to DMAP No. 62 if no Grid Point Singularity Table.

61. ØFP formats table of possible grid point singularities and places it on the system output file for printing.

63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

65. Go to DMAP No. 70 if no multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right] .$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

80. Go to DMAP No. 85 if no omitted coordinates.

81. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

83. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o] .$$

86. Go to DMAP No. 95 if no free-body supports.

87. RBMG1 partitions out free-body supports.

89. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

91. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

93. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

96. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool and Eigenvalue Extraction Data.

98. Go to DMAP No. 157 and print error message if no Eigenvalue Extraction Data.

99. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

102. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D_m \ \phi_{ro} \\ --- \\ \phi_{ro} \end{bmatrix} ,$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:
1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

106. ØFP formats the summary of eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

108. Go to DMAP No. 161 and print error message if no eigenvalues found.

111. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

112. Beginning of loop for additional sets of direct input matrices.

114. CASE extracts user requests from CASECC for current loop.

117. MTRXIN selects the direct input matrices for the current loop, $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$.

120. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied.

122. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$ and $[B^2_{dd}]$.

124. GKAM assembles stiffness, mass and damping matrices in modal coordinates for use in Complex Eigenvalue Analysis.

$$[K_{hh}] = [k] + [\phi^T_{dh}][K^2_{dd}][\phi_{dh}] ,$$

$$[M_{hh}] = [m] + [\phi^T_{dh}][M^2_{dd}][\phi_{dh}],$$

$$[B_{hh}] = [b] + [\phi^T_{dh}][B^2_{dd}][\phi_{dh}],$$

where m_i = modal masses

$b_i = m_i \; 2\pi \; f_i \; g(f_i)$

$k_i = m_i \; 4\pi^2 \; f_i^2$

and direct input matrices may be complex.

127. CEAD extracts complex eigenvalues from the equation

$$[M_{hh}p^2 + B_{hh}p + K_{hh}]\{u_h\} = 0$$

and normalizes eigenvectors according to one of the following user requests:
(1) Unit magnitude of selected coordinate
(2) Unit magnitude of largest component.

130. ØFP formats the summary of complex eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

132. Go to DMAP No. 150 if no complex eigenvalues found.

133. VDR prepares eigenvectors for output, using only the extra points introduced for dynamic analysis and modal coordinates.

135. Go to DMAP No. 138 if no output request for the extra points introduced for dynamic analysis or modal coordinates.

136. ØFP formats eigenvectors for extra points introduced for dynamic analysis and modal coordinates and places them on the system output file for printing.

139. Go to DMAP No. 150 if no output request involving dependent degrees of freedom or forces and stresses.

140. DDR1 transforms the complex eigenvectors from modal to physical coordinates

$$[\phi_d] = [\phi_{dh}][\phi_h].$$

142. Equivalence $[\phi_d]$ to $[\phi_p]$ if no constraints applied.

143. Go to DMAP No. 145 if no constraints applied.

144. SDR1 recovers dependent components of eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_d\} \quad , \qquad \begin{Bmatrix} \phi_d \\ -- \\ \phi_o \end{Bmatrix} = \{\phi_f + \phi_e\} \quad ,$$

$$\begin{Bmatrix} \phi_f + \phi_e \\ --- \\ \phi_s \end{Bmatrix} = \{\phi_n + \phi_e\} \quad , \qquad \{\phi_m\} = [G_m^d]\{\phi_n + \phi_e\} \quad ,$$

$$\begin{Bmatrix} \phi_n + \phi_e \\ --- \\ \phi_m \end{Bmatrix} = \{\phi_p\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}^T]\{\phi_f\}$.

147. SDR2 calculates element forces and stresses (ØEFC1, ØESC1) and prepares eigenvectors and single-point forces of constraint for output (ØCPHIP, ØQPC1).

148. ØFP formats tables prepared by SDR2 and places them on system output file for printing.

151. Go to DMAP No. 163 if no additional sets of direct input matrices need to be processed.

152. Go to DMAP No.112 if additional sets of direct input matrices need to be processed.

153. Go to DMAP No.155 and print error message if more than 100 loops.

154. Go to DMAP No.163 and make normal exit.

156. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

158. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

160. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

162. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

3.11.3 Automatic Output for Modal Complex Eigenvalue Analysis

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

The Complex Eigenvalue Summary Table and the Complex Eigenvalue Analysis Summary, as described under Direct Complex Eigenvalue Analysis, are automatically printed for each set of direct input matrices.

3.11.4 Case Control Deck and Parameters for Modal Complex Eigenvalue Analysis

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Complex Eigenvalue Analysis:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.
2. All of the eigenvectors used in the modal formulation must be determined in a single execution.
3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.
4. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

Output that may be requested is the same as that described under Direct Complex Eigenvalue Analysis. Output for SØLUTIØN points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The eigenvectors used in the modal formulation may be obtained for the SØLUTIØN points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Complex Eigenvalue Analysis:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

4. LFREQ and HFREQ - required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.

5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

3.12 MODAL FREQUENCY AND RANDOM RESPONSE

3.12.1 DMAP Sequence for Modal Frequency and Random Response

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 11

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.11 MODAL FREQUENCY RESPONSE ANALYSIS - SERIES N $

  2  FILE      GOD=SAVE/ GMD=SAVE/ LAMA=APPEND/ PHIA=APPEND $

  3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

  4  SAVE      LUSET $

  5  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  6  GP2       GEOM2,EQEXIN/ECT $

  7  CHKPNT    ECT $

  8  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  9  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

 10  COND      P1,NOPCDB $

 11  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT=-1 $

 12  SAVE      NSIL,JUMPPLOT $

 13  PRTMSG    PLTSETX// $

 14  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 15  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 16  COND      P1,JUMPPLOT $

 17  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/   V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 18  SAVE      PFILE $

 19  PRTMSG    PLOTX1// $

 20  LABEL     P1 $

 21  CHKPNT    PLTPAR,GPSETS,ELSETS $

 22  GP3       GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

 23  CHKPNT    GPTT $

 24  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
               NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

 25  SAVE      NOGENL,NOSIMP,GENEL $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 11

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 26  COND      ERROR1,NOSIMP $

 27  PURGE     OGPST/GENEL $

 28  CHKPNT    EST,GPECT,GEI,OGPST $

 29  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

 30  PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

 31  EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
               N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
               CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
               CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

 32  SAVE      NOKGGX,NOMGG $

 33  CHKPNT    KELM,KDICT,MELM,MDICT $

 34  COND      JMPKGGX,NOKGGX $

 35  EMA       GPECT,KDICT,KELM/KGGX,GPST $

 36  CHKPNT    KGGX,GPST $

 37  LABEL     JMPKGGX $

 38  COND      ERROR1,NOMGG $

 39  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

 40  CHKPNT    MGG $

 41  COND      LGPWG,GRDPNT $

 42  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

 43  OFP       OGPWG,,,,,// $

 44  LABEL     LGPWG $

 45  EQUIV     KGGX,KGG/NOGENL $

 46  CHKPNT    KGG $

 47  COND      LBL11,NOGENL $

 48  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 49  CHKPNT    KGG $

 50  LABEL     LBL11 $

 51  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 52  GP4       CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 11

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.
               LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
               NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 53  SAVE      MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,NSKIP,REPEAT,NOL,NOA $

 54  PARAM     //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $

 55  PURGE     GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PSF/SINGLE/QPC/NOSR/KLR,KRR,MLR,
               MRR,DM,MR/REACT/MOD/MODACC $

 56  CHKPNT    KRR,KLR,DM,MLR,MRR,MR,GM,RG,GO,KFS,PSF,QPC,USET,GOD,GMD,ASET $

 57  COND      LBL4,GENEL $

 58  GPSP      GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 59  SAVE      NOGPST $

 60  COND      LBL4,NOGPST $

 61  OFP       OGPST,,,,,// $

 62  LABEL     LBL4 $

 63  EQUIV     KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

 64  CHKPNT    KNN,MNN $

 65  COND      LBL2,MPCF1 $

 66  MCE1      USET,RG/GM $

 67  CHKPNT    GM $

 68  MCE2      USET,GM,KGG,MGG,,/KNN,MNN,, $

 69  CHKPNT    KNN,MNN $

 70  LABEL     LBL2 $

 71  EQUIV     KNN,KFF/SINGLE/MNN,MFF/SINGLE $

 72  CHKPNT    KFF,MFF $

 73  COND      LBL3,SINGLE $

 74  SCE1      USET,KNN,MNN,,/KFF,KFS,,MFF,, $

 75  CHKPNT    KFS,KFF,MFF $

 76  LABEL     LBL3 $

 77  EQUIV     KFF,KAA/OMIT $

 78  EQUIV     MFF,MAA/OMIT $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 11

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 79  CHKPNT   KAA,MAA $

 80  COND     LBL5,OMIT $

 81  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

 82  CHKPNT   GO,KAA $

 83  SMP2     USET,GO,MFF/MAA $

 84  CHKPNT   MAA $

 85  LABEL    LBL5 $

 86  EQUIV    KAA,KLL/REACT $

 87  CHKPNT   KLL $

 88  COND     LBL6,REACT $

 89  RBMG1    USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

 90  CHKPNT   KLL,KLR,KRR,MLL,MLR,MRR $

 91  JUMP     LBL8 $

 92  LABEL    LBL6 $

 93  COND     LBL7,MODACC $

 94  LABEL    LBL8 $

 95  RBMG2    KLL/LLL $

 96  CHKPNT   LLL $

 97  COND     LBL7,REACT $

 98  RBMG3    LLL,KLR,KRR/DM $

 99  CHKPNT   DM $

100  RBMG4    DM,MLL,MLR,MRR/MR $

101  CHKPNT   MR $

102  LABEL    LBL7 $

103  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,PSDL,FRL,,,
              EED,EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/
              V,N,NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

104  SAVE     LUSETD,NOUE,NODLT,NOFRL,NOEED,NOPSDL $

105  COND     ERROR2,NOEED $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 11

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

106  PURGE    UEVF/NOUE $

107  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $

108  CHKPNT   USETD,EQDYN,TFPOOL,DLT,FRL,EED,GOD,GMD,UEVF,SILD,PSDL,GPLD $

109  PARAM    //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $

110  READ     KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
              NEIGV $

111  SAVE     NEIGV $

112  CHKPNT   LAMA,PHIA,MI,OEIGS $

113  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

114  OFP      OEIGS,LAMA,,,,//V,N,CARDNO $

115  SAVE     CARDNO $

116  COND     ERROR4,NEIGV $

117  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

118  PARAM    //C,N,MPY/V,N,REPEATF/C,N,1/C,N,-1 $

119  JUMP     LBL13 $
------------------------------------------------------------  Top of DMAP Loop
120  LABEL    LBL13 $

121  PURGE    OUHVC1,OUHVC2,XYPLTFA,OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,OPPC2,
              OQPC2,OUPVC2,OESC2,OEFC2,XYPLTF,PSDF,AUTO,XYPLTR,K2PP,M2PP,
              B2PP,K2DD,M2DD,B2DD,OPPCA,IQP1,IPHIP1,IES1,IEF1,OPPCB,IQP2,
              IPHIP2,IES2,IEF2,ZQPC2,ZUPVC2,ZESC2,ZEFC2,ZQPC1,ZUPVC1,ZESC1,
              ZEFC1/NEVER $

122  CASE     CASECC,PSDL/CASEXX/C,N,FREQ/V,N,REPEATF/V,N,NOLOOP $

123  SAVE     REPEATF,NOLOOP $

124  CHKPNT   CASEXX $

125  MTRXIN   CASEXX,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
              NOK2PP/V,N,NOM2PP/V,N,NOB2PP $

126  SAVE     NOK2PP,NOM2PP,NOB2PP $

127  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

128  PARAM    //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

129  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA $

130  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MDD $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 11

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

131  GKAD      USETD,GM,GO,,,MAA,,K2PP,M2PP,B2PP/,,MDD,GMD,    GOD,K2DD,M2DD,
               B2DD/C,N,FREQRESP/C,N,DISP/C,N,MODAL/C,N,0.0/ C,N,0.0/C,N,0.0/
               V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/    V,N,MPCF1/V,N,SINGLE/V,N,
               OMIT/V,N,NOUE/C,N,-1/C,N,-1/    C,N,+1/V,Y,MODACC = -1 $

132  CHKPNT    MDD,GMD,GOD,K2DD,M2DD,B2DD $

133  GKAM      USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASEXX/MHH,BHH,KHH,PHIDH/
               V,N,NOUE/C,Y,LMODES=999999/C,Y,LFREQ=0.0/C,Y,HFREQ=0.0/V,N,
               NOM2PP/V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE $

134  SAVE      NONCUP,FMODE $

135  CHKPNT    MHH,BHH,KHH,PHIDH $

136  COND      ERROR5,NOFRL $

137  COND      ERROR6,NODLT $

138  FRRD      CASEXX,USETD,DLT,FRL,GMD,GOD,KHH,BHH,MHH,PHIDH,DIT/UHVF,PSF,
               PDF,PPF/C,N,DISP/C,N,MODAL/V,N,LUSETD/V,N,MPCF1/V,N,SINGLE/V,N,
               OMIT/V,N,NONCUP/V,N,FRQSET $

139  SAVE      FRQSET $

140  EQUIV     PPF,PDF/NOSET $

141  CHKPNT    PSF,PPF,UHVF,PDF $

142  VDR       CASEXX,EQDYN,USETD,UHVF,PPF,XYCDB,/OUHVC1,/C,N,FREQRESP/C,N,
               MODAL/V,N,NOSORT2/V,N,NOH/V,N,NOP/V,N,FMODE $

143  SAVE      NOH,NOP,NOSORT2 $

144  COND      LBL16,NOH $

145  COND      LBL16A,NOSORT2 $

146  CHKPNT    OUHVC1 $

147  SDR3      OUHVC1,,,,,/OUHVC2,,,,, $

148  OFP       OUHVC2,,,,,//V,N,CARDNO $

149  SAVE      CARDNO $

150  CHKPNT    OUHVC2 $

151  XYTRAN    XYCDB,OUHVC2,,,,/XYPLTFA/C,N,FREQ/C,N,HSET/V,N,PFILE/V,N,
               CARDNO $

152  SAVE      PFILE,CARDNO $

153  XYPLOT    XYPLTFA // $

154  JUMP      LBL16 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 11

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

155  LABEL    LBL16A $

156  OFP      OUHVC1,,,,,//V,N,CARDNO $

157  SAVE     CARDNO $

158  LABEL    LBL16 $

159  COND     LBL14,NOP $

160  PARAM    //C,N,NOT/V,N,NOMOD/V,Y,MODACC $

161  COND     LBDDRM,MODACC $

162  DDR1     UHVF,PHIDH/UDV1F $

163  CHKPNT   UDV1F $

164  DDR2     USETD,UDV1F,PDF,K2DD,B2DD,MDD,PPF,LLL,DM/UDV2F,UEVF,PAF/   C,N,
              FREQRESP/V,N,NOUE/V,N,REACT/V,N,FRQSET $

165  CHKPNT   UDV2F,UEVF,PAF $

166  EQUIV    UDV2F,UDV1F/NOMOD $

167  CHKPNT   UDV1F $

168  EQUIV    UDV1F,UPVC/NOA $

169  COND     LBLNOA,NOA $

170  SDR1     USETD,,UDV1F,,,GOD,GMD,PSF,KFS,,/UPVC,,QPC/C,N,1/C,N,DYNAMICS $

171  LABEL    LBLNOA $

172  CHKPNT   UPVC,QPC $

173  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,PPF,QPC,UPVC,EST,XYCDB,PPF/
              OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,/C,N,FREQ/V,N,NOSORT2 $

174  SAVE     NOSORT2 $

175  COND     LBL18,NOSORT2 $

176  SDR3     OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,/OPPC2,OQPC2,OUPVC2,OESC2,
              OEFC2, $

177  JUMP     P2A $

178  LABEL    LBDDRM $

179  SDR1     USETD,,PHIDH,,,GOD,GMD,,KFS,,/PHIPH,,QPH/C,N,1/C,N,DYNAMICS $

180  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,LAMA,QPH,PHIPH,EST,XYCDB,/
              ,IQP1,IPHIP1,IES1,IEF1,/C,N,MMREIG/V,N,NOSORT2 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 11

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

181  SAVE     NOSORT2 $

182  SDR2     CASEXX,,,,EQDYN,SILD,,,,PPF,,,,XYCDB,PPF/OPPCA,,,,,/C,N,FREQ $

183  EQUIV    OPPCA,OPPC1/MODACC $

184  COND     LBLSORT,NOSORT2 $

185  SDR3     IQP1,IPHIP1,IES1,IEF1,OPPCA,/IQP2,IPHIP2,IES2,IEF2,OPPCB, $

186  EQUIV    OPPCB,OPPC2/MODACC $

187  DDRMM    CASEXX,UHVF,PPF,IPHIP2,IQP2,IES2,IEF2,,EST,MPT,DIT/   ZUPVC2,
              ZQPC2,ZESC2,ZEFC2, $

188  EQUIV    ZUPVC2,OUPVC2/MODACC/ZQPC2,OQPC2/MODACC/ZESC2,OESC2/MODACC/
              ZEFC2,OEFC2/MODACC $

189  JUMP     P2A $

190  LABEL    LBLSORT $

191  DDRMM    CASEXX,UHVF,PPF,IPHIP1,IQP1,IES1,IEF1,,EST,MPT,DIT/   ZUPVC1,
              ZQPC1,ZESC1,ZEFC1, $

192  EQUIV    ZUPVC1,OUPVC1/MODACC/ZQPC1,OQPC1/MODACC/ZESC1,OESC1/MODACC/
              ZEFC1,OEFC1/MODACC $

193  JUMP     LBL18 $

194  LABEL    P2A $

195  CHKPNT   OUPVC2,OPPC2,OQPC2,OESC2,OEFC2 $

196  OFP      OPPC2,OQPC2,OUPVC2,OEFC2,OESC2,//V,N,CARDNO $

197  SAVE     CARDNO $

198  XYTRAN   XYCDB,OPPC2,OQPC2,OUPVC2,OESC2,OEFC2/XYPLTF/C,N,FREQ/C,N,PSET/
              V,N,PFILE/V,N,CARDNO $

199  SAVE     PFILE,CARDNO $

200  XYPLOT   XYPLTF// $

201  COND     LBL14,NOPSDL $

202  RANDOM   XYCDB,DIT,PSDL,OUPVC2,OPPC2,OQPC2,OESC2,OEFC2,CASEXX/PSDF,AUTO/
              V,N,NORD $

203  SAVE     NORD $

204  CHKPNT   PSDF,AUTO $

205  COND     LBL14,NORD $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 11

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

206  XYTRAN    XYCDB,PSDF,AUTO,,,/XYPLTR/C,N,RAND/C,N,PSET/V,N,PFILE/   V,N,
               CARDNO $

207  SAVE      PFILE,CARDNO $

208  XYPLOT    XYPLTR// $

209  JUMP      LBL14 $

210  LABEL     LBL18 $

211  OFP       OUPVC1,OPPC1,OQPC1,OEFC1,OESC1,//V,N,CARDNO $

212  SAVE      CARDNO $

213  LABEL     LBL14 $

214  COND      FINIS,REPEATF $

215  REPT      LBL13,100 $
-----------------------------------------------  Bottom of DMAP Loop
216  JUMP      ERROR3 $

217  JUMP      FINIS $

218  LABEL     ERROR3 $

219  PRTPARM   //C,N,-3/C,N,MDLFRRD $

220  LABEL     ERROR2 $

221  PRTPARM   //C,N,-2/C,N,MDLFRRD $

222  LABEL     ERROR1 $

223  PRTPARM   //C,N,-1/C,N,MDLFRRD $

224  LABEL     ERROR4 $

225  PRTPARM   //C,N,-4/C,N,MDLFRRD $

226  LABEL     ERROR5 $

227  PRTPARM   //C,N,-5/C,N,MDLFRRD $

228  LABEL     ERROR6 $

229  PRTPARM   //C,N,-6/C,N,MDLFRRD $

230  LABEL     FINIS $

231  END       $
```

3.12.2 Description of DMAP Operations for Modal Frequency and Random Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot package is present.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plot request.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 222 and print error messages if there are no structural elements.

31. EMG generates structural element matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 222 if no mass matrix is to be assembled.

39. EMA assembles stiffness matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance request.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information and places it on the system output file for printing.

45. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to stiffness matrix $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

52. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

57. Go to DMAP No. 62 if general elements present.

58. GPSP determines if possible grid point singularities remain.

60. Go to DMAP No. 62 if no grid point singularities remain.

61. ØFP formats table of possible grid point singularities and places it on the system output file for printing.

63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

65. Go to DMAP No. 70 if no multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right] .$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

80. Go to DMAP No. 85 if no omitted coordinates.

81. SMP1 partitions constrained stiffness matrix.

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

83. SMP2 partitions constrained mass matrix.

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o].$$

86. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

88. Go to DMAP No. 92 if no free-body supports.

89. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right]$$

91. Go to DMAP No. 94.

93. Go to DMAP No. 102 if no request for mode acceleration data recovery.

95. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

97. Go to DMAP No. 102 if no free-body supports.

98. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

100. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

103. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Dynamic Loads Table, Power Spectral Density List, Frequency Response List and Eigenvalue Extraction Data.

105. Go to DMAP No. 220 and print error message if no Eigenvalue Extraction Data.

107. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

110. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \left[\begin{array}{c} D_m \, \phi_{ro} \\ \hline \phi_{ro} \end{array}\right] ,$$

calculates modal mass matrix

$$[m] = [\Phi_a^T][M_{aa}][\Phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

114. ØFP formats the summary of eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

116. Go to DMAP No. 224 and print error message if no eigenvalues found.

119. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

120. Beginning of loop for additional sets of direct input matrices.

122. CASE extracts user requests from CASECC for current loop.

125. MTRXIN selects the direct input matrices for the current loop, $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$.

129. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied and $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points introduced for Dynamic analysis.

131. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$ and $[B^2_{dd}]$.

133. GKAM assembles stiffness mass and damping matrices in modal coordinates for use in Frequency Response.

$$[K_{hh}] = [k] + [\phi^T_{dh}][K^2_{dd}][\phi_{dh}] ,$$

$$[M_{hh}] = [m] + [\phi^T_{dh}][M^2_{dd}][\phi_{dh}],$$

$$[B_{hh}] = [b] + [\phi^T_{dh}][B^2_{dd}][\phi_{dh}],$$

where

$$m_i = \text{modal masses}$$

$$b_i = m_i\ 2\pi\ f_i\ g(f_i)$$

$$k_i = m_i\ 4\pi^2 f_i^2$$

and direct input matrices may be complex.

136. Go to DMAP No. 226 and print error message if no Frequency Response List.

137. Go to DMAP No. 228 and print error message if no Dynamic Loads Table.

138. FRRD forms the dynamic load vectors $\{P_h\}$ and solves for the displacements using the following equation

$$[-M_{hh}\omega^2 + iB_{hh}\omega + K_{hh}']\{u_h\} = \{P_h\}.$$

140. Equivalence $\{P_p\}$ to $\{P_d\}$ if no constraints applied.

142. VDR prepares displacements, sorted by frequency, for output using only the extra points introduced for dynamic analysis and modal coordinates (solution points).

144. Go to DMAP No. 158 if no output request for solution points.

145. Go to DMAP No. 155 if no output request for solution points sorted by extra point or mode number.

147. SDR3 sorts the solution point displacements by extra point or mode number.

148. ØFP formats the requested solution point displacements sorted by extra point or mode number and places them on the system output file for printing.

151. XYTRAN prepares the input for X-Y plotting of the solution point displacements vs. frequency.

153. XYPLØT prepares requested X-Y plots of the solution point displacements vs. frequency.

154. Go to DMAP No. 158.

156. ØFP formats the requested solution point displacements sorted by frequency and places them on the system output file for printing.

159. Go to DMAP No. 213 if no output request involving dependent degrees of freedom or forces and stresses.

161. Go to DMAP No. 178 if mode acceleration technique not requested.

162. DDR1 transforms the solution vector of displacements from modal to physical coordinates

$$\{u_d\} = [\phi_{dh}]\{u_h\}$$

164. DDR2 calculates an improved displacement vector using the mode acceleration technique, if requested.

168. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.

169. Go to DMAP No. 171 if no constraints applied.

170. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\} \quad , \qquad \left\{\begin{array}{c} u_d \\ \hline u_o \end{array}\right\} = \{u_f + u_e\} \quad ,$$

$$\left\{\begin{array}{c} u_f + u_e \\ \hline u_s \end{array}\right\} = \{u_n + u_e\} \quad , \qquad \{u_m\} = [G_m^d]\{u_f + u_e\} \quad ,$$

$$\left\{\begin{array}{c} u_n + u_e \\ \hline u_m \end{array}\right\} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

173. SDR2 calculates element forces and stresses (ØEFC1, ØESC1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPPC1, ØUPVC1, ØQPC1) - all sorted by frequency.

175. Go to DMAP No. 210 if no output requests sorted by point number or element number.

176. SDR3 prepares requested output sorted by point number or element number.

177. Go to DMAP No. 194 because no mode accelerations requested.

179. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_n\} \quad , \qquad \left\{\begin{array}{c}\phi_n \\ \hline \phi_o\end{array}\right\} = \{\phi_f + u_e\}$$

$$\left\{\begin{array}{c}\phi_f + u_e \\ \hline \phi_s\end{array}\right\} = \{\phi_n + u_e\} \qquad \{\phi_m\} = [G_m^d]\{\phi_n + u_e\}$$

$$\left\{\begin{array}{c}\phi_n + u_e \\ \hline \phi_m\end{array}\right\} = \{\phi_g + u_e\} = \{\phi_p\}$$

and recovers single-point forces of constraint

$$\{q_s\} = [K_{fs}]^T\{\phi_f\} \quad .$$

180. SDR2 calculates element forces and stresses (IEF1,IES1) and prepares eigenvectors and single-point forces of constraint for output (IPHIP1, IQP1) - all sorted by frequency.

182. SDR2 prepares load vectors for output (ØPPCA) - sorted by frequency.

183. Equivalence ØPPCA to ØPPC1 if mode acceleration requested.

184. Go to DMAP No. 190 if no output requested by point number or element number sort.

185. SDR3 prepares requested output sorted by point number or element number.

186. Equivalence ØPPCB to ØPPC2 if mode acceleration requested.

187. DDRMM prepares a subset of the element forces and stresses (ZEFC2, ZESC2), and displacement vectors and single-point forces of constraint (ZUPVC2, ZQPC2) solutions for output by point number or element number sort.

188. Equivalence ZUPVC2 to ØUPVC2, ZQPC2 to ØQPC2, ZESC2 to ØESC2, and ZEFC2 to ØEFC2 if mode acceleration requested.

189. Go to DMAP No. 194 because requested output is sorted by point number or element number.

191. DDRMM prepares a subset of the element forces and stresses (ZEFC1, ZESC1) and displacement vectors and single-point forces of constraint (ZUPVC1, ZQPC1) solutions for output.

192. Equivalence ZUPVC1 to ØUPVC1, ZQPC1 to ØQPC1, ZESC1 to ØESC1, and ZEFC1 to ØEFC1 if mode accelerations requested.

193. Go to DMAP No. 210 because requested output is not sorted by point number or element number.

196. ØFP formats the requested output sorted by point number or element number and places it on the system output file for printing.

198. XYTRAN prepares the input for requested X-Y plots.

200. XYPLØT prepares requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. frequency.

201. Go to DMAP No. 213 if no Power Spectral Density List.

202. RANDØM calculates power spectral density functions and autocorrelation functions using the previously calculated frequency response.

205. Go to DMAP No. 213 if no RANDØM calculations requested.

206. XYTRAN prepares the input for requested X-Y plots of the RANDØM output.

208. XYPLØT prepares reuqested X-Y plots of autocorrelation functions and power spectral density functions.

209. Go to DMAP No. 213 because there are no frequency response output requests sorted by frequency.

211. ØFP formats the frequency response output requests sorted by frequency and places them on the system output file for printing.

214. Go to DMAP No. 230 if no additional sets of direct input matrices need to be processed.

215. Go to DMAP No. 120 if additional sets of direct input matrices need to be processed.

216. Go to DMAP No. 218 and print error message if more than 100 loops.

217. Go to DMAP No. 230 and make normal exit.

219. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

221. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

223. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

225. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

227. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 5 - FREQUENCY RESPØNSE LIST REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

229. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 6 - DYNAMIC LØADS TABLE REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

3.12.3 Automatic Output for Modal Frequency and Random Response

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

3.12.4 Case Control Deck and Parameters for Modal Frequency and Random Response

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Frequency and Random Response:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.

2. All of the eigenvectors used in the modal formulation must be determined in a single execution.

3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.

4. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

Output that may be requested is the same as that described under Direct Frequency and Random Response. Output for SØLUTIØN points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The eigenvectors used in the modal formulation may be obtained for the SØLUTIØN points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Frequency and Random Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

4. LFREQ and HFREQ - required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.

5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

6. MØDACC - optional - A positive integer value of this parameter causes the Dynamic Data Recovery module to use the mode acceleration method. Not recommended for use in hydroelastic problems.

3.13 MODAL TRANSIENT RESPONSE

3.13.1 DMAP Sequence for Modal Transient Response

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 12

```
        N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

   1  BEGIN    NO.12 MODAL TRANSIENT RESPONSE ANALYSIS - SERIES N $

   2  FILE     LAMA=APPEND/PHIA=APPEND/UHVT=APPEND $

   3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

   4  SAVE     LUSET $

   5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

   6  GP2      GEOM2,EQEXIN/ECT $

   7  CHKPNT   ECT $

   8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

  10  COND     P1,NOPCDB $

  11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT=-1 $

  12  SAVE     NSIL,JUMPPLOT $

  13  PRTMSG   PLTSETX// $

  14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

  15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

  16  COND     P1,JUMPPLOT $

  17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/   V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

  18  SAVE     JUMPPLOT,PLTFLG,PFILE $

  19  PRTMSG   PLOTX1// $

  20  LABEL    P1 $

  21  CHKPNT   PLTPAR,GPSETS,ELSETS $

  22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

  23  CHKPNT   SLT,GPTT $

  24  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/  V,N,
               NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

  25  SAVE     NOGENL,NOSIMP,GENEL $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 12

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 26  COND      ERROR1,NOSIMP $

 27  PURGE     OGPST/GENEL $

 28  CHKPNT    EST,GPECT,GEI,OGPST $

 29  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

 30  PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

 31  EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
               N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
               CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
               CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

 32  SAVE      NOKGGX,NOMGG $

 33  CHKPNT    KELM,KDICT,MELM,MDICT $

 34  COND      JMPKGGX,NOKGGX $

 35  EMA       GPECT,KDICT,KELM/KGGX,GPST $

 36  CHKPNT    KGGX,GPST $

 37  LABEL     JMPKGGX $

 38  COND      ERROR1,NOMGG $

 39  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

 40  CHKPNT    MGG $

 41  COND      LGPWG,GRDPNT $

 42  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

 43  OFP       OGPWG,,,,,// $

 44  LABEL     LGPWG $

 45  EQUIV     KGGX,KGG/NOGENL $

 46  CHKPNT    KGG $

 47  COND      LBL11,NOGENL $

 48  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 49  CHKPNT    KGG $

 50  LABEL     LBL11 $

 51  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 52  GP4       CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 12

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.
                 LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
                 NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 53  SAVE        MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,NSKIP,REPEAT,NOL,NOA $

 54  PARAM       //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $

 55  PURGE       GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PST/SINGLE/QP/NOSR/KLR,KRR,MLR,MR,
                 MRR,DM/REACT $

 56  CHKPNT      KRR,KLR,DM,MLR,MRR,MR,GM,RG,GO,KFS,PST,QP,USET,GOD,GMD,ASET $

 57  COND        LBL4,GENEL $

 58  GPSP        GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 59  SAVE        NOGPST $

 60  COND        LBL4,NOGPST $

 61  OFP         OGPST,,,,,// $

 62  LABEL       LBL4 $

 63  EQUIV       KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

 64  CHKPNT      KNN,MNN $

 65  COND        LBL2,MPCF1 $

 66  MCE1        USET,RG/GM $

 67  CHKPNT      GM $

 68  MCE2        USET,GM,KGG,MGG,,/KNN,MNN,, $

 69  CHKPNT      KNN,MNN $

 70  LABEL       LBL2 $

 71  EQUIV       KNN,KFF/SINGLE/MNN,MFF/SINGLE $

 72  CHKPNT      KFF,MFF $

 73  COND        LBL3,SINGLE $

 74  SCE1        USET,KNN,MNN,,/KFF,KFS,,MFF,, $

 75  CHKPNT      KFS,KFF,MFF $

 76  LABEL       LBL3 $

 77  EQUIV       KFF,KAA/OMIT $

 78  EQUIV       MFF,MAA/OMIT $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 12

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 79   CHKPNT    KAA,MAA $

 80   COND      LBL5,OMIT $

 81   SMP1      USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

 82   CHKPNT    GO,KAA $

 83   SMP2      USET,GO,MFF/MAA $

 84   CHKPNT    MAA $

 85   LABEL     LBL5 $

 86   EQUIV     KAA,KLL/REACT $

 87   CHKPNT    KLL $

 88   COND      LBL6,REACT $

 89   RBMG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

 90   CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $

 91   JUMP      LBL8 $

 92   LABEL     LBL6 $

 93   COND      LBL7,MODACC $

 94   LABEL     LBL8 $

 95   RBMG2     KLL/LLL $

 96   CHKPNT    LLL $

 97   COND      LBL7,REACT $

 98   RBMG3     LLL,KLR,KRR/DM $

 99   CHKPNT    DM $

100   RBMG4     DM,MLL,MLR,MRR/MR $

101   CHKPNT    MR $

102   LABEL     LBL7 $

103   DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,,,NLFT,TRL,
                EED ,EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/
                V,N,NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

104   SAVE      LUSETD,NODLT,NONLFT,NOTRL,NOUE,NOEED $

105   COND      ERROR2,NOEED $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 12

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

106  PURGE    UEVT/NOUE/PNLH/NONLFT $

107  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $

108  CHKPNT   USETD,EQDYN,TFPOOL,DLT,TRL,EED,GOD,GMD,UEVT,NLFT,PNLH,SILD,
              GPLD $

109  PARAM    //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $

110  READ     KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
              NEIGV $

111  SAVE     NEIGV $

112  CHKPNT   LAMA,PHIA,MI,OEIGS $

113  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

114  OFP      OEIGS,LAMA,,,,//V,N,CARDNO $

115  SAVE     CARDNO $

116  COND     ERROR4,NEIGV $

117  MTRXIN   CASECC,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
              NOK2PP/V,N,NOM2PP/V,N,NOB2PP $

118  SAVE     NOK2PP,NOM2PP,NOB2PP $

119  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

120  PARAM    //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

121  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA $

122  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MDD $

123  GKAD     USETD,GM,GO,,,MAA,,K2PP,M2PP,B2PP/,,MDD,GMD,   GOD,K2DD,M2DD,
              B2DD/C,N,TRANRESP/C,N,DISP/C,N,MODAL/C,N,0.0/ C,N,0.0/C,N,0.0/
              V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/V,N,SINGLE/V,N,
              OMIT/V,N,NOUE/C,N,-1/C,N,-1/   C,N,+1/V,Y,MODACC = -1 $

124  CHKPNT   MDD,GMD,GOD,K2DD,M2DD,B2DD $

125  GKAM     USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASECC/MHH,BHH,KHH,PHIDH/
              V,N,NOUE/C,Y,LMODES=999999/C,Y,LFREQ=0.0/C,Y,HFREQ=0.0/V,N,
              NOM2PP/V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE $

126  SAVE     NONCUP,FMODE $

127  CHKPNT   MHH,BHH,KHH,PHIDH $

128  COND     ERROR5,NOTRL $

129  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 12

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

DMAP-DMAP INSTRUCTION
NO.

```
130  PARAM    //C,N,MPY/V,N,REPEATT/C,N,1/C,N,-1 $
131  JUMP     LBL13 $
                                                        Top of DMAP Loop
132  LABEL    LBL13 $
133  PURGE    PNLH,OUHV1,OPNL1,OUHV2,OPNL2,XYPLTTA,OPP1,OQP1,OUPV1,OES1,OEF1,
              OPP2,OQP2,OUPV2,OES2,OEF2,PLOTX2,XYPLTT,OPPA,IQP1,IPHIP1,IES1,
              IEF1,OPPB,IQP2,IPHIP2,IES2,IEF2,ZQP2,ZUPV2,ZES2,ZEF2/NEVER $
134  CASE     CASECC,/CASEXX/C,N,TRAN/V,N,REPEATT/V,N,NOLOOP $
135  SAVE     REPEATT,NOLOOP $
136  CHKPNT   CASEXX $
137  PARAM    //C,N,MPY/V,N,NCOL/C,N,0/C,N,1 $
138  TRLG     CASEXX,USETD,DLT,SLT,BGPDT,SIL,CSTM,TRL,DIT,GMD,GOD,PHIDH, EST,
              MGG/PPT,PST,PDT,PD,PH,TOL/V,N,NOSET/V,N,PDEPDO/V,N,NCOL $
139  SAVE     PDEPDO,NOSET $
140  CHKPNT   PPT,PST,PDT,PD,PH,TOL $
141  EQUIV    PD,PDT/PDEPDO/PPT,PDT/NOSET $
142  CHKPNT   PDT $
143  TRD      CASEXX,TRL,NLFT,DIT,KHH,BHH,MHH,PH/UHVT,PNLH/C,N,MODAL/ V,N,
              NOUE/V,N,NONCUP/V,N,NCOL $
144  SAVE     NCOL $
145  CHKPNT   UHVT,PNLH $
146  VDR      CASEXX,EQDYN,USETD,UHVT,TOL,XYCDB,PNLH/OUHV1,OPNL1/ C,N,
              TRANRESP/C,N,MODAL/C,N,0/V,N,NOH/V,N,NOP/V,N,FMODE $
147  SAVE     NOH,NOP $
148  CHKPNT   OUHV1,OPNL1 $
149  COND     LBL16,NOH $
150  SDR3     OUHV1,OPNL1,,,,/OUHV2,OPNL2,,,, $
151  OFP      OUHV2,OPNL2,,,,//V,N,CARDNO $
152  SAVE     CARDNO $
153  CHKPNT   OPNL2,OUHV2 $
154  XYTRAN   XYCDB,OUHV2,OPNL2,,,/XYPLTTA/C,N,TRAN/C,N,HSET/V,N,PFILE/V,N,
              CARDNO $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 12

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

155  SAVE      PFILE,CARDNO $

156  XYPLOT    XYPLTTA// $

157  LABEL     LBL16 $

158  PARAM     //C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT $

159  COND      LBL15,PJUMP $

160  PARAM     //C,N,NOT/V,N,NOMOD/V,Y,MODACC $

161  PARAM     //C,N,AND/V,N,MPJUMP/V,Y,MODACC/V,N,JUMPPLOT $

162  COND      LBDDRM,MPJUMP $

163  DDR1      UHVT,PHIDH/UDV1T $

164  CHKPNT    UDV1T $

165  COND      LBLMOD,MODACC $

166  DDR2      USETD,UDV1T,PDT,K2DD,B2DD,MDD,,LLL,DM/UDV2T,UEVT,PAF/  C,N,
               TRANRESP/V,N,NOUE/V,N,REACT/C,N,0 $

167  CHKPNT    UDV2T,UEVT,PAF $

168  EQUIV     UDV2T,UDV1T/NOMOD $

169  CHKPNT    UDV1T $

170  LABEL     LBLMOD $

171  EQUIV     UDV1T,UPV/NOA $

172  COND      LBL14,NOA $

173  SDR1      USETD,,UDV1T,,,GOD,GMD,PST,KFS,,/UPV,,QP/C,N,1/C,N,DYNAMICS $

174  LABEL     LBL14 $

175  CHKPNT    UPV,QP $

176  SDR2      CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDT,TOL,QP,UPV,EST,XYCDB,
               PPT/OPP1,OQP1,OUPV1,OES1,OEF1,PUGV/C,N,TRANRESP $

177  SDR3      OPP1,OQP1,OUPV1,OES1,OEF1,/OPP2,OQP2,OUPV2,OES2,OEF2, $

178  JUMP      P2A $

179  LABEL     LBDDRM $

180  SDR1      USETD,,PHIDH,,,GOD,GMD,,KFS,,/PHIPH,,QPH/C,N,1/C,N,REIG $

181  SDR2      CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,LAMA,QPH,PHIPH,EST,XYCDB,/
               ,IQP1,IPHIP1,IES1,IEF1,/C,N,MMREIG $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 12

```
     N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

182  SDR2      CASEXX,,,,EQDYN,SILD,,,,TOL,,,,XYCDB,PPT/OPPA,,,,,/C,N,
               TRANRESP $

183  SDR3      OPPA,IQP1,IPHIP1,IES1,IEF1,/OPPB,IQP2,IPHIP2,IES2,IEF2, $

184  EQUIV     OPPB,OPP2/MODACC $

185  DDRMM     CASEXX,UHVT,TOL,IPHIP2,IQP2,IES2,IEF2,,EST,MPT,DIT/    ZUPV2,
               ZQP2,ZES2,ZEF2, $

186  EQUIV     ZUPV2,OUPV2/MODACC/ZQP2,OQP2/MODACC/ZEF2,OEF2/MODACC/ZES2,OES2/
               MODACC $

187  LABEL     P2A $

188  CHKPNT    OPP2,OQP2,OUPV2,OES2,OEF2 $

189  OFP       OUPV2,OPP2,OQP2,OEF2,OES2,//V,N,CARDNO $

190  SAVE      CARDNO $

191  COND      P2,JUMPPLOT $

192  PLOT      PLTPAR,GPSETS,ELSETS,CASEXX,BGPDT,EQEXIN,SIL,,PUGV,,/PLOTX2/
               V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

193  SAVE      PFILE $

194  PRTMSG    PLOTX2// $

195  LABEL     P2 $

196  XYTRAN    XYCDB,OPP2,OQP2,OUPV2,OES2,OEF2/XYPLTT/C,N,TRAN/C,N,PSET/V,N,
               PFILE/V,N,CARDNO $

197  SAVE      PFILE,CARDNO $

198  XYPLOT    XYPLTT// $

199  LABEL     LBL15 $

200  COND      FINIS,REPEATT $

201  REPT      LBL13,100 $
-------------------------------------------------- Bottom of DMAP Loop
202  JUMP      ERROR3 $

203  JUMP      FINIS $

204  LABEL     ERROR3 $

205  PRTPARM   //C,N,-3/C,N,MDLTRD $

206  LABEL     ERROR2 $

207  PRTPARM   //C,N,-2/C,N,MDLTRD $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 12

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

208  LABEL    ERROR1 $

209  PRTPARM  //C,N,-1/C,N,MDLTRD $

210  LABEL    ERROR4 $

211  PRTPARM  //C,N,-4/C,N,MDLTRD $

212  LABEL    ERROR5 $

213  PRTPARM  //C,N,-5/C,N,MDLTRD $

214  LABEL    FINIS $

215  END      $
```

3.13.2 Description of DMAP Operations for Modal Transient Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot package is present.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plot request.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 208 and print error message if there are no structural elements.

31. EMG generates structural element matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 208 and print error message if no mass matrix is to be assembled.

39. EMA assembles mass matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance request.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information and places it on the system output file for printing.

45. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to stiffness matrix $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

52. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

57. Go to DMAP No. 62 if general elements present.

58. GPSP determines if possible grid point singularities remain.

60. Go to DMAP No. 62 if no grid point singularities remain.

61. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

65. Go to DMAP No. 70 if no multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m] \ .$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints.

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right]$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

80. Go to DMAP No. 85 if no omitted coordinates.

81. SMP1 partitions constrained stiffness matrix.

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

83. SMP2 partitions constrained mass matrix.

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o]$$

86. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if free-body supports.

88. Go to DMAP No. 92 if no free-body supports.

89. RBMG1 partitions out free-body supports.

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right]$$

91. Go to DMAP No. 94.

93. Go to DMAP No. 102 if no request for mode acceleration data recovery.

95. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

97. Go to DMAP No. 102 if no free-body supports.

98. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}] \quad ,$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] \quad ,$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

100. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

103. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Eigenvalue Extraction Data, Dynamic Loads Table, Nonlinear Function Table and Transient Response List.

105. Go to DMAP No. 206 and print error message if no Eigenvalue Extraction Data.

107. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

110. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 \quad ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D_m \phi_{ro} \\ \hline \phi_{ro} \end{bmatrix} ,$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

114. ØFP formats the summary of eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

116. Go to DMAP No. 210 and print error message if no eigenvalues found.

117. MTRXIN selects the direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$.

121. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied, and $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points.

123. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$ and $[B^2_{dd}]$.

125. GKAM assembles stiffness mass and damping matrices in modal coordinates for use in Transient Response

$$[K_{hh}] = [k] + [\phi^T_{dh}][K^2_{dd}][\phi_{dh}] ,$$

$$[M_{hh}] = [m] + [\phi^T_{dh}][M^2_{dd}][\phi_{dh}] ,$$

$$[B_{hh}] = [b] + [\phi^T_{dh}][B^2_{dd}][\phi_{dh}] ,$$

where

$$m_i = \text{modal masses}$$

$$b_i = m_i \; 2\pi \; f_i \; g(f_i)$$

$$k_i = m_i \; 4\pi^2 \; f_i^2$$

and all matrices are real.

128. Go to DMAP No. 212 and print error message if no Transient Response List.

131. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

132. Beginning of loop for additional dynamic load sets.

134. CASE extracts user requests from CASECC for current loop.

138. TRLG generates matrices of loads versus time. $\{P_p^t\}$, $\{P_s^t\}$, and $\{P_d^t\}$ are generated with one column per output time step. $\{P_d\}$ and $\{P_h\}$ are generated with one column per solution time step, and the Transient Output List (TØL) is a list of output time steps.

141. Equivalence $\{P_d\}$ to $\{P_d^t\}$ if the output times are the same as the solution times and $\{P_d^t\}$ to $\{P_p^t\}$ if the d and p sets are the same.

143. TRD forms the linear and nonlinear dynamic load vectors $\{P_d\}$ and $\{P_d^{n\ell}\}$ and integrates the equations of motion over specified time periods to solve for the displacements, velocities and accelerations, using the following equation

$$[M_{hh}p^2 + B_{hh}p + K_{hh}]\{u_h\} = \{P_h\} + \{P_h^{n\ell}\} \quad .$$

146. VDR prepares displacements, velocities and accelerations, sorted by time step, for output using only the extra points introduced for dynamic analysis and modal coordinates (solution points).

149. Go to DMAP No. 157 if no output request for the solution points.

150. SDR3 sorts the solution point displacements, velocities, accelerations and nonlinear load vectors by point number.

151. ØFP formats the requested solution point displacements, velocities, accelerations and nonlinear load vectors sorted by point number and places them on the system output file for printing.

154. XYTRAN prepares the input for X-Y plotting of the solution point displacements, velocities, accelerations and nonlinear load vectors vs time.

156. XYPLØT prepares requested X-Y plots of the solution point displacements, velocities, accelerations and nonlinear load vectors vs time.

159. Go to DMAP No. 199 if no output request involving dependent degrees of freedom, forces and stresses, or deformed structure plot.

163. DDR1 transforms the solution vector displacements from modal to physical coordinates

$$\{u_d\} = [\phi_{dh}]\{u_h\} \quad .$$

165. Go to DMAP No. 170 if mode acceleration technique not requested.

166. DDR2 calculates an improved displacement vector using the mode acceleration technique, if requested.

171. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.

172. Go to DMAP No. 174 if no constraints applied.

173. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\} \qquad \left\{\begin{array}{c} u_d \\ \hline u_o \end{array}\right\} = \{u_f + u_e\} \quad .$$

$$\left\{\begin{array}{c} u_f + u_e \\ \hline u_s \end{array}\right\} = \{u_n + u_e\} \ , \qquad \{u_m\} = [G_m^d]\{u_n + u_e\} \quad ,$$

$$\left\{\begin{array}{c} u_n + u_e \\ \hline u_m \end{array}\right\} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

176. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement, velocity and acceleration vectors and single-point forces of constraint for output (ØPP1, ØUPV1, PUGV, ØQP1) - all sorted by time step.

177. SDR3 prepares requested output sorted by point number or element number.

178. Go to DMAP No. 187 if no mode acceleration requested.

180. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_h\} \ , \qquad \left\{\begin{array}{c} \phi_h \\ \hline \phi_o \end{array}\right\} = \{\phi_f + u_e\}$$

$$\left\{\begin{array}{c} \phi_f + u_e \\ \hline \phi_s \end{array}\right\} = \{\phi_n + u_e\} \qquad \{\phi_m\} = [G_m^d]\{\phi_n + u_e\}$$

$$\left\{\begin{array}{c} \phi_n + u_e \\ \hline \phi_m \end{array}\right\} = \{\phi_g + u_e\} = \{\phi_p\}$$

and recovers single-point forces of constraint

$$\{q_s\} = [K_{fs}]^T\{\phi_f\} \quad .$$

181. SDR2 calculates element forces and stresses (IEF1, IES1) and prepares eigenvectors and single-point forces of constraint for output (IPHIP1, IQP1) - all sorted by time step.

182. SDR2 prepares load vectors for output (ØPPA) sorted by time step.

183. SDR3 prepares requested output sorted by point number or element number.

184. Equivalence ØPPB to ØPP2 if mode acceleration requested.

185. DDRMM prepares a subset of the element forces and stresses (ZEF2, ZES2), and displacement vectors and single-point forces of constraint (ZUPV2, ZQP2) solutions for output by point number or element number sort.

186. Equivalence ZUPV2 to ØUPV2, ZQP2 to ØQP2, ZES2 to ØES2, and ZEF2 to ØEF2 if mode acceleration requested.

189. ØFP formats requested output sorted by point number or element number and places it on the system output file for printing.

191. Go to DMAP No. 195 if no deformed structure plots requested.

192. PLØT prepares all requested deformed structure plots.

194. PRTMSG prints plotter data and engineering data for each deformed plot generated.

196. XYTRAN prepares the input for requested X-Y plots.

198. XYPLØT prepares requested X-Y plots of displacements, velocities, accelerations, forces, stresses, loads or single-point forces of constraint vs time.

200. Go to DMAP No. 214 if no additional dynamic load sets need to be processed.

201. Go to DMAP No. 132 if additional dynamic load sets need to be processed.

202. Go to DMAP No. 204 and print error message if more than 100 loops.

203. Go to DMAP No. 214 and make normal exit.

205. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

207. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

209. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

211. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

213. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 5 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

3.13.3 Automatic Output for Modal Transient Response

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

3.13.4 Case Control Deck and Parameters for Modal Transient Response

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Transient Response:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.
2. All of the eigenvectors used in the modal formulation must be determined in a single execution.
3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.
4. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

Output that may be requested is the same as that described under Direct Transient Response. Output for SØLUTIØN points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The eigenvectors used in the modal formulation may be obtained for the SØLUTIØN points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Transient Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

4. LFREQ and HFREQ - required unless LMØDES is used. The values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.

5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

6. MØDACC - optional - A positive integer value of this parameter causes the Dynamic Data Recovery module to use the mode acceleration method. Not recommended for use in hydroelastic problems.

3.14 NORMAL MODES WITH DIFFERENTIAL STIFFNESS

3.14.1 DMAP Sequence for Normal Modes with Differential Stiffness

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 13
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.13 NORMAL MODES WITH DIFFERENTIAL STIFFNESS - SERIES N $

  2  FILE      LAMA=APPEND/PHIA=APPEND $

  3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

  4  SAVE      LUSET $

  5  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  6  GP2       GEOM2,EQEXIN/ECT $

  7  CHKPNT    ECT $

  8  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  9  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

 10  COND      P1,NOPCDB $

 11  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/  V,N,
               JUMPPLOT=-1 $

 12  SAVE      NSIL,JUMPPLOT $

 13  PRTMSG    PLTSETX// $

 14  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 15  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 16  COND      P1,JUMPPLOT $

 17  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/  V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 18  SAVE      JUMPPLOT,PLTFLG,PFILE $

 19  PRTMSG    PLOTX1// $

 20  LABEL     P1 $

 21  CHKPNT    PLTPAR,GPSETS,ELSETS $

 22  GP3       GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

 23  CHKPNT    SLT,GPTT $

 24  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/  V,N,
               NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

 25  SAVE      NOSIMP,NOGENL,GENEL $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 13

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N

DMAP-NO.	DMAP INSTRUCTION	
26	COND	ERROR1,NOSIMP $
27	PURGE	OGPST/GENEL $
28	CHKPNT	EST,GPECT,GEI,OGPST $
29	PARAM	//C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $
30	EMG	EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V, N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y, CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/ C,Y,CPTUBE/C,Y, CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $
31	SAVE	NOKGGX,NOMGG $
32	CHKPNT	KELM,KDICT,MELM,MDICT $
33	COND	JMPKGG,NOKGGX $
34	EMA	GPECT,KDICT,KELM/KGGX,GPST $
35	CHKPNT	KGGX,GPST $
36	LABEL	JMPKGG $
37	COND	ERROR5,NOMGG $
38	EMA	GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $
39	CHKPNT	MGG $
40	COND	LBL1,GRDPNT $
41	GPWG	BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $
42	OFP	OGPWG,,,,,// $
43	LABEL	LBL1 $
44	EQUIV	KGGX,KGG/NOGENL $
45	CHKPNT	KGG $
46	COND	LBL11,NOGENL $
47	SMA3	GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
48	CHKPNT	KGG $
49	LABEL	LBL11 $
50	PARAM	//C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
51	GP4	CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N, LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N, NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 13

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 52  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

 53  COND     ERROR6,NOL $

 54  PARAM    //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $

 55  PURGE    GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS/SINGLE/  QG/
              NOSR $

 56  CHKPNT   GM,RG,GO,KOO,LOO,PO,UOOV,RUOV,YS,PS,KFS,KSS,USET,ASET,QG $

 57  COND     LBL4D,REACT $

 58  JUMP     ERROR2 $

 59  LABEL    LBL4D $

 60  COND     LBL4,GENEL $

 61  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 62  SAVE     NOGPST $

 63  COND     LBL4,NOGPST $

 64  OFP      OGPST,,,,,// $

 65  LABEL    LBL4 $

 66  EQUIV    KGG,KNN/MPCF1 $

 67  CHKPNT   KNN $

 68  COND     LBL2,MPCF2 $

 69  MCE1     USET,RG/GM $

 70  CHKPNT   GM $

 71  MCE2     USET,GM,KGG,,,/KNN,,, $

 72  CHKPNT   KNN $

 73  LABEL    LBL2 $

 74  EQUIV    KNN,KFF/SINGLE $

 75  CHKPNT   KFF $

 76  COND     LBL3,SINGLE $

 77  SCE1     USET,KNN,,,/KFF,KFS,KSS,,, $

 78  CHKPNT   KFS,KSS,KFF $

 79  LABEL    LBL3 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 13

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 80  EQUIV    KFF,KAA/OMIT $

 81  CHKPNT   KAA $

 82  COND     LBL5,OMIT $

 83  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

 84  CHKPNT   GO,KAA,KOO,LOO $

 85  LABEL    LBL5 $

 86  RBMG2    KAA/LLL $

 87  CHKPNT   LLL $

 88  SSG1     SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/ V,N,
              LUSET/C,N,1 $

 89  CHKPNT   PG $

 90  EQUIV    PG,PL/NOSET $

 91  CHKPNT   PL $

 92  COND     LBL10,NOSET $

 93  SSG2     USET,GM,YS,KFS,GO,,PG/,PO,PS,PL $

 94  CHKPNT   PO,PS,PL $

 95  LABEL    LBL10 $

 96  SSG3     LLL,KAA,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
              C,N,1/V,N,EPSI $

 97  SAVE     EPSI $

 98  CHKPNT   ULV,UOOV,RULV,RUOV $

 99  COND     LBL9,IRES $

100  MATGPR   GPL,USET,SIL,RULV//C,N,L $

101  MATGPR   GPL,USET,SIL,RUOV//C,N,O $

102  LABEL    LBL9 $

103  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PGG,QG/C,N,1/C,N,
              BKLO $

104  CHKPNT   UGV,QG,PGG $

105  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,,PGG/
              OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,BKLO $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 13

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

106  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

107  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

108  SAVE     CARDNO $

109  COND     P2,JUMPPLOT $

110  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

111  SAVE     PFILE $

112  PRTMSG   PLOTX2// $

113  LABEL    P2 $

114  TA1      ECT,EPT,BGPDT,SIL,GPDT,CSTM/X1,X2,ECPT,GPCT/V,N,LUSET/  V,N,
              NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

115  DSMG1    CASECC,GPTT,SIL,EDT,UGV,CSTM,MPT,ECPT,GPCT,DIT/KDGG/  V,N,
              DSCOSET $

116  SAVE     DSCOSET $

117  CHKPNT   KDGG $

118  EQUIV    KDGG,KDNN/MPCF2 / MGG,MNN/MPCF2 $

119  CHKPNT   KDNN,MNN $

120  COND     LBL2D,MPCF2 $

121  MCE2     USET,GM,KDGG,MGG,,/KDNN,MNN,, $

122  CHKPNT   KDNN,MNN $

123  LABEL    LBL2D $

124  EQUIV    KDNN,KDFF/SINGLE / MNN,MFF/SINGLE $

125  CHKPNT   KDFF,MFF $

126  COND     LBL3D,SINGLE $

127  SCE1     USET,KDNN,MNN,,/KDFF,KDFS,KDSS,MFF,, $

128  CHKPNT   KDFF,KDFS,KDSS,MFF $

129  LABEL    LBL3D $

130  EQUIV    KDFF,KDAA/OMIT / MFF,MAA/OMIT $

131  CHKPNT   KDAA,MAA $

132  COND     LBL5D,OMIT $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 13

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

133  SMP2     USET,GO,KDFF/KDAA $

134  SMP2     USET,GO,MFF/MAA $

135  CHKPNT   KDAA,MAA $

136  LABEL    LBL5D $

137  EQUIV    PL,PBL/DSCOSET/PS,PBS/DSCOSET/YS,YBS/DSCOSET/UOOV,UBOOV/
              DSCOSET $

138  CHKPNT   PBL,PBS,YBS,UBOOV $

139  PARAM    //C,N,MPY/V,N,NDSKIP/C,N,0/C,N,0 $

140  DSMG2    MPT,KAA,KDAA,KFS,KDFS,KSS,KDSS,PL,PS,YS,UOOV/KBLL,KBFS,KBSS,
              PBL,PBS,YBS,UBOOV/V,N,NDSKIP/ V,N,REPEATD/ V,N,DSCOSET $

141  SAVE     NDSKIP,REPEATD $

142  CHKPNT   KBLL,KBFS,KBSS,PBL,PBS,YBS,UBOOV $

143  RBMG2    KBLL/LBLL/V,N,POWER/V,N,DET $

144  SAVE     DET,POWER $

145  CHKPNT   LBLL $

146  PRTPARM  //C,N,0/C,N,DET $

147  PRTPARM  //C,N,0/C,N,POWER $

148  SSG3     LBLL,KBLL,PBL,,,/UBLV,,RUBLV,/C,N,-1/V,Y,IRES/V,N,NDSKIP/  V,N,
              EPSI $

149  SAVE     EPSI $

150  CHKPNT   UBLV,RUBLV $

151  COND     LBL9D,IRES $

152  MATGPR   GPL,USET,SIL,RUBLV//C,N,L $

153  LABEL    LBL9D $

154  SDR1     USET,,UBLV,UBOOV,YBS,GO,GM,PBS,KBFS,KBSS,/UBGV,,QBG/V,N,NDSKIP/
              C,N,DS1 $

155  CHKPNT   UBGV,QBG $

156  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QBG,UBGV,EST,,/,
              OQBG1,OUBGV1,OESB1,OEFB1,PUBGV1/C,N,DS1 $

157  OFP      OQBG1,OUBGV1,OESB1,OEFB1,,//V,N,CARDNO $

158  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,,,EED,EQDYN/V,N,
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 13

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.
               LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/  V,
               N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

159  SAVE      NOEED $

160  COND      ERROR3,NOEED $

161  CHKPNT    EED $

162  PARAM     //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $

163  READ      KBLL,MAA,,,EED,USET,CASECC/LAMA,PHIA,,OEIGS/C,N,MODES/ V,N,
               NEIGV/C,N,3 $

164  SAVE      NEIGV $

165  CHKPNT    LAMA,PHIA,OEIGS $

166  OFP       OEIGS,LAMA,,,,//V,N,CARDNO $

167  SAVE      CARDNO $

168  COND      ERROR4,NEIGV $

169  SDR1      USET,,PHIA,,,GO,GM,,KDFS,,/PHIG,,BQG/C,N,1/C,N,REIG $

170  CHKPNT    PHIG,BQG $

171  CASE      CASECC,/CASEXX/C,N,TRANRESP/V,N,REPEAT=3/V,N,LOOP $

172  SDR2      CASEXX,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,BQG,PHIG,EST,,/,
               OBQG1,OPHIG,OBES1,OBEF1,PPHIG/C,N,REIG $

173  OFP       OPHIG,OBQG1,OBEF1,OBES1,,//V,N,CARDNO $

174  SAVE      CARDNO $

175  COND      P3,JUMPPLOT $

176  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,PPHIG,GPECT,
               OBES1/PLOTX3/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,
               PFILE $

177  SAVE      PFILE $

178  PRTMSG    PLOTX3// $

179  LABEL     P3 $

180  JUMP      FINIS $

181  LABEL     ERROR1 $

182  PRTPARM   //C,N,-1/C,N,NMDS $

183  LABEL     ERROR2 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 13

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

184  PRTPARM  //C,N,-2/C,N,NMDS $

185  LABEL    ERROR3 $

186  PRTPARM  //C,N,-3/C,N,NMDS $

187  LABEL    ERROR4 $

188  PRTPARM  //C,N,-4/C,N,NMDS $

189  LABEL    ERROR5 $

190  PRTPARM  //C,N,-5/C,N,NMDS $

191  LABEL    ERROR6 $

192  PRTPARM  //C,N,-5/C,N,NMDS $

193  LABEL    FINIS $

194  END      $
```

3.14.2 Description of DMAP Operations for Normal Modes with Differential Stiffness.

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot package is present.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plot request.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 181 and print error message if no elements have been defined.

30. EMG generates structural element matrix tables and dictionaries for later assembly.

33. Go to DMAP No. 36 if no stiffness matrix is to be assembled.

34. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

37. Go to DMAP No. 189 and print error message if no mass matrix exists.

38. EMA assembles mass matrix $[M_{gg}]$.

40. Go to DMAP No. 43 if no weight and balance request.

41. GPWG generates weight and balance information.

42. ØFP formats weight and balance information and places it on the system output file for printing.

44. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

46. Go to DMAP No. 49 if no general elements.

47. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

51. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

53. Go to DMAP No. 191 and print error message if no independent degrees of freedom are defined.

57. Go to DMAP No. 59 if no support cards.

58. Go to DMAP No. 183 and print error message if free-body supports are present.

60. Go to DMAP No. 65 if general elements present.

61. GPSP determines if possible grid point singularities remain.

63. Go to DMAP No. 65 if no grid point singularities remain.

64. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

66. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

68. Go to DMAP No. 73 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

69. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

71. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

74. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

76. Go to DMAP No. 79 if no single-point constraints.

77. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right]$$

80. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

82. Go to DMAP No. 85 if no omitted coordinates.

83. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

86. RBMG2 decomposes constrained stiffness matrix $[K_{aa}] = [L_{\ell\ell}][U_{\ell\ell}]$.

88. SSG1 generates static load vectors $\{P_g\}$.

90. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

92. Go to DMAP No. 95 if no constraints applied.

93. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ -- \\ P_m \end{Bmatrix} , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} ,$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ -- \\ P_s \end{Bmatrix} , \qquad \{P_f\} = \{\bar{P}_f\} + [K_{fs}]\{Y_s\} ,$$

$$\{P_f\} = \begin{Bmatrix} P_a \\ -- \\ P_o \end{Bmatrix} \quad \text{and} \qquad \{P_\ell\} = \{P_a\} + [G_o^T]\{P_o\} .$$

96. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\} ,$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}} ,$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\} ,$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o\}}$$

99. Go to DMAP No. 102 if residual vectors are not to be printed.

100. Print residual vector for independent coordinates (RULV).

101. Print residual vector for omitted coordinates (RUØV).

103. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_\ell\} + \{u_o^o\} \quad ,$$

$$\begin{Bmatrix} u_a \\ \hline u_o \end{Bmatrix} = \{u_f\} \quad , \qquad \begin{Bmatrix} u_f \\ \hline Y_s \end{Bmatrix} = \{u_n\} \quad ,$$

$$\{u_m\} = [G_m]\{u_n\} \quad , \qquad \begin{Bmatrix} u_n \\ \hline u_m \end{Bmatrix} = \{u_g\} \quad ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} \quad .$$

105. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).

107. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

109. Go to DMAP No. 113 if no static deformed structure plots are requested.

110. PLØT generates all requested static deformed structure plots.

112. PRTMSG prints plotter data and engineering data for each deformed plot generated.

114. TA1 generates element tables for use in matrix assembly for differential stiffness matrix.

115. DSMG1 generates differential stiffness matrix $[K_{gg}^d]$.

118. Equivalence $[K_{gg}^d]$ to $[K_{nn}^d]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

120. Go to DMAP No. 123 if no multipoint constraints.

121. MCE2 partitions differential stiffness matrix

$$[K_{gg}^d] = \left[\begin{array}{c|c} \bar{K}_{nn}^d & K_{nm}^d \\ \hline K_{mn}^d & K_{mm}^d \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}^d] = [\bar{K}_{nn}^d] + [G_m^T][K_{mn}^d] + [K_{mn}^d][G_m] + [G_m^T][K_{mm}^d][G_m] \quad .$$

124. Equivalence $[K^d_{nn}]$ to $[K^d_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

126. Go to DMAP No. 129 if no single-point constraints.

127. SCE1 partitions out single-point constraints

$$[K^d_{nn}] = \left[\begin{array}{c|c} K^d_{ff} & K^d_{fs} \\ \hline K^d_{sf} & K^d_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right]$$

130. Equivalence $[K^d_{ff}]$ to $[K^d_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

132. Go to DMAP No. 136 if no omitted coordinates.

133. SMP2 partitions constrained differential stiffness matrix

$$[K^d_{ff}] = \left[\begin{array}{c|c} \bar{K}^d_{aa} & K^d_{ao} \\ \hline K^d_{oa} & K^d_{oo} \end{array}\right]$$

and performs matrix reduction $[K^d_{aa}] = [\bar{K}^d_{aa}] + [K^d_{ao}][G_o]$.

134. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M^T_{oa}][G_o] + [G^T_o][M_{oa}] + [G^T_o][M_{oo}][G_o] \ .$$

137. Equivalence $\{P_\ell\}$ to $\{P^b_\ell\}$, $\{P_s\}$ to $\{P^b_s\}$, $\{Y_s\}$ to $\{Y^b_s\}$and $\{u^o_o\}$ to $\{u^{ob}_o\}$ if no scale factors are specified on a DSFACT card.

140. DSMG2 adds partitions of stiffness matrix to similar partitions of differential stiffness matrix

$$[K^b_{\ell\ell}] = [K_{aa}] + \beta[K^d_{aa}] \ ,$$

$$[K^b_{fs}] = [K_{fs}] + \beta[K^d_{fs}] \text{ and}$$

$$[K^b_{ss}] = [K_{ss}] + \beta[K^d_{ss}]$$

and multiplies partitions of load vectors and displacement vectors by current value of differential stiffness scale factor (β)

$$\{P_\ell^b\} = \beta\{P_\ell\} \quad , \qquad \{P_s^b\} = \beta\{P_s\} \quad ,$$

$$\{Y_s^b\} = \beta\{Y_s\} \text{ and} \qquad \{u_o^{bo}\} = \beta\{u_o^o\} \quad .$$

143. RBMG2 decomposes the combined differential stiffness matrix and elastic stiffness matrix

$$[K_{\ell\ell}^b] = [L_{\ell\ell}^b][U_{\ell\ell}^b] \quad .$$

146. PRTPARM prints the scaled value of the determinant of the combined differential stiffness matrix and elastic stiffness matrix.

147. PRTPARM prints the scale factor (power of ten) of the determinant of the combined differential stiffness matrix and the elastic stiffness matrix.

148. SSG3 solves for displacements of independent coordinates for current value of differential stiffness scale factor (β)

$$\{u_\ell^b\} = [K_{\ell\ell}^b]^{-1}\{P_\ell^b\}$$

and calculates residual vector (RBULV) and residual vector error ratio for current value of differential stiffness load factor

$$\{\delta P_\ell^b\} = \{P_\ell^b\} - [K_{\ell\ell}^b]\{u_\ell^b\} \quad ,$$

$$\varepsilon_\ell^b = \frac{\{u_\ell^b\}^T\{\delta P_\ell^b\}}{\{P_\ell^b\}^T\{u_\ell^b\}}$$

151. Go to DMAP No. 153 if residual vector for current value of differential stiffness load factor is not to be printed.

152. Print residual vector for current value of differential stiffness load factor.

154. SDR1 recovers dependent displacements for current value of differential stiffness scale factor

$$\{u_o^b\} = [G_o]\{u_\ell^b\} + \{u_o^{ob}\} \quad , \qquad \left\{\begin{array}{c} u_\ell^b \\ \hline u_o^b \end{array}\right\} = \{u_f^b\} \quad ,$$

$$\left\{\begin{array}{c} u_f^b \\ \hline Y_s^b \end{array}\right\} = \{u_n^b\} \quad , \qquad \{u_m^b\} = [G_m]\{u_n^b\} \quad ,$$

$$\left\{\begin{array}{c} u_n^b \\ \hline u_m^b \end{array}\right\} = \{u_g^b\}$$

and recovers single-point forces of constraint for current value of differential stiffness scale factor

$$\{q_s^b\} = -\{P_s^b\} + [K_{sf}^b]\{u_f^b\} + [K_{ff}^b]\{Y_s^b\} \quad .$$

156. SDR2 calculates element forces and stresses (ØEFB1, ØESB1) and prepares displacement vectors and single-point forces of constraint for output (ØUBGV1, PUBGV1, ØQBG1) .

157. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

158. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

160. Go to DMAP No. 185 and print error message if no Eigenvalue Extraction Data.

163. READ extracts real eigenvalues from the equation

$$[K_{\ell\ell}^b - \lambda M_{aa}]\{u_a\} = 0 \quad ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized, computes rigid body eigenvectors

$$[\phi_{ao}] = \frac{D\ \phi_{ro}}{\phi_{ro}}$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

166. ØFP formats eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

168. Go to DMAP No. 187 and exit if no eigenvalues found.

169. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} \quad , \qquad \left\{\begin{array}{c}\phi_a\\ \hline \phi_o\end{array}\right\} = \{\phi_f\} \quad ,$$

$$\left\{\begin{array}{c}\phi_f\\ \hline \phi_s\end{array}\right\} = \{\phi_n\} \quad , \qquad \{\phi_m\} = [G_m]\{\phi_n\} \quad ,$$

$$\left\{\begin{array}{c}\phi_n \\ \hline \phi_m\end{array}\right\} = \{\phi_g\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}^T]\{\phi_f\}$.

172. SDR2 calculates element forces and stresses (ØBEF1, ØBES1) and prepares eigenvectors and single-point forces of constraint for output (ØPHIG, PPHIG, ØBQG1).

173. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

175. Go to DMAP No. 179 if no deformed real eigenvalue structure plots are requested.

176. PLØT generates all requested deformed real eigenvalue structure plots.

178. PRTMSG prints plotter data and engineering data for each deformed plot generated.

180. Go to DMAP No. 193 and make normal exit.

182. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

184. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 2 - FREE BØDY SUPPØRTS NØT ALLØWED.

186. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 3 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

188. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 4 - NØ EIGENVALUE FØUND.

190. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 5 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

192. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 6 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

3.14.3 Automatic Output for Normal Modes with Differential Stiffness

Each eigenvalue is identified with a mode number determined by sorting the eigenvalues by their magnitude. The following summary of the eigenvalues extracted is automatically printed:

1. Mode Number
2. Extraction Order
3. Eigenvalue
4. Radian Frequency
5. Cyclic Frequency
6. Generalized Mass
7. Generalized Stiffness

The following summary of the eigenvalue analysis performed, using the Inverse Power method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of starting points used.
3. Number of starting point moves.
4. Number of triangular decompositions.
5. Number of vector iterations.
6. Reason for termination.
   (1) Two consecutive singularities encountered while performing triangular decomposition.
   (2) Four shift points while tracking a single root.
   (3) All eigenvalues found in the frequency range specified.
   (4) Three times the number of roots estimated in the frequency range have been extracted.
   (5) All eigenvalues that exist in the problem have been found.
   (6) The number of roots desired have been found.
   (7) One or more eigenvalues have been found outside the frequency range specified.
   (8) Insufficient time to find another root.
   (9) Unable to converge.
7. Largest off-diagonal modal mass term and the number failing the criteria.

The following summary of the eigenvalue analysis performed, using the Determinant method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of passes through starting points.
3. Number of criteria changes.
4. Number of starting point moves.
5. Number of triangular decompositions.
6. Number of failures to iterate to a root.
7. Reason for termination.
    (1) The number of roots desired have been found.
    (2) All predictions for eigenvalues are outside the frequency range specified.
    (3) Insufficient time to find another root.
    (4) Matrix is singular at first three starting points.
8. Largest off-diagonal modal mass term and the number failing the criterion.
9. Swept determinant function for each starting point.

The following summary of the eigenvalue analysis performed using the Givens method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of eigenvectors computed.
3. Number of eigenvalue convergency failures.
4. Number of eigenvector convergence failures.
5. Reason for termination.
    (1) Normal termination.
    (2) Insufficient time to calculate eigenvalues and number of eigenvectors requested.
    (3) Insufficient time to find additional eigenvectors.
6. Largest off-diagonal modal mass term and the number failing the criterion.

The value of the determinant of the sum of the elastic stiffness and the differential stiffness is automatically printed.

3.14.4 Case Control Deck and Parameters for Normal Modes with Differential Stiffness

The following items relate to subcase definition and data selection for Normal Modes with Differential Stiffness:

NORMAL MODES WITH DIFFERENTIAL STIFFNESS

1. The Case Control Deck must contain three subcases. The first subcase is used only for output selection for the linear case.

2. DSCØEFFICIENT must appear in the second subcase, either to select a DSFACT set from the Bulk Data Deck, or to explicitly select the default value of unity.

3. METHØD must appear above the subcase level to select an EIGR bulk data card.

4. The static differential stiffness solution is output from the second subcase. The eigenvector solution is output from the third subcase.

5. A static loading condition must be defined above the subcase level with a LØAD, TEMPERATURE(LØAD), or DEFØRM selection, unless all loading is specified by grid point displacements on SPC cards.

6. An SPC set must be selected above the subcase level unless all constraints are specified on GRID cards.

The following output may be requested for Normal Modes with Differential Stiffness:

1. Nonzero components of the applied statis load for the linear solution at selected grid points.

2. Displacement and nonzero components of the single-point forces of constraint, with and without differential stiffness, at selected grid points.

3. Forces and stresses in selected elements, with and without differential stiffness.

4. Deformed and undeformed plots.

The following output may be requested for the Normal Mode Analysis subcase:

1. Eigenvectors along with the associated eigenvalue for each mode.

2. Nonzero components of the single-point forces of constraint for selected modes at selected grid points.

3. Forces and stresses in selected elements for selected modes.

4. Undeformed plot of the structural model and mode shapes for selected modes.

The following parameters are used in Normal Mode Analysis:

1. <u>GRDPNT</u> - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of couples mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.15 STATIC ANALYSIS USING CYCLIC SYMMETRY

3.15.1 DMAP Sequence for Static Analysis Using Cyclic Symmetry

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 14
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN    NO.14 STATIC ANALYSIS WITH CYCLIC SYMMETRY - SERIES N        $

  2  FILE     KKK=SAVE/PK=SAVE $

  3  FILE     UXV=APPEND $

  4  PARAM    //C,N,NOP/V,Y,CYCIO=1 $

  5  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
              NOGPDT $

  6  SAVE     LUSET $

  7  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  8  GP2      GEOM2,EQEXIN/ECT $

  9  CHKPNT   ECT $

 10  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

 11  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

 12  COND     P1,NOPCDB $

 13  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
              JUMPPLOT=-1 $

 14  SAVE     NSIL,JUMPPLOT $

 15  PRTMSG   PLTSETX// $

 16  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 17  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 18  COND     P1,JUMPPLOT $

 19  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/   V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 20  SAVE     JUMPPLOT,PLTFLG,PFILE $

 21  PRTMSG   PLOTX1// $

 22  LABEL    P1 $

 23  CHKPNT   PLTPAR,GPSETS,ELSETS $

 24  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

 25  SAVE     NOGRAV $

 26  PARAM    //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRDPNT=-1 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 14
N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```
27  CHKPNT   SLT,GPTT $

28  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
             NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

29  SAVE     NOSIMP,NOGENL,GENEL $

30  PARAM    //C,N,AND/V,N,NOELMT/V,N,NOGENL/V,N,NOSIMP $

31  COND     ERROR4,NOELMT $

32  PURGE    GPST/NOSIMP/OGPST/GENEL $

33  CHKPNT   EST,GPECT,GEI,GPST,OGPST $

34  COND     LBL1,NOSIMP $

35  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

36  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
             N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
             CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
             CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

37  SAVE     NOKGGX,NOMGG $

38  CHKPNT   KELM,KDICT,MELM,MDICT $

39  COND     JMPKGG,NOKGGX $

40  EMA      GPECT,KDICT,KELM/KGGX,GPST $

41  CHKPNT   KGGX,GPST $

42  LABEL    JMPKGG $

43  COND     JMPMGG,NOMGG $

44  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

45  CHKPNT   MGG $

46  LABEL    JMPMGG $

47  COND     LBL1,GRDPNT $

48  COND     ERROR2,NOMGG $

49  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $

50  OFP      OGPWG,,,,,// $

51  LABEL    LBL1 $

52  EQUIV    KGGX,KGG/NOGENL $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 14

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 53  CHKPNT   KGG $

 54  COND     LBL11A,NOGENL $

 55  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 56  CHKPNT   KGG $

 57  LABEL    LBL11A $

 58  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 59  GP4      CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,
              LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
              NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 60  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

 61  COND     ERROR3,NOL $

 62  PARAM    //C,N,NOT/V,N,REACDATA/V,N,REACT $

 63  COND     ERROR5,REACDATA $

 64  PURGE    GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS,QG/SINGLE $

 65  CHKPNT   GM,GO,KOO,LOO,PO,UOOV,RUOV,PS,KFS,KSS,QG,USET,RG,YS,ASET $

 66  GPCYC    GEOM4,EQEXIN,USET/CYCD/V,Y,CTYPE/V,N,NOGO $

 67  SAVE     NOGO $

 68  CHKPNT   CYCD $

 69  COND     ERROR4,NOGO $

 70  COND     LBL4,GENEL $

 71  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 72  SAVE     NOGPST $

 73  COND     LBL4,NOGPST $

 74  OFP      OGPST,,,,,// $

 75  LABEL    LBL4 $

 76  EQUIV    KGG,KNN/MPCF1 $

 77  CHKPNT   KNN $

 78  COND     LBL2,MPCF2 $

 79  MCE1     USET,RG/GM $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 14
N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```
 80  CHKPNT   GM $

 81  MCE2     USET,GM,KGG,,,/KNN,,, $

 82  CHKPNT   KNN $

 83  LABEL    LBL2 $

 84  EQUIV    KNN,KFF/SINGLE $

 85  CHKPNT   KFF $

 86  COND     LBL3,SINGLE $

 87  SCE1     USET,KNN,,,/KFF,KFS,KSS,,, $

 88  CHKPNT   KFS,KSS,KFF $

 89  LABEL    LBL3 $

 90  EQUIV    KFF,KAA/OMIT $

 91  CHKPNT   KAA $

 92  COND     LBL5,OMIT $

 93  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

 94  CHKPNT   GO,KAA,KOO,LOO $

 95  LABEL    LBL5 $

 96  SSG1     SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N,
              LUSET/V,N,NSKIP $

 97  CHKPNT   PG $

 98  EQUIV    PG,PL/NOSET $

 99  CHKPNT   PL $

100  COND     LBL9,NOSET $

101  SSG2     USET,GM,YS,KFS,GO,,PG/,PO,PS,PL $

102  CHKPNT   PO,PS,PL $

103  COND     LBL9,OMIT $

104  SSG3     LOO,KOO,PO,,,/UOOV,,RUOV,/C,N,-1/V,Y,IRES=-1 $

105  CHKPNT   UOOV,RUOV $

106  COND     LBL9,IRES $

107  MATGPR   GPL,USET,SIL,RUOV//C,N,0 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 14

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

108  LABEL    LBL9 $

109  EQUIV    PL,PX/CYCIO $

110  COND     LBL10,CYCIO $

111  CYCT1    PL/PX,GCYCF/V,Y,CTYPE/C,N,FORE/V,Y,NSEGS=-1/V,Y,KMAX=-1/V,Y,
              NLOAD=1/V,N,NOGO $

112  SAVE     KMAX,NOGO $

113  LABEL    LBL10 $

114  CHKPNT   PX $

115  COND     ERROR6,NOGO $

116  PARAM    //C,N,ADD/V,N,KINDEX/C,N,0/C,N,0 $

117  JUMP     LBL11 $
------------------------------------------------------------  Top of DMAP Loop
118  LABEL    LBL11 $

119  CYCT2    CYCD,KAA,,PX,,/KKK,,PK,,/C,N,FORE/V,Y,NSEGS/V,N,KINDEX/V,Y,
              CYCSEQ=-1/V,Y,NLOAD/V,N,NOGO $

120  SAVE     NOGO $

121  CHKPNT   KKK,PK $

122  COND     ERROR6,NOGO $

123  RBMG2    KKK/LKK $

124  CHKPNT   LKK $

125  SSG3     LKK,KKK,PK,,,/UKV,,RUKV,/C,N,-1/V,Y,IRES $

126  CHKPNT   UKV,RUKV $

127  CYCT2    CYCD,,,UKV,RUKV,/,,UXV,RUXV,/C,N,BACK/V,Y,NSEGS/V,N,KINDEX/
              V,Y,CYCSEQ/V,Y,NLOAD/V,N,NOGO $

128  SAVE     NOGO $

129  CHKPNT   UXV,RUXV $

130  COND     ERROR6,NOGO $

131  COND     LBL14,IRES $

132  MATGPR   GPL,USET,SIL,RUXV//C,N,A $

133  LABEL    LBL14 $

134  PARAM    //C,N,ADD/V,N,KINDEX/V,N,KINDEX/C,N,1 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 14

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

135  PARAM    //C,N,SUB/V,N,DONE/V,Y,KMAX/V,N,KINDEX $

136  COND     LBL15,DONE $

137  REPT     LBL11,100 $
-----------------------------------------------------  Bottom of DMAP Loop
138  JUMP     ERROR1 $

139  LABEL    LBL15 $

140  EQUIV    UXV,ULV/CYCIO $

141  COND     LBL16,CYCIO $

142  CYCT1    UXV/ULV,GCYCB/V,Y,CTYPE/C,N,BACK/V,Y,NSEGS/V,Y,KMAX/V,Y,NLOAD/
              V,N,NOGO $

143  SAVE     NOGO $

144  COND     ERROR6,NOGO $

145  LABEL    LBL16 $

146  CHKPNT   ULV $

147  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PGG,QG/V,N,NSKIP/C,N,
              STATICS $

148  CHKPNT   UGV,PGG,QG $

149  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,,PGG/
              OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,STATICS $

150  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

151  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

152  SAVE     CARDNO $

153  COND     P2,JUMPPLOT $

154  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

155  SAVE     PFILE $

156  PRTMSG   PLOTX2// $

157  LABEL    P2 $

158  JUMP     FINIS $

159  LABEL    ERROR1 $

160  PRTPARM  //C,N,-1/C,N,CYCSTATICS $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 14

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

161  LABEL     ERROR2 $

162  PRTPARM   //C,N,-2/C,N,CYCSTATICS $

163  LABEL     ERROR3 $

164  PRTPARM   //C,N,-3/C,N,CYCSTATICS $

165  LABEL     ERROR4 $

166  PRTPARM   //C,N,-4/C,N,CYCSTATICS $

167  LABEL     ERROR5 $

168  PRTPARM   //C,N,-5/C,N,CYCSTATICS $

169  LABEL     ERROR6 $

170  PRTPARM   //C,N,-6/C,N,CYCSTATICS $

171  LABEL     FINIS $

172  END       $
```

3.15.2 Description of DMAP Operations for Static Analysis Using Cyclic Symmetry

5. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

8. GP2 generates Element Connection Table with internal indices.

12. Go to DMAP No. 22 if no plot package is present.

13. PLTSET transforms user input into a form used to drive structure plotter.

15. PRTMSG prints error messages associated with structure plotter.

18. Go to DMAP No. 22 if no undeformed structure plot request.

19. PLØT generates all requested undeformed structure plots.

21. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

24. GP3 generates Static Loads Table and Grid Point Temperature Table.

28. TA1 generates element tables for use in matrix assembly and stress recovery.

31. Go to DMAP No. 165 and print error message if no elements have been defined.

34. Go to DMAP No. 51 if there are no structural elements.

36. EMG generates structural element matrix tables and dictionaries for later assembly.

39. Go to DMAP No. 42 if no stiffness matrix is to be assembled.

40. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

43. Go to DMAP No. 46 if no mass matrix is to be assembled.

44. EMA assembles mass matrix $[M_{gg}]$.

47. Go to DMAP No. 51 if no weight and balance request.

48. Go to DMAP No. 161 and print error message if no mass matrix exists.

49. GPWG generates weight and balance information.

50. ØFP formats weight and balance information and places it on the system output file for printing.

52. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

54. Go to DMAP No. 57 if no general elements.

55. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

59. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

61. Go to DMAP No. 163 and print error message if no independent degrees of freedom are defined.

63. Go to DMAP No. 167 and print error message if free-body supports are present.

66. GPCYC prepares segment boundary table.

69. Go to DMAP No. 165 and print error message if CYJØIN data is inconsistent.

70. Go to DMAP No. 75 if general elements present.

71. GPSP determines if possible grid point singularities remain.

73. Go to DMAP No. 75 if no grid point singularities remain.

74. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

76. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

78. Go to DMAP No. 83 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

79. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

81. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

84. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

86. Go to DMAP No. 89 if no single-point constraints.

87. SCE1 partitions out single-point constraints.

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right]$$

90. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

92. Go to DMAP No. 95 if no omitted coordinates.

93. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

96. SSG1 generates static load vectors $\{P_g\}$.

98. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

101. SSG2 applies constraints to static load vectors

$$\{P_g\} = \left\{\begin{array}{c}\bar{P}_n \\ -- \\ P_m\end{array}\right\} , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} ,$$

$$\{P_n\} = \left\{\begin{array}{c}\bar{P}_f \\ -- \\ P_s\end{array}\right\} , \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\} ,$$

$$\{P_f\} = \left\{\begin{array}{c}\bar{P}_a \\ -- \\ P_o\end{array}\right\} , \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\} ,$$

$$\{P_a\} = \left\{\begin{array}{c}P_\ell \\ -- \\ P_r\end{array}\right\}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

103. Go to DMAP No. 108 if no omitted coordinates.

104. SSG3 solves for displacements of omitted coordinates (these are not transformed)

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\} ,$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\} ,$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}} .$$

106. Go to DMAP No. 108 if residual vectors are not to be printed.

107. MATGPR prints the residual vector for omitted coordinates (RUØV).

109. Equivalence $\{P_\ell\}$ to $\{P_x\}$ if symmetric components of loads have been input.

110. Go to DMAP No. 113 if symmetric components of loads have been input.

111. CYCT1 transforms loads on analysis points to symmetric components.

115. Go to DMAP No. 169 and print error message if CYCT1 error was found.

117. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

118. Beginning of loop for cyclic index values (KINDEX).

119. CYCT2 transforms matrices and loads from symmetric components to solution set.

122. Go to DMAP No. 169 and print error message if CYCT2 error was found.

123. RBMG2 decomposes constrained stiffness matrix for solution set.

$$[K_{kk}] = [L_{kk}][u_{kk}]$$

125. SSG3 solves for displacements of solution set coordinates

$$\{u_k\} = [K_{kk}]^{-1}\{P_k\} \quad ,$$

and calculates residual vector (RUKV) and residual vector error ratio for solution set coördinates

$$\{\delta P_k\} = \{P_k\} - [K_{kk}]\{u_k\} \quad ,$$

$$\varepsilon_k = \frac{\{u_k^T\}\{\delta P_k\}}{\{P_k^T\}\{u_k\}} \quad .$$

127. CYCT2 finds symmetric components of displacement from solution set data, and appends to output for each KINDEX.

130. Go to DMAP No. 169 and print error message if CYCT2 error was found.

131. Go to DMAP No. 133 if residual vectors are not to be printed.

132. MATGPR prints the residual vector for solution set coordinates (RUXV).

136. Go to DMAP No. 139 if all cyclic index (KINDEX) values are complete.

137. Go to DMAP No. 118 if additional index values are needed.

138. Go to DMAP No. 159 and print error message if number of loops exceeds 100.

140. Equivalence $\{u_x\}$ to $\{u_\ell\}$ if output of symmetric components was requested.

141. Go to DMAP No. 145 if output of symmetric components was requested.

142. CYCT1 transforms displacements from symmetrical components to physical components.

144. Go to DMAP No. 169 and print error message if CYCT1 error was found.

147. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_a\} + \{u_o^o\} \quad ,$$

$$\begin{Bmatrix} u_a \\ -- \\ u_o \end{Bmatrix} = \{u_f\} \quad , \qquad \begin{Bmatrix} u_f \\ -- \\ Y_s \end{Bmatrix} = \{u_n\} \quad ,$$

$$\{u_m\} = [G_m]\{u_n\} \quad , \qquad \begin{Bmatrix} u_n \\ -- \\ u_m \end{Bmatrix} = \{u_g\} \quad ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} \quad .$$

149. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).

151. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

153. Go to DMAP No. 157 if no deformed structure plots are requested.

154. PLØT generates all requested deformed structure plots.

156. PRTMSG prints plotter data and engineering data for each deformed plot generated.

158. Go to DMAP No. 171 and make normal exit.

160. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 1. ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

STATIC ANALYSIS USING CYCLIC SYMMETRY

162. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 2 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIØNS.

164. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDOM HAVE BEEN DEFINED.

166. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

168. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 6 - FREE-BØDY SUPPØRTS NØT ALLØWED.

170. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 7 - CYCLIC SYMMETRY DATA ERRØR.

3.15.3 Case Control Deck and Parameters for Static Analysis Using Cyclic Symmetry

The following items relate to subcase definition and data selection:

1. A separate group of subcases must be defined for each symmetric segment. For dihedral symmetry, a separate group of subcases are defined for each half.
2. The different loading conditions are defined within each group of subcases. The loads on each symmetric segment and the selected output requests may be independent. The number of loading cases is specified on the PARAM card NLØAD.
3. The SPC and MPC request must appear above the subcase level and may not be changed.
4. An alternate loading method is to define a separate group of subcases for each harmonic index, k. The parameter CYCIØ is included and the load components for each index are defined directly within each group for the various loading conditions.

The following printed output, for each loading condition and each symmetric segment or index, may be requested for Static Analysis solutions:

1. Displacements and components of static loads and single-point forces of constraint at selected grid points or scalar points.
2. Forces and stresses in selected elements.

The following plotter output may be requested for Static Analysis solutions:

1. Undeformed and deformed plots of the structural model (1 segment).
2. X-Y plot of any component of displacement, static load, or single-point force of constraint for a grid point or scalar point.
3. X-Y plot of any stress or force component for an element.

The following parameters are used in Static Analysis using Cyclic Symmetry:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.
2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in EMG.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices, rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

5. CTYPE - required - the BCD value of this parameter defines the type of cyclic symmetry as follows:

   (1) RØT - rotational symmetry

   (2) DRL - dihedral symmetry, using right and left halves

   (3) DSA - dihedral symmetry, using symmetric and antisymmetric components

6. NSEGS - required - the integer value of this parameter is the number of identical segments in the structural model.

7. NLØAD - optional - the integer value of this parameter is the number of static loading conditions. The default value is 1.

8. CYCIØ - optional - the integer value of this parameter specifies the form of the input and output data. A value of +1 is used to specify physical segment representation, and a value of -1 for cyclic transform representation. The default value is +1.

9. CYCSEQ - optional - the integer value of this parameter specifies the procedure for sequencing the equations in the solution set. A value of +1 specifies that all cosine terms should be sequenced before all sine terms, and a value of -1 for alternating the cosine and sine terms. The default value is -1.

10. KMAX - optional - the integer value of this parameter specifies the maximum value of the harmonic index. The default value is ALL which is NSEGS/2 for NSEGS even and (NSEGS-1)/2 for NSEGS odd.

3.16 NORMAL MODES ANALYSIS USING CYCLIC SYMMETRY

3.16.1 DMAP Sequence for Normal Modes Analysis Using Cyclic Symmetry

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 15
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.15 NORMAL NODES ANALYSIS WITH CYCLIC SYMMETRY SERIES N $

  2  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

  3  SAVE      LUSET $

  4  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  5  GP2       GEOM2,EQEXIN/ECT $

  6  CHKPNT    ECT $

  7  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  8  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

  9  COND      P1,NOPCDB $

 10  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT=-1 $

 11  SAVE      NSIL,JUMPPLOT $

 12  PRTMSG    PLTSETX// $

 13  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 14  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 15  COND      P1,JUMPPLOT $

 16  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,,/PLOTX1/   V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 17  SAVE      JUMPPLOT,PLTFLG,PFILE $

 18  PRTMSG    PLOTX1//$

 19  LABEL     P1 $

 20  CHKPNT    PLTPAR,GPSETS,ELSETS $

 21  GP3       GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

 22  CHKPNT    GPTT $

 23  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
               NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

 24  SAVE      NOGENL,NOSIMP,GENEL $

 25  COND      ERROR6,NOSIMP $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 15

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I Ø N

```
DMAP-DMAP INSTRUCTION
 NO.

 26   PURGE     OGPST/GENEL $

 27   CHKPNT    EST,GPECT,GEI,OGPST $

 28   PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

 29   PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

 30   EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
                N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/  C,Y,
                CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/ C,Y,
                CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

 31   SAVE      NOKGGX,NOMGG $

 32   CHKPNT    KELM,KDICT,MELM,MDICT $

 33   COND      JMPKGG,NOKGGX $

 34   EMA       GPECT,KDICT,KELM/KGGX,GPST $

 35   CHKPNT    KGGX,GPST $

 36   LABEL     JMPKGG $

 37   COND      ERROR1,NOMGG $

 38   EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

 39   CHKPNT    MGG $

 40   COND      LGPWG,GRDPNT $

 41   GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

 42   OFP       OGPWG,,,,,// $

 43   LABEL     LGPWG $

 44   EQUIV     KGGX,KGG/NOGENL $

 45   CHKPNT    KGG $

 46   COND      LBL11,NOGENL $

 47   SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 48   CHKPNT    KGG $

 49   LABEL     LBL11 $

 50   PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 51   GP4       CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,
                LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
                NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 15

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 52   SAVE      MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

 53   COND      ERROR3,NOL $

 54   PARAM     //C,N,NOT/V,N,REACDATA/V,N,REACT $

 55   COND      ERROR4,REACDATA $

 56   PURGE     GM/MPCF1/GO/OMIT/KFS,QG/SINGLE $

 57   CHKPNT    GM,RG,GO,KFS,QG,USET,ASET $

 58   GPCYC     GEOM4,EQEXIN,USET/CYCD/V,Y,CTYPE/V,N,NOGO $

 59   SAVE      NOGO $

 60   CHKPNT    CYCD $

 61   COND      ERROR5,NOGO $

 62   COND      LBL4,GENEL $

 63   GPSP      GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 64   SAVE      NOGPST $

 65   COND      LBL4,NOGPST $

 66   OFP       OGPST,,,,,// $

 67   LABEL     LBL4 $

 68   EQUIV     KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

 69   CHKPNT    KNN,MNN $

 70   COND      LBL2,MPCF2 $

 71   MCE1      USET,RG/GM $

 72   CHKPNT    GM $

 73   MCE2      USET,GM,KGG,MGG,,/KNN,MNN,, $

 74   CHKPNT    KNN,MNN $

 75   LABEL     LBL2 $

 76   EQUIV     KNN,KFF/SINGLE/MNN,MFF/SINGLE $

 77   CHKPNT    KFF,MFF $

 78   COND      LBL3,SINGLE $

 79   SCE1      USET,KNN,MNN,,/KFF,KFS,,MFF,, $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 15

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 80  CHKPNT   KFS,KFF,MFF $

 81  LABEL    LBL3 $

 82  EQUIV    KFF,KAA/OMIT $

 83  EQUIV    MFF,MAA/OMIT $

 84  CHKPNT   KAA,MAA $

 85  COND     LBL5,OMIT $

 86  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

 87  CHKPNT   GO,KAA $

 88  SMP2     USET,GO,MFF/MAA $

 89  CHKPNT   MAA $

 90  LABEL    LBL5 $

 91  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,,,EED,EQDYN/V,N,
              LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/  V,
              N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

 92  SAVE     NOEED $

 93  COND     ERROR2,NOEED $

 94  CHKPNT   EED $

 95  CYCT2    CYCD,KAA,MAA,,,/KKK,MKK,,,/C,N,FORE/V,Y,NSEGS=-1/V,Y,KINDEX=-1/
              V,Y,CYCSEQ=-1/C,N,1/V,N,NOGO $

 96  SAVE     NOGO $

 97  CHKPNT   KKK,MKK $

 98  COND     ERROR5,NOGO $

 99  READ     KKK,MKK,,,EED,,CASECC/LAMK,PHIK,MI,OEIGS/C,N,MODES/V,N,NEIGV $

100  SAVE     NEIGV $

101  CHKPNT   LAMK,PHIK,MI,OEIGS $

102  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

103  OFP      LAMK,OEIGS,,,,//V,N,CARDNO $

104  SAVE     CARDNO $

105  COND     FINIS,NEIGV $

106  CYCT2    CYCD,,,,PHIK,LAMK/,,,PHIA,LAMA/C,N,BACK/V,Y,NSEGS/V,Y,KINDEX/
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 15

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.
               V,Y,CYCSEQ/C,N,1/V,N,NOGO $

107  SAVE      NOGO $

108  CHKPNT    PHIA,LAMA $

109  COND      ERROR5,NOGO $

110  SDR1      USET,,PHIA,,,GO,GM,,KFS,,/PHIG,,QG/C,N,1/C,N,REIG $

111  CHKPNT    PHIG,QG $

112  PARAM     //C,N,SUB/V,N,SCALAR/V,N,SIL/V,N,LUSET $

113  EQUIV     SIL,SIP/SCALAR/BGPDT,BGPDP/SCALAR $

114  CHKPNT    SIP,BGPDP $

115  COND      LBL7,SCALAR $

116  PLTTRAN   BGPDT,SIL/BGPDP,SIP/V,N,LUSET/V,N,LUSEP $

117  SAVE      LUSEP $

118  CHKPNT    BGPDP,SIP $

119  LABEL     LBL7 $

120  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDP,LAMA,QG,PHIG,EST,,/,
               OQG1,OPHIG,OES1,OEF1,PPHIG/C,N,REIG $

121  OFP       OPHIG,OQG1,OEF1,OES1,,//V,N,CARDNO $

122  SAVE      CARDNO $

123  COND      P2,JUMPPLOT $

124  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIP,,PPHIG,GPECT,OES1/
               PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

125  SAVE      PFILE $

126  PRTMSG    PLOTX2// $

127  LABEL     P2 $

128  JUMP      FINIS $

129  LABEL     ERROR1 $

130  PRTPARM   //C,N,-1/C,N,CYCMODES $

131  LABEL     ERROR2 $

132  PRTPARM   //C,N,-2/C,N,CYCMODES $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 15

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

133  LABEL    ERROR3 $

134  PRTPARM  //C,N,-3/C,N,CYCMODES $

135  LABEL    ERROR4 $

136  PRTPARM  //C,N,-4/C,N,CYCMODES $

137  LABEL    ERROR5 $

138  PRTPARM  //C,N,-5/C,N,CYCMODES $

139  LABEL    ERROR6 $

140  PRTPARM  //C,N,-6/C,N,CYCMODES $

141  LABEL    FINIS $

142  END      $
```

3.16.2 Description of DMAP Operations for Normal Modes Analysis Using Cyclic Symmetry

2. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

5. GP2 generates Element Connection Table with internal indices.

9. Go to DMAP No. 19 if no plot package is present.

10. PLTSET transforms user input into a form used to drive structure plotter.

12. PRTMSG prints error messages associated with structure plotter.

15. Go to DMAP No. 19 if no undeformed structure plot request.

16. PLØT generates all requested undeformed structure plots.

18. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

21. GP3 generates Static Loads Table and Grid Point Temperature Table.

23. TA1 generates element tables for use in matrix assembly and stress recovery.

25. Go to DMAP No. 139 and print error message if no elements have been defined.

30. EMG generates structural element matrix tables and dictionaries for later assembly.

33. Go to DMAP No. 36 if no stiffness matrix is to be assembled.

34. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

37. Go to DMAP No. 129 and print error message if no mass matrix exists.

38. EMA assembles mass matrix $[M_{gg}]$.

40. Go to DMAP No. 43 if no weight and balance request.

41. GPWG generates weight and balance information.

42. ØFP formats weight and balance information and places it on the system output file for printing.

44. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

46. Go to DMAP No. 49 if no general elements.

47. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

51. GP4 generates flags defining members of various displacement sets (USET), forms multi-point constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

53. Go to DMAP No. 133 and print error message if no independent degrees of freedom are defined.

55. Go to DMAP No. 135 and print error message if free-body supports are present.

58. GPCYC prepares segment boundary table.

61. Go to DMAP No. 137 and print error message if CYJØIN data is inconsistent.

62. Go to DMAP No. 67 if general elements present.

63. GPSP determines if possible grid point singularities remain.

65. Go to DMAP No. 67 if no grid point singularities remain.

66. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

68. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

70. Go to DMAP No. 75 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

71. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

73. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] .$$

76. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

78. Go to DMAP No. 81 if no single-point constraints.

79. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \qquad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right]$$

82. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

83. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

85. Go to DMAP No. 90 if no omitted coordinates.

86. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

88. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o] .$$

91. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

93. Go to DMAP No. 131 and print error message if no Eigenvalue Extraction Data.

95. CYCT2 transforms matrices from symmetric components to solution set.

98. Go to DMAP No. 137 and print error message if CYCT2 error was found.

99. READ extracts real eigenvalues from the equation

$$[K_{kk} - \lambda M_{kk}]\{u_k\} = 0 \quad ,$$

calculates modal mass matrix

$$[m] = [\phi_k^T][M_{kk}][\phi_k]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

103. ØFP formats eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

105. Go to DMAP No. 141 and exit if no eigenvalues found.

106. CYCT2 finds symmetric components of eigenvectors from solution set eigenvectors.

109. Go to DMAP No. 137 and print error message if CYCT2 error was found.

110. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} \quad , \qquad \left\{\begin{array}{c}\phi_a \\ -- \\ \phi_o\end{array}\right\} = \{\phi_f\} \quad ,$$

$$\left\{\begin{array}{c}\phi_f \\ -- \\ \phi_s\end{array}\right\} = \{\phi_n\} \quad , \qquad \{\phi_m\} = [G_m]\{\phi_n\} \quad ,$$

$$\left\{\begin{array}{c}\phi_n \\ -- \\ \phi_m\end{array}\right\} = \{\phi_g\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}]^T\{\phi_f\}$.

113. Equivalence SIL to SIP and BGPDT to BGPDP when one or more geometric grid points exist.

116. PLTTRAN modifies BGPDT and SIL for functional modules SDR2 and PLØT.

120. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares eigenvectors and single-point forces of constraint for output (ØPHIG, PPHIG, ØQG1).

121. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

123. Go to DMAP No. 127 if no deformed structure plots are requested.

124. PLØT generates all requested deformed structure plots.

126. PRTMSG prints plotter data and engineering data for each deformed plot generated.

128. Go to DMAP No. 141 and make normal exit.

130. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

132. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

134. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

136. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 4 - FREE BØDY SUPPØRTS NØT ALLØWED.

138. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 5 - CYCLIC SYMMETRY DATA ERRØR.

140. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 6 - NØ STRUCTURAL ELEMENTS DEFINED.

3.16.3 Automatic Output for Normal Mode Analysis Using Cyclic Symmetry

Each eigenvalue is identified with a mode number determined by sorting the eigenvalues by their magnitude. The following summary of the eigenvalues extracted is automatically printed:

1. Mode Number
2. Extraction Order
3. Eigenvalue
4. Radian Frequency
5. Cyclic Frequency
6. Generalized Mass
7. Generalized Stiffness

The following summary of the eigenvalue analysis performed, using the Inverse Power method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of starting points used.
3. Number of starting point moves.
4. Number of triangular decompositions.
5. Number of vector iterations.
6. Reason for termination.
   (1) Two consecutive singularities encountered while performing triangular decomposition.
   (2) Four shift points while tracking a single root.
   (3) All eigenvalues found in the frequency range specified.
   (4) Three times the number of roots estimated in the frequency range have been extracted.
   (5) All eigenvalues that exist in the problem have been found.
   (6) The number of roots desired have been found.
   (7) One or more eigenvalues have been found outside the frequency range specified.
   (8) Insufficient time to find another root.
   (9) Unable to converge.
7. Largest off-diagonal modal mass term and the number failing the criteria.

The following summary of the eigenvalue analysis performed, using the Determinant method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of passes through starting points.
3. Number of criteria changes.
4. Number of starting point moves.
5. Number of triangular decompositions.
6. Number of failures to iterate to a root.
7. Reason for termination.
   (1) The number of roots desired have been found.
   (2) All predictions for eigenvalues are outside the frequency range specified.
   (3) Insufficient time to find another root.
   (4) Matrix is singular at first three starting points.
8. Largest off-diagonal modal mass term and the number failing the criterion.
9. Swept determinant function for each starting point.

The following summary of the eigenvalue analysis performed using the Givens method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of eigenvectors computed.
3. Number of eigenvalue convergence failures.
4. Number of eigenvector convergence failures.
5. Reason for termination.
   (1) Normal termination.
   (2) Insufficient time to calculate eigenvalues and number of eigenvectors requested.
   (3) Insufficient time to find additional eigenvectors.
6. Largest off-diagonal modal mass term and the number failing the criterion.

3.16.4 Case Control Deck and Parameters for Normal Modes Analysis Using Cyclic Symmetry

The following items relate to subcase definition and data selection for Normal Modes:

1. METHØD must be used to select an EIGR card that exists in the Bulk Data Deck.
2. An SPC set must be selected unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.

3. Multiple subcases are used only to control output requests. A single subcase is sufficient if the same output is desired for all modes. If multiple subcases are present, the output requests will be honored in succession for increasing mode numbers. MØDES may be used to repeat subcases in order to make the same output request for several consecutive modes.

Each NASTRAN run calculates modes for only one symmetry index, k. The following output may be requested for Normal Mode Analysis with Cyclic Symmetry:

1. Eigenvectors along with the associated eigenvalue for each mode.
2. Nonzero components of the single-point forces of constraint for selected modes at selected grid points.
3. Forces and stresses in selected elements for selected modes.
4. Undeformed plot of the structural model and mode shapes for selected modes.

The following parameters are used in Normal Mode Analysis using Cyclic Symmetry:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.
2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.
3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.
4. CTYPE - required - the BCD value of this parameter defines the type of cyclic symmetry as follows:
   (1) RØT - rotational symmetry
   (2) DRL - dihedral symmetry, using right and left halves
   (3) DSA - dihedral symmetry, using symmetric and antisymmetric components

5. NSEGS - required - the integer value of this parameter is the number of identical segments in the structural model.

6. CYCSEQ - optional - the integer value of this parameter specifies the procedure for sequencing the equations in the solution set. A value of +1 specifies that all cosine terms should be sequenced before all sine terms, and a value of -1 for alternating the cosine and sine terms. The default value is -1.

7. KINDEX - required in normal modes with cyclic symmetry (Rigid Format 15). The integer value of this parameter specifies a single value of the harmonic index.

3.17 STATIC HEAT TRANSFER ANALYSIS

3.17.1 DMAP Sequence for Static Heat Transfer Analysis

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 01 HEAT

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.1 STATIC HEAT TRANSFER ANALYSIS - SERIES N $

  2  FILE      HLLL=TAPE $

  3  FILE      HQG=APPEND/HPGG=APPEND/HUGV=APPEND/HGM=SAVE/HKNN=SAVE $

  4  GP1       GEOM1,GEOM2,/GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL/V,N,HLUSET/   V,
               N,NOGPDT $

  5  SAVE      HLUSET $

  6  CHKPNT    GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL $

  7  GP2       GEOM2,HEQEXIN/ECT $

  8  CHKPNT    ECT $

  9  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

 10  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

 11  COND      HP1,NOPCDB $

 12  PLTSET    PCDB,HEQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,HNSIL/ V,N,
               JUMPPLOT=-1 $

 13  SAVE      HNSIL,JUMPPLOT $

 14  PRTMSG    PLTSETX// $

 15  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 16  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 17  COND      HP1,JUMPPLOT $

 18  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIL,,,,/PLOTX1/ V,N,
               HNSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 19  SAVE      JUMPPLOT,PLTFLG,PFILE $

 20  PRTMSG    PLOTX1// $

 21  LABEL     HP1 $

 22  CHKPNT    PLTPAR,GPSETS,ELSETS $

 23  GP3       GEOM3,HEQEXIN,GEOM2/HSLT,GPTT/V,N,NOGRAV $

 24  CHKPNT    HSLT,GPTT $

 25  TA1       ECT,EPT,BGPDT,HSIL,GPTT,CSTM/HEST,,HGPECT,/V,N,HLUSET/  V,N,
               NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 01 HEAT

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 26  SAVE     NOSIMP $

 27  COND     ERROR4,NOSIMP $

 28  PURGE    GPST/NOSIMP $

 29  CHKPNT   HEST,HGPECT,GPST $

 30  COND     HLBL1,NOSIMP $

 31  PARAM    //C,N,ADD/V,N,HNOKGG/C,N,1/C,N,0 $

 32  EMG      HEST,CSTM,MPT,DIT,GEOM2,/HKELM,HKDICT,,,,/V,N,HNOKGG $

 33  SAVE     HNOKGG $

 34  CHKPNT   HKELM,HKDICT $

 35  COND     HLBL1,HNOKGG $

 36  EMA      HGPECT,HKDICT,HKELM/HKGG,GPST $

 37  CHKPNT   HKGG,GPST $

 38  LABEL    HLBL1 $

 39  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 40  JUMP     HLBL11 $
---------------------------------------------------- Top of DMAP Loop
 41  LABEL    HLBL11 $

 42  GP4      CASECC,GEOM4,HEQEXIN,HSIL,GPDT,BGPDT,CSTM/RG,YS,HUSET,HASET/V,
              N,HLUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/
              V,N,NSKIP/V,N,HREPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 43  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,HREPEAT,NOSET,NOL,NOA $

 44  COND     ERROR3,NOL $

 45  PARAM    //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $

 46  PURGE    HKRR,HKLR,HQR,HDM/REACT/GM/MPCF1/HGO,HKOO,HLOO,HPO,HUOOV,
              HRUOV/OMIT/HPS,HKFS,HKSS/SINGLE/HQG/NOSR $

 47  CHKPNT   HKRR,HKLR,HQR,HDM,GM,HGO,HKOO,HLOO,HPO,HUOOV,HRUOV,HPS,HKFS,
              HKSS,HQG,HUSET,RG,YS,HASET $

 48  GPSP     GPL,GPST,HUSET,HSIL/OGPST/V,N,NOGPST $

 49  SAVE     NOGPST $

 50  COND     HLBL4,NOGPST $

 51  OFP      OGPST,,,,,// $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 01 HEAT

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 52  LABEL     HLBL4 $

 53  EQUIV     HKGG,HKNN/MPCF1 $

 54  CHKPNT    HKNN $

 55  COND      HLBL2,MPCF2 $

 56  MCE1      HUSET,RG/GM $

 57  CHKPNT    GM $

 58  MCE2      HUSET,GM,HKGG,,,/HKNN,,, $

 59  CHKPNT    HKNN $

 60  LABEL     HLBL2 $

 61  EQUIV     HKNN,HKFF/SINGLE $

 62  CHKPNT    HKFF $

 63  COND      HLBL3,SINGLE $

 64  SCE1      HUSET,HKNN,,,/HKFF,HKFS,HKSS,,, $

 65  CHKPNT    HKFS,HKSS,HKFF $

 66  LABEL     HLBL3 $

 67  EQUIV     HKFF,HKAA/OMIT $

 68  CHKPNT    HKAA $

 69  COND      HLBL5,OMIT $

 70  SMP1      HUSET,HKFF,,,/HGO,HKAA,HKOO,HLOO,,,,, $

 71  CHKPNT    HGO,HKAA,HKOO,HLOO $

 72  LABEL     HLBL5 $

 73  EQUIV     HKAA,HKLL/REACT $

 74  CHKPNT    HKLL $

 75  COND      HLBL6,REACT $

 76  RBMG1     HUSET,HKAA,/HKLL,HKLR,HKRR,,, $

 77  CHKPNT    HKLL,HKLR,HKRR $

 78  LABEL     HLBL6 $

 79  RBMG2     HKLL/HLLL $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 01 HEAT

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 80  CHKPNT   HLLL $

 81  COND     HLBL7,REACT $

 82  RBMG3    HLLL,HKLR,HKRR/HDM $

 83  CHKPNT   HDM $

 84  LABEL    HLBL7 $

 85  SSG1     HSLT,BGPDT,CSTM,HSIL,HEST,MPT,GPTT,EDT,,CASECC,DIT/HPG/V,N,
              HLUSET/V,N,NSKIP $

 86  CHKPNT   HPG $

 87  EQUIV    HPG,HPL/NOSET $

 88  CHKPNT   HPL $

 89  COND     HLBL10,NOSET $

 90  SSG2     HUSET,GM,YS,HKFS,HGO,HDM,HPG/HQR,HPO,HPS,HPL $

 91  CHKPNT   HQR,HPO,HPS,HPL $

 92  LABEL    HLBL10 $

 93  SSG3     HLLL,HKLL,HPL,HLOO,HKOO,HPO/HULV,HUOOV,HRULV,HRUOV/V,N,OMIT/
              V,Y,IRES=-1/V,N,NSKIP/V,N,EPSI $

 94  SAVE     EPSI $

 95  CHKPNT   HULV,HUOOV,HRULV,HRUOV $

 96  COND     HLBL9,IRES $

 97  MATGPR   GPL,HUSET,HSIL,HRULV//C,N,L $

 98  MATGPR   GPL,HUSET,HSIL,HRUOV//C,N,O $

 99  LABEL    HLBL9 $

100  SDR1     HUSET,HPG,HULV,HUOOV,YS,HGO,GM,HPS,HKFS,HKSS,HQR/HUGV,HPGG,HQG/
              V,N,NSKIP/C,N,HSTATICS $

101  CHKPNT   HUGV,HPGG,HQG $

102  COND     HLBL8,HREPEAT $

103  REPT     HLBL11,100 $                              Bottom of DMAP Loop

104  JUMP     ERROR1 $

105  PARAM    //C,N,NOT/V,N,HTEST/V,N,HREPEAT $

106  COND     ERROR5,HTEST $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 01 HEAT

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

107   LABEL     HLBL8 $

108   CHKPNT    CSTM $

109   SDR2      CASECC,CSTM,MPT,DIT,HEQEXIN,HSIL,GPTT,EDT,BGPDT,,HQG,HUGV,
                HEST,,HPGG/HOPG1,HOQG1,HOUGV1,HOES1,HOEF1,HPUGV1/C,N,STATICS $

110   PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

111   OFP       HOUGV1,HOPG1,HOQG1,HOEF1,HOES1,//V,N,CARDNO $

112   SAVE      CARDNO $

113   COND      HP2,JUMPPLOT $

114   PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIL,HPUGV1,,HGPECT,
                HOES1/PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,
                PFILE $

115   SAVE      PFILE $

116   PRTMSG    PLOTX2// $

117   LABEL     HP2 $

118   JUMP      FINIS $

119   LABEL     ERROR1 $

120   PRTPARM   //C,N,-1/C,N,HSTA $

121   LABEL     ERROR3 $

122   PRTPARM   //C,N,-3/C,N,HSTA $

123   LABEL     ERROR4 $

124   PRTPARM   //C,N,-4/C,N,HSTA $

125   LABEL     ERROR5 $

126   PRTPARM   //C,N,-5/C,N,HSTA $

127   LABEL     FINIS $

128   END       $
```

3.17.2 Description of DMAP Operations for Static Heat Transfer Analysis

4. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

7. GP2 generates Element Connection Table with internal indices.

11. Go to DMAP No. 21 if no plot package is present.

12. PLTSET transforms user input into a form used to drive structure plotter.

14. PRTMSG prints error messages associated with structure plotter.

17. Go to DMAP No. 21 if no undeformed structure plot request.

18. PLØT generates all requested undeformed structure plots.

20. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

23. GP3 generates Static Loads Table and Grid Point Temperature Table.

25. TA1 generates element tables for use in matrix assembly and stress recovery.

27. Go to DMAP No. 123 and print error message if no elements have been defined.

30. Go to DMAP No. 38 if there are no structural elements.

32. EMG generates structural element matrix tables and dictionaries for later assembly.

35. Go to DMAP No. 38 if no stiffness matrix is to be assembled.

36. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

40. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

41. Beginning of loop for additional constraint sets.

42. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{\iota_s\}$.

44. Go to DMAP No. 121 and print error message if no independent degrees of freedom are defined.

48. GPSP determines if possible grid point singularities remain.

50. Go to DMAP No. 52 if no grid point singularities remain.

51. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

53. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

55. Go to DMAP No. 60 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

56. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

58. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

61. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

63. Go to DMAP No. 66 if no single-point constraints.

64. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] .$$

67. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

69. Go to DMAP No. 82 if no omitted coordinates.

70. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right] ,$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

73. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

75. Go to DMAP No. 78 if no free-body supports.

76. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] .$$

79. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

81. Go to DMAP No. 84 if no free-body supports.

82. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}] \; ,$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] \quad ,$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||} \; .$$

85. SSG1 generates static load vectors $\{P_g\}$.

87. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

90. SSG2 applies constrains to static load vectors

$$\{P_g\} = \left\{\begin{array}{c} \bar{P}_n \\ \hline P_m \end{array}\right\} \quad , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} \quad ,$$

$$\{P_n\} = \left\{\begin{array}{c} \bar{P}_f \\ \hline P_s \end{array}\right\} \quad , \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\} \quad ,$$

$$\{P_f\} = \left\{\begin{array}{c} \bar{P}_a \\ \hline P_o \end{array}\right\} \quad , \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\} \quad ,$$

$$\{P_a\} = \left\{\begin{array}{c} P_\ell \\ \hline P_r \end{array}\right\}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

93. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} \quad ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\} \quad ,$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\} \quad ,$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\} \quad ,$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}} \quad .$$

96. Go to DMAP No. 99 if residual vectors are not to be printed.

97. MATGPR prints the residual vector for independent coordinates (RULV).

98. MATGPR prints the residual vector for omitted coordinates (RUØV).

100. SDR1 recovers dependent displacements

$$\begin{Bmatrix} u_\ell \\ \hline u_r \end{Bmatrix} = \{u_a\} \quad , \qquad \{u_o\} = [G_o]\{u_a\} + \{u_o^o\} \quad ,$$

$$\begin{Bmatrix} u_a \\ \hline u_o \end{Bmatrix} = \{u_f\} \quad , \qquad \begin{Bmatrix} u_f \\ \hline Y_s \end{Bmatrix} = \{u_n\} \quad ,$$

$$\{u_m\} = [G_m]\{u_n\} \quad , \qquad \begin{Bmatrix} u_n \\ \hline u_m \end{Bmatrix} = \{u_g\} \quad ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} \quad .$$

102. Go to DMAP No. 107 if all constraint sets have been processed.

103. Go to DMAP No. 41 if additional sets of constraints need to be processed.

104. Go to DMAP No. 119 and print error message if number of loops exceeds 100.

106. Go to DMAP No. 125 and print error message if multiple boundary conditions are attempted *with improper subset.*

109. SDR2 calculates element forces and stresses (ØEF1,ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).

111. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

113. Go to DMAP No. 117 if no deformed structure plots are requested.

114. PLØT generates all requested deformed structure plots.

116. PRTMSG prints plotter data and engineering data for each deformed plot generated.

118. Go to DMAP No. 127 and make normal exit.

120. STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

122. STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

124. STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

126. STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

3.17.3 Case Control Deck and Parameters for Static Heat Transfer Analysis

The following items relate to subcase definition and data selection for Static Heat Transfer Analysis:

1. A separate subcase must be defined for each unique combination of constraints and static loads.

2. A static loading condition must be defined for (not necessarily within) each subcase with a LØAD selection, unless all loading is specified with grid point temperatures on SPC cards.

3. An SPC set must be selected for (not necessarily within) each subcase, unless all constraints are specified on GRID cards or Scalar Connection cards.

4. Loading conditions associated with the same sets of constraints should be in contiguous subcases, in order to avoid unnecessary looping.

5. REPCASE may be used to repeat subcases in order to allow multiple sets of the same output item.

The following output may be requested for Static Heat Transfer Analysis solutions:

1. Temperatures (THERMAL) and nonzero components of static loads (ØLØAD) and constrained heat flow (SPCFØRCE) at selected grid points or scalar points.

2. The punch option of a THERMAL request will produce TEMP bulk data cards.

3. Flux density (ELFØRCE) in selected elements.

4. Undeformed plots of the structural model and temperature profiles.

The following parameters are used in Static Heat Transfer Analysis:

1. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

3.18 NONLINEAR STATIC HEAT TRANSFER ANALYSIS

3.18.1 DMAP Sequence for Nonlinear Static Heat Transfer Analysis

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 3 HEAT
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.03 NONLINEAR STATIC HEAT TRANSFER ANALYSIS - SERIES N $

  2  GP1       GEOM1,GEOM2,/GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL/V,N,HLUSET/    V,
               N,NOGPDT $

  3  SAVE      HLUSET $

  4  CHKPNT    GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL $

  5  GP2       GEOM2,HEQEXIN/ECT $

  6  CHKPNT    ECT $

  7  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  8  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

  9  COND      HP1,NOPCDB $

 10  PLTSET    PCDB,HEQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,HNSIL/ V,N,
               JUMPPLOT=-1 $

 11  SAVE      HNSIL,JUMPPLOT $

 12  PRTMSG    PLTSETX// $

 13  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 14  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 15  COND      HP1,JUMPPLOT $

 16  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIL,,,,/PLOTX1/ V,N,
               HNSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 17  SAVE      JUMPPLOT,PLTFLG,PFILE $

 18  PRTMSG    PLOTX1// $

 19  LABEL     HP1 $

 20  CHKPNT    PLTPAR,GPSETS,ELSETS $

 21  GP3       GEOM3,HEQEXIN,GEOM2/HSLT,GPTT/V,N,NOGRAV $

 22  CHKPNT    HSLT,GPTT $

 23  TA1       ECT,EPT,BGPDT,HSIL,GPTT,CSTM/HEST,,HGPECT,/V,N,HLUSET/  V,N,
               NOSIMP/C,N,1/V,N,NOGENL/V,N,HXYZ $

 24  SAVE      NOSIMP $

 25  COND      ERROR2,NOSIMP $
```

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 3 HEAT
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 26  CHKPNT   HEST,HGPECT $

 27  PARAM    //C,N,ADD/V,N,HNOKGG/C,N,1/C,N,0 $

 28  EMG      HEST,CSTM,MPT,DIT,GEOM2,/HKELM,HKDICT,,,,/V,N,HNOKGG $

 29  SAVE     HNOKGG $

 30  CHKPNT   HKELM,HKDICT $

 31  COND     JMPKGGX,HNOKGG $

 32  EMA      HGPECT,HKDICT,HKELM/HKGGX,GPST $

 33  CHKPNT   HKGGX,GPST $

 34  LABEL    JMPKGGX $

 35  RMG      HEST,MATPOOL,GPTT,HKGGX/HRGG,HQGE,HKGG/C,Y,TABS/C,Y,SIGMA=0.0/
              V,N,HNLR/V,N,HLUSET $

 36  SAVE     HNLR $

 37  EQUIV    HKGGX,HKGG/HNLR $

 38  PURGE    HQGE,HRGG/HNLR $

 39  CHKPNT   HKGG,HQGE,HRGG $

 40  GP4      CASECC,GEOM4,HEQEXIN,HSIL,GPDT,BGPDT,CSTM/RG,YS,HUSET,HASET/V,
              N,HLUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/
              V,N,NSKIP/V,N,HREPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 41  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,HREPEAT,NOSET,NOL,NOA $

 42  COND     ERROR1,NOL $

 43  PURGE    GM/MPCF1/HPS,HKFS,HKSS,HKSF,HRSN,HQG/SINGLE $

 44  CHKPNT   GM,HPS,HKFS,HKSS,HUSET,RG,HKSF,HRSN,YS $

 45  GPSP     GPL,GPST,HUSET,HSIL/OGPST/V,N,NOGPST $

 46  SAVE     NOGPST $

 47  COND     HLBL5,NOGPST $

 48  OFP      OGPST,,,,,// $

 49  LABEL    HLBL5 $

 50  EQUIV    HKGG,HKNN/MPCF1/HRGG,HRNN/MPCF1 $

 51  CHKPNT   HKNN,HRNN $

 52  COND     HLBL1,MPCF2 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 3 HEAT

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 53  MCE1     HUSET,RG/GM $

 54  CHKPNT   GM $

 55  MCE2     HUSET,GM,HKGG,HRGG,,/HKNN,HRNN,, $

 56  CHKPNT   HKNN,HRNN $

 57  LABEL    HLBL1 $

 58  EQUIV    HKNN,HKFF/SINGLE/HRNN,HRFN/SINGLE $

 59  CHKPNT   HKFF,HRFN $

 60  COND     HLBL2,SINGLE $

 61  VEC      HUSET/VFS/C,N,N/C,N,F/C,N,S $

 62  PARTN    HKNN,VFS,/HKFF,HKSF,HKFS,HKSS $

 63  PARTN    HRNN,,VFS/HRFN,HRSN,,/C,N,1 $

 64  LABEL    HLBL2 $

 65  CHKPNT   HKFS,HKSS,HKFF,HKSF,HRFN,HRSN $

 66  DECOMP   HKFF/HLLL,HULL/C,N,0/C,N,0/V,N,MDIAG/V,N,DET/V,N,PWR/V,N,
              KSING $

 67  SAVE     KSING $

 68  COND     ERROR3,KSING $

 69  CHKPNT   HLLL,HULL $

 70  SSG1     HSLT,BGPDT,CSTM,HSIL,HEST,MPT,GPTT,EDT,,CASECC,DIT/HPG/V,N,
              HLUSET/V,N,NSKIP $

 71  CHKPNT   HPG $

 72  EQUIV    HPG,HPF/NOSET $

 73  COND     HLBL3,NOSET $

 74  SSG2     HUSET,GM,,HKFS,,,HPG/,,HPS,HPF $

 75  LABEL    HLBL3 $

 76  CHKPNT   HPF,HPS $

 77  SSGHT    HUSET,HSIL,GPTT,GM,HEST,MPT,DIT,HPF,HPS,HKFF,HKFS,HKSF,   HKSS,
              HRFN,HRSN,HLLL,HULL/HUGV,HQG,HRULV/V,N,HNNLK=1/V,N,HNLR/ C,Y,
              EPSHT=.001/C,Y,TABS=0.0/C,Y,MAXIT=4/V,Y,IRES/V,N,MPCF1/V,N,
              SINGLE $

 78  CHKPNT   HUGV,HQG,HRULV $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 3 HEAT

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 79  COND      HLBL4,IRES $

 80  MATGPR    GPL,HUSET,HSIL,HRULV//C,N,F $

 81  LABEL     HLBL4 $

 82  PLTTRAN   BGPDT,HSIL/BGPDP,HSIP/V,N,HLUSET/V,N,HLUSEP $

 83  SAVE      HLUSEP $

 84  CHKPNT    BGPDP,HSIP $

 85  SDR2      CASECC,CSTM,MPT,DIT,HEQEXIN,HSIL,GPTT,EDT,BGPDP,,HQG,HUGV,
               HEST,,HPG/HOPG1,HOQG1,HOUGV1,HOES1,HOEF1,HPUGV1/C,N,STATICS $

 86  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

 87  OFP       HOUGV1,HOPG1,HOQG1,,,//V,N,CARDNO $

 88  SAVE      CARDNO $

 89  SDRHT     HSIL,HUSET,HUGV,HOEF1,HSLT,HEST,DIT,HQGE,,/HOEF1X/C,Y,TABS/
               V,N,HNLR $

 90  OFP       HOEF1X,,,,,//V,N,CARDNO $

 91  SAVE      CARDNO $

 92  COND      HP2,JUMPPLOT $

 93  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIP,HPUGV1,,HGPECT,
               HOES1/PLOTX2/V,N,NSIL/V,N,HLUSEP/V,N,JUMPPLOT/   V,N,PLTFLG/V,
               N,PFILE $

 94  PRTMSG    PLOTX2// $

 95  LABEL     HP2 $

 96  JUMP      FINIS$

 97  LABEL     ERROR1 $

 98  PRTPARM   //C,N,-1/C,N,HNLI $

 99  LABEL     ERROR2 $

100  PRTPARM   //C,N,-2/C,N,HNLI $

101  LABEL     ERROR3 $

102  PRTPARM   //C,N,-3/C,N,HNLI $

103  LABEL     FINIS$

104  END       $
```

3.18.2 Description of DMAP Operations for Nonlinear Static Heat Transfer Analysis

2. GP1 generates grid point location tables and tables relating internal and external degree of freedom numbers.

5. GP2 generates the Element Connection Table.

9. Go to DMAP No. 19 if no plot package is present.

10. PLTSET transforms the input data into plot data tables.

12. PRTMSG prints error messages associated with the plot data.

15. Go to DMAP No. 19 if no undeformed structure plot request.

16. PLØT generates all plots of the structure without temperature profiles.

18. PRTMSG prints plotter and engineering data for each generated plot.

21. GP3 generates applied heat flux load tables (SLT) and the grid point temperature table.

23. TA1 generates element tables for use in matrix formulation, load generation, and element heat flux data recovery.

25. Go to DMAP No. 99 and print error message if no elements have been defined.

28. EMG generates structural element matrix tables and dictionaries for later assembly.

31. Go to DMAP No. 34 if no conductivity matrix is to be assembled.

32. EMA assembles conductivity matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

35. RMG generates the radiation matrix, $[R_{gg}]$, and adds the estimated linear component of radiation to the conductivity matrix. The element radiation flux matrix, $[Q_{ge}]$, is also generated for use in recovery data for the HBDY elements.

37. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no linear component of radiation.

40. GP4 generates flags defining member of various displacement sets (USET) and forms multi-point constraint equations $[R_g]\{u_g\} = \{0\}$.

42. Go to DMAP instruction 97 if no independent degrees of freedom are defined.

45. GPSP determines if possible matrix singularities remain. These may be extraneous in a radiation problem, since some points may transfer heat through radiation only.

47. Go to DMAP No. 49 if no Grid Point Singularity Table.

48. ØFP prints the singularity messages.

50. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[R_{gg}]$ to $[R_{nn}]$ if no multi-point constraints exist.

52. Go to DMAP statement 57 if no multi-point constraints exist.

53. MCE1 partitions the multi-point constraint equation matrix $[R_g] = [R_m \vdots R_n]$ and solves for the multi-point constraint transformation matrix

$$[G_m] = - [R_m]^{-1} [R_n].$$

55. MCE2 partitions conductivity and radiation matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [R_{gg}] = \left[\begin{array}{c|c} \bar{R}_{nn} & R_{nm} \\ \hline R_{mn} & R_{mm} \end{array}\right] ,$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T]\,[K_{mn}] + [K_{mn}^T]\,[G_m] + [G_m^T]\,[K_{mm}]\,[G_m] \text{ and}$$

$$[R_{nn}] = [\bar{R}_{nn}] + [G_m^T]\,[R_{mn}] + [R_{mn}^T]\,[G_m] + [G_m^T]\,[K_{mm}]\,[G_m].$$

58. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[R_{nn}]$ to $[R_{fn}]$ if no single-point constraints exist.

60. Go to DMAP statement 64 if no single-point constraints exist.

61. VEC generates a partitioning vector $u_n \rightarrow u_f + u_s$.

62. PARTN partitions the conductivity matrix

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{fs} & K_{ss} \end{array}\right] .$$

63. PARTN partitions the radiation matrix

$$[R_{nn}] = \left[\begin{array}{c} R_{fn} \\ \hline R_{sn} \end{array}\right] .$$

66. DECØMP decomposes the potentially unsymmetric matrix K_{ff} into upper and lower triangular factors $[U_{\ell\ell}]$ and $[L_{\ell\ell}]$.

68. Go to DMAP statement 101 if the matrix is singular.

70. SSG1 generates the input heat flux vector $\{P_g\}$.

72. Equivalence $\{P_g\}$ to $\{P_f\}$ if no constraints applied.

73. Go to DMAP statement 75 if no constraints of any kind exist.

74. SSG2 reduces the heat flux vector

$$\{P_g\} = \left\{\begin{array}{c} \bar{P}_n \\ \hline P_m \end{array}\right\} ,$$

$$\{P_n\} = \{\bar{P}_n\} + [G_m^T]\,\{P_m\} ,$$

$$\{P_n\} = \left\{\begin{array}{c} P_f \\ \hdashline P_s \end{array}\right\} .$$

77. SSGHT solves the nonlinear heat transfer problems by iteration. User input parameters EPSHT and MAXIT are used to limit the iterations. For details, refer to Section 8 of the NASTRAN Theoretical Manual. The output data blocks are: $\{u_g\}$, the solution temperature vector, $\{q_g\}$, the heat flux due to single point constraints, and $\{\delta P_\ell\}$, the matrix of residual heat fluxes at each iteration step.

79. Go to DMAP statement 81 if no residual vectors are desired.

80. MATGPR prints the matrix of residual vectors.

82. PLTTRAN transforms the grid point definition tables into a format for plotting temperature solutions.

85. SDR2 calculates the heat flux due to conductivity and convection in the elements and prepares the solution vectors for output.

87. ØFP formats tables prepared by SDR2 for output.

89. SDRHT processes the HBDY elements to produce heat flux into the elements due to convection, radiation, and user applied flux.

90. ØFP formats the output element flux table for output.

92. Go to DMAP 95 if no temperature profile plots are requested.

93. PLØT generates temperature profile plots.

94. PRTMSG prints plotter data and engineering data for each plot generated.

96. Go to DMAP No. 103 and make nornal exit.

98. NØNLINEAR STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 1 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

100. NØNLINEAR STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 2 - NØ SIMPLE STRUCTURAL ELEMENTS.

102. NØNLINEAR STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 3 - STIFFNESS MATRIX SINGULAR.

3.18.3 Case Control Deck and Parameters for Nonlinear Static Heat Transfer Analysis

The following items relate to subcase definition and data selection for Nonlinear Static Heat Transfer Analysis:

1. A single subcase must be defined with a single loading condition (LØAD) and a single constraint condition (SPC).

2. An estimated temperature distribution vector must be defined on TEMP cards and selected with a TEMP(MATERIAL) request. Temperatures for constrained components are taken from these TEMP cards and entries on SPC cards are ignored.

The following output may be requested for the last iteration in Nonlinear Static Heat Transfer Analysis:

1. Temperature (THERMAL) and nonzero components of static loads (ØLØAD) and constrained heat flow (SPCFØRCE) at selected grid points or scalar points.

2. The punch option of a THERMAL request will produce TEMP bulk data cards.

3. Flux density (ELFØRCE) in selected elements. In the case of CHBDY elements, a flux density summary is produced that includes applied flux, radiation flux, and convective flux.

4. Undeformed plots of the structural model and temperature profiles.

The following parameters are used in Nonlinear Static Heat Transfer Analysis:

1. MAXIT - optional - the integer value of this parameter limits the maximum number of iterations.

2. EPSHT - optional - the real value of this parameter is used to test the convergence of the solution.

3. TABS - optional - the real value of this parameter is the absolute reference temperature.

4. SIGMA - optional - the real value of this parameter is the Stefan-Boltzmann constant.

5. IRES - optional - a positive value of this parameter will cause the printing of the residual vectors following the execution of SSGHT for each iteration.

3.19 TRANSIENT HEAT TRANSFER ANALYSIS

3.19.1 DMAP Sequence for Transient Heat Transfer Analysis

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9 HEAT

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN    NO.09 TRANSIENT HEAT TRANSFER ANALYSIS - SERIES N $

  2  FILE     HKGGX=TAPE/HKGG=TAPE $

  3  GP1      GEOM1,GEOM2,/GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL/V,N,HLUSET/   V,
              N,NOGPDT/V,N,ALWAYS=-1 $

  4  SAVE     HLUSET,NOGPDT $

  5  PURGE    HUSET,GM,HGO,HKAA,HBAA,HPSO,HKFS,HQP,HEST/NOGPDT $

  6  CHKPNT   GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL,HUSET,GM,HGO,HKAA,HBAA, HPSO,
              HKFS,HQP,HEST $

  7  COND     HLBL5,NOGPDT $

  8  GP2      GEOM2,HEQEXIN/ECT $

  9  CHKPNT   ECT $

 10  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

 11  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

 12  COND     HP1,NOPCDB $

 13  PLTSET   PCDB,HEQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/  V,N,
              JUMPPLOT=-1 $

 14  SAVE     NSIL,JUMPPLOT $

 15  PRTMSG   PLTSETX// $

 16  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 17  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 18  COND     HP1,JUMPPLOT$

 19  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIL,,,,/PLOTX1/ V,N,
              NSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 20  SAVE     JUMPPLOT,PLTFLG,PFILE $

 21  PRTMSG   PLOTX1// $

 22  LABEL    HP1 $

 23  CHKPNT   PLTPAR,GPSETS,ELSETS $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9 HEAT

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 24  GP3      GEOM3,HEQEXIN,GEOM2/HSLT,GPTT/C,N,1 $

 25  CHKPNT   GPTT,HSLT $

 26  TA1      ECT,EPT,BGPDT,HSIL,GPTT,CSTM/HEST,,HGPECT,/V,N,HLUSET/  V,N,
              NOSIMP=-1/C,N,1/C,N,123/C,N,123 $

 27  SAVE     NOSIMP $

 28  CHKPNT   HEST,HGPECT $

 29  COND     HLBL1,NOSIMP $

 30  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

 31  PARAM    //C,N,ADD/V,N,NOBGG/C,N,1/C,N,0 $

 32  EMG      HEST,CSTM,MPT,DIT,GEOM2,/HKELM,HKDICT,,,HBELM,HBDICT/V,N,
              NOKGGX/C,N,/V,N,NOBGG $

 33  SAVE     NOKGGX,NOBGG $

 34  CHKPNT   HKELM,HKDICT,HBELM,HBDICT $

 35  COND     JMPKGGX,NOKGGX $

 36  EMA      HGPECT,HKDICT,HKELM/HKGGX,GPST $

 37  CHKPNT   HKGGX,GPST $

 38  LABEL    JMPKGGX $

 39  COND     JMPHBGG,NOBGG $

 40  EMA      HGPECT,HBDICT,HBELM/HBGG, $

 41  CHKPNT   HBGG $

 42  LABEL    JMPHBGG $

 43  PURGE    HBNN,HBFF,HBAA,HBGG/NOBGG $

 44  CHKPNT   HBGG,HBNN,HBFF,HBAA $

 45  LABEL    HLBL1 $

 46  RMG      HEST,MATPOOL,GPTT,HKGGX/HRGG,HQGE,HKGG/C,Y,TABS/C,Y,SIGMA=0.0/
              V,N,HNLR/V,N,HLUSET $

 47  SAVE     HNLR $

 48  EQUIV    HKGGX,HKGG/HNLR $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9 HEAT

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 49  PURGE     HRGG,HRNN,HRFF,HRAA,HRDD/HNLR $

 50  CHKPNT    HRGG,HRNN,HRFF,HRAA,HRDD,HKGG,HQGE $

 51  GP4       CASECC,GEOM4,HEQEXIN,HSIL,GPDT,BGPDT,CSTM/RG,,HUSET,ASET/    V,
               N,HLUSET/V,N,MPCF1=-1/V,N,MPCF2=-1/V,N,SINGLE=-1/V,N,OMIT=-1/
               V,N,REACT=-1/C,N,0/C,N,123/V,N,NOSET=-1/V,N,NOL/V,N,NOA=-1 $

 52  SAVE      MPCF1,SINGLE,OMIT,NOSET,REACT,MPCF2,NOL,NOA $

 53  PURGE     GM,GMD/MPCF1/HGO,HGOD/OMIT/HKFS,HPSO,HQP/SINGLE $

 54  CHKPNT    GM,RG,HGO,HKFS,HQP,HUSET,GMD,HGOD,HPSO $

 55  COND      HLBL2,NOSIMP $

 56  GPSP      GPL,GPST,HUSET,HSIL/OGPST/V,N,NOGPST $

 57  SAVE      NOGPST $

 58  COND      HLBL2,NOGPST $

 59  OFP       OGPST,,,,,// $

 60  LABEL     HLBL2 $

 61  EQUIV     HKGG,HKNN/MPCF1/HRGG,HRNN/MPCF1/HBGG,HBNN/MPCF1 $

 62  CHKPNT    HKNN,HRNN,HBNN $

 63  COND      HLBL3,MPCF1 $

 64  MCE1      HUSET,RG/GM $

 65  CHKPNT    GM $

 66  MCE2      HUSET,GM,HKGG,HRGG,HBGG,/HKNN,HRNN,HBNN, $

 67  CHKPNT    HKNN,HRNN,HBNN $

 68  LABEL     HLBL3 $

 69  EQUIV     HKNN,HKFF/SINGLE/HRNN,HRFF/SINGLE/HBNN,HBFF/SINGLE $

 70  CHKPNT    HKFF,HRFF,HBFF $

 71  COND      HLBL4,SINGLE $

 72  SCE1      HUSET,HKNN,HRNN,HBNN,/HKFF,HKFS,,HRFF,HBFF, $

 73  CHKPNT    HKFS,HKFF,HRFF,HBFF $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9 HEAT

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 74  LABEL    HLBL4 $

 75  EQUIV    HKFF,HKAA/OMIT $

 76  EQUIV    HRFF,HRAA/OMIT $

 77  EQUIV    HBFF,HBAA/OMIT $

 78  CHKPNT   HKAA,HRAA,HBAA $

 79  COND     HLBL5,OMIT $

 80  SMP1     HUSET,HKFF,,,/HGO,HKAA,HKOO,HLOO,,,,, $

 81  CHKPNT   HGO,HKAA $

 82  COND     HLBLR,HNLR $

 83  SMP2     HUSET,HGO,HRFF/HRAA $

 84  CHKPNT   HRAA $

 85  LABEL    HLBLR $

 86  COND     HLBL5,NOBGG $

 87  SMP2     HUSET,HGO,HBFF/HBAA $

 88  CHKPNT   HBAA $

 89  LABEL    HLBL5 $

 90  DPD      DYNAMICS,GPL,HSIL,HUSET/GPLD,HSILD,HUSETD,TFPOOL,HDLT,,,HNLFT,
              HTRL,,HEQDYN/V,N,HLUSET/V,N,HLUSETD/C,N,123 /V,N,NODLT/   C,N,
              123/C,N,123/V,N,NONLFT/V,N,NOTRL/C,N,123/C,N,/V,N,NOUE $

 91  SAVE     HLUSETD,NODLT,NONLFT,NOTRL,NOUE $

 92  COND     ERROR1,NOTRL $

 93  EQUIV    HGO,HGOD/NOUE/GM,GMD/NOUE $

 94  PURGE    HPPO,HPSO,HPDO,HPDT/NODLT $

 95  CHKPNT   HUSETD,HEQDYN,TFPOOL,HDLT,HTRL,HGOD,GMD,HNLFT,HSILD,GPLD,HPPO,
              HPSO,HPDO,HPDT $

 96  MTRXIN   CASECC,MATPOOL,HEQDYN,,TFPOOL/HK2PP,,HB2PP/V,N,HLUSETD/  V,N,
              NOK2PP/C,N,123/V,N,NOB2PP $

 97  SAVE     NOK2PP,NOB2PP $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9 HEAT

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 98  PARAM    //C,N,AND/V,N,KDEKA/V,N,NOUE/V,N,NOK2PP $

 99  PURGE    HK2DD/NOK2PP/HB2DD/NOB2PP $

100  EQUIV    HKAA,HKDD/KDEKA/HB2PP,HB2DD/NOA/HK2PP,HK2DD/NOA/HRAA,HRDD/
              NOUE $

101  CHKPNT   HK2PP,HB2PP,HK2DD,HB2DD,HKDD,HRDD $

102  COND     HLBL6,NOGPDT $

103  GKAD     HUSETD,GM,HGO,HKAA,HBAA,HRAA,,HK2PP,,HB2PP/HKDD,HBDD,  HRDD,
              GMD,HGOD,HK2DD,HM2DD,HB2DD/C,N,TRANRESP/C,N,DISP/C,N,  DIRECT/
              C,Y,G=0.0/C,Y,W3=0.0/C,Y,W4=0.0/V,N,NOK2PP/C,N,-1/   V,N,
              NOB2PP/V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/  C,N,-1/V,N,
              NOBGG/V,N,NOSIMP/C,N,-1 $

104  LABEL    HLBL6 $

105  EQUIV    HK2DD,HKDD/NOSIMP/HB2DD,HBDD/NOGPDT $

106  CHKPNT   HKDD,HBDD,HRDD,GMD,HGOD $

107  TRLG     CASECC,HUSETD,HDLT,HSLT,BGPDT,HSIL,CSTM,HTRL,DIT,GMD,HGOD,,
              HEST,/HPPO,HPSO,HPDO,HPDT,,HTOL/V,N,NOSET/V,N,PDEPDO $

108  SAVE     PDEPDO,NOSET $

109  EQUIV    HPPO,HPDO/NOSET $

110  EQUIV    HPDO,HPDT/PDEPDO $

111  CHKPNT   HPPO,HPDO,HPSO,HTOL,HPDT $

112  TRHT     CASECC,HUSETD,HNLFT,DIT,GPTT,HKDD,HBDD,HRDD,HPDT,HTRL/ HUDVT,
              HPNLD/C,Y,BETA=.55/C,Y,TABS=0.0/V,N,HNLR/C,Y,RADLIN=-1 $

113  CHKPNT   HUDVT,HPNLD $

114  VDR      CASECC,HEQDYN,HUSETD,HUDVT,HTOL,XYCDB,HPNLD/HOUDV1,HOPNL1/  C,
              N,TRANRESP/C,N,DIRECT/C,N,0/V,N,NOD/V,N,NOP/C,N,0 $

115  SAVE     NOD,NOP $

116  CHKPNT   HOUDV1,HOPNL1 $

117  COND     HLBL7,NOD $

118  SDR3     HOUDV1,HOPNL1,,,,/HOUDV2,HOPNL2,,,, $

119  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
```

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9 HEAT

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

120  OFP       HOUDV2,HOPNL2,,,,//V,N,CARDNO $

121  SAVE      CARDNO $

122  CHKPNT    HOPNL2,HOUDV2 $

126  LABEL     HLBL7 $

127  PARAM     //C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT $

128  COND      HLBL9,PJUMP $

129  EQUIV     HUDVT,HUPV/NOA $

130  COND      HLBL8,NOA $

131  SDR1      HUSETD,,HUDVT,,,HGOD,GMD,HPSO,HKFS,,/HUPV,,HQP/C,N,1/C,N,
               TRANSNT $

132  LABEL     HLBL8 $

133  CHKPNT    HUPV,HQP $

134  PLTTRAN   BGPDT,HSIL/BGPDP,HSIP/V,N,HLUSET/V,N,HLUSEP $

135  SAVE      HLUSEP $

136  SDR2      CASECC,CSTM,MPT,DIT,HEQDYN,HSILD,,,BGPDP,HTOL,HQP,HUPV,HEST,
               XYCDB,HPPO/HOPP1,HOQP1,HOUPV1,,HOEF1,HPUGV/C,N,TRANRESP $

137  SDRHT     HSILD,HUSETD,HUPV,HOEF1,HSLT,HEST,DIT;HQGE,HDLT,/HOEF1X/C,Y,
               TABS/V,N,HNLR $

138  EQUIV     HOEF1X,HOEF1/ALWAYS $

139  SDR3      HOPP1,HOQP1,HOUPV1,,HOEF1,/HOPP2,HOQP2,HOUPV2,,HOEF2, $

140  CHKPNT    HOPP2,HOQP2,HOUPV2,HOEF2 $

141  OFP       HOPP2,HOQP2,HOUPV2,HOEF2,,//V,N,CARDNO $

142  SAVE      CARDNO $

143  COND      HP2,JUMPPLOT $

144  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIP,,HPUGV, HGPECT,/
               PLOTX2/V,N,HNSIL/V,N,HLUSEP/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

145  SAVE      PFILE $

146  PRTMSG    PLOTX2// $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9 HEAT

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

147  LABEL    HP2 $

148  XYTRAN   XYCDB,HOPP2,HOQP2,HOUPV2,,HOEF2/HXYPLTT/C,N,TRAN/C,N,PSET/V,N,
              PFILE/V,N,CARDNO $

149  SAVE     PFILE,CARDNO $

150  XYPLOT   HXYPLTT// $

151  LABEL    HLBL9 $

152  JUMP     FINIS $

153  LABEL    ERROR1 $

154  PRTPARM  //C,N,-1/C,N,HTRD $

155  LABEL    FINIS$

156  END      $
```

3.19.2 Description of DMAP Operations for Transient Heat Transfer Analysis

3. GP1 generates grid point location tables and tables relating internal and external degree of freedom indices.

7. Go to DMAP No. 89 if no grid point definition table.

8. GP2 generates the Element Connection Table.

12. Go to DMAP No. 22 if no plot package is present.

13. PLTSET transforms user input into plot data tables.

15. PRTMSG prints error messages associated with the structure plotter.

18. Go to DMAP No. 22 if no structure-only plots are requested.

19. PLØT generates all plots of the structure without temperature profiles.

21. PRTMSG prints plotter data and engineering data for each generated plot.

24. GP3 generates the table of user defined temperature sets and the tables of static heat flux input data.

26. TA1 generates element tables for use in matrix formulation, load generation, and element data recovery.

29. Go to DMAP No. 45 if no structural or boundary elements exist.

32. EMG generates structural element matrix tables and dictionaries for later assembly.

35. Go to DMAP No. 38 if no stiffness matrix is to be assembled.

36. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

39. Go to DMAP No. 42 if no heat capacity matrix is to be assembled.

40. EMA assembles heat capacity matrix $[B_{gg}]$.

46. RMG generates the radiation matrix, $[R_{gg}]$, and adds the estimated linear component of radiation to the conductivity matrix. The element-radiation flux matrix, $[Q_{ge}]$, is also generated for use in data recovery.

48. Equivalence the linear heat transfer matrix, $[K_{gg}]$, to the conductivity matrix if no radiation exists.

51. GP4 generates flugs defining members of various displacement sets (USET) and forms the multi-point constraint equations, $[R_g]\{u_g\} = 0$.

55. Go to DMAP No. 60 if no simple elements exist.

56. GPSP determines if possible matrix singularities remain. These may be extraneous in a radiation problem, since some points may transfer heat through radiation only.

58. Go to DMAP No. 60 if no Grid Point Singularity Table.

59. ØFP prints the singularity messages.

61. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[R_{gg}]$ to $[R_{nn}]$, and $[B_{gg}]$ to $[B_{nn}]$ if no multi-point constraints exist.

63. Go to DMAP No. 68 if no multi-point constraints exist.

64. MCE1 partitions the multi-point constraint equation matrix, $[R_g] = [R_m \; R_n]$, and solves for the multi-point constraint transformation matrix,

$$[G_m] = - [R_m]^{-1} [R_n] .$$

66. MCE2 partitions conductivity and radiation matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] ,$$

$$[R_{gg}] = \left[\begin{array}{c|c} \bar{R}_{nn} & R_{nm} \\ \hline R_{mn} & R_{mm} \end{array}\right] ,$$

$$B_{gg} = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array}\right] ,$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T] [K_{mn}] + [K_{mn}] [G_m] + [G_m^T] [K_{mm}] [G_m].$$

The same equation is applied to R_{nn} and B_{nn}.

69. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$, and $[R_{nn}]$ to $[R_{ff}]$ if no single point constraints exist.

71. Go to DMAP No. 74 if no single point constraints exist.

72. SCE1 partitions the matrices as follows:

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] .$$

R_{nn} and B_{nn} are partitioned in the same manner, except only the ff partitions are saved.

75. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

76. Equivalence $[R_{ff}]$ to $[R_{aa}]$ if no omitted coordinates.

77. Equivalence $[B_{ff}]$ to $[B_{aa}]$ if no omitted coordinates.

79. Go to DMAP No. 89 if no omitted coordinates are requested.

80. SMP1 partitions the conductivity matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right] ,$$

solves for the transformation matrix $[G_o]$:

$$[K_{oo}]\,[G_o] = -\,[K_{oa}] ,$$

and solves for the reduced conductivity matrix $[K_{aa}]$:

$$[K_{aa}] = [\bar{K}_{aa}] + [K_{ao}]\,[G_o] .$$

82. Go to DMAP No. 85 if no radiation matrix exists.

83. SMP2 partitions constrained radiation matrix

$$[R_{ff}] = \left[\begin{array}{c|c} \bar{R}_{aa} & R_{ao} \\ \hline R_{oa} & R_{oo} \end{array}\right] ,$$

and performs matrix reduction

$$[R_{aa}] = [\bar{R}_{aa}] + [R_{oa}^T]\,[G_o] + [G_o^T]\,[R_{oa}] + [G_o^T]\,[R_{oo}]\,[G_o].$$

86. Go to DMAP No. 89 if no heat capacity matrix, $[B_{ff}]$, exists.

87. SMP2 calculates a reduced heat capacity matrix, $[B_{aa}]$, with the same equation as DMAP No. 83.

90. DPD generates the table defining the displacement sets each degree of freedom belongs to (USETD), including extra points. It prepares the Transfer Function Pool, the Dynamics Load Table, the Nonlinear Function Table, and the Transient Response List.

92. Go to DMAP No. 153 and exit if no time step data was specified.

93. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points were defined.

96. MTRXIN selects the direct input matrices $[K_{pp}^2]$ and $[B_{pp}^2]$.

100. Equivalence $[K_{aa}]$ to $[K_{dd}^1]$ if no direct input stiffness matrices and no extra points; $[B_{pp}]$ to $[B_{dd}^2]$ and $[K_{pp}]$ to $[K_{dd}^2]$ if only extra points are used; and $[R_{aa}]$ to $[R_{dd}]$ if no extra points are used.

102. Go to DMAP No. 194 if no grid point definition table.

103. GKAD expands the matrices to include extra points and assembles conductivity, capacitance, and radiation matrices for use in Direct Transient Response.

$$[K^1_{dd}] = \left[\begin{array}{c|c} K_{aa} & 0 \\ \hline 0 & 0 \end{array}\right] ,$$

$$[B^1_{dd}] = \left[\begin{array}{c|c} B_{aa} & 0 \\ \hline 0 & 0 \end{array}\right] ,$$

$$[R_{dd}] = \left[\begin{array}{c|c} R_{aa} & 0 \\ \hline 0 & 0 \end{array}\right] ,$$

$$[K_{dd}] = [K^1_{dd}] + [K^2_{dd}] ,$$

$$[B_{dd}] = [B^1_{dd}] + [B^2_{dd}] .$$

(Nonzero values of the parameters W4, G, and W3 are not recommended for use in heat transfer analysis.)

105. Equivalence $[K^2_{dd}]$ to $[K_{dd}]$ and $[B^2_{dd}]$ to $[B_{dd}]$ if no matrices were generated from the structural elements.

107. TRLG generates matrices of heat flux loads versus time. $\{P^o_p\}$, $\{P^o_s\}$, and $\{P^o_d\}$ are generated with one column per output time step. $\{P^t_d\}$ is generated with one column per solution time step, and the Transient Output List is a list of output time steps.

109. Equivalence $\{P^o_p\}$ to $\{P^o_d\}$ if the d and p sets are the same.

110. Equivalence $\{P^o_d\}$ to $\{P^t_d\}$ if the output times are the same as the solution times.

112. TRHT integrates the equation of motion:

$$[B_{dd}]\ \{\dot{u}\} + [K_{dd}]\ \{u\} = \{P_d\} + \{N_d\},$$

where $\{u\}$ is a vector of temperatures at any time,
$\{\dot{u}\}$ is the time derivative of $\{u\}$ ("velocity"),
$\{P_d\}$ is the applied heat flux at any time step, and
$\{N_d\}$ is the total nonlinear heat flux from radiation and/or NØLIN data, extrapolated from the previous solution vector.

The output consists of the $[u^t_d]$ matrix containing temperature vectors and temperature "velocity" vectors for the output time steps.

114. VDR processes the user solution set output requests.

117. Go to DMAP No. 126 if no solution set output is desired.

118. SDR3 transforms the requested temperature and nonlinear load values into output SØRT2 format.

120. ØFP formats the temperature, temperature velocity, and heat flux nonlinear loads for printout.

128. Go to DMAP No. 151 and exit if no further output is desired.

129. Equivalence $[u_d]$ to $[u_p]$ if no structure points were input.

130. Go to DMAP No. 132 if no structure points were input.

13'. SDR1 recovers the dependent temperatures:

$$\{u_o\} = [G_o^d]\ \{u_d\}\ ,$$

$$\begin{Bmatrix} u_d \\ \hdashline u_o \end{Bmatrix} = \{u_f\}\ ,$$

$$\begin{Bmatrix} u_f+u_e \\ \hdashline u_s \end{Bmatrix} = \{u_n\}\ ,$$

$$\{u_m\} = [G_m^d]\ \{u_f+u_e\}\ ,$$

$$\begin{Bmatrix} u_n+u_e \\ \hdashline u_m \end{Bmatrix} = \{u_p\}\ .$$

The module also recovers the heat flux into the points having single-point constraints.

$$\{q_s\} = -\ \{P_s\} + [K_{fs}^T]\ \{u_f\}.$$

134. PLTTRAN coverts the grid point tables to standard plot form when grid points with one degree of freedom are used.

136. SDR2 calculates requested heat flux transfer in the elements and transforms temperatures, velocities, and heat flux loads into output form.

139. SDR3 prepares requested output in SØRT2 order.

141. ØFP formats requested output and places it on the system output file.

143. Go to DMAP No. 147 if no deformed structure plots are requested.

144. PLØT generates plots of the temperature profile on the structure for specified times.

146. PRTMSG prints plotter data and engineering data for structure plots.

148. XYTRAN prepares tables of requested grid point or element output quantities for XYPLØT

150. XYPLØT prepares requested plots of temperatures, velocities, element flux, or applied heat loads versus time.

152. Go to DMAP No. 155 and make normal exit.

154. TRANSIENT HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 1 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

3.19.3 Case Control Deck and Parameters for Transient Heat Transfer Analysis

The following items relate to subcase definition and data selection for Transient Heat Transfer Analysis:

1. A single subcase must be defined with a single constraint condition.

2. DLØAD and/or NØNLINEAR must be used to define a single time-dependent loading condition. The static load cards (QVECT, QVØL, QHBDY, QBDY1, and QBDY2) can be used to define a dynamic load by using these cards with, or instead of, the DAREA cards. The set identification number on the static load cards (field 2) is used in the same manner as the set identification number on the DAREA cards (field 2).

3. TSTEP must be used to select the time-step intervals to be used for integration and output.

4. If nonzero initial conditions are desired, IC must be used to select a TEMP set in the Bulk Data Deck.

5. An estimated temperature distribution vector must be defined on TEMP cards and selected with a TEMP (MATERIAL) request if radiation effects are included.

The following printed output, sorted by print number or element number (SØRT2), is available at selected multiples of the integration time step:

1. Temperatures (THERMAL) and derivatives of temperatures (VELØCITY) for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SDISPLACEMENT and SVELØCITY for SØLUTIØN points (points used in formation of dynamic equation).

2. Nonzero components of the applied load vector (ØLØAD) and constrained heat flow (SPCFØRCE) for a list of PHYSICAL points.

3. Nonlinear load vector for a list of SØLUTIØN points.

4. Flux density (ELFØRCE) in selected elements.

The following plotter output is available for Transient Heat Transfer Analysis:

1. Undeformed plot of the structural model.
2. Temperature profiles for selected time intervals.
3. X-Y plot of temperature or defivative of temperature for a PHYSICAL point or SØLUTIØN point.
4. X-Y plot of the applied load vector, nonlinear load vector, or constrained heat flow.
5. X-Y plot of flux density for an element.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.2). Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Transient Heat Transfer Analysis:

1. TABS - optional - the real value of this parameter is the absolute reference temperature.
2. SIGMA - optional - the real value of this parameter is the Stefan-Boltzmann constant.
3. BETA - optional - the real value of this parameter is used as a factor in the integration algorithm.
4. RADLIN - optional - a positive integer value of this parameter causes some of the radiation effects to be linearized.

3.20 MODAL FLUTTER ANALYSIS

3.20.1 DMAP Sequence for Modal Flutter Analysis

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10 AERO

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN    AERO NO.10 MODAL FLUTTER ANALYSIS SERIES N $

  2  FILE     PHIHL=APPEND/AJJL=APPEND/FSAVE=APPEND/CASEYY=APPEND/CLAMAL=
              APPEND/OVG=APPEND/CHHL=APPEND $

  3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
              NOGPDT $

  4  SAVE     LUSET,NOGPDT $

  5  COND     ERROR1,NOGPDT $

  6  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  7  PURGE    D1JE,D2JE/NODJE $

  8  GP2      GEOM2,EQEXIN/ECT $

  9  CHKPNT   ECT $

 10  GP3      GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

 11  CHKPNT   GPTT $

 12  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

 13  SAVE     NOGENL,NOSIMP,GENEL $

 14  COND     ERROR1,NOSIMP $

 15  PURGE    OGPST/GENEL $

 16  CHKPNT   EST,GPECT,GEI,OGPST $

 17  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

 18  PARAM    //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

 19  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
              N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/  C,Y,
              CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/ C,Y,
              CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

 20  SAVE     NOKGGX,NOMGG $

 21  CHKPNT   KELM,KDICT,MELM,MDICT $

 22  COND     JMPKGGX,NOKGGX $

 23  EMA      GPECT,KDICT,KELM/KGGX,GPST $

 24  CHKPNT   KGGX,GPST $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10 AERO

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 25  LABEL    JMPKGGX $

 26  COND     ERROR1,NOMGG $

 27  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

 28  CHKPNT   MGG $

 29  COND     LGPWG,GRDPNT $

 30  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

 31  OFP      OGPWG,,,,,// $

 32  LABEL    LGPWG $

 33  EQUIV    KGGX,KGG/NOGENL $

 34  CHKPNT   KGG $

 35  COND     LBL11,NOGENL $

 36  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 37  CHKPNT   KGG $

 38  LABEL    LBL11 $

 39  GP4      CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,
              LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/C,N,0/
              V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 40  SAVE     MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,REPEAT,NOL,NOA $

 41  PARAM    //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $

 42  PURGE    GM,GMD/MPCF1/GO,GOD/OMIT/KFS/SINGLE/QPC/NOSR/KLR,KRR,MLR,MRR,
              DM,MR/REACT $

 43  COND     LBL4,GENEL $

 44  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

 45  SAVE     NOGPST $

 46  COND     LBL4,NOGPST $

 47  OFP      OGPST,,,,,// $

 48  LABEL    LBL4 $

 49  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

 50  CHKPNT   KNN,MNN $

 51  COND     LBL2,MPCF1 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10 AERO

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 52  MCE1      USET,RG/GM $

 53  CHKPNT    GM $

 54  MCE2      USET,GM,KGG,MGG,,/KNN,MNN,, $

 55  CHKPNT    KNN,MNN $

 56  LABEL     LBL2 $

 57  EQUIV     KNN,KFF/SINGLE/MNN,MFF/SINGLE $

 58  CHKPNT    KFF,MFF $

 59  COND      LBL3,SINGLE $

 60  SCE1      USET,KNN,MNN,,/KFF,KFS,,MFF,, $

 61  CHKPNT    KFF,KFS,MFF $

 62  LABEL     LBL3 $

 63  EQUIV     KFF,KAA/OMIT/ MFF,MAA/OMIT $

 64  CHKPNT    KAA,MAA $

 65  COND      LBL5,OMIT $

 66  SMP1      USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

 67  CHKPNT    GO,KAA $

 68  SMP2      USET,GO,MFF/MAA $

 69  CHKPNT    MAA $

 70  LABEL     LBL5 $

 71  COND      LBL6,REACT $

 72  RBMG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

 73  CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $

 74  RBMG2     KLL/LLL $

 75  CHKPNT    LLL $

 76  RBMG3     LLL,KLR,KRR/DM $

 77  CHKPNT    DM $

 78  RBMG4     DM,MLL,MLR,MRR/MR $

 79  CHKPNT    MR $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10 AERO

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 80  LABEL    LBL6 $

 81  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,EED,EQDYN/V,
              N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/V,
              N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

 82  SAVE     LUSETD,NOUE,NOEED $

 83  COND     ERROR2,NOEED $

 84  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $

 85  READ     KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
              NEIGV $

 86  SAVE     NEIGV $

 87  CHKPNT   LAMA,PHIA,MI,OEIGS $

 88  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

 89  OFP      OEIGS,LAMA,,,,//V,N,CARDNO $

 90  SAVE     CARDNO $

 91  COND     ERROR4,NEIGV $

 92  MTRXIN   CASECC,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
              NOK2PP/V,N,NOM2PP/V,N,NOB2PP $

 93  SAVE     NOK2PP,NOM2PP,NOB2PP $

 94  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

 95  EQUIV    M2PP,M2DD/NOSET/B2PP,B2DD/NOSET/K2PP,K2DD/NOSET $

 96  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD $

 97  GKAD     USETD,GM,GO,,,,,K2PP,M2PP,B2PP/,,,GMD,GOD,K2DD,M2DD,B2DD/C,N,
              CMPLEV/C,N,DISP/C,N,MODAL/C,N,0.0/C,N,0.0/C,N,0.0/V,N,NOK2PP/V,
              N,NOM2PP/V,N,NOB2PP/V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/ C,
              N,-1/C,N,-1/C,N,-1/C,N,-1 $

 98  CHKPNT   K2DD,M2DD,B2DD,GOD,GMD $

 99  GKAM     USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASECC/MHH,BHH,KHH,PHIDH/
              V,N,NOUE/C,Y,LMODES=999999/C,Y,LFREQ=0.0/C,Y,HFREQ=0.0/V,N,
              NOM2PP/V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE/C,Y,KDAMP=-1$

100  SAVE     NONCUP,FMODE $

101  CHKPNT   MHH,BHH,KHH,PHIDH $

102  APD      EDT,EQDYN,ECT,BGPDT,SILD,USETD,CSTM,GPLD/EQAERO,ECTA,BGPA,SILA,
              USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,SILGA/V,N,NK/V,N,NJ/V,
              N,LUSETA $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10 AERO

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

103  SAVE      NK,NJ,LUSETA $

104  CHKPNT    EQAERO,ECTA,BGPA,SILA,USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,
               SILGA $

105  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

106  PURGE     PLTSETA,PLTPARA,GPSETSA,ELSETSA/NOPCDB $

107  COND      P2,NOPCDB $

108  PLTSET    PCDB,EQAERO,ECTA/PLTSETA,PLTPARA,GPSETSA,ELSETSA/V,N,NSIL1/V,N,
               JUMPPLOT=-1 $

109  SAVE      NSIL1,JUMPPLOT $

110  PRTMSG    PLTSETA// $

111  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,1 $

112  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,0/C,N,1 $

113  COND      P2,JUMPPLOT $

114  PLOT      PLTPARA,GPSETSA,ELSETSA,CASECC,BGPA,EQAERO,,,,,/PLOTX2/V,N,
               NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

115  SAVE      PFILE,JUMPPLOT,PLTFLG $

116  PRTMSG    PLOTX2// $

117  LABEL     P2 $

118  COND      ERROR2,NOEED $

119  GI        SPLINE,USET,CSTMA,BGPA,SIL,ECTA,GM,GO/GTKA/V,N,NK/V,N,LUSET $

120  CHKPNT    GTKA $

121  PARAM     //C,N,ADD/V,N,DESTRY/C,N,0/C,N,1 $

122  AMG       AERO,ACPT/AJJL,SKJ,D1JK,D2JK/V,N,NK/V,N,NJ/V,N,DESTRY $

123  SAVE      DESTRY $

124  CHKPNT    AJJL,SKJ,D1JK,D2JK $

125  COND      NODJE,NODJE $

126  INPUTT2   /D1JE,D2JE,,,/C,Y,POSITION=-1/C,Y,UNITNUM=11/   C,Y,USRLABEL=
               TAPEID $

127  LABEL     NODJE $

128  PARAM     //C,N,ADD/V,N,XQHHL/C,N,1/C,N,0 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10 AERO

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

129  AMP       AJJL,SKJ,D1JK,D2JK,GTKA,PHIDH,D1JE,D2JE,USETD,AERO/QHHL,QJHL/
               V,N,NOUE/V,N,XQHHL $

130  SAVE      XQHHL $

131  CHKPNT    QHHL,QJHL $

132  PARAM     //C,N,MPY/V,N,NOP/C,N,-1/C,N,1 $

133  PARAM     //C,N,MPY/V,N,NOP/C,N,1/C,N,1 $

134  PARAM     //C,N,MPY/V,N,NOH/C,N,0/C,N,1 $

135  PARAM     //C,N,MPY/V,N,FLOOP/V,Y,NODJE=-1/C,N,0 $

136  JUMP      LOOPTOP $
--------------------------------------------------- Top of DMAP Loop
137  LABEL     LOOPTOP $

138  FA1       KHH,BHH,MHH,QHHL,CASECC,FLIST/FSAVE,KXHH,BXHH,MXHH/V,N,FLOOP/
               V,N,TSTART $

139  SAVE      FLOOP,TSTART $

140  CEAD      KXHH,BXHH,MXHH,EED,CASECC/PHIH,CLAMA,OCEIGS/V,N,EIGVS $

141  SAVE      EIGVS $

142  COND      LBLZAP,EIGVS $

143  COND      LBL16,NOH $

144  VDR       CASECC,EQDYN,USETD,PHIH,CLAMA,,/OPHIH,/C,N,CEIGEN/C,N,MODAL/C,
               N,123/V,N,NOH/V,N,NOP/V,N,FMODE $

145  SAVE      NOH,NOP $

146  COND      LBL16,NOH $

147  OFP       OPHIH,,,,,//V,N,CARDNO $

148  SAVE      CARDNO $

149  LABEL     LBL16 $

150  FA2       PHIH,CLAMA,FSAVE/PHIHL,CLAMAL,CASEYY,OVG/V,N,TSTART/C,Y,VREF=
               1.0/C,Y,PRINT=YES $

151  SAVE      TSTART $

152  CHKPNT    PHIHL,CLAMAL,CASEYY,OVG $

153  COND      CONTINUE,TSTART $

154  LABEL     LBLZAP $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10 AERO

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

155  COND     CONTINUE,FLOOP $
156  REPT     LOOPTOP,100  $
                                                          Bottom of DMAP Loop
157  JUMP     ERROR3 $
158  LABEL    CONTINUE $
159  CHKPNT   OVG $
160  PARAML   XYCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOXYCDB $
161  COND     NOXYOUT,NOXYCDB $
162  XYTRAN   XYCDB,OVG,,,,/XYPLTCE/C,N,VG/C,N,PSET/V,N,PFILE/V,N,CARDNO $
163  SAVE     PFILE,CARDNO $
164  XYPLOT   XYPLTCE// $
165  LABEL    NOXYOUT $
166  PARAM    //C,N,AND/V,N,PJUMP/V,N,NOP=-1/V,N,JUMPPLOT $
167  COND     FINIS,PJUMP $
168  MODACC   CASEYY,CLAMAL,PHIHL,CASECC,,/CLAMAL1,CPHIH1,CASEZZ,,/C,N,
              CEIGN $
169  DDR1     CPHIH1,PHIDH/CPHID $
170  CHKPNT   CPHID $
171  EQUIV    CPHID,CPHIP/NOA $
172  COND     LBL14,NOA $
173  SDR1     USETD,,CPHID,,,GOD,GMD,,KFS,,/CPHIP,,QPC/C,N,1/C,N,DYNAMICS $
174  LABEL    LBL14 $
175  CHKPNT   CPHIP,QPC $
176  EQUIV    CPHID,CPHIA/NOUE $
177  COND     LBLNOE,NOUE $
178  VEC      USETA/RP/C,N,D/C,N,A/C,N,E $
179  PARTN    CPHID,,RP/CPHIA,,,/C,N,1/C,N,3 $
180  LABEL    LBLNOE $
181  PARAM    //C,N,PREC/V,N,PREC $
182  MPYAD    GTKA,CPHIA,/CPHIK/C,N,1/C,N,1/C,N,0 $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10 AERO

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP  INSTRUCTION
 NO.

183  UMERGE    USETA,CPHIP,/CPHIPS/C,N,PS/C,N,P/C,N,SA $

184  UMERGE    USETA,CPHIPS,CPHIK/CPHIPA/C,N,PA/C,N,PS/C,N,K $

185  CHKPNT    CPHIPA $

186  UMERGE    USETA,QPC,/QPAC/C,N,PA/C,N,P/C,N,K $

187  CHKPNT    QPAC $

188  SDR2      CASEZZ,CSTMA,MPT,DIT,EQAERO,SILA,,,BGPA,CLAMAL1,QPAC,CPHIPA,
               EST,,/,OQPAC1,OCPHIPA,OESC1,OEFC1,PCPHIPA/C,N,CEIGN $

189  CHKPNT    PCPHIPA $

190  OFP       OCPHIPA,OQPAC1,OESC1,OEFC1,,//V,N,CARDNO $

191  COND      P3,JUMPPLOT $

192  PLOT      PLTPARA,GPSETSA,ELSETSA,CASEZZ,BGPA,EQAERO,SILGA,,PCPHIPA,,/
               PLOTX3/V,N,NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

193  PRTMSG    PLOTX3// $

194  LABEL     P3 $

195  JUMP      FINIS $

196  LABEL     ERROR1 $

197  PRTPARM   //C,N,-1/C,N,FSUBSON $

198  LABEL     ERROR2 $

199  PRTPARM   //C,N,-2/C,N,FSUBSON $

200  LABEL     ERROR3 $

201  PRTPARM   //C,N,-3/C,N,FSUBSON $

202  LABEL     ERROR4 $

203  PRTPARM   //C,N,-4/C,N,FSUBSON $

204  LABEL     FINIS $

205  END       $
```

3.20.2 Description of DMAP Operations for Modal Flutter Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

5. Go to DMAP No. 196 and print error message if no grid points are present.

8. GP2 generates Element Connection Table with internal indices.

10. GP3 generates Static Loads Table and Grid Point Temperature Table.

12. TA1 generates element tables for use in matrix assembly and stress recovery.

14. Go to DMAP No. 196 and print error message if no elements have been defined.

19. EMG generates structural element matrix tables and dictionaries for later assembly.

22. Go to DMAP No. 25 if no stiffness matrix is to be assembled.

23. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

26. Go to DMAP No. 196 and print error message if no mass matrix exists.

27. EMA assembles mass matrix $[M_{gg}]$.

29. Go to DMAP No. 32 if no weight and balance request.

30. GPWG generates weight and balance information.

31. ØFP formats weight and balance information and places it on the system output file for printing.

33. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

35. Go to DMAP No. 38 if no general elements.

36. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

39. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

43. Go to DMAP No. 48 if general elements present.

44. GPSP determines if possible grid point singularities remain.

46. Go to DMAP No. 48 if no grid point singularities remain.

47. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

49. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

51. Go to DMAP No. 56 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

52. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

54. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m] \ .$$

57. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

59. Go to DMAP No. 62 if no single-point constraints.

60. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right]$$

63. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted degrees of freedom.

65. Go to DMAP No. 70 if no omitted coordinates.

66. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

and solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

68. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oo}][G_o] + [G_o^T][M_{oa}] \ .$$

71. Go to DMAP No. 80 if no free-body supports.

72. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right]$$

74. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

76. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}]$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] ,$$

and calculates and outputs rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

78. RBMG4 forms rigid body mass matrix $[M_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

81. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool and Eigenvalue Extraction Data.

83. Go to DMAP No. 198 and print error message if no Eigenvalue Extraction Data.

84. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

85. READ extracts real eigenvalues and vectors from the equation

$$[K_{aa} - \lambda M_{aa}]\{\phi_a\} = 0 ,$$

calculates rigid body modes by finding a matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \left[\begin{array}{c} D\phi_{ro} \\ \hline \phi_{ro} \end{array}\right] ,$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass

89. ØFP formats the summary of eigenvalues and the summary of eigenvalue extraction information and places them on the system output file for printing.

91. Go to DMAP No. 202 and print error message if no eigenvalues are found.

92. MTRXIN selects the direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$, and $[B^2_{pp}]$.

95. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied.

97. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$, and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$, and $[B^2_{dd}]$ (see Section 9.3.3 of the Theoretical Manual) and forms $[G_{md}]$ and $[G_{od}]$.

99. GKAM selects eigenvectors to form $[\phi_{dh}]$ and assembles stiffness, mass and damping matrices in modal coordinates:

$$[K_{hh}] = \left[\begin{array}{c|c} ki & 0 \\ \hline 0 & 0 \end{array}\right] + [\phi^T_{dh}][K^2_{dd}][\phi_{dh}] \quad ,$$

$$[M_{hh}] = \left[\begin{array}{c|c} mi & 0 \\ \hline 0 & 0 \end{array}\right] + [\phi^T_{dh}][M^2_{dd}][\phi_{dh}] \quad ,$$

$$[B_{hh}] = \left[\begin{array}{c|c} bi & 0 \\ \hline 0 & 0 \end{array}\right] + [\phi^T_{dh}][B^2_{dd}][\phi_{dh}] \quad .$$

where

KDAMP = 1	KDAMP = -1 (default)
m_i = modal masses	m_i = modal masses
$b_i = m_i \; 2\pi \; f_i \; g(f_i)$	$b_i = 0$
$k_i = m_i \; 4\pi^2 \; f_i$	$k_i = (1+ig(f_i)) \; 4\pi^2 \; f_i^2 m_i$

102. APD processes the aerodynamic data cards from EDT. It adds the k points and the SA points to USETD making USETA. EQAERØ, ECTA, BGPA, CSTMA, GPLA, and SILA are updated to reflect the new elements. AERØ and ACPT reflect the aerodynamic parameters. SILGA is a special SIL for plotting.

107. Go to DMAP No. 117 if no plot package is present.

108. PLTSET transforms user input into a form used to drive structure plotter.

110. PRTMSG prints error messages associated with structure plotter.

113. Go to DMAP No. 117 if no undeformed aerodynamic structure plot request.

114. PLØT generates all requested undeformed aerodynamic structure plots.

116. PRTMSG prints plotter data and engineering data for each undeformed aerodynamic plot generated.

118. Go to DMAP No. 198 and print error message if no Eigenvalue Extraction Data.

119. GI forms a transformation matrix $[G^T_{ka}]$ which interpolates between aerodynamic (k) and structural (a) degrees of freedom.

122. AMG forms the aerodynamic matrix list $[A_{jj}]$, the area matrix $[S_{kj}]$, and the downwash coefficients $[D^1_{jk}]$ and $[D^2_{jk}]$.

125. Go to DMAP No. 127 if no user-supplied downwash coefficients.

126. INPUTT2 provides the user-supplied downwash factors due to extra points ($[D^1_{je}]$, $[D^2_{je}]$).

129. AMP computes the aerodynamic matrix list related to the modal coordinates as follows:

$$[\phi_{dh}] = \left[\begin{array}{c|c} \phi_{ai} & \phi_{ae} \\ \hline \phi_{ei} & \phi_{ee} \end{array}\right] \qquad [G_{ki}] = [G^T_{ka}]^T[\phi_{ai}]$$

$$[D^1_{jh}] \Leftarrow [D^1_{ji} \mid D^1_{je}] \qquad [D^1_{ji}] = [D^1_{jk}]^T[G_{ki}]$$

$$[D^2_{jh}] \Leftarrow [D^2_{ji} \mid D^2_{je}] \qquad [D^2_{ji}] = [D^2_{jk}]^T[G_{ki}]$$

For each (m,k) pair:

$$[D_{jh}] = [D^1_{jh}] + ik[D^2_{jh}]$$

For each group:

$$[Q_{jh}] = [A^T_{jj}]^{-1}_{\text{group}} \, [D_{jh}]_{\text{group}}$$

$$[Q_{kh}] = [S_{kj}][Q_{jh}]$$

$$[Q_{ih}] = [G_{ki}]^T[Q_{kh}]$$

$$[Q_{hh}] \Leftarrow \left[\begin{array}{c} Q_{ih} \\ \hline Q_{eh} \end{array}\right]$$

135. PARAM initializes the flutter loop counter (FLØØP) to zero.

136. Go to next DMAP instruction if cold start or modified restart. LØØPTØP will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

137. Beginning of loop for flutter.

138. FA1 computes the total aerodynamic mass matrix $[M^x_{hh}]$, the total aerodynamic stiffness matrix $[K^x_{hh}]$ and the total aerodynamic damping matrix $[B^x_{hh}]$ as well as a looping table FSAVE. For the k-method

$$M^x_{hh} = (k^2/b^2)M_{hh} + (\rho/2)\, Q_{hh} \quad ,$$

$$K^x_{hh} = K_{hh} \quad ,$$

$$B^x_{hh} = 0 \quad .$$

140. CEAD extracts complex eigenvalues from the equation

$$[M^x_{hh}p^2 + B^x_{hh}p + K^x_{hh}]\{\phi_h\} = 0$$

and normalizes eigenvectors to unit magnitude of largest component.

142. Go to DMAP No. 154 if no complex eigenvalues found.

143. Go to DMAP No. 149 if no output request for the extra points introduced for dynamic analysis or modal coordinates.

144. VDR prepares eigenvectors for output, using only the extra points introduced for dynamic analysis and modal coordinates.

146. Go to DMAP No. 149 if no output request for the extra points introduced for dynamic analysis or modal coordinates.

147. ØFP formats eigenvectors for extra points introduced for dynamic analysis and modal coordinates and places them on the system output file for printing.

150. FA2 appends eigenvectors to PHIHL, eigenvalues to CLAMAL, Case Control to CASEYY, and V-g plot data to ØVG.

153. Go to DMAP No. 158 if there is insufficient time for another flutter loop.

155. Go to DMAP No. 158 if flutter loop complete.

156. Go to DMAP No. 137 for additional aerodynamic configuration triplet values.

161. Go to DMAP No. 165 if no X-Y plot package is present.

162. XYTRAN prepares the input for requested X-Y plots.

164. XYPLØT prepares requested X-Y plots of displacements, velocities, accelerations, forces, stresses, loads or single-point forces of constraint vs. time.

167. Go to DMAP No. 204 if no output requests involve dependent degrees of freedom or forces and stresses.

168. MØDACC selects a list of eigenvalues and vectors whose imaginary parts (velocity in input units) are close to a user input list.

169. DDR1 transforms the complex eigenvectors from modal to physical coordinates

$$[\phi^c_d] = [\phi_{dh}][\phi_h] \quad .$$

171. Equivalence $[\phi^c_d]$ to $[\phi^c_p]$ if no constraints applied.

172. Go to DMAP No. 174 if no constraints applied.

173. SDR1 recovers dependent components of eigenvectors

$$\{\phi^c_o\} = [G^d_o]\{\phi^c_d\} \quad , \qquad \left\{\begin{array}{c}\phi_d \\ \hline \phi_o\end{array}\right\} = \{\phi^c_f + \phi^c_e\} \quad ,$$

$$\left\{\begin{array}{c}\phi^c_f + \phi^c_e \\ \hline \phi^c_s\end{array}\right\} = \{\phi^c_n + \phi^c_e\} \quad , \qquad \{\phi^c_m\} = [G^d_m]\{\phi^c_n + \phi^c_e\} \quad ,$$

$$\left\{\begin{array}{c}\phi_f^c + \phi_e^c \\ \hline \phi_m^c\end{array}\right\} = \{\phi_p^c\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}^T]\{\phi_f\}$, $\left\{\begin{array}{c}o \\ \hline q_s\end{array}\right\} = \{Q_p^c\}$.

176. Equivalence $[\phi_d^c]$ to $[\phi_a^c]$ if no extra points introduced for dynamic analysis.

177. Go to DMAP No. 180 if no extra points present.

178. VEC generates a d-size partitioning vector (RP) for the a and e sets.

179. PARTN performs partition of $[\phi_d^c]$ using RP.

$$\{\phi_d^c\} = \left\{\begin{array}{c}\phi_a^c \\ \hline \phi_e^c\end{array}\right\}$$

182. MPYAD recovers the displacements at the aerodynamic points (k).

$$\{\phi_k^c\} = [G_{ka}^T]^T\{\phi_a^c\} \ .$$

184. UMERGE places $\{\phi_k\}$ in its proper place in the displacement vector

$$\{\phi_{pa}^c\} \Leftarrow \left\{\begin{array}{c}\phi_p^c \\ \hline \phi_k^c \\ \hline 0\end{array}\right\}$$

186. UMERGE is used to expand $\{Q_p^c\}$ to the pa set.

188. SDR2 calculates element forces and stresses (ØEFC1, ØESC1) and prepares eigenvectors and single-point forces of constraint for output (ØCPHIPA, ØQPAC1). It also prepares PCPHIPA for deformed plotting.

190. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

191. Go to DMAP No. 194 if no deformed aerodynamic structure plots are requested.

192. PLØT prepares all deformed aerodynamic structure plots.

193. PRTMSG prints plotter data and engineering data for each deformed plot generated.

195. Go to DMAP No. 204 and make normal exit.

197. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

199. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

201. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

204. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

3.20.3 Output for Modal Flutter Analysis

The Real Eigenvalue Summary Table and the Real Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues are included even though all may not be used in the modal formulation.

The grid point singularities from the structural model are also output.

A flutter summary for each value of the configuration parameters is printed out unless PRINT=NØ. This shows ρ, k, 1/k, m, $m*V_{sound}$, V, g and f for each complex eigenvalue.

V-g and V-f plots may be requested by the XYØUT control cards by specifying the curve type as VG. The "points" are loop numbers and the "components" are G or F.

Printed output of the following types, sorted by complex eigenvalue root number (SØRT1) and (m, k, ρ) may be requested for all complex eigenvalues kept, as either real and imaginary parts or magnitude and phase angle (0° - 360° lead):

1. The eigenvector for a list of PHYSICAL and AERØDYNAMIC points (grid points, extra points, and aerodynamic points) or SØLUTIØN points (modal coordinates and extra points).
2. Nonzero components of the single-point forces of constraint for a list of PHYSICAL points.
3. Complex stresses and forces in selected elements.

The ØFREQUENCY case control card can select a subset of the complex eigenvectors for data recovery. In addition, undeformed and deformed shapes may be requested. Undeformed shapes may include only structural or structural and aerodynamic elements.

The eigenvectors used in the modal formulation may be obtained for the analysis points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis Rigid Format or by making a modified restart using the Normal Mode Analysis Rigid Format.

3.20.4 Case Control Deck and Parameters for Modal Flutter Analysis

1. Only one subcase is allowed.
2. Desired direct input matrices for stiffness $[K^2_{pp}]$, mass $[M^2_{pp}]$, and damping $[B^2_{pp}]$ must be

selected via the keywords K2PP, M2PP, or B2PP.

3. CMETHØD must be used to select an EIGC card from the Bulk Data Deck.

4. FMETHØD must be used to select a FLUTTER card from the Bulk Data Deck.

5. METHØD must be used to select an EIGR card that exists in the Bulk Data Deck.

6. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

The following user parameters are used in Modal Flutter Analysis.

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - These parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

4. LFREQ and HFREQ - required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation. To use this option, LMØDES must be set to 0.

5. LMØDES - used unless set to 0. The integer value of this parameter is the number of lowest modes to be used in the modal formulation. The default value will request all modes to be used.

6. NØDJE - optional in modal flutter analysis. A positive integer of this parameter indicates that user supplied downwash matrices due to extra points are to be read from tape via the INPUTT2 module in the rigid format. The default value is -1.

7. P1, P2 and P3 - required in modal flutter analysis when using NØDJE parameter. See Section 5.3.2 for tape operation parameters required by INPUTT2 module. The defaults for P1, P2 and P3 are -1,11 and TAPEID, respectively.

8. VREF - optional in modal flutter analysis. Velocities are divided by the real value of this parameter to convert units or to compute flutter indices. The default value is 1.0.

9. PRINT - optional in modal flutter analysis. The BCD value, NØ, of this parameter will suppress the automatic printing of the flutter summary for the K method. The default value is YES.

3.20.5 Modal Flutter Analysis Subsets

Modal flutter analysis contains two subsets (4 and 5), primarily for data checking. Subset 4 checks all data cards. Subset 5 further refines subset 4 to check only the aerodynamic data. A data check of only the structural model can be accomplished by ALTERing in an EXIT after DMAP instruction number 13. A listing of subsets 4 and 5 follow.

3.20.6 DMAP Sequence for Modal Flutter Analysis, Subset 4

```
 RIGID FORMAT DMAP LISTING
 SERIES N

 RIGID FORMAT 10 AERO (SUBSET 4)
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

   1  BEGIN     AERO NO.10 MODAL FLUTTER ANALYSIS SERIES N $

   3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

   4  SAVE      LUSET,NOGPDT $

   5  COND      ERROR1,NOGPDT $

   6  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

   8  GP2       GEOM2,EQEXIN/ECT $

   9  CHKPNT    ECT $

  10  GP3       GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

  11  CHKPNT    GPTT $

  12  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
                NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

  13  SAVE      NOGENL,NOSIMP,GENEL $

  14  COND      ERROR1,NOSIMP $

  39  GP4       CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,
                LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/C,N,0/
                V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

  40  SAVE      MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,REPEAT,NOL,NOA $

  41  PARAM     //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $

  81  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,,EED,EQDYN/V,
                N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/V,
                N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

  82  SAVE      LUSETD,NOUE,NOEED $

  92  MTRXIN    CASECC,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
                NOK2PP/V,N,NOM2PP/V,N,NOB2PP $

  93  SAVE      NOK2PP,NOM2PP,NOB2PP $

 102  APD       EDT,EQDYN,ECT,BGPDT,SILD,USETD,CSTM,GPLD/EQAERO,ECTA,BGPA,SILA,
                USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,SILGA/V,N,NK/V,N,NJ/V,
                N,LUSETA $

 103  SAVE      NK,NJ,LUSETA $

 104  CHKPNT    EQAERO,ECTA,BGPA,SILA,USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,
                SILGA $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10 AERO (SUBSET 4)

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

105  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

106  PURGE     PLTSETA,PLTPARA,GPSETSA,ELSETSA/NOPCDB $

107  COND      P2,NOPCDB $

108  PLTSET    PCDB,EQAERO,ECTA/PLTSETA,PLTPARA,GPSETSA,ELSETSA/V,N,NSIL1/V,N,
               JUMPPLOT=-1 $

109  SAVE      NSIL1,JUMPPLOT $

110  PRTMSG    PLTSETA// $

111  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,1 $

112  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,0/C,N,1 $

113  COND      P2,JUMPPLOT $

114  PLOT      PLTPARA,GPSETSA,ELSETSA,CASECC,BGPA,EQAERO,,,,,/PLOTX2/V,N,
               NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

115  SAVE      PFILE,JUMPPLOT,PLTFLG $

116  PRTMSG    PLOTX2// $

117  LABEL     P2 $

118  COND      ERROR2,NOEED $

195  JUMP      FINIS $

196  LABEL     ERROR1 $

197  PRTPARM   //C,N,-1/C,N,FSUBSON $

198  LABEL     ERROR2 $

199  PRTPARM   //C,N,-2/C,N,FSUBSON $

204  LABEL     FINIS $

205  END       $
```

3.20.7 DMAP Sequence for Modal Flutter Analysis, Subset 5

```
RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10 AERO (SUBSET 5)
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     AERO NO.10 MODAL FLUTTER ANALYSIS SERIES N $

  2  FILE      PHIHL=APPEND/AJJL=APPEND/FSAVE=APPEND/CASEYY=APPEND/CLAMAL=
               APPEND/OVG=APPEND/QHHL=APPEND $

  3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

  4  SAVE      LUSET,NOGPDT $

  5  COND      ERROR1,NOGPDT $

  6  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  8  GP2       GEOM2,EQEXIN/ECT $

  9  CHKPNT    ECT $

 39  GP4       CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,
               LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/C,N,0/
               V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

 40  SAVE      MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,REPEAT,NOL,NOA $

 41  PARAM     //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $

 81  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,,EED,EQDYN/V,
               N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/V,
               N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

 82  SAVE      LUSETD,NOUE,NOEED $

 83  COND      ERROR2,NOEED $

102  APD       EDT,EQDYN,ECT,BGPDT,SILD,USETD,CSTM,GPLD/EQAERO,ECTA,BGPA,SILA,
               USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,SILGA/V,N,NK/V,N,NJ/V,
               N,LUSETA $

103  SAVE      NK,NJ,LUSETA $

104  CHKPNT    EQAERO,ECTA,BGPA,SILA,USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,
               SILGA $

105  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

106  PURGE     PLTSETA,PLTPARA,GPSETSA,ELSETSA/NOPCDB $

107  COND      P2,NOPCDB $

108  PLTSET    PCDB,EQAERO,ECTA/PLTSETA,PLTPARA,GPSETSA,ELSETSA/V,N,NSIL1/V,N,
               JUMPPLOT=-1 $

109  SAVE      NSIL1,JUMPPLOT $
```

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10 AERO (SUBSET 5)

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

110  PRTMSG    PLTSETA// $

111  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,1 $

112  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,0/C,N,1 $

113  COND      P2,JUMPPLOT $

114  PLOT      PLTPARA,GPSETSA,ELSETSA,CASECC,BGPA,EQAERO,,,,,/PLOTX2/V,N,
               NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

115  SAVE      PFILE,JUMPPLOT,PLTFLG $

116  PRTMSG    PLOTX2// $

117  LABEL     P2 $

118  COND      ERROR2,NOEED $

195  JUMP      FINIS $

196  LABEL     ERROR1 $

197  PRTPARM   //C,N,-1/C,N,FSUBSON $

198  LABEL     ERROR2 $

199  PRTPARM   //C,N,-2/C,N,FSUBSCN $

204  LABEL     FINIS $

205  END       $
```

4.1 PLOTTING

NASTRAN provides the capability for generating on any of several different plotters the following kinds of plots:

1. Undeformed geometric projections of the structural model.
2. Static deformations of the structural model by either displaying the deformed shape (alone or superimposed on the undeformed shape), or displaying the displacement vectors at the grid points (superimposed on either the deformed or undeformed shape).
3. Modal deformations (sometimes called mode shapes or eigenvectors) resulting from real eigenvalue analysis by the same options stated in 2 above. Complex modes of flutter analysis may be plotted for any user chosen phase lag.
4. Deformations of the structural model for transient response or frequency response by displaying either vectors or the deformed shape for specified times or frequencies.
5. X-Y graphs of transient response or frequency response.
6. V-f and V-g graphs of flutter analysis.
7. Topological displays of matrices.

Structure plots (items 1-4) are discussed in Section 4.2 while X-Y plots (item 5) are discussed in Section 4.3. Matrix plots are generated by Utility Module SEEMAT described in Section 5 and must be accomplished by altering a Rigid Format or using a DMAP sequence. Requests for structure plots or X-Y plots are accomplished in the Case Control Deck by submitting a structure plot request packet or an X-Y output request packet. The discussion of these packets constitutes most of the remainder of this chapter. The optional PLØTID card is considered to be part of the plot packets (although it must precede any ØUTPUT(PLØT), ØUTPUT(XYØUT), or ØUTPUT(XYPLØT) cards, see page 2.3-38).

In order to actually create plots, a plotter and model name must be specified by the user. The method used to specify this information may vary according to the plot request made, but the actual names used do not vary. In addition, a physical plot tape must be set up by the user. The control cards needed to set up a plot tape are generally installation dependent and are described in Section 5 of the Programmer's Manual. There are two plot tapes (PLT1 and PLT2). It is only necessary to set up the plot tape used by the specified plotter. The number of plots for PLT1 on IBM 360 computers is limited (see Section 5.3.5 of the Programmer's Manual).

The following table is a list of permissible plotter and model names, together with the corresponding plot tapes which must be set up by the user. The underlined items are the default models for each plotter. A model name is generally specified as two items, each having a default value. The default value of the second item is in some cases dependent upon the value specified for the first item. If no plotter is specified by the user, the requested plots will be created for the Stromberg Carlson (SC) model 4020 microfilm plotter.

Plotter Name	Plot Tape	Plotter Model
BL	PLT1	$\left\{\begin{matrix}\underline{\text{STE}}\\ \text{LTE}\end{matrix}\right\}, \underline{30}$
CALCØMP	PLT2	$\left\{\begin{matrix}\underline{765}\\ 763\end{matrix}\right\}, \left\{\begin{matrix}\underline{205}\\ 210\\ 105\\ 110\end{matrix}\right\}$ $\left\{\begin{matrix}565\\ 563\end{matrix}\right\}, \left\{\begin{matrix}\underline{205}\\ 210\\ 105\\ 110\\ 305\\ 310\end{matrix}\right\}$
DD	PLT2	$\underline{80}, \underline{B}$
EAI	PLT1	$\underline{3500}, \left\{\begin{matrix}\underline{30}\\ 45\end{matrix}\right\}$
NASTPLT	PLT2	$\left\{\begin{matrix}\underline{M}\\ T\\ D\end{matrix}\right\}, \left\{\begin{matrix}\underline{O}\\ T\end{matrix}\right\}$
<u>SC</u>	PLT2	$\underline{4020}$

The plotter name, BL, is used for Benson Lehner plotters. The default model is an STE, 30. The first model item may be either STE or LTE, where STE is a short line electroplotter and LTE is a long line electroplotter. The second model item may only equal 30, which is the size of the plotter table in inches. Both the STE and LTE plotters are table plotters.

The plotter name, CALCØMP, is used for California Computer plotters. The default model is a 765, 205. The first model item is the plotter model number as used in California Computer hardware descriptions. The 700 series plotters are those having the ZIP mode and 24 incremental directions. The 500 series plotters are those having only 8 incremental directions. The 600 series may have either 24 or 8 incremental directions. If the user has access to only a 663 or 665 plotter, it should be specified as a 563 or 565 if it has only 8 incremental directions, and as a 763 or 765 if it has 24 incremental directions. The 563 and 763 are both 30-inch drum plotters, while the 565 and 765 are both 12-inch drum plotters.

The second model item indicates the type of tape transport used with the CALCØMP plotter and the increment size of the plotter. There are two possible increment sizes, .010 and .005 inches. The last two digits of this second model item represent these two possible increment sizes, i.e., 10 = .010 and 05 = .005. The first digit of the second model item represents the type of tape transport attached to the plotter. There are three types of tape transports available. The primary differences among these transports are the number of characters needed to cause one incremental movement on the plotter. Some transports (e.g. the 470, 570 and 750 models) require three characters. These transports can only be attached to the 500 series plotters. Other transports (e.g. the 760 and 770) require two characters for each incremental movement. Still other transports (e.g. the 780) require only one character for each incremental movement. The first digit of the second model item is the number of characters required by the tape transport for each incremental movement. An example of a legitimate CALCØMP model name is (763,105). This represents a 763, 30-inch drum plotter with an increment size of .005 inches, driven by a tape transport requiring only one character for each incremental movement (e.g. a 780 tape transport).

The plotter name, DD, is used for Data Display plotters. The only permissible model is the (80,B) microfilm plotter.

The plotter name, EAI, is used for Electronic Associates Inc. plotters. The first model item is the model number as described in EAI hardware descriptions. The only permissible model is an EAI 3500. This is a table plotter having either a 30-inch or 45-inch plotting surface. The second model item is the size of the plotting surface. The default size is a 30-inch surface, i.e., 3500, 30.

The plotter name, NASTPLT, is used for the NASTRAN General Purpose plotter package. This plotter package is used if the desired plotter is not available in the NASTRAN plotting software. However, if this package is specified, a separate program must be written to interpret the resulting plot tape and create the corresponding plots on the actual plotter desired. The default model is M, 0. The first model item may either be M, T, or D. This indicates the actual plotter is a microfilm, table or drum plotter, respectively. The second model item indicates whether or not the actual plotter has any typing capability: 0 = typing possible, 1 = no typing possible. If no typing capability exists, all printed characters will be drawn. The default plotter type is a microfilm plotter with typing capability. An example of an acceptable model is (T,1). This represents a table plotter having no typing capability. A more detailed description of the implications of the NASTRAN General Purpose plotter package is given in Section 6 of the Programmer's Manual.

The plotter name, SC, is used for Stromberg Carlson plotters. The only permissible model is the 4020 microfilm plotter. If the only available plotter model is a 4060, the user should determine if it has a 4020 compatibility package, as is usually the case, so as to avoid using the NASTRAN General Purpose plotter.

The operation of the Structure Plotter is of sufficient theoretical content to warrant inclusion in the Theoretical Manual. Section 13 of the Theoretical Manual provides a discussion of the basic theory and gives some examples of plotter output.

The availability of NASTRAN plotting capability is a function of the particular rigid format as shown in the following table.

Plotter Availability for the NASTRAN Rigid Formats

Rigid Format	Structure Plotter		Curve Plotter	Matrix Topology Plotter
	Undeformed	Deformed		
1	x	x	x	*
2	x	x		*
3	x	x		*
4	x	x		*
5	x	x		*
6	x	x		*
7	x	x		*
8	x	x	x	*
9	x	x	x	*
10	x	x		*
11	x	x	x	*
12	x	x	x	*
10(AERØ)	x	x	x	*

* The matrix topology plotter is not automatically available in any rigid format. Utility module SEEMAT must be altered into the Rigid Format DMAP sequence in order to use this feature (see Section 5.2).

4.2 STRUCTURE PLOTTING

In order to assist NASTRAN users both in the preparation of the analytical model and in the interpretation of output, the structure plotter provides the following capabilities for undeformed structures:

1. Place a symbol at the grid point locations. (optional)
2. Identify grid points by placing the grid point identification number to the right of the grid point locations. (optional)
3. Identify elements by placing the element identification number and element symbol at the center of each element. (optional)
4. Connect the grid points in a predetermined manner using the structural elements or PLØTEL elements.

The following capabilities are provided for deformed structures:

1. Place a symbol at the deflected grid point location. (optional)
2. Identify the deflected grid points by placing the grid point identification number to the right of the deflected grid point locations. (optional)
3. Connect the deflected grid points in a predetermined manner using the structural elements or PLØTEL elements.
4. Draw lines originating at the undeflected or deflected grid point location, drawn to user-specified scale, representing the X, Y, Z components or resultant summations of the grid point deflections.

The above plots are available in either orthographic, perspective, or stereoscopic projections on several plotters. Stereoscopic plots are normally made only on microfilm plotters since a stereoscopic viewer or projector must be used to obtain the stereoscopic effect. A request for structure plotting is made in the Case Control Deck by means of a plot request packet which includes all cards from an ØUTPUT(PLØT) card to either a BEGIN BULK or ØUTPUT(XYØUT) [or ØUTPUT(XYPLØT)] card. It should be noted that only elements can be plotted. Grid points that are not associated with elements cannot be plotted. Grid points may be connected with PLØTEL elements for plotting purposes.

The data card format is free-field, subject to rules in paragraphs below. The cards are basically sequence dependent even though some interchanging in sequence of defining parameters is permissible. The elements and grid points to be plotted may be defined anywhere in the submittal, but the parameters describing the characteristics of the plot are evaluated on the current basis every time a PLØT or FIND card (see Section 4.2.2.2) is encountered. In order to minimize mistakes, it is suggested that a strict sequence dependency be assumed.

4.2.1 General Rules

4.2.1.1 Rules for Free-Field Card Specification

1. Only columns 1 thru 72 are available. Any information specified in columns 73 thru 80 will be ignored.
2. If the last character on a card is a comma (not necessarily in column 72), the next card is a continuation of this physical card. Any number of continuation cards may be specified, and together they form a logical card.
3. The mnemonics or values can be placed anywhere on the card, but must be separated by delimiters.
4. The following delimiters are used:

   a. blank

   b. , comma

   c. (left parenthesis

   d.) right parenthesis

   e. = equal sign

   All of these delimiters can be used as needed to aid the legibility of the data.

4.2.1.2 Plot Request Packet Card Format

In the plot request packet card descriptions presented in Section 4.2.2, the following notations will be used to describe the card format:

1. Upper-case letters must be punched exactly as shown.
2. Lower-case letters indicate that a substitution must be made.
3. Braces { } indicate that a choice of the contents is mandatory.
4. Brackets [ ] contain an option that may be omitted or included by the user.
5. Underlined options or values are those for which a default option or an initialized (or computed) value was programmed.
6. A physical card consists of information punched in columns 1 through 72 of a card.
7. A logical card may consist of more than one physical card through the use of continuation cards.
8. Numerical values may always be either integer or real numbers, even though a specific type is at times suggested in order to conform to the input in other sections of the program.

4.2.1.3 Plot Titles

Up to four lines of title information will be printed in the lower left-hand corner of each plot. The text for the top three lines is taken from the TITLE, SUBTITLE, and LABEL cards in the

Case Control Deck. (See Sections 2.3.2 and 2.3.4 for a description of the TITLE, SUBTITLE, and LABEL cards.) The text for the bottom line may be of two forms depending on the type plot requested. One form contains the word UNDEFØRMED SHAPE. The other form contains the type of plot (statics, modal, etc.), subcase number, load set or mode number, frequency or eigenvalue or time, and (for complex quantities) the phase lag or magnitude.

The sequence number for each plot is printed in the upper corners of each frame. The sequence number is determined by the relative position of each PLØT execution card in the plot package. The date and (for deformed plots) the maximum deformation are also printed at the top of each frame.

4.2.2 Plot Request Packet Card Descriptions

The general form for each card of the plot request packet is shown enclosed in a rectangular box. Description of the card contents then follows for each card.

4.2.2.1 SET Definition Cards

These cards specify sets of elements, corresponding to portions of the structure, which may be referenced by PLØT and FIND cards. The SET card is required.

Each set of elements defines by implication a set of grid points connected by those elements. The set may be modified by deleting some of its grid points. The elements are used for creating the plot itself and element labeling while the grid points are used for labeling, symbol printing, and drawing deformation vectors.

SET i [INCLUDE] [ELEMENTS] j_1, j_2, j_3 THRU j_4, j_5, etc.
[INCLUDE / EXCLUDE / EXCEPT] [ELEMENTS / GRID POINTS] k_1, k_2, k_3 THRU k_4, k_5, etc.

i = set identification number (positive integer, unique for each set)

j = element identification numbers or element types

k = element identification numbers or grid point identification numbers or element types

Permissible element types are:

AXIF2, AXIF3, AXIF4, BAR, CØNE, CØNRØD, HEXA1, HEXA2, FLUID2, FLUID3, FLUID4, IHEX1, IHEX2, IHEX3, PLØTEL, QDMEM, QDMEM1, QDMEM2, QDPLT, QUAD1, QUAD2, RØD, SHEAR, SLØT3, SLØT4, TETRA, TØRDRG, TRAPAX, TRAPRG, TRBSC, TRIA1, TRIA2, TRIAAX, TRIARG, TRMEM, TRPLT, TUBE, TWIST, VISC, WEDGE

ALL may be used to select all permissible element types.

INCLUDE may be used at any time for element information. When used with grid points, INCLUDE can be used only to restore previously EXCLUDEd grid points. It cannot be used to include grid points in the original set of grid points.

EXCLUDE can be used to delete elements or element types. All grid points that are associated with deleted elements are also deleted. EXCLUDE can be used to delete deformation vectors from grid points enumerated after an EXCLUDE command.

EXCEPT is a modifier to an INCLUDE or an EXCLUDE statement.

THRU is used to indicate all of the integers in a sequence of identification numbers, starting with the integer preceding THRU and ending with the integer following THRU. The integers in the range of the THRU statement need not be consecutive, e.g., the sequence 2, 4, 7, 9 may be specified as 2 THRU 9.. THRU is not applicable if element types are specified.

Each SET must be a logical card. Redefinition of sets previously defined is not permitted; however, there is no restriction on the number of sets. The sets of identification numbers can be assembled by use of the word ALL, or by individually listing the integers in any order such as 1065, 32, 46, 47, 7020, or by listing sequences using THRU, EXCLUDE, and EXCEPT such as 100 THRU 1000 EXCEPT 182 EXCLUDE 877 THRU 911. Examples of SET cards:

Examples of SET cards:

1. SET 1 INCLUDE 1, 5, 10 THRU 15 EXCEPT 12
   (Set will consist of elements 1, 5, 10, 11, 13, 14 and 15)
2. SET 25 = RØD, CØNRØD, EXCEPT 21
   (Set will consist of all RØD and CØNRØD elements except element 21)
3. SET 10 SHEAR EXCLUDE GRID PØINTS 20, 30 THRU 60, EXCEPT 35, 36 INCLUDE ELEMENTS 70 THRU 80.
   (This set will include all shear elements plus elements 70 thru 80, and the associated grid point set will contain all grid points connected by these elements. Grid points 20, 30 thru 34 and 37 thru 60 will appear on all plots with their symbols and labels, however no deformation vectors will appear at these grid points when VECTØR is commanded.
4. SET (15) = (15 THRU 100) EXCEPT (21 THRU 25)
   (This set will include all elements from 15 to 20 and from 26 to 100).
5. SET 2 = ALL EXCEPT BAR
   (This set will include all elements except bars).

NOTE: The equal signs, commas, and parentheses above are delimiters and are not required, because blanks also serve as delimiters.

4.2.2.2 Cards Defining Parameters

These cards specify how the structure will be plotted, i.e., type of projection, view angles, scales, etc. All the multiple choice parameters are defaulted to a preselected choice if not specified. Each parameter requiring a numerical value that is not specified by the user can either be established internally in the program by means of the FIND card or can assume default values. The FIND card is used to request that the program select a SCALE, ØRIGIN, and/or VANTAGE PØINT to allow the construction of a plot in a user-specified region of the paper or film. The FIND card is described at the end of this Section, following the discussion of the associated parameters.

The parameter cards are listed here in a logical sequence; however, they need not be so specified. Any order may be used, but if a parameter is specified more than once, the value or choice stated last will be used. Each parameter may be either an individual card, or any number of them may be combined on one logical card.

All the parameters used in the generation of the various plots will be printed out as part of the output, whether they are directly specified, defaulted or established using the FIND card.

STRUCTURE PLOTTING

Initialization of parameters to default values occurs only once. Subsequently, these values remain until altered by a direct input. The only exceptions are the view angles, scale factors, vantage point parameters, and the origins. Whenever the plotter or the method of projection is changed, the view angles are reset to the default values, unless they are respecified by the user. In addition, the scale factors, vantage point parameters, and the origin must be redefined by the user.

PLØTTER plotter name, MØDEL name $\left[\text{DENSITY} \begin{Bmatrix} 800 \\ 556 \\ 200 \end{Bmatrix} \text{BPI}\right]$

The plotter names and MØDEL names are listed in Section 4.1. The tape density information is used only in print-out and <u>does not control</u> the <u>density of the generated plot tape</u>. To actually specify the tape density, the user must use the customary means of communication established at a given installation between the user and the computer operators. This card is required for plotters other than the SC 4020.

$\begin{Bmatrix} \text{ØRTHØGRAPHIC} \\ \text{PERSPECTIVE} \\ \text{STEREØSCØPIC} \end{Bmatrix}$ PRØJECTIØN

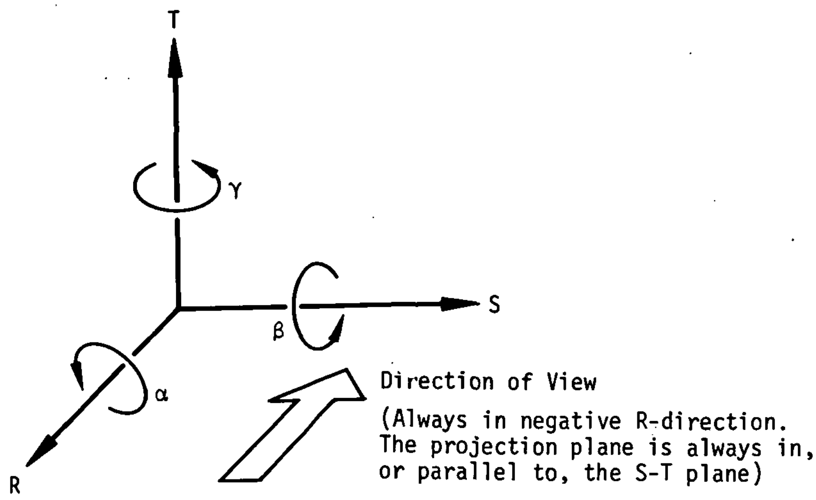
The default option is orthographic projection. See Section 13 of the Theoretical Manual for a discussion of the various projections. This card is optional.

AXES r, s, t $\left[\begin{Bmatrix} \text{SYMMETRIC} \\ \text{ANTISYMMETRIC} \end{Bmatrix}\right]$
VIEW γ, β, α

r, s, t = X or MX, Y or MY, Z or MZ (where "M" implies the negative axis)

γ, β, α = three angles of rotation in degrees (real numbers)

These two parameter cards define the orientation of the object in relation to the observer, that is, the angles of view. Both of these cards are optional. Defining the observer's coordinate system as R, S, T and the basic coordinate system of the object as X, Y, Z, the angular relationship between the two systems is defined by the three angles γ, β and α as follows:



Using the above convention, γ and β represent the angles of turn and tilt. The default values are:

γ = 34.27°

β = 23.17° for orthographic and stereoscopic projections

0.0° for perspective projection

α = 0.0° .

The order in which γ, β, and α are specified is critically important as illustrated in Figure 1, at the end of this section. Also, see section 13.1.1 of the Theoretical Manual.

The AXES card can be used to preposition the object in 90° increments in such a manner that only rotations less than 90° are required by the VIEW card to obtain the desired orientation. This is accomplished by entering X, Y, Z, MX, MY or MZ in the fields corresponding to R, S, T axes, where MX, MY and MZ represent the negative X, Y and Z axis directions respectively. The default values are X, Y, Z.

An undeformed or deformed plot of the symmetric portion of an object can be obtained by reversing the sign of the axis that is normal to the plane of symmetry. In the case of multiple planes of symmetry, the signs of all associated planes should be reversed. The ANTISYMMETRIC option should be specified when a symmetric structure is loaded in an unsymmetric manner. This will cause the deformations to be plotted antisymmetrically with respect to the specified plane or planes. Since the AXES card applies to all parts (SETS) of a single frame, symmetric and antisymmetric combinations cannot be made with this card (see the symmetry option on the PLØT execution card in Section 4.2.2.3).

MAXIMUM DEFØRMATIØN d

This card must always be included if a deformed structure is to be plotted. The value of d represents the length to which the maximum displacement component is scaled in each subcase. The maximum deformation of the structure <u>must be specified in units of the structure</u> (not inches of paper). This data is necessary since the actual deformations are usually too small to be distinguishable from the undeformed structure if they were plotted to true scale. If FIND card parameters are to be based on the deformed structure, the FIND card must be <u>preceded</u> by the MAXIMUM DEFØRMATIØN card.

SCALE a[, b]

a = real number representing scale to which the model is drawn

b = ratio of model size/real object size (stereoscopic projection only)

For orthographic or perspective projections, the scale "a" is the ratio of the plotted object in inches to the real object in the units of the structural model, i.e., one inch of paper equals one unit of structure. For stereoscopic projection, the stereoscopic effect is enhanced by first reducing the real object to a smaller model (scale "b"), and then applying scale "a". The ratio of plotted/real object is then the product a x b. A scale must be defined in order to make a plot; however, the SCALE card is not recommended for general use. See the FIND card described at the end of this Section in order to have the scale determined automatically.

ØRIGIN i, u, v

i = *origin identification number (any positive integer)*

u = horizontal displacement of paper origin from RST origin

v = vertical displacement of paper origin from RST origin

In the transformation performed for any of the three projections, the origins of both the object (XYZ system) and of the observer (RST system) are assumed to be coincident.

This card refers to the <u>paper</u> origin. It represents the displacement of the paper origin (lower left hand corner) from the RST origin. The units are inches and are not subject to the scaling of the plotted object. The ØRIGIN card is not recommended for general use. See the FIND card described at the end of this Section in order to have the origin located so as to place the plotted object in the center of the image area.

Ten (10) origins are permitted to be active at one time. However, any one can be redefined at any time. An eleventh origin is also provided if more than 10 origins are erroneously defined (i.e., only the last of these surplus origins will be retained). <u>CAUTION</u>: when a new projection or plotter is called for, all previously defined origins are deleted.

VANTAGE PØINT r_o, s_o, t_o [, s_{or}]

(perspective and stereoscopic projections only)

r_o = R-coordinate of the observer

s_o = S-coordinate of the observer in perspective projection or
S-coordinate of the left eye of the observer in the stereoscopic projection

t_o = T-coordinate of the observer

s_{or} = S-coordinate of the right eye of the observer in the stereoscopic (not needed in perspective) projection

This card defines the location of the observer with respect to the structural model. A vantage point is required for either perspective or stereoscopic projection. The VANTAGE PØINT card is not recommended for general use. See the FIND card described at the end of this Section. A theoretical description of vantage point is contained in Section 13 of the Theoretical Manual.

PRØJECTIØN PLANE SEPARATIØN d_o

(perspective and stereoscopic projections only)

This card specifies the R-direction separation of the observer and the projection plane.

The PRØJECTIØN PLANE SEPARATIØN card is not recommended for general use. See the FIND card described at the end of this Section. The card may be omitted if VANTAGE PØINT is included on the FIND card. A theoretical description of projection plane separation is contained in Section 13 of the Theoretical Manual.

ØCULAR SEPARATIØN $\left\{\frac{\underline{2.756}}{os}\right\}$

(stereoscopic projection only)

Ocular separation - S-coordinate separation of the two vantage points in the stereoscopic projection is defaulted to 2.756 inches which is the separation used in the standard stereoscopic cameras and viewers (70mm). It is recommended that the default value be used.

CAMERA $\left\{\begin{matrix}\text{FILM}\\ \underline{\text{PAPER}}\\ \text{BØTH}\end{matrix}\right\}$ $\left[, \text{BLANK FRAMES} \left\{\begin{matrix}n\\ \underline{1}\end{matrix}\right\}\right]$

(microfilm plotters only)

This card offers three options of different cameras or combinations:

type = FILM - 35mm or 16mm film (positive or negative images)

type = PAPER - positive prints

type = BØTH - positive prints and 35mm or 16mm film

The request for a 35mm or 16mm camera and positive or negative images must be communicated to the plotter operator through normal means of communications at the installation. Insertion of blank frames between plots is optional and is applicable only to plots generated on film. The type option must be FILM or BØTH if blank frames are desired. The plotter must be operated in the manual mode in order to have blank frames inserted between positive prints. If blank frames are desired only on film, and not on paper, the plotter must be operated in the automatic mode. The default values are type = PAPER, n = 1. This card is completely optional.

PAPER SIZE $\left\{\begin{matrix} a \\ \underline{8.5} \end{matrix}\right\}$ $\left\{\begin{matrix} x \\ BY \end{matrix}\right\}$ $\left\{\begin{matrix} b \\ \underline{11.0} \end{matrix}\right\}$ $\left[, \text{TYPE} \left\{\begin{matrix} \text{BCD value} \\ \underline{\text{VELLUM}} \end{matrix}\right\}\right]$

(table plotters only)

a = horizontal size of paper in inches

b = vertical size of paper in inches

name = any BCD value desired by user for identification purposes.

The default parameters are 8.5 x 11.0, type VELLUM. This card is completely optional.

PEN $\left\{\begin{matrix} i \\ \underline{1} \end{matrix}\right\}$ $\left[, \text{SIZE} \left\{\begin{matrix} j \\ \underline{1} \end{matrix}\right\}\right]$ $\left[, \text{CØLØR} \left\{\begin{matrix} \text{name} \\ \underline{\text{BLACK}} \end{matrix}\right\}\right]$

(table plotters only)

i = pen designation number

j = pen size number (0 thru 3)

name = color desired

This card generates a message on the printed output which may be used to inform the plotter operator as to what size and which color pen point to mount in the various pen holders. The actual number of pens available will depend on the plotter hardware configuration at each installation. This card does not control the pen used in generating the plot (see the PEN option on the PLØT execution card in Section 4.2.2.3). The PEN card is optional, and is not appropriate for microfilm plotters.

The pen designations vary on various plotters; therefore, the designation numbers used here are only the pointers to true identification of the pens. The following table summarizes these pen designations and the acutal pen numbers on the plotters used.

NASTRAN Pen Designation	PLOTTER Pen Number	
	EAI 3500	All Others
1	0	1
2	1	2
3	2	3
4	3	4
5	4	1
6	5	2
7	6	3
8	7	4

```
FIND  [SCALE],[ØRIGIN i],[VANTAGE PØINT],[SET j],[REGIØN le,be,re,te]
```

i = origin identification number (any positive integer).

j = set identification number (any positive integer).

le = fractional distance of left edge of plot region from the lower left corner of the image area (default value = 0).

be = fractional distance of bottom edge of plot region from the lower left corner of the image area (default value = 0).

re = fractional distance of right edge of plot region from the lower left corner of the image area (default value = 1.).

te = fractional distance of top edge of plot region from the lower left corner of the image area (default value = 1.).

The FIND card requests the structure plotter to compute any of the parameters SCALE, ØRIGINi, and/or VANTAGE PØINT indicated by the user based on (a) the plotter requested on the PLØTTER card, (b) the projection requested on the PRØJECTION card, (c) SETj and REGIØN le, be, re, te requested on the FIND card, (d) the orientation requested on the VIEW and/or AXES card(s), (e) the deformation scaling requested on the MAXIMUM DEFØRMATIØN card, and (f) the paper size for table plotters as requested on the PAPER SIZE card. All dependencies on which a FIND card is based must precede the FIND card.

Any one, two, or all three parameters may be computed by the program by using this card, provided that the parameters not requested have already been defined. If no set is specified on this card, the first set defined is used by default. If no options are specified on the FIND card, a SCALE and VANTAGE PØINT are selected and ØRIGIN 1 is located, using the first defined SET, so that the plotted object is located within the image area. The plot region is defined as some fraction of the image area (image area = 0, 0, 1., 1. and first quadrant = .5, .5, 1., 1.). The image area is located inside the margins on the paper. Each FIND card must be one (1) logical card. The FIND card is recommended for general use.

4.2.2.3 PLØT Execution Card

```
      ┌┌STATIC      ┐┐
      ││MØDAL       ││  ┌┌DEFØRMATIØN  ┐┐                          ┌┌RANGE f1, f2┐┐  ┌┌PHASE LAG φ┐┐
PLØT  ││CMØDAL      ││  ││VELØCITY     ││  [i1, i2 THRU i3, etc.]  ││RANGE λ1, λ2││  ││MAGNITUDE  ││ ,
      ││FREQUENCY   ││  └└ACCELERATIØN ┘┘                          └└TIME  t1, t2┘┘  └└           ┘┘
      └└TRANSIENT   ┘┘

[MAXIMUM DEFØRMATIØN d],

                                                                           ┌       ┌GRID PØINTS┐┐
[SET j1][ØRIGIN k1][{SYMMETRY    } w][{PEN    } p][SYMBØLS m[, n]]         │ LABEL │ELEMENTS   ││ ,
                   [{ANTISYMMETRY}  ][{DENSITY}  ]                         └       └BØTH       ┘┘

┌SHAPE            ┐
│VECTØR v         │ ,
└SHAPE, VECTØR v  ┘

[SET j2][ØRIGIN k2] .... etc.
```

This logical card will cause one picture to be generated for each subcase, mode or time step requested, using the current parameter values. If only the word PLØT appears on the card, a picture of the undeformed structure will be prepared using the first defined set and the first defined origin. The available plot options and their meanings are:

1. STATIC - Plot static deformations in Rigid Formats 1, 2, 4, 5, 6 and 14.

   MØDAL - Plot mode shapes in Rigid Formats 3, 5, 13 and 15.

   CMØDAL - Plot mode shapes in Rigid Formats 7 and 10.

   FREQUENCY - Plot frequency deformations in Rigid Formats 8 and 11.

   TRANSIENT - Plot transient deformations in Rigid Formats 9 and 12.

2. DEFØRMATIØN - Nonzero integers following refer to subcases that are to be plotted. Default is all subcases. See SHAPE and VECTØR for use of "0" command.

   VELØCITY - Nonzero integers following refer to subcases that are to be plotted. Default is all subcases.

   ACCELERATIØN - Nonzero integers following refer to subcases that are to be plotted. Default is all subcases.

3. i1, i2, ... - Nonzero integers following refer to subcases that are to be plotted. Default is all subcases. See SHAPE and VECTØR for use of "0" (underlay) command.

4. RANGE - Refers to range of eigenvalues (Rigid Format 5) or frequencies (Rigid Formats 3, 7, 8, 10 and 11), using requested subcases, for which plots will be prepared.

TIME - Refers to time interval, using requested subcases and output time steps, for which plots will be prepared (Rigid Formats 9 and 12).

5. PHASE LAG - Real number, ϕ, in degrees (default is 0.0). The plotted value is $u_R \cos \phi - u_I \sin \phi$, where u_R and u_I are the real and imaginary parts of the response quantity (Rigid Formats 7, 8, 10 and 11).

MAGNITUDE - Plotted value is $\sqrt{u_R^2 + u_I^2}$.

6. MAXIMUM DEFØRMATIØN - Real number following is used as the maximum displacement component in scaling the displacements for all subcases. Each subcase is separately scaled according to its own maximum if this item is absent.

7. SET - Integer following identifies a set which defines the portion of the structure to be plotted. Default is first set defined.

8. ØRIGIN - Integer following identifies the origin to be used for the plot. Default is first origin defined.

9. SYMMETRY w - Prepare an undeformed or deformed plot of the symmetric portion of the object which is defined by SET j. This symmetric portion will be located in the space adjacent to the region originally defined by ØRIGIN k, and will appear as a reflection about the plane whose normal is oriented parallel to the coordinate direction w.

ANTISYMMETRY w - Prepare a deformed plot of the symmetric portion of the antisymmetrically loaded object which is defined by SET j. This symmetric portion will be located in the space adjacent to the region originally defined by ØRIGIN k, and will appear as a reflection of the antisymmetrically deformed structure about the plane whose normal is oriented parallel to the coordinate direction w.

The symbol w may specify the basic coordinates X, Y, or Z or any combination thereof. This option allows the plotting of symmetric and/or antisymmetric combinations, provided that an origin is selected for the portion of the structure defined by the bulk data that allows sufficient room for the complete plot. This does not permit the combination of symmetric and antisymmetric subcases, as each plot must represent a single subcase. In the case of a double reflection, the figure will appear as one reflected about the plane whose normal is parallel to the first of the coordinates w, followed by a reflection about the plane whose normal is oriented parallel to the second of the coordinates w. This capability is primarily used in the plotting of structures that are loaded in a symmetric or an antisymmetric manner. The plane of symmetry must be one of the basic coordinate planes.

10. PEN - Integer following controls the internal NASTRAN pen number (see table in Section 4.2.2.2) that is used to generate the plot on table plotters.

DENSITY - Integer following specifies line density for film plotters. A line density of d is d times heavier than a line density of 1.

11. SYMBØLS m[,n] - All of the grid points associated with the specified set will have symbol m overprinted with symbol n printed at its location. If n is not specified, only symbol m will be printed. Grid points excluded from the set will not have a symbol. Grid points in an undeformed underlay will be identified with symbol 2.

Following is a table of symbols available on each plotter. Symbols that are not available on a given plotter are defaulted to a similar symbol indicated in parentheses.

SYMBØL NØ. m or n	SYMBØL	AVAILABILITY EAI 3500	AVAILABILITY SC4020	AVAILABILITY All Others
0	no symbol	X	X	X
1	X	X	X	X
2	*	X	X	X
3	+	X	X	X
4	-	X	X	X
5	•	X	X	X
6	○	X	X	X
7	□	X	X	X
8	◊	X	(7)	X
9	△	(7)	(7)	X

12. LABEL GRID PØINTS - All the grid points associated with the specified set have their identification number printed to the right of the undeflected or deflected location (undeflected location in the case of superimposed plots).

LABEL ELEMENTS - All the elements included in the specified set are identified by the element identification number and type at the center of each element (undeflected location in the case of superimposed plots).

LABEL BØTH - Label both the grid points and elements.

Labels for element types are given in the following table:

Element Type	Plot Label		Element Type	Plot Label
AERØ	AE		QUAD1	Q1
AXIF2	A2		QUAD2	Q2
AXIF3	A3		RØD	RD
AXIF4	A4		SHEAR	SH
BAR	BR		SLØT3	S3
CØNE	CN		SLØT4	S4
CØNRØD	CR		TETRA	TE
HEXA1	H1		TØRDRG	TR
HEXA2	H2		TRAPAX	T4
FLUID2	F2		TRAPRG	TA
FLUID3	F3		TRBSC	TB
FLUID4	F4		TRIAAX	T3
IHEX1	XL		TRIA1	T1
IHEX2	XQ		TRIA2	T2
IHEX3	XC		TRIRC	T1
PLØTEL	PL		TRMEM	TM
QDMEM	QM		TRPLT	TP
QDMEM1	QM		TUBE	TU
QDMEM2	QM		TWIST	TW
QDPLT	QP		VISC	VS
			WEDGE	WG

13. SHAPE - All the elements included in the specified set are shown by connecting the associated grid points in a predetermined manner.

Both deformed and undeformed shapes may be specified. All of the deformed shapes relating to the subcases listed may be underlaid on each of their plots by including "0" with the subcase string on the PLØT card. The undeformed plot will be drawn using PEN 1 or DENSITY 1 and symbol 2 (if SYMBØLS is specified).

14. VECTØR v - A line will be plotted at the grid points of the set, representing in length and direction the deformation of the point.

Vectors representing the total deformation or its principal components may be plotted by insertion of the proper letter(s) for variable v. Possible vector combinations are:

X or Y or Z - requesting individual components

XY or XZ or YZ - requesting 2 specified components

XYZ - requesting all 3 components

RXY or RXZ or RYZ - requesting vector sum of 2 components

R - requesting total vector deformation

N - used with any of the above combinations to request no underlay shape be drawn.

All plots requesting the VECTØR option shall have an underlay generated of the undeformed shape using the same sets, "PEN 1" or "DENSITY 1," and symbol 2 (if SYMBØLS is specified). If "SHAPE" and "VECTØR" are specified, the underlay will depend on whether "O" is used with DEFØRMATIØN. It will be the deformed shape when not used and will be both deformed and undeformed shapes when it is used. The part of the vector at the grid point will be the tail when the underlay is undeformed and the head when it is deformed. If the "N" parameter is used, no shape will be drawn but other options such as SYMBØLS will still be valid.

Examples of PLØT Cards

1. PLØT

   Undeformed SHAPE using first defined SET, first defined ØRIGIN and PEN 1 (or DENSITY 1).

2. PLØT SET 3 ØRIGIN 4 PEN 2 SHAPE SYMBØLS 3 LABEL

   Undeformed SHAPE using SET 3, ØRIGIN 4, PEN 2 (or DENSITY 2) with each grid point of the set having a + placed at its location, and its identification number printed adjacent to it.

3. PLØT MØDAL DEFØRMATIØN 5 SHAPE

   Modal deformations as defined in subcase 5 using first defined SET, first defined ØRIGIN, and PEN 1 (or DENSITY 1).

4. PLØT STATIC DEFØRMATIØN 0, 3 THRU 5, 8 PEN 4, SHAPE

   STATIC deformations as defined in subcases 3, 4, 5 and 8, deformed SHAPE; drawn with PEN 4, using first defined SET and ØRIGIN, underlayed with undeformed SHAPE drawn with PEN 1. This command will cause four plots to be generated.

5. PLØT STATIC DEFØRMATIØN 0 THRU 5,

   SET 2 ØRIGIN 3 PEN 3 SHAPE,

   SET 2 ØRIGIN 4 PEN 4 VECTØRS XYZ SYMBØLS 6,

   SET 35 SHAPE

   Deformations as defined in subcases 1, 2, 3, 4, and 5, undeformed underlay with PEN 1, consisting of SET 2 at ØRIGIN 3, SET 2 at ØRIGIN 4 (with an * placed at each grid point location), and SET 35 at ØRIGIN 4. Deflected data as follows: SHAPE using SET 2 at ØRIGIN 3 (PEN 3) and SET 35 at ØRIGIN 4 (PEN 4); 3 VECTØRS (X, Y and Z) drawn at each grid point of SET 2 at ØRIGIN 4 (PEN 4) (less any excluded grid points), with O placed at the end of each vector.

6. PLØT STATIC DEFØRMATIØNS 0, 3, 4,

   SET 1 ØRIGIN 2 DENSITY 3 SHAPE,

   SET 1 SYMMETRY Z SHAPE,

   SET 2 ØRIGIN 3 SHAPE,

   SET 2 SYMMETRY Z SHAPE

   Static deformations as defined in subcases 3 and 4, both halves of a problem solved by symmetry using the X-Y principal plane as the plane of symmetry. SET 1 at ØRIGIN 2 and SET 2 at ØRIGIN 3, with the deformed shape plotted using DENSITY 3 and the undeformed structure plotted using DENSITY 1. The deformations of the "opposite" half will be plotted to correspond to symmetric loading. This command will cause two plots to be generated.

7. PLØT TRANSIENT DEFØRMATIØN 1, TIME 0.1, 0.2, MAXIMUM DEFØRMATIØN 2.0, SET 1, ØRIGIN 1,

   PEN 2, SYMBØLS 2, VECTØR R

   Transient deformations as defined in subcase 1 for time = 0.1 to time = 0.2, using set 1 at origin 1. The undeformed shape using pen or density 1 with an * at each grid point location will be drawn as an underlay for the resultant deformation vectors using pen or density 2 with an * typed at the end of each vector drawn. In addition a plotted value of 2.0 will be used for the single maximum deformation occuring on any of the plots produced. All other deformations on all other plots will be scaled relative to this single maximum deformation. This command will cause a plot to be generated for each output time step which lies between 0.1 and 0.2.

8. PLØT CMØDAL DEFØRMATIØN PHASE LAG 90. SET 1 VECTØR R

   The imaginary part of the complex mode shape will be plotted for set 1.

4.2.3 Summary of Structure Plot Request Packet Cards

SET Definition - Required

SET i [INCLUDE][ELEMENTS] j_1, j_2, j_3 THRU j_4, j_5, etc.

$\begin{bmatrix}\text{INCLUDE}\\ \text{EXCLUDE}\\ \text{EXCEPT}\end{bmatrix}\begin{bmatrix}\text{ELEMENTS}\\ \text{GRID PØINTS}\end{bmatrix}$ k_1, k_2, k_3 THRU k_4, k_5, etc.

Parameter Definition - Optional, except as noted

PLØTTER plotter name, MØDEL name $\left[\text{DENSITY}\begin{Bmatrix}800\\556\\200\end{Bmatrix}\text{BPI}\right]$ (Required if not SC-4020)

$\begin{Bmatrix}\text{ØRTHØGRAPHIC}\\ \text{PERSPECTIVE}\\ \text{STEREØSCØPIC}\end{Bmatrix}$ PRØJECTIØN

AXES r, s, t $\left[\begin{Bmatrix}\text{SYMMETRIC}\\ \text{ANTISYMMETRIC}\end{Bmatrix}\right]$

VIEW γ, β, α

SCALE a[, b] (Required if not on FIND card)

ØRIGIN i, u, v (Required if not on FIND card)

VANTAGE PØINT r_o, s_o, t_o[, s_{or}] (Required for perspective and steroscopic projections if not on FIND card)

PRØJECTIØN PLANE SEPARATIØN d_o (Required for perspective and steroscopic projections if VANTAGE PØINT not on FIND card)

ØCULAR SEPARATIØN $\begin{Bmatrix}\underline{2.756}\\ \text{os}\end{Bmatrix}$

MAXIMUM DEFØRMATIØN d (Required if deformed shapes are to be drawn)

PEN $\begin{Bmatrix}\text{i}\\ \underline{1}\end{Bmatrix}$ $\left[\text{, SIZE}\begin{Bmatrix}\text{j}\\ \underline{1}\end{Bmatrix}\right]$ $\left[\text{, CØLØR}\begin{Bmatrix}\text{name}\\ \text{BLACK}\end{Bmatrix}\right]$

```
        ( FILM  )
CAMERA  { PAPER }  [ , BLANK FRAMES {n} ]
        ( BØTH  )                   {1}
```

```
PAPER SIZE { a  } { x } {  b   }  [ , TYPE {BCD value} ]
           {8.5 } {BY } { 11.0 }          { VELLUM  }
```

FIND Card - Optional

```
FIND [SCALE],[ØRIGIN i],[VANTAGE PØINT],[SET j], [REGIØN le, be, re, te]
```

PLØT Execution Card - Required

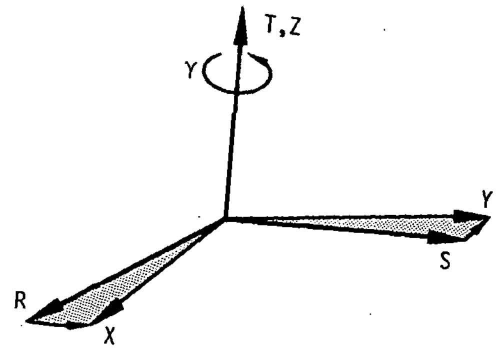
```
      [( STATIC    )] [( DEFØRMATION  )]                             [( RANGE f1, f2 )]
      [( MØDAL     )] [{ VELØCITY     }] [i1, i2 THRU i3, i4, etc.]  [{ RANGE λ1, λ2 }]
PLØT  [{ CMØDAL    }] [( ACCELERATIØN )]                             [( TIME  t1, t2 )]
      [( TRANSIENT )]
      [( FREQUENCY )]

      [{ PHASE LAG  φ }] [MAXIMUM DEFØRMATION d] ,
      [{ MAGNITUDE    }]

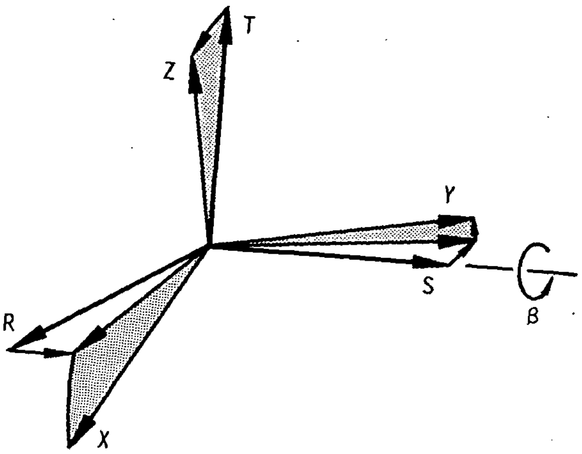
[SET j1] [ØRIGIN k1] [{ SYMMETRY     } w] [{ PEN     } p] [SYMBØLS m[,n]]
                     [{ ANTISYMMETRY }  ] [{ DENSITY }  ]

      [        [ GRID PØINTS ]] [ SHAPE           ]
      [ LABEL  [ ELEMENTS    ]] [ VECTØR v        ] ,
      [        [ BØTH        ]] [ SHAPE, VECTØR v ]

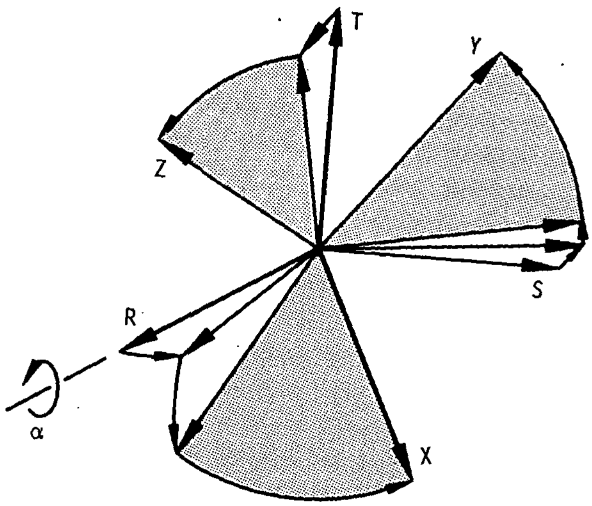
[SET j2] [ØRIGIN k2] ... , etc.
```



(a) γ - rotation about T-axis.



(b) β – rotation about S-axis



(c) α - rotation about R-axis

Figure 1. Plotter coordinate system-model orientation.

4.3 X-Y ØUTPUT

In rigid formats used for transient response, frequency response (including random response), and flutter analysis, the amount of output data generated is voluminous. In order to aid the user in assimilating this vast amount of data, the X-Y output processing modules XYTRAN and XYPLØT have been provided. The primary purpose of these modules is to generate plotted graphs of y(x) where x is frequency, time, or velocity and y is any response quantity selected by the user for observation. The user is not required to specify any parametric data for the X-Y plotter; however, he may do so if he wishes in order to obtain desired scales, regions of observation, etc.

In addition to (or in place of) the plots, X-Y tabular output may be printed or punched, and summary data (e.g., maximum and minimum values and locations of these values) may be obtained for any X-Y output.

The X-Y output described above is obtained by the user via the X-Y output request packet of the Case Control Deck. This packet includes all cards between ØUTPUT(XYPLØT) [or ØUTPUT(XYØUT)] and either BEGIN BULK or ØUTPUT(PLØT). The remainder of this section describes the X-Y output request data cards and the rules for writing them. Examples are provided to illustrate the use of this feature.

4.3.1 X-Y Plotter Terminology

A single set of plotted X-Y pairs is known as a "curve". Curves are the entities that the user requests to be plotted. The surface (paper, microfilm frame, etc.) on which one or more curves is plotted is known as a "frame". Curves may be plotted on a whole frame, an upper half frame, or a lower half frame. Grid lines, tic marks, axes, axis labeling and other graphic control items may be chosen by the user. The program will select defaults for parameters not selected by the user.

Only three cards are required for an X-Y plot request. The required cards are:

1. X-Y output request packet identifier - ØUTPUT(XYPLØT) or ØUTPUT(XYØUT).
2. Plotter selection card.
3. At least one command operation card.

The terms ØUTPUT(XYPLØT) and ØUTPUT(XYØUT) are interchangeable and either form may be used for any of the X-Y output requests. The plotter selection card is described as item 1 in Section 4.3.2.1.

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If the output is limited to printing and/or punching the plotter selection card is not required. The command operation card is used to request the various forms of X-Y output. This card is described in Section 4.3.3.

If only the required cards are used, the graphic control items will all assume default values. Curves using all default parameters have the following general characteristics:

1. Tic marks are drawn on all edges of the frame. Five spaces are provided on each edge of the frame.
2. All tic marks are labeled with their values.
3. Linear scales are used.
4. Scales are selected such that all points fall within the frame.
5. The plotted points are connected with straight lines.
6. The plotted points are not identified with symbols.

The above characteristics may be modified by inserting any of the parameter definition cards, described in Section 4.3.2, ahead of the command operation card or cards. The use of a parameter definition card sets the value of that parameter for all following command operation cards unless the CLEAR card is inserted (see item 16 of Section 4.3.2.1). If grid lines are requested, they will be drawn at the locations of all tic marks that result from defaults or user request. The locations of tic marks (or grid lines) for logarithmic scales cannot be selected by the user. Default values for logarithmic spacing are selected by the program. The default values for the number of tic marks (or grid lines) per cycle depend on the number of logarithmic cycles required for the range of the plotted values.

The definition and rules for the X-Y output request packet cards follow. The definition notation used in Section 4.2.1.2 will also be followed here. The form of statements used in the X-Y output request packet differs in many instances from that of similar cards used in the structure plotter request packet. The user is cautioned to prepare his input decks as specified herein.

4.3.2 Parameter Definition Cards

4.3.2.1 Cards Pertaining to All Curves

1. PLØTTER = plotter name, model name

   Selects plotter; required if plots are requested. Plotter choices are listed in Section 4.1. (Note: one or both of the plot tapes must be set up. See Section 5 of the Programmer's Manual for instructions.)

2. CAMERA = c (Integer)

   Used for microfilm plotters only to select camera as follows: $c \leq 1$ for film, $c = 2$ for paper, $c \geq 3$ for both; default value is 3.

3. PENSIZE = ps (Integer ≥ 0)

   Used to select pen for table plotter; default value is 1. (See Section 4.2.2.2)

4. DENSITY = d (Integer ≥ 0)

   Used to select line density for microfilm plotters only; default value is 1. A line density of d is d times heavier than a line density of 1.

5. SKIP = s (Integer ≥ 0)

   Used to insert blank frames between requested frames for microfilm plotters; default value is 1.

6. XPAPER = x (Real)
   YPAPER = y (Real)

   Defines paper size for table plotters; default value is x = 8.5 inches and y = 11.0 inches.

7. XMIN = x1 (Real)
   XMAX = x2 (Real)

   Specifies limits of abscissa of curve; default values are chosen so as to accommodate all points.

8. XLØG = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

   Request for logarithmic x-coordinate, default value is NØ. Default value for tic division interval depends on number of log cycles (see table at end of this Section).

9. YAXIS = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

   Request for plotting y-axis; default value is NØ.

10. XINTERCEPT = xi (Real)

    Location on the x-axis where the y-axis will be drawn; default value is 0.0.

11. UPPER TICS = ut (Integer*)

    Request for tick marks to be drawn on the upper edge of the frame; default value is integer one.

12. LØWER TICS = lt (Integer*)

    Request for tic marks to be drawn on the lower edge of the frame; default value is integer one.

13. CURVELINESYMBØL = cls (Integer)

    Request for points to be connected by lines (cls = 0), identified by symbol |cls| (cls < 0), or both (cls > 0); default value is 0; see Section 4.2.2.3 for the list of symbols. If cls ≠ 0, subsequent curves on the same frame will cause cls to be incremented by one (decrement by one if cls < 0) for each curve and thus cycle through the available symbols.

14. XDIVISIØNS = xd (Integer > 0)

    Applies xd uniform spaces along the x-direction for whichever of the following are called for: UPPER TICS, LØWER TICS, YINTERCEPT: default value is 5 spaces, not applicable to log scales.

15. XVALUE PRINT SKIP = xps (Integer ≥ 0)

    Request for values to be placed on tic marks. The number of tic marks to be skipped between labeled tic marks is xps.

16. CLEAR

    Causes all parameter values except PLØTTER and titles (XTITLE, YTITLE, YTTITLE, YBTITLE, TCURVE) to revert to their default values.

17. XTITLE = {any legitimate character string}

    Title to be used with x-axis.

18. TCURVE = {any legitimate character string}

    Curve title.

The default values for tic divisions on log plots are given in the following table, but will range over whole cycles:

Number of Cycles	Intermediate Values
1, 2	2., 3., 4., 5., 6., 7., 8., 9.
3	2., 3., 5., 7., 9.
4	2., 4., 6., 8.
5	2., 5., 8.
6, 7	3., 6.
8, 9, 10	3.

4.3.2.2 Cards Pertaining Only to Whole Frame Curves

1. YMIN = y1 (Real)
   YMAX = y2 (Real)

   Specifies limits of ordinate of curve; default values are chosen so as to accommodate all points.

*See note on page 4.3-8.

2. XAXIS = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

   Request for plotting x-axis; default value is NØ.

3. YINTERCEPT = yi (Real)

   Location on the y-axis where x-axis is drawn; default value is 0.0.

4. YLØG = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

   Request for logarithmic y-coordinate; default value is NØ. Default value for tic division interval depends on number of log cycles (see Section 4.3.2.1).

5. LEFT TICS = lt (Integer*)

   Request for tic marks to be drawn on the left edge of the frame; default value is integer one.

6. RIGHT TICS = rt (Integer*)

   Request for tic marks to be drawn on the right edge of the frame; default value is integer one.

7. ALLEDGE TICS = aet (Integer*)

   Request for tic marks to be drawn on all edges of the frame; default value is zero.

8. YDIVISIØNS = yd (Integer > 0)

   y-division tic divisions; default value is 5 spaces; not applicable to log scales.

9. YVALUE PRINT SKIP = yps (Integer ≥ 0)

   Request for values to be placed on tic marks. The number of tic marks to be skipped between labeled tic marks is yps.

10. XGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

    Request for drawing in the grid lines parallel to the y-axis at locations requested for tic marks; default value is NØ.

11. YGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

    Request for drawing in the grid lines parallel to the x-axis at locations requested for tic marks; default value is NØ.

12. YTITLE = {any legitimate character string}

    Title to be used with y-axis.

4.3.2.3 <u>Cards Pertaining Only to Upper Half Frame Curves</u>

1. YTMIN = yt1 (Real)
   YTMAX = yt2 (Real)

   Specifies limits of ordinate of curve; default values are chosen so as to accomodate all points.

*See note on page 4.3-8.

2. XTAXIS = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

   Request for plotting x-axis; default value is NØ.

3. YTINTERCEPT = yti (Real)

   Location on the y-axis where x-axis is drawn; default value if 0.0.

4. YTLØG = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

   Request for logarithmic y-coordinate, default value is NØ. Default value for tic division interval depends on number of log cycles (see table in Section 4.3.2.1).

5. TLEFT TICS = tlt (Integer*)

   Request for tic marks to be drawn on the left edge of the upper half frame; default value is integer one.

6. TRIGHT TICS = trt (Integer*)

   Request for tic marks to be drawn on the right edge of the upper half frame; default value is integer one.

7. TALL EDGE TICS = taet (Integer*)

   Request for tic marks to be drawn on all edges of the upper half frame; default value is zero.

8. YTDIVISIØNS = ytd (Integer > 0)

   y-division tic divisions; default value is 5 spaces; not applicable to log scales.

9. YTVALUE PRINT SKIP = ytps (Integer $\geq$ 0)

   Request for values to be placed on tic marks. The number of tic marks to be skipped between labeled tic marks is ytps.

10. XTGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

    Request for drawing in the grid lines parallel to the y-axis at locations requested for tic marks; default value is NØ.

11. YTGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

    Request for drawing in the grid lines parallel to the x-axis at locations requested for tic marks; default value is NØ.

12. YTTITLE = {any legitimate character string}

    Title to be used with y-axis.

*See note on page 4.3-8.

4.3.2.4 Cards Pertaining Only to Lower Half Frame Curves

1. YBMIN = yb1 (Real)
   YBMAX = yb2 (Real)

   Specifies limits of ordinate of curve; default values are chosen so as to accommodate all points.

2. XBAXIS = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

   Request for plotting x-axis; default value is NØ.

3. YBINTERCEPT = ybi (Real)

   Location on the y-axis where x-axis is drawn; default value is 0.0.

4. YBLØG = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

   Request for logarithmic y-coordinate; default value is NØ; default value for tic division interval depends on number of log cycles (see table in Section 4.3.2.1).

5. BLEFT TICS = blt (Integer*)

   Request for tic marks to be drawn on the left edge of the lower half frame; default value is integer one.

6. BRIGHT TICS = brt (Integer*)

   Request for tic marks to be drawn on the right edge of the lower half frame; default value is integer one.

7. BALL EDGE TICS = baet (Integer*)

   Request for tic marks to be drawn on all edges of the lower half frame; default value is zero.

8. YBDIVISIØNS = ybd (Integer > 0)

   y-direction tic divisions; default value is 5 spaces; not applicable to log scales.

9. YBVALUE PRINT SKIP = ybps (Integer $\geq$ 0)

   Request for values to be placed on tic marks. The number of tic marks to be skipped between labeled tic marks is ybps.

10. XBGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

    Request for drawing in the grid lines parallel to the y-axis at locations requested for tic marks; default value is NØ.

* See note on page 4.3-8.

11. YBGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

Request for drawing in the grid lines parallel to the x-axis at locations requested for tic marks; default value is NØ.

12. YBTITLE = any legitimate character string

Title to be used with y-axis.

* Note

To determine if on any given edge (a) tic marks will be drawn without values, (b) no tic marks or values will be drawn or (c) tic marks with values will be drawn, the following sum must be computed by the user. Add the tic integer value of the edge in question to its associated ALLEDGE TICS, TALL EDGE TICS, or BALL EDGE TICS integer value. If the resulting value is less than 0, tic marks will be drawn without values. If the resulting value is 0, no tic marks or values will be drawn. If the resulting value is greater than 0, tic marks with values will be drawn. The user should be "careful" in his use of the ALLEDGE TICS, TALL EDGE TICS, or BALL EDGE TICS cards. For example, the use of only the ALLEDGE TICS = -1 card will result in no tic marks or values being drawn since the default values for individual edges is + 1. Tic values input may only be -1,0, or 1.

4.3.3 Command Operation Cards

When a command operation is encountered, one or more frames will be generated using the current parameter specifications. The form of this card is:

Operation 1 or more (required)	Curve Type 1 only (required)	Plot Type	Subcase List	Curve Request(s)
{ XYPLØT XYPRINT XYPUNCH XYPEAK XYPAPLØT }	{ ACCE DISP ELFØRCE NØNLINEAR ØLØAD SACCE SDISP SPCF STRESS SVELØ VECTØR VELØ VG }	{ RESPØNSE AUTØ PSDF } NA	{ i_1, i_2, i_3, i_4 THRU i_5, i_6, etc. } default is all subcases NA	"frames"

Operation - The entries in the Operation field have the following meaning:

1. XYPLØT - generate X-Y plots for the selected plotter.
2. XYPRINT - generate tabular printer output for the X-Y pairs.
3. XYPUNCH - generate punched card output for the X-Y pairs. Each card contains the following information:
   1. X-Y pair sequence number
   2. X-value
   3. Y-value
   4. Card sequence number
4. XYPEAK - output is limited to the printed summary page for each curve. This summary page contains the maximum and minimum values of y for the range of x.
5. XYPAPLØT - generate X-Y plots on the printer. When the paper is rotated 90° for viewing the paper plots, the X axis moves horizontally along the page and the Y axis moves vertically along the page. Symbol '*' identifies the points associated with the first curve of a frame, then for successive curves on the frame the points are designated by symbols 'O', 'A', 'B', 'C', 'D', 'E', 'F', 'G' and 'H'.

Curve Type - The entries in the curve type field have the meaning given below. Only one may appear in a single command operation logical card. However, there is no limit to the number of such cards.

Curve Type	Meaning
ACCE	Acceleration in the physical set
DISP	Displacement in the physical set
ELFØRCE	Element Force
NØNLINEAR	Nonlinear load
ØLØAD	Load
SACCE	Acceleration in the solution set
SDISP	Displacement in the solution set
SPCF	Single-point force of constraint
STRESS	Element stress
SVELØ	Velocity in the solution set
VECTØR	Displacement in the physical set
VELØ	Velocity in the physical set
VG	Flutter Analysis Curves

Solution set requests are more efficient, as the time-consuming recovery of the dependent displacements can be avoided. If there is a request for STRESS or ELFØRCE, the recovery of dependent displacements cannot be avoided.

Plot Type - The entries in the Plot Type field have the following meanings:

1. RESPØNSE - generate output for static analysis, frequency response, or transient response. This is the default value.
2. AUTØ - generate output for the autocorrelation function.
3. PSDF - generate output for the power spectral density function.

Subcase List - Generate output for the subcase numbers that are listed. Default is all subcases for which solutions were obtained. The subcase list must be in ascending order.

Curve Request(s) - The word "frames" represents a series of curve identifiers of the following general form:

/a1(b1,c1),a2(b2,c2),etc./d1(e1,f1),d2(e2,f2),etc./etc.

The information between slashes (/) specifies curves that are to be drawn on the same frame. The symbol a1 identifies the grid point or element number associated with the first plot on the first frame. The symbol a2 identifies the grid point or element number associated with the second plot on the first frame. The symbols d1 and d2 identify similar items for plots on the second frame, etc. Symbols are assigned in order by grid point or element identification number.

The symbols b1 and b2 are codes for the items to be plotted on the upper half of the first frame, and c1 and c2 are codes for the items to be plotted on the lower half of the first frame. If any of the symbols b1, c1, b2, or c2 are missing, the corresponding curve is not generated. If the comma (,) and c1 are absent along with the comma (,) and c2, full frame plots will be prepared on the first frame for the items represented by b1 and b2. For any single frame, curve identifiers must be all of the whole frame type or all of the half frame type, i.e., the comma (,) following b1 and b2 must be present for all entries or absent for all entries in a single frame. The symbols e1, f1, e2, and f2 serve a similar purpose for the second frame, etc. If continuation cards are needed the previous card may be terminated with any one of the slashes (/) or commas (,) in the general format.

The manner in which the item code (e.g., b1, b2) is implemented is dependent upon whether the Plot Type is either (a) RESPØNSE or (b) AUTØ or PSDF.

For VG plots, the a1, a2 refers to the loop count of flutter analysis. The quantities b and c may have the values F for frequency and G for damping.

Plot Type RESPØNSE

For geometric grid points, the item code is one of the mneomonics T1, T2, T3, R1, R2, R3, T1RM, T2RM, T3RM, R1RM, R2RM, R3RM, T1IP, T3IP, R1IP, R2IP, or R3IP, where Ti stands for the ith translational component, Ri stands for the ith rotational component, and RM means real or magnitude and IP means imaginary or phase. For scalar or extra points, use T1, T1RM, or T1IP. For elements use a positive integer from the following tables for element stress item codes or element force item codes. See Section 1.3 for interpretation of symbols.

Plot Types AUTØ or PSDF

For geometric grid points, the item code is one of the mnemonics T1, T2, T3, R1, R2, R3; for scalar or extra points use T1. The symbols T1, T2, T3, R1, R2, R3 are defined as above. For elements use a positive integer from the following tables noting that if an item has a real and imaginary part, the selection of either part will result in the use of both parts. Real numbers will be treated as if they are complex numbers with zero imaginary parts. Split frames cannot be used for AUTØ or PSDF plots.

Element Stress Item Codes

(All items are stresses unless otherwise denoted)

Element Name	Real Element Stresses Item Code	Item	Complex Element Stresses Item Code	Item	Real-Mag. or Imag.-Phase
RØD	2	Axial Stress	2	Axial Stress	RM
	3	Axial Safety Margin	3	Axial Stress	IP
	4	Torsional Stress	4	Torsional Stress	RM
	5	Torsional Safety Margin	5	Torsional Stress	IP
TUBE		Same as RØD		Same as RØD	
SHEAR	2	Maximum Shear	2	Maximum Shear	RM
	3	Average Shear	3	Maximum Shear	IP
	4	Safety Margin	4	Average Shear	RM
			5	Average Shear	IP
TWIST	2	Maximum	2	Maximum	RM
	3	Average	3	Maximum	IP
	4	Safety Margin	4	Average	RM
			5	Average	IP
TRIA1		Z1 = Fibre Distance 1		Z1 = Fibre Distance 1	
	3	Normal-x at Z1	3	Normal-x at 1	RM
	4	Normal-y at Z1	4	Normal-x at 1	IP
	5	Shear-xy at Z1	5	Normal-y at 1	RM
	6	θ-Shear Angle at Z1	6	Normal-y at 1	IP
	7	Major-Principal at Z1	7	Shear-xy at 1	RM
	8	Minor-Principal at Z1	8	Shear-xy at 1	IP
	9	Max-Shear at Z1		Z2 = Fibre Distance 2	
		Z2 = Fibre Distance 2	10	Normal-x at 2	RM
	11	Normal-x at Z2	11	Normal-x at 2	IP
	12	Normal-y at Z2	12	Normal-y at 2	RM
	13	Shear-xy at Z2	13	Normal-y at 2	IP
	14	θ-Shear Angle at Z2	14	Shear-xy at 2	RM
	15	Major-Principal at Z2	15	Shear-xy at 2	IP
	16	Minor-Principal at Z2			
	17	Maximum-Shear at Z2			
TRBSC		Same as TRIA1		Same as TRIA1	
TRPLT		Same as TRIA1		Same as TRIA1	
TRMEM	2	Normal-x	2	Normal-x	RM
	3	Normal-y	3	Normal-x	IP
	4	Shear-xy	4	Normal-y	RM
	5	θ-Shear Angle	5	Normal-y	IP
	6	Major-Principal	6	Shear-xy	RM
	7	Minor-Principal	7	Shear-xy	IP
	8	Maximum Shear			
CØNRØD		Same as RØD		Same as RØD	
ELAS1	2	Stress	2	Stress	RM
			3	Stress	IP
ELAS2	2	Stress	2	Stress	RM
			3	Stress	IP

Element Name	Item Code	Real Element Stresses Item	Item Code	Complex Element Stresses Item	Real-Mag. or Imag.-Phase
ELAS3	2	Stress	2	Stress	RM
			3	Stress	IP
QDPLT		Same as TRIA1		Same as TRIA1	
QDMEM		Same as TRMEM		Same as TRMEM	
QDMEM1		Same as TRMEM		Same as TRMEM	
QDMEM2		Same as TRMEM		Same as TRMEM	
TRIA2		Same as TRIA1		Same as TRIA1	
QUAD2		Same as TRIA1		Same as TRIA1	
QUAD1		Same as TRIA1		Same as TRIA1	
BAR	2	SA1	2	SA1	RM
	3	SA2 *	3	SA2 *	RM
	4	SA3	4	SA3	RM
	5	SA4	5	SA4	RM
	6	Axial	6	Axial	RM
	7	SA-maximum	7	SA1	IP
	8	SA-minimum	8	SA2 *	IP
	9	Safety Margin in Tension	9	SA3	IP
	10	SB1	10	SA4	IP
	11	SB2 *	11	Axial	IP
	12	SB3	12	SB1	RM
	13	SB4	13	SB2	RM
	14	SB-maximum	14	SB3	RM
	15	SB-minimum	15	SB4 *	RM
	16	Safety Margin in Comp.	16	SB1	IP
			17	SB2	IP
			18	SB3	IP
			19	SB4	IP
CØNEAX		Z1 = Fibre Distance 1			
	4	Normal-u at 1			
	5	Normal-v at 1			
	6	Shear-uv at 1			
	7	θ-Shear Angle at 1			
	8	Major-Principal at 1			
	9	Minor-Principal at 1			
	10	Maximum Shear at 1			
		Z2 = Fibre Distance 2			
	12	Normal-u at 2			
	13	Normal-v at 2			
	14	Shear-uv at 2			
	15	θ-Shear Angle at 2			
	16	Major-Principal at 2			
	17	Minor-Principal at 2			
	18	Maximum Shear at 2			
TRIARG	2	Radial (x)			
	3	Circum. (Theta)			
	4	Axial (z)			
	5	Shear (zx)			

*See footnote 2 on next page.

Element Name	Real Element Stresses Item Code	Real Element Stresses Item		Complex Element Stresses Item Code	Complex Element Stresses Item	Real-Mag. or Imag.-Phase
TRAPRG	2	Radial (x)	at 1			
	3	Circum. (Theta)	at 1			
	4	Axial (z)	at 1			
	5	Shear (zx)	at 1			
	6	Radial (x)	at 2			
	7	Circum. (Theta)	at 2			
	8	Axial (z)	at 2			
	9	Shear (zx)	at 2			
	10	Radial (x)	at 3			
	11	Circum. (Theta)	at 3			
	12	Axial (z)	at 3			
	13	Shear (zx)	at 3			
	14	Radial (x)	at 4			
	15	Circum. (Theta)	at 4			
	16	Axial (z)	at 4			
	17	Shear (zx)	at 4			
	18	Radial (x)	at 5			
	19	Circum. (Theta)	at 5			
	20	Axial (z)	at 5			
	21	Shear (zx)	at 5			
TØRDRG	2	Mem.-Tangen.	at 1			
	3	Mem.-Circum.	at 1			
	4	Flex.-Tangen.	at 1			
	5	Flex.-Circum.	at 1			
	6	Shear-Force	at 1			
	7	Mem.-Tangen.	at 2			
	8	Mem.-Circum.	at 2			
	9	Flex.-Tangen.	at 2			
	10	Flex.-Circum.	at 2			
	11	Shear-Force	at 2			
	12	Mem.-Tangen.	at 3			
	13	Mem.-Circum.	at 3			
	14	Flex.-Tangen.	at 3			
	15	Flex.-Circum.	at 3			
	16	Shear-Force	at 3			
TETRA	2	Normal (x)		2	Normal (x)	RM
	3	Normal (y)		3	Normal (y)	RM
	4	Normal (z)		4	Normal (z)	RM
	5	Shear (yz)		5	Shear (yz)	RM
	6	Shear (xy)		6	Shear (xy)	RM
	7	Shear (xz)		7	Shear (xz)	RM
	8	Octahedral		8	Normal (x)	IP
	9	Pressure		9	Normal (y)	IP
				10	Normal (z)	IP
				11	Shear (yz)	IP
				12	Shear (xy)	IP
				13	Shear (xz)	IP
WEDGE	Same as TETRA			Same as TETRA		
HEXA1	Same as TETRA			Same as TETRA		
HEXA2	Same as TETRA			Same as TETRA		

Element Name	Real Element Stresses: Item Code	Real Element Stresses: Item	Complex Element Stresses: Item Code	Complex Element Stresses: Item	Real-Mag. or Imag.-Phase
AXIF2	2	Radial-Axis	2	Radial-Axis	RM
	3	Axial-Axis	3	Axial-Axis	RM
	4	Tangential-Edge	4	Tangential-Edge	RM
	5	Circumferential-Edge	5	Circumferential-Edge	RM
			6	Radial-Axis	IP
			7	Axial-Axis	IP
			8	Tangential-Edge	IP
			9	Circumferential-Edge	IP
AXIF3	2	Radial-centroid	2	Radial-centroid	RM
	3	Circumferential-centroid	3	Circumferential-centroid	RM
	4	Axial-centroid	4	Axial-centroid	RM
	5	Tangential-edge 1	5	Tangential-edge 1	RM
	6	Circumferential-edge 1	6	Circumferential-edge 1	RM
	7	Tangential-edge 2	7	Tangential-edge 2	RM
	8	Circumferential-edge 2	8	Circumferential-edge 2	RM
	9	Tangential-edge 3	9	Tangential-edge 3	RM
	10	Circumferential-edge 3	10	Circumferential-edge 3	RM
			11	Radial-centroid	IP
			12	Circumferential-centroid	IP
			13	Axial-centroid	IP
			14	Tangential-edge 1	IP
			15	Circumferential-edge 1	IP
			16	Tangential-edge 2	IP
			17	Circumferential-edge 2	IP
			18	Tangential-edge 3	IP
			19	Circumferential-edge 3	IP
AXIF4	2	Radial-centroid	2	Radial-centroid	RM
	3	Circumferential-centroid	3	Circumferential-centroid	RM
	4	Axial-centroid	4	Axial-centroid	RM
	5	Tangential-edge 1	6	Tangential-edge 1	RM
	6	Circumferential-edge 1	6	Circumferential-edge 1	RM
	7	Tangential-edge 2	7	Tangential-edge 2	RM
	8	Circumferential-edge 2	8	Circumferential-edge 2	RM
	9	Tangential-edge 3	9	Tangential-edge 3	RM
	10	Circumferential-edge 3	10	Circumferential-edge 3	RM
	11	Tangential-edge 4	11	Tangential-edge 4	RM
	12	Circumferential-edge 4	12	Circumferential-edge 4	RM
			13	Radial-centroid	IP
			14	Circumferential-centroid	IP
			15	Axial-centroid	IP
			16	Tangential-edge 1	IP
			17	Circumferential-edge 1	IP
			18	Tangential-edge 2	IP
			19	Circumferential-edge 2	IP
			20	Tangential-edge 3	IP
			21	Circumferential-edge 3	IP
			22	Tangential-edge 4	IP
			23	Circumferential-edge 4	IP

Element Name	Real Element Stresses Item Code	Real Element Stresses Item	Complex Element Stresses Item Code	Complex Element Stresses Item	Real-Mag. or Imag.-Phase
SLØT3	2	Radial-centroid	2	Radial-centroid	RM
	3	Axial-centroid	3	Axial-centroid	RM
	4	Tangential-edge 1	4	Tangential-edge 1	RM
	5	Tangential-edge 2	5	Tangential-edge 2	RM
	6	Tangential-edge 3	6	Tangential-edge 3	RM
			7	Radial-centroid	IP
			8	Axial-centroid	IP
			9	Tangential-edge 1	IP
			10	Tangential-edge 2	IP
			11	Tangential-edge 3	IP
SLØT4	2	Radial-centroid	2	Radial-centroid	RM
	3	Axial-centroid	3	Axial-centroid	RM
	4	Tangential-edge 1	4	Tangential-edge 1	RM
	5	Tangential-edge 2	5	Tangential-edge 2	RM
	6	Tangential-edge 3	6	Tangential-edge 3	RM
	7	Tangential-edge 4	7	Tangential-edge 4	RM
			8	Radial-centroid	IP
			9	Axial-centroid	IP
			10	Tangential-edge 1	IP
			11	Tangential-edge 2	IP
			12	Tangential-edge 3	IP
			13	Tangential-edge 4	IP
CIHEX1*	2	External grid point ID	2	External grid point ID	
	3	Normal - x	3	Normal - x	RM
	4	Shear - xy	4	Normal - y	RM
	5	First principal	5	Normal - z	RM
	6	First principal x cosine	6	Shear - xy	RM
	7	Second principal x cosine	7	Shear - yz	RM
	8	Third principal x cosine	8	Shear - zx	RM
	9	Mean stress	9	Normal - x	IP
	10	Octahedral shear stress	10	Normal - y	IP
	11	Normal - y	11	Normal - z	IP
	12	Shear - yz	12	Shear - xy	IP
	13	Second principal	13	Shear - yz	IP
	14	First principal y cosine	14	Shear - zx	IP
	15	Second principal y cosine			
	16	Third principal y cosine			
	17	Normal - z			
	18	Shear - zx			
	19	Third principal			
	20	First principal z cosine			
	21	Second principal z cosine			
	22	Third principal z cosine			
CIHEX2*	Same as CIHEX1		Same as CIHEX1		
CIHEX3*	2	First external grid point ID	2	First external grid point ID	
	3	Normal - x	3	Normal - x	RM
	4	Shear - xy	4	Normal - y	RM
	5	First principal	5	Normal - z	RM
	6	First principal x cosine	6	Shear - xy	RM

X-Y OUTPUT

Element Name	Real Element Stresses Item Code	Real Element Stresses Item	Complex Element Stresses Item Code	Complex Element Stresses Item	Real-Mag. or Imag.-Phase
	7	Second principal x cosine	7	Shear - yz	RM
	8	Third principal x cosine	8	Shear - zx	RM
	9	Mean stress	9	Second external grid point ID	
	10	Octahedral shear stress	10	Normal - x	IP
	11	Second external grid point ID	11	Normal - y	IP
	12	Normal - y	12	Normal - z	IP
	13	Shear - yz	13	Shear - xy	IP
	14	Second principal	14	Shear - yz	IP
	15	First principal y cosine	15	Shear - zx	IP
	16	Second principal y cosine			
	17	Third principal y cosine			
	18	Normal - z			
	19	Shear - zx			
	20	Third principal			
	21	First principal z cosine			
	22	Second principal z cosine			
	23	Third principal z cosine			
TRAPAX	2	Harmonic or Point Angle			
	3	Radial (R)			
	4	Axial (Z)			
	5	Circum (Theta-T)			
	6	Shear (ZR)			
	7	Shear (RT)			
	8	Shear (ZT)			
TRIAAX	2	Harmonic or Point Angle			
	3	Radial (R)			
	4	Axial (Z)			
	5	Circum (Theta-T)			
	6	Shear (ZR)			
	7	Shear (RT)			
	8	Shear (ZT)			

*The stresses are repeated for each stress point within each element.

<u>Note</u>:

1. If output is magnitude/phase the magnitude replaces the real part and the phase replaces the imaginary part.

2. The symbols SA1,2,3,4 and SB1,2,3,4 stand for stresses on end A or B at locations C, D, E, and F respectively as defined on the first continuation card of the PBAR bulk data card.

Element Force Item Codes

(All items are element forces (or moments) unless otherwise indicated)

Element Name	Real Element Forces: Item Code	Real Element Forces: Item	Complex Element Forces: Item Code	Complex Element Forces: Item	Real-Mag. or Imag.-Phase
RØD	2	Axial Force	2	Axial Force	RM
	3	Torque	3	Axial Force	IP
			4	Torque	RM
			5	Torque	IP
TUBE		Same as RØD		Same as RØD	
SHEAR	2	Force Pts. 1, 3	2	Force Pts. 1, 3	RM
	3	Force Pts. 2, 4	3	Force Pts. 1, 3	IP
			4	Force Pts. 2, 4	RM
			5	Force Pts. 2, 4	IP
TWIST	2	Moment Pts. 1, 3	2	Moment Pts. 1, 3	RM
	3	Moment Pts. 2, 4	3	Moment Pts. 1, 3	IP
			4	Moment Pts. 2, 4	RM
			5	Moment Pts. 2, 4	IP
TRIA1	2	Bend-Moment-x	2	Bend-Moment-x	RM
	3	Bend-Moment-y	3	Bend-Moment-y	RM
	4	Twist-Moment	4	Twist-Moment	RM
	5	Shear-x	5	Shear-x	RM
	6	Shear-y	6	Shear-y	RM
			7	Bend-Moment-x	IP
			8	Bend-Moment-y	IP
			9	Twist-Moment	IP
			10	Shear-x	IP
			11	Shear-y	IP
TRBSC		Same as TRIA1		Same as TRIA1	
TRPLT		Same as TRIA1		Same as TRIA1	
CØNRØD		Same as RØD		Same as RØD	
ELAS1	2	Force	2	Force	RM
			3	Force	IP
ELAS2	2	Force	2	Force	RM
			3	Force	IP
ELAS3	2	Force	2	Force	RM
			3	Force	IP
ELAS4	2	Force	2	Force	RM
			3	Force	IP
QDPLT		Same as TRIA1		Same as TRIA1	
TRIA2		Same as TRIA1		Same as TRIA1	
QUAD2		Same as TRIA1		Same as TRIA1	

Element Name	Real Element Forces: Item Code	Real Element Forces: Item	Complex Element Forces: Item Code	Complex Element Forces: Item	Real-Mag. or Imag.-Phase
QUAD1		Same as TRIA1		Same as TRIA1	
BAR	2	Bend-Moment A1	2	Bend-Moment A1	RM
	3	Bend-Moment A2	3	Bend-Moment A2	RM
	4	Bend-Moment B1	4	Bend-Moment B1	RM
	5	Bend-Moment B2	5	Bend-Moment B2	RM
	6	Shear-1	6	Shear-1	RM
	7	Shear-2	7	Shear-2	RM
	8	Axial Force	8	Axial Force	RM
	9	Torque	9	Torque	RM
			10	Bend-Moment A1	IP
			11	Bend-Moment A2	IP
			12	Bend-Moment B1	IP
			13	Bend-Moment B2	IP
			14	Shear-1	IP
			15	Shear-2	IP
			16	Axial Force	IP
			17	Torque	IP
CQDMEM2	2	Force 4 to 1			
	3	Force 2 to 1			
	4	Force 1 to 2			
	5	Force 3 to 2			
	6	Force 2 to 3			
	7	Force 4 to 3			
	8	Force 3 to 4			
	9	Force 1 to 4			
	10	Kick Force on 1			
	11	Shear-12			
	12	Kick Force on 2			
	13	Shear-23			
	14	Kick Force on 3			
	15	Shear-34			
	16	Kick Force on 4			
	17	Shear-41			
TRAPAX	2	Harmonic or Point Angle			
	3	Radial (R) at 1			
	4	Circum (Theta-T) at 1			
	5	Axial (Z) at 1			
	6	Radial (R) at 2			
	7	Circum (Theta-T) at 2			
	8	Axial (Z) at 2			
	9	Radial (R) at 3			
	10	Circum (Theta-T) at 3			
	11	Axial (Z) at 3			
	12	Radial (R) at 4			
	13	Circum (Theta-T) at 4			
	14	Axial (Z) at 4			

X-Y OUTPUT

Element Name	Real Element Forces: Item Code	Real Element Forces: Item	Complex Element Forces: Item Code	Complex Element Forces: Item	Real-Mag. or Imag.-Phase
TRIAAX	2	Harmonic or Point Angle			
	3	Radial (R) at 1			
	4	Circum (Theta-T)at 1			
	5	Axial (Z) at 1			
	6	Radial (R) at 2			
	7	Circum (Theta-T)at 2			
	8	Axial (Z) at 2			
	9	Radial (R) at 3			
	10	Circum (Theta-T)at 3			
	11	Axial (Z) at 3			

4.3.4 Examples of X-Y Output Request Packets

BEGIN BULK or ØUTPUT(PLØT) card is shown as a reminder to the user to place his X-Y output request packet properly in his Case Control Deck, i.e., at the end of the Case Control Deck or just ahead of any structure plot requests.

Example 1

```
ØUTPUT(XYPLØT)
PLØTTER = SC 4020
XYPLØT SDISP / 16(T1)
BEGIN BULK
```

Causes a single whole frame to be plotted for the T1 displacement component of solution set point 16 using the default parameter values. If 16(T1) is not in the solution set, a warning message will be printed and no plot will be made. The plot will be generated for the SC 4020 plotter on NASTRAN tape PLT2 which must be set up.

Example 2

```
ØUTPUT(XYØUT)
PLØTTER =EAI 3500
XYPLØT, XYPRINT VELØ RESPØNSE 1,5 / 3(R1, ), 5( ,R1)
ØUTPUT(PLØT)
```

Causes a single frame (consisting of an upper half frame and a lower half frame) to be plotted using the default parameter values. The velocity of the first rotational component of grid point 3 will be plotted on the upper half frame and that of grid point 5 will be plotted on the lower half frame for subcases 1 and 5. Tabular printer output will also be generated for both curves. The plots will be generated for the EAI 3500, 30-inch, table plotter on NASTRAN tape PLT1 which must be set up. Scales will be selected such that the frame will fit on 8 1/2 x 11-inch paper.

Example 3

```
ØUTPUT(XYPLØT)
PLØTTER = SC 4020
YDIVISIØNS = 20
XDIVISIØNS = 10
XGRID LINES = YES
YGRID LINES = YES
XYPLØT DISP 2,5 /10(T1),10(T3)
```

Causes two whole frame plots to be generated, one for subcase 2 and one for subcase 5. Each plot contains the T1 and T3 displacement component for grid point 10. The default parameters will be modified to include grid lines in both the x and y-directions with 10 spaces in the x-direction and 20 spaces in the y-direction. The plot will be generated for the SC 4020 plotter on NASTRAN tape PLT2 which must be set up.

Example 4

```
ØUTPUT(XYPLØT)
PLØTTER = EAI 3500
XAXIS = YES
YAXIS = YES
XPAPER = 17.0
YPAPER = 22.0
XYPLØT STRESS 3/ 15(2)/ 21(6)
```

Causes two whole frame plots to be generated using the results from subcase 3. The first plot is the response of the axial stress for rod element number 15. The second plot is the response of the major principal stress for triangular membrane element number 21. The default parameters will be modified to include the x-axis and y-axis drawn through the origin. Each plot will be scaled to fit on 17 x 22-inch paper. The plots will be generated for the EAI 3500, 30-inch, table plotter on NASTRAN tape PLT1 which must be set up.

Example 5

```
ØUTPUT (XYPLØT)
PLØTTER = NASTPLT D,0
CURVELINESYMBØL = -1
XYPLØT VG / 1(G,F) 2(G,F) 3(G,F) 4(G,F)
```

A split frame plot will be made; the upper half is V-g and the lower half is V-f. Data from the first four loops will be plotted. Distinct symbols are used for data from each loop, and no lines are drawn between points (since the flutter analyst must sometimes exercise judgement about which points should be connected).

4.3.5 Summary of X-Y Output Request Packet Cards

Type of value: I = Integer, R = Real, B = BCD. See Sections 4.3.2 and 4.3.3 for details of these cards.

Items pertaining to all plots			
1.	PLØTTER	= p	-
2.	CAMERA	= c	(I)
3.	PENSIZE	= ps	(I)
4.	DENSITY	= d	(I)
5.	SKIP	= s	(I)
6.	XPAPER	= x	(R)
	YPAPER	= y	(R)
7.	XMIN	= x1	(R)
	XMAX	= x2	(R)
8.	XLØG	= yesno*	(B)
9.	YAXIS	= yesno*	(B)
10.	XINTERCEPT	= xi	(R)
11.	UPPER TICS	= ut	(I)
12.	LØWER TICS	= lt	(I)
13.	CURVLINESYMBØL	= cls	(I)
14.	XDIVISIØNS	= xd	(I)
15.	XVALUE PRINT SKIP	= xps	(I)
16.	CLEAR		-
17.	XTITLE	= {anything}	-
18.	TCURVE	= {anything}	-

	Whole frames only	Upper half frames only	Lower half frames only	
1	YMIN = y1	YTMIN = yt1	YBMIN = yb1	(R)
	YMAX = y2	YTMAX = yt2	YBMAX = yb2	(R)
2	XAXIS = yesno*	XTAXIS = yesno*	XBAXIS = yesno*	(B)
3	YINTERCEPT = yi	YTINTERCEPT = yti	YBINTERCEPT = ybi	(I)
4	YLØG = yesno*	YTLØG = yesno*	YBLØG = yesno*	(B)
5	LEFT TICS = lt	TLEFT TICS = tlt	BLEFT TICS = blt	(I)
6	RIGHT TICS = rt	TRIGHT TICS = trt	BRIGHT TICS = brt	(I)
7	ALLEDGE TICS = aet	TALL EDGE TICS = taet	BALL EDGE TICS = baet	(I)
8	YDIVISIØNS = yd	YTDIVISIØNS = ytd	YBDIVISIØNS = ybd	(I)
9	YVALUE PRINT SKIP = yps	YTVALUE PRINT SKIP = ytps	YBVALUE PRINT SKIP = ybps	(I)
10	XGRID LINES = yesno*	XTGRID LINES = yesno*	XBGRID LINES = yesno*	(B)
11	YGRID LINES = yesno*	YTGRID LINES = yesno*	YBGRID LINES = yesno*	(B)
12	YTITLE = {anything}	YTTITLE = {anything}	YBTITLE = {anything}	-

Command operation cards

$$\left\{\begin{array}{l}\text{XYPLØT}\\ \text{XYPRINT}\\ \text{XYPUNCH}\\ \text{XYPEAK}\\ \text{XYPAPLØT}\end{array}\right\}\ \left\{\begin{array}{l}\text{ACCE}\\ \text{DISP}\\ \text{ELFØRCE}\\ \text{NØNLINEAR}\\ \text{ØLØAD}\\ \text{SACCE}\\ \text{SDISP}\\ \text{SPCF}\\ \text{STRESS}\\ \text{SVELØ}\\ \text{VECTØR}\\ \text{VELØ}\\ \text{VG}\end{array}\right\}\ \left\{\begin{array}{l}\underline{\text{RESPØNSE}}\\ \text{AUTØ}\\ \text{PSDF}\end{array}\right\}\ \text{subcases /curves}$$

* yesno must be either YES or NØ

5.1 GENERAL

In addition to using the rigid formats provided automatically by NASTRAN, the user may wish to execute a series of modules in a different manner than provided by the rigid format. Or, he may wish to perform a series of matrix operations which are not contained in any existing rigid format. If the modifications to an existing rigid format are minor, the ALTER feature described in Section 2 may be employed. Otherwise, a user-written Direct Matrix Abstraction Program (DMAP) should be used.

DMAP is the user-oriented language used by NASTRAN to solve problems. A rigid format is basically a collection of statements in this language. DMAP, like English or FØRTRAN, has many grammatical rules which must be followed to be interpretable by the NASTRAN DMAP compiler. Section 5.2 provides the user with the rules of DMAP which will allow him to understand the rigid format DMAP sequences, write ALTER packages, and construct his own DMAP sequences using the many modules contained in the NASTRAN DMAP repertoire.

Section 5.3 is an index of matrix, utility, user and executive DMAP modules which are contained in Sections 5.4 thru 5.7 respectively.

Sections 5.4 thru 5.7 describe individually the many nonstructurally oriented modules contained in the NASTRAN library. Section 5.8 provides several examples of DMAP usage.

User-written modules must conform to the rules and usage conventions described herein.

5.2 DMAP RULES

Grammatically, DMAP instructions consist of two types: Executive Operation Instructions and Functional Module Instructions. Grammatical rules for these two types of instructions will be discussed separately in subsequent sections.

Functional modules are arbitrarily classified as structural modules, matrix operation modules, utility modules, or user-generated modules.

The DMAP sequence itself consists of a series of DMAP instructions or statements, the first of which is BEGIN and the last of which is END. The remaining statements consist of Executive Operation instructions and Functional Module calls.

5.2.1 DMAP Rules for Functional Module Instructions

The primary characteristic of the Functional Module DMAP instruction is its prescribed format. The general form of the Functional Module DMAP statement is:

```
MØD   I1,I2,---,Im/Ø1,Ø2,---,Øn/a1,b1,p1/a2,b2,p2----/az,bz,pz  $

   where   MØD is the DMAP Functional Module name,
           Ii; i = 1,m are the Input Data Block names,
           Øi; i = 1,n are the Øutput Data Block names,
   and     ai,bi,pi; i = 1,z are the Parameter Sections.
```

In the general form shown above, commas (,) are used to separate several like items while slashes (/) are used to separate sections from one another. The module name is separated from the rest of the instruction by a blank or a comma (,). The dollar sign ($) is used to end the instruction and is not required unless the instruction ends in the delimiter / . Blanks may be used in conjunction with any of the above delimiters for ease of reading.

A functional module communicates with other modules and the executive system entirely through its inputs, outputs and parameters. The characteristics or attributes of each functional module are contained in the Module Properties List (MPL) described in Section 2.4 of the Programmer's Manual and are reflected in the DMAP Module Descriptions that follow in Section 5.3 and in the Module Functional Descriptions contained in Chapter 4 of the Programmer's Manual. The module name is a BCD value (which consists of an alphabetic character followed by up to seven additional alphanumeric characters) and must correspond to an entry in the MPL. A Data Block name may be either a BCD value or null. The absence of a BCD value indicates that the Data Block is not needed for a particular application.

5.2.1.1 Each Functional Module DMAP statement must conform to the MPL regarding

1. Name spelling
2. Number of input data blocks
3. Number of output data blocks
4. Number of parameters
5. Type of each parameter

5.2.1.2 Functional Module Names

The only Functional Module DMAP names allowed are those contained in the MPL. Therefore, if a user wishes to add a module, he must either use one of the User Module names provided (see Section 5.6 or add a name to the MPL. The Programmer's Manual should be consulted when adding a new module to NASTRAN.

5.2.1.3 Functional Module Input Data Blocks

An input data must be previously defined in the DMAP sequence. This is accomplished by causing the data block to be output from a previous DMAP instruction. Input File Processor outputs and any user-input (via Bulk Data Cards) DMI or DTI data block names are exempt from this rule as are data blocks existing on the Old Problem Tape. Since the number of Data Blocks is prescribed, the number of separating commas must be one less than the number of Data Blocks, even though one or more Data Blocks are null. An input data block may never be written on (nor have its trailer changed).

5.2.1.4 Functional Module Output Data Blocks

A data block name may appear as an output once and only once. New names may be equivalenced to old ones, however, as described in Section 5.2.3.2. Since the number of Data Blocks is prescribed, the number of separating commas must be one less than the number of Data Blocks, even though one or more Data Blocks are null.

5.2.1.5 Functional Module Parameters

Parameters are used for many purposes. They may convey data values into and/or out from the module, or they may simply serve as flags to control the computational flow within the module. The general form of a parameter section of a DMAP instruction is

ai,bi,pi

where the parameter specifications are:

ai	=	V	Parameter value is variable and may be changed by the module during execution.
		C	Parameter value is prescribed initially by the user and is an unalterable constant.
bi	=	Y	Initial parameter value may be specified on a PARAM bulk data card.
		N	Initial parameter value may <u>not</u> be specified on a PARAM bulk data card.
pi	=	PNAME = v	PNAME is a BCD value selected by the user to represent the name of the parameter.
		PNAME	
		v	

The various forms available for pi require additional clarification. The form v means a value for the parameter and may only be used wnen ai=C and bi=N. The other forms will be clarified in the symbolic examples that follow. Each parameter has an initial value which is established when the DMAP sequence is complied during execution of the NASTRAN preface. The means by which initial values are established for all DMAP parameters will be explained by the symbolic examples that follow. The value used at execution time may differ from the initial value if and only if the module changes the value, if ai = "V", and the parameter name appears in a SAVE (see Section 5.7) instruction immediately following the module. Six parameter types are available. The proper type is specified by the Module Properties List (MPL). The types and examples of values as they would be written in DMAP are given below:

Parameter Type	Value Examples		
Integer	7	-2	0
Real	-3.6	2.4+5	0.01-3
BCD		A12	
Double-Precision		2.5D0	
Complex Single-Precision		(1.0,-1.0)	
Complex Double-Precision		(1.9D0,-4.0D1)	

Many forms of the parameter section may be used. These will be explained in some detail.

null — This is equivalent to /C,N,v where v is the MPL default value <u>which must exist</u>. No nonnull parameters may follow a null parameter in the DMAP statement. A null is not punched, nor is the preceding /.

/C,N,v — Constant input parameter
Examples: /C,N,0/C,N,BKLO/C,N,(1.0,-1.0)

In the three examples shown, the values 0 (integer), BLKO (BCD) and 1.0-i1.0 (complex, single precision) are defined.

/C,Y,PNAME	Constant input parameter; MPL default value is used unless a PARAM bulk data card referencing PNAME is present. Error condition is detected if either no PARAM card is present or if no MPL default value exists.
/C,Y,PNAME=v	Constant input parameter; the value v is used unless a PARAM bulk data card referencing PNAME is present.
/V,Y,PNAME or /V,Y,PNAME=v	Variable parameter; may be input, output, or both; initial value is the first of 1. value from the most recently executed SAVE instruction, if any 2. value from PARAM bulk data card referencing PNAME will be used if present in Bulk Data Deck 3. v, if present in DMAP instruction 4. MPL default value, if any 5. 0 If a parameter is output from a functional module and if the output value is to be carried forward, a SAVE instruction <u>must immediately</u> follow the DMAP instruction in which the parameter is generated.
/V,N,PNAME or /V,N,PNAME=v	Variable parameter; may be input, output, or both; initial value is the first of 1. value from the most recently executed SAVE instruction, if any 2. v, if present in DMAP instruction 3. MPL default value, if any 4. 0

5.2.2 DMAP Rules for Executive Operation Instructions

Each Executive Operation statement has its own format which is generally open-ended, meaning the number of inputs, outputs, etc. is not prescribed. Executive Operation instructions or statements are divided into general categories as follows:

1. Declarative instructions FILE, BEGIN and LABEL which aid the DMAP compiler and the file allocator.
2. Instructions CHKPNT, EQUIV, PURGE and SAVE which aide the NASTRAN executive system in allocating files, interfacing between functional modules and in restarting a problem.
3. Control instructions REPT, JUMP, CØND, EXIT and END which control the order in which DMAP instructions are executed.

The rules associated with the Executive Operation instructions are distinct for each instruction and are discussed individually in Section 5.7.

5.2.3 Techniques and Examples of Executive Module Usage

Even though the DMAP program may be interpretable by the DMAP compiler it does not guarantee that the program will yield the desired results. Therefore this section is provided to acquaint the DMAP programmer with techniques and examples used in writing DMAP programs. In particular the instructions REPT, FILE, EQUIV, PURGE and CHKPNT will now be discussed in some detail. The DMAP module index for all nonstructural modules will be found in Section 5.3.

The new DMAP user should read Sections 5.4 through 5.7 to obtain the necessary knowledge of terminology before reading this section.

The data blocks and functional modules referenced in the following examples are fictitious and have no relationship to any real data blocks or functional modules.

A data block is described as having a status of "not generated," "generated" or "purged." A status of not generated means that the data blocks is available for generation by appearing as output in a functional module. A status of generated means that the data block contains data which is available for input to a subsequent module. A status of purged means that the data block cannot be generated and any functional module attempting to use this data block as input or output will be informed that the purged data block is not available for use.

5.2.3.1 The REPT and FILE Instructions (see Section 5.7)

The DMAP instructions bounded by the REPT instruction and the label referenced by the REPT instruction are referred to as a loop. The location referenced by the REPT is called the top of the loop. In many respects a DMAP loop is like a giant functional module since it requires inputs and generates output data blocks which usually can be handled correctly by the File Allocator (see Section 4.9 of the Programmer's Manual) without any special action by the DMAP programmer. The one exception is a data block that is not referenced outside the loop (i.e., an internal data block with respect to the loop). The file allocator considers internal data blocks as scratch data blocks to be used for the present pass through the loop but not to be saved for input at the top of the loop. Should the DMAP programmer desire to save an internal data block, he may do so by declaring the data block SAVE in the FILE instruction.

When the REPT instruction transfers control back to the top of the loop, the status of all internal data blocks is changed to "not generated" unless the internal data block is declared SAVE or APPEND in a FILE instruction. It should also be noted that equivalences established between internal data blocks (not declared saved) and data blocks referenced outside the loop are not carried over for the next time through the loop. The equivalence must be re-established each time through the loop. Data blocks generated by the Input File Processor are considered referenced outside of all DMAP loops.

<u>EXAMPLE</u> using REPT and FILE instructions.

```
           BEGIN    $
           FILE     X=SAVE / Y=APPEND / Z=APPEND $
           LABEL    L1 $
           MØD1     B/W,Y $
           CØND     L3,PX $
DMAP       MØD2     A/X/V,N,PX=0 $
loop       SAVE     PX $
           LABEL    L3 $
           MØD3     W,X,Y/Z $
           REPT     L1,1 $
           MØD4     Z// $
           END      $
```

Assume that MØD2 sets PX = 0 when it is executed. Note that Z is declared APPEND, whereas Y will be saved since it is an internal data block that is to be appended. X is an internal data block that is to be saved since it will only be generated the first time through the loop but is needed as input each time the loop is repeated. W is an internal data block that is generated each time through the loop; therefore, it is not saved.

The following table shows what happens when the above DMAP program is executed. Only modules being executed are shown in the table. Data blocks A and B are assumed to be generated by the Input File Processor, and hence are considered referenced outside of all DMAP loops.

Module being executed	Input status and comments	Output status and comments
MØD1	B-assumed generated by the input file processor	W, Y - generated
CØND	PX is 0	No transfer occurs since PX ≥ 0
MØD2	A-assumed generated by the input file processor	X - generated PX is set < 0
SAVE	PX < 0	The value created above is saved for subsequent use.
MØD3	W, X, Y are all generated at this point	Z - generated
REPT	Loop count is initially set at 1	Transfer to L1 - set loop count to 1-1=0 Status of data blocks at top of loop will be: A, B, Z - generated (referenced outside loop) X, Y - generated (internal data blocks declared saved) W - not generated (internal data block)
MØD1	B - generated	W - generated Y - generated (appended)
CØND	PX is now < 0 due to SAVE	Transfer to L3 occurs
MØD3	W, X, Y - generated	Z - generated (appended)
REPT	Loop count is now 0	No transfer occurs.
MØD4	Z - generated	Output to printer (assumed)
END		Normal termination of problem.

5.2.3.2 The EQUIV Instruction (see Section 5.7)

There are no restrictions on the status of data blocks referenced in an EQUIV instruction. Consider the instruction EQUIV A,B_1,---,B_N/P \$ when P < 0. Data blocks B_1,---,B_N take on all the characteristics of data block A including the status of A. This means the status of some B_j can change from purged to generated or not generated.

The EQUIV instruction will unequivalence data blocks when P ≥ 0. In an unequivalence operation, the status of all secondary data blocks reverts to not generated.

Suppose A, B, and C are all equivalenced and P ≥ 0. EQUIV A,B/P \$ will break the equivalence between A and B but not between A and C.

Now consider the following situation. Data block B is to be generated by repeatedly executing functional module MØD2. The input to MØD2 is the previous output from MØD2. That is to say, each successive generation of B depends on the previous B generated. The following example shows how the EQUIV instruction is used to solve this problem. Assume parameter BREAK ≥ 0 and parameter LINK < 0.

EXAMPLE of EQUIV instruction.

```
                BEGIN    $
                MØD1     A/B  $
              ( LABEL    L1  $
 DMAP         ) EQUIV    B,BB/BREAK  $
 loop        <  MØD2     B/BB  $
              ) EQUIV    BB,B/LINK  $
              ( REPT     L1,1  $
                MØD3     BB//  $
                END      $
```

The following table shows what happens when the above DMAP program is executed. Only modules being executed are shown in the table.

Module being executed	Input status and comments	Output status and comments
MØD1	A-assumed generated by input processor	B - generated
EQUIV	B will not be equivalenced to BB since BREAK ≥ 0.	No action taken.
MØD2	B-generated	BB - generated
EQUIV	BB and B are not equivalenced. B - generated BB - generated LINK < 0.	B is equivalenced to BB. That is, B assumes all of the characteristics of BB. B and BB then both have the status of generated.
REPT	Loop count is initially 1	Transfer to L1; set loop count to 1-1=0.
EQUIV	B and BB are generated and equivalenced. BREAK ≥ 0.	The equivalence is broken; B - generated, BB - not generated
MØD2	B-generated	BB - generated
EQUIV	BB and B are generated and not equivalenced. LINK < 0.	B equivalenced to BB; B,BB - generated
REPT	Loop count is 0	No transfer occurs.
MØD3	BB - generated	Output to printer (assumed)
END		Normal termination of problem.

Since equivalences are automatically broken between internal files (not declared saved) and files referenced outside the loop, the above DMAP program could be written as follows and the same results achieved.

```
               BEGIN    $
               MØD1     A/B  $
             ( LABEL    L1  $
DMAP         ) MØD2     B/BB  $
loop         ) EQUIV    BB,B/LINK  $
             ( REPT     L1,1  $
               MØD3     B//  $
               END      $
```

Data block BB is now internal; therefore, the instruction EQUIV B,BB/BREAK $ is not needed.

5.2.3.3 The PURGE Instruction (see Section 5.7)

The status of a data block is changed to purged by <u>explicitly</u> or <u>implicitly</u> purging it. A data block is explicitly purged through the PURGE instruction, whereas it is implicitly purged if it is not created by the functional module in which it appears as an output.

The primary purpose of the PURGE instruction is to <u>prepurge</u> data blocks. Prepurging is the explicit purging of a data block prior to its appearance as output from a functional module. Prepurging data blocks allows the NASTRAN executive system to allocate available files more efficiently which decreases problem execution time. The DMAP programmer should look for data blocks that can be prepurged and purge them as soon as it is recognized that they will not be generated.

Sometimes during the execution of a problem it is necessary to generate a data block whose status is purged. This situation can occur both in DMAP looping and in a modified restart situation. In order to generate a data block that is purged it is first necessary to <u>unpurge</u> it (i.e., change its status from purged to not generated). Unpurging is achieved by executing a PURGE instruction which references the purged data block and whose purge parameter is positive.

The PURGE instruction thus has two functions, to unpurge as well as purge data blocks depending on the value of the purge parameter and the status of the referenced data block. The following table shows what action is taken by the PURGE instruction for all combinations of input.

PURGE A/P $		
Status of data block A prior to PURGE	Value of P	Status of Data block A after PURGE
Not generated Not generated	P ≥ 0 P < 0	Not generated (i.e., no action taken) Purged
Generated Generated	P ≥ 0 P < 0	Generated (i.e., no action taken) Purged
Purged Purged	P ≥ 0 P < 0	Not generated (i.e., unpurged) Purged (i.e., no action taken)

The user may wonder why he should not prepurge all data blocks and then unpurge them when necessary in order to really assist the file allocator. One should not do this, since there is a limited amount of space in the table where the status of data blocks is kept. One may overflow this table if too many data blocks are purged at one time. Therefore, only prepurge those data blocks that can truly be prepurged.

EXAMPLE of explicit and implicit purging and prepurging.

```
BEGIN    $
MØD1     IP/A/V,Y,PX/V,Y,PY/V,Y,PB  $
SAVE     PX,PY,PB  $
PURGE    X/PX / Y/PY  $
MØD2     A/B,C,D/V,Y,PB/V,Y,PC  $
SAVE     PC  $
PURGE    C/PC  $
MØD3     B,C,D/E  $
MØD4     E/X,Y,Z  $
MØD5     X,Y,Z//  $
END      $
```

Assume that module MØD1 sets PX < 0, PY ≥ 0 and PB = 0. Assume that B is not generated by MØD2 if PB = 0. Assume that MØD2 sets PC < 0, but does not change PB.

The following table shows what happens when the above DMAP program is executed. Only modules being executed are shown in the table.

Module being executed	Input status and comments	Output status and comments
MØD1	IP-assumed generated by the input file processor	A - generated PX < 0, PY ≥ 0, PB = 0
SAVE	PX < 0, PY ≥ 0, PB = 0	Parameter values are saved for use in subsequent modules.
PURGE	X,Y-not generated PX < 0, PY ≥ 0	X - purged (i.e., prepurged) Y - not generated
MØD2	A - generated; PB = 0	B - purged (i.e., implicitly); C, D - generated; PC < 0.
SAVE	PC < 0	PB value not saved since MØD2 did not reset it.
PURGE	C - generated PC < 0	C - purged
MØD3	B, C - purged D - generated	E - generated
MØD4	E - generated	X - purged; Y - generated; Z - generated
MØD5	X - purged Y, Z - generated	Output to printer (assumed)
END		Normal termination of problem.

<u>EXAMPLE</u> of unpurging.

```
           BEGIN    $
           FILE     X=SAVE/Y=SAVE  $
           FILE     Z=APPEND $
           MØD1     IP/A  $
         / LABEL    L1  $
        |  CØND     L2,NPX  $
        |  PURGE    X/NPX  $
DMAP    |  MØD2     A/X,Y/V,Y,PX=0/V,N,NPX=0 $
loop   <   SAVE     PX,NPX $
        |  PURGE    X/PX  $
        |  LABEL    L2  $
        |  MØD3     X,Y/Z  $
         \ REPT     L1,2  $
           MØD4     Z// $
           END      $
```

Assume that MØD2 sets PX<0 and NPX≥0 the first time it is executed. Assume that MØD2 sets PX ≥ 0 and NPX < 0 the second time it is executed.

The following table shows what happened when the above DMAP program is executed. Only modules being executed are shown in the table.

Module being executed	Input status and comments	Output status and comments
MØD1	IP-assumed generated by input file processor.	A - generated
CØND	NPX = 0	Jump not executed
PURGE	X - not generated	X - not generated (i.e., no action taken)
MØD2	A - generated	X, Y - generated; PX < 0, NPX ≥ 0
SAVE	PX < 0, NPX ≥ 0	
PURGE	X - generated; PX < 0	X - purged
MØD3	X - purged; Y - generated	Z - generated
REPT	Loop count = 2	Transfer to location L1; Loop count = 1
CØND	NPX ≥ 0	Jump not executed
PURGE	X - purged; NPX ≥ 0	X - not generated (i.e., unpurged)
MØD2	A - generated	X - generated; Y - generated (note old data for Y is lost because Y not Appended); PX ≥ 0, NPX < 0
SAVE	PX ≥ 0, NPX < 0	
PURGE	X - generated; PX ≥ 0	X - generated (i.e., no action taken)
MØD3	X,Y - generated	Z - generated (note new data appended to old because Z declared appended)
REPT	Loop count = 1	Transfer to location L1; Loop count = 0
CØND	NPX < 0	Transfer to location L2
MØD3	X, Y - generated	Z - generated (i.e., appended)
REPT	Loop count = 0	Fall through to next instruction
MØD4	Z - generated	Output to printer (assumed)
END		Normal termination of problem

5.2.3.4 The CHKPNT Instruction (see Section 5.7)

The CHKPNT instruction provides the user with a means for saving data blocks for subsequent restart of his problem with a minimum amount of redundant processing. The following rules will assure the DMAP programmer of the most efficient restart.

1. Checkpoint all output data blocks from every functional module.

2. Checkpoint all data blocks mentioned in a PURGE instruction.

3. Checkpoint all secondary data blocks in an EQUIV instruction. Never checkpoint primary data blocks in an EQUIV instruction.

EXAMPLE of checkpointing.

```
BEGIN  $
MØD1   A/B,C/V,Y,P1/V,Y,P2  $
SAVE   P1,P2  $
CHKPNT B,C  $
PURGE  X,Y/P1 / Z/P2  $
CHKPNT X,Y,Z  $
EQUIV  B,BB/P1 / C,CC,D/P2  $
CHKPNT BB,CC,D  $
  .
  .
  .

END    $
```

In the example the data blocks were checkpointed as soon as possible, which is the most straightforward way, but it required three calls to the checkpoint module, which increases problem execution time. Since checkpointing usually requires a small fraction of the total execution time, it is recommended that the user use the most straightforward method to avoid trouble. The rigid format DMAP sequences have been designed for efficiency and, consequently, they appear more complex than they really are.

5.3 INDEX OF DMAP MODULE DESCRIPTIONS

Descriptions of all nonstructurally oriented Modules are contained herein, arranged alphabetically by category as indicated by the lists below. Descriptions for the structurally oriented modules are contained in Section 4 of the Programmer's Manual. They are listed here in order to provide a complete list of all NASTRAN Modules. Additional information regarding nonstructurally oriented modules is also given in Section 4 of the Programmer's Manual.

<u>Matrix Operation Modules</u> (12)
(See Section 5.4)

ADD	PARTN
ADD5	SMPYAD
DECØMP	SØLVE
FBS	TRNSP
MERGE	UMERGE
MPYAD	UPARTN

<u>Utility Modules</u> (23)
(See Section 5.5)

DIAGØNAL	PARAML
INPUT	PARAMR
INPUTT1	PRTPARM
INPUTT2	PVEC
MATGPR	SCALAR
MATPRN	SEEMAT
MATPRT	SETVAL
ØUTPUT1	TABPCH
ØUTPUT2	TABPRT
ØUTPUT3	TABPT
PARAM	TIMETEST
	VEC

<u>User Modules</u> (14)
(See Section 5.6)

DDR	MØDA
DUMMØD1	MØDB
DUMMØD2	MØDC
DUMMØD3	ØUTPUT
DUMMØD4	ØUTPUT4
INPUTT3	PARTVEC
INPUTT4	XYPRNPLT

<u>Executive Operation Modules</u> (12)
(See Section 5.7)

BEGIN	FILE
CHKPNT	JUMP
CØND	LABEL
END	PURGE
EQUIV	REPT
EXIT	SAVE

<u>Structurally Oriented Modules (68)</u>
(See Section 4 of the Programmer's Manual)

BMG	GPCYC	PLA4	SMA1
CASE	GPFDR	PLØT	SMA2
CEAD	GP1	PLTSET	SMA3
DDR1	GP2	PLTTRAN	SMP1
DDR2	GP3	PRTMSG	SMP2
DDRMM	GP4	RANDØM	SSGHT
DPD	GPSP	RBMG1	SSG1
DSCHK	GPWG	RBMG2	SSG2
DSMG1	MCE1	RBMG3	SSG3
DSMG2	MCE2	RBMG4	SSG4
EMA	MTRXIN	READ	TA1
EMG	ØFP	RMG	TRD
FA1	ØPTPR1	SCE1	TRHT
FA2	ØPTPR2	SDR1	TRLG
FRRD	PLA1	SDR2	VDR
GKAD	PLA2	SDR3	XYPLØT
GKAM	PLA3	SDRHT	XYTRAN

In the examples that accompany each description, the following notation is used:

1. Upper case letters and special symbols in the DMAP calling sequence must be punched as shown except for data block names, parameter names, and label names which are symbolic.
2. Lower case letters represent constants whose permissible values are indicated in the descriptive text.

Due to the many possible forms which may be used when writing parameters, a variety of arbitrarily selected forms will be used in the examples. This does not imply that the form used in any example is required or that it is the only acceptable form allowed.

The terms form, type, and precision are used in many functional module descriptions. By form is meant one of the following:

Form	Meaning
1	Square
2	Rectangular
6	Symmetric

By type is meant one of the following:

Type	Meaning
1	Real, single precision
2	Real, double precision
3	Complex, single precision
4	Complex, double precision

By precision is meant one of the following:

Precision Indicator	Meaning
1	Single precision numbers
2	Double precision numbers

INDEX OF DMAP MODULE DESCRIPTIONS

<u>Substructure DMAP ALTERs</u> (19)
(see Section 5.9)

5.4 MATRIX OPERATIONS MODULES

DIRECT MATRIX ABSTRACTION

I. NAME: ADD (Matrix Add)

II. PURPØSE: To compute [X] = a[A] + b[B] where a and b are scale factors.

III. DMAP CALLING SEQUENCE:

```
ADD  A,B / X / C,Y,ALPHA=(1.0,2.0) / C,Y,BETA=(3.0,4.0) $
```

IV. INPUT DATA BLØCKS:

A - Any matrix

B - Any matrix

Note: [A] and/or [B] may be purged, in which case the corresponding term in the matrix sum will be assumed null. The input data blocks must be unique.

V. ØUTPUT DATA BLØCKS:

X - matrix.

The type of [X] is maximum of the types of [A], [B], a, b. The size of [X] is the size of [A] if [A] is present. Otherwise it is that of [B].

Note: [X] cannot be purged.

VI. PARAMETERS:

ALPHA - Input-complex-single precision, default = (1.0, 0.0). This is a, the scalar multiplier for [A].

BETA - Input-complex-single precision, default = (1.0, 0.0). This is b, the scalar multiplier for [B].

Note: If Im(ALPHA) or Im(BETA) = 0.0 the corresponding parameter will be considered real.

I. NAME: ADD5 (Matrix Add)

II. PURPØSE: To compute [X] = a[A] + b[B] + c[C] + d[D] + e[E] where a, b, c, d and e are scale factors.

III. DMAP CALLING SEQUENCE:

```
ADD5  A,B,C,D,E / X / C,Y,ALPHA=(1.0,2.0) / C,Y,BETA=(3.0,4.0) / C,Y,GAMMA=(5.0,6.0) /
                      C,Y,DELTA=(7.0,8.0) / C,Y,EPSLN=(9.0,1.0) $
```

IV. INPUT DATA BLØCKS:

A, B, C, D, and E must be distinct matrices.

Note: Any of the matrices may be purged, in which case the corresponding term in the matrix sum will be assumed null. The input data blocks must be unique.

V. ØUTPUT DATA BLØCKS:

X - matrix.

The type of [X] is maximum of the types of A, B, C, D, E, a, b, c, d, e. The size of [X] is the size of the first nonpurged input.

Note: [X] cannot be purged.

VI. PARAMETERS:

ALPHA - Input-complex-single precision, default = (1.0, 0.0). This is a, the scalar multiplier for [A].

BETA - Input-complex-single precision, default = (1.0, 0.0). This is b, the scalar multiplier for [B].

GAMMA - Input-complex-single precision, default = (1.0, 0.0). This is c, the scalar multiplier for [C].

DELTA - Input-complex-single precision, default = (1.0, 0.0). This is d, the scalar multiplier for [D].

EPSLN - Input-complex-single precision, default = (1.0, 0.0). This is e, the scalar multiplier for [E].

Note: If Im(ALPHA), Im(BETA), Im(GAMMA), Im(DELTA), or Im(EPSLN) = 0.0, the corresponding parameter will be considered real.

I. DECØMP (Matrix Decomposition)

II. PURPØSE: To decompose a square matrix [A] into upper and lower triangular factors [U] and [L] .

[A] => [L][U]

III. DMAP CALLING SEQUENCE:

DECØMP A / L,U / V,Y,KSYM / V,Y,CHØLSKY / V,N,MINDIAG / V,N,DET / V,N,PØWER / V,N,SING $

IV. INPUT DATA BLØCKS:

A - A square matrix

V. ØUTPUT DATA BLØCKS:

L - Nonstandard lower triangular factor of [A].

U - Nonstandard upper triangular factor of [A].

VI. PARAMETERS:

KSYM - Input-integer, default = 1. 1, use symmetric decomposition. 0, use unsymmetric decomposition.

CHØLSKY - Input-integer, default = 0. 1, use Cholesky decomposition - matrix must be positive definite. 0, do not use Cholesky decomposition.

MINDIAG - Output-real double precision, default = 0.0D0. The minimum diagonal term of [U].

DET - Output-complex single precision, default = 0.0D0. The scaled value of the determinant of [A].

PØWER - Output-integer, default = 0. Integer PØWER of 10 by which DET should be multiplied to obtain the determinant of [A].

SING - Output-integer, default = 0. SING is set to -1 if [A] is singular.

VII. REMARKS:

1. Non-standard triangular factor matrix data blocks are used to improve the efficiency of the back substitution process in module FBS. The format of these data blocks is given in Section 2 of the Programmer's Manual.

2. The matrix manipulating utility modules should be cautiously employed when dealing with non-standard matrix data blocks.

3. If the CHØLSKY option is selected, the resulting factor (which will be written as [U]) cannot be input to FBS.

4. Variable parameters output from functional modules must be SAVEd if they are to be subsequently used. See the Executive Module SAVE description.

I. NAME: FBS (Matrix Forward-Backward Substitution)

II. PURPOSE: To solve the matrix equation [L][U][X] = ± [B] where [L] and [U] are the lower and upper triangular factors of a matrix previously obtained via Functional Module DECØMP.

III. DMAP CALLING SEQUENCE:

```
FBS     L,U,B / X / V,Y,SYM / V,Y,SIGN / V,Y,PREC / V,Y,TYPE $
```

IV. INPUT DATA BLOCKS:

L - Nonstandard lower triangular factor
U - Nonstandard upper triangular factor
B - Rectangular matrix

V. OUTPUT DATA BLOCKS:

X - Rectangular matrix having the same dimensions as [B].

VI. PARAMETERS:

SYM - Input-integer-default = 0
- 1 - matrix [L][U] is symmetric
- -1 - matrix [L][U] is unsymmetric
- 0 - reset to 1 or -1 depending upon [U] being purged or not respectively.

- Output-integer: SYM used

SIGN - Input-integer-default = 1.
- 1 - solve [L][U][X] = [B]
- -1 - solve [L][U][X] = -[B]

PREC - Input-integer-default = 0
- 1 - use single precision arithmetic
- 2 - use double precision arithmetic
- 0 - logical choice based on input and system precision flag

- Output-integer: Precision used.

TYPE - Input-integer-default = 0
- Output-integer
- 1 - output type of matrix [X] is real single precision
- 2 - output type of matrix [X] is real double precision
- 3 - output type of matrix [X] is complex single precision
- 4 - output type of matrix [X] is complex double precision
- 0 - logical choice based on input matrices

TYPE used.

VII. REMARKS:

1. Non-standard triangular factor matrix data blocks are used to improve the efficiency of the back substitution process. The format of these data blocks is given in Section 2 of the Programmer's Manual.

2. The matrix manipulating utility modules should be cautiously employed when dealing with non-standard matrix data blocks.

I. NAME: MERGE (Matrix Merge)

II. PURPØSE: To form the matrix [A] from its partitions:

$$[A] \Leftarrow \begin{array}{ccc} & \xleftrightarrow{\quad CP \quad} & \\ RP\updownarrow & \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right] & \begin{array}{l} = 0 \\ \neq 0 \end{array} \\ & \begin{array}{cc} = 0 & \neq 0 \end{array} & \end{array}$$

III. DMAP CALLING SEQUENCE:

MERGE A11,A21,A12,A22,CP,RP / A / V,Y,SYM / V,Y,TYPE / V,Y,FØRM $

IV. INPUT DATA BLØCKS:

A11 - Matrix

A21 - Matrix

A12 - Matrix

A22 - Matrix

CP - Column partitioning vector (see below) - Single precision column vector.

RP - Row partitioning vector (see below) - Single precision column vector.

Notes:

1. Any or all of [A11], [A12], [A21], [A22] can be purged. When all are purged this implies [A] = [0].
2. {RP} and {CP} may not both be purged.
3. See Remarks for meaning when either of {RP} or {CP} is purged.
4. [A11], [A12], [A21], [A22] must be unique matrices.

V. ØUTPUT DATA BLØCKS:

A - merged matrix from [A11], [A12], [A21], [A22]

Notes: [A] cannot be purged.

VI. PARAMETERS:

SYM - Input-integer, default = -1. SYM < 0, {CP} is used for {RP}. SYM $\geq$ 0, {CP} and {RP} are distinct.

TYPE - Input-integer, default = 0. Type of [A] - see Remark 4

FØRM - Input-integer, default = 0. Form of [A] - see Remark 3

VII. REMARKS:

1. MERGE is the inverse of PARTN in the sense that if [A11], [A12], [A21], [A22] were produced by PARTN using {RP}, {CP}, FØRM, SYM, and TYPE from [A], MERGE will produce [A]. See PARTN for options on {RP}, {CP} and SYM.
2. All input data blocks must be distinct.
3. When FØRM = 0, a compatible matrix [A] results as shown in the following table:

		Form of A22		
		Square	Rectangular	Symmetric
Form of A11	Square	Square	Rectangular	Rectangular
	Rectangular	Rectangular	Rectangular	Rectangular
	Symmetric	Rectangular	Rectangular	Symmetric

4. If TYPE = 0, the type of the output matrix will be the maximum type of [A11], [A12], [A21] and [A22].

I. NAME: MPYAD (Matrix Multiply and Add)

II. PURPOSE: MPYAD performs the multiplication of two matrices and, optionally, addition of a third matrix to the product. By means of parameters, the user may compute $\pm$ [A][B] $\pm$ [C] = [X], or $\pm$ $[A]^T$[B] $\pm$ [C] = [X].

III. DMAP CALLING SEQUENCE:

MPYAD A,B,C / X / V,N,T / V,N,SIGNAB / V,N,SIGNC / V,N,PREC $

IV. INPUT DATA BLOCKS:

A - Left hand matrix in the matrix product [A][B]
B - Right hand matrix in the matrix product [A][B]
C - Matrix to be added to [A][B]

Notes:

1. If no matrix is to be added, [C] must be purged.
2. [A], [B], [C] must be physically different data blocks.
3. [A] and [B] must not be purged.

V. OUTPUT DATA BLOCKS:

X - Matrix resulting from the MPYAD operation.

Note: [X] may not be purged.

VI. PARAMETERS:

T - Integer-input, no default. T = { 1, perform $[A]^T$[B]; 0, perform [A][B] }

SIGNAB - Integer-input,default = 1. SIGNAB = { +1, perform [A][B]; 0, omit [A][B]; -1, perform -[A][B] }

SIGNC - Integer-input, default = 1. SIGNC = { +1, add [C]; 0, omit [C]; -1, substract [C] }

PREC - Integer-input, default = 0. PREC = { 1, elements of [X] will be output in single-precision; 2, elements of [X] will be output in double-precision; 0, logical choice based on input and system precision flag }

VII. EXAMPLES:

1. $[X] = [A][B]+[C]$ ([X] see notes)

   MPYAD A,B,C / X / C,N,0 $

2. $[X] = [A]^T[B]-[C]$ ([X] single-precision)

   MPYAD A,B,C / X / C,N,1 / C,N,1 / C,N,-1 / C,N,1 $

3. $[X] = -[A][B]$ ([X] see notes)

   MPYAD A,B, / X / C,N,0 / C,N,-1 $

Notes: The precision of [X] is determined from the input matrices in that if anyone of these matrices is specified as double precision, then [X] will also be double precision. If the precision for the input matrices is not specified, the precision of the system flag will be used.

I. NAME: PARTN (Matrix Partition)

II. PURPØSE: To partition [A] into [A11], [A12], [A21] and [A22]:

$$
[A] \Longrightarrow
\begin{array}{c}
\\
\mathrm{RP} \updownarrow
\end{array}
\begin{array}{cc}
\multicolumn{2}{c}{\longleftarrow \mathrm{CP} \longrightarrow} \\
\left[\begin{array}{c|c}
A11 & A12 \\ \hline
A21 & A22
\end{array}\right] & \begin{array}{l} = 0 \\ \neq 0 \end{array} \\
\begin{array}{cc} = 0 & \neq 0 \end{array} &
\end{array}
$$

III. DMAP CALLING SEQUENCE:

PARTN A,CP,RP / A11,A21,A12,A22 / V,Y,SYM / V,Y,TYPE / V,Y,F11 / V,Y,F21 / V,Y,F12 / V,Y,F22 $

IV. INPUT DATA BLØCKS:

A - Matrix to be partitioned.

CP - Column partitioning vector - single precision column vector.

RP - Row partitioning vector - single precision column vector.

V. ØUTPUT DATA BLØCKS:

A11 - Upper left partition of [A]

A21 - Lower left partition of [A]

A12 - Upper right partition of [A]

A22 - Lower right partition of [A]

Notes: 1. Any or all output data blocks may be purged.
2. For size of outputs see METHØD section below.

VI. PARAMETERS:

SYM - Input-integer, default = -1. SYM chooses between a symmetric partition and one unsymmetric partition. If SYM < 0, {CP} is used as {RP}. If SYM $\geq$ 0, {CP} and {RP} are distinct.

TYPE - Input-integer, default = 0. Type of output matrices - see Remark 8

F11 - Input-integer, default = 0. Form of [A11].
F21 - Input-integer, default = 0. Form of [A21].
F12 - Input-integer, default = 0. Form of [A12].
F22 - Input-integer, default = 0. Form of [A22].

See Remark 7

VII. METHØD:

Let NC = number of nonzero terms in {CP}.

Let NR = number of nonzero terms in {RP}.

Let NRØWA = number of rows in [A].

Let NCØLA = number of columns in [A].

Case 1 {CP} purged and SYM $\geq$ 0.

[A11] is a (NRØWA-NR) by NCØLA matrix.

[A21] is a NR by NCØLA matrix.

[A12] is not written.

[A22] is not written.

$$[A] \rightarrow \left[\begin{array}{c} A11 \\ \hline A21 \end{array}\right]$$

CASE 2 {RP} purged and SYM $\geq$ 0
[A11] is a NRØWA by (NCØLA - NC) matrix.
[A21] is not written.
[A12] is a NRØWA by NC matrix.
[A22] is not written.

$$[A] \rightarrow [A11 \mid A12]$$

CASE 3 SYM < 0 ({RP} must be purged)
[A11] is a (NRØWA - NC) by (NCØLA - NC) matrix.
[A21] is a NC by (NCØLA - NC) matrix.
[A12] is a (NRØWA - NC) by NC matrix.
[A22] is a NC by NC matrix.

$$[A] \rightarrow \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right]$$

CASE 4 neither {CP} nor {RP} purged and SYM $\geq$ 0
[A11] is a (NRØWA - NR) by (NCØLA - NC) matrix.
[A21] is a NR by (NCØLA - NC) matrix.
[A12] is a (NRØWA - NR) by NC matrix.
[A22] is a NR by NC matrix.

$$[A] \rightarrow \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right]$$

VIII. REMARKS:

1. *If [A] is purged, PARTN will cause all output data blocks to be purged.*
2. If {CP} is purged, [A] is partitioned as follows:

$$[A] \Rightarrow \left[\begin{array}{c} A11 \\ \hline A21 \end{array}\right]$$

3. If {RP} is purged and SYM $\geq$ 0, [A] is partitioned as follows:

$$[A] \Rightarrow [A11 \mid A12]$$

4. If {RP} is purged and SYM < 0, [A] is partitioned as follows:

$$[A] \Rightarrow \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right]$$

where {CP} is used as both the row and column partitioner.
5. {RP} and {CP} cannot both be purged.
6.

$$[A] \Rightarrow \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right]$$

Let [A] be a m by n order matrix.
Let {CP} be a n order row matrix containing q zero elements.
Let {RP} be a m order column vector containing p zero element.

Partition [A11] will consist of all elements A_{ij} of [A] for which $CP_j = RP_i = 0$ in the same order as they appear in [A].

Partition [A12] will consist of all elements A_{ij} of [A] for which $CP_j \neq 0$ and $RP_i = 0$ in the same order as they appear in [A].

Partition [A21] will consist of all elements A_{ij} or [A] for which CP_j = 0 and $RP_i \neq 0$ in the same order as they appear in [A].

Partition [A22] will consist of all elements A_{ij} of [A] for which CP_j = 0 and $RP_i \neq 0$ in the same order as they appear in [A].

7. If the defaults for F11, F21, F12 or F22 are used, the corresponding matrix will be output with a compatible form entered in the trailer.

8. If TYPE = 0, the type of the output matrices will be the type of the input matrix [A].

IX. <u>EXAMPLES</u>:

1. Let [A], {CP} and {RP} be defined as follows:

$$[A] = \begin{bmatrix} 1.0 & 2.0 & 3.0 & 4.0 \\ 5.0 & 6.0 & 7.0 & 8.0 \\ 9.0 & 10.0 & 11.0 & 12.0 \end{bmatrix} , \quad \{CP\} = \begin{Bmatrix} 1.0 \\ 0.0 \\ 1.0 \\ 1.0 \end{Bmatrix} , \quad \{RP\} = \begin{Bmatrix} 0.0 \\ 0.0 \\ 1.0 \end{Bmatrix}$$

Then, the DMAP instruction

```
PARTN  A,CP,RP / A11,A21,A12,A22 / C,N,1 $
```

will create the real double precision matrices

$$[A11] = \begin{bmatrix} 2.0 \\ 6.0 \end{bmatrix} , \ F11 = 2 \qquad [A12] = \begin{bmatrix} 1.0 & 3.0 & 4.0 \\ 5.0 & 7.0 & 8.0 \end{bmatrix} , \ F12 = 2$$

$$[A21] = [10.0] , \ F21 = 1 \qquad [A22] = [9.0 \quad 11.0 \quad 12.0] , \ F22 = 2$$

2. If, in Example 1, the DMAP instruction were written as

```
PARTN  A,CP, / A11,A21,A12,A22 / C,N,1 $
```

the resulting matrices would be

$$[A11] = \begin{bmatrix} 2.0 \\ 6.0 \\ 10.0 \end{bmatrix} \qquad [A12] = \begin{bmatrix} 1.0 & 3.0 & 4.0 \\ 5.0 & 7.0 & 8.0 \\ 9.0 & 11.0 & 12.0 \end{bmatrix}$$

[A21] = purged [A22] = purged

3. If, in Example 1, the DMAP instruction were written as

```
PARTN  A,,RP / A11,A21,A12,A22 / C,N,1 $
```

the resulting matrices would be

$$[A11] = \begin{bmatrix} 1.0 & 2.0 & 3.0 & 4.0 \\ 5.0 & 6.0 & 7.0 & 8.0 \end{bmatrix} \qquad [A12] = \text{purged}$$

$$[A21] = [9.0 \quad 10.0 \quad 11.0 \quad 12.0] \qquad [A22] = \text{purged}$$

DIRECT MATRIX ABSTRACTION

I. NAME: SMPYAD (Matrix Series Multiply and Add)

II. PURPOSE: To multiply a series of matrices together:

$$[X] = [A][B][C][D][E] \pm [F] .$$

III. DMAP CALLING SEQUENCE:

```
SMPYAD  A,B,C,D,E,F / X / C,N,n / V,N,SIGNX / V,N,SIGNF / V,N,PX / V,N,TA /
        V,N,TB / V,N,TC / V,N,TD $
```

IV. INPUT DATA BLOCKS:

A, B, C, D, E - Up to 5 matrices to be multiplied together, from left to right.

F - Matrix to be added to the above product.

Notes:

1. If one of the five multiplication matrices is required in the product (see parameter n below) and is purged, the multiplication will not be done.
2. If the [F] matrix is purged, no matrix will be added to the product.

V. OUTPUT DATA BLOCKS:

X - Resultant matrix (may not be pre-purged).

VI. PARAMETERS:

1. n = number of matrices involved in the product, counting from the left (integer, input)
2. SIGNX = sign of the product matrix (e.g., [A][B][C][D][E])
   = 1 for plus, -1 for minus (integer, input)
3. SIGNF = sign of the matrix to be added to the product matrix (integer, input)
   = 1 for plus, -1 for minus
4. PX = output precision of the final result (integer, input)
   = 1 for single-precision, 2 for double-precision, 0 logical choice based on input matrices.
5. TA, TB, TC, TD = transpose indicators for the [A],[B],[C], and [D] matrices (1 if transposed matrix to be used in the product; 0 if untransposed) - (integer, input)

Note:

All the parameters except n have default values as follows:

SIGNX = 1 (sign of product is plus)

SIGNF = 1 (sign of added matrix is plus)

PX = 0 (logical choice based on input matrices)

TA, TB, TC, TD = 0 (use untransposed [A],[B],[C], and [D] matrices in the product)

VII. METHOD:

The method is the same as for the MPYAD module with the following additional remarks:

1. None of the matrices may be diagonal.

2. Except for the final product, all intermediate matrix products are generated in double-precision.

3. The matrices are post-multiplied together from right-to-left, i.e., the first product calculated is the product of matrix n-1 and matrix n.

VIII. EXAMPLES:

1. To compute $[X] = [A][B]^T[C]-[F]$, use

```
SMPYAD   A,B,C,,,F / X / C,N,3 / C,N,1 / C,N,-1 / C,N,0 / C,N,0 / C,N,1 $
```

2. To compute $[Z] = -[U]^T[V]^T[W]^T[X]^T[Y]$, use

```
SMPYAD   U,V,W,X,Y, / Z / C,N,5 / C,N,-1 / C,N,0 / C,N,0 / C,N,1 / C,N,1 /
         C,N,1 / C,N,1 $
```

I. NAME: SØLVE (Linear System Solver)

II. PURPOSE: To solve the Matrix Equation

$$[A][X] = \pm [B]$$

III. DMAP CALLING SEQUENCE:

SØLVE A,B / X / V,Y,SYM / V,Y,SIGN / V,Y,PREC / V,Y,TYPE $

IV. INPUT DATA BLOCKS:

A - square real or complex matrix

B - rectangular real or complex matrix (if purged, the identity matrix is assumed).

V. OUTPUT DATA BLOCKS:

X - A rectangular matrix

Note: A standard matrix trailer will be written, identifying [X] as a rectangular matrix with the same dimensions as [B] and the type specified.

VI. PARAMETERS:

SYM - Input-integer, default = 0
- -1 - use unsymmetric decomposition
- 1 - use symmetric decomposition
- 0 - logical choice based on input matrices

- Output-integer: SYM used.

SIGN - Input-integer, default = 1
- 1 - solve [A][X] = [B]
- -1 - solve [A][X] = -[B]

PREC - Input-integer, default = 0
- 0 - logical choice based on input
- 1 - use single precision arithmetic
- 2 - use double precision arithmetic

- Output-integer: PREC used.

TYPE - Input-integer, default = 0

- 0 - logical choice based on input
- 1 - output type of matrix [X] is real single precision
- 2 - output type of matrix [X] is real double precision
- 3 - output type of matrix [X] is complex single precision
- 4 - output type of matrix [X] is complex double precision

- Output-integer — TYPE used.

VII. METHOD:

Depending on the SYM flag and the type of [A], one of subroutines SDCØMP, DECØMP, or CDCØMP is called to form [A] = [L][U].

One of FBS or GFBS is then called to solve [L][Y] = $\pm$ [B] and [U][X] = [Y], as appropriate.

I. NAME: TRNSP (Matrix Transpose)

II. PURPØSE: To form $[A]^T$ given [A].

III. DMAP CALLING SEQUENCE:

TRNSP A/X $

IV. INPUT DATA BLØCKS:

A - Any matrix data block.

Note: If [A] is purged, TRNSP will cause [X] to be purged.

V. ØUTPUT DATA BLØCKS:

X - The matrix transpose of [A]

Note: [X] cannot be purged.

VI. PARAMETERS: None.

VII. REMARKS:

1. Transposition of large full matrices is very expensive and should be avoided if possible (see Section 2.1.4 of the Theoretical Manual).

2. TRNSP currently uses an algorithm which assumes that the matrix is dense. This algorithm is extremely inefficient for sparce matrices. Sparce matrices should be transposed by using MPYAD.

I. NAME: UMERGE (Merges two matrices based on USET)

II. PURPØSE: To merge two column matrices (such as load vectors or displacement vectors) into a single matrix.

III. DMAP CALLING SEQUENCE:

UMERGE USET,PHIA,PHIØ / PHIF / V,N,MAJØR=F / V,N,SUBO=A / V,N,SUB1=L $

IV. INPUT DATA BLØCKS:

USET - Uset [or U-set (Dynamics)]

PHIA
PHIØ Any matrices

Note: 1. USET may not be purged.

2. PHIA or PHIØ may be purged in which case their respective elements will be zero.

3. PHIA, PHIØ and PHIF must be related by the following matrix equation

$$\left\{\frac{\text{PHIA}}{\text{PHIØ}}\right\} \Longrightarrow \left\{\text{PHIF}\right\}$$

V. ØUTPUT DATA BLØCKS:

PHIF - matrix

Note: PHIF must not be purged.

VI. PARAMETERS:

MAJØR - BCD value from table on page 5.3-17 (Input, no default)

SUBO - BCD value from table on page 5.3-17 (Input, no default)

SUB1 - BCD value from table on page 5.3-17 (Input, no default)

Note: The set equation MAJØR = SUBO + SUB1 should hold.

I. NAME: UPARTN (Partitions a matrix based on USET)

II. PURPØSE: To perform symmetric partitioning of displacement method matrices (particularly to allow user splitting of long running modules such as SMP1).

III. DMAP CALLING SEQUENCE:

UPARTN USET,KII / KJJ,KLJ,KJL,KLL / V,N,MAJØR=I / V,N,SUBO=J / V,N,SUB1=L $

IV. INPUT DATA BLØCKS:

USET - U-set [or U-set (Dynamics)]

KII - Any displacement matrix

Note: 1. USET may not be purged

2. KII may be purged in which case UPARTN will simply return, causing the output matrices to be purged.

V. ØUTPUT DATA BLØCKS:

$$\left.\begin{matrix}\text{KJJ}\\ \text{KLJ}\\ \text{KJL}\\ \text{KLL}\end{matrix}\right\}\ \text{matrix partitions}$$

Note: 1. Any or all output data block(s) may be purged.

2. UPARTN forms:

$$\left[K_{ii}\right] \Longrightarrow \left[\begin{array}{c|c} K_{jj} & K_{j\ell} \\ \hline K_{\ell j} & K_{\ell\ell} \end{array}\right]$$

VI. PARAMETERS:

MAJØR - BCD value from table on page 5.3-17 (Input, no default)

SUBO - BCD value from table on page 5.3-17 (Input, no default)

SUB1 - BCD value from table on page 5.3-17 (Input, no default)

Note: The set equation MAJØR = SUBO + SUB1 should hold.

VII. EXAMPLE:

In Rigid Format 3 module SMP1 performs the following calculations:

SMP1 partitions the constrained stiffness and mass matrices

$$\left[K_{ff}\right] \Longrightarrow \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

and

$$\left[M_{ff}\right] \Longrightarrow \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

solves for transformation matrix

$$[G_o] = -[K_{oo}]^{-1} [K_{oa}]$$

and performs the matrix reductions

$$[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}]^T [G_o]$$

and

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}]^T [G_o] + [G_o]^T [M_{oa}] + [G_o]^T [M_{oo}] [G_o]$$

Step 1 can be performed by two applications of UPARTN:

```
UPARTN USET,KFF / KAAB,KØA,,KØØ / C,N,F / C,N,A / C,N,Ø $
UPARTN USET,MFF / MAAB,MØA,,MØØ / C,N,F / C,N,A / C,N,Ø $
```

Step 2 can be performed by SØLVE

```
SØLVE  KØØ,KØA / GØ / C,N,1 / C,N,-1 $
```

KAA and MAA can be computed by a sequence of applications of the MPYAD module.

Note that checkpoints can be inserted as desired to breakup a long running module into several smaller steps.

5.5 UTILITY MODULES

Utility modules are an arbitrary sub-division of the Functional Modules and are used to output matrix and table data blocks and to manipulate parameters.

The data block names corresponding to the various matrix and table data blocks used in the Rigid Format DMAP sequences may be found in Section 3 or in the NASTRAN mnemonic dictionary, Section 7.

I. NAME: DIAGØNAL (Strip diagonal from matrix)

II. PURPOSE: To remove the real part of the diagonal from a matrix, raise each term to a specified power, and output a column vector or square symmetric matrix.

III. DMAP CALLING SEQUENCE:

```
DIAGØNAL  A/B/C,Y,ØPT=CØLUMN/V,Y,PØWER=1. $
```

IV. INPUT DATA BLOCKS:

A - can be any square or diagonal matrix.

V. OUTPUT DATA BLOCKS:

B - is either a real column vector or symmetric matrix containing the diagonal of A.

VI. PARAMETERS:

OPT - Input-bcd, default=CØLUMN

='CØLUMN' - produces column vector output (labeled as a general rectangular matrix)

='SQUARE' - produces square matrix (labeled a symmetric matrix)

POWER - Input-real single precision, default = 1. Exponent to which the real part of each diagonal element is raised.

VII. REMARKS:

1. The module checks for special cases of PØWER=0.,0.5,1.0,and 2.
2. The precision of the output matrix matches the precision of the input matrix.

I. NAME: INPUT (Input Generator)

II. PURPØSE: Generates the majority of the bulk data cards for selected academic problems. Used in many of the official NASTRAN Demonstration Problems.

III. DMAP CALLING SEQUENCE:

INPUT I1,I2,I3,I4,I5 / Ø1,Ø2,Ø3,Ø4,Ø5 / C,N,a / C,N,b / C,N,c $

IV. INPUT DATA BLØCKS:

Appropriate preface outputs.

V. ØUTPUT DATA BLØCKS:

Appropriate for the problem being generated.

VI. PARAMETERS:

The three parameters are used in conjunction with data read by INPUT from the input stream to define the problem being generated.

VII. METHØD:

Since INPUT is intimately related to bulk data card input, a detailed description of this module has been placed in Section 2.6.

I. NAME: INPUTT1 (Reads User Tapes)
(The companion module is ØUTPUT1)

II. PURPØSE: Recovers up to five data blocks from a user tape and checks the user tape label where the expected format is that created by Utility Module ØUTPUT1. Also used to position the user tape (including handling or multiple reel tapes) prior to reading the data blocks. Multiple calls are allowed. A message is written for each data block successfully recovered and after each tape reel switch.*

III. DMAP CALLING SEQUENCE:
INPUTT1 / DB1,DB2,DB3,DB4,DB5 / V,N,P1 / V,N,P2 / V,N,P3 $

IV. INPUT DATA BLØCKS:
Input data blocks are not used in this module call statement.

V. ØUTPUT DATA BLØCKS:
DBi - Data blocks which will be recovered from one of the NASTRAN permanent tape files INPT, INP1, INP2, through INP9. Any or all of the output data blocks may be purged. Only non-purged data blocks will be taken from the tape. The data blocks will be taken sequentially from the tape starting from a position determined by the value of the first parameter. Note that the output data block sequence A,B,,, is the same as ,A,,B, or ,,,A,B.

*Currently user tape reel switching is available on IBM 360/370 and Univac 1108 only.

VI. PARAMETERS: The meaning of the first parameter (P1) value is given in the table below. (The default value is 0).

P1 Value	Meaning
+n	Skip forward n data blocks before reading.
0	Data blocks are read starting at the current position. The current position for the first use of a tape is at the label (P3). Hence, P3 counts as one Data Block.
-1	Rewind before reading, position tape past label (P3).
-2	Mount new reel and position new reel past label (P3) before reading.
-3	Print data block names and then rewind before reading.
-4	Current tape reel will have an end-of-file mark written on it, will be rewound and dismounted and then a new tape reel will be mounted with ring out and rewound before reading the data blocks. This option should be used when a call to INPUTT1 is preceded by a call to ØUTPUT1 using the same User Tape.
-5	Search user tape for first version of data block (DBi) requested. If any (DBi) are not found, fatal termination occurs.
-6	Search user tape for final version of data block (DBi) requested. If any (DBi) are not found, fatal termination occurs.
-7	Search user tape for first version of data block (DBi) requested. If any (DBi) are not found, warning message is written on the output file and run continues.
-8	Search user tape for final version of data block (DBi) requested. If any (DBi) are not found, warning message is written on the output file and run continues.

The second parameter (P2) for this module is the User Tape Code shown in the table below. (The default value is 0).

User Tape Code	GINØ File Name
0	INPT
1	INP1
2	INP2
3	INP3
4	INP4
5	INP5
6	INP6
7	INP7
8	INP8
9	INP9

The third parameter (P3) for this module is used as the User Tape Label for NASTRAN identification. The label (P3) is an alphanumeric variable of eight characters or less (the first character must be alphabetic). The value of P3 must match a corresponding value on the user tape. The comparison of P3 and the value on the user tape is dependent on the value of P1 as shown in the table below. (The default value for P3 is XXXXXXXX).

P1 Value	Tape Label Checked
+n	No
0	No
-1	Yes
-2	Yes (On new reel)
-3	Yes (Warning Check)
-4	Yes (On new reel)
-5	Yes
-6	Yes
-7	Yes
-8	Yes

VII. EXAMPLES: (Most examples use the default value for P2 and P3 which means the use of permanent NASTRAN tape file INPT and NASTRAN user tape label of XXXXXXXX)

1. INPUTT1 / A,B,,, / $

   Read data blocks A and then B from user tape INPT starting from wherever INPT is currently positioned. If this is the first module to manipulate INPT, the tape will automatically be initially positioned at the beginning of the user tape label. In this case the first parameter of INPUTT1 must be set to either one (1) to skip past the label or minus one (-1) to rewind the tape and position it at the beginning of the first data block (A).

2. INPUTT1 / ,,,, / C,N,-1 / C,N,3 $

   Rewind INP3 and check user tape label.

3. INPUTT1 / A,,,, / C,N,-2 $

   Mount a new reel of tape (without write ring). for INPT and read data block A from the first file position. The label of the new reel of tape will be checked.

4. INPUTT1 / ,,,, / C,N,-2 $
   INPUTT1 / A,,,, / C,N,0 $

   This is equivalent to example 3.

5. INPUTT1 / A,B,C,D,E / C,N,14 $

   Starting from the current position, skip forward 14 data blocks on INPT and read the next five data blocks into A,B,C,D, and E. Do not check the user tape label.

6. INPUTT1 / ,,,, / C,N,-3 $
   INPUTT1 / A,B,C,D,E / C,N,14 $

   A complete list of data block names will be provided including a warning check of the user tape label. Then, it will be the same as example 5 only if the current position in that example were at the beginning of the first data block.

7. INPUTT1 / ,,,, / C,N,-2 $
   INPUTT1 / ,,,, / C,N,-3 $
   INPUTT1 / A,B,,, / C,N,14 $

   Mount a new reel of tape for INPT and check the new reel's label. Print the names of all data blocks on the new tape and give a warning check for tape label. Read the 15th and 16th data blocks into A and B. INPT will end up positioned at the beginning of the 17th data block if present.

VIII. MORE DIFFICULT EXAMPLES USING BOTH INPUTT1 and OUTPUT1:

Example 1:

(a) Objectives:

(1) Obtain printout of the names of all data blocks on INPT.

(2) Skip past the first four data blocks, replace the next two with data blocks A and B, and retain the next three data blocks.

(3) Obtain printout of the names of all data blocks on INPT after (2) has been done.

(b) DMAP Sequence:

```
BEGIN $                                  (1)
INPUTT1  / ,,,, / C,N,-3 $               (2)
INPUTT1  / ,,T1,T2,T3 / C,N,6 $          (3)
INPUTT1  / ,,,, / C,N,-1 $               (4)
ØUTPUT1  A,B,T1,T2,T3 // C,N,4 $         (5)
ØUTPUT1, ,,,, // C,N,-3 $                (6)
END $                                    (7)
```

(c) Remarks:

(1) DMAP sequence (2) accomplishes objective (1) and rewinds INPT.

(2) DMAP sequence (3) recovers data blocks 7, 8, and 9. This is necessary because they would be effectively destroyed by anything written in front of them on INPT.

(3) DMAP sequence (4) rewinds INPT.

(4) DMAP sequence (5) accomplishes objective (2).

(5) DMAP sequence (6) accomplishes objective (3) and leaves INPT positioned after the ninth file, ready to receive additional data blocks.

(6) Note that INPUTT1 is used whenever possible to avoid the possibility of mistakenly writing on INPT prematurely.

Example 2:

(a) Objectives:

(1) Write data blocks A, B, and C on INPT.

(2) Obtain printout of the names of all data blocks on INPT after step (1).

(3) Make two copies of the tape created in (1).

(4) Add data blocks D and E to one of the tapes.

(5) Obtain the names of all data blocks on INPT after (4).

(b) DMAP Sequence:

```
BEGIN $                              (1)
ØUTPUT1 A,B,C,, // C,N,-1 $          (2)
ØUTPUT1, ,,,, // C,N,-3 $            (3)
ØUTPUT1 A,B,C,, // C,N,-2 $          (4)
ØUTPUT1 A,B,C,, // C,N,-2 $          (5)
ØUTPUT1 D,E,,, // C,N,0 $            (6)
ØUTPUT1, ,,,, // C,N,-3 $            (7)
END $                                (8)
```

(c) Remarks:

(1) DMAP Sequence (2) accomplishes objective (1).

(2) DMAP sequence (3) accomplishes objective (2). The statement INPUTT1 / ,,,, / C,N,-3 $ will do the same thing and add a rewind.

(3) Statements (4) and (5) accomplish objective (3).

(4) Statement (6) accomplishes objective (4) where the third tape is used.

(5) Statement (7) accomplishes objective (5). The statement INPUTT1 / ,,,, / C,N,-3 $ will do the same thing and add a rewind.

(6) On machines where tape reel switching is not implemented, the second parameter can be used as follows:

```
BEGIN $
ØUTPUT1  A,B,C,, // C,N,-1 $
ØUTPUT1, ,,,, // C,N,-3 $
ØUTPUT1  A,B,C,, // C,N,-1 / C,N,1 $
ØUTPUT1  A,B,C,, // C,N,-1 / C,N,2 $
ØUTPUT1  D,E,,, // C,N,0 / C,N,2 $
ØUTPUT1, ,,,, // C,N,-3 / C,N,2 $
END $
```

I. <u>NAME</u>: INPUTT2 (Reads User-Written FØRTRAN Tapes)
(The companion module is ØUTPUT2)

II. <u>PURPØSE</u>: Recovers up to five data blocks from a FØRTRAN-written user tape. This tape may be written either by a user-written FØRTRAN program or by the companion module ØUTPUT2. The Programmer's Manual describes the format of the tape which must be written in order to be readable by INPUTT2.

III. <u>DMAP CALLING SEQUENCE</u>:
INPUTT2 / DB1,DB2,DB3,DB4,DB5 / V,N,P1 / V,N,P2 / V,N,P3 $

IV. <u>INPUT DATA BLØCKS</u>:
Input data blocks are not used in this module call statement.

V. <u>ØUTPUT DATA BLØCKS</u>:
DBi - Data blocks which will be recovered from one of the NASTRAN FØRTRAN tape files UT1, UT2, through UT5. Any or all of the output data blocks may be purged. Only non-purged data blocks will be taken from the tape. The data blocks will be taken sequentially from the tape starting from a position determined by the value of the first parameter. Note that the output data block sequence A,B,,, is the same as ,A,,B, or ,,,A,B .

VI. PARAMETERS: The meaning of the first parameter (P1) value is given in the table below. (The default value is 0).

P1 Value	Meaning
+n	Skip forward n data blocks before reading.
0	Data blocks are read starting at the current position. The current position for the first use of a tape is at the label (P3). Hence, P3 counts as one Data Block.
-1	Rewind before reading, position tape past label (P3).
-3	Print data block names and then rewind before reading.
-5	Search user tape for first version of data block (DBi) requested. If any (DBi) are not found, fatal termination occurs.
-6	Search user tape for final version of data block (DBi) requested. If any (DBi) are not found, fatal termination occurs.
-7	Search user tape for first version of data block (DBi) requested. If any (DBi) are not found, warning message is written on the output file and run continues.
-8	Search user tape for final version of data block (DBi) requested. If any (DBi) are not found, warning message is written on the output file and run continues.

The second parameter (P2) for this module is the FØRTRAN unit number from which the data blocks will be read. This unit is not required to be a physical tape. The allowable values for this parameter are highly machine and installation dependent. Reference should be made to Section 4 of the Programmer's Manual for a discussion of this problem. (The default value for P2 is 0).

User Tape Code	FØRTRAN File Name
11	UT1
12	UT2
13	UT3
14	UT4
15	UT5

The third parameter (P3) for this module is used as the FØRTRAN User Tape Label for NASTRAN identification. The label (P3) is an alphanumeric variable of eight characters or less (the first character must be alphabetic). The value of P3 must match a corresponding value on the FØRTRAN User Tape. The comparison of P3 and the value on the User Tape is dependent on the value of P1 as shown in the table below. (The default value for P3 is XXXXXXXX).

P1 Value	Tape Label Checked
+n	No
0	No
-1	Yes
-3	Yes (Warning Check)
-5	Yes
-6	Yes
-7	Yes
-8	Yes

VII. EXAMPLES:

INPUTT2 is intended to have the same logical action as the GINØ User Tape module INPUTT1 except for tape reel switching. It is therefore suggested that the examples shown under module INPUTT1 be used for INPUTT2 as well, excepting the ones involving tape reel switching.

I. NAME: MATGPR (Displacement Approach Matrix Printer)

II. PURPØSE: Prints matrices generated by the Displacement Approach. External grid point identification of each nonzero element is also printed.

III. DMAP CALLING SEQUENCE:

A. For matrices generated in Rigid Formats 1-6 or matrices generated in Rigid Formats 7-12 prior to module GKAD (or GKAM):

MATGPR GPL,USET,SIL,M // C,N,c / C,N,r $

B. For matrices generated in Rigid Formats 7-12 after module GKAD (or GKAM):

MATGPR GPLD,USETD,SILD,M // C,N,c / C,N,r $

IV. INPUT DATA BLØCKS:

GPL - Grid Point List
GPLD - Grid Point List (Dynamics)
USET - U-set
USETD - U-set (Dynamics)
SIL - Scalar Index List
SILD - Scalar Index List (Dynamics)
M - Any displacement approach matrix

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS:

1. c-row size (number of columns) - must be the appropriate BCD value from the table below. (Input, no default)

2. r-column size (number of rows) - must be the appropriate BCD value from the table below. If not specified, it will be assumed that r=c. (Input, default = X which implies r=c)

MATGPR parameter value	Means matrix is same size as
M	U_m
Ø	U_o
R	U_r
SG	U_s (specified on GRID card)
SB	U_s (specified on SPC card)
L	U_ℓ
A	U_a
F	U_f
S	U_s (union of SG and SB)
N	U_n

G	U_g
E	U_e
P	U_p
NE	ξ_o
FE	ξ_i
D	U_d
H	U_h

Notes:

1. See Section 3.3 of the Theoretical Manual for a discussion of set notation.
2. If the value specified for c is not in the above table, the matrix will not be printed.
3. The user must know which sets correspond to the rows and columns of the matrix he wishes to print. This is usually apparent from the DMAP name of the matrix data block.

VII. REMARKS:

1. When using the form specified in IIIA, this module may not be scheduled until after GP4 since data blocks generated by GP4 are required inputs. When using the form specified in IIIB, this module may not be scheduled until after DPD since data blocks generated by DPD are required inputs.
2. If [M] is purged, no printing will be done.
3. The non-zero terms of the matrix will be printed along with the external grid point and component identification numbers corresponding to the row and column position of each term.

I. NAME: MATPRN (General Matrix Printer)

II. PURPØSE: To print general matrix data blocks.

III. DMAP CALLING SEQUENCE:

```
MATPRN  M1,M2,M3,M4,M5 // $
```

IV. INPUT DATA BLØCKS:

Mi - Matrix data blocks, any of which may be purged.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS: None

VII. ØUTPUT:

The nonzero band of each column of each input matrix data block is unpacked and printed in single precision.

VIII. NØTES:

1. Any or all input data blocks can be purged.
2. If any data block is not matrix type, the TABPT routine will be called.

IX. EXAMPLES:

```
1. MATPRN   KGG,,,, // $
2. MATPRN   KGG,PL,PG,BGG,UPV // $
```

I. NAME: MATPRT (Matrix Printer)

II. PURPOSE: To print matrix data blocks associated with grid points only.

III. DMAP CALLING SEQUENCE:

```
MATPRT  X // C,N,rc / C,N,y $
```

IV. INPUT DATA BLOCK:

X - matrix data block to be printed. If [X] is purged, then nothing is done.

V. OUTPUT DATA BLOCKS: None

VI. PARAMETERS:

1. rc - indicates whether [X] is stored by rows (rc = 1) or by columns (rc = 0) (integer, input, default value = 0).

2. y - indicates whether [X] is to be printed even if not purged (y < 0, do not print [X]; y $\geq$ 0, print [X]) (integer, input, default value = 0).

VII. METHOD:

Each column (or row) of the matrix is broken into groups of 6 terms (3 terms if complex) per printed line. If all the terms in a group = 0, the line is not printed. If the entire column (or row) = 0, it is not printed. If the entire matrix = 0, it is not printed.

VIII. REMARKS:

1. MATPRT should not be used if scalar or extra points are present. For this case, use MATPRN.

2. Only one matrix data block is printed by this instruction. The instruction may be repeated as many times as required, however.

I. NAME: ØUTPUT1 (Create User Tapes)
(The companion module is INPUTT1)

II. PURPØSE: Writes up to five data blocks and a user tape label onto a user tape for subsequent use at a later date. (See User Module INPUTT1 for recovery procedures.) ØUTPUT1 is also used to position the user tape (including handling of multiple reel tapes*) prior to writing the data blocks. Multiple calls are allowed. A message is written on the output file for each data block successfully written and after each tape reel switch. The user is cautioned to be careful when positioning a user tape with ØUTPUT1 since he may inadvertently destroy information through improper positioning. Even though no data blocks are written, an EØF will be written at the completion of each call which has the effect of destroying anything on the tape forward of the current position.

III. DMAP CALLING SEQUENCE:
ØUTPUT1 DB1,DB2,DB3,DB4,DB5 // V,N,P1 / V,N,P2 / V,N,P3 $

IV. INPUT DATA BLØCKS:
DBi - Any data block which the user desires to be placed on one of the NASTRAN permanent tape files INPT, INP1, INP2 thru INP9. Any or all of the input data blocks may be purged. Only nonpurged data blocks will be placed on the tape.

V. ØUTPUT DATA BLØCKS: None.

*User tape reel switching is currently available only on the IBM 360/370 and Univac 1108 computers.

VI. PARAMETERS: The meaning of the first parameter (P1) value is given in the table below. (The default value is 0).

P1 Value	Meaning
+n	Skip forward n data blocks before writing.
0	Data Blocks are written starting at the current position. The current position for the first use of a tape is at the label (P3). In this case P3 counts as one Data Block.
-1	Rewind before writing. (This is dangerous!)*
-2	Mount new reel before writing.**
-3	Rewind tape, print data block names and then write after the last data block on the tape.
-4	Current tape reel will be rewound and dismounted and a new tape reel will be mounted with ring in and rewound before writing the data blocks. This option should be used when a call to ØUTPUT1 is preceded by a call to INPUTT1 using the same User Tape.

The second parameter (P2) for this module is the User Tape Code shown in the table below. (The default value is 0).

User Tape Code	GINØ File Name
0	INPT
1	INP1
2	INP2
3	INP3
4	INP4
5	INP5
6	INP6
7	INP7
8	INP8
9	INP9

*An EØF is written at the end of each call to ØUTPUT1.

**An end-of-file mark is written on the tape to be switched. Caution should be used when switching from a user tape being read by INPUTT1 to a tape to be written by ØUTPUT1.

The third parameter (P3) for this module is used to define the User Tape Label. The label is used for NASTRAN identification. The label (P3) is an alphanumeric variable of eight or less characters (the first character must be alphabetic) which is written on the user tape. The writing of this label is dependent on the value of P1 as follows: (The default value for P3 is XXXXXXXX).

P1 Value	Tape Label Written
+n	No
0	No
-1	Yes
-2	Yes (On New Reel)
-3	No (Warning Check)
-4	Yes (On New Reel)

The user may specify the third parameter as V, Y, name. The user then must also include a PARAM card in the bulk data deck to set a value for name.

VII. EXAMPLES:

1. ØUTPUT1 A,B,,, // C,N,0 / C,N,0 $ or ØUTPUT1 A,B,,, // $
   Write data blocks A and then B onto user tape INPT starting wherever INPT is currently positioned. If this is the first write operation on INPT it must be preceded by ØUTPUT1 ,,,,, // C,N,-1 $ which will automatically label the tape positioned at its beginning.

2. ØUTPUT1, ,,,, // C,N,-1 / C,N,0 $
   Rewind INPT and destroy any data blocks that were on INPT and write default value of P3 on tape as a label.

3. ØUTPUT1 A,,,, // C,N,-2 / C,N,2 / C,N,USERTPA $
   Mount a new reel of tape (with write ring) for INP2 and write USERTPA for user tape label and then data block A as the first file.

4. ØUTPUT1, ,,,, // C,N,-2 / C,N,2 / C,N,USERTPA $
   ØUTPUT1 A,,,, // C,N,0 / C,N,2 $
   This is equivalent to example 3.

5. ØUTPUT1 A,B,C,D,E // C,N,14 $
   Starting from the current position, skip forward 14 data blocks on INPT and write A,B,C,D, and E as the next five data blocks. The skip positioning feature cannot be used if the current position of INPT is forward of a just previously written data block end-of-file or before the tape is labeled.

6. ØUTPUT1, ,,,, // C,N,-3 $ THIS IS AN
   ØUTPUT1 A,B,C,D,E // C,N,14 $ IMPRØPER EXAMPLE.
   This is an invalid sequence since the first call positions the tape at the end of all data blocks on the tape. See example 7.

7. INPUTT1 / ,,,, / C,N,-3 $
   ØUTPUT1 A,B,C,D,E // C,N,14 $
   A complete list of data block names will be printed by INPUTT1 which will then rewind the tape. Then, ØUTPUT1 will skip forward 14 data blocks and write A,B,C,D, and E. The user tape label is given a warning check by INPUTT1.

8. ØUTPUT1, ,,,, // C,N,-2 $ THIS IS AN
   ØUTPUT1, ,,,, // C,N,-3 $ IMPRØPER EXAMPLE.
   ØUTPUT1, A,B,,, // C,N,14 $
   This is an invalid sequence since the first call effectively destroys whatever information is on the tape. See example 9.

9.
```
INPUTT1 / ,,,, / C,N,-2 $
INPUTT1 / ,,,, / C,N,-3 $
ØUTPUT1 A,B,,, // C,N,14 $
```

Mount a new reel of tape previously default labeled for INPT (the operator will have to be instructed to ignore the NØRING message and put a ring in the tape). Print the names of all data blocks on the tape and rewind the tape. Skip 14 data blocks on the tape and write A and then B as the 15th and 16th data blocks. Any information forward of this current position is effectively destroyed. See example 10.

10.
```
INPUTT1 / ,,,, / C,N,-2 $
ØUTPUT1 A,B,,, // C,N,-3 $
```

Mount a new reel of tape previously default labeled for INPT (the operator will have to be instructed to ignore the NØRING message and put a ring in the tape). Print the names of all data blocks on the tape and write A and B as new data blocks at the end of the tape. If INPT contained 14 data blocks at the start of this sequence, it would be more efficient to do it this way than by using the sequence of example 9 since a pass on the tape is eliminated.

11.
```
INPUTT1 / ,,,, / C,N,-2 / C,N,0 / V,Y,BDSETLAB $
ØUTPUT1 A,B,,, // C,N,-3 / C,N,0 / V,Y,BDSETLAB $
```

This is equivalent to example 10 except the user tape label is set on a PARAM card which must be included in the BULK DATA deck (i.e., PARAM BDSETLAB USERTP12).

VIII. DIFFICULT EXAMPLES USING INPUTT1 and OUTPUT1:

Example 1:

(a) Objectives:

(1) Obtain printout of the names of all data blocks on INPT.

(2) Skip past the first four data blocks, replace the next two with data blocks A and B, and retain the next three data blocks.

(3) Obtain printout of the names of all data blocks on INPT after (2) has been done.

(b) DMAP Sequence:

```
BEGIN $                                    (1)
INPUTT1 / ,,,, / C,N,-3 $                  (2)
INPUTT1 / ,,T1,T2,T3 / C,N,6 $             (3)
INPUTT1 / ,,,, / C,N,-1 $                  (4)
ØUTPUT1 A,B,T1,T2,T3 // C,N,4 $            (5)
ØUTPUT1, ,,,, // C,N,-3 $                  (6)
END $
```

(c) Remarks:

(1) DMAP sequence (2) accomplishes objective (1) and rewinds INPT.

(2) DMAP sequence (3) recovers data blocks 7,8, and 9. This is necessary because they would be effectively destroyed by anything written in front of them on INPT.

(3) DMAP sequence (4) rewinds INPT.

(4) DMAP sequence (5) accomplishes objective (2).

(5) DMAP sequence (6) accomplishes objective (3) and leaves INPT positioned after the ninth file, ready to receive additional data blocks.

(6) Note that INPUTT1 is used whenever possible to avoid the possibility of mistakenly writing on INPT prematurely.

Example 2:

(a) Objectives:

(1) Write data blocks A, B, and C on INPT.

(2) Obtain printout of the names of all data blocks on INPT after step (1).

(3) Make two copies of the tape created in (1).

(4) Add data blocks D and E to one of the tapes.

(5) Obtain the names of all data blocks on INPT after (4).

(b) DMAP Sequence:

```
BEGIN $                               (1)
ØUTPUT1 A,B,C,, // C,N,-1 $           (2)
ØUTPUT1, ,,,, // C,N,-3 $             (3)
ØUTPUT1 A,B,C,, // C,N,-2 $           (4)
ØUTPUT1 A,B,C,, // C,N,-2 $           (5)
ØUTPUT1 D,E,,, // $                   (6)
ØUTPUT1, ,,,, // C,N,-3 $             (7)
END $                                 (8)
```

(c) Remarks:

(1) DMAP sequence (2) accomplishes objective (1) since the tape must initially have P3 written on it when first used. The DMAP statement ØUTPUT1 A,B,C,, // C,N,-1 $ will accomplish the same thing.

(2) DMAP sequence (3) accomplishes objective (2). The statement INPUTT1 / ,,,, / C,N,-3 $ will do the same thing and add a rewind.

(3) Statements (4) and (5) accomplish objective (3).

(4) Statement (6) accomplishes objective (4) where the third tape is used.

(5) Statement (7) accomplishes objective (5). The statement INPUTT1 / ,,,, / C,N,-3 $ will do the same thing and add a rewind.

(6) On machines where tape reel switching is not implemented, the second parameter can be used as follows:

```
BEGIN $
ØUTPUT1 A,B,C,, // C,N,-1 $
ØUTPUT1, ,,,, // C,N,-3 $
ØUTPUT1 A,B,C,, // C,N,-1 / C,N,1 $
ØUTPUT1 A,B,C,, // C,N,-1 / C,N,2 $
ØUTPUT1 D,E,,, // C,N,0 / C,N,2 $
ØUTPUT1, ,,,, // C,N,-3 / C,N,2 $
END $
```

I. NAME: ØUTPUT2 (Create User Written FØRTRAN Tapes)
(The companion module is INPUTT2)

II. PURPØSE: Writes up to five data blocks and a user tape label onto a FØRTRAN-written user tape for subsequent use at a later date. ØUTPUT2 is also used to position the user tape prior to writing the data blocks. Multiple calls are allowed. A message is written on the output file for each data block successfully written. The user is cautioned to be careful when positioning a user tape with ØUTPUT2 since he may inadvertently destroy information through improper positioning. Even though no data blocks are written, an EØF will be written at the completion of each call which has the effect of destroying anything on the tape forward of the current position.

III. DMAP CALLING SEQUENCE:
ØUTPUT2 DB1,DB2,DB3,DB4,DB5 // V,N,P1 / V,N,P2 / V,N,P3 $

IV. INPUT DATA BLØCKS:
DBi - Any data block which the user desires to be written on one of the NASTRAN FØRTRAN tape files UT1, UT2, through UT5. Any or all of the input data blocks may be purged. Only nonpurged data blocks will be placed on the tape.

V. ØUTPUT DATA BLØCKS: None.

VI. PARAMETERS:
The meaning of the first parameter (P1) value is given in the table below. (The default value is 0).

P1 Value	Meaning
+n	Skip forward n data blocks before writing.
0	Data Blocks are written starting at the current position. The current position for the first use of a tape is at the label (P3). In this case P3 counts as one Data Block.
-1	Rewind before writing.
-3	Rewind tape, print data block names and then write after the last data block on the tape.
-9	Write a final EØF on the tape.

The second parameter (P2) for this module is the FØRTRAN unit number onto which the data blocks will be written. This unit is not required to be a physical tape. The allowable values for this parameter are highly machine or installation dependent. Reference should be made to Section 4 of the Programmer's Manual for a discussion of this problem. (The default value for P2 is 0).

User Tape Code	FØRTRAN File Name
11	UT1
12	UT2
13	UT3
14	UT4
15	UT5

The third parameter (P3) for this module is used to define the FØRTRAN User Tape Label. The label is used for NASTRAN identification. The label (P3) is an alphanumeric variable of eight or less characters (the first character must be alphabetic) which is written on the user tape. The writing of this label is dependent on the value of P1 as follows: (The default value for P3 is XXXXXXXX).

P1 Value	Table Label Written
+n	No
0	No
-1	Yes
-3	No (Warning Check)
-9	No

The user may specify the third parameter as V,Y,name. The user then must also include a PARAM card in the bulk data deck to set a value for name.

VII. EXAMPLES:

ØUTPUT2 is intended to have the same logical action as the GINØ User Tape module ØUTPUT1 except for tape reel switching. It is therefore suggested that the examples shown under module ØUTPUT1 be used for ØUTPUT2 as well, excepting the ones involving tape reel switching. All examples should be ended with a call to ØUTPUT2 with P1 = -9.

VIII. REMARKS:

The primary objective of this module is to write tapes using simple FØRTRAN so that a user can read NASTRAN generated data with his own program. Similarly, matrices can be generated with externally written simple FØRTRAN programs and then read by module INPUTT2.

In order to do this, the format of the information on these tapes must be adhered to. The basic idea is that a one word logical KEY record is written which indicates what follows. A zero value indicates an end-of-file condition. A negative value indicates the end of a record where the absolute value is the record number. A positive value indicates that the next record consists of that many words of data.

The correspondence between FØRTRAN records and GINØ-written NASTRAN files is shown in the following sample:

FØRTRAN Record	Length	Contents	NASTRAN File	File Record
1	1	KEY > 0	1	1
2	KEY	{Data} KEY		
3	1	KEY > 0		
4	KEY	{Data} KEY		
5	1	KEY < 0 (EØR)		
6	1	KEY > 0		2
7	KEY	{Data} KEY		
8	1	KEY < 0 (EØR)		
9	1	KEY = 0 (EØF)		EØF
10	1	KEY > 0	2	1
11	KEY	{Data} KEY		
12	1	KEY < 0 (EØR)		
13	1	KEY = 0 (EØF)		EØF
14	1	KEY = 0 (EØF=EØD)	3	EØF

I. NAME: ØUTPUT3 (Punch Matrix Data Blocks onto Cards)

II. PURPØSE: Punches up to five matrix data blocks onto DMI bulk data cards. These cards may then read into NASTRAN as ordinary bulk data to reestablish the matrix data block at a later date.

III. DMAP CALLING SEQUENCE:

```
ØUTPUT3  M1,M2,M3,M4,M5 // C,N,P1 / C,Y,N1=ABC / C,Y,N2=DEF / C,Y,N3=GHI /
                                    C,Y,N4=JKL / C,Y,N5=MNØ $
```

IV. INPUT DATA BLØCKS:

Mi - Any matrix data block which the user desires to be punched on DMI cards. Any or all of the input data blocks may be purged. Only nonpurged data blocks will be punched.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS:

The first parameter (P1) controls the writing of the DMI card images on a FØRTRAN unit as follows:

P1 < 0 write on FØRTRAN unit |P1| as well as punch DMI cards

P1 ≥ 0 punch DMI cards only

The default value for P1 is 0.

Ni - The values of the five BCD parameters shown above are used to create a unique continuation field configuration on the DMI cards. Only the first three characters are used. These three characters must be unique for all matrices which will be input together during a subsequent run using cards generated by ØUTPUT3. (Input, BCD, default values are N1 = no default, N2=N3=N4=N5=XXX).

VII. <u>METHØD</u>: The nonzero elements of each matrix are punched on double-field DMI cards as shown in the example below. The name of the matrix is obtained from the header record of the data block. Field 10 contains the three character parameter value in columns 74-76 and an incremented integer card count in columns 77-80.

VIII. <u>EXAMPLE</u>:

Let the data block MAT contain the matrix

$$[MAT] = \begin{bmatrix} 1.0 & 0.0 & 6.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 7.0 & 0.0 & 0.0 & 0.0 \\ 2.0 & 4.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 5.0 & 0.0 & 0.0 & 0.0 & 9.0 \\ 3.0 & 0.0 & 8.0 & 0.0 & 0.0 & 0.0 \end{bmatrix}$$

The DMAP instruction OUTPUT3 MAT,,,, // C,N,0 / C,N,XYZ $ will then punch out the DMI cards shown below.

DMI	MAT	0	2	1	2		5	6	+XYZ 0
DMI*	MAT			1		1		1.000000E 00	*XYZ 1
*XYZ 1		3		2.000000E 00		5		3.000000E 00	*XYZ 2
DMI*	MAT			2		3		4.000000E 00	*XYZ 3
*XYZ 3		5.000000E 00							*XYZ 4
DMI*	MAT			3		1		6.000000E 00	*XYZ 5
*XYZ 5		7.000000E 00		5		8.000000E 00			*XYZ 6
DMI*	MAT			6		4		9.000000E 00	*XYZ 7

IX. <u>REMARKS</u>:

1. Only real single- or double-precision matrices may be output.
2. All matrices are output on double-field cards in single-precision.
3. The maximum number of cards that may be punched is 9999. If matrices larger than this are desired, use module ØUTPUT2 and write a program to process the resulting FØRTRAN file.
4. The auxiliary subroutine PHDMIA used by module ØUTPUT3 can be used with stand-alone FØRTRAN programs. See Section 4 of the Programmer's Manual for details.

I. NAME: PARAM (Parameter Processor)

II. PURPOSE: To perform specified operations on integer DMAP parameters.

III. DMAP CALLING SEQUENCE:

PARAM // C,N,op / V,N,ØUT / V,N,IN1 / V,N,IN2 $

IV. INPUT DATA BLOCKS: None

V. OUTPUT DATA BLOCKS: None

VI. PARAMETERS:

1. op is a BCD operation code from the table below (Input, no default). Op is usually specified as a "C,N" parameter.
2. ØUT is the name of the parameter which is being generated by PARAM (output, integer, default = 1).
3. IN1 is the name of a parameter whose value is used to compute ØUT according to the table below (Input, integer, default = 1).
4. IN2 is the name of a parameter whose value is used to compute ØUT according to the table below (Input, integer, default = 1).

VII. REMARKS:

1. The table below gives the results for ØUT as a function of op, IN1, and IN2.

Arithmetic Operations					
op	ADD	SUB	MPY	DIV	NØT
ØUT	IN1+IN2	IN1-IN2	IN1·IN2	IN1/IN2	-IN1

Logical Operations												
op	AND				ØR				IMPL			
ØUT	-1	+1	+1	+1	-1	-1	-1	+1	-1	+1	-1	-1
IN1	<0	<0	≥ 0	≥ 0	<0	<0	≥ 0	≥ 0	<0	<0	≥ 0	≥ 0
IN2	<0	≥ 0	<0	≥ 0	<0	≥ 0	<0	≥ 0	<0	≥ 0	<0	≥ 0

Special Operations	
op	ØUT
NØP	ØUT (unchanged)
KLØCK	Current CPU time in integer seconds from the start of the job.
TMTØGØ	Remaining CPU time in integer seconds based on the TIME card.
PREC	Returns the currently requested precision; 2 = D.P. , 1 = S.P.

2. PARAM does its own SAVE; therefore, a SAVE is not needed following the module.

VIII. EXAMPLES:

1. PARAM // C,N,NØT / V,N,XYZ / V,N,NØXYZ $ - this example changes the sense of parameter NØXYZ which may be useful for the CØND or EQUIV instructions. Alternatively, XYZ could have been set in the following way:

2. PARAM // C,N,MPY / V,N,XYZ / V,N,NØXYZ / C,N,-1 $

3. PARAM // C,N,IMPL / V,N,ABC / V,N,DEF / V,N,GHI $

4. PARAM // C,N,NØP / V,N,P1=5 $ - this example sets the value of parameter P1 to 5 and saves it for subsequent use.

I. NAME: PARAML (Selects parameters from a list)

II. PURPOSE: To select parameters from a user input matrix or table.

III. DMAP CALLING SEQUENCE:

```
PARAML  INPUT // C,N,ØP / V,N,RECNØ / V,N,WØRDN /
        V,N,REAL1 / V,N,INTEG / V,N,REAL2 / V,N,BCD $
```

IV. INPUT DATA BLOCKS:

INPUT - Any matrix or table

V. OUTPUT DATA BLOCKS:

None.

VI. PARAMETERS:

ØP - Input-BCD-no default.

RECNØ - Input-integer-default = 1

WØRDN - Input-integer-default = 1

REAL1 - Output-real-default = 1.0

INTEG - Output-integer-default = 0

REAL2 - Output-real-default = 1.0

BCD - Output-BCD-default = blank

VII. REMARKS:

1. REAL1, INTEG, REAL2, and BCD will be set by the module whenever they are "V" type parameters.

2. RECNØ and WØRDN control the starting point, according to ØP.

   If ØP = DMI, RECNØ is the column number and WØRDN is the row number.
   If ØP = DTI, RECNØ is the record number and WØRDN is the word number.
   If ØP = PRESENCE, INTEG will be -1 if INPUT is purged.

3. PARAML does its own SAVE; therefore, a SAVE is not needed following the module.

VIII. EXAMPLE:

Obtain the value in column 1, row 1 of a matrix.

```
PARAML  KGG // C,N,DMI / C,N,1 / C,N,1 / V,N,TERM $
```

I. NAME: PARAMR (Parameter Processor - Real)

II. PURPOSE: To perform specified arithmetic, logical, and conversion operations on real or complex parameters.

III. DMAP CALLING SEQUENCE:

```
PARAMR   // C,N,ØP / V,N,ØUTR / V,N,INR1 / V,N,INR2 /
                   V,N,ØUTC / V,N,INC1 / V,N,INC2 /
                   V,N,FLAG $
```

IV. INPUT DATA BLOCKS:

None.

V. OUTPUT DATA BLOCKS:

None.

VI. PARAMETERS:

ØP	-	Input-BCD operation code from the table below - no default
ØUTR	-	Output-real-default = 0.0
INR1	-	Input-real-default = 0.0
INR2	-	Input-real-default = 0.0
ØUTC	-	Output-complex-default = (0.0,0.0)
INC1	-	Input-complex-default = (0.0,0.0)
INC2	-	Input-complex-default = (0.0,0.0)
FLAG	-	Output-integer-default = 0

The values of the parameters are dependent upon ØP as shown in the following table:

ØP	OUTPUTS
ADD	ØUTR = INR1 + INR2
SUB	ØUTR = INR1 - INR2
MPY	ØUTR = INR1 * INR2
DIV	ØUTR = INR1 / INR2
NØP	RETURN
SQRT	ØUTR = $\sqrt{\text{INR1}}$
SIN	ØUTR = SIN(INR1)
CØS	ØUTR = CØS(INR1)
ABS	ØUTR = $\lvert$ INR1 $\rvert$
EXP	ØUTR = exp (INR1)

TAN	ØUTR = TAN(INR1)
NØRM	ØUTR = $\|\|$ ØUTC $\|\|$
PØWER	ØUTR = INR1 ** INR2
ADDC	ØUTC = INC1 + INC2
SUBC	ØUTC = INC1 - INC2
MPYC	ØUTC = INC1 * INC2
DIVC	ØUTC = INC1 / INC2
CSQRT	ØUTC = $\sqrt{\text{INC1}}$
CØMPLEX	ØUTC = (INR1,INR2)
CØNJ	ØUTC = $\overline{\text{INC1}}$
REAL	INR1 = Re (ØUTC)
	INR2 = Im (ØUTC)
EQ	FLAG = -1 if INR1 = INR2
GT	FLAG = -1 if INR1 > INR2
LT	FLAG = -1 if INR1 < INR2
LE	FLAG = -1 if INR1 $\leq$ INR2
GE	FLAG = -1 if INR1 $\geq$ INR2
NE	FLAG = -1 if INR1 $\neq$ INR2
LØG	ØUTR = LØG_{10} (INR1)
LN	ØUTR = LØG_{e} (INR1)
FIX	FLAG = FIX (ØUTR)
FLØAT	ØUTR = FLØAT(FLAG)

VII. REMARKS:

1. Any output parameter must be "V" type if the parameter is used by "ØP" as output.
2. For ØP = DIV or ØP = DIVC, the output is zero if the denominator is zero.
3. PARAMR does its own SAVE; therefore, a SAVE is not needed following the module.
4. For ØP = SIN, ØP = CØS or ØP = TAN, the input must be expressed in radians.

I. NAME: PRTPARM (Parameter and DMAP Message Printer)

II. PURPØSE: A. Prints parameter values.
B. Prints DMAP messages.

III. DMAP CALLING SEQUENCE:

PRTPARM // C,N,a / C,N,b / C,N,c $

IV. INPUT DATA BLØCKS: None

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS:

a - Integer value (no default value)

b - BCD value (default value = XXXXXXXX)

c - Integer value (default value = 0)

VII. METHØD:

A. As a parameter printer, use a = 0. There are two options:

1. b = parameter name will cause the printout of the value of that parameter.

   Example: PRTPARM // C,N,0 / C,N,LUSET $

2. b = XXXXXXXX will cause the printout of the values of all parameters in the current variable parameter table. Since this is the default value, it need not be specified.

   Example: PRTPARM // C,N,0 $

B. As a DMAP message printer, use a ≠ 0. There are two options:

1. a > 0 causes the printout of the j^{th} message of category b where $j=|a|$ and b is one of the values shown below. (The number of messages available in each category is also given.)

   Example: PRTPARM // C,N,1 / C,N,DMAP $

2. a < 0 causes the same action as a > 0 with the additional action of program termination. Thus, PRTPARM may be used as a fatal message printer.

   Example: PRTPARM // C,N,-2 / C,N,PLA $

VIII. REMARKS:

1. b is always a value.
2. Meaningless values of a and b will result in diagnostic messages from PRTPARM.

3. TABLE OF b CATEGORY VALUES

	DISPLACEMENT Rigid Formats	Value of b	Number of Messages
1	Static Analysis	STATICS	5
2	Static Analysis with Inertia Relief	INERTIA	5
3	Normal Mode Analysis	MODES	3
4	Static Analysis with Differential Stiffness	DIFFSTIF	4
5	Buckling Analysis	BUCKLING	6
6	Piecewise Linear Analysis	PLA	5
7	Direct Complex Eigenvalue Analysis	DIRCEAD	3
8	Direct Frequency and Random Response	DIRFRRD	4
9	Direct Transient Response	DIRTRD	3
10	Modal Complex Eigenvalue Analysis	MDLCEAD	4
11	Modal Frequency and Random Response	MDLFRRD	6
12	Modal Transient Response	MDLTRD	5
13	Normal Modes Analysis with Differential Stiffness	NMDSTIF	6
14	Static Analysis with Cyclic Symmetry	CYCSTAT	6
15	Normal Modes Analysis with Cyclic Symmetry	CYCMØDES	6
	HEAT Rigid Formats		
1	Static Heat Transfer	HSTAT	4
3	Nonlinear Static Heat Transfer	HNLIN	3
9	Transient Heat Transfer	HTRD	1
	AERØ Rigid Format		
10	Modal Flutter Analysis	FSUBSØN	4
	Direct Matrix Abstraction Program		
	DMAP	DMAP	See Remark 5

4. For details on error messages for the i^{th} Displacement Rigid Format see section 3.(i + 1) User's Manual. The Heat and Aero Rigid Formats follow these.
5. The message number, a, may be any integer for DMAP messages.
6. The third parameter is not currently used.

I. NAME: PVEC (Substructure Analysis Partitioning Vector Data Generator)

II. PURPØSE: Generates a table similar to USET for use in Substructure Analysis.

III. DMAP CALLING SEQUENCE:

PVEC20 I01,I02,---,I20,GEØM4 / Ø1,Ø2,Ø3 / V,N,ØPT1 / V,N,ØPT2 / V,N,P01 / ---- / V,N,P20 $

IV. INPUT DATA BLØCKS:

Iii, ii=01,20 - Table data blocks generated by GP4 in a Phase I Substructure Analysis execution. Up to twenty (20) substructures may be handled simultaneously. The inputs may be purged if either the substructure is absent or if it is identical to a previously appearing substructure.

GEØM4 - Preface output containing the coupling data extracted from the user's SAME and NØSAME bulk data cards.

V. ØUTPUT DATA BLØCKS:

Ø1 - A table similar to USET which can be used to generate partitioning vectors by using utility module VEC.

Ø2 - Reserved for future use (may not be purged).

Ø3 - Reserved for future use (may not be purged).

VI. PARAMETERS:

ØPT1 - Input, integer, default = 1 which indicates no pseudostructure map is to be printed. A value of -1 indicates that the printing of the map is desired.

ØPT2 - Input, integer, default = 1 which indicates coupling is to occur for points mentioned on user-supplied SAME cards. A value of -1 directs PVEC to generate additional coupling information for any points having identical external identifications given on the input data blocks Iii. This additional information is merged with the user-supplied SAME and NØSAME coupling data.

Pii, ii=01,20 - Input, integer, default = 0. The values of these parameters define the substructures in the analysis. For example, if P17 = 20 then the data on input data block I17 would be assumed to represent substructure number 20. Zero values mean that the substructure is not present. In this case Iii should be purged. Negative values imply that the substructure is identical to the immediately preceding substructure. For example, if P07 = -14, then the data for substructure number 14 would be found on I06 unless P06 < 0 in which case it would be on I05, etc. Obviously, P01 $\geq$ 0.

VII. REMARKS:

For user convenience, two alternate forms of the PVEC module have been defined. For two to five substructures the user may use PVEC05.

PVEC05 I01,I02,---,I05,GEØM4 / Ø1,Ø2,Ø3 / V,N,ØPT1 / V,N,ØPT2 / V,N,P1 / V,N,P2 / --- / V,N,P5 $

Similarly, PVEC10 is available for two to ten substructures.

```
PVEC10  I01,I02,---,I10,GEØM4 / Ø1,Ø2,Ø3 / V,N,ØPT1 / V,N,ØPT2 / V,N,P1 / V,N,P2 /
        --- / V,N,P10 $
```

VIII. EXAMPLE:

Consider four substructures having identification numbers 10, 20, 30 and 40. Substructure 30 is identical to substructure 20. Substructure Analysis Phase I runs have been made for substructures 10, 20 and 40 creating data blocks A10, A20 and A40 which have been brought in from user tapes. To generate the partitioning vector bit table VSET, use

```
PVEC05  A10,A20,   ,A40, ,GEØM4 / VSET,Ø2,Ø3 / C,N,-1 / C,N,+1 / C,N,10 / C,N,20 /
        C,N,-30 / C,N,40 $
```

To generate the partitioning vector for substructure 20, use

```
PARAM   // C,N,SUB / V,N,B / C,N,33 / C,N,2 $ 2=SECØND ØNE
VEC     VSET / E20 / C,N,BITID / C,N, / C,N, / V,N,B $
```

To generate the complete partitioning vector matrix, use

```
VEC     VSET / MPV / C,N,CØLUMNS / C,N,RIGHT / C,N, / C,N,4 $ 4=NØ. SUBSTRUCTURES
```

I. NAME: SCALAR (Convert matrix element to parameter)

II. PURPOSE: To extract a specified element from a matrix for use as a parameter.

III. DMAP CALLING SEQUENCE:

SCALAR A//V,Y,NRØW=1/V,N,NCØL=1/C,Y,VALUE $

IV. INPUT DATA BLOCKS:

A - may be any type of matrix.

NOTE: If A is purged, value will be returned as (0.,0.).

V. OUTPUT DATA BLOCKS:

None

VI. PARAMETERS:

NRØW - Input-integer, default=1. Row number of element to be extracted from [A].

NCØL - Input-integer, default=1. Column identification of element.

VALUE - Output-complex-single precision, default=(0.,0.). Contents of element (NRØW,NCØL) in matrix [A].

I. NAME: SEEMAT (Pictorial Matrix Printer)

II. PURPØSE: Shows nonzero matrix elements on printer or plotter output positioned pictorially by row and column within the outlines of the matrix.

III. DMAP CALLING SEQUENCE:

SEEMAT M1,M2,M3,M4,M5 // C,N,$\left\{\begin{array}{c}\text{PRINT}\\ \text{PLØT}\end{array}\right\}$ / V,N,PFILE / V,N,PACK / C,N,plotter /
C,N,modeln1 / C,N,modelb1 / C,N,modeln2 / C,N,modelb2 /
C,N,sizex / C,N,sizey $

IV. INPUT DATA BLØCKS:

Matrix Data Blocks, any of which may be purged.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS:

1. PRINT implies use of the system output file. (Any value other than PLØT implies PRINT.)

   PLØT implies use of one of the plotters. Either of the plotter tapes PLT1 or PLT2 will be used, depending on the type of plotter requested (see Section 4.1).

   The default value for the first parameter is PRINT.

2. PFILE is the Plot File Number. (Used only if first parameter is PLØT.)

   Input/output variable integer parameter. Frame or sheet number. The value of this parameter will be incremented by one (1) for each frame (sheet) plotted by SEEMAT.

   The default value for the second parameter is 0.

3. PACK is reserved for a future modification that will allow the representation of a nonzero block of the matrix with a single character.

   The default value for the third parameter is 100.

4. Plotter Name - If the first parameter = PLØT, one of the plotter names must be selected from the following list. Additional information on plotters and the meaning of the symbols used below is given in Section 4. The associated model identifiers are specified with the next four parameters. Each plotter has a default model associated with it, as indicated by the underlined model identifier.

   The default value for the fourth parameter is SC.

Plotter Name	Model Identifiers
BL	LTE,30 STE,30
EAI	3500,30 3500,45
SC	4020,0
CALCØMP	765,205 765,210 765,105 765,110 763,205 763,210 763,105 763,110 565,205 565,210 565,105 565,110 565,305 565,310 563,205 563,210 563,105 563,110 563,305 563,310
DD	80,B
NASTPLT	M,0 T,0 D,0 M,1 T,1 D,1

5. The parameter modeln1 is used to specify the first of the two model identifiers when it is an integer value. The default value for the fifth parameter is 0.

6. The parameter modelb1 is used to specify the first of the two model identifiers when it is a BCD value. The default value for the sixth parameter is blank.

7. The parameter modeln2 is used to specify the second of the two model identifiers when it is an integer value. The default value for the seventh parameter is 0.

8. The parameter modelb2 is used to specify the second of the two model identifiers when it is a BCD value. The default value for the eighth parameter is blank.

9. The parameter sizex specifies the size of the plotter surface x-dimension on those plotters for which it is appropriate (e.g., the CALCØMP plotter). The default value for sizex is 30.0.

10. The parameter sizey specifies the size of the plotter surface y-dimension on those plotters for which it is appropriate (e.g., the CALCØMP plotter). The default value for sizey is 30.0.

VII. METHØD: The matrix is partitioned into blocks which can be printed on a single sheet of output paper or frame on the plotter selected. Only blocks containing nonzero elements will be output. Row and column indices are indicated. The user of this module is cautioned to make sure his line count limit is large enough. A default of 20,000 lines is provided by NASTRAN. This may be changed via the statement MAXLINES= value in the NASTRAN Case Control Deck. The transpose of the matrix is output.

VIII. REMARKS:

1. If a plotter is used, the appropriate tape must be made available to NASTRAN.
2. If a plotter is used, a SAVE instruction should be executed to update PFILE.
3. The nonzero elements are indicated by asterisks (*), except for diagonal elements of square matrices which are indicated by the letter D, and elements in the last row or column which are indicated by dollar signs ($).
4. The default model for any plotter is specified by omitting the last four parameters.
5. When two of the last four parameters are used to specify model identifiers, the remaining two parameters should be specified as C,N only.

IX. EXAMPLES :

1. Specify CALCØMP 765,205 as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // C,N,PLØT / V,N,PFILE / C,N / C,N,CALCØMP $
```

2. Specify EAI 3500,45 as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // C,N,PLØT / V,N,PFILE / C,N / C,N,EAI / C,N,3500 / C,N /
                          C,N,45 / C,N $
```

3. Specify Benson Lehner STE,30 as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // C,N,PLØT / V,N,PFILE / C,N / C,N,BL / C,N / C,N,STE /
                          C,N,30 / C,N $
```

4. Specify the printer rather than a plotter as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // $
```

5. For additional examples see Section 5.4.8.

I. NAME: SETVAL (Set Values)

II. PURPØSE: Set DMAP Parameter variable values equal to other DMAP Parameter variables or DMAP Parameter constants.

III. DMAP CALLING SEQUENCE:

```
SETVAL // V,N,X1 / V,N,A1 /
          V,N,X2 / V,N,A2 /
          V,N,X3 / V,N,A3 /
          V,N,X4 / V,N,A4 /
          V,N,X5 / V,N,A5 $
```

IV. INPUT DATA BLØCKS: None

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS:

X1, X2, X3, X4, X5	Output, integers, variables
A1, A2, A3, A4, A5	Input, integers; default values = 1, variables or constants.

VII. METHØD: This module sets X1 = A1, X2 = A2, X3 = A3, X4 = A4, and X5 = A5. Only two parameters need be specified in the calling sequence (X1 and A1).

VIII. REMARKS:

1. A SAVE instruction must immediately follow the SETVAL instruction if the output parameter values are to be subsequently used.
2. See PARAM for an alternate method of defining parameter values.
3. As an example, the statements

```
SETVAL  // V,N,X1 / V,N,A1 / V,N,X2 / C,N,3 $
SAVE    X1,X2 $
```

   are equivalent to the statements

```
PARAM  // C,N,ADD / V,N,X1 / V,N,A1 / C,N,0 $
PARAM  // C,N,NØP / V,N,X2=3 $
```

I. NAME: TABPCH (Table Punch)

II. PURPOSE: To punch NASTRAN tables onto DTI cards in order to allow transfer of data from one NASTRAN run to another, or to allow user postprocessing.

III. DMAP CALLING SEQUENCE:

TABPCH TAB1,TAB2,TAB3,TAB4,TAB5 // C,N,A1 / C,N,A2 / C,N,A3 / C,N,A4 / C,N,A5 $

IV. INPUT DATA BLOCKS:

TAB1
TAB2
TAB3 Any NASTRAN Tables
TAB4
TAB5

V. OUTPUT DATA BLOCKS:

None - All output is punched onto DTI cards.

VI. PARAMETERS:

A1, A2, A3, A4, A5 -- Input - BCD - Defaults are 'AA', 'AB', 'AC', 'AD', 'AE'. These parameters are used to form the first two characters (columns 74, 75) of the continuation field for each table respectively.

VII. REMARKS:

1. Any or all tables may be purged.

2. Integer and BCD characters will be punched onto single-field cards. Real numbers will be punched onto double-field cards. Their formats are I8, 2A4, E16.9.

3. Up to 99,999 cards may be punched per table.

4. Currently, twice the entire record must fit in open core.

5. Tables with 1 word BCD values (ELSETS) cannot be punched correctly.

VIII. EXAMPLES:

TABPCH EST,,,, // C,N,ES $ will punch the EST onto cards with a continuation neumonic of $+ES_{bbbb}i$ (where i is the sequence number).

I. NAME: TABPRT (Formatted Table Printer)

II. PURPOSE: To print selected table data blocks with format for ease of reading.

III. DMAP CALLING SEQUENCE:

```
TABPRT      TDB // C,N,KEY / C,N,ØPT1 / C,N,ØPT2 $
```

IV. INPUT DATA BLOCKS:

TDB - Table Data Block from list given under X.

V. ØUTPUT DATA BLOCKS: None

VI. PARAMETERS:

1. KEY - Alphanumeric value, no default. Identifies the format to be used in printing the table. The allowable list is given under X.
2. ØPT1 - Integer, default value = 0. If 0, no blank lines are written between entires. If ≠ 0, one blank line will be written between each entry.
3. ØPT2 - Integer, default value = 0. Not used at present.

VII. ØUTPUT:

The contents of the table are formatted and written on the system output file.

VIII. NØTES:

1. The module returns in the event of any difficulty.
2. The TABPT module can be used to print the contents of any data block.

IX. EXAMPLES:

1. TABPRT CSTM // C,N,CSTM $
2. TABPRT GPL // C,N,GPL / C,N,1 $

X. MISCELLANEØUS

List of data blocks recognized by TABPRT (Rigid Format name used here. The actual DMAP name for the same or equivalent information is acceptable.)

Data Block	Key (Value)
BGPDT	BGPDT
CSTM	CSTM
EQDYN	EQDYN
EQEXIN	EQEXIN
GPCT	GPCT
GPDT	GPDT
GPL	GPL
GPLD	GPLD
GPTT	GPTT

I. NAME: TABPT (Table Printer)

II. PURPØSE: To print table data blocks (may be used for matrix data blocks if desired).

III. DMAP CALLING SEQUENCE:

```
TABPT  TAB1,TAB2,TAB3,TAB4,TAB5 // $
```

IV. INPUT DATA BLØCKS:

TAB1 -
TAB2 -
TAB3 - $\Bigg\}$ Any NASTRAN data block.
TAB4 -
TAB5 -

Note: Any or all input data blocks can be purged.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS: None

VII. REMARKS:

1. Each input data block is treated as a table and its contents are printed on the system output file via a prescribed format. Each word of the table is identified by the module as to type (real, BCD, integer) and an appropriate format is used.
2. The trailer data items for the table are also printed.
3. Purged input data blocks are not printed.

VIII. EXAMPLES:

```
TABPT  GEØM1,,,, // $
TABPT  GEØM1,GEØM2,GEØM3,GEØM4,GEØM5 // $
```

I. NAME: TIMETEST (Provides Timing Data)

II. PURPOSE: To produce timing data for specific NASTRAN unit operations.

III. DMAP CALLING SEQUENCE:

TIMETEST /, / C,N,N / C,N,M / C,N,T / C,N,Ø1 / C,N,Ø2 $

IV. INPUT DATA BLOCKS: None

V. OUTPUT DATA BLOCKS:

FILE1
FILE2 Reserved for future implementation

VI. PARAMETERS

N - Outer Loop Index

M - Inner Loop Index

T - Data type to be processed

Ø1 - TIMTST Routine to be processed

Ø2 - Powers of two table for TIMTS1 option selection

See Section 4.127 of the NASTRAN Programmer's Manual for further description of the parameters.

VII. REMARKS

None.

VIII. EXAMPLES

TIMETEST / , / C,N,100 / C,N,100 / C,N,1 / C,N,2 $

TIMETEST / , / C,N,10 / C,N,10 / C,N,3 / C,N,1 / C,N,127 $

I. NAME: VEC (Creates partitioning vector based on USET).

II. PURPØSE: To create a partitioning vector for displacement method matrices using USET that may be used by Matrix Operation Modules MERGE and PARTN. This allows the user to split up long running modules such as SMP1.

III. DMAP CALLING SEQUENCE:

A. For matrices generated in Rigid Formats 1-6 or prior to module GKAD (or GKAM) in Rigid Formats 7-12:

```
VEC  USET / V / C,N,SET / C,N,SETO / C,N,SET1 / V,N,ID $
```

B. For matrices generated in Rigid Formats 7-12 after module GKAD (or GKAM):

```
VEC  USETD / V / C,N,SET / C,N,SETO / C,N,SET1 / V,N,ID $
```

IV. INPUT DATA BLØCKS:

USET - U-set

or

USETD - U-set (Dynamics)

Note: U-set may not be missing and must fit into open core.

V. ØUTPUT DATA BLØCKS:

V - Partitioning vector.

Note: 1. If all elements are in SETO or SET1 then V will be purged.

2. V may not be purged prior to execution.

VI. PARAMETERS:

SET - Matrix set to be partitioned (Input ,BCD, no default.)

SETO - Upper partition of SET (Input ,BCD, no default).

SET1 - Lower partition of SET (Input ,BCD, no default).

ID - Identification of bit position (see Remarks) (Input, integer, default = 0).

Note: 1. Legal parameter values are given in the table on page 5.3-17.

2. See Section 1.7.3 of the Programmer's Manual for a description of set notation or Section 3.3 of the Theoretical Manual.

VII. REMARKS:

1. Parameters SETO and SET1 must be a subset of the SET matrix parameter. A degree of freedom may not be in both subsets.

2. If desired, one of SETO or SET1 but not both may be requested to be the complement of the other one by giving it a value of CØMP.

3. If SET = BITID, the second and third parameters are ignored and the IDth bit position in USET (or USETD) is used. In this case, SET is assumed equal to G (or P) and SETO will correspond to the zero's in the IDth position and SET1 will correspond to the non-zero's in the IDth position.

VIII. EXAMPLES:

1. To partition $[K_{ff}]$ into a- and o- set based matrices, use

```
VEC   USET / V / C,N,F / C,N,Ø / C,N,A $

PARTN KFF,V, / KØØ,KAØ,KØA,KAA $
```

Note that the same thing can be done in one step by

```
UPARTN USET,KFF / KØØ,KAØ,KØA,KAA / C,N,F / C,N,Ø / C,N,A $
```

2. Example 1 could be accomplished by

```
VEC  USET / V / C,N,F / C,N,Ø / C,N,CØMP $
```

or

```
VEC  USET / V / C,N,F / C,N,CØMP / C,N,A $
```

3. Example 1 could be accomplished by

```
VEC  USET / V / C,N,BITID / C,N,X / C,N,X / C,N,25 $
```

5.6 USER MODULES

A number of modules have been placed in the NASTRAN system for which only dummy code exists. These modules are available to the user who wishes to create his own data blocks by reading tapes or data cards, generate his own output on the printer, punch or plotter, or perform his own matrix computations. The appropriate MPL information is presented for each such user module in this section. All necessary interfaces with the Executive System have been completed for these user modules. The procedures for implementing a user module are described in Section 2 of the Programmer's Manual.

I. NAME: DDR (User Dummy Module)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (see REMARKS below)

```
DDR  A/X/C,N,ABC/C,N,DEF/C,N,GHI $
```

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the constants shown in the calling sequence shown above.

VII. REMARKS:

This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs, as well as the number, type, and default values of the parameters, may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of the Programmer's Manual).

I. NAME: DUMMØD1 (Dummy Module - 1)*

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (see REMARKS)

```
DUMMØD1   I1,I2,I3,I4,I5,I6,I7,I8 /
          Ø1,Ø2,Ø3,Ø4,Ø5,Ø6,Ø7,Ø8 /
          C,N,-1 / V,Y,P2=-1 / V,N,P3=-1 / C,Y,P4=-1 /
          C,Y,P5=-1.0 / C,N,-1.0 /
          C,Y,P7=ABCDEFGH /
          C,Y,P8=-1.0D0 /
          C,Y,P9=(-1.0,-1.0) /
          C,Y,P10=(-1.0D0,-1.0D0) $
```

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the default values shown in the calling sequence above.

VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

*The delivery version of NASTRAN contains a DUMMØD1 module which is used to compute timing constants for the various machines on which the program runs.

I. NAME: DUMMØD2 (Dummy Module - 2)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (see REMARKS)

```
DUMMØD2  I1,I2,I3,I4,I5,I6,I7,I8 /
         Ø1,Ø2,Ø3,Ø4,Ø5,Ø6,Ø7,Ø8 /
         C,N,-1 / V,Y,P2=-1 / V,N,P3=-1 / C,Y,P4=-1 /
         C,Y,P5=-1.0 / C,N,-1.0 /
         C,Y,P7=ABCDEFGH /
         C,Y,P8=-1.0D0 /
         C,Y,P9=(-1.0,-1.0) /
         C,Y,P10=(-1.0D0,-1.0D0) $
```

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the default values shown in the calling sequence above.

VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: DUMMØD3 (Dummy Module - 3)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (see REMARKS)

```
DUMMØD3  I1,I2,I3,I4,I5,I6,I7,I8 /
         Ø1,Ø2,Ø3,Ø4,Ø5,Ø6,Ø7,Ø8 /
         C,N,-1 / V,Y,P2=-1 / V,N,P3=-1 / C,Y,P4=-1 /
         C,Y,P5=-1.0 / C,N,-1.0 /
         C,Y,P7=ABCDEFGH /
         C,Y,P8=-1.0D0 /
         C,Y,P9=(-1.0,-1.0) /
         C,Y,P10=(-1.0D0,-1.0D0) $
```

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the default values shown in the calling sequence above.

VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: DUMMØD4 (Dummy Module - 4)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (see REMARKS)

```
DUMMØD4  I1,I2,I3,I4,I5,I6,I7,I8 /
         Ø1,Ø2,Ø3,Ø4,Ø5,Ø6,Ø7,Ø8 /
         C,N,-1 / V,Y,P2=-1 / V,N,P3=-1 / C,Y,P4=-1 /
         C,Y,P5=-1.0 / C,N,-1.0 /
         C,Y,P7=ABCDEFGH /
         C,Y,P8=-1.0D0 /
         C,Y,P9=(-1.0,-1.0) /
         C,Y,P10=(-1.0D0,-1.0D0) $
```

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the default values shown in the calling sequence above.

VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: INPUTT3 (Auxiliary Input File Processor)

II. PURPØSE: A user-written module to generate data block(s) and parameter(s) based on input data read by the module itself, or on parameter values or Input Data Blocks generated by NASTRAN, or by any combination of these.

III. DMAP CALLING SEQUENCE:
INPUTT3 I1,I2,I3,I4,I5 / Ø1,Ø2,Ø3,Ø4,Ø5 / C,N,a / C,N,b / C,N,c $

IV. INPUT DATA BLØCKS: Any or all of the inputs may be purged according to the user-writer's design.

V. ØUTPUT DATA BLØCKS: May be tables or matrices depending on the user-writer's design; may or may not be purged.

VI. PARAMETERS: May be used as desired by the user-writer. Type is integer with default values of a=-1, b=0, c=0. If parameter is to be output from module, the form C,N,_ must be changed in the above example to V,N,NAME or some other form capable of being output.

VII. REMARKS: This module has been provided for the NASTRAN user who wishes to process his own data cards. Data block(s) created must be compatible with any subsequent module(s) using them as input. The number of input and output data blocks, as well as the number, type and default values of the parameters, may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (See Section 2 of Programmer's Manual).

I. NAME: INPUTT4 (Auxiliary Input File Processor)

II. PURPØSE: A user-written module to generate data block(s) and parameter(s) based on input data read by the module itself, or on parameter values or Input Data Blocks generated by NASTRAN, or by any combination of these.

III. DMAP CALLING SEQUENCE:

INPUTT4 I1,I2,I3,I4,I5 / Ø1,Ø2,Ø3,Ø4,Ø5 / C,N,a / C,N,b / C,N,c $

IV. INPUT DATA BLØCKS: Any or all of the inputs may be purged according to the user-writer's design.

V. ØUTPUT DATA BLØCKS: May be tables or matrices depending on the user-writer's design; may or may not be purged.

VI. PARAMETERS: May be used as desired by the user-writer. Type is integer with default values of a=-1, b=0, c=0. If parameter is to be output from module, the form C,N,_ must be changed in the above example to V,N,NAME or some other form capable of being output.

VII. REMARKS: This module has been provided for the NASTRAN user who wishes to process his own data cards. Data block(s) created must be compatible with any subsequent module(s) using them as input. The number of input and output data blocks, as well as the number, type and default values of the parameters, may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (See Section 2 of Programmer's Manual).

I. NAME: MØDA (User Dummy Module)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (See REMARKS below)

```
MØDA  / W,X,Y,Z / C,N,0.0 / C,N,0.0 / C,N,0.0 / C,N,0.0 / C,N,0.0 / C,N,0 /
        C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0.0 / C,N,0 / C,N,0 $
```

IV. INPUT DATA BLØCKS: None

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the constants shown in the calling sequence shown above.

VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: MØDB (User Dummy Module)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (See REMARKS below)

```
MØDB  A,B,C / W,X,Y,Z / C,N,1.0 / C,N,1.0 / C,N,1.0 / C,N,1.0 / C,N,0 / C,N,0 / C,N,0 /
               C,N,1.0 / C,N,0 / C,N,0 / C,N,0 $
```

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the constants shown in the calling sequence shown above.

VII. REMARKS:

This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: MØDC (User Dummy Module)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (See REMARKS below)

MØDC A,B // C,N,-1 $

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the constants shown in the calling sequence shown above.

VII. REMARKS:

This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: ØUTPUT (Auxiliary Output File Processor)

II. PURPØSE: A user-written module to generate printer, plotter or punch output.

III. DMAP CALLING SEQUENCE: (see remark under METHØD)

ØUTPUT IN // C,Y,P=-1 $

IV. INPUT DATA BLØCKS:

IN - Contains any desired information which the module extracts and writes on the system output file, punch, or either of the two plotters. May be purged.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS: Parameters may be used as desired by the author of the module. Type is integer with MPL default value of -1 as shown above.

VII. METHØD: This module has been provided for the user of NASTRAN who may wish to process his own output. The number of inputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: ØUTPUT4 (Auxiliary Output File Processor)

II. PURPØSE: A user-written module to generate printer, plotter or punch output.

III. DMAP CALLING SEQUENCE: (see remark under METHØD)

ØUTPUT4 IN1,IN2,IN3,IN4,IN5 // V,N,P1=-1 / V,N,P2=-1 $

IV. INPUT DATA BLØCKS:

INi - Contains any desired information which the module extracts and writes on the system output file, punch, or either of the two plotters. May be purged.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS: Parameters may be used as desired by the author of the module. Type is integer with MPL default value of -1 as shown above.

VII. METHØD: This module has been provided for the user of NASTRAN who may wish to process his own output. The number of inputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: PARTVEC (User Dummy Module)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (See REMARKS below)

PARTVEC I01,I02,---,I20,I21 / Ø1,Ø2,Ø3 / V,N,P1=0 / V,N,P2=0 / --- / V,N,P22=0 $

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the values shown in the calling sequence shown above.

VII. REMARKS:

This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: XYPRNPLT (User Dummy Module)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (see REMARKS below)

XYPRNPLT A// $

IV. INPUT DATA BLØCKS: As desired by the author of module.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS: None

VII. REMARKS:

This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section of Programmer's Manual).

5.7 EXECUTIVE OPERATION MODULES

All modules classified as Executive Operation Modules are individually described in this section. Additional discussions concerning the interaction of the Executive Modules with themselves and with the NASTRAN Executive System are contained in Section 5.2.3.

I. NAME: BEGIN (Begin DMAP program)

II. PURPØSE: BEGIN Is a declarative DMAP instruction which denotes the beginning of a DMAP program.

III. DMAP CALLING SEQUENCE:

BEGIN $

IV. REMARKS:

1. The BEGIN card is required when selecting APP DMAP in the Executive Control Deck and must be followed by DMAP instructions up to and including the END card.
2. BEGIN is a non-executable DMAP instruction which is used only by the DMAP compiler for information purposes.

I. NAME: CHKPNT (Checkpoint)

II. PURPØSE: Causes data blocks to be written on the New Problem Tape (NPTP) to enable the problem to be restarted with a minimum of redundant processing.

III. DMAP CALLING SEQUENCE:

CHKPNT D1,D2,...,DN $

where D1,D2,...,DN (N ≥ 1) are data blocks to be copied onto the problem tape for use in restarting problem.

IV. RULES:

1. A data block to be checkpointed must have been referenced in a previous PURGE, EQUIV or functional module instruction.
2. CHKPNT cannot be the first instruction of a DMAP loop.
3. Data Blocks generated by the Input File Processor (including DMI's and DTI's) should not be checkpointed since they are always regenerated on restart.
4. Checkpointing only takes place when a New Problem Tape (NPTP) is set up and the Executive Control Card CHKPNT YES appears in the Executive Control Deck. Otherwise, the CHKPNT instructions are ignored.
5. For each data block that is successfully checkpointed, a card of the restart dictionary is punched which gives the critical data for the data block as it exists on the Problem Tape.
6. For data blocks that have been purged or equivalenced, an entry is made in the restart dictionary to this effect. In these cases data blocks are not written on the Problem Tape.

I. NAME: CØND (Conditional Transfer)

II. PURPØSE: To alter the normal order of execution of DMAP modules by conditionally transferring program control to a specified location in the DMAP program.

III. DMAP CALLING SEQUENCE:

```
CØND  n,V $
```

where:

1. n is a BCD label name specifying the location where control is to be transferred. (See the LABEL instruction.)
2. V is a BCD name of a variable parameter whose value indicates whether or not to execute the transfer. If V < 0 the transfer is executed.

IV. EXAMPLE:

```
BEGIN $
  .
  .
  .
CØND  L1,K  $
MØDULE1  A/B/V,Y,P1  $
  .
  .
  .
LABEL  L1 $
MØDULEN  X/Y  $
  .
  .
  .
END $
```

If K ≥ 0, MØDULE1 is executed. If K < 0 control is transferred to the label L1 and MØDULEN is executed.

V. REMARKS:

Only forward transfers are allowed. See the REPT instruction for backward transfers.

I. NAME: END (End DMAP Program)

II. PURPØSE: Denotes the end of a DMAP program.

III. DMAP CALLING SEQUENCE:

END $

IV. NØTES:

1. The END instruction also acts as an implied EXIT instruction.
2. The END card is required whenever the analyst selects APP DMAP in his Executive Control Deck.

I. NAME: EQUIV (Data Block Name Equivalence)

II. PURPØSE: To attach one or more equivalent (alias) data block names to an existing data block so that the data block can be referenced by several equivalent names.

III. DMAP CALLING SEQUENCE:

EQUIV DBN1A,DBN2A,DBN3A / PARMA / DBN1B,DBN2B / PARMB $

Note: The number of data block names (DBNij) prior to each parameter (PARMj) and the number of such groups in a particular calling sequence are variable.

IV. INPUT DATA BLØCKS:

DBN1A,DBN2A, etc. - Any data block names appearing within the DMAP sequence. The 1st data block name in each group (DBN1A and DBN1B in the examples above) is known as the primary data block and the 2nd, etc. data block names become equivalent to the primary (depending on the associated parameter value). These equivalenced data blocks are known as secondary data blocks.

V. ØUTPUT DATA BLØCKS: (None specified or permitted)

VI. PARAMETERS:

PARMA, etc. - One required for each set of data block names.

VII. METHØD: The data block names in each group are made equivalent if the value of the associated parameter is < 0. If a number of data blocks are already equivalenced and the parameter value is ≥ 0, the equivalence is broken and the data block names again become unique. Also, this unequivalence operation causes the status of all the secondary data blocks to be not generated. If the data blocks are not equivalenced and the parameter value is ≥ 0, no action is taken.

VIII. RULES:

1. The primary data block must be output from a previous functional module.
2. The primary data block must be referenced in the immediately preceding functional module and/or in a subsequent functional module.

I. NAME: EXIT (Terminate DMAP program)

II. PURPØSE: To conditionally terminate the execution of the DMAP program.

III. DMAP CALLING SEQUENCE:

EXIT c $

where c is an integer constant which specifies the number of times the instruction is to be ignored before terminating the program. If c = 0 the calling sequence may be shortened to EXIT $.

IV. EXAMPLE:

```
          BEGIN  $
            .
            .
            .
         /LABEL L1 $
        | MØDULE1 A/B/V,Y,P1 $
        |   .
DMAP    <   .
loop    |   .
        | EXIT 3 $
         \REPT L1,3 $
            .
            .
            .
          END $
```

V. REMARKS:

1. The EXIT instruction will be executed the third time the loop is repeated (i.e., the instructions within the loop will be executed four times).
2. EXIT may appear anywhere within the DMAP sequence.

I. NAME: FILE (File Allocation Aide)

II. PURPØSE: To inform the File Allocator (see Section 4.9 of the Programmer's Manual) of any special characteristics of a data block.

III. DMAP CALLING SEQUENCE:

FILE A=a1,a2...aα / B=b1,b2...bβ / .... / Z=z1,z2...zω $

where:

A,B...Z are the names of the data blocks possessing special characteristics.

a1...aα,b1...bβ....z1...zω are the special characteristics from the list below.

The allowable special characteristics are:

1. SAVE - Indicates data block is to be saved for possible looping in DMAP program.
2. APPEND - Output data blocks which are generated within a DMAP loop are rewritten during each pass through the loop, unless the data block is declared APPEND in a FILE statement. The APPEND declaration allows a module to add information to a data block on successive passes through a DMAP loop.
3. TAPE - Indicates that data block is to be written on a physical tape if a physical tape is available.

Notes:

1. Data blocks created by the NASTRAN preface may not appear in FILE declarations.
2. Symbolic DMAP sequences which explain the use of the FILE instruction are given in Section 5.2.3.1.
3. FILE is a non-executable DMAP instruction which is used only by the DMAP compiler for information purposes.
4. A data block name may appear only once in all FILE statements; otherwise the first appearance will determine all special characteristics applied to the data block.

EXECUTIVE OPERATION MODULE

I. NAME: JUMP (Unconditional Transfer)

II. PURPØSE: To alter the normal order of execution of DMAP modules by unconditionally transferring program control to a specified location in the DMAP program. The normal order of execution of DMAP modules is the order of occurrence of the modules as DMAP instructions in the DMAP program.

III. DMAP CALLING SEQUENCE:

```
JUMP n $
```

where n is a BCD name appearing on a LABEL instruction which specifies where control is to be transferred.

IV. Remarks:

Jumps must be forward in the DMAP sequence. See the REPT instruction for backward jumps.

I. NAME: LABEL (DMAP Location)

II. PURPØSE: To label a location in the DMAP program so that the location may be referenced by the DMAP instructions JUMP, CØND and REPT.

III. DMAP CALLING SEQUENCE:

LABEL n $

where n is a BCD name.

IV. Remarks:

1. The LABEL instruction is inserted just ahead of the DMAP instruction to be executed when transfer of control is made to the label.

2. LABEL is a non-executable DMAP instruction which is used only by the DMAP compiler for information purposes.

I. NAME: PURGE (Explicit Data Block Purge)

II. PURPØSE: To flag a data block so that it will not be assigned to a physical file.

III. DMAP CALLING SEQUENCE:

PURGE DBN1A,DBN2A,DBN3A / PARMA / DBN1B,DBN2B / PARMB $

Note: The number of data block names (DBN_{ij}) prior to each parameter ($PARM_j$) and the number of groups of data block names and parameters in a particular calling sequence is variable.

IV: INPUT DATA BLØCKS:

DBN1A,DBN2A, etc. - Any data block names appearing within the DMAP sequence.

V. ØUTPUT DATA BLØCKS: (None specified or permitted)

VI. PARAMETERS:

PARMA, etc. - One required for each group of data block names.

VII. METHØD: The data blocks in a group are purged if the value of the associated parameter is < 0. If a data block is already purged and the parameter value is ≥ 0, the purged data block is unpurged so that it may be subsequently reallocated. If the data block is not purged and the parameter value is ≥ 0, no action is taken.

I. NAME: REPT (Repeat)

II. PURPØSE: To repeat a group of DMAP instructions a specified number of times.

III. DMAP CALLING SEQUENCE:

```
REPT  n,c  $
```

where:

1. n is a BCD name which specifies the name of a label which marks the beginning of the group of DMAP instructions to be repeated. (See LABEL instruction).
2. c is an integer constant which specifies the number of times to repeat the instructions.

IV. EXAMPLE:

```
BEGIN $
  .
  .
  .
LABEL  L1  $
MØDULE1  A/B/V,Y,P1 $
    .
    .
    .
MØDULEN  B/C/V,Y,PN $
REPT  L1,3 $
  .
  .
  .
END $
```

V. REMARKS:

1. The instructions MØDULE1 to MODULEN will be repeated three times (i.e., executed four times) in the above example.
2. REPT is placed at the end of the group of instructions to be repeated.
3. The constant, c, may not be a parameter name.

EXECUTIVE OPERATION MODULE

I. NAME: SAVE (Save Variable Parameter Values)

II. PURPØSE: To specify which variable parameter values are to be saved from the preceding functional module DMAP instruction for use by subsequent modules.

III. DMAP CALLING SEQUENCE:

SAVE V1,V2,...,VN $

where the V1,V2,...,VN (N > 0) are the BCD names of some or all of the variable parameters which appear in the immediately preceding Functional Module DMAP instruction.

IV. REMARKS:

A SAVE instruction must immediately follow the functional module instruction wherein the parameters being saved are generated.

5.8 EXAMPLES

In order to facilitate the use of DMAP, several examples are provided in this section. The user is urged to study these examples both from the viewpoint of performing a sequence of matrix operations and that of a DMAP flow.

5.8.1 DMAP Example

Objective

1. Print the contents of table data block A.
2. Print matrix data blocks B,C, and D.
3. Print values of parameters P1 and P2.
4. Set parameter P3 equal to -7.

```
BEGIN     $
TABPT     A,,,, // $
MATPRN    B,C,D,, // $
PRTPARM   // C,N,0 / C,N,P1 $
PRTPARM   // C,N,0 / C,N,P2 $
PARAM     // C,N,NØP / V,N,P3=-7 $
END       $
```

Remarks:

To be a practical example, a restart situation is assumed. The user is cautioned to remember to reenter at DMAP instruction 2 by changing the last reentry point in the restart dictionary.

5.8.2 DMAP Example

Let the constrained stiffness matrix $[K_{\ell\ell}]$ and the load vector $\{P_\ell\}$ be defined by means of DMI bulk data cards. The following DMAP sequence will perform the series of matrix operations

$$\{u_1\} = [K_{\ell\ell}]^{-1}\{P_\ell\}$$
$$\{r\} = [K_{\ell\ell}]\{u_1\} - \{P_\ell\}$$
$$\{\delta u\} = [K_{\ell\ell}]^{-1}\{r\}$$
$$\{u_2\} = \{u_1\} + \{\delta u\}$$
$$\text{Print } \{u_2\}$$

```
BEGIN     $
SØLVE     KLL,PL / U1 / C,N,1 / C,N,1 / C,N,1 / C,N,1 $
MPYAD     KLL,U1,PL / R / C,N,0 / C,N,1 / C,N,-1 $
SØLVE     KLL,R / DU / C,N,1 $
ADD       U1,DU / U2 $
MATPRN    U2,,,, // $
END       $
```

Remarks:

1. $[K_{\ell\ell}]$ is assumed symmetric.
2. In the example above, KLL will be decomposed twice. A more efficient DMAP sequence, which requires only a single decomposition for this problem, is given below.

```
BEGIN     $
DECØMP    KLL / LLL,ULL $
FBS       LLL,ULL,PL / U1 / C,N,1 / C,N,1 / C,N,1 / C,N,1 $
MPYAD     KLL,U1,PL / R / C,N,0 / C,N,1 / C,N,-1 $
FBS       LLL,ULL,R / DU $
ADD       U1,DU / U2 $
MATPRN    U2,,,, // $
END       $
```

5.8.3 DMAP Example to Use the Structure Plotter to Generate Undeformed Plots of the Structural Model

```
BEGIN    $
GP1      GEØM1,GEØM2, / GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL / V,N,LUSET / V,N,NØCSTM / V,N,NØGPDT $
SAVE     LUSET $
GP2      GEØM2,EQEXIN / ECT $
PLTSET   PCDB,EQEXIN,ECT / PLTSETX,PLTPAR,GPSETS,ELSETS / V,N,NSIL / V,N,NPSET $
SAVE     NPSET,NSIL $
PRTMSG   PLTSETX // $
PARAM    // C,N,NØP / V,N,PLTFLG=1 $
PARAM    // C,N,NØP / V,N,PFILE=0 $
CØND     P1,NPSET $
PLØT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,, / PLØTX1 / V,N,NSIL / V,N,LUSET /
         V,N,NPSET / V,N,PLTFLG / V,N,PFILE $
SAVE     NPSET,PLTFLG,PFILE $
PRTMSG   PLØTX1 // $
LABEL    P1 $
PRTPARM  // C,N,0 $
END      $
```

Remarks:

1. GEØM1, GEØM2, PCDB and CASECC are generated by the Input File Processor.

2. PRTPARM is used to print all current variable parameter values.

3. This DMAP sequence contains several structurally oriented modules. This sequence of DMAP instructions is essentially identical with the section of each rigid format associated with the operation of the Structure Plot Request Packet of the Case Control Deck (contained in data block PCDB).

5.8.4 Example of DMAP to Print Eigenvectors Associated with any of the Modal Formulation Rigid Formats

```
BEGIN   $
ØFP     LAMA,ØEIGS,,,, // $
SDR1    USET,,PHIA,,,GØ,GM,,KFS,, / PHIG,,QG / C,N,1 / C,N,REIG $
SDR2    CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,QG,PHIG,EST, / , ØQG1,ØPHIG,ØES1,ØEF1, /
        C,N,REIG $
ØFP     ØPHIG,ØQG1,ØEF1,ØES1,, // $
END     $
```

Remarks:

1. A restart from a successfully executed modal formulation is assumed.

2. This DMAP sequence contains several structurally oriented modules.

5.8.5 Example of DMAP Using a User-written Module

As an example of how a user might perform matrix operations of his own design, the following DMAP is provided. Functional modules MØDA, MØDB, and MØDC are assumed to be written by the user and added to the NASTRAN system, replacing dummy modules with the same names. A brief explanation of a problem for which this DMAP is applicable is given.

```
BEGIN     $
PARAM     // C,N,NØP / V,N,TRUE=-1 $
PARAM     // C,N,NØP / V,N,FALSE=+1 $
MØDA      / X,Y,DB,A / V,N,BETA=0.0 / V,N,SIGMA=1.0 / V,N,FW=0.0 / V,N,SW=0.0 /
          V,N,ETAINF=5.0 / V,N,M=100 / C,N,0 / C,N,0 / C,N,0 / V,N,ICØNV=0 /
          V,N,ZCØNV=1.0E-4 / V,N,ITMAX=10 / C,N,0 $
SAVE      BETA,SIGMA,FW,SW,ETAINF,M,ICØNV,ZCØNV,ITMAX $
LABEL     TØP $
FILE      A=SAVE / DB=SAVE $
SØLVE     A,DB / DY / C,N,0 / C,N,1 / C,N,1 / C,N,1 $
EQUIV     X,XX / FALSE / Y,YY / FALSE $
MØDB      X,Y,DY / XX,YY,DBB,AA / V,N,BETA / V,N,SIGMA / V,N,FW / V,N,SW / V,N,M /
          C,N,0 / V,N,ICØNV / V,N,ZCØNV / C,N,0 / V,N,DØNE=1 / V,N,DIVERGED=1 $
SAVE      DØNE,DIVERGED $
CØND      QUIT,DIVERGED $
CØND      ØUT,DØNE $
EQUIV     XX,X / TRUE / YY,Y / TRUE / DBB,DB / TRUE / AA,A / TRUE $
CØND      QUIT,ITMAX $
REPT      TØP,1000 $
PRTPARM   // C,N,-1 / C,N,DMAP $
EXIT      $
LABEL     ØUT $
MØDC      X,Y // $
EXIT      $
LABEL     QUIT $
PRTPARM   // C,N,-2 / C,N,DMAP $
EXIT      $
END       $
```

The above DMAP sequence is designed to solve an iteration problem where {x} is the set of independent variable values on which the discretized solution {y(x)} is defined. Let the discrete values of {y(x)} measured at {x} be called {y}. An iteration sequence

$$\{y\}^{i+1} = \{y\}^{i} + [A(\{y\}^{i},\{x\})]^{-1}\{\delta b(\{y\}^{i},\{x\})\}$$

is to be performed where [A] and $\{\delta b\}$ are computable functions of $\{y\}$ and $\{x\}$. A convergence-divergence criterion is assumed known. It is also assumed that the independent variable distribution $\{x\}$ may be modified as the solution proceeds. A brief description of the significant DMAP instructions is given below:

4 Initialization of all parameters and output data blocks. This module is assumed to be written by the user.

7 Prevents file allocator from dropping A and DB.

8 Compute $\{\delta y\} = [A]^{-1}\{\delta b\}$

9 Break equivalences.

10 Iterate to obtain new $\{x\}$, $\{y\}$, $\{\delta b\}$, [A]; test convergence and set parameters DØNE and DIVERGED. This module is assumed to be written by the user.

14 The new $\{x\}$, $\{y\}$, $\{\delta b\}$, [A] are established as current by replacing the old values.

20 Prints out the converged solutions $\{x\}$ and $\{y\}$. This module is assumed to be written by the user.

5.8.6 DMAP ALTER Package for Using a User-Written Auxiliary Input File Processor

```
ALTER      1
INPUT      GEØM1,,,, / G1,,,G4, / C,N,3 $
PARAM      // C,N,NØP / V,N,TRUE=-1 $
EQUIV      G1,GEØM1 / TRUE / G4,GEØM4 / TRUE $
CØND       LBLXXX,TRUE $
TABPT      G1,G4,,, // $
LABEL      LBLXXX $
ENDALTER
```

Remarks:

1. This is an ALTER package that could be used by any Rigid Format.

2. The last three instructions are needed to avoid violating the Equivalence rule that a primary data block name must be referenced in a subsequent functional module. A way to avoid using these three instructions is to move the PARAM ahead of INPUT, in which case the EQUIV immediately follows the module in which the primary data blocks are output. In this case the ALTER package becomes

```
ALTER      1
PARAM      // C,N,NØP / V,N,TRUE=-1 $
INPUT      GEØM1,,,, / G1,,,G4, / C,N,3 $
EQUIV      G1,GEØM1 / TRUE / G4,GEØM4 / TRUE $
ENDALTER
```

3. It is assumed that a user-written module INPUT exists which reads data block GEØM1 (created by the Input File Processor of the NASTRAN Preface) and creates data blocks G1 and G4. It is then desired to use G1 and G4 in place of GEØM1 and GEØM4, the data blocks normally created by the NASTRAN Preface.

4. ALTER is described in Section 2.2.

5.8.7 DMAP to Perform Real Eigenvalue Analysis Using Direct Input Matrices

```
BEGIN     $
READ      KTEST,MTEST,,,DYNAMICS,,CASECC / LAMA,PHIA,MI,ØEIGS / C,N,MØDES / V,N,NE $
ØFP       LAMA,ØEIGS,,,, // $
MATPRN    PHIA,,,, // $
END       $
```

Notes:

1. The echo of a test problem bulk data deck for the preceding DMAP sequence follows.

```
.   1  ..  2  ..  3  ..  4  ..  5  ..  6  ..  7  ..  8  ..  9  ..  10  .
DMI     KTEST   0       6       1       2               4       4
DMI     KTEST   1       1       200.0   -100.0
DMI     KTEST   2       1       -100.0  200.0   -100.0
DMI     KTEST   3       2       -100.0  200.0   -100.0
DMI     KTEST   4       3       -100.0  200.0
DMI     MTEST   0       6       1       2               4       4
DMI     MTEST   1       1       1.0
DMI     MTEST   2       2       1.0
DMI     MTEST   3       3       1.0
DMI     MTEST   4       4       1.0
EIGR    1       INV     .0      2.5     2       2                       +1
+1      MAX
```

2. Data blocks DYNAMICS and CASECC are generated by the NASTRAN Preface (Input File Processor) and contain the eigenvalue extraction data from the EIGR card and the eigenvalue method selection data extracted from the METHØD card in the Case Control Deck.

3. Data blocks KTEST and MTEST are generated by the NASTRAN Preface (Input File Processor) from the DMI bulk data cards.

4. Data block MI is the modal mass matrix, which is not used in this DMAP subsequent to READ, but which must appear as an output in READ. Parameter NE is an output parameter whose value is the number of eigenvalues extracted. If none are found NE will be set to -1.

Alternate DMAP to perform real eigenvalue analysis using Direct Input Matrices where the degrees of freedom are associated with grid points.

EXAMPLES

```
BEGIN     $
GP1       GEØM1,GEØM2, / GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL / V,N,LUSET / C,N,0 / C,N,0 $
SAVE      LUSET $
GP4       CASECC,,EQEXIN,SIL,GPDT,BGPDT,CSTM / ,,USET, / V,N,LUSET / C,N,0 / C,N,0 /
          C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 $
DPD       DYNAMICS,GPL,SIL,USET / GPLD,SILD,USETD,,,,,,,EED,EQDYN / V,N,LUSET / C,N,0 /
          C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 / V,N,NØEED / C,N,0 / C,N,0 $
SAVE      NØEED $
CØND      E1,NØEED $
READ      KTEST,MTEST,,,EED,,CASECC / LAMA,PHIA,MI,ØEIGS / C,N,MØDES / V,N,NEIGV $
SAVE      NEIGV $
ØFP       LAMA,ØEIGS,,,, // $
CØND      FINIS,NEIGV $
SDR1      USET,,PHIA,,,,,,,, / PHIG,, / C,N,1 / C,N,REIG $
SDR2      CASECC,,,,EQEXIN,SIL,,,BGPDT,LAMA,,PHIG,,, / ,,ØPHIG,,, / C,N,REIG $
ØFP       ØPHIG,,,,, // $
JUMP      FINIS $
LABEL     E1 $
PRTPARM   // C,N,-2 / C,N,MØDES $
LABEL     FINIS $
END       $
```

Notes:

1. The echo of a test problem bulk data deck for the preceding DMAP sequence follows.

```
.   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ...  10  .
DMI     KTEST   0       6       1       2               4       4
DMI     KTEST   1       1       200.0   -100.0
DMI     KTEST   2       1       -100.0  200.0   -100.0
DMI     KTEST   3       2       -100.0  200.0   -100.0
DMI     KTEST   4       3       -100.0  200.0
DMI     MTEST   0       6       1       2               4       4
DMI     MTEST   1       1       1.0
DMI     MTEST   2       2       1.0
DMI     MTEST   3       3       1.0
DMI     MTEST   4       4       1.0
EIGR    1       DET     .0      2.5     2       2                               +1
+1      MAX
SPØINT  1       THRU    4
```

2. Data block EED is generated by DPD, which copies the EIGR or EIGB cards from data block DYNAMICS. The actual card used is selected in case control by METHØD = SID.

3. Each degree-of-freedom defined by the DMI matrices must be associated with some grid or scalar point in this version. In the example above, this is done by defining four scalar points.

4. The EIGR card selected in the Case Control Deck will be used as explained in Note 2.

5. *The use of module MTRXIN and DMIG bulk data cards will allow the user to input matrices via grid point identification numbers.*

5.8.8 DMAP Example to Print and Plot a Topological Picture of Two Matrices

```
 1.   BEGIN      $
 2.   SEEMAT     KGG,KLL,,, // $
 3.   SEEMAT     KGG,KLL,,, // C,N,PLØT / V,N,P=0 / C,N / C,N,SC / C,N,4020 / C,N,X / C,N,0 $
 4.   SAVE       P $
 5.   PRTPARM    // C,N,0 / C,N,P $
 6.   PARAM      // C,N,MPY / V,N,P / C,N,0 / C,N,1 $
 7.   SEEMAT     KGG,KLL,,, // C,N,PLØT / V,N,P / C,N / C,N,EAI / C,N,3500 / C,N,X / C,N,30 $
 8.   SAVE       P $
 9.   PRTPARM    // C,N,0 / C,N,P $
10.   END        $
```

Notes:

1. Instruction number 2 causes the picture to be generated on the printer.

2. Instruction number 3 causes the picture to be generated on the SC 4020 plotter.

3. The parameter P is initialized to zero by instruction number 3. The form V,N,P would also have accomplished the same thing since the MPL default value is zero.

4. Instruction number 5 prints the current value of parameter P. Since P was initially set to zero and instruction number 3 is the first instruction executed which has P as an input, then P will have a zero value on input to instruction number 3. P is incremented by one (1) for every frame generated on the SC 4020 plotter. Since the value of the output parameter P was saved in the immediately following SAVE instruction, the value printed by instruction number 5 will be the number of frames generated by the execution of instruction number 3.

5. Instruction number 6 causes the value of P to be set to zero (0), the product of zero (0) and one (1). Since PARAM is the only module which does its own SAVE, no succeeding SAVE instruction is necessary. This illustrates a commonly used technique for setting parameter values in DMAP programs.

6. Instructions 7, 8 and 9 essentially repeat instructions 3, 4 and 5 using the EAI 3500 table plotter in place of the SC 4020 plotter.

7. The END instruction, which is required, also acts as an EXIT instruction.

8. NASTRAN tapes PLT1 and PLT2 must both be set up in order to execute this DMAP successfully.

9. Matrix data blocks KGG and KLL are assumed to exist on the PØØL file. This will be the case if either DMI input is used or if a restart is being made from a run in which KGG and KLL were generated and checkpointed.

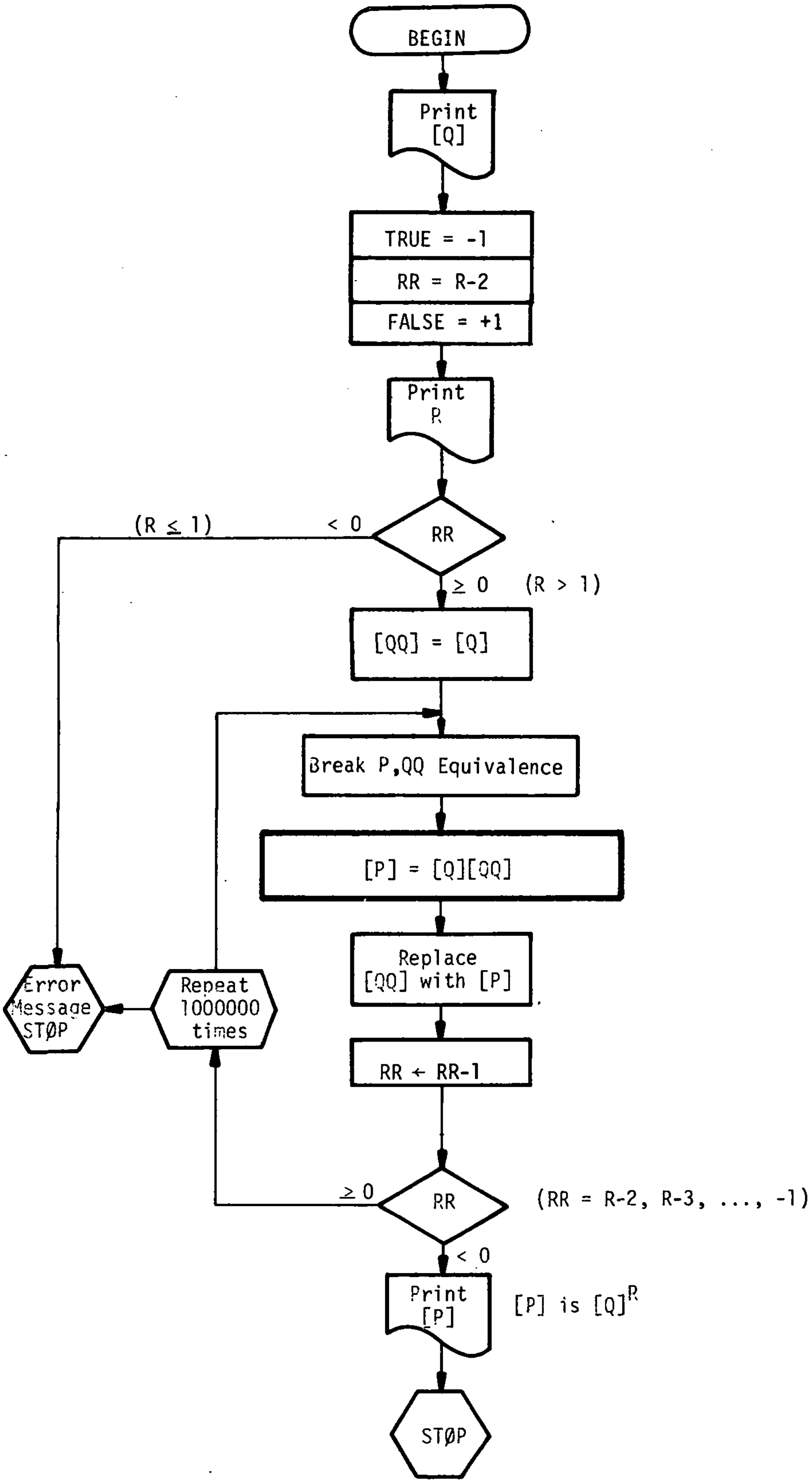
5.8.9 DMAP Example to Compute the r-th Power of a Matrix [Q]

```
BEGIN       $
MATPRN      Q,,,, // $
PARAM       // C,N,NØP / V,N,TRUE=-1 $
PARAM       // C,N,SUB / V,N,RR / V,Y,R=-1 / C,N,2 $
PARAM       // C,N,NØP / V,N,FALSE=+1 $
CØND        ERRØR1,RR $
ADD         Q, / QQ $
LABEL       DØIT $
EQUIV       QQ,P / FALSE $
MPYAD       Q,QQ, / P / C,N,0 $
EQUIV       P,QQ / TRUE $
PARAM       // C,N,SUB / V,N,RR / V,N,RR / C,N,1 $
CØND        STØP,RR $
REPT        DØIT,1000000 $
JUMP        ERRØR2 $
LABEL       STØP $
MATPRN      P,,,, // $
EXIT        $
LABEL       ERRØR1 $
PRTPARM     // C,N,-1 / C,N,DMAP $
EXIT        $
LABEL       ERRØR2 $
PRTPARM     // C,N,-2 / C,N,DMAP $
EXIT        $
END         $
```

Notes:

1. The matrix [Q] is assumed input via DMI bulk data cards.
2. The parameter R is assumed input on a PARAM bulk data card.
3. A logical flow diagram for this DMAP is shown in the following sketch.

DIRECT MATRIX ABSTRACTION



5.8.10 Usage of UPARTN, VEC, and PARTN

In Rigid Format No. 7 (Series N), the functional modules SMP1 and SMP2 perform the following matrix operations:

$$[K_{ff}] \Rightarrow \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

$$[G_o] = -[K_{oo}]^{-1} \; [K_{oa}]$$

$$[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}]^T [G_o]$$

$$[M_{ff}] \Rightarrow \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

$$[A] = [M_{oo}] \; [G_o] + [M_{oa}]$$

$$[B] = [M_{oa}]^T \; [G_o] + [\bar{M}_{aa}]$$

$$[M_{aa}] = [G_o]^T \; [A] + [B]$$

$$[K^4_{ff}] \Rightarrow \left[\begin{array}{c|c} \bar{K}^4_{aa} & K^4_{ao} \\ \hline K^4_{oa} & K^4_{oo} \end{array}\right]$$

$$[A] = [K^4_{oo}] \; [G_o] + [K^4_{oa}]$$

$$[B] = [K^4_{oa}]^T \; [G_o] + [\bar{K}^4_{aa}]$$

$$[K^4_{aa}] = [G_o]^T \; [A] + [B]$$

$$[B_{ff}] \Rightarrow \left[\begin{array}{c|c} \bar{B}_{aa} & B_{ao} \\ \hline B_{oa} & B_{oo} \end{array}\right]$$

$$[A] = [B_{oo}]\ [G_o] + [B_{oa}]$$

$$[B] = [B_{oa}]^T\ [G_o] + [\bar{B}_{aa}]$$

$$[B_{aa}] = [G_o]^T\ [A] + [B]$$

This is far too many time-consuming matrix operations to perform within single modules when the a-set and o-set are large. (Remember, checkpoint only occurs after the module has done all its work.) One way to break the Rigid Format Series N SMP1 into parts is to use an ALTER packet similar to the ALTER Packet which follows for Rigid Format No. 7 (Series N).

```
ALTER 97, 98 $ RIGID FØRMAT SERIES N
SMP1 USET,KFF,,,/GØ,KAA,KØØB,LØØ,UØØ,,,,, $
CHKPNT KAA,GØ $
SMP2 USET,GØ,MFF/MAA $
CHKPNT MAA $
SMP2 USET,GØ,BFF/BAA $
CHKPNT BAA $
SMP2 USET,GØ,K4FF/K4AA $
CHKPNT K4AA $
ENDALTER
```

Unfortunately, most of the time is now spent in SMP2. In order to subdivide the matrix operations further, the partitions of the matrices $[K_{ff}]$ etc. must be obtained. There are two new modules introduced in Level 15 which can be used to do this. The first is UPARTN which forms the symmetric partitions of a symmetric matrix.

EXAMPLES

SMP 1 and SMP2 using UPARTN for Rigid Format No. 7 (Series N)

```
ALTER     96,106 $ ALTER TØ SERIES N
$
UPARTN    USET,KFF / KØØ, ,KØA,KAAB / C,N,F / C,N,Ø / C,N,A $
CHKPNT    KØØ,KØA,KAAB $
SØLVE     KØØ,KØA / GØ / C,N,1 / C,N,-1 $
CHKPNT    GØ $
MPYAD     KØA,GØ,KAAB / KAA / C,N,1 $
CHKPNT    KAA $
$
UPARTN    USET,MFF / MØØ, ,MØA,MAAB / C,N,F / C,N,Ø / C,N,A $
CHKPNT    MØØ,MØA,MAAB $
MPYAD     MØØ,GØ,MØA / MAATEMP1 / C,N,0 $
CHKPNT    MAATEMP1 $
MPYAD     MØA,GØ,MAAB / MAATEMP2 / C,N,1 $
CHKPNT    MAATEMP2 $
MPYAD     GØ,MAATEMP1,MAATEMP2 / MAA / C,N,1 $
CHKPNT    MAA $
$
UPARTN    USET,K4FF / K4ØØ, ,K4ØA,K4AAB / C,N,F / C,N,Ø / C,N,A $
CHKPNT    K4ØØ,K4ØA,K4AAB $
MPYAD     K4ØØ,GØ,K4ØA / K4AATMP1 / C,N,0 $
CHKPNT    K4AATMP1 $
MPYAD     K4ØA,GØ,K4AAB / K4AATMP2 / C,N,1 $
CHKPNT    K4AATMP2 $
MPYAD     GØ,K4AATMP1,K4AATMP2 / K4AA / C,N,1 $
CHKPNT    K4AA $
$
UPARTN    USET,BFF / BØØ, ,BØA,BAAB / C,N,F / C,N,Ø / C,N,A $
CHKPNT    BØØ,BØA,BAAB $
MPYAD     BØØ,GØ,BØA / BAATEMP1 / C,N,0 $
CHKPNT    BAATEMP1 $
```

```
MPYAD     BØA,GØ,BAAB / BAATEMP2 / C,N,1 $
CHKPNT    BAATEMP2 $
MPYAD     GØ,BAATEMP1,BAATEMP2 / BAA / C,N,1 $
CHKPNT    BAA $
$
ENDALTER
```

In order to subdivide the matrix operations further, the partitioning information contained in USET must be made available to PARTN and MERGE so that the various matrix partitions can be formed external to SMP2 and manipulated with matrix operation modules such as MPYAD. The utility module VEC was introduced in Level 15 to accomplish this task. The ALTER Packet on the following page shows the replacement of Structural Matrix Partitioning in Rigid Format No. 7 (Series N) using this utility module.

EXAMPLES

SMP1 and SMP2 using VEC and PARTN for Rigid Format No. 7 (Series N)

```
ALTER     96,106 $
$
VEC       USET / V / C,N,F / C,N,Ø / C,N,A $
CHKPNT    V $
$
PARTN     KFF,V, / KØØ, ,KØA,KAAB $
CHKPNT    KØØ,KØA,KAAB $
DECØMP    KØØ / LØØ,UØØ / C,N,1 / C,N,0 / V,N,MIND / V,N,DET / V,N,NDET / V,N,SING $
SAVE      MIND,DET,NDET,SING $
CØND      LSING,SING $
CHKPNT    LØØ,UØØ $
FBS       LØØ,UØØ,KØA / GØ / C,N,1 / C,N,-1 $
CHKPNT    GØ $
MPYAD     KØA,GØ,KAAB / KAA / C,N,1 $
CHKPNT    KAA $
$
PARTN     MFF,V, / MØØ, ,MØA,MAAB $
CHKPNT    MØØ,MØA,MAAB $
MPYAD     MØØ,GØ,MØA / MAATEMP1 / C,N,0 $
CHKPNT    MAATEMP1 $
MPYAD     MØA,GØ,MAAB / MAATEMP2 / C,N,1 $
CHKPNT    MAATEMP2 $
MPYAD     GØ,MAATEMP1,MAATEMP2 / MAA / C,N,1 $
CHKPNT    MAA $
$
PARTN     K4FF,V, / K4ØØ, ,K4ØA,K4AAB $
CHKPNT    K4ØØ,K4ØA,K4AAB $
MPYAD     K4ØØ,GØ,K4ØA / K4AATMP1 / C,N,0 $
CHKPNT    K4AATMP1 $
MPYAD     K4ØA,GØ,K4AAB / K4AATMP2 / C,N,1 $
CHKPNT    K4AATMP2 $
```

```
MPYAD     GØ,K4AATMP1,K4AATMP2 / K4AA / C,N,1 $
$
PARTN     BFF,V, / BØØ, ,BØA,BAAB $
CHKPNT    BØØ,BØA,BAAB $
MPYAD     BØØ,GØ,BØA / BAATEMP1 / C,N,0 $
CHKPNT    BAATEMP1 $
MPYAD     BØA,GØ,BAAB / BAATEMP2 / C,N,1 $
CHKPNT    BAATEMP2 $
MPYAD     GØ,BAATEMP1,BAATEMP2 / BAA / C,N,1 $
CHKPNT    BAA $
$
ALTER   180  $  ADD ERRØR TRAP FØR SINGULAR KØØ MATRIX  IN R.F. 7 (SERIES N )
$
LABEL     LSING $
PRTPARM   // C,N,0 / C,N,SING $
PRTPARM   // C,N,-1 / C,N,DMAP $
EXIT      $
$
ENDALTER
```

5.8.11 DMAP Example

Let A, B and C be matrices whose values are to be defined at execution time. Let β be a real constant whose value is to be defined at execution time. Let α be an integer constant whose value (defined at execution time) determines the operations to be performed to compute matrix X as follows:

$$[X] = \begin{cases} [A][B] + [C] & , \alpha < 0 \\ \left[\beta[A] + [B]\right]^T & , \alpha = 0 \\ [A]^2[C]^{-1} & , \alpha > 0 \end{cases}$$

Write a DMAP to accomplish the above, assuming A, B and C will be defined by DMI bulk data cards and that α and β will be defined on PARAM bulk data cards. Print the inputs and outputs using the DMAP Utility Functional Modules MATPRN and PRTPARM. Use the DMAP Utility Module SEEMAT to print a topology display of [A] and [X].

A solution to this problem is given on the following page along with data for an actual example.

```
ID A,B
TIME 5
APP DMAP
BEGIN $
JUMP START $
PARAM // C,N,NØP / V,N,TRUE=-1 $  SET TRUE TØ -1 (=.TRUE.)
LABEL START $
MATPRN A,B,C,, // $
CØND ØNE,ALPHA $
PARAM // C,N,NØT / V,N,CHØØSE / V,Y,ALPHA $
CØND THREE,CHØØSE $
JUMP TWØ $
$
LABEL ØNE $                                                  ALPHA .LT. 0
MPYAD A,B,C / X / C,N,0 $
JUMP FINIS $
$
LABEL TWØ $                                                  ALPHA .EQ. 0
ADD A,B / Y / C,Y,BETA=(0.0,0.0) $
TRNSP Y / X2 $
EQUIV X2,X / TRUE $
JUMP FINIS $
$
LABEL THREE $                                                ALPHA .GT. 0
SØLVE C, / Z $
MPYAD A,Z, / W / C,N,0 $
MPYAD A,W, / X3 / C,N,0 $
EQUIV X3,X / TRUE $
$
LABEL FINIS $
MATPRN X,,,, // $
SEEMAT A,X,,, // C,N,PRINT $
PRTPARM // C,N,0 $
END $
CEND
TITLE = TEST MPYAD
BEGIN BULK
DMI        A        0      6      1      2            2      2
DMI        A        1      1      1.01
DMI        A        2      2      1.01
DMI        B        0      6      1      2            2      2
DMI        B        1      1      1.01
DMI        B        2      2      1.01
DMI        C        0      6      1      2            2      2
DMI        C        1      1      1.01
DMI        C        2      2      1.01
PARAM      ALPHA    -1
PARAM      BETA     1.0    .0
ENDDATA
```

5.9 AUTOMATIC SUBSTRUCTURE DMAP ALTERS

In the automated substructure process, the user commands (described in Section 2.7) are converted to the form of DMAP instructions via ALTER card equivalents. This section describes the resulting DMAP data for each command.

The "raw DMAP" data, stored in the program and modified according to the user input data, is listed by command type. The fields in the raw DMAP to be modified, or "variables", are underlined (i.e., <u>XXX</u>). The subcommand control cards are identified by parentheses on the right side. For example, the (P only) for the SUBSTRUCTURE command item 12, implies that this DMAP instruction is included only if the ØPTIØN request includes P (loads).

The ALTER card images are not true DMAP instructions but are used to locate positions in the existing DMAP Rigid Format for replacement by or insertion of the new DMAP instructions. The locations to be specified depend on the Rigid Format selected by the SØL Executive Control Card and are listed in Section 3 for each Rigid Format. The relevant section of the Rigid Format for each ALTER is indicated by the note in parentheses. For instance "After GP4" in Rigid Format 1 (statics) implies "ALTER 54" for insertion of the corresponding DMAP instructions following Rigid Format Series N instruction number 54. If an existing set of DMAP instructions is to be removed. the parenthetical note may indicate "Remove DECØMP", where DECØMP may be a set of NASTRAN modules related to the entire decomposition process.

The descriptions given below are highly dependent on the user input commands and the Rigid Format selected. For an exact listing of all DMAP data generated for the current set of substructure commands, the DIAG 23 Executive Control Card may be input. Adding DIAG 24 will produce a punched deck of the actual ALTER cards generated. This feature allows the user to modify these alters and execute under APP DMAP.

5.9.1 Index of Substructure DMAP ALTERs

5.9.2 DMAP for Command: BRECØVER (Phase 3)

The BRECØVER command converts the results of a Phase 2 substructure analysis to NASTRAN solution vectors for the detailed calculation of basic structure (or an equivalent basic substructure) displacements, forces, loads, and stresses. The same structure model of the primary substructure defined in Phase 1 must be used in Phase 3. It is possible to perform the Phase 3 execution either as a restart of the Phase 1 run or as an independent run, which recalculates the necessary data blocks.

Raw DMAP:

```
 1  ALTER     (Remove solution)
 2  PARAM     //C,N,NØP/V,N,ALWAYS=-1 $
 3  SSG2      USET,GM,YS,KFS,GØ,,PG/QR,PØ,PS,PL $  (P only)
 4  RCØVR3    ,PG,PS,PØ,YS/ULV,QSS,PGS,PSS,POS,YSS,LAMA/C,N,SØLN/
 5            C,N,NAME $
 6  EQUIV     PGS,PG/ALWAYS/PØS,PØ/ALWAYS/YSS,YS/ALWAYS/PSS,PS/ALWAYS $  (P only)
 7  $
 8  CØND      LBSXXX,ØMIT $                                   )
 9  FBS       LØØ,VØØ,PØS/UØØV/C,N,1/C,N,1/C,N,PREC/C,N,1 $   }  (P only)
10  LABEL     LBSXXX $                                        )
11  ØFP       LAMA,,,,,//V,N,CARDNØ$
12  ALTER     (After SDR1)
13  UMERGE    USET,QSS,/QGS/C,N,G/C,N,A/C,N,0 $
14  ADD       QG,QGD/QGT $
15  EQUIV     QGT,QG/ALWAYS $
```

Variables:

SØLN	= Rigid Format solution number
PG,PS,PØ,YS	= Remove data blocks if ØPTIØN not P
NAME	= Name of basic Phase 1 substructure, corresponding to input data
XXX	= Step number

5.9.3 DMAP for Command: CØMBINE

The CØMBINE command initiates the process for combining several substructures defined on the SØF files. The CØMB1 module reads the control deck and the Bulk Data cards and builds the tables and transformation matrices for the combination structure. The CØMB2 module performs the matrix transformations using the matrices stored on the SØF file or currently defined as NASTRAN data blocks. The resultant matrices are stored on the SØF file and retained as NASTRAN data blocks.

Raw DMAP:

```
CØMB1    CASECC,GEØM4//C,N,STP/S,N,DRY/C,N,PØPT $
CØND     LBSTP,DRY $
CØMB2    ,KN01,KN02,KN03,KN04,KN05,KN06,KN07/KNSC/S,N,DRY/C,N,K/        }
         C,N,NAME0001/C,N,NAME0002/C,N,NAME0003/C,N,NAME0004/C,N,      }  (K only)
         DUMPARAM/C,N,NAME0005/C,N,NAME0006/C,N,NAME0007 $             }
SØFØ     ,KNSC,,,,//S,N,DRY/C,N,NAMEC/C,N,KMTX $                       }
CØMB2    MN01,MN02,MN03,MN04,MN05,MN06,MN07/MNSC/V,N,DRY/C,N,M/        }
         C,N,NAME0001/C,N,NAME0002/C,N,NAME0003/C,N,NAME0004/C,N,      }  (M only)
         DUMPARAM/C,N,NAME0005/C,N,NAME0006/C,N,NAME0007 $             }
SØFØ     ,MNSC,,,,//S,N,DRY/C,N,NAMEC/C,N,MMTX $                       }
CØMB2    ,PN01,PN02,PN03,PN04,PN05,PN06,PN07/PNSC/V,N,DRY/C,N,P/       }
         C,N,NAME0001/C,N,NAME0002/C,N,NAME0003/C,N,NAME0004/C,N,      }  (P or PA only)
         PØPT/C,N,NAME0005/C,N,NAME0006/C,N,NAME0007 $                 }
SØFØ     ,PNSC,,,,//S,N,DRY/C,N,NAMEC/C,N,PVEC $                       }
LABEL    LBSTP $
LØDAPP   PNSC//S,N,DRY/C,N,NAMEC $     }  (PA only)
```

Variables:

NAME0001,NAME0002,...,etc.	=	Names of pseudostructures to be combined
N01,N02,...,etc.	=	Internal number for structures to be combined
NAMEC	=	Name of combined structure
NSC	=	Internal number of combined structure
STP	=	Step number
PØPT	=	Flag for appended loads (ØPTIØN=PA)

5.9.4 DMAP for Utility Commands: DELETE, DESTRØY, EDIT, EQUIV, RENAME, SØFPRINT

Several internal operations of the SØF may be performed with the utility commands which create various calls to the SØFUT module. Each of the commands and associated data are inserted as parameters.

Raw DMAP:

```
1  SØFUT    //V,N,DRY/C,N,NAME/C,N,ØPER/C,N,ØPT/C,N,NAME0002/C,N,PREF/
2           C,N,DUMPARAM/C,N,ITM1/C,N,ITM2/C,N,ITM3/C,N,ITM4/C,N,ITM5 $
```

Variables:

NAME = Name of substructure
ØPER = Operation to be performed (first four characters of command, i.e., EDIT)
ØPT = Integer option code
NAME0002 = Second substructure name for EQUIV and RENAME
PREF = Prefix for EQUIV operation
ITM1,ITM2, etc. = SØF data item names

The following chart describes the variables used for each command.

Command	NAME	ØPER	ØPT	NAME0002	PREF	ITM1, etc.
DELETE	X	X				X
DESTRØY	X	X				
EDIT	X	X	X			
EQUIV	X	X		X	X	
RENAME	X	X		X		
SØFPRINT	X	X	X			X

5.9.5 DMAP for Substructure Plots: PLØT

Any level of substructure may be plotted as an undeformed shape using the existing NASTRAN plot logic. The plot sets generated in Phase 1 are combined and transformed for that plotting.

Raw DMAP:

```
1  PLTMRG    CASECC,PCDB/PLTXXX,GPXXX,ELXXX,BCXXX,CASXXX,EQXXX/C,N,
2            NAME/V,N,NGP/V,N,LSIL/V,N,NPSET $
3  SAVE      NGP,LSIL,NPSET $
4  SETVAL    //V,N,PLTFLG/C,N,1/V,N,PFIL/C,N,0 $
5  SAVE      PLTFLG,PFIL $
6  PLØT      PLTXXX,GPXXX,BLXXX,CASXXX,BGXXX,FQXXX,,,/PMXXX/V,N,NGP/V,N,
7            LSIL/V,N,NPSET/V,N,PLTFLG/V,N,PFIL $
8  SAVE      NPSET,PLTFLG,PFIL $
9  PRTMSG    PMXXX// $
```

Variables:

NAME - Name of substructure to be plotted
XXX - Step number

5.9.6 DMAP for Command: RECØVER (Phase 2)

This operation performs the recovery and output of the Phase 2 solution data. The NASTRAN solution displacement vector is transformed and expanded to correspond to the degrees of freedom of the selected component substructures. Each pass through the DMAP loop corresponds to a requested structure to be processed. The RCØVR module selects the substructure to be processed with the loop counter, ILØØP.

Raw DMAP:

```
1   $RECOVER   PHASE 2  (Follows preceding command sequence)
2   PARAM      //C,N,NØP/V,N,ILØØP=0 $
3   LABEL      LBSTP $
4   RCØVR      CASESS,GELA,KGG,MGG,PG,UGPH/ØUG1,ØPG1,ØQG1,U1,U2,U3,
5              U4,U5/V,N,DRY/V,N,ILØØP/C,N,STP/C,N,NAMEFSS/C,N,NSØL/
6              V,N,NEIGV/V,N,LUI/V,N,U1N/V,N,U2N/V,N,U3N/V,N,U4N/V,N,U5N $
7   SAVE       DRY,ILØØP,LUI,U1N,U2N,U3N,U4N,U5N $
8   ØFP        ØUG1,ØQG1,ØPG1,,,//V,N,CARDNØ $
9   SAVE       CARDNØ
10  CØND       LBBSTP,ILØØP $
11  REPT       LBSTP,100 $
12  LABEL      LBBSTP $
```

Variables:

GELA	= GEMØ4 or LAMA depending on rigid format
KGG,MGG,PG	= Data blocks which depend on ØPTIØN
UGPH	= UGV or PHIG depending on rigid format
STP	= Step number
NAMEFSS	= Name of solution structure
NSØL	= Rigid Format solution number

5.9.7 DMAP for Command: REDUCE

The REDUCE command initiates the matrix partitioning operations to be performed on the stiffness, mass, and load vectors in order to produce a set of matrices defined by a subset of the original degrees of freedom. The REDUCE module generates the partitioning vector PV, a USET data block US, and an identity matrix IN from the Bulk Data and the corresponding substructure tables stored on the SØF. The remainder ofthe DMAP sequence directs the actual matrix operations.

Raw DMAP:

```
REDUCE    CASECC,GEØM4/PVNOA,USXXX,INXXX/C,N,STP/V,N,DRY/C,N,PØPT $
SAVE      DRY $
CØND      LBRSTP,DRY $
SØFI      /KNOA,MNOA.PNOA,,/V,N,DRY/C,N,NAME000A/C,N,KMTX/
          C,N,MMTX/C,N,PVEC $
SAVE      DRY $
CØND      LBRSTP,DRY $
SMP1      USXXX,KNØA,,/GØNOA,KNOB,KØNOA,LØNOA      ,,,,, $          }
MERGE     GØNOA,INXXX,,,,PVNOA/GNOA/C,N,1/C,N,TYP/C,N,2 $           } (K only)
SØFØ      GNOA,LØNOA,,,//V,N,DRY/C,N,NAME000A/C,N,HØRG/C,N,LMTX $   }
SØFØ      KNOB,,,,//V,N,DRY/C,N,NAME000B/C,N,KMTX $                 }
SØFI      /GNOA,,,,/V,N,DRY/C,N,NAME000A/C,N,HØRG $    (if not K)
MPYAD     MNOA,GNOA,/MXXX/C,N,0/C,N,1/C,N,0/C,N,TYP $  } (M only)
MPYAD     GNOA,MXXX,/MNOB/C,N,1/C,N,1/C,N,0/C,N,TYP $  }
PARTN     PNOA,,PVNOA/PØNOA,,,/C,N,1/C,N,1/C,N,2 $                      }
MPYAD     GNOA,PNOA,/PNOB/C,N,1/C,N,1/C,N,0/C,N,1 $                     } (P only)
SØFØ      PØNOA,PVNOA,,,//V,N,DRY/C,N,NAME000A/C,N,PØVE/C,N,UPRT $      }
SØFØ      MNOB,PNOB,,,//V,N,DRY/C,N,NAME000B/C,N,MMTX/C,N,PØPT $
LØDAPP    PNOB,PØNOA//V,N,DRY/C,N,NAME000B $
LABEL     LBRSTP $
```

Variables:

XXX,SPT = Step number
NAME000A = Name of input structure, A.
NAME000B = Name of output structure, B.
NOA,NOB = Internal numbers of substructures A and B.
TYP = Matrix precision flag (1 = single)
PØPT,PØVE = Flags for appended loads (ØPTION=PA)

5.9.8 DMAP for Command: RUN

The RUN command defines the DRY parameter for use by the subsequent DMAP instructions. If the user specifies RUN=DRYGØ, a special set of DMAP instructions are placed at the end of the entire command sequence.

Raw DMAP:

```
PARAM      //C,N,ADD/V,N,DRY/C,N,I/C,N,0 $
```

Variables:

I = Integer code for RUN option (DRY = -1, GØ = 0, STEP = 1)

If RUN=DRYGØ, I is set to (DRY) initially and the following DMAP is inserted at the end of the complete ALTER stream:

```
LABEL      LBSEND
PARAM      //C,N,ADD/V,N,DRY/V,N,DRY/C,N,1 $
CØND       FINIS,DRY $
REPT       LBSBEG,1 $
JUMP       FINIS $
```

5.9.9 DMAP for External I/Ø Commands: SØFIN, SØFØUT, RESTØRE, DUMP, CHECK

Several operations may be performed on the NASTRAN user files and the SØF file using the EXIØ module. The various input parameters are set by the Substructure Commands.

Raw DMAP:

```
1   EXIØ        //V,N,DRY/C,N,0/C,N,DEVI/C,N,UNITNAME/C,N,FØRM/C,N,MØDE/
2               C,N,PØSI/C,N,ITEM/C,N,NAME0001/C,N,NAME0002/E,N,NAME0003/
3               C,N,NAME0004/C,N,NAME0005 $
```

Variables:

MØDE = First four characters of command name (i.e., 'SØFI', 'REST')
DEVI = Device used for I/Ø file ('TAPE' or 'DISK')
UNITNAME = Name of NASTRAN user file assigned to I/Ø file (i.e., INPT, INP1, etc.)
FØRM = Format of data ('EXTE' or 'INTE')
PØSI = Position of file on device ('REWI', 'NØRE', or 'EØF')
ITEM = Name of SØF item or 'ALL', 'MATR', 'TABL', or 'PHAS'
NAME0001, etc. = Names of substructures to be copied.

The following chart describes the variables used for each command:

Command	MØDE	DEVI	UNITNAME	FØRM	PØSI	ITEM	$NAME000_i$
SØFIN	X	X	X	X	X	X	X
SØFØUT	X	X	X	X	X	X	X
RESTØRE	X	X	X				
DUMP	X	X	X				
CHECK	X	X	X				

5.9.10 DMAP for Command: SØLVE

The SØLVE command provides the necessary data for execution of the solution phase of NASTRAN. Module SGEN replaces the NASTRAN GP1 module for the purpose of defining an equivalent pseudostructure from data blocks. The new data blocks GE3S and GE4S contain the load and constraint data in the form of converted Bulk Data card images. The stiffness and mass matrices are obtained from the SØF files and added to any user matrix terms.

Raw DMAP:

```
ALTER     (Remove GP1)
PARAM     //C,N,NØP/V,N,ALWAYS=-1 $
SGEN      CASECC,GEØM3,GEØM4/CASESS,CASEI,GPL,EQEXIN,GPDT,BGPDT,SIL,
          GE3S,GE4S,CSTM/V,N,DRY/C,N,NAMESØLS/V,N,LUSET/V,N,NØGPDT $
SAVE      DRY,LUSET,NØGPDT $
EQUIV     GE3S,GEØM3/ALWAYS/GE4S,GEØM4/ALWAYS/CASEI,CASECC/ALWAYS $
CØND      LBSTP/DRY $
ALTER     (Remove PLØT)
ALTER     (Remove NØSIMP CØND)
CØND      LBSØL,NØSINP $
ALTER     (Remove SMA3)
LABEL     LBSØL $
SØFI      /KNØS,MNØS,,,/V,N,DRY/C,N,NAMESØLS/C,N,KNTX/C,N,MMTX $
EQUIV     KNØS,KGG/NØSIMP $  (K only)
EQUIV     MNØS,MGG/NØSIMP $  (M, only used for Rigid Formats 2 and 3)
CØND      LBSTP,NØSIMP $
ADD       KGGX,KNØS/KGG/ $   (K only)
ADD       MGG,MNØS/MGGX/ $
                                 (M, only used for Rigid Formats 2 and 3)
EQUIV     MGGX,MGG/ALWAYS $
LABEL     LBSTP
CHKPNT    MGG $  (M, only used for Rigid Formats 2 and 3)
ALTER     (After GP4)
CØND      LBSEND,DRY $
ALTER     (Remove SDR2-PLØT)
```

Variables

NAMESØLS	= Name of solution structure
NØS	= Internal number of solution structure
STP	= Step number

5.9.11 DMAP for Command: SUBSTRUCTURE

The SUBSTRUCTURE command is necessary to initiate the automatic DMAP process. In Phase 1, the SUBPH1 module is used to build the substructure tables on the SØF from the NASTRAN grid point tables and the SØFØ module is used to copy the matrices onto the SØF. In Phase 2 and Phase 3, the initial value of the DRY parameter is set and the DMAP sequence is initiated.

Raw DMAP:

PHASE 1

```
ALTER     (After GP4)
PARAM     //C,N,ADD/V,N,DRY/C,N,I/C,N,0 $
LABEL     LBSBEG $
CØND      LBLIS,DRY $
ALTER     (Remove DECØMP)
LABEL     LBLIS $
ALTER     (Remove solution)
SUBPH1    CASECC,EQEXIN,USET,BGPDT,CSTM,GPSETS,ELSETS//V,N,
          DRY/C,N,NAME/C,N,PLØTID/C,N,PØPT $
SAVE      DRY $
CØND      LBSEND,DRY $
SSG2      USET,GM,YS,KFS,GØ,,PG/QR,PØ,PS,PL $ (P or PA only)
CHKPNT    PØ,PS,PL $
SØFØ      ,KAA,MAA,PL,,//V,N,DRY/C,N,NAME/C,N,KMTX/C,N,MMTX/C,N,PVEC $
LØDAPP    PL,//V,N,DRY/C,N,NAME $ (PA only)
```

PHASE2

```
ALTER     2,0
PARAM     //C,N,ADD/V,N,DRY/C,N,I/C,N,0 $
LABEL     LBSBEG $
```

PHASE 3

```
ALTER     (Remove DECØMP)
PARAM     //C,N,ADD/V,N,DRY/C,N,I/C,N,0 $
LABEL     LBSBEG $
```

Variables:

I	=	Integer RUN option code (see RUN command)
NAME	=	Phase 1 substructure name
PLØTID	=	Phase 1 Plot Set ID
KAA,MAA,PL	=	Data blocks dependent on ØPTIØN
PØPT	=	Flag for appended loads (ØPTION=PA)

DIAGNOSTIC MESSAGES

6.1 RIGID FORMAT DIAGNOSTIC MESSAGES

A number of fatal errors are detected by DMAP statements in the various rigid formats. These messages indicate the presence of fatal user errors that, either cannot be determined by the functional modules, or that can be more effectively detected by DMAP statements in the rigid format. The detection of such an error causes a transfer to a LABEL instruction near the end of the rigid format. The text of the message is output and the execution is terminated. These messages will always appear at the end of the NASTRAN output.

6.1.1 Displacement Approach Rigid Formats

The texts of the rigid format error messages are given in the following sections for each of the displacement approach rigid formats. The text for each message is given in capital letters and is followed by additional explanatory material, including suggestions for remedial action.

6.1.1.1 Rigid Format Error Messages for Static Analysis

NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDR1.

NØ. 2 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

The stiffness matrix is null because no elements have been defined on either Connection cards or GENEL cards.

NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

A problem requiring boundary condition changes was run on subsets 1 or 3. The problem should be restarted on subset 0.

6.1.1.2 Rigid Format Error Messages for Static Analysis with Inertia Relief

NØ. 1 - MASS MATRIX REQUIRED FØR CALCULATIØN ØF INERTIA LØADS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDR1.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NØ. 4 - FREE BØDY SUPPØRTS ARE REQUIRED.

A statically determinate set of supports must be specified on a SUPØRT card in order to determine the rigid body characteristics of the structural model.

NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

A problem requiring boundary condition changes was run on subsets 1 or 3. The problem should be restarted on subset 0.

6.1.1.3 Rigid Format Error Messages for Normal Mode Analysis

NØ. 1 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

6.1.1.4 Rigid Format Error Messages for Static Analysis with Differential Stiffness

NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

The differential stiffness matrix is null because no structural elements have been defined with Connection cards.

NØ. 2 - FREE BØDY SUPPØRTS NØT ALLØWED.

Free bodies are not allowed in Static Analysis with Differential Stiffness. The SUPØRT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 scale factors for differential stiffness calculations. This number may be increased by altering the REPT instruction following SDR1.

NØ. 4 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 5 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NO. 6 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

A problem requiring multiple differential load factor was run on subset (1 or 3) which does not support them. The problem should be restarted on subset 0.

6.1.1.5 Rigid Format Error Messages for Buckling Analysis

NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

The differential stiffness matrix is null because no structural elements have been defined with Connection cards.

NØ. 2 - FREE BØDY SUPPØRTS NØT ALLØWED.

Free bodies are not allowed in Buckling Analysis. The SUPØRT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 3 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGB card and METHØD must select an EIGB set in the Case Control Deck.

NØ. 4 - NØ EIGENVALUES FØUND.

No buckling modes exist in the range specified by the user.

NØ. 5 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card or the density was not defined on a Material card.

NØ. 6 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVF BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

6.1.1.6 Rigid Format Error Messages for Piecewise Linear Analysis

NØ. 1 - NØ NØNLINEAR ELEMENTS HAVE BEEN DEFINED.

A piecewise linear problem has not been formulated because none of the elements have a stress dependent modulus of elasticity defined on a Material card.

NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 load increments. This number may be increased by altering the REPT instruction preceding SDR2.

NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

The stiffness matrix is null because no elements have been defined on either Connection cards or GENEL cards.

NØ. 5 - STIFFNESS MATRIX SINGULAR DUE TØ MATERIAL PLASTICITY.

The stiffness matrix is singular due either to one or more grid point singularities or element material plasticity.

6.1.1.7 Rigid Format Error Messages for Direct Complex Eigenvalue Analysis.

NØ. 1 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR CØMPLEX EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGC card and CMETHØD must select an EIGC set in the Case Control Deck.

NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 sets of direct input matrices. This number may be increased by altering the REPT instruction following SDR2.

NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS

The mass matrix is null because either no elements were defined on Connection cards, nonstructural mass was not defined an a Property card, or the density was not defined on a Material card.

6.1.1.8 Rigid Format Error Messages for Direct Frequency and Random Response.

NØ. 1 - FREQUENCY RESPØNSE LIST REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

Frequencies to be used in the solution of frequency response problems must be supplied on a FREQ, FREQ1, or FREQ2 card and FREQ must select a frequency response set in the Case Control Deck.

NØ. 2 - DYNAMIC LØADS TABLE REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

Dynamic loads to be used in the solution of frequency response problems must be specified on an RLØAD1 or RLØAD2 card and DLØAD must select a dynamic load set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 sets of direct input matrices. This number may be increased by altering the REPT instruction following the last ØFP instruction.

NØ. 4 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined on Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

6.1.1.9 Rigid Format Error Message for Direct Transient Response

NØ. 1 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

Time step intervals to be used must be specified on a TSTEP card and a TSTEP selection must be made in the Case Control Deck.

NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 dynamic load sets. This number may be increased by altering the REPT instruction following the last XYPLØT instruction.

NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

6.1.1.10 Rigid Format Error Messages for Modal Complex Eigenvalue Analysis.

NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of direct input matrices. This number can be increased by altering the REPT instruction following SDR2.

NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

No real eigenvalues were found in the frequency range specified by the user.

6.1.1.11 Rigid Format Error Messages for Modal Frequency and Random Response.

NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 sets of direct input matrices. This number can be increased by altering the REPT instruction following the last ØFP instruction.

NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

No real eigenvalues were found in the frequency range specified by the user.

NØ. 5 - FREQUENCY RESPØNSE LIST REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

Frequencies to be used in the solution of frequency response problems must be supplied on a FREQ, FREQ1, or FREQ2 card and FREQ must select a frequency response set in the the Case Control Deck.

NØ. 6 - DYNAMIC LØADS TABLE REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

Dynamic loads to be used in the solution of frequency response problems must be specified on an RLØAD1 or RLØAD2 card and DLØAD must select a dynamic load set in the Case Control Deck.

6.1.1.12 Rigid Format Error Messages for Modal Transient Response.

NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 dynamic load sets. This number can be increased by altering the REPT instruction following the last XYPLØT instruction.

NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

No real eigenvalues were found in the frequency range specified by the user.

NØ. 5 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

Time step intervals to be used must be specified on a TSTEP card and a TSTEP selection must be made in the Case Control Deck.

6.1.1.13 Rigid Format Error Messages for Normal Modes with Differential Stiffness.

NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

The differential stiffness matrix is null because no structural elements have been defined with Connection cards.

NØ. 2 - FREE BØDY SUPPØRTS NØT ALLØWED.

Free bodies are not allowed in Normal Modes with Differential Stiffness. The SUPØRT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 3 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 4 - NØ EIGENVALUE FØUND.

No eigenvalues were found in the frequency range specified by the user.

NØ. 5 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card or the density was not defined on a Material card.

NØ. 6 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

6.1.1.14 Rigid Format Error Messages for Statics using Cyclic Symmetry.

NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDR1.

NØ. 2 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card or the density was not defined on a Material card.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

The stiffness matrix is null because no elements have been defined on either Connection cards or GENEL cards.

NØ. 5 - FREE BØDY SUPPØRTS NØT ALLØWED.

Free bodies are not allowed in Statics with Cyclic Symmetry. The SUPØRT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 6 - CYCLIC SYMMETRY DATA ERRØR.

See Section 1.12 for proper modeling techniques and corresponding PARAM card requirements.

6.1.1.15 Rigid Format Error Messages for Normal Modes using Cyclic Symmetry.

NØ. 1 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NØ. 4 - FREE BØDY SUPPØRTS NØT ALLØWED.

Free bodies are not allowed in Normal Modes with Cyclic Symmetry. The SUPØRT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 5 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDR1.

NØ. 6 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

The stiffness matrix is null because no structural elements have been defined with Connection cards.

6.1.2 Heat Approach Rigid Formats

The texts of the rigid format error messages are given in the following sections for each of the heat approach rigid formats. The text for each message is given in capital letters and is followed by additional explanatory material, including suggestions for remedial action.

6.1.2.1 Rigid Format Error Messages for Static Heat Transfer Analysis

NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDR1.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT or GRDSET cards, or grounded on Scalar Connection cards.

NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

The stiffness matrix is null because no elements have been defined on either Connection cards or GENEL cards.

NØ. 5 - A LØØPING PROBLEM RUN ØN NØN-LØØPING SUBSET.

A problem requiring boundary condition changes was run on subset 1. The problem should be restarted on subset 0.

6.1.2.2 Rigid Format Error Messages for Nonlinear Static Heat Transfer Analysis

NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of direct input matrices. This number can be increased by altering the REPT instruction following SDR2.

NØ. 2 - NØ SIMPLE STRUCTURAL ELEMENTS.

The heat conduction matrix is null because no Connection cards (other than GENEL) have been defined.

NØ. 3 - STIFFNESS MATRIX SINGULAR.

The heat conduction matrix is singular due to unspecified grid point temperatures.

6.1.2.3 Rigid Format Error Message for Transient Heat Transfer Analysis

NØ. 1 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

Time step intervals to be used must be specified on a TSTEP card and a TSTEP selection must be made in the Case Control Deck.

6.1.3 Aero Approach Rigid Format

The texts of the rigid format error messages are given in the following section for the aero approach rigid format. The text for each message is given in capital letters and is followed by additional explanatory material, including suggestions for remedial action.

6.1.3.1 Rigid Format Error Messages for Modal Flutter Analysis

NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstuctural mass was not defined on a Property card or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of direct input matrices. This number can be increased by altering the REPT instruction following FA2.

NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

No real eigenvalues were found in the frequency range specified by the user.

6.2 NASTRAN SYSTEM AND USER MESSAGES

NASTRAN system and user messages are identified by number. Message numbers have been assigned in groups as follows:

1 - 1000	Preface Messages
1001 - 2000	Executive Module Messages
2001 -	Functional Module Messages

These messages have the following format:

$$\text{***} \quad \left\{\begin{array}{l}\text{SYSTEM}\\ \text{USER}\end{array}\right\} \left\{\begin{array}{l}\text{FATAL}\\ \text{WARNING}\\ \text{INFØRMATIØN}\end{array}\right\} \text{MESSAGE id, text.}$$

where "id" is a unique message identification number and "text" is the message as indicated in capital letters for each of the diagnostic messages. A series of asterisks (****) in the text indicates information that will be filled in for a specific use of the message, such as, the number of a grid point or the name of a bulk data card. Many of the messages are followed by additional explanatory material, including suggestions for remedial action.

The system and user messages described in this section pertain only to those messages generated by NASTRAN. Although these messages can appear at various places in the output stream, they should be easily identified by their format. The various computer operating systems also produce diagnostic messages that can appear at various places in the output stream. The format of these messages will vary with the operating system. Reference should be made to the operating system manuals for interpretation of the messages that are not generated by NASTRAN.

System messages refer to diagnostics that are associated with program errors. In general such errors cannot be corrected by the user. Reference should be made to the Programmer's Manual and assistance secured from the programming staff. User messages refer to errors that are usually associated with the preparation of the NASTRAN Data Deck. Corrective action is indicated in the message text or the explanatory information following the text. In some cases reference may have to be made to other sections of the User's Manual for proper card formats or for clarification of procedures.

Fatal messages cause the termination of the execution following the printing of the message text. These messages will always appear at the end of the NASTRAN output. Warning and information messages will appear at various places in the output stream. Such messages only convey warnings or information to the user. Consequently, the execution continues in a normal manner following the printing of the message text.

As an example, consider message number 2025, which will appear in the printed output as follows:

*** USER FATAL MESSAGE 2025, UNDEFINED CØØRDINATE SYSTEM 102.

The three leading asterisks (***) are always present in user and system diagnostic messages. The word USER indicates that this is a user message rather than a system message. The word FATAL indicates that this is a fatal message rather than a warning or information message. The number 2025 is the identification number for this message. The text of the message follows the comma (,). The number 102 replaces the asterisks (****) in the general message text, and indicates that 102 is the identification number of the undefined coordinate system.

6.2.1 Preface Messages

01 *** USER WARNING MESSAGE 1, ASSUMED FIRST INPUT FILE IS NULL.
User has specified N input data blocks when there should be N+1.

02 *** USER WARNING MESSAGE 2, PARAMETER NAMED ******** IS DUPLICATED.
No harm done. Parameter is saved just once.

03 *** USER FATAL MESSAGE 3, FØRMAT ERRØR IN PARAMETER NØ.***.
Double delimiter appears in parameter section of previous DMAP instruction.

04 *** SYSTEM FATAL MESSAGE 4, MPL PARAMETER ERRØR, MØDULE NAME = ******** PARAMETER NØ.***.
MPL entry for module is incorrect. See block data program XMPLBD.

05 *** USER FATAL MESSAGE 5, PARAMETER INPUT DATA ERRØR ILLEGAL VALUE FØR PARAMETER NAMED ********.
Type of parameter on PARAM card is inconsistent with type of parameter by same name in above DMAP instruction.

06 *** USER FATAL MESSAGE 6, ILLEGAL VALUE FØR PARAMETER NØ.***.
The type of parameter in DMAP instruction does not correspond to type requested in DMD or MFD section of Programmer's Manual.

07 *** USER FATAL MESSAGE 7, PARAMETER NØ.*** NEEDS PARAMETER NAME.
Parameter is not in correct format.

08 *** USER FATAL MESSAGE 8, BULK DATA PARAM CARD ERRØR. MUST NØT DEFINE PARAMETER NAMED ********.

The "N" in V,N,******** means user cannot set the value of the parameter with name ******** on a PARAM card.

09 *** USER FATAL MESSAGE 9, VALUE NEEDED FØR PARAMETER NØ. ***.

Constant needs value in DMAP instruction or on PARAM card.

10 *** USER FATAL MESSAGE 10, ILLEGAL INPUT SECTIØN FØRMAT.

11 *** USER FATAL MESSAGE 11, ILLEGAL ØUTPUT SECTIØN FØRMAT.

12 *** USER FATAL MESSAGE 12, ILLEGAL CHARACTER IN DMAP INSTRUCTIØN NAME.

Name must be 8 or less alpha-numeric characters, the first character being alpha.

13 *** USER FATAL MESSAGE 13, DMAP INSTRUCTIØN NØT IN MØDULE LIBRARY.

14 *** SYSTEM FATAL MESSAGE 14, ARRAY NAMED ******** ØVERFLØWED.

See XGPI module description in MFD section of Programmer's Manual.

15 *** USER FATAL MESSAGE 15, INCØNSISTENT LENGTH USED FØR PARAMETER NAMED ********.

This parameter was used in a previous DMAP instruction which gave it a different type. See Section 5.2.1 of the User's Manual.

16 *** USER FATAL MESSAGE 16, ILLEGAL FØRMAT.

17 *** USER FATAL MESSAGE 17, UNIDENTIFIED NASTRAN CARD KEYWØRD ********. ACCEPTABLE KEYWØRDS FØLLØW ---

18 *** USER FATAL MESSAGE 18, TØØ MANY PARAMETERS IN DMAP PARAMETER LIST.

Incorrect calling sequence for DMAP instruction.

19 *** USER FATAL MESSAGE 19, LABEL NAMED ******** IS MULTIPLY DEFINED.

LABEL named appears in more than one place in DMAP program.

20 *** USER FATAL MESSAGE 20, ILLEGAL CHARACTERS IN PARAMETER NØ. ***

Name must be 8 or less alpha-numeric characters, the first character being alpha.

21 *** USER FATAL MESSAGE 21, PARAMETER NAMED ******** IS NØT IN PRECEDING DMAP INSTRUCTIØN PARAMETER LIST.

Parameters in SAVE instruction must appear in immediately preceding DMAP instruction.

22 *** USER FATAL MESSAGE 22, DATA BLØCK NAMED ******** MUST BE DEFINED PRIØR TØ THIS INSTRUCTIØN.

See Section 5.2 of the User's Manual.

23 *** USER FATAL MESSAGE 23, DATA BLØCK NAMED ******** IS NØT REFERENCED IN SUBSEQUENT FUNCTIØNAL MØDULE.

See Section 5.2 of the User's Manual. Error can be suppressed by adding the following :

```
PARAM   //C,N,NØP/V,N,TRUE=-1 $
CØND    LABELXXX,TRUE $
TABPT   ********,,,,// $
LABEL   LABELXXX $
```

24 *** SYSTEM FATAL MESSAGE 24, CANNØT FIND FILE NAMED ******** ØN DATA PØØL TAPE.

Contents of /XDPL/ does not match contents of Pool Tape.

25 *** USER FATAL MESSAGE 25, PARAMETER NAMED ******** NØT DEFINED.

Parameter is referenced in nonfunctional module, but is nowhere defined.

26 *** USER FATAL MESSAGE 26, LABEL NAMED ******** NØT DEFINED.

LABEL name does not appear in LABEL instruction.

27 *** USER WARNING MESSAGE 27, LABEL NAMED ******** NØT REFERENCED.

LABEL name appears only in a LABEL instruction.

28 *** SYSTEM FATAL MESSAGE 28, UNEXPECTED END ØF TAPE ØN NEW PRØBLEM TAPE.

Either you truly encountered an EØT or file linkage has been destroyed in /XFIST/, /XPFIST/ and/or /XXFIAT/.

29 *** SYSTEM FATAL MESSAGE 29, UNEXPECTED END ØF TAPE ØN ØLD PRØBLEM TAPE.

File linkage has been destroyed in /XFIST/, /XPFIST/ and/or /XXFIAT/.

30 *** SYSTEM FATAL MESSAGE 30, UNEXPECTED END ØF TAPE ØN DATA PØØL TAPE.

See Message 28.

31 *** SYSTEM FATAL MESSAGE 31, CØNTRØL FILE ******** INCØMPLETE ØR MISSING ØN NEW PRØBLEM TAPE.

Data block XCSA is not in correct format or it is missing.

32 *** USER FATAL MESSAGE 32, FILE NAMED ******** MUST BE DEFINED PRIØR TØ THIS INSTRUCTIØN.

See Section 5.2 of the User's Manual.

33 *** SYSTEM FATAL MESSAGE 33, NAME (********) IN NEW CØNTRØL FILE DICTIØNARY NØT VALID.

First record of data block XCSA on Problem Tape contains a name which is not recognized by XGPI module.

34 *** SYSTEM FATAL MESSAGE 34, CANNØT TRANSLATE DMAP INSTRUCTIØN NØ.***.

Error in subroutine XSCNDM or XRCARD.

35 *** USER FATAL MESSAGE 35, INCØRRECT ØLD PRØBLEM TAPE MØUNTED. ID ØF TAPE MØUNTED = ********, ********,**/**/** FILE =***. ID ØF TAPE DESIRED = ********,********,**/**/** FILE =***.

Wrong reel mounted for multireel Problem Tape.

36 *** SYSTEM FATAL MESSAGE 36, CANNØT FIND FILE NAMED ******** ØN ØLD PRØBLEM TAPE.

Header record of file on Problem Tape does not match file name in restart dictionary.

37 *** USER WARNING MESSAGE 37, WARNING ØNLY - MAY NØT BE ENØUGH FILES AVAILABLE FØR MØDULE REQUIREMENTS. FILES NEEDED = *** FILES AVAILABLE = ***.

Program will execute if enough data blocks referenced by the module are purged. Purged data blocks are not assigned files.

38 *** SYSTEM FATAL MESSAGE 38, NØT ENØUGH CØRE FØR GPI TABLES

User must break up DMAP program.

39 *** SYSTEM FATAL MESSAGE 39, RIGID FØRMAT DMAP SEQUENCE DØES NØT CØRRESPØND TØ MED TABLE.

The MED Table must have the same number of entries as there are DMAP instructions in DMAP sequence.

40 *** USER FATAL MESSAGE 40, ERRØR IN ALTER DECK - CANNØT FIND END ØF DMAP INSTRUCTIØN.

User should check ALTER part of the Executive Control Deck.

41 *** SYSTEM FATAL MESSAGE 41, TABLES INCØRRECT FØR REGENERATING DATA BLØCK ********.

File Name Table and MED Table used by routine XFLDEF are wrong.

42 *** USER WARNING MESSAGE 42, PARAMETER NAMED ******** ALREADY HAD VALUE ASSIGNED PREVIØUSLY.

Parameter appears in a previous instruction which assigned it a value. The previous value will be used.

43 *** USER FATAL MESSAGE 43, INCØRRECT FØRMAT FØR NASTRAN CARD.

44 *** USER FATAL MESSAGE 44, UNABLE TØ FIND END DMAP INSTRUCTIØN.

User has altered out the END instruction.

45 *** USER FATAL MESSAGE 45, DATA BLØCK NAMED ******** ALREADY APPEARED AS ØUTPUT ØR WAS USED AS INPUT BEFØRE BEING DEFINED.

See Section 5.2 of the User's Manual.

46 *** USER FATAL MESSAGE 46, INCØRRECT REENTRY PØINT.

The last reentry card in the restart dictionary has a DMAP instruction number greater than the instruction number on the END card of the DMAP program.

47 *** USER FATAL MESSAGE 47, THIS INSTRUCTIØN CANNØT BE FIRST INSTRUCTIØN ØF LØØP.

CHKPNT DMAP instruction must not follow a LABEL instruction which is located at the top of a loop.

48 *** USER WARNING MESSAGE 48, DATA BLØCK ******** IS ALWAYS REGENERATED, THEREFØRE IT WILL NØT BE CHECKPØINTED.

This data block is generated by Input File Processors (IFP) and must not be checkpointed to insure proper restart.

49 *** SYSTEM FATAL MESSAGE 49, MPL TABLE (MØDULE PRØPERTIES LIST) IS INCØRRECT.

Error is in common block /XGP12/.

50 *** SYSTEM FATAL MESSAGE 50, CANNØT FIND JUMP ØSCAR ENTRY NEEDED FØR THIS RESTART.

There must be a dummy JUMP instruction before every LABEL instruction at top of a loop for rigid formats.

51 *** SYSTEM FATAL MESSAGE 51, NØT ENOUGH ØPEN CØRE FØR XGPIBS RØUTINE.

Additional core memory is required.

52 *** SYSTEM FATAL MESSAGE 52, NAMED CØMMØN /XLINK/ IS TØØ SMALL.

There must be one word in LINK table for every entry in MPL.

53 *** USER FATAL MESSAGE 53, INCØRRECT FØRMAT IN ABØVE CARD.

201 *** USER FATAL MESSAGE 201, REQUESTED BULK DATA DECK ********, NØT ØN USER MASTER FILE.

Requested UMF problem identification number not found on currently mounted UMF tape.

202 *** SYSTEM FATAL MESSAGE 202, UMF CØULD NØT BE ØPENED.

User Master File (UMF) not present (destroyed) in FIST.

203 *** SYSTEM FATAL MESSAGE 203, ILLEGAL EØR ØN UMF.

User Master File (UMF) contains no records in requested file.

204 *** USER FATAL MESSAGE 204, CØLD START, NØ BULK DATA.

No data cards were found after the BEGIN BULK card. A blank card will satisfy this rule.

205 *** USER WARNING MESSAGE 205, CØLD START, DELETE CARDS IGNØRED.

Delete (/) cards were present and ignored within the Bulk Data Deck.

206 *** USER FATAL MESSAGE 206, PREVIØUS CØNTINUATIØN MNEMØNIC HAS A DUPLICATE.

Two or more continuation cards were found with column 2-8 identical.

207 *** USER INFØ MESSAGE 207, BULK DATA NØT SØRTED, XSØRT WILL REØRDER DECK.

Bulk Data Deck was not in alpha-numeric sort. Sorting will be performed. Sorting of large deck can be time consuming.

208 *** USER FATAL MESSAGE 208, PREVIØUS CARD IS A DUPLICATE PARENT.

Two or more cards were found with column 74-80 identical and a continuation card is present with that mnemonic (column 2-8).

209 *** *USER FATAL MESSAGE 209, PREVIØUS **** CØNTINUATIØN CARDS HAVE NØ PARENTS.*

One or more continuation cards were found with a mnemonic (column 2-8) not matching any other card (column 74-80).

210 *** SYSTEM FATAL MESSAGE 210, SCRATCH CØULD NØT BE ØPENED.

One of the required scratch files was not present (destroyed) in FIST.

211 *** SYSTEM FATAL MESSAGE 211, ILLEGAL EØR ØN SCRATCH.

A required scratch file was formatted improperly.

212 *** SYSTEM FATAL MESSAGE 212, ILLEGAL EØF ØN ITAPE4.

Scratch file containing continuations was mispositioned.

213 *** SYSTEM FATAL MESSAGE 213, ILLEGAL EØF ØN ØPTP.

Old Problem Tape contained no bulk data (illegal format).

214 *** SYSTEM FATAL MESSAGE 214, ØPTP CØULD NØT BE ØPENED.

Old Problem Tape (ØPTP) not present (destroyed) in FIST.

215 *** SYSTEM FATAL MESSAGE 215, NPTP CØULD NØT BE ØPENED.

New Problem Tape (NPTP) not present (destroyed) in FIST.

216 *** SYSTEM FATAL MESSAGE 216, ILLEGAL INDEX.

FORTRAN computed-GØ-TØ has received an illogical value.

217 *** SYSTEM FATAL MESSAGE 217, ILLEGAL EØF ØN ITAPE4.

300 *** USER FATAL MESSAGE 300, DATA ERRØR IN FIELD UNDERLINED.
(1)

A data error as described in the text has been detected by utility routine XRCARD or RCARD.

300 *** USER FATAL MESSAGE 300, INVALID DATA CØLUMN 72.
(2)

Error in format of exponent.

300 *** USER FATAL MESSAGE 300, INTEGER DATA ØUT ØF MACHINE RANGE.
(3)

The limits are $2^{31}-1$ for IBM, $2^{59}-1$ for CDC and $2^{35}-1$ for UNIVAC.

300 *** USER FATAL MESSAGE 300, INVALID CHARACTER FØLLØWING INTEGER IN CØLUMN ***.
(4)

Either an illegal delimeter was detected or a real number is missing the decimal.

300 *** USER FATAL MESSAGE 300, DATA ERRØR - UNANTICIPATED CHARACTER IN CØLUMN ***.
(5)

A $\pm$ E or $\pm$ D was expected based on other input data.

300 *** USER FATAL MESSAGE 300, DATA ERRØR MISSING DELIMETER ØR REAL PØWER ØUT ØF MACHINE RANGE.
(6)

Either no delimeter was found or the power was exceeded. The limits are E-78 to E+75 for IBM, E-38 to E+38 for UNIVAC and E-294 to E+322 for CDC.

300 *** USER FATAL MESSAGE 300, RØUTINE XRCARD FINDS ØUTPUT BUFFER TØØ SMALL TØ PRØCESS CARD
(7) CØMPLETELY.

301 *** USER WARNING MESSAGE 301, BULK DATA CARD ******** CØNTAINS INCØNSISTENT DATA. SØRTED CARD CØUNT = ******

302 *** USER WARNING MESSAGE 302, ØNE ØR MØRE GRID CARDS HAVE DISPLACEMENT CØØRDINATE SYSTEM ID ØF -1.

303 *** SYSTEM FATAL MESSAGE 303, NØ ØPEN CØRE FØR IFP.

Overlay structure must be redefined.

304 *** SYSTEM FATAL MESSAGE 304, IFP NØT READING NPTP **** ****.

The Input File Processor subroutine IFP attempts to locate the bulk data file on the NPTP by searching it forward. The first two words of the file header records are examined for a match with the Hollerith string BULKDATA. If the bulk data is not found by the fifth file, the assumption is made that IFP is either not reading NPTP or that it has been badly written. The header record of fifth file is printed as part of the message.

305 *** SYSTEM FATAL MESSAGE 305, GINØ CANNØT ØPEN FILE ******.
Unexpected nonstandard return from ØPEN.

306 *** SYSTEM FATAL MESSAGE 306, READ LØGIC RECØRD ERRØR.
Short record encountered. Bulk data card images occupy 20 words.

307 *** USER FATAL MESSAGE 307, ILLEGAL NAME FØR BULK DATA CARD ******.
See Section 2.4 of the User's Manual.

308 *** USER FATAL MESSAGE 308, CARD ****** NØT ALLØWED IN ****** APPRØACH.
See Section 2.4 of the User's Manual.

309 *** USER WARNING MESSAGE 309, CARD ****** IMPRØPER IN ******** APPRØACH.
See Section 2.4 of the User's Manual.

310 *** USER FATAL MESSAGE 310, CARD ****** NØT ALLØWED IN SAME DECK AS AXIC CARD.
See Section 2.4 of the User's Manual.

311 *** USER FATAL MESSAGE 311, NØNUNIQUE FIELD 2 ØN BULK DATA CARD ******** ***.
Sorted bulk data card indicated must have a unique integer in field 2.

312 *** USER FATAL MESSAGE 312, TØØ MANY CØNTINUATIØNS FØR BULK DATA CARD ******.
See bulk data card description in Section 2.4 of the User's Manual.

313 *** USER FATAL MESSAGE 313, ILLEGAL NUMBER ØF WØRDS ØN BULK DATA CARD ******.
See bulk data card description in Section 2.4 of the User's Manual.

314 *** SYSTEM FATAL MESSAGE 314, INVALID CALL FRØM IFP ******.
Code error, machine failure, or cell is being destroyed.

315 *** USER FATAL MESSAGE 315, FØRMAT ERRØR ØN BULK DATA CARD ******.
See bulk data card description in Section 2.4 of the User's Manual.

316 *** USER FATAL MESSAGE 316, ILLEGAL DATA ØN BULK DATA CARD ******.
See bulk data card description in Section 2.4 of the User's Manual.

317 *** USER FATAL MESSAGE 317, BAD DATA ØR FØRMAT ØR NØN-UNIQUE NAME DTI **** SØRTED CARD CØUNT ****.

See bulk data card description in Section 2.4 of the User's Manual.

318 *** SYSTEM FATAL MESSAGE 318, NØ RØØM IN /XDPL/ FØR DTI ****.

Overflow of Data Pool Table. See Section 2 of the Programmer's Manual.

319 *** SYSTEM FATAL MESSAGE 319, IFP READING EØF ØN NPTP.
Unexpected EØF encountered while attempting to read a card image.

320 *** USER FATAL MESSAGE 320, IFP ERRØR ****** LAST CARD PRØCESSED IS ******.
Code error in IFP or XSØRT.

321 *** USER FATAL MESSAGE 321, NØNUNIQUE PARAM NAME *****.
All names of parameters must be unique.

322 *** SYSTEM FATAL MESSAGE 322, ILLEGAL ENTRY TØ IFSiP.
IFP code error detected in IFS1P, IFS2P, IFS3P, IFS4P, IFS5P.

324 *** USER WARNING MESSAGE 324, BLANK CARD(S) IGNØRED.
Blank bulk data cards are ignored by NASTRAN.

325 *** USER FATAL MESSAGE 325, BAD DATA ØR FØRMAT ØR NØNUNIQUE NAME. DMI ******.
See bulk data card description in Section 2.4 of the User's Manual.

326 *** SYSTEM FATAL MESSAGE 326, NØ RØØM IN /XDPL/ FØR DMI ******.
Overflow of Data Pool Table. See Section 2 of the Programmer's Manual.

327 *** USER FATAL MESSAGE 327, BAD DATA ØR FØRMAT ØR NØNUNIQUE NAME. DMIG ******.
See bulk data card description in Section 2.4 of the User's Manual.

328 *** SYSTEM FATAL MESSAGE 328, ILLEGAL ENTRY TØ IFS3P.
IFP code error.

329 *** USER FATAL MESSAGE 329, ØNLY ØNE (1) AXIC CARD ALLØWED.
See bulk data card description in Section 2.4 of the User's Manual.

330 *** SYSTEM FATAL MESSAGE 330, NØ RØØM IN CØRE FØR PARAM CARDS.
Change overlay or increase core size.

331 *** USER FATAL MESSAGE 331, IMPRØPER PARAM CARD ******.
See bulk data card description in Section 2.4 of the User's Manual.

332 *** USER FATAL MESSAGE 332, AXIC CARD REQUIRED.
The presence of any conical shell data cards requires the presence of an AXIC card.
See the AXIC bulk data card description in Section 2.4 of the User's Manual.

501 *** SYSTEM FATAL MESSAGE 501, MED TABLE INCØRRECT FØR THIS SØLUTIØN.
Input to subroutine XSBSET is incorrect. Look for format error in array SS.

502 *** USER FATAL MESSAGE 502, ILLEGAL SUBSET NUMBER FØR THIS SØLUTIØN.
User specified an incorrect subset number on SØL control card.

503 *** USER FATAL MESSAGE 503, ILLEGAL SØLUTIØN NUMBER.
User specified an incorrect solution number on SØL control card.

504 *** USER FATAL MESSAGE 504, CANNØT CHANGE FRØM SØLUTIØN *** TØ SØLUTIØN ***.

505 *** USER FATAL MESSAGE 505, CONTRØL CARD **** IS ILLEGAL.
Card preceding Message 505 cannot be processed correctly.

506 *** USER FATAL MESSAGE 506, CØNTRØL CARD **** DUPLICATED.
Card preceding Message 506 cannot be input more than once.

507 *** USER FATAL MESSAGE 507, ILLEGAL SPECIFICATIØN ØR FØRMAT ØN PRECEDING CARD.

508 *** USER FATAL MESSAGE 508, PRØBLEM TAPE MUST BE ØN PHYSICAL TAPE FØR CHECKPØINTING.
User requested checkpointing (i.e., CHKPNT YES) therefore Problem Tape must be setup on tape drive.

509 *** USER FATAL MESSAGE 509, WRØNG ØLD PRØBLEM TAPE MØUNTED. ØLD PRØBLEM TAPE ID = ********, ********,**/**/**, REEL NØ. = ***.
The Old Problem Tape identification does not match the identification on the RESTART restart card.

510 *** SYSTEM FATAL MESSAGE 510, CHECKPØINT DICTIØNARY EXCEEDS CØRE SIZE - REMAINING RESTART CARDS IGNØRED.
You have run out of open core. If approach is DMAP try putting restart deck before DMAP sequence. If this does not solve problem, or if approach is not DMAP, then you must decrease size of restart deck.

511 *** SYSTEM FATAL MESSAGE 511, DMAP SEQUENCE EXCEEDS CØRE SIZE - REMAINING DMAP INSTRUCTIØNS IGNØRED.
You have run out of open core. Split the DMAP sequence somewhere prior to where Message 511 was printed out.

512 *** USER FATAL MESSAGE 512, ØLD PRØBLEM TAPE IS MISSING AND IS NEEDED FØR RESTART.
The Problem Tape corresponding to identification on RESTART control card must be setup on the unit assigned to the Old Problem Tape.

513 *** USER FATAL MESSAGE 513, ALTER SEQUENCE NUMBERS ARE ØUT ØF ØRDER.

514 *** USER FATAL MESSAGE 514, ENDALTER CARD IS MISSING.
Alter deck must end with ENDALTER control card.

515 *** USER FATAL MESSAGE 515, END INSTRUCTIØN MISSING IN DMAP SEQUENCE.
DMAP sequence must end with END control card.

516 *** USER FATAL MESSAGE 516, UMF TAPE MUST BE MØUNTED ØN PHYSICAL TAPE DRIVE.

The UMF tape must be setup on the unit assigned to it.

517 *** USER FATAL MESSAGE 517, WRØNG UMF TAPE MØUNTED - TAPE ID = ****.

The tape identification number on the UMF tape does not match the tape identification number on the UMF control card.

518 *** USER FATAL MESSAGE 518, CANNØT USE UMF TAPE FØR RESTART.

519 *** USER FATAL MESSAGE 519, ID CARD MUST PRECEDE ALL ØTHER CØNTRØL CARDS.

520 *** USER FATAL MESSAGE 520, CØNTRØL CARD **** IS MISSING.

The control card mentioned is required for this problem.

521 *** USER FATAL MESSAGE 521, SPECIFY A SØLUTIØN ØR A DMAP SEQUENCE BUT NØT BØTH.

You must either select a DMAP sequence from the library by using the SØL control card or by supplying your own DMAP sequence. Do one or the other, but not both.

522 *** USER FATAL MESSAGE 522, NEITHER A SØL CARD NØR A DMAP SEQUENCE WAS INCLUDED.

See Message 521.

523 *** USER FATAL MESSAGE 523, ENDALTER CARD ØUT ØF ØRDER.

ENDALTER control card must be preceded by the ALTER DECK.

524 *** SYSTEM FATAL MESSAGE 524, ALTERNATE RETURN TAKEN WHEN ØPENING FILE ****.

This occurs if file name is not in FIST or the end of tape was reached while writing on the file. The file name should correspond to one of the permanent entries in the FIST.

525 *** SYSTEM FATAL MESSAGE 525, ILLEGAL FØRMAT ENCØUNTERED WHILE READING FILE ****.

File is not in the correct format. Either the wrong tape was mounted or it does not contain what you think it should.

526 *** USER FATAL MESSAGE 526, CHECKPØINT DICTIØNARY ØUT ØF SEQUENCE - REMAINING RESTART CARDS IGNØRED.

The checkpoint dictionary which follows the RESTART control card must be sequenced according to first number on each card.

527 *** USER FATAL MESSAGE 527, DUPLICATE SUBSET NUMBER *****.

601 *** USER FATAL MESSAGE 601, THE KEYWØRD ØN THE ABØVE CARD IS ILLEGAL ØR MISSPELLED. SEE THE FØLLØWING LIST FØR LEGAL KEY WØRDS.

Case control expects each card to begin with a keyword (usually 4 characters in length). Your card does not. User Message 612 will list the legal keywords along with a brief description of function. To remove the error, consult Message 612 or NASTRAN case control card descriptions, User's Manual Section 2.3, and spell your request correctly.

602 *** USER WARNING MESSAGE 602, TWØ ØR MØRE ØF THE ABØVE CARD TYPES DETECTED WHERE ØNLY ØNE IS LEGAL. THE LAST FØUND WILL BE USED.

Remove the card with the duplicate meaning. Note that some cards have alternate forms.

603 *** USER FATAL MESSAGE 603, THE ABØVE CARD DØES NØT END PRØPERLY. CØMMENTS SHØULD BE PRECEDED BY A DØLLAR SIGN.

Case control cards of the form, name = value, should not contain more than one value. Consult your NASTRAN Case Control Deck document, User's Manual Section 2.3, for a complete description of the card or precede your comments with a dollar sign.

604 *** USER FATAL MESSAGE 604, THE ABØVE CARD HAS A NØNINTEGER IN AN INTEGER FIELD.

Consult your NASTRAN Case Control Deck document, User's Manual Section 2.3, for legal values.

605 *** USER FATAL MESSAGE 605, A SYMSEQ OR SUBSEQ CARD APPEARS WITHØUT A SYMCØM ØR SUBCØM CARD.

SYMSEQ or SUBSEQ cards must appear in a subcase defined by a SYMCØM or SUBCØM card. Check your Case Control Deck order and relabel your combination subcase.

606 *** USER FATAL MESSAGE 606, A REQUEST FØR TEMPERATURE DEPENDENT MATERIALS ØCCURS AT THE SUBCASE LEVEL. ØNLY ØNE ALLOWED PER PRØBLEM.

Only one temperature field for materials is allowed per NASTRAN run. The last specified will be used for the entire run. If additional ones are desired, a modified restart is in order.

607 *** USER FATAL MESSAGE 607, A REPCASE SUBCASE MUST BE PRECEDED BY A SUBCASE ØR SYM SUBCASE.

A REPCASE subcase is an attempt to reoutput the previously computed case, therefore it cannot be the first subcase.

608 *** USER FATAL MESSAGE 608, THE SET ID SPECIFIED ØN THE ABØVE CARD MUST BE DEFINED PRIØR TO THIS CARD.

Set identification numbers must be specified prior to their use. Also sets specified within a subcase die at the end of the subcase. Redefine set (or define set) or move set out of subcase.

609 *** USER FATAL MESSAGE 609, SUBCASE DELIMITER CARDS MUST HAVE A UNIQUE IDENTIFYING INTEGER.

Subcase type cards must have an identifying integer. These numbers must be strictly increasing. Renumber your subcase cards. The use of a nonblank delimiter (e.g., "=") will also cause this message to occur.

610 *** USER FATAL MESSAGE 610, THE VALUE FØLLØWING THE EQUAL SIGN IS ILLEGAL.

Case control cannot identify the BCD value after the equal sign. Consult NASTRAN case control card descriptions, User's Manual Section 2.3, for a full description of the card.

611 *** USER FATAL MESSAGE 611, TEN CARDS HAVE ILLEGAL KEY WØRDS. NASTRAN ASSUMES BEGIN BULK CARD IS MISSING. IT WILL NØW PRØCESS YØUR BULK DATA.

Only ten key words may be misspelled. A common source of this error may be the omission of the ØUTPUT(PLØT) or ØUTPUT(XYØUT) delimiter cards.

612 *** USER FATAL MESSAGE 612, --LIST OF LEGAL CASE CØNTROL MNEMØNICS.

This message is caused by Messages 601 or 611.

513 *** USER FATAL MESSAGE 613, THE ABØVE SET CØNTAINS 'EXCEPT' WHICH IS NØT PRECEDED BY 'THRU'.

Only identification numbers included in THRU statements may be excepted. Simplify your SET request.

614 *** USER FATAL MESSAGE 614, THE ABØVE SET IS BADLY SPECIFIED.

The grammar of the SET list is so confused that IFP1 cannot continue. Simplify the SET list.

615 *** USER FATAL MESSAGE 615, AN IMPRØPER ØR NØ NAME GIVEN TØ THE ABØVE SET.

SET lists must have integer names. This SET list does not have one. SET 10 = is the correct format. Give the SET a correct integer name.

616 *** USER FATAL MESSAGE 616, 'EXCEPT' CANNOT BE FØLLØWED BY 'THRU'. LIST EXPLICITLY ALL EXCEPTIØNS.

EXCEPT in SET list can only be followed by integers. An integer larger than THRU pair terminates THRU. Either list exceptions explicitly, use 2 'THRU's or terminate first THRU.

617 *** USER FATAL MESSAGE 617, A NØNPØSITIVE INTEGER APPEARS IN A PØSITIVE PØSITIØN.

Most integer values in case control must be positive. The above card either has a negative integer or a BCD value in a positive position. Check the Case Control Deck documentation in Section 2.3 of the User's Manual for the proper card format.

618 *** USER FATAL MESSAGE 618, PLØTTER ØUTPUT IS REQUESTED BUT NØ PLØT TAPE IS SET UP.

Neither PLT1 or PLT2 is a physical tape. Remove the plot control packet or set up the appropriate tape.

619 *** USER WARNING MESSAGE 619, SET MEMBER *** BELØNGS TØ *** THRU ***.

A set member is already included in a THRU. The individual member will be absorbed in the THRU.

620 *** USER WARNING MESSAGE 620, DUPLICATE *** IS IN SET LIST.

A set member is listed twice. The second reference will be deleted.

621 *** USER WARNING MESSAGE 621, INTERVAL *** THRU *** ØVERLAPS INTERVAL *** THRU ***. THE MAXIMUM INTERVAL WILL BE USED.

625 *** USER FATAL MESSAGE 625, SUBCASE ID'S MUST BE LESS THAN 99,999,999.

Reduce the size of your subcase identification number. Note also that BCD subcase identification numbers are not legal.

626 *** USER FATAL MESSAGE 626, SUBCØM SUBCASE DØES NØT HAVE A SUBSEQ CARD.

A SUBCØM SUBCASE must contain a SUBSEQ card to define the linear combination coefficients.

627 *** USER FATAL MESSAGE 627, THE ABØVE SUBCASE HAS BØTH A STATIC LØAD AND A REAL EIGENVALUE METHØD SELECTIØN -- REMØVE ØNE.

The Buckling Rigid Format (5) requires two subcases: one for Statics and one for Buckling. Both a load and a method selection cannot take place in the same subcase.

628 *** USER FATAL MESSAGE 628, THERMAL, DEFORMATIØN, AND EXTERNAL LØADS CANNØT HAVE THE SAME SET IDENTIFICATIØN NUMBER.

Set id's specified on the LØAD, TEMP (LØAD), and DEFØRM Case Control Cards must be unique.

629 *** USER WARNING MESSAGE 629, ECHØ CARD HAS REPEATED ØR UNRECØGNIZABLE SPECIFICATION DATA-REPEATED SPECIFICATIONS WILL BE IGNØRED, UNRECØGNIZABLE SPECIFICATIONS WILL BE TREATED AS SØRT.

675 *** USER FATAL ERRØR MESSAGE 675, ABØVE CARD DØES NØT BEGIN WITH A NØNNUMERIC WØRD.

676 *** USER FATAL ERRØR MESSAGE 676, **** IS NØT RECØGNIZED ØN ABØVE CARD.

677 *** USER FATAL ERRØR MESSAGE 677, ILLEGAL VALUE SPECIFIED.

678 *** USER FATAL ERRØR MESSAGE 678, *** CØNTRADICTS PREVIØUS DEFINITIØN.

679 *** USER FATAL ERRØR MESSAGE 679, *** DELIMETER ILLEGALLY USED.

680 *** USER FATAL ERRØR MESSAGE 680, **** ILLEGAL IN STATEMENT.

681 *** USER FATAL ERRØR MESSAGE 681, **** IS ILLEGAL IN STATEMENT.

682 *** USER FATAL ERRØR MESSAGE 682, **** IS ILLEGAL IN STATEMENT.

683 *** USER FATAL ERRØR MESSAGE 683, TØØ MANY SUBCASES. MAXIMUM = 200 ØN ANY ØNE XY-ØUTPUT CØMMAND CARD.

684 *** USER FATAL ERRØR MESSAGE 684, SUBCASE-ID IS LESS THAN 1 ØR IS NØT IN ASCENDING ORDER.

685 *** USER FATAL ERRØR MESSAGE 685, **** = PØINT ØR ELEMENT ID IS ILLEGAL (LESS THAN 1).

686 *** USER FATAL ERRØR MESSAGE 686, NEGATIVE ØR ZERØ CØMPØNENTS ARE ILLEGAL.

687 *** USER FATAL ERRØR MESSAGE 687, ALPHA-CØMPØNENTS ARE NØT PREMITTED FØR STRESS ØR FØRCE XY-ØUTPUT REQUESTS.

688 *** USER FATAL ERRØR MESSAGE 688, **** CØMPØNENT NAME NØT RECØGNIZED.

689 *** USER FATAL ERRØR MESSAGE 689, LAST CARD ENDED WITH A DELIMETER BUT NØ CØNTINUATIØN CARD WAS PRESENT.

690 *** USER FATAL ERRØR MESSAGE 690, TYPE ØF CURVE WAS NØT SPECIFIED. (E.G. DISPLACEMENT, STRESS, ETC.).

691 *** USER FATAL ERRØR MESSAGE 691, MØRE THAN 2 ØR UNEQUAL NUMBER ØF CØMPØNENTS FØR IDENTIFICATIØN NUMBERS WITHIN A SINGLE FRAME.

692 *** USER FATAL ERRØR MESSAGE 692, XY-ØUTPUT CØMMAND IS INCØMPLETE.

693 *** USER FATAL ERRØR MESSAGE 693, INSUFFICIENT CØRE FØR SET TABLE.

694 *** USER FATAL ERRØR MESSAGE 694, AUTØ ØR PSDF REQUESTS MAY NØT USE SPLIT FRAME, THUS ØNLY ØNE CØMPØNENT PER ID IS PERMITTED.

695 *** USER FATAL ERRØR MESSAGE 695, CØMPØNENT VALUE = **** IS ILLEGAL FØR AUTØ ØR PSDF VECTØR REQUESTS.

696 *** USER FATAL MESSAGE 696, CØMPØNENT VALUE = ******** IS ILLEGAL FØR VECTØR TYPE SPECIFIED.

969 *** USER FATAL ERROR MESSAGE 969, CØMPØNENT VALUE = **** IS ILLEGAL FØR VECTØR TYPE SPECIFIED.

975 *** USER WARNING MESSAGE 975, XYTRAN DØES NØT RECØGNIZE **** AND IS IGNØRING.

976 *** USER WARNING MESSAGE 976, ØUTPUT DATA BLØCK **** IS PURGED. XYTRAN WILL PRØCESS ALL REQUESTS ØTHER THAN PLØT.

977 *** USER WARNING MESSAGE 977, FØLLØWING NAMED DATA BLØCK IS NØT IN SØRT2 FØRMAT.

978 *** USER WARNING MESSAGE 978, XYTRAN MØDULE FINDS DATA BLØCK (****) PURGED, NULL, ØR INADEQUATE, AND IS IGNØRING XY-ØUTPUT REQUEST FØR - **** - CURVES.

979 *** USER WARNING MESSAGE 979, AN XY-ØUTPUT REQUEST FØR PØINT ØR ELEMENT ID **** - **** - CURVE IS BEING PASSED ØVER. THE ID CØULD NØT BE FØUND IN DATA BLØCK ****.

980 *** USER WARNING MESSAGE 980, INSUFFICIENT CØRE TØ HANDLE ALL DATA FØR ALL CURVES ØF THIS FRAME ID = **** CØMPØNENT = **** DELETED FRØM ØUTPUT.

981 *** USER WARNING MESSAGE 981, CØMPØNENT = **** FØR ID = **** IS TØØ LARGE. THIS CØMPØNENTS CURVE NØT ØUTPUT.

982 *** USER WARNING MESSAGE 982, FØRMAT ØF SDR3 INPUT DATA BLØCK **** DØES NØT PERMIT SUCCESSFUL SØRT2 PRØCESSING.

983 *** USER WARNING MESSAGE 983, SDR3 HAS INSUFFICIENT CØRE TØ PERFØRM SØRT2 ØN INPUT DATA BLØCK **** ØR DATA BLØCK IS NØT IN CØRRECT FØRMAT.

984 *** USER WARNING MESSAGE 984, SDR3 FINDS ØUTPUT DATA BLØCK **** PURGED.

985 *** USER WARNING MESSAGE 985, SDR3 FINDS SCRATCH **** PURGED.

986 *** USER WARNING MESSAGE 986, INSUFFICIENT CØRE FØR SDR3.

991 *** USER WARNING MESSAGE 991, XYPLØT INPUT DATA FILE **** NØT FØUND. XYPLØT ABANDØNED.

The input data file probably has been purged and there were no plots to be done.

992 *** USER WARNING MESSAGE 992, XYPLØT INPUT DATA FILE I.D. RECØRDS TØØ SHØRT. XYPLØT ABANDØNED.

The input data file records have invalid word counts and further plotting is not feasible.

993 *** USER WARNING MESSAGE 993, XYPLØT FØUND ØDD NØ. ØF VALUES FØR DATA PAIRS IN FRAME ****, CURVE NØ. ****. LAST VALUE IGNØRED.

May indicate a bad input file, but plotting continues.

994 *** USER WARNING MESSAGE 994, XYPLØT ØUTPUT FILE NAME **** NØT FØUND. XYPLØT ABANDØNED.

A magnetic tape for plotting has not been properly set up and further plotting is useless.

995 *** USER WARNING MESSAGE 995, XYPLØT HAS ILLEGAL PLØTTER NUMBER = **** FRØM INPUT DATA FILE. PLØTTER NØ. **** ASSUMED.

Probable cause is the user not setting up the proper plotter number in the Case Control Deck. The plotting will be done on the plotter most commonly used at the installation.

996 *** USER WARNING MESSAGE 996, SPECIFIED PLØTTER PAPER SIZE TØØ SMALL. XYPLØT ASSUMES DIMENSIØN IS 8 INCHES.

Message is for table plotter only. Assumption is made that plotter paper will be at least as large as stated. In any event the table plotter will have an inch margin on all sides.

997 *** USER WARNING MESSAGE 997, NØ. ***. FRAME NØ. **** INPUT DATA INCØMPATIBLE. ASSUMPTIØNS MAY PRODUCE INVALID PLØT.

NØ. *** may take any value from 1 to 4 with the following meaning:

1. Specified X maximum equal X minimum. If this value is zero, then X maximum is set to 5.0 and X minimum to -5.0, otherwise 5 times the absolute value of X maximum is added to X maximum and subtracted from X minimum.
2. Specified X maximum is smaller than X minimum. The values are reversed.
3. Same meaning as number 1 except for Y maximum and Y minimum.
4. Same meaning as number 2 except for Y maximum and Y minimum.

6.2.2 Executive Module Messages

1001 *** SYSTEM FATAL MESSAGE 1001, ØSCAR NØT FØUND IN DPL.
ØSCAR file not present (destroyed) in Data Pool Dictionary.

1002 *** SYSTEM FATAL MESSAGE 1002, ØSCAR CØNTAINS NØ MØDULES.
XSFA found no modules on ØSCAR needing file allocation.

1003 *** SYSTEM FATAL MESSAGE 1003, PØØL CØULD NØT BE ØPENED.
Data Pool File (PØØL) not present (destroyed) in FIST.

1004 *** SYSTEM FATAL MESSAGE 1004, ILLEGAL EØF ØN PØØL.
End-Of-File encountered before ØSCAR file reached on Data Pool.

1011 *** SYSTEM FATAL MESSAGE 1011, MD ØR SØS TABLE ØVERFLØW.
Module description or serial ØSCAR table overflowed.

1012 *** SYSTEM FATAL MESSAGE 1012, PØØL CØULD NØT BE ØPENED.
Data Pool File (PØØL) not present (destroyed) in FIST.

1013 *** SYSTEM FATAL MESSAGE 1013, ILLEGAL EØR ØN PØØL.
ØSCAR record has illegal format.

1014 *** SYSTEM FATAL MESSAGE 1014, PØØL FILE MIS-POSITIØNED.
ØSCAR (PØØL) file not at position passed in XSFA calling sequence.

1021 *** SYSTEM FATAL MESSAGE 1021, FIAT ØVERFLØWED.
FIAT /XFIAT/ Table overflowed - reduce number of logical files. See Section 2 of the Programmer's Manual.

1031 *** SYSTEM FATAL MESSAGE 1031, DPL ØVERFLØW.
Data Pool Dictionary /XDPL/ overflowed - increase complied size. See Section 2 of the Programmer's Manual.

1032 *** SYSTEM FATAL MESSAGE 1032, PØØL ØR FILE BEING PØØLED/UN-PØØLED CØULD NØT BE ØPENED.
Files not present (destroyed) in FIST.

1033 *** SYSTEM FATAL MESSAGE 1033, ILLEGAL EØF ØN FILE BEING PØØLED.
File being pooled has illegal format.

1034 *** SYSTEM FATAL MESSAGE 1034, ILLEGAL EØR ØN FILE BEING PØØLED.
File being pooled has illegal format (bad header).

1035 *** SYSTEM FATAL MESSAGE 1035, EQUIV INDICATED, NØNE FØUND.

File (data block) equivalence not found as indicated by XSFA.

1041 *** SYSTEM FATAL MESSAGE 1041, ØLD/NEW PØØL CØULD NØT BE ØPENED.

Files not present (destroyed) in FIST.

1051 *** SYSTEM FATAL MESSAGE 1051, FIAT ØVERFLØW.

FIAT /XFIAT/ overflowed - reduce number of logical files. See Section 2 of the Programmer's Manual.

1101 *** USER FATAL MESSAGE 1101, CØULD NØT ØPEN FILE NAMED ********.

Data block has not been generated.

1102 *** SYSTEM FATAL MESSAGE 1102, CØULD NØT ØPEN FILE NAMED ********.

Problem Tape (NPTP) or Pool Table (PØØL) File linkage is broken. Look for error in /XFIST/, /XPFIST/ or /XXFIAT/.

1103 *** SYSTEM FATAL MESSAGE 1103, UNABLE TØ PØSITIØN DATA PØØL FILE CØRRECTLY.

Contents of /XDPL/ does not correspond to contents of PØØL file.

1104 *** SYSTEM FATAL MESSAGE 1104, FDICT TABLE IS INCORRECT.

Subroutine XCHK is not generating FDICT correctly.

1105 *** USER FATAL MESSAGE 1105, CANNØT FIND DATA BLØCK NAMED ******** HEADER RECØRD = ********.

Data block name or equivalenced data block name must match header record.

1106 *** USER FATAL MESSAGE 1106, CHECKPØINT DICTIØNARY ØVERFLØWED THERE IS NØ MØRE CØRE AVAILABLE.

Restart problem from this point with dictionary available.

1107 *** SYSTEM FATAL MESSAGE 1107, CANNØT FIT DATA BLØCK NAMED ******** ØN TWØ PRØBLEM TAPE REELS.

Use full tape reels for Problem Tape.

1108 *** SYSTEM FATAL MESSAGE 1108, PURGE TABLE ØVERFLØWED.

Reduce the number of data blocks being checkpointed at one time by replacing a single CHKPNT instruction with two CHKPNT instructions .

1109 *** SYSTEM FATAL MESSAGE 1109, CANNØT FIND DATA BLØCK NAMED NXPTDC HEADER RECØRD = ********.

Problem Tape is not positioned correctly for reading NXPTDC. Problem is in subroutine which previously wrote NXPTDC onto Problem Tape. Suspect modules are XGPI, XCEI or XCHK.

1126 *** SYSTEM FATAL MESSAGE 1126, ADDRESS ØF BUFFER LESS THAN ADDRESS ØF /XNSTRN/.

Highly unlikely. Program bug or machine error.

1127 *** SYSTEM FATAL MESSAGE 1127, BUFFER ASSIGNED EXTENDS INTØ MASTER INDEX AREA.

Calling program bug in buffer allocation or first word of /SYSTEM/ has been altered.

1128 *** SYSTEM FATAL MESSAGE 1128, ØN AN ØPEN CALL WITHØUT REWIND, THE BLØCK NUMBER READ DØES NØT MATCH EXPECTED VALUE.

Probable I/Ø error.

1129 *** SYSTEM FATAL MESSAGE 1129, ØN A CALL WRITE THE WØRD CØUNT IS NEGATIVE.

Definite calling program error.

1130 *** SYSTEM FATAL MESSAGE 1130, ØN A CALL READ THE CØNTRØL WØRD AT WHICH THE FILE IS PØSITIØNED IS NØT ACCEPTABLE.

Attempt to read string formatted record which is not allowed.

1131 *** SYSTEM FATAL MESSAGE 1131, LØGICAL RECØRD TRAILER NØT RECØGNIZABLE AS SUCH.

Probable GINØ bug or hardware error.

1132 *** SYSTEM FATAL MESSAGE 1132, UNRECØGNIZABLE CØNTRØL WØRD DURING PRØCESSING ØF A BCKREC CALL.

Probable GINØ bug or hardware error.

1133 *** SYSTEM FATAL MESSAGE 1133, AFTER A PØSITIØNING CALL TØ IØ6600, DURING PRØCESSING ØF A BCKREC CALL THE BLØCK READ WAS NØT THE EXPECTED ØNE.

Probable IØ6600 bug or possible I/Ø error.

1134 *** SYSTEM FATAL MESSAGE 1134, CALL SKPFIL IN A FØRWARD DIRECTIØN ØN A FILE NØT ØPENED FØR ØUTPUT IS NØT SUPPØRTED.

1135 *** SYSTEM FATAL MESSAGE 1135, FILPØS WAS CALLED ØN A FILE ØPENED FØR ØUTPUT.

1136 *** SYSTEM FATAL MESSAGE 1136, ENDPUT WAS CALLED WITH BLØCK (8) = -1.

Most likely PUTSTR was not called first.

1137 *** SYSTEM FATAL MESSAGE 1137, MØRE TERMS WRITTEN IN STRING THAN WERE AVAILABLE TØ WRITE.

Most likely subroutine logic error.

1138 *** SYSTEM FATAL MESSAGE 1138, CURRENT BUFFER PØINTER EXCEEDS LAST DATA WØRD IN BLØCK.

Probably a bug in PUTSTR in the computation of the number of terms available to write in a string.

1139 *** SYSTEM FATAL MESSAGE 1139, ØN AN INITIAL CALL TØ GETSTR, THE RECØRD IS NØT PØSITIØNED AT THE CØLUMN HEADER.

Either the record is not a string formatted record, or the calling routine has not made a proper sequence of GETSTR, ENDGET calls.

1140 *** SYSTEM FATAL MESSAGE 1140, STRING DEFINITIØN WØRD NØT RECØGNIZABLE.

Probable cause is a failure to call ENDGET to complete processing of the previous string.

1141 *** SYSTEM FATAL MESSAGE 1141, FIRST WØRD ØF A DØUBLE PRECISIØN STRING IS NØT ØN A DØUBLE PRECISIØN BØUNDRY.

This error is probably due to a bug in any of PUTSTR, ØPEN or NASTIØ, all of which have responsibility for insuring proper alignment.

1142 *** SYSTEM FATAL MESSAGE 1142, CURRENT BUFFER PØINTER IS BEYOND RANGE ØF INFØRMATIØN IN BUFFER.

Either an attempt to read beyond end-of-information or a GINØ logic bug.

1143 *** SYSTEM FATAL MESSAGE 1143, ØN AN INITIAL CALL TØ GETSTB, THE FILE IS NØT PØSITIØNED AT AN ACCECTABLE PØINT.

File should be positioned at a beginning of record or end-of-file.

1144 *** SYSTEM FATAL MESSAGE 1144, END-ØF-SEGMENT CØNTRØL WØRD SHØULD HAVE IMMEDIATELY PRECEDED CURRENT PØSITIØN AND IT DID NØT.

GINØ logic error.

1145 *** SYSTEM FATAL MESSAGE 1145, CØLUMN TRAILER NØT FØUND.

Previous record to be read backwards is not a string formatted record.

1146 *** SYSTEM FATAL MESSAGE 1146, PREVIØUS RECØRD TØ BE READ BACKWARDS WAS NØT WRITTEN WITH STRING TRAILERS.

1147 *** SYSTEM FATAL MESSAGE 1147, STRING RECØGNITIØN WØRD NØT RECØGNIZED.

A subroutine may not have called GETSTB to indicate completion of processing of previous string or a bug in GETSTB logic.

1148 *** SYSTEM FATAL MESSAGE 1148, RECØRD CØNTRØL WØRD NØT IN EXPECTED PØSITIØN.

Logic error in GETSTB or PUTSTR when string was written.

1149 *** SYSTEM FATAL MESSAGE 1149, RECTYP WAS CALLED FØR A FILE ØPENED FOR ØUTPUT.

Not allowed.

1150 *** SYSTEM FATAL MESSAGE 1150, RECTYP MUST BE CALLED WHEN THE FILE IS PØSITIØNED AT THE BEGINNING ØF A RECØRD.

1151 *** SYSTEM FATAL MESSAGE 1151, ØN A CALL TØ ØPEN THE BUFFER ASSIGNED ØVERLAPS A PREVIØUSLY ASSIGNED BUFFER.

1152 *** SYSTEM FATAL MESSAGE 1152, CALL TØ ØPEN FØR AN ALREADY ØPEN FILE.

1153 *** SYSTEM FATAL MESSAGE 1153, FILE NØT ØPEN.

1154 *** SYSTEM FATAL MESSAGE 1154, GINØ REFERENCE NAME NØT IN FIST ØR FILE NØT ØPEN.

1155 *** SYSTEM FATAL MESSAGE 1155, CALL TØ GETSTR ØCCURRED WHEN THE FILE WAS PØSITIØNED AT END-ØF-FILE.

1156 *** SYSTEM FATAL MESSAGE 1156, ATTEMPTED TØ WRITE ØN AN INPUT FILE.

1157 *** SYSTEM FATAL MESSAGE 1157, ATTEMPTED TØ READ FRØM AN ØUTPUT FILE.

1158 *** SYSTEM FATAL MESSAGE 1158, A CALL TØ BLDPK ØR PACK IN WHICH EITHER TYPIN ØR TYPØUT IS ØUT ØF RANGE.

1159 *** SYSTEM FATAL MESSAGE 1159, RØW PØSITIØNS ØF ELEMENTS FURNISHED TØ ZBLPKI ØR BLDPKI ARE NØT IN MØNØTØNIC INCREASING SEQUENCE.

1160 *** SYSTEM FATAL MESSAGE 1160, ØN A CALL TØ BLDPKN, FILE NAME DØES NØT MATCH PREVIØUS CALLS.

BLDPK was not called prior to call to BLDPKN.

1161 *** SYSTEM FATAL MESSAGE 1161, A CALL TØ INTPK ØR UNPACK IN WHICH TYPØUT IS ØUT ØF RANGE.

1162 *** SYSTEM FATAL MESSAGE 1162, ØN AN ATTEMPT TØ READ A SUBINDEX AT THE TIME ØF A CALL TØ ØPEN AN END-ØF-FILE WAS ENCØUNTERED ØR WRØNG NUMBER ØF WØRDS READ.

The file has never been written and IØ6600 failed to detect it; possible I/Ø error.

1163 *** SYSTEM FATAL MESSAGE, A READ ATTEMPT WHEN THE CØRRESPØNDING SUBINDEX IS ZERØ.

Normally this indicates an attempt to read past the end-of-information. However, if called from FILPØS, suspect is subroutine error in saving and returning a correct file position.

1164 *** SYSTEM FATAL MESSAGE, FØLLØWING A READ ATTEMPT ØN AN INDEXED FILE, EITHER AN END-ØF-FILE WAS ENCØUNTERED ØR THE NUMBER ØF WØRDS READ WAS INCØRRECT.

I/Ø error.

1165 *** SYSTEM FATAL MESSAGE 1165, ØN AN ATTEMPT TØ READ A SEQUENTIAL FILE, AN END-ØF-FILE ØR AN END-ØF-INFØRMATIØN WAS ENCØUNTERED.

1166 *** SYSTEM FATAL MESSAGE 1166, ØN AN ATTEMPT TØ READ A SEQUENTIAL FILE, A LØNG RECØRD WAS ENCØUNTERED.

1167 *** SYSTEM FATAL MESSAGE 1167, ØN AN ATTEMPT TØ READ A SEQUENTIAL FILE A SHØRT RECØRD WAS ENCØUNTERED.

1168 *** SYSTEM FATAL MESSAGE 1168, A CALL TØ IØ6600 WITH ØPCØDE=5 (FØRWARD SPACE) IS NØT SUPPØRTED.

1169 *** SYSTEM FATAL MESSAGE 1169, ILLEGAL CALL TYPE, LØGIC ERRØR IN IØ6600.

1170 *** SYSTEM FATAL MESSAGE 1170, ILLEGAL CALL TØ NASTIØ, LØGIC ERRØR IN IØ6600.

1171 *** SYSTEM FATAL MESSAGE 1171, ØN A PØSITIØN CALL, THE BLØCK NUMBER REQUESTED IS NØT FØUND IN CØRE WHEN IT IS EXPECTED THERE.

Either the caller has written in the area furnished to NASTIØ or there is a logic error in NASTIØ.

1172 *** SYSTEM FATAL MESSAGE 1172, WHEN ATTEMPTING TØ READ A NEW INDEX, THE NUMBER ØF WØRDS RETURNED WAS INCØRRECT.

Either an I/Ø error or logic error in NASTIØ.

1201 *** SYSTEM FATAL MESSAGE 1201, FIAT ØVERFLØW.

FIAT /XFIAT/ overflowed - reduce number of logical files. See Section 2.4 of the Programmer's Manual.

1202 *** SYSTEM FATAL MESSAGE 1202, DPL ØVERFLØW.

Data Pool Dictionary /XDPL/ overflowed - increase compiled size. See Section 2.4 of the Programmer's Manual.

1300 *** SYSTEM FATAL MESSAGE, END-ØF-FILE WAS CALLED ØN A FILE ØPEN FØR INPUT.

1301 *** SYSTEM FATAL MESSAGE, END-ØF-FILE ENCØUNTERED.

An error in the calling program caused an unexpected end-of-file.

1302 *** SYSTEM FATAL MESSAGE, ZERØ LENGTH RECØRD SEGMENT ENCØUNTERED.

A zero length record segment occurred before the last record in a block.

1303 *** SYSTEM FATAL MESSAGE, ATTEMPT TØ GET A STRING PRIØR TØ INFØRMATIØN.

There is an error in the calling program.

1304 *** SYSTEM FATAL MESSAGE, UNRECØGNIZED CØNTRØL WØRD.

The calling program may have overwritten a buffer.

1305 *** SYSTEM FATAL MESSAGE, BLØCK NUMBER CHECK FAILED.

In the process of making a data block core resident, the block number did not have the expected value.

1306 *** SYSTEM FATAL MESSAGE, BLØCK NUMBER IN BLØCK TØ BE WRITTEN DØES NØT MATCH NUMBER IN FILE CØNTRØL BLØCK.

1307 *** SYSTEM FATAL MESSAGE, BLØCK NUMBER ØF BLØCK TØ BE WRITTEN IS NØT IN CURRENT UNIT.

The block number was not in the current unit and not equal to the block number in the preceeding unit.

1308 *** SYSTEM FATAL MESSAGE, ATTEMPT TØ READ BEYØND DATA.

1309 *** SYSTEM FATAL MESSAGE, CØRE RESIDENT DATA BLØCK NUMBER DØES NØT MATCH NUMBER IN FILE CØNTRØL BLØCK.

1310 *** SYSTEM FATAL MESSAGE, PØINTER TØ NEXT CØRE RESIDENT DATA BLØCK IS ZERØ

Next block should be in core.

1311 *** SYSTEM FATAL MESSAGE, BLØCK NUMBER TØ BE READ IS NØT INCLUDED IN CURRENT CHAIN ØF UNITS.

1312 *** SYSTEM FATAL MESSAGE, BLØCK NUMBER ØF BLØCK READ FRØM DISK DØES NØT MATCH NUMBER IN FILE CØNTRØL BLØCK.

1313 *** SYSTEM FATAL MESSAGE, PØINTER TØ CØRE RESIDENT DATA BLØCK IS PØSITIØNED PRIØR TØ INFØRMATIØN.

1314 *** SYSTEM FATAL MESSAGE, ATTEMPT TØ PØSITION A FILE ØPENED TØ WRITE.

1315 *** SYSTEM FATAL MESSAGE, BLØCK NUMBER NØT FØUND.

Logic error in an attempt to position a core resident data block.

1316 *** SYSTEM FATAL MESSAGE, NØ DATA EVENT CØNTRØL BLØCK AVAILABLE.

1317 *** SYSTEM FATAL MESSAGE, ERRØR IN INTERNAL SUBRØUTINE IN NASTIØ.

1318 *** SYSTEM FATAL MESSAGE, ATTEMPT TØ READ BEYØND END-ØF-DATA.

1319 *** SYSTEM FATAL MESSAGE, DCB SYNCHRØNØUS ERRØR DETECTED.

Data control block improperly written.

1320 *** SYSTEM FATAL MESSAGE, FIRST TERM IN RØW IS NØT A DIAGØNAL TERM.

1321 *** SYSTEM FATAL MESSAGE, FIRST TERM IN RØW IS NØT A DIAGØNAL TERM.

1322 *** SYSTEM FATAL MESSAGE 1322, BAD STATUS RETURN ØN A NTRAN READ CALL.

Possible I/Ø error.

1323 *** SYSTEM FATAL MESSAGE 1323, END-ØF-DATA ENCØUNTERED.

The unit on which the end-of-data occurred is not a tape.

1324 *** SYSTEM FATAL MESSAGE 1324, INCØRRECT WØRD CØUNT ØN A NTRAN READ CALL.

Number of words read by NTRAN is incorrect.

1325 *** SYSTEM FATAL MESSAGE 1325, BAD STATUS RETURN ØN A NTRAN WRITE CALL.

Possible I/Ø error.

1326 *** SYSTEM FATAL MESSAGE 1326, INCØRRECT NUMBER ØF WØRDS PASSED BY NTRAN.

1327 *** SYSTEM FATAL MESSAGE 1327, ILLEGAL RETURN FRØM FWDREC.

1701 *** SYSTEM WARNING MESSAGE 1701, AVAILABLE CØRE EXCEEDED BY ********* LINE IMAGE BLØCKS.

1702 *** SYSTEM INFØRMATIØN MESSAGE 1702, UTILITY MØDULE SEEMAT WILL ABANDØN PRØCESSING DATA BLØCK ********.

1703 *** USER WARNING MESSAGE 1703, PRECEDING BULK DATA DECK HAS BEEN CANCELED AND WILL NØT APPEAR ØN USER MASTER FILE.

The preceding Bulk Data Deck contains errors which preclude its inclusion on the User Master File. Appropriate error messages should appear in the echo of the Bulk Data Deck. Any subsequent Bulk Data Decks will be placed on the User Master File if error-free.

1704*** USER FATAL MESSAGE 1704, ILLEGAL TID VALUE ØN UMF CARD.

The TID value used on all UMF cards must be the same for any run and must match the TID value on the UMF tape being input. See Section 2.5 of the User's Manual for details.

1705 *** Reserved for future implementation in the User Master File Editor.

1706 *** Reserved for future implementation in the User Master File Editor.

1707 *** SYSTEM FATAL MESSAGE 1707, UMFEDT - UNEXPECTED EØF FROM READ.

The occurence of this message indicates a program failure in the User Master File Editor subroutine UMFEDT.

1708 *** SYSTEM FATAL MESSAGE 1708, UMFEDT - UNEXPECTED EØR FROM READ.

The occurence of this message indicates a program failure in the User Master File Editor subroutine UMFEDT.

1709 *** SYSTEM FATAL MESSAGE 1709, UMFEDT UNABLE TØ ØPEN ØNE ØF THE PERMANENT NASTRAN FILES UMF, NUMF, OR NPTP.

1710 *** Reserved for future implementation in the User Master File Editor.

1711 *** USER FATAL MESSAGE 1711, NØ TAPE SETUP FØR EITHER UMF ØR NUMF. THE USER MASTER FILE EDITØR REQUIRES AT LEAST ØNE ØF THESE TAPES TØ BE SET UP.

The tape(s) required must be appropriate to the requested action. See Section 2.5 of the User's Manual for details.

1712 *** Reserved for future implementation in the User Master File Editor.

1713 *** Reserved for future implementation in the User Master File Editor.

1714 *** Reserved for future implementation in the User Master File Editor.

1715 *** Reserved for future implementation in the User Master File Editor.

1716 *** Reserved for future implementation in the User Master File Editor.

1717 (1) *** USER WARNING MESSAGE 1717, REQUEST TØ ADD DECK WITH PRØBLEM IDENTIFICATIØN NØ. = **** CØNFLICTS WITH IMPLIED REQUEST TØ CØPY THE SAME PRØBLEM FRØM THE UMF. THE NEW DECK WILL BE USED.

This message will occur whenever a deck is added whose PID value is the same as that of a problem already existing on the old User Master File.

1717 (2) *** USER WARNING MESSAGE 1717, ILLEGAL PLØTTER SPECIFIED FØR SEEMAT (********).

1718 *** USER WARNING MESSAGE 1718, REMØVE REQUEST FØR PRØBLEM **** IS ØUT ØF SEQUENCE ØR NØT ØN UMF.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1719 *** USER WARNING MESSAGE 1719, LIST REQUEST FØR PRØBLEM **** IS ØUT ØF SEQUENCE ØR NØT ØN UMF.

Use Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1720 *** USER WARNING MESSAGE 1720, PUNCH REQUEST FØR PRØBLEM **** IS ØUT ØF SEQUENCE ØR NØT ØN
(1) UMF.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1720 *** USER WARNING MESSAGE 1720, PLØT FILE - **** NØT SET UP.
(2)

1721 *** USER FATAL MESSAGE 1721, PRØBLEM WITH PID = **** IS NØT ØN UMF ØR CARD IS ØUT ØF SEQUENCE.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1722 *** USER FATAL MESSAGE 1722, NUMF TAPE ID HAS ALREADY BEEN SPECIFIED.

The tape id value for the New User Master File (NUMF) may only be specified once. See Section 2.5 of the User's Manual for details.

1723 *** USER FATAL MESSAGE 1723, NUMF TAPE ID MAY NØT BE RESPECIFIED.

The tape id value for the New User Master File (NUMF) may only be specified once. See Section 2.5 of the User's Manual for details.

1724 *** USER WARNING MESSAGE 1724, PUNPRT REQUEST FØR PRØBLEM **** IS ØUT ØF SEQUENCE ØR NØT ØN
(1) UMF.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1724 *** USER WARNING MESSAGE 1724, LØGIC ERRØR AT STATEMENT ***** IN SUBRØUTINE SEEMAT.
(2)

1725 *** Reserved for future implementation in the User Master File Editor.

1726 *** Reserved for future implementation in the User Master File Editor.

1727 *** Reserved for future implementation in the User Master File Editor.

1728 *** SYSTEM FATAL ERRØR 1728, UMFEDT UNABLE TØ LØCATE BULK DATA ØN NPTP.

1729 *** Reserved for future implementation in the User Master File Editor.

1730 *** Reserved for future implementation in the User Master File Editor.

1731 *** Reserved for future implementation in the User Master File Editor.

1732 *** Reserved for future implementation in the User Master File Editor.

1733 *** Reserved for future implementation in the User Master File Editor.

1734 *** Reserved for future implementation in the User Master File Editor.

1735 *** Reserved for future implementation in the User Master File Editor.

1736 *** USER FATAL ERRØR 1736, BAD USER MASTER FILE EDITØR DATA CARD.

See Section 2.5 of the User's Manual for instructions for using the User Master File Editor.

1737 *** Reserved for future implementation in the User Master File Editor.

1738 *** USER FATAL MESSAGE 1738, UTILITY MØDULE INPUT FIRST PARAMETER VALUE *** ØUT ØF RANGE.

In the test problem generating version of utility module INPUT, the first parameter value specifies the specific problem type as follows:

1. Laplace circuit (an N x N array of scalar points connected by scalar springs and optionally by scalar masses).
2. Rectangular frame made from BARs or RØDs.
3. Rectangular plate made from QUAD1 elements.
4. Rectanqular plate made from TRIA1 elements.
5. N-segment string modeled with scalar elements.
6. N-cell beam made from BAR elements.
7. N-order full matrix generator with optional load.
8. N-spoke bicycle wheel.

1739 *** SYSTEM FATAL MESSAGE 1739, UNABLE TØ ØPEN FILE ***.

This message can occur if a required output file is purged in utility module INPUT.

1740 *** SYSTEM FATAL MESSAGE 1740, EØF ENCØUNTERED.

An unexpected End-Of-File has been encountered while reading an input data block in utility module INPUT.

1741 *** SYSTEM FATAL MESSAGE 1741, EØR ENCØUNTERED.

An unexpected End-Of-Logical Record indicator has been encountered while reading an input data block in utility module INPUT.

1742 *** SYSTEM FATAL MESSAGE 1742, NØ DATA PRESENT.

Utility module INPUT - input data block contains no data records.

1743 *** SYSTEM FATAL MESSAGE 1743, EØF FRØM FWDREC.

Utility module INPUT encountered an End-Of-File on an input data block while attempting to read past the header record.

1744 *** USER FATAL MESSAGE 1744, DATA CARD(S) ******** GENERATED BY UTILITY MØDULE INPUT NØT ALLØWED IN BULK DATA.

Module is not capable of integrating same card type from two sources.

1745 ***********************

Message 1745 is reserved for utility module INPUT.

6.2.3 Functional Module Messages

2001 *** USER FATAL MESSAGE 2001, SEQGP CARD REFERENCES UNDEFINED GRID PØINT ****.

2002 *** SYSTEM FATAL MESSAGE 2002, GRID PØINT **** NØT IN EQEXIN.

This message indicates a program design error in GP1.

2003 *** USER FATAL MESSAGE 2003, CØØRDINATE SYSTEM **** REFERENCES UNDEFINED GRID PØINT ****.

Applies to CØRD1j definitions.

2004 *** USER FATAL MESSAGE 2004, CØØRDINATE SYSTEM **** REFERENCES UNDEFINED CØØRDINATE SYSTEM ****.

Applies to CØRD2j definitions.

2005 *** SYSTEM FATAL MESSAGE 2005, INCØNSISTENT CØØRDINATE SYSTEM DEFINITIØN.

At least one coordinate system cannot be tied to the basic system. See Section 4.21.7 of the Programmer's Manual.

2006 *** USER FATAL MESSAGE 2006, INTERNAL GRID PØINT **** REFERENCES UNDEFINED CØØRDINATE SYSTEM ****.

The grid point whose internal sequence number is printed above references an undefined coordinate system in either field 3 or field 7 of a GRID card.

2007 *** USER FATAL MESSAGE 2007, ELEMENT **** REFERENCES UNDEFINED GRID PØINT ****.

2008 *** USER FATAL MESSAGE 2008, LØAD SET **** REFERENCES UNDEFINED GRID PØINT ****.

2009 *** USER FATAL MESSAGE 2009, TEMP SET **** REFERENCES UNDEFINED GRID PØINT ****.

2010 *** USER FATAL MESSAGE 2010, ELEMENT **** REFERENCES UNDEFINED PRØPERTY ****.

2011 *** USER FATAL MESSAGE 2011, NØ PRØPERTY CARD FØR ELEMENT TYPE ****.

2012 *** USER FATAL MESSAGE 2012, GRID PØINT **** SAME AS SCALAR PØINT.

Identification of grid and scalar points must be unique.

2013 *** USER WARNING MESSAGE 2013, NØ STRUCTURAL ELEMENTS EXIST.

Model checked for structural elements.

2014 *** SYSTEM FATAL MESSAGE 2014, LØGIC ERRØR IN ECPT CØNSTRUCTIØN.

The spill logic in the construction of the skeleton (TA1B) has failed. Problem should be referred to maintenance programming staff. A temporary fix may be available if additional storage can be provided to NASTRAN e.g., by increasing the region size (IBM 360).

2015 *** EITHER NØ ELEMENTS CØNNECT INTERNAL GRID PØINT ******** ØR IT IS CØNNECTED TØ A RIGID ELEMENT ØR A GENERAL ELEMENT.

The message is a warning only since the degrees of freedom associated with the point may be removed by multipoint constraints or in other ways. The internal identification number is formed by assigning to each grid point and scalar point one of the integers 1,2, --- according to its resequenced position. It may be determined from data block EQEXIN via a DMAP TABPT instruction.

2016 (1) *** USER INFØRMATIØN MESSAGE 2016, GIVENS TIME ESTIMATE IS ******** SECØNDS. PRØBLEM SIZE IS ********, SPILL WILL ØCCUR FØR THIS CØRE AT A PRØBLEM SIZE ØF ******** .

2016 (2) *** USER FATAL MESSAGE 2016, NØ MATERIAL PRØPERTIES EXIST.

2017 *** USER FATAL MESSAGE 2017, MATS1 CARD REFERENCES UNDEFINED MAT1 **** CARD.

The user should check that all MATS1 cards reference MAT1 cards that exist in the Bulk Data Deck.

2018 *** USER FATAL MESSAGE 2018, MATS2 CARD REFERENCES UNDEFINED MAT2 **** CARD.

The user should check that all MATS2 cards reference MAT2 cards that exist in the Bulk Data Deck.

2019 *** USER FATAL MESSAGE 2019, MATT1 CARD REFERENCES UNDEFINED MAT1 **** CARD.

The user should check that all MATT1 cards reference MAT1 cards that exist in the Bulk Data Deck.

2020 *** USER FATAL MESSAGE 2020, MATT2 CARD REFERENCES UNDEFINED MAT2 **** CARD.

The user should check that all MATT2 cards reference MAT2 cards that exist in the Bulk Data Deck.

2021 *** SYSTEM FATAL MESSAGE 2021, BAD GMMAT CALLING SEQUENCE.

The calling sequence of the subroutine which call either subroutine GMMATD or GMMATS defined a nonconformable matrix product. The subroutine examines the transpose flags in combination with the orders of the matrices to make sure that a conformable matrix product is defined by this input data. This test clearly is made for purposes of calling routine checkout only. No tests are made, nor can they be made, to insure that the calling routine has provided sufficient storage for arrays.

2022 *** SYSTEM FATAL MESSAGE 2022, SMA-B SCALAR PØINT INSERTIØN LØGIC ERRØR.

Problem error in creating the ECPT data block in module TA1. Use the TABPT module to print ECPT.

2023 *** SYSTEM FATAL MESSAGE 2023, DETCK UNABLE TO FIND PIVØT POINT **** IN GPCT.

Probable error in creating the ECPT data block in module TA1. Use the TABPT module to print ECPT.

2024 *** USER FATAL MESSAGE 2024, ØPERATIØN CØDE ******** NØT DEFINED FØR MØDULE PARAM.

The use of V,N,SUB rather than C,N,SUB can cause this.

2025 *** USER FATAL MESSAGE 2025, UNDEFINED CØØRDINATE SYSTEM ****.

The coordinate system identification number transmitted via ECPT(1) could not be found in the CSTM array. The user should check coordinate system numbers used on bulk data cards against those defined on CØRD1C, CØRD1R, etc., bulk data cards to insure that there are no undefined coordinate systems.

2026 *** USER FATAL MESSAGE 2026, ELEMENT **** GEØMETRY YIELDS UNREASØNABLE MATRIX.

Referenced element geometry and/or properties yields a numerical result which causes an element stiffness or mass matrix to be undefined. Possible causes include, but are not limited to, (1) the length of a rod or bar is zero because the end points have the same coordinates, (2) the sides of a triangle or quadrilateral are collinear which leads to a zero cross product in defining an element coordinate system, or (3) the bar orientation vector is parallel to the bar axis. Check GRID bulk data cards defining element end points for bad data.

2027 *** USER FATAL MESSAGE 2027, ELEMENT **** HAS INTERIØR ANGLE GREATER THAN 180 DEG. AT GRID PØINT ****.

SHEAR or TWIST panel element with the referenced element number has been defined with the four grid points out of the proper cyclical order. See bulk data card definitions for CSHEAR and CTWIST cards.

2028 *** SYSTEM FATAL MESSAGE 2028, SMA3A ERRØR NØ. ****.

Internal logic error in subroutine SMA3A of module SMA3. Possible error in generation of the GEI data block. Use the TABPT module to print GEI.

2029 *** USER FATAL MESSAGE 2029, UNDEFINED TEMPERATURE SET ****.

The referenced temperature set had no default temperature defined. Define a temperature or default temperature for each grid point in the model.

2030 *** SYSTEM FATAL MESSAGE 2030, BAD GPTT.

The format of the GPTT data block is incorrect. Use the TABPT module to print the GPTT data block.

2031 *** USER FATAL MESSAGE 2031, ELEMENT **** UNACCEPTABLE GEØMETRY.

2032 *** USER FATAL MESSAGE 2032, ELEMENT **** UNACCEPTABLE GEØMETRY.

2033 *** USER FATAL MESSAGE 2033, SINGULAR H-MATRIX FØR ELEMENT ****.

2034 *** SYSTEM FATAL MESSAGE 2034, ELEMENT **** SIL'S DØ NØT MATCH PIVØT.

Possible error in generation of the ECPT data block. Use the TABPT module to print ECPT.

2035 *** USER FATAL MESSAGE 2035, QUADRILATERAL **** INTERIØR ANGLE GREATER THAN 180 DEG.

2036 *** USER FATAL MESSAGE 2036, SINGULAR MATRIX FØR ELEMENT ****.

2037 *** USER FATAL MESSAGE 2037, BAD ELEMENT **** GEØMETRY.

2038 *** SYSTEM FATAL MESSAGE 2038, SINGULAR MATRIX FØR ELEMENT ****.

2039 *** USER FATAL MESSAGE 2039, ZERØ SLANT LENGTH FØR HARMØNIC **** ØF CCØNEAX ****.

2040 *** USER FATAL MESSAGE 2040, SINGULAR MATRIX FØR ELEMENT ****.

2041 *** USER FATAL MESSAGE 2041, A MATT1,MATT2,MATT3 OR MATS1 CARD REFERENCES TABLE NUMBER **** WHICH IS NØT DEFINED ØN A TABLEM1, TABLEM2, TABLEM3, TABLEM4 ØR TABLES1 CARD.

The user must insure that all table identification numbers on MATT1, MATT2, MATT3, or MATS1 cards reference tables which exist in the Bulk Data Deck.

2042 *** USER FATAL MESSAGE 2042, MISSING MATERIAL TABLE **** FØR ELEMENT ****.

The referenced material table identification number is missing. The user should check to see that all element property bulk data cards (e.g., PBAR, PRØD) reference material card identification numbers for material property cards that exist in the Bulk Data Deck.

2043 (1) *** USER WARNING MESSAGE 2043, ØFP HAS INSUFFICIENT CØRE FØR ØNE GINØ BUFFER **** ØFP NØT EXECUTED.

2043 (2) *** USER FATAL MESSAGE 2043, MISSING MATERIAL TABLE ********.

2044 *** USER FATAL MESSAGE 2044, UNDEFINED TEMPERATURE SET ****.

The referenced temperature set was selected in the Case Control Deck but not defined in the Bulk Data Deck.

2045 *** USER FATAL MESSAGE 2045, TEMPERATURE UNDEFINED AT GRID PØINT WITH INTERNAL INDEX ****.

Temperatures must be defined at all grid points in a selected temperature set. The grid point whose internal index was printed had no temperature defined and a default temperature was not supplied for the selected temperature set.

2046 *** USER FATAL MESSAGE 2046, UNDEFINED ELEMENT DEFØRMATIØN SET ****.

2047 *** USER FATAL MESSAGE 2047, UNDEFINED MULTIPØINT CØNSTRAINT SET ****.

A multipoint constraint set selected in the Case Control Deck could not be found in either an MPC or MPCADD card or a set referenced on a MPCADD card could not be found on an MPC card.

2048 *** USER FATAL MESSAGE 2048, UNDEFINED GRID PØINT **** IN MULTI-PØINT CØNSTRAINT SET ****.

2049 *** USER FATAL MESSAGE 2049, UNDEFINED GRID PØINT **** HAS AN ØMITTED CØØRDINATE.

An ØMIT or ØMIT1 card references a grid point which has not been defined.

2050 *** USER FATAL MESSAGE 2050, UNDEFINED GRID PØINT **** HAS A SUPPØRT CØØRDINATE.

A SUPØRT card references a grid point which has not been defined.

2051 *** USER FATAL MESSAGE 2051, UNDEFINED GRID PØINT **** IN SINGLE PØINT CØNSTRAINT SET ****.

An SPC1 card in the selected SPC set references a grid point which has not been defined.

2052 *** USER FATAL MESSAGE 2052, UNDEFINED GRID PØINT *** IN SINGLE-PØINT CØNSTRAINT SET ****.

An SPC card in the selected SPC set references a grid point which has not been defined.

2053 *** USER FATAL MESSAGE 2053, UNDEFINED SINGLE-PØINT CØNSTRAINT SET ****.

A single point constraint set selected in the Case Control Deck could not be found on either an SPCADD, SPC or SPC1 card, or a set referenced on an SPCADD card could not be found on either an SPC or SPC1 card.

2054 *** USER FATAL MESSAGE 2054, SUPER ELEMENT **** REFERENCES UNDEFINED SIMPLE ELEMENT ****.

2055 *** SYSTEM WARNING MESSAGE 2055, NØGØ FLAG IS ØN AT ENTRY TØ SMA1A AND IS BEING TURNED ØFF.

2056 *** USER FATAL MESSAGE 2056, UNDEFINED SUPER ELEMENT **** PRØPERTIES.

2057 *** USER FATAL MESSAGE 2057, IRRATIØNAL SUPER ELEMENT **** TØPØLØGY.

2058 *** USER WARNING MESSAGE 2058, ELEMENT ********** CONTRIBUTES TO THE DAMPING MATRIX WHICH IS PURGED. IT WILL BE IGNORED.

2059 *** USER FATAL MESSAGE 2059, UNDEFINED GRID PØINT **** ØN SE--BFE FØR SUPER ELEMENT ****.

2060 *** USER FATAL MESSAGE 2060, UNDEFINED GRID PØINT **** ØN QDSEP CARD FØR SUPER ELEMENT ****.

2061 *** USER FATAL MESSAGE 2061, UNDEFINED GRID PØINT **** ØN GENERAL ELEMENT ****.

2062 *** USER FATAL MESSAGE 6062, UNDEFINED SUPER ELEMENT PRØPERTY **** FØR SUPER ELEMENT ****.

2063 *** SYSTEM FATAL MESSAGE 2063, TA1C LØGIC ERRØR. GENERAL ELEMENT DATA CØULD NØT BE FØUND IN THE ECT DATA BLØCK WHEN TRAILER LIST INDICATED IT WAS PRESENT. REFER PRØBLEM TO MAINTENANCE PRØGRAMMING STAFF.

2064 *** USER FATAL MESSAGE 2064, UNDEFINED EXTRA PØINT **** REFERENCED ØN SEQEP CARD.

2065 *** USER FATAL MESSAGE 2065, UNDEFINED GRID PØINT **** ØN DMIG CARD.

2066 *** USER FATAL MESSAGE 2066, UNDEFINED GRID PØINT **** ØN RLØAD- ØR TLØAD- CARD.

2067 *** USER FATAL MESSAGE 2067, UNDEFINED GRID PØINT **** ØN NØLIN- CARD.

2068 *** USER FATAL MESSAGE 2068, UNDEFINED GRID PØINT **** IN TRANSFER FUNCTIØN SET ****.

2069 *** USER FATAL MESSAGE 2069, UNDEFINED GRID PØINT **** IN TRANSIENT INITIAL CØNDITION SET ****.

2070 *** USER FATAL MESSAGE 2070, REQUESTED DMIG MATRIX **** IS UNDEFINED.

2071 *** USER FATAL MESSAGE 2071, DYNAMIC LØAD SET **** REFERENCES UNDEFINED TABLE ****.

2072 *** SYSTEM WARNING MESSAGE 2072, CARD TYPE *** NØT FØUND ØN DATA BLØCK.

This warning message is issued when the trailer bit for the card type = 1 but the corresponding record is not on the data block.

2073 *** USER INFØRMATIØN MESSAGE 2073, MPYAD METHØD = ****, NØ. ØF PASSES = ****.

This message gives the method selected and number of passes required.

2074 *** USER FATAL MESSAGE 2074, UNDEFINED TRANSFER FUNCTIØN SET ****.

2075 *** SYSTEM ØR USER DMAP FATAL MESSAGE 2075, IMPRØPER VALUE **** FØR FIRST PARAMETER IN DMAP INSTRUCTIØN SDR2.

2076 *** USER WARNING MESSAGE 2076, SDR2 ØUTPUT DATA BLØCK NØ. 1 IS PURGED.

2077 *** USER WARNING MESSAGE 2077, SDR2 ØUTPUT DATA BLØCK NØ. 2 IS PURGED.

2078 *** USER WARNING MESSAGE 2078, SDR2 ØUTPUT DATA BLØCK NØ. 3 IS PURGED.

2079 *** USER WARNING MESSAGE 2079, SDR2 FINDS THE -EDT-, -EST-, ØR -GPTT- PURGED ØR INADEQUATE AND IS THUS NØT PRØCESSING ANY REQUESTS FØR STRESSES ØR FØRCES.

2080 *** USER WARNING MESSAGE 2080, SDR2 ØUTPUT DATA BLØCK NØ. 6 IS PURGED.

2081 *** USER FATAL MESSAGE 2081, NULL DIFFERENTIAL STIFFNESS MATRIX.

Differential stiffness is not defined for all structural elements. Only the following elements are defined for differential stiffness calculations: RØD, TUBE, SHEAR (but not TWIST) panels, triangular and quadrilateral membranes (TRMEM, TRIA2, QDMEM, QUAD2), and BAR. The combination two dimensional elements TRIA1 and QUAD1, are defined only if their membrane thickness is nonzero. The user has not included any of these elements in his model and therefore a null differential stiffness matrix was generated.

2083 *** USER FATAL MESSAGE 2083, NULL DISPLACEMENT VECTØR.

The displacement vector for the linear solution part of a static analysis with differential stiffness problem, or the incremental displacement vector in a piecewise linear analysis rigid format problem is the zero vector. Check loading conditions.

2084 *** SYSTEM FATAL MESSAGE 2084, DSMG2 LØGIC ERRØR ****.

Incompatible input and output pairs in the DMAP calling sequence to module DSMG2. See the module description for DSMG2 in the Programmer's Manual.

2085 *** USER INFØRMATIØN MESSAGE 2085, **** SPILL, NPVT ****.

During processing of the ECPT data block in module ****, so many elements were attached to the referenced pivot point (NPVT) that module spill logic was initiated.

2086 *** USER INFØRMATIØN MESSAGE 2086, SMA2 SPILL, NPVT ****.

See explanation for Message 2085.

2087 *** SYSTEM FATAL MESSAGE 2087, ECPT CØNTAINS BAD DATA.

Use the TABPT module to print the ECPT data block.

2088 *** USER FATAL MESSAGE 2088, DUPLICATE TABLE ID ****.

All tables must have unique numbers. Check for uniqueness.

2089 *** USER FATAL MESSAGE 2089, TABLE **** UNDEFINED.

The table number in the list of table numbers input to subroutine PRETAB via argument 7 was not found after reading the DIT data block. Check list of tables in the Bulk Data Deck.

2090 *** SYSTEM FATAL MESSAGE 2090, TABLE DICTIØNARY ENTRY **** MISSING.

Logic error in subroutine PRETAB, or open core used by PRETAB has been destroyed.

2091 *** SYSTEM FATAL MESSAGE 2091, PLA3, BAD ESTNL EL ID ****.

ESTNL data block is not in expected format. Use TABPT module to print the ESTNL data block.

2092 *** SYSTEM WARNING MESSAGE 2092, SDR2 FINDS A SYMMETRY SEQUENCE LENGTH = **** AND AN INSUFFICIENT NUMBER ØF VECTØRS AVAILABLE = **** WHILE ATTEMPTING TØ CØMPUTE STRESSES AND FORCES. ALL FURTHER STRESS AND FØRCES CØMPUTATIØN TERMINATED.

2093 *** USER FATAL MESSAGE 2093, NØLIN CARD FRØM NØLIN SET **** REFERENCES GRID PØINT **** UD SET.

2094 *** USER WARNING MESSAGE 2094, SUBRØUTINE TABFMT, KEYNAME ******** NØT IN LIST ØF AVAILABLE KEYNAMES. *** LIST ØF RECØGNIZED KEYNAMES FØLLOWS.

The TABPRT Module can only be used to print certain table data blocks. For table data blocks not appearing in the list, use the TABPT Module.

2095 *** USER WARNING MESSAGE 2095, SUBRØUTINE TABFMT, PURGED INPUT.

2096 *** USER WARNING MESSAGE 2096, SUBRØUTINE TABFMT, EØF ENCØUNTERED.

2097 *** USER WARNING MESSAGE 2097, SUBRØUTINE TABFMT, EØR ENCØUNTERED.

2098 *** USER WARNING MESSAGE 2098, SUBRØUTINE TABFMT, INSUFFICIENT CØRE.

2099 *** USER WARNING MESSAGE 2099, SUBRØUTINE TABFMT, KF **********.

2101A *** USER FATAL MESSAGE 2101A, GRID PØINT **** CØMPØNENT *** ILLEGALLY DEFINED IN SETS ****.

The above grid point and component has been defined in each of the above dependent subsets. A point may belong to at most one dependent subset.

2101B *** USER FATAL MESSAGE 2101B, SCALAR PØINT **** ILLEGALLY DEFINED IN SETS ****.

2102 *** USER WARNING MESSAGE 2102, LEFT-HAND MATRIX RØW PØSITIØN **** ØUT ØF RANGE - IGNØRED.

A term in the A matrix whose row position is larger than the stated dimension was detected and ignored.

2103 *** SYSTEM FATAL MESSAGE 2103, SUBRØUTINE MAT WAS CALLED WITH INFLAG=2, THE SINE ØF ANGLE X, MATERIAL ØRIENTATIØN ANGLE, NØNZERØ, BUT SIN(X)**2+CØS(X)**2 DIFFERED FRØM 1 IN ABSOLUTE VALUE BY MØRE THAN .0001.

A check is made in MAT to insure that ABS(SIN(THETA)**2+CØS(THETA)**2-1.00) .LE. .0001 when INFLAG = 2. The calling routine did not set SINTH and CØSTH cells in /MATIN/ properly.

2104 *** USER FATAL MESSAGE 2104, UNDEFINED CØØRDINATE SYSTEM ****.

See the explanation for Message 2025.

2105 *** USER FATAL MESSAGE 2105, PLØAD2 CARD FRØM LØAD SET **** REFERENCES MISSING ØR NØN-2-D ELEMENT ****.

PLØAD2 cards must reference two-dimensional elements.

2106 *** USER FATAL MESSAGE 2106, LØAD CARD DEFINES NØNUNIQUE LØAD SET ****.

2107 *** USER FATAL MESSAGE 2107, EIG-CARD FRØM SET **** REFERENCES DEPENDENT CØØRDINATE ØR GRID PØINT ****.

When the point option is used on an EIGB, EIGC or EIGR card, the referenced point and component must be in the analysis set for use in normalization.

2108 *** USER FATAL MESSAGE 2108, NØ XY-PLØTTER HAS BEEN SPECIFIED TØ THIS PØINT.

2109 *** USER FATAL MESSAGE 2109, NØ GRID, SCALAR ØR EXTRA PØINTS DEFINED.

2110 *** USER WARNING MESSAGE 2110, INSUFFICIENT CØRE TØ HØLD CØNTENTS ØF GINØ FILE *** FURTHER PRØCESSING ØF THIS DATA BLØCK IS ABANDØNED.

2111 *** USER WARNING MESSAGE 2111, BAR **** CØUPLED BENDING INERTIA SET TØ 0.0 IN DIFFERENTIAL STIFFNESS.

The coupled bending inertia term on a PBAR card, if nonzero, is set to zero in the differential stiffness routine for the BAR.

2112 *** SYSTEM FATAL MESSAGE 2112, UNDEFINED TABLE ****.

The referenced table number could not be found in core.

2113 *** USER FATAL MESSAGE 2113, MATERIAL ****, A NØN-MAT1 TYPE, IS NØT ALLØWED TØ BE STRESS DEPENDENT.

Only MAT1 material cards may be present in a piecewise linear analysis problem.

2114 *** USER FATAL MESSAGE 2114, MATT3 CARD REFERENCES UNDEFINED MAT3 **** CARD.

The user should check that all MATT3 cards reference MAT3 cards that exist in the Bulk Data Deck. This can also happen if ID noted by **** could not be found on MAT1 card (see Message 2042).

2115 *** USER FATAL MESSAGE 2115, TABLE **** (TYPE ****) ILLEGAL WITH STRESS-DEPENDENT MATERIAL.

Only TABLES1 cards may be used to define stress-strain curves for use in piecewise linear analysis.

2116 *** SYSTEM FATAL MESSAGE 2116, MATID **** TABLEID ****.

The referenced material table identification number could not be found among the set of all MAT1 cards in core.

2117 *** USER FATAL MESSAGE 2117, TEMPERATURE DEPENDENT MATERIAL PRØPERTIES ARE NØT PERMISSIBLE IN A PIECEWISE LINEAR ANALYSIS PRØBLEM. TEMPERATURE SET = ****.

User should redefine his problem without temperature dependent material properties.

2118 *** USER INFØRMATIØN MESSAGE 2118, SUBRØUTINE GP4PRT, - DIAG 21 SET-DØF VS. DISP SETS FØLLØWS.

2119 *** USER INFØRMATIØN MESSAGE 2119, SUBRØUTINE GP4PRT, - DIAG 22 SET-DISP SETS VS. DØF FØLLØWS.

2120 *** USER FATAL MESSAGE 2120, MØDULE VEC - BØTH SUBSET BITS ARE NØN-ZERØ. I **********.

2121 *** USER FATAL MESSAGE 2121, MØDULE VEC - BØTH SUBSET BITS ARE ZERØ. I **********.

2122 *** USER FATAL MESSAGE 2122, MØDULE VEC - SET X BIT IS ZERØ BUT SUBSET XO BIT IS NØT. I **********.

2123 *** USER FATAL MESSAGE 2123, MØDULE VEC - SET X BIT IS ZERØ BUT SUBSET X1 BIT IS NØT. I **********.

2124 *** USER WARNING MESSAGE 2124, MØDULE VEC - NR=0, ØUTPUT WILL BE PURGED.

2125 *** USER WARNING MESSAGE 2125, MØDULE VEC - NZ=0, ØUTPUT WILL BE PURGED.

2126 *** USER FATAL MESSAGE 2126, MØDULE VEC UNABLE TØ ØPEN GINØ FILE **** DATA BLØCK ********.
(1)

2126 *** USER FATAL MESSAGE 2126, UNDEFINED MATERIAL FØR ELEMENT ********.
(2)

2127 *** SYSTEM FATAL MESSAGE 2127, PLA2 INPUT DATA BLØCK NØ. **** IS PURGED.

Data blocks DELTAUGV and DELTAPG cannot be purged. See module description for PLA2 in Section 4 of the Programmer's Manual.

2128 *** SYSTEM FATAL MESSAGE 2128, PLA2 ØUTPUT DATA BLØCK NØ. **** IS PURGED.

Data blocks UGV1, PGV1 cannot be purged. See module description for PLA2 in Section 4 of the Programmer's Manual.

2129 *** SYSTEM FATAL MESSAGE 2129, PLA2, ZERØ VECTØR ØN APPENDED DATA BLØCK NØ. ****.

Zero displacement vector found on UGV1 data block output from PLA2. Possible system failure.

2130 *** USER FATAL MESSAGE 2130, ZERØ INCREMENTAL DISPLACEMENT VECTØR NØT ADMISSIBLE AS INPUT TØ MØDULE PLA2.

See discussion of the Piecewise Linear Analysis rigid format.

2131 *** USER FATAL MESSAGE 2131, NØN-SCALAR ELEMENT *** REFERENCES A SCALAR PØINT.

An element which must be attached to a geometric grid point has been attached to a scalar point. No geometry data can be inferred.

2132 *** USER FATAL MESSAGE 2132, NØN-ZERØ SINGLE PØINT CONSTRAINT VALUE SPECIFIED BUT DATA BLØCK YS IS PURGED.

Many rigid formats do not support constrained displacements (especially dynamic solutions). An attempt to specify a constrained displacement in these cases results in this message.

2133 *** USER FATAL MESSAGE 2133, INITIAL CØNDITIØN IN SET **** SPECIFIED FØR PØINT NØT IN ANALYSIS SET.

Initial conditions can only be specified for analysis set points. Therefore the point/component mentioned on TIC cards must belong to the D or H sets.

2134 *** USER FATAL MESSAGE 2134, LØAD SET *** DEFINED FØR BØTH GRAVITY AND NØN-GRAVITY LØADS.

The same load set identification number cannot appear on both a GRAV card and another loading card such as FØRCE or MØMENT. To apply both a gravity load and a concentrated load simultaneously the LØAD card must be used.

2135 *** USER FATAL MESSAGE 2135, DLØAD CARD *** HAS A DUPLICATE SET ID FOR SET ID ***.

The Li set ID's on a DLØAD card are not unique. See DLØAD card description in the User's Manual.

2136 *** USER FATAL MESSAGE 2136, SET ID *** HAS BEEN DUPLICATED ØN A DLØAD, RLØAD1,2 or TLØAD1,2 CARD.

All dynamic load set ID's must be unique.

2137 *** USER FATAL MESSAGE 2137, PRØGRAM RESTRICTIØN FØR MØDULE SSG1 - ØNLY 100 LØAD SET ID'S ALLØWED. DATA CØNTAINS **** LØAD SET ID'S.

Reduce the number of Load Set ID's.

2138 *** USER FATAL MESSAGE 2138, ELEMENT IDENTIFICATION NUMBER **** IS TØØ LARGE.

Element identification numbers (on connection cards) must be less than 16,777,215.

2139 *** USER FATAL MESSAGE 2139, ELEMENT **** IN DEFØRM SET **** IS UNDEFINED.

A selected element deformation set includes an element twice, includes a non-existent element, or includes a non-one-dimensional element.

2140 *** USER FATAL MESSAGE 2140, GRID PØINT ØR SCALAR PØINT ID *** IS TØØ LARGE.

Program restriction on the size of integer numbers. A card defining a grid point or scalar point has a number larger than 2,000,000.

2141 *** USER FATAL MESSAGE 2141, MØDULE VEC - EØF ENCØUNTERED WHILE READING GINØ FILE **** DATA BLØCK ********.

2142 *** USER FATAL MESSAGE 2142, INSUFFICIENT CØRE FØR MØDULE VEC. AVAILABLE CØRE = ********** WØRDS. ADDITIONAL CØRE NEEDED = ********** WØRDS.

2143 *** USER FATAL MESSAGE 2143, MØDULE VEC UNABLE TØ IDENTIFY SET ØR SUBSET DESCRIPTØR ********.

2144 *** USER FATAL MESSAGE 2144, MØDULE VEC - EØF ENCØUNTERED DURING FWDREC ØF GINØ FILE **** DATA BLØCK ********.

2145 *** USER FATAL MESSAGE 2145, ******** FATAL MESSAGES HAVE BEEN GENERATED IN SUBRØUTINE VEC. ØNLY THE FIRST **** HAVE BEEN PRINTED.

2146 *** USER FATAL MESSAGE 2146, BØTH ØF THE SECØND AND THIRD VEC PARAMETERS REQUEST CØMPLEMENT.

2147 *** SYSTEM FATAL MESSAGE 2147, ILLEGAL ELEMENT TYPE = ********** ENCØUNTERED BY DSMG MØDULE.

2150 *** USER FATAL MESSAGE 2150, ILLEGAL VALUE FØR FØURTH PARAMETER = **********.

2151 *** USER WARNING MESSAGE 2151, -PLAARY- ARRAY IS SMALLER THAN MAXIMUM NUMBER ØF ELEMENT TYPES.

2152 *** USER FATAL MESSAGE 2152, GRID PØINT ******** CØMPØNENT ** DUPLICATELY DEFINED IN THE **** SET.

2153 *** USER FATAL MESSAGE 2153, SCALAR PØINT ******** DUPLICATELY DEFINED IN THE **** SET.

2154 *** USER WARNING MESSAGE 2154, ZERØ AREA ØR ILLEGAL CØNNECTIØN FØR HBDY ELEMENT NUMBER ********.

2155 *** USER WARNING MESSAGE 2155, MAT4 AND MAT5 MATERIAL DATA CARDS HAVE SAME ID = ************** MAT4 DATA WILL BE SUPPLIED WHEN CALLED FØR THIS ID.

2156 *** SYSTEM FATAL MESSAGE 2156, ILLEGAL INFLAG = ************** RECEIVED BY HMAT.

2157 *** USER FATAL MESSAGE 2157, MATERIAL ID = ************** DØES NØT APPEAR ØN ANY MAT4 ØR MAT5 MATERIAL DATA CARD.

2158 *** SYSTEM WARNING MESSAGE 2158, A TRAPRG ELEMENT = ************** DØES NØT HAVE SIDE 1-2 PARALLEL TØ SIDE 3-4.

2159 *** USER FATAL MESSAGE 2159, TRIRG ØR TRAPRG ELEMENT = ************** PØSSESSES ILLEGAL GEØMETRY.

2160 *** USER FATAL MESSAGE 2160, BAD GEØMETRY ØR ZERØ CØEFFICIENT FØR SLØT ELEMENT NUMBER ******************.

2161 *** SYSTEM WARNING MESSAGE 2161, PARTITIØN FILE, **** IS ØF SIZE ********** RØWS BY ********** CØLS. PARTITIØNING VECTØRS INDICATE THAT THIS PARTITIØN SHØULD BE ØF SIZE ********** RØWS BY ********** CØLUMNS FØR A SUCCESSFUL MERGE.

2162 *** SYSTEM WARNING MESSAGE 2162, THE FØRM PARAMETER AS GIVEN TØ THE MERGE MØDULE IS INCØNSISTENT WITH THE SIZE ØF THE MERGED MATRIX, HØWEVER IT HAS BEEN USED. FØRM = **********, SIZE = ********** RØWS BY ********** CØLUMNS.

2163 *** SYSTEM WARNING MESSAGE 2163, THE FØRM PARAMETER AS GIVEN TØ THE MERGE MØDULE HAS NØT BEEN SET, ØR IS ØF ILLEGAL VALUE. THE FØRM ØF THE MERGED MATRIX HAS BEEN SET = **********.

2164 *** SYSTEM WARNING MESSAGE 2164, THE TYPE PARAMETER AS GIVEN TØ THE MERGE MØDULE HAS NØT BEEN SET ØR IS ØF ILLEGAL VALUE. THE TYPE ØF THE MERGED MATRIX HAS BEEN SET TØ REAL-SINGLE-PRECISIØN.

2165 *** USER FATAL MESSAGE 2165, ILLEGAL GEØMETRY ØR ZERØ CØEFFICIENT FØR SLØT ELEMENT NUMBER ******************.

2166 *** SYSTEM WARNING MESSAGE 2166, MATRIX TØ BE PARTITIØNED IS ØF SIZE ********** RØWS BY ********** CØLUMNS. RØW PARTITIØN SIZE IS ********** CØLUMN PARTITIØN SIZE IS ********** (INCØMPATIBLE).

2167 *** SYSTEM WARNING MESSAGE 2167, THE TYPE PARAMETER AS GIVEN TØ THE PARTITIØNING MØDULE HAS NØT BEEN SET ØR IS ØF ILLEGAL VALUE. THE TYPE ØF THE PARTITIØNS HAS BEEN SET TØ REAL-SINGLE-PRECISIØN.

2168 *** SYSTEM WARNING MESSAGE 2168, THE FØRM PARAMETER AS GIVEN TØ THE PARTITIØNING MØDULE FØR SUB-PARTITIØN ******** IS INCØNSISTENT WITH ITS SIZE. FØRM = **********, SIZE = ********** ROWS BY ********** CØLUMNS.

2169 *** SYSTEM WARNING MESSAGE 2169, THE FØRM PARAMETERS AS GIVEN TØ THE PARTITIØNING MØDULE FØR SUB-PARTITIØN ******** HAS NØT BEEN SET ØR IS ØF ILLEGAL VALUE. IT HAS BEEN RESET = **********.

2170 *** SYSTEM FATAL MESSAGE 2170, BØTH THE RØW AND CØLUMN PARTITIØNING VECTØRS ARE PURGED AND ØNLY ØNE MAY BE.

2171 *** SYSTEM WARNING MESSAGE 2171, SYM FLAG INDICATES TØ THE PARTITIØN ØR MERGE MØDULE THAT A SYMMETRIC MATRIX IS TØ BE ØUTPUT. THE PARTITIØNING VECTØRS ******** HØWEVER DØ NØT CØNTAIN AN IDENTICAL NUMBER ØF ZERØS AND NØN-ZERØS.

2172 *** SYSTEM WARNING MESSAGE 2172, RØW AND CØLUMN PARTITIØNING VECTØRS DØ NØT HAVE IDENTICAL ØRDERING ØF ZERØ AND NØN-ZERØ ELEMENTS, AND SYM FLAG INDICATES THAT A SYMMETRIC PARTITIØN ØR MERGE IS TØ BE PERFØRMED.

2173 *** SYSTEM WARNING MESSAGE 2173, PARTITIØNING VECTØR FILE **** CØNTAINS ********** CØLUMNS. ØNLY THE FIRST CØLUMN IS BEING USED.

2174 *** SYSTEM WARNING MESSAGE 2174, PARTITIØNING VECTØR ØN FILE **** IS NØT REAL-SINGLE ØR REAL-DØUBLE PRECISIØN.

2175 *** SYSTEM FATAL MESSAGE 2175, THE RØW PØSITIØN ØF AN ELEMENT ØF A CØLUMN ØN FILE **** IS GREATER THAN NUMBER ØF RØWS SPECIFIED BY TRAILER.

2176 *** SYSTEM FATAL MESSAGE 2176, FILE **** EXISTS BUT IS EMPTY.

2177 *** USER INFØRMATIØN MESSAGE 2177, SPILL WILL ØCCUR IN SYMMETRIC CØMPLEX DECØMPØSITIØN.

2178 *** SYSTEM FATAL MESSAGE 2178, GINØ REFERENCE NAMES, IMPRØPER FØR SUBRØUTINE FILSWI.

2179 *** SYSTEM FATAL MESSAGE 2179, ERRØR DETECTED IN FUNCTIØN FØRFIL ****, **** NØT IN FIST.

2180 *** USER WARNING MESSAGE 2180, SYMMETRIC DECØMPØSITIØN ØF A MATRIX WHØSE FØRM IS SQUARE (BUT NØT SYMMETRIC) WILL BE ATTEMPTED.

2181 *** SYSTEM FATAL MESSAGE 2181, SCDCMP CALLED TØ SØLVE A 1X1 ØR 2X2 MATRIX.

2182 *** USER WARNING MESSAGE 2182, SUBRØUTINE ******** IS DUMMY. ØNLY ØNE ØF THESE MESSAGES WILL APPEAR PER ØVERLAY ØF THIS DECK.

2183 *** USER WARNING MESSAGE 2183, SYMMETRIC DECØMPØSITIØN ØF A MATRIX WHØSE FØRM IS SQUARE (BUT NØT SYMMETRIC) WILL BE ATTEMPTED.

2184 *** SYSTEM WARNING MESSAGE 2184, STRESS ØR FØRCE REQUESTS FØR ELEMENT TYPE = **************** WILL NØT BE HØNØRED AS THIS ELEMENT IS UNDEFINED TØ SDR2.

Stress and force requests for fluid, mass, damping, plotel, and heat boundary elements are automatically ignored.

2187 *** USER FATAL MESSAGE 2187, INSUFFICIENT WØRKING CØRE TØ HØLD FØRTRAN LØGICAL RECØRD.
LENGTH ØF WØRKING CØRE = **********.
LENGTH ØF FØRTRAN LØGICAL RECØRD = **********.

2188 *** USER INFØRMATION MESSAGE 2188, UNUSED CØRE = ********** WØRDS.

2189 *** USER INFØRMATION MESSAGE 2189, ADDITIØNAL CØRE REQUIRED TØ AVØID SPILL = ********** (DECIMAL) WØRKS.

2190 *** SYSTEM FATAL MESSAGE 2190, ILLEGAL VALUE FOR KEY = **********. EXPECTED VALUE = **********.

2191 *** USER WARNING MESSAGE 2191, ELEMENT TYPE ********** IS PRESENT AND IS BEING IGNØRED BY SMA1 SINCE ØPTION PARAM = ********.

2192 *** USER FATAL MESSAGE 2192. UNDEFINED GRID PØINT, ********, IN RIGID ELEMENT, ********.

2193 *** USER FATAL MESSAGE 2193, A REDUNDANT SET ØF RIGID BØDY MØDES WAS SPECIFIED FØR THE GENERAL ELEMENT.

Only a non-redundant list of rigid body modes is allowed to appear in the u_d set when the S matrix is to be internally calculated in subroutine TA1CA.

2194 *** USER FATAL MESSAGE 2194, A MATRIX D IS SINGULAR IN SUBRØUTINE TA1CA.

While attempting to calculate the [S] matrix for a general element in TA1CA, it was discovered that the matrix D_d which relates $\{u_b\}$ to $\{u_d\}$ was singular and could not be inverted.

2195 *** USER WARNING MESSAGE 2195, ILLEGAL VALUE FØR P4 = ******.

2196 *** USER WARNING MESSAGE 2196, DUMMY SUBRØUTINE TIMTS3.
DUMMY SUBRØUTINE TIMTS4.
DUMMY SUBRØUTINE TIMTS5.

2197 *** SYSTEM FATAL MESSAGE 2197, ABØRT CALLED DURING TIME TEST ØF *********.

2198 *** SYSTEM FATAL MESSAGE 2198, INPUT DATA BLØCK, ******** HAS BEEN PURGED.

2199 *** SYSTEM FATAL MESSAGE 2199, SUMMARY/ ØNE ØR MØRE ØF THE ABØVE FATAL ERRØRS WAS ENCØUNTERED IN SUBRØUTINE ********.

2200 *** USER FATAL MESSAGE 2200. INCØNSISTENT RIGID BØDY SYSTEM.

2201 *** USER FATAL MESSAGE 2201. REQUIRED DATA BLØCK FØR GINØ FILE, ***, IS PURGED IN SUB-RØUTINE ********.

2202 *** USER FATAL MESSAGE 2202. PARAMETER, ***, HAS ILLEGAL VALUE ØF ********.

2203 *** USER FATAL MESSAGE 2203. PARAMETER, ***, FOR SUBSTRUCTURE ID ******** INDICATES IT IS AN IDENTICAL SUBSTRUCTURE BUT INPUT DATA BLØCK ØF PREVIØUS SUBSTRUCTURE IS PURGED.

2204 *** USER FATAL MESSAGE 2204. PARAMETER, ***, HAS A VALUE ØF ********, BUT CØRRESPØNDING INPUT DATA BLØCK, ***, IS NØN-PURGED.

2205 *** USER WARNING MESSAGE 2205. *** SUBSTRUCTURE HAVE BEEN SPECIFIED. NØ WØRK CAN BE DØNE FØR THIS CASE.

2206 *** USER FATAL MESSAGE 2206. PARAMETERS ** AND ** HAVE THE SAME SUBSTRUCTURE ID VALUES.

2207 *** USER FATAL MESSAGE 2207. NØ SAME DATA SUPPLIED ØR GENERATED FØR PVEC RUN - EXECUTION TERMINATED.

2208 *** USER FATAL MESSAGE 2208. END ØF FILE ENCØUNTERED ØN GINØ FILE, ***, IN SUBRØUTINE ********.

2209 *** USER FATAL MESSAGE 2209. END ØF RECØRD ENCØUNTERED ØN GINØ FILE, ***, IN SUBRØUTINE ******.

2211 *** USER FATAL MESSAGE 2211. LØGIC ERRØR IN ********.

2213 *** USER FATAL MESSAGE 2213. ILLEGAL SAME DATA. PSEUDØSTRUCTURE CØNTAINS INCØRRECTLY CØUPLED SUBSTRUCTURES.

2251 *** USER WARNING MESSAGE 2251. PHYSICALLY UNREALISTIC VALUE FØR NU ØN MAT1 CARD ********. VALUE = ****************.

2252 *** USER FATAL MESSAGE 2252. GINØ FILE, ***, IS PURGED.

2253 *** USER FATAL MESSAGE 2253. ILLEGAL VALUE FØR ØNE ØR MØRE INPUT PARAMETERS - ********** ********** **********).

2254 *** USER FATAL MESSAGE 2254. END-ØF-FILE ØN GINØ FILE ***.

2255 *** USER FATAL MESSAGE 2255. GINØ FILE 102 HAS CØNTRØL RECORD ØF LENGTH, ***** / EXPECTED LENGTH ØF CØNTRØL RECØRD IS *****.

2256 *** USER FATAL MESSAGE 2256. NØN-UNIQUE FIRST GRØUP ENTRY. THE TWØ GRØUPS FØLLØW.

2257 *** USER WARNING MESSAGE 2257, SET **** REFERENCED ØN SPLINE CARD **** IS EMPTY.

While processing the SET1 or SET2 card referenced on the SPLINEi card, no included grid points were found. If SET1 was used, either no points were included or they were all scalar points. If SET2 was used, the volume of space referenced did not include any structural grid points. This may occur if a tapered element is extended too far. The spline is omitted from the problem and processing continues.

2258 *** USER FATAL MESSAGE 2258, SET **** REFERENCED ØN SPLINE CARD **** NØT FØUND.

The necessary SET1 or SET2 card was not found. Include the proper set card.

2259 *** SYSTEM FATAL MESSAGE 2259, PØINT ASSIGNED TØ BØX **** FØR CAERO1 **** NØT IN EQAERØ.

No internal k point could be found for external box. If box number is okay, module APD is in error; if box number is bad, module GI is in error.

2260 *** USER FATAL MESSAGE 2260, SINGULAR MATRIX DEVELØPED WHILE PRØCESSING SPLINE ****

Matrix developed by SSPLIN or LSPLIN (depending on type of spline) could not be inverted; possibly for the Surface Spline all points lie in a straight line, or not enough points are included.

2261 *** USER FATAL MESSAGE 2261, PLANE ØF LINEAR SPLINE **** PERPENDICULAR TØ PLANE ØF AERØ ELEMENT ****

Y-axis of linear spline was perpendicular to connected element and could not be projected onto element.

2262 *** USER FATAL MESSAGE 2262, SPLINE **** INCLUDES AERØ BØX INCLUDED ØN AN EARLIER SPLINE.

Two splines are attached to the same box. Splines may be connected to the same structural grid point but not the same aerodynamic grid point. This type of error checking will stop with one error, so check this spline and subsequent splines (sorted) for overlaps before resubmitting.

2263 *** USER FATAL MESSAGE 2263, INSUFFICIENT CØRE TØ PRØCESS SPLINE ****

Depending on type of spline and input options, subroutine SSPLIN, or LSPLIN would not have had enough core for this spline. Either allow more core or break this spline into smaller splines.

2264 *** SYSTEM FATAL MESSAGE 2264, NUMBER ØF RØWS CØMPUTED (****) WAS GREATER THAN SIZE REQUESTED FØR ØUTPUT MATRIX (****)

Module ADD determines size of output matrices (j set size). Sum of number of rows added by different method total more than maximum allowed.

2265 *** USER FATAL MESSAGE 2265, METHØD **** FØR AERØELASTIC MATRIX GENERATIØN IS NØT IMPLEMENTED.

A nonimplemented method for computing these matrices was input.

2266 *** USER FATAL MESSAGE 2266, ØNE ØR MØRE ØF THE FØLLØWING FLFACT SETS WERE NØT FØUND *** ***

One or more of the FLFACT ID's on the flutter data card could not be found. Include all sets mentioned.

2267 *** USER FATAL MESSAGE 2267, INTERPØLATIØN METHØD **** UNKNØWN.

Matrix interpolation method on FLUTTER card is not implemented.

2268 *** USER FATAL MESSAGE 2268, FMETHØD SET **** NØT FØUND.

FLUTTER data card for FMETHØD = **** in case control could not be found.

2269 *** USER FATAL MESSAGE 2269, FLUTTER METHØD **** NØT IMPLEMENTED.

Flutter analysis method on FLUTTER data card is not implemented.

2270 *** USER FATAL MESSAGE 2270, LINEAR INTERPØLATIØN WITHØUT ENØUGH INDEPENDENT MACH NUMBERS EQUAL TØ DEPENDENT MACH ****

Linear interpolation is for points with the same Mach number, and less than two more found from the QHHL list which matched the requested Mach on an FLFACT list.

2271 *** USER FATAL MESSAGE 2271, INTERPØLATIØN MATRIX IS SINGULAR.

Possibly for the surface spline, all the Mach numbers were the same, or for either method, not enough points were included.

2288 *** SYSTEM FATAL MESSAGE 2288. **** READ INCØRRECT NUMBER WØRDS (**** ****).

Subroutine **** read **** words on the **** card which is incorrect.

2289 *** USER FATAL MESSAGE 2289. **** INSUFFICIENT CØRE (****). **** = MATERIAL, **** = PØINTERS, **** = ELEMENTS, **** = PRØPERTIES.

Module ØPTPR1 or ØPTPR2 gives the open core available and the pointers to the start of each contiguous section of core.

2290 *** USER FATAL MESSAGE 2290. THE FØLLØWING ILLEGAL ELEMENT TYPES FØUND ØN PLIMIT CARD.

This message is followed by a list of element types. Processing of legal element types continues so as to discover other errors.

2291 *** USER FATAL MESSAGE 2291, PLIMIT RANGE INCØRRECT FØR **** THRU **** AND **** THRU ****.

Property identification numbers are repeated. The first pair is rejected and processing of the remaining ranges continues to discover other errors.

2292 *** USER FATAL MESSAGE 2292. INSUFFICIENT CØRE FØR PLIMIT DATA, ELEMENT ****, **** WØRDS SKIPPED.

The element type **** being processed exceeded core by **** words. Processing of other element types continues to discover additional requirements.

2293 *** USER FATAL MESSAGE 2293. NØ PID ENTRIES ØN PLIMIT CARD (****).

A PLIMIT card of element type **** had no property entries.

2294 *** USER FATAL MESSAGE 2294. DUPLICATE **** THRU **** RANGE FØR ELEMENT **** REJECTED PLIMIT. SCAN CØNTINUED.

Property identification numbers are repeated for element type ****.

2295 *** USER FATAL MESSAGE 2295. NØ ELEMENTS EXIST FØR ØPTIMIZATIØN.

A non-null property card and its corresponding material stress limit is needed. In subroutine ØPT2A stress data is also required.

2296 *** USER FATAL MESSAGE 2296. INSUFFICIENT CØRE **** (****), ELEMENT ****.

Subroutine **** has insufficient core when loading element type or number ****. Elements are read into core by element type (see /GPTA1/ sequence) then by sequential element number.

2297 *** SYSTEM FATAL MESSAGE 2297. INCØRRECT LØGIC FØR ELEMENT TYPE ****, ELEMENT ****, (****).

Subroutine (****) has sequential element search. Element type can be found in /GPTA1/.

2298 *** USER FATAL MESSAGE 2298. INSUFFICIENT CØRE **** (****), PROPERTY ****.

Subroutine **** (core ****) had insufficient core when loading property ****.

2299 *** SYSTEM FATAL MESSAGE 2299. INCØRRECT LØGIC FØR ELEMENT TYPE ***, PRØPERTY **** (****).

Subroutine ØPTP1B has sequential property search. A property card had two entries per card and it was unsorted.

2300 *** SYSTEM FATAL MESSAGE 2300. **** UNABLE TØ LØCATE PRØPERTY **** ØN EPT ØR IN CØRE.

2301 *** SYSTEM FATAL MESSAGE 2301. ØPTP1D FILE ØPTIMIZATIØN PARAMETER INCØRRECT AS **** ****.

Check subroutines ØPTPX and ØPTP1D use of the scratch file. In ØPTPR2, the corresponding stress limit(s) is zero.

2302 *** USER FATAL MESSAGE 2302. SUBRØUTINE **** HAS NØ PRØPERTY ØR ELEMENT DATA.

File ØPTP1 has incorrect number of words.

2303 *** USER INFORMATIØN MESSAGE 2303. ØPTPR2 DETECTED ZERØ ALPHA FØR PRØPERTY****.

The stress in the element was zero. Only 100 messages per iteration may occur.

2304 *** USER INFORMATIØN MESSAGE 2304. ØTP2B CØNVERGENCE ACHIEVED, HIGHEST VALUE IS ****.

2305 *** USER INFØRMATIØN MESSAGE 2305. ØPTPR2 DETECTED NEGATIVE ALPHA FØR ELEMENT ****.

The element did not have stress data or appropriate material stress limits. The element properties were not changed. Only 100 of these messages will occur per print iteration.

2314 *** USER INFØRMATIØN MESSAGE 2314. STATISTICS FØR SYMMETRIC DECØMPØSITIØNS ØF DATA BLØCK, **** ****, FØLLØW / NUMBER ØF UII .LT. 0 = ***** / MAXIMUM ABSØLUTE VALUE ØF AII/UII = 1PE12.5 / N1 THRU N6 = ****** ****** ****** ****** ****** ****** / RØW NUMBERS ØF 5 LARGEST AII/UII = ****** ****** ****** ****** ******.

This message will appear if the NASTRAN card system(57=1) is placed before the ID card.

2316 *** USER INFØRMATIØN MESSAGE 2316. INSUFFICIENT CØRE, TØ PREPARE DECØMPØSITIØN STATISTICS.

2317 *** USER WARNING MESSAGE 2317. PARAM HAS STØRED ØUTSIDE DEFINED RANGE ØF CØMMØN BLØCK /SYSTEM/. INDEX VALUE = ********************.

2318 *** USER FATAL MESSAGE 2318, NO AERØ CARD FOUND.

An AERØ card is required to run APD.

2319 *** USER FATAL MESSAGE 2319, NO CAERØ1 CARDS FOUND.

At least one CAERØ1 card is required for APD.

2320 *** USER FATAL MESSAGE 2320, NO AEFACT CARDS FOUND.

An AEFACT has been referenced and none have been found in the input.

2321 *** USER FATAL MESSAGE 2321, NØ FLUTTER CARDS FØUND.

Flutter analysis requires at least one FLUTTER card.

2322 *** USER FATAL MESSAGE 2322, NEITHER MKAERØ1 ØR MKAERØ2 CARDS FØUND.

Either MKAERØ1 or MKAERØ2 cards are required.

2323 *** USER FATAL MESSAGE 2323, PAERØ1 CARD NØ. XXXXXXX REFERENCED BY CAERØ1 CARD NØ. XXXXXXX BUT DØES NØT EXIST.

CAERØ1 card points to missing PAERØ1 card.

2324 *** USER FATAL MESSAGE 2324, CAERØ1 ELEMENT NØ. XXXXXXX REFERENCED ØN A SPLINE1 CARD DØES NØT EXIST.

Either a SPLINE1 or a SPLINE2 card references a CAERØ1 card which is missing.

2325 *** USER FATAL MESSAGE 2325, CAERØ1 ELEMENT NØ. XXXXXXX REFERENCED ØN A SET2 CARD DØES NØT EXIST.

A SET2 card points to a CAERØ1 which was not included.

2326 *** USER FATAL MESSAGE 2326, CAERØ1 ELEMENT NØ. XXXXXXX REFERENCES AEFACT CARD NØ. XXXXXXX WHICH DØES NØT EXIST.

The listed CAERØ1 card requires one AEFACT card for LCHØRD or LSPAN.

2327 *** USER FATAL MESSAGE 2327, CAERØ1 ELEMENT NØ. XXXXXXX REFERENCES AEFACT CARD NØ. XXXXXXX WHICH DØES NØT EXIST.

The listed CAERØ1 card requires one AEFACT card for LCHØRD or LSPAN.

2328 *** USER FATAL MESSAGE 2328, SETI AND SPLINEI CARDS REQUIRED.

At least one SET1 or SET2 card and at least one SPLINE1 or SPLINE2 card required.

2329 *** USER FATAL MESSAGE 2329, DUPLICATE EXTERNAL ID NØ. XXXXXXX GENERATED.

The external ID's assigned to each generated box must be unique.

2330 *** USER FATAL MESSAGE 2330, SET1 CARD NØ. XXXXXXX REFERENCES EXTERNAL ID NØ. XXXXXXX WHICH DØES NØT EXIST.

External ID on SET1 card does not exist as structural grid point.

2331 *** USER FATAL MESSAGE 2331, BØX PICKED ØN SPLINE CARD NØ. XXXXXXX NØT GENERATED BY CAERØ CARD NØ. XXXXXXX.

SPLINE card XXXXXXX points to a box which was not generated by the CAERØ card.

2332A *** USER FATAL MESSAGE 2332. DEPENDENT MPC CØMPØNENT HAS BEEN SPECIFIED TWICE. SIL VALUE = ********.

2332B *** USER WARNING MESSAGE 2332. INVALID INPUT DATA DETECTED IN DATA BLØCK, ****, PRØCESSING STØPPED FØR THIS DATA BLØCK.

2333 *** USER INFØRMATIØN MESSAGE 2333. MØDULE DDRMM TERMINATED WITH VARIABLE IERRØR = **********.

2334 *** USER WARNING MESSAGE 2334. ILLEGAL MAJØR ØR MINØR ØFP-ID IDENTIFICATIONS = ********** ********** DETECTED IN DATA BLØCK, ****, PRØCESSING ØF SAID DATA BLØCK DISCØNTINUED.

2335 *** USER WARNING MESSAGE 2335. THE AMØUNT ØF DATA IS NØT CØNSISTENT FØR EACH EIGENVALUE IN DATA BLØCK **** PRØCESSING ØF THIS DATA BLØCK TERMINATED.

2336 *** USER WARNING MESSAGE 2336. A CHANGE IN WØRD 2 ØF THE ØFP-ID RECØRDS ØF DATA BLØCK **** HAS BEEN DETECTED. PRØCESSING ØF THIS DATA BLØCK HAS BEEN TERMINATED.

2337 *** USER WARNING MESSAGE 2337. DATA BLØCK **** CAN NØT BE PRØCESSED DUE TØ A CØRE INSUFFICIENCY ØF APPRØXIMATELY ********** DECIMAL WØRDS.

2338 *** USER WARNING MESSAGE 2338. DATA BLØCK **** MAY NØT BE FULLY CØMPLETED DUE TØ A CØRE INSUFFICIENCY ØF APPRØXIMATELY ********** DECIMAL WØRDS.

2339 *** USER WARNING MESSAGE 2339. A CHANGE IN WØRD 2 ØF THE ØFP-ID RECØRDS ØF DATA BLØCK **** HAS BEEN DETECTED. PRØCESSING ØF THIS DATA BLØCK HAS BEEN TERMINATED.

2340 *** SYSTEM WARNING MESSAGE 2340. MØDULE **** ****, HAS BEEN REQUESTED TØ DØ UNSYMMETRIC DECØMPØSITIØN ØF A SYMMETRIC MATRIX.

2341 *** USER WARNING MESSAGE 2341. MØDULE **** **** HAS BEEN FURNISHED A SQUARE MATRIX MARKED UNSYMMETRIC FØR SYMMETRIC DECØMPØSITIØN.

2342 *** USER WARNING MESSAGE 2342. UNRECØGNIZED DMAP APPRØACH PARAMETER = **** ****.

2343 *** SYSTEM WARNING MESSAGE 2343. DATA BLØCK, *****, IS EITHER NØT -EQEXIN- ØR PØSSIBLY INCØRRECT.

2344 *** SYSTEM WARNING MESSAGE 2344. GPFDR FINDS ELEMENT = **** ****, HAS AN ECT ENTRY LENGTH TØØ LONG FØR A PRØGRAM LØCAL ARRAY.

2345 *** SYSTEM WARNING MESSAGE 2345. GPFDR FINDS AND IS IGNØRING UNDEFINED ECT DATA WITH LØCATE NUMBERS = ******** ******** ********.

2346 *** SYSTEM WARNING MESSAGE 2346. GPFDR FINDS DATA FØR EL-TYPE = **********, IN DATA BLØCK, ********** NØT TØ BE IN AGREEMENT WITH THAT WHICH IS EXPECTED.

2347 *** SYSTEM WARNING MESSAGE 2347. GPFDR FINDS TØØ MANY ACTIVE CØNNECTING GRID PØINTS FØR ELEMENT ID = **********.

2348 *** SYSTEM WARNING MESSAGE 2348. GPFDR DØES NØT UNDERSTAND THE MATRIX-DICTIØNARY ENTRY FØR ELEMENT ID = **********.

2349 *** SYSTEM WARNING MESSAGE 2349. GPFDR FINDS AN ELEMENT ENTRY CØNNECTING PIVØT SIL = **********, ØN DATA BLØCK ***** TØØ LARGE FØR A LØCAL ARRAY. ENTRY IS BEING IGNØRED.

2350 *** SYSTEM WARNING MESSAGE 2350. GPFDR CANNØT FIND PIVØT SIL = **********, AMØNG THE SILS ØF ELEMENT ID = ********** AS READ FRØM DATA BLØCK, *****, ENTRY THUS IGNØRED.

2351 *** USER INFØRMATION MESSAGE 2351. A FØRCE CONTRIBUTIØN DUE TØ ELEMENT TYPE = **** ****, ØN PØINT ID = **********, WILL NØT APPEAR IN THE GRID-PØINT-FØRCE-BALANCE SUMMARY.

2352 *** SYSTEM WARNING MESSAGE 2352. GPFDR IS NØT ABLE TØ FIND PIVØT SIL = ********** AS READ FROM DATA BLØCK ***** IN TABLE ØF SILS.

2353 *** USER WARNING MESSAGE 2353. INSUFFICIENT CØRE TØ HØLD ALL NØN-ZERØ APP-LØAD AND F-ØF-SPC ØUTPUT LINE ENTRIES ØF GRID-PØINT-FØRCE-BALANCE REQUESTS. SØME PØINTS REQUESTED FØR ØUTPUT WILL BE MISSING THEIR APP-LØAD ØR F-ØF-SPC CØNTRIBUTIØN IN THE PRINTED BALANCE.

2354 *** USER WARNING MESSAGE 2354. GPFDR MØDULE IS UNABLE TØ CØNTINUE AND HAS BEEN TERMINATED DUE TØ ERRØR MESSAGE PRINTED ABØVE ØR BELØW THIS MESSAGE. THIS ERRØR ØCCURRED IN GPFDR CØDE WHERE THE VARIABLE -NERRØR- WAS SET = *****.

2355 *** USER FATAL MESSAGE 2355, GRID PØINT CØØRDINATES ØF ELEMENT ******** ARE IN ERRØR. ØNE ØR MØRE ØF THE R-CØØRDINATES ARE ZERØ ØR NEGATIVE.

2357 *** USER WARNING MESSAGE 2357. ØNE VECTØR (DEFAULT) WILL BE CØMPUTED IN THE CØMPLEX REGIØN.

If more than one vector is desired from the Hessenburg method, make a specific request on the EIGC card.

2358 *** USER WARNING MESSAGE 2358, SYMMETRIC SCRIPT-AF MATRIX (HREE) ASSUMED IN RADMTX.

2359 *** USER WARNING MESSAGE 2359, CØL *****, RØW ***** ØF RADMTX IS NEGATIVE.

2360 *** USER FATAL MESSAGE 2360, TØTAL VIEW FACTØR (FA/A), FØR ELEMENT ******** IS **************(ELEMENT AREA IS **************).

Provides view factors and areas for all elements with a view factor greater than 1.01. This message is also a WARNING for all elements with a view factor between .99 and 1.01 provided the NASTRAN card, SYSTEM(58)=1, is included in the deck.

2361 *** USER INFØRMATION MESSAGE 2361, **** ELEMENTS HAVE A TØTAL VIEW FACTØR (FA/A) LESS THAN 0.99, ENERGY MAY BE LØST TØ SPACE.

Provides the total number of elements with a view factor less than .99.

2362 *** USER FATAL MESSAGE 2362, CHBDY CARDS WITH DUPLICATE IDS FØUND IN EST, CHBDY ID NUMBER = **********.

2364 *** USER FATAL MESSAGE 2364, GRID PØINT CØØRDINATES ØF ELEMENT ******** ARE IN ERRØR. ØNE ØR MØRE ØF THE THETA-CØØRDINATES ARE NØNZERØ.

2365 *** USER WARNING MESSAGE 2365, INSUFFICIENT CØRE FØR HESSENBURG METHØD. SWITCHING TO INVERSE PØWER.

2366 *** USER FATAL MESSAGE 2366, REGIØN IMPRØPERLY DEFINED ØN EIGC CARD.

If insufficient core has caused an automatic switch from Hessenburg method to Inverse Power Method, the EIGC card must have the region(s) defined (they are ignored for the Hessenburg method). Either increase core to use the Hessenburg method or define the region(s) for Inverse Power.

2367 *** USER WARNING MESSAGE 2367, FREQUENCY F1 (FIELD 4) ØN THE EIGR BULK DATA CARD IS NEGATIVE. IT IS ASSUMED TØ BE ZERØ FØR CALCULATIØN PURPØSES.

2382 *** USER WARNING MESSAGE 2382, ELEMENT MATRICES FØR ELEMENTS CØNGRUENT TØ ELEMENT ID = ***** ***** WILL BE RE-CØMPUTED AS THERE IS INSUFFICIENT CØRE AT THIS TIME TØ HØLD CØNGRUENCY MAPPING DATA.

2383 *** SYSTEM WARNING MESSAGE 2383, UNABLE TØ LØCATE CØNGRUENCY MAPPING DATA FØR ELEMENT ID = **********. ELEMENT MATRICES FØR THIS ELEMENT WILL, THEREFØRE, BE RE-CØMPUTED.

2384 *** USER WARNING MESSAGE 2384, CØNGRUENCY ØF ELEMENT ID = ********** WILL BE IGNØRED AND ITS ELEMENT MATRICES WILL BE RE-CØMPUTED AS THERE IS INSUFFICIENT CØRE AT THIS TIME TØ PERFØRM CØNGRUENCY MAPPING CØMPUTATIØNS.

3001 *** SYSTEM FATAL MESSAGE 3001, ATTEMPT TØ ØPEN DATA SET *** IN SUBRØUTINE ****** WHICH WAS NØT DEFINED IN FIST.

Subroutine did not expect data block to be purged. Check data block requirements for module. This message is also a WARNING when STRESS output is requested in a heat transfer problem.

3002 *** SYSTEM FATAL MESSAGE 3002, EØF ENCØUNTERED WHILE READING DATA SET ********(FILE ***) IN SUBRØUTINE ******.

This message is issued when an End-Of-File occurs while trying to skip the header record. The data block is not in the proper format.

3003 *** SYSTEM FATAL MESSAGE 3003, ATTEMPT TØ READ PAST THE END ØF A LØGICAL RECØRD IN DATA SET ********(FILE ***) IN SUBRØUTINE ********.

This message is issued when the file is positioned at the beginning of a logical record and the record does not contain at least three words. Data block is not in proper format.

3004 *** SYSTEM FATAL MESSAGE 3004, INCØNSISTENT TYPE FLAGS ENCØUNTERED WHILE PACKING DATA SET ****.

3005 *** USER FATAL MESSAGE 3005, ATTEMPT TØ ØPERATE ØN SINGULAR MATRIX **** IN SUBRØUTINE ****.

A diagonal term does not exist for a column of (U). This is normally detected in DECØMP implying care was not taken in processing singular matrices in the calling routine.

3006 *** SYSTEM FATAL MESSAGE 3006, BUFFER ASSIGNED WHEN ØPENING DATA BLØCK **** FILE (****) CØNFLICTS WITH BUFFERS CURRENTLY ØPEN.

Computation of buffer pointers or allocation of open core is in error.

3007 *** SYSTEM FATAL MESSAGE 3007, ILLEGAL INPUT TØ SUBRØUTINE ****.

Subroutine **** has encountered data which it cannot process. This error should not be caused by user input data. A system or programming error is indicated. Go directly to the subroutine listing or description to determine the exact cause of the problem.

3008 *** SYSTEM FATAL MESSAGE 3008, INSUFFICIENT CØRE AVAILABLE FØR SUBRØUTINE ********.

This message implies that the particular subroutine does not have sufficient core to meet its demands. The subroutine or module description should be consulted to determine the core requirements.

3009 *** SYSTEM FATAL MESSAGE 3009, DATA TRANSMISSIØN ERRØR ØN DATA SET *******(FILE ***).

A conflict exists between the SGINØ subroutine for the UNIVAC 1108 and the resident NTRAN$. Either recode SGINØ or remove the PLØT request from the NASTRAN job.

3010 *** SYSTEM FATAL MESSAGE 3010, ATTEMPT TØ MANIPULATE DATA SET ********(FILE ***) BEFØRE ØPENING FILE.

An operation other than ØPEN or CLØSE is requested on a file which is not defined in the FIST.

3011 *** SYSTEM FATAL MESSAGE 3011, ATTEMPT TØ WRITE A TRAILER ØN FILE *** WHEN IT HAS BEEN PURGED.

The file did not exist in the FIST when WRTTRL was called.

3012 *** SYSTEM FATAL MESSAGE 3012, ATTEMPT TØ ØPEN DATA SET ********(FILE ***) WHICH HAS ALREADY BEEN ØPENED.

GINØ ØPEN was called while the file was already open.

3013 *** SYSTEM FATAL MESSAGE 3013, ATTEMPT TØ READ DATA SET ********(FILE ***) WHEN IT WAS ØPENED FØR ØUTPUT.

GINØ was called to READ a data block opened for output.

3014 *** SYSTEM FATAL MESSAGE 3014, ATTEMPT TØ WRITE DATA SET ********(FILE ***) WHEN IT WAS ØPENED FØR INPUT.

GINØ was called to WRITE a data block opened for input.

3015 *** SYSTEM FATAL MESSAGE 3015, ATTEMPT TØ FWDREC ØN DATA SET ********(FILE ***) WHEN IT WAS ØPENED FØR ØUTPUT.

GINØ was called to FWDREC a file opened for output.

3016 *** SYSTEM FATAL MESSAGE 3016, **** MATRIX IS NØT IN PRØPER FØRM IN SUBRØUTINE ****.

This implies that the input matrix is not in the proper form or type acceptable to the subroutine. Check the trailer information on the matrix and the subroutine description for the discrepancy.

3017 *** USER WARNING MESSAGE 3017, ØNE ØR MØRE GRID PØINT SINGULARITIES HAVE NØT BEEN REMØVED BY SINGLE ØR MULTI-PØINT CØNSTRAINTS.

Singularities or near singularities may exist at the grid point level. The listed singularities should be examined for data errors. The check performed here is neither necessary nor sufficient for a singular matrix.

3018 *** SYSTEM FATAL MESSAGE 3018, MØDULE ********, SEQUENCE NØ. ***, REQUIREMENTS EXCEED AVAILABLE FILES.

Segment File Alloctor (SFA) did not have sufficient logical files available to fill the request of the module. Cut module requirements or increase the logical files within the computer system. See Section 5 of the Programmer's Manual.

3019 *** USER FATAL MESSAGE 3019, MAXIMUM LINE CØUNT EXCEEDED IN SUBRØUTINE **** LINE CØUNT EQUALS ****.

The total number of lines written on the system output file has exceeded the set limit (default value is 20,000). If you wish to increase this value, include a card of the form "MAXLINES=n" in your Case Control Deck.

3020 *** SYSTEM FATAL MESSAGE 3020, GNFIST ØVERFLØWED FIST TABLE AT SEQUENCE NØ. *** DATA SET ********.

Generate FIST (GNFIST) routine overflowed FIST /XFIST/. Increase complied size. See Section 2 of the Programmer's Manual.

3021 *** SYSTEM FATAL MESSAGE 3021, FILE *** NØT DEFINED IN FIST.

An operation other than ØPEN or CLØSE is requested on a file which is not defined in the FIST.

3022 *** SYSTEM WARNING MESSAGE 3022, DATA SET ******** IS REQUIRED AS INPUT AND IS NØT ØUTPUT BY A PREVIØUS MØDULE IN THE CURRENT DMAP RØUTE.

Segment File Allocator (SFA) detected that an input data block to a future module has not been generated. If the future module requires that this data block exist, the module may terminate with a fatal error.

This message may occur (and most often does) when the Segment File Allocator has removed from its tables (due to a need for more room) previously purged data blocks. In this case no error or even a warning is implied.

3023 *** USER INFØRMATION MESSAGE 3023--PARAMETERS FOR SYMMETRIC DECØMPOSITION OF DATA BLØCK ******** (N = *****) TIME ESTIMATE = *******

C AVG = ******	S AVG = ******	PC MAX = ******
PC AVG = ******	ADDITIØNAL CØRE = *******	PC GRØUPS = ******
SPILL GRØUPS = ******	C MAX = ******	PREFACE LØØPS = ******

N is the number of rows in the data block; TIME is the estimate (in seconds) to perform the decomposition; C AVG is the average number of active columns per pivot row; PC AVG is the average number of passive columns at each active termination point; SPILL GRØUPS is the number of spill groups; S AVG is the average number of rows in each spill group; ADDITIØNAL CØRE (positive) is the amount of core required to avoid spill, (negative) is the amount of unused core; C MAX is the maximum number of active columns in any one pivot row; PC MAX is the maximum number of passive columns at any one active column termination point; PC GRØUPS is the number of active column termination points; PREFACE LØØPS is the number of times the preface of the decomposition subroutine is executed.

3024 *** USER INFØRMATIØN MESSAGE 3024, THE BANDWIDTH ØF MATRIX **** EXCEEDS THE MAXIMUM BANDWIDTH. A MAXIMUM BANDWIDTH ØF **** WILL BE USED.

This message indicates that a matrix has scattered terms way off the diagonal (i.e., a large bandwidth). Instead of searching all combinations of B and C, the search is started at the maximum bandwidth.

3025 *** SYSTEM FATAL MESSAGE 3025, ILLEGAL INDEX IN ACTIVE RØW ØR CØLUMN CALCULATIØN IN ****.

Possible machine error. Rerun problem. If error persists, a code error exists in the decomposition routine.

3026 *** SYSTEM FATAL MESSAGE 3026, MATRIX **** EXCEEDS MAXIMUM ALLØWABLE SIZE FØR BANDWIDTH PLUS ACTIVE CØLUMNS. BMAX = ****, CMAX = ****.

Sufficient space was not reserved for the generation of the B vs. C vector. SDCØMP should be recompiled to increase BMAX and CMAX.

3027 *** USER INFØRMATIØN MESSAGE 3027, **** DECØMPØSITIØN TIME ESTIMATE IS ******** SECØNDS.

Gives the estimated time required for a decomposition in seconds and the type of matrix, i.e., complex, real (double or single precision), symmetric or unsymmetric.

3028 *** USER INFØRMATION MESSAGE 3028, B = ****, BBAR = ****, C = ****, CBAR = ****, R = ****.

Gives the upper bandwidth (B), lower bandwidth (BBAR), number of active columns (C), and active rows (CBAR) used in the unsymmetric decomposition.

3029 *** SYSTEM FATAL MESSAGE 3029, PHYSICAL END-ØF-FILE ENCØUNTERED ØN DATA SET **** (FILE ****).

Since logical End-of-Files are used by GINØ, a physical End-of-File indicates an attempt to read beyond valid data.

3030 *** USER WARNING MESSAGE 3030, ØFP UNABLE TØ PRØCESS DATA BLØCK. A TABLE ØF THE DATA BLØCK FØLLØWS.

3031 Same as message 3032.

3032 *** USER FATAL MESSAGE 3032, UNABLE TØ FIND SELECTED SET (****) IN TABLE (****) IN SUBRØUTINE (****).

A particular set used in the problem was not included in the data. Good examples are loads, initial conditions, or frequency sets. Include the required data or change the Case Control Deck to select data already in problem. Set zero (0) has a special meaning. A set selection was required, but none was made. For example, no METHØD was selected for an eigenvalue extraction problem.

This message can also indicate that a LØAD card has referenced another LØAD card, which is not permitted.

3033 *** USER FATAL MESSAGE 3033, SUBCASE ID **** IS REFERENCED ØN ØNE ØR MØRE RANDPS CARDS BUT IS NØT A CURRENT SUBCASE ID.

The RANDPS set selected can only reference subcase identification numbers included in the current loop. All subcases in which the direct input matrices or transfer functions do not change are run together. Either add a subcase with referenced identification number, change your RANDPS cards or change the identification numbers on your current subcases.

3034 *** USER WARNING MESSAGE 3034, ØRTHØGØNALITY CHECK FAILED, LARGEST TERM = **** EPSI = ****.

The off-diagonal terms of the modal mass matrix are larger than the user input criteria on the EIGB or EIGR bulk data card. The eigenvectors are not orthogonal to this extent. This nonorthogonality is especially important if a modal formulation is contemplated.

3035 *** USER INFØRMATIØN MESSAGE 3035, FØR LØAD ** EPSILØN SUB E=*****.

This is an informative message reflecting the accumulated round-off error of the static solution.

3036 *** SYSTEM FATAL MESSAGE 3036, DATA SET ******** IS REQUIRED AS INPUT BUT HAS NØT BEEN GENERATED ØR PURGED.

The above mentioned data set is not accounted for on the ØPTP checkpoint dictionary. The message indicates a failure of the File Name Table. As an interim measure the user can use the ALTER feature to execute the proper module to create the needed data set.

3037 *** SYSTEM FATAL MESSAGE 3037, JØB TERMINATED IN SUBRØUTINE ****.

This message designates the subroutine in which the program terminated. It should be preceeded by a user message which explains the cause of the termination. The module in which the program terminated can be found by examining the online time messages.

3038 *** SYSTEM FATAL MESSAGE 3038, DATA SET *** DØES NØT HAVE MULTIREEL CAPABILITY.

Computer hardware/software does not support multireel files.

3039 *** SYSTEM FATAL MESSAGE 3039, ENDSYS CANNØT FIND SAVE FILE.

File cannot be found to save and restore executive tables during link switching.

3040 *** SYSTEM FATAL MESSAGE 3040, ATTEMPT TØ WRITE DATA SET ********(FILE ***) WHEN IT IS AN INPUT FILE.

Input data blocks for a module (100 .LT. NAME .LT. 200) may be read only.

3041 *** USER WARNING MESSAGE 3041, EXTERNAL GRID PØINT *** DØES NØT EXIST ØR IS NØT A GEØMETRIC GRID PØINT. THE BASIC ØRIGIN WILL BE USED.

The reference grid point specified on the PARAM GRDPNT card for weight and balance calculations in GPWG cannot be used.

3042 *** USER WARNING MESSAGE 3042, INCØNSISTENT SCALAR MASSES HAVE BEEN USED. EPSILØN/DELTA = *****.

The GPWG has detected inconsistant scalar masses. Direct masses have been used. Skew inertia's will result. Examine your scalar masses and CØNM1 cards.

3043 *** USER FATAL MESSAGE 3043, UNCØNNECTED EXTRA PØINT (MØDAL CØØRDINATE=***) HAS BEEN DETECTED BY SUBRØUTINE ****.

Extra points must be connected via Direct Matrix Input (or Transfer Functions) in modal transient or frequency response.

3044 *** USER FATAL MESSAGE 3044, A PØINT ØN NØNLINEAR LØAD SET **** NØLIN **** IS NØT AN EXTRA PØINT. ØNLY EXTRA PØINTS MAY HAVE NØNLINEAR LØADS IN A MØDAL FØRMULATIØN.

Modal transient analysis (Rigid Format D-12) will support nonlinear loads only on extra points. Pick another nonlinear load set.

3045 *** USER WARNING MESSAGE 3045, INSUFFICIENT TIME TØ CØMPLETE THE REMAINING ** SØLUTIØN(S) IN MØDULE ***.

The time specified on the NASTRAN TIME card has expired in the named module. The module will be terminated. NASTRAN will continue running until the time on the job card expires. Restart to obtain print-out, complete solutions or rerun problem.

3046 *** USER FATAL MESSAGE 3046, YØUR SELECTED LØADING CØNDITIØN, INITIAL CØNDITIØN, AND NØNLINEAR FØRCES ARE NULL. A ZERØ SØLUTIØN WILL RESULT.

Transient solution must have one of the above nonzero.

3047 *** USER FATAL MESSAGE 3047, NØ MØDES WITHIN RANGE AND LMØDES=0. A MØDAL FØRMULATIØN CANNØT BE MADE.

The modes used for a modal formulation must be selected by a PARAM card. Set LFREQ, HFREQ or LMØDES to request modes.

3048 *** SYSTEM FATAL MESSAGE 3048, BUFFER CØNTRØL WØRD INCØRRECT FØR GINØ **** ØPERATIØN ØN DATA BLØCK ****.

The buffer control word has been destroyed outside of GINØ or an attempt to READ a file opened to WRITE or similar error has occurred.

3049 *** SYSTEM FATAL MESSAGE 3049, GINØ UNABLE TØ PØSITIØN DATA BLØCK **** CØRRECTLY DURING **** ØPERATIØN.

A block number read does not match the expected block number. The file has been repositioned outside the GINØ environment or a machine or operating system error has occurred.

3050 *** USER FATAL MESSAGE 3050, INSUFFICIENT TIME REMAINING FØR DECØMPØSITIØN, ****. TIME ESTIMATE IS **** SECONDS.

The time estimated for a decomposition exceeds the remaining time. Increase the time estimate for the run.

3051 *** USER FATAL MESSAGE 3051, INITIAL CØNDITIØN SET **** WAS SELECTED FØR A MØDAL TRANSIENT PRØBLEM. INITIAL CØNDITIØNS ARE NØT ALLØWED IN SUCH A PRØBLEM.

3052 *** USER WARNING MESSAGE 3052, A RANDØM REQUEST FØR CURVE TYPE - **** -, PØINT - **** CØMPØNENT - **** -, SPECIFIES TØØ LARGE A CØMPØNENT ID. THE LAST CØMPØNENT WILL BE USED.

3053 *** USER WARNING MESSAGE 3053, THE ACCURACY ØF EIGENVALUE **** IS IN DØUBT. GIVENS-QR FAILED TØ CØNVERGE IN **** ITERATIØNS.

Each eigenvalue is computed to the precision limits of each machine consistent with the maximum number of iterations allowed. A programming change would be required to increase the maximum iteration parameter.

3054 *** USER WARNING MESSAGE 3054, THE ACCURACY ØF EIGENVECTØR **** CØRRESPØNDING TØ THE EIGENVALUE **** IS IN DØUBT.

The eigenvector failed to converge in the allowable number of iterations. Particular attention should be given to the off-diagonal terms of the modal mass matrix (MI) to determine if this vector is orthogonal to the remaining vectors. These terms will be computed and checked if field 9 on the EIGR card contains a nonzero value. The message is expected in the case of close or multiple eigenvalues, even though the vectors are properly computed.

3055 *** USER FATAL MESSAGE 3055, AN ATTEMPT TØ MULTIPLY ØR MULTIPLY AND ADD NØN-CØNFØRMABLE MATRICES TØGETHER WAS MADE IN MØDULE ******.

The multiply/add subroutine requires conformable matrices. There are two possible equations

1. $[X] = [A][B] + [C]$

The number of columns of [A] must be equal to the number of rows of [B] and the number of columns of [C] must be equal to the number of columns of [B] and the number of rows of [C] must be equal to the number of rows of [A].

2. $[X] = [A]^T[B] + [C]$

The number of rows of [A] must be equal to the number of rows of [B]; the number of columns of [C] must be equal to the number of columns of [B] and the number of rows of [C] must be equal to the number of columns of [A].

3056 *** USER FATAL MESSAGE 3056, NØ MASS MATRIX IS PRESENT BUT MASS DATA IS REQUIRED.

An operation with the mass matrix is required, such as a gravity loading condition, but none was created. A typical cause is the omission of RHØ on the MAT1 card.

3057 *** USER FATAL MESSAGE 3057, MATRIX **** IS NØT PØSITIVE DEFINITE.

A Cholesky decomposition was attempted on the above matrix, but a diagonal term was negative or equal to zero, such that the decomposition failed.

3058 *** USER WARNING MESSAGE 3058, EPSILØN IS LARGER THAN **** FØR SUBCASE ****.

The error residual (either ε_{ℓ} or ε_{ϕ})

$$\varepsilon = \frac{\{u\}^T \{\delta P\}}{\{P\}^T \{u\}}$$ is larger than would be expected for

a well conditioned problem. Near singularities may exist.

3059 *** USER FATAL MESSAGE 3059, SET IDENTIFIER **** DØES NØT EXIST. ERRØR DETECTED IN SUBRØUTINE ****.

When describing displacement matrices only those set identifier (such as M or G) listed in DMAP module MATGPR are legal set descriptors. Choose a set descriptor which is legal (and describes the matrices to be operated on).

3060 *** USER FATAL MESSAGE 3060, SUBRØUTINE ******** - ØPTIØN **** NØT IN APPRØVED LIST.

3061 *** USER INFØRMATIØN MESSAGE 3061, THE MEASURE ØF NØN-PLANARITY IS **** FØR ELEMENT NUMBER ********.

The measure of non-planarity for isoparametric quadrilateral membrane elements is the distance from actual grid points to mean plane divided by the average length of the diagonals. This message is issued only when the absolute value of this measure is greater than .01.

3062 *** SYSTEM FATAL MESSAGE 3062, HMAT MATERIAL RØUTINE CALLED IN A NØN-HEAT-TRANSFER PRØBLEM.

3063 *** SYSTEM WARNING MESSAGE 3063, INPUT FØRCES DATSDRHA BLØCK DØES NØT HAVE CØRRECT DATA.

3064 *** SYSTEM WARNING MESSAGE 3064, INCØNSISTENT HBDY DATA RECØRDS. ********** **********

3065 *** SYSTEM WARNING MESSAGE 3065, THERE IS NØ EST DATA FØR HBDY ELEMENT ID = **********.

3066 *** USER WARNING MESSAGE 3066, THERE IS NØ TLØAD1 ØR TLØAD2 DATA FØR LØAD-ID = **********.

3067 *** USER WARNING MESSAGE 3067, LØAD SET ID = ********** IS NØT PRESENT.

3068 *** SYSTEM WARNING MESSAGE 3068, UNRECØGNIZED CARD TYPE = ********** FØUND IN -SLT- DATA BLØCK.

3069 *** USER WARNING MESSAGE 3069, ØUTPUT DATA BLØCK FØR FØRCES IS PURGED.

3070 *** USER WARNING MESSAGE 3070, QGE IS REQUIRED BY THIS MØDULE AND IS PURGED. NØ ØUTPUT FILE HAS BEEN CREATED.

3071 *** SYSTEM WARNING MESSAGE 3071, EXTRA DATA IN RADLST RECØRD ØF MATPØØL DATA BLØCK IGNØRED.

3072 *** USER WARNING MESSAGE 3072, TØØ MANY MATRIX VALUES INPUT VIA RADMTX BULK DATA FØR CØLUMN ********. EXTRA VALUES IGNØRED AS MATRIX SIZE IS DETERMINED TØ BE ØF SIZE ******** FRØM RADLST CØUNT ØF ELEMENT ID-S.

3073 *** USER FATAL MESSAGE 3073, NØ -HBDY- ELEMENT SUMMARY DATA IS PRESENT FØR ELEMENT ID = ********, WHICH APPEARS ØN A -RADLST- BULK DATA CARD.

3074 *** USER FATAL MESSAGE 3074, CØLUMN ******** ØF THE Y MATRIX IS NULL.

3075 *** USER FATAL MESSAGE 3075, INTERMEDIATE MATRIX Y IS SINGULAR.

3076 *** SYSTEM FATAL MESSAGE 3076, GPTT DATA IS NØT IN SØRT BY INTERNAL ID.

3077 *** USER FATAL MESSAGE 3077, THERE IS NØ GRID PØINT TEMPERATURE DATA ØR DEFAULT TEMPERATURE DATA FØR SIL PØINT ******** AND PØSSIBLY ØTHER PØINTS.

3078 *** USER FATAL MESSAGE 3078, NØ GPTT DATA IS PRESENT FØR TEMPERATURE SET ********.

3079 *** USER FATAL MESSAGE 3079, THERE ARE NØ -HBDY- ELEMENTS PRESENT.

3080 *** USER FATAL MESSAGE 3080, INTEGER VALUES ØF EMISSIVITY ENCØUNTERED ********** ELEMENT ID = **********.

3081 *** SYSTEM FATAL MESSAGE 3081, INCØNSISTENT USET DATA DETECTED.

3082 *** USER WARNING MESSAGE 3082, M = **********, N = **********.

More than one n-set degree-of-freedom is associated with an m-set degree-of-freedom. The term associated with the m-n indices given in the message is ignored.

3083 *** USER FATAL MESSAGE 3083, UM PØSITIØN = **********, SIL = **********.

An m-set degree-of-freedom is not expressed in terms of an n-set degree-of-freedom.

3084 *** USER FATAL MESSAGE 3084, THERE IS NØ TEMPERATURE DATA FØR SIL NUMBER **********.

3085 *** USER FATAL MESSAGE 3085, THE PF LØAD VECTØR IS EITHER PURGED ØR NULL.

3086 (1) *** USER INFØRMATIØN MESSAGE 3086, ENTERING SSGHT EXIT MØDE BY REASON NUMBER 1 (NØRMAL CØNVERGENCE).

3086 (2) *** USER INFØRMATIØN MESSAGE 3086, ENTERING SSGHT EXIT MØDE BY REASØN NUMBER 2 (MAXIMUM ITERATIØNS).

3086 (3) *** USER INFØRMATIØN MESSAGE 3086, ENTERING SSGHT EXIT MØDE BY REASØN NUMBER 3 (DIVERGING SØLUTIØN).

3086 (4) *** USER INFØRMATIØN MESSAGE 3086, ENTERING SSGHT EXIT MØDE BY REASØN NUMBER 4 (INSUFFICIENT TIME).

3086 (5) *** USER INFØRMATIØN MESSAGE 3086, ENTERING SSGHT EXIT MØDE BY REASØN NUMBER 5 (MAXIMUM CØNVERGENCE).

1. Normal convergence occurs when the solution meets the convergence criteria defined by the parameter EPSHT.
2. Iterations are terminated when the number defined by the parameter MAXIT is attained.
3. Iterations are terminated when the solution diverges.
4. Iterations are terminated when there is insufficient time to complete the next loop.
5. Iterations are terminated when there is no change to the solution vector but the parameter EPSHT criteria was not met.

3087 *** USER FATAL MESSAGE 3087, TEMPERATURE SET ********** IS NØT PRESENT IN GPTT DATA BLØCK.

3088 *** USER FATAL MESSAGE 3088, ILLEGAL GEØMETRY FØR REVØLUTIØN ELEMENT ****.

3089 *** USER FATAL MESSAGE 3089, ILLEGAL GEØMETRY FØR TRIANGLE ELEMENT ****.

3090 *** USER FATAL MESSAGE 3090, ILLEGAL GEØMETRY FØR QUAD. ELEMENT ****.

3091 *** SYSTEM WARNING MESSAGE 3091, A TRAPRG ELEMENT = ************** DØES NØT HAVE SIDE 1-2 PARALLEL TØ SIDE 3-4.

3092 *** USER FATAL MESSAGE 3092, TRIRG ØR TRAPRG ELEMENT = ************** PØSSESSES ILLEGAL GEØMETRY.

3093 *** SYSTEM FATAL MESSAGE 3093, ELEMENT = ******** REASØN = ******.

1. Less than 2 points have been referenced.
2. Unable to locate SIL value.
3. Unrecognized form for element.
4. Illegal number of points for this form of the element.
5. Illegal number of points for this form of the element.

3094 *** SYSTEM FATAL MESSAGE 3094, SLT LØAD TYPE ********** IS NØT RECØGNIZED.

3095 *** USER WARNING MESSAGE 3095, ELEMENT TYPE ********* WITH ID = *********, AND APPEARING ØN EITHER A QVECT, QBDY1, QBDY2, ØR QVØL LØAD CARD HAS THE SAME ID AS AN ELEMENT ØF ANØTHER TYPE AND IS NØT BEING USED FØR LØADING.

3096 *** USER FATAL MESSAGE 3096, ELEMENT ID = ********** AS REFERENCED ØN A QVØL, QBDY1, QBDY2, ØR QVECT LØAD CARD CØULD NØT BE FØUND AMØNG ACCEPTABLE ELEMENTS FØR THAT LØAD TYPE.

3097 *** USER FATAL MESSAGE 3097, CØLUMN ****** IS SINGULAR. UNSYMMETRIC ******** DECØMP ABØRTED.

USER FATAL MESSAGE 3097, CØLUMN ****** IS SINGULAR. SYMMETRIC ********** DECØMP ABØRTED.

When a matrix being read in is singular (null column or for symmetric decomposition a zero diagonal) the internal column number and type of decomposition is identified. The message does not appear for special cases such as less than three columns or for proportional rows.

3098 *** USER FATAL MESSAGE 3098, QDMEM2 ELEMENT STIFFNESS RØUTINE DETECTS ILLEGAL GEØMETRY FØR ELEMENT ID = **********.

3099 *** USER FATAL MESSAGE 3099, ELEMENT STIFFNESS CØMPUTATIØN FØR QDMEM2 ELEMENT ID = ********** IS IMPØSSIBLE DUE TØ SINGULARITY IN CØNSTRAINT EQUATIØN.

3100 *** USER WARNING MESSAGE 3100, ELEMENT THERMAL LØAD CØMPUTATIØN FØR QDMEM2 ELEMENT ID = ********** FINDS ILLEGAL GEØMETRY THUS NØ LØADS ØUTPUT FØR ELEMENT-ID NØTED.

3101 *** USER WARNING MESSAGE 3101, SINGULARITY ØR BAD GEØMETRY FØR QDMEM2 ELEMENT ID = ********* STRESS ØR FØRCES WILL BE INCØRRECT.

3102 (1) *** SYSTEM FATAL MESSAGE 3102. LØGIC ERRØR EMA- ****.

3102 (2) *** USER WARNING MESSAGE 3102, SUBRØUTINE TRHTIC, UNSTABLE TEMP. VALUE ØF *************** ****, CØMPUTED FØR TIME STEP ***** AT PØINT NUMBER ****** IN THE ANALYSIS STEP.

3103 (1) *** USER WARNING MESSAGE 3103. EMGCØR ØF EMG MØDULE FINDS EITHER ØF DATA BLØCKS **** ØR **** ABSENT AND THUS ****, MATRIX WILL NØT BE FØRMED.

3103 (2) *** USER FATAL MESSAGE 3103, SUBRØUTINE TRHTIC TERMINATING DUE TØ ERRØR CØUNT FØR MESSAGE 3102.

This occurs for 10 errors detected in the temperature computation.

3104 *** SYSTEM WARNING MESSAGE 3104. EMGCØR FINDS SET (ASSUMED DATA BLØCK *****) MISSING. EMG MØDULE CØMPUTATIØNS LIMITED.

3105 *** SYSTEM FATAL MESSAGE 3105. EMGPRØ FINDS ELEMENT ØF TYPE = ******** ******** UNDEFINED IN EST DATA BLØCK AND/ØR ELEMENT RØUTINE.

3106 *** SYSTEM FATAL MESSAGE 3106. EMGPRØ FINDS THAT ELEMENT TYPE ********** HAS EST ENTRIES TØØ LARGE TØ HANDLE CURRENTLY.

3107 *** SYSTEM INFØRMATIØN MESSAGE 3107. EMGØLD IS PRØCESSING ELEMENTS ØF TYPE = ***, BEGINNING WITH ELEMENT ID = **********.

3108 *** SYSTEM FATAL MESSAGE 3108. EMGØUT RECEIVES ILLEGAL FILE TYPE = **********.

3109 *** SYSTEM FATAL MESSAGE 3109. EMGØUT HAS BEEN SENT AN INVALID DICTIØNARY WØRD-2 = ********** FRØM ELEMENT ID = **********.

3110 *** SYSTEM FATAL MESSAGE 3110. EMGØUT HAS BEEN CALLED TØ WRITE AN INCØRRECT NUMBER ØF WØRDS FØR ELEMENT ID = **********.

3111 *** SYSTEM FATAL MESSAGE 3111. INVALID NUMBER ØF PARTITIØNS WERE SENT EMGØUT FØR ELEMENT ID = ********** WITH RESPECT TØ DATA BLØCK TYPE = ***.

3112 *** USER INFØRMATION MESSAGE 3112. ELEMENTS CØNGRUENT TØ ELEMENT ID = ********** WILL BE RE-CØMPUTED AS THERE IS INSUFFICIENT CØRE AT THIS MØMENT TØ HØLD DICTIØNARY DATA.

3113A*** SYSTEM INFØRMATIØN MESSAGE 3113. EMGPRØ PRØCESSING **** PRECISIØN ELEMENTS ØF TYPE ******** STARTING WITH ID ********.

3113B*** SYSTEM WARNING MESSAGE 3113. EMGØLD HAS RECEIVED A CALL FØR ELEMENT ********** WHICH IS ØF ELEMENT TYPE ********** AND NØT HANDLED BY EMGØLD. ELEMENT IGNØRED.

3114 *** SYSTEM FATAL MESSAGE 3114. EMGØLD CØMPATIBILITY RØUTINE CAN NØT HANDLE THE QUANTITY ØF CØNNECTIØNS FØR SILS ELEMENT **********.

3115 *** USER WARNING MESSAGE 3115. EMGØLD FINDS ELEMENT TYPE ********** PRESENT IN A HEAT FØRMULATIØN AND IS IGNØRING SAME.

3116 *** SYSTEM FATAL MESSAGE 3116. ELEMENT ID ********** SENDS BAD SIL TØ RØUTINE EMG1B.

3118 *** USER FATAL MESSAGE 3118. RØD ELEMENT NØ. ********* HAS ILLEGAL GEØMETRY ØR CØNNECTIØNS.

3119 *** USER FATAL MESSAGE 3119. INSUFFICIENT CØRE TØ PRØCESS RØD ELEMENTS.

3120 *** USER WARNING MESSAGE 3120. IMPRØPER CØNNECTIØN ØN CELAS ELEMENT, **********.

3123 *** USER FATAL MESSAGE 3123. PARAMETER NUMBER ***** NØT IN DMAP CALL.

3124 *** USER FATAL MESSAGE 3124. PARAMETER NUMBER ***** IS NØT A VARIABLE.

3125 *** SYSTEM FATAL MESSAGE 3125. INVALID TABLE NUMBER. ***********, IS NØ. *****, ØF *****, PASSED TØ PRETABLE.

3128 *** SYSTEM WARNING MESSAGE 3128. **** **** AND **** **** ARE EQUIVALENT LABELS. CØNSULT BØTH FØR INTERCHANGEABLE XREF.

3131 *** USER FATAL MESSAGE 3131. INPUT STIFFNESS AND MASS MATRICES ARE NØT COMPATIBLE.

The matrices must be the same size to properly perform matrix operations.

3199 *** USER WARNING MESSAGE 3199. NØN-FATAL MESSAGES MAY HAVE BEEN LØST BY ATTEMPTING TØ QUEUE MØRE THAN ***** MESSAGES.

3300 *** SYSTEM WARNING MESSAGE 3300. INVALID PARAMETER **** **** SUPPLIED TØ MØDULE DIAGØNAL, CØLUMN SUBSTITUTED.

4000 *** USER WARNING MESSAGE 4000, ØNE SIDE ØF ELEMENT ******** CØNNECTING FØUR PØINTS IS NØT APPRØXIMATELY PLANAR.

Check CWEDGE and CHEXAi cards for order of grid point identification numbers, or incorrect grid point identification numbers.

4001 *** USER FATAL MESSAGE 4001, ELEMENT ********** DØES NØT HAVE CØRRECT GEØMETRY.

4002 *** USER FATAL MESSAGE 4002, MØDULE SSG1 DETECTS BAD ØR REVERSED GEØMETRY FØR ELEMENT ID ********.

Check CWEDGE and CHEXAi cards for order of grid point identification numbers or incorrect grid point identification numbers. Subtetrahedra must have nonzero volume.

4003 *** USER FATAL MESSAGE 4003, AN ILLEGAL VALUE OF -NU- HAS BEEN SPECIFIED UNDER MATERIAL ID ******** FØR ELEMENT ID ********.

Solid WEDGE and HEXAi elements must not have Poisson's Ratio equal to 0.5.

4004 *** USER FATAL MESSAGE 4004, MØDULE SMA1 DETECTS BAD ØR REVERSED GEØMETRY FØR ELEMENT ID ********.

Check CWEDGE and CHEXAi cards for order of grid point identification numbers, or incorrect grid point identification numbers. Subtetrahedra must have nonzero volume.

4005 *** USER FATAL MESSAGE 4005, AN ILLEGAL VALUE OF -NU- HAS BEEN SPECIFIED UNDER MATERIAL ID ******** FØR ELEMENT ID ********.

Solid TETRA elements must not have Poisson's Ratio equal to C.5.

4010 *** USER FATAL MESSAGE 4010, TEMPP3 BULK DATA CARD WITH SETID = ******** AND ELEMENT ID = ******** DØES NØT HAVE ASCENDING VALUES SPECIFIED FØR Z.

4011 *** USER FATAL MESSAGE 4011, ELEMENT TEMPERATURE SET ******** CØNTAINS MULTIPLE TEMPERATURE DATA SPECIFIED FØR ELEMENT ID ********.

Temperature for element is specified on more than one bulk data card.

4012 *** USER FATAL MESSAGE 4012, THERE IS NØ ELEMENT, GRID PØINT, ØR DEFAULT TEMPERATURE DATA FØR TEMPERATURE SET ******** WITH RESPECT TØ ELEMENT ********.

4013 *** USER FATAL MESSAGE 4013, PROBLEM LIMITATION OF 66 TEMPERATURE SETS HAS BEEN EXCEEDED.

4014 *** SYSTEM FATAL MESSAGE 4014, RØUTINE EDTL DETECTS BAD DATA ØN TEMPERATURE DATA BLØCK FØR SET ID = ********.

Data block GPTT should be investigated.

4015 *** SYSTEM WARNING MESSAGE 4015, ELEMENT THERMAL AND DEFØRMATIØN LØADING NØT CØMPUTED FØR ILLEGAL ELEMENT TYPE ******** IN MØDULE SSG1.

Only certain elements have algorithms for enforced deformation or thermal loading. This element type will not produce a load. Check DEFØRM and TEMPP1, TEMPP2, TEMPP3, and TEMPRB bulk data cards.

4016 *** USER FATAL MESSAGE 4016, THERE IS NØ TEMPERATURE DATA FØR ELEMENT ******** IN SET ********.

4017 *** USER FATAL MESSAGE 4017, THERE IS NØ TEMPERATURE DATA FØR ELEMENT ******** IN SET ********.

4018 *** USER FATAL MESSAGE 4018, A SINGULAR MATERIAL MATRIX -D- FØR ELEMENT ******** HAS BEEN DETECTED BY RØUTINE SSGKHI WHILE TRYING TØ CØMPUTE THERMAL LØADS WITH TEMPP2 CARD DATA.

The element bending load - curvature relation is at fault and cannot be inverted.

4019 *** SYSTEM FATAL MESSAGE 4019, SDR2E DETECTS INVALID TEMPERATURE DATA FØR ********.

Data block table GPTT should be investigated.

4020 *** SYSTEM FATAL MESSAGE 4020, TA1A HAS PICKED UP TEMPERATURE SET ******** AND NØT THE REQUESTED SET ********.

The requested temperature set Id. for temperature dependent material properties can not be found in data block GPTT.

4021 *** SYSTEM FATAL MESSAGE 4021, TA1B HAS PICKED UP TEMPERATURE SET ******** AND NØT THE REQUESTED SET ********.

The requested temperature set Id. for temperature dependent material properties can not be found in data block GPTT.

4022 *** USER FATAL MESSAGE 4022, TA1B FINDS NØ ELEMENT, GRIDPØINT, ØR DEFAULT TEMPERATURE DATA FØR ELEMENT ID = ********.

4023 *** USER FATAL MESSAGE 4023, TA1A FINDS NØ ELEMENT, GRIDPØINT, ØR DEFAULT TEMPERATURE DATA FØR ELEMENT ID = ********.

4024 *** USER FATAL MESSAGE 4024, NØ CYJØIN CARDS WERE SUPPLIED.

4025 *** USER FATAL MESSAGE 4025, NØ SIDE 1 DATA FØUND.

4026 *** USER FATAL MESSAGE 4026, TØØ MANY SIDE 1 CARDS.

4027 *** USER FATAL MESSAGE 4027, NUMBER ØF ENTRIES IN SIDE 1 NØT EQUAL TØ NUMBER IN SIDE 2.

4028 *** USER FATAL MESSAGE 4028, THE CØDE FØR GRID PØINT, ********** DØES NØT MATCH THE CØDE FØR GRID PØINT **********.

A GRID point on SIDE 1 must be connected to a GRID point on SIDE 2 and a SCALAR point on SIDE 1 must be connected to a SCALAR point on SIDE 2.

4029 *** USER FATAL MESSAGE 4029, GRID PØINT, ********** APPEARS IN BØTH SIDE LISTS.

4030 *** USER WARNING MESSAGE 4030, CØMPØNENT *** ØF GRID PØINTS, ********** AND ********** CANNØT BE CØNNECTED.

4031 *** USER FATAL MESSAGE 4031, INSUFFICIENT CØRE = **** TØ READ DATA ØN AXIF CARD.

4032 *** USER WARNING MESSAGE 4032, NØ CØMPØNENTS ØF GRID PØINTS, ********** AND ********** WERE CØNNECTED.

4033 *** USER FATAL MESSAGE 4033, CØØRDINATE SYSTEM ID = **** AS SPECIFIED ØN AXIF CARD IS NØT PRESENT AMØNG ANY ØF CØRD1C, CØRD1S, CØRD2C, ØR CØRD2S CARD TYPES.

Cylindrical type assumed for continuing data check.

4034 *** USER FATAL MESSAGE 4034, INSUFFICIENT CØRE = **** TØ HØLD GRIDB CARD IMAGES.

4035 *** USER FATAL MESSAGE 4035, THE FLUID DENSITY HAS NØT BEEN SPECIFIED ØN A BDYLIST CARD AND THERE IS NØ DEFAULT FLUID DENSITY SPECIFIED ØN THE AXIF CARD.

4036 *** USER FATAL MESSAGE 4036, INSUFFICIENT CØRE TØ BUILD BØUNDARY LIST TABLE.

4037 *** USER FATAL MESSAGE 4037, GRID PØINT ********** IS LISTED MØRE THAN ØNCE.

4038 *** USER FATAL MESSAGE 4038, RINGFL CARD HAS ID = **** WHICH HAS BEEN USED.

An identification number of a RINGFL card is not unique.

4039 *** USER FATAL MESSAGE 4039, NØ CØØRDINATE SYSTEM DEFINED FØR GRID PØINT **********.

4040 *** USER FATAL MESSAGE 4040, ID = **** APPEARS ØN A BDYLIST CARD, BUT NØ RINGFL CARD IS PRESENT WITH THE SAME ID.

4041 *** USER FATAL MESSAGE 4041, ID = **** IS ØUT ØF PERMISSABLE RANGE ØF 1 to 499999.

The identification number of a RINGFL is too large to be processed.

4042 *** USER FATAL MESSAGE 4042, CØØRDINATE SYSTEM IS CYLINDRICAL BUT RINGFL CARD ID = **** HAS A NØNZERØ X2 VALUE.

The azimuthal angle of a RINGFL point must be zero.

4043 *** USER FATAL MESSAGE 4043, CØØRDINATE SYSTEM IS SPHERICAL BUT RINGFL CARD ID = **** HAS A NØNZERØ X3 VALUE.

The azimuthal angle of a RINGFL point must be zero.

4044 *** USER FATAL MESSAGE 4044, RINGFL CARD ID = **** HAS SPECIFIED A ZERØ RADIAL LØCATIØN.

4045 *** USER FATAL MESSAGE 4045, THE BØUNDARY LIST ENTRY FØR ID = **** HAS A ZERØ CRØSS-SECTIØNAL LENGTH.

A hydroelastic boundary can not be defined between two RINGFL points having the same location. Check BDYLIST and RINGFL.

4047 *** USER FATAL MESSAGE 4047, INSUFFICIENT CØRE TØ HØLD RINGFL IMAGES.

4048 *** USER FATAL MESSAGE 4048, THE FLUID DENSITY HAS NØT BEEN SPECIFIED ØN A FSLIST CARD AND THERE IS NØ DEFAULT FLUID DENSITY SPECIFIED ØN THE AXIF CARD.

4049 *** USER FATAL MESSAGE 4049, INSUFFICIENT CØRE TØ BUILD FREE SURFACE LIST TABLE.

4050 *** USER FATAL MESSAGE 4050, FSLIST CARD HAS INSUFFICIENT IDF DATA, ØR FSLIST DATA MISSING.

A referenced RINGFL point doesn't exist or the FSLIST card is in error. At least two points must be defined.

4051 *** USER FATAL MESSAGE 4051, AN MPC CARD HAS A SET ID SPECIFIED = 102. SET 102 IS ILLEGAL WHEN FLUID DATA IS PRESENT

This set identification number is reserved for internal use in hydroelastic problems.

4052 *** USER FATAL MESSAGE 4052, IDF = **** ØN A FREEPT CARD DØES NØT APPEAR ØN ANY FSLIST CARD.

A referenced RINGFL point must also appear on a FSLIST card.

4053 *** USER FATAL MESSAGE 4053, INSUFFICIENT CØRE TØ PERFØRM ØPERATIØNS REQUIRED AS A RESULT ØF FREEPT ØR PRESPT DATA CARDS.

4054 *** USER FATAL MESSAGE 4054, SET ID = 102 MAY NOT BE USED FOR SPC CARDS WHEN USING THE HYDROELASTIC-FLUID ELEMENTS.

This set identification number is reserved for internal use in hydroelastic problems.

4055 *** USER FATAL MESSAGE 4055, SET ID = 102 MAY NØT BE USED FØR SPC CARDS WHEN USING THE HYDRØELASTIC-FLUID ELEMENTS.

This set identification number is reserved for internal use in hydroelastic problems.

4056 *** USER FATAL MESSAGE 4056, RECORD ID **** **** IS ØUT ØF SYNC ØN DATA BLØCK NUMBER **** AN IFP4 SYSTEM ERRØR.

The record identification numbers are the values of LØCATE record ID. The data block numbers are the GINØ file numbers. Error implies that IFP4 is possibly operating on the wrong data block. This system error should not occur. Message comes from IFP4B.

4057 *** USER FATAL MESSAGE 4057, GRIDB CARD WITH ID = **** HAS A REFERENCE IDF = **** WHICH DØES NØT APPEAR IN A BØUNDARY LIST.

4058 *** USER FATAL MESSAGE 4058, THE FLUID DENSITY HAS NØT BEEN SPECIFIED ØN A CFLUID CARD WITH ID = *** AND THERE IS NØ DEFAULT ØN THE AXIF CARD.

4059 *** USER FATAL MESSAGE 4059, THE FLUID BULK MØDULUS HAS NØT BEEN SPECIFIED ØN A CFLUID CARD WITH ID = **** AND THERE IS NØ DEFAULT ØN THE AXIF CARD.

4060 *** SYSTEM FATAL MESSAGE 4060, CØØRDINATE SYSTEM = **** CAN NØT BE FØUND IN CSTM DATA.

Data blocks MATPØØL or CSTM have been changed illegally.

4061 *** SYSTEM FATAL MESSAGE 4061, CØNNECTED FLUID PØINT ID = **** IS MISSING BGPDT DATA.

Data blocks MATPØØL or BGPDT have been changed illegally.

4062 *** USER FATAL MESSAGE 4062, DMIG BULK DATA CARD SPECIFIES DATA BLØCK **** WHICH ALSØ APPEARS ØN A DMIAX CARD.

One direct input matrix may not be specified by both types of bulk data cards.

4063 *** USER FATAL MESSAGE 4063, ILLEGAL VALUE **** FØR PARAMETER CTYPE.

4064 *** USER FATAL MESSAGE 4064, ILLEGAL VALUES ******** FØR PARAMETERS NSEGS, KMAX.

4065 *** USER FATAL MESSAGE 4065, ILLEGAL VALUE ******** FØR PARAMETER NLØAD.

4066 *** USER FATAL MESSAGE 4066, SECØND ØUTPUT DATA BLØCK MUST NØT BE PURGED.

The transformation matrix between physical and symmetric components does not exist. Ensure the number of Case Control subcases is specified correctly and that the component loads are properly ordered.

4067 *** USER FATAL MESSAGE 4067, VIN HAS ******** CØLS, GCYC HAS ******** RØWS.

Follows message 4064 indicating the illegal values for NSEGS and KMAX.

4081 *** USER FATAL MESSAGE 4081, AXSLØT DATA CARD IS NØT PRESENT ØR IS INCØRRECT.

Acoustic analysis data is present and this data card is necessary.

4082 *** USER FATAL MESSAGE 4082, INSUFFICIENT CØRE TO HØLD ALL GRIDS CARD IMAGES.

Executive Module IFP5 must hold this data in core. Increase core size or decrease amount of data.

4083 *** USER FATAL MESSAGE 4083, INSUFFICIENT CØRE TØ HØLD ALL GRIDF CARD IMAGES.

Executive Module IFP5 must hold this data in core. Increase core size or decrease amount of data.

4084 *** USER FATAL MESSAGE 4084, INSUFFICIENT CØRE TØ HØLD ALL GRIDF CARD IMAGES BEING CREATED INTERNALLY DUE TØ GRIDS CARDS SPECIFYING AN IDF.

Executive Module IFP5 is creating GRIDF cards from GRIDS cards. Increase core size.

4085 *** USER FATAL MESSAGE 4085, INSUFFICIENT CØRE TØ CØNSTRUCT ENTIRE BØUNDARY TABLE FØR SLBDY DATA CARDS.

Executive Module IFP5 requires five words of core for each entry in the SLBDY cards.

4086 *** USER FATAL MESSAGE 4086, CELAS2 DATA CARD HAS ID = XXX WHICH IS GREATER THAN 10000000, AND 10000000 IS THE LIMIT FØR CELAS2 ID WITH ACØUSTIC ANALYSIS DATA CARDS PRESENT.

Executive Module IFP5 is generating CELAS2 images and a possible conflict of ID numbers exists.

4087 *** USER FATAL MESSAGE 4087, SLBDY ID = XXX DØES NØT APPEAR ØN ANY GRIDS DATA CARD.

The SLBDY data card has a point listed which does not exist in the data.

4088 *** USER FATAL MESSAGE 4088, ØNE ØR MØRE ØF THE FØLLØWING ID-S NØT EQUAL TØ -1 HAVE INCØRRECT ØR NØ GEØMETRY DATA. ID = XXX, ID = XXX, ID = XXX.

The listed GRIDS points may have a bad radius or a slot width greater than geometrically possible.

4089 *** USER FATAL MESSAGE 4089, RHØ AS SPECIFIED ØN SLBDY ØR AXSLØT DATA CARD IS 0.0 FØR ID = XXX.

A value of density is required to formulate the slot boundary matrix terms.

4090 *** USER FATAL MESSAGE 4090, ØNE ØF THE FØLLØWING NØN-ZERØ IDENTIFICATIØN NUMBERS APPEARS ØN SØME CØMBINATIØN GRID, GRIDS, ØR GRIDF BULK DATA CARDS. ID = XXX, ID = XXX, ID = XXX.

All GRID, SPØINT, EPØINT, GRIDS, and GRIDF data cards should have unique identification numbers.

4091 *** USER FATAL MESSAGE 4091, BAD GEØMETRY ØR ZERØ CØEFFICIENT FØR SLØT ELEMENT NUMBER XXX.

The listed CSLØT3 or CSLØT4 element has its connected points defining zero area or its density equal to zero.

4100 *** SYSTEM FATAL MESSAGE 4100, ØUTPUT3 UNABLE TØ ØPEN DATA BLØCK ********.

4101 *** SYSTEM FATAL MESSAGE 4101, ØUTPUT3 UNABLE TØ FIND NAME FØR DATA BLØCK *******************.

4102 *** SYSTEM FATAL MESSAGE 4102, ØUTPUT3 EØF.

4103 *** USER INFØRMATIØN MESSAGE 4103, ØUTPUT3 HAS PUNCHED MATRIX DATA BLØCK ******** ØNTØ DMI CARDS.

4104 *** USER FATAL MESSAGE 4104, ATTEMPT TØ PUNCH MØRE THAN 9999 DMI CARDS FØR A SINGLE MATRIX.

4105 *** USER INFØRMATIØN MESSAGE 4105, DATA BLØCK ******** RETRIEVED FRØM USER TAPE **** NAME ØF DATA BLØCK WHEN PLACED ØN USER TAPE WAS ********.

4106 *** SYSTEM FATAL MESSAGE 4106, MØDULE INPUTT1 - SHØRT REC.

4107 *** SYSTEM FATAL MESSAGE 4107, SUBRØUTINE INPTT1 UNABLE TØ ØPEN NASTRAN FILE ****.

4108 *** SYSTEM FATAL MESSAGE 4108, SUBRØUTINE INPTT1 UNABLE TØ ØPEN ØUTPUT DATA BLØCK ****.

4109 *** SYSTEM FATAL MESSAGE 4109, UNEXPECTED EØF IN SUBRØUTINE INPTT1.

4110 *** SYSTEM FATAL MESSAGE 4110, UNEXPECTED EØR IN SUBRØUTINE INPTT1.

4111 *** USER FATAL MESSAGE 4111, MØDULE INPUTT1 IS UNABLE TØ SKIP FØRWARD ********** DATA BLØCKS ØN PERMANENT NASTRAN FILE **** NUMBER ØF DATA BLØCKS SKIPPED = *****.

4112 *** USER FATAL MESSAGE 4112, MØDULE INPUTT1 - ILLEGAL VALUE FØR SECØND PARAMETER = *******************.

4113 *** USER FATAL MESSAGE 4113, MØDULE INPUTT1 - ILLEGAL VALUE FØR FIRST PARAMETER = *******************.

4114 *** USER INFØRMATIØN MESSAGE 4114, DATA BLØCK ******** WRITTEN ØN NASTRAN FILE ****, TRL = ************.

4115 *** SYSTEM FATAL MESSAGE 4115, MØDULE ØUTPUT1 - SHØRT REC.

4116 *** SYSTEM FATAL MESSAGE 4116, SUBRØUTINE ØUTPT1 UNABLE TØ ØPEN INPUT DATA BLØCK *****.

4117 *** SYSTEM FATAL MESSAGE 4117, SUBRØUTINE ØUTPT1 UNABLE TØ ØPEN NASTRAN FILE ****.

4118 *** USER FATAL MESSAGE 4118, ***** MØDULE ØUTPUT1 IS UNABLE TØ SKIP FØRWARD ********** DATA BLØCKS ØN PERMANENT NASTRAN FILE ****.   **** NUMBER ØF DATA BLØCKS SKIPPED = *****.

4119 *** USER FATAL MESSAGE 4119, MØDULE ØUTPUT1 - ILLEGAL VALUE FØR SECØND PARAMETER = ******************.

4120 *** USER FATAL MESSAGE 4120, MØDULE ØUTPUT1 - ILLEGAL VALUE FØR FIRST PARAMETER =

4121 *** USER FATAL MESSAGE 4121, ØNLY ØNE (1) AXIF CARD ALLØWED IN BULK DATA.

4122 *** USER FATAL MESSAGE 4122, AXIF CARD REQUIRED.

4123 *** USER FATAL MESSAGE 4123, ØNLY ØNE (1) FLSYM CARD ALLØWED IN BULK DATA.

4124 *** USER WARNING MESSAGE 4124, THE SPCADD ØR MPCADD UNIØN CØNSISTS ØF A SINGLE SET.

4125 *** USER FATAL MESSAGE 4125, MAXIMUM ALLØWABLE HARMØNIC ID IS 99. DATA CØNTAINS MAXIMUM = ****.

4126 *** USER FATAL MESSAGE 4126, BAD DATA ØR FØRMAT ØR NØNUNIQUE NAME, DMIAX ****.

4127 *** USER FATAL MESSAGE 4127, USER TAPE **** NØT SET UP.

4128 *** USER FATAL MESSAGE 4128, MØDULE ØUTPUT1 - END-ØF-FILE ENCØUNTERED WHILE ATTEMPTING TØ READ TAPE ID CØDE ØN USER TAPE ****.

4129 *** USER FATAL MESSAGE 4129, MØDULE ØUTPUT1 - END-ØF-RECØRD ENCØUNTERED WHILE ATTEMPTING TØ READ TAPE ID CØDE ØN USER TAPE ****.

4130 *** USER FATAL MESSAGE 4130, MØDULE ØUTPUT1 - ILLEGAL TAPE CØDE HEADER = ******************.

4131 *** USER WARNING MESSAGE 4131, USER TAPE ID CØDE - ******** - DØES NØT MATCH THIRD ØUTPUT1 DMAP PARAMETER - ********.

4132 *** USER FATAL MESSAGE 4132, MØDULE INPUTT1 - END-ØF-FILE ENCØUNTERED WHILE ATTEMPTING TØ READ TAPE ID CØDE ØN USER TAPE ****.

4133 *** USER FATAL MESSAGE 4133, MØDULE INPUTT1 - END-ØF-RECØRD ENCØUNTERED WHILE ATTEMPTING TØ READ TAPE ID CØDE ØN USER TAPE ****.

4134 *** USER FATAL MESSAGE 4134, MØDULE INPUTT1 - ILLEGAL TAPE CØDE HEADER = ******************.

4135 *** USER WARNING MESSAGE 4135, USER TAPE ID CØDE - ******** DØES NØT MATCH THIRD INPUTT1 DMAP PARAMETER - ******** -.

4136 *** USER FATAL MESSAGE 4136, USER TAPE ID CØDE - ******** - DØES NØT MATCH THIRD INPUTT1 DMAP PARAMETER - ******** -.

4137 *** USER WARNING MESSAGE 4137, ALL ØUTPUT DATA BLØCKS FØR INPUTT1 ARE PURGED.

4138 *** USER WARNING MESSAGE 4138, DATA BLØCK ******** (DATA BLØCK CØUNT = ***** HAS PREVIØUSLY BEEN RETRIVED FRØM USER TAPE **** AND WILL BE IGNØRED.

4139 *** USER INFØRMATIØN MESSAGE 4139, DATA BLØCK ******** RETRIEVED FRØM USER TAPE **** (DATA BLØCK CØUNT = *****)

4140 *** USER WARNING MESSAGE 4140, SECØNDARY VERSION ØF DATA BLØCK HAS REPLACED EARLIER ØNE.

4141 *** USER WARNING MESSAGE 4141, ØNE ØR MØRE DATA BLØCKS NØT FØUND ØN USER TAPE.

4142 *** USER FATAL MESSAGE 4142, ØNE ØR MØRE DATA BLØCKS NØT FØUND ØN USER TAPE.

5000 *** USER FATAL MESSAGE 5000, NEG. ØR ZERØ RADIUS DETECTED FØR CFLUID2 ELEMENT. ELEMENT NØ. ****.

5001 *** USER FATAL MESSAGE 5001, NEG. ØR ZERØ RADIUS DETECTED FØR CFLUID3 ØR CFLUID4 ELEMENT. ELEMENT NØ. ****.

5002 *** USER FATAL MESSAGE 5002, INTERIØR ANGLE GREATER THAN ØR EQUAL TØ 180 DEGREES. CFLUID4 ELEMENT NØ. ****.

5011 *** USER FATAL MESSAGE 5011, FIRST PARAMETER ***** NE TRAILER RECØRD PARAMETER *****.

5012 *** USER FATAL MESSAGE 5012, ENTRY ***** ØF SIL TABLE INCØMPATIBLE WITH NEXT ENTRY.

6001 *** USER FATAL MESSAGE 6001, SUBSTRUCTURE DATA IS REQUIRED WITH THIS APPRØACH.

The program expects a SUBSTRUCTURE card following the CEND card if APP DISP, SUBS was used.

6002 *** USER WARNING MESSAGE 6002, INCØRRECT PHASE DATA

The second word on the substructure command should be PHASEi, i = 1, 2, 3. The default is 2.

6003 *** USER FATAL MESSAGE 6003. ILLEGAL CØMMAND ØR ØPTIØN DEFINED ØN PREVIØUS CARD.

The program does not recognize the previous card. If any "subcommand" cards follow this error, they may produce this message until a legitimate command card is encountered.

6004 *** USER WARNING MESSAGE 6004, NØ PREFIX DEFINED AFTER EQUIVALENCE CØMMAND.

A non-basic substructure requires a prefix for the equivalent lower level basic substructures. A basic substructure does not require the prefix.

6005 *** USER FATAL MESSAGE 6005, ILLEGAL ØR MISSING INPUT DATA GIVEN FØR PREVIØUS CØMMAND.

Either the basic command data is insufficient or mandatory additional subcommands are missing.

6006 *** USER FATAL MESSAGE 6006, DMAP ALTERS INTERFERE WITH SUBSTRUCTURE ALTERS.

The DMAP instruction numbers on the user ALTER data card overlaps or conflicts with the sections automatically modified. Use DIAG 23 to print the DMAP ALTER package or see Section 5.5.

6007 *** SYSTEM FATAL MESSAGE 6007, IMPROPER FILE SETUP FOR ****.

An external I/Ø operation has been defined but the file is missing or the card is improper.

6008 *** USER FATAL MESSAGE 6008, ILLEGAL INPUT ØN THE PREVIØUS CØMMAND. MISSING FILE NAME FØR I/Ø OPERATION.

6009 *** SYSTEM FATAL MESSAGE 6009, UNRECØVERABLE ERRØR CØNDITIØNS IN SUBRØUTINE ASDMAP.

6010 *** SYSTEM FATAL MESSAGE 6010, ILLEGAL VARIABLE TØ BE SET IN DMAP STATEMENT, (N).

The system has been encountered illegal type of word to be inserted in a DMAP sequence. Could possibly occur if a floating point number were used instead of an integer on an input card.

6011 *** USER FATAL MESSAGE 6011, MISSING PASSWØRD ØR SØF DATA.

The SØF and PASSWØRD cards are mandatory. At least one SØF file (SØF(1) must be defined.

6012 *** SYSTEM FATAL MESSAGE 6012, FILE=**** IS PURGED ØR NULL AND IS REQUIRED IN PHASE1 SUBSTRUCTURE ANALYSIS.

6013 *** USER FATAL MESSAGE 6013, ILLEGAL TYPE ØF PØINT DEFINED FØR SUBSTRUCTURE ANALYSIS. PØINT NUMBER=********.

6014 *** USER FATAL MESSAGE 6014, INSUFFICIENT CØRE TO LØAD TABLES IN MØDULE SUBPH1, CØRE=********.

6015 *** USER FATAL MESSAGE 6015, TØØ MANY CHARACTERS TØ BE INSERTED IN A DMAP LINE. N=***,

A BCD word has been defined with too many characters to fit the space in the DMAP. (Usual limit = 8.) Message could also occur if block data subprogram ASDBD has an error.

6016 *** USER FATAL MESSAGE 6016, TØØ MANY DIGITS TØ BE INSERTED IN DMAP VALUE=***.

An integer is limited to eight digits.

6022 *** USER FATAL MESSAGE 6022, SUBSTRUCTURE ***, GRID PØINT ***, CØMPØNENT ***, REFERENCED ØN *** CARD DØES NØT EXIST IN SØLUTIØN STRUCTURE ***.

6050 *** USER WARNING MESSAGE 6050, REQUESTED PLØT SET NØ. ****************** HAS NØT BEEN DEFINED.

6101 *** SYSTEM FATAL MESSAGE 6101, REQUESTED SØF ITEM DØES NØT EXIST. ITEM ***, SUBSTRUCTURE ***.

Either the item has never been created or it only pseudo exists from a prior dry run.

6102 *** SYSTEM FATAL MESSAGE 6102, REQUESTED SUBSTRUCTURE DØES NØT EXIST. ITEM ***, SUBSTRUCTURE ***.

6103 *** SYSTEM FATAL MESSAGE 6103, REQUESTED SØF ITEM HAS INVALID NAME. ITEM ***, SUBSTRUCTURE ***.

Item name is illegal.

6104 *** USER FATAL MESSAGE 6104, ATTEMPT TØ CREATE DUPLICATE SUBSTRUCTURE NAME ***.

6105 *** USER FATAL MESSAGE 6105, ATTEMPT TØ RE-USE SUBSTRUCTURE *** IN A REDUCE ØR CØMBINE ØPERATIØN. USE EQUIV SUBSTRUCTURE CØMMAND.

A single substructure may be reduced or combined repeatedly only if it is given equivalent names with the EQUIV substructure command.

6106 *** SYSTEM FATAL MESSAGE 6106, UNEXPECTED END ØF GRØUP ENCØUNTERED WHILE READING ITEM *** SUBSTRUCTURE ***.

6107 *** SYSTEM FATAL MESSAGE 6107, UNEXPECTED END ØF ITEM ENCØUNTERED WHILE READING ITEM *** SUBSTRUCTURE ***.

6108 *** SYSTEM FATAL MESSAGE 6108, INSUFFICIENT SPACE ØN SØF FØR ITEM ***, SUBSTRUCTURE ***.

6201 *** SYSTEM INFØRMATIØN MESSAGE 6201, *** FILES HAVE BEEN ALLØCATED TØ THE SØF WHERE
SIZE ØF FILE 1 = *** BLØCKS
:
SIZE ØF FILE *** = *** BLØCKS
AND WHERE A BLØCK CØNTAINS *** WØRDS

6202 *** USER FATAL MESSAGE 6202, THE REQUESTED NUMBER ØF FILES IS NØN-PØSITIVE.

6204 *** USER FATAL MESSAGE 6204, SUBRØUTINE *** - THE SUBRØUTINE SØFØPN SHØULD BE CALLED PRIØR TØ ANY ØF THE SØF UTILITY SUBRØUTINES.

6205 *** USER FATAL MESSAGE 6205, SUBRØUTINE *** - THE BUFFER SIZE HAS BEEN MØDIFIED.

6206 *** USER FATAL MESSAGE 6206, SUBRØUTINE *** - WRØNG PASSWØRD ØN SØF FILE ***.

6207 *** USER FATAL MESSAGE 6207, SUBRØUTINE *** - THE SØF FILE *** IS ØUT ØF SEQUENCE.

6208 *** USER FATAL MESSAGE 6208, SUBRØUTINE *** - THE SIZE OF THE SØF FILE *** HAS BEEN MØDIFIED.

6209 *** USER FATAL MESSAGE 6209, SUBRØUTINE *** - THE NEW SIZE ØF FILE *** IS TØØ SMALL.

6211 *** USER WARNING MESSAGE 6211, MØDULE *** - ITEM *** ØF SUBSTRUCTURE *** HAS ALREADY BEEN WRITTEN.

6212 *** USER WARNING MESSAGE 6212, MØDULE *** - THE SUBSTRUCTURE *** DØES NØT EXIST.

6213 *** USER WARNING MESSAGE 6213, MØDULE *** - *** IS AN ILLEGAL ITEM NAME.

6215 *** USER WARNING MESSAGE 6215, MØDULE *** - ITEM *** ØF SUBSTRUCTURE *** PSEUDØ-EXISTS ØNLY.

6216 *** USER WARNING MESSAGE 6216, MØDULE *** - ITEM *** ØF SUBSTRUCTURE *** DØES NØT EXIST.

6217 *** USER WARNING MESSAGE 6217, MØDULE *** - *** IS AN ILLEGAL PARAMETER NAME.

6218 *** USER WARNING MESSAGE 6218, MØDULE *** - THE SUBSTRUCTURE *** CANNØT BE DESTRØYED BECAUSE IT IS AN IMAGE SUBSTRUCTURE.

6219 *** USER WARNING MESSAGE 6219, MØDULE *** RUN EQUALS DRY ØR STEP, AND, SUBSTRUCTURE *** ØR ØNE ØF THE NEW NAMES ALREADY EXISTS.

6220 *** USER WARNING MESSAGE 6220, MØDULE *** - RUN EQUALS GØ, AND, SUBSTRUCTURE *** ØR ØNE ØF THE NEW NAMES DØES NØT EXIST.

6222 *** USER FATAL MESSAGE 6222 - ATTEMPT TØ CALL SØFØPN MØRE THAN ØNCE WITHØUT CALLING SØFCLS.

6223 *** USER FATAL MESSAGE 6223 - SUBRØUTINE *** - THERE ARE NØ MORE FREE BLØCKS AVAILABLE ØN THE SØF.

6224 *** SYSTEM FATAL MESSAGE 6224, SØF UTILITY SUBRØUTINE ***.

Text follows the message to describe the error.

6225 *** SYSTEM FATAL MESSAGE 6225, BLØCK NUMBER *** ØUT ØF RANGE ØF SØF FILES.

This can be caused only by a logic error in one of the SOF subroutines.

6226 *** SYSTEM WARNING MESSAGE 6226, SUBRØUTINE SØFIØ - HIBLK PARAMETER FØR SØFIØ DID NØT CØNFØRM TØ PHYSICAL FILE. PARAMETER VALUE HAS BEEN CHANGED FRØM *** TØ ***.

This can be caused when the previous run using the SØF terminated abnormally. (CDC only.)

6227 *** SYSTEM FATAL MESSAGE 6227, AN ATTEMPT HAS BEEN MADE TØ ØPERATE ØN THE MATRIX ITEM *** ØF SUBSTRUCTURE *** USING SFETCH.

6228 *** USER INFØRMATIØN MESSAGE 6228, SUBSTRUCTURE *** IS ALREADY EQUIVALENT TØ SUBSTRUCTURE ***.
ØNLY ITEMS NØT PREVIØUSLY EXISTING FØR *** HAVE BEEN MADE EQUIVALENT.

6229 *** USER INFØRMATIØN MESSAGE 6229, SUBSTRUCTURE *** HAS BEEN RENAMED TØ ***.

6230 *** USER WARNING MESSAGE 6230, SUBSTRUCTURE *** HAS NØT BEEN RENAMED BECAUSE *** ALREADY
EXISTS ØN THE SØF.

6231 *** USER WARNING MESSAGE 6231, INSUFFICIENT CØRE AVAILABLE ØR ILLEGAL ITEM FØRMAT REQUIRES
AN UNFØRMATTED DUMP TØ BE PERFØRMED FØR ITEM *** ØF SUBSTRUCTURE ***.

6301 *** SYSTEM FATAL MESSAGE 6301, DATA MISSING IN GØ MØDE FØR SUBSTRUCTURE ***, ITEM ***.

Item was created in dry run mode and has no real data.

6302 *** SYSTEM FATAL MESSAGE 6302, *** IS ILLEGAL MATRIX TYPE FØR MØDULE CØMB2.

6303 *** SYSTEM FATAL MESSAGE 6303, HØRG TRANSFØRMATION MATRIX FOR SUBSTRUCTURE *** CANNØT BE FØUND ØN SØF.

6304 *** SYSTEM FATAL MESSAGE 6304, MØDULE CØMB2 INPUT MATRIX NUMBER *** FØR SUBSTRUCTURE *** HAS INCØMPATIBLE DIMENSIØNS.

Matrix dimensions conflict with those of its H or G transformation matrix.

6305 *** SYSTEM WARNING MESSAGE 6305, RECØRD NUMBER *** ØF CASESS IS NØT A RECØVER RECØRD. IT IS A *** RECØRD.

The step parameter for module RCØVR is incorrect. It should be the CASESS record number of a recover record.

6306 *** USER WARNING MESSAGE 6306, ATTEMPT TØ RECØVER DISPLACEMENTS FØR NØN-EXISTANT SUBSTRUCTURE ***.

6307 *** USER WARNING MESSAGE 6307, WHILE ATTEMPTING TØ RECØVER DISPLACEMENTS FØR SUBSTRUCTURE ***, THE DISPLACEMENTS FØR SUBSTRUCTURE *** WERE FØUND TØ EXIST IN DRY RUN FØRM ØNLY.

Before you can recover displacements of any substructure, you must first perform an actual solution. See RUN substructure command.

6308 *** USER WARNING MESSAGE 6308, NØ SØLUTIØN AVAILABLE FRØM WHICH DISPLACEMENTS FØR SUBSTRUCTURE *** CAN BE RECØVERED. HIGHEST LEVEL SUBSTRUCTURE FØUND WAS ***.

Solve the highest level substructure found or combine it to an even higher level and solve.

6309 *** SYSTEM FATAL MESSAGE 6309, INSUFFICIENT TIME REMAINING TØ RECØVER DISPLACEMENTS ØF SUBSTRUCTURE *** FRØM THØSE ØF SUBSTRUCTURE ***. (PRØCESSING USER RECØVER REQUEST FØR SUBSTRUCTURE ***.)

6310 *** SYSTEM WARNING MESSAGE 6310, INSUFFICIENT SPACE ØN SØF TØ RECØVER DISPLACEMENTS ØF SUBSTRUCTURE *** FRØM THØSE ØF SUBSTRUCTURE *** WHILE PRØCESSING USER RECØVER REQUEST FØR SUBSTRUCTURE ***.

Use the SØF substructure command and increase the size of the SØF and/or add more SØF units. Alternately, use EDIT to remove unwanted data.

6311 *** SYSTEM WARNING MESSAGE 6311, SDCØMP DECØMPØSITIØN FAILED ØN KØØ MATRIX FØR SUBSTRUCTURE ***.

6312 *** USER INFØRMATIØN MESSAGE 6312, LEVEL *** DISPLACEMENTS FØR SUBSTRUCTURE *** HAVE BEEN RECØVERED AND SAVED ØN SØF.

6313 *** SYSTEM WARNING MESSAGE 6313, INSUFFICIENT CØRE FØR RCØVR MØDULE WHILE TRYING TØ PRØCESS PRINTØUT DATA BLØCKS FØR SUBSTRUCTURE ***.

6314 *** SYSTEM WARNING MESSAGE 6314, ØUTPUT REQUEST CANNØT BE HØNØRED. RCØVR MØDULE ØUTPUT DATA BLØCK *** IS PURGED.

6315 *** USER WARNING MESSAGE 6315, RCØVR MØDULE IS UNABLE TØ FIND SUBSTRUCTURE *** AMØNG THØSE ØN EQSS. LØAD SET *** FØR THAT SUBSTRUCTURE WILL BE IGNØRED IN CREATING THE SØLN ITEM FØR FINAL SØLUTIØN STRUCTURE ***.

6316 *** USER WARNING MESSAGE 6316, RCØVR MØDULE IS UNABLE TØ FIND LØAD SET *** FØR SUBSTRUCTURE *** AMØNG THØSE ØN LØDS. IT WILL BE IGNØRED IN CREATING THE SØLN ITEMS FØR FINAL SØLUTIØN STRUCTURE ***.

6317 *** SYSTEM WARNING MESSAGE 6317, RECØVER ØF DISPLACEMENTS FØR SUBSTRUCTURE *** ABØRTED.

6318 *** SYSTEM WARNING MESSAGE 6318, ØUTPUT REQUEST FØR REACTIØN FØRCES IGNØRED.

6319 *** SYSTEM WARNING MESSAGE 6319, DISPLACEMENT MATRIX FØR SUBSTRUCTURE *** MISSING. DISPLACEMENT ØUTPUT REQUESTS CANNØT BE HØNØRED AND SPCFØRCE ØUTPUT REQUESTS CANNØT BE HØNØRED UNLESS THE REACTIØNS HAVE BEEN PREVIØUSLY CØMPUTED.

6320 *** SYSTEM WARNING MESSAGE 6320, LØADC DATA MISSING FØR SUBSTRUCTURE ***, EXTERNAL STATIC LØAD SET ***.

No LØADC bulk data cards can be found on GEØM4 or GEØM4 is purged.

6321 *** USER INFØRMATIØN MESSAGE 6321, SUBSTRUCTURE PHASE 3 RECØVER FØR FINAL SØLUTIØN STRUCTURE *** AND BASIC SUBSTRUCTURE ***.

6322 *** SYSTEM FATAL MESSAGE 6322, SØLN ITEM HAS INCØRRECT RIGID FØRMAT NUMBER. PHASE 2 RIGID FØRMAT WAS *** AND PHASE 3 IS ***.

The Rigid Format of Phase 3 must be the same as that used in Phase 2 to obtain the solution.

6323 *** USER WARNING MESSAGE 6323, NØ EIGENVALUES FØR THIS SØLUTIØN.

6324 *** USER FATAL MESSAGE 6324, PHASE 3 RECØVER ATTEMPTED FØR NØN-BASIC SUBSTRUCTURE ***.

Substructure Phase 3 can be executed only for basic substructures.

6325 *** USER WARNING MESSAGE 6325, SUBSTRUCTURE PHASE 1, BASIC SUBSTRUCTURE *** ALREADY EXISTS ØN SØF. ITEMS WHICH ALREADY EXIST WILL NØT BE REGENERATED.

Use DESTRØY or EDIT to remove items which are to be regenerated.

6326 *** USER WARNING MESSAGE 6326, SUBSTRUCTURE ***, ITEM *** ALREADY EXISTS ØN SØF.

Follows message 6325, above.

6327 *** USER INFØRMATIØN MESSAGES 6327, SUBSTRUCTURE ***, SUBCASE *** IS IDENTIFIED BY *** SET *** IN LØDS ITEM. REFER TØ THIS NUMBER ØN LØADC CARDS.

6328 *** SYSTEM FATAL MESSAGE 6328, MØRE THAN 100 SUBCASES DEFINED. SGEN PRØGRAM LIMIT EXCEEDED.

To increase this limit to more than 100 subcases, change the dimensions of local arrays LØAD, MPC, and SPC in subroutine SGEN and change the IF test which causes termination.

6329 *** USER FATAL MESSAGE 6329, SUBSTRUCTURE ***, REFERENCED ØN *** CARD, IS NØT A CØMPØNENT BASIC SUBSTRUCTURE ØF SØLUTIØN STRUCTURE ***.

6330 *** USER FATAL MESSAGE 6330, SØLUTIØN SUBSTRUCTURE *** -- *** AND *** CARDS CANNØT BE USED TØGETHER. USE EITHER ØNE, BUT NØT BØTH.

6331 *** USER FATAL MESSAGE 6331, SØLUTIØN SUBSTRUCTURE *** -- LØADC SET *** REFERENCES UNDEFINED LØAD SET *** ØF BASIC SUBSTRUCTURE ***.

6332 *** SYSTEM FATAL MESSAGE 6332, CAN'T FIND LØAD VECTØR NUMBER *** IN LØAD MATRIX ØF *** CØLUMNS BY *** RØWS FØR SØLUTIØN STRUCTURE ***.

The LØDS item and PVEC item are inconsistent. Possibly they were generated in different Phase 1 runs for a component basic substructure where the Case Control definition of external loads, thermal loads, or element deformations was changed.

6333 *** USER FATAL MESSAGE 6333, *** IS AN INVALID FØRMAT PARAMETER FØR MØDULE EXIØ.

6334 *** USER WARNING MESSAGE 6334, EXIØ DEVICE PARAMETER SPECIFIES TAPE, BUT UNIT *** IS NØT A PHYSICAL TAPE.

6335 *** USER WARNING MESSAGE 6335, *** IS AN INVALID DEVICE FØR MØDULE EXIØ.

6336 *** USER INFØRMATIØN MESSAGE 6336, EXIØ FILE IDENTIFICATIØN. PASSWØRD ***. DATE ***. TIME ** ** **.

6337 *** USER INFØRMATIØN MESSAGE 6337, *** BLØCKS (*** SUPERBLØCKS) ØF THE SØF SUCCESSFULLY DUMPED TØ EXTERNAL FILE ***.

6338 *** USER WARNING MESSAGE 6338, *** IS AN INVALID MØDE PARAMETER FØR MØDULE EXIØ.

6339 *** USER WARNING MESSAGE 6339, *** IS AN INVALID FILE PØSITIØNING PARAMETER FØR MØDULE EXIØ.

6340 *** USER WARNING MESSAGE 6340, SUBSTRUCTURE *** ITEM *** PSEUDØ-EXISTS ØNLY AND CANNØT BE CØPIED ØUT BY EXIØ.

6341 *** USER INFØRMATIØN MESSAGE 6341, SUBSTRUCTURE *** ITEM *** SUCCESSFULLY CØPIED FRØM *** TØ *** (***, ***).

6342 *** USER WARNING MESSAGE 6342, SØF RESTØRE ØPERATIØN FAILED. THE RESIDENT SØF IS NØT EMPTY.

Use the NEW option on the SØF substructure command to create a "new" SØF.

6343 *** SYSTEM WARNING MESSAGE 6343, *** IS NØT AN EXTERNAL SØF FILE.

Either (1) tape contained no data, (2) first record read was not an ID or header record, (3) tape was incorrectly positioned, or (4) GINØ buffer size was changed.

6344 *** USER INFØRMATIØN MESSAGE 6344, SØF RESTØRE ØF *** BLØCKS SUCCESSFULLY CØMPLETED.

6345 *** USER WARNING MESSAGE 6345, SUBSTRUCTURE *** ITEM *** IS DUPLICATED ØN EXTERNAL FILE ***. ØLDER VERSIØN (***, ***) IS IGNØRED.

6346 *** USER WARNING MESSAGE 6346, SUBSTRUCTURE *** ITEM *** NØT CØPIED. IT ALREADY EXISTS ØN THE SØF.

6347 *** USER INFØRMATIØN MESSAGE 6347, SUBSTRUCTURE *** ADDED TØ THE SØF.

6348 *** USER WARNING MESSAGE 6348, SUBSTRUCTURE *** ITEM *** NØT FØUND ØN EXTERNAL FILE ***.

6349 *** USER INFØRMATIØN MESSAGE 6349, CØNTENTS ØF EXTERNAL SØF FILE *** FØLLØW.

6350 *** USER WARNING MESSAGE 6350, SØF APPEND ØF FILE *** FAILED. "text"

"text" explains why the append operation failed.

6351 *** USER WARNING MESSAGE 6351, DUPLICATE SUBSTRUCTURE NAME *** FØUND DURING SØF APPEND ØF FILE ***. THE SUBSTRUCTURE WITH THIS NAME ØN THE FILE BEING APPENDED WILL BE PREFIXED WITH "Q".

6352 *** USER INFØRMATIØN MESSAGE 6352, EXTERNAL SØF FILE *** SUCCESSFULLY APPENDED TØ THE RESIDENT SØF.

6353 *** USER INFØRMATIØN MESSAGE 6353, SUBSTRUCTURE *** ITEM *** HAS BEEN SUCCESSFULLY CØMPRESSED.

6354 *** USER INFØRMATIØN MESSAGE 6354, THERE ARE *** FREE BLØCKS (*** WØRDS) ØN THE RESIDENT SØF.

6355 *** SYSTEM INFØRMATIØN MESSAGE 6355, EXIØ TERMINATED WITH ERRØRS. DRY RUN MØDE ENTERED.

The parameter DRY has been set to -2 to prevent matrix operations from occurring downstream in this run.

6356 *** USER WARNING MESSAGE 6356, *** IS AN INVALID UNIT FØR MØDULE EXIØ, EXTERNAL FØRMAT.

6357 *** USER INFØRMATIØN MESSAGE 6357, SUBSTRUCTURE *** ITEM *** SUCCESSFULLY CØPIED FRØM *** TØ ***.

6359 *** USER INFORMATIØN MESSAGE 6359, SUBSTRUCTURE *** WAS ØRIGINALLY A SECØNDARY SUBSTRUCTURE. ØN THIS SØF, IT IS A PRIMARY SUBSTRUCTURE.

6361 *** USER INFØRMATION MESSAGE 6361, PHASE 1 SUCCESSFULLY EXECUTED FØR SUBSTRUCTURE ***.

6362 *** USER FATAL MESSAGE 6362, MPCS SET *** IS ILLEGAL. SUBSTRUCTURE *** GRID PØINT *** CØMPØNENT *** SIGNIFIES A NØN-UNIQUE DEPENDENT DEGREE ØF FREEDØM.

6365 *** USER WARNING MESSAGE 6365, REQUESTED ØUTPUT SET ID *** IS NØT DECLARED IN CASE CØNTRØL, ALL ØUTPUT WILL BE PRØDUCED.

6366 *** USER WARNING MESSAGE 6366, THE RECØVER ØUTPUT CØMMAND SØRT MUST APPEAR BEFØRE THE FIRST BASIC SUBCØMMAND. ANY ØTHER SØRT CØMMANDS ARE IGNØRED.

6367 *** USER WARNING MESSAGE 6367, ILLEGAL FØRMAT ØN THE RECØVER ØUTPUT CØMMAND ***, CØMMAND IGNORED.

6368 *** USER WARNING MESSAGE 6368, THE SUBSTRUCTURE *** APPEARING ØN A BASIC CØMMAND IS NØT A CØMPØNENT ØF ***. ALL ØUTPUT REQUESTS UNTIL THE NEXT BASIC, PRINT, ØR SAVE ARE IGNØRED.

6501 *** USER FATAL MESSAGE 6501, THE MANUAL CØMBINE ØPTIØN HAS BEEN SPECIFIED, BUT NØ CØNNECTIØN SET WAS GIVEN.

6502 *** USER FATAL MESSAGE 6502, NØ NAME HAS BEEN SPECIFIED FØR THE RESULTANT CØMBINED PSEUDØ-STRUCTURE.

6504 *** USER FATAL MESSAGE 6504, A TØLERANCE MUST BE SPECIFIED FØR A CØMBINE ØPERATIØN.

6505 *** USER FATAL MESSAGE 6505, THE SYMMETRY ØPTIØN *** CØNTAINS AN INVALID SYMBØL.

6506 *** USER FATAL MESSAGE 6506, THE CØMPØNENT SUBSTRUCTURE *** IS NØT ØNE ØF THØSE ØN THE CØMBINE CARD.

6507 *** USER FATAL MESSAGE 6507, THE SUBSTRUCTURE *** DØES NØT EXIST ØN THE SØF.

6508 *** USER FATAL MESSAGE 6508, THE NAME SPECIFIED FØR THE RESULTANT PSEUDØSTRUCTURE ALREADY EXISTS ØN THE SØF.

6510 *** USER FATAL MESSAGE 6510, THE REQUESTED CØMBINE ØPERATIØN REQUIRES SUBSTRUCTURE BULK DATA WHICH HAS NØT BEEN GIVEN.

6511 *** USER FATAL MESSAGE 6511, THE REQUESTED TRANS SET ID *** HAS NØT BEEN DEFINED BY BULK DATA.

6512 *** USER FATAL MESSAGE 6512, REDUNDANT CØNNECTIØN SET ID'S HAVE BEEN SPECIFIED.

6513 *** USER FATAL MESSAGE 6513, THE TRANS SET ID *** REQUESTED BY A GTRAN BULK DATA CARD HAS NØT BEEN DEFINED.

6514 *** USER FATAL MESSAGE 6514, ERRØRS HAVE BEEN FØUND IN THE MANUALLY SPECIFIED CØNNECTIØN ENTRIES. SUMMARY FØLLØWS.

6515 *** USER FATAL MESSAGE 6515, GRID PØINT *** BASIC SUBSTRUCTURE *** DØES NØT EXIST.

6516 *** USER INFØRMATION MESSAGE 6516, ALL MANUAL CØNNECTIØNS SPECIFIED ARE ALLØWABLE WITH RESPECT TØ TØLER.

6517 *** USER FATAL MESSAGE 6517, THE BASIC SUBSTRUCTURE *** REFERRED TØ BY A RELES BULK DATA CARD CANNØT BE FØUND IN THE PRØBLEM TABLE ØF CØNTENTS.

6518 *** USER FATAL MESSAGE 6518, CØMPØNENT SUBSTRUCTURE *** ALREADY HAS AN HØRG ITEM.

6519 *** USER FATAL MESSAGE 6519, REDUNDANT NAMES FØR RESULTANT PSEUDØSTRUCTURE HAVE BEEN SPECIFIED.

6520 *** USER FATAL MESSAGE 6520, REDUNDANT VALUES FØR TØLER HAVE BEEN SPECIFIED.

6521 *** USER INFØRMATION MESSAGE 6521, MØDULE CØMB1 SUCCESSFULLY CØMPLETED.

6522 *** USER FATAL MESSAGE 6522, THE BASIC SUBSTRUCTURE *** REFERRED TØ BY A CONCT1 BULK DATA CARD CANNØT BE FØUND IN THE PROBLEM TABLE ØF CØNTENTS.

6523 *** USER FATAL MESSAGE 6523, THE BASIC SUBSTRUCTURE *** REFERRED TØ BY A CØNCT BULK DATA CARD CANNØT BE FØUND IN THE PRØBLEM TABLE ØF CØNTENTS.

6524 *** USER INFØRMATIØN MESSAGE 6524, ***** CØLUMNS ØF THE CENTER MATRIX CAN BE PUT IN CØRE FØR THE CURRENT MPY3 EXECUTIØN.

6525 *** USER INFØRMATIØN MESSAGE 6525, ESTIMATED TIME FØR THE CURRENT MPY3 EXECUTION IS ********* SECØNDS.

6526 *** USER INFØRMATIØN MESSAGE 6526, THE CENTER MATRIX IS TØØ LARGE FØR IN-CØRE PRØCESSING. ØUT-ØF-CØRE PRØCESSING WILL BE PERFØRMED.

6528 *** USER FATAL MESSAGE 6528, INCØMPATIBLE LØCAL CØØRDINATE SYSTEMS HAVE BEEN FØUND. CØNNECTIØN ØF PØINTS IS IMPØSSIBLE, SUMMARY FØLLØWS.

6530 *** USER FATAL MESSAGE 6530, THE BASIC SUBSTRUCTURE *** REFERRED TØ BY A GTRAN CARD CANNØT BE FØUND IN THE PRØBLEM TABLE ØF CØNTENTS.

6531 *** USER FATAL MESSAGE 6531, NØ CØNNECTIØNS HAVE BEEN FØUND DURING THE AUTØMATIC CØNNECTIØN PRØCEDURE.

6532 *** USER FATAL MESSAGE 6532, THE GNEW ØPTIØN IS NØT CURRENTLY AVAILABLE.

6533 *** USER FATAL MESSAGE 6533, ØPTIØNS PA HAS BEEN SPECIFIED BUT THE LØAP ITEM ALREADY EXISTS FØR SUBSTRUCTURE ***.

6534 *** USER FATAL MESSAGE 6534, ØPTIØNS PA HAS BEEN SPECIFIED BUT THE SUBSTRUCTURE *** DØES NØT EXIST.

6551 *** USER FATAL MESSAGE 6551, MATRIX B IN MPY3 IS NØT SQUARE.

6553 *** USER FATAL MESSAGE 6553, NØ. ØF RØWS ØF MATRIX A IN MPY3 IS UNEQUAL TØ NØ. ØF CØLUMNS ØF MATRIX B.

6554 *** USER FATAL MESSAGE 6554, NØ. ØF CØLUMNS ØF MATRIX E IN MPY3 IS UNEQUAL TØ NØ. ØF CØLUMNS ØF MATRIX A.

6555 *** USER FATAL MESSAGE 6555, MATRIX E IN MPY3 IS NØT SQUARE FØR A(T)BA + E PRØBLEM.

6556 *** USER FATAL MESSAGE 6556, NØ. ØF RØWS ØF MATRIX E IN MPY3 IS UNEQUAL TØ NØ. ØF RØWS ØF MATRIX B FØR BA + E PRØBLEM.

6557 *** USER FATAL MESSAGE 6557, UNEXPECTED NULL CØLUMN ØF A(T) ENCØUNTERED.

6601 *** USER FATAL MESSAGE 6601, REQUEST TØ REDUCE PSEUDØSTRUCTURE *** INVALID. DØES NØT EXIST ØN THE SØF.

6602 *** USER FATAL MESSAGE 6602, THE NAME *** CANNØT BE USED FØR THE REDUCED PSEUDØSTRUCTURE. IT ALREADY EXISTS ØN THE SØF.

6603 *** USER FATAL MESSAGE 6603, A BØUNDARY SET MUST BE SPECIFIED FØR A REDUCE ØPERATIØN.

6604 *** USER WARNING MESSAGE 6604, A BØUNDARY SET HAS BEEN SPECIFIED FØR ***, BUT IT IS NØT A CØMPØNENT ØF THE PSEUDØSTRUCTURE BEING REDUCED. THE BØUNDARY SET WILL BE IGNØRED.

6605 *** USER WARNING MESSAGE 6605, A BØUNDARY SET HAS BEEN SPECIFIED FØR *** BUT IT IS NØT A PHASE1 BASIC SUBSTRUCTURE. THE BØUNDARY SET WILL BE IGNØRED.

6606 *** USER FATAL MESSAGE 6606, BØUNDARY SET *** SPECIFIED IN CASE CØNTRØL HAS NØT BEEN DEFINED BY BULK DATA.

No BDYC bulk data has been entered.

6607 *** USER FATAL MESSAGE 6607, NØ BDYS ØR BDYS1 BULK DATA HAS BEEN INPUT TØ DEFINE BØUNDARY SET ***.

6608 *** USER FATAL MESSAGE 6608, THE REQUEST FØR BØUNDARY SET ***, SUBSTRUCTURE *** WAS NØT DEFINED.

6609 *** USER INFØRMATIØN MESSAGE 6609, NØ BØUNDARY SET HAS BEEN SPECIFIED FØR CØMPØNENT *** ØF PSEUDØSTRUCTURE ***. ALL DEGREES ØF FREEDØM WILL BE REDUCED.

6610 *** USER WARNING MESSAGE 6610, DEGREES ØF FREEDØM AT GRID PØINT *** CØMPØNENT SUBSTRUCTURE *** INCLUDED IN A BØUNDARY SET DØ NØT EXIST. REQUEST WILL BE IGNØRED.

6611 *** USER FATAL MESSAGE 6611, GRID PØINT *** SPECIFIED IN BØUNDARY SET *** FØR SUBSTRUCTURE *** DØES NØT EXIST.

6612 *** USER FATAL MESSAGE 6612, THE REDUCE ØPERATIØN REQUIRES SUBSTRUCTURE BULK DATA WHICH HAS NØT BEEN GIVEN.

6613 *** USER FATAL MESSAGE 6613, FØR RUN=GØ, THE REDUCED SUBSTRUCTURE *** MUST ALREADY EXIST.

6614 *** USER FATAL MESSAGE 6614, ILLEGAL ØR NØN-EXISTANT STRUCTURE NAME USED ABØVE.

6615 *** USER FATAL MESSAGE 6615, ILLEGAL BØUNDARY SET IDENTIFICATIØN NUMBER.

6616 *** USER INFØRMATIØN MESSAGE 6616, MØDULE REDUCE SUCCESSFULLY CØMPLETED.

6900 *** USER INFØRMATIØN MESSAGE 6900, LØADS HAVE BEEN SUCCESSFULLY APPENDED FØR SUBSTRUCTURE ***.

6901 *** USER INFØRMATIØN MESSAGE 6901, ADDITIØNAL LØADS HAVE BEEN SUCCESSFULLY MERGED FØR SUBSTRUCTURE.

6951 *** USER FATAL MESSAGE 6951, INSUFFICIENT CØRE TØ LØAD TABLES. IN MØDULE LØDAPP, CØRE = ***.

6952 *** USER FATAL MESSAGE 6952, REQUESTED SUBSTRUCTURE *** DØES NØT EXIST.

6953 *** SYSTEM FATAL MESSAGE 6953, A WRØNG CØMBINATIØN ØF LØAD VECTØRS EXISTS FØR SUBSTRUCTURE ***.

7019 *** USER INFØRMATIØN MESSAGE 7019. MØDULE DSCHK IS EXITING FØR REASØN *** ØN ITERATIØN NUMBER ****** / PARAMETER VALUES ARE AS FØLLØWS DØNE = **********, SHIFT = **********, DSEPSI = **************.

See Section 3.5 for a discussion of Rigid Format 4 output features.

7.1 NASTRAN DICTIONARY

This section contains descriptions of mnemonics, acronyms, phrases, and other commonly used NASTRAN terms. The first column of the Dictionary contains the NASTRAN terms in alphabetical order. The second column contains a code indicating a general category for each term. The codes and categories, along with general references to the Programmer's Manual and User's Manual, are as follows:

Code	Category	General Reference
IA	Input - Executive Control	UM-2.2
IB	Input - Bulk Data	UM-2.4
IC	Input - Case Control	UM-2.3
EM	Executive Module	UM-5.3.4
FMH	Functional Module - Heat	PM-4
FMS	Functional Module - Structural	PM-4
FMM	Functional Module - Matrix Operation	UM-5.3.1
FMU	Functional Module - Utility	UM-5.3.2
FMX	Functional Module - User	UM-5.3.3
DBM	Data Block - Matrix	PM-2
DBML	Data Block - Matrix List	PM-2
DBT	Data Block - Table	PM-2
P	Parameter Name	UM-3
PU	Parameter set by user	UM-2.4
L	Rigid Format Label	UM-3
PH	Common Phrase or Term	
M	Miscellaneous	

The third column of the Dictionary contains a definition or description of the terms given in the first column. References to the User's Manual are indicated by UM-i and the Programmer's Manual by PM-i, where i is the section number of the manual. References to particular rigid formats are indicated by D-i where i is the displacement approach rigid format number.

A	P	Parameter value used to control utility module MATGPR print of A-set matrices.
ABFL	DBM	$[A_{b,f\ell}]$ - Hydroelastic boundary area factor matrix.
ABFLT	DBM	Transpose of $[A_{b,f\ell}]$
ACCE	IC	Abbreviated form of ACCELERATIØN.
ACCELERATIØN	IC	Output request for acceleration vector. (UM-2.3, 4.2)
ACPT	DBT	Aerodynamic Connection and Property Data.
Active Column	PH	Column containing at least one nonzero term outside the band.
ADD	FMM	Functional module to add two matrices together.
ADD	M	Parameter constant used in utility module PARAM.
ADD5	FMM	Functional module to add up to five matrices together.
ADUMi	IB	Defines attributes of dummy elements 1 through 9.
AEFACT	IB	Specifies box division points.
AERØ	DBT	Aerodynamic Matrix Generation Data.
AERØ	IB	Gives basic aerodynamic parameters.
AJJL	DBML	Aerodynamic Influence Matrix List.
ALL	IC	Output request for all of a specified type of output.
ALLEDGE TICS	IC	Request tic marks on all edges of X-Y plot.
ALTER	IA	Alter statement for DMAP or rigid format.
ALWAYS	P	Parameter set to -1 by a PARAM statement in the Piecewise Linear Analysis Rigid Format (D-6).
AMG	FMS	Aerodynamic Matrix Generator.
AMP	FMS	Aerodynamic Matrix Processor.
AND	M	Parameter constant used in executive module PARAM.
AØUT$	M	Indicates restart with solution set output request.
APD	FMS	Aerodynamic Pool Distributor.
APP	IA	Control card which specifies approach (DISP or DMAP).
APPEND	M	File may be extended (see FILE).
ASET	IB	Analysis set coordinate definition card.
ASET1	IB	Analysis set coordinate definition card.
AUTØ	IC	Requests X-Y plot of autocorrelation function.
AUTØ	DBT	Autocorrelation function table.

AXES	IC	Defines orientation of object for structure plot.
AXIC	DBT	Generated by Input File Processor 3 (IFP3) for axisymmetric conical shell problems.
AXIC	IB	Axisymmetrical conical shell definition card. When this card is present, most other bulk data cards may not be used.
AXIF	IB	Controls the formulation of a hydroelastic problem.
AXISYM$	M	Indicates restart with conical shell or hydroelastic elements.
AXISYMMETRIC	IC	Selects boundary conditions for axisymmetric shell problems or specifies the existence of hydroelastic fluid harmonics.
AXSLØT	IB	Controls the formulation of acoustic analysis problems.

B	PH	Upper semiband of matrix
B2DD	DBM	$[B^2_{dd}]$ - Partition of direct input damping matrix.
B2PP	DBM	$[B^2_{pp}]$ - Direct input damping matrix for all physical points.
B2PP	IC	Selects direct input matrices - input on DMIG bulk data cards for use in Dynamics Rigid Formats (D-7 thru D-12).
B2PP$	M	Indicates restart with change in direct input damping matrices.
BAA	DBM	$[B_{aa}]$ - Partition of damping matrix
BALL EDGE TICS	IC	Request for all edge tic marks to be plotted on lower frame of an X-Y plot.
BAR	IC	Requests structure plot for all bar elements.
BARØR	IB	Bar orientation default definition.
BBAR	PH	Lower semiband of matrix.
BDD	DBM	$[B_{dd}]$ - Damping matrix used in direct formulation of dynamics problems (D-7 thru D-9).
BDEBA	P	Parameter used to indicate equivalence of BDD and BAA.
BDPØØL	DBT	Hydroelastic boundary description table.
BDYLIST	IB	Structure-fluid hydroelastic boundary definition.
BEGIN	EM	The first DMAP statement is always BEGIN.
BEGIN BULK	IB	Control card which marks the end of the case control deck. Cards following this card are assumed to be bulk data cards.
BETA	P	Factor in integration algorithm in transient heat transfer analysis.
BFF	DBM	$[B_{ff}]$ - Partition of damping matrix.
BGG	DBM	$[B_{gg}]$ - Damping matrix generated by Structural Matrix Assembler.
BGPA	DBT	Basic Grid Point Definition Table - aerodynamics.
BGPDT	DBT	Basic grid point definition table.
BHH	DBM	$[B_{hh}]$ - Partition of damping matrix.
BKLO	P	Constant parameter value used in functional module SDR2 in the Buckling Analysis Rigid Format (D-5).
BKL1	P	Constant parameter value used in functional module SDR2 in the Buckling Analysis Rigid Format (D-5).
BL	IC	Requests Benson Lehner plotter.
BLANK FRAMES	IC	Requests blank frames between structure plots (UM-4.1).
BLEFT TICS	IC	Request for left edge tic marks to be plotted on bottom frame of an X-Y plot.

BMG	FMS	Generates DMIG card images describing interconnection of fluid and structure.
BNN	DBM	$[B_{nn}]$ - Partition of damping matrix.
BØTH	IC	Bulk data echo option - Requests both unsorted and sorted printout of bulk data deck.
BPI	IC	Bits per inch - Plot tape density must be specified on control cards in addition to this data card. The required value will vary from one installation to another.
BQG	DBM	Single-point forces of constraint for a Buckling Analysis problem (D-5).
BRIGHT TICS	IC	Request for right edge tic marks to be plotted on bottom frame for X-Y plot.
BUCKLING	IA	Selects rigid format for buckling analysis.
BUCKLING	P	Constant parameter value used in functional module READ in the Buckling Analysis Rigid Format (D-5).
BUCKLING	P	Used in printing rigid format error messages for Buckling Analysis (D-5).
Bulk Data Deck	PH	The third of the three data decks necessary to run a problem under the NASTRAN system. This deck begins with the BEGIN BULK card and ends with the ENDDATA card, and contains the data of the mathematical model. The format of each bulk data card is fixed field, 8 or 16 columns for each value.
BXHH	DBM	Total modal damping matrix - h set.

C	M	Used in parameter section of DMAP statement. Indicates that parameter is a constant.
C	PH	Symbol for active column in triangular decomposition ($\bar{C}$ used for active rows).
CAERØ1	IB	Defines aerodynamic macro-element.
CALCØMP	IC	Request California Computer plotter.
CAMERA	IC	Selects one or both of the two cameras for the SC 4020 cathode ray tube electronic plotter. This information must usually also be given to the plotter operator on the run submittal slip which will vary from one installation to another. (UM-4)
CARDNØ	P	Parameter used to accumulate a count of all card output punched except the NASTRAN restart dictionary.
CASE	FMS	Extracts user request from CASECC for current loop in dynamics rigid formats (D-7 thru D-12).
Case Control Deck	PH	The second of the three data decks necessary to run a problem under the NASTRAN system. It contains cards which select particular data sets from the Bulk Data Deck, output request cards and titling information. Cards in this deck are free field.
CASECC	DBT	Case control data block.
CASEXX	DBT	Case control data block as modified by functional module CASE.
CASEYY	DBT	Appended case control data table.
CASEZZ	DBT	CASEYY reduced to ØFREQ list.
CAXIF2	IB	Acoustic core element connection definition card.
CAXIF3	IB	Acoustic triangular element connection definition card.
CAXIF4	IB	Acoustic quadrilateral element connection definition card.
CBAR	IB	Bar element connection definition card.
CCØNEAX	IB	Axisymmetrical conical shell element connection card.
CDAMP1	IB	Scalar damper connection definition card.
CDAMP2	IB	Scalar damper property and connection definition card.
CDAMP3	IB	Scalar damper connection definition card (connecting scalar points).
CDAMP4	IB	Scalar damper property and connection definition card (connecting scalar points).
CDUMi	IB	Defines definition card for dummy elements 1 through 9.
CEAD	FMS	Complex Eigenvalue Analysis - Displacement.
CEIG	P	Parameter used in SDR2 in Complex Eigenvalue Analysis (D-7 and D-10).

CEIGN	P	Parameter used in VDR in Complex Eigenvalue Analysis (D-7 and D-10).
CELAS1	IB	Scalar spring connection definition card.
CELAS2	IB	Scalar spring property and connection definition card.
CELAS3	IB	Scalar spring connection definition card (connecting scalar points).
CELAS4	IB	Scalar spring property and connecting definition card (connecting scalar points).
CEND	IA	The last card of the Executive Control Deck.
CFLUID2	IB	Fluid core element connection definition card.
CFLUID3	IB	Fluid triangular element connection definition card.
CFLUID4	IB	Fluid quadrilateral element connection definition card.
CHBDY	IB	Boundary element connection definition card for heat transfer analysis.
Checkpoint	PH	The process of writing selected data blocks onto the New Problem Tape for subsequent restarts.
CHEXA1	IB	Hexahedron element connection definition card - five tetrahedra.
CHEXA2	IB	Hexahedron element connection definition card - ten tetrahedra.
CHKPNT	EM	Checkpoint module.
CHKPNT	IA	Request for checkpoint execution.
CLAMA	DBT	Complex eigenvalue output table.
CLAMAL	DBT	Appended case control data table.
CLAMAL1	DBT	CLAMAL reduced to ØFREQ list.
CLEAR	IC	Causes all parameter values used for X-Y plots to be reset to their default values except plotter and the titles (UM-4.2).
CMASS1	IB	Scalar mass connection definition card.
CMASS2	IB	Scalar mass property and connection definition card.
CMASS3	IB	Scalar mass connection definition card (connecting scalar points).
CMASS4	IB	Scalar mass property and connection definition card (connecting scalar points).
CMETHØD	IC	Complex eigenvalue analysis method selection.
CMETHØD$	M	Indicates restart with change in complex eigenvalue analysis method selection.
CMPLEV	P	Parameter used in GKAD to indicate complex eigenvalue problem.

Cold Start	PH	A NASTRAN problem initiated at its logical beginning. A cold start will never use an Old Problem Tape but it may create a New Problem Tape for subsequent restarts.
CØLØR	IC	Selects ink color for table plotters (UM-4.1).
CØND	EM	Conditional transfer
CØNM1	IB	Structural mass element connection definition card.
CØNM2	IB	Structural mass element connection definition card.
CØNRØD	IB	Rod element property and connection definition card.
CØNRØD	IC	Requests structure plot for all CØNRØD elements.
CØRD1C	IB	Cylindrical coordinate system definition (by grid point ID).
CØRD1R	IB	Rectangular coordinate system definition (by grid point ID).
CØRD1S	IB	Spherical coordinate system definition (by grid point ID).
CØRD2C	IB	Cylindrical coordinate system definition (by coordinates).
CØRD2R	IB	Rectangular coordinate system definition (by coordinates).
CØRD2S	IB	Spherical coordinate system definition (by coordinates).
CØSINE	IC	Indicates cosine boundary conditions for conical shell problem.
CØUPMASS	P	Parameter used to request coupled mass.
CPBAR	P	Selects coupled mass option for BAR element.
CPHID	DBM	Complex Eigenvectors - solution set.
CPHIH1	DBM	PHIHL reduced to ØFREQ list.
CPHIP	DBM	Complex Eigenvectors - physical set.
CPQDPLT	P	Selects coupled mass option for QDPLT element.
CPQUAD1	P	Selects coupled mass option for QUAD1 element.
CPQUAD2	P	Selects coupled mass option for QUAD2 element.
CPRØD	P	Selects coupled mass option for RØD and CØNRØD elements.
CPTRBSC	P	Selects coupled mass option for TRBSC element.
CPTRIA1	P	Selects coupled mass option for TRIA1 element.
CPTRIA2	P	Selects coupled mass option for TRIA2 element.
CPTRPLT	P	Selects coupled mass option for TRPLT element.
CPTUBE	P	Selects coupled mass option for TUBE element.
CQDMEM	IB	Quadrilateral membrane element connection definition card.
CQDMEM1	IB	Isoparametric quadrilateral membrane element connection definition card.

CQDMEM2	IB	Quadrilateral membrane element connection definition card.
CQDPLT	IB	Quadrilateral bending element connection definition card.
CQUAD1	IB	General Quadrilateral element connection definition card.
CQUAD2	IB	Homogeneous quadrilateral element connection definition card.
CRØD	IB	Rod element connection definition card.
CSHEAR	IB	Shear panel element connection definition card.
CSLØT3	IB	Triangular slot element connection definition card for acoustic analysis.
CSLØT4	IB	Quadrilateral slot element connection definition card for acoustic analysis.
CSTM	DBT	Coordinate System Transformation Matrices.
CSTMA	DBT	Coordinate System Transformation Matrices - Aerodynamics.
CTETRA	IB	Tetrahedron element connection definition card.
CTØRDRG	IB	Toroidal ring element connection card.
CTRAPRG	IB	Trapezoidal ring element connection card.
CTRBSC	IB	Basic bending triangular element connection definition card.
CTRIA1	IB	General triangular element connection definition card.
CTRIA2	IB	Homogeneous triangular element connection definition card.
CTRIARG	IB	Triangular ring element connection card.
CTRMEM	IB	Triangular membrane element connection definition card.
CTRPLT	IB	Triangular bending element connection definition card.
CTUBE	IB	Tube element connection definition card.
CTWIST	IB	Twist panel element connection definition card.
CURVLINESYMBØL	IC	Request to connect points with lines and/or to use symbols for X-Y plots.
CVISC	IB	Viscous damper element connection definition card.
CWEDGE	IB	Wedge element connection definition card.

D	P	Parameter value used to control utility module MATGPR print of solution set matrices.
DAREA	IB	Dynamic load scale card.
Data Block	PH	Designates a set of data (matrix, table) occupying a file. A file is "allocated" to a data block and a data block is "assigned" to a file.
Data Pool File	PH	An executive file containing the ØSCAR and any data blocks pooled by the Executive Segment File Allocator (XSFA) module. The contents of this file are described within the data pool dictionary (DPL).
DD	IC	Requests Data Display plotter.
DDR	FMX	This module is reserved for user implementation.
DDR1	FMS	Dynamic Data Recovery - Phase 1.
DDR2	FMS	Dynamic Data Recovery - Phase 2.
Deck	PH	1. NASTRAN Data Deck 2. Executive Control Deck 3. Case Control Deck 4. Bulk Data Deck 5. Restart Deck
DECØMØPT	P	Controls type of arithmetic used in the decomposition for frequency-response problems.
DECØMP	FMM	To decompose a square matrix into upper and lower triangular factors.
Default	PH	Many NASTRAN data items have default values supplied by the system. For example, the default value for MAXLINES is 20000.
DEFØRM	IB	Enforced element deformation definition card.
DEFØRM	IC	Enforced element deformation set selection.
DEFØRM$	M	Indicates restart with change in enforced element deformation selection.
DEFØRMATIØN	IC	Indicates subcases to be used for deformed structure plots.
DELAY	IB	Dynamic load time delay card.
Delete	IB	Delete cards from Bulk Data Deck.
DELTAPG	DBM	Incremental load vector in Piecewise Linear Analysis Rigid Format (D-6).
DELTAQG	DBM	Incremental vector of single point constraint forces in the Piecewise Linear Analysis Rigid Format (D-6).
DELTAUGV	DBM	Incremental displacement vector in the Piecewise Linear Analysis Rigid Format (D-6).
DENSITY	IC	Density of lines for SC 4020 plotter.
DENSITY	IC	Plot tape density must be specified to plotter operator on run submittal form and will vary from one installation to another (UM-4.1).

DESTRY	P	Appended AJJL parameter.
DET	IB	Eigenvalue analysis method option - determinant (see EIGR, EIGB, EIGC).
DIFF	P	Parameter used in the Piecewise Linear Analysis Rigid Format (D-6).
DIFFERENTIAL STIFFNESS	IA	Selects rigid format for static analysis with differential stiffness.
DIFFSTIF	P	Parameter used in the PRTPARM module in the Differential Stiffness Rigid Format (D-4).
DIRCEAD	P	Used in printing rigid format error messages for direct complex eigenvalue analysis (D-7).
DIRECT	P	Parameter used to indicate direct formulation of dynamics problems (D-7 thru D-9).
DIRECT CØMPLEX EIGENVALUES	IA	Selects rigid format for direct complex eigenvalue analysis.
DIRECT FREQUENCY RESPONSE	IA	Selects rigid format for direct frequency and random response.
DIRECT TRANSIENT RESPONSE	IA	Selects rigid format for direct transient response.
DIRFRRD	P	Used in printing rigid format error messages for direct frequency response.
DIRTRD	P	Used in printing rigid format error messages for direct transient response (D-9).
DISP	IA	Displacement approach to structural analysis.
DISP	IC	Abbreviated form of DISPLACEMENT.
DISPLACEMENT	IC	Request for output of displacement vector or eigenvector. (UM-2.3, 4.2)
DIT	DBT	Direct Input Table.
DIV	P	Parameter constant used in utility module PARAM.
DLØAD	IB	Dynamics load assembly definition.
DLØAD	IC	Dynamic load set solution request.
DLØAD$	M	Indicates restart with change in dynamic load set request.
DLT	DBT	Dynamic Loads Table.
DM	DBM	[D] - Rigid body transformation matrix.
DMAP	IA	Approach option (Direct Matrix Abstraction Program).
DMAP Instruction	PH	A statement in the DMAP Language.
DMAP Language	PH	Data block-oriented language used by the NASTRAN Executive System to direct the sequence and flow of modules to be executed.

DMAP Loop	PH	A DMAP sequence to be repeated, initiated with a LABEL DMAP instruction and terminated by a REPT DMAP instruction.
DMAP Module	PH	A module called by means of a DMAP instruction.
DMAP Sequence	PH	A set of DMAP instructions.
DMI	IB	Direct Matrix Input (data block is defined and used by user).
DMIAX	IB	Direct Matrix Input - Axisymmetric, used in dynamic rigid formats (D-7 thru D-12).
DMIG	IB	Direct Matrix Input - used in dynamic rigid formats (D-7 thru D-12).
DPD	*FMS*	*Dynamic Pool Distributor.*

DPH	M	Data Pool Housekeeper - Executive routine.
DPHASE	IB	Dynamic load phase lead card.
DSO	P	Parameter used in functional module SDR2 in the Differential Stiffness Rigid Format (D-4).
DS1	P	Parameter used in functional module SDR2 in the Differential Stiffness Rigid Format (D-4).
DSCØ	IC	Abbreviated form of DSCØEFFICIENT.
DSCØ$	M	Indicates restart with change in differential stiffness load factors.
DSCØEFFICIENT	IC	Selects set of differential stiffness factors which have been input on DSFACT cards.
DSCØSET	P	Differential Stiffness coefficient set number. Used in the Differential Stiffness Rigid Format (D-4).
DSFACT	IB	Differential stiffness factor set definition card.
DSLØØP	P	Controls DMAP looping in the Differential Stiffness Rigid Format (D-4).
DSMG1	FMS	Differential Stiffness Matrix Generator - Phase 1.
DSMG2	FMS	Differential Stiffness Matrix Generator - Phase 2.
DTI	IB	Direct Table Input - means by which user may directly input any table data block.
DUMMØD1	FMX	This module is reserved for user implementation.
DUMMØD2	FMX	This module is reserved for user implementation.
DUMMØD3	FMX	This module is reserved for user implementation.
DUMMØD4	FMX	This module is reserved for user implementation.
Dummy Element	PH	Provision for user to insert additional finite element into the NASTRAN element library.
Dump	PH	Printed output of contents of all, or a portion, of main memory at some point in the problem solution.
DYNAMICS	DBT	Generated by the Input File Processor (IFP) for Real Eigenvalue, Buckling, or any of the Dynamics Rigid Formats (D-3, D-5 and D-7 thru D-12).
D1JE	DBM	Downwash factors due to extra points - real.
D2JE	DBM	Downwash factors due to extra points - complex.
D1JK	DBM	Real part of downwash matrix.
D2JK	DBM	Imaginary part of downwash matrix.

E	P	Parameter value used by MATGPR to print matrices associated with extra points.
EAI	IC	Requests EAI 3500 plotter.
ECHØ	IC	Ouput request statement for echo of bulk data.
ECPT	DBT	Element Connection and Properties Table.
ECPTNL	DBT	Nonlinear subset of the ECPT. This data block is used only in the Piecewise Linear Analysis Rigid Format (D-6).
ECPTNL1	DBT	Updated version of the ECPTNL data block. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
ECPTNLPG	P	Error flag for the Piecewise Linear Analysis Rigid Format (D-6). If all elements in a piecewise linear analysis problem are linear, this error flag is set and a DMAP exit occurs.
ECT	DBT	Element Connection Table.
ECTA	DBT	Element Connection Table - Aerodynamics.
EDT	DBT	Enforced Deformation Table - generated by Input File Processor.
EED	DBT	Eigenvalue Extraction Data table (D-3, D-5, D-7, D-10, D-11, D-12).
EIGB	IB	Real eigenvalue extraction data for buckling analysis (D-5).
EIGC	IB	Complex eigenvalue extraction data card (D-7 and D-10).
EIGP	IB	Complex eigenvalue pole definition card (D-7 and D-10).
EIGR	IB	Real eigenvalue extraction data for normal mode analysis (D-3, D-10 thru D-12).
ELEMENTS	IC	Used in element set definition for structure plot.
ELFØRCE	IC	Ouput request card for element forces. (UM-2.3, 4.2).
ELSETS	DBT	Element plot set connection tables.
ELSTRESS	IC	Request for output of element stresses.(UM-2.3, 4.2)
END	IA	END is the last statement in all DMAP sequences.
ENDALTER	IA	Last card of alter packet.
ENDDATA	IB	End of Bulk Data Deck.
EØF	PH	End-of-File.
EPØINT	IB	Extra point definition card - used in dynamics problems only.
EPSHT	P	Used in convergence tests for nonlinear heat transfer analysis.
EPSILØN SUB E (ε_e)	PH	Error ratio computed in SSG3. $\varepsilon_e = \varepsilon_\ell$ if the referenced load is $\{P_\ell\}$ and $\varepsilon_e = \varepsilon_o$ if the referenced load is $\{P_o\}$. See page 3.2-10 for mathematical definition of ε_o and ε_ℓ.
EPT	DBT	Element Property Table - output by Input File Processor.

EQAERØ	DBT	Equivalence between external points and scalar index values - Aerodynamics.
EQDYN	DBT	Equivalence of internal and external indices - dynamics.
EQEXIN	DBT	Equivalence of internal and external indices.
EQUIV	EM	Equivalence data blocks.
Equivalence	PH	Data blocks are considered equivalenced when references to their equivalent names access the same physical data file.
ERRØR1	L	Label used when rigid format errors are detected.
ERRØR2	L	Label used when rigid format errors are detected.
ERRØR3	L	Label used when rigid format errors are detected.
ERRØR4	L	Label used when rigid format errors are detected.
ERRØR5	L	Label used when rigid format errors are detected.
ERRØR6	L	Label used when rigid format errors are detected.
EST	DBT	Element Summary Table.
ESTL	DBT	Element Summary Table for Linear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
ESTNL	DBT	Element Summary Table for Nonlinear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
ESTNL1	DBT	Updated version of the ESTNL data block. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
EXCEPT	IC	Forms exceptions to string of values in set declarations.
EXCLUDE	IC	Used in set definition for structure plots.
Executive	PH	1. Executive Control Deck 2. NASTRAN Executive System
Executive Control Deck	PH	The first of the three data decks necessary to run a problem under the NASTRAN system. This deck begins with the ID card and ends with the CEND card. Among other things, cards in this deck select the solution approach and rigid format to be used, limit the execution time, and control checkpointing and restart.
Executive System	PH	The Executive System initiates a NASTRAN problem solution via the Preface, allocates files to data blocks during problem solution, controls the sequence of the modules to be executed, and provides for problem restart capability.
EXIT	EM	Program termination DMAP statement.
External Sort	PH	Order of grid, scalar and extra points determined by the user's numerical order of point identification.
Extra Point	PH	A "point" which is defined on an EPØINT bulk data card. An extra point has no geometrical coordinates, defines only one degree of freedom of the model and is used only in dynamics solutions.

F	P	Parameter value used by MATGPR to print F-set matrices.
FA1	FMS	Flutter Analysis - Phase 1.
FA2	FMS	Flutter Analysis - Phase 2.
FBS	FMM	Forward and Backward Substitution.
FE	P	Parameter used by MATGPR to print out FE-set matrices.
FIAT	M	File Allocation Table. Core resident executive table where data block names, status of the data blocks (assigned to a file, purged, equivalenced, etc.) and trailer for the data blocks are stored.
FILE	IA	Term appearing on the checkpoint dictionary cards indicating the file number (internal) associated with a particular data block.
FILE	M	The FILE DMAP statement specifies data block characteristics such as TAPE, SAVE, and APPEND.
File	PH	Designates an auxiliary storage area or unit.
FIND	IC	Selects parameters for structure plot.
FINIS	L	Label used in all displacement rigid format DMAPs to terminate execution of DMAP.
Finite Element	PH	Idealized unit of a structural model that represents the distributed elastic properties of a structure.
FIST	M	File Status Table. Core resident executive table where internal file names and pointers to the FIAT, pertaining only to the module being executed, are stored.
FLAGS	IA	Term appearing on the checkpoint dictionary cards indicating the status of a data block (equivalenced or not).
FLFACT	IB	Specifies densities, Mach numbers and frequencies.
FLIST	DBT	Flutter Control Table.
FLØØP	P	Flutter loop counter/control.
FLSYM	IB	Structural symmetry definition card for use in hydroelastic problems.
FLUID	IC	Indicates hydroelastic harmonic degrees of freedom.
FLUTTER	IB	Defines flutter data.
FMETHØD	IC	Flutter Analysis Method Selection.
FMØDE	P	Mode number of first mode selected by user in modal dynamics formulations.
FØRCE	IB	Static load definition (vector).
FØRCE	IC	Request for output of element forces.
FØRCE1	IB	Static load definition (magnitude and two grid points).

FØRCE2	IB	Static load definition (magnitude and four grid points).
FØRCEAX	IB	Static load definition for conical shell problem.
FREEPT	IB	Defines point on a free surface of a fluid for output purposes.
FREQ	IB	Frequency list definition.
FREQ$	M	Indicates restart with change in frequencies to be solved.
FREQ1	IB	Frequency list definition (linear increments).
FREQ2	IB	Frequency list definition (logarithmic increments).
FREQRESP	P	Parameter used in SDR2 to indicate a frequency response problem.
FREQUENCY	IC	Selects the set of frequencies to be solved in frequency response problems.
FRL	DBT	Frequency Response List.
FRQSET	P	Used in FRRD to indicate user selected frequency set.
FRRD	FMS	Frequency and Random Response - Displacement approach.
FSAVE	DBT	Flutter Storage Save Table.
FSLIST	IB	Defines a free surface of a fluid in a hydroelastic problem.
Functional Module	PH	An independent group of subroutines that perform a structural analysis function.

G	P	1. Parameter used by MATGPR to print G-set matrices. 2. Parameter used to input uniform structural damping coefficient (D-7 thru D-9).
GEI	DBT	General Element Input.
GENEL	IB	General element definition.
GEØM1	DBT	Geometric data input table - generated by the Input File Processor.
GEØM2	DBT	Connection input table - generated by the Input File Processor.
GEØM3	DBT	Static load and temperature input table - generated by the Input File Processor.
GEØM4	DBT	Displacement sets definition input table - generated by the Input File Processor.
GI	FMS	Geometry Interpolator.
GINØ	M	General input/output. GINØ is a collection of subroutines which is the input/output control system for NASTRAN.
GINØ Buffer	PH	Storage reserved in open core for each GINØ file opened. The size of the buffer is machine dependent.
GINØ File Number	PH	File number used internally in DMAP modules to access data blocks.
GIV	IB	Eigenvalue analysis method option - Givens (see EIGR).
GKAD	FMS	General [K] Assembler - Direct.
GKAM	FMS	General [K] Assembler - Modal.
GM	DBM	$[G_m]$ - multipoint constraint transformation matrix.
GMD	DBM	$[G_m^d]$ - mulitpoint constraint transformation matrix used in dynamic analysis.
GNFIAT	M	Generate FIAT. The preface routine which generates the initial FIAT.
GØ	DBM	$[G_o]$ - structural matrix partitioning transformation matrix.
GØD	DBM	$[G_o^d]$ - Structural matrix partitioning transformation matrix used in dynamic analysis.
GP1	FMS	Geometry Processor - part 1.
GP2	FMS	Geometry Processor - part 2.
GP3	FMS	Geometry Processor - part 3.
GP4	FMS	Geometry Processor - part 4.
GPCT	DBT	Grid Point Connection Table.
GPDT	DBT	Grid Point Definition Table.
GPI	M	General Problem Initialization (see XGPI).
GPL	DBT	Grid Point List.

GPLA	DBT	Grid Point List - Aerodynamics.
GPLD	DBT	Grid Point List used in dynamic analysis.
GPSETS	DBT	Grid point plot sets.
GPSP	FMS	Grid Point Singularity Processor.
GPST	DBT	Grid Point Singularity Table.
GPTT	DBT	Grid Point Temperature Table.
GPWG	FMS	Grid Point Weight Generator.
GRAV	IB	Gravity vector definition card.
GRDPNT	P	Used in all displacement rigid formats to specify execution of the grid point weight generator (GPWG) by the user. A positive value references a grid point of the structural model. A value of zero indicates the origin of the basic coordinate system.
GRDSET	IB	Grid point default definition card.
GRID	IB	Grid point definition card.
Grid Point	PH	A point in Euclidean 3 dimensional space defined on a GRID bulk data card. A grid point defines 6 degrees of freedom, 3 translational and 3 rotational.
GRID PØINTS	IC	Used in set definition for structure plots.
GRIDB	IB	Grid point definition card for hydroelastic model.
GRIDF	IB	Grid point definition card for axisymmetric fluid cavity.
GRIDS	IB	Grid point definition card for slotted acoustic cavity.
GTKA	DBM	Aerodynamic transformation matrix - k-set to a-set.
HARMØNICS	IC	Controls number of harmonics output in axisymmetric shell problems and hydroelastic problems.
HB2DD	DBM	$[B^2_{dd}]$ - Partition of heat capacity matrix.
HB2PP	DBM	$[B^2_{pp}]$ - Partition of heat capacity matrix.
HBAA	DBM	$[B_{aa}]$ - Partition of heat capacity matrix.
HBDD	DBM	$[B_{dd}]$ - Partition of heat capacity matrix.
HBFF	DBM	$[B_{ff}]$ - Partition of heat capacity matrix.
HBGG	DBM	$[B_{gg}]$ - Heat capacity matrix.
HBNN	DBM	$[B_{nn}]$ - Partition of heat capacity matrix.
HDLT	DBT	Dynamic loads table for heat transfer analysis.
Header record	PH	Initial record of a data block. Typically a header record contains only 2 BCD words, the alphanumeric name of the data block.

HEAT	IA	Selects heat transfer analysis on APProach card.
HFREQ	P	High frequency limit for modal formulation of dynamics problems (D-10 thru D-12).
HK2DD	DBM	$[K^2_{dd}]$ - Partition of heat conductivity matrix.
HK2PP	DBM	$[K^2_{pp}]$ - Partition of heat conductivity matrix.
HKAA	DBM	$[K_{aa}]$ - Partition of heat conductivity matrix.
HKDD	DBM	$[K_{dd}]$ - Partition of heat conductivity matrix.
HKFF	DBM	$[K_{ff}]$ - Partition of heat conductivity matrix.
HKFS	DBM	$[K_{fs}]$ - Partition of heat conductivity matrix.
HKGG	DBM	$[K_{gg}]$ - Heat conductivity matrix, including estimated linear component of radiation.
HKGGX	DBM	$[K^x_{gg}]$ - Heat conductivity matrix.
HKNN	DBM	$[K_{nn}]$ - Partition of heat conductivity matrix.
HØEF1X	DBT	Heat flux output table for CHBDY elements.
HPDØ	DBM	$\{P^o_d\}$ - Partition of dynamic load vector.
HPDT	DBM	$\{P^t_d\}$ - Partition of dynamic load vector.
HPPØ	DBM	$\{P^o_p\}$ - Partition of dynamic load vector.
HPSØ	DBM	$\{P^o_s\}$ - Partition of dynamic load vector.
HQGE	DBM	$[Q_{ge}]$ - Element radiation flux matrix for heat transfer analysis.
HRAA	DBM	$[R_{aa}]$ - Partition of radiation matrix.
HRDD	DBM	$[R_{dd}]$ - Partition of radiation matrix.
HRFF	DBM	$[R_{ff}]$ - Partition of radiation matrix.
HRGG	DBM	$[R_{gg}]$ - Radiation matrix for heat transfer analysis.
HRNN	DBM	$[R_{nn}]$ - Partition of radiation matrix.
HSLT	DBT	Static heat flux table.
HTØL	DBT	List of output time steps for heat transfer.

IC	IC	Transient analysis initial condition set selection.
ID	IA	The first card of any data deck is the identification (ID) card. The two data items on this card are BCD values.
IFP	EM	Input File Processor. The preface module which processes the sorted Bulk Data Deck and outputs various data blocks depending on the card types present in the Bulk Data Deck.
IFP1	EM	Input File Processor 1. The preface module which processes the Case Control Deck and writes the CASECC, PCDB and XYCDB data blocks.
IFP3	EM	Input File Processor 3. The preface module which processes bulk data cards for a conical shell problem.
IFP4	EM	Input File Processor 4. The preface module which processes bulk data cards for a hydroelastic problem.
IMAG	IC	Output request for real and imaginary parts of some quantity such as displacement, load, single point force of constraint element force, or stress.
IMPL	P	Parameter constant used in executive module PARAM.
INCLUDE	IC	Used in set definition for structure plots.
INERTIA	P	Used in printing rigid format error messages for Static Analysis with Inertia Relief (D-2).
INERTIA RELIEF	IA	Selects rigid format for static analysis with inertia relief.
INPT	M	A reserved NASTRAN physical unit (Tape) which must be set up by the user when used.
INPUT	FMU	Generates most of bulk data for selected academic problems.
Input Data Block	PH	A data block input to a module. An input data block must have been previously output from some module and may not be written on.
Input Data Cards	PH	The card input data to the NASTRAN system are in 3 sets, the Executive Control Deck, the Case Control Deck, and the Bulk Data Deck.
INPUTT1	FMU	Reads data blocks from GINØ-written user tapes.
INPUTT2	FMU	Reads data blocks from FØRTRAN-written user tapes.
INPUTT3	FMX	Dummy user input module.
INPUTT4	FMX	Dummy user input module.
Internal Sort	PH	Same order as external sort except when SEQGP or SEQEP bulk data cards are used to change the sequence.
INV	IB	Inverse power eigenvalue analysis option - specified on EIGR, EIGB or EIGC cards.
IRES	P	Causes printout of residual vectors in statics rigid formats when set nonnegative via a PARAM bulk data card. (D-1, D-2, D-4, D-5, D-6).

JUMP	EM	Unconditional transfer DMAP statement.
JUMPPLØT	P	Parameter used by structure plotter modules PLTSET and PLØT.
K2DD	DBM	$[K^2_{dd}]$ - Partition of direct input stiffness matrix.
K2DPP	DBM	$[K^{2d}_{pp}]$ - Direct input stiffness matrix for all physical points from bulk data deck.
K2PP	DBM	$[K^2_{pp}]$ - Direct input stiffness matrix for all physical points.
K2PP	IC	Direct input stiffness matrix selection.
K2PP$	M	Indicates restart with change in direct input stiffness matrices.
K2XPP	DBM	$[K^{2x}_{pp}]$ - Direct input stiffness matrix excluding hydroelastic boundary stiffness matrix.
K4AA	DBM	$[K^4_{aa}]$ - Partition of structural damping matrix.
K4FF	DBM	$[K^4_{ff}]$ - Partition of structural damping matrix.
K4GG	DBM	$[K^4_{gg}]$ - Structural damping matrix generated by Structural Matrix Assembler.
K4NN	DBM	$[K^4_{nn}]$ - Partition of structural damping matrix.
KAA	DBM	$[K_{aa}]$ - Partition of stiffness matrix.
KBFS	DBM	$[K^b_{fs}]$ - Partition of combination of elastic stifffness matrix and differential stiffness matrix.
KBFL	DBM	$[K_{b,f\ell}]$ - Hydroelastic boundary stiffness matrix.
KBLL	DBM	$[K^b_{\ell\ell}]$ - Combination of elastic stiffness and differential stiffness used in static analysis with differential stiffness.
KBSS	DBM	$[K^b_{ss}]$ - Partition of combination of stiffness matrix and differential stiffness matrix.
KDAA	DBM	$[K^d_{aa}]$ - Partition of differential stiffness matrix.
KDAAM	DBM	$-[K^d_{aa}]$ - Differential stiffness matrix used in formulation of buckling problems (D-5).
KDAMP	PU	Method of computing damping.
KDD	DBM	$[K_{dd}]$ - Stiffness matrix used in direct formulation of dynamics problems (D-7 thru D-9).
KDEK2	P	Parameter indicating equivalence of KDD and K2DD.
KDEKA	P	Parameter indicating equivalence of KDD and KAA.
KDFF	DBM	$[K^d_{ff}]$ - Partition of differential stiffness matrix.
KDFS	DBM	$[K^d_{fs}]$ - Partition of differential stiffness matrix.
KDGG	DBM	$[K^d_{gg}]$ - Differential stiffness matrix prepared by Differential Stiffness Matrix Generator
KDNN	DBM	$[K^d_{nn}]$ - Partition of differential stiffness matrix.

KDSS	DBM	$[K_{ss}^{d}]$ - Partition of differential stiffness matrix.
KFF	DBM	$[K_{ff}]$ - Partition of stiffness matrix.
KFS	DBM	$[K_{fs}]$ - Partition of stiffness matrix.
KGG	DBM	$[K_{gg}]$ - Stiffness matrix generated by Structural Matrix Assembler.
KGGL	DBM	$[K_{gg}^{\ell}]$ - Stiffness matrix for linear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
KGGLPG	P	Purge flag for KGGL matrix. If set to -1, it implies that there are no linear elements in the structural model. (D-6).
KGGNL	DBM	$[K_{gg}^{n\ell}]$ - Stiffness matrix for the nonlinear elements. Used in the Piecewise Linear Analysis Rigid Format only. (D-6).
KGGSUM	DBM	Sum of KGGNL and KGGL. Used in the Piecewise Linear Analysis Rigid Format only. (D-6).
KGGX	DBM	$[K_{gg}^{x}]$ - Stiffness matrix excluding general elements.
KGGXL	DBM	$[K_{gg}^{x\ell}]$ - Stiffness matrix for linear elements (excluding general elements). Used in the Piecewise Linear Rigid Format only. (D-6).
KHH	DBM	$[K_{hh}]$ - Stiffness matrix used in modal formulation of dynamics problems (D-10 thru D-12).
KLL	DBM	$[K_{\ell\ell}]$ - Stiffness matrix used in solution of problems in static analysis (D-1, D-2, D-4, D-5, D-6).
KLR	DBM	$[K_{\ell r}]$ - Partition of stiffness matrix.
KNN	DBM	$[K_{nn}]$ - Partition of stiffness matrix.
KØØ	DBM	$[K_{oo}]$ - Partition of stiffness matrix.
KRR	DBM	$[K_{rr}]$ - Partition of stiffness matrix.
KSS	DBM	$[K_{ss}]$ - Partition of stiffness matrix.
KXHH	DBM	Total modal stiffness matrix - h-set.

L	P	Parameter value used by MATGPR to print L-set matrices.
LABEL	EM	DMAP location.
LABEL	IC	Defines third line of titles to be printed on each page of printer output. Also used on plots.
LABEL	IC	Requests identification of grid points and/or elements on structure plot.
LAMA	DBT	Real eigenvalues.
LBLi	L	A label used in displacement approach rigid formats where i represents one or more characters used to form unique labels.
LBLL	DBM	$[L^b_{\ell\ell}]$ - Lower triangular factor of $[K^b_{\ell\ell}]$.
LEFT TICS	IC	Request for tic marks to be plotted on left hand edge of frame for X-Y plots.
LFREQ	P	Low frequency limit for modal formulation of dynamics problems (D-10 thru D-12).
LGPWG	L	Label used in conjunction with the Grid Point Weight Generator.
LINE	IC	Number of data lines printed per page of printer output. It should be set to 50 for 11 x 17 inch paper, and to 35 for 8 1/2 x 17 inch paper.
LLL	DBM	$[L_{\ell\ell}]$ - Lower triangular factor of $[K_{\ell\ell}]$.
LMØDES	P	Number of lowest modes for modal formulation of dynamics problems (D-10 thru D-12).
LØAD	IB	Static load combination definition.
LØAD	IC	Static load set selection.
LØAD$	M	Indicates restart with change in static load set request.
LØGARITHMIC	IC	Requests logarithmic scales for X-Y plots.
LØGPAPER	IC	Requests logarithmic paper for X-Y plots.
LØØ	DBM	$[L_{oo}]$ - Lower triangular factor of $[K_{oo}]$.
LØØP1$	M	Indicates looping problem in modified restart. (PM-4.3.7.1)
LØØPBGN	L	Signifies the beginning of the Piecewise Linear Analysis Rigid Format DMAP Loop. (D-6).
LØØPEND	L	Signifies the end of the Piecewise Linear Analysis Rigid Format DMAP loop. (D-6).
LØØP$	M	Indicates looping problem in modified restart. (PM-4.3.7.1)
LØWER TICS	IC	Request for tic marks to be plotted on bottom edge of frame for X-Y plots.
LUSET	P	Order of USET.
LUSETA	P	Number of degrees of freedom in the pa displacement set.
LUSETD	p	Order of USETD.

M	P	Parameter value used by MATGPR to print M-set matrices.
M2DD	DBM	$[M^2_{dd}]$ - Partition of direct input mass matrix.
M2DPP	DBM	$[M^{2d}_{pp}]$ - Direct input mass matrix for all physical points from Bulk Data Deck.
M2PP	DBM	$[M^2_{pp}]$ - Direct input mass matrix for all physical points.
M2PP	IC	Direct input mass matrix selection.
M2PP$	M	Indicates restart with change in direct input mass matrices.
MAA	DBM	$[M_{aa}]$ - Partition of mass matrix.
MASS	IB	Eigenvector normalization option - used on EIGR card.
MAT1	IB	Material definition card for isotropic material.
MAT2	IB	Material definition card for anisotropic material.
MAT3	IB	Material definition card for orthotropic material.
MAT4	IB	Thermal material definition card for isotropic material.
MAT5	IB	Thermal material definition card for anisotropic material.
MATGPR	FMU	Utility module for printing matrices.
MATPØØL	DBT	Grid point oriented direct input matrix data pool, output by Input File Processor and used by functional module MTRXIN.
MATPRN	FMU	Utility module for printing matrices.
MATPRT	FMU	Utility module for printing matrices.
Matrix Control Block	PH	A seven word array, the first word is a GINØ file number, and words 2 through 7 comprise a matrix trailer.
Matrix Data Block	PH	A data block is classified as a matrix if and only if it is generated by one of the NASTRAN matrix packing routines, PACK or BLDPK.
Matrix Decomposition	PH	A factorization of a matrix K so that K = LU where L is a unit lower triangular matrix and U is an upper triangular matrix.
MATS1	IB	Specifies table references for stress-dependent material properties.
MATT1	IB	Specifies table references for temperature-dependent isotropic material properties.
MATT2	IB	Specifies table references for temperature-dependent anisotropic material properties.
MATT3	IB	Specifies table references for temperature-dependent orthotropic material properties.
MATT4	IB	Specifies table references for temperature-dependent isotropic, thermal material properties.

MATT5	IB	Specifies table references for temperature-dependent, anisotropic, thermal material properties.
MAX	IB	Eigenvector normalization option - used on EIGR, EIGB and EIGC cards.
MAXIMUM DEFØRMATIØN	IC	Indicates scale for deformed structure plots.
MAXIT	P	Limits maximum number of iterations in nonlinear heat transfer analysis.
MAXLINES	IC	Maximum printer output line count - default value is 20000.
MCE1	FMS	Multipoint Constraint Eliminator - part 1.
MCE2	FMS	Multipoint Constraint Eliminator - part 2.
MDD	DBM	$[M_{dd}]$ - Mass matrix used in direct formulation of dynamics problems (D-7 thru D-9).
MDEMA	P	Parameter indicating equivalence of MDD and MAA.
MDLCEAD	P	Used in printing rigid format error messages for modal complex eigenvalue analysis (D-10).
MDLFRRD	P	Used in printing rigid format error messages for modal frequency response (D-11).
MDLTRD	P	Used in printing rigid format error messages for modal transient response (D-12).
MERGE	FMM	Matrix merge functional module.
METHØD	IC	Selects method for real eigenvalue analysis.
METHØD$	M	Indicates restart with change in eigenvalue extraction procedures.
MFF	DBM	$[M_{ff}]$ - Partition of mass matrix.
MGG	DBM	$[M_{gg}]$ - Mass matrix generated by Structural Matrix Assembler.
MHH	DBM	$[M_{hh}]$ - Mass matrix used in modal formulation of dynamics problems (D-10 thru D-12).
MI	DBM	[m] - Modal mass matrix.
MKAERØ1	IB	Provides table of Mach numbers and reduced frequencies (k).
MKAERØ2	IB	Provides list of Mach numbers (m) and reduced frequencies (k).
MLL	DBM	$[M_{\ell\ell}]$ - Partition of mass matrix.
MLR	DBM	$[M_{\ell r}]$ - Partition of mass matrix.
MNN	DBM	$[M_{nn}]$ - Partition of mass matrix.
MØA	DBM	$[\bar{M}_{oa}]$ - Partition of mass matrix.
MØDA	FMX	This module is reserved for user implementation.
MØDACC	FMS	Mode Acceleration Output Reduction Module.

MØDAL	IC	Requests structure plots of mode shapes.
MØDAL	P	Indicates modal as opposed to direct formulation of dynamics problems. (D-10 thru D-12).
MØDAL CØMPLEX EIGENVALUES	IA	Selects rigid format for modal complex eigenvalue analysis.
MØDAL FREQUENCY RESPØNSE	IA	Selects rigid format for modal frequency and random response.
MØDAL TRANSIENT RESPØNSE	IA	Selects rigid format for modal transient response.
MØDB	FMX	This module is reserved for user implementation.
MØDC	FMX	This module is reserved for user implementation.
MØDEL	IC	Indicates model number of structure plotter.
MØDES	IA	Selects rigid format for normal mode analysis.
MØDES	IC	Duplicates output requests for eigenvalue problems.
MØDES	P	Used in printing rigid format error messages for normal modes analysis (D-3).

Modified Restart	PH	Restarting (see Restart) a NASTRAN problem and redirecting its solution by changing the rigid format and/or selected input data.
Module	PH	A logical group of subroutines which performs a defined function.
MØMAX	IB	Conical shell moment definition card.
MØMENT	IB	Static moment load definition (vector).
MØMENT1	IB	Static moment load definition (magnitude and two grid points).
MØMENT2	IB	Static moment load definition (magnitude and four grid points).
MØØ	DBM	$[M_{oo}]$ - Partition of mass matrix.
MPC	IB	Multipoint constraint definition.
MPC	IC	Multipoint constraint set request.
MPC$	M	Indicates restart with change in multipoint constraints.
MPCADD	IB	Multipoint constraint set definition.
MPCAX	IB	Conical shell multipoint constraint definition.
MPCF1	P	No multipoint constraints.
MPCF2	P	No change in multipoint constraints for loop.
MPL	PH	Module properties list. The MPL defines each DMAP module's name, the number of input, output and scratch files required and the parameter list. It is used by the preface module XGPI to generate the ØSCAR.
MPT	DBT	Material Properties Table - output by Input File Processor.
MPY	M	Parameter constant used in executive module PARAM.
MPYAD	FMM	Performs multiply-add matrix operation.
MR	DBM	$[m_r]$ - Rigid body mass matrix.
MRR	DBM	$[M_{rr}]$- Partition of mass matrix.
MTRXIN	FMS	Selects direct input matrices for current loop in dynamics problems (D-7 thru D-12).
MX	IC	Indicates negative x-axis direction for structure plot.
MXHH	DBM	Total modal mass matrix - h-set.
MY	IC	Indicates negative y-axis direction for structure plot.
MZ	IC	Indicates negative z-axis direction for structure plot.

N	M	Used in parameter section of DMAP statement. Indicates that parameter may not be given an initial value with a PARAM bulk data card.
N	P	Parameter value used by MATGPR to print N-set matrices.
NASTPLT	IC	Requests NASTRAN general purpose plotter.
NASTRAN	M	Acronym for NAsa STRuctural ANalysis program.
NASTRAN Data Deck	PH	The composite deck consisting of the Executive Control Deck, the Case Control Deck, and the Bulk Data Deck. This deck, when preceeded by any necessary operating system control cards, constitutes the complete card input for a NASTRAN run (PM-5).
NE	P	Parameter value used by MATGPR to print out NE-set matrices.
NEIGV	P	Number of real eigenvalues found.
NEVER	P	Set to +1 by a DMAP PARAM statement in the Piecewise Linear Analysis Rigid Format (D-6).
New Problem Tape	PH	See Problem Tape.
NJ	P	Number of degrees of freedom in the j displacement set.
NK	P	Number of degrees of freedom in the k displacement set.
NLFT	DBT	Nonlinear function table.
NLLØAD	IC	Requests nonlinear load output for transient problems.
NØ	IA	Option used on CHKPNT card, indicates that no checkpoint is desired.
NØA	P	Indicates no constraints applied to structural model.
NØABFL	P	No fluid-structure interface in a hydroelastic problem.
NØB2PP	P	No direct input damping matrix.
NØBGG	P	No viscous damping matrix (D-7 thru D-9).
NØCSTM	P	No Coordinate System Transformation Matrices.
NØD	P	No output request that is limited to independent degrees of freedom.
NØDJE	PU	Positive value selects D1JE and D2JE from INPUTT2.
NØDLT	P	No Dynamic Loads Table.
NØEED	P	No Eigenvalue Extraction Data
NØELMT	P	No elements are defined.
NØFL	P	No fluid-structure interface and no fluid gravity in a hydroelastic problem.
NØFRL	P	No Frequency Response List.
NØGENEL	P	No general elements.

NØGPDT	P	No Grid Point Definition Table.
NØGRAV	P	No gravity loads.
NØK2DPP	P	No direct input stiffness matrix from Bulk Data Deck.
NØK2PP	P	No direct input stiffness matrices.
NØK4GG	P	No structural damping matrix.
NØKBFL	P	No fluid gravity or structural interface in a hydroelastic problem.
NØL	P	No independent degrees of freedom.
NØLIN1	IB	Nonlinear transient dynamic load set definition card.
NØLIN2	IB	Nonlinear transient dynamic load set definition card.
NØLIN3	IB	Nonlinear transient dynamic load set definition card.
NØLIN4	IB	Nonlinear transient dynamic load set definition card.
NØLØØP$	M	Indicates restart of problem without DMAP loop. (PM-4.3.7.1).
NØM2DPP	P	No direct input mass matrix from Bulk Data Deck.
NØM2PP	P	No direct input mass matrices.
NØMGG	P	If functional module SMA2 generates a zero mass matrix, NØMGG is set to -1. Otherwise, it is set to +1.
NØMØD	P	Mode acceleration data recovery not requested.
NØNCUP	P	Indicates diagonal MHH, BHH, and KHH allowing uncoupled solution in TRD and FRRD.
NØNE	IC	Override for output and bulk data deck echo requests.
NØNLFT	P	No nonlinear function table.
NØNLINEAR	IC	Selects nonlinear load for transient problems.
NØNLSTR	P	No stress output request for nonlinear elements (D-6).
NØP	M	Parameter constant used in executive module PARAM.
NØP	P	No output request involving dependent degrees of freedom or stresses.
NØPSDL	P	No Power Spectral Density List.
NØRMAL MØDES	IA	Selects rigid format for normal mode analysis.
NØSET	P	No dependent coordinates.
NØSIMP	P	No structural elements are defined.
NØSØRT2	P	No request for output sorted by point number or element number.
NØSR	P	No single-point constraints or free body supports.
NØT	M	Parameter constant used in utility module PARAM.

NØTFL	P	No Transfer Function List.
NØTRL	P	No Transient Response List.
NØUE	P	No extra points introduced for dynamic analysis.
NØXYCBD	P	-1 indicates no XY output requests.
NPLALIM	P	Set by module PLA1 as the Piecewise Linear Analysis Rigid Format DMAP loop counter. (D-6)
NPTP	M	New Problem Tape - a reserved NASTRAN physical unit (TAPE) which must be set up by the user when used.
NSIL	P	Order of SIL table.
NSKIP	P	Locate current boundary conditions in Case Control.
NUMF	M	New User Master File - used only when operating NASTRAN as a user master file editor. (See UMFEDIT). A reserved NASTRAN physical unit (tape) which must be set up by the user when used.
NVECTS	P	Number of eigenvectors found.

Ø	P	Parameter value used by MATGPR to print Ø-set matrices.
ØBEF1	DBT	Element force output table (D-5).
ØBES1	DBT	Element stress output table (D-5).
ØBQG1	DBT	Forces of single point constraint output table (D-5).
ØCEIGS	DBT	Complex eigenvalue summary table (D-7, D-10).
ØCPHIP	DBT	Complex eigenvector output table (D-7, D-10).
ØEF1	DBT	Element force output table (D-1, D-2, D-4, D-5, D-6).
ØEF2	DBT	Element force output table - SØRT2 (D-9, D-12).
ØEFB1	DBT	Element force output table (D-4).
ØEFC1	DBT	Element force output table - complex (D-7, D-8, D-10, D-11).
ØEFC2	DBT	Element force output table - complex - SØRT2 (D-8, D-11).
ØEIGS	DBT	Real Eigenvalue summary output table (D-3, D-5).
ØES1	DBT	Element stress output table (D-1, D-2, D-4, D-5, D-6).
ØES2	DBT	Element stress output table - SØRT2 (D-9, D-12).
ØESB1	DBT	Element stress output table (D-4).
ØESC1	DBT	Element stress output table - complex (D-7, D-8, D-10, D-11).
ØESC2	DBT	Element stress output table - complex - SØRT2 (D-8, D-11).
ØFP	FMS	Output File Processor.
ØFREQ	IC	Output Frequency set.
ØFREQUENCY	IC	Selects from the solution set of frequencies a subset for output requests.
ØGPST	DBT	Grid point singularity output table.
ØGPWG	DBT	Grid point weight generator output table.
Old Problem Tape	PH	See Problem Tape.
ØLØAD	IC	Request for output of external load vector.
ØMIT	IB	Omitted coordinate definition card.
ØMIT	P	Indicates no omitted coordinates.
ØMIT1	IB	*Omitted coordinate definition card.*
ØMITAX	IB	Omitted coordinate definition card for conical shell problems.
ØNLES	DBT	Output table for nonlinear element stresses (D-6).
Open Core	PH	A contiguous block of working storage defined by a labeled common block, whose length is a variable determined by the NASTRAN executive routine CØRSZ.
ØPG1	DBT	Static load output table (D-1, D-2, D-4, D-5, D-6).

ØPHID	DBT	Output table for complex eigenvectors - solution set (D-7).
ØPHIG	DBT	Eigenvector output table (D-3, D-5).
ØPHIH	DBT	Output table for complex eigenvectors - solution set (D-10).
ØPNL1	DBT	Output table for nonlinear loads - solution set, SØRT1 (D-9, D-12).
ØPNL2	DBT	Output table for nonlinear loads - solution set, SØRT2 (D-9, D-12).
ØPP1	DBT	Dynamic load output table (D-9, D-12).
ØPP2	DBT	Dynamic load output table - SØRT2 (D-9, D-12).
ØPPC1	DBT	Dynamic load output table - SØRT1, complex (D-8, D-11).
ØPPC2	DBT	Dynamic load output table - SØRT2, complex (D-8, D-11).
ØPTP	M	Old Problem Tape - a reserved NASTRAN physical unit (tape) which must be set up by the user when used.
ØQBG1	DBT	Forces of single-point constraint output table (D-4).
ØQG1	DBT	Single-point constraint force output table (D-1, D-2, D-4, D-5, D-6).
ØQP1	DBT	Single-point constraint force output table SØRT1 (D-9, D-12).
ØQP2	DBT	Single-point constraint force output table SØRT2 (D-9, D-12).
ØQPC1	DBT	Single-point constraint force output table - complex, SØRT1 (D-7, D-8, D-10, D-11).
ØQPC2	DBT	Single-point constraint force output table - complex, SØRT2 (D-7, D-8, D-10, D-11).
ØR	M	Parameter constant used in executive module PARAM.
ØRIGIN	IC	Locates origin for structure plot.
ØRTHØGRAPHIC	IC	Specifies orthographic projection for structure plot.
ØSCAR	PH	Operation sequence control array. Executive table residing on the Data Pool File which contains the sequence of operations to be executed for a problem solution. The ØSCAR is an expansion of a DMAP sequence, either input by the user or extracted from a rigid format, in internal format.
ØUBGV1	DBT	Displacement vector output table (D-4).
ØUDV1	DBT	Displacement vector output table - solution set, SØRT1 (D-9).
ØUDV2	DBT	Displacement vector output table - solution set, SØRT2 (D-9).
ØUDVC1	DBT	Displacement vector output table - solution set, SØRT1, complex (D-8, D-11).

ØUDVC2	DBT	Displacement vector output table - solution set, SØRT2, complex (D-8, D-11).
ØUGV1	DBT	Displacement output table (D-1, D-2, D-4, D-5, D-6).
ØUHV1	DBT	Displacement vector output table - solution set, SØRT1 (D-12).
ØUHV2	DBT	Displacement vector output table - solution set, SØRT2 (D-12).
ØUHVC1	DBT	Displacement vector output table - solution set, SØRT1, complex (D-11).
ØUHVC2	DBT	Displacement vector output table - solution set, SØRT2 complex (D-11).
ØUPV1	DBT	Displacement vector output table - SØRT1 (D-9, D-12).
ØUPV2	DBT	Displacement vector output table - SØRT2 (D-9, D-12).
ØUPVC1	DBT	Displacement vector output table - complex, SØRT1 (D-8, D-11).
ØUPVC2	DBT	Displacement vector output table - complex, SØRT2 (D-8, D-11).
ØUTPUT	FMX	This module is reserved for user implementation.
ØUTPUT	IC	Marks beginning of printer output request packet - optional.
Output Data Block	PH	A data block output from a module. A data block may be output from one and only one module. Having been output, it may be used as an input data block as many times as necessary.
ØUTPUT1	FMU	Writes data blocks on GINØ-written user tapes.
ØUTPUT2	FMU	Writes data blocks on FØRTRAN-written user tapes.
ØUTPUT3	FMU	Punches matrices on DMI cards.
ØUTPUT4	FMX	Dummy user output module.
ØUTPUT(PLØT)	IC	Marks beginning of output request packet for structure plots.
ØUTPUT(XYØUT)	IC	Marks beginning of output request packet for X-Y plots.
ØUTPUT(XYPLØT)	IC	Marks beginning of output request packet for X-Y plots.
ØVG	DBT	Output aeroelastic curve requests (V-g or V-f).

P	P	Parameter value used in MATGPR to print P-set matrices.
Packed Format	PH	A matrix is said to be in packed format if only the nonzero elements of the matrix are written.
PAPER SIZE	IC	Selects paper size for structure plots using table plotters.
PARAM	FMU	Performs specified operations on DMAP parameters.
PARAM	IB	Parameter definition card.
Parameter	PH	A FØRTRAN variable communicated to a DMAP module by the NASTRAN Executive System through blank common. A parameter's position in the DMAP calling sequence to a module corresponds to the position of the parameter in blank common at module execution time.
PARAML	FMU	Selects parameters from a user input matrix or table.
PARAMR	FMU	Performs specified operations on real or complex parameters.
PARTN	FMM	Matrix partitioning functional module.
PBAR	IB	Bar property definition card.
PBL	DBM	A scalar multiple of the PL load vector. Used only in the Differential Stiffness Rigid Format (D-4).
PBS	DBM	A scalar multiple of the PL load vector. Used only in the Differential Stiffness Rigid Format (D-4).
PCDB	DBT	Plot control data block (table for use with structure plotter functional module PLTSET).
PCØNEAX	IB	Conical shell element property definition card.
PDAMP	IB	Scalar damper property definition card.
PDF	DBM	Dynamic load matrix for frequency analysis.
PDT	DBM	Linear dynamic load matrix for transient analysis.
PDUMi	IB	Property definition card for dummy elements 1 through 9.
PELAS	IB	Scalar elastic property definition card.
PEN	IC	Selects pen size for structure plots using table plotters.
PENSIZE	IC	Selects pen size for X-Y plots using table plotters.
PERSPECTIVE	IC	Specifies perspective projection for structure plots.
PFILE	P	Parameter used by PLØT module.
PG	DBM	Incremental load vector used in Piecewise Linear Analysis (D-6).
PG	DBM	Statics load vector generated by SSG1.
PG1	DBM	Static load vector for Piecewise Linear Analysis (D-6).
PGG	DBM	Appended static load vector (D-1, D-2).

PGV1	DBM	Matrix of successive sums of incremental load vectors used only in Piecewise Linear Analysis Rigid Format (D-6).
PHASE	IC	Requests magnitude and phase form of complex quantities.
PHBDY	IB	Boundary element property definition card for heat transfer analysis.
PHIA	DBM	$[\phi_a]$ - Real eigenvectors - solution set.
PHID	DBM	$[\phi_d]$ - Complex eigenvectors - solution set, direct formulation.
PHIDH	DBM	$[\phi_{dh}]$ - Transformation matrix between modal and physical coordinates.

PHIG	DBM	$[\phi_g]$ - Real eigenvectors.
PHIH	DBM	$[\phi_h]$ - Complex eigenvectors - solution set, modal formulation.
PHIHL	DBM	Appended complex mode shapes - h-set.
Physical Points	PH	Grid points and extra scalar points introduced for dynamic analysis.
PIECEWISE LINEAR	IA	Selects rigid format for piecewise linear analysis.
Pivot Point	PH	The first word of each record of the GPCT and ECPT data blocks is called the pivot point.
PL	DBM	$\{P_\ell\}$ - Partition of load vector.
PLA	P	Used in printing rigid format error messages for Piecewise Linear Analysis (D-6).
PLA1	FMS	Piecewise Linear Analysis - phase 1.
PLA2	FMS	Piecewise Linear Analysis - phase 2.
PLA3	FMS	Piecewise Linear Analysis - phase 3.
PLA4	FMS	Piecewise Linear Analysis - phase 4.
PLACØUNT	P	Loop counter in Piecewise Linear Analysis (D-6).
PLALBL2A	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLALBL3	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLALBL4	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLCØEFFICIENT	IC	Selects the coefficient set for Piecewise Linear Analysis problems.
PLFACT	IB	Piecewise Linear Analysis factor definition card.
PLI	DBM	$\{P^i_\ell\}$ - Partition of inertia relief load vector.
PLØAD	IB	Pressure load definition (D-1, D-2, D-4, D-5, D-6).
PLØAD2	IB	Element pressure loading for two-dimensional elements (D-1, D-2, D-4, D-5, D-6).
PLØT	FMS	Structure plot generator.
PLØT	IC	Execution card for structure plotter.
PLØT$	M	Indicates restart with a structure plot request.
Plot Tapes	PH	Magnetic tapes containing NASTRAN generated data to drive offline plotters. PLT1 is the name of the BCD plot tape, used by the EAI 3500, and PLT2 is the name of binary plot tape, used by the SC-4020.
PLØTEL	IB	Plot element definition card used to define convenient reference lines in structure plots.
PLØTTER	IC	Used to select one of several available plotters for structure plotter.

PLØTX1	DBT	Messages from plot module concerning action taken by the structure plotter in processing undeformed structure plots.
PLØTX2	DBT	Messages from plot module concerning action taken by the structure plotter in processing deformed structure plots.
PLSETNØ	P	Set number on a PLFACT bulk data card chosen by the user in his case control deck. Used only in Piecewise Linear Analysis (D-6).
PLT1	M	A reserved NASTRAN physical unit (tape) which must be set up by the user when used - see Plot Tapes.
PLT2	M	A reserved NASTRAN physical unit (tape) which must be set up by the user when used - see Plot Tapes.
PLTFLG	P	Parameter used by PLØT module.
PLTPAR	DBT	Plot control table.
PLTSET	FMS	Plot set definition processor.
PLTSETX	DBT	Error messages for plot sets.
PLTTRAN	FMS	Prepares data blocks for acoustic analysis plots.
PLTTRAN	FMS	Transforms grid point definition tables for scalar points into a format for plotting.
PMASS	IB	Scalar mass property definition card.
PNLD	DBM	$\{P_d^n\}$ - Nonlinear loads in direct transient problem.
PNLH	DBM	$\{P_h^n\}$ - Nonlinear loads in modal transient problem.
PØ	DBM	$\{P_o\}$ - Partition of load vector.
PØI	DBM	$\{P_o^i\}$ - Partition of inertia relief load vector.
PØINT	IB	Eigenvalue analysis normalization option for eigenvectors - see EIGR, EIGC, EIGB cards.
PØINTAX	IB	Conical shell point used for data recovery.
PØØL	M	Pool tape used by file allocator.
PØUT$	M	Indicates restart with a printer output request.
PPF	DBM	Dynamic loads for frequency response.
PPHIG	DBM	Eigenvector components used to plot deformed shape. (D-3, D-5).
PPT	DBM	Linear dynamic loads for transient analysis.
PQDMEM	IB	Quadrilateral membrane element property definition card.
PQDMEM1	IB	Isoparametric quadrilateral membrane element property definition card.
PQDMEM2	IB	Quadrilateral membrane element property definition card.

PQDPLT	IB	Quadrilateral bending element property definition card.
PQUAD1	IB	General quadrilateral element property definition card.
PQUAD2	IB	Homogeneous quadrilateral element property definition card.
PREC	P	Precision of computer IBM = 2 UNIVAC CDC = 1
Preface	PH	Executive routines which are executed prior to the execution of the first module in a DMAP sequence. The Preface consists of the executive routines necessary to generate initial NASTRAN operational data and tables. The primary Preface routines are GNFIAT, XCSA, IFP1, XSØRT, IFP, IFP3, and XGPI.

PRESAX	IB	Defines static pressure loading for the conical shell element.
PRESPT	IB	Defines a point in a hydroelastic model for output purposes.
PRESSURE	IC	Request for output of pressure and displacement vector or eigenvector for a hydroelastic problem.
PRINT	PU	Controls printing of flutter summary.
Problem Tape	PH	A magnetic tape containing data necessary for NASTRAN problem restarts. A tape being generated is designated as the New Problem Tape (NPTP) and its content is largely controlled by the DMAP instruction CHKPNT. This same tape when used as input to a subsequent NASTRAN restart is designated as the Old Problem Tape (ØPTP).
PRØD	IB	Rod property definiton card.
PRØJECTIØN PLANE SEPARATIØN	IC	Separation of observer and projection plane for structure plots.
PRTMSG	FMS	Message generator.
PRTPARM	FMU	Prints DMAP diagnostic messages and parameter values.
PS	DBM	$\{P_s\}$ - Partition of static load vector.
PSDF	DBM	Power Spectral Density Function table.
PSDF	IC	Request for output of Power Spectral Density Function in Random Analysis (D-9, D-11).
PSDL	DBT	Power Spectral Density List.
Pseudo Modified Restart	PH	Restarting (see Restart) a NASTRAN problem and redirecting its solution but only affecting output data.
PSF	DBM	Partition of load vector for transient analysis.
PSHEAR	IB	Shear panel property definition card.
PST	DBM	Partition of linear load vector for transient analysis.
PTØRDRG	IB	Toroidal ring property definition card.
PRTBSC	IB	Basic bending triangular element property definition card.
PTRIA1	IB	General triangular element property definition card.
PTRIA2	IB	Homogeneous triangular element property definition card.
PTRMEM	IB	Triangular membrane element property definition card.
PTRPLT	IB	Triangular bending element property definition card.
PTUBE	IB	Tube property definition card.
PTWIST	IB	Twist panel property definition card.
PUBGV1	DBT	Displacement vector components used to plot deformed shape (D-4, D-5).
PUGV	DBT	Displacement vector components used to plot deformed shape (D-1, D-2).

PUGV1	DBT	Displacement components used to plot deformed shape (D-6).
PUNCH	IC	Output media request (PRINT or PUNCH).
PURGE	EM	DMAP statement which causes conditional purging of data blocks.
Purge	PH	A data block is said to be purged when it is flagged in the FIAT so that it will not be allocated to a physical file and so that modules attempting to access it will be signaled.
PVISC	IB	Viscous element property definition card.
PVT	PH	Parameter value table. The PVT contains BCD names and values of all parameters input by means of PARAM bulk data cards. It is generated by the preface module IFP and is written on the Problem Tape.
P1	PU	INPUTT2 rewind option.
P2	PU	INPUTT2 unit number.
P3	PU	INPUTT2 tape ID.
QBDY1	IB	Defines uniform heat flux into HBDY elements.
QBDY2	IB	Defines grid point heat flux into HBDY elements.
QBG	DBM	Single point forces of constraint in the Differential Stiffness Rigid Format (D-4).
QDMEM	IC	Requests structure plot for all QDMEM elements.
QDMEM1	IC	Requests structure plot for all QDMEM1 elements.
QDMEM2	IC	Requests structure plot for all QDMEM2 elements.
QDPLT	IC	Requests structure plot for all QDPLT elements.
QG	DBM	Constraint forces for all grid points.
QHBDY	IB	Defines thermal load for steady-state heat conduction.
QHHL	DBML	Aerodynamic matrix list - h-set.
QJHL	DBML	Aerodynamic transformation matrix between h and j sets.
QP	DBM	Constraint forces for all physical points.
QPC	DBM	Complex single point forces of constraint for all physical points.
QR	DBM	$\{q_r\}$ - Determinant support forces.
QS	DBM	$\{q_s\}$ - Single-point constraint forces.
QUAD1	IC	Requests structure plot for all QUAD1 elements.
QUAD2	IC	Requests structure plot for all QUAD2 elements.
QVECT	IB	Defines thermal vector flux from distant source.
QVØL	IB	Defines volume heat generation.

R	P	Parameter value used by MATGPR to print R-set matrices.
R1	IC	Request for X-Y plot of the first rotational component (UM-4.2).
R1IP	IC	Request for X-Y plot of the first rotational component - imaginary and phase angle (UM-4.2).
R1RM	IC	Request for X-Y plot of the first rotational component - real and magnitude (UM-4.2).
R2	IC	Request for X-Y plot of the second rotational component (UM-4.2).
R2IP	IC	Request for X-Y plot of the second rotational component - imaginary and phase angle (UM-4.2).
R2RM	IC	Request for X-Y plot of the second rotational component - real and magnitude (UM-4.2).
R3	IC	Request for X-Y plot of the third rotational component (UM-4.2).
R3IP	IC	Request for X-Y plot of the third rotational component - imaginary and phase angle (UM-4.2).
R3RM	IC	Request for X-Y plot of the third rotational component - real and magnitude (UM-4.2).
RADLIN	P	Controls linearization of radiation effects in transient heat transfer analysis.
RADLST	IB	List of radiation areas.
RADMTX	IB	Radiation exchange coefficients.
RANDØM	IC	Selects the RANDPS and RANDT cards to be used in random analysis.
RANDØM	FMS	Random response solution generator.
RANDPS	IB	Power spectral density specification.
RANDT1	IB	Autocorrelation function time lag.
RANDT2	IB	Autocorrelation function time lag.
RBMG1	FMS	Rigid body matrix generator - part 1.
RBMG2	FMS	Rigid body matrix generator - part 2.
RBMG3	FMS	Rigid body matrix generator - part 3.
RBMG4	FMS	Rigid body matrix generator - part 4.
READ	FMS	Real Eigenvalue Analysis - Displacement.
REAL	IC	Requests real and imaginary form of complex quantities.
REAL EIGENVALUES	IA	Selects rigid format for normal mode analysis.
REEL	IA	Term appearing on the checkpoint dictionary cards indicating the physical reel on which a data block appears.

Reentry Point	PH	The point in the DMAP sequence at which a problem terminated and hence the point at which it can be restarted (see Restart).
REGIØN	IC	Specifies portion of frame to be used for structure plot.
REIG	P	Parameter used in SDR2 to indicate Normal Mode Analysis (D-3).
REPCASE	IC	Allows another output request for the previous subcase (D-1, D-2).
REPEAT	P	Controls looping in Static Analysis (D-1, D-2).
REPEATD	P	Controls looping in Static Analysis with Differential Stiffness (D-4).
REPEATE	P	Controls looping in Complex Eigenvalue Analysis (D-7, D-10).
REPEATF	P	Controls looping in Frequency Response Analysis (D-8, D-11).
REPEATT	P	Controls looping in Transient Response Analysis (D-9, D-12).
REPT	EM	DMAP statement to conditionally repeat a loop.
RESPØNSE	I′	Request for X-Y plot of any response outputs from transient or frequency response analysis (D-8, D-9, D-11, D-12).
RESTART	IA	First control card of checkpoint dictionary. Contains identification of checkpoint tape.
Restart	PH	Initiating a NASTRAN problem solution at a place other than its logical beginning by utilizing an Old Problem Tape created during a previous run.
RFØRCE	IB	Rotational force definition card.
RFØRCE$	M	Indicates restart with change in rotational force.
RG	DBM	Multipoint constraint equations.
RIGHT TICS	IC	Request for tic marks to be plotter on right hand edge of frame for X-Y plots.
Rigid Format	PH	A fixed prestored DMAP sequence and its associated restart tables which perform a specific problem solution.
Rigid Format Switch	PH	A type of restart (see Restart) in which the problem is changed from one Rigid Format to another.
RINGAX	IB	Conical shell ring definition card.
RINGFL	IB	Hydroelastic axisymmetric point definition card.
RLØAD1	IB	Frequency response load set definition.
RLØAD2	IB	Frequency response load set definition.
RMG	FMH	Radiation matrix generator - generates $[R_{gg}]$.
RØD	IC	Requests structure plot for all RØD elements.
RUBLV	DBM	Residual vector - Differential Stiffness Rigid Format (D-4).

RULV	DBM	Residual vector for independent degrees of fredom.
RUØV	DBM	Residual vector for omitted degrees of freedom.
RXY	IC	Requests vector sum of X and Y deformation components for structure plot.
RXYZ	IC	Requests vector sum of X, Y and Z deformation components for structure plot.
RXZ	IC	Requests vector sum of X and Z deformation components for structure plot.
RYZ	IC	Requests vector sum of Y and Z deformation components for structure plot.

S	P	Parameter value used by MATGPR to print S-set matrices.
SACCE	IC	Abbrecivated form of SACCELERATIØN.
SACCELERATIØN	IC	Output request for solution set acceleration vector. (UM-2.3, 4.2)
SAVE	EM	DMAP statement which causes current value of parameter to be saved.
SAVE	M	Save data block for possible looping in DMAP sequence (see FILE).
SC	IC	Selects SC 4020 plotter.
Scalar Point	PH	A point which is defined on an SPØINT, CELAS1, CELAS2, CELAS3, CELAS4, CMASS1, CMASS2, CMASS3, CMASS4, CDAMP1, CDAMP2, CDAMP3, or CDAMP4 bulk data card. A scalar point has no geometrical coordinates and defines only one degree of freedom of the model.
SCALE	IC	Selects scale for structure plot.
SCE1	FMS	Single-point Constraint Eliminator.
SDAMP	IC	Modal structural damping table selection.
SDAMP$	M	Indicates restart with change in modal damping.
SDAMPING	IC	Selects table which defines damping as a function of frequency in modal formulation problems.
SDISP	IC	Abbreviated form of SDISPLACEMENT.
SDISPLACEMENT	IC	Output request for solution set displacement vector. (UM-2.3, 4.2)
SDR1	FMS	Stress Data Recovery - part 1.
SDR2	FMS	Stress Data Recovery - part 2.
SDR3	FMS	Stress Data Recovery - part 3.
SDRHT	FMH	Heat flux data recovery.
SECTAX	IB	Defines conical shell sector for data recovery.
SEEMAT	FMU	Prints pictorial representation of matrix showing location of nonzero elements.
SEM1	M	The NASTRAN Preface.
SEQEP	IB	Extra point resequencing.
SEQGP	IB	Grid or scalar point resequencing.
SET	IC	Definition of a set of elements, grid and/or scalar and/or extra points, frequencies, or times to be used in selecting output.
SET1	IB	Defines a set of structural grid points by a list.
SET2	IB	Defines a set of structural grid points by aerodynamic macro elements.
SETVAL	FMU	Parameter value initiator.
SHEAR	IC	Requests structure plot for all shear panel elements.

SIGMA	P	Defines Stefan-Boltzmann constant in heat transfer analysis.
SIL	DBT	Scalar Index List for all grid points.
SILA	DBT	Scalar Index List - Aerodynamics.
SILD	DBT	Scalar Index List for all grid points and extra scalar points introduced for dynamic analysis.
SILGA	DBT	Scalar Index List - Aerodynamic boxes only.
SINE	IC	Conical shell request for sine set boundary conditions.
SINGLE	P	No single-point constraints.
SKIP BETWEEN FRAMES	IC	Request to insert blank frames on SC 4020 plotter for X-Y plots.
SKJ	DBM	Integration matrix.
SKPMGG	P	Parameter used in statics to control execution of functional module SMA2.
SLBDY	IB	Defines list of points on interface between axisymmetric fluid and radial slots.
SLØAD	IB	Scalar point load definition.
SLT	DBT	Static Loads Table.
SMA1	FMS	Structural Matrix Assembler - phase 1 - generates stiffness matrix $[K_{gg}]$ and structural damping matrix $[K^4_{gg}]$.
SMA2	FMS	Structural Matrix Assembler - phase 2 - generates mass matrix $[M_{gg}]$ and viscous damping matrix $[B_{gg}]$.
SMA3	FMS	Structural Matrix Assembler - phase 3 - add general element contributions to the stiffness matrix $[K_{gg}]$.
SMP1	FMS	Structural Matrix Partitioner - part 1.
SMP2	FMS	Structural Matrix Partitioner - part 2.
SMPYAD	FMM	Performs multiply-add matrix operation for up to five multiplications and one addition.
SØL	IA	Specifies which rigid format solution is to be used when APP is DISPLACEMENT.
Solution Points	PH	Points used in the formulation of the general K system.
SØLVE	FMM	Solves a set of linear algebraic equations.
SØRT1	IC	Output is sorted by frequency or time and then by external ID.
SØRT2	IC	Output is sorted by external ID and then by frequency or time.
SØRT3	M	Output is sorted by individual item or component and then by frequency or time.
SPC	IB	Single-point constraint and enforced deformation definition.

SPC	IC	Single-point constraint set selection.
SPC$	M	Indicates restart with change in single-point constraint set selection.
SPC1	IB	Single-point constraint definition.
SPCADD	IB	Single-point constraint set combination definition.
SPCAX	IB	Conical shell single-point constraint definition.
SPCF	IC	Abbreviated form of SPCFØRCE.
SPCFØRCE	IC	Single-point constraint force output request. (UM-2.3,4.2)
Spill	PH	Secondary storage devices are used because there is insufficient main storage to perform a matrix calculation or a data processing operation.
SPLINE	DBT	Splining Data Table.
SPLINE1	IB	Defines surface spline.
SPLINE2	IB	Defines beam spline.
SPØINT	IB	Scalar point definition card.
SSG1	FMS	Static Solution Generator - part 1.
SSG2	FMS	Static Solution Generator - part 2.
SSG3	FMS	Static Solution Generator - part 3.
SSG4	FMS	Static Solution Generator - part 4.
SSGHT	FMH	Solution generator for nonlinear heat transfer analysis.
STATIC	IC	Requests deformed structure plot for problem in Static Analysis.
STATICS	IA	Selects statics rigid format for heat transfer or structural analysis.
STATICS	P	Parameter used in SDR2 to indicate Static Analysis.
STEADY STATE	IA	Selects rigid format for nonlinear static heat transfer analysis.
STEREØSCØPIC	IC	Requests stereoscopic projections for structure plot.
STRESS	IC	Element stress output request. (UM-2.3, 4.2)
Structural Element	PH	One of the finite elements used to represent a part of a structure.
SUBCASE	IC	Subcase definition.
SUBCØM	IC	This subcase is a linear combination of previous subcases.
SUBSEQ	IC	Specifies coefficients for SUBCØM subcases.
SUBTITLE	IC	Output labeling data for printer output.
SUPAX	IB	Ficticious support for conical shell problem.

SUPØRT	IB	Ficticious support definition card.
SVECTØR	IC	Request for output of eigenvectors in the solution set (D-7, D-10) (UM-2.3, 4.2).
SVELØ	IC	Abbreviated form of SVELØCITY.
SVELØCITY	IC	Requests velocity output for solution set. (UM-2.3, 4.2)
SYM	IC	Symmetry subcase delimiter card.
SYMBØLS	IC	Requests symbols at grid points on structure plot.
SYMCØM	IC	Assembly of symmetry subcase delimiter card.
SYMSEQ	IC	Assembly value of symmetry combination card.

T1	IC	Request for X-Y plot of the first translational component (UM-4.2).
T1IP	IC	Request for X-Y plot of the first translational component - imaginary and phase angle (UM-4.2).
T1RM	IC	Request for X-Y plot of the first translational component - real and magnitude (UM-4.2).
T2	IC	Request for X-Y plot of the second translational component (UM-4.2).
T2IP	IC	Request for X-Y plot of the second translational component - imaginary and phase angle (UM-4.2).
T2RM	IC	Request for X-Y plot of the second translational component - real and magnitude (UM-4.2).
T3	IC	Request for X-Y plot of the third translational component (UM-4.2).
T3IP	IC	Request for X-Y plot of the third translational component - imaginary and phase angle (UM-4.2).
T3RM	IC	Request for X-Y plot of the third translational component - real and magnitude (UM-4.2).
TA1	FMS	Table Assembler.
TABDMP1	IB	Tabular structural damping function for modal formulation (D-10, D-11, D-12).
Table Data Block	PH	A data block which is in tabular form rather than matrix form.
TABLED1	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED2	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED3	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED4	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLEM1	IB	Material property tabular function.
TABLEM2	IB	Material property tabular function.
TABLEM3	IB	Material property tabular function.
TABLEM4	IB	Material property tabular function.
TABLES1	IB	Stress-dependent material tabular function for use in Piecewise Linear Analysis (D-6).
TABPCH	FMU	Punches selected tables on DTI bulk data cards.
TABPRT	FMU	Formats selected table data blocks for printing.
TABPT	FMU	Table printer.
TABRND1	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABRND2	IB	Tabular function for use in Random Analysis (D-8, D-11).

TABRND3	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABRND4	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABS	P	Defines absolute reference temperature in heat transfer analysis.
TALL EDGE TICS	IC	Request for plotting all edge tic marks on upper half frame for X-Y plots.
TAPE	M	Write data block on physical tape (see FILE).
TCURVE	IC	Curve title for X-Y plot.
TEMP	IB	Grid temperature definition card.
TEMPAX	IB	Temperature definition for conical shell problem.
TEMPD	IB	Grid default temperature definition card.
TEMPERATURE	IC	Selects the temperature set to be used in both material property calculation and thermal loading.
TEMPLD$	M	Indicates restart with change in thermal set for static loading.
TEMPMT$	M	Indicates restart with change in thermal set for material properties.
TEMPMX$	M	Indicates restart with change in thermal field with thermally dependent material properties.
TEMP(LØAD)	IC	Temperature set selection (applies to thermal load generation only).
TEMP(MAT)	IC	Temperature set selection (applies to material properties only).
TEMPP1	IB	Plate element temperature definition card.
TEMPP2	IB	Plate element temperature definition card.
TEMPP3	IB	Plate element temperature definition card.
TEMPRB	IB	One-dimensional element temperature definition.
TF	IB	Dynamic transfer function definition.
TF$	M	Indicates restart with change in transfer function set selection.
TFL	IC	Transfer function set selection.
TFPØØL	DBT	Transfer function pool.
THERMAL	IC	Request for output of temperature vector in thermal analysis (UM-2.3).
THRU	IC	Forms strings of values within set declarations.
TIC	IB	Transient Initial Condition set definition card.

TIME	IA	User time estimate for problem. This card is required in Executive Control Deck. Integer time value is in minutes.
TITLE	IC	Output labeling data for printer output.
TLEFT TICS	IC	Request for tic marks to be plotted on left hand edge of top half frame for X-Y plot.
TLØAD1	IB	Transient load set definition card.
TLØAD2	IB	Transient load set definition card.
Trailer	PH	A six word control block associated with a data block.
TRANRESP	P	Parameter used in SDR2 to indicate Transient Response Analysis (D-9, D-12).
TRANSIENT	IA	Selects rigid format for transient heat transfer analysis.
TRBSC	IC	Requests structure plot for all basic bending triangle elements.
TRD	FMS	Transient Response - Displacement.
TRHT	FMH	Integrates dynamic equation for heat transfer analysis.
TRIA1	IC	Requests structure plot for all TRIA1 elements.
TRIA2	IC	Requests structure plot for all TRIA2 elements.
TRIGHT TICS	IC	Request for tic marks to be plotted on right hand edge of top half frame for X-Y plots.
TRL	DBT	Transient Response List.
TRLG	FMH	Generates dynamic heat flux loads.
TRMEM	IC	Requests structure plot for all triangular membrane elements.
TRNSP	FMM	Transpose functional module.
TRPLT	IC	Request structure plot for all TRPLT elements.
TSTART	P	CPU time at start of flutter loop.
TSTEP	IB	Transient time steps for integration and output.
TSTEP	IC	Transient time step set selection.
TSTEP$	M	Indicates restart with change in transient time step set selection.
TUBE	IC	Requests structure plot for all TUBE elements.
TWIST	IC	Requests structure plot for all TWIST elements.
TYPE	IC	Indicates paper type for structure plots.

UBGV	DBM	Displacement vector for all grid points (D-4).
UBLL	DBM	$[U^b_{\ell\ell}]$ - Upper triangular factor of $[K^b_{\ell\ell}]$.
UBLV	DBM	Displacement solution vector (D-4).
UBØØV	DBM	Scalar multiple of UØØV in Differential Stiffness Rigid Format (D-4).
UDET	IB	Selects unsymmetric decomposition option for determinant method of real eigenvalue analysis.
UDV1T	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem - SØRT1. (D-9)
UDV2T	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem - SØRT2 (D-9).
UDVF	DBM	Displacement solution vector in a frequency response problem (D-8).
UDVT	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem (D-9).
UEVF	DBM	Displacement vector for extra points in a frequency response problem (D-11).
UEVT	DBM	Displacement vector for extra points in a transient response problem (D-12).
UGV	DBM	Displacement vector for all grid points (D-1, D-2, D-4, D-5).
UGV1	DBM	Successive sums of incremental displacement vectors. Piecewise Linear Analysis Rigid Format only (D-6).
UHVF	DBM	Modal frequency response solution vectors (D-11).
UHVT	DBM	Modal transient response solution vectors (D-12).
UINV	IB	Selects unsymmetric decomposition option for inverse power method of eigenvalue analysis.
ULL	DBM	$[U_{\ell\ell}]$ - Upper triangular factor of $[K_{\ell\ell}]$.
ULV	DBM	Displacement solution vector in static analyses (D-1, D-2, D-4, D-5).
UMERGE	FMM	Functional module to merge column matrices based on U-set.
UMF	IA	Requests User Master File as input source.
UMF	M	User Master File, a reserved NASTRAN physical unit (tape) which must be set up by the user when used.
UMFEDIT	IA	Requests User Master File operational mode of NASTRAN.
Unmodified Restart	PH	Restarting (see Restart) a problem without changing any data, other than output requests, of the previous run.
Unpool	PH	Remove data block from Pool Tape and place on a file for use by a functional module.
UNSØRT	IC	Requests unsorted echo of Bulk Data Deck (ECHØ=UNSØRT).

UØØ	DBM	$[U_{oo}]$ - Upper triangular factor of $[K_{oo}]$.
UØØV	DBM	Partition of displacement solution vector.
UPARTN	FMM	Functional module to partition matrices based on U-set.
UPPER TICS	IC	Request for tic marks to be plotted on upper edge of frame for X-Y plot.
UPV	DBM	Transient solution vectors for all physical points.
UPVC	DBM	Frequency response solution vectors for all physical points.
USET	DBT	Displacement set definitions. (PM-1.7.3)
USETA	DBT	Displacement set definitions table - Aerodynamics.
USETD	DBT	Displacement set definitions including extra scalar points introduced by dynamic analysis. (PM-1.7.3)
V	M	Used in parameter section of DMAP statement. Indicates that parameter is variable and may be changed by module. If changed value is to be used in subsequent DMAP instruction, it must be saved (see SAVE).
VANTAGE PØINT	IC	Location of observer for structure plot.
VDR	FMS	Vector Data Recovery.
VEC	FMU	Creates partitioning vector based on USET.
VECTØR	IC	Request for output of eigenvectors from real or complex eigenvalue analysis (D-3, D-5, D-7, D-10).
VECTØR	IC	Requests deformations on structure plot with vectors.
VELØ	IC	Abbreviated form of VELØCITY.
VELØCITY	IC	Output request statement for velocity vector. (UM-2.3, 4.2)
VFS	DBM	Partitioning vector for heat transfer analysis.
VIEW	IC	Rotation of object for structure plot.
VISC	IC	Request structure plot for all viscous damper element.
VPS	M	See XVPS.
VREF	PU	Velocity division factor.
W3	P	Pivotal frequency for uniform structure damping in the direct formulation of transient response problems (D-9).
W4	P	Pivotal frequency for element structural damping in the direct formulation of transient response problems (D-9).
WTMASS	P	Weight to mass conversion factor used in SMA2 and GPWG. Default value is 1.0.

X	IC	Requests X vector for deformed structure plot.
XAXIS	IC	Request for drawing of X-axis for X-Y plot.
XBAXIS	IC	Request for drawing of X-axis on bottom half frame for X-Y plot.
XBGRID LINES	IC	Request for drawing grid lines for X-axis on bottom half frame for X-Y plot.
XCSA	EM	Executive Control Section Analysis. The preface module which processes the Executive Control Deck and prepares the control file on the New Problem Tape.
XDIVISIØNS	IC	Request for division marking on X-axis.
XGPI	EM	Executive General Problem Initialization. The preface module whose principal function is to generate the ØSCAR. If the problem is a restart, XGPI initializes data blocks and named common blocks for proper restart.
XGRID LINES	IC	Request for grid lines to be drawn on X-axis for X-Y plots.
XINTERCEPT	IC	Specifies intercept of Y-axis on X-axis.
XLØG	IC	Request for logarithmic scales in X-direction.
XMAX	IC	Do not plot points whose X value lies above this value.
XMIN	IC	Do not plot points whose X value lies below this value.
XPAPER	IC	Specifies length of paper in X-direction for table plotter.
XQHHL	P	Appended QHHL data parameter.
XSFA	EM	Executive Segment File Allocator - the administrative manager of data blocks for NASTRAN.
XSØRT	EM	Executive sort routine - the preface module which reads and sorts the Bulk Data Deck and writes the sorted Bulk Data Deck on the New Problem Tape.
XTAXIS	IC	Request for drawing of X-axis on top half frame.
XTGRID LINES	IC	Request for drawing of grid lines on top half frame.
XTITLE	IC	X-axis title for X-Y plots.
XVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
XVPS	M	Variable Parameter Set Table. Executive table needed for restart. (PM-2.4)
XY	IC	Requests X and Y vectors for deformed structure plot.
XYCDB	DBT	SØRT3 type output requests (XYPLØTTER, XYPRINTER, Random Request).
XYØUT	IC	Request to generate X-Y plots.
XYØUT$	M	Indicates restart with an X-Y plot request.
XYPEAK	IC	Request to print the maximum and minimum values of the specified response.

XYPLØT	FMS	X-Y plot generator.
XYPLØT	IC	Request to generate X-Y plots.
XYPLTF	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTFA	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTR	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTT	DBT	XYPLØT input data block. (D-9, D-12)
XYPLTTA	DBT	XYPLØT input data block. (D-9, D-12)
XYPRINT	IC	Request to tabulate XY pairs on the printer.
XYPRNPLT	FMU	Dummy output module.
XYPUNCH	IC	Request to punch XY pairs.
XYTRAN	FMS	XY output translator.
XYZ	IC	Requests X, Y and Z vectors for deformed structure plot.
XZ	IC	Requests X and Z vectors for deformed structure plot.

Y	IC	Requests Y vector for deformed structure plot.
Y	M	Used in parameter section of DMAP statement. Indicates that parameter may be given an initial value with a PARAM bulk data card.
YAXIS	IC	Request for drawing of Y-axis.
YBDIVISIØNS	IC	Request for division marking on Y-axis of lower half frame.
YBGRID LINES	IC	Request for grid lines to be drawn on Y-axis of lower half frame.
YBINTERCEPT	IC	Specifies intercept of X-axis on Y-axis on lower half frame.
YBLØG	IC	Request for logarithmic scales in Y-direction on lower half frame.
YBMAX	IC	Do not plot points whose Y value lies above this value for lower half frame.
YBMIN	IC	Do not plot points whose Y value lies below this value for lower half frame.
YBS	DBM	Scalar multiple of YS matrix. Used in Differential Stiffness Rigid Format only. (D-4).
YBTITLE	IC	Y-axis title on lower half frame.
YBVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
YDIVISIØNS	IC	Request for division marking on Y-axis.
YES	IA	Option used on CHKPNT card, indicates that checkpoint is desired.
YGRID LINES	IC	Request for grid lines to be drawn on Y-axis.
YINTERCEPT	IC	Specifies intercept of X-axis on Y-axis.
YLØG	IC	Request for logarithmic scales in Y-direction.
YMAX	IC	Do not plot points whose Y value lies above this value.
YMIN	IC	Do not plot points whose Y value lies below this value.
YPAPER	IC	Specifies length of paper in Y-direction for table plotter.
YS	DBM	$\{Y_s\}$ - Constrained displacement vector.
YTDIVISIØNS	IC	Request for division marking on Y-axis for upper half frame.
YTGRID LINES	IC	Request for grid lines to be drawn on Y-axis for upper half frame.
YTINTERCEPT	IC	Specifies intercept of X-axis on Y-axis for upper half frame.
YTITLE	IC	Y-axis title.
YTLØG	IC	Request for logarithmic scales in Y-direction for upper half frame.

YTMAX	IC	Do not plot points whose Y value lies above this value for upper half frame.
YTMIN	IC	Do not plot points whose Y value lies below this value for upper half frame.
YTITLE	IC	Y-axis title for upper half frame.
YTVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval for upper half frame.
YVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
YZ	IC	Requests Y and Z vectors for deformed structure plot.
	IC	Requests Z vector for deformed structure plot.

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THE NASTRAN® USER'S MANUAL

(Level 16.0 Supplement)

July 1976

Scientific and Technical Information Office
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

A new SØF composed of five physical files would be declared as follows:

```
SØF(1)=SØF1,200,NEW
SØF(2)=SØF2,200
SØF(3)=SØF3,400
SØF(4)=SØF4,600
SØF(5)=SØF5,700
```

All data stored on the SØF is accessed via the substructure name. For each substructure, various types of SØF data may be stored. These types of data are called items and are accessed via their item names. Thus, the substructure name and item name are all that is required to access any block of data on the SØF. The items which can be stored for any substructure are described in Table 2. The program automatically keeps track of the data, stores the data as it is created, and retrieves these data when required. The user's only responsibility is to maintain the file. It must be accessible by the system when needed. The user must remove items already created in the event input errors were detected during processing or if that data is no longer needed for subsequent analyses.

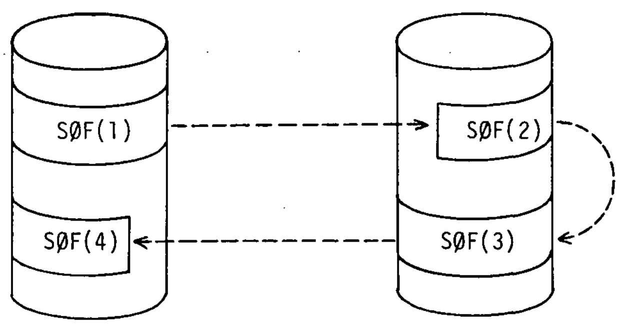


Figure 4. Substructure Operating File (SØF).

1.14.3 <u>The Case Control Deck for Substructuring Analyses</u>

The Case Control Deck controls loading conditions, constraint set selection, output requests, and so forth in a substructuring analysis just as in a non-substructuring analysis. However, in a substructuring analysis, there are very important relationships among the Case Control Decks to be input for the three Phases of a substructuring analysis. Compatibility among the substructuring Phases must be maintained for load sets, constraint sets, and subcase definitions. This section will describe how the Case Control Deck should be used for each of the three Phases.

1.14.3.1 Phase 1

The following requirements must be satisfied by the Case Control Deck in Phase 1:

1. Constraint set selections (MPC, SPC) must be above the subcase level. That is, only one set of constraints is allowed in Phase 1 for all loading conditions.

2. One subcase must be defined for each loading condition which is to be saved on the SØF. The loading condition may consist of any combination of external static loads, thermal loads, element deformation loads, or enforced displacements. Loading conditions which are not saved on the SØF in Phase 1 cannot be used in any solution in Phase 2.

1.14.3.2 Phase 2

The Phase 2 Case Control Deck is exactly like the Case Control used in a non-substructuring analysis. It is only needed, however, if plots are requested or when there is a SØLVE command in the Substructure Control Deck. In this latter case, the subcase definitions, load and constraint set selections, etc. are used in the usual fashion to control the solution process.

Case Control output requests are honored only if there is a PRINT subcommand under the RECØVER command in the Substructure Control Deck. If a RECØVER command with a PRINT or SAVE subcommand is used for a solution obtained in a previous execution, the Case Control should be identical (except for output requests) to that used to obtain that solution.

1.14.3.3 Phase 3

The following requirements must be satisfied by the Case Control Deck in Phase 3:

1. Constraint sets (MPC, SPC) must be identical to those used in Phase 1 for this substructure.

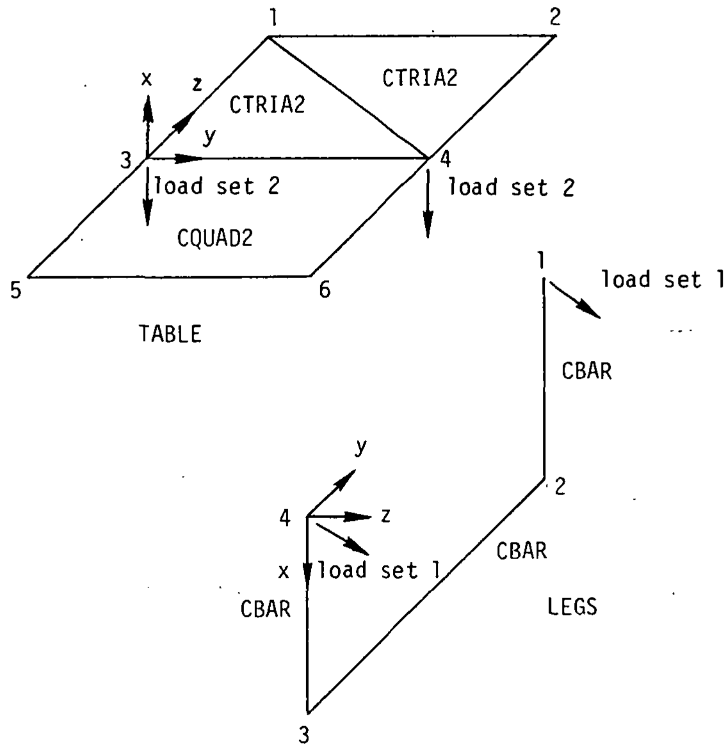
2. The subcase definition for load set IDs must be identical to those used in Phase 1 for this substructure including those for appended loads, if any. All load definitions must appear in the order generated.

3. The subcase definition for the Phase 3 output requests for solution vectors generated in Phase 2 must be merged with the above subcase definition for load set IDs. Note, the ØLØAD output requested in Phase 3 will correspond to the load factors defined during Phase 2 solution, <u>not</u> those defined by Phase 3 Case Control.

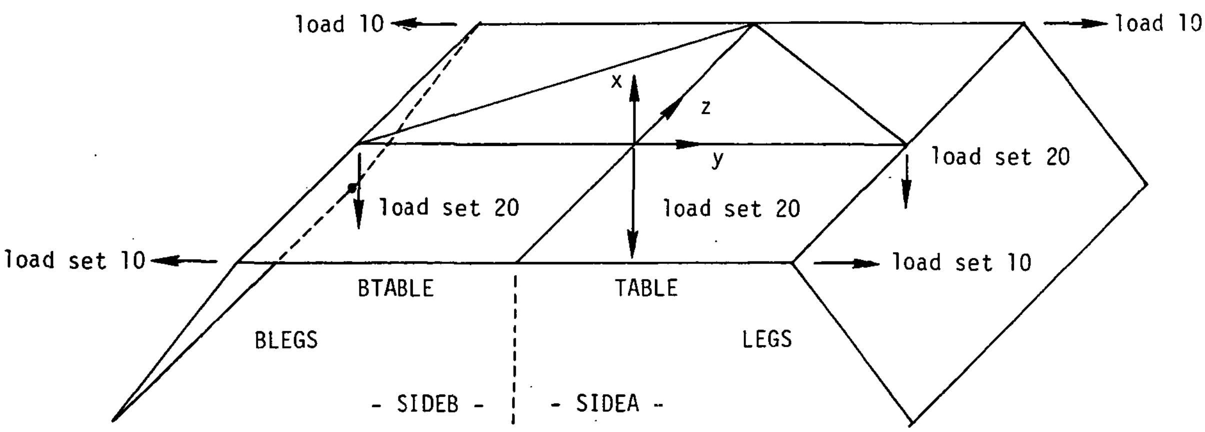
The number of Phase 3 subcases required is the maximum of those defined in Phase 1 and Phase 2. All output requests will correspond to the Phase 2 subcase sequence, starting with the first subcase defined in Phase 3. It is essential to assign the same thermal and element deformation loadings to the same subcase in both Phase 1 and Phase 2 in order to provide the correct Phase 1 load data to the Phase 3 output processing of element stresses.

1.14.4 Example of Substructure Analysis

This example illustrates a simple substructuring analysis. Figure 5a shows two basic substructures, TABLE and LEGS. Note that these structures have different basic coordinate systems as shown in the figure. Figure 5b shows a combined structure which is assembled from the basic substructures. The entire data decks to generate and analyze this structure are listed in Tables 3 - 6. These include the data for the generation of the basic substructures in Phase 1, the assembly of the complete structure, solution, and data recovery in Phase 2, and the data recovery in Phase 3. The remainder of this section is devoted to a detailed description of each of the data decks used in this analysis.



a. Phase 1 basic substructures.



b. Phase 2 combined substructure.

Figure 5. Substructure example problem.

2.1 GENERAL DESCRIPTION OF DATA DECK

The input deck begins with the required resident operating system control cards. The type and number of these cards will vary with the installation. Instructions for the preparation of these control cards should be obtained from the programming staff at each installation.

The operating system control cards are followed by the NASTRAN Data Deck (see Figure 1), which is constructed in the following order (depending on the particular job requirements):

1. The NASTRAN Card
2. The Executive Control Deck
3. The Substructure Control Deck
4. The Case Control Deck
5. The Bulk Data Deck
6. The INPUT Module Data Card(s)

The NASTRAN card is used to change the default values for certain operational parameters, such as buffer size and machine model number. The NASTRAN card is optional, but, if present, it must be the first card of the NASTRAN Data Deck. The NASTRAN card is a free-field card (similar to cards in the Executive Control Deck). Its format is as follows:

$$\text{NASTRAN keyword}_1 = \text{value, keyword}_2 = \text{value, . . .}$$

The most frequently used keywords are as follows:

1. BUFFSIZE - Defines the number of words in a GINØ buffer. Usually this value is standardized at any particular installation. However, the desired value may be different from the default value of 1803 (IBM), 1183 (CDC) and 871 (UNIVAC). In any event, related runs, such as restarts and User Master File runs, must use the same BUFFSIZE for all parts of the runs.

2. CØNFIG - Defines the model number of the configuration for use in timing equations for matrix operations. Entries exist for the following configurations:

MACHINE	CØNFIG	MØDEL NØ.
IBM 360/370	0 (default)	91, 95
	3	50
	4	65
	5	75
	6	85
	7	195
	9	155
	10	165

MACHINE	CØNFIG	MØDEL NØ.
CDC 6000	0 (default)	6600
	6	6400
UNIVAC 1100	0 (default)	1108/1110

The machine type is automatically determined by NASTRAN. If the model number is the default, the CØNFIG keyword is not needed on the NASTRAN card. It is important to indicate the proper configuration; otherwise, all time-dependent matrix decisions will be incorrect.

3. MØDCØM(i) - Defines a nine-word array for module communications. Currently, only MØDCØM(1) is supported. If MØDCØM(1) = 1, diagnostic statistics from subroutine SDCØMP are printed.

4. HICØRE - Defines the amount of open core available to the user on the UNIVAC 1100 series machines. The user area default is nominally 65K decimal words. The ability to increase this value may be installation limited.

5. FILES - Establishes NASTRAN permanent files as being disk files rather than tape files. The FILES are PØØL, ØPTP, NPTP, UMF, NUMF, PLT1, PLT2, INPT, INP1, ... INP9. Multiple file names must be enclosed with parentheses such as FILES = (UMF,NPTP). The FILES parameter(s) must be last on the NASTRAN card. Note the plot files, PLT1 and PLT2, are not supported on the UNIVAC, therefore a physical tape must be assigned prior to job execution.

Additional information for all NASTRAN card options is given in Section 6.3.1 of the Programmer's Manual.

The Executive Control Deck begins with the NASTRAN ID card and ends with the CEND card. It identifies the job and the type of solution to be performed. It also declares the general conditions under which the job is to be executed, such as, maximum time allowed, type of system diagnostics desired, restart conditions, and whether or not the job is to be checkpointed. If the job is to be executed with a rigid format, the number of the rigid format is declared along with any alterations to the rigid format that may be desired. If Direct Matrix Abstraction is used, the complete DMAP sequence must appear in the Executive Control Deck. The executive control cards and examples of their use are described in Section 2.2.

2.7 SUBSTRUCTURE CONTROL DECK

The Substructure Control Deck options provide the user commands needed to control the execution of NASTRAN for automated multi-stage substructure analyses. These commands are input on cards with the same format conventions as are used for the normal NASTRAN Case Control Deck.

Initiation of a substructure analysis is achieved via the Executive Control Deck command (see Section 2.1):

APP DISPLACEMENT,SUBS

This command directs NASTRAN to automatically generate the required DMAP sequence of alters to the specified Rigid Format necessary to perform the operations requested in the Substructure Control Deck. Following the Substructure Control Deck in the NASTRAN input data stream comes the standard Case Control Deck which specifies the loading conditions, omit sets, method of eigenvalue extraction, element sets for plotting, plot control, and output requests, etc.

The Substructure Control Deck commands are summarized in Table 1 where they are listed under one of three categories according to whether they:

1. Specify the phase and mode of execution
2. Specify the substructuring matrix operations
3. Define and control the substructure operating file (SØF)

Several commands have associated with them a set of subcommands used to specify additional control information appropriate to the processing requested by the primary command. These subcommands are defined together with the alphabetically sorted descriptions of their primary commands in Section 2.7.3. Examples utilizing these commands are presented in Section 1.

The sections that follow discuss the interaction between the substructure commands and the standard case control commands, the translation of substructure commands into DMAP ALTER sequences, and the format conventions to be used. The bulk data cards provided for substructure analyses are included with the standard bulk data descriptions in Section 2.3 and they are summarized for convenient reference in Table 2.

Table 1. Summary of substructure commands.

A. Phase and Mode Control	
SUBSTRUCTURE #	- Defines execution phase (1, 2, or 3) (Required)
ØPTIØNS	- Defines matrix options (K, M, P, or PA)
RUN	- Limits mode of execution (DRY, GØ, DRYGØ, STEP)
ENDSUBS #	- Terminates Substructure Control Deck (Required)
B. Substructure Operations	
CØMBINE	- Combines sets of substructures
NAME*	- Names the resulting substructure
TØLERANCE*	- Limits distance between automatically connected grids
CØNNECT	- Defines sets for manually connected grids and releases
ØUTPUT	- Specified optional output results
CØMPØNENT	- Identifies component substructure for special processing
TRANSFØRM	- Defines transformations for named component substructures
SYMTRANSFØRM	- Specifies symmetry transformation
SEARCH	- Limits search for automatic connects
EQUIV	- Creates a new equivalent substructure
PREFIX*	- Prefix to rename equivalenced lower level substructures
REDUCE	- Reduces substructure matrices
NAME*	- Names the resulting substructure
BØUNDARY*	- Defines set of retained degrees of freedom
ØUTPUT	- Specifies optional output requests
RSAVE	- Save REDUCE decomposition product
SØLVE	- Initiates substructure solution (statics or normal modes)
RECØVER	- Recovers Phase 2 solution data
SAVE	- Stores solution data on SØF
PRINT	- Stores solution and prints data requested
DISP	- Displacement output request
SPCF	- Reaction force output request
ØLØAD	- Applied load output request
BASIC	- Basic substructure for output requests
SØRT	- Output sort order
SUBCASES	- Subcase output request
MØDES	- Modes output request
RANGE	- Mode range output request
BRECØVER	- Basic substructure data recovery, Phase 3
PLØT	- Initiates substructure undeformed plots

 # Mandatory Control Cards   ** Required Subcommand*

Table 1. Summary of substructure commands (continued).

C. SØF Controls	
SØF #	- Assigns physical files for storage of the SØF (Required)
PASSWØRD*	- Protects and ensures access to correct file
SØFØUT or SØFIN	- Copies SØF data to or from an external file
PØSITIØN	- Specifies initial position of input file
NAMES	- Specifies substructure name used for input
ITEMS	- Specifies data items to be copies in
SØFPRINT	- Prints selected items from the SØF
DUMP	- Dumps entire SØF to a backup file
RESTØRE	- Restores entire SØF from a previous DUMP operation
CHECK	- Checks contents of external file created by SØFØUT
DELETE	- Edits out selected groups of items from the SØF
EDIT	- Edits out selected groups of items from the SØF
DESTRØY	- Destroys all data for a named substructure and all the substructures of which it is a component

\# Mandatory Control Cards

* Required Subcommand

Substructure Command CØMBINE - Combine Sets of Substructures

Purpose: This operation will perform the operations to combine the matrices and loads up to seven substructures into matrices and loads representing a new pseudostructure. Each component structure may be translated, rotated, and reflected before it is connected. The user may manually select the points to be connected or direct the program to connect them automatically.

Request Format:

$$\text{CØMBINE}\left(\left\{\frac{\text{AUTØ}}{\text{MAN}}\right\},\left\{\begin{matrix}X\\Y\\Z\end{matrix}\right\}\right) \quad \text{name1, name2, etc.}$$

Subcommands:

NAME	= new name	(required)
TØLERANCE	= ε	(required)
CØNNECT	= n	
ØUTPUT	= $m_1, m_2, \ldots$	

Each individual component substructure may have the following added commands:

CØMPØNENT = name

TRANSFØRM = m

SYMTRANSFØRM = $\left\{\begin{matrix}X\\Y\\Z\\XY\\XZ\\YZ\\XYZ\end{matrix}\right\}$

SEARCH = namej, namek, etc.

(repeat for each component)

Definitions:

AUTØ/MAN - Defines method of connecting points. If AUTØ is chosen, the physical location of grid points is used to determine connections. If MAN, all connections are defined on CØNCT or CØNCT1 bulk data.

X, Y, Z - Are used on CØMBINE card for searching geometry data for AUTØ connections. Denotes preferred search direction for processing efficiency.

name1, name2, etc. - Unique names of substructures to be combined. Limits are from one to seven component structures.

new name - Defines name of combination structure (required).

ε - Defines limit of distance between points which will be automatically connected (real > 0).

n - Defines set number of manual connections and releases specified on bulk data cards, CØNCT, CØNCT1, and RELES.

name - On CØMPØNENT card defines which substructure (name1, etc.) to which the following data is applied.

m - Set identification number of TRANS and GTRAN bulk data cards which define the orientation of the substructure and/or selected grid points relative to new basic coordinates.

X,Y,...XY,...XYZ - Defines axis (or set of axes) normal to the plane(s) of symmetry in the new basic coordinate system. The displacement and location coordinates in these directions will be reversed in sign.

namej - Limits the automatic connection process such that only connections between component "name" and these structures are produced. Multiple search commands may appear for any one component (see Note 4).

m_1, m_2, etc. - Optional output requests (see Note 5).

Notes:

1. The automatic connections are produced by first sorting the grid point coordinates in the specified coordinate direction and then searching within limited groups of coordinates. If the boundary of a substructure to be connected is aligned primarily along one of the coordinate axes, this axis should be used as the preferred search direction. If the boundary is parallel with, say, the yz plane and all boundary coordinates have a constant x value, then the search should be specified along either the y or the z axis.

2. The transformation (TRANS) data defines the orientation of the component substructure (old basic) in terms of the new basic coordinate system. All grid points originally defined in the old basic system will be transformed to the new basic system. Points defined in local coordinate systems will not be transformed unless otherwise specified on a GTRAN card, and their directions will rotate with the substructure.

3. The SYMTRANFØRM (or SYMT) request is primarily used to produce symmetric reflections of a structure. This is usually preceded by an EQUIV command to produce a new, unique substructure name. Note that the results for the new reflected substructure may reference a left-handed coordinate system wherever local coordinate systems are retained during the transformation. However, those coordinates which are originally in the old basic or are newly specified via a GTRAN card are automatically transformed to a right-handed coordinate system of the combined structure during the combination process.

4. If any search option is present then all connections between substructures must be specified explicitly with SEARCH commands. Only those combinations specified will be searched for possible connects. Symmetric connects need not be declared (i.e., CØMPØNENT A SEARCH B implies CØMPØNENT B SEARCH A). The user is warned that care must be taken to assure all proper connections of substructures should any SEARCH commands be utilized.

5. The following output requests are available for the CØMBINE operation (* marks recommended output options):

CODE	OUTPUT
2*	SØF table of contents
3	CØNCT1 bulk data summary
4	CØNCT bulk data summary
6	GTRAN bulk data summary
7*	TRANS bulk data summary
9	RELES bulk data summary
11	Summary of automatically-generated connections (in terms of internal point numbers)
12*	Complete connectivity map of final combined pseudostructure defining each internal point in terms of the grid point ID and component substructure it represents

13	The EQSS item	Output printed is formatted SØF data for the newly created pseudostructure (See Section 1.14 for definitions)
14	The BGSS item	
15	The CSTM item	
16	The PLTS item	
17	The LØDS item	

Examples:

1. CØMBINE PANEL SPAR

```
TØLE = .0001
NAME = SECTA
```

2. CØMBINE (AUTØ,Z)   TANK1, TANK2, BULKHD

```
NAME = TANKS
TØLE = .01
CØMPØNENT TANK1
TRAN = 4
SEARCH = BULKHD
CØMPØNENT TANK2
SEARCH = BULKHD
```

3. CØMBINE (MAN)   LWING, RWING

```
TØLE = 1.0
NAME = WING
CØMPØNENT LWING
SYMT = Y
```

Substructure Command DELETE

Purpose: To delete individual substructure items from the SØF.

Request Format:

DELETE name, item1, item2, item3, item4, item5

Subcommands: None

Definitions:

name - Substructure name

item1, item2,... - Item names (HØRG, KMTR, LØDS, SØLN, etc.)

Notes:

1. DELETE may be used to remove from one to five items of any single substructure.
2. For primary substructures, items of related secondary substructures are removed only if the later point to the same data (KMTX, MMTX, etc.).
3. For secondary and image substructures, no action is taken on items of related substructures, i.e., items of equivalenced substructures or higher or lower level substructures.
4. See the EDIT and DESTRØY commands for other means of removing substructure data.

Substructure Command EDIT - Selectively Removes Data from SØF File

Purpose: To permanently remove selected substructure data from the SØF.

Request Format:

EDIT (opt) name

Subcommands: None

Definitions:

name - Name of substructure.

opt - Integer value reflecting combinations of requests. The sum of the following integers defines the combination of data items to be removed from the SØF.

ØPT	Items Removed
1	Stiffness Matrix (KMTX)
2	Mass Matrix (MMTX)
4	Load Data (LØDS, LØAP, PVEC, PAPP)
8	Solution Data (UVEC, QVEC, SØLN)
16	Transformation Matrices defining next level (HØRG, UPRT, PØVE, PØAP, LMTX)
32	All items for the substructure
64	Appended loads data (LØAP, PAPP, PØAP)

Notes:
1. The user is cautioned on the removal of the HØRG matrix data. These matrices are required for the recovery of the solution results.
2. For primary substructures, items of related secondary substructures are removed only if they point to the same data (KMTX, MMTX, etc.).
3. For secondary and image substructures, no action is taken on items of related substructures, i.e., items of equivalenced or higher or lower level substructures.
4. If the EDIT feature is to be employed, the user should consider also using SØFØUT to ensure the existence of backup data in the event of an error.
5. See DELETE and DESTRØY for other means of removing substructure data.

Substructure Command EQUIV - Create a New Equivalent Substructure

Purpose: To assign an alias to an existing substructure and thereby create a new equivalent substructure. The new secondary substructure may be referenced independently of the original primary substructure in subsequent substructure commands. However, the data actually used in substructuring operations is that of the primary substructure.

Request Format:

EQUIV name1, name2

Subcommands:

PREFIX = p

Definitions:

p - Single BCD character.

name1 - Existing primary substructure name.

name2 - New equivalent substructure name.

Notes:

1. A substructure created by this command is referred to as a secondary substructure.
2. All substructures which were used to produce the primary substructure will produce equivalent image substructures. The new image substructure names will have the prefix p.
3. A DESTRØY operation on the primary substructure data will also destroy the secondary substructure data and all image substructures.
4. An EDIT or DELETE opeartion on the primary substructure will not remove data of the secondary substructure and vice versa.

Substructure Mode Control ØPTIØNS - Defines Matrix Types

Purpose: This allows the user to selectively control the type of matrices being processed.

Request Format:

ØPTIØNS m1,m2,m3

Subcommands: None

Definition:

m1,m2,m3 - Any combination of the characters K, M, and either P or PA, where:

K = Stiffness Matrices
M = Mass Matrices
P = Load Matrices
PA = Appended Load Vectors

Notes: 1. The default depends on the NASTRAN rigid format:

Rigid Format	Default
1 - Statics	K,P
2 - Inertia Relief	K,M,P
3 - Normal Modes	K,M

2. In a Phase 1 execution, Rigid Formats 1 and 3 will provide only two of the matrices, as shown above. In Rigid Format 1, the mass matrix is not generated. In Rigid Format 3, the loads matrix is not generated. An error condition will result unless the user adds the required DMAP alters to provide the requested data.

3. Stiffness, mass, or load matrices must exist if the corresponding K, M, P, or PA option is requested in the subsequent Phase 2 run.

4. Matrices or loads may be modified by rerunning the substructure sequence for only the desired type. However, the old data must be deleted first with the EDIT or DELETE command. See Section 1.14 for the actual item names.

5. The append load option, PA, is used when additional load sets are required for solution, and it is not desired to regenerate existing loads. To generate these new load vectors, re-execute all required Phase 1 runs with the new load sets and ØPTIØN = PA. Then, repeat the Phase 2 operations with ØPTIØN = PA. At each step, the new vectors are appended to the existing loads so that all load vectors will be available in the SØLVE stage.

6. Each ØPTIØN command overrides the preceding command to control subsequent steps of the substructure process.

7. When executing the SØLVE command, the option selected must provide the matrices required for the rigid format being executed.

Substructure Operating File Declaration PASSWØRD

Purpose: This declaration is required in the substructure command deck. The password is written on the SØF file and is used to protect the file and insure that the correct file is assigned for the current run.

Request Format:

PASSWØRD   password

Subcommands: None

Definition:

password - BCD password for the SØF (8 characters maximum). See the SØF file declaration card description.

Substructure Command PLØT - Substructure Plot Command

Purpose: This operation is used to plot the undeformed shape of a substructure which may be composed of several component substructures. This command initiates the execution of a plot at any stage of the substructure process. The actual plot commands; origin data, etc., must be included in the normal case control data.

Request Format:

PLØT name

Subcommands: None

Definitions:

name - Name of component substructure to be plotted.

Notes:

1. The set of elements to be plotted will consist of all the elements and grid points saved in Phase 1 for each basic substructure comprising the substructures named in the PLØT command. (Only one plot set from each basic substructure is saved in Phase 1.)

2. The structure plotter output request packet, while part of the standard Case Control Deck, are treated separately in Sections 4.2 and 4.3, respectively.

Substructure Command RECØVER - Phase 2 Solution Data Recovery

Purpose: This operation recovers displacements and boundary forces on specified substructures in the Phase 2 execution. The results are saved on the SØF file and they may be printed upon user request. This command should be input after the SØLVE command to store the solution results on the SØF file.

Request Format:

RECØVER s-name

Subcommands:

SAVE = name

PRINT = name

DISP $= \left\{\begin{array}{c}\text{ALL}\\ \text{n}\\ \underline{\text{NØNE}}\end{array}\right\}$

SPCF $= \left\{\begin{array}{c}\text{ALL}\\ \text{n}\\ \underline{\text{NØNE}}\end{array}\right\}$

ØLØAD $= \left\{\begin{array}{c}\text{ALL}\\ \text{n}\\ \underline{\text{NØNE}}\end{array}\right\}$

BASIC = b-name

for static analysis only:

SØRT $= \left\{\begin{array}{l}\underline{\text{SUBCASE}}\\ \text{SUBSTRUCTURE}\end{array}\right\}$

SUBCASES $= \left\{\begin{array}{c}\underline{\text{ALL}}\\ \text{n}\\ \text{NØNE}\end{array}\right\}$

for dynamic analysis only:

SØRT $= \left\{\begin{array}{l}\underline{\text{MØDES}}\\ \text{SUBSTRUCTURE}\end{array}\right\}$

MØDES $= \left\{\begin{array}{c}\underline{\text{ALL}}\\ \text{n}\\ \text{NØNE}\end{array}\right\}$

RANGE $= \lambda_1, \lambda_2$

Definitions:

s-name - Name of the substructure named in a prior SØLVE command from which the solution results are to be recovered.

name - Name of the component structure for which results are to be recovered. May be the same as "s-name".

b-name - Name of component basic substructure that following output requests are to apply to.

ALL - Output for all points will be produced.

NØNE - No output is to be produced.

n - Set identification number of a SET card appearing in Case Control. Only output for those points, subcases, or modes whose identification number appears on this SET card will be produced.

λ_1, λ_2 - Range of eigenvalues for which output will be produced. If only λ_1 is present the range is assumed to be $0 - \lambda_1$.

SUBCASE - All output requests for each subcase will appear together.

MØDES - All output requests for each mode will appear together.

SUBSTRUCTURE - All output requests for each basic substructure will appear together.

Output Requests: Printed output produced by the RECØVER PRINT command can be controlled by requests present in either Case Control or the RECØVER command in the Substructure Control Deck. If no output requests are present, the PRINT command is equivalent to SAVE and no output will be printed.

The RECØVER output options described above may appear after any PRINT command. These output requests will then override any Case Control requests. The output requests for any PRINT command can also be specified for any or all basic component substructures of the results being recovered. These requests will then override any requests in Case Control or after the PRINT command.

Example of output control:

```
RECØVER SØLSTRCT
    PRINT   ABSC
        SØRT = SUBSTRUCTURE  }
        DISP = ALL           }  basic defaults for ABDC output
        ØLØAD = 10           }
        BASIC   A            }  override requests for BASIC  A
            DISP = 5         }
        BASIC   C            }
            ØLØAD = NØNE     }  override requests for BASIC  C
            SUBCASES = 20    }
    SAVE   ABC
```

Notes: 1. SAVE will save the solution for substructure "name" on the SØF. PRINT will save and print the solution.

2. If the solution data already exists on the SØF, the existing data can be printed without costs of regeneration with the PRINT command.

3. For efficiency, the user should order multiple SAVE and/or PRINT commands so as to trace one branch at a time starting from his solution structure.

4. Reaction forces are computed for a substructure only if (1) the substructure is named on a PRINT subcommand and, (2) an output request for SPCFØRCE exists in the Case Control or the RECØVER command.

5. All set definitions should appear in Case Control to ensure their availability to the RECØVER module.

6. The SØRT output option should only appear after a PRINT command. Any SØRT commands appearing after a BASIC command will be ignored.

7. If both a MØDES request and a RANGE request appear for dynamic analysis, both requests must be satisfied for any output to be produced.

8. The media, print or punch, where output is produced is controlled through Case Control requests. If no Case Control requests are present, the default of print is used.

Examples:

1. Create a new SØF file with a filename of SØF1 and catalogue it.

```
REQUEST(SØF1,*PF)
NASTRAN.
CATALØG(SØF1,username)
789
:
:
NASTRAN data cards including the SØF declaration --
SØF(1)=SØF1,1000,NEW
:
:
6789
```

2. Use of an existing SØF file with a filename of ABCD.

```
ATTACH(ABCD,username)
NASTRAN.
EXTEND(ABCD)
789
:
:
NASTRAN data cards including the SØF declaration --
SØF(1)=ABCD,1000
:
:
6789
```

UNIVAC 1108/1110

The filename used on the SØF declaration must specify one of the NASTRAN user files INPT, INP1,..., INP9.

Examples:

1. Create a new SØF file named INPT.

```
@ASG,U INPT.,F///1000
@HDG,N
@XQT *NASTRAN.LINK1
NASTRAN FILES=INPT
NASTRAN data cards including the SØF declaration --
SØF(1)=INPT,400,NEW
:
:
@ADD,P *NASTRAN.CØNTRL
@FIN
```

2. Use of an existing SØF file with a filename of INP7.

```
@ASG,AX INP7.
@HDG,N
@XQT  *NASTRAN.LINK1
NASTRAN FILES=INP7
NASTRAN data cards including the SØF declaration --
SØF(1)=INP7,250
:
:
@ADD,P *NASTRAN.CØNTRL
@FIN
```

IBM 360/370

The file name used on the SØF declaration must specify a FØRTRAN unit by using the form FTxx from the table of allowable file names shown below which correspond to the direct access devices that are supported under the SØF implementation. The allocation of space for the direct access FØRTRAN data sets can be made in terms of blocks, tracks or cylinder. If the allocation is in blocks, the block size in the space allocation corresponds to (BUFFSIZE-4)*4 bytes where BUFFSIZE is the GINØ buffer size found in SYSTEM(1).

In order to use the SØF on IBM computers, it is necessary to specify the PARM on the EXEC PGM=NASTRAN card. This PARM sets the amount of core (in bytes) NASTRAN releases to the operating system for system use and FØRTRAN buffers. The following formula should be used to determine the value for the PARM:

$$\text{PARM} = \begin{cases} (4096 + m*((\text{BUFFSIZE}-4) + 64))*4 & \text{single buffering, BUFN}\emptyset\text{=1} \\ (4096 + m*(2*(\text{BUFFSIZE}-4) + 96))*4 & \text{double buffering, BUFN}\emptyset\text{=2} \end{cases}$$

where m = number of physical datasets comprising the SØF.

Examples:

1. Create a new SØF data set with a filename of FT11.

```
//NSGØ EXEC NASTRAN,PARM.NS='CØRE=(,24K)'
//NS.FT11F001 DD DSN = User Name, UNIT=2314, VØL=SER=User No.,
//   DISP=(NEW,KEEP), SPACE=(TRK,(1000)), DCB=BUFNØ=1
//NS.SYSIN DD *
NASTRAN BUFFSIZE=1826
:
NASTRAN data cards including the SØF declaration --
SØF(1)=FT11,,NEW
:
/*
```

Notes:

1. The SØF parameters - filename, filesize, and (ØLD/NEW) are positional parameters. The filesize parameter is not required for IBM 360/370 computers, but its position must be noted if NEW is coded for the SØF file.

2. The dataset disposition <u>must</u> be DISP=(NEW,KEEP) when the SØF dataset is created. However, an existing SØF dataset may be re-initialized by coding NEW on the SØF declaration in the NASTRAN data deck. In this case, the disposition on the DD card must be coded DISP=ØLD.

2. Use of an existing SØF dataset with a filename of FT23.

```
//NS EXEC NASTRAN,PARM.NS='CØRE=(,72K)'
//NS.FT23F001 DD DSN = User Name, UNIT=3330, VØL=SER=User No.,
// DCB=BUFNØ=1, DISP=ØLD
//NS.SYSIN DD *
NASTRAN BUFFSIZE=3260
SØF(1)=FT23
:
/*
```

SUBSTRUCTURE CONTROL DECK

SØF File Name	FØRTRAN Unit DDName	SØF File Name	FØRTRAN Unit DDName
FT02	FT02F001	FT16	FT16F001
FT03	FT03F001	FT17	FT17F001
FT08	FT08F001	FT18	FT18F001
FT09	FT09F001	FT19	FT19F001
FT10	FT10F001	FT20	FT20F001
FT11	FT11F001	FT21	FT21F001
FT12	FT12F001	FT22	FT22F001
FT15	FT15F001	FT23	FT23F001

Note: A maximum of 10 SØF file names is allowed in any NASTRAN substructuring run.

Substructure Command SØFPRINT

Purpose: To print selected contents of the SØF file for data checking purposes.

Request Format:

SØFPRINT(opt)   name, item1, item2, etc.

Subcommands: None

Definitions:

opt - integer, control option, default = 0.

opt = 1: prints data items only
opt = 0: prints table of contents
opt = -1: prints both

name - Name of substructure for which data is to be printed.

item1, item2 - SØF item name, used only when opt ≠ 0, limit = 5 (See Table 2, Section 1.14).

Notes: 1. If only the table of contents is desired (opt = 0), this command may be coded:

SØFPRINT TØC

On the page heading for the table of contents, the labels are defined as follows:

IS - Image substructure flag. 0 - not an image substructure
1 - image substructure

SS - Secondary substructure number (successor)

PS - Primary substructure number (predecessor)

LL - Lower level substructure number

CS - Combined substructure number

HL - Higher level substructure number

Substructure Command SØLVE - Substructure Solution

Purpose: This command initiates the substructure solution phase. The tables and matrices for the pseudostructure are converted to their equivalent NASTRAN data blocks. The substructure grid points referenced on bulk data cards SPCS, MPC, etc., are converted to pseudostructure scalar point identification numbers. The NASTRAN execution then proceeds as though a normal structure were being processed.

Request Format:

SØLVE name

Subcommands: None (Case Control and Bulk Data decks control the operations.)

Definition:

name - Name of pseudostructure to be analyzed with NASTRAN.

Notes: 1. Before requesting a SØLVE, the user should check to be sure that all necessary matrices are available on the SØF file. For instance, loads and stiffness matrices are necessary in statics analysis. Mass and stiffness matrices are necessary in eigenvalue analysis, etc.

5.2 DMAP RULES

Grammatically, DMAP instructions consist of two types: Executive Operation Instructions and Functional Module Instructions. Grammatical rules for these two types of instructions will be discussed separately in subsequent sections.

Functional modules are arbitrarily classified as structural modules, matrix operation modules, utility modules, or user-generated modules.

The DMAP sequence itself consists of a series of DMAP instructions or statements, the first of which is BEGIN or XDMAP and the last of which is END. The remaining statements consist of Executive Operation instructions and Functional Module calls.

5.2.1 DMAP Rules for Functional Module Instructions

The primary characteristic of the Functional Module DMAP instruction is its prescribed format. The general form of the Functional Module DMAP statement is:

```
MØD   I1,I2,---,Im/Ø1,Ø2,---,Øn/a1,b1,p1/a2,b2,p2----/az,bz,pz  $

   where   MØD is the DMAP Functional Module name,
           Ii; i = 1,m are the Input Data Block names,
           Øi; i = 1,n are the Øutput Data Block names,
   and     ai,bi,pi; i = 1,z are the Parameter Sections.
```

In the general form shown above, commas (,) are used to separate several like items while slashes (/) are used to separate sections from one another. The module name is separated from the rest of the instruction by a blank or a comma (,). The dollar sign ($) is used to end the instruction and is not required unless the instruction ends in the delimiter / . Blanks may be used in conjunction with any of the above delimiters for ease of reading.

A functional module communicates with other modules and the executive system entirely through its inputs, outputs and parameters. The characteristics or attributes of each functional module are contained in the Module Properties List (MPL) described in Section 2.4 of the Programmer's Manual and are reflected in the DMAP Module Descriptions that follow in Section 5.3 and in the Module Functional Descriptions contained in Chapter 4 of the Programmer's Manual. The module name is a BCD value (which consists of an alphabetic character followed by up to seven additional alphanumeric characters) and must correspond to an entry in the MPL. A Data Block name may be either a BCD value or null. The absence of a BCD value indicates that the Data Block is not needed for a particular application.

5.2.1.1 Each Functional Module DMAP statement must conform to the MPL regarding:

1. Name spelling
2. Number of input data blocks
3. Number of output data blocks
4. Number of parameters
5. Type of each parameter

Note: See Sections 5.2.1.3 and 5.2.1.4 for allowable exceptions to these rules.

5.2.1.2 Functional Module Names

The only Functional Module DMAP names allowed are those contained in the MPL. Therefore, if a user wishes to add a module, he must either use one of the User Module names provided (see Section 5.6) or add a name to the MPL. The Programmer's Manual should be consulted when adding a new module to NASTRAN.

5.2.1.3 Functional Module Input Data Blocks

In most cases an input data block should have been previously defined in a DMAP program before it is used. However, there may be instances in which a module can handle, or may even expect, a data block to be undefined at the time the module is initially called. An input data block is previously defined if it appears as an output data block in a previous DMAP instruction, as output from the Input File Processor, any user-input (via Bulk Data Cards) DMI or DTI data block name, or exists on the Old Problem Tape in a restart problem. Although the number of data blocks is prescribed, if any number of final data blocks are null, they may be omitted from the section. For example, the module TABPT, which uses five input data blocks, may be defined by:

```
TABPT   GEØM1,,,, //  $
```

or

```
TABPT   GEØM1 //  $
```

A potentially fatal error message (See Section 5.2.1.7) will be issued at compilation time to warn the user that a discrepancy in the data block name list has been detected. This is also true in the event that a previously undefined data block is used as input. Also, see the "error-level" option on the XDMAP compiler option card which may be invoked by the user to terminate execution in the event of such errors.

5.2.1.4 Functional Module Output Data Blocks

In general, a data block name will appear as output only once. However, there are cases in which an output data block may be of no subsequent use in a DMAP program. In such a case the name may be used again, but caution should be used when employing such techniques. Although the number of output data blocks is prescribed, the data block name list may be abbreviated in the manner of Section 5.2.1.3. Potentially fatal error messages will warn the user if possible ambiguities may occur from these usages.

5.2.1.5 Functional Module Parameters

Parameters may serve many purposes in a DMAP program. They may pass data values into and/or out from a module, or they may be used as flags to control the computational flow within the module or the DMAP program. There are two allowable forms of the parameter section of the DMAP instruction. The first explicitly states the attributes of the parameters, while the second is a briefer simplified specification. The general form of the formal parameter section is

/ ai,bi,pi /

where the allowable parameter specifications are:

ai =	V		Parameter value is variable and may be changed by the module during execution.
	C		Parameter value is prescribed initially by the user and is an unalterable constant.
	S		Parameter is of type V, and will be saved automatically at completion of module. (See description of the SAVE instruction.)
bi =	Y		Initial parameter value may be specified on a PARAM Bulk Data card.
	N		Initial parameter value may not be specified on a PARAM Bulk Data card.
pi =	PNAME = v		PNAME is a BCD name selected by the user to represent a given parameter.
	PNAME		
	v		

The default values for ai and bi depend on the value given for pi, as described below. The three forms available for pi require additional clarification. The symbol 'v' represents an actual numeric value for the parameter and may be used only when ai = C and bi = N. The other forms will be clarified by the examples found at the end of this section. Each parameter has an initial value which is established when the DMAP sequence is compiled during execution of the NASTRAN preface. The means by which initial values are established for all DMAP parameters will be explained by the symbolic examples that follow. The value used at execution time may differ from the initial value if and only if the module changes the value, if ai = "V", and the parameter name appears in a SAVE (see Section 5.7) instruction immediately following the module.

The formal parameter specifications defined above can, in frequently encountered instances, be greatly simplified. Situations where these simplifications may be used are:

1. / C,N,v / can be written as / v /

   The value 'v' is written exactly as it would be in the formal specification with the exception of BCD constant parameters, in which case the BCD string is enclosed by asterisks, i.e., / *STRING* / .

2. / V,N,PNAME / can be written as / PNAME /

   / V,N,PNAME=v / can be written as / PNAME=v /

   Again, in the case where the value 'v' appears, it is written exactly as in the case of the formal specification. In this case, BCD strings are not delimited by asterisks.

3. / (default value) / can be written as //

   If a particular parameter has a predefined default value specified in the Module Properties List (MPL), and the user wishes to choose this value, then it is necessary only to code successive slashes. If a parameter does not have a default value, an error message will be issued.

Six parameter types are available and the type of each parameter is given in the MPL and may not be changed. The types and examples of values as they would be written in DMAP are given below:

Parameter Type	Value Examples		
Integer	7	-2	0
Real	-3.6	2.4+5	0.01-3
BCD	VAR01	STRING3	B3R56
Double Precision	2.5D-3	1.354D7	
Complex Single Precision		(1.0,-3.24)	
Complex Double Precision		(1.23D-2,-3.67D2)	

Many possible forms of the parameter section may be used. The following examples will help to clarify the possibilities.

// This is equivalent to / C,N,v / where v is the MPL default value which must exist.

/ C,Y,v — Constant input parameter

Examples: / C,N,0 / C,N,BKLO / C,N,(1.0,-1.0)
or
/ 0 / *BKLO* / (1.0,-1.0)

In the examples shown, both in formal and simplified form, the values 0 (integer), BKLO (BCD), and 1.0-i1.0 (complex single precision) are defined.

/ C,Y,PNAME — Constant input parameter; MPL default value is used unless a PARAM Bulk Data card referencing PNAME is present. Error condition is detected if either no PARAM card is present or if no MPL default value exists.

/ C,Y,PNAME=v — Constant input parameter; the value v is used unless a PARAM Bulk Data card referencing PNAME is present.

/ V,Y,PNAME
or
/ V,Y,PNAME=v — Variable parameter; may be input, output, or both; initial value is the first of

1. value from the most recently executed SAVE instruction, if any
2. value from PARAM Bulk Data card referencing PNAME will be used if present in Bulk Data Deck
3. v, if present in DMAP instruction
4. MPL default value, if any
5. 0

If a parameter is output from a functional module and if the output value is to be carried forward, a SAVE instruction must immediately follow the DMAP instruction in which the parameter is generated.

/ V,N,PNAME
or
/ PNAME
or
/ V,N,PNAME=v
or
/ PNAME=v — Variable parameter; may be input, output, or both; initial value is the first of

1. value from the most recently executed SAVE instruction, if any
2. v, if present in DMAP instruction
3. MPL default value, if any
4. 0

5.2.1.6 DMAP Compiler Options - The XDMAP Instruction (see Section 5.7)

The user has the ability to elect several options when compiling and executing a DMAP program by including an XDMAP compiler option instruction in the program. Similarly, the Rigid Formats may be altered by replacing the BEGIN statement with XDMAP to invoke the same options. The available options are:

GØ (default) or NØGØ

The GØ option compiles and executes the program, while NØGØ terminates the job at the conclusion of compilation.

LIST or NØLIST (default)

This option produces a DMAP program source listing.

DECK or NØDECK (default)

This option will produce a punched card deck of the program.

ØSCAR or NØØSCR (default)

If the ØSCAR option is selected, a complete listing of the Operation Sequence Control Array will be given.

REF or NØREF (default)

This option will product a complete cross reference of variable parameters, data block names, and module calls for the DMAP program.

ERR=0 or 1 or 2 (default)

This option specifies the error level, '0' for WARNING, '1' for PØTENTIALLY FATAL, and '2' for FATAL ERRØR MESSAGE, at which termination of the job will occur, see Section 5.2.1.7 for further explanation.

The complete description of the XDMAP card may be found in the DMAP Module Description section. Note that an XDMAP card need not appear when all default values are elected, but may be replaced with a BEGIN instruction.

5.2.1.7 Extended Error Handling Facility

There are three levels of error messages generated during the compilation of a DMAP sequence. These levels are WARNING MESSAGE, PØTENTIALLY FATAL ERRØR MESSAGE, and FATAL ERRØR MESSAGE. The user has, through available compiler options, the ability to specify the error level at which the job will be terminated. (See Section 5.2.1.6 for the manner of specification.) The class of PØTENTIALLY FATAL ERRØR MESSAGES is generated by certain compiler conveniences which, if not fully understood by the user, could cause an erroneous or incorrect execution of the DMAP sequence. The default value for the error level is that of the FATAL ERRØR.

5.2.2 DMAP Rules for Executive Operation Instructions

Each executive operation statement has its own format which is generally open-ended, meaning the number of inputs, outputs, etc. is not prescribed. Executive operation instructions or statements are divided into general categories as follows:

1. Declarative instructions FILE, BEGIN, LABEL, XDMAP, and PRECHK which aid the DMAP compiler and the file allocator as well as provide user convenience.

2. Instructions CHKPNT, EQUIV, PURGE, and SAVE which aid the NASTRAN Executive System in allocating files, interfacing between functional modules, and in restarting a problem.

3. Control instructions REPT, JUMP, CØND, EXIT, and END which control the order in which DMAP instructions are executed.

The rules associated with the executive operation instructions are distinct for each instruction and are discussed individually in Section 5.7.

5.2.3 Techniques and Examples of Executive Module Usage

Even though the DMAP program may be interpretable by the DMAP compiler it does not guarantee that the program will yield the desired results. Therefore, this section is provided to acquaint the DMAP programmer with techniques and examples used in writing DMAP programs. In particular, the instructions REPT, FILE, EQUIV, PURGE, and CHKPNT will now be discussed in some detail. The DMAP modules available are listed in Section 5.3.

5.3 INDEX OF DMAP MODULE DESCRIPTIONS

Descriptions of all nonstructurally oriented Modules are contained herein, arranged alphabetically by category as indicated by the lists below. Descriptions for the structurally oriented modules are contained in Section 4 of the Programmer's Manual. They are listed here in order to provide a complete list of all NASTRAN Modules. Additional information regarding nonstructurally oriented modules is also given in Section 4 of the Programmer's Manual.

<u>Matrix Operation Modules</u> (12)
(See Section 5.4)

ADD	PARTN
ADD5	SMPYAD
DECØMP	SØLVE
FBS	TRNSP
MERGE	UMERGE
MPYAD	UPARTN

<u>Utility Modules</u> (25)
(See Section 5.5)

CØPY	PARAMR
DIAGØNAL	PRTPARM
INPUT	PVEC
INPUTT1	SCALAR
INPUTT2	SEEMAT
MATGPR	SETVAL
MATPRN	SWITCH
MATPRT	TABPCH
ØUTPUT1	TABPRT
ØUTPUT2	TABPT
ØUTPUT3	TIMETEST
PARAM	VEC
PARAML	

<u>User Modules</u> (14)
(See Section 5.6)

DDR	MØDA
DUMMØD1	MØDB
DUMMØD2	MØDC
DUMMØD3	ØUTPUT
DUMMØD4	ØUTPUT4
INPUTT3	PARTVEC
INPUTT4	XYPRNPLT

<u>Executive Operation Modules</u> (14)
(See Section 5.7)

BEGIN	JUMP
CHKPNT	LABEL
CØND	PRECHK
END	PURGE
EQUIV	REPT
EXIT	SAVE
FILE	XDMAP

<u>Structurally Oriented Modules</u> (68)
(See Section 4 of the Programmer's Manual)

BMG	GPCYC	PLA4	SMA1
CASE	GPFDR	PLØT	SMA2
CEAD	GP1	PLTSET	SMA3
DDR1	GP2	PLTTRAN	SMP1
DDR2	GP3	PRTMSG	SMP2
DDRMM	GP4	RANDØM	SSGHT
DPD	GPSP	RBMG1	SSG1
DSCHK	GPWG	RBMG2	SSG2
DSMG1	MCE1	RBMG3	SSG3
DSMG2	MCE2	RBMG4	SSG4
EMA	MTRXIN	READ	TA1
EMG	ØFP	RMG	TRD
FA1	ØPTPR1	SCE1	TRHT
FA2	ØPTPR2	SDR1	TRLG
FRRD	PLA1	SDR2	VDR
GKAD	PLA2	SDR3	XYPLØT
GKAM	PLA3	SDRHT	XYTRAN

In the examples that accompany each description, the following notation is used:

1. Upper case letters and special symbols in the DMAP calling sequence must be punched as shown except for data block names, parameter names, and label names which are symbolic.
2. Lower case letters represent constants whose permissible values are indicated in the descriptive text.

Due to the many possible forms which may be used when writing parameters, a variety of arbitrarily selected forms will be used in the examples. This does not imply that the form used in any example is required or that it is the only acceptable form allowed.

The terms form, type, and precision are used in many functional module descriptions. By form is meant one of the following:

Form	Meaning
1	Square
2	Rectangular
6	Symmetric

By type is meant one of the following:

Type	Meaning
1	Real, single precision
2	Real, double precision
3	Complex, single precision
4	Complex, double precision

By precision is meant one of the following:

Precision Indicator	Meaning
1	Single precision numbers
2	Double precision numbers

5.5 UTILITY MODULES

Utility modules are an arbitrary sub-division of the Functional Modules and are used to output matrix and table data blocks and to manipulate parameters.

The data block names corresponding to the various matrix and table data blocks used in the Rigid Format DMAP sequences may be found in Section 3 or in the NASTRAN mnemonic dictionary, Section 7.

I. NAME: CØPY

II. PURPOSE: To generate a physical copy of a data block.

III. DMAP CALLING SEQUENCE:

CØPY DB1 / DB2 / PARAM $

IV. INPUT DATA BLOCKS:

DB1 - Any NASTRAN data block

V. OUTPUT DATA BLOCKS:

DB2 - Any valid NASTRAN data block name

VI. PARAMETERS:

PARAM - If PARAM < 0 the copy will be performed - integer, input, default = -1.

VII. METHOD: If PARAM ≥ 0 a return is made, otherwise a physical copy of the input data block is generated.

VIII. REMARKS:

1. The input data block may not be purged.

I. NAME: DIAGØNAL (Strip diagonal from matrix)

II. PURPOSE: To remove the real part of the diagonal from a matrix, raise each term to a specified power, and output a column vector or square symmetric matrix.

III. DMAP CALLING SEQUENCE:

```
DIAGØNAL  A/B/C,Y,ØPT=CØLUMN/V,Y,PØWER=1. $
```

IV. INPUT DATA BLOCKS:

A - can be any square or diagonal matrix.

V. OUTPUT DATA BLOCKS:

B - is either a real column vector or symmetric matrix containing the diagonal of A.

VI. PARAMETERS:

ØPT - Input-bcd, default=CØLUMN

='CØLUMN' - produces column vector output (labeled as a general rectangular matrix)

='SQUARE' - produces square matrix (labeled a symmetric matrix)

PØWER - Input-real single precision, default = 1. Exponent to which the real part of each diagonal element is raised.

VII. REMARKS:

1. The module checks for special cases of PØWER=0.0, 0.5, 1.0, and 2.0.
2. The precision of the output matrix matches the precision of the input matrix.

I. NAME: SETVAL (Set Values)

II. PURPØSE: Set DMAP Parameter variable values equal to other DMAP Parameter variables or DMAP Parameter constants.

III. DMAP CALLING SEQUENCE:

```
SETVAL  // V,N,X1 / V,N,A1 /
           V,N,X2 / V,N,A2 /
           V,N,X3 / V,N,A3 /
           V,N,X4 / V,N,A4 /
           V,N,X5 / V,N,A5 $
```

IV. INPUT DATA BLØCKS: None

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS:

X1, X2, X3, X4, X5	Output, integers, variables
A1, A2, A3, A4, A5	Input, integers; default values = 1, variables or constants.

VII. METHØD: This module sets X1 = A1, X2 = A2, X3 = A3, X4 = A4, and X5 = A5. Only two parameters need be specified in the calling sequence (X1 and A1).

VIII. REMARKS:

1. A SAVE instruction must immediately follow the SETVAL instruction if the output parameter values are to be subsequently used.
2. See PARAM for an alternate method of defining parameter values.
3. As an example, the statements

```
SETVAL  // V,N,X1 / V,N,A1 / V,N,X2 / C,N,3 $
SAVE    X1,X2 $
```

are equivalent to the statements

```
PARAM  // C,N,ADD / V,N,X1 / V,N,A1 / C,N,0 $
PARAM  // C,N,NØP / V,N,X2=3 $
```

I. NAME: SWITCH

II. PURPOSE: To interchange two data block names.

III. DMAP CALLING SEQUENCE:

SWITCH DB1,DB2 // PARAM $

IV. INPUT DATA BLOCKS:

DB1, DB2 } Any NASTRAN data blocks

V. OUTPUT DATA BLOCKS: None

VI. PARAMETERS:

PARAM - If PARAM < 0 the switch will be performed - integer, input, default=-1.

VII. METHOD: If PARAM ≥ 0 a return is made, otherwise the names of the data blocks are interchanged. All attributes of the data within the blocks remains constant, only the names are changed.

VIII. REMARKS:

1. Neither input data block may be purged.
2. This option is of use in iterative DMAP operations.

I. NAME: TABPCH (Table Punch)

II. PURPOSE: To punch NASTRAN tables onto DTI cards in order to allow transfer of data from one NASTRAN run to another, or to allow user postprocessing.

III. DMAP CALLING SEQUENCE:

TABPCH TAB1,TAB2,TAB3,TAB4,TAB5 // C,N,A1 / C,N,A2 / C,N,A3 / C,N,A4 / C,N,A5 $

IV. INPUT DATA BLOCKS:

TAB1
TAB2
TAB3 Any NASTRAN Tables
TAB4
TAB5

V. OUTPUT DATA BLOCKS:

None - All output is punched onto DTI cards.

VI. PARAMETERS:

A1, A2, A3, A4, A5 -- Input - BCD - Defaults are 'AA', 'AB', 'AC', 'AD', 'AE'. These parameters are used to form the first two characters (columns 74, 75) of the continuation field for each table respectively.

VII. REMARKS:

1. Any or all tables may be purged.
2. Integer and BCD characters will be punched onto single-field cards. Real numbers will be punched onto double-field cards. Their formats are I8, 2A4, E16.9.
3. Up to 99,999 cards may be punched per table.
4. Currently, twice the entire record must fit in open core.
5. Tables with 1 word BCD values (ELSETS) cannot be punched correctly.

VIII. EXAMPLES:

TABPCH EST,,,, // C,N,ES $ will punch the EST onto cards with a continuation neumonic of $+ES_{bbbb}i$ (where i is the sequence number).

5.7 EXECUTIVE OPERATION MODULES

All modules classified as Executive Operation Modules are individually described in this section. Additional discussions concerning the interaction of the Executive Modules with themselves and with the NASTRAN Executive System are contained in Section 5.2.3.

I. NAME: BEGIN (Begin DMAP Program)

II. PURPOSE: BEGIN is a declarative DMAP instruction which may be used to denote the beginning of a DMAP program.

III. DMAP CALLING SEQUENCE:

```
BEGIN $
```

IV. REMARKS:

1. BEGIN is a non-executable DMAP instruction which is used only by the DMAP compiler for information purposes.
2. Either a BEGIN card or an XDMAP card is required when selecting APP DMAP in the Executive Control Deck. This is followed by DMAP instructions up to and including the END card.
3. The use of BEGIN implicitly elects all compiler defaults. (See XDMAP instruction.)

I. NAME: CHKPNT (Checkpoint)

II. PURPOSE: Causes data blocks to be written on the New Problem Tape (NPTP) to enable the problem to be restarted with a minimum of redundant processing.

III. DMAP CALLING SEQUENCE:

CHKPNT D1,D2,...,DN $

where D1,D2,...,DN ($N \geq 1$) are data blocks to be copied onto the problem tape for use in restarting problem.

IV. RULES:

1. A data block to be checkpointed must have been referenced in a previous PURGE, EQUIV, or functional module instruction.
2. CHKPNT cannot be the first instruction of a DMAP loop.
3. Data Blocks generated by the Input File Processor (including DMI's and DTI's) should not be checkpointed since they are always regenerated on restart.
4. Checkpointing only takes place when a New Problem Tape (NPTP) is set up and the Executive Control Card CHKPNT YES appears in the Executive Control Deck. Otherwise, the CHKPNT instructions are ignored.
5. For each data block that is successfully checkpointed, a card of the restart dictionary is punched which gives the critical data for the data block as it exists on the Problem Tape.
6. For data blocks that have been purged or equivalenced, an entry is made in the restart dictionary to this effect. In these cases data blocks are not written on the Problem Tape.

V. REMARKS:

1. See the PRECHK instruction for an automated CHKPNT capability.

I. NAME: CØND (Conditional Transfer)

II. PURPØSE: To alter the normal order of execution of DMAP modules by conditionally transferring program control to a specified location in the DMAP program.

III. DMAP CALLING SEQUENCE:

```
CØND  n,V $
```

where:

1. n is a BCD label name specifying the location where control is to be transferred. (See the LABEL instruction.)
2. V is a BCD name of a variable parameter whose value indicates whether or not to execute the transfer. If V < 0 the transfer is executed.

IV. EXAMPLE:

```
BEGIN $
  .
  .
  .
CØND  L1,K  $
MØDULE1  A/B/V,Y,P1  $
  .
  .
  .
LABEL  L1 $
MØDULEN  X/Y  $
  .
  .
  .
END $
```

If K ≥ 0, MØDULE1 is executed. If K < 0 control is transferred to the label L1 and MØDULEN is executed.

V. REMARKS:

Only forward transfers are allowed. See the REPT instruction for backward transfers.

I. NAME: END (End DMAP Program)

II. PURPØSE: Denotes the end of a DMAP program.

III. DMAP CALLING SEQUENCE:

```
END $
```

IV. NØTES:

1. The END instruction also acts as an implied EXIT instruction.
2. The END card is required whenever the analyst selects APP DMAP in his Executive Control Deck.

I. NAME: EQUIV (Data Block Name Equivalence)

II. PURPOSE: To attach one or more equivalent (alias) data block names to an existing data block so that the data block can be referenced by several equivalent names.

III. DMAP CALLING SEQUENCE:

```
EQUIV DBN1A,DBN2A,DBN3A / PARMA / DBN1B,DBN2B / PARMB $
```

Note: The number of data block names (DBNij) prior to each parameter (PARMj) and the number of such groups in a particular calling sequence are variable.

IV. INPUT DATA BLOCKS:
DBN1A,DBN2A, etc. - Any data block names appearing within the DMAP sequence. The 1st data block name in each group (DBN1A and DBN1B in the examples above) is known as the primary data block and the 2nd, etc. data block names become equivalent to the primary (depending on the associated parameter value). These equivalenced data blocks are known as secondary data blocks.

V. OUTPUT DATA BLOCKS: (None specified or permitted)

VI. PARAMETERS:
PARMA, etc. - One required for each set of data block names.

VII. METHOD: The data block names in each group are made equivalent if the value of the associated parameter is < 0. If a number of data blocks are already equivalenced and the parameter value is ≥ 0, the equivalence is broken and the data block names again become unique. If the data blocks are not equivalenced and the parameter value is ≥ 0, no action is taken.

VIII. REMARKS:

1. An EQUIV statement may appear at any time as long as the primary data block name has been previously defined.
2. If an equivalence is to be performed at all times, i.e., the parameter value is always negative, it is not necessary to specify a parameter name. For example,

```
EQUIV DB1,DB2 // DB3,DB4 $
```

I. NAME: PRECHK (Predefined Automated Checkpoint)

II. PURPOSE: To allow the user to specify a single, or limited number, of checkpoint declarations thereby removing the need for a large number of individual CHKPNT instructions to appear in a DMAP program.

III. DMAP CALLING SEQUENCE:

PRECHK *name* list $

PRECHK ALL $

PRECHK ALL EXCEPT name list $

where name is a list of data block names separated by commas and not exceeding 50 data blocks per command .

IV. REMARKS:

1. PRECHK is, in itself, a non-executable DMAP instruction which actuates the automatic generation of explicity CHKPNT instructions during the DMAP compilation.
2. Any number of PRECHK declarations may appear in a DMAP program. Each time a new statement is encountered the previous one is invalidated. The PRECHK END $ option will negate the current PRECHK status.
3. CHKPNT instructions may be used in conjunction with PRECHK declarations. The CHKPNT instruction will override any PRECHK condition. For example, if the PRECHK ALL EXCEPT option is in effect, a data block named in the excepted list may still be explicitly CHKPNTed.
4. PRECHK automatically CHKPNTs all output data blocks from each functional module or purge instruction, and all secondary data block of an EQUIV instruction.

EXECUTIVE OPERATION MODULE

I. NAME: PURGE (Explicit Data Block Purge)

II. PURPOSE: To flag a data block so that it will not be assigned to a physical file.

III. DMAP CALLING SEQUENCE:

PURGE DBN1A,DBN2A,DBN3A / PARMA / DBN1B,DBN2B / PARMB $

Note: The number of data block names (DBN_{ij}) prior to each parameter ($PARM_j$) and the number of groups of data block names and parameters in a particular calling sequence is variable.

IV. INPUT DATA BLOCKS:

DBN1A,DBN2A, etc. - Any data block names appearing within the DMAP sequence.

V. OUTPUT DATA BLOCKS: (None specified or permitted)

VI. PARAMETERS:

PARMA, etc. - One required for each group of data block names.

VII. METHOD: The data blocks in a group are purged if the value of the associated parameter is < 0. If a data block is already purged and the parameter value is ≥ 0, the purged data block is unpurged so that it may be subsequently reallocated. If the data block is not purged and the parameter value is ≥ 0, no action is taken.

VIII. REMARKS:

1. If a purge is to be made at all times, i.e., the parameter value is always negative, it is not necessary to specify a parameter name. For example,

   PURGE DB1,DB2,DB3,DB4 $

I. <u>NAME</u>: REPT (Repeat)

II. <u>PURPOSE</u>: To repeat a group of DMAP instructions a specified number of times.

III. <u>DMAP CALLING SEQUENCE</u>:

REPT n,c $ or REPT n,p $

where:

1. n is a BCD name appearing in a LABEL instruction which specifies the location of the beginning of a group of DMAP instructions to be repeated. (See LABEL instruction.)
2. c is an integer constant hard coded into the DMAP program which specifies the number of times to repeat the instructions.
3. p is a variable parameter set by a previously executed module specifying the number of times to repeat the instructions.

IV. <u>EXAMPLE</u>:

```
BEGIN  $
  .
  .
  .
LABEL L1  $
MØDULE1 A/B/V,Y,P1  $
  .
  .
  .
MØDULEN B/C/V,Y,P2  $
REPT L1,3  $
  .
  .
  .
END  $
```

or

```
BEGIN  $
  .
  .
  .
MODULEI X/Y/V,Y,NLØØP  $
LABEL L1  $
MODULE1 A/B/V,Y,P1  $
  .
  .
  .
MODULE N B/C/V,Y,P2  $
REPT L1,NLØØP  $
  .
  .
  .
END  $
```

V. <u>REMARKS</u>:

1. REPT is placed at the end of the group of instructions to be repeated.
2. When a variable number of loops is to be performed as in the second example above, the value of the variable at the first time the REPT instruction is encountered will determine the number of loops. This number will <u>not</u> be changed after the initial assignment.
3. A CØND (conditional jump) instruction may be used to exit from the loop if desired.
4. In the first example, the instructions MØDULE1 to MØDULEN will be repeated three times (i.e., executed four times).

EXECUTIVE OPERATION MODULE

I. NAME: SAVE (Save Variable Parameter Values)

II. PURPOSE: To specify which variable parameter values are to be saved from the preceding functional module DMAP instruction for use by subsequent modules.

III. DMAP CALLING SEQUENCE:

SAVE V1,V2,...,VN $

where the V1,V2,...,VN (N > 0) are the BCD names of some or all of the variable parameters which appear in the immediately preceding Functional Module DMAP instruction.

IV. REMARKS:

1. A SAVE instruction must immediately follow the functional module instruction wherein the parameters being saved are generated.
2. See Section 5.2.1.5 for a description of the alternate method of saving parameter values by means of the parameter specification statement.

I. NAME: XDMAP (Execute DMAP Program)

II. PURPOSE: To control the DMAP compiler options.

III. DMAP CALLING SEQUENCE:

$$\text{XDMAP} \left\{\begin{matrix}\underline{\text{GØ}}\\ \text{NØGØ}\end{matrix}\right\}, \left\{\begin{matrix}\text{ERR = 0}\\ \text{ERR = 1}\\ \underline{\text{ERR = 2}}\end{matrix}\right\}, \left\{\begin{matrix}\text{LIST}\\ \underline{\text{NØLIST}}\end{matrix}\right\}, \left\{\begin{matrix}\text{DECK}\\ \underline{\text{NØDECK}}\end{matrix}\right\}, \left\{\begin{matrix}\text{ØSCAR}\\ \underline{\text{NØØSCR}}\end{matrix}\right\}, \left\{\begin{matrix}\text{REF}\\ \underline{\text{NØREF}}\end{matrix}\right\}$$

where:

GØ - compile and execute program (default)

NØGØ - compile only and terminate job.

ERR - defines the error level at which suspension of execution will occur.

ERR = 0 Warning error level
1 Potentially Fatal error level
2 Fatal error level (default)

LIST - a listing of the DMAP program will be printed.

NØLIST - no listing (default)

DECK - a deck of the DMAP program will be punched.

NØDECK - a deck will not be punched (default)

ØSCAR - detailed listing of ØSCAR (Operation Sequence Control Array), the output of the DMAP compiler.

NØØSCR - no ØSCAR listing (default)

REF - a cross reference listing of the program will be printed.

NØREF - no cross reference (default)

IV. REMARKS:

1. The XDMAP card is optional and may be replaced by a BEGIN instruction. But, one or the other MUST appear in an APP DMAP execution.
2. The XDMAP instruction is non-executable and is used to control the above options by the DMAP compiler.
3. If all defaults are chosen the instruction need not appear, use BEGIN instead.
4. The DMAP compiler option defaults can also be overriden with DIAG 14 (DMAP listing), DIAG 17 (punch DMAP deck), and DIAG 4 (ØSCAR listing) in the Executive Control Deck. However, the option summary, printed before the DMAP source, will not change to reflect DIAG selections.

5.8 EXAMPLES

In order to facilitate the use of DMAP, several examples are provided in this section. The user is urged to study these examples both from the viewpoint of performing a sequence of matrix operations and that of a DMAP flow. In addition, some examples have been written to illustrate the improved DMAP syntax.

5.8.1 DMAP Example

Objective

1. Print the contents of table data block A.
2. Print matrix data blocks B, C, and D.
3. Print values of parameters P1 and P2.
4. Set parameter P3 equal to -7.

```
BEGIN     $                               XDMAP     $
TABPT     A,,,, // $                      TABPT     A // $
MATPRN    B,C,D,, // $                    MATPRN    B,C,D // $
PRTPARM   // C,N,0 / C,N,P1 $             PRTPARM   // 0 / *P1* $
PRTPARM   // C,N,0 / C,N,P2 $             PRTPARM   // 0 / *P2* $
PARAM     // C,N,NØP / V,N,P3=-7 $        PARAM     // *NØP* / P3=-7 $
END       $                               END       $
```

Remarks:

1. To be a practical example, a restart situation is assumed. The user is cautioned to remember to reenter at DMAP instruction 2 by changing the last reentry point in the restart dictionary.

2. In the alternate form, the omission of trailing commas in the TABPT and MATPRN instructions will generate PØTENTIALLY FATAL ERRØR messages alerting the user to possible errors in the data block name list.

5.8.2 DMAP Example

Let the constrained matrix $[K_{\ell\ell}]$ and the load vector $\{P_\ell\}$ be defined by means of DMI bulk data cards. The following DMAP sequence will perform the series of matrix operations

$$\{u_1\} = [K_{\ell\ell}]^{-1}\{P_\ell\}$$

$$\{r\} = [K_{\ell\ell}]\{u_1\} - \{P_\ell\}$$

$$\{\delta u\} = [K_{\ell\ell}]^{-1}\{r\}$$

$$\{u_2\} = \{u_1\} + \{\delta u\}$$

Print $\{u_2\}$

```
BEGIN   $
SØLVE   KLL,PL / U1 / C,N,1 / C,N,1 / C,N,1 / C,N,1 $
MPYAD   KLL,U1,PL / R / C,N,0 / C,N,1 / C,N,-1 $
SØLVE   KLL,R / DU / C,N,1 $
ADD     U1,DU / U2 $
MATPRN  U2,,,, // $
END     $
```

or

```
XDMAP   $
SØLVE   KLL,PL / U1 / 1 / 1 / 1 / 1 $
MPYAD   KLL,U1,PL / R / 0 / 1 / -1 $
SØLVE   KLL,R / DU / 1 $
ADD     U1,DU  /U2 $
MATPRN  U2 // $
END     $
```

Remarks:

1. $[K_{\ell\ell}]$ is assumed symmetric.

2. In the example above, KLL will be decomposed twice. A more efficient DMAP sequence, which requires only a single decomposition for this problem is given below.

```
BEGIN   $
DECØMP  KLL / LLL,ULL $
FBS     LLL,ULL,PL / U1 / C,N,1 / C,N,1 / C,N,1 / C,N,1 $
MPYAD   KLL,U1,PL / R / C,N,0 / C,N,1 / C,N,-1 $
FBS     LLL,ULL,R / DU $
ADD     U1,DU / U2 $
MATPRN  U2,,,, // $
END     $
```

or

```
XDMAP   $
DECØMP  KLL / LLL,ULL $
FBS     LLL,ULL,PL / U1 / 1 / 1 / 1 / 1  $
MPYAD   KLL,U1,PL / R / 0 / 1 / -1 $
FBS     LLL,ULL,R / DU $
ADD     U1,DU / U2 $
MATPRN  U2 // $
END     $
```

5.8.9 DMAP Example to Compute the r-th Power of a Matrix [Q]

```
BEGIN       $
MATPRN      Q,,,, // $
PARAM       // C,N,NØP / V,N,TRUE=-1 $
PARAM       // C,N,SUB / V,N,RR / V,Y,R=-1 / C,N,2 $
PARAM       // C,N,NØP / V,N,FALSE=+1 $
ADD         Q, / QQ $
LABEL       DØIT $
EQUIV       QQ,P / FALSE $
MPYAD       Q,QQ, / P / C,N,0 $
EQUIV       P,QQ / TRUE $
PARAM       // C,N,SUB / V,N,RR / V,N,RR / C,N,1 $
CØND        STØP,RR $
REPT        DOIT,1000000 $
LABEL       STØP $
MATPRN      P,,,, // $
END         $
```

or

```
BEGIN       $
MATPRN      Q // $
PARAM       // *SUB* / RR / V,Y,R=-1 / 2 $
CØPY        Q / P $
LABEL       TØP $
MPYAD       Q,P / PP / 0 $
SWITCH      P,PP // $
REPT        TØP,RR $
MATPRN      P // $
END         $
```

Notes:

1. The matrix [Q] is assumed input via DMI bulk data cards.
2. The parameter R is assumed input on a PARAM bulk data card.
3. A logical flow diagram for this DMAP is shown in the following sketch.
4. The improved DMAP to perform the same operation can be done with substantially fewer commands.

DIRECT MATRIX ABSTRACTION