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NASTRAN DOCUMENTATION FOR

FLUTTER ANALYSIS OF ADVANCED TURBOPROPELLERS

by

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16. Abstract

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This report presents the Theoretical, User's, Programmer's and Demonstration manuals for this new capability in NASTRAN Level 17.7. The work was conducted under Contract NAS 3-22533 from NASA Lewis Research Center, Cleveland, Ohio, with Mr. Richard E. Morris as the Technical Monitor.

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An existing capability developed by the authors to conduct modal flutter analysis of tuned bladed-shrouded discs in NASTRAN Level 17.7 has been modified to facilitate investigation of the subsonic unstalled flutter characteristics of advanced turbopropellers. The modifications pertain to the inclusion of oscillatory modal aerodynamic loads of blades with large (backward and forward) varying sweep.

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1. THEORETICAL MANUAL

MODAL FLUTTER ANALYSIS OF ADVANCED TURBOPROPELLERS

1.1 Introduction

An existing capability to conduct modal flutter analysis of tuned bladed-shrouded discs in NASTRAN (Ref. 1) has been modified to analyze the subsonic unstalled flutter characteristics of advanced turbopropellers in NASTRAN Level 17.7.

The modifications pertain to the inclusion of oscillatory modal aerodynamic loads of blades with large (backward and forward) varying sweep.

The following section summarizes the theoretical aspects of turboprop flutter analysis from Ref. 2.

1.2 Theory

Multi-bladed advanced turbopropellers are geometrically cyclic structures with thin blades of low aspect ratio and varying sweep. The blades are mounted on a relatively rigid hub and, therefore, can be considered to be structurally independent. This permits modal analysis of only one root-fixed blade without recourse to special harmonic analysis techniques applicable to cyclic structures. From a flutter aerodynamics viewpoint, the estimation of the generalized oscillatory aerodynamic loads on the propeller blades depends on the aerodynamic theory employed. In the present capability, the two-dimensional subsonic cascade unsteady aerodynamic theory of Jones and Rao (Ref. 3) is applied in a strip theory manner similar to that of Barmby et al (Ref. 4) with appropriate modifications recognizing the variability of the blade sweep and chord with radius.

To facilitate the use of the two-dimensional cascade theory, the aerodynamic model of the blade is based on a grid defined by the intersection of a series of chords and "computing stations" as shown by the thick solid lines in Figure 1. The chords are selected normal to any spanwise reference curve such as the blade leading edge. Due to its resemblance to the structural model of the blade, and the adequacy of a relatively coarse grid to describe the spanwise flow variations, the aerodynamic model is chosen as a subset of the structural model.

The modified two-dimensional cascade theory is applied on each of these chords to determine the generalized aerodynamic forces acting on the associated strips. The strip results are added to obtain the blade aerodynamic matrix.

An overall flowchart for modal flutter analysis of advanced turbopropellers is shown in Figure 2.

The User's, Programmer's and Demonstration Manuals are presented in Sections 2, 3 and 4, respectively.

1.3 References

1. Elchuri, V., and Smith, G. C. C., "NASTRAN Level 16 Theoretical Manual Updates for Aeroelastic Analysis of Bladed Discs," NASA CR-159823, March 1980.
2. Elchuri, V., and Smith, G. C. C., "NASTRAN Flutter Analysis of Advanced Turbopropellers," Final Technical Report, NASA CR-167926 , April 1982.
3. Rao, B. M., and Jones, W. P., "Unsteady Airloads for a Cascade of Staggered Blades in Subsonic Flow," 46th Propulsion Energetics Review Meeting, Monterey, California, September 1975.
4. Barmby, J. G., Cunningham, H. J., and Garrick, I. E., "Study of Effects of Sweep on the Flutter of Cantilever Wings," NACA Report 1014, 1951.

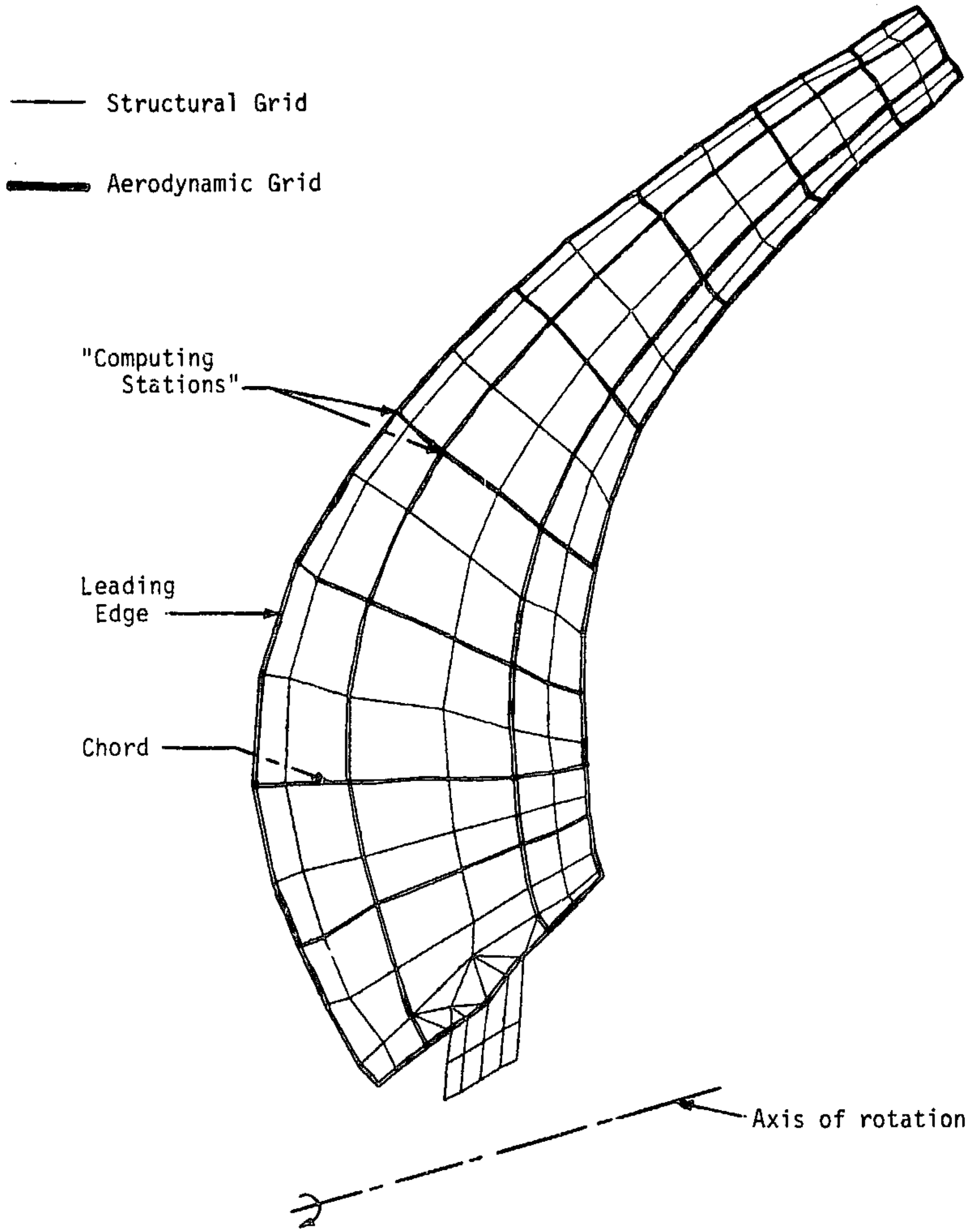

Figure 1. NASTRAN Structural and Aerodynamic Models of the Advanced Turbopropeller for Flutter Analysis

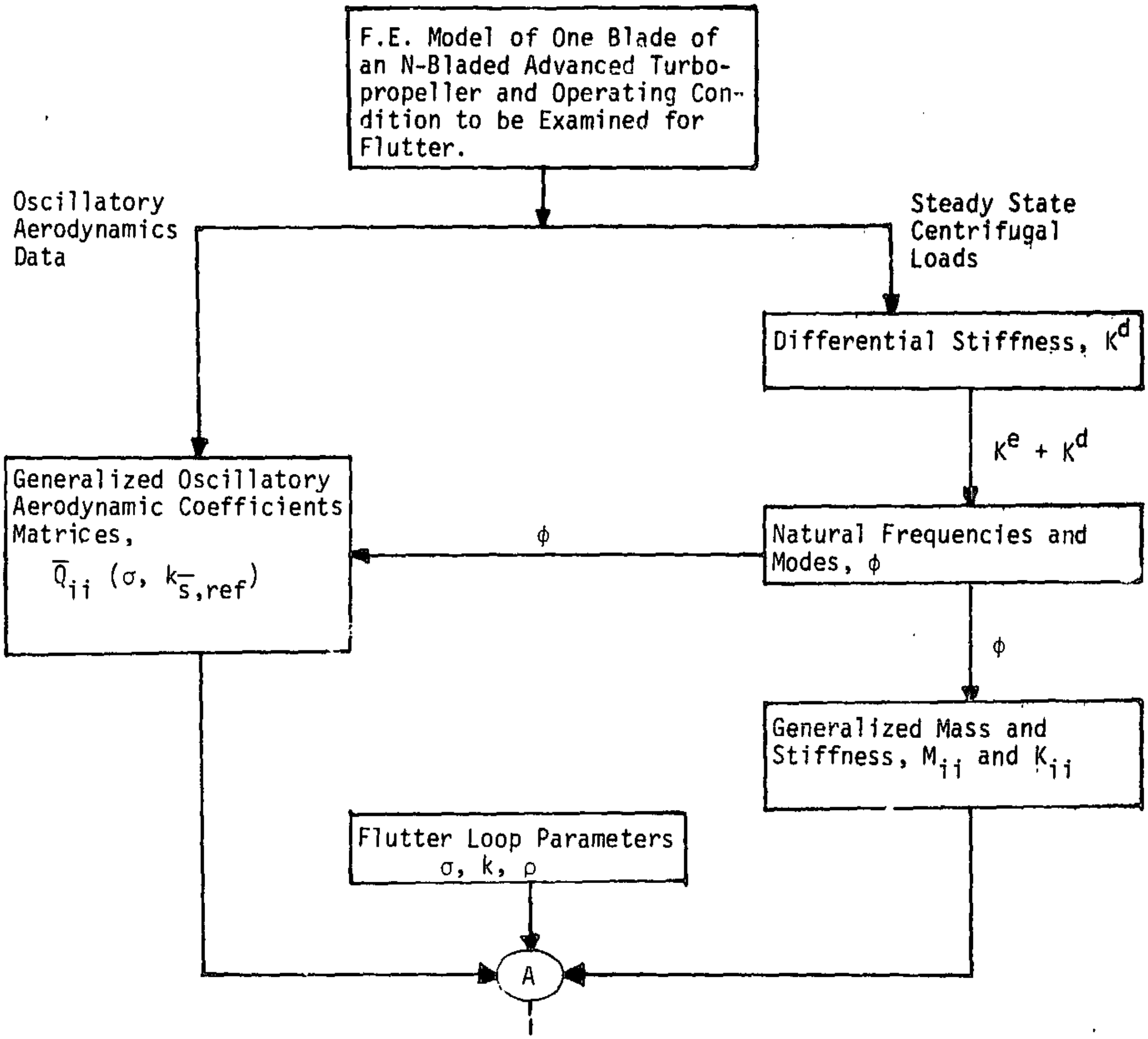

Figure 2. Overall Flowchart of Advanced Turbopropeller Modal Flutter Analysis (continued).

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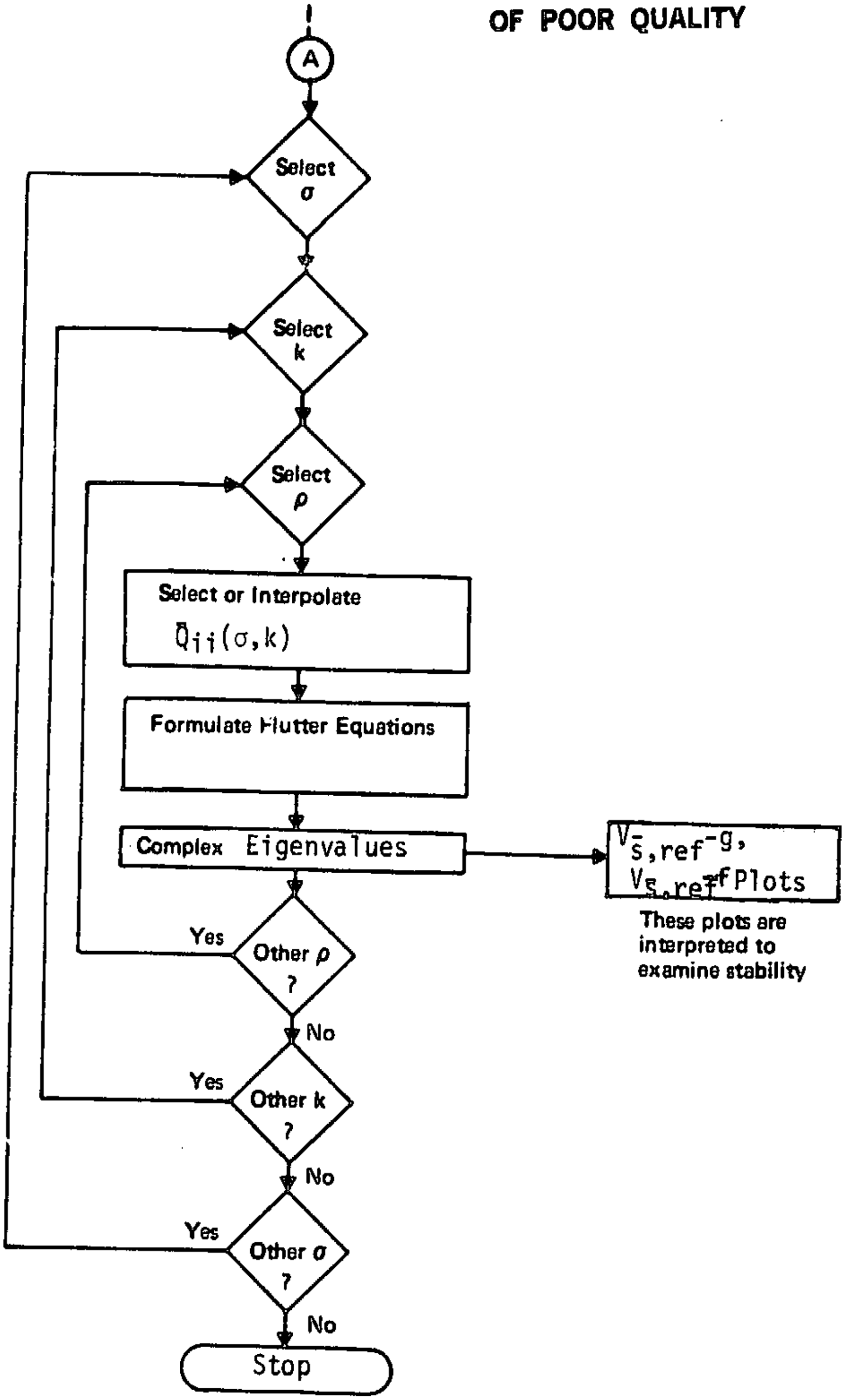


Figure 2. Overall Flowchart of Advanced Turbopropeller Modal Flutter Analysis (Concluded)

2. USER'S MANUAL

MODAL FLUTTER ANALYSIS OF ADVANCED TURBOPROPELLERS

2.1 Introduction

Subsonic unstalled (modal) flutter analysis of advanced turbopropellers can be conducted using this capability. The AERO APPROACH Rigid Format 9, Series R, in NASTRAN Level 17.7 (Section 2.6) with modified functional modules APDB, AMG and AMP forms the basis for modal flutter analysis. Section 4 demonstrates the use of the capability. Section 1 presents the theoretical aspects.

2.2 Solution Phases

As illustrated by the example in the Demonstration Manual (Section 4), the flutter analysis can, in general, be conducted in three phases--phase 1 to generate differential stiffness, phase 2 to compute natural modes and frequencies and phase 3 to compute flutter eigenvalues.

Phase 1 uses DISP RF4 while phases 2 and 3 use AERO RF9.

2.3 NASTRAN Model

With the assumption of tuned blades mounted on a relatively rigid hub, the user models one blade of the advanced turbopropeller as shown in Figure 1.

The structural model is prepared using the general modelling capabilities of NASTRAN. The basic coordinate system is fixed to the rotating propeller such that the X-axis always coincides with the axis of rotation and is directly opposing the flight direction. Location of the origin is arbitrary.

The XZ plane is approximately located such as to contain the maximum projected area of the blade being modelled. This orientation is consistent with the internally generated chordline coordinate systems for the unsteady aerodynamics.

The aerodynamic model comprises a grid defined by the intersection of a series of chords and "computing stations" (Figure 1). The chords are selected normal to any spanwise reference curve such as the blade leading edge. The choice of the number and location of the chords and the computing stations is dictated by the expected variation of the relative flow properties across the blade span, and the complexity of the mode shapes exhibited by the propeller blade. Due to its resemblance to the structural model of the blade, and the adequacy of a relatively coarse grid to describe the spanwise flow variations, the aerodynamic model is chosen as a subset of the structural model as shown in Figure 1.

The aerodynamic grid is specified on STREAML1 bulk data cards.

2.4 Remarks on the Use of Some Cards

As noted in the Theoretical Manual (Section 1), the present capability to analyze turboprop flutter is derived by modifying the modal flutter analysis capability originally developed for bladed discs. These modifications as reflected in the user input preparation are discussed below.

The NASTRAN card is required for flutter analysis only if sweep aerodynamic effects are to be included. It is placed preceding the Executive Control Deck, and is specified as

NASTRAN SYSTEM (76) = 1

Section 2.1 of the NASTRAN User's Manual, and Section 7.3.1 of the NASTRAN Programmer's Manual discuss this card in detail.

In light of the assumption of structurally independent blades,

a) CYJOIN bulk data cards are required merely for their presence in the Bulk Data Deck,

b) PARAM KINDEX is set to zero to save computational time in the real eigenvalue extraction process and

c) PARAM MTYPE is set to COSINE (default) because of KINDEX = 0.

The STREAML2 bulk data card (see Section 2.5) has been modified to include the parameters associated with the swept blade aerodynamics. Figure 2 defines some of these parameters. In this figure, A_-B_-, AB and A_+B_+ represent three successive chords with points A's on the leading edge. For the chord AB, at any operating condition $\overrightarrow{WA}$ represents the absolute inflow velocity while $\overrightarrow{AU}$ ($= \vec{\Omega} \times \overrightarrow{RA}$) is the blade (tangential) velocity. WA and AU uniquely define a plane in which the inflow properties are defined.

In the plane WAU, $\overrightarrow{VA} = \overrightarrow{WA} - \overrightarrow{AU}$ represents the relative inflow velocity. $\overrightarrow{CA}$ represents the chordwise, cascade relative inflow velocity (Field 2, continuation card). Mach number in Field 8 is based on CA. AI is the line of intersection between the axial plane through point A and the plane WAU. Angle IAV defines the relative inflow angle β (shown positive).

The angle of sweep Λ is defined as the angle of inclination of the chord BA with the plane WAU. Λ shown in Figure 2 is positive.

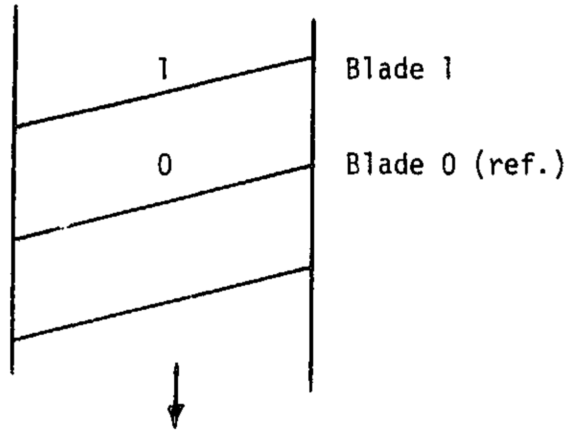
AD is the projection of AC (BA extended to C) in the plane WAU. Angle IAD represents the stagger angle λ, and is shown positive.

A local coordinate system $\bar{x}\bar{y}\bar{z}$ is internally defined at the leading edge point A of the chord AB such that $\bar{x}$ is directed along AB. $\bar{y}$ is defined normal to the 'mean' surface containing the points A_-, A, A_+, B_+, B and B_-. The unit vector along $\bar{y}$, for the sense of Ω shown in Figure 2, is given by

$$\hat{j} = \frac{1}{2}\left|\frac{(\overrightarrow{A_-B_+}) \times (\overrightarrow{AB})}{|(\overrightarrow{A_-B_+}) \times (\overrightarrow{AB})|} + \frac{(\overrightarrow{AB}) \times (\overrightarrow{A_+B_-})}{|(\overrightarrow{AB}) \times (\overrightarrow{A_+B_-})|}\right| .$$

Modal translations along $\bar{y}$ and rotations about $\bar{x}$ are used in deriving the generalized airforce matrix. For the opposite sense of rotation, $\bar{x}\bar{y}\bar{z}$ is internally defined to be left handed with $\bar{y}$ reversing direction. The shaded area about the chord AB represents the strip of integration associated with AB.

The <u>FLFACT</u>, <u>FLUTTER</u> and <u>MKAEROi</u> bulk data cards (Section 2.5) have been modified to specify the interblade phase angles. Referring to the sketch below, a positive interblade phase angle implies that blade 1 of the two-dimensional cascade <u>leads</u> the reference blade 0.



Section 2.5 contains all the bulk data cards associated with aerodynamics data specification for the turboprop flutter analysis. Section 2.6 describes all the PARAMeters.

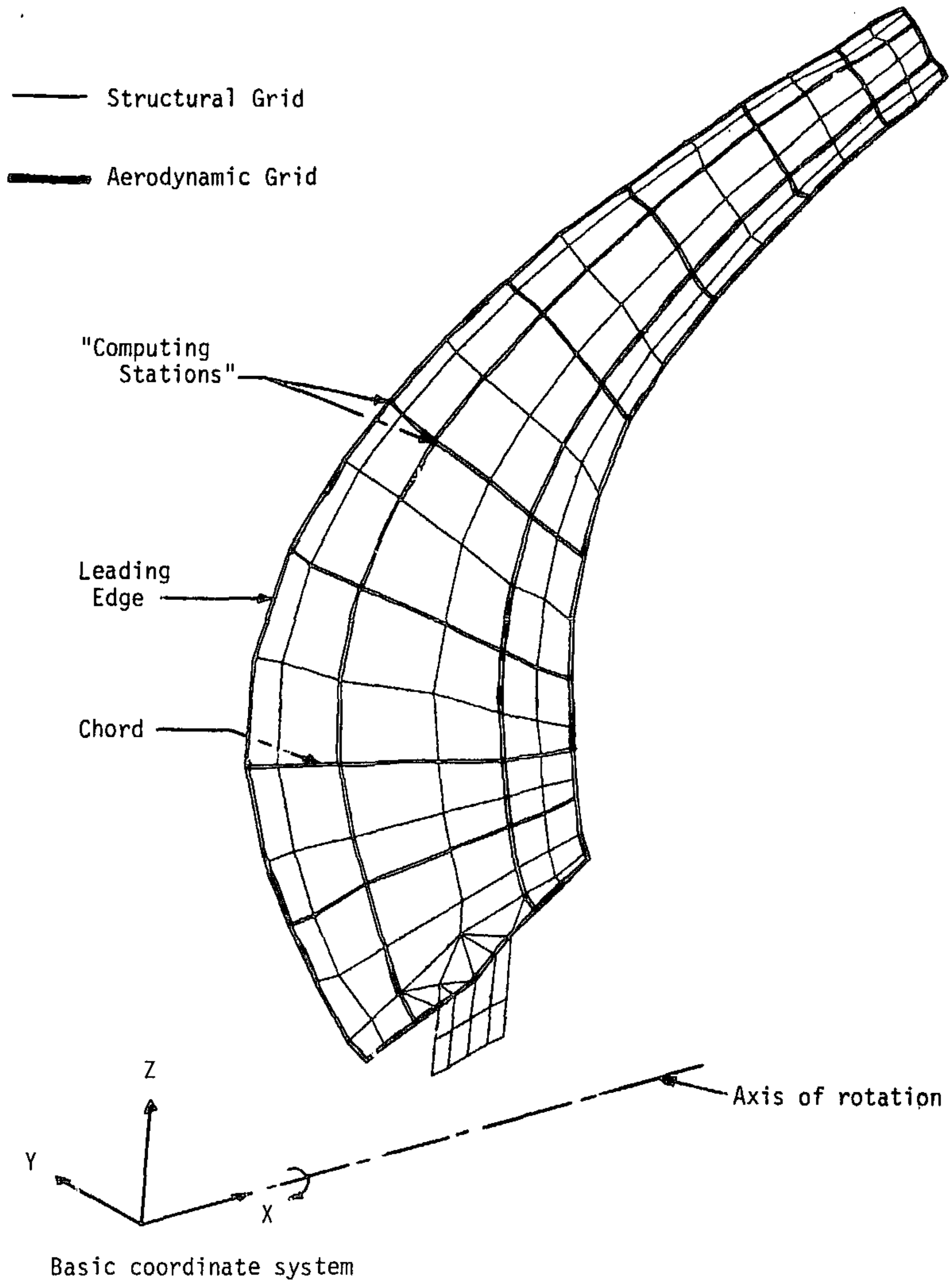


Figure 1. NASTRAN Structural and Aerodynamic Models of the Advanced Turbopropeller for Flutter Analysis

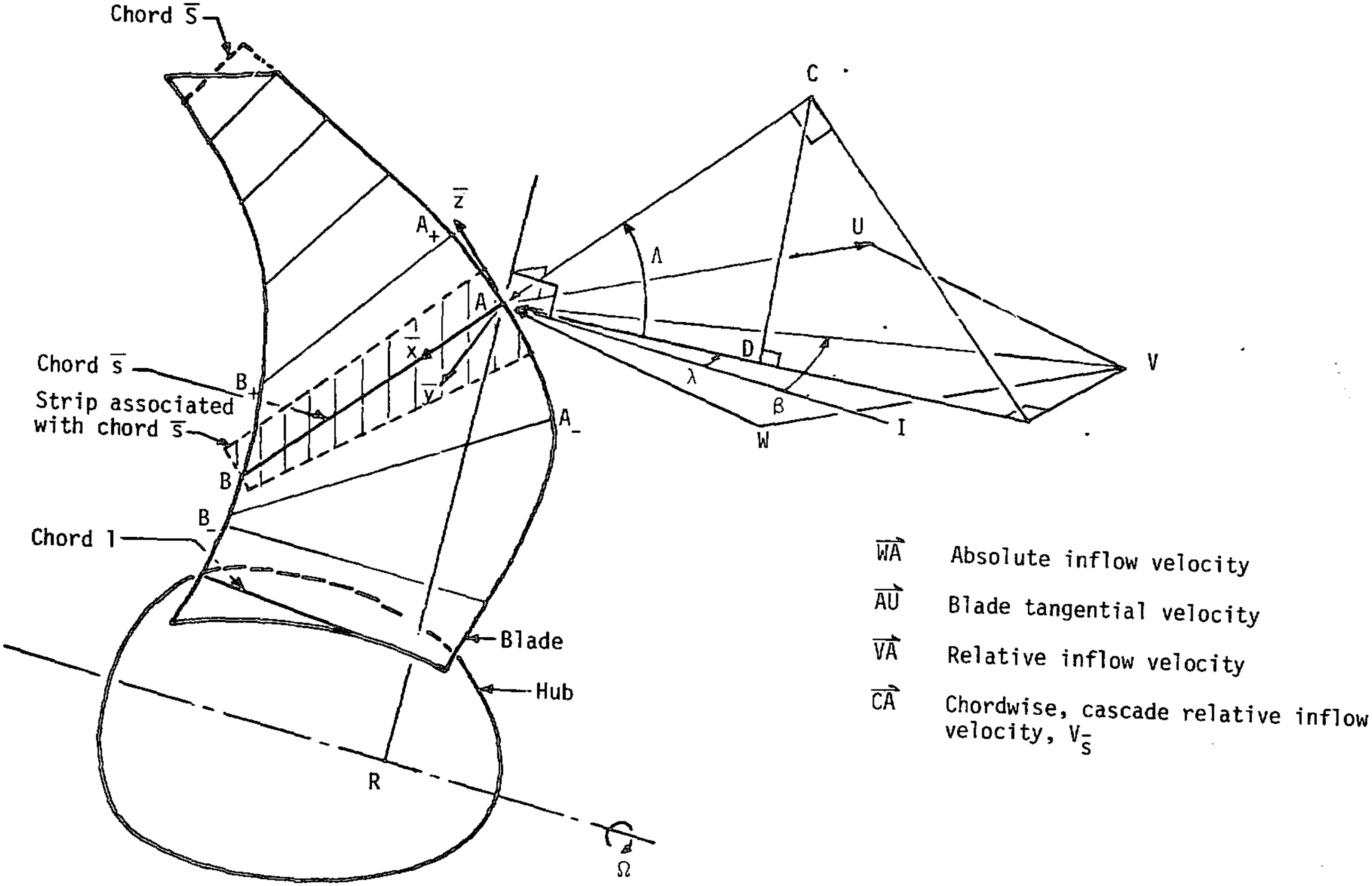


Figure 2. Some Definitions for Swept Blade Aerodynamics

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	VELØCITY	REFC	RHØREF	SYMXZ	SYMXY			
AERØ	3	1.3+4	100.	1.-5		1			

Field	Contents
ACSID	Aerodynamic coordinate system identification (Integer ≥ 0). See Remark 2.
VELØCITY	Velocity (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 response problems. Only one AERØ card is allowed.
2. The ACSID must be a rectangular coordinate system. Flow is in the positive x direction.
3. Reference length, $b = REFC/2$

   $$\left(k = \frac{\omega b}{V} \right)$$

BULK DATA DECK

Input Data Card FLFACT Aerodynamic Physical Data

Description: Used to specify densities, Mach numbers or interblade phase angles, 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					abc
+BC	F8	F9	--etc.--						

Alternate Form:

FLFACT	SID	F1	THRU	FNF	NF	FMID	X	X	
FLFACT	201	.200	THRU	.100	11	.133333			

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.
4. For the alternate form, NF must be greater than 1. F_{mid} must lie between F_1 and F_{NF}, otherwise F_{mid} will be set to $(F_1 + F_{NF})/2$. Then

$$F_i = \frac{F_1(F_{NF}-F_{mid})(NF-i) + F_{NF}(F_{mid}-F_1)(i-1)}{(F_{NF}-F_{mid})(NF-i) + (F_{mid}-F_1)(i-1)} \qquad i = 1,2,\ldots,NF$$

The use of F_{mid} (middle factor selection) allows unequal spacing of the factors. $F_{mid} = 2F_1F_{NF}/(F_1+F_{NF})$ gives equal values to increments of the reciprocal of F_i.

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	EPS	
FLUTTER	19	K	119	219	319	S	5	1.-4	

Field	Contents
SID	Set identification number (Unique Integer > 0).
METHØD	Flutter analysis method, "K" for K-method, "PK" for P-K method, "KE" for the K-method restricted for efficiency.
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 or interblade phase angles (m) to be used in flutter analysis (integer ≥ 0).
RFREQ (or VEL)	Identification number of an FLFACT data card specifying reduced frequencies (k) to be used in flutter analysis (Integer > 0); for the p-k method, the velocity.
IMETH	Choice of interpolation method for matrix interpolation (BCD: L = linear, S = surface).
NVALUE	Number of eigenvalues for output and plots (Integer > 0).
EPS	Convergence parameter for k; used in the P-K method (Real)(default = 10^{-3}).

Remarks:

1. The FLUTTER data card must be selected in Case Control Deck (FMETHOD = SID).
2. The density is given by DENS · RHØREF, where RHØREF is the reference value 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.
4. An eigenvalue is accepted in the P-K method when $|k - k_{estimate}| < EPS$.

Input Data Card MKAERØ1 Mach Number - Frequency Table

Description: Provides a table of Mach numbers or interblade phase angles (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 > 0.0, $1 \leq j \leq 8$).

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.
4. Since 0.0 is not allowed, it may be simulated with a very small number such as 0.0001.
5. Mach numbers are input for wing flutter and interblade phase angles for blade flutter.

Input Data Card MKAERØ2 Mach Number - Frequency Table

Description: Provides a list of Mach numbers or interblade phase angles (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	List of Mach numbers (Real > 0.0).
k_i	List of reduced frequencies (Real > 0.0).

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.
3. Imbedded blank pairs are skipped.
4. Mach numbers are input for wing flutter and interblade phase angle for blade flutter.

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BULK DATA DECK

Input Data Card **STREAML1** Blade Streamline Data

Description: Defines grid points on the blade streamline from blade leading edge to blade trailing edge.

Format and Example:

1	2	3	4	5	6	7	8	9	10
STREAML1	SLN	G1	G2	G3	G4	G5	G6	G7	+ABC
STREAML1	3	2	4	6	8	10			

+ABC	G8	G9	-etc-						
+ABC									

Alternate Form:

STREAML1	SLN	GID1	"THRU"	GID2	X	X	X	X	
STREAML1	5	6	THRU	12					

Field	Contents
SLN	Streamline number (integer > 0).
Gi, GIDi	Grid point identification numbers (integer > 0).

Remarks:

1. This card is required for blade steady aeroelastic and blade flutter problems.

2. There must be one STREAML1 card for each streamline on the blade. For blade flutter problems, there must be an equal number of STREAML1 and STREAML2 cards.

3. The streamline numbers, SLN, must increase with increasing radial distance of the blade section from the axis of rotation. The lowest and the highest SLN, respectively, will be assumed to represent the blade sections closest to and farthest from the axis of rotation.

4. All grid points should be unique.

5. All grid points referenced by GID1 through GID2 must exist.

6. Each STREAML1 card must have the same number of grid points. The nodes must be input from the blade leading edge to the blade trailing edge in the correct positional order.

Input Data Card STREAML2 Blade Streamline Data

Description: Defines aerodynamic data for a blade streamline.

Format and Example:

STREAML2	SLN	NSTNS	STAGGER	CHORD	RADIUS/ DCBDZB	BSPACE	MACH	DEN	+abc
STREAML2	2	3	23.5	1.85	6.07	.886	.934	.066	

+abc	VEL	FLOWA/ SWEEP							
+ABC	1014.2	55.12							

Field	Contents
SLN	Streamline number (Integer >0)
NSTNS	Number of computing stations on the blade streamline. ($3 \leq$ NSTNS ≤ 10, Integer)
STAGGER	Blade stagger angle (-90.0 <stagger <90.0, degrees)
CHORD	Blade chord (real >0.0)
RADIUS/DCBDZB	Radius of streamline for flutter analysis without sweep effects (real >0.0) or $\partial\overline{C}/\partial\overline{Z}$ for flutter analysis with sweep effects. $\overline{C}$ is the swept chord and $\overline{Z}$ is the (local) spanwise reference direction (real)
BSPACE	Blade spacing (real >0.0)
MACH	Relative flow mach number at blade leading edge (real >0.0)
DEN	Gas density at blade leading edge (real >0.0)
VEL	Relative flow velocity at blade leading edge (real >0.0)
FLOWA/SWEEP	Relative flow angle at blade leading edge for flutter analysis without sweep effects (-90.0 <FLOWA <90.0 degrees) or Blade sweep angle for flutter analysis with sweep effects (-90.0 <SWEEP <90.0 degrees)

Remarks:

1. At least three (3) and no more than fifty (50) STREAML2 cards are required for a blade flutter analysis.

2. The streamline number, SLN, must be the same as its corresponding SLN on a STREAML1 card. There must be a STREAML1 card for each STREAML2 card.

3. It is not required that all streamlines be used to define the aerodynamic matrices used in blade flutter analysis.

4. For flutter analysis with sweep effects, the use of the <u>NASTRAN card</u> is required as follows:
   NASTRAN SYSTEM (76) = 1
   Refer to Section 2.1 of the User's Manual and Section 6.3.1 of the Programmer's Manual for description and placement in the Executive Control Deck.

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2.6 COMPRESSOR BLADE CYCLIC MODAL FLUTTER ANALYSIS

2.6.1 DMAP Sequence For Compressor Blade Cyclic Modal Flutter Analysis

RIGID FORMAT DMAP LISTING

AERO APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
OPTIONS IN EFFECT:  GO        ERR=2    NOLIST   NODECK   NOREF    NOOSCAR

  1  BEGIN    AERO NO.9 COMPRESSOR BLADE CYCLIC MODAL FLUTTER ANALYSIS $
  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 $
  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  PARAM    // C,N,NOP / V,Y,KGGIN=-1 $
 20  COND     JMPKGGIN,KGGIN $
 21  PARAM    //C,N,ADD /V,N,NOKGGX /C,N,-1 /C,N,0 $
 22  INPUTT1  /KTOTAL,,,,/C,Y,LOCATION=-1 /C,Y,INPTUNIT=0 $
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RIGID FORMATS

RIGID FORMAT DMAP LISTING

AERO APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
23  EQUIV    KTOTAL,KGGX $
24  CHKPNT   KGGX $
25  LABEL    JMPKGGIN $
26  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 $
27  SAVE     NOKGGX,NOMGG $
28  CHKPNT   KELM,KDICT,MELM,MDICT $
29  COND     JMPKGGX,NOKGGX $
30  EMA      GPECT,KDICT,KELM/KGGX,GPST $
31  CHKPNT   KGGX,GPST $
32  LABEL    JMPKGGX $
33  COND     ERROR1,NOMGG $
34  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $
35  CHKPNT   MGG $
36  COND     LGPWG,GRDPNT $
37  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $
38  OFP      OGPWG,,,,,// $
39  LABEL    LGPWG $
40  EQUIV    KGGX,KGG/NOGENL $
41  CHKPNT   KGG $
42  COND     LBL11,NOGENL $
43  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
44  CHKPNT   KGG $
45  LABEL    LBL11 $
46  GP4      CASECC,GEOM4,EQEXIN,    GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,
```

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COMPRESSOR BLADE CYCLIC MODAL FLUTTER ANALYSIS

RIGID FORMAT DMAP LISTING

AERO APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
             USET/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 $
47  SAVE     MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,REPEAT,NOL,NOA $
48  PARAM    //C,N,NOT/V,N,REACDATA /V,N,REACT $
49  COND     ERROR5,REACDATA $
50  PURGE    GM,GMD/MPCF1/GO,GOD/OMIT/KFS,QPC/SINGLE $
51  GPCYC    GEOM4,EQEXIN,USET /CYCD/ V,Y,CTYPE / V,N,NOGO $
52  SAVE     NOGO $
53  CHKPNT   CYCD $
54  COND     ERROR6,NOGO $
55  COND     LBL4,GENEL $
56  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
57  SAVE     NOGPST $
58  COND     LBL4,NOGPST $
59  OFP      OGPST,,,,,// $
60  LABEL    LBL4 $
61  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $
62  CHKPNT   KNN,MNN $
63  COND     LBL2,MPCF1 $
64  MCE1     USET,RG/GM $
65  CHKPNT   GM $
66  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $
67  CHKPNT   KNN,MNN $
68  LABEL    LBL2 $
69  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE $
70  CHKPNT   KFF,MFF $
```

RIGID FORMAT DMAP LISTING

AERO APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
71  COND     LBL3,SINGLE $
72  SCE1     USET,KNN,MNN,,/KFF,KFS,,MFF,, $
73  CHKPNT   KFF,KFS,MFF $
74  LABEL    LBL3 $
75  EQUIV    KFF,KAA/OMIT/ MFF,MAA/OMIT $
76  CHKPNT   KAA,MAA $
77  COND     LBL5,OMIT $
78  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $
79  CHKPNT   GO,KAA $
80  SMP2     USET,GO,MFF/MAA $
81  CHKPNT   MAA $
82  LABEL    LBL5 $
83  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 $
84  SAVE     LUSETD,NOUE,NOEED $
85  COND     ERROR2,NOEED $
86  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $
87  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 $
88  SAVE     NOGO $
89  CHKPNT   KKK,MKK $
90  COND     ERROR6,NOGO $
91  READ     KKK,MKK,,,EED,,CASECC / LAMK,PHIK, ,OEIGS / C,N,MODES /V,N,
             NEIGV $
92  SAVE     NEIGV $
93  CHKPNT   LAMK,PHIK, OEIGS $
```

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COMPRESSOR BLADE CYCLIC MODAL FLUTTER ANALYSIS

RIGID FORMAT DMAP LISTING

AERO APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 94  PARAM    //C,N,MPY / V,N,CARDNO / C,N,0 / C,N,0 $
 95  OFP      OEIGS,LAMK,,,, // V,N,CARDNO $
 96  SAVE     CARDNO $
 97  COND     ERROR4,NEIGV $
 98  CYCT2    CYCD,,,,PHIK,LAMK /,,,PHIA,LAMA / C,N,BACK / V,Y,NSEGS /V,Y,
              KINDEX / V,Y,CYCSEQ / C,N,1 / V,N,NOGO $
 99  SAVE     NOGO $
100  CHKPNT   LAMA,PHIA $
101  COND     ERROR6,NOGO $
102  SDR1     USET,,PHIA,,,GO,GM,,KFS,, / PHIG,, / C,N,1 / C,N,REIG $
103  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,,PHIG,EST,, / ,,
              OPHIG,,, / C,N,REIG $
104  OFP      OPHIG,,,,,// V,N,CARDNO $
105  SAVE     CARDNO $
106  APDB     EDT,USET,BGPDT,CSTM,EQEXIN,GM,GO / AERO,ACPT,FLIST,GTKA,PVECT/
              V,N,NK/V,N,NJ/V,Y,MINMACH/V,Y,MAXMACH/V,Y,IREF/V,Y,MTYPE/V,N,
              NEIGV/V,Y,KINDEX=-1 $
107  SAVE     NK,NJ $
108  CHKPNT   AERO,ACPT,FLIST,GTKA,PVECT $
109  PARTN    PHIA,PVECT, / PHIAX,,, / C,N,1 $
110  SMPYAD   PHIAX,MAA,PHIAX,,, / MI / C,N,3/C,N,1/C,N,1/C,N,0/C,N,1 $
111  MTRXIN   CASECC,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
              NOK2PP/V,N,NOM2PP/V,N,NOB2PP $
112  SAVE     NOK2PP,NOM2PP,NOB2PP $
113  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $
114  EQUIV    M2PP,M2DD/NOSET/B2PP,B2DD/NOSET/K2PP,K2DD/NOSET $
115  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD $
116  GKAD     USETD,GM,GO,,,,,K2PP,M2PP,B2PP/,,,GMD,GOD,K2DD,M2DD,B2DD/C,N,
```

RIGID FORMAT DMAP LISTING

AERO APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
                 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 $
117  CHKPNT      K2DD,M2DD,B2DD,GOD,GMD $
118  GKAM        USETD,PHIAX,MI,LAMK,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 $
119  SAVE        NONCUP,FMODE $
120  CHKPNT      MHH,BHH,KHH,PHIDH $
121  PARAML      PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
122  PURGE       PLTSETX,PLTPAR,GPSETS,ELSETS / NOPCDB $
123  COND        P2,NOPCDB $
124  PLTSET      PCDB,EQDYN,ECT / PLTSETX,PLTPAR,GPSETS,ELSETS / V,N,NSIL1 /V,N,
                 JUMPPLOT=-1 $
125  SAVE        NSIL1,JUMPPLOT $
126  PRTMSG      PLTSETX // $
127  PARAM       //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
128  PARAM       //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
129  COND        P2,JUMPPLOT $
130  PLOT        PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQDYN,,,,,/PLOTX1/V,N,NSIL1/
                 V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
131  SAVE        JUMPPLOT,PLTFLG,PFILE $
132  PRTMSG      PLOTX1 // $
133  LABEL       P2 $
134  COND        ERROR2,NOEED $
135  PARAM       //C,N,ADD/V,N,DESTRY/C,N,0/C,N,1 $
136  AMG         AERO,ACPT/AJJL,SKJ,D1JK,D2JK/V,N,NK/V,N,NJ/V,N,DESTRY $
137  SAVE        DESTRY $
```

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RIGID FORMAT DMAP LISTING

AERO APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
138  CHKPNT    AJJL,SKJ,D1JK,D2JK $
139  COND      NODJE,NODJE $
140  INPUTT2   /D1JE,D2JE,,,/C,Y,POSITION=-1/C,Y,UNITNUM=11/   C,Y,USRLABEL=
               TAPEID $
141  LABEL     NODJE $
142  PARAM     //C,N,ADD/V,N,XQHHL/C,N,1/C,N,0 $
143  AMP       AJJL,SKJ,D1JK,D2JK,GTKA,PHIDH,D1JE,D2JE,USETD,AERO/QHHL,,  /V,
               N,NOUE/V,N,XQHHL $
144  SAVE      XQHHL $
145  CHKPNT    QHHL $
146  PARAM     //C,N,MPY/V,N,NOP/C,N,-1/C,N,1 $
147  PARAM     //C,N,MPY/V,N,NOP/C,N,1/C,N,1 $
148  PARAM     //C,N,MPY/V,N,NOH/C,N,0/C,N,1 $
149  PARAM     //C,N,MPY/V,N,FLOOP/V,Y,NODJE=-1/C,N,0 $
150  JUMP      LOOPTOP $
151  LABEL     LOOPTOP $
152  FA1       KHH,BHH,MHH,QHHL,CASECC,FLIST/FSAVE,KXHH,BXHH,MXHH/V,N,FLOOP/V,
               N,TSTART $
153  SAVE      FLOOP,TSTART $
154  CEAD      KXHH,BXHH,MXHH,EED,CASECC/PHIH,CLAMA,OCEIGS/V,N,EIGVS $
155  SAVE      EIGVS $
156  COND      LBLZAP,EIGVS $
157  COND      LBL16,NOH $
158  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 $
159  SAVE      NOH,NOP $
160  COND      LBL16,NOH $
```

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RIGID FURMAT DMAP LISTING

AERO APPROACH, RIGID FURMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
161  OFP      OPHIH,,,,,//V,N,CARDNO $
162  SAVE     CARDNU $
163  LABEL    LBL16 $
164  FA2      PHIH,CLAMA,FSAVE/PHIHL,CLAMAL,CASEYY,OVG/V,N,TSTART/C,Y,VREF=
              1.0/C,Y,PRINT=YESB $
165  SAVE     TSTART $
166  CHKPNT   PHIHL,CLAMAL,CASEYY,OVG $
167  COND     CONTINUE,TSTART $
168  LABEL    LBLZAP $
169  COND     CONTINUE,FLOOP $
170  REPT     LOOPTOP,100 $
171  JUMP     ERROR3 $
172  LABEL    CONTINUE $
173  CHKPNT   OVG $
174  PARAML   XYCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOXYCDB $
175  COND     NOXYOUT,NOXYCDB $
176  XYTRAN   XYCDB,OVG,,,,/XYPLTCE/C,N,VG/C,N,PSET/V,N,PFILE/V,N,CARDNO $
177  SAVE     PFILE,CARDNO $
178  XYPLOT   XYPLTCE// $
179  LABEL    NOXYOUT $
180  PARAM    //C,N,AND/V,N,PJUMP/V,N,NOP=-1/V,N,JUMPPLOT $
181  COND     FINIS,PJUMP $
182  MODACC   CASEYY,CLAMAL,PHIHL,CASECC,,/CLAMAL1,CPHIH1,CASEZZ,,/C,N,
              CEIGN $
183  DDRL     CPHIH1,PHIDH/CPHID $
184  CHKPNT   CPHID $
```

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COMPRESSOR BLADE CYCLIC MODAL FLUTTER ANALYSIS

RIGID FORMAT DMAP LISTING

AERO APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
185  EQUIV    CPHID,CPHIP/NOA $
186  COND     LBL14,NOA $
187  SDR1     USETD,,CPHID,,,GOD,GMD,,KFS,,/CPHIP,,QPC/C,N,1/C,N,DYNAMICS $
188  LABEL    LBL14 $
189  CHKPNT   CPHIP,QPC $
190  EQUIV    CPHID,CPHIA/NOUE $
191  COND     LBLNOE,NOUE $
192  VEC      USETD/RP/C,N,D/C,N,A/C,N,E $
193  PARTN    CPHID,,RP/CPHIA,,,/C,N,1/C,N,3 $
194  LABEL    LBLNOE $
195  SDR2     CASEZZ,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDT,CLAMAL1,QPC,CPHIP,EST,,/
              ,OQPC1,OCPHIP,OESC1,OEFC1,PCPHIP/C,N,CEIGN $
196  CHKPNT   PCPHIP $
197  OFP      OCPHIP,OQPC1,OESC1,OEFC1,,//V,N,CARDNO $
198  COND     P3,JUMPPLOT $
199  PLOT     PLTPAR,GPSETS,ELSETS,CASEZZ,BGPDT,EQDYN,SILD,,PCPHIP,,/PLOTX3/
              V,N,NSIL1/V,N,LUSET/V,N,JUMPPLOT /V,N,PLTFLG/V,N,PFILE $
200  PRTMSG   PLOTX3// $
201  LABEL    P3 $
202  JUMP     FINIS $
203  LABEL    ERROR1 $
204  PRTPARM  //C,N,-1/C,N,FSUBSCN $
205  LABEL    ERROR2 $
206  PRTPARM  //C,N,-2/C,N,FSUBSCN $
207  LABEL    ERROR3 $
208  PRTPARM  //C,N,-3/C,N,FSUBSCN $
```

RIGID FORMAT DMAP LISTING

AERO APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
209  LABEL      ERROR4 $
210  PRTPARM    //C,N,-4/C,N,FSUBSUN $
211  LABEL      ERROR5 $
212  PRTPARM    // C,N,-4 / C,N,CYCMODES $
213  LABEL      ERROR6 $
214  PRTPARM    // C,N,-5 / C,N,CYCMODES $
215  LABEL      FINIS $
216  END        $
```

NO ERRORS FOUND - EXECUTE NASTRAN PROGRAM

2.6.2 Description of DMAP Operations for Compressor Blade Cyclic 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. 203 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. 203 and print error message if no elements have been defined.

20. Go to DMAP No. 25 if stiffness matrix is not user input.

21. Set parameter NOKGGX = -1 so that the stiffness matrix will not be generated in DMAP No. 26.

22. INPUTT1 reads the user supplied stiffness matrix from tape (GINO file INPT).

23. Equivalence $[K_{gg}^{x}]$ to $[K_{gg}^{IN}]$.

26. EMG generates structural element matrix tables and dictionaries for later assembly.

29. Go to DMAP No. 32 if no stiffness matrix is to be assembled.

30. EMA assembles stiffness matrix $[K_{gg}^{x}]$ and Grid Point Singularity Table.

33. Go to DMAP No. 203 and print error message if no mass matrix exists.

34. EMA assembles mass matrix $[M_{gg}]$.

36. Go to DMAP No. 39 if no weight and balance request.

37. GPWG generates weight and balance information.

38. ØFP formats weight and balance information and places it on the system output file for printing.

40. Equivalence $[K_{gg}^{x}]$ to $[K_{gg}]$ if no general elements.

42. Go to DMAP No. 45 if no general elements.

43. SMA3 adds general elements to $[K_{gg}^{x}]$ to obtain stiffness matrix $[K_{gg}]$.

46. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

49. Go to DMAP No. 211 and print error message if free-body supports are present.

51. GPCYC prepares segment boundary table.

54. Go to DMAP No. 213 and print error message if CYJOIN data is inconsistent.

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55. Go to DMAP No. 60 if general elements present.

56. GPSP determines if possible grid point singularities remain.

58. Go to DMAP No. 60 if no grid point singularities remain.

59. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

61. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

63. Go to DMAP No. 68 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

64. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

66. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \begin{bmatrix} \bar{M}_{nn} & M_{nm} \\ M_{mn} & M_{mm} \end{bmatrix}$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_M^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_M^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

69. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

71. Go to DMAP No. 74 if no single-point constraints.

72. SCE1 partitions out single-point constraints.

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right]$$

75. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if r omitted degrees of freedom.

77. Go to DMAP No. 82 if no omitted coordinates.

78. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \begin{bmatrix} \bar{K}_{aa} & \vdots & K_{ao} \\ --- & + & --- \\ K_{oa} & \vdots & K_{oo} \end{bmatrix}$$

and solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

80. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \begin{bmatrix} \bar{M}_{aa} & \vdots & M_{ao} \\ --- & + & --- \\ M_{oa} & \vdots & M_{oo} \end{bmatrix}$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oo}][G_o] + [G_o^T][M_{oa}].$$

83. 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.

85. Go to DMAP No. 205 and print error message if no Eigenvalue Extraction Data.

86. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

87. CYCT2 transforms matrices from symmetric components to solution set.

90. Go to DMAP No. 213 and print error message if CYCT2 error was found.

91. READ extracts real eigenvalues from the equation

$$[K_{kk} - \lambda M_{kk}]\{u_k\} = 0 \quad ,$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest components
3) Unit value of generalized mass.

95. ØFP formats eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

97. Go to DMAP No. 209 and exit if no eigenvalues found.

98. CYCT2 finds symmetric components of eigenvectors from solution set eigenvectors.

RIGID FORMATS

101. Go to DMAP No. 213 and print error message if CYCT2 error was found.

102. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} \quad , \qquad \begin{Bmatrix} \phi_a \\ -- \\ \phi_o \end{Bmatrix} = \{\phi_f\} \quad ,$$

$$\begin{Bmatrix} \phi_f \\ -- \\ \phi_s \end{Bmatrix} = \{\phi_n\} \quad , \qquad \{\phi_m\} \ [G_m]\{\phi_n\} \quad .$$

$$\begin{Bmatrix} \phi_n \\ -- \\ \phi_m \end{Bmatrix} = \{\phi_g\}$$

103. SDR2 prepares eigenvectors for output (ØPHIG).

104. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

106. APDB processes the aerodynamic data cards from EDT. AERO and ACPT reflect the aerodynamic parameters. PVECT is a partitioning vector and GTKA is a transformation matrix between aerodynamic (K) and structural (a) degrees of freedom.

109. PARTN partitions the eigenvector into all sine or all cosine components.

110. SMPYAD calculates modal mass matrix

$$[M] = [\phi_a^x]^T [M_{aa}] [\phi_a^x]$$

111. MTRXIN selects the direct input matrices $[K_{pp}^2]$, $[M_{pp}^2]$, and $[B_{pp}^2]$.

114. 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 no constraints applied.

116. GKAD applies constraints to direct input matrices $[K_{pp}^2]$, $[M_{pp}^2]$, and $[M_{dd}^2]$, and $[B_{dd}^2]$ (see Section 9.3.3 of the Theoretical Manual) and forms $[G_{md}]$ and $[G_{od}]$.

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COMPRESSOR BLADE CYCLIC MODAL FLUTTER ANALYSIS

118. GKAM selects eigenvectors to form $[\phi_{dh}]$ and assembles stiffness, matrices and damping matrices in modal coordinates:

$$[K_{hh}] = \begin{bmatrix} k_i & 0 \\ 0 & 0 \end{bmatrix} + [\phi_{dh}^T][K_{dd}^2][\phi_{dh}] \ ,$$

$$[M_{hh}] = \begin{bmatrix} m_i & 0 \\ 0 & 0 \end{bmatrix} + [\phi_{dh}^T][M_{dd}^2][\phi_{dh}] \ ,$$

$$[B_{hh}] = \begin{bmatrix} b_i & 0 \\ 0 & 0 \end{bmatrix} + [\phi_{dh}^T][B_{dd}^2][\phi_{dh}] \ .$$

where

KDAMP = 1	KDAMP = -1 (default)
m_i = modal masses	m_i = modal masses
$b_i = m_i \, 2\pi \, f_i g(f_i)$	$b_i = 0$
$k_i = m_i \, 4\pi^2 \, f_i$	$k_i = (1+ig(f_i)) \, 4\pi^2 f_i^2 m_i$

123. Go to DMAP No. 133 if no plot package is present.

124. PLTSET transforms user input into a form used to drive structure plotter.

126. PRTMSG prints error messages associated with structure plotter.

129. GO to DMAP No. 133 if no undeformed aerodynamic structure plot request.

130. PLØT generates all requested undeformed structure plots.

132. PRTMSG prints plotter data and engineering data for each undeformed aerodynamic plot generated.

134. Go to DMAP No. 205 and print error message if no Eigenvalue Extraction Data.

136. AMG forms the aerodynamic materix list $[A_{jj}]$, the area matrix $[S_{kj}]$, and the downwash coefficients $[D_{jk}^1]$ and $[D_{jk}^2]$.

139. Go to DMAP No. 141 if no user-supplied downwash coefficients.

140. INPUTT2 provides the user-supplied downwash factors due to extra points($[D_{je}^1]$, $[D_{je}^2]$).

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143. AMP computes the aerodynamic matrix list related to the modal coordinates as follows:

$$[\phi_{dh}] = \begin{bmatrix} \phi_{ai} & \phi_{ae} \\ \phi_{ei} & \phi_{ee} \end{bmatrix} \qquad [G_{ki}] = [G_{ka}^T]^T[\phi_{ai}]$$

$$[D_{jh}^1] \leftarrow [D_{ji}^1 \mid D_{je}^1] \qquad [D_{ji}^1] = [D_{jk}^1]^T[G_{ki}]$$

$$[D_{jh}^2] \leftarrow [D_{ji}^2 \mid D_{je}^2] \qquad [D_{ji}^2] = [D_{jk}^2]^T[G_{ki}]$$

For each (m,k) pair:

$$[D_{jh}] = [D_{jh}^1] + ik[D_{jh}^2]$$

for each group:

$$[Q_{jh}] = [A_{jj}^T]^{-1}{}_{group}\ [D_{jh}]\ group$$

$$[Q_{kh}] = [S_{kj}][Q_{jh}]$$

$$[Q_{ih}] = [G_{ki}]^T[Q_{kh}]$$

$$[Q_{hh}] \leftarrow \begin{bmatrix} Q_{ih} \\ Q_{eh} \end{bmatrix}$$

149. PARAM initializes the flutter loop couter (FLØØP) to zero.

150. 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.

151. Beginning of loop for flutter.

152. FA1 computes the total aerodynamic mass matrix $[M_{hh}^x]$, the total aerodynamic stiffness matrix $[K_{hh}^x]$ and the total aerodynamic damping matrix $[B_{hh}^x]$ as well as a looping table FSAVE. For the K-method

$$M_{hh}^x = (k^2/b^2)M_{hh} + (\rho/2)\,Q_{hh} \;,$$

$$K_{hh}^x = K_{hh} \;,$$

$$B_{hh}^x = 0$$

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COMPRESSOR BLADE CYCLIC MODAL FLUTTER ANALYSIS

154. 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.

156. Go to DMAP No. 168 if no complex eigenvalues found.

157. Go to DMAP No. 163 if no output request for the extra points introduced for dynamic analysis or modal coordinates.

158. VDR prepares eigenvectors for output, using only the extra points introduced for dynamic analysis and modal coordinates.

160. Go to DMAP No. 163 if no output request for the extra points introduced for dynamic analysis or modal coordinates.

161 ØFP formats eigenvectors for extra points introduced for dynamic analysis and modal coordinates and places them on the system output file for printing.

164. FA2 appends eigenvectors to PHIHL, eigenvalues to CLAMAL, Case Control to CASEYY, and V-g plot data to ØVG.

167. Go to DMAP No. 172 if there is insufficient time for another flutter loop.

169. Go to DMAP No. 172 if flutter loop complete.

171. Go to DMAP No. 207 for additional aerodynamic configuration triplet values.

175. Go to DMAP No. 179 if no X-Y plot package is present.

176. XYTRAN prepares the input for requested X-Y plots.

178. XYPLØT prepares requested X-Y plots of displacements, velocities, accelerations, forces, stresses, loads or single-point forces of constraint vs. time.

181. Go to DMAP No. 215 if no output requests involve dependent degrees of freedom or forces and stresses.

182. MØDACC selects a list of eigenvalues and vectors whose imaginary parts (velocity in input units) are close to a user input list.

183. DDR1 transforms the complex eigenvectors from modal to physical coordinates

$$[\phi^c_d] = [\phi_{dh}][\phi_h] \ .$$

185. Equivalence $[\phi^c_p]$ to $[\phi^c_p]$ if no constraints applied.

186 Go to DMAP No. 188 if no constraints applied.

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167. SDR1 recovers dependent components of eigenvectors

$$\{\phi_d^c\} = [G_o^d]\{\phi_d^c\} \quad , \qquad \begin{Bmatrix} \phi_d \\ \phi_o \end{Bmatrix} = \{\phi_f^c + \phi_e^c\} \quad ,$$

$$\begin{Bmatrix} \phi_f^c + \phi_e^c \\ \phi_s^c \end{Bmatrix} = \{\phi_n^c + \phi_e^c\} \quad , \qquad \{\phi_m^c\} = [G_m^d]\{\phi_n^c + \phi_e^c\} \quad ,$$

$$\begin{Bmatrix} \phi_f^c + \phi_e^c \\ \phi_e^c \end{Bmatrix} = \{\phi_p^c\}$$

and recovers single-point forces of constraint $\{q_s\}$ =

$$[K_{fs}^T]\{\phi_f\}, \quad \begin{Bmatrix} o \\ q_s \end{Bmatrix} = \{Q_p^c\} \quad .$$

190. Equivalence $[\phi_d^c]$ to $[\phi_a^c]$ if no extra points introduced for dynamic analysis.

191. Go to DMAP No. 194 if no extra points present.

192. VEC generates a d-size partitioning vector (RP) for the a and e sets.

193. PARTN performs partition of $[\phi_d^c]$ using RP.

$$\{\phi_d^c\} = \begin{Bmatrix} \phi_a^c \\ \phi_e^c \end{Bmatrix}$$

195. SDR2 calculates element forces and stresses (ØEFC1, ØESC1) and prepares eigenvectors and single-point forces of constraint for output (ØCPHIP, ØQPC1). It also prepares PCPHIP for deformed plotting.

197. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

198. Go to DMAP No. 194 if no deformed structure plots are requested.

199. PLØT prepares all deformed structure plots.

200. PRTMSG prints plotter data and engineering data for each deformed plot generated.

202. Go to DMAP No. 215 and make normal exit.

204. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

206. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

208. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 3 - ATTEMPT TO EXECUTE MØRE THAN 100 LØØPS.

210. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 4 - REAL EIGEN-VALUES REQUIRED FØR MØDAL FØRMULATIØN.

212. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 4 - FREE BØDY SUPPØRTS NØT ALLØWED.

214. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 5 - CYCLIC SYMMETRY DATA ERRØR.

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2.6.3 Output for Compressor Blade Modal Flutter Analysis

The Real Eigen value 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 if PRINT=YESB. This shows ρ, k, 1/k, σ, σ * 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 (SORT1) 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 points (grid points, extra points) or SØLUTION 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 elements.

2.6.4 Case Control Deck and Parameters for Compressor Blade Cyclic 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.
7. 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.
8. Each NASTRAN run calculates modes for only one symmetry index, K.

The following user parameters are used in Compressor Blade Cyclic 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 defalult 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 flutter summary table will be printed if the BCD value is YES for wing flutter, or YESB for blade flutter. The default is YES.

10. 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 anti-symmetric components

11. NSEGS - required - the integer value of this parameter is the number of identical segments in the structural model.

12. 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.

13. KINDEX - required in compressor blade cyclic modal flutter analysis. The integer value of this parameter specifies a single value of the harmonic index.

14. MINMACH - optional in blade flutter analysis. This is the minimum Mach number above which the supersonic unsteady cascade theory is valid. The default is 1.01.

15. MAXMACH - optional in blade flutter analysis. This is the maximum Mach number below which the subsonic unsteady cascade theory is valid. The default value is 0.80.

16. IREF - optional in blade flutter analysis. This defines the reference streamline number. IREF must be equal to a SLN on a STREAML2 bulk data card. The default value, -1, represents the streamsurface at the blade tip. If IREF does not correspond to a SLN, then the default will be taken.

17. MTYPE - optional in cyclic modal blade flutter analysis. This controls which components of the cyclic modes are to be used in the modal formulation. MTYPE = SINE for sine components and MTYPE = COSINE for cosine components. The default BCD value is COSINE.

18. KGGIN - optional in blade flutter analysis. A positive integer of this parameter indicates that the user supplied stiffness matrix is to be read from tape (GINO file INPT) via the INPUTT1 module in the rigid format. The default is -1.

3. PROGRAMMER'S MANUAL

3.1 DATA BLOCK AND TABLE DESCRIPTIONS

3.1.1 EDT (TABLE)

Card Types and Header Information:

Card Type	Header Word 1 Card Type	Header Word 2 Trailer Bit Position	Header Word 3 Internal Card Number
AEFACT	4002	40	273
AERØ	3202	32	265
CAERØ1	3002	30	263
CAERØ2	4301	43	301
CAERØ3	4401	44	302
CAERØ4	4501	45	303
CAERØ5	5001	50	309
DEFØRM	104	1	81
FLFACT	4102	41	274
FLUTTER	3902	39	272
MKAERØ1	3802	38	271
MKAERØ2	3702	37	270
PAERØ1	3102	31	264
PAERØ2	4601	46	304
PAERØ3	4701	47	305
PAERØ4	4801	48	306
PAERØ5	5101	51	310
SET1	3502	35	268
SET2	3602	36	269
SPLINE1	3302	33	266
SPLINE2	3402	34	267
SPLINE3	4901	49	307
STREAML1	3292	92	292
STREAML2	3293	93	293
VARIAN	4202	42	290

Card Type Formats:

AEFACT (Open Ended)	SID	F1	F2
	etc.	-1	
AERØ (6 words)	ACSID	VSØUND	BREF
	RHØREF	SYMXZ	SYMXX
CAERØ1 (16 words)	PID	CP	NSPAN
	NCHØRD	LSPAN	LCHØRD
	0	X1	Y1
	Z1	X12	X4
	Y4	Z4	X43
CAERØ2 (16 words)	EID	PID	CP
	NSB	MINT	LSB
	LDNT	IGID	X1
	Y1	Z1	X12
	...	...	...
	...		
CAERØ3 (16 words)	EID	PID	LP
	LISTW	LISTC1	LISTC2
	...	...	X1
	Y1	Z1	X12
	X4	Y4	Z4
	X43		

Card Type Formats (Cont.):

SET2 (8 words)	SID	EID	SP1
	SP2	CH1	CH2
	Z1	Z2	
SPLINE1 (6 words)	EID	CAERØ	BØX1
	BØX2	SETG	DZ
SPLINE2 (10 words)	EID	CAERØ	BØX1
	BØX2	SETG	DZ
	DTØR	CID	DTHX
	DTHY		
SPLINE3 (Open Ended)	SID	CAERØ	UFID
	CØMP	G1	C1
	A1	...	GM
	CM	AM	-1
STREAML1 (open ended)	SLN	G1	G2
	G3	G4	G5
	G6	...	Gn
	-1		
STREAML2 (10 words)	SLN	NSTNS	STAGGER
	CHØRD	RADIUS/DCBDZB	BSPACE
	MACH	DEN	VEL
	FLOWA/SWEEP		
VARIAN (Open Ended)	$DB\ell_2$	$DB\ell_2$	etc.

3.1.2 Data Blocks Output from Module APD8

3.1.2.1 AERØ (Table)

Description

See description and format of AERØ table

3.1.2.2 FLIST (Table)

Description

See description and format of FLIST table

3.1.2.3 GTKA (Matrix)

Description

See description and format of GTKA matrix

3.1.2.4 PVECT (Matrix)

Description

{ PVECT } - Partitioning vector for cyclic modes.

Matrix Trailer

Number of columns = 1
Number of rows = NEIGV (for KINDEX > 0, 2 · NEIGV)
Form = rectagular
Type = real-single precision

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3.1.3 ACPT (Table)

Description

Aerodynamic connection and property table for compressor or turboprop blades. Contains one record for each compressor/or turboprop blade.

Table Format

Record	Word	Type	Item	
0	1-2	B	Data block name (ACPT)	
1	1	I	Key word, 6 for compressor blades	
	2	I	IREF parameter	
	3	R	MINMACH parameter	
	4	R	MAXMACH parameter	
	5	I	Number of blade streamlines, NLINES	
	6	I	Number of stations on blade, NSTNS	
	7	I	Streamline number, SLN	REPEAT NLINES TIMES (words 7-19)
	8	I	Number of stations on streamline, NSTNSX	
	9	R	Stagger angle, STAGGER	
	10	R	Chord length, CHORD	
	11	R	Radius of streamline, RADIUS	
	12	R	Blade spacing, BSPACE	
	13	R	Mach number, MACH	
	14	R	Gas density, DEN	
	15	R	Flow velocity, VEL	
	16	R	Flow angle, FLOWA	
	17	R	X-coordinate, basic } REPEAT NSTNS TIMES (words 17-19)	
	18	R	Y-coordinate, basic	
	19	R	Z-coordinate, basic	
or 1	1	I	Key word, 7 for turboprop blades	
	2	I	IREF parameter	
	3	R	MINMACH parameter	
	4	R	MAXMACH parameter	
	5	I	Number of blade streamlines, NLINES	
	6	I	Number of stations on blade, NSTNS	
	7	I	Streamline number, SLN	REPEAT NLINES TIMES (words 7-19)
	8	I	Number of stations on streamline, NSTNSX	
	9	R	Stagger angle, STAGGER	
	10	R	Chord length, CHORD	
	11	R	Radius of streamline or $\partial\bar{C}/\partial\bar{Z}$, RADIUS/DCBDZB	
	12	R	Blade spacing, BSPACE	
	13	R	Mach number, MACH	
	14	R	Gas density, DEN	
	15	R	Flow velocity, VEL	
	16	R	Flow Angle or Sweep Angle, FLOWA/SWEEP	
	17	R	X-coordinate, basic } REPEAT NSTNS TIMES (words 17-19)	
	18	R	Y-coordinate, basic	
	19	R	Z-coordinate, basic	
2			Additional records for other blade	

Table Trailer

Word 1 = 1
Word 2-6 = zero

3.1.3 ACPT (Table) (Cont'd.)

Notes

1. Words 7-19 are repeated for each streamline. There are NLINES streamlines and they are from the blade root to the blade tip. These data items are taken from the STREAML2 bulk data cards.

2. Words 17-19 are repeated for each node on the streamline. There are NSTNS triplets (X, Y, Z). They are from the blade leading edge to the blade trailing edge.

3. All records 1 to N will be all Keyword 6 or Keyword 7 and may not be mixed.

3.2 FUNCTIONAL MODULE AMG (AERODYNAMIC MATRIX GENERATOR)

3.2.1 Entry Point: AMG

3.2.2 Purpose

To generate a list of aerodynamic influence matrices (AJJL) and the transformation matrices needed to convert these to the interpolated structural system (SKJ, D1JK, D2JK).

3.2.3 DMAP Calling Sequence

```
AMG     AERØ,ACPT/AJJL,SKJ,S1JK,D2JK/V,N,NK/V,N,NJ $
```

3.2.4 Input Data Blocks

AERØ - Aerodynamic matrix generation data

ACPT - Aero connection and property data.

Note: Neither AERØ or ACPT may be purged.

3.2.5 Output Data Blocks

AJJL - Aerodynamic influence matrix list

SKJ - Integration matrix list

D1JK - Real part of downwash matrix

D2JK - Imaginary part of downwash matrix

3.2.6 Parameters

NK - Input - integer - no default, number of degrees of freedom in k-set

NJ - Input - integer - no default,

$$N_j = \sum N_b + \sum_{i=1}^{N_{sb}} f_i + \sum_{j=1}^{N_{ib}} g_i$$

where N_b = number of aero boxes

N_{sb} = number of slender bodies

N_{ib} = number of interference bodies

f_i = degrees of freedom for each slender body

g_i = degrees of freedom for each interference body

3.2 .7 Method

Module AMG is broken into two sections. Section one outputs AJJL and SKJ and Section two outputs D1JK and D2JK. Each section has a branch on method to output columns of the matrices. Each section has a common block to communicate between the module driver and the method dependent code. (See description of design requirements.)

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MODULE FUNCTIONAL DESCRIPTIONS

The flow for Section one is as follows: Four buffers are allocated from the bottom of core and ACPT, AERØ, AJJL, and SKJ are opened. Record 1 of AERØ is read into /AMGMN/ at ND and the header and trailer for AJJL are initialized by passing the ACPT and counting the method groups.

The rest of Section one involves a loop where pairs of m and k are read into /AMGMN/ and then each record in the ACPT is processed. For each record of ACPT processed, one word (the method) is read and then a branch on method is taken. Each method is expected to:

1. Read its record of the ACPT and leave it positioned to read the next record.
2. Output columns of AJJL and SKJ of proper size.
   The row number to start at is NRØW+1 for AJJL and ISK for SKJ.
3. Always increment NRØW, ISK and NSK by the number of rows added.

Once an end of file is reached in AERØ, AERØ, AJJL and SKJ are closed and Section two starts.

The flow in Section two is as follows: Three buffers are allocated and D1JK and D2JK are opened (ACPT is left open). The trailers are initialized and the method of ACPT is read. The program branches on method and then loops until all records on the ACPT have been processed. When an EØF is reached the files are closed and their trailers written.

3.2.7.1 Doublet Lattice Method without Bodies

The flow for Section one of the Doublet Lattice method is as follows: Subroutine DLAMG is the driver for this method. It reads in the ACPT record for this method and sets up the pointers to the various arrays in common DLCØM. Columns of SKJ are output. If there is enough core available, GEND is called to output one matrix of the AJJL list. When GEND is through, DLAMG bumps NRØW and returns.

Subroutine GEND outputs a row of the AJJL matrix for each box on the CAERØ1 element. To do this, it picks up the proper strip and panel data and calls DPPS once for each box. A row is packed out after each call to DPPS.

Subroutine DPPS is also in a loop. There is one row element for each box and DPPS prepares the variables necessary for the computation of each element and calls SUBP to calculate the element. When the row is done DPPS returns to GEND.

Subroutine SUBP computes the downwash factor elements by calling subroutines SNPDF and INCRØ to compute the indicated components that make up the element. SNPDF computes the steady downwash factors and INCRØ computes the unsteady downwash factors for one receiving-sending point combination.

Each combination has four influence quadrants (upper left, upper right, lower left, lower right), so these routines must be called four times for each element and then the result summed before SUBP returns. Subroutine INCRØ uses subroutines TKER, IDF1, and IDF2 to compute the final result.

The flow for Section two of the Doublet Lattice method is as follows: Subroutine DLPT2 prepares all the computations necessary. DLPT2 reads the record of ACPT and then loops through each box packing out a column of D1JK and D2JK for each box.

The row position of each pair of values for a column is 2*(box number-1) + 1. Successive rows of SKJ (output in Section one) have the following form:

$$SKJ \rightarrow \left[\begin{array}{c} 2.0 * EE_{strip} * DELX_{box} \\ \hline EE_{strip} * DELX^2_{box} / 2.0 \end{array} \right] . \qquad (1)$$

Successive rows of D1JK have the following form:

$$D1JK \rightarrow \left[\begin{array}{c} 0.0 \\ \hline 1.0 \end{array} \right] . \qquad (2)$$

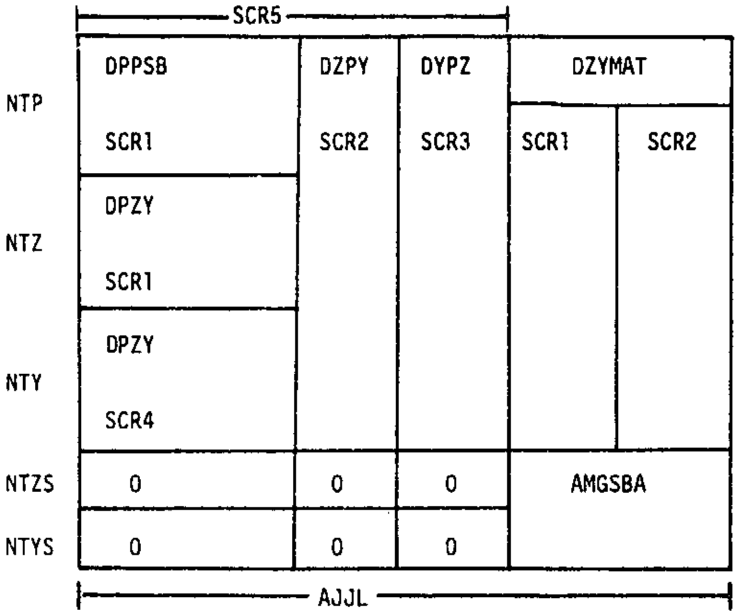
Successive rows of D2JK have the following form:

$$D2JK \rightarrow \left[\begin{array}{c} -2.0/REFC \\ \hline DELX_{box}/2.0*REFC \end{array} \right] . \qquad (3)$$

3.1.7.2 Doublet Lattice Method with Bodies

The flow for Section one of the Doublet Lattice method with bodies is as follows: Subroutine DLAMBG is the driver for this method. It reads the ACPT record and sets up the pointers to the various arrays in common DLBDY. The flow then depends on the type of problem submitted. If panels exist then GENDSB is called to build part of AJJL on a scratch file. If panels and slender bodies are used, AMGRØD is called to build this combination on a scratch file. Then AMGSBA is called to output this method's part of AJJL. AMGBFS is called to build SKJ for this method. Up to four additional buffers may be needed by this method.

Figure one shows the subroutines and scratch files used to put AJJL together.



NTP, NTZ, NTY, NTZS, and NTYS are lengths.

SCR1 - SCR5 are scratch files.

Other names are subroutines.

Figure 1. Subroutines and Scratch files for AJJL

Subroutine GENDSB calls DPPSB once for each row on SCR1 (NTP times), and DPZY once for each NTZ and NTY rows on SCR1 and SCR4. Then DZPY once for each row on SCR2 and DYPZ once for each row on SCR3. Once this process is done, GENDSB builds the data collected from SCR1, SCR2, SCR3 and SCR4 on SCR5.

Subroutine AMGRØD calls DZYMAT once to build SCR1 and once to build SCR2. Then AMGSBA is called to put SCR1, SCR2 and SCR5 together plus AMGSBA's part of AJJL onto AJJL.

Matrix SKJ is built by AMGBFS. It calls BFSMAT, builds some data on SCR1, then SKJ is built and packed out. (See the Theoretical Manual for description of SKJ.)

Figure 2 shows the various calls that may take place during Section one of this method.

For Section two DLBPT2 is called and the ACPT is read. Then the pointers to the necessary arrays are computed and D1JK and D2JK are packed out. D1JK and D2JK look like the Doublet Lattice Method without Bodies except D1JK has a -1. instead of a 1.0 for D1JK on y-slender elements, and D2JK has a 0.0 for slender elements instead of DELX/2*REFC.

FUNCTIONAL MODULE AMG (AERODYNAMIC MATRIX GENERATOR)

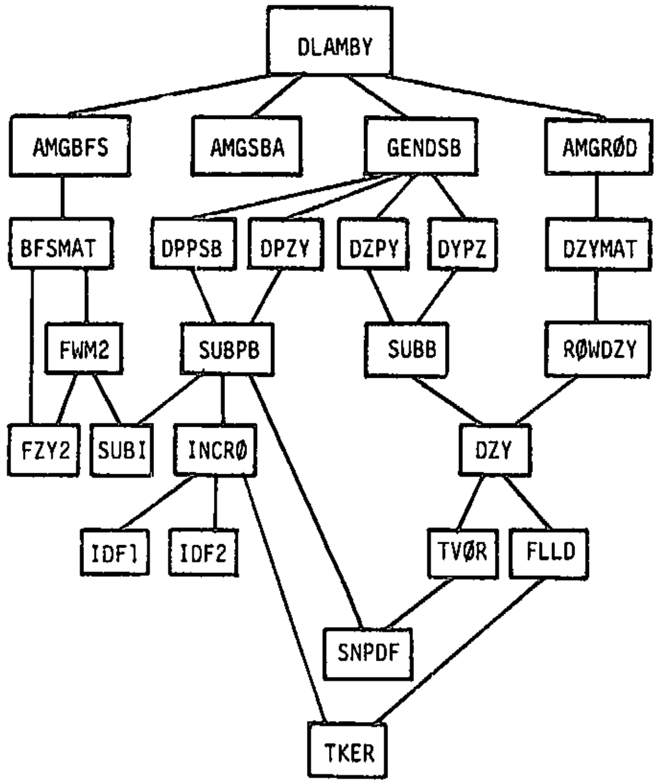


Figure 2. Section One Calls for the Doublet Lattice Method with Bodies

3.2.7.3 Mach Box Method

The flow for Section one of the Mach Box Method is as follows: Subroutine MBAMG is called to read the ACPT and set up pointers to arrays in common MBAMGX. MBAMG then makes calls to various subroutines to get AJJL built. Most of the arrays used by the Mach Box method are generated by subroutine MBREG, so, in general, fixed dimensions are used. One additional buffer is used.

Once the pointers, common MBØXN and common MBØXL are set up, MBAMG calls MBGEØD to set up the regions and geometry for the problem in common MBØXA. Then MBAMG calls MBREG to generate the boxes. MBREG fills in the box arrays based on the area to cover, Mach number, and number of boxes requested. MBCTR1 and MBCTR2 can be called to make box arrays if the control surface exists. MBPLOT is then called to print a picture of the planform regions.

MBAMG then calls MBMØDE to generate mode-like data on SCR2. The SSPLIN routine is used to spline from the Mach box points to the input control points for the wing, control one and control two separately.

The influence coefficients are computed by MBCAP, then SKJ (Identity) is output, and finally MBDPDH is called to compute and output the AJJL contribution.

Section two is a call to STPPT2 with outputs D1JK (Identity) and D2JK (Null).

3.2.7.4 Strip Theory Method

Section one of the Strip Theory Method is driven by Subroutine STPDA. STPDA reads the ACPT, fills in common STRIPL, and sets up pointers to common STRIPX where the various arrays will be stored. After all the input arrays have been set up an SKJ (Identity) matrix is built.

STPDA then calls: STPBG to build a BM and GM matrix for each strip; STPPHI to build the PHI functions for each strip; and finally STPAIC to combine these matrices and build AJJL.

Section two is a call to STPPT2 which output D1JK (Identity) and D2JK (Null).

3.2.7.5 Piston Theory Method

Section one of the Piston Theory method is driven by subroutine PSTAMG. PSTAMG reads the ACP1 and sets up the core pointer to the arrays. Then SKJ (Identity) is output and PSTA is called to build AJJL.

Section two is a call to STPPT2 with outputs D1JK (Identity) and D2JK (Null).

3.2.7.6 Compressor Blade Method

The flow for Section one of the compressor blade method is as follows. Subroutine AMGB1 is the driver for this method. It reads in the ACPT record for this method and locates reference parameters from the reference streamline on the blade. If there is enough core available, it calls AMGB1A to output one matrix of the AJJL list. When AMGB1A is through, AMGB1 bumps NRØW and returns. Subroutine AMGB1S is called to output columns of SKJ.

Subroutine AMGB1A outputs a portion of the AJJL matrix for each streamline on the compressor blade. Each streamline may be subsonic, transonic or supersonic, depending on the Mach number for that streamline. Subroutine AMGB1B calculates terms for subsonic streamlines. Subroutine AMGB1C calculates terms for supersonic streamlines and subroutine AMGB1D calculates terms for transonic streamlines.

Each submatrix of AJJL corresponds to a blade streamline and is of order NSTNS X NSTNS, where NSTNS is the number of computing stations on the blade. The submatrices are located along the diagonal of AJJL.

The flow for Section two of the compressor blade method is as follows. Subroutine AMGB2 prepares all the computations necessary. It reads the ACPT record and locates the reference streamline parameters. Subroutine AMGB2A is called to calculate matrix $[F^{-1}]$ for each streamline. AMGB2 outputs the NSTNS X NSTNS submatrix for each streamline to [D1JK].

Each submatrix of [SKJ] and [D1JK] has the following form:

$$[SKJ] = W \cdot [F^{-1}]^T$$

and

$$[D1JK] = [F^{-1}]^T$$

The [D2JK] matrix is null.

3.2.7.7 Swept Turboprop Blade Method

The flow for Section one of the swept turboprop blade method is as follows: Subroutine AMGT1 is the driver for this method. It reads in the ACPT record for this method and locates reference parameters from the reference streamline on the blade. It calls AMGT1A to output one matrix of the AJJL list. Subroutine AMGT1S is called to output matrices used in SKJ.

Subroutine AMGT1A outputs a portion of the AJJL matrix for each streamline on the swept turboprop blade. Each streamline must be subsonic based on the Mach number for that streamline. Subroutine AMGT1T calculates constants used by AMGT1B which computes the terms for the subsonic streamlines. AMGT1C and AMGT1D cause error exits with diagnostic printout when the streamlines are supersonic or transonic, respectively.

Each submatrix of AJJL corresponds to a blade streamline and is of the order NSTNS*2 X NSTNS*2, where NSTNS is the number of computing stations on the blade. The submatrices are located along the diagonal of AJJL.

The flow for Section two of the swept turboprop blade method is as follows: Subroutine AMGT2 reads the ACPT record and locates the reference streamline parameters. Subroutine AMGT2A is called to calculate the matrix $[F^{-1}]$ for each streamline. AMGT2 then outputs the transpose of this NSTNS X NSTNS submatrix twice along the diagonal for each streamline to [D1JK]. Each submatrix of [SKJ] and [D1JK] has the following form:

$$[SKJ]^{S} = \begin{bmatrix} ([F^{S}]^{-1})^{T} & \\ & ([F^{S}]^{-1})^{T} \end{bmatrix}$$

$$[D1JK] = [SKJ]$$

The [D2JK] matrix is null.

3.2.8 Subroutines

Besides the module driver AMG, the subroutines of Section one are divided into groups by method:

For the Doublet Lattice Methods five subroutines are shared:

SNPDF, INCRØ, TKER, IDF1, and IDF2

The Doublet Lattice Method without Bodies also uses:

DLAMG, GEND, DPPS, and SUBP

The Doublet Lattice Method with Bodies also uses:

DLAMBY, SUBI, AMGBFS, FZY2, FWMW, BFSMAT, AMGRØD, AMGSBA, GENDSB, DPPSB, DPZY, DYPZ, DZPY, SUBB, SUBPB, DZY, FLLD, TVØR, DZYMAT, and RØWDZY

FUNCTIONAL MODULE AMG (AERODYNAMIC MATRIX GENERATOR)

The Mach Box Method uses:

MBAMG, MBPRIT, MBGEØD, MBREG, MBCTR1, MBCTR2, MBPLØT, MBMØDE, MBCAP, MBBSLJ, GØ, ZJ, MBDPDH, MBGAE, MBGAW, MBGATE, SUMPHI, and TRAILE

The Strip Theory Method uses:

STPDA, STPBG, STPPHI, STPAIC, STPK, STPBSO, and STPBS1

The Piston Theory Method uses:

PSTAMG and PSTA

For Section two the subroutines are DLPT2, STPPT2 and DLBPT2.

3.2.8.1 Subroutine Name: AMG

1. Entry Point: AMG
2. Purpose: Module driver for AMG - see description above.
3. Calling Sequence: CALL AMG

3.2.8.2 Subroutine Name: DLAMG

1. Entry Point: DLAMG
2. Purpose: Output AJJL and SJK parts for Doublet Lattice without bodies.
3. Calling Sequence: CALL DLAMG (ACPT, AJJL, SKJ)

   ACPT - GINØ file number of ACPT.

   AJJL - GINØ file number of AJJL.

   SKJ - GINØ file number of SKJ.
4. Core Requirement: Core needed is four buffers plus record of ACPT plus 2*NJ.

3.2.8.3 Subroutine Name: GEND

1. Entry Point: GEND
2. Purpose: Output all the columns of AJJL associated with a record on ACPT.
3. Calling Sequence: CALL GEND (NCARAY,NBARAY,YS,ZS,SG,CG,DT,WØRK,MATØUT)

   NCARAY, NBARAY, YS, ZS, SG, and CG are the locations of these arrays from the ACPT record.

   DT - location to put column of AJJL - complex

   WØRK - start of open core

   MATØUT - GINØ file number of AJJL.

3.2.8.4 Subroutine Name: DPPS

1. Entry Point: DPPS

2. Purpose: Compute the elements in a row of AJJL.

3. Calling Sequence: CALL DPPS (KS,I,J1,J2,SGR,CGR,YS,ZS,NBARAY,NCARAY,DT,WØRK)

   KS - Strip number in which receiver point I lies

   I - Box number of receiver point

   J1 - 1

   J2 - Number of boxes

   SGR - Sine of dihedral angle of receiver strip (from SG array)

   CGR - Cosine of dihedral angle of receiver strip (from CG array)

   YS, ZS, NBARAY, NCARAY - location of these arrays from ACPT record

   DT - location to start putting elements of column - complex

   WØRK - start of open core

3.2.8.5 Subroutine Name: SUBP

1. Entry Point: SUBP

2. Purpose: Compute downwash factor element.

3. Calling Sequence: CALL SUBP(I,L,LS,J,SGR,CGR,YREC,ZREC,SUM,XIC,DELX,EE,XLAM,SG,CG,YS,ZS)

   I - Box number of receiving point

   L - Panel number in which sending point J lies

   LS - Strip number in which sending point J lies

   J - Box number of sending point (also row number of output column)

   SGR - Sine (see DPPS)

   CGR - Cosine (see DPPS)

   YREC - YS(KS) - y coordinate from ACPT array

   ZREC - ZS(KS) - z coordinate from ACPT array

   SUM - Output element - complex

   XIC,DELX,EE,XLAM,SG,CG,YS,ZS - locations of these arrays for ACPT record.

3.2.8.6 Subroutine Name: SNPDF

1. Entry Point: SNPDF

2. Purpose: Compute the steady downwash factors for one receiving-sending point combination.

3. Calling Sequence: CALL SNPDF (SL,CL,TL,SGS,CGS,SGR,CGR,XO,YO,ZO,ES,DIJ,BETA,CV)

   SL - Sine of sweep angle of sending box

   CL - Cosine of sweep angle of sending box

   TL - Tangent of sweep angle of sending box (from ACPT)

   SGS - Sine of dihedral angle of sending point

   CGS - Cosine of dihedral angle of sending point

   SGR - Sine of dihedral angle of receiving point

   CGR - Cosine of dihedral angle of receiving point

   XO - X coordinate of receiving point, X coordinate of "center" of sending point

   YO - Y coordinate of receiving point, Y coordinate of "center" of sending point

   ZO - Z coordinate of receiving point, Z coordinate of "center" of sending point

   ES - Sending point strip half width

   DIJ - Steady contribution to downwash - output

   BETA - Square root of $1.0-M^2$

   CV - Chord of sending point

3.2.8.7 Subroutine Name: INCRØ

1. Entry Point: INCRØ

2. Purpose: Computes the unsteady downwash factor for one receiving-sending point combination

3. Calling Sequence: CALL INCRØ(AX,AY,AZ,AX1,AY1,AZ1,AX2,AY2,AZ2,SGR,CGR,SGS,CGS,KR,RL,BETA, SDELX,DELY,DELR,DELI)

   AX - XO

   AY - YO

   AZ - ZO

   AX1 - XO+ES*TL

   AY1 - YO+ES*CGS

   AZ1 - ZO-ES*SGS

   AX2 - XO-ES*TL

   AY2 - YO-ES*CGS

   AZ2 - ZO-ES*SGS

   SGR -

   CGR -

   SGS -

   CGS -

   (AX through CGS:) See definitions for SNPDF (Section 4.114.8.6).

KR - Reduced frequency

RL - REFC

BETA - Square root of $1.0-M^2$

SDELX - Box chord of sending point

DELY - 2.0* sending point strip half width

DELR - Output - real part of downwash factor

DELI - Output - imaginary part of downwash factor

4. Method: INCRØ calls TKER for three points for each receiving-sending box combination (the center, the inboard point, and the outboard point). Then INCRØ calls IDF1 and IDF2 to perform the integration of the kernels.

3.2.8.8 Subroutine Name: TKER

1. Entry Point: TKER
2. Purpose: Compute incremental oscillating kernel
3. Calling Sequence: CALL TKER(X,Y,Z,KR,BR,SGR,CGR,SGS,CGS,T1,T2,M)

X - AX, AX1, or AX2 for center, inboard, outboard }
Y - AY, AY1, or AY2 for center, inboard, outboard } see INCRØ (see Section 4.114.8.7)
Z - AZ, AZ1, or AZ2 for center, inboard, outboard }

KR - Reduced frequency

BR - REFC/2.0

SGR, CGR, SGS, CGS - See SNPDF (section 4.114.8.6)

T1 - Output - cosine $(\gamma_r - \gamma_s)\gamma$ - dihedral angle (receiving (r) or sending (s))

T2 - Output - $[(Z \cos \gamma_r - Y \sin \gamma_r) \times (Z \cos \gamma_s - Y \sin \gamma_s)]/(BR/M)^2$

M - Mach number

4. Method: Kernel components are returned in common DLM.

3.2.8.9 Subroutine Name: IDF1

1. Entry Point: IDF1
2. Purpose: Integration of the planar parts of the kernels
3. Calling Sequence: CALL IDF1(EE,E2,ETA01,ZET01,ARE,AIM,BRE,BIM,CRE,CIM,R1SQX,XIIJR,XIIJI)

EE - Sending strip half width

E2 - EE^2

ETA01 - AY cos γ_r + AZ sin γ_r (AY and AX, see INCRØ)(γ see TKER) (Sections 4.114.7, 4.114.8)

ZET01 - AZ cos γ_r - AY sin γ_r

ARE, AIM, BRE, BIM, CRE, CIM - coefficients of the parabola for planar part

R1SQX - $AY^2 + AZ^2$

XIIJR - output - real part of planar integral contribution

XIIJI - output - imaginary part of planar integral contribution

3.2.8.10 Subroutine Name: IDF2

1. Entry Point: IDF2
2. Purpose: Integration of the nonplanar parts of kernels
3. Calling Sequence: CALL IDF2(EE,E2,ETA01,ZET01,A2R,A2I,B2R,B2I,C2R,C2I,R1SQX,DIIJR,DIIJI)

   EE, E2, ETA01, ZET01 - same as IDF1 (Section 4.114.8.9)

   A2R, A2I, B2R, B2I, C2R, C2I - coefficients of the parabola for the nonplanar part

   R1SQX - See IDF1 (Section 4.114.8.9)

   DIIJR - output - real part of nonplanar integral contribution

   DIIJI - output - imaginary part of nonplanar integral contribution

3.2.8.11 Subroutine Name: DLPT2

1. Entry Point: DLPT2
2. Purpose: To output the Doublet Lattice without Bodies parts for matrices D1JK and D2JK.
3. Calling Sequence: CALL DLPT2(ACPT,D1JK,D2JK)

   ACPT - GINØ number

   D1JK - GINØ number

   D2JK - GINØ number

3.2.8.12 Subroutine Name: DLAMBY

1. Entry Point: DLAMBY
2. Purpose: Output AJJL and SKJ parts for Doublet Lattice with Bodies
3. Calling Sequence: CALL DLAMBY(ACPT,AJJL,SKJ)

   ACPT, AJJL, and SKJ are GINØ file numbers
4. Core Requirements: Four buffers plus record of ACPT plus 4*NJ.

3.2.8.13 Subroutine Name: GENDSB

1. Entry Point: GENDSB
2. Purpose: Generate part of the AJJL influence coefficient matrix
3. Calling Sequence: CALL GENDSB(NCARAY,NBARAY,SG,CG,NFL,NBEA1,NBEA2,IFLA1,IFLA2,DT,DPY)

   NCARAY to IFLA2 - the locations of these arrays from ACPT record

   DT - storage for 2*NJ words

   DPY - storage for 2*NJ words
4. Core Requirements: Up to 4 buffers may be used (2 for Y bodies, 1 for Z bodies, and 1 for panels).

3.2.8.14 Subroutine Name: DPPSB

1. Entry Point: DPPSB
2. Purpose: Compute the element in a panel on panel row of AJJL.
3. Calling Sequence: CALL DPPSB(KS,I,J1,J2,SGR,CGR,YS,ZS,NBARAY,NCARAY,DT,WØRK)

   Same as DPPS

3.2.8.15 Subroutine Name: DPZY

1. Entry Point: DPZY
2. Purpose: Compute the elements in an interference element on a panel in AJJL
3. Calling Sequence: CALL DPZY(KB,IZ,I,J1,J2,IFIRST,ILAST,YB,ZB,AVR,ARB,TH1A,TH2A,NT121,
   NT122,NBARAY,NCARAY,NZYKB,DPZ,DPY)

   KB - Body number in which receiving point I lies

   IZ - Body element number of body KB in which I lies

   I - Receiving point

   J1 - Starting element number

   J2 - Ending element number

   IFIRST- θ_1 starting element

   ILAST - θ_1 ending element

   YB to NCARAY - locations of arrays in ACPT record

   NZYKB - Z-Y flag

   DPZ - Storage for row of AJJL

   DPY - Storage for row of AJJL

3.2.8.16 Subroutine Name: DZPY

1. Entry Point: DZPY
2. Purpose: Compute the elements in a column of AJJL for Z interference elements
3. Calling Sequence: CALL DZPY(KB,KS,LS,I,J1,J2,NYFLAG,SGR,CGR,FMACH,ARB,NBEA1,DT)

   KB - See DPZY (Section 4.114.8.15)

   KS - index of receiving point Y-Z coordinates

   LS - strip number

   I,J1,J2 - See DPZY (Section 4.114.8.15)

   NYFLAG- Type to build

   SGR,CGR - See DPPS (Section 4.114.8.4

   FMACH - Mach number

   ARB,NBEA1 - location of arrays in ACPT record

   DT - Storage for row of AJJL

3.2.8.17 Subroutine Name: DYPZ

1. Entry Point: DYPZ
2. Purpose: Compute the elements in a column of AJJL for Y-interference elements
3. Calling Sequence: CALL DYPZ(KB,KS,LS,I,J1,J2,NYFLAG,SGR,CGR,FMACH,ARB,NBEA1,LBO,LSO,JBO,DT)

   KB to NBEA1 - See DZPY (Section 4.114.8.16)

   LBO - first body with Y orientation

   LSO - Z-Y coordinate index for first element of LBO

   JBO - Sending point index for first Y oriented body element

   DT - Storage for row of AJJL

3.2.8.18 Subroutine Name: SUBPB

1. Entry Point: SUBPB
2. Purpose: Compute downwash factor elements on panels
3. Calling Sequence: CALL SUBPB(I,L,LS,J,SGR,CGR,YREC,ZREC,SUM,XIC,DELX,EE,XLAM,SG,CG,YS,ZS, NAS,NASB,AVR,ZB,YB,ARB,XLE,XTE,X,NB)

   I to SUM - See SUBP (Section 4.114.8.5)

   XIC to X - location of arrays from ACPT record

   NB - number of bodies

3.2 .8.19 Subroutine Name: SUBB

1. Entry Point: SUBB
2. Purpose: Compute downwash factor elements on bodies
3. Calling Sequence: CALL SUBB(KB,KS,I,J,JB,LB,LS,NDY,NYFL,PI,EPS,SGR,CGR,AR,BETA,SUM,RIA, DELX,YB,ZB,YS,ZS,X)

KB - index of receiving body

KS - strip number of receiving point

I - receiving point index

J - sending point index

JB - sending point index

LB - body number of sending point

NDY - Z-Y flag

NYFL - type to build

PI - π

EPS - .00001

SGR - CGR - See DPPS (Section 4.114.8.4)

AR - aspect ratio of body

BETA - See SNPDF (Section 4.114.8.6)

SUM - Output

RIA-X - locations of arrays in ACPT record

3.2 .8.20 Subroutine Name: SUBI

1. Entry Point: SUBI
2. Purpose: Compute the image point coordinates inside associated bodies on MU-Z and MU-Y.
3. Calling Sequence: CALL SUBI(DA,DZB,DYB,DAR,DETA,DZETA,DCGAM,DSGAM,DEE,DXI,TL,DETAI, DZETAI,DLGAMI,DSGAMI,DEEI,DTLAMI,DMUY,DMUZ,INFL,IOTFL)

See Reference 1 (Section 4.114.11) for argument list.

3.2 .8.21 Subroutine Name: DZY

1. Entry Point: DZY
2. Purpose: Calculated effect of slender body element on a panel element
3. Calling Sequence: CALL DZY(X,Y,Z,SGR,CGR,SI1,XI2,ETA,ZETA,AR,AO,KR,REFC,BETA,FMACH,LNS, IDZDY,DZDYR,DZDYI)

See Reference 1 (Section 4.114.11) for argument list.

3.2.8.22 Subroutine Name: TVØR

1. Entry Point: TVØR
2. Purpose: Calculate normalwash at a point due to a trapezoidal unsteady index ring
3. Calling Sequence: CALL TVØR(SL1,CL1,TL1,SL2,CL2,TL2,SGS,CGS,SGR,CGR,X01,X02,Y0,Z0,E, BETA,REFC,FMACH,KR,BRE,BIM)

   See Reference 1 (Section 4.114.11) for argument list.

3.2.8.23 Subroutine Name: FLLD

1. Entry Point: FLLD
2. Purpose: Calculate the velocity normal to a surface due to a finite length line doubled.
3. Calling Sequence: CALL FLLD(X01,X02,Y0,Z0,SGR,CGR,SGS,CGS,KR,REFC,FMACH,E,L,KD1R,KD1I, KD2R,KD2I)

   See Reference 1 (Section 4.114.11) for argument list.

3.2.8.24 Subroutine Name: AMGRØD

1. Entry Point: AMGRØD
2. Purpose: Calculate normalwash at panels and interference elements due to slender elements
3. Calling Sequence: CALL AMGRØD(D,BETA)

   D - storage for a row of AJJL

   BETA - square root of $1.-M^2$

3.2.8.25 Subroutine Name: DZYMAT

1. Entry Point: DZYMAT
2. Purpose: Calculate a slender element column of AJJL
3. Calling Sequence: CALL DZYMAT(D,NFB,NLB,NTZYS,IDZDY,NTAPE,X,BETA,IPRT,NS,NC,YS,ZS,SG,CG, YB,ZB,NBEA1)

   D - storage for a row of AJJL

   NFB - number of first body

   NLB - number of last body

   NTZYS - number of slender elements

   IDZDY - Z-Y flag

   NTAPE - GINØ file for output

   X - location of array from ACPT record

BETA - see AMGRØD

IPRT - print flag

NS to NBEA1 - locations of array from ACPT record

3.2.8.26 Subroutine Name: RØWDZY

1. Entry Point: RØWDZY
2. Purpose: To set up call to DZY
3. Calling Sequence: CALL RØWDZY(NFB,NLB,RØW,NTZYS,D,DX,DY,DZ,BETA,IDZDY,NTAPE,SG,CG,IPRT, YB,ZB,ARB,NSBEA,XIS1,XIS2,AØ)

   NFB,NLB,NTZYS,D,BETA,IIDZD1,NTAPE,IPRT - same as DZYMAT

   RØW - row position of answer

   DX,DY,DZ - X, Y, Z of receiving point

   SG,CG,YB,ZB,ARB,NSBEA,XIS1,XIS2,AØ - locations of arrays from ACPT record

3.2.8.27 Subroutine Name: AMGSBA

1. Entry Point: AMGSBA
2. Purpose: Add slender body terms and pack out final AJJL for bodies
3. Calling Sequence: CALL AMGSBA(AJJL,AØ,AR,NSBE,A)

   AJJL - GINØ file number

   AØ,AR - locations of arrays from ACPT record

   NSBE - number of slender body elements

   A - storage for a row of AJJL

3.2.8.28 Subroutine Name: AMGBFS

1. Entry Point: AMGBFS
2. Purpose: Build the SKJ matrix for bodies
3. Calling Sequence: CALL AMGBFS(SKJ,EE,DELX,NCARAY,NBARAY,XIS2,XIS1,AØ,AØP,NSBE)

   SKJ - GINØ file number

   EE to AØP - locations of arrays from ACPT record

   NSBE - number of slender body elements

3.2.8.29 Subroutine Name: BFSMAT

1. Entry Point: BFSMAT
2. Purpose: Form force matrices for slender elements
3. Calling Sequence: CALL BFSMAT(ND,NE,NB,NP,NTP,LENGTH,NTO,SCR1,JF,JL,NAS,FMACH,YB,ZB,YS,
ZS,X,DELX,EE,XIC,SG,CG,AR,RIA,NBEA1,NBEA2,NASB,NSARAY,
NCARAY,BFS,AVR,REFC,AØ,XIS1,XIS2,KR,NSBEA,NTØ)

   See Reference 1 (Section 4.114.11) for argument list.

3.2.8.30 Subroutine Name: FWMW

1. Entry Point: FWMW
2. Purpose: Add in images, symmetry, plane and ground effects
3. Calling Sequence: CALL FWMW(ND,NE,SGS,CGS,IRB,AØ,ARB,XBLE,XBTE,YB,ZB,XS,YS,ZS,NAS,NAS3,
KR,BETA2,REFC,AVR,FWZ,FWY)

   See Reference 1 (Section 4.114.11) for argument list.

3.2.8.31 Subroutine Name: FZY2

1. Entry Point: FZY2
2. Purpose: Calculate the force numbers for FWMW
3. Calling Sequence: CALL FZY2(XIJ,X1,X2,ETA,ZETA,YB,ZB,A,BETA2,REFC,KR,FZZR,FZZI,FZYR,
FZYI,FYZR,FYZI,FYYR,FYYI)

   See Reference 1 (Section 4.114.11) for argument list.

3.2.8.32 Subroutine Name: DLBPT2

1. Entry Point: DLBPT2
2. Purpose: Output the Doublet Lattice with Bodies parts of D1JK, D2JK
3. Calling Sequence: CALL DLBPT2(ACPT,D1JK,D2JK)

   ACPT, D1JK, D2JK - GINØ file numbers

3.2.8.33 Subroutine Name: MBAMG

1. Entry Point: MBAMG
2. Purpose: Driver for Mach Box Method
3. Calling Sequence: CALL MBAMG(ACPT,AJJL,SKJ)

   ACPT, AJJL, SKJ - GINØ file numbers

3.2.8.34 Subroutine Name: MBPRIT

1. Entry Point: MBPRIT
2. Purpose: Print geometry data
3. Calling Sequence: CALL MBPRIT(AW,AC,AT)

   AW - area of wing

   AC - area of control one

   AT - area of control two

3.2.8.35 Subroutine Name: MBGEØD

1. Entry Point: MBGEØD
2. Purpose: Compute the geometry of the planform
3. Calling Sequence: MBGEØD

3.2.8.36 Subroutine Name: MBREG

1. Entry Point: MBREG
2. Purpose: Compute the limits of the region and the percentage of box in each
3. Calling Sequence: CALL MBREG(IREG,NW1,NWN,NC21,NC2N,NC1,NCN,ND1,NDN,XK,YK,XK1,YK1,XK2,
   YK2,XWTE,YWTE,KTE,KTE1,KTE2,PAREA)

   IREF - flag for MBREG success - 2 = fail

   NW1 - PAREA - location of arrays which MBREG is to build

3.2.8.37 Subroutine Name: MBCTR1

1. Entry Point: MBCTR1
2. Purpose: Compute the region calculations for control one
3. Calling Sequence: CALL MBCTR1(IC1,IR1,NCN,NC1,NWN,NW1,PAREA)

   IC1 - starting box number for control one

   IR1 - ending box number for control one

   NCN to PAREA - locations of arrays which MBCTR1 is to build

3.2.8.38 Subroutine Name: MBCTR2

1. Entry Point: MBCTR2
2. Purpose: Compute the region calculations for control two

3. Calling Sequence: CALL MBCTR2(IL2,IR2,NC2N,NC21,NWN,NW1,PAREA)

   IL2 - startinj box for control two

   IR2 - ending box for control two

   NC2N to PAREA - location of arrays which MBCTR2 is to build

3.2.8.39 Subroutine Name: MBPLØT

1. Entry Point: MBPLØT
2. Purpose: Print a representation of the planform
3. Calling Sequence: CALL MBPLØT(NW1,ND1,NWN,NC21,NC2N,NC1,NCN,NDN)

   NW1 - NDN - locations of arrays which define planform boxes

3.2.8.40 Subroutine Name: MBMØDE

1. Entry Point: MDMØDE
2. Purpose: Build the mode-like data from surface interpolation
3. Calling Sequence: CALL MBMØDE(ACPT,SCR2,ICØR,NCØR,Z,NI,ND,XD,YD,IS,CR)

   ACPT, SCR2 - GINØ file numbers

   ICØR - first available location in MBAMGX

   NCØR - last available location in MBAMGX

   Z - start of open core

   NI - number of independent points

   ND - number of dependent points

   XD - X location of dependent points

   YD - Y location of dependent points

   IS - singularity flag

   CR - non-dimensionalizing number

3.2.8.41 Subroutine Name: MBCAP

1. Entry Point: MBCAP
2. Purpose: Compute the velocity potential influence coefficients
3. Calling Sequence: CALL MBCAP(NPNI,CAPPNI)

   NPNI - number of coefficients computed

   CAPPNI - location to store coefficients

3.2.8.42 Subroutine Name: MBBSLJ

1. Entry Point: MBBSLJ
2. Purpose: Compute even-ordered Bessel Functions
3. Calling Sequence: CALL MBBSLJ(ARG,N,BSL)

ARG - input argument

N - order

BSL - storage for answers (length N)

3.2.8.43 Subroutine Name: ZJ

1. Entry Point: ZJ
2. Zero order Bessel Function
3. Calling Sequence: X=ZJ(ARG)

ARG - input argument

3.2.8.44 Subroutine Name: GØ

1. Entry Point: GØ
2. Purpose: Evaluate an Expression $[\psi(\Omega, n_u) - \psi(\Omega, n_1)]$
3. Calling Sequence: ANS=GØ(R,ETAR,ETAL,EKM)

R = Ψ

ETAR = n_u

ETAL = n_1

EKM = Ω

3.2.8.45 Subroutine Name: MBDPDH

1. Entry Point: MBDPDH
2. Purpose: Driver for computing and outputing the terms of AJJL for Mach Box Method
3. Calling Sequence: CALL MBDPDH(AJJL,F,DF,F1,DF1,F2,DF2,XWTE,YWTE,PAREA,CAPPNI,DPNITE, DSS,Q,Q1,Q2,NDN,ND1,NW1,NWN,KTE,KTE1,KTE2,NTE,NNCB, NNSBD,IW17,IBUF,A)

AJJL - GINØ file number

F - NTE - locations of array for Mach box

NNCB - number or chordwise boxes

NNSBD - number of spanwise boxes

IW17 - GINØ file number

IBUF - pointer to a buffer

A - storage for a row of AJJL

3.2.8.46 Subroutine Name: MBGAE

1. Entry Point: MBGAE
2. Purpose: Final calculation and output for AJJL
3. Calling Sequence: CALL MBGAE(AJJL,IN17,A,F,DF,F1,DF1,F2,DF2,Q,Q1,Q2,MØØD)

   AJJL,IN17 - GINØ file numbers

   F to Q2 - locations of Mach box arrays

   MØØD - row number of AJJL

3.2.8.47 Subroutine Name: MBGATE

1. Entry Point: MBGATE
2. Purpose: Compute sum on trailing edge
3. Calling Sequence: CALL MBGATE(NTØTE,DPHITE,N,YWTE,Q,Q1,Q2,KTE,KTE1,KTE2)

   NTØTE - number of trailing edge terms

   DPHITE - KTE2 - locations of Mach Box arrays

3.2.8.48 Subroutine Name: MBGAW

1. Entry Point: MBGAW
2. Purpose: Compute sum on wing
3. Calling Sequence: CALL MBGAW(BØXL,DPHI,WS,PAW,PAF1,PAF2,Q, Q1,Q2,M,KC,KC1,KC2)

   BØXL - box length

   DPHI - Q2 - location of Mach Box arrays

   M - KC2 - indexes to arrays

3.2.8.49 Complex Function Name: SUMPHI

1. Entry Point: SUMPHI
2. Purpose: Compute sum of (N*ΔH) on the wing
3. Calling Sequence: SUM=SUMPHI(IXR,IYR,ND1,NDN,CAPPNI,DSS,N,M,ASYM)

   IXR,IYR,N,M,ASYM - index and flags

   ND1,NDN,CAPPNI,DSS - location of arrays

3.2.8.50 Complex Function Name: TRAILE

1. Entry Point: TRAILE
2. Purpose: Compute sum of (N*ΔH) on tip
3. Calling Sequence: SUM=TRAILE(X,J,N,P,M,BØXL)

   J,M,N - pointers

   X - values

   P - location of array

   BØXL - box length

3.2.8.51 Subroutine Name: STPDA

1. Entry Point: STPDA
2. Purpose: Driver for Section one of Strip Theory
3. Calling Sequence: CALL STPDA(ACPT,AJJL,SKJ)

   ACPT,AJJL,SKJ - GINØ file numbers

3.2.8.52 Subroutine Name: STPBG

1. Entry Point: STPBG
2. Purpose: Builds two intermediate matrices for Strip Theory calculations (BM and GM)
3. Calling Sequence: CALL STPBG(BM,GM,NS,BLØC,D,CA,NSIZE)

   BM - storage for BM matrix

   GM - storage for GM matrix

   NS - number of strips

   BLØC - array of semi-chord lengths for strips

   D - array of hinge line lengths

   CA - array of control surface chords

   NSIZE - array of strip types

3.2.8.53 Subroutine Name: STPPHI

1. Entry Point: STPPHI
2. Purpose: Calculate the Φ functions
3. Calling Sequence: CALL STPPHI(CA,BLØC,PM,NS)

   CA,BLØC,NS - See STPBG

   DM - Storage for Φ functions

3.2.8.54 Subroutine Name: STPAIC

1. Entry Point: STPAIC
2. Purpose: Calculate and output AJJL for Strip Theory
3. Calling Sequence: CALL STPAIC(BLØC,DY,NSIZE,GAP,BM,GM,PM,NS,CLA,AJJL)

   BLØC,NSIZE,NS,BM,GM - See STPBG

   GAP - array of control surface gap

   PM - See STPPHI

   DY - array of Strip widths

   CLA - array of lift curve slopes

   AJJL - GINØ file numbers

3.2.8.55 Subroutine Name: STPK

1. Entry Point: STPK
2. Purpose: Calculate the K-matrix for Strip Theory
3. Calling Sequence: CALL STPK(EK,N,NSTØP,NØPEN,NSTED,TSR,PM,CR,CI,IM,J1)

   EK - modified reduced frequency

   N - strip number

   NSTØP - strip type

   NØPEN - control surface flag

   NSTED - reduced frequency flag

   TSR - .5*GAP/BLØC

   PM - Φ

   CR - Theodorsen Function

   CI - 0.

   IM - k-size

   J1 - J-size

3.2.8.56 Subroutine Name: STPBSO

1. Entry Point: STPBSO
2. Purpose: J and Y Bessell functions of order zero
3. Calling Sequence: CALL STPBSO(X,NCØDE,BJO,BYO)

   X - input argument

NCØDE - flag

BJ0 - J Bessel

BY0 - Y Bessel

3.2.8.57 Subroutine Name: STPBS1

1. Entry Point: STPBS1
2. Purpose: J and Y Bessel Function of first order
3. Calling Sequence: CALL STPBS1(X,NCØDE,BJ1,BY1)

X - input argument

NCØDE - flag

BJ1 - J Bessel

BY1 - Y Bessel

3.2.8.58 Subroutine Name: STPPT2

1. Entry Point: STPPT2
2. Purpose: Output D1JK and D2JK for Strip Theory, Mach Box and Piston Theory
3. Calling Sequence: CALL STPPT2(ACPT,D1JK,D2JK)

ACPT,D1JK,D2JK - GINØ file numbers

3.2.8.59 Subroutine Name: PSTAMG

1. Entry Point: PSTAMG
2. Purpose: Driver for Section one of Piston Theory
3. Calling Sequence: CALL PSTAMG(ACPT,AJJL,SKJ)

ACPT,AJJL,SKJ - GINØ file numbers

3.2.8.60 Subroutine Name: PSTA

1. Entry Point: PSTA
2. Purpose: Calculate and output AJJL for Piston Theory
3. Calling Sequence: CALL PSTA(DELTY,BI,CA,ALPH,THI,AJJL)

DELTY - array of strip width

BI - array of semi-chord lengths for strips

CA - array of chord lengths of each strip

ALPH - Alpha array (angle of attack)

THI - Theta array (thickness ratio)

AJJL - GINØ file number

3.2.8.61 Subroutine Name: AMGB1

1. Entry Point: AMGB1

2. Purpose: Driver for the compressor blade method for AJJL and SKJ Generation.

3. Calling Sequence: CALL AMGB1 (INPUT, MATØUT, SKJ)

   INPUT = GINØ file number for ACPT

   MATØUT = GINØ file number for AJJL

   SKJ = GINØ file number for SKJ

3.2.8.62 Subroutine Name: AMGB1A

1. Entry Point: AMGB1A

2. Purpose: Output all the columns of AJJL associated with a record of ACPT.

3. Calling Sequence: CALL AMGB1A (INPUT, MATØUT, AJJ, AJJT, TSØNX, TAMACH, TREFD)

INPUT = GINØ file number of ACPT

MATØUT = GINØ file number of AJJL

AJJ = Storage for AJJL submatrices - complex

AJJT = Storage for one column of AJJL

TSØNX = Stores position of transonic submatrix in AJJL for a particular transonic streamline

TAMACH = Stores Mach numbers of transonic streamlines

TREFD = Stores reduced frequencies of transonic streamlines

3.2.8.63 Subroutine Name: AMGB1B

1. Entry Point: AMGB1B

2. Purpose: Calculates AJJL terms for subsonic streamlines.

3. Calling Sequence: CALL AMGB1B (AJJL)

AJJL = Location to put subsonic AJJL submatrix for this streamline

3.2.8.64 Subroutine Name: AMGB1C

1. Entry Point: AMGB1C

2. Purpose: Calculates AJJL terms for supersonic streamlines.

3. Calling Sequence: CALL AMGB1C (AJJL)

AJJL = Location to put supersonic AJJL submatrix for this streamline

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3.2.8.65 Subroutine Name: AMGB1D

1. Entry Point: AMGB1D

2. Purpose: Calculates AJJL terms for transonic streamlines.

3. Calling Sequence: CALL AMGB1D (AJJL, TSØNX, TAMACH, TREDF)

   AJJL = AJJL submatrices for all subsonic and supersonic streamlines. It also contains space for transonic submatrices.

   TSØNX = (integer) - vector - non-zero indicates transonic streamline zero if known streamline

   TAMACH = Vector of streamline Mach numbers

   TREDF = Vector of streamline reduced frequencies

3.2.8.66 Subroutine Name: INTERT

1. Entry Point: INTERT

2. Purpose: To linearly interpolate by Mach number a transonic general Air Force matrix given two known streamline matrices.

3. Calling Sequence: CALL INTERT (NL, NL1, NL2, NM, AJJ, TA)

   NL = Streamline number of unknown transonic

   NL1, NL2 = Two known streamlines

   NM = Size of matrix in AJJ = 2 * NSTNS * NSTNS

   AJJ = Contains all generalized Air Force matrices for all streamlines

   TA = Vector of streamline Mach numbers

3.2.8.67 Subroutine Names: SUBA, SUBB, SUBC, SUBD, ALAMDA, AKP2, AKAPPA, DLKAPM, ASYCON, AKAPM, DRKAPM

1. Entry Points: The same as name

2. Purpose: Called by AMGB1C

3.2.8.68 Subroutine Name: GAUSS

1. Entry Point: GAUSS

2. Purpose: Equation Solver used by AMGB1B.

3. Calling Sequence: CALL GAUSS (A, N, NL)

3.2.8.69 Subroutine Name: AMGB2

1. Entry Point: AMGB2

2. Purpose: To output the compressor blade parts for matrices D1JK and D2JK.

3. Calling Sequence: CALL AMGB2 (INPUT, W1JK, W2JK)

   INPUT = GINØ file number for ACTP

   W1JK = GINØ file number for D1JK
   W2JK = GINØ file number for D2JK

3.2.8.70 Subroutine Name: AMGB2A

1. Entry Point: AMGB2A

2. Purpose: Calculate $[F^{-1}]$ matrix used in the generation of D1JK.

3. Calling Sequence: CALL AMGB2A (INPUT, FMAT, XYZB, INDEX)

   INPUT = GINØ file number of ACPT
   FMAT = Location for $[F^{-1}]$ matrix
   XYZB = Location for basic coordinates of nodes on streamline
   INDEX = Work storage for INVERS

3.2.8.71 Subroutine Name: AMGB1S

1. Entry Point: AMGB1S

2. Purpose: Calculate $[F^{-1}]$ matrix and W factor used in the generation of SKJ.

3. Calling Sequence: CALL AMGB1S (INPUT, FMAT, XYZB, INDEX, RADII, WFACT, NLINE)

   INPUT = GINØ file number of ACPT
   FMAT = Location for $[F^{-1}]$ matrix
   XYZB = Location for basic coordinates of nodes on streamline
   INDEX = Work storage for INVERS
   WFACT = Factor for output
   NLINE = Number of streamlines
   RADII = Streamline radius

3.2.8.72 Subroutine Name: AMGT1

1. Entry Point: AMGT1
2. Purpose: Driver for the swept turboprop blade method for AJJL and SKJ generation.
3. Calling Sequence: CALL AMGT1 (INPUT, MATØUT, SKJ)

INPUT = GINØ file number for ACPT

MATØUT = GINØ file number for AJJL

SKJ = GINØ file number for SKJ

3.1.8.73 Subroutine Name: AMGT1A

1. Entry Point: AGMT1A
2. Purpose: Output all the columns of AJJL associated with a record of ACPT.
3. Calling Sequence: CALL AMGT1A (INPUT, MATØUT, AJJ, AJJT, TSONX, TAMACH, TREFD, NSTNS2).

INPUT = GINØ file number of ACPT

MATØUT = GINØ file number of AJJL

AJJ = Storage of AJJL submatrices - complex

AJJT = Storage for one column of AJJL

TSONX =
TAMACH = } Not used.
TREFD =

NSTNS2 = 2* no. of stations on a streamline.

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3.2.8.74 Subroutine Name: AMGT1B

1. Entry Point: AMGT1B
2. Purpose: Calculates AJJL terms for subsonic streamlines.
3. Calling Sequence: CALL AMGT1B (AJJL, NSTNS2, C3, C4)

AJJL = Location to put subsonic AJJL submatrix for this streamline

NSTNS2 = No. of stations on a streamline X 2

C3, C4 = Input constants

3.2.8.75 Subroutine Name: AMGT1C

1. Entry Point: AMGT1C
2. Purpose: Writes error message for supersonic streamlines for turboprop blades.
3. Calling Sequence: CALL AMGT1C (AJJL, NSTNS2)

3.2.8.76 Subroutine Name: AMGT1D

1. Entry Point: AMGT1D
2. Purpose: Writes error message for transonic streamlines for turboprop blades.
3. Calling Sequence: CALL AMGT1D (AJJL, TSONX, TAMACH, TRDF, NSTNS2)

3.2.8.77 Subroutine Name: AMGT1S

1. Entry Point: AMGT1S
2. Purpose: Calculate $[F^{-1}]$ matrix used in the generation of SKJ.
3. Calling Sequence: CALL AMGT1S (INPUT, FMAT, XYZB, INDEX).

INPUT = GINO file number of ACPT

FMAT = Location for $[F^{-1}]$ matrix

XYZB = Location for basic coordinates of nodes on streamline

INDEX = Work storage for INVERS

3.2.8.78 Subroutine Name: AMGT1T

1. Entry Point: AMGT1T
2. Purpose: Calculate constants C3, C4 for subsonic streamline on swept turboprop blade.
3. Calling Sequence: CALL AMGT1T (NLINES, NLINE, INPUT, NSTNS, C3, C4)

NLINES = Total no. of streamlines on blade

NLINE = Streamline being considered

INPUT = GINO file number for ACPT

NSTNS = No. of stations on a streamline.

C3, C4 = Output constants

3.2.8.79 Subroutine Name: AMGT2

1. Entry Point: AMGT2
2. Purpose: To output the swept turboprop blade parts for matrices D1JK and D2JK.
3. Calling Sequence: CALL AMGT2 (INPUT, D1JK, D2JK)

INPUT = GINO file number for ACTP

D1JK = GINO file number for D1JK

D2JK = GINO file number for D2JK

3.2.8.80 Subroutine Name: AMGT2A

1. Entry Point: AMGT2A
2. Purpose: Calculate $[F^{-1}]$ matrix used in the generation of D1JK.
3. Calling Sequence: CALL AMGT2A (INPUT, FMAT, XYZB, INDEX)

INPUT = GINO file number of ACPT

FMAT = Location for $[F^{-1}]$ matrix

XYZB = Location for basic coordinates of nodes on streamline

INDEX = Work storage for INVERS

3.2.9 Design Requirements

For Section one, four buffers are allocated at the bottom of core. For Section two, three buffers are allocated at the bottom of core. Each method may have its own open core common block but they must not overlap these buffers.

3.2.9.1 Common Blocks

AMGMN - Doublet Lattice without Bodies Communication

Words			
1-7	MCB	- Trailer for AJJL	
8	NRØW	- Last row number output for any method on AJJL	
9	ND	- Y-symmetry flag	1 record of AERØ Data Block
10	NE	- Z-symmetry flag	
11	REFC	- Reference card	
12	FMACH	- Mach number (M)	Pairs from 2 record of AERØ Data Block
13	RFK	- Reduced frequency	
14-20	TSKJ	- Trailer for SKJ	
21	ISK	- Row number to start building on SKJ	
22	NSK	- Last row number output for any method on SKJ	

AMGP2 - Section Two Communication

Words		
1-7	TW1JK	- trailer for D1JK
8-14	TW2JK	- trailer for D2JK

DLCØM - Doublet Lattice without Bodies Communication

Words		
1	NP	- number of panels
2	NSTRIP	- number of strips

DLCØM (Cont'd.)

Words

3	NTP	- number of boxes
4	F	- fraction of box chord
5	NJJ	- NJ (Input parameter)
6	NEXT	- first location of open core available after allocation
7	LENGTH	- number of boxes along longest panel (from NCARAY)
8	INC	- pointer to NCARAY array
9	INB	- pointer to NBARAY array
10	IYS	- pointer to YS array
11	IZS	- pointer to ZS array
12	IEE	- Pointer to EE array
13	ISG	- pointer to SG array
14	ICG	- pointer to CG array
15	IXIC	- pointer to XIC array
16	IDELX	- pointer to DELX array
17	IXLAM	- pointer to XLAM array
18	IDT	- complex pointer to storage for column of AJJL

DLM - Both Doublet Lattice methods

ords

1	K10	- Planar part of steady contribution to the kernel	
2	K20	- Nonplanar part of steady contribution to the kernel	
3	K1RT1 -		Unsteady parts of modified kernel
4	K1IT1 -		
5	K2RT2P-		
6	K2IT2P-		
7	K10T1	- K10*T1	T1 and T2 are defined under TKER
8	K20T2P	- K20*T2	

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DLAXX - Open Core for Doublet Lattice without Bodies

Words 6 to End of Record on ACPT	(Doublet Lattice Arrays)
Column of AJJL 2*NJ	
Free	
4 Buffers: SKJ, AJJL, AERØ, ACPT	

DLP2X - Open core for Section two

Record of ACPT
Free
3 Buffers: D2JK, D1JK, ACPT

KDS - Both Doublet Lattice Methods

Words

1	IHD	- 0 = total kernel, 1 = incremental part only
2	KD1R	- real part of k_1
3	KD1I	- imaginary part of k_1
4	KD2R	- real part of k_2
5	KD2I	- imaginary part of k_2

MODULE FUNCTIONAL DESCRIPTIONS

DLBDY - Doublet Lattice with Bodies Communication

Words

1-12	Words 2-13 of ACPT record
13-51	pointers into DLBXX for arrays on ACPT
52	ECØRE - end of core in DLBXX
53	NEXT - next available location in DLBXX
54-58	SCR1-SCR5 - GINØ file numbers for scratch files
59	NTBE - number of columns to add to AJJL

DLBXX - Open core for Doublet Lattice with Bodies

Word 13 to End of Record on ACPT		(Doublet Lattice Arrays)
2 columns of AJJL 4*NJ		
Free Used for Scratch Storage		
8 Buffers	SCR4 SCR3 SCR2 SCR1 SCR5 SKJ AJJL AERØ ACPT	

MBØXA - Mach Box Wing Definitions

Words

1-12	X	- X locations of wing
13-24	Y	- Y locations of wing
25-34	TANG	- Tangents of wing sweep angles
35-44	ANG	- Sweep angles of wing
45-54	CØTANG	- Cotangents of wing sweep angles

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<u>MBØXC</u> - Mach Box Communications

<u>Words</u>

1-9	Words 2-10 of ACPT record
10-30	Intercommunication between Mach Box subroutines

<u>MBAMGX</u> - Open core for Mach Box Method

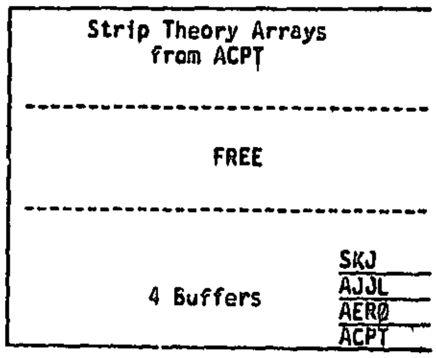
Words 1 to 9051		Mach Box Arrays
Scratch storage for MBDPDH		
Free		
5 Buffers	SCR2 SKJ AJJL AERØ ACPT	

<u>STRIPC</u> - Strip Theory Communications

<u>Words</u>

1	NS	- number of strips
2	BREF	- reference chord/2.0
3	CLAM	- cosine of sweep angle
4	FM	- Mach number
5	NCIRC	- Theodorsen function selection
6	NNCIRC	- NCIRC+1
7	EKR	- reduced frequency
8	Not Used	
9-12	BB(u)	- b's for approximate function
13-16	BETA(u)	- B's for approximate function
17-48	EKM(u,u) complex	- storage for STPK output (k matrix)

STRIPX - Strip Theory Open Core

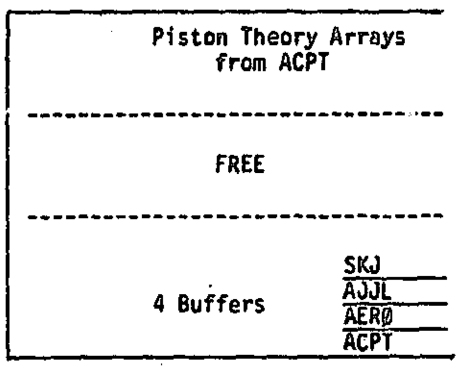


PSTØNC - Piston Theory Communication

Words

1-9 Words 2-10 of ACPT record

PSTØNX - Piston Theory Open Core



BAMG1L and BAMG2L - Common Blocks for Compressor Blade Method

Words:

1	IREF	- Reference streamline number
2	MINMAC	- Parameter MINMACH
3	MAXMAC	- Parameter MAXMACH
4	NLINES	- Number of streamlines on blade
5	NSTNS	- Number of stations on blade
6	REFSTG	- Reference blade stagger angle
7	REFCRD	- Reference blade chord
8	REFMAC	- Reference Mach number
9	REFDEN	- Reference density
10	REFVEL	- Reference velocity
11	REFFLØ	- Reference flow angle
12	SLN	- Streamline number
13	NSTNSX	- Number of stations on streamline
14	STAGER	- Blade stagger angle
15	CHØRD	- Blade chord
16	RADIUS	- Radius of streamline
17	BSPACE	- Blade spacing
18	MACH	- Relative flow Mach number at blade leading edge
19	DEN	- Gas density at blade leading edge
20	VEL	- Relative flow velocuty at blade leading edge
21	FLØWA	- Relative flow angle at blade leading edge
22	AMACH	- Internal Mach number
23	REDF	- Internal reduced frequency
24	BLSPC	- Internal blade spacing
25	AMACHR	- Internal reference Mach number
26	TSØNIC	- Transonic indicator

BAMGXX - Open Core for Compressor Blades

Words 6 to End of Record on ACPT
Column of AJJL 2*NJ
Free
4 Buffers — SKJ / AJJL / AERO / ACPT

BAMG2X - Open core for Section two

Record of ACPT
Free
3 Buffers — D2JK / D1JK / ACPT

FUNCTIONAL MODULE AMG (AERODYNAMIC MATRIX GENERATOR)

<u>TAMG1L</u> and <u>TAMG2L</u> - Common Blocks for Swept Turboprop Blade Method

Words:

1	IREF	- Reference Streamline number
2	MINMAC	- Parameter MINMACH
3	MAXMAC	- Parameter MAXMACH
4	NLINES	- Number of streamlines on blade
5	NSTNS	- Number of stations on bla[illegible]
6	REFSTG	- Reference blade stagger angle
7	REFCRD	- Reference blade chord
8	REFMAC	- Reference Mach number
9	REFDEN	- Reference density
10	REFVEL	- Reference velocity
11	REFFLØ	- Reference flow angle
12	SLN	- Streamline number
13	NSTNSX	- Number of stations on streamline
14	STAGER	- Blade stagger angle
15	CHØRD	- Blade chord
16	DCBDZB	- $\partial\overline{C}/\partial\overline{Z}$
17	BSPACE	- Blade spacing
18	MACH	- Relative flow Mach number at blade leading edge
19	DEN	- Gas density at blade leading edge
20	VEL	- Relative flow velocity at blade leading edge
21	SWEEP	- Sweep angle of blade
22	AMACH	- Internal Mach number
23	REDF	- Internal reduced frequency
24	BLSPC	- Internal blade spacing
25	AMACHR	- Internal reference Mach number
26	TSØNIC	- Transonic indicator

TAMGXX - Open Core for Swept Turboprop Blades

Words 6 to End of Record or ACPT	
Column of AJJL 2*NJ	
Free	
3 Buffers	D2JK D1JK ACPT

TAMG2X - Open Core for Section two

Record of ACPT	
Free	
3 Buffers	D2JK D1JK ACPT

3.2.10 Diagnostic Messages

System fatal messages 3001, 3002, 3003, 3007, 3008 and (10) 3061. User fatal messages 2264 and 2265.

3.2.11 References

Most of the equations and code for the Doublet Lattice Method were taken from

(1) Giesing, J.P., Kalman, T.P., Rodden, W.P., "Application of the Doublet-Lattice Method and the Method of Images to Lifting-Surface/Body Interference," AFFDL-TR-71-5, Part II, Vol. 1, April 1972.

Most of the equations and code for the Mach Box Method were taken from

(2) Donato, V.W., Huhn, C.R., Jr., "Supersonic Unsteady Aerodynamics for Wings with Trailing Edge Control Surfaces and Folded Tips," AFFDL-TR-68-30, August 1968.

Most of the equations and code for the Strip Theory Method were taken from

(3) Albano, E., "Strip Theory Aerodynamic Influence Coefficients for Wings with Aerodynamically Balanced Control Surfaces," Northrop Corporation, Moran Division Report NOR 68-125, August 1968.

Most of the equations and code for the Piston Theory Method were taken from

(4) Rodden, W.P., Forkos, E.F., Malcom, H.A., and Kliszewski, A.M., "Aerodynamic Influence Coefficients from Piston Theory: Analytical Development and Computational Procedure," Space Systems Division, United States Air Force Report No. TDR-169 (3230-11)TN-2, August 1962.

3.3 FUNCTIONAL MODULE AMP (AERODYNAMIC MATRIX PROCESSOR)

3.3.1 Entry Point:

AMP

3.3.2 Purpose

The purpose of this module is to produce "modal" aerodynamic matrices. This requires the combination of matrices from four sources.

1. The aerodynamic matrices for aerodynamic cells, produced by the Aerodynamic Matrix Generator (AMG) module.
2. The interpolation from the structure to the aerodynamic cells, produced by the Geometry Interpolator (GI) module.
3. The modes of the structure, produced by the Real Eigenvalue Analysis (READ) module, and selected by GKAM.
4. The matrix of downwashes due to "extra" points, which may be supplied by the user via module INPUTT2. These extra points in NASTRAN are used for control systems and other special effects.

3.3.3 DMAP Calling Sequence

```
AMP  AJJL,SKJ,D1JK,D2JK,GTKA,PHIDH,D1JE,D2JE,USETD,AERØ/QHHL,QKHL,QHJL/V,N,NØUE/V,N,XQHHL/
     V,N,GUSTAERØ $
```

3.3.4 Input Data Blocks

AJJL	Aerodynamic influence matrix list
SKJ	Integration matrix
D1JK	Real part of downwash matrix
D2JK	Complex part of downwash matrix
GTKA	Aerodynamic transformation matrix k-set to a-set
PHIDH	Transformation between modal and physical coordinates
D1JE	Downwash factors due to extra points; real
D2JE	Downwash factors due to extra points; complex
USETD	Displacement sets definition - dynamics

AERØ   Aerodynamic matrix generation data

Notes:

1. AJJL, SKJ, D1JK, D2JK, GTKA, PHIDH, USETD, and AERØ may not be purged.
2. D1JE and D2JE are used only if NØUE > 0. Even in this case they may be purged.

3.3 .5 Output Data Blocks

QHHL -- Aerodynamic matrix list - h-set

QKHL -- Aerodynamic transformation matrix between hand k sets

QHJL -- Aerodynamic transformation matrix between j and k sets

Notes:

1. QHHL, QKHL, and QHJL are matrix lists - one submatrix for each (m,k) pair.
2. If QHHL, QKHL, and QHJL are present before the module begins (APPEND on restart) and XQHHL = -1, the old data needed is read from these data blocks.

3.3 .6 Parameters

NØUE -- Integer, input, no default. The number of extra points.

XQHHL - Integer, input/output, no default. If +1, the data found on appended data blocks must be discarded. If -1, it can be used. AMP sets XQHHL to -1 on exit.

GUSTAERØ - Integer, input, default = 0. If, and only if, GUSTAERØ < 0, AMP will compute QHJL.

3.3 .7 Method

There are several important features which must be kept in mind.

1. In general, the input and output matrices may depend upon the aerodynamic parameters k (reduced frequency) and m (Mach number). A set of matrices (called a list) are processed in one pass through the module.
2. Special code will be introduced for restart. This is required for Doublet Lattice solutions where matrix solution time may be long. This will allow the addition (or deletion) of (m,k) pairs without redecomposing the downwash matrix.
3. An output, Q_{kh}, relating aerodynamic pressures to modal coordinates may be required for use in a data reduction module. This output will not be used in Phase 1; hence it will be purged from the calling sequence. The matrix of generalized forces, Q_{hh}, may be purged, if only data reduction is desired.

FUNCTIONAL MODULE AMP (AERODYNAMIC MATRIX PROCESSOR)

The flow chart is shown in Figure 1. The basic loop is to write out matrices for the list of (m,k) pairs found on the AERØ data block. The source of these matrices is normally the input. In the case of a restart which involves only changes in the (m,k) pairs, special code is provided to avoid recalculation; and the matrices are found on the output data block which is declared APPEND. This occurs when XQHHL = -1.

3.3 .7.1 Subroutine AMPA

Put the output m,k list in core. This list is found in the second record of the AERØ data block. The index I will be used to index down this list of pairs. IMAX is the number of pairs.

Check to see if the output data blocks QKHL, QHHL, and QHJL exist and are valid. If they do, then this is a restart. These must be copied onto scratch files. Their (m,k) lists are put in core. Build a scenario file which lists the (m,k) pair, the AJJL column associated with this (m,k) pair, and the corresponding QHHL column.

3.3 .7.2 Subroutine AMPB

Calculate the D_{jh} matrices. The superscript (1) is for the real part and (2) is for the imaginary part.

$$[\phi_{ai}] = \text{Partition of } [\phi_{dh}] \quad ,$$
$$[G_{ki}] = [G_{ka}^T]^T[\phi_{ai}] \quad . \tag{1}$$

$[G_{ki}]$ may be needed again later to calculate Q_{ih}.

$$[D_{ji}^{(1)}] = [D_{jk}^{(1)}]^T[G_{ki}] \quad , \tag{2}$$

$$[D_{ji}^{(2)}] = [D_{jk}^{(2)}]^T[G_{ki}] \quad , \tag{3}$$

$$[D_{jh}^{(1)}] = \text{Merge } [D_{ji}^{(1)} D_{je}^{(1)}] \quad , \tag{4}$$

$$[D_{jh}^{(2)}] = \text{Merge } [D_{ji}^{(2)} D_{je}^{(2)}] \quad . \tag{5}$$

If the input data blocks are purged, $D_{je}^{(1,2)}$ is zero. Start a loop with I = 0. Check the time left.

3.3 .7.3 Subroutine AMPC

Calculate (or find) Q_{jh} if it is needed. It will be needed if either (a) Q_{kh} is to be output, or (b) Q_{hh} is to be output and is not found on the scratch file. The Q_{kh} and Q_{hh} are not to be output only when their output data blocks are purged. If Q_{kh} can be found on a scratch file, get it from there; otherwise, it must be calculated. First, check to see if $D_{jh}(k)$ has been calculated for the present k. If not, find it by

$$[D_{jh}] = [D_{jh}^{(1)}] + i\,k[D_{jh}^{(2)}] \quad , \tag{6}$$

and save for possible later use. Next, solve for Q_{jh}. The algebra included here will be theory dependent. The header record of AJJL will specify aerodynamic groups (see Section 4.115.7.5). Retrieve the submatrix $[A_{jj}]$ from AJJL. If there is more than one group, D_{jh} must be unpacked into row groups. For each group, solve for $[Q_{jh}]$, then pack the groups. For Doublet Lattice method, and the Double Lattice method with slender bodies,

$$[Q_{jh}]_{group} = [A_{jj}^T]_{group}^{-1}[D_{jh}]_{group} \quad . \tag{7}$$

For other methods,

$$[Q_{jh}]_{group} = [A_{jj}][D_{jh}]_{group} \tag{7a}$$

3.3 .7.4 Subroutine AMPD

Calculate (or find) $[Q_{hh}]$ and $[Q_{kh}]$ if they are needed. They will be needed unless the output data blocks are purged. If $[Q_{hh}]$ can be found on a scratch file, get it there, otherwise, it must be calculated. If it must be calculated $[Q_{jh}]$ will be available. To compute $[Q_{hh}]$

Where S_{kj} is a matrix list for (m,k),

$$[Q_{kh}] = [S_{kj}][Q_{jh}] \quad , \tag{8}$$

$[Q_{kh}]$ is copied onto QKHL.

$$[Q_{ih}] = [G_{ki}^T][Q_{kh}] \quad , \tag{9}$$

$$[Q_{hh}] = \text{Merge}\begin{bmatrix} Q_{ih} \\ \hline Q_{eh} \end{bmatrix} \quad , \tag{10}$$

where $[Q_{eh}]$ is zero. Note that this requires only an update of $[Q_{ih}]$'s trailer.

FUNCTIONAL MODULE AMP (AERODYNAMIC MATRIX PROCESSOR)

Check the time. If $[Q_{jh}]$ and $[Q_{hh}]$ were calculated (rather than found), then the time per calculation can be found. If the time per calculation is known and it is not enough (with a 10% margin), no more loops should be attempted.

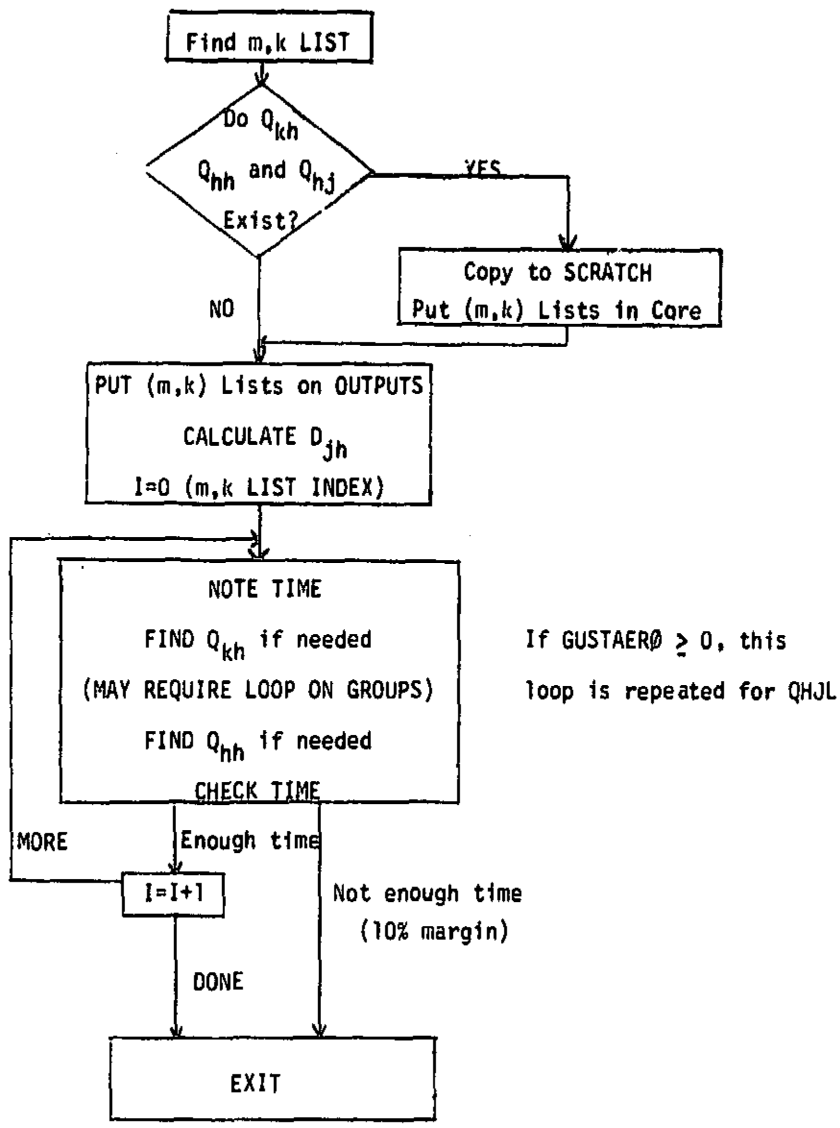


Figure 1. AMP Module Flow.

Repeat the loop (subroutines AMPC and AMPD) for additional values of I until the job is done.

If GUSTAERØ $\geq$ 0, the following equations are evaluated:

Partition PHIDH (Real)

$$\underset{d \updownarrow}{\overset{\leftarrow h \rightarrow}{\begin{bmatrix} PHIDH \end{bmatrix}}} \longrightarrow \begin{matrix} a \updownarrow \\ e \updownarrow \end{matrix} \overset{\leftarrow h \rightarrow}{\begin{bmatrix} \overset{\leftarrow e \rightarrow}{} PHIAH \end{bmatrix}} \qquad (11)$$

Multiply (TRANSPØSE) (Real)

$$a \updownarrow \overset{\leftarrow k \rightarrow}{\begin{bmatrix} GIKA \end{bmatrix}}^T \circ \; a \updownarrow \overset{\leftarrow h \rightarrow}{\begin{bmatrix} PHIAH \end{bmatrix}} \longrightarrow k \updownarrow \overset{\leftarrow h \rightarrow}{\begin{bmatrix} GKH \end{bmatrix}} \qquad (12)$$

Start loop on reduced (m,k) pairs (use all).

Multiply (TRANSPØSE) (S is complex)

$$k \updownarrow \overset{\leftarrow j \rightarrow}{\begin{bmatrix} SKJ(k) \end{bmatrix}}^T \circ \begin{bmatrix} GKH \end{bmatrix} \longrightarrow j \updownarrow \overset{\leftarrow h \rightarrow}{\begin{bmatrix} S(k) \end{bmatrix}} \qquad (13)$$

Partition into Groups - (1) = Doublet Lattice, (2) = non-Doublet Lattice

$$\begin{bmatrix} S(k) \end{bmatrix} \longrightarrow \begin{matrix} j_1 \updownarrow \\ j_2 \updownarrow \end{matrix} \overset{\leftarrow h \rightarrow}{\begin{bmatrix} S(1) \\ \hdashline S(2) \end{bmatrix}} \qquad (14)$$

Solve each group R_{jh}:

a. Doublet Lattice group

$$A_{jj}(\text{group})\, R_{jh}(1) = S(1) \qquad (15)$$

b. Non-Doublet Lattice group

$$R_{jh}(2) = A^T_{jj}\, S(2) \qquad (16)$$

FUNCTIONAL MODULE AMP (AERODYNAMIC MATRIX PROCESSOR)

Merge Results

$$\left[\begin{array}{c} R_{jh}(1) \\ \hline R_{jh}(2) \end{array} \right] \longrightarrow \underset{\updownarrow j}{} \overset{\leftarrow h \rightarrow}{\left[\quad R_{jh} \quad \right]} \tag{17}$$

Append R_{hj}

$$\left[QJHL \; \middle| \; Q_{jh}(k) \right] \longrightarrow \left[QHJL \right] \tag{18}$$

Repeat the last five steps for (m,k) pairs.

3.3 .7.5 Matrix List Data Blocks

The matrix list data block is a special data block used for NASTRAN aeroelastic calculations. It is used to store a series of matrices. The matrices in the list will depend upon two parameters. The format is similar to that of a matrix. If there are NMK matrices, each with NRØW rows and NCØL columns, then it will be stored like a matrix with NRØW rows, and NMK times NCØL columns. The matrix for the first parameter pair is stored in the first NCØL columns. The matrix for other parameter pairs is then added on at the end, one at a time.

A special header record is written which contains the following information:

Word	Value
1-2	The name
3	NCØL, for the individual matrices
4	NMK
5-(4+2NMK)	M(I), K(I), I=1, NMK
+	Other information

If a single matrix exists, it can be read as a normal NASTRAN matrix. It is possible that the matrix list was not completed by the generating module. The number of columns (found in the trailer) divided by NCØL should be an integer. This should be equal to NMK. If it is less than NMK, it is the actual number of matrices on the list. For the AJJL, there is additional information in the header

Word	Value
(6+2NMK)	NGP, number of uncoupled aerodynamic groups
(7+2NMK) - (6+2NMK+3NGP)	KT(N), NJ(N), N=1, NK(N) to NGPT, the theory identifier and the number of U_j degrees of freedom associated with this group. $\sum$ NJ = NCØL.

The matrix AJJL might look like (1 is the identifier for Doublet Lattice theory):

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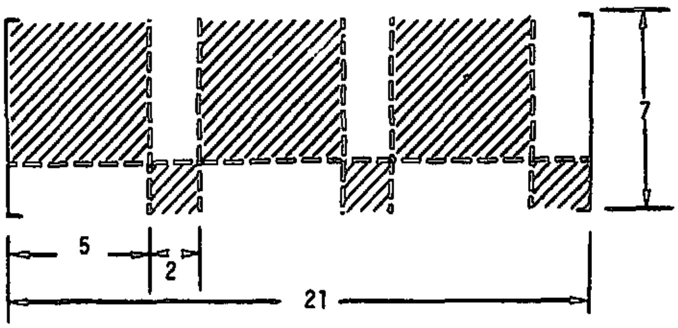
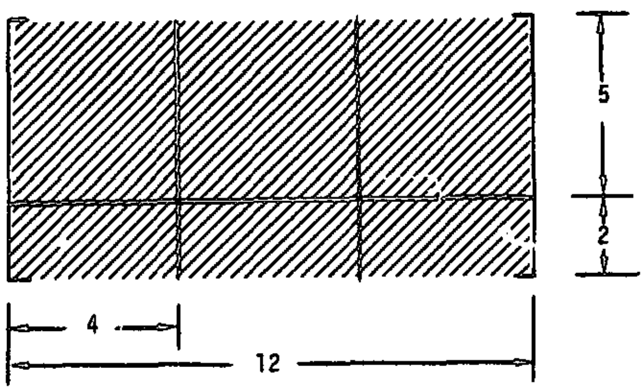
FUNCTIONAL MODULE AMP (AERODYNAMIC MATRIX PROCESSOR)

NCØL = 7	KT(1) = 1
NMK = 3	KT(2) = 1
NGP = 2	NJ(1) = 5
	NJ(2) = 2



The shaded areas may be nonzero.

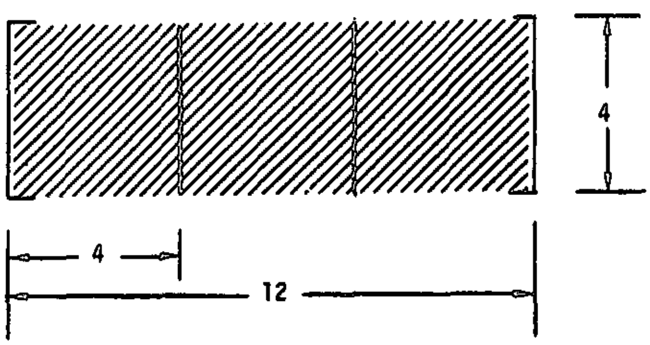
The output QKHL might look like (for 3 modes):



NCØL = 4 (number of modes + extra points)

NMK = 3 (the M(I), K(I) are found from the AERØ data block)

The output QHHL might look like:



NCØL = 4

NMK = 3

3.3 .8 Subroutines

Numerous utility subroutines are used by the functional phases as shown below.

AMPA	AMPB	AMPC	AMPD	AMPE	AMPF
CYCT2B	CALCV	CYCT2B	CYCT2B	CYCT2B	CYCT2B
	SSG2B	SSG2C	SSG2B	SSG2B	SSG2B
	MERGED	CFACTR	SKPREC	SSG2A	CFACTR
	PARTN	CFBSØR		SKPREC	CFBSØR
		FILSWI			FILSWI
		TRANP1			SKPREC
		SSG2B			

3.3 .8.1 Subroutine Name: AMPA

1. Entry Point: AMPA

2. Purpose: To provide a scenario for later phases and to prepare for use of the appended output files.

3. Calling Sequence: CALL AMPA (AERØ, QJHL, QHHL, AJJL, QHHLØ, QJHLØ, INDEX, IMAX, IANY)

AERØ, QJHL, QHHL, and AJJL are the GINØ file numbers of their respective data blocks.

QHHLØ and QJHLØ are the GINØ file numbers of two scratch files to hold valid submatrices from QHHL and QJHL on restart.

INDEX is the GINØ file number of the scenario data block. Its contents are as follows:

Record No.	Word	Contents
0	1	Header
1	1	M column number
	2	K column number
	3	AJJL column number
	4	QHHLØ column number (0 implies recompute)
⋮		
IMAX		

IMAX is the total number of (m,k) pairs on output.

IANY is the flag for necessity to compute at least 1 QJH or QHH (0 implies compute -- 1 implies all retrieved modes).

4. Common Blocks

/AMPCØM/NCØLJ,NSUB,XM,XK,AJJCØL,QHHCØL,NGP,NGPD(2,30),MCBQHH(7),MCBQKH(7),NCØLH, IDJH,MCBRJH(7)

NCØLJ - Number of columns in a submatrix of AJJL

NSUB - Number of submatrices in AJJL

XM - Current M value

XK - Current K value

AJJCØL - Current column number of AJJL

QHHCØL - Current column number in QHHLØ (a zero value implies compute a new QHH)

NPG - Number of groups

NGPD - Two words for each group - Theory ID (1 = D.L.) - Number of columns of AJJ belonging to this group

MCBQHH - Matrix control block for QHHL

MCBQKH - Matrix control block for QJHL

NCØLH - Number of H points

IDJH - Flag for change in k value in (m,k) pair

MCBRJH - Matrix control block for QJHL

3.3.8.2 Subroutine Name: AMPB

1. Entry Point: AMPB

2. Purpose: To compute GKI and the DJH1 and DJH2.

3. Calling Sequence: CALL AMPB (PHIDH,GTKA,D1JK,D2JK,D1JE,D2JE,USETD,DJH1,DJH2,GKI,SCR1, SCR2,SCR3)

All inputs are GINØ file numbers.

3.3.8.3 Subroutine Name: AMPB1

1. Entry Point: AMPB1

2. Purpose: To build a partitioning vector which will add a given number of columns to another matrix.

3. Calling Sequence: CALL AMPB1 (IPVECT,NCØL1,NCØL2)

IPVECT - the GINØ file number on which the partitioning matrix will be built.

NCØL1 - the number of columns in first matrix.

NCØL2 - the number of columns in second matrix (to add onto the first matrix).

3.3.8.4 Subroutine Name: AMPB2

1. Entry Point: AMPB2

2. Purpose: This routine is a general driver for PARTN.

3. Calling Sequence: CALL AMPB2 (A,A11,A12,A21,A22,RP,CP,N1,N2)

A, A11, A12, A21, A22, RP, and CP are the GINØ file numbers of the matrices supplied to PARTN.

$$\begin{matrix} & & [\quad RP \quad] \\ [A] = & \left\{CP\right\} & \begin{bmatrix} A11 & A12 \\ A21 & A22 \end{bmatrix} \end{matrix}$$

If any partition is not desired, set its file name to zero.

N1 and N2 are the number of rows of RP and CP respectively. These are used only if RP or CP = 0. A, RP and CP must have matrix trailers. Trailers will be written on all existing outputs.

3.3.8.5 Subroutine Name: AMPC

1. Entry Point: AMPC

2. Purpose: To compute (or retrieve) QJH and to form QJHL (if not purged).

3. Calling Sequence: CALL AMPC (DJH1,DJH2,DJH,AJJL,QJHL,QJHØ,QJHUA,SCR1,SCR2,SCR3,SCR4,SCR5,SCR6)

DJH1,DJH2,DJH,AJJL and QJHL are the GINØ file numbers (GFN) of their respective data blocks

QJHØ is the GFN of a data block containing old QJH's from restart

QJHUA is the GFN of a data block containing the current QJH

SCR1 - SCR6 are the GINØ file numbers of six scratch files

3.3.8.6 Subroutine Name: AMPC1

1. Entry Point: AMPC1

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2. Purpose: To copy columns of one open matrix to another matrix.

3. Calling Sequence: CALL AMPC1 (INPUT,ØUTPUT,NCØL,IZ,MCB)

INPUT = GINØ file number of the input matrix

ØUTPUT = GINØ file number of the output matrix

NCØL = the number of columns to copy

IZ = open core

MCB = matrix control block for ØUTPUT.

/UNPAKX/ and /PACKX/ control AMPC1.

4. Design Requirements: Both matrices must be opened and properly positioned. No trailers are written. Both matrices are left open.

3.3.8.7 Subroutine Name: AMPC2

1. Entry Point: AMPC2

2. Purpose: To copy each column of the INPUT file onto the bottom of each column of the ØUTPUT file.

3. Calling Sequence: CALL AMPC2 (INPUT,ØUTPUT,SCR1)

INPUT, ØUTPUT, and SCR1 are the GINØ file numbers of their respective data blocks.

4. Method: On the first entry, INPUT and ØUTPUT are switched. On subsequent entries ØUTPUT and SCR1 are switched and read together, one column at a time to produce ØUTPUT.

3.3.8.8 Subroutine Name: AMPD

1. Entry Point: AMPD

2. Purpose: To compute or retrieve QHH and to write QHHL.

3. Calling Sequence: CALL AMPD (QJHUA,QHHØ,SKJ,GKI,QHHL,SCR1,SCR3,SCR4)

All inputs are the GINØ file numbers of their respective data blocks.

3.3.8.9 Subroutine Name: AMPE

1. Entry Point: AMPE
2. Purpose: To compute GKH
3. Calling Sequence: CALL AMPE(PHIDH,GTKA,GKH,SCR1,SCR2,USETA)

   All inputs are the GINØ file numbers of their respective data blocks.
4. Method: AMPE calls CALCV and SSG2A to partition PHIDH. It then calls SSG2B to compute GKH.

3.3.8.10 Subroutine Name: AMPF

1. Entry Point: AMPF
2. Purpose: To solve for QHJL
3. Calling Sequence: CALL AMPF(SKJ,GKH,AJJL,QHJL,PLAN,IMAX,SCR1,SCR2,SCR3,SCR4,SCR5,SCR6,
SCR7,SCR8,SCR9,SCR10)

   SKH, GKH, AJJL, QHJL, PLAN, SCR1-SCR10 are GINØ file numbers of their respective data blocks.

   IMAX is the number of m,k pairs.

3.3.9 Design Requirements

1. AMP requires 14 scratch files. These files are used as follows:

FUNCTIONAL MODULE AMP (AERODYNAMIC MATRIX PROCESSOR)

NAME	DATA BLOCK	COMPUTED BY	USED BY
SCR1	Old QHHL (QHHØ)	AMPA	A,D
SCR2	Old QKHL (QJHØ)	AMPA	A,C
SCR3	Index of work to do (INDEX)	AMPA	A,DRIVER
SCR4	DJH1	AMPB	B,C
SCR5	DJH2	AMPB	B,C
SCR6	GKI	AMPB	B,D
SCR7	DJH	AMPB	C,C
SCR8	QJHUA	AMPC	C,D
SCR9	Scratch File		B,C,D
SCR10	Scratch File		B,C,D
SCR11	Scratch File		B,C,D
SCR12	Scratch File		C,D
SCR13	Scratch File		C
SCR14	Scratch File		C

2. Open Core:

ROUTINE	OPEN CORE	FUNCTION
AMP	AMPB2X	Buffer
AMPA	AMPA1X	See layout
AMPB	AMPB2X	CALCV
AMPB1	AMPB1X	Buffer
AMPB2	AMPB2X	PARTN
AMPC	AMPC1X	Buffer, CYCT2B, AMPC1
AMPC2	AMPC1X	Buffer
AMPD	AMPD1X	Buffer, CYCT2B
AMPE	AMPEX	Buffer, CYCT2B
AMPF	AMPFX	Buffer, CYCT2B, AMPC1

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Open core AMPA1X is laid out as follows:

Contents	Length	Pointer
NCØLJ	1	
NSUB	1	
m-k pairs from AJJL Header	2*NSUB	IAJJL
m-k pairs from AERØ	2*IMAX	IAERØ
NCØLH	1	
NØH	1	
m-k pairs from old QHH	2*NQHH	IQHH
2 Buffers		

3. The loop between AMPC and AMPD would require much overlaying. Thus, AMP currently is a single overlay chain.

3.3.10 Diagnostic Messages

The following messages may occur: 3045, 3001, 3002, 3003, 3008, 3007

3007 occurs when a theory is used which AMP does not understand; 3045 occurs when insufficient time remains to compute another m-k pair.

3.4 FUNCTIONAL MODULE FA2 (FLUTTER ANALYSIS - PHASE 2)

3.4.1 Entry Point: FA2

3.4.2 Purpose

To collect data for reduction and presentation for each loop through the configuration parameters..

3.4.3 DMAP Calling Sequence

FA2 PHIH,CLAMA,FSAVE / PHIHL,CLAMAL,CASEYY,ØVG / V,N,TSTART / C,Y,VREF=1.0 / C,Y,PRINT=YES $

3.4.4 Input Data Blocks

PHIH - Complex eigenvectors - h set, modal formulations.

CLAMA - Complex eigenvalue output table.

FSAVE - Flutter storage save table.

Note: No input data block may be purged.

3.4.5 Output Data Blocks

PHIHL - Appended complex mode shapes - h set.

CLAMAL - Appended complex eigenvalue output table.

CASEYY - Appended case control data table.

ØVG - Output aeroelastic curve requests (V-g or V-f).

Notes:

1. No output data block may be purged.
2. All output data blocks are read (DMAP attribute APPEND) on subsequent calls (FLØØP from FSAVE ≠ 1 if the method is K).

3.4.6 Parameters

TSTART - Integer-input/output-no default value. On input TSTART is the CPU time at the start of the DMAP flutter loop. On output TSTART will be -1 if there is insufficient time for another DMAP loop.

VREF - Real-user input; no default. V_{out} will be scaled by VREF:

$$V_{out} = V/V_{ref}$$

PRINT - BCD-user input-default = YES. If PRINT = NØ, no flutter summary will be printed. For YES the wing flutter summary will be printed. For YESB the blade summary will be printed.

3.4 .7 <u>Method</u>

The primary purpose of module FA2 is to gather data for reduction and presentation. The header record of FSAVE will contain the METHØD. The actions of FA2 are method dependent.

3.4 .7.1 K-Method

This module is near the end of a DMAP loop. Its output files PHIHL, CLAMAL, CASEYY and ØVG are appended for each entry. On the first pass, special code must be executed to initiate the files.

The complex eigenvalues λ have been found by module CEAD. These should have been sorted by Im(λ) increasing. Only use the first "NVALUE" modes. The quantities that need to be computed are:

$$V_{out} = Im(\lambda)/V_{ref} \quad ,$$

$$g = \begin{cases} (2.0)\ Re(\lambda)/Im(\lambda) & \text{if } Im(\lambda) \neq 0 \\ 0 & \text{if } Im(\lambda) = 0 \end{cases} \quad ,$$

$$f = k\ Im(\lambda)/2\pi b_{ref} \quad ,$$

$$V_{Mach} = V_{sound} m/V_{ref} \quad .$$

The values of the parameter FLØØP, m, k, b_{ref} and NVALUE are found in the file FSAVE. A printer output is prepared.

The PHIHL, CASEYY and CLAMAL data blocks are created by appending the PHIH, CASEYY and CLAMA data blocks.

The CASEYY data block is for modules SDR2 and PLØT. It must keep in step with the append vectors. m, k, ρ and FLØØP will be added to the LABEL.

The ØVG data block is appended each time through the LØØP. This will be used to create V-g or V-f plots. m, k, ρ and FLØØP will be added to the LABEL.

3.4 .7.2 PK-Method

The values for λ, I, and G are supplied by FA1 on FSAVE for all eigenvalues and all MACH number RHØ pairs. FA2 collects all k values together and outputs each collection of N such eigenvalues on a curve for V-g plotting. CASEYY, PHIHL and CLAMAL are not written.

3.4 .7.3 KE-Method

Existing FSAVE records contain records of length 2 x N where 2 = Real, Imag = V, N = number of modes.

The records are sorted by (see Figure 1)

m = mach number

k = reduced frequency

ρ = density.

The output should be sorted by

m = mach number

ρ = density

n = mode number.

The records will be used for ØVG, and for formatted print.

A special "sorting" algorithm will be used to order the roots. For the first k value in each loop, the roots are accepted in the order of ALLMAT. Define

P_{in} = the ith eigenvalue for the nth reduced frequency k.

In the above, i = 1, 2, 3, ... (number of modes)

n = 1, 2, 3, ... (number of k values)

Define the extrapolated value based upon previous n's to be

$$P^e_{i,2} = P_{i,1}$$

$$P^e_{i,n} = P_{i,(n-1)} + (k_n - k_{n-1})(P_{i,(n-1)} - P_{i,(n-2)})/(k_{n-1} - k_{n-2}) \qquad n \geq 3$$

where $P_{i,0}$ will be chosen equal to $P_{i,1}$. Then, select for $P_{1,n}$ the root found in the nth loop closest to $P^e_{1,n}$. Delete that root and let $P_{2,n}$ be the one of the remaining roots closest to $P^e_{2,n}$. Continue until all roots are exhausted. The measure of "closeness" of the complex numbers is the square of the magnitude of the difference. If P_1 and P_2 are two roots,

$$P_1 = \text{Re } P_1 + i \text{ Im } P_1 \quad ,$$

then the square is,

$$[\text{Re}(P_2 - P_1)]^2 + [\text{Im}(P_2 - P_1)]^2 \quad .$$

All eigenvalues are put on the FSAVE data block to be passed to FA2 module. CASEYY, PHIHL and CLAMAL are not written.

In Summary

	Flutter Summary (skip if PRINT ≠ YES)	Complex Eigenvectors
K - method (FA2 in loop)	Output in order received Point = (m,k,ρ) triplet # of entries = # of modes	Always Come in loop and PHIH, CLAMA slots (No change)
K - method (no loop)	Sorting required Point = (m,ρ,mode) triplet # of entries = # of k's	None
PK - method (no loop)	Transpose required Point = (m,ρ,mode) triplet # of entries = # of V's	None

Note: All must have ØVG

Figure 1.

3.4.8 Subroutines

Utility routine CYCT2B is called.

3.4.9 Design Requirements

Open core for FA2 is at /FA2X/ .

FA2 uses no scratch files.

3.4.10 Diagnostic Messages

The following messages may occur: 3001, 3002, 3003, 3007, 3008 and 3045. Only 3045 is a user message. It indicates that the DMAP loop was not completed by exhausting the configuration parameters but rather by a time-to-go failure.

3.5 FUNCTIONAL MODULE APDB (AERODYNAMIC POOL DISTRIBUTOR FOR BLADES)

3.5.1 Entry Point: APDB

3.5.2 Purpose

Bulk data cards which control the solution of aerodynamic problems are processed and assembled into various blocks for convenience and efficiency in the solution of the aerodynamic problem. APDB also generates the transformation matrix $[G_{ka}]^T$ (GTKA) and the partitioning vector PVECT.

3.5.3 DMAP Calling Sequence

```
APDB     EDT, USET, BGPDT, CSTM, EQEXIN, GM, GØ/ AERØ, ACPT, FLIST, GTKA,
         PVECT/ V, N, NK/ V, N, NJ/ V, Y, MINMACH/ V, Y, MAXMACH/ V, Y, IREF/
         V, Y, MTYPE/ V, N, NEIGV/ V, Y, KINDEX = -1 $
```

3.5.4 Input Data Blocks

EDT - Aerodynamic bulk data cards

USET - Displacement set definition table

BGPDT - Basic grid point definition table

CSTM - Coordinate system transformation matrices

EQEXIN - Equivalence between external points and scalar index values

GM - Multipoint constraint transformation matrix

GØ - Structural matrix partitioning transformation matrix

Notes:

1. EDT, USET, BGPDT and EQEXIN cannot be purged.

2. CSTM may be purged if all points are in the basic system.

3. GM and GØ may be purged if there are no multipoint or no omitted points.

3.5.5 Output Data Blocks

AERØ - Control information for control of aerodynamic matrix generation and flutter analysis

ACPT - Information pertaining to each independent group of aerodynamic elements

FLIST - Contains AERØ, FLFACT and FLUTTER cards copied from EDT

GTKA - Aerodynamic transformation matrix - K set to a set

PVECT - Cyclic modes partitioning vector for matrix PHIA from module CYCT2

Notes:

1. AERØ, ACPT, FLIST and GTKA cannot be purged.

2. PVECT may be purged if there are no cyclic modes to be partitioned.

3.5.6 Parameters

NK - Output - integer - no default. Degrees of freedom in the NK displacement set.

NJ - Output - integer - no default. Degrees of freedom in the NJ displacement set.

MAXMACH - Input - real - default = 0.8. This is the maximum Mach number below which the subsonic unsteady cascade theory is valid.

MINMACH - Input - real - default = 1.01. This is the minimum Mach number above which the supersonic unsteady cascade theory is valid.

IREF - Input - integer - default = -1. This defines the streamline number of the reference stream surface. IREF must equal an SLN on a STREAML2 card. The default value, -1, represents the stream surface at the blade tip. If IREF does not correspond to an SLN, then the default will be taken.

MTYPE - Input - BCD - default = CØSINE. This controls which components of the cyclic modes are to be used in the modal formulation. MTYPE = SINE for sine components and MTYPE = CØSINE for cosine components.

NEIGV - Input - BCD - no default. The number of eigenvalues found. Usually output by the READ module.

KINDEX - Input - BCD - default = -1. Harmonic index number used in cyclic analyses.

3.5.7 Method

Subroutine APDB is the main control program for this module. It allocates buffers, reads input files, and initializes output files. APDB creates the AERØ, ACPT and FLIST tables and generates the PVECT partitioning vector. Subroutine APDB1 or APDB2 generates the GTKA transformation matrix. They reduce $[G^T_{Kg}]$ to $[G^T_{Ka}]$, much like module SSG2, using the following matrix operations:

$$[G^T_{Kg}] \rightarrow \begin{bmatrix} \bar{G}^T_{KN} \\ \hline G^T_{KM} \end{bmatrix}$$

$$[G^T_{KN}] = [G_M]^T [G^T_{KM}] + [\bar{G}^T_{KN}]$$

$$[G^T_{KN}] \rightarrow \begin{bmatrix} G^T_{Kf} \\ \hline G^T_{KS} \end{bmatrix}$$

$$[G^T_{K\ell}] \leftarrow \begin{bmatrix} \bar{G}^T_{Ka} \\ \hline G^T_{K\phi} \end{bmatrix}$$

$$[G^T_{Ka}] = [G_\phi]^T [G^T_{K\phi}] + [\bar{G}^T_{Ka}]$$

At each step where a matrix multiply is indicated, the multiply is skipped if the result is known to be zero (i.e., U_n or U_ϕ are null).

3.5 .8 <u>Subroutines Called</u>

Utility routines BISLØC, CALCV, SSG2B, TRANSS and GMMATS are called.

3.5.8.1 Subroutine Name: APDB1

1. Entry Point: APDB1
2. Purpose: To generate transformation matrix $[G^T_{Ka}]$, for compressor blades Method 6.
3. Calling Sequence: CALL APDB1 (IBUF1, IBUF2, NEXT, LEFT, NØTNØ, NLINEØ, XØIGN, LCØTM, ACØTM, NODEX, NODEI, IØILC, XYZB).

3.5 .8.2 Subroutine Name: APDB2

1. Entry Point: APDB2
2. Purpose: To generate transformation matrix $[G^T_{Ka}]$, for turboprop blades Method 7.
3. Calling Sequence: CALL APDB2 (IBUF1, IBUF2, NEXT, LEFT, NØTNØ, NLINEØ, XØIGN, LCØTM, ACØTM, NODEX, NODEI, IØILC, XYZB).

3.5 .8.3 Subroutine Name: APDB2A

1. Entry Point: APDB2A
2. Purpose: To generate basic to local transformation matrix for APDB2.
3. Calling Sequence: CALL APDB2A (NLINE, NL, ØCR1, NØTNØ, M1, Ø1, ØN, TBLT, TBLR).

3.5.9 Design Requirements

Open core is located at /APDBZZ/. APDB uses five scratch files.

3.5.10 Diagnostic Messages

System fatal messages 3001, 3002, 3003, 3008 and 3037 may occur. The APDB module also generates its own messages that are not numbered. These messages are self-explanatory.

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3.6 RESTART TABLES FOR COMPRESSOR BLADE CYCLIC MODAL FLUTTER ANALYSIS

3.6.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.	Card Name	Bit Pos.	Card Name	Bit Pos.
ADUM1	1	CQDPLT	2	MAT2	8
ADUM2	1	CQUAD1	2	MAT3	8
ADUM3	1	CQUAD2	2	MATT1	8
ADUM4	1	CQUADTS	2	MATT2	8
ADUM5	1	CROD	2	MATT3	8
ADUM6	1	CSHEAR	2	TABLEM1	8
ADUM7	1	CTETRA	2	TABLEM2	8
ADUM8	1	CTORDRG	2	TABLEM3	8
ADUM9	1	CTRAPAX	2	TABLEM4	8
AXIC	1	CTRAPRG	2	TEMPMT$	8
AXIF	1	CTRBSC	2	TEMPMX$	8
CELAS1	1	CTRIA1	2	AXISYM	9
CELAS2	1	CTRIA2	2	CRIGD1	9
CELAS3	1	CTRIAAX	2	CRIGD2	9
CELAS4	1	CTRIARG	2	MPC	9
CMASS1	1	CTRIATS	2	MPCADD	9
CMASS2	1	CTRMEM	2	MPC$	9
CMASS3	1	CTRPLT	2	MPCAX	9
CMASS4	1	CTUBE	2	SPC	10
CORD1C	1	CTWIST	2	SPC1	10
CORD1R	1	CWEDGE	2	SPCADD	10
CORD1S	1	PBAR	3	SPCAX	10
CORD2C	1	PCONEAX	3	SPC$	10
CORD2R	1	PDUM1	3	ASET	11
CORD2S	1	PDUM2	3	ASET1	11
GRDSET	1	PDUM3	3	OMIT	11
GRID	1	PDUM4	3	OMIT1	11
GRIDB	1	PDUM5	3	OMITAX	11
POINTAX	1	PDUM6	3	SUPAX	12
RINGAX	1	PDUM7	3	SUPORT	12
RINGFL	1	PDUM8	3	TEMP	13
SECTAX	1	PDUM9	3	TEMPAX	13
SEQGP	1	PIHEX	3	TEMPD	13
SPOINT	1	PQDMEM	3	TEMPP1	13
BAROR	2	PQDPLT	3	TEMPP2	13
CBAR	2	PQUAD1	3	TEMPP3	13
CCONEAX	2	PQUAD2	3	TEMPRB	13
CDUM1	2	PQUADTS	3	GRDPNT	15
CDUM2	2	PROD	3	PLOTEL	16
CDUM3	2	PSHEAR	3	PLOT$	18
CDUM4	2	PTORDRG	3	POUT$	19
CDUM5	2	PTRAPAX	3	XYOUT$	20
CDUM6	2	PTRBSC	3	AOUT$	21
CDUM7	2	PTRIA1	3	COUPMASS	24
CDUM8	2	PTRIA2	3	CPBAR	24
CDUM9	2	PTRIAAX	3	CPQPLT	24
CFLUID2	2	PTRIATS	3	CPQUAD1	24
CFLUID3	2	PTRMEM	3	CPQUAD2	24
CFLUID4	2	PTRPLT	3	CPROD	24
CHEXA1	2	PTUBE	3	CPTRBSC	24
CHEXA2	2	PTWIST	3	CPTRIA1	24
CIHEX1	2	GENEL	4	CPTRIA2	24
CIHEX2	2	CONM1	5	CPTRPLT	24
CIHEX3	2	CONM2	5	CPTUBE	24
CONROD	2	PELAS	6	WTMASS	24
CQDMEM	2	PMASS	7	MODJE	26
		MAT1	8	PAERO1	29

RIGID FORMAT RESTART TABLES

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Card Name	Bit Pos.
SET1	32
SET2	32
SPLINE1	32
SPLINE2	32
MKAERO1	34
MKAERO2	34
AEFACT	35
FLFACT	36
FLUTTER	36
AERO	37
CAERO1	37
FMETHOD$	38
VREF	39
TF	40
CYJOIN	41
CTYPE	41
NSEGS	41
KINDEX	41
CYCSEQ	42
STREAML1	42
STREAML2	42
IREF	42
MINMACH	42
MAXMACH	42
MTYPE	42
KGGIN	43
SDAMP$	55
TABDMP1	55
EPOINT	56
SEQEP	56
B2PP$	57
DMIG	57
K2PP$	57
M2PP$	57
TF$	57
EIGR	58
METHOD$	59
EIGC	60
EIGP	60
CMETHOD$	61
HFREQ	62
LFREQ	62
LMODES	62

3.6.2 Bit Positions for File Name Restart Table

File Name	Bit Pos.	File Name	Bit Pos.
BGPDT	94	KELM	122
CSTM	94	MDICT	122
EQEXIN	94	MELM	122
GPDT	94	MAA	123
GPL	94	ACPT	124
SIL	94	AERO	124
ECT	95	BGPA	124
GPTT	96	CSTMA	124
EST	97	ECTA	124
GEI	97	EQAERO	124
GPECT	97	FLIST	124
GPST	98	GPLA	124
KGGX	98	SILA	124
MGG	99	SILGA	124
KGG	100	SPLINE	124
RG	101	USETA	124
USET	101	ELSETS	125
OGPST	102	GPSETS	125
GM	103	PLTPAR	125
KNN	104	PLTSETX	125
MNN	104	GTKA	126
KFF	105	AJJL	127
KFS	105	D1JK	127
MFF	105	D2JK	127
KAA	106	SKJ	127
KLL	107	D1JE	128
KLR	107	D2JE	128
KRR	107	BXHH	129
MLL	107	KXHH	129
MLR	107	MXHH	129
MRR	107	FSAVE	129
LLL	108	CASEYY	130
DM	109	CLAMAL	130
MR	110	OVG	130
EED	111	PHIHL	130
EQDYN	111	CLAMAL1	131
GPLD	111	CPHIH1	131
SILD	111	CPHIA	132
TFPOOL	111	RP	132
USETD	111	CASEEE	133
LAMA	112	OEIGS	134
MIX	112	ME	136
OEIGSX	112	QPACX	136
PHIA	112	OCPHIP	137
GO	113	OEFC1	137
B2PP	114	OESC1	137
K2PP	114	OQPC1	137
M2PP	114	PCPHIP	137
GMD	115	QHHL	138
GOD	115	QJHL	138
BHH	116	B2DD	139
KHH	116	K2DD	139
MHH	116	M2DD	139
PHIDH	116	CYCD	140
CLAMA	117	KKK	141
OCEIGS	117	MKK	141
PHIH	117	PHIK	142
CPHID	118	LAMK	142
CPHIP	120	PHIG	143
QPC	120	PVECT	144
KDICT	122	PHIAX	145

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3.6.3 Card Name Restart Table

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
BEGIN	1234567890	123456 890	1234 6 9	2 4567890		567890	12
FILE	1234567890	1234 9	1234 6 9	2 4567890		567890	12
GP1	1						
SAVF	1						
COND	1						
CHKPNT	1						
SSS	6						
PURGE			6	7			
GP2	12 45	6					
CHKPNT	12 45	6					
SSS	6						
GP3	12	3					
CHKPNT	12	3					
SSS	6						
TA1	1234567	3					
SAVE	1234567	3					
COND	1234567	34					
PURGE	1234567						
CHKPNT	1234567	3					
SSS	6						
PARAM	123 6 8	3					
PARAM	123 5 78	34	4				
PARAM					3		
COND					3		
PARAM					3		
INPUTT1					3		
EQUIV					3		
CHKPNT					3		
SSS	6						
LABEL					3		
EMG	123 5678	34	4		3		
SAVE	123 5678	34	4		3		
CHKPNT	123 5678	34	4		3		
SSS	6						
COND	123 6 8	3			3		
EMA	123 6 8	3			3		
CHKPNT	123 6 8	3			3		
SSS	6						
LABEL	123 6 8	3			3		
COND	123 5 78	34	4				
EMA	123 5 78	34	4				
CHKPNT	123 5 78	34	4				
SSS	6						
COND	123 5 78	345	4				
GPWG	123 5 78	345	4				
OFP	123 5 78	345	4				
LABEL	123 5 78	345	4				
EQUIV	1234 6 8	3			3		
CHKPNT	1234 6 8	3			3		
SSS	6						
COND	1234 6 8	3			3		

COMPRESSION BLADE CYCLIC MODAL FLUTTER ANALYSES

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60
SMA3	1234 6 8	3			3	
CHKPNT	1234 6 8	3			3	
BSS	6					
LABEL	1234 6 8	3			3	
GP4	1	90	12			
SAVE	1	90	12			
PARAM	1	90	12		3	
COND	1	90	12		3	
PURGE	1	90	12		3	
GPCYC	1 90	1			1	
SAVE	1 90	1			1	
CHKPNT	1 90	1			1	
BSS	6					
COND	1 90	1			1	
COND	1234 6 890	3			3	
GPSP	1234 6 890	3			3	
SAVE	1234 6 890	3			3	
COND	1234 6 890	3			3	
OFP	1234 6 890	3			3	
LABEL	1234 6 890	3			3	
EQUIV	123456789	4	4		3	
CHKPNT	123456789	4	4		3	
BSS	6					
COND	123456789	34	4		3	
MCE1	1 9	3			3	
CHKPNT	1 9	3			3	
BSS	6					
MCE2	123456789	34	4		3	
CHKPNT	123456789	34	4		3	
BSS	6					
LABEL	123456789	34	4		3	
EQUIV	1234567890	34	4		3	
CHKPNT	1234567890	34	4		3	
BSS	6					
COND	1234567890	34	4		3	
SCE1	1234567890	34	4		3	
CHKPNT	1234567890	34	4		3	
BSS	6					
LABEL	1234567890	34	4		3	
EQUIV	1234567890	1 34	4		3	
CHKPNT	1234567890	1 34	4		3	
BSS	6					
COND	1234567890	1 34	4		3	
SMP1	1234 6 890	1 3			3	
CHKPNT	1234 6 890	1 3			3	
BSS	6					
SMP2	1234567890	1 34	4			
CHKPNT	1234567890	1 34	4			
BSS	6					
LABEL	1234567890	1 34	4			
DPO	1 90	12		0		6 8 0

RIGID FORMAT RESTART TABLES

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
SAVE	1 90	12		0		6 8 0	
COND	1 90	12		0		6 8 0	
EQUIV	1234567 90	12 4	234			6 8	
CYCT2	1234567890	1			1 3		
SAVE	1234567890	1			1 3		
CHKPNT	1234567890	1			1 3		
$SS	6						
COND	1234567890	1			1 3		
READ	1234567890	1234	4		1 3	89	
SAVE	1234567890	1234	4		1 3	89	
CHKPNT	1234567890	1234	4		1 3	89	
$SS	6						
PARAM	1234567890	1234	4		1 3	89	
OFP	1234567890	1234	4		1 3	89	
SAVE	1234567890	1234	4		1 3	89	
COND	1234567890	1234	4		1 3	89	
CYCT2	1234567890	1	4		1 3	89	
SAVE	1234567890	1	4		1 3	89	
CHKPNT	1234567890	1	4		1 3	89	
$SS	6						
COND	1234567890	1	4		1 3	89	
SDR1	1234567890	1	4		1 3	89	
SDR2		89					
OFP		9					
SAVE		9					
APDB	12 90	12		4567	123		
SAVE	12 90	12		4567	123		
CHKPNT	12 90	12		4567	123		
$SS	6						
PARTN	12 90	12			1 3	89	
SMPYAD	12 90	12			1 3	89	
MTRXIN	1		23	0		67	
SAVE	1		23	0		67	
PURGE	12 4		23	0		67	
EQUIV	12 4 9	1	23	0		67	
CHKPNT	12 4 9	1	23	0		67	
$SS	6						
GKAD	1234 6 890	1 34	23	0	123	67	
CHKPNT	1234 6 890	1 34	23	0	123	67	
$SS	6						
GKAM	1234567890	1234	234	0	123	56789	2
SAVE	1234567890	1234	234	0	123	56789	2
CHKPNT	1234567890	1234	234	0	123	56789	2
$SS	6						
PARAML		8					
$SS	7						
PURGE		8					
$SS	7						
COND		8					
$SS	7						
PLTSET		8					

COMPRESSOR BLADE CYCLIC MODAL FLUTTER ANALYSIS

```
DAMP                          Bit Position
Inst.    1       10        20        30        40        50        60

BSS            7
SAVE                     8
BSS            7
PRTMSG                   8
BSS            7
PARAM                    8
BSS            7
PARAM                    8
BSS            7
COND                     8
BSS            7
PLOT                     8
BSS            7
SAVE                     8
BSS            7
PRTMSG                   8
BSS            7
LABEL                    8
BSS            7
COND     1       9012                           0               6 8 0
PARAM    1                           9     5 7
AMG      1                           9    45 7    23
SAVE     1                           9    45 7    23
CHKPNT   1                           9    45 7    23
BSS           6
COND                             6           7
INPUTT2                          6           7
LABEL                            6           7
PARAM    1234567890123         4 6   9  2 45 7   123            6 89  2
AMP      1234567890123         4 6   9  2 45 7   123            6 89  2
SAVE     1234567890123         4 6   9  2 45 7   123            6 89  2
CHKPNT   1234567890123         4 6   9  2 45 7   123            6 89  2
BSS           6
PARAM                      0
PARAM                    8
PARAM                       1
PARAM    1234567890123         4 6   9  2 4567890              56789012
JUMP     1234567890123         4 6   9  2 4567890              56789012
LABEL    1234567890123         4 6   9  2 4567890              56789012
FAI      1234567890123         4 6   9  2 4567890123           56789012
SAVE     1234567890123         4 6   9  2 4567890123           56789012
CEAD     1234567890123         4 6   9  2 4567890123           56789012
SAVE     1234567890123         4 6   9  2 4567890123           56789012
COND     1234567890123         4 6   9  2 4567890123           56789012
COND                        1
VDR                         1
SAVE                        1
COND                        1
OFP                         1
SAVE                        1
LABEL                       1
```

RIGID FORMAT RESTART TABLES

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
FA2	1234567890	123	4 6 9	2 4567890	123	567890	12
SAVE	1234567890	123	4 6 9	2 4567890	123	567890	12
CHKPNT	1234567890	123	4 6 9	2 4567890	123	567890	12
$SS	6						
COND	1234567890	123	4 6 9	2 4567890	123	567890	12
LABEL	1234567890	123	4 6 9	2 4567890	123	567890	12
COND	1234567890	123	4 6 9	2 4567890	123	567890	12
REPT.	1234567890	123	4 6 9	2 4567890	123	567890	12
JUMP	1234567890	123	4 6 9	2 4567890	123	567890	12
LABEL	1234567890	123	4 6 9	2 4567890	123	567890	12
CHKPNT	1234567890	123	4 6 9	2 4567890	123	567890	12
$SS	6						
PARAML		0					
COND		0					
XYTRAN		0					
SAVE		0					
XYPLOT		0					
LABEL		0					
PARAM	1234567890	123	1 4 6 9	2 4567890	123	567890	12
COND	1234567890	123	1 4 6 9	2 4567890	123	567890	12
MODACC	1234567890	123	4 6 9	2 4567890	123	567890	12
DDR1	1234567890	123	4 6 9	2 4 67890	123	567890	12
CHKPNT	1234567890	123	4 6 9	2 4 67890	123	567890	12
$SS	6						
EQUIV	1234567890	123	4 6 9	2 4567890	123	567890	12
COND	1234567890	123	4 6 9	2 4567890	123	567890	12
SDR1	1234567890	123	4 6 9	2 4567890	123	567890	12
LABEL	1234567890	123	4 6 9	2 4567890	123	567890	12
CHKPNT	1234567890	123	4 6 9	2 4567890	123	567890	12
$SS	6						
EQUIV	1234567890	123	4 6 9	2 4567890	123	567890	12
COND	1234567890	123	4 6 9	2 4567890	123	567890	12
VEC	1234567890	123	4 6 9	2 4567890	123	567890	12
PARTN	1234567890	123	4 6 9	2 4567890	123	567890	12
LABEL	1234567890	123	4 6 9	2 4567890	123	567890	12
SDR2	1234567890	123	4 6 9	2 4567890	123	567890	12
CHKPNT	1234567890	123	4 6 9	2 4567890	123	567890	12
$SS	6						
OFP		9					
COND		8					
$SS	7						
PLOT		8					
$SS	7						
PRTMSG		8					
$SS	7						
LABEL		8					
$SS	7						
JUMP	1234567890	123456 890	1234 6 9	2 4567890	123	567890	12
LABEL	1234567890	123456 890	1234 6 9	2 4567890	123	567890	12
PRTPARM	1234567890	123456 890	1234 6 9	2 4567890	123	567890	12
LABEL	1234567890	123456 890	1234 6 9	2 4567890	123	567890	12

COMPRESSOR BLADE CYCLIC MODAL FLUTTER ANALYSIS

DMAP Inst.	Bit Position (1 ... 10 ... 20 ... 30 ... 40 ... 50 ... 60)
PRTPARM	1234567890123456 8901234 6 9 2 4567890123 56789012
LABEL	1234567890123456 8901234 6 9 2 4567890123 56789012
PRTPARM	1234567890123456 8901234 6 9 2 4567890123 56789012
LABEL	1234567890123456 8901234 6 9 2 4567890123 56789012
PRTPARM	1234567890123456 8901234 6 9 2 4567890123 56789012
LABEL	1234567890123456 8901234 6 9 2 4567890123 56789012
PRTPARM	1234567890123456 8901234 6 9 2 4567890123 56789012
LABEL	1234567890123456 8901234 6 9 2 4567890123 56789012
PRTPARM	1234567890123456 8901234 6 9 2 4567890123 56789012
LABEL	1234567890123456 8901234 6 9 2 4567890123 56789012
END	1234567890123456 8901234 6 9 2 4567890123 56789012

3.6.4 Rigid Format Change Restart Table

DMAP Inst.	Bit Position 63 70	80
BEGIN	345678901234567	345
FILE	345678901234567	345
GP1		
SAVE		
COND	345678901234567	345
CHKPNT		
PURGE		
GP2		
CHKPNT		
GP3		
CHKPNT		
TA1		
SAVE		
COND	345678901234567	345
PURGE		
CHKPNT		
PARAM		
PARAM	3 678	
PARAM		
COND		
PARAM		
INPUTT1		
EQUIV		
CHKPNT		
LABEL		
EMG	3 678	
SAVE	3 678	
CHKPNT	3 678	
COND		
EMA		
CHKPNT		
LABEL		
COND	3 678	
EMA	3 678	
CHKPNT	3 678	
COND		
GPWG		
OFP		
LABEL		
EQUIV		
CHKPNT		
COND		
SMA3		
CHKPNT		
LABEL		
GP4		
SAVE		
PARAM		
COND		
PURGE		
GPCYC		

DMAP Inst.	Bit Position 63 70	80
SAVE		
CHKPNT		
COND		
COND		
GPSP		
SAVE		
COND		
OFP		
LABEL		
EQUIV		
CHKPNT		
COND		
MCE1		
CHKPNT		
MCE2		
CHKPNT		
LABEL		
EQUIV		
CHKPNT		
COND		
SCE1		
CHKPNT		
LABEL		
EQUIV		
CHKPNT		
COND		
SMP1		
CHKPNT		
SMP2		
CHKPNT		
LABEL		
DPD		
SAVE		
COND	345678901234567	345
EQUIV		
CYCT2		
SAVE		
CHKPNT		
COND		
READ		
SAVE		
CHKPNT		
PARAM		
OFP		
SAVE		
COND	345678901234567	345
CYCT2		
SAVE		
CHKPNT		
COND		
SDR1		

DMAP Inst.	Bit Position 63	70	80
SDR2			
OFP			
SAVE			
APDB			
SAVE			
CHKPNT			
PARTN			
SMPYAD			
MTRXIN			
SAVE			
PURGE			
EQUIV			
CHKPNT			
GKAD			
CHKPNT			
GKAM	3	234	
SAVE	3	234	
CHKPNT	3	234	
PARAML			
PURGE			
COND			
PLTSET			
SAVE			
PRTMSG			
PARAM			
PARAM			
COND			
PLOT			
SAVE			
PRTMSG			
LABEL			
COND			
PARAM	345678901234567		345
AMG			
SAVE			
CHKPNT			
COND			
INPUTT2			
LABEL			
PARAM			
AMP			
SAVE			
CHKPNT			
PARAM			
PARAM			
PARAM	345678901234567		345
PARAM	345678901234567		345
JUMP	345678901234567		345
LABEL	345678901234567		345
FA1			
SAVE			

COMPRESSOR BLADE CYCLIC MODAL FLUTTER ANALYSIS

DMAP Inst.	Bit Position 63 70	80
CEAD		
SAVE		
COND		
COND		
VDR		
SAVE		
COND		
OFP		
SAVE		
LABEL		
FA2		
SAVE		
CHKPNT		
COND	345678901234567	345
LABEL	345678901234567	345
COND	345678901234567	345
REPT	345678901234567	345
JUMP	345678901234567	345
LABEL	345678901234567	345
CHKPNT	345678901234567	345
PARAML		
COND		
XYTRAN		
SAVE		
XYPLOT		
LABEL		
PARAM		
COND		
MODACC		
DDR1		
CHKPNT		
EQUIV		
COND		
SDR1		
LABEL		
CHKPNT		
EQUIV		
COND		
VEC		
PARTN		
LABEL		
SDR2		
CHKPNT		
OFP		
COND		
PLOT		
PRTMSG		
LABEL		
JUMP	345678901234567	345
LABEL	345678901234567	345
PRTPARM	345678901234567	345

DMAP Inst.	Bit Position 63 70	80
LABEL	345678901234567	345
PRTPARM	345678901234567	345
LABEL	345678901234567	345
PRTPARM	345678901234567	345
LABEL	345678901234567	345
PRTPARM	345678901234567	345
LABEL	345678901234567	345
PRTPARM	345678901234567	345
LABEL	345678901234567	345
PRTPARM	345678901234567	345
LABEL	345678901234567	345
END	345678901234567	345

7.6.5 File Name Restart Table

DMAP Inst.	94	100	110	120	130	140	150
BEGIN							
FILE							
GP1	4						
SAVE	4						
COND	4						
CHKPNT	4						
PURGE					8		
GP2	5						
CHKPNT	5						
GP3	6						
CHKPNT	6						
TA1	7						
SAVE	7						
COND	7						
PURGE	7	2					
CHKPNT	7	2					
PARAM	8						
PARAM	9						
PARAM	8						
COND	8						
PARAM	8						
INPUTT1	8						
EQUIV	8						
CHKPNT	8						
LABEL							
EMG				2			
SAVE				2			
CHKPNT				2			
COND	8						
EMA	8						
CHKPNT	8						
LABEL	8						
COND	9						
EMA	9						
CHKPNT	9						
COND							
GPWG							
OFP							
LABEL							
EQUIV		0					
CHKPNT		0					
COND		0					
SMA3		0					
CHKPNT		0					
LABEL		0					
GP4		1					
SAVE		1					
PARAM		1					
COND							
PURGE		3 5	3 5	0			
GPCYC						0	

RIGID FORMAT RESTART TABLES

DMAP Inst.	94	100	110	120	130	140	150
SAVE						0	
CHKPNT						0	
COND						0	
COND		2					
GPSP		2					
SAVE		2					
COND		2					
OFP		2					
LABEL		2					
EQUIV		4					
CHKPNT		4					
COND		34					
MCE1		3					
CHKPNT		3					
MCE2		4					
CHKPNT		4					
LABEL		34					
EQUIV		5					
CHKPNT		5					
COND		5					
SCE1		5					
CHKPNT		5					
LABEL		5					
EQUIV		6		3			
CHKPNT		6		3			
COND		6	3	3			
SMP1		6	3				
CHKPNT		6	3				
SMP2				3			
CHKPNT				3			
LABEL		6	3	3			
DPD			1				
SAVE			1				
COND			1				
EQUIV			5				
CYCT2						1	
SAVE						1	
CHKPNT						1	
COND						1	
READ					4	2	
SAVE					4	2	
CHKPNT					4	2	
PARAM					4	2	
OFP					4	2	
SAVE					4	2	
COND					4	2	
CYCT2			2				
SAVE			2				
CHKPNT			2				
COND			2				
SDR1						3	

COMPRESSOR BLADE CYCLIC MODAL FLUTTER ANALYSIS

```
DMAP                      Bit Position
Inst.     94    100       110       120       130       140       150

SDR2                                                    3
OFP                                                     3
SAVE                                                    3
APDB                             4 6                 4
SAVE                             4 6                 4
CHKPNT                           4 6                 4
PARTN                                                     5
SMPYAD                                            6
MTRXIN                   4
SAVE                     4
PURGE                    4                        9
EQUIV                    4                        9
CHKPNT                   4                        9
GKAD                      5                       9
CHKPNT                    5                       9
GKAM                       6
SAVE                       6
CHKPNT                     6
PARAML                            5
PURGE                             5
COND                              5
PLTSET                            5
SAVE                              5
PRTMSG                            5
PARAM                             5
PARAM                             5
COND                              5
PLOT                              5
SAVE                              5
PRTMSG                            5
LABEL                             5
COND
PARAM
AMG                                 7
SAVE                                7
CHKPNT                              7
COND                                 8
INPUTT2                              8
LABEL                                8
PARAM                                          8
AMP                                            8
SAVE                                           8
CHKPNT                                         8
PARAM
PARAM
PARAM
PARAM
JUMP
LABEL
FA1                                   9
SAVE                                  9
```

RIGID FORMAT RESTART TABLES

DMAP Inst.	94	100	110	120	130	140	150
CEAD			7				
SAVE			9				
COND			7				
COND							
VDR							
SAVE							
COND							
OFP							
SAVE							
LABEL							
FA2					0		
SAVE					0		
CHKPNT					0		
COND							
LABEL							
COND							
REPT							
JUMP							
LABEL							
CHKPNT							
PARAML							
COND							
XYTRAN							
SAVE							
XYPLOT							
LABEL							
PARAM							
COND							
MODACC					1 3		
DDR1			8				
CHKPNT			8				
EQUIV			0				
COND			0				
SDR1			0				
LABEL			0				
CHKPNT			0				
EQUIV					2		
COND					2		
VEC					2		
PARTN					2		
LABEL					2		
SDR2					7		
CHKPNT					7		
OFP							
COND							
PLOT							
PRTMSG							
LABEL							
JUMP							
LABEL							
PRTPARM							

COMPRESSOR BLADE CYCLIC MODAL FLUTTER ANALYSIS

DMAP Inst.	94	100	Bit Position 110	120	130	140	150
LABEL							
PRTPARM							
LABEL							
PRTPARM							
LABEL							
PRTPARM							
LABEL							
PRTPARM							
LABEL							
PRTPARM							
LABEL							
END							

4. DEMONSTRATION MANUAL

MODAL FLUTTER ANALYSIS OF AN ADVANCED TURBOPROPELLER

A. Description

The dynamic aeroelastic stability of a ten-bladed advanced turbopropeller at a given operating condition is examined in three phases:

Phase 1 generates the differential stiffness matrix when the propeller is subjected to the centrifugal loads due to its rotation. The presence of any steady state airloads is neglected.

Phase 2 calculates the "running" natural modes and frequencies using the total (elastic plus the differential) stiffness from, and the geometry at the end of, phase 1. This phase is checkpointed, and allows the user to select the structural modes to be included for flutter analysis.

Phase 3 is a restart of Phase 2 and computes the flutter eigenvalues. V-g, V-f curves and plotted to examine stability.

The blades of the propeller are assumed to be:

a) identical in all respects,

b) mounted on a relatively rigid hub, and hence

c) structurally independent, and

d) aerodynamically coupled via discrete interblade phase angles

$$\sigma = 2\pi n/10, \; n = 0, \pm 1, \ldots, \pm 4, 5.$$

Therefore, only one blade of the propeller is modelled as shown in Figure 1.

B. Input

1. Parameters:

<u>Propeller</u>

Number of blades	= 10
Diameter at blade tip (grid point 4)	= 23.8 in.
Diameter at shank root (grid point 153)	= 4.1 in.
Chordlength at tip	= 1.28 in.

Chordlength at root = 3.03 in.

Sweep angle at tip = 51.0 deg.

Sweep angle at root = -15.9 deg.

Young's modulus = 16.0×10^6 lbf/in^2

Poisson's ratio = 0.35

Material density = 4.141×10^{-4} $lbf.sec^2/in^4$

No structural damping included in flutter calculations.

Operating Point

Blade setting angle (at 8.98"R) with the plane of rotation = 69.0 deg.

Rotational speed = 6800 rpm

Free stream Mach number = 0.70

Free stream velocity = 9336 in/sec.

Free stream density = 9.763×10^{-8} $lbf.sec^2/in^4$

2. Constraints:

All degrees of freedom at the root of the shank are constrained to zero.

C. Results

Phase 1: Results are shown in Figures 2 and 3.

Phase 2: Figures 4 through 6 illustrate the first three natural modes at 6800 rpm.

Phase 3: Typical flutter results are shown in Figures 7 and 8 wherein the first bending mode is seen to be unstable ($g, \mu > 0$).

The results are in good agreement with the experimental observations, as reported in Reference 1.

D. Reference

1. Elchuri, V., and Smith, G. C. C., "NASTRAN Flutter Analysis of Advanced Turbopropellers," Final Technical Report, NASA CR-167926 , April 1982.

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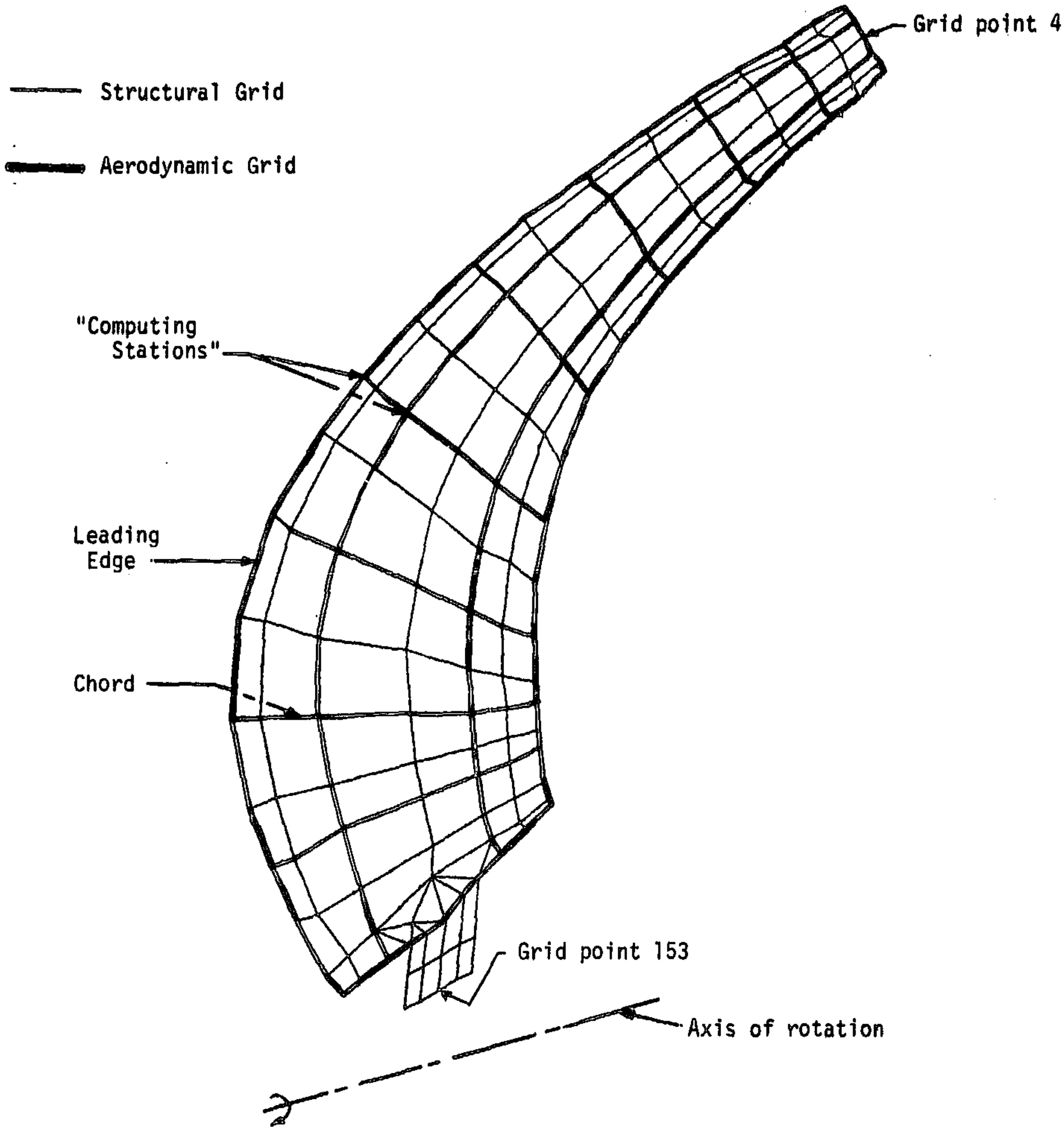

Figure 1. NASTRAN Structural and Aerodynamic Models of the Advanced Turbopropeller for Flutter Analysis

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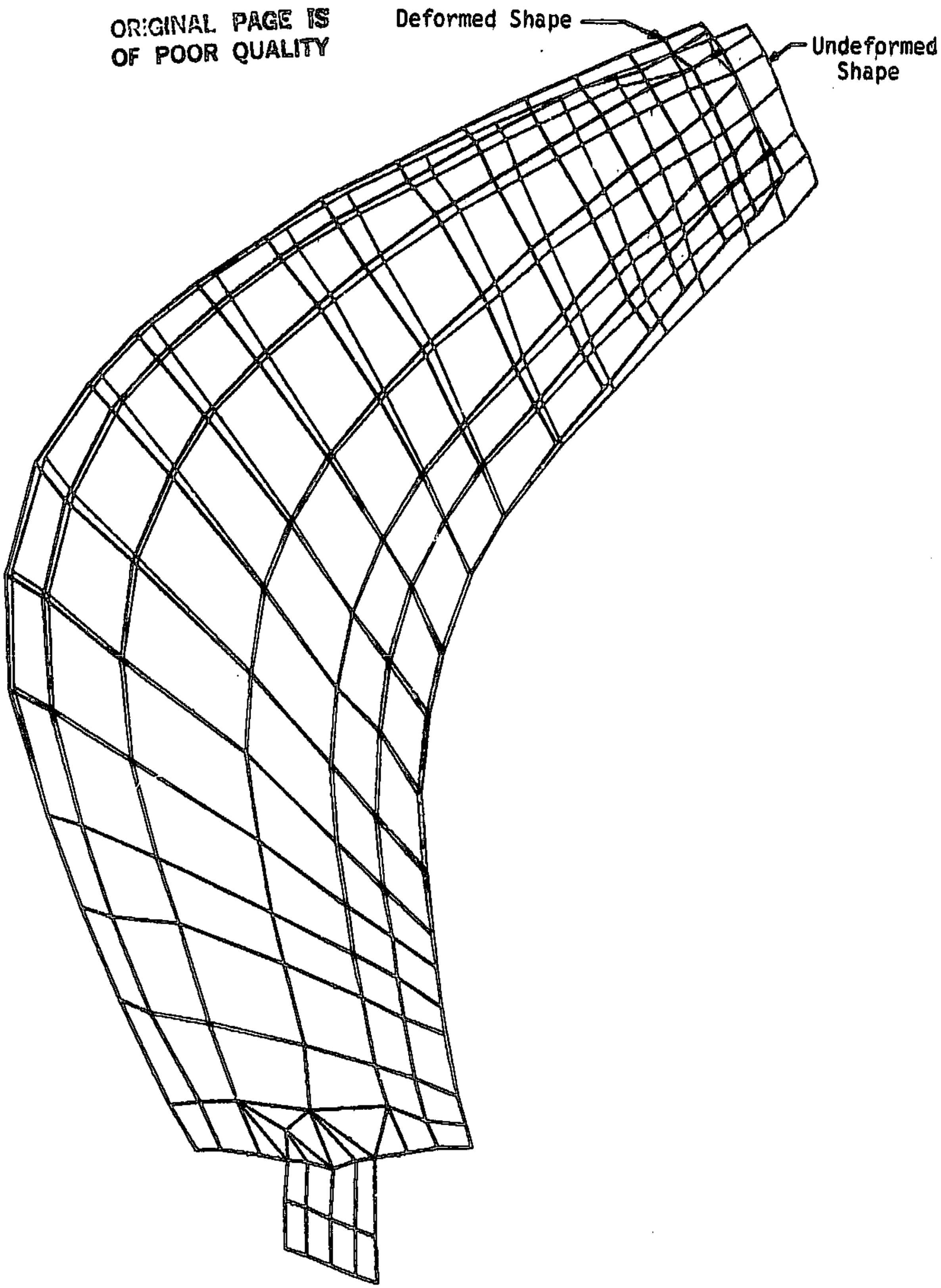

Figure 2. SR-5 Steady State Deflections Without Differential Stiffness

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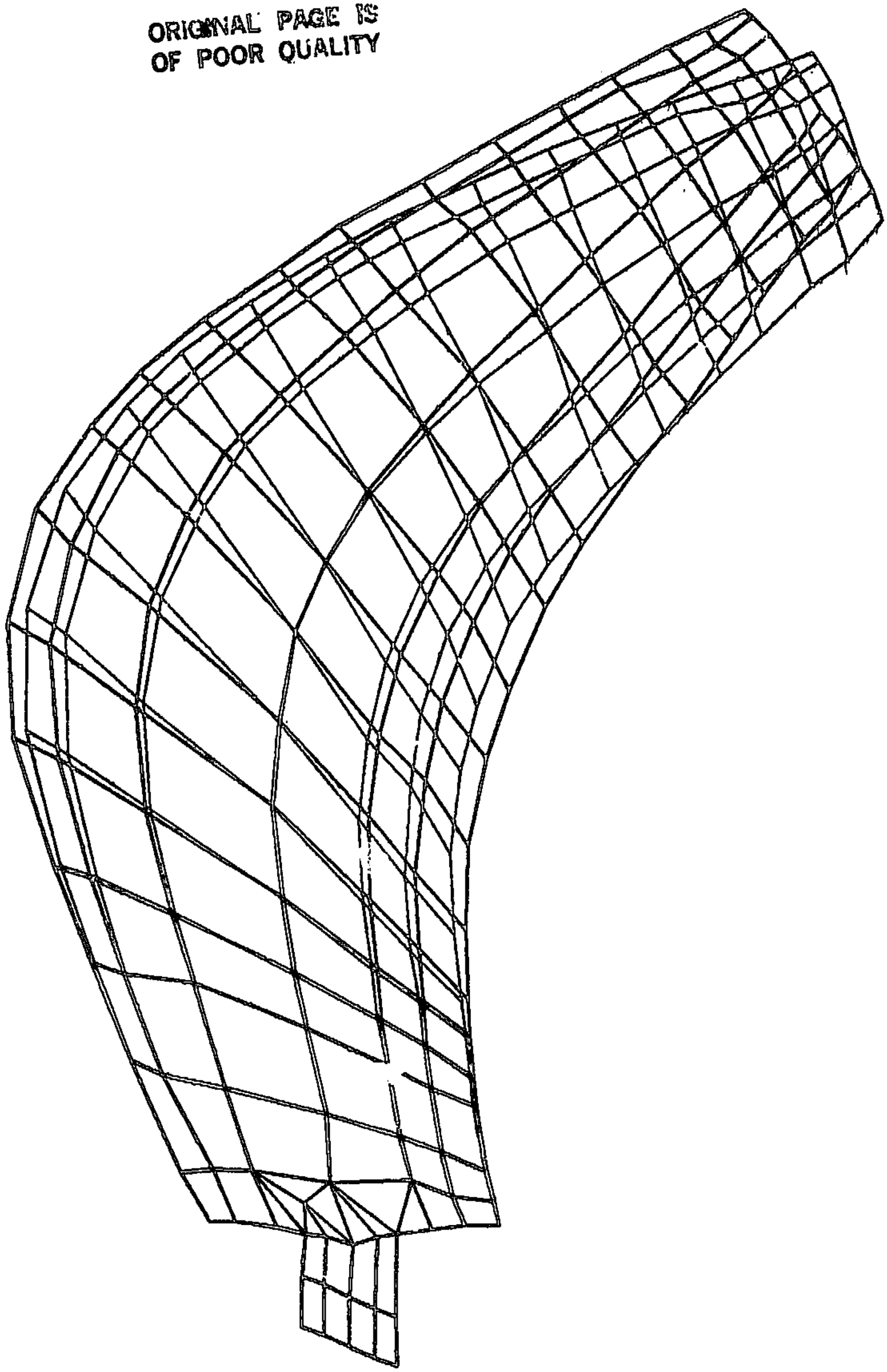

Figure 3. SR-5 Steady State Deflections with Differential Stiffness

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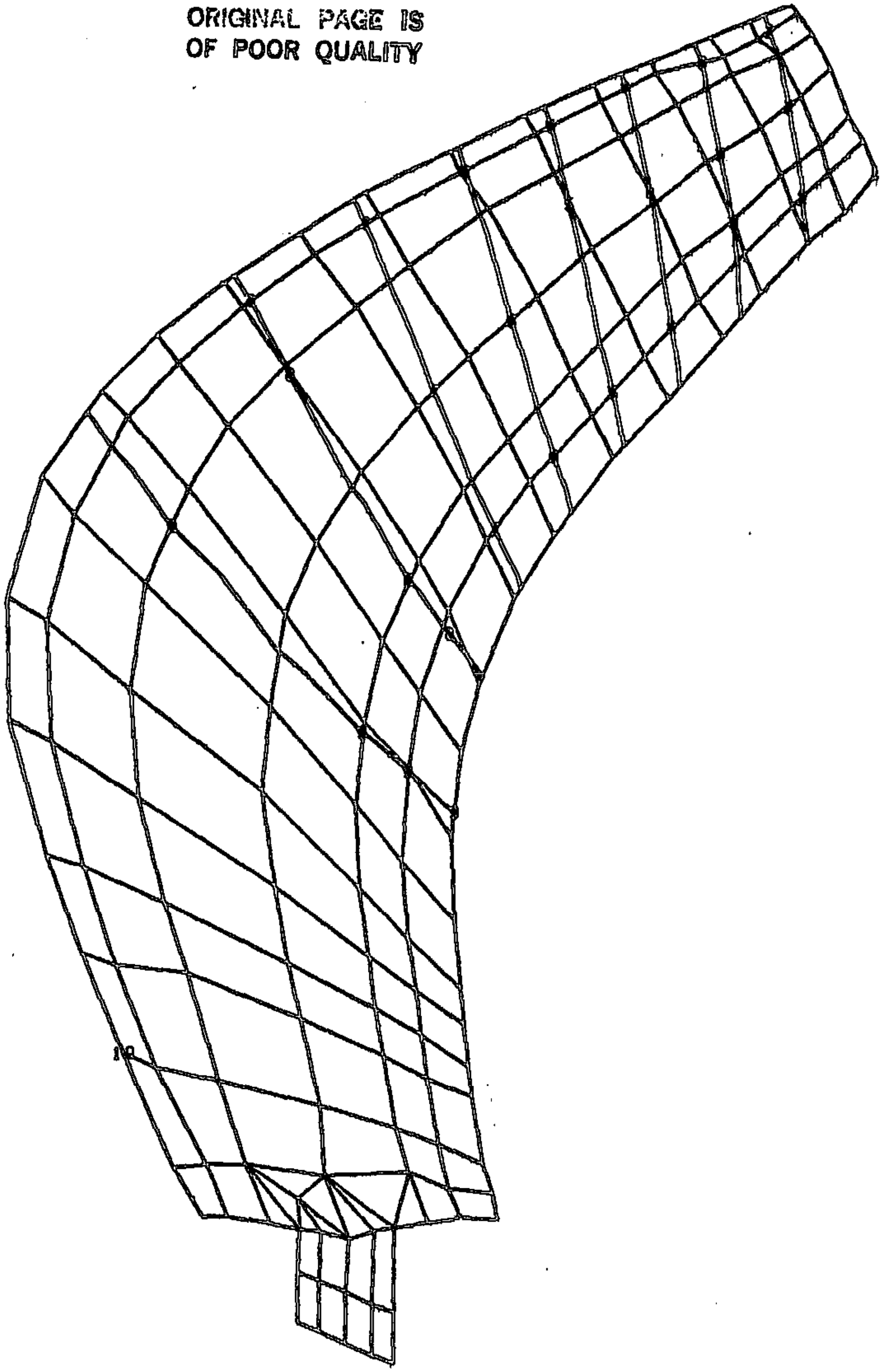
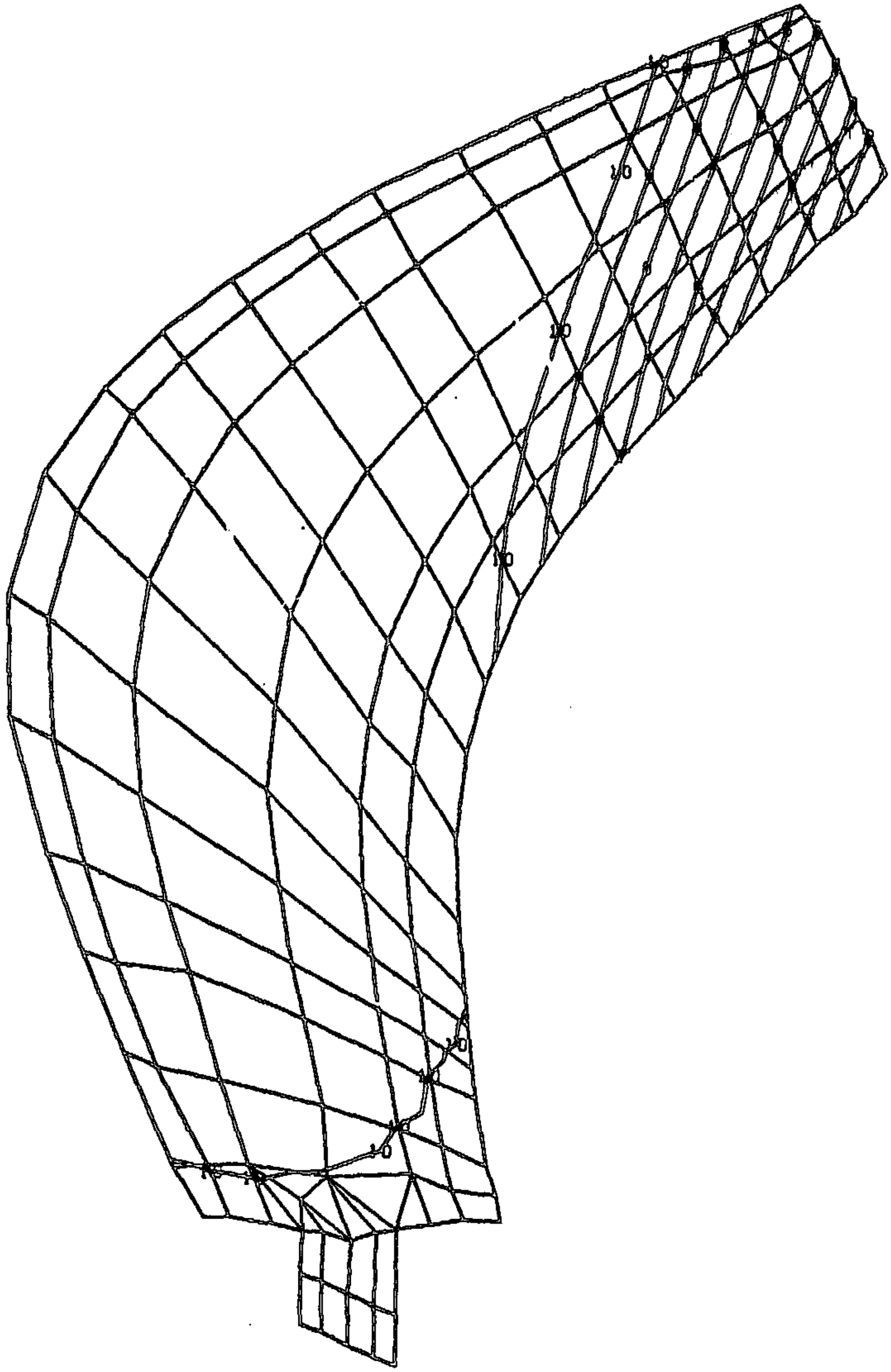
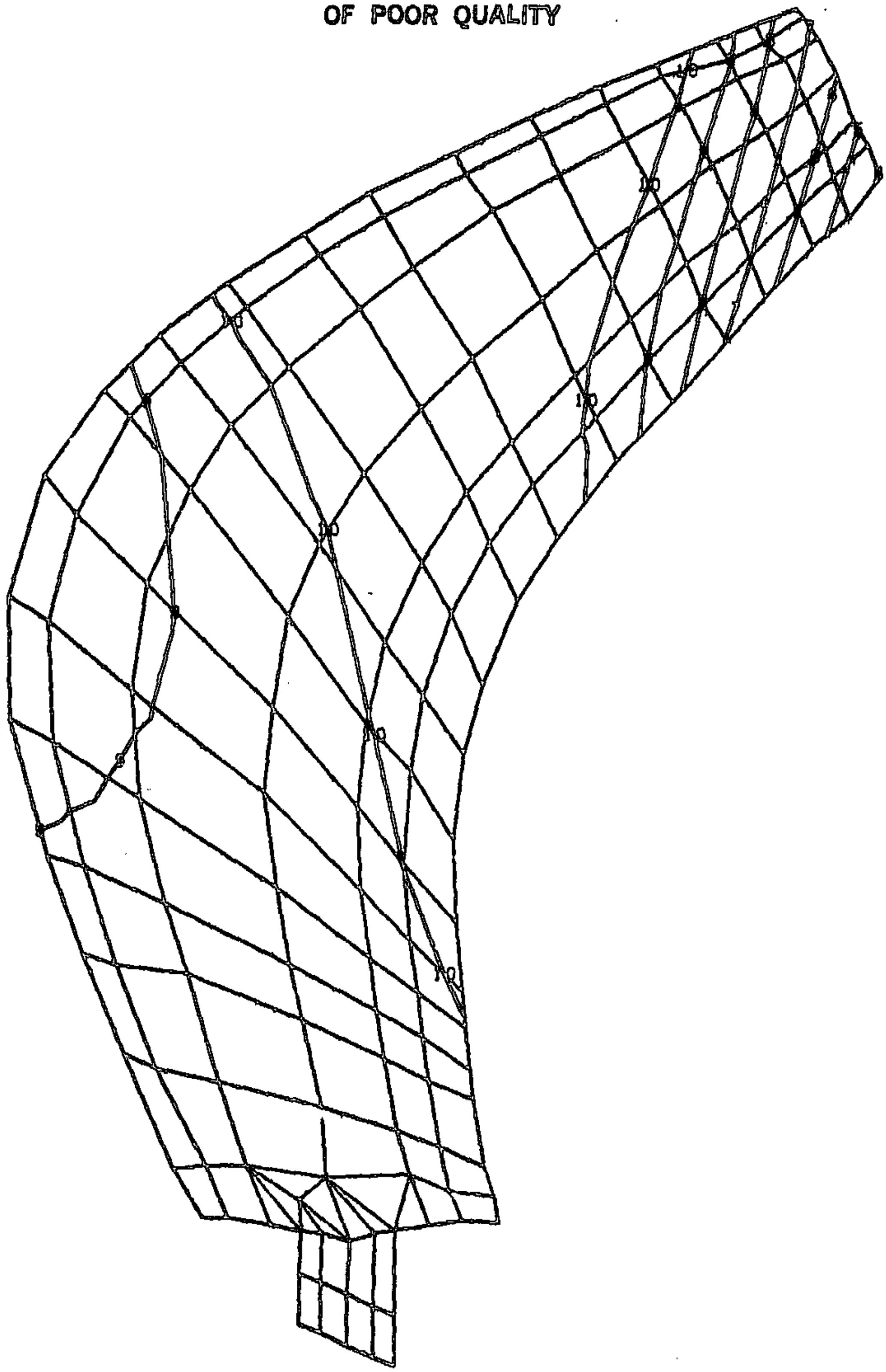


SRS ADVANCED TURBOPROP
DEFORMED MODEL AT 6800 RPM,CASE 3
SOL 9 AERO,EXIT AFTER K=0 MODES
MODAL DEFOR. SUBCASE 1   MODE 1   FREQ. 107.9298   Figure 4.



SRS ADVANCED TURBOPROP
DEFORMED MODEL AT 6800 RPM, CASE 3
SOL 9 AERO, EXIT AFTER K=0 MODES
MODAL DEFOR. SUBCASE 1   MODE 2   FREQ. 292.8112   Figure 5.



SR5 ADVANCED TURBOPROP
DEFORMED MODEL AT 6800 RPM, CASE 3
SOL 9 AERO, EXIT AFTER K=0 MODES
MODAL DEFOR. SUBCASE 1 MODE 3 FREQ. 612.6408 Figure 6.

SOL 9 AERO

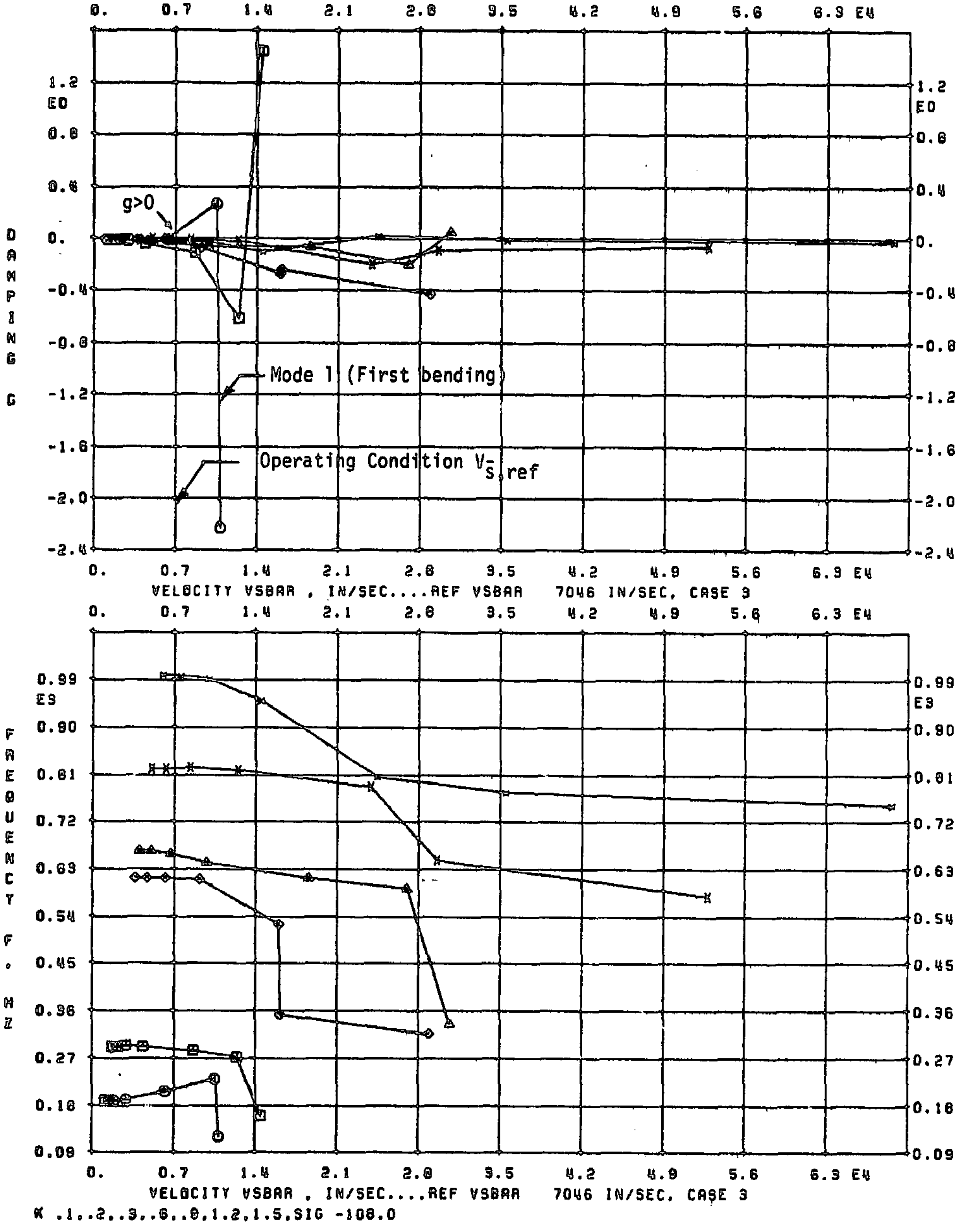
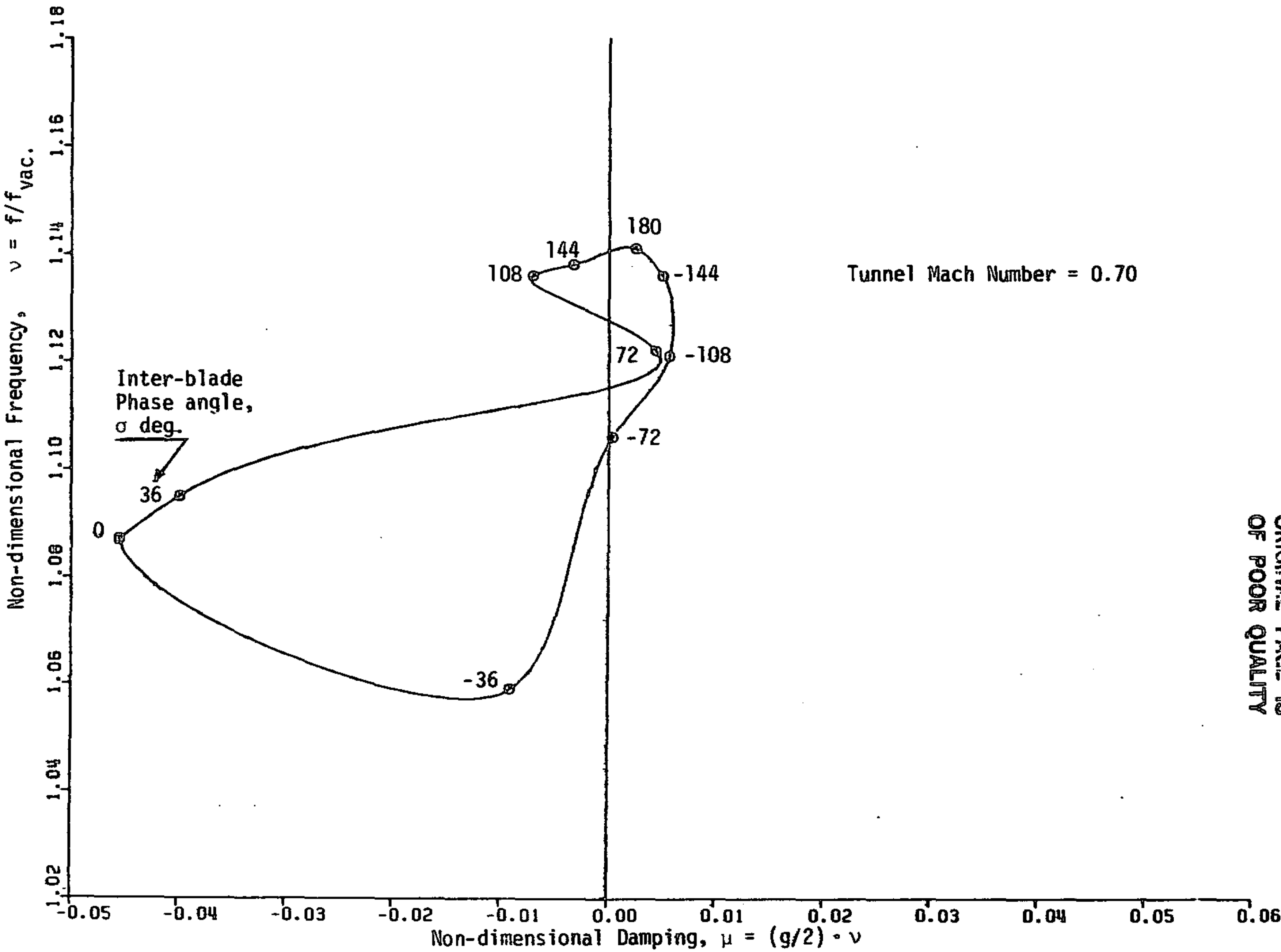


Figure 7. Typical V-g, V-f Curves

Figure 8. SR-5 FLUTTER ANALYSIS AT 6800 RPM (10 BLADES)
ROOT LOCUS OF FIRST BENDING MODE (FREQ IN VACUUM = 187.9 HZ.)



N A S T R A N   E X E C U T I V E   C O N T R O L   D E C K   E C H O

```
ID        NASA,SR5PROP
APP       DISP
SOL       4
TIME      20  $ IBM 370/3031
$
$    ALTERS TO SAVE ELASTIC PLUS DIFFERENTIAL STIFFNESS ( KTOTAL )
$                          ( RF 4, SERIES R )
$
ALTER 153
ADD     DKDGG,KDGG / KDGGX / C,N,(-1.0,0.0) $
ADD     KGG,KDGGX / KTOTAL $
OUTPUT1 KTOTAL,,,,//C,N,-1/C,N,0 $
OUTPUT1, ,,,,//C,N,-3/C,N,0 $
ENDALTER
$
CEND
```

```
SR5 ADVANCED TURBOPROP FLUTTER ANALYSIS
NASTRAN RF 4 DISP. DIFFERENTIAL STIFFNESS

10 BLADES, 6800 RPM, .70 TUNNEL MACH NO.

                                           C A S E    C O N T R O L    D E C K    E C H O
              CARD
              COUNT
                1        $
                2        TITLE = SR5 ADVANCED TURBOPROP FLUTTER ANALYSIS
                3        SUBTITLE = NASTRAN RF 4 DISP. DIFFERENTIAL STIFFNESS
                4        LABEL = 10 BLADES, 6800 RPM, .70 TUNNEL MACH NO.
                5        $
                6          ECHO    = SORT,PUNCH
                7          SPC     = 1
                8          LOAD    = 1
                9        $
               10          SUBCASE 1
               11            LABEL = LINEAR SOLUTION
               12            DISP  = ALL
               13          SUBCASE 2
               14            LABEL = NONLINEAR SOLUTION
               15            DISP(SORT1,PRINT,PUNCH) = ALL
               16        $
               17        OUTPUT(PLOT)
               18          SET 1 = ALL
               19            PLOTTER NASTPLT,MODEL D,0
               20            PAPER SIZE  8.5 BY 11.0
               21            MAXIMUM DEFORMATION 0.5
               22            FIND SCALE,ORIGIN 1,SET 1
               23            PTITLE = SOL 4
               24            PLOT STATIC DEFORMATION  0,SET 1,ORIGIN 1,PEN 2
               25        BEGIN BULK

* USER INFORMATION MESSAGE 207, BULK DATA NOT SORTED,XSORT WILL RE-ORDER DECK.
```

THE BLADE SHAPE DEFINED BY THE GRID DATA IS THE "AS MANUFACTURED" (PRETWISTED) SHAPE. ONLY CENTRIFUGAL LOADS ARE CONSIDERED IN COMPUTING THE DIFFERENTIAL STIFFNESS IN THIS RUN.

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S O R T E D   B U L K   D A T A   E C H O

1	2	3	4	5	6	7	8	9	10
CORD2R	1		.0	.0	.0	-.0277	-.9996	.0	+C2R1
+C2R1	.9996	-.0277	0.0						
CQUAD2	1	1	1	2	9	8			
CQUAD2	2	2	2	3	10	9			
CQUAD2	3	3	3	4	11	10			
CQUAD2	4	4	4	5	12	11			
CQUAD2	5	5	5	6	13	12			
CQUAD2	6	6	6	7	14	13			
CQUAD2	7	7	8	9	16	15			
CQUAD2	8	8	9	10	17	16			
CQUAD2	9	9	10	11	18	17			
CQUAD2	10	10	11	12	19	18			
CQUAD2	11	11	12	13	20	19			
CQUAD2	12	12	13	14	21	20			
CQUAD2	13	13	15	16	23	22			
CQUAD2	14	14	16	17	24	23			
CQUAD2	15	15	17	18	25	24			
CQUAD2	16	16	18	19	26	25			
CQUAD2	17	17	19	20	27	26			
CQUAD2	18	18	20	21	28	27			
CQUAD2	19	19	22	23	30	29			
CQUAD2	20	20	23	24	31	30			
CQUAD2	21	21	24	25	32	31			
CQUAD2	22	22	25	26	33	32			
CQUAD2	23	23	26	27	34	33			
CQUAD2	24	24	27	28	35	34			
CQUAD2	25	25	29	30	37	36			
CQUAD2	26	26	30	31	38	37			
CQUAD2	27	27	31	32	39	38			
CQUAD2	28	28	32	33	40	39			
CQUAD2	29	29	33	34	41	40			
CQUAD2	30	30	34	35	42	41			
CQUAD2	31	31	36	37	44	43			
CQUAD2	32	32	37	38	45	44			
CQUAD2	33	33	38	39	46	45			
CQUAD2	34	34	39	40	47	46			
CQUAD2	35	35	40	41	48	47			
CQUAD2	36	36	41	42	49	48			
CQUAD2	37	37	43	44	51	50			
CQUAD2	38	38	44	45	52	51			
CQUAD2	39	39	45	46	53	52			
CQUAD2	40	40	46	47	54	53			

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SORTED BULK DATA ECHO

. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
CQUAD2	41	41	47	48	55	54			
CQUAD2	42	42	48	49	56	55			
CQUAD2	43	43	50	51	58	57			
CQUAD2	44	44	51	52	59	58			
CQUAD2	45	45	52	53	60	59			
CQUAD2	46	46	53	54	61	60			
CQUAD2	47	47	54	55	62	61			
CQUAD2	48	48	55	56	63	62			
CQUAD2	49	49	57	58	65	64			
CQUAD2	50	50	58	59	66	65			
CQUAD2	51	51	59	60	67	66			
CQUAD2	52	52	60	61	68	67			
CQUAD2	53	53	61	62	69	68			
CQUAD2	54	54	62	63	70	69			
CQUAD2	55	55	64	65	72	71			
CQUAD2	56	56	65	66	73	72			
CQUAD2	57	57	66	67	74	73			
CQUAD2	58	58	67	68	75	74			
CQUAD2	59	59	68	69	76	75			
CQUAD2	60	60	69	70	77	76			
CQUAD2	61	61	71	72	79	78			
CQUAD2	62	62	72	73	80	79			
CQUAD2	63	63	73	74	81	80			
CQUAD2	64	64	74	75	82	81			
CQUAD2	65	65	75	76	83	82			
CQUAD2	66	66	76	77	84	83			
CQUAD2	67	67	78	79	86	85			
CQUAD2	68	68	79	80	87	86			
CQUAD2	69	69	80	81	88	87			
CQUAD2	70	70	81	82	89	88			
CQUAD2	71	71	82	83	90	89			
CQUAD2	72	72	83	84	91	90			
CQUAD2	73	73	85	86	93	92			
CQUAD2	74	74	86	87	94	93			
CQUAD2	75	75	87	88	95	94			
CQUAD2	76	76	88	89	96	95			
CQUAD2	77	77	89	90	97	96			
CQUAD2	78	78	90	91	98	97			
CQUAD2	79	79	92	93	100	99			
CQUAD2	80	80	93	94	101	100			
CQUAD2	81	81	94	95	102	101			
CQUAD2	82	82	95	96	103	102			

SORTED BULK DATA ECHO

1	2	3	4	5	6	7	8	9	10
CQUAD2	83	83	96	97	104	103			
CQUAD2	84	84	97	98	105	104			
CQUAD2	85	85	99	100	107	106			
CQUAD2	86	86	100	101	108	107			
CQUAD2	87	87	101	102	109	108			
CQUAD2	88	88	102	103	110	109			
CQUAD2	89	89	103	104	111	110			
CQUAD2	90	90	104	105	112	111			
CQUAD2	91	91	106	107	114	113			
CQUAD2	92	92	107	108	115	114			
CQUAD2	93	93	108	109	116	115			
CQUAD2	94	94	109	110	117	116			
CQUAD2	95	95	110	111	118	117			
CQUAD2	96	96	111	112	119	118			
CQUAD2	97	97	113	114	121	120			
CQUAD2	98	98	114	115	122	121			
CQUAD2	99	99	115	116	123	122			
CQUAD2	100	100	116	117	124	123			
CQUAD2	101	101	117	118	125	124			
CQUAD2	102	102	118	119	126	125			
CQUAD2	103	103	120	121	128	127			
CQUAD2	104	104	121	122	129	128			
CQUAD2	105	105	122	123	130	129			
CQUAD2	106	106	123	124	131	130			
CQUAD2	107	107	124	125	132	131			
CQUAD2	108	108	125	126	133	132			
CQUAD2	109	109	127	128	135	134			
CQUAD2	110	110	128	129	136	135			
CQUAD2	121	121	131	132	144	143			
CQUAD2	122	122	132	133	145	144			
CQUAD2	123	123	138	139	147	146			
CQUAD2	124	124	139	140	148	147			
CQUAD2	125	125	140	141	149	148			
CQUAD2	126	126	141	142	150	149			
CQUAD2	127	127	146	147	152	151			
CQUAD2	128	128	147	148	153	152			
CQUAD2	129	129	148	149	154	153			
CQUAD2	130	130	149	150	155	154			
CTRIA2	111	111	129	138	136				
CTRIA2	112	112	129	137	138				
CTRIA2	113	113	129	130	137				
CTRIA2	114	114	137	130	140				

S O R T E D   B U L K   D A T A   E C H O

```
.   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
CTRIA2  115     115     138     137     139
CTRIA2  116     116     139     137     140
CTRIA2  117     117     140     130     141
CTRIA2  118     118     141     130     142
CTRIA2  119     119     130     131     142
CTRIA2  120     120     142     131     143
GRDSET          1                               1
GRID    1               2.45    12.33   -2.17
GRID    2               2.49    12.27   -2.19
GRID    3               2.59    12.14   -2.23
GRID    4               2.7298  11.9176 -2.2624
GRID    5               2.92    11.62   -2.27
GRID    6               3.05    11.48   -2.29
GRID    7               3.19    11.30   -2.28
GRID    8               2.22    12.18   -1.98
GRID    9               2.28    12.06   -2.00
GRID    10              2.4133  11.9625 -2.0722
GRID    11              2.5932  11.6987 -2.1036
GRID    12              2.7863  11.4046 -2.1076
GRID    13              2.89    11.23   -2.09
GRID    14              3.06    11.00   -2.09
GRID    15              1.9857  12.0279 -1.8016
GRID    16              2.07    11.9    -1.84
GRID    17              2.14    11.78   -1.85
GRID    18              2.39    11.46   -1.9
GRID    19              2.59    11.17   -1.90
GRID    20              2.73    10.99   -1.89
GRID    21              2.90    10.78   -1.89
GRID    22              1.6448  11.8048 -1.5295
GRID    23              1.6901  11.7189 -1.5436
GRID    24              1.84    11.53   -1.59
GRID    25              2.1     11.17   -1.63
GRID    26              2.35    10.81   -1.65
GRID    27              2.49    10.62   -1.63
GRID    28              2.69    10.40   -1.61
GRID    29              1.3169  11.5806 -1.2715
GRID    30              1.37    11.48   -1.28
GRID    31              1.52    11.25   -1.32
GRID    32              1.82    10.84   -1.38
GRID    33              2.09    10.50   -1.38
GRID    34              2.27    10.26   -1.38
GRID    35              2.52    10.08   -1.392
```

S O R T E D   B U L K   D A T A   E C H O

1	2	3	4	5	6	7	8	9	10
GRID	36		.9141	11.2942	-0.9631				
GRID	37		.99	11.18	-1.0				
GRID	38		1.14	10.92	-1.02				
GRID	39		1.48	10.46	-1.07				
GRID	40		1.82	10.07	-1.09				
GRID	41		2.0	9.83	-1.09				
GRID	42		2.25	9.60	-1.1				
GRID	43		.4730	10.9578	-0.6356				
GRID	44		.55	10.82	-.66				
GRID	45		.75	10.59	-.74				
GRID	46		1.16	10.05	-.82				
GRID	47		1.50	9.60	-.82				
GRID	48		1.71	9.35	-.83				
GRID	49		1.95	9.12	-.83				
GRID	50		-0.0421	10.5713	-0.2723				
GRID	51		.05	10.42	-.32				
GRID	52		.28	10.10	-.39				
GRID	53		.75	9.55	-.51				
GRID	54		1.13	9.05	-.54				
GRID	55		1.34	8.80	-.55				
GRID	56		1.6209	8.4923	-0.5412				
GRID	57		-0.4359	10.2056	-0.0037				
GRID	58		-.34	10.06	-.05				
GRID	59		-0.0559	9.7290	-0.1641				
GRID	60		.44	9.12	-.29				
GRID	61		.86	8.62	-.34				
GRID	62		1.10	8.32	-.36				
GRID	63		1.3993	7.9926	-0.3687				
GRID	64		-0.9302	9.7396	.3066				
GRID	65		-.82	9.57	.24				
GRID	66		-.51	9.20	.12				
GRID	67		.09	8.57	-.05				
GRID	68		.59	8.05	-.15				
GRID	69		.86	7.75	-.20				
GRID	70		1.15	7.30	-.26				
GRID	71		-1.3863	9.2455	.5677				
GRID	72		-1.25	9.06	.49				
GRID	73		-.89	8.68	.35				
GRID	74		-0.1881	7.9931	.1377				
GRID	75		.35	7.4	-.02				
GRID	76		.66	7.1	-.12				
GRID	77		.99	6.75	-.23				

S O R T E D   B U L K   D A T A   E C H O

. 1 .	. 2 .	. 3 .	. 4 .	. 5 .	. 6 .	. 7 .	. 8 .	. 9 .	. 10 .
GRID	78		-1.7477	8.7493	.7742				
GRID	79		-1.0	8.58	.69				
GRID	80		-1.16	8.15	.51				
GRID	81		-.42	7.4	.24				
GRID	82		.19	6.75	.02				
GRID	83		.5400	6.4943	-0.1089				
GRID	84		.91	6.1	-.21				
GRID	85		-2.2101	8.0024	1.0004				
GRID	86		-2.0	7.75	.89				
GRID	87		-1.47	7.37	.66				
GRID	88		-.57	6.67	.27				
GRID	89		.11	6.12	.03				
GRID	90		.5	5.8	-.1				
GRID	91		.9494	5.4972	-0.2274				
GRID	92		-2.5336	7.0007	1.0946				
GRID	93		-2.27	6.87	.95				
GRID	94		-1.6800	6.4964	.6669				
GRID	95		-0.6637	5.9958	.2676				
GRID	96		.1296	5.4969	-0.0002				
GRID	97		.56	5.25	-.12				
GRID	98		1.0091	4.9992	-0.2541				
GRID	99		-2.6781	5.9958	1.0111				
GRID	100		-2.36	5.9	.87				
GRID	101		-1.68	5.67	.6				
GRID	102		-.6	5.3	.21				
GRID	103		.1945	4.9979	-0.0355				
GRID	104		.62	4.87	-.15				
GRID	105		1.05	4.75	-.26				
GRID	106		-2.5075	4.9937	.8290				
GRID	107		-2.2036	4.9941	.7208				
GRID	108		-1.55	4.90	.48				
GRID	109		-.51	4.75	.16				
GRID	110		.24	4.62	-.06				
GRID	111		.65	4.55	-.17				
GRID	112		1.10	4.45	-.27				
GRID	113		-2.28	4.30	.68				
GRID	114		-2.0	4.3	.59				
GRID	115		-1.41	4.4	.39				
GRID	116		-.42	4.35	.11				
GRID	117		.32	4.3	-.08				
GRID	118		.72	4.25	-.18				
GRID	119		1.15	4.25	-.27				

S O R T E D   B U L K   D A T A   E C H O

```
.  1  ..  2  ..  3  ..  4  ..  5  ..  6  ..  7  ..  8  ..  9  ..  10  .
GRID    120                 -2.0     3.62     .53
GRID    121                 -1.72    3.59     .44
GRID    122                 -1.17    3.66     .29
GRID    123                 -.25     3.75     .05
GRID    124                 .45      3.80     -.11
GRID    125                 .84      3.80     -.2
GRID    126                 1.29     3.80     -.28
GRID    127                 -1.61    2.87     .36
GRID    128                 -1.31    2.99     .29
GRID    129                 -.94     3.1      .21
GRID    130                 -.09     3.3      .12
GRID    131                 .56      3.5      -.14
GRID    132                 .95      3.5      -.22
GRID    133                 1.3693   3.6013   -0.2971
GRID    134                 -1.3691  2.5735   .2786
GRID    135                 -1.14    2.64     .22
GRID    136                 -.75     2.72     .13
GRID    137                 -.46     3.0      .09
GRID    138                 -.47     2.76     .07
GRID    139                 -.27     2.80     .03
GRID    140                 .0       2.83     -.02
GRID    141                 .27      2.98     -.05
GRID    142                 .47      3.07     -.08
GRID    143                 .79      3.20     -.16
GRID    144                 1.10     3.34     -.23
GRID    145                 1.4744   3.4553   -0.2758
GRID    146                 -.47     2.44     .09
GRID    147                 -.27     2.44     .04
GRID    148                 .0       2.44     .0
GRID    149                 .27      2.44     -.04
GRID    150                 .47      2.44     -.08
GRID    151                 -.47     2.06     .09
GRID    152                 -.27     2.06     .04
GRID    153                 .0       2.06     .0
GRID    154                 .27      2.06     -.04
GRID    155                 .47      2.06     -.09
MAT1    1       1.6     E7           .35      .0004141
PQUAD2  1       1           .012
PQUAD2  2       1           .024
PQUAD2  3       1           .032
PQUAD2  4       1           .036
PQUAD2  5       1           .030
```

S O R T E D   B U L K   D A T A   E C H O

. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
PQUAD2	6	1	.018						
PQUAD2	7	1	.014						
PQUAD2	8	1	.028						
PQUAD2	9	1	.037						
PQUAD2	10	1	.043						
PQUAD2	11	1	.036						
PQUAD2	12	1	.022						
PQUAD2	13	1	.016						
PQUAD2	14	1	.032						
PQUAD2	15	1	.048						
PQUAD2	16	1	.051						
PQUAD2	17	1	.042						
PQUAD2	18	1	.023						
PQUAD2	19	1	.018						
PQUAD2	20	1	.034						
PQUAD2	21	1	.053						
PQUAD2	22	1	.058						
PQUAD2	23	1	.046						
PQUAD2	24	1	.025						
PQUAD2	25	1	.021						
PQUAD2	26	1	.042						
PQUAD2	27	1	.061						
PQUAD2	28	1	.066						
PQUAD2	29	1	.051						
PQUAD2	30	1	.027						
PQUAD2	31	1	.024						
PQUAD2	32	1	.049						
PQUAD2	33	1	.070						
PQUAD2	34	1	.073						
PQUAD2	35	1	.057						
PQUAD2	36	1	.050						
PQUAD2	37	1	.028						
PQUAD2	38	1	.054						
PQUAD2	39	1	.078						
PQUAD2	40	1	.082						
PQUAD2	41	1	.065						
PQUAD2	42	1	.035						
PQUAD2	43	1	.031						
PQUAD2	44	1	.061						
PQUAD2	45	1	.088						
PQUAD2	46	1	.093						
PQUAD2	47	1	.075						

S O R T E D   B U L K   D A T A   E C H O

. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
PQUAD2	48	1	.039						
PQUAD2	49	1	.038						
PQUAD2	50	1	.068						
PQUAD2	51	1	.098						
PQUAD2	52	1	.103						
PQUAD2	53	1	.083						
PQUAD2	54	1	.046						
PQUAD2	55	1	.041						
PQUAD2	56	1	.076						
PQUAD2	57	1	.110						
PQUAD2	58	1	.118						
PQUAD2	59	1	.091						
PQUAD2	60	1	.047						
PQUAD2	61	1	.043						
PQUAD2	62	1	.083						
PQUAD2	63	1	.120						
PQUAD2	64	1	.129						
PQUAD2	65	1	.100						
PQUAD2	66	1	.044						
PQUAD2	67	1	.045						
PQUAD2	68	1	.090						
PQUAD2	69	1	.135						
PQUAD2	70	1	.138						
PQUAD2	71	1	.100						
PQUAD2	72	1	.048						
PQUAD2	73	1	.053						
PQUAD2	74	1	.106						
PQUAD2	75	1	.152						
PQUAD2	76	1	.148						
PQUAD2	77	1	.099						
PQUAD2	78	1	.044						
PQUAD2	79	1	.063						
PQUAD2	80	1	.123						
PQUAD2	81	1	.171						
PQUAD2	82	1	.157						
PQUAD2	83	1	.099						
PQUAD2	84	1	.046						
PQUAD2	85	1	.071						
PQUAD2	86	1	.141						
PQUAD2	87	1	.206						
PQUAD2	88	1	.177						
PQUAD2	89	1	.112						

S O R T E D   B U L K   D A T A   E C H O

1	2	3	4	5	6	7	8	9	10
PQUAD2	90	1	.048						
PQUAD2	91	1	.084						
PQUAD2	92	1	.172						
PQUAD2	93	1	.232						
PQUAD2	94	1	.198						
PQUAD2	95	1	.135						
PQUAD2	96	1	.062						
PQUAD2	97	1	.119						
PQUAD2	98	1	.206						
PQUAD2	99	1	.266						
PQUAD2	100	1	.230						
PQUAD2	101	1	.152						
PQUAD2	102	1	.071						
PQUAD2	103	1	.161						
PQUAD2	104	1	.237						
PQUAD2	105	1	.347						
PQUAD2	106	1	.319						
PQUAD2	107	1	.167						
PQUAD2	108	1	.075						
PQUAD2	109	1	.222						
PQUAD2	110	1	.373						
PQUAD2	121	1	.242						
PQUAD2	122	1	.089						
PQUAD2	123	1	.441						
PQUAD2	124	1	.830						
PQUAD2	125	1	.830						
PQUAD2	126	1	.441						
PQUAD2	127	1	.441						
PQUAD2	128	1	.830						
PQUAD2	129	1	.830						
PQUAD2	130	1	.441						
PTRIA2	111	1	.531						
PTRIA2	112	1	.532						
PTRIA2	113	1	.396						
PTRIA2	114	1	.544						
PTRIA2	115	1	.590						
PTRIA2	116	1	.591						
PTRIA2	117	1	.557						
PTRIA2	118	1	.519						
PTRIA2	119	1	.396						
PTRIA2	120	1	.377						
RFORCE	1	0		113.34	1.0	.0	.0		

S O R T E D   B U L K   D A T A   E C H O

```
.   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
SPC1    1       4       1       57
SPC1    1       6       7       91      98      134     145
SPC1    1       123456  151     THRU    155
ENDDATA
```

N A S T R A N   E X E C U T I V E   C O N T R O L   D E C K   E C H O

```
NASTRAN SYSTEM(76)= 1    $ SWEPT TURBOPROP OPTION
ID        NASA,SR5PROP
APP       AERO
SOL       9
TIME      12   $ IBM 370/3031
$
CHKPNT YES
$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$    BELL/NASA NASTRAN AERO SOL 9 ALTERS TO PLOT MODE SHAPES AND      $
$          INCLUDE KE AND PK METHODS OF FLUTTER ANALYSIS              $
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$
$        ALTERS TO PLOT MODE SHAPES.
$
ALTER 103,103
SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,,PHIG,EST,,/,,
         OPHIG,,,PPHIG/C,N,REIG $
CHKPNT   PHIG,PPHIG $
ALTER 105
PLTSET   PCDB,EQEXIN,ECT/PLTSETZ,PLTPARZ,GPSETSZ,ELSETSZ/
         S,N,NSILZ/S,N,JUMPZ=-1 $
PRTMSG   PLTSETZ // $
COND     PZZ,JUMPZ $
PLOT     PLTPARZ,GPSETSZ,ELSETSZ,CASECC,BGPDT,EQEXIN,SIL,,PPHIG,,/
         PLOTZ/V,N,NSILZ/V,N,LUSET/V,N,JUMPZ/V,N,PLTFLGZ=-1/
         S,N,PFILEZ=0 $
PRTMSG   PLOTZ // $
LABEL    PZZ $
$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
EXIT $ INCLUDE ONLY IF TERMINATION AFTER MODE PLOTS IS DESIRED.      $
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$
$        ALTERS FOR KE AND PK METHODS OF FLUTTER ANALYSIS.
$
ALTER 152,153
FA1      KHH,BHH,MHH,QHHL,CASECC,FLIST/FSAVE,KXHH,BXHH,MXHH/
         S,N,FLOOP/S,N,TSTART/S,N,NOCEAD $
EQUIV    KXHH,PHIH/NOCEAD/BXHH,CLAMA/NOCEAD/
         KXHH,PHIHL/NOCEAD/BXHH,CLAMAL/NOCEAD/
         CASECC,CASEYY/NOCEAD $
```

N A S T R A N   E X E C U T I V E   C O N T R O L   D E C K   E C H O

```
COND     VDR,NOCEAD $
ALTER 156
LABEL    VDR $
ENCALTER
$
CEND
```

N A S T R A N   E X E C U T I V E   C O N T R O L   D E C K   E C H O

ECHO OF FIRST CARD IN CHECKPOINT DICTIONARY TO BE PUNCHED OUT FOR THIS PROBLEM

RESTART   NASA   ,SR5PROP , 4/15/82,   47702,

```
SR5 ADVANCED TURBOPROP FLUTTER ANALYSIS
BELL/NASA NASTRAN RF 9 AERO.   MODES

10 BLADES, 6800 RPM, .70 TUNNEL MACH NO.

                                        C A S E   C O N T R O L   D E C K   E C H O
            CARD
            COUNT
              1        $
              2        TITLE = SR5 ADVANCED TURBOPROP FLUTTER ANALYSIS
              3        SUBTITLE = BELL/NASA NASTRAN RF 9 AERO.   MODES
              4        LABEL = 10 BLADES, 6800 RPM, .70 TUNNEL MACH NO.
              5        $
              6          SPC      = 1
              7          METHOD   = 1
              8          VECTOR   = ALL
              9        $
             10        OUTPUT(PLOT)
             11          SET 1 = ALL
             12            PLOTTER NASTPLT,MODEL D.0
             13            PAPER SIZE  8.5 BY 11.0
             14            MAXIMUM DEFORMATION 0.5
             15            FIND SCALE,ORIGIN 1,SET 1
             16            PTITLE = SOL 9 AERO
             17            CONTOUR YDISPLAC
             18            PLOT MODAL DEFORMATION CONTOUR  ,SET 1,ORIGIN 1,PEN 2
             19        BEGIN BULK


*** USER INFORMATION MESSAGE 207, BULK DATA NOT SORTED,XSORT WILL RE-ORDER DECK.
```

THE BLADE SHAPE DEFINED BY THE GRID DATA IS THE DEFORMED SHAPE OBTAINED AT THE END OF THE DIFFERENTIAL STIFFNESS RUN.

DUE TO THE REQUEST IN THE EXECUTIVE CONTROL DECK TO EXIT AFTER PLOTTING MODE SHAPES, IT IS AT THE USER'S OPTION TO INCLUDE OR EXCLUDE THE AERODYNAMIC DATA FOR FLUTTER ANALYSIS. IN THIS EXAMPLE THE AERODYNAMIC DATA HAVE BEEN LEFT OUT.

S O R T E D   B U L K   D A T A   E C H O

. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
CORD2R	1		.0	.0	.0	-.0277	-.9996	.0	+C2R1
+C2R1	.9996	-.0277	0.0						
CQUAD2	1	1	1	2	9	8			
CQUAD2	2	2	2	3	10	9			
CQUAD2	3	3	3	4	11	10			
CQUAD2	4	4	4	5	12	11			
CQUAD2	5	5	5	6	13	12			
CQUAD2	6	6	6	7	14	13			
CQUAD2	7	7	8	9	16	15			
CQUAD2	8	8	9	10	17	16			
CQUAD2	9	9	10	11	18	17			
CQUAD2	10	10	11	12	19	18			
CQUAD2	11	11	12	13	20	19			
CQUAD2	12	12	13	14	21	20			
CQUAD2	13	13	15	16	23	22			
CQUAD2	14	14	16	17	24	23			
CQUAD2	15	15	17	18	25	24			
CQUAD2	16	16	18	19	26	25			
CQUAD2	17	17	19	20	27	26			
CQUAD2	18	18	20	21	28	27			
CQUAD2	19	19	22	23	30	29			
CQUAD2	20	20	23	24	31	30			
CQUAD2	21	21	24	25	32	31			
CQUAD2	22	22	25	26	33	32			
CQUAD2	23	23	26	27	34	33			
CQUAD2	24	24	27	28	35	34			
CQUAD2	25	25	29	30	37	36			
CQUAD2	26	26	30	31	38	37			
CQUAD2	27	27	31	32	39	38			
CQUAD2	28	28	32	33	40	39			
CQUAD2	29	29	33	34	41	40			
CQUAD2	30	30	34	35	42	41			
CQUAD2	31	31	36	37	44	43			
CQUAD2	32	32	37	38	45	44			
CQUAD2	33	33	38	39	46	45			
CQUAD2	34	34	39	40	47	46			
CQUAD2	35	35	40	41	48	47			
CQUAD2	36	36	41	42	49	48			
CQUAD2	37	37	43	44	51	50			
CQUAD2	38	38	44	45	52	51			
CQUAD2	39	39	45	46	53	52			
CQUAD2	40	40	46	47	54	53			

SORTED BULK DATA ECHO

. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
CQUAD2	41	41	47	48	55	54			
CQUAD2	42	42	48	49	56	55			
CQUAD2	43	43	50	51	58	57			
CQUAD2	44	44	51	52	59	58			
CQUAD2	45	45	52	53	60	59			
CQUAD2	46	46	53	54	61	60			
CQUAD2	47	47	54	55	62	61			
CQUAD2	48	48	55	56	63	62			
CQUAD2	49	49	57	58	65	64			
CQUAD2	50	50	58	59	66	65			
CQUAD2	51	51	59	60	67	66			
CQUAD2	52	52	60	61	68	67			
CQUAD2	53	53	61	62	69	68			
CQUAD2	54	54	62	63	70	69			
CQUAD2	55	55	64	65	72	71			
CQUAD2	56	56	65	66	73	72			
CQUAD2	57	57	66	67	74	73			
CQUAD2	58	58	67	68	75	74			
CQUAD2	59	59	68	69	76	75			
CQUAD2	60	60	69	70	77	76			
CQUAD2	61	61	71	72	79	78			
CQUAD2	62	62	72	73	80	79			
CQUAD2	63	63	73	74	81	80			
CQUAD2	64	64	74	75	82	81			
CQUAD2	65	65	75	76	83	82			
CQUAD2	66	66	76	77	84	83			
CQUAD2	67	67	78	79	86	85			
CQUAD2	68	68	79	80	87	86			
CQUAD2	69	69	80	81	88	87			
CQUAD2	70	70	81	82	89	88			
CQUAD2	71	71	82	83	90	89			
CQUAD2	72	72	83	84	91	90			
CQUAD2	73	73	85	86	93	92			
CQUAD2	74	74	86	87	94	93			
CQUAD2	75	75	87	88	95	94			
CQUAD2	76	76	88	89	96	95			
CQUAD2	77	77	89	90	97	96			
CQUAD2	78	78	90	91	98	97			
CQUAD2	79	79	92	93	100	99			
CQUAD2	80	80	93	94	101	100			
CQUAD2	81	81	94	95	102	101			
CQUAD2	82	82	95	96	103	102			

SORTED BULK DATA ECHO

. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
CQUAD2	83	83	96	97	104	103			
CQUAD2	84	84	97	98	105	104			
CQUAD2	85	85	99	100	107	106			
CQUAD2	86	86	100	101	108	107			
CQUAD2	87	87	101	102	109	108			
CQUAD2	88	88	102	103	110	109			
CQUAD2	89	89	103	104	111	110			
CQUAD2	90	90	104	105	112	111			
CQUAD2	91	91	106	107	114	113			
CQUAD2	92	92	107	108	115	114			
CQUAD2	93	93	108	109	116	115			
CQUAD2	94	94	109	110	117	116			
CQUAD2	95	95	110	111	118	117			
CQUAD2	96	96	111	112	119	118			
CQUAD2	97	97	113	114	121	120			
CQUAD2	98	98	114	115	122	121			
CQUAD2	99	99	115	116	123	122			
CQUAD2	100	100	116	117	124	123			
CQUAD2	101	101	117	118	125	124			
CQUAD2	102	102	118	119	126	125			
CQUAD2	103	103	120	121	128	127			
CQUAD2	104	104	121	122	129	128			
CQUAD2	105	105	122	123	130	129			
CQUAD2	106	106	123	124	131	130			
CQUAD2	107	107	124	125	132	131			
CQUAD2	108	108	125	126	133	132			
CQUAD2	109	109	127	128	135	134			
CQUAD2	110	110	128	129	136	135			
CQUAD2	121	121	131	132	144	143			
CQUAD2	122	122	132	133	145	144			
CQUAD2	123	123	138	139	147	146			
CQUAD2	124	124	139	140	148	147			
CQUAD2	125	125	140	141	149	148			
CQUAD2	126	126	141	142	150	149			
CQUAD2	127	127	146	147	152	151			
CQUAD2	128	128	147	148	153	152			
CQUAD2	129	129	148	149	154	153			
CQUAD2	130	130	149	150	155	154			
CTRIA2	111	111	129	138	136				
CTRIA2	112	112	129	137	138				
CTRIA2	113	113	129	130	137				
CTRIA2	114	114	137	130	140				

S O R T E D   B U L K   D A T A   E C H O

1	2	3	4	5	6	7	8	9	10
CTRIA2	115	115	138	137	139				
CTRIA2	116	116	139	137	140				
CTRIA2	117	117	140	130	141				
CTRIA2	118	118	141	130	142				
CTRIA2	119	119	130	131	142				
CTRIA2	120	120	142	131	143				
CYJOIN	1		155						
CYJOIN	2		151						
EIGR	1	FEER				5			+E1
+E1	MAX								
GRDSET		1				1			
GRID	*1				2.419817E+00		1.244079E+01		*GD 1
*GD 1	-2.031032E+00								
GRID	*2				2.457173E+00		1.238143E+01		*GD 2
*GD 2	-2.058249E+00								
GRID	*3				2.551602E+00		1.225216E+01		*GD 3
*GD 3	-2.114527E+00								
GRID	*4				2.683628E+00		1.202870E+01		*GD 4
*GD 4	-2.173213E+00								
GRID	*5				2.865225E+00		1.172653E+01		*GD 5
*GD 5	-2.216011E+00								
GRID	*6				2.990463E+00		1.158475E+01		*GD 6
*GD 6	-2.254392E+00								
GRID	*7				3.126074E+00		1.140011E+01		*GD 7
*GD 7	-2.266630E+00								
GRID	*8				2.194761E+00		1.226047E+01		*GD 8
*GD 8	-1.843213E+00								
GRID	*9				2.250464E+00		1.216055E+01		*GD 9
*GD 9	-1.876635E+00								
GRID	*10				2.377542E+00		1.206568E+01		*GD 10
*GD 10	-1.563854E+00								
GRID	*11				2.548495E+00		1.179959E+01		*GD 11
*GD 11	-2.027197E+00								
GRID	*12				2.733165E+00		1.150046E+01		*GD 12
*GD 12	-2.066389E+00								
GRID	*13				2.832836E+00		1.132142E+01		*GD 13
*GD 13	-2.069136E+00								
GRID	*14				2.996484E+00		1.108674E+01		*GD 14
*GD 14	-2.097482E+00								
GRID	*15				1.964924E+00		1.211923E+01		*GD 15
*GD 15	-1.666834E+00								
GRID	*16				2.043783E+00		1.199233E+01		*GD 16

S O R T E D   B U L K   D A T A   E C H O

. 1 ..	2 ..	3 .. 4 .. 5 ..	6 .. 7 ..	8 .. 9 ..	10 .
*GD	16	-1.720535E+00			
GRID	*17		2.109893E+00	1.187122E+01	*GD 17
*GD	17	-1.744548E+00			
GRID	*18		2.348317E+00	1.154853E+01	*GD 18
*GD	18	-1.835006E+00			
GRID	*19		2.540135E+00	1.125291E+01	*GD 19
*GD	19	-1.870254E+00			
GRID	*20		2.675576E+00	1.106813E+01	*GD 20
*GD	20	-1.882862E+00			
GRID	*21		2.839677E+00	1.085337E+01	*GD 21
*GD	21	-1.909663E+00			
GRID	*22		1.631763E+00	1.188205E+01	*GD 22
*GD	22	-1.396830E+00			
GRID	*23		1.673820E+00	1.179605E+01	*GD 23
*GD	23	-1.420859E+00			
GRID	*24		1.815764E+00	1.160683E+01	*GD 24
*GD	24	-1.491647E+00			
GRID	*25		2.063309E+00	1.124282E+01	*GD 25
*GD	25	-1.576361E+00			
GRID	*26		2.302190E+00	1.087758E+01	*GD 26
*GD	26	-1.640171E+00			
GRID	*27		2.437845E+00	1.068192E+01	*GD 27
*GD	27	-1.643727E+00			
GRID	*28		2.632743E+00	1.045467E+01	*GD 28
*GD	28	-1.652845E+00			
GRID	*29		1.311218E+00	1.164496E+01	*GD 29
*GD	29	-1.141120E+00			
GRID	*30		1.360893E+00	1.154351E+01	*GD 30
*GD	30	-1.161242E+00			
GRID	*31		1.501914E+00	1.131251E+01	*GD 31
*GD	31	-1.229293E+00			
GRID	*32		1.786772E+00	1.089894E+01	*GD 32
*GD	32	-1.340499E+00			
GRID	*33		2.047144E+00	1.055134E+01	*GD 33
*GD	33	-1.383823E+00			
GRID	*34		2.220435E+00	1.030633E+01	*GD 34
*GD	34	-1.413691E+00			
GRID	*35		2.465178E+00	1.012088E+01	*GD 35
*GD	35	-1.453387E+00			
GRID	*36		9.178853E-01	1.134436E+01	*GD 36
*GD	36	-8.344505E-01			
GRID	*37		9.881784E-01	1.123093E+01	*GD 37

SORTED BULK DATA ECHO

1	2	3	4	5	6	7	8	9	10
*GD	37	-8.854066E-01							
GRID	*38				1.129425E+00		1.096814E+01	*GD	38
*GD	38	-9.357375E-01							
GRID	*39				1.453193E+00		1.050240E+01	*GD	39
*GD	39	-1.043262E+00							
GRID	*40				1.781501E+00		1.010489E+01	*GD	40
*GD	40	-1.113802E+00							
GRID	*41				1.955276E+00		9.860262E+00	*GD	41
*GD	41	-1.142711E+00							
GRID	*42				2.199200E+00		9.625038E+00	*GD	42
*GD	42	-1.183993E+00							
GRID	*43				4.878750E-01		1.099476E+01	*GD	43
*GD	43	-5.068682E-01							
GRID	*44				5.593370E-01		1.085660E+01	*GD	44
*GD	44	-5.470380E-01							
GRID	*45				7.476242E-01		1.062701E+01	*GD	45
*GD	45	-6.576909E-01							
GRID	*46				1.137788E+00		1.008176E+01	*GD	46
*GD	46	-8.041450E-01							
GRID	*47				1.466719E+00		9.623438E+00	*GD	47
*GD	47	-8.569880E-01							
GRID	*48				1.670425E+00		9.369388E+00	*GD	48
*GD	48	-8.965883E-01							
GRID	*49				1.905910E+00		9.134694E+00	*GD	49
*GD	49	-9.252617E-01							
GRID	*50				-1.396976E-02		1.059563E+01	*GD	50
*GD	50	-1.396792E-01							
GRID	*51				7.075590E-02		1.044524E+01	*GD	51
*GD	51	-2.047331E-01							
GRID	*52				2.875357E-01		1.012399E+01	*GD	52
*GD	52	-3.129540E-01							
GRID	*53				7.360002E-01		9.570383E+00	*GD	53
*GD	53	-5.007564E-01							
GRID	*54				1.103680E+00		9.064291E+00	*GD	54
*GD	54	-5.847520E-01							
GRID	*55				1.308623E+00		8.811132E+00	*GD	55
*GD	55	-6.212754E-01							
GRID	*56				1.586562E+00		8.499916E+00	*GD	56
*GD	56	-6.411608E-01							
GRID	*57				-4.000301E-01		1.022161E+01	*GD	57
*GD	57	1.274626E-01							
GRID	*58				-3.109443E-01		1.007667E+01	*GD	58

S O R T E D   B U L K   D A T A   E C H O

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 .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
*GD     58      6.474346E-02
GRID    *59                                    -4.257504E-02   9.746097E+00   *GD     59
*GD     59     -9.011447E-02
GRID    *60                                     4.317413E-01   9.133682E+00   *GD     60
*GD     60     -2.848848E-01
GRID    *61                                     8.400738E-01   8.629044E+00   *GD     61
*GD     61     -3.864452E-01
GRID    *62                                     1.075119E+00   8.326850E+00   *GD     62
*GD     62     -4.330833E-01
GRID    *63                                     1.372284E+00   7.998097E+00   *GD     63
*GD     63     -4.656390E-01
GRID    *64                                    -8.876041E-01   9.747480E+00   *GD     64
*GD     64      4.344531E-01
GRID    *65                                    -7.852193E-01   9.579490E+00   *GD     65
*GD     65      3.506024E-01
GRID    *66                                    -4.903399E-01   9.209817E+00   *GD     66
*GD     66      1.900352E-01
GRID    *67                                     8.824563E-02   8.577651E+00   *GD     67
*GD     67     -4.811718E-02
GRID    *68                                     5.764167E-01   8.055484E+00   *GD     68
*GD     68     -1.565310E-01
GRID    *69                                     8.417380E-01   7.754916E+00   *GD     69
*GD     69     -2.687562E-01
GRID    *70                                     1.127948E+00   7.304899E+00   *GD     70
*GD     70     -3.480781E-01
GRID    *71                                    -1.340348E+00   9.248205E+00   *GD     71
*GD     71      6.895647E-01
GRID    *72                                    -1.211896E+00   9.064268E+00   *GD     72
*GD     72      5.941403E-01
GRID    *73                                    -8.663878E-01   8.684826E+00   *GD     73
*GD     73      4.148975E-01
GRID    *74                                    -1.849050E-01   7.997163E+00   *GD     74
*GD     74      1.370639E-01
GRID    *75                                     3.419222E-01   7.404170E+00   *GD     75
*GD     75     -6.006306E-02
GRID    *76                                     6.469184E-01   7.104341E+00   *GD     76
*GD     76     -1.762950E-01
GRID    *77                                     9.723798E-01   6.754175E+00   *GD     77
*GD     77     -2.997903E-01
GRID    *78                                    -1.721028E+00   8.748784E+00   *GD     78
*GD     78      8.876511E-01
GRID    *79                                    -1.560428E+00   8.580663E+00   *GD     79
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S O R T E D   B U L K   D A T A   E C H O

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.   1   ..   2   ..   3   ..   4   ..   5   ..   6   ..   7   ..   8   ..   9   ..   10   .
*GD     79      7.867939E-01
GRID    *80                                    -1.135652E+00   8.151909E+00     *GD    80
*GD     80      5.662700E-01
GRID    *81                                    -4.147282E-01   7.403061E+00     *GD    81
*GD     81      2.401156E-01
GRID    *82                                     1.852081E-01   6.753466E+00     *GD    82
*GD     82     -9.743430E-03
GRID    *83                                     5.310093E-01   6.498033E+00     *GD    83
*GD     83     -1.498038E-01
GRID    *84                                     9.002047E-01   6.103145E+00     *GD    84
*GD     84     -2.552683E-01
GRID    *85                                    -2.167293E+00   7.999124E+00     *GD    85
*GD     85      1.095234E+00
GRID    *86                                    -1.965024E+00   7.748323E+00     *GD    86
*GD     86      9.662098E-01
GRID    *87                                    -1.447637E+00   7.370351E+00     *GD    87
*GD     87      7.037064E-01
GRID    *88                                    -5.651237E-01   6.672748E+00     *GD    88
*GD     88      2.690339E-01
GRID    *89                                     1.080579E-01   6.122757E+00     *GD    89
*GD     89      9.317569E-03
GRID    *90                                     4.961708E-01   5.802341E+00     *GD    90
*GD     90     -1.257418E-01
GRID    *91                                     9.450005E-01   5.499189E+00     *GD    91
*GD     91     -2.549328E-01
GRID    *92                                    -2.501855E+00   6.998549E+00     *GD    92
*GD     92      1.159885E+00
GRID    *93                                    -2.243557E+00   6.869573E+00     *GD    93
*GD     93      1.004043E+00
GRID    *94                                    -1.663980E+00   6.498133E+00     *GD    94
*GD     94      6.963711E-01
GRID    *95                                    -6.590906E-01   5.998307E+00     *GD    95
*GD     95      2.671809E-01
GRID    *96                                     1.295218E-01   5.498876E+00     *GD    96
*GD     96     -1.361039E-02
GRID    *97                                     5.590604E-01   5.251667E+00     *GD    97
*GD     97     -1.359098E-01
GRID    *98                                     1.008383E+00   5.000014E+00     *GD    98
*GD     98     -2.679553E-01
GRID    *99                                    -2.658578E+00   5.997640E+00     *GD    99
*GD     99      1.050546E+00
GRID    *100                                   -2.343632E+00   5.902313E+00     *GD   100
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S O R T E D   B U L K   D A T A   E C H O

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 .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
*GD  100     9.020252E-01
GRID    *101                                    -1.669497E+00   5.672649E+00   *GD   101
*GD  101     6.170529E-01
GRID    *102                                    -5.963364E-01   5.302208E+00   *GD   102
*GD  102     2.088603E-01
GRID    *103                                     1.954939E-01   4.999296E+00   *GD   103
*GD  103    -4.400190E-02
GRID    *104                                     6.204426E-01   4.870985E+00   *GD   104
*GD  104    -1.597679E-01
GRID    *105                                     1.050502E+00   4.750490E+00   *GD   105
*GD  105    -2.685744E-01
GRID    *106                                    -2.496761E+00   4.997375E+00   *GD   106
*GD  106     8.496489E-01
GRID    *107                                    -2.194051E+00   4.997557E+00   *GD   107
*GD  107     7.381414E-01
GRID    *108                                    -1.543487E+00   4.903041E+00   *GD   108
*GD  108     4.893306E-01
GRID    *109                                    -5.069078E-01   4.751890E+00   *GD   109
*GD  109     1.591752E-01
GRID    *110                                     2.414709E-01   4.620979E+00   *GD   110
*GD  110    -6.520444E-02
GRID    *111                                     6.511260E-01   4.550488E+00   *GD   111
*GD  111    -1.757268E-01
GRID    *112                                     1.101048E+00   4.450042E+00   *GD   112
*GD  112    -2.750542E-01
GRID    *113                                    -2.273488E+00   4.304033E+00   *GD   113
*GD  113     6.919722E-01
GRID    *114                                    -1.994164E+00   4.303668E+00   *GD   114
*GD  114     5.999017E-01
GRID    *115                                    -1.405457E+00   4.402983E+00   *GD   115
*GD  115     3.958974E-01
GRID    *116                                    -4.174645E-01   4.351565E+00   *GD   116
*GD  116     1.095533E-01
GRID    *117                                     3.215386E-01   4.300690E+00   *GD   117
*GD  117    -8.331943E-02
GRID    *118                                     7.212664E-01   4.250240E+00   *GD   118
*GD  118    -1.836711E-01
GRID    *119                                     1.151106E+00   4.249871E+00   *GD   119
*GD  119    -2.738665E-01
GRID    *120                                    -1.996529E+00   3.623911E+00   *GD   12[illegible]
*GD  120     5.362222E-01
GRID    *121                                    -1.717033E+00   3.593472E+00   *GD   121
```

S O R T E D   B U L K   D A T A   E C H O

```
.   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
*GD   121     4.447856E-01
GRID   *122                                  -1.167562E+00   3.662519E+00   *GD   122
*GD   122     2.925791E-01
GRID   *123                                  -2.483512E-01   3.751040E+00   *GD   123
*GD   123     4.970558E-02
GRID   *124                                  4.511786E-01    3.800256E+00   *GD   124
*GD   124    -1.118595E-01
GRID   *125                                  8.409850E-01    3.799903E+00   *GD   125
*GD   125    -2.023238E-01
GRID   *126                                  1.290810E+00    3.799548E+00   *GD   126
*GD   126    -2.828727E-01
GRID   *127                                  -1.608941E+00   2.873360E+00   *GD   127
*GD   127     3.625186E-01
GRID   *128                                  -1.308840E+00   2.992764E+00   *GD   128
*GD   128     2.919613E-01
GRID   *129                                  -9.387804E-01   3.101987E+00   *GD   129
*GD   129     2.111757E-01
GRID   *130                                  -8.885711E-02   3.300630E+00   *GD   130
*GD   130     1.195536E-01
GRID   *131                                  5.608683E-01    3.500004E+00   *GD   131
*GD   131    -1.414182E-01
GRID   *132                                  9.507490E-01    3.499724E+00   *GD   132
*GD   132    -2.217990E-01
GRID   *133                                  1.369986E+00    3.600738E+00   *GD   133
*GD   133    -2.995755E-01
GRID   *134                                  -1.368847E+00   2.576391E+00   *GD   134
*GD   134     2.804042E-01
GRID   *135                                  -1.139708E+00   2.642426E+00   *GD   135
*GD   135     2.214295E-01
GRID   *136                                  -7.496524E-01   2.721577E+00   *GD   136
*GD   136     1.307743E-01
GRID   *137                                  -4.592137E-01   3.001000E+00   *GD   137
*GD   137     9.034532E-02
GRID   *138                                  -4.695653E-01   2.760897E+00   *GD   138
*GD   138     7.035846E-02
GRID   *139                                  -2.695652E-01   2.800594E+00   *GD   139
*GD   139     3.012025E-02
GRID   *140                                  3.953020E-04    2.830271E+00   *GD   140
*GD   140    -2.015355E-02
GRID   *141                                  2.705058E-01    2.980117E+00   *GD   141
*GD   141    -5.050298E-02
GRID   *142                                  4.705606E-01    3.069980E+00   *GD   142
```

S O R T E D   B U L K   D A T A   E C H O

```
.   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
*GD     142    -8.079284E-02
GRID    *143                                    7.906197E-01    3.199841E+00    *GD     143
*GD     143    -1.611942E-01
GRID    *144                                    1.100652E+00    3.339638E+00    *GD     144
*GD     144    -2.316611E-01
GRID    *145                                    1.475051E+00    3.454741E+00    *GD     145
*GD     145    -2.780864E-01
GRID    *146                                    -4.697902E-01   2.440455E+00    *GD     146
*GD     146     9.014469E-02
GRID    *147                                    -2.698651E-01   2.440315E+00    *GD     147
*GD     147     4.007889E-02
GRID    *148                                    8.703647E-05    2.440156E+00    *GD     148
*GD     148    -1.476011E-05
GRID    *149                                    2.700679E-01    2.440040E+00    *GD     149
*GD     149    -4.009397E-02
GRID    *150                                    4.700607E-01    2.439936E+00    *GD     150
*GD     150    -8.015493E-02
GRID    *151                                    -4.700000E-01   2.060000E+00    *GD     151
*GD     151     8.999997E-02
GRID    *152                                    -2.700000E-01   2.060000E+00    *GD     152
*GD     152     4.000000E-02
GRID    *153                                    .0              2.060000E+00    *GD     153
*GD     153     0.0
GRID    *154                                    2.700000E-01    2.060000E+00    *GD     154
*GD     154    -4.000000E-02
GRID    *155                                    4.700000E-01    2.060000E+00    *GD     155
*GD     155    -8.999997E-02
MAT1    1       1.6  E7         .35     .0004141
PARAM   CTYPE   ROT
PARAM   KGGIN   1
PARAM   KINDEX  0
PARAM   NSEGS   10
PQUAD2  1       1       .012
PQUAD2  2       1       .024
PQUAD2  3       1       .032
PQUAD2  4       1       .036
PQUAD2  5       1       .030
PQUAD2  6       1       .018
PQUAD2  7       1       .014
PQUAD2  8       1       .028
PQUAD2  9       1       .037
PQUAD2  10      1       .043
```

SORTED BULK DATA ECHO

. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
PQUAD2	11	1	.036						
PQUAD2	12	1	.022						
PQUAD2	13	1	.016						
PQUAD2	14	1	.032						
PQUAD2	15	1	.048						
PQUAD2	16	1	.051						
PQUAD2	17	1	.042						
PQUAD2	18	1	.023						
PQUAD2	19	1	.018						
PQUAD2	20	1	.034						
PQUAD2	21	1	.053						
PQUAD2	22	1	.058						
PQUAD2	23	1	.046						
PQUAD2	24	1	.025						
PQUAD2	25	1	.021						
PQUAD2	26	1	.042						
PQUAD2	27	1	.061						
PQUAD2	28	1	.066						
PQUAD2	29	1	.051						
PQUAD2	30	1	.027						
PQUAD2	31	1	.024						
PQUAD2	32	1	.049						
PQUAD2	33	1	.070						
PQUAD2	34	1	.073						
PQUAD2	35	1	.057						
PQUAD2	36	1	.030						
PQUAD2	37	1	.028						
PQUAD2	38	1	.054						
PQUAD2	39	1	.078						
PQUAD2	40	1	.082						
PQUAD2	41	1	.065						
PQUAD2	42	1	.035						
PQUAD2	43	1	.031						
PQUAD2	44	1	.061						
PQUAD2	45	1	.088						
PQUAD2	46	1	.093						
PQUAD2	47	1	.075						
PQUAD2	48	1	.039						
PQUAD2	49	1	.038						
PQUAD2	50	1	.068						
PQUAD2	51	1	.098						
PQUAD2	52	1	.103						

S O R T E D   B U L K   D A T A   E C H O

. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
PQUAD2	53	1	.083						
PQUAD2	54	1	.046						
PQUAD2	55	1	.041						
PQUAD2	56	1	.076						
PQUAD2	57	1	.110						
PQUAD2	58	1	.118						
PQUAD2	59	1	.091						
PQUAD2	60	1	.047						
PQUAD2	61	1	.043						
PQUAD2	62	1	.083						
PQUAD2	63	1	.120						
PQUAD2	64	1	.129						
PQUAD2	65	1	.100						
PQUAD2	66	1	.044						
PQUAD2	67	1	.045						
PQUAD2	68	1	.090						
PQUAD2	69	1	.135						
PQUAD2	70	1	.138						
PQUAD2	71	1	.100						
PQUAD2	72	1	.048						
PQUAD2	73	1	.053						
PQUAD2	74	1	.106						
PQUAD2	75	1	.152						
PQUAD2	76	1	.148						
PQUAD2	77	1	.099						
PQUAD2	78	1	.044						
PQUAD2	79	1	.063						
PQUAD2	80	1	.123						
PQUAD2	81	1	.171						
PQUAD2	82	1	.157						
PQUAD2	83	1	.099						
PQUAD2	84	1	.046						
PQUAD2	85	1	.071						
PQUAD2	86	1	.141						
PQUAD2	87	1	.206						
PQUAD2	88	1	.177						
PQUAD2	89	1	.112						
PQUAD2	90	1	.048						
PQUAD2	91	1	.084						
PQUAD2	92	1	.172						
PQUAD2	93	1	.232						
PQUAD2	94	1	.198						

S O R T E D   B U L K   D A T A   E C H O

1	2	3	4	5	6	7	8	9	10
PQUAD2	95	1	.135						
PQUAD2	96	1	.062						
PQUAD2	97	1	.119						
PQUAD2	98	1	.206						
PQUAD2	99	1	.266						
PQUAD2	100	1	.230						
PQUAD2	101	1	.152						
PQUAD2	102	1	.071						
PQUAD2	103	1	.161						
PQUAD2	104	1	.237						
PQUAD2	105	1	.347						
PQUAD2	106	1	.319						
PQUAD2	107	1	.167						
PQUAD2	108	1	.075						
PQUAD2	109	1	.222						
PQUAD2	110	1	.373						
PQUAD2	121	1	.242						
PQUAD2	122	1	.089						
PQUAD2	123	1	.441						
PQUAD2	124	1	.830						
PQUAD2	125	1	.830						
PQUAD2	126	1	.441						
PQUAD2	127	1	.441						
PQUAD2	128	1	.830						
PQUAD2	129	1	.830						
PQUAD2	130	1	.441						
PTRIA2	111	1	.531						
PTRIA2	112	1	.532						
PTRIA2	113	1	.396						
PTRIA2	114	1	.544						
PTRIA2	115	1	.590						
PTRIA2	116	1	.591						
PTRIA2	117	1	.557						
PTRIA2	118	1	.519						
PTRIA2	119	1	.396						
PTRIA2	120	1	.377						
RFORCE	1	0		113.34	1.0	.0	.0		
SPC1	1	4	1	57					
SPC1	1	6	7	91	98	134	145		
SPC1	1	123456	151	THRU	155				
ENDDATA									

N A S T R A N   E X E C U T I V E   C O N T R O L   D E C K   E C H O

```
NASTRAN SYSTEM(76)= 1     $ SWEPT TURBOPROP OPTION
ID        NASA,SR5PROP
APP       AERO
SOL       9
$
RESTART   NASA      ,SR5PROP ,00/C0/C0,    00000,
          1,   XVPS      ,   FLAGS = 0,    REEL =  1,    FILE =      6
          2,   REENTER AT DMAP SEQUENCE NUMBER       7
          3,   GPL       ,   FLAGS = 0,    REEL =  1,    FILE =      7
          4,   EQEXIN    ,   FLAGS = 0,    REEL =  1,    FILE =      8
          5,   GPDT      ,   FLAGS = 0,    REEL =  1,    FILE =      9
          6,   CSTM      ,   FLAGS = 0,    REEL =  1,    FILE =     10
          7,   BGPDT     ,   FLAGS = 0,    REEL =  1,    FILE =     11
          8,   SIL       ,   FLAGS = 0,    REEL =  1,    FILE =     12
          9,   XVPS      ,   FLAGS = 0,    REEL =  1,    FILE =     13
         10,   REENTER AT DMAP SEQUENCE NUMBER      10
         11,   ECT       ,   FLAGS = 0,    REEL =  1,    FILE =     14
         12,   XVPS      ,   FLAGS = 0,    REEL =  1,    FILE =     15
         13,   REENTER AT DMAP SEQUENCE NUMBER      12
         14,   XVPS      ,   FLAGS = 0,    REEL =  1,    FILE =     16
         15,   GPTT      ,   FLAGS = 0,    REEL =  0,    FILE =      0
         16,   REENTER AT DMAP SEQUENCE NUMBER      17
         17,   EST       ,   FLAGS = 0,    REEL =  1,    FILE =     17
         18,   GPECT     ,   FLAGS = 0,    REEL =  1,    FILE =     18
         19,   XVPS      ,   FLAGS = 0,    REEL =  1,    FILE =     19
         20,   GEI       ,   FLAGS = 0,    REEL =  0,    FILE =      0
         21,   OGPST     ,   FLAGS = 0,    REEL =  0,    FILE =      0
         22,   REENTER AT DMAP SEQUENCE NUMBER      29
         23,   MELM      ,   FLAGS = 0,    REEL =  1,    FILE =     20
         24,   MDICT     ,   FLAGS = 0,    REEL =  1,    FILE =     21
         25,   XVPS      ,   FLAGS = 0,    REEL =  1,    FILE =     22
         26,   KELM      ,   FLAGS = 0,    REEL =  0,    FILE =      0
         27,   KDICT     ,   FLAGS = 0,    REEL =  0,    FILE =      0
         28,   REENTER AT DMAP SEQUENCE NUMBER      36
         29,   MGG       ,   FLAGS = 0,    REEL =  1,    FILE =     23
         30,   XVPS      ,   FLAGS = 0,    REEL =  1,    FILE =     24
         31,   REENTER AT DMAP SEQUENCE NUMBER      42
         32,   KTOTAL    ,   FLAGS = 4,    REEL =  1,    FILE =     25
         33,   KGGX      ,   FLAGS = 4,    REEL =  1,    FILE =     25
         34,   KGG       ,   FLAGS = 4,    REEL =  1,    FILE =     25
         35,   XVPS      ,   FLAGS = 0,    REEL =  1,    FILE =     26
         36,   REENTER AT DMAP SEQUENCE NUMBER      54
```

```
         37,   CYCD     ,   FLAGS = 0,   REEL =  1,   FILE =     27
         38,   XVPS     ,   FLAGS = 0,   REEL =  1,   FILE =     28
         39,   REENTER AT DMAP SEQUENCE NUMBER     63
         40,   KNN      ,   FLAGS = 4,   REEL =  1,   FILE =     25
         41,   MGG      ,   FLAGS = 4,   REEL =  1,   FILE =     23
         42,   MNN      ,   FLAGS = 4,   REEL =  1,   FILE =     23
         43,   XVPS     ,   FLAGS = 0,   REEL =  1,   FILE =     29
         44,   REENTER AT DMAP SEQUENCE NUMBER     71
         45,   XVPS     ,   FLAGS = 0,   REEL =  1,   FILE =     30
         46,   KFF      ,   FLAGS = 0,   REEL =  0,   FILE =      0
         47,   MFF      ,   FLAGS = 0,   REEL =  0,   FILE =      0
         48,   REENTER AT DMAP SEQUENCE NUMBER     74
         49,   KFF      ,   FLAGS = 0,   REEL =  1,   FILE =     31
         50,   KFS      ,   FLAGS = 0,   REEL =  1,   FILE =     32
         51,   MFF      ,   FLAGS = 0,   REEL =  1,   FILE =     33
         52,   XVPS     ,   FLAGS = 0,   REEL =  1,   FILE =     34
         53,   REENTER AT DMAP SEQUENCE NUMBER     77
         54,   KFF      ,   FLAGS = 4,   REEL =  1,   FILE =     31
         55,   KAA      ,   FLAGS = 4,   REEL =  1,   FILE =     31
         56,   MAA      ,   FLAGS = 4,   REEL =  1,   FILE =     33
         57,   MFF      ,   FLAGS = 4,   REEL =  1,   FILE =     33
         58,   XVPS     ,   FLAGS = 0,   REEL =  1,   FILE =     35
         59,   REENTER AT DMAP SEQUENCE NUMBER     90
         60,   KKK      ,   FLAGS = 0,   REEL =  1,   FILE =     36
         61,   MKK      ,   FLAGS = 0,   REEL =  1,   FILE =     37
         62,   XVPS     ,   FLAGS = 0,   REEL =  1,   FILE =     38
         63,   REENTER AT DMAP SEQUENCE NUMBER     94
         64,   LAMK     ,   FLAGS = 0,   REEL =  1,   FILE =     39
         65,   PHIK     ,   FLAGS = 0,   REEL =  1,   FILE =     40
         66,   OEIGS    ,   FLAGS = 0,   REEL =  1,   FILE =     41
         67,   XVPS     ,   FLAGS = 0,   REEL =  1,   FILE =     42
         68,   MI       ,   FLAGS = 0,   REEL =  0,   FILE =      0
         69,   REENTER AT DMAP SEQUENCE NUMBER    101
         70,   LAMA     ,   FLAGS = 0,   REEL =  1,   FILE =     43
         71,   PHIA     ,   FLAGS = 0,   REEL =  1,   FILE =     44
         72,   XVPS     ,   FLAGS = 0,   REEL =  1,   FILE =     45
$ END OF CHECKPOINT DICTIONARY
$
TIME     35    $ IBM 370/3031
$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$    BELL/NASA NASTRAN AERO SOL 9 ALTERS TO PLOT MODE SHAPES AND        $
```

```
$            INCLUDE KE AND PK METHODS OF FLUTTER ANALYSIS             $
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$
$        ALTERS TO PLOT MODE SHAPES.
$
ALTER 103,103
SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,,PHIG,EST,,/,,
         OPHIG,,,PPHIG/C,N,REIG $
CHKPNT   PHIG,PPHIG $
ALTER 105
PLTSET   PCDB,EQEXIN,ECT/PLTSETZ,PLTPARZ,GPSETSZ,ELSETSZ/
         S,N,NSILZ/S,N,JUMPZ=-1 $
PRTMSG   PLTSETZ // $
COND     PZZ,JUMPZ $
PLOT     PLTPARZ,GPSETSZ,ELSETSZ,CASECC,BGPDT,EQEXIN,SIL,,PPHIG,,/
         PLOTZ/V,N,NSILZ/V,N,LUSET/V,N,JUMPZ/V,N,PLTFLGZ=-1/
         S,N,PFILEZ=0 $
PRTMSG   PLOTZ // $
LABEL    PZZ $
$
$        ALTERS FOR KE AND PK METHODS OF FLUTTER ANALYSIS.
$
ALTER 152,153
FA1      KHH,BHH,MHH,QHHL,CASECC,FLIST/FSAVE,KXHH,BXHH,MXHH/
         S,N,FLOOP/S,N,TSTART/S,N,NOCEAD $
EQUIV    KXHH,PHIH/NOCEAD/BXHH,CLAMA/NOCEAD/
         KXHH,PHIHL/NOCEAD/BXHH,CLAMAL/NOCEAD/
         CASECC,CASEYY/NOCEAD $
COND     VDR,NOCEAD $
ALTER 156
LABEL    VDR $
ENDALTER
$
CEND
```

SR5 ADVANCED TURBOPROP FLUTTER ANALYSIS
BELL/NASA NASTRAN RF 9 AERO. MODES

ORIGINAL PAGE IS
OF POOR QUALITY

10 BLADES, 6800 RPM, .70 TUNNEL MACH NO.

C A S E   C O N T R O L   D E C K   E C H O

```
CARD
COUNT
  1      $
  2      TITLE = SR5 ADVANCED TURBOPROP FLUTTER ANALYSIS
  3      SUBTITLE = BELL/NASA NASTRAN RF 9 AERO. FLUTTER
  4      LABEL = 10 BLADES, 6800 RPM, .70 TUNNEL MACH NO.
  5      $
  6        SPC      = 1
  7        METHOD   = 1
  8        FMETHOD  = 1
  9      $
 10      OUTPUT(XYOUT)
 11      $
 12      PLOTTER NASTPLT D,0
 13      XPAPER = 8.5
 14      YPAPER = 11.0
 15      YAXIS  = YES
 16      XINTERCEPT = 7046.0  $ OPERATING VELOCITY
 17      XTAXIS =  YES
 18      XBAXIS =  YES
 19      CURVELINESYMBOL = 6
 20      XDIVISIONS = 10
 21      YTDIVISIONS = 10
 22      YBDIVISIONS = 10
 23      YTGRID LINES = YES
 24      YBGRID LINES = YES
 25      XTGRID LINES = YES
 26      XBGRID LINES = YES
 27      XTITLE =      VELOCITY VSBAR , IN/SEC....REF VSBAR = 7046 IN/SEC
 28      YTTITLE =          DAMPING G
 29      YBTITLE =      FREQUENCY F, HZ
 30      TCURVE =    K=.1,.2,.3,.6,.9,1.2,1.5,SIG=0.0
 31      XYPLOT,XYPRINT VG/ 1(G,F), 2(G,F), 3(G,F), 4(G,F), 5(G,F), 6(G,F
 32      TCURVE =    K=.1,.2,.3,.6,.9,1.2,1.5,SIG=36.0
 33      XYPLOT,XYPRINT VG/ 7(G,F), 8(G,F), 9(G,F),10(G,F),11(G,F),12(G,F
 34      TCURVE =    K=.1,.2,.3,.6,.9,1.2,1.5,SIG=72.0
 35      XYPLOT,XYPRINT VG/13(G,F),14(G,F),15(G,F),16(G,F),17(G,F),18(G,F
 36      TCURVE =    K=.1,.2,.3,.6,.9,1.2,1.5,SIG=108.0
 37      XYPLOT,XYPRINT VG/19(G,F),20(G,F),21(G,F),22(G,F),23(G,F),24(G,F
 38      TCURVE =    K=.1,.2,.3,.6,.9,1.2,1.5,SIG=144.0
 39      XYPLOT,XYPRINT VG/25(G,F),26(G,F),27(G,F),28(G,F),29(G,F),30(G,F
 40      TCURVE =    K=.1,.2,.3,.6,.9,1.2,1.5,SIG=180.0
 41      XYPLOT,XYPRINT VG/31(G,F),32(G,F),33(G,F),34(G,F),35(G,F),36(G,F
 42      TCURVE =    K=.1,.2,.3,.6,.9,1.2,1.5,SIG=-144.0
```

SR5 ADVANCED TURBOPROP FLUTTER ANALYSIS
BELL/NASA NASTRAN RF 9 AERO. MODES

ORIGINAL PAGE IS
OF POOR QUALITY

10 BLADES, 6800 R.PM, .70 TUNNEL MACH NO.

C A S E   C O N T R O L   D E C K   E C H O

```
CARD
COUNT
43      XYPLOT,XYPRINT VG/37(G,F),38(G,F),39(G,F),40(G,F),41(G,F),42(G,F
44      TCURVE =    K=.1,.2,.3,.6,.9,1.2,1.5,SIG=-108.0
45      XYPLOT,XYPRINT VG/43(G,F),44(G,F),45(G,F),46(G,F),47(G,F),48(G,F
46      TCURVE =K=.1,.2,.3,.6,.9,1.2,1.5,SIG=-72.0
47      XYPLOT,XYPRINT VG/49(G,F),50(G,F),51(G,F),52(G,F),53(G,F),54(G,F
48      TCURVE =K=.1,.2,.3,.6,.9,1.2,1.5,SIG=-36.0
49      XYPLOT,XYPRINT VG/55(G,F),56(G,F),57(G,F),58(G,F),59(G,F),60(G,F
50      BEGIN BULK
```

C-3

ORIGINAL PAGE IS
OF POOR QUALITY

I N P U T   B U L K   D A T A   D E C K   E C H O

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.   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
$
$        AERODYNAMIC DATA FOR FLUTTER ANALYSIS
$
AERO     0       1.0     2.905   9.763E-8
FLFACT   1       1.0
FLFACT   2       0.0     36.0    72.0    108.0   144.0   180.0   -144.0  +FL21
+FL21    -108.0  -72.    -36.
FLFACT   3       .10     .20     .30     .6      .9      1.2     1.5
FLUTTER  1       KE      1       2       3       L       6
MKAERO2  0.0     .001    0.0     .3      0.0     .6      0.0     .9
MKAERO2  36.     .001    36.     .3      36.     .6      36.     .9
MKAERO2  72.     .001    72.     .3      72.     .6      72.     .9
MKAERO2  108.    .001    108.    .3      108.    .6      108.    .9
MKAERO2  144.    .001    144.    .3      144.    .6      144.    .9
MKAERO2  180.    .001    180.    .3      180.    .6      180.    .9
MKAERO2  -144.   .001    -144.   .3      -144.   .6      -144.   .9
MKAERO2  -108.   .001    -108.   .3      -108.   .6      -108.   .9
MKAERO2  -72.    .001    -72.    .3      -72.    .6      -72.    .9
MKAERO2  -36.    .001    -36.    .3      -36.    .6      -36.    .9
MKAERO2  0.0     1.2     0.0     1.5     0.0     .15
MKAERO2  36.     1.2     36.     1.5     36.0    .15
MKAERO2  72.     1.2     72.     1.5     72.0    .15
MKAERO2  108.    1.2     108.    1.5     108.    .15
MKAERO2  144.    1.2     144.    1.5     144.    .15
MKAERO2  180.    1.2     180.    1.5     180.    .15
MKAERO2  -144.   1.2     -144.   1.5     -144.   .15
MKAERO2  -108.   1.2     -108.   1.5     -108.   .15
MKAERO2  -72.    1.2     -72.    1.5     -72.    .15
MKAERO2  -36.    1.2     -36.    1.5     -36.    .15
PARAM    IREF    6
PARAM    LMODES  6
PARAM    MAXMACH 0.95
PARAM    MINMACH 1.01
PARAM    MTYPE   COSINE
PARAM    PRINT   YESB
STREAML1   1     134     136     143     145
STREAML1   2     113     115     117     119
STREAML1   3     99      101     103     105
STREAML1   4     85      87      89      91
STREAML1   5     71      73      75      77
STREAML1   6     57      59      61      63
STREAML1   7     43      45      47      49
```

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                    I N P U T   B U L K   D A T A   D E C K   E C H O
.   1  ..    2  ..    3  ..    4  ..    5  ..    6  ..    7  ..    8  ..    9  ..   10  .
STREAML1    8      29         31         33         35
STREAML1    9      15         17         19         21
STREAML1    10     1          3          5          7
STREAML2    1          4         11.075     3.028     0.278     1.626     0.6869.763E-8+STR    1
+STR   1    9152.  -15.899
STREAML2    2          4         13.895     3.559     0.336     2.733     0.7349.763E-8+STR    4
+STR   4    9794.   2.890
STREAML2    3          4         14.946     4.129     0.152     3.818     0.7139.763E-8+STR    6
+STR   6    9512.   20.206
STREAML2    4          4         16.492     4.214    -0.355     5.068     0.6189.763E-8+STR    8
+STR   8    8246.   38.813
STREAML2    5          4         17.712     3.542    -0.389     5.825     0.5679.763E-8+STR   10
+STR  10    7558.   46.112
STREAML2    6          4         16.167     2.905    -0.367     6.423     0.5289.763E-8+STR   12
+STR  12    7046.   50.138
STREAML2    7          4         17.910     2.376    -0.316     6.915     0.5359.763E-8+STR   14
+STR  14    7139.   50.796
STREAML2    8          4         19.990     1.937    -0.369     7.350     0.5569.763E-8+STR   16
+STR  16    7419.   50.323
STREAML2    9          4         23.516     1.558    -0.294     7.682     0.5579.763E-8+STR   18
+STR  18    7424.   51.910
STREAML2   10          4         27.788     1.280    -0.541     7.913     0.5879.763E-8+STR   20
+STR  20    7830.   50.992
ENDDATA


      BULK DATA NOT SORTED,XSORT WILL RE-ORDER DECK.
```

ORIGINAL PAGE IS
OF POOR QUALITY

SORTED BULK DATA ECHO

. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
AERO	0	1.0	2.905	9.763E-8					
CORD2R	1		.0	.0	.0	-.0277	-.9996	.0	+C2R1
+C2R1	.9996	-.0277	0.0						
CQUAD2	1	1	1	2	9	8			
CQUAD2	2	2	2	3	10	9			
CQUAD2	3	3	3	4	11	10			
CQUAD2	4	4	4	5	12	11			
CQUAD2	5	5	5	6	13	12			
CQUAD2	6	6	6	7	14	13			
CQUAD2	7	7	8	9	16	15			
CQUAD2	8	8	9	10	17	16			
CQUAD2	9	9	10	11	18	17			
CQUAD2	10	10	11	12	19	18			
CQUAD2	11	11	12	13	20	19			
CQUAD2	12	12	13	14	21	20			
CQUAD2	13	13	15	16	23	22			
CQUAD2	14	14	16	17	24	23			
CQUAD2	15	15	17	18	25	24			
CQUAD2	16	16	18	19	26	25			
CQUAD2	17	17	19	20	27	26			
CQUAD2	18	18	20	21	28	27			
CQUAD2	19	19	22	23	30	29			
CQUAD2	20	20	23	24	31	30			
CQUAD2	21	21	24	25	32	31			
CQUAD2	22	22	25	26	33	32			
CQUAD2	23	23	26	27	34	33			
CQUAD2	24	24	27	28	35	34			
CQUAD2	25	25	29	30	37	36			
CQUAD2	26	26	30	31	38	37			
CQUAD2	27	27	31	32	39	38			
CQUAD2	28	28	32	33	40	39			
CQUAD2	29	29	33	34	41	40			
CQUAD2	30	30	34	35	42	41			
CQUAD2	31	31	36	37	44	43			
CQUAD2	32	32	37	38	45	44			
CQUAD2	33	33	38	39	46	45			
CQUAD2	34	34	39	40	47	46			
CQUAD2	35	35	40	41	48	47			
CQUAD2	36	36	41	42	49	48			
CQUAD2	37	37	43	44	51	50			
CQUAD2	38	38	44	45	52	51			
CQUAD2	39	39	45	46	53	52			

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OF POOR QUALITY

S O R T E D   B U L K   D A T A   E C H O

. 1 .. 2 .. 3 .. 4 .. 5 .. 6 .. 7 .. 8 .. 9 .. 10 .

CQUAD2	40	40	46	47	54	53
CQUAD2	41	41	47	48	55	54
CQUAD2	42	42	48	49	56	55
CQUAD2	43	43	50	51	58	57
CQUAD2	44	44	51	52	59	58
CQUAD2	45	45	52	53	60	59
CQUAD2	46	46	53	54	61	60
CQUAD2	47	47	54	55	62	61
CQUAD2	48	48	55	56	63	62
CQUAD2	49	49	57	58	65	64
CQUAD2	50	50	58	59	66	65
CQUAD2	51	51	59	60	67	66
CQUAD2	52	52	60	61	68	67
CQUAD2	53	53	61	62	69	68
CQUAD2	54	54	62	63	70	69
CQUAD2	55	55	64	65	72	71
CQUAD2	56	56	65	66	73	72
CQUAD2	57	57	66	67	74	73
CQUAD2	58	58	67	68	75	74
CQUAD2	59	59	68	69	76	75
CQUAD2	60	60	69	70	77	76
CQUAD2	61	61	71	72	79	78
CQUAD2	62	62	72	73	80	79
CQUAD2	63	63	73	74	81	80
CQUAD2	64	64	74	75	82	81
CQUAD2	65	65	75	76	83	82
CQUAD2	66	66	76	77	84	83
CQUAD2	67	67	78	79	86	85
CQUAD2	68	68	79	80	87	86
CQUAD2	69	69	80	81	88	87
CQUAD2	70	70	81	82	89	88
CQUAD2	71	71	82	83	90	89
CQUAD2	72	72	83	84	91	90
CQUAD2	73	73	85	86	93	92
CQUAD2	74	74	86	87	94	93
CQUAD2	75	75	87	88	95	94
CQUAD2	76	76	88	89	96	95
CQUAD2	77	77	89	90	97	96
CQUAD2	78	78	90	91	98	97
CQUAD2	79	79	92	93	100	99
CQUAD2	80	80	93	94	101	100
CQUAD2	81	81	94	95	102	101

S O R T E D   B U L K   D A T A   E C H O

1	2	3	4	5	6	7	8	9	10
CQUAD2	82	82	95	96	103	102			
CQUAD2	83	83	96	97	104	103			
CQUAD2	84	84	97	98	105	104			
CQUAD2	85	85	99	100	107	106			
CQUAD2	86	86	100	101	108	107			
CQUAD2	87	87	101	102	109	108			
CQUAD2	88	88	102	103	110	109			
CQUAD2	89	89	103	104	111	110			
CQUAD2	90	90	104	105	112	111			
CQUAD2	91	91	106	107	114	113			
CQUAD2	92	92	107	108	115	114			
CQUAD2	93	93	108	109	116	115			
CQUAD2	94	94	109	110	117	116			
CQUAD2	95	95	110	111	118	117			
CQUAD2	96	96	111	112	119	118			
CQUAD2	97	97	113	114	121	120			
CQUAD2	98	98	114	115	122	121			
CQUAD2	99	99	115	116	123	122			
CQUAD2	100	100	116	117	124	123			
CQUAD2	101	101	117	118	125	124			
CQUAD2	102	102	118	119	126	125			
CQUAD2	103	103	120	121	128	127			
CQUAD2	104	104	121	122	129	128			
CQUAD2	105	105	122	123	130	129			
CQUAD2	106	106	123	124	131	130			
CQUAD2	107	107	124	125	132	131			
CQUAD2	108	108	125	126	133	132			
CQUAD2	109	109	127	128	135	134			
CQUAD2	110	110	128	129	136	135			
CQUAD2	121	121	131	132	144	143			
CQUAD2	122	122	132	133	145	144			
CQUAD2	123	123	138	139	147	146			
CQUAD2	124	124	139	140	148	147			
CQUAD2	125	125	140	141	149	148			
CQUAD2	126	126	141	142	150	149			
CQUAD2	127	127	146	147	152	151			
CQUAD2	128	128	147	148	153	152			
CQUAD2	129	129	148	149	154	153			
CQUAD2	130	130	149	150	155	154			
CTRIA2	111	111	129	138	136				
CTRIA2	112	112	129	137	138				
CTRIA2	113	113	129	130	137				

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S O R T E D   B U L K   D A T A   E C H O

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.   1   ..   2   ..   3   ..   4   ..   5   ..   6   ..   7   ..   8   ..   9   ..  10  .
CTRIA2  114     114     137     130     140
CTRIA2  115     115     138     137     139
CTRIA2  116     116     139     137     140
CTRIA2  117     117     140     130     141
CTRIA2  118     118     141     130     142
CTRIA2  119     119     130     131     142
CTRIA2  120     120     142     131     143
CYJOIN  1               155
CYJOIN  2               151
EIGR    1       FEER                            5                               +E1
+E1     MAX
FLFACT  1       1.0
FLFACT  2       .0      36.0    72.0    108.0   144.0   180.0   -144.0  +FL21
+FL21   -108.0  -72.    -36.
FLFACT  3       .10     .20     .30     .6      .9      1.2     1.5
FLUTTER 1       KE      1       2       3       L       6
GRDSET          1                               1
GRID    *1                              2.419817E+00    1.244079E+01    *GD     1
*GD     1   -2.031032E+00
GRID    *2                              2.457173E+00    1.238143E+01    *GD     2
*GD     2   -2.058249E+00
GRID    *3                              2.551602E+00    1.225216E+01    *GD     3
*GD     3   -2.114527E+00
GRID    *4                              2.683628E+00    1.202870E+01    *GD     4
*GD     4   -2.173213E+00
GRID    *5                              2.865225E+00    1.172653E+01    *GD     5
*GD     5   -2.216011E+00
GRID    *6                              2.990463E+00    1.158475E+01    *GD     6
*GD     6   -2.254392E+00
GRID    *7                              3.126074E+00    1.140011E+01    *GD     7
*GD     7   -2.266630E+00
GRID    *8                              2.194761E+00    1.228047E+01    *GD     8
*GD     8   -1.843213E+00
GRID    *9                              2.250464E+00    1.216055E+01    *GD     9
*GD     9   -1.876635E+00
GRID    *10                             2.377542E+00    1.206568E+01    *GD    10
*GD    10   -1.963854E+00
GRID    *11                             2.548495E+00    1.179959E+01    *GD    11
*GD    11   -2.027197E+00
GRID    *12                             2.733165E+00    1.150046E+01    *GD    12
*GD    12   -2.066389E+00
GRID    *13                             2.832836E+00    1.132142E+01    *GD    13
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S O R T E D   B U L K   D A T A   E C H O

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.   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
*GD     13     -2.069136E+00
GRID    *14                                   2.996484E+00    1.108674E+01    *GD     14
*GD     14     -2.097482E+00
GRID    *15                                   1.964924E+00    1.211923E+01    *GD     15
*GD     15     -1.666834E+00
GRID    *16                                   2.043783E+00    1.199233E+01    *GD     16
*GD     16     -1.720535E+00
GRID    *17                                   2.109893E+00    1.187122E+01    *GD     17
*GD     17     -1.744548E+00
GRID    *18                                   2.348317E+00    1.154853E+01    *GD     18
*GD     18     -1.835006E+00
GRID    *19                                   2.540135E+00    1.125291E+01    *GD     19
*GD     19     -1.870254E+00
GRID    *20                                   2.675576E+00    1.106813E+01    *GD     20
*GD     20     -1.882862E+00
GRID    *21                                   2.839677E+00    1.085337E+01    *GD     21
*GD     21     -1.909663E+00
GRID    *22                                   1.631763E+00    1.188205E+01    *GD     22
*GD     22     -1.396830E+00
GRID    *23                                   1.673820E+00    1.179605E+01    *GD     23
*GD     23     -1.420859E+00
GRID    *24                                   1.815764E+00    1.160683E+01    *GD     24
*GD     24     -1.491647E+00
GRID    *25                                   2.063309E+00    1.124282E+01    *GD     25
*GD     25     -1.576361E+00
GRID    *26                                   2.302190E+00    1.087758E+01    *GD     26
*GD     26     -1.640171E+00
GRID    *27                                   2.437845E+00    1.068192E+01    *GD     27
*GD     27     -1.643727E+00
GRID    *28                                   2.632743E+00    1.045467E+01    *GD     28
*GD     28     -1.652845E+00
GRID    *29                                   1.311218E+00    1.164496E+01    *GD     29
*GD     29     -1.141120E+00
GRID    *30                                   1.360893E+00    1.154351E+01    *GD     30
*GD     30     -1.161242E+00
GRID    *31                                   1.501914E+00    1.131251E+01    *GD     31
*GD     31     -1.229293E+00
GRID    *32                                   1.786772E+00    1.089894E+01    *GD     32
*GD     32     -1.340499E+00
GRID    *33                                   2.047144E+00    1.055134E+01    *GD     33
*GD     33     -1.383823E+00
GRID    *34                                   2.220435E+00    1.030633E+01    *GD     34
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S O R T E D   B U L K   D A T A   E C H O

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.   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
*GD      34     -1.413691E+00
GRID     *35                                      2.465178E+00    1.012088E+01    *GD      35
*GD      35     -1.453387E+00
GRID     *36                                      9.178853E-01    1.134436E+01    *GD      36
*GD      36     -8.344505E-01
GRID     *37                                      9.881784E-01    1.123093E+01    *GD      37
*GD      37     -8.854066E-01
GRID     *38                                      1.129425E+00    1.096814E+01    *GD      38
*GD      38     -9.357375E-01
GRID     *39                                      1.453193E+00    1.050240E+01    *GD      39
*GD      39     -1.043262E+00
GRID     *40                                      1.781501E+00    1.010489E+01    *GD      40
*GD      40     -1.113802E+00
GRID     *41                                      1.955276E+00    9.860262E+00    *GD      41
*GD      41     -1.142711E+00
GRID     *42                                      2.199200E+00    9.625038E+00    *GD      42
*GD      42     -1.183993E+00
GRID     *43                                      4.878750E-01    1.099476E+01    *GD      43
*GD      43     -5.068682E-01
GRID     *44                                      5.593370E-01    1.085660E+01    *GD      44
*GD      44     -5.470380E-01
GRID     *45                                      7.476242E-01    1.062701E+01    *GD      45
*GD      45     -6.576909E-01
GRID     *46                                      1.137788E+00    1.008176E+01    *GD      46
*GD      46     -8.041450E-01
GRID     *47                                      1.466719E+00    9.623438E+00    *GD      47
*GD      47     -8.569880E-01
GRID     *48                                      1.670425E+00    9.369388E+00    *GD      48
*GD      48     -8.965883E-01
GRID     *49                                      1.905910E+00    9.134694E+00    *GD      49
*GD      49     -9.252617E-01
GRID     *50                                     -1.396976E-02    1.059563E+01    *GD      50
*GD      50     -1.396792E-01
GRID     *51                                      7.075590E-02    1.044524E+01    *GD      51
*GD      51     -2.047331E-01
GRID     *52                                      2.875357E-01    1.012399E+01    *GD      52
*GD      52     -3.129540E-01
GRID     *53                                      7.360002E-01    9.570383E+00    *GD      53
*GD      53     -5.007564E-01
GRID     *54                                      1.103680E+00    9.064291E+00    *GD      54
*GD      54     -5.847520E-01
GRID     *55                                      1.308623E+00    8.811132E+00    *GD      55
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S O R T E D   B U L K   D A T A   E C H O

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.   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
*GD      55    -6.212754E-01
GRID     *56                             1.586562E+00    8.499916E+00    *GD     56
*GD      56    -6.411608E-01
GRID     *57                            -4.000301E-01    1.022161E+01    *GD     57
*GD      57     1.274626E-01
GRID     *58                            -3.109443E-01    1.007667E+01    *GD     58
*GD      58     6.474346E-02
GRID     *59                            -4.257504E-02    9.746097E+00    *GD     59
*GD      59    -9.011447E-02
GRID     *60                             4.317413E-01    9.133682E+00    *GD     60
*GD      60    -2.848848E-01
GRID     *61                             8.400738E-01    8.629044E+00    *GD     61
*GD      61    -3.864452E-01
GRID     *62                             1.075119E+00    8.326850E+00    *GD     62
*GD      62    -4.330833E-01
GRID     *63                             1.372284E+00    7.998097E+00    *GD     63
*GD      63    -4.656390E-01
GRID     *64                            -8.876041E-01    9.747480E+00    *GD     64
*GD      64     4.344531E-01
GRID     *65                            -7.852193E-01    9.579490E+00    *GD     65
*GD      65     3.506024E-01
GRID     *66                            -4.903399E-01    9.209817E+00    *GD     66
*GD      66     1.900352E-01
GRID     *67                             8.824563E-02    8.577651E+00    *GD     67
*GD      67    -4.811718E-02
GRID     *68                             5.764167E-01    8.055484E+00    *GD     68
*GD      68    -1.965310E-01
GRID     *69                             8.417380E-01    7.754916E+00    *GD     69
*GD      69    -2.687562E-01
GRID     *70                             1.127948E+00    7.304899E+00    *GD     70
*GD      70    -3.480781E-01
GRID     *71                            -1.340348E+00    9.248205E+00    *GD     71
*GD      71     6.895647E-01
GRID     *72                            -1.211896E+00    9.064268E+00    *GD     72
*GD      72     5.941403E-01
GRID     *73                            -8.663878E-01    8.684826E+00    *GD     73
*GD      73     4.148975E-01
GRID     *74                            -1.849050E-01    7.997163E+00    *GD     74
*GD      74     1.370639E-01
GRID     *75                             3.419222E-01    7.404170E+00    *GD     75
*GD      75    -6.006306E-02
GRID     *76                             6.469184E-01    7.104341E+00    *GD     76
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S O R T E D   B U L K   D A T A   E C H O

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.   1  ..   2   ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
*GD     76    -1.762950E-01
GRID    *77                                  9.723798E-01    6.754175E+00    *GD    77
*GD     77    -2.997903E-01
GRID    *78                                 -1.721028E+00    8.748784E+00    *GD    78
*GD     78     8.876511E-01
GRID    *79                                 -1.560428E+00    8.580663E+00    *GD    79
*GD     79     7.867939E-01
GRID    *80                                 -1.135652E+00    8.151909E+00    *GD    80
*GD     80     5.662700E-01
GRID    *81                                 -4.147282E-01    7.403061E+00    *GD    81
*GD     81     2.401156E-01
GRID    *82                                  1.852081E-01    6.753466E+00    *GD    82
*GD     82    -9.743430E-03
GRID    *83                                  5.310093E-01    6.498033E+00    *GD    83
*GD     83    -1.498038E-01
GRID    *84                                  9.002047E-01    6.103145E+00    *GD    84
*GD     84    -2.552683E-01
GRID    *85                                 -2.167293E+00    7.999124E+00    *GD    85
*GD     85     1.095234E+00
GRID    *86                                 -1.965024E+00    7.748323E+00    *GD    86
*GD     86     9.662098E-01
GRID    *87                                 -1.447637E+00    7.370351E+00    *GD    87
*GD     87     7.037064E-01
GRID    *88                                 -5.651237E-01    6.672748E+00    *GD    88
*GD     88     2.690339E-01
GRID    *89                                  1.080579E-01    6.122757E+00    *GD    89
*GD     89     9.317569E-03
GRID    *90                                  4.961708E-01    5.802341E+00    *GD    90
*GD     90    -1.257418E-01
GRID    *91                                  9.450005E-01    5.499189E+00    *GD    91
*GD     91    -2.549328E-01
GRID    *92                                 -2.501855E+00    6.998549E+00    *GD    92
*GD     92     1.159885E+00
GRID    *93                                 -2.243557E+00    6.869573E+00    *GD    93
*GD     93     1.004043E+00
GRID    *94                                 -1.663980E+00    6.498133E+00    *GD    94
*GD     94     6.963711E-01
GRID    *95                                 -6.590906E-01    5.998307E+00    *GD    95
*GD     95     2.671809E-01
GRID    *96                                  1.295218E-01    5.498876E+00    *GD    96
*GD     96    -1.361039E-02
GRID    *97                                  5.590804E-01    5.251667E+00    *GD    97
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S O R T E D   B U L K   D A T A   E C H O

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.   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
*GD     97    -1.359098E-01
GRID     *98                                        1.008383E+00     5.000014E+00     *GD     98
*GD     98    -2.679553E-01
GRID     *99                                       -2.658578E+00     5.997640E+00     *GD     99
*GD     99     1.050546E+00
GRID     *100                                      -2.343632E+00     5.902313E+00     *GD    100
*GD    100     9.020252E-01
GRID     *101                                      -1.669497E+00     5.672649E+00     *GD    101
*GD    101     6.170529E-01
GRID     *102                                      -5.963364E-01     5.302208E+00     *GD    102
*GD    102     2.088603E-01
GRID     *103                                       1.954939E-01     4.999296E+00     *GD    103
*GD    103    -4.400190E-02
GRID     *104                                       6.204426E-01     4.870985E+00     *GD    104
*GD    104    -1.597679E-01
GRID     *105                                       1.050502E+00     4.750490E+00     *GD    105
*GD    105    -2.685744E-01
GRID     *106                                      -2.496761E+00     4.997375E+00     *GD    106
*GD    106     8.496489E-01
GRID     *107                                      -2.194051E+00     4.997557E+00     *GD    107
*GD    107     7.381414E-01
GRID     *108                                      -1.543487E+00     4.903041E+00     *GD    108
*GD    108     4.893306E-01
GRID     *109                                      -5.069078E-01     4.751890E+00     *GD    109
*GD    109     1.591752E-01
GRID     *110                                       2.414709E-01     4.620979E+00     *GD    110
*GD    110    -6.520444E-02
GRID     *111                                       6.511260E-01     4.550488E+00     *GD    111
*GD    111    -1.757268E-01
GRID     *112                                       1.101048E+00     4.450042E+00     *GD    112
*GD    112    -2.750542E-01
GRID     *113                                      -2.273488E+00     4.304033E+00     *GD    113
*GD    113     6.919722E-01
GRID     *114                                      -1.994164E+00     4.303668E+00     *GD    114
*GD    114     5.999017E-01
GRID     *115                                      -1.405457E+00     4.402983E+00     *GD    115
*GD    115     3.958974E-01
GRID     *116                                      -4.174645E-01     4.351565E+00     *GD    116
*GD    116     1.095533E-01
GRID     *117                                       3.215386E-01     4.300690E+00     *GD    117
*GD    117    -8.331943E-02
GRID     *118                                       7.212664E-01     4.250240E+00     *GD    118
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.   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
*GD     118    -1.836711E-01
GRID    *119                            1.151106E+00    4.249871E+00    *GD     119
*GD     119    -2.738665E-01
GRID    *120                           -1.996529E+00    3.623911E+00    *GD     120
*GD     120     5.362222E-01
GRID    *121                           -1.717033E+00    3.593472E+00    *GD     121
*GD     121     4.447856E-01
GRID    *122                           -1.167562E+00    3.662519E+00    *GD     122
*GD     122     2.925791E-01
GRID    *123                           -2.483512E-01    3.751040E+00    *GD     123
*GD     123     4.970558E-02
GRID    *124                            4.511786E-01    3.800256E+00    *GD     124
*GD     124    -1.118595E-01
GRID    *125                            8.409850E-01    3.799903E+00    *GD     125
*GD     125    -2.023238E-01
GRID    *126                            1.290810E+00    3.799548E+00    *GD     126
*GD     126    -2.828727E-01
GRID    *127                           -1.608941E+00    2.873360E+00    *GD     127
*GD     127     3.625186E-01
GRID    *128                           -1.308840E+00    2.992764E+00    *GD     128
*GD     128     2.919613E-01
GRID    *129                           -9.387804E-01    3.101987E+00    *GD     129
*GD     129     2.111757E-01
GRID    *130                           -8.885711E-02    3.300630E+00    *GD     130
*GD     130     1.195536E-01
GRID    *131                            5.608683E-01    3.500004E+00    *GD     131
*GD     131    -1.414182E-01
GRID    *132                            9.507490E-01    3.499724E+00    *GD     132
*GD     132    -2.217990E-01
GRID    *133                            1.369986E+00    3.600738E+00    *GD     133
*GD     133    -2.995755E-01
GRID    *134                           -1.368847E+00    2.576391E+00    *GD     134
*GD     134     2.804042E-01
GRID    *135                           -1.139708E+00    2.642426E+00    *GD     135
*GD     135     2.214295E-01
GRID    *136                           -7.496524E-01    2.721577E+00    *GD     136
*GD     136     1.307743E-01
GRID    *137                           -4.592137E-01    3.001000E+00    *GD     137
*GD     137     9.034532E-02
GRID    *138                           -4.695653E-01    2.760897E+00    *GD     138
*GD     138     7.035846E-02
GRID    *139                           -2.695652E-01    2.800594E+00    *GD     139
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S O R T E D   B U L K   D A T A   E C H O

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 .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
*GD  139    3.012025E-02
GRID   *140                                     3.953020E-01    2.830271E+00    *GD   140
*GD  140   -2.015355E-02
GRID   *141                                     2.705058E-01    2.980117E+00    *GD   141
*GD  141   -5.050298E-02
GRID   *142                                     4.705606E-01    3.069980E+00    *GD   142
*GD  142   -8.079284E-02
GRID   *143                                     7.906197E-01    3.199841E+00    *GD   143
*GD  143   -1.611942E-01
GRID   *144                                     1.100652E+00    3.339638E+00    *GD   144
*GD  144   -2.316611E-01
GRID   *145                                     1.475051E+00    3.454741E+00    *GD   145
*GD  145   -2.780864E-01
GRID   *146                                    -4.697902E-01    2.440455E+00    *GD   146
*GD  146    9.014469E-02
GRID   *147                                    -2.698651E-01    2.440315E+00    *GD   147
*GD  147    4.007889E-02
GRID   *148                                     8.703647E-05    2.440156E+00    *GD   148
*GD  148   -1.476011E-05
GRID   *149                                     2.700679E-01    2.440040E+00    *GD   149
*GD  149   -4.009397E-02
GRID   *150                                     4.700607E-01    2.439936E+00    *GD   150
*GD  150   -8.013493E-02
GRID   *151                                    -4.700000E-01    2.060000E+00    *GD   151
*GD  151    8.999997E-02
GRID   *152                                    -2.700000E-01    2.060000E+00    *GD   152
*GD  152    4.000000E-02
GRID   *153                                     .0              2.060000E+00    *GD   153
*GD  153    0.0
GRID   *154                                     2.700000E-01    2.060000E+00    *GD   154
*GD  154   -4.000000E-02
GRID   *155                                     4.700000E-01    2.060000E+00    *GD   155
*GD  155   -8.999997E-02
MAT1    1       1.6  E7         .35     .0004141
MKAERO2 .0      1.2     .0      1.5     .0      .15
MKAERO2 .0      .001    .0      .3      .0      .6      .0      .9
MKAERO2 36.     1.2     36.     1.5     36.0    .15
MKAERO2 36.     .001    36.     .3      36.     .6      36.     .9
MKAERO2 72.     1.2     72.     1.5     72.0    .15
MKAERO2 72.     .001    72.     .3      72.     .6      72.     .9
MKAERO2 108.    1.2     108.    1.5     108.    .15
MKAERO2 108.    .001    108.    .3      108.    .6      108.    .9
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S O R T E D   B U L K   D A T A   E C H O

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.   1  ..   2   ..   3   ..   4   ..   5   ..   6   ..   7   ..   8   ..   9   ..  10  .
MKAERO2 144.    1.2     144.    1.5     144.    .15
MKAERO2 144.    .001    144.    .3      144.    .6      144.    .9
MKAERO2 180.    1.2     180.    1.5     180.    .15
MKAERO2 180.    .001    180.    .3      180.    .6      180.    .9
MKAERO2 -108.   1.2     -108.   1.5     -108.   .15
MKAERO2 -108.   .001    -108.   .3      -108.   .6      -108.   .9
MKAERO2 -144.   1.2     -144.   1.5     -144.   .15
MKAERO2 -144.   .001    -144.   .3      -144.   .6      -144.   .9
MKAERO2 -36.    1.2     -36.    1.5     -36.    .15
MKAERO2 -36.    .001    -36.    .3      -36.    .6      -36.    .9
MKAERO2 -72.    1.2     -72.    1.5     -72.    .15
MKAERO2 -72.    .001    -72.    .3      -72.    .6      -72.    .9
PARAM   CTYPE   ROT
PARAM   IREF    6
PARAM   KGGIN   1
PARAM   KINDEX  0
PARAM   LMODES  6
PARAM   MAXMACH .95
PARAM   MINMACH 1.01
PARAM   MTYPE   COSINE
PARAM   NSEGS   10
PARAM   PRINT   YESB
PQUAD2  1       1       .012
PQUAD2  2       1       .024
PQUAD2  3       1       .032
PQUAD2  4       1       .036
PQUAD2  5       1       .030
PQUAD2  6       1       .018
PQUAD2  7       1       .014
PQUAD2  8       1       .028
PQUAD2  9       1       .037
PQUAD2  10      1       .043
PQUAD2  11      1       .036
PQUAD2  12      1       .022
PQUAD2  13      1       .016
PQUAD2  14      1       .032
PQUAD2  15      1       .042
PQUAD2  16      1       .051
PQUAD2  17      1       .042
PQUAD2  18      1       .023
PQUAD2  19      1       .018
PQUAD2  20      1       .034
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S O R T E D   B U L K   D A T A   E C H O

. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
PQUAD2	21	1	.053						
PQUAD2	22	1	.058						
PQUAD2	23	1	.046						
PQUAD2	24	1	.025						
PQUAD2	25	1	.021						
PQUAD2	26	1	.042						
PQUAD2	27	1	.061						
PQUAD2	28	1	.066						
PQUAD2	29	1	.051						
PQUAD2	30	1	.027						
PQUAD2	31	1	.024						
PQUAD2	32	1	.049						
PQUAD2	33	1	.070						
PQUAD2	34	1	.073						
PQUAD2	35	1	.057						
PQUAD2	36	1	.030						
PQUAD2	37	1	.028						
PQUAD2	38	1	.054						
PQUAD2	39	1	.078						
PQUAD2	40	1	.082						
PQUAD2	41	1	.065						
PQUAD2	42	1	.035						
PQUAD2	43	1	.031						
PQUAD2	44	1	.061						
PQUAD2	45	1	.088						
PQUAD2	46	1	.093						
PQUAD2	47	1	.075						
PQUAD2	48	1	.039						
PQUAD2	49	1	.038						
PQUAD2	50	1	.068						
PQUAD2	51	1	.098						
PQUAD2	52	1	.103						
PQUAD2	53	1	.083						
PQUAD2	54	1	.046						
PQUAD2	55	1	.041						
PQUAD2	56	1	.076						
PQUAD2	57	1	.110						
PQUAD2	58	1	.118						
PQUAD2	59	1	.091						
PQUAD2	60	1	.047						
PQUAD2	61	1	.043						
PQUAD2	62	1	.083						

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S O R T E D   B U L K   D A T A   E C H O

. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
PQUAD2	63	1	.120						
PQUAD2	64	1	.129						
PQUAD2	65	1	.100						
PQUAD2	66	1	.044						
PQUAD2	67	1	.045						
PQUAD2	68	1	.090						
PQUAD2	69	1	.135						
PQUAD2	70	1	.138						
PQUAD2	71	1	.100						
PQUAD2	72	1	.048						
PQUAD2	73	1	.053						
PQUAD2	74	1	.106						
PQUAD2	75	1	.152						
PQUAD2	76	1	.148						
PQUAD2	77	1	.099						
PQUAD2	78	1	.044						
PQUAD2	79	1	.063						
PQUAD2	80	1	.123						
PQUAD2	81	1	.171						
PQUAD2	82	1	.157						
PQUAD2	83	1	.099						
PQUAD2	84	1	.046						
PQUAD2	85	1	.071						
PQUAD2	86	1	.141						
PQUAD2	87	1	.206						
PQUAD2	88	1	.177						
PQUAD2	89	1	.112						
PQUAD2	90	1	.048						
PQUAD2	91	1	.084						
PQUAD2	92	1	.172						
PQUAD2	93	1	.232						
PQUAD2	94	1	.198						
PQUAD2	95	1	.135						
PQUAD2	96	1	.062						
PQUAD2	97	1	.119						
PQUAD2	98	1	.206						
PQUAD2	99	1	.266						
PQUAD2	100	1	.230						
PQUAD2	101	1	.152						
PQUAD2	102	1	.071						
PQUAD2	103	1	.161						
PQUAD2	104	1	.237						

S O R T E D   B U L K   D A T A   E C H O

1	2	3	4	5	6	7	8	9	10
PQUAD2	105	1	.347						
PQUAD2	106	1	.319						
PQUAD2	107	1	.167						
PQUAD2	108	1	.075						
PQUAD2	109	1	.222						
PQUAD2	110	1	.373						
PQUAD2	121	1	.242						
PQUAD2	122	1	.089						
PQUAD2	123	1	.441						
PQUAD2	124	1	.830						
PQUAD2	125	1	.830						
PQUAD2	126	1	.441						
PQUAD2	127	1	.441						
PQUAD2	128	1	.830						
PQUAD2	129	1	.830						
PQUAD2	130	1	.441						
PTRIA2	111	1	.531						
PTRIA2	112	1	.532						
PTRIA2	113	1	.396						
PTRIA2	114	1	.544						
PTRIA2	115	1	.590						
PTRIA2	116	1	.591						
PTRIA2	117	1	.557						
PTRIA2	118	1	.519						
PTRIA2	119	1	.396						
PTRIA2	120	1	.377						
RFORCE	1	0		113.34	1.0	.0	.0		
SPC1	1	4	1	57					
SPC1	1	6	7	91	98	134	145		
SPC1	1	123456	151	THRU	155				
STREAML11		134	136	143	145				
STREAML12		113	115	117	119				
STREAML13		99	101	103	105				
STREAML14		85	87	89	91				
STREAML15		71	73	75	77				
STREAML16		57	59	61	63				
STREAML17		43	45	47	49				
STREAML18		29	31	33	35				
STREAML19		15	17	19	21				
STREAML110		1	3	5	7				
STREAML21		4	11.075	3.028	0.278	1.626	0.686	9.763E-8	+STR 1
+STR 1	9152.	-15.899							

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.   1   ..   2   ..   3   ..   4   ..   5   ..   6   ..   7   ..   8   ..   9   ..  10   .
STREAML22        4          13.895  3.559   0.336   2.733   0.734   9.763E-8+STR    4
+STR   4   9794.   2.890
STREAML23        4          14.946  4.129   0.152   3.818   0.713   9.763E-8+STR    6
+STR   6   9512.  20.206
STREAML24        4          16.492  4.214  -0.355   5.068   0.618   9.763E-8+STR    8
+STR   8   8246.  38.813
STREAML25        4          17.712  3.542  -0.389   5.825   0.567   9.763E-8+STR   10
+STR  10   7558.  46.112
STREAML26        4          16.167  2.905  -0.367   6.423   0.528   9.763E-8+STR   12
+STR  12   7046.  50.138
STREAML27        4          17.910  2.376  -0.316   6.915   0.535   9.763E-8+STR   14
+STR  14   7139.  50.796
STREAML28        4          19.990  1.937  -0.369   7.350   0.556   9.763E-8+STR   16
+STR  16   7419.  50.323
STREAML29        4          23.516  1.558  -0.294   7.682   0.557   9.763E-8+STR   18
+STR  18   7424.  51.910
STREAML210       4          27.788  1.280  -0.541   7.913   0.587   9.763E-8+STR   20
+STR  20   7830.  50.992
ENDDATA
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