

UNCLASSIFIED

AD NUMBER
AD894895
NEW LIMITATION CHANGE
TO Approved for public release, distribution unlimited
FROM Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; APR 1972. Other requests shall be referred to Air Force Flight Dynamics Lab., Wright-Patterson AFB, OH 45433.
AUTHORITY
AFWAL ltr, 13 Mar 1981

THIS PAGE IS UNCLASSIFIED

*
AD 894 895

AFFDL-TR-71-5

PART II, VOLUME II

WRIGHT-PATTERSON
AIR FORCE BASE
OHIO 45433

SUBSONIC UNSTEADY AERODYNAMICS FOR GENERAL CONFIGURATIONS

PART II

VOLUME II COMPUTER PROGRAM N5KA

J. P. GIESING

T. P. KALMAN

W. P. RODDEN

TECHNICAL REPORT AFFDL-TR-71-5, PART II, VOLUME II

APRIL 1972

Approved for public release; distribution is unlimited.

Distribution limited to U. S. Government agencies only; test and evaluation statement applied in September 1971. Other requests for this document must be referred to Air Flight Dynamics Laboratory, (FY), Wright-Patterson AFB, Ohio 45433.

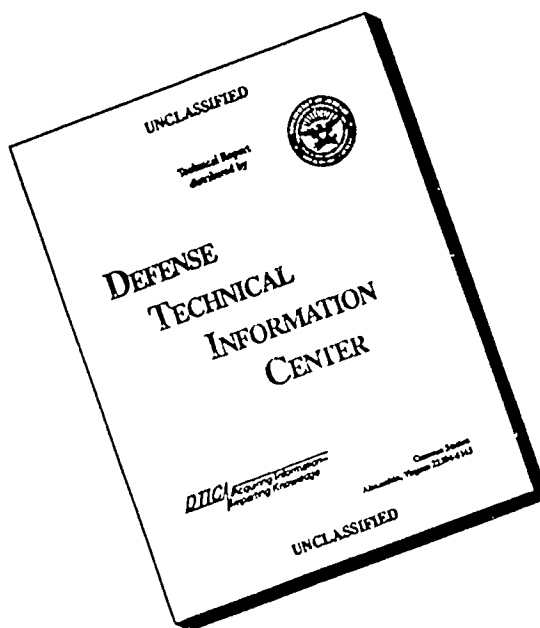
**AIR FORCE FLIGHT DYNAMICS LABORATORY
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO**

NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST
QUALITY AVAILABLE. THE COPY
FURNISHED TO DTIC CONTAINED
A SIGNIFICANT NUMBER OF
PAGES WHICH DO NOT
REPRODUCE LEGIBLY.

SUBSONIC UNSTEADY AERODYNAMICS FOR GENERAL CONFIGURATIONS

PART II

VOLUME II COMPUTER PROGRAM N5KA

J. P. GIESING

T. P. KALMAN

W. P. RODDEN

Approved for public release; distribution is unlimited.

Distribution limited to U. S. Government agencies only; test and evaluation; statement applied in September 1971. Other requests for this document must be referred to AF Flight Dynamics Laboratory (FY), Wright-Patterson AFB, Ohio 45433.

CODE
23

FOREWORD

This report was prepared by the Douglas Aircraft Company, Aircraft Division, Long Beach, California, for the Aerospace Dynamics Branch, Vehicle Dynamics Division, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio under Contract F33615-70-C-1167. This research was conducted under Project 1370, "Dynamic Problems in Military Flight Vehicles", and Task 137003, "Prevention of Dynamic Aeroelastic Instabilities in Advanced Military Aircraft." Mr. S. J. Pollock of the Aerospace Dynamics Branch was Task Engineer.

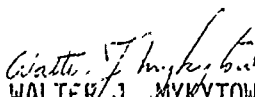
This report consists of two parts with two volumes for each part. This volume, Volume II of Part II is the Computer Program N5KA. Volume I of Part II contains a method which uses an image system and an axial singularity system to account for the effects of the bodies. Volume I of Part I contains the method of direct application of nonplanar lifting surface elements, and Volume II of Part I is the Computer Program H7WC.

The work reported herein was conducted during the period of December 1969 to August 1971.

The Principal Investigator was Joseph P. Giesing. Mrs. T. P. Kalman was responsible for the computer programming and Dr. W. P. Rodden was a McDonnell Douglas Company Consultant. Others have made significant contributions to this project including Messrs. D. H. Larson, D. S. Warren, and W. E. Henry.

The contractor's designation of this report is MDC-J0944. The report was released by the authors in August 1971 for publication as an AFFDL Technical Report.

This technical report has been reviewed and is approved.


WALTER J. MYKYTOW
Asst. for Research & Technology
Vehicle Dynamics Division

ABSTRACT

A technique for predicting steady and oscillatory aerodynamic loads on general configurations has been developed which is based on the Doublet-Lattice Method and the method of images. Chord- and spanwise loading on lifting surfaces and longitudinal body load distributions are determined. Configurations may be composed of an assemblage of bodies (elliptic cross sections and a distribution of width or radius) and lifting surfaces (arbitrary planform and dihedral, with or without control surfaces). Loadings predicted by this method are required for flutter, gust, frequency response and static aeroelastic analyses and may be used to determine static and dynamic stability derivatives. Volume I presents the theory and calculated results while Volume II presents the details of the computer program used to implement the theory.

CONTENTS

	Page
1.0 INTRODUCTION	1
2.0 INPUT PROCEDURE AND EXAMPLE CASE	6
2.1 Input Sheets	6
2.2 Description of Input Data	9
2.3 Example Case Input Sheets	19
2.4 Example Case Output	26
3.0 BLANK AND LABELED COMMON BLOCKS	43
3.1 Blank Common Block	43
3.2 Labeled Common Blocks	47
4.0 LOGICAL TAPE UNITS	49
4.1 Tape Numbers and Symbols	49
4.2 Table of Input Output Units	50
5.0 DESCRIPTION OF SUBROUTINES	51
5.1 Segment 1	51
5.1.1 MAIN	51
5.1.2 ATAIL	56
5.1.3 DZY	56
5.1.4 FLLL	59
5.1.5 FWMW	61
5.1.6 IDF1	63
5.1.7 IDF2	65
5.1.8 INCRO	66
5.1.9 READD	73
5.1.10 RWREC	73
5.1.11 SNPDF	74
5.1.12 SUBI	75
5.1.13 TIME	80
5.1.14 TKER	80
5.1.15 TVOR	83
5.1.16 WRTFMF	85
5.1.17 WRTFMU	86

		Page
5.2	Segment 2	87
	5.2.1 DATA	87
5.3	Segment 3	96
	5.3.1 GEND	96
	5.3.2 DPPS	107
	5.3.3 DPZY	108
	5.3.4 DYPZ	112
	5.3.5 DZPY	114
	5.3.6 SUBB	116
	5.3.7 SUBP	124
5.4	Segment 4	132
	5.4.1 RDMODE	132
5.5	Segment 5	133
	5.5.1 SB	133
	5.5.2 DUMULT	138
	5.5.3 DZYMAT	138
	5.5.4 MUZYC	140
	5.5.5 OUTCOR	142
	5.5.6 ROWDYZ	143
5.6	Segment 6	148
	5.6.1 WANDWT	148
5.7	Segment 7	150
	5.7.1 SOLVIT	150
5.8	Segment 8	152
	5.8.1 BFSMAT	152
	5.8.2 FZY2	155
5.9	Segment 9	163
	5.9.1 BFM	163
	5.9.2 FMZY	166
	5.9.3 ORGAN	172
	5.9.4 SBLOAD	173

	Page
5.10 Segment 10	175
5.10.1 AERO	175
5.11 Segment 11	182
5.11.1 GENF	182
6.0 PROGRAM LISTING	187
7.0 REFERENCES	243

NOMENCLATURE

A	Reference total area
a	Average body width
a_o	Local body width
$\bar{a}$	Radius of curvature
b	Average body height
b_o	Local body height
$\bar{c}$	Position vector to center of curvature
C_ℓ	Rolling moment coefficient (moment/ qA_S) (+ right wing down)
C_m	Pitching moment coefficient (moment/ $qA_{\bar{c}}$) (+ nose up)
C_n	Yawing moment coefficient (moment/ $qA_{\bar{c}}$) (+ nose right)
C_p	Pressure coefficient
C_Y	Side force coefficient (Force/ qA) (+ out right wing)
C_Z	Vertical force coefficient (Force/ qA) (+ up)
c	Local chord length
$\bar{c}$	Reference chord length
c_m	Local pitching moment coefficient
c_n	Local normal force coefficient
c.p.	Center of pressure
D	Matrix relating normalwash to lifting pressures for lifting surface elements
D_I	Matrix relating normalwash to lifting pressures for image elements
$\bar{D}$	Matrix relating normalwash to lifting pressures for elements and all their images
$\bar{D}$	Matrix relating normalwash to lifting pressures for elements plus their images plus the contributions due to symmetry and ground effect

D_T	Partitioned matrix $[\bar{D} \bar{E}]$, relating normalwash to lifting pressures and doublet strengths
D_θ	Matrix relating the flow normal to a body surface (at the meridian angle θ) to the lifting pressure for elements and their images
$D^{(y)}, D^{(z)}$	Matrix relating the average side- or upwash at a body due to lifting surface elements
$D2D$	Matrix relating the doublet strength to the local up- or side-wash using quasi-steady, two-dimensional slender-body theory
d	Spacing of doublets or vortices within slender bodies (simulation of body aspect ration (b/a))
E	Matrix relating normalwash to axial doublet strengths
$\bar{E}$	Matrix relating normalwash to axial doublet strengths with the effects of symmetry and ground effect included
$E^{(y)}, E^{(z)}$	Matrix relating the normalwash to y- or z-oriented axial doublets
e	Lifting surface element semi-width; also cross-sectional element semi-width
$F^{(z)}, F^{(y)}$ $F_y^{(z)}, F_y^{(y)}$	Total force on a body due to a point pressure doublet. Subscript indicates direction of force; superscript indicates direction of pressure doublet
f	Nondimensional deflection. Also function involving Hankel functions
$H_v^{(2)}$	Hankel function of the second kind of order v
h	Deflections normal to a lifting surface
h_y, h_z	Deflections of a body in y- and z-directions, respectively
$\vec{i}, \vec{j}, \vec{k}$	Unit vectors in x-, y- and z-directions, respectively
$\vec{i}_F$	Unit vector in the direction of the body force
K	Velocity kernel function; the normalwash due to a point pressure doublet; also $(a_0^2 - b_0^2)/4$
K_ϕ	Potential kernel function; the potential due to a point pressure doublet
k_r	Reduced frequency ($\omega \bar{c}/2U_\infty$)
$\bar{k}$	$\omega r M/U_\infty$

L	The normalwash due to a potential doublet
L_ϕ	The potential due to a potential doublet
M	Mach number; also normalwash due to a point source; also moment
$\vec{N}$	Orientation of pressure doublet
$\vec{n}, \vec{t}$	Outward normal and tangent vectors
p	Function involving Hankel functions
Q	Generalized force; also modified acceleration potential
q	Dynamic pressure
$\bar{q}$	Generalized modal coordinate
R	$\sqrt{(x - \zeta)^2 + \beta^2 r^2}$
r	$\sqrt{(y - \eta)^2 + (z - \zeta)^2}$
$\tilde{r}$	$(a + b)/2$
s	semi-span
U_∞	Freestream velocity
w	Normalwash boundary values
w_i	Normalwash due to image lifting surface elements
w_n	Normalwash due to body interference doublet distribution
w_R	$w_S + w_I$
w_S	Normalwash due to lifting surface elements
w_T	$w - \Delta w$
$\bar{w}$	Normalwash in the circle plane
x, y, z	Coordinates of a receiving point
XM	Coordinate about which moments are taken
α	angle of attack
β	$\sqrt{1 - M^2}$
γ	Dihedral angle: γ_r , receiving point, γ_s , sending point
Γ	Vortex strength

ΔC_p	Lifting pressure
$\Delta \bar{Q}$	Modified acceleration potential jump
Δw	Normalwash due to slender body elements
Δx	Longitudinal length of lifting surface box
$\Delta \xi$	Longitudinal length of axial element
$\Delta \phi$	Potential jump
δ	Symmetry plane indication (1 symmetry, 0 no symmetry, -1 anti-symmetry); also a delta function; also a virtual displacement
δA	Elemental area
ϵ	Ground-effect indication (-1 ground effect, 0 no ground effect, 1 antiground effect)
ζ	z-coordinate of sending point
η	y-coordinate of sending point
$\bar{\eta}$	Lateral coordinates in the plane of the lifting surface
θ	Meridian angle for a body of circular cross section
λ	Sweep of 1/4-chord of lifting surface element; also inclination angle in z-y-plane of a cross-sectional surface element
μ_d	Quadrupole strength
μ_n	Doublet strength of interference-body elements
μ_s	Doublet strength of slender-body elements
$\bar{\mu}_v$	Multipole strength in circle plane; v gives order of pole
$\tilde{\mu}_y, \tilde{\mu}_z$	Doublet strength of modified acceleration potential distribution in y- and z-directions; also reduction factors for image doublets
ξ	x-coordinate of sending point
$\bar{\rho}$	Distance from center curvature to external singularity
σ	Source strength
ϕ	Velocity potential
Ω	Acceleration potential
ω	Frequency

ξ_c	Center of axial-body element
ξ_1	Leading edge of body element
ξ_2	Trailing edge of body element

Subscripts and Superscripts

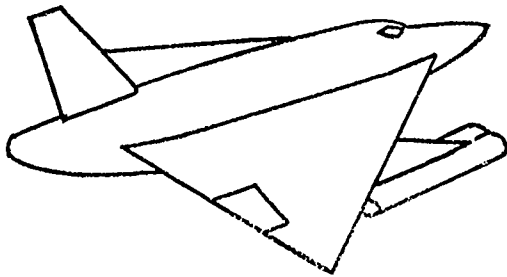
a	Body axis
b	Body
I	Image
LL	Lower left-hand quadrant
LR	Lower right-hand quadrant
n	Residual or interference flow
r,s	Receiving and sending points, respectively
UL	Upper left-hand quadrant
UR	Upper right-hand quadrant
s	Steady
y,q	y- and z-directions
θ	On the body surface
1,2	Planar and nonplanar parts, respectively
1/4	Quarter chord of element

1.0 INTRODUCTION

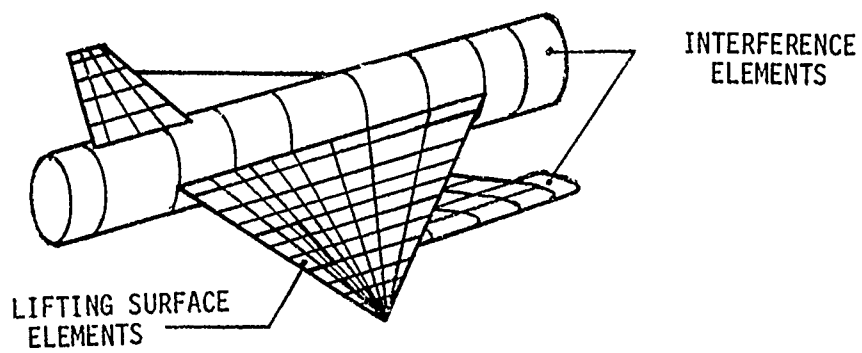
Program N5KA is the result of implementing the equations of Section 2.0, Part II, Vol. I (Reference 1) for the computer. The organization of these computations is outlined as follows:

- 1) All of the data required (except modal data) are generated from the input data in program Segment No. 2.
- 2) The influence coefficient matrix $[D_T]$ is generated in program Segment No. 3. This matrix relates the normalwash, upwash and sidewash to the lifting surface pressures and body axial doublet strengths in the z- and y-directions.
- 3) The normalwash, sidewash and upwash flow fields, Δw , caused by the slender body elements is generated in program Segment No. 5 for all modes. Modal data is read in and organized in program Segment No. 4. Currently the source distributions for steady flow are not included.
- 4) The final normalwash (also side and upwash) boundary condition, w_T , caused by the motions of the lifting surfaces and the slender body flow field, Δw , is generated in program Segment No. 6.
- 5) The augmented matrix $[D_T \mid w_T]$ is formed in program Segment 1 and solved in program Segment 7 for the lifting surface pressures and body doublet strengths (both in z- and y-directions).
- 6) The solution obtained in program Segment 7 is used to calculate the body forces and moments in either program Segment 8 or program Segment 9 depending on the method of calculations desired.
- 7) The lifting surface pressures and body axial force and moment distributions are integrated to form aerodynamic coefficients in program Segment No. 10. Also in this segment the body forces are redistributed.
- 8) The lifting surface pressures and body axial force and moment distributions are integrated to form the generalized forces in program Segment 11.

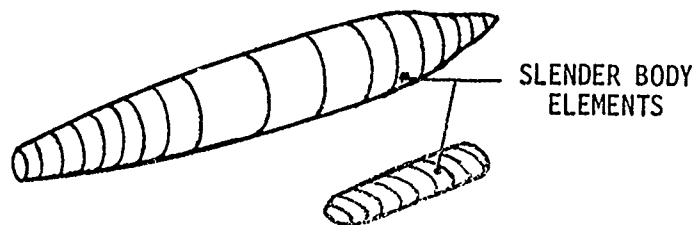
Configurations are built up of lifting surface panels and bodies to any degree of complexity desired (see Sketch 1.0-1). A lifting surface panel is a



||



+



SKETCH 1.0-1

trapezoid (two edges parallel to the x-axis) defined by the coordinates of its corner points. The panel is divided arbitrarily chordwise and spanwise to produce a surface of elements or boxes. Hinge lines, fold lines, and lines of intersection (of two or more panels) must lie on box boundaries. Lifting surface panels that lie one in back of another must be aligned so that those box edges lying in the same plane coincide. Part I, Volume I of this report² provides additional information on the distribution of lifting surface boxes (pages 49-50). Bodies are defined in two ways: 1) a tube of constant cross section, of aspect ratio b/a , divided into interference elements and 2) an equivalent body of elliptic cross section of varying radius divided up into slender body elements. The interference elements are provided to complete the body interference and are concentrated in regions of maximum interference while the slender body elements and radius distribution are used to obtain the slender body flow field of the body. It is important that the radius distribution be accurate because a numerical derivative of the radius must be taken with respect to x . Also provided, for bodies, are one or two distributions of pickup points. Pickup points are the points on the body surface where the normalwash is to be determined in order to calculate an average up- or side wash. The distribution of pickup points is given in terms of θ , which for a circle is the meridian angle. For an ellipse θ is defined as $\tan^{-1} \left(\frac{az}{by} \right)$. There are two possible θ distributions; one for regions where many (e.g. 8) points are required and regions where few (e.g., 4) are required.

When the actual lifting-surface/body geometry is built up the constant section tube is used to represent the body. It is important that the lifting surfaces adjacent to bodies be attached to the body surfaces without any gaps. Even small gaps cause a reduction in load near the gap. The relationship between lifting surface panels and bodies may be incorrect because the average tube is used instead of the actual body shape. In order to correct this difficulty and obtain the proper flow field at the lifting surface panel due to the slender body elements, a shifting of the panel is provided for. The shift of a panel may be different for different bodies. Thus the quantities $\Delta\eta_b^{(p)}$, $\Delta\zeta_b^{(p)}$ are input into the program, where p indicates panel and b indicates body.

To increase the efficiency of the method a further input is required for each panel. This input identifies the bodies "associated" with that panel.

Associated bodies are those that are required to possess an image of the panel in question. It is important to have only as many images as is necessary for accuracy since each image doubles the number of kernel functions that are to be calculated. It may even be desirable to break up lifting surfaces into more panels than necessary so that panels, located a considerable distance from the body, may not be required to possess an image within that body.

Symmetry planes and ground effect are included by the use of the input quantities δ and ϵ . Symmetry, no symmetry and antisymmetry are activated by setting δ equal to 1, 0 and -1 respectively. The plane of symmetry is the $y = 0$ plane. Ground effect, no ground effect and antiground effect are activated by setting ϵ equal to -1, 0 and 1 respectively. The ground effect plane is the $z = 0$ plane. Thus if ground effect is desired the configuration must be placed a distance above the $z = 0$ plane.

Polynomial modes are input for panels (motion normal to the surface) and for bodies (motions in the z - and y -directions). The coefficients of the polynomials are the input quantities to the program.

The following list gives the program limits:

- 1) The maximum number of unknowns, i.e. the total number of all the lifting surface elements plus the interference body elements, is 500.
 - 2) The maximum number of modes is either 50 or $\frac{NWORK}{NTOT}$ whichever is smaller, where $NWORK = 10000$ and $NTOT$ is the total number of unknowns for the case.
 - 3) The maximum number of panels is 99 while the maximum number of bodies is 10.
 - 4) The maximum number of spanwise strips per panel is 50 while the maximum number of chordwise boxes per strip is 50.
 - 5) The maximum number of body interference elements (for all bodies) is 100 while the maximum number of slender body elements is 200.
- The work area dimension, $NWORK$, imposes the following overall restriction: $4 (NSTRIP + NBZ + NBY + NTZS + NTYS)$ must be $\leq NWORK$, where $NSTRIP$ is the total number of strips, NBZ is the number of z -oriented bodies, NBY is the number of y -oriented bodies, and $NTZS$, $NTYS$ are the total number of slender body elements with z - and y -orientations respectively.

- 6) The maximum number of modal coefficients for panels is 150. The maximum number of modal coefficients for bodies is 150 for z-motions and 150 for body y-motions.
- 7) The maximum number of reduced frequencies is 6.

It is important that none of the above maximum values is exceeded. Not all maximums can be utilized at the same time without violating others. For example if the maximum number of spanwise strips and chordwise boxes is input then the total number of lifting surface boxes will exceed the maximum number of unknowns. The maximums outlined above are tailored to allow the computer program to fit into a core (360/65) of 260 K bytes. If more core is available, the user may wish to increase the dimension (NWORK) of the work array (WORK, see Section 5.5.1) in order to accommodate larger cases in the program.

2.0 INPUT PROCEDURE AND EXAMPLE CASE

2.1 Input Sheets

The input sheets for program N5KA are shown on the next two pages. The first three cards represent general data that is input once per case. The next four* cards (sequence numbers 4, 5, 6 and 7) represent panel data that is repeated per panel.

If the data includes bodies also, the next input card (#8) contains general information for the first body of the case. The subsequent two** cards (sequence numbers 9 and 10) are interference body element data, and the next two** cards (#11 and #12) represent slender body element data. Next, the θ_1 - and θ_2 -arrays are input (cards #13 and 14) which describe the angular distribution of points on the surface of interference body elements. Card 15 identifies the sections of the interference body for which θ_1 -distribution is specified. The next card (#16) contains the y- and z-shift information for all panels if this is also desired (see control items in card 8).

Cards 8 through 16 represent all the body data required and are repeated per body. Note, that bodies oscillating in the z-direction are input first, then bodies that can oscillate both in the z- and y-directions, and finally, bodies that oscillate in the y-direction only.

The last four[†] cards represent the polynomial mode information for the case. Card 17 contains the modal data for z-oriented bodies, card 18 contains the same for y-oriented bodies, and card 19 represents modal data for panels. Modal data may be input in any order with a maximum of three sets of data per card, a total of 100 sets of data per case, and only the nonzero modal coefficients need to be input. Card 20 terminates the reading of modal data; always input card 20 as the last card following all modal information. If the case specifies more than one reduced frequency, all modal data cards are to be repeated for each reduced frequency (see card #3).

A detailed description of all data items is given following the input sheets for program N5KA.

* There may be more than four cards in order to present all θ and τ values.

** There may be more than two cards in order to present all ξI , $R I$ elements for interference bodies, and ξS , $R S$ elements for slender bodies.

† There may be more than four cards needed to enter all modal information.

DATE _____

73 74 75 76

PROGRAM NO.

A
K
5
Z

[illegible]

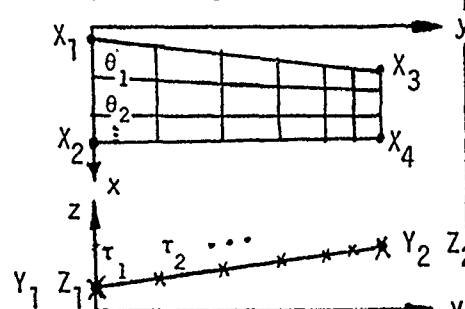
2.2 Description of Input Data

CARD NO.	ITEM NO.	MNEMONIC	SYMBOL	CARD COLUMN	FIELD	SOURCE	DESCRIPTION
1	0	HDR(15)		1-60	15A4	MAIN	Header information
	1	IBFS		61-70	110		Body force calculation method flag, alternate #1 IBFS = 1; }* alternate #2 IBFS = 0. }
2	2	FMACH	M	1-10			Mach number, usual definition
	3	REFA	A	11-20			Reference area; usually total area of both wings
	4	REFS	S	21-30	5F10.0		Reference semispan
	5	REFC	$\bar{c}$	31-40			Reference chord; usually average chord of wing
	6	XM	XM	41-50			Moment axis
	7	ND	δ	51-52	I2		Symmetry flag ($y = 0$ plane) $\delta = 1$ for symmetry $\delta = -1$ for antisymmetry $\delta = 0$ for no symmetry
	8	NE	ϵ	53-54	I2		Second symmetry flag ($z = 0$ plane) $\epsilon = 1$ for biplane effect (symmetry)

*Use #1 for circular and #2 for elliptic cross-sections

CARD NO.	ITEM NO.	MNEMONIC	SYMBOL	CARD COLUMN	FIELD	SOURCE	DESCRIPTION
2							$\epsilon = -1$ for ground effect (antisymmetry) $\epsilon = 0$ no symmetry
	9	NP, NOPAN		55-56	I2		Total number of panels on all lifting surfaces
	10	NB		57-58	I2		Total number of bodies
	11	NK		59-60	I2		Total number of reduced frequencies; max. 6 per case
	12	MK1		61-63	I3		Sequence number of first box on first panel representing a body surface, whenever this body is at zero incidence; otherwise MK1 = 0
	13	MK2		64-66	I3		Sequence number of last box on last panel representing a body surface, whenever this body is at zero incidence; otherwise MK2 = 0. Note that panels on body surfaces need not be input last
	14	N1, NPR1		67	I1	MAIN	Print flag for solutions; N1 = 1 means all solutions are printed, N1 = 0 means no print. Usual setting is N1 = 0

CARD NO.	ITEM NO.	MNEMONIC	SYMBOL	CARD COLUMN	FIELD	SOURCE	DESCRIPTION
2	15	N2, NPR2		68	I1	MAIN	Control flag for pressures and generalized forces. N2 = 0 means no pressures and no generalized forces; N2 = 1 means pressures printed, and generalized forces computed according to AGAKD definition; N2 = 2 means pressures and conventional generalized forces - see Sec. 5.11.1
	16	N3		69	I1		Data flag; N3 = 1 means DT matrix print; N3 = 0 means no print. Usually N3 = 0
	17	N4		70	I1		Detail print flag for subroutines RDMODE, SB, WANDWT and BFM; N4 = 0 means no print; N4 = 1 means detail print in subroutine BFM only; N4 = 2 means detail print in all four subroutines. Usually N4 = 0
3	18	FREQ(10)	k_r	1-60	6F10.0		Array of reduced frequencies $k_r = \frac{\omega \bar{c}}{2U_\infty}$

CARD NO.	ITEM NO.	MNEMONIC	SYMBOL	CARD COLUMN	FIELD	SOURCE	DESCRIPTION
4	19	X1	X_1	1-60	6F10.0		Panel edge coordinates (X_1, Y_1, Z_1) - inboard leading edge (X_2, Y_1, Z_1) - inboard trailing edge (X_3, Y_2, Z_2) - outboard leading edge (X_4, Y_2, Z_2) - outboard trailing edge
	20	X2	X_2				
	21	X3	X_3				
	22	X4	X_4				
	23	Y1	Y_1				
	24	Y2	Y_2				
5	25	Z1	Z_1	1-20	2F10.0	DATA	
	26	Z2	Z_2				
	27	NC	nc	21-30	2I10		Number of chordwise divisions for panel Number of spanwise divisions for panel
	28	NS	ns	31-40			
	29	NAB(10)		41-60	10I2		Associated bodies; a max. of six per panel
6	30	TH(50)	θ_i	1-60	6F10.0		Fractional chordwise divisions for panel. Usually varies from 0 at leading edge to 1.0 at trailing edge
7	31	TAU(50)	τ_j	1-60	6F10.0		Fractional spanwise divisions for panel. Usually varies from 0 at inboard edge to 1.0 at outboard edge

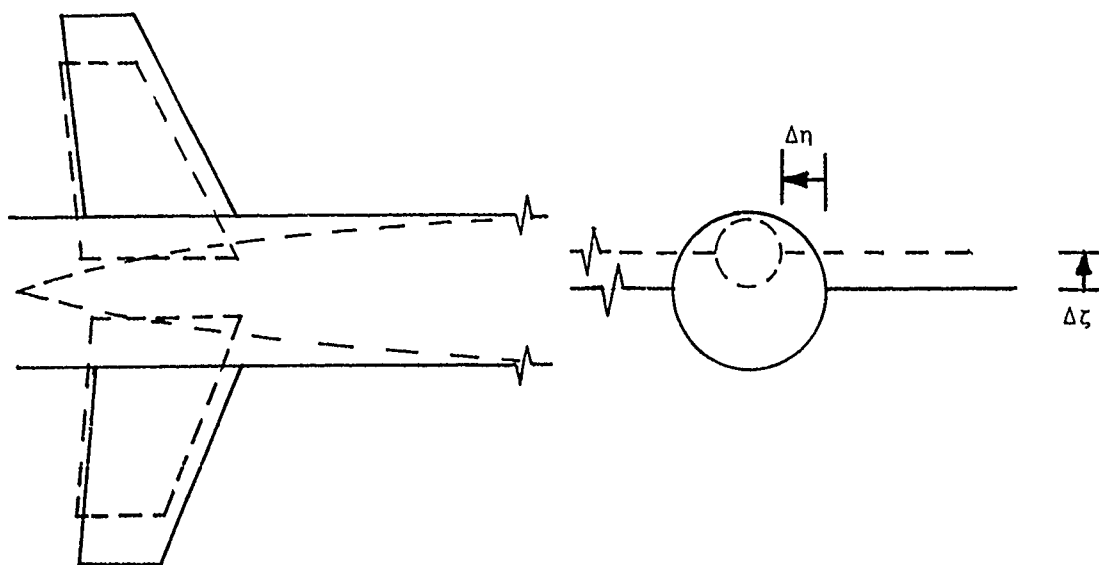
Repeat Items #19 through 31 for all panels

CARD	ITEM	MNEMONIC	SYMBOL	CARD COLUMN	FIELD	SOURCE	DESCRIPTION
8	32	ZC	z_c	1-10	4F10.0	DATA	$\left. \begin{array}{l} \text{z-coordinate} \\ \text{y-coordinate} \end{array} \right\} \text{ of body axis}$
	33	YC	y_c	11-20			
	34	RAD	a	21-30			Average characteristic semi-width of body
	35	AR	AR	31-40			Cross-sectional aspect ratio of body
	36	NBE		41-43	2I3		$\left. \begin{array}{l} \text{Number of interference} \\ \text{Number of slender} \end{array} \right\} \text{ body elements}$
	37	NSBE		44-46			
	38	NZY		47-48	I2		NZY=1 - z-oriented body NZY=2 - z-and y-oriented NZY=3 - y-oriented body Input bodies in this order, i.e. z-oriented bodies first, then z-and y-, then y- bodies
	39	NRI		49-50	I2		Interference 'radius' flag; NRI = 1 - RI - array is input (see below); NRI = 0 - RI-array is not input, but rather is taken as 'a', i.e. $RI_i=a$ for all $i = 1, NBE$
	40	NRS		51-52	I2		Slender body 'radius' flag; NRS=1 - RS-array is input (see below) NRS=0 - RS-array is not input; instead, $RS_i=a$, all $i = 1, NSBE$

CARD NO.	ITEM NO.	MNEMONIC	SYMBOL	CARD COLUMN	FIELD	SOURCE	DESCRIPTION
8	41	NSH		53-54	I2	DATA	Number of $\Delta\eta$ - $\Delta\zeta$ pairs for body - see Items #51 - 53
	42	NT1	$N\theta_1$	55-56	I2		Number of elements in the θ_1 -array - see item #48
	43	NT2	$N\theta_2$	57-58	I2		Number of elements in the θ_2 -array - see item #49. Note that, if $NT2=0$, the θ_2 -array is not input
9	44	XII(100)	ξI_i	1-60	6F10.0		x-coordinates of Average characteristic semi-widths of interference* body element endpoint; $i=1, (NBE+1)$ Omit RI if NRI = 0
10	45	RI(100)	RI_i	1-60	6F10.0		
11	46	XIS(100)	ξS_i	1-60	6F10.0		x-coordinates of Average characteristic semi-widths of Slender body element endpoints; $i+1, (NSBE+1)$ Omit RS if NRS = 0
12	47	RS(100)	RS_i	1-60	6F10.0		

* Omit Items #44 and 45 if NBE = 0

CARD NO.	ITEM NO.	MNEMONIC	SYMBOL	CARD COLUMN	FIELD	SOURCE	DESCRIPTION
16	51	NCD1		1-10	I10		Panel member for $\Delta\eta$, $\Delta\zeta$ pair
	52	CD2	$\Delta\eta_i$	11-20	2F10.0		y-shift of panel, first set
	53	CD3	$\Delta\zeta_i$	21-30		DATA	z shift
		NCD4		31-40	I10		
		CD5	$\Delta\eta_{i+1}$	41-50	2F10.0		Another set of the above three items.
		CD6	$\Delta\zeta_{i+1}$	51-60			Repeat for all $i = 1, NSH$



Omit Items #51-53 if
NSH = 0

Repeat Items #32 through
53 for all bodies; omit
same if there are no
bodies for case.

CARD NO.	ITEM NO.	MNEMONIC	SYMBOL	CARD COLUMN	FIELD	SOURCE	DESCRIPTION
17	54	AZ	AZ	1-2	I2	RDMODE	Punch 'AZ' in cc 1-2 of all modal data cards for z-oriented bodies
	55	q	NQ	3-4 23-24 43-44	I2		Mode number first set for the second of third modal data
	56	r	NRZ	5-7 25-27 45-47	I3		Body number first second value third
	57	n	N	8 28 48	I1		Power of $x/\bar{c}$ first in the mode second value polynomial third
	58	$az_{qn}^{(b)}$		11-20 31-40 51-60	F10.0		Coefficient first of $(x/\bar{c})^n$ in second value the mode third polynomial
18	59	AY	AY	1-2	I2		Punch 'AY' in cc 1-2 of all modal data cards for y-oriented bodies
	60	q					As Items #55-58, but now for y-oriented bodies
	61	r					
	62	n					
	63	$ay_{qn}^{(b)}$					Omit cards #17-18 if NB=0 Omit card #17 if NBZ=0 Omit card #18 if NBY=0 Punch 'A' in cc 1 of all modal data cards for panels
	64	A	A	1	I1		

CARD NO.	ITEM NO.	MNEMONIC	SYMBOL	CARD COLUMN	FIELD	SOURCE	DESCRIPTION			
19	65	NQ	q	3-4 23-24 43-44	I2		Mode number for the <table><tr><td>first</td><td>second</td><td>third</td></tr></table> set of modal data	first	second	third
	first	second	third							
	66	NRP	p	5-7 25-27 45-47	I2		Panel number - 3 sets			
	67	M	m	8 28 48	I1		Power of $\bar{y}/\bar{c}$ in the mode polynomial, where $\bar{y}$ is a 'spanwise' coordinate along the lifting surface, e.g., for fins $\bar{y} = z$			
	68	N	n	9 29 49	I1	RDMODE	Power of $x/\bar{c}$ in the mode polynomial			
69	N8	N8	10 30 50	I1		Flag that sets the origin of the spanwise coordinate $\bar{y}$. N8=0 means origin of coordinates; N8=1 means inboard edge of panel. See Sec. 5.4.1 (Sub-routine RDMODE) for details.				
	70		$a_{qmn}^{(p)}$	11-20 31-40 51-60	F10.0		Coefficient of $(x/\bar{c})^n(\bar{y}/\bar{c})^m$ in the mode polynomial			

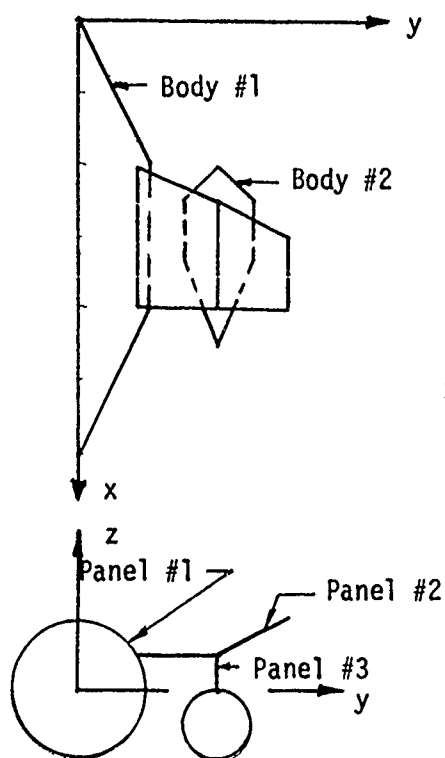
CARD NO.	ITEM NO.	MNEMONIC	SYMBOL	CARD COLUMN	FIELD	SOURCE	DESCRIPTION
20	71	-1	-1	1-2	I2	RDMODE	Punch '-1' in cc 1-2 of card following last modal data card for case

Note that only the nonzero coefficients need to be input; each of the cards #17, 18 and 19 accommodate 3 sets of modal data.

If $NK > 1$, the modal data cards #17-20 have to be repeated for each reduced frequency, i.e., input these NK times.

2.3 Example Case Input Sheets

The following case is to be viewed only as an example of the proper input procedure and not as an optimum idealization. The configuration is shown in Sketch 2.3-1.



SKETCH 2.3-1

$$\begin{aligned}
 k_r &= 0.5 \\
 M &= 0.85 \\
 A &= 6.4 \\
 S &= 3.0 \\
 \bar{c} &= 1.5 \\
 XM &= 2.0 \\
 \delta &= 1 \\
 \epsilon &= 0
 \end{aligned}$$

The configuration consists of 3 panels and 2 bodies. The panels are given as follows:

$$\begin{aligned}
 (1) \quad & X_1 = 2.0 & X_2 = 4.0 & X_3 = 2.5 & X_4 = 4.0 \\
 & Y_1 = 0.86603 & Y_2 = 2.0 & Z_1 = 0.5 & Z_2 = 0.5 \\
 & \theta = 0.0, 0.5, 1.0 & \text{and} & \tau = 0.0, 0.5, 1.0
 \end{aligned}$$

Associated body is body #1.

$$\begin{aligned}
 (2) \quad & X_1 = 2.5 & X_2 = 4.0 & X_3 = 3.0 & X_4 = 4.0 \\
 & Y_1 = 2.0 & Y_2 = 3.0 & Z_1 = .05 & Z_2 = 1.0 \\
 & \theta = 0.0, 0.5, 1.0 & \text{and} & \tau = 0.0, 0.5, 1.0
 \end{aligned}$$

Panel #2 has no associated bodies.

$$\begin{aligned}
 (3) \quad & X_1 = 2.5 & X_2 = 4.0 & X_3 = 2.5 & X_4 = 4.0 \\
 & Y_1 = 2.0 & Y_2 = 2.0 & Z_1 = 0.5 & Z_2 = 0.0 \\
 & \theta = 0.0, 0.5, 1.0 & \text{and} & \tau = 0.0, 1.0
 \end{aligned}$$

Associated body is body #2.

The body data is as follows:

Body #1 is z-oriented with $Z_C = 0.0$, $Y_C = 0.0$ and is divided into 3 interference elements and 5 slender body elements with end points

$$\xi I = 0.0, \quad 2.0, \quad 4.0, \quad 6.0$$

$$\xi S = 0.0, \quad 1.0, \quad 2.0, \quad 4.0, \quad 5.0, \quad 6.0$$

The interference body radius is $a = 1.0$, and the array of the slender body element radii is

$$RS = 0.0, \quad 0.5, \quad 1.0, \quad 1.0, \quad 0.5, \quad 0.0.$$

The second element of the interference body has θ_1 distribution on its surface, while the other elements have θ_2 distribution:

$$\theta_1 = 0, \quad 60, \quad 120, \quad 180, \quad 240, \quad 300$$

$$\theta_2 = 0, \quad 90, \quad 180, \quad 270.$$

Body #2 is both z- and y-oriented with $Z_c = -0.5$ and $Y_c = 2.0$. The element endpoints are defined by

$$\xi I = 2.0, \quad 2.5, \quad 3.25, \quad 4.0, \quad 4.5$$

$$\xi S = 2.0, \quad 2.25, \quad 2.5, \quad 3.25, \quad 4.0$$

The interference body radius is 0.5 and the slender body radii are given by the array

$$RS = 0.0, \quad 0.25, \quad 0.5, \quad 0.0$$

All interference elements of body #2 have θ_1 distribution:

$$\theta_1 = 45, \quad 135, \quad 225, \quad 315.$$

The configuration is given three modes of motion:

Mode #1 is a plunging motion. The coefficients of motion are given by $a_{00}^{(p)} = \cos \gamma$ for all panels p, where γ = dihedral angle of panel, and $az_0^{(b)} = 1.0$ for bodies with z-orientation.

Mode #2 is a pitching motion. The coefficients are $a_{01}^{(p)} = \cos \gamma$ for all panels p, and $az_1^{(b)} = 1.0$ for the z-bodies.

Mode #3 is a rolling motion. The coefficients are $a_{00}^{(p)} = (Y_1 \cos \gamma + Z_1 \sin \gamma)/\bar{c}$ and $a_{10}^{(p)} = 1.0$ for all panels p. Body #1 has no motion in this mode while body #2 has two modal coefficients $az_0^{(2)} = 2.0/\bar{c}$ and $ay_0^{(2)} = 0.5/\bar{c}$.

The input sheets are shown on the next several pages, while the output for the case is found on the subsequent pages.

[illegible]

[illegible]

2.4 Example Case Output

N5KA EXAMPLE CASE

** ARRAY OF REDUCED FREQUENCIES **

0.500000

REFERENCE CHORD = 1.50000
 REFERENCE SEMI-SPAN = 1.00000
 REFERENCE AREA = 0.40000
 MACH NUMBER = 0.35000
 MOMENT AXIS = 2.00000
 SYMMETRY FLAGS ** DELTA = 1 EPSILON = 0
 NUMBER OF PANELS = 3
 NUMBER OF BODIES = 2

** PANEL NO. 1 INPUT VALUES **

X1 = 2.000000 X2 = 4.000000 Y1 = 0.866030 Z1 = 0.500000
 X3 = 2.500000 X4 = 4.000000 Y2 = 2.000000 Z2 = 0.500000
 NC = 2 NS = 2

ASSOCIATED BODIES = 1 0 0 0 0 0

3 CHORDWISE DIVISIONS FOR PANEL 1

0.0 0.50000000E 00 0.10000000E 01

3 SPANWISE DIVISIONS FOR PANEL 1

0.0 0.50000000E 00 0.10000000E 01

** PANEL NO. 2 INPUT VALUES **

X1 = 2.500000 X2 = 4.000000 Y1 = 2.000000 Z1 = 0.500000
 X3 = 3.000000 X4 = 4.000000 Y2 = 3.000000 Z2 = 1.000000
 NC = 2 NS = 2

ASSOCIATED BODIES = 0 0 0 0 0 0

3 CHORDWISE DIVISIONS FOR PANEL 2

0.0 0.50000000E 00 0.10000000E 01

3 SPANWISE DIVISIONS FOR PANEL 2

0.0 0.50000000E 00 0.10000000E 01

** PANEL NO. 3 INPUT VALUES **

X1 = 2.500000 X2 = 4.000000 Y1 = 2.000000 Z1 = 0.500000
 X3 = 2.500000 X4 = 4.000000 Y2 = 2.000000 Z2 = 0.0
 NC = 2 NS = 1

ASSOCIATED BODIES = 2 0 0 0 0 0

3 CHORDWISE DIVISIONS FOR PANEL 3

0.0 0.50000000E 00 0.10000000E 01

2 SPANWISE DIVISIONS FOR PANEL 3

0.0 0.10000000E 01

** SUMMARY OF PANEL DATA **

PANEL	NC	NS	NB-ARRAY	DIRECTIONAL ANGLE	NO. OF ASSOC. BODIES	LIST OF ASSOCIATED BODIES
1	2	2	4	0.0	1	1
2	2	2	8	26.56505	0	2
3	2	1	10	270.00000	1	2

** GEOMETRY ARRAYS FOR ALL PANELS **

PANEL NO.	STRIP NO.	BOX NO.	3/4 CHORD X	1/4 CHORD INBOARD	X-COORDINATES CENTER	OUTBOARD	BOX CHORD DELTA-X	1/4 CHORD SWEEP ANGLE
1	1	1	2.82813	2.25000	2.35938	2.46875	0.93750	0.36822
1	1	2	3.76563	3.25000	3.29688	3.34375	0.93750	0.16387
1	2	3	2.98438	2.46875	2.57813	2.68750	0.81250	0.36822
1	2	4	3.79688	3.34375	3.39063	3.43750	0.81250	0.16387
2	3	5	3.14063	2.68750	2.79688	2.90625	0.68750	0.37299
2	3	6	3.82813	3.43750	3.48438	3.53125	0.68750	0.16616
2	4	7	3.29688	2.90625	3.01563	3.12500	0.56250	0.37299
2	4	8	3.85938	3.53125	3.57813	3.62500	0.56250	0.16616
3	5	9	3.06250	2.68750	2.68750	2.68750	0.75000	0.0
3	5	10	3.81250	3.43750	3.43750	3.43750	0.75000	0.0

STRIP NO.	Y	Z	DELTA-Y	DELTA-Z	F	CHORD	X-L.F.
1	1.14952	0.50000	0.56698	0.0	0.24349	1.87500	2.12500
2	1.71651	0.50000	0.56698	0.0	0.28349	1.62500	2.37500
3	2.25000	0.62500	0.50000	0.25000	0.27951	1.37500	2.62500
4	2.75000	0.87500	0.50000	0.25000	0.27951	1.12500	2.87500
5	2.00000	0.25000	0.0	-0.50000	0.25000	1.50000	2.50000

** BODY NO. 1 INPUT VALUES **
 CENTER OF BODY COORDINATES Y = 0.0 Z = 0.0
 AVERAGE HALF-WIDTH OF BODY = 1.000000
 CROSS-SECTIONAL ASPECT RATIO = 1.000000
 NUMBER OF INTERFERENCE ELEMENTS ON BODY = 3
 NUMBER OF SLENDER BODY ELEMENTS = 5
 Z-Y ORIENTATION FLAG = 1
 RI-FLAG = 0 R-S FLAG = 1
 NUMBER OF DELTA-ETA DELTA-ZETA PAIRS = 0

4 XI-1 ELEMENTS FOR BODY 1

0.0 0.2000000E 01 0.4000000E 01 0.6000000E 01

4 R-1 ELEMENTS FOR BODY 1

0.1000000E 01 0.1000000E 01 0.1000000E 01 0.1000000E 01

6 XI-5 ELEMENTS FOR BODY 1

0.0 0.1000000E 01 0.2000000E 01 0.4000000E 01 0.5000000E 01 0.6000000E 01

6 R-5 ELEMENTS FOR BODY 1

0.0 0.5000000E 00 0.1000000E 01 0.1000000E 01 0.5000000E 00 0.0

6 THETA-1 ELEMENTS FOR BODY 1

0.0 0.6000000E 02 0.1200000E 03 0.1800000E 03 0.2400000E 03 0.3000000E 03

4 THETA-2 ELEMENTS FOR BODY 1

0.0 0.9000000E 02 0.1800000E 03 0.2700000E 03

THE FIRST AND LAST BODY ELEMENTS FOR THETA-1 IN BODY 1

2 2 0 0 0

** BODY NO. 2 INPUT VALUES **
 CENTER OF BODY COORDINATES Y = 2.000000 Z = -0.500000
 AVERAGE HALF-WIDTH OF BODY = 0.500000
 CROSS-SECTIONAL ASPECT RATIO = 1.000000
 NUMBER OF INTERFERENCE ELEMENTS ON BODY = 4
 NUMBER OF SLENDER BODY ELEMENTS = 4
 Z-Y ORIENTATION FLAG = 2
 PI-FLAG = 0 R-S FLAG = 1
 NUMBER OF DELTA-ETA DELTA-ZETA PAIRS = 0

5 XI-I ELEMENTS FOR BODY 2

0.20000000E 01 0.25000000E 01 0.32500000E 01 0.40000000E 01 0.45000000E 01

5 R-I ELEMENTS FOR BODY 2

0.50000000E 00 0.50000000E 00 0.50000000E 00 0.50000000E 00 0.50000000E 00

5 XI-S ELEMENTS FOR BODY 2

0.20000000E 01 0.22500000E 01 0.25000000E 01 0.32500000E 01 0.45000000E 01

5 R-S ELEMENTS FOR BODY 2

0.0 0.25000000E 00 0.50000000E 00 0.50000000E 00 0.0

4 THETA-I ELEMENTS FOR BODY 2

0.45000000E 02 0.13500000E 03 0.22500000E 03 0.31500000E 03

THE FIRST AND LAST BODY ELEMENTS FOR THETA-I ON BODY 2

1 4 0 0 0 0

** RECEIVING POINT ARRAYS X, Y, Z, GAMMA **

0.28281250E 01	0.37656250E 01	0.29843750E 01	0.37968750E 01	0.31406250E 01	0.38281250E 01
0.32968750E 01	0.38593750E 01	0.30625000E 01	0.38125000E 01	0.10000000E 01	0.30000000E 01
0.50000000E 01	0.22500000E 01	0.28750000E 01	0.36250000E 01	0.42500000E 01	
0.11495218E 01	0.17165000E 01	0.22500000E 01	0.27500000E 01	0.20000000E 01	0.0
0.20000000E 01					
0.50000000E 00	0.50000000E 00	0.62500000E 00	0.87500000E 00	0.25000000E 00	0.0
-0.50000000E 00					
0.0	0.0	0.46364743E 00	0.46364743E 00	0.47127871E 01	0.0
0.0					

** SENDING POINT ARRAYS X11, X12, A0, A0-PRIME **

0.0	0.10000000E 01	0.20000000E 01	0.40000000E 01	0.50000000E 01	0.20000000E 01
0.22500000E 01	0.25000000E 01	0.32500000E 01			
0.10000000E 01	0.20000000E 01	0.40000000E 01	0.50000000E 01	0.60000000E 01	0.22500000E 01
0.25000000E 01	0.32500000E 01	0.45000000E 01			
0.25000000E 00	0.75000000E 00	0.10000000E 01	0.75000000E 00	0.25000000E 00	0.12500000E 00
0.17500000E 00	0.50000000E 00	0.75000000E 00			
0.50000000E 00	0.50000000E 00	0.0	-0.50000000E 00	-0.50000000E 00	0.10000000E 01
0.10000000E 01	0.0	-0.39999998E 00			

EXECUTION TIME(MINUTES)
CPU 0.0067
I/O 0.0186
TOTAL 0.0253

EXECUTION TIME(MINUTES)
CPU 0.0
I/O 0.0
TOTAL 0.0

EXECUTION TIME(MINUTES)
CPU 0.3162
I/O 0.0351
TOTAL 0.3512

INPUT MODAL DATA FOR -- A --
 1001000 1.0000 1002000 0.8660 2001010 1.0000 2002010 0.8660
 3001001 0.5774 3001101 1.0000 3002001 1.3214 3002101 1.0000
 3003001 -0.3333 3003101 1.0000

INPUT MODAL DATA FOR -- A7 --
 1001000 1.0000 1002000 1.0000 2001100 1.0000 2002100 1.0000
 3002000 1.6667

INPUT MODAL DATA FOR -- AY --
 3002000 0.3333

EXECUTION TIME(MINUTES)
 CPU 0.0000
 I/O 0.0062
 TOTAL 0.0062

EXECUTION TIME(MINUTES)
 CPU 0.0
 I/O 0.0
 TOTAL 0.0

CALCULATION OF DZ AND DY. N = 21 NM = 3 NTYS = 9 NTYS = 4
 MAX. CORE NEEDED = 320 CORE AVAIL. = 10000

ALL CALCULATIONS DONE IN CORE.

MODE - 1
 NTYS - 9
 NTYS - 4
 U-Z, U-Y, CP-Z*DELTA-A, CP-Y*DELTA-A

0.0	0.7854E 00	0.0	0.7069E 01	0.0	0.1257E 02
0.0	0.7069E 01	0.0	0.7854E 00	0.0	0.1963E 00
0.0	0.1767E 01	0.0	0.3142E 01	0.0	0.7854E 00
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	-0.5236E 00	0.3142E 01	-0.4712E 01	0.9425E 01
-0.1676E 02	0.0	-0.4712E 01	-0.9425E 01	-0.5236E 00	-0.3142E 01
-0.3272E-01	0.7854E 00	-0.2945E 00	0.2356E 01	-0.1571E 01	0.0
-0.6545E 00	-0.3142E 01	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0

MODE - 2
 NTYS - 9
 NTYS - 4
 U-Z, U-Y, CP-Z*DELTA-A, CP-Y*DELTA-A

0.7854E 00	0.2618E 00	0.7069E 01	0.7069E 01	0.1257E 02	0.2513E 02
0.7069E 01	0.2121E 02	0.7854E 00	0.2880E 01	0.1963E 00	0.2782E 00
0.1767E 01	0.2798E 01	0.3142E 01	0.6021E 01	0.7854E 00	0.2029E 01
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.2967E 01	0.2094E 01	0.4712E 01	0.1885E 02
-0.3351E 02	0.3351E 02	-0.2356E 02	-0.1885E 02	-0.5061E 01	-0.1047E 02
0.7399E 00	0.1178E 01	0.1890E 01	0.4320E 01	-0.3011E 01	0.3142E 01
-0.4832E 01	-0.6807E 01	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0

MODE - 3
 NTYS - 9
 NTYS - 4
 U-Z, U-Y, CP-Z*DELTA-A, CP-Y*DELTA-A

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.3272E 00
0.0	0.2945E 01	0.0	0.5236E 01	0.0	0.1309E 01
0.0	0.6545E-01	0.0	0.5890E 00	0.0	0.1047E 01
0.0	0.2618E 00	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
-0.5454E-01	0.1309E 01	-0.4909E 00	0.3927E 01	-0.2618E 01	0.0
-0.1091E 01	-0.5236E 01	-0.1091E-01	0.2618E 00	-0.9817E-01	0.7854E 00
-0.5236E 00	0.0	-0.2182E 00	-0.1047E 01	0.0	0.0

COLUMN 1 OF DELTA- W-

1	-0.16765E 00	-0.26775E 00	2	-0.27663E 00	-0.40265E 00
3	-0.17858E 00	0.47632E-01	4	-0.22729E 00	-0.17359E 00
5	-0.16776E 00	0.19570E-01	6	-0.19306E 00	-0.10716E 00
7	-0.12543E 00	-0.63007E-02	8	-0.14421E 00	-0.46031E-01
9	0.21474E 01	0.56584E-01	10	0.27743E-01	0.76273E-01
11	0.75136E-02	-0.13743E-01	12	-0.77854E-01	-0.40619E-01
13	-0.19596E-02	-0.38105E-01	14	-0.12996E 00	-0.10007E 00
15	-0.10968E 00	-0.10643E 00	16	-0.17229E 00	-0.11741E 00
17	-0.17035E 00	-0.18190E 00	18	-0.20427E-01	-0.12301E 00
19	-0.13418E-01	-0.10852E 00	20	-0.44763E-01	-0.12254E 00
21	-0.91678E-02	-0.13222E 00			

COLUMN 2 OF DELTA- W-

1	-0.59579E 00	-0.29402E 00	2	-0.10651E 01	-0.45037E 00
3	-0.28245E 00	0.32520E 00	4	-0.69030E 00	-0.05980E-02
5	-0.27637E 00	0.25650E 00	6	-0.50948E 00	0.58693E-01
7	-0.22315E 00	0.15608E 00	8	-0.33829E 00	0.11830E 00
9	0.10460E 00	0.80871E-01	10	0.15617E 00	0.12543E 00
11	-0.19271E-02	-0.33447E-01	12	-0.18143E 00	0.56348E-02
13	-0.44642E-01	-0.81319E-01	14	-0.33736E 00	0.27377E-02
15	-0.30299E 00	-0.57571E-01	16	-0.47061E 00	0.14893E-01
17	-0.60529E 00	-0.16253E 00	18	-0.18410E 00	-0.18497E 00
19	-0.14730E 00	-0.18584E 00	20	-0.24727E 00	-0.19016E 00
21	-0.19684E 00	-0.29960E 00			

COLUMN 3 OF DELTA- W-

1	-0.77452E-01	0.78302E-01	2	-0.67830E-01	-0.57944E-01
3	-0.92054E-01	0.72170E 00	4	-0.64814E-01	0.21943E-01
5	-0.84912E-01	0.23316E 00	6	-0.42804E-01	0.09844E-01
7	-0.52960E-01	0.70497E-01	8	-0.37714E-01	0.29099E-01
9	0.81054E-02	-0.13012E 00	10	-0.15097E-01	-0.11022E 00
11	0.12523E-01	-0.22905E-01	12	-0.12142E 00	-0.67699E-01
13	-0.32660E-02	-0.63509E-01	14	0.12716E-01	0.96548E-02
15	-0.29452E-02	0.18996E-01	16	-0.17280E-01	0.10752E-01
17	-0.19371E-01	0.14849E-02	18	0.13709E-01	0.33783E-02
19	0.11211E-01	0.64860E-02	20	0.13454E-01	0.10831E-01
21	0.97084E-02	0.17423E-01			

EXECUTION TIME(MINUTES)

CPU 0.0754

I/O 0.0404

TOTAL 0.1158

ABSOLUTE COORDINATES USED FOR PANEL 1.

ABSOLUTE COORDINATES USED FOR PANEL 2.

W FOR MODE 1

0.0	0.1000E 01	0.0	0.1000E 01	0.0	0.1000E 01
0.0	0.1000E 01	0.0	0.9660E 00	0.0	0.8660E 00
0.0	0.8660E 00	0.0	0.8660E 00	0.0	0.0
0.0	0.0				

--WT-- FOR MODE 1

0.1676E 00	0.1267E 01	0.2766E 00	0.1403E 01	0.1706E 00	0.9530E 00
0.2273E 00	0.1114E 01	0.1628E 00	0.8405E 00	0.1831E 00	0.9732E 00
0.1252E 00	0.8723E 00	0.1442E 00	0.9121E 00	-0.2147E-01	-0.5658E-01
-0.2776E-01	-0.7622E-01	-0.7514E-02	0.1374E-01	0.7285E-01	0.4062E-01
0.1960E-02	0.3811E-01	0.1300E 00	0.1010E 00	0.1097E 00	0.1064E 00
0.1723E 00	0.1174E 00	0.1703E 00	0.1819E 00	0.2043E-01	0.1230E 00
0.1347E-01	0.1025E 00	0.4476E-01	0.1225E 00	0.9168E-02	0.1322E 00
ABSOLUTE COORDINATES USED FOR PANEL	1.				
ABSOLUTE COORDINATES USED FOR PANEL	2.				

W FOR MODE 2

0.1000E 01	0.1885E 01	0.1000E 01	0.2510E 01	0.1000E 01	0.1990E 01
0.1000E 01	0.2531E 01	0.8660E 00	0.1813E 01	0.8660E 00	0.2210E 01
0.8660E 00	0.1903E 01	0.8660E 00	0.2228E 01	0.0	0.0
0.0	0.0				

--WT-- FOR MODE 2

0.1596E 01	0.2179E 01	0.2065E 01	0.2961E 01	0.1282E 01	0.1664E 01
0.1690E 01	0.2540E 01	0.1142E 01	0.1557E 01	0.1376E 01	0.2151E 01
0.1089E 01	0.1747E 01	0.1204E 01	0.2110E 01	0.1046E 00	-0.8087E-01
-0.1561E 00	-0.1254E 00	0.1927E-02	0.3345E-01	0.1814E 00	-0.5635E-02
0.4464E-01	0.8132E-01	0.3374E 00	-0.2773E-02	0.3030E 00	0.5757E-01
0.4706E 00	-0.1489E-01	0.6053E 00	0.1625E 00	0.1841E 00	0.1850E 00
0.1473E 00	0.1859E 00	0.2473E 00	0.1902E 00	0.1968E 00	0.2996E 00

RELATIVE COORDINATES USED FOR PANEL 1.
RELATIVE COORDINATES USED FOR PANEL 2.
RELATIVE COORDINATES USED FOR PANEL 3.

W FOR MODE 3

0.0	0.7663E 00	0.0	0.7663E 00	0.0	0.1144E 01
0.0	0.1144E 01	0.0	0.1508E 01	0.0	0.1508E 01
0.0	0.1880E 01	0.0	0.1880E 01	0.0	-0.1667E 00
0.0	-0.1667E 00				

--WT-- FOR MODE 3

0.7745E-01	0.6880E 00	0.6783E-01	0.8243E 00	0.9205E-01	0.8226E 00
0.6481E-01	0.1122E 01	0.8491E-01	0.1275E 01	0.4280E-01	0.1438E 01
0.5296E-01	0.1810E 01	0.3771E-01	0.1851E 01	-0.8105E-02	-0.3655E-01
0.1510E-01	-0.5644E-01	-0.1252E-01	0.2291E-01	0.1214E 00	0.6770E-01
0.3266E-02	0.6351E-01	-0.1272E-01	-0.9655E-02	0.2945E-02	-0.1900E-01
0.1728E-01	-0.1075E-01	0.1937E-01	-0.1485E-02	-0.1321E-01	-0.3978E-02
-0.1121E-01	-0.6486E-02	-0.1345E-01	-0.1083E-01	-0.9708E-02	-0.1742E-01

EXECUTION TIME(MINUTES)
CPU 0.0133
I/O 0.0106
TOTAL 0.0240

EXECUTION TIME(MINUTES)
CPU 0.0111
I/O 0.0133
TOTAL 0.0244

COLUMN NO. 1 OF GAMMAS FOLLOWS

0.19665623E 01	0.42423382E 01	-0.11037083E 01	0.46211680E 01	0.26930857E 01	0.48133154E 01
-0.17455091E 01	0.49378624E 01	0.18580713E 01	0.43687847E 01	-0.10078661E 01	0.30424414E 01
0.16448707E 01	0.43148623E 01	-0.14925518E 01	0.19979200E 01	0.13595405E 01	0.10761557E 01
-0.76321185E 01	0.16339111E 01	0.57397359E 01	0.15478647E 00	0.64442226E 00	-0.33000479E 01
-0.54306471E 00	-0.96502858E 00	0.30278474E 00	0.16926819E 00	-0.44599447E 00	-0.56636047E 00
0.41055709E 00	-0.86979937E 00	-0.12179962E 00	-0.16611433E 00	0.34147331E 00	0.40218151E 00
0.10244246E 01	0.94769959E 00	0.13733473E 01	0.15877180E 01	0.14319002E 01	0.99667245E 00

COLUMN NO. 2 OF GAMMAS FOLLOWS

0.83234043E 01	0.55460453E 01	0.36448412E 01	0.12989089E 02	0.16454334E 02	0.62213135E 01
0.24164743E 01	0.14484083E 02	0.34354034E 01	0.69312430E 01	-0.34786558E 00	0.10142633E 02
0.79701028E 01	0.73800545E 01	-0.97627325E 00	0.72473288E 01	0.37644078E 01	0.34082592E 00
0.20209637E 01	0.39445601E 01	0.29087279E 00	0.11433595E 00	-0.34475050E 01	-0.75162716E 01
-0.74493293E 01	-0.19528704E 01	0.65337712E 00	-0.14427942E 00	-0.72344648E 00	-0.12275944E 01
-0.10911363E 00	-0.28704632E 01	-0.31925070E 00	-0.55605429E 00	0.15817321E 01	0.29040349E 00
0.79690113E 01	0.55575371E 00	0.47090960E 01	0.19422626E 01	0.47681456E 01	0.82420814E 00

COLUMN NO. 3 OF GAMMAS FOLLOWS

0.17746496E 01	0.27028809E 01	-0.95816278E 00	0.40935907E 01	0.21796160E 01	0.41750928E 01
-0.21127090E 01	0.47413349E 01	0.16989136E 01	0.62863846E 01	-0.30868311E 01	0.36716051E 01
0.13319178E 01	0.77920647E 01	-0.30928459E 01	0.24183979E 01	0.71831417E 00	-0.43916274E 01
0.19243479E 00	0.84363409E 00	0.85615346E 01	0.19928093E 00	0.15352192E 01	-0.21076336E 01
-0.38684684E 00	-0.39633286E 00	-0.15489656E 00	-0.13395346E 00	-0.25440876E 00	-0.07130507E 00
0.69175780E 01	-0.13086824E 01	-0.44596702E 00	-0.89562064E 00	0.20327300E 00	-0.15731261E 02
0.51055562E 00	0.27052313E 00	0.47117102E 00	0.48530942E 00	0.61559707E 00	0.19583944E 01

THE 21 X 21 MATRIX WITH 3 RIGHT SIDES WAS SOLVED DIRECTLY IN 0.005 MINUTES.

EXECUTION TIME(MINUTES)
 CPU 0.0211
 I/O 0.0146
 TOTAL 0.0357

LOADS ON SLENDER BODY ELEMENTS DUE TO LIFTING SURFACE BOXES.

		FZ		FY		MZ		MY
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.5731E 00	0.7088E 01	0.0	0.0	0.1142E 01	-0.9615E 00	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

LOADS ON SLENDER BODY ELEMENTS DUE TO LIFTING SURFACE BOXES AND INTERFERENCE BODY ELEMENTS.

		FZ		FY		MZ		MY
1	0.2869E-01	0.7739E-01	0.0	0.0	0.0	0.0	0.0	0.0
2	0.2869E-01	0.7739E-01	0.0	0.0	0.0	0.0	0.0	0.0
3	0.5476E 00	0.6812E 01	0.0	0.0	0.1246E 01	-0.9483E 00	0.0	0.0
4	-0.4099E 00	0.7298E 00	0.0	0.0	-0.2773E-01	0.3652E-01	0.0	0.0
5	-0.2940E 00	0.5838E 00	0.0	0.0	0.0	0.0	0.0	0.0

ELEMENT LOADS FOR SLENDER BODY NUMBER 1. MODE NO. 1

		FZ		FY		MZ		MY
1	-0.2331E 00	0.1648E 01	0.0	0.0	0.0	0.0	0.0	0.0
2	-0.2327E 01	0.4790E 01	0.0	0.0	0.0	0.0	0.0	0.0
3	-0.8306E 01	0.7073E 01	0.0	0.0	0.1212E 01	-0.2553E 00	0.0	0.0
4	-0.2819E 01	-0.4243E 01	0.0	0.0	-0.4132E-01	-0.2870E-01	0.0	0.0
5	-0.5598E 00	-0.9870E 00	0.0	0.0	0.0	0.0	0.0	0.0

LOADS ON SLENDER BODY ELEMENTS DUE TO LIFTING SURFACE BOXES.

		FZ		FY		MZ		MY
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.9193E 01	0.1513E 02	0.0	0.0	0.9295E 00	-0.4479E 01	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

LOADS ON SLENDER BODY ELEMENTS DUE TO LIFTING SURFACE BOXES AND INTERFERENCE BODY ELEMENTS.

		FZ		FY		MZ		MY
1	0.1454E 00	0.5717E-01	0.0	0.0	0.0	0.0	0.0	0.0
2	0.1454E 00	0.5717E-01	0.0	0.0	0.0	0.0	0.0	0.0
3	0.8732E 01	0.1435E 02	0.0	0.0	0.1097E 01	-0.4602E 01	0.0	0.0
4	-0.5408E-01	0.1861E 01	0.0	0.0	-0.1091E-01	0.1175E 00	0.0	0.0
5	-0.1046E-01	0.1391E 01	0.0	0.0	0.0	0.0	0.0	0.0

ELEMENT LOADS FOR SLENDER BODY NUMBER 1. MODE NO. 2

		FZ		FY		MZ		MY
1	0.1629E 01	0.1104E 01	0.0	0.0	0.0	0.0	0.0	0.0
2	0.2502E 01	0.9482E 01	0.0	0.0	0.0	0.0	0.0	0.0
3	-0.8704E 01	0.3205E 02	0.0	0.0	0.1774E 01	-0.3216E 01	0.0	0.0
4	-0.1224E 02	-0.8129E 01	0.0	0.0	-0.1112E 00	-0.2379E-01	0.0	0.0
5	-0.2541E 01	-0.3845E 01	0.0	0.0	0.0	0.0	0.0	0.0

LOADS ON SLENDER BODY ELEMENTS DUE TO LIFTING SURFACE BOXES.

	FZ			FY			MZ			MY		
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.1804E 00	0.6356E 01	0.0	0.0	0.0	0.1214E 01	-0.1200E 01	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	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	0.0	0.0	0.0	0.0

LOADS ON SLENDER BODY ELEMENTS DUE TO LIFTING SURFACE BOXES AND INTERFERENCE BODY ELEMENTS.

	FZ			FY			MZ			MY		
1	0.4281E-01	0.9964E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.4281E-01	0.9964E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.1335E-02	0.6022E 01	0.0	0.0	0.0	0.1181E 01	-0.1277E 01	0.0	0.0	0.0	0.0	0.0
4	-0.5875E 00	0.5136E 00	0.0	0.0	0.0	-0.2674E-01	0.2144E-01	0.0	0.0	0.0	0.0	0.0
5	-0.4805E 00	0.4278E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

ELEMENT LOADS FOR SLENDER BODY NUMBER 1. MODE NO. 3

	FZ			FY			MZ			MY		
1	0.4281E-01	0.9964E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.4281E-01	0.9964E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	-0.7913E 00	0.6456E 01	0.0	0.0	0.0	0.1125E 01	-0.1217E 00	0.0	0.0	0.0	0.0	0.0
4	-0.6781E 00	0.7876E-01	0.0	0.0	0.0	-0.4938E-01	-0.8727E-01	0.0	0.0	0.0	0.0	0.0
5	-0.4805E 00	0.4278E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

LOADS ON SLENDER BODY ELEMENTS DUE TO LIFTING SURFACE BOXES.

	FZ			FY			MZ			MY		
1	-0.8696E-03	-0.1876E-02	0.1507E-01	0.3250E-01	0.5435E-04	0.1172E-03	-0.9417E-03	-0.2031E-02	0.0	0.0	0.0	0.0
2	-0.1760E-01	-0.3209E-01	0.4533E-01	0.9217E-01	0.9910E-03	0.1771E-02	-0.9499E-03	-0.1698E-02	0.0	0.0	0.0	0.0
3	-0.1263E 00	-0.2681E 00	0.2013E 00	0.3089E 00	-0.2897E-02	0.5300E-02	0.2062E-01	0.1438E-01	0.0	0.0	0.0	0.0
4	0.9830E-01	-0.2649E 00	-0.5555E-01	0.3871E 00	0.2221E-01	-0.6709E-01	-0.2193E-01	0.9212E-01	0.0	0.0	0.0	0.0

LOADS ON SLENDER BODY ELEMENTS DUE TO LIFTING SURFACE BOXES AND INTERFERENCE BODY ELEMENTS.

	FZ			FY			MZ			MY		
1	0.1519E 00	0.8226E-01	0.1879E 00	0.2358E 00	0.5435E-04	0.1172E-03	-0.9417E-03	-0.2031E-02	0.0	0.0	0.0	0.0
2	0.1352E 00	0.5205E-01	0.2182E 00	0.2954E 00	0.9910E-03	0.1771E-02	-0.9499E-03	-0.1698E-02	0.0	0.0	0.0	0.0
3	-0.1019E 00	-0.5373E 00	0.4617E 00	0.6071E 00	-0.2897E-02	0.5300E-02	0.2062E-01	0.1438E-01	0.0	0.0	0.0	0.0
4	-0.2140E 00	0.2037E 00	0.7197E-01	0.1046E 00	0.1186E 00	-0.1827E 00	-0.6059E-02	0.2040E 00	0.0	0.0	0.0	0.0

ELEMENT LOADS FOR SLENDER BODY NUMBER 2. MODE NO. 1

	FZ			FY			MZ			MY		
1	0.8094E-01	0.4811E 00	0.1587E 00	0.2358E 00	0.5435E-04	0.1172E-03	-0.9417E-03	-0.2031E-02	0.0	0.0	0.0	0.0
2	-0.6873E-01	0.1249E 01	0.1892E 00	0.2954E 00	0.9910E-03	0.1771E-02	-0.9499E-03	-0.1698E-02	0.0	0.0	0.0	0.0
3	-0.1063E 01	-0.5373E 00	0.3748E 00	0.6071E 00	-0.2897E-02	0.5300E-02	0.2062E-01	0.1438E-01	0.0	0.0	0.0	0.0
4	-0.7706E 00	-0.1514E 01	-0.4761E-01	0.3935E-01	0.1007E 00	-0.1369E 00	-0.1557E-01	0.2285E 00	0.0	0.0	0.0	0.0

LOADS ON SLENDER BODY ELEMENTS DUE TO LIFTING SURFACE BOXES.

	FZ	FY	MZ	MY
1	-0.3680E-02	-0.2452E-02	0.6377E-01	0.4249E-01
2	-0.6492E-01	-0.4153E-01	0.1865E-00	0.1201E-00
3	-0.5393E-00	-0.3938E-00	0.7260E-00	0.3489E-00
4	-0.1137E-00	-0.7851E-00	0.4096E-00	0.1012E-01

LOADS ON SLENDER BODY ELEMENTS DUE TO LIFTING SURFACE BOXES AND INTERFERENCE BODY ELEMENTS.

	FZ	FY	MZ	MY
1	0.3236E-00	-0.7907E-01	0.6104E-00	0.1844E-00
2	0.2584E-00	-0.1182E-00	0.7332E-00	0.2660E-00
3	-0.7464E-00	-0.1083E-01	0.1640E-01	0.7629E-00
4	-0.1315E-00	0.5613E-00	0.5082E-00	0.5264E-00

ELEMENT LOADS FOR SLENDER BODY NUMBER 2. MODE NO. 2

	FZ	FY	MZ	MY
1	0.5902E-00	0.6279E-00	0.5525E-00	0.2464E-00
2	0.1109E-01	0.2184E-01	0.6752E-00	0.3240E-00
3	-0.2601E-01	0.4381E-00	0.1466E-01	0.9168E-00
4	-0.3217E-01	-0.2814E-01	0.1712E-00	0.5699E-00

LOADS ON SLENDER BODY ELEMENTS DUE TO LIFTING SURFACE BOXES.

	FZ	FY	MZ	MY
1	-0.7847E-03	-0.1195E-02	0.1360E-01	0.2071E-01
2	-0.1440E-01	-0.2697E-01	0.3940E-01	0.6498E-01
3	-0.1022E-00	-0.2735E-00	0.1241E-00	0.3230E-01
4	0.1360E-00	-0.2694E-00	0.2965E-01	0.2340E-00

LOADS ON SLENDER BODY ELEMENTS DUE TO LIFTING SURFACE BOXES AND INTERFERENCE BODY ELEMENTS.

	FZ	FY	MZ	MY
1	-0.8021E-01	-0.9558E-01	0.1164E-00	0.1939E-01
2	-0.9383E-01	-0.1214E-00	0.1423E-00	0.6366E-01
3	-0.4761E-01	-0.5620E-00	0.1909E-00	0.1544E-00
4	-0.1890E-00	-0.3217E-01	0.1218E-00	-0.6183E-01

ELEMENT LOADS FOR SLENDER BODY NUMBER 3. MODE NO. 3

	FZ	FY	MZ	MY
1	-0.1079E-03	0.5691E-00	0.1109E-00	0.1523E-00
2	-0.3431E-00	0.1873E-01	0.9246E-01	0.4625E-00
3	-0.1377E-01	-0.5620E-00	-0.7495E-01	0.1544E-00
4	-0.7424E-00	-0.2691E-01	0.1101E-01	-0.5436E-00

EXECUTION TIME(MINUTES)

CPU 0.0300
I/O 0.0319
TOTAL 0.0619

MODE NO 1									
STRIP NO.	Y	Z	YOS	LIFT COEFFICIENT		MOMENT COEFFICIENT		CP-X AND CP-Y	
1	1.1495	0.5000	0.3832	0.431427	4.437753	0.329855	-0.601078	-0.51457	0.38574
2	1.7165	0.5000	0.5722	0.473788	4.875587	0.495600	-0.625017	-0.79604	0.37819
3	2.2500	0.6250	0.7500	0.025103	3.705612	0.455104	-0.297408	-17.87962	0.33026
4	2.7500	0.8750	0.9167	0.096159	3.156390	0.385158	-0.104931	-3.75541	0.28374
5	2.0000	0.2500	0.6667	0.441614	1.355033	0.099787	-0.239099	0.09526	0.42645
BODY ELEM.	Y	Z	XOL	LIFT COEFFICIENT		MOMENT COEFFICIENT			
1	0.0	0.0	0.0833	-0.233106	1.648189	0.0	0.0		
1	0.0	0.0	0.0833	0.0	0.0	0.0	0.0		
2	0.0	0.0	0.2500	-2.327499	4.789781	0.0	0.0		
2	0.0	0.0	0.2500	0.0	0.0	0.0	0.0		
3	0.0	0.0	0.5000	-4.152803	3.536185	0.605896	-0.127639		
3	0.0	0.0	0.5000	0.0	0.0	0.0	0.0		
4	0.0	0.0	0.7500	-2.817430	-4.243449	-0.041323	-0.028705		
4	0.0	0.0	0.7500	0.0	0.0	0.0	0.0		
5	0.0	0.0	0.9167	-0.559796	-0.987041	0.0	0.0		
5	0.0	0.0	0.9167	0.0	0.0	0.0	0.0		
BODY ELEM.	Y	Z	XOL	MODIFIED LIFT COEFFICIENTS, Z- AND Y-DIRECTIONS					
1	0.0	0.0	0.0833	1.437844	1.588631	0.0	0.0		
2	0.0	0.0	0.2500	-2.298744	6.563907	0.0	0.0		
3	0.0	0.0	0.5000	-8.822783	12.580199	0.0	0.0		
4	0.0	0.0	0.7500	-6.624901	-4.239579	0.0	0.0		
5	0.0	0.0	0.9167	-1.623070	-2.175775	0.0	0.0		
BODY NO.	Y	Z	X-CENTER	TOTAL LIFT COEFF.		TOTAL MOMENT COEFF.			
1	0.0	0.0	0.0000	-2.225857	1.293789	4.735582	-0.519459		
1	0.0	0.0	0.0000	0.0	0.0	0.0	0.0		
BODY ELEM.	Y	Z	XOL	LIFT COEFFICIENT		MOMENT COEFFICIENT			
6	2.0000	-0.5000	0.0500	0.323774	1.924397	0.000217	0.000469		
6	2.0000	-0.5000	0.0500	0.635755	0.943069	-0.003767	-0.008126		
7	2.0000	-0.5000	0.1500	-0.749799	4.994207	0.003964	0.007085		
7	2.0000	-0.5000	0.1500	0.756814	1.151733	-0.003799	-0.006191		
8	2.0000	-0.5000	0.3500	-1.468093	-0.716422	-0.003862	0.007066		
8	2.0000	-0.5000	0.3500	0.499667	0.809400	0.027492	0.019173		
9	2.0000	-0.5000	0.7500	-0.616455	-1.711128	0.080586	-0.109485		
9	2.0000	-0.5000	0.7500	-0.035064	0.031481	-0.012456	0.182784		
BODY ELEM.	Y	Z	XOL	MODIFIED LIFT COEFFICIENTS, Z- AND Y-DIRECTIONS					
6	2.0000	-0.5000	0.0500	0.740464	2.146836	0.705551	0.560741		
7	2.0000	-0.5000	0.1500	-0.314993	3.342005	0.709525	0.833136		
8	2.0000	-0.5000	0.3500	-2.580956	-0.578183	0.865402	1.410345		
9	2.0000	-0.5000	0.7500	-0.869089	-3.230846	-0.112051	0.158218		
BODY NO.	Y	Z	X-CENTER	TOTAL LIFT COEFF.		TOTAL MOMENT COEFF.			
2	2.0000	-0.5000	0.2500	-0.284574	-0.050246	0.259284	0.276117		
2	2.0000	-0.5000	0.2500	0.105513	0.184000	-0.033990	-0.052717		
CL =		-2.492867	5.420483	CY =		0.0	0.0		
CM =		2.574017	-1.015308	CN =		0.0	0.0		
CSL =		0.0	0.0						

MODE NO 2									
STRIP NO.	Y	Z	YOS	LIFT COEFFICIENT		MOMENT COEFFICIENT		CP-R AND CP-I	
1	1.1495	0.5000	0.3832	5.984121	9.267561	-0.163195	-2.088826	0.27727	0.47539
2	1.7165	0.5000	0.5722	6.435728	10.352689	0.200348	-2.326933	0.21887	0.47477
3	2.2500	0.6250	0.7500	4.043764	8.536767	0.592437	-1.469541	0.10349	0.42202
4	2.7500	0.8750	0.9167	3.496903	7.311690	0.686186	-0.897620	0.05377	0.37273
5	2.0000	0.2500	0.6667	2.892935	2.142693	-0.143624	-0.718103	0.29965	0.58523
BODY ELEM.	Y	Z	XOL	LIFT COEFFICIENT		MOMENT COEFFICIENT			
1	0.0	0.0	0.0833	1.628965	1.104363	0.0	0.0		
1	0.0	0.0	0.0833	0.0	0.0	0.0	0.0		
2	0.0	0.0	0.2500	2.501630	9.481741	0.0	0.0		
2	0.0	0.0	0.2500	0.0	0.0	0.0	0.0		
3	0.0	0.0	0.5000	-4.352225	16.024748	0.887208	-1.607799		
3	0.0	0.0	0.5000	0.0	0.0	0.0	0.0		
4	0.0	0.0	0.7500	-12.276346	-8.129765	-0.111233	-0.073787		
4	0.0	0.0	0.7500	0.0	0.0	0.0	0.0		
5	0.0	0.0	0.9167	-2.541192	-3.845133	0.0	0.0		
5	0.0	0.0	0.9167	0.0	0.0	0.0	0.0		
BODY ELEM.	Y	Z	XOL	MODIFIED LIFT COEFFICIENTS, Z- AND Y-DIRECTIONS					
1	0.0	0.0	0.0833	3.875882	-1.427946	0.0	0.0		
2	0.0	0.0	0.2500	3.660136	10.856790	0.0	0.0		
3	0.0	0.0	0.5000	0.109172	46.399570	0.0	0.0		
4	0.0	0.0	0.7500	-22.057449	-2.866498	0.0	0.0		
5	0.0	0.0	0.9167	-7.123833	-6.340250	0.0	0.0		
BODY NO.	Y	Z	X-CENTER	TOTAL LIFT COEFF.		TOTAL MOMENT COEFF.			
1	0.0	0.0	0.0000	-3.023586	4.790936	9.609210	-5.878701		
1	0.0	0.0	0.0000	0.0	0.0	0.0	0.0		
BODY ELEM.	Y	Z	XOL	LIFT COEFFICIENT		MOMENT COEFFICIENT			
6	2.0000	-0.5000	0.0500	2.360761	2.511539	0.000920	0.000613		
6	2.0000	-0.5000	0.0500	2.209809	0.985413	-0.015943	-0.010623		
7	2.0000	-0.5000	0.1500	4.437428	8.736561	0.015389	0.009157		
7	2.0000	-0.5000	0.1500	2.700893	1.295815	-0.014750	-0.008777		
8	2.0000	-0.5000	0.3500	-3.468510	1.117512	0.001119	0.023807		
8	2.0000	-0.5000	0.3500	1.954647	1.249796	0.070149	-0.008061		
9	2.0000	-0.5000	0.7500	-2.573794	-2.250778	0.049156	-0.340507		
9	2.0000	-0.5000	0.7500	3.136960	0.455902	0.210737	0.455594		
BODY ELEM.	Y	Z	XOL	MODIFIED LIFT COEFFICIENTS, Z- AND Y-DIRECTIONS					
6	2.0000	-0.5000	0.0500	3.423564	2.662498	1.930327	0.205220		
7	2.0000	-0.5000	0.1500	2.955787	6.027204	2.287436	0.718613		
8	2.0000	-0.5000	0.3500	-5.456857	3.166936	3.402420	2.092484		
9	2.0000	-0.5000	0.7500	-7.399488	-5.741770	0.469216	1.369649		
BODY NO.	Y	Z	X-CENTER	TOTAL LIFT COEFF.		TOTAL MOMENT COEFF.			
2	2.0000	-0.5000	3.2500	-0.643606	0.130693	0.821367	0.337447		
2	2.0000	-0.5000	3.2500	0.44715	0.324532	-0.168504	-0.154367		
CT =	1.013682		14.231640	CT =	0.0		0.0		
CM =	4.635420		-5.763388	CM =	0.0		0.0		
CSI =	0.0		0.0						

MODE NO 3									
STRIP NO.	Y	Z	YOS	LIFT COEFFICIENT		MOMENT COEFFICIENT		CP-R AND CP-I	
1	1.1495	0.5000	0.3817	0.408243	3.398235	0.290571	-0.598618	-0.46176	0.42616
2	1.7164	0.5000	0.5722	0.033454	4.458212	0.532358	-0.628056	-15.66328	0.39088
3	2.2597	0.6250	0.7500	-0.693959	4.978993	0.684963	-0.295527	1.23704	0.30935
4	2.7500	0.8750	0.9167	-0.980463	5.105230	0.663153	0.033554	1.00319	0.24343
5	2.9000	0.2500	0.6667	0.455374	0.420309	0.008813	-0.168370	0.23065	0.65059
BODY ELEM.	Y	Z	XOL	LIFT COEFFICIENT		MOMENT COEFFICIENT			
1	0.0	0.0	0.3333	0.042809	0.099640	0.0	0.0		
1	0.0	0.0	0.0333	0.0	0.0	0.0	0.0		
2	0.0	0.0	0.2500	0.042809	0.099640	0.0	0.0		
2	0.0	0.0	0.7500	0.0	0.0	0.0	0.0		
3	0.0	0.0	0.5000	-0.395654	3.228248	0.562377	-0.060363		
3	0.0	0.0	0.5000	0.0	0.0	0.0	0.0		
4	0.0	0.0	0.7500	-0.678054	0.078767	-0.049384	-0.087266		
4	0.0	0.0	0.7500	0.0	0.0	0.0	0.0		
5	0.0	0.0	0.9167	-0.440516	0.427825	0.0	0.0		
5	0.0	0.0	0.9167	0.0	0.0	0.0	0.0		
BODY ELEM.	Y	Z	XOL	MODIFIED LIFT COEFFICIENTS, Z- AND Y-DIRECTIONS					
1	0.0	0.0	0.0333	0.361449	0.043729	0.0	0.0		
2	0.0	0.0	0.2500	-0.630596	-0.051170	0.0	0.0		
3	0.0	0.0	0.5000	1.215433	8.440580	0.0	0.0		
4	0.0	0.0	0.7500	-1.268764	0.836463	0.0	0.0		
5	0.0	0.0	0.9167	-0.812666	0.906177	0.0	0.0		
BODY NO.	Y	Z	X-CENTER	TOTAL LIFT COEFF.		TOTAL MOMENT COEFF.			
1	0.0	0.0	3.0000	-0.291291	1.119119	0.943517	-2.342206		
2	0.0	0.0	3.0000	0.0	0.0	0.0	0.0		
BODY ELEM.	Y	Z	XOL	LIFT COEFFICIENT		MOMENT COEFFICIENT			
6	2.0000	-0.5000	0.0500	-0.431625	2.276594	0.000196	0.000299		
6	2.0000	-0.5000	0.0500	0.443492	0.609356	-0.003399	-0.005177		
7	2.0000	-0.5000	0.1500	-1.372394	7.491276	0.003208	0.006145		
7	2.0000	-0.5000	0.1500	0.369820	1.849773	-0.003075	-0.006890		
8	2.0000	-0.5000	0.3500	-1.836075	-0.749341	-0.003833	0.010936		
8	2.0000	-0.5000	0.3500	-0.099934	0.205834	0.024563	0.027676		
9	2.0000	-0.5000	0.7500	-0.594350	-2.152855	0.096763	-0.118245		
9	2.0000	-0.5000	0.7500	0.008805	-0.474888	-0.017719	0.094607		
BODY ELEM.	Y	Z	XOL	MODIFIED LIFT COEFFICIENTS, Z- AND Y-DIRECTIONS					
6	2.0000	-0.5000	0.0500	0.451001	2.988956	0.572718	0.627555		
7	2.0000	-0.5000	0.1500	-1.039745	4.824802	0.344584	1.192759		
8	2.0000	-0.5000	0.3500	-3.490913	-0.419818	-0.217383	0.532570		
9	2.0000	-0.5000	0.7500	-1.962565	-5.778206	-0.053222	-1.257548		
BODY NO.	Y	Z	X-CENTER	TOTAL LIFT COEFF.		TOTAL MOMENT COEFF.			
2	2.0000	-0.5000	3.2500	-2.401718	-0.126736	0.297814	0.481882		
2	2.0000	-0.5000	3.2500	0.021779	0.027438	-0.000930	0.096011		
CZ =		-1.253331	5.245323	CY =	0.0	0.0			
CM =		1.816684	-2.882576	CN =	0.0	0.0			
CSL =		0.0	0.0						

MODE NO 1								
PANEL NO	STRIP NO	BOX NO	XDC	X	Y	Z	PRESSURES	
1	1	1	0.12500	2.35938	1.14952	0.50000	1.966562	4.242338
1	1	2	0.62500	3.29688	1.14952	0.50000	-1.103708	4.623168
1	2	3	0.12500	2.57813	1.71651	0.50000	2.693086	4.813315
1	2	4	0.62500	3.39063	1.71651	0.50000	-1.745509	4.937862
2	3	5	0.12500	2.79688	2.25000	0.62500	1.858071	4.368785
2	3	6	0.62500	3.48438	2.25000	0.62500	-1.807866	3.042441
2	4	7	0.12500	3.01563	2.75000	0.87500	1.684871	4.314862
2	4	8	0.62500	3.57813	2.75000	0.87500	-1.492552	1.997920
3	5	9	0.12500	2.68750	2.00000	0.25000	1.359550	1.076156
3	5	10	0.62500	3.43750	2.00000	0.25000	-0.076321	1.633911

THE 23 MODIFIED H-ELEMENTS FOR MODE NO. 1					
1.59464	1.59464	1.38202	1.38202	0.99851	0.99851
0.81696	0.81696	0.0	0.0	1.50000	1.50000
1.50000	1.50000	1.50000	3.00000	3.00000	3.00000
3.00000	0.0	0.0	0.0	0.0	

THE 9 MODIFIED DH/DX-ELEMENTS FOR MODE NO. 1					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0			

DEFLECTION MODE	PRESSURE MODE	GENERALIZED FORCES			
		PANELS ONLY		TOTAL	
1	1	0.30132967E 00	0.41844883E 01	-0.24935694E 01	0.53777828E 01
1	2	0.52773800E 01	0.90902803E 01	0.96658516E 00	0.14132598E 02
1	3	-0.14895672E 00	0.43172178E 01	-0.12436838E 01	0.51828642E 01

MODE NO 2								
PANEL NO	STRIP NO	BOX NO	XDC	X	Y	Z	PRESSURES	
1	1	1	0.12500	2.35938	1.14952	0.50000	8.323404	5.546045
1	1	2	0.62500	3.29688	1.14952	0.50000	3.644841	12.989089
1	2	3	0.12500	2.57813	1.71651	0.50000	10.454984	6.221313
1	2	4	0.62500	3.39063	1.71651	0.50000	2.416474	14.484083
2	3	5	0.12500	2.79688	2.25000	0.62500	8.435404	6.931283
2	3	6	0.62500	3.48438	2.25000	0.62500	-0.347866	10.142653
2	4	7	0.12500	3.01563	2.75000	0.87500	7.990103	7.380054
2	4	8	0.62500	3.57813	2.75000	0.87500	-0.996293	7.247329
3	5	9	0.12500	2.68750	2.00000	0.25000	3.764908	0.340826
3	5	10	0.62500	3.43750	2.00000	0.25000	2.020964	3.944560

THE 23 MODIFIED H-ELEMENTS FOR MODE NO. 2

2.50824	3.90489	2.37535	3.12395	1.86180	2.31945
1.64243	1.94179	0.0	0.0	0.50000	1.50000
3.00000	4.50000	5.50000	4.25000	4.75000	5.75000
7.75000	0.0	0.0	0.0	0.0	

THE 9 MODIFIED OH/OX-ELEMENTS FOR MODE NO. 2

1.00000	1.00000	1.00000	1.00000	1.00000	2.00000
2.00000	2.00000	2.00000			

DEFLECTION MODE	PRESSURE MODE	GENERALIZED FORCES			
		PANELS ONLY	TOTAL		
2	1	0.11803071E 00	0.83272486E 01	-0.56997927E 01	0.80402927E 01
2	2	0.45952450E 01	0.18972519E 02	-0.79987698E 01	0.23680984E 02
2	3	-0.45063422E 00	0.87069798E 01	-0.31874332E 01	0.96464167E 01

MODE NO. 3

PANEL NO	STRIP NO	BOX NO	XOC	X	Y	Z	PRESSURES	
1	1	1	0.12500	2.35938	1.14952	0.50000	1.774650	2.702881
1	1	2	0.62500	3.29688	1.14952	0.50000	-0.958163	4.093591
1	2	3	0.12500	2.57813	1.71651	0.50000	2.179616	4.175091
1	2	4	0.62500	3.39063	1.71651	0.50000	-2.112709	4.741535
2	3	5	0.12500	2.79688	2.25000	0.62500	1.698914	6.286385
2	3	6	0.62500	3.49438	2.25000	0.62500	-3.086831	3.671605
2	4	7	0.12500	3.01563	2.75000	0.87500	1.331918	7.792065
2	4	8	0.62500	3.57813	2.75000	0.87500	-3.092846	2.418398
3	5	9	0.12500	2.68750	2.00000	0.25000	0.719314	-0.043016
3	5	10	0.62500	3.43750	2.00000	0.25000	0.192435	0.883634

THE 23 MODIFIED H-ELEMENTS FOR MODE NO. 3

1.37274	1.37274	1.97330	1.97330	1.84577	1.84577
2.03752	2.03752	-0.09375	-0.09375	0.0	0.0
0.0	0.0	0.0	4.99999	4.99999	4.99999
4.99999	1.00000	1.00000	1.00000	1.00000	

THE 13 MODIFIED OH/OX-ELEMENTS FOR MODE NO. 3

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0					

DEFLECTION MODE	PRESSURE MODE	GENERALIZED FORCES			
		PANELS ONLY	TOTAL		
3	1	0.35609788E 00	0.60103865E 01	-0.52197278E 00	0.59655657E 01
3	2	0.73399734E 01	0.13251885E 02	0.54930477E 01	0.13903881E 02
3	3	-0.51838241E 00	0.68781071E 01	-0.18435221E 01	0.64739475E 01

EXECUTION TIME(MINUTES)
CPU 0.0410
I/O 0.0377
TOTAL 0.0788

3.0 BLANK AND LABELED COMMON BLOCKS

3.1 Blank Common Block

ITEM NO.	SYMBOL	MNEMONICS	DESCRIPTION	
1		NP	No. of panels	Input 9
2		NTP	Total no. of boxes on all panels	
3		NB	No. of bodies	Input 10
4		NBZ	No. of bodies with z-orientation	
5		NBY	No. of bodies with y-orientation	
6		NTZ	Total no. of body elements with z-orientation	
7		NTY	Total no. of body elements with y-orientation	
8		FMACH	Mach Number	Input Items 2
9	A	REFA	Reference area	3
10	S	REFS	Reference span	4
11	$\bar{c}$	REFC	Reference chord	5
12	δ	ND	Symmetry flag for y = 0 plane	7
13	ϵ	NE	Symmetry flag for z = 0 plane	8
14		NBEA(10,2)	1. No. of interference elements (NBE) for all bodies	
			2. Z-Y flag (NZY) for all bodies	
15		NSBEA(10)	No. of slender body elements (NSBE) for all bodies	

ITEM NO.	SYMBOL	MNEMONICS	DESCRIPTION
15		NSBEA(10)	No. of slender body elements (NSBE) for all bodies
16	nc	NCARRAY(100)	No. of chordwise boxes for all panels
17	ns	NSARRAY(100)	No. of spanwise strips for all panels
18	nba	NBARAY(100)	$nba_i = \sum_{j=1}^i nc_j ns_j$, where $i = 1, NP$
19	z_c	ZB(10)	z-coordinate of body center
20	y_c	YB(10)	y-coordinate of body center
21	$x_{L.E.}$	XLE(10)	x-coordinate of leading edge of body
22	$x_{T.E.}$	XTE(10)	x-coordinate of trailing edge of body
23	AR	ARB(10)	Cross sectional aspect ratio of body
24	a	AVR(10)	Average characteristic half-width of body
25	a_o	AO(200)	Local body half-width (y-direction; radius for circle)
26	a_o	AOP(200)	x-derivative of body half-width
27	$\xi S1$	XIS1(200)	x-coordinate of slender body element leading edge
28	$\xi S2$	XIS2(200)	x-coordinate of slender body element trailing edge

Eq.
(5.2.1-17)

Eq.
(5.2.1-18)

Eq.
(5.2.1-22)

Slender
body
arrays
Eq.
(5.2.1-23)

Eq.
(5.2.1-20)

Eq.
(5.2.1-21)

ITEM NO.	SYMBOL	MNEMONICS	DESCRIPTION
29		XIJ(200)	x-coordinate of leading edge of strips (on all panels)
30	c	CS(210)	chordlength of strips
31	yPs, nPs	YS(210)	y-coordinate of strip center-lines and body center-lines Eq. (5.2.1-9)
32	zPs, zPs	ZS(210)	z-coordinate of strip center-lines and body center-lines Eq. (5.2.1-10)
33	e _s	EE(200)	Half-width of strips Eq. (5.2.1-11)
34	sin γ_s	SG(200)	sine of the dihedral angle of strip Eq. (5.2.1-14)
35	cos γ_s	CG(200)	cosine of the dihedral angle of strip Eq. (5.2.1-15)
36	xP, xI	X(500)	3/4 chord x-coordinates of all boxes (receiving points) and interference body section midpoints Eq. (5.2.1-1 and -2)
37	ξ_P	XIC(500)	1/4 chord x-coordinates of all boxes (sending points)
38	k _r	KR	Reduced frequency
39	XM	XM	Moment axis Input Item 6
40	$\Delta x_P, \Delta x_I$	DELX(500)	Average chord-lengths of all boxes, and interference body element lengths Eq. (5.2.1-7 and -8)
41	tan λ	XLAM(500)	Tangent of the sweep angle of the 1/4-chord line (bound vortex) of all boxes
42		RIA(100)	Radii of all body interference elements

ITEM NO.	SYMBOL	MNEMONICS	DESCRIPTION
43		TH1A(100)	θ_1 's for all bodies
44		TH2A(100)	θ_2 's for all bodies
45		NFL(10)	Number of body sections with θ_1 -distribution - for all bodies (max is 3 per body)
46		IFLA(30,2)	1. Sequence number of the first body element with θ_1 distribution 2. Sequence number of the last body element with θ_1 -distribution - for all bodies
47		NT12(10,2)	1. Number of θ_1 's all 2. Number of θ_2 's bodies
48		NAS(100)	Number of associated bodies for all panels
49		NASB(200)	Associated bodies - all panels
50		YIN(100)	y-coordinate of inboard edge of panel
51		ZIN(100)	z-coordinate of inboard edge of panel - all panels
52	$\Delta\eta$	DETA(50)	y-shift elements all panels
53	$\Delta\zeta$	DZET(50)	z-shift elements and all bodies
54		NBODY(50)	Body number
55		NPANEL(50)	Panel number
56		NT0	$NTP + \sum_{i=1}^{NB} NBE_i$, where NTP = total number of boxes on all panels and NBE_i = number of interference elements on body i

ITEM NO.	SYMBOL	MNEMONICS	DESCRIPTION
57		NTZS	Total no. of slender body elements with z-orientation
58		NTYS	Total no. of slender body elements with y-orientation

Subroutines using the Blank Common Block are:

MAIN, DATA, GEND, SUBP, SUBB, SB, BFM, AERO and GENF.

3.2 Labeled Common Blocks

Common DLM

ITEM NO.	SYMBOL	MNEMONICS	DESCRIPTION
1	$K_1(s)$	K10	Planar part of
2	$K_2(s)$	K20	Nonplanar part of
3	$\text{Re}\bar{K}_1$	K1RT1	$\text{Re}(\Delta K_1)T_1$
4	$\text{Im}\bar{K}_1$	K1IT1	$\text{Im}(\Delta K_1)T_1$
5	$\text{Re}\bar{K}_2$	K2RT2P	$\text{Re}(\Delta K_2)T_2^*$
6	$\text{Im}\bar{K}_2$	K2IT2P	$\text{Im}(\Delta K_2)(T_2^*)$
7		K10T1	$K_1(s) T_1$
8		K20T2P	$K_2(s) T_2^*$

the steady
contribution
to the kernel

Unsteady part
of modified
kernel

Subroutines using Common DLM are:

FLLD, INCRO and TKER.

Common KDS

ITEM NO.	SYMBOL	MNEMONICS	DESCRIPTION
1		IND	Flag, 0 or 1. - If 0, the total kernel is computed; if 1, the incremental part only.
2	$\text{Re}(\tilde{K}_1)$	KD1R	Real part of $\tilde{K}_1$
3	$\text{Im}(\tilde{K}_1)$	KD1I	Imaginary part of $\tilde{K}_1$
4	$\text{Re}(\tilde{K}_2)$	KD2R	Real part of $\tilde{K}_2$
5	$\text{Im}(\tilde{K}_2)$	KD2I	Imaginary part of $\tilde{K}_2$ - $\tilde{K}_1$ and $\tilde{K}_2$ are defined in Sec. 5.5.1.4 Subroutine FLLD.

Subroutines using Common KDS are:

FLLD, INCRO AND TKER.

4.0 LOGICAL TAPE UNITS

4.1 Tape Numbers and Symbols

SYMBOLS	TAPE NUMBER		USER SUBROUTINES
		PRESENT ASSIGNMENT	
NTAPE(1), ITP1, NM, NDZ	1		GEND, SOLVIT MAIN
NTAPE(2), ITP2, NO, MTAPE, NDY	2		GEND, SOLVIT MAIN
NTAPE(3), ITP3, NW, NPTAP, NDW	3		AERO, BFM, GEND, GENF, SB, SOLVIT, WANDWT, MAIN, RWREC
NTAPE(4), ITP4, NW5, NWT	4		MAIN, GEND, SB, WANDWT
NTAPE(8), ITAPE, NEWBFM	8		MAIN, GEND, AERO, GENF
NTAPE(9), NPSTAP, NW2	9		BFM, SB, MAIN
NTAPE(10), NI, NW3	10		MAIN, SB, SOLVIT
NTAPE(11), NBFM, NW4	11		AERO, BFM, SB, MAIN, BFSMAT

In addition to the above tapes, units #5 and 6 are used throughout the program as the standard 'card-read' and 'print' units. The following table explains the use of the logical tape units within the user subroutines in the order of the program flow.

4.2 Table of Input Output Units

SUBROUTINE NAME	TAPE NUMBER				
	INPUT	CONTENTS	OUTPUT	CONTENTS	SCRATCH
GEND			ITAPE	[DT]	ITP1 ITP2 ITP3 ITP4
SB			NW1=NDW NW2 = NPSTAP	{ ΔW } $\{\Delta C_p^{body}\}$	NW3 NW4 NW5
WANDWT	NDW	{ ΔW }	NWT	{WT} = $\{W\} + \{\Delta W\}$	
MAIN	ITAPE NWT	[DT] {WT}	NI	Augmented Matrix [DT WT]	
SOLVIT	NI	[DT WT]	NW	Solutions {P}	NM NO
BFSMAT			NBFM	BFS**	
MAIN	NBFM NW	BFS {P}	NEWBFM	BFM*	
BFM	NPSTAP NW	ΔC_p^{body} {P}	NBFM	BFM	
AERO	NW NBFM	{P} BFM	NEWBFM	BFM*	
GENF	NW NBFM	{P} BFM			

* BFM represents all the body forces and moments for all modes.

** BFS represents the body forces FZ and FY described in Sec. 5.8.1.

5.0 DESCRIPTION OF SUBROUTINES

5.1 Segment 1

5.1.1 MAIN

Functional Description

The MAIN part of program N5KA reads the header card, the reference variables, control and print flags, and the array of reduced frequencies for the case. It calls subroutine DATA which computes the basic data arrays - these are saved in the blank common block. The other 10 major subroutines are called from MAIN in an overall frequency do-loop for each element of the frequency array.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
FREQ(10)	k_r	IN	Card	Reduced frequency array
HDR(15)		IN	Card	Header information, one card
IA(2, 150,3)		IN	ARG of RDMODE	See Section 5.4.1
NA(3)			ARG of RDMODE	
DT(500)	[DT]	IN	I/O (ITAPE)	One row of the [DT] matrix generated in subroutine GEND
RHS(100)		OUT		One row of right-hand-sides for one unknown (panel box, or interference body element) and all modes
WORK (10000)	[WT]	IN	I/O (NWT)	Complete mode matrix for all unknowns and modes generated in subroutine WANDWT
RA (2, 10000)		OUT		A two-dimensional 'real' work array equivalenced with the complex work array WORK (10000) used in subroutine SOLVIT
NTAPE(20)		OUT	Data initialization	Variable name of the logical tape unit array
IERROR		OUT	MAIN	Error flag initialized to 0
NWORK		OUT	MAIN	Work array size

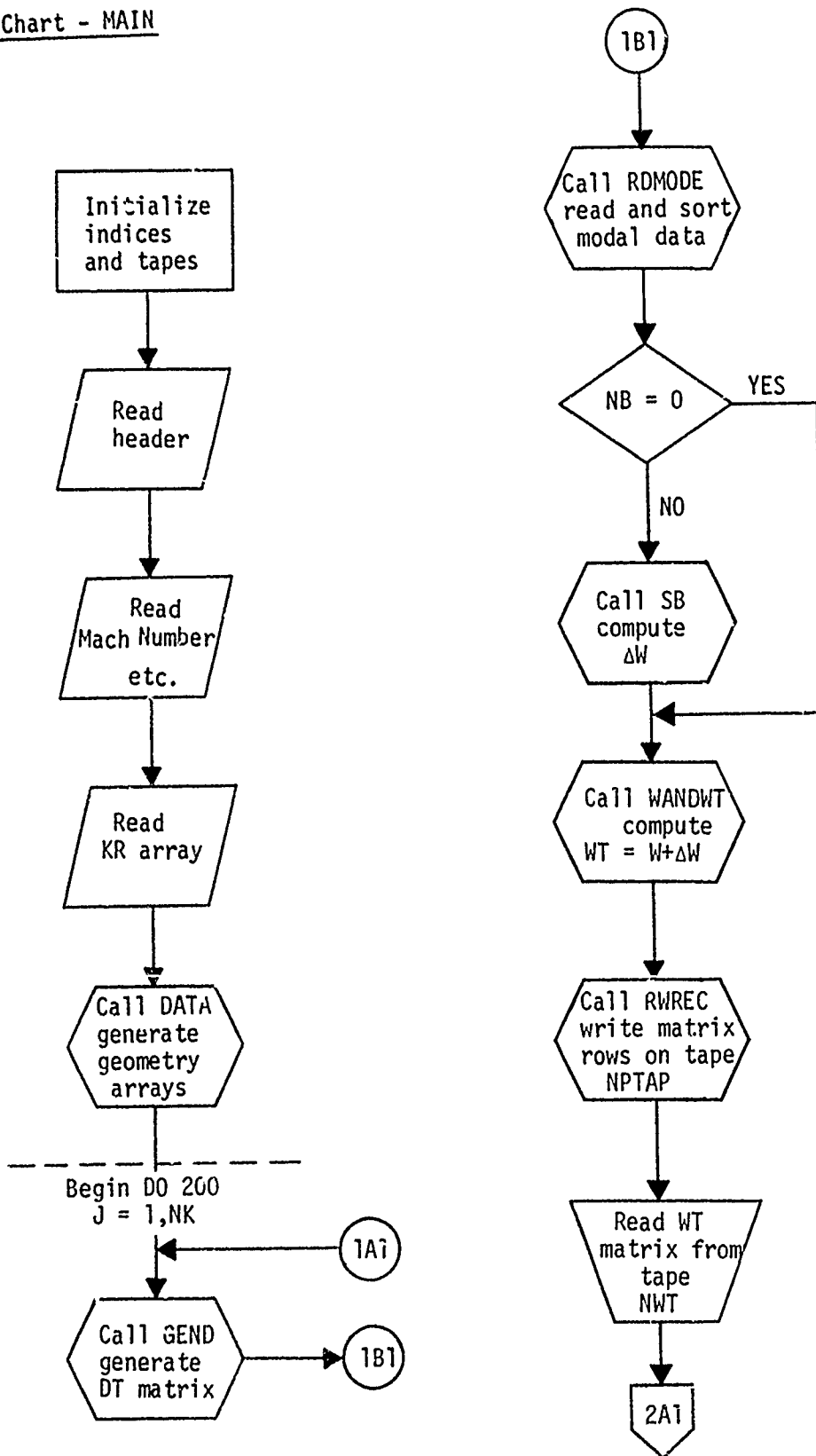
MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
NDZ NDY MTAPE ITAPE NPTAP NIN NOUT NPSTAP NM NO NDW NWT NI NBFM NW		IN	NTAPE (20)	See the argument list description of the user subroutines
FMACH REFA REFS REFC XM ND NE NP NB NK N1 N2 N3 N4 IBFS NEWBFM	M A S $\overline{C}$ δ ϵ	IN	Card	Mach Number Reference area Reference semispan Reference chord Moment axis Symmetry flag Second symmetry flag No. of panels No. of bodies No. of reduced frequencies Print and control flags Option flag for body force calculation method; 0 or 1 Number of logical tape unit containing body forces

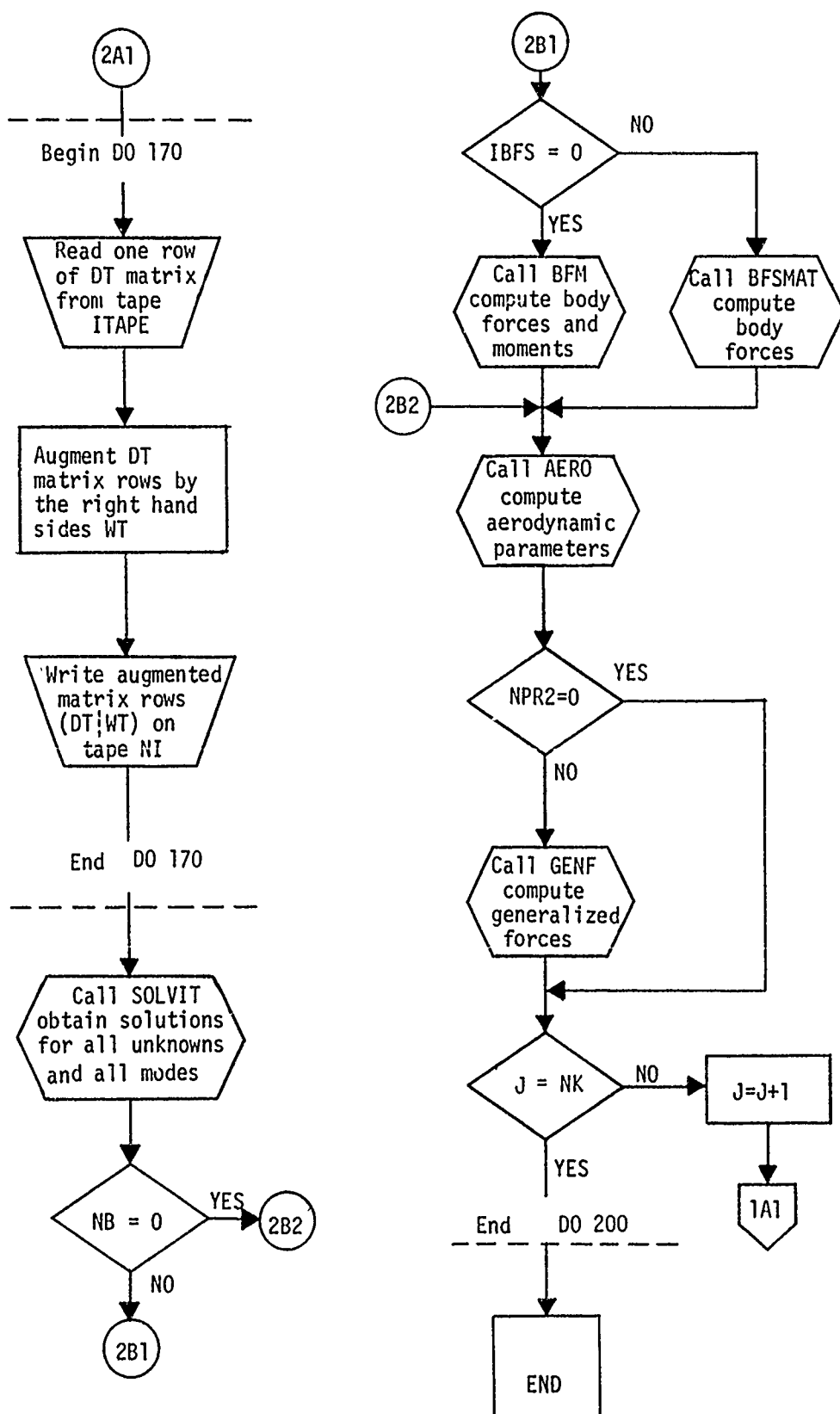
MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
BETA NPR1,N1 NPR2,N2 NPRINT,N3 NTOT NTIBE NTSBE N NSTRIP ID,NTOT KD NR,NTOT KR	β $\hat{r}_j$	OUT	MAIN	$\beta = \sqrt{1 - M^2}$ Print flag for SOLVIT Control flag for GENF Print flag for GEND Total number of unknowns Number of interference body elements Number of slender body elements Number of panel boxes plus number of interference body elements Total number of strips on all panels See NTOT above Total dimension of the real work-array RA See NTOT above j-th element of reduced frequency array
MD,NMT		IN	Arg list of RDMODE	Total number of modes
NMODE,MD NIM NFC NWKR		OUT		Total number of modes See Section 5.5.8.1
JX1 JX2 JM JJ JX		IN	MAIN	Index of first-(JX1) and last (JX2) elements in the modal matrix array when read from logical unit number NWT one column at a time Indices used in the do loop transposing the modal matrix array

Subroutines Called DATA, GEND, RDMODE, SB, WANPWT, RWREC, SOLVIT, BFM, BFSMAT, AERO and GENF

Common Blocks Blank Common Block

Flow Chart - MAIN





5.1.2 Subroutine ATAN3 (Y, X, T)

Functional Description

Subroutine ATAN3 evaluates $T = \text{atan}(Y, X)$ by considering the signs of both Y and X, and thereby providing a result, T, that lies in the proper quadrant. The resulting angle, T, is returned to the calling program in radians.

Calling Subroutine DATA

5.1.3 SUBROUTINE DZY (X, Y, Z, SGR, CGR, XI1, XI2, ETA, ZETA, AR, AO, KR, CBAR, BETA, FMACH, IDZDY, DZDYR, DZDYI)

Functional Description

Subroutine DYZ calculates the effect of a finite length doublet, a multi finite length doublet, or a trapezoidal vortex, of unit strength, at a field point. Each slender body is composed of a series of segments or elements. This subroutine calculates the effect of such elements on field points (lifting surface boxes, etc.). If the cross sectional shape is circular then a doublet is used. If $AR > 1$, two doublets are used. If $AR < 1$ a trapezoidal vortex is used. This subroutine is used for bodies oriented in both the z- and y-directions.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
X	X	IN	ARG	x-coordinate of the receiving point
Y	Y			y-coordinate of the receiving point
Z	Z			z-coordinate of the receiving point
AO	a_0			Radius of sending body
AR	AR			Aspect ratio of sending body
KR	k_r			Reduced frequency
CGR	$\cos \gamma_r$			Cosine of receiving point dihedral angle
ETA	η			y-coordinate of the sending strip
SGR	$\sin \gamma_r$			Sine of receiving point dihedral angle
XI1	ξ_1			Leading edge of sending element
XI2	ξ_2			Trailing edge of sending element

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
BETA	β			$\sqrt{1 - M^2}$
CBAR	$\bar{c}$	IN	ARG	Reference chord length
ZETA	ζ			z-coordinate of the sending strip
DZDYI	$\text{Im}(D_z)$ $\text{Im}(D_y)$	OUT	ARG	Imaginary part of D_z or D_y
DZDYR	$\text{Re}(D_z)$ $\text{Re}(D_y)$	OUT	ARG	Real part of D_z or D_y
FMACH	M			MACH number
IDZDY		IN	ARG	Flag indicating whether D_z or D_y is to be calculated

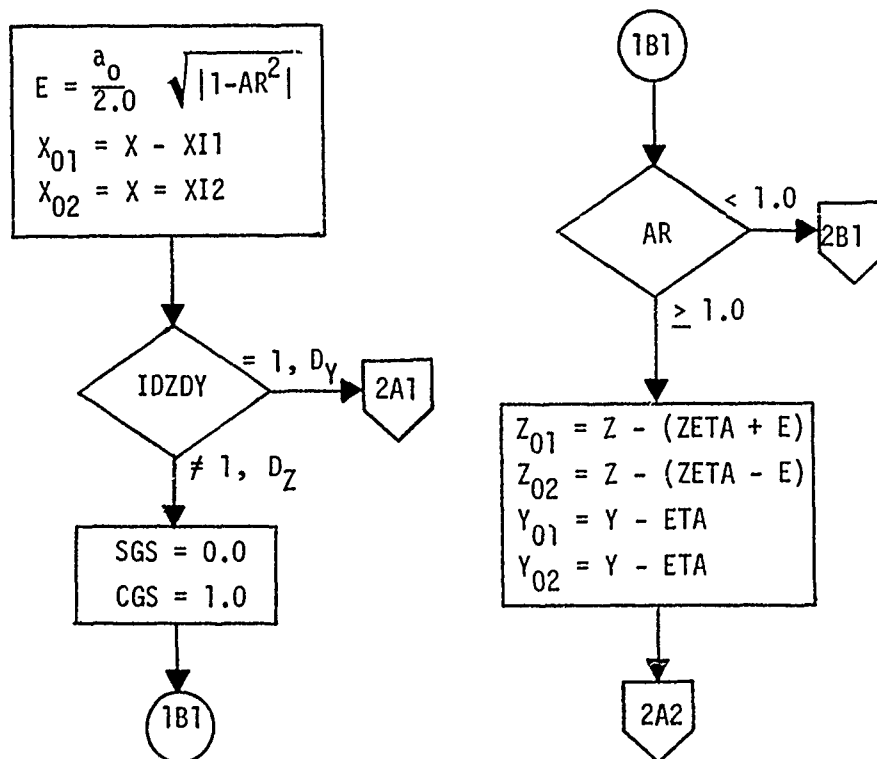
Calling Subroutines

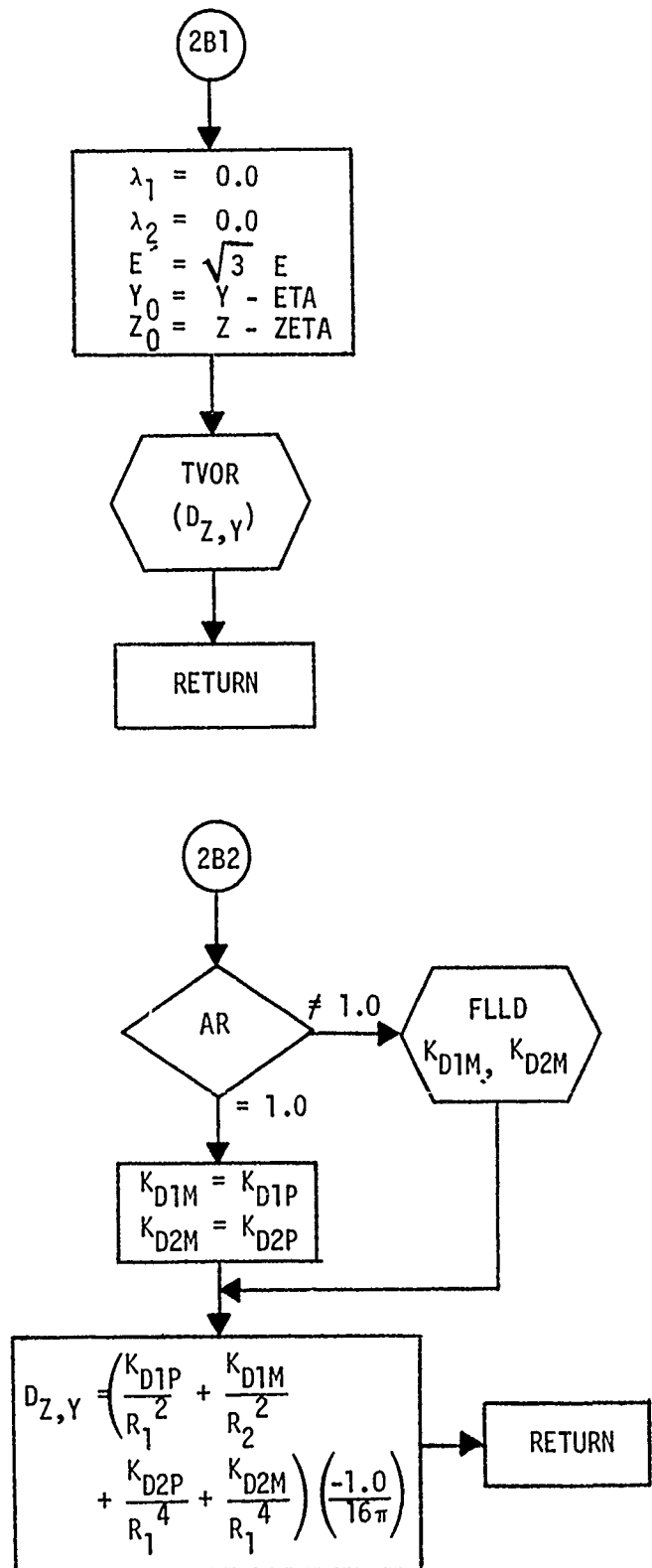
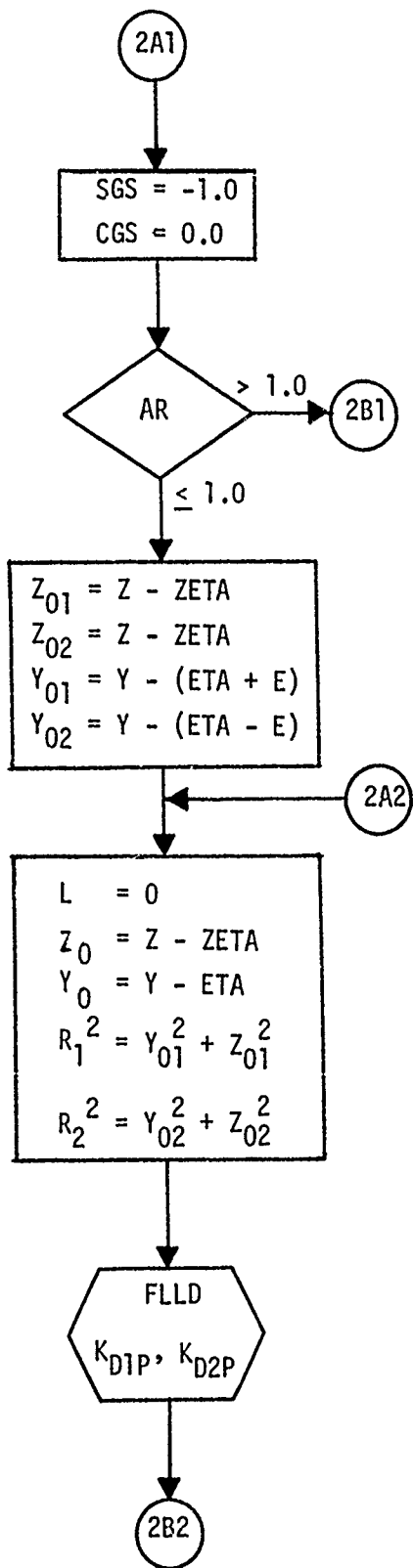
ROWDYZ

Called Subroutines

FLLD, TVOR

Flow Chart - Subroutine DZY





5.1.4 SUBROUTINE FLLD (X01 , X02, Y0,Z0, SGR, CGR, SGS, CGS, KR, CBAR,
FMACH, E, L, KD1R, KD1I, KD2R, KD2I)

Functional Description

This subroutine calculates the velocity normal to a surface of dihedral, γ_r , due to a finite length line doublet.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
E	e	IN	ARG	Semi width of singularity
L				Option flag for use in subroutine TKER
KR	k_r			Reduced frequency
Y0	$y-\eta$			Difference in lateral coordinates of receiving and sending points respectively
Z0	$z-\zeta$			Difference in vertical coordinates of receiving and sending points respectively
CGR	$\cos \gamma_r$			
CGS	$\cos \gamma_s$			
SGR	$\sin \gamma_r$			
SGS	$\sin \gamma_s$			
X01	$x-\xi_1$			Difference in longitudinal coordinates of receiving and leading edge of sending points respectively
X02	$x-\xi_2$	OUT	ARG	Same as above except ξ_2 is the trailing edge
CBAR	$\bar{c}$			Reference chord
KD1I	$\text{Im}(K_{d1})$			See Equation (5.1.4-1)
KD1R	$\text{Re}(K_{d1})$			
KD2I	$\text{Im}(K_{d2})$	OUT	ARG	See Equation (5.1.4-2)
KD2R	$\text{Re}(K_{d2})$			
FMACH	M	IN	ARG	Mach number
E2	e^2	OUT	DLM	

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
IND	L	OUT	KDS	See Section 3.2
KK1I	$I_m(KK1)$	IN	KDS	
KK1R	$R_e(KK1)$			
KK2I	$I_m(KK2)$			
KK2R	$R_e(KK2)$			
K1OT1		IN	DLM	See Section 3.2
KZOT2P				

Calling Subroutines TVOR, DZY

Called Subroutines and Common Blocks

TKER, KDS, DLM

Equations

$$K_{d1} = \tilde{K}_1(\xi_1) e^{ik_r \Delta \xi / \bar{c}} - \tilde{K}_1(\xi_2) e^{-ik_r \Delta \xi / \bar{c}} + K_{d1r} L \quad (5.1.4-1)$$

$$K_{d2} = \tilde{K}_2(\xi_1) e^{ik_r \Delta \xi / \bar{c}} - \tilde{K}_2(\xi_2) e^{-ik_r \Delta \xi / \bar{c}} + K_{d2r} L \quad (5.1.4-2)$$

where

$$\Delta \xi = \xi_2 - \xi_1$$

$$\tilde{K}(\xi) = \text{output from subroutine TKER}$$

$$K_{d1r} = -T_1 (K_{10}(\xi_1) - K_{10}(\xi_2))$$

$$K_{d2r} = -T_2^* (K_{20}(\xi_1) - K_{20}(\xi_2))$$

$T_1, T_2^*, K_{10}, K_{20}$ are output from TKER

L is an option flag for TKER and is either unity or zero.

5.1.5 SUBROUTINE FMMW (ND, NE, SGS, CGS, IRB, AO, ARB, XBLE, XBTE, YB, ZB, XS, YS, ZS, NAS, NASB, KR, BETA2, CBAR, FWZ, FWY, MWZ, MWY, IF1, IPRNT, IBFS)

Functional Description

Given a unit pressure doublet this subroutine calculates the effect of this doublet plus any contributions due to images, symmetry plane and ground effect on a given body.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
ND	δ	IN	ARG	Symmetry flag.
NE	ϵ			Ground effects flag.
SGS	$\sin \gamma_s$			Sine of sending point dihedral angle
CGS	$\cos \gamma_s$			Cosine of sending point dihedral angle
IRB				Number of the receiving body
AO	a_o			Radius of the body
ARB	$\bar{A}$			Array of ratios of body axes
XBLE				Leading edge location of slender body element
XBTE				Trailing edge location of slender body element
YB	Y_B			Array containing the y-coordinates of the bodies
ZB	Z_B			Array containing the z-coordinates of the bodies
XS				1/4-chord x-coordinate of slender body element
YS				y-coordinate of sending point
ZS				z-coordinate of sending point
NAS				Number of associated bodies
NASB				Array containing the associated body numbers
KR	k_r			Reduced frequency
BETA2	β^2			$1-M^2$
CBAR	$\bar{c}$			Reference chord length
FWZ	F_{wz}	OUT	ARG	Force in z direction
FWY	F_{wy}			Force in y direction

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
MWZ	M_{wz}	OUT	ARG	Moment in z direction
MWY	M_{wy}			Moment in y direction
IF1		IN	ARG	Flag indicating the orientation of the receiving body
IPRINT		IN/OUT	ARG	Print flag
IBFS				Option flag; 0 to select subroutine FMZY, 1 to select subroutine FZY2

Calling Subroutines

BFM, BFSMAT

Called Subroutines and Common Blocks

FMZY, SUBI, FZY2

Equations

$$\begin{aligned}
 FWZ = & \cos \gamma_s F_{zz} - \sin \gamma_s F_{zy} \\
 & + \sum_{bI=\text{range}} [\ddot{u}_z F_{zz}^I + \ddot{u}_y F_{zy}^I] \\
 & + \delta \left\{ \cos \gamma_s F_{zz}^S + \sin \gamma_s F_{zy}^S + \sum_{bI=\text{range}} [\ddot{u}_z F_{zz}^{I(S)} + \ddot{u}_y F_{zy}^{I(S)}] \right\} \\
 & + \epsilon \left\{ \cos \gamma_s F_{zz}^G + \sin \gamma_s F_{zy}^G + \sum_{bI=\text{range}} [\ddot{u}_z F_{zz}^{I(G)} + \ddot{u}_y F_{zy}^{I(G)}] \right\} \\
 & + \delta \epsilon \left\{ \cos \gamma_s F_{zz}^{S(G)} + \sin \gamma_s F_{zy}^{S(G)} + \sum_{bI=\text{range}} [\ddot{u}_z F_{zz}^{I(S(G))} + \ddot{u}_y F_{zy}^{I(S(G))}] \right\}
 \end{aligned}$$

FWY = same as FWZ replacing F_{zz} with F_{yz} and replacing F_{zy} with F_{yy}

MWZ - same as FWZ replacing F_{zz} with M_{zz} and F_{zy} with M_{zy}

MWY - same as FWZ replacing F_{zz} with M_{yz} and F_{zy} with M_{yy}

The superscripts on F correspond to

I - Image points

S - Symmetry points

G - Ground effect points

bI range refers to the bodies associated with the lifting surface
sending element

5.1.6 SUBROUTINE IDFl (EE, E2, ETA)1, ZET01, ARE, AIM, BRE, BIM, CRE, CIM, RISQX, XIIJR, XIIJI)

Functional Description

Subroutine IDFl performs the integration of the planar parts of the incremental oscillatory kernels according to Equation (B.9)*. The result of the integration is the complex number (XIIJR, XIIJI) which is returned to subroutine INCRO via the argument list of subroutine IDFl.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
EE	e	IN	ARG	Semi-width of sending element
E2	e ²			
ETA01	$\bar{y}$			$y_0 \cos \gamma_r + z_0 \sin \gamma_r$
ZET01	$\bar{z}$			$z_0 \cos \gamma_r - y_0 \sin \gamma_r$
ARE	Re(A ₁)			Coefficients of the parabola for the planar part of kernel integration - See Eq's (B.3) through (B.5)
AIM	Im(A ₁)			
BRE	Re(B ₁)			
BIM	Im(B ₁)			
CRE	Re(C ₁)			
CIM	Im(C ₁)			
RISQX	r ₁ ²			$\bar{y}^2 + \bar{z}^2$
XIIJR	Re(D _{1rs})	OUT		Real part of integral
XIIJI	Im(D _{1rs})			Imaginary part of integral
TRM2R		OUT	IDF1	Real part
TRM2I				Imaginary part
TRM3R				Real part
TRM3I				Imaginary part
				planar contribution See Eq. (B.9)
				of the second term inside the brackets
				of the third term inside the brackets of Eq. (B.9)

* Appendix B in Part IVol. I of this report (Reference 2)

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
TESTO				A test value: $\frac{\bar{y}^2 + \bar{z}^2 - e^2}{2 e \bar{z} }$
TEST				Alternate test value: $\frac{2 e \bar{z}}{\bar{y}^2 + \bar{z}^2 - e^2}$
ARGT		OUT	IDF1	The argument to the arctangent in Eq. (B.6b)
S				The argument to the series in Eq. (B.8)
SER				The sum of the series in Eq. (B.8)
ALPHA				See Eq. (B.8)
FUNCT	F			See Eq. (B.6b) and Eq. (B.7)
TRM1R				Real part
TRM1I				Imaginary part
				} of the first term inside the brackets of Eq. (B.9)

Calling Subroutine INCRO

Equations - See Appendix B in Part I Volume I of this report (Reference 2)

5.1.7 SUBROUTINE IDF2 (EE, E2, ETA01, ZET01, A2R, A2I, B2R, B2I, C2R, C2I, R1SQX, DIIJR, DIIJI)

Functional Description

Subroutine IDF2 performs the integration of the nonplanar parts of the incremental oscillatory kernels according to Equations (B.15) or (B.16)*. The result of the integration is the complex number (DIIJR, DIIJI) which is returned to subroutine INCRO via the argument list of subroutine IDF2.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
EE E2 ETA01 ZET01	e e^2 $\bar{y}$ $\bar{z}$	IN	ARG	See Subroutine IDF1
A2R A2I B2R B2I C2R C2I	$\text{Re}(A_2)$ $\text{Im}(A_2)$ $\text{Re}(B_2)$ $\text{Im}(B_2)$ $\text{Re}(C_2)$ $\text{Im}(C_2)$			Coefficients of the parabola for the nonplanar part of the kernel integration - See Eq's (B.12) - (B.14)
R1SQX	r_1^2			$\bar{y}^2 + \bar{z}^2$
DIIJR DIIJI TEST0 TRM2R TRM2I	$\text{Re}(D_{2rs})$ $\text{Im}(D_{2rs})$	OUT	IDF2	Real part of integral Imaginary part of integral Test value: $\left \frac{\bar{y}^2 + \bar{z}^2 - e^2}{2 e \bar{z}} \right $ Real part Imaginary part
				Nonplanar contribution See Eq (B.15) or (B.16) of the second term inside the brackets of Eq (B.15) or same of Eq (B.16)

* Appendix B in Part I Vol. I of this report (Reference 2)

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
TRM3R				Real part } of the third term
TRM3I				Imaginary part } inside the brackets
TEST				Alternate test value: $\frac{2 e \bar{z}}{\bar{y}^2 + \bar{z}^2 - e^2}$
S SER ALPHA FUNCT ARGT	α F	OUT	IDF2	See Subroutine IDF1
TRM1R				Real part } of the first term
TRM1I				Imaginary part } inside the brackets of Eq. (B.15) or same of Eq. (B.16)

Calling Subroutine INCRO

Equations - See Appendix B in Part I Vol. I of this report (Reference 2)

5.1.8 SUBROUTINE INCRO (AX, AY, AZ, AX1, AY1, AZ1, AX2, AY2, AZ2, SGR, CGR, SGS, CGS, KR, FL, BETA, SDELX, DELY, DELR, DELI, IO, IR, NBXS, NCPNB, LHS, NDBLE, IMG, NOBI, IMGS, USE1, USE2, USE3, USE4, XUSE1, XUSE2, XUSE3, XUSE4)

Functional Description

Subroutine INCRO prepares the arguments for the subroutines TKER, IDF1 and IDF2. It calls subroutine TKER which computes the incremental oscillatory part of the kernel K for each receiving-sending box combination at the three points of the bound vortex segment: at the center (K_c), at the inboard point (K_i) and at the outboard point (K_o). Since even a relatively small case requires many kernel computations (e.g. an unsteady 100-box all

panel case, in symmetry, requires $2 \times 100 \times 3 \times 100 = 60,000$ kernel values) extra programming effort was made to reduce the number of kernel computations. Neighboring strips have common kernels on the common boundary lines; this property is utilized in subroutine INCRO for all lifting surface strips as well as their images inside associated bodies, by saving the arrays of kernels for all common boundary lines and using these in the subsequent calculations.

After the triplet of kernels, (K_c, K_j, K_o) is obtained for one receiving-sending box combination, subroutine INCRO computes the coefficients of the parabolas for the numerical integrations, done in subroutines IDF1 and IDF2.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION	
AX	$\bar{x}$	IN	ARG	$x - \xi$	where (x, y, z)
AY	$\bar{y}$			$y - \eta$	define the receiving
AZ	$\bar{z}$			$z - \zeta$	point, and ξ, η, ζ are
AX1				$x - \xi_1$	the 'center' sending
AY1				$y - \eta_1$	point coordinates,
AZ1				$z - \zeta_1$	ξ_1, η_1, ζ_1 are the
AX2				$x - \xi_2$	'inboard' sending point
AY2				$y - \eta_2$	coordinates and
AZ2				$z - \zeta_2$	ξ_2, η_2, ζ_2 are the 'outboard' sending point coordinates

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
LHS				Flag activated by δ (input) for the contribution of the first symmetry plane effect
NDBLE				Flag activated by ϵ (input) for the contribution of the second symmetry plane effect
IMG		IN	ARG	Flag activated by the presence of image points inside associated bodies for sending panel
NOBI				Sequence number of the body in which the image of the sending point lies
IMGS				IMGS = IMG whenever kernels are saved for image sending points; IMGS = 0 otherwise
K10	$K_1(s)$			Planar part
K20	$K_2(s)$			Nonplanar part
K1RT1				
K1IT1				
K2RT2P		IN	Labeled	
K2IT2P			Common	See Sec. 3.2
K10T1				
K20T2P			DLM	
E2	e^2	OUT		

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION		
IND		OUT	Labeled Common KDS	See Sec. 3.2		
KD1R KD1I KD2R KD2I	Re(Kd ₁) Im(Kd ₁) Re(Kd ₂) Im(Kd ₂)	IN				
USE1(50, 14) USE2(50, 14) USE3(50, 14) USE4(50, 14)		IN			ARG	Utility arrays for use of the planar kernel values which are saved for future use
XUSE1(50, 14) XUSE2(50, 14) XUSE3(50, 14) XUSE4(50, 14)		IN			ARG	Utility arrays for use of the nonplanar kernel values which are saved for future use
M BR EPS PI	M $\bar{c}/2$ π	OUT			INCR'O	Mach Number Reference <u>semi</u> -chord $\epsilon = 0.00001$
XDELX XDELY EE E2			See Subroutine IDF1			
COUNT			An internal flag to select logic of subroutine			

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
XO YO ZO		OUT	INCRO	Differences of the x, y and z coordinates of the current receiving and sending points (see AX, AY, AZ, AX1, AY1, AZ1 and AX2, AY2, AZ2 above)
AT1 AT2	$ T_1 $ $ T_2 $	IN	Argument List of TKER	See Appendix A in Part I, Vol I of this report
DKRC DKIC XKRC XKIC DKRI KDJI XKRI XKII DKRO DKIO XKRO XKIO JO XMULT		IN	INCRO	Planar kernel for the center point of the bound vortex segment Nonplanar kernel Planar kernel for the inboard point of the bound vortex segment Nonplanar kernel Planar kernel for the outboard point of the bound vortex segment Nonplanar kernel Index for the selection of the proper utility array in which the kernels are saved $\Delta x_j / 8\pi$
ETA01 ZET01 RISQX ARE		OUT	INCRO	See Subroutine IDF1

MNEMONIC	SENSE	IN/OUT	SOURCE	DESCRIPTION
AIM BRE BIM CRE CIM		OUT	INCRO	See Subroutine IDF1
XIIJR XIIJI		IN	Argument List of IDF1	
A2R A2I B2R B2I C2R C2I		OUT	INCRO	See Subroutine IDF2
DIIJR DIIJI		IN	Argument List of IDF2	
DELR DELI	ΔD_{rs} ΔD_{rs}	OUT	INCRO	

Calling Subroutine

SUBP

Called Subroutines and Common Blocks

Subroutines KLP, IDF1 and IDF2, and the Labeled Common Blocks OLM and KDS.

Equations See Appendix B in Part I Vol. I of this report (Reference 2)

5.1.9 SUBROUTINE READD (D, N, NTAPE)

Functional Description

This routine reads the complex array D which is N complex words long from the I/O unit NTAPE.

Input Output Variables

MNEMONICS	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
D		OUT	ARG	Complex array read
N		IN	ARG	Number of complex words in array D
NTAPE		IN	ARG	Input unit number

Calling Subroutines OUTCOR, SB

5.1.10 SUBROUTINE RWREC (IFLAG, NTAP, A, NCWORD, NUMBR)

Functional Description

This routine is used to read and write the array A which is NCWORD complex words long on the I/O unit NTAP.

Input-Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
IFLAG		IN		Read-write flag = 0 write A = 1 read A = 2 write NUMBR, A = 3 read NUMBR, A
NTAP		IN	ARG	I/O unit number to use
A		IN/OUT		Complex array to be read or written
NCWORD		IN		Length of array A
NUMBR		IN/OUT		The number to precede array A if desired; zero otherwise

Calling Subroutines BFM, BFSMAT, MAIN, OUTCOR, SB

5.1.11 SUBROUTINE SNPDF (SL, CL, TL, SGS, CGS, SGR, CGR,
XO, YO, ZO, EE, EIJ, BETA, CV)

Functional Description

Subroutine SNPDF computes the steady downwash factors for one receiving-sending point combination at a time according to Eq. (C.35b), Appendix C*. The result, DIJ, is returned to the calling subroutine via the argument list of subroutine SNPDF.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
SL CL TL		IN	ARG	$\sin\lambda$ where λ is the $\cos\lambda$ sweep angle of the $\tan\lambda$ 1/4-chord line of the sending box, i.e. the sweep angle of the bound vortex
SGS CGS SGR CGR XO YO ZO EE	$\dot{x}$ $\bar{y}$ $\bar{z}$ e			See Subroutine INCRO AX AY AZ
DIJ	$D_{rs}^{(s)}$	OUT	SNPDF	Steady contribution to the downwash factor See Eq. (C.35b)
BETA CV	β Δx_s	IN	ARG	See Subroutine INCRO

* Appendix C in Part IVol. I of this report (Reference 2)

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
RIMAG	R_i		SNPDF	See Eq. (C.14)
ROMAG	R_o			See Eq. (C.16)
DB2	d_b^2			See Eq. (C.30)
VBZ	v_{bz}	IN		See Eq. (C.33b)
VIZ	v_{iz}			
VOY	v_{oy}			
VOZ	v_{oz}			
WW	w			

Calling Subroutines

SUBP and TVØR

Equations

See Appendix C in Part I, Vol. I of this report
(Reference 2)

5.1.12 SUBROUTINE SUBI (DA, DZB, DYB, DAR, DETA, DZETA, DCGAM, DSGAM, DEE, DXI, TL, DETAI, DZETAI, DCGAMI, DSGAMI, DEEI, DTLAMI, DMUY, DMUZ, INFL, IOTFL

Functional Description

Subroutine SUBI has a dual role: depending on the setting of the flag INFL, subroutine SUBI either computes the arguments necessary for the calculation of the influence coefficient-contribution of lifting surface image points inside associated bodies (INFL = 0), or it calculates the $\tilde{u}_y, \tilde{u}_z$ for one body element according to Eqs. (5.1.12-21 and -22) respectively (INFL = 1).

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION	
DA DZB DYB DAR	a z_c y_c AR	IN	ARG	Body data	
DETA DZETA DCGAM DSGAM DEE DXI TL	η_s ζ_s $\cos \gamma_s$ $\sin \gamma_s$ e_s ξ $\tan \lambda$			Sending point data (on panels)	
DETAI DZETAI DCGAMI DSGAMI DEEI DTLAMI DMUY DMUZ	η_I ζ_I $\cos \gamma_I$ $\sin \gamma_I$ e_I $\tan \lambda_I$ $\tilde{\mu}_y$ $\tilde{\mu}_z$			OUT	y-coordinate of (Eq. 5.1.12-1 image point or -19) z-coordinate of (Eq. 5.1.12-2 or -20) cosine of the (Eq. 5.1.12-3 dihedral angle and -4) of the image of the bound vortex plane Sine Semi-width of image of sending strip (Eq. 5.1.12-6) Tangent of the sweep angle of the image of bound vortex; Eq.(5.1.12-5) Eq.(5.1.12-21) Eq.(5.1.12-22)

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
INFL IOUTFL	f	IN/OUT	ARG	'In'-flag - 0 or 1 'Out'-flag - zero if the image of bound vortex lies beyond the symmetry plane of the body - 1 otherwise
PSQR YCBAR ZCBAR ABAR RH012 RH022 ETAI1 ETAI2 ZETI1 ZETI2 RH02 ELLIPS TEST	P $\bar{y}_c$ $\bar{z}_c$ $\bar{a}$ ρ_1^2 ρ_2^2 η_{I1} η_{I2} ζ_{I1} ζ_{I2} ρ^2 See Eq. (5.1.12-24 or -26) Test value; (Eq. 5.1.12-25 or -27)	IN	SUBI	Intermediate variables used in SUBI Eq. (5.1.12-18) (5.1.12-14) (5.1.12-15) (5.1.12-11) (5.1.12-12) (5.1.12-13) (5.1.12-7) (5.1.12-8) (5.1.12-9) (5.1.12-10) (5.1.12-23)

Calling Subroutines SURP and FMMW

Equations

Option 1. - INFL = 0

$$\eta_I = (\eta_{I1} + \eta_{I2})/2 \quad (5.1.12-1)$$

$$\zeta_I = (\zeta_{I1} + \zeta_{I2})/2 \quad (5.1.12-2)$$

$$\cos \gamma I = - \frac{\eta I2 - \eta I1}{2eI} \quad (5.1.12-3)$$

$$\sin \lambda I = - \frac{\zeta I2 - \zeta I1}{2eI} \quad (5.1.12-4)$$

$$\tan \lambda I = \frac{\xi I2 - \xi I1}{2eI} \quad (5.1.12-5)$$

$$eI = \sqrt{(\eta I2 - \eta I1)^2 + (\zeta I2 - \zeta I1)^2} / 2.0 \quad (5.1.12-6)$$

where

$$\eta I1 = \bar{y}_c + \frac{\bar{a}^2}{\rho_1^2} (\eta 1 - \bar{y}_c) \quad (5.1.12-7)$$

$$\eta I2 = \bar{y}_c + \frac{\bar{a}^2}{\rho_2^2} (\eta 2 - \bar{y}_c) \quad (5.1.12-8)$$

$$\zeta I1 = \bar{z}_c + \frac{\bar{a}^2}{\rho_1^2} (\zeta 1 - \bar{z}_c) \quad (5.1.12-9)$$

$$\zeta I2 = \bar{z}_c + \frac{\bar{a}^2}{\rho_2^2} (\zeta 2 - \bar{z}_c) \quad (5.1.12-10)$$

$$\bar{a} = \frac{a}{AR} (\sin^2 \theta + AR^2 \cos^2 \theta)^{3/2} \quad (5.1.12-11)$$

$$\rho_1^2 = (\eta 1 - \bar{y}_c)^2 + (\zeta 1 - \bar{z}_c)^2 \quad (5.1.12-12)$$

$$\rho_2^2 = (\eta 2 - \bar{y}_c)^2 + (\zeta 2 - \bar{z}_c)^2 \quad (5.1.12-13)$$

$$\bar{y}_c = a(1-AR^2) \cos^3 \theta + YB \quad (5.1.12-14)$$

$$\bar{z}_c = a \frac{AR^2-1}{AR} \sin^3 \theta + ZB \quad (5.1.12-15)$$

$$\cos \theta = \frac{\eta - YB}{p} AR$$

$$\sin \theta = \frac{\zeta - ZB}{p}$$

$$P = \sqrt{(\eta - YB)^2 AR^2 + (\zeta - ZB)^2} \quad (5.1.12-18)$$

and where

$$\eta_1 = \eta - e \cos \gamma$$

$$\eta_2 = \eta + e \cos \gamma$$

$$\zeta_1 = \zeta - e \sin \gamma$$

$$\zeta_2 = \zeta + e \sin \gamma$$

Option 2. - INFL = 1

$$\eta I = \bar{y}_c + \frac{\bar{a}^2}{\rho^2} (\eta - \bar{y}_c) \quad (5.1.12-19)$$

$$\zeta I = \bar{z}_c + \frac{\bar{a}^2}{\rho^2} (\zeta - \bar{z}_c) \quad (5.1.12-20)$$

$$\tilde{\mu}_y = -\frac{\bar{a}^2}{\rho^4} \{-\sin \gamma [(\eta - \bar{y}_c)^2 - (\zeta - \bar{z}_c)^2] + 2 \cos \gamma (\eta - \bar{y}_c)(\zeta - \bar{z}_c)\} \quad (5.1.12-21)$$

$$\tilde{\mu}_z = -\frac{\bar{a}^2}{\rho^4} \{-2 \sin \gamma (\eta - \bar{y}_c)(\zeta - \bar{z}_c) - \cos \gamma [(\eta - \bar{y}_c)^2 - (\zeta - \bar{z}_c)^2]\} \quad (5.1.12-22)$$

where

$$\rho^2 = (\eta - \bar{y}_c)^2 + (\zeta - \bar{z}_c)^2 \quad (5.1.12-23)$$

and where

$\bar{a}$, $\bar{y}_c$ and $\bar{z}_c$ are defined by Eq's 5.1.12-11, -14 and -15 respectively.

Both Options 1 and 2.

IF $AR > 1$

$$ELLIPS = 2aAR \quad (5.1.12-24)$$

$$TEST = TRMA + TRMB \quad (5.1.12-25)$$

where

$$TRMA = \sqrt{[a \sqrt{AR^2 - 1} - (zI - z_c)]^2 + (yI - y_c)^2}$$

and

$$TRMB = \sqrt{[a \sqrt{AR^2 - 1} + (zI - z_c)]^2 + (yI - y_c)^2}$$

If $AR < 1$

$$ELLIPS = 2a \quad (5.1.12-26)$$

$$TEST = TRMC + TRMD \quad (5.1.12-27)$$

where

$$TRMC = \sqrt{[a \sqrt{1 - AR^2} - (yI - y_c)]^2 + (zI - z_c)^2}$$

and

$$TRMD = \sqrt{[a \sqrt{1 - AR^2} + (yI - y_c)]^2 + (zI - z_c)^2}$$

and where yI and zI are the image point coordinates: $nI, \zeta I$ for the 'center' sending point, $nI1, \zeta I1$ for the 'inboard', and $nI2, \zeta I2$ for the 'outboard' sending point.

5.1.13 SUBROUTINE TIME (NN)

Functional Description

Subroutine TIME is a utility subroutine which is used to printing out the CPU- and I/O-time spent on the computer either since the beginning of the run (setting: $NN = 0$), or since the last call to TIME ($NN = 1$). In program N5KA subroutine TIME is called from MAIN for each major subroutine, so that a breakdown on the computing time per major computations is obtained for the case.

5.1.14 SUBROUTINE TKER (X0, Y0, Z0, KR, BR, SGR, CGR, SGS, CGS, T1, T2, M)

Functional Description

Subroutine TKER computes the incremental oscillatory kernel, K , for one receiving-sending box combination at a time. The result is obtained in six components and is returned to the calling program, subroutine INCR, via the labeled common block DLM (see Sec. 3.2). Subroutine TKER also computes the total planar and nonplanar kernels $\tilde{K}_1$ and $\tilde{K}_2$ whenever the flag

IND is set to 0; this option is exercised by the calling subroutine FLLD. The flag IND, as well as the total kernels, are transmitted via the labeled common block KDS.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
X0	$\bar{x}$	IN	ARG	AX for center AX1 for inboard AX2 for outboard
Y0	$\bar{y}$			AY for center AY1 for inboard AY2 for outboard
Z0	$\bar{z}$			AZ for center AZ1 for inboard AZ2 for outboard
KR	k_r			See Subroutine INCRO
BR	$b_r, \bar{c}/2$			
SGR				
CGR				
SGS				
CGS				
T1	T_1	OUT	TKER	$T_1 = \cos(\gamma_r - \gamma_s)$
T2	T_2			$T_2 = [(z_0 \cos \gamma_r - y_0 \sin \gamma_r) \times (z_0 \cos \gamma_s - y_0 \sin \gamma_s)] / (b_r/10)^2$
M	M	IN	ARG	Mach Number

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
R1	r	IN	TKER	$r = \bar{y}^2 + \bar{z}^2$
T2P	T_2^*			See Eq. (A.8) [†]
BETA2	β^2			
BIGR	R			See Eq. (A.14)
K1	k_1			Eq. (A.12)
MU1	μ_1			Eq. (A.11)
IOUR	$\text{Re}(I_0)$			Eq. (A.30)
IOUI	$\text{Im}(I_0)$			
JOUR	$\text{Re}(J_0)$			Eq. (A.31)
JOUI	$\text{Im}(J_0)$			
I1UR	$\text{Re}(I_1)$			Eq. (A.25)
I1UI	$\text{Im}(I_1)$			
I2UR3	$3\text{Re}(I_2)$			Eq. (A.27)
I2UI3	$3\text{Im}(I_2)$			
K10T1	$K_1^{(s)} T_1$	OUT	TKER	Planar part
K20T2P	$K_2^{(s)} T_2^*$			Nonplanar part
K1RT1				of the steady kernel
K1IT1				
K2RT2P				
K2TI2P				
				Planar part of Nonplanar part of the unsteady kernel; see Sec. 3.2

[†] Appendix A in Part I Vol. I of this report (Reference 2)

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
KD1R	$\text{Re}(K_1)$	OUT	TKER	See Sec. 3.2
KD1J	$\text{Im}(K_1)$			
KD2R	$\text{Re}(K_2)$			
KD2I	$\text{Im}(K_2)$			

Calling Subroutines INCR0 and FLLD.

Common Blocks

Common DLM and Common KDS

Equations See Appendix A in Part I Vol. I of this report (Reference 2)

5.1.15 SUBROUTINE TVOR (SL1, CL1, TL1, SL2, CL2, TL2, SGS, CGS, SGR, X01, X02, Y0, Z0, E, BETA, CBAR, FMACH, KR, BRE, BIM)

Functional Description

This routine calculates the normalwash at a point (x, y, z) of surface dihedral γ_r , due to a trapezoidal unsteady vortex ring of unit strength.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
SL1	$\sin\lambda_1$	IN	ARG	λ_1 is the sweep angle of leading edge of box
CL1	$\cos\lambda_1$			
TL1	$\tan\lambda_1$			
SL2	$\sin\lambda_2$			λ_2 is the sweep angle of trailing edge of box
CL2	$\cos\lambda_2$			
TL2	$\tan\lambda_2$			
SGS	$\sin\gamma_s$			sine of dihedral angle at sending point

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
CGS	$\cos \gamma_s$	IN	ARG	Cosine of dihedral angle at sending point
SGR	$\sin \gamma_r$			Sine of dihedral angle of receiving point
CGR	$\cos \gamma_r$			Cosine of dihedral angle of receiving point
X01	$x - \xi_1$			Distance in x-direction from receiving point to leading edge of box ξ_2 indicates trailing edge of box
X02	$x + \xi_2$			
Y0	$y - \eta$			Distance in y-direction from receiving point to center of box
Z0	$y - \xi$			Distance in z-direction from receiving point to center of box
E	e			$\sqrt{1 - M^2}$ Length of reference chord
BETA	β			
CBAR	$\bar{c}$			
FMACH	M			
KR	k_r	OUT	ARG	Mach Number
				Reduced frequency
BRE	$\text{Re}(B)$			Real part of the normalwash
BIM	$\text{Im}(B)$	OUT	ARG	Imaginary part of the normalwash

Calling Subroutines

DZY

Called Subroutines and common blocks

SNPDF, FLLD

Equations

$$B = \frac{BS}{2e\Delta x} - \frac{\Delta B}{48\pi} \quad (5.1.15-1)$$

where

$$BS = D^{(s)}[(\lambda_1, x_{01}), (\gamma_r, \gamma_s, Z_0, Y_0, e, \beta, \Delta x)] \\ - D^{(s)}[(\lambda_2, x_{02}), (\gamma_r, \gamma_s, Z_0, Y_0, e, \beta, \Delta x)]$$

$D(s)$ - is calculated in subroutine SNPDPF

$$\Delta x = \xi_2 - \xi_1$$

$$\begin{aligned} & \underline{r_i \text{ and } r_o \geq \frac{e}{4}} \\ & \Delta B' = \Delta \tilde{K}_{d_i} + 4\Delta \tilde{K}_{d_c} + \Delta \tilde{K}_{d_o} \end{aligned}$$

$$\underline{r_i \text{ or } r_o < \frac{e}{4}}$$

$$\Delta B' = 6\Delta \tilde{K}_{d_c}$$

$$\underline{r_c \leq \frac{e}{4}}$$

$$\Delta B' = 3\Delta \tilde{K}_{d_i} + 3\Delta \tilde{K}_{d_o}$$

where

$$\Delta \tilde{K}_d = \frac{\Delta K_{d1}}{r^2} + \frac{\Delta K_{d2}}{r^4}$$

$$r_i^2 = (y_o + e \cos \gamma_s)^2 + (z_o + e \cos \gamma_s)^2$$

$$r_c^2 = y_o^2 + z_o^2$$

$$r_o^2 = (y_o - e \cos \gamma_s)^2 + (z_o - e \cos \gamma_s)^2$$

and

ΔK_{d1} and ΔK_{d2} are calculated by FLLD

5.1.16 SUBROUTINE WRTFMF (IUNT, NBE, FZ, FY, EMZ, EMY)

Functional Description

This routine writes the NBE elements of the complex arrays FZ, FY, EMZ, and EMY with a format on I/O unit IUNT.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
IUNT				I/O unit on which the data is to be written
NBE				Number of complex words in each array
FZ		IN	ARG	Array to be written
FY				Array to be written
EMZ				Array to be written
EMY				Array to be written

Calling Subroutine

BFM

5.1.17 SUBROUTINE WRTFMU (IUNT, MODE, NBE, FZ, FY, EMZ, EMY)

Functional Description

This routine writes MODE and the NBE elements of the complex arrays FZ, FY, EMZ, EMY without a format on the I/O unit IUNT.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
IUNT				I/O unit on which the data is to be written
MODE				The mode number to be written
FZ		IN	ARG	Array to be written
FY				Array to be written
EMZ				Array to be written
EMY				Array to be written

Calling Subroutine

BFM

5.2 Segment 2

5.2.1 SUBROUTINE DATA

Functional Description

Subroutine DATA reads the x-, y- and z-coordinates that define each panel, interference body and slender body for the case considered. It also reads the fractional chordwise and spanwise divisions for each panel and calculates arrays of geometry that define the sending- and receiving control points on the lifting surfaces. In the case when bodies are also present, similar geometry arrays are calculated for all interference body elements, and all slender body elements. These basic data arrays are saved in the Blank Common Block for use in the subsequent calculations.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
X1	x_1	IN	card	Panel coordinates Number of chordwise boxes Number of spanwise strips
X2	x_2			
X3	x_3			
X4	x_4			
Y1	y_1			
Y2	y_2			
Z1	z_1			
Z2	z_2			
NC	nc			
NS	ns			
NAB(10)	$y_1^{(p)}$	OUT	DATA	Associated bodies
YIN(100)				y-coordinate of inboard edge of panel p

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
ZIN(100)	$z_1^{(p)}$	OUT	DATA	z-coordinate of inboard edge of panel
NASB(200)				Array of all associated bodies for all panels
NAS(100)				Array of the number of associated bodies for all panels
NCARAY(100)	nc			Array of the number of chordwise boxes for all panels
NSARAY(100)	ns			Array of the number of spanwise strips for all panels
NBARAY(100)	nba			$nba_p = \sum_{i=1}^p nc_i ns_i$ where p is the panel number
TH(50)	$e_c^{(p)}$	IN	card	Fractional chordwise divisions for panel p
TAU(50)	$\tau_s^{(p)}$			Fractional spanwise divisions for panel p
GMA(100)	$\gamma^{(p)}$	OUT	DATA	Dihedral angle of panel p
X(500)	$x_{c,s}^p$ and x_k^I			3/4-chord x-coordinate of all boxes and x-coordinate of interference body section midpoints - see Eqs.(5.2.1-1 and -2)
XI1(500)	$\xi P1_{c,s}$			1/4-chord coordinates of inboard- and
XI2(500)	$\xi P2_{c,s}$			outboard edge of panel boxes - see Eqs.(5.2.1-3 and -4)
DELX(500)	$\Delta x P_{c,s}$ and $\Delta x I_k$			Average chordlength of boxes and Δx of interference body sections - see Eqs.(5.2.1-7 and -8)

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
YS(210)	yP_s	OUT	DATA	y-coordinate of centerline of panel strips - Eq.(5.2.1-9)
ZS(210)	zP_s			z-coordinates of centerline of panel strips - Eq.(5.2.1-10)
DYS(200)	Δy_s			See Eqs. $\left\{ \begin{array}{l} (5.2.1-12) \text{ and} \\ (5.2.1-13) \end{array} \right.$
DZS(200)	Δz_s			
SE(200)	e_s			Half-width of panel strips - Eq.(5.2.1-11)
CS(200)	c_s			Average chord of panel strips - Eq.(5.2.1-16)
SG(200)				sine of dihedral angle
CG(200)				and for strips -
XIJ(200)				cosine Eqs. (5.2.1-14 and -15)
GMAR(200)	γ_s			Dihedral angle of strips in radians
XLAM(500)	$\tan \lambda_{c,s}$			Tangent of the sweep angle of the 1/4-chordline of all lifting surface boxes - see Eq.(5.2.1-13a)
ZC	z_c	IN	card	z-coordinate of body centerline
YX	y_c			y-coordinate of body centerline
RAD	a			Average half-width of body
AR				Cross-sectional aspect ratio of body
NBE				No. of interference body elements
NSBE				No. of slender body elements
NZY				z-y orientation flag

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
NRI				Interference body element radius flag (RI-flag)
NRS				Slender body element radius flag (RS-flag)
NSH				Number of $\Delta\eta - \Delta\zeta$ pairs for body
NT1	$N\theta_1$	IN	card	Number of θ_1 's for body
NT2	$N\theta_2$			Number of θ_2 's for body
ZB(10)				Array of z-coordinates of body centerlines
YB(10)				Array of y-coordinates of body centerlines
AVR(10)				Array of average characteristic half widths,
ARB(10)		OUT	DATA	Array of aspect ratios,
NBEA(10,2)				1. No. of interference body elements
NSBEA(10)				2. z-y flags,
				No. of slender body elements - for all bodies
XII(100)	ξI			x-coordinates of interference body element endpoints
RI(100)	RI			Radii of interference body element endpoints
XIS(100)	ξS	IN	card	x-coordinates of slender body element endpoints
RS(100)	RS			Radii of slender body element endpoints

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
TH1(24)	θ^1_{μ}	IN	card	Angular orientation of point μ on body, first set
TH2(24)	θ^2_{μ}			Angular orientation of point μ on body, second set
TH1A(100)		OUT	DATA	Array of θ^1_{μ} 's for all bodies
TH2A(100)				Array of θ^2_{μ} 's for all bodies
L1 L2 L3 L4 L5 L6		IN	card	First and last interference body elements associated with θ^1_{μ}
IFLA(30,2)		OUT	DATA	1. Array of 'first' interference body elements, 2. Array of 'last' interference body elements,
NFL(10)				Array of the number of pairs of 'first- and last' elements - for all bodies
NCD1 CD2 CD3		IN	card	Panel no. for $\Delta\eta$, $\Delta\zeta$ y-shift of panel z-shift of panel
NCD4 CD5 CD6				another set of the above 3 items
NOBODY(50)				Array of the body no.'s,
NPANEL(50)				Array of the panel no's for the $\Delta\eta$, $\Delta\zeta$ shift

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
DETA(50)	$\Delta\eta$	OUT	DATA	Array of the y-shifts for panels
DZET(50)	$\Delta\zeta$			Array of the z-shifts for panels
RIA(100)				Array of the radii of all interference body element midpoints
XLE(10)				Eq.(5.2.1-17) when NBE $\neq$ 0. If NBE=0, but NSBE $\neq$ 0, the
XTE(10)				Eq.(5.2.1-18) slender body leading- and trailing x-coordinates are used
XIS1(200)	$\xi S1_t$			Array of the x-coordinates of leading- and trailing edges (respectively) of all slender body elements; see Eq's (5.2.1-20 and -21)
XIS2(200)	$\xi S2_t$			
A0(200)	a_{0t}			Array of the average radii of all slender body elements; see Eq.(5.2.1-22)
AOP(200)	a_{0t}			Array of the first derivatives of a_{0t} for all slender body elements; see Eq.(5.2.1-23)

Calling Subroutine: MAIN

Equations

3/4-chord x-coordinate for all boxes of panel:

$$\begin{aligned}
 xP_{c,s} = \frac{(\tau_s + \tau_{s+1})}{2} & \left[\left(\frac{1}{4}\theta_c + \frac{3}{4}\theta_{c+1} \right) (x_4 - x_3 - x_2 + x_1) + (x_3 - x_1) \right] \\
 & + \left(\frac{1}{4}\theta_c + \frac{3}{4}\theta_{c+1} \right) (x_2 - x_1) + x_1 \quad (5.2.1-1)
 \end{aligned}$$

x-coordinate of interference-body section midpoint:

$$xI_k = \frac{\xi I_{k+1} + \xi I_k}{2} \quad (5.2.1-2)$$

1/4-chord x-coordinate of inboard edge of panel boxes:

$$\xi P1_{c,s} = \tau_s BR + CR \quad (5.2.1-3)$$

1/4-chord x-coordinate of outboard edge of panel boxes:

$$\xi P2_{c,s} = \tau_{s+1} BR + CR \quad (5.2.1-4)$$

where

$$BR = \left(\frac{3}{4} \theta_c + \frac{1}{4} \theta_{c+1}\right)(x_4 - x_3 - x_2 + x_1) + (x_3 - x_1)$$

$$CR = \left(\frac{3}{4} \theta_c + \frac{1}{4} \theta_{c+1}\right)(x_2 - x_1) + x_1$$

x-coordinate of ^{leading} and _{trailing} edges of interference-body sections:

$$\xi I1_k = \xi I_k \quad (5.2.1-5)$$

$$\xi I2_k = \xi I_{k+1} \quad (5.2.1-6)$$

Average chord-length of panel boxes:

$$\Delta XP_{c,s} = \frac{\tau_{s+1} + \tau_s}{2} [(\theta_{c+1} - \theta_c)(x_4 - x_3 - x_2 + x_1) + (\theta_{c+1} - \theta_c)(x_3 - x_1)] \quad (5.2.1-7)$$

Δx for interference body-sections:

$$\Delta x_k = \xi I2_k - \xi I1_k \quad (5.2.1-8)$$

y-coordinate of centerline of panel strips:

$$yP_s = \frac{\tau_s + \tau_{s+1}}{2} (y_2 - y_1) + y_1 \quad (5.2.1-9)$$

z-coordinate of centerline of panel strips:

$$zP_s = \frac{\tau_s + \tau_{s+1}}{2} (z_2 - z_1) + z_1 \quad (5.2.1-10)$$

Half-width of panel strips

$$e_s = \frac{1}{2} \sqrt{\Delta y_s^2 + \Delta z_s^2} \quad (5.2.1-11)$$

where

$$\Delta y_s = (\tau_{s+1} - \tau_s) (y_2 - y_1) \quad (5.2.1-12)$$

$$\Delta z_s = (\tau_{s+1} - \tau_s) (z_2 - z_1) \quad (5.2.1-13)$$

$$\tan \lambda_{c,s} = (\xi P2_{c,s} - \xi P1_{c,s}) / (2e_s) \quad (5.2.1-13a)$$

Sine and cosine of dihedral angle of panel strips

$$\sin \gamma_s = \Delta z_s / 2e_s \quad (5.2.1-14)$$

$$\cos \gamma_s = \Delta y_s / 2e_s \quad (5.2.1-15)$$

Average chord of panel strips

$$c_s = \frac{\tau_s + \tau_{s+1}}{2} (x_4 - x_3 - x_2 + x_1) + (x_2 - x_1) \quad (5.2.1-16)$$

Leading and trailing edge coordinates of bodies

$$x_{L.E.} = \xi I1_k, \quad k = 1 \quad (5.2.1-17)$$

$$x_{T.E.} = \xi I2_k, \quad k = NBE \quad (5.2.1-18)$$

x-coordinate of slender body section midpoint

$$xS_t = (\xi T_t + \xi S_{t+1}) / 2 \quad (5.2.1-19)$$

x-coordinates of ^{leading} and ^{trailing} edges of slender body sections

$$\xi S1_t = \xi S_t \quad (5.2.1-20)$$

$$\xi S2_t = \xi S_{t+1} \quad (5.2.1-21)$$

Average radius of slender body sections:

$$a_{0t} = \frac{RS_t + RS_{t+1}}{2} \quad (5.2.1-22)$$

First derivative of a_0 :

$$a_{0t}' = \frac{RS_{t+1} - RS_t}{\Delta x S_t} \quad (5.2.1-23)$$

where

$$\Delta x S_t = \xi S2_t - \xi S1_t \quad (5.2.1-24)$$

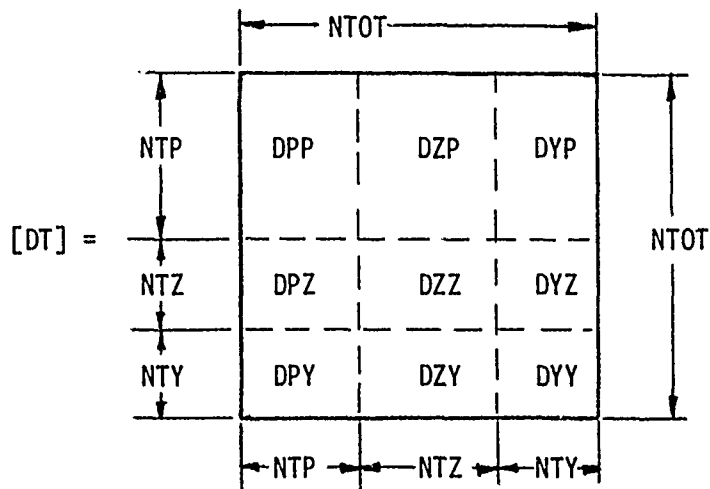
5.3 Segment 3

5.3.1 SUBROUTINE GEND (NPRINT, NTAPE, WORK)

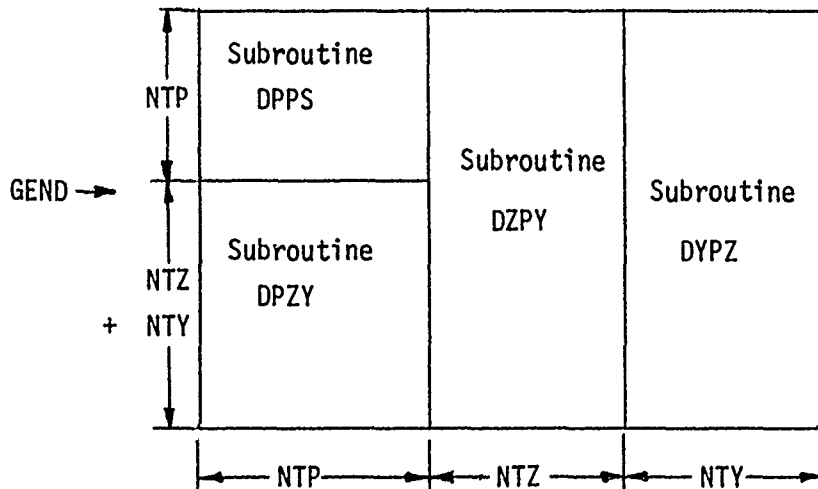
Functional Description

Subroutine GEND generates the nine submatrices of the [DT] matrix, then assembles the [DT] matrix and writes it on logical tape unit no. ITP8 in row order. The submatrices generated by GEND, and the major subroutines that compute these, are shown in the diagrams below.

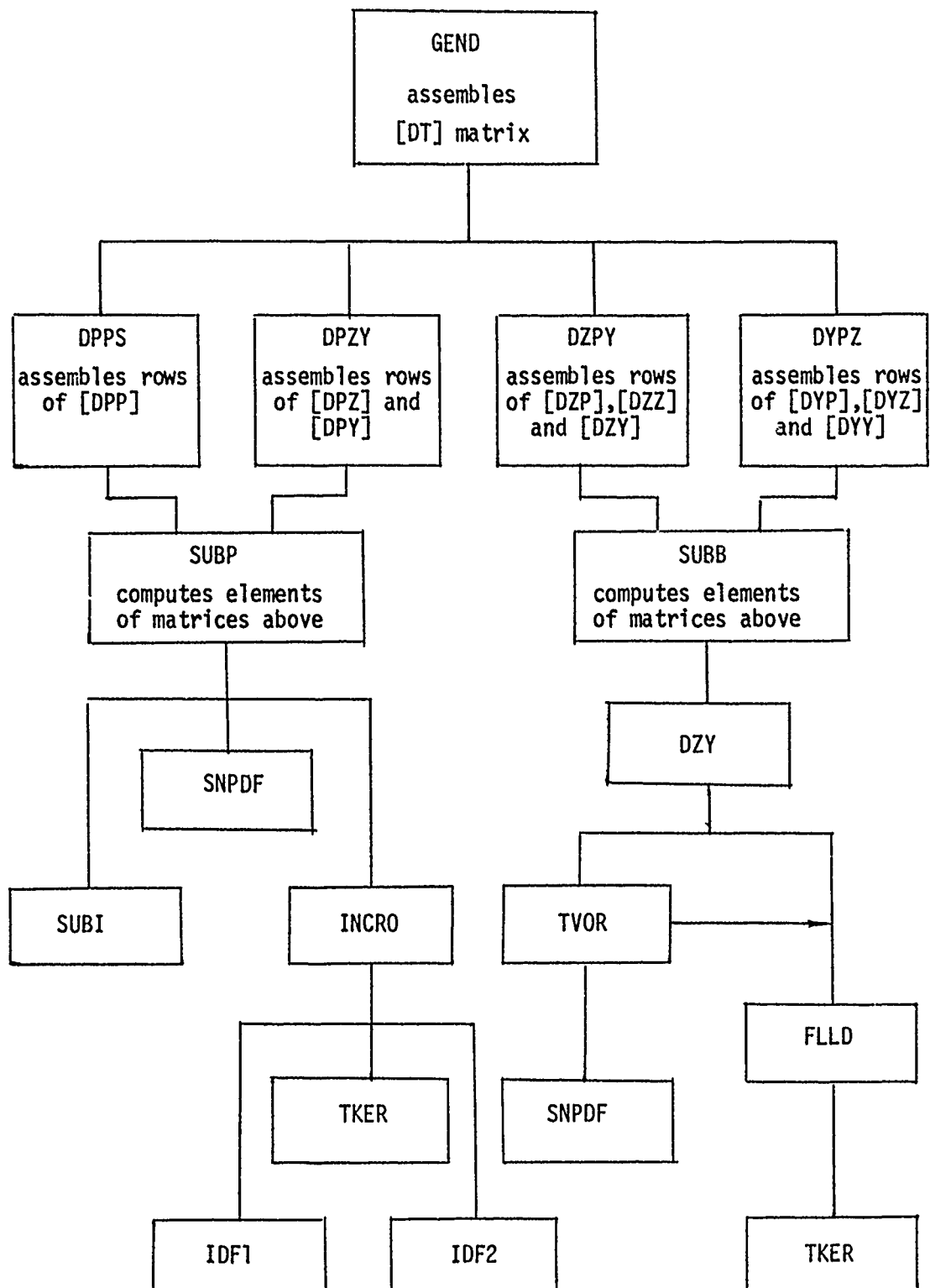
DT Matrix Structure



Major Subroutines Generating DT



General Flow Chart - Subroutine GEND



Input Output Variables

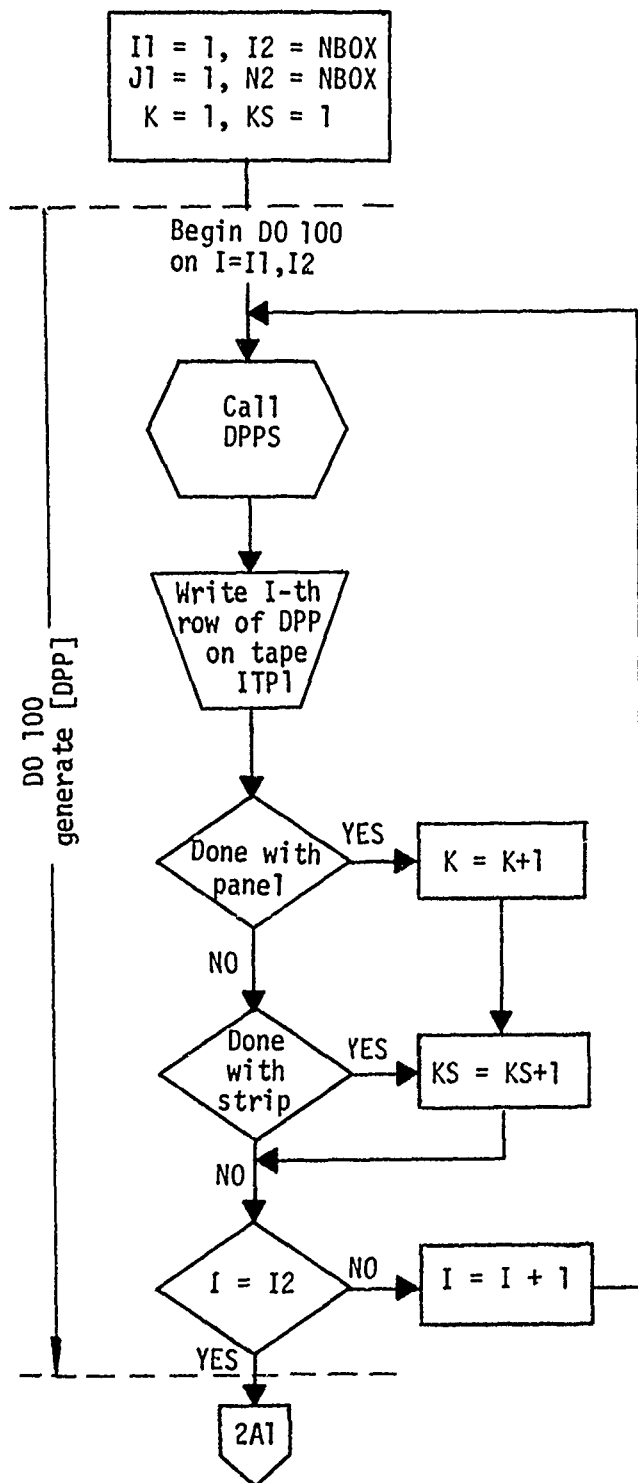
MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
NPRINT		IN	ARG	Print flag for DT matrix
NTAPE(20)		IN	ARG	Logical tape unit array
WORK		IN/OUT		Complex work array
DT(500)	DT.	OUT	GEND	One row of the complex DT matrix - also used for temporary storage of rows of all submatrices of DT, except those of DPZ and DPY.
DPZ(500)	DPZ			One row of the complex DPZ matrix
DPY(500)	DPY			One row of the complex DPY matrix
FLND	δ		Blank	Floating point variable for δ
FLNE	ϵ	IN	Common	the integer input ϵ
FL,REFC	$\bar{c}$		Block	Reference chord
I1		OUT	GEND	Do-loop delimiters for the number of rows of a particular submatrix to be computed within the do loop
I2				
J1				Do-loop delimiters for the number of elements in one row of a particular submatrix to be computed within do-loop.
J2				
ICOUNT				Running index of the section number of the receiving body, KB, with θ_1 distribution.
IFL				The number of sections of body KB with θ_1 distribution.
NZYKB				z-y flag of body KB
NZYSV				z-y flat of body preceding the present body KB; 0 for KB=1
IFIRST				Sequence number of the first element in the current section of body KB with θ_1 distribution
ILAST				Sequence no. of the last element in the current section of body KB with θ_1 distribution
NYFLAG				Internal flag selecting correct do-loop for bodies

Calling Subroutine MAIN

Called Subroutines and Common Blocks

Subroutines DPPS, DPZY, DZYP and DYPZ, and the Blank Common Block.

Semi-Detailed Block Diagram of Subroutine GEND



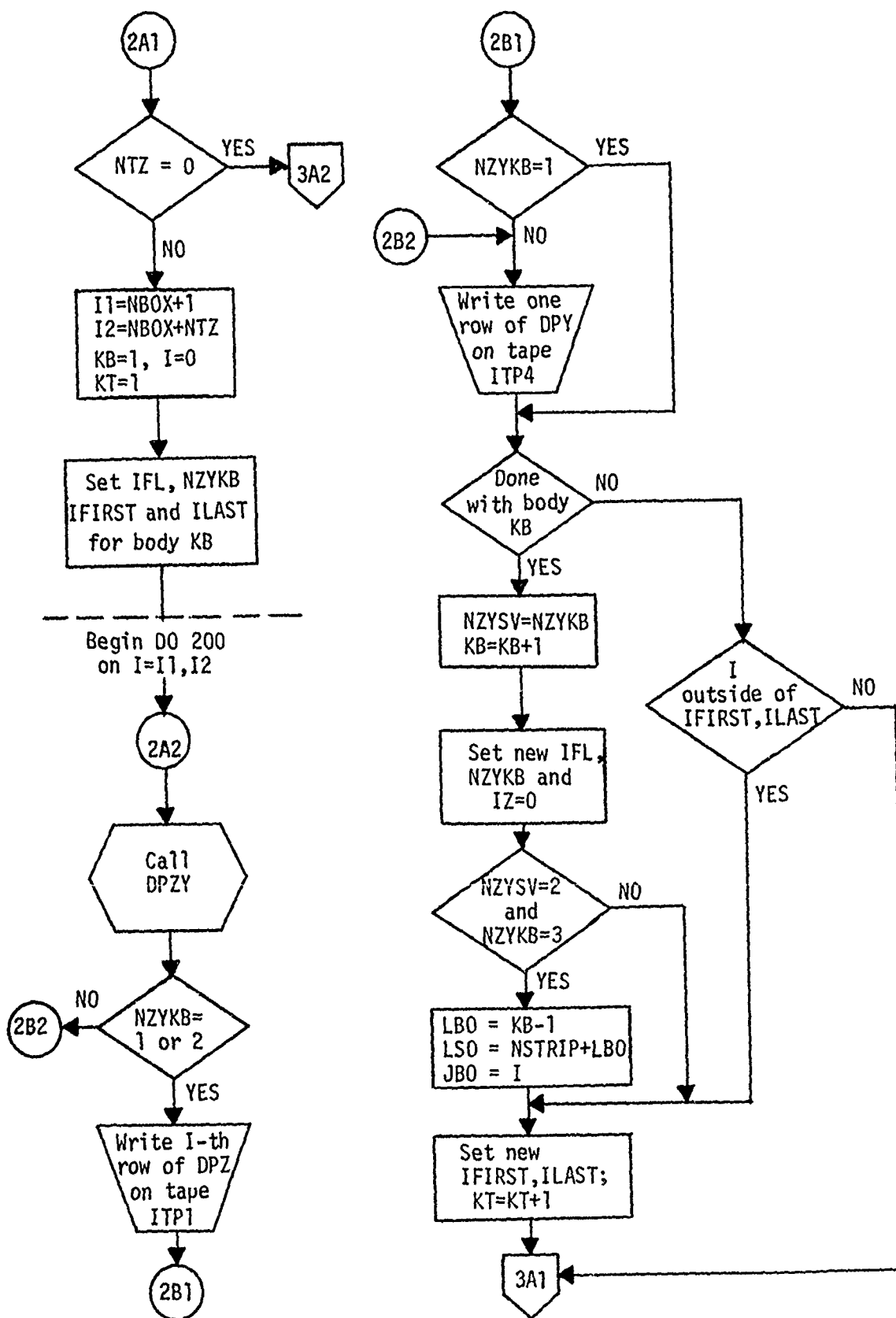
Legend

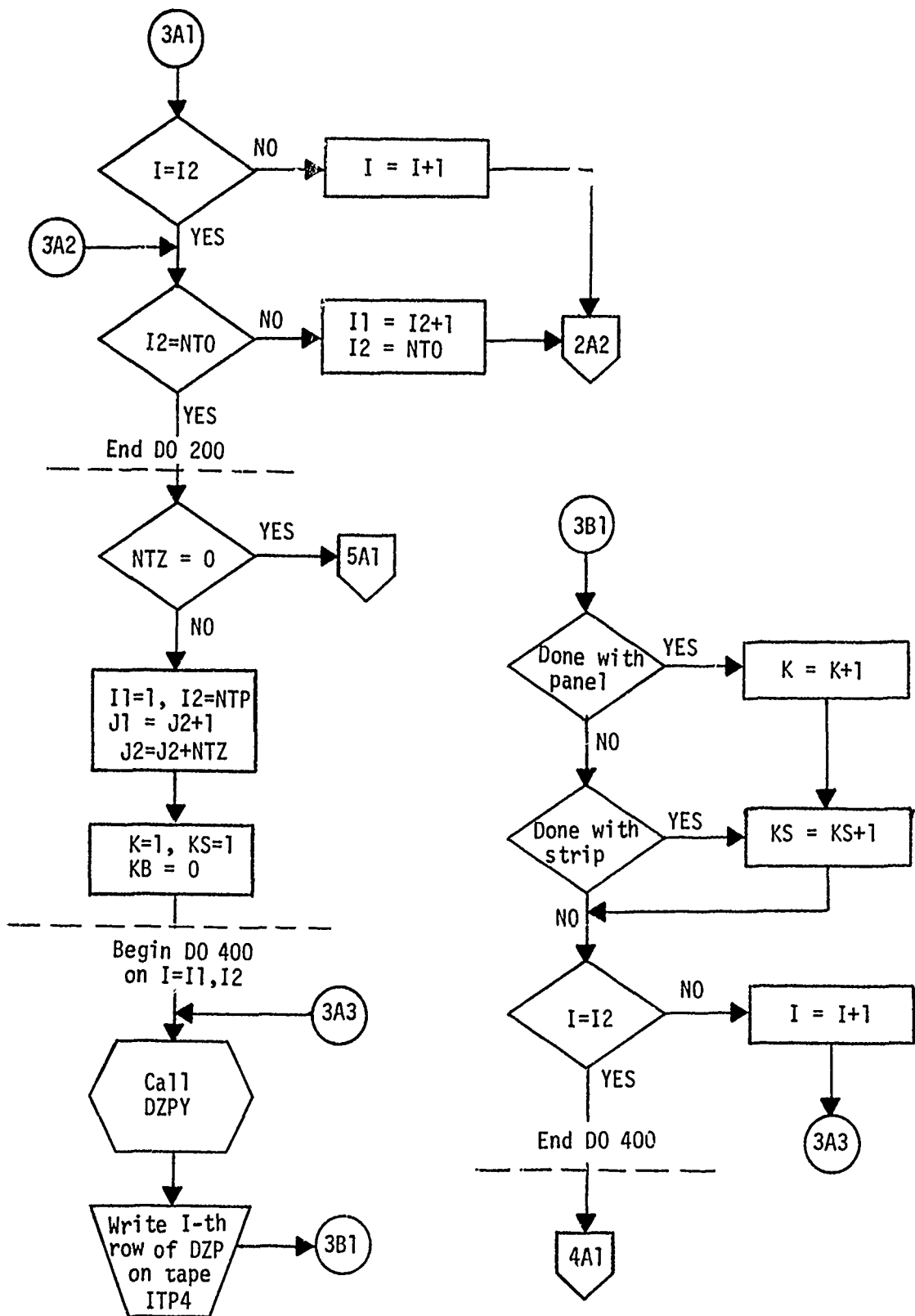
Receiving indices 'r'

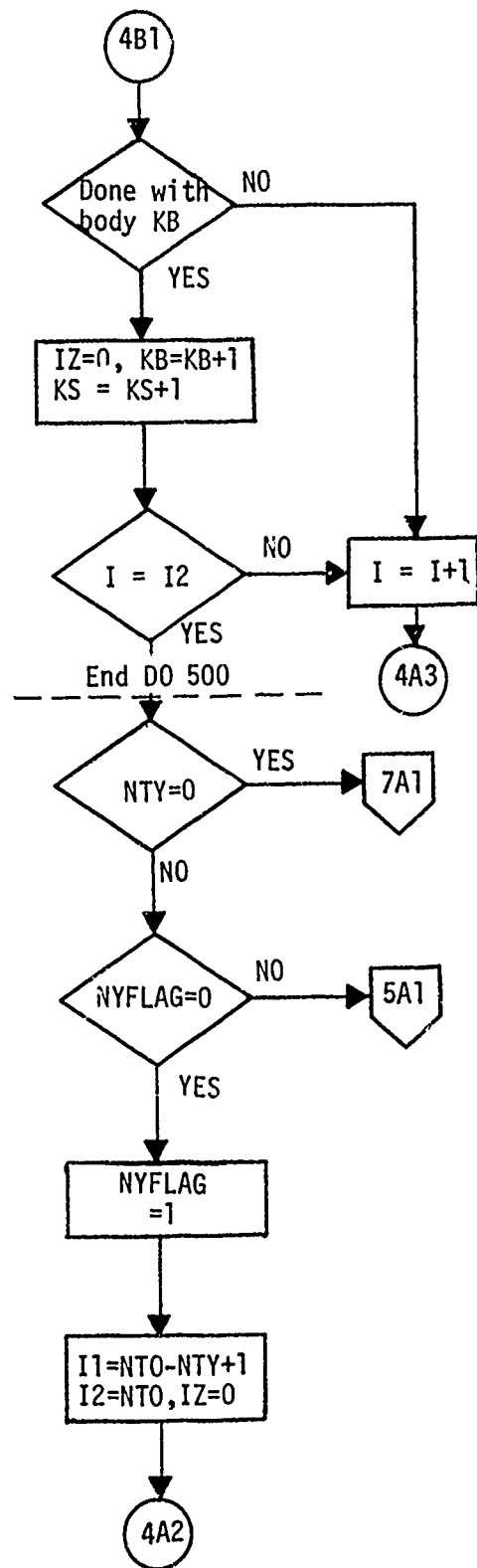
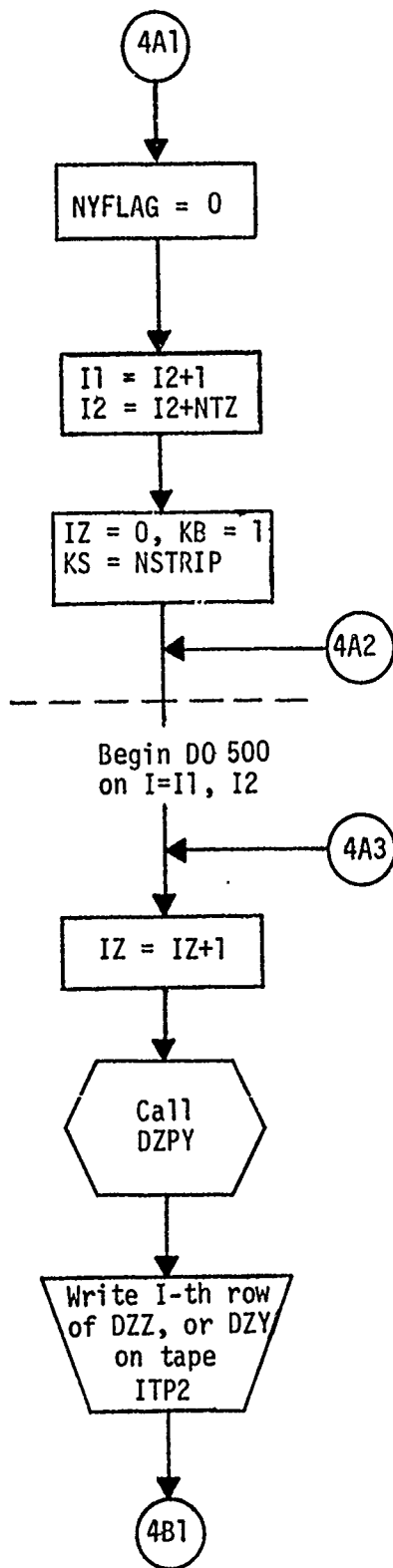
- I - r point
- K - r panel
- KS - r strip (or equivalent for body)
- KB - r body (if any)
- KT - index of the array of the 'first-and-last elements' for θ_1
- IZ - r body element

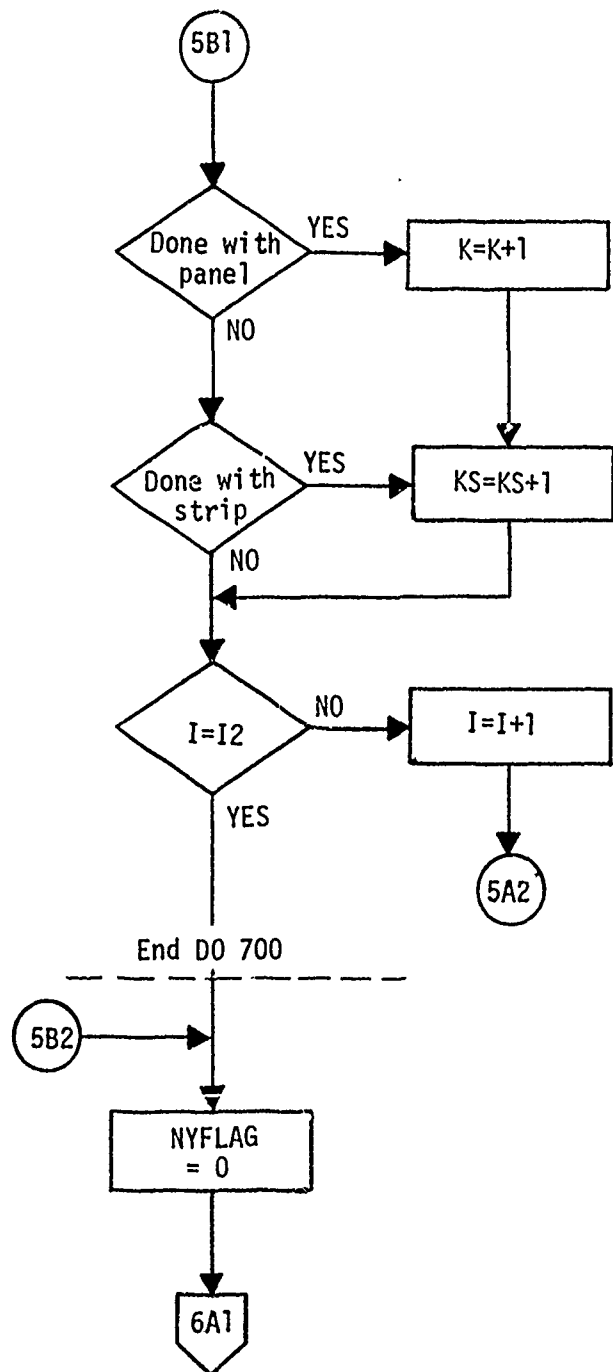
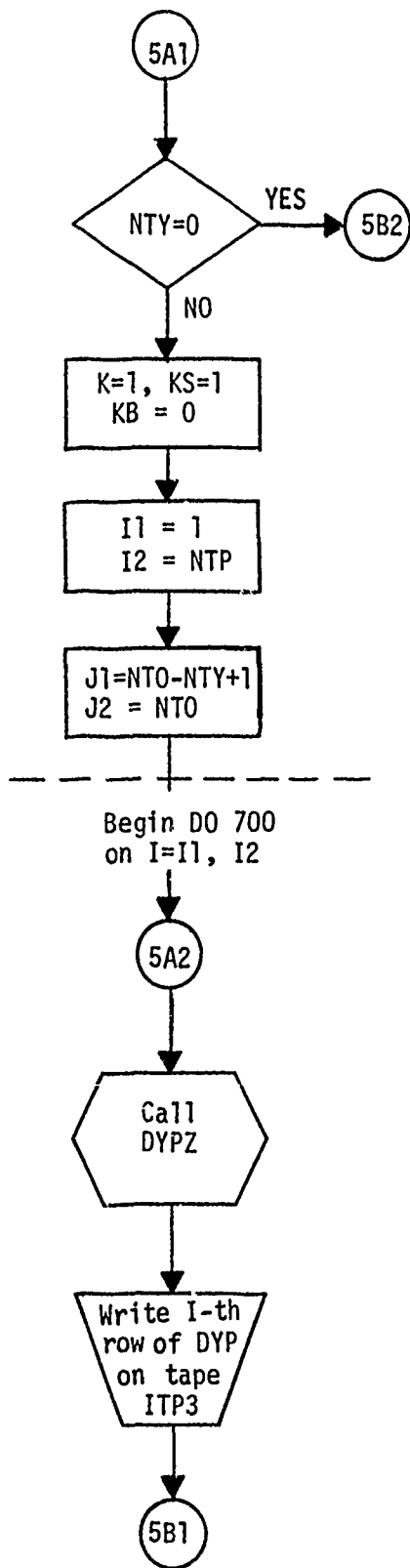
Sending indices 's'

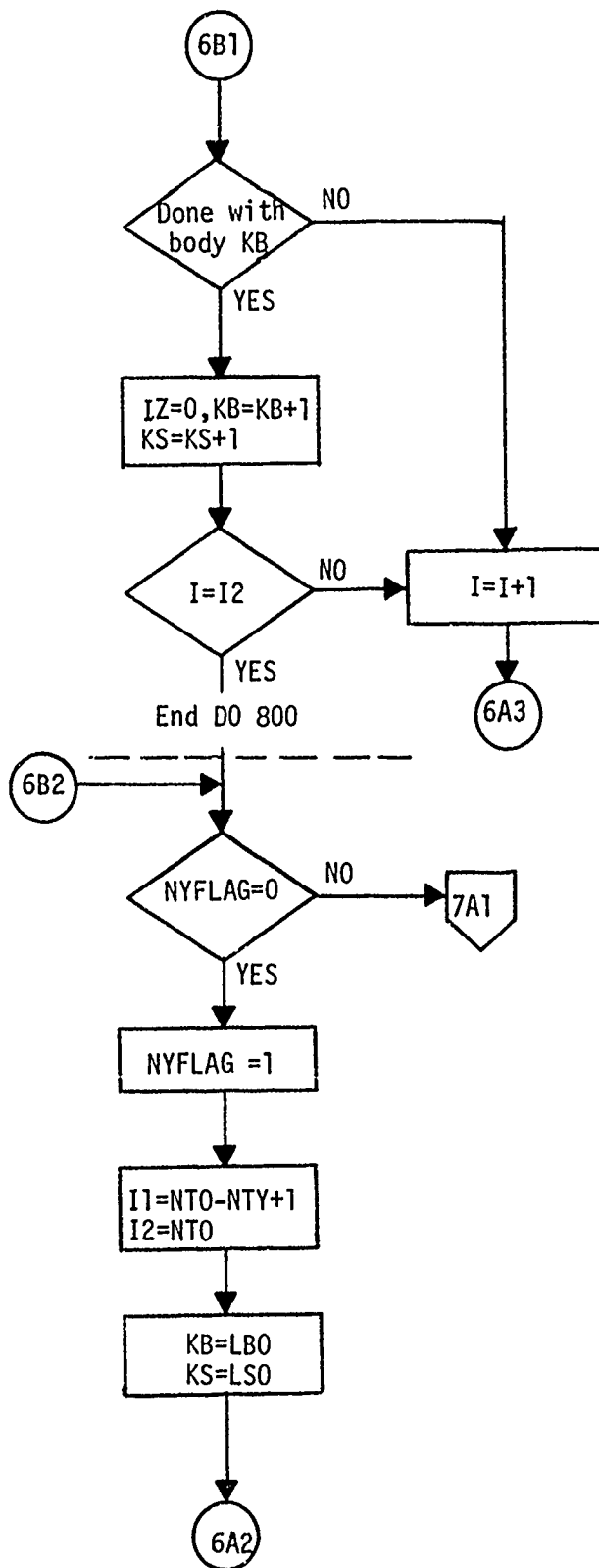
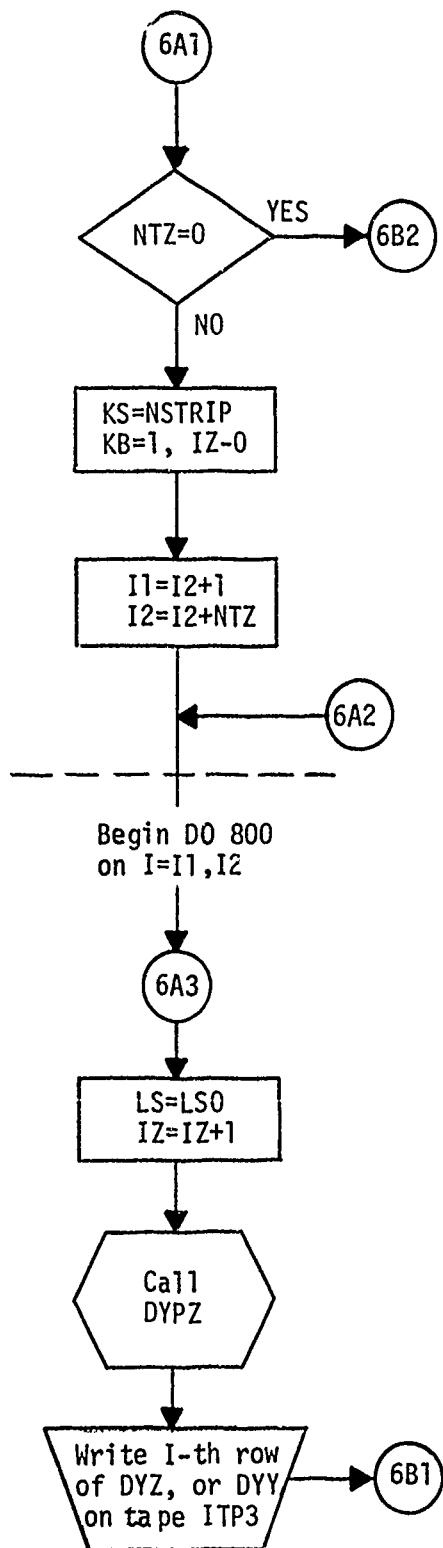
- J - s point
- L - s panel
- LS - s strip (or equivalent for body)
- LB - s body

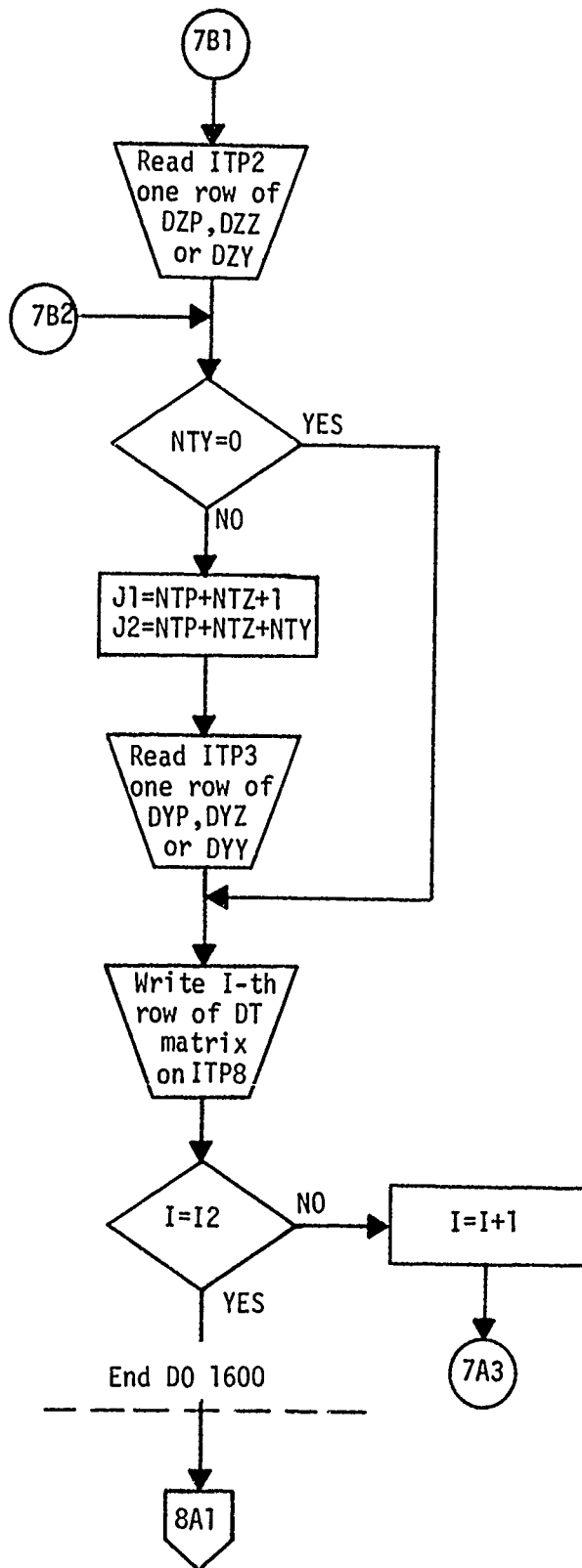
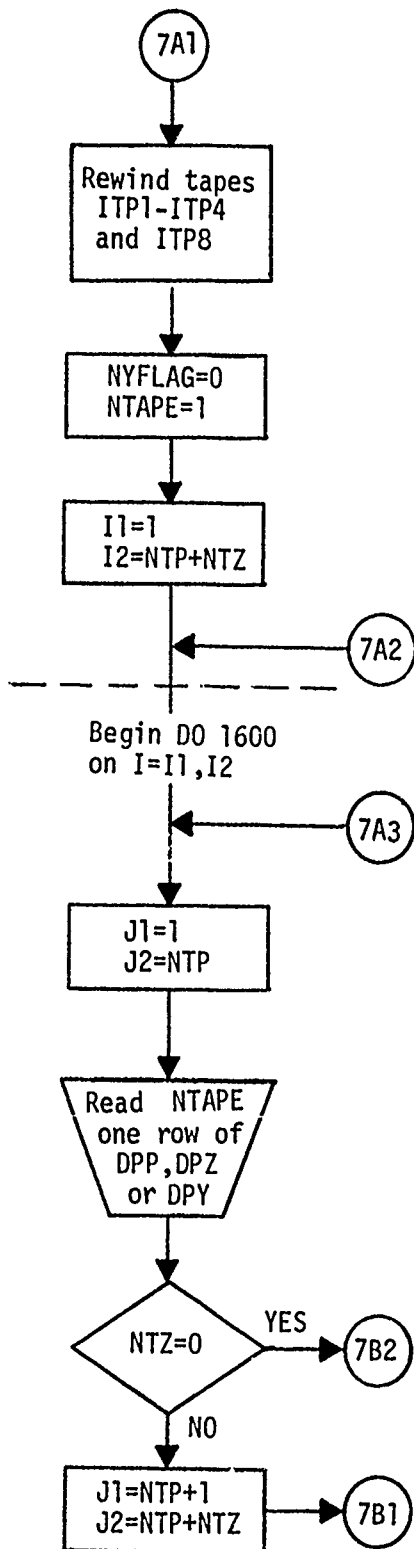


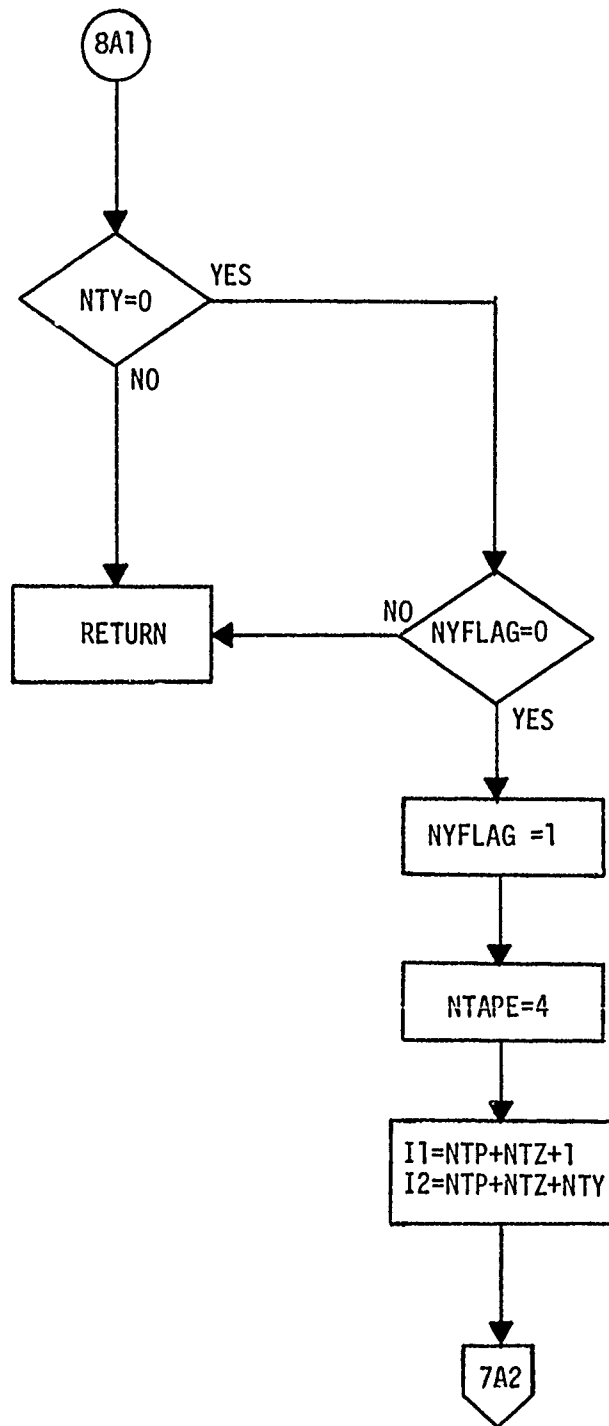












5.3.2 SUBROUTINE DPPS (K, KS, I, J1, J2, SGR, CGR, REFC, FMACH, YS, ZS, NBARAY, NCARAY, DT, WORK)

Functional Description

Subroutine DPPS prepares the variables necessary for the computation of one row of the DPP-submatrix and calls subroutine SUBP in a do-loop for each element of this row. The resulting matrix row, DT(500), is returned to subroutine GEND via the argument list of subroutine DPPS.

Input-Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
K		IN	ARG	Panel number in which the receiving point 'i' lies
KS				Strip number in which the receiving point 'i' lies
I	i	IN/OUT		Receiving point index
J1		IN		Do-loop delimiters for the number of elements in one row of the DPP matrix
J2				
SGR	$\sin\gamma_r$	IN/OUT		sine, and cosine of the dihedral angle of receiving strip
CGR	$\cos\gamma_r$			
REFC	$\bar{c}$	IN		Reference chord
FMACH	M			Mach Number
YS(210)	y			y-array
ZS(210)	z			z-array
NBARAY(100				See Sec. 5.2.1
NCARAY(100				See Blank Common, Sec. 3.1
DT(500)		IN/OUT		One row of the DPP matrix
WORK				

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
IO NBXS NCPNB		OUT	DPPS	See INCRO; Sec. 5.1.7
IR				Index of sending point
YREC	y			y-coordinate } of receiving z-coordinate } point i
ZREC	z			
L				Panel number } in which the Strip number } sending point
LS				'j' lies

Calling Subroutine GEND

Called Subroutine SUBP

5.3.3 SUBROUTINE DPZY (KB, KT, IZ, I, J1, J2, IFIRST, ILAST, REFC, FMACH, YB, ZB, AVR, ARB, TH1A, TH2A, NT12, NBARAY, NCARAY, NZYKB, DPZ, DPY, WORK)

Functional Description

Subroutine DPZY prepares the variables necessary for the computation of one row of either the DPZ, or the DPY submatrix and calls subroutine SUBP in a double do-loop for each element of the row, to perform the summation given in Eqs (5.3.3-1 and -9). The resulting matrix row is returned to the calling subroutine GEND via the argument list of DPZY.

Input-Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
KB		IN/OUT	ARG	Body number in which the receiving point 'i' lies
IZ				Body element number of body KB in which 'i' lies
I	i			Receiving point index

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
J1 J2 IFIRST ILAST				Do-loop delimiters for the number of elements in one row of either the DPZ, or DPY matrix See Subroutine GEND Sec. 5.3.1
REFC FMACH YB(10) ZB(10) AVR(10) ARB(10) TH1A(100) TH2A(100) NT12(10,2) NBARAY(100) NCARAY(100)	$\bar{c}$ M $y_c^{(b)}$ $z_c^{(b)}$ $a^{(b)}$ $R^{(b)}$ $\theta_{1\mu}$ $\theta_{2\mu}$	IN	ARG	Reference chord See Blank Common Sec. 3.1 See Blank Common Sec. 3.1
NZYKB DPZ(500) DPY(500)		IN/OUT		z-y flag of receiving body One row of the $\left\{ \begin{array}{l} \text{DPZ matrix} \\ (5.3.3-1) \\ \text{DPY matrix} \\ \text{Eq. (5.3.3-9)} \end{array} \right.$
IX1 IX2		OUT	DPZY	Do-loop delimiters in the summation of Eq.(5.3.3-1)
WORK		IN/OUT	ARG	Complex work array

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
DELTH	$\Delta\theta$	OUT	DPZY	(5.3.3-3)
YREC	y_r			See Eq's (5.3.3-4)
ZREC	z_r			(5.3.3-5)
RHO	ζ_μ			(5.3.3-8)
SGR	$\sin\gamma_{r\ell}$			(5.3.3-7)
CGR	$\cos\gamma_{r\ell}$			(5.3.3-6)
SMULT				(5.3.3-2)
CMULT				(5.3.3-10)
L				Panel number
LS				Strip number
				in which the sending point 'j' lies
IO		OUT	DPZY	See INCRO; Sec. 5.1.8
NBXS				
NCPNB				
IR				Index of sending point

Calling Subroutine GEND

Called Subroutine SUBP

Equations

When the receiving point 'i' lies on a z-oriented body, subroutine DPZY computes

$$DPZ_{ij} = \sum_{\mu=1}^{N\theta} DP(ARG_0, ARG_R, ARG_S) S(\theta_\mu, AR^{(b)}) \Delta\theta_\mu \quad (5.3.3-1)$$

where

$$S(\theta_\mu, AR^{(b)}) = \frac{1}{\pi} \sin\theta_\mu \sqrt{1 + \cos^2\theta_\mu (AR^2 - 1)} \quad (5.3.3-2)$$

$$\Delta\theta_{\mu} = \frac{\theta_{\mu+1} - \theta_{\mu} - 1}{2} \quad (5.3.3-3)$$

where

$$\theta_0 = \theta_{N\theta} - 2\pi \text{ and } \theta_{N\theta+1} = \theta_1 + 2\pi$$

and $\mu = 1, 2, \dots, N\theta$.

Note that $N\theta$ is either $N\theta^{(1)}$ or $N\theta^{(2)}$, depending on the body section in which the body receiving point lies; accordingly, θ_{μ} is either $\theta_{1\mu}$ or $\theta_{2\mu}$ - see input data, Sec. 1.2, and $DP(\text{ARG}_0, \text{ARG}_R, \text{ARG}_S)$ is given by Eq.(5.5.3.7-2) computed in Subroutine SUBP.

Here, however, the receiving point arguments depend on the θ -distribution of the body section, and are defined as follows:

ARG_R:

$$x_i = XI_i$$

$$y_k = YB^{(b)} + a^{(b)} \cos\theta_{\mu} \quad (5.3.3-4)$$

$$z_k = ZB^{(b)} + a^{(b)} AR^{(b)} \sin\theta_{\mu} \quad (5.3.3-5)$$

$$\cos\gamma_{r_{\ell}} = \sin\theta_{\mu} / \zeta_{\mu} \quad (5.3.3-6)$$

$$\sin\gamma_{r_{\ell}} = -AR^{(b)} \cos\theta_{\mu} / \zeta_{\mu} \quad (5.3.3-7)$$

$$\text{and } \zeta_{\mu} = \cos^2\theta_{\mu} (AR^2 - 1) + 1 \quad (5.3.3-8)$$

A complete summary of the ARG_R and ARG_S are given in the table at the end of this section. ARG_0 denotes the constant arguments k_r and M - this holds true for all nine submatrices of the total downwash factor matrix [DT].

For receiving points on y-oriented bodies subroutine DPZY computes

$$DPY_{ij} = \sum_{\mu=1}^{N\theta} DP(\text{ARG}_0, \text{ARG}_R, \text{ARG}_S) C(\theta_{\mu}, AR^{(b)}) \Delta\theta_{\mu} \quad (5.3.3-9)$$

wher

$$C(\theta_{\mu}, AR^{(b)}) = \frac{1}{\pi} \cos\theta_{\mu} \sqrt{1 + \cos^2\theta_{\mu} (AR^2 - 1)} \quad (5.3.3-10)$$

and

$$\Delta\theta_{\mu} \text{ is given by Eq. (5.3.3-3)}$$

DP(ARG_o , ARG_R , ARG_S) is given by Eq. (5.3.7-2) and the arguments ARG_R and ARG_S are summarized in the table below.

Receiving Point on Body, Sending Point on Panel

POINTS	ARGUMENTS	COORDINATES			DIHEDRAL ANGLE	θ	$\Delta\theta$	AR
		x	y	z				
Receiving point 'i'	ARG_{R_μ}	xI_i	y_μ See Eqs.(5.3.3-4 through -7)	z_μ	γ_{rk}	θ_μ	$\Delta\theta_\mu$ See Eq. (5.3.3 -3)	$AR^{(b)}$
Sending point 'j' strip 'l'	ARG_S	ϵ_{cj}	n_{cl}	ζ_{cl}	γ_{sl}	Sweep Angle λ_{sj}	Box semi- width	Aver- age box chord
	$S(ARG_S)$		$-n_{cl}$		$-\gamma_{sl}$	λ_{sj}	e_l	c_l
	$G(ARG_S)$		n_{cl}					
	$S(G(ARG_S))$		$-n_{cl}$		γ_{sl}	λ_{sj}		

A detailed description of the "Arguments" above is given in Sec. 5.3.7 along with their usage in the computation of the DP-matrix element components.

5.3.4 SUBROUTINE DYPZ (KB, KS, LS, IZ, I, J1, J2, NYFLAG, FLND, FLNE, SGR, CGR, REFC, FMACH, KR, ARB, NBEA, LBO, LSO, JBO, DT)

Functional Description

Subroutine DYPZ prepares the variables necessary for the computation of one row of either the DYP-, or the DYZ-, or the DYY submatrix, depending on the location of the receiving point. In either case it calls subroutine SUBB in a do loop for each element of a row; latter is returned to the calling subroutine GEND via the argument list of DYPZ.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
KB		IN	ARG	Body number in which receiving point 'i' lies
KS				Index of receiving point y- and z-coordinates
LS				See Subroutine DPZY
IZ				Sec. 5.3.3
I	i			
J1				Do-loop delimiters for the number of elements in one row of the submatrix
J2				
NYFLAG				0 for DYP and DYZ elements, 1 for DYY elements
FLND	δ			See Blank Common Sec. 3.1
FLNE	ϵ			
SGR	$\sin \gamma_r$			
CGR	$\cos \gamma_r$			
REFC	$\bar{c}$			
FMACH	M			
KR	k_r			
ARB(10)	$AR^{(b)}$			
NBEA(10,2)				
LBO				Sequence number of first body with y-orientation

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
LSO		IN	ARG	y- and z-coordinate index for first y-oriented body element
JBO				Sending point index for first y-oriented body element
DT(500)		IN/OUT	ARG	One row of either of the submatrices DYP, DYZ or DYY
NDY		OUT	DYPZ	Flag used in subroutine SUBB - 1 for sending points in y-oriented bodies
LB				Body number in which sending point 'j' is located
JB				Sending point index (column no. of DT-matrix)
JZ				Body element number for sending body LB
NZYL B		IN		z-y orientation flag for body LB
SL		OUT		$\sin\lambda=0$ Variables used in
CL			$\cos\lambda=1$ the called subrou-	
TL			$\tan\lambda=0$ ine SUBB: $\lambda=0$ and	
SGS			$\sin\gamma_s=-1$ $\gamma_s=-90^0$ for send-	
CGS			$\cos\gamma_s=0$ ing elements on y-oriented bodies	

Calling Subroutine

GEND

Called subroutine

SUBB

5.3.5 SUBROUTINE DZPY (KB, KS, LS, IZ, I, J1, J2, NYFLAG, FLND, FLNE, SGR, CGR, REFC, FMACH, KR, ARB, NBEA, DT)

Functional Description

Subroutine DZPY prepares the variables necessary for the computation

of one row of either the DZP-, or the DZZ-, or the DZY matrix, depending on the location of the receiving point. In either case it calls subroutine SUBB in a do loop for each element of a row; latter is returned to the calling subroutine GEND via the argument list of DZPY.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
KB				
KS				
LS				
IZ				
I	i			
J1				
J2				
NYFLAG				See Subroutine DYPZ
FLND	δ	IN	ARG	Sec. 5.3.4
FLNE	ϵ			
SGR	$\sin \gamma_r$			
CGR	$\cos \gamma_r$			
REFC	$\bar{c}$			
FMACH	M			
KR	k_r			
ARB(10)				
NBEA(10,2)				
DT(500)		IN/OUT		One row of either of the submatrices DZP, DZZ or DZY
NDY		OUT	DZPY	Flag used in subroutine SUBB; 0 for sending points in z-oriented bodies

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
LB		OUT	DZPY	See Subroutine DYPZ Sec. 5.3.4
JB				
JZ				
NZYL		IN		
SL		OUT		$\sin\lambda=0$ Variables used in
CL			$\cos\lambda=1$ subroutine SUBB;	
TL			$\lambda=0$, and $\gamma_s=0$ for	
SGS			$\tan\lambda=0$ sending elements	
CGS			$\sin\gamma_s=0$ on z-oriented	
			$\cos\gamma_s=1$ bodies	

Calling Subroutine GEND

Called Subroutine SUBB

5.3.6 SUBROUTINE SUBB (KB, KS, I, J, JZ; JB, LB, LS, NDY, NYFL, FLND, FLNE, PI, EPS, SGR, CGR, SGS, CGS, AR, SL, CL, TL, FL, BETA, SUM)

Functional Description

Subroutine SUBB computes the downwash factor matrix elements for all receiving points and sending points on interference bodies, one element at a time, according to Eqs. (5.3.6-1 and -2) or Eq. (5.3.6-3 and -4) depending on the orientation of the interference body in which the sending point is located. The actual computation of the components to the matrix elements is done in Subroutine DZY which is called from SUBB. The final result - one downwash factor, SUM - is returned to the calling subroutine GEND via the argument list of SUBB.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
KB		IN	ARG	Index of receiving body - 0 when receiving point is on panel

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
KS				'Strip' number in which receiving point lies
I	i			Receiving point index - row number of DT-matrix
J	j			Sending point index - column number of DT-matrix
JZ				
JB				
LB				
LS				
NDY				
NYFL, NYFLAG		IN	ARG	See Subroutine DYPZ Sec. 5.3.4
FLND	δ			
FLNE	ϵ			
PI	π			
EPS	0.00001			
SGR	$\sin \gamma_r$			
CGR	$\cos \gamma_r$			
CGS	$\sin \gamma_s$			
CGS	$\cos \gamma_s$			
AR	AR.			
SL				$\sin \lambda = 0$
CL				$\cos \lambda = 1$
TL				$\tan \lambda = 0$
FL	$\bar{c}$			

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
BETA	β	IN	ARG	$\beta = \sqrt{1 - M^2}$
SUM	DT_{ij}	IN/OUT		One element of DT-matrix where the sending point 'j' is an interference body element
IND	$\bar{c}/2$	OUT	SUBB	Flag for subroutine TKER; 0 for 'total' kernel, 1 otherwise
BR				Reference semi-chord
ANOT				Local characteristic half-width of interference body element 'j'
DXS				Body element length
TEST1*		IN		$ y_c^r - y_c^s $ where y_c^r, z_c^r are the y- and z coordinates of receiving body centerline -
TEST2*				$ z_c^r - z_c^s $ and y_c^s, z_c^s are same for sending body centerline
D2D				See Eq. (5.3.6-2)
XX		OUT		See argument list of Subroutine DZY;
Y				Sec. 5.1.3
Z				
XI1				
XI2				
ETA				
ZETA				
A0				
IDZDY				

* Used only if receiving point is an interference body element

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
IGO		IN	SUBB	Internal flag, 1 through 4, corresponding to the 'quadrant' in which the sending point lies: 1 - upper right (UR) 2 - upper left (UL) 3 - lower right (LR) 4 - lower left (LL)
DPUR				UR
DPUL				UL
DPLR				LR
DPLL				LL

Calling Subroutines

DZPY and DYPZ

Called Subroutine and Common Blocks DZY, the Blank Common Block and the Labeled Common Block KDS

Equations

A. Sending points 'j' on z-oriented bodies (b).

When the receiving points 'i' are on panels, subroutine SUBB computes

$$DZP_{ij} = DZ_{UR} + \delta DZ_{UL} + \epsilon DZ_{LR} + \delta \epsilon DZ_{LL} \quad (5.3.6-1)$$

where the $DZ(\text{ARG}_O, \text{ARG}_R, \text{ARG}_S)$ elements are described in Sec. 5.1.3 (Subroutine DZY).

When the receiving points i are on a z-oriented body 'b' subroutine SUBB computes DZZ_{ij} as follows:

- a) If the two bodies b and $\bar{b}$ are not identical ($b \neq \bar{b}$) and their centerlines do not coincide,

$$DZZ_{ij} = DZ_{UR} + \delta DZ_{UL} + \epsilon DZ_{LR} + \delta \epsilon DZ_{LL}$$

b) if $b \neq \bar{b}$, but the centerlines of the two bodies coincide

$$DZZ_{ij} = 0$$

c) if $b = \bar{b}$, but $i \neq j$

$$DZZ_{ij} = 0$$

d) if $b = \bar{b}$ and $i = j$

$$DZZ_{ij} = D2D$$

$$= \frac{1.0}{2\pi(a_o \bar{b})^2 (1 + AR \bar{b})} \quad (5.3.6-2)$$

When the receiving point 'i' is on a y-oriented body, subroutine SUBB computes DZY_{ij} as follows:

a) if $b \neq \bar{b}$

$$DZY_{ij} = DZ_{UR} + \delta DZ_{UL} + \epsilon DZ_{LR} + \delta \epsilon DZ_{LL}$$

b) if $b = \bar{b}$

$$DZY_{ij} = 0$$

B. Sending points 'j' on y-oriented bodies ($\bar{b}$).

When the receiving points 'i' are on panels, subroutine SUBB computes

$$DYP_{ij} = DY_{UR} + \delta DY_{UL} + \epsilon DY_{LR} + \delta \epsilon DY_{LL} \quad (5.3.6-3)$$

where the $DY(ARG_o, ARG_R, ARG_S)$ elements are described in Sec. 5.1.3.

When the receiving points are on z-oriented bodies

a) if $b \neq \bar{b}$

$$DYZ_{ij} = DY_{UR} + \delta DY_{UL} + \epsilon DY_{LR} + \delta \epsilon DY_{LL}$$

b) if $b = \bar{b}$, or $b \neq \bar{b}$ but their centerlines coincide

$$DYZ_{ij} = 0$$

When the receiving points are also on y-oriented bodies

a) if $b \neq \bar{b}$ and their centerlines do not coincide

$$DYY_{ij} = DY_{UR} + \delta DY_{UL} + \epsilon DY_{OR} + \delta \epsilon DY_{LL}$$

b) if $b \neq \bar{b}$, but their centerlines coincide

$$DYY_{ij} = 0$$

c) if $b = \bar{b}$, but $i \neq j$

$$DYY_{ij} = 0$$

d) if $b = \bar{b}$, and $i = j$

$$DYY_{ij} = DY2D = D2D/AR$$

$$= \frac{1}{AR} \frac{1}{2\pi(a_0 \bar{b})^2 (1+AR \bar{b})} \quad (5.3.6-4)$$

The arguments that are used in the computations of the DZ and DY elements are tabulated below.

Receiving Point on Panel, Sending Point on Body

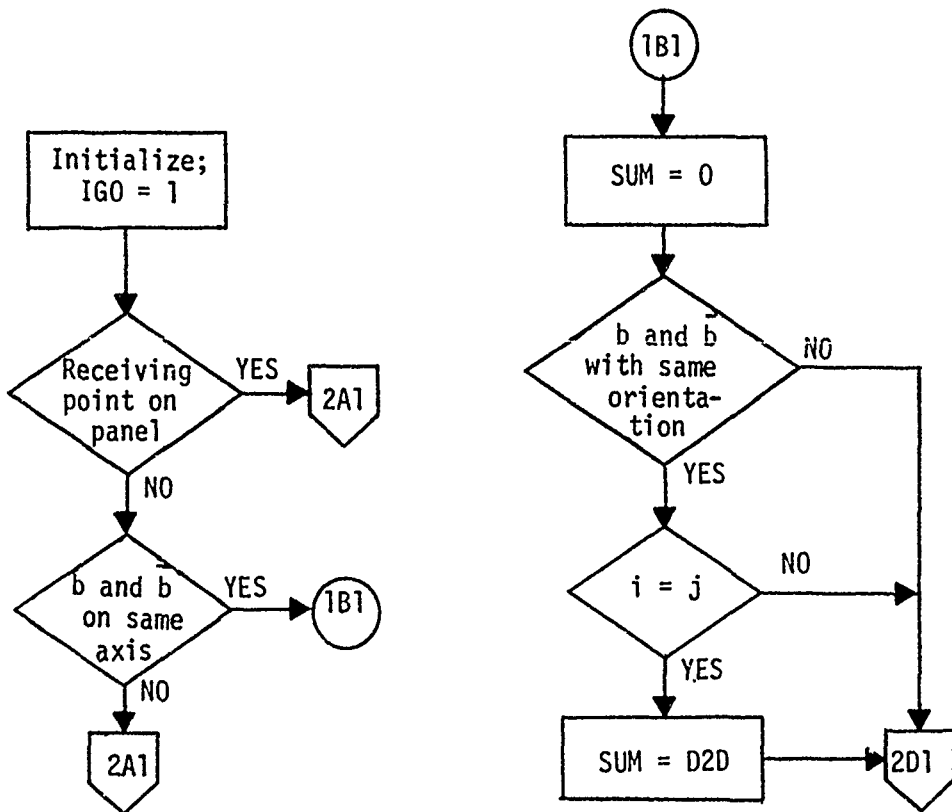
POINTS	ARGUMENTS	COORDINATES			DIHEDRAL ANGLE	HALF WIDTH OF BODY	AVG RADIUS	AR
		x	y	z				
Receiving point i, strip k	ARG_R	x_i	y_k	z_k	γ_{Rk}			
Sending point j	ARG_S		η_c			e^*	a_0	$AR(\bar{b})$
	$S(ARG_S)$	ξ_{1j}	$-\eta_c$	ζ	$\gamma_S = 0$ for z-body			
	$G(ARG_S)$	and ξ_{2j}	η_c	$-\zeta$	$\gamma_S \neq -\pi/2$ for y- body			
	$S(G(ARG_S))$		$-\eta_c$					

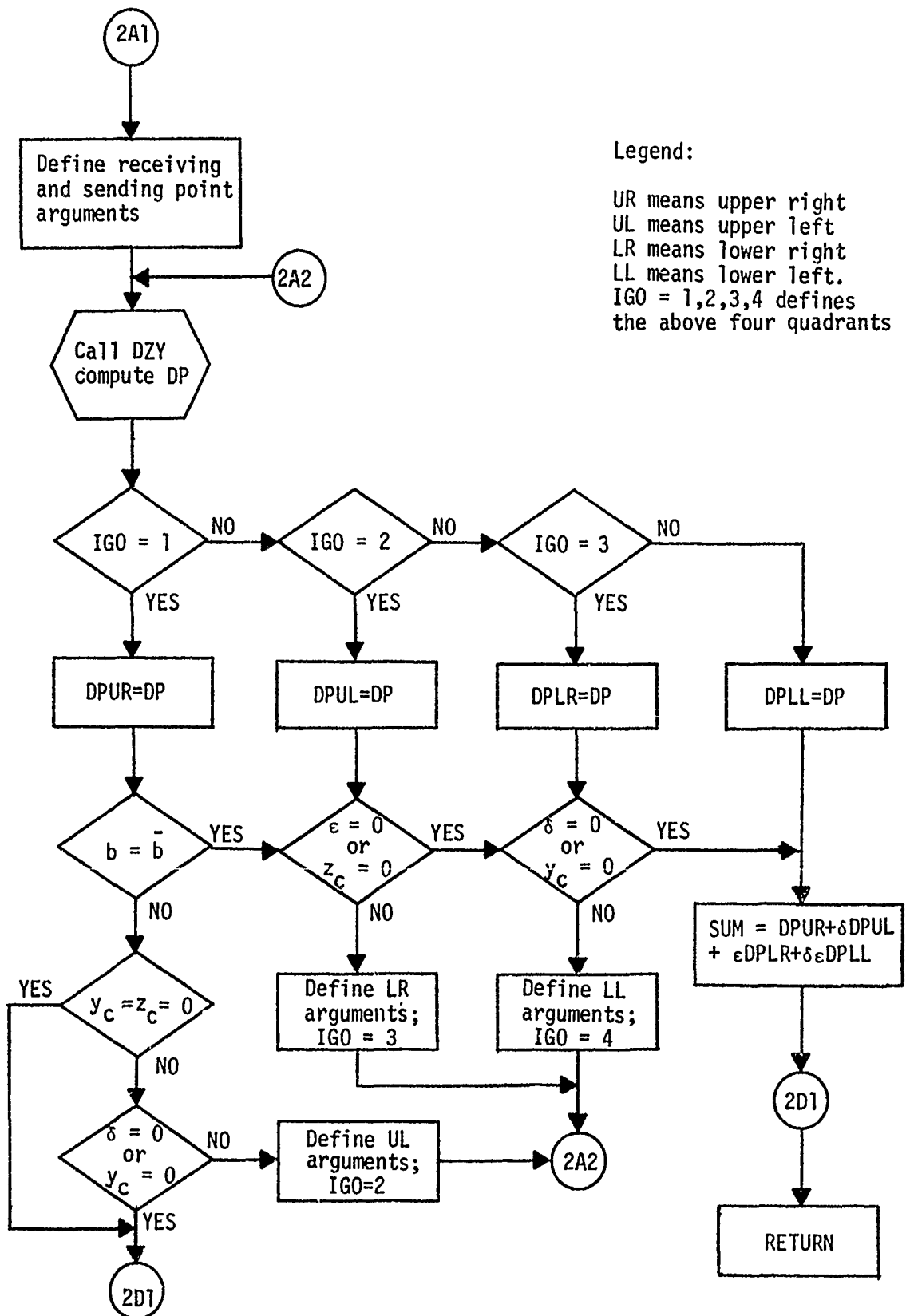
*Note that $e = a_0/2\sqrt{|1-AR|^2}$ for z-oriented, $AR \geq 1$ and for y-oriented $AR < 1$ bodies and $e = a_0\sqrt{3}/2\sqrt{|1-AR|^2}$ for z-oriented, $AR < 1$ and for y-oriented, $AR \geq 1$ bodies.

Receiving Point on Body, Sending Point on Body

POINTS	ARGUMENTS	COORDINATES			DIHEDRAL ANGLE	Δx	AVG RADIUS	AR
		x	y	z		OF BODY SECTION		
Receiving point i	ARG_R	XI_i	$YB_k^{(b)}$	$ZB_k^{(b)}$	$\gamma_r=0$ for z-body, $\gamma_r = -\pi/2$ for y- body	Δx_k	a_o	$AR^{(b)}$
Sending point j	ARG_S	See Table above						

Flow Chart - Subroutine SUBB





5.3.7 SUBROUTINE SUBP (I, L, LS, J, IO, JR, NBXS, NCPNB, SGR, CGR, YREC, ZREC, SUM, WORK)

Functional Description

Subroutine SUBP computes the downwash factor matrix elements, DP_{ij} for all receiving points on panels and interference bodies and sending points on panels, one element at a time, according to Equations (5.3.7-1 through -6). The computation of the individual components that make up each downwash factor element is done in Subroutines SNPDP and INCRO, which are called from SUBP. Additional arguments that are needed for the calculation of the downwash factor contribution of image sending points inside associated bodies are calculated by subroutine SUBI, which is also called from SUBP. The resulting total downwash factor element 'SUM' is returned to the calling subroutine via the argument list of SUBP.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
I L LS		IN	ARG	See DPPS, Sec. 5.3.2
J	j			Running index of the element number in DPP matrix row (column number)
IO IR NBXS NCPNB				See INCRO, Sec. 5.1.7
SGR CGR YREC ZREC	$\sin \gamma_r$ $\cos \gamma_r$ y_r z_r			See DPPS, Sec. 5.3.2

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
SUM		IN/OUT	SUBP	One element of the DT matrix for receiving point 'i', sending point 'j', when 'i' is on a panel. Note that, if 'i' represents a receiving interference body section, SUM is only the contribution (to this DT-element) of one point on the surface of the body section – see Eq.(5.3.3-1).
TL SL CL XO YO ZO ES CV				See Subroutine SNPDF, Sec.5.1.11
AX AY AZ AX1 AY1 AZ1 AX2 AY2 AZ2		OUT		See Subroutine INCRO, Sec. 5.1.8
DIJS DIJI	D I(D)	IN	Argument List of SNPDF	Steady contribution to the downwash factor } of sending point 'j' on panel of the image of 'j' inside the current associated body
WORK		IN/OUT	ARG	Complex work array

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
DELRS	$\text{Re}(\Delta D)$	IN	Argument List of INCRO	Real part of the unsteady contribution to the downwash factor Imaginary part of unsteady contribution to the downwash factor { of sending point 'j' on panel of the image of 'j'
DELIS	$\text{Re}[I(\Delta D)]$			
DELRI	$\text{Im}(\Delta D)$			
DELI	$\text{Im}[I(\Delta D)]$			
DPUR DPUL DPLR DPLL NOAS NA1 NA2		IN	SUBP	See Eqs. (5.3.7-2 through -6) The number of associated bodies for panel in which the sending point 'j' lies Delimiters to the do-loop for all associated bodies of panel
DA DZB DYB DAR DETA DZETA DCGAM DSGAM DEE				Arguments to Subroutine SUBI; see Sec. 5.1.12
DXI DETAI DZETAI DCGAMI DSGAMI DEEI DTLAMI		IN	Argument List of SUBI	Image point arguments; see Sec. 5.1.12

$I(ARG_S)^*$ = images of ARG_S inside associated body IR
 $S(ARG_S)$ = images of ARG_S with respect to the $y = 0$ plane
 $G(ARG_S)$ = images of ARG_S with respect to the $z = 0$ plane

The arguments that constitute ARG_R and ARG_S are tabulated below.

Receiving Point on Panel, Sending Point on Panel

Points	Arguments	Coordinates			Dihedral Angle	Sweep Angle	Box Half Width	Arg Box Chord
		x	y	z				
Receiving point 'i', strip 'k'	ARG_R	x_i	y_k	z_k	γ_{rk}			
Sending point 'j', strip 'l'	ARG_S	ξ_{cj}	η_{cl}	ζ_{cl}	γ_{sl}	λ_{sj}	e_l	c_l
	$S(ARG_S)$		$-\eta_{cl}$		$-\gamma_{sl}$	$-\lambda_{sj}$		
	$G(ARG_S)$		η_{cl}	$-\zeta_{cl}$				
	$S[G(ARG_S)]$		$-\eta_{cl}$		γ_{sl}	λ_{sj}		

For receiving points on interference body elements, the ARG_R are defined in Section 5.5.3.3 (Subroutine DPZY).

The evaluation of D in Equations (5.3.7-3 through -6) is done by the following subroutines:

SNPDF — for the steady case ($k_r = 0$), yields $D^{(s)}$;

SNPDF, INCRO, TKER, IDFI and IDF2 — for the unsteady case, yielding ΔD ($\Delta D = 0$ for steady cases).

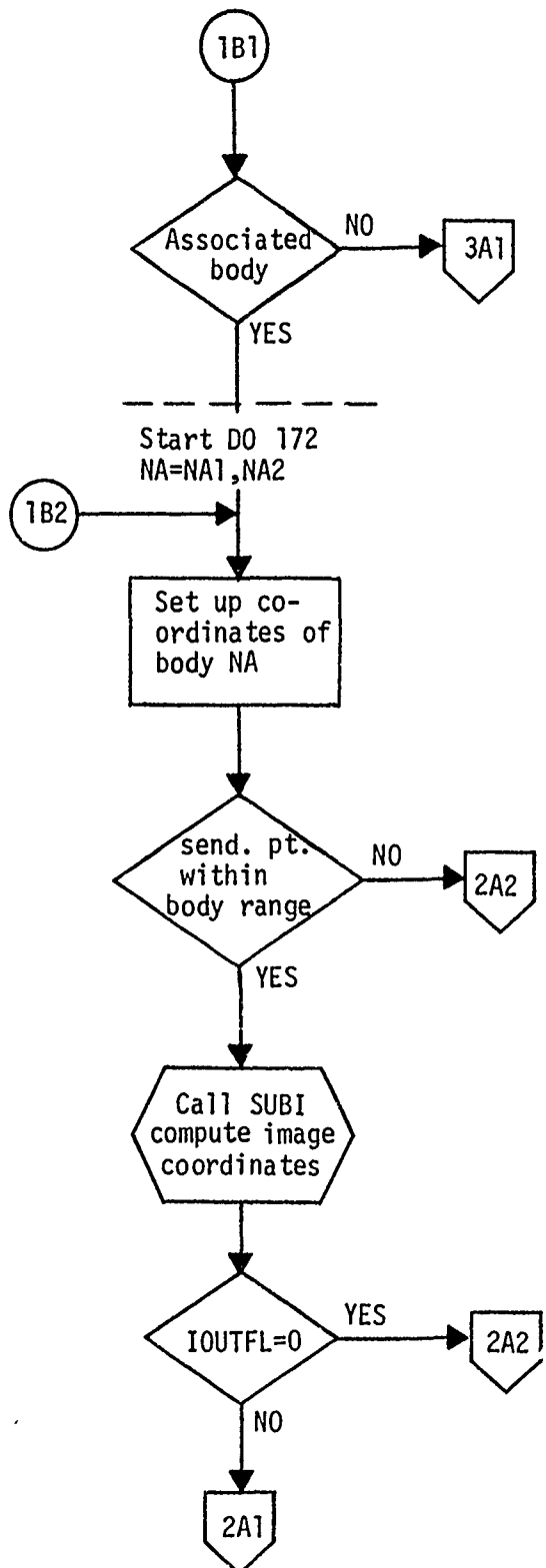
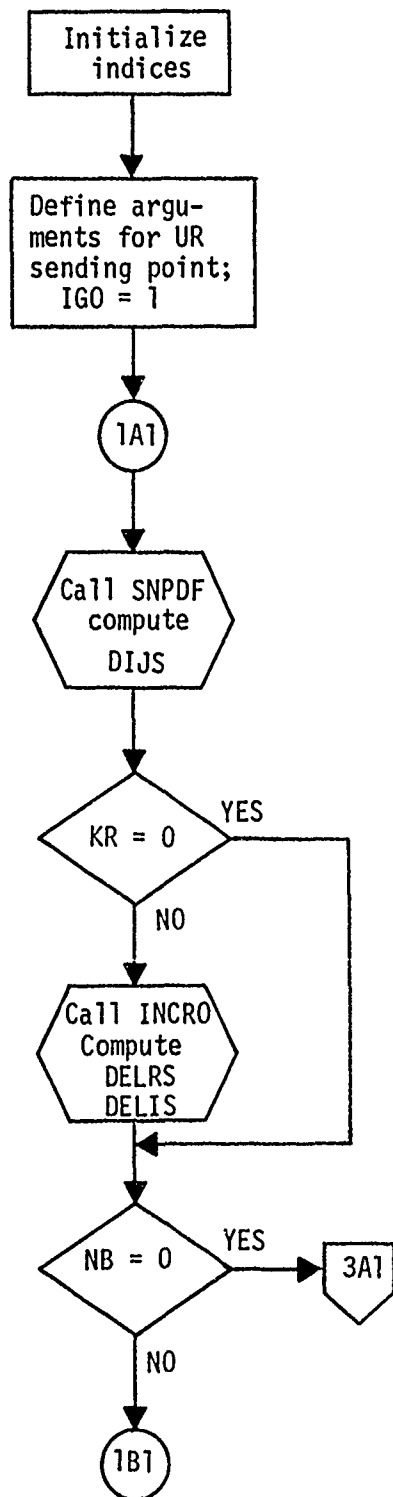
Then, in general

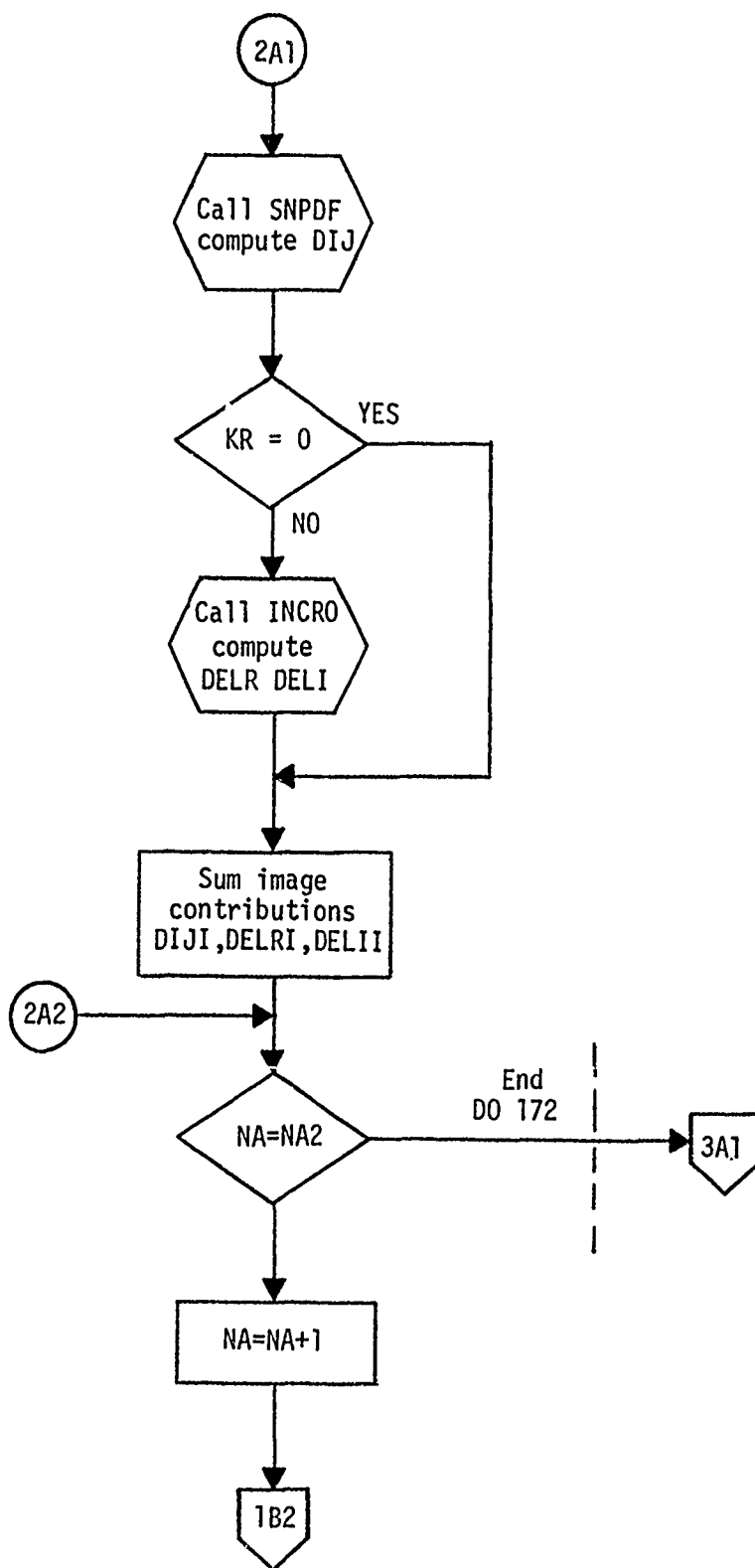
$$D = D^{(s)} + \Delta D \quad (5.3.7-7)$$

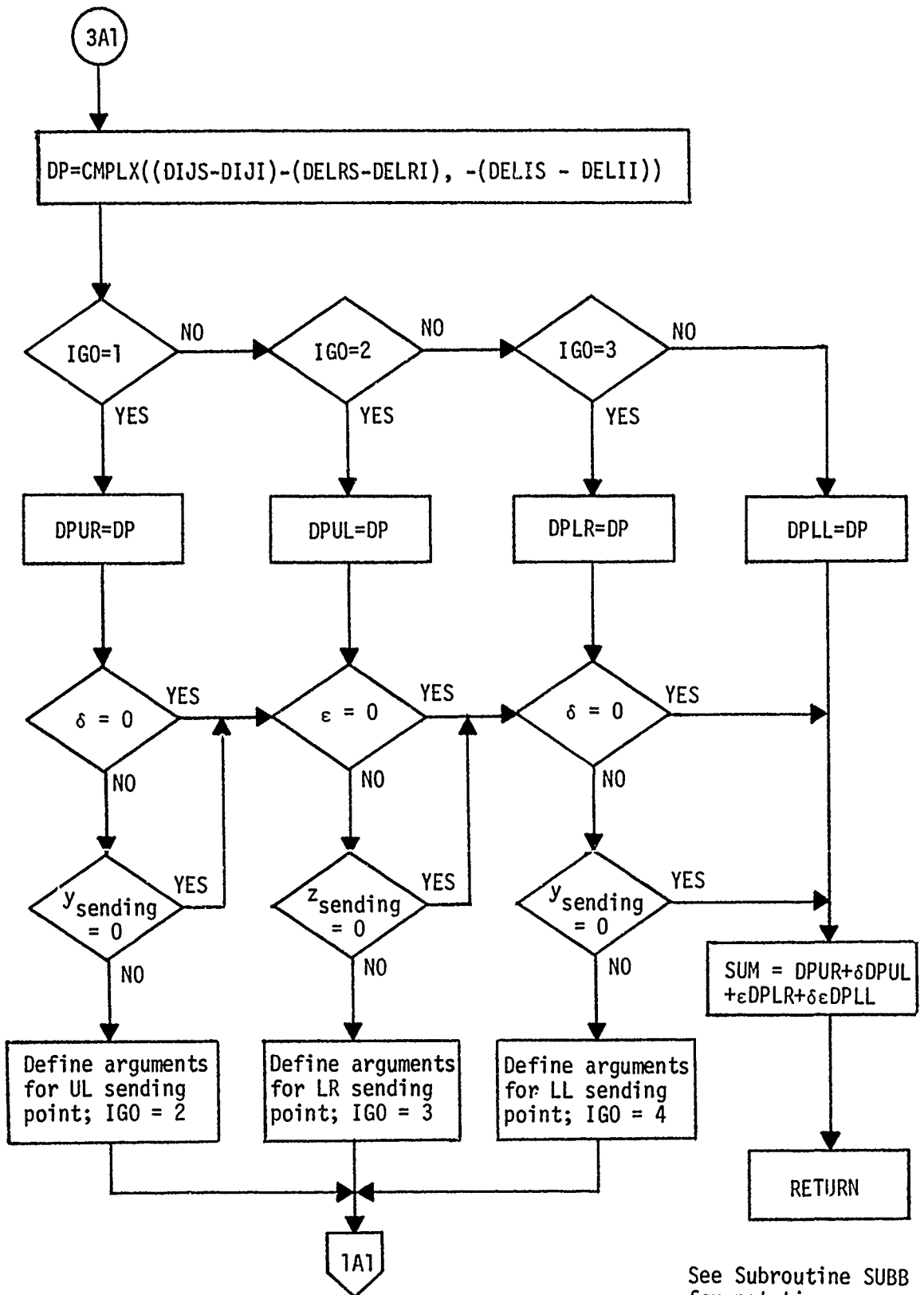
Description of the above five subroutines is given in Section 5.1.

* $I(ARG_S)$ is computed by Subroutine SUBI described in Sec. 5.1.

Flow Chart - Subroutine SUBP







Calling Subroutines

DPPS and DPZY

Called Subroutines and Common Blocks Subroutines SNPDF, INCRO and SUBI, and the Blank Common Block.

Equations

Subroutine SUBP computes one element of either the DPP or the DPZ or the DPY-matrix, depending on the location of the receiving points.

$$\left. \begin{array}{l} \text{DPP}_{ij} \\ \text{DPZ}_{i\mu j} \\ \text{DPY}_{i\mu j} \end{array} \right\} = \text{DP}(\text{ARG}_0, \text{ARG}_R, \text{ARG}_S) \quad (5.3.7-1)$$

for receiving point 'i' on panels, or 'i_μ' on bodies and sending point 'j' on panels, where

$$\text{DP} = \text{DP}_{UR} + \delta \text{DP}_{UL} + \epsilon \text{DP}_{LR} + \delta \epsilon \text{DP}_{LL} \quad (5.3.7-2)$$

and

$$\text{DP}_{UR} = \text{D}(\text{ARG}_S) - \sum_{\text{IR}=\text{RANGE}(p)} \text{D}\{\text{I}(\text{ARG}_S)\} \quad (5.3.7-3)$$

$$\text{DP}_{UL} = \text{D}\{\text{S}(\text{ARG}_S)\} - \sum_{\text{IR}=\text{RANGE}(p)} \text{D}\{\text{I}\{\text{S}(\text{ARG}_S)\}\} \quad (5.3.7-4)$$

$$\text{DP}_{LR} = \text{D}\{\text{G}(\text{ARG}_S)\} - \sum_{\text{IR}=\text{RANGE}(p)} \text{D}\{\text{G}\{\text{S}(\text{ARG}_S)\}\} \quad (5.3.7-5)$$

$$\text{DP}_{LL} = \text{D}\{\text{S}\{\text{G}(\text{ARG}_S)\}\} - \sum_{\text{IR}=\text{RANGE}(p)} \text{D}\{\text{I}\{\text{S}\{\text{G}(\text{ARG}_S)\}\}\} \quad (5.3.7-6)$$

where

ARG_0 represents the constant arguments k_r and M ;

ARG_R represents the variable receiving point arguments

ARG_S = sending point arguments

and

$\text{RANGE}(p)$ refers to the bodies associated with panel p in which the sending point lies

5.4 Segment 4

5.4.1 SUBROUTINE RDMODE(IA, NA, NIN, NM, NOUT)

Functional Description

This routine reads the panel and body modal data from cards. The data for each modal coefficient consists of the coefficient and an integer containing the mode number, the panel or body number, the exponent for the x coordinate, and a flag indicating whether relative or absolute coordinates for x and y are to be used. This data is then sorted according to mode number, then panel or body number and then the x and y exponents, respectively. The routine returns the input coefficients and their identifiers, the number of coefficients for panels and the z and y oriented bodies and the number of modes.

Input-Output Variables

MNEMONICS	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
IA		OUT	ARG	Array containing the modal coefficients and coefficient description for panels and bodies.
NA		OUT	ARG	Array containing the number of coefficients for panels and z and y oriented bodies.
NIN		IN	ARG	I/O unit number containing the input modal data.
NM		OUT	ARG	Number of modes
NOUT		IN	ARG	I/O unit number for printing on.

Calling Subroutines

MAIN

Error Messages

SUBROUTINE **RDMODE** INVALID DATA CARD. -- IGNORED --

The data card which has been read is invalid and has been ignored.

5.5 Segment 5

5.5.1 SUBROUTINE SB (A, NM, NAY, NAZ, WORK, NWORK)

Functional Description

Subroutine SB, 'Slender Body', calculates the normalwash at lifting surface boxes and interference body elements due to slender body elements.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
A		IN	ARG	Array containing the modal data read by subroutine RDMODE.
X				Array of box and interference body elements x-coordinate.
AR	AR	IN	Blank Common Block	Array of body aspect ratios.
AO	a_0			Array of body radius.
KR	k_r			Reduced frequency.
NB	NB			Number of bodies.
NM	NM	IN	ARG	Number of modes.
AOP	a'_0	IN	Blank Common Block	Array of rate of change of body radius with respect to x.
NAY		IN	ARG	Number of modal coefficients for y-oriented bodies.
NAZ		IN	ARG	Number of modal coefficients for z-oriented bodies.
NBY	NBY			Number of y-oriented bodies.
NBZ	NBZ			Number of z-oriented bodies.
NTP	NTP			Number of lifting surface boxes.
NTY	NTY			Number of y-oriented interference body elements.
NTZ	NTZ	IN	Blank Common Block	Number of z-oriented interference body elements.
CBAR	$\bar{c}$			Reference chord length.
NSBE	NSBE			Array of number of slender body elements per body.
NTYS	NTYS			Number of y-oriented slender body elements.

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
NTZS	NTZS			Number of z-oriented slender body elements
WORK	S			Complex working array
XIS1	ϵ_{s1}	IN	ARG	Array containing the leading edge x-coordinate of the slender body elements
XIS2	ϵ_{s2}			Array containing the trailing edge x-coordinate of the slender body elements
FMACH	M			Mach number
NWORK				Length of working array WORK

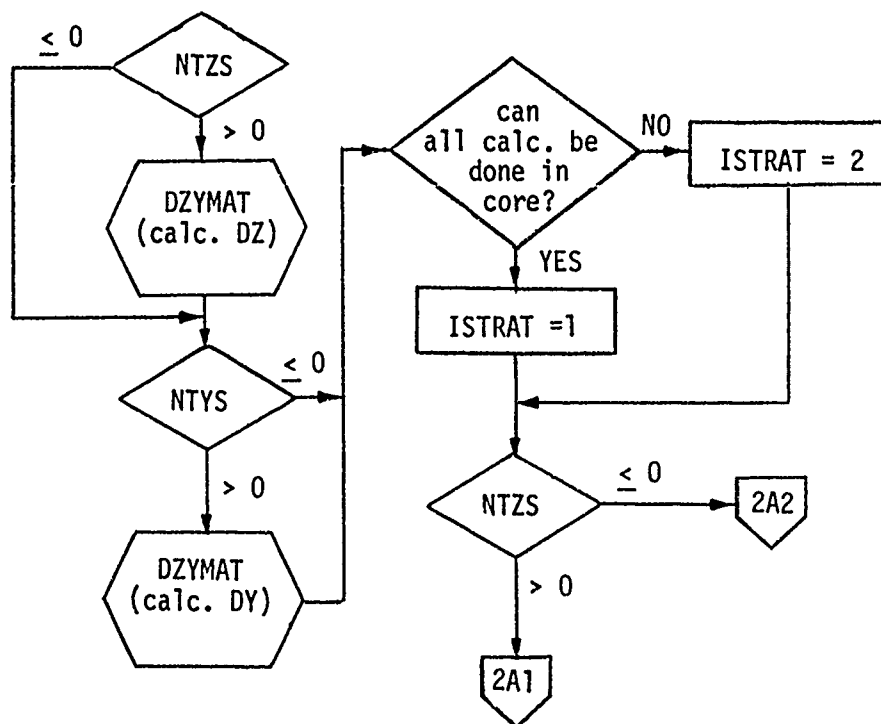
Calling Subroutines

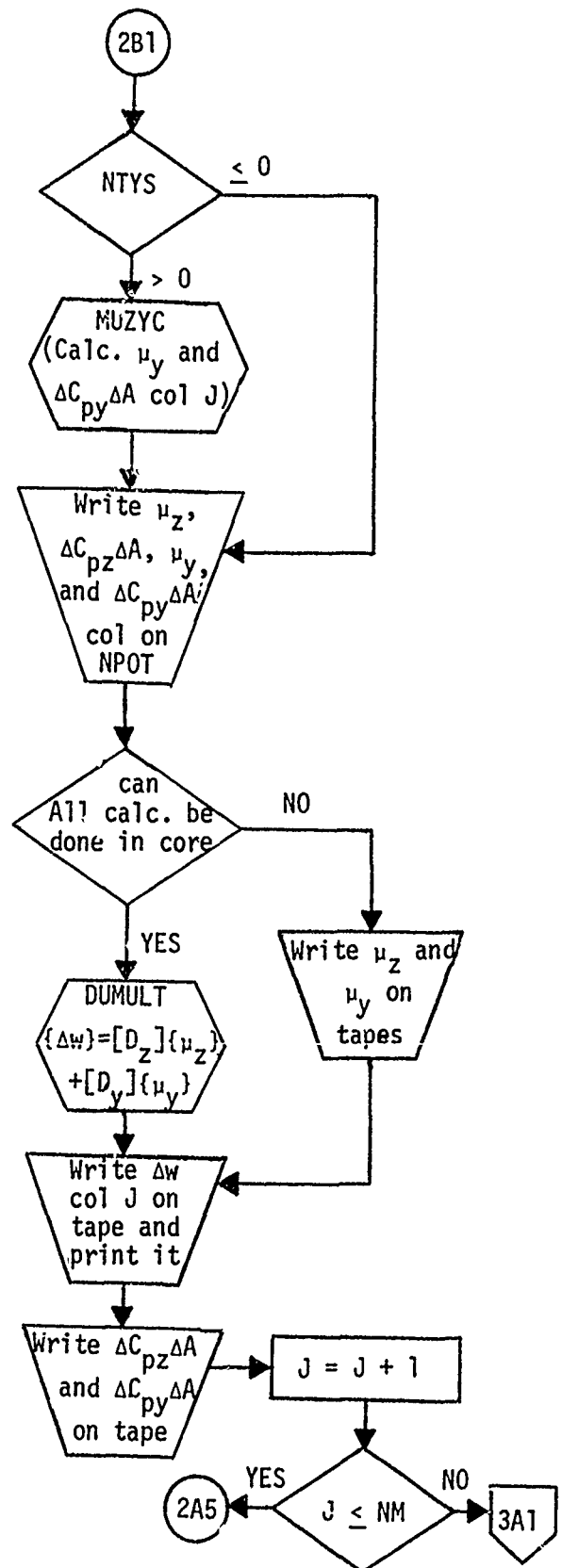
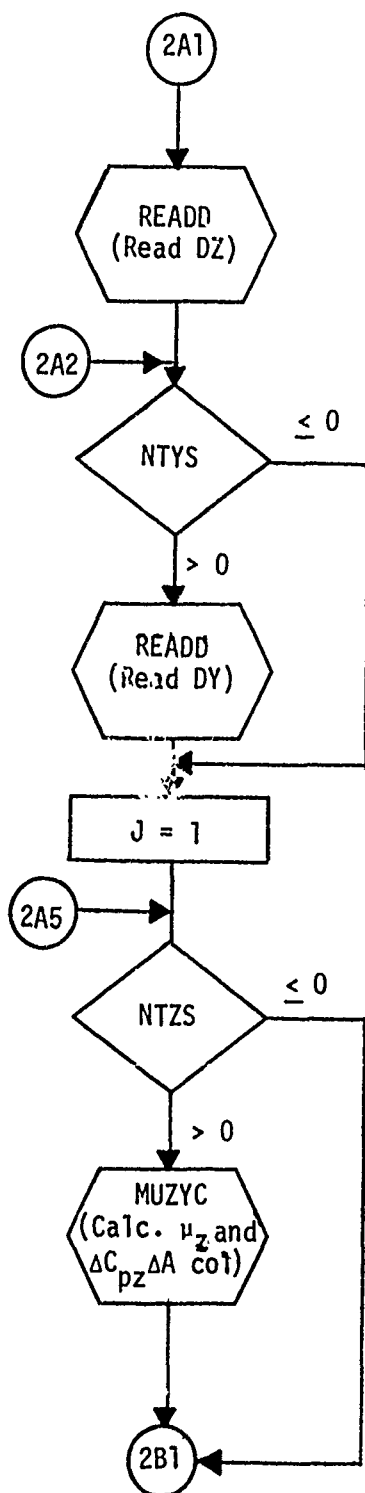
MAIN

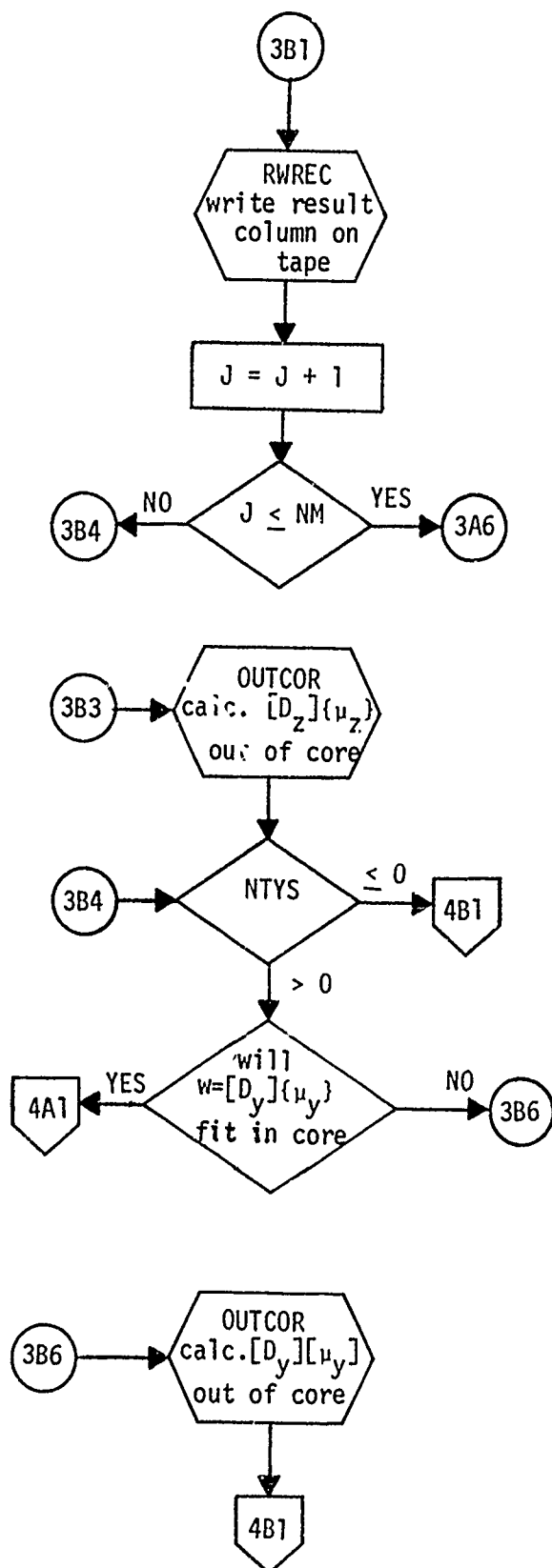
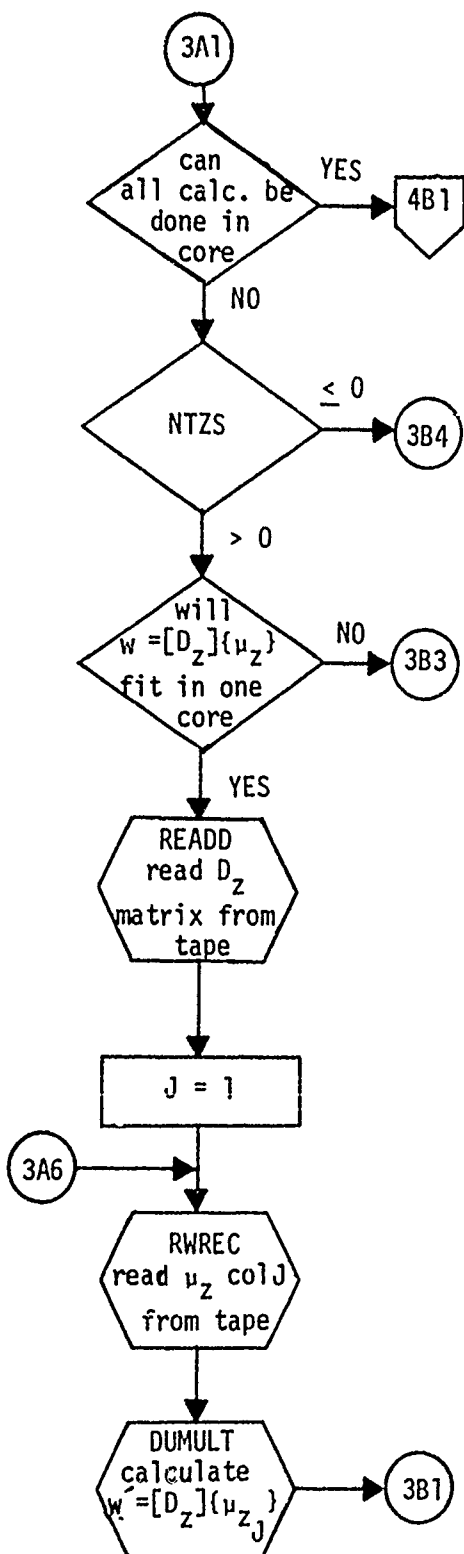
Called Subroutines and Common Blocks

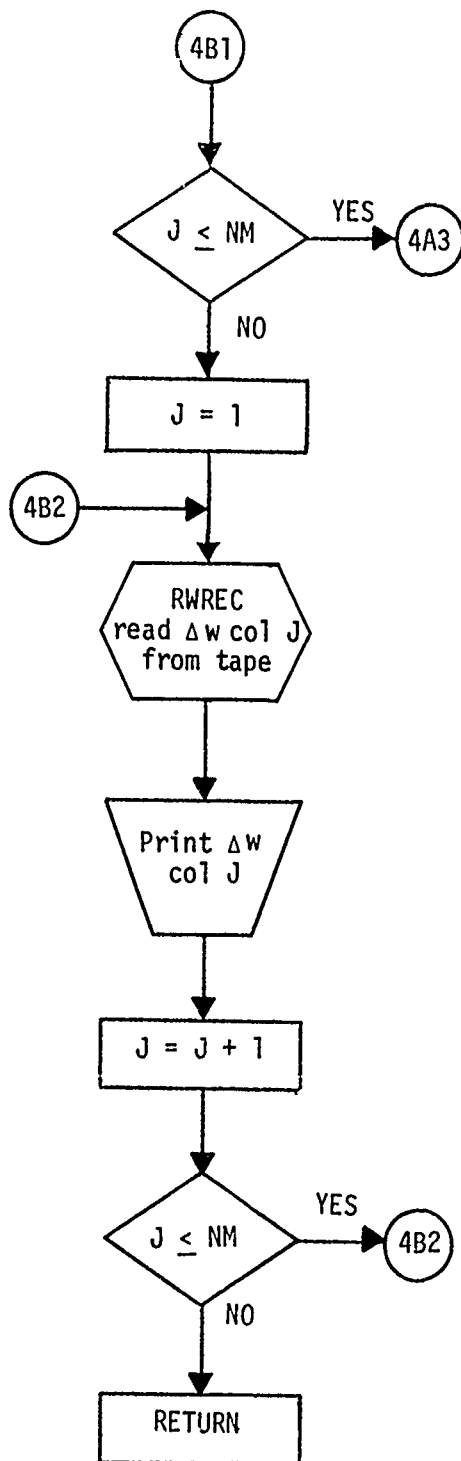
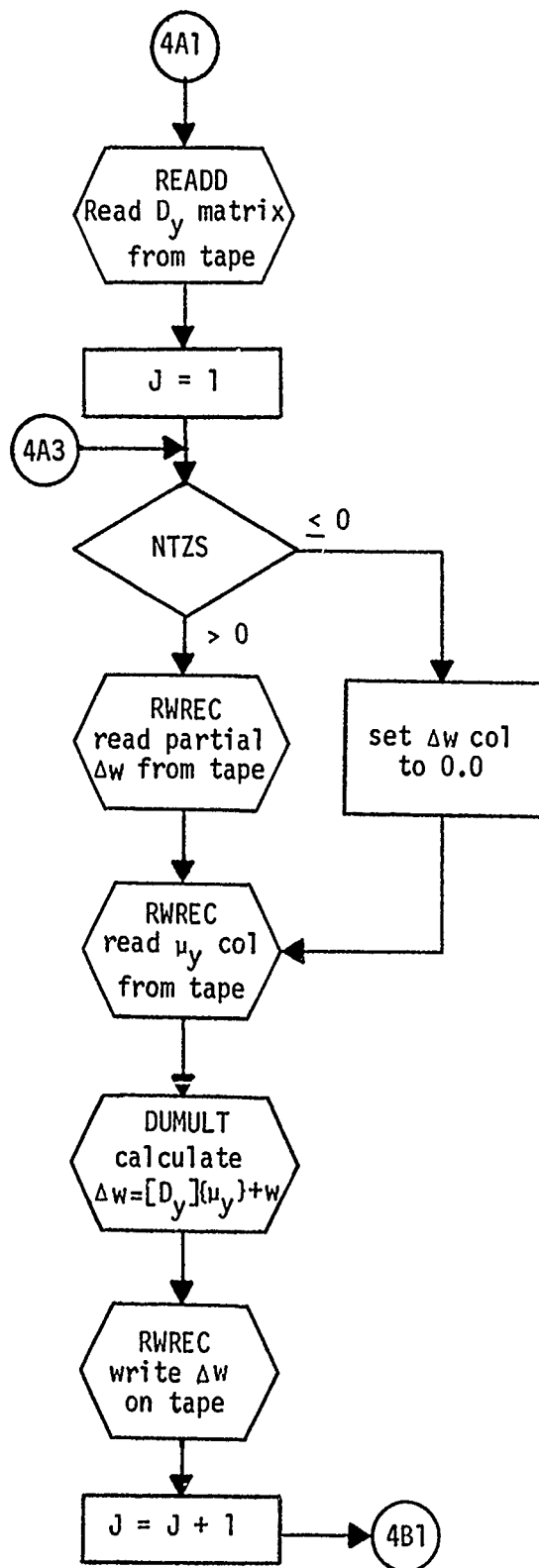
Blank Common, RWREC, MYZYC, DUMULT, READD, DZYMAT, OUTCOR

Flow Chart - Subroutine SB









5.5.2 SUBROUTINE DUMULT (N1, N2, NTZS, NTYS, W, DZ, UZ, DY, UY)

Functional Description

This subroutine performs the following complex matrix operation.

$$\{\Delta w_{OUT}\} = [D_z] \{\mu_z\} + [D_y] \{\mu_y\} + \{\Delta w_{IN}\}$$

The result of this operation (Δw) is returned to the calling routine as w.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
DY	D_y	IN	ARG	Input matrix.
DZ	D_z			Input matrix
N1				The first row of Δw to calculate
N2				The last row of Δw to calculate
NTYS				Number of columns in D_y
NTZS				Number of columns in D_z
UY	μ_y			Input matrix
UZ	μ_z	IN/OUT	ARG	Input matrix
W	Δw			Input matrix and output result

Calling Subroutines

SB, OUTCOR

5.5.3 SUBROUTINE DZYMAT (D, NFB, NLB, NTZYS, IDZDY, NTAPE, XP, BETA)

Functional Description

This subroutine sets up the proper argument lists for the calculation of each row of the D_z or D_y matrix and then calls subroutine ROWDYZ.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
D		IN	ARG	Working array used to store a row of D_z or D_y
CG	$\cos \gamma$			Array containing the cosine of the lifting surface strip dihedral angle

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
NB	NB	IN	ARG	Total number of bodies
NC	NC			Array containing the number of chord-wise boxes per strip in a panel
NP	NP			Number of panels
NS	NS			Array containing the number of strips in a panel
SG	siny			Array containing the sine of the lifting surface strip dihedral angle
XP				x-control point coordinate of lifting surface boxes
YB				y-coordinate of center of bodies
YP				y-control point coordinate of lifting surface strip
ZB				z-coordinate of center of bodies
ZP				z-control point coordinate of lifting surface strip
NBY				Number of y oriented bodies
NBZ				Number of z oriented bodies
NFB				Number of the first body with the orientation requested
NLB				Number of the last body with the orientation requested
NTP		IN	ARG	Total number of boxes
BETA	β			$\sqrt{1 - M^2}$
MACH	M			Mach number
NBEA				Array containing number of interference body elements per body and the body orientation
IDZDY				Flag indicating whether the $D_z(0)$ or $D_y(1)$ matrix is to be calculated
NTAPE				I/O unit number which the output matrix is to be written on
NTZYS				Number of z or y oriented slender body elements

Calling Subroutines

SB

Called Subroutines and Common Blocks

ROWDYZ, Blank Common Block

5.5.4 SUBROUTINE MUZYC (NMODE, NCOEF, K, NTZY, NFBODY, NLBODY, NSBE, KR, IA, A, CBAR, AO, AOP, XIS1, XIS2, AR, UZY, CPZY)

Functional Description

Subroutine MUZYC calculates the axial doublet strengths and loading for slender bodies.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
A				Real array containing the modal coefficients and a key identifying the coefficients.
K				Code identifying which type coefficient to use = 2 use a_z = 3 use a_y
AR	AR	IN	ARG	Array containing aspect ratios of the bodies.
AO	a_o			Array containing the radii of the bodies.
IA				Integer array equivalent to the array "A".
KR	k_r			Reduced frequency.
AOP	a'_o			
UZY	$\bar{\mu}_z, \bar{\mu}_y$	OUT		The μ_z or μ_y column
CBAR	$\bar{c}$	IN		Reference chord length.
CPZY	$\Delta C_{p_z} \Delta A(1+AR)$ $\Delta C_{p_y} \Delta A(1+AR)$	OUT OUT	ARG	
NSBE		IN		Array containing the number of slender body elements per body
NTZY	NTZS NTYS	IN	ARG	Total number of z or y oriented slender body elements
XIS1	ξ_{s1}	IN		Array containing the leading edge x-coordinate of the slender body elements.

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
XIS2	ξ_{s2}			Array containing the trailing edge x-coordinate of the slender body elements
NCOEF				Number of modal coefficients input for this orientation of body.
NMODE		IN	ARG	Number of modes in analysis.
NFBODY				Number of the first body with orientation requested.
NLBODY				Number of the last body with orientation requested.

Calling Subroutines

SB

Equations

$$\bar{\mu}_z \text{ and } \bar{\mu}_y = \frac{ws}{D2D}$$

$$\left. \begin{array}{l} \Delta C_{p_z} \Delta A \text{ AR} \\ \text{and} \\ \Delta C_{p_y} \Delta A \text{ AR} \end{array} \right\} = \left[(ws)L + i(ws') (M) \right] 2a_0 \text{ AR}$$

where for

$K = 2$ or z subscript

$$D2D = \frac{1.0}{2\pi (1 + \text{AR}) a_0^2}$$

$$L = 2\pi (a_0' + i k_r / \bar{c})$$

$$M = \pi a_0 / \bar{c}$$

K = 3 or y subscript

$$D2D = \frac{1.0}{2\pi (1 + R) a_0^2 R}$$

$$L = 2\pi R (a_0' + i k_r / \bar{c})$$

$$M = R \pi a_0 / \bar{c}$$

and

$$ws = wsR + i wsI$$

$$wsR = \sum_{n=0}^9 A_n \left(\frac{xs}{\bar{c}} \right)^{n-1}$$

$$wsI = \sum_{n=1}^9 A_{2k_r} \left(\frac{xs}{\bar{c}} \right)^n$$

$$ws' = wsR' + i wsR(2k_r)$$

$$wsR' = \sum_{n=1}^9 A_{n(n-1)} \left(\frac{xs}{\bar{c}} \right)^{n-2}$$

5.5.5 SUBROUTINE OUTCOR (WORK, NWORK, NTS, N, NM, NUTAP, NDWIN, NDWOUT, NDTAP)

Functional Description

This routine performs the following matrix operation

$$[\Delta w] = [\Delta w'] + [D] [U]$$

It is assumed that all the matrices will not fit into core. As many columns of U and $\Delta w'$ are read into core as possible and the matrix D is read a row at a time performing the necessary operations to calculate the columns of Δw which are written on an I/O unit. This operation is repeated until all the columns of U have been read and hence all of Δw written.

Input Output Variables

MNEMONICS	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
WORK				Complex working array.
NWORK				Length of working array.
NTS				Number of columns in the matrix D.
N				Number of rows in the matrix D.
NM				Number of columns in the matrix U.
NUTAP				I/O unit number containing the matrix U in column sort.
NDWIN		IN	ARG	I/O unit number containing the $\Delta w'$ matrix in column sort. If it is equal 0, the w' matrix is set to zero.
NDWOUT				I/O unit number which the Δw matrix is written on in column sort.
NDTAP				I/O unit number containing the D matrix in row sort.

Calling Subroutines SB

Called Subroutines and Common Blocks

RWREC, DUMULT, READD

Error Messages

SUBROUTINE **OUTCOR** NUMBER OF MODES IS LESS THAN OR EQUAL TO ZERO.

CALCULATIONS SKIPPED

5.5.6 SUBROUTINE ROWDYZ (NFB, NLB, ROW, NTZYS, D, DX, DY, DZ, BETA, IDZDY, NTAPE, SGR, CGR)

Functional Description

This routine performs the logic required to set up the argument list to DZY for the purpose of calculating a row of the D_z or D_y matrix.

Input Output Variables

MNEMONICS	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
D		OUT	ARG	The output row of D_z or D_y (complex)
AR	AR	IN	Blank Common Block	Aspect ratio at the body.
AO	a_0	IN		Radius of the body.
DX	X	IN	ARG	x-coordinate of receiving point.

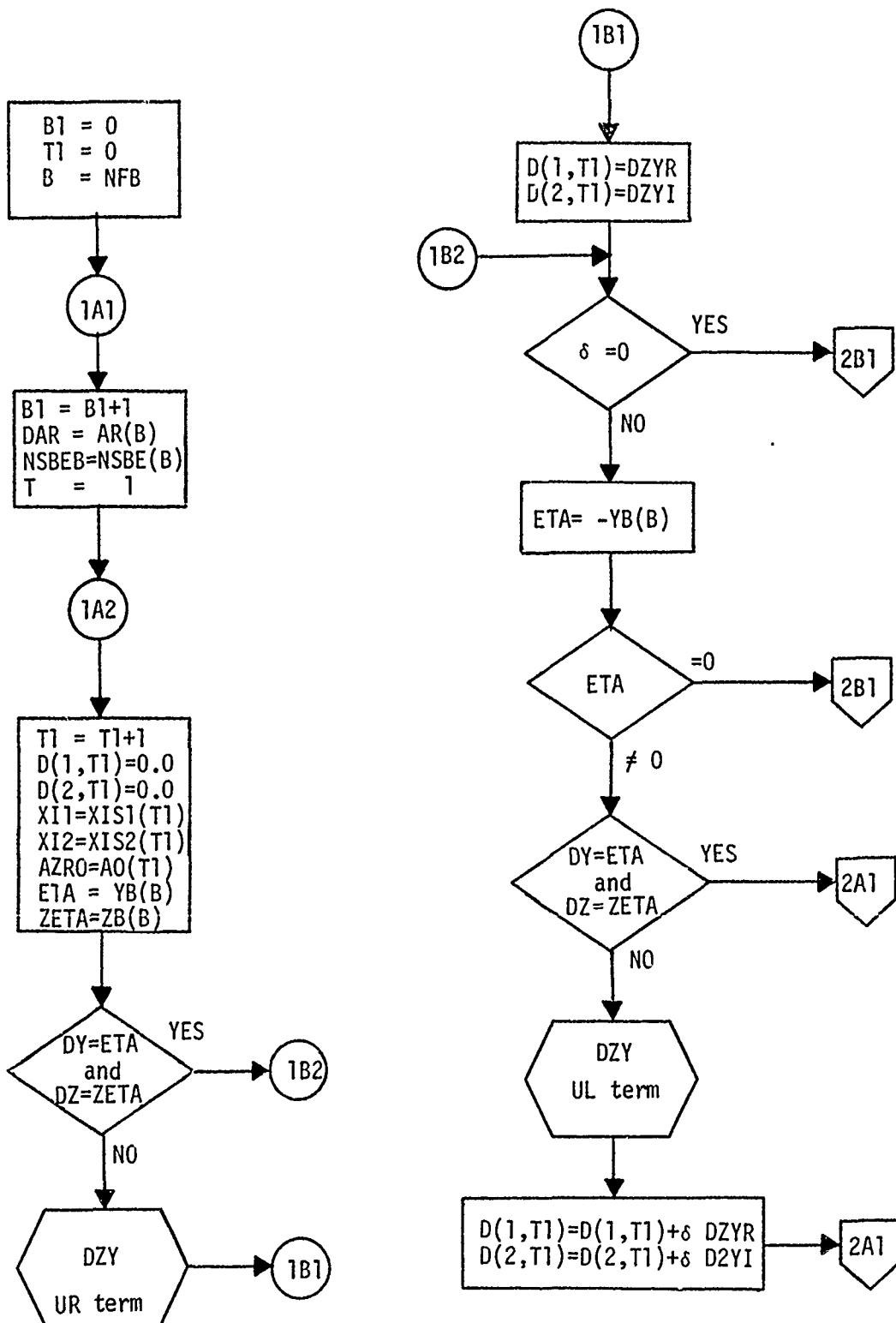
MNEMONICS	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
DY	Y	IN	ARG	y-coordinate of receiving point.
DZ	Z	IN	ARG	z-coordinate of receiving point.
KR	k_r	IN	Blank Common Block	Reduced frequency.
ND	δ			Symmetry flag.
NE	ϵ			Ground effects flag.
YB	y_B			Array containing y-coordinates of bodies
ZB	z_B			Array containing z-coordinates of bodies.
CGR	$\cos \gamma_r$	IN	ARG	Cosine of dihedral angle of receiving point.
NFB				Number of the first body having the desired z or y orientation.
NLB				Number of the last body having the desired z or y orientation.
ROW				The row number of D_z or D_y to be calculated.
SGR	$\sin \gamma_r$			Sine of dihedral angle of receiving point.
BETA	β			$\sqrt{1 - M^2}$
CBAR	c	IN	Blank Common Block	Length of reference chord
MACH	M			Mach number.
NSBE				Array containing the number of slender body elements per body
XIS1	ξ_{s1}			Array containing the x-coordinate of the leading edges of the slender body elements
XIS2	ξ_{s2}			Array containing the x-coordinate of the trailing edges of the slender body elements

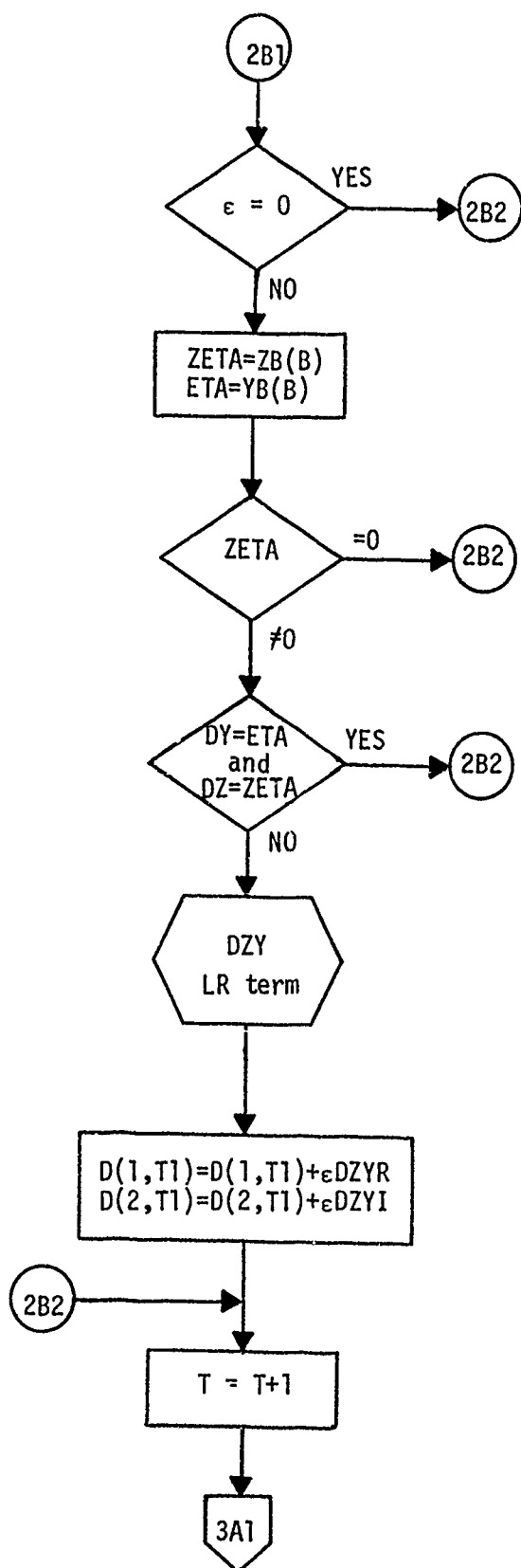
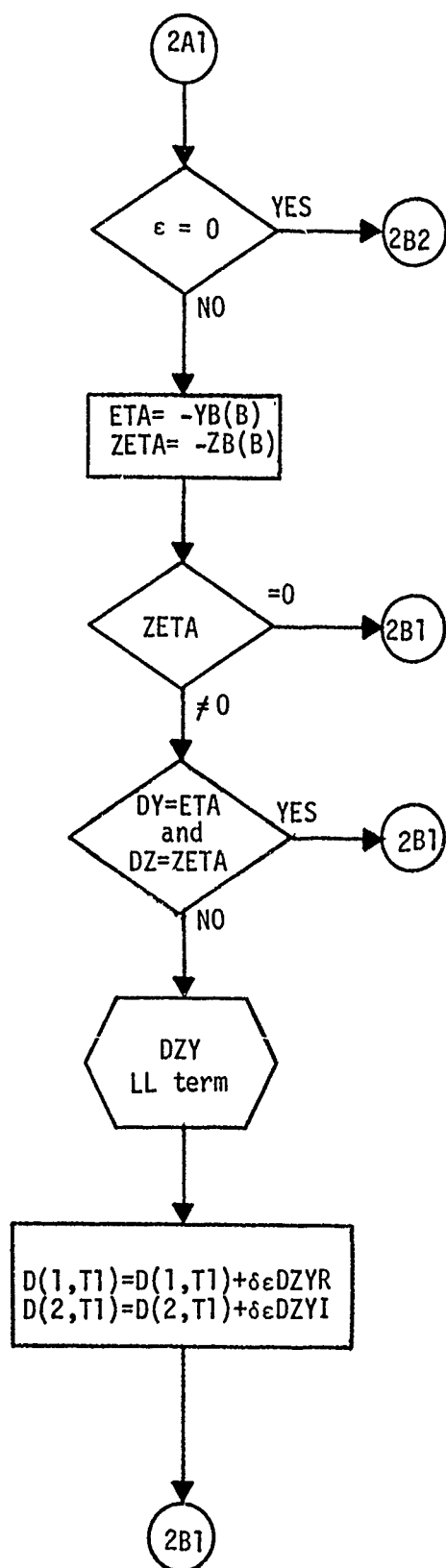
Calling Subroutines

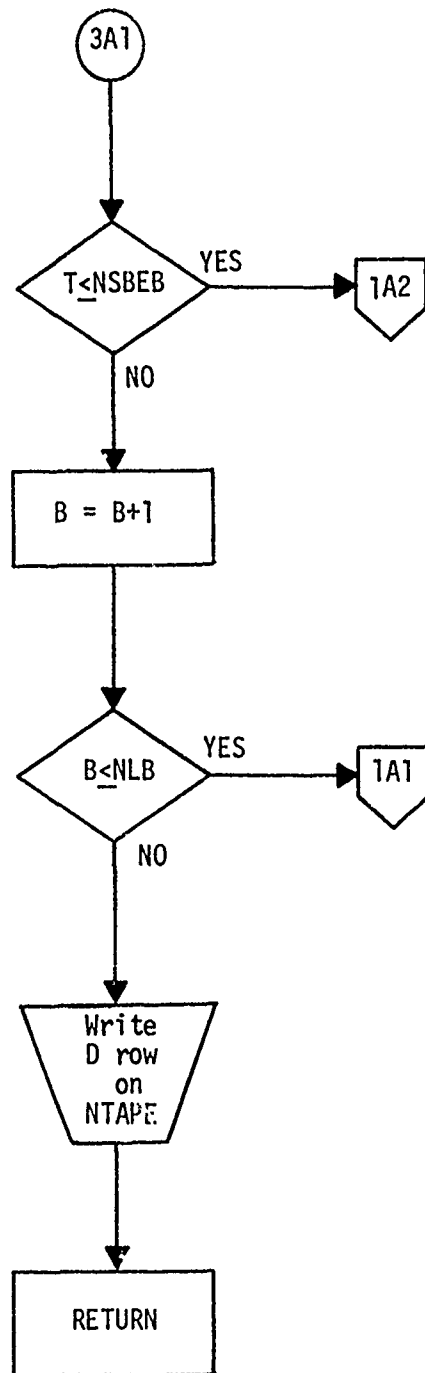
DZYMAT

Called Subroutines and Common Blocks Subroutine DZY and the Blank Common Block

Flow Chart - Subroutine ROWDYZ







See Subroutine SUBB
for notation

5.6 Segment 6

5.6.1 SUBROUTINE WANDWT (A, IA, NSARRY, NBARAY, X, YP, Y1, ZP, Z1, NR, CBAR, KR, NP, NTP, NM, COEF, NDW, NWT, NOUT, W, DW, NB, IPRINT)

Functional Description

This subroutine calculates the complex boundary conditions (w) on the lifting surfaces due to lifting surface motion and adds to it the incremental normalwash, Δw , due to the slender bodies. Also included in Δw is a normalwash induced at the interference body elements.

Input Output Variables

MNEMONICS	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
A	a	IN	ARG	Array containing modal coefficients
W	w	OUT	ARG	A column of the matrix w
X	xp	IN	ARG	3/4 chord x-coordinate of lifting surface box
DW	Δw	IN	I/O(NDW)	Input Δw matrix column
	WT	OUT	I/O(NWT)	The output matrix column WT
IA		IN	ARG	Coded array describing the modal coefficients
KR	k_r			Reduced frequency
NM	NM			Number of modes
NP	NP			Number of lifting surface panels
NR	N			Total number of rows in the WT matrix
YP	y_{p_s}			y-coordinate of the lifting surface strip 3/4-chord point
Y1	Y1			y-coordinate of the inboard edge of panel
ZP	z_{p_s}			z-coordinate of 3/4-chord point of the lifting surface strip
Z1	Z1			z-coordinate of the inboard edge of panel
NDW				I/O unit number containing the Δw matrix
NTP	NTP			Number of lifting surface boxes
NWT				I/O unit number on which the WT matrix is written
CBAR	$\bar{c}$			Length of the reference chord

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
NOUT				I/O unit number for printing output on.
NCOEF				Number of modal coefficients in the array A.
NBARAY		IN	ARG	Array containing the number of the last box in each panel.
NSARRY	NS			Array containing the number of strips in a panel.
NB				Number of bodies.
IPRINT				Print flag.

Calling Subroutines

MAIN

Equations

$$w_{iq} = \sum_m \sum_n a_{qmn}^p \left\{ \left(\frac{\bar{y}_p}{c} \right)^m \left[n \left(\frac{x_p}{c} \right)^{n-1} + 2 i k_r \left(\frac{x_p}{c} \right)^n \right] \right\}$$

$$\bar{y}_p = \sqrt{(y_{ps} - (N8)Y1)^2 + (z_{ps} - (N8)Z1)^2}$$

The array describing the modal coefficients is an integer at least 7 to 8 digits long

8 7 6 5 4 3 2 1

where

The digits -	87	- the mode number
	654	- the panel number
	3	- m in the w_{iq} equation
	2	- n in the w_{iq} equation
	1	- N8 in the $\bar{y}_p$ equation

5.7 Segment 7

5.7.1 SUBROUTINE SOLVIT (A, RA, ND, MD, KD, NI, NM, NO, NW, NPR1)

Functional Description

Subroutine SOLVIT solves the system of simultaneous linear equations represented by the augmented rectangular $(n \times m)^*$ matrix $[DT|WT]$, which is written on logical tape unit NI, row by row, in the MAIN program. All other information necessary for the operation of SOLVIT, is entered via its argument list. The solutions obtained by SOLVIT are saved on logical tape unit NW in column order, i.e., one set of solutions per record; the data, entered from input tape NI is not preserved.

A detailed description of Subroutine SOLVIT can be found in Reference 3. Here we give only a brief description of the variables in the argument list.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
A(10000)				Complex work array
RA(2,10000)				Equivalenced real work array in which all the computations are done
ND	n			Total number of unknowns, i.e., size of the square DT-matrix
MD		IN	ARG	Total number of righthand sides in the system of simultaneous linear equations solved in SOLVIT
KD				Work array size (total real-variable dimension) — present value is 8000
NI				Tape number assigned to logical tape unit containing all rows of the augmented matrix $[DT WT]$

*where n = number of unknowns and $m = n +$ the number of right hand sides for which the solutions are obtained.

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
NM NO NW NPR1,N1		IN	ARG	Tape numbers, used as scratch units Tape number assigned to tape containing all solutions Print flag for solutions 0 - no print 1 - print

For the present assignment of tape units, see Section 4.1.

Calling Subroutine MAIN

5.8 Segment 8

5.8.1 SUBROUTINE BFSMAT (ND, NE, NB, NP, NTP, NTOTAL, IO, IPRNT, NAS, FMACH, YB, ZB, YS, ZS, X, DELX, EE, XIC, SG, CG, AR, RIA, NBEA1, NBEA2, NASB, NSARAY, NCARAY, BFS, AVR, CBAR, AO, XIS1, XIS2, KR, NSBEA, IBFS)

Functional Description

This subroutine is the basic calling routine that forms the $[FZ]^{(b)}$ and $[FY]^{(b)}$ matrices. (See equation (2.6-35 of Vol. 1. These matrices are written on tape a row at a time, alternating first a row of FZ then one of FY, etc. This set of matrices is formed for each body. The element FZ_{ij} gives the force in the z-direction due to either (1) a lifting surface box or (2) an axial doublet. The element FY_{ij} gives the force in the y-direction. The formulas differ depending on whether a lifting surface box or doublet is considered. The point pressure doublet is $\Delta C_p \delta A$ for the case of the lifting surface boxes. The point pressure doublet for an axial doublet involves a derivative with respect to x.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
ND	δ			Symmetry flag
NE	ϵ			Ground effect flag
NB				Number of bodies
NP				Number of panels
NTOTAL	$NB \sum_{i=1}^{2} NSBEA_i$	IN	ARG	2x (total number of slender body elements)
IO				Logical tape unit on which rows of the BFS matrix are written
IPRNT				Print flag
NAS				Array containing the number of associated bodies for each panel

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
FMACH				Mach Number
YB	y_B			Array of y-coordinates of the bodies
ZB	z_B			Array of z-coordinates of the bodies
YS	y			Array of y-coordinates of strips and bodies
ZS	z			Array of z-coordinates of strips and bodies
X	x			Array of the 3/4-chord locations of boxes and midpoints of interference body elements
DELX	Δx			Array of lengths of boxes and interference body elements
EE	e	IN	ARG	Array of the semi-widths of strips
XIC	ϵ_c			Array of 1/4-chord locations of all boxes
SG	$\sin \gamma_s$			Array of the sines of the dihedral angles of strips
CG	$\cos \gamma_s$			Array of the cosines of the dihedral angles of strips
AR	A/R			Array of the cross sectional aspect ratios of the bodies
RIA				Array of the radii of interference body elements
NBEA1				Array of the number of interference body elements per body
NBEA2				Z-y orientation flag array per body

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
NASB		IN	ARG	Array of the bodies associated with panels
NSARRAY				Array of the number of strips per panel
NCARRAY				Array of the number of chordwise boxes per panel
BFS				One row of the z- and y-forces in the BFS matrix
AVR				Array of the average radii of all bodies
CBAR	$\bar{c}$			Reference chord
AO	a_0			Array of the radii of slender body elements
XIS1	$\xi S1$			Array of the slender body element leading edge coordinates
XIS2	$\xi S2$			Array of the slender body element trailing edge coordinates
KR	k_r	IN	ARG	Reduced frequency
NSBEA				Array of the number of slender body elements per body
IBFS				Option flag = 1 to select subroutine FZY2 for the computation of the individual force element contributions

Calling Subroutine MAIN

Called Subroutine FWMW

Equations

The forces in the z- and y-directions on the slender body elements are related to the lifting surface box pressures, Δc_p , and axial doublet strengths $\tilde{\mu}^{(z)}$, $\tilde{\mu}^{(y)}$ through the [FZ] and [FY] matrices.

$$\begin{aligned} \begin{Bmatrix} F_z \end{Bmatrix}^{(b)} &= [FZ]^{(b)} \{p\} \\ \begin{Bmatrix} F_y \end{Bmatrix}^{(b)} &= [FY]^{(b)} \{p\} \end{aligned}$$

where $\{p\} = \begin{Bmatrix} \Delta c_p \\ \tilde{\mu}^{(z)} \\ \tilde{\mu}^{(y)} \end{Bmatrix}$

The element $FZ_{ij} = FWMW_{ij}^{(z)} \Delta A_j$ when the sending element is a lifting surface box.

$$FZ_{ij} = FWMW_{ij}^{(z)} e^{-ik \frac{\Delta \xi}{\bar{c}} j} - FWMW_{ij+1}^{(z)} e^{+ik \frac{\Delta \xi}{\bar{c}} j+1}$$

where the superscript (z) on $FWMW_{ij}$ indicates that the force in the z-direction is desired, i.e., $|F| = 1$. If the y-direction is desired set $|F| = 3$. The subtraction indicated above numerically performs the differentiation required of $\tilde{\mu}^{(z)}$ and $\tilde{\mu}^{(y)}$.

5.8.2 SUBROUTINE FZY2 (XIJ, X1, X2, ETA, ZETA, YB, ZB, A, BETA2, CBAR, K, FZZR, FZZI, FZYR, FZYI, FZYR, FZYI, FYYR, FYYI, MFLG)

Functional Description

This subroutine calculates the forces in the z- and y-directions on all slender body elements of circular cross sections due to a unit pressure doublet located either inside or outside of the cross section. Subroutine FZY2 is called by subroutine FWMW, which in turn is called by BFSMAT and main only if the option flag IBFS = 1 (card input); it is

bypassed for all other cases (IBFS = 0).

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
XIJ	ξ_j	IN	ARG	1/4-chord x-coordinate of slender body element
X1	x_1			Leading edge of slender body element
X2	x_2			Trailing edge of slender body element
ETA	η			y-coordinate of sending point
ZETA	ζ			z-coordinate of sending point
YB	y_B			y coordinate of body centerline
ZB	z_B			z coordinate of body centerline
A	a			Radius of slender body element
BETA2	β^2			$1-M^2$, where M = Mach Number
CBAR	$\bar{c}$			Reference chord
K, KR	k_r			Reduced frequency
FZZR		OUT	ARG	Real part of the $F_z^{(z)}$
FZZI				Imaginary part of the $F_z^{(z)}$
FZYR				Real part of the $F_z^{(y)}$
FZYI				Imaginary part of the $F_z^{(y)}$

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
FYYR		OUT	ARG	Real
FYYI				Imaginary
				part of the $F_y^{(y)}$ Eq. (5.8.2-3)
MFLG		IN	ARG	Detail print flag
TEST1		IN	FZY2	The number 1/7
TEST 2				The number 1/2
KBAR	$\bar{K}$			Eq. (5.8.2-9)
DX	Δx			$x_2 - x_1$
RAA	R_{aA}			Eq. (5.8.2-6)
DELTA	δ			$\Delta x / R_{aA}$
XA	x_a			$(x_1 + x_2) / 2$
RWIG	$\tilde{r}$			Eq. (5.8.2-7)
RAIJ	ra_{ij}			Eq. (5.8.2-5)
QR	$Re(Q)$			Eq. (5.8.2-8)
QI	$Im(Q)$			
CAPA	A			Eq. 5.8.2-15)
CAPDR	$Re(\Delta)$			Eq. (5.8.2-12) or Eq. (5.8.2-16)
CAPDI	$Im(\Delta)$			
FTHR	$Re(f_\theta^{(\theta)})$			Eq. (5.8.2-10) or Eq. (5.8.2-13)
FTHI	$Im(f_\theta^{(\theta)})$			
FRR	$Re(f_r^{(r)})$			Eq. (5.8.2-11) or Eq. (5.8.2-14)
FRI	$Im(f_r^{(r)})$			

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
CTH	$\cos\theta$	IN	FZY2	Eq. (5.8.2-4)
STH	$\sin\theta$			
I1 through I11	I_1 through I_{11}			The integrals I_1 through I_{11}

Calling Subroutine FWMW

Equations

Subroutine FZY2 computes the unsteady body forces for circular cross sections according to the following equations.

$$FZZ_{ij} = \cos^2\theta f_\theta(\theta) + \sin^2\theta f_r(r) \quad (5.8.2-1)$$

$$FZY_{ij} = FYZ_{ij} = \cos\theta \sin\theta (f_r(r) - f_\theta(\theta)) \quad (5.8.2-2)$$

$$FYY_{ij} = \sin^2\theta f_\theta(\theta) + \cos^2\theta f_r(r) \quad (5.8.2-3)$$

where

$$\cos\theta = \frac{\eta_j - YB_i}{r_{aij}}, \quad \sin\theta = \frac{\zeta_j - ZB_i}{r_{aij}} \quad (5.8.2-4)$$

and

$$r_{aij}^2 = (\eta_j - YB_i)^2 + (\zeta_j - ZB_i)^2 \quad (5.8.2-5)$$

where i is the index of the receiving body element
and j is the index of the sending element.

Note that we set

$\cos\theta = 1.0$ and $\sin\theta = 0.0$ whenever $r_{aij} = 0.0$.

The formulae for $f_{\theta}^{(\theta)}$ and $f_r^{(r)}$ are calculated depending on the location of the sending element, as shown below.

Define a number δ as follows

$$\delta = \Delta x / R_{aA}$$

where

$$R_{aA} = \sqrt{(x_A - \xi_j)^2 + \beta^2 \tilde{r}^2} \quad (5.8.2-6)$$

$$\tilde{r}^2 = \begin{cases} r_{a ij}^2 & \text{if } r_{a ij}^2 > a^2 \\ a^2 & \text{otherwise} \end{cases} \quad (5.8.2-7)$$

$$\Delta x = x_{2j} - x_{1i}$$

$$x_A = \frac{x_{1i} + x_{2i}}{2}$$

Also, define

$$Q = \frac{1}{4\Delta x} e^{i \frac{\bar{k}}{\beta 2a} [M(x_A - \xi_j) - R_{aA}]} \quad (5.8.2-8)$$

where

$$\bar{k} = 2 k M a_i / \bar{c} \quad (5.8.2-9)$$

Then, if $\delta \leq 1/7$

$$f_{\theta}^{(\theta)} = Q a (\beta^2 a I_1 + i \bar{k} I_4) \quad (5.8.2-10)$$

and

$$f_r^{(r)} = f_{\theta}^{(\theta)} + \Delta \quad (5.8.2-11)$$

where

$$\Delta = \begin{cases} Qr_{aij}^2 [-3\beta^2 a (\beta^2 a I_6 + i\bar{k} I_9) + \bar{k}^2 I_1] & \text{if } r_{aij}^2 > a^2 \\ 0 & \text{otherwise} \end{cases} \quad (5.8.2-12)$$

and

$$I_1 = \delta / R_{aA}^2$$

$$I_4 = \delta / R_{aA}$$

$$I_6 = \delta / R_{aA}^4$$

$$I_9 = \delta / R_{aA}^3$$

If $\delta > 1/7$

$$f_\theta(\theta) = Qa[(\beta^2 a I_1 - \frac{\bar{k}^2}{\beta^2 a} A I_5) + i\bar{k}(A I_2 + I_4 - \frac{I_3 \beta^2 r^2}{2R_{aA}^3})] \quad (5.8.2-13)$$

$$f_r(r) = f_\theta(\theta) + \Delta \quad (5.8.2-14)$$

where

$$A = M - (x_A - \xi_j) / R_{aA} \quad (5.8.2-15)$$

and

$$\Delta = \begin{cases} Qr_{aij}^2 [-3\beta^4 a^2 I_6 + \bar{k}^2 (I_1 + 3A I_{10}) + i3\beta^2 a \bar{k} (-A I_7 + \frac{I_8 \beta^2 r^2}{2R_{aA}^3} - I_9) + i \frac{k^{-3} A I_2}{\beta^2 a}] & \text{if } r_{aij}^2 > a^2 \\ 0 & \text{otherwise} \end{cases} \quad (5.8.2-16)$$

and where the integrals I_1 through I_{10} are calculated two different ways, depending on the value of the number δ :

If $\delta \leq 1/2$

$$I_1 = \frac{\delta}{R_{aA}^2} \left[1 - \frac{\delta^2}{8} (-1 + 5\tau^2) \right]$$

$$I_2 = \frac{\delta^3}{R_{aA}} (-\tau/4)$$

$$I_3 = \delta^3/12$$

$$I_4 = \frac{\delta}{R_{aA}} \left[1 + \frac{\delta^2}{12} (-1 + 3\tau^2) \right]$$

$$I_5 = -\tau\delta^3/6$$

$$I_6 = \frac{\delta}{R_{aA}^4} \left[1 + \frac{5\delta^2}{24} (-1 + 7\tau^2) \right]$$

$$I_7 = \frac{\delta^3}{R_{aA}^3} (-5\tau/12)$$

$$I_8 = \delta^3/(12 R_{aA}^2)$$

$$I_9 = \frac{\delta}{R_{aA}^3} \left[1 + \frac{\delta^2}{6} (-1 + 6\tau^2) \right]$$

$$I_{10} = \frac{\delta^3}{R_{aA}^2} (-\tau/3)$$

where

$$\tau = \frac{x_A - \xi_j}{R_{aA}}$$

while, if $\delta > 1/2$

$$I_1 = \frac{1}{\beta^2 r^2} \left[\frac{(x_2 - \xi)}{R_{a2}} - \frac{(x_1 - \xi)}{R_{a1}} \right]$$

$$I_2 = -\frac{1}{\beta^2 r^2} \left[\frac{(x_A - \xi)\Delta x_2 + R_{aA}^2}{R_{a2}} + \frac{(x_A - \xi)\Delta x/2 - R_{aA}^2}{R_{a1}} \right]$$

$$I_{11} = \ln \left| \frac{x_2 - \xi + R_{a2}}{x_1 - \xi + R_{a1}} \right|$$

$$I_3 = I_{11} - 2(x_A - \xi)I_2 - R_{aA}^2 I_1$$

$$I_4 = \frac{1}{\beta \tilde{r}} \left[\text{Atan} \frac{x_2 - \xi}{\beta \tilde{r}} - \text{Atan} \frac{x_1 - \xi}{\beta \tilde{r}} \right]$$

$$I_5 = \frac{1}{2} \ln \left(\frac{R_{a2}^2}{R_{a1}^2} \right) - (x_A - \xi)I_4$$

$$I_6 = \frac{1}{3\beta^2 \tilde{r}^2} \left[\frac{(x_2 - \xi)}{R_{a2}^3} - \frac{(x_1 - \xi)}{R_{a1}^3} + 2 I_1 \right]$$

$$I_7 = -\frac{1}{3} \left(\frac{1}{R_{a2}^3} - \frac{1}{R_{a1}^3} \right) - (x_A - \xi)I_6$$

$$I_8 = I_1 - 2(x_A - \xi)I_7 - R_{aA}^2 I_6$$

$$I_9 = \frac{1}{2\beta^2 \tilde{r}^2} \left[\frac{(x_2 - \xi)}{R_{a2}^2} - \frac{(x_1 - \xi)}{R_{a1}^2} + I_4 \right]$$

$$I_{10} = -\frac{1}{2\beta^2 \tilde{r}^2} \left[\frac{(x_A - \xi)\Delta x/2 + R_{aA}^2}{R_{a2}^2} + \frac{(x_A - \xi)\Delta x/2 - R_{aA}^2}{R_{a1}^2} + (x_A - \xi)I_4 \right]$$

where

$$R_{a1} = \sqrt{(x_1 - \xi)^2 + \beta^2 \tilde{r}^2} \quad \text{and} \quad R_{a2} = \sqrt{(x_2 - \xi)^2 + \beta^2 \tilde{r}^2}$$

5.9 Segment 9

5.9.1 SUBROUTINE BFM (IWORK, RWORK, WORK, NWORK, NPTAP, NPSTAP, NBFM, NPOT, NM, IPRNT, IERRØR, IBFS)

Functional Description

Each and every singularity in the flow field, whether it be inside or outside of a body, contributes to the force distribution on a body.

Subroutine BFM determines this loading, force and moment, on bodies that occurs due to these singularities. The following are the flow singularities considered.

- (a) Slender body singularities.
- (b) Interference element singularities.
- (c) Lifting surface boxes external to the body.
- (d) Lifting surface box images both inside and outside of the body.
- (e) The additional contributions due to considerations of symmetry and ground effects for the above singularities.

Subroutine BFM is essentially a calling routine. Generally speaking, FWMW determines the loading on the body for a pressure singularity of unit strength, including images, symmetry, and ground effect. Subroutine ORGAN gives the region, on the body, over which the loading acts. Subroutine SBLOAD determines the pressure singularity strength from the various flow singularity strengths and gives the detailed loads on each slender body element. BFM then uses the unit loading obtained from FWMW and the results from SBLOAD in conjunction with ORGAN to find the load (both forces and moments) on each of the slender body elements. The slender body elements have been chosen as a convenient set of elements over which all body forces are distributed.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
AR	R	IN	Blank Common Block	Aspect ratio of the bodies.
CG	$\cos(\gamma)$			Cosine dihedral angle.
EE	e			
NB	NB			Number of bodies.
ND	δ			Symmetry flag
NE	ϵ			Ground effects flag
NM	NM	IN	ARG	Number of modes.
NP	NP	IN	Blank Common Block	Number of panels.
SG	$\sin(\gamma)$			Sine dihedral angle.
YB	y_c			y coordinate of body center.
YP	y			y coordinate of centerline of strip
ZB	z_c			z coordinate of body center.
ZP	z			z coordinate of centerline of strip
AVR				Average radius of bodies
NAS				Number of associated bodies per panel
NBY				Number of y-oriented bodies.
NZ				Number of z-oriented bodies.
NT0				Total number of boxes and interference body elements.
NTP				Total number of boxes
NTY				Number of y-oriented interference body elements
NTZ				Number of z-oriented reference body elements
XLE	x_{LE}	IN		Leading edge of bodies
XTE	x_{LE}			Trailing edge of bodies
DELX				Length of boxes and interference body elements
MACH	M			Mach number
NASB				Number of the associated bodies per panel
NBFA				Number of interference body elements per body and body orientation.
IPRNT				Print flag
IERROR		IN	ARG	Error flag
IBFS				Body force calculation method flag

MNEMONICS	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
NBFM		IN	ARG	I/O unit which output body and forces are to be written on (unformatted)
NPOT				Print output unit
NSBE				Number of slender body elements per body
NTYS	NTYS			Number of y-oriented slender body elements
NTZS	NTZS			Number of z-oriented slender body elements
WORK				Complex array for temporary storage of results. The length in complex words required is 4 (No. Strips + NB2 + NBY) + 4(NTZS + NTYS)
XIS1	ξ_{s1}			Leading edge of slender body elements
XIS2	ξ_{s2}	IN		Training edge of slender body elements
IWORK			ARG	Integer array for temporary storage of results its length is 2(NTP + NTZ + NTY + NTZS + NTYS) words
NPTAP				I/O unit containing the P matrix
NWORK				Size of the array WORK
RWORK				Real array for temporary storage. The length is = NTP + 1 + 2 {maximum [(NTP + NTZ + NTY) or (NTZS + NTYS)]}
NCARRY				Array containing the number of chordwise boxes per strip in a panel
NPSTAP		IN	ARG	I/O unit number containing the PS matrix
NSARRY				Array containing the number of strips in a panel.

Calling Subroutines MAIN

Called Subroutines and Common Blocks

RWREC, WRTFMU, FWMW, ORGAN, SBLOAD, WRTFMF, Blank Common

Error Messages

SUBROUTINE **BFM** NWORD(NNNNNNNN) IS GREATER THAN NWORK(NNNNNNNN)

JOB TERMINATED

The available working array is too small to execute the subroutine. Either decrease the problem requirements or increase the size of the work area.

5.9.2 SUBROUTINE FMZY (DYB, DZB, DA, DAR, DY, DZ, DKR, DM, DCBAR, DRFZZ, DIFZZ, DRFZY, DIFZY, DRFYZ, DIFYZ, DRFYY, DIFYY, DRMZZ, DIMZZ, DRMZY, DIMZY, DRMYZ, DIMYZ, DRMYY, DIMYY, IF1, IF2)

Functional Description

This subroutine calculates the force and moment on an elliptic cross section due to a unit pressure doublet located either inside or outside of the cross section.

Input Output Variables

MNEMONICS	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
DYB DZB	YB ZB	IN	ARG	Origin of ellipse
DA	a			Width of ellipse in y-direction
DAR	AR=b/a			Ratio of semi height to semi width of the ellipse
DY DZ	y and $\bar{y}$ z and $\bar{z}$			Coordinates of pressure doublet. For bared quantity $\bar{y}=y-yB$, $\bar{z}=z-zB$
DKR	k			Reduced frequency, $\omega\bar{c}/2U_\infty$
DM	M			Mach number
DCBAR	$\bar{c}$	OUT	ARG	Reference chord length
DRFZZ DIFZZ	$F_z^{(z)}$			Real and imaginary parts of z-force due to doublet oriented in z-direction
DRFZY DIFZY	$F_z^{(y)}$			Real and imaginary parts of z-force due to y-doublet
DRFYZ DIFYZ	$F_y^{(z)}$			Real and imaginary parts of y-force due to z-doublet
DRFYY DIFYY	$F_y^{(y)}$			Real and imaginary parts of y-force due to y-doublet
DRMZZ DIMZZ	$M_y^{(z)}$			Real and imaginary parts of z-moment due to z-doublet
DRMZY DIMZY	$M_z^{(y)}$			etc
DRMYZ DIMYZ	$M_y^{(z)}$			etc
DRMYY DIMYY	$M_y^{(y)}$			etc

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
IF1		IN	ARG	1 if body z-oriented, 2 if body z and y oriented and 3 if y-oriented
IF2		IN	ARG	0 if doublet outside of ellipse 1 if doublet inside of ellipse
DTHETO	θ_0			Elliptic coordinate at which integration starts
FMUR FMUI	f			Real and imaginary parts of f
PMUR PMUI	p			Real and imaginary parts of p
DKJO DKYO DKJ1 DKY1	$kJ_0(\bar{k})$ $kY_0(\bar{k})$ $kJ_1(\bar{k})$ $kY_1(\bar{k})$	IN	FMZY	J_γ, Y_γ are Bessel function of order γ
EF1 EF2	$\cos\lambda$ $\sin\lambda$			λ is the surface slope of the elliptic cross section at the point
DKK DRR	$\bar{k}$ R			Distance from field point to surface point
RCURV DEE	$\bar{a}$ e			Surface curvature of the ellipse Element half width

Calling Subroutines

FWMW

Equations

If $k\bar{m} = 0$ and $\bar{R} = 1$ and $r/a > 1$

$$F_z(z) = (\bar{y}^2 - \bar{z}^2) \frac{1}{2} \frac{a^2}{r^4}$$

$$F_z(y) = -(\bar{z} \bar{y}) a^2 / r^4$$

$$F_y(z) = F_z(y)$$

$$F_y(y) = F_z(z)$$

$$M_z^{(z)} = M_z^{(y)} = M_y^{(z)} = M_y^{(y)} = 0$$

$$\bar{z} = z - zB$$

$$\bar{y} = y - yB$$

$$\text{If } kM = 0 \text{ and } r/a < 1$$

$$F_z^{(z)} = 1 / (1 + AR)$$

$$F_y^{(y)} = AR / (1 + AR)$$

$$F_z^{(y)} = F_y^{(z)} = M_z^{(z)} = M_z^{(y)} = M_y^{(z)} = M_y^{(y)} = 0$$

Otherwise numerical integration is performed

$$\theta_0 = \theta_1 \quad \text{if } \bar{z} \text{ and } \bar{y} > 0$$

$$\theta_0 = -\theta_1 \quad \text{if } \bar{y} > 0 \text{ and } \bar{z} < 0$$

$$\theta_0 = \theta_1 + \pi \quad \text{if } \bar{y} < 0 \text{ and } \bar{z} < 0$$

$$\theta_0 = \pi - \theta_1 \quad \text{if } \bar{y} < 0 \text{ and } \bar{z} > 0$$

$$\cos^2 \theta_1 = 1 - \sin^2 \theta_1$$

$$\sin^2 \theta_1 = \frac{-A + \sqrt{A^2 + 4a^2(1 - AR^2)(z - zB)^2}}{2a^2(1 - AR^2)}$$

$$A = (y - yB)^2 + (z - zB)^2 + a^2(AR^2 - 1)$$

$$\text{If } |1 - AR^2| < .001$$

$$\sin^2 \theta_1 = (z - zB)^2 / r^2$$

$$\theta = \theta_1 + \Delta\theta$$

$$\Delta\theta = 2\pi / N \quad (\text{Currently } N = (\text{NUMB}) = 30)$$

$$F_z(z) = \sum_{j=1}^N f(\bar{k}_j) EFZZ_j$$

$$F_z(y) = \sum_{j=1}^N f(\bar{k}_j) EFZY_j$$

$$F_y(z) = \sum_{j=1}^N f(\bar{k}_j) EFYZ_j$$

$$F_y(y) = \sum_{j=1}^N f(\bar{k}_j) EFYY_j$$

$$M_z(z) = \sum_{j=1}^N P(\bar{k}_j) EF1_j EIM2_j$$

$$M_z(y) = \sum_{j=1}^N P(\bar{k}_j) EF1_j EIM1_j$$

$$M_y(z) = \sum_{j=1}^N -P(\bar{k}_j) EF2_j EIM2_j$$

$$M_y(y) = \sum_{j=1}^N -P(\bar{k}_j) EF2_j EIM1_j$$

$$f(\bar{k}_j) = -\frac{1}{4} \bar{k}_j \left\{ Y_1(\bar{k}_j) + i J_1(\bar{k}_j) \right\}$$

$$P(\bar{k}_j) = \frac{M}{4} \bar{k}_j \left\{ J_0(\bar{k}_j) - i Y_0(\bar{k}_j) \right\}$$

Y_ν and J_ν are Bessel functions of order ν and are approximated by polynomials taken from Reference 4

$$\bar{k} = 2 k M R / \bar{c}$$

$$EF1 = \cos \lambda$$

$$EF2 = \sin \lambda$$

$$EIM1 = 2e (y - n)/R$$

$$EIM2 = 2e (z - \zeta)/R$$

$$R^2 = (\bar{y} - \eta)^2 + (\bar{z} - \zeta)^2$$

$$e = -\frac{\pi}{N} \frac{1}{AR} \sqrt{\zeta^2 + AR^4 \eta^2}$$

$$\eta = a \cos \theta$$

$$\zeta = b \sin \theta$$

$$\cos \lambda = \frac{\zeta}{\sqrt{\zeta^2 + AR^4 \eta^2}}$$

$$\sin \lambda = \frac{-AR^2 \eta}{\sqrt{\zeta^2 + AR^4 \eta^2}}$$

$$\text{If } R/e \geq 5.0$$

$$EF = \bar{k} \frac{2e}{R^2}$$

$$\text{If } 1.5 \geq R/e < 5.0$$

$$EF = \bar{k} \frac{2e}{R^2} + \frac{2}{3} \left(\frac{e}{R} \right)^3 \left[I \frac{R}{\bar{a}} - \frac{BJ}{R} + \frac{\bar{k}}{R} \left(\frac{D}{\bar{a}} - 1 + \frac{B^2}{R^2} \right) \right]$$

$$+ \frac{2}{5} \left(\frac{e}{R}\right)^5 \left[\frac{\bar{K}}{R} \left\{ - \left(\frac{R}{\bar{a}}\right)^2 \frac{1}{4} + 1 \frac{-2D}{\bar{a}} + \frac{D^2}{\bar{a}^2} - 3 \left(\frac{B}{R}\right)^2 (1 - D/\bar{a}) + \left(\frac{B}{R}\right)^4 \right\} \right. \\ \left. + \bar{J} \left\{ 2 \frac{B}{R} (1 - D/\bar{a}) - (B/R)^3 \right\} + I \frac{R}{\bar{a}} \left\{ (B/R)^2 - 1 + D/\bar{a} \right\} \right]$$

$$\text{IF } R/e < 1.5$$

$$\text{EF} = \left\{ -\frac{R^2 I}{\bar{a}} - \frac{\bar{J} B}{2} + \bar{K} - \frac{3}{4} \frac{D \bar{J} B}{\bar{a}} + \frac{D \bar{K}}{2 \bar{a}} \right\} \frac{1}{R} \text{Atan} \left(\frac{2Re}{R^2 - e^2} \right) \\ + \frac{2eI}{\bar{a}} + \frac{1}{e^2 + R^2} \left\{ eB\bar{J} (1 + D/\bar{a}) + \frac{D\bar{J}Be(3e^2 + R^2)}{2\bar{a}(e^2 + R^2)} - \frac{D\bar{K}e}{\bar{a}} \right\}$$

$$\text{EFZZ} = \text{EF} \quad \text{with} \quad \begin{cases} I = 3/2 \sin^2 \lambda - 1/2 \\ \bar{J} = \sin \lambda \cos \lambda - i n \lambda \frac{(\bar{z} - \zeta)}{\bar{a}} \\ \bar{K} = -\cos \lambda (\bar{z} - \zeta) \end{cases}$$

$$\text{EFYZ} = \text{EF} \quad \text{with} \quad \begin{cases} I = 3/2 \cos \gamma \sin \gamma \\ \bar{J} = \cos^2 \lambda - \sin \lambda \frac{(\bar{y} - n)}{\bar{a}} \\ \bar{K} = -\cos \lambda (\bar{y} - n) \end{cases}$$

$$\text{EFYZ} = \text{EF} \quad \text{with} \quad \begin{cases} I = 3/2 \cos \lambda \sin \lambda \\ \bar{J} = -\sin^2 \lambda - \cos \lambda \frac{(\bar{z} - \zeta)}{\bar{a}} \\ \bar{K} = \sin \lambda (z - \zeta) \end{cases}$$

$$\text{EFYY} = \text{EF} \quad \text{with} \quad \begin{cases} I = 3/2 \cos^2 \lambda - 1/2 \\ \bar{J} = -\cos \lambda \sin \lambda - \cos \lambda \frac{(\bar{y} - n)}{\bar{a}} \\ \bar{K} = \sin \lambda (\bar{y} - n) \end{cases}$$

$$B = -2 (\cos \lambda (\bar{y} - n) + \sin \lambda (\bar{z} - \zeta))$$

$$D = \sin \lambda (\bar{y} - n) - \cos \lambda (\bar{z} - \zeta)$$

$$\bar{a} = \frac{a}{R} \left\{ \sin^2 \theta + R^2 \cos^2 \theta \right\}^{2/3}$$

5.9.4 SUBROUTINE ORGAN (ISTART, ISTOP, NLBE, NTP, X, DELX, PERCNT, XLE, XTE, XIS1, XIS2, ITYPE)

Functional Description

It is assumed that the effect of a flow singularity in a body acts exactly at the same x-location as the flow singularity itself. This routine therefore generates two output arrays, one identifying the slender body elements which the leading edges of the sending elements lie within and the other the trailing edges.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
X	x	IN	ARG	<u>ITYPE#1</u> Array of sending box or body element location <u>ITYPE = 1</u> Array of sending slender body elements leading edge x-location.
NTP	NTP	IN	ARG	Number of boxes or elements sending loads
XLE	$x_{L.E.}$			Leading edge of receiving slender body
XTE	$x_{T.E.}$			Trailing edge of receiving slender body
DELX		IN	ARG	<u>ITYPE#1</u> Array of sending box or body element length <u>ITYPE = 1</u> Array of sending slender body elements trailing edge x-location
NLBE		IN	ARG	Number of elements in the receiving slender body.
XIS1	ϵ_{S1}			Array of leading edge x-coordinates of the receiving slender body elements
XIS2	ϵ_{S2}			Array of the x-coordinates of the trailing edges of the elements of the receiving slender body

ITYPE		IN	ARG	Flag indicating the type of the sending elements <u>≠ 1</u> sending elements are either boxes or interference bodies. <u>= 1</u> sending elements are slender bodies.
ISTART		OUT	ARG	An array containing the first slender body element receiving a load contribution from the sending element. The length of this array is (NTP)
ISTOP		OUT	ARG	An array containing the last slender body element receiving a load contribution from the sending element. The length of this array is (NTP).
PERCNT		IN	ARG	The fractional location of the input x with respect to the length of the sending element. This is used to calculate the leading edge of the sending element.

Calling Subroutine

BFM

5.9.5 SUBROUTINE SBLOAD (COEF, IFIRST, ILAST, KS, XIS1, XIS2, DELTA, W, PERCNT, XLE, XTE, NBE, FWZ, FWY, MWZ, MWY, FZ, FY, MZ, MY

Functional Description

It is assumed that the x-distribution of the flow singularity is constant over the flow of the flow singularity element. It is further assumed that the effect of a flow singularity on a body acts exactly at the same x-location as the flow singularity itself. This routine distributes the forces and moments on a body due to internal and external flow singularities. The center of force in each of the slender body elements is also calculated. The output from subroutine ORGAN determines which slender body elements are affected.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
X		IN	ARG	x-coordinate of sending element or box
FY	F_y	OUT	ARG	y-force array
FZ	F_z	OUT	ARG	z-force array
KS		IN	ARG	reserved
MY	M_y	OUT	AGR	y-moment (yawing) array
MZ	M_z	OUT	ARG	z-moment (pitching) array
FWY	F_{wy}	IN	ARG	unit y-force on sending body or strip
FWZ	F_{wz}			unit z-force on sending body or strip
MWY	M_{wy}			unit y-moment on sending body or strip
MWZ	M_{wz}			unit z-moment on sending body or strip
NBE	N			Number of body elements or receiving body.
XLE		IN	ARG	Reserved
XTE				Reserved
COEF				
XIS1	ϵ_{s1}	IN	ARG	Array of leading edge x-coordinate
XIS2	ϵ_{s2}			Array of trailing edge x-coordinates of the slender body elements.
DELTA	Δx			Length of sending box or element.
ILAST				Last slender body element to which the loads are to be applied.
PERCNT				$\text{PERCNT} = (x - x_{LE})/\text{DELTA}$ where x_{LE} is the x-coordinate of the leading edge of the sending element or box.

Calling Subroutines

BFM

5.10 Segment 10

5.10.1 SUBROUTINE AERO (NMODE, NSTRIP, NW, NBFM, NEWBFM, IBFS)

Functional Description

Subroutine AERO computes the aerodynamic parameters for each mode. These include the sectional lift and moment coefficients for all strips of all lifting surface panels, and the center of pressure locations (Eqs. 5.10.1-1 through 5.10.1-3); lift and moment coefficients (z- and y-components) for all slender body elements (Eqs. 5.10.1-4 through 5.10.1-9); total lift and moment coefficients for each slender body (Eqs. 5.10.1-10 through 5.10.1-13); and the total lift and moment coefficients including body effect (Eqs. 5.10.1-14 through 5.10.1-18). The above aerodynamic parameters are printed along with the strip number, or body element number in case of a slender body, and the y- and z-coordinates of the strips and slender bodies.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
NMODE				Total number of modes
NSTRIP				Total number of strips on all lifting surface panels
NW		IN	Argument	Tape number for logical tape unit containing the solutions (ΔC_p) for all unknowns* 'n' and all modes
NBFM			List of AERO	Tape number for logical tape unit containing all slender body element forces and moments for all modes when IBFS = 0
NEWBFM				Tape number for logical tape unit containing all slender body element forces when IBFS = 1
IBFS				Body force calculations method flag
FZ(200)	$\partial f_z / q$			z-forces
FY(200)	$\partial f_y / q$			y-forces
MZ(200)				z-moments
MY(200)				y-moments
		IN	Tape NBFM or NEWBFM	for all slender body elements and all modes

*n = total number of boxes + total number of interference body elements.

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
DCP(500)	ΔC_p		Tape NW	Pressure coefficients (solutions) for all unknowns and all modes
CN(200)	$c_{n_{qj}}$	OUT	AERO	See Equation (5.10.1-1)
CM(200)	$c_{m_{qj}}$			See Equation (5.10.1-2)
CPR(200)	CPR_{qj}			See Equation (5.10.1-3a)
CPI(200)	CPI_{qj}			See Equation (5.10.1-3b)
FZLB	$c_z^{(b)}$			See Equation (5.10.1-4)
FYLB	$c_y^{(b)}$			See Equation (5.10.1-5)
MZLB	$c_{mz}^{(b)}$			See Equation (5.10.1-6)
MYLB	$c_{my}^{(b)}$			See Equation (5.10.1-7)
DFZX	$\frac{\partial f_{zt}/\partial x}{q}$			See Equation (5.10.1-8)
DFYX	$\frac{\partial f_{yt}/\partial x}{q}$			See Equation (5.10.1-9)
CZB(10)	$c_{Zq}^{(b)}$			See Equation (5.10.1-10)
CYB(10)	$c_{Yq}^{(b)}$			See Equation (5.10.1-11)
CMB(10)	$c_M^{(b)}$			See Equation (5.10.1-12)
CNB(10)	$c_N^{(b)}$			See Equation (5.10.1-13)
CMULT SMULT	G_j $g^{(b)}$	IN	AERO	$2e \cos \gamma$ $2e \sin \gamma$
GUCJ				1 or 0.5; Equation (5.10.1-19)
GLCB				1 or 0.5; Equation (5.10.1-20)
SYMA SYMB				$1 + \delta$ where δ is the symmetry $1 - \delta$ flag (input)
CZT	C_{Zq}	OUT		See Equation (5.10.1-14)
CYT	C_{Yq}			See Equation (5.10.1-15)
CMT	C_M			See Equation (5.10.1-16)
CNT	C_N			See Equation (5.10.1-17)
CLT	C_ξ			See Equation (5.10.1-18)

Calling Subroutine

MAIN

Common Blocks The Blank Common BlockEquations

The following aerodynamic parameters are calculated for each mode:

A. Lifting Surface Strips

$$c_{n_{qj}} = \frac{1}{c_j} \sum_{i=i_1}^{i_2} \Delta C_{pqi} \Delta x_i \quad (5.10.1-1)$$

$$c_{m_{qj}} = \frac{-1}{c_j} \sum_{i=i_1}^{i_2} \Delta C_{pqi} \Delta x_i (\xi_{c_i} - \xi_{1/4_j}) \quad (5.10.1-2)$$

$$CPR_{qj} = \frac{\operatorname{Re}(C_{m_{qj}})}{\operatorname{Re}(C_{n_{qj}})} + \frac{1}{4} \quad (5.10.1-3a)$$

$$CPI_{qj} = \frac{\operatorname{Im}(C_{m_{qj}})}{\operatorname{Im}(C_{n_{qj}})} + \frac{1}{4} \quad (5.10.1-3b)$$

where

- i_1 and i_2 are the indices of the first and last boxes in strip j , where $j = 1, NSTRIP$;
- c_j is the chordlength of strip j , and
- $\xi_{1/4_j}$ is the x-coordinate of the 1/4-chord point on the centerline of strip j .

B. Slender Body Elements

$$c_z^{(b)} = \frac{f_z^{(b)} q t}{\Delta x SB_t^{(b)}} \quad (5.10.1-4)$$

$$c_y^{(b),1} = \frac{f_y^{(b)} q t}{\Delta x SB_t^{(b)}} \quad (5.10.1-5)$$

$$c_{m_z}^{(b),1} = \frac{m_z^{(b)} q t}{\Delta x SB_t^{(b)}} \quad (5.10.1-6)$$

and

$$c_{m_y}^{(b),1} = \frac{m_y^{(b)} q t}{\Delta x SB_t^{(b)}} \quad (5.10.1-7)$$

where

$$\Delta x SB_t^{(b)} = \xi S2_t^{(b)} - \xi S1_t^{(b)} = \text{length of slender body element 't' in body 'b'; see Blank Common, Sec. 3.1.}$$

In addition to the above aerodynamic parameters, subroutine AERO also computes modified lift coefficients (z- and y-components) for all slender body elements according to the following equations.

$$\left(\frac{\partial f_{zt}}{\partial x} \right) = AR \left[\overline{GZ}_{t\bar{t}} \right] \left(\frac{\partial f_{z\bar{t}}}{q} \right) \quad (5.10.1-8)$$

and

$$\left(\frac{\partial f_{yt}}{\partial x} \right) = \left[\overline{GY}_{t\bar{t}} \right] \left(\frac{\partial f_{y\bar{t}}}{q} \right) \quad (5.10.1-9)$$

where the elements of the $NSBE^{(b)} \times NSBE^{(b)}$ matrices $\overline{GZ}_{t\bar{t}}$ and $\overline{GY}_{t\bar{t}}$ are defined as follows:

$$\overline{GZ}_{t\bar{t}} = \overline{G}(a^{(b)}, k, M, \bar{c}, AR, R = RZ_{t\bar{t}}, x - \xi = xSB_t - xSB_{\bar{t}})$$

$$\overline{GY}_{t\bar{t}} = \overline{G}(a^{(b)}, k, M, \bar{c}, AR, R = RY_{t\bar{t}}, x - \xi = xSB_t - xSB_{\bar{t}})$$

where

$$\overline{G}(a, k, M, \bar{c}, AR, R, x - \xi) = \frac{a^2 \beta^2}{R^2} \left(\frac{1 + AR}{4} \right) \left(\frac{1}{R} + i \frac{2kM}{\beta^2 \bar{c}} \right) e^{i(2kMf/\beta^2)}$$

$$f = [(x - \xi)M - R]/\bar{c}$$

$$RZ_{t\bar{t}} = \sqrt{(x_t - \xi_{\bar{t}})^2 + \beta^2 a^2 R(1 + R)/2}$$

and

$$RY_{t\bar{t}} = \sqrt{(x_t - \xi_{\bar{t}})^2 + \beta^2 a^2 (1 + R)/2}$$

The indices 't' and ' $\bar{t}$ ' denote the 'row' and 'column' subscripts for the matrices $[\bar{G}Z_{t\bar{t}}]$ and $[\bar{G}Y_{t\bar{t}}]$ corresponding to the slender body elements 't' and ' $\bar{t}$ ', and $NSBE^{(b)}$ = number of slender body elements in body 'b'. The total lift and moment coefficients (z- and y-directions) for all slender bodies are defined by the following equations.

$$C_{Z_q}^{(b)} = \frac{1}{A} \sum_{t=1}^{NSBE^{(b)}} f_{Z_{qt}}^{(b)} \quad (5.10.1-10)$$

$$C_{Y_q}^{(b)} = \frac{1}{A} \sum_{t=1}^{NSBE^{(b)}} f_{Y_{qt}}^{(b)} \quad (5.10.1-11)$$

$$C_M^{(b)} = \frac{1}{Ac} \sum_{t=1}^{NSBE^{(b)}} \left[-f_{Z_{qt}}^{(b)} (\xi_t^{(b)} - x_{LE}^{(b)}) + m_{Z_{qt}}^{(b)} \right] \quad (5.10.1-12)$$

$$C_N^{(b)} = \frac{1}{Ac} \sum_{t=1}^{NSBE^{(b)}} \left[-f_{Y_{qt}}^{(b)} (\xi_t^{(b)} - x_{LE}^{(b)}) + m_{Y_{qt}}^{(b)} \right] \quad (5.10.1-13)$$

where

b is the index of the slender body,

$NSBE^{(b)}$ is the number of elements in slender body 'b'

$\xi_t^{(b)}$ is the x-coordinate of element 't' in slender body 'b', and

$x_{LE}^{(b)}$ is the leading edge x-coordinate of slender body 'b'.

The total lift and moment coefficients, including body effect are defined as follows:

$$C_{Z_q} = (1 + \delta) \left\{ \frac{1}{A} \sum_{j=1}^{NSTRIP} G_j 2e_j c_j c_{n_{qj}} \cos \gamma_j + \sum_{b=1}^{NB} g^{(b)} C_{Z_q}^{(b)} \right\} \quad (5.10.1-14)$$

$$C_{Y_q} = (1 - \delta) \left\{ \frac{1}{A} \sum_{j=1}^{NSTRIP} G_j 2e_j c_j c_{n_{qj}} \sin \gamma_j + \sum_{b=1}^{NB} g^{(b)} C_{Y_q}^{(b)} \right\} \quad (5.10.1-15)$$

$$C_M = (1 + \delta) \left\{ \frac{1}{Ac} \sum_{j=1}^{NSTRIP} G_j \left[c^2 c_{m_{qj}} - c c_{n_{qj}} (\xi 14_j - XM) \right] 2e_j \cos \gamma_j + \sum_{b=1}^{NB} g^{(b)} [C_M^{(b)} - C_{Z_q}^{(b)} (x_{LE}^{(b)} - XM) / \bar{c}] \right\} \quad (5.10.1-16)$$

$$C_N = (1 - \delta) \left\{ \frac{1}{Ac} \sum_{j=1}^{NSTRIP} -G_j [c^2 c_{m_{qj}} - c c_{n_{qj}} (\xi 14_j - XM)] 2e_j \sin \gamma_j + \sum_{b=1}^{NB} g^{(b)} [C_N^{(b)} - C_{Y_q}^{(b)} (x_{LE}^{(b)} - XM) / \bar{c}] \right\} \quad (5.10.1-17)$$

and

$$C_{\ell} = (1 - \delta) \frac{1}{2s} \left\{ \frac{1}{A} \sum_{j=1}^{NSTRIP} G_j c c_{n_{qj}} (y_j \cos \gamma_j + z_j \sin \gamma_j) 2e_j + \sum_{b=1}^{NB} g^{(b)} C_{Z_q}^{(b)} y_c^{(b)} + \sum_{b=1}^{NB} g^{(b)} C_{Y_q}^{(b)} z_c^{(b)} \right\} \quad (5.10.1-18)$$

where

A = reference area

XM = moment axis

δ = symmetry flag

$$\left. \begin{matrix} y_j \\ z_j \end{matrix} \right\} = \text{y- and z-coordinates of the centerline of strip 'j'}$$

$$\left. \begin{matrix} y_c^{(b)} \\ z_c^{(b)} \end{matrix} \right\} = \text{y- and z-coordinates of the centerline of slender body 'b'}$$

$$G_j = \begin{cases} 1/2 & \text{if } y_j = 0 \text{ and } \cos \gamma_j = 0 \text{ and } \delta \neq 0 \\ 1 & \text{otherwise} \end{cases} \quad (5.10.1-19)$$

and

$$g^{(b)} = \begin{cases} 1/2 & \text{if } y_c^{(b)} = 0 \\ 1 & \text{otherwise} \end{cases} \quad (5.10.1-20)$$

5.10 Segment 11

5.11.1 SUBROUTINE GENF (NMODE, NSTRIP, NW, NEWBFM, IMODE, AA, NAI, NPR2, IBFS)

Functional Description

Subroutine GENF computes generalized forces for all pressure and deflection modes according to either of the two definitions given in Equations (5.11.1-1) (AGARD definition) and (5.11.1-2) (conventional generalized forces) depending on the setting of the input flag NPR2 - 1 for AGARD forces, 2 otherwise. It also prints the pressure coefficients ' ΔC_p ' for all boxes of all lifting surface panels along with the panel, strip and box number, and the fractional chordwise locations (x/c) for the ' ΔC_p '. Note that Subroutine GENF can be bypassed through MAIN by specifying NPR2 = 0 (input) whenever generalized forces and pressures are not desired.

Input Output Variables

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
NMODE NSTRIP NW NEWBFM		IN	ARG	See AERO, Sec. 5.10.1
IMODE (2,150,3) AA(2, 150,3) NAI(3), NA(3) NPR2				Modal input array, IA(2,150,3) in Subroutine RDMODE; see Sec. 5.4.1 Floating point equivalent of the array IMODE See RDMODE, Sec. 5.4.1 Control flag; 1 for AGARD generalized forces, 2 for conventional generalized forces
FZ(200) FY(200) MZ(200) MY(200)		IN	Tape BFSMAT	See Sec. 3.2
DCP(500)	ΔC_p	IN	Tape NW	See AERO, Sec. 5.10.1

MNEMONIC	SYMBOL	IN/OUT	SOURCE	DESCRIPTION
N8	N8	IN	GENF	One set of modal input for panel — see Sec. 5.4.1
N	n			
M	m			
AMODE	$a_{i_{nm}}$			
X40C	$x4_k/\bar{c}$			
Y40C	$\tilde{y}4_k/\bar{c}$			See Equation (5.11.1-4)
DELA	ΔA_k			Area of box 'k'
HQA(500)				See Equations(5.11.1-11 through -13)
DHQ(100)				See Equations(5.11.1-14 and -15)
BMODE	az_{i_n} ay_{i_n}			One modal coefficient for body; see Sec. 5.4.1
QW(50)	QW_{ij}	OUT	GENF	One row of each of the generalized force components for all pressure modes and one deflection mode — see Equations (5.11.1-3, -5 and -8)
QZ(50)	QZ_{ij}			
QY(50)	QY_{ij}			
QIJ(50)	Q_{ij}			See Equation (5.11.1-1 and -2)

Calling Subroutine

MAIN

Common Blocks Blank Common Block

Equations

AGARD definition

$$Q_{ij} = \frac{-1}{2s^3} (QW_{ij} + QZ_{ij} + QY_{ij}) \quad (5.11.1-1)$$

Conventional definition

$$Q_{ij} = \frac{1}{A\bar{c}} (QW_{ij} + QZ_{ij} + QY_{ij}) \quad (5.11.1-2)$$

The Q_{ij} are computed for all deflection modes 'i' and all pressure modes 'j', where i and j run from 1 through NMODE.

The three components of the Q_{ij} are computed by Subroutine GENF as follows:

A. Lifting Surface Contribution

$$QW_{ij} = \sum_{k=1}^{NBOX} G_k \Delta C_{p_{kj}} h_{ki} \Delta A_k \quad (5.11.1-3)$$

where

$G_k = 1$ if y-coordinate of centerline of strip is 0 and $\cos \gamma_{strip} = 0$
2 otherwise

$\Delta C_{p_{kj}}$ is the pressure coefficient for box 'k' for pressure mode 'j'

h_{ki} is the modal deflection of box 'k' at the 1/4-chord x-coordinate of the panel box centerline, ' x_{4k} ', defined by

$$h_{ki} = \bar{c} \sum_{n=0}^5 \sum_{m=0}^5 a_{i_{nm}} \left(\frac{x_{4k}}{\bar{c}} \right)^n \left(\frac{\tilde{y}_{4k}}{\bar{c}} \right)^m \quad (5.11.1-4)$$

where

$$\tilde{y}_{4k} = \sqrt{(y_{\ell} - (N8)Y1(p))^2 + (z_{\ell} - (N8)Z1(b))^2}$$

y_{ℓ} and z_{ℓ} are the y- and z-coordinates of the centerline of strip ' ℓ ',
and $Y1(p)$ and $Z1(p)$ are y- and z-coordinates of the inboard edge of
panel 'p', and ΔA_k = area of box 'k'.

The variables $a_{i_{nm}}$ and N8 are modal input data; see Section 1.2.

B. Slender Body Contribution

The QZ_{ij} and QY_{ij} in Equations (5.11.1-1 and -2) denote the z- and y-components of the slender contribution to the total generalized forces.

$$QZ_{ij} = \sum_{b=1}^{NB} g^{(b)} \sum_{t=1}^{NSBE^{(b)}} \left(f_{z_{ij}}^{(b)} h_{z_{ti}}^{(b)} + m_{z_{tj}} \frac{dh_{z_{ti}}^{(b)}}{dx} \right) \quad (5.11.1-5)$$

where

$$h_{z_{ti}}^{(b)} = \bar{c} \sum_{n=0}^5 a_{z_{in}} \left(\frac{x_{SB_t}^{(b)}}{\bar{c}} \right)^n \quad (5.11.1-6)$$

$$\frac{dh_{z_{ti}}}{dx} = \sum_{n=0}^5 n a_{z_{in}} \left(\frac{x_{SB_t}^{(b)}}{\bar{c}} \right)^{n-1} \quad (5.11.1-7)$$

and

$$QY_{ij} = \sum_{b=1}^{NB} g^{(b)} \sum_{t=1}^{NSBE^{(b)}} \left(f_{y_{tj}} h_{y_{ti}} + m_{y_{tj}} \frac{dh_{y_{ti}}^{(b)}}{dx} \right) \quad (5.11.1-8)$$

where

$$h_{y_{ti}}^{(b)} = \bar{c} \sum_{n=0}^5 a_{y_{in}} \left(\frac{x_{SB_t}^{(b)}}{\bar{c}} \right)^n \quad (5.11.1-9)$$

$$\frac{dh_{y_{ti}}^{(b)}}{dx} = \sum_{n=0}^5 n a_{y_{in}} \left(\frac{x_{SB_t}^{(b)}}{\bar{c}} \right)^{n-1} \quad (5.11.1-10)$$

and where the variables a_{inm} , $a_{z_{in}}$, $a_{y_{in}}$, and NS are modal input data (see Section 1.2); $x_{SB_t}^{(b)}$ is the x-coordinate of the slender body element midpoint for element 't' of slender body 'b', and

$$g^{(b)} = \begin{cases} 1 & \text{if } y_c^{(b)} = 0 \\ 2 & \text{if } y_c^{(b)} \neq 0 \end{cases}$$

Note that, to facilitate programming, one array, $HQA(500)$ is generated in Subroutine GENF for all boxes and all slender body elements, defined as

$$HQA(K) = Gh_k \Delta A_K, \quad k = 1, NBOX \quad (5.11.1-11)$$

and h_k is defined in Equation 5.11.1-4 as

$$HQA(KZ) = g^{(b)} h_{kz}, \quad kz = kz_1, kz_2 \quad (5.11.1-12)$$

where

$$ky_1 = kz_2 + 1, \quad ky_2 = kz_2 + \sum_{b=1}^{NBY} NSBE^{(b)}$$

and h_{ky} is given in Equation (5.11.1-9).

Also, one array, DHQ(100), is generated to contain all the dh_z/dx and dh_y/dx in Equations (5.11.1-7) and (5.11.1-10) as follows:

$$DHQ(\ell z) = g^{(b)} \frac{dh_{z\ell z}}{dx}, \quad \ell z = \ell z_1, \ell z_2 \quad (5.11.1-14)$$

where

$$\ell z_1 = 1$$

and

$$\ell z_2 = \sum_{b=1}^{NBZ} NSBE^{(b)}$$

and

$$DHQ(\ell y) = g^{(b)} \frac{dh_{y\ell y}}{dx}, \quad \ell y = \ell y_1, \ell y_2, \quad (5.11.1-15)$$

where

$$\ell y_1 = \ell z_2 + 1$$

and

$$\ell y_2 = \ell z_2 + \sum_{b=1}^{NBY} NSBE^{(b)}$$

[illegible]

190

[illegible][illegible][illegible]

```

      IF2 = 0
      K = 1
      ASSIGN 100 TO IRET1
      GO TO 2000
100 SY = 1.0
      SZ = 1.0
      S = 1.0
      SCS
      ASSIGN 200 TO IRET1
      GO TO 5000
200 CONTINUE
      CHECK SYMMETRY FLAG-- BRANCH IF EQUAL TO ZERO
      IF ( I ND -EQ. 0 ) GO TO 700
      PORTION FOR SYMMETRIC CALCULATIONS
      C
      DELEPS = ND
      C = CGS
      S = SCS
      DY = -YS
      DZ = ZS
      ITYPE = 1
      IF2 = 1
      K = 0
      IF SENDING ELEMENT LIES ON THE Z AXIS.. DON'T USE SYMMETRY
      C
      IF ( I DY -EQ. 0.0 ) GO TO 700
      ASSIGN 300 TO IRET1
      GO TO 2700
300 CONTINUE
      SY = -1.0
      SZ = 1.0
      S = -SGS
      ASSIGN 400 TO IRET1
      GO TO 5000
400 CONTINUE CHECK GROUND EFFECTS FLAG--SKIP IF ZERO
      IF ( I NE -EQ. 0 ) GO TO 7000
      PORTION FOR COMBINATION OF SYMMETRY AND GROUND EFFECTS
      C
      ITYPE = 1
      IF2 = 0
      K = 3
      DELEPS = ND * NE
      C = CGS
      S = -SGS
      DY = -YS
      DZ = ZS
      IF SENDING ELEMENT LIES ON THE Z OR Y AXIS DON'T USE GRND.
      C
      IF ( I DZ -EQ. 0.0 ) OR SYMMETRY
      GO TO 2000
      ASSIGN 500 TO IRET1
      GO TO 5000
500 CONTINUE
      SY = -1.0
      SZ = 1.0
      S = -SGS
      ASSIGN 600 TO IRET1
      GO TO 5000
600 CONTINUE
      GO TO 800
      SKIP GROUND EFFECTS CALCULATIONS IF FLAG IS ZERO
      C
      700 IF ( I NE -EQ. 0 ) GO TO 7000
      PORTION FOR G-ROUND EFFECTS ONLY
      C
      FMH0700
      FMH0710
      FMH0720
      FMH0730
      FMH0740
      FMH0750
      FMH0760
      FMH0770
      FMH0780
      FMH0790
      FMH0800
      FMH0810
      FMH0820
      FMH0830
      FMH0840
      FMH0850
      FMH0860
      FMH0870
      FMH0880
      FMH0890
      FMH0900
      FMH0910
      FMH0920
      FMH0930
      FMH0940
      FMH0950
      FMH0960
      FMH0970
      FMH0980
      FMH0990
      FMH1000
      FMH1010
      FMH1020
      FMH1030
      FMH1040
      FMH1050
      FMH1060
      FMH1070
      FMH1080
      FMH1090
      FMH1100
      FMH1110
      FMH1120
      FMH1130
      FMH1140
      FMH1150
      FMH1160
      FMH1170
      FMH1180
      FMH1190
      FMH1200
      FMH1210
      FMH1220
      FMH1230
      FMH1240
      FMH1250
      FMH1260
      FMH1270
      FMH1280
      IF2 = 0
      K = 1
      ASSIGN 100 TO IRET1
      GO TO 2000
100 SY = 1.0
      SZ = 1.0
      S = 1.0
      SCS
      ASSIGN 200 TO IRET1
      GO TO 5000
200 CONTINUE
      CHECK SYMMETRY FLAG-- BRANCH IF EQUAL TO ZERO
      IF ( I ND -EQ. 0 ) GO TO 700
      PORTION FOR SYMMETRIC CALCULATIONS
      C
      DELEPS = ND
      C = CGS
      S = SCS
      DY = -YS
      DZ = ZS
      ITYPE = 1
      IF2 = 1
      K = 0
      IF SENDING ELEMENT LIES ON THE Z AXIS.. DON'T USE SYMMETRY
      C
      IF ( I DY -EQ. 0.0 ) GO TO 700
      ASSIGN 300 TO IRET1
      GO TO 2700
300 CONTINUE
      SY = -1.0
      SZ = 1.0
      S = -SGS
      ASSIGN 400 TO IRET1
      GO TO 5000
400 CONTINUE CHECK GROUND EFFECTS FLAG--SKIP IF ZERO
      IF ( I NE -EQ. 0 ) GO TO 7000
      PORTION FOR COMBINATION OF SYMMETRY AND GROUND EFFECTS
      C
      ITYPE = 1
      IF2 = 0
      K = 3
      DELEPS = ND * NE
      C = CGS
      S = -SGS
      DY = -YS
      DZ = ZS
      IF SENDING ELEMENT LIES ON THE Z OR Y AXIS DON'T USE GRND.
      C
      IF ( I DZ -EQ. 0.0 ) OR SYMMETRY
      GO TO 2000
      ASSIGN 500 TO IRET1
      GO TO 5000
500 CONTINUE
      SY = -1.0
      SZ = 1.0
      S = -SGS
      ASSIGN 600 TO IRET1
      GO TO 5000
600 CONTINUE
      GO TO 800
      SKIP GROUND EFFECTS CALCULATIONS IF FLAG IS ZERO
      C
      700 IF ( I NE -EQ. 0 ) GO TO 7000
      PORTION FOR G-ROUND EFFECTS ONLY
      C
      FMH1290
      FMH1300
      FMH1310
      FMH1320
      FMH1330
      FMH1340
      FMH1350
      FMH1360
      FMH1370
      FMH1380
      FMH1390
      FMH1400
      FMH1410
      FMH1420
      FMH1430
      FMH1440
      FMH1450
      FMH1460
      FMH1470
      FMH1480
      FMH1490
      FMH1500
      FMH1510
      FMH1520
      FMH1530
      FMH1540
      FMH1550
      FMH1560
      FMH1570
      FMH1580
      FMH1590
      FMH1600
      FMH1610
      FMH1620
      FMH1630
      FMH1640
      FMH1650
      FMH1660
      FMH1670
      FMH1680
      FMH1690
      FMH1700
      FMH1710
      FMH1720
      FMH1730
      FMH1740
      FMH1750
      FMH1760
      FMH1770
      FMH1780
      FMH1790
      FMH1800
      FMH1810
      FMH1820
      FMH1830
      FMH1840
      FMH1850
      FMH1860
      FMH1870
      FMH1880
      FMH1890
      FMH1900

```



```

C      IF (N12-EQ-01) GO TO 630
C
C **  READ THETA-Z-MU = ANGULAR ORIENTATION, OF POINT MU ON BODY
C **  SECOND SET OF VALUES * THE SPARSE ONE * INPUT IN DEGREES
C **  -- SAVE CONTINUOUS ARRAY FOR ALL BODIES IN THETA(100) IN RADIAN*DATA471P
C
C      READ (5,101) (TH2(I), I=1,N12)
C      WRITE (6,200) N12, L3 (1+1,N12)
C      630 CONTINUE
C      IA = 0
C      I111 = I112+1
C      I112 = I112+1
C      DO 94C I=I111,I112
C      IA = IA+1
C      TH2(I111) = TH1(I111)*PI/180.0
C      640 CONTINUE
C      IA = 0
C      I121 = I122+1
C      I122 = I122+1
C      DO 95C I=I121,I122
C      IA = IA+1
C      TH2(I121) = TH1(I121)*PI/180.0
C      650 CONTINUE
C      K11 = 0
C
C **  READ SETS OF FIRST- AND LAST INTERFERENCE BODY ELEMENTS
C **  ASSOCIATED WITH THETA-1-MU -- SAVE THE NUMBER OF PAIRS, P
C **  BODY IN ARRAY, NPL101, AND SAVE CONTINUOUS ARRAYS OF FIRST-
C **  AND LAST BODY ELEMENTS IN I1P130,1) AND I1P130,2)
C **  RESPECTIVELY
C
C      READ (5,80) L1,L2,L3,L4,L5,L6
C      K1 = K1+1
C      K11 = K11+1
C      I1P1K1,1) = L1
C      I1P1K1,2) = L2
C      IF (L3-EQ-0) GO TO 660
C      K1 = K1+1
C      K11 = K11+1
C      I1P1K1,1) = L3
C      I1P1K1,2) = L4
C      K1 = K1+1
C      K11 = K11+1
C      I1P1K1,1) = L5
C      I1P1K1,2) = L6
C      660 CONTINUE
C
C **  BYPASS READING, Y= AND Z-SHIFT ELEMENTS IF NSH = 1
C
C      IF (NSH,F4,0) GO TO 640
C
C **  READ NSH SETS OF Y= AND Z-SHIFT ELEMENTS, FOR BODY --
C **  SAVE THE FOLLOWING RELATED INFORMATION -- NORDY(100) = BODY
C **  NUMBER, NPANEL(100) = PANEL NUMBER, OFTA(2) = DELTA-E/A =
C **  Y-SHIFT IF PANEL FOR BODY, OFTA(100) = DELTA-ETA = Z-SHIFT IF
C **  PANEL FOR BODY
C
C      70 67C I1SH=1,NSH,2
C      READ (5,150) NC1,CN2,CN3, I1CD4,C05,C06
C      IAX = IAX+1
C      NORDY(11XX) = LB
C      NPANEL(11XX) = LB
C      OFTA(11XX) = C01
C      OFTA(11XX) = C02
C      OFTA(11XX) = C03
C      IF (I1CD4-EQ-0,OR,I1SH-EQ-NSH) GO TO 670
C      IXX = IAX+1
C      NORDY(11XX) = LB
C      NPANEL(11XX) = NC04
C      OFTA(11XX) = C05
C      OFTA(11XX) = C06
C      670 CONTINUE
C      680 CONTINUE
C      690 CONTINUE
C      700 CONTINUE
C      710 CONTINUE
C      720 CONTINUE
C      730 CONTINUE
C      740 CONTINUE
C      750 CONTINUE

```

[illegible]

```

DATA5440
DATA5450
DATA5460
DATA5470
DATA5480
DATA5490
DATA5500
DATA5510
DATA5520
DATA5530
DATA5540
DATA5550
DATA5560
DATA5570
DATA5580
DATA5590
DATA5600
DATA5610
DATA5620
DATA5630
DATA5640
DATA5650
DATA5660
DATA5670
DATA5680
DATA5690
DATA5700
DATA5710

```

```

DATA54700
DATA54710
DATA54720
DATA54730
DATA54740
DATA54750
DATA54760
DATA54770
DATA54780
DATA54790
DATA54800
DATA54810
DATA54820
DATA54830
DATA54840
DATA54850
DATA54860
DATA54870
DATA54880
DATA54890
DATA54900
DATA54910
DATA54920
DATA54930
DATA54940
DATA54950
DATA54960
DATA54970
DATA54980
DATA54990
DATA55000
DATA55010
DATA55020
DATA55030
DATA55040
DATA55050
DATA55060
DATA55070
DATA55080
DATA55090
DATA55100
DATA55110
DATA55120
DATA55130
DATA55140
DATA55150
DATA55160
DATA55170
DATA55180
DATA55190
DATA55200
DATA55210
DATA55220
DATA55230
DATA55240
DATA55250
DATA55260
DATA55270
DATA55280
DATA55290
DATA55300
DATA55310
DATA55320
DATA55330
DATA55340
DATA55350
DATA55360
DATA55370
DATA55380
DATA55390
DATA55400
DATA55410
DATA55420
DATA55430

```

207

COMPUT	COMPLEX MATRIX MULTIPLICATION W = Z * U + V * DY * DY	
C	SUBROUTINE SUBMULT (N1 , N2 , N3 , N4 , N5 , N6 , N7 , N8 , N9 , N10 , N11 , N12 , N13 , N14 , N15 , N16 , N17 , N18 , N19 , N20 , N21 , N22 , N23 , N24 , N25 , N26 , N27 , N28 , N29 , N30 , N31 , N32 , N33 , N34 , N35 , N36 , N37 , N38 , N39 , N40 , N41 , N42 , N43 , N44 , N45 , N46 , N47 , N48 , N49 , N50 , N51 , N52 , N53 , N54 , N55 , N56 , N57 , N58 , N59 , N60 , N61 , N62 , N63 , N64 , N65 , N66 , N67 , N68 , N69 , N70 , N71 , N72 , N73 , N74 , N75 , N76 , N77 , N78 , N79 , N80 , N81 , N82 , N83 , N84 , N85 , N86 , N87 , N88 , N89 , N90 , N91 , N92 , N93 , N94 , N95 , N96 , N97 , N98 , N99 , N100 , N101 , N102 , N103 , N104 , N105 , N106 , N107 , N108 , N109 , N110 , N111 , N112 , N113 , N114 , N115 , N116 , N117 , N118 , N119 , N120 , N121 , N122 , N123 , N124 , N125 , N126 , N127 , N128 , N129 , N130 , N131 , N132 , N133 , N134 , N135 , N136 , N137 , N138 , N139 , N140 , N141 , N142 , N143 , N144 , N145 , N146 , N147 , N148 , N149 , N150 , N151 , N152 , N153 , N154 , N155 , N156 , N157 , N158 , N159 , N160 , N161 , N162 , N163 , N164 , N165 , N166 , N167 , N168 , N169 , N170 , N171 , N172 , N173 , N174 , N175 , N176 , N177 , N178 , N179 , N180 , N181 , N182 , N183 , N184 , N185 , N186 , N187 , N188 , N189 , N190 , N191 , N192 , N193 , N194 , N195 , N196 , N197 , N198 , N199 , N200 , N201 , N202 , N203 , N204 , N205 , N206 , N207 , N208 , N209 , N210 , N211 , N212 , N213 , N214 , N215 , N216 , N217 , N218 , N219 , N220 , N221 , N222 , N223 , N224 , N225 , N226 , N227 , N228 , N229 , N230 , N231 , N232 , N233 , N234 , N235 , N236 , N237 , N238 , N239 , N240 , N241 , N242 , N243 , N244 , N245 , N246 , N247 , N248 , N249 , N250 , N251 , N252 , N253 , N254 , N255 , N256 , N257 , N258 , N259 , N260 , N261 , N262 , N263 , N264 , N265 , N266 , N267 , N268 , N269 , N270 , N271 , N272 , N273 , N274 , N275 , N276 , N277 , N278 , N279 , N280 , N281 , N282 , N283 , N284 , N285 , N286 , N287 , N288 , N289 , N290 , N291 , N292 , N293 , N294 , N295 , N296 , N297 , N298 , N299 , N300 , N301 , N302 , N303 , N304 , N305 , N306 , N307 , N308 , N309 , N310 , N311 , N312 , N313 , N314 , N315 , N316 , N317 , N318 , N319 , N320 , N321 , N322 , N323 , N324 , N325 , N326 , N327 , N328 , N329 , N330 , N331 , N332 , N333 , N334 , N335 , N336 , N337 , N338 , N339 , N340 , N341 , N342 , N343 , N344 , N345 , N346 , N347 , N348 , N349 , N350 , N351 , N352 , N353 , N354 , N355 , N356 , N357 , N358 , N359 , N360 , N361 , N362 , N363 , N364 , N365 , N366 , N367 , N368 , N369 , N370 , N371 , N372 , N373 , N374 , N375 , N376 , N377 , N378 , N379 , N380 , N381 , N382 , N383 , N384 , N385 , N386 , N387 , N388 , N389 , N390 , N391 , N392 , N393 , N394 , N395 , N396 , N397 , N398 , N399 , N400 , N401 , N402 , N403 , N404 , N405 , N406 , N407 , N408 , N409 , N410 , N411 , N412 , N413 , N414 , N415 , N416 , N417 , N418 , N419 , N420 , N421 , N422 , N423 , N424 , N425 , N426 , N427 , N428 , N429 , N430 , N431 , N432 , N433 , N434 , N435 , N436 , N437 , N438 , N439 , N440 , N441 , N442 , N443 , N444 , N445 , N446 , N447 , N448 , N449 , N450 , N451 , N452 , N453 , N454 , N455 , N456 , N457 , N458 , N459 , N460 , N461 , N462 , N463 , N464 , N465 , N466 , N467 , N468 , N469 , N470 , N471 , N472 , N473 , N474 , N475 , N476 , N477 , N478 , N479 , N480 , N481 , N482 , N483 , N484 , N485 , N486 , N487 , N488 , N489 , N490 , N491 , N492 , N493 , N494 , N495 , N496 , N497 , N498 , N499 , N500 , N501 , N502 , N503 , N504 , N505 , N506 , N507 , N508 , N509 , N510 , N511 , N512 , N513 , N514 , N515 , N516 , N517 , N518 , N519 , N520 , N521 , N522 , N523 , N524 , N525 , N526 , N527 , N528 , N529 , N530 , N531 , N532 , N533 , N534 , N535 , N536 , N537 , N538 , N539 , N540 , N541 , N542 , N543 , N544 , N545 , N546 , N547 , N548 , N549 , N550 , N551 , N552 , N553 , N554 , N555 , N556 , N557 , N558 , N559 , N560 , N561 , N562 , N563 , N564 , N565 , N566 , N567 , N568 , N569 , N570 , N571 , N572 , N573 , N574 , N575 , N576 , N577 , N578 , N579 , N580 , N581 , N582 , N583 , N584 , N585 , N586 , N587 , N588 , N589 , N590 , N591 , N592 , N593 , N594 , N595 , N596 , N597 , N598 , N599 , N600 , N601 , N602 , N603 , N604 , N605 , N606 , N607 , N608 , N609 , N610 , N611 , N612 , N613 , N614 , N615 , N616 , N617 , N618 , N619 , N620 , N621 , N622 , N623 , N624 , N625 , N626 , N627 , N628 , N629 , N630 , N631 , N632 , N633 , N634 , N635 , N636 , N637 , N638 , N639 , N640 , N641 , N642 , N643 , N644 , N645 , N646 , N647 , N648 , N649 , N650 , N651 , N652 , N653 , N654 , N655 , N656 , N657 , N658 , N659 , N660 , N661 , N662 , N663 , N664 , N665 , N666 , N667 , N668 , N669 , N670 , N671 , N672 , N673 , N674 , N675 , N676 , N677 , N678 , N679 , N680 , N681 , N682 , N683 , N684 , N685 , N686 , N687 , N688 , N689 , N690 , N691 , N692 , N693 , N694 , N695 , N696 , N697 , N698 , N699 , N700 , N701 , N702 , N703 , N704 , N705 , N706 , N707 , N708 , N709 , N710 , N711 , N712 , N713 , N714 , N715 , N716 , N717 , N718 , N719 , N720 , N721 , N722 , N723 , N724 , N725 , N726 , N727 , N728 , N729 , N730 , N731 , N732 , N733 , N734 , N735 , N736 , N737 , N738 , N739 , N740 , N741 , N742 , N743 , N744 , N745 , N746 , N747 , N748 , N749 , N750 , N751 , N752 , N753 , N754 , N755 , N756 , N757 , N758 , N759 , N760 , N761 , N762 , N763 , N764 , N765 , N766 , N767 , N768 , N769 , N770 , N771 , N772 , N773 , N774 , N775 , N776 , N777 , N778 , N779 , N780 , N781 , N782 , N783 , N784 , N785 , N786 , N787 , N788 , N789 , N790 , N791 , N792 , N793 , N794 , N795 , N796 , N797 , N798 , N799 , N800 , N801 , N802 , N803 , N804 , N805 , N806 , N807 , N808 , N809 , N810 , N811 , N812 , N813 , N814 , N815 , N816 , N817 , N818 , N819 , N820 , N821 , N822 , N823 , N824 , N825 , N826 , N8	

[illegible]

```

C      CHECK TO SEE IF CALCULATIONS ARE TO BE MADE
C      IF ( ( DY * EQ, FTA * AND, T1, OZ * ZETA ) ) GO TO 100
C      ASSIGN GO TO J020Y
C      GO TO 200
C      50 3 (1, T1) = OI 1, T1 ) + EPSLON * DELTA * OZYX
C      3 (2, T1) = OI 2, T1 ) + EPSLON * DELTA * OZVI
C      130 IF ( EPSLON * EQ, O, O ) GO TO 140
C      ZETA = -ZETA
C      IF *NO* BODY LIES IN THE Y AXIS.. SKIP *ROUND EFFECTS
C      IF ( ZETA * EQ, O, O ) GO TO 140 TO BE MADE
C      CHECK TO SEE IF CALCULATIONS ARE TO BE MADE
C      IF ( ( IN * EQ, FTA ) ) GO TO 140
C      ASSIGN RETURN ADDRESS FROM OZY
C      ASSIGN 120 TO J020Y
C      120 3 (1, T1) = OI 1, T1 ) + EPSLON * OZYX
C      3 (2, T1) = OI 2, T1 ) + EPSLON * OZVI
C      140 CONTINUE
C      130 CONTINUE
C      200 CONTINUE
C      WRITE ROM IN TABLE, ROM NUMBER, NO. ELEMENTS, DATA
C      WRITE ( NTADE ) ROM, T1, O
C      IF ( IPROM * EQ, O ) WRITE ( * ) ROM, T1, O
C      RETURN
C      CALL SEQUENCE TO OZY
C      500 CALL OZY ( OX, OY, OZ, XT2, YTA, ZETA, CGR,
C      * AFSA, * NR, * COM, * META,
C      * WACH, * TOZY, * OZYX, * DEVI,
C      * IPRNT )
C      GO TO J020Y + ( 20, 40, 60, 120 )
C      1000 FORMAT (1PH QUANT--- ROM NO., 15, 1PH, 11, 1PH ELEMENTS, /
C      * 6E12.4)
C      1100 FORMAT (1PH QUANT 3 *, 11D, 4E20.4)
C      1320 FORMAT (1H, 210 )
C      END

```

```

ROM01020
ROM01030
ROM01040
ROM01050
ROM01060
ROM01070
ROM01080
ROM01090
ROM01100
ROM01110
ROM01120
ROM01130
ROM01140
ROM01150
ROM01160
ROM01170
ROM01180
ROM01190
ROM01200
ROM01210
ROM01220
ROM01230
ROM01240
ROM01250
ROM01260
ROM01270
ROM01280
ROM01290
ROM01300
ROM01310
ROM01320
ROM01330
ROM01340
ROM01350
ROM01360
ROM01370
ROM01380
ROM01390
ROM01400
ROM01410
ROM01420
ROM01430
ROM01440
ROM01450
ROM01460
ROM01470
ROM01480
ROM01490
ROM01500
ROM01510

```



```

XX
226 CONTINUE " YMA * XCS ** (N-1)
W41.181 * RN * XZ * 41 (1, 18)
412.131 * XX * XCS * 412 (1, 18)
GO TO 240
C
C SET THE POINT XCS IS EQUAL TO 0.0, CHECK THE VALUE OF N---
C SET THE RESULT OF 0.0+0 EQUAL TO 1.0
230 IF ( N-1 ) 232, 234, 225
232 412.191 * Y4 * 412.18 )
234 412.191 * Y4 * 412.18 )
234 XX * XZ * 41 (1, 18)
234 XCS * 41 (1, 18)
GO TO 226
240 CONTINUE " N82 * NC
N81 * NC
N81 * 1
C
C 260 CONTINUE INCREMENT COEFFICIENT NUMBER
N8P * 1
N8P * 1
290 CONTINUE INCREMENT STRIP AND BOX NUMBERS
320 N8STRP * N8STRP + 1
N8BOX * 1
340 CONTINUE INCREMENT STRIP AND BOX NUMBERS
350 CONTINUE INCREMENT STRIP AND BOX NUMBERS
360 CONTINUE INCREMENT STRIP AND BOX NUMBERS
370 CONTINUE INCREMENT STRIP AND BOX NUMBERS
380 CONTINUE INCREMENT STRIP AND BOX NUMBERS
390 CONTINUE INCREMENT STRIP AND BOX NUMBERS
400 CONTINUE INCREMENT STRIP AND BOX NUMBERS
410 CONTINUE INCREMENT STRIP AND BOX NUMBERS
420 CONTINUE INCREMENT STRIP AND BOX NUMBERS
430 CONTINUE INCREMENT STRIP AND BOX NUMBERS
440 CONTINUE INCREMENT STRIP AND BOX NUMBERS
450 CONTINUE INCREMENT STRIP AND BOX NUMBERS
460 CONTINUE INCREMENT STRIP AND BOX NUMBERS
470 CONTINUE INCREMENT STRIP AND BOX NUMBERS
480 CONTINUE INCREMENT STRIP AND BOX NUMBERS
490 CONTINUE INCREMENT STRIP AND BOX NUMBERS
500 CONTINUE INCREMENT STRIP AND BOX NUMBERS
510 CONTINUE INCREMENT STRIP AND BOX NUMBERS
520 CONTINUE INCREMENT STRIP AND BOX NUMBERS
530 CONTINUE INCREMENT STRIP AND BOX NUMBERS
540 CONTINUE INCREMENT STRIP AND BOX NUMBERS
550 CONTINUE INCREMENT STRIP AND BOX NUMBERS
560 CONTINUE INCREMENT STRIP AND BOX NUMBERS
570 CONTINUE INCREMENT STRIP AND BOX NUMBERS
580 CONTINUE INCREMENT STRIP AND BOX NUMBERS
590 CONTINUE INCREMENT STRIP AND BOX NUMBERS
600 CONTINUE INCREMENT STRIP AND BOX NUMBERS
610 CONTINUE INCREMENT STRIP AND BOX NUMBERS
620 CONTINUE INCREMENT STRIP AND BOX NUMBERS
630 CONTINUE INCREMENT STRIP AND BOX NUMBERS
640 CONTINUE INCREMENT STRIP AND BOX NUMBERS
650 CONTINUE INCREMENT STRIP AND BOX NUMBERS
660 CONTINUE INCREMENT STRIP AND BOX NUMBERS
670 CONTINUE INCREMENT STRIP AND BOX NUMBERS
680 CONTINUE INCREMENT STRIP AND BOX NUMBERS
690 CONTINUE INCREMENT STRIP AND BOX NUMBERS
700 CONTINUE INCREMENT STRIP AND BOX NUMBERS
710 CONTINUE INCREMENT STRIP AND BOX NUMBERS
720 CONTINUE INCREMENT STRIP AND BOX NUMBERS
730 CONTINUE INCREMENT STRIP AND BOX NUMBERS
740 CONTINUE INCREMENT STRIP AND BOX NUMBERS
750 CONTINUE INCREMENT STRIP AND BOX NUMBERS
760 CONTINUE INCREMENT STRIP AND BOX NUMBERS
770 CONTINUE INCREMENT STRIP AND BOX NUMBERS
780 CONTINUE INCREMENT STRIP AND BOX NUMBERS
790 CONTINUE INCREMENT STRIP AND BOX NUMBERS
800 CONTINUE INCREMENT STRIP AND BOX NUMBERS
810 CONTINUE INCREMENT STRIP AND BOX NUMBERS
820 CONTINUE INCREMENT STRIP AND BOX NUMBERS
830 CONTINUE INCREMENT STRIP AND BOX NUMBERS
840 CONTINUE INCREMENT STRIP AND BOX NUMBERS
850 CONTINUE INCREMENT STRIP AND BOX NUMBERS
860 CONTINUE INCREMENT STRIP AND BOX NUMBERS
870 CONTINUE INCREMENT STRIP AND BOX NUMBERS
880 CONTINUE INCREMENT STRIP AND BOX NUMBERS
890 CONTINUE INCREMENT STRIP AND BOX NUMBERS
900 CONTINUE INCREMENT STRIP AND BOX NUMBERS
910 CONTINUE INCREMENT STRIP AND BOX NUMBERS
920 CONTINUE INCREMENT STRIP AND BOX NUMBERS
930 CONTINUE INCREMENT STRIP AND BOX NUMBERS
940 CONTINUE INCREMENT STRIP AND BOX NUMBERS
950 CONTINUE INCREMENT STRIP AND BOX NUMBERS
960 CONTINUE INCREMENT STRIP AND BOX NUMBERS
970 CONTINUE INCREMENT STRIP AND BOX NUMBERS
980 CONTINUE INCREMENT STRIP AND BOX NUMBERS
990 CONTINUE INCREMENT STRIP AND BOX NUMBERS
1000 CONTINUE INCREMENT STRIP AND BOX NUMBERS

```

223

224

```

SOLV3040
SOLV3050
SOLV3060
SOLV3070
SOLV3080
SOLV3090
SOLV3100
SOLV3110
SOLV3120
SOLV3130
SOLV3140
SOLV3150
SOLV3160
SOLV3170
SOLV3180
SOLV3190
SOLV3200
SOLV3210
SOLV3220
SOLV3230
SOLV3240
SOLV3250
SOLV3260
SOLV3270
SOLV3280
SOLV3290
SOLV3300
SOLV3310
SOLV3320
SOLV3330
SOLV3340
SOLV3350
SOLV3360
SOLV3370
SOLV3380
SOLV3390
SOLV3400
SOLV3410
SOLV3420
SOLV3430
SOLV3440
SOLV3450
SOLV3460
SOLV3470
SOLV3480
SOLV3490
SOLV3500
SOLV3510
SOLV3520
SOLV3530
SOLV3540
SOLV3550
SOLV3560
SOLV3570
SOLV3580
SOLV3590
SOLV3600
SOLV3610
SOLV3620
SOLV3630
SOLV3640
SOLV3650
SOLV3660
SOLV3670
SOLV3680
SOLV3690
SOLV3700
SOLV3710
SOLV3720
SOLV3730
SOLV3740
SOLV3750
SOLV3760
SOLV3770
SOLV3780
SOLV3790
SOLV3800
SOLV3810
SOLV3820
SOLV3830
SOLV3840
SOLV3850
SOLV3860
SOLV3870
SOLV3880
SOLV3890
SOLV3900
SOLV3910
SOLV3920
SOLV3930
SOLV3940
SOLV3950
SOLV3960
SOLV3970
SOLV3980
SOLV3990
SOLV4000
SOLV4010
SOLV4020
SOLV4030
SOLV4040
SOLV4050

```

```

C -- READ IN THE SOLUTIONS
C
DO 210 IO = 1, N
  READ (NFI) (A(NH), NH = NS, NT)
  NT = NT + N
210 NS = NS + N
220 N2 = N1 - 1
C -- WRITE THE SOLUTIONS ON TAPE
C
NT = 0
DO 230 IO = 1, N
  NS = NT + 1
  NT = NT + N
  WRITE (NFI) (A(NH), NH = NS, NT)
230 WRITE (NFI) (A(NH), NH = NS, NT)
C
CALL TIMEV(88)
88 = 88/60.0
WRITE (6, 300) N, N1, N2, B1
300 FORMAT (40H THE 15, 2H X 15, 12H MATRIX WITH 14, 35H RIGHT SIDES WAS SOLVED DIRECTLY IN 14.3, 9H MINUTES. )
RETURN
END

```

225

```

SOLV3040
SOLV3050
SOLV3060
SOLV3070
SOLV3080
SOLV3090
SOLV3100
SOLV3110
SOLV3120
SOLV3130
SOLV3140
SOLV3150
SOLV3160
SOLV3170
SOLV3180
SOLV3190
SOLV3200
SOLV3210
SOLV3220
SOLV3230
SOLV3240
SOLV3250
SOLV3260
SOLV3270
SOLV3280
SOLV3290
SOLV3300
SOLV3310
SOLV3320
SOLV3330
SOLV3340
SOLV3350
SOLV3360
SOLV3370
SOLV3380
SOLV3390
SOLV3400
SOLV3410
SOLV3420
SOLV3430
SOLV3440
SOLV3450
SOLV3460
SOLV3470
SOLV3480
SOLV3490
SOLV3500
SOLV3510
SOLV3520
SOLV3530
SOLV3540
SOLV3550
SOLV3560
SOLV3570
SOLV3580
SOLV3590
SOLV3600
SOLV3610
SOLV3620
SOLV3630
SOLV3640
SOLV3650
SOLV3660
SOLV3670
SOLV3680
SOLV3690
SOLV3700
SOLV3710
SOLV3720
SOLV3730
SOLV3740
SOLV3750
SOLV3760
SOLV3770
SOLV3780
SOLV3790
SOLV3800
SOLV3810
SOLV3820
SOLV3830
SOLV3840
SOLV3850
SOLV3860
SOLV3870
SOLV3880
SOLV3890
SOLV3900
SOLV3910
SOLV3920
SOLV3930
SOLV3940
SOLV3950
SOLV3960
SOLV3970
SOLV3980
SOLV3990
SOLV4000
SOLV4010
SOLV4020
SOLV4030
SOLV4040
SOLV4050

```

```

NT = NT - 1
IF (18. LE. NROM) GO TO 160
NS = NS + NN
NT = NT + NN
160 READ (NT) NN, (A(10), IO = NS, NT)
NP = NT - 1
NF = NT - N - RM1
NN = NN - KOLD
N2 = NF
N1 = NN + 1, N
N4 = NP + NN
N5 = NA
SUM = 0.0
SUMR = 0.0
SUMI = 0.0
DO 165 IO = 1, KOLD
  SUM = SUM + A(N2) + A(N4)
  SUMR = SUMR + REAL(A(N2)) + REAL(A(N4)) + AIMAG(A(N2)) + AIMAG(A(N4))
  SUMI = SUMI + REAL(A(N2)) + REAL(A(N4)) + AIMAG(A(N2)) + AIMAG(A(N4))
N2 = N2 + 1
165 NA = NA + N
N2 = N2 + NN - 1
C 170 A(N2) = A(N2) - SUM
C
RA1(N2) = RA1(N2) - SUMR
170 RA1(N2) = RA1(N2) - SUMI
C -- WRITE THE MODIFIED ROW IN TAPE OR CONDENSE THE ROW
C
NL = NT - N + 1
IF (18. GE. NROM) GO TO 175
NF = NF + 1
WRITE (NFI) NN, (A(10), IO = NS, NF), (A(10), IO = NL, NT)
GO TO 190
175 NF = NL - KOLD
DO 180 NN = NL, NT
  A(NF) = A(NN)
180 NF = NF + 1
190 CONTINUE
REWIN NT
REWIND NFI
C -- SWITCH THE TAPES
C
IT = NT
NT = NOUT
NOUT = IT
C -- LDDP BACK THRU THE SOLUTION
C
NL = NF
GO TO 110
C -- START TO WRAP IT UP
C
200 END FILE NFI
REWIND NFI
N2 = N
C * * * AT THIS POINT ALL LOCATIONS ALL THRU A(NKRF) ARE FREE
C
DO 220 IO = 1, NPASS
  READ (NFI) K
  N1 = N2 - K + 1
  NS = N1
  NT = N2

```

225


```

370 CONTINUE
  GO TO 250
380 CONTINUE
  R413 = R412
  R423 = R422
  R6 = (R42-R413)/R423-(R41-R413)/R413 + 2.*R11/(R13-R42-R41R12)
  GO TO 200
390 R411 = 0.5 * R6 * (R4 - R413)
  R421 = -(R4R11+R421)/R42 + (R4R11-R421)/R411 / (R4R12+R41R12)
  IF (R4R11+R421) 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, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 
```


234

[illegible]

[illegible]

AER02320
AER02310
AER02340
AER02350
AER02360
AER02370
AER02380
AER02390
AER02400
AER02410
AER02420
AER02430
AER02440
AER02450
AER02460
AER02470
AER02480
AER02490
AER02500

NO 360 J=J1,J2
GLCR = 1.0
IF (ABS(YA(J1).LF-0.0001) GLCR = 0.5
L1 = L2+1
L2 = L2+NSRFA(J1)
CMT = CMT + CMT*(CMT/J1) * GLCR
CNT = CNT + REFA * CMT(J1) * GLCR
CLT = CLT + REFA * CMT(J1) * GLCR
160 CONTINUE
370 CONTINUE
CMT = SYMA * CMT
CNT = SYMA * CMT
CLT = SYMA * CMT
WRITE (6,60) CMT,CNT,CLT
RETURN
END

AER01600
AER01610
AER01620
AER01630
AER01640
AER01650
AER01660
AER01670
AER01680
AER01690
AER01700
AER01710
AER01720
AER01730
AER01740
AER01750
AER01760
AER01770
AER01780
AER01790
AER01800
AER01810
AER01820
AER01830
AER01840
AER01850
AER01860
AER01870
AER01880
AER01890
AER01900
AER01910
AER01920
AER01930
AER01940
AER01950
AER01960
AER01970
AER01980
AER01990
AER02000
AER02010
AER02020
AER02030
AER02040
AER02050
AER02060
AER02070
AER02080
AER02090
AER02100
AER02110
AER02120
AER02130
AER02140
AER02150
AER02160
AER02170
AER02180
AER02190
AER02200
AER02210
AER02220
AER02230
AER02240
AER02250
AER02260
AER02270
AER02280
AER02290
AER02300
AER02310

GBAR = PAQTR * PARTI
IF (L2VFL.FQ.0. GR * INNY-NE.0) GO TO 250
DFIX = DEFZ * GRAR * FZ(K3)
IF (L2VFL.FQ.1) GO TO 260
INDY = 1
GO TO 230
250 CONTINUE
DEFX = GBAR * FV(K8)
260 CONTINUE
WRITE (6,50) LA, YB(IN), ZB(IN), XOL, DEFZ, FVX
270 CONTINUE
CZAINI = CZR(IN)/REFA
CYR(IN) = CYR(IN)/REFA
CNR(IN) = CNR(IN)/REFA
CNR(IN) = CNR(IN)/REFA
XCEN = (XIS1(L1) + XIS2(L2))/2.0
WRITE (6,40) N, YB(IN), ZB(IN), XCEH, CZB(IN), CNR(IN)
WRITE (6,50) N, YB(IN), ZB(IN), XCEH, CYR(IN), CNR(IN)
280 CONTINUE
290 CONTINUE
CZT = (0.0-0.0)
CVT = (0.0-0.0)
CMT = (0.0-0.0)
CNT = (0.0-0.0)
CLT = (0.0-0.0)
ON 310 J=1,NSTRIP
CH2 = C5(J)*2
XIS1 = 0.25*(XIS1(J) + XIS2(J))
CMT = CMT + CMT*(CMT/J1)
CNT = CNT + CNT*(CNT/J1)
CLT = CLT + CLT*(CLT/J1)
GUCJ = 1.0
IF (ND.EQ.0) GO TO 300
IF (ABS(YA(J1).LF-0.0001) .AND. ABS(CG(J1).LF-0.0001) GUCJ=0.5
300 CONTINUE
CMT = CH2*CM(J) - C5(J)*CN(J)*(XIS1-XIS2)
CZT = CZT + C5(J)*CN(J)*GUCJ
CVT = CVT + C5(J)*CN(J)*SMULT * GUCJ
CMT = CMT + CMT * SMULT * GUCJ
CNT = CNT + CNT * SMULT * GUCJ
CLT = CLT + CLT * SMULT * GUCJ
310 CONTINUE
CMT = CLT*(C5(J)+CN(J))*YS(J)*CG(J)+ZS(J)*SG(J)+2.0*EF(J)*GUCJ
CZT = CZT/REFA
CVT = CVT/REFA
CMT = CMT/REFA
CNT = CNT/REFA
CLT = CLT/REFA
IF (NTZ5 .EQ. 0) GO TO 330
L1 = 0
L2 = 0
J1 = 1
J2 = N87
ON 320 J=J1,J2
GLCR = 1.0
IF (ABS(YA(J1).LF-0.0001) GLCR = 0.5
L1 = L2+1
L2 = L2+NSRFA(J1)
CMT = CMT + CMT*(CMT/J1) * GLCR
CNT = CNT + (CMT(J1)-CZB(J1))*(XIS1(L1)-XIS2(L2))/REFA * GLCR
CLT = CLT + REFA * CMT(J1) * GLCR
320 CONTINUE
330 CONTINUE
IF (NTYS .EQ. 0) GO TO 370
L1 = 0
L2 = 0
J1 = N8-NAY+1
J2 = N8
ON 340 J=J1,J2
DFIX = DFIX*FQ.01
GO TO 350
L2 = L2+NSRFA(J1)
340 CONTINUE
350 CONTINUE

[illegible]

References

1. Giesing, J. P., Kalman, T. P., and Rodden, W. P., "Subsonic Unsteady Aerodynamics for General Configurations: Part II, Volume I - Application of the Doublet-Lattice Method and the Method of Images to Lifting-Surface/Body Interference," AFFDL-TR-71-5, Part II, Volume I, August 1971, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio.
2. Giesing, J. P., Kalman, T. P., and Rodden, W. P., "Subsonic Unsteady Aerodynamics for General Configurations: Part I, Volumes I and II - Direct Application of the Nonplanar Doublet-Lattice Method," AFFDL-TR-71-5, Part I, Volumes I and II, February 1971, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio.
3. Hess, J. L., and Riddell, T. M., "Direct Solution of a Square Matrix Whose Size Greatly Exceeds High-Speed Storage," Douglas Aircraft Company Report No. DAC-70000, July 1969.
4. Abramowitz, M., Stegun, I. A., "Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables", National Bureau of Standards Applied Mathematics Series 55, March 1965.

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R&D		
(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)		
1. ORIGINATING ACTIVITY (Corporate author) Douglas Aircraft Company Long Beach, California		2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED
		2b. GROUP N/A
3. REPORT TITLE Subsonic Unsteady Aerodynamics for General Configurations Part II, Volume II. Computer Program N5KA		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) December 1969 to August 1971		
5. AUTHOR(S) (Last name, first name, initial) J. P. Giesing, T. P. Kalman, W. P. Rodden		
6. REPORT DATE APRIL 1972	7a. TOTAL NO. OF PAGES 243	7b. NO. OF REFS 60
8a. CONTRACT OR GRANT NO. F33615-70-C-1167	9a. ORIGINATOR'S REPORT NUMBER(S) AFFDL-TR-71-5, Part II, Volume II	
b. PROJECT NO. 1370		
c. Task No. 137003	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) Douglas Report No. MDC-J0944	
d.		
10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution is unlimited.		
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY Air Force Flight Dynamics Laboratory Wright-Patterson AFB, Ohio 45433
13. ABSTRACT A technique for predicting steady and oscillatory aerodynamic loads on general configurations has been developed which is based on the Doublet-Lattice Method and the method of images. Chord- and spanwise loading on lifting surfaces and longitudinal body load distributions are determined. Configurations may be composed of an assemblage of bodies, elliptic cross sections and a distribution of width or radius) and lifting surfaces (arbitrary planform and dihedral, with or without control surfaces). Loadings predicted by this method are required for flutter, gust, frequency response and static aeroelastic analyses and may be used to determine static and dynamic stability derivatives. The methods described in this report are intended to be used by airplane designers to calculate with improved accuracy, the unsteady aerodynamic pressures that act on a lifting surface being propelled at subsonic speeds. The new feature of these calculations is that the effects on the pressure field induced by interference between the fuselage, for example, and the wing or the wing, pylon and nacelle, are taken into account. These calculations are an essential ingredient of flutter analyses and will improve the confidence level of such calculations in preventing wing-store flutter and flutter of advanced vehicles where fuselages are relatively large, provide some lifting capability and cause noticeable interference effects. The general requirement for such calculations are contained in Military Specification MIL- 8870A(USAF).		

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
subsonic lifting surface theory wing-body interference aircraft flutter dynamic loads analysis nonplanar lifting surface theory vortex lattice doublet lattice fuselage and nacelle loads generalized forces control surface aerodynamic loads oscillatory aerodynamics unsteady aerodynamic loads						

INSTRUCTIONS

1. **ORIGINATING ACTIVITY.** Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization (*corporate author*) issuing the report.

2a. **REPORT SECURITY CLASSIFICATION:** Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. **GROUP:** Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. **REPORT TITLE:** Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. **DESCRIPTIVE NOTES:** If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. **AUTHOR(S).** Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. **REPORT DATE.** Enter the date of the report as day, month, year, or month, year. If more than one date appears on the report, use date of publication.

7a. **TOTAL NUMBER OF PAGES.** The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. **NUMBER OF REFERENCES.** Enter the total number of references cited in the report.

8a. **CONTRACT OR GRANT NUMBER:** If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. **PROJECT NUMBER:** Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. **ORIGINATOR'S REPORT NUMBER(S).** Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. **OTHER REPORT NUMBER(S):** If the report has been assigned any other report numbers (*either by the originator or by the sponsor*), also enter this number(s).

10. **AVAILABILITY/LIMITATION NOTICES:** Enter any limitations on further dissemination of the report, other than those

imposed by security classification, using standard statements such as:

- (1) "Qualified requesters may obtain copies of this report from DDC."
- (2) "Foreign announcement and dissemination of this report by DDC is not authorized."
- (3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."
- (4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."
- (5) "All distribution of this report is controlled. Qualified DDC users shall request through _____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. **SUPPLEMENTARY NOTES.** Use for additional explanatory notes.

12. **SPONSORING MILITARY ACTIVITY:** Enter the name of the departmental project office or laboratory sponsoring (*paying for*) the research and development. Include address.

13. **ABSTRACT:** Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as (TS), (S), (C), or (U).

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. **KEY WORDS:** Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.

UNCLASSIFIED

Security Classification