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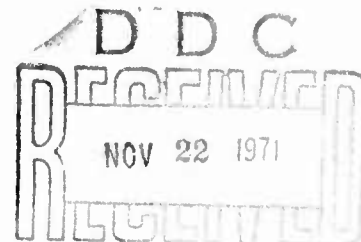
A STUDY OF FOLDING PROPROTOR VTOL AIRCRAFT DYNAMICS

VOLUME II. COMPUTER PROGRAMS

H. E. LOSEY

P. Y. HSIEH

BELL HELICOPTER COMPANY



TECHNICAL REPORT AFFDL-TR-71-7, VOLUME II

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FOREWORD

This report was prepared by Bell Helicopter Company of Fort Worth, Texas for the Aerospace Dynamics Branch, Vehicle Dynamics Division, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio under Contract F33615-69-C-1339. This research is part of a continuing dynamic and aeroelastic phenomena for rotor/propeller powered V/STOL flight vehicles under the Air Force Systems Command's exploratory development program. The Project Number is 1370, "Dynamic Problems in Military Flight Vehicles", Task Number is 137005, "Prediction and Control of Flight Vehicle Vibration". Mr. A. R. Basso of the Aerospace Dynamics Branch was the Project Engineer.

The final report is presented in two volumes. The first volume describes the development of analytical methods of predicting folding prop rotor (FPR) aircraft dynamic behavior, correlation of these methods with model test data, and the results of the dynamic analysis of a representative FPR design. The second volume is a guide to the digital computer programs and contains input and output formats and FORTRAN listings of the programs.

Mr. Troy Gaffey was the Bell Helicopter Company Project Engineer. The authors acknowledge the assistance of Dr. Jing Yen and Mr. Gottfried Weber in providing the equations of motion and in checking out the programs.

This report covers work conducted from February 1969 to February 1971. Manuscript was released by authors in February 1971 for publication as an AFFDL Technical Report.

This technical report has been reviewed and is approved.

Walter J. Morkow
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Asst. for Research & Technology
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ABSTRACT

This report describes the results of a study of the dynamic stability and response during the feathering and folding of the blades of a folding-prop rotor VTOL. This study involved the development of analytical methods of predicting the dynamic characteristics during feathering and folding, correlation of the theoretical methods with experimental data, a dynamic analysis of a representative folding-prop rotor VTOL design, and a parametric study to identify design factors which can be used to control dynamic characteristics during feathering and folding. Correlation of the theory with measured dynamic stability and response characteristics during feathering and folding is good, and indicates the analytical methods can be used with confidence. The results of the dynamic analysis indicate satisfactory stability and response characteristics can be achieved in a 66,000-pound gross-weight class, folding-prop rotor VTOL. The results of the parametric study are summarized in terms of design guidelines. This volume is a guide to the computer programs, and contains FORTRAN listings. Volume I contains the development of the theory, correlation of theory with experimental data, and the dynamic response and parametric study.

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LIST OF SYMBOLS

AC	aerodynamic center
a,b,c	coefficients
a_i	estimated lift curve slope
B	reference semichord
CG	center of gravity
C_T	chord tip
$\bar{D}Y_i$	actual geometric strip width
EA	elastic axis
EI	segment beam or chord stiffness
e	chord root divided by chord tip
$F(t)$	forcing function
{ F }	force matrix on a wing
GJ	segment torsional stiffness
h	integration interval
1/K	reduced velocity
$ k $	modified wing stiffness matrix
S	V_t divided by B
SIC	flexibility matrix
t	time
V	forward velocity
x	variable
{ x }	wing normal coordinate matrix
x_c	calculated value of x
x_g	guessed value of x

α	local angle of attack
ϵ	error tolerance
$\partial L / \partial \alpha$	lift curve slope
Δx	$x_c - x_g$
λ_R	real part of the eigenvalue
θ	element pitch

SECTION I

INTRODUCTION

This volume provides a guide to the use of the computer programs developed during this study. It also contains the information necessary to modify the programs or to adapt them to a given computer. A FORTRAN listing of the programs is included in this volume. It should be noted that the program listings are the only source for the complete equations of motion. Section II of Volume I provides an overview of the theory mechanized in the programs.

Three computer programs were developed: ARAP06, which treats that portion of the FPR transition mode where the blades are rotating, and DFAL17 and DFAL18, which treat that portion where the proprotor has been stopped and the blades are being folded. ARAP06 is all inclusive in that it may be used to calculate the stability, loads, and response in proprotor mode and during blade feathering. DFAL17 is used to calculate the system stability during folding; DFAL18, the loads and response during folding.

Sample cases for each program are contained in Appendix I. These include card data and condensed output.

SECTION II

USER GUIDE TO PROGRAMS

In preparing this section it is assumed that the reader has read Section II of Volume I and is familiar with the math model and capabilities and limitations of each program.

This user's guide consists of four parts for each program: (1) an input format identifying the information contained on each card, (2) an input format guide explaining the function and source of each input, (3) an output format and guide, and (4) suggested techniques for using the programs.

A. ARAP06 - FPR FEATHERING DYNAMICS ANALYSIS

The inputs to ARAP06 consist of two types of data: (1) math model configuration and control options and (2) vehicle descriptive data. The options allow the user to select the math model, the type of excitation and/or the maneuver to be considered, and the output data. The descriptive data consist of the geometry, certain spring rates, mass distributions, and the coupled normal modes of the subject vehicle.

To generate the normal mode input data the user must have access to a coupled beam-chord-torsion vibration analysis (to determine the normal modes of the wing/pylon system) and to a rotating beam vibration analysis (to determine the blade normal modes).

Because of the various options with regard to the math model, all of the input data will generally not be required. For example, in many cases the equations representing blade elastic motion may be deleted without significantly influencing the results. In those cases blade normal mode data are not required as a program input. Careful selection of the options for a given case can greatly reduce the data preparation effort.

Figure 1 illustrates the card order in a ARAP06 data deck.

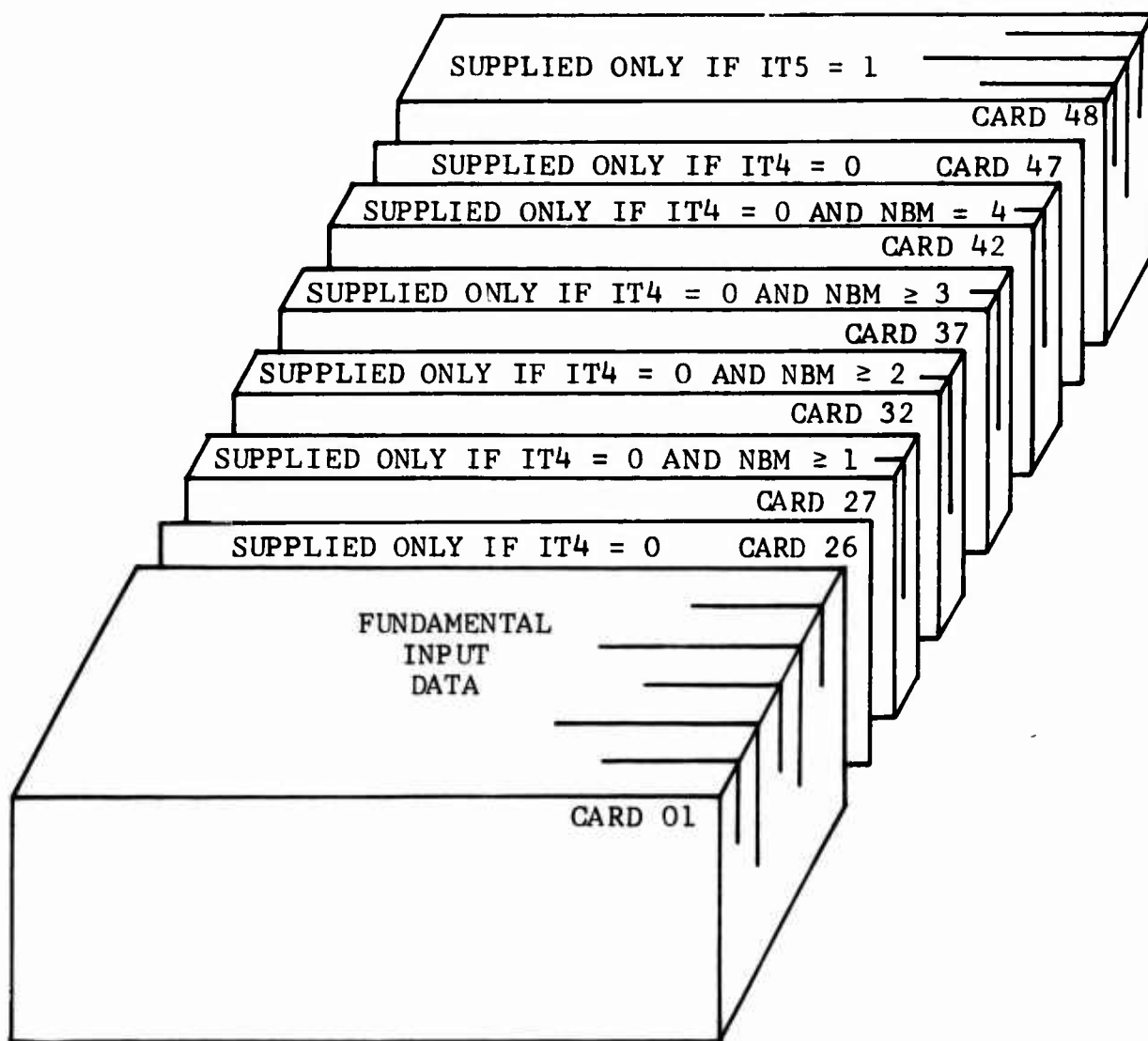


Figure 1. Card Order in ARAP06 Data Deck.

1. Input Format

CARD 01 Title Card; Column 1-80, alphameric.

CARD 02 Format 16I5:

Col. 1 - 5	IT1
Col. 6 - 10	IT2
Col. 11 - 15	IT3
Col. 16 - 20	IT4
Col. 21 - 25	IT5
Col. 26 - 30	IT6
Col. 31 - 35	IT7
Col. 36 - 40	IT8
Col. 41 - 45	IT9
Col. 46 - 50	IT10
Col. 51 - 55	IT11
Col. 56 - 60	IT12
Col. 61 - 65	IT13
Col. 66 - 70	IT14
Col. 71 - 75	IT15

CARD 03 Format 16I5:

Col. 1 - 5	NS
Col. 6 - 10	NBM
Col. 11 - 15	NMT
Col. 16 - 20	NTHC
Col. 21 - 25	NPSID
Col. 26 - 30	NCASE

CARD 04 Format 8F10.0:

(1) Pylon length	(in)
(2) Speed of sound	(ft/sec)
(3) Air density	(slug/ft ³)
(4) Pylon conversion angle	(deg)
(5) Structural damping ratio of rotor-blades	
(6) Rotor rpm	(rpm)
(7) Blade fundamental torsional natural frequency	(rad/sec)
(8) Gravitational acceleration	(in/sec ²)

CARD 05 Format 8F10.0:

(1) Blade built-in precone angle	(deg)
(2) Blade pitch-flap coupling, (δ_3)	
(3) Blade collective pitch at initial rpm	(deg)
(4) Blade lateral cyclic pitch	(deg)
(5) Blade longitudinal cyclic pitch	(deg)
(6) Aircraft true airspeed	(kt)
(7) Real time limit	(sec)
(8) Gravitational acceleration	(in/sec ²)

CARD 06 Format 8F10.0:

(1)	Integration interval	(sec)
(2)	Initial azimuth position of master blade	(deg)
(3)		
(4)		
(5)		
(6)		
(7)		
(8)		

CARD 07 Format 8F10.0:

(1)	RPM 1	(rpm)
(2)	RPM 2	(rpm)
(3)	RPM 3	(rpm)
(4)	RPM 4	(rpm)
(5)	Longitudinal hub restraint spring rate for rpm 1	(ft-lb/deg)
(6)	Longitudinal hub restraint spring rate for rpm 2	(ft-lb/deg)
(7)	Longitudinal hub restraint spring rate for rpm 3	(ft-lb/deg)
(8)	Longitudinal hub restraint spring rate for rpm 4	(ft-lb/deg)

CARD 08 Format 8F10.0:

(1)	Lateral hub restraint spring rate for rpm 1	(ft-lb/deg)
(2)	Lateral hub restraint spring rate for rpm 2	(ft-lb/deg)
(3)	Lateral hub restraint spring rate for rpm 3	(ft-lb/deg)
(4)	Lateral hub restraint spring rate for rpm 4	(ft-lb/deg)
(5)	Flapping stop spring rate	(ft-lb/deg)
(6)	Blade flapping amplitude at which flapping stop is encountered	(deg)
(7)		
(8)		

CARD 09 Format 8F10.0:

(1)	Blade collective pitch at which feathering or unfeathering is to end	(deg)
(2)	Real time at which feathering or unfeathering starts	(sec)
(3)	Real time at which feathering or unfeathering ends	(sec)
(4)		

- (5)
- (6)
- (7)
- (8)

CARD 10

Format 8F10.0:

- (1) Amplitude of vertical gust (in/sec)
- (2) Amplitude of head-on gust (in/sec)
- (3) Frequency of sinusoidal gust (cps)
- (4) Real time at which sharp-edged gust starts (sec)
- (5) Real time at which sharp-edged gust ends (sec)
- (6) Real time at which 1-cosine shaped gust starts (sec)
- (7) Real time at which 1-cosine shaped gust ends (sec)
- (8)

CARD 11

Format 8F10.0:

- (1) Wing angle of attack (deg)
- (2) Mean aerodynamic chord of wing (in)
- (3) Two-dimensional lift curve slope of wing (/rad)
- (4) Wing thickness ratio
- (5) Wing sweep angle (deg)
- (6) Distance between pylon conversion hinge and leading edge of wing at wing tip (in)
- (7) Distance between shaft hinge and wing tip section (in)
- (8)

CARD 12

Format 8F10.0:

- (1) Initial frequency of cosine function for swashplate lateral excitation (cps)
- (2) Initial frequency of sine function for swashplate lateral excitation (cps)
- (3) Initial frequency of cosine function for swashplate longitudinal excitation (cps)
- (4) Initial frequency of sine function for swashplate longitudinal excitation (cps)
- (5) Amplitude of cosine function for function for swashplate lateral excitation (deg)
- (6) Amplitude of sine function for swashplate lateral excitation (deg)
- (7) Amplitude of cosine function for swashplate longitudinal excitation (deg)
- (8) Amplitude of sine function for swashplate longitudinal excitation (deg)

CARD 13 Format 8F10.0:

- (1) Rate-of-change of frequency of cosine function for swashplate lateral excitation (cyc/sec²)
- (2) Rate-of-change of frequency of sine function for swashplate lateral excitation (cyc/sec²)
- (3) Rate-of-change of frequency of cosine function for swashplate longitudinal excitation (cyc/sec²)
- (4) Rate-of-change of frequency of sine function for swashplate longitudinal excitation (cyc/sec²)
- (5) Real time at which both excitations of swashplate start (sec)
- (6)
- (7)
- (8)

CARD 14 Format 8F10.0:

- (1) Component in a cartesian coordinate to define the location of an aerodynamic vane (in)
- (2) Component in a cartesian coordinate to define the location of an aerodynamic vane (in)
- (3) Component in a cartesian coordinate to define the location of an aerodynamic vane (in)
- (4) Span of aerodynamic vane (in)
- (5) Chord of aerodynamic vane (in)
- (6) Initial frequency for aerodynamic vane excitation (cps)
- (7) Steady angle-of-attack of aerodynamic vane, relative to pylon (deg)
- (8) Amplitude of angle-of-attack oscillation of aerodynamic vane, relative to pylon (deg)

CARD 15 Format 8F10.0:

- (1) Real time at which excitation of aerodynamic vane starts (sec)
- (2) Two-dimensional lift curve slope for aerodynamic vane (/deg)
- (3) Rate-of-change of the excitation frequency for aerodynamic vane (cyc/sec²)
- (4)
- (5)
- (6)
- (7)
- (8)

CARD 16*	Format 8F10.0: Blade build-in twists	(deg)
CARD 17*	Format 8F10.0: Radial distances to blade discrete masses	(in)
CARD 18*	Format 8F10.0: Discrete blade masses	(chug)**
CARD 19*	Format 8F10.0: Blade mass unbalances	(in)
CARD 20*	Format 8F10.0: Blade torsional mass moments-of-inertia	(chug-in ²)
CARD 21*	Format 8F10.0: Distances from blade feathering axis to blade aerodynamic center	(in)
CARD 22*	Format 8F10.0: Distances from blade aerodynamic center to blade center of gravity	(in)
CARD 23*	Format 8F10.0: Distances from blade aerodynamic center to blade elastic axis	(in)
CARD 24*	Format 8F10.0: Blade chord lengths	(in)
CARD 25*	Format 8F10.0: Blade aerodynamic segment lengths	(in)
CARD 26	Format 13F6.0, 2X: Blade root collective pitches followed by rotor angular velocities	(deg & rad/sec)
CARD 27	Col. 1 - 80, alphameric. Title card to identify blade first normal mode	
CARD 28*	Format 13F6.0, 2X: Blade natural frequencies for first normal mode	(rad/sec)

* Indicates more than one card may be required for these data.

**A unit of mass. The corresponding unit of acceleration is in inches per second².

Col. 1 - 5	LC(1)
Col. 6 - 10	LC(2)
Col. 11 - 15	LC(3)
Col. 16 - 20	KDR

Normalized blade flexible (in/in,
out-of-plane, in-plane, and in/in,
torsional modes rad/in)

Blade normalized beamwise bending moments and chordwise bending moments (in-lb/in)

CARD 36

CARD 41

CARD 46

Initial conditions of normal coordinates for flexible blades

Col. 1 - 5	NSW
Col. 6 - 10	NSHP
Col. 11 - 15	NPDD

(1)	Wing structural damping ratio	
(2)	Pylon mass	(chug)
(3)	Component of distance from pylon conversion axis to pylon center of gravity in cartesian coordinates	(in)
(4)	Component of distance from pylon conversion axis to pylon center of gravity in cartesian coordinates	(in)
(5)	Component of distance from pylon conversion axis to pylon center of gravity in cartesian coordinates	(in)

9

	(6) Hub mass	(chug)
	(7) Mean distance from wing aerodynamic center to its elastic axis	(in)
	(8) Pylon pitching mass moment-of-inertia about its center of gravity	(chug-in ²)
CARD 50	Format 8F10.0: Initial conditions for wing normal coordinates	
CARD 51*	Format 8F10.0: Wing chordwise normal modes	(in/in)
CARD 52*	Format 8F10.0: Wing beamwise normal modes	(in/in)
CARD 53*	Format 8F10.0: Wing torsional normal modes	(rad/in)
CARD 54*	Format 8F10.0: Discrete wing masses, wing torsional mass moments-of-inertia, wing mass unbalances, and wing aerodynamic segment lengths	(chug, chug-in ² , in, in)
CARD 55*	Format 8F10.0: Wing/pylon natural frequencies; normalized F/A deflections, lateral deflections, and vertical deflections at CA Normalized pylon yawings, pitchings, and effective masses	(rad/sec, in/in, in/in, in/in, rad/in, rad/in, chug)
CARD 56*	Format 5D15.0: Elements of stiffness matrix at a specified wing buttline	
CARD 57*	Format 8F10.0: Locations of pylon accelerometers, relative to pylon conversion axis	(in)

*Indicates more than one card may be required for these data

2. Guide to Input Format

CARD 01 This card is used to identify the output.

CARD 02 This card is used to specify the options desired. The options selected will depend on the configuration simulated and on the users objectives. It is pointed out that much of the other data which must be supplied is dependent to some extent on the options selected. Any discrepancy between the data requirements of the options selected and the data supplied will cause the program to terminate.

IT1 allows the hub restraint springs used with a gimbaled rotor to be simulated.

If IT1 = 0, hub restraint springs are not simulated.

If IT1 = 1, hub restraint springs are simulated.

IT2 is used to feather or unfeather the blades to start or stop the propotor.

If IT2 = 0, the blades will be feathered or unfeathered.

If IT2 = 1, the blade collective pitch will be constant.

IT3 is used to simulate a discrete gust encounter or an oscillation of a wind tunnel airstream such as in the NASA-Langley 16-foot TDT.

If IT3 = 0, no gust will be encountered.

If IT3 = 1, a sharp edged gust will be encountered.

If IT3 = 2, a 1-cosine gust of specified length will be encountered.

If IT3 = 3, a continuous, sinusoidal gust is applied.

IT4 allows the program to be run with or without the blade elastic degrees of freedom.

If IT4 = 0, the blade elastic degrees of freedom will be simulated (cards 26-47 must be supplied).

If IT4 = 1, the blades are rigid (cards 26-47 must be deleted).

IT5 allows the program to be run with or without the wing/pylon elastic degrees of freedom.

If IT5 = 0, the wing degrees of freedom are deleted (cards 48 through end of deck must be deleted).

If IT5 = 1, the wing/pylon degrees of freedom are simulated (cards 48 through end of deck must be supplied).

IT6 gives the user a choice as to machine plotted data.

If IT6 = 0, plots will not be generated.

If IT6 = 1, time histories will be plotted for rotor rpm, longitudinal and lateral flapping, rotor H-force, rotor Y-force, rotor thrust, and torque.

If IT6 = 2, time histories will be plotted for the inplane and out-of-plane deflections of the master blade, beamwise and chordwise bending moments at the first specified blade station, beamwise and chordwise moments at the second specified blade station and flapping in the rotating system.

If IT6 = 3, time histories will be plotted for the wing tip beamwise, chordwise and, torsional deflections, vertical accelerations of the first two specified accelerometers, and the axial and lateral accelerations at the first accelerometer.

IT7 allows the aerodynamic interference between the wing and rotor to be simulated.

If IT7 = 0, the aerodynamic interference will be zero.

If IT7 = 1, the aerodynamic interference will be simulated.

IT8 allows the user to excite the system using either the swashplate or an aerodynamic vane located on the pylon.

If IT8 = 0, there is no excitation.

If IT8 = 1, the swashplate will be excited cyclically.

If IT8 = 2, the aerodynamic vane will be oscillated in pitch.

IT9 allows the user to collect peak values for several variables throughout the time history. This option prints out at the end of the output data the maximum and minimum values of master blade flapping (rotating system), beamwise and chordwise deflections of the wing tip, and the first normal coordinate of the wing/pylon system.

If IT9 = 0, peaks will not be printed out.

If IT9 = 1, peaks are printed out.

IT10 allows the accelerations at specified pylon stations to be calculated and printed out.

If IT10 = 0, the accelerations will not be printed.

If IT10 = 1, the accelerations at up to nine specified locations will be printed.

If IT5 = 0, this option is ignored by the program.

IT11 allows wing bending moments to be calculated.

If IT11 = 0, wing bending moments will not be calculated.

If IT11 = 1, wing bending moments at a specified station will be calculated and printed out.

IT12 allows the user a choice of rigid-body freedoms of the proprotor.

If IT12 = 0, a gimbaled semirigid rotor with rotational freedom (variable rpm) is simulated.

If IT12 = 1, the blade rigid-body flapping is locked out to allow simulating of hingeless or articulated rotors. Rotor rpm is a variable.

If IT12 = 2, the rotor rpm is constant (flapping is free).

If IT12 = 3, the rigid-body flapping and rotational freedoms are locked out.

IT13 allows the effective mass of the wing/pylon modes to be calculated by the program.

If IT13 = 0, the wing/pylon normal modes effective masses are calculated internally.

If IT13 = 1, input values of the wing/pylon effective masses are used (card 55).

IT14 is used to overcome a numerical problem often encountered with time history analyses. In some cases pylon accelerations with frequencies the same as one-half the reciprocal of the integration interval have been encountered. By averaging the accelerations to be calculated these high frequency accelerations can be eliminated.

If IT14 = 0, no averaging takes place.

If IT14 = 1, calculated accelerations are averaged.

IT15 is not used at present.

CARD 03 is used to read in parameters which specify the amount of the input data to follow.

NS is the number of blade lumped mass stations.
 $0 < NS \leq 10$

NBM is the number of normal blade modes used.
 $0 < NBM \leq 4$. NBM is used only if IT4 = 0.

NMT is the number of blade stations at which blade bending moments are to be calculated.
 $0 < NMT \leq 4$. NMT is used only if IT4 = 0.

NTHC is the number of blade collective pitch angles used in the blade normal mode tables. $0 < NTHC \leq 6$

NPSID is the number of rotor rpm used in the blade normal mode tables. $0 < \text{NPSID} \leq 6$

NCASE number of cases in a single computer run. It is read in from the data deck of the first case only. If NCASE is left blank, the program will assume there is only one case.

CARD 04 contains descriptive data.

ZH is the pylon length; the distance from the pylon conversion axis to the rotor hub.

S is the speed of sound; must be greater than zero.

RHO is the air density. If it is input as zero, computation of rotor aerodynamics, wing aerodynamics, pylon aerodynamic excitation, and the wing/rotor aerodynamic interference is not made. If user does not wish to include rotor aerodynamic forces, zeros should be input on card 25. If user does not wish to include wing aerodynamics, zeros should be input for the wing aerodynamic segment lengths on card 54.

TPC is the pylon conversion angle, measured relative to flight path. It is zero for a proprotor in propeller mode, 90 degrees for helicopter mode.

BZETA is the blade structural damping ratio, ignored by the program if $\text{IT4} = 1$.

RPM is initial rotor rpm. $\text{rpm} \geq 0$

OMT is blade fundamental torsional natural frequency. $\text{OMT} > 0$. OMT is used in the calculation of blade pitch damping coefficients.

G is the gravitational acceleration normal to the wing. $G \geq 0$

CARD 05 a_0 is the rotor precone angle.

δ_3 is the blade pitch-flap coupling. Positive if blade pitch decreases when the blade flaps upward.

θ_c is the blade initial collective pitch. Corresponds to initial rotor rpm.

A_1 is the blade lateral cyclic pitch (sign convention is that given in Reference 1).

B_1 is the blade longitudinal cyclic pitch.

U is the velocity along flight path. Must be greater than or equal to zero.

REALTM the real time required for the case. Program execution is contained in the time history loop until REALTM is reached. To avoid waste of machine time due to input errors the program is terminated if the rotor rotational speed is below -2 rad/sec.

GY Gravitational acceleration parallel to the wing span. For example, GY is used for a wind tunnel floor-mounted semispan model wing.

CARD 06 DTMIN is the time increment used in the time history calculation. The user should not attempt to use a DTMIN which is larger than the equivalent of $\Delta\psi = 15$ degrees. A value of DTMIN = 0.005 second is picked by the program if it is not specified. Experience suggests the use DTMIN = 0.005 second for runs where the blade normal modes are included. Otherwise the following DTMINs may be used:

For rotor rpm ≥ 300	DTMIN = 0.006 second
300 rotor rpm ≥ 200	DTMIN = 0.007 second
200 rotor rpm ≥ 100	DTMIN = 0.01 second
rotor rpm < 100	DTMIN = 0.012 second

Since averaging process is taken if IT14 = 1, integration interval will then be twice of DTMIN. This doubled value should not be larger than the equivalent of $\Delta\psi = 15$ degrees.

PSIE is the initial azimuth position of the master blade.

CARD 07

The data on this card can be used to simulate a nonisotropic, variable rate, hub restraint spring. The rpm range is divided into three parts, and the variation of spring rate is assumed to be linear over these three regions, see Figure 2.

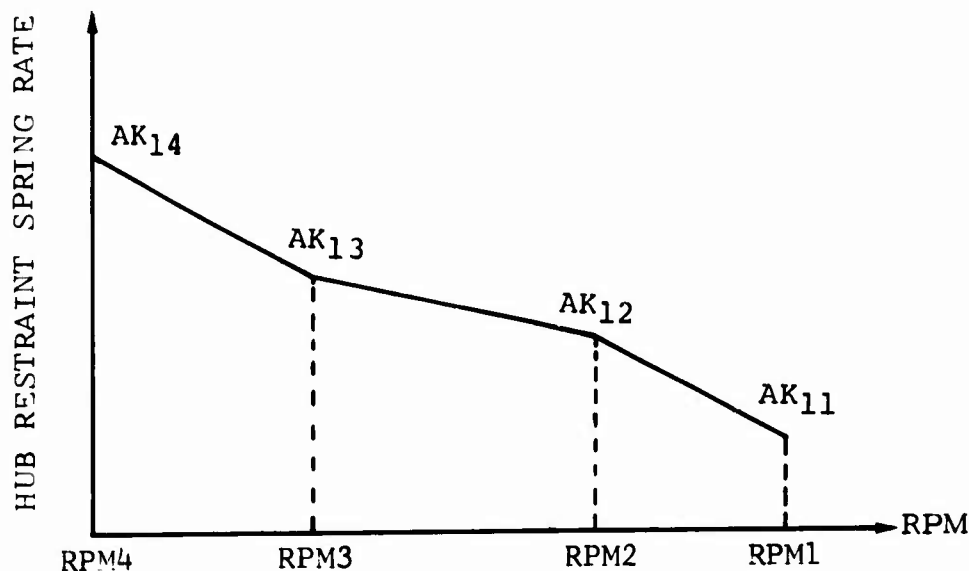


Figure 2. Hub Restraint Spring Rate-rpm Relationship.

The first four floating point numbers, RPM1, RPM2, RPM3, and RPM4 give the rpm at which the spring rate is specified. The last four, AK11, AK12, AK13, and AK14, specify the longitudinal hub spring rate at these rpm.

CARD 08

This card is used in conjunction with Card 07. The first four floating point numbers BK11, BK12, BK13, and BK14 give the lateral hub spring rates at the four rpm specified on Card 07. The fifth, STOPK, is a hub spring rate simulating flapping stops. The sixth, STOPTH, is the blade flapping angle at which the blade (or hub) contacts the flapping stop. If the longitudinal hub spring rate on Card 07 is constant, and the lateral hub spring rate on Card 08 is also constant; it is then suggested that zeros be input for each rpm to avoid an interpolation requirement.

CARD 09 This card controls blade feathering. It is ignored if $IT2 = 1$.

THCMAX This is the blade collective pitch at which feathering or unfeathering stops.

TMST Real time at which feathering or unfeathering starts.

TMED Real time at which feathering or unfeathering ends.

CARD 10 This card specifies the magnitude and time a gust is encountered. The magnitude and time relationships are illustrated in Figure 3.

(a) Step Gust

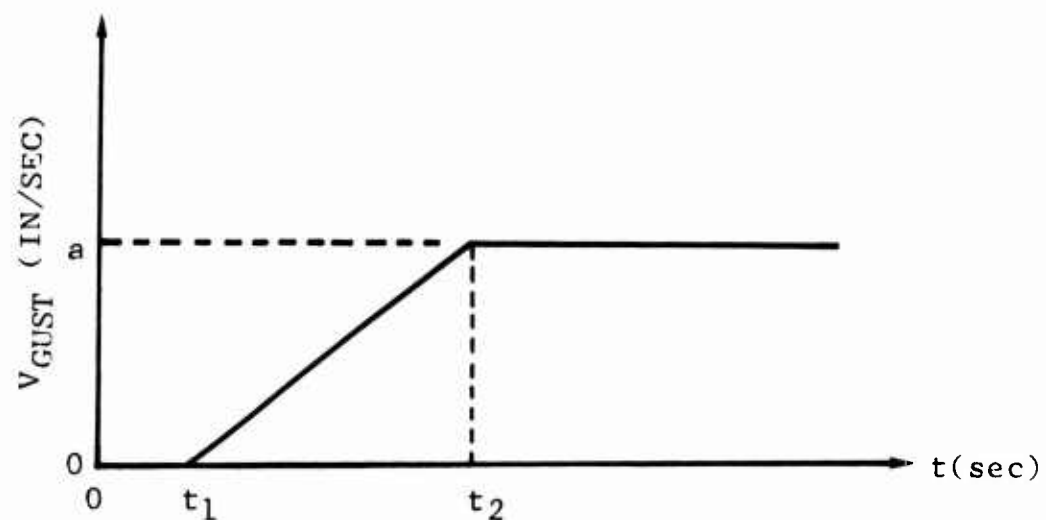
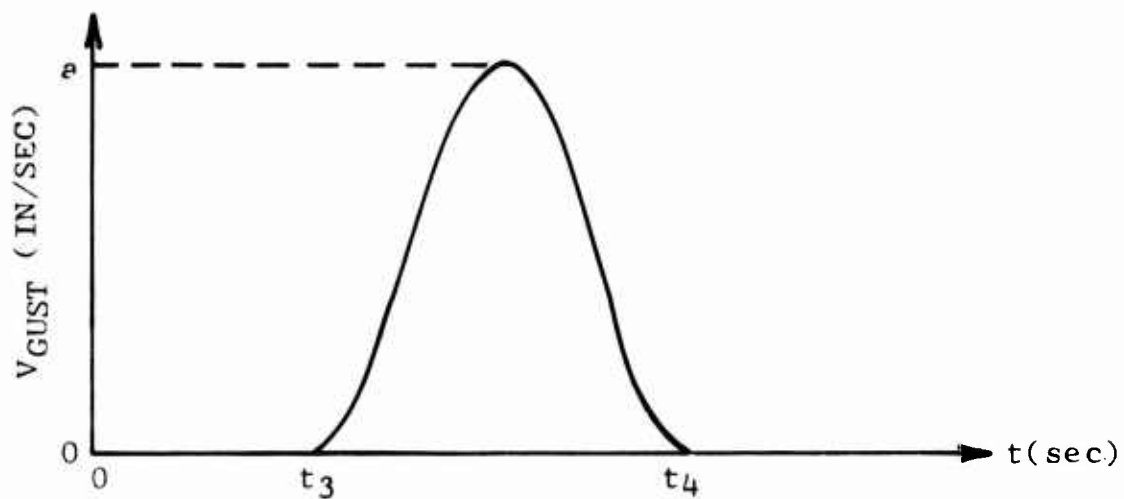


Figure 3. Gust Magnitude and Time Relationships.

(b) 1 - cosine gust

$$v_{\text{gust}} = a \sin^2 \left[\frac{\pi}{2} \frac{t - t_3}{(t_4 - t_3)/2} \right]$$



(c) Sinusoidal gust

$$v_{\text{gust}} = a \sin \omega t$$

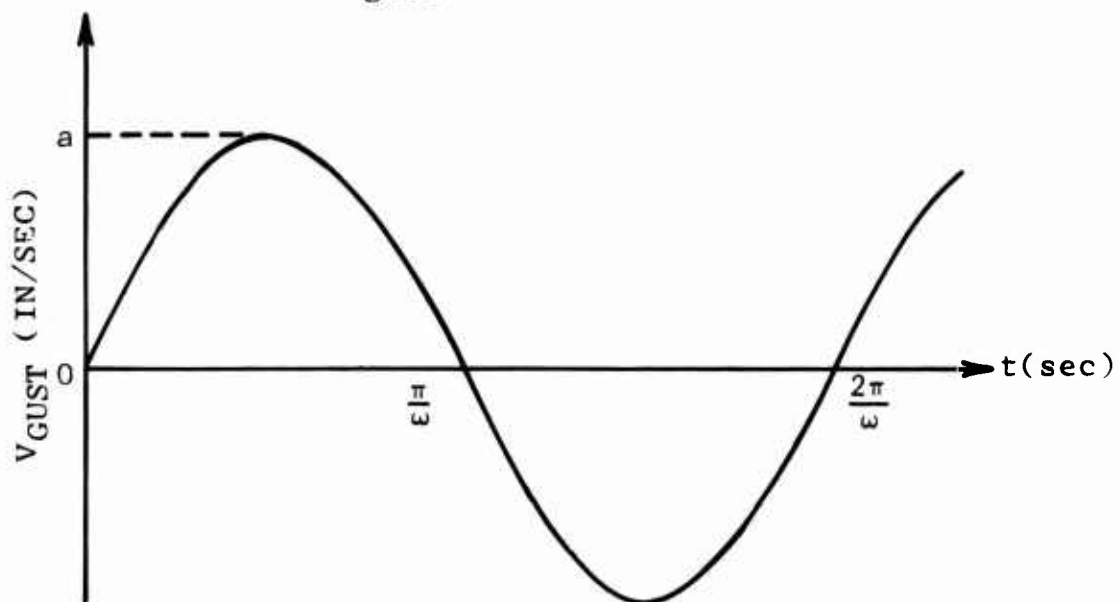


Figure 3. Concluded.

CARD 11 This card is used to specify wing aerodynamic and wing/rotor aerodynamic interference parameters. If $IT5 = 0$ and $IT7 = 0$, the data on this card will not be used.

ALW is the wing angle of attack. Positive wing leading-edge up.

WC is the wing mean aerodynamic chord, must be greater than zero.

SLC is the two-dimensional lift curve slope for wing. Stall is not considered.

DEL is the ratio of wing thickness to wing mean chord.

ALAM is the wing sweep angle, positive forward.

AL Illustrated in Figure 3.

YCA Illustrated in Figure 3.

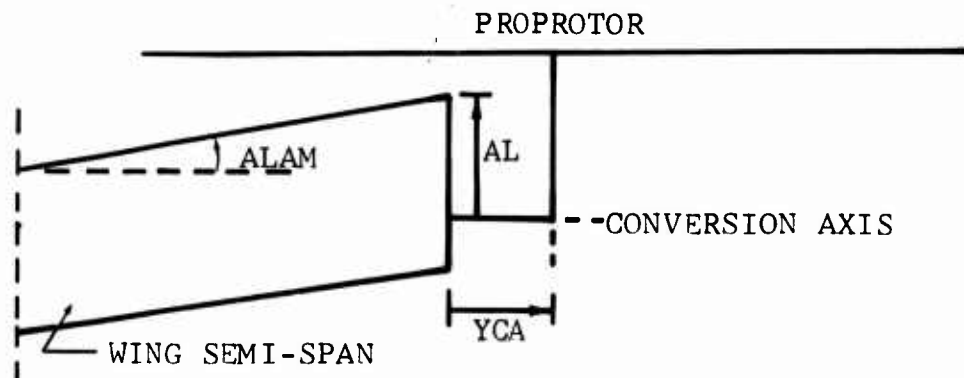


Figure 4. Rotor/Wing Geometrical Relations.

CARD 12 This card and Card 13 are used for swashplate cyclic excitation. For $IT8 = 1$, the position of the swashplate is given by:

for $t < t_\tau$

$$A_1(t) = A_1$$

$$B_1(t) = B_1$$

for $t \geq t_\tau$

$$A_1(t) = A_1 + A_{1c} \cos[\omega_{ac}(t-t_\tau)] + A_{1s} \sin[\omega_{as}(t-t_\tau)]$$

$$B_1(t) = B_1 + B_{1c} \cos[\omega_{bc}(t-t_\tau)] + A_{1s} \sin[\omega_{bs}(t-t_\tau)]$$

where t_τ is the time excitation initiated.

And,

$$\omega_{ac} = \omega_{ac0} + \frac{\partial \omega_{ac}}{\partial t} (t-t_\tau)$$

$$\omega_{as} = \omega_{as0} + \frac{\partial \omega_{as}}{\partial t} (t-t_\tau)$$

$$\omega_{bc} = \omega_{bc0} + \frac{\partial \omega_{bc}}{\partial t} (t-t_\tau)$$

$$\omega_{bs} = \omega_{bs0} + \frac{\partial \omega_{bs}}{\partial t} (t-t_\tau)$$

The eight floating point numbers on this card are input in the order that: ω_{ac0} , ω_{as0} , ω_{bc0} , ω_{bs0} , A_{1c} , A_{1s} , B_{1c} , and B_{1s} .

CARD 13 Inputs are in the following order: $\partial \omega_{ac} / \partial t$, $\partial \omega_{as} / \partial t$, $\partial \omega_{bc} / \partial t$, $\partial \omega_{bs} / \partial t$, and t_τ .

CARD 14 The data on this card and Card 15 are used for an aerodynamic vane mounted on the pylon to excite the wing/pylon normal modes. The location and dimensions of the exciter can be specified. The angle of attack of the vane is calculated by

$$\alpha_e = \alpha_{pc} + \alpha_{0e} + \alpha_{0s} \sin[\omega_e(t-t_e)]$$

in which α_{pc} is the pylon conversion angle, α_{0e} and α_{0s} are the steady and oscillatory angle of attack of the vane relative to the pylon respectively, t_e is the time when excitation of the vane begins, and ω_e is the exciting frequency given by:

$$\omega_e = \omega_{e0} + \frac{\partial \omega_e}{\partial t}(t-t_e)$$

$\left. \begin{array}{l} \text{UE} \\ \text{VE} \\ \text{WE} \end{array} \right\}$ are the Cartesian coordinates used to locate the aerodynamic vane in the pylon coordinate system. The intersection of the quarter chord and midspan of the vane is used as the reference point.

SPNE is the span of the vane.

CDE is the aerodynamic chord of the vane.

OME is the ω_{e0} in the expression for ω_e .

ALX is the α_{0e} in the equation for α_e . Positive if the leading edge of the vane is up.

ALS is the α_{0s} in the equation for α_e . It is positive if leading edge of the vane is up.

CARD 15 This card is a continuation of Card 14.

TEX is the time excitation begins (t_e).

CLX0 is the lift curve slope of the vane.

OMES is the rate of change of vane frequency, $\partial \omega_e / \partial t$.

CARD 16* Card 16 through 25 contain blade geometry and inertial data.

THT(I) is the blade built-in twist for a given blade segment. THT is read in from blade root to blade tip. Washout is negative thrust (I = 1 to NS).

CARD 17* R(I) is the radial distance for the blade lumped masses. R(I) is read in from root to tip (I = 1 to NS).

*Indicates more than one card may be required for these data.

CARD 18* AM(I) is the blade lumped masses. AM(I) is read in from root to tip (I = 1 to NS).

CARD 19* YB(I) is the blade mass unbalance. YB(I) is read in from root to tip (I = 1 to NS).

CARD 20* AIC(I) is the blade torsional mass moment of inertia. AIC(I) is read in from root to tip (I = 1 to NS).

CARD 21* EPF(I) is the distance from the blade feathering axis to the blade aerodynamic center. Positive if AC is ahead of the feathering axis. Input is read in from root to blade tip (I = 1 to NS).

CARD 22* EPC(I) is the distance from the blade aerodynamic center to the blade center of gravity. Positive if the center of gravity is ahead of the aerodynamic center (I = 1 to NS). Read in from blade root to blade tip.

CARD 23* EPE(I) is the distance from the blade aerodynamic center to the blade elastic axis. Positive if aerodynamic center is ahead of the elastic axis (I = 1 to NS). Read in from blade root to blade tip.

CARD 24* C(I) is the blade segment chord length. Input from root to tip (I = 1 to NS).

CARD 25* DR(I) is the width of the blade segments. A zero value of DR(I) can be used to eliminate the blade aerodynamics. By varying the segment lengths at the blade root and tip, blade root cut-out and tip loss may be simulated.

CARDS 26-47 are used to input the blade normal modes. The information on Card 26 is used for all of the modes. Cards 27 through 31 contain data describing the first blade mode. Cards 32 through 36, 37 through 41, and 42 through 46 contain data for the second, third and fourth modes respectively. If IT4 = 1, cards 26 through 47 should be deleted from the data deck. If IT4 = 0, then NBM on Card 03 will determine how many data cards must be deleted from the data deck.

*Indicates more than one card may be required for these data.

The blade normal mode data are supplied in a three-dimensional array format as illustrated in Figure 5.

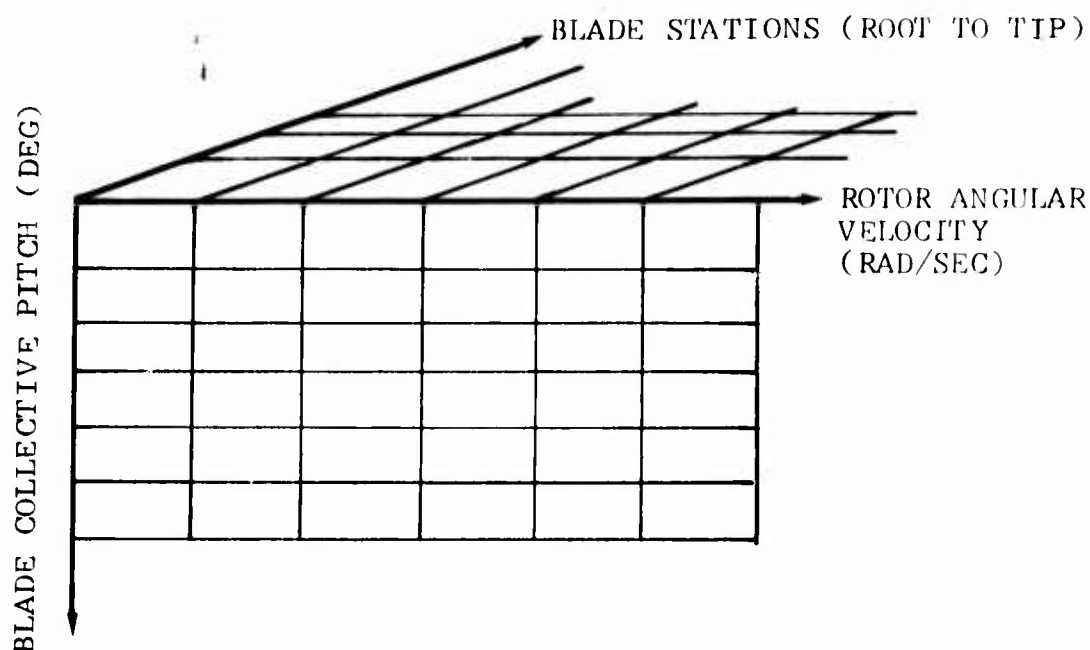


Figure 5. Three-Dimensional Array Format for Blade Normal Modes Data.

- CARD 26 contains the collective pitch and rotor angular velocity arguments. The number of collective pitch values and rotor angular velocity values to be read is specified by NTHC and NPSID on Card 03, respectively. Should the collective pitch or rpm fall outside the tabulated domain, extrapolation will not be made. Instead, the program will use the closest value obtainable from the table, i.e. a value on the boundary of the tabulated domain.
- CARD 27 is used to identify the first input blade mode, i.e. collective or cyclic, flatwise or edgewise etc.
- CARD 28* contains the natural frequencies, in radians per second, for the first normal blade mode. The frequencies are read in first as a function of the collective (pitch for the lowest rpm), then for successively higher rpm.

*Indicates more than one card may be required for these data.

CARD 29 allows the user to specify if the shapes of the normal modes are functions of: (1) both rotor rpm and collective, (2) collective pitch only, and (3) rpm only.

If $LC(L) = 1$, means the mode shapes are functions of rotor rpm and collective pitch.

If $LC(L) = 2$, means the mode shapes are functions of collective pitch only.

If $LC(L) = 3$, means the mode shapes are functions of rpm only.

If $LC(L) = 4$, means the mode shapes do not vary with rpm or collective pitch.

There are two types of mode shapes associated with gimballed rotors, collective modes, and cyclic modes. The former are polar symmetric modes; the latter polar antisymmetric modes. KDR on Card 29 specifies whether the input mode is a collective or cyclic mode. KDR is used only if IT12 equals 0 or 2.

If $KDR = 0$, a collective mode is input.

If $KDR = 1$, a cyclic mode is input.

CARD 30* contains the matrix of out-of-plane, in-plane, and torsional components for the blade normal mode. The out-of-plane component is read in first, followed by the inplane and torsional components. Each component is read in from root to tip, first versus collective pitch, then versus rpm.

CARD 31* contains the matrix of beamwise and chordwise normalized bending moment for the first normal mode. The beamwise moments are read in first, followed by the chordwise moments. Each component is read in first versus collective pitch, then versus rpm. NMI on Card 03 specifies the number of blade stations where moment data will be read in.

CARDS 32* to 36*, 37* to 41*, and 42* to 46* are arranged in the same order as Cards 27 through 31. The data on cards 32 to 36 are for the second blade mode and should be deleted if NBM on Card 03 ≤ 1 .

*Indicates more than one card may be required for these data.

The data on cards 37 to 41 are for the third blade mode and should be deleted if NBM on Card 03 ≤ 2 . The data on cards 42 to 46 are for the fourth blade mode and are deleted if NBM on Card 03 ≤ 3 .

CARD 47 contains the initial conditions for the normal blade modes. The initial conditions for the first mode of each blade are read in first, followed by those for the second blade mode, etc.

CARD 48 is used to specify parameters which indicate the amount of the input data to follow.

NSW is the number of wing lumped mass stations. $0 < NSW \leq 10$. NSW is read in only if IT5 = 1.

NSHP is the number of normal modes used for the wing/pylon system. $0 < NSHP \leq 4$. NSHP is read in only if IT5 = 1.

NPDD is the number of pylon accelerometers. $0 < NPDD \leq 9$. NPDD is used only if IT5 = 1 and IT10 = 1.

CARD 49 contains data for the wing/pylon system.

WZETA is the wing structural damping ratio. A zero value is acceptable.

PM is the lumped pylon mass (complete nacelle mass less the rotor group) $PM \geq 0$.

ZP is the location (Z direction) of the pylon center of gravity along the shaft centerline from the conversion axis (see Figure 6).

YP is the lateral location (Y direction) of the pylon center of gravity with respect to the shaft axis (see Figure 6).

XP is the vertical location (X direction) of the pylon center of gravity with respect to the shaft axis (see Figure 6).

HM Concentrated hub mass (rotor group mass less the blade's mass) $HM \geq 0$ (see Figure 6).

WEPE is the mean distance from the wing aerodynamic center to the wing elastic axis. Positive if the aerodynamic center is ahead of the elastic axis.

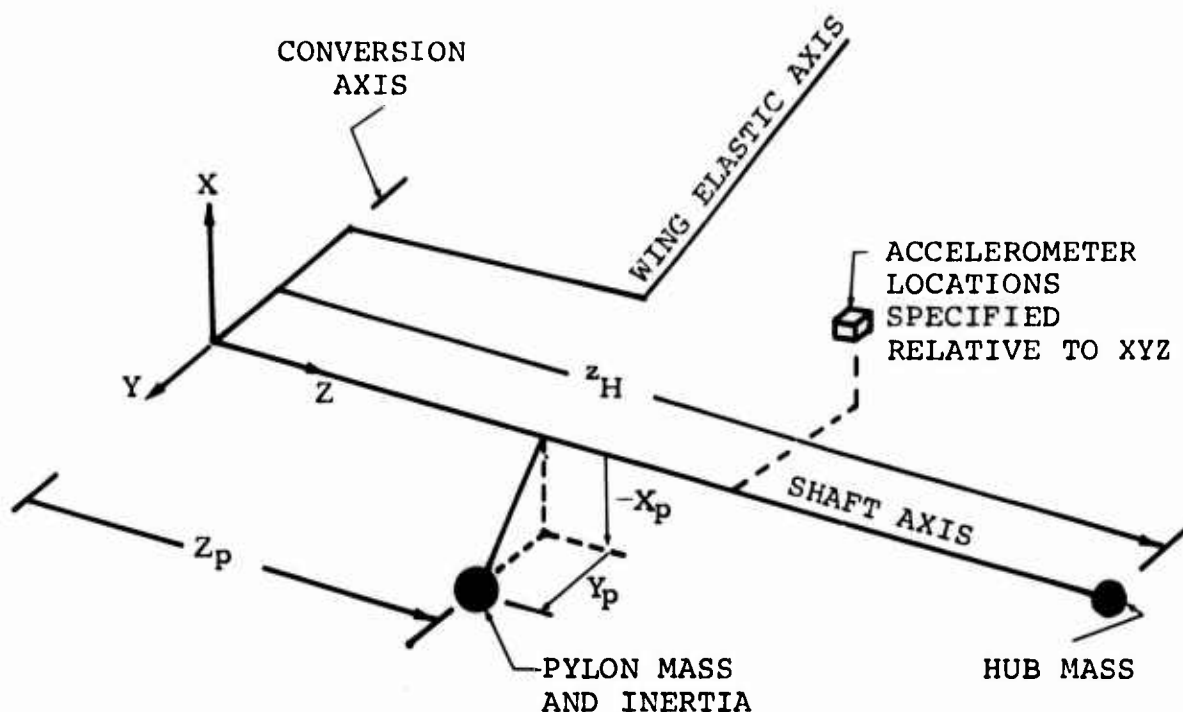


Figure 6. Pylon Geometries.

WIPP is the pylon pitching mass moment-of-inertia about the pylon center of gravity.

CARD 50 contains SHPE(J), the initial conditions for the wing normal modes ($J = 1$ to NSHP).

CARD 51* contains the chordwise components of the wing normal modes. They are read in from wing root to wing tip for first mode, then for the second mode, etc. The number of the discrete wing stations is specified by NSW on Card 48.

CARD 52* contains the beamwise components of the wing normal modes. They are read in the same order as the chordwise components.

*Indicates more than one card may be required for these data.

- CARD 53* contains the torsional components of the wing normal modes. They are read in the same order as the chordwise components.
- CARD 54* contains the wing lumped inertial properties. The masses from wing root to tip are read in first followed by the torsional mass moments-of-inertia about the wing elastic axis, and the wing mass unbalances. The wing segment widths are read in last. The number of discrete wing stations for which data must be supplied is specified by NSW on Card 48. Wing mass unbalances are considered positive if wing center of gravities are in front of the wing elastic axis. Wing aerodynamic segment lengths can be set to zero in order to zero out wing aerodynamic forces.
- CARD 55* contains the natural frequencies and pylon mode shapes for the wing normal modes. The number of modes is specified by NSHP on Card 48. The natural frequencies are read in first, in succession for each mode followed by the normalized pylon fore and aft deflections, the normalized pylon lateral deflections, the normalized vertical deflections, the normalized pylon yaw angles, the normalized pylon pitch angles, and the wing/pylon effective masses. The wing/pylon effective masses will be calculated by the program if IT13 = 0. In this case, the input values for the wing/pylon effective mass are not used.
- CARD 56* contains a modified wing stiffness matrix by rows. The wing moments are calculated using the relationship between force and normal coordinates given by:

$$\{F\} = [k] \{x\}$$

in which $\{F\}$ is the force matrix, $\{x\}$ the normal coordinates matrix, and $[k]$ the modified wing stiffness matrix obtained by premultiplying the mode shape matrix by a stiffness matrix. The order of $[k]$ is determined by the number of wing normal modes, i.e. the order of $[k] = 10 \times \text{NSHP on Card 48}$.

*Indicates more than one card may be required for these data.

CARD 57* is used to specify the location of up to nine (9) accelerometers located on the pylon. The locations are referred to the pylon coordinate system. The X, Y, Z components are read in first, followed sequentially by those for the second accelerometer etc. The number of accelerometers is specified by NPDD on Card 48.

3. Output Format and Guide

The output of ARAP06 consists of two parts: (1) the input data and (2) a time history of the system displacements, accelerations, and loads. Machine (CALCOMP) plots of selected variables may be obtained if desired.

The print-out of the input data is in order of the flight condition being simulated, options, propotor data, and wing/pylon data. All of the data used in the case is printed out.

The printed time history output may be conveniently divided into seven groups. The first group, consisting of the first two lines, is always printed. The printing of the other groups depends upon the options selected.

a. Proprotor Rigid-Body Motion and Forces and Moments (Rows 1 and 2)

TIME	is the real time (sec)
PSID	is the rotor instantaneous rotational speed about the rotor shaft axis (rpm)
PSI	is the azimuth position of the master blade, measured from X-axis of the rotor-fixed system (deg)
BET-LG	is the longitudinal flapping in rotor-fixed system positive about negative Y-axis (deg)
BET-LT	is the lateral flapping in rotor-fixed system, positive about positive X-axis (deg)
BET(1)	is the total flapping of the master blade, positive if flapping up (deg)
FFX	is the rotor aerodynamic H-force referred to rotor-fixed system. Positive along positive X-axis (lb)

*Indicates more than one card may be required for these data.

FFY is the rotor aerodynamic side force referred to rotor-fixed system. Positive along positive Y-axis (lb)

FFZ is the rotor aerodynamic drag force, referred to rotor-fixed system. Positive along positive Z-axis (lb)

WBX is the X-component of the gravitational force on rotor-blades, referred to rotor-fixed system. Positive along positive X-axis (lb)

WBY is the Y-component of the gravitational force on rotor-blades, referred to rotor-fixed system. Positive along positive Y-axis (lb)

WBZ is the Z-component of the gravitational force on rotor-blades, referred to rotor-fixed system. Positive along positive Z-axis (lb)

FI is the component of rotor inertial loads in rotor-rotating system, positive along x-axis (lb)

FJ is the component of rotor inertial loads in rotor-rotating system, positive along y-axis (lb)

FK is the component of rotor inertial loads in rotor-rotating system, positive along z-axis (lb)

MI is the component of rotor inertial moments in rotor-rotating system, positive about x-axis (in-lb)

MJ is the component of rotor inertial moments in rotor-rotating system, positive about y-axis (in-lb)

MK is the component of rotor inertial moments in rotor-rotating system, positive about z-axis (in-lb)

TFFX is the component of net rotor force referred to rotor-fixed system. Positive along X-axis (lb). And

$$TFFX = FFX + FI \cos\psi - FJ \sin\psi + WBX$$

TFFY is the component of net rotor force referred to rotor fixed system. Positive along Y-axis (lb). And

$$TFFY = FFY + FI \sin\psi + FJ \cos\psi + WBY$$

TFFZ is the component of net rotor force referred to rotor fixed system. Positive along Z-axis (lb). And

$$TFFZ = FFZ + FK + WBZ$$

TFMX is the component of net rotor moment referred to rotor fixed system. Positive about X-axis (in-lb)

TFMY is the component of net rotor moment referred to rotor fixed system. Positive about Y-axis (in-lb)

TFMZ is the component of net rotor moment referred to rotor fixed system. Positive about Z-axis (in-lb)

b. Blade Deflections and Bending Moments

This group is calculated and printed only if IT4 = 0. The bending moments are written symbolically as follows:

JBMN where BM stands for a beamwise moment, J stands for the Jth blade, N stands for the Nth blade station at which the moment is calculated (in-lb)

JCMN where CM stands for chordwise moments, J and N have been defined above (in-lb)

The blade tip deflections are with respect to the preconed axis, and are written symbolically as follows:

ZTIPJ where TIP stands for blade tip, J stands for the Jth blade, Z indicates a beamwise deflection. It is positive if the blade is being bent upward. (in)

XTIPJ where X indicates a chordwise deflection. It is positive in the lag sense, i.e. compression in trailing edge (in)

The normal coordinates for the blade normal modes are written symbolically as follows:

JQBN where QB stands for the normal coordinates,
J indicates the Jth blade, N stands for the
Nth normal mode

c. Deflections and Rotations of Wing/Pylon System

This group is executed and printed only if IT5 = 1.

THP is the pylon instantaneous pitch angle,
positive about Y_F -axis in the inertial
fixed system. THP contains the pylon
steady conversion angle as well as the
pitch due to wing torsional deflections
(rad)

PSIP is the pylon instantaneous yaw angle,
positive about Z_F -axis in the inertial
fixed system (rad)

XHB is the X_F -component of hub deflection,
referred to reference inertial coordinate
system (in)

$$X_{HB} = X_O + z_H (\cos \psi_p \cos \theta_p - 1)$$

in which X_O is X_F -component deflection of
pylon conversion axis, z_H is the total
pylon length (CA to hub), ψ_p is the pylon
yawing angle, and θ_p is the pylon pitching
angle

YHB is the Y_F -component of hub deflection,
referred to reference inertial coordinate
system (in)

$$Y_{HB} = Y_O + z_H \sin \psi_p$$

ZHB is the Z_F -component of hub deflection,
referred to reference inertial coordinate
system (in)

$$Z_{HB} = Z_O - z_H \cos \psi_p \sin \theta_p$$

WBM is the beamwise deflection at the wing-tip,
positive down (in)

WCD is the chordwise deflection at the wing-tip,
positive forward (in)

WTN	is the torsional deflection at the wing-tip, positive leading-edge up (rad)
QW1	is the first normal coordinate of the wing/pylon system
QW2	Second, third, and fourth normal
QW3	coordinates of the wing/pylon system,
QW4	respectively

d. Wing Loads and Moments

The execution and printing of this group are controlled by option IT11. If IT11 = 1, the following variables are printed.

FXL	is the chordwise shearing force at the left end of a wing segment, positive forward (lb)
FZL	is the beamwise shearing force at the left end of a wing segment, positive down (lb)
MXL	is the beamwise bending moment at the left end of a wing segment, positive if tension is produced on the wing upper surface (in-lb)
MYL	is the torsional moment at the left end of a wing segment, positive if wing leading edge is up (in-lb)
MZL	is the chordwise bending moment at the left end of a wing segment, positive if tension is produced on the wing surface at the leading-edge (in-lb)

The remaining variables in this group are chordwise and beamwise shearing forces, beamwise, torsional, and chordwise bending moments for the right end of the wing segment.

e. Pylon Accelerations

This group is controlled by option IT10. If IT10 = 1, the computation of pylon accelerations is executed.

XPDDL	is the X-component acceleration of the first accelerometer, referred to pylon coordinate system (in fraction of g)
-------	--

YPDDL is the Y-component acceleration of the first accelerometer, referred to pylon coordinate system (in fraction of g)

ZPDDL is the Z-component acceleration of the first accelerometer, referred to pylon coordinate system (in fraction of g)

The remaining variables in this group are component accelerations for the accelerometers, --NPDD.

f. Peak Values of Selected Variables

The printing-out of this group is controlled by option IT9. If IT9 = 1, peaks of master blade flapping, wing-tip beamwise deflection, wing-tip chordwise deflection, and first normal coordinate of wing/pylon are selected versus time. They are printed at the end of each run.

g. Details of Rotor and Wing Aerodynamics

This group is printed at the end of the second rotor revolution for all runs. Instantaneous aerodynamic details at all blade and wing stations are printed for reference.

(1) Rotor Airloads Details (see Figure 7)

VP is the vertical component of the blade local velocity (in/sec)

VT is the tangential component of the blade local velocity (in/sec)

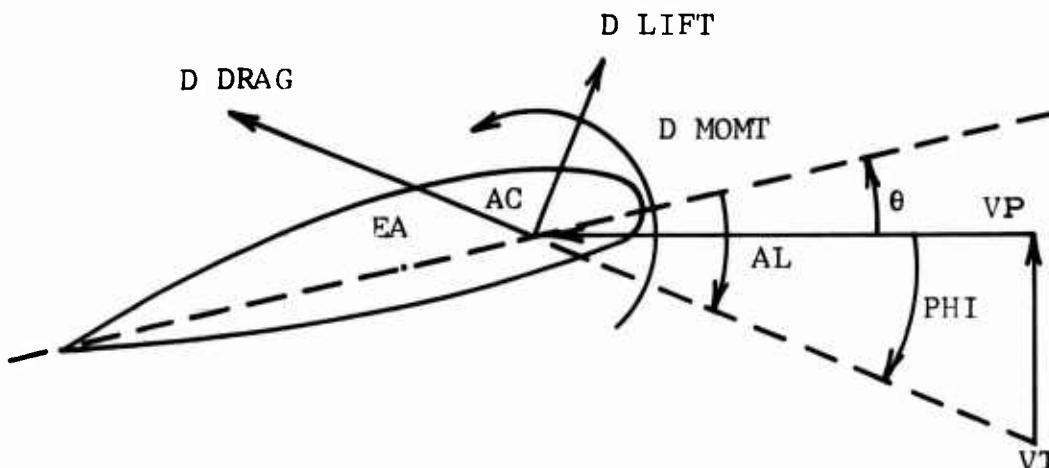


Figure 7. Blade Element Aerodynamic Details.

PHI is the inflow angle (rad)

AL is the angle of attack (rad)

CL,CD is the local blade lift, drag, and
CM pitching moment coefficients respectively

MACH is the local Mach number

DHF is the rotor in-plane aerodynamic drag force, it is positive if it tends to slow down the rotor (lb)

DQ is the aerodynamic pitching moment about the blade elastic axis, positive for leading edge nose up (lb)

DRADF is the blade aerodynamic radial force in shaft plane. Positive if it points to the blade root (lb)

DTHST is the blade aerodynamic thrust perpendicular to shaft plane. Positive if it is outward from the shaft plane (lb)

DLIFT is the local aerodynamic lift at the quarter chord. It is perpendicular to the local total velocity and is calculated directly from C_L (lb)

DDRAG is the blade local aerodynamic drag at the quarter chord. It is parallel to the local total velocity and is calculated directly from C_D (lb)

DMOMT is the blade local aerodynamic pitching moment at the quarter chord. It is positive if blade leading-edge is up, and is calculated directly from C_M (in-lb)

(2) Wing Airloads Details (see Figure 8)

VP is the vertical component of the wing local velocity (in/sec)

VT is the tangential component of the wing local velocity (in/sec)

PH is the local inflow angle (rad)

AL is the local angle of attack (rad)

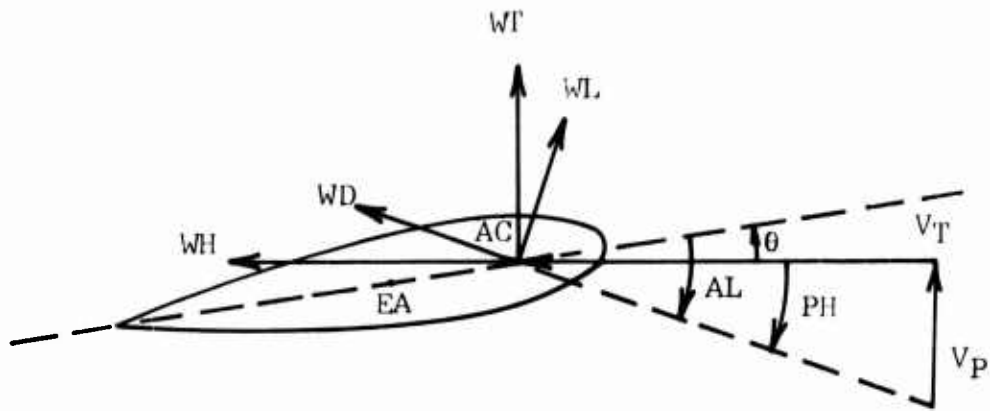


Figure 8. Wing Element Aerodynamic Details.

CL is the local lift coefficient for the wing, calculated by

$$C_L = \frac{\partial L}{\partial \alpha} \cdot \alpha$$

where

$\partial L / \partial \alpha$ is the lift curve slope, an input on Card 11 and, α is the local angle of attack

CD is the local drag coefficient

WL is the local aerodynamic lift force

WD is the aerodynamic drag force

WT is the local thrust force perpendicular to the free stream (lb)

WH is the wing local drag force parallel to the free stream (lb)

WQ is the local torsional moment about the elastic axis, positive leading-edge is up (in-lb)

The machine plots are self-explanatory. An example is given in Appendix I.

4. Suggested User Techniques

a. Data Deck Build-up

In preparing a data deck for program ARAP06, the following steps are suggested.

(1) Start With Rotor Rigid-Body Freedom - The user should start with rotor rigid-body equations (OPTION IT5 = 0). The data required for this option consist of the blades inertia and aerodynamic properties, i.e. the blade twist, mass distribution, mass unbalance, variation of blade chord with blade radius, rotor precone, pitch-flap coupling, and blade collective pitch. Tabulated forms for the blade section C_L , C_D , and C_M are also needed. These data form a fundamental data deck for the program which can be readily checked out.

(2) Add Wing Elastic Degrees-of-Freedom - After checking out the rotor rigid-body degrees-of-freedom, the wing flexible motion should be added (IT5 = 1). This requires that the wing/pylon inertial properties, linear dimensions and normal modes as well as natural frequencies be supplied. The lift-curve slope of wing airfoil must also be estimated. The wing equations should first be checked out with the proprotor blade segment lengths set to zero which eliminate the proprotor aerodynamics. Checkout should include verification of coupled mode shapes and frequencies.

(3) Add Blade Elastic Degrees-of-Freedom - The proprotor blade elastic motion should be added last. This requires that the blade natural frequencies, normal modes, and normalized blade bending moments for each mode be supplied in tabulated forms (IT4 should be 0).

(4) Other Options - The various ARAP06 options such as those for wing/rotor aerodynamic interference, blade feathering or gust encounter should be used only after the basic math model has been checked out. Many of the options require hand calculation prior to their use. For example, if option IT2 is to be used to feather or unfeather the proprotor, the proper blade collective pitches should be calculated by equation 134 in Volume I. Likewise for the 1-cosine gust encounter option, IT3 = 2, the gust encounter period may be calculated by

$$\Delta t = \frac{25 \text{ WC}}{U}$$

in which WC is the wing mean aerodynamic chord, U is the velocity along flight path. These are input parameters on card 11 and card 05, respectively.

b. Machine Time Requirements

The ratio of the machine time to the simulated real time depends upon flight conditions and options. Since the equations of motion in ARAP06 are nonlinear in nature and are solved simultaneously by iterations, the more complicated the input condition the greater the number of iterations required. A few examples of machine time requirements are given below. (The machine time here referred is based upon an IBM 360-65.)

Example 1 - The blade rigid-body flapping and rotor angular freedom are locked out. The blades are inelastic and the propotor is coupled with the wing/pylon degrees-of-freedom (4 modes). Forty seconds of machine time for one second of real time was required.

Example 2 - With the blade flapping and rotor angular freedoms added, the machine time is increased to ninety seconds per second of real time.

Example 3 - With the blade rigid-body flapping and rotor angular freedoms locked out, but with flexible blades (4 modes) coupled with wing/pylon motions (4 modes), approximately six minutes of machine time is required for one second of real time.

Example 4 - If the propotor blade flapping and angular freedom is added to example 3, approximately nine minutes of machine time is required for one second of real time.

Proper choice of integration step has impact on both the machine time and program accuracy. Too small an integration step increases the machine time. However, too large integration step will prevent the program from giving accurate results. The user should experiment with integration step and establish the largest, accurate step.

c. Acceleration Averaging Requirements

Numerical difficulties are occasionally encountered with ARAP06 because of the nonlinearity of the equations of motion. This manifests itself as a higher frequency vibration at the time step frequency. A weighted average of the accelerations can be used to eliminate this problem. This option is controlled by IT14.

B. DFAL17 - FPR Blade Folding Flutter Analysis

The inputs to DFAL17 consist of the geometry, mass and stiffness distributions of the wing, pylon, and blades. The following section properties can vary with blade fold angle: strip width, chord, reference semispan and chord, cosine of blade fold angle, mean aerodynamic chord, distance between dumbbells, blade sweep, distance from elastic axis to dumbbells, mass unbalance, and inertia.

The card order in a DFAL17 data deck is shown in Figure 9. If the program is being used to calculate natural frequencies and mode shapes, the aerodynamic data set is not required.

1. Input Format

CARD 01 Format 20A4:

Title Card; Column 1-80, alphameric.

CARD 02 Format I4:

Col. 1 - 4 NSIZ Matrix size = 74, if minus,
punch flexibility matrix
and eigenvalues

Col. 5 - 8 NAERO Reduced velocities (1/K),
if NAERO = 0, skip Cards
3-19 (aero input)

Col. 9 - 12 MODES Number of eigenvalues to
be calculated

Format E12.5:

Col. 13 - 24 FK Flex scaling factor; if
FK = 0 then a value of
FK = 1 is assumed

Col. 25 - 36 AMK Mass scaling factor;
if AMK = 0, FM = 1

Col. 37 - 48 RHO Density; if RHO = 0, (slug/ft³)
RHO = 0.002378

Cards 03 through 19 contain aerodynamic inputs, omit Cards 03 through 19 if NAERO = 0.

CARD 03 Format E12.5:

Col. 1 - 12 BR Reference semichord (ft)
Col. 13 - 24 s Reference semispan (ft)
Col. 25 - 36 BREF Reference semichord (ft)
Col. 37 - 48 Reduced velocities in
Col. 49 - 60 VELCTY fields of E12.5 until
Col. 61 - 72 NAERO values have been
entered

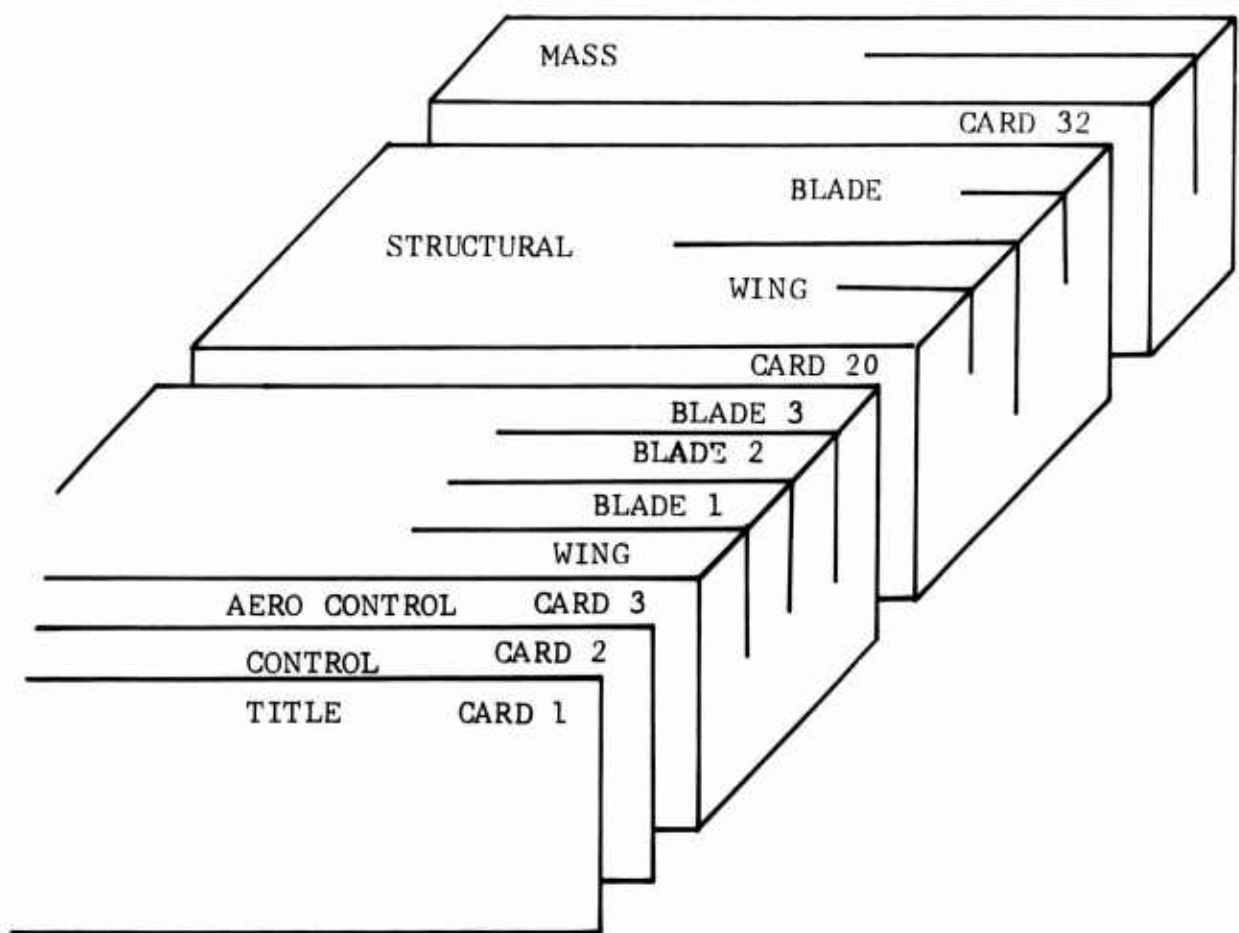


Figure 9. Card Order in DFAL17 Data Deck.

CARD 04 Format E12.5:
 Col. 1 - 12 COSLMA Cosine of wing
 sweep angle
 Col. 13 - 24 BRA Reference wing semichord (ft)
 Col. 25 - 36 SA Reference wing semispan (ft)
 Col. 37 - 48 CAPA Reference wing area (ft²)
 Col. 49 - 60 CBAA Wing mean aerodynamic (ft)
 chord

CARD 05* Format 6E12.5:
 Col. 1 - 72 DELTAY_i Width of wing panels (ft)
 (5 wing, 2 pylon)
 Format E12.5:
 Col. 1 - 12

CARD 06* Format 6E12.5:
 Col. 1 - 72 B_i Wing panel semichords (ft)
 (5 wing, 2 pylon)
 Format E12.5:
 Col. 1 - 12

CARD 07* Format 6E12.5:
 Col. 1 - 72 D_i Distance between dumb- (ft)
 bells on wing & pylon
 (5 wing, 2 pylon)
 Format E12.5:
 Col. 1 - 12

CARD 08 Format E12.5:
 Col. 1 - 12 COSLMA Cosine of blade fold
 angle
 Col. 13 - 24 BRA Reference semichord (ft)
 Col. 25 - 36 SA Reference semispan (ft)
 Col. 37 - 48 CAPA Reference area (ft²)
 Col. 49 - 60 CBAA Mean aerodynamic chord (ft)

CARD 09 Format 5E12.5:
 Col. 1 - 60 DELTAY_i Blade 1, section widths (ft)

CARD 10 Format 5E12.5:
 Col. 1 - 60 B_i Blade 1, section
 semichords (ft)

CARD 11 Format 5E12.5:
 Col. 1 - 60 D_i Blade 1, distance (ft)
 between dumbbells

*Indicates more than one card may be required for these data.

CARD 12	Format E12.5:		
	Col. 1 - 12	COSLMA	Cosine of blade fold angle
	Col. 13 - 24	BRA	Reference semichord (ft)
	Col. 25 - 36	SA	Reference semispan (ft)
	Col. 37 - 48	CAPA	Reference area (ft ²)
	Col. 49 - 60	CBAA	Mean aerodynamic chord (ft)
CARD 13	Format 5E12.5:		
	Col. 1 - 60	DELTAY _i	Blade 2, section widths (ft)
CARD 14	Format 5E12.5:		
	Col. 1 - 60	B _i	Blade 2, section semichords (ft)
CARD 15	Format 5E12.5:		
	Col. 1 - 60	D _i	Blade 2, distance between dumbbells (ft)
CARD 16	Format E12.5:		
	Col. 1 - 12	COSLMA	Cosine of blade sweep angle
	Col. 13 - 24	BRA	Reference semichord (ft)
	Col. 25 - 36	SA	Reference semispan (ft)
	Col. 37 - 48	CAPA	Reference area (ft ²)
	Col. 49 - 60	CBAA	Mean aerodynamic chord (ft)
CARD 17	Format 5E12.5:		
	Col. 1 - 60	DELTAY _i	Blade 3, section widths (ft)
CARD 18	Format 5E12.5:		
	Col. 1 - 60	B _i	Blade 3, section semichords (ft)
CARD 19	Format 5E12.5:		
	Col. 1 - 60	D _i	Blade 3, distance between dumbbells (ft)

Structural Input

CARD 20	Format E12.5:		
	Col. 1 - 12	WGSWEP	Wing sweep, forward is minus (deg)
	Col. 13 - 24	BLDSWP	Blade sweep, aft is plus (deg)

Col. 25 - 36	VRPYLS	Pylon fore and aft stiffness	(in-lb/rad)
Col. 37 - 48	LTPYLS	Pylon lateral stiffness	(in-lb/rad)
Col. 49 - 60	FOLDSF	Blade fold stiffness	(in-lb/rad)
Col. 61 - 72	SMASTF	Mast torsional stiffness	(in-lb/rad)

CARD 21 Format E12.5:

Col. 1 - 12	FXCLST	Fixed control stiffness	(in-lb/rad)
Col. 13 - 24	MVCLST	Movable control stiffness	(in-lb/rad)
Col. 25 - 36	LCA	Distance elastic axis to conversion axis	(in)
Col. 37 - 48	PYLOFF	Pylon offset	(in)
Col. 49 - 60	H	Mast length	(in)
Col. 61 - 72	EHUB	Hub offset	

CARD 22 Format E12.5:

Col. 1 - 12	LW	Length wing segment 1	(in)
Col. 13 - 24	EIBW	EI beam wing segment 1	(lb-in ²)
Col. 25 - 36	EICW	EI chord wing segment 1	(lb-in ²)
Col. 37 - 48	GJW	CG wing segment 1	(lb-in ²)

CARD 23 Format E12.5:

Col. 1 - 12	LW	Length wing segment 2	(in)
Col. 13 - 24	EIBW	EI beam wing segment 2	(lb-in ²)
Col. 25 - 36	EICW	EI chord wing segment 2	(lb-in ²)
Col. 37 - 48	GJW	GJ wing segment 2	(lb-in ²)

CARD 24 Format E12.5:

Col. 1 - 12	LW	Length wing segment 3	(in)
Col. 13 - 24	EIBW	EI beam wing segment 3	(lb-in ²)
Col. 25 - 36	EICW	EI chord wing segment 3	(lb-in ²)
Col. 37 - 48	GJW	GJ wing segment 3	(lb-in ²)

CARD 25	Format E12.5:		
	Col. 1 - 12	LW	Length wing segment 4 (in)
	Col. 13 - 24	EIBW	EI beam wing segment 4 (lb-in ²)
	Col. 25 - 36	EICW	EI chord wing segment 4 (lb-in ²)
	Col. 37 - 48	GJW	GJ wing segment 4 (lb-in ²)
CARD 26	Format E12.5:		
	Col. 1 - 12	LW	Length wing segment 5 (in)
	Col. 13 - 24	EIBW	EI beam wing segment 5 (lb-in ²)
	Col. 25 - 36	EICW	EI chord wing segment 5 (lb-in ²)
	Col. 37 - 48	GJW	GJ wing segment 5 (lb-in ²)
CARD 27	Format E12.5:		
	Col. 1 - 12	LB	Length blade segment 1 (in)
	Col. 13 - 24	EIBB	EI beam blade segment 1 (lb-in ²)
	Col. 25 - 36	EIBC	EI chord blade segment 1 (lb-in ²)
	Col. 37 - 48	GJB	GJ blade segment 1 (lb-in ²)
CARD 28	Format E12.5:		
	Col. 1 - 12	LB	Length blade segment 2 (in)
	Col. 13 - 24	EIBB	EI beam blade segment 2 (lb-in ²)
	Col. 25 - 36	EIEC	EI chord blade segment 2 (lb-in ²)
	Col. 37 - 48	GJ	GJ blade segment 2 (lb-in ²)
CARD 29	Format E12.5:		
	Col. 1 - 12	LB	Length block segment 3 (in)
	Col. 13 - 24	EIBB	EI beam blade segment 3 (lb-in ²)
	Col. 25 - 36	EIBC	EI chord blade segment 3 (lb-in ²)
	Col. 37 - 48	GJB	GJ blade segment 3 (lb-in ²)
CARD 30	Format E12.5:		
	Col. 1 - 12	LB	Length blade segment 4 (in)

	Col. 13 - 24	EIBB	EI beam blade segment 4	(lb-in ²)
	Col. 25 - 36	EIBC	EI chord blade segment 4	(lb-in ²)
	Col. 37 - 48	GJB	GJ blade segment 4	(lb-in ²)
CARD 31.	Format E12.5:			
	Col. 1 - 12	LB	Length blade segment 5	(in)
	Col. 13 - 24	EIBB	EI beam blade segment 5	(lb-in ²)
	Col. 25 - 36	EIBC	EI chord blade segment 5	(lb-in ²)
	Col. 37 - 48	GJB	GJ blade segment 5	(lb-in ²)
<u>Mass Input</u>				
CARDS 32 & 33	Format 6E12.5:			
	Col. 1 - 72	X _i	Distance EA to forward central point--12 total, 5 wing, 2 pylon, 5 blade is positive	(in)
CARDS 34 & 35	Format 6E12.5:			
	Col. 1 - 72	Y _i	Distance EA to aft central point--12 total, 5 wing, 2 pylon, 5 blade is positive	(in)
CARDS 36 & 37	Format 6E12.5:			
	Col. 1 - 72	M	Weight to be lumped at each dumbbell	(lb)
CARDS 38 & 39	Format 6E12.5:			
	Col. 1 - 72	S	Unbalance to be lumped at dumbbell is minus if forward of EA	(in-lb)
CARDS 40 & 41	Format 6E12.5:			
	Col. 1 - 72	I	Inertia to be lumped at each dumbbell	(in-lb ²)

2. Guide to Input Format

CARD 01	TTL	is used to identify case being run. All alphabetic or numeric information is reproduced and centered on first output page.
CARD 02	NSIZ	is the matrix size (74 max). If this number is negative (-74), then the structural influence coefficient matrix and all 74 eigenvalues are punched on cards (6E12.5 format) for use as input to DFALL8. The flexibility matrix and eigenvalues are punched for the first 1/K.
	NAERO	is the number of reduced velocities (1/K) ≤ 15 . If NAERO = 0, cards 3 through 19 are omitted. If NAERO is negative, the aerodynamic matrix is printed out.
	MODES	is the number of eigenvalues to be printed out and the number of eigenvectors to be calculated.
	FK	is the flexibility (SIC) matrix scaling factor. The EI and GI will be multiplied by this factor to reduce input data requirements. It can also be used for quick stiffness changes in parametric studies. If FK = 0 or blank, a 1 is assumed.
	AMK	is the mass matrix scaling factor. The section weights, inertias, and unbalances are multiplied by AMK. This can be used for quick mass changes in parameter changes. If AMK = 0 or blank, a 1 is assumed.
	RHO	is the air density (slug/ft ³). It is used in the calculation of airloads. If RHO = 0 then 0.002378 is assumed.
CARD 03*	BR	is the reference semichord (ft). The calculated aerodynamics are multiplied by BR to form oscillatory airloads.
	S	is the reference semispan (ft). The calculated aerodynamics are multiplied by S to form oscillatory airloads.
	BREF	The reference semichord (ft). Usually the same as BR. Is used only in the velocity calculation

*Indicates more than one card may be required for these data.

$$V = \frac{1}{K} * \frac{BREF}{\lambda_R}$$

where λ_R = real part of the eigenvalue.

VELCTY is the reduced velocity ($1/K = \frac{V}{B_R \omega}$) values.

There will be three on Card 3 and six on each succeeding card until NAERO reduced velocities are input.

CARD 04 COSLMA is the cosine of the wing sweep angle.

BRA is the reference wing semichord (ft). This should be same as BR on Card 3.

SA is the reference wing semispan (ft). This should be the same as S on Card 03.

CAPA is the reference area (ft²). This should be the total area of the wing and three blades.

CBAA is the wing mean aerodynamic chord (ft).

$$CBAA = \frac{2}{3} C_T \left[e + \frac{1}{e+1} \right]$$

where $e = \frac{\text{chord root}}{\text{chord tip}}$

C_T = chord tip

CARD 05* DELTAY_i is delta y (the strip width of the wing segments. There are seven strips--five for the wing and two representing the pylon. Strip six is for pylon pitch airloads and strip seven for pylon yawing airloads. These values can be scaled for 3-D lift distribution using the formula

$$DY_i = \frac{a_i}{2\pi} \cdot D\bar{Y}_i$$

where a_i is the estimated lift curve slope of the individual segment (sweep effects neglected), $D\bar{Y}_i$ is the actual geometric strip width.

Two cards are required since there are seven strips. $D\bar{Y}_i$ can be zero if desired.

CARD 06	B_i	is the wing section semichord (ft). These are the semichords for each wing segment plus the two pylon sections. Two cards are required. B_i must be nonzero.
CARD 07	D_i	is the distance (ft) between the forward and aft dumbbell. Normally the forward control point is on the quarter chordline and the aft control point is on the three-quarter chordline. This makes D_i equal to B_i . D_i must be nonzero.
CARDS 08, 09, 10, 11	(Blade 1 aero data)	same format as cards 04 through 07 except blade parameters are used. There are only 5 sections for each blade, so there are only 5 DY_i , 5 B_i , and 5 D_i .
CARDS 12, 13, 14, 15	(Blade 2 aero data)	same format as cards 08 through 11.
CARDS 16, 17, 18, 19	(Blade 3 aero data)	same format as cards 08 through 11.
CARD 20	WGSWEP	is the wing sweep angle (degrees). Forward sweep is negative.
	BLDSWP	is the blade fold angle (degrees). Fold aft is positive. Precone is a negative blade fold angle.
	VRPYLS	is the pylon fore and aft (pitch) mounting spring rate (in-lb/rad). This number is used to calculate the GJ of the pylon offset element.
	LTPYLS	is the pylon lateral mounting spring rate (in-lb/rad). This stiffness is used to calculate the chord EI of the pylon offset element.
	FOLDSF	is the blade fold hinge spring rate (in-lb/rad). This stiffness is used to calculate the EIC of the one-inch element located between the fold hinge and the first blade element.
	SMASTF	is the mast torsional stiffness (in-lb/rad). This number is used to calculate the mast GJ.

CARD 21 FXCLST is the fixed pitch change axis spring rate (in-lb/rad). This stiffness is used to calculate the GJ of the element inboard of the fold hinge.

 MVCLST is the moveable pitch change axis spring rate (in-lb/rad). This stiffness is used to calculate the GJ of the one-inch element located between the blade fold axis and the first blade segment.

 LCA is the distance in inches between the wing elastic axis and the conversion axis. Parallel to rotor shaft. Positive if conversion axis is aft of the elastic axis.

 PYLOFF is the lateral distance from the wing tip to the shaft centerline (pylon offset).

 H is the distance from the intersection of the conversion axis and the shaft axis to the hub (mast length - in).

 EHUB is the distance from the intersection of the shaft centerline and hub to the blade fold axis (fold hinge offset - in).

CARDS contain wing structural data. Each card corresponds to a wing segment. The format for each card is the same.

 LW is the length of ith wing segment in inches

 EIBW is the beamwise EI for ith wing segment in lb-in²

 EICW is the chordwise EI for ith wing segment in lb-in²

 GJW is the GJ for ith wing segment in lb-in²

Each wing structural segment ends at a lumped mass point. The mass point should be located in the center of the corresponding aerodynamic panel. The distance from the end of the fifth segment to the wing tip (segment 6) is assumed to be one-half the length of the fifth wing segment. The stiffness of segment 6 is assumed to be the same as segment 5.

CARDS
27-31

contain blade structural data. Each card corresponds to a blade segment. The blades are assumed to be identical. The format for each card is the same.

LB is the length of ith blade segment in inches

EIBB is the beamwise EI for ith blade segment in lb-in²

EICB is the chordwise EI for ith blade segment in lb-in²

GJB is the GJ for ith blade segment in lb-in²

Each blade segment ends at a mass point which should be located at the center of the corresponding aerodynamic panel. Therefore the fifth blade segment will end short of the blade tip. The blade begins one-inch outboard of the fold hinge.

CARDS
32-41

contain inertial data for the wing and blades.

X_i is the distance in inches from the elastic axis to the forward control point. The forward central point is located on the quarter chordline. X_i is used in the generation of the coupled mass matrix and the SIC matrix. X_i is always positive and it is advisable (for matrix conditioning) that X_i be of some value rather than zero. The X_i for the pylon could be the same as the mast length and thus show the hub motion. The five wing X_i , the pylon pitch, pylon yaw, and five X_i for one blade are input consecutively. The blades are assumed to be identical so the blade input is not repeated.

Y_i is the distance in inches from the elastic axis to the aft control point. The aft control point is normally located on the three-quarter chordline. Y_i is used in the generation of the coupled mass matrix and the SIC matrix. Y_i is used in the generation of the coupled mass matrix and the SIC matrix. Y_i is always positive and it is advisable that it be of some value rather than zero. The five wing Y_i , the pylon pitch, pylon yaw, and the Y_i for one blade are input consecutively. The blades are assumed to be identical so the blade data are not repeated.

- M is the section weight in pounds. This weight is distributed on the fore and aft control points forming a dumbbell. M cannot be zero. M for the five wing segments, pylon pitch and yaw, and the five blade segments are in consecutive order. The hub weight is normally lumped in the pylon weight rather than the first blade segment.
- S is the section unbalance in in-lb. The unbalance is used in forming the mass matrix. A section center of gravity forward of the elastic axis produces a negative unbalance. S can be zero. The unbalance for the five wing segments, pylon pitch and yaw, and the five blade segments are in consecutive order.
- I is the section inertia I, in lb-in². This term is the inertia about the elastic axis. This parameter cannot be zero. The inertias for five wing segments, pylon pitch inertia, pylon yaw inertia, and five blade segments are entered consecutively.

3. Output Format and Guide

The output of DFAL17 consists of four parts:

- All input data.
- Constants which are internally calculated. These include the wing-tip spring rates, the flexibility and mass matrices, and the aerodynamic matrix, if desired.
- Flutter information consisting of the eigenvalues and vectors for each mode, the frequency structural damping required, and velocity in knots associated with each frequency.
- Punched cards containing the structural influence coefficient matrix and eigenvalues, if desired.

The output format is illustrated by a sample case in Appendix I.

4. Suggested User Techniques

a. Problems Encountered

Any large computer program is susceptible to numerical inaccuracies. DFALL7 is no exception. Because of the manipulation of large complex matrices, roundoff errors will occur. The numerical difficulties have been eliminated as much as possible, but the remaining oddities still remain.

- The tip spring rates (beam and chord--printed output) will be different for various blade fold angles. This variation is small (3-5 percent) and produces little change in output (frequency, damping, velocity, and mode shapes). The variation is caused by numerical inaccuracies during the condensation step.
- At higher reduced velocities, numerous modes will have printed "Imaginary frequency" in lieu of a frequency. Physically this signifies a divergence mode. By taking smaller reduced velocity increments prior to this point, the velocities, damping, and frequencies of interest can be calculated.
- All data must be checked for accuracy since input errors may produce little or no change in frequency but gross differences in damping required and mode shapes.
- When making an element "rigid" do not input EI or GJ more than 10^6 larger than the stiffnesses of surrounding elements. This can cause extreme numerical errors.

b. Usage Hints

Given below are some hints to make the program more flexible.

- Aerodynamics, as calculated by the program, are 2-D and incompressible. By variation of strip widths, semichords, and density, the effect of 3-D theory, compressibility, and altitude variations can be approximated. (See 3-D theory example, Figure 10.)
- Make full use of the flexibility and mass constants, the spring rate inputs, and pylon parameters. These terms will enable most parameter sweeps to be accomplished by single number change each run.

Example, 3-D theory:

The surface is assumed to have an elliptic lift distribution as shown below:

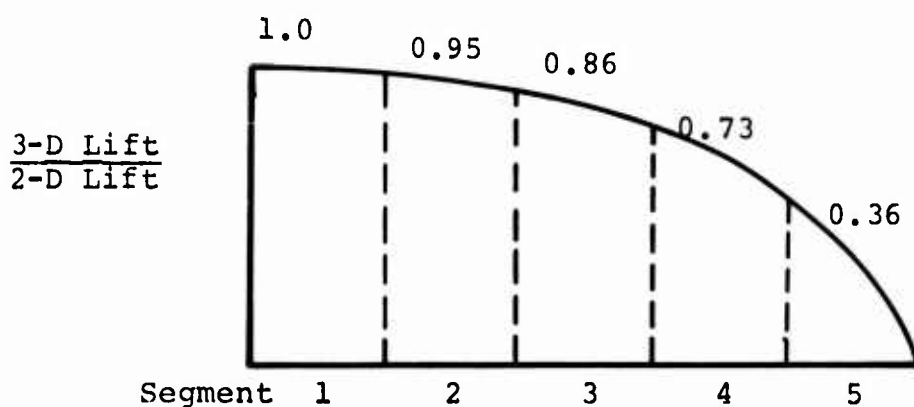


Figure 10. 3-D Lift Distribution.

To approximate 3-D theory, multiply the corresponding ΔY 's by 1.0, 0.95, 0.86, 0.73, and 0.36.

To approximate the effect of compressibility, multiply the b_i 's by the ratio of $\frac{C_L \text{ compressible}}{C_L \text{ incompressible}}$.

The altitude can be approximated by varying the RHO input to correspond to the altitude desired.

c. Time Estimating

Computer time for this program is a function of modes requested, time sharing, priority, and aerodynamics. Generally, for multiple problems within a run allow three minutes for the first case and two minutes for each additional case. Clock time on an IBM 360/65 runs about 2:1.

C. DFAL18 - FPR Blade Folding Response Analysis

Most of the inputs to DFAL18 are the same as used in DFAL17. A DFAL17 case must be run prior to running DFAL18 to generate the flexibility matrix and eigenvalues inputs to DFAL18.

The card order in a DFAL18 data deck is shown in Figure 11.

1. Input Format

CARD 01 Format 20A4:

 Title Card; Column 1-80, alphameric.

CARD 02 Format I4:

 Col. 1 - 4 NG

 If NG is minus, then
 all response points
 will be printed.

 If NG = 1, sine wave
 gust.

 If NG = 2, sine-
 squared gust.

 If NG = 3, step gust.

 If NG = 4, pulse gust.

 If NG = 5, step gust
 with Wagner function.

 Col. 5 - 8 NT

 If NT = 0, calculate
 coordinates only.

 If NT = 1, calculate
 force, torque, and
 moments only.

 If NT = 2, calculate
 coordinates and forces,
 torques, and moments.

 Col. 9 - 12 NP

 Number of input flutter
 frequencies $NP \leq 10$.

 Col. 13 - 16 NSG

 Number of coordinates
 to be run $NSG \leq 10$.

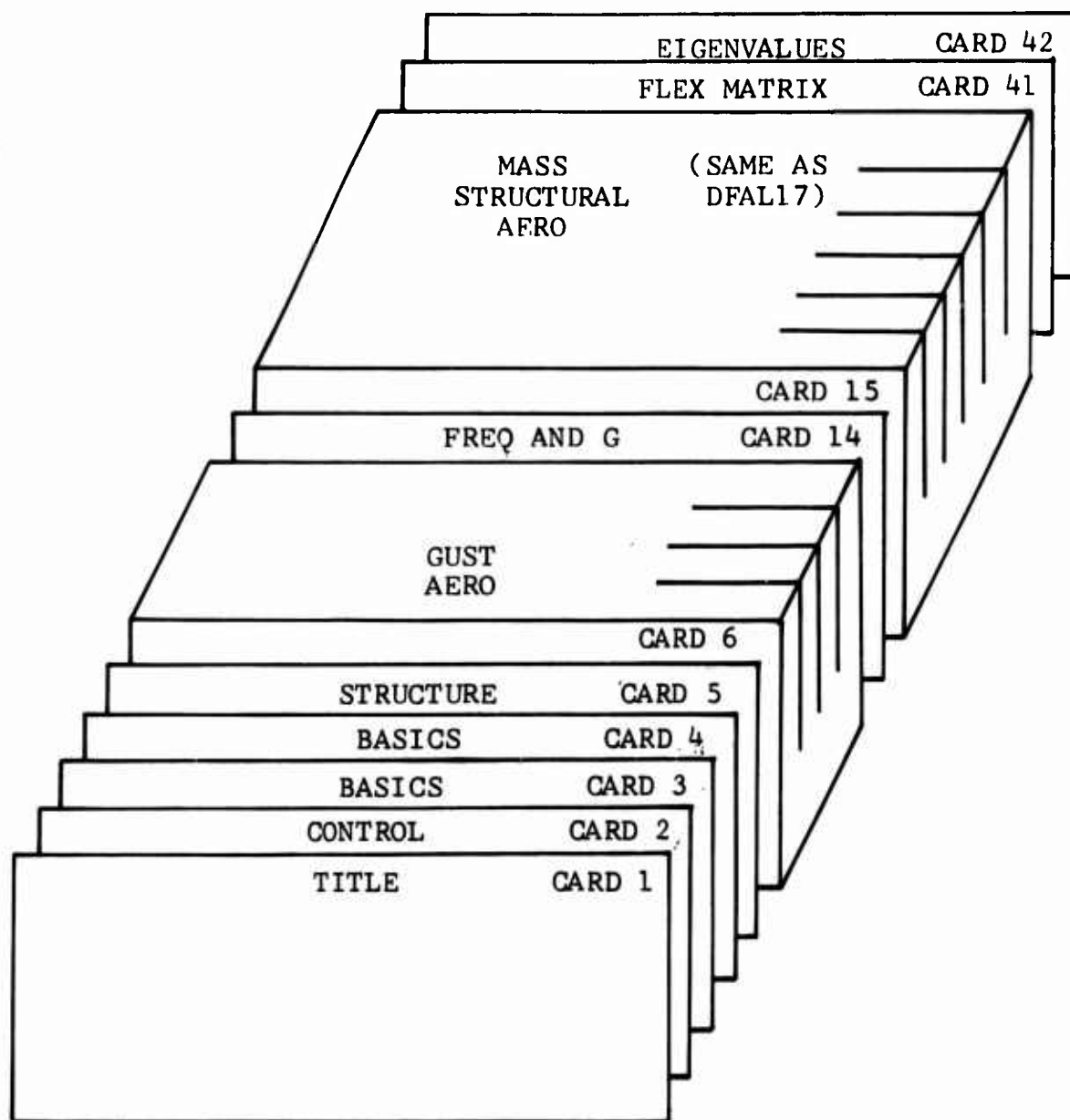


Figure 11. Card Order in DFAL18 Data Deck.

Col. 17 - 20	NSCB	Coordinate designa-
21 - 27		tion to be run,
...		NSG values.

CARD 03 Format E12.5:

Col. 1 - 12	RHO	Air density	(slug/ft ³)
Col. 13 - 24	V	Aircraft forward velocity	(knots)
Col. 25 - 36	CLA	Lift curve slope for gust	
Col. 37 - 48	VG	Gust velocity	(ft/sec)
Col. 49 - 60	BR	Reference semichord	(ft)
Col. 61 - 72	S	Reference semispan	(ft)

CARD 04 Format E12.5:

Col. 1 - 12	DT	Incremental time step	(sec)
Col. 13 - 24	OM	Blank, gust frequency or a pulse duration	(cps) (sec)
Col. 25 - 36	TMAX	Maximum response time	(sec)
Col. 37 - 48	FK	Flex matrix scale factor	
Col. 49 - 60	WGSWEP	Wing sweep, minus (-) forward	(deg)
Col. 61 - 72	BLDSWP	Blade sweep, plus (+) aft	(deg)

Card 05 is repeated for each coordinate to be analyzed, i.e. NSG cards are required.

CARD 05 Format E12.5:

Col. 1 - 12	EIB	(lb-in ²)
Col. 13 - 24	GJ	(lb-in ²)
Col. 25 - 36	L ₁	(in)
Col. 37 - 48	L ₂	(in)

CARDS Format 6E12.5:
6 - 9 Col. 1 - 72 DY_i

(ft)

CARDS Format 6E12.5:
10-13 Col. 1 - 72 B_i

(ft)

CARD 14 Format E12.5:

Col. 1 - 12	G ₁	
Col. 13 - 24	ω ₁	(cps)
Col. 25 - 36	G ₂	
Col. 37 - 48	ω ₂	(cps)
Col. 49 - 60	G ₃	
Col. 61 - 72	ω ₃	(cps)

Card 14 is repeated until NP damping and frequency pairs have been input--three to a card. A maximum of 10 frequencies is allowed.

Cards 15 through 30 are identical with Cards 4 through 19 of DFAL17. Cards 31 through 40 are identical with Cards 32 through 41 of DFAL17.

CARD 41 Format 6E12.5:
 Col. 1 - 72

CARD 42 Format 6E12.5:
 Col. 1 - 72

2. Guide to Input Format

CARD 01 TTL is the title card consisting of alphabetic or numeric information required for identification of the run. This card is reproduced on the first sheet of output and on the plots.

CARD 02 NG is a control number designating the gust shape. The gust begins at time = 0.

If NG > 0, a plot tape is generated.

If NG < 0, all response points and loads will be printed as well as plotted.

If NG = 1, a continuous sine wave with frequency defined by OM (Card 4) in cps and magnitude defined by VG in ft/sec.

If NG = 2, a half cycle, 1-cosine wave with frequency defined by OM in cps and magnitude defined by VG in ft/sec.

If NG = 3, a step gust input with magnitude defined by VG in ft/sec.

If NG = 4, a pulse gust with a duration defined by OM in seconds with a magnitude defined by VG in ft/sec.

If NG = 5, a step gust modified by the Wagner function. The Wagner function is approximated as:

$$1 - 0.165 e^{-0.4555} - 0.335 e^{-0.3S}$$

where $S = \frac{Vt}{B}$

V = forward velocity, ft/sec

t = time seconds

B = reference semichord, ft

The magnitude defined by VG in feet per second.

NT is an option designating the output required. Consideration should be given to minimize the output since each additional output requires computer time.

If NT = 0, only the coordinate responses will be calculated.

If NT = 1, only the forces, moments, and torques will be calculated.

If NT = 2, the forces, moments, torques, and displacements of all coordinates will be calculated.

NP is the number of coupled modes to be input, $NP \leq 10$.

NSG is the total number of coordinates to be considered, $NSG \leq 10$.

NSCP is the number of each coordinate to be run. There will be NSG coordinates entered successively in I4 format.

CARD 03 RHO is the air density in slug/ft³.

V is the aircraft forward velocity (knots).

CLA is the lift curve slope of the lifting surfaces, i.e. wing and three blades. This lift curve slope is used only for the gust induced airloads.

VG is the maximum vertical gust velocity in feet per second.

BR is the reference semichord (ft). Should be the same as that used in the flutter analysis DFAL17.

S is the reference semispan (ft). Should be the same as that used in the flutter analysis DFAL17.

CARD 04 DT is the incremental time for response in seconds. This increment should be small enough to allow twelve points for the smallest frequency of interest. Space is provided for up to a 5-second response at 0.0005 second increments. That is, 1000 time points can be run for each coordinate. There is no need to run a response case for long periods of response time since the points of interest usually are the starting transient and the resultant steady state. Both of these are easily achieved within 1000 time points.

OM depending on gust option (NG), selected OM could be a blank (step), gust frequency (sine wave, 1-cosine, cps) or a pulse duration (sec).

TMAX Maximum time for response in seconds.

$$\frac{TMAX}{DT} \leq 1000$$

FK is the flexibility matrix scale factor which must be the same as FK used in DFAL17 used to scale the flexibility matrix.

WGSWEP is the wing elastic axis sweep angle in degrees. Forward sweep is negative.

BLDSWP is the blade elastic axis sweep angle in degrees. Folding aft is positive.

CARD 05 One card must be supplied for each coordinate that is to be analyzed. This card provides the structural parameters required to calculate internal loads at the coordinate.

EIB is the beamwise EI for the segment corresponding to node being analyzed (Table I) in lb-in²

GJ is the torsional stiffness for segment corresponding to node being analyzed, Table I.

L_1 is the length from the origin to the left node of the segment being analyzed. Can be any length desired but must be ΔL shorter than L_2 , $\Delta L = L_2 - L_1$. For the wing L_1 is the length from the root to node left. For the blade is the length from the intersection of the mast centerline and the blade elastic axis.

L_2 is the length from the origin to the right node of the segment being analyzed. Can be any length desired, but must be ΔL longer than L_1 , $\Delta L = L_2 - L_1$. For the wing, L_2 is the length from the root to the node right. For the blade, L_2 is the length from the intersection of the mast centerline and the blade elastic axis.

CARDS
6 - 9

DY is the width (in feet) of the aerodynamic surfaces used to compute the gust loadings on the wing and blades. These are the DYs used in DFALL7, except that for blades 2 and 3, the DYs must be one-half of those for blade 1. This is because blades 2 and 3 have one-half of the gust velocity normal to their planform. These DYs should reflect span and aspect ratio effects. The DYs are entered in order on four succeeding cards in the order:

CARD 06 Wing - five segment pylon plot

CARD 07 Pylon yaw and blade 1 all five segments

CARD 08 Blade 2 - five segments,
Blade 3 - one segment

CARD 09 Blade 3 - segments two to five.

DY can be zero.

CARDS
10-13

B is the local semichord (in feet) of the aerodynamic surfaces. B is used to compute the gust loads on the wing and blades. These Bs would normally correspond to the Bs used in DFALL7. The Bs are entered in order on four succeeding cards in the order:

CARD 10 Wing (five segments) and pylon pitch

CARD 11 Pylon yaw and blade 1 (five segments)

CARD 12 Blade 2 (five segments), and first segment of blade 3

CARD 13 Blade 3 (segments two through five).

B cannot be zero.

CARD 14 NP G_i and ω_i are the damping factor and frequency in cps, respectively. These are obtained from the DFAL17 output for the velocity input to DFAL18. NP pairs must be input.

Cards 15 through 30 are identical with Cards 4 through 19 of DFAL17.

Cards 31 through 40 are identical with Cards 32 through 41 of DFAL17.

CARD 41 FLEX is the structural influences coefficient matrix generated with DFAL17. This matrix is 74 x 74 and consists of 962 cards, sequentially numbered and in 6E12.5 format. If a card is out of order, the program will stop and print an error message identifying the last good card.

CARD 42 CMPLXR are the complex eigenvalues for the first reduced velocity and are generated using DFAL17. The reduced frequency should be zero. CMPLXR consists of 25 cards, sequentially numbered.

3. Output Format and Guide

DFAL18 output of DFAL18 consists of four parts:

- All input data.
- The calculated aerodynamic matrix and eigenvalues.
- A printed time history of the coordinate displacements, forces, moments, and torques.
- A machine (CALCOMP) plot of displacements and the forces, moments, and torques at the right and left nodes.

The output format is shown by a sample case in Appendix I.

4. Suggested User Techniques

a. Problems Encountered

As in Program DFAL17, there are peculiarities associated with the program. Given below are the most frequent complaints.

- (1) Loads calculated are too high or too low. This can be caused by any of the following:
 - (a) Input data error; card out of place, integer number not right oriented or floating number out of field.
 - (b) Incorrect number of modes. Since blade modes occur in threes, to include one or two will result in erroneous loads.
 - (c) GJ or EI for the segment is wrong.
 - (d) Loads are correct and the users estimator is off.
- (2) The job will terminate if a card in the flexibility matrix is out of order. All cards punched as output from DFAL17 are sequentially numbered. This sequence number is checked in DFAL18.

b. Time Estimate

The approximate run time for the loads at one node is approximately six minutes. This time will vary with priority time sharing procedures and whether output is printed on line or off line.

SECTION III

PROGRAMMING GUIDES

This section contains the fundamental structure of programs developed under this contract. Details of numerical methods and program organization are then discussed. FORTRAN listings will not be included in this section; they are listed in Appendix II.

A. ARAP06

1. Method of Digital Computer Solution

A predictor-corrector integration technique is used in the solution of the simultaneous equations of motion which are nonlinear, open-form in nature. In general the solution of a set of differential equations by this method requires the isolation of the highest order derivatives. For example given the equation

$$a\ddot{x} + b\dot{x} + cx = F(t)$$

where the coefficients a , b , c and forcing function, $F(t)$, may all be time dependent and/or nonlinear.

To solve for $\ddot{x}$, the equation is rearranged in the following form

$$\ddot{x} = \frac{F(t)}{a} - \frac{b}{a}\dot{x} - \frac{c}{a}x$$

Prior to evaluating this equation, a value of $\ddot{x}$, called $\ddot{x}_g$, is guessed. When an iterative procedure starts at a new time point, $\ddot{x}_g$ is used from the solution at the previous time point. Otherwise it is predicted by use of point-slope computational methods to minimize the difference between the value calculated and the value guessed.

Since values of velocities and displacements are also required, to evaluate the equation Taylor's series is used to provide a numerical integration form for determining them as functions of the guessed acceleration.

By definition the integral of a function $f'(x)$ over the interval h is:

$$f(x+h) - f(x) = \int_x^{x+h} f'(x)dx$$

Also the incremental form of Taylor's series expansion of a function $f(x)$ is:

$$f(x+h) = f(x) + hf'(x) + \frac{h^2}{2!}f''(x) + \frac{h^3}{6}f'''(x) + \dots$$

Thus the integral

$$\int_x^{x+h} f'(x)dx = hf'(x) + \frac{h^2}{2}f''(x) + \frac{h^3}{6}f'''(x) + \dots$$

Defining derivatives of $f(x)$ in the following way:

$$f'(x) = \frac{f(x) - f(x-h)}{h}$$

We can produce an integration form which permits evaluation of $f(x+h)$ in terms of its derivatives, i.e. numerical integration. The derivative can be defined in other ways, for example

$$f'(x) = \frac{f(x+h) - f(x-h)}{2h}$$

But for simplicity of programming the first definition is used here.

Substituting and letting $h = \Delta t$:

$$\begin{aligned} f(x+\Delta t) = f(x) + \Delta t \cdot f'(x) + \frac{(\Delta t)^2}{2} [f'(x+\Delta t) - f'(x)] \\ + \frac{(\Delta t)^3}{6} [f''(x+\Delta t) - f''(x)] + \dots \end{aligned}$$

Thus

$$\begin{aligned} f(x+\Delta t) = f(x) + \frac{\Delta t}{2} [f'(x+\Delta t) + f'(x)] \\ + \frac{(\Delta t)^2}{6} [f''(x+\Delta t) - f''(x)] + \dots \end{aligned}$$

Let

$$f(x+\Delta t) = \dot{x}_g$$

retain the second term only, one obtains,

$$\dot{x}_g = \dot{x}_{n-1} + (\ddot{x}_g + \ddot{x}_{n-1}) \frac{\Delta t}{2}$$

Then let

$$f(x+\Delta t) = x_g$$

one obtains

$$x_g = x_{n-1} + (\dot{x}_g + \dot{x}_{n-1}) \frac{\Delta t}{2} + (\ddot{x}_g - \ddot{x}_{n-1}) \frac{(\Delta t)^2}{2}$$

where the subscript n-1 refers to the previous time point.

A computed acceleration is then obtained by using the guessed values of $\dot{x}_g$ and x_g , i.e.

$$\ddot{x}_c = \frac{F(t)}{a} - \frac{b}{a} \dot{x}_g - \frac{c}{a} x_g$$

This computed value in general will not be equal to the guessed one. A convergence criterion has to be met such that

$$\frac{|\ddot{x}_c - \ddot{x}_g|}{|\ddot{x}_c|} \leq \varepsilon$$

where ε is the error tolerance.

If the error percentage fails to be less than ε , a quadratic point-slope subroutine is called using parabolic curve fitting to minimize the error percentage to zero. A better predicted $\ddot{x}_g$ is then obtained for the next iteration. The process repeats itself until the convergence criterion is met. Throughout these prediction and correction procedures, the independent variable-time remains constant. When the error percentage is within the tolerance, the convergence is completed. The value of time is then increased by an increment and the iterative process is repeated.

2. Subroutine Descriptions

a. FORTTRAN Subroutines

The FORTRAN subroutines contained in the Proprotor Aeroelastic Analysis, ARAP06, are listed in alphabetical order except for the main program which is first. A few remarks are made for each subroutine, which indicate the general purpose or use of the subroutine in the general structure of the program. Great detail of explanation is not attempted here since it would be redundant.

- (1) MAIN - This routine is the main program of ARAP06. This subprogram sets up the time loop and directs the flow of beginning and ending of the whole program. The rate of feathering or unfeathering of rotor-blades is computed here.
- (2) AIRLDS - This subroutine handles the computation of rotor aerodynamics.
- (3) BEXIOM - Tabulated forms of natural frequencies, normal modes and bending moments of flexible blades as functions of rotor rpm and blade feathering are read in. Printing out of these tables is also included in this subroutine.
- (4) BLOCK DATA - This subroutine contains tabulated forms of blade aerodynamic lift, drag, and moment coefficients C_L , C_D , and C_M as functions of Mach number and angle-of-attack. It also contains the tabulated coefficients of blade pitch-damping as functions of angle-of-attack and reduced velocity.
- (5) CLCDR - A maximum of four different blade airfoil sections can be handled in ARAP06. This subroutine determines the airfoil for each blade segment. This subroutine also provides the interpolation for values of C_L , C_D , and C_M for the most inboard blade airfoil section.
- (6) FLAPN1 - Forcing functions for blade rigid-body flappings and rotor rotational degrees-of-freedom are calculated. These equations are then solved simultaneously.
- (7) FLAPN3 - Tests of converging criteria for blade rigid-body flappings and rotor rpm are conducted. If convergence is completed, forces and moments due to rotor aerodynamics, rotor inertials and rotor gravity are summed and ready to be used as a forcing function for wing/pylon dynamic equations. Print-out of converged rotor variables is then processed. The peaks of master blade flapping are stored if required.
- (8) FLEXBD - This subroutine solves for generalized coordinates for the flexible blades.
- (9) FLEX1 - Because of limitations on the size of subprograms in the FORTRAN compiler, all dynamic terms used in the dynamic equations of motion for rotor-blades cannot be handled in any single subroutine. Some terms are, therefore, calculated in this subroutine and will be used in both subprograms FLAPN1 and FLEXBD.
- (10) FORCES - Rotor inertial loads and moments are calculated when the convergence of blade generalized coordinates is completed.

(11) HEADNG - This subroutine handles the **FORMAT** of the print-out headings. The input options have control on the selection of variables to be computed as well as on the output headings.

(12) INPUT - The read-and-write of input data is done in subroutines BEXIOM and READWR. The subroutine INPUT changes input parameter units if necessary, and computes time-invariant quantities from input data.

(13) PLTS - This subroutine plots the specified variables.

(14) PSLOP - This subroutine minimizes the difference between the calculated acceleration and the predicted one and provides a better prediction for next iteration. Let $\ddot{x}_g$ be the predicted acceleration, $\ddot{x}_c$ be what calculated, and $\Delta\ddot{x} = \ddot{x}_c - \ddot{x}_g$. a point, $(\ddot{x}_g, \Delta\ddot{x})$ is then obtained in a two-dimensional space. When iteration loop starts at a new time point, there is only one $(\ddot{x}_g, \Delta\ddot{x})$ available. The next prediction is given by simply averaging $\ddot{x}_g$ and $\ddot{x}_c$. After the second iteration, there are two points of $(\ddot{x}_g, \Delta\ddot{x})$ available. A straight line passing through these two points and intersecting the axis of abscissa gives a value of $\ddot{x}_g$. This $\ddot{x}_g$ is used as a predicted value for the next iteration. After the third iteration, there should always be three points of $(\ddot{x}_g, \Delta\ddot{x})$ available, a quadratic equation is then used. The intersection of the curve represented by this quadratic equation and the abscissa provides the next predicted $\ddot{x}_g$ for use in the following iteration. Two subroutines are generally obtained by solving a quadratic equation, the one which is closest to the last guess is used.

(15) READWR - This subroutine reads and writes all the input data for proprotor and wing/pylon except those for the rotor flexible blades.

(16) RSTN - Flapping restraint and stops of a gimbaled rotor are handled in this subroutine.

(17) TABINA - Interpolation of tabulated forms of natural frequencies, normal modes and bending moments of flexible blades as functions of instantaneous rotor rpm and blade feathering is done in this subroutine.

(18) TABINT - Excluding the most inboard blade airfoil section, the C_L , C_D , and C_M of the rest of the three sections of a blade are provided by interpolation.

(19) WING - Wing aerodynamics and generalized force for wing/pylon system are calculated. Dynamic equations of motion of wing/pylon are then solved. Converging criteria for the solved normal coordinates are tested. Pylon accelerations after completion of the convergence are computed.

b. Subroutines Cross-Reference

The information provided in Table I is vital for understanding of the subroutine organization of program ARAP06. The first column contains the names of the subroutines in alphabetical order, except for the main program which is first. The second column, length, contains the size, in bytes in hexadecimal number base, of the compiled subprogram. The FORTRAN subroutines, all but BLOCK DATA, have been compiled on the IBM operation system 360 FORTRAN IV (H) Compiler with OPT = 2. The subroutine, BLOCK DATA, has to be compiled on FORTRAN IV (G) Compiler because of its size. The third column contains two operations, and the fourth column contains the names of the subroutines associated with that operation and given in the order of call sequence.

3. Flow Outline

The flow charts in Figures 13 and 14 describe the functional structure of the program and the logic used in the subroutine AIRLDS respectively, without regard to flow by subroutines. Figure 13 provides a clear picture of the numerical technique used in ARAP06 to solve the equations-of-motion simultaneously. Figure 14 demonstrates how the wing-rotor aerodynamic interference is handled in the calculation of blade airloads. Tedious flow charts are not given in this report. The reader can refer to FORTRAN listings for details.

TABLE I
ARAP06 SUBROUTINE CROSS-REFERENCE

Name	Length	Operation	Cross-Reference
MAIN	CE0	Calls	INPUT, HEADNG, FLEX1, AIRLDS, FLEXBD, FLAPN1, FLAPN3, PLTS
AIRLDS	147A	Calls Is Called By	CLCDR MAIN
BEXIOM	1274	Is Called By	READWR
BLOCK DATA	2A08	Is Used By	TABINT
CLCDR	930	Calls Is Called By	TABINT AIRLDS
FLAPN1	1274	Calls Is Called By	RSTN MAIN
FLAPN3	1814	Calls Is Called By	PSLOP, TABINA, FORCES, RSTN, WING, HEADNG MAIN
FLEXBD	1ECA	Calls Is Called By	PSLOP MAIN
FLEX1	94C	Is Called By	MAIN
FORCES	F1E	Is Called By	FLAPN3
HEADNG	56C	Is Called By	MAIN, FLAPN3
INPUT	13A6	Calls Is Called By	READWR, TABINA MAIN
PLTS	2A2C	Is Called By	MAIN
PSLOP	41A	Is Called By	FLAPN3, FLEXBD, WING
READWR	24E6	Calls Is Called By	BEXIOM INPUT
RSTN	304	Is Called By	FLAPN1, FLAPN3
TABINA	5F0	Is Called By	INPUT, FLAPN3
TABINT	9C2	Is Called By	CLCDR
WING	12C0	Calls Is Called By	PSLOP FLAPN3

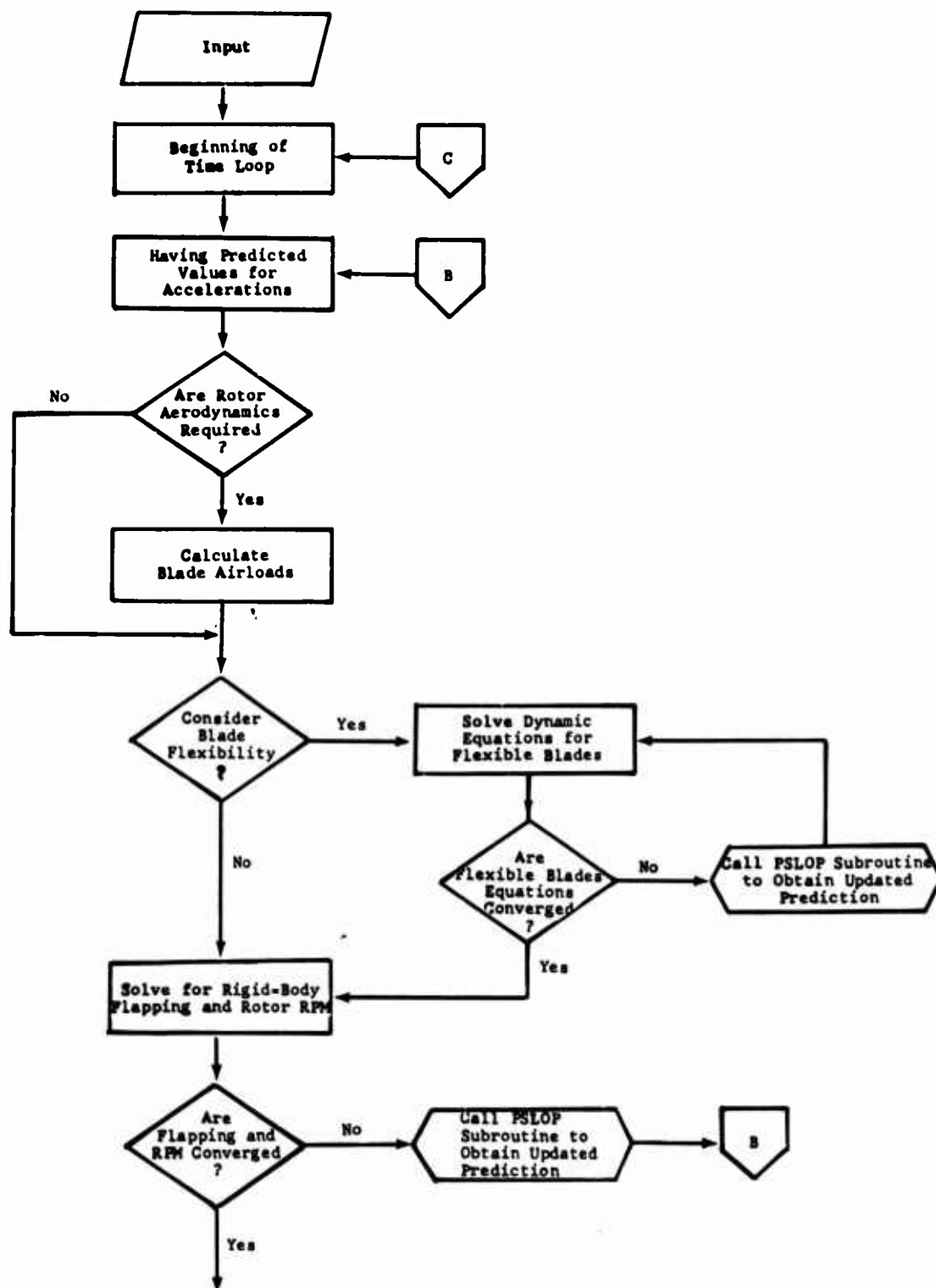


Figure 12. Flow Chart for Program Structure - ARAP06.

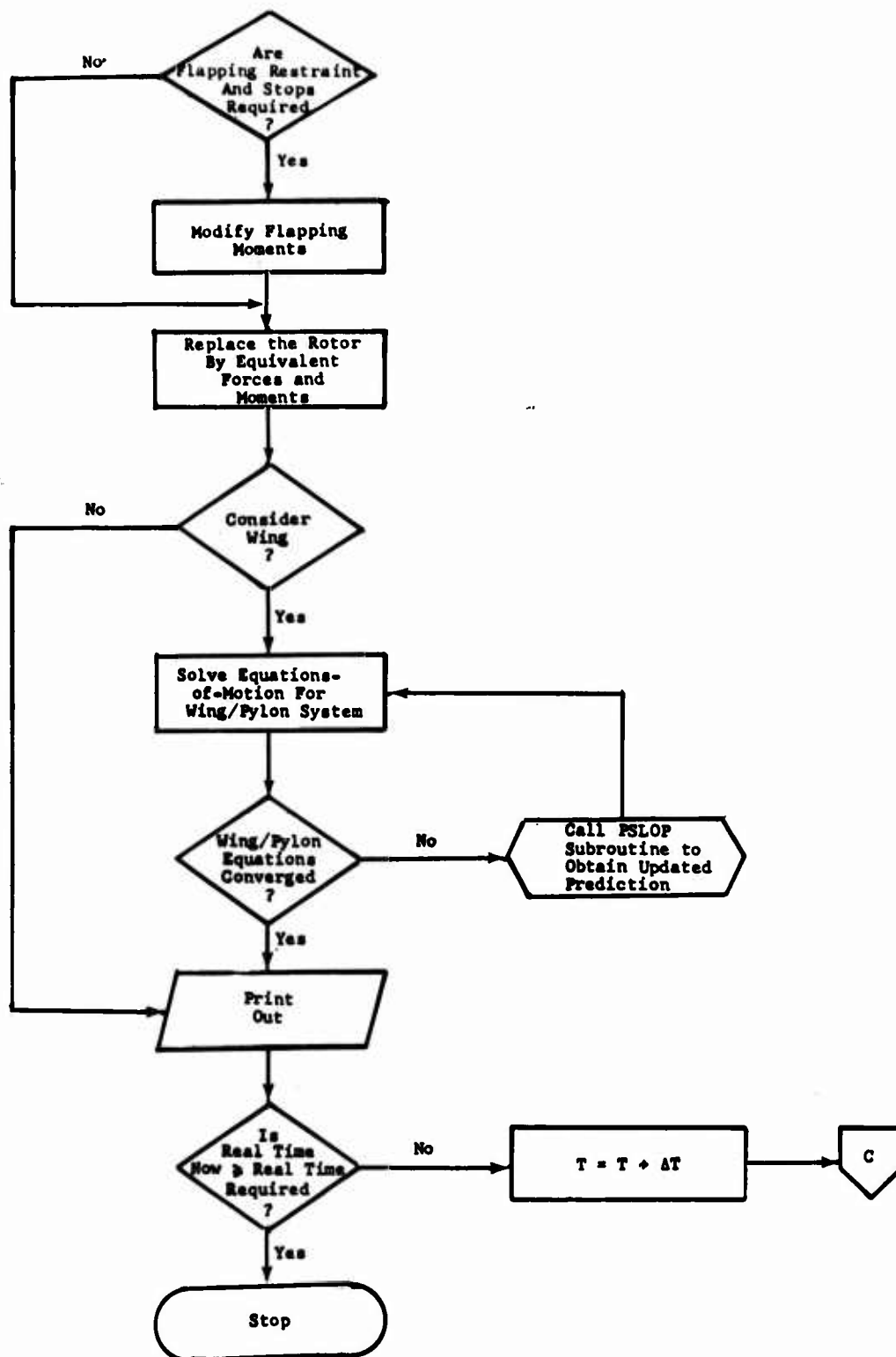


Figure 12. Concluded

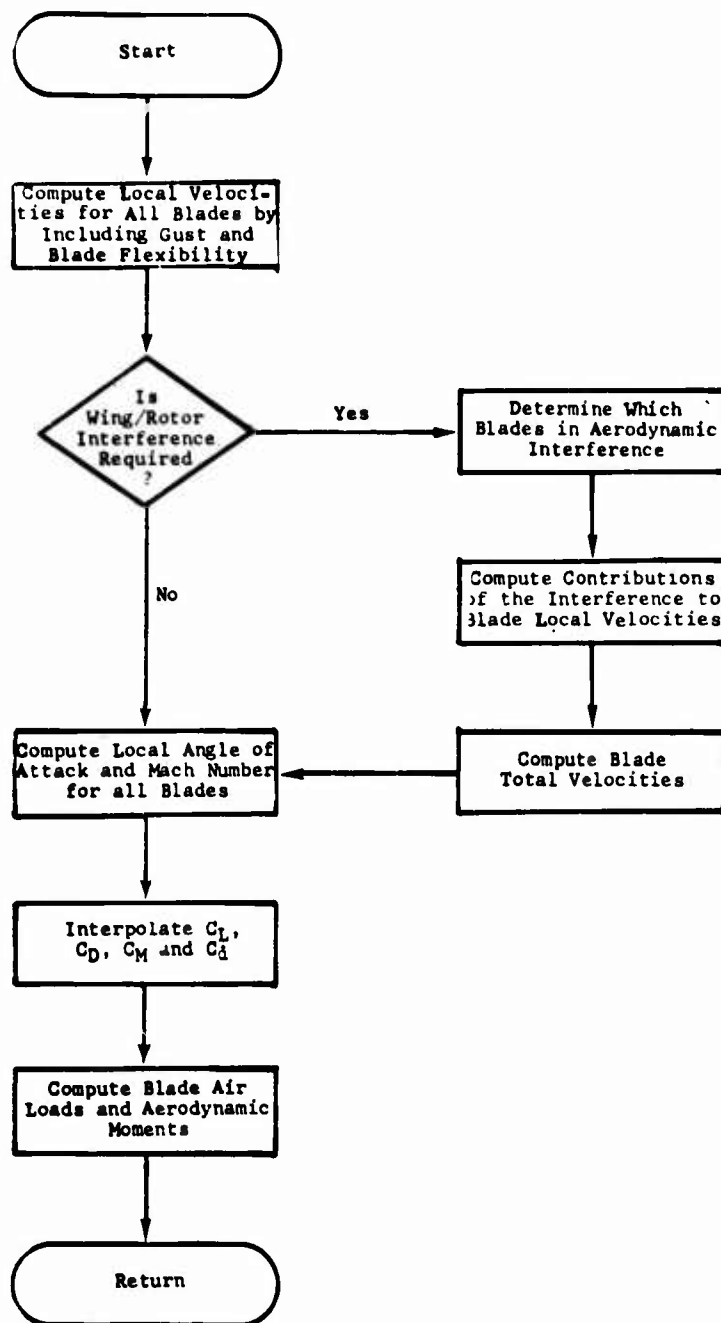


Figure 13. Flow Chart for Subroutine AIRLDS.

B. DFAL17

1. Method of Solution

Computer program DFAL17 solves for the flutter speed of a folding propotor. The stiffness matrix, mass matrix, and aerodynamic matrices are constructed, arranged and solved with a minimum of input data. The user needs only to specify stiffnesses, geometric sizings, and fold angles.

The dynamics matrix is solved by ALLMAT, a QR algorithm, which solves for all 74 eigenvalues in a minimum of computer time. The eigenvalues are then arranged in order of decreasing real part (increasing frequency) and the appropriate number of eigenvectors are calculated. The structural influence coefficient matrix and 74 eigenvalues can be punched output for use as input to computer program DFAL18.

The flow of the computer program is shown by a macroscopic flow diagram (Figure 13). A brief description of each subroutine, a flow outline, and a list of variable arrays are given on the following pages. The main variable arrays are defined at the end of this chapter. The reader is referred to the FORTRAN listing (Volume III) for program details.

2. Subroutine Description

SUBROUTINE PRT3

Initializes and builds the dynamics matrix using an assumed reduced velocity or flutter frequency.

SUBROUTINE PRT4

Solves the dynamic system for all eigenvalues and requested eigenvectors. Orders eigenvalues for lowest frequency, outputs eigenvalues, eigenvectors, natural frequencies, and punched eigenvalues if necessary.

SUBROUTINE DFAE, BESJ, BESY

This subroutine and its associated routines BESJ, BESY, form the aerodynamic influence coefficient matrix corresponding to a given reduced velocity or flutter frequency. BESJ computes J Bessel functions. Methods used are those given in IBM SYSTEM/360 SCIENTIFIC SUBROUTINE PACKAGE, VERSION III PROGRAMMER'S MANUAL, H20-0205-3, page 363-364.

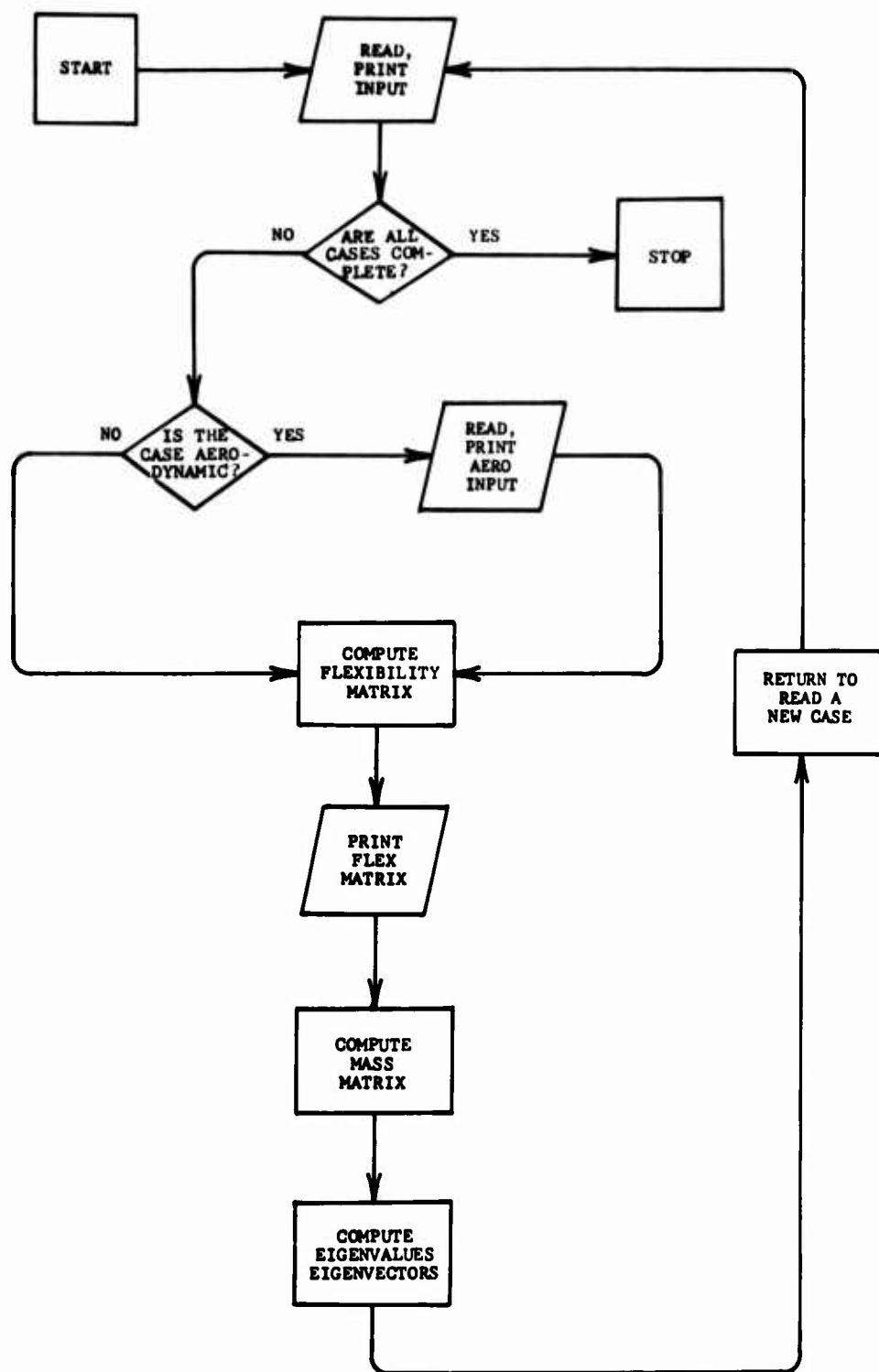


Figure 14. DFAL17 Flow Diagram.

SUBROUTINE STGN

Reads stiffness inputs, forms stiffness matrix parameters, inverts, transforms, and produces flexibility matrix. Punches flex matrix if necessary.

SUBROUTINE ROTATE

Builds large stiffness matrix, 180th order, and transformation matrix.

SUBROUTINE MPRINT

Prints a program matrix in column form.

SUBROUTINE REDUCE

Eliminates undesired coordinates from the symmetric stiffness matrix by Gaussian pivotal reduction, reduction of degrees of freedom from 180 to 74.

SUBROUTINE MULT

Forms a matrix product UA where A is a real matrix, in this program a flex matrix, and U is a complex aerodynamic-inertial matrix.

SUBROUTINE ALLMAT

This program uses a QR algorithm with special attention to minimization of required storage to solve for the eigenvalues and eigenvectors of a general system of the form $A - \lambda I = 0$, where A is a complex valued matrix. In this case the matrix A is 74th order, and not symmetric.

SUBROUTINE INVERS

This routine inverts an $N \times N$ matrix by Gaussian row and column pivot operations.

SUBROUTINE TPROD

This subroutine performs a specific matrix triple product X^TAX where A is a 180th order symmetric stiffness matrix in upper triangular form and X is a quinary diagonal transformation matrix.

SUBROUTINE DPROD

Performs a matrix triple product X^TAX where A is a symmetric $N \times N$ matrix and X is a general transformation matrix.

SUBROUTINE ERRSET

This IBM 360 System subroutine suppresses underflow error printouts which occur from solution of an undamped dynamics matrix problem with an eigenvalue routine, ALLMAT which is intended for solution of damped systems. In some cases, the imaginary part of the eigenvalues approaches zero slowly.

3. Flow Outline

MAIN

- (1) Begin reading input for new case. Define default parameters. If no aero input is to be called for, go to (3).
- (2) Read aero input and call subroutine DFAE to set up aero coefficients.
- (3) Call subroutine STGN to compute flexibility matrix.
- (4) Output flexibility matrix and scale by k factor.
- (5) Start loop to evaluate distributed mass matrix.
- (6) Form mass matrix by triple product coordinate transformation. When all mass elements are complete, go to (7).
- (7) Print mass matrix and call subroutine PRT3 for eigenvalue-eigenvector computations.

SUBROUTINE PRT3

- (1) Set up loop to build and evaluate system for each reduced velocity input in MAIN (2) or once for the structural system if no aero exists.
- (2) Zero and build aero matrix transpose by calling subroutine DF67.
- (3) Add the mass matrix transpose to the aero matrix. Units of slugs are consistent.
- (4) Form product $(M+A)K^{-1}$, the augmented mass matrix post-multiplied by the flexibility matrix.
- (5) Transpose the dynamics matrix transpose to form the dynamics matrix.
- (6) Call subroutine PRT4 to compute eigenvalues and eigenvectors of dynamics matrix.

- (7) If all reduced velocities have been run return to MAIN, otherwise go back to (2) for next velocity.

SUBROUTINE PRT4

- (1) Compute all 74 eigenvalues by calling subroutine ALLMAT.
- (2) Use loop to order the first MODES eigenvalues in ascending order of magnitude of the real or frequency component only. This corresponds to lowest flutter frequencies first.
- (3) Print eigenvalues. If punch option is on, punch eigenvalues.
- (4) Start loop to evaluate eigenvectors.
- (5) Call subroutine entry ALLVEC to compute the eigenvector corresponding to a given eigenvalue.
- (6) Normalize the eigenvector by division by the largest element.
- (7) Go through logic to print eigenvectors in groups of threes.
- (8) If all eigenvectors needed have been computed, go to (9), otherwise to (4) for next eigenvector.
- (9) Start loop to evaluate all frequency and damping factors derived from flutter frequencies of interest.
- (10) Compute and print flutter frequency, damping and equivalent velocity.
- (11) At end of loop (9) return to subroutine PRT3.

SUBROUTINE DFAE

- (1) Read input aero data case and print all quantities input. Return to MAIN program.
- (2) At entry DF67 the reduced velocity EKR to be used is input to the subprogram.
- (3) Start loop over all surfaces, in this program, four.
- (4) Start inner loop over all strips on each surface.
- (5) Set up transformation matrix A dependent on surface-strip geometry.

- (6) Compute J and Y Bessel functions for the modified frequency.
- (7) Set up the oscillatory aerodynamic coefficient matrix B using Bessel functions from (6).
- (8) Do a transformation matrix triple product $A^T B A$ to get aerodynamic influence coefficient matrix.
- (9) Scale the coefficients by an equivalent air mass factor.
- (10) Use a loop to set up the transpose of the aerodynamic matrix by distributing the aerodynamic influence coefficients along the diagonal.
- (11) Have all strips been computed? If not return to (4).
- (12) Have all surfaces been computed? If not return to (3).
- (13) Return to subroutine PRT3 with complex aerodynamic matrix.

SUBROUTINE STGN

- (1) Read structural inputs and print.
- (2) Use loop to initialize angles and lengths.
- (3) Set up quantities required for stiffness matrix.
- (4) Call subroutine ROTATE to build 180th order stiffness matrix A and transformation matrix B.
- (5) Call subroutine TPROD to form triple product $B^T A B$.
- (6) Call subroutine REDUCE to reduce large stiffness matrix to 74th order by elimination of coordinates.
- (7) Read parameters required for mass matrix and coordinate transformation.
- (8) Interchange columns 11, 12, and 13 in stiffness matrix and initialize transformation matrix.
- (9) Invert stiffness matrix to get 74th order flexibility matrix.
- (10) Print computed stiffnesses and input from (7).
- (11) Build transformation matrix from input of (7).

- (12) Call subroutine DPROD to do transformation triple product.
- (13) If punch option is on, punch the final flexibility matrix.
- (14) Return to MAIN.

SUBROUTINE ROTATE

- (1) Zero upper triangular stiffness matrix storage.
- (2) Start loop to build 180th order upper triangular stiffness matrix.
- (3) Look at each node point, 30 in all; build the elements of the stiffness matrix by coordinate transformations of a coupled 2 node stiffness system.
- (4) Store all computed values of node stiffness quantities in an upper triangular form due to symmetry.
- (5) If all nodes have been completed go to (6), otherwise to (2).
- (6) Initialize node independent values of the gamma transformation matrix.
- (7) Build the gamma transformation matrix as a set of 3 x 3 matrices, 2 for each node.
- (8) When the entire gamma transformation matrix is complete, return to subroutine STGN.

SUBROUTINE REDUCE

- (1) Start loop to evaluate all 180 degrees of freedom.
- (2) If the selected degree of freedom is not to be reduced to (8).
- (3) Select pivot element of coordinate to be reduced.
- (4) Use loop to build a row vector for use in reduction.
- (5) Start loop to modify the row vector by division by the pivot element.
- (6) Use inner loop to subtract the divided row from all other rows.

- (7) When all row elements defined in (4) have been modified as in (5) go to (9), otherwise back to (5).
- (8) Increment counter of the coordinates to be retained.
- (9) If all coordinates have been analyzed, go to (10), otherwise back to (1) for new coordinate.
- (10) Use loop to do reduction of triangular 180th order elements to be kept, to a triangular 74th order form.
- (11) Transfer 74th order symmetric form to a 74th order square matrix. Reason for the double step ((10) - (11)) is because of space limitations.
- (12) Return to subroutine STGN.

4. Variable Arrays

(* Signifies Input Parameter)

* VELCTY(15)	Values of reduced velocities
A(74,74)	Flexibility matrix
C(2,2), B(2,2)	Transformation matrices
* X(22)	Mass matrix parameters for building distributed mass matrix and also for forming dumbbell transformation matrix
* Y(22)	
* M(22)	
* SX(22)	
* IX(22)	
AM(150)	Mass matrix element values. Only nonzero values are saved.
ICT(150)	Mass matrix subscript value, respective storage position stored columnwise.
U(74,74)	Dynamics matrix work area
VS(74,3)	Storage for up to three eigenvectors for printout purposes
EIG(74)	Eigenvalues computed
VECT(74)	Work area for eigenvector computation
NCB(3)	Numbers of eigenvectors computed
FMT(3,3)	Storage for variable eigenvector formats

FMA(3)	Work area for eigenvector formats
* COSLMA(4)	
* BRA(4)	Storage for surface variables input to
* SA(4)	aero coefficient evaluation
* CAPA(4)	
* DELTAY(7,4)	
* B(7,4)	Storage for surface and strip variables
* D(7,4)	input to aero coefficient evaluation
AM(2,2), BM(2,4)	Work areas for use in aero
CH1(2,4), PARTA(2,4)	coefficient evaluation
* XDL(5,2)	
* XDEIB(5,2)	Lengths, bending stiffnesses, torsional
* XDEIC(5,2)	rigidity for all coordinates, for
* XDGJ(5,2)	building stiffness matrix
ALPHA(30), PSI(30)	Transformation angles and various
BETA(30), EIB(30)	other quantities used to set up
EIC(30), GJ(30),	original stiffness matrix
AE(30), L(30)	
IX(74)	Subscript list of variables to be
	kept during reduction of 180th order
	stiffness matrix to 74th order
STIF(74,74)	Reduced stiffness matrix
* PARM(22,5)	Same as X,Y,M,SX,IX above
FINAL(74,74)	Transformation matrix for flexibility
	modification
REDK(16290)	Upper triangular 180th order stiffness
	matrix
KMAT(12,12), AMAT(12,12)	Work areas for building large
S(12)	stiffness matrix
RED(180)	Column work area for reduction of upper
	triangular stiffness matrix
H92921)	Work area to hold upper Hessenberg form
	of the dynamics matrix during eigenvalue
	analysis
MULT(74), SHIFT(3),	Work areas for eigenvalue-
INTH(74), NS(74), ING(74)	eigenvector analysis

NSZ(74)

Transformation matrix for 180th order
triple product

XTD(3,3),XTE(3,3) Work areas for above triple product

C. DFAL18

1. Method of Solution

DFAL18 solves for the internal forces, moments, and torques acting at a specific node on a FPR wing, pylon, blade system, due to an externally applied airload. The solution involves determining the response of selected coordinates $q_n(t)$ and using the responses to compute internal loads.

The response of each coordinate is calculated by adding the time dependent transfer functions for each flexible mode. Each mode has the unsteady aerodynamics associated with its frequency. The transfer functions are expressed as polynomials in terms of the Laplacian operator s . While the inverse Laplacian could be formed a finite differencing integration technique is used to calculate the coordinate time responses. Internal loads are then calculated by multiplying the coordinate displacement times the elemental stiffness matrix. This product is done at each time step.

Coordinate responses and internal loads are shown as a function of terms on CALCOMP plots and, if desired, printed output.

The flow of the computer program is shown by a macroscopic flow diagram (Figure 15). A brief description of each subroutine with a written flow explanation is given on the following pages. The main variable arrays are defined at the end of this chapter. The reader is referred to the FORTRAN listing (Volume III) for program details.

2. Subroutine Descriptions

SUBROUTINE TMF

This subroutine sets the plotting axes, scales the variables, and plots the time gust function.

ENTRY HIST

This subroutine entry point prints and plots each force, moment, or coordinate displacement.

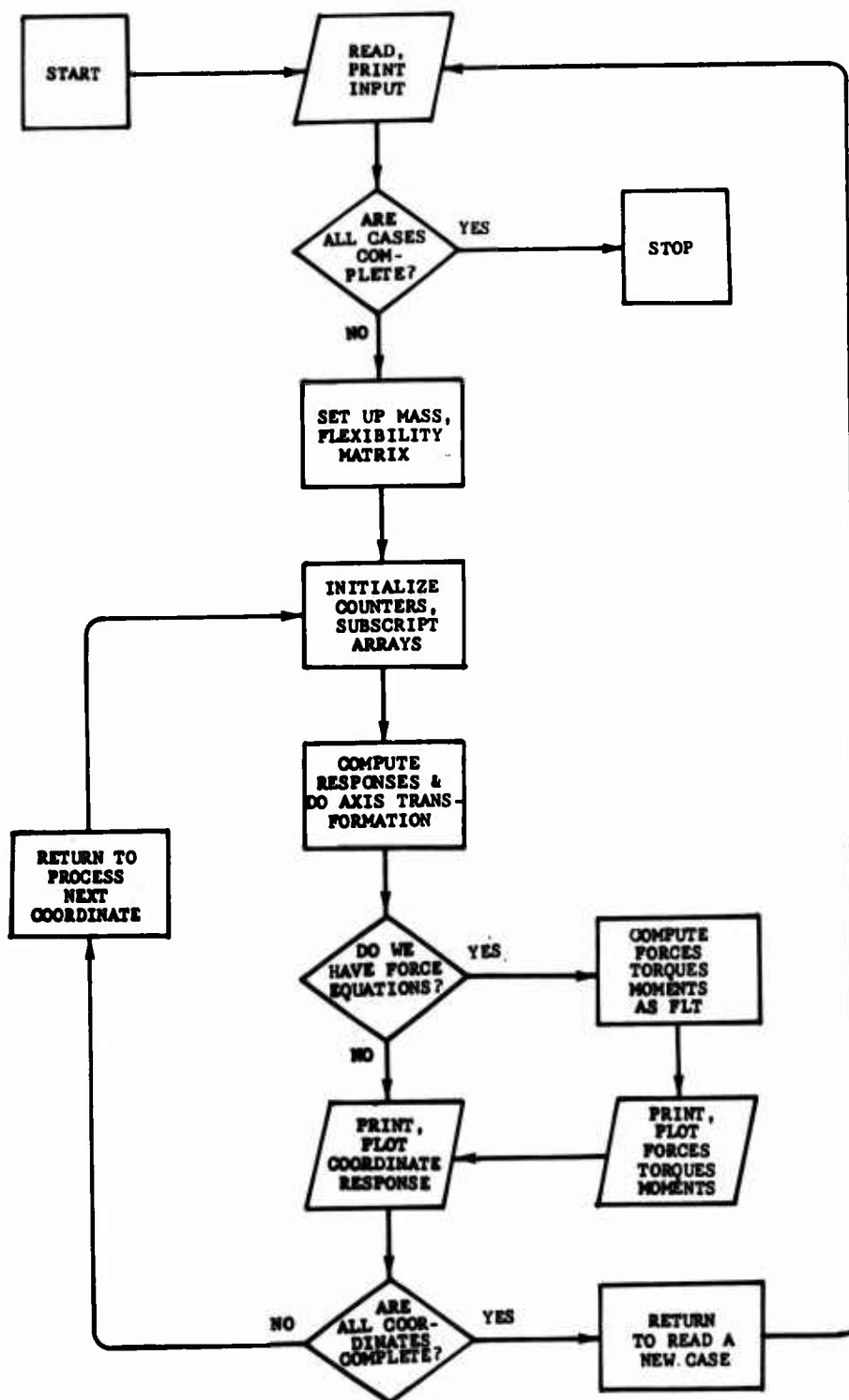


Figure 15. DFAL18 Flow Diagram.

SUBROUTINE RESP

This routine evaluates the time response of all second order transfer functions and accumulates the real part of the response for each transfer function to form a total forced response for each coordinate.

SUBROUTINE MASS

Forms a mass matrix corresponding to the mass matrix distribution of the generalized coordinates.

SUBROUTINE FN

This subroutine computes the time history of the gust input function. The routine may be simply modified or extended to provide any gust input desired, according to a user's needs.

SUBROUTINE INVDET

This subroutine computes the complex determinant value of a complex matrix by Gaussian pivotal reduction.

SUBROUTINE MULT

This subroutine forms a matrix product UA where A is a real matrix, in this program a flex matrix, and U is a complex aerodynamic-inertial matrix.

SUBROUTINE DPROD

This subroutine forms a matrix triple product A^TBA where B is a symmetric matrix, that is, $B = B^T$.

SUBROUTINE DFAE, BESJ, BESY

This subroutine and its associated routines BESJ, BESY, form the aerodynamic influence coefficient matrix corresponding to a given reduced velocity or flutter frequency. BESJ computes J Bessel functions of order 0 and 1, BESY does likewise for Y Bessel functions. Methods used are those given in IBM SYSTEM/360 SCIENTIFIC SUBROUTINE PACKAGE, VERSION III PROGRAMMER'S MANUAL, H20-205-3, page 363-364.

SUBROUTINE RESCOM

This subroutine sets up, evaluates, and reduces each dynamics matrix formed. It then evaluates transfer function coefficients and time responses for all coordinates.

SUBROUTINE REDUCE

This subroutine eliminates undesired coordinates by Gaussian reduction, and retains the modified matrix and forcing vector for determinant evaluation.

SUBROUTINE ERRSET

An IBM 360 subroutine which suppressed underflow error printouts when the J Bessel functions are evaluated very near a zero value.

3. Flow Outline

- (1) Initialize CALCOMP plot buffer storage for plot output.
- (2) Start reading input for a new case. The termination point for a run when all cases have been completed is (23). Read all general input and control parameters and print.
- (3) Compute constants used in iteration loops.
- (4) Read wing parameters and compute gust force magnitude for each coordinate station.
- (5) Read damping and frequency values obtained from DFAL17 for each reduced velocity and print.
- (6) Call subroutine DFAE to initialize, read and print aerodynamic input parameters.
- (7) Call subroutine MASS to read mass matrix inputs and compute mass matrix.
- (8) Read flexibility matrix and flutter frequencies output from DFAL17.
- (9) Compute flutter frequencies in λ form from input frequency and damping.
- (10) Print flutter system roots and flexibility matrix.
- (11) Convert flex matrix to foot units and form modified forcing vector F' .

- (12) Start iteration loop on all coordinates at which a force and bending moment or a coordinate response is required.
- (13) Initialize counters to indicate flutter frequencies and coordinate stations to be used and call subroutine RESCOM.
- (14) Begin loop over all time points. This loop transforms all coordinate responses from the generalized form of two vertical displacements to the coordinates representing the dumbbell model, that is, one rotational and one vertical translational mode at each station.
- (15) If only the translational-rotational coordinates are to be printed and plotted (input option NT), go to (21).
- (16) Compute parameters required to compute forces, torques, moments.
- (17) Start iteration loop to evaluate all quantities which are functions of the translational-rotational coordinate responses computed in (14).
- (18) Compute bending slopes as functions of translations and torsional angles as functions of rotations and translations. If response at the first station is to be evaluated, set cantilever boundary condition.
- (19) Compute forces, torques, moments.
- (20) Call subroutine HIST to print and plot time histories of forces and moments computed in (19).
- (21) Call subroutine HIST to print and plot time histories of rotational and translational coordinates computed in (14) as well as slopes, etc., computed in (18), if any.
- (22) End of loop (12). If all stations of force and displacement analysis have been completed, go to (2) for a new case, otherwise to (13) for the next station.
- (23) Close the plot tape and stop.

SUBROUTINE RESCOM

- (1) Start loop over all flutter frequencies to form reduced matrices and forcing functions.
- (2) Zero the dynamics matrix and call subroutine DF67 with a reduced velocity given by the forward speed and the flutter frequency. Upon return, the complex aerodynamics matrix transpose is provided.

- (3) Add the mass matrix transpose to the aerodynamics matrix transpose to form an effective mass matrix.
- (4) Call subroutine MULT to form the product of the flexibility transpose and effective mass matrix. The result is the transpose of the system dynamics matrix.
- (5) Transpose the dynamics matrix to get in normal column form.
- (6) Choose the particular flutter frequency defined by loop (1) and substitute the value for λ in the matrix $A - \lambda I$. In addition, form the complex valued forcing function.
- (7) Call subroutine REDUCE to eliminate all unwanted coordinates and retain the 6×6 matrix and 6×1 force vector necessary to compute determinant values. If all coordinates have not been done, go back to (1).
- (8) Call subroutine FN to build the form of the time gust function.
- (9) Start loop over all coordinates to compute transfer function coefficients for each flutter frequency and coordinate.
- (10) Pick up the reduced matrix corresponding to a particular flutter frequency and substitute the forcing column for the coordinate whose response is desired.
- (11) Call subroutine INVDET to evaluate determinant of substituted matrix.
- (12) Store coefficients corresponding to a particular coordinate and frequency. If more frequencies remain to be evaluated, return to (10) for another flutter frequency.
- (13) Call subroutine RESP to compute the response of a particular coordinate as a linear combination of the responses of each flutter frequency transfer function to the gust input. If all coordinate responses have not been computed, return to (9) for another coordinate.

REDUCE

- (1) Set up column subscript vector.
- (2) Use loop to divide determinant by denominator factors formed when the first six flutter frequency terms are evaluated at a given flutter frequency.

- (3) Start loop over all coordinates to be reduced or eliminated.
- (4) Use loop to find the largest diagonal or pivot element remaining of those coordinates which are to be reduced.
- (5) If all coordinates to be reduced have been reduced, go to (14).
- (6) Set indicator for the coordinate to be reduced to zero, multiply determinant by the pivot element chosen and divide it by the corresponding denominator element evaluated at the given flutter frequency.
- (7) Use loop to divide forcing vector and matrix row by the pivot element.
- (8) Set the reduced force element to zero to minimize computational error.
- (9) Start loop to reduce matrix coordinate.
- (10) Skip to (12) if product element is zero or row is the row to be reduced.
- (11) Use inner loop to subtract the modified divided row from each row defined by (9).
- (12) If all rows have been modified go to (13), otherwise back to (9) for new row.
- (13) Use loop to zero the reduced row and column elements. Go to (5) for new coordinate.
- (14) Start loop to pick out those elements to be retained for the 6 x 6 matrix.
- (15) Pick out all elements of force vector and matrix to be saved and save for column substitution.
- (16) Return to subroutine RESCOM.

SUBROUTINE FN

- (1) Set the time zero forcing value to zero.
- (2) If the gust number is 1 go to (4), if greater than 2 go to (7).
- (3) Compute number of points for half cycle sine wave. Gust form is sine wave with input frequency.

- (4) Compute sine wave using recursive relationship for sine:

$$\sin(\psi + \Delta\psi) = \sin\psi \cos\Delta\psi + \cos\psi \sin\Delta\psi$$
- (5) If the gust number is 1, go to (11).
- (6) Use a loop to square the sine wave for gust number 2.
 Then go to (10).
- (7) If the gust number is not equal to 5, go to (9).
- (8) Compare Kussner gust function as function of time, forward velocity, and semichord. Then go to (11).
- (9) For gust numbers 3 and 4 a step input must be computed.
 Set the time function to 1. If gust number is 3, go to (11).
- (10) For pulse gust and half cycle sine² wave the remainder of the response must be set to zero.
- (11) Call subroutine TMF to initialize and plot forcing function time response.
- (12) Return to subroutine RESCOM.

4. Variable Arrays

(* signifies input parameter)

PC(10,2)	Complex natural frequencies in S domain
FV(74)	Wind force vector amplitudes
Y (1003)	Coordinate response as f(time)
* AWK(74,74)	Flexibility matrix
* G(10)	Flutter damping coefficients
FY(74)	Modified gust forcing vector amplitudes
* Ø(10)	Flutter frequency coefficients
AM(150)	Nonzero mass matrix values
XM(10,6,4)	Storage for transfer function coefficients
YC(1003,6)	Storage for coordinate time responses

C(2,2,22)	Transformation matrices for each linear to displacement rotational coordinate transform
MSB(150)	Nonzero mass matrix indices
NSG(22)	Starting coordinate numbers
NSB(4)	Numbers of coordinate response to be run
NSCB(10)	Coordinate numbers for which response is desired
BUF(512)	Buffer storage for plot output, multiple of 256
TTL(20)	Run title
DY(22)	Section width
B(22)	Section length
XD(1003,3)	Storage for responses to be plotted
EI(10)	EIB section values
GK(10)	GJ section values
SLC(10)	L1 section length values
SLD(10)	L2 section length values
A(74,74)	Complex flutter equations matrix
Z(74)	Work area
* Q(74)	Zero velocity poles or flexible frequencies

APPENDIX I

SAMPLE PROBLEMS

Sample problems are provided to assist the user in checking out and using the computer programs. Each sample problem consists of the data sheets, the input display included in the output, and condensed output. Examples of the CALCOMP machine plots for programs ARAP06 and DFAL18 are also included. The sample problems are taken from the D270A FPR dynamic analysis, discussed in Section IV of Volume I.

FORTRAN Coding Form

IBM

PROGRAM ARAP06		DATE		PUNCHING INSTRUCTIONS		GRAPHIC PUNCH		PAGE / OF 10		CARD ELECTRIC NUMBER	
PROGRAMMER											

FORTRAN STATEMENT												IDENTIFICATION MARKS
1	2	3	4	5	6	7	8	9	10	11	12	13
JUNE 11, 1971												
SAMPLE CASE FOR PROGRAM ARAP06 USING MODEL D270 PARAMETERS												
10	2	6	1	2	1	1	1	1	1	1	1	CARD 01
122.	1117.	002378								160.	386.	CARD 02
3.	-25.	62.9								175.	1.	CARD 03
.0045	0.											CARD 04
2000.	2000.	2000.	2000.	2000.	2000.	2000.	2000.	2000.	2000.	2000.	2000.	CARD 05
109.4	.2	.1										CARD 06
600.	10.	10.	1.4	6.	72.2	1.44	30.5					CARD 07
9.	133.4	5.78	.17									CARD 08
												CARD 09
												CARD 10
												CARD 11
												CARD 12
												CARD 13
												CARD 14
												CARD 15
												CARD 16
												CARD 17
												CARD 18
												CARD 19
												CARD 20

ARAP06 Sample Problem, Input Data

FORTMAN Coding Form

IBM

ARAP06		DATE	2 10
PROBLEM	PROBLEM	PROBLEM	PROBLEM

FORTMAN STATEMENT										UNIFICATION									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0																			
40.	40.																		
40.	40.																		
15.	30.																		
30.	15.																		
40.	64.																		
MODEL	52.	76.	90.	105.	7.85	15.7	23.55	28.78	32.86										
D270	GIMBALLE	RPTOR	FIRST	COLLECTIVE	MODE														
28.89	31.4	40.82	49.61	55.89	30.77	93.28	37.05	42.7	50.87	57.15	35.17								
37.68	41.45	46.47	54.64	59.66	41.45	43.96	47.73	52.12	59.66	62.8	46.47	48.36							
52.12	56.52	62.8	65.31	50.24	52.12	55.26	59.66	65.94	67.2										
1	1	4	0																
.005	.019	.044	.090	.164	.274	.418	.594	.792	1.	.006	.021	.048							
.094	.167	.274	.417	.592	.791	1.	.008	.027	.057	.104	.177	.282							
.421	.594	.792	1.	.010	.036	.072	.123	.195	.297	.432	.600	.794							
1.	.016	.055	.106	.167	.243	.344	.471	.627	.807	1.	.025	.037							
.166	.262	.373	.495	.622	.751	.876	1.	.005	.019	.045	.092	.168							
.278	.422	.597	.794	1.	.006	.023	.050	.098	.172	.281	.423	.597							
.793	1.	.008	.028	.059	.108	.182	.287	.427	.598	.794	1.	.011							

CARD 20
CARD 21
CARD 22
CARD 23
CARD 24
CARD 25
CARD 26
CARD 27
CARD 28
CARD 29
CARD 30

ARAP06 Sample Problem, Input Data (Continued)

IBM

236-727-4 U 10000
Printed in U.S.A.

FORTRAN Coding Form

PROGRAM	ARAP06	DATE		CHARACTER		REVISION	3
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FORTRAN STATEMENT																														OPERATING SYSTEM																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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CARD 30
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ARAP06 Sample Problem Input Data (Continued)

IBM

FORTRAN Coding Form

ARAPOL

01

CARD 30
(CONTINUED)

STATION	DATE	19	271	321	32	243	078	171	488	633	108	212
555	- .096	- .19	- .271	- .321	- .32	- .243	- .078	- .171	- .488	- .633	- .108	- .212
295	- .335	- .318	- .225	- .053	- .19	- .486	- .804	- .027	- .052	- .072	- .079	- .071
046	- .006	- .047	- .108	- .172	- .039	- .076	- .106	- .118	- .109	- .073	- .012	- .069
165	- .266	- .053	- .104	- .145	- .165	- .154	- .107	- .022	- .095	- .235	- .384	- .070
137	- .193	- .223	- .214	- .153	- .039	- .124	- .325	- .54	- .09	- .178	- .254	- .301
299	- .226	- .072	- .161	- .455	- .778	- .084	- .164	- .225	- .252	- .234	- .16	- .031
146	- .358	- .584	- .026	- .052	- .07	- .077	- .068	- .043	- .004	- .046	- .104	- .164
038	- .075	- .103	- .114	- .103	- .069	- .01	- .067	- .157	- .252	- .051	- .101	- .14
157	- .145	- .099	- .319	- .091	- .23	- .36	- .066	- .129	- .181	- .207	- .196	- .139
033	- .117	- .299	- .495	- .077	- .153	- .217	- .256	- .254	- .191	- .06	- .137	- .367
66	- .049	- .095	- .128	- .136	- .117	- .071	- .001	- .085	- .18	- .278	- .026	- .051
068	- .073	- .1063	- .039	- .002	- .045	- .097	- .152	- .037	- .073	- .099	- .108	- .096
061	- .006	- .065	- .147	- .233	- .049	- .096	- .131	- .145	- .132	- .086	- .014	- .065
202	- .326	- .06	- .117	- .163	- .184	- .172	- .12	- .026	- .105	- .263	- .433	- .059
116	- .165	- .193	- .189	- .141	- .043	- .104	- .288	- .49	- .032	- .061	- .079	- .079
061	- .029	- .011	- .054	- .096	- .135	- .026	- .050	- .067	- .070	- .06	- .035	- .079
044	- .092	- .143	- .036	- .07	- .095	- .102	- .089	- .055	- .004	- .062	- .137	- .216
047	- .091	- .124	- .136	- .122	- .079	- .01	- .081	- .187	- .299	- .055	- .109	- .15
168	- .155	- .106	- .021	- .096	- .237	- .369	- .049	- .096	- .136	- .159	- .155	- .114
034	- .086	- .236	- .401	- .027	- .051	- .066	- .063	- .047	- .019	- .012	- .044	- .074
101	- .025	- .049	- .065	- .067	- .056	- .033	- .001	- .042	- .058	- .135	- .035	- .069
092	- .098	- .084	- .051	- .002	- .06	- .13	- .204	- .045	- .008	- .119	- .128	- .114
072	- .008	- .077	- .175	- .28	- .051	- .101	- .139	- .154	- .14	- .094	- .017	- .084
216	- .352	- .01	- .082	- .115	- .134	- .13	- .095	- .027	- .072	- .196	- .336	- .033

ARAP06 Sample Problem, Input Dat (Continued)

VARIATION NUMBER		FORTRAN STATEMENT																				UNIT PRICE		TOTAL PRICE																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516</

ARAP06 Sample Problem, Input Data (Continued)

IBM

FORTRAN Coding Form

#28-7377-6 U. S. A.
Printed in U. S. A.

PROGRAM		PROJECT		DATE		AUTHOR		REVISION		PAGE		TOTAL	
ARAP06													
STATEMENT NO.		STATEMENT		STATEMENT		STATEMENT		STATEMENT		STATEMENT		STATEMENT	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
-269	-324	-311	-182	096	512	1	153	219	056	111	176	25	311
-194	078	499	1	-05	-097	-1	-153	-219	-056	-276	-282	-125	-311
924	-027	-051	-077	-105	-13	-133	-038	09	085	026	219	457	06
-024	-021	-017	-014	-01	005	038	097	085	085	067	-132	-182	-02
-13	-025	118	289	472	-049	-097	-101	135	135	-152	-141	-097	-19
218	351	-035	-068	-095	-108	-101	039	101	101	-015	062	153	088
-044	-061	-07	-067	-047	-011	039	004	008	008	168	-009	-018	-022
-031	-023	-007	016	047	08	004	-165	-182	-145	-01	009	006	-031
-007	-009	-01	-061	-12	-165	-182	-013	082	082	194	-016	107	-003
-047	-092	-126	-14	-127	-084	-013	23	-021	-021	-042	312	-033	404
-101	-093	-063	-011	-059	142	23	-025	029	029	-029	-059	-066	-091
-009	038	094	154	-009	-017	-025	001	003	003	007	-021	-006	-043
073	004	008	01	009	006	001	204	320	320	-043	-009	-01	-105
-141	-152	-133	-082	-005	093	204	-061	-084	-084	-092	-084	-114	-109
-068	-006	075	167	263	-031	-061	-056	037	037	-006	-082	-053	055
125	199	-02	-04	-055	-061	-056	-015	039	039	065	036	095	-008
-016	-023	-027	-026	-019	-005	-015	-048	094	094	-126	-132	008	009
006	011	-003	-007	-009	-011	-048	-105	-096	-096	-058	-001	-112	001
082	173	267	-04	-078	-105	-112	-045	-003	052	113	-177	-019	229
-03	-053	-079	-085	-074	-045	-003	071	123	008	-015	-022	-025	-052
-057	-051	-032	-003	034	071	123	008	009	009	006	001	-003	-016
-004	014	035	059	004	008	01	005	004	004	075	151	23	-001
-012	-044	-086	-114	-118	-097	-055	004	004	004	075	151	23	-038
-099	-102	-066	-05	-002	064	133	205	205	205	-028	-055	-075	-073
													-079

CARD 35

(CONTINUED)

ARAP06 Sample Problem, Input Data (Continued)

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(CONTINUED)

ARAP06 Sample Problem, Input Data (Continued)

IBM

FORTRAN Coding Form

PROGRAM	ARAP06	DATE		GRAPHIC		8	10
PROGRAMMER				REMARKS			

FORTRAN STATEMENT										IDENTIFICATION									
LINE	STATEMENT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	141		.336		359		502		661		.829		1.		.008		.028		.066
2	49		.652		.824		1.		.008		.028		.064		.127		.219		.339
3	1.		.018		.062		.124		.21		.315		.438		.571		.711		.855
4	.103		.182		.285		.409		.547		.694		.846		.012		.04		.068
5	.388		.528		.68		.839		1.		.035		.079		.15		.249		.372
6	.834		1.		.009		.231		.072		.141		.237		.36		.503		.661
7	.031		.07		.137		.231		.352		.495		.655		.825		1.		.829
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CARD 35

CARD 36

CARDS 37 → 46
ARE DELETED
FOR THIS RUN.

ARAP06 Sample Problem, Input Data (Continued)

CARD 47
CARD 48
CARD 49
CARD 50
CARD 51
CARD 52
CARD 53
CARD 54
CARD 55

IBM **ARAP06** **FORTRAN Coding Form** **ARAP06** **10-10**

PROGRAM NAME: ARAP06 DATE: 10-10-10

FORTRAN STATEMENT

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
103. 83.8																																																																																																			

CARD 56

CARD 57

ARAP06 Sample Problem, Input Data (Concluded)

ARAP06 FOLDING PROPRITOR FEATHER-STOP DYNAMIC ANALYSIS

TITLE JUNE 11, 1971 SAMPLE CASE FOR PROGRAM ARAP06 USING MODEL D270 PARAMETERS

FLIGHT CONDITION
 U = 175.00 KTS RPM = 160.0 G = 386.0 IN/SEC**2 GV = 0.0 IN/SEC**2 S = 1117. FT/SEC
 TPC = 0.0 DEG RND = 0.002378 SLUG/FT**3

OPTIONS AND CONTROLS

IT1 = 1 IT2 = 1 IT3 = 0 IT4 = 0 IT5 = 1
 IT6 = 2 IT7 = 1 IT8 = 0 IT9 = 1 IT10 = 1
 IT11 = 0 IT12 = 0 IT13 = 1 IT14 = 1 IT15 = 0
 NCASE = 1 DTMIN = 0.0045 SEC PSIE = 0.0 DEG
 RPM1 = C.C RPM RPM2 = 0.0 RPM RPM3 = 0.0 RPM RPM4 = 0.0 RPM
 AK12 = 2000.0 FT-LB/DEG AK13 = 2000.0 FT-LB/DEG AK14 = 2000.0 FT-LB/DEG BK11 = 2000.0 FT-LB/DEG BK12 = 2000.0 FT-LB/DEG
 BK13 = 2000.0 FT-LB/DEG BK14 = 2000.0 FT-LB/DEG STOPK = 50000.0 FT-LB/DEG STOPTH = -10.0 DEG
 ALW = 9.00 DEG WC = 133.40 IN SLC = 5.780
 DEL = 0.17 ALAM = 6.00 DEG AL = 72.20 IN YCA = 30.50 IN

PROPRITOR DATA

NS = 10 A3 = 3.0 DEG DEL3 = -25.00 DEG TMC = 62.90 DEG AI = 0.0 DEG
 B1 = 0.0 DEG NBM = 2 BZETA = 0.0 OMT = 160.00 RAD/SEC ZM = 122.0 IN
 NMT = 2 NTHC = 6 NPSID = 6

SEGMENT	TIME DEG	R(I) IN	AM(I) CHUG	YB(I) IN	AIC(I) CHUG-IN.53	EPF(I) IN	EPC(I) IN	EPE(I) IN	-I(I) IN	DR(I) IN
1	-2.50	30.0	1.5738	0.0	0.0	3.0	0.0	0.0	40.00	15.0
2	-5.00	60.0	0.2176	0.0	0.0	3.0	0.0	0.0	40.00	30.0
3	-7.50	50.0	0.1344	0.0	0.0	0.0	0.0	0.0	40.00	30.0
4	-10.00	120.0	0.1127	0.0	0.0	3.0	0.0	0.0	40.00	30.0
5	-12.50	150.0	0.1204	0.0	0.0	0.0	0.0	0.0	40.00	30.0
6	-15.00	180.0	0.1325	0.0	0.0	3.0	0.0	0.0	40.00	30.0
7	-17.50	210.0	0.1204	0.0	0.0	3.0	0.0	0.0	40.00	30.0
8	-20.00	240.0	0.1100	0.0	0.0	3.0	0.0	0.0	40.00	30.0
9	-22.50	270.0	0.0972	0.0	0.0	0.0	0.0	0.0	40.00	30.0
10	-25.00	300.0	0.0435	0.0	0.0	3.0	0.0	0.0	40.00	15.0

ARAP06 Sample Problem, Input Display

PROPRATOR BLADE NORMAL MODES

MODEL 0270 GIMBALLED ROTOR FIRST COLLECTIVE MODE

KOR(1) = 0

MIL-RESEARCH COMPANY

NATURAL FREQUENCY

TWC (DEG)	0.0	7.8	15.7	23.5	28.8	32.9				
40.0	28.9	30.8	35.2	41.4	46.5	50.2				
52.0	31.4	33.3	37.7	44.0	48.4	52.1				
64.0	35.8	37.0	41.4	47.7	52.1	55.3				
76.0	40.8	42.9	46.5	52.1	56.5	59.7				
90.0	46.6	50.9	54.6	59.7	62.8	65.9				
105.0	55.9	57.1	59.7	62.8	65.3	67.2				

OUT-OF-PLANE MODE SHAPE

LC(1) = 1										
RPM = 0.0 RAD/SEC										
STATION	1	2	3	4	5	6	7	8	9	10
T/C	0.005	0.019	0.044	0.090	0.164	0.274	0.418	0.594	0.792	1.000
40.0	0.005	0.021	0.048	0.094	0.167	0.274	0.417	0.592	0.791	1.000
52.0	0.006	0.027	0.057	0.104	0.177	0.282	0.421	0.594	0.792	1.000
64.0	0.008	0.036	0.072	0.123	0.195	0.297	0.432	0.600	0.794	1.000
76.0	0.010	0.055	0.106	0.167	0.245	0.346	0.471	0.627	0.807	1.000
90.0	0.016	0.085	0.168	0.262	0.373	0.495	0.622	0.751	0.876	1.000
105.0	0.025	0.087	0.166	0.262	0.373	0.495	0.622	0.751	0.876	1.000

RPM = 7.8 RAD/SEC										
STATION	1	2	3	4	5	6	7	8	9	10
T/C	0.005	0.019	0.044	0.090	0.164	0.274	0.422	0.597	0.794	1.000
40.0	0.005	0.023	0.050	0.098	0.172	0.281	0.423	0.597	0.793	1.000
52.0	0.006	0.028	0.059	0.108	0.182	0.287	0.427	0.598	0.794	1.000
64.0	0.011	0.037	0.075	0.127	0.201	0.303	0.438	0.605	0.797	1.000
76.0	0.017	0.058	0.111	0.175	0.254	0.355	0.481	0.635	0.812	1.000
90.0	0.026	0.088	0.168	0.264	0.374	0.494	0.620	0.748	0.874	1.000
105.0	0.043	0.141	0.264	0.404	0.544	0.684	0.824	0.964	1.000	1.000

RPM = 15.7 RAD/SEC										
STATION	1	2	3	4	5	6	7	8	9	10
T/C	0.006	0.022	0.051	0.103	0.182	0.294	0.438	0.610	0.801	1.000
40.0	0.006	0.026	0.057	0.108	0.186	0.294	0.439	0.609	0.800	1.000
52.0	0.007	0.032	0.064	0.119	0.196	0.304	0.443	0.611	0.801	1.000
64.0	0.009	0.042	0.083	0.140	0.218	0.322	0.457	0.619	0.804	1.000
76.0	0.012	0.062	0.121	0.191	0.274	0.377	0.503	0.652	0.821	1.000
90.0	0.019	0.064	0.121	0.191	0.274	0.377	0.503	0.652	0.821	1.000
105.0	0.026	0.088	0.171	0.267	0.376	0.493	0.617	0.744	0.872	1.000

RPM = 23.5 RAD/SEC										
STATION	1	2	3	4	5	6	7	8	9	10
T/C	0.007	0.027	0.060	0.117	0.201	0.316	0.460	0.626	0.810	1.000
40.0	0.007	0.030	0.064	0.123	0.206	0.316	0.459	0.626	0.810	1.000
52.0	0.009	0.037	0.072	0.133	0.218	0.328	0.464	0.628	0.810	1.000
64.0	0.011	0.047	0.096	0.159	0.243	0.353	0.481	0.635	0.815	1.000
76.0	0.014	0.064	0.121	0.191	0.274	0.377	0.503	0.652	0.821	1.000
90.0	0.021	0.072	0.137	0.213	0.293	0.410	0.535	0.672	0.835	1.000
105.0	0.027	0.091	0.173	0.270	0.377	0.494	0.617	0.743	0.871	1.000

ARAP06 Sample Problem, Input Display (Continued)

RPM = 28.8 RAD/SEC										
STATION 1										
T/C	1	2	3	4	5	6	7	8	9	10
40.0	0.008	0.030	0.067	0.128	0.216	0.333	0.476	0.639	0.816	1.000
52.0	0.010	0.035	0.076	0.135	0.222	0.337	0.477	0.639	0.816	1.000
64.0	0.012	0.042	0.085	0.148	0.236	0.346	0.483	0.642	0.817	1.000
76.0	0.016	0.054	0.105	0.172	0.258	0.366	0.501	0.651	0.822	1.000
90.0	0.023	0.077	0.145	0.226	0.319	0.427	0.551	0.690	0.842	1.000
105.0	0.027	0.092	0.175	0.271	0.379	0.495	0.617	0.743	0.871	1.000
RPM = 32.9 RAD/SEC										
STATION 1										
T/C	1	2	3	4	5	6	7	8	9	10
40.0	0.009	0.033	0.073	0.138	0.229	0.348	0.489	0.648	0.822	1.000
52.0	0.011	0.038	0.080	0.145	0.236	0.350	0.489	0.648	0.821	1.000
64.0	0.013	0.045	0.092	0.158	0.246	0.359	0.495	0.651	0.822	1.000
76.0	0.017	0.058	0.112	0.183	0.271	0.381	0.512	0.662	0.827	1.000
90.0	0.024	0.081	0.151	0.235	0.330	0.440	0.563	0.700	0.847	1.000
105.0	0.027	0.093	0.175	0.272	0.380	0.497	0.620	0.746	0.873	1.000
IMPLANE MODE SHAPE										
LC(2) = 1										
RPM = 0.0 RAD/SEC										
STATION 1										
T/C	1	2	3	4	5	6	7	8	9	10
40.0	-0.027	-0.052	-0.072	-0.079	-0.072	-0.047	-0.006	0.047	0.109	0.174
52.0	-0.039	-0.077	-0.107	-0.120	-0.111	-0.075	-0.014	0.070	0.168	0.272
64.0	-0.054	-0.105	-0.147	-0.167	-0.158	-0.110	-0.024	0.096	0.239	0.392
76.0	-0.071	-0.140	-0.192	-0.228	-0.219	-0.156	-0.041	0.127	0.333	0.545
90.0	-0.096	-0.190	-0.271	-0.321	-0.320	-0.243	-0.078	0.171	0.448	0.833
105.0	0.108	0.212	0.295	0.335	0.318	0.225	0.053	-0.190	-0.486	-0.804
RPM = 7.8 RAD/SEC										
STATION 1										
T/C	1	2	3	4	5	6	7	8	9	10
40.0	-0.027	-0.052	-0.072	-0.079	-0.071	-0.046	-0.004	0.047	0.108	0.172
52.0	-0.039	-0.076	-0.106	-0.118	-0.109	-0.073	-0.012	0.069	0.165	0.266
64.0	-0.053	-0.104	-0.145	-0.165	-0.154	-0.107	-0.022	0.095	0.235	0.386
76.0	-0.070	-0.137	-0.193	-0.223	-0.214	-0.153	-0.039	0.124	0.325	0.540
90.0	-0.090	-0.178	-0.254	-0.301	-0.299	-0.226	-0.077	0.161	0.455	0.778
105.0	0.084	0.164	0.225	0.252	0.234	0.160	0.031	-0.146	-0.358	-0.584
RPM = 15.7 RAD/SEC										
STATION 1										
T/C	1	2	3	4	5	6	7	8	9	10
40.0	-0.026	-0.052	-0.070	-0.077	-0.068	-0.043	-0.004	0.046	0.104	0.164
52.0	-0.036	-0.075	-0.103	-0.114	-0.103	-0.068	-0.010	0.067	0.167	0.262
64.0	-0.051	-0.101	-0.140	-0.157	-0.145	-0.099	-0.019	0.091	0.271	0.450
76.0	-0.066	-0.124	-0.161	-0.207	-0.196	-0.139	-0.033	0.117	0.289	0.495
90.0	-0.077	-0.153	-0.217	-0.246	-0.234	-0.161	-0.060	0.137	0.347	0.600
105.0	0.049	0.095	0.128	0.136	0.117	0.071	0.001	-0.085	-0.180	-0.278
RPM = 23.5 RAD/SEC										
STATION 1										
T/C	1	2	3	4	5	6	7	8	9	10
40.0	-0.026	-0.051	-0.068	-0.073	-0.063	-0.039	-0.002	0.045	0.097	0.142
52.0	-0.037	-0.073	-0.099	-0.108	-0.096	-0.061	-0.006	0.065	0.147	0.233
64.0	-0.049	-0.096	-0.131	-0.145	-0.132	-0.088	-0.014	0.085	0.207	0.326
76.0	-0.060	-0.117	-0.163	-0.184	-0.172	-0.120	-0.024	0.105	0.263	0.433
90.0	-0.074	-0.146	-0.193	-0.213	-0.189	-0.141	-0.043	0.104	0.288	0.490
105.0	0.012	0.061	0.079	0.079	0.061	0.029	-0.011	-0.096	-0.206	-0.334

ARAP06 Sample Problem, Input Display (Continued)

RPM = 28.8 RAD/SEC										
STATION 1										
T/C	1	2	3	4	5	6	7	8	9	10
40-0	-0.026	-0.050	-0.067	-0.070	-0.060	-0.035	0.0	0.044	0.092	0.143
52-0	-0.036	-0.070	-0.095	-0.102	-0.089	-0.055	-0.004	0.062	0.137	0.216
64-0	-0.045	-0.081	-0.124	-0.136	-0.122	-0.079	-0.010	0.081	0.187	0.298
76-0	-0.054	-0.101	-0.156	-0.168	-0.135	-0.136	-0.021	0.096	0.237	0.389
88-0	-0.069	-0.134	-0.199	-0.219	-0.159	-0.114	-0.034	0.096	0.276	0.481
100-0	-0.087	-0.166	-0.246	-0.266	-0.196	-0.146	-0.054	0.096	0.316	0.581
112-0	-0.101	-0.191	-0.281	-0.301	-0.231	-0.181	-0.074	0.096	0.356	0.681
124-0	-0.116	-0.216	-0.316	-0.336	-0.266	-0.216	-0.084	0.096	0.396	0.781
136-0	-0.131	-0.236	-0.336	-0.356	-0.286	-0.236	-0.094	0.096	0.436	0.881
148-0	-0.146	-0.256	-0.356	-0.376	-0.306	-0.256	-0.104	0.096	0.476	0.981
160-0	-0.161	-0.276	-0.376	-0.396	-0.326	-0.276	-0.114	0.096	0.516	1.081
172-0	-0.176	-0.296	-0.396	-0.416	-0.346	-0.296	-0.124	0.096	0.556	1.181
184-0	-0.191	-0.316	-0.416	-0.436	-0.366	-0.316	-0.134	0.096	0.596	1.281
196-0	-0.206	-0.336	-0.436	-0.456	-0.386	-0.336	-0.144	0.096	0.636	1.381
208-0	-0.221	-0.356	-0.456	-0.476	-0.406	-0.356	-0.154	0.096	0.676	1.481
220-0	-0.236	-0.376	-0.476	-0.496	-0.426	-0.376	-0.164	0.096	0.716	1.581
232-0	-0.251	-0.396	-0.496	-0.516	-0.446	-0.396	-0.174	0.096	0.756	1.681
244-0	-0.266	-0.416	-0.516	-0.536	-0.466	-0.416	-0.184	0.096	0.796	1.781
256-0	-0.281	-0.436	-0.536	-0.556	-0.486	-0.436	-0.194	0.096	0.836	1.881
268-0	-0.296	-0.456	-0.556	-0.576	-0.506	-0.456	-0.204	0.096	0.876	1.981
280-0	-0.311	-0.476	-0.576	-0.596	-0.526	-0.476	-0.214	0.096	0.916	2.081
292-0	-0.326	-0.496	-0.596	-0.616	-0.546	-0.496	-0.224	0.096	0.956	2.181
304-0	-0.341	-0.516	-0.616	-0.636	-0.566	-0.516	-0.234	0.096	0.996	2.281
316-0	-0.356	-0.536	-0.636	-0.656	-0.586	-0.536	-0.244	0.096	1.036	2.381
328-0	-0.371	-0.556	-0.656	-0.676	-0.606	-0.556	-0.254	0.096	1.076	2.481
340-0	-0.386	-0.576	-0.676	-0.696	-0.626	-0.576	-0.264	0.096	1.116	2.581
352-0	-0.401	-0.596	-0.696	-0.716	-0.646	-0.596	-0.274	0.096	1.156	2.681
364-0	-0.416	-0.616	-0.716	-0.736	-0.666	-0.616	-0.284	0.096	1.196	2.781
376-0	-0.431	-0.636	-0.736	-0.756	-0.686	-0.636	-0.294	0.096	1.236	2.881
388-0	-0.446	-0.656	-0.756	-0.776	-0.706	-0.656	-0.304	0.096	1.276	2.981
400-0	-0.461	-0.676	-0.776	-0.796	-0.726	-0.676	-0.314	0.096	1.316	3.081
412-0	-0.476	-0.696	-0.796	-0.816	-0.746	-0.696	-0.324	0.096	1.356	3.181
424-0	-0.491	-0.716	-0.816	-0.836	-0.766	-0.716	-0.334	0.096	1.396	3.281
436-0	-0.506	-0.736	-0.836	-0.856	-0.786	-0.736	-0.344	0.096	1.436	3.381
448-0	-0.521	-0.756	-0.856	-0.876	-0.806	-0.756	-0.354	0.096	1.476	3.481
460-0	-0.536	-0.776	-0.876	-0.896	-0.826	-0.776	-0.364	0.096	1.516	3.581
472-0	-0.551	-0.796	-0.896	-0.916	-0.846	-0.796	-0.374	0.096	1.556	3.681
484-0	-0.566	-0.816	-0.916	-0.936	-0.866	-0.816	-0.384	0.096	1.596	3.781
496-0	-0.581	-0.836	-0.936	-0.956	-0.886	-0.836	-0.394	0.096	1.636	3.881
508-0	-0.596	-0.856	-0.956	-0.976	-0.906	-0.856	-0.404	0.096	1.676	3.981
520-0	-0.611	-0.876	-0.976	-0.996	-0.926	-0.876	-0.414	0.096	1.716	4.081
532-0	-0.626	-0.896	-0.996	-1.016	-0.946	-0.896	-0.424	0.096	1.756	4.181
544-0	-0.641	-0.916	-1.016	-1.036	-0.966	-0.916	-0.434	0.096	1.796	4.281
556-0	-0.656	-0.936	-1.036	-1.056	-0.986	-0.936	-0.444	0.096	1.836	4.381
568-0	-0.671	-0.956	-1.056	-1.076	-1.006	-0.956	-0.454	0.096	1.876	4.481
580-0	-0.686	-0.976	-1.076	-1.096	-1.026	-0.976	-0.464	0.096	1.916	4.581
592-0	-0.701	-0.996	-1.096	-1.116	-1.046	-0.996	-0.474	0.096	1.956	4.681
604-0	-0.716	-1.016	-1.116	-1.136	-1.066	-1.016	-0.484	0.096	1.996	4.781
616-0	-0.731	-1.036	-1.136	-1.156	-1.086	-1.036	-0.494	0.096	2.036	4.881
628-0	-0.746	-1.056	-1.156	-1.176	-1.106	-1.056	-0.504	0.096	2.076	4.981
640-0	-0.761	-1.076	-1.176	-1.196	-1.126	-1.076	-0.514	0.096	2.116	5.081
652-0	-0.776	-1.096	-1.196	-1.216	-1.146	-1.096	-0.524	0.096	2.156	5.181
664-0	-0.791	-1.116	-1.216	-1.236	-1.166	-1.116	-0.534	0.096	2.196	5.281
676-0	-0.806	-1.136	-1.236	-1.256	-1.186	-1.136	-0.544	0.096	2.236	5.381
688-0	-0.821	-1.156	-1.256	-1.276	-1.206	-1.156	-0.554	0.096	2.276	5.481
700-0	-0.836	-1.176	-1.276	-1.296	-1.226	-1.176	-0.564	0.096	2.316	5.581
712-0	-0.851	-1.196	-1.296	-1.316	-1.246	-1.196	-0.574	0.096	2.356	5.681
724-0	-0.866	-1.216	-1.316	-1.336	-1.266	-1.216	-0.584	0.096	2.396	5.781
736-0	-0.881	-1.236	-1.336	-1.356	-1.286	-1.236	-0.594	0.096	2.436	5.881
748-0	-0.896	-1.256	-1.356	-1.376	-1.306	-1.256	-0.604	0.096	2.476	5.981
760-0	-0.911	-1.276	-1.376	-1.396	-1.326	-1.276	-0.614	0.096	2.516	6.081
772-0	-0.926	-1.296	-1.396	-1.416	-1.346	-1.296	-0.624	0.096	2.556	6.181
784-0	-0.941	-1.316	-1.416	-1.436	-1.366	-1.316	-0.634	0.096	2.596	6.281
796-0	-0.956	-1.336	-1.436	-1.456	-1.386	-1.336	-0.644	0.096	2.636	6.381
808-0	-0.971	-1.356	-1.456	-1.476	-1.406	-1.356	-0.654	0.096	2.676	6.481
820-0	-0.986	-1.376	-1.476	-1.496	-1.426	-1.376	-0.664	0.096	2.716	6.581
832-0	-0.101	-1.396	-1.496	-1.516	-1.446	-1.396	-0.674	0.096	2.756	6.681
844-0	-0.116	-1.416	-1.516	-1.536	-1.466	-1.416	-0.684	0.096	2.796	6.781
856-0	-0.131	-1.436	-1.536	-1.556	-1.486	-1.436	-0.694	0.096	2.836	6.881
868-0	-0.146	-1.456	-1.556	-1.576	-1.506	-1.456	-0.704	0.096	2.876	6.981
880-0	-0.161	-1.476	-1.576	-1.596	-1.526	-1.476	-0.714	0.096	2.916	7.081
892-0	-0.176	-1.496	-1.596	-1.616	-1.546	-1.496	-0.724	0.096	2.956	7.181
904-0	-0.191	-1.516	-1.616	-1.636	-1.566	-1.516	-0.734	0.096	2.996	7.281
916-0	-0.206	-1.536	-1.636	-1.656	-1.586	-1.536	-0.744	0.096	3.036	7.381
928-0	-0.221	-1.556	-1.656	-1.676	-1.606	-1.556	-0.754	0.096	3.076	7.481
940-0	-0.236	-1.576	-1.676	-1.696	-1.626	-1.576	-0.764	0.096	3.116	7.581
952-0	-0.251	-1.596	-1.696	-1.716	-1.646	-1.596	-0.774	0.096	3.156	7.681
964-0	-0.266	-1.616	-1.716	-1.736	-1.666	-1.616	-0.784	0.096	3.196	7.781
976-0	-0.281	-1.636	-1.736	-1.756	-1.686	-1.636	-0.794	0.096	3.236	7.881
988-0	-0.296	-1.656	-1.756	-1.776	-1.706	-1.656	-0.804	0.096	3.276	7.981
1000-0	-0.311	-1.676	-1.776	-1.796	-1.726	-1.676	-0.814	0.096	3.316	8.081
1012-0	-0.326	-1.696	-1.796	-1.816	-1.746	-1.696	-0.824	0.096	3.356	8.181
1024-0	-0.341	-1.716	-1.816	-1.836	-1.766	-1.716	-0.834	0.096	3.396	8.281
1036-0	-0.356	-1.736	-1.836	-1.856	-1.786	-1.736	-0.844	0.096	3.436	8.381
1048-0	-0.371	-1.756	-1.856	-1.876	-1.806	-1.756	-0.854	0.096	3.476	8.481
1060-0	-0.386	-1.776	-1.876	-1.896	-1.826	-1.776	-0.864	0.096	3.516	8.581
1072-0	-0.401	-1.796	-1.896	-1.916	-1.846	-1.796	-0.874	0.096	3.556	8.681
1084-0	-0.416	-1.816	-1.916	-1.936	-1.866	-1.816	-0.884	0.096	3.596	8.781
1096-0	-0.431	-1.836	-1.936	-1.956	-1.886	-1.836	-0.894	0.096	3.636	8.881
1108-0	-0.446	-1.856	-1.956	-1.976	-1.906	-1.856	-0.904	0.096	3.676	8.981
1120-0	-0.461	-1.876	-1.976	-1.996	-1.926	-1.876	-0.914	0.096	3.716	9.081
1132-0	-0.476	-1.896	-1.996	-2.016	-1.946	-1.896	-0.924	0.096	3.756	9.181
1144-0	-0.491	-1.916	-2.016	-2.036	-1.966	-1.916	-0.934	0.096	3.796	9.281
1156-0	-0.506	-1.936	-2.036	-2.056	-1.986	-1.936	-0.944	0.096	3.836	9.381
1168-0	-0.521	-1.956	-2.056	-2.076	-2.006	-1.956	-0.954	0.096	3.876	9.481
1180-0	-0.536	-1.976	-2.076	-2.096	-2.026	-1.976	-0.964	0.096	3.916	9.581
1192-0	-0.551	-1.996	-2.096	-2.116	-2.046	-1.996	-0.974	0.096	3.956	9.681
1204-0	-0.566	-2.016	-2.116	-2.136	-2.066	-2.016	-0.984	0.096	3.996	9.781
1216-0	-0.581	-2.036	-2.136	-2.156	-2.086	-2.036	-0.994	0.096	4.036	9.881
1228-0	-0.596	-2.056	-2.156	-2.176	-2.106	-2.056	-1.004	0.096	4.076	9.981
1240-0	-0.611	-2.076	-2.176	-2.196	-2.126	-2.076	-1.014	0.096	4.116	10.081
1252-0	-0.626	-2.096	-2.196	-2.216	-2.146	-2.096	-1.024	0.096	4.156	10.181
1264-0	-0.641	-2.116	-2.216	-2.236	-2.166	-2.116	-1.034	0.096	4.196	10.281
1276-0	-0.656	-2.136	-2.236	-2.256	-2.186	-2.136	-1.044	0.096		

BEAM MOMENT AT SPECIFIED STATION 2									
TMC (DEG)	0.0	7.8	15.7	23.5	28.8	32.9			
40.0	29047.0	29168.0	29767.0	30158.0	30283.0	30245.0			
52.0	31062.0	31225.0	31565.0	31667.0	31578.0	31284.0			
64.0	34171.0	34294.0	34621.0	34507.0	32855.0	32136.0			
76.0	38127.0	37757.0	36587.0	34598.0	32879.0	31342.0			
90.0	43043.0	40397.0	35110.0	28331.0	26154.0	21099.0			
105.0	53331.0	43144.0	28467.0	20642.0	17813.0	19417.0			
CHORD MOMENT AT SPECIFIED STATION 2									
TMC (DEG)	0.0	7.8	15.7	23.5	28.8	32.9			
40.0	-15145.0	-15178.0	-17301.0	-19991.0	-22212.0	-24296.0			
52.0	-23292.0	-24410.0	-27540.0	-31371.0	-35166.0	-37707.0			
64.0	-36496.0	-37899.0	-42168.0	-48361.0	-53172.0	-56618.0			
76.0	-56299.0	-58363.0	-64736.0	-73357.0	-79388.0	-84368.0			
90.0	-96712.0	-100524.0	-109557.0	-121804.0	-127767.0	-131796.0			
105.0	-148271.0	-150425.0	-154275.0	-155000.0	-154409.0	-152690.0			
MODEL-0270 - GIMBALED MOTOR SECOND CYCLIC MODE									
KBR12) = 1									
NATURAL FREQUENCY									
TMC (DEG)	0.0	7.8	15.7	23.5	28.8	32.9			
40.0	81.0	39.6	42.1	44.6	46.5	47.7			
52.0	89.2	34.3	37.0	39.6	41.4	43.3			
64.0	95.4	31.4	33.3	35.8	38.3	39.6			
76.0	100.9	28.9	30.8	33.3	35.2	37.0			
90.0	104.2	27.4	29.5	32.0	33.9	35.2			
105.0	106.6	27.0	28.9	31.4	33.9	35.2			
OUT-OF-PLANE MODE SHAPE									
LC110 = 1	2	3	4	5	6	7	8	9	10
RPM = 0.0 RAD/SEC									
TMC									
40.0	-0.072	-0.143	-0.219	-0.293	-0.309	-0.165	0.118	0.527	1.000
52.0	-0.063	-0.129	-0.194	-0.269	-0.324	-0.311	-0.182	0.096	0.912
64.0	-0.056	-0.111	-0.176	-0.250	-0.311	-0.310	-0.194	0.499	1.000
76.0	-0.050	-0.097	-0.153	-0.219	-0.276	-0.282	-0.185	0.452	0.926
90.0	-0.027	-0.081	-0.077	-0.105	-0.130	-0.133	-0.090	0.026	0.457
105.0	-0.011	-0.020	-0.024	-0.021	-0.017	-0.014	-0.010	0.018	0.085

ARAP06 Sample Problem, Input Display (Continued)

RPM = 7.8 RAD/SEC										
STATION	1	2	3	4	5	6	7	8	9	10
T/C	-0.067	-0.132	-0.182	-0.205	-0.190	-0.130	-0.025	0.118	0.249	0.472
40.0	-0.049	-0.097	-0.135	-0.152	-0.141	-0.097	-0.019	0.088	0.215	0.451
52.0	-0.035	-0.068	-0.095	-0.108	-0.101	-0.070	-0.015	0.062	0.153	0.251
64.0	-0.022	-0.044	-0.061	-0.070	-0.067	-0.047	-0.011	0.036	0.101	0.168
76.0	-0.009	-0.018	-0.026	-0.031	-0.031	-0.023	-0.007	0.016	0.047	0.080
90.0	0.004	0.008	0.010	0.009	0.006	0.001	-0.003	-0.007	-0.009	-0.010
105.0										
RPM = 15.7 RAD/SEC										
STATION	1	2	3	4	5	6	7	8	9	10
T/C	-0.061	-0.120	-0.165	-0.182	-0.165	-0.108	-0.016	0.107	0.251	0.404
40.0	-0.047	-0.092	-0.126	-0.140	-0.127	-0.094	-0.013	0.087	0.194	0.312
52.0	-0.033	-0.066	-0.091	-0.101	-0.093	-0.063	-0.011	0.059	0.142	0.230
64.0	-0.021	-0.042	-0.059	-0.066	-0.062	-0.043	-0.009	0.038	0.094	0.154
76.0	-0.009	-0.017	-0.025	-0.029	-0.029	-0.021	-0.006	0.016	0.043	0.073
90.0	0.004	0.008	0.010	0.009	0.006	0.001	-0.003	-0.007	-0.009	-0.010
105.0										
RPM = 23.5 RAD/SEC										
STATION	1	2	3	4	5	6	7	8	9	10
T/C	-0.054	-0.105	-0.141	-0.152	-0.133	-0.082	-0.005	0.093	0.204	0.320
40.0	-0.043	-0.084	-0.114	-0.124	-0.109	-0.068	-0.004	0.075	0.167	0.263
52.0	-0.031	-0.061	-0.084	-0.092	-0.082	-0.053	-0.006	0.055	0.125	0.199
64.0	-0.020	-0.040	-0.055	-0.061	-0.056	-0.037	-0.006	0.036	0.085	0.137
76.0	-0.008	-0.016	-0.023	-0.027	-0.026	-0.019	-0.005	0.015	0.039	0.066
90.0	0.004	0.008	0.010	0.009	0.006	0.001	-0.003	-0.007	-0.009	-0.011
105.0										
RPM = 28.8 RAD/SEC										
STATION	1	2	3	4	5	6	7	8	9	10
T/C	-0.048	-0.094	-0.126	-0.132	-0.112	-0.066	0.001	0.082	0.173	0.287
40.0	-0.040	-0.078	-0.105	-0.112	-0.096	-0.058	-0.001	0.069	0.147	0.229
52.0	-0.030	-0.056	-0.079	-0.085	-0.074	-0.045	-0.003	0.052	0.113	0.177
64.0	-0.019	-0.038	-0.052	-0.057	-0.051	-0.032	-0.003	0.034	0.077	0.123
76.0	-0.008	-0.015	-0.022	-0.025	-0.023	-0.016	-0.004	0.014	0.035	0.059
90.0	0.004	0.008	0.010	0.009	0.006	0.001	-0.003	-0.007	-0.010	-0.012
105.0										
RPM = 32.9 RAD/SEC										
STATION	1	2	3	4	5	6	7	8	9	10
T/C	-0.044	-0.086	-0.114	-0.118	-0.097	-0.055	0.004	0.075	0.151	0.230
40.0	-0.038	-0.073	-0.098	-0.102	-0.086	-0.050	0.002	0.064	0.133	0.205
52.0	-0.028	-0.055	-0.075	-0.079	-0.067	-0.040	-0.001	0.049	0.104	0.162
64.0	-0.018	-0.036	-0.050	-0.053	-0.047	-0.029	-0.002	0.032	0.071	0.113
76.0	-0.007	-0.014	-0.020	-0.023	-0.022	-0.015	-0.003	0.013	0.033	0.053
90.0	0.004	0.008	0.010	0.009	0.006	0.001	-0.003	-0.007	-0.010	-0.012
105.0										

ALL HELICOPTER COMPANY

ARAP06 Sample Problem, Input Display (Continued)

IMPLANE MODE SHAPE										
LC(2) = 1										
RPM = 0.0 RAD/SEC										
STATION	1	2	3	4	5	6	7	8	9	10
T+C	-0.021	-0.072	-0.139	-0.215	-0.284	-0.373	-0.313	-0.249	-0.149	-0.011
40.0	-0.023	-0.077	-0.155	-0.231	-0.339	-0.380	-0.341	-0.270	-0.175	-0.043
52.0	-0.026	-0.089	-0.185	-0.312	-0.434	-0.490	-0.423	-0.316	-0.175	-0.043
64.0	-0.030	-0.103	-0.223	-0.389	-0.554	-0.633	-0.537	-0.206	-0.142	-0.000
76.0	-0.024	-0.085	-0.186	-0.333	-0.484	-0.554	-0.472	-0.316	-0.142	-0.000
90.0	-0.023	-0.080	-0.176	-0.316	-0.462	-0.537	-0.454	-0.316	-0.142	-0.000
105.0	-0.023	-0.080	-0.176	-0.316	-0.462	-0.537	-0.454	-0.316	-0.142	-0.000
RPM = 7.8 RAD/SEC										
STATION	1	2	3	4	5	6	7	8	9	10
T+C	0.011	0.039	0.083	0.149	0.240	0.358	0.499	0.637	0.827	1.000
40.0	0.008	0.029	0.065	0.125	0.212	0.329	0.473	0.638	0.816	1.000
52.0	0.007	0.024	0.055	0.111	0.195	0.317	0.457	0.626	0.810	1.000
64.0	0.006	0.020	0.049	0.102	0.184	0.299	0.446	0.617	0.805	1.000
76.0	0.005	0.018	0.045	0.096	0.176	0.291	0.438	0.611	0.802	1.000
90.0	0.005	0.018	0.045	0.096	0.176	0.291	0.438	0.611	0.802	1.000
105.0	0.005	0.018	0.045	0.096	0.176	0.291	0.438	0.611	0.802	1.000
RPM = 15.7 RAD/SEC										
STATION	1	2	3	4	5	6	7	8	9	10
T+C	0.013	0.045	0.094	0.165	0.260	0.380	0.519	0.673	0.835	1.000
40.0	0.010	0.034	0.074	0.139	0.231	0.350	0.493	0.653	0.825	1.000
52.0	0.008	0.027	0.063	0.123	0.211	0.330	0.475	0.640	0.817	1.000
64.0	0.007	0.023	0.055	0.113	0.199	0.317	0.463	0.631	0.813	1.000
76.0	0.006	0.021	0.051	0.106	0.190	0.307	0.453	0.623	0.808	1.000
90.0	0.006	0.020	0.049	0.102	0.184	0.300	0.446	0.617	0.805	1.000
105.0	0.006	0.020	0.049	0.102	0.184	0.300	0.446	0.617	0.805	1.000
RPM = 23.5 RAD/SEC										
STATION	1	2	3	4	5	6	7	8	9	10
T+C	0.015	0.053	0.108	0.186	0.286	0.408	0.545	0.692	0.845	1.000
40.0	0.012	0.040	0.087	0.158	0.255	0.377	0.518	0.672	0.835	1.000
52.0	0.009	0.033	0.073	0.140	0.234	0.356	0.499	0.658	0.827	1.000
64.0	0.008	0.028	0.065	0.128	0.220	0.340	0.485	0.647	0.821	1.000
76.0	0.007	0.025	0.059	0.120	0.209	0.329	0.474	0.639	0.817	1.000
90.0	0.007	0.024	0.058	0.116	0.204	0.322	0.467	0.634	0.814	1.000
105.0	0.007	0.024	0.058	0.116	0.204	0.322	0.467	0.634	0.814	1.000
RPM = 28.8 RAD/SEC										
STATION	1	2	3	4	5	6	7	8	9	10
T+C	0.017	0.058	0.117	0.200	0.303	0.425	0.560	0.704	0.851	1.000
40.0	0.013	0.045	0.096	0.172	0.273	0.396	0.535	0.685	0.842	1.000
52.0	0.011	0.037	0.082	0.153	0.255	0.374	0.516	0.671	0.834	1.000
64.0	0.009	0.032	0.073	0.141	0.236	0.354	0.502	0.661	0.829	1.000
76.0	0.008	0.028	0.066	0.131	0.225	0.344	0.490	0.642	0.824	1.000
90.0	0.008	0.028	0.066	0.131	0.225	0.344	0.490	0.642	0.824	1.000
105.0	0.008	0.028	0.066	0.131	0.225	0.344	0.490	0.642	0.824	1.000

ARAP06 Sample Problem, Input Display (Continued)

RPM = 32.9 RAD/SEC										
STATION 1										
T/C	2	3	4	5	6	7	8	9	10	
40.0	0.018	0.062	0.124	0.210	0.315	0.438	0.571	0.711	0.855	1.000
52.0	0.014	0.046	0.085	0.162	0.265	0.409	0.547	0.694	0.846	1.000
64.0	0.012	0.040	0.076	0.153	0.254	0.388	0.528	0.680	0.839	1.000
76.0	0.010	0.035	0.068	0.141	0.237	0.360	0.515	0.670	0.834	1.000
90.0	0.009	0.031	0.072	0.141	0.237	0.360	0.503	0.661	0.829	1.000
105.0	0.009	0.031	0.070	0.137	0.231	0.352	0.495	0.655	0.825	1.000
TORSIONAL MODE SHAPE										
LC433 - 4 FOR ALL TMC AND RPM										
STATION 1										
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BEAM MOMENT AT SPECIFIED STATION 1										
TMC (DEG)	ROTOR RPM (RAD/SEC)									
	0.0	7.8	15.7	23.5	28.8	32.9				
40.0	0.0	0.0	0.0	0.0	0.0	0.0				
52.0	0.0	0.0	0.0	0.0	0.0	0.0				
64.0	0.0	0.0	0.0	0.0	0.0	0.0				
76.0	0.0	0.0	0.0	0.0	0.0	0.0				
90.0	0.0	0.0	0.0	0.0	0.0	0.0				
105.0	0.0	0.0	0.0	0.0	0.0	0.0				
LOAD MOMENT AT SPECIFIED STATION 1										
TMC (DEG)	ROTOR RPM (RAD/SEC)									
	0.0	7.8	15.7	23.5	28.8	32.9				
40.0	-24374.0	12787.0	14788.0	17476.0	19375.0	20921.0				
52.0	-28072.0	9318.0	10908.0	13149.0	14864.0	16213.0				
64.0	-29685.0	7348.0	8580.0	10458.0	11956.0	13186.0				
76.0	-34484.0	6177.0	7254.0	8846.0	10196.0	11317.0				
90.0	-28237.0	5527.0	6467.0	7904.0	9120.0	10176.0				
105.0	-26981.0	5363.0	6282.0	7730.0	8898.0	9953.0				
BEAM MOMENT AT SPECIFIED STATION 2										
TMC (DEG)	ROTOR RPM (RAD/SEC)									
	0.0	7.8	15.7	23.5	28.8	32.9				
40.0	8883.0	41891.0	40283.0	37661.0	35491.0	33641.0				
52.0	-3221.0	36499.0	36238.0	35437.0	34488.0	33477.0				
64.0	-16466.0	32607.0	32846.0	32853.0	32579.0	32103.0				
76.0	-31267.0	29914.0	30444.0	30766.0	30858.0	30643.0				
90.0	-32854.0	28178.0	28744.0	29243.0	29463.0	29496.0				
105.0	-33316.0	27495.0	28065.0	28675.0	28875.0	28978.0				

ARAP06 Sample Problem, Input Display (Continued)

WILCOX COMPANY

CHORD MOMENT AT SPECIFIED STATION 2

TMC IDEG	0.0	7.0	15.7	24.5	32.9				
40.0	-118814.0	51459.0	59854.0	70437.0	77271.0	82068.0			
52.0	-117055.0	51883.0	59450.0	69440.0	76017.0	80193.0			
64.0	-114283.0	51975.0	59378.0	68478.0	74543.0	78736.0			
76.0	-103125.0	51144.0	58437.0	67478.0	73546.0	77746.0			
88.0	-99901.0	50977.0	58372.0	67325.0	73494.0	77694.0			
100.0	-77553.0	-28822.0	-3241.0	-3822.0	-4330.0	-4768.0			
RETA(1)	0.0	0.0	0.0	0.0	0.0	0.0			
WING/PILOD DATA									
NSM = 0	NSMP = 4	MEETA = 0.010	PM = 7.00 CMUG	2P = 81.80 IN	YP = 0.0 IN				
RP = 0.00 IN	RP00 = 3	RM = 0.01 CMUG	MEPE = 0.35 IN	WIPP = 16390. CMUG-10002					
SMPE(1) = -1.100	SMPE(2) = 0.258	SMPE(3) = -0.750	SMPE(4) = -0.370						
SEGMENT (1)	1	2	3	4	5	6	7	8	
PMT(1,J) (IN/IN)	0.01020	0.01070	0.01480	0.01720	0.02030	0.02520	0.02850	0.03140	
	0.31870	0.27400	0.17010	0.07890	-0.05110	-0.24735	-0.36540	-0.47440	
	-0.02040	-0.02040	0.02710	0.03180	0.03460	0.03740	0.04100	0.04410	
	-0.00900	-0.00620	0.00100	0.00160	0.00440	-0.00740	-0.01140	-0.01040	
PMT(1,J) (IN/IN)	0.34930	0.34270	0.21000	0.11990	-0.03350	-0.31710	-0.39750	-0.48100	
	0.03550	0.02270	0.01000	0.00140	-0.01190	-0.03800	-0.04260	-0.07710	
	-0.09700	-0.04440	0.03350	0.14850	0.25440	0.40720	0.44040	0.56260	
	-0.29240	-0.31160	0.35070	0.53890	0.27720	-0.06790	0.00510	0.49160	
PMT(1,J) (RAD/IN)	0.0	0.0	0.00010	0.00030	0.00070	0.00100	0.00140	0.00170	
	0.0	0.00010	0.00070	0.00070	0.00070	0.00090	0.00110	0.00120	
	0.0	0.00140	0.00770	0.00750	0.00530	0.00870	0.00860	0.00850	
	0.00030	0.00140	0.00250	0.00340	0.00470	0.00580	0.00640	0.00680	
WRI(1) (CMUG)	28.0434	0.1100	0.5500	0.1800	0.8900	7.3800	3.5700	0.8010	
WRI(1) (CMUG-10002)	0.0	0.0	0.0	15760.0000	0.0	15760.0000	0.0	0.0	
WRI(1) (IN)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
WRI(1) (IN)	0.0	37.50	55.00	37.50	50.00	37.50	47.50	40.00	

J	ONE(J)	PMT(1,J)	PMT(1,J)	PMT(1,J)	PMT(1,J)	PMT(1,J)	PMT(1,J)	PMT(1,J)	PMT(1,J)
	RAD/SEC	IN/IN	IN/IN	IN/IN	IN/IN	RAD/IN	RAD/IN	RAD/IN	CMUG
1	17.480	0.03610	0.0	-1.00000	-0.00070	0.00070	0.00070	0.00070	17.2407
2	25.060	-1.00000	0.0	-0.13750	0.00550	0.00550	-0.00550	-0.00550	14.2171
3	86.640	-0.11000	0.0	1.00000	0.00000	0.00000	0.00000	0.00000	6.62008
4	0.0	0.0	0.0	0.0	0.0	0.00077	0.00000	0.00000	3.00000

ARAP06 Sample Problem, Input Display (Continued)

TIME	APM	PSI	BET-LG	BET-LT	BET-LL	FFA	FFV	FFZ	MBK	MBV	MBZ
F1	MI	FK	MI	MJ	MK	TFKA	TFV	TFZ	TFMK	TFMV	TFMZ
18-1	LCM1	2CM1	2CML	2CML	3CML	18M2	18M2	20M2	20M2	20M2	30M2
21P1	21P1	21P2	21P2	21P3	21P3	10B1	10B1	10B1	10B1	20B2	30B2
21P2	21P2	21P3	21P3	21P4	21P4	10B2	10B2	10B2	10B2	20B3	30B3
21P3	21P3	21P4	21P4	21P5	21P5	10B3	10B3	10B3	10B3	20B4	30B4
21P4	21P4	21P5	21P5	21P6	21P6	10B4	10B4	10B4	10B4	20B5	30B5
21P5	21P5	21P6	21P6	21P7	21P7	10B5	10B5	10B5	10B5	20B6	30B6
21P6	21P6	21P7	21P7	21P8	21P8	10B6	10B6	10B6	10B6	20B7	30B7
21P7	21P7	21P8	21P8	21P9	21P9	10B7	10B7	10B7	10B7	20B8	30B8
21P8	21P8	21P9	21P9	21P10	21P10	10B8	10B8	10B8	10B8	20B9	30B9
21P9	21P9	21P10	21P10	21P11	21P11	10B9	10B9	10B9	10B9	20B10	30B10
21P10	21P10	21P11	21P11	21P12	21P12	10B10	10B10	10B10	10B10	20B11	30B11
21P11	21P11	21P12	21P12	21P13	21P13	10B11	10B11	10B11	10B11	20B12	30B12
21P12	21P12	21P13	21P13	21P14	21P14	10B12	10B12	10B12	10B12	20B13	30B13
21P13	21P13	21P14	21P14	21P15	21P15	10B13	10B13	10B13	10B13	20B14	30B14
21P14	21P14	21P15	21P15	21P16	21P16	10B14	10B14	10B14	10B14	20B15	30B15
21P15	21P15	21P16	21P16	21P17	21P17	10B15	10B15	10B15	10B15	20B16	30B16
21P16	21P16	21P17	21P17	21P18	21P18	10B16	10B16	10B16	10B16	20B17	30B17
21P17	21P17	21P18	21P18	21P19	21P19	10B17	10B17	10B17	10B17	20B18	30B18
21P18	21P18	21P19	21P19	21P20	21P20	10B18	10B18	10B18	10B18	20B19	30B19
21P19	21P19	21P20	21P20	21P21	21P21	10B19	10B19	10B19	10B19	20B20	30B20
21P20	21P20	21P21	21P21	21P22	21P22	10B20	10B20	10B20	10B20	20B21	30B21
21P21	21P21	21P22	21P22	21P23	21P23	10B21	10B21	10B21	10B21	20B22	30B22
21P22	21P22	21P23	21P23	21P24	21P24	10B22	10B22	10B22	10B22	20B23	30B23
21P23	21P23	21P24	21P24	21P25	21P25	10B23	10B23	10B23	10B23	20B24	30B24
21P24	21P24	21P25	21P25	21P26	21P26	10B24	10B24	10B24	10B24	20B25	30B25
21P25	21P25	21P26	21P26	21P27	21P27	10B25	10B25	10B25	10B25	20B26	30B26
21P26	21P26	21P27	21P27	21P28	21P28	10B26	10B26	10B26	10B26	20B27	30B27
21P27	21P27	21P28	21P28	21P29	21P29	10B27	10B27	10B27	10B27	20B28	30B28
21P28	21P28	21P29	21P29	21P30	21P30	10B28	10B28	10B28	10B28	20B29	30B29
21P29	21P29	21P30	21P30	21P31	21P31	10B29	10B29	10B29	10B29	20B30	30B30
21P30	21P30	21P31	21P31	21P32	21P32	10B30	10B30	10B30	10B30	20B31	30B31
21P31	21P31	21P32	21P32	21P33	21P33	10B31	10B31	10B31	10B31	20B32	30B32
21P32	21P32	21P33	21P33	21P34	21P34	10B32	10B32	10B32	10B32	20B33	30B33
21P33	21P33	21P34	21P34	21P35	21P35	10B33	10B33	10B33	10B33	20B34	30B34
21P34	21P34	21P35	21P35	21P36	21P36	10B34	10B34	10B34	10B34	20B35	30B35
21P35	21P35	21P36	21P36	21P37	21P37	10B35	10B35	10B35	10B35	20B36	30B36
21P36	21P36	21P37	21P37	21P38	21P38	10B36	10B36	10B36	10B36	20B37	30B37
21P37	21P37	21P38	21P38	21P39	21P39	10B37	10B37	10B37	10B37	20B38	30B38
21P38	21P38	21P39	21P39	21P40	21P40	10B38	10B38	10B38	10B38	20B39	30B39
21P39	21P39	21P40	21P40	21P41	21P41	10B39	10B39	10B39	10B39	20B40	30B40
21P40	21P40	21P41	21P41	21P42	21P42	10B40	10B40	10B40	10B40	20B41	30B41
21P41	21P41	21P42	21P42	21P43	21P43	10B41	10B41	10B41	10B41	20B42	30B42
21P42	21P42	21P43	21P43	21P44	21P44	10B42	10B42	10B42	10B42	20B43	30B43
21P43	21P43	21P44	21P44	21P45	21P45	10B43	10B43	10B43	10B43	20B44	30B44
21P44	21P44	21P45	21P45	21P46	21P46	10B44	10B44	10B44	10B44	20B45	30B45
21P45	21P45	21P46	21P46	21P47	21P47	10B45	10B45	10B45	10B45	20B46	30B46
21P46	21P46	21P47	21P47	21P48	21P48	10B46	10B46	10B46	10B46	20B47	30B47
21P47	21P47	21P48	21P48	21P49	21P49	10B47	10B47	10B47	10B47	20B48	30B48
21P48	21P48	21P49	21P49	21P50	21P50	10B48	10B48	10B48	10B48	20B49	30B49
21P49	21P49	21P50	21P50	21P51	21P51	10B49	10B49	10B49	10B49	20B50	30B50
21P50	21P50	21P51	21P51	21P52	21P52	10B50	10B50	10B50	10B50	20B51	30B51
21P51	21P51	21P52	21P52	21P53	21P53	10B51	10B51	10B51	10B51	20B52	30B52
21P52	21P52	21P53	21P53	21P54	21P54	10B52	10B52	10B52	10B52	20B53	30B53
21P53	21P53	21P54	21P54	21P55	21P55	10B53	10B53	10B53	10B53	20B54	30B54
21P54	21P54	21P55	21P55	21P56	21P56	10B54	10B54	10B54	10B54	20B55	30B55
21P55	21P55	21P56	21P56	21P57	21P57	10B55	10B55	10B55	10B55	20B56	30B56
21P56	21P56	21P57	21P57	21P58	21P58	10B56	10B56	10B56	10B56	20B57	30B57
21P57	21P57	21P58	21P58	21P59	21P59	10B57	10B57	10B57	10B57	20B58	30B58
21P58	21P58	21P59	21P59	21P60	21P60	10B58	10B58	10B58	10B58	20B59	30B59
21P59	21P59	21P60	21P60	21P61	21P61	10B59	10B59	10B59	10B59	20B60	30B60
21P60	21P60	21P61	21P61	21P62	21P62	10B60	10B60	10B60	10B60	20B61	30B61
21P61	21P61	21P62	21P62	21P63	21P63	10B61	10B61	10B61	10B61	20B62	30B62
21P62	21P62	21P63	21P63	21P64	21P64	10B62	10B62	10B62	10B62	20B63	30B63
21P63	21P63	21P64	21P64	21P65	21P65	10B63	10B63	10B63	10B63	20B64	30B64
21P64	21P64	21P65	21P65	21P66	21P66	10B64	10B64	10B64	10B64	20B65	30B65
21P65	21P65	21P66	21P66	21P67	21P67	10B65	10B65	10B65	10B65	20B66	30B66
21P66	21P66	21P67	21P67	21P68	21P68	10B66	10B66	10B66	10B66	20B67	30B67
21P67	21P67	21P68	21P68	21P69	21P69	10B67	10B67	10B67	10B67	20B68	30B68
21P68	21P68	21P69	21P69	21P70	21P70	10B68	10B68	10B68	10B68	20B69	30B69
21P69	21P69	21P70	21P70	21P71	21P71	10B69	10B69	10B69	10B69	20B70	30B70
21P70	21P70	21P71	21P71	21P72	21P72	10B70	10B70	10B70	10B70	20B71	30B71
21P71	21P71	21P72	21P72	21P73	21P73	10B71	10B71	10B71	10B71	20B72	30B72
21P72	21P72	21P73	21P73	21P74	21P74	10B72	10B72	10B72	10B72	20B73	30B73
21P73	21P73	21P74	21P74	21P75	21P75	10B73	10B73	10B73	10B73	20B74	30B74
21P74	21P74	21P75	21P75	21P76	21P76	10B74	10B74	10B74	10B74	20B75	30B75
21P75	21P75	21P76	21P76	21P77	21P77	10B75	10B75	10B75	10B75	20B76	30B76
21P76	21P76	21P77	21P77	21P78	21P78	10B76	10B76	10B76	10B76	20B77	30B77
21P77	21P77	21P78	21P78	21P79	21P79	10B77	10B77	10B77	10B77	20B78	30B78
21P78	21P78	21P79	21P79	21P80	21P80	10B78	10B78	10B78	10B78	20B79	30B79
21P79	21P79	21P80	21P80	21P81	21P81	10B79	10B79	10B79	10B79	20B80	30B80
21P80	21P80	21P81	21P81	21P82	21P82	10B80	10B80	10B80	10B80	20B81	30B81
21P81	21P81	21P82	21P82	21P83	21P83	10B81	10B81	10B81	10B81	20B82	30B82
21P82	21P82	21P83	21P83	21P84	21P84	10B82	10B82	10B82	10B82	20B83	30B83
21P83	21P83	21P84	21P84	21P85	21P85	10B83	10B83	10B83	10B83	20B84	30B84
21P84	21P84	21P85	21P85	21P86	21P86	10B84	10B84	10B84	10B84	20B85	30B85
21P85	21P85	21P86	21P86	21P87	21P87	10B85	10B85	10B85	10B85	20B86	30B86
21P86	21P86	21P87	21P87	21P88	21P88	10B86	10B86	10B86	10B86	20B87	30B87
21P87	21P87	21P88	21P88	21P89	21P89	10B87	10B87	10B87	10B87	20B88	30B88
21P88	21P88	21P89	21P89	21P90	21P90	10B88	10B88	10B88	10B88	20B89	30B89
21P89	21P89	21P90	21P90	21P91	21P91	10B89	10B89	10B89	10B89	20B90	30B90
21P90	21P90	21P91	21P91	21P92	21P92	10B90	10B90	10B90	10B90	20B91	30B91
21P91	21P91	21P92	21P92	21P93	21P93	10B91	10B91	10B91	10B91	20B92	30B92
21P92	21P92	21P93	21P93	21P94	21P94	10B92	10B92	10B92	10B92	20B93	30B93
21P93	21P93	21P94	21P94	21P95	21P95	10B93	10B93	10B93	10B93	20B94	30B94
21P94	21P94	21P95	21P95	21P96	21P96	10B94	10B94	10B94	10B94	20B95	30B95
21P95	21P95	21P96	21P96	21P97	21P97	10B95	10B95	10B95	10B95	20B96	30B96
21P96	21P96	21P97	21P97	21P98	21P98	10B96	10B96	10B96	10B96	20B97	30B97
21P97	21P97	21P98	21P98	21P99	21P99	10B97					

ROTOR AIRLOADS DETAILS

STAT	BLADE	VP DNF	VT DO	PMS DRAUF	AL DTMST	CL %LIFT	CD DRAG	CM DRMT	MACH
1	1	-3567. -348.	697. 15.	-82.02 -8.20	-21.48 -137.55	-0.824 -364.	0.220 98.	-0.001 -19.	0.267
2	1	-3535. -631.	998. -939.	-74.23 -16.76	-16.20 -281.07	-0.736 -684.	0.107 100.	-0.026 -973.	0.274
3	1	-3523. -530.	1459. -1861.	-66.97 -15.62	-11.43 -282.02	-0.586 -591.	0.034 34.	-0.047 -1877.	0.286
4	1	-3513. -418.	1956. -2666.	-60.40 -15.37	-7.36 -257.80	-0.437 -491.	0.016 18.	-0.057 -2570.	0.301
5	1	-3505. -410.	2482. -495.	-54.59 -16.27	-4.05 -306.32	-0.402 -512.	0.010 12.	-0.009 -435.	0.321
6	1	-3498. -116.	2986. -551.	-49.52 -8.57	-1.48 -111.79	-0.110 -161.	0.007 10.	-0.008 -486.	0.343
7	1	-3494. 162.	3477. -1283.	-65.14 8.78	0.41 147.31	0.131 219.	0.006 10.	-0.017 -1164.	0.368
8	1	-3491. 371.	3967. -1521.	-41.35 24.04	1.71 403.13	0.285 548.	0.006 12.	-0.019 -1434.	0.394
9	1	-3489. 539.	4455. -1922.	-38.06 39.72	2.49 666.14	0.389 858.	0.006 13.	-0.021 -1879.	0.422
10	1	-3487. 326.	4944. -1127.	-35.20 26.69	2.86 447.55	0.440 554.	0.006 8.	-0.022 -1087.	0.451
1	2	-3569. -341.	473. 79.	-82.46 -5.14	-22.49 -143.91	-0.300 -357.	0.220 98.	0.005 98.	0.269
2	2	-3572. -671.	976. -834.	-74.72 -10.90	-17.26 -304.98	-0.771 -727.	0.125 118.	-0.022 -819.	0.276
3	2	-3576. -570.	1479. -1719.	-67.53 -10.31	-12.56 -238.27	-0.618 -637.	0.047 49.	-0.042 -1718.	0.289
4	2	-3579. -500.	1983. -2610.	-61.01 -10.77	-9.55 -301.29	-0.506 -593.	0.019 21.	-0.057 -2614.	0.305
5	2	-3582. -578.	2487. -457.	-55.23 -14.93	-5.27 -417.54	-0.545 -713.	0.010 14.	-0.009 -482.	0.325
6	2	-3586. -280.	2991. -486.	-50.17 -8.88	-2.70 -248.43	-0.249 -374.	0.008 12.	-0.008 -488.	0.348
7	2	-3589. 14.	3495. -1178.	-45.76 -0.10	-0.90 -2.77	0.005 9.	0.007 12.	-0.017 -1174.	0.374
8	2	-3593. 209.	3959. -1405.	-41.94 7.69	0.53 215.20	0.151 300.	0.006 12.	-0.018 -1384.	0.401
9	2	-3597. 384.	4503. -1984.	-38.61 16.41	1.35 453.08	0.262 594.	0.006 14.	-0.022 -1973.	0.430
10	2	-3601. 248.	5007. -1168.	-35.72 11.93	1.74 330.99	0.316 414.	0.006 8.	-0.022 -1161.	0.460

ARAP06 Sample Problem, Condensed Output (Continued)

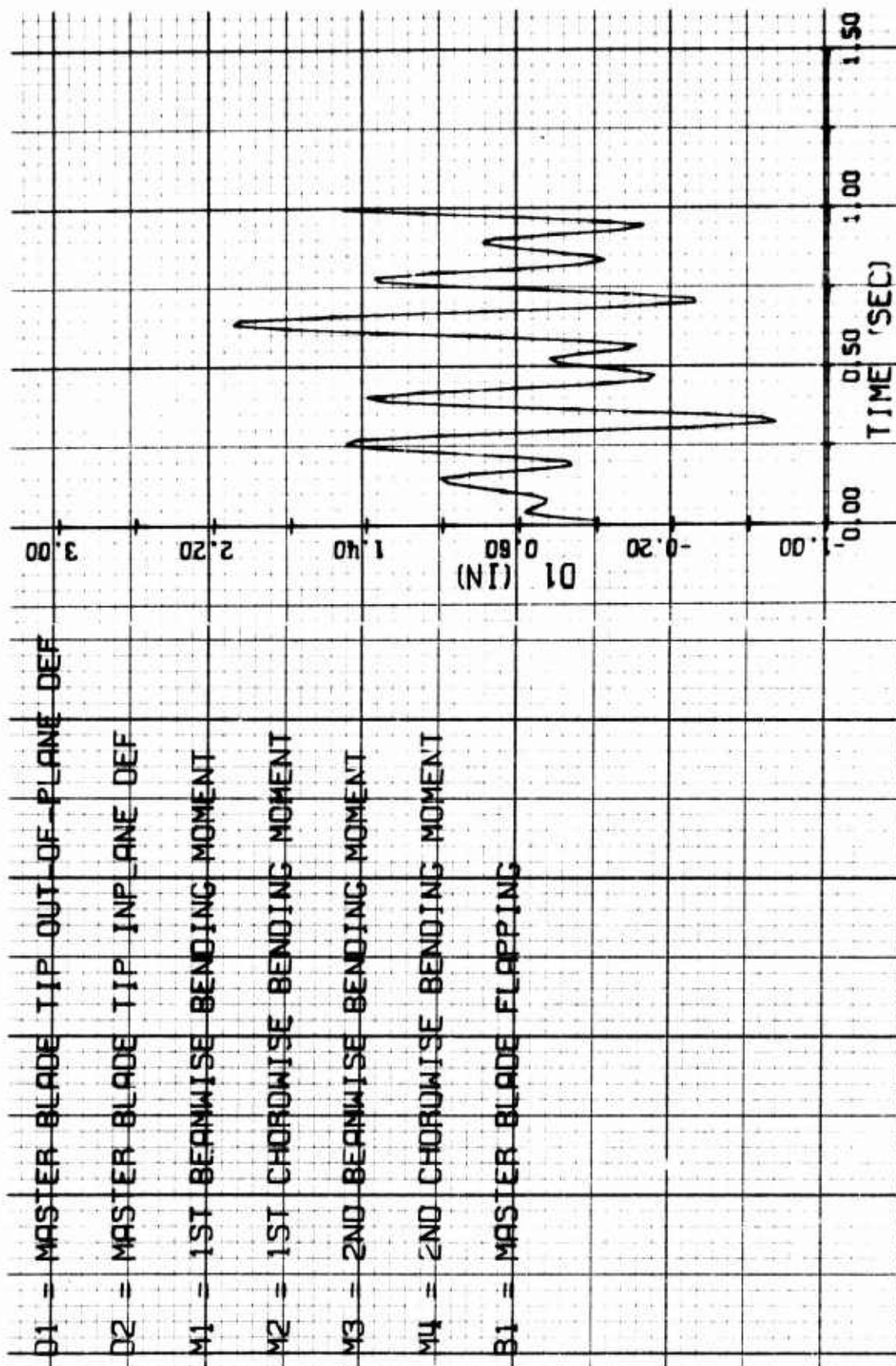
▼

1	3	-3317.	224.	-86.14	-25.44	-0.729	0.280	0.023	0.248
		-270.	369.	-7.71	-124.56	-277.	106.	345.	
2	3	-3333.	788.	-76.70	-18.50	-0.811	0.145	-0.016	0.256
		-610.	-377.	-16.34	-264.19	-655.	117.	-529.	
3	3	-3358.	1336.	-68.31	-12.61	-0.620	0.048	-0.041	0.270
		-502.	-1489.	-15.19	-245.54	-557.	43.	-1492.	
4	3	-3336.	1871.	-61.07	-7.88	-0.480	0.017	-0.058	0.289
		-424.	-2432.	-15.70	-253.73	-494.	17.	-2388.	
5	3	-3414.	2398.	-56.92	-4.23	-0.423	0.010	-0.009	0.311
		-437.	-465.	-18.57	-300.18	-506.	12.	-414.	
6	3	-3442.	2917.	-49.72	-1.53	-0.115	0.007	-0.008	0.337
		-117.	-472.	-6.92	-111.87	-162.	10.	-448.	
7	3	-3448.	3432.	-45.10	0.38	0.127	0.006	-0.017	0.364
		155.	-1122.	8.82	135.41	209.	10.	-1139.	
8	3	-3493.	3942.	-41.54	1.64	0.278	0.006	-0.019	0.393
		360.	-1378.	24.05	388.80	531.	11.	-1420.	
9	3	-3518.	4450.	-38.32	2.36	0.376	0.006	-0.021	0.423
		527.	-1830.	39.82	643.75	833.	13.	-1892.	
10	3	-3541.	4956.	-35.54	2.64	0.417	0.006	-0.022	0.454
		316.	-1071.	26.49	428.19	533.	8.	-1109.	

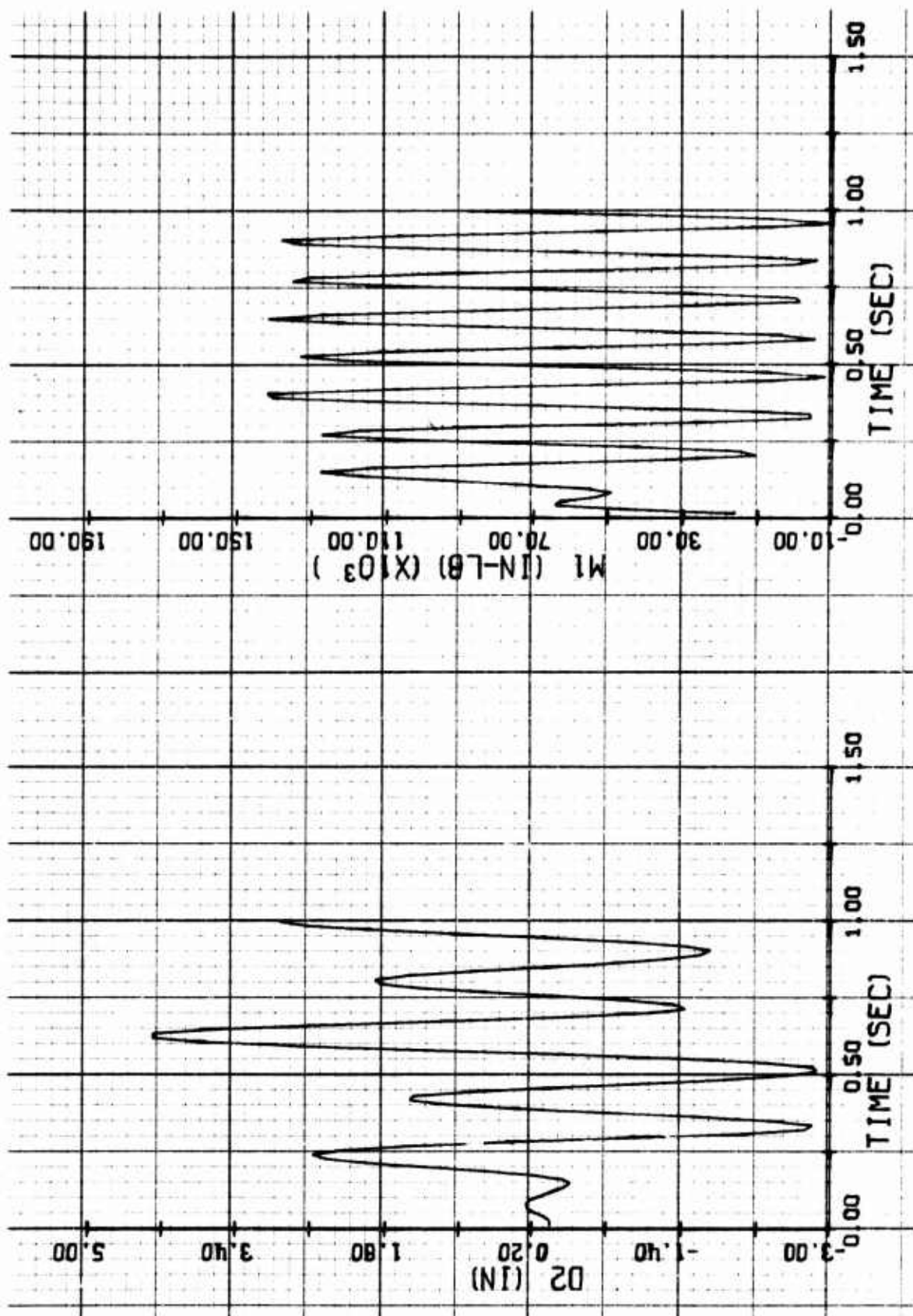
WING AIRLOADS DETAILS

STAT	WP	VT	PH	AL	CL	CD	WL	WD	WT	WM	WG
1	4.62	3548.	0.07	9.07	0.915	0.015	0.	0.	0.	0.	0.
2	4.56	3548.	0.07	9.03	0.911	0.013	3288.	55.	3288.	51.	30446.
3	4.87	3548.	0.06	8.97	0.905	0.013	4793.	80.	4793.	75.	44381.
4	5.04	3547.	0.05	8.92	0.899	0.013	3246.	54.	3246.	51.	30064.
5	1.54	3547.	0.02	8.84	0.892	0.015	4293.	72.	4293.	70.	39762.
6	1.02	3546.	-0.03	8.74	0.882	0.015	3180.	53.	3180.	55.	29463.
7	2.11	3546.	-0.05	8.67	0.875	0.015	3998.	67.	3998.	70.	37045.
8	5.95	3545.	-0.16	8.52	0.859	0.014	3304.	55.	3304.	64.	30632.

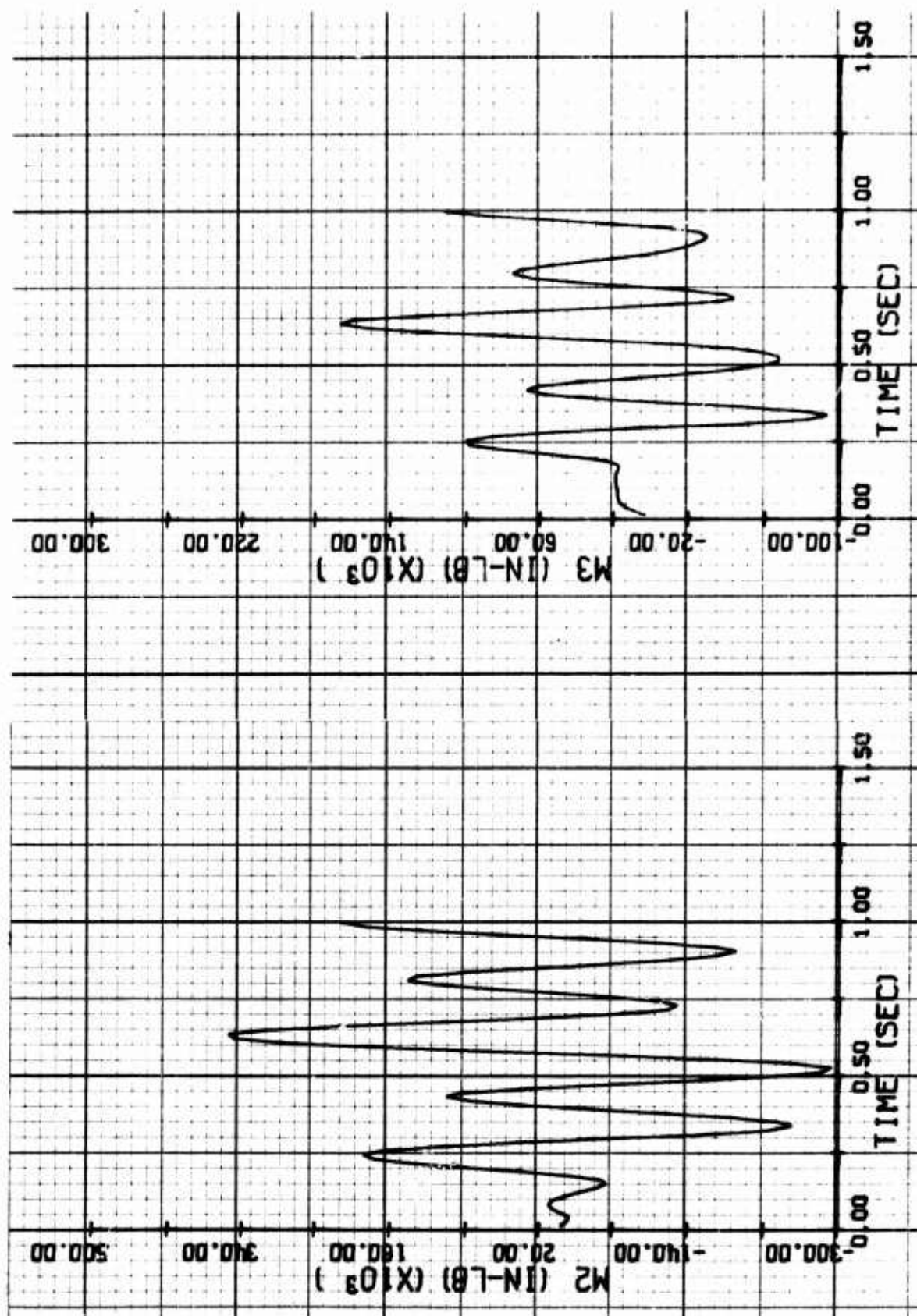
ARAP06 Sample Problem, Condensed Output (Continued)



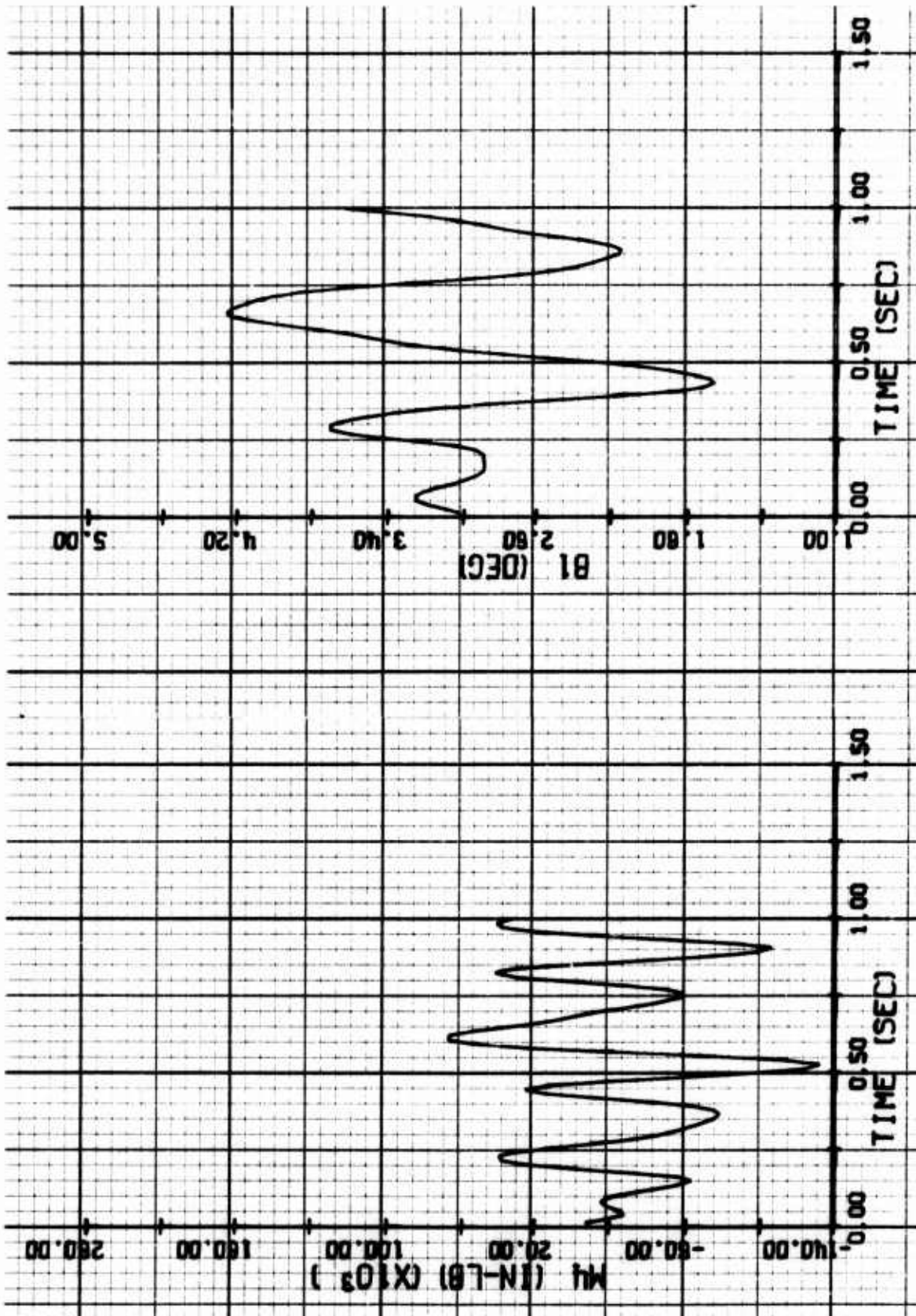
ARAF06 Sample Problem, CALCOMP Plots



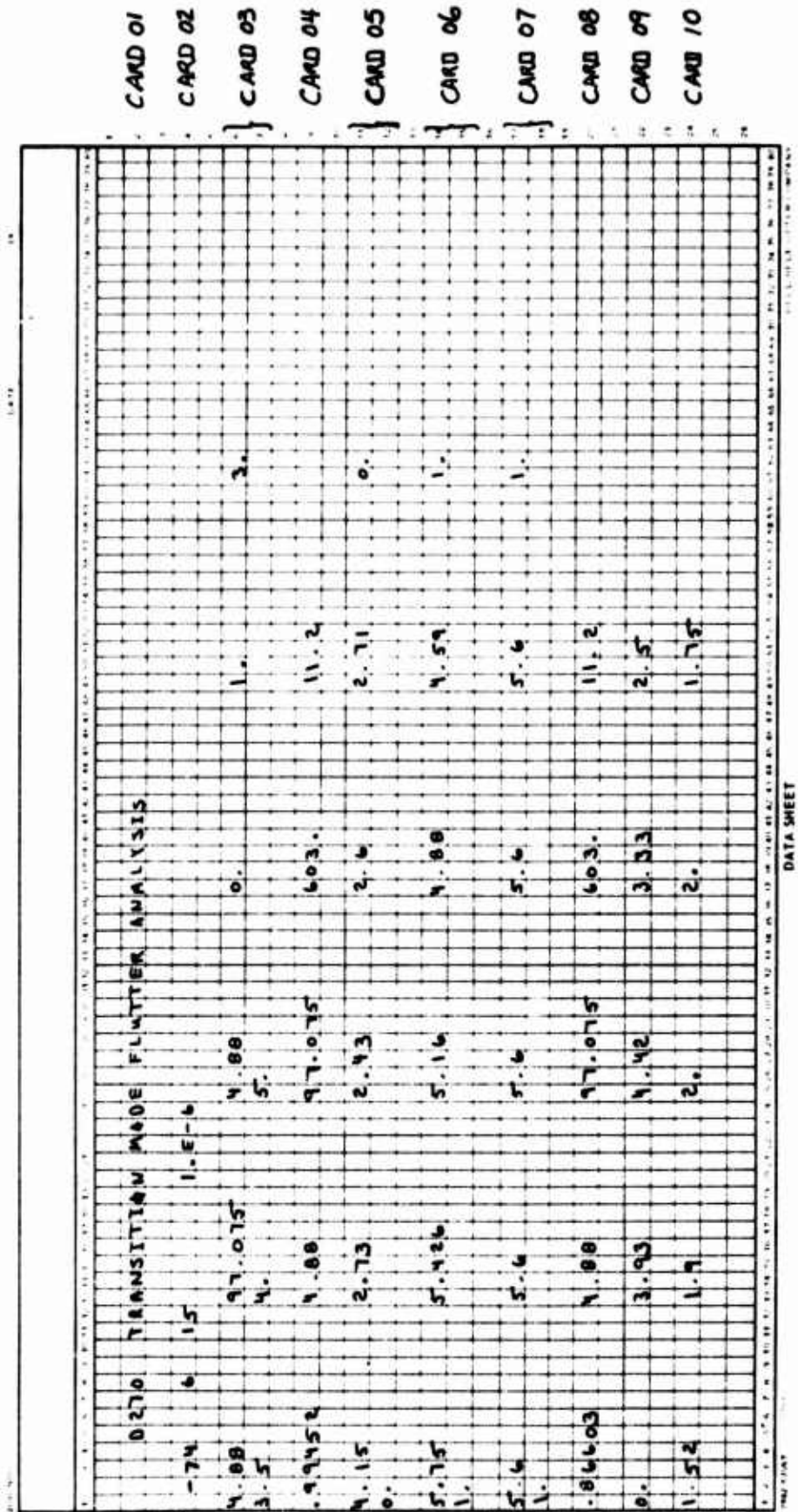
ARAP06 Sample Problem, CALCOMP Plots (Continued)



ARAP06 Sample Problem, CALCOMP Plots (Continued)



ARAP06 Sample Problem, CALCOMP Plots (Concluded)



DFALL7 Sample Problem, Input Data

0

CARD 11	CARD 12	CARD 13	CARD 14	CARD 15	CARD 16	CARD 17	CARD 18	CARD 19	CARD 20	CARD 21	CARD 22	CARD 23
1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667
.86603	4.88	97.075	603.	11.2								
0.	3.93	4.42	3.33	2.5								
1.52	1.9	2.	2.	1.75								
1.667	1.667	1.667	1.667	1.667								
.86603	4.88	97.075	603.	11.2								
0.	3.93	4.42	3.33	2.5								
1.52	1.9	2.	2.	1.75								
1.667	1.667	1.667	1.667	1.667								
-7.5	30.	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6
1.E+6	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6	1.E+6
55.	46000.	180000.	22000.	27.								
55.	34000.	155000.	18000.									

DATA SHEET

DFALL7 Sample Problem, Input Data (Continued)

44	25000.	125000.	14500.	CARD 24
46	17500.	100000.	12500.	CARD 25
50	16000.	90000.	10500.	CARD 26
3	1500.	1500.	100000.	CARD 27
60	1800.	12500.	100000.	CARD 28
60	750.	12000.	100000.	CARD 29
75	300.	9500.	100000.	CARD 30
55.5	110.	8450.	100000.	CARD 31
13.4	13.4	13.4	13.4	CARD 32
10.	.1	.1	.1	CARD 33
53.6	53.6	53.6	53.6	CARD 34
20.0	20.0	20.0	20.0	CARD 35
1730.	1450.	2950.	1450.	CARD 36
4187	213.2	105.7	108.5	CARD 37

DATA SHEET

DFALL7 Sample Problem, Input Data (Continued)

		CARD 38		CARD 39		CARD 40		CARD 41	
1	2	3	4	5	6	7	8	9	10
128000.	43700.	9650.	38050.	9650.	-39000.				
10.	.1	.1	.1	.1	.1				
33000000.	7540000.	1660000.	1250000.	120000.	44800000.				
448000000.	100.	42200.	8700.	12500.	9650.				

DATA SHEET

DFAL17 Sample Problem, Input Data (Concluded)

U270 TRANSITION MODE FLUTER ANALYSIS

CONTROL DATA

WISSE -74
 NAMEU 15
 MODEL-OUT 15
 FLER K 0.10000E-05
 MASS K 0.10000E-01
 DENSITY 0.22100E-02
 BR 0.48000E-01
 S 0.97075E-02
 BARS1 0.48000E-01

REDUCED VELOCITIES

0.0 0.10000E-01 0.30000E-01 0.50000E-01 0.70000E-01 0.90000E-01

AERODYNAMIC INPUT DATA

SURFACE COSINE LAMBDA UM S CAP S C BAR

1 0.99992E-00 0.48800E-01 0.97075E-02 0.48800E-03 0.11207E-02
 2 0.48800E-01 0.48800E-01 0.97075E-02 0.48800E-03 0.11207E-02
 3 0.48800E-01 0.48800E-01 0.97075E-02 0.48800E-03 0.11207E-02
 4 0.48800E-01 0.48800E-01 0.97075E-02 0.48800E-03 0.11207E-02

STRIP

1 2 3 4 5 6 7
 SURFACE DY 0.41500E-01 0.27300E-01 0.24300E-01 0.24300E-01 0.27300E-01 0.27300E-01 0.27300E-01
 1 0.41500E-01 0.27300E-01 0.24300E-01 0.24300E-01 0.27300E-01 0.27300E-01 0.27300E-01
 2 0.41500E-01 0.27300E-01 0.24300E-01 0.24300E-01 0.27300E-01 0.27300E-01 0.27300E-01
 3 0.41500E-01 0.27300E-01 0.24300E-01 0.24300E-01 0.27300E-01 0.27300E-01 0.27300E-01
 4 0.41500E-01 0.27300E-01 0.24300E-01 0.24300E-01 0.27300E-01 0.27300E-01 0.27300E-01
 5 0.41500E-01 0.27300E-01 0.24300E-01 0.24300E-01 0.27300E-01 0.27300E-01 0.27300E-01
 6 0.41500E-01 0.27300E-01 0.24300E-01 0.24300E-01 0.27300E-01 0.27300E-01 0.27300E-01
 7 0.41500E-01 0.27300E-01 0.24300E-01 0.24300E-01 0.27300E-01 0.27300E-01 0.27300E-01

FLIGHT TEST MATHEMATICS

NING SWEEP -7.50000 (DEGREES)
 BLADE SWEEP 30.00000 (DEGREES)
 DIST-TO CONVERSION AXIS 29.400 (INCHES)
 PYLON LENGTH 50.00000 (INCHES)
 NING LENGTH 122.00000 (INCHES)
 NING OFFSET 37.00000 (INCHES)
 PYLON-2/A STIFFNESS 1000000.0 (IN-LBS/RADIANS)
 PYLON-1/A STIFFNESS 1000000.0 (IN-LBS/RADIANS)
 BLADE TAIL STIFFNESS 1000000.0 (IN-LBS/RADIANS)
 BLADE CONTROL STIFFNESS 1000000.0 (IN-LBS/RADIANS)
 BLADE CONTROL STIFFNESS 1000000.0 (IN-LBS/RADIANS)
 BLADE STIFFNESS 10.0 (IN-LBS/RADIANS)
 BLADE STIFFNESS/CONVERSION AXIS 2324.6 (IN-LBS/IN)
 BLADE STIFFNESS/CONVERSION AXIS 11515.2 (IN-LBS/IN)

NING PARAMETERS

SEG	LENGTH	EIB	ETC	EJ	X	Y	M	S	I
1	0.250000	0.400000	0.800000	0.220000	0.134000	0.2	0.193000	0.128000	0.132000
2	0.550000	0.340000	0.155000	0.180000	0.134000	0.2	0.132000	0.432000	0.284000
3	0.800000	0.250000	0.150000	0.145000	0.134000	0.2	0.145000	0.965000	0.166000
4	0.800000	0.175000	0.100000	0.125000	0.134000	0.2	0.295000	0.385000	0.152000
5	0.500000	0.140000	0.900000	0.135000	0.134000	0.2	0.145000	0.045000	0.132000

PYLON PARAMETERS

SEG	LENGTH	Y	M	S	I
PITCH	0.120000	0.100000	0.2	-0.300000	0.5
YAW	0.100000	0.100000	0.2	0.418000	0.4
				0.100000	0.2
				0.448000	0.8

BLADE PARAMETERS

SEG	LENGTH	EIB	ETC	EJ	X	Y	M	S	I
1	0.300000	0.150000	0.150000	0.100000	0.100000	0.2	0.100000	0.100000	0.100000
2	0.600000	0.180000	0.125000	0.150000	0.150000	0.2	0.150000	0.150000	0.150000
3	0.800000	0.250000	0.200000	0.200000	0.200000	0.2	0.200000	0.200000	0.200000
4	0.750000	0.200000	0.150000	0.150000	0.150000	0.2	0.150000	0.150000	0.150000
5	0.550000	0.110000	0.845000	0.100000	0.100000	0.2	0.448000	0.100000	0.985000

DFAL17 Sample Problem, Input Display (Continued)

[illegible]

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MASS MATRIX

	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6	COLUMN 7	COLUMN 8
1	0.1555555E 04	0.111014E 03	0.0	0.0	0.0	0.0	0.0	0.0
2	0.111014E 03	0.1047450E 03	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

IBM RESEARCH COMPANY

DFALL7 Sample Problem, Input Display (Concluded)

OUTPUT DATA			
MODE	MEASUREMENT	REDUCED VELOCITY	
1	0.12305840-C1	0.0	
2	0.06413340-C2	0.0	
3	0.17693520-C2	0.0	
4	0.11891000-C2	0.0	
5	0.21267840-C2	0.0	
6	0.17176940-C2	0.0	
7	0.22571000-C3	0.0	
8	0.23003940-C3	0.0	
9	0.17786250-C3	0.0	
10	0.14751300-C3	0.0	
11	0.23353440-C3	0.0	
12	0.14237800-C3	0.0	
13	0.20607680-C4	0.0	
14	0.20607680-C4	0.0	
15	0.40531410-C4	0.0	

DFAI.17 Sample Problem, Condensed Output

MODE	WAVELENGTH (CM)	DAMPING	VELOCITY (CM/SEC)
1	0.14347105E 01	0.0	0.0
2	0.19102849E 01	0.0	0.0
3	0.25921090E 01	0.0	0.0
4	0.37690525E 01	0.0	0.0
5	0.40598422E 01	0.0	0.0
6	0.4182918E 01	0.0	0.0
7	0.92324397E 01	0.0	0.0
8	0.10981708E 02	0.0	0.0
9	0.11111555E 02	0.0	0.0
10	0.13472447E 02	0.0	0.0
11	0.14490707E 02	0.0	0.0
12	0.16720047E 02	0.0	0.0
13	0.17097181E 02	0.0	0.0
14	0.17097181E 02	0.0	0.0
15	0.24876633E 02	0.0	0.0

DFALL17 Sample Problem, Condensed Output (Continued)

DEFL18 SAMPLE PROBLEM

DATA	LAST CASE	SINE-SCANNED	10 FT	20 FOLD	175 KNOTS	
-2	2	8	1			
.002376	175.	5.7	10.	4.88	97.075	CARD 01
.005	1.33	5.		1.5-6-7.5	30.	CARD 02
4600000000	2200000000.55.		110.			CARD 03
4.15	2.73	2.43	2.6	2.71	0.	CARD 04
0.	0	3.93	4.42	3.33	2.5	CARD 05
0.	1.965	2.21	1.665	1.25	0.	CARD 06
1.965	2.21	1.665	1.25			CARD 07
5.75	5.926	5.16	4.88	4.59	1.	CARD 08
1.	1.52	1.9	2.	2.	1.75	CARD 09
1.52	1.9	2.	2.	1.75	1.52	CARD 10
1.9	2	2.	1.75			CARD 11
.77	1.72	.145	1.88	.011	2.54	CARD 12
.002	3.77	.341	4.7	.324	4.0	CARD 13
.101	9.45	.00994	10.8			CARD 14

DEFL18 Sample Problem, Input Data

99452	4.88	97.075	603	11.2	CARD 15
4.15	2.73	2.43	2.6	2.71	CARD 16
0.				0.	
5.75	5.426	5.16	4.88	4.59	CARD 17
1.				1.	
5.6	5.6	5.6	5.6	5.6	CARD 18
1.				1.	
.86603	4.88	97.075	603	11.2	CARD 19
0.	3.93	4.42	3.33	2.5	CARD 20
1.52	1.9	2.	2.	1.75	CARD 21
1.667	1.667	1.667	1.667	1.667	CARD 22
.86603	4.88	97.075	603	11.2	CARD 23
0.	3.93	4.42	3.33	2.5	CARD 24
1.52	1.9	2.	2.	1.75	CARD 25

DATA SHEET

DFAL18 Sample Problem, Input Data (Continued)

2

1.667	1.667	1.667	1.667	1.667	1.667	1.667	CARD 26
.86603	4.88	97.075	603.	11.2			CARD 27
0.	3.93	4.42	3.33	2.5			CARD 28
1.52	1.9	2.	2.	1.75			CARD 29
1.667	1.667	1.667	1.667	1.667			CARD 30
13.4	13.4	13.4	13.4	13.4	122.0		CARD 31
10.	.1	.1	.1	.1			CARD 32
53.6	53.6	53.6	53.6	53.6	10.		CARD 33
10.	20.	20.	20.	20.	20.		CARD 34
1930.	3370.	1450.	2950.	1450.	7187		CARD 35
4187.	170.	213.2	105.7	108.5	46.		CARD 36
12800	43700.	9650.	38050.	9650.	-390000.		CARD 37
10.	1.	1.	1.	1.	1.		CARD 38
33000000.	75400000.	1660000.	6250000.	120000.	44800000.		CARD 39
442000000.	100.	42200.	8700.	12500.	9650.		CARD 40

DFALL18 Sample Problem, Input Data (Continued)

CARD 41

CARD 42

FLEX. MATRIX (74X74).

EIGENVALUES -74

DATA SHEET

DFAL18 Sample Problem, Input Data (Concluded)

GUST RESPONSE ANALYSIS FOR FOLDING PROPORTION

0270 GUST CASE SINE-SOURCE 10 FT 30 FOLD 175 KNOTS

CONTROL DATA

GUST NUMBER -2
 OPTION NUMBER 2
 NO. OF SECTION FREQUENCIES 8
 NO. OF SECTIONS 1
 DENSITY, SLUG/FT³ 0.2388E-02
 AIRCRAFT VELOCITY, FT 0.4750E 03
 LEFT CURVE SLOPE 0.5700E 01
 GUST VELOCITY 0.1000E 02
 REF. LENGTH, G-FT 0.4690E 01
 TIME INCREMENT, SEC 0.7073E 02
 NO. OF POINTS 0.1000E-02
 WIND VELOCITY, FPS 0.1330E 01
 WIND DIRECTION, DEG 0.0000E 03
 FLEXIBILITY FACTOR 0.2000E 01
 WIND SLEEP, DEG -0.5000E 01
 WIND SLEEP, DEG 0.1000E 02

SECTION PARAMETERS

SECTION	ELN-LB-IN=02	GJ-LB-IN=02	LL-IN	L2-IN
1	0.0000E 11	0.2200E 11	0.5500E 02	0.1100E 03

STRIP WIDTHS, GUSTS

STRIP WIDTH, GUSTS	SEMICIRCULGUSTS
0.4150E 01	0.5750E 01
0.2740E 01	0.5420E 01
0.2400E 01	0.5180E 01
0.2600E 01	0.4900E 01
0.2710E 01	0.4600E 01
0.3	0.4300E 01
0.3	0.4000E 01
0.3900E 01	0.3700E 01
0.4420E 01	0.3400E 01
0.4300E 01	0.3100E 01
0.4500E 01	0.2800E 01
0.4750E 01	0.2500E 01
0.2210E 01	0.2200E 01
0.1655E 01	0.1900E 01
0.1250E 01	0.1600E 01
0.3	0.1300E 01
0.1965E 01	0.1000E 01
0.2100E 01	0.0700E 01
0.1645E 01	0.0400E 01
0.1300E 01	0.0100E 01

DEALL8 Sample Problem, Input Display

► INPUT FREQUENCY-DAMPING VALUES

MODE	DAMPING	FREQUENCY
1	0.77000 00	0.172000 01
2	0.145000 00	0.188000 01
3	0.110000-01	0.254000 01
4	0.200000-02	0.377000 01
5	0.341000 00	0.470000 01
6	0.324000 00	0.480000 01
7	0.101000 00	0.945000 01
8	0.997000-02	0.106000 02

AERODYNAMIC INPUT DATA

SURFACE	COSINE	LAMBDA	DM	S	Cx ϕ S	C ϕ S	C BAR
1	C.55452E 00	0.44803E 01	0.44803E 01	C.57075E 02	0.50303E 03	0.11200E 02	
2	C.66603E 00	0.44803E 01	0.44803E 01	C.57075E 02	0.50303E 03	0.11200E 02	
3	C.66603E 00	0.44803E 01	0.44803E 01	C.57075E 02	0.50303E 03	0.11200E 02	
4	C.66603E 00	0.44803E 01	0.44803E 01	C.57075E 02	0.50303E 03	0.11200E 02	

SURFACE	CY	1	2	3	4	5	6	7
1	B	0.41500E 01	0.27300E 01	0.24400E 01	0.26000E 01	0.27100E 01	0.0	0.0
1	D	0.57500E 01	0.54280E 01	0.51600E 01	0.48400E 01	0.45800E 01	0.10000E 01	0.10000E 01
1	D	0.55000E 01	0.56000E 01	0.56000E 01	0.56000E 01	0.56000E 01	0.10000E 01	0.10000E 01
2	B	0.0	0.49300E 01	0.44200E 01	0.43000E 01	0.25000E 01		
2	D	0.15200E 01	0.19000E 01	0.20000E 01	0.20000E 01	0.17500E 01		
2	D	0.15570E 01	0.16670E 01	0.1670E 01	0.1670E 01	0.1670E 01		
3	B	0.0	0.49300E 01	0.44200E 01	0.43000E 01	0.25000E 01		
3	D	0.15200E 01	0.19000E 01	0.20000E 01	0.20000E 01	0.17500E 01		
3	D	0.16670E 01	0.16670E 01	0.16670E 01	0.16670E 01	0.16670E 01		
4	B	0.0	0.49300E 01	0.44200E 01	0.43000E 01	0.25000E 01		
4	D	0.15200E 01	0.19000E 01	0.20000E 01	0.20000E 01	0.17500E 01		
4	D	0.16670E 01	0.16670E 01	0.16670E 01	0.16670E 01	0.16670E 01		

DFAL18 Sample Problem, Input Display (Continued)

► MASS INPUT DATA

SEGMENT	A	V	M	SR	IR
1	0.134000 02	0.536000 02	0.193000 04	0.129000 05	0.330000 07
2	0.134000 02	0.536000 02	0.337000 04	0.417000 05	0.754000 07
3	0.134000 02	0.536000 02	0.145000 04	0.395000 04	0.166000 07
4	0.134000 02	0.536000 02	0.295000 04	0.380000 05	0.625000 07
5	0.134000 02	0.536000 02	0.145000 04	0.965000 04	0.120000 06
6	0.122000 03	0.100000 02	0.418700 04	-0.390000 06	0.648000 08
7	0.100000 02	0.100000 02	0.418700 04	0.130000 02	0.648000 08
8	0.109000 03	0.200000 02	0.170000 03	0.100000 00	0.130000 03
9	0.100000 00	0.200000 02	0.213200 03	0.100000 00	0.622000 05
10	0.100000 00	0.200000 02	0.100000 00	0.100000 00	0.970000 04
11	0.100000 00	0.200000 02	0.100000 00	0.100000 00	0.125000 05
12	0.100000 00	0.200000 02	0.100000 00	0.100000 00	0.965000 04
13	0.100000 00	0.200000 02	0.100000 00	0.100000 00	0.100000 03
14	0.100000 00	0.200000 02	0.213200 03	0.100000 00	0.622000 05
15	0.100000 00	0.200000 02	0.100000 00	0.100000 00	0.870000 04
16	0.100000 00	0.200000 02	0.100000 00	0.100000 00	0.125000 05
17	0.100000 00	0.200000 02	0.100000 00	0.100000 00	0.965000 04
18	0.100000 00	0.200000 02	0.100000 00	0.100000 00	0.100000 03
19	0.100000 00	0.200000 02	0.213200 03	0.100000 00	0.622000 05
20	0.100000 00	0.200000 02	0.100000 00	0.100000 00	0.870000 04
21	0.100000 00	0.200000 02	0.100000 00	0.100000 00	0.125000 05
22	0.100000 00	0.200000 02	0.100000 00	0.100000 00	0.965000 04

FLUTTER SYSTEM ROOTS

1	0.454220-02	0.654290-02	2	0.716540-02	0.103920-02	3	0.397620-02	0.411590-04
4	0.179420-02	0.456440-05	5	0.114670-02	0.591320-03	6	0.109940-02	0.355210-03
7	0.233650-03	0.286480-04	8	0.217170-03	0.216510-05	9	0.178980-03	0.0
10	0.147340-03	0.0	11	0.139750-03	0.0	12	0.114240-03	0.0
13	0.935080-04	0.0	14	0.866540-04	0.0	15	0.409110-04	0.0
16	0.221810-04	0.0	17	0.193090-04	0.0	18	0.224370-04	0.0
19	0.221810-04	0.0	20	0.135220-04	0.0	21	0.105590-04	0.0
22	0.394440-05	0.0	23	0.446720-05	0.0	24	0.571830-05	0.0
25	0.565790-05	0.0	26	0.533220-05	0.0	27	0.514940-05	0.0
28	0.637330-05	0.0	29	0.165540-05	0.0	30	0.214100-05	0.0
31	0.123520-05	0.0	32	0.904330-06	0.0	33	0.609070-06	0.0
34	0.505190-06	0.0	35	0.883220-06	0.0	36	0.897220-06	0.0
37	0.876440-06	0.0	38	0.516520-06	0.0	39	0.274420-06	0.0
40	0.624420-06	0.0	41	0.189470-06	0.0	42	0.274380-06	0.0
43	0.216430-06	0.0	44	0.274420-06	0.0	45	0.239610-06	0.0
46	0.216430-06	0.0	47	0.218370-06	0.0	48	0.166420-06	0.0
49	0.216430-06	0.0	50	0.120180-06	0.0	51	0.119520-06	0.0
52	0.216430-06	0.0	53	0.181130-06	0.0	54	0.114250-06	0.0
55	0.159480-06	0.0	56	0.181130-06	0.0	57	0.114250-06	0.0
58	0.102060-09	0.0	59	0.171600-10	0.0	60	0.350920-10	0.0
61	0.316340-10	0.0	62	0.792500-13	0.0	63	0.137500-14	0.0
64	0.137630-14	0.0	65	0.135200-14	0.0	66	0.421690-15	0.0
67	0.421690-15	0.0	68	0.417320-15	0.0	69	0.210360-15	0.0
70	0.210360-15	0.0	71	0.210360-15	0.0	72	0.122450-15	0.0
73	0.122450-15	0.0	74	0.122120-15	0.0			

DFALL8 Sample Problem, Input Display (Concluded)

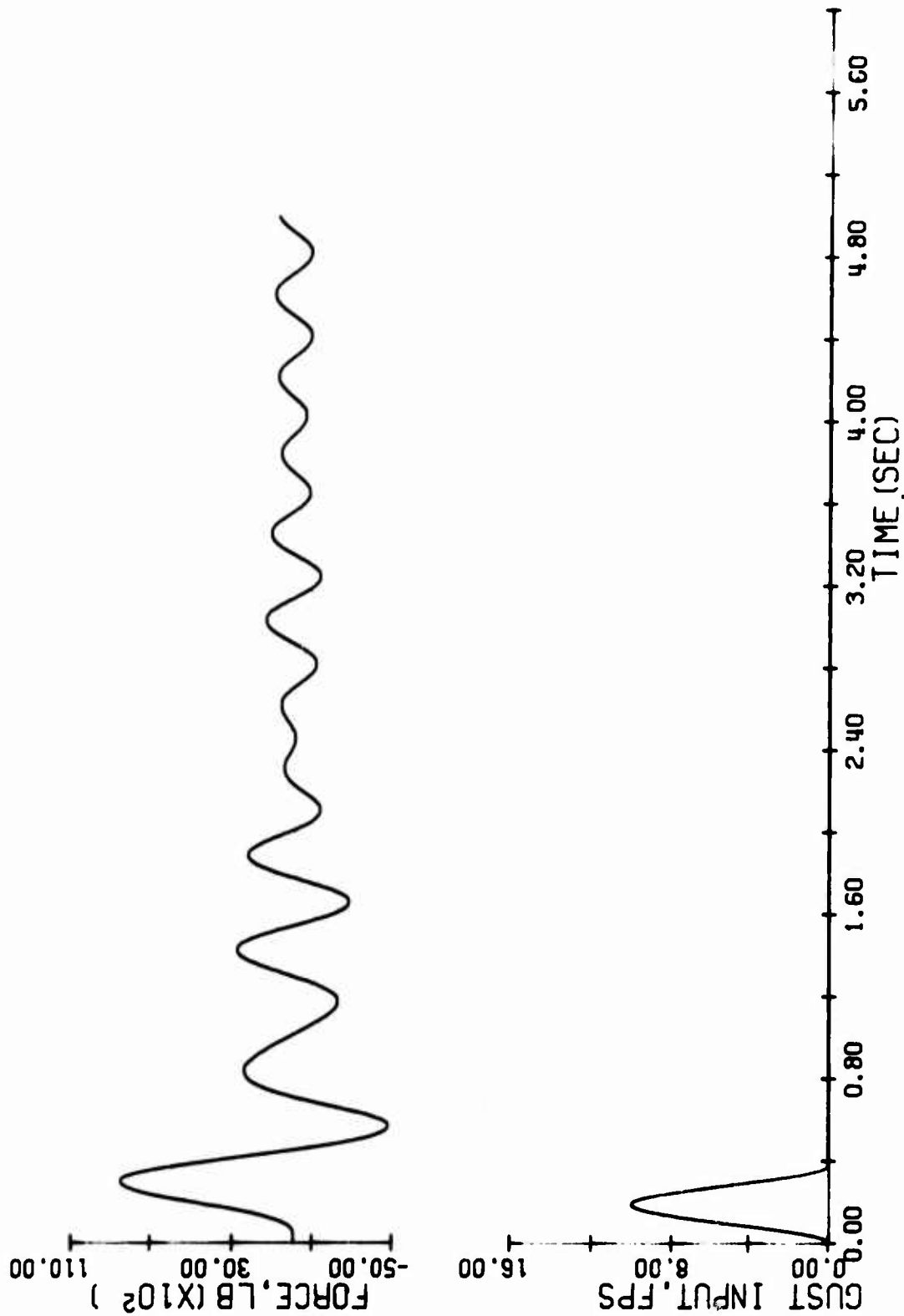
5750745 34 671545

[illegible]

310

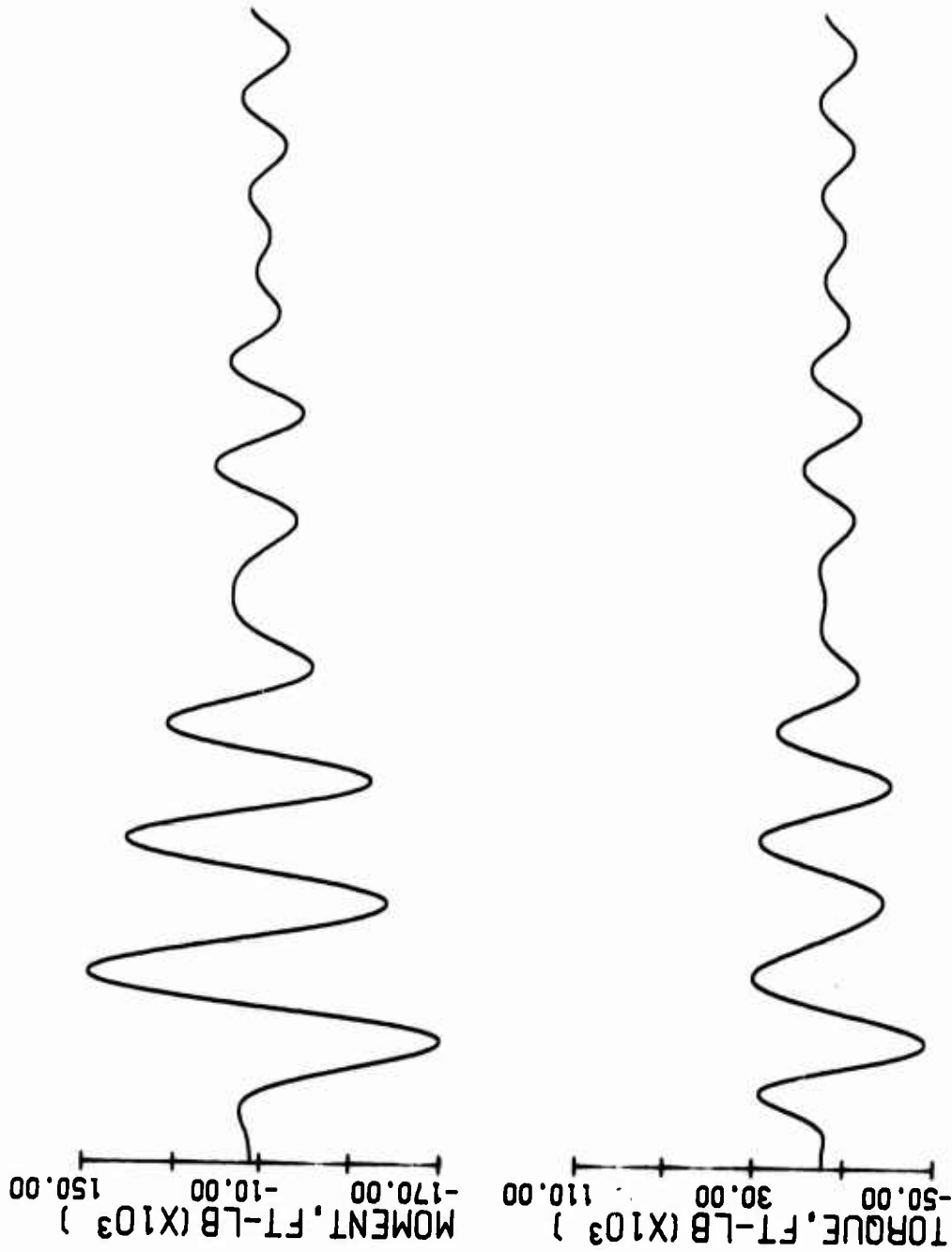
[illegible]

DFALL18 Sample Problem, Condensed Output

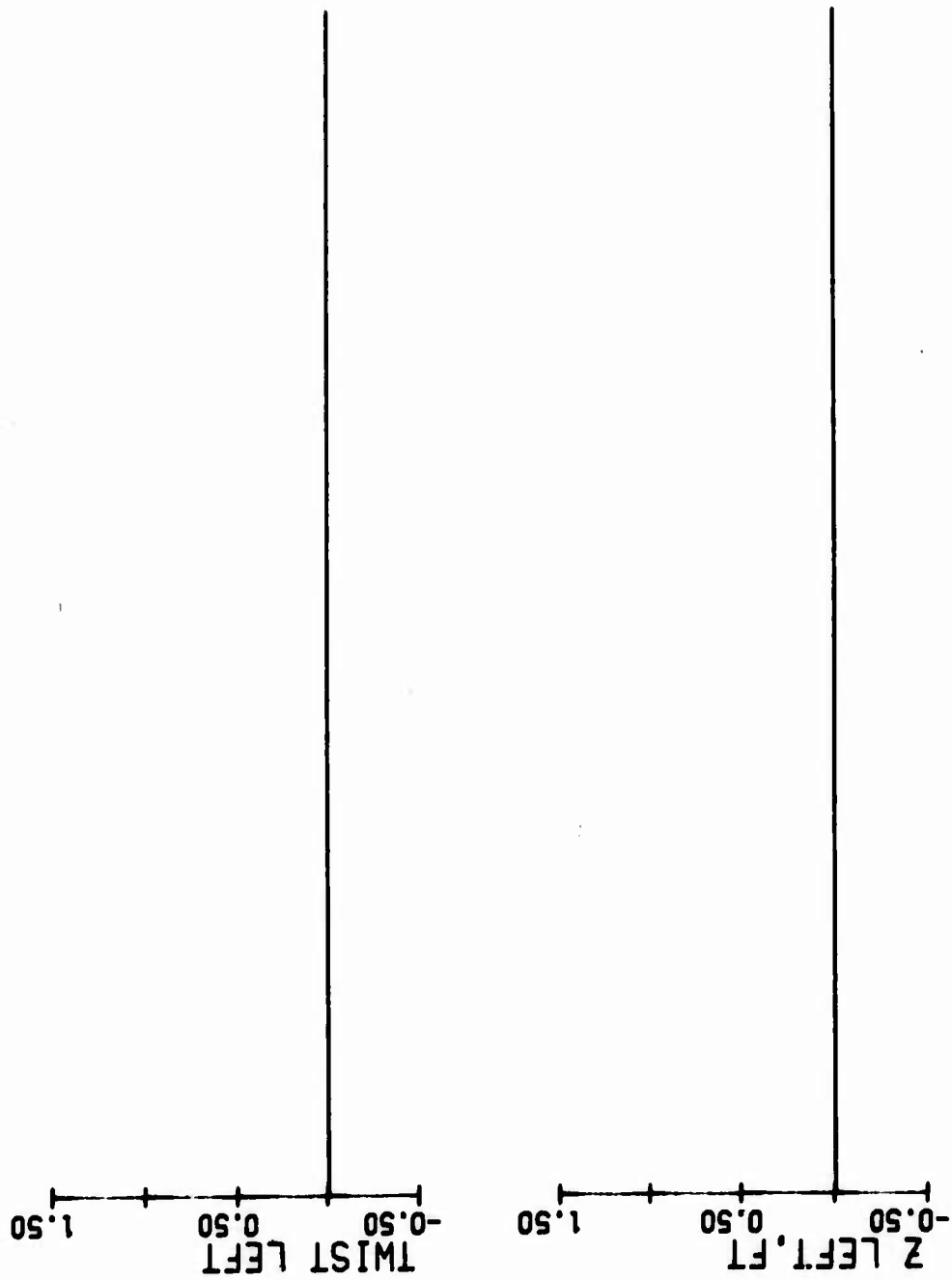


COORDINATE 01

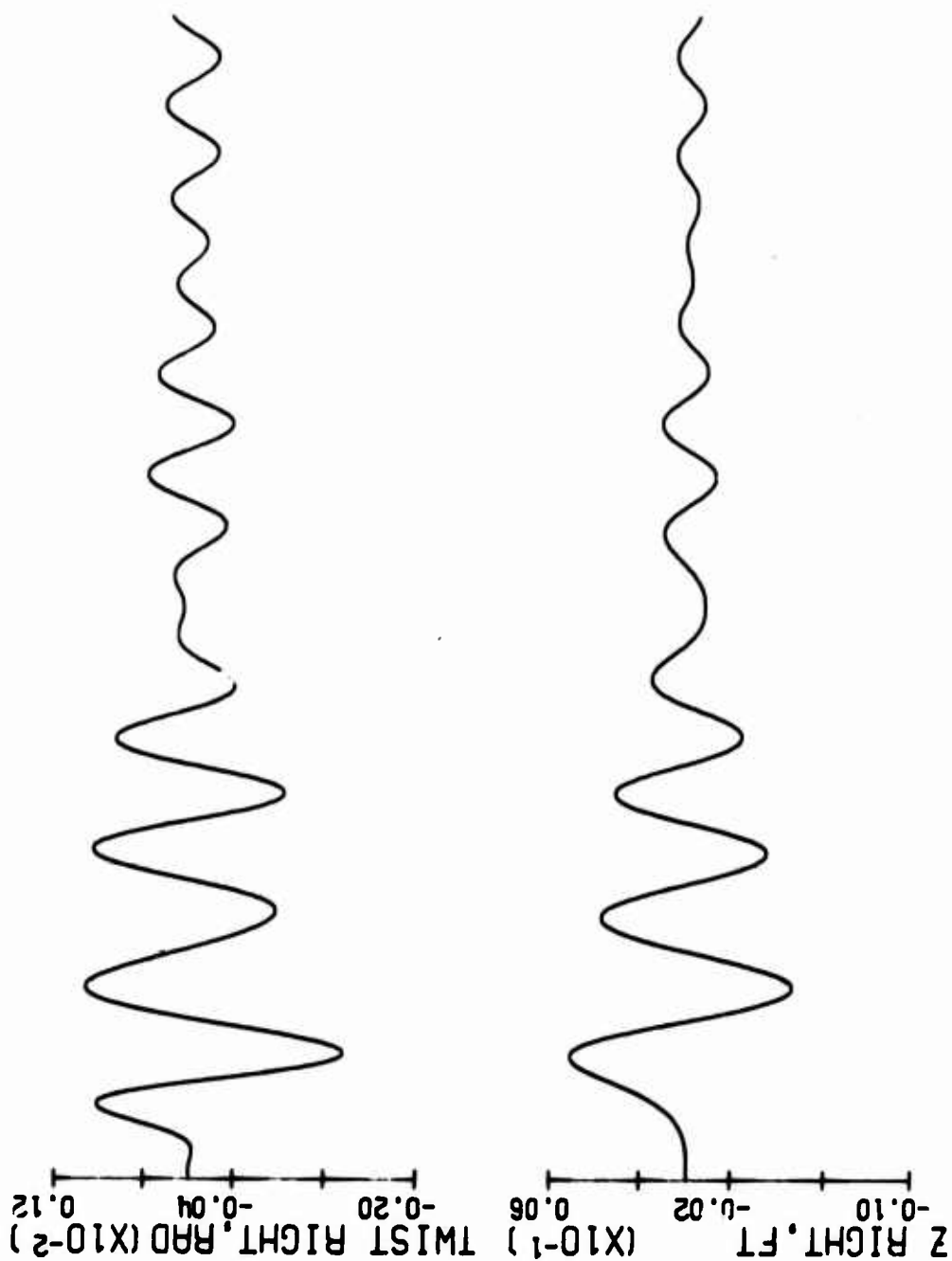
DFALL18 Sample Problem CALCOMP Plots



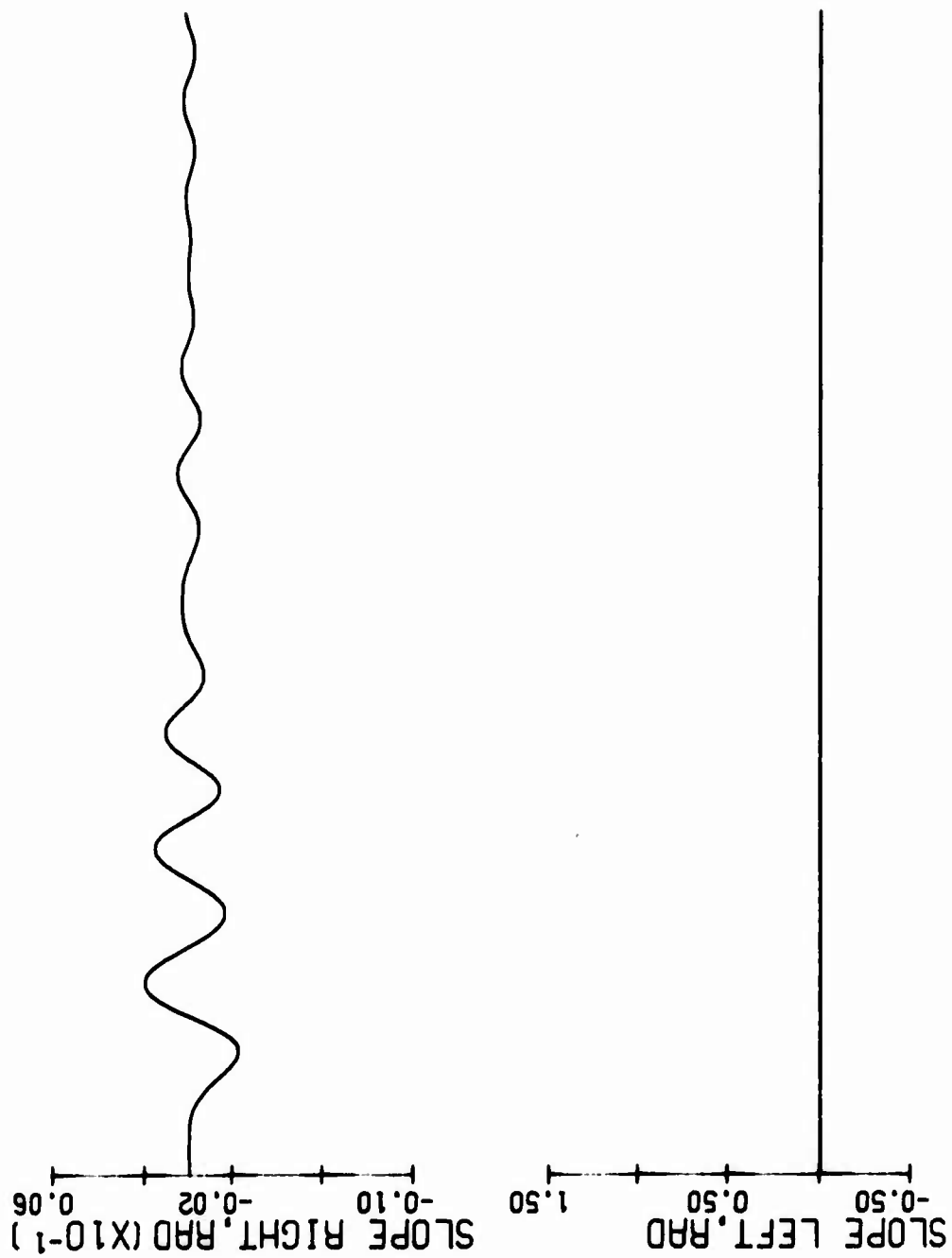
DFALL18 Sample Problem, CALCOMP Plots (Continued)



DFAL18 Sample Problem, CALCOMP Plots (Continued)



DFAL18 Sample Problem, CALCOMP Plots (Continued)



DFAL18 Sample Problem, CALCOMP Plots (Concluded)

APPENDIX II

FORTRAN LISTINGS

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Line	Code	Text
1		THPOP = 0.00
2		TSP = 0.00
3		CCP = CTFP*2H
4		R2 = CCP - ALL
5		V2 = 7HMSCP
6		WRITE (6,12)
7		FORMAT (1,1M)
8		CALL HEADNG
9		WRITE (6,24)
10		PCMAT (77)
11		IF (ITR-EG-0) GO TO 15
12		NR = 0
13		CALL PLOTS (IBUF,512)
14		JST1 = 1
15		PS100 = 1
16		ATMO = ATMOB11
17		PS100 = PS100B11
18		ATMO = ATMOB11
19		PS100 = PS100B11
20		ATMO = ATMOB11
21		PS100 = PS100B11
22		ATMO = ATMOB11
23		PS100 = PS100B11
24		ATMO = ATMOB11
25		PS100 = PS100B11
26		ATMO = ATMOB11
27		PS100 = PS100B11
28		ATMO = ATMOB11
29		PS100 = PS100B11
30		ATMO = ATMOB11
31		PS100 = PS100B11
32		ATMO = ATMOB11
33		PS100 = PS100B11
34		ATMO = ATMOB11
35		PS100 = PS100B11
36		ATMO = ATMOB11
37		PS100 = PS100B11
38		ATMO = ATMOB11
39		PS100 = PS100B11
40		ATMO = ATMOB11
41		PS100 = PS100B11
42		ATMO = ATMOB11
43		PS100 = PS100B11
44		ATMO = ATMOB11
45		PS100 = PS100B11
46		ATMO = ATMOB11
47		PS100 = PS100B11
48		ATMO = ATMOB11
49		PS100 = PS100B11
50		ATMO = ATMOB11
51		PS100 = PS100B11
52		ATMO = ATMOB11
53		PS100 = PS100B11
54		ATMO = ATMOB11
55		PS100 = PS100B11
56		ATMO = ATMOB11
57		PS100 = PS100B11
58		ATMO = ATMOB11
59		PS100 = PS100B11
60		ATMO = ATMOB11
61		PS100 = PS100B11
62		ATMO = ATMOB11
63		PS100 = PS100B11
64		ATMO = ATMOB11
65		PS100 = PS100B11
66		ATMO = ATMOB11
67		PS100 = PS100B11
68		ATMO = ATMOB11
69		PS100 = PS100B11
70		ATMO = ATMOB11
71		PS100 = PS100B11
72		ATMO = ATMOB11
73		PS100 = PS100B11
74		ATMO = ATMOB11
75		PS100 = PS100B11
76		ATMO = ATMOB11
77		PS100 = PS100B11
78		ATMO = ATMOB11
79		PS100 = PS100B11
80		ATMO = ATMOB11
81		PS100 = PS100B11
82		ATMO = ATMOB11
83		PS100 = PS100B11
84		ATMO = ATMOB11
85		PS100 = PS100B11
86		ATMO = ATMOB11
87		PS100 = PS100B11
88		ATMO = ATMOB11
89		PS100 = PS100B11
90		ATMO = ATMOB11
91		PS100 = PS100B11
92		ATMO = ATMOB11
93		PS100 = PS100B11
94		ATMO = ATMOB11
95		PS100 = PS100B11
96		ATMO = ATMOB11
97		PS100 = PS100B11
98		ATMO = ATMOB11
99		PS100 = PS100B11
100		ATMO = ATMOB11

ARAP06 FORTRAN Listings (Continued)

RK = R01
 GD TO 24
 CONTINUE
 RK = 1
 NST = NSTLGRK
 MED = MEDLGRK
 DO B5 J=NST,MED,NIC
 IF (IK-EO-4) NIC = 2
 KVI = CNETJJOSPCIALJJOSPSIP + SNETJJOCPSIP
 V1 = CNETJJOSPCIALJJOSTMP + NV1 OCSTMP
 NV1 = SPALJJOCPSIP + SBCPSIP
 NV2 = SPALJJOSPSIP + CBCPSIP
 K1 = CPCSIALJJOSTMP + NV1OCSTMP
 K2 = CBCPSIPCTMP + ICPCSIALJJOSTMP + SPSCIALJJOSPSIPCTMPJOS
 K3 = SBCPSIPCTMP + SBCPSIPCLJ
 K4 = CBCPSIP + SBCPSIPCLJ
 K5 = SYMP NV1 + CBCPSIALJJOCSTMP
 K6 = SBCPSIALJJOCSTMP + NV2OSTMP
 DO B5 I=1,N5
 K7 = SPSCIALJJOCSTMP II,J + CPCSIALJJOSPSIP I,J
 NV2 = CPCSIALJJOCSTMP II,J + STS0II,J
 K3 = STMPNV2 CXTMPSTBCIIJJOCPSIP + NV3O SPSPCXTMP
 E1 = CCP - RII0II + MRET0IIJJOK01 + EVIIJJOK2 + ETNIIJJOK
 I ACCTJ1 + VRII0II
 E2 = ZMS0PSIP - RII0IASSPJI + MRET0IIJJOK03 + ETNIIJJOK4 -
 I FVIIJJOCPSIPJ1 + VRII0IAPSIPNV3 + STBCIIJJOSPSIP
 E3 = MRET0IIJJOK05 + V2 - RII0II + ETNIIJJOK6 + ETNIIJJOK
 I ASSPJI + IRY2CXTMP + STBCIIJJOCSP + NV3OSTMPJRYBII
 K1 = IES0II - E10II + ALL + IYZ+VCAIOTLI/MC + .500
 V = -E10II + E30II/MC
 Y50 = Y0Y
 EP = XIOX0.25 - Y500.25 - R250
 E1 = RIV0Y.5
 RP = DSORTIERWER + E10E11
 SN = 1.00
 IF (R1-ET0.00) SN = -1.00
 I2 = DSORTIRK + ERI0.50I034 + R10.500
 V2 = DSORTIER - R10.500I05ICHTI.D0E1I034 + Y0.500
 Y250 = R20E2
 Y250 = Y20E2
 K1 = IRY2CXTMP02 + Y250I01IYZ-R2I002 + Y250I
 DUE = IRY250 Y250I002 + R1500E250 - IRY50-Y250I01R150-R250I01R01
 DUE = -E20E2I01I50 - R250I01R01
 DVP = 0.00
 IF (ALM-ER-0.001 GO TO 140
 O1 = R1 + .5
 O2 = R1 + .5
 O3 = R1 - SICJ1.254039501
 PM12 = DATA21,D31 - (DATA21V,D11 + DATA21V,D21) - 500
 R12 = DSORTIRK03 + Y50I050STII01 + Y50I042202 + Y50I11
 NUPP = VRII0I205I01PM12
 DVP = VRII0I205I01PM12
 VRL = U100E + DVP

4

0

;

```

SURROUTINE BEXION
REAL*8 DUM1,ZEE
COMMON /FRIN/ FTHC(16),FPSID(16),DMS(6,6,4),DTMC(15),DFPSID(15),
1 FBEL(140),FRI(140),FTM(140),BT(16,6,4),CT(16,6,4),
COMMON /FLAP/ IDUM1(10),NS,NB,IDUM2(4),NBW,IDUM3(10),NTMC,
1 MPSID,NMT,IDUM4(13),NDR(4)
DIMENSION FBAT(10,6,6,4,3),LC(13),MT(10),NOMG(7),KLC(132),
1 KLC2(26),KLC3(26),FTT(20)
DATA NMT/ 1 2 3 4 5 6 7 8 9 10/, NOMG/ 1/110
1X,F10,1.2X, 9F10,10) /, KLC1/ 1/110,3MLC(11,3M) =12,1/110
2 *SHAPM =F5,1.8M RAD/SEC/T21,7MSTATION,13, 810 / T1,3MTC,
3 56/ 12X,F10,1.2X, 5F10,3) /, KLC2/ 1/110,3MLC(11, 3M
4 =12,2X,11MFCR ALL RNM/T21,7MSTATION,13, 910/T1,3MTC/110X,F1
5,1.2X, 5F10,3) /, KLC3/ 1/110,3MLC(11,3M) =12,2X,11MFCR
6 ALL TMC/ T21,7MSTATION,13, 910/T1,3MTC/110X,F10,1.2X, 5F10
7,3) /
EQUIVALENCE (FBAT(1,1,1,1),FBF(1)),(FBAT(1,1,1,1),FBF(1)),
1 (FBT(1,1,1,3),FTM(1))
C
10 FORMAT (16I5)
16 FORMAT (13F6,0.2X)
18 FORMAT (9F8,0.8X)
20 FORMAT (20M4)
22 FORMAT (// T1,"*9FAM MOMENT AT SPECIFIED STATION",I2 // T1",
1 *TMC (DEG)", T40,"*ROTOR RPM (RAD/SEC)", / 22X,5F10,1)
24 FORMAT (// T1,"*CHORD MOMENT AT SPECIFIED STATION",I2 // T1",
1 *TMC (DEG)", T40,"*ROTOR RPM (RAD/SEC)", / 22X,6F18,1)
26 FORMAT (// " * ROTOR BLADE NORMAL MODES")
28 FORMAT (// 1X,20M4 // " * K(1",I1,") =,12 // T10,
30 "NATURAL FREQUENCY", / 11X,TMC (DEG)", T40,"*ROTOR RPM (RAD/SEC)
32 / 22X,6F10,1)
34 FORMAT (// T1,"*DUT-OF-PLANE MODE SHAPE")
62 FORMAT (// T1,"*IMPLANE MODE SHAPE")
64 FORMAT (// T1,"*TORSIONAL MODE SHAPE")
66 FORMAT (// T10,"LC(1",I1,3M) =,12, T21,"*FOR ALL TMC AND RPM" / T21,
1 *STATION",I3, 9110)
78 FORMAT (// 22X,10F10,3)
C
NOMG(15) = NMT(MPSID)
KLC(119) = NMT(NS-1)
KLC(125) = NMT(NTMC)
KLC(130) = NMT(NS)
KLC(216) = NMT(NS-1)
KLC(216) = NMT(NS-1)
KLC(216) = NMT(NS-1)
KLC(216) = NMT(NS-1)
KLC(216) = NMT(NS-1)
WRITE (6,30)
READ (5,10) (FTHC(4),N=1,NTMC), (FPSID(N),N=1,MPSID)
DO 52 M=1,NMT
READ (5,20) FTT
READ (5,16) (NOMG(4),N=1,NTMC), (N=1,MPSID)
READ (5,17) KLC(1),LC(1,3),KDR(4)
WRITE (6,30) FTT,NDR(NTMC), (FPSID(M),N=1,MPSID)

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ARAP06 FORTRAN Listings (Continued)

MILITARY SYSTEMS COMPANY

三

CARD COUNT

2

ARAP06 FORTRAN Listings (Continued)

WILKINS COMPANY

10

10

1	275	0	3	013	019	027	035	088	168	230
2	299	3	2	014	018	035	048	068	131	2
3	281	316	3	27	017	036	0	058	093	161
4	315	335	333	0	2	023	11	098	123	135
5	205	0	2	034	113	136	168	187	224	4
6	241	106	141	2	195	245	460	3	211	218
7	223	236	440	2	23	245	460	2	242	253
8	60	2	23	9	0	2	298	9	0	2
9	116	0	301	401	502	603	656	705	758	795
10	180	1	3	7	6	5	4	12	2	1
11	2	4	5	6	7	8	9	10	11	12
12	15	25	180							
13	2	45	067	037	045	028	007	048	037	0
14	057	054	028	007	048	037	0	2	007	005
15	021	035	028	007	048	037	0	2	019	015
16	045	028	037	048	037	0	2	019	017	015
17	034	029	037	032	037	0	2	015	018	022
18	027	03	024	0	037	0	2	016	017	02
19	024	036	037	0	2	016	017	018	02	021
20	024	036	037	0	2	016	017	018	02	021
21	024	036	037	0	2	016	017	018	02	021
22	024	036	037	0	2	016	017	018	02	021
23	024	036	037	0	2	016	017	018	02	021
24	024	036	037	0	2	016	017	018	02	021
25	024	036	037	0	2	016	017	018	02	021
26	024	036	037	0	2	016	017	018	02	021
27	024	036	037	0	2	016	017	018	02	021
28	024	036	037	0	2	016	017	018	02	021
29	024	036	037	0	2	016	017	018	02	021
30	024	036	037	0	2	016	017	018	02	021
31	024	036	037	0	2	016	017	018	02	021
32	024	036	037	0	2	016	017	018	02	021
33	024	036	037	0	2	016	017	018	02	021
34	024	036	037	0	2	016	017	018	02	021
35	024	036	037	0	2	016	017	018	02	021
36	024	036	037	0	2	016	017	018	02	021
37	024	036	037	0	2	016	017	018	02	021
38	024	036	037	0	2	016	017	018	02	021
39	024	036	037	0	2	016	017	018	02	021
40	024	036	037	0	2	016	017	018	02	021
41	024	036	037	0	2	016	017	018	02	021
42	024	036	037	0	2	016	017	018	02	021
43	024	036	037	0	2	016	017	018	02	021
44	024	036	037	0	2	016	017	018	02	021
45	024	036	037	0	2	016	017	018	02	021
46	024	036	037	0	2	016	017	018	02	021
47	024	036	037	0	2	016	017	018	02	021
48	024	036	037	0	2	016	017	018		

MILLER & COMPANY

2	0	0.01	0.04	0.05	1.01	1.11	1.10	1.7	15
3	0	2.17	1.85	0	2.267	2.16	2.25	28	32
4	0	3.35	3.35	0	3.35	3.35	3.57	300	416
5	0	4.61	4.49	0	4.61	4.61	4.61	4.61	4.61
DATA C168 /									
6	0	5.85	5.85	0	5.85	5.85	5.85	5.85	5.85
7	0	7.12	7.12	0	7.12	7.12	7.12	7.12	7.12
8	0	8.38	8.38	0	8.38	8.38	8.38	8.38	8.38
9	0	9.64	9.64	0	9.64	9.64	9.64	9.64	9.64
10	0	10.90	10.90	0	10.90	10.90	10.90	10.90	10.90
11	0	12.16	12.16	0	12.16	12.16	12.16	12.16	12.16
12	0	13.42	13.42	0	13.42	13.42	13.42	13.42	13.42
13	0	14.68	14.68	0	14.68	14.68	14.68	14.68	14.68
14	0	15.94	15.94	0	15.94	15.94	15.94	15.94	15.94
15	0	17.20	17.20	0	17.20	17.20	17.20	17.20	17.20
16	0	18.46	18.46	0	18.46	18.46	18.46	18.46	18.46
17	0	19.72	19.72	0	19.72	19.72	19.72	19.72	19.72
18	0	20.98	20.98	0	20.98	20.98	20.98	20.98	20.98
19	0	22.24	22.24	0	22.24	22.24	22.24	22.24	22.24
20	0	23.50	23.50	0	23.50	23.50	23.50	23.50	23.50
21	0	24.76	24.76	0	24.76	24.76	24.76	24.76	24.76
22	0	26.02	26.02	0	26.02	26.02	26.02	26.02	26.02
23	0	27.28	27.28	0	27.28	27.28	27.28	27.28	27.28
24	0	28.54	28.54	0	28.54	28.54	28.54	28.54	28.54
25	0	29.80	29.80	0	29.80	29.80	29.80	29.80	29.80
26	0	31.06	31.06	0	31.06	31.06	31.06	31.06	31.06
27	0	32.32	32.32	0	32.32	32.32	32.32	32.32	32.32
28	0	33.58	33.58	0	33.58	33.58	33.58	33.58	33.58
29	0	34.84	34.84	0	34.84	34.84	34.84	34.84	34.84
30	0	36.10	36.10	0	36.10	36.10	36.10	36.10	36.10
31	0	37.36	37.36	0	37.36	37.36	37.36	37.36	37.36
32	0	38.62	38.62	0	38.62	38.62	38.62	38.62	38.62
33	0	39.88	39.88	0	39.88	39.88	39.88	39.88	39.88
34	0	41.14	41.14	0	41.14	41.14	41.14	41.14	41.14
35	0	42.40	42.40	0	42.40	42.40	42.40	42.40	42.40
36	0	43.66	43.66	0	43.66	43.66	43.66	43.66	43.66
37	0	44.92	44.92	0	44.92	44.92	44.92	44.92	44.92
38	0	46.18	46.18	0	46.18	46.18	46.18	46.18	46.18
39	0	47.44	47.44	0	47.44	47.44	47.44	47.44	47.44
40	0	48.70	48.70	0	48.70	48.70	48.70	48.70	48.70
41	0	49.96	49.96	0	49.96	49.96	49.96	49.96	49.96
42	0	51.22	51.22	0	51.22	51.22	51.22	51.22	51.22
43	0	52.48	52.48	0	52.48	52.48	52.48	52.48	52.48
44	0	53.74	53.74	0	53.74	53.74	53.74	53.74	53.74
45	0								

PAGE 5

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1  -.074, -.074, -.029, -.049, -.159, 0., 20-.019, -.071, -.027,
2  -.024, -.024, -.03, -.044, -.159, 0., 20-.019, 20-.02, -.019,
3  -.02, -.036, -.103, -.159, 0., 20-.019, -.018, -.017, -.012,
4  -.015, -.049, -.123, -.159, 0., 20-.018, -.016, -.013, -.004,
5  -.016, -.04, -.123, -.159, 0., 20-.016, -.012, -.013, -.001,
6  -.022, -.077, -.123, -.159, 0., /
DATA C649/20-.015, -.03, -.034, -.003, -.03, -.089, -.123, -.159,
1  0., 20-.042, -.359, -.044, -.004, -.037, -.097, -.123, -.159,
2  0., 20-.075, -.082, -.041, -.044, -.037, -.097, -.123, -.159,
3  0., 20-.1, -.104, 20-.11, -.037, -.045, -.123, -.159, 0., 20-.118
4  -.109, -.113, -.11, -.037, -.043, -.123, -.159, 0., 20-.124,
5  -.11, -.113, -.11, -.037, -.043, -.123, -.159, 0., 20-.124,
6  -.11, -.113, -.11, -.037, -.043, -.123, -.159, 0., 20-.124,
7  -.11, -.113, -.11, -.037, -.043, -.123, -.159, 0., 20-.124,
8  -.11, -.113, -.11, -.037, -.043, -.123, -.159, 0., 20-.124,
9  -.019, -.016, -.022, -.041, -.074, -.02, 1, 0., 20-.019, 0.,
DATA C649 / 1.-2.-3.-4.-5.-6.-7.-8.-9., 0., 1.-2.-3.-4.-5.-6.-7.-8.-9.,
1  10-.12, 10-.16, 10-.18, 20-.22, 20-.24, -.194, 339, 519, 785, 942,
2  1.176, 1.376, 1.571, 1.767, -.194, 339, 519, 785, 942,
3  1.335, 1.536, 1.744, -.194, 339, 519, 785, 942,
4  1.492, 1.714, -.194, 339, 519, 785, 942,
5  1.676, -.159, -.124, 43, 377, 51, 73, 942, 125, 1404,
6  -.124, -.073, -.141, -.194, 339, 519, 785, 942,
7  -.02, -.041, 0, -.118, 319, 577, 88, 252, 841, 904,
8  -.141, -.157, -.044, -.118, 319, 577, 88, 252, 841, 904,
9  -.298, -.236, -.071, 192, 319, 577, 88, 252, 841, 904,
10 -.441, -.283, 0, 319, 577, 88, 252, 841, 904,
11 -.545, -.289, 078, 477, 124, 259, 172, 435, 972, 948,
12 -.591, -.504, 212, 724, 34, 1001, 1-104, 1-247,
13 -.143, -.536, -.444, 871, 124, 259, 172, 435, 972, 948,
14 -.541, -.429, 212, 724, 34, 1001, 1-104, 1-247,
15 -.074, -.477, /
END

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CARD COUNT 252

ARAP06 FORTRAN Listings (Continued)

WILLIAMSON COMPANY

YIND= CURVE(M-1) * (ALP-CURVE(M-1)) / DS(XI * N) * (CURVE(M)-CURVE(M-1))

CONTINUE

15 RETURN

25 DO 12 N=1,3

12 YIND = 0.

RETURN

END

CARD COUNT 62

ARAP06 FORTRAN Listings (Continued)

ARAP06 FORTRAN Listings

ARAP06 FORTRAN Listings (Continued)

[illegible]

CARD COUNT 193

ARAP06 FORTRAN Listings (Continued)

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SUMMARY FLAP03
IMPLICIT REAL*8(A-H, O-Z)
COMMON /FAP03/ DUM(100), DUM2(100), DUM3(100), DUM4(100), DUM5(100), DUM6(100), DUM7(100), DUM8(100), DUM9(100), DUM10(100), DUM11(100), DUM12(100), DUM13(100), DUM14(100), DUM15(100), DUM16(100), DUM17(100), DUM18(100), DUM19(100), DUM20(100), DUM21(100), DUM22(100), DUM23(100), DUM24(100), DUM25(100), DUM26(100), DUM27(100), DUM28(100), DUM29(100), DUM30(100), DUM31(100), DUM32(100), DUM33(100), DUM34(100), DUM35(100), DUM36(100), DUM37(100), DUM38(100), DUM39(100), DUM40(100), DUM41(100), DUM42(100), DUM43(100), DUM44(100), DUM45(100), DUM46(100), DUM47(100), DUM48(100), DUM49(100), DUM50(100), DUM51(100), DUM52(100), DUM53(100), DUM54(100), DUM55(100), DUM56(100), DUM57(100), DUM58(100), DUM59(100), DUM60(100), DUM61(100), DUM62(100), DUM63(100), DUM64(100), DUM65(100), DUM66(100), DUM67(100), DUM68(100), DUM69(100), DUM70(100), DUM71(100), DUM72(100), DUM73(100), DUM74(100), DUM75(100), DUM76(100), DUM77(100), DUM78(100), DUM79(100), DUM80(100), DUM81(100), DUM82(100), DUM83(100), DUM84(100), DUM85(100), DUM86(100), DUM87(100), DUM88(100), DUM89(100), DUM90(100), DUM91(100), DUM92(100), DUM93(100), DUM94(100), DUM95(100), DUM96(100), DUM97(100), DUM98(100), DUM99(100), DUM100(100)
DO 10 I=1,100
  DUM(I)=0
END DO
DO 20 J=1,100
  DUM2(J)=0
END DO
DO 30 K=1,100
  DUM3(K)=0
END DO
DO 40 L=1,100
  DUM4(L)=0
END DO
DO 50 M=1,100
  DUM5(M)=0
END DO
DO 60 N=1,100
  DUM6(N)=0
END DO
DO 70 O=1,100
  DUM7(O)=0
END DO
DO 80 P=1,100
  DUM8(P)=0
END DO
DO 90 Q=1,100
  DUM9(Q)=0
END DO
DO 100 R=1,100
  DUM10(R)=0
END DO
DO 110 S=1,100
  DUM11(S)=0
END DO
DO 120 T=1,100
  DUM12(T)=0
END DO
DO 130 U=1,100
  DUM13(U)=0
END DO
DO 140 V=1,100
  DUM14(V)=0
END DO
DO 150 W=1,100
  DUM15(W)=0
END DO
DO 160 X=1,100
  DUM16(X)=0
END DO
DO 170 Y=1,100
  DUM17(Y)=0
END DO
DO 180 Z=1,100
  DUM18(Z)=0
END DO
DO 190 AA=1,100
  DUM19(AA)=0
END DO
DO 200 BB=1,100
  DUM20(BB)=0
END DO
DO 210 CC=1,100
  DUM21(CC)=0
END DO
DO 220 DD=1,100
  DUM22(DD)=0
END DO
DO 230 EE=1,100
  DUM23(EE)=0
END DO
DO 240 FF=1,100
  DUM24(FF)=0
END DO
DO 250 GG=1,100
  DUM25(GG)=0
END DO
DO 260 HH=1,100
  DUM26(HH)=0
END DO
DO 270 II=1,100
  DUM27(II)=0
END DO
DO 280 JJ=1,100
  DUM28(JJ)=0
END DO
DO 290 KK=1,100
  DUM29(KK)=0
END DO
DO 300 LL=1,100
  DUM30(LL)=0
END DO
DO 310 MM=1,100
  DUM31(MM)=0
END DO
DO 320 NN=1,100
  DUM32(NN)=0
END DO
DO 330 OO=1,100
  DUM33(OO)=0
END DO
DO 340 PP=1,100
  DUM34(PP)=0
END DO
DO 350 QQ=1,100
  DUM35(QQ)=0
END DO
DO 360 RR=1,100
  DUM36(RR)=0
END DO
DO 370 SS=1,100
  DUM37(SS)=0
END DO
DO 380 TT=1,100
  DUM38(TT)=0
END DO
DO 390 UU=1,100
  DUM39(UU)=0
END DO
DO 400 VV=1,100
  DUM40(VV)=0
END DO
DO 410 WW=1,100
  DUM41(WW)=0
END DO
DO 420 XX=1,100
  DUM42(XX)=0
END DO
DO 430 YY=1,100
  DUM43(YY)=0
END DO
DO 440 ZZ=1,100
  DUM44(ZZ)=0
END DO
DO 450 AA=1,100
  DUM45(AA)=0
END DO
DO 460 BB=1,100
  DUM46(BB)=0
END DO
DO 470 CC=1,100
  DUM47(CC)=0
END DO
DO 480 DD=1,100
  DUM48(DD)=0
END DO
DO 490 EE=1,100
  DUM49(EE)=0
END DO
DO 500 FF=1,100
  DUM50(FF)=0
END DO
DO 510 GG=1,100
  DUM51(GG)=0
END DO
DO 520 HH=1,100
  DUM52(HH)=0
END DO
DO 530 II=1,100
  DUM53(II)=0
END DO
DO 540 JJ=1,100
  DUM54(JJ)=0
END DO
DO 550 KK=1,100
  DUM55(KK)=0
END DO
DO 560 LL=1,100
  DUM56(LL)=0
END DO
DO 570 MM=1,100
  DUM57(MM)=0
END DO
DO 580 NN=1,100
  DUM58(NN)=0
END DO
DO 590 OO=1,100
  DUM59(OO)=0
END DO
DO 600 PP=1,100
  DUM60(PP)=0
END DO
DO 610 QQ=1,100
  DUM61(QQ)=0
END DO
DO 620 RR=1,100
  DUM62(RR)=0
END DO
DO 630 SS=1,100
  DUM63(SS)=0
END DO
DO 640 TT=1,100
  DUM64(TT)=0
END DO
DO 650 UU=1,100
  DUM65(UU)=0
END DO
DO 660 VV=1,100
  DUM66(VV)=0
END DO
DO 670 WW=1,100
  DUM67(WW)=0
END DO
DO 680 XX=1,100
  DUM68(XX)=0
END DO
DO 690 YY=1,100
  DUM69(YY)=0
END DO
DO 700 ZZ=1,100
  DUM70(ZZ)=0
END DO
DO 710 AA=1,100
  DUM71(AA)=0
END DO
DO 720 BB=1,100
  DUM72(BB)=0
END DO
DO 730 CC=1,100
  DUM73(CC)=0
END DO
DO 740 DD=1,100
  DUM74(DD)=0
END DO
DO 750 EE=1,100
  DUM75(EE)=0
END DO
DO 760 FF=1,100
  DUM76(FF)=0
END DO
DO 770 GG=1,100
  DUM77(GG)=0
END DO
DO 780 HH=1,100
  DUM78(HH)=0
END DO
DO 790 II=1,100
  DUM79(II)=0
END DO
DO 800 JJ=1,100
  DUM80(JJ)=0
END DO
DO 810 KK=1,100
  DUM81(KK)=0
END DO
DO 820 LL=1,100
  DUM82(LL)=0
END DO
DO 830 MM=1,100
  DUM83(MM)=0
END DO
DO 840 NN=1,100
  DUM84(NN)=0
END DO
DO 850 OO=1,100
  DUM85(OO)=0
END DO
DO 860 PP=1,100
  DUM86(PP)=0
END DO
DO 870 QQ=1,100
  DUM87(QQ)=0
END DO
DO 880 RR=1,100
  DUM88(RR)=0
END DO
DO 890 SS=1,100
  DUM89(SS)=0
END DO
DO 900 TT=1,100
  DUM90(TT)=0
END DO
DO 910 UU=1,100
  DUM91(UU)=0
END DO
DO 920 VV=1,100
  DUM92(VV)=0
END DO
DO 930 WW=1,100
  DUM93(WW)=0
END DO
DO 940 XX=1,100
  DUM94(XX)=0
END DO
DO 950 YY=1,100
  DUM95(YY)=0
END DO
DO 960 ZZ=1,100
  DUM96(ZZ)=0
END DO
DO 970 AA=1,100
  DUM97(AA)=0
END DO
DO 980 BB=1,100
  DUM98(BB)=0
END DO
DO 990 CC=1,100
  DUM99(CC)=0
END DO
DO 1000 DD=1,100
  DUM100(DD)=0
END DO

```

ARAP06 FORTRAN Listings (Continued)

BULLHORN COMPANY

```

20 ZEDF (J,N) = ZED (J,N) + ZEE(J,N)/2.00
   ZEF (J,N) = ZEE (J,N) + ZEE(J,N)/2.00
   GO TO 94
   ZEDF(J,N) = ZEDF(J,N)
   ZEEF (J,N) = ZEE (J,N)
   ZFE (J,N) = ZE (J,N)
   CCNTIME
   IF (1172.00) CALL YASINATHCN,PSID)
   DO 30 J=1,NB
   DO 30 L=1,NBT
   BMT(J,L) = 0.00
   BCTF(J,L) = 0.00
   DN 30 N=1,NOM
   BMT(J,L) = BMT(J,L) + ZEE(J,N)*BMT(J,L)
   BCTF(J,L) = BCTF(J,L) + ZEE(J,N)*BCTF(J,L)
   CONTINUE
95 IF (1174.00) GO TO 40
   - (ATMD0011) + ATMD01/2.00
   - (ATMD011) + BTMD01/2.00
   - (PSID0011) + PSID01/2.00
   - (ATMD) + ATMD01/2.00
   - (BTMD) + BTMD01/2.00
   - (PSID) + PSID01/2.00
   - (ATM) + ATM01/2.00
   - (BTM) + BTM01/2.00
   PSIE = (PSI + PSIE)/2.00
   GO TO 50
40 ATMD0F
   BTMD0F
   PSID0F
   ATM0F
   BTM0F
   PSIDF
   ATMF
   BTMF
   PSIE = PSI
   FFRA = SSP0CPSI - SSP0MSPSI
   FFVA = SSP0CPSI + SSP0MCPPI
   FFR = 0.00
   FFV = 0.00
   PFZ = 0.00
   WBA=0.00
   WBY=0.00
   WBZ=0.00
   DO 50 I=1,N5
   WBA = WBA - AMG110FFRA
   WBY = WBY - AMG110FFVA
   WBZ = WBZ - AMG110SCP
   DO 50 J=1,NB
   FFR = FFR + DMF(1,J)*CPSIA(J)
   FFV = FFV + DMF(1,J)*CPSIA(J)
   PFZ = PFZ + DMF(1,J)
   PH(1,J) = PH(1,J)
   CONTINUE
50 CALL FORCES

```

[illegible]

CONCLUSIONS

[illegible]

CARD COUNTY 240

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ARAP06 FORTNA Listings (Continued)

ARAP06 FORTRAN Listings (Continued)

ARAP06 FORTRAN Listings (Continued)

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ARAP06 FORTRAN Listings (Continued)

TABLE 1

ARAP06 FORTRAN Listings (Continued)

THE UNIVERSITY OF CHICAGO

```

ACCPH(J) = TMPDC * CPSIA(J) - PSID * CPSIA(J)
ALCPH(J) = TMPDC * SP5IA(J) + PSID * CPSIA(J)
ASSPH(J) = SP5IA(J) * STMP + CPSIA(J) * CTMP
ACSTPH(J) = SP5IA(J) * CSTPA + CPSIA(J) * CSTPB
CTTHM = THINE(J) - THNOTDEL3
STHIM = STINE(J) - THNOTDEL3
CTHIM = STINE(J) - THNOTDEL3
DO 70 I=1,NS
THOHI(J) = PSIDAL(J) - BYT
THOII(J) = PSIDAL(J) - BETH JIOTDEL3 * PEMA
THI(J) = THIIOTTHIM
STM(I,J) = STMIOTCTHIM + CTMIOTSTHIM
CTM(I,J) = CTMIOTCTHIM - STMIOTSTHIM
SSHI(J) = STMIOTSTHIM + CTMIOTCTHIM
SCBI(J) = STMIOTCTHIM - CTMIOTSTHIM
CCBI(J) = CTMIOTCTHIM + STMIOTSTHIM
CSHI(J) = CTMIOTCTHIM - STMIOTSTHIM
THOHI(J) = THOII(J) + ETYHI(J)
STHII(J) = STHII(J)
CTHII(J) = CTHII(J)
IF (IY5-EO-1) GO TO 74
THB = THII(J) + EYHI(J)
SYHII(J) = STHII(J)
CTHII(J) = CTHII(J)
STHII(J) = STHII(J) + STHII(J) * STHII(J)
SYHII(J) = STHII(J) + STHII(J) * STHII(J)
THOHI(J) = THOHI(J) + ETYHI(J)
ESHI(J) = EYHI(J) + STHII(J) + STHII(J)
EYHI(J) = EYHI(J) + STHII(J) + STHII(J)
CONTINUE
CSPH = ACSPHII
SSPH = -ASSPHII
CCPH = ACCPHII
SSPH = ASSPHII
PTP = PSID - THNOTSPSP
CSTP = ACSTPHII
CTTH = CTTHII
CSPH = CTTH * STMP + STMP * STMP
PTP = PSID - STP
PAH = ROD * CSPH + (SPH * STMP + STMP * STMP) * PSID * STMP
2 * 2000 * STMP + STMP * STMP + SPH * STMP + STMP * STMP
3 * 200 * STMP
PAH = ROD * CSPH + VOD * STMP + 2000 * STMP + STMP * STMP
1 * 200 * STMP + STMP * STMP + STMP * STMP + STMP * STMP
2 * 2000 * STMP + STMP * STMP + STMP * STMP + STMP * STMP
3 * 200 * STMP
PAH = ROD * CSPH + VOD * STMP + 2000 * STMP + STMP * STMP
RETURN
END

```

CARD COUNT 100

ARAP06 FORTARN Listings (Continued)

BELL & HOWELL COMPANY


```

53 = CTB5B      *CNBJ - STWBI,JI*SNBJ
54 = STB5BI,JI*CNBJ + CTWBI,JI*SNBJ
TBC50 = TMDII,JI*02
RETEO = (ETII,JI*ETDI,JI) + ETMI,JI*ETMDI,JI / REII
RETSN = (ETDI,JI*02 + ETMDI,JI*02,ETII,JI*ETDII,JI) +
1 ETMI,JI*ETMDI,JI / REII
TRCCB = --BEYDI,JI*STB5BI,JI) + TMDII,JI*CTCB
ETDSB = ETDI,JI*02
FALLR = TMDII,JI*CTCB - TBSO *STB5BI,JI) + 2*
1 TDCYI,JI*BSRJI) - BETDI,JI*STB5BI,JI) - BDSOI,JI*STB5BI,JI)
2 + EYDII,JI*CTCB - ITMDII,JI*01 + BDSOI,JI*STB5BI,JI)
3 SNBJ*CSPP - CSPP*02 + ITMDII,JI*03 + BCB,JI*STB5BI,JI*SNBJ*
4 CCPI + CCTM*04
FALX = -(TMDII,JI*CTB5B - TBSO *STB5BI,JI) + 2*
1 TDCYI,JI*BSRJI) - BDSOI,JI*STB5BI,JI) - BDSOI,JI*STB5BI,JI)
2 + ETMDII,JI*STB5BI,JI) + TBSO*CTB5BI,JI) *SNBJ + CCTM*CTCB +
3 STB5BI,JI*CTM + ITMDII,JI*01 + BCB,JI*STB5BI,JI*SNBJ*ETP +
4 PTTP*02 - EYDII,JI*03
FALX = TBSO *02 + BDSOI,JI*STB5BI,JI) - TMDII,JI*01 - TCCB
1 *CSPP - STB5BI,JI*CTM - (TDCYI,JI*BSRJI) + BDSOI,JI*STB5BI,JI)
2 STB5BI,JI*SNBJ - ITMDII,JI*03 + BCB,JI*STB5BI,JI*SNBJ*ETP
3 - PTTP*04 - EYDII,JI*01
FALZ = TCCB - SZ*CSPP + S*CCPI
FAL4 = SZ*ETP + STB5BI,JI*CTM - BDSOI,JI*SNBJ - STB5BI,JI)
FAL4 = -S*ETP - STB5BI,JI*CTM + BDSOI,JI*SNBJ - STB5BI,JI)
FALZ = FALZ + FALX + FALX + FALX + FALX + FALX + FALX + FALX
1 ACSP*01
FAL4 = FAL4 + FALX + FALX + FALX + FALX + FALX + FALX + FALX
1 (REII) - METS(II,JI)*06 + (ETMI,JI)*ETP - ETDSB -
2 RETED*01*CNBJ
FAL6 = FAL6 + FALX + FALX + FALX + FALX + FALX + FALX + FALX
1 (METS(II,JI) - REII)*06 + (ETMI,JI)*ETP - ETDSB -
2 PETED*01*CNBJ
FAL7 = -ETDI,JI*BSRJI) - SHETI,JI*RETSN - VISO*ETED + VBI*FALX
1 + FALX + ETDI,JI*BSRJI) + IMETSOI,JI*BSRJI) - BDSOI,JI)
2 EDS(II,JI) - ETDS(II,JI) + IMETSOI,JI*02 + ES(II,JI)*01 +
3 FAL*CSPP - FAL*CCPI - ACSP*JI*ETMDI,JI) - ACSP*JI*ETMDI,JI)
FAL = FALZ*CCPI + FAL*ETP + ETMDII,JI*SNBJ + VBI*FALX + FALX
1 + (ETMDII,JI)*ETP + ETMI,JI*ETP - ETMDII,JI*01 - METSOI,JI*
2 CNBJ + RETED*01 + (REII) - METSOI,JI*01 + ETII,JI*01 +
3 EYDII,JI*01
FAL6 = FAL6 + FALX + FALX + FALX + FALX + FALX + FALX + FALX
1 + FALX + (METSOI,JI) - REII*01 + RETED + VZ + ETII,JI)
2 + VZ - ETMI,JI*01 + (ETMDII,JI)*ETP - RETSN + 02 + ETII,JI)
3 ETMI,JI*ETP - ETMDII,JI*SNBJ
AV3 = FALX + FALX + FALX + FALX + FALX + FALX + FALX + FALX
AV5 = FALX + FALX + FALX + FALX + FALX + FALX + FALX + FALX
AV6 = FALX + FALX + FALX + FALX + FALX + FALX + FALX + FALX
AV7 = FALX + FALX + FALX + FALX + FALX + FALX + FALX + FALX
R3 = FCS(II,JI) + STB5BI,JI*01
R5 = ETMI,JI*SNBJ - ES(II,JI)*SNBJ - S*ETP
R6 = -ETMI,JI*SNBJ - ES(II,JI)*SNBJ - S*ETP
A103 = (FAL6) - FAL6*01 + (FAL6) - S*ETP + STB5BI,JI*SNBJ*01 +
A105 = (FAL6) - FAL6*01 + (FAL6) - S*ETP + STB5BI,JI*SNBJ*01 +
1 A105
A106 = (FAL6) - FAL6*01 + (FAL6) - S*ETP + STB5BI,JI*SNBJ*01 +

```

ARAP06 FORTRAN Listings (Continued)

MILITARY COMMAND

PAGE 3

1 AIMS
73 A-FA3 0AM1 0 28
75 A-FA5 0AM1 0 28
76 A-FA6 0AM1 0 28
CONTINUE
RETURN
END

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CARD COUNT 117

ARAP06 FORTRAN Listings (Continued)

REPLACEMENT COMPANY

ARAP06 FORTRAN Listings (Continued)

ARAP06 FORTRAN Listings (Continued)

```

PMA = PMAO-10072
DO 15 K=1,15
XV(K) = 0.00
DC 10 K=1, 0.00
ATMOD(K) = TPC
ATMOD(K) = PMA
ATMOD(K) = PSIEORAD
AO = RADPAD
CB = DCSEAD
CB = OSINIAO
YDEL = DYANDEL30RAD
AL = RADPAL
AL = RADPAL
U = U-1.00012-
ANGV = 0.00
DO 50 J=1,N5
ANGV = ANGV + ANI1J
GV(K1) = ANI1JGV
GR(K1) = ANI1JVS
ANGZ(K1) = ANI1JG
ANGZ(K1) = 2.0*ANI1JVS(K1)
ALMSY(K1) = AL(K1) + ANI1JY(K1)+YDEL
CYM(K1) = DCNSY(K1)+YDEL
SYM(K1) = OSIN(Y(K1))
HRCSD(K1) = 50*HRC(K1)+OSIN(K1)
MCRSD(K1) = 50*HRC(K1)+YDEL
YOC(K1) = 2.0*Y(K1)
B(K1) = HRC(K1)+YOC(K1)+OSIN(K1)
DO 50 J=1,N6
PHE(K1,J) = 0.02
DO 50 K=1,10
EY(K1,J,K) = 0.00
CONTINUE
ANGV = ANGVGV3.
VGV = 0.00
VGV = 0.00
FAIR = 0.00
FAIR = 0.00
VGR = 0.00
VGR = 0.00
VI = 0.00
PTMA = 0.00
IF (117-EQ-11) GO TO 24
TMCWR = TMCWRAD
PTMA = (TMCWR - TMC)/ITMED - TMSF)
PTMB = TMC - PTMA*TMST
IF (117-EQ-01) GO TO 26
IF (GVTL-NE-GC01) GUST1 = 1.00/(GV01-GST1)
IF (117-EQ-20) GUST2 = 3.141592650/(IGD2 - 1.21)
CPS = CPS00-203
IF (117-EQ-01) GO TO 77
STOPK = STOPK007.0
STOPTH = STOPTHRAD
DO 71 K=1,4

```



```

1E1(J) = ME1 + PH1*MEVZA + IZP50 + V0*V1*OMPAS0 + IZP50 + X0*OP1
1  *PH1AS0 + PH1AXA*(IP*CTPC2 + IP*STPC2) - Y0*1-2*OP*PH1ALJ1
2  *PH1ALJ1 + CTPC2*OP*PH1ALJ1 + STPC2*OP*PH1ALJ1 - 2*
3  *PH1*PH1A + PH1ATA*(IP*CTPC2 - IP*STPC2) + M0*PH1VZA + ZM0
4  *IZM*(PH1AS0 + PH1AS0) - STPC2*PH1ATA - 2*OP*PH1A + CTPC2*OP*PH1ALJ1
5  * M0*PH1*PH1AS0 + PH1AS0)
6QALJ1) - PH0*PH1ALJ1 + IZP*CTPC - X0*STPC*OP*PH1ALJ1 - Y0*
1  STPC*OP*PH1ALJ1 - M0*PH1ALJ1 + ZM*CTPC*OP*PH1ALJ1 + IZP*OP*PH1ALJ1
2  - PH1ALJ1*OP*CT
OFFV1J) = PH1*PH1ALJ1 + CTPC*OP*PH1ALJ1 - STPC*OP*PH1ALJ1
OFFV1J) = PH1ALJ1 - ZM*OP*PH1ALJ1
OFFV1J) = CTPC*OP*PH1ALJ1 + STPC*OP*PH1ALJ1
SHOPEE1J) = 0.00
XV1 6) = PH1ALJ1*SHOPEE1J + XV1 M1
XV1 7) = PH1ALJ1*SHOPEE1J + XV1 79
XV1 8) = PH1ALJ1*SHOPEE1J + XV1 80
XV1 9) = PH1ALJ1*SHOPEE1J + XV1 90
XV1 10) = PH1ALJ1*SHOPEE1J + XV1 100
DO 70 K=1,4
SHOPEE1J) = 0.00
CONTINUE
70 IF (IYB-NE-1) GO TO 20
DO 26 K=1,4
OMAC1K) = OMAC1K*2031000
OMAC1K) = OMAC1K*2031000
26 A1C1K) = A1C1K*OPAD
IF (IYB-NE-2) GO TO 34
M05 = -507*OPAD*SHOPEE1J
OM1 = OM1*20300
OM15 = OM15*20300
AL1 = AL1*OPAD
DO 18 K=1,5
PH1K1) = 0.00
34 IF (IYB-EQ-0) GO TO 30
KP = 1
IF (IYB-EQ-1) KP = 4
DO 38 K=1,KP
PH1K1) = 0.00
KSH1K1) = 0
KSH1K1) = 0
38 IF (IYB-EQ-1) RETURN
CT = DCOS(PI*CT)
SY = COS(PI*CT)
DO 45 I=1,M5
CTH0B11) = CT*CTH111 - ST*STH111
STH0B11) = ST*CTH111 + CT*STH111
45 CONTINUE
NGC10 = 0
CALL TABINITING,OM1
NGC10 = -1
CALL TABINITING,OM1
DO 205 M=1,MM
REPE 4) = 0.00

```

ARAP06 FORTRAN Listings (Continued)

M11 10-1-1978 (Continued)

```

22  DO 22 J=1,NB
    IF (A(N+1,1) .EQ. 0.0)
    DO 204 N=1,NB
        IF (N .EQ. 1) THEN
            A(N+1,1) = A(N+1,1) + A(N+1,1) * A(N+1,1)
        ELSE
            A(N+1,1) = A(N+1,1) * A(N+1,1)
        END IF
    END DO
    CONTINUE
204  IF (N .EQ. 1) THEN
        A(N+1,1) = A(N+1,1) * A(N+1,1)
    ELSE
        A(N+1,1) = A(N+1,1) * A(N+1,1)
    END IF
    CONTINUE
205  RETURN
    END

```

CARD COUNT 236

1A	GO TO 16	
22	GO TO 15,NPTS	
24	DO 20 I=1,NPTS	
26	DO 28 J=1,NPTS	
18	REAL(1,DUMK1,K=1,7),V(1)	
	IF (BLE,ME,1) CALL PLOT (V(1),-3)	
	CALL SCALE (V,5,NPTS,1,20,0)	
	CALL AXIS (10,2,10,TIME (ISEC)-10,AK,0,0,0,5,20,1)	
	GO TO 131,32,33,34,35,36,37,38,39,40,41,42,43,50,1	
	CALL AXIS (10,2,2,30RPR,3,5,0,0,V(NPTS),V(NPTS),2,20,1)	
31	GO TO 38	
32	CALL AXIS (10,0,0,12MBET-LY (DEC),12,5,0,0,V(NPTS),V(NPTS),2,20,1)	
33	CALL AXIS (10,0,0,10HTEFF (LBS),10,5,0,0,V(NPTS),V(NPTS),2,20,1)	
34	GO TO 38	
35	CALL AXIS (10,0,2,12HTEFFZ (1M-LB),12,5,0,0,V(NPTS),V(NPTS),2,20,1)	
36	GO TO 38	
37	CALL AXIS (10,0,0,7H01 (IN),7,5,0,0,V(NPTS),V(NPTS),2,20,1)	
38	GO TO 38	
39	CALL AXIS (10,0,0,10HM1 (1M-LB),10,5,0,0,V(NPTS),V(NPTS),2,20,1)	
40	GO TO 38	
41	CALL AXIS (10,0,2,10HM3 (1M-LB),10,5,0,0,V(NPTS),V(NPTS),2,20,1)	
42	GO TO 38	
43	CALL AXIS (10,0,0,0H01 (DEC),0,5,0,0,V(NPTS),V(NPTS),2,20,1)	
44	GO TO 38	
45	CALL AXIS (10,0,0,0HMM (IN),0,5,0,0,V(NPTS),V(NPTS),2,20,1)	
46	GO TO 38	
47	CALL AXIS (10,0,2,0.9MMTH (RAD),0,9,5,0,0,V(NPTS),V(NPTS),2,20,1)	
48	GO TO 38	
49	CALL AXIS (10,0,0,0.9MPD01 (G),0,9,5,0,0,V(NPTS),V(NPTS),2,20,1)	
50	GO TO 38	
51	CALL AXIS (10,0,2,0.9MPD02 (G),0,9,5,0,0,V(NPTS),V(NPTS),2,20,1)	
52	CALL TIME (10,7,NPTS,1,0,0)	
53	CALL TIME (0,0,0,0,0,0)	
54	CALL SCALE (2,5,NPTS,1,20,0)	
55	GO TO 141,42,43,44,45,46,47,50,01,62,63,50,1	
56	CALL AXIS (10,0,2,12MBET-LG (DEC),12,5,0,0,V(NPTS),V(NPTS),2,20,1)	
57	GO TO 49	
58	CALL AXIS (10,0,2,10HTEFFX (LBS),10,5,0,0,V(NPTS),V(NPTS),2,20,1)	
59	GO TO 48	
60	CALL AXIS (10,0,2,10HTEFFZ (LBS),10,5,0,0,V(NPTS),V(NPTS),2,20,1)	
61	GO TO 48	
62	CALL AXIS (10,0,2,7H02 (IN),7,5,0,0,V(NPTS),V(NPTS),2,20,1)	
63	GO TO 48	
64	CALL AXIS (10,0,2,10HM2 (1M-LB),10,5,0,0,V(NPTS),V(NPTS),2,20,1)	
65	GO TO 48	
66	CALL AXIS (10,0,2,10HM3 (1M-LB),10,5,0,0,V(NPTS),V(NPTS),2,20,1)	
67	GO TO 48	
68	CALL AXIS (10,0,2,0.9HMC0 (IN),0,9,0,0,V(NPTS),V(NPTS),2,20,1)	
69	GO TO 48	
70	CALL AXIS (10,0,0,0.9MPD01 (G),0,9,0,0,V(NPTS),V(NPTS),2,20,1)	
71	GO TO 48	
72	CALL AXIS (10,0,0,0.9MPD02 (G),0,9,0,0,V(NPTS),V(NPTS),2,20,1)	
73	GO TO 48	

63

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CARD COUNT **36**

ARAP06 FORTRAN Listings (Continued)

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ARAP06 FORTRAN Listings (Continued)

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145  FORMAT (/' MIE(1) (CMUC-IN021)', F10.4, 'PF11-4)
146  FORMAT (/' MY(1) (1M)'.5X, 10F11.2)
155  FORMAT (/' WDR(1) (1M)'.5X, 10F11.2)
C
NB = 1
READ (5,12) FND-26,ERR-26) TITLE
READ (5,12) IT1, IT2, IT3, IT4, IT5, IT6, IT7, IT8, IT9, IT10, IT11, IT12,
1  IT13, IT14, IT15
READ (5,12) NS-NRM-MMT, NTMC-MPSID-MCASE
IF (MCA-EQ-0) VC = MCASE
MCA = 1
READ (5,15) ZM, S-RMO, TMC-BZETA, RPM-OMT, G-AD-DEL3, T4C-A1, B1, U,
1  REALM-GY-DT4IN-PSIE
READ (5,15) 2P41-RPH2-RPH3-RPM-AK11-AK12-AK13,
1  AK14-BK11-BK12-BK13-BK14-STOPR, STOPTM
READ (5,15) TCMAX, TMST, TMED
READ (5,15) ANPV-ANPM-CPS-GST1-GED1-GST2-GED2
READ (5,15) ALM-MC-SLC-DEL-ALAP-AL-YCA
READ (5,15) OMAC-OMAS-OMBS-ATC-A1S-B1C-B1S-OMACS-OMASS-OMBCS,
1  OMBS-TA1B1
READ (5,15) UK-VE-ME-SPNE-CDE-OME-ALX-ALS-TEX-CLKO, OMS
READ (5,15) (TMT(1), I=1, MS)
READ (5,15) (R(1), I=1, MS)
READ (5,15) (AN(1), I=1, MS)
READ (5,15) (V(1), I=1, MS)
READ (5,15) (ATC(1), I=1, MS)
READ (5,15) (EPF(1), I=1, MS)
READ (5,15) (EPC(1), I=1, MS)
READ (5,15) (C(1), I=1, MS)
READ (5,15) (D(1), I=1, MS)
IF (DT4IN-EQ-0) DT4IN = .5D-2
IF (IT4-EQ-0) GO TO 40
REWIND 1
WRITE (1) TITLE
WRITE (6,20) TITLE-U-RPM-GY-S-TPC-RMO-IT1-IT2-IT3-IT4-IT5-IT6,
1  IT7-IT8-IT9-IT10-IT11-IT12-IT13-IT14-IT15-MCASE-DT4IN-PSIE
IF (IT1-EQ-1) WRITE (6,55) 2P41-RPH2-RPH3-RPM-AK11-AK12-AK13,
1  AK14-BK11-BK12-BK13-BK14-STOPR, STOPTM
IF (IT2-EQ-0) WRITE (6,22) TCMAX, TMST, TMED
IF (IT3-EQ-0) GO TO 36
IF (IT3-2) 28,46,54
WRITE (6,56) ANPV-ANPM-GST1-GED1
GO TO 36
WRITE (6,50) ANPV-ANPM-GST2-GED2
GO TO 36
WRITE (6,60) ANPV-ANPM-CPS
IF (IT5-EQ-1) 3R-IT7-EQ-1) WRITE (6,65) ALM-MC-SLC
IF (IT7-EQ-1) WRITE (6,105) DEL-ALAP-AL-YCA
IF (IT4-EQ-1) WRITE (6,42) OMAC-OMAS-OMBS-ATC-A1S-B1C-B1S,
1  OMACS-OMASS-OMBCS-OMBS-TA1B1
IF (IT8-EQ-2) WRITE (6,52) UK-VE-ME-SPNE-CDE-OME-ALX-ALS-TEX-CLKO,
1  OMS
WRITE (6,45) NS-AD-DEL3-TMC-A1-B1-NRM-BZETA-OMT-7M-MMT-NTMC,
1  MPSID-IT1-TMT(1)-R(1)-AN(1)-V(1)-ATC(1)-EPF(1)-EPC(1),

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ARAP06 FORTRAN Listings (Continued)

KELLER, DITTE COMPANY

CARD COUNT 45

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SUBROUTINE TABINA (TMC,PSIDM)
  REAL*8 BE,AL,BOM,DUM4,THH,VST,TMCM,PSIDM,TBMT,TCMT,BZETA
  COMMON /PRIN/ 5F10.4,3E10.4,3Y8.1,3A3,THH(10,4),DUM4(244),
  1 NMH(4),BZETA,TBMT(4,4),TCMT(4,4)
  COMMON /PRIN1/ FTMC(6),FPSID(6),DMG(144),DTMC(13),DFPSID(5),
  1 TMT(144),FTH(144),FTMC(44),TMT(44),CTMT(576)
  COMMON /TAB/ 10UM(10),10P(10),45,45,45,45,45,45,45,45,45,45,
  1 10UM(5113),NTMC,DFPSID,DMT
  PSID = PSIDM
  TMC = TMC*97.296
  PSID = AMAL(PSID,FPSID(1))
  PSID = AMAL(PSID,FPSID(2))
  TMC = AMAL(TMC,FTMC(1))
  TMC = AMAL(TMC,FTMC(2))
  DO 10 K=2,NTMC
    IF (TMC(1,FTMC(K)) EQ 10 20
    CONTINUE
  10 K = NTMC
  20 DE = (TMC - FTMC(1)) / DFMC(1)
  DO 30 M=2,MPSID
    IF (PSID(1,FTMC(M)) EQ 10 40
    CONTINUE
  30 M = MPSID
  40 OF = (PSID - FPSID(M-1)) / DFPSID(M-1)
  IF (MGOTO(1,3)) GO TO 52
  KC = 60M + K - 49
  KD = 60M + K - 500
  DO 50 N=1,NBM
    KA = TMC(K)
    VL = FTMC(K) + (DMG(KA+1) - DMG(KA)) * DX
    KA = 60M + K
    DO 50 L=1,NS
      SA = 360M + L + KD
      VL = FBE(KA) + (FBE(KA+10) - FBE(KA)) * DX
      VLX = FRI(KA) + (FRI(KA+10) - FRI(KA)) * DX
      VLY = FTH(KA) + (FTH(KA+10) - FTH(KA)) * DX
      KA = KA + 60
      REFL(N) = (FBE(KA) + (FBE(KA+10) - FBE(KA)) * DX - VL) * DX + VL
      TMT(L,N) = (FRI(KA) + (FRI(KA+10) - FRI(KA)) * DX - VLX) * DX + VLX
      TMT(L,N) = (FTH(KA) + (FTH(KA+10) - FTH(KA)) * DX - VLY) * DX + VLY
    CONTINUE
  50 RETURN
  52 KC = 60M + K - 193
  DO 60 N=1,NBM
    KA = 360M + L + KD
    VL = FBE(KA) + (FBE(KA+10) - FBE(KA)) * DX
    VLX = FRI(KA) + (FRI(KA+10) - FRI(KA)) * DX
    VLY = FTH(KA) + (FTH(KA+10) - FTH(KA)) * DX
    KA = KA + 60
    TMT(L,N) = (FBE(KA) + (FBE(KA+10) - FBE(KA)) * DX - VL) * DX + VL
    TMT(L,N) = (FRI(KA) + (FRI(KA+10) - FRI(KA)) * DX - VLX) * DX + VLX
    TMT(L,N) = (FTH(KA) + (FTH(KA+10) - FTH(KA)) * DX - VLY) * DX + VLY
  60 CONTINUE
  RETURN

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PAGE 2

CARD COUNT 56

END

ARAP06 FORTRAN Listings (Continued)

ALL INFORMATION CONTAINED

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SUPROUTINE TAPINT (V,M)
COMMON /LL DD/ M-Z-CURVE(2600)
DIMENSION DSK(10,10),IL(10),DSK(31,10),NZ(10),MX(10),IZ(10)
DATA 'X' / 0.0,0.1,1.0,1.1,1.1,1.0,0.0, NZ / 17.16,17.20,2.30,30.25,
1 15%, IL/ 0.141,313.492,007.120,1622.193,2744.250,DSK / .26,
2 .04,.1,
3 .1,11.25,34.300, .26,0.04,1.1,1.1,0.05,34.300, .251,.151
4 .20,171.052,054,062,228.200, .130,1.1,05,20.05,06,03,.15,
5 .3,20.10,06,20,05,06,03,.15, .301,1.20,10,12,051,053,.037
6 .255,0, .3,3,1.0,06,30,05,04,15, .3,3,1.0,06,30,05,04,
7 .15, .301,20,1.101,05,051,052,054,101,0, .801,200, /,
2 057 / 172.162,160,156,
3 172.302,16,002,160,160, .172,162,153,.150,
4 170.271,02,1.160, .170,271,02,1.160, .170,261,
5 .4,167.206, .174,221,164, .700, .174,221,164, .700,
6 174.201,02,4,167, .700, .401,0102,170, /,
7 177 / 0.160,222,03,008,1202,1633,1044,2756,2530 /

NM=NZ(1)
IL=IL(1)
NM=IL+2
NL=NM+IL
NM=NL-1
DO 1 K=1,NM,MU
IF (X-IL,CURVE(K)) GO TO 3
CONTINUE
K=NM-IL-1
IL=IZ(1)
NM=NZ(1)
NM=IL+2
NL=NM+IL
NM=NL-1
DO 2 K=1,NM,MU
IF (Z-IL,CURVE(K)) GO TO 6
CONTINUE
K=NM-IL
KZ=KZ+NM+MU
J=KZ+NM+NM+K
DX=IL-CURVE(K-1)/DSK(K,M)
V=CURVE(J-1)+DX
J=J+NM
VU=V
V=CURVE(J-1)+DX
V=VU+Z-CURVE(KZ-1)/DSK(K,M)+V-VU
RETURN
END

```

CARD COUNT 48

ARAP06 FORTRAN Listings (Continued)

ARAP06 FORTRAN Listings (Continued)

ARAP06 FORTRAN Listings (Continued)

PAGE 4

```
DN 35 K=1,MP00
ADD = IX03D - PCIKI*XP00C + PBILK*XP00B - PAIKI*XP00A / 384.
Y00 = (Y00D - PCIKI*Y00C - PBILK*Y00B) / 384.
Z00 = (Z00D - PCIKI*Z00C + PBILK*Z00B - PAIKI*Z00A) / 384.
XP00IK1 = Z00*CTMP - X00*STMP
YP00IK1 = X00*CTMP + Y00*CP5IP + I00*STMP
ZP00IK1 = X00*CCP - Y00*SP5IP + Z00*SCP
35 CONTINUE
RETURN
END
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CARD COUNT 175

ARAP06 FORTRAN Listings (Concluded)

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DFAL17 FORTRAN Listings

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DFALL7 FORTRAN Listings (Continued)

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DFALL7 FORTRAN Listings (Continued)

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CARD COUNT 20

DFALL7 FORTRAN Listings (Continued)

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DFAL17 FORTRAN Listings (Continued)

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SUBROUTINE MORT (N)
  COMMON DATA (MORT)
  C = 0.01
  DO 10 I = 1, N
    MORT(I) = C
    C = C * 1.05
  10 CONTINUE
  RETURN
END

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CARD COUNT 14

DFALL7 FORTRAN Listings (Continued)

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DFAL17 FORTRAN Listings (Continued)

DATE OF BIRTH: 08/09/1967

DFALL7 FORTRAN Listings (Continued)

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      AWA (1,2) = 0.00
      AWA (2,2) = 0.00
      AWA (3,2) = 1.00
      AWA (4,2) = 0.00
      AWA (1,2) = 0.00
      DO 7 I1=1,3C
      SG=CSIN(CAM*AT(I1))
      IF (CARS(SG),I1,D-1)SG=0.00
      CG = COS(CAM*AT(I1))
      AWA (1,1) = CG
      AWA (1,3) = SG
      AWA (3,1) = -SG
      AWA (3,3) = CG
      DO 7 J1=1,3
      HBARC(J1,2*AT(I1)) = AWA (I1,J1)
      HBARC(J1,2*AT(I1+1)) = AWA (I1,J1)
      RETURN
      END

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CARD COUNT 129

DFALL7 FORTRAN Listings (Continued)

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DFAL17 FORTRAN Listings (Continued)

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CARD COUNTY 163

DFALL17 FORTRAN Listings (Continued)

4290 J. Neurosci., July 26, 2006 • 26(30):4283–4290

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SUBROUTINE TPR00
  COMMON/PRGTS/PA,STO,RTG,DUM(263),XTC
  REAL*8 RTG(20),RTG.DUM
  1,XTC(1,2,3),XTC(1,3,3),XTC(1,3,3)
  NFI(1)=79(1/233333)
  DO 1 I=1,60
    DC 1 J=1,60
    ISC = (J+J-21)/233333
    IF(I-90.J) GOTO 3
    DO 2 K=1,3
      ISP=ISC*K
      DO 3 L=1,3
        XTC(K,L)=RESPONSE(L)
        GO TO 10
      DO 11 P=1,3
        ISP=ISC*K
        DO 11 L=1,3
          XTC(K,L)=RESPONSE(L)
          XTC(L,K)=XTC(K,L)
        DO 2 K=1,3
          XTC(K,M)=0.00
          DO 3 L=1,3
            XTC(K,M)=XTC(K,M)+XTC(L,L)*XTC(L,M)
          DO 1 L=1,3
            ISP=ISC*L
            DO 1 P=1,3
              IF(L-90.J.AND.L-90.M) GO TO 1
              XTC(K,M)=0
            DO 15 P=1,3
              XTC(K,M)=XTC(K,M)+XTC(L,M)*XTC(L,K)
            RESPONSE(L)=XTC(K,M)
          CONTINUE
          RETURN
        END
      END
    END
  END
  CARD COUNT 35

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DFALL7 FORTRAN Listings (Concluded)

WILLIAMS COMPANY

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DFAL18 FORTRAN Listings

DFAL18 FORTRAN Listings (Continued)

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WRITE(6,14) TIL
14  FLAP(1,1)=2000/'SYSTEM RESPONSES'
    DO 22 ISC=1,NSC
      NS=NSC*ISC
      ICR(1)=NSC(NS)
      DO 26 J=1,4
        NSD(J)=NSD(J)
        IF(AS-LT=0) NSD(J)=J
      26  ICR(1)=ICR(1)+J
      ICR(1)=ICR(1)+1
      NS=4
      IF(NT-EQ=0) UR=NS*10.6-UR-NS*CU.7) NV=2
      CALL RESC(NT,5.6, 'ICF)
      NS=PAR(INS-1,1)
      IF(AS-GT=5) AND-NS-LT=9) NSK=NS
      DO 8 L=2,NV,2
        LA=L-1
      8  DC 43 J=1,NPTS
        D=C(1,1)-NSK*VC(J,LA)+C(1,2)*NSK*VC(J,1,1)
        VC(1,LA)=LA
      43  VC(1,LA)=LA
        NSK=NSK+1
        MV=2
        IF(AY-EQ=2) GO TO 59
        EL0= E(1,SC)/1.4402
        GJ = G(1,SC)/1.4402
        SLA = SL(1,SC)/1.201
        SLB = SL(1,SC)/1.201
        SLE = SLB -SLA
        SLAS=SLA**2
        XMS = SLB**2
        TL =2.00/SLE
        CUW = 3.00/SLE
        CEA = TL*EL0
        CCG = GJ/SLE
        CCB = CCG*CUA
        DP=SLAS*XMS*SLE
        DP=XMS*EL3-DP*SLAS-2.00*SLA*SLB/CA
        DC=SLAS*(2.00*SLA*SLB-3.00*XMS)/UA
        SLAT=SLAS**2/CA
        XT=XMS**2/CA
        GT=BLDS*DP*PIA
        IF(AS-LT=6) GF=MGSL*DP*PIA
        CC= CCG*ICF)
        CS= SIN(CT)
        DC 54 I=1,NPTS
          VC(1,5)= VC(1,1)+DB-VC(1,3)*SLAT
        54  IF(AS-NE=1) GO TO 57
          VC(1,6)=VC(1,5)
          VC(1,5)=0.
          VC(1,3)=VC(1,1)
          VC(1,4)=VC(1,2)
          VC(1,1)=0.
          VC(1,2)=0.
          GC TC 58

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DFAL18 FORTRAN Listings (Continued)

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SUBROUTINE INOUT (N)
  COMMON/MAIN/DUM,STIFF
  CHARACTER STIFF* 40, BIGC,P,DUM(76,76)
  WRITE(10,100) BIGC,P,DUM(76,76)
  100 FORMAT(100A40)
  DO 40 J=1,N
    BIGC = STIFF(J)
    IF (BIGC.EQ.0.000) STOP
    WRITE(10,110) J,BIGC
    110 FORMAT(100A40)
  END DO
  40 CONTINUE
  STIFF(1,N) = STIFF(1,N)/BIGC
  DO 60 J=1,N
    DO 60 J=1,N
      STIFF(J,J) = STIFF(J,J)+STIFF(J,J)
  60 CONTINUE
  RETURN
END

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CARD COUNT 19 STIFFIN

DFALL18 FORTRAN Listings (Continued)

MILWAUKEE COUNTY

CARD COUNT 13

DFAL18 FORTRAN Listings (Continued)

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SUBROUTINE RESPEV (A,IP)
  COMMON/MATAS/COM160181,2
  COMMON/MATAC/TOTANI
  NEAR98 DUP,TOT,CA,CT  ,Y11003),Z11003),X11C,C1,TOT4
  DO 13 J=1,N1
    Y11000,DO
  13  DO 15 I=1,IP
    I=1+(CTX11N,3)
    CH=1+(CTX11N,5)
    CA=1+(CTX11N,5)
    X11N,5 J=1+(CTX11N,5)
    X11N,5 J=1+(CTX11N,5)
    X11N,5 J=1+(CTX11N,5)
    X11N,5 J=1+(CTX11N,5)
  15  RETURN
  END

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CARD COUNT 15

DFAL18 FORTRAN Listings (Continued)

WILLIAMS COMPANY

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13. ABSTRACT This report describes the results of a study of the dynamic stability and response during the feathering and folding of the blades of a folding-proprotor VTOL. This study involved the development of analytical methods of predicting the dynamic characteristics during feathering and folding, correlation of the theoretical methods with experimental data, a dynamic analysis of a representative folding-proprotor VTOL design, and a parametric study to identify design factors which can be used to control dynamic characteristics during feathering and folding. Correlation of the theory with measured dynamic stability and response characteristics during feathering and folding is good, and indicates the analytical methods can be used with confidence. The results of the dynamic analysis indicate satisfactory stability and response characteristics can be achieved in a 66,000-pound gross-weight class, folding-proprotor VTOL. The results of the parametric study are summarized in terms of design guidelines. This volume is a guide to the computer programs and contains FORTRAN listings.			

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14	KEY WORDS	LINK A		LINK B		LINK C	
		ROLE	WT	ROLE	WT	ROLE	WT
	Folding Proprotor Dynamic Stability Dynamic Response Feathering/Unfeathering Propeller Whirl Flutter Reduced Frequency						

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