NASA Contractor Report 3122

# Computer Programs for Calculating Pressure Distributions Including Vortex Effects on Supersonic Monoplane or Cruciform Wing-Body-Tail Combinations With Round or Elliptical Bodies

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Marnix F. E. Dillenius and Jack N. Nielsen
*Nielsen Engineering & Research, Inc.*
*Mountain View, California*

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## TABLE OF CONTENTS

# SUMMARY

Computer programs have been developed capable of calculating detailed aerodynamic loadings and pressure distributions acting on pitched and rolled supersonic missile configurations which utilize bodies of circular or elliptical cross section. The applicable range in angle of attack is up to 20°. Mach number may range from 1.3 to about 3.0.

The theoretical approach described in this report is based on representing the components by three-dimensional singularities associated with supersonic, linear flow theory. The body with circular cross section is modeled by a distribution along the centerline of supersonic line sources or sinks to account for volume effects and supersonic line doublets to account for effects of angle of attack. If the body cross section is elliptical, supersonic body source panels are placed on the body surface accounting for both volume and angle of attack effects. Constant u-velocity panels are distributed over the lifting fins or wings to account for lift. Fin thickness is modeled by planar source panels. The fins may be arbitrarily deflected. In order to account for fin-body interference, a shell with constant cross section is placed around the body over a length equal to the fin rootchord. Constant u-velocity panels are distributed on this interference shell to account for lift carryover onto the body. Behind the trailing edges, fin-body interference is accounted for by the inclusion of the effects of fin trailing vorticity, determined from slender-body theory, in the calculation of body pressures. Body nose vortex shedding is modeled by potential flow vortices whose strengths and positions in the cross flow plane are determined from an analytical-empirical approach. If the body cross section is circular, the body nose shedding vortex data is built into the main program. For bodies with elliptical cross section, this data is input to the body flow modeling program and must be determined from other means. Body nose and canard fin vortex paths along the configuration are calculated by the

vortex chasing program based on slender-body theory including effects of fin deflection.

Over the body nose section, the calculated pressure distribution can include effects of vorticity shed from the body nose. Through the canard or monoplane wing section, the pressures acting on the body and lifting surfaces can be influenced by the body vortices as they travel along the body. From the canard to the tail section, the body pressures can be affected by body and canard fin vortices. The effects of the vortices may also be included in the calculation of the loads on the tail fins.

A description is given for the procedure required to calculate, in a series of steps, pressure distributions and loadings acting on complete configurations. Two calculative examples are shown. The first case involves a cruciform canard-body with circular cross section-cruciform tail. The second case is concerned with a monoplane wing-elliptical cross section body-interdigitated tail configuration. The computer programs are described and documented in the appendices of this report.

# 1. INTRODUCTION

Methods for computing the supersonic pressure distributions on missiles having monoplane or cruciform fins or missiles with bodies of elliptical cross section are not well developed, and much work is required to produce programs that can be used for design purposes. It is the purpose of the work reported here to extend an existing three-dimensional, supersonic, lifting-surface computer program to include various options required for missiles of the above types. The work was jointly supported by Langley Research Center and the Air Force Flight Dynamics Laboratories. Langley technical directors were Wallace C. Sawyer, Raymond L. Barger, and Jerry M. Allen; Air Force technical director was Calvin L. Dyer.

Before describing the extensions to the preexisting program, a brief description of it will be given. The program was developed under ONR sponsorship and is described in references 1 and 2. In reference 1 supersonic planar or cruciform wing-body combinations with round bodies were treated, and fin loadings were determined using panel methods and linear theory. No vortices were included, and a tandem set of lifting surfaces was not covered. In reference 2 the full Bernoulli pressure equation was used in determining fin loadings. The paths of vortices behind cruciform fins were studied for a cylindrical afterbody using both slender-body theory and the full wave equation. It was decided that slender-body results were sufficiently accurate. Provision to account for specified nose vortices on the fin loading was included. Preliminary leading- and side-edge suction calculations were implemented for the purpose of modeling separation vortices from the leading- and side-edges of the fins using the Polhamus vortex lift analogy described in reference 3. Furthermore, the effects of body nose and canard vortices on the cruciform tail were determined. The applicable range of included angle of attack was increased to about 20°.

The additional scope of the present report covers extensions to the computer program of reference 2 to two missile types, cruciform wing-body combinations with an axisymmetric body and a combination with elliptic body cross sections, monoplane wing and cruciform interdigitated tails. With regard to the first configuration the following items have been added to the computer program:

(1) Add option for determining body nose vortex characteristics explicitly.

(2) Calculate body pressure coefficients for entire missile.

(3) Explicitly determine the positions of all vortices at the canard trailing edge including nose vortices and vortices from canard fin leading edges, side edges, and trailing edges.

(4) Add an option to calculate the trajectories of all vortices over the entire length of the missile.

(5) Include effects of canard and tail fins deflection on vortex paths and fin loadings.

(6) Add option to include effects of canard fin thickness.

With regard to the missile with a body of elliptical cross section, the following tasks are addressed herein:

(1) The three dimensional, supersonic, lifting-surface computer program is to be extended to monoplane wing - combinations for elliptical cross-section missile bodies with cylindrical and boat-tailed aft ends having various conventional wing planform shapes. Pressure distributions shall be calculated including thickness and vortex effects. The resulting forces and moments are to be determined.

(2) The program is to be extended to include provisions for handling a cruciform interdigitated tail that can be located at various cant angles to the body surface. The loads on the tail fins are to be calculated including tail fin-body interference effects together with wing vortex effects. No thickness need be included for the tail fins. The fin contributions to the overall forces and moments are to be determined.

In this report the general approaches are described first for determining the pressure distributions on the two configurational types under consideration. Then a more detailed description of the approach is given with the bulk of the analytical material given in a series of appendices. Next, detailed procedures are given for applying the component computer programs to complete configurations, followed by two calculative examples. Some comparisons between predictions and experiment are then given. Complete descriptions of the component computer programs are given in appendices together with input and output format.

## SYMBOLS EXCLUSIVE OF APPENDICES

| | |
|---|---|
| $a$ | local body radius |
| $c$ | chord of a fin panel through its centroid |
| $c_2$ | chord of fin panels at fin side edge |
| $C_m\big\|_{\text{body axis}}$ | component moments per unit dynamic pressure along $y_B$, $z_B$, and $x_B$ due to net effect of $C_N\big\|_{\text{panels}}$ summed over all body panels |
| $C_n\big\|_{\text{body axis}}$ | |
| $C_\ell\big\|_{\text{body axis}}$ | |
| $C_m\big\|_{\text{panel}}$ | pitching moment, yawing moment, and rolling moment for unit dynamic pressure of single body source panel in $x_B$, $y_B$, $z_B$ coordinates |
| $C_n\big\|_{\text{panel}}$ | |
| $C_\ell\big\|_{\text{panel}}$ | |
| $C_m\big\|_{\text{wind axis}}$ | component moments for unit dynamic pressure along $\bar{y}$, $\bar{z}$ axes due to net effect of $C_N\big\|_{\text{panels}}$ summed over all body panels |
| $C_n\big\|_{\text{wind axis}}$ | |
| $C_D$ | $C_x\big\|_{\text{wind axis}}$ |
| $C_L$ | $C_N\big\|_{\text{wind axis}}$ |
| $C_{x_B}$, $C_{y_B}$, $C_{z_B}$ | components in $x_B$, $y_B$, $z_B$ coordinates of $C_N\big\|_{\text{panel}}$ summed over all body panels |
| $C_{x_B}\big\|_{\text{panel}}$ | components of $C_N\big\|_{\text{panel}}$ along $x_B$, $y_B$, and $z_B$, respectively |
| $C_{y_B}\big\|_{\text{panel}}$ | |
| $C_{z_B}\big\|_{\text{panel}}$ | |
| $C_N\big\|_{\text{panel}}$ | force normal to body panel for unit dynamic pressure, $(C_p) \cdot$ (panel area) |

## SYMBOLS EXCLUSIVE OF APPENDICES (Continued)

| | |
|---|---|
| $C_x\Big\vert_{\text{wind axis}}$<br>$C_z\Big\vert_{\text{wind axis}}$<br>$C_z\Big\vert_{\text{wind axis}}$ | components in $\bar{x}$, $\bar{y}$, $\bar{z}$ coordinates of $C_N\Big\vert_{\text{panels}}$ summed over all body panels |
| $C_{N_{LE}}$ | fin normal-force coefficient due to leading-edge suction |
| $C_{N_{SE}}$ | fin normal-force coefficient due to side-edge suction |
| $C_S$ | suction coefficient, suction force divided by $qS_R$ |
| $C_P$ | pressure coefficient, $(p-p_\infty)/q$ |
| $C_{P_{min}}$ | pressure coefficient for vacuum |
| $\Delta F_X$ | force in $-x_W$ direction acting on lifting vortex element of fin panel |
| $\Delta F_{Y_1}$ | force in $y_W$ direction acting on lifting vortex element of fin panel |
| $\Delta F_{Y_2}$ | force in $y_W$ direction acting on trailing vortices along side edge of a panel for a distance "$c_2$" between successive trailing vortex element intersections with the edge |
| GAMT | nondimensional body vortex strength, equation (7) |
| $K_{LE}$, $K_{v,LE}$ | $C_{N_{LE}}/C_{S_{LE}}$ |
| $K_{SE}$, $K_{v,SE}$ | $C_{N_{SE}}/C_{S_{SE}}$ |
| $M_\infty$ | free-stream Mach number |

## SYMBOLS EXCLUSIVE OF APPENDICES (Continued)

| | |
|---|---|
| n | summation index for all constant u-velocity panels |
| NCW | number of fin panels along the chord |
| NHP | number of constant u-velocity panels on both horizontal fins |
| NPANLS | sum of panels on horizontal and vertical fins |
| NRP | number of panels on right horizontal fin |
| NWBP | total number of panels on cruciform fins and body interference shell |
| N3P | number of constant u-velocity panels on upper vertical fin and horizontal fins |
| p | load static pressure |
| $p_\infty$ | free-stream static pressure |
| $q$, $q_\infty$ | free-stream dynamic pressure |
| $r_b$ | body radius at start of cylindrical section |
| $S_R$ | missile reference area |
| SUMFT2 | see quation (24) |
| SUMFX | sum of all forces acting upstream on vortex elements of fin in vortex lattice structure nondimensionalized by $qS_R$ |
| SUMFY1 | see equation (22) |
| SUMFY2 | see equation (23) |

## SYMBOLS EXCLUSIVE OF APPENDICES (Continued)

| | |
|---|---|
| $u, v, w$ | components of the flow velocity along axes $x_B$, $y_B$, and $z_B$, respectively |
| $u^+$ | axial velocity on outward surface of constant u-velocity panel |
| $\bar{u}, \bar{v}, \bar{w}$ | components of velocity $V_R$ along wind axes corresponding to $x_B$, $y_B$, and $z_B$ for $\alpha_c = 0$ and $\phi = 0$ |
| $v_N$ | velocity normal to body interference panel due to constant u-velocity panels of fins and interference shell |
| $v_{N_t}$ | velocity normal to body interference panel due to fin thickness source panels |
| $V_R$ | total resultant velocity at point on the body surface |
| $v_W$ | velocity induced normal to vertical fin by all constant u-velocity panels of fins and interference shell |
| $v_{W_i}$ | velocity induced normal to vertical fin by body axis singularities and external vortices |
| $V_\infty$ | free-stream velocity |
| $w_N$ | velocity normal to body source panel with orientation angles $\theta$ and $\delta$ |
| $w_W$ | velocity induced normal to horizontal fin by all constant u-velocity panels of fins and interference shell |
| $w_{W_i}$ | velocity induced normal to horizontal fin by body axis singularities and external vortices |

## SYMBOLS EXCLUSIVE OF APPENDICES (Continued)

| | |
|---|---|
| $\alpha$ | angle of pitch, equation (12) |
| $\alpha_c$ | included angle of attack, angle between free-stream velocity vector and body longitudinal axis |
| $\beta$ | angle of sideslip, equation (12) |
| $\gamma$ | ratio of specific heats of air |
| $\Gamma_B$ | strength of right body nose vortex |
| $\delta$ | pitch of panel about y' axis positive in direction $x' \rightarrow z'$ |
| $\delta_{H,L}$ | deflection of left horizontal fin, positive trailing edge down |
| $\delta_{H,R}$ | deflection of right horizontal fin, positive trailing edge down |
| $\delta_{V,D}$ | deflection of lower vertical fin, positive trailing edge right |
| $\delta_{V,U}$ | deflection of upper vertical fin, positive trailing edge right |
| $\theta$ | polar angle in $y_B$, $z_B$ plane |
| $\theta_s$ | streamwise slope of bevelled leading edge of fin |
| $\theta_{2,BIP}$ | angle between trailing edge of body panel and $y_B$ or $y_W$ axis |
| $\nu$ | index of all control points on cruciform fin and body interference shell |
| $\phi$ | roll angle of missile, positive for clockwise rotation looking toward the nose |

## SYMBOLS EXCLUSIVE OF APPENDICES (Continued)

| | |
|---|---|
| $x_B$, $y_B$, $z_B$ | Cartesian coordinates fixed to missile with the origin at the body nose tip; $x_B$ is positive rearward, $y_B$ is positive to right looking forward, and $z_B$ is positive upward |
| $\bar{x}$, $\bar{y}$, $\bar{z}$ | wind axes corresponding to $x_B$, $y_B$, $z_B$ when $\alpha_c = 0$, $\phi = 0$ |
| $x'$, $y'$, $z'$ | set of axes obtained by first rotating $y_B$ and $z_B$ about $x_B$ by angle $\theta$ in positive sense followed by rotating angle $\delta$ about new $y_B$ ($=y'$) axis |
| $x_{B,V}$, $y_{B,V}$, $z_{B,V}$ | coordinates of body vortex in $x_B$, $y_B$, $z_B$ coordinates |
| $x_B$ | axial distance behind body nose |
| $x_{B,s}$ | distance from body nose to body separation location |
| $x_{B,TLE}$ | value of $x_B$ at leading edge of tail fin root chord |
| $x_{B,TTE}$ | value of $x_B$ at trailing edge of tail fin root chord |
| $x_{B,WLE}$ | value of $x_B$ at leading edge of wing root chord |
| $x_{B,WTE}$ | value of $x_B$ at trailing edge of wing root chord |
| XST | axial distance parameter, equation (6) |
| XM, YM, ZM | coordinates of moment center in $x_B$, $y_B$, $z_B$ coordinates; YM = 0 |
| $y_V$, $z_V$ | coordinates of right body vortex with $y_V$ measured positive to right of plane of $\alpha_c$ and $z_V$ measured in $\alpha_c$ plane normal to flow direction |

# 2. GENERAL APPROACH

## 2.1 Body of Revolution with Cruciform Fins

The basic methods employed to represent an axisymmetric body with cruciform fins have been described in reference 1. The computer program of that reference is based on the wave equation associated with supersonic, linear flow theory. The program models axisymmetric bodies and the fins accounting for mutual interference by the inclusion of an interference panel shell around the body where fins are attached. This program served as the starting point for the determination of the aerodynamic characteristics at higher angles of attack by the inclusion of nonlinear features in the methods initially developed in reference 2. They include the full Bernoulli relationship for the pressure coefficient and the capability to account for specified or hand calculated vorticity shed from the body nose and the fins. In the computer program of reference 2, the body nose vortex strengths and positions for the case at hand were extracted from the experimental data presented in reference 4 and added to the program input.

The present wing-body program, designated DEMON2, incorporates the data for body nose vorticity as a function of axial distance from the nose if the body is circular in cross section. These data, used if the included angle of attack exceeds 4°, are tabulated in this report. The calculation of the vorticity shed from the edges of the fins is now performed by program DEMON2, as described in Appendices B and C. Results include the distribution of vorticity along the leading and side edges, which contribute to one or more concentrated vortices at the trailing edge on each side. A program designated VPATH2, based on slender-body theory, is used to track body nose vortices past the canard section, and to track body nose vortices and canard vortices past the afterbody and tail section for the case involving an axisymmetric body. The fins can have arbitrary deflection. This program serves as a companion to program DEMON2. The crossflow plane solutions are given in Appendix I. For cases involving axisymmetric bodies, program DEMON2 then computes, in a series of steps, the pressures acting on the body surface, fins and the part of the body covered by the interference shell including the effects of body and fin vortices where applicable. A detailed description of the procedure is given subsequently in section 5.1.

## 2.2 Elliptical Body with Monoplane Wing and Interdigitated Fins

For the purpose of handling a body with elliptical cross section, a separate program designated WDYBDY has been developed. This program serves as a companion to program DEMON2 and performs the body-alone modeling when the cross section of the body is elliptical. The method makes use of supersonic body source panels distributed on the surface of the body to account simultaneously for volume and angle of-attack effects. In addition, program DEMON2 has been generalized to treat an interference panel shell with elliptical cross section to which either a monoplane wing or interdigitated tail fins can be attached. The required geometrical transformations and extended flow tangency condition are described in Appendix E. For a body with elliptical cross section, the body nose vorticity characteristics are read in to program WDYBDY and are determined from a separate method since no data base is available as yet. A combined theoretical-empirical computer program for this purpose was developed for the spin-entry studies described in reference 5. This program was specialized to determine the strengths and positions of vortices shed from noses with elliptical cross section at supersonic conditions. For the sake of illustrating the use of the programs, an application of it is included in the second calculative example described later. The vortices are tracked by program VPATHL, based on slender-body theory, past the monoplane wing section and along the body with elliptical cross section up to the tail section if the length of the body is long enough.

For configurations involving bodies with elliptical cross section, program WDYBDY computes the pressures on the body surface up to the forward lifting surfaces (monoplane wing) and between the forward surfaces and tail surfaces (interdigitated tails) including effects of body and wing vortices where applicable. In the monoplane wing and interdigitated tail regions, program DEMON2 determines the pressures on the lifting surfaces and the part of the body covered by the interference panel shell including the effects of vortices where applicable.

By using the above mentioned programs in sequence it is possible to compute the pressure distributions and fin loadings acting on complete configurations by treating first the nose section, then the forward lifting surface section, followed by the afterbody and the tail section.

# 3. DETAILED APPROACH FOR BODIES OF REVOLUTION WITH CRUCIFORM FINS

In this section, the paneling method used to model lifting surfaces and the line singularity distributions used to model axisymmetric bodies will first be summarized. The method used to account for body-fin mutual interference is described. Features added to the boundary condition, to be shown below, include an account for fin thickness and arbitrary fin deflection. The separation vorticity data associated with axisymmetric body noses is tabulated and the pressure calculation method is described.

## 3.1 Modeling of Fins by Constant u-velocity Panels

Each fin of a cruciform fin-axisymmetric body combination is divided into trapezoidal area panels. The geometrical layout is accomplished by subroutine LAYOUT of program DEMON2. These panels are called constant u-velocity panels for supersonic flow and are located in the chordal planes of the lifting surfaces. When the full Bernoulli equation is used to calculate pressure, these panels are no longer constant pressure panels as referred to by Woodward et al. in reference 6. The solution for a given panel is generated by a superposition of the basic solutions for semi-infinite triangles with their apexes at the panel corners. The basic solution and superposition schemes, as implemented in subroutines VELO and VELNOR of program DEMON2, are described in great detail in sections 3.3.2 through 3.3.6 and Appendix II of reference 7. In addition, the effects of fin thickness are accounted for by the use of constant strength source panels located in the chordal planes of the fins. Their solutions are also obtained by a superposition scheme of semi-infinite triangles as described in section 3.3.4 and Appendix II of reference 7. In program DEMON2, the basic solution and superposition schemes associated with the constant strength source panels for fin thickness are programmed in subroutines VELOTH and THKVEL, respectively.

## 3.2 Modeling of Body of Revolution Alone

The potential flow model used to represent an axisymmetric body in supersonic flow is described in detail in section 3.2 and Appendix I of reference 7. Such a body can be represented by a distribution of line sources/sinks and line doublets along the body centerline to account for volume and angle of attack effects, respectively. The strengths of these singularities are determined from the flow tangency condition applied at points on the body surface using a marching procedure from the nose tip to body base. Subroutine BDYGEN of program DEMON2 is concerned with the layout and strength determination of the line singularities. It is possible that a portion of the body nose contour lies outside the Mach cone from its apex at the nose tip. This can occur for high Mach numbers. In this case, the present version of subroutine BDYGEN has been programmed to move the origins of the line singularities up towards the body nose. The result is to minimize the inherent error in the solution near the nose if the Mach cone from the nose tip intersects the body contour. The part of the nose contour outside the Mach cone is then replaced by a cone. This constitutes a limitation to the method. An illustration of this scheme will be discussed later in connection with the pressure distribution on an ogive-cylinder using the Bernoulli pressure expression.

## 3.3 Body Interference Shell for Fin-Body Interference

An interference shell is positioned around the body over the length covered by the fins to account for fin-body interference. Constant u-velocity panels are distributed on this shell by subroutine LAYOUT in addition to those on the fins. The panels on the interference shell and fins contain one control point each, which is located at the 95 percent chord containing the panel centroid. A typical distribution of constant u-velocity panels is shown in figure 1. The body and wing coordinate system, $(x_B, y_B, z_B)$ and $(x_W, y_W, z_W)$, respectively, are also shown. The axial location on the centerline of the origin of the latter is at the axial location of the leading edge of the fin root chords. Both coordinate systems can be the reference coordinate system. Fins in the $z_W = 0$ or $z_B = 0$ plane are called horizontal fins. Fins in the $y_W = 0$ or $y_B = 0$ plane are called vertical fins. Angle of pitch, $\alpha$, and sideslip, $\beta$, are determined from the included angle of attack, $\alpha_c$, and roll angle $\phi$.*

---

*See equation (12)

### 3.4 Wing-Body Interference Solution

For the cruciform fin-axisymmetric body combination shown in figure 1, the strengths of the line singularities representing the body itself are solved for by subroutine BDYGEN in program DEMON2. Body on fin interference is accounted for as follows. The velocities normal to the fins at the control points induced by the body line singularities are computed by subroutine VELCAL in program DEMON2. On the horizontal fins these velocities are added to the free-stream component normal to the fin surface including the effect of fin deflection. On the vertical fins, the body induced normal velocity is added to the free-stream component normal to the vertical fin surface. These additions are performed in routine CRFWBD of program DEMON2. If external vortices are present, their effects are determined separately by program VPATH2 and added to the body induced velocities by an exchange of data sets between VPATH2 and DEMON2. The flow tangency condition applied to the control points on the horizontal fins is built up in routine CRFWBD of program DEMON2 as follows. Let the number of panels laid out over the cruciform fins and interference shell be NWBP and let NRP be the number of panels on the right horizontal fin only. Then, with $\nu$ as index for all the control points and n the summation index for all the constant u-velocity panels, the flow tangency condition for the right horizontal fin is given by

$$\sum_{n=1}^{NWBP} w_{W_{\nu,n}} = -\sin(\alpha + \delta_{H,R}) - w_{W_i,\nu} \quad , \quad \nu = 1,2,\ldots NRP \qquad (1)$$

where $\alpha$ is the angle of pitch and $\delta_{H,R}$ is the deflection of the right horizontal fin. The term on the left-hand side represents the summed velocity component (for unit $V_\infty$) normal to the horizontal fin induced by all constant u-velocity panels on the fins and interference shell of the finned section under consideration. The method for calculating the terms on the left-hand side of equations (1) through (5) is given on page 6 of reference 1 or section 3.3.4 of reference 7. The first term on the right-hand side is due to the free-stream velocity, and the second term $w_{W_i,\nu}$ is induced by the body singularities and external vortices if present. Setting NHP equal to the number of constant u-velocity panels on both horizontal fins, the flow tangency on the left horizontal fin is expressed as

$$\sum_{n=1}^{NWBP} w_{W_{\nu,n}} = -\sin(\alpha + \delta_{H,L}) - w_{W_i,\nu} \quad , \quad \nu = NRP+1,...NHP \qquad (2)$$

where $\delta_{H,L}$ is the deflection of the left horizontal fin. Let N3P be equal to the number of constant u-velocity panels on the upper vertical fin plus the number on the horizontal fins. The flow tangency condition applied at the control points of the upper vertical fin is written as follows:

$$\sum_{n=1}^{NWBP} v_{W_{\nu,n}} = \sin(\beta + \delta_{V,U}) - v_{W_i,\nu} \quad , \quad \nu = NHP+1,...N3P \qquad (3)$$

Angle β is angle of sideslip and $\delta_{V,U}$ is the deflection of the upper vertical fin. The term on the left-hand side represents the summed velocity normal to the upper vertical fin induced by all constant u-velocity panels on the fins and interference shell. The first term on the right-hand side is due to the free-stream velocity, and the second term $v_{W_i,\nu}$ is induced by the body singularities and external vortices if present. The flow tangency applied at the control points of the lower vertical fin is

$$\sum_{n=1}^{NWBP} v_{W_{\nu,n}} = \sin(\beta + \delta_{V,D}) - v_{W_i,\nu} \quad , \quad \nu = N3P+1,...NPANLS \qquad (4)$$

Here $\delta_{V,D}$ is the deflection of the lower vertical fin and NPANLS is the sum of the panels on the horizontal and vertical fins.

For cruciform fin-axisymmetric body combination the fins lie in mutually perpendicular planes of symmetry of the cylindrical body (at least for the fins at zero cant angle). Consequently, thickness effects of one fin cannot influence the loading on other fins but they can affect the panels on the interference shell. Therefore, if fin thickness is to be accounted for, the flow tangency condition applied at a control point on the interference shell is now stated as follows:

$$\sum_{n=1}^{NWBP} v_{N_{\nu,n}} = - v_{N_t,\nu} \quad , \quad \nu = NPANLS+1,...NWBP \qquad (5)$$

In this instance, the term on the left-hand side is the summed velocity normal to the body interference panel with index ν induced by the constant u-velocity panels on the fins and the shell itself. The term on the right-hand side is the velocity normal to the $\nu^{th}$ body interference panel induced by all the source panels laid out over the fins to model thickness effects. In this way, fin on body interference is accounted for. Note that vortex induced velocity components are not included in the boundary condition associated with the interference shell, equation (5). The two-dimensional approach used to track vortices past bodies and body-fin combinations already insures that there is no flow through the body surface and fins due to the presence of external vortices. However, to satisfy the fin boundary condition in a three-dimensional sense, the loading on the fins due to the vortices is accounted for on the basis of the panel method from the known vortex paths. Thus, the vortex paths from the leading edge of the cruciform canard on to the tail are first calculated by program VPATH2 on the basis of slender-body theory accounting for the geometry of the configuration. Then, for the axial location of each control point on the fins, subroutine VVELS of program VPATH2 also calculates the velocities at the fin control points induced by the external vortices and their images for the body alone. In this approach, the reaction of the fins to the effect of external velocities comes from two sources. First, the strengths of constant u-velocity are affected by the vortex induced effects in the boundary condition. Second, the pressures calculated subsequently by subroutine SPECPR of program DEMON2 at points on the fins contain all induced velocity components from the external vortices. Further discussion of fin pressures can be found at the end of this description. Pressures as calculated by subroutine BDYPR at the control points of the constant u-velocity panels on the body interference shell also include contributions from the external vortices and their images for the body alone as calculated by program VPATH2.

Equations (1) through (5) form a set of simultaneous equations from which the unknown constant u-velocity panel strengths can be solved. The number of unknown in the set of simultaneous equations is given by NWBP. The matrix solution is performed by subroutines LINEQS and SOLVE in program DEMON2. Constant u-velocity panel strengths are expressed in terms of the axial perturbation velocity component $\frac{1}{\pi}\frac{u^+}{V_\infty}$. It has a constant value for all points in the constant u-velocity panel.

### 3.5 Nose Vortex Characteristics

For configurations involving body noses with circular cross section, program DEMON2 is now equipped to determine body nose vortex characteristics up to the cruciform canard section from a data base built into subroutine BDYVTX. The data base is extracted from the compiled experimental data displayed in figure 5 of reference 4. The shed vorticity is represented by two concentrated symmetrical vortices whose strengths and positions in the cross flow plane are given as a function of axial distance from the nose. The separation distance, $x_{B,s}$, measured from the nose is obtained from either equation (5), reference 4, for sharp noses or equation (6), reference 4, for noses with cone semi-apex angles in excess of 30°.

The vorticity characteristics are to be determined at some axial distance from the nose, $x_B$. The axial location aft of the separation point is nondimensionalized by the body radius at the base of the nose designated RB in subroutine BDYPR. This subroutine calls subroutine BDYVTX and computes the pressure distributions on the body nose (and the portion of the body between the canard and tail fin regions). In subroutine BDYVTX, the nondimensionalized axial distance is multiplied by $\sin \alpha_c$, where $\alpha_c$ is the included angle of attack, and the result is named XPAR. This subroutine then proceeds to interpolate in a table containing a finite set of values for the axial distance parameter called XST.

$$\mathrm{XST} = \frac{x_B - x_{B,s}}{r_b} \sin \alpha_c \tag{6}$$

Vortex strengths are designated GAMT and are nondimensionalized by the free-stream velocity $V_\infty$ and the local body radius, a, which is a function of axial distance. As a function of the axial parameter XST, the table contains values for GAMT taken off the lower curve of figure 5(a) in reference 4.

$$\mathrm{GAMT} = \frac{\Gamma_B}{2\pi a(x_B) V_\infty \sin \alpha_c} \tag{7}$$

This curve contains data for both supersonic and subsonic speeds. The coordinates in the cross flow plane are also divided by the local body radius with $z_V$ aligned with the component of the free stream in the cross flow plane and $y_V$ normal to it, positive to the right. The tables in subroutine BDYVTX contain $y_V$ coordinates for both subsonic and supersonic flow conditions denoted YA1 and YA2, respectively. The latter is used here. Only one set is given for the $z_V$ coordinate designated ZA1.

$$\left.\begin{aligned} YA2 &= \left.\frac{y_V}{a(x_B)}\right|_{\text{supersonic}} \\ ZA1 &= \frac{z_V}{a(x_B)} \end{aligned}\right\} \tag{8}$$

Thus, for a given axial distance from the nose, $x_B$, ahead of the forward lifting surface region, the vortex strengths and positions are determined by interpolation from the table shown below.

| XST | GAMT | YA2 | ZA1 |
|---|---|---|---|
| 0 | 0.3 | 0.63 | 1.14 |
| 1.0 | 0.32 | 0.64 | 1.26 |
| 2.0 | 0.34 | 0.663 | 1.38 |
| 3.0 | 0.40 | 0.665 | 1.5 |
| 4.0 | 0.48 | 0.678 | 1.615 |
| 5.0 | 0.62 | 0.69 | 1.73 |
| 6.0 | 0.77 | 0.70 | 1.84 |
| 7.0 | 0.90 | 0.715 | 1.95 |
| 8.0 | 1.0 | 0.725 | 2.05 |
| 9.0 | 1.08 | 0.735 | 2.14 |
| 10.0 | 1.15 | 0.74 | 2.20 |

The coordinates $y_V/a$ and $z_V/a$ obtained from the above table by interpolation for given $x_B$ are transformed into the body fixed coordinate system by a rotation through angle of roll $\phi$. This process is performed in subroutine BDYPR and it is followed by a call to subroutine VRTVEL to calculate all velocity components induced by the separation vortices at points on the axisymmetric body at axial location $x_B$. These velocity components are then combined with the velocity components induced by the line sources/sinks and line doublets of the body of revolution itself for the purpose of determining the pressure distribution, as described below.

### 3.6 Pressure Distribution Calculations

The resultant velocity at a point on the body surface, including effects of free stream, is given by

$$\frac{V_R}{V_\infty} = 1 + \frac{2u}{V_\infty} \cos \alpha_c - \frac{2v}{V_\infty} \sin \alpha_c \sin \phi + \frac{2w}{V_\infty} \sin \alpha_c \cos \phi + \frac{u^2 + v^2 + w^2}{V_\infty^2} \tag{9}$$

where flow angle $\alpha_c$ is the included angle of attack and $\phi$ is the angle of roll. This result is obtained by applying the pitch-roll transformation shown in table 1-2 of reference 8 to the velocity components (u,v,w) aligned with the body coordinate system $(x_B,y_B,z_B)$. The resultant velocity calculated in subroutine BDYPR using equation (9) is then substituted into the Bernoulli pressure-velocity relationship repeated here for convenience.

$$C_P = \frac{p - p_\infty}{q_\infty} = \frac{2}{\gamma M_\infty^2} \left\{ \left[ 1 + \frac{\gamma-1}{2} M_\infty^2 \left( 1 - \frac{V_R^2}{V_\infty^2} \right) \right]^{\frac{\gamma}{\gamma-1}} - 1 \right\} \tag{10}$$

The pressure coefficient has the limiting value corresponding to vacuum pressure (p = 0) so that it is equal to

$$C_{P_{min}} = \frac{-2}{\gamma M_\infty^2} \tag{11}$$

The above pressure calculations at points on the surface of an axisymmetric body are performed by subroutine BDYPR of program DEMON2. For the parts of the body covered by the interference shell, the pressures are calculated by program BDYPR also in the same manner using ENTRY BDYAFT. The resultant velocity calculated by means of equation (9) then includes contributions from the constant u-velocity panels on the fins and interference shell in addition to the contributions from the body line singularities and external vortices when applicable. Pressures on the fin are also computed with the Bernoulli pressure equation (10). The velocity component contains contributions from the constant u-velocity panels distributed over the fins and interference shell, contributions from the body singularities and external vortices where applicable. Special care must be taken in the calculation of the discontinuous velocity components immediately above and below the control points of the constant u-velocity panels on the fins. In subroutine SPECPR of program DEMON2, they are related directly to the strength of the panel under consideration.

Some comparisons with measurements are given in the results comparisons, section 7, for the case of an ogive cylindrical body without body nose vorticity. These comparisons serve to test the body modeling method and the pressure expression used.

In determining the effect of the canard vortices on the pressure distribution, it is first necessary to establish the strength and position at the canard fin trailing edges. This is accomplished as described in Appendices B and C. The vortices are tracked back to the empennage using a vortex tracking program based on slender-body theory. The velocities included in this calculation are described in Appendix I.

## 4. DETAILED APPROACH FOR ELLIPTICAL BODY WITH MONOPLANE WING AND INTERDIGITATED CRUCIFORM TAIL

This section of the report gives a short description of the method using body source panels to represent a body with elliptical cross sections at combined angle of pitch and sideslip. Extensions to the flow tangency conditions are pointed out. The method used to include effects of specified body nose vorticity is described. The flow angles and the velocity components used in the pressure expression are given. Figure 2 shows a body source panel layout for a body with elliptical cross sections.

### 4.1 Modeling of Monoplane Wing, Interdigitated Tails and Elliptical Body by Body Source Panels

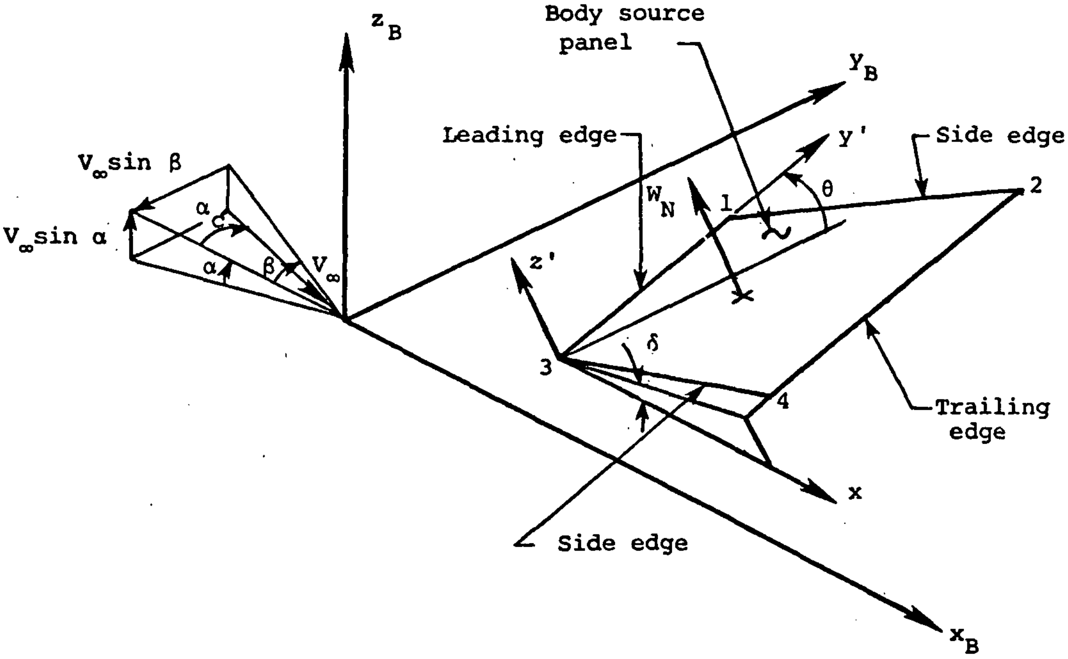
Basically, the layout of constant u-velocity panels on the monoplane wing or interdigitated tails is performed in the same way as for cruciform fins by subroutine LAYOUT of program DEMON2. For interdigitated tails, additional geometric transformations are required to express panel corner coordinates and induced velocities in the reference coordinate system which can be either the body $(x_B,y_B,z_B)$ or wing $(x_W,y_W,z_W)$ coordinate system shown in figure 1. These transformations are discussed in Appendix D. At the present time thickness effects are included only for the monoplane wing using planar source panels mentioned earlier in connection with cruciform fins. Program DEMON2 has been extended to allow for an interference shell with elliptical cross section. The additional analysis required with regard to the load calculation is given in Appendix G concerned with body interference panels on a shell with elliptical cross section. As far as the attitude of a given body interference panel is concerned, the angle between the panel trailing edge and the $y_B$ or $y_W$ axis is now calculated in accordance with the expressions for $\theta_{2,BIP}$ shown in figure 3. This angle is used in the transformation from the body interference panel coordinate system to the wing or body reference coordinate system (and vice versa) as performed by subroutine TRBIPW of program DEMON2.

The body itself with elliptical cross section is modeled by program WDYBDY using supersonic body source panels which can be inclined to the flow. A typical layout of body source panels on a body with elliptical cross section is shown in figure 2. The angle of inclination between a body source panel and the body centerline is limited to the semi-apex angle of the Mach cone associated with the free-stream Mach number. Thus, there is a limit to which body noses can be modeled by the body source panel method. The solution for such a panel is based on supersonic, linear theory as described in reference 9. As is the case for constant u-velocity panels, the influence of one body source panel (not to be mistaken for the planar source panel used to model fin thickness) is also obtained by summing the influences of the four panel corners. The basic expressions for perturbation velocity components are given on page 35 of the cited reference. Program WDYBDY consists of body modeling subroutines extracted from the computer program described in reference 10 and modified to account for combined angles of pitch and sideslip. The subroutines affected by this modification are SOLVE, PRESS, and FORMOM in program WDYBDY. The specific modifications will now be described.

Angle of pitch, $\alpha$, and angle of sideslip, $\beta$, are related to the included angle of attack, $\alpha_c$, and angle of roll, $\phi$ (positive right fin or wing down), in accordance with the pitch-roll sequence described in reference 8, Table 1-2. As a result, the pitch and sideslip angles are determined from the following expressions.

$$\left.\begin{aligned} \sin\alpha &= \sin\alpha_c \cos\phi \\ \sin\beta &= \sin\alpha_c \sin\phi \end{aligned}\right\} \qquad (12)$$

The orientation angles, $\delta$ and $\theta$, associated with an inclined body source panel and the flow angles, $\alpha$ and $\beta$, are shown in the sketch below. Also indicated are the local coordinate systems x', y', z' associated with the source panel and the reference coordinate system $x_B, y_B, z_B$. The orientation angles $\delta$ and $\theta$ are shown in their positive sense if the panel corner numbering sequence is as indicated in the sketch. Axis x' is aligned with $x_B$.



In subroutine SOLVE of program WDYBDY, the contribution from the free stream to the flow tangency condition has been modified to include components due to pitch and sideslip. The component from the free stream normal to the body source panel inclined at angle $\delta$ to the x',y' plane and inclined to the $z_B = 0$ plane at angle $\theta$ is expressed below. This quantity is designated $W_N/V_\infty$ and is programmed as NB(I) in subroutine SOLVE.

$$\frac{W_N}{V_\infty} = \sin \alpha \cos \theta \cos \delta + \sin \beta \sin \theta \cos \delta - \cos \alpha_c \sin \delta \qquad (13)$$

With the contribution from the free stream given by the above equation, the flow tangency condition is applied at the control points (centroids) of the body source panels. The result is a set of simultaneous equations from which the panel strengths are obtained. The matrix solution is an iterative one if the number of source panels is in excess of 60.

## 4.2 Pressures, Forces, and Moments on Body with Elliptical Cross Section

The pressure coefficient is computed at the body source panel control points by subroutine PRESS in program WDYBDY using the Bernoulli pressure-velocity relationship, equation (10). In subroutine PRESS the resultant velocity $V_R$ was originally determined from the velocity components in the wind-axis system for the unrolled case. Using the transformations indicated in Table 1-2 of reference 8 for the combined pitch and roll case, the components in the wind-axis system $(\bar{u},\bar{v},\bar{w})$ are related to the components $(u,v,w)$ aligned with the body axis system $(x_B,y_B,z_B)$ as follows.

$$\left.\begin{aligned}
\frac{\bar{u}}{V_\infty} &= \frac{u}{V_\infty}\cos\alpha_c - \frac{v}{V_\infty}\sin\beta + \frac{w}{V_\infty}\sin\alpha \\
\frac{\bar{v}}{V_\infty} &= \frac{v}{V_\infty}\cos\phi + \frac{w}{V_\infty}\sin\phi \\
\frac{\bar{w}}{V_\infty} &= -\frac{u}{V_\infty}\sin\alpha_c - \frac{v}{V_\infty}\cos\alpha_c\sin\phi + \frac{w}{V_\infty}\cos\alpha_c\cos\phi \\
\frac{V_R^2}{V_\infty^2} &= \left(\frac{\bar{u}}{V_\infty}\right)^2 + \left(\frac{\bar{v}}{V_\infty}\right)^2 + \left(\frac{\bar{w}}{V_\infty}\right)^2
\end{aligned}\right\}\qquad(14)$$

The last quantity is denoted Q2 in subroutine PRESS of program WDYBDY. The angles associated with the trigonometric functions are described in connection with equation (12).

In order to add the capability of including effects from specified body nose vorticity in the body pressure calculation, program WDYBDY is equipped with additional subroutines. Subroutine READVX reads in an array of axial locations measured from the body nose, ELBDVT reads arrays containing the lateral coordinates and strengths of the vortices. For the axial location of a given control point in a body source panel, these subroutines interpolate for the coordinates in the cross flow plane and strengths of the vortices. Subroutine VVELS then proceeds to compute the velocity components induced by the set of external vortices and their images inside of an elliptical cross section at the control point. This application of slender-body theory is a degenerate form of one of the crossflow plane solutions described in Appendix I in connection with vortex path calculations. The flow tangency condition at the body surface is therefore satisfied and the body source panel strengths are not affected. The vortex induced velocities are calculated in the body reference coordinate system and added to the v and w velocity components in equation (14). In connection with the application of slender-body theory to elliptical cross sections, a special procedure is followed to avoid numerical problems leading to unrealistic values for the velocity components at the body source panel control points. Essentially, the control points are moved just outside the actual body circumference as described in detail in Appendix H.

Once the pressures on the body are known, subroutine FORMOM, as applied to the body modeling program WDYBDY, computes the overall forces and moments acting on a body with elliptical cross section. This subroutine was extended to include calculating the side force and yawing moment for the pitched and rolled case. First, a normal-force "coefficient" is defined* for one body source panel as follows.

$$C_N\Big|_{\text{panel}} = - C_P \text{ Area}\Big|_{\text{panel}} \tag{15}$$

By first resolving through the panel inclination angle $\delta$ and then through the azimuthal orientation angle $\theta$, the forces on the panel expressed in the body coordinate system $(x_B, y_B, z_B)$ indicated in figures 1 and 2 are given by

$$\left.\begin{aligned} C_{x_B}\Big|_{\text{panel}} &= - C_N\Big|_{\text{panel}} \sin\delta \\ C_{y_B}\Big|_{\text{panel}} &= - C_N\Big|_{\text{panel}} \cos\delta \sin\theta \\ C_{z_B}\Big|_{\text{panel}} &= C_N\Big|_{\text{panel}} \cos\delta \cos\theta \end{aligned}\right\} \tag{16}$$

Angles $\delta$ and $\theta$ are shown in the sketch discussed above.

The contributions from one body source panel to the moments are determined as follows. The pitching and yawing moments are first calculated in terms of the body coordinate system. In this way, the pitching-moment vector is normal to the $y_B = 0$ plane and the yawing-moment vector

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*Normal force per unit dynamic pressure.

is normal to the $z_B = 0$ plane. Rolling-moment vector lies along the $x_B$ axis. For one body source panel, the contribution to the pitching-moment coefficient in the body coordinate system is stated below.

$$C_m\Big|_{panel} = - C_{z_B}\Big|_{panel}(x_{c,B} - XM) + C_{x_B}\Big|_{panel}(z_{c,B} - ZM) \qquad (17a)$$

nose up positive

The contribution to yawing moment in the body coordinate system is given by

$$C_n\Big|_{panel} = - C_{y_B}\Big|_{panel}(x_{c,B} - XM) + C_{x_B}\Big|_{panel} y_{c,B}\ , \qquad (17b)$$

nose to right positive

and the contribution to rolling moment in the body coordinate system is written as

$$C_\ell\Big|_{panel} = - C_{z_B}\Big|_{panel} y_{c,B} + C_{y_B}\Big|_{panel}(z_{c,B} - ZM), \qquad (17c)$$

right fin down positive

In the above equations, $(x_{c,B}, y_{c,B}, z_{c,B})$ are the coordinates of the centroid or control point of the body source panel. The moment center is given by (XM, 0, ZM) in the body coordinate system. In subroutine FORMOM, the quantities defined by equations (16) and (17) are designated DCXB, DCYB, DCZB and DCMB, DCNYAW, DCLROL, respectively. The contributions to the forces from all the panels are then added and divided by a reference area designated REFA. The contributions to the moments are also added and divided by reference area REFA and reference length REFD.

For the pitched and rolled case, an additional transformation is performed in subroutine FORMOM to finally determine the forces and moments in the wind-axis system. Thus, let $C_z\Big|_{wind\ axis}$ be in the plane formed by the body centerline and the free-stream velocity vector and lie in the direction normal to that vector. This quality is in fact the lift in coefficient form acting on the body and it is obtained by applying the body to wind axis transformation indicated on page 12 of reference 8.

$$C_L = C_z\Big|_{\text{wind axis}} = -C_{x_B} \sin \alpha_c - C_{y_B} \cos \alpha_c \sin \phi$$

$$+ C_{z_B} \cos \alpha_c \cos \phi \qquad (18a)$$

Let $C_Y\Big|_{\text{wind axis}}$ be the force normal to the plane formed by the body centerline and the free-stream vector, positive to the right.

$$C_Y\Big|_{\text{wind axis}} = C_{z_B} \sin \phi + C_{y_B} \cos \phi \qquad (18b)$$

The axial force in the wind axis system, $C_X\Big|_{\text{wind axis}}$, lies along the free-stream vector. It equals the drag-force coefficient $C_D$.

$$C_D = C_x\Big|_{\text{wind axis}} = C_{x_B} \cos \alpha_c - C_{y_B} \sin \alpha_c \sin \phi$$

$$+ C_{z_B} \sin \alpha_c \cos \phi \qquad (18c)$$

In the wind axis system, the pitching-moment vector is normal to the plane formed by the free-stream vector and the body centerline, positive nose up. The pitch-roll transformation is applied again to the moments in the body axis system.

$$C_m\Big|_{\text{wind axis}} = C_m\Big|_{\text{body axis}} \cos \phi - C_n\Big|_{\text{body axis}} \sin \phi \qquad (19a)$$

The yawing-moment vector in the wind axis system lies in the direction of the lift force, positive nose right.

$$C_n\Big|_{\text{wind axis}} = - C_\ell \sin \alpha_c + C_m\Big|_{\text{body axis}} \cos \alpha_c \sin \phi$$

$$+ C_n\Big|_{\text{body axis}} \cos \alpha_c \cos \phi \qquad (19b)$$

In equations (18) and (19), angles $\alpha_c$, $\phi$, $\alpha$ and $\beta$ are discussed above in connection with equation (12). They are designated ALPHAC, PHIR, ALPHA and BETA, respectively, in subroutines FORMOM, SOLVE and PRESS of program WDYBDY.

### 4.3 Wing-Body and Tail-Body Interference

Once the body with elliptical cross section is modeled by program WDYBDY for given included angle of attack, $\alpha_c$, angle of roll, $\phi$, and Mach number, the velocity components induced by the body source panels with known strengths are computed at the control points on the monoplane wing or interdigitated tail fins by an added subroutine BDYVEL of program WDYBDY. In this way, body to wing or fin interference is accounted for. This is accomplished by interchanging data sets between programs WDYBDY and DEMON2. Note that for axisymmetric bodies, program DEMON2 performs both the body modeling and fin modeling and no such data set exchange is required.

For the monoplane wing attached to the interference shell, the flow tangency condition for the right wing is given by equation (1). If the configuration is rolled in addition to pitched, the flow tangency condition must also be set up for the left wing, equation (2). The flow tangency condition applied at the control points of the constant u-velocity panels in the interference shell with elliptical cross section is given by equation (5). This boundary condition accounts for wing or fin on body interference. The strengths of the constant u-velocity panels distributed over the monoplane wing and the interference shell with elliptical cross section are then solved from the set of simultaneous equations generated by the flow tangency condition. Effects of external vorticity can be included in the wing boundary condition by exchanging data sets between programs DEMON2 and VPATHL. The latter program determines the paths of the body nose vortices as they pass through the monoplane wing section up to the tail section. It also computes velocity components induced at the control points of the constant u-velocity panels on the monoplane wing by the external (body nose) vortices in the presence of the body only. In this way the monoplane wing is influenced by the external vorticity in the boundary condition and in the calculation of pressures acting on the wing as performed by subroutine SPECPR in program DEMON2. The reason for this procedure is increased accuracy as mentioned in the previous section 3.4 concerned with cruciform fins on an axisymmetric body.

# 5. PROCEDURE FOR APPLICATION OF PROGRAMS TO COMPLETE CONFIGURATIONS

## 5.1 Circular Body with Cruciform Canard and Tail Fins

The following is a description of the step-wise use of programs DEMON2 and VPATH2 for handling a complete configuration with a body of circular cross section. The manner in which the programs are used sequentially and the exchange of data sets are indicated. The first three steps are concerned with the part of the configuration from the body nose to the trailing edge of the canard section. The remaining steps deal with the body aft of the canard and with the cruciform tail-fins. Finally, the procedure required to assemble pressure distributions acting on the entire configuration is given. The steps at which fin forces and moments are calculated are also indicated.

### 5.1.1 Sequential use of programs

Step 1(a). Run lifting-surface program DEMON2, with index NCPOUT set equal to 2 in namelist INPUT. This step generates the coordinates of the control points associated with the constant u-velocity panels distributed on the fins of the cruciform-canard and the body-interference shell. The number of control points and the sets of coordinates are stored in a data set designated TAPE4 = CPTS1. There are NWBP sets of coordinates where NWBP is the number of control points on the canard fins and the interference shell. This shell has constant circular cross-sectional area and covers the body from the leading-edge to the trailing-edge of the canard section. This step can be combined with step 1(b) discussed next by setting NCPOUT equal to 1 instead of 2.

Step 1(b). Consider the canard fins mounted on the body. The body is modeled from its nose to the trailing edge of the canard fin as a minimum. Run lifting-surface program DEMON2 with index NCPOUT set equal to zero in namelist INPUT. This step can be combined with step 1(a) by setting NCPOUT = 1. If the latter value is used, the program not only generates the data set containing the control point characteristics, CPTS1, but will also proceed to compute the pressure distributions on the body nose up to the canard section. If the included angle of attack is sufficiently high, the effects of body nose vorticity will be accounted for in the body pressures. In addition, the strengths of the constant u-velocity panels and subsequently the pressure distributions and loadings acting on the canard fins and interference shell are calculated without the effects of body nose vorticity. The output includes information concerning fin leading- and side-edge separation vorticity.

Step 2. Vortex path program VPATH2 is now employed to track the body nose vortices over the canard section. Input includes the data set designated CPTS1 containing the number and sets of coordinates of the control points on the cruciform canard fins and interference shell. This data set was generated in either step 1(a) or 1(b). In the input to program VPATH2, indices NCPIN and NVLOUT are set equal to 1 for this run. The former causes data set CPTS1 to be read in and the latter generates a data set designated VELOS1. The input to this program also includes the strengths and coordinates in the crossflow plane of the body nose vortices at the axial station corresponding to the start or leading edge of the canard section. These vortices are tracked back to the end or trailing edge of the canard section. Effects of fin edge vorticity (kept stationary) can be included in the determination of the paths of the body nose vortices. Fin leading- and side-edge vortex strengths (if comparable in magnitude to the body nose vortices) and locations are read-in by the program separately from the input associated with the vortices whose paths and effects are to be calculated.

After the vortex paths have been calculated, program VPATH2 calculates the perturbation velocities induced by the body nose vortices at the control points of the canard fins and interference shell. The velocity components are stored in data set TAPE7 = VELOS1 mentioned earlier. In this velocity calculation, the effects of the vortices are calculated in the presence of the body only, or in other words as if the canard fins are not present.

Step 3. Program DEMON2 is run again with NVLIN = 1 and NCPOUT = 0 in namelist INPUT. The value of the first index tells the program to read in velocity components induced by the body nose vortices at the control points on the canard fins and the interference shell as the vortices pass by the canard section. This information was generated in step 2 by program VPATH2 and stored in data set TAPE7 = VELOS1. The strengths of the constant u-velocity panels are then recalculated including the effects of the external body nose vortices. As a result of this calculation, the pressure distributions, forces and moments on the canard fins and pressures on the body aft of the leading edge of the canard root chord include effects induced by the body nose vortices.

At this stage, the output also contains specifications for the concentrated vortices associated with the fin trailing edges. Specifications calculated on the basis of Bernoulli-type loading pressures will be used in a later step. Furthermore, the distributions of fin leading- and side-edge vorticity calculated on the basis of linear ($u/V_\infty$ type loading pressure) theory will be considered in the calculations that follow.

Step 4. Program DEMON2 is applied to treat the tail fin section mounted on the body. The body is modeled from the nose to its base. In this step, effects of external vortices are not accounted for. Index NCPOUT = 1, NVLIN = 0 and ITAIL = 1 in namelist INPUT for this run. In addition, quantity XSTART must be set equal to the axial location of the trailing edge of the canard section.

The first index causes the program to generate a data set designated CPTS2 which contains the number and sets of coordinates associated with control points on the tail fins and interference shell. Additionally, this data set contains the sets of coordinates specifying points on the body surface between the canard and tail section at which pressures will be calculated. At this stage, the calculated pressures on the body do not include effects of external vorticity. The tail fin loadings do not include effects of body nose and canard fin vorticity so far.

Step 5. The vortex path program VPATH2 is now used to chase external vortices from the canard section, along the aft body, past the tail section, to the body base. Index NCPIN = 1 and NVLOUT = 1 for this run. The value given to the first index causes the program to read in data set CPTS2 containing control and body pressure points. Velocity components induced by the external vortices are calculated at the points whose coordinates are in data set CPTS2. The value given to the second index results in the generation of data set TAPE7 = VELOS2 which contains the induced velocity components. The strengths and positions of the vortices at the trailing edge of the canard section as required by the input to program VPATH2 for this run include the following:

1. Body nose vortices whose characteristics are available at the trailing edge of the canard section as a result of step 2 calculated by program VPATH2.
2. Concentrated vortices emanating from the trailing edges of the canard fins. Strengths and locations of these vortices are available from the results (based on Bernoulli pressures) generated by program DEMON2 at the end of step 3.
3. Fin leading- and side-edge separation vortices, if their strengths are comparable to the strengths of the vortices of 1 and 2. Their strengths and spanwise positions (based on linear pressures) at the fin trailing edge are also calculated by and appear in the output of program DEMON2. The user may input a distance off the fin plane equal to the product of the root chord and the tangent of half the angle of attack seen by the fin in question.

After the paths of the above vortices are calculated, program VPATH2 proceeds to compute their effects at points on the aft body and on the tail section as mentioned above. In this process, the velocity components induced by the external vortices are calculated in the presence of the body only, or in other words as if the tail fins are not present.

Step 6. Finally, program DEMON2 is applied again to the tail fins on the body. Index NCPOUT = 0, NVLIN = 1 and ITAIL = 1. The program reads in data set TAPE7 = VELOS2 which contains vortex effects calculated in the previous step at points on the aft body and the tail section including the fins.

The strengths of the constant u-velocity panels are recalculated including the effects of body- and canard-fin vortices. As a result of this calculation, the pressure distributions, forces and moments acting on the tail fins and the pressure distributions on the body from the canard section to the body base are affected by the body and canard fin vortices.

### 5.1.2 Assembly of pressure, force and moment data

The results obtained in the stepwise manner described above allow for the determination of the pressure distributions on the body and forces and moments acting on the fins as follows.

Nose section: $0 < x_B < x_{B,WLE}$

At the end of step 1, the output of program DEMON2 includes circumferential pressure distributions at a finite number of axial stations from the nose tip to the leading edge of the canard section. From this information, meridional pressure distributions can also be obtained. Effects of body nose vorticity are accounted for in the velocity components used to compute Bernoulli pressures.

Canard section: $x_{B,WLE} < x_B < x_{B,WTE}$

Pressure distributions on the body aft of the leading edge of the fin root chords (up to the trailing edge) and on the fins are calculated by program DEMON2 in step 3. The results include effects of body nose vorticity. Normal forces and moments acting on the fins including the influence of body nose vorticity are also calculated and output by the program (refer to quantities under Bernoulli-type loading pressures). Any augmentation to the fin normal force due to fin leading- and side-edge separation can be determined from the following hand calculation using the quantities printed under the U/VINF (linear) type loading pressure. Consider the right horizontal fin (the other fins are treated the same way).

$$\left.\begin{array}{l}
C_N\Big|_{LE} + C_N\Big|_{SE} = K_{LE}C_S\Big|_{LE} + K_{SE}C_S\Big|_{SE} \quad \text{(Polhamus' Analogy)} \\
\text{If } K_{LE} \text{ and } K_{SE} \text{ are not input, then the following} \\
\text{values are used in obtaining vortex strengths:} \\
K_{LE} \cong 0.5;\ K_{SE} \cong 0.5 \text{ (default value)} \\
C_S\Big|_{LE} = [(\text{SUMFX})^2 + (\text{SUMFY1} + \text{SUMFY2})^2]^{1/2} \\
C_S\Big|_{SE} = \text{SUMFT2}
\end{array}\right\} \qquad (20)$$

In the above SUMFX is the sum of all the forces acting upstream in the plane of the fin. For example, if NRP equals the number of constant u-velocity panels on the right horizontal fin

$$\text{SUMFX}\Big|_{\text{Right hor. fin}} = \sum_{n=1}^{\text{NRP}} \frac{\Delta F_{x,n}}{q} \qquad (21)$$

The axial in-plane force $\Delta F_x$ for one panel is shown in the second sketch of Appendix C. In-plane side force $\Delta F_{y_1}$ is also indicated and

$$\text{SUMFY1} = \sum_{n=1}^{\text{NRP}} \frac{\Delta F_{y_{1,n}}}{q} \qquad (22)$$

The in-plane side force $\Delta F_{y_2}$ acting at the outboard aft corner is also shown in the second sketch of Appendix C. For all the panels on the fin except those at the tip chord

$$\text{SUMFY2} = \sum_{n=1}^{\text{NRP-NCW}} \frac{\Delta F_{y_{2,n}}}{q} \qquad (23)$$

where NCW is the number of panels along the chord. Then by adding the contributions from the panels at the tip

$$\text{SUMFT2} = \sum_{n=\text{NRP}-\text{NCW}+1}^{\text{NRP}} \frac{\Delta F_{Y_2,n}}{q} \qquad (24)$$

Section behind canard section: $x_{B,WTE} < x_B < x_{B,TTE}$

Pressure distributions on the aft body from the canard section up to the tail section are calculated in step 6 using program DEMON2. From the leading edge of the tail section to the trailing edge (assumed to be at the same axial location as the body base), the pressure distributions on the body appear under the heading AFT OF LEADING EDGE OF FIN ROOT CHORDS . Normal forces and moments acting on the tail fins including influence of body nose and canard vorticity are also calculated and printed by the program (refer to quantities under Bernoulli-type loading pressure). Any augmentation to the fin normal force due to fin leading- and side-edge separation can be determined from the hand calculation discussed earlier in connection with the canard fins, equations (20) through (24).

## 5.2 Elliptic Cross Section Body-Monoplane Wing-Interdigitated Tail Fins

The following is a description of the stepwise use of programs DEMON2, WDYBDY and VPATHL for handling a complete configuration with a body of elliptical cross section. The manner in which the programs are used sequentially and the exchange of data sets are indicated. The first five steps are concerned with the part of the configuration from the body nose to the trailing edge of the monoplane wing. The remaining steps deal with the body aft of the monoplane wing section and with the tail fins. Finally, the procedure required to assemble pressure distributions and overall forces and moments acting on the entire configuration is indicated.

### 5.2.1 Sequential use of program

Step 1. Run lifting-surface program DEMON2 with index NCPOUT = 2 in namelist INPUT. This run generates the coordinates of the control points associated with the constant u-velocity panels distributed on the monoplane-wing and the body-interference shell. The number of control points and the sets of coordinates are stored in a data-set designated TAPE4 = WCPTS. There are NWBP coordinates where NWBP equals the number of control points on the monoplane wing and the interference shell. This shell has constant elliptical cross section and covers the body from the leading edge to the trailing edge of the monoplane wing.

Step 2. Run body source panel program WDYBDY for the elliptical body alone with index NCWPT = NWBP in the input. This causes the data set containing control point coordinates designated TAPE4 = WCPTS to be read in. The body length should extend at least up to the trailing edge of the monoplane wing if the trailing edge is supersonic. If this edge is subsonic, the body length should extend past the monoplane wing section in order to account fully for body-wing interference. This program can also read in forebody separation vorticity characteristics calculated by a separate program mentioned in section 2 entitled GENERAL APPROACH. Results of this run include pressure distributions along body meridians up to the wing section including effects of body nose vorticity if applicable. In addition, perturbation velocities induced by body source panels alone at the specified control points are calculated. These velocities are stored in another data set designated TAPE4 = WVELS and passed to program DEMON2.

Step 3. Program DEMON2 is run again for the monoplane wing/elliptical interference shell with NCPOUT = 0 and NVLIN = 0 in the namelist INPUT. The program proceeds to calculate the constant u-velocity panel strengths including the effects induced by the body source panels. Output includes the strength and lateral positions of the leading- and side-edge vorticity associated with the monoplane wing as a function of axial location. So far, effects of body nose vortices have not been included.

Step 4. Run program VPATHL with indices NVLOUT = 1 and NCPIN = 1 in the input. It is applied to the monoplane wing/elliptical cross section body. The axial starting point is at the leading edge of the monoplane wing rootchord. Vortices to be tracked to the trailing edge are the body nose vortices whose strengths and positions are known at the leading edge of the monoplane wing root chord from results obtained with a separate program. The effects of wing leading- and side-edge vorticity (kept stationary) can be included in the calculation of the paths of the body nose vortices. The values given to the indices NCP and NCPIN causes program VPATHL to read in data set TAPE4 = WCPTS containing coordinates of the control points distributed on the monoplane wing and interference shell. After the body nose vortex paths have been calculated, perturbation velocities induced by the body nose vortices at the control points are computed and stored in data set TAPE7 = VRTVEL. In this velocity calculation, the effects of the vortices are calculated in the presence of the elliptical body only.

Step 5. Use program DEMON2 again with indices NVLIN = 1 and NCPOUT = 0 in the namelist INPUT. The value of the first index tells the program to read in velocities induced by the body nose vortices at the control points on the wing and interference shell as the vortices pass by the wing section. This information is stored in data set TAPE7 = VRTVEL. The strengths of the constant u-velocity panels are then recalculated including the effects of the external body nose vortices, and the body itself. The output includes pressure distributions on the monoplane wing and the length of body spanned by the wing section accounting for all vortices. In addition, strengths and positions of the trailing-edge vorticity of the monoplane wing are calculated from the spanwise load distributions. At this stage, the configuration has been treated from the body nose up to the trailing edge of the monoplane wing section. Strengths and locations of the body nose vortices, wing leading- and side-edge vortices and wing trailing-edge vortices are now known at the end of the wing section.

Step 6. If the tail section is located aft of the wing section by some length of body, this and the following step must be taken in order to track body nose and monoplane wing vorticity along the body up to the tail fin section. Program WDYBDY is run for the elliptic body only to generate coordinates of control points associated with the source panels laid out from the wing section to the tail section. These coordinates are stored in another data set designated TAPE4 = BCPTS, which is passed to program VPATHL.

Step 7. Program VPATHL is applied again to the elliptical body alone from the wing section to the tail section. If there is no body length between the wing rootchord trailing-edge and the tail fin rootchord leading-edge, this step is omitted. Vortices to be tracked over this length along the body include the body vortices, wing leading- and side-edge vortices and the wing trailing-edge vortices. Strengths and positions of these vortices are known at the monoplane wing trailing-edge location (see steps 4 and 5). Once the vortex paths have been determined, program VPATHL calculates the velocities induced by the vortices at the control points on the body passed through by means of data set TAPE4 = BCPTS generated by step 6. These velocities are to be passed back to program WDYBDY using data set designated TAPE7 = VRTVEB (step 9).

Step 8. Program DEMON2 is applied to the interdigitated tails to generate the coordinates of the NWBP control points distributed on the fins and the interference shell. Index NCPOUT is set equal to 2 in namelist INPUT and the coordinates are stored in a data set designated TAPE4 = TCPTS. This step is essentially a repeat of step 1 applied to the tail fin in this instance.

Step 9. The body program WDYBDY is applied to the entire body length of the configuration. Index NCWPT is set equal to NWBP, the number of control points on the tail fin and interference shell. As in step 2, a data set designated TAPE4 = TCPTS containing control points is read in. Velocities induced by the body source panels at the control points are calculated by program WDYBDY. They are stored in a data set designated TAPE4 = TVELS to be passed back to program DEMON2. In addition, by setting index NVLIN = 1 in the input to program WDYBDY, data set TAPE4 = VRTVEB generated in step 7 is read in. It contains velocities induced by external body and wing vortices. Their effects are included in the calculation of pressure distributions on the body from the wing section trailing edge to the leading edge of the tail fins. If there is no body length between these two stations, no such pressure distributions are calculated.

Step 10. In this final step, program DEMON2 is applied to the interdigitated tail fins with NCPOUT set equal to zero. This index signals the program to read in the body source panel induced velocities stored on data set TAPE4 = TVELS. For any case involving interdigitated fins, set NDRAG equal to zero. Strengths and positions of forebody vorticity, wing leading-, side- and trailing-edge vorticity are known at the leading edge of the tail section as a result of step 7, or 5 if there is no body length separating the wing and tail sections. Their influences are calculated at the tail fin control points assuming that the vortex paths are not disturbed by the presence of the fin surfaces. Pressure distributions are calculated on the fins and the part of the body spanned by the tailfin section. In addition, forces and moments acting on the fins are computed.

### 5.2.2 Assembly of pressure, force and moment data

The results obtained in the stepwise manner described above allow for the determination of the pressure distributions and overall forces and moments acting on the entire configuration by adding those calculated for the separate sections as follows.

Nose section: $0 < x_B < x_{B,WLE}$

Pressure distributions along body meridians, normal- and side-force, pitching- and yawing-moment contributions are calculated by program WDYBDY up to the leading-edge of the monoplane wing root chord. This is accomplished by step 2. Forces and moments are referred to the body-axis system with $x_B$ directed back along the centerline, $y_B$ to the right along the horizontal semi-axis viewing forward and $z_B$ upwards along the vertical semi-axis for an elliptical body. In this way, the normal force $C_Z$ points along the positive $z_B$ direction and side force $C_Y$

in the positive $y_B$ direction. Pitching moment is measured in the $y_B = 0$ plane. If the pitching moment acts to bring the nose up in this plane, the sense of this moment is positive. Yawing moment is measured in the $z_B = 0$ plane. If this moment acts to move the nose into the positive $y_B$ direction, the sense of this moment is positive.

Canard section: $x_{B,WLE} < x_B < x_{B,WTE}$

Pressure distributions along body meridians are calculated by program DEMON2 over this body section in step 5. Normal- and side-force, pitching- and yawing-moment contributions from this body section* and the monoplane wing are also computed as a result of step 5.

Section behind canard section up to tail fins (if applicable): $x_{B,WTE} < x_B < x_{B,TLE}$

Over this length of body, the pressure distributions along body meridians are calculated by program WDYBDY as part of step 9. Normal- and side-force, pitching- and yawing-moment contributions are also computed. If there is no body length, $x_{B,WTE} - x_{B,TLE} \leq 0$, this part of the procedure is not applicable.

Tail section: $x_{B,TLE} < x_B < x_{B,TTE}$

Over this last body section, pressure distributions along body meridians are calculated by program DEMON2 in step 10. In addition, contributions to the normal- and side-force, pitching- and yawing-moment from this body section* and the tail fins are also calculated as part of step 10.

In general it is advantageous to let the number of source panels on the body circumference read into program WDYBDY match the number of circumferential constant u-velocity specified in namelist $INPUT of program DEMON1. In this way, the meridians on which pressures are computed are essentially the same. Reference areas and lengths must be the same in the inputs to programs WDYBDY and DEMON2. Force and moment coefficients calculated for the individual sections of the entire configuration can then be added to obtain overall forces and moments.

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*Note that force and moment coefficients associated with the interference shell as calculated by program DEMON2 are only representative of lift carryover from the lifting surfaces to the body; refer to Appendix J.

# 6. CALCULATIVE EXAMPLES

In this section, two sample cases will be described. The first concerns a configuration designated $B_1W_4T_4$ associated with UPWT Project 1126, for which unpublished data was made available by NASA/Langley. This model consists of a cruciform canard and a cruciform tail attached to a body with circular cross section. The second case involves a wind tunnel model consisting of a monoplane wing and interdigitated tail section mounted on a body with elliptical cross section described in reference 11. These models are used in the sample cases to illustrate the use of the computer program described in this report.

For both cases, first the procedures used to determine the effects of body nose vorticity on the forebody pressures are indicated. Second, canard or monoplane loadings are determined including effects of the body nose vorticity. Third, the calculated canard edge vortices and the body nose vortices are tracked back through the tail section for the first sample case. Finally, the tail fin loadings are calculated including effects of all vortices. Special care must be taken in the positioning of the interference shell around a body with elliptical cross section as will be discussed below.

References will be made to the steps listed earlier in section 5. The method used to hand calculate the augmentation to normal force due to wing edge vorticity is indicated in section 6.2.3.

## 6.1 Sample Case 1: Axisymmetric Body-Cruciform Canard-Cruciform Tail Fins

The configuration of a model including a body with circular cross section and an ogive nose is shown in figure 4. The cruciform canard and tail fins are identical and details of the bevelled sections are indicated. Programs DEMON2 and VPATH2 are used to treat this configuration rolled 45° and at included angle of attack of 14.216°. Under these conditions the angle of pitch and sideslip are both equal to 10°. The Mach number is 1.70. Note that there will be no symmetry with respect to the wing-axis system $x_W$, $y_W$, $z_W$ in terms of aerodynamic loading. Thus, all fins must be modeled. However, there will be symmetry in loading with respect to the direction of the free-stream component in the crossflow plane. In other words, the configuration is in the X-position relative to that direction. This condition serves as a check on the programs. For example, the loads on the upper vertical and left horizontal fins, indicated in figure 4, must be equal. Likewise, the vortex paths must be symmetrically positioned relative to the free-stream velocity component in the crossflow plane.

### 6.1.1 Geometry and singularity layout

The following geometrical specifications and singularity distributions will be used for the axisymmetric body and fins. The specified numbers of singularities along the body centerline and on the fins may not be sufficient for precise calculated results but serve to generate this sample case. Refer to figure 4 for geometrical details.

Namelist $BODY in subroutine BDYGEN of program DEMON2 includes specifications for the body:

number of line sources/sinks and line doublets, NXBODY = 39
nose length, LNOSE = 7.8
body length, LBODY = 39.0

The body radius for the cylindrical section, RB, is specified in the following.

Namelist $INPUT in main routine CRFWBD of program DEMON2 includes specifications for either the canard or the tail fins and the corresponding body interference shell.

rootchord, CRP = CRPV = 3.6
exposed semi-span, B2 = B2V = 2.34
leading-edge sweep, SWLEP = SWLEV = 30.0°
trailing-edge sweep, SWTEP = SWTEV = 0.0°
number of constant u-velocity panels along a chord, NCW = 3
number of planar source panels along a chord, NCWT = 8
number of constant u-velocity panels along the span, MSWR = 5 (right horizontal fin)
MSWL = 5 (left horizontal fin)
MSWU = 5 (upper vertical fin)
MSWD = 5 (lower vertical fin)

number of planar source panels along the span is specified in subroutine THKIN of program DEMON2, MSWT = 5 for all fins
length of body interference shell, BIL = 3.6
radius of body interference shell, RB = 1.3
number of body interference panels on the circumference (ring), NBDCR = 16
number of body interference panel rings, NCWB = 3
distance from body nose to leading edge of lifting surface section, XWLE = 19.8 for canard, XWLE = 35.4 for tail

The thickness slopes are read in by subroutine THETIN of program DEMON2 and are determined as follows. The layout specified above for the planar source panels is shown by the thin lines superimposed on the fin planform in figure 4. At the centroid of each panel, the streamwise slope is to be specified. If the centroid lies on a bevelled portion of the fin, the streamwise slope equals the slope of the fin surface measured parallel to the fin rootchord. For centroids on the bevelled portion near the leading edge, the streamwise slope is given by

$$\mathrm{THET} = \tan\theta_s = \frac{0.075}{0.6145} = 0.122 \tag{25}$$

On the unbevelled portion, the slope equals zero. Near the trailing edge, the streamwise slope equals

$$\mathrm{THET} = \tan\theta_s = -\frac{0.075}{0.532} = -0.141 \tag{26}$$

Near the side edge, the streamwise slopes are chosen on the basis of the location of the source panel centroid on the fin. The above input parameters will be used in all runs with program DEMON2 described in the procedure for an axisymmetric body configuration, section 5.1.

### 6.1.2 Body nose vortices, pressure distributions on forebody

In accordance with step 1b described in section 5.1.1, program DEMON2 is run using the input data shown in figure 5. These data include the geometrical specifications and numbers of singularities laid out to represent the body-canard section of the complete configuration. The input data required by program DEMON2 is described in detail in Appendix J. Note that control index NCPOUT must be set equal to 1. The output of this run is shown in figure 6. It includes a printout of the data set, designated CPTS1, containing the 108 sets of coordinates of the control points distributed over the canard fins and the interference shell. This data set will be used later. The output also includes pressure coefficients as a function of polar angle for 10 axial locations from the body nose. The polar angle is named THETA and is measured positive counterclockwise from the positive $y_B$ or $y_W$ axis. The number of axial stations on the forebody at which the pressures are calculated is equal to one half of the body line singularities up to the canard section. Subroutine BDYVTX of program DEMON2 calculates the separation point to be at $x_B$ = 17.2 inches or at about the fifth axial station. From that location on to the canard section, the shed vorticity is represented by two concentrated vortices growing in strength and moving in the crossflow plane in accordance with the data base built into subroutine BDYVTX.

The pressures acting on the forebody are calculated in subroutine BDYPR using the Bernoulli pressure expression, equation (10) in coefficient form. In terms of $p/p_\infty$, where $p_\infty$ is the free-stream static pressure, the pressures are plotted in figures 7(a) and 7(b) as a function of axial distance $x_B$ from the body nose for several polar angles. The solid line represents pressures including body vortex effects. Pressures computed without effects of body vorticity are indicated by the crosses. From the onset of the body vortex shedding modeled by two discrete vortices, the Bernoulli pressures include effects induced by the external vortices and their images inside the body. Along the symmetrically located meridians, at $\theta = 45°$ and 225° on figure 7(a), the effect of the body vortices is to increase the pressures slightly. Note that the pressure distributions along these meridians are identical due to flow symmetry. However, the meridians at $\theta = 135°$ and 315°, figure 7(b) show no effect from the body vortices. On account of flow symmetry, the vortices and their images inside the body induce zero lateral velocity components along these meridians. Thus, the pressures are not affected by the body nose vortices along these meridians.

At the leading edge of the canard section, the body nose vortices are fully developed. The paths of the vortices as they pass through the canard section will now be determined and the canard fin loadings calculated.

### 6.1.3 Pressures and loads acting on the cruciform canard-body section

The pressures, forces and moments acting on the fins and body covered by the interference shell excluding body nose vortex effects are available in the output of the run performed with program DEMON2 just described. To account for the body vortices requires knowledge of their lateral coordinates as a function of axial distance through the canard region. In accordance with step 2 of the procedure, section 5.1.1, vortex tracking program VPATH2 is now employed to accomplish that task.

In order to improve accuracy, the strengths and positions of the body nose vorticity at the leading edge of the canard section are obtained from figure 5, reference 4, instead of the body pressure output mentioned above. For the last axial station, $x_B = 18.98$, at which body pressures are calculated as a result of the previous step, the body vortex strength, $\Gamma/V_\infty$, equals 0.71. The canard leading edge is at $x_B = 19.8$ and the value for the body vortex strength equals 0.8024 in accordance with the cited figure. The lateral positions of the vortices are also determined at the canard leading-edge location. Body nose vortex strengths and lateral coordinates, in the body reference coordinate system, to be read in to program VPATH2 are given in the following table.

| $\Gamma/V_\infty$ | $y_{B,V}$ | $z_{B,V}$ | $x_{B,V}$ |
|---|---|---|---|
| 0.8024 | -0.64337 | 1.8382 | 19.8 |
| -0.8024 | -1.8382 | 0.64337 | 19.8 |

For this run with program VPATH2, indices NCPIN and NVLOUT are set equal to 1. After the vortex paths are calculated, the vortex induced velocities are determined at the control points on the canard fins and the interference shell. In this process, the vortices are in the presence of the body only. The purpose for this approach is described in section 3.4.

The input for program VPATH2 for this run is shown in figure 8. The output is shown in figure 9. It includes the lateral positions, in the body reference coordinate system, of the body nose vortices at the trailing edge of the canard section. They are given in the following table.

| $\Gamma/V_\infty$ | $y_{B,V}$ | $z_{B,V}$ | $x_{B,V}$ |
|---|---|---|---|
| 0.8024 | -0.68451 | 1.9192 | 23.4 |
| -0.8024 | -1.9192 | 0.68451 | 23.4 |

Comparison with the previous table indicates a small amount of lateral movement of the body vortices as they travel through the canard section. The vortices are located symmetrically with respect to the free-stream component in the crossflow plane. The output also shows the vortex induced velocities at the 108 control points associated with the canard fins and interference shell. Control point coordinates and vortex induced velocities are stored in a data set designated VELOS1.

In order to determine the effects of the body nose vortices on the canard section, program DEMON2 is run again in accordance with step 3 of section 5.1.1. The input for this run is the same as shown in figure 5 except for index NVLIN now set equal to 1 and index NCPOUT set equal to its default value 0. The forebody pressures appear unchanged in the output shown in figure 10. Vortex induced velocity components designated VVEL and WVEL are printed out under the heading POINT COORDINATES AND PERTURBATION VELOCITIES CALCULATED BY PROGRAM VPATH2 or VPATHL. These velocity components are included in the boundary conditions, equations (1) through (4), and the strengths of the constant u-velocity panels are recalculated. The pressures calculated at the control points on the fins and interference shell are changed because of the recalculated panel strengths and the inclusion of vortex induced velocities in the Bernoulli pressure determination.

Figures 11(a) and 11(b) show the pressure distributions on the forebody and over the length of the canard section. The latter are taken from program DEMON2 output under the heading AFT OF LEADING EDGE OF FIN ROOTCHORDS. As before, the solid line represents pressures calculated including the body nose vorticity; the crosses are pressures without body vorticity. For the symmetrically located meridians at $\theta = 56.25°$ and $\theta = 213.75°$, the effects of body nose vorticity are negligible over the canard section. Along the symmetrically located meridians at $\theta = 101.25°$ and $\theta = 168.75°$, the effects of the body vorticity are to increase the pressures. The output shown in figure 10 includes loadings for all fins based on linear pressure and Bernoulli pressure. In both cases, due to flow symmetry the loadings on the right horizontal and lower vertical fins are identical as are the loadings on the upper vertical and left horizontal fins. On the right horizontal fins, figure 12 shows slight effect of the body nose vorticity on the span loading. Due to the closer proximity of the upper vertical fin to the vorticity, the span loading is reduced significantly in the inboard region. In figure 13 the dashed curve (with vortices) exhibits a maximum and drops off in magnitude towards the fin root. In accordance with the analysis in Appendix B, this type of span load distribution gives rise to an inboard and outboard concentrated vortex at the trailing edge of this canard fin. The right horizontal fin does not show any extrema off the root and only one concentrated vortex results at the trailing edge. The leading edges of the fins are supersonic for the Mach number at hand so there is no leading-edge separation vortex in accordance with the analysis in Appendix C. The side edges of the fins give rise to a separation vortex with negligible strength as shown below. Thus, at the trailing edge of the canard section, the strengths and locations of body and canard vortices are assembled for the purpose of determining their paths to the base of the body. Their characteristics are taken from the output of program DEMON2 as a result of step 3, section 5.1.1. The body nose vortex specifications are taken from the output of program VPATH2 as a result of step 2.

| $\Gamma/V_\infty$ | $y_{B,V}$ | $z_{B,V}$ | $x_{B,V}$ | | |
|---|---|---|---|---|---|
| 0.8024 | -0.68451 | 1.9192 | 23.4 | body nose vortices | |
| -0.8024 | -1.9192 | 0.68451 | ↓ | | |
| 0.94911 | 3.15424 | 0.0 | 23.4 | right hor. fin T.E. vortex | |
| 0.05844 | -2.09688 | 0.0 | | inboard | left hor. fin T.E. vortices |
| -0.59187 | -3.46609 | 0.0 | | outboard | |
| -0.05844 | 0.0 | 2.09688 | | inboard | upper vert. fin T.E. vortices |
| 0.59187 | 0.0 | 3.46609 | | outboard | |
| -0.94911 | 0.0 | -3.15424 | ↓ | lower vert. fin T.E. vortex | |
| 0.01491 | 3.64 | $\sim$0.0 | 23.4 | right hor. fin S.E. vortex | |
| -0.01797 | -3.64 | $\sim$0.0 | | left hor. fin S.E. vortex | |
| 0.01797 | $\sim$0.0 | 3.64 | | upper vert. fin S.E. vortex | |
| -0.01491 | $\sim$0.0 | -3.64 | ↓ | lower vert. fin S.E. vortex | |

In this table, the trailing-edge vortex characteristics, GAMMA/VINF and Y.C.G. or Z.C.G., are obtained from the loading output under the heading BERNOULLI TYPE LOADING PRESSURE. The side-edge vortex characteristics, GAMMA,SE/VINF and YBAR or ZBAR, are obtained from the loading output under the heading U/VINF LOADING PRESSURE. The strengths of the side edge vortices are negligible compared to the strengths of the body nose and trailing edge vortices and will not be included in further analysis.

At the top of figure 14, all the vortices excepting the side-edge vortices listed in the above table are shown in position at the canard trailing edge, $x_B = 23.4$. They will eventually be tracked down the body through the tail section. However, before determining the vortex paths over the aft body, the body tail section must be dealt with in accordance with step 4 of section 5.1.1. Program DEMON2 is used again to model the body and the cruciform tail fins without accounting for the presence of body nose and canard fin vortices. The input for this run is the same as shown in figure 5 except that the distance from the nose to the tail section, XWLE, is now set equal to 35.4. Also, indices NCPOUT = 1, NVLIN = 0 and ITAIL = 1 in namelist $INPUT. Quantity XSTART is set equal to the trailing-edge location of the canard section, XSTART = 23.4. With these specifications, the program generates a data set, designated CPTS2, containing 268 sets of coordinates. Of this set, the first 108 sets pertain to the control points on the tail fins and interference shell. The remaining 160 are associated with points on the body aft of the canard section up to the tail section at which pressures will be calculated. The output for this run is not shown. The calculated pressures on the body meridians and the tail fin loadings do not include effects of body nose and canard vortices so far.

### 6.1.4 Vortex positions at body base, pressure distributions on aft body, tail fin loadings

Using program VPATH2, the vortices shown in the upper part of figure 14 are chased from the trailing edge of the canard section, past the aft body, through the tail section to the body base. In accordance with step 5 in section 5.1.1, the input to program VPATH2 for this run includes index NCPIN = 1 and index NVLOUT = 1. The input for this run is shown in figure 15. Under the influence of the free stream, the mutual interaction between the vortices and the effects of the presence of the body and tail section, the vortices move as a function of axial distance.

After the vortex paths have been determined, the vortex induced velocity components will be calculated at the 268 sets of coordinates associated with points on the aft body, tail fins and interference shell. Again, in this process the vortices are in the presence of the body only. The output of program VPATH2 is shown in figure 16. The bottom half of figure 14 shows the vortices at the base of the body as taken from the output at the $x_B$ = 39.0 station (x-station no. 26). Comparison with the upper half shows that the body nose vortices did not move nearly as much as the vortices associated with the fins. The output also includes the velocity components induced by the vortices at the set of 268 points read in to the program. The control point coordinates and the induced velocity components are stored in a data set called VELOS2.

As described in the last step 6 of section 5.1.1, program DEMON2 is applied one more time to the tail fins and body. However, in this instance the input to program DEMON2 includes index NVLIN = 1 and ITAIL = 1. The input is shown in figure 17. Vortex induced velocity components are now included in the flow tangency condition applied at the control points distributed over the fins, equations (1) through (14). They are also included in the Bernoulli pressures calculated by subroutine BDYPR over the aft body and the part of the body covered by the interference shell associated with the tail fins. The output of this run is shown in figure 18. The pressure distributions and forces and moments acting on the tail fins now include effects induced by the body and canard fin vortices.

The pressures calculated along meridians at θ = 11.25°, 56.25° and 101.25° are shown in figure 19. The solid lines are the pressure distributions calculated including vortex effects and the crosses are calculated with vortices absent. The 11.25° and 101.25° meridians are on the suction sides of the right horizontal and upper vertical fins, respectively. Therefore, through the tail section, the pressures on these meridians are lower than the pressures on the 56.25° meridian. In general, over the aft body and through the tail section, the calculated effect of the body nose and canard vortices is to increase the pressures along the meridians shown.

The effect of the presence of vortices on the span loadings acting on the right horizontal and upper vertical fins are shown in figures 20 and 21. The tail fins are identical in geometry to the canard fins. Without vortices, the solid lines indicate that the span loading on the right horizontal and upper vertical fins are practically identical to those on the corresponding canard fins; see figures 12 and 13. However, in the tail region the body nose and canard vortices have larger influence in reducing the loadings on the two fins as shown in the figures by the dashed lines. On account of symmetry about the component of free stream in the crossflow plane, the loadings on the left horizontal fin are reduced to the same extent shown for the upper vertical fin in figure 21. Likewise, the loading on the lower vertical fin is reduced to the same extent indicated in figure 20.

## 6.2 Sample Case 2: Elliptic Cross Section Body-Monoplane Wing-Interdigitated Tails

The configuration of a model including a body with elliptical cross section is shown in figure 22. The body has an ellipticity ratio of 3. A monoplane wing and interdigitated tail fins with bevelled streamwise sections are attached to the body. Programs WDYBDY, DEMON2 and VPATHL are used to analyze this configuration at angle of attack of 10° and zero roll angle. The Mach number is 1.70. Under these conditions, there will be a symmetry plane at $y_B = 0$ in terms of the aerodynamic loading. Thus, only the right monoplane wing and the right upper and right lower interdigitated tail fins need to be modeled by program DEMON2. For the same reason, only the right half of the body needs to be modeled by source panels by means of program WDYBDY. Any vortices analyzed by program VPATHL will also be symmetrically positioned with respect to the $y_B = 0$ plane.

### 6.2.1 Geometry and singularity layout

The following geometrical specifications and singularity distributions will be used for the elliptical cross section body with monoplane wing and interdigitated tail fins. The specified numbers of body source panels to model the body and the numbers of chordwise and spanwise constant u-velocity panels to model the wing and tail fins give rise to a sparse layout. As such they may not be sufficient for precise calculated results but serve to generate this sample case. Refer to figures 22 in connection with input to program WDYBDY and figure 23 in connection with input to program DEMON2 for geometrical details.

The input to program WDYBDY includes the following specifications for the body with elliptic cross section. There will be two sets, depending on which lifting-surface section the effects of the body are to be determined.

Set #1 - Monoplane Wing Section

Body length to be modeled = 25.6 (covers the monoplane wing section)
Number of body source panels on the half circumference or half ring + 1 = KRAD, KRAD = 9 (8 panels/half ring)
Number of body source panels in the axial direction or number of rings + 1 = KFORX, KFORX = 11 (10 panels axially)
Body length over which pressures and loads are to be computed by program WDYBDY, XWLE = 18 (Program DEMON2 covers the winged section).

Set #2 - Interdigitated Tail Section

Body length to be modeled = 28.0 (covers the interdigitated tail section)
Number of body source panels on the half circumference or half ring + 1 = KRAD, KRAD = 9 (8 panels/half ring)
Number of body source panels in the axial direction or number of rings + 1 = KFORX, KFORX = 12 (11 panels axially)
The step for which this data is the partial input, no pressures and loads are computed

The first set will be used for the run with program WDYBDY in accordance with step 2, section 5.2.1, and the second set will be used for the run in accordance with step 9, section 5.2.1. The body source paneling layout associated with both sets is shown in figures 24(a), 24(b) and 24(c) in planview, sideview and cross section, respectively. Note that only the right half of the body will be modeled.

Namelist $INPUT in main routine CRFWBD of program DEMON2 includes specifications for the lifting surfaces and their associated interference shells. If the body is modeled by means of body source panels, as is the case here, it is important that the entire interference shell be exterior to the body source panels. If the shell were made to lie partially on the inside of the body outline, some of the control points distributed on the interference shell may lie on the interior side of one or more body source panels. In this case, the velocity components induced by the source panels at those points would be invalid.* As a consequence, the interference shells are laid out and the monoplane wing is idealized as shown in figure 23. For the monoplane wing attached to its interference shell with elliptic cross section, the input includes the following (refer to figure 23):

rootchord, CRP = 7.55
exposed semispan, B2 = 1.0935
leading edge sweep, SWLEP = 75.0°
trailing edge sweep, SWTEP = 30.016°
number of constant u-velocity panels along a chord, NCW = 2
number of planar source panels along a chord, NCWT = 4
number of constant u-velocity panels along the span, MSWR = 3
number of planar source panels along the span is specified in subroutine THKIN of program DEMON2, MSWT = 3
length of body interference shell, BIL = 7.55
horizontal semi-axis of elliptical interference shell, RB = 3.4641
vertical semi-axis of elliptical interference shell, RA = 1.155
Note: the ellipticity ratio, RB/RA = 3.0
number of body interference panels on the circumference (ring), NBDCR = 16
number of body interference rings, NCWB = 2
distance from body nose to monoplane wing section, XWLE = 18.0

The thickness slopes are read in by subroutine THETIN of program DEMON2. They are determined in the manner described for the first sample case, section 6.1.1. Using the detailed streamwise sections available from reference 11, the following streamwise slopes are used. For centroids of planar source panels near the leading edge, the streamwise slope is given by

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*The solution associated with body source panels, reference 9, is valid only in the plane of the panel and along the outward normal.

$$\text{THET} = \tan \theta_s = \frac{0.125}{2.516} = 0.049692 \quad (27)$$

On the unbevelled portion, the slope equals zero. Near the trailing edge, the streamwise slope equals

$$\text{THET} = \tan \theta_s = - \frac{0.125}{1.5845} = -0.07889 \quad (28)$$

For the upper right and lower right interdigitated tail fins attached to its interference shell, the input includes the following (refer to figure 23). Thickness is not accounted for.

rootchord, CRP = CRPV = 3.6
exposed semispan, B2 = B2V = 3.6

upper right fin
leading-edge sweep (varies with distance along the span),
VSWLER = 45.0° up to YRT = 2.0
VSWLER = 14.04° up to YRT = 3.6
Note: since leading-edge sweep varies, the trailing edge must also be specified as if it varies with distance along the span
trailing-edge sweep, VSWTER = 0.0 for all YRT

lower right fin
leading-edge sweep (varies with distance along the span),
VSWLEU = 45.0° up to ZUT = 2.0
VSWLEU = 14.04° up to ZUT = 3.6
see note above
trailing-edge sweep, VSWTEU = 0.0 for all ZUT

number of constant u-velocity panels along a chord, NCW = 2
number of constant u-velocity panels along the span, MSWR = 4 (upper right fin)
MSWU = 4 (lower right fin)
length of body interference shell, BIL = 3.6
horizontal semi-axis of elliptical interference shell, RB = 3.129
vertical semi-axis of elliptical interference shell, RA = 1.043
Note: the ellipticity ratio, RB/RA = 3.0
number of body interference panels on the circumference (ring), NBDCR = 16
number of body interference panel rings, NCWB = 2

distance from body nose to tail section, XWLE = 24.4
angle of the location of the fins on the interference shell measured from positive $y_w$-axis, THETIT = 22.545°
dihedral angle of the fins, PHIDIH = 30°

Angles THETIT and PHIDIH are also indicated in figure 3. The above sets of input parameters will be used in the runs with programs WDYBDY and DEMON2 described in the procedure for a body with elliptical cross section, section 5.2.

### 6.2.2 Body nose vorticity, pressure distributions on forebody

After running program DEMON2 in accordance with step 1, section 5.2.1, to generate data set WCPTS, program WDYBDY is then run to model the body with elliptical cross section. The input to program WDYBDY includes the parameters in the first set described above and index NCWPT which must be set equal to the sum of all constant u-velocity panels on the monoplane wing and the interference shell. The length of body, to be modeled for this run, is taken to the trailing edge of the interference shell associated with the monoplane wing. The input for this run is shown in figure 25. For this case, the geometry of the body with elliptical cross section is given in terms of the horizontal semi-axis, FUSBY, and the vertical semi-axis, FUSAZ, as a function of axial location XFUS. Also included are the body nose vorticity characteristics, if indices NVTX and NXVTX are nonzero, provided by a separate program; see section 2.2. The axial stations at which this data is to be specified are read in from subroutine READVX and the lateral locations and strengths of the vortices are read in by subroutine ELBDVT. The output of this run is given in figure 26. Included in the output are the pressure coefficients designated CP and printed on the page identified with **FORMOM**. They are plotted in figures 27(a) and 27(b) from the body nose up to the leading edge of the monoplane wing section.

Figure 27(a) shows pressure distributions on the upper half of the body. The open symbols include effects of body nose vorticity. Pressure distributions without vortex effects are also shown by the solid symbols. In the legend, the first column of symbols are for meridians on which pressures are calculated over the forebody, the second column are for the monoplane wing section and the third for the tail section. For the moment, the forebody only is considered. The pressures shown in figure 27(a) are below free-stream static pressure. The effects of the specified body nose vortices are to increase the pressures along the $\theta = 9.07°$ meridian and to decrease the pressures along the $\theta = 31.41°$ meridian. On the lower half of the body, figure 27(b) shows that the effects of the body vortices are much less. Only one result is shown without vortex effects and there is little difference between the dark and light triangles. The output also includes the contributions from the forebody to the overall forces and moments under the heading TOTAL COEFFICIENTS ON THE BODY FROM XSTART = 0.0 to XWLE = 18.0. In order to improve the accuracy of these contributions, especially with vortex effects, the number of source panels should be larger than used here in this sample case.

Program WDYBDY also computes velocity components, induced by the body source panels only, at the control points distributed over the monoplane wing and interference shell read in by means of data set WCPTS. These velocity components are stored in a data set designated WVELS for later use by program DEMON2.

### 6.2.3 Pressures and loads acting on the monoplane wing-body section

After completing the calculations of pressures and loads acting on the forebody, program DEMON2 is applied to the monoplane wing-body section in accordance with step 3 of section 5.2.1. As a result of this run, the loadings acting on the monoplane wing section are calculated excluding effects of body nose vorticity. The output also includes the strength, $\Gamma/V_\infty\big|_{edge}$, and lateral position, $\bar{y}_W$, of the leading- and side-edge vorticity as a function of axial coordinate $x_W$. Values for these characteristics are taken from the loading output under the heading U/VINF TYPE LOADING PRESSURE. Leading-edge vorticity is designated GAMMA,LE/VINF, side-edge vorticity is GAMMA,SE/VINF, and the lateral location appears as YBAR. Along the leading-edge, the axial coordinate is XLE, along the side-edge it is XSE, both are in the wing coordinate system. The values shown in the following table are taken from the output of program DEMON2 for the right monoplane wing half. They are calculated with $K_{v,LE} = K_{v,SE} = 0.5$ (refer to Appendix C, equation C11, etc.). Note that $x_W$ is the axial coordinate in the wing coordinate system.

| $x_W$ | $\bar{y}_W$ | $\left.\frac{\Gamma}{V_\infty}\right\|_{edge}$ | |
|---|---|---|---|
| 0.66148 | 3.64135 | 0.27984 | along leading edge |
| 2.01812 | 3.82511 | 0.27786 | |
| 3.37295 | 4.03457 | 0.28634 | |
| 4.081 | 4.34073 | 0.44937 | along side edge |
| 6.13099 | 4.40075 | 0.58150 | |

Following step 4 of section 5.2.1, the vortex chasing program VPATHL is then employed to determine the paths of the two body nose vortices from the leading edge to the trailing edge of the monoplane wing section. The input for this run is shown in figure 28. Characteristics of the two symmetric body nose vortices at the start of the wing section are specified on the 9th line. Note that these two sets of characteristics are also shown in the input to program WDYBDY indicated in figure 25 at the last axial station associated with the forebody, XV = 18.0, on the cards marked YVRTX1, ZVRTX1, GAM1, and YVRTX2, ZVRTX2, GAM2, respectively. Also, the characteristics of the symmetric vortices on the opposite side of the plane of symmetry, $y_B = 0$ plane, must also be input to VPATHL. The starting values of the symmetric body nose vortex strengths and lateral positions are given in the following table with $x_B$, $y_B$ and $z_B$ in the body coordinate system.

| $x_B$ | $y_B$ | $z_B$ | $\left.\frac{\Gamma}{V_\infty}\right\|_{\text{Body nose}}$ |
|---|---|---|---|
| 18 | 2.35 | 1.673 | 1.52 |
| 18 | -2.35 | 1.673 | -1.52 |

The body nose vortex characteristics as a function of distance from the nose were determined by an adapted version of the program associated with reference 5 as mentioned earlier in section 2.2. Although the magnitude of the body nose vortex strength is at least 2.5 times the magnitude of the edge vorticity strength, for illustrative purposes the edge vorticity will be included in the determination of the body nose vortex paths. Thus, the input to program VPATHL shown in figure 28 also includes the edge vorticity specifications listed in the first table above. At this stage, the edge vorticity characteristics are only approximate in that the body nose vortex effects have not been included in the wing loading nor the edge vorticity distribution as calculated in step 3.

After the body nose vortex paths are known and the wing loading recalculated in step 5, described later, the updated edge vorticity distribution should be compared with the one given in the first table. If differences are sufficiently large, the calculations performed by steps 4 and 5 should be repeated until the edge vorticity distribution is converged.

Figure 29 shows the output of program VPATHL. The geometry of the monoplane plane wing in planform appears under the heading FIN GEOMETRY. The specified strengths and lateral coordinates of the leading- and side-edge vorticity as a function of axial distance measured from the body nose also appears on the first page of the output. The horizontal and vertical semi-axes of the body are held constant over the monoplane wing section. In fact, the body nose vortices pass over the idealized monoplane wing attached to the interference shell as indicated in figure 23. At the location corresponding to the trailing edge of the monoplane wing section, $x_B = 25.5$, the coordinates in the crossflow plane of the body nose vortices are given below.

| $x_B$ | $y_B$ | $z_B$ | $\frac{\Gamma}{V_\infty}$ Body nose |
|---|---|---|---|
| 25.5 | 2.4609 | 1.8792 | 1.52 |
| 25.5 | -2.4609 | 1.8792 | -1.52 |

Comparison with the preceeding table shows that the body nose vortices move upward and outboard by a small amount. If the monoplane edge vorticity is neglected in the calculation of the body nose vortex paths, the results shown in the table below would be generated by program VPATHL. It is seen that for this illustrative example, the body nose vortices move higher but do not move as much outboard when the effects of edge vorticity are not included. In an actual calculation, the characteristics of the leading- and side-edge vorticity must be determined with a larger number of panels than is used in step 3. The last part of the output generated by program VPATHL contains the velocity components induced by

| $x_B$ | $y_B$ | $z_B$ | $\frac{\Gamma}{V_\infty}$ Body nose |
|---|---|---|---|
| 25.5 | 2.4276 | 1.9509 | 1.52 |
| 25.5 | -2.4276 | 1.9509 | -1.52 |

the body nose vortices at the control points of the monoplane wing. These data are stored in data set VRTVEL.

In accordance with step 5 of section 5.2.1, program DEMON2 is run again to obtain the pressures acting on the monoplane wing-body section including effects of body nose vortices. In this run index NVLIN is set equal to 1 thereby causing data set VRTVEL to be read in. The input of program DEMON2 is shown in figure 30 for this run. Output generated by program DEMON2 is shown in figure 31. The last part contains the pressures acting along meridians on the interference shell under the heading AFT OF LEADING EDGE OF FIN ROOTCHORDS. Figures 27(a) and 27(b) include calculated pressures along 4 meridians on the interference shell. They are indicated by the second column of symbols and correspond to axial locations $x_B = 21.58$ and $x_B = 25.36$. These meridians are essentially the same* as the meridians for which pressures are plotted on the forebody. Over the upper half of the body, figure 27(a), the pressures through the monoplane wing section continue below free stream. Open symbols include effects of body nose vortex effects and the solid symbols are calculated excluding the body nose vortex effects. Along the $\theta_p = 11.25°$ meridian the effects of the vorticity is to increase the pressure appreciably and along the $\theta_p = 33.75°$ meridian the pressure is decreased. On the lower half of the body, the results shown on figure 27(b) show little effects from the body nose vorticity including the axial locations at $x_B = 21.58$ and 25.36.

The span-load distribution associated with the monoplane wing is shown in figure 32. The calculated results include body nose vortex effects. The solid line represents the potential span-load distribution which does not exhibit a maximum off the wing rootchord in contradistinction with the results computed for the cruciform canard of Sample Case 1 shown in figure 13 and discussed in section 6.1. For the indicated Mach number, the leading edge of the monoplane wing lies aft of the Mach cone with its vertex at the leading edge of the rootchord. Therefore, the leading edge is subsonic and the program calculates the suction distribution along that edge. Using the Polhamus vortex-lift analogy with the proportion of the leading edge suction converted to normal force equal

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*Slight differences in polar angle are due to differences between geometry of body source panel layout and body interference panel layouts.

to 0.5 (refer to Appendix C), the dashed line represents the augmented span loading up to the side edge. The increments added to the potential span loading are obtained from the spanwise distribution CS*C/(2*B) for the right wing. They are calculated on the basis of linear pressure loading under the heading U/VINF TYPE LOADING PRESSURE, and must be multiplied by 0.5. The side edge also contributes to the calculated additional normal-force distribution which would be concentrated near the tip but is not shown in figure 32.

The augmentation to the normal-force coefficient for one wing half can be determined by multiplying the suction coefficient $C_S\big|_{LE}$ for the leading edge by the appropriate factor $K_{v,LE}$ and adding it to the suction coefficient for the side edge $C_S\big|_{SE}$ multiplied by the appropriate factor $K_{v,SE}$. The suction coefficient for the leading edge is proportional to the accumulated quantity CSINT(I) with index I equal to the number of panels in the spanwise direction. This number is equal to the quantity MSWR, specified in the input for program DEMON2, for the right wing half. In other words, the last value under the heading CSINT is taken from the spanwise distributions calculated on the basis of linear pressure loading of the lifting surface under consideration. This value must be multiplied by 2b where b is twice the exposed semispan, b/2, specified in the input of program DEMON2 and divided by the reference area $S_{REF}$. The suction for the side edge can be obtained from a numerical integration of the quantity SUCTION FORCE PER UNIT LENGTH/(Q*TIPCHORD) which appears under the heading SIDE EDGE DISTRIBUTION in the loading output calculated with linear pressure loading. Setting this quantity equal to $c_{S,JSE}$, the suction coefficient associated with the side edge is given by

$$C_S\Big|_{\text{side edge}} = \frac{(c_{TIP})^2}{S_{REF}} \sum_{JSE=1}^{NCW} c_{S,JSE} \cdot \frac{c_{TIP,JSE}}{c_{TIP}} \tag{27}$$

In the above expression, $c_{TIP}$ is the chord of the side edge or wing tip, $S_{REF}$ is the reference area and NCW is the number of constant u-velocity panels in the chordwise direction. Thus for one wing half, the augmentation to the normal-force coefficient due to leading- and side-edge vorticity can be computed as follows.

$$C_N\Big|_{\substack{LE+SE\\ \text{vorticity}}} = K_{v,LE}C_S\Big|_{LE} + K_{v,SE}C_S\Big|_{SE} \tag{28}$$

The vortex lift factors $K_{v,LE}$ and $K_{v,SE}$ are discussed in Appendix C.

The above process for the calculation of the augmentation to normal force due to leading- and side-edge vorticity must be repeated for each wing half. Since the flow conditions (including the presence of body nose vorticity) and configuration geometry are symmetric with respect to the $y_B = 0$ plane, the resulting loading on the body and lifting surfaces are also symmetric. Thus, the augmentation given by equation (28) must be doubled.

Finally, the updated characteristics of the monoplane wing leading- and side-edge vorticity also appear in the loading output under the heading U/VINF TYPE LOADING PRESSURE. They are listed below and at this stage (step 5) include effects of body nose vorticity. Comparison with the results excluding body nose vorticity shown in the first table of this section indicates an appreciable drop in strength and a slight outboard movement. On the basis of the difference in vorticity strength, an iteration would be recommended for an actual calculation. Note that a drop in edge vorticity strength would result in less influence in the body nose vortex path calculation. This should speed up the convergence mentioned earlier in this section.

| $x_W$ | $\bar{y}_W$ | $\left.\frac{\Gamma}{V_\infty}\right\|_{edge}$ | |
|---|---|---|---|
| 0.66148 | 3.64135 | 0.19406 | along leading edge |
| 2.01812 | 3.83365 | 0.19763 | |
| 3.37295 | 4.05562 | 0.21123 | |
| 4.081 | 4.36126 | 0.35606 | along side edge |
| 6.13099 | 4.41828 | 0.47179 | |

### 6.2.4 Pressures and loads acting on the interdigitated tail-body section

According to figure 23, the monoplane wing-body section actually overlaps the interdigitated tail-body section. Thus, there is no afterbody separating the former from the latter. Consequently, steps 6 and 7 described in section 5.2.1 are omitted.

In dealing with the overlap situation, the following approximate procedure is adopted. The strengths and positions of the body nose vortices and the monoplane wing vortices are calculated by the preceding steps 4 and 5. The axial locations at which these characteristics are now known vary a little. The body nose vortices are known at $x_B = 25.5$.

The monoplane wing vortices are calculated somewhat aft of this location on or slightly above the trailing edge at different spanwise locations. For the purpose of determining the effects on the interdigitated tails, the vortices are assumed to pass through the tail section in a direction parallel to the body centerline. Their lateral positions are taken from the results obtained earlier. The following table contains the coordinates in the crossflow plane and the strengths of the external vortices influencing the pressures and loads acting on the interdigitated tails and body section. They will be part of the input to program DEMON2 applied

| $y_B$ | $z_B$ | $\frac{\Gamma}{V_\infty}$ | |
|---|---|---|---|
| 2.4609 | 1.8792 | 1.52 | body nose vortices |
| -2.4609 | 1.8792 | -1.52 | |
| 4.41828 | 0.661 | 0.47179 | combined LE and SE vorticity at TE of monoplane wing |
| -4.41828 | 0.661 | -0.47179 | |
| 4.38465 | 0.0 | 0.59704 | TE vortices on TE of monoplane wing |
| -4.38465 | 0.0 | -0.59704 | |

to the tail section. Note that the strengths and positions of the symmetry vortices must also be specified. The body nose vortex characteristics appear in the output of program VPATHL for the last axial station at $x_B = 25.5$ as a result of step 4. The combined leading- and side-edge vorticity characteristics at the wing trailing edge are obtained from the output of program DEMON2 as a result of step 5. They are taken from the distribution of vorticity along the side edge under the heading U/VINF TYPE LOADING PRESSURE. The accumulated value of the side-edge vorticity added to the leading-edge vorticity is taken at the wing trailing edge. In other words, the last values in the columns headed YBAR and GAMMA,SE/VINF are listed above. The vertical displacement is determined on the basis of the leading- and side-edge vorticity leaving the monoplane wing surface at an angle equal to half the angle of attack seen by the wing. With a rootchord equal to 7.55, refer to figure 23, the vertical displacement at the trailing edge is given by

$$z_B = (7.55)\tan 5° = 0.661 \qquad (29)$$

The trailing-edge vortex characteristics are taken from the loading information output generated by program DEMON2 as a consequence of step 5 described in section 5.2.1. Trailing-edge vortex strength(s) and position(s) are taken from the results calculated on the basis of Bernoulli type loading pressures. They appear under the heading T. E. FIN VORTEX INFO.

Before the loads on the interdigitated tail section can be determined, program DEMON2 must first be run in accordance with step 8 of section 5.2.1 for the purpose of generating the data set TCPTS containing the coordinates of the control points distributed over the tail fins and the interference shell. Index NCPOUT must be set equal to 2 for this fin. The input is otherwise the same as the input to be discussed in connection with step 10. Once data set TCPTS has been generated, step 9 involves the application of program WDYBDY to the entire body length (i.e. up to the base of the tail section). The primary function of this run is to calculate the store in data set TVELS the velocity components induced by the body source panels at the control points on the tail fins and body interference shell. This last data set will be passed back to program DEMON2 in accordance with step 10.

The loads acting on the interdigitated tail-body section are calculated by program DEMON2 as per step 10 of section 5.2.1. Effects of the body nose and monoplane wing vortices will be included. The strengths and positions in the crossflow plane of these external vortices are listed in the discussion above. The input is shown in figure 33 and includes the break in sweep of the tail fins as described in section 6.2.1. For this run involving interdigitated tails, control index NDRAG must equal its default value 0. With this control, the program will not compute in plane forces used in the determination of edge suction. Note that with the Mach number at hand (1.7), the leading edge of the tail fin is supersonic for both sweep angles. Thus, the leading edge would have zero suction in this case. At the present time, program DEMON2 cannot compute in plane forces nor span loadings if the lifting surfaces under consideration involve interdigitated fins.

The input in figure 33 also includes the 6 external vortices listed in the table above. Index NVRTX=6 in namelist $INPUT causes the program to read in the strengths and lateral coordinates of the 6 body nose and monoplane wing vortices. In figure 33, the vortex specifications start on the 9th line from the end of the input. The listed $z_B$ (or $z_W$) coordinates of the two body nose vortices are slightly in error. The number

1.8809 should have been 1.8792. The output generated by program DEMON2 using the latter value appears in figure 34. As mentioned earlier, the influences of the external vortices are accounted for in the loading calculations on the basis of their paths being aligned with the body centerline.

Pressure distributions along the meridians of the interference shell indicated in figure 23 appear under the heading AFT OF LEADING EDGE OF FIN ROOTCHORDS. The outline of the interference shell is the idealization of the actual body contour. Figure 27(a) contains calculated pressure coefficients for two meridians, at $\theta_p = 5.64°$ and $\theta_p = 16.91°$, respectively, on the upper half of the body. Both correspond to locations on the body contour below the right upper tail fin; in fact they lie on the impact side of that fin at axial stations $x_B = 26.11$ and $27.91$. The pressures in this region rise rapidly from the leading edge of the tail section to the trailing edge. On the lower half of the body, figure 27(b), pressure coefficients are shown for the $\theta_p = 298.09°$ and $\theta_p = 354.36°$ meridians through the tail section. These two meridians lie on opposite sides of the right lower fin. Consequently, the pressure on the body below the fin ($\theta_p = 298.09°$) is higher than the pressure above the fin ($\theta_p = 354.36°$).

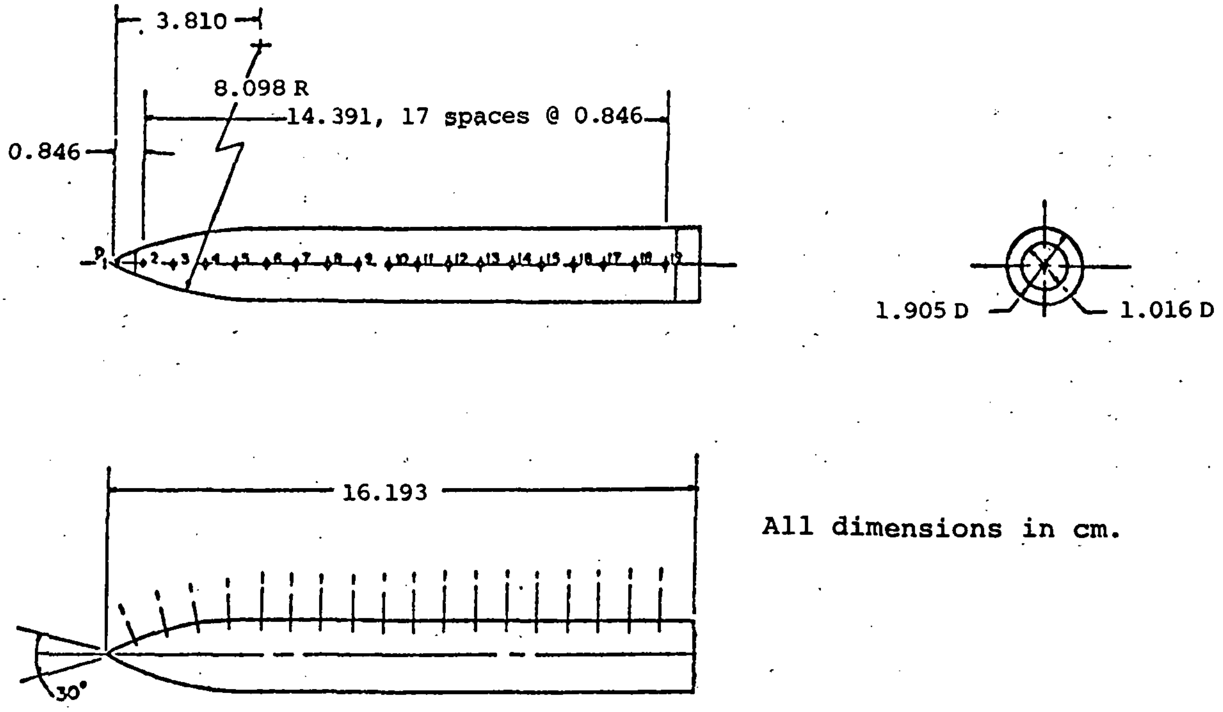
The pressure loading distributions for the upper and lower right fins appear under the heading PRESSURE LOADING AT CONTROL POINTS. Results are available on the basis of linear pressures under the heading DELTP,LIN., and on the basis of Bernoulli pressures under the heading DELTP,BERN. Forces acting on the fins in coefficient form are shown in the loading information output also for both types of loading pressures. If the effects of the body nose vortices are omitted, the loadings on the upper fins of the interdigitated tail section would be increased.

## 7. COMPARISON WITH EXPERIMENTAL DATA

During the development of the axisymmetric body modeling and pressure calculation methods described in section 3, some comparisons were made with experimental data. The ogive cylinder model shown at the top of figures 35, 36 and 37 is in fact the pressure distribution model used in connection with the store separation work associated with references 12, 13, and 14. This model is equipped with 19 pressure taps and the dimensions in inches are shown below. At the angle of attack under consideration

(5°), very little if any body vorticity will be generated. Thus, calculations were performed using program DEMON2.

The ogive cylindrical body is modeled with 30 line sources/sinks to account for volume effects and 30 line doublets to account for angle of attack. The calculated results are computed by subroutine BDYPR in conjunction with subroutine BDYGEN of program DEMON2. They are represented by a solid line in figure 35 for $M_\infty = 1.5$, in figure 36 for $M_\infty = 2.0$ and in figure 37 for $M_\infty = 2.5$. Program DEMON2 is not capable of modeling a body alone in its present state. Thus, near the body base a set of fins are attached as far as that program is concerned. The solid line is terminated at the leading edge of this imaginary fin section.



All dimensions in cm.

In general, the calculated results match the data well for all three Mach numbers. Near the body nose, some differences are evident for the two lower Mach numbers, figures 35 and 36. It is interesting to note that if the linear pressure relationship is used instead of the Bernoulli expression, the results near the nose tip are improved. However, at other locations, the agreement is then diminished. At the highest Mach number, $M_\infty = 2.5$, the Mach cone at the nose tip intersects the body. The part of the body nose outside of the Mach cone is then idealized by a conical surface, in fact by the Mach cone itself. In addition, as described in section 3, subroutine BDYGEN moves the line singularities up towards the nose in an effort to minimize the errors attendant to this approximation and the method of body modeling employed. Even so, if the pressure were calculated on the body between the nose tip and the location where the Mach cone emerges, the body singularities would have no effects. Thus, this constitutes a limit to the applicability of the body modeling method. Note that in figure 37 the most forward static pressure tap lies behind the intersection of the Mach cone and the body so that this location is affected by the forward line singularities.

## 8. CONCLUDING REMARKS

Existing cruciform wing-body computer programs have been extended and additional programs developed to compute, in a stepwise manner, pressure distributions acting on complete missile configurations. The applicable flow regime is supersonic and the configuration can be at combined angle of pitch and sideslip. The body can be circular or elliptic in cross section. The lifting surfaces can be a cruciform canard and/or curciform tail or a monoplane wing and interdigitated tail fins. Effects of body nose- and canard- or monoplane wing-vortices, tracked along the configuration, can be accounted for in the body pressures and tail fin loadings. For cases involving axisymmetric bodies, the body nose shed vortex characteristics are built into the program. Two calculative examples are given: the first concerns a cruciform canard-axisymmetric body-cruciform tail configuration and the second involves a monoplane wing-elliptic cross section body-interdigitated tail configuration. Limited comparisons between calculated and measured pressures are shown for an ogive cylinder at 5° angle of attack. Fin loads comparisons are described in earlier work. Fin edge vorticity characteristics are calculated by the program from the suction distributions using Polhamus' vortex lift analogy. Some comparisons with other theories are shown for leading- and side-edge suction forces in an appendix.

Some of the limitations of the program in their range of applicability are pointed out in this report. The limitations discussed herein are consequences of the basic linear methods used to model the components or to account for effects of vortices on the components. The limitation in applicability with regard to flow conditions is estimated to be about 20° in included angle of attack and supersonic velocities up to Mach number 3. A better estimate of the limitations of the program must await detailed pressure distribution data not now available.

The precision of the calculative method is associated with the number of body source panels used to model bodies with elliptical cross section, the number of discrete vortices used to represent body nose vortex shedding, and the number of constant u-velocity panels used to model the lifting surfaces.

The behavior of a vortex in the close proximity of a lifting surface can be a limiting factor in accuracy of prediction. It is possible to include a core in the model for the purpose of reducing the effect of the singularity in tangential velocity associated with the potential vortex model. To the best of our knowledge, there are no data available as yet for the vortex-shedding characteristics associated with bodies with elliptical cross section. A predictive program is available, as discussed herein, but must be thoroughly tested against experimental data not yet available.

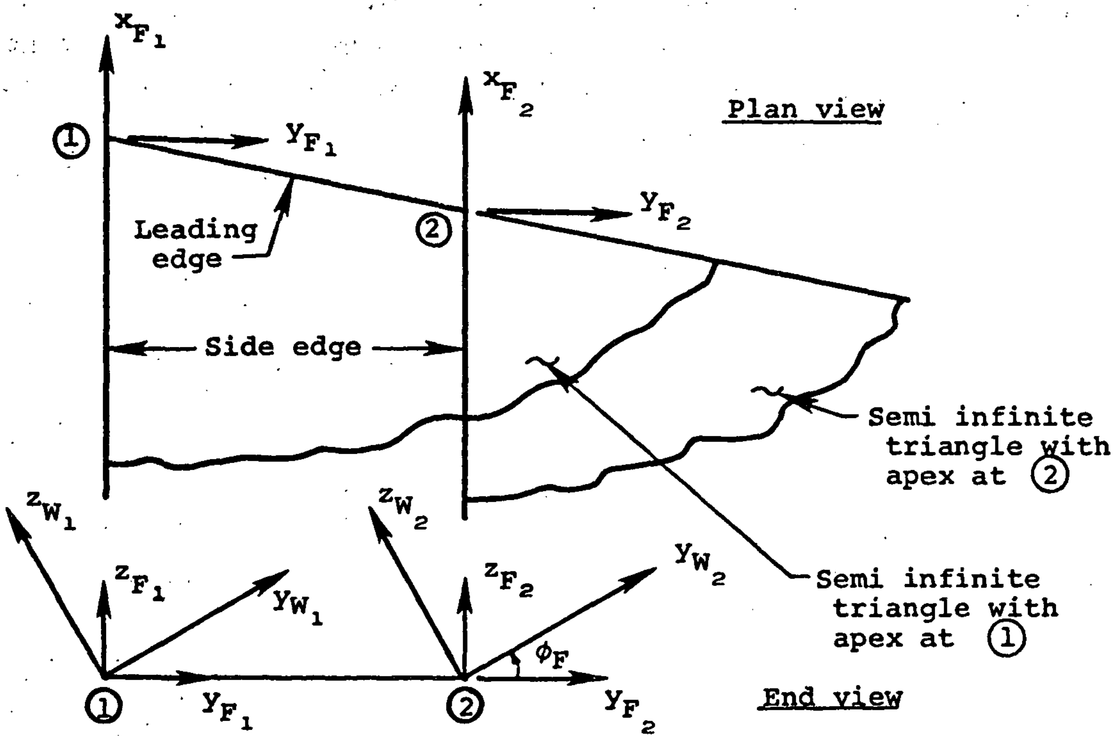
At the present time, the programs are used in a sequential manner without the benefit of an executive program. Running time is a function of the number of panels used. Some decrease in running time is possible by further refining the program.

# APPENDIX A

## SUPERPOSITION OF CORNER SOLUTIONS FOR A CONSTANT u-VELOCITY PANEL AT ARBITRARY DIHEDRAL ANGLE

In representing fin configurations by a distribution of constant u-velocity panels, questions arise concerning the coordinate system used in the panel corner superposition scheme. The superposition scheme is described in references 1 and 7. Furthermore, if the configuration geometry and flow conditions dictate symmetry in the flow field around the configuration, the aerodynamic influence coefficient matrix must reflect that condition. This appendix addresses these two topics in relation to the wing-body program DEMON2 only.

For simplicity consider only the corners on the leading edge of a constant u-velocity panel. Corners on the trailing edge are treated in the same manner. The following sketch shows the plan view and end view of the leading- and side-edges. Also indicated are the local panel coordinate systems with origins at panel corners 1 and 2. Axes $x_{F_1}$, $y_{F_1}$ and axes $x_{F_2}$, $y_{F_2}$ lie in the plane of the panel ($z_{F_1} = 0$, $z_{F_2} = 0$).



The end view shows the local lateral coordinates $(y_{W_1}, z_{W_1})$ and $(y_{W_2}, z_{W_2})$ with origins at corners 1 and 2, respectively. They are parallel to the reference wing coordinate system $(x_W, y_W, z_W)$, and we will need velocity components in this system. Coordinate systems $(x_{F1}, y_{F1}, z_{F1})$ and $(x_{W_1}, y_{W_1}, z_{W_1})$ are different by a rotation about the $x_{F_1}$ or $x_{W_1}$ axis through fin dihedral angle $\phi_F$. The same is true for the two systems at corner 2. The leading edge shown above has positive sweep. The superposition principle states that the solution for this infinitely long panel is given by the solution associated with the semi-infinite triangle with its apex at corner 1 minus the solution associated with the semi-infinite triangle with its apex at corner 2. Thus, in terms of flow velocity components, the superposition scheme specifies the velocity components in the $x_F, y_F, z_F$ directions as follows for the semi-infinite panel.

$$\left.\begin{aligned} u_{F,TOT} &= u_{F_1} - u_{F_2} \\ v_{F,TOT} &= v_{F_1} - v_{F_2} \\ w_{F,TOT} &= w_{F_1} - w_{F_2} \end{aligned}\right\} \qquad \text{(A1)}$$

The corresponding velocities in the wing coordinate system are obtained from those given by equation (A1) by means of a rotational coordinate transformation.

$$\left.\begin{aligned} v_{W,TOT} &= v_{F,TOT} \cos \phi + w_{F,TOT} \sin \phi \\ w_{W,TOT} &= w_{F,TOT} \cos \phi - v_{F,TOT} \sin \phi \end{aligned}\right\} \qquad \text{(A2)}$$

In equation (A1), the superposition principle is applied to the velocities expressed in the panel coordinate system $(x_F, y_F, z_F)$. These velocities are then transformed to the wing coordinate system $(x_W, y_W, z_W)$ as indicated in equation (A2).

Alternately, velocities $v_{F_1}, w_{F_1}$, and $v_{F_2}, w_{F_2}$ can first be transformed into the wing coordinate system and the superposition applied to the result. The lateral velocity components in the wing coordinate system are obtained from the ones in the panel coordinate system as follows.

$$\left.\begin{array}{l}\left.\begin{array}{l} v_{W_1} = v_{F_1} \cos\phi + w_{F_1} \sin\phi \\ w_{W_1} = w_{F_2} \cos\phi - v_{F_1} \sin\phi \end{array}\right\} \\ \\ \left.\begin{array}{l} v_{W_2} = v_{F_2} \cos\phi + w_{F_2} \sin\phi \\ w_{W_2} = w_{F_2} \cos\phi - v_{F_2} \sin\phi \end{array}\right\} \end{array}\right\} \qquad (A3)$$

Applying the superposition scheme to the velocities in the wing system and substituting from equations (A3) has the result

$$v_{W,TOT} = v_{W_1} - v_{W_2} = (v_{F_1} - v_{F_2}) \cos\phi + (w_{F_1} - w_{F_2}) \sin\phi$$

$$w_{W,TOT} = w_{W_1} - w_{W_2} = (w_{F_2} - w_{F_2}) \cos\phi - (v_{F_1} - v_{F_2}) \sin\phi$$

Or rewriting in terms of the quantities shown in equation (A1) then gives

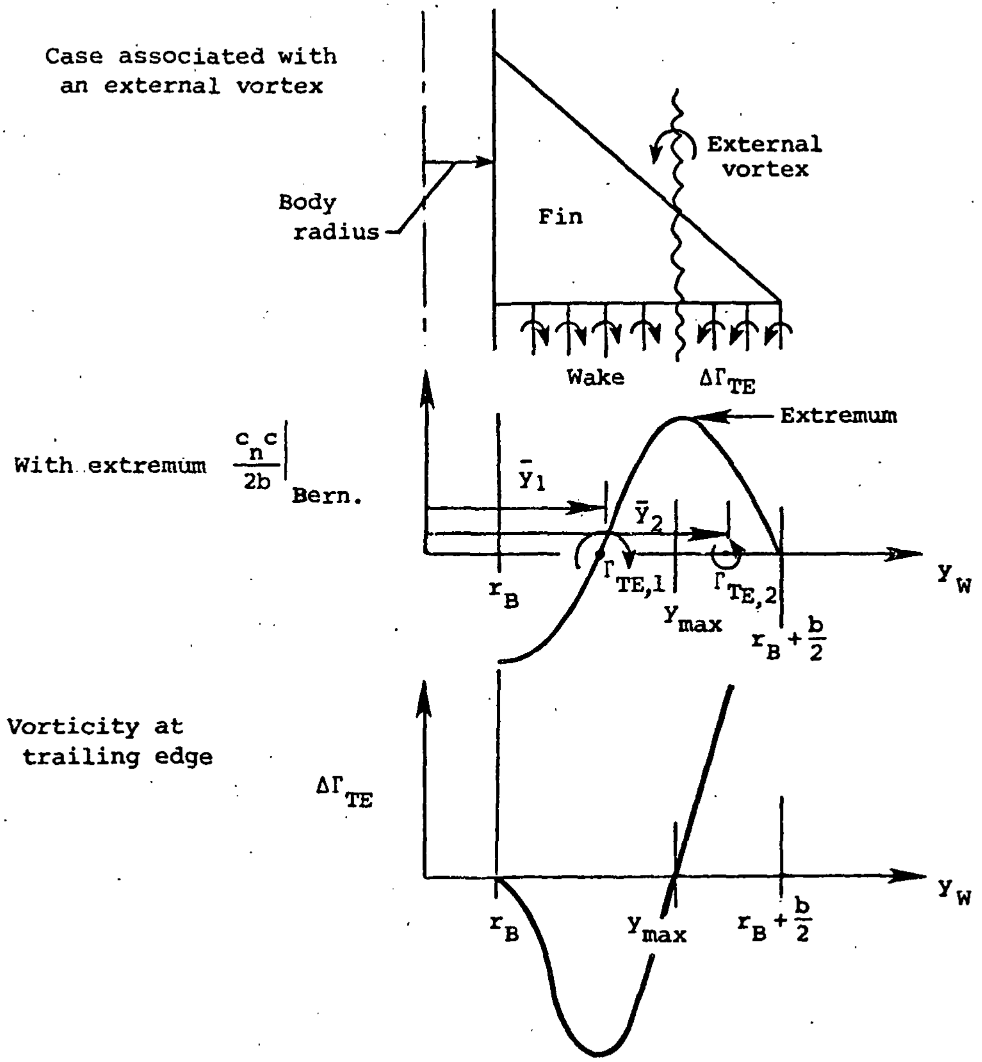
$$\left.\begin{array}{l} v_{W,TOT} = v_{F,TOT} \cos\phi + w_{F,TOT} \sin\phi \\ w_{W,TOT} = w_{F,TOT} \cos\phi - v_{F,TOT} \sin\phi \end{array}\right\} \qquad (A4)$$

This result is the same as the expressions shown in equation (A2). The conclusion is that the superposition scheme and the coordinate rotation can be interchanged. However, in program DEMON2, the actual procedure employed is as follows: In subroutine VELNOR, the coordinates of a given field point are first calculated relative to corner 1 in the wing reference coordinate system $(x_W,y_W,z_W)$. These relative coordinates are then transformed to the local panel coordinate system $(x_F,y_F,z_F)$ and the influence of the semi-infinite triangle with apex at corner 1 is calculated at the field point by a call to subroutine VELO. The induced velocities are returned in the local coordinate system and transformed back to the wing reference system. Before proceeding to corner 2, however, subroutine VELNOR checks on the possibility of symmetry, that is, for the case of zero sideslip or symmetry in the external vortices if present. If affirmative, the effect of the image corner on the opposite side of the body must be taken into account. To accomplish this, the field point instead is moved to its image point on the other side of the fuselage. The effect of the actual corner 1 is computed there in the wing coordinate system. The velocity components calculated in this way are then transferred to the actual field point with a change in sign on the side wash, v, aligned with the $y_W$-axis, if corner 1 belongs to a panel on the right horizontal fin. Thus, the procedure used to account for flow symmetry depends on expressing the velocity components in the wing reference coordinate system. The same procedure applies to all corners of panels at any dihedral angle. Thus, these panels include the constant u-velocity panels on cruciform fins, interdigitated fins, monoplane wings and the interference shell.

## APPENDIX B

## DETERMINATION OF STRENGTHS AND POSITIONS OF CONCENTRATED VORTICES AT THE FIN TRAILING EDGE

Consider a fin or a wing attached to a body as shown in the following sketch. An external vortex passes over the fin. The resulting span load distribution is indicated. The distribution at the trailing edge of the trailing-edge vorticity is also shown. It is desired to determine the strength(s) and location(s) of the concentrated vortex (vortices) representing the wake.



In order to represent the distributed trailing-edge vorticity by concentrated vortices, the spanwise load distribution based on the Bernoulli pressure expressions must be calculated first. For the case when this distribution exhibits extrema in between the end points, the number of concentrated vortices is given by the number of extrema plus 1. The trailing-edge vortex strength and position for the inboard portion of the normal-force distribution are then given by

$$\frac{\Gamma_{TE,1}}{V_\infty} = -\frac{1}{2}\int_{r_B}^{y_{max}} \frac{\partial}{\partial y}(cc_n)\,dy = -\frac{1}{2}\int_{r_B}^{y_{max}} d(cc_n) \tag{B1}$$

$$\bar{y}_1 = \frac{-\frac{1}{2}\int_{r_B}^{y_{max}} y\,\frac{\partial}{\partial y}(cc_n)\,dy}{-\frac{1}{2}\int_{r_B}^{y_{max}} \frac{\partial}{\partial y}(cc_n)\,dy} \tag{B2}$$

The basic relationship between the trailing-edge vorticity and the span-loading used here is described in detail in section 9.1 of reference 15. Fundamentally, it is shown that the rate of change in trailing-edge vorticity with spanwise distance equals the negative of the rate of change of the difference in potential between the upper and lower surfaces of the wing or fin. This is obtained by performing a contour integration parallel to the fin plane just behind the trailing edge. With simplifying assumptions, the potential difference (jump) at the trailing edge can be related to the span load distribution. The combination of these results leads to equation (B1). Integrating equation (B1) yields

$$\frac{\Gamma_{TE,1}}{V_\infty} = -\frac{1}{2}\left[cc_n\Big|_{y_{max}} - cc_n\Big|_{r_B}\right] \tag{B3}$$

and integration of equation (B2) by parts results in

$$\bar{y}_1 = \frac{-\frac{1}{2}\left[ y(cc_n)\Big|_{r_B}^{y_{max}} - \int_{r_B}^{y_{max}} (cc_n)\,dy \right]}{-\frac{1}{2}\int_{r_B}^{y_{max}} d(cc_n)}$$

$$\bar{y}_1 = \frac{y_{max}\, cc_n\Big|_{y_{max}} - r_B\, cc_n\Big|_{r_B} - \int_{r_B}^{y_{max}} (cc_n)\,dy}{cc_n\Big|_{y_{max}} - cc_n\Big|_{r_B}} \tag{B4}$$

After splitting up the terms, the spanwise location of the inboard vortex is

$$\bar{y}_1 = \frac{y_{max}\, cc_n\Big|_{y_{max}} - r_B\, cc_n\Big|_{r_B}}{cc_n\Big|_{y_{max}} - cc_n\Big|_{r_B}} - \frac{\int_{r_B}^{y_{max}} (cc_n)\,dy}{cc_n\Big|_{y_{max}} - cc_n\Big|_{r_B}} \tag{B5}$$

The strength and position of the outboard vortex is obtained in the same fashion by changing the limits of integration.

$$\begin{aligned} \frac{\Gamma_{TE,2}}{V_\infty} &= -\frac{1}{2}\int_{y_{max}}^{r_B + \frac{b}{2}} d(cc_n) \\ &= -\frac{1}{2}\left[ \cancelto{0}{cc_n\Big|_{r_B + \frac{b}{2}}} - cc_n\Big|_{y_{max}} \right] \end{aligned} \tag{B6}$$

Since the spanwise loading is zero at the side edge, equation (B6) simplifies to

$$\frac{\Gamma_{TE,2}}{V_\infty} = \frac{1}{2}\, cc_n\Big|_{y_{max}} . \tag{B7}$$

The spanwise location at the trailing edge is given by equation (B2) with the proper limits of integration

$$\bar{y}_2 = \frac{-\frac{1}{2}\displaystyle\int_{y_{max}}^{r_B + \frac{b}{2}} y \,\frac{\partial}{\partial y}(cc_n)\,dy}{-\frac{1}{2}\displaystyle\int_{y_{max}}^{r_B + \frac{b}{2}} d(cc_n)} \tag{B8}$$

After integration by parts, the result is

$$\bar{y}_2 = \frac{\cancelto{0}{(r_B+\frac{b}{2})\, cc_n\Big|_{r_B+\frac{b}{2}}} - y_{max} cc_n\Big|_{y_{max}}}{\cancelto{0}{cc_n\Big|_{r_o+\frac{b}{2}}} - cc_n\Big|_{y_{max}}} - \frac{\displaystyle\int_{y_{max}}^{r_B+\frac{b}{2}} (cc_n)\,dy}{\cancelto{0}{cc_n\Big|_{r_\Delta+\frac{b}{2}}} - cc_n\Big|_{y_{max}}}$$

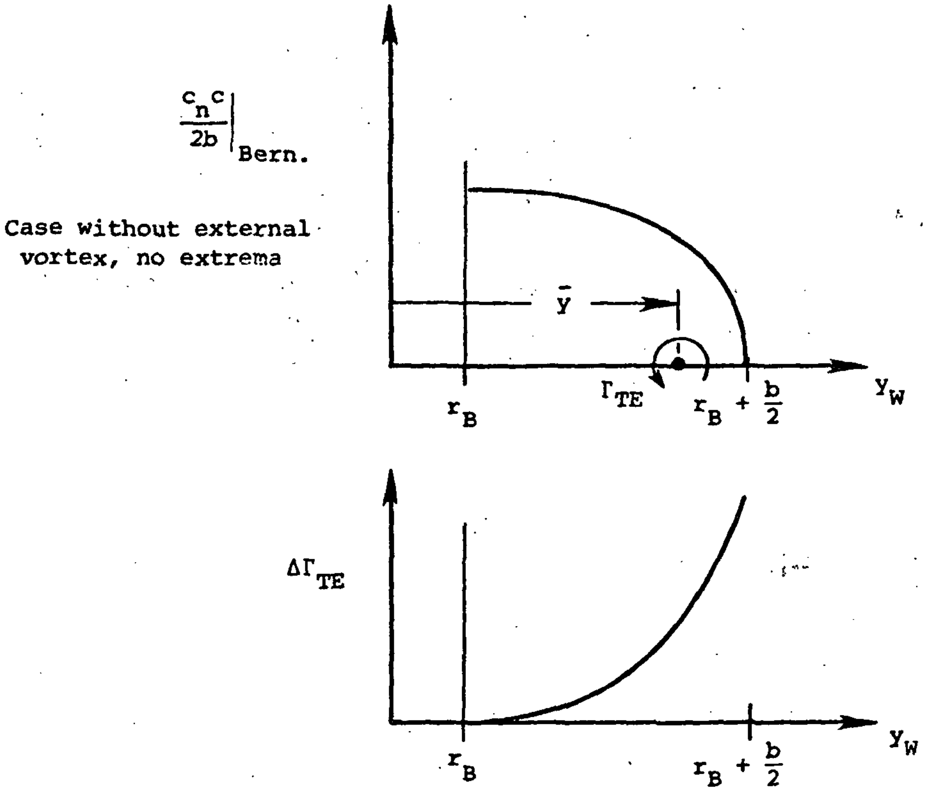
$$= \frac{-y_{max}\; cc_n\Big|_{y_{max}}}{-cc_n\Big|_{y_{max}}} - \frac{\displaystyle\int_{y_{max}}^{r_B+\frac{b}{2}} (cc_n)\,dy}{-cc_n\Big|_{y_{max}}}$$

and finally

$$\bar{y}_2 = y_{max} + \frac{\int_{y_{max}}^{r_B+\frac{b}{2}} (cc_n)\,dy}{cc_n\big|_{y\ max}} \tag{B9}$$

If the span-load distribution exhibits additional extrema, equations (B3) and (B5) must be applied again with the appropriate limits of integration $y_{max,1}$ to $y_{max,2}$. For the outboard vortex, equations (B7) and (B9) hold.

For the sake of completeness, expressions for the strength and spanwise location of the trailing-edge vorticity will be given for the case of spanwise load distributions such as the one shown below. Only one concentrated vortex is associated with this type of distribution.



Equations (B1) and (B2) are applied again with the upper limit of integration changed to $r_B + \frac{b}{2}$. The results are

$$\frac{\Gamma_{TE}}{V_\infty} = -\frac{1}{2}\int_{r_B}^{r_B+\frac{b}{2}} \frac{\partial}{\partial y}(cc_n)\,dy \tag{B10}$$

$$\bar{y} = \frac{-\frac{1}{2}\int_{r_B}^{r_B+\frac{b}{2}} y\,\frac{\partial}{\partial y}(cc_n)\,dy}{-\frac{1}{2}\int_{r_B}^{r_B+\frac{b}{2}} \frac{\partial}{\partial y}(cc_n)\,dy} \tag{B11}$$

Integrating equation (B10) gives

$$\frac{\Gamma_{TE}}{V_\infty} = -\frac{1}{2}\left[\cancelto{0}{cc_n\Big|_{r_B+\frac{b}{2}}} - cc_n\Big|_{r_B}\right]$$

and since the wing loading vanishes at the side edges, there results

$$\frac{\Gamma_{TE}}{V_\infty} = \frac{1}{2}\,cc_n\Big|_{r_B} \tag{B12}$$

After integration by parts, equation (B11) becomes

$$\bar{y} = \frac{-\frac{1}{2}\left[y(cc_n)\Big|_{r_B}^{r_B+\frac{b}{2}} - \int_{r_B}^{r_B+\frac{b}{2}} (cc_n)\,dy\right]}{-\frac{1}{2}\,(cc_n)\Big|_{r_B}^{r_B+\frac{b}{2}}}$$

Making use again of the fact that the wing load is zero on the side edge simplifies the above equation to

$$\bar{y} = \frac{-r_B(cc_n)\Big|_{r_B} - \int_{r_B}^{r_B+\frac{b}{2}}(cc_n)\,dy}{-cc_n\Big|_{r_B}}$$

or

$$\bar{y} = r_B + \frac{\int_{r_B}^{r_B+\frac{b}{2}}(cc_n)\,dy}{cc_n\Big|_{r_B}} \tag{B13}$$

Subroutine SPNLD in program DEMON2 generates discrete values for the spanwise loading $c_n c/2b$ at specific y locations. The extrema are searched for. The integrals appearing in equations (B5) and (B9) can then be represented by finite summations. For example, if for a fin the number of y stations up to $y_{max}$ is $MSW_{max}$ and the total number of y stations is MSWR then the integrals are rewritten as follows.

$$\int_{r_B}^{y_{max}} (cc_n)\,dy = 2b \sum_{i=1}^{MSW_{max}} \frac{c_n c}{2b}\Big|_i \Delta y_i \tag{B14}$$

and

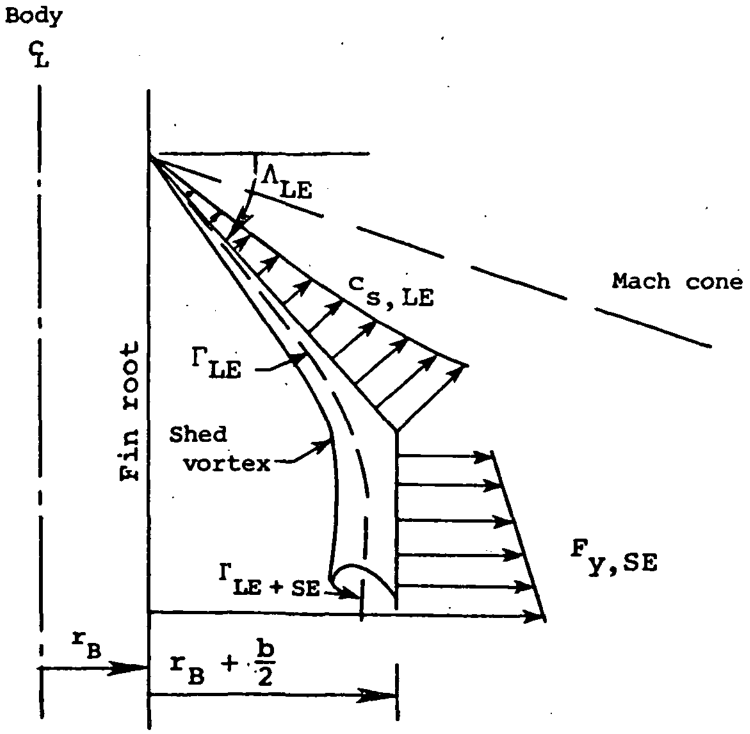
$$\int_{y_{max}}^{r_B + \frac{b}{2}} (cc_n)\,dy = 2b \sum_{i=MSW_{max}}^{MSWR} \frac{c_n c}{2b}\Big|_i \Delta y_i \tag{B15}$$

Subroutine SPNLD then proceeds to compute $\Gamma_{TE}/V_\infty$ designated as GAMMA and $\bar{y}$ as YCG in accordance with equations (B5) and (B9). Note again that in all of the above the span loading is based on the Bernoulli pressure calculation.

# APPENDIX C

## CALCULATION OF LEADING- AND SIDE-EDGE VORTICITY DISTRIBUTIONS

This appendix contains a description of the improved method used to calculate leading- and side-edge vorticity characteristics associated with cruciform fins on bodies in supersonic flow. First the distributions of suction force acting on these edges must be determined. Then Polhamus' leading-edge suction analogy, reference 3, is used and applied also to the side edges. As a consequence of this analogy, the normal force acting on a lifting surface in supersonic flow is augmented by an amount proportional to the suction force acting on the leading- and side-edges for sharp edges. Consider the following sketch. It shows a general planform of a fin attached to a body. A schematic distribution of the suction force along the leading- and side-edge is also indicated. The objective is to determine the position and strength of the shed vortex from knowledge of the suction distribution. Note that if the leading edge is supersonic (this occurs when the Mach cone lies between the leading edge and the fin root chord), the suction force acting on that edge equals zero.



## APPENDIX C

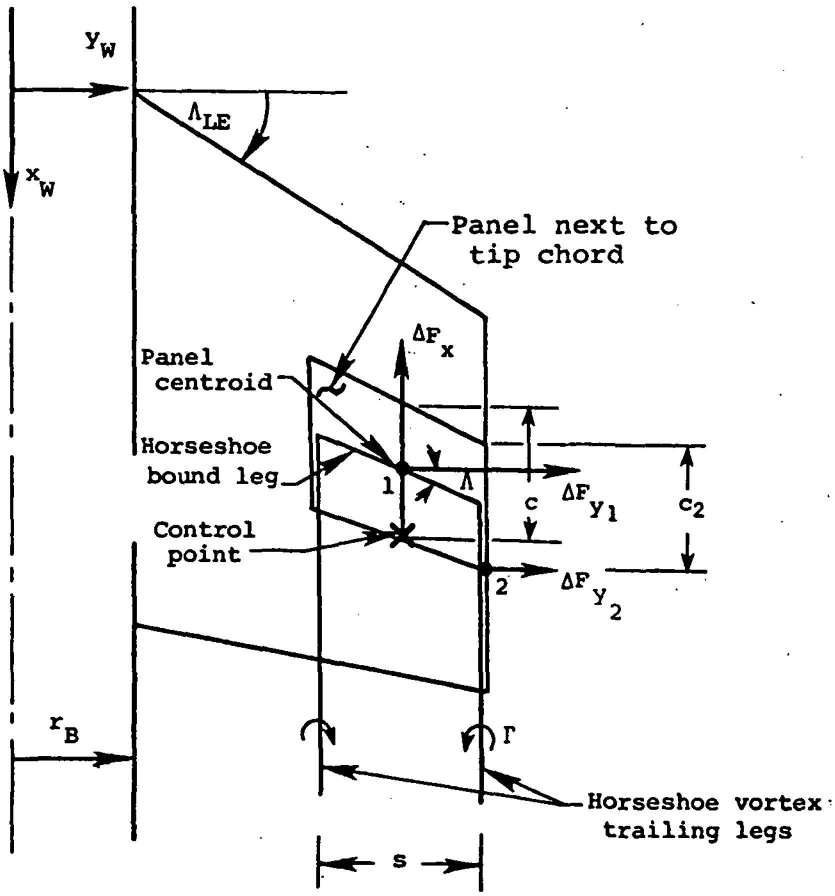
The method used to calculate the suction forces is described below in some detail. The subroutines in program DEMON2 concerned with the suction calculations are identified. The new procedure used for the side-edge suction calculation is pointed out. Calculated leading-edge thrust and suction-force distributions are compared with conical theory for the case of a slender delta wing. The predicted variation of side force along the side edge of a cropped delta wing is compared with two other theories. The side-edge suction factor, obtained using results computed by program DEMON2, is compared with conical theory for a case involving a rectangular wing.

After the suction distribution along the leading- and side-edges is described, the method used to convert the suction to edge vorticity is indicated.

### Calculation of Suction Distribution

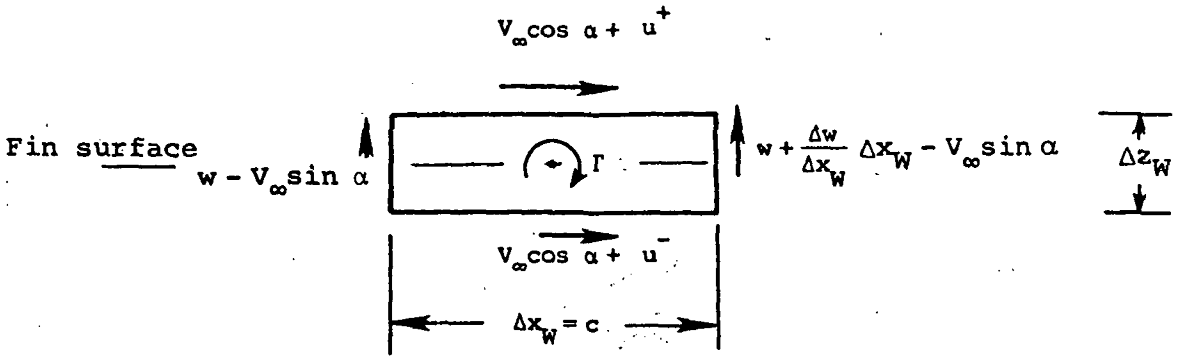
The present method used to calculate forces acting in the plane of a fin or wing in supersonic flow was first described in reference 1. For the sake of completeness, the important features and improvements to the method will be described here in the application to the determination of the suction forces acting on the leading edge and side edge of a fin.

First, the constant u-velocity panel strengths are recast in vorticity strengths. In fact, an equivalent vortex lattice is constructed using the same geometric paneling layout. The bound portion of each horseshoe vortex passes through the centroid of each constant u-velocity panel while the trailing legs extend in the streamwise direction as shown in the following sketch for a horizontal fin attached to a body.



A vertical fin attached to a body is treated in a similar manner. The above sketch also shows the in-plane force $\Delta F_x$ (acting in the negative $x_w$-direction) and side forces $\Delta F_{y_1}$ and $\Delta F_{y_2}$. The quantity $\Delta F_{y_2}$ is the side force acting on the side edge for a distance $c_2/2$ forward of point 2 and a distance $c_2/2$ downstream of the point. It should be noted that the resultant in-plane forces must appear at the edges of the fin. The trailing edge has no such forces by virtue of the Kutta condition if subsonic, and in no event if supersonic. Thus, the elemental forces $\Delta F_x$, $\Delta F_{y_1}$, and $\Delta F_{y_2}$ summed over all the panels and vectorially added on a given fin appear either as leading- or side-edge suction forces.

The strength of the constant u-velocity panel is taken as the u-velocity in and immediately above its plane and is denoted $u^+$. The perturbation velocity immediately below, $u^-$, equals $-u^+$. The equivalent circulation can then be determined from the closed path (clockwise) integral of the product of the total velocity tangential to the path and the path length shown in the following sketch. Neglecting terms of higher



order in $\Delta x$, the equivalent circulation strength $\Gamma$ is then given by

$$\frac{\Gamma}{V_\infty} = 2\ c\ \frac{u^+}{V_\infty} \tag{C1}$$

*In subroutine LOADS of program DEMON2, the linear loading pressure acting* on a panel is used instead of the panel strength $u^+$ in the determination of the equivalent circulation strengths. The linear loading pressure is related to the constant u-velocity panel strength as follows.

$$\left.\frac{\Delta p}{q}\right|_{\text{linear}} = 4\ \frac{u^+}{V_\infty} \tag{C2}$$

The circulation strengths are calculated using equations (C1) and (C2). The velocity normal to the panels induced by the constant u-velocity panels distributed on all fins and the body interference shell are then calculated and added to the contribution to the velocity normal to the fin induced by the singularities modeling the body. The in-plane forces can be calculated using the Kutta-Joukowski law for lift acting on a vortex filament. The forces acting on the bound vortex with sweep angle $\Lambda$ and the side force acting on the outboard trailing leg of one panel are given by the following expressions. Angle $\alpha$ is the sum of the angle of pitch added to the fin deflection angle if applicable.

$$\frac{\Delta F_x}{q} = 2\ s\ \frac{\Gamma}{V_\infty}\left(\sin\alpha + \frac{w_1}{V_\infty}\right) \tag{C3}$$

$$\frac{\Delta F_{y_1}}{q} = \frac{\Delta F_x}{q}\tan\Lambda \tag{C4}$$

$$\frac{\Delta F_{y_2}}{q} = 2\ c_2\ \frac{\Delta\Gamma}{V_\infty}\left(\sin\alpha + \frac{w_2}{V_\infty}\right) \tag{C5}$$

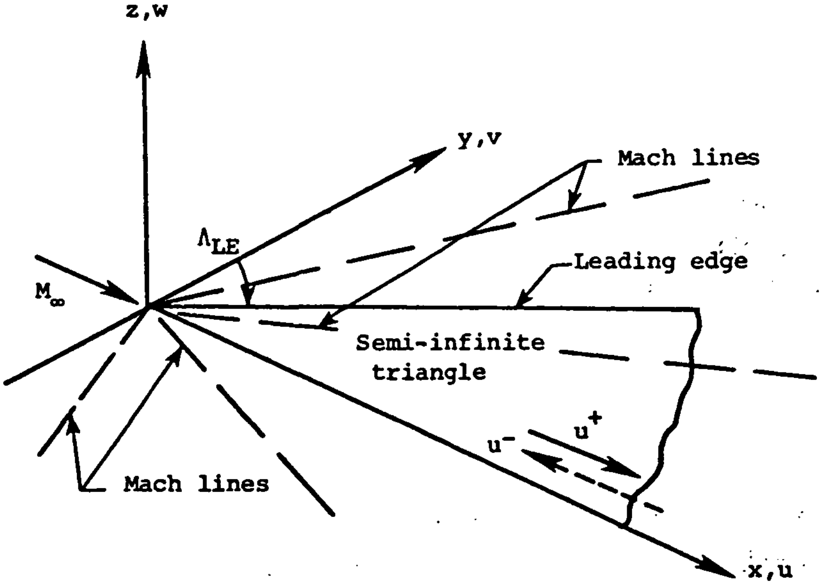
In equation (C5) $\Delta\Gamma$ is the sum of all the trailing vorticity along the panel side edge for all panels in the chordwise row ahead of the outboard aft corner. For the last panel $c_2$ is replaced by $c_2/2$. The above panel forces apply to panels on a horizontal fin. For panels on the vertical fin, $y_1$ and $y_2$ are replaced by $z_1$ and $z_2$, $w_1$ and $w_2$ are replaced by $v_1$ and $v_2$, $\sin\alpha$ is replaced by $\sin\beta$ and the sign inside the brackets is changed to negative. Perturbation upwash velocity $w_1$ is computed at the centroid of the panel and $w_2$ is computed at the aft outboard corner. The forces at the centroid, $F_x$ and $F_{y_1}$ divided by the dynamic pressure are computed in subroutine LOADS. The side force on the outboard leg is calculated in subroutine SPNLD of program DEMON2.

The forces calculated for every panel in accordance with equations (C3) through (C5) can be summed to obtain the net in-plane forces acting on a column (strip in chordwise direction) of panels and on the entire fin. If the number of panels in a given column is large, the vector sum of forces $\Delta F_x$ and $(\Delta F_{y_1} + \Delta F_{y_2})$ equals the suction force for that column acting in the direction normal to the leading edge. In order to obtain good results for the leading edge without having to resort to a large number of panels it was found advantageous to calculate the suction force from the sum of the $F_x$ forces and the leading-edge sweep of the fin under consideration. The section coefficient for suction, $c_s$, is the suction force per unit span divided by qc, where c is the local chord. This section coefficient is calculated in nondimensional form in accordance with

$$\frac{c_s c}{2b} = \frac{\sum_{i=1}^{NCW} \left.\frac{\Delta F_x}{q}\right|_i}{s\ (2b)\ \cos\Lambda_{LE}} \tag{C6}$$

by subroutine SPNLD of program DEMON2. The index NCW is the number of panels in the chordwise direction. Panel width s is constant for a column of panels but can vary from one column to the next. By adding the contributions from all constant u-velocity panels distributed on a fin, excluding the outboard leg side forces of the panels at the tipchord, the summed in-plane forces $F_x$, $F_{y_1}$ and $F_{y_2}$ for the leading edge are computed in subroutine SPNLD. When divided by $q_\infty$, they are designated SUMFX, SUMFY1 and SUMFY2, respectively, for horizontal fins (a horizontal fin lies in the $z_B = 0$ plane; see figure 1). Total forces $F_x$, $F_{z_1}$ and $F_{z_2}$ are designated SUMFX, SUMFZ1 and SUMFZ2, respectively, for the vertical fins (a vertical fin lies in the $y_B = 0$ plane). The forces acting on the outboard legs of panels at the fin tipchords are added separately and designated SUMFT2 in subroutine SPNLD. The sum represents the suction force on the side edge of the fin. Velocity components $w_2/V_\infty$ (for horizontal fins) and $v_2/V_\infty$ (for vertical fins) calculated at points on the side edge of fins with subsonic leading edges are calculated in accordance with the special procedure described next.

Consider a basic semi-infinite triangle with its apex at one of the corners of a constant u-velocity panel. The sketch below shows one semi-infinite triangle with two Mach lines corresponding to two free-stream Mach numbers. When the leading edge of the triangle lies inside the Mach cone, it is a subsonic leading edge. If it lies outside the Mach cone, the edge is supersonic. The outboard aft corner points of panels at the side edge, marked 2 on the second sketch of this appendix, lie on the extended leading and extended trailing edges of many panels inboard of the side edge panels. In particular, the point lies on the trailing edge of the panel shown in the sketch. If the edges are subsonic, the



contributions to the upwash from the semi-infinite triangles on whose leading edge the point lies are in fact singular as shown in figure II-1(a) in reference 7. To avoid numerical difficulties, subroutine VELO in program DEMON2 sets the downwash equal to zero. As a consequence, the points on the side edge of a fin with subsonic leading and trailing edges only receive upwash contributions from those basic semi-infinite triangles whose leading edges do not pass through the points. It was found that the side force calculated on the side edge of a cropped delta wing using the upwash, $w_2$, calculated this way was underestimated. By moving the points on the side edge off the fin a distance equal to the width of the nearest panel width, the values of the upwash are increased and more reasonable values for the side edge forces are obtained. For a cropped delta wing with supersonic leading and trailing edges the above problem does not exist. The upwash at the leading edge is discontinuous in this case; refer to figure II-1(c) in reference 7. The mean value is used.

A few examples will now be discussed. Consider figure C-1 first. It shows the distribution of thrust and suction along the leading edge of a delta wing with aspect ratio equal to 1. The Mach number is $\sqrt{2}$. The conical theory results for the linear thrust distribution shown by the lower dashed line, is based on the thrust coefficient calculated from the lift and drag coefficient for small angle of attack as follows.

$$C_T = \alpha C_L - \left( \frac{C_{D_i}}{C_L^2} \right) C_L = \frac{T}{q\, c_r\, (b/2)} \qquad \text{(C7)}$$

For a delta wing, page 292 in reference 8 contains expressions for lift and drag. The slope of the spanwise thrust distribution $cc_t/2b$ for the half wing is then related to the thrust coefficient by

$$k_T = \frac{\frac{C_T}{2}\, c_r}{2b} \qquad \text{(C8)}$$

where $c_r$ is the rootchord. The suction coefficient of one wing half is related to the thrust through the leading edge sweep $\Lambda$ of the leading edge.

$$C_S \Big|_{\text{half wing}} = \frac{\frac{C_T}{2}}{\cos \Lambda} = \frac{S}{c_r\, (b/2)\, q} \qquad \text{(C9)}$$

Therefore, the linear slope of the spanwise suction distribution is given by

$$k_S = \frac{C_S c_r}{2b} = \frac{k_T}{\cos \Lambda} \qquad \text{(C10)}$$

The results calculated by subroutine SPNLD in program DEMON2 with a layout of five chordwise and 20 spanwise panels agree well with the linear thrust distribution from conical theory. The suction coefficient is actually calculated on the basis of vectorially adding the forward and side forces acting on all the constant u-velocity panels. The results calculated from the program are higher than the conical result from the 70 percent spanwise station on although the curve tends to return to the conical value near the tip. Nevertheless, the resultant suction force calculated this way was almost exactly normal to the leading edge. If the values of $(c_t c)/2b$ are simply divided by $\cos \Lambda$, the resulting $(c_s c)/2b$ values, as indicated by the crosses, are very close to the conical results. However, the suction as calculated in the program is away from the normal to the leading edge by a few degrees.

The distribution of the suction force along the side edge of a cropped delta wing is shown in figure C-2. Results calculated by subroutine SPNLD of program DEMON2 are indicated by the solid circles. The solid line is a distribution calculated on the basis of conical theory and given by an adapted version of equation 10 on page 8 of reference 16. Certain restrictions are imposed on the application of the expression shown in figure C-2. For example, the Mach lines from the leading edges of the tip chords must not intersect the opposite wing tip. The dashed line represents an exact linear theory result obtained by J. N. Nielsen using some of the results derived in reference 17 and the lift-cancellation method. Other than close to the leading and trailing edges of the tip chord, the program results match the exact theory well. Overall suction force along the side edge calculated by the program is slightly below that calculated by the linear theory. For this case, the leading edges and trailing edges of the panels along the side edge are subsonic near the leading edge of the side edge and supersonic near the trailing edge. This is a mixed case and the offset scheme described above may not apply to all of the points on the side edge.

The last example of suction force calculation is shown in figure C-3 for the case of a rectangular wing. The result shown by the dashed line is based on conical theory and can be obtained by the methods employed by Lamar in reference 18 for rectangular wings. The solid line is the result calculated by the program using the following definition of $K_{v,SE}$, the side-edge suction coefficient.

$$K_{v,SE} = \frac{2(F_{Y_2} + F_{T_2})}{qS_{Ref}\sin^2\alpha} \tag{C11}$$

Quantity $F_{Y_2}/q$ (SUMFY2 in subroutine SPNLD) is the sum of the in-plane forces, divided by the dynamic pressure, in the $y_w$-direction acting at the outboard aft corner of all the panels except those next to the side edge. Quantity $F_{T_2}/q$ (SUMFT2 in subroutine SPNLD) is the sum of the forces, divided by the dynamic pressure, in the $y_w$-direction acting on the outboard aft corners of the panels at the side edge. Results were calculated for five panels in the chordwise direction as a function of the number of panels in the spanwise direction. The solid line approaches the conical theory result as the number of spanwise panels is increased. Increasing the number of chordwise panels also improves the agreement. With 10 along the chord and 15 along the span, the point marked by the cross corresponds to $K_{v,SE} = 1.099$.

## Conversion of Suction to Edge Vorticity

With the distribution of suction along the leading and side edges of a given lifting surface calculated by the methods described above, the Polhamus analogy is used to convert the suction to additional normal force and accompanying edge vorticity. The analogy is described in reference 3 and states that at high angles of attack the normal force acting on a delta type wing is augmented by an amount proportional to the suction force acting on the leading edge. The additional lift is associated with flow separation along swept leading edges. This analogy is extended to the side edges of a wing or fin of general planform.

Section 6.2.3 contains a description of the procedure used to compute the increment in normal force due to edge vorticity from the suction force coefficients calculatable from quantities in the output of program DEMON2. In the following, the method for relating the distribution along the leading and side edges of suction force to the distribution of augmented normal force is indicated. Then, a discussion follows concerning the analysis required to relate the distribution of edge vorticity to the distribution of augmented normal force.

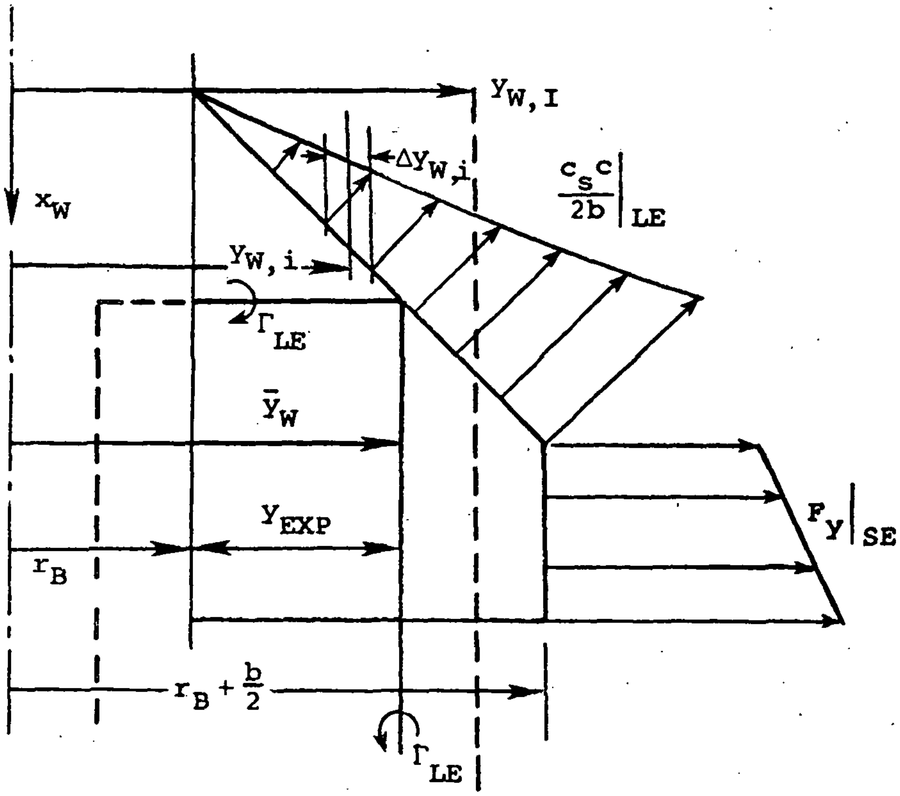
For the leading edge, the spanwise distribution of suction is given by equation (C6). Define $K_{v,LE}$, assumed constant, as the proportion of the suction converted to normal force

$$K_{v,LE} = \frac{\dfrac{\Delta c_n c}{2b}}{\dfrac{c_s c}{2b}} \tag{C12}$$

This factor is called the vortex lift vector for the leading edge. It is a function of leading edge sweep, Mach number and leading-edge geometry. For sharp edges, figure 9(a) in reference 4 contains graphs from which estimates can be obtained for $K_{v,LE}$ values as a function of aspect ratio and Mach number. In accordance with equation (30), the vortex lift factor $K_{v,LE}$ is also applicable to the suction coefficient associated with the entire leading edge to give the increment in normal force due to leading-edge vorticity (for one wing half)

$$K_{v,LE} = \frac{C_N|_{\text{L.E. vorticity}}}{C_S|_{\text{L.E.}}} \tag{C13}$$

Refer now to the sketch below. Schematic distributions of suction



are shown for the leading and side edge of the wing or fin attached to a body. Up to given spanwise position $y_{W,I}$ subroutine SPNLD of program DEMON2 integrates the spanwise suction distribution. The integrated quantity is named CSINT. It is equal to the suction force divided by 2b (b/2 is the exposed semispan of the fin) accumulated up to spanwise location $y_{W,I}$.

$$\text{CSINT} = \sum_{i=1}^{I} \frac{c_s c}{2b}\Big|_i \Delta y_{W,i} \tag{C14}$$

The moment of the suction force divided by factor 2b is formed as follows.

$$\text{CSMOM} = \sum_{i=1}^{I} y_{W,i} \left.\frac{c_s c}{2b}\right|_i \Delta y_{W,i} \tag{C15}$$

The spanwise location of the "center of gravity" of the suction distribution along the leading edge up to $y_{W,I}$ is given by the ratio of the moment over the force.

$$\left.\begin{aligned} \bar{y}_W &= \frac{\text{CSMOM}}{\text{CSINT}} \\ y_{EXP} &= \bar{y}_W - r_b \end{aligned}\right\} \tag{C16}$$

A horseshoe vortex is laid-out on the wing or fin attached to the body. The outboard trailing filament is at spanwise position $\bar{y}_W$. The lift acting on the bound or spanwise leg is made equal to the increment in normal force due to leading-edge vorticity. Up to spanwise location $y_{W,I}$, the increment in normal force in coefficient form is given by equation (C13) in conjunction with equation (C14).

$$C_N\Big|_{\text{L.E. vorticity}} = K_{v,LE}\ (\text{CSINT})2b \tag{C17}$$

Taking the component in the direction of the lift force results in

$$C_L\Big|_{\text{L.E. vorticity}} = K_{v,LE}\ (\text{CSINT})2b \cos\alpha \tag{C18}$$

where α is the angle of attack seen by the lifting surface in question. Then, with the Kutta-Joukowski law for lift on a vortex filament, the vortex strength $\Gamma_{LE}$ associated with the added lift can be obtained from the following approximate relation.

$$\frac{\Gamma_{LE}}{V_\infty} = \frac{K_{v,LE}\ (\text{CSINT})2b \cos\alpha}{2y_{EXP}} \tag{C19}$$

This relation is correct for a wing alone ($r_b = 0$) for which the span of the horseshoe vortex would be equal to 2 $\bar{y}_W$ or 2 $y_{EXP}$. However, for a wing or fin attached to a body as shown in the sketch above, the span or width of the horseshoe vortex is the difference between $\bar{y}_W$ and the distance from the body centerline to the image (shown dashed) of the outboard trailing filament, $r_b^2/\bar{y}_W$. At the present time, equation (C19) is programmed in subroutine SPNLD of program DEMON2. In any event, equation (C19) provides the spanwise distribution of $\Gamma_{LE}$ and its location $\bar{y}_W$ is given by equation (C16).

A similar procedure is followed for determining the strength and spanwise location of vorticity along the side edge. The summing process indicated in equation (C14) to calculate quantity CSINT is continued along the side edge using the side force designated $FT_2(J_{TIP})$ and computed in accordance with equation (C5). The vorticity associated with the added normal force is also determined by expressions (C18) and (C19) replacing $K_{v,LE}$ with $K_{v,SE}$. The same remarks made above in connection with the spanwise width apply. In addition, it is recommended to set $K_{v,SE} = K_{v,LE}$ for use in the program as written at the present time. Note that these vortex lift factors have the default value 0.5 in main routine CRFWBD of program DEMON2.

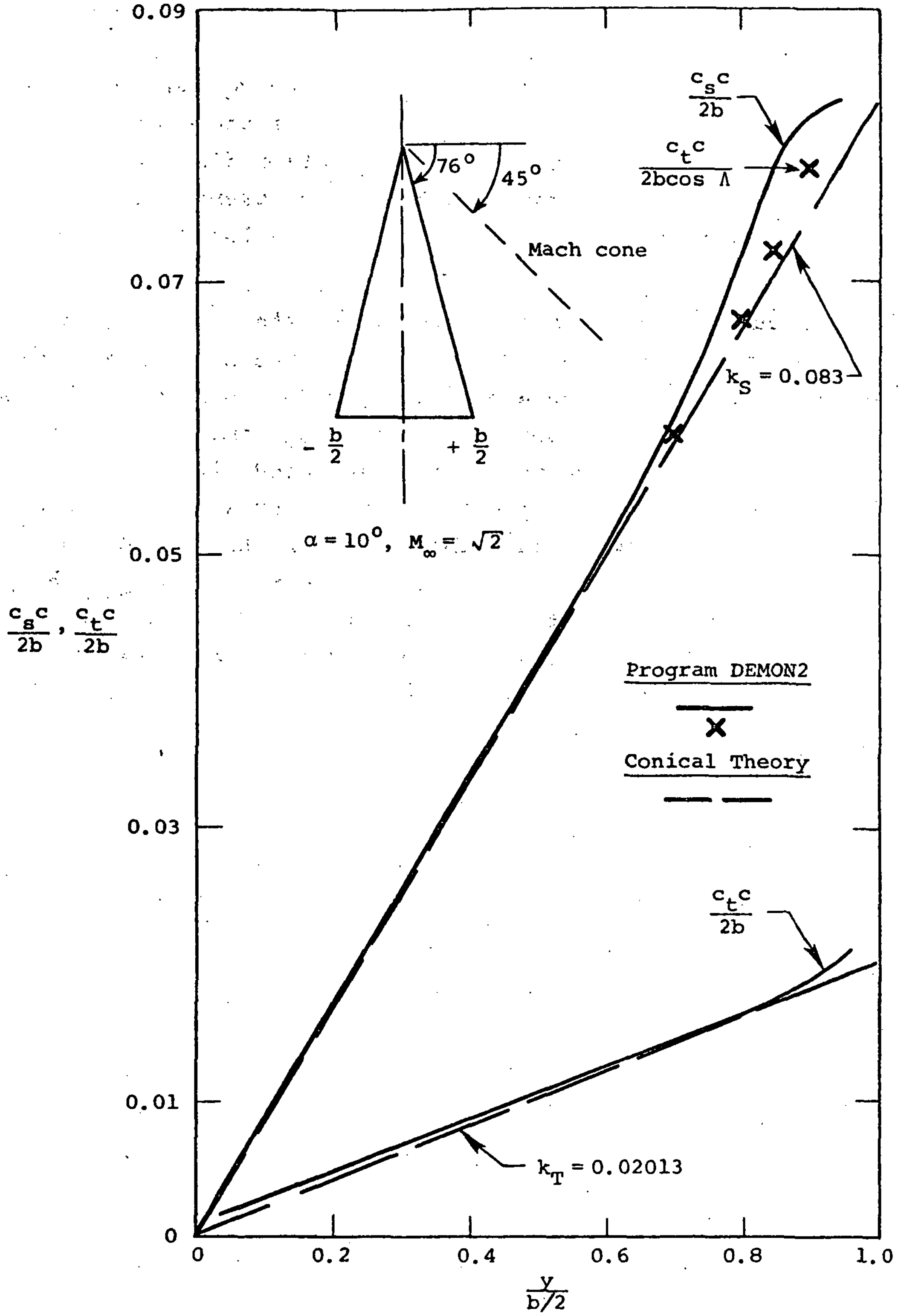


Figure C-1.- Spanload distribution of suction and thrust for a delta wing with aspect ratio 1.

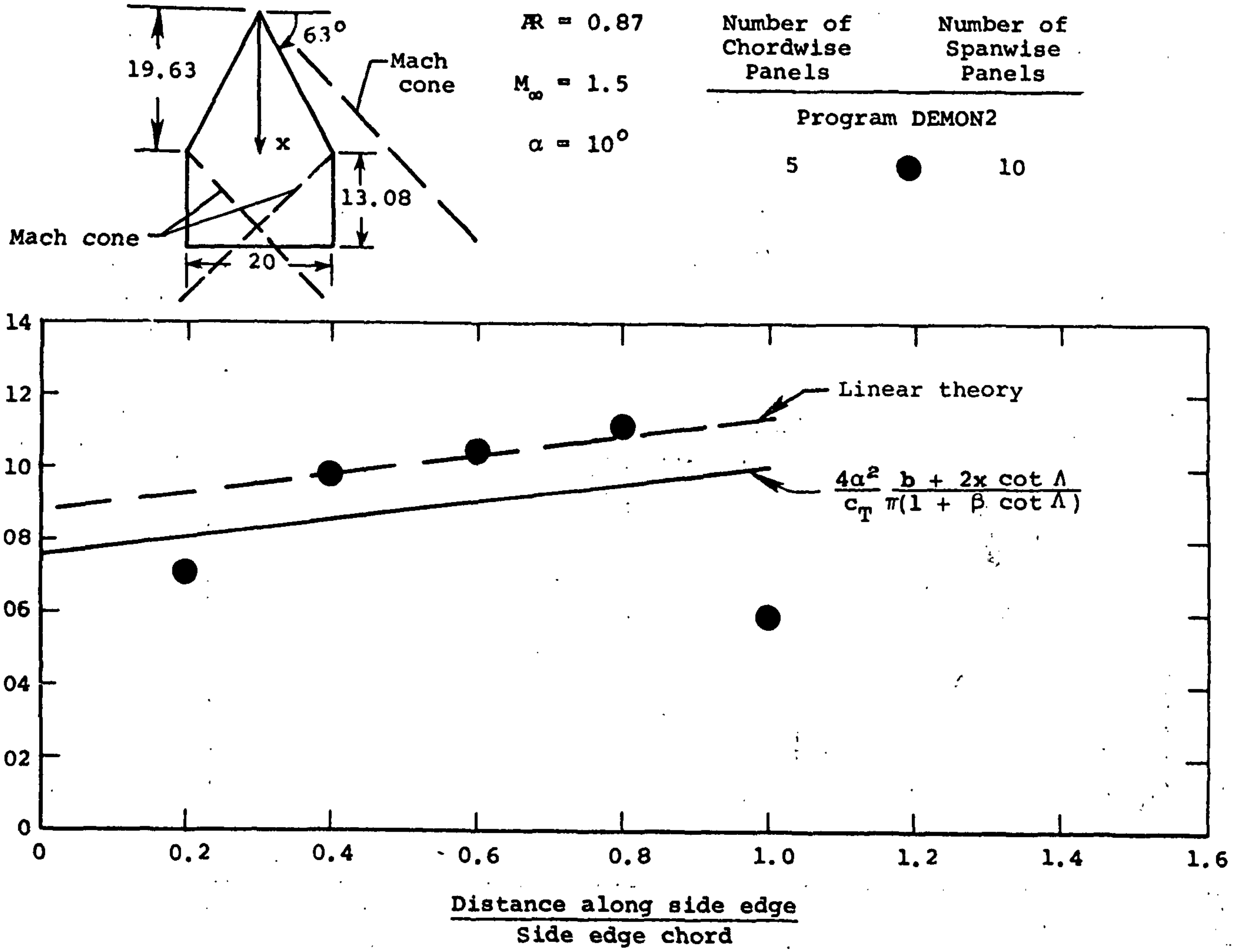


Figure C-2.- Distribution of suction force along side edge of a cropped delta wing; $b = 20$, $c_T = 13.08$, $\Lambda = 63°$.

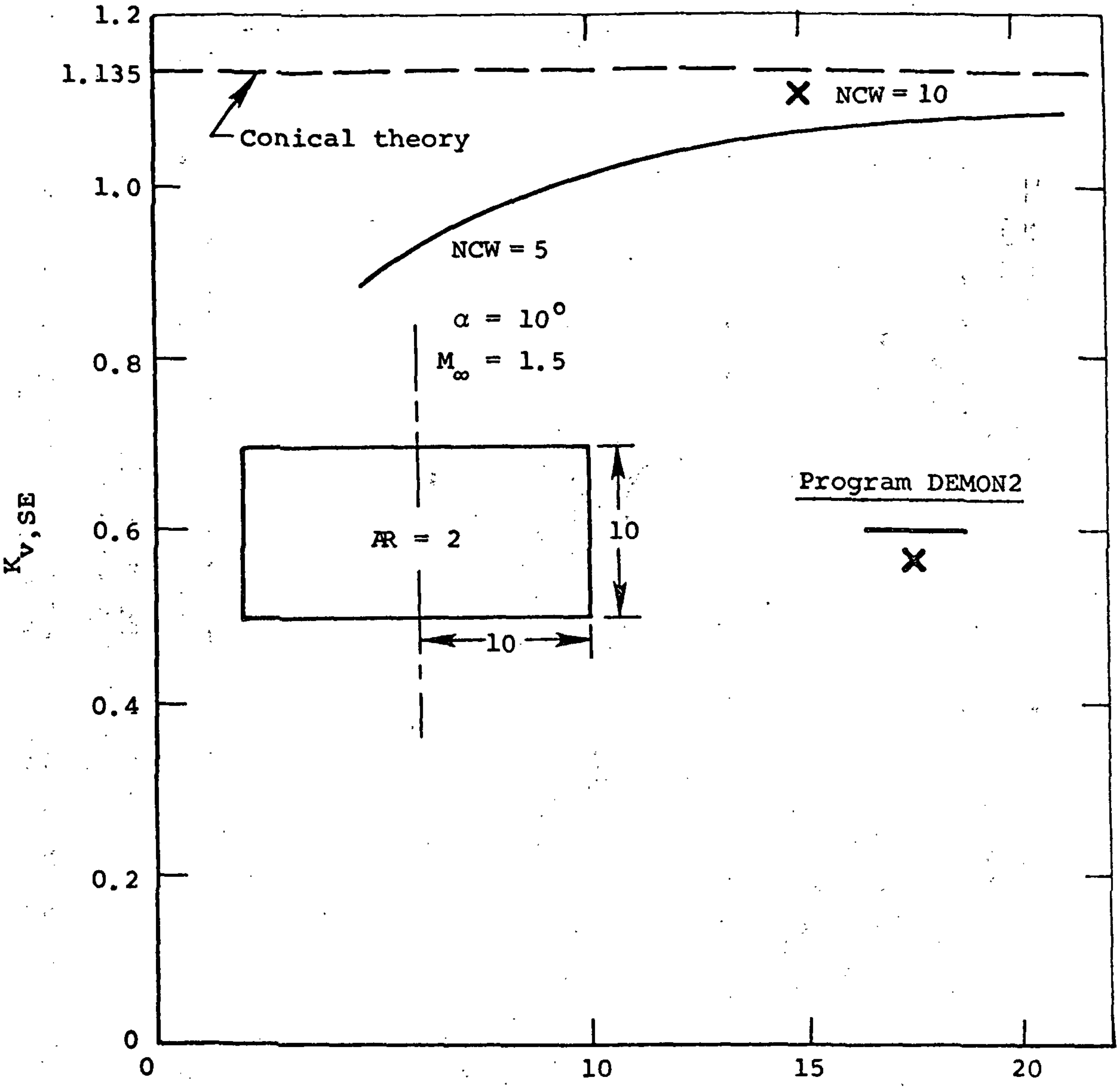
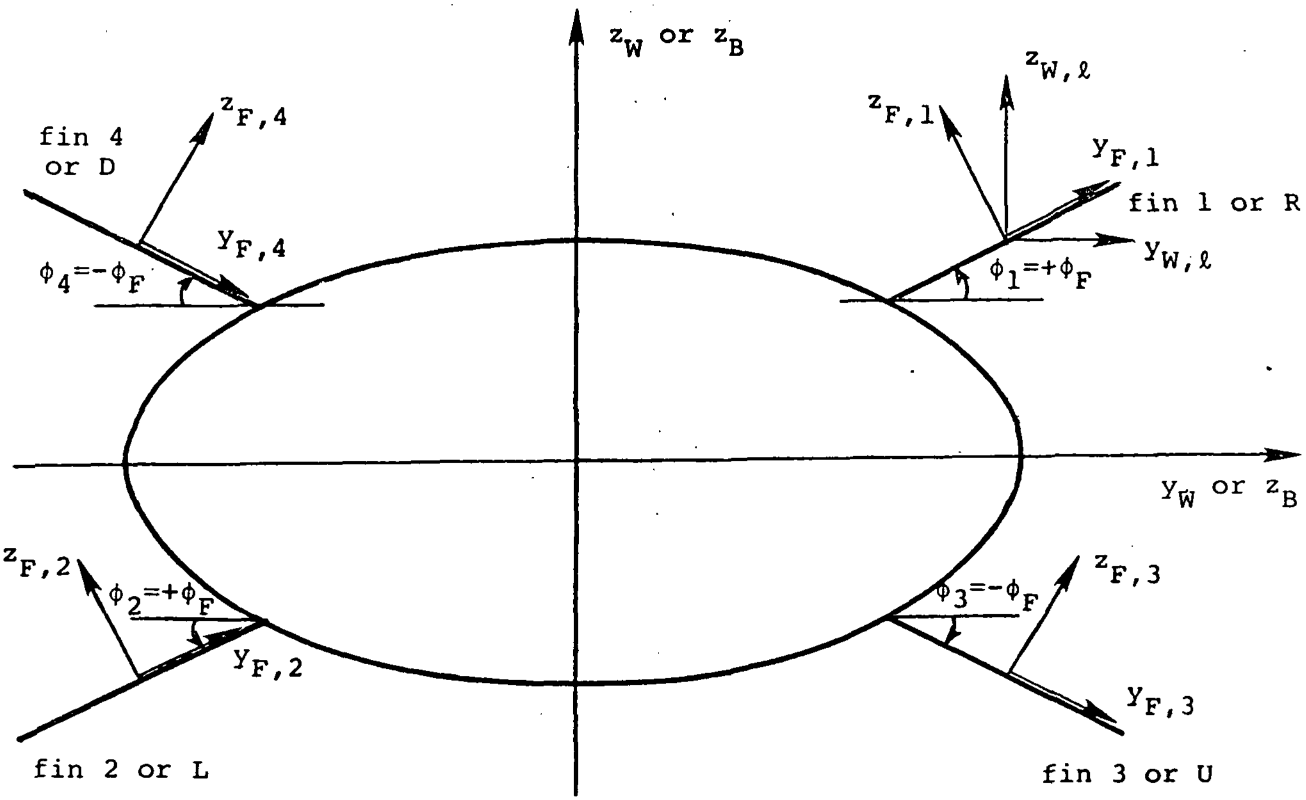


Figure C-3.- Side-edge suction factor $K_{V,SE}$ for a rectangular wing.

# APPENDIX D

## TRANSFORMATION FROM FIN COORDINATES TO WING OR BODY REFERENCE COORDINATE SYSTEM AND VICE VERSA

In the calculation of the influence of one constant u-velocity panel at the control point of another or at a given field point, the following procedure is used. The coordinates of the four corners of all the constant u-velocity panels are calculated by subroutine LAYOUT in program DEMON2 in the wing coordinate system ($x_W$, $y_W$, $z_W$). The coordinates of the control points (or field points) are also determined by subroutine LAYOUT (or specified) in the wing coordinate system. The first step is to calculate the coordinates of the point relative to the corners of the influencing panel under consideration. Then these local coordinates ($x_{W,\ell}$, $y_{W,\ell}$, $z_{W,\ell}$), which are parallel to the wing coordinate system, are transformed to a panel coordinate system with the $y_F$ and $x_F$ axes in the plane of the fin. In this process the origin at one corner of the constant u-velocity panel remains fixed. Thus, the transformation is a simple rotation through the applicable fin dihedral angle. Only one local coordinate system is shown on each fin in the sketch below.



For the right upper and left lower fins, fin 1 or fin R and fin 2 or fin L, the local wing to local fin coordinate transformation is stated as follows.

$$\left.\begin{aligned} y_{F,1 \text{ or } 2} &= y_{W,\ell} \cos \phi_{1 \text{ or } 2} + z_{W,\ell} \sin \phi_{1 \text{ or } 2} \\ z_{F,1 \text{ or } 2} &= z_{W,\ell} \cos \phi_{1 \text{ or } 2} - y_{W,\ell} \sin \phi_{1 \text{ or } 2} \end{aligned}\right\} \quad \text{(D1)}$$

Fin dihedral angles $\phi_1$ and $\phi_2$ are taken equal to the specified fin dihedral angle, $+\phi_F$, also shown in figure 3. The coordinate system rotation for the left upper and right lower fins, fin 4 or fin D and fin 3 or fin U is given by

$$\left.\begin{aligned} y_{F,3 \text{ or } 4} &= y_{W,\ell} \cos \phi_{3 \text{ or } 4} - z_{W,\ell} \sin \phi_{3 \text{ or } 4} \\ z_{F,3 \text{ or } 4} &= z_{W,\ell} \cos \phi_{3 \text{ or } 4} + y_{W,\ell} \sin \phi_{3 \text{ or } 4} \end{aligned}\right\} \quad \text{(D2)}$$

Fin dihedral angles $\phi_3$ and $\phi_4$ are taken equal to negative specified fin dihedral angle, $-\phi_F$. Thus, the transformation given by equations (D1) and (D2) are in fact the same provided the negative dihedral angle, $-\phi_F$, associated with fins 3 and 4 is substituted in equation (D1). The local fin to local wing coordinate transformation is given by the following expression. For the right upper and left lower fins, fin 1 or fin R and fin 2 or fin L, the transformation is

$$\left.\begin{aligned} y_{W,\ell} &= y_{F,1 \text{ or } 2} \cos \phi_{1 \text{ or } 2} - z_{F,1 \text{ or } 2} \sin \phi_{1 \text{ or } 2} \\ z_{W,\ell} &= z_{F,1 \text{ or } 2} \cos \phi_{1 \text{ or } 2} + y_{F,1 \text{ or } 2} \sin \phi_{1 \text{ or } 2} \end{aligned}\right\} \quad \text{(D3)}$$

Fin dihedral angles $\phi_1$ and $\phi_2$ are equal to positive fin dihedral angle, $+\phi_F$. The local fin to local wing coordinate transformation for the left upper and right lower fins, fin 4 or fin D and fin 3 or U can be expressed as

$$\left.\begin{aligned} y_{W,\ell} &= y_{F,3 \text{ or } 4} \cos \phi_{3 \text{ or } 4} + z_{F,3 \text{ or } 4} \sin \phi_{3 \text{ or } 4} \\ z_{W,\ell} &= z_{F,3 \text{ or } 4} \cos \phi_{3 \text{ or } 4} - y_{F,3 \text{ or } 4} \sin \phi_{3 \text{ or } 4} \end{aligned}\right\} \quad \text{(D4)}$$

Fin dihedral angles $\phi_3$ and $\phi_4$ are equal to negative specified fin dihedral angle, $-\phi_F$. Again, equation (D4) can be obtained from equation (D3) by accounting for the negative dihedral angle, $-\phi_F$, associated with fins 3 and 4.

The transformations indicated by equations (D1) and (D3) are programmed in subroutine ROTATE of program DEMON2. The former is accomplished through entry point ROTWF and the latter through entry point ROTFW in subroutine ROTATE.

The transformation given by equation (D1) also applies to the flow velocity components in the wing coordinate system $v_W$, $w_W$ aligned with the $y_W$ and $z_W$ axes. After calculating the components $v_W$ and $w_W$, the velocity components $v_F$ and $w_F$ in the local panel or fin coordinate system can be determined. Conversely, equation (D3) is used to transform velocities in the local panel or fin coordinate system to the local wing coordinate system which is aligned with the reference wing coordinate system ($x_W$, $y_W$, $z_W$). The following appendix concerned with the flow boundary condition makes use of the above equations.

# APPENDIX E

## INTERDIGITATED FINS, BOUNDARY CONDITIONS

The flow tangency condition states that the net flow velocity normal to the fin must equal zero. Besides the free-stream component, there are external contributions from the body source panels calculated by program WDYBDY and effects induced by vortices associated with the body nose and the monoplane wing calculated by subroutine VVELS in program DEMON2. For all of these external contributions, the coordinate system in which they are expressed is the body or wing reference coordinate system. Body and wing coordinate systems are parallel to one another; see figure 1. The former has its origin at the body nose while the latter has its origin on the body centerline at the axial location of the wing or fin rootchord leading edge. Thus, in order to determine the external contribution to the flow velocity normal to the fin, the components must be resolved and added as follows.

Referring to figure 1, the sidewash, $v_W$ or $v_B$ is aligned with the $y_W$ or $y_B$ axis. Upwash $w_W$ or $w_B$ is in the $z_W$ or $z_B$ direction. The component of the flow normal to the fin surface at the j'th control point ($x_{CPT,j}$, $y_{CPT,j}$, $z_{CPT,j}$) can be determined from the transformations discussed in Appendix D. For example, the normal velocity components on the right upper fin, fin 1 or fin R are obtained from

$$v_{N,j} = w_{W,j} \cos \phi_1 - v_{W,j} \sin \phi_1 \qquad \text{(E1)}$$

In this instance the fin dihedral angle $\phi_1$ equals the specified fin dihedral angle $\phi_F$ listed as PHIDIH in namelist $INPUT of routine CRFWBD in program DEMON2. Angle $\phi_F$ is also indicated in figure 3. The velocity normal to the left lower fin, fin 2 or fin L is also given by equation (E1) with fin dihedral angle $\phi_2$ taken equal to dihedral angle $\phi_F$. For the right lower fin, fin 3 or fin U, the velocity normal to the fin surface at the j'th control point is obtained from the velocity components expressed in the wing coordinate system as follows.

$$v_{N,j} = w_{W,j} \cos \phi_3 + v_{W,j} \sin \phi_3 \qquad \text{(E2)}$$

In this equation, angle $\phi_3$ is taken equal to negative specified fin dihedral angle, $-\phi_F$. The velocity normal to the left upper fin is also given by equation (E2) substituting angle $\phi_4$ for angle $\phi_3$. Angle $\phi_4$ equals negative fin dihedral angle, $-\phi_F$.

Expressions (E1) and (E2) cause the normal velocity component to be aligned with the direction of the normal load $C_N$ shown in figure 3 for each fin. The contribution from the free stream can be expressed in components directed along the wing or body coordinate system.

$$\left.\begin{aligned} W_W &= V_\infty \sin \alpha \\ V_W &= -V_\infty \sin \beta \end{aligned}\right\} \tag{E3}$$

where α is angle of pitch and β is angle of sideslip. These angles are calculated from the combined angle of attack, $\alpha_c$, and the angle of roll, φ, in accordance with the pitch-roll sequence described in the section entitled GENERAL APPROACH, equation (12).

All external contributions to the normal velocity component are added and substituted directly into equations (E1) and (E2). The sum of all the external contributions to the normal velocity at a control point on a fin must be offset by the sum of the normal velocity components induced by all constant u-velocity panels on the fins and the body interference shell. In computer program DEMON2, the contributions from the constant u-velocity panels on the fins or interference shell are determined in a coordinate system associated with the plane of the panel in question and then transformed to the wing or body coordinate system. Equations (E1) and (E2) together with the transformations discussed in Appendix D are subsequently employed to determine the normal component induced by one panel at the control point of another. The result is a set of simultaneous equations from which the unknown panel strengths can be calculated. Thickness effects from the interdigitated tail fin are not accounted for. For the case of cruciform fins, thickness effects can be accounted for and detailed expressions for the boundary condition are given in section 2 entitled GENERAL APPROACH.

# APPENDIX F

## INTERDIGITATED FINS, FORCE AND MOMENT CALCULATIONS

The following force- and moment-coefficient calculations are programmed in subroutine LOADS of program DEMON2. Each fin of an interdigitated fin configuration is dealt with separately.

Right upper fin:

Let $C_{N,j}$ be equal to the normal-force coefficient for one constant u-velocity panel with control point coordinates $x_{CPT,j}$, $y_{CPT,j}$ and $z_{CPT,j}$ specified in the wing coordinate system ($x_W$, $y_W$, $z_W$). The positive sense of the normal force is shown in figure 3. Then the components in the positive $z_W$ and $y_W$ or $z_B$ and $y_B$ directions are given by

$$\left.\begin{aligned} C_{Z,j} &= C_{N,j} \cos \phi_F \\ C_{y,j} &= -C_{N,j} \sin \phi_F \end{aligned}\right\} \tag{F1}$$

in accordance with the rotational coordinate transformation discussed in Appendix D. The pitching moment in the body coordinate system about a specified moment center (XM, 0, ZM) is defined as a moment with its axis normal to the $y_B = 0$ or $y_W = 0$ plane. Clockwise rotation about the $y_B$ or $y_W$ axis when viewing along its positive direction corresponds to positive pitching moment (positive pitching moment causes nose up). For one panel, the contribution to the pitching-moment coefficient is given by

$$C_{m,j} = -C_{z,j} \frac{(x_{CPT,j} - XM)}{\ell_{ref}} \tag{F2}$$

The yawing moment in the body coordinate system about a specified moment center (XM, 0, ZM) is defined as a moment with its axis normal to the $z_B = 0$ or $z_W = 0$ plane. Clockwise rotation about the $z_B$ or $z_W$ axis when viewing along its negative direction corresponds to positive yawing moment (nose to right is positive yawing). The contribution from one panel equals

$$C_{n,j} = -C_{y,j} \frac{(x_{CPT,j} - XM)}{\ell_{ref}} \tag{F3}$$

Rolling moment measured about the body centerline is positive if the right fin(s) move in the clockwise direction viewing upstream. Both components $C_{z,j}$ and $C_{y,j}$ contribute to the rolling-moment coefficient. Thus, the contribution from one panel is

$$C_{\ell,j} = \frac{-C_{z,j}\, y_{CPT,j} + C_{y,j}\, z_{CPT,j}}{\ell_{ref}} \tag{F4}$$

By adding all contributions from the constant u-velocity panels on the right upper fin, the total force and moment coefficients acting on that fin can be determined. Thus for the upper right fin designated Fin 1 or Fin R, the forces acting on it in the $z_W$ and $y_W$ directions, respectively, are given in coefficient form as

$$\left.\begin{aligned} C_{z,1} \text{ or } C_{z,R} &= \sum_{j=1}^{NRP} C_{N,j} \cos \phi_F \\ C_{y,1} \text{ or } C_{y,R} &= -\sum_{j=1}^{NRP} C_{N,j} \sin \phi_F \end{aligned}\right\} \tag{F5}$$

Here NRP is the number of constant u-velocity panels on the right upper fin. The pitching-, yawing- and rolling-moment coefficients are obtained from the following expressions, respectively.

$$\left.\begin{aligned} C_{m,1} \text{ or } C_{m,R} &= -\sum_{j=1}^{NRP} C_{N,j} \cos \phi_F \frac{(x_{CPT,j}-XM)}{\ell_{ref}} \\ C_{n,1} \text{ or } C_{n,R} &= \sum_{j=1}^{NRP} C_{N,j} \sin \phi_F \frac{(x_{CPT,j}-XM)}{\ell_{ref}} \\ C_{\ell,1} \text{ or } C_{\ell,R} &= -\sum_{j-1}^{NRP} \frac{(C_{N,j} \cos \phi_F y_{CPT,j} - C_{N,j} \sin \phi_F (z_{CPT,j} - ZM))}{\ell_{ref}} \end{aligned}\right\} \tag{F6}$$

The reference length $\ell_{ref}$ as well as the reference area $S_{ref}$ are specified in namelist INPUT of routine CRFWBD in program DEMON2 as REFL and SREF, respectively. Fin dihedral angle, $\phi_1$ or $\phi_R$, is defined as shown in figure 3 and equals positive angle $\phi_F$. Angles $\phi_F$ and $\theta$ are specified in namelist $INPUT in the main program CRFWBD of program DEMON2 as PHIDIH and THETIT, respectively.

Left lower fin:

All expressions shown and discussed above for the right upper fin apply except for equation (E5) which gives the forces acting on the left lower fin. They are changed to

$$\left.\begin{aligned} C_{z,2} \text{ or } C_{z,L} &= \sum_{j=NRP+1}^{NHP} C_{N,j} \cos \phi_F \\ C_{y,2} \text{ or } C_{y,L} &= -\sum_{j=NRP+1}^{NHP} C_{N,j} \sin \phi_F \end{aligned}\right\} \qquad (F7)$$

where NHP is the number of constant u-velocity panels on the right upper fin plus the number of panels on the lower left fin. Likewise, the expressions (F6) for moments become

$$\left.\begin{aligned} C_{m,2} \text{ or } C_{m,L} &= -\sum_{j=NRP+1}^{NHP} C_{N,j} \cos \phi_F \frac{(x_{CPT,j}-XM)}{\ell_{ref}} \\ C_{n,2} \text{ or } C_{n,L} &= \sum_{j=NRP+1}^{NHP} C_{N,j} \sin \phi_F \frac{(x_{CPT,j}-XM)}{\ell_{ref}} \\ C_{\ell,2} \text{ or } C_{\ell,L} &= -\sum_{j=NRP+1}^{NHP} \frac{(C_{N,j}\cos\phi_F \, y_{CPT,j} - C_{N,j}\sin\phi_F \, (z_{CPT,j}-ZM))}{\ell_{ref}} \end{aligned}\right\} \qquad (F8)$$

Note that in accordance with the convention indicated in figure 3, the dihedral angle, $\phi_2$ or $\phi_L$, associated with this fin equals positive angle $\phi_F$. Fin location angle, $\theta_{2 \text{ or } L}$, is defined as shown and equals positive angle $\theta$.

Right lower fin:

Referring again to figure 3, the dihedral angle of this fin, $\phi_3$ or $\phi_U$, equals the negative angle, $-\phi_F$. The positive sense of $C_N$ is also indicated. For this fin, the fin location angle, $\theta_3$ or $\theta_U$, equals the negative angle, $-\theta$. All expressions shown and discussed above for the right upper fin apply except equations (F5) and (F6) for which the index of the summations is changed and also accounting for the change in sign on terms involving dihedral angle $\phi_F$.

$$\left.\begin{aligned} C_{Z,3} \text{ or } C_{Z,U} &= \sum_{j=NHP+1}^{N3P} C_{N,j} \cos \phi_F \\ C_{Y,3} \text{ or } C_{Y,U} &= \sum_{j=NHP+1}^{N3P} C_{N,j} \sin \phi_F \end{aligned}\right\} \tag{F9}$$

where N3P equals the number of constant u-velocity panels on the right upper fin added to the number on the left lower fin added to the number on the lower right fin. The pitching-, yawing- and rolling-moment coefficients are

$$\left.\begin{aligned} C_{m,3} \text{ or } C_{m,U} &= -\sum_{j=NHP+1}^{N3P} C_{N,j} \cos \phi_F \frac{(x_{CPT,j} - XM)}{\ell_{ref}} \\ C_{n,3} \text{ or } C_{n,U} &= -\sum_{j=NHP+1}^{N3P} C_{N,j} \sin \phi_F \frac{(x_{CPT,j} - XM)}{\ell_{ref}} \\ C_{\ell,3} \text{ or } C_{\ell,U} &= -\sum_{j=NHP+1}^{N3P} \frac{(C_{N,j} \cos\phi_F \, Y_{CPT,j} - C_{N,j} \sin\phi_F \, (z_{CPT,j} - ZM))}{\ell_{ref}} \end{aligned}\right\} \tag{F10}$$

Left upper fin:

The dihedral angle for this fin, $\phi_4$ or $\phi_D$, and its location angle, $\theta_4$ or $\theta_D$, have the same sense as those for the right lower fin. Thus, $\phi_4$ equals negative angle, $-\phi_F$, and $\phi_4$ equals negative angle, $-\theta$. The expressions for the forces and moments acting on this fin are the same as equations (E5) and (E6) except for a change in the index and accounting for the change in sign for terms involving $\phi_F$.

$$\left.\begin{aligned} C_{Z,4} \text{ or } C_{Z,D} &= \sum_{j=N3P+1}^{NPANLS} C_{N,j} \cos \phi_F \\ C_{Y,4} \text{ or } C_{Y,D} &= \sum_{j=N3P+1}^{NPANLS} C_{N,j} \sin \phi_F \end{aligned}\right\} \qquad (F11)$$

Here, NPANLS equals the sum of the number of constant u-velocity panels on all four fins. The pitching-, yawing- and rolling-moment coefficients are given by

$$\left.\begin{aligned} C_{m,4} \text{ or } C_{m,D} &= -\sum_{j=NHP+1}^{NPANLS} C_{N,j} \cos \phi_F \frac{(x_{CPT,j}-XM)}{\ell_{ref}} \\ C_{n,4} \text{ or } C_{n,D} &= -\sum_{j=NHP+1}^{NPANLS} C_{N,j} \sin \phi_F \frac{(x_{CPT,j}-XM)}{\ell_{ref}} \\ C_{\ell,4} \text{ or } C_{\ell,D} &= -\sum_{j=NHP+1}^{NPANLS} \frac{(C_{N,j} \cos\phi_F \; y_{CPT,j} - C_{N,j} \sin\phi_F \; (z_{CPT,j}-ZM))}{\ell_{ref}} \end{aligned}\right\} \qquad (F12)$$

If the aerodynamic loading is symmetric about the vertical or $y_B = 0$ plane as is the case for an unrolled configuration with symmetric body nose vorticity, only the right upper and lower fins are considered and the overall sideforce, $C_y$, and yawing moment, $C_n$, are zero.

## BODY INTERFERENCE PANELS IN SHELL OF ELLIPTICAL CROSS SECTION, FORCE AND MOMENT CALCULATIONS

The following force and moment coefficients are computed in subroutine LOADS of program DEMON2. Let $C_{N,k}$ be equal to the normal-force coefficient for one body interference panel (a constant u-velocity panel) with control point coordinates $x_{CPT,k}$, $y_{CPT,k}$, $z_{CPT,k}$ specified in the wing coordinate system ($x_W$, $y_W$, $z_W$). The positive sense of the normal force corresponds to a force pointing outward from the body as shown in figure 3. The components in the $z_W$ and $y_W$ or $z_B$ and $y_B$ direction are given by

$$\left.\begin{aligned} C_{z,k} &= C_{N,k} \cos \theta_{2_k} \\ C_{y,k} &= C_{N,k} \sin \theta_{2_k} \end{aligned}\right\} \tag{G1}$$

when $\theta_2$ is the angle between the panel trailing edge and the $y_W$ axis. It is calculated in accordance with

$$\left.\begin{aligned} \sin \theta_{2_k} &= \frac{z_{W_{k,i}} - z_{W_{k,i-1}}}{\left[\left(z_{W_{k,i}} - z_{W_{k,i-1}}\right)^2 + \left(y_{W_{k,i}} - y_{W_{k,i-1}}\right)^2\right]^{\frac{1}{2}}} \\ \cos \theta_{2_k} &= -\frac{y_{W_{k,i}} - y_{W_{k,i-1}}}{\left[\left(z_{W_{k,i}} - z_{W_{k,i-1}}\right)^2 + \left(y_{W_{k,i}} - y_{W_{k,i-1}}\right)^2\right]^{\frac{1}{2}}} \end{aligned}\right\} \tag{G2}$$

Subscript i and i-1 refer to the two parallel panel side edges as shown in figure 3. Note that panel location angle $\theta_{BIP}$ positions the side edge designated i on the body circumference (BIP stands for body interference panel).

For the k'th body interference panel, the contribution to the pitching-moment coefficient is taken about moment center (XM, 0, ZM) and is given by

$$C_{m,k} = -C_{z,k} \frac{x_{CPT,k} - XM}{\ell_{ref}} \tag{G3}$$

where as discussed earlier in connection with the right upper fin, positive pitching corresponds to nose-up motion. The contribution to the yawing-moment coefficient from the k'th body interference panel equals

$$C_{n,k} = -C_{y,k} \frac{x_{CPT,k} - XM}{\ell_{ref}} \tag{G4}$$

where positive yawing corresponds to nose to right motion. As is the case for the interdigitated fins, both components of the normal-force coefficient contribute to the rolling-moment coefficient.

$$C_{\ell,k} = \frac{-C_{z,k}\, y_{CPT,k} + C_{y,k}(z_{CPT,k} - ZM)}{\ell_{ref}} \tag{G5}$$

By adding all contributions from all the constant u-velocity panels laid out on the interference shell, the total force and moment coefficients acting on the part of the body covered by the interference shell can be calculated. Thus, the contributions to the overall forces acting in the $z_W$ and $y_W$ directions are given in coefficient form as

$$\left.\begin{aligned} C_{z,BIP} &= \sum_{k=1}^{NBIP} C_{N,k} \cos \theta_{2_k} \\ C_{y,BIP} &= \sum_{k=1}^{NBIP} C_{N,k} \sin \theta_{2_k} \end{aligned}\right\} \tag{G6}$$

Here, the number of constant u-velocity panels in the interference shell if given by NBIP. The contributions to the overall pitching-, yawing- and rolling-moment coefficients are specified as follows, respectively.

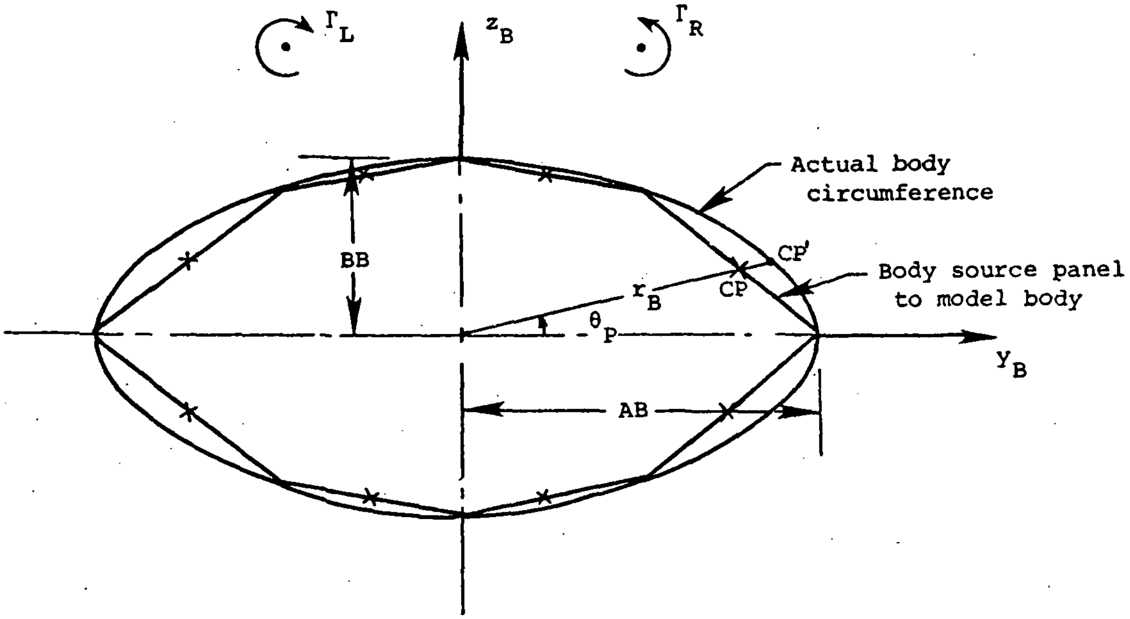
$$\left.\begin{aligned}
C_{m,BIP} &= -\sum_{k=1}^{NBIP} C_{N,k} \cos \theta_{2_k} \frac{x_{CPT,k}-XM}{\ell_{ref}} \\
C_{n,BIP} &= -\sum_{k=1}^{NBIP} C_{N,k} \sin \theta_{2_k} \frac{x_{CPT,k}-XM}{\ell_{ref}} \\
C_{\ell,BIP} &= -\sum_{k=1}^{NBIP} \frac{C_{N,k}\cos\theta_{2_k} y_{CPT,k}-C_{N,k}\sin\theta_{2_k}(Z_{CPT,k}-ZM)}{\ell_{ref}}
\end{aligned}\right\} \qquad \text{(G7)}$$

As mentioned earlier, the reference length $\ell_{ref}$ and the reference area $S_{ref}$ are specified in namelist $INPUT of routine CRFWBD in program DEMON2 as REFL and SREF, respectively.

## APPENDIX H

## EFFECTS OF EXTERNAL VORTICITY ON BODY WITH ELLIPTICAL CROSS SECTION

The sketch below shows the circumference of an elliptical body. Also indicated are eight panels in end view as an example of a sparse body paneling layout. The panels can be source panels as employed in program WDYBDY to account for body volume, angle of pitch and angle of sideslip. However, in program DEMON2, these panels are constant u-velocity panels to account for wing-body or tail fin-body interference. In either case, the panel control points designated CP in the sketch lie inside the actual body circumference. In the calculation of pressure distribution on the body, it is desired to account for external vortices at the control points. Let $\Gamma_R$ and $\Gamma_L$ be body nose vorticity idealized to two potential flow vortices.



The solution for the flow field around a body with elliptical cross section in the presence of specified external vortices is given in Appendix I. This solution is programmed in subroutine VVELS in both programs WDYBDY and DEMON2 and provides valid flow field velocities at points on and outside the body circumference. However, the control points, CP, are inside the body by virtue of the method resulting in a layout of inscribed panels. For the purpose of accounting for the presence of the vortices, their induced velocities are calculated at points CP' instead. They lie on the intersection of the body radius which contains control point CP and the body circumference. In actuality, points CP' are displaced further out a distance equal to one percent of the body radius $r_B$ in the programs using subroutine VVELS. This is done to prevent numerical problems encountered when computing velocities on the body surface if the coordinates of the body points are calculated and specified to subroutine VVELS. To accomplish this, the polar angle $\theta_P$ designated THETP in the computer program is calculated first as follows.

$$\theta_P = \tan^{-1} \frac{z_{CPT}}{y_{CPT}} \tag{H1}$$

The coordinates of a given control point CP are $x_{CPT}$, $y_{CPT}$ and $z_{CPT}$ in either the body or wing reference coordinate system. Then to determine the body radius $r_B$ at angle $\theta_P$, the equation for the ellipse is used.

$$r_B^2 = \frac{1}{\dfrac{\cos^2\theta_P}{AB^2} + \dfrac{\sin^2\theta_P}{BB^2}} \tag{H2}$$

Here AB is the horizontal semi-axis and BB is the vertical semi-axis of the elliptical cross section for given axial body station. The coordinates of the corresponding body surface point CP' displaced one percent of the radius $r_B$ outside the actual body circumference are

$$\begin{aligned} y_{CPB} &= 1.01 r_B \cos \theta_P \\ z_{CPB} &= 1.01 r_B \sin \theta_P \end{aligned} \tag{H3}$$

Thus, subroutine VVELS computes the vortex induced velocities at points CP'. These velocities are added to all other velocity component contributions calculated at the panel control points, CP. The pressure is then calculated at points CP in accordance with the Bernoulli relation, equation (10).

# APPENDIX I

## VELOCITY COMPONENTS IN CROSSFLOW PLANE REQUIRED TO CALCULATE VORTEX TRAJECTORIES

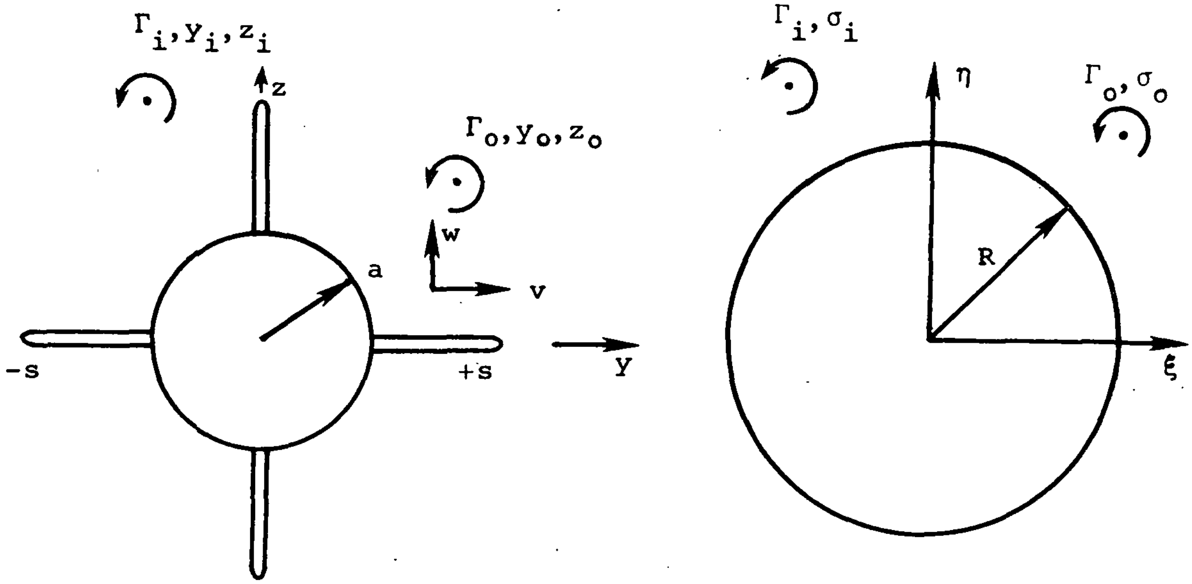
In order to calculate vortex trajectories using slender-body methods, it is necessary to know the two velocity components in the crossflow plane at the vortices. The lateral movement between two axial stations a distance $\Delta x$ apart can be calculated from these quantities. Since a number of different cross sectional shapes in the crossflow planes are of interest in the present computer program, a number of different solutions are needed. Specifically the following eight velocity fields are used.

1. *Velocity field induced in crossflow plane by a set of vortices in the presence of a cruciform wing-body combination on one member of the set.*
2. Velocity components in crossflow plane due to pitch and bank of a cruciform wing-body combination including volume effects.
3. Flow field in crossflow plane due to symmetrical deflection of two panels of a planar wing-body combination.
4. Flow field in crossflow plane due to deflection of a single panel on a cruciform wing-body combination.
5. Velocities on a vortex due to other vortices in the crossflow plane in the presence of a monoplane midwing mounted on a body of elliptical cross-section.
6. Velocity components in crossflow plane due to pitch and bank of a monoplane midwing mounted on a body of elliptical cross-section.
7. Velocities on a vortex due to other vortices in the presence of a monoplane midwing mounted on a body of elliptical cross-section including effects of angles of pitch and sideslip.
8. Velocity components in the crossflow plane due to expansion of a body with elliptical cross sections.

The expressions for all these velocity fields are given in this Appendix. Although some of the expressions have been published elsewhere, they are all being presented here for completeness and to collect the results in one place.

## 1.- Velocity Field Induced in Crossflow Plane by a Set of Vortices in the Presence of a Cruciform Wing-Body Combination on One Member of the Set

This solution is required to determine the trajectory of a vortex in the presence of a cruciform wing-body combination. The solution for v and w will be determined using slender-body theory. The following transformation of a cruciform wing-body into a circle of radius R is used.



$\tau = y + iz$ $\sigma = \xi + i\eta$

$$\tau^2 + \frac{a^4}{\tau^2} = \sigma^2 + \frac{R^4}{\sigma^2} \qquad 2R^2 = s^2 + \frac{a^4}{s^2} \tag{I1}$$

$$\sigma = \frac{1}{2}\left[\sqrt{\left(\tau^2 + \frac{a^4}{\tau^2}\right)^2 - 2R^2} + \sqrt{\left(\tau^2 + \frac{R^4}{\tau^2}\right) + 2R^2}\right] \tag{I2}$$

$$\tau = \frac{1}{2}\left[\sqrt{\left(\sigma^2 + \frac{R^4}{\sigma^2}\right)^2 - 2a^2} + \sqrt{\left(\sigma^2 + \frac{R^4}{2}\right) + 2R^2}\right] \tag{I3}$$

The potential for one vortex in the presence of the circle in the σ plane is

$$W_1(\sigma) = \frac{-i\Gamma_o}{2\pi}\,\ell n\,(\sigma - \sigma_o) + \frac{i\Gamma_o}{2\pi}\,\ell n\left(\sigma - \frac{R^2}{\bar{\sigma}_o}\right) \tag{I4}$$

We omit center vortices to keep the solution regular for large $\sigma$. The complex potential for the set of vortices is

$$W_t(\sigma) = \frac{-i\Gamma_o}{2\pi} \ln(\sigma-\sigma_o) + \frac{i\Gamma_o}{2\pi} \ln\left(\sigma - \frac{R^2}{\bar{\sigma}_o}\right) - \frac{i}{2\pi}\sum_{i=1}^{N} \Gamma_i \ln\left[\frac{\sigma - \sigma_i}{\left(\sigma - \frac{R^2}{\bar{\sigma}_i}\right)}\right] \tag{I5}$$

The complex potential in the $\tau$ plane is given by equation (I5) with the substitution $\sigma = \sigma(\tau)$.

Consider now the complex potential for the motion of vortex $\Gamma_o$ in the $\tau$ plane.

$$W_{\Gamma_o}(\tau) = W_t(\sigma(\tau)) + \frac{i\Gamma_o}{2\pi} \ln(\tau - \tau_o) \tag{I6}$$

The velocity components of $\Gamma_o$ in the $\tau$ plane are

$$v_o - iw_o = \frac{d}{d\tau} W_{\Gamma_o}(\tau)\bigg|_{\tau=\tau_o} \tag{I7}$$

$$\frac{d}{d\tau} W_{\Gamma_o}(\tau) = \frac{d}{d\tau}\left[\frac{-i\Gamma_o}{2\pi} \ln\left(\frac{\sigma-\sigma_o}{\tau-\tau_o}\right)\right] + \frac{d}{d\tau}\left[\frac{i\Gamma_o}{2\pi} \ln\left(\sigma - \frac{R^2}{\bar{\sigma}_o}\right)\right] - \frac{i}{2\pi}\frac{d}{d\tau}\sum \Gamma_i \ln\left[\frac{\sigma - \sigma_i}{\sigma - \frac{R^2}{\bar{\sigma}_i}}\right] \tag{I8}$$

It is shown (ref. 4) that

$$\frac{d}{d\tau} \ln\left(\frac{\tau-\tau_o}{\sigma-\sigma_o}\right)\bigg|_{\tau\to\tau_o} = \lim_{\tau\to\tau_o}\left[\frac{1}{\tau-\tau_o} - \frac{1}{(\sigma-\sigma_o)}\frac{d\sigma}{d\tau}\right]$$

$$\sigma-\sigma_o = (\tau-\tau_o)\left(\frac{d\sigma}{d\tau}\right)_{\tau_o} + \frac{1}{2}(\tau-\tau_o)^2 \frac{d^2\sigma}{d\tau^2}\bigg|_{\tau_o}$$

$$\frac{d\sigma}{d\tau} = \left(\frac{d\sigma}{d\tau}\right)_{\tau_o} + (\tau-\tau_o)\frac{d^2\sigma}{d\tau^2}\bigg|_{\tau_o} \tag{I9}$$

$$\frac{1}{\tau-\tau_o} - \frac{1}{(\sigma-\sigma_o)}\frac{d\sigma}{d\tau} = \frac{1}{\sigma-\sigma_o}\left(\frac{\sigma-\sigma_o}{\tau-\tau_o} - \frac{d\sigma}{d\tau}\right)$$

$$= \frac{1}{\sigma-\sigma_o}\left[\left(\frac{d\sigma}{d\tau}\right)_{\tau_o} + \frac{1}{2}(\tau-\tau_o)\left.\frac{d^2\sigma}{d\tau^2}\right|_{\tau_o} - \left.\frac{d\sigma}{d\tau}\right|_{\tau_o} - (\tau-\tau_o)\left.\frac{d^2\sigma}{d\tau^2}\right|_{\tau_o} \cdots\right]$$

$$= -\frac{1}{2}\left(\frac{\tau-\tau_o}{\sigma-\sigma_o}\right)\left.\frac{d^2\sigma}{d\tau^2}\right|_{\tau_o} \tag{I10}$$

$$\lim_{\tau\to\tau_o}\left(\frac{d}{d\tau}\right)\left[\ell n\left(\frac{\tau-\tau_o}{\sigma-\sigma_o}\right)\right] = -\frac{1}{2}\left(\frac{d\tau}{d\sigma}\right)_{\tau_o}\left(\frac{d^2\sigma}{d\tau^2}\right)_{\tau_o} \tag{I11}$$

$$v_o - iw_o = \frac{i\Gamma_o}{2\pi}\left[-\frac{1}{2}\left(\frac{d\tau}{d\sigma}\right)\frac{d^2\sigma}{d\tau^2}\right]_{\tau_o} + \frac{i\Gamma_o}{2\pi}\,\frac{\bar{\sigma}_o}{\sigma_o\bar{\sigma}_o - R^2}\left(\frac{d\sigma}{d\tau}\right)_{\tau_o}$$

$$- \frac{i}{2\pi}\sum_{i=1}^{N}\Gamma_i\left(\frac{1}{\sigma_o-\sigma_i} - \frac{\bar{\sigma}_i}{\sigma_o\bar{\sigma}_i - R^2}\right)\left(\frac{d\sigma}{d\tau}\right)_{\tau_o} \tag{I12}$$

$$\frac{d\sigma}{d\tau} = \frac{\frac{1}{2}\left(\tau^3 - \frac{a^4}{\tau}\right)\left[\sqrt{\left(\tau^2+\frac{a^4}{\tau^2}\right)+2R^2} + \sqrt{\left(\tau^2+\frac{a^4}{\tau^2}\right)-2R^2}\right]}{\sqrt{\left(\tau^2+\frac{a^4}{\tau^2}\right)^2 - 4R^4}} \tag{I13}$$

Equations (I1), (I2) and (I3) yield the following relationships.

$$\frac{d\sigma}{d\tau} = \frac{(\tau^4 - a^4)\sigma^3}{\tau^3(\sigma^4 - R^4)} \tag{I14}$$

$$\frac{d^2\sigma}{d\tau^2} = \frac{\sigma^3(\tau^4 + 3a^4)}{(\sigma^4 - R^4)\tau^4} - \frac{\sigma^5(\tau^4 - a^4)^2(\sigma^4 + 3R^4)}{\tau^6(\sigma^4 - R^4)^3} \tag{I15}$$

$$\frac{d\tau}{d\sigma}\,\frac{d^2\sigma}{d\tau^2} = \frac{\tau^2(\sigma^4 - R^4)^2(\tau^4 + 3a^4) - \sigma^2(\tau^4 - a^4)^2(\sigma^4 + 3R^4)}{\tau^3(\sigma^4 - R^4)^2(\tau^4 - a^4)} \tag{I16}$$

With these results, we find the desired velocity

$$v_o - iw_o = \frac{-i\Gamma_o}{4\pi} \frac{\left[\tau_o^2\left(\sigma_o^4 - R_o^4\right)^2\left(\tau^4 + 3a^4\right) - \sigma_o^2\left(\tau_o^4 - a^4\right)^2\left(\sigma_o^4 + 3R^4\right)\right]}{\tau_o^3\left(\sigma_o^4 - R^4\right)^2\left(\tau_o^4 - a^4\right)}$$

$$+ \frac{i\Gamma_o}{2\pi} \frac{\bar{\sigma}_o}{\left(\sigma_o\bar{\sigma}_o - R^2\right)} \frac{\left(\tau_o^4 - a^4\right)\sigma_o^3}{\tau_o^3\left(\sigma_o^4 - R^4\right)}$$

$$- \frac{i}{2\pi} \frac{(\tau_o^4 - a^4)(\sigma_o^3)}{\tau_o^3\left(\sigma_o^4 - R^4\right)} \sum_{i=1}^{N} \Gamma_i \left[\frac{1}{\sigma_o - \sigma_i} - \frac{\bar{\sigma}_i}{\sigma_o\bar{\sigma}_i - R^2}\right] \qquad \text{(I17)}$$

where

$\Gamma_o$ = strength of vortex, the velocity components of which are being calculated

$v_o, w_o$ = velocity component of vortex $\Gamma_o$

$\Gamma_i$ = strength of any vortex except $\Gamma_o$; $i=1,2,\ldots N$

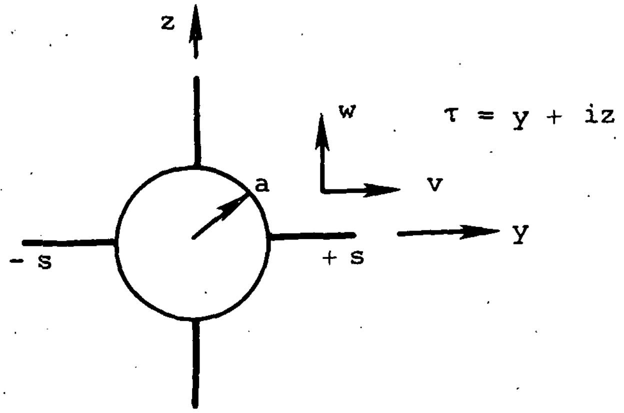
$\tau_o$ = position of $\Gamma_o$ in $\tau$ plane

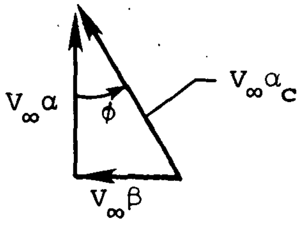
$\sigma_o$ = position of $\Gamma_o$ in $\sigma$ plane

$\sigma_i$ = position of $\Gamma_i$ in $\sigma$ plane

## 2.- Velocity Components in Crossflow Plane Due to Pitch and Bank of a Cruciform Wing-Body Combination Including Volume Effects

For a pitched and banked cruciform missile the induced flow field can be obtained by superimposing two planar missile flow fields at right angles





The flow field about a planar wing-body with horizontal wings is described by complex potential $W_\alpha$ corresponding to $V_\infty \cos\phi \sin\alpha_c$ along the positive axis of z. The complex potential $W_\beta$ is associated with velocity $-V_\infty \sin\phi \sin\alpha_c$ along the negative axis of y. The total potential is then

$$\frac{W(\tau)}{V_\infty} = b_o(x) + a\left(\frac{da}{dx}\right) \ell n\, \tau + W_\alpha(\tau) + W_\beta(\tau) \qquad \text{(I18)}$$

If $\phi = 0$, the perturbation complex potential is given in equation 5.3 of reference 8. Using the small angle approximation:

$$\frac{W(\tau)}{V_\infty} = b_o(x) + a\left(\frac{da}{dx}\right) \ell n\, \tau - i\alpha\left\{\left[\left(\tau + \frac{a^2}{\tau}\right)^2 - \left(s + \frac{a^2}{s}\right)^2\right]^{\frac{1}{2}} - \tau\right\} \qquad \text{(I19)}$$

The velocity v-iw for $\phi = 0$ is then

$$\frac{v-iw}{V_\infty} = \frac{1}{V_\infty}\frac{dW}{d\tau} = a\left(\frac{da}{dx}\right)\frac{1}{\tau} + i\alpha$$

$$\frac{-\, i\alpha\ (\tau^4 - a^4)s}{\tau^2\sqrt{\left(\tau^2 - s^2\right)\left(\tau^2 s^2 - a^4\right)}}\ ;\ \phi = 0 \qquad \text{(I20)}$$

and

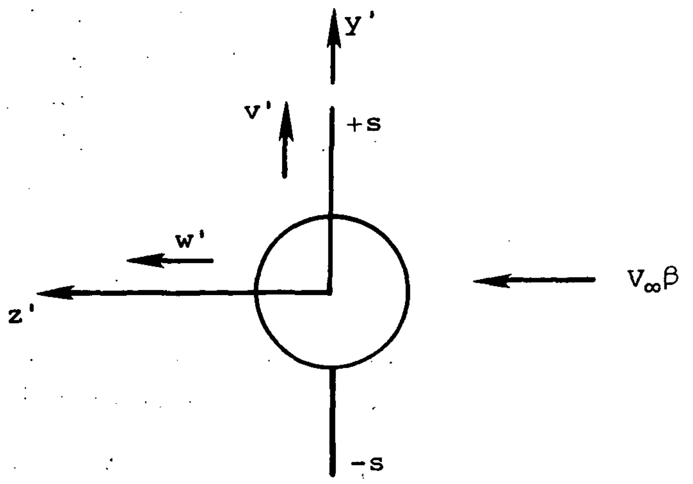
$$v-iw \to 0 \quad \text{as} \quad \tau \to \infty$$

The perturbation velocity $v_\infty - iw_\alpha$ associated with the velocity component $V_\infty\alpha$ is

$$\frac{v_\alpha - iw_\alpha}{V_\infty} = \frac{-\, i\alpha\ (\tau^4 - a^4)s}{\tau^2\sqrt{\left(\tau^2 - s^2\right)\left(\tau^2 s^2 - a^4\right)}} + i\alpha \qquad \text{(I21)}$$

From this expression we can determine the perturbation velocity $v_\beta - iw_\beta$ associated with the velocity $V_\infty\beta$ along the negative axis of y.

Consider a set of coordinates y' and z' as shown with velocity components v' and w' with $\tau' = -i\tau$.



The perturbation velocity v'-iw' is given analogous to equation (I21) as

$$\frac{v'-iw'}{V_\infty} = \frac{-\,i\beta\,(\tau'^4 - a^4)s}{\tau'^2\sqrt{\left(\tau'^2 - s^2\right)\left(\tau'^2 s^2 - a^4\right)}} + i\beta$$

$$= \frac{-\,i\beta\,(\tau^4 - a^4)s}{\tau^2\sqrt{\left(\tau^2 + s^2\right)\left(\tau^2 s^2 + a^4\right)}} + i\beta \qquad \text{(I22)}$$

$$-i(v'-iw') = v_\beta - iw_\beta = \frac{-\,\beta\,(\tau^4 - a^4)s}{\tau^2\sqrt{\left(\tau^2 + s^2\right)\left(\tau^2 s^2 + a^4\right)}} + \beta \qquad \text{(I23)}$$

It is possible to add $v_\beta - iw_\beta$ to the results of equation (I20) for $\phi = 0$ to obtain the total complex potential for the cruciform wing-body combination since the sum satisfies the boundary condition. Accordingly we have the final result

$$v-iw = a\left(\frac{da}{dx}\right)\left(\frac{1}{\tau}\right) + i\alpha + \beta - \frac{i\alpha\,(\tau^4 - a^4)s}{\tau^2\sqrt{\left(\tau^2 - s^2\right)\left(\tau^2 s^2 - a^4\right)}}$$

$$- \frac{\beta\,(\tau^4 - a^4)s}{\tau^2\sqrt{\left(\tau^2 + s^2\right)\left(\tau^2 s^2 + a^4\right)}} \qquad \text{(I24)}$$

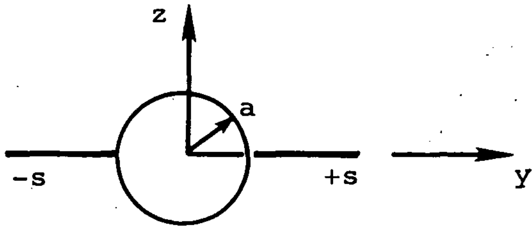
## 3.- Flow Field in Crossflow Plane Due to Symmetrical Deflection of Two Panels of a Planar Wing-Body Combination

### 3.1 Introduction

In determining the perturbation velocity components in the flow field of a cruciform wing-body combination, we must have flow field solutions (1) for no fin deflection at $\alpha \neq 0$, (2) for symmetrical fin deflection of opposing panels at $\alpha = 0$, and (3) for the deflection of a single fin of a cruciform configuration at $\alpha = 0$. The first two flow fields for a cruciform wing-body can be formed by superimposing solutions for a planar wing-body combination at right angles to each other. The first solution is given in the preceding sections; the second solution is the subject of this section, and the third solution is the subject of the next section.

### 3.2 Boundary Value Problem

Consider a planar wing-body combination with a circular body of radius a and a fin of total semispan s.



$\tau = y + iz$

The left and right fins are deflected trailing edge down by an angular deflection $\delta$ such that the normal velocity on the fins due to the free stream is $V_\infty \delta$. The complex velocity in the crossflow plane is $v + iw$. We have to find perturbation velocity components $u,v,w$ at a point $x,y,z$ in the crossflow plane. The complex variable in the crossflow plane is $\tau = y + iz$.

### 3.3. Method of Solution

Let $W(\tau)$ be the complex potential for crossflow about the wing-body combination in the crossflow plane at $x$ = constant. Let the missile cross section in the $\tau$ plane be transformed to a circle of radius $R_o$ in the $\sigma$ plane. We will find a complex potential $W(\sigma)$ which when transformed back to the $\tau$ plane satisfies the boundary condition in this plane. If

$$\begin{aligned} \frac{dW}{d\sigma} &= V - iW \\ \frac{dW}{d\tau} &= v-iw = (V - iW)\left(\frac{d\sigma}{d\tau}\right) \end{aligned} \tag{I25}$$

The transformation taking the missile cross section into the circle of radius $R_o$ is

$$\tau + \frac{a^2}{\tau} = \sigma + \frac{R_o^2}{\sigma} \tag{I26}$$

with

$$2R_o = s + \frac{a^2}{s} \tag{I27}$$

where a is the body radius and s the fin semispan. In this transformation the field far from the cross section is undistorted. The reciprocal relationships between corresponding points in the $\sigma$ and $\tau$ planes are obtained from the equations for the upper half plane

$$\sigma = \frac{1}{2}\left(\tau + \frac{a^2}{\tau}\right) + \frac{1}{2}\sqrt{\left(\tau + \frac{a^2}{\tau}\right)^2 - 4R_o^2} \tag{I28}$$

$$\tau = \frac{1}{2}\left(\sigma + \frac{R_o^2}{\sigma}\right) + \frac{1}{2}\sqrt{\left(\sigma + \frac{R_o^2}{\sigma}\right)^2 - 4a^2} \tag{I29}$$

On the circle $\sigma = R_o e^{i\theta}$, we have

$$\tau = R_o \cos\theta + R_o\sqrt{\cos^2\theta - \frac{a^2}{R_o^2}} \tag{I30}$$

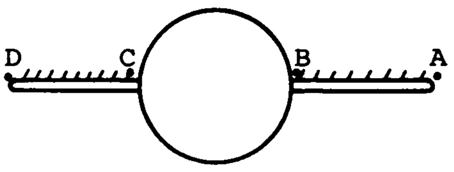
If $\theta = 0°$

$$\tau = s \tag{I31}$$

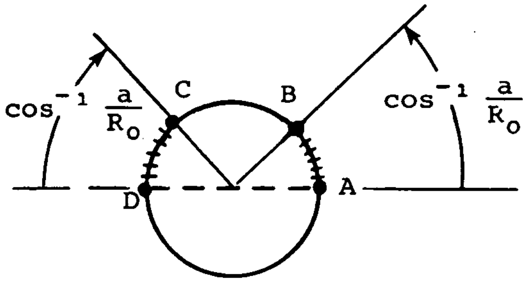
If $\cos\theta = a/R_o$, then

$$\tau = a \tag{I32}$$

These points are shown in the following sketch



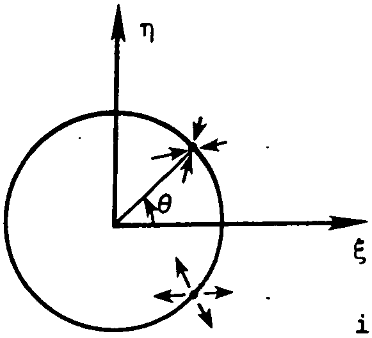
τ Plane



σ Plane

## 3.4 Complex Potential

To obtain the complex potential, we follow a variation of the method of Adams and Dugan (ref. 21). Consider points on the upper and lower surfaces of the right wing at the same y location between y = a and y = s.



Let the corresponding points in the σ plane be $R_o e^{i\theta_o}$ and $R_o e^{-i\theta_o}$.

Let a sink of strength dm exist at the point $R_o e^{i\theta_o}$ and a source of opposite strength exist at $R_o e^{-i\theta_o}$. The complex potential due to the sum of these two singularities is

$$dW_R = -\frac{dm}{2\pi}\,\ell n\left(\frac{\sigma - R_o e^{i\theta_o}}{\sigma - R_o e^{i\theta_o}}\right) \tag{I33}$$

The circle $R_o e^{i\theta}$ is a streamline of the flow except at the singular points. In the τ plane an amount of fluid dm/2 enters the fin from above and an amount of fluid dm/2 goes out beneath the fin. Since the upwash through the fin $\delta V_\infty$ must be countered by the source-sink combination, we have

$$dm = 2\delta V_\infty dy \tag{I34}$$

Accordingly the complex potential due to the right fin is

$$W_R = -\frac{\delta V_\infty}{\pi} \int_a^s \ell n \left[\frac{\frac{\sigma}{R_o} - e^{i\theta_o}}{\frac{\sigma}{R_o} - e^{-i\theta_o}}\right] dy \tag{I35}$$

For the left fin, we have by analogy

$$dW_L = -\frac{dm}{\pi} \ell n \left[\frac{\sigma - R_o e^{i(\pi-\theta_o)}}{\sigma - R_o e^{i(\pi+\theta_o)}}\right]$$

$$= -\frac{dm}{2\pi} \ell n \left[\frac{\sigma - R_o e^{-i\theta_o}}{\sigma + R_o e^{i\theta_o}}\right]$$

$$W_L = -\frac{\delta V_\infty}{\pi} \int_{-s}^{-a} \ell n \left[\frac{\sigma + R_o e^{-i\theta_o}}{\sigma + R_o e^{i\theta_o}}\right] dy \tag{I36}$$

$$W_R + W_L = -\frac{\delta V_\infty}{\pi} \int_a^s \ell n \frac{\left[\sigma - R_o e^{i\theta_o}\right]\left[\sigma + R_o e^{-i\theta_o}\right]}{\left[\sigma - R_o e^{-i\theta_o}\right]\left[\sigma + R_o e^{i\theta_o}\right]}$$

$$W = -\frac{\delta V_\infty}{\pi} \int_a^s \ell n \left[\frac{\sigma^2 - R_o^2 - 2iR_o\sigma \sin\,\theta_o}{\sigma^2 - R_o^2 + 2iR_o\sigma \sin\,\theta_o}\right] dy \tag{I37}$$

To solve equation (I37) for $W(\sigma)$, we first assume that $\sigma$ is real, and integrate equation (I37) on this basis. We then invoke the principle of analytic continuation, and assume the result is valid for $\sigma$ complex. The complex velocity in the $\tau$ plane is determined by

$$v - iw = \frac{dW}{d\sigma}\frac{d\sigma}{d\tau} \tag{I38}$$

and it can be examined to make sure it satisfies the boundary conditions. Setting

$$\frac{\sigma^2 - R_o^2}{2R_o\sigma} = \lambda \tag{I39}$$

$$W = -\frac{\delta V_\infty}{\pi}\int_a^s \ell n\left[\frac{\lambda - i\sin\theta_o}{\lambda + i\sin\theta_o}\right] dy \tag{I40}$$

Integrating by parts

$$W = -\frac{\delta V_\infty}{\pi}\left[-a\,\ell n\left|\frac{\lambda - i\sqrt{1 - \frac{a^2}{R_o^2}}}{\lambda + i\sqrt{1 - \frac{a^2}{R_o^2}}}\right| + i\int_a^s \frac{y\,d(\sin\theta_o)}{\lambda - i\sin\theta_o} + i\int_a^s \frac{y\,d(\sin\theta_o)}{\lambda + i\sin\theta_o}\right] \tag{I41}$$

Let

$$I_1 = \int_a^s \frac{y\,d(\sin\theta_o)}{\lambda - i\sin\theta_o}$$

$$I_2 = \int_a^s \frac{y\,d(\sin\theta_o)}{\lambda + i\sin\theta_o}$$

With the help of subsequent results in section 3.6 for $I_1 + I_2$, we obtain

$$W(\sigma,a,R_o) = -\frac{\delta V_\infty}{\pi}\left\{-a\,\ell n\left|\frac{\lambda - i\sqrt{1 - \frac{a^2}{R_o^2}}}{\lambda + i\sqrt{1 + \frac{a^2}{R_o^2}}}\right|\right.$$

(equation continued on next page)

$$- 2iR_o\sqrt{\lambda^2 + 1}\,\tan^{-1}\left(\frac{\sqrt{\lambda^2 + 1}}{\lambda}\,\frac{\sqrt{1 - \frac{a^2}{R_o^2}}}{\frac{a}{R_o}}\right)$$

$$\left. - iR_o\pi\sqrt{\lambda^2 + 1 - \frac{a^2}{R_o^2}} + 2\lambda R_o i\left[\frac{\pi}{2} + \cos^{-1}\left(\frac{a}{R_o}\right)\right]\right\} \qquad \text{(I42)}$$

## 3.5 Crossflow Velocity Components

Having the complex potential, we may now obtain the velocity components in the σ plane and the τ plane.

$$V - iW = \frac{dW}{d\lambda}\left(\frac{d\lambda}{d\sigma}\right) \qquad \text{(I43)}$$

We will carry out the differentiation

$$\ell n\left(\frac{\lambda - i\sqrt{1 - \frac{a^2}{R_o^2}}}{\lambda + i\sqrt{1 - \frac{a^2}{R_o^2}}}\right) = \left(-2i\,\tan^{-1}\frac{\sqrt{1 - \frac{a^2}{R_o^2}}}{\lambda}\right) \qquad \text{(I44)}$$

$$\frac{d}{d\lambda}\,\ell n\left(\frac{\lambda - i\sqrt{1 - \frac{a^2}{R_o^2}}}{\lambda + i\sqrt{1 - \frac{a^2}{R_o^2}}}\right) = \frac{+\,2i\sqrt{1 - \frac{a^2}{R_o^2}}}{\lambda^2 + 1 - \frac{a^2}{R_o^2}} \qquad \text{(I45)}$$

$$\frac{d\lambda}{d\sigma} = \frac{\sigma^2 + R_o^2}{2R_o\sigma^2} \qquad \lambda = \frac{\sigma^2 - R_o^2}{2R_o\sigma} \qquad \text{(I46)}$$

Thus

$$\frac{d}{d\sigma}\,\ell n\left(\frac{\lambda - i\sqrt{1 - \frac{a^2}{R_o^2}}}{\lambda + i\sqrt{1 - \frac{a^2}{R_o^2}}}\right) = \frac{4iR_o\left(\sigma^2 + R_o^2\right)\sqrt{1 - \frac{a^2}{R_o^2}}}{\left(\sigma^2 + R_o^2\right)^2 - 4a^2\sigma^2} \tag{I47}$$

The other differentiation yields

$$\begin{aligned}\frac{d}{d\sigma}\left[\sqrt{\lambda^2 + 1}\,\tan^{-1}\left(\frac{\sqrt{\lambda^2 + 1}}{\lambda}\,\frac{\sqrt{1 - \frac{a^2}{R_o^2}}}{\frac{a}{R_o}}\right)\right] &= \frac{2(\sigma^2 + R_o^2)a\sqrt{1 - \frac{a^2}{R_o^2}}}{(\sigma^2 + R_o^2)^2 - 4a^2\sigma^2} \\ &+ \frac{(\sigma^2 - R_o^2)}{2R_o\sigma^2}\,\tan^{-1}\left[\left(\frac{\sigma + R_o^2}{\sigma^2 - R_o^2}\right)\left(\frac{\sqrt{1 - \frac{a^2}{R_o^2}}}{\frac{a}{R_o}}\right)\right]\end{aligned} \tag{I48}$$

$$\frac{d}{d\sigma}\,\sqrt{\lambda^2 + 1 - \frac{a^2}{R_o^2}} = \frac{\sigma^4 - R_o^4}{2R_o\sigma^2}\,\frac{1}{\sqrt{(\sigma^2 + R_o^2)^2 - 4a^2\sigma^2}}$$

The expression in complex form for V - iW is

$$\begin{aligned}V - iW = -\frac{\delta V_\infty}{\pi}\Bigg\{&-\frac{4iaR_o(\sigma^2 + R_o^2)\sqrt{1 - \frac{a^2}{R_o^2}}}{(\sigma^2 + R_o^2)^2 - 4a^2\sigma^2} - \frac{4iaR_o(\sigma^2 + R_o^2)\sqrt{1 - \frac{a^2}{R_o^2}}}{(\sigma^2 + R_o^2)^2 - 4a^2\sigma^2} \\ &- \frac{i(\sigma^2 - R_o^2)}{\sigma^2}\,\tan^{-1}\left[\left(\frac{\sigma^2 + R_o^2}{\sigma^2 - R_o^2}\right)\left(\frac{\sqrt{1 - \frac{a^2}{R_o^2}}}{\frac{a}{R_o}}\right)\right]\end{aligned}$$

(equation continued on next page)

$$- \frac{i\pi}{2\sigma^2} \frac{(\sigma^4 - R_o^4)}{\sqrt{(\sigma^2 + R_o^2)^2 - 4a^2\sigma^2}} + \frac{i(\sigma^2 + R_o^2)}{\sigma^2} \left[\frac{\pi}{2} + \cos^{-1}\left(\frac{a}{R_o}\right)\right]\Bigg\} \tag{I49}$$

We now determine v - iw in the τ plane

$$v - iw = (V - iW)\,\frac{d\sigma}{d\tau} \tag{I50}$$

From the transformation we find the following relationships

$$\left.\begin{aligned} \frac{d\sigma}{d\tau} &= \frac{\sigma^2}{(\sigma^2 - R_o^2)} \frac{(\tau^2 - a^2)}{\tau^2} \\ \frac{\sigma^2 + R_o^2}{\sigma} &= \tau + \frac{a^2}{\tau} \\ \frac{\sigma^2 - R_o^2}{\sigma} &= \sqrt{\left(\tau + \frac{a^2}{\tau}\right)^2 - 4R_o^2} \end{aligned}\right\} \tag{I51}$$

The following results are needed to accomplish the transformation of the results to the τ plane

$$\begin{aligned} \frac{\sigma^2 + R_o^2}{(\sigma^2 + R_o^2)^2 - 4a^2\sigma^2} \left(\frac{d\sigma}{d\tau}\right) &= \frac{\dfrac{\sigma^2 + R_o^2}{\sigma}}{\left(\dfrac{\sigma^2 + R_o^2}{\sigma}\right)^2 - 4a^2} \frac{\sigma}{(\sigma^2 - R_o^2)} \left(\frac{\tau^2 - a^2}{\tau^2}\right) \\ &= \frac{\left(\tau + \dfrac{a^2}{\tau}\right)}{\left[\left(\tau + \dfrac{a^2}{\tau}\right)^2 - 4a^2\right]} \frac{1}{\sqrt{\left(\tau + \dfrac{a^2}{\tau}\right)^2 - 4R_o^2}} \left(\frac{\tau^2 - a^2}{\tau^2}\right) \\ &= \frac{(\tau^2 + a^2)}{(\tau^2 - a^2)\sqrt{(\tau^2 + a^2)^2 - 4R_o^2\tau^2}} \end{aligned} \tag{I52}$$

Since

$$\frac{\sigma^2 - R_o^2}{\sigma^2}\,\frac{d\sigma}{d\tau} = \left(\frac{\tau^2 - a^2}{\tau^2}\right) \tag{I53}$$

we find

$$\left(\frac{d\sigma}{d\tau}\right)\left(\frac{\sigma^2 - R_o^2}{\sigma^2}\right)\tan^{-1}\left[\left(\frac{\sigma^2 + R_o^2}{\sigma^2 - R_o^2}\right)\frac{\sqrt{1 - \frac{a^2}{R_o^2}}}{\frac{a}{R_o}}\right] = \left(\frac{\tau^2 - a^2}{\tau^2}\right)\tan^{-1}\left[\frac{(\tau^2 + a^2)\sqrt{1 - \frac{a^2}{R_o^2}}}{\left(\frac{a}{R_o}\right)\sqrt{(\tau^2 + a^2)^2 - 4R_o^2\tau^2}}\right] \tag{I54}$$

$$\frac{\sigma^4 - R_o^4}{\sigma^2\sqrt{(\sigma^2 + R_o^2)^2 - 4a^2\sigma^2}}\left(\frac{d\sigma}{d\tau}\right) = \frac{(\tau^2 + a^2)}{\tau^2} \tag{I55}$$

$$\frac{\sigma^2 + R_o^2}{\sigma^2}\,\frac{d\sigma}{d\tau} = \frac{\tau^4 - a^4}{\tau^2\sqrt{(\tau^2 + a^2)^2 - 4R_o^2\tau^2}} \tag{I56}$$

These results yield the complex velocity in the τ plane.

$$(v - iw) = \frac{\delta V_\infty}{\pi}\left\{ i\left(\frac{\tau^2 - a^2}{\tau^2}\right)\tan^{-1}\left[\frac{(\tau^2 + a^2)\sqrt{1 - \frac{a^2}{R_o^2}}}{\left(\frac{a}{R_o}\right)\sqrt{(\tau^2 + a^2)^2 - 4R_o^2\tau^2}}\right]\right.$$

(equation continued on next page)

$$\left. + i\left(\frac{\pi}{2}\right) \frac{\tau^2 + a^2}{\tau^2} - \frac{i}{\sqrt{(\tau^2 + a^2)^2 - 4R_o^2\tau^2}} \left(\frac{\tau^4 - a^4}{\tau^2}\right) \left[\frac{\pi}{2} + \cos^{-1}\left(\frac{a}{R_o}\right)\right] \right\} \tag{I57}$$

The expression can be broken down into real and imaginary parts to obtain v and w, but is probably more convenient to obtain v - iw on the computer using complex calculations.

### 3.6 Evaluation of Certain Definite Integrals

The following integrals are to be evaluated

$$I_1 = \int_{\sqrt{1-a^2/R_o^2}}^{o} \frac{y\, d(\sin\theta)}{\lambda - i\sin\theta} \tag{I58}$$

$$I_2 = \int_{\sqrt{1-a^2/R_o^2}}^{o} \frac{y\, d(\sin\theta)}{\lambda + i\sin\theta} \tag{I59}$$

where

$$y = R_o\left[\cos\theta + \sqrt{1 - \frac{a^2}{R_o^2} - \sin^2\theta}\right] \tag{I60}$$

We want the sum $I_1 + I_2$ in particular

$$I_1 + I_2 = 2\lambda R_o \int_{\sqrt{1-a^2/R_o^2}}^{o} \frac{1}{\lambda^2 + \sin^2\theta}\left(\cos\theta + \sqrt{1 - \frac{a^2}{R_o^2} - \sin^2\theta}\right) d(\sin\theta) \tag{I61}$$

$$= 2\lambda R_o \left[ (1 + \lambda^2) \int_{\cos^{-1}a/R_o}^{o} \frac{d\theta}{(\lambda^2 + \sin^2\theta)} - \int_{\cos^{-1}a/R_o}^{o} d\theta \right.$$

(equation continued on next page)

$$+\left(1-\frac{a^2}{R_o^2}+\lambda^2\right)\int_{\sqrt{1-a^2/R_o^2}}^{0}\frac{d(\sin\theta)}{(\lambda^2+\sin^2\theta)\sqrt{1-\frac{a^2}{R_o^2}-\sin^2\theta}}$$

$$-\int_{\sqrt{1-a^2/R_o^2}}^{0}\frac{d(\sin\theta)}{\sqrt{1-\frac{a^2}{R_o^2}-\sin^2\theta}}\Bigg] \qquad \text{(I62)}$$

(Concluded)

We now integrate each of the four separate integrals. From pg. 323 in reference 19.

$$\int_{\cos^{-1}(a/R_o)}^{0}\frac{d\theta}{\left(\lambda^2+\sin^2\theta\right)}=\frac{1}{\sqrt{\lambda^2(\lambda^2+1)}}\tan^{-1}\left[\frac{\sqrt{\lambda^2(\lambda^2+1)}\tan\theta}{\lambda^2}\right]\Bigg|_{\cos^{-1}(a/R_o)}^{0}$$

$$=-\frac{1}{\lambda\sqrt{\lambda^2+1}}\tan^{-1}\left[\frac{\sqrt{\lambda^2+1}}{\lambda}\,\frac{\sqrt{1-\frac{a^2}{R_o^2}}}{\left(\frac{a}{R_o}\right)}\right] \qquad \text{(I63)}$$

$$\int_{\cos^{1}(a/R_o)}^{0}d\theta=-\cos^{-1}\left(\frac{a}{R_o}\right) \qquad \text{(I64)}$$

The third integral can be evaluated with the help of the following result from page 55 in reference 20.

$$\int\frac{dx}{(\lambda^2+x^2)\sqrt{\nu^2-x^2}}=\frac{1}{\lambda\sqrt{\lambda^2+\nu^2}}\tan^{-1}\frac{x\sqrt{\lambda^2+\nu^2}}{\lambda\sqrt{\nu^2-x^2}}+C \qquad \text{(I65)}$$

$$\int_{\sqrt{1-a^2/R_o^2}}^{0}\frac{d(\sin\theta)}{(\lambda^2+\sin^2\theta)\sqrt{1-\frac{a^2}{R_o^2}-\sin^2\theta}}=\frac{1}{\lambda\sqrt{\lambda^2+1-\frac{a^2}{R_o^2}}}$$

$$\tan^{-1}\left[\frac{\sqrt{\lambda^2+1-\frac{a^2}{R_o^2}}\,\sin\theta}{\lambda\sqrt{1-\frac{a^2}{R_o^2}-\sin^2\theta}}\right]\Bigg|_{\sqrt{1-a^2/R_o^2}}^{0} = -\left(\frac{\pi}{2}\right)\frac{1}{\lambda\sqrt{\lambda^2+1-\frac{a^2}{R_o^2}}} \qquad \text{(I66)}$$

The fourth integral is

$$\int_{\sqrt{1-a^2/R_o^2}}^{0}\frac{d(\sin\theta)}{\sqrt{1-\frac{a^2}{R_o^2}-\sin^2\theta}} = \sin^{-1}\left(\frac{\sin\theta}{\sqrt{1-\frac{a^2}{R_o^2}}}\right)\Bigg|_{\sqrt{1-a^2/R_o^2}}^{0}$$

$$= -\frac{\pi}{2} \qquad \text{(I67)}$$

Finally we have

$$I_1 + I_2 = 2\lambda R_o\left\{-\frac{\sqrt{\lambda^2+1}}{\lambda}\tan^{-1}\left[\frac{\sqrt{\lambda^2+1}}{\lambda}\,\frac{\sqrt{1-\frac{a^2}{R_o^2}}}{\frac{a}{R_o}}\right]\right.$$

$$\left. + \cos^{-1}\left(\frac{a}{R_o}\right) - \frac{\pi}{2}\left[\frac{\sqrt{\lambda^2+1-\frac{a^2}{R_o^2}}}{\lambda}\right] + \frac{\pi}{2}\right\} \qquad \text{(I68)}$$

## 4.- Flow Field in Crossflow Plane Due to Deflection of a Single Panel on a Cruciform Wing-Body Combination

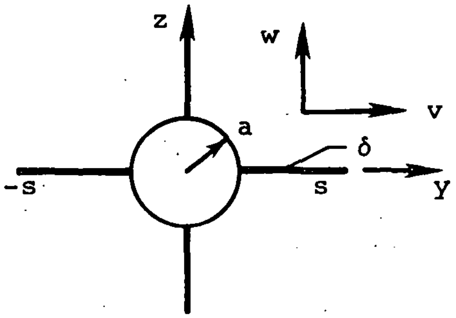
### 4.1 Introduction

For a cruciform wing-body with no panel deflection, the flow field based on slender-body theory is given in section 2. However, the general flow field due to panel deflection is not known. From the results for single panel deflection, the effect of arbitrary deflections of all four panels can be obtained by superposition. This result will now be derived.

### 4.2 Boundary Value Problem

Consider the cross section of a cruciform wing-body combination at zero roll angle and zero angle of attack but with the right fin deflected by angle, $\delta$, positive trailing edge down. The crossflow plane is designated by the complex variable

$$\tau = y + iz$$



The body radius is "a" and the fin semispan is "s". The vector velocity in the crossflow plane is $v + iw$, and the axial component of velocity is "u". Let the right panel be deflected by the angle $\delta$ so that free-stream velocity $V_\infty$ causes an uniform upwash $V_\infty \sin\,\delta$ through the fin. We must find a potential $\phi$ which produces equal and opposite downwash on the right fin and at the same time causes no flow normal to the other fins or the body. We then are to find the flow velocity components u and w at points x,y,z in the field due to this potential. The quantities a and s can be functions of x.

## 4.3 Method of Solution

The method of solution is to find the complex potential W which produces unit velocity at a given point on the deflected wing in the range $a \leq y \leq s$ and zero at all other points. Then the effect of all such fundamental solutions over the range is summed by integration. The fundamental solution is that given by Adams and Dugan in reference 21. The velocity components are found by differentiation of W.

In obtaining the solution, recourse will be had to the theory of conformal transformation. In this connection let the cross-section of the cruciform wing-body combination in the $\tau$ plane be transformed into a circle of radius R in the $\sigma$ plane with

$$\sigma = \xi + i\eta \tag{I69}$$

Such a transformation is given as

$$\tau^2 + \frac{a^4}{\tau^2} = \sigma^2 + \frac{R^4}{\sigma^2} \tag{I70}$$

with

$$2R^2 = s^2 + \frac{a^4}{s^2} \tag{I71}$$

The reciprocal relationships between points in the τ and σ planes are

$$\left.\begin{aligned} \sigma &= \frac{1}{2}\sqrt{\left(\tau^2 + \frac{a^4}{\tau^2}\right) - 2R^2} + \sqrt{\left(\tau^2 + \frac{a^4}{\tau^2}\right) + 2R^2} \\ \tau &= \frac{1}{2}\sqrt{\left(\sigma^2 + \frac{R^4}{\sigma^2}\right) - 2a^2} + \sqrt{\left(\sigma^2 + \frac{R^4}{\sigma^2}\right) + 2a^2} \end{aligned}\right\} \tag{I72}$$

In these relationships we confine our attention to the upper half plane. In equation (I70) we have put the fields at ∞ into the identity relationship

$$\sigma \to \tau \quad \text{as} \quad \tau \to \infty \tag{I73}$$

A point $Re^{i\theta_o}$ on the circle $Re^{i\theta}$ corresponds to $y_o$ in the physical plane. From equation (I70)

$$2R^2 \left(\frac{e^{2i\theta_o} + e^{-2i\theta_o}}{2}\right) = y_o^2 + \frac{a^4}{y_o^2} \tag{I74}$$

so that

$$\frac{y_o^2}{R^2} = \cos 2\theta_o + \sqrt{\left(\cos 2\theta_o - \frac{a^2}{R^2}\right)\left(\cos 2\theta_o + \frac{a^2}{R^2}\right)} \tag{I75}$$

and

$$\frac{y_o}{R} = \frac{1}{\sqrt{2}}\left[\sqrt{\cos 2\theta_o - \frac{a^2}{R}} + \sqrt{\cos 2\theta_o + \frac{a^2}{R}}\right] \tag{I76}$$

If $y_o = s$, then from equation (I74) and (I71)

$$2R^2 \cos 2\theta_o = 2R^2$$

or

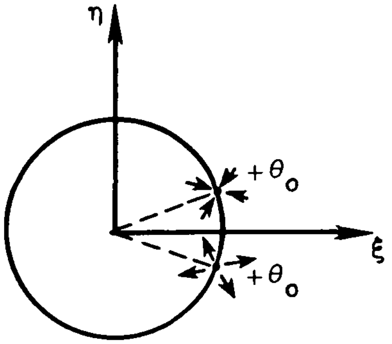
$$\theta_o = 0; \quad y = s \tag{I77}$$

Let the point $Re^{i\gamma}$ correspond in the $\sigma$ plane to $y = a$ in the $\tau$ plane. Then from equation (I74)

$$\cos 2\gamma = \frac{a^2}{R^2} \tag{I78}$$

## 4.4 Complex Potential

To obtain the complex potential for the fundamental solution, we follow the method of Adams and Dugan. Consider points on the upper and lower surfaces of the wing at $y = y_o$ and consider a sink of strength dm at $Re^{i\theta_o}$ and a source at point $Re^{-i\theta_o}$ in the $\sigma$ plane, corresponding to the two points at $y=y_o$ in the $\tau$ plane.



The complex potential for the sink is (assuming dm is positive)

$$dW_1 = -\frac{dm}{2\pi} \ell n(\sigma - Re^{i\theta_o})$$

and for the pair, we have

$$dW = \frac{-dm}{2\pi} \ell n \left(\frac{\sigma - Re^{i\theta_o}}{\sigma - Re^{-i\theta_o}}\right) \tag{I79}$$

It can be shown that the circle

$$\sigma = Re^{i\theta}$$

is a streamline of the complex potential given by equation (I79) although the points $Re^{i\theta_o}$ and $Re^{-i\theta_o}$ are singular points since many streamline converge at these points, with a net mass flow through the circle at these points. Since $\phi$ and $\psi$ are equal at corresponding points in the $\tau$ and $\sigma$ planes in the conformal transformation of the flow, we can evaluate $\psi$ on the wing panel in the $\tau$ plane. Let the velocity components in the

$\tau$ plane be v and w. Then on the wing panel

$$\frac{d\psi_o}{dy_o} = -w = +\ \delta V_\infty; \qquad a \le y_o \le s \tag{I80}$$

Now since only half the source or sink flow passes through the fin

$$\frac{dm}{2} = \delta V_\infty dy \tag{I81}$$

and we have

$$dm = 2d\psi_o = 2\delta V_\infty dy_o \tag{I82}$$

Now summing all sources and sinks along both sides of the right panel between $a \le y_o \le s$, we have

$$W = -\frac{1}{\pi}\int_{\psi(a)}^{\psi(s)} \ell n\left(\frac{\sigma - Re^{i\theta_o}}{\sigma - Re^{-i\theta_o}}\right) d\psi_o \tag{I83}$$

*Integrating by parts, yields*

$$W(\sigma) = \frac{\psi(\gamma)}{\pi}\,\ell n\left(\frac{\sigma - Re^{i\gamma}}{\sigma - Re^{-i\gamma}}\right) - \frac{1}{\pi}\int_0^\gamma \psi(\theta_o)\,\frac{d}{d\theta_o}\left[\ell n\left(\frac{\sigma - Re^{+i\theta_o}}{\sigma - Re^{-i\theta_o}}\right)\right] d\theta_o$$

$$W(\sigma) = \frac{\psi(\gamma)}{\pi}\,\ell n\left(\frac{\sigma - Re^{+i\gamma}}{\sigma - Re^{-i\gamma}}\right) - \frac{2iR}{\pi}\int_0^\gamma \frac{(\sigma\cos\theta_o - R)\psi(\theta_o)d\theta_o}{\sigma^2 - 2\sigma R\cos\theta_o + R^2} \tag{I84}$$

We now evaluate $\psi_o$ by integrating equation (I80)

$$\psi_o = \delta V_\infty y_o + k \tag{I85}$$

where k is an arbitrary constant which we will set equal to zero. We thus find the complex potential

$$W(\sigma) = \frac{\delta V_\infty}{\pi}\left\{ a\ \ell n\left(\frac{\sigma - Re^{i\gamma}}{\sigma - Re^{i\gamma}}\right) - i\sqrt{2}\,R^2\int_0^\gamma \frac{(\sigma\cos\theta_o - R)\left[\sqrt{\cos 2\theta_o - \frac{a^2}{R^2}} + \sqrt{\cos 2\theta_o + \frac{a^2}{R^2}}\right]}{(\sigma^2 - 2\sigma R\cos\theta_o + R^2)}\, d\theta_o \right\} \tag{I86}$$

The expression of equation (I86) is the one which will be used to determine u, v and w. Several approaches are possible. First we might consider $\sigma$ as a real quantity, and integrate equation (I86) to obtain $W(\sigma)$. Then invoking the principle of analytical continuation, we would assume $\sigma$ was complex again, and separate $W(\sigma)$ into $\phi$ and $\psi$. Differentiation of $\phi$ then leads to u, v, and w. This approach was tried and the part of the second integral involving $\sqrt{\cos 2\theta_o - a^2/R^2}$ yields complete elliptical integrals of the third kind. The second part involving $\sqrt{\cos 2\theta_o + a^2/R^2}$ yields incomplete elliptic integrals of the third kind. To separate such an incomplete elliptic integral into real and imaginary parts was considered too formidable a task so that an alternate approach was decided. In this approach $W(\sigma)$ is differentiated, and an expression for $V - iW$ is obtained. Complex integration then yields V and W, the velocity components in the $\sigma$ plane.

## 4.5 Determination of V and W

We will determine V, and W by carrying out the operation

$$V - iW = \frac{dW}{d\sigma} \tag{I87}$$

on equation (I86) and evaluating the complex integral. Carrying out the operations yields

$$\frac{V - iW}{\delta V_\infty/\pi} = \frac{a}{\sigma - Re^{i\gamma}} - \frac{a}{\sigma - Re^{-i\gamma}}$$

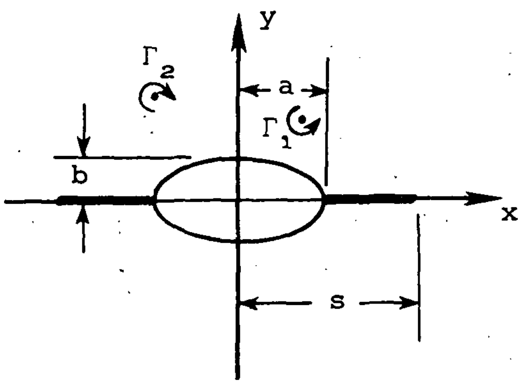
$$+ i\sqrt{2}\, R^2 \int_0^{\gamma} \frac{\left[(\sigma^2+R^2)\cos\theta_o - 2R\sigma\right]\left[\sqrt{\cos 2\theta_o + a^2/R^2} + \sqrt{\cos 2\theta_o - a^2/R^2}\right] d\theta_o}{(\sigma^2 - 2\sigma R\cos\theta_o + R^2)^2} \tag{I88}$$

Equation (I88) is solved numerically.

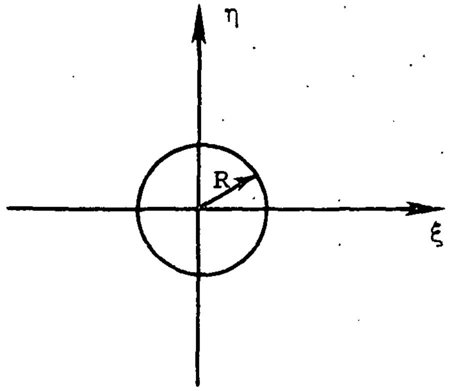
## 5.- Velocities on a Vortex Due to Other Vortices in the Crossflow Plane in the Presence of a Monoplane Midwing Mounted on a Body of Elliptic Cross-Section

### 5.1 Conformal Mapping

As the first step in the analysis, we transform the elliptical configuration into a circle of radius R.



real plane: $Z = x + iy$

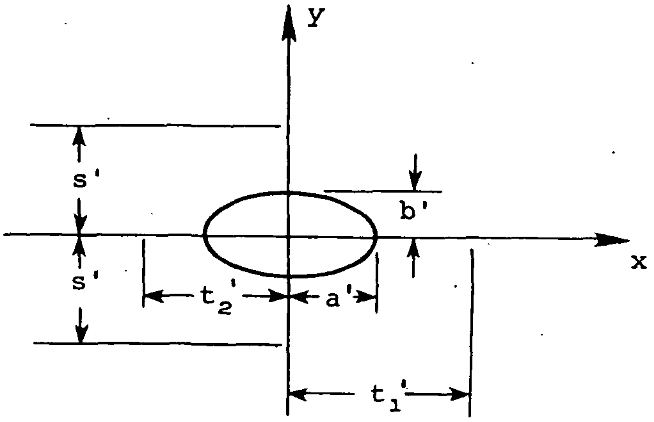


transformed plane: $\zeta = \xi + i\eta$

Bryson (ref. 22) has presented the desired conformal mapping for an elliptical body with wings and vertical tail. Bryson's configuration is rotated 90° from the present one. The conformal mapping for the configuration shown below is:

$$Z = w + \frac{a'^2 - b'^2}{4w} \tag{I89}$$

$$\left[w + \frac{(a' + b')^2}{4w}\right]^2 = \left[\frac{h-f}{2} + \zeta + \frac{(h+f)^2}{16\zeta}\right]^2 - k^2 \tag{I90}$$



where

$$k = \sigma - \left[\frac{(a' + b')^2}{4\sigma}\right] \tag{I91}$$

$$h^2 = k^2 + \left[\tau_1 + \frac{(a' + b')^2}{4\tau_1}\right]^2 \tag{I92}$$

$$f^2 = k^2 + \left[\tau_2 + \frac{(a' + b')^2}{4\tau_2}\right]^2 \tag{I93}$$

and

$$\sigma = \frac{1}{2}\left(s' + \sqrt{s'^2 + a'^2 - b'^2}\right) \tag{I94}$$

$$\tau_1 = \frac{1}{2}\left(t_1' + \sqrt{t_1'^2 - a'^2 + b'^2}\right) \tag{I95}$$

$$\tau_2 = \frac{1}{2}\left(t_2' + \sqrt{t_2'^2 - a'^2 + b'^2}\right) \tag{I96}$$

For a configuration consisting of a monoplane midwing attached to the body with elliptical cross section (i.e. no vertical surfaces), we get the following special results.

$$t_1' = t_2' = s \tag{I97}$$

$$a' = a \tag{I98}$$

$$b' = b \tag{I99}$$

$$s' = b' = b \tag{I100}$$

In addition, we obtain

$$\tau_1 = \tau_2 = \frac{1}{2}\left\{s + \sqrt{s^2 - a^2 + b^2}\right\} \tag{I101}$$
$$= \tau$$

$$\sigma = \frac{1}{2}(b + a) \tag{I102}$$

$$k = \frac{1}{2}(a + b) - \frac{(a + b)^2}{2(a + b)} = 0 \tag{I103}$$

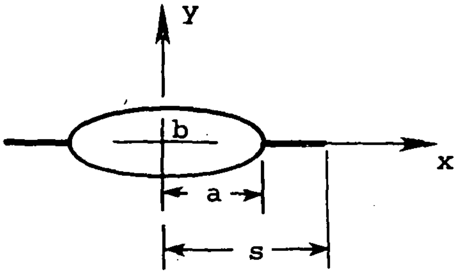
$$h = f = \tau + \frac{\sigma^2}{\tau} \tag{I104}$$

The required conformal mapping without the tail fins is

$$Z = w + \frac{a^2 - b^2}{4w} \tag{I105}$$

with

$$w + \frac{\sigma^2}{w} = \zeta + \frac{(h/2)^2}{\zeta} \tag{I106}$$



where

$$\sigma = \frac{1}{2}(a + b) \tag{I107}$$

$$h = \tau + \frac{\sigma^2}{\tau} \tag{I108}$$

$$\tau = \frac{1}{2}\left\{s + \sqrt{s^2 - a^2 + b^2}\right\} \tag{I109}$$

The radius of the circle in the transformed plane is

$$R = \frac{h}{2} = \frac{1}{4}\left[s + \sqrt{s^2 - a^2 + b^2} + \frac{(a + b)^2}{s + \sqrt{s^2 - a^2 + b^2}}\right] \tag{I110}$$

From equation (I106)

$$w = \frac{1}{2}\left\{\zeta + \frac{(h/2)^2}{\zeta} \pm \sqrt{\left[\zeta + \frac{(h/2)^2}{\zeta}\right]^2 - (a + b)^2}\right\} \tag{I111}$$

also, from equation (I105)

$$w = \frac{1}{2}\left[z + \sqrt{z^2 - a^2 + b^2}\right] \qquad \text{(I112)}^*$$

and, from equation (I106)

$$\zeta = \frac{1}{2}\left[w + \frac{\sigma^2}{w} \pm \sqrt{\left(w + \frac{\sigma^2}{w}\right)^2 - h^2}\right] \qquad \text{(I113)}^*$$

The choice of signs in equations (I111) and (I113) will now be addressed. When evaluating these equations, use of the positive (+) sign will produce the correct result if the square root function is evaluated properly. The rule to follow in evaluating the square roots, is that the result should be a complex quantity in the same quadrant as the complex quantity appearing in the argument. This is particularly important if the original quantity is a negative real number. Thus, if:

$$\zeta + \frac{(h/2)^2}{\zeta} = -A$$

Then,

$$\left[\zeta + \frac{(h/2)^2}{\zeta}\right]^2 - (a + b)^2 = A^2 - (a + b)^2$$

Assuming $A^2 >> (a + b)^2$, the square root of this is positive, and $\approx \pm A$. Then, for equation (I111)

$$w \approx \frac{1}{2}[-A \pm A] = 0$$

This does not follow from equation (I106) which suggests that if $\zeta + \frac{(h/2)^2}{\zeta}$ is large, then w should also be large. Thus, the proper solution of the square root would use the negative sign. In complex notation:

$$\zeta + \frac{(h/2)^2}{\zeta} = Ae^{i\pi}$$

Therefore,

---

[*] For body with elliptical cross section it can be shown that $w = \zeta$. Set $s = a$ in equation (I110), then compare equations (I111) and (I113).

$$\left[\zeta + \frac{(h/2)^2}{\zeta}\right]^2 - (a+b)^2 = A^2 e^{i2\pi} - (a+b)^2$$

$$= \left[A^2 - (a+b)^2\right] e^{i2\pi}$$

so that

$$\left[\zeta + \frac{(h/2)^2}{\zeta}\right]^2 - (a+b)^2 = \sqrt{A^2 - (a+b)^2}\; e^{i\pi}$$

$$= -\sqrt{A^2 - (a+b)^2}$$

## 5.2 Velocity of Vortex in Plane of Elliptical Wing-Body

In the circle plane, the complex potential for a set of vortices in the presence of the circle of radius R is given by equation (I5) as follows

$$W_1(\zeta) = -\frac{i}{2\pi}\Gamma_0 \,\ell n\,(\zeta - \zeta_0) + \frac{i}{2\pi}\Gamma_0 \,\ell n \left(\zeta - \frac{R^2}{\bar{\zeta}_0}\right)$$

$$- \frac{i}{2\pi}\sum_{j=1}^{N}\Gamma_j \,\ell n \left(\frac{\zeta - \zeta_j}{\zeta - \frac{R^2}{\bar{\zeta}_j}}\right) \qquad \text{(I114)}$$

To find the motion of vortex $\Gamma_0$ in the Z plane the proper complex potential must take account of the fact that $\Gamma_0$ induces no velocity on itself

$$W_{\Gamma_0}(Z) = W_1\left[\zeta(Z)\right] + \frac{i\Gamma_0}{2\pi}\,\ell n\,(Z - Z_0) \qquad \text{(I115)}$$

The velocity of the vortex at $Z_0$ is then:

$$v_0 - iw_0 = \lim_{Z\to Z_0}\left\{\frac{d}{dZ}\left[W_{\Gamma_0}(Z)\right]\right\} \qquad \text{(I116)}$$

Equation (I116) yields

$$\frac{d}{dZ}\left[W_{\Gamma_0}(Z)\right] = \frac{d}{dZ}\left[-\frac{i}{2\pi}\,\Gamma_0\,\ell n\left(\frac{\zeta - \zeta_0}{Z - Z_0}\right)\right] + \frac{d}{dZ}\left[\frac{i\Gamma_0}{2\pi}\,\ell n\left(\zeta - \frac{R^2}{\bar{\zeta}_0}\right)\right]$$

$$- \frac{i}{2\pi}\,\frac{d}{dZ}\sum_{j=1}^{N} \Gamma_j\;\ell n\left(\frac{\zeta - \zeta_j}{\zeta - \frac{R^2}{\bar{\zeta}_j}}\right) \qquad \text{(I117)}$$

The first term presents a problem which must be resolved by the following limiting process

$$- \frac{i\Gamma_0}{2\pi}\,\frac{d}{dZ}\left[\ell n\left(\frac{\zeta - \zeta_0}{Z - Z_0}\right)\right] = - \frac{i\Gamma_0}{2\pi}\left[\frac{Z - Z_0}{\zeta - \zeta_0}\right]\left[\frac{1}{Z - Z_0}\,\frac{d\zeta}{dZ} - \frac{\zeta - \zeta_0}{(Z - Z_0)^2}\right]$$

$$= \frac{i\Gamma_0}{2\pi}\left[\frac{1}{Z - Z_0} - \frac{1}{\zeta - \zeta_0}\,\frac{d\zeta}{dZ}\right] \qquad \text{(I118)}$$

Expand $\zeta$ in a Taylor series about $Z_0$.

$$\zeta = \zeta(Z)$$

$$\zeta - \zeta_0 = (Z - Z_0)\left.\frac{d\zeta}{dZ}\right|_{Z_0} + \frac{1}{2}\,(Z - Z_0)^2\left.\frac{d^2\zeta}{dZ^2}\right|_{Z_0}$$

$$+ \frac{1}{6}\,(Z - Z_0)^3\left.\frac{d^3\zeta}{dZ^3}\right|_{Z_0} + 0(Z - Z_0)^4$$

$$\frac{d\zeta}{dZ} - \left.\frac{d\zeta}{dZ}\right|_{Z_0} = (Z - Z_0)\left.\frac{d^2\zeta}{dZ^2}\right|_{Z_0} + \ldots \qquad \text{(I119)}$$

Then

$$\frac{\zeta - \zeta_0}{Z - Z_0} = \left.\frac{d\zeta}{dZ}\right|_{Z_0} + \frac{1}{2}\,(Z - Z_0)\left.\frac{d^2\zeta}{dZ^2}\right|_{Z_0} + \frac{1}{6}\,(Z - Z_0)^2\left.\frac{d^3\zeta}{dZ^3}\right|_{Z_0}$$

$$+ 0(Z - Z_0)^3 \qquad \text{(I120)}$$

Applying the limiting process to equation (I118), the result is

$$\lim_{Z\to Z_0}\left\{-\frac{i\Gamma_0}{2\pi}\frac{d}{dZ}\left[\ln\frac{\zeta-\zeta_0}{Z-Z_0}\right]\right\} = \frac{i\Gamma_0}{2\pi}\lim_{Z\to Z_0}\frac{1}{(\zeta-\zeta_0)}\left[\frac{(\zeta-\zeta_0)}{Z-Z_0}-\frac{d\zeta}{dZ}\right]$$

$$= \frac{i\Gamma_0}{2\pi}\lim_{Z\to Z_0}\frac{1}{\zeta-\zeta_0}\left[\frac{1}{2}(Z-Z_0)\frac{d^2\zeta}{dZ^2}\bigg|_{Z_0} + \frac{1}{6}(Z-Z_0)^2\frac{d^3\zeta}{dZ^3}\bigg|_{Z_0} + \cdots - (Z-Z_0)\frac{d^2\zeta}{dZ^2}\bigg|_{Z_0} - \cdots\right] \tag{I121}$$

by substitution from equation (I119) and (I120). Since

$$\lim_{Z\to Z_0}\frac{Z-Z_0}{\zeta-\zeta_0} = \frac{dZ}{d\zeta}\bigg|_{Z_0} \tag{I122}$$

we finally obtain for the first term

$$\lim_{Z\to Z_0}\left\{-\frac{i\Gamma_0}{2\pi}\frac{d}{dZ}\left[\ln\left(\frac{\zeta-\zeta_0}{Z-Z_0}\right)\right]\right\} = -\frac{i\Gamma_0}{2\pi}\frac{dZ}{d\zeta}\bigg|_{Z_0}\frac{d^2\zeta}{dZ^2}\bigg|_{Z_0} \tag{I123}$$

Carrying out the remaining differentiation yields an expression for the velocity at vortex $\Gamma_0$ due to the other vortices

$$v_0 - iw_0 = -\frac{i\Gamma_0}{4\pi}\frac{dZ}{d\zeta}\bigg|_{Z_0}\frac{d^2\zeta}{dZ^2}\bigg|_{Z_0} + \frac{i\Gamma_0}{2\pi}\frac{\bar{\zeta}_0}{\zeta_0\bar{\zeta}_0 - R^2}\frac{d\zeta}{dZ}\bigg|_{Z_0} - \frac{i}{2\pi}\sum_{j=1}^{N}\Gamma_j\left[\frac{1}{\zeta_0-\zeta_j} - \frac{\bar{\zeta}_j}{\zeta_0\bar{\zeta}_j - R^2}\right]\frac{d\zeta}{dZ}\bigg|_{Z_0} \tag{I124}$$

## 5.3 Evaluation of Certain Derivatives

We now evaluate the derivatives $\frac{dZ}{d\zeta}$ and $\frac{d^2\zeta}{dZ^2}$ required in equation (I124). From equations (I105) and (I111)

$$\frac{dZ}{d\zeta} = \frac{dZ}{dw}\,\frac{dw}{d\zeta} = \frac{1}{2}\left[1 - \frac{a^2 - b^2}{4w^2}\right]\left[1 - \frac{R^2}{\zeta^2}\right]\left[1 + \frac{\zeta + \frac{R^2}{\zeta}}{\sqrt{\left(\zeta + \frac{R^2}{\zeta}\right)^2 - (a + b)^2}}\right] \qquad \text{(I125)}$$

From equations (I112) and (I113)

$$\frac{d\zeta}{dZ} = \frac{d\zeta}{dw}\,\frac{dw}{dZ} = \frac{1}{2}\left[1 - \frac{\sigma^2}{w^2}\right]\left[1 + \frac{w + \frac{\sigma^2}{w}}{\sqrt{\left(w + \frac{\sigma^2}{w}\right)^2 - h^2}}\right]\frac{dw}{dZ} \qquad \text{(I126)}$$

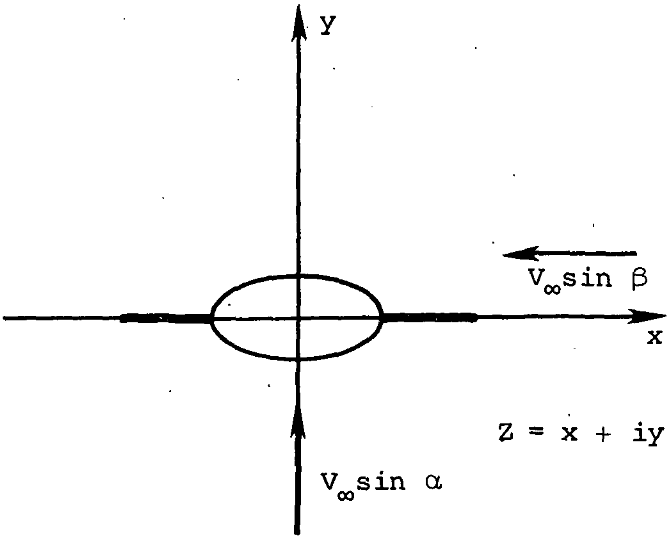
$$\frac{dw}{dZ} = \frac{1}{2}\left(1 + \frac{Z}{\sqrt{Z^2 - a^2 + b^2}}\right) \qquad \text{(I127)}$$

For the second derivative, we thus find

$$\begin{aligned}
\frac{d^2\zeta}{dZ^2} &= \frac{d}{dZ}\left[\frac{d\zeta}{dZ}\right] = \frac{dw}{dZ}\,\frac{d}{dw}\left[\frac{d\zeta}{dZ}\right] \\
&= \left(\frac{dw}{dZ}\right)^2 \frac{d}{dw}\left[\frac{1}{2}\left(1 - \frac{\sigma^2}{w^2}\right)\left(1 + \frac{w + \frac{\sigma^2}{w}}{\sqrt{\left(w + \frac{\sigma^2}{w}\right)^2 - h^2}}\right)\right] \qquad \text{(I128)} \\
&= \left(\frac{dw}{dZ}\right)^2 \left[\frac{\sigma^2}{w^3}\left(1 + \frac{w + \frac{\sigma^2}{w}}{\sqrt{\left(w + \frac{\sigma^2}{w}\right)^2 - h^2}}\right)\right. \\
&\qquad \left. - \frac{1}{2}\left(1 - \frac{\sigma^2}{w^2}\right)^2 \frac{1}{\sqrt{\left(w + \frac{\sigma^2}{w}\right)^2 - h^2}}\left(\frac{h^2}{\left(w + \frac{\sigma^2}{w}\right)^2 - h^2}\right)\right]
\end{aligned}$$

## 6.- Velocity Components in the Crossflow Plane Due to Pitch and Bank of a Monoplane Midwing Mounted on a Body of Elliptical Cross Section

The sketch below shows a monoplane wing mounted on a body with elliptical cross section. The upwash is $V_\infty \sin \alpha$ and the sidewash is $V_\infty \sin \beta$ in the negative x-direction.



Consider the transformation of the wing-body combination into a circle of radius R in the $\zeta$ plane as described in section 5.1. For the pitch flow, the complex potential in the $\zeta$ plane is:

$$W_\alpha(\zeta) = - i V_\infty \sin \alpha \left(\zeta - \frac{R^2}{\zeta}\right) \tag{I129}$$

The velocity in the Z plane is then

$$v_\alpha - iw_\alpha = \frac{dw}{dZ} = \frac{dw_\alpha}{d\zeta} \frac{d\zeta}{dZ}$$

or

$$v_\alpha - iw_\alpha = i V_\infty \sin \alpha \left(1 + \frac{R^2}{\zeta^2}\right) \frac{d\zeta}{dZ} \tag{I130}$$

For the sideslip flow the complex potential in the $\zeta$ plane is

$$
\begin{aligned}
W_\beta(\zeta) &= - i \, V_\infty \sin \beta \, e^{-i\frac{\pi}{2}} \left( \zeta - \frac{R^2 e^{i\pi}}{\zeta} \right) \\
&= - V_\infty \sin \beta \left( \zeta + \frac{R^2}{\zeta} \right)
\end{aligned}
\qquad \text{(I131)}
$$

The associated velocity components in the Z plane are given by

$$
v_\beta - i w_\beta = - V_\infty \sin \beta \left( 1 - \frac{R^2}{\zeta^2} \right) \frac{d\zeta}{dZ} \qquad \text{(I132)}
$$

## 7.- Velocities on a Vortex Due to Other Vortices in the Presence of a Monoplane Midwing Mounted on a Body of Elliptical Cross-Section Including Effects of Angles of Pitch and Sideslip

We follow the same conformal transformation described in section 5.1. The complete potential for the flow in the $\zeta$ plane is

$$
\begin{aligned}
W[\zeta(Z)] = &- i \, V_\infty \sin \alpha \left( \zeta - \frac{R^2}{\zeta} \right) + V_\infty \sin \beta \left( \zeta + \frac{R^2}{\zeta} \right) \\
&- \frac{i}{2\pi} \Gamma_0 \, \ell n \left( \frac{\zeta - \zeta_0}{Z - Z_0} \right) + \frac{i}{2\pi} \Gamma_0 \, \ell n \left( \zeta - \frac{R^2}{\bar{\zeta}_0} \right) \\
&- \frac{i}{2\pi} \sum_{j=i}^{N} \Gamma_j \, \ell n \left( \frac{\zeta - \zeta_j}{\zeta - \frac{R^2}{\bar{\zeta}_j}} \right)
\end{aligned}
\qquad \text{(I133)}
$$

and the velocity at $Z_0$ is:

$$
\begin{aligned}
v_0 - i w_0 = &- i \, V_\infty \sin \alpha \left( 1 + \frac{R^2}{\zeta_0^2} \right) \frac{d\zeta}{dZ}\bigg|_{Z_0} + V_\infty \sin \beta \left( 1 - \frac{R^2}{\zeta_0^2} \right) \frac{d\zeta}{dZ}\bigg|_{Z_0} \\
&- \frac{i\Gamma_0}{4\pi} \frac{dZ}{d\zeta}\bigg|_{Z_0} \frac{d^2\zeta}{dZ^2}\bigg|_{Z_0} + \frac{i\Gamma_0}{2\pi} \frac{\bar{\zeta}_0}{\zeta_0 \bar{\zeta}_0 - R^2} \frac{d\zeta}{dZ}\bigg|_{Z_0}
\end{aligned}
$$

(equation continued on next page)

$$- \frac{i}{2\pi} \sum_{j=1}^{N} \Gamma_j \left[ \frac{1}{\zeta_0 - \zeta_j} - \frac{\overline{\zeta}_j}{\zeta_0 \overline{\zeta}_j - R^2} \right] \frac{d\zeta}{dZ}\bigg|_{Z_0} \tag{I134}$$

The derivatives $\frac{dZ}{d\zeta}$ and $\frac{d^2\zeta}{dZ^2}$ are given in section 5.3.

## 8.- Velocity Components in the Crossflow Plane Due to Expansion of a Body With Elliptical Cross Sections

Assume that the expansion occurs with constant a/b ratio. Equation (4-30) of reference 8 gives the desired complex potential

$$W_1(Z) = \frac{S'}{2\pi} \ln \frac{Z + \sqrt{Z^2 - a^2 + b^2}}{2} \tag{I135}$$

$$S = \pi \, ab$$

$$a = a(x)$$

$$b = b(x)$$

If $\frac{a}{b} = 1/k$ then $S = \pi k a^2$ and $S' = 2\pi k a a' = 2\pi k a \frac{da}{dx}$ .

Carrying out the differentiation yields the velocity components.

$$v - iw = \frac{dw}{dZ} = \frac{S'}{2\pi} \frac{2}{Z + \sqrt{Z^2 - a^2 + b^2}} \left( \frac{1}{2} + \frac{2Z}{2(2)\sqrt{Z^2 - a^2 + b^2}} \right)$$

$$= \frac{S'}{2\pi} \frac{1}{Z + \sqrt{Z^2 - a^2 + b^2}} \left( \frac{\sqrt{Z^2 - a^2 + b^2} + Z}{\sqrt{Z^2 - a^2 + b^2}} \right)$$

$$= \frac{S'}{2\pi} \frac{1}{\sqrt{Z^2 - a^2 + b^2}} \tag{I136}$$

# APPENDIX J

## DESCRIPTION OF PROGRAM DEMON2

The purpose of this appendix is to describe the supersonic lifting surface-body computer program in sufficient detail to permit understanding and use of the program. The present program is an extended and improved version of a pre-existing wing-body program as described in section 1 of this report.

Program DEMON2 computes pressure distributions on lifting surfaces and along the meridians of the body if it is circular in cross section. In this case, the program is equipped with body nose shed vorticity data modeled by two symmetric, discrete potential flow vortices. The effects of this vorticity are accounted for in the calculation of pressures on the body and lifting surfaces. If the body is elliptical in cross section, program WDYBDY described in Appendix K is employed to model the body and to compute pressures acting on it. Program WDYBDY also serves as a companion to DEMON2 for the purpose of calculating body induced velocities at the control points on the lifting surfaces through an exchange of data sets. The lifting surfaces can be cruciform canard fins or cruciform tail fins, a monoplane wing or interdigitated tail fins. For all but the last case, edge vorticity characteristics are calculated by the program.

By repeated application, program DEMON2 in conjunction with other programs can be employed to handle complete configurations including forward and tail lifting surfaces mounted on bodies with circular or elliptical cross section. Detailed descriptions of the required procedures are given in section 5.

The theoretical basis of program DEMON2 and its usage will first be summarized. Configuration parameters taken into consideration are listed. The general calculation procedure is given and it is followed by a description of the program operation. Program limitations and precautions are pointed out. The input required and the output generated by the program are described. Program listings appear at the end of this appendix.

### Program Description

Fundamentally, the program is based on representing the lifting surfaces by constant u-velocity panels and the body with circular cross section by a distribution of line sources/sinks and doublets along its centerline. Fin or wing thickness effects are modeled by planar source panels. The body source/sink and doublet strengths are determined explicitly from the flow tangency condition at points on the body surface. The body singularities and body nose vorticity, if applicable, induce velocity components at points on the lifting surfaces. The strengths of the constant u-velocity panels associated with the lifting surfaces and those laid out in a shell around the body to account for interference are obtained from a set of simultaneous equations which result from applying the flow tangency condition at a finite set of control points distributed over the lifting surfaces and interference shell. Thus, mutual interference between one lifting surface and another and between the lifting surfaces and the body are fully accounted for. Further details are given in section 2 and 3 of this report.

If the body is elliptical in cross section, a companion program designated WDYBDY, described in Appendix K, models the body using body source panels. In the main routine CRFWBD of program DEMON2, the effects induced by the body source panels and body nose vorticity, if applicable, are included in the flow tangency condition applied at points on the lifting surfaces. The program has been arranged to allow for an interference shell with elliptical cross section. The lifting surfaces attached to this shell can be a monoplane wing or a set of interdigitated tail fins. Mutual interference is accounted for in the manner described above. Refer to section 4 for more detail.

In the case involving an axisymmetric body, the program first treats the forebody and the forward or canard-body section. Effects of body nose vortices can be included in the calculation of pressures on the body and fins. The afterbody and tail fins are treated by another application of this program. Effects of body nose vortices and the canard edge vortices can be included in the calculated pressures acting on the aft body and loads on the tail fins. A separate program VPATH2, based on slender-body theory and described in Appendix L, is employed to determine the vortex paths along the complete configuration from the leading edge of the canard section back to the body base. The required procedure is described in section 5.1.

When the body is elliptical in cross section, the program first treats the forward or monoplane wing-body section. The forebody is handled by program WDYBDY. Effects of body nose vortices can be accounted for in the calculation of pressures on the body and the monoplane wing. The part of the body between the monoplane wing and tail section is handled also by program WDYBDY. The interdigitated tail-body section is treated by another application of program DEMON2. Effects of body nose and monoplane wing edge vortices can be included in the calculated pressures acting on the afterbody and on the interdigitated tail fin-body section. A separate program VPATHL, based on slender-body theory and described in Appendix L, is used to track vortices from the leading edge of the monoplane wing section to the leading edge of the interdigitated tail section. Section 5.2 describes the required procedure in detail.

As far as the lifting surface sections are concerned, program DEMON2 computes pressure distributions, forces and moments including effects of external vortices, if applicable. The pressures on the fins or wing are calculated on the basis of linear and Bernoulli pressure relationships. For all cases except those including interdigitated tails, leading- and side-edge suction distributions are calculated for the purpose of modeling separation vorticity characteristics at these edges using Polhamus' analogy as described in Appendix C. At the trailing edges, one or more concentrated vortices are computed from the span load distribution using the method described in Appendix B.

Two calculative examples are described in section 6. It should be noted here that the program can also treat wings or fins alone. However, axisymmetric bodies alone cannot be handled. In the latter case, the program can still be used to obtain forebody pressures by including a set of artificial lifting surfaces at the base of the body of interest. Note that the program WDYBDY treats bodies alone. However, in the application of WDYBDY to axisymmetric bodies, computation time far exceeds the time required by program DEMON2 on account of the different type and number of singularities used to represent the body.

## Geometrical Characteristics

Program DEMON2 contains the subroutines required to flow model bodies with circular cross section. The body is composed of a nose section followed by a cylindrical section. The nose section may have the following shapes (the choice is set by control index BCODE in namelist $BODY read in by subroutine BDYGEN):

| | Forebody Shape |
|---|---|
| BCODE = 0 | Parabolic |
| = 1 | Sears-Haack* |
| = 2 | Tangent-ogive |
| = 3 | Ellipsoidal |
| = 4 | Conical |

The geometrical characteristics of the lifting surfaces that can be accounted for include the following:

| | |
|---|---|
| Leading-edge shape: | Straight line which may be swept or it can be composed of straight line elements with different sweeps. |
| Trailing-edge shape: | Straight line which may be swept or it can be composed of straight line elements with different sweeps. |
| Thickness: | Accounted for by specifying streamwise slopes (not applicable to interdigitated tails). |
| Taper: | Uniform or broken. |
| Mean camber surface: | Planar. |
| Side edges: | Streamwise (not essential). |
| Dihedral: | Arbitrary, set by angle PHIDIH (see figure 3). |
| Location of interference shell: | Arbitrary, set by angle THETIT (see figure 3). |

The lifting surfaces can be cruciform canard fins, cruciform tail fins, a monoplane wing or a set of interdigitated tails. In all instances, there must be a vertical plane of symmetry ($y_B = 0$ plane) as far as the geometry is concerned.

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*Ashley, H. and Landahl, M.: Aerodynamics of Wings and Bodies, Addison-Wesley Publishing Co., Inc., 1965, pp. 180-181.

## Calculation Procedure

Program DEMON2 proceeds through various stages as follows. After reading in the run identification, namelist $INPUT is read in by main routine CRFWBD. Basically, this list contains wing or fin geometry data, flow conditions, geometry specifications for the interference shell and specifications for the distribution of constant u-velocity panels on the fin and the shell. In addition, moment-center coordinates and the vortex lift factors are specified. The wing- and body-coordinate systems are shown in figures 1 and 2.

The wings or fins of any fin-body combination are covered with a constant u-velocity panel layout with the panel side edges parallel to the fin root chords which, in turn, are made to be parallel to the body centerline. An optional input allows for unequal spanwise spacing of the side edges and breaks in sweep. The actual construction of the panel sweeps, centroid and control point coordinates is performed in subroutine LAYOUT. All coordinates are expressed in the $x_w$, $y_w$, $z_w$ or wing coordinate system. Coordinate transformations relating a fin coordinate system with origin on the fin rootchord to the wing coordinate system are implemented in subroutine LAYOUT by means of function statements FYROT and FZROT. Subroutine LAYOUT also computes the geometrical characteristics of the body interference panels. Note that the leading and trailing edges of the interference panels are unswept, see figure 1.

As an option, the above process is repeated in subroutine THKLYT for the layout of planar source panels. They are used to account for thickness associated with the wings or fins of a cruciform, planar but not an interdigitated configuration such as the combination shown in figure 3. Streamwise thickness slopes are read in by subroutine THKIN. Depending on the procedural steps described in section 5, main routine CRFWBD can write a data set containing the coordinates, in the wing coordinate system, of the control points associated with the wings or fins and the interference shell. If control index NCPOUT is set equal to 2 in namelist $INPUT, the run is stopped at this stage. Otherwise, the program continues as follows.

If the body is circular in cross section, main routine CRFWBD calls subroutine BDYGEN. This subroutine proceeds to read in namelist $BODY which contains body nose length and length of body to be modeled as well as control indices governing the number of line singularities distributed along the body centerline and the shape of the body nose. The layout and strengths of the line sources/sinks and line doublets employed to flow model the body are then computed for the flow conditions read in by namelist $INPUT. Main routine CRFWBD then calls subroutine BDYPR which computes pressure distributions at points along the meridians on the body with circular cross section. The Bernoulli pressure, equation (10), is used for this purpose on this process, effects of body nose vorticity and body line singularities are accounted in the pressures calculated on the forebody. Over the length of body covered by the lifting surfaces, the pressures are computed at the control points of the body interference panels in the interference shell. This is performed following entry point BDYAFT after the panel strengths are calculated. The velocity components used in the pressure calculation include contributions from the body line singularities, external vortices and constant u-velocity and source panels distributed over the fins or wings. The effects of external vortices (such as body nose vortices) can be accounted for on the basis of the vortices moving parallel to the body centerline (subroutine VRTVEL) or the vortices moving in the crossflow plane (program VPATH2 or VPATHL). Subroutine BDYPR also calculates the pressures on the length of body between the forward and aft lifting surface sections.

Velocity components induced by line singularities associated with the axisymmetric body at the control points on the lifting surfaces and interference shell are calculated by subroutine VELCAL. These components will be used in the flow tangency condition applied at points on the lifting surfaces and in the calculation of pressures at points on the lifting surfaces and the interference shell.

For cases involving bodies with elliptical cross sections, main routine CRFWBD calls subroutine BDYRD which reads in velocity components induced by the body source panels at the control points distributed over the lifting surfaces and interference shell. These velocities will be used in the flow tangency condition applied at the control points on the lifting surfaces and the calculation of pressures at points on the lifting surfaces and the interference shell.

Routine CRFWBD continues with the construction of the influence coefficient matrix associated with the constant u-velocity panels laid out on the lifting surfaces and the interference shell. In this process, subroutine VELNOR performs the superposition of 4 corner solutions associated with a trapezoidal, constant u-velocity panel. For each corner subroutine VELO computes the influence of a semi infinite triangle. If the flow conditions dictate symmetry in loading (w.r.t. the $y_B$ (or $y_W$) = 0 plane), subroutine VELNOR also accounts for the influence of the constant u-velocity panels on the opposite side of the plane of symmetry. Appendix A contains a discussion concerning the superposition scheme and the symmetry account.

The aerodynamic influence matrix, designated FVN, consists of the left-hand sides of equations (1) through (5) in section 3.4 and is triangularised by subroutine LINEQS. The right-hand sides of these equations are formed as a single column matrix designated RHS. For the control points on the lifting surfaces, the latter contains contributions from the free stream (including effect of deflection angle), body singularities (line singularities or source panels) and external vortices if applicable. For the control points on the interference shell, the right-hand side only contains contributions from the planar source panels modeling thickness of the lifting surfaces. These contributions are calculated by a call to subroutine THKVEL. Note that thickness effects are not accounted for if the lifting surfaces are interdigitated tails.

In the determination of velocity components normal to the panels on the lifting surfaces, transformations from the reference or wing coordinate system to the fin coordinate system are required. Subroutine ROTATE with entry points ROTWF and ROTFW contains the rotational coordinate transformation described in Appendix D. These transformations are used in the determination of normal velocity components as indicated in Appendix E and apply to cruciform, monoplane and interdigitated lifting surface configurations. Likewise, velocity transformations are performed from the reference or wing coordinate system to the local body interference panel coordinate system. These transformations are performed in subroutine TRBIPW with entry points TRWBIP (for coordinates), ROTBW and ROTWB (for velocities). The angles associated with the transformations are indicated in figure 3. The velocity transformations apply to both the left- and right-hand sides of equations (1) through (5).

Main routine CRFWBD then calls subroutine SOLVE which takes the triangulated aerodynamic influence coefficient matrix, FVN, generated by LINEQS and the single column matrix, RHS, and proceeds to solve for the unknown strengths of the constant u-velocity panels.

Subroutine LOADS is then called to compute forces and moments acting on the lifting surfaces and the interference shell. Transformations from the local fin or body interference panel coordinate system to the reference or wing coordinate system are performed for the force and moment coefficients. For example, the force acting normal to the fins must be resolved into the $y_W$ or $y_B$ and $z_W$ or $z_B$ directions associated with the wing or body coordinate systems. The procedure is described in Appendix F. Note that the force and moment transformations also apply to monoplane or cruciform lifting surface configurations. The forces and moments are calculated in the body coordinate system and then transformed into the wind axis coordinate system in accordance with equations (18) and (19). These equations appear in section 4.2 in connection with calculations performed in program WDYBDY and apply to subroutine LOADS of program DEMON2 as well.

The loads acting on the interference shell calculated by subroutine LOADS represent only the lift carryover from the lifting surfaces to the body and may include interference due to fin or wing thickness. The pressures acting on the interference shell calculated by subroutine BDYPR (through entry point BDYAFT) include effects not only from the lifting surfaces but also include contributions from body singularities and external vortices if applicable. As such the pressures are indicative of the total load acting on the body over the length covered by the lifting surfaces.

Subroutine LOADS calculates the fin and interference shell loads first on the basis of linear pressure. This is followed by a call to subroutine SPECPR from subroutine LOADS to compute pressures acting on the lifting surfaces using the Bernoulli pressure equation (10). The loads acting on the lifting surfaces are then recalculated on the basis of the Bernoulli pressures.

If the lifting surfaces do not form an interdigitated fin configuration, subroutine LOADS calls subroutine SPNLD for the purpose of calculating spanload distributions, leading- and side-edge suction distributions. Using the span loading information, the strength and spanwise location of the concentrated trailing-edge vortices are calculated in accordance with Appendix B. The vorticity characteristics associated with the leading and side edges are determined from the suction distributions as described in Appendix C.

## Program Operation

The cruciform wing-body computer program is written in the FORTRAN IV language (029 punch) and has been run on the CDC 6600 machine belonging to Boeing Computer Services, Inc. The main program is arranged so that a total of 250 constant u-velocity panels is available to cover the wing surfaces and to be used as body interference panels. A total of 100 sources and 100 doublets can be used to model the body. If the program is to be run on a different computer with smaller core memory, dimension statements need to be changed to permit operation on that machine.

In addition to the standard input and output tapes (TAPE5=INPUT, TAPE6=OUTPUT), the program may require additional devices such as disc files or tapes for storing data sets generated when certain options are used. One data set would consist of a set of control point coordinates and the other would contain a set of perturbation velocities. Devices used for these purposes are TAPE4 and TAPE7. The program employs a system-supplied subroutine REQFL which computes the actual dimension requirement for the aerodynamic coefficient matrix FVN. This subroutine makes use of special machine-dependent parameters. Certain other systems may have a similar subroutine available. If no such subroutine is available, the dimension of array FVN should be set to 62,500 and the four calls to REQFL marked in the main program removed.

Additional system-supplied devices used by the main program are the BUFFER OUT and BUFFER IN options. They are used as an option to save the triangulated aerodynamic influence matrix FVN associated with the fins and body interference shell. TAPE3 is used for this purpose. This procedure saves time when calculations are done for a given configuration at some Mach number but with different included angles of attack or roll.

However, the pertinent calls should be removed from the main program if other systems do not offer such devices.

Program DEMON2 treats one set of lifting surfaces on a body. In order to handle complete configurations involving forward and tail lifting surfaces, the program must be used in a stepwise manner in conjunction with other programs described in this report. A detailed description of the required procedure is given in section 5.

Running time required by program DEMON2 is governed by the number of constant u-velocity panels laid out on the lifting surfaces. For a pitched and rolled cruciform wing-body combination employing 192 constant u-velocity panels and 22 sources/sinks and doublets, the running time on the CDC 6600 is about 60 seconds for one set of flow conditions.

## Program Limitations and Precautions

There are some problems that could arise in the use of the cruciform wing-body program. It should be noted that subroutines LOADS, BDYPR, VRTVEL, ROTATE and TRBIPW contain entry points. The first does not employ an argument list and should not cause any problems. However, the entry points in the second, third, fourth and fifth may need to have the appropriate subroutine argument list attached to them if other computer machines are used.

A warning is concerned with the use of system subroutine REQFL and the BUFFER devices already mentioned above under program operation. If the subroutine is not available, an equivalent subroutine can be called or the calls to REQFL can be removed and the dimension on FVN set to 62,500. Similarly, if the BUFFER devices are not system supplied, calls to them in the main program should be removed.

In the specification of the number of constant u-velocity panels to be distributed on the fins and body in namelist $INPUT, the following limits must be kept in mind. For the fins, a maximum of 150 panels are available. In the spanwise direction, the maximum number of panels is 19. The number of body interference panels must not exceed 100. Finally, the total number of panels on the fins and interference shell cannot exceed 250. In namelist $BODY, the number of sources/sinks and the number of doublets (both specified by NXBODY) cannot exceed 100.

Care must be taken with the use of control indices NOUT and NPR. A very large amount of additional output is generated when these indices are set equal to one. This output should only be used for debugging purposes employing a minimum number of constant u-velocity panels such as two per fin and four on the circumference of the body interference shell with two in the lengthwise direction.

A maximum magnitude is set by the program for the perturbation velocities induced by external vortices at the control points in the flow tangency condition. Since these velocities are based on potential vortex theory, their values could assume large magnitudes if the vortices run close to the fins and cause undue influence. Consequently, their magnitude is limited to 0.35. This value can be overridden by setting variable VRTMAX in namelist $INPUT equal to the desired value.

At the present time, program DEMON2 computes pressure distributions on the body surface and lifting surfaces of complete configurations in conjunction with other programs as described in section 5. The program also determines the force and moment coefficients associated with the lifting surfaces but it does not compute the forces and moments acting on the body if it is circular in cross section. The latter quantities can be determined by an integration of the program calculated pressure distributions. In this connection, the program calculated forces and moments associated with the interference shell only represent the effects of lift carryover from the lifting surfaces to the body although effects of thickness may be included. The actual loads acting on the part of the body in the lifting surface section can also be determined from the pressure distributions.

Span load and suction distributions and the associated edge vorticity characteristics are not calculated for interdigitated fins at this time. Thickness effects are also not accounted for this type of lifting surface configuration.

## Description of Input

This section describes the input for program DEMON2 for treating one set of lifting surfaces on a body. In the following discussion, the content of all input cards is summarized. All possible input variables are listed at the end of this section in the order of appearance in the input deck, except for the first four variables which do not appear in the input deck but are needed for program input preparation. Sample inputs are discussed in section 6 concerned with the calculative examples. Note that the correspondence in designation between interdigitated fins and cruciform fins is indicated in figure 3 and also referred to in item 2 below.

Item 1

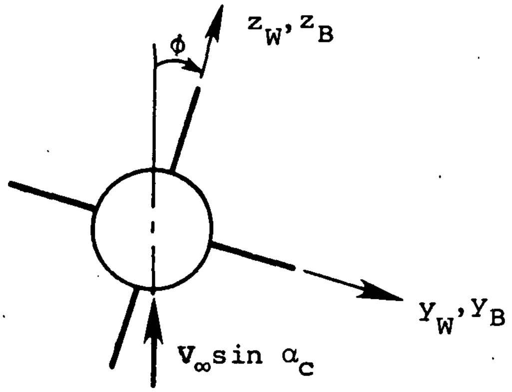
The first card serves as identification and may contain any alphanumeric information desired. This information is printed on the first page of the output.

Item 2

The second and following cards form the namelist $INPUT which specifies the geometrical parameters of the wing surfaces and interference shell. These parameters are the leading-edge and trailing-edge sweeps, semispan and rootchord. For a planar wing or cruciform wing alone, the rootchord is the wing centerline or the cruciform wing junction. In the case of a wing-body combination, the rootchord is the line formed by the junction of the lifting surface and the body. The semispan is measured from the rootchord in any case.

This namelist also contains the deflection angles and the number of chordwise and spanwise constant u-velocity panels for each lifting surface. The spanwise number may differ from one fin to another but the chordwise number NCW is the same for all. Similar information is specified for the layout of planar source panels. The number of body interference panels, NBDCR, on the circumference are also included in this namelist. The specification of the latter also determines whether or not a body is present. The number of body interference panels in the axial direction is specified by NCWB. The body can be cylindrical or elliptical in cross section over the interference length, BIL, spanned by the lifting surfaces. If the interference shell is elliptical, the horizontal semi-axis RB and vertical semi-axis RA must be specified. The ratio RB/RA must equal ERATIO. If the interference shell is circular, set RB equals RA and ERATIO equals 1. If the lifting surfaces are delta wings (unswept trailing edges), length BIL equals the rootchord CRP. If the trailing edges are swept back, the length BIL should be extended to include the trailing edge of the tip chord to account properly for the interference of the lifting surfaces on the body.

The included angle of attack, ALFAC, is the angle between the free stream and the body/wing centerline ($x_B$-axis in figure 1). Angle of roll, PHI, is indicated by $\phi$ in the sketch below. The program computes pitch and sideslip angles in accordance with the pitch-roll transformation mentioned in section 4 of this report.



Setting control index NDRAG equal to 1 results in the calculation of in-plane forces (Appendix C) acting on the lifting surfaces. At the present time, this is not possible when the lifting surfaces form an interdigitated configuration and NDRAG should be set equal to 0 (the default value) for this case.

In addition, more control indices, free-stream Mach number, and reference quantities SREF and REFL are read in. Breaks in leading-edge and/or trailing-edge sweeps are also allowed if the configuration is a wing or cruciform wing alone at zero sideslip or if the configuration consists of a monoplane or cruciform or interdigitated wing-body. This option is governed by control index LVSWP. Angles SWLEP, SWTEP, SWLEV, and SWTEV need not be specified if LVSWP $\neq$ 0.

Indices NCPOUT, NVLIN, ITAIL, JCPT play an important part in the procedural use of program DEMON2 as described in section 5 in this report. Quantities FKLE and FKSE are the vortex lift factors discussed in Appendix C. The axial location of the moment center, XM, must be specified in the body coordinate system with origin at the nose.

Angles PHIDIH and THETIT are indicated on figure 3 and apply to monoplane and interdigitated lifting surface configurations. Note that the correspondence in designation between interdigitated fins and cruciform fins is indicated in figure 3. It is also referred to in connection with the fin deflection angles listed under item 2.

Item 3

This optional input is required when there are breaks in the wing sweep or if the constant u-velocity panel side edges are to be laid out with user-determined unequal spanwise spacings. This input pertains only to a wing or cruciform wing alone at zero sideslip. Variable YR is the distance from the rootchord to the outboard panel side edges. Therefore, the first value for YR is zero. The last value for YR must equal wing semispan, B2, specified in the namelist $INPUT. In effect, this specification positions the panel outboard side edges on the right wing. The sweep angles are positive for wings with sweptback leading and trailing edges.

Item 4

The optional input of this item is associated with a wing-body combination with breaks in leading-edge and/or trailing-edge sweeps. Also, this input should be used for this configuration if the constant u-velocity panel side edges are to be laid out with user-determined unequal spacings. Variable YRT is the distance from the wing rootchord to the outboard constant u-velocity panel edges on the right wing or fin. The first value should equal 0.0 and the last value for YRT equals the semispan, B2; the latter is specified in the namelist $INPUT. The sweep angles are positive for right wings or fins with sweptback leading and trailing edges.

Item 5

This optional input accompanies Item 4 and is associated with the left wing or fin. Variable YLT is the distance from the wing rootchord to the outboard constant u-velocity panel edges on the left wing or fin. The first value should equal 0.0 and the last value for YLT equals the negative semispan, -B2. The sweep angles are negative for left wings or fins with sweptback leading and trailing edges.

Item 6

The information in this optional item accompanies Items 4 and 5 if the configuration is a cruciform or interdigitated wing-body combination. Again, this input should only be used if there are breaks in the wing or fin sweeps or if the panel side edges are to be laid out with user-determined unequal spacings. Variable ZUT is the distance from the wing rootchord to the outboard constant u-velocity panel edges on the upper wing or fin. The first value should equal 0.0 and the last equals the semispan, B2V. The latter is specified in namelist $INPUT. The sweep angles are positive for upper wings or fins with sweptback leading and trailing edges.

Item 7

This optional information is the last of four inputs associated with a cruciform or interdigitated wing-body combination if there are breaks in sweep or if the constant u-velocity panel side edges are to be laid out with user determined spacings; see Items 4 through 6. Variable ZDT is the distance from the wing rootchord to the outboard constant u-velocity panel edges on the lower wing or fin. The first value should equal 0.0 and the last value for ZDT must equal -B2V. The sweep angles are negative for lower wings or fins with sweptback leading and trailing edges.

Item 8

This item is concerned with the specification of the layout and strengths of the planar source panels employed to model thickness of the lifting surfaces. If the case at hand involves interdigitated lifting surfaces, this item must be omitted in the input (NTDAT=0). Basically, the planar source panels are laid out in the same manner used to layout the constant u-velocity panels. However, in this case the distance out to the outboard panel edge is now measured from the body centerline not the rootchord of the lifting surface under consideration. Breaks in sweep are handled by control index LVSWT in the same way control index LVSWP handled breaks in sweep in the layout of constant u-velocity panels.

The strengths of the planar source panels are related directly to the streamwise slopes and must be specified a priori. An example of such a specification is shown in section 6.2.. Note that quantity THET is in fact the tangent of the thickness envelope angle, tan $\theta_s$.

Item 9

The input cards for this item form the namelist $BODY which is required only when a body with circular cross section is part of the configuration under consideration. If the integer NBDCR in namelist $INPUT under Item 2 is specified to be nonzero, and RB equals RA, a body with circular cross section is present. The information in this input includes specification of body geometry parameters and is read in by subroutine BDYGEN. The length of the nose, LNOSE, determines the body length over which the radius is changing as a function of the body axial coordinate. The actual nose configuration is governed by control index, BCODE, which selects preprogrammed forebody shapes described above in this appendix.

Normally, the body length, LBODY, should at least equal the axial distance from the body nose to the trailing edges of the lifting surfaces under consideration. If the trailing edges are sweptback, length LBODY should be taken to include the trailing edge of the tip chords or side edges of the lifting surfaces at hand.

The minimum number of body modeling singularities NXBODY should be determined as follows. Let the density (sources and doublets/unit body length) be determined by the number of constant u-velocity panels in the chordwise direction on the wing divided by the rootchord (or length of wing-body junction). Then, number NXBODY equals the density times body length.

Item 10(a)

This input is required only when variable NVRTX specified in namelist $INPUT, Item 2, is nonzero and if the body is circular in cross section. In fact, NVRTX is the number of external, two-dimensional vortices whose influences are to be included in the pressure and loading calculations. Each vortex is assumed to be infinite in length and to be parallel to the body centerline. Therefore, with each vortex there is associated a nondimensional strength, GAMMA, and nondimensional crossflow plane coordinate, YVRTX, ZVRTX, given in the body or wing coordinate system shown in figure 1. These quantities are input in subroutine VRTVEL.

## Item 10(b)

This input is required only when variable NVRTX specified in namelist $INPUT, Item 2, is nonzero and if the body is elliptical in cross section. As in item 10, each vortex is assumed infinite in length and to be parallel to the body centerline. In this case, the strength GAMMA is $\Gamma/V_\infty$, and YVRTX and ZVRTX are the coordinates expressed in the wing coordinate system for each vortex. This information is read in by main routine CRFWBD.

## Items 11, 12, 13, 14

The information specified in these items pertain to leading- and side-edge vorticity characteristics. If specified in the input, their influence would influence the pressures and loads on the lifting surfaces and the interference shell under consideration. Presently, it is not recommended to include edge vorticity effects associated with a lifting surface in the calculation of the loading acting on the same lifting surface. Thus, a blank card can be inserted for items 11 and 13.

## Item 15

This card ends the process of reading in data for program DEMON2. It should only be put at the end of all data cards for the case(s) to be run. The computer program stops the search for more data and the run is finished.

## INPUT VARIABLES, PROGRAM DEMON2

The terms "right and "left" refer to an observer looking forward.

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| MSWRP | Definitions of terms used below | (Number of chordwise rows on right wing) + 1; MSWRP = MSWR + 1. |
| MSWLP | | (Number of chordwise rows on left wing) + 1; MSWLP = MSWL + 1. |
| MSWUP | | (Number of chordwise rows on upper wing) + 1; MSWUP = MSWU + 1. |
| MSWDP | | (Number of chordwise rows on lower wing) + 1; MSWDP = MSWD + 1. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| Item 1 | (20A4) | Any alphanumeric information may be put on this card for identification of the calculation. |
| Item 2 | | Namelist $INPUT. |
| CRP | $c_{r,H}$ | Horizontal wing rootchord, dimensional. |
| SWLEP | $\Lambda_{LE,H}$ | Horizontal wing leading-edge sweep angle measured in wing planform, positive for sweep back, degrees. |
| SWTEP | $\Lambda_{TE,H}$ | Horizontal wing trailing-edge sweep angle measured in wing planform, positive for sweep back, degrees. |
| NCW | | Number of chordwise constant u-velocity panels on the wing. |
| MSWR | | Number of spanwise constant u-velocity panels on right wing; $1 \leq \text{MSWR} \leq 19$. |
| MSWL | | Number of spanwise constant u-velocity panels on left wing; $1 \leq \text{MSWL} \leq 19$, default is 0. |
| MSWU | | Number of spanwise constant u-velocity panels on the upper wing; $1 \leq \text{MSWU} \leq 19$, default is 0. |
| MSWD | | Number of spanwise constant u-velocity panels on the lower wing; $1 \leq \text{MSWD} \leq 19$, default is 0.<br>Note: When running symmetric case do not include vertical surfaces. Set<br>NCRX = 0<br>MSWL = 0<br>MSWU = 0<br>MSWD = 0 |
| SWLEV | $\Lambda_{LE,V}$ | Vertical wing leading-edge sweep angle measured in wing planform positive for sweep back, degrees, default is 0.0. |
| SWTEV | $\Lambda_{TE,V}$ | Vertical wing trailing-edge sweep angle measured in wing planform, positive for sweep back, degrees, default is 0.0. |
| CRPV | $c_{r,V}$ | Vertical wing rootchord, dimensional, default is 0. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| B2 | $b_H/2$ | Exposed horizontal wing semispan, dimensional. |
| B2V | $b_V/2$ | Exposed vertical wing semispan, dimensional, default is 0.0. |
| RA | b | Vertical semi-axis for body with elliptical cross section. |
| RB | a | Horizontal semi-axis for body with elliptical cross section. |
| ERATIO | a/b | Ratio of RB over RA<br>Note: If body has circular cross section set RA = RB and ERATIO = 1.0. |
| BIL | | Length of body influenced by fins to account for interference. For fins with delta planform and for wing-alone cases, BIL = CRP. |
| NFVNPR | | NFVNPR ≠ 0 Print influence coefficient matrix FVN for debugging, default is 0.0. |
| NOLINP | | NOLINP = 0 Loadings calculated on the basis of linear pressures only, default value.<br>NOLINP = 1 Loadings calculated on the basis of linear and Bernoulli pressures. |
| NOUT | | NOUT ≠ 0 Print large amount of output for debugging, default is 0.0. |
| NPR | | Same as NOUT, default is 0.0. |
| NDRAG | | NDRAG = 0 Omit calculation of in-plane forces, default value.<br>NDRAG = 1 Include calculation of in-plane forces. Use default value when treating interdigitated tails. |
| FAC | | FAC = 0.95 Fraction of the constant pressure panel chord (which contains the centroid) where the control point is located. |
| TOLFAC | | TOLFAC = 1 Multiplication factor used in the evaluation of the tolerance, TLRNC, used in subroutine VELO. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| NPRESS | | NPRESS = 0 This value insures that loadings are also computed on the basis of the linear pressure relationship in addition to the Bernoulli pressure relationship. |
| VRTMAX | | Maximum magnitude of vortex induced velocities included in flow tangency condition, default is 0.35. |
| NVRTPL | | NVRTPL = 0 Component of velocity parallel to fin induced by vortices not included in Bernoulli loading pressure, default value.<br>NVRTPL = 1 Loading pressure calculated including parallel component of vortex induced velocity. |
| NAGAIN | | NAGAIN = 0 No use made of buffer to save aerodynamic influence matrix, FVN, after triangulation, default value = 0.<br>NAGAIN = 1 Buffer out FVN array. For succeeding runs, keep NAGAIN = 1. |
| DELR | $\delta_{H,R}$ | Deflection angle of horizontal right wing. Positive: trailing edge down, degrees, default is zero. |
| DELL | $\delta_{H,L}$ | Deflection angle of horizontal left wing, Positive: trailing edge down, degrees, default is 0.0. |
| DELU | $\delta_{V,U}$ | Deflection angle of vertical upper wing, Positive: trailing edge to right, degrees, default is 0.0. |
| DELD | $\delta_{V,D}$ | Deflection angle of vertical lower wing, Positive: trailing edge to right, degrees, default is 0.0.<br>If case involves interdigitated fins:<br>$\delta_{H,R}$ applies to right upper fin, trailing edge down is positive.<br>$\delta_{H,L}$ applies to left lower fin, trailing edge down is positive.<br>$\delta_{V,U}$ applies to right lower fin, trailing edge down is positive.<br>$\delta_{V,D}$ applies to left upper fin, trailing edge down is positive. |
| ALFAC | $\alpha_c$ | Included angle of attack, measured between free-stream velocity vector and body/wing centerline. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| PHI | $\phi$ | Angle of roll, measured from the plane containing the free-stream velocity vector and the body/wing centerline to the upper wing, positive clockwise looking forward, default is 0.0. |
| FMACH | $M_\infty$ | Free-stream Mach number. |
| LVSWP | | LVSWP = 0 No breaks in wing leading or trailing edges, or equal spanwise spacings of panel side edges, default value.<br>LVSWP $\neq$ 0 Up to 19 breaks in wing leading or trailing edges or up to 19 unequal spanwise spacings. |
| NVRTX | | Number of external vortices present, NVRTX $\leq$ 10 (see Item 10(a)). |
| NCRX | | NCRX = 0 Horizontal wing only present, default value.<br>NCRX = 1 Vertical wing surfaces in addition to horizontal wing surfaces present. |
| NBDCR | | Number of constant u-velocity panels on the circumference of the body.<br>NBDCR = 0 No body present, default value.<br>NBDCR > 0 Body present (see Item 8). |
| NCWB | | Number of constant u-velocity panels in the longitudinal direction on the surface of the body over the body interference length BIL, default is 0.0. |
| SREF | $S_{ref}$ | Reference area used in load calculations, default is 1. |
| REFL | $\ell_{ref}$ | Reference length used in rolling-moment calculations, default is 1. |
| ITAIL | | ITAIL = 1 Tail fins to be considered, default is 0. If case involves interdigitated fins mounted on body with elliptic cross section set ITAIL = 0. |
| NBDYPR | | NBDYPR = 1 Pressures to be calculated along body meridians, default is 0. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| NTPR | | NTPR = 1 Print debug output from subroutine THKVEL, default is 0. |
| NTDAT | | Number of sets of thickness data to be input. Set NTDAT=0 for cases involving interdigitated fins.<br>NTDAT = 0 No thickness input data, default value.<br>NTDAT = 1 For horizontal wing, symmetric layout <u>or</u> for cruciform wing, symmetric layout with layout on vertical wings same as on horizontal wings.<br>NTDAT = 2 For cruciform wing, symmetric layout. Vertical wing layout different from horizontal <u>or</u> for horizontal wing alone (delta wing) with asymmetric layout.<br>NTDAT = 4 For cruciform wing alone (delta wing), asymmetric layout. |
| NCWT | | Number of source panels in a chordwise row, default is 0. |
| NCPOUT | | NCPOUT = 0 No control point coordinates written, default value.<br>NCPOUT = 1 Write coordinates (in wing coordinate system) of control points on fin and body interference shell in data set (TAPE4), and continue the run.<br>NCPOUT = 2 Write coordinates (in wing coordinate system) of control points on fin and body interference shell in data set (TAPE4) and stop the run (STOP77). |
| NVLIN | | NVLIN = 0 Do not read in velocity components induced by moving vortices.<br>NVLIN = 1 Read in velocities induced by moving vortices (calculated by program VPATH2 or VPATHL) from a data set (TAPE7), default is 0. |
| XSTART | | Axial station aft of which body pressures are to be calculated. If case involves interdigitated tails on body with elliptic cross section, set XSTART = 0.0, default is 0.0. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| JCPT | | Number of control points and body pressure points calculated by subroutine BDYPR and printed in output. This number is required when NVLIN = 1 and ITAIL = 1, default is 0. |
| FKLE | | Fraction of leading-edge suction converted into normal force, default is 0.5. |
| FKSE | | Fraction of side-edge suction converted into normal force, default is 0.5. |
| XM | | x-coordinate of moment center in body coordinate system, default is 0.0. |
| ZM | | z-coordinate of moment center in body coordinate system, default is 0.0. |
| PHIDIH | $\phi_F$ | Dihedral angle associated with interdigitated fin, default is 0.0, $0 \leq \phi_F < 90°$. |
| THETIT | $\theta$ | Location angle associated with interdigitated fin, default is 0.0, $0 \leq \theta < 90°$. |
| XWLE | | Axial location of wing rootchord leading edge measured from body nose, default is 0.0. |
| <u>Item 3</u> | (3F10.5) | Optional input for planar or cruciform wing alone at zero sideslip. |
| YR(KJ) | $y_{W,R}(KJ)$ | Distance from wing rootchord to the constant pressure panel outboard side edge on right wing, $1 \leq KJ \leq MSWRP$, $(MSWRP \leq 30)$, YR(1) = 0.0, YR(MSWRP) = B2. |
| VSWLER(KJ) | $\Lambda_{LE,R}(KJ)$ | Leading-edge sweep of wing between YR(KJ-1) and YR(KJ), positive for sweep back, degrees, $1 \leq KJ \leq MSWRP$, $(MSWRP \leq 20)$, VSWLER(1) = 0.0. |
| VSWTER(KJ) | $\Lambda_{TE,R}(KJ)$ | Trailing-edge sweep of wing between YR(KJ-1) and YR(KJ), positive for sweep back, degrees. $1 \leq KJ \leq MSWRP$, $(MSWRP \leq 20)$, VSWTER(1) = 0.0. |
| <u>Item 4</u> | (3F10.5) | Optional input for wing-body combination. |
| YRT(KJ) | $y_R(KJ)$ | Distance from wing rootchord to the constant u-velocity panel outboard side edge on right wing, $1 \leq KJ \leq MSWRP$, $(MSWRP \leq 20)$, YRT(1) = 0.0, YRT(MSWRP) = B2. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| VSWLER(KJ) | $\Lambda_{LE,R}(KJ)$ | Leading-edge sweep of wing between (YRT(KJ-1) and YRT(KJ), positive for sweep back, degrees, $1 \leq KJ \leq MSWRP$, ($MSWRP \leq 20$), VSWLER(1) = 0.0. |
| VSWTER(KJ) | $\Lambda_{TE,R}(KJ)$ | Trailing-edge sweep of wing between (YRT(KJ-1) and YRT(KJ), positive for sweep back, degrees, $1 \leq KJ \leq MSWRP$, (MSWRP 20), VSWTER(1) = 0.0. |
| Item 5 | (3F10.5) | Optional input for wing-body combination. |
| YLT(KJ) | $y_{W,L}(KJ)$ | Distance from wing rootchord to the constant u-velocity panel outboard side edge on left wing, $1 \leq KJ \leq MSWLP$, ($MSWLP \leq 20$), YLT(1) = 0.0, YLT(MSWLP) = -B2. |
| VSWLEL(KJ) | $\Lambda_{LE,L}(KJ)$ | Leading-edge sweep of wing between YLT(KJ-1) and YLT(KJ), negative for sweep back, degrees, $1 \leq KJ \leq MSWLP$, ($MSWLP \leq 20$), VSWLEL(1) = 0.0. |
| VSWTEL(KJ) | $\Lambda_{TE,L}(KJ)$ | Trailing-edge sweep of wing between YLT(KJ-1) and YLT(KJ), negative for sweep back, degrees, $1 \leq KJ \leq MSWLP$, ($MSWLP \leq 20$), VSWTEL(1) = 0.0. |
| Item 6 | (3F10.5) | Optional input for cruciform wing-body combination. |
| ZUT(KJ) | $z_{W,U}(KJ)$ | Distance from wing rootchord to the constant u-velocity panel outboard side edge on upper wing, $1 \leq KJ \leq MSWUP$, ($MSWUP \leq 20$), ZUT(1) = 0.0, ZUT(MSWUP) = B2V. |
| VSWLEU(KJ) | $\Lambda_{LE,U}(KJ)$ | Leading-edge sweep of wing between ZUT(KJ-1) and ZU(KJ), positive for sweep back, degrees, $1 \leq KJ \leq MSWUP$, ($MSWUP \leq 20$), VSWLEU(1) = 0.0. |
| VSWTEU(KJ) | $\Lambda_{TE,U}(KJ)$ | Trailing-edge sweep of wing between ZUT(KJ-1) and ZUT(KJ), positive for sweep back, degrees, $1 \leq KJ \leq MSWUP$, ($MSWUP \leq 20$), VSWTEU(1) = 0.0. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| Item 7 | (3F10.5) | Optional input for cruciform wing-body combination. |
| ZDT(KJ) | $z_{W,D}(KJ)$ | Distance from wing rootchord to the constant u-velocity panel outboard side edge on lower wing, 1 ≤ KJ ≤ MSWDP, (MSWDP ≤ 20), ZDT(1) = 0.0, ZDT(MSWDP) = -B2V. |
| VSWLED(KJ) | $\Lambda_{LE,D}(KJ)$ | Leading-edge sweep of wing between ZDT(KJ-1) and ZDT(KJ), negative for sweep back, degrees, 1 ≤ KJ ≤ MSWDP, (MSWDP ≤ 20), VSWLED(1) = 0.0. |
| VSWTED(KJ) | $\Lambda_{TE,D}(KJ)$ | Trailing-edge sweep of wing between ZDT(KJ-1) and ZDT(KJ), negative for sweep back, degrees, 1 ≤ KJ ≤ MSWDP, (MSWDP ≤ 20), VSWTED(1) = 0.0. |
| Item 8 | | Optional thickness input data when NTDAT ≠ 0. If case involves interdigitated fins, this option is not used. |
| Item 8(a) | (3I5) | Information in items 8(a), 8(b) are read in by subroutine THKIN for the right horizontal wing. |
| MSWT | | Number of source panels in the spanwise direction, 1 ≤ 19 ≤ MSWT. |
| LVSWT | | LVSWT = 0 No breaks in wing leading or trailing edges, or equal spanwise spacings of source panel sides, default is 0.<br>LVSWT = 1 Up to 19 breaks in wing leading or trailing edges or up to 19 unequal spanwise spacings. |
| NUNIS | | NUNIS = 1 Thickness distribution varies over the span.<br>NUNIS = 0 Thickness distribution constant over the span. |
| Item 8(b) | (3F10.0) | Optional input for LVSWT = 1. |
| YTH(1,J) | | Distance from body centerline to the source panel outboard side edge, 1 ≤ J ≤ MSWT+1. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| SWLET(J) | | Leading-edge sweep of wing between YTH(1,J-1) and YTH(1,J), positive for sweep back, degrees, $1 \leq J \leq MSWT+1$. |
| SWTET(J) | | Trailing-edge sweep of wing between YTH(1,J-1) and YTH(1,J), positive for sweep back, degrees, $1 \leq J \leq MSWT+1$. |
| Item 8(c) | (8F10.0) | Optional input specifying streamwise thickness slopes read in by subroutine THETIN. |
| THET(K) | tan $\theta_s$ | NUNIS = 1  K = 1, NWCT<br>NUNIS = 0  K = 1, (NCWT*MSWT) |
| Item 8(d) | | Optional input for left wing when body is not present and if geometric yaw angle is accounted for (skewed panels). All input same as for right wing above, items 8(a), 8(b), and 8(c). |
| Item 8(e) | | Optional input for upper wing if NTDAT = 2 or 4 and NCRX = 1. Same input as for right wing, items 8(a), 8(b) and 8(c). |
| Item 8(f) | | Optional input for lower wing if NCRX = 1 and body is not present and if geometric pitch angle is accounted for (skewed panels). All input same as for right wing, items 8(a), 8(b) and 8(c). |
| Item 9 | | Namelist $BODY read in by subroutine BDYGEN. Optional input when body with circular cross section is present, NBDCR $\neq$ 0. |
| NXBODY | | Number of line source/sinks and line doublet singularities distributed along body centerline. |
| LNOSE | | Length of nose part of body measured from nose tip, dimensional (real variable). |
| LBODY | | Length of body, dimensional (real variable). |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| BCODE | | Control index (integer) for specifying forebody shape.<br>BCODE = 0 Parabolic<br>= 1 Sears-Haack<br>= 2 Tangent ogive<br>= 3 Ellipsoidal<br>= 4 Conical |
| Item 10(a) | (8F10.5) | Optional input read by subroutine VRTVEL when the effect of fixed external vortices are considered, for bodies with circular cross section only (RB = RA), $1 \leq \text{NVRTX} \leq 10$. |
| GAMMA(I) | $\frac{\Gamma}{2\pi V_\infty a}$ (I) | Nondimensional vortex strengths, a is body radius RB, $1 \leq I \leq \text{NVRTX}$. |
| YVRTX(I) | $\frac{y(I)}{a}$ | Nondimensional y-coordinate, $1 \leq I \leq \text{NVRTX}$. |
| ZVRTX(I) | $\frac{z(I)}{a}$ | Nondimensional z-coordinate, $1 \leq I \leq \text{NVRTX}$. |
| | | There will be NVRTX sets of vortex inputs. |
| Item 10(b) | (3F10.5) | Optional input when the effect of fixed external vortices are considered, for bodies with elliptical cross section only (RB $\neq$ RA), $1 \leq \text{NVRTX} \leq 10$. |
| GAMMA(I) | $\frac{\Gamma}{V_\infty}$ (I) | Vortex strength divided by free stream velocity, $1 \leq I \leq \text{NVRTX}$. |
| YVRTX(I) | $y_w$(I) | y-coordinate in wing coordinate system of I'th vortex, $1 \leq I \leq \text{NVRTX}$. |
| ZVRTX(I) | $z_w$(I) | z-coordinate in wing coordinate system of I'th vortex, $1 \leq I \leq \text{NVRTX}$. |
| | | There will be NVRTX sets of vortex inputs. |
| Item 11 | (8I10) | |
| MLEVR | | Number of leading-edge vortex information stations for the right horizontal fin. |
| MLEVL | | Number of leading-edge vortex information stations for the left horizontal fin. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| MLEVU | | Number of leading-edge vortex information stations for the upper vertical fin. |
| MLEVD | | Number of leading-edge vortex information stations for the lower vertical fin. |
| Item 12 | (6F10.5) | Optional input concerning leading-edge vorticity when MLEVR+MLEVL+MLEVU +MLEVD = NEDGV $\neq$ 0. |
| XLE(IFV) | $x_{w,LE}$ | Wing x-coordinate of station of fin leading edge. |
| CGLOC(IFV) | $\bar{y}_{LE}$, $\bar{z}_{LE}$ | Center of gravity of the leading-edge vorticity distribution. |
| GAMLE(IFV) | $\frac{\Gamma_{LE}}{V_\infty}$ | Strength of the vorticity distribution at XLE(IFV), 1 $\leq$ IFV $\leq$ NEDGV. |
| Item 13 | (I10) | |
| NSEV | | Number of fin side-edge vortex information stations. Same for all fins. |
| Item 14 | (6F10.5) | Optional input concerning side-edge vorticity when 4(NSEV) = NSIDGE $\neq$ 0. |
| XSE(JSE) | $x_{w,SE}$ | Wing x-coordinate of station on fin side edge. |
| CGSELC(JSE) | $\bar{y}_{SE}$, $\bar{z}_{SE}$ | Center of gravity of the side-edge vorticity distribution. |
| GAMSE(JSE) | $\frac{\Gamma_{SE}}{V_\infty}$ | Strength of vorticity distribution at XSE(JSE), 1 $\leq$ JSE $\leq$ NSIDGE. |
| Item 15 | (20A4) | |
| ZZZZ | | End of information. |

APPENDIX J

## Description of Output

This section gives a summarized description of the output generated by program DEMON2 for a typical case involving one set of lifting surfaces on a body. Sample outputs are shown in connection with the discussion of 2 sample cases in section 6. In the following, the important items of output are described. Note that if print control indices NOUT and NPR are not set equal to zero in namelist $INPUT, very large output will be generated. As such, this additional output serves to aid in debugging.

The first page identifies the run. The second and possibly the third show the namelist $INPUT. All length dimensions in the output are the same as in the input.

On the next page, the wing geometry and flow conditions are listed. The quantities ALFA and BETA correspond to angle of pitch, $\alpha$, and sideslip, $\beta$, respectively, calculated by the program, using the pitch-bank convention described in section 4, from the angle of incidence ALFAC and angle of roll PHI specified in namelist $INPUT. Information concerning the geometrical layout of the planar source panels used to model thickness of the lifting surfaces is then shown. On the next page, the specified streamwise slopes are printed. No thickness is accounted for for cases including interdigitated lifting surfaces.

If the body is circular in cross section, the next page shows namelist $BODY which was read in by subroutine BDYGEN. It is followed by the program calculated cylindrical coordinates of the body definition points and streamwise body slopes. Together with this body geometry output, the origin of each line singularity (line sources/sinks and line doublets) are given under the heading TX. All axial coordinates are in the body coordinate system with origin at the nose, refer to figure 1. The strengths of the singularities are given by T(I) for the line sources or sinks and by TC(I) for the line doublets. On the next pages, the output shows the pressures calculated on the circumference of the body with circular cross section. This information is calculated at axial locations under the heading XB in the body coordinate system. Each circumference or ring is given a BODY RING number which is written on top of the pressure point coordinates, the velocity component involved, pressure coefficients, body slopes, and pressure ratios. The pressures are calculated by subroutine BDYPR on the basis of the linear and Bernoulli pressure-velocity relationships. The latter is given by equation (10) in this report. If the pressures are calculated on the forebody, body nose shed vorticity characteristics can appear in the output if the included angle of attack is in excess of about 5°. The vorticity is represented by 2 concentrated vortices located symmetrically with respect to the crossflow free-stream component vector (unrolled coordinates). The vortex coordinates are also given in the body coordinate system (rolled coordinates) nondimensionalized by the local body radius. The calculated pressures include effects of the body nose vortices, if present. At the end of the print out of the pressures acting on the body, the number of control points, JCPT, is written. This number must be noted for runs involving the afterbody and tail fins, refer to sections 6.1.3 and 6.1.4.

For bodies with elliptical cross section, the horizontal and vertical semiaxes are printed immediately following the print out of local surface slope of the thickness distribution. Pressures at points on the surface of a body with elliptical cross section are calculated by program WDYBDY described in Appendix K.

The next pages of output contain the velocity components induced by external vortices, if applicable. They are calculated by program VPATH2 for axisymmetric bodies or by program VPATHL for bodies with elliptic cross section. Both programs are described in Appendix L. These programs compute the paths of the vortices and then proceed to calculate the vortex induced velocity components at the control points given under the headings XCP, YCP and ZCP.

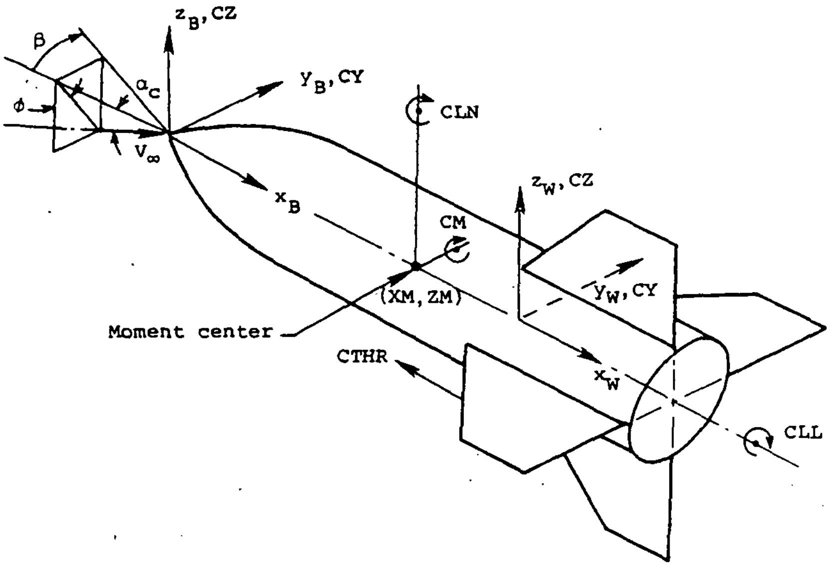
The next page in the output lists the calculated control point coordinates $(x_W, y_W, z_W)$ in the wing coordinate system shown in figure 1 for the constant u-velocity panels distributed on the lifting surfaces. Perturbation velocities, in the wing coordinate system, induced at these points by the body and external vortices with their paths fixed to be parallel to the body centerline are also shown. The quantities BU, BV, BW and VVRTX, WVRTX, are due to body singularities and vortices specified in Item 10(a) or 10(b) of the input. The velocity components induced by the body singularities are calculated by subroutine VELCAL if the body is axisymmetric. For bodies with elliptic cross section, they are computed by program WDYBDY, stored on a data set and read in by subroutine BDYRD.

Coordinates of the control points associated with the body interference panels are given on the next page. They are expressed in the wing coordinate system. Velocity components THU(J), THV(J) and THW(J) are induced by the planar source panels on the lifting surfaces used to model thickness.

Loading information is printed on the next pages. First, the loadings are based on linear pressure loadings. For each lifting surface the force and moment coefficients, spanwise loading and suction distributions and distributions along the side edge of suction force are given. The heading specifies flow conditions and reference quantities including the moment-center coordinates in the body system. It is followed by a list of the deflection angle, thrust coefficient, CTHR, acting in the negative $x_B$ (or $x_W$) direction, force coefficient CZ in the $z_B$ (or $z_W$) direction, force coefficient CY in the $y_B$ (or $y_W$) direction, pitching moment CM (nose up positive), yawing moment CLN (nose to right positive) and rolling-moment CLL (right wing down positive) coefficients.

Force coefficients CZ, CY and moment coefficients CM, CLN and CLL are also printed for the interference shell which covers the body over the length covered by the lifting surfaces. They are only representative of the lift carryover or interference from the lifting surfaces. If actual loads acting on this section of body are to be computed, the pressure distributions mentioned at the end of this section must be integrated.

So far, the loading coefficients have been expressed in the body axis system. For convenience, the positive directions of the forces and moments in the body coordinate system are indicated in the following sketch together with the body and wing reference coordinate systems. The loading information is also specified in the wind axis system, refer to section 4.2 in this report. All force and moment coefficients are then based on a coordinate system with its longitudinal axis aligned with the free stream vector. Under the heading SPANWISE DISTRIBUTIONS, the quantities of interest are the span loading CN*C/(2*B), thrust distribution CT*C/(2*B), suction distribution CS*C/(2*B) and the calculated leading-edge vorticity strength GAMMA,LE/VINF with its spanwise location YBAR. Quantity XLE is the axial coordinate, in the wing system, of the leading edge. The sums of the in-plane forces in coefficient form are then printed. Precise definitions of the terms SUMFX, SUMFY1, etc., are



given in Appendix C. Along the side edge, the distribution of suction force per unit length divided by the dynamic head times the tip chord is given together with the strength GAMMA,SE/VINF of the side-edge vorticity and the spanwise location YBAR. Quantity YBAR lies along the $y_W$ coordinate. Finally, for the lifting surface at hand the strength(s) and spanwise location(s) of the concentrated trailing-edge vortex (vortices) are printed under the heading T.E. FIN INFO.

After displaying the loading information and spanwise distributions for all the lifting surfaces, the output of program DEMON2 proceeds to specify pressure distributions on the lifting surfaces calculated on the basis of the Bernoulli pressure expression, equation (10). PRESSA is the pressure coefficient acting on the upper side and PRESSB is the pressure coefficient on the lower side of the horizontal lifting surface. For a planar (monoplane) and cruciform fin or wing configuration, the horizontal surfaces lie in the $z_W$ (or $z_B$) = 0 plane. For interdigitated fins, the horizontal fins are the right upper and left lower fins, refer also to figure 3 and the sketch in Appendix D. Coordinates X(J), Y(J) and Z(J) are in the wing coordinate system. The same pressure coefficient information is given for the vertical fins. For a cruciform fin configuration, the vertical surfaces lie in the $y_W$ (or $y_B$) = 0 plane. For interdigitated fins, the vertical fins are the right lower and left upper fins, refer to figure 3 and the sketch in Appendix D. The loading pressures coefficients, DELTP,LIN. and DELTP,BERN., pertain to the differences in pressures acting on the lifting surfaces based on linear and Bernoulli pressure expressions, respectively.

The loading calculation is then repeated using the Bernoulli loading pressures. The next pages of output contain the same loading information described above but all results are now based on the Bernoulli pressure equation.

The calculation of loading information based on linear pressure loadings and Bernoulli pressure loadings serves the following purposes. It should be noted first that the linear loading pressures are directly related to the constant u-velocity panel strengths in accordance with equation (C2) in Appendix C whereas the Bernoulli pressures are computed from the velocity components, included angle of attack and roll angle as indicated by equations (9) and (10). Fin forces, moments and trailing edge vorticity characteristics (related to span load distributions as shown in Appendix B) should be taken from the loading information calculated with Bernoulli pressures. At low angles of attack with zero roll and in the absence of external vorticity, the loadings based on the two pressures will be comparable. However, any loading increment due to leading- and side-edge vorticity calculated with the Polhamus analogy must be taken from the loading information based on linear pressures. This is based on the fact that the characteristics of the leading- and side-edge vorticity are related to the suction distributions which is calculated using the constant u-velocity panel strengths as described in Appendix C.

Finally, the pressures acting at the control points of the body interference shell are printed out. They are a continuation of the pressures, described at the beginning of this section, calculated at points on the body ahead of the wing-body section at hand. The same remarks apply. The pressures include effects of body singularities, external vortices, planar source panels on the lifting surfaces, and all the constant u-velocity panels on the lifting surfaces and body interference shell.

## Program Listing

The wing-body program DEMON2 is written in FORTRAN IV (029 punch) computer language for the CDC 6600 machine. The program consists of a main routine, CRFWBD and 32 subroutines. Their listings are shown on pages indicated below:

# APPENDIX J

## PROGRAM DEMON2

| | ROUTINE | ADDITIONAL ENTRIES | IDENTIFICATION Cols. 73-76 | PAGE NO. |
|---|---|---|---|---|
| 1 | CRFWBD | | DMN01 | 179 |
| 2 | BDYGEN | | 02 | 196 |
| 3 | BDYPR | BDYAFT | 03 | 201 |
| 4 | BDYRD | | 04 | 207 |
| 5 | BDYVTX | | 05 | 208 |
| 6 | BODYR | | 06 | 209 |
| 7 | DBLU | | 07 | 210 |
| 8 | DOUBLT | | 08 | 211 |
| 9 | DSDZ | | 09 | 212 |
| 10 | EDGES | | 10 | 212 |
| 11 | EDGVOR | | 11 | 212 |
| 12 | LAYOUT | | 12 | 216 |
| 13 | LINEQS | | 13 | 223 |
| 14 | LOADS | SPECLD | 14 | 224 |
| 15 | OUT | | 15 | 235 |
| 16 | ROTATE | ROTWF,ROTFW | 16 | 235 |
| 17 | SOLVE | | 17 | 236 |
| 18 | SOURCE | | 18 | 236 |
| 19 | SPECPR | | 19 | 237 |
| 20 | SPNLD | | 20 | 242 |
| 21 | THETIN | | 21 | 253 |
| 22 | THKIN | | 22 | 254 |
| 23 | THKLYT | | 23 | 255 |
| 24 | THKOUT | | 24 | 258 |
| 25 | THKVEL | | 25 | 260 |
| 26 | TRBIPW | TRWBIP,ROTBW,ROTWB | 26 | 266 |
| 27 | VELCAL | | 27 | 267 |
| 28 | VELNOR | | 28 | 268 |
| 29 | VELO | | 29 | 276 |
| 30 | VELOTH | | 30 | 279 |
| 31 | VRTVEL | VORTEX | 31 | 282 |
| 32 | VVELS | | 32 | 284 |
| 33 | Z | | 33 | 285 |

# PROGRAM DEMON2

```
      PROGRAM CRFWBD(INPUT,OUTPUT,TAPE3,TAPE5=INPUT,TAPE6=OUTPUT,
     1 TAPE4,TAPE7)
C
C     VERSION:DEMON2.
C
C     PLANAR OR CRUCIFORM WING-BODY PROGRAM, SUPERSONIC FLOW
C     SET UP GEOMETRY, COORDINATES, AERODYNAMIC INFLUENCE COEFFICIENT
C     MATRIX, SOLVE FOR CONSTANT U-VELOCITY PANEL STRENGTHS.
C
      DIMENSION RHS(250),YR(20),YRT(20),THU(100),THV(100),THW(100),
     1YLT(20),HEAD(20),ZUT(20),ZDT(20)
C
      LOGICAL ASYM,BODY,DELTA,TRUSYM,NOSYM,DELTAS,TAIL,ASYMT
C
      COMMON FVN(1)
      COMMON/ONE/CIRC(250),DELTP(250),FN(250),PNLC(250),SWPPLE(250),
     1SWPPTE(250),VNOR(250),XBAR(250),ZBAR(250),XCPT(250),YCPT(250),ZCPT
     2(250),XLF(250),XLB(250),XRF(250),XRB(250),YLC(250),YRC(250),ZLF(25
     30),ZRF(250),ZLB(250),ZRB(250),SNT(125),CST(125),SNT2(125),CST2(125
     4),IP(300),XFBIP(100),A,ALFA,ALFR,ARWING,B2,B2V,BETA,BETAR,CONST,
     5COSALF,COSBET,CN,DX,EM,FMACH,RCIR,SINALF,SINBET,SLOPE,TLRNC,TIPY,
     6TOTLR,U,V,W,UCHK,VCHK,WCHK,WHIP,X,Y,Z,IV,IF,II,JV,MSWR,MSWL,MSWU,
     7MSWD,NBIP,NCRX,NCW,NDRAG,NHP,NPR,NRP,N3P,NOCPT,NOLINP,NOUT,NPANLS,
     8NPRESS,NWHP,ASYM,BODY,DELTAS,NOSYM
      COMMON/THREE/ANGLR,ANGLL,ANGLU,ANGLD,DELR,DELL,DELU,DELD,SREF,REFL
      COMMON/SWEEPS/VSWLER(20),VSWTER(20),VSWLEL(20),VSWTEL(20),
     1  VSWLEU(20),VSWTEU(20),VSWLED(20),VSWTED(20),LVSWP,LEFT,FAC,NCWB,
     2ARPNL(250),WIDTH(250)
      COMMON/BVEL/BOU(150),BOV(150),BOW(150),XFLOP(150),YFLOP(150),
     1 ZFLOP(150)
      COMMON/SPSANG/SINALC,COSALC,SINPHI,COSPHI
      COMMON/VRTXV/VVRTX(150),WVRTX(150),NVRTPL,NVRTX,VRTMAX
      COMMON/WHTR/THTI(125),XWLE
      COMMON/THKDAT/NTDAT,NCWT,NTPR,MSWT(4),NRPT,NHPT,N3PT,NTHP,ASYMT,
     1       NVERT,SWLET(20,4),SWTET(20,4),YTH(20,4),THETAL(400)
      COMMON/THVELO/THETA,TTLRNC,THTSQ
      COMMON/ICVEL/UTCHK,VTCHK,WTCHK,IIT,IFT,MJ
      COMMON/TSPANS/SPANR,SPANL,SPANU,SPAND,SWPLER,SWPLEL,SWPLEU,
     1       SWPLED,SWPTER,SWPTEL,SWPTEU,SWPTED,RBOD
      COMMON/VPTHVL/VVEL(500),WVEL(500),JCPT,NCPOUT,NVLIN
      COMMON/VORSPC/GAMMA(10),YVRTX(10),ZVRTX(10),RLOC
      COMMON/FINLE/XLE(80),CGLOC(80),GAMLE(80),FKLE,NEDGV,MLEVR,MLEVL,
     1 MLEVU,MLEVD
      COMMON/FINSE/XSF(80),CGSELC(80),GAMSE(80),FKSE,NSIDGE,NSEV
      COMMON /ELLIPS/ RA,RB,ERATIO
      COMMON /INTROT/ PHIDIH,THETIT,YBOD,ZBOD,PHIFR,PHIFU
      COMMON/OAFM/XM,ZM,CZOA,CYOA,CMUA,CLNOA,CLLOA
C
C
      DATA PI/3.14159265359O/
      DATA QUIT/4HZZZZ/
C
      NAMELIST /INPUT/CRP,SWLEP,SWTEP,NCW,MSWR,MSWL,ALFAC,PHI,B2,FMACH,
     1  LVSWP,   FAC,       NFVNPR,       TOLFAC,MSWU,MSWD,SWLEV,SWTEV,
     1  CRPV,B2V,NCRX,RB,RA,ERATIO,NBDCR,DELR,DELL,DELU,DELD,SREF,REFL,
     1  PHIDIH,THETIT,XWLE,
     1 NOLINP,NOUT,NPR,NDRAG,NVRTX,NPRESS,VRTMAX ,NCWB,NAGAIN,BIL,
     1 ITAIL,NVRTPL, NBDYPR,NTPW,
     2NTDAT,NCWT,NCPOUT,NVLIN,XSTART,JCPT,FKLF,FKSE,XM,ZM
C
C
    1 FORMAT (20A4)
    2 FORMAT (1H1,20A4)
```

```
  701 FORMAT(1H1,20X,15HWING GEOMETRY///                                   DM01  64
     3 18X,12HTIP CHORD = ,F10.5//                                         DM01  65
     4 17X,13HROOT CHORD = ,F10.5//                                        DM01  66
     9 14X,16HWING SEMISPAN = ,F10.5//)                                    DM01  67
  702 FORMAT (//20X,15HFLOW CONDITIONS//5X,7HMACH = ,F10.5,4X,8HALPHAC= DM01  68
     1 ,F10.5,4X,7HPHI   = ,F10.5,4X,7HALFA = ,F10.5,4X,7HBETA = ,F10.5/)DM01  69
  703 FORMAT(1H1,18X,52H                 PANEL CORNER COORDINATES FOR WING PADM01  70
     1NELS)                                                                DM01  71
  704 FORMAT (1H1,10X,30HCONTROL POINT COORDINATES FOR ,I2,14H CHORDWISEDM01  72
     1 BY ,I2,32H SPANWISE PANELS ON WING 1 OR R,     ,2X,I2,5X,           DM01  73
     123HSPANWISE ON WING 2 OR L,    /53X,3HAND,I2,31H SPANWISE PANELS ONDM01  74
     3WING 3 OR U,1X,I2,5X,    23HSPANWISE ON WING 4 OR D,     //          DM01  75
     4                         5X,1HJ,6X,4HX(J),8X,4HY(J),8X,4HZ(J),       DM01  76
     5  7X,5HBU(J),9X,5HBV(J),9X,5HBW(J),10X,5HVVRTX,10X,5HWVRTX,/)       DM01  77
  705 FORMAT(1X,I5,2X,F10.5,2X,F10.5,2X,F10.5,2X,F12.5,2X,F12.5,           DM01  78
     1       2X,E12.5,2X,E12.5,2X,E12.5)                                   DM01  79
  706 FORMAT(3X,I3,3X,F9.4,1X,F9.4,1X,F9.4,1H*,F9.4,1X,F9.4,1X,F9.4,       DM01  80
     1  1H*,F9.4,1X,F9.4,1X,F9.4,1H*,F9.4,1X,F9.4,1X,F9.4)                 DM01  81
  707 FORMAT(1H1,30X,20HINFLUENCE MATRIX FVN//)                            DM01  82
  708 FORMAT(/1X,58(1H=),13HWING 1 PANELS    ,59(1H=)/)                    DM01  83
  709 FORMAT(/1X,58(1H=),13HWING 2 PANELS    ,59(1H=)/)                    DM01  84
  710 FORMAT(/1X,58(1H=),13HWING 3 PANELS    ,59(1H=)/)                    DM01  85
  711 FORMAT(/1X,58(1H=),13HWING 4 PANELS    ,59(1H=)/)                    DM01  86
  712 FORMAT (8I10)                                                        DM01  87
  713 FORMAT(3F10.5)                                                       DM01  88
  714 FORMAT (6F10.5)                                                      DM01  89
  715 FORMAT(//  30X,15HPARAMETERS USED//                                  DM01  90
     1  12X,7HASYM = ,L3/12X,8HTLRNC = ,E12.5/12X,7HLEFT = ,L3/            DM01  91
     213X,7HBODY = ,L3,12X,8HDELTA = ,L3,11X,9HTRUSYM = ,L3,               DM01  92
     312X,8HNOSYM = ,L3///)                                                DM01  93
  717 FORMAT(1H1,30X,21HSLOPES OF PANEL EDGES//6X,1HJ,5X,10HL.E. SLOPE, DM01  94
     1  5X,10HT.E. SLOPE/)                                                 DM01  95
  716 FORMAT (15X,I2, 8X,F10.5, 17X, F10.5, 9X, F10.5)                     DM01  96
  718 FORMAT(5X,I3,5X,F10.5,5X,F10.5)                                      DM01  97
  719 FORMAT( 9X,21HLEADING EDGE SWEEP = ,F10.5,2X,7HDEGREES//             DM01  98
     2 8X,22HTRAILING EDGE SWEEP = ,F10.5,2X,7HDEGREES/)                   DM01  99
  720 FORMAT(1H1, 5X,31HCONTROL POINTS WRITTEN ON TAPE4 //                 DM01 100
     *    ,4X,1HI,4X,4HXCPT,8X,4HYCPT,8X,4HZCPT)                           DM01 101
  721 FORMAT(9X,8HCRPTV = ,F10.5//)                                        DM01 102
  722 FORMAT (//10X,23HRIGHT WING PART SPAN = ,F10.5/                      DM01 103
     110X,  23H LEFT WING PART SPAN = ,F10.5)                              DM01 104
  723 FORMAT(//10X,7HCRPT = ,F10.5)                                        DM01 105
  724 FORMAT (1H1,10X,75H TWO DIMENSIONAL VORTEX STRENGTHS AND FIXED COODM01 106
     1RDINATES IN CROSS FLOW PLANE//                                       DM01 107
     215X,5HIVRTX, 6X,  10HGAMMA/VINF, 19X,                                DM01 108
     3 5HYVRTX,14X,5HZVRTX//)                                              DM01 109
  725 FORMAT(1H1,30X,48HCONTROL POINT COORDINATES FOR BIP*S (WING FRAME)DM01 110
     1        //5X,1HJ,6X,4HX(J),8X,4HY(J),8X,4HZ(J),6X,6HTHU(J),8X,       DM01 111
     2        6HTHV(J),8X,6HTHW(J)//)                                      DM01 112
  726 FORMAT(///25X,36HBIP CORNER COORDINATES IN WING FRAME)               DM01 113
  727 FORMAT(10X,23HUPPER WING PART SPAN = ,F10.5/                         DM01 114
     1        10X,23HLOWER WING PART SPAN = ,F10.5//)                      DM01 115
  728 FORMAT(1H1,30X,22HRIGHT HAND SIDE VECTOR//4X,1HJ,5X,6HRHS(J)//)      DM01 116
  729 FORMAT(2X,I3,2X,E12.5)                                               DM01 117
  731 FORMAT(1H1,30X,19HPRESSURE ON PANEL J//4X,1HJ,4X,4HP(J)//)           DM01 118
 7030 FORMAT (                                   //5X,1HJ,15X,2HLF,15X,    DM01 119
     1  1H*,12X,2HLB,15X,1H*,12X,2HRF,15X,1H*,12X,2HRB/12X,1HX,9X,1HY,     DM01 120
     2  9X,1HZ,5X,1H*,3X,1HX,9X,1HY,9X,1HZ,5X,1H*,3X, 1HX,9X,1HY,9X,1HZ,DM01 121
     3  5X,1H*,3X,1HX,9X,1HY,9X,1HZ/38X,1H*,29X,1H*,29X,1H*/130(1H*)/      DM01 122
     4  38X,1H*,29X,1H*,29X,1H*)                                           DM01 123
  732 FORMAT (3X,69HSPECIFIED SPANWISE LOCATIONS OF OUTBOARD PANEL EDGESDM01 124
     1 AND SWEEP ANGLES//2X,1HK,4X,6HY OR Z,7X,10HL.E. SWEEP,5X,           DM01 125
     2 10HT.E. SWEEP/23X,5HANGLE,10X,5HANGLE///)                           DM01 126
```

```
  733 FORMAT (1X,I2,2X,F10.5,2(5X,F10.5))
  734 FORMAT (1H1,4X,14HWING 1 SURFACE //)
  735 FORMAT (1H1,4X,14HWING 2 SURFACE //)
  736 FORMAT (1H1,4X,14HWING 3 SURFACE //)
  737 FORMAT (1H1,4X,14HWING 4 SURFACE //)
  744 FORMAT (1H1,4X,12HWING SURFACE//)
  745 FORMAT (I5,3G12.5)
  746 FORMAT (I5,5E12.5)
  747 FORMAT (1H1,10X,83HPOINT COORDINATES AND PERTURBATION VELOCITIES C
     1ALCULATED BY PROGRAM VPATH OR VPATHL,//,
     2 5X,2HIC,5X,3HXCP,9X,3HYCP,9X,3HZCP,8X,8HVVEL(IC),6X,8HWVEL(IC)/)
C
C
C
  999 CONTINUE
C
C     DEFAULT VALUES FOR NAMELIST INPUT
C
      ASYM=.FALSE.
      BIL=0.0
      BODY=.FALSE.
      B2V=0.0
      CRPV=0.0
      DELR=0.0
      DELL=0.0
      DELU=0.0
      DELD=0.0
      FRATIO=1.
      FAC=0.95
      FKLE=0.5
      FKSE=0.5
      ITAIL=0
      JCPT=0
      LVSWP=0
      MSWL=0
      MSWD=0
      MSWU=0
      NAGAIN=0
      NBDCR=0
      NBDYPR=0
      NCPOUT=0
      NCRX=0
      NCWB=0
      NCWT=0
      NDRAG=0
      NFVNPR=0
      NOLINP=0
      NOUT=0
      NPR=0
      NPRESS=0
      NIDAT=0
      NTPR=0
      NVLIN=0
      NVRTPL=0
      NVRTX=0
      PHI=0.0
      RA=0.
      RB=0.0
      REFL=1.0
      SREF=1.0
      SWLEP=0.0
      SWLEV=0.0
      SWTEP=0.0
```

```
      SMTEV=0.0
      TOLFAC=1.0
      VRTMAX=0.35
      XM=0.0
      XSTART=0.0
      XMLE=0.0
      ZM=0.0
C
C        THE FOLLOWING FIN ORIENTATION ANGLES AND TRIG. FUNCTIONS ARE
C     THE DEFAULT VALUES FOR  CRUCIFORM FIN CASE.
C
      PHIFR=0.0
      PHIFL=0.0
      PHIFU=90.0
      PHIFD=90.0
      THETR=0.0
      THETL=0.0
      THETU=90.0
      THETD=90.0
      PHIDIH=0.0
      THETIT=0.0
C
C
C
C***********************************************************************
C     SET CORE REQUIREMENT BASED ON FVN(1)                              *
      LFL=0
      CALL REQFL(LFL)
C                                                                      *
C***********************************************************************
C
C     WING GEOMETRY SPECIFIED IN PLANFORM.
C     GEOMETRICALLY SYMMETRIC WINGS ONLY
C
C
C     READ HEADER CARD
C
      READ(5,1) HEAD
      IF(HEAD(1).EQ.QUIT) STOP
C
C     READ NAMELIST INPUT
C
      READ (5,INPUT)
C
C
C     ANGLE OF ATTACK AND SIDESLIP ARE CALCULATED IN ACCORDANCE WITH
C     PITCH-ROLL TRANSFORMATION, SEE NIELSEN PAGE 5.
C
      DTOR=PI/180.0
      ALFACR=ALFAC*DTOR
      SINALC=SIN(ALFACR)
      COSALC=COS(ALFACR)
      PHIR=PHI*DTOR
      SINPHI=SIN(PHIR)
      COSPHI=COS(PHIR)
      SINALF=SINALC*COSPHI
      ALFR=ASIN(SINALF)
      COSALF=COS(ALFR)
      SINBET=SINALC*SINPHI
      BETAR=ASIN(SINBET)
      COSBET=COS(BETAR)
      BETAY=BETAR/DTOR
      ALFA=ALFR/DTOR
```

```
C
C     FIN ANGLE PROPERTIES
C
      SLPWLE=TAN(SWLEP*DTOR)
      SLPWTE=TAN(SWTEP*DTOR)
      SLPVLE=TAN(SWLEV*DTOR)
      SLPVTE=TAN(SWTEV*DTOR)
C
C        CHECK FOR INTERDIGITATED TAIL DIHEDRAL ANGLES
C
C  NOTE: IF INTERDIGITATED FINS ARE UNDER CONSIDERATION,THE FOLLOWING
C     CORRELATION HOLDS.
C
C        RIGHT UPPER FIN.....RIGHT OR 1
C        LEFT LOWER FIN.....LEFT OR 2
C        RIGHT LOWER FIN.....UPPER OR 3
C        LEFT UPPER FIN.....LOWER OR DOWN OR 4
C     THIS DESIGNATION ESTABLISHES CORRESPONDENCE BETWEEN CRUCIFORM AND
C     INTERDIGITATED FINS.
C NOTE:THE DIHEDRAL ANGLE DEFINED AS THE CANT ANGLE HERE.
C
      IF (THETIT.LE.0.0 .OR. THETIT.GE.90.) GO TO 22
C
C        PHIFR = UPPER RIGHT CANT ANGLE.   PHIFL = LOWER LEFT CANT ANGLE
C        PHIFU = LOWER RIGHT CANT ANGLE.   PHIFD = UPPER LEFT CANT ANGLE
C
      PHIFR= PHIDIH
      PHIFL= PHIDIH
      PHIFU=-PHIDIH
      PHIFD=-PHIDIH
C
C
C     THETR,THETU DEFINE LOCATIONS OF RHS FINS ON BODY CIRCUMFERENCE
C                 MEASURED POS. FROM +YW-AXIS COUNTERCLOCKWISE.
C     THETL,THETD DEFINE LOCATIONS OF LHS FINS ON BODY CIRCUMFERENCE
C                 MEASURED POS. FROM -YW-AXIS COUNTERCLOCKWISE.
C
      THETR= THETIT
      THETL= THETIT
      THETU=-THETIT
      THETD=-THETIT
   22 CONTINUE
C
C     ELLIPSE PROPERTIES
C        RB...HORIZONTAL SEMI-AXIS
C        RA...VERTICAL SEMI-AXIS
C
      IF (RA.EQ.0. .AND .RB.EQ.0.) GO TO 23
      IF (RA.EQ.0.) RA=RB/ERATIO
      IF (RB.EQ.0.) RB=RA*ERATIO
      ERATIO=RB/RA
   23 CONTINUE
      RCIR=SQRT(RA*RB)
      RBOD=RB
C
C
C     LOGICAL VARIABLE ASYM GOVERNS LAYOUT OF SKEWED PANELS WHICH
C     ONLY CAN BE DONE WHEN THERE IS NO BODY PRESENT.
C     PRESENTLY,PLANAR DELTA WINGS ONLY.
C
C     LOGICAL VARIABLE TRUSYM MAKES USE OF GEOMETRIC AND LOADING
C     SYMMETRY PROPERTIES
C
```

```
      ASYM=(BETAY.NE.0.0).AND.(NBDCR.EQ.0)
      BODY=NBDCR.NE.0
      DELTA=DELR.NE.0..OR.DELL.NE.0..OR.DELU.NE.0..OR.DELD.NE.0.
      DELTAS=DELR.NE.DELL.OR.DELU.NE.0..OR.DELD.NE.0.
      TRUSYM=BETAY.EQ.0.0.AND..NOT.DELTAS
      NOSYM= .NOT. TRUSYM
      TAIL=ITAIL .NE. 0
C
      TIPY=B2
      NRP=NCW*MSWR
      NRP1=NRP+1
      NHP=NCW*(MSWR+MSWL)
      NHP1=NHP+1
      N3P=NCW*(MSWL+MSWR+MSWU)
      N3P1=N3P+1
      NPANLS=NCW*(MSWR+MSWL+MSWU+MSWD)
      IF (TRUSYM) NPANLS=NRP
      IF (TRUSYM .AND. THETIT.GT.0.) NPANLS=NCW*(MSWR+MSWU)
      NPANLP=NPANLS+1
      NBIP=NCWB*NBDCR
      IF (TRUSYM.AND.BODY) NBIP=NBIP/2
      NWBP=NPANLS+NBIP
      IF (NWBP.GT.8) NPR=0
C
      WRITE (6,2) HEAD
C
C
C     ANGLES ANGLR,ANGLL,ANGLU,ANGLD GOOD ONLY FOR CRUCIFORM FINS OR
C     MONO-PLANE WING.
C
      RDELR=DELR*DTOR
      ANGLR=RDELR + ALFR
      RDELL=DELL*DTOR
      ANGLL=ALFR+RDELL
      RDELU=DELU*DTOR
      ANGLU=BETAR+RDELU
      RDELD=DELD*DTOR
      ANGLD=BETAR+RDELD
      BETA=SQRT(ABS(FMACH*FMACH-1.) )
      TLRNC=(B2*15.E-5)**2*TOLFAC
      TOTLR=2.0*TLRNC
      CONST= 4.0*PI
      TBETA=BETA
      TBTSQ=BETA*BETA
      TTLRNC=TLRNC
      NVERT=NCRX
      ASYMT=ASYM
C
C
      WRITE(6,INPUT)
      IF (NAGAIN.GT.1) GO TO 53
C
C
C***********************************************************************
C     UP TO STATEMENT 69 IS FOR WING ALONE CASE
C***********************************************************************
C     NOTE: IF NDRAG=1, USE A MAXIMUM OF 150 PANELS
C
      IF(ASYM.OR.BODY.OR.NCRX.NE.0) GO TO 69
      MSWRP=MSWR+1
      IF(LVSWP.EQ.0) GO TO 25
C
C     FOR THIS CASE YR(KJ) MEASURED FROM WING CENTERLINE.
```

```
C
      READ(5,715) (YR(KJ),VSWLER(KJ),VSWTER(KJ),KJ=1,MSWRP)
      SWPLER=VSWLER(MSWRP)
      SWPTER=VSWTER(MSWRP)
      GO TO 26
C
C     LAY OUT THE SPANWISE LOCATION OF PANEL RHS, YR(I)IN THE PLANFORM
C     PLANE
C     IF THEY WERE NOT READ IN ALREADY
C
   25 YR(1)=0.0
      YR(MSWRP)=B2
      DY=B2/MSWR
      DO 110 I=2,MSWR
      AI=I-1
  110 YR(I)= YR(1)+DY*AI
      SWPLER=SWLER
      SWPTER=SWTER
   26 SPANR=B2
      CRPT=CRP
      GO TO 69
C
C     IF WITH SIDESLIP AND WITHOUT BODY.
C     YAWED WING GEOMETRY LAID OUT RELATIVE TO LINE FORMED BY
C     INTERSECTION OF STREAMWISE PLANE THROUGH WING ROOT CHORD LE AND
C     WING PLANFORM PLANE (A STREAMWISE LINE)
C     THIS PROGRAM OPTION CAN ONLY BE USED FOR DELTA WING
C     WITHOUT BODY.
C
   69 CONTINUE
      MSWRP=MSWR+1
      MSWLP=MSWL+1
      MSWUP=MSWU+1
      MSWDP=MSWD+1
      IF (BODY) GO TO 74
      IF (.NOT.ASYM) GO TO 74
      IF (IVSWP.NE.0) GO TO 60
      SWPLER=SWLER-BETAY
      SWPTER=SWTER-BETAY
      SWPLEL=SWLER+BETAY
      SWPTEL=SWTER+BETAY
      CTP=CRP-B2*(SLPWLE-SLPWTE)
      CRPT= CRP*(COSBET+SINBET*TAN(SWPTEL*DTOR))
      SPANL= (B2/COS(SWLER*DTOR))*COS(SWPLEL*DTOR)
      SPANR=(B2/COS(SWLER*DTOR))*COS(SWPLER*DTOR)+CTP*SINBET
      GO TO 76
C
C     SET UP GEOMETRICALLY SYMMETRIC LAY-OUT.
C
   74 SWPLER=SWLER
      SWPTER=SWTER
      SWPLEL=SWLER
      SWPTEL=SWTER
      CRPT=CRP
      SPANR=B2
      SPANL=B2
   76 CONTINUE
      IF(NCPY.EQ.0) GO TO 77
C
C     CASE FOR VERTICAL WING PANELS
C
      IF (BODY) GO TO 75
```

```
      IF (.NOT.ASYM) GO TO 75
      SWPLEU=SWLEV+ALFA
      SWPTEU=SWTEV+ALFA
      SWPLED=SWLEV-ALFA
      SWPTED=SWTEV-ALFA
      CTPV=CRPV-B2V*(SLPVLE-SLPVTE)
      CRPTV=CRPV*(COSALF+SINALF*TAN(SWPTEU*DTOR))
      SPANU=(B2V/COS(SWLEV*DTOR))*COS(SWPLEU*DTOR)
      SPAND=(B2V/COS(SWLEV*DTOR))*COS(SWPLED*DTOR)+CTPV*SINALF
      GO TO 77
   75 SWPLEU=SWLEV
      SWPTEU=SWTEV
      SWPLED=SWLEV
      SWPTED=SWTEV
      CRPTV=CRPV
      SPANU=B2V
      SPAND=B2V
   77 CONTINUE
C
C
      SLPWLR= TAN(SWPLER*DTOR)
      SLPWTR= TAN(SWPTER*DTOR)
      SLPWLL= TAN(SWPLEL*DTOR)
      SLPWTL= TAN(SWPTEL*DTOR)
      IF (NCRX.EQ.0) GO TO 64
      SLPWLU=TAN(SWPLEU*DTOR)
      SLPWLD=TAN(SWPLED*DTOR)
      SLPWTU=TAN(SWPTEU*DTOR)
      SLPWTD=TAN(SWPTED*DTOR)
   64 IF (LVSWP.EQ.0) GO TO 65
C
C     READ IN NON UNIFORM DISTANCES TO PANEL OUTBOARD EDGES.
C     IF WITH A BODY, MEASURE FROM FIN ROOT CHORD.
C
   60 READ (5,713) (YRT(KJ),VSWLER(KJ),VSWTER(KJ),KJ=1,MSWRP)
      SWPLER=VSWLER(MSWRP)
      SWPTER=VSWTER(MSWRP)
      SWPLEU=SWPLER
      SWPTEU=SWPTER
      SPANR=YRT(MSWRP)-YRT(1)
      SPANL=SPANR
      SPANU=SPANR
      IF (TRUSYM.AND. THETIT.LE.0.) GO TO 68
      IF (TRUSYM) GO TO 61
      READ (5,713) (YLT(KJ),VSWLEL(KJ),VSWTEL(KJ),KJ=1,MSWLP)
      SWPLEL=-VSWLEL(MSWLP)
      SWPTEL=-VSWTEL(MSWLP)
      SPANL=-(YLT(MSWLP)-YLT(1))
      IF (NCRX.EQ.0) GO TO 68
C
C     IF TRUSYM IS TRUE AND INTERDIGITATED TAIL IS TREATED,
C     DATA IS EXPECTED FOR THE RIGHT UPPER AND LOWER FINS
C
   61 READ(5,713) (ZUT(KJ),VSWLEU(KJ),VSWTEU(KJ),KJ=1,MSWUP)
      SWPLEU=VSWLEU(MSWUP)
      SWPTEU=VSWTEU(MSWUP)
      SPANU=ZUT(MSWUP)-ZUT(1)
      IF (TRUSYM) GO TO 68
      READ(5,713)  (ZDT(KJ),VSWLED(KJ),VSWTED(KJ),KJ=1,MSWDP)
      SWPLED=-VSWLED(MSWDP)
      SWPTED=-VSWTED(MSWDP)
      SPAND=-(ZDT(MSWDP)-ZDT(1))
      GO TO 68
   65 CONTINUE
```

```
C
C     EQUAL SPANWISE WIDTHS, CONSTANT SWEEPS
C     PANELS IN HORIZONTAL WING SURFACES
C
      YRT(1)=0.0
      YRT(MSWRP)=SPANR+YRT(1)
      DYR=SPANR/MSWR
      DO 51 I=2,MSWR
      AI=I-1
   51 YRT(I)=DYR*AI+YRT(1)
      IF (TRUSYM .AND. THETIT.EQ.0.0) GO TO 68
C
      IF (TRUSYM) GO TO 57
      YLT(1)=0.0
      YLT(MSWLP)=-SPANL+YLT(1)
      DYL=SPANL/MSWL
      DO 52 I=2,MSWL
      AI=I-1
   52 YLT(I)=-DYL*AI+YLT(1)
      IF (NCRX.EQ.0) GO TO 68
C
C     PANELS IN VERTICAL PLANE
C
   57 ZUT(1)=0.0
      ZUT(MSWUP)=SPANU+ZUT(1)
      DZU=SPANU/MSWU
      DO 54 I=2,MSWU
      AI=I-1
   54 ZUT(I)=DZU*AI+ZUT(1)
C
      IF (TRUSYM) GO TO 68
      ZDT(1)=0.0
      ZDT(MSWDP)=-SPAND+ZDT(1)
      DZD=SPAND/MSWD
      DO 55 I=2,MSWD
      AI=I-1
   55 ZDT(I)=-DZD*AI+ZDT(1)
   68 CONTINUE
C
      IF (LVSWP.EQ.0) GO TO 79
      IF (ASYM.OR.BODY.OR.NCRX.NE.0) GO TO 28
      WRITE (6,744)
      WRITE (6,732)
      DO 29 K=1,MSWRP
   29 WRITE (6,733) K,YR(K),VSWLER(K),VSWTER(K)
      GO TO 79
   28 WRITE (6,734)
      WRITE (6,732)
      DO 80 K=1,MSWRP
   80 WRITE (6,733) K,YRT(K),VSWLER(K),VSWTER(K)
      IF (TRUSYM .AND. THETIT.LE.0.) GO TO 79
      IF (TRUSYM) GO TO 84
      WRITE (6,735)
      DO 81 K=1,MSWLP
   81 WRITE (6,733) K,YLT(K),VSWLEL(K),VSWTEL(K)
      IF (NCRX.EQ.0) GO TO 79
   84 WRITE (6,736)
      DO 82 K=1,MSWUP
   82 WRITE (6,733) K,ZUT(K),VSWLEU(K),VSWTEU(K)
      IF (TRUSYM) GO TO 79
      WRITE (6,737)
      DO 83 K=1,MSWDP
   83 WRITE(6,733) K,ZDT(K),VSWLED(K),VSWTED(K)
```

```
   79 CONTINUE
C
C
C     LAY-OUT ELEMENTAL PANELS ON WING ALONE.
C
      IF(ASYM.OR.BODY.OR.NCRX.NE.0) GO TO 50
      CALL LAYOUT(SLPWLE,SLPWTE,YR,MSWRP,CRP,1,CTP,PHIFR,THETR)
      IF (NOUT.EQ.1) WRITE (6,715) ASYM,TLRNC,LEFT,BODY,DELTA,TRUSYM,
      NOSYM
      GO TO 53
C
C
C     LAY-OUT ELEMENTAL PANELS ON THE FINS.
C
C    NOTE: DISTANCES YRT,YLT,ZUT,ZDT ARE MEASURED FROM THE FIN ROOT
C     CHORDS IF BODY IS PRESENT
C
C
   50 CALL LAYOUT(SLPWLR,SLPWTR,YRT,MSWRP,CRPT,1,CTR,PHIFR,THETR)
      IF (NOUT.EQ.1) WRITE (6,715) ASYM,TLRNC,LEFT,BODY,DELTA,TRUSYM,
     1NOSYM
      IF (NCRX.NE.0) CTPV=CTR
      IF (TRUSYM .AND. THETIT.LE.0.0) GO TO 62
C
      IF (TRUSYM) GO TO 63
      CALL LAYOUT(SLPWLL,SLPWTL,YLT,MSWLP,CRPT,2,CTPL,PHIFL,THETL)
      IF (NOUT.EQ.1) WRITE (6,715) ASYM,TLRNC,LEFT,BODY,DELTA,TRUSYM,
     1NOSYM
      IF (NCRX.EQ.0) GO TO 62
C
   63 CALL LAYOUT(SLPWLU,SLPWTU,ZUT,MSWUP,CRPTV,3,CTPV,PHIFU,THETU)
      IF (NOUT.EQ.1) WRITE (6,715) ASYM,TLRNC,LEFT,BODY,DELTA,TRUSYM,
     1NOSYM
C
      IF (TRUSYM) GO TO 62
      CALL LAYOUT(SLPWLD,SLPWTD,ZDT,MSWUP,CRPTV,4,CTPVD,PHIFD,THETD)
      IF (NOUT.EQ.1) WRITE (6,715) ASYM,TLRNC,LEFT,BODY,DELTA,TRUSYM,
     1NOSYM
C
C     LAY-OUT BODY INTERFERENCE PANELS
C
   62 IF(NBDCR.EQ.0) GO TO 53
      CALL LAYOUT(SLPWLE,SLPWTE,0.0,NBDCR,HIL,5,0.,0.,0.)
      IF (NOUT.EQ.1) WRITE (6,715) ASYM,TLRNC,LEFT,BODY,DELTA,TRUSYM,
     1NOSYM
   53 CONTINUE
C
C
      WRITE(6,701)  CTP,CRP,B2
      IF (LVSWP.EQ.0) WRITE(6,719) SWLEP,SWTEP
      WRITE (6,702) FMACH,ALFAC,PHI,ALFA,BETAY
      IF(.NOT.ASYM) GO TO 56
      WRITE(6,722) SPANR,SPANL
      IF(NCRX.NE.0)WRITE(6,727) SPANU,SPAND
   56 CONTINUE
      WRITE(6,723) CRPT
      IF(NCRX.NE.0) WRITE(6,721) CRPTV
      IF (NOUT.NE.1) GO TO 7813
      WRITE(6,703)
      WRITE(6,7030)
      WRITE(6,708)
      WRITE(6,706) (J,XLF(J),YLC(J),ZLF(J),XLR(J),YLC(J),ZLR(J),XRF(J),
     1  YRC(J),ZRF(J),XRR(J),YRC(J),ZRR(J),J=1,NRP)
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```
      IF (TRUSYM .AND. THETIT.LE.0.) GO TO 71
C
      IF (TRUSYM) GO TO 73
      WRITE(6,709)
      WRITE(6,706) (J,XLF(J),YLC(J),ZLF(J),XLB(J),YLC(J),ZLB(J),XRF(J),
     1  YRC(J),ZRF(J),XRB(J),YRC(J),ZRB(J),J=NRP1,NHP)
      IF(NCRX.EQ.0) GO TO 71
C
   73 WRITE(6,710)
      WRITE(6,706) (J,XLF(J),YLC(J),ZLF(J),XLB(J),YLC(J),ZLB(J),XRF(J),
     1  YRC(J),ZRF(J),XRB(J),YRC(J),ZRB(J),J=NHP1,NSP)
      IF (TRUSYM) GO TO 71
C
      WRITE(6,711)
      WRITE(6,706) (J,XLF(J),YLC(J),ZLF(J),XLB(J),YLC(J),ZLB(J),XRF(J),
     1  YRC(J),ZRF(J),XRB(J),YRC(J),ZRB(J),J=N3P1,NPANLS)
C
   71 IF(NBDCR.EQ.0) GO TO 72
      WRITE(6,726)
      WRITE(6,7030)
      WRITE (6,706) (J,XLF(J),YLC(J),ZLF(J),XLB(J),YLC(J),ZLB(J),XRF(J),
     1YRC(J),ZRF(J),XRB(J),YRC(J),ZRB(J),J=NPANLP,NWBP)
      WRITE (6,717)
      WRITE (6,718) (J,SWPPLE(J),SWPPTE(J),J=1,NWBP)
      GO TO 7813
   72 WRITE(6,717)
      WRITE(6,718) (J,SWPPLE(J),SWPPTE(J),J=1,NPANLS)
 7813 CONTINUE
C
C
C
C     INPUT THICKNESS DATA, PRINT INPUT VALUES, AND LAY
C     OUT SOURCE PANELS ON FINS.
C     SUBROUTINE THKIN READS IN STREAMWISE THICKNESS SLOPES.
C
      IF(NTDAT.EQ.0) GO TO 88
      CALL THKIN
      CALL THKOUT
      CALL THKLYT(CRPT,0)
      IF(ASYM) CALL THKLYT(CRPT,1)
C
      IF(NCRX.EQ.0) GO TO 88
      CALL THKLYT(CRPTV,2)
      IF(ASYM) CALL THKLYT(CRPTV,3)
   88 CONTINUE
C
C     INITIALIZE BODY INDUCED VELOCITIES AND VORTEX INDUCED VELOCITIES
C
      DO 10 KM=1,150
      VVRTX(KM)=0.0
      WVRTX(KM)=0.0
      BDU(KM)=0.0
      BDV(KM)=0.0
   10 BDW(KM)=0.0
C
      DO 11 IC=1,500
      VVEL(IC)=0.0
   11 WVEL(IC)=0.0
C
C
C     WHEN NCPOUT NOT ZERO,
C     PUT WING OR FIN CONTROL POINTS AND BODY INTERFERENCE PANEL
C     CONTROL POINTS IN DATA SET ON TAPE 4.
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C                                                                      *DM01 821
C     SPECIAL PURPOSE CORE MEMORY ECONOMY SECTION FOR BCS 6600         *DM01 822
C     SET CORE REQUIREMENT BASED ON LFL PLUS FVN(NWBP,NWBP)            *DM01 823
C     NOTE: ALREADY SET FVN(1).                                         DM01 824
C                                                                      *DM01 825
      MFLTOT=LFL+NWBP*NWBP-1                                            DM01 826
      CALL REQFL(MFLTOT)                                                DM01 827
C                                                                      *DM01 828
C***********************************************************************DM01 829
C                                                                       DM01 830
C     SET UP INFLUENCE COEFFICIENT MATRIX                               DM01 831
C     IT IS THE LHS OF THE FLOW TANGENCY CONDITION.                     DM01 832
C     NOTE: THE B.C. STATES THAT VELOCITY NORMAL TO THE PANELS MUST     DM01 833
C     BE ZERO.                                                          DM01 834
C     THEREFORE ALL VELOCITIES MUST BE TRANSFORMED INTO INDIVIDUAL      DM01 835
C     FLAP COORDINATE SYSTEM.                                           DM01 836
C                                                                       DM01 837
C                                                                       DM01 838
C     CALCULATE THE INFLUENCE OF EACH PANEL ON EACH CONTROL POINT       DM01 839
C     II AND IF ARE THE LIMITS FOR SUMMATION OF THE INFLUENCE FUNCTION  DM01 840
C     IN SUBROUTINE VELNOR                                              DM01 841
C     IF II = IF, THE INFLUENCE OF A SINGLE PANEL AT A POINT RESULTS    DM01 842
C     AS IN THE COMPUTATION OF THE ARRAY FVN.  IF II=1 AND IF=NWBP,     DM01 843
C     THE INFLUENCES ARE SUMMED OVER ALL PANELS, AS IN THE COMPUTATION ODM01 844
C     RESULTANT VELOCITIES BELOW....                                    DM01 845
C                                                                       DM01 846
C     --- I IS THE INDEX OF THE INFLUENCING PANEL                       DM01 847
C                                                                       DM01 848
C                                                                       DM01 849
      JJ=0                                                              DM01 850
      NOCPT=0                                                           DM01 851
      DO 450 I=1,NWBP                                                   DM01 852
      II=I                                                              DM01 853
      IF=I                                                              DM01 854
C                                                                       DM01 855
C     J IS THE INDEX OF THE INFLUENCED PANEL,I.E. ITS CONTROL POINT.    DM01 856
C                                                                       DM01 857
      DO 425 J=1,NWBP                                                   DM01 858
      JB=J-NPANLS                                                       DM01 859
      CALL VELNOR(XCPT(J),YCPT(J),ZCPT(J))                              DM01 860
      JJ=JJ+1                                                           DM01 861
      IF(J.LE.NPANLS) GO TO 417                                         DM01 862
C                                                                       DM01 863
C     INFLUENCED PANEL IS ON THE BODY INTERFERENCE SHELL.               DM01 864
C                                                                       DM01 865
      CALL ROTWB (VCHK,WCHK,VV,WW,JB)                                   DM01 866
      GO TO 418                                                         DM01 867
C                                                                       DM01 868
C     INFLUENCED PANEL IS ON A FIN.                                     DM01 869
C                                                                       DM01 870
  417 IF (J.LE.NHP) PHIF=PHIFR*DTOR                                     DM01 871
      IF (J.GT.NHP.AND.J.LE.NPANLS) PHIF=PHIFU*DTOR                     DM01 872
      CALL ROTWF(VCHK,WCHK,VV,WW,PHIF)                                  DM01 873
  418 FVN(JJ)=WW                                                        DM01 874
  425 CONTINUE                                                          DM01 875
  450 CONTINUE                                                          DM01 876
C                                                                       DM01 877
C     DEBUG DUMP OF THE FVN ARRAY                                       DM01 878
C                                                                       DM01 879
      IF(NFVNPR.EQ.0) GO TO 618                                         DM01 880
      WRITE (6,707)                                                     DM01 881
      CALL OUT(FVN,NWBP)                                                DM01 882
  618 CONTINUE                                                          DM01 883
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      CALL LINEQS(NWBP,FVN)                                             DM01 884
      IF (NAGAIN.NE.1) GO TO 9000                                       DM01 885
      JMAX=NWBP**2                                                      DM01 886
      REWIND 3                                                          DM01 887
      BUFFER OUT (3,1) (FVN(1),FVN(JMAX))                               DM01 888
      NAGAIN=NAGAIN+1                                                   DM01 889
      IF (UNIT(3)) 27,27,27                                             DM01 890
   27 CONTINUE                                                          DM01 891
      GO TO 9000                                                        DM01 892
C***********************************************************************DM01 893
C                                                                      *DM01 894
C     CASE FOR NAGAIN G.T. 1, SET REQUIRED FIELD LENGTH.                DM01 895
C                                                                       DM01 896
 8889 JMAX=NWBP**2                                                      DM01 897
      MFLTOT=LFL+NWBP*NWBP-1                                            DM01 898
      CALL REQFL(MFLTOT)                                                DM01 899
C                                                                      *DM01 900
C***********************************************************************DM01 901
      REWIND 3                                                          DM01 902
      BUFFER IN (3,1) (FVN(1),FVN(JMAX))                                DM01 903
      IF (UNIT(3)) 30,30,30                                             DM01 904
   30 CONTINUE                                                          DM01 905
 9000 CONTINUE                                                          DM01 906
C                                                                       DM01 907
C     SET UP SINGLE COLUMN MATRIX RHS FOR RIGHT HAND SIDE               DM01 908
C     IT REPRESENTS THE EXTERNALLY INDUCED VELOCITIES AND ANGLE OF      DM01 909
C     PITCH AND SIDESLIP EFFECTS AS WELL AS FIN THICKNESS.              DM01 910
C  NOTE: NO THICKNESS EFFECTS ACCOUNTED FOR IF INTERDIGITATED FINS      DM01 911
C     ARE CONSIDERED.                                                   DM01 912
C                                                                       DM01 913
C                                                                       DM01 914
      IF (NVLIN.EQ.0.OR.ITAIL.EQ.1) GO TO 607                           DM01 915
      REWIND 7                                                          DM01 916
      WRITE (6,747)                                                     DM01 917
  607 CONTINUE                                                          DM01 918
C                                                                       DM01 919
C     CASE FOR WING OR FIN ALL AT SAME ANGLE AS BODY                    DM01 920
C                                                                       DM01 921
C     READ IN VELOCITIES INDUCED BY MOVING VORTICES (CALCULATED BY      DM01 922
C     PROGRAM VPATH) AT ALL CONSTANT U-VELOCITY PANEL CONTROL POINTS.   DM01 923
C                                                                       DM01 924
C                                                                       DM01 925
      IF(DELTA) GO TO 627                                               DM01 926
      DO 620 I=1,NWBP                                                   DM01 927
      IC=I                                                              DM01 928
      IF (NVLIN.EQ.0.OR .ITAIL.EQ.1) GO TO 605                          DM01 929
      READ (7,746) IC,XCP,YCP,ZCP,VVEL(IC),WVEL(IC)                     DM01 930
      WRITE (6,705) IC,XCP,YCP,ZCP,VVEL(IC),WVEL(IC)                    DM01 931
  605 CONTINUE                                                          DM01 932
      WEXT=SINALF+BDW(I)+WVRTX(I)+WVEL(IC)                              DM01 933
      VEXT=-SINBET+BDV(I)+VVRTX(I)+VVEL(IC)                             DM01 934
      IF (I.GT.NPANLS) GO TO 601                                        DM01 935
      IF(I.LE.NHP) GO TO 602                                            DM01 936
      IF(I.LE.NPANLS) GO TO 604                                         DM01 937
  601 RHS(I)=0.0                                                        DM01 938
      GO TO 620                                                         DM01 939
  602 PHIF=PHIFR*DTOR                                                   DM01 940
      CALL ROTWF(VEXT,WEXT,VV,WW,PHIF)                                  DM01 941
      RHS(I)=-WW                                                        DM01 942
      GO TO 620                                                         DM01 943
  604 PHIF=PHIFU*DTOR                                                   DM01 944
      CALL ROTWF(VEXT,WEXT,VV,WW,PHIF)                                  DM01 945
                                                                        DM01 946
```

```
      RHS(I)=-WW
  620 CONTINUE
      GO TO 646
C
C     RIGHT HAND SIDE FOR WINGS OR FINS TILTED WITH RESPECT TO BODY
C
  627 CONTINUE
      DO 645 K=1,NWBP
      IC=K
      IF (NVLIN.EQ.0.OR.ITAIL.EQ.1) GO TO 606
      READ (7,746) IC,XCP,YCP,ZCP,VVEL(IC),WVEL(IC)
      WRITE (6,705) IC,XCP,YCP,ZCP,VVEL(IC),WVEL(IC)
  606 CONTINUE
      VEXT=-SINBET+BDV(K)+VVRTX(K)+VVEL(IC)
      WEXT=SINALF+BDW(K)+WVRTX(K)+WVEL(IC)
      IF (K.GT.NPANLS) GO TO 603
      IF(K.LE.NRP) GO TO 641
      IF(K.LE.NHP) GO TO 642
      IF(K.LE.N3P) GO TO 643
      IF(K.LE.NPANLS) GO TO 644
  603 RHS(K)=0.0
      GO TO 645
  641 PHIF=PHIFR*DTOR
      CALL ROTWF(VEXT,WEXT,VV,WW,PHIF)
      RHS(K)=-WW-SIN(RDELR)
      GO TO 645
  642 PHIF=PHIFL*DTOR
      CALL ROTWF(VEXT,WEXT,VV,WW,PHIF)
      RHS(K)=-WW-SIN(RDELL)
      GO TO 645
  643 PHIF=PHIFU*DTOR
      CALL ROTWF(VEXT,WEXT,VV,WW,PHIF)
      RHS(K)=-WW-SIN(RDELU)
      GO TO 645
  644 PHIF=PHIFD*DTOR
      CALL ROTWF(VEXT,WEXT,VV,WW,PHIF)
      RHS(K)=-WW-SIN(RDELD)
  645 CONTINUE
  646 CONTINUE
C
C     ADD IN PERTURBATION VELOCITY COMPONENTS INDUCED BY FIN
C     SOURCE PANELS AT THE BODY INTERFERENCE PANEL CONTROL POINTS.
C
      IF(NTOAT.EQ.0.OR..NOT.BODY) GO TO 91
      IIT=1
      IFT=NTHP
      DO 90 K=NPANLP,NWBP
      MJ=K
      CALL THKVEL(XCPT(K),YCPT(K),ZCPT(K))
      KB=K-NPANLS
      THU(KB)=UTCHK
      THV(KB)=VTCHK
      THW(KB)=WTCHK
C
C     INFLUENCED PANEL IS A BIP.  RESOLVE WING-FRAME
C     VELOCITIES INTO BIP FRAME.
C
      CALL ROTWB(VTCHK,WTCHK,VT,WT,KB)
      RHS(K)=RHS(K)-WT
   90 CONTINUE
      GO TO 92
   91 DO 93 K=NPANLP,NWBP
      KB=K-NPANLS
      THU(KB)=0.0
      THV(KB)=0.0
```

```
   93 THW(KB)=0.0
   92 CONTINUE
C
      IF (NOUT.NE.0) WRITE (6,728)
      IF (NOUT.EQ.0) GO TO 648
      WRITE(6,729) (K,RHS(K),K=1,NWBP)
  648 CONTINUE
      CALL SOLVE(RHS,FVN,NWBP)
      IF (NOUT.NE.0) WRITE(6,731)
      DO 630 I=1,NWBP
      DEMONP=RHS(I)*CONST
      DELTP(I)=DEMONP
      IF (ABS(DELTP(I)).LT.1.0E-10) DELTP(I)=0.0
      IF (NOUT.EQ.0) GO TO 630
      WRITE(6,729) I,DELTP(I)
  630 CONTINUE
C************************************************************************
C     REDUCE REQUIRED CORE ALLOCATION BACK TO LFL SIZE                 *
C                                                                      *
      CALL REQFL(LFL)
C                                                                      *
C************************************************************************
C
C     PRINT CONTROL POINT COORDINATES OF THE CONSTANT U-VELOCITY PANELS
C     ON THE WING OR FIN SURFACES AND THE EXTERNALLY INDUCED
C     VELOCITIES AT THE CONTROL POINTS.
C
C
      WRITE(6,704) NCW,MSWR,MSWL,MSWU,MSWD
      WRITE(6,705) (J,XCPT(J),YCPT(J),ZCPT(J),BDU(J),BDV(J),BDW(J),
     1VVRTX(J),WVRTX(J),J=1,NPANLS)
      IF(.NOT.BODY) GO TO 655
      WRITE(6,725)
      DO 650 K=NPANLP,NWBP
  650 WRITE(6,705) K,XCPT(K),YCPT(K),ZCPT(K),THU(K-NPANLS),
     1      THV(K-NPANLS),THW(K-NPANLS)
  655 CONTINUE
C
C
C
C     CALCULATE LOADINGS ON THE WINGS OR FINS WITH LINEAR PRESSURE
C     LOADINGS
C
      IF (NPRESS.EQ.0) CALL LOADS
C
C
C     NON LINEAR PRESSURE LOADING CALCULATION
C     NVRTPL=0 MEANS EXCLUDE VORTEX INDUCED VELOCITIES PARALLEL TO WING
C     SURFACES
C
C
C
      IF (NOLINP.NE.0) CALL SPECPR
C
C     CONTINUE CALCULATION OF PRESSURES ON THE BODY MERIDIANS IN THE
C     REGION AFT OF LEADING EDGES OF FIN-BODY JUNCTIONS.
C     BDYAFT IS ENTRY POINT IN SUBROUTINE BDYPR
C
      IF (BODY.AND.NBDYPR.NE.0) CALL BDYAFT(ITAIL,XSTART)
C
C
      GO TO 999
      END
```

```
      SUBROUTINE BODYGEN                                                DM02
C                                                                       DM02
C     VERSION:DEMON2.                                                   DM02
C                                                                       DM02
C   THIS SUBROUTINE DETERMINES STRENGHTS OF SUPERSONIC LINEARLY         DM02
C        VARYING LINE SOURCES/SINKS AND LINE DOUBLETS TO MODEL A BODY OF DM02
C     REVOLUTION AT GIVEN INCLUDED ANGLE OF ATTACK AND MACH NUMBER.     DM02
C                                                                       DM02
      DIMENSION A(100)                                                  DM02
C                                                                       DM02
      LOGICAL ASYM,DUMBDY,DELTA,NOSYM                                   DM02
C                                                                       DM02
      COMMON/ONE/DUM1(6402),ALFR,ARWING,B2,DUM2(9),FMACH,RB,DUM3(3),    DM02
     1 TLRNC,TIPY,TOTLR,DUM4(18) ,                                      DM02
     2  NBIP,DUM5(2),NDRAG,DUM6(4),NOCPT,NOLINP,NOUT,NPANLS,NPRESS,NWBP,DM02
     2ASYM,DUMBDY,DELTA,NOSYM                                           DM02
      COMMON/TWO/TX(101),UBD(101),UBS(101),VBD(101),VBS(101),VTBD(101), DM02
     1XBODY(101),RBODY(101),RPBODY(101),DRDX(100),T(100),TC(100),COEFF  DM02
     2(5),BCODE,BETASQ,BSQ,RADIUS,RFIELD,DUM7 ,U,V,VT,LNOSE,MACH,MACHSQ,DM02
     3BETA,XFIELD,X2,LBODY,NXBODY                                       DM02
      COMMON/WBTR/THTI(125),XWLE                                        DM02
      COMMON/SPSANG/SINALC,COSALC,SINPHI,COSPHI                         DM02
      COMMON/WBTR1/XF(100),RF(100)                                      DM02
C                                                                       DM02
C                                                                       DM02
      REAL MACH,MACHSQ,LNOSE,LBODY,LBODYR                               DM02
C                                                                       DM02
      INTEGER BCODE                                                     DM02
C                                                                       DM02
C                                                                       DM02
      NAMELIST/BODY/NXBODY,LNOSE,LBODY,BCODE                            DM02
C                                                                       DM02
C                                                                       DM02
C                                                                       DM02
    6 FORMAT(I4,F9.4,10G11.4)                                           DM02
  227 FORMAT(1H0,63HVELOCITIES INDUCED ON BODY BY BODY LINE SINGULARITIEDM02
     1S FOR MACH=,F7.4,5X,6HALFAC=,F7.4//20X,12HBODY SOURCES,25X,13HBODYDM02
     2 DOUBLETS,//9X,1HX,5X,1HU,10X,1HV,10X,2HVN,9X,1HU,9X,1HV,10X,     DM02
     3 2HVT, 9X,2HVN/)                                                  DM02
  700 FORMAT(1X,8(1H-),22HBODY DEFINITION POINTS,7(1H-),3X,10(1H-),     DM02
     1 14HCONTROL POINTS,9(1H-)/3X,1HI,6X,5HXBODY,6X,5HRBODY,5X,        DM02
     2  6HRPBODY,12X,2HXF,9X,2HRF,6X,5HDR/DX//)                         DM02
  701 FORMAT(1X,I3,1X,F10.4,1X,F10.4,1X,F10.4,4X,F10.4, 1X,F10.4,1X,    DM02
     1  F10.4)                                                          DM02
  702 FORMAT(20X,20H***REVISED LAYOUT***/)                              DM02
  703 FORMAT(1H1)                                                       DM02
  704 FORMAT (//,9X,54HBODY MERIDIAN-BODY NOSE MACH CONE INTERSECTION ATDM02
     1 XI= ,F10.5/)                                                     DM02
  799 FORMAT(1H1,89HPHYSICAL DIMENSIONS OF BODY AND LINE SINGULARITY STRDM02
     1ENGTHS REPRESENTING THE BODY AT MACH=,F7.4,5X,7HALFAC= ,F7.4/     DM02
     2 9X,1HX,12X,1HR,11X,5HDR/DX,12X,2HTX,10X,4HT(I),10X,5HTC(I))      DM02
  801 FORMAT(I4,F9.4, 6G15.5)                                           DM02
  802 FORMAT (1H1,48HBODY RADIUS TOO LARGE IN RELATION TO BODY LENGTH//)DM02
  803 FORMAT(///5X,63HMACH CONE-BODY MERIDIAN INTERSECTION NOT FOUND AFTDM02
     1ER 100 TRIALS///)                                                 DM02
C                                                                       DM02
C                                                                       DM02
      MACH=FMACH                                                        DM02
      RADIUS=RB                                                         DM02
C                                                                       DM02
C     READ NAMELIST BODY                                                DM02
C                                                                       DM02
```

```
      READ(5,BODY)
C
C
      WRITE(6,BODY)
      IF(NXBODY.LE.0.OR.NXBODY.GT.101)NXBODY=51
C
C
C     INITIALIZE DOUBLET STRENGHTS
C
      DO 103 I=1,NXBODY
  103 TC(I)=0.0
C
C CALCULATION OF AERODYNAMIC DATA
C
      MACHSQ=MACH*MACH
      BETASQ=MACHSQ-1.0
      BETA=SQRT(BETASQ)
      ALPHA=ASIN(SINALC)
      ALFAC=ALPHA*57.2957795
      N=NXBODY-1
      XBODY(1)=0.0
      XBODY(NXBODY)=LBODY
C
C
C     BAIL OUT IF MACH CONE FROM NOSE TIP LIES INSIDE THE ENTIRE LENGTH
C     OF THE BODY
C
      IF (BETA*RADIUS.GE.LBODY) GO TO 200
      GO TO 204
  200 WRITE (6,802)
      STOP
  204 CONTINUE
C
C SETUP OF POINTS ON BODY AXIS BY DIVIDING BODY LENGTH INTO N  EQUAL
C SEGMENTS
C
      DEL=LBODY/N
      DO 33 I=2,N
   33 XBODY(I)=XBODY(I-1)+DEL
C
C
C     CALCULATION OF BODY RADII AND STREAM WISE SLOPES AT THE X-STATIONS
C     OF THE AXIS POINTS.
C     THEY ARE THE COORDINATES AND SLOPE AT THE BODY DEFINITION POINTS
C
      DO 35 I=1,NXBODY
   35 CALL BODYR(XBODY(I)       ,RBODY(I),RPBODY(I))
C
C     NOW DETERMINE SLOPES DR/DX AT THE CONTROL POINTS TAKEN MID-WAY
C     BETWEEN THE BODY DEFINITION POINTS
C
      DO 36 I=1,N
      XF(I)=.5*(XBODY(I+1)+XBODY(I))
      CALL BODYR(XF(I),RF(I),DRDX(I))
   36 CONTINUE
      IF(NOUT.NE.1) GO TO 9
      WRITE(6,703)
      WRITE(6,700)
      WRITE(6,701) (I,XBODY(I),RBODY(I),RPBODY(I),XF(I),RF(I),
     1  DRDX(I),I=1,N)
      WRITE(6,701) NXBODY,XBODY(NXBODY),RBODY(NXBODY),RPBODY(NXBODY)
    9 CONTINUE
C
```

```
C NEXT LOOP DETERMINES THE LOCATIONS OF THE ORIGINS OF THE LINEARLY
C VARYING LINE SOURCES/SINKS AND DOUBLETS.
C THEIR STARTING POINTS ARE GIVEN BY TX(I)
C
      DO 10 I=1,NXBODY
   10 TX(I)=XBODY(I)-BETA*RBODY(I)
C
C  IF CONTROL POINTS LIE OUTSIDE THE MACH CONE WITH ITS ORIGIN AT THE
C  BODY NOSE, REVISE LAY-OUT OF BODY DEFINITION POINTS ETC.
C
      IF(BETA*RF(1).LT.XF(1))GO TO 199
C
C     DETERMINE X-STATION OF INTERSECTION OF BODY NOSE MACH CONE
C     WITH BODY
C
      DO 37 I=2,N
      IF((BETA*RF(I)-XF(I)).LT.0.0)  GO TO 38
   37 CONTINUE
   38 IAFT=I
      IBFR=I-1
      DELTX=(XF(IAFT)-XF(IBFR))*0.1
      ITRY=0
      XTRY=XF(IBFR)
   40 RMCNE=XTRY/BETA
      CALL BODYR(XTRY,RI,SLPE)
      ITRY=ITRY+1
      ERR=RI-RMCNE
      IF(ITRY.GE.100) GO TO 42
      IF(ERR.LT.0.0) GO TO 39
      XTRY=XTRY+DELTX
      GO TO 40
   42 WRITE(6,803)
      STOP
   39 IF(ABS(ERR).LT.(.01*RI)) GO TO 41
      XTRY=XTRY-DELTX
      DELTX=0.1*DELTX
      GO TO 40
   41 XI=XTRY
C
C     REVISE LAYOUT OF BODY DEFINITION POINTS, CONTROL POINTS, AND
C     ORIGINS OF LINE SINGULARITIES
C
      LBODYR=LBODY-XI
      DEL=LBODYR/N
      XBODY(2)=XI+DEL
      DO 43 I=3,N
   43 XBODY(I)=XBODY(I-1)+DEL
C
      DO 44 I=1,NXBODY
   44 CALL BODYR(XBODY(I),RBODY(I),RPBODY(I))
C
      XF(1)=0.5*(XI+XBODY(2))
      CALL BODYR(XF(1),RF(1),DRDX(1))
      DO 45 I=2,N
      XF(I)=0.5*(XBODY(I)+XBODY(I+1))
      CALL BODYR(XF(I),RF(I),DRDX(I))
   45 CONTINUE
      IF(NOUT.NE.1) GO TO 455
      WRITE(6,703)
      WRITE(6,702)
      WRITE (6,704) XI
      WRITE(6,700)
```

```
      WRITE(6,701) (I,XBODY(I),RBODY(I),RPBODY(I),XF(I),RF(I),
     1  DRDX(I),I=1,N)
      WRITE(6,701) NXBODY,XBODY(NXBODY),RBODY(NXBODY),RPBODY(NXBODY)
  455 CONTINUE
      TX(1)=0.0
      DO 46 I=2,NXBODY
   46 TX(I)=XBODY(I)-BETA*RBODY(I)
  199 CONTINUE
C
C     DETERMINATION OF SOURCE STRENGTHS AT CONTROL POINTS MIDWAY BETWEEN
C      BODY DEFINITION POINTS.
C
C CALCULATION OF THE FIRST SOURCE STRENGTH.
C
      XFIELD=XF(1)
      RFIELD=RF(1)
      SLOPE=DRDX(1)
      RSQ=BETASQ*RFIELD*RFIELD
      X2=XFIELD-LBODY
      CALL SOURCE(1)
      A(1)=V-SLOPE*U
      T(1)=DRDX(1)/A(1)
C
C CALCULATION OF THE REST OF SOURCE STRENGTHS.
C
      DO 210 I=2,N
      XFIELD=XF(I)
      RFIELD=RF(I)
      SLOPE=DRDX(I)
      RSQ=BETASQ*RFIELD*RFIELD
      X2=XFIELD-LBODY
      DO 205 J=1,I
      CALL SOURCE(J)
  205 A(J)=V-SLOPE*U
      SUM=0.
      IM1=I-1
      DO 201 J=1,IM1
  201 SUM=T(J)*A(   J)+SUM
  210 T(I)=(DRDX(I)-SUM)/A(I)
      T(NXBODY)=0.0
C
C     DETERMINATION OF DOUBLET STRENGTHS AT CONTROL POINTS MIDWAY
C      BETWEEN BODY DEFINITION POINTS
C
C CALCULATION OF THE FIRST DOUBLET STRENGTH.
C
      IF (ABS(ALPHA).LT.1.0E-10.OR.RB.LT.(0.1*R2)) GO TO 798
      XFIELD=XF(1)
      RFIELD=RF(1)
      SLOPE=DRDX(1)
      RSQ=BETASQ*RFIELD*RFIELD
      X2=XFIELD-LBODY
      CALL DOUBLT(1)
      A(1)=SLOPE*U-V
      TC(1)=ALPHA/A(1)
C
C CALCULATION OF THE REST OF THE DOUBLET STRENGTHS.
C
      DO 215 I=2,N
      XFIELD=XF(I)
      RFIELD=RF(I)
      SLOPE=DRDX(I)
      RSQ=BETASQ*RFIELD*RFIELD
```

```
      X2=XFIELD-LBODY
      DO 212 J=1,I
      CALL DOUBLT(J)
  212 A(  J)=SLOPE*U-V
      SUM=0.
      IM1=I-1
      DO 203 J=1,IM1
  203 SUM=TC(J)*A(  J)+SUM
  215 TC(I)=(ALPHA-SUM)/A(I)
      TC(NXBODY)=0.0
  798 CONTINUE
C
C PRINT OUT OF BODY CHARACTERISTICS
C
      WRITE(6,799)MACH,ALFAC
      DO 800 I=1,NXBODY
  800 WRITE(6,801) I,XBODY(I),RBODY(I),RPBODY(I),TX(I),T(I),TC(I)
C
C COMPUTATION OF VELOCITIES INDUCED ON BODY BY BODY SOURCES AND
C DOUBLETS AT BODY DEFINITION POINTS, THT=0 DEGR. MEANS LEEWARD SIDE
C
      IF(NOUT.EQ.0) RETURN
      WRITE(6,227)MACH,ALFAC
C
C     COSTH,SINTH ARE COSINE AND SINE,RESPECTIVELY, OF THE STREAMWISE
C     BODY SLOPE ANGLE.
C
      DO 225 I=1,NXBODY
      COSTH=SQRT(1./(RPBODY(I)**2+1.))
      SINTH=SQRT(1.-COSTH*COSTH)
      XFIELD=XBODY(I)
      RFIELD=RBODY(I)
      IF(RFIELD.GT.0.   )GO TO 214
C
C  IF THE FIELD POINT IS ON THE AXIS, THEN WE SHIFT OUT TO AVOID THE
C   SINGULARITY IN THE VELOCITY FUNCTION ON THE AXIS.
C
      IF(I.EQ.NXBODY)GO TO 221
      RFIELD=RBODY(I+1)/10.
      XFIELD=XFIELD+(XBODY(I+1)-XBODY(I))/10.
      GO TO 214
  221 RFIELD=RBODY(I-1)/10.
      XFIELD=XFIELD-(XBODY(I)-XBODY(I-1))/10.
  214 RSQ=BETASQ*RFIELD*RFIELD
      X2=XFIELD-LBODY
C
C     VELOCITIES UD,VD ARE CALCULATED ON THE BODY OPPOSITE THE CROSS
C     FLOW STREAM VECTOR (LEEWARD SIDE)
C     VELOCITY VTD IS CALCULATED AT 90 DEGREES FROM THE CROSS FLOW
C     STREAM DIRECTION
C
      US=0.
      VS=0.
      UD=0.
      VD=0.
      VTD=0.
      DO 218 J=1,I
      CALL SOURCE(J)
      US=US+T(J)*U
      VS=VS+T(J)*V
      CALL DOUBLT(J)
      UD=UD+U*TC(J)
      VD=VD+V*TC(J)
```

```
C
C     VNS,VND ARE INDICATORS OF LEAKAGE THROUGH THE BODY SURFACE
C     AT THE BODY DEFINITION POINTS.
C NOTE: THE BOUNDARY CONDITION IS SATISFIED AT THE CONTROL POINTS IN
C     BETWEEN THE BODY DEFINITION POINTS.
C
  218 VTD=VTD+VT*TC(J)
      IF(RPBODY(I).LT.0.)GO TO 220
      VNS=VS*COSTH-(1.+US)*SINTH
      VND=(VD+ALPHA)*COSTH-UD*SINTH
      GO TO 222
  220 VNS=VS*COSTH+(1.+US)*SINTH
      VND=(VD+ALPHA)*COSTH+US*SINTH
  222 UBS(I)=US
      VBS(I)=VS
      UBD(I)=UD
      VBD(I)=VD
      VTBD(I)=VTD
  225 WRITE(6,6) I,XBODY(I),US,VS,VNS,UD,VD,VTD,VND
      RETURN
      END


      SUBROUTINE BDYPR(ITAIL,XSTART)
C
C     VERSION:DEMON2.
C
C     THIS SUBROUTINE COMPUTES LINEAR AND BERNOULLI PRESSURES AT POINTS
C     ON THE BODY SURFACE.
C     THE POINTS LIE ON BODY MERIDIANS. THEIR X-COORDINATES ARE A SUBSET
C     OF THE X-COORDINATES OF THE BODY CONTROL POINTS (XF(I),RF(I))
C     DETERMINED IN SUBROUTINE BDYGEN.
C     THE DENSITY OF THE POINTS IS TAKEN AS HALF THE DENSITY OF
C     THE BODY SINGULARITIES.
C     WHERE THE BODY
C     IS COVERED WITH INTERFERENCE PANELS, THE POINTS COINCIDE WITH
C     THE PANEL CONTROL POINTS.  THE BODY MERIDIANS ON WHICH THE
C     POINTS LIE PASS THROUGH THE CONTROL POINTS OF THE BODY
C     INTERFERENCE PANELS.  THE NUMBER OF BODY MERIDIANS IS EQUAL TO
C     NBDCR, THAT IS, THE NUMBER OF BODY INTERFERENCE PANELS ON THE
C     BODY CIRCUMFERENCE.
C
C
C
      DIMENSION THETD(100)
C
C
      LOGICAL BODY,NOSYM
C
C
      COMMON/ONE/CIRC(250),DELTP(250),FN(250),PNLC(250),SWPPLE(250),
     1SWPPTE(250),VNOR(250),XBAR(250),ZBAR(250),XCPT(250),YCPT(250),ZCPT
     2(250),XLF(250),XLB(250),XRF(250),XRB(250),YLC(250),YRC(250),ZLF(25
     30),ZRF(250),ZLB(250),ZRB(250),SNT(125),CST(125),SNT2(125),CST2(125
     4),IP(300),XFBIP(100),A,ALFA,ALFR,ARWING,B2,B2V,BETA,BETAR,CONST,
     5COSALF,COSBET,CN,DX,EM,FMACH,RCIR,SINALF,SINBET,SLOPE,TLRNC,TIPY,
     6TOTLR,U,V,W,UCHK,VCHK,WCHK,WBIP,X,Y,Z,I,IF,IT,J,MSWR,MSWL,MSWU,
     7MSWD,NBIP,NCBX,NCW,NDRAG,NHP,NPR,NRP,N3P,NOCPT,NOLINP,NOUT,NPANLS,
     8NPRESS,NWRP,ASYM,BODY,DELTAS,NOSYM
      COMMON/SWEEPS/VSWLER(20),VSWTER(20),VSWLEL(20),VSWTEL(20),
     1  VSWLEU(20),VSWTEU(20),VSWLED(20),VSWTED(20),LVSWP,LEFT,FAC,NCWB,
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```
     2ARPNL(250),WIDTH(250)
      COMMON/BVEL/BDU(150),BDV(150),BDW(150),XFLDP(150),YFLDP(150),
     1 ZFLDP(150)
      COMMON/SPSANG/SINALC,COSALC,SINPHI,COSPHI
      COMMON/WBTR/THTI(125),XWLE
      COMMON/TWO/TX(101),UBD(101),UBS(101),VBD(101),VBS(101),VTHD(101),
     1XBODY(101),RBODY(101),RPBODY(101),DRDX(100),T(100),TC(100),COEFF
     2(5),BCODE,BETASQ,BSQ,RADIUS,RFIELD,RNOSE,DUMVEL(3),LNOSE,MACH,
     3MACHSQ,DMBETA,XFIELD,X2,LBODY,NXBODY
      COMMON /WBTR1/ XF(100),RF(100)
      COMMON/VRTXV/VVRTX(150),WVRTX(150),NVRTPL,NVRTX,VRTMAX
      COMMON/THKDAT/NTDAT,NCWT,NTPR,MSWT(4),NRPT,NHPT,N3PT,NTHP,ASYMT,
     1       NVERT,SWLET(20,4),SWTET(20,4),YTH(20,4),THETAL(400)
      COMMON/ICVEL/UTCHK,VTCHK,WTCHK,IIT,IFT,MJ
      COMMON/VPTHVL/VVEL(500),WVEL(500),JCPT,NCPOUT,NVLIN
      COMMON/VORSPC/GAMMA(10),YVRTX(10),ZVRTX(10),RLOC
      COMMON/ELLIPS/RA,RB,ERATIO
C
C
      REAL LBODY
C
C
      DATA RADTOD/57.2957795/
C
C
C
  700 FORMAT(1H1,25X,49HPRESSURE COEFFICIENTS AT POINTS ON BODY MERIDIAN
     13//)
  701 FORMAT (//45X,10HBODY RING=,1X,I3/)
  702 FORMAT(1X,I3,12F10.5)
  703 FORMAT (2X,1HJ,4X,6HTHETA,,6X,2HX8,6X,2HY8,8X,2HZ8,8X,4HUTOT,6X,
     1 4HVTOT,6X,4HWTOT,4X,7HCP,LIN,,3X,8HCP,BERN,,3X,5HDP/DX,5X,
     2 7HP/PINF,,3X,7HP/PINF,/8X,4HDEG,,97X,5HBERN,,5X,4HLIN,/)
  704 FORMAT (1H1,106(1H*)/1X,37HAFT OF LEADING EDGE OF FIN ROOTCHORDS)
  705 FORMAT (1X,I5,3(2X,F10.5),2(2X,E12.5))
  706 FORMAT (/40X,46HRIGHT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)= ,
     1 F10.5/
     2              40X,46HRIGHT VORTEX Y(ROLLED COORDS.)/RLOC          = ,
     3  F10.5/
     4              40X,46HRIGHT VORTEX Z(ROLLED COORDS.)/RLOC          = ,
     5 F10.5/
     6              40X,46HLEFT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) = ,
     7 F10.5/
     8              40X,46HLEFT VORTEX Y(ROLLED COORDS.)/RLOC           = ,
     9 F10.5/
     1              40X,46HLEFT VORTEX Z(ROLLED COORDS.)/RLOC           = ,
     2 F10.5/)
  745 FORMAT (I5,3E12.5)
  746 FORMAT (I5,5E12.5)
  747 FORMAT (///10X,38HTOTAL NUMBER OF PRESSURE POINTS,JCPT= ,I4)
  748 FORMAT (1H1,10X,73HPOINT COORDINATES AND PERTURBATION VELOCITIES C
     1ALCULATED BY PROGRAM VPATH//,
     2 5X,2HIC,5X,3HXCP,9X,3HYCP,9X,3HZCP,8X,8HVVEL(IC),6X,8HWVEL(IC)/)
C
C
C
      IF (.NOT.BODY) RETURN
      FACTR1=1.428571429/(FMACH*FMACH)
      FACTR2=0.2*FMACH*FMACH
      DEGTOR=1.0/RADTOD
      ALFAC=ASIN(SINALC)*RADTOD
      THETAN=ATAN(RPBODY(1))*RADTOD
      FINF=XWLE/(2.0*RB)
      XA=XWLE/RB
```

```
      NOCPT=1
C
C
C NOTE: UP TO ENTRY BOYAFT,FOLLOWING APPLIES TO CIRCULAR CROSS SECTION
C     BODIES ONLY.
C     SET UP ARRAY OF COORDINATES IN WING COORDINATE SYSTEM FOR
C     THE PRESSURE POINTS AHEAD OF THE WING- OR FIN-BODY JUNCTION,
C     CALCULATE VELOCITY COMPONENTS IN BODY COORDINATE SYSTEM,
C     THEN CALCULATE PRESSURE COEFFICIENTS.
C
C     READ IN PERTURBATION VELOCITIES CALCULATED BY PROGRAM VPATH2
C     IF NVLIN IS NOT ZERO.
C     ONLY APPLICABLE WHEN TAIL IS UNDER CONSIDERATION.
C
      IF (NVLIN.EQ.0.OR.ITAIL.EQ.0) GO TO 8
      REWIND 7
      WRITE (6,748)
      DO 9  I=1,JCPT
      READ (7,746) IC,XCP,YCP,ZCP,VVEL(IC),WVEL(IC)
    9 WRITE (6,705) IC,XCP,YCP,ZCP,VVEL(IC),WVEL(IC)
    8 CONTINUE
C
      WRITE(6,700)
      WRITE (6,703)
      NRING=NBJP/NCWB
      NRINGD=2*NRING
      IF (.NOT.BOSYM) NRINGD=NRINGD+1
      NHALF=NXBODY/2
      DTHETA=THTI(1)/2.0
      ANBODY=NXBODY
      DELX=LBODY/(ANBODY-1.0)
      IF (ITAIL.EQ.1) GO TO 5
      JCPT=0
      ISTART=1
      IL=0
      GO TO 6
    5 JCPT=NWBP
      ISTART=(XSTART/(DELX*2.0))+2
    6 CONTINUE
C
C
C
C     WRITE DATA-SET CONTAINING CONTROL POINTS.
C
      IF (ITAIL.EQ.0.AND.NCPOUT.EQ.0) GO TO 7
      DO 21 IXSTAT=ISTART,NHALF
      ICPT=(IXSTAT-1)*2+1
      XPT=XF(ICPT)-XWLE
      IF (XPT.GE.0.0) GO TO 22
      DO 23 J=1,NRINGD
   23 JCPT=JCPT+1
   21 CONTINUE
   22 CONTINUE
      WRITE(6,747) JCPT
      REWIND 4
      WRITE(4,745) JCPT
      WRITE(4,745) (J,XCPT(J),YCPT(J),ZCPT(J),J=1,NWBP)
      JCPT=NWBP
    7 CONTINUE
C
C
      DO 10 IXSTAT=ISTART,NHALF
      ICPT=(IXSTAT-1)*2+1
      XPT=XF(ICPT)-XWLE
```

```fortran
      IF(XPT.GE.0.0) GO TO 15
      WRITE(6,701) IXSTAT
      DO 11 JPOLAR=1,NRING
      JDBLE=JPOLAR*2
      JDM1=JDBLE-1
      THETD(JDM1)=THTI(JPOLAR)-DTHETA
      THETD(JDBLE)=THTI(JPOLAR)
      THETEV=THETD(JDBLE)*DEGTOR
      THETOD=THETD(JDM1)*DEGTOR
      YPTEV=RF(ICPT)*COS(THETEV)
      YPTOD=RF(ICPT)*COS(THETOD)
      ZPTEV=RF(ICPT)*SIN(THETEV)
      ZPTOD=RF(ICPT)*SIN(THETOD)
C
C  NOTE: XFLDP,YFLDP,ZFLDP ARE IN THE WING COORDINATE SYSTEM.
C
      XFLDP(JDM1)=XPT
      XFLDP(JDBLE)=XPT
      YFLDP(JDM1)=YPTOD
      YFLDP(JDBLE)=YPTEV
      ZFLDP(JDM1)=ZPTOD
   11 ZFLDP(JDBLE)=ZPTEV
C
C     IF TRUSYM IS TRUE, ADD FIELDPOINT AT 270 DEGREES
C     TO COORDINATE ARRAYS.
C
      IF(NOSYM) GO TO 25
      DO 20 J=1,NRING
      JJ=NRINGD-J
      XFLDP(JJ+1)=XFLDP(JJ)
      YFLDP(JJ+1)=YFLDP(JJ)
      ZFLDP(JJ+1)=ZFLDP(JJ)
      THETD(JJ+1)=THETD(JJ)
   20 CONTINUE
      XFLDP(NRING+1)=XPT
      YFLDP(NRING+1)=0.0
      ZFLDP(NRING+1)=-RF(ICPT)
      THETD(NRING+1)=270.0
   25 CONTINUE
C
C     COMPUTE CONTRIBUTION TO VELOCITIES FROM BODY SINGULARITIES.
C     BDU, BDV, BDW.
C
      CALL VELCAL (NRINGD,ALFR,BETAR,1)
C
C  NOTE: AHEAD OF THE FIN-BODY JUNCTION,NO INFLUENCE FROM CONSTANT
C     U-VELOCITY OR SOURCE PANELS.
C
C
C     ADD CONTRIBUTION FROM NOSE VORTICES IF APPLICABLE.
C     THEIR INFLUENCE IS LIMITED TO THE DISTANCE ALONG THE BODY UP TO
C     THE ROOTCHORD LE OF THE CANARDS.
C
      IF (ITAIL.EQ.1) GO TO 19
      IF (ABS(ALFAC).LE.4.0) GO TO 19
      XGAMN=XF(ICPT)/RB
      PLOC=RF(ICPT)
      CALL BDYVTX (ALFAC,THETAN,FINE,XA,FMACH,GAMN,1,XGAMN,YGAMN,
     1 ZGAMN,XSA,IL)
      IF (GAMN.EQ.0.0) GO TO 19
      NVRT=NVRTX
      NVRTX=2
      GAMMA(1)=GAMN
      GAMMA(2)=-GAMN
```

```
      YVRTX(1)=-ZGAMN*SINPHI+YGAMN*COSPHI
      YVRTX(2)=-ZGAMN*SINPHI-YGAMN*COSPHI
      ZVRTX(1)=ZGAMN*COSPHI+YGAMN*SINPHI
      ZVRTX(2)=ZGAMN*COSPHI-YGAMN*SINPHI
      WRITE (6,706) GAMMA(1),YVRTX(1),ZVRTX(1),
     1                 GAMMA(2),YVRTX(2),ZVRTX(2)
      NOCPT=1
      CALL VORTEX (1,NRINGD)
      NVRTX=NVRT
   19 CONTINUE
C
C     PRESSL=LINEAR PRESSURE COEFFICIENT
C     PRESSB=BERNOULLI PRESSURE COEFFICIENT
C
      DO 12 J=1,NRINGD
      JCPT=JCPT+1
      IC=JCPT
      XBDY=XFLDP(J)+XWLE
      IF (NOUT.NE.0)
     1WRITE (6,702) J,THETD(J),XBDY,YFLDP(J),ZFLDP(J),BDU(J),BDV(J),
     1 BDW(J)
      UTOT=BDU(J)
      VTOT=BDV(J)+VVRTX(J)
      WTOT=BDW(J)+WVRTX(J)
      IF (NOUT.NE.0)
     1WRITE (6,702) J,THETD(J),XBDY,YFLDP(J),ZFLDP(J),UTOT,VTOT,WTOT
      VTOT=VTOT+VVEL(IC)
      WTOT=WTOT+WVEL(IC)
      IF (NOUT.NE.0)
     1WRITE (6,702) J,THETD(J),XBDY,YFLDP(J),ZFLDP(J),UTOT,VTOT,WTOT
      PRESSL=-2.0*UTOT
      BDUSQ=UTOT*UTOT
      BDVSQ=VTOT*VTOT
      BDWSQ=WTOT*WTOT
      UBAR=UTOT*COSALC-VTOT*SINBET+WTOT*SINALF
      ARG=1.0-FACTR2*(2.0*UBAR+BDUSQ+BDVSQ+BDWSQ)
      PRESSB=-FACTR1
      IF(ARG.GE.TOTLR) PRESSB=FACTR1*(ARG**3.5-1.0)
      POPINF=PRESSB/FACTR1+1.0
      PLINOP=PRESSL/FACTR1+1.0
      WRITE(6,702) J,THETD(J),XBDY,YFLDP(J),ZFLDP(J),UTOT,VTOT,WTOT,
          PRESSL,PRESSB,DRDX(ICPT),POPINF   ,PLINOP
C
C
C     FINISH WRITING DATA-SET WITH BODY PRESSURE POINTS.
C     APPLICABLE ONLY WHEN ITAIL=1 AND NCPOUT.NE.0.
C
C NOTE: THEY ARE SPECIFIED IN THE WING COORDINATE SYSTEM.
C
      IF (ITAIL.EQ.1.AND.NCPOUT.NE.0)
     1                    WRITE (4,745) JCPT,XFLDP(J),YFLDP(J),ZFLDP(J)
C
      VVRTX(J)=0.0
      WVRTX(J)=0.0
   12 CONTINUE
   10 CONTINUE
   13 CONTINUE
      WRITE (6,747) JCPT
      RETURN
C
C     CALCULATE PRESSURE COEFFICIENTS AFT OF LEADING EDGE OF FIN-BODY
C     JUNCTION AT CONTROL POINTS OF BODY INTERFERENCE PANELS.
C     CONTROL POINT COORDINATES ARE IN WING SYSTEM.
```

```
C
      ENTRY BDYAFT
C
      WRITE (6,704)
      WRITE (6,700)
      WRITE (6,703)
      DO 14 IBD=1,NBIP
      JBD=IBD+NPANLS
      XFLDP(IBD)=XCPT(JBD)
      YFLDP(IBD)=YCPT(JBD)
   14 ZFLDP(IBD)=ZCPT(JBD)
C
C     COMPUTE CONTRIBUTION TO VELOCITIES FROM BODY SINGULARITIES, BDU,
C     BDV, BDW.
C     IF BODY HAS ELLIPTICAL CROSS SECTION,BDU,BDV,BDW ARE ALREADY READ
C     IN BY ROUTINE CRFWBD FROM A DATA SET.(SEE SUBROUTINE BDYRD)
C
      IF (RA.EQ.RB) CALL VELCAL (NBIP,ALFR,BETAR,1)
C
C
C     ADD EFFECTS OF 2-D TYPE VORTICES IF APPLICABLE
C     THEY HAVE BEEN CALCULATED ALREADY IN CRFWBD.
C     (BY MEANS OF SUBROUTINE VRTVEL OR VVELS)
C
      DO 18 K=1,NBIP
      KK=K+NPANLS
      IF (RA.EQ.RB) GO TO 16
      BDU(K)=BDU(KK)
      BDV(K)=BDV(KK)
      BDW(K)=BDW(KK)
   16 BDV(K)=BDV(K)+VVRTX(KK)
   18 BDW(K)=BDW(K)+WVRTX(KK)
C
C     ADD CONTRIBUTION FROM SOURCE PANELS ON WINGS
C
      IF(NTDAT.EQ.0) GO TO 35
      IIT=1
      IFT=NTHP
      DO 30 K=1,NBIP
      KJ=K
      CALL THKVEL(XFLDP(K),YFLDP(K),ZFLDP(K))
      BDU(K)=BDU(K)+UTCHK
      BDV(K)=BDV(K)+VTCHK
      BDW(K)=BDW(K)+WTCHK
   30 CONTINUE
   35 CONTINUE
C
C     CALCULATE CONTRIBUTION FROM CONSTANT U-VELOCITY PANELS ON BODY
C     INTERFERENCE SHELL AND WINGS OR FINS.
C     ADD IN VELOCITIES INDUCED BY MOVING VORTICES(IF APPLICABLE).
C
C
      IBD=0
      II=1
      IF=NWHP
      NRING=NBIP/NCWB
      DTHETA=THTI(1)/2.0
      FACTR1=1.428571429/(FMACH*FMACH)
      FACTR2=0.2*FMACH*FMACH
      DO 15 IL=1,NCWB
      WRITE (6,701) IL
      DO 17 JL=1,NRING
      IBD=IBD+1
```

```
      IC=NPANLS+IBD
      THTSD=THTI(JL)-DTHETA
      XBDY=XFLDP(IBD)+XWLE
      IF (NOUT.NE.0)
     1WRITE (6,702) JL,THTSD,XBDY,YFLDP(IBD),ZFLDP(IBD),BDU(IBD),
     1 BDV(IBD),BDW(IBD)
      CALL VELNOR (XFLDP(IBD),YFLDP(IBD),ZFLDP(IBD))
      UTOT=UCHK+BDU(IBD)
      VTOT=VCHK+BDV(IBD)+VVEL(IC)
      WTOT=WCHK+BDW(IBD)+WVEL(IC)
      IF (NOUT.NE.0)
     1WRITE (6,702) JL,THTSD,XBDY,YFLDP(IBD),ZFLDP(IBD),UTOT,VTOT,
     1 WTOT
      PRESSL=-2.0*UTOT
      BDUSQ=UTOT*UTOT
      BDVSQ=VTOT*VTOT
      BDWSQ=WTOT*WTOT
      UBAR=UTOT*COSALC-VTOT*SINBET+WTOT*SINALF
      ARG=1.0-FACTR2*(2.0*UBAR+BDUSQ+BDVSQ+BDWSQ)
      PRESSB=-FACTR1
      IF(ARG.GE.TOTLR) PRESSB=FACTR1*(ARG**3.5-1.0)
      POPINF=PRESSB/FACTR1+1.0
      PLINOP=PRESSL/FACTR1+1.0
      SLP=0.0
      WRITE(6,702)JL,THTSD,XBDY,          YFLDP(IBD),ZFLDP(IBD),UTOT
     1,VTOT,WTOT,PRESSL,PRESSB,SLP,POPINF,PLINOP
   17 CONTINUE
   15 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE BDYRD(BDU,BDV,BDW,NWBP,NPANLS,NAGAIN)
C
C     VERSION: DEMON2
C
C  ROUTINE TO READ ELLIPTICAL CROSS SECTION BODY INDUCED VELOCITIES
C     AT WING AND BODY INTERFERENCE SHELL.
C     THEY ARE READ IN FROM TAPE4.
C
      DIMENSION BDU(NWBP),BDV(NWBP),BDW(NWBP)
C
      COMMON/ELLIPS/RA,RB,ERATIO
C
  700 FORMAT (////,5X,54HBODY UNDER CONSIDERATION HAS ELLIPTICAL CROSS S
     1ECTION./
     2 5X,44HINTERFERENCE SHELL HAS FOLLOWING PROPERTIES:/
     3 5X,23HHORIZONTAL SEMI-AXIS = ,F10.5/
     4 5X,23HVERTICAL SEMI-AXIS   = ,F10.5////)
745   FORMAT(I5,3E12.5)
750   FORMAT(///,10X,24HWARNING - NWCPT,NF,NWBP,76X,12H** BDYRD ** //,
     *    7H NWCPT=,I5,7H XMACH=,F10.4,7H ALPHA=,F10.4)
C
C     READ PAST CONTROL POINT COORDINATES.
C
      IF (NAGAIN.LE.0) REWIND 4
      IF (NAGAIN.LE.0) READ (4,745) NDUM
      IF (NAGAIN.LE.0) READ(4,745) (I,XPTJ,YPTJ,ZPTJ,J=1,NWBP)
      WRITE (6,700) RB,RA
C
C
```

```
C   READ VELOCITY COMPONENTS
C
      READ(4,745) NWCPT,XMACH,XALPHA
      IF (NWCPT.NE.NWBP) WRITE(6,750) NWCPT,XMACH,XALPHA
      READ(4,745) (I,BDU(J),BDV(J),BDW(J),J=1,NWCPT)
      RETURN
      END


      SUBROUTINE BDYVTX (ALPHAD,THETAN,FINE,XA,EMACH,GAMN,NG,
     1                   XGAMN,YGAMN,ZGAMN,XSA,IL)
C
C     VERSION: DEMON2
C
C     FOR BODIES WITH CIRCULAR CROSS SECTION ONLY
C     THIS SUBROUTINE COMPUTES STRENGTH AND POSITION IN THE CROSS FLOW
C     PLANE OF THE BODY NOSE VORTICES AS A FUNCTION OF AXIAL DISTANCE.
C     THE METHOD USED IS BASED ON EXPERIMENTAL DATA.
C     REFERENCE IS NASA CR-2473,1975.
C
      DIMENSION XST(11),ZA1(11),YA1(11),YA2(11),GAMT(11)
C
      DATA XST/0.0,1.0,2.0,3.0,4.0,5.0,6.0,7.0,8.0,9.0,10.0/
      DATA GAMT/0.3,0.32,0.34,0.40,0.48,0.62,0.77,0.90,1.0,1.08,1.15/
      DATA YA1/.45,.463,.477,.492,.505,0.52,.534,0.55,0.565,0.575,0.585/
      DATA YA2/.63,.64,.653,.665,.678,.69,.7,.715,.725,.735,.74/
      DATA ZA1/1.14,1.26,1.38,1.5,1.615,1.73,1.84,1.95,2.05,2.14,2.20/
C
  701 FORMAT (///1X5H*****,3X62HASYMMETRIC OR UNSTEADY BODY VORTEX SEPARA
     1TION POSSIBLE   *****//)
  702 FORMAT (40X,41HBODY NOSE SEPARATION AT XB/RB           =  ,F10.5/
     1 40X,    41HVORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) = ,F10.5/
     2  40X,41HVORTEX Y/RLOC (UNROLLED COORDS)          = ,F10.5/
     3  40X,41HVORTEX Z/RLOC (UNROLLED COORDS)          = ,F10.5/)
C
      IF (IL.GE.1) GO TO 16
      BDYVRT=1.0
      NTABLE=11
      DELTA=0.0
      F=1.0
      IF (ALPHAD.LT.0.0) F=-1.0
      ALPHA=F*ALPHAD
C
C     XSA=XSEPARATION/RB
C
      IF (THETAN.LE.30.0) GO TO 10
      XSA=10./(ALPHA -4.0) + 2.0
      GO TO 13
   10 XSA=32.0 - SQRT(1024.0*(ALPHA -4.0)/(THETAN-4.0))
   13 IF (XSA.LT.0.0) XSA=0.0
      IL=IL+1
      IF(XSA.GE.XA) BDYVRT=0.0
      IF(BDYVRT.EQ.0.0) GO TO 31
      IF (XSA.GE.XA) GO TO 31
C
C      COMPUTE UPPER LIMIT FOR SYMMETRIC VORTEX SEPARATION
C
      ALMT=((FINE-12.0)**2)/3.57 + 12.0
      IF (ALPHA .GT.ALMT) WRITE (6,701)
      SNALP=SIN(ALPHAD/57.2957795)*F
   16 CONTINUE
      IF(BDYVRT.EQ.0.0) GO TO 31
```

```
      XPAR=(XGAMN-XSA)*SNALP
      IF (XPAR .LT. 0.0) GO TO 31
C
C     INTERPOLATE IN DATA TABLES FOR THE X-STATION XGAMN=X/RR.
C     GAMT=GAMMA/(2*PI*RLOC*VINF*SIN(ALFA))
C     YA1,YA2,ZA1 ARE DIVIDED BY RLOC.
C
      DO 20 J=1,NTABLE
      K=J
      IF (XPAR-XST(J)) 22,23,20
   20 CONTINUE
   23 GAMN     =GAMT(K)*SNALP
      ZGAMN    =ZA1(K)
      Y1=YA1(K)
      Y2=YA2(K)
      GO TO 30
   22 DELTA=(XPAR-XST(K-1))/(XST(K)-XST(K-1))
      GAMN     =GAMT(K-1) + DELTA*(GAMT(K)-GAMT(K-1))
      GAMN=GAMN*SNALP
      ZGAMN    =ZA1(K-1) + DELTA*(ZA1(K)-ZA1(K-1))
      Y1=YA1(K-1) + DELTA*(YA1(K)-YA1(K-1))
      Y2=YA2(K-1) + DELTA*(YA2(K)-YA2(K-1))
   30 YGAMN    =Y1
      IF (EMACH .GT. 1.0) YGAMN    =Y2
      GAMN=GAMN*F
      ZGAMN=ZGAMN*F
      GO TO 32
   31 GAMN=0.0
   32 CONTINUE
      IF (GAMN.NE.0.0) WRITE (6,702) XSA,GAMN,YGAMN,ZGAMN
      RETURN
      END
```

```
      SUBROUTINE BODYR(X,R,RPRIME)
C
C     VERSION: DEMON1
C
C SUBROUTINE FOR THE CALCULATION OF BODY RADII AND SLOPE.  THE INTEGER
C VARIABLE BCODE CONTROLS THE TYPE OF NOSE DEFINITION
C     BCODE=0   PARABOLIC BODY
C     BCODE=1   SEARS-HAACK-ADAMS BODY
C     BCODE=2   TANGENT OGIVE
C     BCODE=3   ELLIPSOIDAL BODY
C     BCODE=4   CONICAL BODY
C
      COMMON/TWO/DUM1(1214),BCODE,BETASQ,BSQ,RADIUS,RFIELD,DUM3 ,U,V,VT,
     1LNOSE,DUM2(5),LBODY,NXBODY
C
      REAL LNOSE,LBODY
      INTEGER BCODE
C
      IF(X.LE.LNOSE) GO TO 20
C
C CYLINDRICAL SECTION OF BODY
C
      R=RADIUS
      RPRIME=0.
      RETURN
C
C NOSE SECTION
```

```
C
   20 XX=(LNOSE-X)/LNOSE
      RR=RADIUS
      IF(BCODE.GT.0)GO TO 22
C
C PARABOLIC NOSE
C
      R=        RR*(1.-XX*XX)
      RPRIME=RR/LNOSE*2.*XX
      RETURN
   22 GO TO(23,24,25,26),BCODE
C
C SEARS-HAACK-ADAMS FOREBODY
C
   23 IF(XX.GT.9.999E-1) GO TO 223
      XY=1.-XX*XX
      PHI=XY**.75
      R=        RR*PHI
      RPRIME=RR/LNOSE*1.5*XX*PHI/XY
      RETURN
  223 R=0.0
      RPRIME=1.E9
      RETURN
C
C TANGENT OGIVE NOSE
C
   24 RL=RR/LNOSE
      RDL=.5*(1.+RL*RL)/RL
      XY=SQRT(RDL*RDL-XX*XX)
      R=RADIUS-LNOSE*(RDL-XY)
      RPRIME=XX/XY
      RETURN
C
C ELLIPSOID FOREBODY
C
   25 IF(XX.GT.9.999E-1) GO TO 223
      PHI=SQRT(1.-XX*XX)
      R=        RR*PHI
      RPRIME=RR/LNOSE*XX/PHI
      RETURN
C
C CONE FOREBODY
C
   26 R=        RR*(1.-XX)
      RPRIIME=RR/LNOSE
      RETURN
      END


      COMPLEX FUNCTION DBLU(Z)
C
C     VERSION: DEMON1
C
C     THIS FUNCTION SUBROUTINE CALCULATES THE INTERMEDIATE TRANSFORM
C     VARIABLE W FOR THE CONFORMAL TRANSFORMATION OF AN ELLIPTICAL
C     BODY WITH WINGS
C
      COMMON/COM1/A2,B2,R2
      COMMON/COM3/ZR,ZI
      COMMON/COM5/CWDZ
      COMMON/COM6/W2,W
```

```
C                                                                       DM07  13
      COMPLEX Z,Z2,DWDZ,W,W2,WW                                         DM07  14
C                                                                       DM07  15
      Z2=Z*Z                                                            DM07  16
      ZR=REAL(Z)                                                        DM07  17
      ZI=AIMAG(Z)                                                       DM07  18
      IF(ZR.NE.0.0) ZR=ZR/ABS(ZR)                                       DM07  19
      IF(ZI.NE.0.0) ZI=ZI/ABS(ZI)                                       DM07  20
      Z2=Z2-A2+B2                                                       DM07  21
      Y=AIMAG(Z2)                                                       DM07  22
      AY=1.0                                                            DM07  23
      IF(Y.LT.0.0) AY=-1.0                                              DM07  24
      AYZ=1.0                                                           DM07  25
      IF(ZI.LT.0.0) AYZ=-1.0                                            DM07  26
      Z2=CSQRT(Z2)*AY*AYZ                                               DM07  27
      IF((ABS(ZI).LE.0.0).AND.(REAL(Z).LT.0.0)) Z2=CMPLX(-REAL(Z2),     DM07  28
     1     AIMAG(Z2))                                                   DM07  29
      DWDZ=0.5*(1.0+Z/Z2)                                               DM07  30
      WW=0.5*(Z+Z2)                                                     DM07  31
      W2=1.0/WW/WW                                                      DM07  32
      DBLU=WW                                                           DM07  33
      RETURN                                                            DM07  34
      END                                                               DM07  35


      SUBROUTINE DOUBLT(J)                                              DM08   1
C                                                                       DM08   2
C     VERSION: DEMON1                                                   DM08   3
C                                                                       DM08   4
C SUBROUTINE TO CALCULATE THE VELOCITIES DUE TO A LINEAR LINE DOUBLET OFDM08   5
C UNIT SLOPE WITH ORIGIN AT TX(J).                                      DM08   6
C                                                                       DM08   7
      INTEGER BCODE                                                     DM08   8
      COMMON/TWO/TX(101),DUM1(505),ZZ(403),T(100),TC(100),COEFF(5),     DM08   9
     1BCODE,BETASQ,BSQ,RADIUS,RFIELD,RNOSE,U,V,VT,XA,XC,XD,BETA,XFIELD, DM08  10
     2X2,XB,NXBODY                                                      DM08  11
C                                                                       DM08  12
  100 FORMAT(1H0,59HFIELD POINT IS WITHIN TAIL MACH CONE.  U AND V SET TDM08  13
     1O ZERO.)                                                          DM08  14
C                                                                       DM08  15
C                                                                       DM08  16
C                                                                       DM08  17
C   IN THE FOLLOWING, U AND V SHOULD HAVE FACTOR COS(THPLPH) FACTOR IN  DM08  18
C     FRONT.                                                            DM08  19
C                       VT SHOULD HAVE FACTOR SIN(THPLPH) FACTOR IN FRONT.DM08  20
C   ANGLE THPLPH IS MEASURED CLOCKWISE FROM THE LEEWARD DIRECTION WHEN  DM08  21
C   VIEWED FROM THE REAR.                                               DM08  22
C   THE ANGULAR DEPENDENCE ON ANGLE THPLPH IS ACCOUNTED FOR IN          DM08  23
C   SUBROUTINE VELCAL.                                                  DM08  24
      X1=XFIELD-TX(J)                                                   DM08  25
      BR=BETA*RFIELD                                                    DM08  26
      IF(X1.LE.BR     )GO TO 10                                         DM08  27
      IF(X2.LE.BR     )GO TO 21                                         DM08  28
      WRITE(6,100)                                                      DM08  29
      GO TO 10                                                          DM08  30
   21 XBR=X1/BR                                                         DM08  31
      XX=SQRT(XBR*XBR-1.)                                               DM08  32
      U=BETA*XX                                                         DM08  33
      ACOSH=ALOG(XBR+XX)                                                DM08  34
      YY=XBR*XX                                                         DM08  35
```

```
      V=-.5*BETASQ*(ACOSH+XX)
      VT= .5*BETASQ*(ACOSH-XX)
      RETURN
C
C FIELD POINT IS AHEAD OF MACH CONE FROM DOUBLET ORIGIN.
C
   10 U=0.
      V=0.
      VT=0.
      RETURN
      END
```

```
      COMPLEX FUNCTION DSDZ(S)
C
C     VERSION: DEMON1
C
      COMMON/COM2/SIG2,M2
      COMMON/COM5/DWDZ
      COMMON/COM4/G2,G1
      COMMON/COM6/W2,W
      COMPLEX W,W2,DWDZ,G1,G2
      DSDZ=0.5*(1.0-SIG2*W2)*(1.0+G1/G2)*DWDZ
      RETURN
      END
```

```
      SUBROUTINE EDGES(MSWP,SPAN,RBOD,ANGLE,ANGTE,Y,SWLE,SWTE)
C
C     VERSION: DEMON1
C
C     THIS ROUTINE CALCULATES EQUALLY SPACED SIDE-EDGES.
C          SWEEP ANGLE ARRAYS ARE SET EQUAL TO CONSTANT
C          LEADING EDGE AND TRAILING EDGE VALUES.
C
      DIMENSION Y(1),SWLE(1),SWTE(1)
C
      DYR=SPAN/(MSWP-1)
      DO 50 I=1,MSWP
      AI=I-1
      SWLE(I)=ANGLE
      SWTE(I)=ANGTE
      Y(I)=DYR*AI+RBOD
   50 CONTINUE
      SWLE(1)=0.0
      SWTE(1)=0.0
C
      RETURN
      END
```

```
      SUBROUTINE EDGVOR
C
C     VERSION: DEMON1
C
C     COMPUTE EFFECTS AT CONTROL POINTS ON FINS AND BODY INTERFERENCE
C     SHELL OF FIN LEADING AND SIDE EDGE VORTICITY.
```

```
C
      LOGICAL BODY
C
      COMMON/ONE/CIRC(250),DELTP(250),FN(250),PNLC(250),SWPPLE(250),
     1SWPPTE(250),VNOR(250),XBAR(250),ZBAR(250),XCPT(250),YCPT(250),ZCPT
     2(250),XLF(250),XLB(250),XRF(250),XRB(250),YLC(250),YRC(250),ZLF(250
     30),ZRF(250),ZLB(250),ZRB(250),SNT(125),CST(125),SNT2(125),CST2(125
     4),IP(300),XFBIP(100),A,ALFA,ALFR,ARWING,B2,B2V,BETA,BETAR,CONST,
     5COSALF,COSBET,CN,DX,EM,FMACH,RCIR,SINALF,SINBET,SLOPE,TLRNC,TIPY,
     6TOTLR,U,V,W,UCHK,VCHK,WCHK,WBIP,X,Y,Z,I,IF,II,J,MSWR,MSWL,MSWU,
     7MSWD,NBIP,NCRX,NCW,NDRAG,NHP,NPR,NRP,NSP,NOCPT,NOLINP,NOUT,NPANLS,
     8NPRESS,NWBP,ASYM,BODY,DELTAS,NOSYM
      COMMON/VRTXV/VVRTX(150),WVRTX(150),NVRTPL,NVRTX,VRTMAX
      COMMON/BVEL/BDU(150),BDV(150),BDW(150),XFLDP(150),YFLDP(150),
     1 ZFLDP(150)
      COMMON/FINLE/XLE(80),CGLOC(80),GAMLE(80),FKLE,NEDGV,MLEVR,MLEVL,
     1 MLEVU,MLEVD
      COMMON/FINSE/XSE(80),CGSELC(80),GAMSE(80),FKSE,NSIDGE,NSEV
      COMMON/VORSPC/GAMMA(10),YVRTX(10),ZVRTX(10),PLOC
      COMMON/ELLIPS/RA,RB,ERATIO
C
      DATA PI/3.141592653589/
C
  716 FORMAT (1H1,15X,43HFIN L.E. AND S.E. EFFECTS AT CONTROL POINTS//
     1 2X,1HK,5X,4HX,CP,7X,4HY,CP,7X,4HZ,CP,6X,6HGAMMA/,6X,7HY,VRTX/,4X,
     2 7HZ,VRTX/,3X,6HV,VRTX,5X,6HW,VRTX/39X,11H2PI*RB*VINF,2X,2HRB,9X,
     3 2HRB/)
  717 FORMAT (1X,I3,8(1X,F10.5))
C
C
C     EFFECT OF FIN L.E. VORTICITY AT THE FIN CONTROL POINTS AND THE
C     BODY INTERFERENCE PANEL CONTROL POINTS.
C
      NOCPT=1
      NVRT=NVRTX
      IF (NOUT.NE.0) WRITE (6,716)
      JTIPLE=NRP-NCW+1
      XTIPLE=XRF(JTIPLE)
      DENOM=2.0*PI*RB
      JTIPTE=NRP
      XTIPTE=XRB(JTIPTE)
      DO 33 K=1,NWBP
      XFLDP(K)=XCPT(K)
      YFLDP(K)=YCPT(K)
      ZFLDP(K)=ZCPT(K)
      IF (NEDGV.EQ.0) GO TO 34
      IFIN=1
      KSTART=1
      KUL=MLEVR
   35 CONTINUE
      IF (IFIN.EQ.5) GO TO 34
      IF (IFIN.EQ.2) KSTART=MLEVR+1
      IF (IFIN.EQ.3) KSTART=MLEVR+MLEVL+1
      IF (IFIN.EQ.4) KSTART=MLEVR+MLEVL+MLEVU+1
      DO 36 IFV=KSTART,KUL
      IF (XCPT(K).LT.XLE(KSTART)) GO TO 34
      JV=IFV-1
      IF (IFV.EQ.1) JV=1
      IF (XCPT(K).LE.XLE(IFV)) GO TO 37
   36 CONTINUE
      IF (XCPT(K).LE.XTIPLE) GO TO 38
      GO TO 34
   37 KV=JV+1
```

```
      X1=XLE(JV)
      X2=XLE(KV)
      DIFF=X2-X1
      WT1=(X2-XCPT(K))/DIFF
      WT2=(XCPT(K)-X1)/DIFF
      IF (IFIN.EQ.3.OR.IFIN.EQ.4) GO TO 39
      YVINT=WT1*CGLOC(JV)+WT2*CGLOC(KV)
      ZVBAR=XCPT(K)*TAN(ALFR/2.0)
      GAMINT=WT1*GAMLE(JV)+WT2*GAMLE(KV)
      YVRTX(1)=YVINT/RB
      ZVRTX(1)=ZVBAR/RB
      GAMMA(1)=GAMINT/DENOM
      GO TO 31
   38 GAMMA(1)=GAMLE(KUL)/DENOM
      GAMINT=GAMLE(KUL)
      IF (IFIN.EQ.3.OR.IFIN.EQ.4) GO TO 32
      YVRTX(1)=CGLOC(KUL)/RB
      ZVRTX(1)=XCPT(K)*TAN(ALFR/2.0)/RB
      YVINT=CGLOC(KUL)
      ZVBAR=ZVRTX(1)*RB
      GO TO 31
   32 YVRTX(1)=-XCPT(K)*TAN(BETAR)/RB
      ZVRTX(1)=CGLOC(KUL)/RB
      YVINT=YVRTX(1)*RB
      ZVBAR=CGLOC(KUL)
   31 RLOC=RB
      NVRTX=1
      IF (BODY.AND.RA.EQ.RB) CALL VORTEX (K,K)
      YCP=YFLDP(K)
      ZCP=ZFLDP(K)
      THETP=ATAN2(ZCP,YCP)
      SINTH=SIN(THETP)
      COSTH=COS(THETP)
      RCPT=SQRT(YCP*YCP+ZCP*ZCP)
      RBODY=SQRT(1.0/((SINTH/RA)**2+(COSTH/RB)**2))
      IF (RCPT.LE.RBODY) GO TO 20
      GO TO 21
   20 YCP=1.01*RBODY*COSTH
      ZCP=1.01*RBODY*SINTH
   21 CONTINUE
      IF (BODY.AND.RA.NE.RB) CALL VVELS(1,YCP      ,ZCP      ,YVINT,ZVBAR,
     1 GAMINT,RB,RA,VVRTX(K),WVRTX(K),VRTMAX)
      IF (NOUT.NE.0) WRITE (6,717) K,XFLDP(K),YFLDP(K),ZFLDP(K),
     1 GAMMA(1),YVRTX(1),ZVRTX(1),VVRTX(K),WVRTX(K)
      GO TO 40
   39 ZVINT=WT1*CGLOC(JV)+WT2*CGLOC(KV)
      YVBAR=-XCPT(K)*TAN(BETAR/2.0)
      GAMINT=WT1*GAMLE(JV)+WT2*GAMLE(KV)
      YVRTX(1)=YVBAR/RB
      ZVRTX(1)=ZVINT/RB
      GAMMA(1)=GAMINT/DENOM
      RLOC=RB
      NVRTX=1
      IF (BODY.AND.RA.EQ.RB) CALL VORTEX (K,K)
      YCP=YFLDP(K)
      ZCP=ZFLDP(K)
      THETP=ATAN2(ZCP,YCP)
      SINTH=SIN(THETP)
      COSTH=COS(THETP)
      RCPT=SQRT(YCP*YCP+ZCP*ZCP)
      RBODY=SQRT(1.0/((SINTH/RA)**2+(COSTH/RB)**2))
      IF (RCPT.LE.RBODY) GO TO 22
      GO TO 23
```

```
   22 YCP=1.01*RBODY*COSTH                                                DM11 133
      ZCP=1.01*RBODY*SINTH                                                DM11 134
   23 CONTINUE                                                            DM11 135
      IF (BODY.AND.RA.NE.RB) CALL VVELS(1,YCP     ,ZCP     ,YVBAR,ZVINT,DM11 136
     1 GAMINT,RB,RA,VVRTX(K),WVRTX(K),VRTMAX)                             DM11 137
      IF (NOUT.NE.0) WRITE (6,717) K,XFLDP(K),YFLDP(K),ZFLDP(K),          DM11 138
     1 GAMMA(1),YVRTX(1),ZVRTX(1),VVRTX(K),WVRTX(K)                       DM11 139
   40 CONTINUE                                                            DM11 140
      IFIN=IFIN+1                                                         DM11 141
      IF (IFIN.EQ.2) KUL=MLEVR+MLEVL                                      DM11 142
      IF (IFIN.EQ.3) KUL=MLEVR+MLEVL+MLEVU                                DM11 143
      IF (NCPX.EQ.0) GO TO 34                                             DM11 144
      IF (IFIN.EQ.4) KUL=MLEVR+MLEVL+MLEVU+MLEVD                          DM11 145
      GO TO 35                                                            DM11 146
   34 CONTINUE                                                            DM11 147
C                                                                         DM11 148
C     EFFECTS OF FIN S.E. VORTICITY AT FIN CONTROL POINTS AND BODY        DM11 149
C     INTERFERENCE PANELS.                                                DM11 150
C                                                                         DM11 151
      IF (NSIDGE.EQ.0) GO TO 48                                           DM11 152
      IFIN=1                                                              DM11 153
      KSTART=1                                                            DM11 154
      KUL=NSEV                                                            DM11 155
   47 CONTINUE                                                            DM11 156
      IF (IFIN.EQ.5) GO TO 48                                             DM11 157
      IF (IFIN.EQ.2) KSTART=NSEV+1                                        DM11 158
      IF (IFIN.EQ.3) KSTART=2*NSEV+1                                      DM11 159
      IF (IFIN.EQ.4) KSTART=3*NSEV+1                                      DM11 160
      DO 49 JSE=KSTART,KUL                                                DM11 161
      IF (XCPT(K).LT.XSE(KSTART)) GO TO 48                                DM11 162
      JVSE=JSE-1                                                          DM11 163
      IF (JSE.EQ.1) JVSE=1                                                DM11 164
      IF (XCPT(K).LE.XSE(JSE)) GO TO 46                                   DM11 165
   49 CONTINUE                                                            DM11 166
      IF (XCPT(K).LE.XTIPTE) GO TO 41                                     DM11 167
      GO TO 48                                                            DM11 168
   46 CONTINUE                                                            DM11 169
      KVSE=JVSE+1                                                         DM11 170
      X1=XSE(JVSE)                                                        DM11 171
      X2=XSE(KVSE)                                                        DM11 172
      DIFF=X2-X1                                                          DM11 173
      WT1=(X2-XCPT(K))/DIFF                                               DM11 174
      WT2=(XCPT(K)-X1)/DIFF                                               DM11 175
      IF (IFIN.EQ.3.OR.IFIN.EQ.4) GO TO 45                                DM11 176
      YVINT=WT1*CGSELC(JVSE)+WT2*CGSELC(KVSE)                             DM11 177
      ZVBAR=XCPT(K)*TAN(ALFR/2.0)                                         DM11 178
      GAMINT=WT1*GAMSE(JVSE)+WT2*GAMSE(KVSE)                              DM11 179
      YVRTX(1)=YVINT/RB                                                   DM11 180
      ZVRTX(1)=ZVBAR/RB                                                   DM11 181
      GAMMA(1)=GAMINT/DENOM                                               DM11 182
      GO TO 42                                                            DM11 183
   41 GAMMA(1)=GAMSE(KUL)/DENOM                                           DM11 184
      GAMINT=GAMSE(KUL)                                                   DM11 185
      IF (IFIN.EQ.3.OR.IFIN.EQ.4) GO TO 43                                DM11 186
      YVRTX(1)=CGSELC(KUL)/RB                                             DM11 187
      ZVRTX(1)=XCPT(K)*TAN(ALFR/2.0)/RB                                   DM11 188
      YVINT=CGSELC(KUL)                                                   DM11 189
      ZVBAR=ZVRTX(1)*RB                                                   DM11 190
      GO TO 42                                                            DM11 191
   43 YVRTX(1)=(-XCPT(K)*TAN(BETAR/2.0))/RB                               DM11 192
      ZVRTX(1)=CGSELC(KUL)/RB                                             DM11 193
      YVINT=YVRTX(1)*RB                                                   DM11 194
      ZVBAR=CGSELC(KUL)                                                   DM11 195
```

```
   42 RLOC=RB
      NVRTX=1
      IF (BODY.AND.RA.EQ.RB) CALL VORTEX (K,K)
      IF (BODY.AND.RA.NE.RB) CALL VVELS(1,YFLDP(K),ZFLDP(K),YVINT,ZVBAR,
     1 GAMINT,RB,RA,VVRTX(K),WVRTX(K),VRTMAX)
      IF (NOUT.NE.0) WRITE (6,717) K,XFLDP(K),YFLDP(K),ZFLDP(K),
     1 GAMMA(1),YVRTX(1),ZVRTX(1),VVRTX(K),WVRTX(K)
      GO TO 44
   45 ZVINT=WT1*CGSELC(JVSE)+WT2*CGSELC(KVSE)
      YVBAR=-XCPT(K)*TAN(BETAR/2.0)
      GAMINT=WT1*GAMSE(JVSE)+WT2*GAMSE(KVSE)
      YVRTX(1)=YVBAR/RB
      ZVRTX(1)=ZVINT/RB
      GAMMA(1)=GAMINT/DENUM
      RLOC=RB
      NVRTX=1
      IF (BODY.AND.RA.EQ.RB) CALL VORTEX (K,K)
      IF (BODY.AND.RA.NE.RB) CALL VVELS(1,YFLDP(K),ZFLDP(K),YVBAR,ZVINT,
     1 GAMINT,RB,RA,VVRTX(K),WVRTX(K),VRTMAX)
      IF (NOUT.NE.0) WRITE (6,717) K,XFLDP(K),YFLDP(K),ZFLDP(K),
     1 GAMMA(1),YVRTX(1),ZVRTX(1),VVRTX(K),WVRTX(K)
   44 CONTINUE
      IFIN=IFIN+1
      IF (IFIN.EQ.2) KUL=2*NSEV
      IF (IFIN.EQ.3) KUL=3*NSEV
      IF (NCRX.EQ.0) GO TO 48
      IF (IFIN.EQ.4) KUL=4*NSEV
      GO TO 47
   48 CONTINUE
   33 CONTINUE
      NVRTX=NVRT
      RETURN
      END
```

```
      SUBROUTINE LAYOUT (SLPWLE,SLPWTE,Y,MSWP,CRP,NS,CTP,PHI,THET)
C
C     VERSION: DEMON2
C
C     THIS SUBROUTINE LAYS OUT AND DETERMINES GEOMETRICAL PROPERTIES
C     OF THE CONSTANT U-VELOCITY PANELS ON THE WING OR FIN SURFACES
C     AND ON THE BODY OR FUSELAGE WHERE MUTUAL WING-BODY INTERFERENCE
C     OCCURS.
C
      DIMENSION CSIDE(20),NPD(3),Y(1)
C
      LOGICAL LEFT,ASYM,BODY,DELTA,TRUSYM,NOSYM
C
      COMMON/ONE/CIRC(250),DELTP(250),FN(250),PNLC(250),SWPPLE(250),
     1SWPPTE(250),VNOR(250),XBAR(250),ZBAR(250),XCPT(250),YCPT(250),ZCPT
     2(250),XLF(250),XLH(250),XRF(250),XRB(250),YLC(250),YRC(250),ZLF(25
     30),ZRF(250),ZLB(250),ZRB(250),SNT(125),CST(125),SNT2(125),CST2(125
     4),IP(300),XFBIP(100),A,ALFA,ALFR,ARWING,B2,B2V,BETA,BETAR,CONST,
     5COSALF,COSBET,CN,DX,EM,FMACH,RCIR,SINALF,SINBET,SLOPE,TLRNC,TIPY,
     6TOTLR,U,V,W,UCHK,VCHK,WCHK,WBIP,X,DUMY,Z,IV,IF,II,JV,MSWR,MSWL,
     7MSWU,MSWD,NBIP,NCRX,NCW,NDRAG,NHP,NPR,NRP,N3P,NOCPT,NOLINP,NOUT,
     8NPANLS,NPRESS,NWBP,ASYM,BODY,DELTA,NOSYM
      COMMON/SWEEPS/VSWLER(20),VSWTER(20),VSWLEL(20),VSWTEL(20),
     1  VSWLEU(20),VSWTEU(20),VSWLED(20),VSWTED(20),LVSWP,LEFT,FAC,NCWB
     2,ARPNL(250),WIDTH(250)
```

```
      COMMON/VRTXV/DUMMY(301),NVRTX,VRTMAX
      COMMON/WBTR/THTI(125),XWLE
      COMMON /ELLIPS/ RA,RB,ERATIO
      COMMON /INTROT/ PHIDIH,THETIT,YBOD,ZBOD,PHIFR,PHIFU
C
C
      DATA PI/3.1415926535897/
C
C     FUNCTION DEFINING THE RADIUS OF AN ELLIPSE IN TERMS OF THT
C
      FRAD(SN,CS)=1.0/SQRT((CS/RB)**2+(SN/RA)**2)
      FYROT(YP) = COSINE*YP+YBOD
      FZROT(YP) = SINE  *YP+ZBOD
C
      TRUSYM=BETAR.EQ.0.0.AND..NOT.DELTA
      DTOR = PI/180.
C
C  NS(=IL+1) IS WING QUADRANT INDICATOR
C      NS=1, RIGHT FIN=  =2, LEFT FIN=  =3, UPPER FIN=  =4, LOWER FIN
C      NS=5, BODY
C     REFER TO MAIN PROGRAM CRFWBD FOR CORRESPONDENCE BETWEEN FINS ON
C     CRUCIFORM AND INTERDIGITATED CONFIGURATIONS.
C
      IF (NS.EQ.5) GO TO 200
      LEFT = NS.EQ.2 .OR. NS.EQ.4
      ANCW=NCW
      SLPDIF= SLPWLE-SLPWTE
      CSIDE(1)= CRP
      NPD(1)=NRP
      NPD(2)=NHP
      NPD(3)=N3P
C
C     VERTICAL WING TREATED IN THE SAME WAY AS HORIZONTAL WING
C     Y AND Z COORDINATES ARE INTERCHANGED FOR VERTICAL WING
C
C     LEFT STANDS FOR EITHER LEFT HORIZONTAL WING OR FOR LOWER
C     VERTICAL WING
C
C
C  LOCATE (Y,Z) OF WING BODY JUNCTION
C
      IF (THET.EQ.90.0) GO TO 100
      GO TO 101
  100 CS=0.0
      SN=1.0
      GO TO 104
  101 CONTINUE
      CS = COS(THET*DTOR)
      SN = SIN(THET*DTOR)
  104 CONTINUE
      RAD = FRAD(SN,CS)
      IF (LEFT) RAD=-RAD
      YBOD = RAD*CS
      ZBOD = RAD*SN
C
C         DEFINE DIHEDRAL ANGLES OF FINS
C
      IF (PHI.EQ.90.0) GO TO 102
      GO TO 103
  102 COSINE=0.0
      SINE=1.0
      GO TO 105
  103 CONTINUE
```

```
      COSINE = COS(PHI*DTOR)
      SINE   = SIN(PHI*DTOR)
  105 CONTINUE
C
C     INDEX I RUNS SPANWISE, K CHORDWISE ALONG WING
C     CALCULATE LENGTHS OF OUTBOARD PANEL SIDE,CSIDE
C     J IS THE PANEL NUMBER
C
      WLEX=0.0
      DO 140 I=2,NSWP
      IM=I-1
C
C     LVSWP:  VARIABLE WING SWEEP OPTION
C        LVSWP=0,  GENERATE  Y  INTERNALLY(IN CREWBD)
C        LVSWP=1,  READ IN  Y*S.
C
      IF (LVSWP.EQ.0) GO TO 40
      GO TO (42,41,30,31),NS
C
C     CASE FOR YAWED WING, STREAMWISE PLANE PASSING THROUGH ROOTCHORD
C     LE INTERSECTS WING TE
C     TE SWEEPS MAY VARY AS A CONSEQUENCE
C
C     PANELS ON RIGHT HAND WING
C
   42 SLPWLE= TAN(VSWLER(I)*DTOR)
      SLPWTE= TAN(VSWTER(I)*DTOR)
      GO TO 44
C
C     PANELS ON LEFT HAND WING
C
   41 SLPWLE= TAN(-VSWLEL(I)*DTOR)
      SLPWTE= TAN(-VSWTEL(I)*DTOR)
      GO TO 44
C
C     PANELS ON UPPER WING
C
   30 SLPWLE=TAN(VSWLEU(I)*DTOR)
      SLPWTE=TAN(VSWTEU(I)*DTOR)
      GO TO 44
C
C     PANELS ON LOWER WING
C
   31 SLPWLE=TAN(-VSWLED(I)*DTOR)
      SLPWTE=TAN(-VSWTED(I)*DTOR)
C
C
   44 SLPDIF= SLPWLE-SLPWTE
      CSIDE(I)= CSIDE(IM)-(Y(I)-Y(IM))*SLPDIF
      IF (LEFT) CSIDE(I)=CSIDE(IM)+(Y(I)-Y(IM))*SLPDIF
      GO TO 43
C
C     NONVARYING L.E. AND T.E. SWEEPS  CONSTANT VALUES USED
C
   40 CSIDE(I)=CRP-(Y(I)-Y(1))*SLPDIF
      IF (LEFT) CSIDE(I)= CRP+(Y(I)-Y(1))*SLPDIF
   43 CONTINUE
C
C     SWPPLE AND SWPPTE ARE PANEL L.E. AND T.E. SWEEPS
C     CALCULATE PANEL CORNER POINT COORDINATES
C
      IF (I.EQ.2) GO TO 45
      JLE=(I-3)*NCW+1
```

```
      IF (NS.GT.1) JLE=JLE+NPD(NS-1)
      WLEX=XRF(JLE)
      IF (LEFT) WLEX=XLF(JLE)
   45 CONTINUE
C
      DO 130 K=1,NCW
      J=(I-2)*NCW+K
      IF (NS.GT.1) J=J+NPD(NS-1)
      AKM=K-1
      AK=K
      SWPPLE(J)=SLPWLE-AKM*SLPDIF/ANCW
      SWPPTE(J)=SLPWLE-AK*SLPDIF/ANCW
      IF (ABS(SWPPLE(J)).LE.0.001) SWPPLE(J)=0.0
      IF (ABS(SWPPTE(J)).LE.0.001) SWPPTE(J)=0.0
      IF (LEFT) GO TO 50
C
C   PANEL LAY OUT FOR RIGHT RIGHT HAND WING CORNER POINYS.
C      THEY APPLY TO RIGHT AND UPPER FINS.
C
      XLF(J)=AKM*CSIDE(IM)/ANCW+WLEX
      XLB(J)=XLF(J)+CSIDE(IM)/ANCW
      XRF(J)=AKM*CSIDE(I)/ANCW+(Y(I)-Y(IM))*SLPWLE+WLEX
      XRB(J)=XRF(J)+CSIDE(I)/ANCW
      YLC(J)=Y(IM)
      YRC(J)=Y(I)
      GO TO 51
C
C   PANEL LAY OUT FOR LEFT HAND WING CORNER POINTS.
C      THEY APPLY TO LEFT AND LOWER FINS.
C
   50 CONTINUE
      XLF(J)=AKM*CSIDE(I)/ANCW-(Y(I)-Y(IM))*SLPWLE+WLEX
      XRF(J)=AKM*CSIDE(IM)/ANCW+WLEX
      XRB(J)= XRF(J)+CSIDE(IM)/ANCW
      XLB(J)= XLF(J)+CSIDE(I)/ANCW
      YLC(J)=Y(I)
      YRC(J)=Y(IM)
   51 CONTINUE
      ZLF(J)=0.0
      ZRF(J)=0.0
      ZLB(J)=0.0
      ZRB(J)=0.0
C
C     FIND Y-COORDINATE OF CONTROL POINT AND PANEL CENTROID
C
      A1=XRB(J)-XRF(J)
      A2=XLB(J)-XLF(J)
      H=Y(I)-Y(IM)
      YBAR=(2.0*A1+A2)*H/(3.0*(A1+A2))
      YCPT(J)=Y(IM)+YBAR
      IF (LEFT) YBAR=-(2.0*A2+A1)*H/(3.0*(A1+A2))
      IF (LEFT) YCPT(J)=Y(IM)-YBAR
C
C     FIND X-COORDINATE OF CONTROL POINT AND PANEL CENTROID
C
      XPCLE=XLF(J)+YBAR *SWPPLE(J)
      XPCTE=XLB(J)+YBAR*SWPPTE(J)
      IF (LEFT) XPCLE=XRF(J)+YBAR*SWPPLE(J)
      IF (LEFT) XPCTE=XRB(J)+YBAR*SWPPTE(J)
      PNLC(J)=XPCTE-XPCLE
      XCPT(J)=XPCLE+FAC *PNLC(J)
      XBAR(J)=(XPCTE+XPCLE)/2.0
C
```

```
C
      ZCPT(J)=0.0
      ZBAR(J)=0.0
      IF (.NOT.LEFT) GO TO 120
      IF (SWPPLE(J).EQ.0.0) SWPPLE(J)=TLRNC
      IF (SWPPTE(J).EQ.0.0) SWPPTE(J)=TLRNC
      SWPPLE(J)=-SWPPLE(J)
      SWPPTE(J)=-SWPPTE(J)
  120 CONTINUE
C
C         AREA AND WIDTH OF PANEL IN LOCAL COORDINATES
C
  121 ARPNL(J)=0.5*(YRC(J)-YLC(J))*(XLB(J)-XLF(J)+XRB(J)-XRF(J))
      WIDTH(J)=YRC(J)-YLC(J)
C
C     TRANSFORM FROM FIN COORDINATES TO THE WING REFERENCE COORDINATE
C     SYSTEM XW,YW,ZW.
C
      ZLF(J) = FZROT(YLC(J)-Y(1))
      ZLB(J) = ZLF(J)
      YLC(J) = FYROT(YLC(J)-Y(1))
      ZRF(J) = FZROT(YRC(J)-Y(1))
      ZRB(J) = ZRF(J)
      YRC(J) = FYROT(YRC(J)-Y(1))
      ZBAR(J) = FZROT(YCPT(J)-Y(1))
      ZCPT(J) = ZBAR(J)
      YCPT(J) = FYROT(YCPT(J)-Y(1))
  130 CONTINUE
  140 CONTINUE
      CTP=CSIDE(MSWP)
      RETURN
C
C     ************** LAY OUT BODY INTERFERENCE PANELS *********************
C
  200 DX=CRP/NCWB
C
C
C     NOTE: MSWP IS ACTUALLY NBDCR
C
      MSWP = 4*(MSWP/4)
      MS90  = MSWP/4
      MS180 = 2*MS90
      MS270 = 3*MS90
      MMSWP = MSWP
      IF (TRUSYM) MMSWP=MMSWP/2
      DTHTDG = 90./FLOAT(MS90)
      DTHTS = DTHTDG
      DTHTU = DTHTDG
C
C     IT1IT2,IT3,IT4....INDEX OF INTERFERENCE PANEL IMMEDIATELY
C     PRECEDING FIN LOCATIONS ON BODY CIRCUMFERENCE.
C
C     INITIALIZE
      IT1 = 0
      IT2 = 0
      IT3 = 0
      IT4 = 0
      IF (THETIT.GE.90. .OR. THETIT.LE.0.) GO TO 210
C
C  INTERDIGITATED TAIL EXISTS
C
C
C     RECALCULATE RADIUS AT AND YB,ZB COORDINATES OF FIN LOCATION
```

```
C     ON THE BODY CIRCUMFERENCE FOR THE RIGHT UPPER FIN ONLY.
C
      CS=COS(THETIT*DTOR)
      SN=SIN(THETIT*DTOR)
      RAD=FRAD(SN,CS)
      YBOD=RAD*CS
      ZBOD=RAD*SN
C
C     CHECK RATIO OF APPROXIMATE ARC LENGTH ON EITHER SIDE OF THETIT.
C
C
      ARCU=SQRT(YBOD**2+(ZBOD-RA)**2)
      ARCS=SQRT((RB-YBOD)**2+ZBOD**2)
      DARC=(ARCU+ARCS)/FLOAT(MS90)
C
C     DETERMINE NUMBER OF PANELS BETWEEN Y-AXIS AND FIN LOCATION ON THE
C     BODY CIRCUMFERENCE.
C
      IT1= IFIX((ARCS/DARC)+0.5)
      IT1= MAX0(IT1,1)
      IT1=MIN0(IT1,MS90-1)
C
C         DTHTS IS INCREMENT BETWEEN PANELS ON RIGHT AND LEFT (0-THETIT)
C         DTHTU IS INCREMENT BETWEEN PANELS ON TOP AND BOTTOM (THETIT-90)
C
      DTHTS = THETIT/IT1
      DTHTU = (90.-THETIT)/(MS90-IT1)
      IT2 = MS180-IT1
      IT3 = MS180+IT1
      IT4 = MSWP-IT1
210   CONTINUE
C
C     HERE K HAS ONE VALUE FOR EACH RING OF BIP*S
C     FOR EACH CIRCUMFERENTIAL RING, THE X FRONT POSITION, XFBIP(L)
C     IS A CONSTANT --
C     XFBIP(L) IS THE X-STATION OF THE BODY RING IN WING COORDINATES
C
  201 KX=0
      DO 230 K=1,NBIP,MMSWP
      XS=KX*DX
      KP=K+MMSWP-1
C
C         L IS BODY PANEL INDEX
C
      DO 220 L=K,KP
      XFBIP(L)=XS
220   CONTINUE
      KX=KX+1
230   CONTINUE
C
C     CALCULATE THE TRIG FUNCTIONS OF THE ANGLES ASSOCIATED WITH EACH
C     BIP.  THIS LOOP EXECUTES ONCE FOR EACH DIFFERENT BIP ORIENTATION,
C     SETS THE FUNCTIONS FOR ALL BIP*S THAT ARE AT THE SAME ANGLE.
C
C     ANG IS THE ANGLE OF ROTATION OF THE BIP WITH RESPECT TO THE WING
C     COORDINATE SYSTEM.
C     THT IS THE POLAR ANGLE OF THE BIP WITH RESPECT TO THE WING Y-AXIS.
C
C
C BODY PANEL NUMBERING BEGINS AT Z=0, Y=RB AND PROCEEDS
C COUNTERCLOCKWISE IN ANGLE , THEN INCREMENTED IN X.
C
      IK = 0
```

```
      THTIDG = 0.0
      YIM1 = RB
      ZIM1 = 0.0
C
C     I IS THE RUNNING INDEX ON THE BODY CIRCUMFERENCE.
      DO 260 I=1,MSWP
C
C  GENERATE ANGLE TO BE INCREMENTED BETWEEN TAIL SEGMENTS
C
      DTHT = DTHTS
C
C        TEST FOR UPPER OR LOWER BODY PANEL WIDTH
C
      IF (I.GT.IT1 .AND. I.LE.IT2) DTHT=DTHTU
      IF (I.GT.IT3 .AND. I.LE.IT4) DTHT=DTHTU
      THTIDG = THTIDG+DTHT
      IF (I.EQ.MS90)  THTIDG=90.
      IF (I.EQ.MS180) THTIDG=180.
      IF (I.EQ.MS270) THTIDG=270.
      IF (I.EQ.MSWP)  THTIDG=360.
C
C  COMPUTE GEOMETRY OF ELLIPTIC BODY AND PRESCRIBED ANGLE.
C
      THT=THTIDG*DTOR
C
C     COMPUTE PROPERTIES OF ELLIPTIC BODY
C     RAD IS THE LOCAL BODY RADIUS AS A FUNCTION OF THT
C     THT IS THE MERIDIAN ANGLE FOR THE PANEL MEASURED COUNTERCLOCKWISE
C     FROM THE Y(WING) AXIS
C
      SN=SIN(THT)
      CS=COS(THT)
      YI=FRAD(SN,CS)*CS
      ZI=FRAD(SN,CS)*SN
C
C  CHECK FOR BODY SYMMETRY
C
      IF (I.GT.MS90 .AND. I.LE.MS270 .AND. TRUSYM) GO TO 250
      IK = IK+1
      DY=YI-YIM1
      DZ=ZI-ZIM1
      WBIP=SQRT(DZ*DZ+DY*DY)
      SN2= DZ/WBIP
      CS2=-DY/WBIP
      AREAP=WBIP*DX
C
C        J IS THE PANEL INDEX OF BIPS
C        K IS THE PANEL INDEX OF WING AND BODY PANELS
C
      DO 240 J=IK,NBIP,MMSWP
      K=J+NPANLS
      THTI(J)=THTIDG
      SNT(J)=SN
      CST(J)=CS
      SNT2(J)=SN2
      CST2(J)=CS2
C
C
      YCPT(K)=0.5*(YI+YIM1)
      ZCPT(K)=0.5*(ZI+ZIM1)
C
      SWPPLE(K)=0.0
      SWPPTE(K)=0.0
```

```
      ARPNL(K)=AREAP
C
C     NOTE -- IN THE **BIP** SYSTEM, YLC=0 AND YRC=*BIP
C
C     DEFINE BIP PANEL CORNER POINTS IN  WING COORDINATE SYSTEM
C
      YLC(K)=YI
      YRC(K)=YIM1
      ZLF(K)=ZI
      ZLB(K)=ZI
      ZRF(K)=ZIM1
      ZRB(K)=ZIM1
      XLF(K)=XFBIP(J)
      XRF(K)=XLF(K)
      XLB(K)=XLF(K)+DX
      XRB(K)=XLB(K)
C
C     CONTROL POINT X COORDINATE IN WING SYSTEM
C
240   XCPT(K)=XFBIP(J)+FAC*DX
250   CONTINUE
      YIM1=YI
      ZIM1=ZI
  260 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE LINEQS(N,A)
C
C     VERSION: DEMON1
C
C     THIS SUBROUTINE TAKES IN SINGLE COLUMN MATRIX A(N*N), CONVERTS IT
C     TO SQUARE MATRIX A(N*N) AND
C     IP(300) REMEMBERS WHAT WAS DONE TO TRIANGULATE MATRIX A
C      IT IS USED IN SOLVE TO DO SAME THING TO B
C
      DIMENSION A(N,N)
C
      LOGICAL ASYM,BODY,DELTA,NOSYM
C
      COMMON/ONE/DUM1(6000),IP(300),DUM2(100),DUM3(54),ASYM,BODY,DELTA,
     1NOSYM
C
      IP(N)=1
      DO 6 K=1,N
      IF(K.EQ.N)GO TO 5
      KP1=K+1
      M=K
      IP(K)=M
      IF(M.NE.K)IP(N)=-IP(N)
      T=A(M,K)
      A(M,K)=A(K,K)
      A(K,K)=T
      IF(T.EQ.0.)GO TO 5
      DO 2 I=KP1,N
    2 A(I,K)=-A(I,K)/T
      DO 4 J=KP1,N
      T=A(M,J)
      A(M,J)=A(K,J)
      A(K,J)=T
      IF(T.EQ.0.)GO TO 4
      DO 3 I=KP1,N
    3 A(I,J)=A(I,J)+A(I,K)*T
```

```
    4 CONTINUE
    5 IF(A(K,K).EQ.0.)IP(N)=0
    6 CONTINUE
      RETURN
      END


      SUBROUTINE LOADS
C
C     VERSION:DEMON2.
C
C     THIS SUBROUTINE CALCULATES FORCES AND MOMENTS ACTING ON THE
C     WINGS OR FINS AND THE INTERFERENCE SHELL.
C     THEY ARE FIRST CALCULATED IN THE WING REFERENCE COORDINATE SYSTEM
C     AND THEN TRANSFORMED TO WIND-AXIS SYSTEM.
C
C     IN-PLANE FORCES FX AND FY1 OR FZ1 ARE ALSO COMPUTED. HERE,FX
C     IS POSITIVE FORWARD PARALLEL TO BODY CENTERLINE.
C     IN-PLANE FORCE FY2 IS CALCULATED IN SUBROUTINE SPNLD.
C
      DIMENSION BFY(100),BFZ(100)
      DIMENSION XB(150),YC(150),ZB(150)
C
      LOGICAL ASYM,NOSYM,BODY,DELTA,ANY,ANYMO
C
      COMMON/ONE/CIRC(250),DELTP(250),FN(250),PNLC(250),SWPPLE(250),
     1SWPPTE(250),VNOR(250),XBAR(250),ZBAR(250),XCPT(250),YCPT(250),ZCPT
     2(250),XLF(250),XLB(250),XRF(250),XRB(250),YLC(250),YRC(250),ZLF(250
     30),ZRF(250),ZLB(250),ZRB(250),SNT(125),CST(125),SNT2(125),CST2(125
     4),IP(300),XFBIP(100),A,ALFA,ALFR,ARWING,B2,B2V,BETA,BETAR,CONST,
     5COSALF,COSBET,CN,DX,EM,FMACH,RCIR,SINALF,SINBET,SLOPE,TLRNC,TIPY,
     6TOTLR,U,V,W ,UCHK,VCHK,WCHK,WBIP,X,Y,Z,IV,IF,II,JV,MSWR,MSWL,MSWU,
     7MSWD,NBIP,NCRX,NCW,NDRAG,NHP,NPR,NRP,NSP,NOCPT,NOLINP,NOUT,NPANLS,
     8NPRESS,NWBP,ASYM,BODY,DELTA,NOSYM
      COMMON/THREE/ANGLR,ANGLL,ANGLU,ANGLD,DELR,DELL,DELU,DELD,SREF,REFL
      COMMON/SWEEPS/VSWLER(20),VSWTER(20),VSWLEL(20),VSWTEL(20),
     1  VSWLEU(20),VSWTEU(20),VSWLED(20),VSWTED(20),LVSWP,LEFT,FAC,NCWB
     2,ARPNL(250),WIDTH(250)
      COMMON/BVEL/BDU(150),BDV(150),BDW(150),XFLDP(150),YFLDP(150),
     1 ZFLDP(150)
      COMMON/SPCPRS/DLTP(150)
      COMMON/VRTXV/VVRTX(150),WVRTX(150),NVRTPL,NVRTX,VRTMAX
      COMMON/WBTR/THTI(125),XWLE
      COMMON/FRCDIS/VNOROS(150),FX(150),FY(150),FZ(150),DLTPG(150),ANYMO
      COMMON/VRTHVL/VVEL(500),WVEL(500),JCPT,NCPOUT,NVLIN
      COMMON/SPSANG/SINALC,COSALC,SINPHI,COSPHI
      COMMON /ELLIPS/ RA,RB,ERATIO
      COMMON/INTRDT/PHIDTH,THETIT,YBOD,ZBOD,PHIFR,PHIFU
      COMMON/DARM/XM,ZM,CZOA,CYOA,CMOA,CLNOA,CLLOA
C
      DATA PI/3.141592653590/
C
C
  701 FORMAT(1H1,25X,21HWING PANEL PROPERTIES,//,2X,1HJ,5X,7HYCPT(J),3X,
     1 10HCHORD THRU,4X,5HPANEL,3X,8HMIDCHORD,9X,6HDELTA-,5X,5HFN(J),/
     2 18X,8HCENTROID,6X,4HSPAN,4X,10HSWEEP,DEG.,7X,2HCP,//)
  702 FORMAT(////25X,21HWING PANEL PROPERTIES,//2X,1HJ,5X,7HZCPT(J),3X,
     1 10HCHORD THRU,4X,5HPANEL,3X,8HMIDCHORD,9X,6HDELTA-,5X,5HFN(J),/
     2 18X,8HCENTROID,6X,4HSPAN,4X,10HSWEEP,DEG,7X,2HCP,//)
  705 FORMAT (8X,I3,7X,F10.5,2X,F10.5,2X,F10.5,2X,F10.5,2X,F10.5,
     12X,F10.5,2X,F10.5)
  706 FORMAT (1X,I3,2(1X,F10.5),5(2X,F10.5))
```

```
  707 FORMAT(1H1,20X,31HBODY INFLUENCE PANEL PROPERTIES//2X,1HJ,6X,
     1  7HYCPT(J),4X,6HLENGTH,6X,5HWIDTH,6X,8HTHETA(J),2X,5HFY(J),5X,
     2  5HFZ(J),5X,5HFN(J),5X,8HDELTA-CP,3X,7HGAMMA/V/)
  710 FORMAT (1X,I3,9(1X,F10.5))
  716 FORMAT(1H1,25X,35HVELOCITIES AT PANEL CENTROID POINTS//
     1  10X,1HJ,11X,7HXBAR(J),5X,7HYBAR(J),5X,7HZBAR(J),9X,1HU,11X,
     2  1HV,11X,1HW,8X,4HVNOR//)
  717 FORMAT(1H1,40X,19HLOADING INFORMATION//
     X  11X,14HMACH NUMBER = ,E12.5/
     1  7X,18HANGLE OF ATTACK = ,F8.3,1X,7HDEGREES/
     27X,18HSIDE SLIP ANGLE = ,F8.3,1X,7HDEGREES/
     3 13X,12HWING AREA = ,F10.5/
     4 8X,17HREFERENCE AREA = ,F10.5/
     5 6X,19HREFERENCE LENGTH = ,F10.5/
     6 3X,22HEXPOSED WING SPAN B = ,F10.5/
     7 3X,22HMOMENT CENTER:   XM = ,F10.5/
     8   20X,5HZM = ,F10.5///)
  718 FORMAT(/29X,5HTOTAL,12X,10HFIN 1 OR R,8X,10HFIN 2 OR L,7X,
     1 10HFIN 3 OR U,8X,10HFIN 4 OR D,5X,13HINTERF. SHELL,/
     2  6X,19HDEFL. ANGLE DEG. = ,12X,4(6X,F12.5)/
     * 18X,7HCTHR = ,E12.5,4(6X,F12.5)/
     3  20X,5HCZ = ,E12.5,5(6X,E12.5)/
     4  20X,5HCY = ,E12.5,5(6X,E12.5)/
     5 20X,5HCM = ,E12.5,5(6X,E12.5)/
     6 19X,6HCLN = ,E12.5,5(6X,E12.5)/
     7 19X,6HCLL = ,E12.5,5(6X,E12.5)/
     * //,20X,33HFOLLOWING ARE IN WIND-AXIS SYSTEM//
     8  20X,5HCL = ,E12.5,5(6X,E12.5)/
     * 16X,9HCYWIND = ,E12.5,5(6X,E12.5)/
     9  19X,6HCDI = ,E12.5,5(6X,E12.5)/
     1  13X,12HCDI/CL**2 = ,E12.5/
     * 16X,9HCMWIND = ,E12.5,5(6X,E12.5)/
     * 15X,10HCLNWIND = ,E12.5,5(6X,E12.5)////)
  725 FORMAT (//1X,28HU/VINF TYPE LOADING PRESSURE//)
  726 FORMAT (//1X,32HBERNOULLI TYPE LOADING PRESSURE//)
  727 FORMAT(1H1,27X,40HVELOCITIES AT PANEL OUTBOARD AFT CORNERS/)
  728 FORMAT(1H0,9X,1HJ,11X,6HXRB(J),6X,6HYRC(J),6X,6HZRB(J),10X,1HU,
     1  11X,1HV,11X,1HW,8X,4HVNOR//)
  729 FORMAT(1H0,9X,1HJ,11X,6HXLB(J),6X,6HYLC(J),6X,6HZLB(J),10X,1HU,
     1  11X,1HV,11X,1HW,8X,4HVNOR//)
  730 FORMAT (///10X,61HNOTE: L.E. OF LEAD PANEL IN FIRST CHORDWISE ROW
     1IS SUPERSONIC/)
C
C
C
C
C
C     CALCULATE WING AND BODY PANEL INDUCED VELOCITIES AT THE CENTROID
C     POINTS AND OUTBOARD AFT CORNER OF FIN CONSTANT U-VELOCITY PANELS
C     ALSO ADD VELOCITIES DUE TO FIXED VORTICES AND/OR MOVING VORTICES.
C
C
C     IF BODY HAS ELLIPTICAL CROSS SECTION, USE BDU,BDV,BDW CAL-
C     CULATED AT FIN CONTROL POINTS.
C
      IF (NDRAG.EQ.0) GO TO 513
      NOCPT=1
      II=1
      IF=NWBP
      IF(NOUT.EQ.1) WRITE (6,716)
      DO 508 J=1,NPANLS
      XFLDP(J)=XBAR(J)
      YFLDP(J)=YCPT(J)
```

```
  508 ZFLDP(J)=ZCPT(J)
      NSTART=1
      IF (BODY.AND.RA.EQ.RB) CALL VELCAL(NPANLS,ALFR,BETAR,NSTART)
      DO 510 J=1,NPANLS
      CALL VELNOR(XBAR(J),YCPT(J),ZBAR(J))
      UCT=UCHK
      VCT=VCHK
      WCT=WCHK
      IF(J.GT.NHP) GO TO 509
      VNOR(J)=WCHK+BDW(J)+WVEL(J)+WVRTX(J)
      GO TO 512
  509 VNOR(J)=VCHK+BDV(J)+VVEL(J)+VVRTX(J)
  512 CONTINUE
      IF (NOUT.NE.1) GO TO 510
      WRITE (6,705) J,XBAR(J),YCPT(J),ZBAR(J),UCT,VCT,WCT,VNOR(J)
  510 CONTINUE
C
C     HERE    N=1.....RIGHT HOR. FIN
C             N=2.....LEFT  HOR. FIN
C             N=3.....UPPER VERT. FIN
C             N=4.....LOWER VERT. FIN
C
      IF(NOUT.EQ.1) WRITE (6,727)
      N=0
      JSTART=1
      JTIP=NRP-NCW+1
      TIPCHD=XRB(NRP)-XRF(JTIP)
      JEND=NRP
  607 N=N+1
      IF (NOUT.EQ.1.AND.(N.EQ.1.OR.N.EQ.3)) GO TO 911
      IF (NOUT.EQ.1) WRITE (6,729)
      GO TO 912
  911 WRITE (6,728)
  912 DO 608 J=JSTART,JEND
      IF(N.EQ.2.OR.N.EQ.4) GO TO 908
      XFLDP(J)=XRB(J)
      YFLDP(J)=YRC(J)
      ZFLDP(J)=ZRB(J)
      XB(J)=XRB(J)
      YC(J)=YRC(J)
      ZB(J)=ZRB(J)
C
C     FOR WINGS WITH SIDE EDGES:
C     IF L.E. SWEEP OF CHORDWISE ROW NEAREST THE TIP IS SUBSONIC,
C     MOVE THE OUTBOARD CORNER OUT ONE PANEL WIDTH
C
      IF (TIPCHD.LT.100.0*TLRNC) GO TO 608
      IF (N.EQ.1.AND.J.GE.JTIP.AND.SWPPLE(JTIP).GT.BETA) GO TO 909
      IF (N.EQ.3.AND.J.GE.JTIP.AND.SWPPLE(JTIP).GT.BETA) GO TO 925
      GO TO 608
  909 YC(J)=YRC(J)+1.0*WIDTH(J)
      GO TO 608
  925 ZB(J)=ZRB(J)+1.0*WIDTH(J)
      GO TO 608
  908 XFLDP(J)=XLB(J)
      YFLDP(J)=YLC(J)
      ZFLDP(J)=ZLB(J)
      XB(J)=XLB(J)
      YC(J)=YLC(J)
      ZB(J)=ZLB(J)
      IF (TIPCHD.LT.100.0*TLRNC) GO TO 608
      IF (N.EQ.2.AND.J.GE.JTIP.AND.ABS(SWPPLE(JTIP)).GT.BETA) GO TO 924
      IF (N.EQ.4.AND.J.GE.JTIP.AND.ABS(SWPPLE(JTIP)).GT.BETA) GO TO 926
```

```
      GO TO 608
  924 YC(J)=YLC(J)-1.0**IOTH(J)
      GO TO 608
  926 ZB(J)=ZBB(J)-1.0**IOTH(J)
  608 CONTINUE
      IF (BODY.AND.NA.EQ.NB) CALL VELCAL(JEND,ALFR,BETAR,JSTART)
      DO 610 J=JSTART,JEND
      CALL VELNOR(XB(J),YC(J),ZB(J))
      UCT=UCHK
      VCT=VCHK
      WCT=WCHK
      IF (J.GT.NHP) GO TO 915
      VNOROS(J)=WCHK+BDW(J)+WVEL(J)+WVRTX(J)
      GO TO 913
  915 VNOROS(J)=VCHK+BDV(J)+VVEL(J)+VVRTX(J)
  913 IF(NOUT.NE.1) GO TO 610
      WRITE (6,705) J,XB(J),YC(J),ZB(J),UCT,VCT,WCT,VNOROS(J)
  610 CONTINUE
      IF (.NOT.NOSYM) GO TO 513
      IF (N.NE.1) GO TO 611
      JSTART=NRP+1
      JEND=NHP
      JTIP=NHP-NCW+1
      TIPCHD=XLB(NHP)-XLF(JTIP)
      GO TO 607
  611 IF (N.NE.2.OR.NHP.EQ.NPANLS) GO TO 612
      JSTART=NHP+1
      JEND=N3P
      JTIP=N3P-NCW+1
      TIPCHD=XRB(N3P)-XRF(JTIP)
      GO TO 607
  612 IF (N.NE.3) GO TO 513
      JSTART=N3P+1
      JEND=NPANLS
      JTIP=NPANLS-NCW+1
      TIPCHD=XLB(NPANLS)-XLF(JTIP)
      GO TO 607
  513 CONTINUE
C
C
C
C     INITIALIZE VARIABLES
C
      CNB=0.
      CYB=0.
      CZBIP=0.0
      CYBIP=0.0
      CMBIP=0.0
      CLNBIP=0.0
      CLLBIP=0.0
      CLBIP=0.0
      CDIBIP=0.0
      CYWBIP=0.0
      CMBIPW=0.0
      CLNBPW=0.0
C
C        ENTER HERE FOR NONLINEAR PRESSURE LOADINGS
C
      ENTRY SPECLD
C
      DTOR=PI/180.0
      AREA=0.0
      CZOA=0.0
```

```
      CYOA=0.0
      CMOA=0.0
      CLNOA=0.0
      CLLOA=0.0
      CZFINU=0.0
      CZFIND=0.0
      CYFINU=0.0
      CYFIND=0.0
      CMFINU=0.0
      CMFIND=0.0
      CLNFU=0.0
      CLNFD=0.0
      CLLFU=0.0
      CLLFD=0.0
      CYU=0.
      CYD=0.
      CTHRU=0.
      CTHRD=0.
      CTHRR=0.0
      CTHRL=0.0
      CLR=0.0
      CLL=0.0
      CLU=0.0
      CLD=0.0
      CDIR=0.0
      CDIL=0.0
      CDIU=0.
      CDID=0.
      CDCLS=0.0
      CYWR=0.0
      CYWL=0.0
      CYWU=0.0
      CYWD=0.0
      CMFRW=0.
      CMFLW=0.
      CMFUW=0.
      CMFDW=0.
      CLNFRW=0.0
      CLNFLW=0.0
      CLNFUW=0.0
      CLNFDW=0.0
      CNADDV=0.0
      CYADDH=0.0
C
      BETAY= BETAR/DTOR
      ANY=NOSYM
      ANYMO=.NOT.ASYM
C
C     PUT MOMENT CENTER IN WING COORDINATE SYSTEM.
C
      XMW=XM-XWLE
C
C
C     NOTE:  DLTPG IS DELTA-LOADING PRESSURE/Q  OR DELTA-CP
C
      DO 902 I=1,NPANLS
      IF (NPRESS.EQ.0) DLTPG(I)=DELTP(I)
      IF (NPRESS.EQ.1) DLTPG(I)=DLTP(I)
  902 CONTINUE
C
C
C
C     WRITE OUT BTP PANEL PROPERTIES
```

```
C     CONTRIBUTION FROM BODY INTERFERENCE PANELS TO CZ...CNB
C     CONTRIBUTION FROM BODY INTERFERENCE PANELS TO CY...CYB
C
      IF(NBIP.EQ.0) GO TO 160
      IF (NPRESS.NE.0) GO TO 161
      IF (NOUT.NE.0) WRITE (6,707)
      DO 140 K=1,NBIP
      I=K+NPANLS
      F=DELTP(I)*ARPNL(I)
      FN(I)=F
      CALL ROTBW(0.,F,BFY(K),BFZ(K),K)
      CNB=CNB+BFZ(K)
      L=I
      CYB=CYB+BFY(K)
      CIRC(L)=0.5*DELTP(I)*DX
      ARM=XCPT(I)-XM*
      BFZM=-BFZ(K)*ARM
      CMBIP=CMBIP+BFZM
      BFYM=-BFY(K)*ARM
      CLNBIP=CLNBIP+BFYM
      BIPRM=-BFZ(K)*YCPT(L)+BFY(K)*(ZCPT(L)-ZM)
      CLLBIP=CLLBIP+BIPRM
      IF (NOUT.NE.0)
     1WRITE(6,710) L,YCPT(L),DX,NBIP,THTI(K),BFY(K),BFZ(K),FN(L),
     1DELTP(L),CIRC(L)
  140 CONTINUE
      CZBIP=CNB/SREF
      CYBIP=CYB/SREF
      CMBIP=CMBIP/(SREF*REFL)
      CLNBIP=CLNBIP/(SREF*REFL)
      CLLBIP=CLLBIP/(SREF*REFL)
      IF (ANY) GO TO 161
      CZBIP=2.0*CZBIP
      CYBIP=0.0
      CMBIP=2.0*CMBIP
      CLNBIP=0.0
      CLLBIP=0.0
  161 CONTINUE
  160 CONTINUE
C
C
C
C     CALCULATE FORCES,CZFIN,CYFIN, ACTING ON THE FINS,
C     PITCHING MOMENT,CMFIN,YAWING MOMENT,CLNF,ROLLIN MOMENT,CLLF.
C     CTHR IS THRUST FORCE. LAST LETTER DESIGNATES FIN AS FOLLOWS.
C        R.....HOR. RIGHT FIN
C        L.....HOR. LEFT FIN
C        U.....VERT. UPPER FIN
C        D.....VERT. LOWER FIN
C     BIP......INTERFERENCE SHELL.
C
C     ALSO:
C     IN WING OR BODY COORDINATE SYSTEM,
C     FX.....THRUST FORCE IN NEG. X-DIR. IN PLANE OF WING/Q
C     FY.....SIDE FORCE IN Y-DIRECTION IN PLANE OF WING/Q
C     FZ.....UPWARDS FORCE IN Z-DIR. IN PLANE OF VERTICAL WING
C  NOTE:  ADDITIONAL CONTRIBUTIONS TO IN PLANE FORCES ARE CALCULATED
C     IN SUBROUTINE SPNLD.
C     PRESENTLY, IN-PLANE FORCES  SUITABLE FOR CRUCIFORM OR PLANAR
C     FINS OR WINGS ONLY.
C
C     THE 300 LOOP IS USED FOR THE RIGHT AND LEFT HORIZONTAL PANELS
C
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```
      IF (NOUT .NE.0) WRITE (6,701)                                     DM14 371
      JL=1                                                              DM14 372
      JU=NRP                                                            DM14 373
      IL=0                                                              DM14 374
      ANGL=ANGLR                                                        DM14 375
      SINANG=SIN(ANGL)                                                  DM14 376
      PHIF=PHIFR*DTOR                                                   DM14 377
  302 CONTINUE                                                          DM14 378
      CZFIN=0.0                                                         DM14 379
      CYFIN=0.0                                                         DM14 380
      CMFIN=0.0                                                         DM14 381
      CLNFIN=0.0                                                        DM14 382
      CLLFIN=0.0                                                        DM14 383
      CNN=0.0                                                           DM14 384
      CTHR=0.0                                                          DM14 385
      DO 300 J=JL,JU                                                    DM14 386
      AREA=AREA+ARPNL(J)                                                DM14 387
      I=J                                                               DM14 388
      F=     ARPNL(J)*DLTPG(I)                                          DM14 389
      FN(I)=F                                                           DM14 390
      YCHK= YCPT(I)*COSBET-XBAR(I)*SINBET                               DM14 391
      IF (ANYMO) YCHK=YCPT(I)                                           DM14 392
      ARM=XCPT(J)-XMW                                                   DM14 393
      CALL ROTFM(0.0,F,CYP,CZP,PHIF)                                    DM14 394
      CMP=-CZP*ARM                                                      DM14 395
      CLNP=-CYP*ARM                                                     DM14 396
      PRM=-CZP*YCPT(J)+CYP*(ZCPT(J)-ZM)                                 DM14 397
      CZFIN=CZFIN+CZP                                                   DM14 398
      CYFIN=CYFIN+CYP                                                   DM14 399
      CMFIN=CMFIN+CMP                                                   DM14 400
      CLNFIN=CLNFIN+CLNP                                                DM14 401
      CLLFIN=CLLFIN+PRM                                                 DM14 402
      CNN=CNN+F                                                         DM14 403
C                                                                       DM14 404
C     CIRC IS GAMMA/V (FT),BASED ON LINEAR PRESSURE.                    DM14 405
C                                                                       DM14 406
      CIRC(J)=0.5*DLTPG(J)*PNLC(J)                                      DM14 407
      SLPMC=0.5*(SWPPLE(J)+SWPPTE(J))                                   DM14 408
      SWPMC=ATAN(SLPMC)*57.2957795                                      DM14 409
      IF (NDRAG.EQ.0) GO TO 299                                         DM14 410
      FX(J)=2.*WIDTH(J)*CIRC(J)*(SINANG+VNOR(J))                        DM14 411
      FY(J)=FX(J)*SLPMC                                                 DM14 412
      CYADDM=CYADDM+FY(J)                                               DM14 413
      CTHR=CTHR+FX(J)                                                   DM14 414
  299 IF (NOUT.NE.0)                                                    DM14 415
     1WRITE (6,706) J,YCPT(J),PNLC(J),WIDTH(J),SWPMC,DLTPG(J),FN(J)     DM14 416
  300 CONTINUE                                                          DM14 417
C                                                                       DM14 418
      IF (IL.EQ.1) GO TO 310                                            DM14 419
      CNR=CNN/SREF                                                      DM14 420
      CZFINR=CZFIN/SREF                                                 DM14 421
      CYFINR=CYFIN/SREF                                                 DM14 422
      CMFINR=CMFIN/(SREF*REFL)                                          DM14 423
      CLNFR=CLNFIN/(SREF*REFL)                                          DM14 424
      CLLFR=CLLFIN/(SREF*REFL)                                          DM14 425
      CTHRR=CTHR/SREF                                                   DM14 426
C                                                                       DM14 427
C  NOTE: SYMMETRY CONSIDERATIONS ARE USED IN DIFFERENT MANNER FOR       DM14 428
C     THE CASE OF INTERDIGITATED TAIL FINS (THETIT.NE.0).               DM14 429
C     REFER TO MAIN PROGRAM CRF*BD FOR DESIGNATIONS OF INTERDIGITATED   DM14 430
C     FINS.                                                             DM14 431
C                                                                       DM14 432
      IF(ANY) GO TO 301                                                 DM14 433
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```
      AREA=2.0*AREA                                                     DM14 434
      IF (THETIT.NE.0.0) GO TO 303                                      DM14 435
      GO TO 304                                                         DM14 436
  303 CZFIND=CZFINR                                                     DM14 437
      CYFIND=-CYFINR                                                    DM14 438
      CMFIND=CMFINR                                                     DM14 439
      CLNFD=-CLNFR                                                      DM14 440
      CLLFD=-CLLFR                                                      DM14 441
      CTHRD=CTHRR                                                       DM14 442
      CYD=CNR                                                           DM14 443
      GO TO 311                                                         DM14 444
  304 CZFINL=CZFINR                                                     DM14 445
      CYFINL=-CYFINR                                                    DM14 446
      CMFINL=CMFINR                                                     DM14 447
      CLNFL=-CLNFR                                                      DM14 448
      CLLFL=-CLLFR                                                      DM14 449
      CTHRL=CTHRR                                                       DM14 450
      CNL = CNR                                                         DM14 451
      CYADDH=0.0                                                        DM14 452
      GO TO 311                                                         DM14 453
  301 CONTINUE                                                          DM14 454
C                                                                       DM14 455
C     REENTER ABOVE LOOP FOR LEFT HORIZONTAL PANEL                      DM14 456
C                                                                       DM14 457
      IL=1                                                              DM14 458
      JL=JU+1                                                           DM14 459
      JU=NHP                                                            DM14 460
      ANGL=ANGLL                                                        DM14 461
      SINANG=SIN(ANGL)                                                  DM14 462
      GO TO 302                                                         DM14 463
  310 CZFINL=CZFIN/SREF                                                 DM14 464
      CYFINL=CYFIN/SREF                                                 DM14 465
      CMFINL=CMFIN/(SREF*REFL)                                          DM14 466
      CLNFL=CLNFIN/(SREF*REFL)                                          DM14 467
      CLLFL=CLLFIN/(SREF*REFL)                                          DM14 468
      CTHRL=CTHR/SREF                                                   DM14 469
      CNL=CNN/SREF                                                      DM14 470
  311 CONTINUE                                                          DM14 471
      IF(NHP.EQ.NPANLS) GO TO 350                                       DM14 472
C                                                                       DM14 473
C     THE 320 LOOP IS USED FOR THE UPPER AND LOWER VERTICAL PANELS      DM14 474
C                                                                       DM14 475
      IF (NOUT .NE.0) WRITE (6,702)                                     DM14 476
      JL=NHP+1                                                          DM14 477
      JU=N3P                                                            DM14 478
      IL=0                                                              DM14 479
      ANGL=ANGLU                                                        DM14 480
      SINANG=SIN(ANGL)                                                  DM14 481
      PHIF=PHIFU*DTOR                                                   DM14 482
  325 CONTINUE                                                          DM14 483
      CZFIN=0.0                                                         DM14 484
      CYFIN=0.0                                                         DM14 485
      CMFIN=0.0                                                         DM14 486
      CLNFIN=0.0                                                        DM14 487
      CLLFIN=0.0                                                        DM14 488
      CYY=0.0                                                           DM14 489
      CTHR=0.0                                                          DM14 490
      DO 320 J=JL,JU                                                    DM14 491
      I=J                                                               DM14 492
      F=    ARPNL(J)*DLTPG(I)                                           DM14 493
      FN(I)=F                                                           DM14 494
      ZCHK= ZCPT(I)*COSALF+XBAR(I)*SINALF                               DM14 495
      IF (ANYMO) ZCHK=ZCPT(I)                                           DM14 496
```

```
      ARM=XCPT(J)-XMW
      CALL ROTFW(0,0,F,CYP,CZP,PHIF)
      CMP=-CZP*ARM
      CLNP=-CYP*ARM
      PRM=-CZP*YCPT(J)+CYP*(ZCPT(J)-ZM)
      CZFIN=CZFIN+CZP
      CYFIN=CYFIN+CYP
      CMFIN=CMFIN+CMP
      CLNFIN=CLNFIN+CLNP
      CLLFIN=CLLFIN+PRM
      CYY=CYY-F
      CIRC(J)=0.5*DLTPG(J)*PNLC(J)
      SLPMC=0.5*(SWPPLE(J)+SWPPTE(J))
      SWPMC=ATAN(SLPMC)*57.2957795
      IF (NDRAG.EQ.0) GO TO 319
      FX(J)=2.*WIDTH(J)*CIRC(J)*(SINANG-VNOR(J))
      FZ(J)=FX(J)*SLPMC
      CNADDV=CNADDV+FZ(J)
      CTHR=CTHR+FX(J)
  319 IF (NOUT.NE.0)
     1WRITE (6,706) J,ZCPT(J),PNLC(J),WIDTH(J),SWPMC,DLTPG(J),FN(J)
  320 CONTINUE
      IF (IL.EQ.1) GO TO 330
      CZFINU=CZFIN/SREF
      CYFINU=CYFIN/SREF
      CMFINU=CMFIN/(SREF*REFL)
      CLNFU=CLNFIN/(SREF*REFL)
      CLLFU=CLLFIN/(SREF*REFL)
      CTHRU=CTHR/SREF
      CYU=CYY/SREF
      IF(ANY) GO TO 321
      IF (THETIT.NE.0.0) GO TO 322
      GO TO 350
  322 CZFINL=CZFINU
      CYFINL=-CYFINU
      CMFINL=CMFINU
      CLNFL=-CLNFU
      CLLFL=-CLLFU
      CTHRL=CTHRU
      CNL=CYU
      GO TO 350
  321 CONTINUE
C
C     REENTER ABOVE LOOP FOR LOWER VERTICAL PANEL
C
      IL=1
      JL=JU+1
      JU=NPANLS
      ANGL=ANGLD
      SINANG=SIN(ANGL)
      GO TO 325
  330 CZFIND=CZFIN/SREF
      CYFIND=CYFIN/SREF
      CMFIND=CMFIN/(SREF*REFL)
      CLNFD=CLNFIN/(SREF*REFL)
      CLLFD=CLLFIN/(SREF*REFL)
      CTHRD=CTHR/SREF
      CYD=CYY/SREF
  350 CONTINUE
C
C
C
C
```

```
C
C     OVERALL FORCE AND MOMENTT COEFFICIENTS FOR FINS AND INTERFERENCE
C     SHELL IN WING OR BODY REFERNCE SYSTEM.
C
C     CTHROA.....ACTS ALONG NEGATIVE X-AXIS
C     CYOA.......ACTS ALONG POSITIVE Y-AXIS
C     CZOA.......ACTS ALONG POSITIVE Z-AXIS
C     CMOA.......VECTOR ALONG NEGATIVE Y-AXIS,NOSE UP POS.
C     CLNOA......VECTOR ALONG POSITIVE Z-AXIS,NOSE TO RIGHT POS.
C     CLLNOA.....VECTOR ALONG POSITIVE X-AXIS, RIGHT WING DOWN POS.
C
C     CNADDV,CYADDH...ADDITIONS TO CZOA,CYOA DUE TO IN PLANE FORCES,NOT
C     SUCTION CONVERSION TO NORMAL FORCE.
C
C     FORCE COEFFICIENTS IN X,Y,Z DIRECTIONS.
C
      CTHROA=CTHRR+CTHRL+CTHRU+CTHRD
      CZOA=CZFINR+CZFINL+CZFINU+CZFIND+CZBIP
      CYOA=CYFINR+CYFINL+CYFINU+CYFIND+CYBIP
      CNADDV=CNADDV/SREF
      CYADDH=CYADDH/SREF
C
C     PITCHING,YAWING,ROLLING MOMENTS COEFFICIENTS.
C
      CMOA=CMFINR+CMFINL+CMFINU+CMFIND+CMBIP
      CLNOA=CLNFR+CLNFL+CLNFU+CLNFD+CLNBIP
      CLLOA=CLLFR+CLLFL+CLLFU+CLLFD+CLLBIP
C
C
C     OVERALL FORCE AND MOMENT COEFFICIENTS IN WIND-AXIS SYSTEM(EXCEPT
C     ROLLING MOMENT)
C
C     CDI.....ACTS BACK ALONG FREE STREAM DIRECTION,XWIND-AXIS
C     CYW.....ACTS TO THE RIGHT NORMAL TO FREE STREAM VECTOR-BODY
C             CENTER LINE PLANE,YWIND-AXIS
C     CL......ACTS UPWARDS IN FREE STREAM VECTOR-BODY CENTERLINE
C             PLANE NORMAL TO FREE STREAM VECTOR,ZWIND-AXIS
C     CMOAW...VECTOR ALONG NEGATIVE YWIND-AXIS,NOSE UP POS.
C     CLNOAW..VECTOR ALONG POSITIVE ZWIND-AXIS,NOSE TO RIGHT,POS.
C
C     DRAG,LATERAL,LIFT FORCE COEFFICIENTS
C
      CDIR=-CTHRR*COSALC-CYFINR*SINALC*SINPHI+CZFINR*SINALC*COSPHI
      CDIL=-CTHRL*COSALC-CYFINL*SINALC*SINPHI+CZFINL*SINALC*COSPHI
      CDIU=-CTHRU*COSALC-CYFINU*SINALC*SINPHI+CZFINU*SINALC*COSPHI
      CDID=-CTHRD*COSALC-CYFIND*SINALC*SINPHI+CZFIND*SINALC*COSPHI
      CDIBIP=           -CYBIP*SINALC*SINPHI+CZBIP*SINALC*COSPHI
      CDI=CDIR+CDIL+CDIU+CDID+CDIBIP
C
C
      CYWR=CZFINR*SINPHI+CYFINR*COSPHI
      CYWL=CZFINL*SINPHI+CYFINL*COSPHI
      CYWU=CZFINU*SINPHI+CYFINU*COSPHI
      CYWD=CZFIND*SINPHI+CYFIND*COSPHI
      CYWBIP=CZBIP*SINPHI+CYBIP*COSPHI
      CYW=CYWR+CYWL+CYWU+CYWD+CYWBIP
C
C
      CLR=CTHRR*SINALC-CYFINR*COSALC*SINPHI+CZFINR*COSALC*COSPHI
      CLL=CTHRL*SINALC-CYFINL*COSALC*SINPHI+CZFINL*COSALC*COSPHI
```

```
      CLU=CTHRU*SINALC-CYFINU*COSALC*SINPHI+CZFINU*COSALC*COSPHI
      CLD=CTHRD*SINALC-CYFIND*COSALC*SINPHI+CZFIND*COSALC*COSPHI
      CLBIP=            -CYBIP*COSALC*SINPHI+CZBIP*COSALC*COSPHI
      CL=CLR+CLL+CLU+CLD+CLBIP
      CDCLS=CDI/(CL*CL)
C
C     PITCHING,YAWING MOMENTS
C
      CMFRW=CMFINR*COSPHI-CLNFR*SINPHI
      CMFLW=CMFINL*COSPHI-CLNFL*SINPHI
      CMFUW=CMFINU*COSPHI-CLNFU*SINPHI
      CMFDW=CMFIND*COSPHI-CLNFD*SINPHI
      CMBIPW=CMBIP*COSPHI-CLNBIP*SINPHI
      CMOAW=CMFRW+CMFLW+CMFUW+CMFDW+CMBIPW
C
C
      CLNFRW=-CLLFR*SINALC+CMFINR*COSALC*SINPHI+CLNFR*COSALC*COSPHI
      CLNFLW=-CLLFL*SINALC+CMFINL*COSALC*SINPHI+CLNFL*COSALC*COSPHI
      CLNFUW=-CLLFU*SINALC+CMFINU*COSALC*SINPHI+CLNFU*COSALC*COSPHI
      CLNFDW=-CLLFD*SINALC+CMFIND*COSALC*SINPHI+CLNFD*COSALC*COSPHI
      CLNBPW=-CLLBIP*SINALC+CMBIP*COSALC*SINPHI+CLNBIP*COSALC*COSPHI
      CLNOAW=CLNFRW+CLNFLW+CLNFUW+CLNFDW+CLNBPW
C
C
C     WRITE ALL LOADING RESULTS.
C
      SPAN=2.0*B2
      WRITE(6,717) FMACH,ALFA,BETAY,AREA,SREF,REFL,SPAN,XM,ZM
      IF (NPRESS.EQ.0) WRITE (6,725)
      IF (NPRESS.EQ.1) WRITE (6,726)
      WRITE (6,718) DELR,DELL,DELU,DELD,
     1 CTHROA,CTHRR,CTHRL,CTHRU,CTHRD,
     2 CZOA,CZFINR,CZFINL,CZFINU,CZFIND,CZBIP,
     3 CYOA,CYFINR,CYFINL,CYFINU,CYFIND,CYBIP,
     4 CMOA,CMFINR,CMFINL,CMFINU,CMFIND,CMBIP,
     5 CLNOA,CLNFR,CLNFL,CLNFU,CLNFD,CLNBIP,
     6 CLLOA,CLLFR,CLLFL,CLLFU,CLLFD,CLLBIP,
     7 CL,CLR,CLL,CLU,CLD,CLBIP,
     * CYW,CYWR,CYWL,CYWU,CYWD,CYWBIP,
     8 CDI,CDIR,CDIL,CDIU,CDID,CDIBIP,
     9 CDCLS,
     *CMOAW,CMFRW,CMFLW,CMFUW,CMFDW,CMBIPW,
     *CLNOAW,CLNFRW,CLNFLW,CLNFUW,CLNFDW,CLNBPW
C
C     CHECK ON SUPERSONIC L.E. BASED ON L.E. SWEEP OF INBOARD
C     CHORDWISE ROW
C
      ARGTAN=1.0/BETA
      ANGMCH=(ATAN(ARGTAN))*57.2957795
      PSIMCH=90.0-ANGMCH
      PSIPLE=(ATAN(SWPPLE(1)))*57.2957795
      IF (PSIMCH.GT.PSIPLE) WRITE(6,730)
C
C
C
C
      IF (THETIT.NE.0.0) RETURN
      CALL SPNLD
      RETURN
      END
```

```
      SUBROUTINE OUT(A,N)
C
C     VERSION: DEMON1
C
      DIMENSION A(N,N)
    1 FORMAT(10(1X,E11.4))
    2 FORMAT (1H )
      DO 100 I=1,N
      WRITE (6,1) (A(I,J),J=1,N)
  100 WRITE(6,2)
      RETURN
      END
```

```
      SUBROUTINE ROTATE(YIN,ZIN,YOUT,ZOUT,PHIF)
C
C     VERSION:DEMON2.
C
C     THIS SUBROUTINE ROTATES LOCAL  COORDINATES RELATIVE TO CONSTANT
C     U-VELOCICITY PANEL CORNERS AND PARALLEL TO WING COORDINATE
C     SYSTEM TO LOCAL COORDINATES IN THE PLANE OF THE PANEL ITSELF AND
C     VICE VERSA.
C
      COMMON/ONE/DUM1(6400),A,DUM2(5),BETA,DUM3(6),EM,DUM4(4),SLOPE,
     1TLRNC,TIPY,TOTLR,U,V,W,DUM5(4),X,YS,ZS,MI,DUM6(2),MJ,DUM7(8),NHP,
     2NPR,DUM8(2),NOCPT,NULINP,NOUT,NPANLS,DUM9(2),ASYM,BODY,DELTA,NOSYM
      COMMON/INTROT/PHIDIH,THETIT,YBOD,ZBOD,PHIFR,PHIFU
C
      DATA PI02/1.5707963267951/
C
C
C     WING TO FIN
C
      ENTRY ROTWF
      IF (ABS(PHIF-PI02).LT.TLRNC) GO TO 100
      GO TO 101
  100 COSPHI=0.0
      SINPHI=1.0
      GO TO 104
  101 CONTINUE
      COSPHI=COS(PHIF)
      SINPHI=SIN(PHIF)
  104 CONTINUE
      YOUT=YIN*COSPHI+ZIN*SINPHI
      ZOUT=ZIN*COSPHI-YIN*SINPHI
      RETURN
C
C     FIN TO WING
C
      ENTRY ROTFW
      IF (ABS(PHIF-PI02).LT.TLRNC) GO TO 102
      GO TO 103
  102 COSPHI=0.0
      SINPHI=1.0
      GO TO 105
  103 CONTINUE
      COSPHI=COS(PHIF)
      SINPHI=SIN(PHIF)
  105 CONTINUE
      YOUT=YIN*COSPHI-ZIN*SINPHI
      ZOUT=ZIN*COSPHI+YIN*SINPHI
      RETURN
      END
```

```
      SUBROUTINE SOLVE (B,A,N)                                          DM17   1
C                                                                       DM17   2
C     VERSION: DEMON1                                                   DM17   3
C                                                                       DM17   4
C                                                                       DM17   5
C     THIS SUBROUTINE TAKES IN THE TRIANGULATED MATRIX A, RIGHT HAND    DM17   6
C     SIDE VECTOR B, IT IS OPERATED ON BY IP(300)                       DM17   7
C     SOLUTION THEN PROCEEDS, ANSWER IS IN VECTOR B AGAIN               DM17   8
C                                                                       DM17   9
      DIMENSION B(1)                                                    DM17  10
      DIMENSION A(N,N)                                                  DM17  11
C                                                                       DM17  12
      LOGICAL ASYM,BODY,DELTA,NOSYM                                     DM17  13
C                                                                       DM17  14
      COMMON/ONE/DUM1(6000),IP(300),DUM2(102),ALFR,DUM3(18),TOTLR,      DM17  15
     1DUM4(21),NDRAG,DUM5(4),NOCPT,NOLINP,NOUT,NPANLS,NPRESS,NWBP,ASYM, DM17  16
     2BODY,DELTA,NOSYM                                                  DM17  17
C                                                                       DM17  18
C                                                                       DM17  19
      IF(N.EQ.1)GO TO 9                                                 DM17  20
      NM1=N-1                                                           DM17  21
      DO 7 K=1,NM1                                                      DM17  22
      KP1=K+1                                                           DM17  23
      M=IP(K)                                                           DM17  24
      T=B(M)                                                            DM17  25
      B(M)=B(K)                                                         DM17  26
      B(K)=T                                                            DM17  27
      DO 7 I=KP1,N                                                      DM17  28
    7 B(I)=B(I)+A(I,K)*T                                                DM17  29
C                                                                       DM17  30
C                                                                       DM17  31
      DO 8 KB=1,NM1                                                     DM17  32
      KM1=N-KB                                                          DM17  33
      K=KM1+1                                                           DM17  34
      B(K)=B(K)/A(K,K)                                                  DM17  35
      T=-B(K)                                                           DM17  36
      IF (T.EQ.0.0) GO TO 9                                             DM17  37
      DO 8 I=1,KM1                                                      DM17  38
    8 B(I)=B(I)+A(I,K)*T                                                DM17  39
    9 B(1)=B(1)/A(1,1)                                                  DM17  40
      RETURN                                                            DM17  41
      END                                                               DM17  42
```

```
      SUBROUTINE SOURCE(J)                                              DM18   1
C     VERSION: DEMON                                                    DM18   2
C                                                                       DM18   3
C     VERSION: DEMON1                                                   DM18   4
C                                                                       DM18   5
C SUBROUTINE TO CALCULATE THE VELOCITIES DUE TO A LINEAR LINE SOURCE OF DM18   6
C UNIT SLOPE WITH ORIGIN AT TX(J).                                      DM18   7
C SOLUTIONS GIVEN BY WOODWARD AND LARSEN (BOING REPT. D6-10741),EQUATIONDM18   8
C (53) OR ANTONIO FERRI, "ELEMENTS OF AERODYNAMICS OF SUPERSONIC FLOWS,"DM18   9
C EQUATION (378).                                                       DM18  10
C                                                                       DM18  11
      INTEGER BCODE                                                     DM18  12
      COMMON/TWO/TX(101),DUM1(1113),BCODE,BETASQ,BSQ,RADIUS,RFIELD,RNOSEDM18  13
     1,U,V,VT,XA,XC,XD,BETA,XFIELD,X2,XB,NXBODY                         DM18  14
C                                                                       DM18  15
C                                                                       DM18  16
  100 FORMAT(1H0,59HFIELD POINT IS WITHIN TAIL MACH CONE.  U AND V SET TDM18  17
```

```
     10 ZERO.)
C
      X1=XFIELD-TX(J)
      BR=BETA*RFIELD
      IF(X1.LE.BR) GO TO 10
      IF(X2.LE.BR)GO TO 11
      WRITE(6,100)
      GO TO 10
   11 XL=X1/BR
      D23= SQRT(XL*XL-1.)
      U=-ALOG(XL+D23)
      V=BETA*D23
      RETURN
C
C FIELD POINT IS AHEAD OF MACH CONE FROM SOURCE ORIGIN.
C
   10 U=0.
      V=0.
      RETURN
      END
```

```
      SUBROUTINE SPECPR
C
C     VERSION: DEMON1
C
C     THIS SUBROUTINE COMPUTES BERNOULLI PRESSURES AT CONTROL POINTS
C     OF THE CONSTANT U-VELOCITY PANELS
C     ON THE WING OR FIN SURFACES
C
C
C
      DIMENSION PRESSA(150),PRESSB(150),PRESSR(150),PRESSL(150)
C
      LOGICAL BODY,ASYM,DELTA,NOSYM
C
      COMMON/ONE/DUM1(250),DELTP(250),DUM2(1750),XCPT(250),YCPT(250),
     1ZCPT(250),DUM3(3402),ALFR,ARWING,DUM4(2),BETA,BETAR,CONST,COSALF,
     2COSBET,CN,DX,EM,FMACH,RCIR,
     2                           SINALF,SINBET,DUM5(3),TOTLR,DUM6(3),UCHK,
     3VCHK,WCHK,DUM7(4),I,IF,II,K,DUM8(4),NBIP,NCRX,NCW,NDRAG,NHP,NPR,
     4NRP,N3P,NOCPT,NOLINP,NOUT,NPANLS,NPRESS,NWBP,ASYM,BODY,DELTA,NOSYM
      COMMON/BVEL/BDU(150),BDV(150),BDW(150),XFLDP(150),YFLDP(150),
     1 ZFLDP(150)
      COMMON/SPCPRS/DLTP(150)
      COMMON/SPSANG/SINALC,COSALC,SINPHI,COSPHI
      COMMON/VRTXV/VVRTX(150),WVRTX(150),NVRTPL,NVRTX,VRTMAX
      COMMON/THKDAT/NTDAT,NCWT,NTPR,MSWT(4),NRPT,NHPT,N3PT,NTHP,ASYMT,
     1        NVERT,SWLET(20,4),SWTET(20,4),YTH(20,4),THETAL(400)
      COMMON/ICVEL/UTCHK,VTCHK,WTCHK,IIT,IFT,MJ
      COMMON/VPTHVL/VVEL(500),WVEL(500),JCPT,NCPOUT,NVLIN
      COMMON /ELLIPS/ RA,RB,ERATIO
C
C
C
  720 FORMAT(1X,I3,11F11.6)
  721 FORMAT (1X,I3,6F11.6,11X,3F11.6)
  732 FORMAT(////10X,104HVELOCITIES AND BERNOULLI PRESSURES AT CONTROL P
     1OINTS IMMEDIATELY ABOVE AND BELOW HORIZONTAL WING SURFACE//
     22X,1HJ,6X,4HX(J),7X,4HY(J),7X,4HZ(J),5X,5HUTOTA,6X,5HVTOTA,
     36X,5HWTOTA,6X,6HPRESSA,5X,5HUTOTB,6X,5HVTOTB,6X,5HWTOTB,
     46X,6HPRESSB/)
```

```
  734 FORMAT(////10X,107HVELOCITIES AND BERNOULLI PRESSURES AT CONTROL P
     1OINTS IMMEDIATELY TO RIGHT AND LEFT OF VERTICAL WING SURFACE//
     22X,1HJ,6X,4HX(J),7X,4HY(J),7X,4HZ(J),5X,5HUTOTR,6X,5HVTOTR,
     36X,5HWTOTR,6X,6HPRESSR,5X,5HUTOTL,6X,5HVTOTL,6X,5HWTOTL,6X,
     46HPRESSL/)
  736 FORMAT (////5X,35HPRESSURE LOADINGS AT CONTROL POINTS//
     1 2X,1HJ,7X,4HX(J),7X,4HY(J),7X,4HZ(J),4X,10HDELTP,LIN.,1X,
     2    11HDELTP,BERN./)
  737 FORMAT (1H1,77HPRESSURE LOADINGS EXCLUDE VORTEX INDUCED COMPONENTS
     1 PARALLEL TO WING SURFACES//)
  738 FORMAT (1H1,77HPRESSURE LOADINGS INCLUDE VORTEX INDUCED COMPONENTS
     1 PARALLEL TO WING SURFACES//)
C
C
      NOCPT=1
      NHP1=NHP+1
      NPNLS1=NPANLS+1
      IF (NVRTX.NE.0.AND.NVRTPL.EQ.0) WRITE (6,737)
      IF (NVRTX.NE.0.AND.NVRTPL.EQ.1) WRITE (6,738)
C
C
C     POINTS IMMEDIATELY ABOVE AND BELOW WING SURFACE TREATED
C     SEPARATELY DUE TO DISCONTINUITY IN INFLUENCE FUNCTIONS
C     WHEN Z EQUALS ZERO.
C
C
      WRITE (6,732)
C
C
C
C     WING SURFACES AND BODY INTERFERENCE PANELS CONTRIBUTION
C
      FACTR1=1.428571429/(FMACH*FMACH)
      FACTR2=0.2*FMACH*FMACH
C
      DO 805 J=1,NHP
      XFLDP(J)=XCPT(J)
      YFLDP(J)=YCPT(J)
  805 ZFLDP(J)=ZCPT(J)
      NSTART=1
      IF (BODY.AND.RA.EQ.RB) CALL VELCAL(NHP,ALFR,BETAR,NSTART)
      DO 807 K=1,NHP
      VADVRT=VVRTX(K)
      IF (NVRTX.NE.0.AND.NVRTPL.EQ.0) VADVRT=0.0
C
C     DISCONTINOUS CONTRIBUTION
C     ADD IN CONTRIBUTIONS FROM EXTERNAL VORTICES.
C
      II=K
      IF=K
      CALL VELNOR(XCPT(K),YCPT(K),ZCPT(K))
C
C     A...ABOVE         B...BELOW
C
      UTOTA=UCHK+BDU(K)
      VTOTA=VCHK+BDV(K)+VADVRT+VVEL(K)
      WTOTA=      BDW(K)+WVRTX(K)+WVEL(K)
C
      UTOTB=-UCHK+BDU(K)
      VTOTB=-VCHK+BDV(K)+VADVRT+VVEL(K)
      WTOTB=      BDW(K)+WVRTX(K)+WVEL(K)
      IF (NOUT.NE.0)
     1WRITE (6,721) K,XCPT(K),YCPT(K),ZCPT(K),UTOTA,VTOTA,WTOTA,UTOTB,
```

```
     1 VTOTB,WTOTB                                                      DM19 104
C                                                                       DM19 105
C      CONTINOUS CONTRIBUTION FROM HORIZONTAL FINS                      DM19 106
C                                                                       DM19 107
      II=1                                                              DM19 108
      IF=NHP                                                            DM19 109
      CALL VELNOR(XCPT(K),YCPT(K),ZCPT(K))                              DM19 110
      WTOTA=WTOTA+WCHK                                                  DM19 111
      WTOTB=WTOTB+WCHK                                                  DM19 112
      IF (NOUT.NE.0)                                                    DM19 113
     1WRITE (6,721) K,XCPT(K),YCPT(K),ZCPT(K),UTOTA,VTOTA,WTOTA,UTOTB,  DM19 114
     1 VTOTB,WTOTB                                                      DM19 115
      IF (NHP.EQ.NWBP) GO TO 801                                        DM19 116
C                                                                       DM19 117
C      CONTRIBUTION FROM VERTICAL FINS AND BODY INTERFERENCE PANELS,    DM19 118
C                                                                       DM19 119
      II=NHP1                                                           DM19 120
      IF=NWBP                                                           DM19 121
      CALL VELNOR(XCPT(K),YCPT(K),ZCPT(K))                              DM19 122
      UTOTA=UTOTA+UCHK                                                  DM19 123
      VTOTA=VTOTA+VCHK                                                  DM19 124
      WTOTA=WTOTA+WCHK                                                  DM19 125
C                                                                       DM19 126
      UTOTB=UTOTB+UCHK                                                  DM19 127
      VTOTB=VTOTB+VCHK                                                  DM19 128
      WTOTB=WTOTB+WCHK                                                  DM19 129
      IF (NOUT.NE.0)                                                    DM19 130
     1WRITE (6,721) K,XCPT(K),YCPT(K),ZCPT(K),UTOTA,VTOTA,WTOTA,UTOTB,  DM19 131
     1 VTOTB,WTOTB                                                      DM19 132
  801 CONTINUE                                                          DM19 133
C                                                                       DM19 134
C      SOURCE PANEL CONTRIBUTION                                        DM19 135
C                                                                       DM19 136
      IF(NTDAT.EQ.0) GO TO 830                                          DM19 137
      III=1                                                             DM19 138
      IFT=NTHP                                                          DM19 139
      MJ=K                                                              DM19 140
      CALL THKVEL(XCPT(K),YCPT(K),ZCPT(K))                              DM19 141
      UTOTA=UTOTA+UTCHK                                                 DM19 142
      VTOTA=VTOTA+VTCHK                                                 DM19 143
      WTOTA=WTOTA+WTCHK                                                 DM19 144
      UTOTB=UTOTB+UTCHK                                                 DM19 145
      VTOTB=VTOTB+VTCHK                                                 DM19 146
      WTOTB=WTOTB+WTCHK                                                 DM19 147
      IF (NOUT.NE.0)                                                    DM19 148
     1WRITE (6,721) K,XCPT(K),YCPT(K),ZCPT(K),UTOTA,VTOTA,WTOTA,UTOTB,  DM19 149
     1 VTOTB,WTOTB                                                      DM19 150
  830 CONTINUE                                                          DM19 151
C                                                                       DM19 152
      BDUSQ=UTOTA*UTOTA                                                 DM19 153
      BDVSQ=VTOTA*VTOTA                                                 DM19 154
      BDWSQ=WTOTA*WTOTA                                                 DM19 155
      UBAR=UTOTA*COSALC-VTOTA*SINBET+WTOTA*SINALF                       DM19 156
      ARG=1.0-FACTR2*(2.0*UBAR+BDUSQ+BDVSQ+BDWSQ)                       DM19 157
      PRESSA(K)=-FACTR1                                                 DM19 158
      IF(ARG.GE.TOTLR)PRESSA(K)=FACTR1*(ARG**3.5-1.0)                   DM19 159
      BDUSQ=UTOTB*UTOTB                                                 DM19 160
      BDVSQ=VTOTB*VTOTB                                                 DM19 161
      BDWSQ=WTOTB*WTOTB                                                 DM19 162
      UBAR=UTOTB*COSALC-VTOTB*SINBET+WTOTB*SINALF                       DM19 163
      ARG=1.0-FACTR2*(2.0*UBAR+BDUSQ+BDVSQ+BDWSQ)                       DM19 164
      PRESSB(K)=-FACTR1                                                 DM19 165
      IF(ARG.GE.TOTLR)PRESSB(K)=FACTR1*(ARG**3.5-1.0)                   DM19 166
```

```
      WRITE(6,720)K,XCPT(K),YCPT(K),ZCPT(K),UTOTA,VTOTA,WTOTA,
     1      PRESSA(K),UTOTB,VTOTB,WTOTB,PRESSB(K)
  807 CONTINUE
C
C     POINTS IMMEDIATELY TO THE RIGHT AND THE LEFT OF VERTICAL
C     WING SURFACE TREATED SEPARATELY DUE TO DISCONTINUITY IN
C     INFLUENCE FUNCTIONS WHEN Y EQUALS ZERO.
C     ADD IN CONTRIBUTIONS FROM EXTERNAL VORTICES.
C
C
      IF (NCRX.EQ.0) GO TO 841
      WRITE (6,734)
C
C
      DO 808 J=NHP1,NPANLS
      XFLOP(J)=XCPT(J)
      YFLOP(J)=YCPT(J)
  808 ZFLOP(J)=ZCPT(J)
      NSTART=NHP1
C
      IF (BODY.AND.RA.EQ.RB) CALL VELCAL(NPANLS,ALFR,BETAR,NSTART)
      DO 813 K=NHP1,NPANLS
      WADVRT=WVRTX(K)
      IF (NVRTX.NE.0.AND.NVRTPL.EQ.0) WADVRT=0.0
C
      II=K
      IF=K
      CALL VELNOR(XCPT(K),YCPT(K),ZCPT(K))
      UTOTR=-UCHK+BDU(K)
      VTOTR=         BDV(K)+VVRTX(K)+VVEL(K)
      WTOTR=-WCHK+BDW(K)+WADVRT+WVEL(K)
      UTOTL=UCHK+BDU(K)
      VTOTL=       BDV(K)+VVRTX(K)+VVEL(K)
      WTOTL=WCHK+BDW(K)+WADVRT+WVEL(K)
      IF (NOUT.NE.0)
     1WRITE (6,721) K,XCPT(K),YCPT(K),ZCPT(K),UTOTR,VTOTR,WTOTR,UTOTL,
     1  VTOTL,WTOTL
C
      II=NHP1
      IF=NPANLS
      CALL VELNOR(XCPT(K),YCPT(K),ZCPT(K))
      VTOTR=VTOTR+VCHK
      VTOTL=VTOTL+VCHK
      IF (NOUT.NE.0)
     1WRITE (6,721) K,XCPT(K),YCPT(K),ZCPT(K),UTOTR,VTOTR,WTOTR,UTOTL,
     1  VTOTL,WTOTL
C
      II=1
      IF=NHP
      CALL VELNOR(XCPT(K),YCPT(K),ZCPT(K))
      UTOTR=UTOTR+UCHK
      VTOTR=VTOTR+VCHK
      WTOTR=WTOTR+WCHK
      UTOTL=UTOTL+UCHK
      VTOTL=VTOTL+VCHK
      WTOTL=WTOTL+WCHK
      IF (NOUT.NE.0)
     1WRITE (6,721) K,XCPT(K),YCPT(K),ZCPT(K),UTOTR,VTOTR,WTOTR,UTOTL,
     1  VTOTL,WTOTL
C
      IF (NPANLS.EQ.NWBP) GO TO 803
      II=NPNLS1
      IF=NWBP
      CALL VELNOR(XCPT(K),YCPT(K),ZCPT(K))
```

```
      UTOTR=UTOTR+UCHK
      VTOTR=VTOTR+VCHK
      WTOTR=WTOTR+WCHK
      UTOTL=UTOTL+UCHK
      VTOTL=VTOTL+VCHK
      WTOTL=WTOTL+WCHK
C
      IF (NOUT.NE.0)
     1WRITE (6,721) K,XCPT(K),YCPT(K),ZCPT(K),UTOTR,VTOTR,WTOTR,UTOTL,
     1  VTOTL,WTOTL
  805 CONTINUE
C
C     SOURCE PANEL CONTRIBUTION
C
      IF(NTDAT.EQ.0) GO TO 835
      NJ=K
      CALL THKVEL(XCPT(K),YCPT(K),ZCPT(K))
      UTOTR=UTOTR+UTCHK
      VTOTR=VTOTR+VTCHK
      WTOTR=WTOTR+WTCHK
      UTOTL=UTOTL+UTCHK
      VTOTL=VTOTL-VTCHK
      WTOTL=WTOTL+WTCHK
      IF (NOUT.NE.0)
     1WRITE (6,721) K,XCPT(K),YCPT(K),ZCPT(K),UTOTR,VTOTR,WTOTR,UTOTL,
     1  VTOTL,WTOTL
  835 CONTINUE
C
      RDUSQ=UTOTR*UTOTR
      RDVSQ=VTOTR*VTOTR
      RDWSQ=WTOTR*WTOTR
      UBAR=UTOTR*COSALC-VTOTR*SINBET+WTOTR*SINALF
      ARG=1.0-FACTR2*(2.0*UBAR+RDUSQ+RDVSQ+RDWSQ)
      PRESSR(K)=-FACTR1
      IF(ARG.GE.TOTLR)PRESSR(K)=FACTR1*(ARG**3.5-1.0)
      RDUSQ=UTOTL*UTOTL
      RDVSQ=VTOTL*VTOTL
      RDWSQ=WTOTL*WTOTL
      UBAR=UTOTL*COSALC-VTOTL*SINBET+WTOTL*SINALF
      ARG=1.0-FACTR2*(2.0*UBAR+RDUSQ+RDVSQ+RDWSQ)
      PRESSL(K)=-FACTR1
      IF(ARG.GE.TOTLR)PRESSL(K)=FACTR1*(ARG**3.5-1.0)
      WRITE(6,720)K,XCPT(K),YCPT(K),ZCPT(K),UTOTR,VTOTR,WTOTR,
     1      PRESSR(K),UTOTL,VTOTL,WTOTL,PRESSL(K)
  813 CONTINUE
C
C
C     CALCULATE PRESSURE DIFFERENCES AT CONTROL POINTS
C
  801 CONTINUE
      WRITE (6,736)
      DO 821 K=1,NPANLS
      IF (K.LE.NHP) GO TO 822
      GO TO  823
  822 DLTP(K)=PRESSB(K)-PRESSA(K)
      GO TO 824
  823 DLTP(K)=PRESSR(K)-PRESSL(K)
  824 CONTINUE
  821 WRITE (6,720) K,XCPT(K),YCPT(K),ZCPT(K),DELTP(K),DLTP(K)
C
C     CALCULATE WING LOADINGS DUE TO BERNOULLI LOADING PRESSURES
C
      NPRESS=1
```

```
      CALL SPECLD                                                       DM19 294
C                                                                       DM19 295
C                                                                       DM19 296
      RETURN                                                            DM19 297
      END                                                               DM19 298
```

```
      SUBROUTINE SPNLD                                                  DM20   1
C                                                                       DM20   2
C     VERSION: DEMON1                                                   DM20   3
C                                                                       DM20   4
C     THIS SUBROUTINE COMPUTES SPAN LOAD DISTRIBUTIONS                  DM20   5
C     THIS SUBROUTINE COMPUTES SPAN LOAD DISTRIBUTIONS FOR MONOPLANE    DM20   6
C     OR CRUCIFORM WING OR FIN CONFIGURATIONS ONLY.                     DM20   7
C NOTE: INTERDIGITATED FINS PRESENTLY EXCLUDED.                         DM20   8
C     ALSO ADDITIONAL IN-PLANE FORCES,FY2,FZ2,                          DM20   9
C     AND SUCTION DISTRIBUTIONS ALONG THE LEADING EDGE AND SIDE EDGE.   DM20  10
C     USING THIS INFORMATION, FIN LEADING AND SIDE EDGE VORTICITY       DM20  11
C     DISTRIBUTIONS ARE CALCULATED.                                     DM20  12
C     IN ADDITION, FIN TRAILING EDGE VORTEX STRENGTH AND SPANWISE       DM20  13
C     LOCATION ARE DETERMINED FROM THE LOAD DISTRIBUTIONS.              DM20  14
C                                                                       DM20  15
      DIMENSION SLOAD (20),CHORDS(150),FY2(150),FZ2(150),FT2(20),       DM20  16
     1 YCG(20),ZCG(20),VALMAX(5),YMAX(5),VALNUM(5),ZMAX(5),SLP(20),     DM20  17
     2 CIRNET(80),GAMMA(20)                                             DM20  18
C                                                                       DM20  19
      LOGICAL ASYM,ANYMO,SSLE                                           DM20  20
C                                                                       DM20  21
      COMMON/ONE/CIRC(250),DELTP(250),FN(250),PNLC(250),SWPPLE(250),    DM20  22
     1SWPPTE(250),VNOR(250),XBAR(250),ZBAR(250),XCPT(250),YCPT(250),ZCPTDM20  23
     2(250),XLF(250),XLR(250),XRF(250),XRR(250),YLC(250),YRC(250),ZLF(25DM20  24
     30),ZRF(250),ZLR(250),ZRR(250),SNT(125),CST(125),SNT2(125),CST2(125DM20  25
     4),IP(300),XFHIP(100),A,ALFA,ALFR,ARWING,B2,P2V,BETA,BETAR,CONST,  DM20  26
     5COSALF,COSBET,CN,DX,EM,FMACH,RCIR,SINALF,SINBET,SLOPE,TIPNC,TIPY, DM20  27
     6TOTLR,U ,V ,W ,UCHK,VCHK,WCHK,WHIP,X,Y,Z,I,IF,II,J,MSWR,MSWL,MSWU,DM20  28
     7MSWD,NBIP,NCRX,NCW,NDRAG,NHP,NPR,NRP,N3P,NOCPT,NOLINP,NOUT,NPANLS,DM20  29
     8NPRESS,NWBP,ASYM,BODY,DELTA,NOSYM                                 DM20  30
      COMMON/THREE/ANGLR,ANGLL,ANGLU,ANGLD,DELR,DELL,DELU,DELD,SREF,REFLDM20  31
      COMMON/SWEEPS/VSWLER(20),VSWTER(20),VSWLEL(20),VSWTEL(20),        DM20  32
     1  VSWLEU(20),VSWTEU(20),VSWLED(20),VSWTED(20),LVSWP,LEFT,FAC,NCWB DM20  33
     2,ARPNL(250),WIDTH(250)                                            DM20  34
      COMMON/FRCDIS/VNORDS(150),FX(150),FY(150),FZ(150),DLTPG(150),ANYMODM20  35
      COMMON/VRTXV/VVRTX(150),WVRTX(150),NVRTPL,NVRTX,VRTMAX            DM20  36
      COMMON/VPTHVL/VVEL(500),WVEL(500),JCPT,NCPOUT,NVLIN               DM20  37
      COMMON/FINLE/XLE(80),CGLOC(80),GAMLE(80),FKLE,NEDGV,MLEVR,MLEVL,  DM20  38
     1 MLEVU,MLEVD                                                      DM20  39
      COMMON/FINSE/XSE(80),CGSELC(80),GAMSE(80),FKSE,NSIDGE,NSEV        DM20  40
      COMMON/ELLIPS/RA,RB,ERATIO                                        DM20  41
C                                                                       DM20  42
C                                                                       DM20  43
  702 FORMAT(////31X,22HSPANWISE DISTRIBUTIONS//)                       DM20  44
  703 FORMAT (2X,I2,2X,8(F10.5,2X),F10.5,1X,2F10.5)                     DM20  45
  704 FORMAT ( 2X,I2,2X,F10.5,2X,F10.5,74X,F10.5)                       DM20  46
  706 FORMAT (1X,I3,2(1X,F10.5),5(2X,F10.5))                            DM20  47
  707 FORMAT (////10X,22HSIDE EDGE DISTRIBUTION//2X,4HJTIP,2X,          DM20  48
     1   3HJSE,2X,8HDISTANCE,7X,13HSUCTION FORCE,7X,8HGAMMA,SE,6X,      DM20  49
     2 4HZBAR,7X,3HXSE/13X,7HFROM LE,8X,15HPER UNIT LENGTH,5X,          DM20  50
     3 5H/VINF/13X,9H/TIPCHORD,6X,13H/(J*TIPCHORD)/)                    DM20  51
  708 FORMAT (////10X,22HSIDE EDGE DISTRIBUTION//2X,4HJTIP,2X,          DM20  52
     1   3HJSE,2X,8HDISTANCE,7X,13HSUCTION FORCE,7X,8HGAMMA,SE,6X,      DM20  53
     2 4HYBAR,7X,3HXSE/13X,7HFROM LE,8X,15HPER UNIT LENGTH,5X,          DM20  54
```

```
    3 5H/VINF/13X,9H/TIPCHORD,6X,13H/(4*TIPCHORD)/)                     DM20  55
  709 FORMAT (3X,I2,4X,I2,1X,F10.5,6X,F10.5,6X,F10.5,4X,F10.5,1X,F10.5) DM20  56
  710 FORMAT (1X,I3,9(1X,F10.5))                                        DM20  57
  712 FORMAT (////                                                      DM20  58
    1 10X,9HSUMFX   = ,E12.5,/10X,9HSUMFY1 = ,E12.5,/10X,9HSUMFY2 = ,   DM20  59
    1E12.5,/10X,9HSUMFT2 = ,E12.5)                                      DM20  60
  721 FORMAT(1H1,20(1H=),A10,21(1H=))                                   DM20  61
  723 FORMAT( 3X,1HI,5X,7HZ/(B/2),2X,10HCN*C/(2*B),2X,10HCT*C/(2*B),    DM20  62
    1 1X,11HCZ1*C/(2*B),1X,13HCZTOT*C/(2*B),1X,10HCS*C/(2*B),5X,        DM20  63
    2 5HCSINT,5X,4HZBAR,7X,9HGAMNET(I),2X,13HGAMMA,LE/VINF,2X,3HXLE/)   DM20  64
  724 FORMAT( 3X,1HI,5X,7HY/(B/2),2X,10HCN*C/(2*B),2X,10HCT*C/(2*B),    DM20  65
    1 1X,11HCY1*C/(2*B),1X,13HCYTOT*C/(2*B) ,1X,10HCS*C/(2*B),5X,       DM20  66
    2 5HCSINT,5X,4HYBAR,7X,9HGAMNET(I),2X,13HGAMMA,LE/VINF,2X,3HXLE/)   DM20  67
  731 FORMAT (////10X,9HSUMFX   = ,E12.5/10X,9HSUMFZ1 = ,E12.5/10X,     DM20  68
    1 9HSUMFZ2 = ,E12.5/10X,9HSUMFT2 = ,E12.5/)                         DM20  69
  733 FORMAT (///,25X,17HWING PANEL FORCES//2X,1HJ,5X,7HYCPT(J),3X,     DM20  70
    18HDELTA-CP,6X,6HGAMMA/,6X,2HFX,10X,3HFY1, 9X,3HFY2/                DM20  71
    2 32X,4HVINF,//)                                                    DM20  72
  734 FORMAT (//8X,1HI,3X,3HDLT,6X,3HSLP,4X,4HISEQ,3X,4HYCHK,5X,        DM20  73
    1 6HVALINT,1X,4HNUM=,3X,6HVALMAX,3X,6HVALNUM,3X,4HYMAX/51X,3HEXT)   DM20  74
  735 FORMAT (/7X,I2,2(1X,F8.4),2X,I2,1X,2(1X,F8.4),2X,I2,1X,           DM20  75
    1 3(1X,F8.4)/)                                                      DM20  76
  736 FORMAT (////30H******T.E. FIN VORTEX INFO*****/)                  DM20  77
  738 FORMAT (1X,4HIVRT,1X,10HGAMMA/VINF,3X,6HY.C.G./)                  DM20  78
  739 FORMAT (///25X,17HWING PANEL FORCES//2X,1HJ,5X,7HZCPT(J),,3X,     DM20  79
    1 8HDELTA-CP,6X,6HGAMMA/,5X,2HFX,10X,3HFZ1,10X,3HFZ2,/              DM20  80
    2 18X,4HLIN,,10X,4HVINF,//)                                         DM20  81
  742 FORMAT (1X,4HIVRT,1X,10HGAMMA/VINF,3X,6HZ.C.G./)                  DM20  82
  743 FORMAT (//8X,1HI,3X,3HDLT,6X,3HSLP,4X,4HISEQ,3X,4HZCHK,5X,        DM20  83
    1 6HVALINT,1X,4HNUM=,3X,6HVALMAX,3X,6HVALNUM,3X,4HZMAX/51X,3HEXT)   DM20  84
C                                                                       DM20  85
      DATA ARW/10HRIGHT WING/,ALW/10H LEFT WING/,AUW/10HUPPER WING/,    DM20  86
    1 ADW/10HLOWER WING/                                                DM20  87
C      INITIALIZE                                                       DM20  88
C                                                                       DM20  89
      DO 903 I=1,50                                                     DM20  90
  903 CIRNET(I)=0.0                                                     DM20  91
C                                                                       DM20  92
C                                                                       DM20  93
C                                                                       DM20  94
C     CALCULATE SPANWISE LOAD DISTRIBUTIONS                             DM20  95
C                                                                       DM20  96
      MSWRP=MSWR+1                                                      DM20  97
      MSWLP=MSWL+1                                                      DM20  98
      MSWUP=MSWU+1                                                      DM20  99
      MSWDP=MSWD+1                                                      DM20 100
      CFC=1.0/(4.0*B2)                                                  DM20 101
      TWOB=4.0*B2                                                       DM20 102
      ARGTAN=1.0/BETA                                                   DM20 103
      ANGMCH=(ATAN(ARGTAN))*57.2957795                                  DM20 104
      PSIMCH=90.0-ANGMCH                                                DM20 105
C                                                                       DM20 106
C     LOOP 542 IS FOR RIGHT AND LEFT HORIZONTAL FINS                    DM20 107
C                                                                       DM20 108
      HTW=1.0/B2                                                        DM20 109
      WRITE(6,721) ARW                                                  DM20 110
      WRITE(6,702)                                                      DM20 111
      WRITE(6,724)                                                      DM20 112
      J=1                                                               DM20 113
      TL=0                                                              DM20 114
      ANGL=ANGLR                                                        DM20 115
      SINANG=SIN(ANGL)                                                  DM20 116
      COSANG=COS(ANGL)                                                  DM20 117
```

```
      NSPANP=MSWRP
      SIGN=+1.0
      KUL=MSWRP
      JSTART=1
      JEND=NRP
      JTIP=NRP-NCW+1
      TIPCHD=XRB(NRP)-XRF(JTIP)
      IVRT=0
      IFV=0
  540 CONTINUE
      CIRNET(NSPANP)=0.0
      I=0
C
C
      SUMFX=0.0
      SUMFY1=0.0
      SUMFY2=0.0
      SUMFT2=0.0
C
C
      SLP(1)=0.0
      DLT=0.
      VALINT=0.0
      CSINT=0.0
      CSMOM=0.0
      NUMEXT=0
      ISEQ=0
      NOEXT=0
C
C     ALL CIRNET ARE POSITIVE IN THE COUNTER CLOCKWISE DIRECTION LOOKING
C     FORWARD
C     NOTE: IN PLANE FORCE FY2 ACTS ON OUTBOARD AFT CORNER OF EACH PANEL
C     HERE:  IL=0.....RIGHT FIN
C            IL=1.....LEFT FIN
C
      DO 542 K=2,KUL
      I=I+1
      IFV=IFV+1
      SCSMX=0.0
      SCSMY1=0.0
      SCSMY2=0.0
      SWPANG=ABS(ATAN(SWPPLE(J)))
      COSSWP=COS(SWPANG)
      PSIPLE=SWPANG*57.2957795
      SSLE=PSIMCH.GT.PSIPLE
      SUM1=0.0
      YCHK=YCPT(J)*COSBET-XBAR(J)*SINBET
      IF (ANYMO) YCHK=YCPT(J)
      YLOC=YCHK*HTW
      IP1=I+1
      IF (IL.EQ.1) GO TO 460
      NFRST=1
      ISPN=IP1
      IC=I
      XLE(IFV)=XLF(J)+(YCPT(J)-YLC(J))*SWPPLE(J)
      GO TO 461
  460 NFRST=MSWRP+1
      ISPN=IP1+MSWRP
      IC=I+MSWRP
      XLE(IFV)=XRF(J)+(YCPT(J)-YRC(J))*SWPPLE(J)
  461 CONTINUE
      CIRNET(ISPN)=0.0
      DO 541 L=1,NCW
```

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      SUM1=SUM1+FN(J)                                                   DM20 181
      WIDI=1./WIDTH(J)                                                  DM20 182
      IF (I.NE.1) GO TO 812                                             DM20 183
      CIRNET(NFRST)=CIRNET(NFRST)-CIRC(J)*SIGN                          DM20 184
  812 JADJ=J+NCW                                                        DM20 185
      IF (K.EQ.KUL) GO TO 916                                           DM20 186
      GO TO 917                                                         DM20 187
  916 CIRNET(NSPANP)=CIRNET(NSPANP)+CIRC(J)*SIGN                        DM20 188
      GO TO 813                                                         DM20 189
  917 CIRNET(ISPN)=CIRNET(ISPN)+(CIRC(J)-CIRC(JADJ))*SIGN               DM20 190
  813 CONTINUE                                                          DM20 191
      IF (NDRAG.EQ.0) GO TO 815                                         DM20 192
      IF(IL.EQ.1) GO TO 440                                             DM20 193
      CHORDS(J)=XRB(J)-XRF(J)                                           DM20 194
      GO TO 441                                                         DM20 195
  440 CHORDS(J)=XLB(J)-XLF(J)                                           DM20 196
  441 CONTINUE                                                          DM20 197
      IF (L.EQ.NCW) CHORDS(J)=0.5*CHORDS(J)                             DM20 198
      FY2(J)=2.0*CHORDS(J)*CIRNET(ISPN)*(SINANG+VNORDS(J))              DM20 199
      IF (FX(J).LT.0.0.OR.SSLE) GO TO 818                               DM20 200
      SCSMX=SCSMX+FX(J)                                                 DM20 201
      SCSMY1=SCSMY1+FY(J)                                               DM20 202
  818 CONTINUE                                                          DM20 203
      IF (K.EQ.KUL) GO TO 816                                           DM20 204
      SCSMY2=SCSMY2+FY2(J)                                              DM20 205
      GO TO 815                                                         DM20 206
  816 FT2(L)=FY2(J)                                                     DM20 207
      SUMFT2=SUMFT2+FT2(L)                                              DM20 208
  815 CONTINUE                                                          DM20 209
C                                                                       DM20 210
C     WIDTH(J) IS PANEL SPANWISE DIMENSION,ALWAYS POSITIVE.             DM20 211
C     IT IS CALCULATED IN SUBROUTINE LAYOUT.                            DM20 212
C                                                                       DM20 213
  541 J=J+1                                                             DM20 214
      DELY=WIDTH(J-1)                                                   DM20 215
      SUMFX=SUMFX+SCSMX                                                 DM20 216
      SUMFY1=SUMFY1+SCSMY1                                              DM20 217
      SUMFY2=SUMFY2+SCSMY2                                              DM20 218
      FACTOR=WIDI*CFC                                                   DM20 219
C                                                                       DM20 220
C     SLOAD....CNC/2B,SECFXX....CTC/IB,SECFY....CYC/2B,SECFY2....CY(TOT)DM20 221
C     /2B,SECSUC....CSC/2B                                              DM20 222
C     VALINT.....ACCUMULATED VALUE OF THE INTEGRAL (CNC/2*B)*DELY OVER  DM20 223
C     THE SPANWISE DIRECTION.                                           DM20 224
C     CSINT.....ACCUMULATED VALUE OF THE INTEGRAL (CSC/2*B)*DELY OVER   DM20 225
C     THE SPANWISE DIRECTION.                                           DM20 226
C                                                                       DM20 227
      SLOAD(I)=SUM1*WIDI*CFC                                            DM20 228
      VALINT=VALINT+(SLOAD(I)*DELY)                                     DM20 229
      IF (NDRAG.NE.0) GO TO 562                                         DM20 230
      WRITE (6,703) IC,YLOC,SLOAD(I),CIRNET(IC)                         DM20 231
      IF (K.NE.KUL) GO TO 542                                           DM20 232
      YLOC=((B2+RB)/B2)*SIGN                                            DM20 233
      SLDTIP=0.0                                                        DM20 234
      WRITE (6,704) NSPANP,YLOC,SLDTIP,CIRNET(NSPANP)                   DM20 235
      GO TO 542                                                         DM20 236
  562 CONTINUE                                                          DM20 237
      IF (SSLE) GO TO 551                                               DM20 238
      SECFXX=SCSMX*FACTOR                                               DM20 239
      SECFY=SCSMY1*FACTOR                                               DM20 240
      SECFY2=(SCSMY2+SCSMY1)*FACTOR                                     DM20 241
      SECSUC=SECFXX/COSSWP                                              DM20 242
      CSINT=CSINT+(SECSUC*DELY)                                         DM20 243
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      CSMOM=CSMOM+ABS(YCHK*SECSUC*DELY)
      CGLOC(IFV)=(CSMOM/CSINT)*SIGN
      YEXP=CGLOC(IFV)-(RB*SIGN)
      GAMLE(IFV)=FKLE*((CSINT*THOM)/(2.0*YEXP))*COSANG
      GO TO 552
  551 SECFXX=0.0
      SECFY=0.0
      SECFY2=SCSMY2*FACTOR
      SECSUC=0.0
      CGLOC(IFV)=0.0
      GAMLE(IFV)=0.0
  552 CONTINUE
      WRITE (6,703) IC,YLOC,SLOAD(I),SECFXX,SECFY,SECFY2,SECSUC,CSINT,
     1 CGLOC(IFV),CIRNET(IC),GAMLE(IFV),XLE(IFV)
      IF (K.NE.KUL) GO TO 525
      YLOC=((B2+RB)/B2)*SIGN
      SLOTIP=0.0
      WRITE (6,704) NSPANP,YLOC,SLOTIP,CIRNET(NSPANP)
  525 CONTINUE
      IF (I.EQ.1) GO TO 645
      IM1=I-1
      DLT=ABS(YCHK-YCHKBF)
      SLP(I) =(SLOAD(I)-SLOAD(IM1))/DLT
      REFSLP=ABS(SLOAD(1)/(10.0*B2))
      IF (ABS(SLP(I)).LE.REFSLP) SLP(I)=0.0
      IF (I.EQ.2) GO TO 646
      IF (K.EQ.KUL) GO TO 521
      GO TO 522
  521 SLP(NSPANP)=-SLOAD(I)/(DLT/2.0)
      IF (ABS(SLP(NSPANP)).LE.REFSLP) GO TO 646
      SLPCHK=SLP(I)
      IF (SLPCHK.EQ.0.0) SLPCHK=SLP(I-1)
      IF (SLPCHK.GT.0.0.AND.SLP(NSPANP).LT.0.0) GO TO 643
      IF (SLPCHK.LT.0.0.AND.SLP(NSPANP).GT.0.0) GO TO 643
  522 CONTINUE
      IF (SLP(I).EQ.0.0) GO TO 646
      IF (SLPBF.EQ.0.0.AND.I.GE.4) SLPBF=SLP(I-2)
      IF (SLPBF.GT.0.0.AND.SLP(I).LT.0.0) GO TO 643
      IF (SLPBF.LT.0.0.AND.SLP(I).GT.0.0) GO TO 643
      GO TO 646
C
C     VALMAX IS THE EXTREME VALUE OF CNC/2*B
C     ITS VALUE IS TAKEN EQUAL TO THE (I-1)TH VALUE OF CNC/2B
C     LIKEWISE YMAX
C     VALMAX(1) IS THE VALUE OF CNC/2B NEAREST THE ROOT
C
  643 NUMEXT=NUMEXT+1
      ISEQ=NUMEXT+1
      VALMAX(1)=SLOAD(1)
      YMAX(1)=RB*SIGN
      VALMAX(ISEQ  )=SLOAD(IM1)
      YMAX(ISEQ  )=YCHKBF
      IF (IL.EQ.0) YOUTSD=YRC(J-1-NCW)
      IF (IL.EQ.1) YOUTSD=YLC(J-1-NCW)
      RSINT=SLOAD(IM1)*(YOUTSD-YMAX(ISEQ))*SIGN
      VALINT=RSINT+(SLOAD(I)*DELY)
      VALNUM(ISEQ)=VLINBF-RSINT
  646 SLPBF=SLP(I)
  645 YCHKBF=YCHK
      VLINBF=VALINT
      IF (K.EQ.KUL.AND.NUMEXT.EQ.0) GO TO 526
      GO TO 527
  526 VALMAX(1)=SLOAD(1)
```

```
      YMAX(1)=YCHK
      VALNUM(1)=VALINT
      NOEXT=1
  527 CONTINUE
      IF (I.EQ.1.AND.NOUT.NE.0) WRITE (6,734)
      IF (NOUT.NE.0) WRITE (6,735) I,DLT,SLP(I),ISEQ,YCHK,VALINT,NUMEXT,
     1 VALMAX(ISEQ  ),VALNUM(ISEQ  ),YMAX(ISEQ  )
      IF (NOUT.NE.0.AND.K.EQ.KUL) WRITE (6,735) IP1,   DLT,SLP(NSPANP),
     1 ISEQ,YCHK,VALINT,NUMEXT,VALMAX(ISEQ),VALNUM(ISEQ),YMAX(ISEQ)
  542 CONTINUE
C
      SUMFX=SUMFX/SREF
      SUMFY1=SUMFY1/SREF
      SUMFY2=SUMFY2/SREF
      SUMFT2=SUMFT2/SREF
      WRITE (6,712) SUMFX,SUMFY1,SUMFY2,SUMFT2
C
C     SIDE FORCE PER UNIT TIPCHORD/(Q*C)
C
      IF (NDRAG.EQ.0) GO TO 600
      IF (TIPCHD.LT.100.0*TLRNC) GO TO 600
      TIPEPL=TIPCHD/NCW
      DENOM=TIPCHD*TIPEPL
      WRITE (6,708)
      JSE=0
      FACTRK= 1.0/(FKLE*TWOB)
      FACTRI=1.0/FACTRK
      DO 914 JTIP=1,NCW
      AJTIP=JTIP
      XLOC=AJTIP*TIPEPL
      XLOCOC=XLOC/TIPCHD
      FT=FT2(JTIP)/DENOM
      JSE=JSE+1
      IF (IL.EQ.1) GO TO 918
      J=NRP-NCW+JTIP
      XSE(JSE)=XRF(J)
      GO TO 919
  918 J=NHP-NCW+JTIP
      XSE(JSE)=XLF(J)
  919 CSMOM=CSMOM+ABS((RB+R2)*FACTRK*FT2(JTIP)*FKSE)
      CSINT=CSINT+ABS(FACTRK*FT2(JTIP)*FKSE)
      CGSELC(JSE)=(CSMOM/CSINT)*SIGN
      YEXP=CGSELC(JSE)-(RB*SIGN)
      GAMSE(JSE)=((CSINT*FACTRI)/(2.0*YEXP))*COSANG
  914 WRITE (6,709) JTIP,JSE,XLOCOC,FT,GAMSE(JSE),CGSELC(JSE),XSE(JSE)
  600 CONTINUE
C
C
C     PRINT INDIVIDUAL PANEL FORCES
C
      IF (NOUT.NE.1) GO TO 548
      WRITE (6,733)
      DO 550 J=JSTART,JEND
  550 WRITE (6,706) J,YCPT(J),DLTPG(J),CIRC(J),FX(J),FY(J),FY2(J)
  548 CONTINUE
C
C
C
C
C     FIN TRAILING EDGE VORTICES CALCULATED NEXT.
C     GAMMA.....GAMMA/VINF,POSITIVE COUNTERCLOCKWISE.
C     YCG.......YBAR,MEASURED FROM BODY CENTERLINE.
C
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      IF (NDRAG.EQ.0) GO TO 531                                          DM20 370
      WRITE (6,736)                                                      DM20 371
      WRITE (6,738)                                                      DM20 372
      IF (NOEXT.EQ.0) GO TO 528                                          DM20 373
      IVRT=IVRT+1                                                        DM20 374
      GAMMA(IVRT )=(SLOAD(1)*TWOB/2.0)*SIGN                              DM20 375
      YCG(IVRT)=(HB+(VALNUM(1)/SLOAD(1)))*SIGN                           DM20 376
      WRITE (6,710) IVRT,GAMMA(IVRT),YCG(IVRT)                           DM20 377
      GO TO 531                                                          DM20 378
  528 CONTINUE                                                           DM20 379
      NLST=NUMEXT+1                                                      DM20 380
      DO 650 ISEQ=1,NLST                                                 DM20 381
      IVRT=IVRT+1                                                        DM20 382
      ISEQP1=ISEQ+1                                                      DM20 383
      IF (ISEQ.EQ.NLST) GO TO 534                                        DM20 384
      DIFMAX=VALMAX(ISEQP1)-VALMAX(ISEQ)                                 DM20 385
      GAMMA(IVRT)=-(TWOB/2.0)*DIFMAX*SIGN                                DM20 386
      YCG(IVRT)= ((YMAX(ISEQP1)*VALMAX(ISEQP1)-YMAX(ISEQ)*VALMAX(ISEQ))  DM20 387
     1 /DIFMAX)-(VALNUM(ISEQP1)/DIFMAX)*SIGN                             DM20 388
      GO TO 533                                                          DM20 389
  534 GAMMA(IVRT)=(TWOB/2.0)*VALMAX(ISEQ)*SIGN                           DM20 390
      YCG(IVRT)=YMAX(ISEQ)+(VALINT/VALMAX(ISEQ))*SIGN                    DM20 391
  533 CONTINUE                                                           DM20 392
      WRITE (6,710) IVRT,GAMMA(IVRT),YCG(IVRT)                           DM20 393
  650 CONTINUE                                                           DM20 394
  531 CONTINUE                                                           DM20 395
C                                                                        DM20 396
C                                                                        DM20 397
      IF (MSWL.EQ.0) GO TO 549                                           DM20 398
      IF(IL.NE.0) GO TO 543                                              DM20 399
C                                                                        DM20 400
C     RE-ENTER ABOVE LOOP FOR LEFT HORIZONTAL WING                       DM20 401
C                                                                        DM20 402
      IL=1                                                               DM20 403
      KUL=MSWLP                                                          DM20 404
      JSTART=NBP+1                                                       DM20 405
      JEND=NHP                                                           DM20 406
      JTIP=NHP-MCW+1                                                     DM20 407
      TIPCHD=XLB(NHP)-XLF(JTIP)                                          DM20 408
      WRITE(6,721) ALW                                                   DM20 409
      WRITE (6,702)                                                      DM20 410
      WRITE(6,720)                                                       DM20 411
      ANGL=ANGLL                                                         DM20 412
      SINANG=SIN(ANGL)                                                   DM20 413
      COSANG=COS(ANGL)                                                   DM20 414
      NSPANP=NSPANP+MSWLP                                                DM20 415
      SIGN=-1.0                                                          DM20 416
      J=NRP+1                                                            DM20 417
      GO TO 540                                                          DM20 418
  543 IF(MSWU.EQ.0) GO TO 549                                            DM20 419
C                                                                        DM20 420
C     LOOP 546 IS FOR UPPER AND LOWER FINS                               DM20 421
C     HERE   IL=0....UPPER FIN                                           DM20 422
C            IL=1.....LOWER FIN                                          DM20 423
C                                                                        DM20 424
C                                                                        DM20 425
      BTW=1.0/B2V                                                        DM20 426
      TWOB=4.0*B2V                                                       DM20 427
      WRITE(6,721) AUW                                                   DM20 428
      WRITE (6,702)                                                      DM20 429
      WRITE(6,723)                                                       DM20 430
      KU=MSWUP                                                           DM20 431
      IL=0                                                               DM20 432
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      ANGL=ANGLU                                                        DM20 433
      SINANG=SIN(ANGL)                                                  DM20 434
      COSANG=COS(ANGL)                                                  DM20 435
      NSPANP=MSWUP+NSPANP                                               DM20 436
      SIGN=+1.0                                                         DM20 437
      J=NHP+1                                                           DM20 438
      JSTART=NHP+1                                                      DM20 439
      JEND=N3P                                                          DM20 440
      JTIP=N3P-NCW+1                                                    DM20 441
      TIPCHD=XRB(N3P)-XRF(JTIP)                                         DM20 442
  544 CONTINUE                                                          DM20 443
      CIRNET(NSPANP)=0.0                                                DM20 444
      I=0                                                               DM20 445
      SUMFX=0.0                                                         DM20 446
      SUMFZ1=0.0                                                        DM20 447
      SUMFZ2=0.0                                                        DM20 448
      SUMFT2=0.0                                                        DM20 449
      SLP(1)=0.0                                                        DM20 450
      DLT=0.0                                                           DM20 451
      VALINT=0.0                                                        DM20 452
      CSINT=0.0                                                         DM20 453
      CSMOM=0.0                                                         DM20 454
      NUMEXT=0                                                          DM20 455
      ISEQ=0                                                            DM20 456
      NOEXT=0                                                           DM20 457
      DO 546 K=2,KU                                                     DM20 458
      I=I+1                                                             DM20 459
      IFV=IFV+1                                                         DM20 460
      SCSMX=0.0                                                         DM20 461
      SCSMZ1=0.0                                                        DM20 462
      SCSMZ2=0.0                                                        DM20 463
      SUM1=0.0                                                          DM20 464
      SWPANG=ABS(ATAN(SWPPLE(J)))                                       DM20 465
      COSSWP=COS(SWPANG)                                                DM20 466
      PSIPLE=SWPANG*57.2957795                                          DM20 467
      SSLE=PSIMCH.GT.PSIPLE                                             DM20 468
      ZCHK=ZCPT(J)*COSALF+XBAR(J)*SINALF                                DM20 469
      IF (ANYMO  ) ZCHK=ZCPT(J)                                         DM20 470
      ZLOC=ZCHK*BTW                                                     DM20 471
      IP1=I+1                                                           DM20 472
      IF (IL.EQ.1) GO TO 560                                            DM20 473
      NFRST=MSWRP+MSWLP+1                                               DM20 474
      ISPN=IP1+MSWRP+MSWLP                                              DM20 475
      IC=I+MSWRP+MSWLP                                                  DM20 476
      XLE(IFV)=XLF(J)+(ZCPT(J)-ZLF(J))*SWPPLE(J)                        DM20 477
      GO TO 561                                                         DM20 478
  560 NFRST=MSWRP+MSWLP+MSWUP+1                                         DM20 479
      ISPN=IP1+MSWRP+MSWLP+MSWUP                                        DM20 480
      IC=I+MSWRP+MSWLP+MSWUP                                            DM20 481
      XLE(IFV)=XRF(J)+(ZCPT(J)-ZRF(J))*SWPPLE(J)                        DM20 482
  561 CONTINUE                                                          DM20 483
      CIRNET(ISPN)=0.0                                                  DM20 484
C                                                                       DM20 485
C  NOTE: IN PLANE FORCE FZ2 ACTS ON OUTBOARD AFT CORNER OF EACH PANEL   DM20 486
C                                                                       DM20 487
C  HERE: IL=0....UPPER FIN                                              DM20 488
C        IL=1....LOWER FIN                                              DM20 489
C                                                                       DM20 490
      DO 545 L=1,NCW                                                    DM20 491
      SUM1=SUM1+FN(J)                                                   DM20 492
      WIDI=1./WIDTH(J)                                                  DM20 493
      IF (I.NE.1) GO TO 212                                             DM20 494
      CIRNET(NFRST)=CIRNET(NFRST)-CIRC(J)*SIGN                          DM20 495
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  212 JADJ=J+NCW
      IF (K.EQ.KU) GO TO 216
      GO TO 217
  216 CIRNET(NSPANP)=CIRNET(NSPANP)+CIRC(J)*SIGN
      GO TO 213
  217 CIRNET(ISPN)=CIRNET(ISPN)+(CIRC(J)-CIRC(JADJ))*SIGN
  213 CONTINUE
      IF (NDRAG.EQ.0) GO TO 317
      IF (IL.EQ.1) GO TO 340
      CHORDS(J)=XRB(J)-XRF(J)
      GO TO 341
  340 CHORDS(J)=XLB(J)-XLF(J)
  341 CONTINUE
      IF (L.EQ.NCW) CHORDS(J)=0.5*CHORDS(J)
      FZ2(J)=2.0*CHORDS(J)*CIRNET(ISPN)*(SINANG-VNORMS(J))
      IF (FX(J).LT.0.0.OR.SSLE) GO TO 342
      SCSMX=SCSMX+FX(J)
      SCSMZ1=SCSMZ1+FZ(J)
  342 CONTINUE
      IF (K.EQ.KUL) GO TO 316
      SCSMZ2=SCSMZ2+FZ2(J)
      GO TO 317
  316 FT2(L)=FZ2(J)
      SUMFT2=SUMFT2+FT2(L)
  317 CONTINUE
  545 J=J+1
      DELZ=WIDTH(J-1)
      SUMFX=SUMFX+SCSMX
      SUMFZ1=SUMFZ1+SCSMZ1
      SUMFZ2=SUMFZ2+SCSMZ2
C
      FACTOR=WIDI*CFC
      SLOAD(I)=SUM1*FACTOR
      VALINT=VALINT+(SLOAD(I)*DELZ)
      IF (NDRAG.NE.0) GO TO 563
      WRITE (6,704) IC,ZLOC,SLOAD(I),CIRNET(IC)
      IF (K.NE.KU) GO TO 546
      ZLOC=((B2V+RA)/B2V)*SIGN
      SLDTIP=0.0
      WRITE (6,704) NSPANP,ZLOC,SLOAD(I),CIRNET(NSPANP)
      GO TO 546
  563 CONTINUE
      IF (SSLE) GO TO 851
      SECFXX=SCSMX*FACTOR
      SECFZ=SCSMZ1*FACTOR
      SECFZ2=(SCSMZ2+SCSMZ1)*FACTOR
      SECSUC=SECFXX/COSSWP
      CSINT=CSINT+(SECSUC*DELZ)
      CSMOM=CSMOM+ABS(ZCHK*SECSUC*DELZ)
      CGLOC(IFV)=(CSMOM/CSINT)*SIGN
      ZEXP=CGLOC(IFV)-(RA*SIGN)
      GAMLE(IFV)=FKLE*((CSINT*TWOB)/(2.0*ZEXP))*COSANG
      GO TO 852
  851 SECFXX=0.0
      SECFZ=0.0
      SECFZ2=SCSMZ2*FACTOR
      SECSUC=0.0
      CGLOC(IFV)=0.0
      GAMLE(IFV)=0.0
  852 CONTINUE
      WRITE (6,703) IC,ZLOC,SLOAD(I),SECFXX,SECFZ,SECFZ2,SECSUC,CSINT,
     1 CGLOC(IFV),CIRNET(IC ),GAMLE(IFV),XLE(IFV)
      IF (K.NE.KUL) GO TO 564
```

```
      ZLOC=((B2V+RA)/B2)*SIGN                                           DM20 559
      SLDTIP=0.0                                                        DM20 560
      WRITE (6,704) NSPANP,ZLOC,SLDTIP,CIRNET(NSPANP)                   DM20 561
  564 CONTINUE                                                          DM20 562
      IF (I.EQ.1) GO TO 845                                             DM20 563
      IM1=I-1                                                           DM20 564
      DLT=ABS(ZCHK-ZCHKBF)                                              DM20 565
      SLP(I) =(SLOAD(I)-SLOAD(IM1))/DLT                                 DM20 566
      REFSLP=ABS(SLOAD(1)/(10.0*B2V))                                   DM20 567
      IF (ABS(SLP(I)).LE.REFSLP) SLP(I)=0.0                             DM20 568
      IF (I.EQ.2) GO TO 846                                             DM20 569
      IF (K.EQ.KU) GO TO 821                                            DM20 570
      GO TO 822                                                         DM20 571
  821 SLP(NSPANP)=-SLOAD(I)/(DLT/2.0)                                   DM20 572
      IF (ABS(SLP(NSPANP)).LE.REFSLP) GO TO 846                         DM20 573
      SLPCHK=SLP(I)                                                     DM20 574
      IF (SLPCHK.EQ.0.0) SLPCHK=SLP(I-1)                                DM20 575
      IF (SLPCHK.GT.0.0.AND.SLP(NSPANP).LT.0.0) GO TO 843               DM20 576
      IF (SLPCHK.LT.0.0.AND.SLP(NSPANP).GT.0.0) GO TO 843               DM20 577
  822 CONTINUE                                                          DM20 578
      IF (SLP(I).EQ.0.0) GO TO 846                                      DM20 579
      IF (SLPBF.EQ.0.0.AND.I.GE.4) SLPBF=SLP(I-2)                       DM20 580
      IF (SLPBF.GT.0.0.AND.SLP(I).LT.0.0) GO TO 843                     DM20 581
      IF (SLPBF.LT.0.0.AND.SLP(I).GT.0.0) GO TO 843                     DM20 582
      GO TO 846                                                         DM20 583
  843 NUMEXT=NUMEXT+1                                                   DM20 584
      ISEQ=NUMEXT+1                                                     DM20 585
      VALMAX(1)=SLOAD(1)                                                DM20 586
      ZMAX(1)=RA*SIGN                                                   DM20 587
      VALMAX(ISEQ)=SLOAD(IM1)                                           DM20 588
      ZMAX(ISEQ)=ZCHKBF                                                 DM20 589
      IF (IL.EQ.0) ZOUTSD=ZRB(J-1-NCW)                                  DM20 590
      IF (IL.EQ.1) ZOUTSD=ZLB(J-1-NCW)                                  DM20 591
      RSINT=SLOAD(IM1)*(ZOUTSD-ZMAX(ISEQ))*SIGN                         DM20 592
      VALINT=RSINT+(SLOAD(I)*DELZ)                                      DM20 593
      VALNUM(ISEQ)=VLINBF-RSINT                                         DM20 594
  846 SLPBF=SLP(I)                                                      DM20 595
  845 ZCHKBF=ZCHK                                                       DM20 596
      VLINBF=VALINT                                                     DM20 597
      IF (K.EQ.KU.AND.NUMEXT.EQ.0) GO TO 826                            DM20 598
      GO TO 827                                                         DM20 599
  826 VALMAX(1)=SLOAD(1)                                                DM20 600
      ZMAX(1)=ZCHK                                                      DM20 601
      VALNUM(1)=VALINT                                                  DM20 602
      NOEXT=1                                                           DM20 603
  827 CONTINUE                                                          DM20 604
      IF (I.EQ.1.AND.NOUT.NE.0) WRITE (6,743)                           DM20 605
      IF (NOUT.NE.0) WRITE (6,735) I,DLT,SLP(I),ISEQ,ZCHK,VALINT,NUMEXT,DM20 606
     1 VALMAX(ISEQ),VALNUM(ISEQ),ZMAX(ISEQ)                             DM20 607
      IF (NOUT.NE.0.AND.K.EQ.KU ) WRITE (6,735) IP1,   DLT,SLP(NSPANP), DM20 608
     1 ISEQ,ZCHK,VALINT,NUMEXT,VALMAX(ISEQ),VALNUM(ISEQ),ZMAX(ISEQ)     DM20 609
  546 CONTINUE                                                          DM20 610
C                                                                       DM20 611
      SUMFX=SUMFX/SREF                                                  DM20 612
      SUMFZ1=SUMFZ1/SREF                                                DM20 613
      SUMFZ2=SUMFZ2/SREF                                                DM20 614
      SUMFT2=SUMFT2/SREF                                                DM20 615
      WRITE (6,731) SUMFX,SUMFZ1,SUMFZ2,SUMFT2                          DM20 616
C                                                                       DM20 617
C                                                                       DM20 618
C     SIDE FORCE PER UNIT TIPCHORD/(Q*C)                                DM20 619
C                                                                       DM20 620
      IF (NDRAG.EQ.0) GO TO 400                                         DM20 621
```

```
      IF (TIPCHD.LT.100.0*TLRNC) GO TO 400
      TIPEPL=TIPCHD/NCW
      DENOM=TIPCHD*TIPEPL
      WRITE (6,707)
      FACTRK= 1.0/(FKLE*TWOP)
      FACTRI=1.0/FACTRK
      DO 414 JTIP=1,NCW
      AJTIP=JTIP
      XLOC=AJTIP*TIPEPL
      XLOCOC=XLOC/TIPCHD
      FT=FT2(JTIP)/DENUM
      JSE=JSE+1
      IF (IL.EQ.1) GO TO 920
      J=N3P-NCW+JTIP
      XSE(JSE)=XRF(J)
      GO TO 921
  920 J=NPANLS-NCW+JTIP
      XSE(JSE)=XLF(J)
  921 CSMOM=CSMOM+ABS((RA+B2)*FACTRK*FT2(JTIP)*FKSE)
      CSINT=CSINT+ABS(FACTRK*FT2(JTIP)*FKSE)
      CGSELC(JSE)=(CSMOM/CSINT)*SIGN
      ZEXP=CGSELC(JSE)-(RA*SIGN)
      GAMSE(JSE)=((CSINT*FACTRI)/(2.0*ZEXP))*COSANG
  414 WRITE (6,709) JTIP,JSE,XLOCOC,FT,GAMSE(JSE),CGSELC(JSE),XSE(JSE)
  400 CONTINUE
C
C     PRINT INDIVIDUAL PANEL FORCES
C
      IF (NOUT.EQ.0) GO TO 448
      WRITE (6,739)
      DO 450 J=JSTART,JEND
  450 WRITE (6,706) J,ZCPT(J),DLTPG(J),CIRC(J),FX(J),FZ(J),FZ2(J)
  448 CONTINUE
C
C     FIN TRAILING EDGE VORTICES CALCULATED NEXT.
C     GAMMA.....GAMMA/VINF,POSITIVE COUNTERCLOCKWISE.
C     ZCG.......ZBAR,MEASURED FROM BODY CENTERLINE.
C
      IF (NDRAG.EQ.0) GO TO 631
      WRITE (6,736)
      WRITE (6,742)
      IF (NOEXT.EQ.0) GO TO 628
      IVRT=IVRT+1
      GAMMA(IVRT)= (SLOAD(1)*TWOB/2.0)*SIGN
      ZCG(IVRT)=(RA+(VALNUM(1)/SLOAD(1)))*SIGN
      WRITE (6,710) IVRT,GAMMA(IVRT),ZCG(IVRT)
      GO TO 631
  628 CONTINUE
      NLST=NUMEXT+1
      DO 651 ISEQ=1,NLST
      IVRT=IVRT+1
      ISEQP1=ISEQ+1
      IF (ISEQ.EQ.NLST) GO TO 634
      DIFMAX=VALMAX(ISEQP1)-VALMAX(ISEQ)
      GAMMA(IVRT)=-(TWOB/2.0)*DIFMAX*SIGN
      ZCG(IVRT)= ((ZMAX(ISEQP1)*VALMAX(ISEQP1)-ZMAX(ISEQ)*VALMAX(ISEQ))
     1 /DIFMAX)-(VALNUM(ISEQP1)/DIFMAX)*SIGN
      GO TO 633
  634 GAMMA(IVRT)=(TWOB/2.0)*VALMAX(ISEQ)*SIGN
      ZCG(IVRT)=ZMAX(ISEQ)+(ABS(VALINT/VALMAX(ISEQ)))*SIGN
  633 CONTINUE
      WRITE (6,710) IVRT,GAMMA(IVRT),ZCG(IVRT)
  651 CONTINUE
```

```
  631 CONTINUE                                                          DM20 685
C                                                                       DM20 686
C                                                                       DM20 687
C     RE-ENTER ABOVE LOOP FOR LOWER WING                                DM20 688
C                                                                       DM20 689
      IF(IL.NE.0) GO TO 549                                             DM20 690
      WRITE(6,721) ADW                                                  DM20 691
      WRITE (6,702)                                                     DM20 692
      WRITE(6,723)                                                      DM20 693
      IL=1                                                              DM20 694
      KU=MSWD+1                                                         DM20 695
      JSTART=N3P+1                                                      DM20 696
      JEND=NPANLS                                                       DM20 697
      ANGL=ANGLD                                                        DM20 698
      SINANG=SIN(ANGL)                                                  DM20 699
      NSPANP=NSPANP+MSWDP                                               DM20 700
      SIGN=-1.0                                                         DM20 701
      J=N3P+1                                                           DM20 702
      JTIP=NPANLS-NCW+1                                                 DM20 703
      TIPCHD=XLR(NPANLS)-XLF(JTIP)                                      DM20 704
      GO TO 544                                                         DM20 705
  549 CONTINUE                                                          DM20 706
C                                                                       DM20 707
C                                                                       DM20 708
      RETURN                                                            DM20 709
      END                                                               DM20 710
```

```
      SUBROUTINE THETIN(MSW,MT)                                         DM21   1
C                                                                       DM21   2
C     VERSION: DEMON1                                                   DM21   3
C                                                                       DM21   4
C     THIS ROUTINE READS THICKNESS SLOPES FOR AN ARBITRARY WING.         DM21   5
C                                                                       DM21   6
      COMMON/THKDAT/NTDAT,NCWT,NTPR,MSWT(4),NRPT,NHPT,N3PT,NTHP,ASYMT,  DM21   7
     1       NVERT,SWLET(20,4),SWTET(20,4),YTH(20,4),THETAL(400)        DM21   8
      COMMON/THTAS/NUNIS,THET(400)                                      DM21   9
C                                                                       DM21  10
  500 FORMAT(8F10.0)                                                    DM21  11
C                                                                       DM21  12
      MT=NCWT*MSW                                                       DM21  13
      IF(NUNIS.NE.0) GO TO 5                                            DM21  14
      MN=0                                                              DM21  15
      DO 1 JNW=1,MT,NCWT                                                DM21  16
      MN=MN+NCWT                                                        DM21  17
    1 READ(5,500) (THET(J),J=JNW,MN)                                    DM21  18
      RETURN                                                            DM21  19
    5 READ(5,500) (THET(J),J=1,NCWT)                                    DM21  20
      DO 6 J=2,MSW                                                      DM21  21
      JJ=(J-1)*NCWT                                                     DM21  22
      DO 6 K=1,NCWT                                                     DM21  23
      KK=JJ+K                                                           DM21  24
    6 THET(KK)=THET(K)                                                  DM21  25
      RETURN                                                            DM21  26
      END                                                               DM21  27
```

```
      SUBROUTINE THKIN
C
C     VERSION: DEMON1
C
C     SUBROUTINE TO INPUT THICKNESS DATA.
C
      LOGICAL ASYMT
      COMMON/THKDAT/NTDAT,NCWT,NTPP,MSWT(4),NRPT,NHPT,N3PT,NTHP,ASYMT,
     1       NVERT,SWLET(20,4),SWTET(20,4),YTH(20,4),THETAL(400)
      COMMON/TSPANS/SPANR,SPANL,SPANU,SPAND,SWPLER,SWPLEL,SWPLEU,
     1       SWPLED,SWPTER,SWPTEL,SWPTEU,SWPTED,RBOD
      COMMON/THTAS/NUNIS,THET(400)
C
  500 FORMAT(10I5)
  510 FORMAT(3F10.0)
C
C
C     INITIALIZE INDICES
C
      NLP=0
      NUP=0
      NDP=0
C
C           INPUT RIGHT WING DATA.
C
      READ(5,500) MSWT(1),LVSWT,NUNIS
      MSWP=MSWT(1)+1
C
C           IF SIDESLIP IS NON-ZERO OR IF LVSWT=0, SPANWISE SPACINGS
C           ARE NOT READ IN.  THEY MUST BE CALCULATED AND EQUALLY
C           SPACED.  NO BREAKS IN SWEEP ARE ALLOWED.
C
      IF(ASYMT.OR.LVSWT.EQ.0) GO TO 5
      READ(5,510) (YTH(I,1),SWLET(I,1),SWTET(I,1),I=1,MSWP)
      GO TO 10
    5 CALL EDGES(MSWP,SPANR,RBOD,SWPLER,SWPTER,YTH(1,1),SWLET(1,1),
     1           SWTET(1,1))
   10 CONTINUE
C
C           SUBROUTINE THETIN READS THICKNESS SLOPES.
C
      CALL THETIN(MSWT(1),NRPT)
      DO 15 I=1,NRPT
   15 THETAL(I)=THET(I)
      IF(NTDAT.EQ.1) GO TO 40
C
C           INPUT LEFT WING DATA IF SIDESLIP IS NON-ZERO, WING ALONE.
C
      IF(.NOT.ASYMT) GO TO 25
      READ(5,500) MSWT(2),LVSWT,NUNIS
      MSWP=MSWT(2)+1
      CALL EDGES(MSWP,-SPANL,-RBOD,-SWPLEL,-SWPTEL,YTH(1,2),
     1           SWLET(1,2),SWTET(1,2))
      CALL THETIN(MSWT(2),NLP)
      DO 20 I=1,NLP
   20 THETAL(I+NRPT)=THET(I)
C
C     INPUT UPPER WING DATA IF VERTICAL WINGS ARE PRESENT
C          AND THEIR GEOMETRY IS DIFFERENT FROM HORIZONTAL WINGS.
C          NOTE THAT NTDAT IS NOW NE 1.
C
   25 CONTINUE
      IF(NVERT.EQ.0) GO TO 50
      READ(5,500) MSWT(3),LVSWT,NUNIS
```

```
      MSWP=MSWT(3)+1
      IF(ASYMT.OR.LVSWT.EQ.0) GO TO 27
      READ(5,510) (YTH(I,3),SWLET(I,3),SWTET(I,3),I=1,MSWP)
      GO TO 28
   27 CALL EDGES(MSWP,SPANU,RHOD,SWPLEU,SWPTEU,YTH(1,3),SWLET(1,3),
     1           SWTET(1,3))
   28 CONTINUE
      CALL THETIN(MSWT(3),NUP)
      DO 30 I=1,NUP
   30 THETAL(NRPT+NLP+I)=THET(I)
C
C           INPUT LOWER WING DATA IF SIDESLIP IS NON-ZERO, WING ALONE.
C
      IF(.NOT.ASYMT) GO TO 50
      READ(5,500) MSWT(4),LVSWT,NUNIS
      MSWP=MSWT(4)+1
      CALL EDGES(MSWP,-SPAND,-RHOD,-SWPLED,-SWPTED,YTH(1,4),SWLET(1,4),
     1           SWTET(1,4))
      CALL THETIN(MSWT(4),NDP)
      DO 35 I=1,NDP
   35 THETAL(NRPT+NLP+NUP+I)=THET(I)
      GO TO 50
C
C     ALL DATA INPUT AT THIS POINT.
C
C           SET UPPER WING EQUAL TO RIGHT WING IN SYMMETRIC
C           CASE (NTDAT=1 AND NVERT NE 0)
C
   40 CONTINUE
      IF(NVERT.EQ.0) GO TO 50
      MSWT(3)=MSWT(1)
      MSWP=MSWT(1)+1
      DO 45 I=1,MSWP
      YTH(I,3)=YTH(I,1)
      SWLET(I,3)=SWLET(I,1)
   45 SWTET(I,3)=SWTET(I,1)
      NUP=NRPT
      DO 46 I=1,NRPT
   46 THETAL(NRPT+I)=THETAL(I)
C
C     CALCULATE INDICES.
C
   50 CONTINUE
      NHPT=NRPT+NLP
      N3PT=NHPT+NUP
      NTHP=N3PT+NDP
C
      RETURN
      END
```

```
      SUBROUTINE THKLYT(CRP,IL)
C
C     VERSION: DEMON1
C
C     THIS ROUTINE LAYS OUT SOURCE PANELS ON A SINGLE WING SURFACE.
C
      DIMENSION NDP(3)
C
      COMMON/ONE/CIRC(250),DELTP(250),FN(250),PNLC(250),SWPPLE(250),
     1SWPPTE(250),VNOR(250),XBAR(250),ZBAR(250),XCPT(250),YCPT(250),ZCPT
```

```
     2(250),XLF(250),XLB(250),XRF(250),XRB(250),YLC(250),YRC(250),ZLF(250
     30),ZRF(250),ZLB(250),ZRB(250),SNT(125),CST(125),SNT2(125),CST2(1250
     4),IP(300),XFBIP(100),A,ALFA,ALFR,ARWING,B2,B2V,BETA,BETAR,CONST,
     5COSALF,COSBET,CN,DX,EM,FMACH,RB,SINALF,SINBET,SLOPE,TLRNC,TIPY,
     6TOTLR,U,V,W,UCHK,VCHK,WCHK,WBIP,X,DUMY,Z,I,IF,II,J,MSWR,MSWL,MSWU,
     7MSWD,NBIP,NCRX,NCW,NDRAG,NHP,NPR,NRP,N3P,NOCPT,NOLINP,NOUT,NPANLS,
     8NPRESS,NWAP,ASYM,BODY,DELTA,NOSYM
      COMMON/THKDAT/NTDAT,NCWT,NTPR,MSWT(4),NRPT,NHPT,N3PT,NTHP,ASYMT,
     1        NVERT,SWLET(20,4),SWTET(20,4),YTH(20,4),THETAL(400)
      COMMON/THKPAN/XRFT(400),XLFT(400),XRBT(400),XLBT(400),
     1        YRCT(400),YLCT(400),ZRFT(400),ZLFT(400),ZRBT(400),
     2        ZLBT(400),SLLET(400),SLTET(400)
      LOGICAL LEFT
      DATA DTOR/.0174532925/
C
C     FORMAT STATEMENTS
C
  700 FORMAT(1H1,50X,40HPANEL CORNER COORDINATES FOR WING PANELS)
  705 FORMAT(//5X,1HJ,15X,2HLF,15X,1H*,12X,2HLB,15X,1H*,12X,2HRF,15X,
     1        1H*,12X,2HRB/12X,1HX,9X,1HY,9X,1HZ,5X,1H*,3X,1HX,9X,1HY,
     2        9X,1HZ,5X,1H*,3X,1HX,9X,1HY,9X,1HZ,5X,1H*,3X,1HX,9X,1HY,
     3        9X,1HZ,/38X,1H*,29X,1H*,29X,1H*/130(1H*)/
     4        38X,1H*,29X,1H*,29X,1H*)
  710 FORMAT(/1X,56(1H=),17HRIGHT WING PANELS,57(1H=)/)
  711 FORMAT(/1X,57(1H=),16HLEFT WING PANELS,57(1H=)/)
  712 FORMAT(/1X,56(1H=),17HUPPER WING PANELS,57(1H=)/)
  713 FORMAT(/1X,56(1H=),17HLOWER WING PANELS,57(1H=)/)
  720 FORMAT(3X,I3,3X,F9.4,1X,F9.4,1X,F9.4,1H*,F9.4,1X,F9.4,1X,F9.4,
     1        1H*,F9.4,1X,F9.4,1X,F9.4,1H*,F9.4,1X,F9.4,1X,F9.4)
C
C     VERTICAL WING COORDINATES ARE CALCULATED IN THE SAME WAY
C           AS HORIZONTAL COORDINATES.  Y AND Z COORDINATES ARE
C           THEN INTERCHANGED FOR VERTICAL WING.
C           LEFT STANDS FOR EITHER LEFT HORIZONTAL WING
C           OR LOWER VERTICAL WING.
C
      LEFT=IL.EQ.1.OR.IL.EQ.3
      NS=IL+1
      NDP(1)=NRPT
      NDP(2)=NHPT
      NDP(3)=N3PT
      MSWP=MSWT(NS)+1
C
C     SET CONSTANT SWEEP INDICATOR.
C
      LVSWT=0
      IF(MSWP.EQ.2) GO TO 15
      DO 10 I=3,MSWP
      IM=I-1
   10 IF(SWLET(I,NS).NE.SWLET(IM,NS).OR.SWTET(I,NS).NE.SWTET(IM,NS))
     1       LVSWT=1
   15 SLPWLE=TAN(SWLET(MSWP,NS)*DTOR)
      SLPWTE=TAN(SWTET(MSWP,NS)*DTOR)
      CSIDEP=CRP
      ANCW=NCWT
      WLEX=0.0
C
C     LAY OUT PANELS.  INDEX I RUNS SPANWISE, K CHORDWISE.
C
C           CALCULATE OUTBOARD SIDE EDGE FOR A CHORDWISE ROW.
C
      DO 60 I=2,MSWP
      IM=I-1
      IF(LVSWT.EQ.0) GO TO 20
```

```
      SLPWLE=TAN(SWLET(I,NS)*DTOR)
      SLPWTE=TAN(SWTET(I,NS)*DTOR)
   20 SLPDIF=SLPWLE-SLPWTE
      CSIDE=CSIDEP-(YTH(I,NS)-YTH(IM,NS))*SLPDIF
      IF(I.EQ.2) GO TO 30
      JLE=(I-3)*NCWT+1
      IF(NS.GT.1) JLE=JLE+NDP(NS-1)
      WLEX=XRFT(JLE)
      IF(LEFT) WLEX=XLFT(JLE)
   30 CONTINUE
C
C     CALCULATE PANEL LEADING AND TRAILING EDGE
C          SLOPES AND CORNER COORDINATES.
C
      DO 50 K=1,NCWT
      J=(I-2)*NCWT+K
      IF(NS.GT.1) J=J+NDP(NS-1)
      AKM=K-1
      AK=K
      SLLET(J)=SLPWLE-AKM*SLPDIF/ANCW
      SLTET(J)=SLPWLE-AK*SLPDIF/ANCW
      IF (ABS(SLLET(J)).LE.0.001) SLLET(J)=0.0
      IF (ABS(SLTET(J)).LE.0.001) SLTET(J)=0.0
      XLFT(J)=AKM*CSIDEP/ANCW+WLEX
      XLBT(J)=XLFT(J)+CSIDEP/ANCW
      XRFT(J)=AKM*CSIDE/ANCW+(YTH(I,NS)-YTH(IM,NS))*SLPWLE+WLEX
      XRBT(J)=XRFT(J)+CSIDE/ANCW
      YLCT(J)=YTH(IM,NS)
      YRCT(J)=YTH(I,NS)
      IF(.NOT.LEFT) GO TO 40
C
C     INTERCHANGE LEFT AND RIGHT COORDINATES FOR LEFT WING.
C
      TEMP=XLFT(J)
      XLFT(J)=XRFT(J)
      XRFT(J)=TEMP
      TEMP=XLBT(J)
      XLBT(J)=XRBT(J)
      XRBT(J)=TEMP
      TEMP=YLCT(J)
      YLCT(J)=YRCT(J)
      YRCT(J)=TEMP
      IF (SLLET(J).EQ.0.0) SLLET(J)=-TLRNC
      IF (SLTET(J).EQ.0.0) SLTET(J)=-TLRNC
C
   40 CONTINUE
      ZLFT(J)=0.0
      ZRFT(J)=0.0
      ZLBT(J)=0.0
      ZRBT(J)=0.0
C
C     INTERCHANGE Y AND Z COORDINATES FOR VERTICAL PANELS.
C
      IF(NS.LE.2) GO TO 50
      ZLFT(J)=YLCT(J)
      ZLBT(J)=YLCT(J)
      YLCT(J)=0.0
      ZRFT(J)=YRCT(J)
      ZRBT(J)=YRCT(J)
      YRCT(J)=0.0
C
   50 CONTINUE
      CSIDEP=CSIDE
```

```
   60 CONTINUE
C
C     DEBUG PRINT OF PANEL CORNER COORDINATES.
C
      IF(NTPR.EQ.0) RETURN
      IF(IL.GT.0) GO TO 70
      WRITE(6,700)
      WRITE(6,705)
      WRITE(6,710)
      NI=1
      NF=NRPT
      GO TO 90
   70 IF(IL.GT.1) GO TO 75
      WRITE(6,711)
      NI=NRPT+1
      NF=NHPT
      GO TO 90
   75 IF(IL.EQ.3) GO TO 80
      WRITE(6,712)
      NI=NHPT+1
      NF=N3PT
      GO TO 90
   80 WRITE(6,713)
      NI=N3PT+1
      NF=NTHP
   90 WRITE(6,720) (J,XLFT(J),YLCT(J),ZLFT(J),XLBT(J),YLCT(J),ZLBT(J),
     1      XRFT(J),YRCT(J),ZRFT(J),XRBT(J),YRCT(J),ZRBT(J),J=NI,NF)
C
      RETURN
      END
```

```
      SUBROUTINE THKOUT
C
C     VERSION: DEMON1
C
C     THIS ROUTINE PRINTS OUT THICKNESS DATA.  AFTER THE
C          THICKNESS SLOPES ARE PRINTED, THEY ARE DIVIDED BY PI.
C
      LOGICAL ASYMT
      COMMON/THKDAT/NTDAT,NCHT,NTPR,MSWT(4),NRPT,NHPT,N3PT,NTHP,ASYMT,
     1      NVERT,SWLET(20,4),SWTET(20,4),YTH(20,4),THETAL(400)
      DATA PI/3.141592654/
C
  600 FORMAT(1H1,30X,56HINPUT VALUES OF THE LOCAL SURFACE SLOPE OF THE T
     1HICKNESS/32X,52HDISTRIBUTION. FOR EACH CHORDWISE ROW THE FIRST VAL
     2UE/37X,41HIS FOR THE PANEL NEAREST THE LEADING EDGE)
  610 FORMAT( //5X,18HRIGHT WING SURFACE/)
  620 FORMAT( //5X,17HLEFT WING SURFACE/)
  630 FORMAT( //5X,18HUPPER WING SURFACE/)
  640 FORMAT( //5X,18HLOWER WING SURFACE/)
  650 FORMAT(11X,3HROW,30X,6HSLOPES)
  660 FORMAT(8X,I5,4X,(/1H+,27X,8F10.5))
  670 FORMAT(1H1,26H WING THICKNESS INPUT DATA///15X,
     1      55HSPANWISE LOCATIONS OF PANEL SIDE EDGES AND SWEEP ANGLES/
     2      20X,27HOF WING SECTION TO THE LEFT.//26X,
     3      29HSPANWISE   LE SWEEP  TE SWEEP/20X,1HI,5X,8HLOCATION/
     4      28X,4HFEET,5X,7HDEGREES,3X,7HDEGREES)
  675 FORMAT(18X,I3,4X,3F10.5)
  680 FORMAT(/16X,I3,36H THICKNESS PANELS ARE TO BE LAID OUT/16X,I3,
     1      20H CHORDWISE ROWS WITH,I3,12H IN EACH ROW)
```

```
C
C     ---------- OUTPUT THICKNESS PANEL GEOMETRY ----------
C
C     HEADING AND RIGHT WING DATA
C
      WRITE(6,670)
      WRITE(6,610)
      NSP=MSWT(1)+1
      WRITE(6,675) (I,YTH(I,1),SWLET(I,1),SWTET(I,1),I=1,NSP)
      WRITE(6,680) NRPT,MSWT(1),NCWT
C
C     LEFT WING DATA IF NON-ZERO SIDESLIP AND WING ALONE.
C
      IF(.NOT.ASYMT) GO TO 2
      WRITE(6,620)
      NSP=MSWT(2)+1
      WRITE(6,675) (I,YTH(I,2),SWLET(I,2),SWTET(I,2),I=1,NSP)
      NLFT=NHPT-NRPT
      WRITE(6,680) NLFT,MSWT(2),NCWT
C
C     UPPER WING DATA IF VERTICAL WINGS PRESENT
C
    2 CONTINUE
      IF(NVERT.EQ.0) GO TO 4
      WRITE(6,630)
      NSP=MSWT(3)+1
      WRITE(6,675) (I,YTH(I,3),SWLET(I,3),SWTET(I,3),I=1,NSP)
      NUPP=N3PT-NHPT
      WRITE(6,680) NUPP,MSWT(3),NCWT
C
C     LOWER WING DATA IF NON-ZERO SIDESLIP AND WING ALONE.
C
      IF(.NOT.ASYMT) GO TO 4
      WRITE(6,640)
      NSP=MSWT(4)+1
      WRITE(6,675) (I,YTH(I,4),SWLET(I,4),SWTET(I,4),I=1,NSP)
      NDP=NTHP-N3PT
      WRITE(6,680) NDP,MSWT(4),NCWT
C
C     ---------- OUTPUT THICKNESS SLOPES ----------
C
    4 CONTINUE
C
C     HEADING AND RIGHT WING DATA
C
      WRITE(6,600)
      WRITE(6,610)
      WRITE(6,650)
      MN=0
      I=0
      DO 5 JNW=1,NRPT,NCWT
      MN=MN+NCWT
      I=I+1
      WRITE(6,660) I,(THETAL(J),J=JNW,MN)
    5 CONTINUE
C
C     LEFT WING DATA IF NON-ZERO SIDESLIP AND WING ALONE
C
      IF(.NOT.ASYMT) GO TO 20
      WRITE(6,620)
      WRITE(6,650)
      I=0
      NRPP=NRPT+1
```

```
      DO 10 JNW=NRPP,NHPT,NCWT
      MN=MN+NCWT
      I=I+1
      WRITE(6,660) I,(THETAL(J),J=JNW,MN)
   10 CONTINUE
C
C     UPPER WING DATA IF VERTICAL WINGS PRESENT
C
   20 CONTINUE
      IF(NVERT.EQ.0) GO TO 40
      WRITE(6,630)
      WRITE(6,650)
      I=0
      NHPP=NHPT+1
      DO 25 JNW=NHPP,N3PT,NCWT
      MN=MN+NCWT
      I=I+1
      WRITE(6,660) I,(THETAL(J),J=JNW,MN)
   25 CONTINUE
C
C     LOWER WING DATA IF NON-ZERO SIDESLIP AND WING ALONE.
C
      IF(.NOT. ASYMT) GO TO 40
      WRITE(6,640)
      WRITE(6,650)
      I=0
      N3PP=N3PT+1
      DO 30 JNW=N3PP,NTHP,NCWT
      MN=MN+NCWT
      I=I+1
      WRITE(6,660) I,(THETAL(J),J=JNW,MN)
   30 CONTINUE
C
C     DIVIDE INPUT SLOPES BY PI
C
   40 CONTINUE
      DO 45 J=1,NTHP
   45 THETAL(J)=THETAL(J)/PI
C
      RETURN
      END
```

```
      SUBROUTINE THKVEL(XX,YY,ZZ)
C
C
C     VERSION: DEMON1
C
C     THIS SUBROUTINE CALCULATES PERTURBATION VELOCITIES INDUCED BY
C     THE WING THICKNESS PANELS.
C     SUPERPOSITION OF 4 CORNER SOLUTIONS IS USED.
C     THKVEL RETURNS VELOCITIES UTH,VTH,WTH IN WING
C     REFERENCE FRAME.
C
      LOGICAL NOPR,SDSLIP,VERPNL
C
      COMMON/THKDAT/NTDAT,NCWT,NTPR,NSWT(4),NRPT,NHPT,N3PT,NTHP,SDSLIP,
     1      NVERT,SWLET(20,4),SWTET(20,4),YTH(20,4),THETAL(400)
      COMMON/THKPAN/XRFT(400),XLFT(400),XRBT(400),XLBT(400),
     1      YRCT(400),YLCT(400),ZRFT(400),ZLFT(400),ZRBT(400),
     2      ZLBT(400),SLLET(400),SLTET(400)
```

```
      COMMON/ICVEL/UPT,VPT,WPT,IIT,IFT,MJ
      COMMON/THVARG/X,Y,Z,U,V,W,EM ,VERPNL,NOPR
C
    1 FORMAT(5X,5HPANEL,I4,6X,6HCORNER,I2,
     1                        6X,4HC.P.,I5,3X,4HX = ,E12.5,3X,4HY = ,E12.5
     1 ,3X,4HZ = E12.5/6X,4HU = ,E12.5,6X,4HV = ,E12.5,6X,4HW = ,E12.5/
     2  5X,5HTU = ,E12.5,5X,5HTV = ,E12.5,5X,5HTW = ,E12.5)
    2 FORMAT(///6H UPT =,E12.5,5X,5HVTP =,E12.5,5X,5HWPT =,E12.5)
C
      NOPR=NTPR.NE.0
C
      UPT=0.0
      VPT=0.0
      WPT=0.0
      XI=XX
      YI=YY
      ZI=ZZ
C
C     I IS INDEX OF INFLUENCING PANEL
C
      DO 100 I=IIT,IFT
      VERPNL=I.GT.NHPT
      MI=I
      TU=0.
      TV=0.
      TW=0.
      EM1=SLLET(I)
      EM2=SLTET(I)
C
C********************  CORNER 1  ***************************************
C
C
      IF(EM1.LT.0.0) GO TO 15
      EM=EM1
      X=XI-XLFT(I)
      Y=YI-YLCT(I)
      Z=ZI-ZLFT(I)
      CALL VELOTH
      TU=TU+U
      TV=TV+V
      TW=TW+W
      ICNR=1
      MNJ=MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(SDSLIP) GO TO 10
      IF (VERPNL) GO TO 31
      Y=-(YI+YLCT(I))
      CALL VELOTH
      TU=TU+U
      TV=TV-V
      TW=TW+W
      GO TO 32
   31 Z=-(ZI+ZLFT(I))
      CALL VELOTH
      TU=TU+U
      TV=TV+V
      TW=TW-W
   32 CONTINUE
      MNJ=-MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      GO TO 10
C
C     CORNER 1 FOR M .LT.0.0
```

```
C
   15 CONTINUE
      EM=-EM1
      X=XI-XLFT(I)
      Y=YLCT(I)-YI
      Z=ZI-ZLFT(I)
      IF(VERPNL) GO TO 51
      CALL VELOTH
      TU=TU-U
      TV=TV+V
      TW=TW-W
      GO TO 52
   51 Y=-Y
      Z=-Z
      CALL VELOTH
      TU=TU-U
      TV=TV-V
      TW=TW+W
   52 CONTINUE
      ICNR=1
      MNJ=MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(SDSLIP) GO TO 17
      IF(VERPNL) GO TO 41
      Y=YLCT(I)+YI
      CALL VELOTH
      TU=TU-U
      TV=TV-V
      TW=TW-W
      GO TO 42
C
   41 Z=ZLFT(I)+ZI
      CALL VELOTH
      TU=TU-U
      TV=TV-V
      TW=TW-W
   42 CONTINUE
      MNJ=-MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      GO TO 17
   10 CONTINUE
C
C*********************  CORNER 2  ******************************************
C
      X=XI-XRFT(I)
      Y=YI-YRCT(I)
      Z=ZI-ZRFT(I)
      CALL VELOTH
      TU=TU-U
      TV=TV-V
      TW=TW-W
      ICNR=2
      MNJ=MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(SDSLIP) GO TO 20
      IF (VERPNL) GO TO 33
      Y=-(YI+YRCT(I))
      CALL VELOTH
      TU=TU-U
      TV=TV+V
      TW=TW-W
      GO TO 34
   33 Z=-(ZI+ZRFT(I))
      CALL VELOTH
```

```
      TU=TU-U
      TV=TV-V
      TW=TW+W
   34 CONTINUE
      MNJ=-MJ
      IF(NOPR)       WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      GO TO 20
C
C     CORNER 2 FOR M .LT. 0
C
   17 CONTINUE
      X=XI-XRFT(I)
      Y=YRCT(I)-YI
      Z=ZI-ZRFT(I)
      IF(VERPNL) GO TO 53
      CALL VELOTH
      TU=TU+U
      TV=TV-V
      TW=TW+W
      GO TO 54
   53 Y=-Y
      Z=-Z
      CALL VELOTH
      TU=TU+U
      TV=TV+V
      TW=TW-W
   54 CONTINUE
      ICNR=2
      MNJ=MJ
      IF(NOPR)       WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(SDSLIP) GO TO 20
      IF(VERPNL) GO TO 43
      Y=YRCT(I)+YI
      CALL VELOTH
      TU=TU+U
      TV=TV+V
      TW=TW+W
      GO TO 44
   43 Z=ZRFT(I)+ZI
      CALL VELOTH
      TU=TU+U
      TV=TV+V
      TW=TW+W
   44 CONTINUE
      MNJ=-MJ
      IF(NOPR)       WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
   20 CONTINUE
C
C**********************   CORNER 3   ****************************************
C
      IF(EM2.LT.0.0) GO TO 19
      EM=EM2
      X=XI-XLBT(I)
      Y=YI-YLCT(I)
      Z=ZI-ZLBT(I)
      CALL VELOTH
      TU=TU-U
      TV=TV-V
      TW=TW-W
      ICNR=3
      MNJ=MJ
      IF(NOPR)       WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(SDSLIP) GO TO 30
```

```
      IF (VERPNL) GO TO 35
      Y=-(YI+YLCT(I))
      CALL VELOTH
      TU=TU-U
      TV=TV+V
      TW=TW-W
      GO TO 36
   35 Z=-(ZI+ZLBT(I))
      CALL VELOTH
      TU=TU-U
      TV=TV-V
      TW=TW+W
   36 CONTINUE
      MNJ=-MJ
      IF(NOPR)     WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      GO TO 30
C
C     CORNER 3 FOR M .LT. 0
C
   19 CONTINUE
      EM=-EM2
      X=XI-XLBT(I)
      Y=YLCT(I)-YI
      Z=ZI-ZLBT(I)
      IF (VERPNL) GO TO 55
      CALL VELOTH
      TU=TU+U
      TV=TV-V
      TW=TW+W
      GO TO 56
   55 Y=-Y
      Z=-Z
      CALL VELOTH
      TU=TU+U
      TV=TV+V
      TW=TW-W
   56 CONTINUE
      ICNR=3
      MNJ=MJ
      IF(NOPR)     WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(SDSLIP) GO TO 21
      IF(VERPNL) GO TO 45
      Y=YLCT(I)+YI
      CALL VELOTH
      TU=TU+U
      TV=TV+V
      TW=TW+W
      GO TO 46
   45 Z=ZLBT(I)+ZI
      CALL VELOTH
      TU=TU+U
      TV=TV+V
      TW=TW+W
   46 CONTINUE
      MNJ=-MJ
      IF(NOPR)     WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      GO TO 21
   30 CONTINUE
C
C********************   CORNER 4   ****************************************
C
      X=XI-XRBT(I)
      Y=YI-YRCT(I)
      Z=ZI-ZRBT(I)
```

```
      CALL VELOTH
      TU=TU+U
      TV=TV+V
      TW=TW+W
      ICNR=4
      MNJ=MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(SDSLIP) GO TO 40
      IF (VERPNL) GO TO 37
      Y=-(YI+YRCT(I))
      CALL VELOTH
      TU=TU+U
      TV=TV-V
      TW=TW+W
      GO TO 38
   37 Z=-(ZI+ZRBT(I))
      CALL VELOTH
      TU=TU+U
      TV=TV+V
      TW=TW-W
   38 CONTINUE
      MNJ=-MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      GO TO 40
C
C     CORNER 4 FOR M.LT.0
C
   21 CONTINUE
      X=XI-XRBT(I)
      Y=YRCT(I)-YI
      Z=ZI-ZRBT(I)
      IF(VERPNL) GO TO 57
      CALL VELOTH
      TU=TU-U
      TV=TV+V
      TW=TW-W
      GO TO 58
   57 Y=-Y
      Z=-Z
      CALL VELOTH
      TU=TU-U
      TV=TV-V
      TW=TW+W
   58 CONTINUE
      ICNR=4
      MNJ=MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(SDSLIP) GO TO 40
      IF(VERPNL) GO TO 47
      Y=YI+YRCT(I)
      CALL VELOTH
      TU=TU-U
      TV=TV-V
      TW=TW-W
      GO TO 48
   47 Z=ZRBT(I)+ZI
      CALL VELOTH
      TU=TU-U
      TV=TV-V
      TW=TW-W
```

```
   48 CONTINUE
      MNJ=-MJ
      IF(NOPR)       WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
   40 CONTINUE
C
      UPT=UPT+TU*THETAL(I)
      VPT=VPT+TV*THETAL(I)
      WPT=WPT+TW*THETAL(I)
  100 CONTINUE
C
      IF(NOPR) WRITE(6,2) UPT,VPT,WPT
C
      RETURN
      END


      SUBROUTINE TRBIPW(YI,ZI,YO,ZO,I)
C
C     VERSION: DEMON1
C
C     THIS SUBROUTINE TRANSFORMS COORDINATES AND VELOCITIES FROM WING
C     COORDINATE SYSTEM TO INTERFERENCE PANEL COORDINATE SYSTEM AND
C     VICE VERSA.
C
      LOGICAL ASYM,BODY,DELTA,NOSYM
C
      COMMON/ONE/DUM1(5500),SNT(125),CST(125),SNT2(125),CST2(125),
     1IP(300),XFBIP(100),DUM2(12),DX,DUM3(2),RB,DUM4(12),WBIP,DUM5(11),
     2NBIP,DUM6(10),NPANLS,NPRESS,NWBP,ASYM,BODY,DELTA,NOSYM
C
      DIMENSION YLC(250),ZLF(250)
      EQUIVALENCE (YLC(1),DUM1(4001)),   (ZLF(1),DUM1(4501))
C
C     TRANSFORM FROM BIP TO WING COORDINATES
C
      INP=I+NPANLS
      YO=YI*CST2(I) + ZI*SNT2(I) + YLC(INP)
      ZO=ZI*CST2(I) - YI*SNT2(I) + ZLF(INP)
      RETURN
C
C     TRANSFORM FROM WING TO BIP COORDINATES
C
      ENTRY TRWBIP
      INP=I+NPANLS
      ZC=ZI-ZLF(INP)
      YC=YI-YLC(INP)
   10 YO=YC*CST2(I) - ZC*SNT2(I)
      ZO=ZC*CST2(I) + YC*SNT2(I)
      RETURN
C
C     VELOCITY TRANSFORM -- BIP TO WING
C
      ENTRY ROTBW
      YO=YI*CST2(I) + ZI*SNT2(I)
      ZO=ZI*CST2(I) - YI*SNT2(I)
      RETURN
C
C     WING TO BIP VELOCITY TRANSFORM
C
      ENTRY ROTWB
      ZC=ZI
      YC=YI
```

```
      GO TO 10
      END


      SUBROUTINE VELCAL(NDIM,ALPHA,BETA,NSTART)
C
C     VERSION: DEMON1
C
C SUBROUTINE TO CALCULATE THE VELOCITIES FOR THE FIELD POINTS X,Y,Z DUE
C TO THE BODY SINGULARITIES.
C
C
      DIMENSION X(150),YY(150),ZZ(150)
C
      LOGICAL ASYM,BODY,DELTA,NOSYM
C
      COMMON/ONE/CIRC(250),DUM1(500),PNLC(250),DUM2(500),VNNOR(250),
     1XBAR(250),ZBAR(250),DUMB(750),          DUM3(2500),DUM4(904),
     2B2,B2V,DUM5(5),CN,DUM6(24),MSWR,MSWL,MSWU,MSWD,DUM7(2),NCW,NDRAG,
     3NHP,NPR,NRP,N3P,DUM8(6),ASYM,BODY,DELTA,NOSYM
      COMMON/TWO/TX(101),DUM9(505),DUMZZ(403),T(100),TC(100),COEFF(5),
     1BCODE,BETASQ,BSQ,RADIUS,RFIELD,RNOSE,U,V,VT,XA,XB,XC,XD,XFIELD,X2,
     2LBODY,NXBODY
      COMMON/BVEL/U1(150),V1(150),W1(150),XFLDP(150),YFLDP(150),
     1 ZFLDP(150)
      COMMON/WBTR/THTI(125),XWLE
C
C
      REAL LBODY
      INTEGER BCODE
C
C
C     TRANSFORM X-COORDINATES INTO THE BODY SYSTEM
C
      DO 50 K=NSTART,NDIM
      X(K)=XFLDP(K)+XWLE
      YY(K)=YFLDP(K)
   50 ZZ(K)=ZFLDP(K)
      N=NXBODY-1
C
C CALCULATION OF COORDINATE ROTATION ANGLE.
C
      IF (ABS(ALPHA).LT.1.0E-04) GO TO 51
      PHI=ATAN(BETA/ALPHA)
      GO TO 52
   51 PHI=0.0
   52 CONTINUE
C
C CALCULATION OF VELOCITIES.
C
C
C   NOTE: FOR A ROLLED CONFIGURATION,ANGLE THPLPH EQUALS ROLL ANGLE PHI
C    PLUS ANGLE THETA(ZB TO YB) ASSOCIATED WITH THE BODY COORDINATE
C    SYSTEM.
C
      DO 100 I=NSTART,NDIM
C
C
      XFIELD=X(I)
      RFIELD=SQRT(YY(I)**2+ZZ(I)**2)
      THETA=ATAN2(YY(I),ZZ(I))
      THPLPH=THETA+PHI
```

```
      RSQ=BETASQ*RFIELD*RFIELD
      X2=XFIELD-LBODY
C
      US=0.
      VS=0.
      UD=0.
      VD=0.
      VTD=0.
      DO 110 J=1,N
      CALL SOURCE(J)
      US=US+T(J)*U
      VS=VS+T(J)*V
      CALL DOUBLT(J)
      UD=UD+U*TC(J)
      VD=VD+V*TC(J)
  110 VTD=VTD+VT*TC(J)
C
C TRANSFORMATION OF VELOCITIES INTO BODY COORDINATE SYSTEM.
C U,V,W, RATHER THAN U,VR,VTHETA.
C
      COSTH=COS(THPLPH)
      U1(I)=US+UD*COSTH
      VR=VD*COSTH+VS
      VTD=VTD*SIN(THPLPH)
      SINTH=SIN(THETA)
C
C  AT THIS STAGE U1,VR,VTD ARE THE LONGITUDINAL,RADIAL AND TANGENTIAL
C  VELOCITY COMPONENTS IN THE BODY CYLINDRICAL COORDINATE SYSTEM.
C  NEXT,TRANSFORM INTO RECTANGULAR BODY COODINATE SYSTEM.
C
      COSTH=COS(THETA)
      V1(I)=VR*SINTH+VTD*COSTH
      W1(I)=VR*COSTH-VTD*SINTH
      IF (ABS(U1(I)).LT.1.0E-06) U1(I)=0.0
      IF (ABS(V1(I)).LT.1.0E-06) V1(I)=0.0
      IF (ABS(W1(I)).LT.1.0E-06) W1(I)=0.0
  100 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE VELNOR(XX,YY,ZZ)
C
C     VERSION: DEMON1
C
C     THIS SUBROUTINE CALCULATES PERTURBATION VELOCITIES INDUCED BY
C     THE WING AND BODY INTERFERENCE PANELS USING SUPERPOSITION SCHEME
C     SUPERPOSITION OF 4 CORNER SOLUTIONS IS USED
C     VELNOR RETURNS VELOCITIES UP,VP,WP IN WING REFERENCE FRAME...
C
      LOGICAL ASYM,ASYMI,DELTA,BODY,NOSYM,IGTNP,NOPR
C
      COMMON/ONE/CIRC(250),DELTP(250),FN(250),PNLC(250),SWPPLE(250),
     1SWPPTE(250),DUM1(1000),YCPT(250),ZCPT(250),XLF(250),XLB(250),
     2XRF(250),XRB(250),YLC(250),YRC(250),ZLF(250),ZRF(250),ZLB(250),
     3ZRB(250),SNT(125),CST(125),DUM2(550),
     $                   XFRIP(100),A,ALFA,ALFR,ARWING,B2,B2V,BETA,
     4BETAR,CONST,COSALF,COSBET,CN,DX,EM,FMACH,RR,SINALF,SINBET,SLOPE,
     5TLRNC,TIPY,TOTLR,U,V,W,UP,VP,WP,WBIP,X,Y,Z,MI,IF,II,MJ,MSWR,MSWL,
     6MSWU,MSWD,NBIP,NCRX,NCW,NDRAG,NHP,NPR,NRP,NSP,NOCPT,NOLINP,NOUT,
     7NPANLS,NPRESS,NWBP,ASYMI,BODY,DELTA,NOSYM
C
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      COMMON/WHTR/THTI(125),XWLE                                        DM28
      COMMON /INTRDT/ PHIDIH,THETIT,YBOD,ZBOD,PHIFR,PHIFU               DM28
C                                                                       DM28
      DATA PI/3.141592653590/                                           DM28
C                                                                       DM28
    1 FORMAT(5X,5HPANEL,I4,6X,6HCORNER,I2,                              DM28
     1                          6X,4HC.P.,I5,3X,4HX = ,E12.5,3X,4HY = ,E12.5DM28
     1 ,3X,4HZ = E12.5/6X,4HU = ,E12.5,6X,4HV = ,E12.5,6X,4HW = ,E12.5/ DM28
     2  5X,5HTU = ,E12.5,5X,5HTV = ,E12.5,5X,5HTW = ,E12.5)             DM28
    2 FORMAT(1X,7HASYM = ,L3)                                           DM28
C                                                                       DM28
      ASYM= NOSYM                                                       DM28
      NOPR= (NPR.NE.0)                                                  DM28
      DTOR=PI/180.0                                                     DM28
C                                                                       DM28
      UP=0.                                                             DM28
      VP=0.                                                             DM28
      WP=0.                                                             DM28
      XI=XX                                                             DM28
      YI=YY                                                             DM28
      ZI=ZZ                                                             DM28
C                                                                       DM28
C     I IS INDEX OF INFLUENCING PANEL                                   DM28
C                                                                       DM28
      DO 100 I=II,IF                                                    DM28
      IGTNP= I.GT.NPANLS                                                DM28
      K=I-NPANLS                                                        DM28
      MI=I                                                              DM28
      TU=0.                                                             DM28
      TV=0.                                                             DM28
      TW=0.                                                             DM28
      EM1=SWPPLE(I)                                                     DM28
      EM2=SWPPTE(I)                                                     DM28
C                                                                       DM28
C********************  CORNER 1  ****************************************DM28
C                                                                       DM28
C                                                                       DM28
C                                                                       DM28
C     IF INFLUENCER IS A BODY INTERFERENCE PANEL,SUPERPOSITION IS       DM28
C     PERFORMED IN THE WING SYSTEM , SAME FOR INTERDIGITATED FINS.      DM28
C     NOTE: BODY INTERFERENCE PANELS IN 2ND. AND 4TH. QUARTERS ACT LIKE DM28
C     WING PANELS WITH NEGATIVE SWEEP                                   DM28
C                                                                       DM28
      IF (I.LE.NPANLS) GO TO 60                                         DM28
      IF              ((THTI(K).GT.90.0.AND.THTI(K).LE.180.0).OR.       DM28
     1(THTI(K).GT.270.0.AND.THTI(K).LE.360.0)) GO TO 15                 DM28
   60 CONTINUE                                                          DM28
      IF (I.LE.NHP) PHIF=PHIFR*DTOR                                     DM28
      IF (I.GT.NHP.AND.I.LE.NPANLS) PHIF=PHIFU*DTOR                     DM28
      IF (EM1.LT.0.0) GO TO 15                                          DM28
      SLOPE=EM1                                                         DM28
      EM=EM1                                                            DM28
      X=XI-XLF(I)                                                       DM28
      YT=YI-YLC(I)                                                      DM28
      ZT=ZI-ZLF(I)                                                      DM28
      IF (ABS(X).LE.TLRNC) X=0.0                                        DM28
      IF (ABS(YT).LE.TLRNC) YT=0.0                                      DM28
      IF (ABS(ZT).LE.TLRNC) ZT=0.0                                      DM28
      Y=YT                                                              DM28
      Z=ZT                                                              DM28
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)                        DM28
C                                                                       DM28
C     FOR PANELS WITH POSITIVE SWEEP,SUPERPOSITION IS CORNER 1-2-3+4.   DM28
```

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C
C     IF INFLUENCER IS A BODY INFLUENCING PANEL, TRANSFORM WING Y,Z
C     COORDINATES INTO BIP COORDINATE SYSTEM,ONLY NEED TO ROTATE SINCE
C     ORIGIN IS ALREADY AT BIP CORNER
C     THEN TRANSFORM VELOCITIES FROM BIP FRAME BACK TO WING,SAME FOR
C     INTERDIGITATED FINS.
C
      IF (IGTNP) CALL ROTWB(YW,ZW,Y,Z,K)
      CALL VELO
      VB=V
      WB=W
      VT=V
      WT=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU+U
      TV=TV+V
      TW=TW+W
      ICNR=1
      MNJ=MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(NOPR)      WRITE(6,2) ASYM
      IF(ASYM) GO TO 10
      YT=-(YI+YLC(I))
      YW=YT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP) CALL ROTWB(YW,ZW,Y,Z,K)
      CALL VELO
      VB=V
      WB=W
      VT=V
      WT=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU+U
      TV=TV-V
      TW=TW+W
      MNJ=-MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      GO TO 10
C
C
C     FOR PANELS WITH NEGATIVE SWEEP,SUPERPOSITION IS CORNER -1+2+3-4
C
C     CORNER 1 FOR M .LT.0.0
C
   15 CONTINUE
      SLOPE=-EM1
      EM=-EM1
      X=XI-XLF(I)
      YT=YI-YLC(I)
      ZT=ZI-ZLF(I)
      IF (ABS(X).LE.TLRNC) X=0.0
      IF (ABS(YT).LE.TLRNC) YT=0.0
      IF (ABS(ZT).LE.TLRNC) ZT=0.0
      YW=YT
      ZW=ZT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP)  CALL ROTWB(YW,ZW,Y,Z,K)
      Y=-Y
      CALL VELO
      VT=-V
      WT=W
```

```
      VB=-V
      WB=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU-U
      TV=TV-V
      TW=TW-W
      ICNR=1
      MNJ=MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(ASYM) GO TO 17
      YT=-(YI+YLC(I))
      YW=YT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP)  CALL ROTWB(YW,ZW,Y,Z,K)
      Y=-Y
      CALL VELO
      VT=-V
      WT=W
      VB=-V
      WB=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU-U
      TV=TV+V
      TW=TW-W
      MNJ=-MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      GO TO 17
   10 CONTINUE
C
C*********************  CORNER 2  ****************************************
C
      X=XI-XRF(I)
      YT=YI-YRC(I)
      ZT=ZI-ZRF(I)
      IF (ABS(X).LE.TLRNC) X=0.0
      IF (ABS(YT).LE.TLRNC) YT=0.0
      IF (ABS(ZT).LE.TLRNC) ZT=0.0
      YW=YT
      ZW=ZT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP) CALL ROTWB(YW,ZW,Y,Z,K)
      CALL VELO
      VB=V
      WB=W
      VT=V
      WT=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU-U
      TV=TV-V
      TW=TW-W
      ICNR=2
      MNJ=MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(ASYM) GO TO 20
      YT=-(YI+YRC(I))
      YW=YT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP) CALL ROTWB(YW,ZW,Y,Z,K)
      CALL VELO
      VB=V
```

```
      WB=W
      VT=V
      WT=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU-U
      TV=TV+V
      TW=TW-W
      MNJ=-MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      GO TO 20
C
C     CORNER 2 FOR M .LT. 0
C
   17 CONTINUE
      X=XI-XRF(I)
      YT=YI-YRC(I)
      ZT=ZI-ZRF(I)
      IF (ABS(X).LE.TLRNC) X=0.0
      IF (ABS(YT).LE.TLRNC) YT=0.0
      IF (ABS(ZT).LE.TLRNC) ZT=0.0
      YW=YT
      ZW=ZT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP)  CALL ROTWB(YW,ZW,Y,Z,K)
      Y=-Y
      CALL VELO
      VT=-V
      WT=W
      VB=-V
      WB=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU+U
      TV=TV+V
      TW=TW+W
      ICNR=2
      MNJ=MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(ASYM) GO TO 20
      YT=-(YI+YRC(I))
      YW=YT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP)  CALL ROTWB(YW,ZW,Y,Z,K)
      Y=-Y
      CALL VELO
      VT=-V
      WT=W
      VB=-V
      WB=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU+U
      TV=TV-V
      TW=TW+W
      MNJ=-MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
   20 CONTINUE
C
C*********************  CORNER 3  **************************************
C
      IF (I.LE.NPANLS) GO TO 61
      IF              ((THTI(K).GT.90.0.AND.THTI(K).LE.180.0).OR.
```

```
     1(THTI(K).GT.270.0.AND.THTI(K).LE.360.0)) GO TO 19
   61 IF (EM2.LT.0.0) GO TO 19
      EM=EM2
      SLOPE=EM2
      X=XI-XLB(I)
      YT=YI-YLC(I)
      ZT=ZI-ZLB(I)
      YW=YT
      IF (ABS(X).LE.TLRNC) X=0.0
      IF (ABS(YT).LE.TLRNC) YT=0.0
      IF (ABS(ZT).LE.TLRNC) ZT=0.0
      ZW=ZT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP) CALL ROTWB(YW,ZW,Y,Z,K)
      CALL VELO
      VB=V
      WB=W
      VT=V
      WT=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU-U
      TV=TV-V
      TW=TW-W
      ICNR=3
      MNJ=MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(ASYM) GO TO 30
      YT=-(YI+YLC(I))
      YW=YT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP) CALL ROTWB(YW,ZW,Y,Z,K)
      CALL VELO
      VB=V
      WB=W
      VT=V
      WT=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU-U
      TV=TV+V
      TW=TW-W
      MNJ=-MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      GO TO 30
C
C     CORNER 3 FOR M .LT. 0
C
   19 CONTINUE
      SLOPE=-EM2
      EM=-EM2
      X=XI-XLB(I)
      YT=YI-YLC(I)
      ZT=ZI-ZLB(I)
      IF (ABS(X).LE.TLRNC) X=0.0
      IF (ABS(YT).LE.TLRNC) YT=0.0
      IF (ABS(ZT).LE.TLRNC) ZT=0.0
      YW=YT
      ZW=ZT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP)  CALL ROTWB(YW,ZW,Y,Z,K)
      Y=-Y
      CALL VELO
```

```
      VT=-V
      WT=W
      VB=-V
      WB=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU+U
      TV=TV+V
      TW=TW+W
      ICNR=3
      MNJ=MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(ASYM) GO TO 21
      YT=-(YI+YLC(I))
      YW=YT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP)  CALL ROTWB(YW,ZW,Y,Z,K)
      Y=-Y
      CALL VELO
      VB=-V
      WB=W
      VT=-V
      WT=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU+U
      TV=TV-V
      TW=TW+W
      MNJ=-MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      GO TO 21
   30 CONTINUE
C
C********************  CORNER 4  ****************************************
C
      X=XI-XRB(I)
      YT=YI-YRC(I)
      ZT=ZI-ZRB(I)
      IF (ABS(X).LE.TLRNC) X=0.0
      IF (ABS(YT).LE.TLRNC) YT=0.0
      IF (ABS(ZT).LE.TLRNC) ZT=0.0
      YW=YT
      ZW=ZT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP) CALL ROTWB(YW,ZW,Y,Z,K)
      CALL VELO
      VB=V
      WB=W
      VT=V
      WT=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU+U
      TV=TV+V
      TW=TW+W
      ICNR=4
      MNJ=MJ
      IF(NOPR)      WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(ASYM) GO TO 40
      YT=-(YI+YRC(I))
      YW=YT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP) CALL ROTWB(YW,ZW,Y,Z,K)
      CALL VELO
```

```
      VT=V
      WT=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU+U
      TV=TV-V
      TW=TW+W
      MNJ=-MJ
      IF(NOPR)     WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      GO TO 40
C
C     CORNER 4 FOR M.LT.0
C
   21 CONTINUE
      X=XI-XRB(I)
      YT=YI-YRC(I)
      ZT=ZI-ZRB(I)
      IF (ABS(X).LE.TLRNC) X=0.0
      IF (ABS(YT).LE.TLRNC) YT=0.0
      IF (ABS(ZT).LE.TLRNC) ZT=0.0
      YW=YT
      ZW=ZT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP)  CALL ROTWB(YW,ZW,Y,Z,K)
      Y=-Y
      CALL VELO
      VT=-V
      WT=W
      VB=-V
      WB=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU-U
      TV=TV-V
      TW=TW-W
      ICNR=4
      MNJ=MJ
      IF(NOPR)     WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
      IF(ASYM) GO TO 40
      YT=-(YI+YRC(I))
      YW=YT
      IF (.NOT.IGTNP) CALL ROTWF(YT,ZT,Y,Z,PHIF)
      IF (IGTNP)  CALL ROTWB(YW,ZW,Y,Z,K)
      Y=-Y
      CALL VELO
      VB=-V
      WB=W
      VT=-V
      WT=W
      IF (.NOT.IGTNP) CALL ROTFW(VT,WT,V,W,PHIF)
      IF (IGTNP) CALL ROTBW(VB,WB,V,W,K)
      TU=TU-U
      TV=TV+V
      TW=TW-W
      MNJ=-MJ
      IF(NOPR)     WRITE(6,1) MI,ICNR,MNJ,X,Y,Z,U,V,W,TU,TV,TW
   40 CONTINUE
C
      IF(II.EQ.IF.AND.NOCPT.EQ.0) GO TO 101
      UP=UP+TU*DELTP(I)
      VP=VP+TV*DELTP(I)
      WP=WP+TW*DELTP(I)
  100 CONTINUE
```

```
      UP=UP/CONST
      VP=VP/CONST
      WP=WP/CONST
      RETURN
C
C     UP,VP,WP BELOW ARE FOR SETTING UP INFLUENCE FUNCTIONS FOR USE IN
C     THE INFLUENCE MATRIX
C
  101 UP=TU
      VP=TV
      WP=TW
      RETURN
      END
```

```
      SUBROUTINE VELO
C
C     VERSION:DEMON2.
C
C     THIS SUBROUTINE CALCULATES THE INFLUENCE OF THE BASIC
C     SEMI-INFINITE TRIANGLES WHICH ARE UNDER CONSTANT LOADING.
C     MORE CORRECTLY, THEY ARE UNDER CONSTANT U DIFFERENCE
C     THE COORDINATE SYSTEM USED HERE IS THE COORDINATE SYSTEM ASSO-
C     CIATED WITH THE TRIANGLE UNDER CONSIDERATION.
C
      LOGICAL ASYM,BODY,DELTA,NOSYM
C
      COMMON/ONE/DUM1(6400),A,DUM2(5),BETA,DUM3(6),EM,DUM4(4),SLOPE,
     1TLRNC,TIPY,TOTLR,U,V,W,DUM5(4),X,YS,ZS,MI,DUM6(2),MJ,DUM7(8),NMP,
     2NPR,DUM8(2),NOCPT,NOLINP,NOUT,NPANLS,DUM9(2),ASYM,BODY,DELTA,NOSYM
C
      NAMELIST /DEBUG/X,Y,Z,F1,F2,   F4,F5,   F7,ARG,  EML,BETA,U,V,W
     1,TOP,BOT,ARGY,     TLRNC,YEDGE
C
      DATA PI/3.14159265359/
C
C
C     STATEMENT FUNCTIONS.
C     PLANAR FORMULATION
C
      F1T(X,Y,Z) = Z*SQRT(XSQ-BTSQ*(YSQ+ZSQ))
      F1B(X,Y,Z) = Y*(EML*Y-X)+EML*ZSQ
      FF2(X,Y,Z) = EML*ALOG((X*EML-BTSQ*Y
     1  + SQRT((X*EML-BTSQ*Y)*(X*EML-BTSQ*Y)
     2  - BTSQ*((Y*EML-X)*(Y*EML-X)+ EMLSQ*ZSQ-BTSQ*ZSQ)))
     4  /(BETA*SQRT((Y*EML-X)*(Y*EML-X) + EMLSQ*ZSQ-BTSQ*ZSQ)))
     6  / SQRT(ABS(EMLSQ-BTSQ))
      FF4(X,Y,Z) = (Y/(YSQ+ZSQ))*SQRT(XSQ-BTSQ*(YSQ+ZSQ))
      FF5(X,Y,Z) = ALOG((X+SQRT(XSQ-BTSQ*(YSQ+ZSQ)))
     1  /(BETA*SQRT(YSQ+ZSQ)))
      FF7(X,Y,Z) = (Z/(YSQ+ZSQ))*SQRT(XSQ-BTSQ*(YSQ+ZSQ))
      FFSON(X,Y,Z) = (SQRT(XSQ-BTSQ*(YSQ+ZSQ)))/(X-BETA*Y)
      FSS(X,Y,Z) = EML*ATAN2(SQRT((BTSQ-EMLSQ)*(XSQ-BTSQ*(YSQ+ZSQ))),
     1   X*EML-BTSQ*Y)  / SQRT(ABS(EMLSQ-BTSQ))
C
C
      Y=YS
      Z=ZS
      TOP=0.0
      BOT=0.0
```

```
      EML=EM
      XSQ=X*X
      YSQ=Y*Y
      ZSQ=Z*Z
      BTSQ=BETA*BETA
      EMLSQ=EML*EML
C
C     CHECK FOR SUBSONIC,SONIC OR SUPERSONIC LEADING EDGE
C
      IF (X.LT.0.0) GO TO 50
      IF (X.EQ.0.0.AND.Y.EQ.0.0.AND.Z.EQ.0.0) GO TO 50
      IF(ABS(EML).LT.(100.0*TLRNC)) GO TO 120
      YEDGE=X/EML
      GO TO 121
  120 YEDGE=10.0E+07
      GO TO 20
C
C     CHECK FOR SUBSONIC,SONIC, OR SUPERSONIC LEADING EDGE
C
  121 ARG=BTSQ*(1./EMLSQ)
      IF (ABS(ARG-1.0).LT.TLRNC) GO TO 25
      IF(ARG.LT.1.0) GO TO 10
      RBT=SQRT(YSQ+ZSQ)*BETA
      IF(X.GT.RBT) GO TO 63
      GO TO 21
   50 U=0.
      V=0.
      W=0.
      RETURN
C
C     SUPERSONIC LEADING EDGE CASE --
C
   20 CONTINUE
C
C     CHECK IF POINT (X,Y,Z) LIES INSIDE, ON, OR OUTSIDE MACH CONE
C     FROM ORIGIN
C
      RBT=SQRT(YSQ+ZSQ)*BETA
      IF(X.GT.RBT) GO TO 24
   21 IF(Y.LT.0.0.OR.Y.GE.YEDGE) GO TO 50
C
C     POINT LIES OUTSIDE MACH CONE FROM ORIGIN BUT THE POINT LIES
C     INSIDE MACH CONE FROM LEADING EDGE AT SAME Y AS P(X,Y,Z)
C
      YC=X*EML/BTSQ
      IF (Y.LT.YC) GO TO 50
      XLE=Y*SLOPE
      XTRNSF=X-XLE
      IF (ABS(XTRNSF).LE.(100.0*TLRNC)) XTRNSF=0.0
      ZCONE=XTRNSF/(SQRT(BTSQ-EMLSQ))
      IF (ABS(Z).GT.ZCONE) GO TO 50
      IF(ABS(Z)    .LT.TLRNC.OR.(Z)    .GT.0.) GO TO 70
      GO TO 71
   70 F1=PI
      GO TO 74
   71 F1=-PI
   74 F2=-(EML*PI)/SQRT(ABS(BTSQ-EMLSQ))
      IF (ABS(EML).LT.(100.0*TLRNC)) F2=-BETA*PI
      IF (XTRNSF.EQ.0.0.AND.Z.EQ.0.0) F2=F2/2.0
      F4= 0.0
      F5=0.
      F7=0.0
      GO TO 47
C
```

```
C     POINT LIES INSIDE MACH CONE FROM ORIGIN
C
   24 CONTINUE
      F2=-BETA*ATAN2(SQRT(X*X-BTSQ*(YSQ+ZSQ)),-BETA*Y)
      GO TO 22
   63 F2=-FSS(X,Y,Z)
      GO TO 22
C
C     SONIC LEADING EDGE CASE--
C
   25 CONTINUE
C
C     CHECK IF POINT(X,Y,Z) LIES ON OR OUTSIDE MACH CONE FROM ORIGIN
C     IF TRUE SET PERTURBATION VELOCITIES EQUAL TO ZERO
C
      RBT=SQRT(YSQ+ZSQ)*BETA
      IF (X.LE.RBT) GO TO 50
      F2=-FFSON(X,Y,Z)
      XTRNSF=X-XLE
      IF (XTRNSF.EQ.0.0.AND.Z.EQ.0.0) F2=F2/2.0
      GO TO 22
C
C     SUBSONIC LEADING EDGE CASE--
C
   10 CONTINUE
C
C     CHECK IF POINT (X,Y,Z) LIES ON OR OUTSIDE MACH CONE
C     IF TRUE SET PERTURBATION VELOCITIES TO ZERO
C
      RBT=SQRT(YSQ+ZSQ)*BETA
      IF(X.LE.RBT) GO TO 50
      ARG2=BETA*SQRT((Y*EML-X)*(Y*EML-X)+EMLSQ*ZSQ-BTSQ*ZSQ)
      IF (ABS(ARG2).LT.TLRNC) GO TO 26
      F2=FF2(X,Y,Z)
      GO TO 22
   26 F2=0.0
   22 CONTINUE
      IF (Y.EQ.0.0.AND.Z.EQ.0.0) GO TO 50
      ARGY=Y-YEDGE
      IF(ABS(ARGY).LT.(100.0*TLRNC).AND.ABS(Z).LT.TLRNC) GO TO 50
      TOP=F1T(X,Y,Z)
      BOT=F1B(X,Y,Z)
      IF(ABS(TOP).GE.TLRNC) GO TO 43
      IF (Y.GT.0.0.AND.Y.LT.YEDGE.AND.ABS(Z)    .LT.TLRNC) GO TO 48
      GO TO 44
   48 F1=PI
      GO TO 46
   43 F1=ATAN2(TOP,BOT)
      IF(ABS(F1).LT.TLRNC) F1= 0.
      GO TO 46
   44 F1=0.0
   46 CONTINUE
      F4= FF4(X,Y,Z)
      F5=FF5(X,Y,Z)
      F7=FF7(X,Y,Z)
C
C     CALCULATE PERTURBATION VELOCITIES U/V,V/V,W/V
C
   47 U=F1
      IF(ABS(EML).LT.(100.0*TLRNC)) GO TO 101
      V=-EML*F1+F7
      W=        (EML*(ABS (1.0-BTSQ/EMLSQ)*F2-F5)-F4)
      GO TO 102
```

```
  101 CONTINUE
      V= F7
      W=-F4+F2
  102 CONTINUE
C
      IF (NPR.NE.0) WRITE (6,DEBUG)
C
      RETURN
      END
```

```
      SUBROUTINE VELOTH
C
C     VERSION: DEMON1
C
C     THIS SUBROUTINE CALCULATES THE INFLUENCE OF A SEMI-INFINITE
C     TRIANGLE WITH  CONSTANT SOURCE STRENGTH.
C
      LOGICAL VERPNL,INSIDE,NOPR
C
      COMMON/THVARG/XTH,YTH,ZTH,UTH,VTH,WTH,EML,VERPNL,NOPR
      COMMON/THVFLO/BETA,TLRNC,BTSQ
C
      NAMELIST/DEBUG/X,Y,Z,EML,INSIDE,ARG1,BETA,F1,F2,F5,
     1        UTH,VTH,WTH,YEDGE,ARGY
      DATA PI/3.14159265/
C
C     SET VELOCITIES TO ZERO FOR WHATEVER REASON
C
      IF(XTH.GE.TLRNC) GO TO 3
    1 UTH=0.0
      VTH=0.0
      WTH=0.0
      RETURN
C
C     CHECK IF THE INFLUENCING PANEL IS A VERTICAL PANEL.
C     IF SO, Y=ZTH AND Z=-YTH
C     THI TRANSFORMATION ROTATES SEMI INFINITE TRIANGLE 90 DEG. IN
C     COUNTERCLOCKWISE DIRECTION.
C
    3 CONTINUE
      X=XTH
      IF(VERPNL) GO TO 4
      Y=YTH
      Z=ZTH
      GO TO 5
    4 Y=ZTH
      Z=-YTH
    5 YSQ=Y*Y
      ZSQ=Z*Z
      EMLSQ=EML*EML
      ARG1=X*X-BTSQ*(YSQ+ZSQ)
      INSIDE=ARG1 .GT. TLRNC
C
C     CHECK FOR SPECIAL CASE OF UNSWEPT LEADING EDGE
C
      IF(ABS(EML).LT.(100.0*TLRNC)) GO TO 70
      YEDGE=X/EML
      ARGY=Y-YEDGE
C
C     CHECK WHETHER LEADING EDGE IS SUBSONIC, SONIC, OR SUPERSONIC
```

```
C
      STEST=BTSQ-EMLSQ
      IF(ABS(STEST).LT.TLRNC) GO TO 20
      IF(STEST.GT.0.0) GO TO 30
C
C********** SUBSONIC LEADING EDGE **********
C
C     DETERMINE IF POINT LIES INSIDE OR OUTSIDE MACH CONE FROM ORIGIN
C     IF IT LIES OUTSIDE, SET PERTURBATION VELOCITIES TO ZERO
C
      IF(.NOT.INSIDE) GO TO 1
C
C     POINT LIES INSIDE MACH CONE FROM ORIGIN
C
      RAD=SQRT(ARG1)
      T1=X*EML-BTSQ*Y
      T2=BETA*SQRT((Y*EML-X)*(Y*EML-X)+ZSQ*(EMLSQ-BTSQ))
C
C     TEST FOR POSSIBLE SINGULARITY IN F1 OR F2
C
      IF(ABS(ARGY).LT.(100.0*TLRNC).AND.ABS(Z).LT.TLRNC) GO TO 1
      F2=(EML/SQRT(EMLSQ-BTSQ))*ALOG((T1+SQRT(T1*T1-T2*T2))/T2)
      IF(ABS(Y).LT.TLRNC.AND.ABS(Z).LT.TLRNC) GO TO 13
      F1=ATAN2(Z*RAD,EML*(YSQ+ZSQ)-Y*X)
      F5=ALOG((X+RAD)/(BETA*SQRT(YSQ+ZSQ)) )
      GO TO 100
C
C     CASE FOR Y AND Z BOTH SMALL
C
   13 F1=0.0
      VTH=0.0
      GO TO 101
C
C********** SONIC LEADING EDGE **********
C
   20 IF(.NOT.INSIDE) GO TO 1
      RAD=SQRT(ARG1)
      F2=RAD/(X-BETA*Y)
C
C     F1 AND F5 SAME AS IN SUBSONIC LEADING EDGE
C
      IF (ABS(Y) .LT. TLRNC .AND. ABS(Z) .LT. TLRNC) GO TO 21
      F5=ALOG((X+RAD)/(BETA*SQRT(YSQ+ZSQ)))
      IF(ABS(ARGY).LT.TLRNC.AND.ABS(Z).LT.TLRNC) GO TO 22
      F1=ATAN2(Z*RAD,EML*(YSQ+ZSQ)-Y*X)
      GO TO 100
C
C     Y AND Z BOTH SMALL
C
   21 F1=0.
      VTH = 0.
      GO TO 101
C
C     Z SMALL AND Y CLOSE TO LEADING EDGE
C
   22 F1=0.
      GO TO 100
C
C********** SUPERSONIC LEADING EDGE **********
C
C     DETERMINE WHETHER POINT LIES INSIDE MACH CONE FROM ORIGIN
C     IF OUTSIDE, THERE IS ONE MORE CHECK TO BE MADE
C
```

```
   30 IF(INSIDE) GO TO 31
C
C      POINT IS OUTSIDE MACH CONE FROM ORIGIN
C      DETERMINE IF IT IS INSIDE MACH CONE FROM LEADING EDGE
C      IF OUTSIDE, SET PERTURBATION VELOCITIES TO ZERO
C
       IF(Y .LT. 0.0 .OR. Y .GE. YEDGE) GO TO 1
       YC=X*EML/BTSQ
       IF (Y.LT.YC) GO TO 1
       XLE=Y*EML
       XTRNSF=X-XLE
       ZCONE=XTRNSF/SQRT(STEST)
       IF (ABS(Z).GT.ABS(ZCONE)) GO TO 1
C
C      POINT IS INSIDE MACH CONE FROM LEADING EDGE
C
       F2= PI*EML/SQRT(BTSQ-EMLSQ)
       F1=PI
       IF(Z.LT.0.0) F1=-PI
       F5=0.0
       GO TO 100
C
C      POINT IS INSIDE MACH CONE FROM ORIGIN
C
   31  T3=SQRT(BTSQ-EMLSQ)
       RAD=SQRT(ARG1)
       F2=(EML/T3)*ATAN2(RAD*T3,X*EML-BTSQ*Y)
C
C      USE F1 AND F5 AS IN SUBSONIC LEADING EDGE CASE
C
       IF (ABS(Y) .LT. TLRNC .AND. ABS(Z) .LT. TLRNC) GO TO 32
       F5=ALOG((X+RAD)/(BETA*SQRT(YSQ+ZSQ)))
       F1=ATAN2(Z*RAD,EML*(YSQ+ZSQ)-Y*X)
       GO TO 100
C
C      Y AND Z BOTH SMALL
C
   32  F1=0.
       VTH=0.
       GO TO 101
C
C
C********** SPECIAL CASE FOR UNSWEPT LEADING EDGE **********
C
C      DETERMINE WHETHER POINT LIES INSIDE MACH CONE FROM ORIGIN
C      IF OUTSIDE, THERE IS ONE MORE CHECK TO BE MADE
C
   70 IF(INSIDE) GO TO 72
C
C      POINT IS OUTSIDE MACH CONE FROM ORIGIN
C      DETERMINE IF IT IS INSIDE MACH CONE FROM LEADING EDGE
C      IF OUTSIDE, SET PERTURBATION VELOCITIES TO ZERO
C
       IF(Y .LT. 0.) GO TO 1
       RSTB=ABS(Z)*BETA
       XTEST=X-RSTB
       IF((RSTB .LT. TLRNC .AND. X.LE.0.).OR.XTEST.LE.TLRNC)GO TO 1
C
C      POINT BETWEEN MACH CONE FROM ORIGIN AND LEADING EDGE
C
       UTH=-PI/BETA
       F1=PI
       IF(Z.LT.0.0) F1=-PI
```

```
      VTH=0.0                                                           DM30 177
      WTH=F1                                                            DM30 178
      GO TO 102                                                         DM30 179
C                                                                       DM30 180
C     POINT IS INSIDE MACH CONE FROM ORIGIN                             DM30 181
C                                                                       DM30 182
   72 RAD=SQRT(ARG1)                                                    DM30 183
      UTH=-ATAN2(RAD,-BETA*Y)/BETA                                      DM30 184
      F2=0.0                                                            DM30 185
      IF(ABS(Z) .LT. TLRNC .AND. ABS(Y) .LT. TLRNC)GO TO 73             DM30 186
      F1=ATAN2(Z*RAD,-Y*X)                                              DM30 187
      F5=ALOG((X+RAD)/(BETA*SQRT(YSQ+ZSQ)))                             DM30 188
      VTH=-F5                                                           DM30 189
      WTH=F1                                                            DM30 190
      GO TO 102                                                         DM30 191
   73 VTH=0                                                             DM30 192
      WTH=0                                                             DM30 193
      GO TO 102                                                         DM30 194
C                                                                       DM30 195
C     COMPUTE PERTURBATION VELOCITIES                                   DM30 196
C                                                                       DM30 197
  100 VTH=F2-F5                                                         DM30 198
  101 UTH=-F2/EML                                                       DM30 199
      WTH=F1                                                            DM30 200
  102 IF(.NOT. VERPNL) GO TO 103                                        DM30 201
      TEMP=VTH                                                          DM30 202
      VTH=-WTH                                                          DM30 203
      WTH=TEMP                                                          DM30 204
  103 CONTINUE                                                          DM30 205
      IF(NOPR) WRITE(6,DEBUG)                                           DM30 206
      RETURN                                                            DM30 207
      END                                                               DM30 208
```

```
      SUBROUTINE VRTVEL(NSTART,N)                                       DM31   1
C                                                                       DM31   2
C     VERSION: DEMON1                                                   DM31   3
C                                                                       DM31   4
C                                                                       DM31   5
C     SUBROUTINE FOR CALCULATION OF VELOCITIES INDUCED BY FIXED EXTERNALDM31   6
C     VORTICES IN THE PRESENCE OF A CIRCULAR BODY AT FIELDPOINTS        DM31   7
C     WITH COORDINATES XFLDP,YFLDP,ZFLDP.                               DM31   8
C                                                                       DM31   9
C     THIS SUBROUTINE READS IN UP TO 10 VORTEX STRENGHTS AND THEIR      DM31  10
C     LOCATIONS  IN THE CROSSFLOW PLANE                                 DM31  11
C     Y IS TO THE RIGHT WHEN VIEWING FORWARDS, Z IS UP                  DM31  12
C     VORTEX INDUCED VELOCITIES ARE NAMED VVRTX,WVRTX                   DM31  13
C                                                                       DM31  14
C                                                                       DM31  15
      LOGICAL ASYM,BODY,DELTA,NOSYM                                     DM31  16
C                                                                       DM31  17
C                                                                       DM31  18
      COMMON/ONE/CIRC(250),DELTP(250),FN(250),PNLC(250),SWPPLF(250),    DM31  19
     1SWPPTE(250),VNOR(250),XBAR(250),ZBAR(250),XCPT(250),YCPT(250),ZCPTDM31  20
     2(250),XLF(250),XLB(250),XRF(250),XRB(250),YLC(250),YRC(250),ZLF(25DM31  21
     30),ZRF(250),ZLB(250),ZRB(250),SNT(125),CST(125),SNT2(125),CST2(125DM31  22
     4),IP(300),XFBIP(100),A,ALFA,ALFR,ARWING,B2,B2V,BETA,BETAR,CONST,  DM31  23
     5COSALF,COSBET,CN,DX,EM,FMACH,RB,SINALF,SINBET,SLOPE,TLRNC,TIPY,   DM31  24
     6TOTLR,U,V,W,UCHK,VCHK,WCHK,WBIP,X,DUMY,Z,I,IF,II,J,MSWR,MSWL,MSWU,DM31  25
     7MSWD,NBIP,NCRX,NCW,NDRAG,NHP,NPW,NRP,NSP,NOCPT,NOLINP,NOUT,NPANLS,DM31  26
     8NPRESS,NWBP,ASYM,BODY,DELTA,NOSYM                                 DM31  27
```

```
      COMMON/VRTXV/VVRTX(150),WVRTX(150),NVRTPL,NVRTX,VRTMAX
      COMMON/VORSPC/GAMMA(10),YVRTX(10),ZVRTX(10),RLOC
      COMMON/BVEL/DUMB(450),XFLDP(150),YFLDP(150),ZFLDP(150)
C
    1 FORMAT (8F10.5)
    2 FORMAT (1H1,10X,79H2DIM,VORTEX NON-DIMENSIONAL STRENGHTS AND FIXED
     1 COORDINATES IN CROSS LOW PLANE
     1                         //15X,1HI,10X,6HGAMMA/,23X,2HY/,17X,
     22HZ/,/24X,23H(2.0*PI*BODY RAD.*VINF),5X,11H(BODY RAD.),8X,
     311H(BODY RAD.)//)
    3 FORMAT (15X,I2,8X,F10.5,17X,F10.5,9X,F10.5)
C
C     READ IN NON-DIMENSIONALIZED VORTEX STRENGHTS,GAMMA=GAMMA/
C     (2*PI*BODY RADIUS*VINF)
C     AND NON-DIMENSIONALIZED LOCATIONS,YVRTX/BODY RADIUS,
C     ZVRTX/BODY RADIUS
C
      WRITE (6,2)
      DO 100 I=1,NVRTX
      READ (5,1) GAMMA(I),YVRTX(I),ZVRTX(I)
      WRITE (6,3) I,GAMMA(I),YVRTX(I),ZVRTX(I)
  100 CONTINUE
C
C     COMPUTE VORTEX INDUCED PERTURBATION VELOCITIES AT CONTROL POINTS
C     OF ALL WING SURFACES AND BODY INTERFERENCE SHELL.
C     CONTRIBUTION DUE TO EXTERNAL VORTEX....VVRTXE,WVRTXE
C     CONTRIBUTION DUE TO IMAGE    VORTEX....VVRTXI,WVRTXI
C     CONTRIBUTION DUE TO CENTER   VORTEX....VVRTXC,WVRTXC
C  NOTE:***CENTER VORTEX EFFECTS ARE SET ZERO
C
C     ENTER HERE IF VORTICES HAVE BEEN READ IN ALREADY OR CALCULATED IN
C     SUBROUTINE BDYPR.
C
      ENTRY VORTEX
C
      DO 101 IC=NSTART,N
      Y=YFLDP(IC)/RLOC
      YS=Y*Y
      Z=ZFLDP(IC)/RLOC
      ZS=Z*Z
      DENOM=YS+ZS
      DO 102 JV=1,NVRTX
      ZVSYVS=ZVRTX(JV)*ZVRTX(JV)+YVRTX(JV)*YVRTX(JV)
      DELTY=Y-YVRTX(JV)
      DELTYS=DELTY*DELTY
      DELTZ=Z-ZVRTX(JV)
      DELTZS=DELTZ*DELTZ
      DENOM1=DELTYS+DELTZS
      IF ((DENOM1).LE.TLRNC) GO TO 105
      VVRTXE=-GAMMA(JV)*(DELTZ/DENOM1)
      WVRTXE= GAMMA(JV)*(DELTY/DENOM1)
      GO TO 106
  105 VVRTXE=0.
      WVRTXE=0.
  106 CONTINUE
      DENOM2=(Y-YVRTX(JV)/ZVSYVS)**2+(Z-ZVRTX(JV)/ZVSYVS)**2
      IF (ABS(DENOM2).LE.TLRNC) GO TO 107
      VVRTXI=GAMMA(JV)*(Z-ZVRTX(JV)/ZVSYVS)/DENOM2
      WVRTXI=-GAMMA(JV)*(Y-YVRTX(JV)/ZVSYVS)/DENOM2
      GO TO 108
  107 VVRTXI=0.0
      WVRTXI=0.0
  108 CONTINUE
```

```
      VVRTXC=0.0                                                        DM31  91
      WVRTXC=0.0                                                        DM31  92
      VVRTX(IC)=VVRTX(IC)+VVRTXE+VVRTXI+VVRTXC                          DM31  93
      WVRTX(IC)=WVRTX(IC)+WVRTXE+WVRTXI+WVRTXC                          DM31  94
C                                                                       DM31  95
C     LIMIT MAGNITUDE OF PERTURBATION VELOCITIES TO VRTMAX.             DM31  96
C                                                                       DM31  97
      IF (VVRTX(IC).GT.0.0.AND. ABS(VVRTX(IC)).GE.VRTMAX) VVRTX(IC)=    DM31  98
     1  VRTMAX                                                          DM31  99
      IF (VVRTX(IC).LT.0.0.AND. ABS(VVRTX(IC)).GE.VRTMAX) VVRTX(IC)=    DM31 100
     1 -VRTMAX                                                          DM31 101
      IF (WVRTX(IC).GT.0.0.AND. ABS(WVRTX(IC)).GE.VRTMAX) WVRTX(IC)=    DM31 102
     1  VRTMAX                                                          DM31 103
      IF (WVRTX(IC).LT.0.0.AND. ABS(WVRTX(IC)).GE.VRTMAX) WVRTX(IC)=    DM31 104
     1 -VRTMAX                                                          DM31 105
  102 CONTINUE                                                          DM31 106
  101 CONTINUE                                                          DM31 107
C                                                                       DM31 108
      RETURN                                                            DM31 109
      END                                                               DM31 110
```

```
      SUBROUTINE VVELS(NV,YY,ZZ,VX,VY,G,AB,BB,V,W,VRTMAX)               DM32   1
C                                                                       DM32   2
C     VERSION1 DEMON1                                                   DM32   3
C                                                                       DM32   4
C     THIS SUBROUTINE COMPUTES PERTURBATION VELOCITY COMPONENTS DUE TO  DM32   5
C     NV EXTERNAL VORTICES AND THEIR IMAGES INSIDE A BODY WITH          DM32   6
C     ELLIPTICAL CROSS SECTION. THEY ARE ADDED TO V AND W IN THE        DM32   7
C     ARGUMENT LIST.                                                    DM32   8
C                                                                       DM32   9
C                                                                       DM32  10
      DIMENSION VX(1),VY(1),G(1)                                        DM32  11
C                                                                       DM32  12
      COMMON/COM1/A2,B2,R2                                              DM32  13
      COMMON/COM2/SIG2,H2                                               DM32  14
C                                                                       DM32  15
      COMPLEX TO,V1,DSDT,Z,DSDZ,SI,SIB,SO,TAU,CI,VEL                    DM32  16
C                                                                       DM32  17
      EXTERNAL Z,DSDZ                                                   DM32  18
      PI=3.14159265                                                     DM32  19
      TLC=0.001                                                         DM32  20
      CI=CMPLX(0.0,1.0)                                                 DM32  21
      A2=AB*AB                                                          DM32  22
      B2=BB*BB                                                          DM32  23
      APB=AB+BB                                                         DM32  24
      APB2=APB*APB                                                      DM32  25
      R=0.5*APB                                                         DM32  26
      H2=APB2                                                           DM32  27
      R2=R*R                                                            DM32  28
      SIG2=R2                                                           DM32  29
      TO=CMPLX(YY,ZZ)                                                   DM32  30
      SO=Z(TO)                                                          DM32  31
      V1=CMPLX(0.0,0.0)                                                 DM32  32
      DSDT=DSDZ(SO)                                                     DM32  33
C                                                                       DM32  34
C   LOOP OVER THE NUMBER OF VORTICES,NV                                 DM32  35
C                                                                       DM32  36
      DO 1 I=1,NV                                                       DM32  37
      TAU=CMPLX(VX(I),VY(I))                                            DM32  38
```

```
      SI=Z(TAU)
      SIB=CONJG(SI)
      D=CABS(SI-SO)
      IF(D.LE.TLC) GO TO 2
      V1=V1-G(I)/(SO-SI)
    2 CONTINUE
      D=CABS(SO-R2/SIB)
      IF(D.LE.TLC) GO TO 1
      V1=V1+G(I)/(SO-R2/SIB)
    1 CONTINUE
C
      VEL=0.5*CI*V1*DSDT/PI
      V=REAL(VEL)+V
      W=-AIMAG(VEL)+W
      AV=ABS(V)
      AW=ABS(W)
      IF(V.GT.0.0.AND.AV.GE.VRTMAX) V=VRTMAX
      IF(V.LT.0.0.AND.AV.GE.VRTMAX)V=-VRTMAX
      IF(W.GT.0.0.AND.AW.GE.VRTMAX) W=VRTMAX
      IF(W.LT.0.0.AND.AW.GE.VRTMAX)W=-VRTMAX
      RETURN
      END
```

```
      COMPLEX FUNCTION Z(CT)
C     VERSION: DEMON1
C
C     VERSION: DEMON1
C
C     THIS FUNCTION SUBROUTINE CALCULATES THE SIGMA VALUE IN THE
C     TRANSFORMED (CIRCLE) PLANE FOR GIVEN TAU IN THE PHYSICAL PLANE
C     FOR AN ELLIPTICAL BODY WITH WINGS
C
      COMMON/COM2/SIG2,H2
      COMMON/COM3/ZR,ZI
      COMMON/COM4/G2,G1
      COMMON/COM6/W2,W
C
C
      COMPLEX W,G1,G2,CT,W2,DBLU
C
      EXTERNAL DBLU
C
      W=DBLU(CT)
      G1=W+SIG2/W
      G2=G1*G1-H2
      Y=AIMAG(G2)
      AY=1.0
      IF(Y.LT.0.0) AY=-1.0
      YZ=AIMAG(G1)
      AYZ=1.0
      IF(YZ.LT.0.0)AYZ=-1.0
      G2=CSQRT(G2)*AY*AYZ
      IF((ABS(YZ).LE.0.0).AND.(REAL(G1).LT.0.0)) G2=CMPLX(-REAL(G2),
     1     AIMAG(G2))
      Z=0.5*(G1+G2)
      IF((ABS(ZI).NE.0.0).AND.(ABS(ZR).NE.0.0)) Z=CMPLX(ZR*ABS(REAL(Z)),
     1ZI*ABS(AIMAG(Z)))
      RETURN
      END
```

# APPENDIX K

## DESCRIPTION OF PROGRAM WDYBDY

### INTRODUCTION

The purpose of this appendix is to describe the body source paneling program. Attention is given to the program's input, its output, the added special features to account for specified body nose shed vortices, and its interplay with program DEMON2 described in Appendix J. In relation to the work described in this report, program WDYBDY is employed to handle bodies in supersonic flow when they are elliptical in cross section.

Basically, the building blocks of this body modeling program have been extracted from Woodward's improved method described in reference 9 and documented in reference 10. Existing subroutines have been modified to account for combined angle of pitch and sideslip. Subroutines have been added to include effects of specified body nose vorticity in the calculation of pressures on the body.

This program performs the following tasks when the body of the configuration of interest is elliptical in cross section. First, the pressures acting on the forebody are calculated by this program including effects of specified body nose vortices if applicable. Second, the program has been arranged to compute velocity components induced by the body source panels at the control points distributed over the forward set of lifting surfaces (monoplane wing) and the associated body interference shell. If the length of body between the forward and tail lifting surfaces is long enough to influence the overall loads, program WDYBDY should be used to compute the pressure distributions over the afterbody. Effects of body nose and monoplane wing vortices must first be determined by program VPATHL which is described in Appendix L. This program computes the vortex paths along the afterbody. By means of an exchange of data sets with program WDYBDY, vortex induced velocity components are transferred to subroutine PRESS for inclusion in the calculation of pressures at points on the afterbody. Finally, this program calculates the velocity components induced by the body source panels at the control points of the tail lifting surfaces/interdigitated tails.

Thus, program WDYBDY, together with programs DEMON2 and VPATHL, is used repeatedly in accordance with the procedure described in Section 5.2.

In this way, complete configurations involving bodies with elliptical cross section are handled.

The theoretical basis of program WDYBDY and its usage will be summarized. The calculation procedure, program operation, program limitations and termination conditions are described. Special debugging output options are discussed. Detailed descriptions of the program input and output are then given. Program listings appear at the end of this appendix.

## PROGRAM DESCRIPTION

A summary of the theory associated with body source panels is given in Section 4. Body source panels are distributed over the body surface as shown in figures 2 and 24. Panel orientation angles $\delta$ and $\theta$ are indicated in the sketch of Section 4.1. These panels model the body with elliptical cross section in supersonic flow.

Program WDYBDY is an adaptation of the computer program of reference 10. It has been specialized to flow model bodies with elliptic cross section. Body geometry can be specified in terms of the horizontal and vertical semiaxes FUSBY and FUSAZ as a function of axial distance from the body nose XFUS. The configuration can be pitched and rolled giving rise to angles of pitch and sideslip. The boundary condition and pressure equations have been extended to account for angle of sideslip in addition to angle of pitch, see Section 4. The force and moment calculations have also been modified to include angle of sideslip. Normal force and side force, as well as pitching moment and yawing moment are calculated in the body- and wind-axis coordinate systems. The subroutines affected by the changes involving the inclusion of effects of combined angle of pitch and sideslip are SOLVE, PRESS and FORMOM.

In addition, subroutines READVX, ELBDVT and VVELS have been included to read in body nose separation vortex positions and strengths as a function of axial distance and to compute their contributions to the velocity components used in the Bernoulli pressure expression, equation 10. In the latter process, a slender-body theory solution is used. The solution is concerned with the calculation of velocity components induced by a set of vortices at specified points in the presence of a body with elliptical cross section. As such, the solution is a simplified version of the general solution described in Appendix I for the case involving a monoplane wing mounted on a body with elliptical cross section. Subroutine VVELS makes use of function subroutines DBLU, DSDZ and Z. The vortex induced velocity components are computed from expressions implemented in these routines using complex quantities.

A certain amount of graphical display can be generated through the use of routines PLOTG, PLOTA2, PLOTA3, PLOTA5, PLOTA6, PLOTA8 and PLOTV2. This capability serves as an aid in checking the input parameters that govern the geometrical layout of the body source panels. It also allows for an initial look at the pressure distributions on the body.

## Calculation Procedure

The program calculations are blocked into four parts, each of which depends on the completion of the previous step but which do not interact with each other. The four major partitions of the calculations are: the generation of panel geometric properties, the calculation of the aerodynamic influence coefficients, the solution for the strengths, pressures and loadings and the calculation of velocities induced at specified set of control points. All data interchanged between these blocks is either saved in common or on external files. The basic program description is contained in reference 10. A flow chart of the subroutine flow sequence is shown in figure K-1.

In the geometry block of routine GEOM, the configuration is read by CONFIG. Body paneling may be computed for a subset of the geometry used to define the configuration. NEWRAD is used to redefine the meridional lines describing the panel side edges and BODPAN both redefines the x-spacing of the panels and computes the panel corner points and inclination angles $\delta$ and $\theta$. The geometry description is saved on TAPE 7. If vortices are to be accounted for, the x-location at which vorticity characteristics are given are read from READVX before calling NEWRAD. If the control points are to be saved for use by other programs, a table of panel control points is written on TAPE 4 at the completion of the generation of the geometry.

The generation of the aerodynamic matrix coefficients is organized in VELCMP. The velocity contributions and influences between panels are computed by BODVEL and SORPAN. The aerodynamic matrix and velocities are saved on files TAPE 8, TAPE 9, and TAPE 10.

The solution of the equations and the calculation of pressures and forces is governed by routine SOLVE. The flow tangency boundary condition is defined and the solution of the equations is computed by a combination of routines DIAGIN, PARTIN, ITRATE and INVERT. The contribution to the velocity components from external vortices is included by either interpolation in a vortex strength table or by directly reading the contributions computed by external programs such as program VPATHL described in Appendix L. The pressure coefficient on each panel and the forces and moments acting on the body are then computed in PRESS and FORMOM, respectively. If the integration of the forces and moments over the length of body between specified x-locations XSTART and XWLE is required, the force and moment calculations are repeated for that length of body.

The last calculation block is performed when the calculation of velocity components at specified control points is requested. The velocity components in the body coordinate directions are computed using the solution strengths obtained in the previous part. No contribution due to vorticity is included in this calculation. The velocities are written after the control points on TAPE 4 for transmittal to program DEMON2 described in Appendix J in accordance with the procedures given in Section 5.2.

## Program Operation

The body modeling program using source panels on the surface is written in FORTRAN IV language (029 punch) and has been run on a CDC 6600 machine. The program is an adaptation of the wing-body-tail program in reference 10 simplified to body-only modeling. The program is arranged so that a total of 600 source panels are available to cover the body surface. The current version requires 122000 octal core locations to run on the CDC 6600.

The program requires seven disk files for operation. Because of the input copy feature of the program, the normal program input is read from TAPE 5 and not the INPUT tape. The normal input file may not be rewound. TAPE 4 may be used for either of three functions. If NWCPT is greater than one, specified control points are read from TAPE 4, velocities computed and written after the control points on TAPE 4. If NCPOUT is equal to one, the control points associated with the body source panels aft of XSTART and forward of XWLE are written on TAPE 4. If NVLIN is equal to one, the velocity components calculated by program VPATHL for control points aft of XSTART and forward of XWLE are read from TAPE 4. Files TAPE 7, TAPE 8, TAPE 9, and TAPE 10 are used to store intermediate results required for the solution of the aerodynamic matrix.

## Programs Limitations

The body modeling program has several limitations due to current code dimensions and due to the limitations inherent to the linear theory. The code will handle up to 600 body source panels during solution. There is a further limitation with regard to the number of panels in a given ring and the total number of rings. The maximum number of panels on the half body for symmetric cases and on the full body for nonsymmetric cases is restricted to 20 panels on a single ring. Similarly, the maximum number of rings of panels in the axial direction is limited to thirty. The flow limitation on the code is that the angle of inclination of all panels be less than the vertex angle of the Mach cone at supersonic speeds. No provisions are incorporated in the program for the presence of detached shocks. A summary of the program termination conditions that are checked for in the code follows. When body nose vortices are present, up to ten vortices may be handled simultaneously. When the calculation of velocities are performed at external field points, a maximum of 600 field point coordinates may be read in at a time.

## Program Termination Conditions

A number of labeled STOP conditions exist in the program. These may exist as a result of error conditions or end-of-data checks. They are as follows:

| STOP | Routine | Description |
|---|---|---|
| STOP 20 | GEOM | Normal program termination for end of data on TAPE 5. |

| STOP | Routine | Description |
|---|---|---|
| STOP 200 | GEOM | Error - body has more than 20 columns panels around circumference. |
| STOP 120 | NEWRAD | Error - body has more than 20 meridians. |
| STOP 130 | NEWRAD | Error - body has more than 60 axial stations. |
| STOP 20 | BODPAN | Error - number of rows of source panels in section exceeds 30. |
| STOP 30 | BODPAN | Error - number of rows of source panels on body exceeds 30. |
| STOP 500 | PRTCPT | Termination for NCPOUT equals 2. |
| STOP 210 | SORPAN | Panel slope exceeds Mach cone angle. |

## Supplementary Print from CDUMP

The routine CDUMP was written to provide additional print of variables in common for debugging purposes during execution. It is called at several points within the program as specified by the print controls IPRT. The information is printed according to the value of the option as follows:

| Value | Supplementary print |
|---|---|
| 0 | Prints only name of routine from which called. |
| 1 | Prints variables and arrays of less than 11 in length for common blocks: JOPTNS, PARAM, NEWCOM, VELCOM, and SEG. |
| 2 | Prints all of above common blocks. |
| 3 | Prints variable array BLOCK in unlabelled common. |
| 4 | Prints variables array ARRAY in common block POINT. |
| 5 | Prints common block COMPS. |
| 6 | Prints common block TRAN. |
| 7 | Prints common block BTHET |
| 8 | Prints common blocks COEF, MATCOM, and ITERAT. |

Note for print control IPRINT = 0, no print is output.

## Description of Configuration Geometry Input Cards

The configuration geometry input defines the external shape of the body only. The auxiliary geometry input later defines the sequence to be used in paneling the configuration by interpolation in the external geometry. The input description used here was adapted directly from reference 10 where it is used to describe an entire configuration. In all cases the original definitions have been preserved. For certain options additional meanings have been attached.

### WDYBDY Program Input Data

This program was adapted from the body analysis portion of the program detailed in reference 10. Herein, the geometric variables and their definitions used to describe the body have been maintained wherever possible. Several additional cards have been added to the program to facilitate the input of new program options and the description of parameters associated with discrete vortex properties. An additional input file used to exchange control points and velocities is also required. The original description of the cards and documentation in reference 10 has been maintained for simplicity. A sample input deck is described in Section 6.2 and shown in figure 25.

The input to the program consists of four parts: the definition of program options associated with printing, plotting and vortex options; the numerical description of the configuration geometry; an auxiliary data set specifying the singularity paneling scheme and program options; and the case cards defining the Mach number, combined angle of attack and roll, and vortex locations and strengths.

The definition of the coordinate axes used in this program is defined in figure 2. The $x_B$, $y_B$ and $z_B$ axes in figure 2 correspond to the $x_B$, $y_B$, and $z_B$ axes used in program DEMON2 and shown in figure 1. The body is considered to be viewed facing forward with the positive $x_B$-axis aft, the positive $y_B$-axis out the right and the positive $z_B$-axis up. In the following, the B-subscript is omitted wherever the body coordinates are mentioned.

## Descriptions of Input Option Cards

The options defined here control supplementary output and online plotting not defined by IPRINT and the specification of special control point and vortex options. The latter variables control the additional input to be read in later.

Card 1 - Title card - Card 1 contains any desired identifying information in columns 1-80.

Card 2 - Option Integers - Card 2 contains 14 integers, each punched right justified in a 3-columnar field (14I3). Columns 73-80 may be used in any desired manner. It is designated the IPRT card for reference. Subroutine CDUMP referenced to in the following in connection with print control IRPT is discussed above as part of the program description. Card 2 reads the following:

| Column | Variable | Value | Description |
|---|---|---|---|
| 1-3 | IPRT(1) | 0 | Do not print copy of input |
| | | 1 | Print formatted copy of input data |
| 4-6 | IPRT(2) | 0 | No supplementary print after GEOM |
| | | >0 | Call CDUMP for special print after GEOM |
| 7-9 | IPRT(3) | 0 | No supplementary print of vortices |
| | | 1 | Print supplementary information after calculation of vortex velocity components |
| 10-12 | IPRT(4) | 0 | No supplementary print after VELCMP |
| | | >0 | Call CDUMP for special print after VELCMP |
| 13-15 | IPRT(5) | 0 | No supplementary print after SOLVE |
| | | >0 | Call CDUMP for special print after SOLVE |
| 16-18 | IXZSYM | 0 | Panel only symmetric half of configuration |
| | | 1 | Panel full configuration symmetrically using geometry of positive y side. |
| | | -1 | Panel full configuration by reading geometry of both sides |
| 19-21 | IPLOT(1) | 0 | Do not plot geometry |
| | | 1 | Plot three orthographic projections and perspective of geometry of panel layout on line printer |

| Column | Variable | Value | Description |
|---|---|---|---|
| 22-24 | IPLOT(2) | 0 | Do not plot CP |
| | | 1 | Plot CP at each control point versus x location and versus meridional angle θ |
| 25-27 | IPLOT(3) | 0 | Not available |
| 28-30 | IPLOT(4) | 0 | Not available |
| 31-33 | NWCPT | 0 | Do not call BDYVEL. TAPE 4 input is not required |
| | | 1-600 | NWCPT values of I, XPT, YPT, ZPT control points are read from TAPE 4 and velocities induced by body source panels computed at these coordinates |
| | | -1 | NBODY values of XPT, YPT, ZPT control points are generated internally and velocities computed to test routine BDYVEL. TAPE 4 is not used. NBODY is the total number of source panels distributed over the body surface |
| 34-36 | NVTX | 0 | No body nose vortex strengths or Y and Z location data is read. All vortex contributions to velocities are set to zero |
| | | 1-10 | Vortex Y and Z locations, YVRTX and ZVRTX, and strengths, Γ/V are read for each of NXVTX x-stations, XV. Three cards are read for each vortex |
| 37-39 | NXVTX | 0 | No body nose vortex x-station data is read. All vortex contributions to velocities are set to zero |
| | | 1-10 | Body nose vortex x-body stations are read. These x values define the stations at which vortex Y, Z and Γ/V data will be read. One XV card is to be read. Maximum number of x-stations is 10 |
| 40-42 | NCPOUT | 0 | No control points are output on TAPE 4 |
| | | 1 | X,Y,Z body control points aft of XSTART and forward of XWLE are written in (I5, 3E12.5) format on TAPE 4. Conversely, options specified by NWCPT and NVLIN will not work |
| | | 2 | Same function as NCPOUT = 1 except program execution is terminated at that point |
| 43-45 | NVLIN | 0 | No vortex velocities are read |

| Column | Variable | Value | Description |
|---|---|---|---|
| | | 1 | Body source panel control point and V and W data are read for each of the x-stations aft of XSTART and forward of XWLE from TAPE 4 as defined previously for NCPOUT = 1. XCP, YCP, ZCP, VA and WA are read in (I5, 5E12.5) for each of the x-stations. Conversely, options defined by NWCPT and NCPOUT will not work. |

Card 3 - Option X-stations - Card 3 contains two real numbers punched in a 7-column field (2F7.0). Columns 73-80 may be used to identify the card. It is designated the XWLE card for reference. Card 3 reads the following:

| Column | Variable | Description |
|---|---|---|
| 1-7 | XWLE | x-station of wing root chord leading edge. This variable has two meanings:<br>1) For NWCPT>0, XWLE is the reference distance from zero of the body axis coordinate system to the reference zero of the lifting surfaces whose control points are to be read from TAPE 4. It is added to the x-values read for the control points.<br>2) For NCPOUT = 1 or NVLIN=1, XWLE is the aft boundary of control points to be output or read in. It would correspond to the leading edge of the wing or tail surface root chord |
| 8-14 | XSTART | x-station of start of region of additional velocity influence. For NCPOUT=1 or NVLIN=1, XSTART is the forward boundary of control points for which additional velocity components are computed or read in and control points calculated |

Note: The special force calculation computes the loadings acting on the body panels with control points between x-locations XSTART and XWLE. For this calculation to be valid between these values, the user should also make the x-locations of appropriate panel leading or trailing edges correspond to the XSTART and XWLE locations as prescribed on the XFUSK card.

The geometry of the configuration may either be symmetrical or nonsymmetrical about the y-0 plane (the plane of symmetry). The original configuration definition, which allowed only the description of symmetric configurations, may be used to define only one side of the configuration or to define a paneling sequence for both sides. The input of both sides of the geometry is also allowed. The convention used in this program for definition of a symmetric configuration is to present that half of the configuration located on the positive y side of the y=0 plane. The number of input cards depends on the number of segments and the amount of detail used to describe each component. In connection with the work described in this report, disregard all references to wings, tails, and pods.

Card 4 - Control integers - Card 4 contains 24 integers, each punched right justified in a 3-column field. Columns 73-80 may be used in any desired manner. It is designated the JCARD in the data deck for reference. Card 4 contains the following:

| Column | Variable | Value | Description |
|---|---|---|---|
| 1-3 | J0 | 0 | No reference area |
| | | 1 | Reference area to be read in |
| 4-6 | J1 | 0 | Wing data option - not available |
| 7-9 | J2 | 0 | No fuselage data |
| | | 1 | Data for arbitrarily shaped fuselage to be read |
| | | -1 | Data for circular fuselage in form of cross sectional areas versus XFUS to be read |
| | | -2 | Data for circular fuselage in form of radii versus XFUS to be read |
| | | -3 | Data for elliptic fuselage in form of semi-axis in y-direction and semi-axis in z-direction to be read (With J6=0, fuselage will be cambered. With J6= -1, fuselage will be symmetrical with xy-plane. With J6=1, entire configuration will be symmetrical with y=0 plane.) |
| 10-12 | J3 | 0 | Pod data option - not available |
| 13-15 | J4 | 0 | Fin data option - not available |
| 16-18 | J5 | 0 | Canard (horizontal tail) option - not available |
| 19-21 | J6 | 0 | A cambered circular or arbitrary fuselage if J2 is nonzero. Read ZFUS data cards (described later under fuselage data cards) |

| Column | Variable | Value | Description |
|---|---|---|---|
| | | 1 | Complete configuration is symmetrical with respect to xy-plane, which implies an uncambered circular fuselage |
| | | -1 | Uncambered circular fuselage with J2 nonzero |
| 22-24 | NWAF | 0 | Number of airfoil sections - not available |
| 25-27 | NWAFOR | 0 | Number of airfoil ordinates - not available |
| 28-30 | NFUS | 1-4 | Number of fuselage segments |
| 31-33 | NRADX(1) | 3-30 | Number of points used to represent the first fuselage segment about the circumference. If the configuration is symmetric (IXZSYM=0,1) NRADX is input for the half section. If the entire configuration is input (IXZSYM= -1) NRADX is input for the full section. If fuselage is circular, the program computes the indicated number of y- and z-ordinates |
| 34-36 | NFORX(1) | 2-30 | Number of x-stations for first fuselage segment |
| 34-39 | NRADX(2) | 3-30 | Same as NRADX(1), but for second fuselage sement |
| 40-42 | NFORX(2) | 2-30 | Same as NFORX(1), but for second fuselage segment |
| 43-45 | NRADX(3) | 3-30 | Same as NRADX(1), but for third fuselage segment |
| 46-48 | NFORX(3) | 2-30 | Same as NFORX(1), but for third fuselage segment |
| 49-51 | NRADX(4) | 3-30 | Same as NRADX(1), but for fourth fuselage segment |
| 52-54 | NFORX(4) | 2-30 | Same as NFORX(1), but for fourth fuselage segment |
| 55-57 | NP | 0 | Number of pods - not available |
| 58-60 | NPODOR | 0 | Number of pod stations - not available |
| 61-63 | NF | 0 | Number of fins - not available |
| 64-66 | NFINOR | 0 | Number of fin ordinates - not available |
| 67-69 | NCAN | 0 | Number of canards - not available |
| 70-72 | NCANOR | 0 | Number of canard ordinates - not available |

Card 5,6,... - remaining input data cards - The remaining input data cards contain a detailed description of the body component configuration. Each card contains up to 10 values, each value punched in a 7-column field with a decimal point (10F7.0 format) and may be identified in columns 73-80. The cards are arranged in the following order as required by the above options: reference area card and fuselage data cards.

Reference area card: The reference area value is punched in columns 1-7 and may be identified as REFA in columns 73-80.

Fuselage data cards: The first card (or cards) specifies the x-values of the fuselage stations of the first segment. There will be NFORX(1) values and the cards may be identified in columns 73-80 by the symbols XFUSJ where J denotes the number of the last fuselage station given on that card. If the fuselage is cambered (J2<0, and J6=0) the z-values of the fuselage centerline are read next. There will be NFORX(1) values of z at the above x-stations.

If the fuselage is circular or elliptical, the next card (or cards) is specified according to option J2. If J2= -1, the card contains NFORX(1) values of fuselage cross-sectional areas and may be identified in columns 73-80 by the symbol FUSARDJ where J denotes the number of the last fuselage stations given on that card. If J2= -2, the card contains NFORX(1) values of fuselage section radii, and may be identified in columns 73-80 by the symbol FUSRADJ. If J2= -3, two cards (or sets of cards) containing the elliptic body horizontal and vertical semi-axes are given. The first is the horizontal semi-axis and is designated by the symbol FUSBYJ. The second contains NFORX(1) values of the vertical semi-axis and is designated by the symbol FUSAZJ.

If the fuselage is of arbitrary shape, NRAD(1) values of the y-ordinates for a half section are given and identified in columns 73-80 as YJ where J is the station number. Following the y-ordinates are the NRADX(1) values of the corresponding z-ordinates for the half-section (or full section for IXZSYM= -1) identified in columns 73-80 as ZJ. Each station will have a set of y and z, and the convention of ordering the ordinates from bottom to top is observed. If the full section is given, the ordering continues from the top back to and including the bottom point to close the section.

For each fuselage segment a new set of cards as described must be provided. The segment descriptions should be given in the order of increasing values of x.

Description of Auxiliary Input Cards

Card 1 - Identification - Card 1 contains any desired identifying information in columns 1-80.

Card 2 - Boundary condition and control point definition - The specification of the lifting-surface boundary conditions are not applicable in the body alone version. This card also selects the output print options as originally described in reference 10. This card contains the following:

| Column | Variable | Value | Description |
|---|---|---|---|
| 1-3 | LINBC | 0 | Planar boundary condition - not available |
| 4-6 | THICK | 0 | Thickness option - not available |
| 7-9 | IPRINT | 0 | Print out the pressures and the forces and moments |
| | | 1 | Print out option 0 and spanwise loads on the wing, fins, and canards |
| | | 2 | Print out option 1 and the velocity components and source and vortex strengths |
| | | 3 | Print out option 2 and the steps in the iterative solution |
| | | 4 | Print out option 3 and the axial and normal velocity matrices |

A negative value of print adds the panel geometry print out to the output indicated for options 1 through 4.

LINBC, THICK, and IPRINT are punched as right justified integers.

Card 3 - Revised configuration paneling description control integers - The contents of card 2 are punched as right justified integers as follows:

| Column | Variable | Value | Description |
|---|---|---|---|
| 1-3 | K0 | 0 | No reference lengths |
| | | 1 | Reference length data to be read |

| Column | Variable | Value | Description |
|---|---|---|---|
| 4-6 | K1 | 0 | No wing data - not available |
| 7-9 | K2 | 0 | No body data |
| | | 1 | Body data follows |
| 10-12 | K3 | | Not used |
| 13-15 | K4 | 0 | No fin (vertical tail) data - not available |
| 16-18 | K5 | 0 | No canard (horizontal tail) data - not available |
| 19-21 | K6 | | Not used |
| 22-24 | KWAF | 0 | Number of wing sections - not available |
| 25-27 | KWAFOR | 0 | Number of wing ordinates - not available |
| 28-30 | KFUS | | The number of fuselage segments. The program sets KFUS = NFUS |
| 31-33 | KRADX(1) | 0,<br>3-20 | Number of meridian lines used to define panel edges on first body segment. There are three options for defining the panel edges. If KRADX(1) = 0, the merdian lines are defined by NRADX(1) in the geometry input. If KRADX(1) is positive, the meridian lines are calculated at KRADX(1) equally spaced PHIKs. If KRADX(1) is negative, the meridian lines are calculated at specified values of PHIK. For symmetric configurations (IXZSYM=0,1), KRADX is the number of meridians on the half-section. For full configurations (IXZSYM=1), KRADX is the number of meridians on the full section including meridians at 0° and 360° |
| 34-36 | KFORX(1) | 0,<br>2-30 | Number of axial stations used to define leading and trailing edges of panels on first body segment. If KFORX(1) = 0, the panel edges are defined by NFORX(1) in the geometry input |
| 37-39 | KRADX(2) | 0,<br>3-20 | Same as KRADX(1), but for second body segment |
| 40-42 | KFORX(2) | 0,<br>2-30 | Same as KFORX(1), but for second body segment |
| 43-45 | KRADX(3) | 0,<br>3-20 | Same as KRADX(1), but for third body segment |
| 46-48 | KFORX(3) | 0,<br>2-30 | Same as KFORX(1), but for third body segment |

| Column | Variable | Value | Description |
|---|---|---|---|
| 49-51 | KRADX(4) | 0,<br>3-20 | Same as KRADX(1), but for fourth body segment |
| 52-54 | KFORX(4) | 0,<br>2-30 | Same as KFORX(1), but for fourth body segment |

The program is restricted to 600 body singularity panels. For this program there is an additional restriction that the total number of singularity panels in the axial direction on the body (fuselage) cannot exceed 30. The arbitrary body (fuselage) capability of this program is limited to those shapes for which the radius is a single-valued function of PHIK for each cross section of the body.

Card 4,5,... - remaining input data cards - The remaining input data cards contain a detailed description of the singularity paneling of each component of the configuration. Each card contains up to 10 values, each value punched in a 7-column field with a decimal point (10F7.0 format) and may be identified in columns 73-80. The cards are arranged in the following order as required by the above options: reference lengths, vortex x-station card, and fuselage (body) data cards.

Reference length card: This card may be identified as REFL in columns 73-80 and contains the following:

| Column | Variable | Description |
|---|---|---|
| 1-7 | REFA | Wing reference area. If REFA = 0, the reference area is defined by the value of REFA in the geometry input |
| 8-14 | REFB | Wing semispan - not used |
| 15-21 | REFC | Wing reference chord - not used |
| 22-28 | REFD | Body (fuselage) reference diameter. If REFD = 0, a value of 1.0 is used for the reference diameter. This reference length is used to non-dimensionalize all moment coefficients |
| 29-35 | REFL | Body (fuselage) reference length. If REFL = 0, a value of 1.0 is used for the reference length |
| 36-42 | REFX | x coordinate of moment center |
| 43-49 | REFZ | z coordinate of moment center |

Vortex x-station card: This card is read if NXVTX is greater than zero. It is identified in columns 73-80 by the symbol XV. This card contains NXVTX values (maximum is 10) of the x-stations at which vortex strength and location will be input later, XV. These locations constitute the table in which the strength of the vortices will be obtained for each control point on the body in order to compute the cross flow solutions due to the presence of discrete vortices. The first and last x-values in this table also constitute boundaries between which vortex solutions will be computed. Outside of this range of x-stations, the contribution of the vortices will be set to zero. The values XV are punched in up to ten 7-column fields (10F7.0 format). The interpolation is currently limited by dimensions to 10 values of XV.

Fuselage (body) data cards: If KRADX(1) is negative, the first body card is the body meridian angle card. This card contains KRADX(1) values of body meridian angle expressed in degrees and may be identified in columns 73-80 as PHIKJ where J denotes the body segment number. The convention is observed that PHIK = 0, is at the bottom of the body and PHIK = 180, is at the top of the body. Repeat this card for each fuselage segment.

If KFORX(1) is non-zero, the second body card is the body axial station card. This card contains KFORX(1) values of the x-ordinate of the body axial stations and may be identified in columns 73-80 as XFUSKJ where J denotes the body segment number. Repeat this card for each fuselage segment. If forces and moments are to be integrated between values of XSTART and XWLE, the panel boundaries specified in XFUSK should correspond to one or both of these values where appropriate.

If either of these cards are omitted, the program generates the values internally from the previous configuration definition.

Description of case control cards

Card 1 - Mach number and angle of attack card - This card may be identified in columns 73-80 as MALPHA and contains the following in three 7-column fields:

| Column | Variable | Description |
|---|---|---|
| 1-7 | MACH | The subsonic Mach number (including the value MACH = 0.) or the supersonic MACH number at which it is desired to calculate the aerodynamic data |
| 8-14 | ALPHAC | Included angle of attack at which it is desired to calculate the aerodynamic data, measured in degrees between the free-stream velocity vector and the body centerline |
| 15-21 | PHIR | Angle of roll, measured in degrees from the plane containing the free-stream velocity vector and the body centerline (the z-axis) positive clockwise |

A value of MACH = -1 on this card signifies the termination of the present case. Geometry cards for a new case can follow such a terminal card.

Card 2,3,4... - Vortex strength and locations cards - If NVTX is greater than one, three cards are read for each of NVTX number of vortices. Each of the cards contains up to ten values punched in 7-column fields (10F7.0 format).

The first vortex card contains the y-location of the vortex at each of the x-stations on the XV card. There are NXVTX values on the card which is designated by the symbol YVRTXI where I is the vortex number in columns 73-80.

The second vortex card contains the z-location of the vortex at each of the x-stations on the XV card. There are NXVTX values on the card which is designated by the symbol ZVRTXI where I is the vortex number in columns 73-80.

The third vortex card contains the vortex strength divided by free stream velocity, Γ/V, of the vortex at each of the x-stations on the XV card. There are NXVTX values on the card which is designated by the symbol GAMI where I is the vortex number in columns 73-80.

A series of Mach number, angle of attack, and vortex card combinations for the same geometry may be calculated by repeating this sequence of case control cards with the desired values. If the case control sequence has been terminated by MACH = -1 on the MALPHA card an attempt to read a new set of geometry will be made. The program will terminate if no cards exist by testing for the end of file.

## Description of Output

This section describes the minimum output for the body source panel program, WDYBDY. This output occurs when IPRINT = -3 and IPRT(1)=1 in the input. All primary output items are summarized here. The outputs associated with source panel properties is described in detail in reference 10 and will only be mentioned here. A sample is given in connection with the description of the second calculative example, Section 6.2 and figure 26. For general reference the subroutine names from which the print was made is written starting in column 110 between two asterisks for the first occurrence of print within a routine. Wherever possible these identifications will be used in specifying the output to be described.

The first page of output is the list of the input cards copied directly from TAPE 5, on which it is stored, as card images. The input is rewound after copying to the output file (TAPE 6), and read again by the program as needed.

The next two (or more pages) are a copy of the input data with its mnemonic name or function as it is read from the input. The output is in the following order: the run title and option summary read in GEOM, the vehicle geometry cards as read by CONFIG, and the paneling title card and options as read by GEOM. If NXVTX>0, routine READVX prints a summary of body x-stations (XV) as read from input and the horizontal and vertical semi-axes of an elliptic section at those stations (BY and AZ). The horizontal and vertical axes are computed by interpolation in the program input geometry.

The next page is a summary of the body panel corner point coordinates as generated in BODPAN. The x,y,z coordinates of each corner point of each panel is printed. The next page is a summary of the x, y, and z coordinates of the body source panel centroids. The next page is a summary of the body panel areas and inclination angles in radian and degrees. The angle DELTA is the inclination of the source panel to the body x-axis and the angle THETA is the angle between the leading edge of the panel and the body y-axis. These angle are indicated in the shock of Section 4.1. Additional output may be obtained for debugging purposes at the end of the geometry calculations as specified by the print options IPRT(2) and IPLOT(1).

The output from VELCMP is printed next summarizing the aerodynamic velocity matrix computations. The normal output is a summary of the numbers of panels and the CPU time required for the calculation of the velocity matrix coefficients. Output of the coefficients may be obtained from IPRINT=±4. If the number of panels exceeds sixty, the solution vector is printed for intermediate iterations.

After the aerodynamic matrix has been computed a new case is begun from WDYBDY. This consists of the solution for the source strengths for a given Mach number, angle of attack, $\alpha_c$, and angle of roll, $\phi$. If the Mach number changes between cases, the program goes back to recompute the aerodynamic matrix.

The output from ELBDVT, concerned with body nose vorticity, is given next. A copy of the input y and z locations and the vortex strength, $\Gamma/V$, is printed first for the I'th vortex. This print is controlled by the option IPRT(1). A vortex interpolation table summarizing the strengths and locations of each of the discrete vortices to be used by VVELS in the computation of velocities induced by the nose separation vortices. The vortex trajectory is defined by XV, YVRTX, and ZVRTX for an elliptic body with horizontal and vertical semi-axes, BY and AZ. An additional debug output may be obtained for IPRT(3)=1 which summarizes the vortex properties at each of the control points as the velocities are computed.

The next page of output is printed from SOLVE summarizing the velocities on the body. For each of the panels the source strength, GB, and the axial, lateral and vertical velocity components, u, v, w, and the resultant inward normal, NB, due to only the source strength are given. In addition the velocity contributions due to discrete external vortices in the lateral and vertical directions, VA and WA, are printed. All velocity components are assumed to be positive in their respective positive coordinate directions. The sum of the contributions of the velocities due to source panels and discrete vortices is used in the calculation of pressures.

The next page of output is printed from FORMOM. It contains a summary of the forces on the panels due to the pressure acting on each of the panels. At each control point with coordinates X, Y, Z, and polar angle, THETP, measured positive counterclockwise from the positive y-axis, the pressure coefficient, CP, and the panel forces, CX, CY, and CZ acting along the body coordinate axes, and the moments of these forces about the reference center about each of the axes, CLL, CM, and CLN, are given. The pressure coefficient, CP, has a minimum value corresponding to zero static pressure, equation 11. The sense of the axial force, CX, is positive acting aft on the body; the force CY is positive acting to the right; and the force CZ is positive acting up. The pitching moment, CM, is positive nose up about the y-axis; the yawing moment, CLN, is positive nose right viewing downwards about the z-axis; and the rolling moment, CLL, is positive clockwise viewing forwards about the x-axis.

The total coefficients on the body are printed on the next page. These are the sum of the force components of the individual panels described above. The forces in the body coordinate system, CX, CY, and CZ are normalized bv the reference area, REFA. The moments, CM, CLN, and CLL, have been normalized by the product of the reference area and the reference diameter, REFD. The moments are taken about the center, (REFX, 0, REFZ). The x-location of the center of pressure, XCP, is printed as computed from the ratio, -CM/CZ. The force and moment coefficients are also specified in the wind axis system, see Section 4.2.

If distinct values of XSTART and XWLE have been specified the next two pages are a repeat of the previous two pages with the difference that only the forces and moments between XSTART and XWLE are computed. The total force coefficients are then the sum of the forces acting on panels between the above two variables. The program only checks on the location of control points within the x-range specified. For the integration to be valid the user must make the leading edges of the first ring of panels inside the range correspond to XSTART and the trailing edges of the last ring of panels in the range must correspond to XWLE. This is necessary since only the integration over whole panels is within the current capability of the program.

APPENDIX K

The next page is printed when NWCPT≠0. It is a summary of the calculation of velocity components at specified field points. If NWCPT>0, the field points are read from TAPE 4 as created by program DEMON2. If NWCPT<0, the control points for panels generated within WDYBDY are used. In this case the velocities should reproduce the results first printed in SOLVE. The information printed by BDYVEL for each panel are the X, Y, Z of each field point at which the velocities is computed, the inclination angles, DELTA and THETA, and the velocity components, U, V, and W, in the coordinate axis directions, and the resultant outward normal velocity to the panel. The inclination angles $\delta$ and $\theta$ are defined either in the geometry definition. When the field points are read from TAPE 4 the angles are printed out as zero for the lack of better information.

This is the last page for a given case. The program will continue to read additional Mach number and $\alpha_c$ cases or new configurations until the end of data is reached. The output also continues to repeat as specified. The use of TAPE 4, however, is not organized to handle multiple cases at this time.

## PROGRAM LISTINGS

The body modeling program is written in FORTRAN IV (029 punch) computer language for the CDC 6600 computer. The program consists of a main program, WDYBDY, and 42 subroutines. A listing of the program subroutine names in alphabetical order follows.

### PROGRAM WDYBDY

| | ROUTINE | IDENTIFICATION col 73-76 | PAGE NO. |
|---|---|---|---|
| 1. | WDYBDY (main program) | WB01 | 312 |
| 2. | BDYVEL | WB02 | 313 |
| 3. | BODPAN | WB03 | 317 |
| 4. | BODVEL | WB04 | 319 |
| 5. | CDUMP | WB05 | 322 |
| 6. | CPUTIM | WB06 | 324 |
| 7. | COMCU | WB07 | 325 |

| ROUTINE | | IDENTIFICATION col 73-76 | PAGE NO. |
|---|---|---|---|
| 8. CONFIG | | WB08 | 326 |
| 9. CUBIC2 | | WB09 | 333 |
| 10. DBLU | | WB10 | 333 |
| 11. DERIV | | WB11 | 334 |
| 12. DERIV1 | | WB12 | 334 |
| 13. DERIV2 | | WB13 | 334 |
| 14. DIAGIN | | WB14 | 335 |
| 15. DSDZ | | WB15 | 336 |
| 16. DZDS | | WB16 | 336 |
| 17. ELBDVT | | WB17 | 336 |
| 18. FORMOM | | WB18 | 338 |
| 19. GEOM | | WB19 | 342 |
| 20. INVERT | | WB20 | 345 |
| 21. ITRATE | | WB21 | 346 |
| 22. MXOUT | | WB22 | 349 |
| 23. NEWRAD | | WB23 | 351 |
| 24. PANEL | | WB24 | 353 |
| 25. PARTIN | | WB25 | 356 |
| 26. PLOTA2 | Note: these subroutines are to be stored in LIBRARY(PLOTS) called by VPATH2,VPATHL, WDYBDY | WB26 | 357 |
| 27. PLOTA3 | | WB27 | 360 |
| 28. PLOTA5 | | WB28 | 363 |
| 29. PLOTA6 | | WB29 | 363 |
| 30. PLOTA7 | | WB30 | 365 |
| 31. PLOTA8 | | WB31 | 366 |
| 32. PLOTG | | WB32 | 370 |
| 33. PLOTV2 | " " | WB33 | 372 |
| 34. PRESS | | WB34 | 376 |
| 35. PRTCPT | | WB35 | 377 |
| 36. READVX | | WB36 | 378 |
| 37. RDVEL | | WB37 | 379 |

APPENDIX K

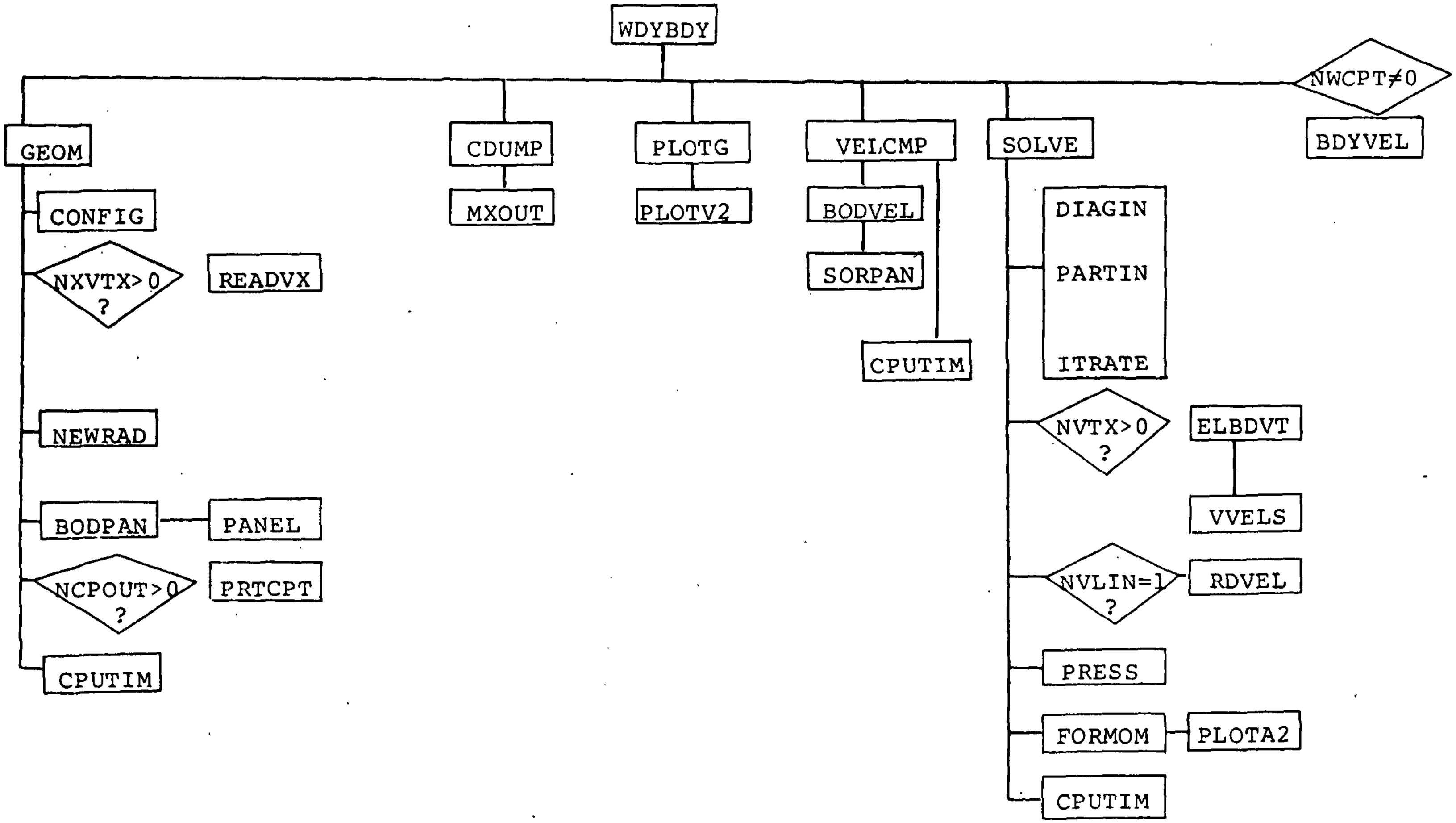

Figure K-1.- Program Subroutine Flow

## PROGRAM WDYBDY

```
      PROGRAM WDYBDY(OUTPUT,TAPE6=OUTPUT,TAPE4,TAPE5,TAPE7,
     1 TAPE8,TAPE9,TAPE10)
C     PROGRAM WDYBDY(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7,
CDC   OVERLAY(LWB,0,0)
C
C ----------------------------------------------------------------------
C  BODY ONLY VERSION:                            JOE MULLEN,  JUNE, 1977
C ----------------------------------------------------------------------
C
C     PROGRAM WDYBDY COMPUTES THE SUBSONIC AND SUPERSONIC POTENTIAL
C     FLOW AERODYNAMIC CHARACTERISTICS OF BODY CONFIGURATIONS.
C     THE BODY IS REPRESENTED BY SOURCE PANELS.
C     THE THEORY IS DESCRIBED IN NASA CR-2228 (PART I) AND THE
C     COMPUTER PROGRAM IS DESCRIBED IN NASA CR-2228 (PART II).
C
C     A CONVERGENCE CRITERIA TEST HAS BEEN INCORPORATED INTO SUBROUTINE
C     ITRATE TO CONTROL THE ITERATIVE SOLUTION PROCEDURE. THE MAXIMUM
C     NUMBER OF ITERATIONS AND THE CONVERGENCE CRITERIA TEST PARAMETER
C     HAVE BEEN ADDED TO THE PROGRAM INPUT.
C
C     THE FOLLOWING ARE LIMITATIONS OR KNOWN PROBLEMS
C
C     THE PROGRAM IS INTENDED TO HANDLE 600 BODY PANELS,
C     HOWEVER THE INPUT SPECIFIES CUTTING PLANES RATHER THAN
C     PANELS WHICH MAY LIMIT THE INPUT TO DEFINING LESS THAN 600 PANELS.
C
C     THE PROGRAM WILL NOT HANDLE NACELLES.
C
C     THE TRAILING VORTEX SHEET FROM THE WING LEAVES THE TRAILING EDGE
C     IN A PLANE PARALLEL TO THE X AXIS.
C
      COMMON /PARAM / NBODY,NWING,NTAIL,LBC,THK,XMACH,ALPHA,BETA,ALPHAC
     1    ,PHIR,REFA,REFB,REFC,REFD,REFL,REFX,REFZ
      COMMON /VELCOM/ NPOINT,NPART,IMAX,JMAX,NMAX,EM,IPRINT,NWTHK
     1    ,NWBLOK,NWROW(20),NBBLOK,NBROW(60)
      COMMON /JOPTNS/ IZ1(60)
     *    ,NCPOUT,XSTART,XWLE,NWCPT,IPLOT(4),IPRT(5),IXZSYM
      DIMENSION ICARD(8)
C
      CALL CPUTIM(TIME,DT,0)
      EM=-1.
      XMACH=-1.
      REWIND 5
      WRITE (6,90)
      WRITE (6,100)
C
C   LIST INPUT CARDS
C
10    READ (5,110) ICARD
      IF (EOF(5)) 30,20,30
20    WRITE (6,120) ICARD
      GO TO 10
30    CONTINUE
      REWIND 5
50    WRITE (6,70)
C
C   INPUT CONFIGURATION GEOMETRY AND COMPUTE PANELS
C
      CALL GEOM
CDC   CALL OVERLAY (LWB,1,0)
C
C  GENERATE INTERMEDIATE PRINT AND PLOT GEOMETRY
C
```

```
      CALL CDUMP(IPRT(2),8HEND=GEOM)
      IF (IPLOT(1).GT.0) CALL PLOTG
C
C   INPUT MACH NUMBER AND COMPUTE AERODYNAMIC MATRIX
C   A NEGATIVE MACH NUMBER IS USED TO TERMINATE MACH NUMBER AND ANGLE
C   OF ATTACK CASES FOR A GIVEN GEOMETRY
C
60    CONTINUE
      CALL VELCMP
CDC   CALL OVERLAY (LWB,2,0)
      CALL CDUMP(IPRT(4),8HEND=VELC)
      IF (XMACH.LT.0.) GO TO 50
      WRITE (6,80)
C
C   SOLVE RESULTING MATRIX EQUATIONS AND
C   COMPUTE PRESSURES, FORCES, AND MOMENTS
C
      CALL SOLVE
CDC   CALL OVERLAY (LWB,3,0)
      CALL CDUMP(IPRT(5),8HEND=SOLV)
C
C  COMPUTE ARBITRARY FIELD POINT VELOCITIES
C
      IF (NWCPT.NE.0) CALL BDYVEL
      GO TO 60
   70 FORMAT (1H1,20X,25HBEGIN A NEW CONFIGURATION,64X,12H** WDYBDY **)
   80 FORMAT (1H1,20X,16HBEGIN A NEW CASE,73X,12H** WDYBDY **)
   90 FORMAT (1H1,10X,37HWOODWARD*S SOURCE PANEL BODY MODELING,
     1 8H PROGRAM,10X,16HDATED JUNE, 1977/)
  100 FORMAT (1H0,25X,19HLIST OF INPUT CARDS//)
  110 FORMAT (8A10)
  120 FORMAT (10X,8A10)
      END
```

```
      SUBROUTINE BDYVEL
C
C  COMPUTE THE THREE COMPONENTS OF VELOCITY INDUCED AT SPECIFIED
C  FIELD  POINTS BY THE BODY PANELS.  GIVEN THE STRENGTHS, GB, OF
C  BODY SOURCE PANELS COMPUTE THE FLU  VELOCITY COMPONENTS INDUCED
C  BY BODY SOURCE PANELS AT SPECIFIED POINTS (I.E. WING MONOPLANE
C  CENTROIDS)
C
      COMMON /JOPTNS/ IZ1(62),XWLE,NWCPT,IPLOT(4),IPRT(5),IXZSYM
      COMMON /PARAM / NBODY,NWING,NTAIL,LBC,THK,XMACH,ALPHA,BETA,ALPHAC
     1   ,PHIR,REFA,REFB,REFC,REFD,REFL,REFX,REFZ
      COMMON /VELCOM/ NPOINT,NPART,IZ4(2),NMAX,EM,IPRINT,NWTHK
     1   ,NWBLOK,NWROW(20),NBBLOK,NBROW(60)
      COMMON /NEWCOM/K1,KWAF,KWAFOR,KRADX(4),KFORX(4),KFUS,MAX,K4,K5
     1   ,KF(6),KAN(6),KFINOR(6),KANOR(6),KOL,NCPT,LOCPT(20),XCPT(20)
      COMMON          U(600),V(600),W(600),VI(600),WI(600),AN(600),
     1   ZB(600),XBT(600),YBT(600),ZBT(600),GW(600),GB(600),Z9(600)
      COMMON /POINT / XPT(600),YPT(600),ZPT(600),THET(600),DELTA(600),
     1   XC(30,20),YC(30,20),ZC(30,20),DELTI(600),XLE(600)
      COMMON /BODCOM/ AMACH,TANO,CX,XCOR(4),YCOR(4),ZCOR(4)
     1   ,XI,YI,ZI,XJ,ZJ
      COMMON /BTHET / THETA(600)
C
      DIMENSION ARRAY(6000)
```

```
      EQUIVALENCE                      (XPT(1),ARRAY(1))
      LOGICAL LBC
      DATA RADDEG/0.0174532926/
      DATA ICASE/0/
      ICASE=ICASE+1
C
      AMACH=XMACH
C
C  READ BODY GEOMETRY COORDINATES
C
      IF (NBODY.LE.0) RETURN
      REWIND 7
      READ (7) ARRAY
      DO 10 I=1,NBODY
      DELTI(I)=DELTA(I)
      THETA(I)=THET(I)
      XBT(I) = XPT(I)
      YBT(I) = YPT(I)
10    ZBT(I) = ZPT(I)
C
C  READ WING CONTROL POINTS
C
      IF (NWCPT.LT.0 .OR. ICASE.GT.1) GO TO 30
C
C  IF NWCPT IS LESS THAN 0 USE BODY POINTS*
C  IF NWCPT IS GREATER THAN 0 READ POINTS FROM INPUT FILE ON TAPE4
C
      REWIND 4
      READ (4,745) NWBP
      READ (4,745) (J,XPT(I),YPT(I),ZPT(I),I=1,NWCPT)
      DO 20 I=1,NWCPT
      THET(I)=0.0
      DELTI(I)=0.0
      XPT(I)=XPT(I)+XWLE
20    CONTINUE
C
C  FIND END OF CONTROL POINT DATA ON TAPE 4.
C
      JP1=NWCPT+1
      IF (NWBP.GT.NWCPT) READ (4,745) (J,XDUM,YDUM,ZDUM,I=JP1,NWBP)
30    IF (NWCPT.LT.0) NWCPT=NBODY
C
C  I IS THE INDEX OF THE FIELD POINT
C  J IS THE INDEX OF THE INFLUENCING PANEL
C
      WRITE(6,170)
C
C     COORDINATES OF I*TH FIELD POINT
C
      DO 110 I=1,NWCPT
      SINTI=SIN(THET(I))
      COSTI=COS(THET(I))
      XPTI=XPT(I)
      YPTI=YPT(I)
      ZPTI=ZPT(I)
C
C             BODY PANEL INCIDENCE ANGLE
C
      SIND=SIN(DELTA(I))
      COSD=COS(DELTA(I))
     SUMU = 0.
     SUMV = 0.
     SUMW = 0.
```

```
      SUMN = 0.                                                         WB02  88
      J=0                                                               WB02  89
      JPN=0                                                             WB02  90
      L=0                                                               WB02  91
      DO 70 KFU=1,KFUS                                                  WB02  92
      NROW=KRADX(KFU)-1                                                 WB02  93
      NCOL=KFCRX(KFU)-1                                                 WB02  94
      DO 60 MC=1,NCOL                                                   WB02  95
      L=L+1                                                             WB02  96
      JP1=1+JPN                                                         WB02  97
      JPN=JP1+NROW-1                                                    WB02  98
      DO 50 N=1,NROW                                                    WB02  99
      J=J+1                                                             WB02 100
      TAND=TAN(DELTA(J))                                                WB02 101
      COST=COS(THETA(J))                                                WB02 102
      SINT=SIN(THETA(J))                                                WB02 103
      XW=SINT*COSTI                                                     WB02 104
      XX=COST*SINTI                                                     WB02 105
      XY=COST*COSTI                                                     WB02 106
      XZ=SINT*SINTI                                                     WB02 107
      SINTR=XW-XX                                                       WB02 108
      COSTR=XY+XZ                                                       WB02 109
      NP1=N+1                                                           WB02 110
      XC1=XC(L,NP1)                                                     WB02 111
      YC1=YC(L,NP1)                                                     WB02 112
      ZC1=ZC(L,NP1)                                                     WB02 113
C                                                                       WB02 114
C  CALCULATION OF PANEL CORNER POINTS IN PANEL COORDINATE SYSTEM        WB02 115
C                                                                       WB02 116
      XCOR(1)=0.                                                        WB02 117
      YCOR(1)=0.                                                        WB02 118
      ZCOR(1)=0.                                                        WB02 119
      XCOR(2)=XC(L+1,NP1)-XC1                                           WB02 120
      XCOR(3)=0.                                                        WB02 121
      XCOR(4)=XCOR(2)                                                   WB02 122
      DO 40 K=2,4                                                       WB02 123
      LP1=L+1                                                           WB02 124
      NP1=N+1                                                           WB02 125
      IF (K.GE.3) NP1=N                                                 WB02 126
      IF (K.EQ.3) LP1=L                                                 WB02 127
      DELY=YC(LP1,NP1)-YC1                                              WB02 128
      DELZ=ZC(LP1,NP1)-ZC1                                              WB02 129
      YCOR(K)=DELY*COST+DELZ*SINT                                       WB02 130
      ZCOR(K)=DELZ*COST-DELY*SINT                                       WB02 131
40    CONTINUE                                                          WB02 132
      CX=XCOR(2)                                                        WB02 133
C                                                                       WB02 134
C  CALCULATION OF FIELD   POINT IN PANEL COORDINATE SYSTEM              WB02 135
C                                                                       WB02 136
      XI=XPTI-XC1                                                       WB02 137
      DY=YPTI-YC1                                                       WB02 138
      DZ=ZPTI-ZC1                                                       WB02 139
      YI=DY*COST+DZ*SINT                                                WB02 140
      ZI=DZ*COST-DY*SINT                                                WB02 141
      XJ=XBT(J)-XC1                                                     WB02 142
      DYJ=YBT(J)-YC1                                                    WB02 143
      DZJ=ZBT(J)-ZC1                                                    WB02 144
      ZJ=DZJ*COST-DYJ*SINT                                              WB02 145
C                                                                       WB02 146
C  CALCULATE VELOCITY COMPONENTS INDUCED BY CONSTANT SOURCE             WB02 147
C  DISTRIBUTION PANELS                                                  WB02 148
C                                                                       WB02 149
      CALL SORPAN(UR,VR,WR)                                             WB02 150
```

```
      UBJ=UR
      VIJ=VR*COSTR-WR*SINTR
      WIJ=VR*SINTR+WR*COSTR
      UL=0.
      VL=0.
      WL=0.
C
C   CALCULATE VELOCITY COMPONENTS FROM LEFT SIDE FOR SYMMETRIC
C   CONFIGURATIONS INDUCED BY CONSTANT SOURCE PANEL
C
      IF (IXZSYM.NE.0) GO TO 45
      SINTL=XW+XX
      COSTL=XY-XZ
      DY=-YPTI-YC1
      YI=DY*COST+DZ*SINT
      ZI=DZ*COST-DY*SINT
      CALL SORPAN(UL,VL,WL)
      UBJ=UBJ+UL
      VIJ=VIJ-VL*COSTL+WL*SINTL
      WIJ=WIJ+VL*SINTL+WL*COSTL
45    CONTINUE
C
C
      VBJ=VIJ*COSTI-WIJ*SINTI
      WBJ=WIJ*COSTI+VIJ*SINTI
      ANJ=WIJ*COSD-UBJ*SIND
      SUMU = SUMU+UBJ*GB(J)
      SUMV = SUMV+VBJ*GB(J)
      SUMW = SUMW+WBJ*GB(J)
      SUMN = SUMN+ANJ*GB(J)
50    CONTINUE
60    CONTINUE
70    CONTINUE
C
C   COMPUTE VELOCITY AT I*TH FIELD POINT
C
      U(I) = SUMU
      V(I) = SUMV
      W(I) = SUMW
      ALP=ALPHA*RADDEG
      PHI=PHIR*RADDEG
      SINAL=SIN(ALP)
      COSAL=COS(ALP)
      SINB=SINAL*SIN(PHI)
      SINA=SINAL*COS(PHI)
      BNI=COSAL*SIN(DELTA(I))+COS(DELTA(I))*(-SINA*COS(THET(I))
     *     +SINB*SIN(THET(I)))
C
C
      WRITE(6,180) I,XPT(I),YPT(I),ZPT(I),THET(I),DELTA(I)
     *  ,U(I),V(I),W(I),SUMN
110   CONTINUE
C
C   WRITE VELOCITIES INDUCED AT FIELD POINTS AFTER CONTROL POINT DATA
C      ON TAPE 4.
C
      WRITE(4,745) NWCPT,XMACH,ALPHAC,PHIR
      WRITE(4,745) (I,U(I),V(I),W(I),I=1,NWCPT)
      RETURN
C
170   FORMAT (1H1,10X,44HPERTURBATION VELOCITIES AT SPECIFIED CONTROL
     *    24H POINTS BY SOURCE PANELS ,31X,12H** BDYVEL **
     *    ,//7X,13HCONTROL POINT,20X,12HPANEL ANGLES,10X,10HVELOCITIES,
```

```
     *    //6H  JCPT,5X,1HX,9X,1HY,9X,1HZ,7X,4HTHET,5X,5HDELTA,8X,1HU       WB02 214
     *    ,9X,1HV,9X,1HW,6X,6HNORMAL/)                                      WB02 215
180   FORMAT(I5,5F10.5,5F10.5)                                              WB02 216
745   FORMAT(I5,3E12.5)                                                     WB02 217
      END                                                                   WB02 218




      SUBROUTINE BODPAN                                                     WB03   1
CDC   OVERLAY (LWB,1,5)                                                     WB03   2
CDC   PROGRAM BODPAN                                                        WB03   3
C                                                                           WB03   4
C   REVISE AXIAL SPACING ON BODY (FUSELAGE) AND COMPUTE NEW PANEL           WB03   5
C   GEOMETRY                                                                WB03   6
C                                                                           WB03   7
      COMMON /JOPTNS/ IZ1(8)                                                WB03   8
     1    ,J0,J1,J2,J3,J4,J5,J6,NWAF,NWAFOR,NFUS,NRADX(4),NFORX(4)          WB03   9
     2    ,NP,NBODOR,NF,NFINOR,NCAN,NCANOR,J2TEST,NW                        WB03  10
     3    ,IZ2(34),IPRT(5),IXZSYM                                           WB03  11
      COMMON /PARAM / NBODY,NWING,NTAIL,LBC,THK,XMACH,ALPHA,BETA,ALPHAC WB03  12
     1    ,PHIR,REFA,REFB,REFC,REFD,REFL,REFX,REFZ                          WB03  13
      COMMON          BLOCK(7500)                                           WB03  14
      COMMON /POINT / ARRAY(6000)                                           WB03  15
      COMMON /NEWCOM/ K1,KWAF,KWAFOR,KRADX(4),KFORX(4),KFUS,MAX,K4,K5       WB03  16
     1    ,KF(6),KAN(6),KFINOR(6),KANOR(6),KOL,NCPT,LOCPT(20),XCPT(20)      WB03  17
      COMMON /VELCOM/ NPOINT,NPART,IZ4(2),NMAX,EM,IPRINT,NWTHK              WB03  18
     1    ,NWBLOK,NWROW(20),NBBLOK,NBROW(60)                                WB03  19
      COMMON /BTHET / THETA(600)                                            WB03  20
C                                                                           WB03  21
      DIMENSION XB(30),YB(30,30),ZB(30,30),XJ(60),AREA(600),XPT(600),       WB03  22
     1 YPT(600),ZPT(600),THET(600),DELTA(600),XC(30,20),YC(30,20),          WB03  23
     2 ZC(30,20),XFUS(30,4)                                                 WB03  24
C                                                                           WB03  25
      EQUIVALENCE (BLOCK(1),XFUS(1,1)), (BLOCK(121),YB(1,1))                WB03  26
     1    ,(BLOCK(5721),XB(1)),          (BLOCK(1921),ZB(1,1))              WB03  27
      EQUIVALENCE (XPT(1),ARRAY(1)),    (YPT(1),ARRAY(601))                 WB03  28
     *    ,(ZPT(1),ARRAY(1201)),        (THET(1),ARRAY(1801))               WB03  29
     *    ,(DELTA(1),ARRAY(2401)),      (XC(1,1),ARRAY(3001))               WB03  30
     *    ,(YC(1,1),ARRAY(3601)),       (ZC(1,1),ARRAY(4201))               WB03  31
     *    ,(AREA(1),ARRAY(4801))                                            WB03  32
C                                                                           WB03  33
      XIN(X1,Y1,X2,Y2,Y)=X1+(X2-X1)*(Y-Y1)/(Y2-Y1)                          WB03  34
C                                                                           WB03  35
      RADEG=180./3.141592654                                                WB03  36
      REWIND 10                                                             WB03  37
      IF (IPRINT.LT.0) WRITE (6,220)                                        WB03  38
C                                                                           WB03  39
C   CALCULATE COORDINATES OF PANEL CORNERS                                  WB03  40
C               JP = INDEX OF PANEL NUMBER (TOTAL=NBODY)                    WB03  41
C               JM = TOTAL NUMBER OF AXIAL STATIONS (MAX=30)                WB03  42
C                                                                           WB03  43
10    J=1                                                                   WB03  44
      L=0                                                                   WB03  45
      JP=0                                                                  WB03  46
      JM=0                                                                  WB03  47
      DO 120 NFU=1,NFUS                                                     WB03  48
      KFUSOR=KFORX(NFU)                                                     WB03  49
      NFUSOR=NFORX(NFU)                                                     WB03  50
      KRAD=KRADX(NFU)                                                       WB03  51
      KRAD=IABS(KRAD)                                                       WB03  52
      IF (KRAD.EQ.0) KRAD=NRADX(NFU)                                        WB03  53
```

```
      READ (10) XB,YB,ZB
      IF (KFUSOR.EQ.0) GO TO 20
C
C   READ IN NEW AXIAL STATIONS (XJ) FOR BODY (FUSELAGE)
C
      READ (5,210) (XJ(K),K=1,KFUSOR)
      GO TO 50
20    KFUSOR=NFORX(NFU)
      IF (KFUSOR.LE.30) GO TO 30
      WRITE (6,190) NFU
      STOP 20
C
C  USE ORIGINAL AXIAL STATIONS XJ=XFUS
30    KFORX(NFU)=KFUSOR
      DO 40 K=1,KFUSOR
      XJ(K)=XFUS(K,NFU)
40    CONTINUE
50    JM=JM+KFUSOR
      IF (JM.LE.30) GO TO 60
      WRITE (6,200)
      STOP 50
C
C  INITIALIZE COORDINATES EQUAL TO SEGMENT LEADING EDGE
60    DO 70 K=1,KRAD
      XC(J,K)=XB(1)
      YC(J,K)=YB(1,K)
      ZC(J,K)=ZB(1,K)
70    CONTINUE
C
C  INTERPOLATE FOR REMAINING PANEL COORDINATES  ------------------------
      DO 110 JJ=2,KFUSOR
      JM1=J
      J=J+1
C
C  FIND X-STATION
C
      DO 100 M=2,NFUSOR
      MM1=M-1
      IF (XB(M).LT.XJ(JJ)) GO TO 100
      DO 90 K=1,KRAD
      XC(J,K)=XJ(JJ)
      YC(J,K)=XIN(YB(MM1,K),XB(MM1),YB(M,K),XB(M),XJ(JJ))
      ZC(J,K)=XIN(ZB(MM1,K),XB(MM1),ZB(M,K),XB(M),XJ(JJ))
      IF (K.EQ.1) GO TO 90
      KM1=K-1
      JP=JP+1
C
C   CALCULATE PANEL INCLINATION AND CENTROID
C
      CALL PANEL(0,0,J,K,L,JP,AP)
C
C  PRINT BODY PANEL COORDINATES
      IF (IPRINT.GE.0) GO TO 80
      WRITE (6,240) JP,XC(JM1,KM1),YC(JM1,KM1),ZC(JM1,KM1),XC(J,KM1),
     1   YC(J,KM1),ZC(J,KM1),XC(JM1,K),YC(JM1,K),ZC(JM1,K),
     2   XC(J,K),YC(J,K),ZC(J,K)
80    AREA(JP)=AP
90    CONTINUE
      GO TO 110
100   CONTINUE
110   CONTINUE
120   CONTINUE
C
```

```
      NBODY=JP
      IF (NBODY.GT.600) GO TO 170
      IF (IPRINT.GE.0) GO TO 150
      WRITE (6,250)
      DO 130 JP=1,NBODY
      WRITE (6,270) JP,XPT(JP),YPT(JP),ZPT(JP)
130   CONTINUE
      WRITE (6,280)
      DO 140 JP=1,NBODY
      DDEG=DELTA(JP)*RADEG
      TDEG=THET(JP)*RADEG
      WRITE (6,270) JP,AREA(JP),DELTA(JP),THET(JP),DDEG,TDEG
140   CONTINUE
150   DO 160 JP=1,NBODY
      THETA(JP)=THET(JP)
160   CONTINUE
C
C   STORE BODY GEOMETRY ON TAPE 7
C
      WRITE (7) ARRAY
      REWIND 10
      RETURN
170   WRITE (6,300)
      STOP
190   FORMAT (50H  ERROR - NUMBER OF ROWS OF PANELS IN BODY SECTION
     1 ,I5,2X,10HEXCEEDS 30)
200   FORMAT (49H  ERROR - NUMBER OF ROWS OF SINGULARITY PANELS ON
     1 16H BODY EXCEEDS 30)
210   FORMAT (10F7.0)
220   FORMAT (1H1,9X,35HBODY PANEL CORNER POINT COORDINATES
     * 65X,12H** BODPAN **,///10X,5H1 AND
     1 60H 3 INDICATE BODY PANEL LEADING-EDGE POINTS, 2 AND 4 INDICATE
     2 21H TRAILING-EDGE POINTS/5X,5HPANEL,4(8X,1HX,8X,1HY,8X,1HZ)/
     3 19X,3(1H1,8X),3(1H2,8X),3(1H3,8X),3(1H4,8X)/)
240   FORMAT (I8,4X,12F9.5)
250   FORMAT (1H1,38H BODY PANEL CENTROID POINT COORDINATES
     1 //4X,5HPOINT,4X,1HX,10X,1HY,10X,1HZ/15X,3(2HCP,9X)/)
270   FORMAT (I8,1X,4F11.5,F11.3)
280   FORMAT (1H1,4X,39HBODY PANEL AREAS AND INCLINATION ANGLES/
     1 1H0,3X,5HPANEL,2X,4HAREA,7X,5HDELTA,6X,5HTHETA,6X,5HDELTA,6X,
     2 5HTHETA/24X,3HRAD,8X,3HRAD,8X,3HDEG,8X,3HDEG/)
300   FORMAT (43H  ERROR - NUMBER OF BODY PANELS EXCEEDS 600)
      END
```

```
      SUBROUTINE BODVEL
C
C  COMPUTE THE THREE COMPONENTS OF VELOCITY INDUCED AT SPECIFIED
C  CONTROL POINTS BY THE BODY PANELS
C
      COMMON /JOPTNS/ IZ1(73),IXZSYM
      COMMON /PARAM / NBODY,NWING,NTAIL,LBC,THK,XMACH,ALPHA,BETA,ALPHAC
     1    ,PHIR,REFA,REFB,REFC,REFD,REFL,REFX,REFZ
      COMMON /VELCOM/ NPOINT,NPART,IMAX,JMAX,NMAX,EM,IPRINT,NWTHK
     1    ,NWBLOK,NWROW(20),NBBLOK,NBROW(30)
      COMMON /NEWCOM/K1,KWAF,KWAFOR,KRADX(4),KFORX(4),KFUS,MAX,K4,K5
     1    ,KF(6),KAN(6),KFINOR(6),KANOR(6),KOL,NCPT,LOCPT(20),XCPT(20)
      COMMON              UB(600),VB(600),WB(600),VI(600),WI(600),AN(600),
     1    DN(60),ZB(240),XBT(600),YBT(600),ZBT(600),IT(600),Z9(1200)
```

```
      COMMON /POINT / XPT(600),YPT(600),ZPT(600),THET(600),DELTA(600),
     1   XC(30,20),YC(30,20),ZC(30,20),DELTI(600),XLE(600)
      COMMON /BODCOM/ AMACH,TAND,CX,XCOR(4),YCOR(4),ZCOR(4)
     1   ,XI,YI,ZI,XJ,ZJ
      COMMON /BTHET / THETA(600)
      LOGICAL LBC
      AMACH=XMACH
      JMAX=MAX
      II=0
C
C  I IS THE INDEX OF THE CONTROL POINT
C  J IS THE INDEX OF THE INFLUENCING PANEL
C
      DO 110 I=1,NPOINT
      IF (LBC .AND. I.EQ.IT(I) .AND. NPART.EQ.3) GO TO 110
      II=II+1
      SINTI=SIN(THET(I))
      COSTI=COS(THET(I))
      XPTI=XPT(I)
      YPTI=YPT(I)
      ZPTI=ZPT(I)
      IF (NPART.EQ.3) GO TO 10
C              BODY PANEL INCIDENCE ANGLE
      SIND=SIN(DELTA(I))
      COSD=COS(DELTA(I))
      GO TO 20
C              WING PANEL INCIDENCE ANGLE
10    DELT=0.
CNP   IF (.NOT.LBC) DELT=DELTI(I)
      SIND=SIN(DELT)
      COSD=COS(DELT)
20    DO 30 J=1,NBODY
      UB(J)=0.
      VI(J)=0.
      WI(J)=0.
30    CONTINUE
      J=0
      JPN=0
      L=0
      DO 70 KFU=1,KFUS
      NROW=KRADX(KFU)-1
      NCOL=KFORX(KFU)-1
      DO 60 NC=1,NCOL
      L=L+1
      JP1=1+JPN
      JPN=JP1+NROW-1
      DO 50 N=1,NROW
      J=J+1
      TAND=TAN(DELTA(J))
      COST=COS(THETA(J))
      SINT=SIN(THETA(J))
      XW=SINT*COSTI
      XX=COST*SINTI
      XY=COST*COSTI
      XZ=SINT*SINTI
      SINTR=XW-XX
      SINTL=XW+XX
      COSTR=XY+XZ
      COSTL=XY-XZ
      NP1=N+1
      XC1=XC(L,NP1)
      YC1=YC(L,NP1)
      ZC1=ZC(L,NP1)
```

```
C
C   CALCULATION OF PANEL CORNER POINTS IN PANEL COORDINATE SYSTEM
C
      XCOR(1)=0.
      YCOR(1)=0.
      ZCOR(1)=0.
      XCOR(2)=XC(L+1,NP1)-XC1
      XCOR(3)=0.
      XCOR(4)=XCOR(2)
      DO 40 K=2,4
      LP1=L+1
      NP1=N+1
      IF (K.GE.3) NP1=N
      IF (K.EQ.3) LP1=L
      DELY=YC(LP1,NP1)-YC1
      DELZ=ZC(LP1,NP1)-ZC1
      YCOR(K)=DELY*COST+DELZ*SINT
      ZCOR(K)=DELZ*COST-DELY*SINT
40    CONTINUE
      CX=XCOR(2)
C
C   CALCULATION OF CONTROL POINT IN PANEL COORDINATE SYSTEM
C
      XI=XPTI-XC1
      DY=YPTI-YC1
      DZ=ZPTI-ZC1
      YI=DY*COST+DZ*SINT
      ZI=DZ*COST-DY*SINT
      XJ=XBT(J)-XC1
      DYJ=YBT(J)-YC1
      DZJ=ZBT(J)-ZC1
      ZJ=DZJ*COST-DYJ*SINT
C
C   CALCULATE VELOCITY COMPONENTS INDUCED BY CONSTANT SOURCE
C   DISTRIBUTION PANELS
C
      CALL SORPAN(UR,VR,WR)
      UB(J)=UR
      VI(J)=VR*COSTR-WR*SINTR
      WI(J)=VR*SINTR+WR*COSTR
      UL=0.
      VL=0.
      WL=0.
C
C   CALCULATE VELOCITY COMPONENTS FROM LEFT SIDE FOR SYMMETRIC
C   CONFIGURATIONS INDUCED BY CONTANT SOURCE PANEL
C
      IF (IXZSYM.NE.0) GO TO 45
      DY=-YPTI-YC1
      YI=DY*COST+DZ*SINT
      ZI=DZ*COST-DY*SINT
      CALL SORPAN(UL,VL,WL)
      UB(J)=UB(J)+UL
      VI(J)=VI(J)-VL*COSTL+WL*SINTL
      WI(J)=WI(J)+VL*SINTL+WL*COSTL
45    CONTINUE
C
C   CALCULATE VELOCITY COMPONENTS IN ORIGINAL COORDINATE SYSTEM
C
      VB(J)=VI(J)*COSTI-WI(J)*SINTI
      WB(J)=WI(J)*COSTI+VI(J)*SINTI
      AN(J)=WI(J)*COSD-UB(J)*SIND
      IF (NPART.GT.1.OR.NBODY.LE.NMAX) GO TO 50
```

```
      IF (II.LT.JP1.OR.II.GT.JPN) GO TO 50                           WB04 141
      JS1=JP1                                                        WB04 142
      JS2=JPN                                                        WB04 143
      NS=NROW                                                        WB04 144
50    CONTINUE                                                       WB04 145
60    CONTINUE                                                       WB04 146
70    CONTINUE                                                       WB04 147
      JMAX=L                                                         WB04 148
      IF (NBODY.LE.NMAX.OR.NPART.GT.1) GO TO 90                      WB04 149
C                                                                    WB04 150
C  STORE DIAGONAL BLOCKS OF AERODYNAMIC MATRIX IN DN ARRAY           WB04 151
C                                                                    WB04 152
      DO 80 J=1,NBODY                                                WB04 153
      IF (J.LT.JS1.OR.J.GT.JS2) GO TO 80                             WB04 154
      K=J-JS1+1                                                      WB04 155
      DN(K)=AN(J)                                                    WB04 156
      AN(J)=0.                                                       WB04 157
80    CONTINUE                                                       WB04 158
      WRITE (10) (DN(J),J=1,NS)                                      WB04 159
90    IF (IABS(IPRINT).LT.4) GO TO 100                               WB04 160
      WRITE (6,160) II                                               WB04 161
      WRITE (6,120) NBODY                                            WB04 162
      WRITE (6,150) (UB(J),J=1,NBODY)                                WB04 163
      WRITE (6,130) NBODY                                            WB04 164
      WRITE (6,150) (AN(J),J=1,NBODY)                                WB04 165
      IF (NBODY.LE.NMAX.OR.NPART.NE.1) GO TO 100                     WB04 166
      WRITE (6,140) NS                                               WB04 167
      WRITE (6,150) (DN(J),J=1,NS)                                   WB04 168
100   WRITE (8) (UB(J),VB(J),WB(J),J=1,NBODY)                        WB04 169
      WRITE (9) (AN(J),J=1,NBODY)                                    WB04 170
110   CONTINUE                                                       WB04 171
      RETURN                                                         WB04 172
120   FORMAT (2X,10HUB(J),J=1,,I3)                                   WB04 173
130   FORMAT (2X,10HAN(J),J=1,,I3)                                   WB04 174
140   FORMAT (2X,10HDN(J),J=1,,I3)                                   WB04 175
150   FORMAT (1X,10F10.5)                                            WB04 176
160   FORMAT (1H0,22HAERODYNAMIC MATRIX, I=,I3)                      WB04 177
      END                                                            WB04 178
```

```
      SUBROUTINE CDUMP(IPRNT,ROUTIN)                                 WB05   1
C                                                                    WB05   2
C  ROUTINE TO PRINT LABELED COMMON BLOCK DATA BY REQUEST.            WB05   3
C  INFORMATION TO BE PRINTED IS DETERMINED BY PRINT OPTION IPRNT.    WB05   4
C                                                                    WB05   5
C  PRINT CONTROL                                                     WB05   6
C    IPRNT = 0 - PRINT ROUTINE NAME ONLY                             WB05   7
C          = 1, PRINTS VARIABLES AND ARRAYS LESS THAN 11 IN LENGTH   WB05   8
C               FOR COMMON BLOCKS: JOPTNS, PARAM, NEWCOM, VELCOM, + SEG WB05   9
C          = 2, PRINTS ALL OF ABOVE COMMON BLOCKS                    WB05  10
C          = 3, PRINT ARRAY BLOCK                                    WB05  11
C          = 4, PRINT VARIABLE - ARRAY                               WB05  12
C          = 5, PRINTS COMMON: COMPS                                 WB05  13
C          = 6, PRINTS COMMON: TRAN                                  WB05  14
C          = 7, PRINTS COMMON: BTHET                                 WB05  15
C          = 8, PRINTS COMMON: COEF, MATCOM, + ITERAT                WB05  16
C    ROUTIN - HOLLERITH VARIABLE WITH NAME OF CALLING PROGRAM        WB05  17
C             SPECIFIED AS 8H--------.                               WB05  18
C                                                                    WB05  19
```

```
CDC    DIMENSION ROUTIN(2)
C
       COMMON /JOPTNS/ IZ1(8)
      1   ,J0,J1,J2,J3,J4,J5,J6,NWAF,NWAFOR,NFUS,NRADX(4),NFORX(4)
      2   ,NP,NPODOR,NF,NFINOR,NCAN,NCANOR,J2TEST,NW,IZ2(25)
      3   ,NVLIN,NCPOUT,XSTART,XWLE,NWCPT,IPLOT(4),IPRT(5),IXZSYM
       COMMON /PARAM / NBODY,NWING,NTAIL,LBC,THK,XMACH,ALPHA,BETA,ALPHAC
      1   ,PHIR,REFA,REFB,REFC,REFD,REFL,REFX,REFZ
       COMMON /HEAD  / TITLE1(8),TITLE2(8)
       COMMON /SEG   / NSEG,NROW(20),NCOL(20),COSS(20),SINS(20)
      1   ,BTE(20),NWT(20),SPAN(20),XLEW(20),BLE(20),ZLEW(20),Z5(60)
       COMMON             BLOCK(7500)
       COMMON /POINT / ARRAY(6000)
       COMMON /NEWCOM/ K1,KWAF,KWAFOR,KRADX(4),KFORX(4),KFUS,MAX,K4,K5
      1   ,KF(6),KAN(6),KFINOR(6),KANOR(6),KOL,NCPT,IOCPT(20),XCPT(20)
       COMMON /VELCOM/ NPOINT,NPART,IMAX,JMAX,NMAX,EM,IPRINT,NWTHK
      1   ,NWBLOK,NWROW(20),NBBLOK,NBROW(60)
       COMMON /COMPS / TCOMPS(11)
       COMMON /TRAN  / TTRAN(12)
       COMMON /HTHET / THETI(600)
       COMMON /MATCOM/ MATIN
       COMMON /COEF  / TCOEF(400)
       COMMON /ITERAT/ ITMAX,CCTEST
C
       IF (IPRINT.LE.0) RETURN
       IF (IPRNT.GE.0) WRITE(6,10) ROUTIN
10     FORMAT(1H1,10X,31HCOMMON BLOCK PRINT CALLED FROM ,A8)
C
       IF (IPRNT.EQ.1 .OR. IPRNT.EQ.2)
      *    WRITE(6,15) J0,J1,J2,J3,J4,J5,J6,NWAF,NWAFOR
      *    ,NFUS,NRADX,NFORX,NP,NPODOR,NF,NFINOR,NCAN,NCANOR
      *    ,J2TEST,NW,NVLIN,NCPOUT,NWCPT,IPLOT,IPRT,IXZSYM
      *    ,NBODY,NWING,NTAIL,LBC,THK,XMACH,ALPHA,BETA,ALPHAC,PHIR
      *    ,REFA,REFB,REFC,REFD,REFL,REFX,REFZ,XSTART,XWLE
       IF (IPRNT.EQ.1 .OR. IPRNT.EQ.2)
      *    WRITE(6,16) K1,KWAF,KWAFOR,KRADX,KFORX,KFUS,MAX,K4
      *    ,KF,K5,KAN,KFINOR,KANOR,KOL,NCPT
      *    ,NPOINT,NPART,IMAX,JMAX,NMAX,IPRINT,NWTHK,NWBLOK,NBBLOK
      *    ,EM,NSEG
15     FORMAT(/5X,15HCOMMON /JOPTNS/
      *  ,/49H      J0      J1      J2      J3      J4      J5      J6,/7I7
      *  ,/49H    NWAF NWAFOR   NFUS  NRADX     (2)     (3)     (4),/7I7
      *  ,/49H   NFORX     (2)     (3)     (4)      NP NPODOR     NF,/7I7
      *  ,/49H NFINOR    NCAN NCANOR J2TEST      NW   NVLIN NCPOUT,/7I7
      *   ,/49H   NWCPT  IPLOT     (2)     (3)     (4)    IPRT     (2),/7I7
      *  ,/28H     (3)     (4)     (5) IXZSYM,/4I7,
      *  ,//5X,15HCOMMON /PARAM /
      *  ,/35H   NBODY  NWING  NTAIL     LBC     THK,/3I7,2L7
      *  ,/4X,5HXMACH,7X,5HALPHA,8X,4HBETA,6X,6HALPHAC,8X,4HPHIR,/5G12.5
      *  ,/5X,4HREFA,8X,4HREFB,8X,4HREFC,8X,4HREFD,8X,4HREFL,/5G12.5
      *   ,/5X,4HREFX,8X,4HREFZ,6X,6HXSTART,8X,4HXWLE,/4G12.5)
16     FORMAT(/5X,15HCOMMON /NEWCOM/
      *   ,/49H      K1   KWAF KWAFOR  KRADX     (2)     (3)     (4),/7I7
      *   ,/49H   KFORX     (2)     (3)     (4)    KFUS     MAX     K4,/7I7
      *   ,/49H      KF     (2)     (3)     (4)     (5)     (6)     K5,/7I7
      *   ,/7H    KAN,/6I7
      *   ,/7H KFINOR,6I7
      *   ,/7H  KANOR,6I7
      *   ,/14H    KOL   NCPT,/2I7
      *   ,//5X,15HCOMMON /VELCOM/
      *   ,/49H NPOINT  NPART   IMAX   JMAX   NMAX IPRINT  NWTHK,/7I7
      *   ,/21H NWBLOK NBBLOK     EM,/2I7,G12.5
      *   ,//5X,15HCOMMON /SEG   /
```

```
     *    ,/7H   NSEG,/I7)
C
      IF (IPRNT.EQ.2) WRITE(6,20) IZZ
      IF (IPRNT.EQ.2) WRITE(6,21) NROW,NCOL,COSS,SINS,BTE,NAT,SPNW,XLEW
     *                            ,RLE,ZLEW
      IF (IPRNT.EQ.2) WRITE(6,22) LOCPT,XCPT
      IF (IPRNT.EQ.2) WRITE(6,23) NWROW,NBROW
20    FORMAT(/5X,6HARRAYS,/7H     IZZ,2(/10I5))
21    FORMAT(7H   NROW,2(/10I5)
     *    ,/7H   NCOL,2(/10I5)
     *    ,/7H   COSS,2(/10G12.5)
     *    ,/7H   SINS,2(/10G12.5)
     *    ,/7H    BTE,2(/10G12.5)
     *    ,/7H    NAT,2(/10I5)
     *    ,/7H   SPNW,2(/10G12.5)
     *    ,/7H   XLEW,2(/10G12.5)
     *    ,/7H    RLE,2(/10G12.5)
     *    ,/7H   ZLEW,2(/10G12.5))
22    FORMAT(7H  LOCPT,2(/10I5)
     *    ,/7H   XCPT,2(/10G12.5))
23    FORMAT(7H  NWROW,2(/10I5)
     *    ,/7H  NBROW,6(/10I5))
C
C   IPRNT=3 - ARRAY BLOCK
C
      IF (IPRNT.EQ.3)
     *   CALL MXOUT(8H CDUMP  ,1,,BLOCK,10,750,60,132,3,10,750)
C
C   IPRNT=4, VARIABLE ARRAY
C
      IF (IPRNT.EQ.4)
     *   CALL MXOUT(8H COUMP  ,1,ARRAY,10,600,60,132,3,10,600)
C
C   IPRNT=5, COMMON /COMPS/
      IF (IPRNT.EQ.5) WRITE(6,30) TCOMPS
30    FORMAT(/5X,15HCOMMON /COMPS /,2(/10G12.5))
C
C   IPRNT=6,  COMMON /TRAN  /
      IF (IPRNT.EQ.6) WRITE(6,35) TTRAN
35    FORMAT(/5X,15HCOMMON /TRAN  /,2(/10G12.5))
C
C   IPRNT=7, COMMON /BTHET /
      IF (IPRNT.EQ.7) WRITE(6,40) THETI
40    FORMAT(/5X,15HCOMMON /BTHET /,60(/10G12.5))
C
C   IPRNT=8, COMMON COEF,MATCOM,ITERAT
      IF (IPRNT.EQ.8) WRITE(6,45) TCOEF,MATIN,ITMAX,CCTEST
45    FORMAT(/5X,15HCOMMON /COEF  /,40(/10G12.5)
     *    ,//5X,15HCOMMON /MATCOM/,10X,7H  MATIN, I5
     *    ,//5X,15HCOMMON /ITERAT/
     *    ,10X,7H  ITMAX,I5,7H CCTEST,G12.5)
      RETURN
      END
```

```
      SUBROUTINE CPUTIM(T,DT,IT)
C
C  ROUTINE TO COMPUTE ABSOLUTE AND RELATIVE CPUTIME DURING EXECUTION
C          * * * *  UNITS - SECONDS  * * * *
C
```

```
C   USAGE:
C   (IT=0) TIME IS INITIALIZED BY FIRST CALL AS T=0, DT=0
C             CALL CPUTIM(T,DT,0)
C
C   (IT=1) COMPUTE ABSOLUTE AND INCREMENT IN CPU TIME FROM INITIAL
C           AND LAST CALL TO *CPUTIM*.
C             T = TOTAL SECONDS FROM INITAL CALL TO *CPUTIM*
C                 AS OUTPUT, T = TIME AT CURRENT CALL
C            DT = INCREMENT IN TIME (SECONDS)
C                 DT = T(CUR)-T(PREV)
C
C   BY JOSEPH MULLEN, JR                              OCTOBER, 1973
C
C        * * * * *   CDC - VERSION    * * * * *
      IF (IT.LE.0) GO TO 100
C
C   COMPUTE NEW TIME AND INCREMENT
      CALL SECOND(TIME)
      TIME = TIME-T0
      DT   = TIME-TSAV
      T    = TIME
      TSAV = TIME
      RETURN
C
C   INITIALIZE CPU TIME
100   T    = 0.0
      DT   = 0.0
      TIME = 0.0
      TSAV = 0.0
      CALL SECOND(T0)
      RETURN
      END
```

```
      SUBROUTINE COMCU(DA,DB,S,X,Y,M,N,NDA,NDB)
C
C    FIT A COMPOSITE CUBIC THROUGH N POINTS, I. E., A SEPARATE CUBIC
C    BETWEEN EACH PAIR OF ADJACENT POINTS. SUCH THAT N-1 CUBICS ARE SO
C    DETERMINED THAT EACH MATCHES ITS NEIGHBORS IN FUNCTION VALUE AND
C    IN THE FIRST AND SECOND DERIVATIVES.
C
      COMMON/COEF/C(50),D(50),E(50),Z1(250)
      DIMENSION S(N),X(N),Y(N)
      K=N-1
      KUF=0
C                TEST FOR N LESS THAN 2
      IF (N-2) 10,20,60
10    M=-1
      RETURN
C                TEST FOR N EQUAL TO 2
20    IF (NDA.NE.1.OR.NDB.NE.1) GO TO 50
      S(1)=DA
      S(2)=DB
      M=0
      RETURN
50    KUF=1
60    M=0
      E(1)=0.
      C(N)=0.
      IF (NDA.GT.1) GO TO 80
```

```
      D(1)=1.
      C(1)=0.
      S(1)=DA
      GO TO 90
80    D(1)=4.
      C(1)=2.
      S(1)=6.*(Y(2)-Y(1))/(X(2)-X(1))-DA*(X(2)-X(1))
90    IF (KUE.NE.0) GO TO 120
      DO 110 I=2,K
      U=X(I)-X(I-1)
      V=X(I+1)-X(I)
      C(I)=U
      D(I)=2.*(U+V)
      E(I)=V
      S(I)=3./(U*V)*(U*U*(Y(I+1)-Y(I))+V*V*(Y(I)-Y(I-1)))
110   CONTINUE
120   IF (NDB.GT.1) GO TO 140
      E(N)=0.
      D(N)=1.
      S(N)=DB
      GO TO 150
140   E(N)=2.
      D(N)=4.
      S(N)=6.*(Y(N)-Y(N-1))/(X(N)-X(N-1))+DB*(X(N)-X(N-1))
150   C(1)=C(1)/D(1)
      S(1)=S(1)/D(1)
      DO 160 I=2,N
      F=D(I)-C(I-1)*E(I)
      C(I)=C(I)/F
      S(I)=(S(I)-S(I-1)*E(I))/F
160   CONTINUE
      DO 170 J=1,K
      I=N-J
      S(I)=S(I)-S(I+1)*C(I)
170   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CONFIG
C
C     INPUT AND INITIALIZE CONFIGURATION DESCRIPTION
C
      COMMON /JOPTNS/ IZ1(8)
     1    ,J0,J1,J2,J3,J4,J5,J6,NWAF,NWAFOR,NFUS,NRADX(4),NFORX(4)
     2    ,NP,NPODOR,NF,NFINOR,NCAN,NCANOR,J2TEST,NW
     3    ,IZ2(34),IPRT(5),IYZSYM
      COMMON /PARAM / NBODY,NWING,NTAIL,LBC,THK,XMACH,ALPHA,BETA,ALPHAC
     1    ,PHIP,REFA,REFB,REFC,REFD,REFL,REFX,REFZ
      COMMON              BLOCK(7500)
C
C   GEOMETRY ARRAYS
C         WING                BODY              V.FIN             H.TAIL
      DIMENSION ABCD(8)
     1 ,    XAF(30)       ,    XFUS(30,4)    , FINORG(6,2,4) , CANORG(6,2,4)
     2 ,WAFORG(20,4)      ,    ZFUS(30,4)    ,   XFIN(6,10)  ,   XCAN(6,10)
     3 ,WAFORD(20,3,40), FUSARD(30,4)    , FINORD(6,2,10), CANORD(6,2,10)
     4 ,  IZORD(20,30)    , FUSRAD(30,4)    ,  FINX2(6,2,10), CANOR1(6,2,10)
     5 ,  WAFOR(20,30)    ,    SFUS(30,30,8),  FINX3(6,2,10), CANORX(6,2,10)
     6 ,                    FUSBY(30,4)    ,  FINOR(6,10)   ,  CANOR(6,10)
```

```
     7 ,                     FUSAZ(30,4)    ,  FINCR(6,10)   ,  CANCR(6,10)
C
C                  WING                                        BODY
      EQUIVALENCE
     1     (   XAF(1)      ,BLOCK(1))      ,      (   XFUS(1,1)   ,BLOCK(1))
     2    ,(WAFORG(1,1)    ,BLOCK(31))     ,      (   ZFUS(1,1)   ,BLOCK(121))
     3    ,(WAFORD(1,1,1),BLOCK(111))      ,      (FUSARD(1,1)    ,BLOCK(241))
     4    ,( TZORD(1,1)    ,BLOCK(1911)),         (FUSRAD(1,1)    ,BLOCK(361))
     5    ,( WAFCR(1,1)    ,BLOCK(2511)),         (   SFUS(1,1,1),BLOCK(241))
     6    ,                                       ( FUSRY(1,1)    ,BLOCK(361))
     7    ,                                       ( FUSAZ(1,1)    ,BLOCK(481))
C                  V.FIN                                       H.TAIL
      EQUIVALENCE
     6     (FINORG(1,1,1),BLOCK(1))        ,      (CANORG(1,1,1),BLOCK(1))
     7    ,(   XFIN(1,1)   ,BLOCK(49))     ,      (  XCAN(1,1)    ,BLOCK(49))
     8    ,(FINORD(1,1,1),BLOCK(109))      ,      (CANORD(1,1,1),BLOCK(109))
     9    ,( FINX2(1,1,1),BLOCK(229))      ,      (CANOR1(1,1,1),BLOCK(229))
     0    ,( FINX3(1,1,1),BLOCK(349))      ,      (CANORX(1,1,1),BLOCK(349))
     1    ,( FINOR(1,1)    ,BLOCK(469))    ,      ( CANOR(1,1)    ,BLOCK(469))
     2    ,( FINCR(1,1)    ,BLOCK(529))    ,      ( CANCR(1,1)    ,BLOCK(529))
C
      LOGICAL LPRT,READA,READR,READF
      DATA PI/3.14159265/
      REWIND 9
      LPRT=IPRT(1).GT.0
C
C     REFERENCE AREA
C
      REFA=1.
      IF (J0.NE.0) READ (5,480) REFA
CW    WRITE (9) REFA
      IF (LPRT) WRITE(6,490) REFA
C
C     WING  -------------------------------------------------------------
C
      IF (J1.EQ.0) GO TO 160
      IF (LPRT) WRITE(6,500)
      N=IABS(NWAFOR)
      NREC=(N+9)/10
      I1=-9
      I2=0
      DO 20 NN=1,NREC
      I1=I1+10
      I2=I2+10
      READ (5,480) (XAF(I),I=I1,I2)
      IF (LPRT) WRITE(6,510) NN,(XAF(I),I=I1,I2)
20    CONTINUE
C
      IF (LPRT) WRITE(6,520)
      DO 30 I=1,NWAF
      READ (5,480) (WAFORG(I,J),J=1,4)
      IF (LPRT) WRITE(6,510) I,(WAFORG(I,J),J=1,4)
30    CONTINUE
C
C     J1 = -1 INDICATES UNCAMBERED WING DATA
C
      IF (J1.LT.0) GO TO 50
      IF (LPRT) WRITE(6,540)
      DO 50 NN=1,NWAF
      I1=-9
      I2=0
      DO 40 NI=1,NREC
```

```
      I1=I1+10
      I2=I2+10
      READ (5,480) (TZORD(NN,I),I=I1,I2)
      DO 40 I=I1,I2
      IF (WAFORG(NN,4).EQ.0.) GO TO 40
      TZORD(NN,I)=TZORD(NN,I)*100./WAFORG(NN,4)
 40   CONTINUE
      IF (LPRT) WRITE(6,510) NN,(TZORD(NN,I),I=I1,I2)
 50   CONTINUE
      GO TO 80
 60   DO 70 I=1,NWAF
      DO 70 K=1,N
      TZORD(I,K)=0.
 70   CONTINUE
 80   L=1
C
C     NWAFOR POSITIVE INDICATES SYMMETRICAL ORDINATES
C            NEGATIVE INDICATES UPPER AND LOWER ORDINATES GIVEN
C
      IF (NWAFOR.LT.0) L=2
      IF (LPRT) WRITE(6,550)
      DO 100 NN=1,NWAF
      DO 100 K=1,L
      I1=-9
      I2=0
      DO 90 N1=1,NREC
      I1=I1+10
      I2=I2+10
      READ (5,480) (WAFORD(NN,K,I),I=I1,I2)
      IF (LPRT) WRITE(6,510) NN,(WAFORD(NN,K,I),I=I1,I2)
 90   CONTINUE
 100  CONTINUE
      DO 110 NN=1,NWAF
      DO 110 K=1,N
      WAFOR(NN,K)=WAFORD(NN,1,K)
      IF (L.EQ.1) GO TO 110
      WAFOR(NN,K)=(WAFORD(NN,1,K)+WAFORD(NN,2,K))/2.
      TZORD(NN,K)=(WAFORD(NN,1,K)-WAFORD(NN,2,K))/2.+TZORD(NN,K)
 110  CONTINUE
      IF (NWAFOR.LT.0) GO TO 130
      DO 120 NN=1,NWAF
      DO 120 K=1,N
      WAFORD(NN,2,K)=WAFORD(NN,1,K)
 120  CONTINUE
 130  NWAFOR=IABS(NWAFOR)
      NW=NWAFOR
      J1=IABS(J1)
C
C     CHANGE WING TO ACTUAL UNITS
C
      DO 150 I=1,NWAF
      E=.01*WAFORG(I,4)
      E3=WAFORG(I,3)
      DO 140 J=1,NWAFOR
      WAFORD(I,1,J)=E*WAFORD(I,1,J)+E3+TZORD(I,J)*E
      WAFORD(I,2,J)=-E*WAFORD(I,2,J)+E3+TZORD(I,J)*E
      WAFORD(I,3,J)=WAFORG(I,1)+E*XAF(J)
 140  CONTINUE
 150  CONTINUE
C*    WRITE (9) BLOCK
 160  CONTINUE
      N=IABS(NWAFOR)
C
C     FUSELAGE (BODY) ---------------------------------------------
```

```
C
      IF (J2.EQ.0) GO TO 290
      J2TEST=3
C
C     J2 < 0 AND J6 = -1 INDICATE CIRCULAR/ELLIPTIC FUSELAGE SYMMETRICAL
C                       WITH THE XY-PLANE
C     J2 < 0 AND J6 = 0 INDICATE CIRCULAR/ELLIPTIC CAMBERED FUSELAGE
C     J6 = 1 INDICATES COMPLETE CONFIGURATION SYMMETRICAL WITH THE
C            XY-PLANE
C     J2 = -1, READ FUSELAGE CROSS SECTIONAL AREAS VS XFUS ON INPUT
C     J2 = -2, READ FUSELAGE RADII VS XFUS ON INPUT
C     J2 = -3, READ ELLIPTIC FUSELAGE SEMI-MAJOR AXES VS XFUS
C
      IF (J2.LE.-1.AND.J6.EQ.-1) J2TEST=1
      IF (J2.LE.-1.AND.J6.EQ.0) J2TEST=2
      IF (J6.EQ.1) J2TEST=1
      READA=J2.EQ.-1
      READR=J2.EQ.-2
      READE=J2.EQ.-3
      J2=1
C
C     READ XFUS
      IF (LPRT) WRITE(6,570)
      DO 290 NFU=1,NFUS
      NRAD=NRADX(NFU)
      NFUSOR=NFORX(NFU)
      N=NFUSOR
      NREC=(N+9)/10
      I1=-9
      I2=0
      DO 170 NI=1,NREC
      I1=I1+10
      I2=I2+10
      READ (5,480) (XFUS(I,NFU),I=I1,I2)
      IF (LPRT) WRITE(6,510) NFU,(XFUS(I,NFU),I=I1,I2)
  170 CONTINUE
C
C     J2TEST = 2 INDICATES CIRCULAR/ELLIPTIC CAMBERED FUSELAGE
C
      IF (J2TEST.NE.2) GO TO 190
      I1=-9
      I2=0
      IF (LPRT) WRITE(6,580)
      DO 180 NI=1,NREC
      I1=I1+10
      I2=I2+10
      READ (5,480) (ZFUS(I,NFU),I=I1,I2)
      IF (LPRT) WRITE(6,510) NFU,(ZFUS(I,NFU),I=I1,I2)
  180 CONTINUE
      GO TO 210
  190 DO 200 I=1,NFUSOR
      ZFUS(I,NFU)=0.
  200 CONTINUE
C
C     J2TEST = 3 INDICATES ARBITRARY FUSELAGE - READ YJ + ZJ OF SECTION
C
  210 IF (J2TEST.NE.3) GO TO 250
      NCARD=(NRAD+9)/10
      DO 240 JX=1,NFUSOR
      DO 230 K=1,2
      IF (LPRT.AND.K.EQ.1) WRITE(6,590)
      IF (LPRT.AND.K.EQ.2) WRITE(6,600)
      KK=K+(NFU-1)*2
```

```
      II=10                                                             WB08 211
      I1=-9                                                             WB08 212
      I2=0                                                              WB08 213
      DO 220 NN=1,NCARD                                                 WB08 214
      IF (NN.EQ.NCARD) II=MOD(NRAD,10)                                  WB08 215
      IF (II.EQ.0) II=10                                                WB08 216
      I1=I1+10                                                          WB08 217
      I2=I2+II                                                          WB08 218
      READ (5,480) (SFUS(I,JX,KK),I=I1,I2)                              WB08 219
      IF (LPRT) WRITE(6,510) JX,(SFUS(I,JX,KK),I=I1,I2)                 WB08 220
 220  CONTINUE                                                          WB08 221
 230  CONTINUE                                                          WB08 222
 240  CONTINUE                                                          WB08 223
      GO TO 280                                                         WB08 224
C                                                                       WB08 225
C  CIRCULAR/ELLIPTIC FUSELAGE - READ CROSS SECTIONAL AREAS/RADII        WB08 226
C                                                                       WB08 227
 250  CONTINUE                                                          WB08 228
      IF (LPRT.AND.READA) WRITE(6,610)                                  WB08 229
      IF (LPRT.AND.READR) WRITE(6,615)                                  WB08 230
      IF (LPRT.AND.READE) WRITE(6,680)                                  WB08 231
      DO 255 I=1,NFUSOR                                                 WB08 232
 255  FUSAZ(I,NFU)=0.0                                                  WB08 233
      I1=-9                                                             WB08 234
      I2=0                                                              WB08 235
      DO 260 NI=1,NREC                                                  WB08 236
      I1=I1+10                                                          WB08 237
      I2=I2+10                                                          WB08 238
      IF (READA) READ (5,480) (FUSARD(I,NFU),I=I1,I2)                   WB08 239
      IF (READR) READ (5,480) (FUSRAD(I,NFU),I=I1,I2)                   WB08 240
      IF (READE) READ (5,480) (FUSBY(I,NFU),I=I1,I2)                    WB08 241
      IF (LPRT.AND.READA) WRITE(6,510) NFU,(FUSARD(I,NFU),I=I1,I2)      WB08 242
      IF (LPRT.AND.READR) WRITE(6,510) NFU,(FUSRAD(I,NFU),I=I1,I2)      WB08 243
      IF (LPRT.AND.READE) WRITE(6,510) NFU,(FUSBY(I,NFU),I=I1,I2)       WB08 244
 260  CONTINUE                                                          WB08 245
C                                                                       WB08 246
      IF (.NOT.READE) GO TO 268                                         WB08 247
      WRITE(6,690)                                                      WB08 248
      DO 264 I1=1,NFUSOR,10                                             WB08 249
      I2=I1+9                                                           WB08 250
      READ(5,480) (FUSAZ(I,NFU),I=I1,I2)                                WB08 251
      IF (LPRT) WRITE(6,510) NFU,(FUSAZ(I,NFU),I=I1,I2)                 WB08 252
 264  CONTINUE                                                          WB08 253
 268  CONTINUE                                                          WB08 254
      DO 270 I=1,NFUSOR                                                 WB08 255
      IF (READA) FUSRAD(I,NFU)=SQRT(FUSARD(I,NFU)/PI)                   WB08 256
      IF (READR) FUSARD(I,NFU)=PI*FUSRAD(I,NFU)**2                      WB08 257
      IF (FUSAZ(I,NFU).LE.0.) FUSAZ(I,NFU)=FUSBY(I,NFU)                 WB08 258
 270  CONTINUE                                                          WB08 259
 280  CONTINUE                                                          WB08 260
C8    WRITE (9) BLOCK                                                   WB08 261
 290  CONTINUE                                                          WB08 262
C                                                                       WB08 263
C     POD GEOMETRY DUMMY READ STATEMENTS ------  -----------------------WB08 264
C                                                                       WB08 265
      IF (J3.EQ.0) GO TO 330                                            WB08 266
      N=NPODOR                                                          WB08 267
      NREC=(N+9)/10                                                     WB08 268
      DO 320 NN=1,NP                                                    WB08 269
      READ (5,470) ABCD                                                 WB08 270
      DO 300 NI=1,NREC                                                  WB08 271
      READ (5,470) ABCD                                                 WB08 272
 300  CONTINUE                                                          WB08 273
```

```
      DO 310 N1=1,NREC                                                  WB08 274
      READ (5,470) ABCD                                                 WB08 275
310   CONTINUE                                                          WB08 276
320   CONTINUE                                                          WB08 277
C                                                                       WB08 278
C     FINS (VERTICAL TAILS) --------------------------------------------WB08 279
C                                                                       WB08 280
330   IF (J4.EQ.0) GO TO 380                                            WB08 281
      N=NFINOR                                                          WB08 282
      DO 350 NN=1,NF                                                    WB08 283
      READ (5,480) ((FINORG(NN,I,J),J=1,4),I=1,2)                       WB08 284
      IF (LPRT) WRITE(6,620) NN,((FINORG(NN,I,J),J=1,4),I=1,2)          WB08 285
      READ (5,480) (XFIN(NN,I),I=1,N)                                   WB08 286
      IF (LPRT) WRITE(6,630) (XFIN(NN,I),I=1,N)                         WB08 287
      READ (5,480) (FINORD(NN,1,J),J=1,N)                               WB08 288
      IF (LPRT) WRITE(6,640) (FINORD(NN,1,J),J=1,N)                     WB08 289
      DO 340 J=1,N                                                      WB08 290
      FINCR(NN,J)=0.                                                    WB08 291
      FINOR(NN,J)=FINORD(NN,1,J)                                        WB08 292
340   CONTINUE                                                          WB08 293
350   CONTINUE                                                          WB08 294
C                                                                       WB08 295
C     CHANGE FINS TO ACTUAL UNITS                                       WB08 296
C                                                                       WB08 297
      DO 370 LQ=1,NF                                                    WB08 298
      DO 370 I=1,2                                                      WB08 299
      J=3-I                                                             WB08 300
      E=.01*FINORG(LQ,J,4)                                              WB08 301
      E2=FINORG(LQ,J,2)                                                 WB08 302
      DO 360 K=1,NFINOR                                                 WB08 303
      EE=FINORD(LQ,1,K)*E                                               WB08 304
      FINORD(LQ,J,K)=E2+EE                                              WB08 305
      FINX2(LQ,J,K)=E2-EE                                               WB08 306
      FINX3(LQ,J,K)=FINORG(LQ,J,1)+E*XFIN(LQ,K)                         WB08 307
360   CONTINUE                                                          WB08 308
370   CONTINUE                                                          WB08 309
C8    WRITE (9) BLOCK                                                   WB08 310
380   CONTINUE                                                          WB08 311
C                                                                       WB08 312
C     CANARDS (HORIZONTAL TAILS) ---------------------------------------WB08 313
C                                                                       WB08 314
      IF (J5.EQ.0) GO TO 460                                            WB08 315
      N=IABS(NCANOR)                                                    WB08 316
      DO 420 NN=1,NCAN                                                  WB08 317
      READ (5,480) ((CANORG(NN,I,J),J=1,4),I=1,2)                       WB08 318
      IF (LPRT) WRITE(6,510) NN,((CANORG(NN,I,J),J=1,4),I=1,2)          WB08 319
      READ (5,480) (XCAN(NN,I),I=1,N)                                   WB08 320
      IF (LPRT) WRITE(6,660) (XCAN(NN,I),I=1,N)                         WB08 321
      READ (5,480) (CANORD(NN,1,J),J=1,N)                               WB08 322
      IF (LPRT) WRITE(6,670) (CANORD(NN,1,J),J=1,N)                     WB08 323
C                                                                       WB08 324
C     NCANOR POSITIVE INDICATES SYMMETRICAL ORDINATES                   WB08 325
C     NCANOR NEGATIVE INDICATES UPPER AND LOWER ORDINATES ARE GIVEN     WB08 326
C                                                                       WB08 327
      IF (NCANOR.LT.0) GO TO 400                                        WB08 328
      DO 390 J=1,N                                                      WB08 329
      CANCR(NN,J)=0.                                                    WB08 330
      CANOR(NN,J)=CANORD(NN,1,J)                                        WB08 331
      CANOR1(NN,1,J)=CANORD(NN,1,J)                                     WB08 332
390   CONTINUE                                                          WB08 333
      GO TO 420                                                         WB08 334
400   CONTINUE                                                          WB08 335
      READ (5,480) (CANOR1(NN,1,J),J=1,N)                               WB08 336
```

```
      IF (LPRT) WRITE(6,670) (CANORI(NN,1,J),J=1,N)
      DO 410 J=1,N
      CANOR(NN,J)=(CANORD(NN,1,J)+CANORI(NN,1,J))/2.
      CANCR(NN,J)=(CANORD(NN,1,J)-CANORI(NN,1,J))/2.
410   CONTINUE
420   CONTINUE
C
C     CHANGE CANARD TO ACTUAL UNITS
C
      DO 450 NN=1,NCAN
      DO 440 K=1,2
      I=3-K
      E=.01*CANORG(NN,I,4)
      E3=CANORG(NN,I,3)
      DO 430 J=1,N
      CANORD(NN,I,J)=E*CANORD(NN,1,J)+E3
      CANORI(NN,I,J)=-E*CANORI(NN,1,J)+E3
      CANORX(NN,I,J)=CANORG(NN,I,1)+E*XCAN(NN,J)
430   CONTINUE
440   CONTINUE
450   CONTINUE
C8    WRITE (9) BLOCK
460   CONTINUE
      REWIND 9
      RETURN
C
470   FORMAT (8A10)
480   FORMAT (10F7.0)
490   FORMAT(///10X,26HVEHICLE GEOMETRY DEFFINTION,74X,12H** CONFIG **
     *    ,/5X,33HREFERENCE AREA (J0.GT.0)    REFA=,G13.6)
500   FORMAT(//5X,45H    XAF = WING ORDINATES FOR AIRFOIL (: CHORD)
     *    ,10H (J1.NE.0))
510   FORMAT(I5,10F10.4)
520   FORMAT(/5X,42HWAFORG - WING AIRFOIL LEADING EDGE + CHORD
     *    /4X,1HI,7X,1HX,9X,1HY,9X,1HZ,5X,5HCHORD)
540   FORMAT(/5X,30H TZORD - WING CAMBER, Z VS XAF)
550   FORMAT(/5X,45HWAFORD - WING AIRFOIL ORDINATE (+SYM,-UP/LOW)
     *    ,9H  NWAFOR=,I3)
570   FORMAT(//5H  NFU,5X,26HXFUS - FUSELAGE X-STATIONS)
580   FORMAT(/5H  NFU,5X,37HZFUS - FUSELAGE Z-CAMBER VS XFUS FOR
     *    ,16HCIRCULAR SECTION)
590   FORMAT(/5H   JX,5X,42HY - COORDINATE ARBITRARY FUSELAGE SECTION
     1    ,6H(SFUS))
600   FORMAT(/5H   JX,5X,42HZ - COORDINATE ARBITRARY FUSELAGE SECTION
     1    ,6H(SFUS))
610   FORMAT(/5X,45HFUSARD - CIRCULAR FUSELAGE CROSS SECTION AREA)
615   FORMAT(/5X,32HFUSRAD - CIRCULAR FUSELAGE RADII)
620   FORMAT(//5X,38HFINORG - VERTICAL FIN AIRFOIL ORIGION#
     *    ,5X,8HFIN SEG=,I3,/10X,1HX,9X,1HY,9X,1HZ,5X,5HCHORD
     *    ,5H  IN ,4F10.3,5H  OUT,4F10.3)
630   FORMAT(/5X,40H  XFIN - X-STATION FIN AIRFOIL (: CHORD),/10F10.4)
640   FORMAT(/5X,40HFINORD - AIRFOIL ORDINATES VS XFIN (SYM),/10F10.4)
650   FORMAT(//5X,41HCANORG - HORIZONTAL TAIL AIRFOIL ORIGION#
     *    ,5X,9HTAIL SEG=,I3,/10X,1HX,9X,1HY,9X,1HZ,5X,5HCHORD
     *    ,5H  IN ,4F10.3,5H  OUT,4F10.3)
660   FORMAT(/5X,41H  XCAN - X-STATION TAIL AIRFOIL (: CHORD),/10F10.4)
670   FORMAT(/5X,41HCANORD - AIRFOIL ORDINATES VS XCAN (SYM),/10F10.4)
680   FORMAT(/5H  NFU,5X,41HFUSAY - ELLIPTIC FUSELAGE SEMI-MAJOR AXES)
690   FORMAT(/5H  NFU,5X,41HFUSAZ - ELLIPTIC FUSELAGE SEMI-MINOR AXES)
      END
```

```
      SUBROUTINE CUBIC2(X,Y,D,C,J)
C
C   FIT A CUBIC TO TWO POINTS GIVEN THE SLOPE AT EACH POINT
C
      DIMENSION X(2),Y(2),D(2),C(4)
      X2=X(2)
      B=X(1)-X2
      IF (B.NE.0.) GO TO 20
10    J=3
      RETURN
20    A=(Y(1)-Y(2))/B
      E=X(1)+X2
      C(4)=(D(1)+D(2)-A-A)/B/B
      C(3)=(A-D(2))/B-C(4)*(E+X2)
      C(2)=A-E*C(3)-C(4)*(E*X2+X(1)**2)
      C(1)=Y(2)-X2*(C(2)+X2*(C(3)+X2*C(4)))
      J=1
      RETURN
      END
```

```
      COMPLEX FUNCTION DBLU(Z)
C
C     THIS FUNCTION SUBROUTINE CALCULATES THE INTERMEDIATE TRANSFORM
C     VARIABLE W FOR THE CONFORMAL TRANSFORMATION OF AN ELLIPTICAL
C     BODY WITH WINGS
C
      COMMON/COM1/A2,B2,R2
      COMMON/COM3/ZR,ZI
      COMMON/COM5/DWDZ
      COMMON/COM6/W2,W
C
      COMPLEX Z,Z2,DWDZ,W,W2,WW
C
      Z2=Z*Z
      ZR=REAL(Z)
      ZI=AIMAG(Z)
      IF(ZR.NE.0.0) ZR=ZR/ABS(ZR)
      IF(ZI.NE.0.0) ZI=ZI/ABS(ZI)
      Z2=Z2-A2+B2
      Y=AIMAG(Z2)
      AY=1.0
      IF(Y.LT.0.0) AY=-1.0
      AYZ=1.0
      IF(ZI.LT.0.0) AYZ=-1.0
      Z2=CSQRT(Z2)*AY*AYZ
      IF((ABS(ZI).LE.0.0).AND.(REAL(Z).LT.0.0)) Z2=CMPLX(-REAL(Z2),
     1      AIMAG(Z2))
      DWDZ=0.5*(1.0+Z/Z2)
      WW=0.5*(Z+Z2)
      W2=1.0/WW/WW
      DBLU=WW
      RETURN
      END
```

```
      SUBROUTINE DERIV(X,Y,N,NDA,DA,FD)
C
C     FIT A CHAIN OF CUBIC CURVES THROUGH A SET OF N POINTS HAVING
C     CONTINUOUS FIRST AND SECOND DERIVATIVES AT THE INTERMEDIATE POINTS
C     AND SPECIFIED FIRST OR SECOND DERIVATIVE AT THE END POINTS
C
      COMMON/COEF/C(4,50),Z1(200)
      DIMENSION X(1),Y(1),FD(1)
      CALL SCAMP4(X,Y,N,NDA,-1,DA,0.,C,FD,0)
      RETURN
      END
```

```
      FUNCTION DERIV1(X1,Y1,N)
C
C     FIND THE FIRST DERIVATIVE OF THE QUADRATIC THROUGH THREE GIVEN
C     POINTS AT A SPECIFIED ONE OF THESE POINTS. THIS PROVIDES A GOOD
C     APPROXIMATION TO THE SLOPE OF A FUNCTION AT A POINT, PARTICULARLY
C     IF THE OTHER TWO POINTS USED ARE NEARBY.
C
      DIMENSION X(3),Y(3),X1(3),Y1(3)
      EQUIVALENCE (S,K)
      DO 10 I=1,3
      X(I)=X1(I)
      Y(I)=Y1(I)
10    CONTINUE
      K=N
      E=Y(1)-Y(2)
      H=Y(1)-Y(3)
      A=X(1)-X(2)
      B=X(1)-X(3)
      C=A*(X(1)+X(2))
      DT=B*(X(1)+X(3))
      C3=(B*E-A*H)/(B*C-A*DT)
      C2=(E-C3*C)/A
      K1=IABS(K)
      DO 20 I=1,3
      IF (K1.EQ.I) GO TO 30
20    CONTINUE
      GO TO 40
30    S=X(K1)
40    DERIV1=C2+2.*C3*S
      RETURN
      END
```

```
      FUNCTION DERIV2(X,Y,XX)
C
C     FIND THE SECOND DERIVATIVE OF THE CUBIC THROUGH FOUR GIVEN POINTS
C     AT AN ARBITRARY POINT WHOSE X COORDINATE IS SPECIFIED
C
      DIMENSION X(4),Y(4)
      DERIV2=0.
      IF (X(4).EQ.X(3)) RETURN
      IF (X(4).EQ.X(2)) RETURN
      IF (X(4).EQ.X(1)) RETURN
      IF (X(3).EQ.X(2)) RETURN
```

```
      IF (X(3).EQ.X(1)) RETURN
      IF (X(2).EQ.X(1)) RETURN
      Q41=(Y(4)-Y(1))/(X(4)-X(1))
      Q31=(Y(3)-Y(1))/(X(3)-X(1))
      Q21=(Y(2)-Y(1))/(X(2)-X(1))
      E=(Q31-Q21)/(X(3)-X(2))
      D=((Q41-Q21)/(X(4)-X(2))-E)/(X(4)-X(3))
      C=E-D*(X(3)+X(2)+X(1))
      DERIV2=2.*(C+3.*D*XX)
      RETURN
      END
```

```
      SUBROUTINE DIAGIN
C
C  INVERT THE DIAGONAL BLOCKS OF THE MATRIX
C  FOR MATRIX PARTITIONS % 60X60  INVERTED DIAGONALS ARE ON TAPE10.
C
      COMMON /PARAM / NBODY,NWING,NTAIL,LRC,THK,XMACH,ALPHA,BETA,ALPHAC
     1   ,PHIR,REFA,REFB,REFC,REFD,REFL,REFX,REFZ
      COMMON /VELCOM/ NPOINT,NPART,IMAX,JMAX,NMAX,EM,IPRINT,NWTHK
     1   ,NWBLOK,NWROW(20),NBBLOK,NBROW(60)
      COMMON /POINT / D(60,60),ZW(2400)
C
      CALL CPUTIM(TIME,DT,1)
      REWIND 9
      REWIND 10
      NDIM=60
      IF (NBODY.EQ.0) GO TO 50
C
C  READ MATRICES AND INVERT DIAGONAL BLOCKS
C
      DO 40 NB=1,NBBLOK
      NROW=NBROW(NB)
      NCOL=NROW
      IF (NBODY.GT.NMAX) GO TO 20
C        IF NBODY)61, USE ENTIRE MATRIX ON TAPE9
      DO 10 I=1,NBODY
      READ (9) (D(I,J),J=1,NBODY)
10    CONTINUE
      GO TO 30
C        IF NBODY%60, USE DIAGONAL BLOCKS ON TAPE7
20    READ (7) D
30    CALL INVERT(D,NCOL,NDIM)
      WRITE (10) D
40    CONTINUE
C
C  READ WING MATRICES AND INVERT DIAGONAL BLOCKS -------------------------
C
50    CONTINUE
C*    IF (NWING.EQ.0) GO TO 140
C        IF NWING)61, READ PAST WING/BODY MATRICES AND USE ENTIRE MATRIX
C*130   CONTINUE
140   REWIND 10
      REWIND 9
      REWIND 7
      CALL CPUTIM(TIME,DT,1)
      WRITE(6,150) TIME,DT
150   FORMAT(/10X,14HEND DIAGIN,  TIME=,F10.4,5X,3HDT=,F10.4)
      RETURN
      END
```

```
      COMPLEX FUNCTION DSDZ(S)
      COMMON/COM2/SIG2,H2
      COMMON/COM5/DWDZ
      COMMON/COM4/G2,G1
      COMMON/COM6/W2,W
      COMPLEX W,W2,DWDZ,G1,G2
      DSDZ=0.5*(1.0-SIG2**2)*(1.0+G1/G2)*DWDZ
      RETURN
      END
```

```
      COMPLEX FUNCTION DZDS(S)
      COMMON/COM1/A2,B2,R2
      COMMON/COM2/SIG2,H2
      COMMON/COM6/W2,W
      COMPLEX W,S,W2,G1,S2,Z,Z2
      S2=S*S
      G1=0.5*(1.0-0.25*(A2-B2)**2)*(1.0-R2/S2)
      Z=S+R2/S
      Z2=Z*Z-4.0*SIG2
      Y=AIMAG(Z)
      YZ=AIMAG(Z2)
      AY=1.0
      AYZ=1.0
      IF(Y.LT.0.0) AY=-1.0
      IF(YZ.LT.0.0) AYZ=-1.0
      Z2=CSQRT(Z2)*AY*AYZ
      IF((ABS(Y).LE.0.0).AND.(REAL(Z).LT.0.0)) Z2=CMPLX(-REAL(Z2),
     1     AIMAG(Z2))
      DZDS=G1*(1.0+Z/Z2)
      RETURN
      END
```

```
      SUBROUTINE ELBDVT (VA,WA,XPT,YPT,ZPT,NBODY)
C
C  ROUTINE ELBDVT - ELLIPTICAL BODY NOSE SEPARATION VORTEX CALCULATION
C                   --          -   -                       -   -
C  THIS ROUTINE INTERPOLATES IN TABLES OF VORTEX STRENGTH AND LOCATION
C  VERSUS X-STATION TO COMPUTE THE VORTEX VELOCITIES AT BODY CONTROL
C  POINTS
C
      DIMENSION VA(1),WA(1),XPT(1),YPT(1),ZPT(1)
      DIMENSION G(10),VX(10),VY(10)
      DIMENSION YVRTX(10,10),ZVRTX(10,10),GX(10,10)
      COMMON /BVRTX / NVTX,NXVTX,XV(10),AV(10),BV(10)
      COMMON /JOPTNS/ IZ1(68),IPRT(5),IXZSYM
      LOGICAL LPRT,LPRT3
      IF (NVTX.LE.0)                              RETURN
      IF (NXVTX.LE.0)                             RETURN
      LPRT = IPRT(1).GT.0
      LPRT3 = IPRT(3).GT.0
C
C  ---------------- VORTEX LOCATION AND STRENGTHS ----------------------
C          FIRST SUBSCRIPT = VORTEX NO.#   SECOND SUBSCRIPT = X-STATION
C
C  READ VORTEX (Y,Z) LOCATIONS AT EACH STATION BY VORTEX
C
```

```
      IF (LPRT) WRITE(6,190)
      DO 130 I=1,NVTX
      READ(5,180) (YVRTX(I,J),J=1,NXVTX)
      IF (LPRT) WRITE(6,220) I,(YVRTX(I,J),J=1,NXVTX)
      READ(5,180) (ZVRTX(I,J),J=1,NXVTX)
      IF (LPRT) WRITE(6,200) I,(ZVRTX(I,J),J=1,NXVTX)
      READ(5,180) (GX(I,J),J=1,NXVTX)
      IF (LPRT) WRITE(6,210) I,(GX(I,J),J=1,NXVTX)
  130 CONTINUE
C
C  VORTEX INTERPOLATION SUMMARY TABLE
C
      WRITE(6,230)
      DO 135 I=1,NVTX
      WRITE(6,240) I
      WRITE(6,250) (J,XV(J),YVRTX(I,J),ZVRTX(I,J),BV(J),AV(J),GX(I,J)
     *   ,J=1,NXVTX)
  135 CONTINUE
C
C  ---------------- LOOP ON BODY CONTROL POINTS ------------------------
C
      IF (LPRT3) WRITE(6,270)
      DO 170 I=1,NBODY
      VA(I) = 0.0
      WA(I) = 0.0
      IF (XPT(I).LT.XV(1)     ) GO TO 170
      IF (XPT(I).GT.XV(NXVTX)) GO TO 170
C
C  LOCATE X-CONTROL POINTS IN VORTEX TABLE
C
      DO 140 J=2,NXVTX
      IF (XPT(I).LE.XV(J)) GO TO 150
  140 CONTINUE
      J = NXVTX
  150 JM1 = J-1
      SLOPE = XV(J)-XV(JM1)
      IF (SLOPE.NE.0.) SLOPE=(XPT(I)-XV(JM1))/SLOPE
C
C  INTERPOLATE FOR STRENGTH AND LOCATION OF EACH VORTEX
C
      DO 160 K=1,NVTX
      G(K) = GX(K,JM1)+(GX(K,J)-GX(K,JM1))*SLOPE
      VX(K) = YVRTX(K,JM1)+(YVRTX(K,J)-YVRTX(K,JM1))*SLOPE
      VY(K) = ZVRTX(K,JM1)+(ZVRTX(K,J)-ZVRTX(K,JM1))*SLOPE
  160 CONTINUE
C
C              RH IS HORIZONTAL AXIS AND  BL IS VERTICAL AXIS
C
      BL = AV(JM1)+(AV(J)-AV(JM1))*SLOPE
      RH = BV(JM1)+(BV(J)-BV(JM1))*SLOPE
C
C
C     DETERMINE Y AND Z COORDINATES OF POINT ON THE BODY SURFACE,
C     LYING ON THE SAME RADIUS AS POINT XPT,YPT,ZPT,THAT IS WITH THE
C     SAME POLAR ANGLE.
C
      THTP=ATAN2(ZPT(I),YPT(I))
      SINE=SIN(THTP)
      COSINE=COS(THTP)
      RAD=1.0/SQRT((COSINE/RH)**2+(SINE/BL)**2)
C
C     MOVE POINT OUT 1 PERCENT OF BODY RADIUS.
C
      RAD=1.01*RAD
```

```
      YSURF=RAD*COSINE
      ZSURF=RAD*SINE
C
C  COMPUTE VELOCITY COMPONENTS INDUCED BY THE SPECIFIED VORTICITY
C  AT THE POINTS CALCULATED ABOVE.
C
      CALL VVELS(NVTX,YSURF ,ZSURF ,VX,VY,G,RB,BL,VA(I),WA(I),0,35)
C
      IF (LPRT3) WRITE(6,260) I,XPT(I),YSURF ,ZSURF ,VA(I),WA(I),RB,BL
      IF (LPRT3) WRITE(6,265) (K,VX(K),VY(K),G(K),K=1,NVTX)
170   CONTINUE
      RETURN
180   FORMAT(10F7.3)
190   FORMAT(///,10X,28HVORTEX LOCATION AND STRENGTH,
     *   72X,12H** ELBOVT **)
200   FORMAT(/,5H   I=,I3,7H ZVRTX=,10F10.4)
210   FORMAT(/,5H   I=,I3,7H    GX=,10F10.4)
220   FORMAT(//5H   I=,I3,7H YVRTX=,10F10.4)
230   FORMAT(//10X,26HVORTEX INTERPOLATION TABLE)
240   FORMAT(/ 5X,6HVORTEX,I5,
     *   //5H STAT,7X,2HXV,5X,5HYVRTX,5X,5HZVRTX,8X,2HBY,8X,2HAZ
     *   ,5X,5HGAM/V/)
250   FORMAT(I5,F10.3,5F10.4)
260   FORMAT(6H    I=,I5,7H   XPT=,F10.4,7H YSURF=,F10.4,7H ZSURF=,F10.4
     * ,7H    VA=,F10.5,7H    WA=,F10.5,7H    RB=,F10.4,7H    BL=,F10.4)
265   FORMAT(6H    K=,I5,7H    VX=,F10.4,7H    VY=,F10.4,
     *   7H     G=,F10.4)
270   FORMAT(1H1,10X,43HVORTEX STRENGTHS AND VELOCITIES AFTER VVELS /)
      END
```

```
      SUBROUTINE FORMOM(NPAN,NPASS,ALFA,COMPT,TSTXCP)
C
C  CALCULATE THE FORCE AND MOMENT COEFFICIENTS ON THE BODY, WING,
C  FIN (VERTICAL TAIL) AND CANARD (HORIZONTAL TAIL)
C NOTE: AS USED IN PROGRAM WOYBDY, BODY ONLY IS TREATED.
C
      COMMON /JOPTNS/ IZ1(59),NVLIN
     *   ,NCPOUT,XSTART,XMLF,NPCPT,IPLOT(4),IPRT(5),IXZSYM
      COMMON /HEAD  / TITLE1(8),TITLE2(8)
      COMMON           DCN(600),DCM(600),DCT(600),ZS(600),SIND(600),
     1   COSD(600),CP(600),DUD(300),SINT(600),COST(600),GW(600),
     2   GB(600),DZTDX(600)
      COMMON /FORM  / CNW,CTW,CMW,CNB,CTB,CMB,CNS(20),CTS(20),CMS(20)
      COMMON /PARAM / NBODY,NWING,NTAIL,LBC,THK,XMACH,ALPHA,BETA,ALPHAC
     1   ,PHIR,REFA,REFB,REFC,REFD,REFL,REFX,REFZ
      COMMON /VELCOM/ NPOINT,NPART,IMAX,JMAX,NMAX,EM,IPRINT,NWTHK
     1   ,NWBLOK,NWROW(20),NBBLOK,NBROW(60)
      COMMON /NEWCOM/ K1,KWAF,KWAFOR,KRADX(4),KFORX(4),KFUS,MAX,K4,K5
     1   ,KF(6),KAN(6),KFINOR(6),KANOR(6),KOL,NCPT,LOCPT(20),XCPT(20)
      COMMON /SEG   / NSEG,NROW(20),NCOL(20),COSS(20),SINS(20)
     1   ,BTE(20),NAT(20),SPAN(20),XLEW(20),BLE(20),ZLEW(20),NPLT(60)
      COMMON /POINT / ARRAY(6000)
C
      DIMENSION XPT(600),YPT(600),ZPT(600),THET(600),DELTA(600),SGN(600)
     1   ,AREA(600),POLAR(600),CHD(20),XLE(600),          XC(30,20)
C
      EQUIVALENCE                    (CHD(1),DUD(1))
```

```
     1   ,(XPT(1),ARRAY(1)),            (YPT(1),ARRAY(601))
     2   ,(ZPT(1),ARRAY(1201)),         (THET(1),ARRAY(1801))
     3   ,(DELTA(1),ARRAY(2401)),       (XC(1,1),ARRAY(3001))
     4   ,(SGN(1),ARRAY(3601)),         (AREA(1),ARRAY(4801))
     5   ,(XLEC(1),ARRAY(5401)),        (POLAR(1),DZTDX(1))
      INTEGER COMPT
      LOGICAL LBC,LPLT,TSTXCP
      DATA RADDEG/0.0174532926/
C
C  NOTE THAT THE WING, CANARD, AND TAIL ARE ALL SEGMENTS OF THE WING
C  IN THIS SUBROUTINE
C
C  COMPT=1 INDICATES BODY FORCE AND MOMENT CALCULATION
C       =2 INDICATES WING FORCE AND MOMENT CALCULATION
C
C  NPASS=1 FOR THE BODY
C       =1 FOR THE WING UPPER AND LOWER SURFACES IF THE NON-PLANAR
C          BOUNDARY CONDITION OPTION IS SELECTED
C       =1 FOR THE WING UPPER SURFACE IF THE PLANAR BOUNDARY
C          CONDITION OPTION IS SELECTED
C       =2 FOR THE WING LOWER SURFACE IF THE PLANAR BOUNDARY
C          CONDITION OPTION IS SELECTED
C
C  TSTXCP=FALSE, COMPUTE FORCES FOR ALL PANELS
C        =TRUE , COMPUTE FORCE ONLY BETWEEN XSTART AND XWLE
C
      IF (TSTXCP .AND. XSTART.GE.XWLE)                          RETURN
      NPANL=NPAN
      IF (COMPT.EQ.1) XON=XC(1,1)
      CNB=0.
      CTB=0.
      CMB=0.
C
C     ALFA IS ALPHA SUB C IN RADS.
C
      SIAL=SIN(ALFA)
      COAL=COS(ALFA)
      WRITE (6,320) TITLE1,TITLE2
      WRITE (6,310)
      IF (.NOT.TSTXCP) WRITE (6,450)
      IF (      TSTXCP) WRITE(6,460) XSTART,XWLE
      WRITE (6,330) XMACH,ALPHAC,PHIR
      WRITE (6,350)
      DO 50 I=1,NPAN
      SGN(I)=1.
      SIND(I)=SIN(DELTA(I))
      COSD(I)=COS(DELTA(I))
      SINT(I)=SIN(THET(I))
      COST(I)=COS(THET(I))
50    CONTINUE
      CN=0.
      CT=0.
      CM=0.
      CYB=0.
      CLROLL=0.
      CNYAW=0.
      IP=0
C
C  CALCULATE THE FORCES AND MOMENT ACTING ON EACH PANEL AND SUM OVER
C  THE ENTIRE COMPONENT
C
      DO 160 I=1,NPANL
      IP=IP+1
```

```
      XP=XPT(I)
      YP=YPT(I)
      ZP=ZPT(I)
C
C  CHECK WHETHER TO COMPUTE FORCE BETWEEN XSTART AND XWLE ONLY.
C
      IF (.NOT.TSTXCP) GO TO 150
      DCN(I) = 0.
      DCT(I) = 0.
      DCM(I) = 0.
      IF (XP.LT.XSTART .OR. XP.GT.XWLE) GO TO 160
150   CONTINUE
      CNORM=-CP(I)*AREA(I)*SGN(I)
C
C  FORCE AND MOMENT SIGN CONVENTIONS,BODY COORDINATE SYSTEM.
C        CNORM  = POSITIVE OUTWARD NORMAL FORCE ON PANEL
C        CXB    = POSITIVE AFT
C        CYB    = POSITIVE TO RIGHT
C        CZB    = POSITIVE UP
C        CMB    = POSITIVE NOSE UP
C        CNYAW  = POSITIVE NOSE RIGHT VIEWING FORWARDS
C        CLROLL = POSITIVE CLOCKWISE VIEWING FORWARDS
C
      DCXB = -CNORM*SIND(I)
      DCYB = -CNORM*COSD(I)*SINT(I)
      DCZB =  CNORM*COSD(I)*COST(I)
      DCMB   = -DCZB*(XP-REFX)+DCXB*(ZP-REFZ)
      DCNYAW = -DCYB*(XP-REFX)+DCXB*YP
      DCLROL = -DCZB*YP        +DCYB*(ZP-REFZ)
      DCN(I) = DCZB
      DCT(I) = DCXB
      DCM(I) = DCMB
      XQ=XP
      YQ=YP
      ZQ=ZP
C
C  NONDIMENSIONALIZE BODY PANEL CONTROL POINT COORDINATES
C  X COORDINATES ARE DIVIDED BY THE BODY REFERENCE LENGTH
C  Y AND Z COORDINATES ARE DIVIDED BY THE BODY REFERENCE DIAMETER
C
      XQ=(XP-XON)/REFL
      YQ=YP/REFD
      ZQ=ZP/REFD
      THETP=ATAN2(ZP,YP)*57.29578
      IF (THETP.LT.0.0) THETP=THETP+360.0
      WRITE (6,360) IP,XP,YP,ZP,THETP,CP(I),DCXB,DCYB,DCZB,DCMB
     *    ,DCNYAW,DCLROL
      CN=CN+DCN(I)
      CT=CT+DCT(I)
      CM=CM+DCM(I)
      CYB = CYB+DCYB
      CNYAW = CNYAW+DCNYAW
      CLROLL = CLROLL+DCLROL
160   POLAR(I)=ATAN2(YP,-ZP)*57.29
C
C  PLOT CP VERSUS X AND POLAR ANGLE AROUND BODY
C
      IF (TSTXCP) GO TO 168
      LPLT=IPLOT(2).GT.0
      IF (.NOT.LPLT) GO TO 168
      NCUR=KFORX(1)-1
      NOP =KRADX(1)-1
      IF (KFUS.GT.1) NOP=NPANL
```

```
      IF (KFUS.GT.1) NCUR=1
      DO 164 I=1,NCUR
164   NPLT(I)=NDP
      CALL PLOTA2(XPT,CP,2,NPLT,NDP,NCUR,100,50)
      WRITE(6,500)
      CALL PLOTA2(POLAR,CP,2,NPLT,NDP,NCUR,100,50)
      WRITE(6,510)
168   CONTINUE
C
C  STORE BODY AND WING FORCES AND MOMENT
C
      CNB=CN
      CTB=CT
      CMB=CM
      WRITE (6,370)
      IF (.NOT.TSTXCP) WRITE (6,450)
      IF (      TSTXCP) WRITE(6,460) XSTART,XALF
C
C  COMPUTE NORMAL AND TANGENTIAL (AXIAL) FORCE, PITCHING MOMENT,
C  LIFT AND DRAG COEFFICIENTS, AND COMPONENT CENTER OF PRESSURE
C
C               CHECK FOR SYMMETRIC CONFIGURATION
      SYM = 2.0
      IF (IXZSYM.NE.0) SYM=1.0
      CN=SYM*CN/REFA
      CT=SYM*CT/REFA
      CM=SYM*CM/(REFA*REFD)
      CYB=CYB/REFA
      CNYAW=CNYAW/(REFA*REFD)
      CLROLL=CLROLL/(REFA*REFD)
C
C
      IF (IXZSYM.EQ.0) CYB=0.
      IF (IXZSYM.EQ.0) CLROLL=0.
      IF (IXZSYM.EQ.0) CNYAW=0.
C
C     TRANSFORM FORCES AND MOMENTS (EXCEPT ROLLING MOMENT) INTO
C     WIND-AXIS SYSTEM.
C
      PHI=PHIR*RADDEG
      SINPHI=SIN(PHI)
      COSPHI=COS(PHI)
C
      CL=CN*COSPHI*COAL-CYB*SINPHI*COAL-CT*SIAL
      CY=CN*SINPHI+CYB*COSPHI
      CD=CT*COAL-CYB*SIAL*SINPHI+CN*SIAL*COSPHI
C
      CMW=CM*COSPHI-CNYAW*SINPHI
      CNYAWW=CM*COAL*SINPHI+CNYAW*COAL*COSPHI-CLROLL*SIAL
C
C
C     DXN IS CENTER OF PRESSURE LOCATION MEASURED FROM NOSE TIP
C
      DXN=0.
      IF (CN.NE.0.) DXN=(-CM/CN)*REFD+REFX
      IF (COMPT.EQ.1) WRITE (6,390) REFA,REFD,REFL
      WRITE (6,400) REFX,REFZ
      WRITE (6,410) XMACH,ALPHAC,ALPHA,PHIR,BETA,CT,CYB,CN,CM,CNYAW
     *   ,CLROLL,DXN,CL,CY,CD,CMW,CNYAWW
      RETURN
310   FORMAT (//10X,40HINTEGRATION OF THE PRESSURE DISTRIBUTION
     *   ,60X,12H** FORMOM ** /)
320   FORMAT (1H1,9X,8A10/10X,8A10)
```

```
330   FORMAT (/10X,6HMACH =,F8.4,3X,7HALPHAC=,F8.4,4X,5HPHIR=,F8.4/)     WB18 217
350   FORMAT (3X,5HPOINT,7X,1HX,10X,1HY,10X,1HZ,6X,5HTHETP,8X,2HCP,9X,   WB18 218
     *    2HCX,9X,2HCY,9X,2HCZ,9X,2HCM,8X,3HCLN,8X,3HCLL/)                WB18 219
360   FORMAT (I7,11F11.5)                                                 WB18 220
370   FORMAT (1H1,9X,18HTOTAL COEFFICIENTS/10X,18(1H=))                   WB18 221
390   FORMAT (10X,5HREFA=,F14.4,3X,5HREFD=,F14.4,3X,5HREFL=,F14.4)        WB18 222
400   FORMAT (/10X,5HXM  =,F14.4,3X,5HZM  =,F14.4)                        WB18 223
410   FORMAT (/8X,5HMACH=,F15.5/6X,7HALPHAC=,F15.5,7X,6HALPHA=,F15.5,     WB18 224
     *    /8X,5HPHIR=,F15.5,8X,5HBETA=,F15.5,/10X,3HCX=,F15.5             WB18 225
     *    ,/10X,3HCY=,F15.5,/10X,3HCZ=,F15.5,/10X,3HCM=,F15.5             WB18 226
     *    ,/9X,4HCLN=,F15.5,/9X,4HCLL=,F15.5,/9X,4HXCP=,F15.5,            WB18 227
     *    //10X,33HFOLLOWING ARE IN WIND AXIS SYSTEM,                     WB18 228
     *     /10X,3HCL=,F15.5,/10X,3HCY=,F15.5,                             WB18 229
     *     /10X,3HCD=,F15.5,/9X,4HCMW=,F15.5,                             WB18 230
     *     /6X,7HCNYAWW=,F15.5,/)                                         WB18 231
450   FORMAT (10X,11HON THE BODY//)                                       WB18 232
460   FORMAT(10X,24HON THE BODY FROM XSTART=,F10.4,9H TO XWLE=,F10.4//) WB18 233
500   FORMAT(/20X,11HCP VERSUS X)                                         WB18 234
510   FORMAT(/20X,24HCP VERSUS MERIDIAN ANGLE)                            WB18 235
      END                                                                 WB18 236
```

```
      SUBROUTINE GEOM                                                     WB19   1
CDC   OVERLAY (LW0,1,0)                                                   WB19   2
CDC   PROGRAM GEOM                                                        WB19   3
C                                                                         WB19   4
C    INPUT CONFIGURATION GEOMETRY AND COMPUTE PANELS                      WB19   5
C                                                                         WB19   6
C   SPECIAL COMMENT CARDS STARTING WITH:                                  WB19   7
C     CH  - ELIMINATED FOR BODY PROGRAM VERSION ONLY                      WB19   8
C     CNP - ELIMINATED FOR NON PLANAR PANEL ONLY                          WB19   9
C                                                                         WB19  10
C   TAPE USAGE IN GEOM-                                                   WB19  11
C     TAPE5:  GEOM,     READ INPUT                                        WB19  12
C                                                                         WB19  13
C     TAPE7:  GEOM,     REWIND                                            WB19  14
C             BODPAN,   WRITE  ARRAY      - SAVE BODY GEOMETRY            WB19  15
C                                                                         WB19  16
C     TAPE8:            NOT USED IN BODY VERSION                          WB19  17
C     TAPE9:            NOT USED IN BODY VERSION                          WB19  18
C                                                                         WB19  19
C     TAPE10: GEOM,     REWIND                                            WB19  20
C             NEWRAD,   WRITE XB,YB,ZB - FROM ARRAY                       WB19  21
C             BODPAN,   REWIND                                            WB19  22
C                       READ  XB,YB,ZB - INTO BLOCK                       WB19  23
C                       REWIND                                            WB19  24
C                                                                         WB19  25
      COMMON /JOPTNS/ IZ1(8)                                              WB19  26
     1   ,J0,J1,J2,J3,J4,J5,J6,NWAF,NWAFOR,NFUS,NRADX(4),NFORX(4)         WB19  27
     2   ,NP,NPODOR,NF,NFINOR,NCAN,NCANOR,J2TEST,NW,    IZ2(25)           WB19  28
     3   ,NVLIN,NCPOUT,XSTART,XWLE,NWCPT,IPLOT(4),IPRT(5),IXZSYM          WB19  29
      COMMON /PARAM / NBODY,NWING,NTAIL,LBC,THK,XMACH,ALPHA,BETA,ALPHAC WB19  30
     1   ,PHIR,REFA,REFB,REFC,REFD,REFL,REFX,REFZ                         WB19  31
      COMMON /HEAD  / TITLE1(8),TITLE2(8)                                 WB19  32
      COMMON /SEG   / NSEG,NROW(20),NCOL(20),COSS(20),SINS(20)            WB19  33
     1   ,RTE(20),NWT(20),SPNW(20),XLEW(20),BLE(20),ZLEW(20),ZB(60)       WB19  34
      COMMON          BLOCK(7500)                                         WB19  35
      COMMON /NEWCOM/ K1,KWAF,KWAFOR,KRADX(4),KFORX(4),KFUS,MAX,K4,K5     WB19  36
     1   ,KF(6),KAN(6),KFINOR(6),KANOR(6),KBL,NCPT,LOCPT(20),XCPT(20)     WB19  37
      COMMON /VELCOM/ NPOINT,NPART,IZ4(2),NMAX,EM,IPRINT,NWTHK            WB19  38
```

```
     1    ,NWBLOK,NWROW(20),NBBLOK,NBROW(60)
      COMMON/ITERAT/ITMAX,CCTEST
      COMMON /RVRTX / NVTX,NXVTX,XV(10),AV(10),BV(10)
C
      LOGICAL LBC,THK,TAIL,LPRT
C
      IF (INIT.EQ.1) GO TO 9
      DO 5 I=1,24
5     KF(I)=0
      DO 6 I=1,260
6     NROW(I)=0
9     INIT=1
C
C   LBC=.TRUE.,  FOR PLANAR BOUNDARY CONDITION ON WINGS (LINBC=1)
C   LBC=.FALSE., FOR NON-PLANAR BOUNDARY CONDITION (LINBC=0)
C   THK = .TRUE.,  FOR WINGS WITH THICKNESS AND NONPLANAR PANELING
C                             (ITHICKX0)
CNP   LBC=.FALSE.
      LBC=.TRUE.
      THK=.FALSE.
      EM=-1.
      ALPHA = 0.0
      BETA  = 0.0
      IPRINT=0
      NCPT=0
      NBODY=0
      NWING=0
      NTAIL=0
      NSEG=0
      KOL=0
      REFB=1.
      REFC=1.
      REFD=1.
      REFL=1.
      REFX=0.
      REFZ=0.
      ITMAX=0
      CCTEST=0.
      REWIND 7
C8    REWIND 8
C9    REWIND 9
      REWIND 10
C
C    INPUT CONFIGURATION PARAMETERS
C
      READ (5,150) TITLE1
      IF (EOF(5).NE.0.)                                    STOP 20
10    WRITE (6,170) TITLE1
C
C   DEBUG PRINT CONTROL OPTIONS
      READ (5,180) IPRT,IXZSYM,IPLOT,NWCPT,NVTX,NXVTX,NCPOUT,NVLIN
      LPRT = IPRT(1).GT.0
      IF (LPRT) WRITE(6,220) IPRT,IXZSYM,IPLOT,NWCPT,NVTX,NXVTX,NCPOUT
     *    ,NVLIN
C
C   VORTEX CALCULATION PARAMETERS
      READ (5,160) XWLE,XSTART
      IF (LPRT) WRITE(6,290) XWLE,XSTART
C
C   GEOMETRY DEFINTION OPTIONS
      READ (5,180) J0,J1,J2,J3,J4,J5,J6,NWAF,NWAFOR,NFUS,
     1    (NRADX(I),NFORX(I),I=1,4),NP,NPODOR,NF,NFINOR,NCAN,NCANOR
      IF (LPRT) WRITE(6,230) J0,J1,J2,J3,J4,J5,J6,NWAF,NWAFOR,NFUS
```

```
     1    ,NRADX,NFORX,NP,NPFDOR,NF,NFINOR,NCAN,NCANOR
C
C    INPUT DESCRIPTION AND INITIALIZATION
C    SET BOUNDARY CONDITION AND WING THICKNESS OPTIONS
C
30     CALL CONFIG
CDC    CALL OVERLAY (LWB,1,1)
       READ (5,150) TITLE2
       IF (LPRT) WRITE(6,170) TITLE2
       READ (5,140) LINBC,ITHICK,IPRINT,LCPA,LCPB,LCPC,ITMAX,CCTEST
       IF (LPRT) WRITE(6,240)
      *   LINBC,ITHICK,IPRINT,LCPA,LCPB,LCPC,ITMAX,CCTEST
       IF (LINBC.GT.0) LBC=.TRUE.
       IF (LBC.AND.ITHICK.GT.0) THK=.TRUE.
C
C    INPUT REVISED CONFIGURATION PANELING DESCRIPTION CONTROL INTEGERS
C
       READ (5,180) K0,K1,K2,K3,K4,K5,K6,KWAF,KWAFOR,KFUS,
      1    (KRADX(I),KFORX(I),I=1,4)
       IF (LPRT) WRITE(6,250) K0,K1,K2,K3,K4,K5,K6,KWAF,KWAFOR,KFUS,
      1    KRADX,KFORX
       TAIL=.FALSE.
       IF (K4.GT.0.OR.K5.GT.0) TAIL=.TRUE.
       IF (TAIL)
      1    READ (5,180) (KF(I),KFINOR(I),I=1,6),(KAN(I),KANOR(I),I=1,6)
       IF (LPRT.AND.TAIL) WRITE(6,260) KF,KFINOR,KAN,KANOR
C
C840    READ (9) REFA
       IF (K0.EQ.0) GO TO 50
       READ (5,160) REFAR,REFB,REFC,REFD,REFL,REFX,REFZ
       IF (LPRT) WRITE (6,270) REFAR,REFB,REFC,REFD,REFL,REFX,REFZ
       IF (REFAR.NE.0.) REFA=REFAR
       IF (REFB.EQ.0.) REFB=1.
       IF (REFC.EQ.0.) REFC=1.
       IF (REFD.EQ.0.) REFD=1.
       IF (REFL.EQ.0.) REFL=1.
C
C   GENERATE GEOMETRY IN ORDER WING, V.TAIL, H.TAIL, BODY
C
50     CONTINUE
       IF (KRADX(1).LE.21) GO TO 70
       WRITE (6,200)
       STOP 200
70     CONTINUE
C
C   READ AND COMPUTE BODY VORTEX GEOMETRY REQUIRED ----------------------
C
       CALL READVX (NFUS,NFORX,LPRT)
C
C    REVISE BODY (FUSELAGE) MERIDIAN LINE SPACING, THEN
C    REVISE AXIAL PANEL SPACING ON BODY (FUSFLAGE) AND
C    COMPUTE NEW PANEL GEOMETRY
C
       CALL NEWRAD
       CALL BODPAN
CDC    CALL OVERLAY (LWB,1,4)
CDC    CALL OVERLAY (LWB,1,5)
C
C   WRITE CONTROL POINTS ON TAPE4 ---------------------------------------
C   IF NCPOUT.GT.0, PRTCPT GENERATES CONTROL POINT FOR VPATHL
C   IF NCPOUT=2,   STOP AFTER WRITING POINTS
C
       IF (NCPOUT.GT.0) CALL PRTCPT(NBODY)
```

```
C                                                                        WB19 165
      CALL CPUTIM (TIME,DT,1)                                            WB19 166
      IF (IPRINT.LT.0) WRITE(6,210) TIME,DT                              WB19 167
      RETURN                                                             WB19 168
C                                                                        WB19 169
C                                                                        WB19 170
140   FORMAT (7I3,F7.0)                                                  WB19 171
150   FORMAT (8A10)                                                      WB19 172
160   FORMAT (10F7.0)                                                    WB19 173
170   FORMAT (///5X,8A10,25X,12H** GEOM    **)                           WB19 174
180   FORMAT (24I5)                                                      WB19 175
200   FORMAT (1H0,46HERROR- BODY HAS MORE THAN 20 COLUMNS OF PANELS)     WB19 176
210   FORMAT(///10X,18HEND GEOM    ,  TIME=,F10.3,5X,3HDT=,F10.3)        WB19 177
220   FORMAT(//5X,52HADDITIONAL PRINT OPTIONS (IPRT) + XZ-PANEL SYMMETRYWB19 178
     *   ,/43H     IN   GEOM VORTEX    VEL   SOLN  IXZSYM ,/6I7          WB19 179
     *   ,//5X,20HPLOT OPTIONS (IPLOT)                                   WB19 180
     *   ,/28H    GEOM     CP  U/V/W          ,/4I7                      WB19 181
     *   ,//5X,26HVORTEX CALCULATION CONTROL                             WB19 182
     *   ,/35H  NNCPT   NVTX  NXVTX NCPOUT  NVLIN,/5I7)                  WB19 183
230   FORMAT(//10X,37HJ-DATA CARDS REQUIRED (NO=0,YES.NE.0)              WB19 184
     *   ,//50H    REFA   WING  BODY   POD  V.FIN H.TAIL XY-SYM          WB19 185
     *   ,/49H     J0     J1     J2     J3     J4     J5     J6,/7I7     WB19 186
     *   ,//21H  WING GEOM:   NWAF=,I5,3X,7HNWAFOR=,I5,                  WB19 187
     *   ,/21H  BODY GEOM:   NFUS=,I5,4X,6HNRADX=,4I5                    WB19 188
     *   ,/30X,6HNFORX=,4I5                                              WB19 189
     *   ,/21H   POD GEOM:     NP=,I5,3X,7HNPODOR=,I5                    WB19 190
     *   ,/21H  V.FIN GEOM:     NF=,I5,3X,7HNFINOR=,I5                   WB19 191
     *   ,/21H H.TAIL GEOM:   NCAN=,I5,3X,7HNCANOR=,I5)                  WB19 192
240   FORMAT(//50H   LINHC  THICK IPRINT   LCPA   LCPB   LCPC  ITMAX     WB19 193
     *   ,7H CCTEST,/7I7,F10.5)                                          WB19 194
250   FORMAT(//10X,44HK-DATA CARDS,  ADDITIONAL CARDS FOR PANELING       WB19 195
     *   ,//50H     REF   WING   BODY    N/A  V.FIN H.TAIL    N/A        WB19 196
     *   ,/50H      K0     K1     K2     K3     K4     K5     K6 ,/7I7   WB19 197
     *   ,//22H   WING PANEL:   KWAF=,I5,5X,7HKWAFOR=,I5,                WB19 198
     *   ,/22H   BODY PANEL:   KFUS=,I5,4X,6HKRADX=,4I5                  WB19 199
     *   ,/31X,6HKFORX=,4I5)                                             WB19 200
260   FORMAT(14H  V.FIN PANEL:,16X,7H     KF=,6I5,/30X,7HKFINOR=,6I5     WB19 201
     *   ,/14H H.TAIL PANEL:,16X,7H    KAN=,6I5,/30X,7H KANOR=,6I5)      WB19 202
270   FORMAT(//10X,23HPANEL REFERENCE LENGTHS                            WB19 203
     *   ,/4X,5HREFAR,5X,4HREFB,6X,4HREFC,6X,4HREFD,6X,4HREFL            WB19 204
     *   ,6X,4HREFX,6X,4HREFZ,/8F10.3)                                   WB19 205
290   FORMAT (/6X,4HXWLE,4X,6HXSTART ,/2F10.3)                           WB19 206
      END                                                                WB19 207
```

```
      SUBROUTINE INVERT(A,IA,NROWS)                                      WB20   1
C                                                                        WB20   2
C  MATRIX INVERSION --- GAUSS-JORDAN ELIMINATION WITHOUT PIVOTING        WB20   3
C                                                                        WB20   4
      DIMENSION IPIVOT(60),INDXR(60),INDXC(60),A(NROWS,NROWS)            WB20   5
      N=IA                                                               WB20   6
      DO 10 J=1,N                                                        WB20   7
      IPIVOT(J)=0                                                        WB20   8
10    CONTINUE                                                           WB20   9
      DO 100 I=1,N                                                       WB20  10
      T=0.                                                               WB20  11
      DO 30 J=1,N                                                        WB20  12
      IF (IPIVOT(J).EQ.1) GO TO 30                                       WB20  13
      DO 20 K=1,N                                                        WB20  14
      IF (IPIVOT(K).EQ.1) GO TO 20                                       WB20  15
```

```
      IF (.NOT.(ABS(A(J,K))-ABS(T).GT.0.)) GO TO 20
      IROW=J
      ICOL=K
      T=A(J,K)
20    CONTINUE
30    CONTINUE
      IPIVOT(ICOL)=IPIVOT(ICOL)+1
      IF (IROW.EQ.ICOL) GO TO 50
      DO 40 L=1,N
      T=A(IROW,L)
      A(IROW,L)=A(ICOL,L)
      A(ICOL,L)=T
40    CONTINUE
50    INDXR(I)=IROW
      INDXC(I)=ICOL
      PIVOT=A(ICOL,ICOL)
      IF (PIVOT.EQ.0.) GO TO 130
      A(ICOL,ICOL)=1.
      DO 70 L=1,N
      A(ICOL,L)=A(ICOL,L)/PIVOT
70    CONTINUE
      DO 90 L=1,N
      IF (L.EQ.ICOL) GO TO 90
      T=A(L,ICOL)
      A(L,ICOL)=0.
      DO 80 M=1,N
      A(L,M)=A(L,M)-A(ICOL,M)*T
80    CONTINUE
90    CONTINUE
100   CONTINUE
      DO 120 I=1,N
      L=N+1-I
      IF (INDXR(L).EQ.INDXC(L)) GO TO 120
      IROW=INDXR(L)
      ICOL=INDXC(L)
      DO 110 K=1,N
      T=A(K,IROW)
      A(K,IROW)=A(K,ICOL)
      A(K,ICOL)=T
110   CONTINUE
120   CONTINUE
      RETURN
130   WRITE (6,140)
      STOP
140   FORMAT (1H0,30HERROR - THE MATRIX IS SINGULAR)
      END
```

```
      SUBROUTINE ITRATE
C
C  SOLVE THE BOUNDARY CONDITION EQUATIONS BY AN ITERATIVE METHOD AND
C  DETERMINE THE STRENGTHS OF THE BODY SOURCES AND THE WING, FIN
C  (VERTICAL TAIL), AND CANARD (HORIZONTAL TAIL) VORTICES.
C
      COMMON /POINT / D(60,60),DNB(600),DNW(600),Z6(1200)
      COMMON          NW(600),NB(600),NT(600),A(600),RW(600),RB(600),
     1 Z7(2100),GW(600),GB(600),GT(600)
      COMMON /PARAM / NBODY,NWING,NTAIL,LHC,THK,XMACH,ALPHA,BETA,ALPHAC
     1   ,PHIR,REFA,REFB,REFC,REFD,REFL,REFX,REFZ
      COMMON /VELCOM/ NPOINT,NPART,IMAX,JMAX,NMAX,EM,IPRINT,NWTHK
```

```
     1    ,NWBLOK,NWROW(20),NBBLOK,NBROW(60)
      COMMON /ITERAT/ ITMAX,CCTEST
      REAL NB,NW,NT
C
C   VARIABLE DEFINITIONS:
C          NW,NB - INPUT NORMAL VELOCITY , WING AND BODY
C          GW,GB - OUTPUT STRENGTH (WING AND BODY)
C          D     - DIAGONAL BLOCK MATRIX
C          RW,RB - RESIDUAL NORMAL VELOCITY COMPONENT
C          NT,GT - TEMPORARY VECTORS FOR LAST ITERATION
C
      IMAX=15
      IF (ITMAX.NE.0) IMAX=ITMAX
      EPS=1.E-3
      IF (CCTEST.NE.0.) EPS=CCTEST
      REWIND 9
C
C   INITIALIZE WING AND BODY SOLUTION
C
      IF (NBODY.EQ.0) GO TO 20
      DO 10 N=1,NBODY
      NT(N)=0.
      RB(N)=NB(N)
 10   CONTINUE
 20   CONTINUE
CB       IF (NWING.EQ.0) GO TO 40
CB       DO 30 N=1,NWING
CB       GT(N)=0.
CB       RW(N)=NW(N)
CB30     CONTINUE
C
C   START ITERATION ---------------------------------------------------------
C
 40   DO 250 IT=1,IMAX
      CALL CPUTIM(TIME,DT,1)
      IF (IABS(IPRINT).GT.2) WRITE(6,390) IT,TIME,DT
      ITEST=0
      IB=0
      IW=0
      IF (NBODY.EQ.0) GO TO 80
C
C   COMPUTE BODY STRENGTHS FROM DIAGONAL BLOCKS - GB = D*RB
C
      JS=0
      NBLOK=NBBLOK
      DO 60 NN=1,NBLOK
      NROW=NBROW(NN)
      NCOL=NROW
      READ (10) D
      DO 50 I=1,NROW
      IB=IB+1
      GB(IB)=0.
      DO 50 J=1,NCOL
      JJ=J+JS
      GB(IB)=GB(IB)+D(I,J)*RB(JJ)
 50   CONTINUE
      JS=JS+NROW
 60   CONTINUE
C          BODY CONVERGENCE TEST
      IF (IT.EQ.1) GO TO 80
      DO 70 N=1,NBODY
      IF (ABS(GB(N)-NT(N)).GE.EPS) ITEST=1
      IF (ITEST.EQ.1) GO TO 80
```

```
70     CONTINUE
C
C  COMPUTE WING STRENGTHS FROM DIAGONAL BLOCKS - GW = D*RW
C
80     CONTINUE
CB       IW = 0
CB       IF (NWING.EQ.0) GO TO 120
CB       JS=0
CB       NBLOK=NWBLOK
CB       DO 100 NN=1,NBLOK
CB       NROW=NWROW(NN)
CB       NCOL=NROW
CB       READ (10) D
CB       DO 90 I=1,NROW
CB       IW=IW+1
CB       GW(IW)=0.
CB       DO 90 J=1,NCOL
CB       JJ=J+JS
CB       GW(IW)=GW(IW)+D(I,J)*RW(JJ)
CB90     CONTINUE
CB       JS=JS+NROW
CB100    CONTINUE
CBC          WING CONVERGENCE TEST
CB       IF (IT.EQ.1) GO TO 120
CB       DO 110 N=1,NWING
CB       IF (ABS(GW(N)-GT(N)).GE.EPS) ITEST=1
CB       IF (ITEST.EQ.1) GO TO 120
CB110    CONTINUE
C
C  PRINT ITERATION INFORMATION  -------------------------------------------
C
120    REWIND 10
       IF (IABS(IPRINT).LT.3) GO TO 130
       WRITE (6,360) IT
       IF (NBODY.GT.0) WRITE (6,370) NBODY,(GB(N),N=1,NBODY)
       IF (NWING.GT.0) WRITE (6,380) NWING,(GW(N),N=1,NWING)
130    IF (IABS(IPRINT).LT.4) GO TO 140
       IF (NBODY.GT.0) WRITE (6,290) NBODY,(RB(N),N=1,NBODY)
       IF (NWING.GT.0) WRITE (6,300) NWING,(RW(N),N=1,NWING)
140    IF (ITEST.EQ.0.AND.IT.NE.1) GO TO 260
       IF (IT.GE.IMAX) GO TO 270
C
C  COMPUTE CROSS INFLUENCE BETWEEN BLOCKS  ------------------------------
C          BODY PANEL J ON BODY CONTROL POINT I
C
CB     IF (NBODY.EQ.0) GO TO 200
       DO 165 I=1,NBODY
       BT(I)=GB(I)
       DNB(I)=0.
       READ (9) (A(J),J=1,NBODY)
       IF (NBODY.LE.NMAX) GO TO 160
       DO 150 J=1,NBODY
       DNB(I)=DNB(I)+A(J)*GB(J)
150    CONTINUE
160    RB(I)=NB(I)-DNB(I)
165    CONTINUE
C          WING PANEL J ON BODY CONTROL POINT I
CB     IF (NWING.EQ.0) GO TO 200
CB240    CONTINUE
250    REWIND 9
C
C  PRINT ITERATION SUMMARY    ----------------------------------------------
260    WRITE (6,310) IT,EPS
```

```
      GO TO 280
270   WRITE (6,320) IMAX,EPS
280   WRITE (6,330)
      IF (NBODY.GT.0) WRITE (6,370) NBODY,(NT(N),N=1,NBODY)
      IF (NWING.GT.0) WRITE (6,380) NWING,(GT(N),N=1,NWING)
      WRITE (6,340)
      IF (NBODY.GT.0) WRITE (6,370) NBODY,(GB(N),N=1,NBODY)
      IF (NWING.GT.0) WRITE (6,380) NWING,(GW(N),N=1,NWING)
      RETURN
290   FORMAT (2X,10HRB(N),N=1,,I3/(1X,10F10.5))
300   FORMAT (2X,10HRW(N),N=1,,I3/(1X,10F10.5))
310   FORMAT (1H0,29HTHE ITERATION CONVERGED AFTER,I4,2X,
     1 35HITERATIONS WITH A TEST CRITERION OF,F10.7)
320   FORMAT (1H0,36HTHE ITERATION DID NOT CONVERGE AFTER,I4,2X,
     1 35HITERATIONS WITH A TEST CRITERION OF,F10.7)
330   FORMAT (1H0,41HTHE SOLUTION AT THE PREVIOUS ITERATION IS)
340   FORMAT (1H0,40HTHE SOLUTION AT THE PRESENT ITERATION IS)
360   FORMAT (17H0ITERATION NUMBER,I4)
370   FORMAT (2X,10HGB(N),N=1,,I3/(1X,10F10.5))
380   FORMAT (2X,10HGW(N),N=1,,I3/(1X,10F10.5))
390   FORMAT(/10X,25HCPU TIME IN ITRATE AT IT=,I4
     *   ,5X,5HTIME=,F10.4,5X,3HDT=,F10.4)
      END
```

```
      SUBROUTINE MXOUT (PAR,VAL,A,N,M,LINS,IPOS,ISP,ND,MD)
C
C     ...................................................................
C
C        SUBROUTINE MXOUT
C
C     PURPOSE
C           PRODUCES AN OUTPUT LISTING OF ANY SIZED ARRAY ON
C           LOGICAL UNIT 6
C
C        USAGE
C           CALL MXOUT (PAR,VAL,A,N,M,LINS,IPOS,ISP,ND,MD)
C
C        DESCRIPTION OF PARAMETERS
C           PAR - ALPHANUMERIC  PARAMETER NAME,  8H--------
C           VAL - NUMERICAL VALUE OF PAR
C           A - NAME OF OUTPUT MATRIX
C           N - NUMBER OF ROWS IN A
C           M - NUMBER OF COLUMNS IN A
C           LINS - NUMBER OF PRINT LINES ON THE PAGE (USUALLY 60)
C           IPOS - NUMBER OF PRINT POSITIONS ACROSS THE PAGE (132)
C           ISP - LINE SPACING CODE, 1 SINGLE SPACE, 2 DOUBLE SPACE
C                 3 SINGLE SPACE, NEW PAGE, 4 DOUBLE SPACE, NEW PAGE
C           ND = N DIMENSIONED SIZE OF A
C           MD = M DIMENSIONED SIZE OF A
C
C        SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
C           NONE
C
C        METHOD
C           THIS SUBROUTINE CREATES A STANDARD LISTING OF ANY
C           SIZED ARRAY WITH ANY STORAGE MODE, EACH PAGE IS HEADED WITH
C           THE CODE NUMBER, DIMENSION AND STORAGE MODE OF THE ARRAY,
C           EACH COLUMN AND ROW IS ALSO HEADED WITH ITS RESPECTIVE
C           NUMBER,
```

```
C
C     ------------------------------------------------------------------
C
      DIMENSION A(ND,MD)
CDC   DIMENSION PAR(2)
1     FORMAT(/  ,5X, A8,1XF7.3 ,4X,I3,5H ROWS,4X,I3,8H COLUMNS,
     *                        4X,4X,5HPART ,I2  )
2     FORMAT(1X,10HROW/COLUMN,10(1X,I3,8X))
3     FORMAT(1H )
4     FORMAT(1H ,I7,10G12.5)
5     FORMAT(1H0,I7,10G12.5)
6     FORMAT (1H1)
      J = 1
C
C        WRITE HEADING
C
      NEND = IPOS/12-1
      LEND = (LINS/(MOD(ISP-1,2)+1))-2
      IPAGE = 1
10    LSTRT = 1
20    IF (ISP.GE.3) WRITE (6,6)
      WRITE(6,1)PAR,VAL,N,M,IPAGE
      JNT = J+NEND-1
      IPAGE = IPAGE+1
31    IF (JNT-M) 33,33,32
32    JNT = M
33    CONTINUE
      WRITE(6,2)(JCUR,JCUR=J,JNT)
40    LTEND = LSTRT+LEND-1
      DO 80 L=LSTRT,LTEND
C
C        FORM OUTPUT ROW LINE
C
      DO 55 K=1,NEND
      KK = K+J-1
      JT = J+K-1
C
C        CHECK IF LAST COLUMN.  IF YES GO TO 60
C
      IF (JT-M) 55,60,60
55    CONTINUE
C
C        END OF LINE, NOW WRITE
C
60    IF (MOD(ISP-1,2)) 65,65,70
65    WRITE(6,4)L,(A(L,JW),JW=J,KK)
      GO TO 75
70    WRITE(6,5)L,(A(L,JW),JW=J,KK)
C
C        IF END OF ROWS, GO CHECK COLUMNS
C
75    IF (N-L) 85,85,80
80    CONTINUE
C
C        END OF PAGE, NOW CHECK FOR MORE OUTPUT
C
      LSTRT = LSTRT+LEND
      GO TO 20
C
C        END OF COLUMNS, THEN RETURN
85    IF(JT-M) 90,95,95
90    J = JT+1
      GO TO 10
95    RETURN
      END
```

```
      SUBROUTINE NEWRAD
CDC   OVERLAY (LAB,1,4)
CDC   PROGRAM NEWRAD
C
C  REVISE BODY (FUSELAGE) MERIDIAN LINE SPACING
C  BODY DIEFINATION OPTIONS FOR EACH SEGMENT:
C    J2TEST = 1, CIRCULAR FUSELAGE WITH NO BODY CAMBER
C           = 2, CIRCULAR FUSELAGE WITH BODY CAMBER
C           = 3, ARBITRARY Y,Z CROSS SECTION
C    KRADX  = 0, USE NRADX MERIDIAN ANGLES
C           < 0, READ KRADX METIDIAN ANGLES
C           > 0, GENERATE KRADX EQUAL SPACING MERIDIAN ANGLES
C                 TOTAL NUMBER OF ANLGES MUST BE LESS THAN 21.
C    IXZSYM = 0, SYMMETRIC GEOMETRY AND LOADS ASSUMED
C           = 1, GENERATE FULL SYMMETRIC CONFIGURATION
C           = -1, READ FULL CONFIGURATION (2KRADX-1 VALUES)
C
      COMMON /JOPTNS/ IZ1(8)
     1  ,J0,J1,J2,J3,J4,J5,J6,NWAF,NWAFOR,NFUS,NRADX(4),NFORX(4)
     2  ,NP,NPODOR,NF,NFINOR,NCAN,NCANOR,J2TEST,NW
     3  ,IZ2(34),IPRT(5),IXZSYM
      COMMON           BLOCK(7500)
      COMMON /POINT / ARRAY(6000)
      COMMON /NEWCOM/ K1,KWAF,KWAFOR,KRADX(4),KFORX(4),KFUS,MAX,K4,K5
     1  ,KF(6),KAN(6),KFINOR(6),KANOR(6),KOL,NCPT,LOCPT(20),XCPT(20)
C
      DIMENSION XFUS(30,4),ZFUS(30,4),ZB(30,30),FUSRAD(30,4),
     1 SFUS(30,30,8),ANSIN(30),ANCOS(30),PHIN(30),PHIK(30),XB(30),
     2 YB(30,30),YF(30),ZF(30),FUSAZ(30,4)
C
      EQUIVALENCE  (XFUS(1,1),BLOCK(1)), (ZFUS(1,1),BLOCK(121))
     *  ,(SFUS(1,1,1),BLOCK(241)),       (FUSRAD(1,1),BLOCK(361))
     *  ,(FUSAZ(1,1),BLOCK(481))
      EQUIVALENCE  (YB(1,1),ARRAY(1)),   (ZB(1,1),ARRAY(1801))
     *  ,(XB(1),ARRAY(3601)),            (ANSIN(1),ARRAY(3661))
     *  ,(ANCOS(1),ARRAY(3691)),         (PHIN(1),ARRAY(3721))
     *  ,(PHIK(1),ARRAY(3751))
      LOGICAL NEWPHI
C
      XIN(X1,Y1,X2,Y2,Y)=X1+(X2-X1)*(Y-Y1)/(Y2-Y1)
C
      NEWPHI=.FALSE.
      EPS=1.E-6
      EP2=EPS*EPS
C         M = AXIAL STATION NUMBER
      M=0
      KFUS=NFUS
      KTEST=0
      RADD=1./57.2957795
      REWIND 10
      DO 110 NFU=1,NFUS
      NRAD=NRADX(NFU)
      KRAD=KRADX(NFU)
C
C   J2TEST = 3 AND KRAD = 0 INDICATE AN ARBITRARY FUSELAGE WITH
C   MERIDIAN LINES DEFINED BY NRAD IN THE GEOMETRY INPUT
C   KTEST = ARBITRARY BODY INDICATOR: 0=CIR., 1=ARBITRARY
C
      IF (J2TEST.EQ.3.AND.KRAD.EQ.0) KTEST=1
      IF (KRAD.EQ.0)  KRAD=NRAD
      IF (KRAD.GT.20) GO TO 130
      IF (IXZSYM.NE.0 .AND. (2*KRAD-1).GT.30) GO TO 130
      IF (KRAD.LT.0) NEWPHI=.TRUE.
```

```
      KRAD=IABS(KRAD)
      KRADX(NFU)=KRAD
      NFUSQR=NFQRX(NFU)
      FANG=FLOAT(2*(KRAD-1))
      DELE=6.2831853/FANG
C
C   READ NEW MERIDIAN ANGLES FOR SYMMETRIC HALF
C
      IF (NEWPHI) READ (5,160) (PHIK(K),K=1,KRAD)
      IF (NEWPHI .AND. IPRT(1).GT.0) WRITE(6,190) NFU,(PHIK(K),K=1,KRAD)
      DO 30 K=1,KRAD
      IF (      NEWPHI) PHIR=PHIK(K)*RADD
      IF (.NOT.NEWPHI) PHIR=DELE*FLOAT(K-1)
20    PHIK(K)=PHIR
      IF (J2TEST.EQ.3) GO TO 30
      PHIR4=PHIR+4.712389
      ANSIN(K)=SIN(PHIR4)
      ANCOS(K)=COS(PHIR4)
30    CONTINUE
      KY=1+(NFU-1)*2
      KZ=KY+1
C
C  COMPUTE INTERMEDIATE VALUES AROUND CIRCUMFERENCE --------------------
C                N=AXIAL STATION INDEX
      DO 100 N=1,NFUSQR
      M=M+1
      IF (M.GT.60) GO TO 120
      XB(N)=XFUS(N,NFU)
      IF (J2TEST.EQ.3) GO TO 50
C
C  CASE 1, COMPUTE SECTION Y + Z COORDINATES FOR CIRCULAR/ELLIPTIC BODY
C
      BY=FUSRAD(N,NFU)
      AZ=FUSAZ(N,NFU)
      CAM=ZFUS(N,NFU)
      DO 40 K=1,KRAD
      RAD=0.0
      IF (BY.NE.0.)
     *   RAD=1.0/SQRT((ANCOS(K)/BY)**2+(ANSIN(K)/AZ)**2)
      YB(N,K)=RAD*ANCOS(K)
      ZB(N,K)=RAD*ANSIN(K)+CAM
40    CONTINUE
      GO TO 100
C
C  CASE2, COMPUTE SECTION Y AND Z ORDINATES FOR NONCIRCULAR BODY
C   BY LINEAR INTERPOLATION
C                K,NN=CIRUMFERENTIAL STATION INDICES
C
50    K1=2
      PHIN(1)=0.
      YB(N,1)=SFUS(1,N,KY)
      ZB(N,1)=SFUS(1,N,KZ)
      YF(1)=YB(N,1)
      ZF(1)=ZB(N,1)
      ZC=(SFUS(1,N,KZ)+SFUS(NRAD,N,KZ))/2.
      DO 90 NN=2,NRAD
      IF (KTEST.EQ.1) GO TO 80
      YF(NN)=SFUS(NN,N,KY)
      ZF(NN)=SFUS(NN,N,KZ)-ZC
      NM1=NN-1
      IF (YF(NN).EQ.0..AND.ZF(NN).EQ.0.) GO TO 80
      IF (ABS(YF(NN)).LE.EPZ) YF(NN)=0.
      PHIN(NN)=ATAN2(YF(NN),-ZF(NN))
```

```
      DO 60 K=KI,KRAD                                                   WB23 127
      IF (PHIK(K).GT.PHIN(NN)) GO TO 70                                 WB23 128
      YB(N,K)=XIN(YF(NM1),PHIN(NM1),YF(NN),PHIN(NN),PHIK(K))            WB23 129
      ZB(N,K)=XIN(ZF(NM1),PHIN(NM1),ZF(NN),PHIN(NN),PHIK(K))+ZC         WB23 130
60    CONTINUE                                                          WB23 131
70    KI=K                                                              WB23 132
      GO TO 90                                                          WB23 133
C                                                                       WB23 134
C  CASE 3, USE INPUT Y,Z VALUES                                         WB23 135
C                                                                       WB23 136
80    YB(N,NN)=SFUS(NN,N,KY)                                            WB23 137
      ZB(N,NN)=SFUS(NN,N,KZ)                                            WB23 138
90    CONTINUE                                                          WB23 139
100   CONTINUE                                                          WB23 140
C                                                                       WB23 141
C  GENERATE SYMMETRIC HALF OF BODY FOR IXZSYM=1 ------------------------WB23 142
C                                                                       WB23 143
      IF (IXZSYM.LE.0) GO TO 106                                        WB23 144
      DO 104 N=1,NFUSOR                                                 WB23 145
      K=KRAD                                                            WB23 146
      DO 104 I=2,KRAD                                                   WB23 147
      K=K+1                                                             WB23 148
      IK=KRAD-I+1                                                       WB23 149
      YB(N,K)=-YB(N,IK)                                                 WB23 150
      ZB(N,K)=ZB(N,IK)                                                  WB23 151
104   CONTINUE                                                          WB23 152
      KRAD=K                                                            WB23 153
      KRADX(NFU)=KRAD                                                   WB23 154
106   CONTINUE                                                          WB23 155
      MAX=M                                                             WB23 156
      WRITE (10) XB,YB,ZB                                               WB23 157
110   CONTINUE                                                          WB23 158
      RETURN                                                            WB23 159
120   WRITE (6,180)                                                     WB23 160
      STOP 120                                                          WB23 161
130   WRITE (6,170)                                                     WB23 162
      STOP 130                                                          WB23 163
160   FORMAT (10F7.0)                                                   WB23 164
170   FORMAT (40H ERROR - BODY HAS MORE THAN 20 MERIDIANS               WB23 165
     *    ,70X,12H** NEWRAD **)                                         WB23 166
180   FORMAT (45H ERROR - BODY HAS MORE THAN 60 AXIAL STATIONS          WB23 167
     *    ,65X,12H** NEWRAD **)                                         WB23 168
190   FORMAT(7H   NFU=,I5,/7H  PHIK=,10G12.5,2(/7X,10G12.5))            WB23 169
      END                                                               WB23 170
```

```
      SUBROUTINE PANEL(IP,IQ,J,K,L,NP,AP)                               WB24   1
C                                                                       WB24   2
C   CALCULATE PANEL GEOMETRY (BASED ON THE HYPERSONIC ARBITRARY BODY    WB24   3
C   PROGRAM OF A. E. GENTRY)  FOR NON-PLANAR PANELS                     WB24   4
C                                                                       WB24   5
      COMMON /POINT/ XPT(600),YPT(600),ZPT(600),THET(600),DELTA(600),   WB24   6
     1   XC(30,20),YC(30,20),ZC(30,20),DUM(1200)                        WB24   7
      COMMON           Z1(6900),Z0(30,20)                               WB24   8
      DIMENSION XIN(4),YIN(4),ZIN(4),XI(4),ETA(4)                       WB24   9
      REAL NX,NY,NZ                                                     WB24  10
C                                                                       WB24  11
C   REORDER THE PANEL CORNER POINTS TO CORRESPOND TO GENTRY CONVENTION  WB24  12
C                                                                       WB24  13
```

```
      EPS=1.E-6
      J1=J-1
      K1=K-1
      XIN(1)=XC(J1,K1)
      XIN(2)=XC(J,K1)
      XIN(3)=XC(J,K)
      XIN(4)=XC(J1,K)
      YIN(1)=YC(J1,K1)
      YIN(2)=YC(J,K1)
      YIN(3)=YC(J,K)
      YIN(4)=YC(J1,K)
      IF (L.EQ.1) GO TO 10
      ZIN(1)=ZC(J1,K1)
      ZIN(2)=ZC(J,K1)
      ZIN(3)=ZC(J,K)
      ZIN(4)=ZC(J1,K)
      GO TO 20
 10   ZIN(1)=ZU(J1,K1)
      ZIN(2)=ZU(J,K1)
      ZIN(3)=ZU(J,K)
      ZIN(4)=ZU(J1,K)
C
C    FORM DIAGONAL VECTORS
C    FORM VECTOR CROSS PRODUCT, N = T2 X T1
C
 20   T1X=XIN(3)-XIN(1)
      T2X=XIN(4)-XIN(2)
      IF (IP.EQ.1) T2X=-T2X
      T1Y=YIN(3)-YIN(1)
      T2Y=YIN(4)-YIN(2)
      IF (IP.EQ.1) T2Y=-T2Y
      T1Z=ZIN(3)-ZIN(1)
      T2Z=ZIN(4)-ZIN(2)
      IF (IP.EQ.1) T2Z=-T2Z
      NX=T2Y*T1Z-T1Y*T2Z
      NY=T1X*T2Z-T2X*T1Z
      NZ=T2X*T1Y-T1X*T2Y
      IF (ABS(NX).LE.EPS) NX=0.
      IF (ABS(NY).LE.EPS) NY=0.
      IF (ABS(NZ).LE.EPS) NZ=0.
      VN=SQRT(NX*NX+NY*NY+NZ*NZ)
      IF (VN.EQ.0.) GO TO 30
C
C    FORM UNIT NORMAL VECTOR, THEN COMPUTE AVERAGE POINT
C
      VNO=1./VN
      NX=NX*VNO
      NY=NY*VNO
      NZ=NZ*VNO
 30   AVX=.25*(XIN(1)+XIN(2)+XIN(3)+XIN(4))
      AVY=.25*(YIN(1)+YIN(2)+YIN(3)+YIN(4))
      AVZ=.25*(ZIN(1)+ZIN(2)+ZIN(3)+ZIN(4))
C
C    COMPUTE PROJECTION DISTANCE
C
      D=NX*(AVX-XIN(1))+NY*(AVY-YIN(1))+NZ*(AVZ-ZIN(1))
      T=SQRT(T1X*T1X+T1Y*T1Y+T1Z*T1Z)
      IF (T.EQ.0.) GO TO 40
      TD=1./T
      T1X=T1X*TD
      T1Y=T1Y*TD
      T1Z=T1Z*TD
 40   T2X=NY*T1Z-NZ*T1Y
```

```
      T2Y=NZ*T1X-NX*T1Z
      T2Z=NX*T1Y-NY*T1X
C
C   COMPUTE COORDINATES OF CORNER POINTS IN REFERENCE COORDINATE
C   SYSTEM
C   TRANSFORM CORNER POINT TO ELEMENT COORDINATE SYSTEM (XI,ETA)
C   WITH AVERAGE POINT AS ORIGIN
C
      DO 50 N=1,4
      XPA=XIN(N)+NX*D
      YPA=YIN(N)+NY*D
      ZPA=ZIN(N)+NZ*D
      D=-D
      XDIF=XPA-AVX
      YDIF=YPA-AVY
      ZDIF=ZPA-AVZ
      XI(N)=T1X*XDIF+T1Y*YDIF+T1Z*ZDIF
      ETA(N)=T2X*XDIF+T2Y*YDIF+T2Z*ZDIF
50    CONTINUE
C
C   COMPUTE CENTROID
C   OBTAIN CORNER POINTS IN SYSTEM WITH CENTROID AS ORIGIN
C
      ETACK=ETA(2)-ETA(4)
      IF (ETACK.NE.0.) GO TO 60
      XI0=0.
      GO TO 70
60    XI0=(XI(4)*(ETA(1)-ETA(2))+XI(2)*(ETA(4)-ETA(1)))/(3.*ETACK)
70    ETA0=-ETA(1)/3.
      XI(1)=XI(1)-XI0
      XI(2)=XI(2)-XI0
      XI(3)=XI(3)-XI0
      XI(4)=XI(4)-XI0
      ETA(1)=ETA(1)-ETA0
      ETA(2)=ETA(2)-ETA0
      ETA(3)=ETA(3)-ETA0
      ETA(4)=ETA(4)-ETA0
C
C   TRANSFORM CENTROID TO REFERENCE COORDINATE SYSTEM
C
      XPT(NP)=AVX+T1X*XI0+T2X*ETA0
      YPT(NP)=AVY+T1Y*XI0+T2Y*ETA0
      ZPT(NP)=AVZ+T1Z*XI0+T2Z*ETA0
C
C   COMPUTE PANEL INCIDENCE AND INCLINATION ANGLE
C   COMPUTE PANEL AREA
C
      DELTA(NP)=0.
      THET(NP)=0.
      RN=SQRT(NY*NY+NZ*NZ)
      IF (L.EQ.0) GO TO 90
      SL=-1.
      IF (L.EQ.2) SL=1.
C
C  DELTA = ANGLE BETWEEN THE X-AXIS AND THE LINE OF INTERSECTION
C  WITH THE PANEL OF A PLANE PASSING THROUGH THE X-AXIS AND THE
C  PERPENDICULAR TO THE PANEL.
      IF (NX.NE.0.) DELTA(NP)=ATAN2(SL*NX,RN)
      SP=FLOAT(1-2*IP)
      IF (ABS(SP).LE.(EPS*EPS)) SP=0.
      IF (IS.EQ.1) GO TO 80
C
C  THET =  ANGLE BETWEEN THE Y-AXIS AND THE LINE OF INTERSECTION
```

```
C   OF THE PANEL WITH THE Y-Z PLANE.
      IF (NY.NE.0.) THET(NP)=ATAN2(SP*NY,-SP*NZ)
      GO TO 100
80    IF (NZ.NE.0.) THET(NP)=ATAN2(-SP*NZ,SP*NY)
      GO TO 100
90    IF (NX.NE.0.) DELTA(NP)=ATAN2(-NX,RN)
      IF (NY.EQ.0..AND.NZ.EQ.0.) GO TO 100
      THET(NP)=ATAN2(-NY,NZ)
100   AP=.5*(XI(3)-XI(1))*ETACK
      IF (IP.EQ.1) AP=-AP
      RETURN
      END
```

```
      SUBROUTINE PARTIN
C
C   FOR WING-BODY COMBINATIONS, INVERT THE MATRIX PATITIONS (PROVIDED
C   THE ORDER DOES NOT EXCEED 60).
C
C   FOR ISOLATED WINGS OR BODIES, ALSO SOLVE THE BOUNDARY CONDITION
C   EQUATIONS AND DETERMINE THE WING VORTEX STRENGTHS OR BODY SOURCE
C   STRENGTHS.
C
      COMMON            NW(600),NB(600),NT(600),A(60,60),Z3(300),GW(600),
     1   GB(600),GT(600)
      COMMON /PARAM / NBODY,NWING,NTAIL,LBC,THK,XMACH,ALPHA,BETA,ALPHAC
     1   ,PHIR,REFA,REFB,REFC,REFD,REFL,REFX,REFZ
      COMMON /POINT / ARRAY(6000)
      DIMENSION D(60,60)
      EQUIVALENCE (D(1,1),ARRAY(1))
      REAL NW,NB,NT
C
      CALL CPUTIM(TIME,DT,1)
      NDIM=60
      REWIND 9
      NPANEL=NBODY+NWING
      IF (NWING.EQ.0.OR.NBODY.EQ.0) GO TO 50
C
C   INVERT DIAGONAL BLOCKS  ---------------------------------------------
C   INVERT BODY INFLUENCE MATRIX AND WRITE ON TAPE10
C
      REWIND 10
      DO 10 I=1,NBODY
      READ (9) (D(I,J),J=1,NBODY)
10    CONTINUE
      CALL INVERT(D,NBODY,NDIM)
      WRITE (10) D
C
C   READ PAST BODY/WING INFLUENCE MATRICES
CB       DO 20 I=1,NBODY
CB       READ (9) (D(I,J),J=1,NWING)
CB20     CONTINUE
CB       DO 30 I=1,NWING
CB       READ (9) (D(I,J),J=1,NBODY)
CB30     CONTINUE
CB       DO 40 I=1,NWING
CB       READ (9) (D(I,J),J=1,NWING)
CB40     CONTINUE
CB       CALL INVERT(D,NWING,NDIM)
CB       WRITE (10) D
CB       REWIND 9
```

```
      REWIND 10
      GO TO 100
C
C  SOLVE ENTIRE MATRIX IF NPANEL)61 - ONLY WINGS OR BODIES -------------
C
50    DO 60 I=1,NPANEL
      READ (9) (A(I,J),J=1,NPANEL)
60    CONTINUE
      REWIND 9
      CALL INVERT(A,NPANEL,NDIM)
C
C  SUBSTITUTE WING BOUNDARY CONDITION AND COMPUTE STRENGTHS - GW
C
      IF (NWING.EQ.0) GO TO 80
CB      DO 70 I=1,NWING
CB      GW(I)=0.
CB      DO 70 J=1,NWING
CB      GW(I)=GW(I)+A(I,J)*WW(J)
CB70    CONTINUE
      GO TO 100
C
C  SUBSTITUTE BODY BOUNDARY CONDITION AND COMPUTE STRENGTHS - GB
C
80    DO 90 I=1,NBODY
      GB(I)=0.
      DO 90 J=1,NBODY
      GB(I)=GB(I)+A(I,J)*WB(J)
90    CONTINUE
100   REWIND 9
      CALL CPUTIM(TIME,DT,1)
      WRITE(6,110) TIME,DT
110   FORMAT(/10X,18HEND PARTIN.  TIME=,F10.4,5X,3HDT=,F10.4)
      RETURN
      END
```

```
      SUBROUTINE PLOTA2 (X,Y,IOPT,NP,NDP,NC,LWID,LENG)
C*----------------------------------------------------------------------
C
C     SUBROUTINE PLOTA2
C
C     PURPOSE
C        ROUTINE TO GENERATE A SINGLE CHARACTER PLOT OF NC SIMULTANEOUS
C        CURVES OF  Y VERSUS X.  THE J*TH CURVE IS STORED COLUMNWISE IN
C        ARRAYS X(I,J) AND Y(I,J) AND MAY HAVE A VARIABLE NUMBER OF
C        POINTS, NP(J)
C
C
C     CALLING FORMAT
C        CALL PLOTA2 (X,Y,IOPT,NP,NDP,NC,LWID,LENG)
C
C     PARAMETERS
C        NAME   TYPE  I/O/S  DIM    DESCRIPTION
C
C        X,Y      R      I (NDP,NC) ORDINATE + ABSCISSA ARRAYS
C        IOPT     I      I     NONE OPTION FOR TYPE OF PAGE SCALING
C                                   1. USER SPECIFIES SCALE LIMITS
C                                   2. INTERNAL AUTOMATIC BEST SCALING
C                                   3. AUTOMATIC TRUE SHAPE SCALING,  SES
C                                      RATIO: 0.6*LWID/LENG = XDIFF/YDIFF
C                                   4. USE MAX AND MIN VALUES OF DATA
```

```
C                                   5, INPUT XMAX,XMIN# AUTO Y-SCALING
C                                   6, INPUT YMAX,YMIN# AUTO X-SCALING
C        NP         I      I   NONE VECTOR OF NUMBER OF POINTS IN J*TH
C                                   CURVE.  IF NDP=1, NP IS ASSUMED EQUAL
C                                   TO 1 FOR ALL CURVES.
C        NDP        I      I   NONE FIRST DIMENSION OF ARRAYS *X,Y* IN
C                                   CALLING ROUTINE
C        NC         I      I   NONE NUMBER OF SIMULTANEOUS PLOTS.
C                                   IF NC>40, CHARACTER SET REPEATS.
C        LWID       I      I   NONE WIDTH OF PLOTTED REGIONS AT 10
C                                   CHARACTERS/INCH.  NORMALLY=100,
C                                   FOR CRT OR T.I. TERMINALS=50.
C                                   MAXIMUM DIMENSIONED = 100.
C        LENG       I      I   NONE NUMBER OF LINES IN PLOTTED REGION
C                                   NORMALLY=50 AT 6 LINES/INCH#
C                                   FOR 8.5" PAPER=40.
C
C     USER SUPPLIED COMMON BLOCKS
C        IOPT =1,5,6:  /BSCALE/ XMAX,XMIN,YMAX,YMIN
C
C     COMMON /BSCALE/
C        NAME   TYPE  I/O/S  DIM   DESCRIPTION
C
C        XMAX     R    I/O   NONE  MAXIMUM X SCALE VALUE ACROSS PAGE
C        XMIN     R    I/O   NONE  MINIMUM X SCALE VALUE ACROSS PAGE
C        YMAX     R    I/O   NONE  MAXIMUM Y SCALE VALUE AT TOP OF PAGE
C        YMIN     R    I/O   NONE  MINIMUM Y SCALE VALUE DOWN PAGE
C
C     EXTERNAL REFERENCES
C        PLOTA SUBROUTINES:  PLOTA7, PLOTA8
C
C     AUTHOR
C        JOSEPH MULLEN JR., NIELSEN ENGINEERING + RESEARCH, INC.
C        DATED: DECEMBER, 1976
C
C-----------------------------------------------------------------------
      DIMENSION X(NDP,NC),Y(NDP,NC),XPRINT(7),NP(NC),FMT(6)
      INTEGER SYMBOL(40)
      COMMON /BPLTA1/ NXPR,NYPR,IYAXIS,IXAXIS,IOFFX,IOFFY,LLINE
      COMMON /BPLTA2/ LINE(103)
      COMMON /BSCALE/ XMAX,XMIN,YMAX,YMIN
C
      DATA FMT/4H(7X ,4H,G16,4H.4,6,4H( 4X,4HG16.,4H4)) /
      DATA SYMBOL/1H*,1H+,1H-,1H.,1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7
     *,1H8,1H9,1HA,1HB,1HC,1HD,1HE,1HF,1HG,1HH,1HI,1HJ,1HK,1HL,1HM
     *,1HN,1HO,1HP,1HQ,1HR,1HS,1HT,1HU,1HV,1HW,1HX,1HY,1HZ/
C
C  FIND MAX AND MIN OF X (ORDINATE) AND Y (ABSCISSA)
C
      NPJ = 1
      IF (IOPT.LT.1) IOPT=2
      IF (IOPT.EQ.1) GO TO 80
      IF (IOPT.EQ.5) GO TO 60
      XMAX = X(1,1)
      XMIN = X(1,1)
      DO 50 J=1,NC
      IF (NDP.GT.1) NPJ = NP(J)
      IF (NPJ.LT.1) GO TO 50
      DO 40 I=1,NPJ
      XMAX = AMAX1(X(I,J),XMAX)
40    XMIN = AMIN1(X(I,J),XMIN)
50    CONTINUE
      IF (IOPT.EQ.6) GO TO 80
```

```
C
60    YMAX = Y(1,1)
      YMIN = Y(1,1)
      DO 70 J=1,NC
      IF (NOP.GT.1) NPJ = NP(J)
      IF (NPJ.LT.1) GO TO 70
      DO 65 I=1,NPJ
      YMAX = AMAX1(Y(I,J),YMAX)
65    YMIN = AMIN1(Y(I,J),YMIN)
70    CONTINUE
C
C  DETERMINE SCALING AND ROUND OFF MAX AND MIN VALUES AND LOCATE
C  X- AND Y-AXES.
C
80    CALL PLOTAB(DX,DY,FMT,LWID,LENG,IOPT)
      NROWS = LENG+1
C
C  INITIALIZE PLOTING BANDWIDTH
C
      YLOW = YMAX-0.5*DY
      YMID = YMAX
      YUP = YMAX+0.5*DY
C
C  FORM UPPER BOUNDARY
C
      CALL PLOTA7 (LINE,1,1)
      WRITE(6,1) (LINE(I),I=1,LLINE)
      DO 230 L=1,NROWS
C
C  INITIALIZE BLANK ROW OR X-AXIS
C
      IF (L.NE.IXAXIS) CALL PLOTA7 (LINE,L-IOFFX,2)
      IF (L.EQ.IXAXIS) CALL PLOTA7 (LINE,L-IOFFX,1)
C
C  TEST FOR DATA IN L-TH ROW
C
      DO 210 J=1,NC
      JSYM = MOD(J-1,40)+1
      IF (NOP.GT.1) NPJ = NP(J)
      IF (NPJ.LT.1) GO TO 210
      DO 210 I=1,NPJ
      IF (Y(I,J).GT.YUP) GO TO 210
      IF (Y(I,J).LE.YLOW) GO TO 210
C
C  FIND X LOCATION OF POINT - CHECK IF WITHIN SIDE BOUNDS
C
      NDX = IFIX((X(I,J)-XMIN)/DX+0.5)+2
      IF (NDX.LE.1) GO TO 210
      IF (NDX.GE.LLINE) GO TO 210
      LINE(NDX) = SYMBOL(JSYM)
210   CONTINUE
C
C  PRINT ROW OF OUTPUT - TEST TO WRITE SCALES
C
      IMOD = MOD(L-IOFFX-1,NYPR)
      IF (IMOD.EQ.0) WRITE (6,2) YMID,(LINE(I),I=1,LLINE)
      IF (IMOD.NE.0) WRITE (6,3) (LINE(I),I=1,LLINE)
C
C  INCREMENT Y-STRIP; REDEFINE YLOW AND YUP
C
      YUP = YLOW
      YMID = YMID-DY
      IF (ABS(YMID/DY).LT.0.001) YMID=0.0
```

```
      YLOW = YLOW-DY
230   CONTINUE
C
C  FORM LOWER BOUNDARY
C
      CALL PLOTA7 (LINE,1,1)
      WRITE (6,3) (LINE(I),I=1,LLINE)
C
C  PRINT SCALES
C
      NXP = (LLINE-IOFFY)/NXPR+1
      XPRINT(1) = XMIN+DX*(IOFFY-2)
      DO 240 I=2,NXP
      XPRINT(I) = XPRINT(I-1)+DX*NXPR
      IF (ABS(XPRINT(I)/DX).LT.0.001) XPRINT(I)=0.0
240   CONTINUE
      WRITE(6,FMT) (XPRINT(I),I=1,NXP)
      RETURN
1     FORMAT (1H1,14X,103A1)
2     FORMAT (1X,G13.4,1X,103A1)
3     FORMAT (15X,103A1)
      END
```

```
      SUBROUTINE PLOTA3 (X,Y,Z,NP,NDP,NC,THETA,XCG,XP,YP,ISC)
C+-----------------------------------------------------------------------
C
C     SUBROUTINE PLOTA3
C
C     PURPOSE
C        ROUTINE TO PERFORM AN ARBITRARY ROTATION IN 3-SPACE OF (X,Y,Z)
C        DATA.  THE THREE DIMENSIONAL DATA IS REDUCE TO THE (X,Y)
C        PROJECTION, XP,YP.
C
C     CALLING FORMAT
C        CALL PLOTA3 (X,Y,Z,NP,NDP,NC,THETA,XCG,XP,YP,ISC)
C
C     PARAMETERS
C        NAME    TYPE  I/O/S  DIM    DESCRIPTION
C
C        X,Y,Z     R      I (NDP,NC) COORDINATE POINT ARRAYS
C        NP        I      I     NONE VECTOR OF NUMBER OF POINTS IN J*TH
C                                    CURVE
C        NDP       I      I     NONE FIRST DIMENSION OF ARRAY *X,Y,Z* IN
C                                    CALLING ROUTINE
C        NC        I      I     NONE NUMBER OF CURVES TO BE TRANSFORMED
C        THETA     R      I      (3) ROTATION ANGLES-THETAX,THETAY,THETAZ
C                                    (DEGREES).  ROTATIONS ARE PERFORMED
C                                    IN REVERSE ORDER.
C        XCG       R      I      (3) LOCATION OF CENTER OF ROTATION
C                                    XCG = (XCG,YCG,ZCG)
C        XP,YP     R      O (NDP,NC) COORDINATES OF TRANSFORMED POINT
C                                    NOTE1  XP,YP MAY BE STORED  IN X,Y.
C        ISC       I      I     NONE SCALING OPTION
C                                    1, AUTOMATIC SCALING
C                                    2, AUTOMATIC SCALING ON ONLY Z
C                                    3, NO SCALING OF COORDINATES
C                                    4, INPUT SCALING VECTOR - S
C                                    5, INPUT XMAX,....,ZMIN - SCALE X,Y,Z
C
```

```
C       USER SUPPLIED COMMON BLOCKS
C          ISC  =4,5:  /BSCAL2/ XMAX,XMIN,YMAX,YMIN,ZMAX,ZMIN,S(3)
C
C       COMMON /BSCAL2/
C          NAME    TYPE   I/O/S   DIM    DESCRIPTION
C
C          XMAX      R      I/O    NONE   MAXIMUM OF Y DATA VALUES
C          XMIN      R      I/O    NONE   MINIMUM OF X DATA VALUES
C          YMAX      R      I/O    NONE   MAXIMUM OF Y DATA VALUES
C          YMIN      R      I/O    NONE   MINIMUM OF Y DATA VALUES
C          ZMAX      R      I/O    NONE   MAXIMUM OF Z DATA VALUES
C          ZMIN      R      I/O    NONE   MINIMUM OF Z DATA VALUES
C          S         R      I/O    NONE   VECTOR USED FOR RELATIVE SCALING
C                                         OF X,Y,Z COMPONENTS BEFORE ROTATION,
C
C       AUTHOR
C          JOSEPH MULLEN JR., NIELSEN ENGINEERING + RESEARCH, INC.
C          DATED: DECEMBER, 1976
C
C-----------------------------------------------------------------------
        DIMENSION X(NDP,NC),Y(NDP,NC),Z(NDP,NC),NP(NC)
        DIMENSION XP(NDP,NC),YP(NDP,NC),THETA(3),XCG(3)
        REAL RX(3,3),RY(3,3),RZ(3,3),R(3,3)
        COMMON /BSCAL2/XMAX,XMIN,YMAX,YMIN,ZMAX,ZMIN,S(3)
        DATA RX,RY,RZ/1.0,12*0.0,1.0,12*0.0,1.0/
        DATA RADDEG/0.0174532926/
        NPJ = 1
C
C   BUILD TRANSFORMATION MATRICES
C
        COSX = COS(THETA(1)*RADDEG)
        SINX = SIN(THETA(1)*RADDEG)
        COSY = COS(THETA(2)*RADDEG)
        SINY = SIN(THETA(2)*RADDEG)
        COSZ = COS(THETA(3)*RADDEG)
        SINZ = SIN(THETA(3)*RADDEG)
C
C DEFINE X-ROTATION
C
        RX(2,2) = COSX
        RX(2,3) = -SINX
        RX(3,2) = SINX
        RX(3,3) = COSX
C
C  DEFINE Y-ROTATION
C
        RY(1,1) = COSY
        RY(1,3) = SINY
        RY(3,1) = -SINY
        RY(3,3) = COSY
C
C  DEFINE Z-ROTATION
C
        RZ(1,1) = COSZ
        RZ(1,2) = -SINZ
        RZ(2,1) = SINZ
        RZ(2,2) = COSZ
C
C  OBTAIN SCALING - FIND MAXIMA AND MINIMA
C
        GO TO (100,100,150,160,130), ISC
100     XMAX = X(1,1)
        XMIN = X(1,1)
```

```
      YMAX = Y(1,1)
      YMIN = Y(1,1)
      ZMAX = Z(1,1)
      ZMIN = Z(1,1)
      DO 120 J=1,NC
      IF (NDP.GT.1) NPJ = NP(J)
      IF (NPJ.LT.1) GO TO 110
      DO 110 I=1,NPJ
      XMAX = AMAX1(XMAX,X(I,J))
      XMIN = AMIN1(XMIN,X(I,J))
      YMAX = AMAX1(YMAX,Y(I,J))
      YMIN = AMIN1(YMIN,Y(I,J))
      ZMAX = AMAX1(ZMAX,Z(I,J))
110   ZMIN = AMIN1(ZMIN,Z(I,J))
120   CONTINUE
      XDIFF = XMAX-XMIN
      YDIFF = YMAX-YMIN
      ZDIFF = ZMAX-ZMIN
C
C  CHOOSE SCALING - ISC=1,5, SCALE X,Y,Z
C
      GO TO (130,140,150,160,130),ISC
130   D = SQRT(XDIFF*XDIFF+YDIFF*YDIFF+ZDIFF*ZDIFF)
      S(1) = D/XDIFF
      S(2) = D/YDIFF
      S(3) = D/ZDIFF
      GO TO 160
C
C  ISC=2, SCALE ONLY Z.
C
140   D = SQRT(XDIFF*XDIFF+YDIFF*YDIFF)
      S(1) = 1.0
      S(2) = 1.0
      S(3) = D/ZDIFF
      GO TO 160
C
C  ISC=3, USE NO SCALING
C
150   S(1) = 1.0
      S(2) = 1.0
      S(3) = 1.0
C
C  COMPUTE GLOBAL TRANSFORMATION:   R = RZ*RY*RX*S
C
160   DO 180 J=1,3
      DO 180 I=1,3
      SUM = 0.0
      DO 170 K=1,3
      DO 170 L=1,3
170   SUM = SUM+RZ(I,K)*RY(K,L)*RX(L,J)
180   R(I,J) = SUM*S(J)
C
C  TRANSFORM COORDINATE VARIABLES:  XP = R*(X-XCG)
C
      DO 210 J=1,NC
      IF (NDP.GT.1) NPJ = NP(J)
      IF (NPJ.LT.1) GO TO 210
      DO 200 I=1,NPJ
      DX = X(I,J)-XCG(1)
      DY = Y(I,J)-XCG(2)
      DZ = Z(I,J)-XCG(3)
      XP(I,J) = R(1,1)*DX+R(1,2)*DY+R(1,3)*DZ
      YP(I,J) = R(2,1)*DX+R(2,2)*DY+R(2,3)*DZ
```

```
 200    CONTINUE                                                        WB27 163
 210    CONTINUE                                                        WB27 164
        RETURN                                                          WB27 165
        END                                                             WB27 166
```

```
      SUBROUTINE PLOTA5 (X,IEXP,IROUND)                                 WB28   1
C+----------------------------------------------------------------------WB28   2
C                                                                       WB28   3
C     SUBROUTINE PLOTA5                                                 WB28   4
C                                                                       WB28   5
C     PURPOSE                                                           WB28   6
C        ROUTINE TO ROUND OFF X                                         WB28   7
C                                                                       WB28   8
C     CALLING FORMAT                                                    WB28   9
C        CALL PLOTA5 (X,IEXP,IROUND)                                    WB28  10
C                                                                       WB28  11
C     PARAMETERS                                                        WB28  12
C        NAME    TYPE  I/O/S  DIM   DESCRIPTION                         WB28  13
C                                                                       WB28  14
C        X        R     I/O   NONE  VALUE TRUNCATED AT GIVEN EXPONENT   WB28  15
C        IEXP     I      I    NONE  EXPONENT AT WHICH TRUNCATION OCCURS WB28  16
C        IROUND   I      I    NONE  ROUND OFF INDICATOR:                WB28  17
C                                   ROUND UP (=+1), DOWN (=0)           WB28  18
C                                                                       WB28  19
C     AUTHOR                                                            WB28  20
C        JOSEPH MULLEN JR., NIELSEN ENGINEERING + RESEARCH, INC.        WB28  21
C        DATED: DECEMBER, 1976                                          WB28  22
C                                                                       WB28  23
C     NOTES                                                             WB28  24
C        CALLED BY PLOTA8, PLOTA9, PLOTI, + IRPLOT.                     WB28  25
C                                                                       WB28  26
C-----------------------------------------------------------------------WB28  27
      COMMON /OHUGA / IPR                                               WB28  28
      IF (X.LT.0.0) IR = IROUND-1                                       WB28  29
      IF (X.GE.0.0) IR = IROUND                                         WB28  30
      XS = X                                                            WB28  31
      X = X/10.**IEXP                                                   WB28  32
      IX = IFIX(X)                                                      WB28  33
      IF (FLOAT(IABS(IX)).LT.ABS(X)) IX = IX+IR                         WB28  34
      X = FLOAT(IX)*10.**IEXP                                           WB28  35
C                                                                       WB28  36
      IF (IPR.GT.0) WRITE(6,10) X,IEXP,IROUND,XS                        WB28  37
 10   FORMAT(23H PLOTA5 - DEBUG PRINT -,8H  X-OUT=,G12.5,               WB28  38
     *   7H  IEXP=,I5,8H IROUND=,I4,7H  X-IN=,G12.5)                    WB28  39
      RETURN                                                            WB28  40
      END                                                               WB28  41
```

```
      SUBROUTINE PLOTA6 (DX,IEXP,NPRINT)                                WB29   1
C+----------------------------------------------------------------------WB29   2
C                                                                       WB29   3
C     SUBROUTINE PLOTA6                                                 WB29   4
C                                                                       WB29   5
C     PURPOSE                                                           WB29   6
C        ROUTINE TO ROUND OFF SCALING TO NEAREST ACCEPTABLE PLOTTING    WB29   7
C        SCALE.                                                         WB29   8
```

```
C
C     CALLING FORMAT
C        CALL PLOTA6 (DX,IEXP,NPRINT)
C
C     PARAMETERS
C        NAME    TYPE  I/O/S  DIM   DESCRIPTION
C
C        DX       R     I/O   NONE  VARIABLE TO ROUNDED OFF
C        IEXP     I      O    NONE  EXPONENT OF ROUNDED VARIABLE
C        NPRINT   I      O    NONE  NUMBER OF CHARACTERS BETWEEN LABELS
C
C     AUTHOR
C        JOSEPH MULLEN JR., NIELSEN ENGINEERING + RESEARCH, INC.
C        DATED: DECEMBER, 1976
C
C     NOTES
C        ARRAYS XSCL AND NPR IN THIS ROUTINE DETERMINE THE *ACCEPTABLE*
C        VALUES TO BE USED AS EVEN INCREMENTS IN PERFORMING SCALING.
C        CALLED BY PLOTA8, PLOTA9, PLOTI, + IRPLOT.
C
C-----------------------------------------------------------------------
      COMMON /DBUGA / IPR
      DIMENSION XSCL(6),NPR(6)
      DATA XSCL/2.,2.5,4.,5.,8.,10./
      DATA NPR /25,20,25,20,25,20/ ,NSCL/6/
      DATA DXSAVE /1.0/
C
      ABSX = ABS(DX)
      IF (ABSX.LE.0.) WRITE(6,10) DX
      IF (ABSX.LE.0.) ABSX=DXSAVE
      IF (ABSX.GT.0.) DXSAVE=ABSX
10    FORMAT(///5(2H *),45H WARNING - ILLEGAL DATA TO BE SCALED (PLOTA6)
     *     ,6H - DX=,G20.13,5(2H *))
C
C  DETERMINE EXPONENT OF DX
      AL = ALOG10(ABSX)
      IEXP = AL
      IF (ABSX.LT.1.) IEXP=IEXP-1
      AL = DX
C
C  SET ABSX BETWEEN 1 AND 10
      ABSX = ABSX/10.**IEXP
C
C  COMPARE WITH + LOCATE ACCEPTABLE SCALE
      DO 80 I=1,NSCL
      IF (ABSX.LE.XSCL(I)) GO TO 85
80    CONTINUE
      I = NSCL
85    ABSX = XSCL(I)
      NPRINT = NPR(I)
C
C  RETURN SCALED VALUES
      DX = SIGN(ABSX,DX)*10.**IEXP
      IF (IPR.GT.0) WRITE(6,12) DX,IEXP,NPRINT,I,AL
12    FORMAT(23H PLOTA6 - DEBUG PRINT -,8H DX-OUT=,G12.5,7H  IEXP=,I5,
     *     8H NPRINT=,I4,4H  I=,I3,7H DX-IN=,G12.5)
      RETURN
      END
```

```
      SUBROUTINE PLOTA7 (LINE,L,IOPT)
C+-----------------------------------------------------------------------
C
C     SUBROUTINE PLOTA7
C
C     PURPOSE
C        ROUTINE TO INITIALIZE A ROW OF PLOTTED OUTPUT.  THE ARRAY LINE
C        IS INITIALIZED WITH THE BORDER AND WITH X- AND Y-AXES.
C
C
C     CALLING FORMAT
C        CALL PLOTA7 (LINE,L,IOPT)
C
C     PARAMETERS
C        NAME    TYPE   I/O/S   DIM    DESCRIPTION
C
C        LINE     I       O     NONE   VECTOR CONTAINING LINE OF OUTPUT.
C        L        I       I     NONE   L*TH ROW OF OUTPUT
C        IOPT     I       I     NONE   OPTION: IOPT=1, INITIALIZE LINE AS
C                                      BOUNDARY OR AXIS
C                                      IOPT=2, INITIALIZE LINE AS BLANK
C
C     AUTHOR
C        JOSEPH MULLEN JR., NIELSEN ENGINEERING + RESEARCH, INC.
C        DATED: DECEMBER, 1976
C
C     NOTES
C        CALLED BY ARPLOT, PLOTA1, PLOTA2, + PLOTV2
C
C        THE DATA VARIABLES DASH, SLASH, BLANK, AND SLASHI DETERMINE THE
C        CHARACTERS WHICH MAKE UP THE PLOT BOARDER AND TICK MARKS.
C        THIS IS THE ONLY STATEMENT REQUIRED TO CHANGE THESE CHARACTER
C        REPRESENTATIONS.
C
C------------------------------------------------------------------------
      INTEGER DASH,SLASH,BLANK,SLASHI,SYM,LINE(103)
      COMMON /BPLTA1/ NXPR,NYPR,IYAXIS,IXAXIS,IOFFX,IOFFY,LLINE
      DATA DASH,SLASH,BLANK,SLASHI/1H-,1HI,1H ,1HI/
CIBM  DATA DASH,SLASH,BLANK,SLASHI/1H-,1H!,1H ,1HI/
      SYM = SLASH
      LM1 = LLINE-1
C
C  SET Y-SCALE TICK MARKS
      IF (MOD(L-1,NYPR/2).EQ.0) SYM = DASH
      LINE(1) = SYM
      LINE (LLINE) = SYM
      IF (IOPT.EQ.2) GO TO 200
C
C  INITIALIZE BOUNDARY WITH X-SCALE TICK MARKS
      DO 70 J=2,LM1
70    LINE(J) = DASH
      IS = MOD(IOFFY,10)
      IF (IS.LE.0) IS=IS+10
      DO 80 J=IS,LM1,10
80    LINE(J) = SLASH
      DO 90 J=IOFFY,LM1,NXPR
90    LINE(J) = SLASHI
      RETURN
C
C  INITIALIZE BLANK ROW
200   DO 210 I=2,LM1
210   LINE(I) = BLANK
      IF (IYAXIS.GT.0) LINE(IYAXIS) = SYM
```

```
      RETURN                                                            WB30  64
      END                                                               WB30  65


      SUBROUTINE PLOTA8 (DX,DY,FMT,LWID,LENG,IOPT)                      WB31   1
C+----------------------------------------------------------------------WB31   2
C                                                                       WB31   3
C     SUBROUTINE PLOTA8                                                 WB31   4
C                                                                       WB31   5
C     PURPOSE                                                           WB31   6
C        ROUTINE TO SELECT SCALES, AND ROUND MAX AND MIN VALUES TO      WB31   7
C        ACCEPTABLE VALUES, AND LOCATE X- AND Y-AXES.                   WB31   8
C                                                                       WB31   9
C                                                                       WB31  10
C     CALLING FORMAT                                                    WB31  11
C        CALL PLOTA8 (DX,DY,FMT,LWID,LENG,IOPT)                         WB31  12
C                                                                       WB31  13
C     PARAMETERS                                                        WB31  14
C        NAME    TYPE  I/O/S  DIM   DESCRIPTION                         WB31  15
C                                                                       WB31  16
C        DX        I    I/O   NONE  X DATA INCREMENT (OUTPUT)           WB31  17
C        DY        I    I/O   NONE  Y DATA INCREMENT (OUTPUT)           WB31  18
C        FMT       H    I/O   (6)   OBJECT TIME FORMAT FOR PRINTING     WB31  19
C                                   X-AXIS SCALES.                      WB31  20
C        LWID      I     I    NONE  WIDTH OF PLOT (NO. OF CHARACTERS)   WB31  21
C        LENG      I     I    NONE  LENGTH OF PLOT (NO. OF CHARACTERS)  WB31  22
C        IOPT      I     I    NONE  OPTION FOR TYPE OF PAGE SCALING     WB31  23
C                                   1, USER SPECIFIES SCALE LIMITS      WB31  24
C                                   2, INTERNAL AUTOMATIC BEST SCALING  WB31  25
C                                   3, AUTOMATIC TRUE SHAPE SCALING, USESWB31  26
C                                      RATIO: 0.6*LWID/LENG = XDIFF/YDIFFWB31  27
C                                   4, USE MAX AND MIN VALUES OF DATA   WB31  28
C                                   5, INPUT XMAX,XMIN# AUTO Y-SCALING  WB31  29
C                                   6, INPUT YMAX,YMIN# AUTO X-SCALING  WB31  30
C                                                                       WB31  31
C     EXTERNAL REFERENCES                                               WB31  32
C        PLOTA SUBROUTINES:  PLOTA5, PLOTA6                             WB31  33
C                                                                       WB31  34
C     AUTHOR                                                            WB31  35
C        JOSEPH MULLEN JR., NIELSEN ENGINEERING + RESEARCH, INC.        WB31  36
C        DATED: DECEMBER, 1976                                          WB31  37
C                                                                       WB31  38
C     NOTES                                                             WB31  39
C        1. PRODUCES SCALING CONSISTENT WITH ARPLOT, PLOTA1, PLOTA2, ANDWB31  40
C        PLOTV2.  VALUES COMPUTED BESIDES THE ARGUEMENT LIST ARE XMAX,  WB31  41
C        XMIN,YMAX,YMIN,NXPR,NYPR,IXAXIS,IYAXIS,IOFFX,IOFFY, AND FMT.   WB31  42
C        CALLED BY ARPLOT, PLOTA1, PLOTA2, + PLOTV2.                    WB31  43
C                                                                       WB31  44
C        2. THE DATA VARIABLE *RATIO* IN THIS ROUTINE SETS THE CHARACTERWB31  45
C        SIZE WIDTH-TO-HEIGHT RATIO FOR TRUE CHAPE SCALING.  TO CHANGE  WB31  46
C        SET *RATIO* EQUAL TO NO. OF CHARACTERS/INCH DOWN PAGE DIVIDED  WB31  47
C        BY NO. OF CHARACTERS /INCH ACROSS PAGE.                        WB31  48
C                                                                       WB31  49
C-----------------------------------------------------------------------WB31  50
      DIMENSION DXI(4),DYI(4),IEXP(4),NPR(4),FMT(6),FMTX(27)            WB31  51
      COMMON /APLTA1/ NXPR,NYPR,IYAXIS,IXAXIS,IOFFX,IOFFY,LLINE         WB31  52
      COMMON /ASCALE/ XMAX,XMIN,YMAX,YMIN                               WB31  53
      COMMON /DBUGA / IPR                                               WB31  54
C                                                                       WB31  55
      DATA FMTX/ 4H(    ,4H(4X ,4H(7X ,4H(8X ,4H(9X ,4H(10X,4H(11X,4H(12XWB31  56
     *    ,4H(13X,4H(14X,4H(15X,4H(16X,4H(17X,4H(18X,4H(19X,4H(20X      WB31  57
```

```
     *    ,4H(21X,4H(22X,4H(23X,4H(24X,4H(25X,4H(26X,4H(27X,4H(28X
     *    ,4H(29X,4H(30X,4H(31X/
      DATA RND,HALF/0.0001,0.5001/
C  DEFINE RATIO OF PRINTED CHARACTER WIDTH-TO-HEIGHT
      DATA RATIO/0.6/
C
C  TEST FOR ILLEGAL WIDTH AND LENGTH
C
      IF (LENG.LT.2) LENG=40
      IF (LWID.GT.100) LWID=100
      IF (LWID.LT.2)   LWID=100
      LLINE = LWID+3
C
C  DEBUG DATA CHECK OF INPUT
      IF (IPR.LT.0) IPR=0
      IF (IPR.GT.0) WRITE(6,10) IOPT,LWID,LENG,LLINE,XMAX,XMIN,YMAX,YMIN
10    FORMAT(23H PLOTAB - DEBUG PRINT -,7H  IOPT=,I5,7H  LWID=,I5,
     *    7H  LENG=,I5,7H LLINE=,I5,/10X,7H  XMAX=,G12.5,
     *    7H  XMIN=,G12.5,7H  YMAX=,G12.5,7H  YMIN=,G12.5)
C
      XDIFF = XMAX-XMIN
      YDIFF = YMAX-YMIN
      DX = XDIFF/LWID
      DY = YDIFF/LENG
      IXPAS = 0
      IYPAS = 0
C
C  BRANCH TO APPROPRIATE TYPE OF SCALING REQUESTED
C
230   GO TO (240,250,260,240,290,300),IOPT
C
C  IOPT=1,4, SPECIFY X-Y SCALE LIMITS
C
240   NXPR = 20
      NYPR = 10
      IF (ABS(RATIO*DY/DX-1.0).LT.0.01) NYPR=12
      GO TO 330
C
C  IOPT=2, COMPUTE AUTOMATIC SCALED LIMITS
C
250   CALL PLOTA6 (DX,IEXPX,NXPR)
      CALL PLOTA6 (DY,IEXPY,NYPR)
      NYPR = 10
      GO TO 310
C
C  IOPT=3, COMPUTE AUTOMATIC TRUE SHAPE SCALES
C
260   DYI(1) = DY
      DXI(2) = DY*RATIO
      DXI(3) = DX
      DYI(4) = DX/RATIO
      CALL PLOTA6(DYI(1),IEXP(1),NPR(1))
      CALL PLOTA6(DXI(2),IEXP(2),NPR(2))
      CALL PLOTA6(DXI(3),IEXP(3),NPR(3))
      CALL PLOTA6(DYI(4),IEXP(4),NPR(4))
      DXI(1) = DYI(1)*RATIO
      DYI(2) = DXI(2)/RATIO
      DYI(3) = DXI(3)/RATIO
      DXI(4) = DYI(4)*RATIO
      DXM = AMAX1(DXI(1),DXI(2),DXI(3),DXI(4))
      DO 270 I=1,4
      IF (DXI(I).LT.DX) GO TO 270
      IF (DYI(I).LT.DY) GO TO 270
```

```
      IF (DXI(I).GT.DXM) GO TO 270
      DXM = DXI(I)
      IBEST = I
  270 CONTINUE
      DX = DXI(IBEST)
      DY = DYI(IBEST)
      IEXPX = IEXP(IBEST)
      IEXPY = IEXP(IBEST)
      IF (IBEST.LE.2) NXPR=20
      IF (IBEST.LE.2) NYPR=NPR(IBEST)/2
      IF (IBEST.GE.3) NXPR=NPR(IBEST)
      IF (IBEST.GE.3) NYPR=12
      GO TO 310
C
C  IOPT=5, SPECIFY X-SCALES, AUTOMATIC Y-SCALE SELECTION
C
  290 NXPR = 20
      CALL PLOTA6(DY,IEXPY,NYPR)
      NYPR = 10
      GO TO 310
C
C  IOPT=6, SPECIFY Y-SCALES, AUTOMATIC X-SCALE SELECTION
C
  300 NYPR = 10
      CALL PLOTA6(DX,IEXPX,NXPR)
      GO TO 320
C
C  RELOCATE AND ROUND OFF YMAX + XMIN
C   YMIN
  310 IYPAS = IYPAS+1
      IF (IYPAS.GT.1) GO TO 315
      IYPAS = 1
      YMIN1 = YMIN-0.5*(DY*LENG-YDIFF)
      CALL PLOTA6 (YDIFF,IRND,NRND)
      CALL PLOTA5 (YMIN1,IRND,0)
  315 IF (YMIN1.LE.0.) YMIN1=DY*FLOAT(IFIX(YMIN1/DY+SIGN(RND,YMIN1)))
C
C              CHECK FOR ZERO AS A POSSIBLE MINIMUM SCALE
      IF (ABS(YMIN/DY).LT.0.25) YMIN1=0.0
      IF (YMIN.GE.0.0) YMIN=AMAX1(YMIN1,0.0)
      IF (YMIN.LT.0.0) YMIN=YMIN1
      IF (IYPAS.GT.2) GO TO 320
C
C              CHECK FOR POSSIBLE LOSS OF DATA
      YMAX1 = YMIN+DY*LENG
      IF (YMAX1.LT.YMAX) DY=(YMAX-YMIN)/LENG
      IF (YMAX1.LT.YMAX) GO TO 250
      YMAX = YMIN+DY*LENG
C
C   XMIN
C
  320 IF (IOPT.EQ.5) GO TO 330
      IXPAS = IXPAS+1
      IF (IXPAS.GT.1) GO TO 325
      IXPAS = 1
      XMIN1 = XMIN-0.5*(DX*LWID-XDIFF)
      CALL PLOTA6 (XDIFF,IRND,NRND)
      CALL PLOTA5 (XMIN1,IRND,0)
  325 XMIN1=DX*FLOAT(IFIX(XMIN1/DX+SIGN(RND,XMIN1)))
C
C              CHECK FOR ZERO AS A POSSIBLE MINIMUM SCALE
      IF (ABS(XMIN/DX).LT.0.25) XMIN1=0.0
```

```
      IF (XMIN.GE.0.0) XMIN=AMAX1(XMIN1,0.0)
      IF (XMIN.GE.0.0 .AND. (XMAX-DX*LWID).LE.0.0) XMIN=0.0
      IF (XMIN.LT.0.0) XMIN=XMIN1
      IF (IXPAS.GT.2) GO TO 330
C
C             CHECK FOR POSSIBLE LOSS OF DATA
      XMAX1 = XMIN+DX*LWID
      IF (XMAX1.LT.XMAX) DX=(XMAX-XMIN)/LWID
      IF (XMAX1.LT.XMAX) GO TO 230
      XMAX = XMIN+DX*LWID
C
C  ESTABLISH LOCATION OF Y-AXIS, IF ANY
C
330   IF (XMIN.LT.0.0) IYAXIS=IFIX(ABS(XMIN/DX)+HALF)+2
      IF (XMIN.GE.0.0) IYAXIS=0
C
C  ESTABLISH LOCATION OF X-AXIS, IF ANY
C
      IF (YMIN.LT.0.0) IXAXIS=IFIX(ABS(YMAX/DY)+RND)+1
      IF ((YMIN.GE.0.0).OR.(YMAX.LE.0.0)) IXAXIS=0
C
C  COMPUTE Y-SCALE OFFSET OF ZERO OR BOTTOM OF PLOT
C
      IF (YMIN.LT.0.0) IOFFX = MOD(IXAXIS,NYPR)-1
      IF (YMIN.GE.0.0) IOFFX = MOD(LENG,NYPR)
C
C  COMPUTE X-SCALE OFFSET OF ZERO OR FIRST LABEL
C
      IF (XMIN.LT.0.) IOFFY=IYAXIS
      IF (XMIN.GE.0.) IOFFY=IFIX(-XMIN/DX-HALF)+2
      IOFFY = MOD(IOFFY,NXPR)
      IF (IOFFY.LT.2) IOFFY=IOFFY+NXPR
      IF ((IOPT.EQ.1).OR.(IOPT.EQ.5)) IOFFY=2
C
C  SET FORMAT, FMT, FOR X-AXIS
C
      IFMT = MAX0(3,IOFFY+1)
      FMT(1) = FMTX(IFMT)
      IF (NXPR.EQ.25) FMT(4)=FMTX(5)
      IF (NXPR.EQ.20) FMT(4)=FMTX(2)
      IF (NXPR.EQ.16) FMT(4)=FMTX(1)
C
      IF (IPR.LE.0) GO TO 999
      WRITE(6,12) XMAX,XMIN,DX,NXPR,IXAXIS,IOFFX,XMAX1,XMIN1,IXPAS
      WRITE(6,14) YMAX,YMIN,DY,NYPR,IYAXIS,IOFFY,YMAX1,YMIN1,IYPAS
      IF (IOPT.EQ.3) WRITE(6,16) DXI,DYI,IEXP,NPR,IREST
      WRITE(6,18) FMT
12    FORMAT(20H PLOTAB - X-SCALES -,7H  XMAX=,G12.5,7H  XMIN=,G12.5,
     *   7H    DX=,G12.5,7H  NXPR=,I5,8H IXAXIS=,I4,7H IOFFX=,I4,
     *   /20X,7H XMAX1=,G12.5,7H XMIN1=,G12.5,7H IXPAS=,I5)
14    FORMAT(20H PLOTAB - Y-SCALES -,7H  YMAX=,G12.5,7H  YMIN=,G12.5,
     *   7H    DY=,G12.5,7H  NYPR=,I5,8H IYAXIS=,I4,7H IOFFY=,I4,
     *   /20X,7H YMAX1=,G12.5,7H YMIN1=,G12.5,7H IYPAS=,I5)
16    FORMAT(20H PLOTAB - IOPT=3    -,6H  DXI=,4G12.5,
     *   /20X,6H  DYI=,4G12.5,/20X,6H IEXP=,4I12,
     *   /20X,6H  NPR=,4I12,10X,6HIREST=,I4)
18    FORMAT(20H PLOTAB - FORMAT    -,7H   FMT=,2X,6A4)
999   RETURN
      END
```

```
      SUBROUTINE PLOTG
C
C   ROUTINE TO PLOT PANEL GEOMETRY AND ROTATE CONFIGURATION FOR
C   PERSPECTIVE VIEWING
C
C   DATA STORAGE (TAPE7):
C     1. ARRAY(6000) = WING/TAIL CORNER POINTS AND PANEL GEOMETRY
C     2. ARRAY(6000) = BODY CORNER POINTS
C
      DIMENSION ARRAY(6000),X(5,300),Y(5,300),Z(5,300)
     *    ,CHORD(600),SLOPE(600),XP(5,300),YP(5,300)
     *    ,NPLT(300),XCG(3),AROT(3),LINE(3000)
C
      COMMON /JOPTNS/ IZ1(8)
     1    ,J0,J1,J2,J3,J4,J5,J6,NWAF,NWAFOR,NFUS,NRADX(4),NFORX(4)
     2    ,NP,NPODOR,NF,NFINOR,NCAN,NCANOR,J2TEST,NW
     3    ,IZ2(34),IPRT(5),IXZSYM
      COMMON /PARAM / NBODY,NWING,NTAIL,LBC,THK,XMACH,ALPHA,BETA,ALPHAC
     1    ,PHIR,REFA,REFB,REFC,REFD,REFL,REFX,REFZ
      COMMON /POINT / XPT(600),YPT(600),ZPT(600),THET(600)
     *    ,DELTA(600),XC(30,20),YC(30,20),ZC(30,20),AREA(600),XLE(600)
      COMMON          BLOCK(7500)
      COMMON /NEWCOM/ K1,KWAF,KWAFOR,KRADX(4),KFORX(4),KFUS,MAX,K4,K5
     1    ,KF(6),KAN(6),KFINOR(6),KANOR(6),KOL,NCPT,LOCPT(20),XCPT(20)
      COMMON /SEG   / NSEG,NROW(20),NCOL(20),COSS(20),SINS(20)
     1    ,HT(20),NNT(20),BL(140)
      COMMON /BSIZE / XYPT(4),ITAPE
C
      EQUIVALENCE (ARRAY(1),XPT(1))
     *    ,(X(1),BLOCK(1)),       (Y(1),BLOCK(1501)),    (Z(1),BLOCK(3001))
     *    ,(XP(1),BLOCK(4501)), (YP(1),BLOCK(6001))
     *    ,(CHORD(1),AREA(1)),  (SLOPE(1),XLE(1))
     *    ,(XPT(1),LINE(1))
C
      DATA XCG,AROT/3*0.,  3*0./,  NPLT/300*5/
      DATA IOPT,NOP,LWID,LENG/3,5,100,50/
      DATA NLIN/3000/
      ITAPE=9
C
C   COPY WING PANEL POINTS IN TO (X,Y,Z)
C
      CALL CPUTIM(TIME,DT,1)
      REWIND 7
      JP = 0
      IF (K1.EQ.0 .AND. K4.EQ.0 .AND. K5.EQ.0) GO TO 150
      READ (7) ARRAY,CHORD,SLOPE
      ONE = 1.
      CALL MXOUT (8H XC=WING,ONE,XC,30,20,60,132,1,30,20)
C     CALL MXOUT (8H YC=WING,ONE,YC,30,20,60,132,1,30,20)
C     CALL MXOUT (8H ZC=WING,ONE,ZC,30,20,60,132,1,30,20)
C
C   DEFINE CLOSED CURVE AROUND BOUNDARY OF PANEL
C   POINTS ARE ACCESSED IN THE FOLLOWING ORDER
C     1 = (J-1,K-1),       3 = (J-1,K)
C     2 = (J  ,K-1),       4 = (J  ,K)
C   CURVE IS DRAWN IN FOLLOWING ORDER:  (1,2,4,3,1)
C
      IF (NSEG.EQ.0) GO TO 150
      L = 1
      DO 140 N=1,NSEG
      NR = NROW(N)
      NC = NCOL(N)
C
```

```
      DO 130 K=2,NC
      L = L+1
      KM1 = L-1
C
      DO  120 J=2,NR
      JM1 = J-1
      JP = JP+1
C  1ST CORNER
      X(1,JP) = XC(JM1,KM1)
      Y(1,JP) = YC(JM1,KM1)
      Z(1,JP) = ZC(JM1,KM1)
C  2ND CORNER
      X(2,JP) = XC(J,KM1)
      Y(2,JP) = YC(J,KM1)
      Z(2,JP) = ZC(J,KM1)
C  3RD CORNER
      X(3,JP) = XC(J,K)
      Y(3,JP) = YC(J,K)
      Z(3,JP) = ZC(J,K)
C  4TH CORNER
      X(4,JP) = XC(JM1,K)
      Y(4,JP) = YC(JM1,K)
      Z(4,JP) = ZC(JM1,K)
C  5TH CORNER  - CLOSE CURVE
      X(5,JP) = XC(JM1,KM1)
      Y(5,JP) = YC(JM1,KM1)
      Z(5,JP) = ZC(JM1,KM1)
      IF (JP.GE.300) GO TO 250
120   CONTINUE
130   CONTINUE
140   CONTINUE
C
C  READ BODY PANEL DATA FOR CORNER POINTS (XC,YC,ZC) ------------------
C
150   IF (NFUS.EQ.0) GO TO 250
      READ (7) ARRAY
      TWO = 2.
C     CALL MXOUT (8H XC-BODY,TWO,XC,30,20,60,132,1,30,20)
C     CALL MXOUT (8H YC-BODY,TWO,YC,30,20,60,132,1,30,20)
C     CALL MXOUT (8H ZC-BODY,TWO,ZC,30,20,60,132,1,30,20)
C
C  COPY BODY CORNER POINTS INTO CURVES
C
      L = 1
      DO 240 IFUS=1,NFUS
      NC = KRADX(IFUS)
      NR = KFORX(IFUS)
C
      DO 230 K=2,NC
      L = L+1
      KM1 = L-1
C
      DO 220 J=2,NR
      JP = JP+1
      JM1 = J-1
C  1ST CORNER
      X(1,JP) = XC(JM1,KM1)
      Y(1,JP) = YC(JM1,KM1)
      Z(1,JP) = ZC(JM1,KM1)
C  2ND CORNER
      X(2,JP) = XC(J,KM1)
      Y(2,JP) = YC(J,KM1)
      Z(2,JP) = ZC(J,KM1)
```

```
C   3RD CORNER                                                          WB32 127
       X(3,JP) = XC(J,K)                                                WB32 128
       Y(3,JP) = YC(J,K)                                                WB32 129
       Z(3,JP) = ZC(J,K)                                                WB32 130
C   4TH CORNER                                                          WB32 131
       X(4,JP) = XC(JM1,K)                                              WB32 132
       Y(4,JP) = YC(JM1,K)                                              WB32 133
       Z(4,JP) = ZC(JM1,K)                                              WB32 134
C   5TH CORNER  - CLOSE CURVE                                           WB32 135
       X(5,JP) = XC(JM1,KM1)                                            WB32 136
       Y(5,JP) = YC(JM1,KM1)                                            WB32 137
       Z(5,JP) = ZC(JM1,KM1)                                            WB32 138
       IF (JP.GE.300) GO TO 250                                         WB32 139
220    CONTINUE                                                         WB32 140
230    CONTINUE                                                         WB32 141
240    CONTINUE                                                         WB32 142
C                                                                       WB32 143
C   PLOT PERSPECTIVE VIEWS OF PANEL GEOMETRY ---------------------------WB32 144
250    CONTINUE                                                         WB32 145
       IF (JP.LE.0) GO TO 999                                           WB32 146
C                                                                       WB32 147
C   TOP VIEW                                                            WB32 148
       CALL PLOTV2(X,Y,IOPT,NPLT,NDP,JP,LWID,LENG,LINE,NLIN)            WB32 149
       WRITE(6,10)                                                      WB32 150
C      CALL PLOTI (X,Y,IOPT,NPLT,NDP,JP,1,1,2HX*,2HY*)                  WB32 151
C                                                                       WB32 152
C   SIDE VIEW                                                           WB32 153
       CALL PLOTV2(X,Z,IOPT,NPLT,NDP,JP,LWID,LENG,LINE,NLIN)            WB32 154
       WRITE(6,11)                                                      WB32 155
C      CALL PLOTI (X,Z,IOPT,NPLT,NDP,JP,1,1,2HX*,2HZ*)                  WB32 156
C                                                                       WB32 157
C   FRONT VIEW                                                          WB32 158
       CALL PLOTV2(Y,Z,IOPT,NPLT,NDP,JP,LWID,LENG,LINE,NLIN)            WB32 159
       WRITE(6,12)                                                      WB32 160
C      CALL PLOTI (Y,Z,IOPT,NPLT,NDP,JP,1,1,2HY*,2HZ*)                  WB32 161
C                                                                       WB32 162
C   PERSPECTIVE VIEW                                                    WB32 163
       AROT(2) = 45.                                                    WB32 164
       AROT(3) = -45.                                                   WB32 165
       CALL PLOTA3(X,Y,Z,NPLT,NDP,JP,AROT,XCG,XP,YP,3)                  WB32 166
       CALL PLOTV2(XP,YP,IOPT,NPLT,NDP,JP,LWID,LENG,LINE,NLIN)          Added
C      CALL PLOTI (XP,YP,IOPT,NPLT,NDP,JP,1,1,3HXP*,3HYP*)              WB32 167
       WRITE(6,13) AROT                                                 WB32 168
       CALL CPUTIM(TIME,DT,1)                                           WB32 169
       WRITE(6,15) TIME,DT                                              WB32 170
10     FORMAT(/20X,20HTOP VIEW   = Y VS X )                             WB32 171
11     FORMAT(/20X,20HSIDE VIEW  = Z VS X )                             WB32 172
12     FORMAT(/20X,20HFRONT VIEW = Z VS Y )                             WB32 173
13     FORMAT(/20X,19HPERSPECTIVE VIEW -                                WB32 174
     *    ,7HTHETAX=,F8.3,5X,7HTHETAY=,F8.3,5X,7HTHETAZ=,F8.3)          WB32 175
15     FORMAT(/10X,18HEND PLOTG ,  TIME= ,F10.3,5X,3HDT=,F10.3)         WB32 176
C                                                                       WB32 177
999    RETURN                                                           WB32 178
       END                                                              WB32 179
```

```
      SUBROUTINE PLOTV2 (X,Y,IOPT,NP,NDP,NC,LWID,LENG,LINE,NLIN)        WB33    1
C+---------------------------------------------------------------------WB33    2
C                                                                       WB33    3
C       SUBROUTINE PLOTV2                                               WB33    4
C                                                                       WB33    5
```

```
C        PURPOSE
C           ROUTINE TO GENERATE A CHARACTER PLOT OF NC SIMULTANEOUS
C           CURVES OF  Y VS X.  A LINEAR INTERPOLATION IS MADE BETWEEN
C           SEQUENTIAL POINTS.
C
C
C        CALLING FORMAT
C           CALL PLOTV2 (X,Y,IOPT,NP,NDP,NC,LWID,LENG,LINE,NLIN)
C
C        PARAMETERS
C           NAME    TYPE   I/O/S   DIM     DESCRIPTION
C
C           X,Y       R        I (NDP,NC) ORDINATE + ABSCISSA ARRAYS
C           IOPT      I        I      NONE  OPTION FOR TYPE OF PAGE SCALING
C                                           1, USER SPECIFIES SCALE LIMITS
C                                           2, INTERNAL AUTOMATIC BEST SCALING
C                                           3, AUTOMATIC TRUE SHAPE SCALING, USES
C                                              RATIO: 0.6*LWID/LENG = XDIFF/YDIFF
C                                           4, USE MAX AND MIN VALUES OF DATA
C                                           5, INPUT XMAX,XMIN# AUTO Y=SCALING
C                                           6, INPUT YMAX,YMIN# AUTO X=SCALING
C           NP        I        I      NONE  VECTOR OF NUMBER OF POINTS IN J*TH
C                                           CURVE
C           NDP       I        I      NONE  FIRST DIMENSION OF ARRAYS *X,Y* IN
C                                           CALLING ROUTINE
C           NC        I        I      NONE  NUMBER OF SIMULTANEOUS PLOTS.
C                                           IF NC%41, CHARACTER SET REPEATS.
C           LWID      I        I      NONE  WIDTH OF PLOTTED REGIONS AT 10
C                                           CHARACTERS/INCH.  NORMALLY=100,
C                                           FOR CRT OR T.I. TERMINALS=50.
C                                           MAXIMUM DIMENSIONED = 100.
C           LENG      I        I      NONE  NUMBER OF LINES IN PLOTTED REGION
C                                           NORMALLY=50 AT 6 LINES/INCH#
C                                           FOR 8.5" PAPER=40.
C           LINE      I        S   (NLINE) SCRATCH MATRIX USED IN PLOTTING
C                                           CHARACTERS.  WHERE:
C                                           (LWID+3).LE.NLIN.LE.(LWID+3)(LENG+1)
C           NLIN      I        I      NONE  DIMENSIONED LENGTH OF SCRATCH ARRAY
C                                           *LINE*,  VALUES GREATER THAN (LWID+3)
C                                            ONLY IMPROVE THE EFFICIENCY OF THE
C                                           PLOT ALGORITHM
C
C
C        USER SUPPLIED COMMON BLOCKS
C           IOPT =1,5,6:  /BSCALE/ XMAX,XMIN,YMAX,YMIN
C
C        COMMON /BSCALE/
C           NAME    TYPE   I/O/S   DIM     DESCRIPTION
C
C           XMAX      R      I/O    NONE  MAXIMUM X SCALE VALUE ACROSS PAGE
C           XMIN      R      I/O    NONE  MINIMUM X SCALE VALUE ACROSS PAGE
C           YMAX      R      I/O    NONE  MAXIMUM Y SCALE VALUE AT TOP OF PAGE
C           YMIN      R      I/O    NONE  MINIMUM Y SCALE VALUE DOWN PAGE
C
C        EXTERNAL REFERENCES
C           PLOTA SUBROUTINES:  PLOTA7, PLOTA8
C
C        AUTHOR
C           JOSEPH MULLEN JR., NIELSEN ENGINEERING + RESEARCH, INC.
C           DATED: DECEMBER, 1975
C
C-----------------------------------------------------------------------
      DIMENSION X(NDP,NC),Y(NDP,NC),XPRINT(7),NP(NC),FMT(6)
```

```
      INTEGER SYMBOL(40),LINE(NLIN)
      COMMON /HPLTA1/ NXPR,NYPR,IYAXIS,IXAXIS,IOFFX,IOFFY,LLINE
      COMMON /HSCALE/ XMAX,XMIN,YMAX,YMIN
C
      DATA FMT/4H(7X ,4H,G16,4H.4,6,4H( 4X,4HG16.,4H4)) /
      DATA SYMBOL/1H*,1H+,1H-,1H.,1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7
     *,1H8,1H9,1HA,1HB,1HC,1HD,1HE,1HF,1HG,1HH,1HI,1HJ,1HK,1HL,1HM
     *,1HN,1HO,1HP,1HQ,1HR,1HS,1HT,1HU,1HV,1HW,1HX,1HY,1HZ/
C
C   FIND MAX AND MIN OF X (ORDINATE) AND Y (ABSCISSA)
C
      NPJ = 1
      IF (IOPT.LT.1) IOPT=2
C
      IF (IOPT.EQ.1) GO TO 80
      IF (IOPT.EQ.5) GO TO 60
      XMAX = X(1,1)
      XMIN = X(1,1)
      DO 50 J=1,NC
      NPJ = NP(J)
      IF (NPJ.LT.1) GO TO 50
      DO 40 I=1,NPJ
      XMAX = AMAX1(X(I,J),XMAX)
40    XMIN = AMIN1(X(I,J),XMIN)
50    CONTINUE
      IF (IOPT.EQ.6) GO TO 80
C
60    YMAX = Y(1,1)
      YMIN = Y(1,1)
      DO 70 J=1,NC
      NPJ = NP(J)
      IF (NPJ.LT.1) GO TO 70
      DO 65 I=1,NPJ
      YMAX = AMAX1(Y(I,J),YMAX)
65    YMIN = AMIN1(Y(I,J),YMIN)
70    CONTINUE
C
C   DETERMINE SCALING AND ROUND OFF MAX AND MIN VALUES AND LOCATE
C   X- AND Y-AXES.
C
80    CALL PLOTAH(DX,DY,FMT,LWID,LENG,IOPT)
      NROWS = LENG+1
      NDL = MAX0(NLIN/LLINE,1)
      IF (NDL.GT.NROWS) NDL=NROWS
C
C   INITIALIZE PLOTTING BANDWIDTH
C
      YLOW = YMAX+(0.5-NDL)*DY
      YMID = YMAX
      YUP  = YMAX+0.5*DY
C
C   FORM UPPER BOUNDARY
C
      CALL PLOTA7 (LINE,1,1)
      WRITE(6,1) (LINE(I),I=1,LLINE)
C
C   START LOOP ON COMPUTING ALL LINES THAT PASS THROUGH NEXT NDL LINES
C
      NBLK = NROWS/NDL
      IF (NBLK*NDL.LT.NROWS) NBLK=NBLK+1
      JSAVE = 0
      DO 160 JBLK=1,NBLK
C
```

```
C  INITIALIZE BLANK ROW OR X-AXIS
C
      J = JSAVE
      JK = 1
      DO 110 K=1,NOL
      J = J+1
      IF (J.GT.NROWS) GO TO 115
      IF (J.EQ.IXAXIS) CALL PLOTA7 (LINE(JK),J-IOFFX,1)
      IF (J.NE.IXAXIS) CALL PLOTA7 (LINE(JK),J-IOFFX,2)
      JK = JK+LLINE
110   CONTINUE
C
C  TEST FOR VECTOR DRAWN ACROSS NEXT NOL LINES OF OUTPUT
C
115   DO 140 L=1,NC
      LSYM = MOD(L-1,40)+1
      NPL = NP(L)
      IF (NPL.LT.1) GO TO 140
      X2 = X(1,L)
      Y2 = Y(1,L)
C
C  START LOOP ON NUMBER OF VECTORS IN EACH LINE
C
      DO 130 K=1,NPL
      X1 = X2
      Y1 = Y2
      X2 = X(K,L)
      Y2 = Y(K,L)
C
C  TEST WHETHER VECTOR CROSSES BLOCK OF LINES
C
      IF ((Y1.GE.YUP).AND.(Y2.GE.YUP)) GO TO 130
      IF ((Y1.LT.YLOW).AND.(Y2.LT.YLOW)) GO TO 130
C
C  COMPUTE INTERMEDIATE POINTS AND STORE IN LINE.
C
      DELX = X2-X1
      DELY = Y2-Y1
      IDX = IFIX(ABS(DELX/DX))
      IDY = IFIX(ABS(DELY/DY))
      NV = MAX0(IDX,IDY)+1
      DELX = DELX/NV
      DELY = DELY/NV
      NV = NV+1
      XV = X1
      YV = Y1
C
      DO 125 IV=1,NV
      IX = IFIX((XV-XMIN)/DX+0.5)+2
      IY = IFIX((YUP-YV)/DY+1.)
      IF ((IY.LT.1).OR.(IY.GT.NOL))   GO TO 120
      IF ((IX.LT.2).OR.(IX.GE.LLINE)) GO TO 120
      IXY = LLINE*(IY-1)+IX
      LINE(IXY) = SYMBOL(LSYM)
120   XV = XV+DELX
      YV = YV+DELY
125   CONTINUE
130   CONTINUE
140   CONTINUE
C
C  PRINT NOL LINES OF OUTPUT - CHECK FOR SCALES
C
      J = JSAVE
```

```
      JK = 1
      JK2 = LLINE
      DO 150 K=1,NCOL
      J = J+1
      IF (J.GT.NROWS) GO TO 160
      IMOD = MOD(J-IOFFX-1,NYPR)
      IF (IMOD.EQ.0) WRITE (6,2) YMID,(LINE(I),I=JK,JK2)
      IF (IMOD.NE.0) WRITE (6,3) (LINE(I),I=JK,JK2)
      JK = JK+LLINE
      JK2 = JK2+LLINE
C
C  INCREMENT Y-STRIP; REDEFINE YLOW AND YUP
C
      YUP = YUP-DY
      YMID = YMID-DY
      IF (ABS(YMID/DY).LT.0.001) YMID=0.0
      YLOW = YLOW-DY
150   CONTINUE
      JSAVE = J
160   CONTINUE
C
C  FORM LOWER BOUNDARY
C
      CALL PLOTA7 (LINE,1,1)
      WRITE (6,3) (LINE(I),I=1,LLINE)
C
C  PRINT SCALES
C
      NXP = (LLINE-IOFFY)/NXPR+1
      XPRINT(1) = XMIN+DX*(IOFFY-2)
      DO 240 I=2,NXP
      XPRINT(I) = XPRINT(I-1)+DX*NXPR
      IF (ABS(XPRINT(I)/DX).LT.0.001) XPRINT(I)=0.0
240   CONTINUE
      WRITE(6,FMT) (XPRINT(I),I=1,NXP)
      RETURN
1     FORMAT (1H1,14X,103A1)
2     FORMAT (1X,G13.4,1X,103A1)
3     FORMAT (15X,103A1)
      END
```

```
      SUBROUTINE PRESS(NP,XMACH,ARA,U,V,W,CPP,CPSTAG,CPCRIT,CPVAC,COMPT)
C
C  THE PRESSURE COEFFICIENT IS CALCULATED USING THE EXACT ISENTROPIC
C  FORMULA IN ALL CASES EXCEPT FOR WING, CANARD (HORIZONTAL TAIL),
C  AND FIN (VERTICAL TAIL) COMPONENTS ANALYZED UNDER THE PLANAR
C  BOUNDARY CONDITION OPTION. IN THESE CASES, THE LINEARIZED THEORY
C  PRESSURE COEFFICIENT FORMULA IS USED AND THE PRESSURE COEFFICIENT
C  IS LIMITED BY THE VACUUM PRESSURE COEFFICIENT.
C
C  COMPUTE THE STAGNATION PRESSURE COEFFICIENT, CRITICAL PRESSURE
C  COEFFICIENT, AND VACUUM PRESSURE COEFFICIENT.
C
      COMMON /PARAM / NBODY,NWING,NTAIL,LBC,THK,AMACH,ALPHA,BETA,ALPHAC
     1    ,PHIR,REFA,REFB,REFC,REFD,REFL,REFX,REFZ
      DIMENSION U(1),V(1),W(1),CPP(1)
      INTEGER COMPT
      LOGICAL LBC
```

```
      XM2=XMACH*XMACH
      CPCRIT=0.
      CPSTAG=1.
      CPVAC=0.
      COSARA=COS(ARA)
      SINARA=SIN(ARA)
      IF (XM2.EQ.0.) GO TO 10
      CON=1.42857/XM2
      CPVAC=-CON
      CON1=.2*XM2
C
C  LOOP THROUGH NP-PANELS TO CALCUALTE PRESSURE COEFFICIENTS  ----------
C
10    DO 40 J=1,NP
      UWPM=U(J)*COSARA+W(J)*SINARA
      IF (LBC.AND.COMPT.EQ.2) GO TO 20
      UWIND=1.+UWPM
      VWIND=V(J)
      WWIND=W(J)*COSARA-U(J)*SINARA
      VW2=VWIND*VWIND+WWIND*WWIND
      Q2=UWIND*UWIND+VW2
      IF (XMACH.EQ.0.) GO TO 30
      ARG=1.+CON1*(1.-Q2)
      IF (ARG.LT.0.) ARG=0.
      CPP(J)=CON*(ARG**3.5-1.)
      GO TO 40
20    CPP(J)=-2.*U(J)
C
C  CONSTRAIN THE PRESSURE COEFFICIENT SO THAT IT DOES NOT
C  EXCEED THE VACUUM PRESSURE COEFFICIENT
C
      IF (CPP(J).LT.CPVAC) CPP(J)=CPVAC
      GO TO 40
30    CPP(J)=1.-Q2
40    CONTINUE
      IF (XMACH.EQ.0.) RETURN
      CPSTAG=CON*((1.+CON1)**3.5-1.)
      CPCRIT=CON*((5./6.+XM2/6.)**3.5-1.)
      RETURN
      END
```

```
      SUBROUTINE PRTCPT(NBODY)
C
C  ROUTINE TO PRINT A COPY OF THE CONTROL POINTS AFT OF *XSTART*
C  AND FORWARD OF *XWLE* ON TAPE4 FOR USE BY OTHER PROGRAMS
C
      COMMON /JOPTNS/ IZ1(59),NVLIN
     *   ,NCPOUT,XSTART,XWLE,NWCPT,IPLOT(4),IPRT(5),IXZSYM
      COMMON /POINT / XPT(600),YPT(600),ZPT(600),THET(600),DELTA(600),
     1   XC(30,20),YC(30,20),ZC(30,20),DELTI(600),XLE(600)
C
      IF (NWCPT.NE.0) GO TO 999
      IF (NVLIN.GT.0) GO TO 999
      WRITE(6,750)
      REWIND 4
      IJ = 0
      DO 100 I=1,NBODY
      IF (XPT(I).LT.XSTART) GO TO 100
```

```
      IF (XPT(I).GT.XWLE) GO TO 100
      IJ = IJ+1
      WRITE(4,745) IJ,XPT(I),YPT(I),ZPT(I)
      WRITE(6,745) IJ,XPT(I),YPT(I),ZPT(I)
100   CONTINUE
      ENDFILE 4
      IF (NCPOUT.EQ.2) STOP 500
999   RETURN
C
750   FORMAT(1H1,9X,42HSUMMARY OF CONTROL POINTS WRITTEN ON TAPE4
     *   ,58X,12H** PRTCPT **)
745   FORMAT(I5,3G12.5)
      END
```

```
      SUBROUTINE READVX (NFUS,NFORX,LPRT)
C
C  ROUTINE TO READ THE VORTEX LOCATIONS AND STRENGTHS OF BODY VORTICES
C
      DIMENSION XFUS(30,4),FUSBY(30,4),FUSAZ(30,4),NFORX(4)
      LOGICAL LPRT
C
      COMMON /BVRTX / NVTX,NXVTX,XV(10),AV(10),BV(10)
      COMMON          BLOCK(7500)
C
      EQUIVALENCE (XFUS(1,1),BLOCK(1))
     *   ,(FUSBY(1,1),BLOCK(361))       ,(FUSAZ(1,1),BLOCK(481))
C
      IF (NXVTX.LE.0) GO TO 999
C
C  READ VORTEX PATH X-STATIONS
      READ (5,160) (XV(I),I=1,NXVTX)
      IF (LPRT) WRITE(6,170) (XV(I),I=1,NYVTX)
C
C  INTERPOLATE IN GEOMETRY FOR MAJOR AND MINOR AXES,
C  B AND A RESPECTIVELY.
C
      DO 120 K=1,NXVTX
C        FIND GEOMETRY BODY STATION.
      DO 100 NFU=1,NFUS
      NFUSOR=NFORX(NFU)
      DO 100 J=2,NFUSOR
      IF (XV(K).LE.XFUS(J,NFU)) GO TO 110
100   CONTINUE
      J = NFUSOR
      NFU = NFUS
110   JM1 = J-1
      DX = XFUS(J,NFU)-XFUS(JM1,NFU)
      IF (DX.NE.0.) DX=(XV(K)-XFUS(JM1,NFU))/DX
C
C        INTERPOLATE FOR A AND B
C
      AV(K) = FUSAZ(JM1,NFU)+DX*(FUSAZ(J,NFU)-FUSAZ(JM1,NFU))
      BV(K) = FUSBY(JM1,NFU)+DX*(FUSBY(J,NFU)-FUSBY(JM1,NFU))
120   CONTINUE
      IF (LPRT) WRITE(6,180) (BV(I),I=1,NXVTX)
      IF (LPRT) WRITE(6,190) (AV(I),I=1,NXVTX)
999   RETURN
C
```

```
160   FORMAT(10F7.0)                                                    WB36  45
170   FORMAT(///,10X,30HVORTEX LOCATIONS AND BODY AXES,                 WB36  46
     *   70X,12H** READVX ** ,//5H  XV=,10F10.4)                        WB36  47
180   FORMAT(/5H  BY=,10F10.4)                                          WB36  48
190   FORMAT(/5H  AZ=,10F10.4)                                          WB36  49
      END                                                               WB36  50
```

```
      SUBROUTINE RDVEL(VA,WA,XPT,YPT,ZPT,NBODY,XSTART,XMLE)             WB37   1
C                                                                       WB37   2
C  ROUTINE TO READ VELOCITY COMPONENTS AT CONTROL POINTS DEFINED IN     WB37   3
C  PRTCPT.                                                              WB37   4
C                                                                       WB37   5
      DIMENSION VA(1),WA(1),XPT(1),YPT(1),ZPT(1)                        WB37   6
      REWIND 4                                                          WB37   7
C                                                                       WB37   8
      WRITE(6,750)                                                      WB37   9
      DO 100 I=1,NBODY                                                  WB37  10
      IF (XPT(I).LT.XSTART) GO TO 100                                   WB37  11
      IF (XPT(I).GT.XMLE) GO TO 100                                     WB37  12
      READ(4,745) IJ,XCP,YCP,ZCP,VA(I),WA(I)                            WB37  13
      IF (EOF(4).NE.0.) GO TO 100                                       WB37  14
      WRITE(6,745) I,XPT(I),YPT(I),ZPT(I),VA(I),WA(I)                   WB37  15
100   CONTINUE                                                          WB37  16
      RETURN                                                            WB37  17
C                                                                       WB37  18
745   FORMAT(I5,5G12.5)                                                 WB37  19
750   FORMAT(1H1,9X,34HVORTEX VELOCITIES READ FROM TAPE4 ,              WB37  20
     *   56X,12H** RDVEL  **,                                           WB37  21
     *  //4X,1HI,3X,3HXPT,9X,3HYPT,9X,3HZPT,10X,2HVA,10X,2HWA/)         WB37  22
      END                                                               WB37  23
```

```
      SUBROUTINE SCAMP4(X,Y,N,NDA,NDB,DA,DB,C,S,M)                      WB38   1
C                                                                       WB38   2
C   GIVEN A SET OF N POINTS WHOSE ABSCISSAE FORM A STRICTLY MONOTONIC   WB38   3
C   SEQUENCE, AND GIVEN A FIRST OR SECOND DERIVATIVE AT X(1) AND A      WB38   4
C   FIRST OR SECOND DERIVATIVE AT X(N), TO FIND THE SMOOTHEST POSSIBLE  WB38   5
C   CURVE PASSING RIGOROUSLY THROUGH THE GIVEN POINTS, SATISFYING THE   WB38   6
C   SPECIFIED BOUNDARY CONDITIONS, AND POSSESSING CONTINUOUS FIRST AND  WB38   7
C   SECOND DERIVATIVES. THE CRITERION OF SMOOTHNESS IS THE              WB38   8
C   MINIMIZATION OF THE INTEGRAL OF THE SQUARE OF THE SECOND            WB38   9
C   DERIVATIVE, AND THE CUBIC FOUND IS ACCORDINGLY A CHAIN OF CUBICS.   WB38  10
C   I. E., A SEPARATE CUBIC ON EACH INTERVAL (X(I),X(I+1))              WB38  11
C                                                                       WB38  12
      DIMENSION C(4,1),S(1),X(1),Y(1),Z(4)                              WB38  13
      L=1                                                               WB38  14
      KK=1                                                              WB38  15
      D1=DA                                                             WB38  16
      D2=DB                                                             WB38  17
      IF (M.NE.12) GO TO 10                                             WB38  18
      KK=2                                                              WB38  19
10    IF ((NDA+1).LT.0) D1=DERIV2(X,Y,X)                                WB38  20
      IF ((NDA+1).EQ.0) D1=DERIV1(X,Y,1)                                WB38  21
      NA=IABS(NDA)                                                      WB38  22
60    IF (( DB+1).LT.0) D2=DERIV2(X(N-3),Y(N-3),X(N))                   WB38  23
      IF ((NDB+1).EQ.0) D2=DERIV1(X(N-2),Y(N-2),3)                      WB38  24
```

```
      NN=IABS(NOB)
      CALL COMCU(D1,D2,S,X,Y,M,N,NA,NB)
      IF (M.NE.0) RETURN
      K=N-1
      DO 50 J=1,K
      CALL CUBIC2(X(J),Y(J),S(J),Z,M)
      IF (M.EQ.1) GO TO 20
      M=100*J+M
      RETURN
20    IF (KK.EQ.2) GO TO 40
      DO 30 I=1,4
      C(I,J)=Z(I)
30    CONTINUE
      GO TO 50
40    L=7*J
      C(L-6,1)=X(J)
      C(L-5,1)=X(J+1)
      C(L-4,1)=3.
      C(L-3,1)=Z(1)
      C(L-2,1)=Z(2)
      C(L-1,1)=Z(3)
      C(L,1)=Z(4)
50    CONTINUE
      M=0
      RETURN
      END
```

```
      SUBROUTINE SOLVE
CDC   OVERLAY (LWB,3,0)
CDC   PROGRAM SOLVE
C
C   SOLVE FOR THE STRENGTHS OF THE BODY SOURCES AND WING VORTICES
C   WHICH SATISFY THE BOUNDARY CONDITION OF TANGENTIAL FLOW AT THE
C   PANEL CONTROL POINTS. ALSO DETERMINE THE CORRESPONDING PRESSURE
C   DISTRIBUTION AND THE FORCES AND MOMENTS ON THE CONFIGURATION.
C
C   THE PROGRAM MUST SOLVE A SYSTEM OF LINEAR EQUATIONS OF MAXIMUM
C   ORDER 1200. THE SOLUTION TECHNIQUE SELECTED CAN BE DESCRIBED AS A
C   BLOCKED JACOBI ITERATIVE METHOD. THE 1200 BY 1200 MATRIX IS
C   NATURALLY PARTITIONED INTO FOUR 600 BY 600 BLOCKS. EACH PARTITION
C   IS FURTHER SUBDIVIDED INTO BLOCKS OF MAXIMUM SIZE 60 BY 60. THE
C   MATRIX ELEMENTS IN EACH BLOCK ARE CAREFULLY CHOSEN TO REPRESENT
C   SOME WELL DEFINED FEATURE OF THE ORIGINAL CONFIGURATION. FOR
C   EXAMPLE, A BODY BLOCK REPRESENTS THE INFLUENCE OF ONE RING OF
C   PANELS AROUND THE BODY, WHILE A WING BLOCK REPRESENTS THE
C   INFLUENCE OF ONE CHORDWISE COLUMN OF WING PANELS. FOR WINGS USING
C   THE NON-PLANAR BOUNDARY CONDITION OPTION, THE BLOCK SIZE
C   CORRESPONDS TO THE TOTAL NUMBER OF PANELS ON THE UPPER AND LOWER
C   SURFACES OF THE COLUMN.  THIS ENSURES DOMINANCE OF THE ELEMENTS
C   ALONG THE DIAGONAL
C
C   THE INITIAL ITERATION CALCULATES THE SINGULARITY STRENGTHS
C   CORRESPONDING TO EACH BLOCK IN ISOLATION. FOR THIS STEP, ONLY THE
C   DIAGONAL BLOCKS ARE PRESENT IN THE AERODYNAMIC MATRIX.  ONCE THE
C   INITIAL APPROXIMATION TO THE SINGULARITY STRENGTHS IS DETERMINED,
C   THE INTERFERENCE EFFECT OF EACH BLOCK ON ALL THE OTHERS IS
C   CALCULATED BY MATRIX MULTIPLICATION.  THE INCREMENTAL NORMAL
C   VELOCITIES OBTAINED ARE SUBTRACTED FROM THE NORMAL VELOCITIES
C   SPECIFIED BY THE BOUNDARY CONDITIONS.  THIS PROCESS IS ITERATED
```

```
C   UNTIL A CONVERGENCE TEST ON THE MAXIMUM RESIDUAL IS SATISFIED OR A
C   MAXIMUM NUMBER OF ITERATIONS IS REACHED..
C   ---------------------------------------------------------------------
C   BODY ONLY VERSION:                                  JUNE 1977
C   THOSE PORTIONS OF THE ORIGINAL PROGRAM *UNAERO* WHICH PERTAINED
C   TO CALCULATIONS OF WINGS HAVE BEEN DELETED.
C                                                    JOE MULLEN
C   ---------------------------------------------------------------------
C
C   TAPE USAGE IN SOLVE=
C     TAPE7:  SOLVE,    READ  ARRAY      - CALCULATE BOUNDARY CONDITION
C             DIAGIN,   READ  D          - INVERT DIAGONALS,  N GT NMAX
C             SOLVE,    REWIND
C                       READ  ARRAY      - CALCULATE NORMAL VELOCITIES
C                       REWIND
C
C     TAPE8:  SOLVE,    REWIND
C                       READ  UA,VA,WA   - CALCULATE U,V,W
C                       REWIND
C
C     TAPE9:  PARTIN,   REWIND
C                       READ  D        - INVERT DIAGONAL BLOCKS, N LT NMAX
C                       REWIND
C             DIAGIN,   REWIND
C                       READ  D        - INVERT DIAGONAL BLOCKS, N LT NMAX
C             ITRATE,   REWIND
C                       READ  A        - ITERATE WITH AIC FOR SOLN
C
C     TAPE10: PARTIN,   REWIND
C                       WRITE  D(INVERSE)
C                       REWIND
C             DIAGIN,   REWIND
C                       WRITE  D(INVERSE) - DIAGONAL BLOCKS
C                       REWIND
C             ITRATE,   REWIND
C                       READ    D(INVERSE) - ITERATE ON SOLUTION
C
      COMMON /JOPTNS/ IZ1(59),NVLIN
     *   ,NCPOUT,XSTART,XWLE,NWCPT,IPLOT(4),IPRT(5),IXZSYM
      COMMON            U(600),V(600),W(600),A(60,60),Z3(300),GW(600),
     1   GB(600),DZTDX(600)
      COMMON /PARAM / NBODY,NWING,NTAIL,LBC,THK,XMACH,ALPHA,BETA,ALPHAC
     1   ,PHIR,REFA,REFB,REFC,REFD,REFL,REFX,REFZ
      COMMON /VELCOM/ NPOINT,NPART,IMAX,JMAX,NMAX,EM,IPRINT,NWTHK
     1   ,NWBLOK,NWROW(20),NBBLOK,NBROW(60)
      COMMON /POINT / ARRAY(6000)
      COMMON /MATCOM/ MATIN
C
      DIMENSION UA(600),VA(600),WA(600),CP(600),NS(600),CHORD(600)
     1   ,THET(600),DELTA(600),NB(600),NW(600),NT(600),DEL(600)
     2   ,COSTH(600),XPT(600),YPT(600),ZPT(600)
C
      EQUIVALENCE                          (U(1),NW(1))
     1   ,(V(1),NB(1)),                    (W(1),NT(1))
     2   ,(UA(1),A(1,1)),                  (VA(1),A(1,11))
     3   ,(WA(1),A(1,21)),                 (CP(1),A(1,31))
     4   ,(NS(1),A(1,41)),                 (GW(1),DEL(1))
     5   ,(GB(1),COSTH(1))
     6   ,(XPT(1),ARRAY(1)),               (YPT(1),ARRAY(601))
     7   ,(ZPT(1),ARRAY(1201)),            (THET(1),ARRAY(1801))
     8   ,(DELTA(1),ARRAY(2401)),          (CHORD(1),ARRAY(3601))
      REAL NB,NW,NT,NS
      INTEGER COMPT
```

```
      LOGICAL LBC,THK
      DATA RADDEG/0.0174532926/
C
      CALL CPUTIM(TIME0,DT,1)
      EM=XMACH
      NPASS=0
      REWIND 7
      REWIND 8
      ALP=ALPHA*RADDEG
      ALPHAC=ALPHA
      PHI=PHIR*RADDEG
      SINAL=SIN(ALP)
      COSAL=COS(ALP)
      SINB=0.
      SINA=SINAL
C
C
C     ALPHAC.......INCLUDED ANGLE OF ATTACK
C     PHI..........ANGLE OF ROLL
C     ALPHA........ANGLE OF PITCH
C     BETA.........ANGLE OF SIDE SLIP
C     ALL IN DEGREES.
C
C
      IF (IXZSYM.EQ.0) GO TO 5
      SINB=SINAL*SIN(PHI)
      SINA=SINAL*COS(PHI)
      BETA=ASIN(SINB)/RADDEG
      ALPHA=ASIN(SINA)/RADDEG
      IF (IPRINT.NE.0) WRITE(6,430) ALPHAC,PHIR,ALPHA,BETA
5     CONTINUE
C
C  CALCULATE NORMAL VELOCITIES REQUIRED TO SATISFY BOUNDARY
C  CONDITIONS AT BODY CONTROL POINTS
C
20    IF (NBODY.EQ.0) GO TO 70
C
C  BOUNDARY CONDITION FOR BODY.CONTRIBUTION FROM FREE STREAM.
C
      READ (7) ARRAY
      DO 30 I=1,NBODY
      NW(I)=COSAL*SIN(DELTA(I))
     1   +COS(DELTA(I))*(-SINA*COS(THET(I))-SINB*SIN(THET(I)))
30    CONTINUE
C
C ----------------------------------------------------------------------
C  SOLVE MATRIX EQUATIONS - DIRECT SOLUTION IF MATRIX LESS THAN 60X60,
C   OTHERWISE ITERATIVE SOLUTION
C
70    IF (NBODY.LE.NMAX.AND.NWING.LE.NMAX) GO TO 80
      IF (MATIN.EQ.1) CALL DIAGIN
      REWIND 10
      GO TO 90
80    CALL PARTIN
      IF (NBODY.EQ.0.OR.NWING.EQ.0) GO TO 100
90    CALL ITRATE
100   REWIND 7
110   NPASS=NPASS+1
      IF (NBODY.EQ.0) GO TO 220
C
C  CALCULATE VELOCITY COMPONENTS ON BODY PANELS ------------------------
C            U = UA*GB,  V = VA*GB,  W = WA*GB
C
```

```
      DO 140 I=1,NBODY
      U(I)=0.
      V(I)=0.
      W(I) = 0.
      READ (8) (UA(J),VA(J),WA(J),J=1,NBODY)
      DO 130 J=1,NBODY
      U(I)=U(I)+UA(J)*GB(J)
      V(I)=V(I)+VA(J)*GB(J)
      W(I)=W(I)+WA(J)*GB(J)
130   CONTINUE
140   CONTINUE
C
C  CALCULATE WING VELOCITY COMPONENTS HERE DUE TO VORTEX SHEDDING ------
C  FROM NOSE:             V = V+V(VOR),    W = W+W(VOR)
C
      IF (NPASS.EQ.1) READ (7) ARRAY
      DO 145 I=1,NBODY
      VA(I)=0.
145   WA(I)=0.
C
C  COMPUTE VORTEX VELOCITIES BY INTERPOLATION IN STRENGTHS USING VVELS
C
      CALL ELBOVT (VA,WA,XPT,YPT,ZPT,NBODY)
C
C  READ IN VELOCITY CONTRIBUTIONS FOR CONTROL POINTS WRITTEN OUT BY
C  PRTCPT.  VELOCITY COMPONENTS ARE COMPUTED BY VPATHL
C
      IF (NVLIN.EQ.1 .AND. NCPOUT.LE.0)
     *   CALL RDVEL(VA,WA,XPT,YPT,ZPT,NBODY,XSTART,XWLE)
C
C  COMPUTE NORMAL VELOCITIES AT CONTROL POINTS
C
      DO 190 I=1,NBODY
180   NS(I)=(W(I)*COS(THET(I))-V(I)*SIN(THET(I)))*COS(DELTA(I))-U(I)*
     1 SIN(DELTA(I))
190   CONTINUE
      IF (IABS(IPRINT).LT.2) GO TO 210
      WRITE (6,350) EM,ALPHAC,PHIR
      WRITE (6,400)
      DO 200 N=1,NBODY
      WRITE (6,420) N,GB(N),U(N),V(N),W(N),NS(N),VA(N),WA(N)
200   CONTINUE
C
C  CALCULATE PRESSURES ON BODY PANELS, THEN
C  CALCULATE FORCES AND MOMENT ON BODY
C
210   COMPT=1
      DO 150 I=1,NBODY
      V(I) = V(I)+VA(I)
150   W(I) = W(I)+WA(I)
      CALL PRESS(NBODY,EM,ALP,U,V,W,CP,CPSTAG,CPCRIT,CPVAC,COMPT)
      CALL FORMOM(NBODY,NPASS,ALP,COMPT,.FALSE.)
C
C  COMPUTE FORCE AND MOMENTS FOR CONTROL POINTS BETWEEN XSTART AND XWLE
C
      CALL FORMOM(NBODY,NPASS,ALP,COMPT,.TRUE.)
220   CONTINUE
340   WRITE (6,390) CPSTAG,CPCRIT,CPVAC
      REWIND 7
C     REWIND 8
      CALL CPUTIM(TIME,DT,1)
      DT=TIME-TIME0
      WRITE(6,440) TIME,DT
```

```
      RETURN                                                            WB39 222
  350 FORMAT (///10X,16HVELOCITY ON BODY,84X,12H** SOLVE  **,           WB39 223
     *  //5X,5HMACH=,F6.3,3X,6HALPHA=,F7.3,3X,5HPHIR=,F7.3//)          WB39 224
  390 FORMAT (/9H CPSTAG =,F10.5,3X,8HCPCRIT =,F10.5,3X,7HCPVAC =,F10.5)WB39 225
  400 FORMAT (8X,5HPANEL,3X,6HSOURCE, 7X,5HAXIAL,10X,7HLATERAL,10X,     WB39 226
     1    8HVERTICAL,10X,6HNORMAL,8X,10HLAT.VORTEX,7X,10HVER.VORTEX     WB39 227
     2    ,/8X,3HNO.,4X,8HSTRENGTH,4X,8HVELOCITY,5(9X,8HVELOCITY))      WB39 228
  420 FORMAT (I12,F10.5,G15.5,5G17.5)                                   WB39 229
  430 FORMAT(//10X,25HCOMBINED ANGLES OF ATTACK,75X,12H** SOLVE **      WB39 230
     *    ,/5X,7HALPHAC=,F10.4,5X,7H  PHIR=,F10.4                       WB39 231
     *    ,/5X,7H ALPHA=,F10.4,5X,7H  BETA=,F10.4)                      WB39 232
  440 FORMAT(/5X,18HEND SOLVE,   TIME=,F10.4,5X,3HDT=,F10.4)            WB39 233
      END                                                               WB39 234
```

```
      SUBROUTINE SORPAN(UPM,VPM,WPM)                                    WB40   1
C                                                                       WB40   2
C  COMPUTE THE THREE COMPONENTS OF VELOCITY INDUCED AT A SPECIFIED     WB40   3
C  CONTROL POINT BY A CONSTANT SOURCE DISTRIBUTION ON A                WB40   4
C  QUADRILATERAL PANEL HAVING LONGITUDINAL TAPER AND INCLINED AT AN    WB40   5
C  ANGLE DELTA TO THE FREE STREAM DIRECTION                            WB40   6
C                                                                       WB40   7
      COMMON /BODCOM/ AMACH,SA,CX,XC(4),YC(4),ZC(4),XI,YI,ZI,XJ,ZJ      WB40   8
      DIMENSION SX(4),SM(4),DX(4),DY(4),DZ(4),D(4),E(4),F(4),G(4),      WB40   9
     1 H(4),XPM(4),YMX(4),ZAX(4),AYM(4),RPM2(4)                         WB40  10
C                                                                       WB40  11
      REAL NUM                                                          WB40  12
      DATA EPS,PI/1.E-5,3.14195265/                                     WB40  13
C                                                                       WB40  14
      EP2=EPS*EPS                                                       WB40  15
      BT2=1.-AMACH*AMACH                                                WB40  16
      BTA=SQRT(ABS(BT2))                                                WB40  17
      BA2=BT2*SA*SA                                                     WB40  18
      TA=1.+BA2                                                         WB40  19
      IF (TA.LT.0.) GO TO 200                                           WB40  20
      SM(3)=0.                                                          WB40  21
      DO 190 I=1,4                                                      WB40  22
      ZC(I)=ZJ-SA*(XJ-XC(I))                                            WB40  23
      IF (I.LE.2) SM(1)=(YC(2)-YC(1))/CX                                WB40  24
      IF (I.GT.2) SM(3)=(YC(4)-YC(3))/CX                                WB40  25
      SM(2)=SM(1)                                                       WB40  26
      SM(4)=SM(3)                                                       WB40  27
      SSM=SIGN(1.,SM(I))                                                WB40  28
      BM2=BT2*SM(I)*SM(I)                                               WB40  29
      TAM=TA+BM2                                                        WB40  30
      IF (ABS(TAM).LE.EPS) TAM=0.                                       WB40  31
      SAM=SQRT(ABS(TAM))                                                WB40  32
      SAMD=1./SAM                                                       WB40  33
      CPM=CX*SAM                                                        WB40  34
      DX(I)=XI-XC(I)                                                    WB40  35
      DY(I)=YI-YC(I)                                                    WB40  36
      DZ(I)=ZI-ZC(I)                                                    WB40  37
      IF (ABS(DX(I)).LE.EPS) DX(I)=0.                                   WB40  38
      IF (ABS(DY(I)).LE.EPS) DY(I)=0.                                   WB40  39
      IF (ABS(DZ(I)).LE.EPS) DZ(I)=0.                                   WB40  40
      RPM2(I)=0.                                                        WB40  41
      DX2=DX(I)*DX(I)                                                   WB40  42
      DY2=DY(I)*DY(I)                                                   WB40  43
      DZ2=DZ(I)*DZ(I)                                                   WB40  44
      DR2=DY2+DZ2                                                       WB40  45
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```
      D2=DX2+BT2*DR2                                                    WB40  46
      D(I)=0.                                                           WB40  47
      IF (AMACH.GE.1.) DXZ=DX(I)-BTA*ABS(DZ(I))                         WB40  48
      IF (AMACH.GE.1..AND.DXZ.LT.0.) GO TO 170                          WB40  49
      IF (D2.GT.0.) D(I)=SQRT(D2)                                       WB40  50
      XPM(I)=DX(I)+BT2*(SM(I)*DY(I)+SA*DZ(I))                           WB40  51
      YMX(I)=DY(I)-SM(I)*DX(I)                                          WB40  52
      ZAX(I)=DZ(I)-SA*DX(I)                                             WB40  53
      AYM(I)=SA*DY(I)-SM(I)*DZ(I)                                       WB40  54
      IF (ABS(XPM(I)).LE.EPS) XPM(I)=0.                                 WB40  55
      IF (ABS(YMX(I)).LE.EPS) YMX(I)=0.                                 WB40  56
      IF (ABS(ZAX(I)).LE.EPS) ZAX(I)=0.                                 WB40  57
      IF (ABS(AYM(I)).LE.EPS) AYM(I)=0.                                 WB40  58
      IF (I.LE.2) RPM2(1)=YMX(1)**2+ZAX(1)**2+BT2*AYM(1)**2             WB40  59
      RPM2(2)=RPM2(1)                                                   WB40  60
      IF (I.GT.2) RPM2(3)=YMX(3)**2+ZAX(3)**2+BT2*AYM(3)**2             WB40  61
      RPM2(4)=RPM2(3)                                                   WB40  62
      IF (ABS(RPM2(I)).LE.EP2) RPM2(I)=0.                               WB40  63
      RPM=SQRT(ABS(RPM2(I)))                                            WB40  64
      IF (RPM.LE.EPS) RPM=0.                                            WB40  65
      DPM=SAM*D(I)                                                      WB40  66
      F(I)=0.                                                           WB40  67
      DNOM=-DX(I)*YMX(I)-BT2*DZ(I)*AYM(I)                               WB40  68
      FNUM=D(I)*ZAX(I)                                                  WB40  69
      IF (FNUM.EQ.0..AND.DNOM.EQ.0.) GO TO 10                           WB40  70
      IF (D(I).EQ.0..OR.ZAX(I).EQ.0.) FNUM=0.                           WB40  71
      F(I)=ATAN2(FNUM,DNOM)                                             WB40  72
      IF (D(I).EQ.0.) F(I)=F(I)*SIGN(1.,ZAX(I))                         WB40  73
10    IF (TAM) 100,90,20                                                WB40  74
20    IF (AMACH.GT.1..AND.D(I).EQ.0.) GO TO 70                          WB40  75
      IF (RPM.LE.EPS) GO TO 40                                          WB40  76
      NUM=XPM(I)+DPM                                                    WB40  77
      G(I)=ALOG(NUM/(BTA*RPM))*SAMD                                     WB40  78
      GO TO 160                                                         WB40  79
40    SX(I)=SIGN(1.,XPM(I))                                             WB40  80
      IF (AMACH.LT.1.) GO TO 50                                         WB40  81
      IF (I.EQ.1.AND.XPM(1).LT.CPM) GO TO 130                           WB40  82
      IF (I.EQ.3.AND.XPM(3).LT.CPM) GO TO 140                           WB40  83
50    IF (I.EQ.2) SGN12=SX(1)*SX(2)                                     WB40  84
      IF (I.EQ.4) SGN34=SX(3)*SX(4)                                     WB40  85
      IF (XPM(I)) 60,70,80                                              WB40  86
60    IF (I.EQ.2.AND.SGN12.LT.0.) GO TO 150                             WB40  87
      IF (I.EQ.4.AND.SGN34.LT.0.) GO TO 140                             WB40  88
      G(I)=-ALOG(ABS(XPM(I)))*SAMD                                      WB40  89
      GO TO 160                                                         WB40  90
70    G(I)=0.                                                           WB40  91
      GO TO 160                                                         WB40  92
80    G(I)=ALOG(XPM(I))*SAMD                                            WB40  93
      GO TO 160                                                         WB40  94
90    G(I)=0.                                                           WB40  95
      IF (XPM(I).GT.BTA*RPM) G(I)=D(I)/XPM(I)                           WB40  96
      GO TO 160                                                         WB40  97
100   G(I)=0.                                                           WB40  98
      ARG=SIGN(1.,XPM(I))                                               WB40  99
      IF (RPM.NE.0.) ARG=XPM(I)/(BTA*RPM)                               WB40 100
      IF (ARG.GE.1.) GO TO 160                                          WB40 101
      IF (ARG.LE.-1.) GO TO 110                                         WB40 102
      IF (D(I).GT.0.) G(I)=ACOS(ARG)*SAMD                               WB40 103
      GO TO 160                                                         WB40 104
110   AM2=SA*SA+SM(I)*SM(I)                                             WB40 105
      TRM1=(SM(I)*DY(I)+SA*DZ(I)+ABS(AYM(I))*SAM)/AM2                   WB40 106
      IF (DX(I).GT.TRM1) GO TO 120                                      WB40 107
      F(I)=0.                                                           WB40 108
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```
      IF (SSM.GT.0.) F(I)=PI*SIGN(1.,ZAX(I))                          WB40 109
      GO TO 160                                                       WB40 110
  120 IF (SSM*YMX(I).GE.0.) GO TO 160                                 WB40 111
      G(I)=PI*SAMD                                                    WB40 112
      GO TO 160                                                       WB40 113
  130 G(1)=500.*SAMD                                                  WB40 114
      IF (AMACH.LT.1.) G(2)=-G(1)                                     WB40 115
      GO TO 160                                                       WB40 116
  140 G(3)=500.*SAMD                                                  WB40 117
      IF (AMACH.LT.1.) G(4)=-G(3)                                     WB40 118
  160 H(I)=0.                                                         WB40 119
      HARG=-BTA*DY(I)                                                 WB40 120
      IF (D(I).EQ.0..AND.HARG.EQ.0.) GO TO 180                        WB40 121
      IF (AMACH.LT.1.) H(I)=BTA*.5*ALOG((D(I)+HARG)/(D(I)-HARG))      WB40 122
      IF (AMACH.GT.1.) H(I)=BTA*ATAN2(D(I),HARG)                      WB40 123
      GO TO 180                                                       WB40 124
  170 F(I)=0.                                                         WB40 125
      G(I)=0.                                                         WB40 126
      H(I)=0.                                                         WB40 127
      AYM(I)=0.                                                       WB40 128
      YMX(I)=0.                                                       WB40 129
      ZAX(I)=0.                                                       WB40 130
      XPM(I)=0.                                                       WB40 131
      DPM=0.                                                          WB40 132
      RPM=0.                                                          WB40 133
      RPM2(2)=RPM2(1)                                                 WB40 134
      RPM2(4)=RPM2(3)                                                 WB40 135
  180 E(I)=H(I)+BT2*SM(I)*G(I)                                        WB40 136
  190 CONTINUE                                                        WB40 137
      TAD=1./TA                                                       WB40 138
      E14=(E(1)-E(2)-E(3)+E(4))*TAD                                   WB40 139
      F14=(F(1)-F(2)-F(3)+F(4))*TAD                                   WB40 140
      G14=G(1)-G(2)-G(3)+G(4)                                         WB40 141
      R4PI=1./(4.*PI)                                                 WB40 142
      IF (AMACH.GT.1.) R4PI=2.*R4PI                                   WB40 143
      UPM=R4PI*(E14/BT2-SA*F14)                                       WB40 144
      VPM=-R4PI*G14                                                   WB40 145
      WPM=R4PI*(F14+SA*E14)                                           WB40 146
      RETURN                                                          WB40 147
  200 WRITE (6,210)                                                   WB40 148
      STOP                                                            WB40 149
  210 FORMAT (1H0,43HERROR - BODY PANEL SLOPE EXCEEDS MACH ANGLE)     WB40 150
      END                                                             WB40 151
```

```
      SUBROUTINE VELCMP                                               WB41   1
CDC   OVERLAY (LWB,2,0)                                               WB41   2
CDC   PROGRAM VELCMP                                                  WB41   3
C                                                                     WB41   4
C  COMPUTE THE VELOCITY COMPONENTS (U,V,W) AT THE PANEL CONTROL       WB41   5
C  POINTS AND FORM THE AERODYNAMIC INFLUENCE COEFFICIENT MATRICES     WB41   6
C                                                                     WB41   7
C  TAPE USAGE IN VELCMP-                                              WB41   8
C    TAPE5:  READ XMACH,ALPHA,PHIR                                    WB41   9
C                                                                     WB41  10
C    TAPE7:  VELCMP,  REWIND                                          WB41  11
C                     READ ARRAY    - CALCULATE BODY INDUCED VELOCITIES WB41  12
C                     WRITE D       - DIAGONAL BLOCKS, N GT NMAX      WB41  13
C                     REWIND                                          WB41  14
```

```
C     TAPE8:  VELCMP,  REWIND
C             BODVEL,  WRITE  UB,VB,WB - COMPONENT VELOCITY MATRICES
C             VELCMP,  REWIND
C
C     TAPE9:  VELCMP,  REWIND
C             BODVEL,  WRITE  AN     - NORMAL VELOCITY MATRIX
C             VELCMP.  REWIND
C
C     TAPE10: VELCMP,  REWIND
C             BODVEL,  WRITE  DN     - DIAGONAL BLOCKS, N GT NMAX
C             VELCMP,  REWIND
C                      READ  D       - COPY TO TAPE7
C                      REWIND
C
C     TAPE11:  NOT USED BY BODY VERSION
C
      COMMON /JOPTNS/ IZ1(65),NWCPT,IPLOT(4),IPRT(5),IXZSYM
      COMMON /PARAM / NBODY,NWING,NTAIL,LBC,THK,XMACH,ALPHA,BETA,ALPHAC
     1    ,PHIR,REFA,REFB,REFC,REFD,REFL,REFX,REFZ
      COMMON /VELCOM/ NPOINT,NPART,IMAX,JMAX,NMAX,EM,IPRINT,NWTHK
     1    ,NWBLOK,NWROW(20),NBBLOK,NBROW(30)
      COMMON /NEWCOM/K1,KWAF,KWAFOR,KRADX(4),KFORX(4),KFUS,MAX,K4,K5
     1    ,KF(6),KAN(6),KFINOR(6),KANOR(6),KOL,NCPT,LOCPT(20),XCPT(20)
      COMMON          BLOCK(7500)
      COMMON /POINT / ARRAY(6000)
      COMMON /SEG   / NSEG,NROW(20),NCOL(20),COSS(20),SINS(20)
     1    ,BTE(20),NWT(20),SPNW(20),XLEW(20),BLE(20),ZLEW(20),ZB(60)
      COMMON /MATCOM/ MATIN
C
      DIMENSION XLE(600),XPT(600),DEL(600),COSTH(600),XBT(600),YBT(600),
     1 ZBT(600),YPT(600),ZPT(600),CHORD(600),DZTDX(600),IT(600),
     2 D(60,60),DELTA(600),DELTI(600)
C
      EQUIVALENCE                         (DEL(1),BLOCK(1))
     1    ,(COSTH(1),BLOCK(601)),         (XBT(1);BLOCK(3901))
     2    ,(YBT(1),BLOCK(4501)),          (ZBT(1),BLOCK(5101))
     3    ,(IT(1),BLOCK(5701)),           (CHORD(1),BLOCK(6301))
     4    ,(DZTDX(1),BLOCK(6901))
     5    ,(XPT(1),ARRAY(1)),             (YPT(1),ARRAY(601))
     6    ,(ZPT(1),ARRAY(1201)),          (D(1),ARRAY(1801))
     7    ,(DELTA(1),ARRAY(2401)),        (DELTI(1),ARRAY(4801))
     7    ,(XLE(1),ARRAY(5401))
      LOGICAL LBC,SUB
C
      MATIN=0
      NMAX=60
CB    EPS=1.E-3
      CALL CPUTIM(TIMEO,DT,1)
C
C  READ IN MACH NUMBER AND ANGLE OF ATTACK
C
      READ (5,290) XMACH,ALPHA,PHIR
      ALPHAC=ALPHA
      IF (XMACH.LT.0..OR.XMACH.EQ.EM) RETURN
      IF (IABS(IPRINT).GT.1) WRITE(6,300)
      SUB=XMACH.LT.1.
      BETAM=SQRT(ABS(XMACH*XMACH-1.))
CB    BETAD=1./BETAM
      NBBLOK=0
      NWBLOK=0
      REWIND 8
      REWIND 9
      REWIND 10
```

```
      NPOINT=NCPT
      NPANEL=NBODY+NWING
      IF (NPANEL.EQ.0) RETURN
      REWIND 7
      NCPT=NWING
CB    IF (NWING.EQ.0) GO TO 70
C
C  COMPUTE SIZES OF WING DIAGONAL BLOCKS, THEN
C  COMPUTE CHORDWISE CONTROL POINT LOCATIONS ON WING
C  (PLANAR BOUNDARY CONDITION OPTION ONLY)
C
C  ------------------ INSERT WING BLOCK CODE HERE ---------------------
C
70    EM=XMACH
      NPART=1
      WRITE (6,310) NPART
      WRITE (6,250) NWING,NBODY,NCPT,NSEG
      IF (NSEG.EQ.0) GO TO 75
      WRITE (6,260) NSEG,(NROW(N),N=1,NSEG)
      WRITE (6,270) NSEG,(NCOL(N),N=1,NSEG)
75    CONTINUE
CB    IF (NWING.NE.0) READ (7) ARRAY,CHORD,DZTDX
      IF (NBODY.EQ.0) GO TO 100
      READ (7) ARRAY
      DO 80 N=1,NBODY
      XBT(N)=XPT(N)
      YBT(N)=YPT(N)
      ZBT(N)=ZPT(N)
80    CONTINUE
      NPOINT=NBODY
90    IF (NPART.EQ.1) WRITE (6,320)
C
C  COMPUTE VELOCITY COMPONENTS INDUCED BY BODY PANELS
C
      CALL BODVEL
      CALL CPUTIM(TIME,DT,1)
      WRITE(6,360) TIME,DT,NPART
100   CONTINUE
160   REWIND 8
      REWIND 9
      REWIND 10
      MATIN=1
C
C  WRITE DIAGONAL BLOCKS OF AERODYNAMIC MATRIX ON TAPE 7
C
      IF (NBODY.EQ.0) GO TO 190
      NBBLOK=1
      NBROW(1)=NBODY
      IF (NBODY.LE.NMAX) GO TO 190
      NBBLOK=0
      DO 180 KFU=1,KFUS
      NR=KRADX(KFU)-1
      NC=KFORX(KFU)-1
      DO 180 NN=1,NC
      NBBLOK=NBBLOK+1
      NBROW(NBBLOK)=NR
      DO 170 M=1,NR
      READ (10) (D(M,N),N=1,NR)
170   CONTINUE
      WRITE (7) D
180   CONTINUE
190   CONTINUE
CB    IF (NWING.LE.NMAX.OR.NWING.EQ.0) GO TO 220
```

```
C8    TRANSFER WING DIAGONAL BLOCKS
220   NWBLOK=1
      NWROW(1)=NWING
230   REWIND 7
      REWIND 10
      WRITE (6,280) NBBLOK,NWBLOK
      CALL CPUTIM(TIME,DT,1)
      DT=TIME-TIME0
      WRITE(6,370) TIME,DT
      RETURN
250   FORMAT (7H NWING=,I6,2X,6HNBODY=,I6,2X,5HNCPT=,I6,2X,5HNSEG=,I6)
260   FORMAT (13H NROW(N),N=1,,I4/(1X,20I6))
270   FORMAT (13H NCOL(N),N=1,,I4/(1X,20I6))
280   FORMAT (10X,7HNBBLOK=,I6,2X,7HNWBLOK=,I6)
290   FORMAT (10F7.0)
300   FORMAT(1H1,10X,38HAERODYNAMIC VELCITY MATRIX COMPUTATION,
     *   63X,12H** VELCMP **)
310   FORMAT (/// 12H PARTITION =,I3)
320   FORMAT (26H INFLUENCE OF BODY ON BODY)
360   FORMAT(/10X,18HEND BODVEL,  TIME=,F10.4,5X,3HDT=,F10.4
     *   ,5X,6HNPART=,I3)
370   FORMAT(/10X,18HEND VELCMP,  TIME=,F10.4,5X,3HDT=,F10.4)
      END
```

```
      SUBROUTINE VVELB(NV,YY,ZZ,VX,VY,G,AB,BB,V,W,VRTMAX)
C
C     THIS SUBROUTINE COMPUTES PERTURBATION VELOCITY COMPONENTS DUE TO
C     NV EXTERNAL VORTICES AND THEIR IMAGES INSIDE A BODY WITH
C     ELLIPTICAL CROSS SECTION
C
C
      DIMENSION VX(1),VY(1),G(1)
C
      COMMON/COM1/A2,B2,R2
      COMMON/COM2/SIG2,H2
C
      COMPLEX T0,V1,DSDT,Z,DSDZ,SI,SIB,S0,TAU,CT,VEL
C
      EXTERNAL Z,DSDZ
      PI=3.14159265
      TLC=0.001
      CT=CMPLX(0.0,1.0)
      A2=AB*AB
      B2=BB*BB
      APB=AB+BB
      APB2=APB*APB
      R=0.5*APB
      H2=APB2
      R2=R*R
      SIG2=R2
      T0=CMPLX(YY,ZZ)
      S0=Z(T0)
      V1=CMPLX(0.0,0.0)
      DSDT=DSDZ(S0)
C
C   LOOP OVER THE NUMBER OF VORTICES,NV
C
```

```
      DO 1 I=1,NV                                                       WB42  34
      TAU=CMPLX(VX(I),VY(I))                                            WB42  35
      SI=Z(TAU)                                                         WB42  36
      SIB=CONJG(SI)                                                     WB42  37
      D=CABS(SI-S0)                                                     WB42  38
      IF(D.LE.TLC) GO TO 2                                              WB42  39
      V1=V1-G(I)/(S0-SI)                                                WB42  40
    2 CONTINUE                                                          WB42  41
      D=CABS(S0-R2/SIB)                                                 WB42  42
      IF(D.LE.TLC) GO TO 1                                              WB42  43
      V1=V1+G(I)/(S0-R2/SIB)                                            WB42  44
    1 CONTINUE                                                          WB42  45
C                                                                       WB42  46
      VEL=0.5*CI*V1*DSDT/PI                                             WB42  47
      V=REAL(VEL)                                                       WB42  48
      W=-AIMAG(VEL)                                                     WB42  49
      AV=ABS(V)                                                         WB42  50
      AW=ABS(W)                                                         WB42  51
      IF(V.GT.0.0.AND.AV.GE.VRTMAX) V=VRTMAX                            WB42  52
      IF(V.LT.0.0.AND.AV.GE.VRTMAX)V=-VRTMAX                            WB42  53
      IF(W.GT.0.0.AND.AW.GE.VRTMAX) W=VRTMAX                            WB42  54
      IF(W.LT.0.0.AND.AW.GE.VRTMAX)W=-VRTMAX                            WB42  55
      RETURN                                                            WB42  56
      END                                                               WB42  57
```

```
      COMPLEX FUNCTION Z(CT)                                            WB43   1
C                                                                       WB43   2
C     THIS FUNCTION SUBROUTINE CALCULATES THE SIGMA VALUE IN THE        WB43   3
C     TRANSFORMED (CIRCLE) PLANE FOR GIVEN TAU IN THE PHYSICAL PLANE    WB43   4
C     FOR AN ELLIPTICAL BODY WITH WINGS                                 WB43   5
C                                                                       WB43   6
      COMMON/COM2/SIG2,H2                                               WB43   7
      COMMON/COM3/ZR,ZI                                                 WB43   8
      COMMON/COM4/G2,G1                                                 WB43   9
      COMMON/COM6/W2,W                                                  WB43  10
C                                                                       WB43  11
C                                                                       WB43  12
      COMPLEX W,G1,G2,CT,W2,DBLU                                        WB43  13
C                                                                       WB43  14
      EXTERNAL DBLU                                                     WB43  15
C                                                                       WB43  16
      W=DBLU(CT)                                                        WB43  17
      G1=W+SIG2/W                                                       WB43  18
      G2=G1*G1-H2                                                       WB43  19
      Y=AIMAG(G2)                                                       WB43  20
      AY=1.0                                                            WB43  21
      IF(Y.LT.0.0) AY=-1.0                                              WB43  22
      YZ=AIMAG(G1)                                                      WB43  23
      AYZ=1.0                                                           WB43  24
      IF(YZ.LT.0.0)AYZ=-1.0                                             WB43  25
      G2=CSQRT(G2)*AY*AYZ                                               WB43  26
      IF((ABS(YZ).LE.0.0).AND.(REAL(G1).LT.0.0)) G2=CMPLX(-REAL(G2),    WB43  27
     1       AIMAG(G2))                                                 WB43  28
      Z=0.5*(G1+G2)                                                     WB43  29
      IF((ABS(ZI).NE.0.0).AND.(ABS(ZR).NE.0.0)) Z=CMPLX(ZR*ABS(REAL(Z)),WB43  30
     1ZI*ABS(AIMAG(Z)))                                                 WB43  31
      RETURN                                                            WB43  32
      END                                                               WB43  33
```

# APPENDIX L

## DESCRIPTION OF PROGRAM VPATH2 AND VPATHL

This appendix is concerned with the description of the vortex chasing programs. They are used to accompany programs DEMON2 and WDYBDY in accordance with the procedures described in section 5 of this report.

Program VPATH2 computes the paths of external vortices along a body with circular cross section with or without cruciform fins attached to it. The configuration can be pitched and rolled. The cruciform fins may have arbitrary deflection angles. Program VPATHL determines the paths of external vortices along a body with elliptical cross section with or without a monoplane wing in the midwing position.

In what follows, the basic theoretical method is described. The geometrical characteristics accounted for in the programs are listed. This is followed by a description of the flow of the programs and program operation. Program limitations and precautions are discussed and the input and output described. Finally program listings are given for programs VPATH2 and VPATHL.

### Program Description

The vortex chasing scheme implemented in programs VPATH2 and VPATHL makes use of crossflow plane solutions obtained from slender-body theory. Because of the linear nature of the problem it is possible to superimpose different solutions.

Fundamentally, at given axial stations, velocity components are computed in the crossflow plane at the points occupied by a finite set of external vortices in the presence of a wing-body combination. In this calculation, mutual interaction between the vortices, the interaction between the vortices and the wing-body, the effects of included angle of attack and roll, and fin deflection (if applicable) must be included. Once the lateral velocity components are known, the vortex locations at the next axial station downstream can be determined by means of an integration scheme. The vortices move from one axial station to the next in accordance with the flow angle calculated from the lateral velocity components.

# APPENDIX L

Appendix I contains the crossflow plane solutions for 8 different conditions and/or cross sectional shapes. In both programs, the calculation is started at given axial locations (starting station) with a set of vortices with specified strengths and lateral coordinates. The geometry in the crossflow plane is specified a priori and the programs proceed to integrate in the downstream direction to obtain the vortex paths.

Once the vortex paths are calculated over the length of body or body-wing of interest, the programs can calculate velocity components induced by the set of vortices at specified points. In this process, the vortices are taken to be in the presence of the body only, i.e., the lifting surfaces are not accounted for. This approach serves two purposes. First, for wing-body combinations, the effects of the external vortices with known paths induced in the flow tangency condition can be applied at the control points of the constant u-velocity panels laid out over the wings or fins in program DEMON2, Appendix J. Second, the velocity components induced by the external vortices in the presence of the body only are included in the calculation of pressures on the fins and the body surface. Further discussions are given in sections 3.4 and 4.3 of this report.

## Geometrical Characteristics

This section describes the geometrical characteristics which can be accounted for by the programs. Since the two programs were written for different cross sections, the geometric details of the configurations will be listed separately for each program.

### Program VPATH2

| | |
|---|---|
| Body: | axisymmetric, constant cross-sectional area |
| Lifting surfaces: | cruciform fins, each fin planar, may have breaks in sweep, each fin can be arbitrarily deflected |

### Program VPATHL

| | |
|---|---|
| Body: | elliptic in cross section, ellipticity constant, may change size of cross section |
| Lifting surfaces: | monoplane wing in midwing position, may have breaks in sweep |

## Calculation Procedure

In this section, the sequence of the calculative processes is indicated. The description will be given for both programs simultaneously. Important differences between programs VPATH2 and VPATHL will be pointed out, however.

After reading in the run title, body geometry and wing or fin geometry, the programs proceed to define the side edge of the wing or fin. Flow conditions, the permissible error used in the integration scheme and maximum magnitude of the vortex induced velocity components are then input to both programs. In addition, program VPATH2 reads in the fin deflection angles.

Both programs proceed to read the lateral coordinates of the vortices at the axial station at which they start. The geometrical characteristics of the configuration at hand and flow conditions are written out. Leading- and side-edge vorticity characteristics, if applicable, are then input to both programs. Their influence will be included in the computation of the vortex paths. Program VPATH2 expects this information for 4 fins, program VPATHL expects information for both sides of the monoplane wing.

At the axial station where the vortex path integration is started, program VPATH2 calculates the body radius, the distance from the body centerline to the edge of the lifting surfaces as seen in this crossflow plane. For this and all subsequent axial stations, subroutine SHAPE of program VPATH2 performs this task. For bodies with elliptical cross section (and with constant ellipticity), subroutine SHAPE of program VPATHL computes the horizontal and vertical semiaxes in addition to the distance out to the edge of the monoplane wing as seen in the crossflow plane.

After printing the vortex strengths and the initial vortex coordinates, both programs call on subroutine DASCRU to compute the flow angles at the vortex locations and to determine the vortex locations at the next downstream axial station. To accomplish the former, subroutine DASCRU calls subroutine F. The latter contains calls to subroutines implemented with the various crossflow plane solutions described in Appendix I. The two programs are equipped with different versions of subroutine F on account of the different configurations and/or conditions handled.

Consider program VPATH2 first. It treats a cruciform fin-body combination or body alone. Subroutine F in this program first calculates the lateral velocity components at the vortex points due to angle of attack and roll by calling subroutine PITROL. The crossflow plane solution programmed in PITROL is given in Appendix I, section 2. The source term is omitted in that it leads to unbounded potential at infinity. If two opposite fins are symmetrically deflected, subroutine SYMFIN is called from subroutine F to compute an additional contribution to the velocity components at the vortex points. The crossflow plane solution is given in Appendix I, section 3. If only one fin is deflected or if all fins are arbitrarily deflected, subroutine CRUCI is called by subroutine F to calculate the contribution to the velocity components at the vortex points due to this condition. Then, if edge vorticity associated with the lifting surfaces is specified, its contribution to the velocity components at the vortex points is also computed. Subroutine VVELS is used to accomplish this task. The solution implemented in this subroutine is a specialized adaptation of the solution given in Appendix I, section 1. Finally, subroutine F calls subroutine VOTEX to compute the contributions to the velocity components at each vortex point due to the effect of all vortices in the presence of the cruciform fin-body combination. The solution for this sub problem is given in Appendix I, section 1.

The version of subroutine F in program VPATHL treats elliptical cross sections with or without a monoplane wing. The effects of included angle of attack and roll are calculated by a different version of PITROL. The crossflow plane solution is given in Appendix I, section 6. Provision exists to account for a growing body by the use of subroutine EXPAND. The associated solution is given in Appendix I, section 8. Contributions from specified vorticity associated with the monoplane wing edges are calculated with another version of subroutine VVELS. It employs an adaptation of the solution given in Appendix I, section 5. Finally, the contributory effects due to all vortices, in the presence of the monoplane wing-body, at each vortex location is computed by a call to a different version of subroutine VOTEX. The crossflow plane solution implemented in it is described in Appendix I, section 5. The solutions given in sections 5 and 7 in Appendix I only differ by angles of pitch and sideslip effects.

With the lateral velocities determined by subroutine F at each vortex location and passed back to subroutine DASCRU, the vortices are moved to the next axial station in accordance with the flow angle calculated from the velocity components. The velocity calculation process is repeated and the vortices moved to the next axial station in the downstream direction. This process is repeated until the last axial station, specified in the input, is reached.

Both programs can proceed with the calculation of velocity components in the crossflow plane induced by the vortices at specified points. As mentioned earlier in this appendix, for the purpose of inclusion in the wing boundary condition implemented in program DEMON2, the vortices are considered to be in the presence of the body only.

Program Operation

Programs VPATH2 and VPATHL are written in the FORTRAN IV language (029 punch) and has been run on the CDC 6600 machine belonging to Boeing Computer Services, Inc.. Core requirement is about 60K octal words.

In addition to the standard input (TAPE5) and output (TAPE6) tapes, the program may require additional devices such as disc files or tapes for reading or storing data sets generated when certain options are used. TAPE4 and TAPE7 are used for this purpose. One data set would consist of a set of control-point coordinates and the other would contain a set of perturbation velocities. It should also be noted that these programs contain complex variables.

Running time required by both programs is a function of the length over which the vortex paths are to be calculated and the permissible error E5 specified in the input. As an example, with E5 equal to 0.0001, running time should not exceed 5 seconds for a pitched and rolled configuration with about 8 external vortices including the computation of vortex induced velocity components at 268 field points.

As an aid in debugging and quick visual inspection, both programs are equipped with a simplified plotting capability. They should only be used with few vortices and over a short running length.

APPENDIX L

## Program Limitations and Precautions

There are certain limitations associated with the dimension statements programmed in the vortex tracking programs VPATH2 and VPATHL. The number of vortices to be tracked should not exceed 30. One fin of a cruciform fin configuration or one half of a monoplane wing must be described by a maximum of 7 points in planform. This poses a limitation on the number of allowable breaks in sweep. Some care must be exercised in the choice of the permissible error, E5. If its value is orders of magnitude smaller than $10^{-4}$, computation time may become unduly long. The number of stations at which the vortex coordinates are printed in the output cannot exceed 50.

Subroutine DASCRU adjusts the integration interval in accordance with the permissible error E5. If for some reason it cannot satisfy the built in criteria for deciding whether or not given stepsize is accurate enough, DASCRU will stop reducing the stepsize after 32 attempts. The program will then stop and register STOP40. A faulty crossflow plane flow field can cause this problem. At times, the problem can be alleviated by reducing the difference between the first and second stations XIP (see input section).

At the present time, program VPATHL is limited to elliptical cross sections with constant ellipticity. Program VPATH2 cannot handle expanding or contracting axisymmetric cross sections.

Both programs may suffer from slight numerical errors when the running length is very long. It is suspected to be caused by errors introduced by the integration scheme in subroutine DASCRU. This behavior can be observed when chasing a set of vortices, initially symmetrically located relative to the free stream vector in the cross flow plane, along an axisymmetric body of considerable length (15 radii long).

A further limitation occurs when a vortex comes very close to the leading edge of a lifting surface. The computer program will tend to move the vortex away from the lifting surface, or it may move along the contour in an unrealistic fashion. This constitutes a limit to the theory used in the programs. In reality, a vortex is made up of a cloud of small vortices with cores in which the lateral velocity components go to zero towards the center. In any event, such a vortex cloud passes right over (and under) the lifting surface in question. It is recommended in such a case to forego the vortex chasing calculation and to assume that the vortex moves back parallel to the body centerline.

## Description of Input

This section contains a description of the input for programs VPATH2 and VPATHL. There are some differences in the input on account of the differences in the configurations treated by each program. The input for program VPATH2 will be described first. Then, the description of the input for program VPATHL follows with references made to items of the input for program VPATH2. Listings of all input variables are given at the end of the respective input descriptions.

### Input for program VPATH2

#### Item 1

The first card serves as identification and may contain any alphanumeric information desired. This information is printed on the first page of the output.

#### Item 2

The second card contains indices concerning the body and lifting-surface geometry, control indices governing the number of axial stations at which information is to be printed, reading in control-point coordinates, writing velocity components, amount of output, and the option to print plots in the program generated output.

#### Item 3

This card contains the endpoints for each body section for which coefficients describing a meridian will be given (Item 4). Usually, only one endpoint is required; that is, one body section will be considered.

#### Item 4

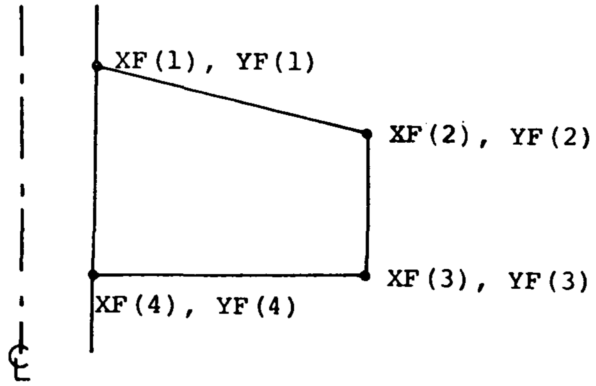
For each body section, a set of coefficients (7 maximum) are specified on this card. They are members of the polynomial shown below and programmed in subroutine SHAPE.

$$\frac{r}{\ell} = C_1 + C_7\sqrt{C_2\left(\frac{x}{\ell}\right)^2 + C_3\left(\frac{x}{\ell}\right) + C_4} + C_5\left(\frac{x}{\ell}\right) + C_6\left(\frac{x}{\ell}\right)^2 \qquad \text{(L1)}$$

where $C_1$ through $C_7$ are the coefficients, r is the local body radius, and $\ell$ is the body length. The body length $\ell$ equals the difference of the endpoints specified in item 3.

Item 5

The coordinates of the fin planform outline corner points are read in if a fin or wing is present. Only one fin or one wing half needs to be described. The XF and YF coordinates are shown in the example shown below; XF is measured from the body nose and YF is measured from the body centerline. Note: the axial coordinate of the trailing edge of the rootchord must be made to be slightly larger than the axial coordinate of the trailing edge of the side edge.



Item 6

Flow conditions and fin deflection angles, if applicable, are specified on this card. In addition, the permissible error, E5, used as a criterion in the integration scheme programmed in subroutine DASCRU is read in. Note: E5 must not be taken too small or the running time required may become unduly large. This card also reads in the upper bound, VRTMAX, imposed on the magnitude of the vortex induced velocity components.

Item 7

The number of vortices at the axial stations to be specified in item 9 are read in by this card. This arrangement allows for the introduction of additional vortices. This information must be supplied for increasing axial location ($x_B$-station).

Item 8

The starting coordinates, in the crossflow plane with $y_B$ to the right and $z_B$ upwards (i.e. the body coordinate system shown in figure 1), and strengths of the vortices are read in by these cards. If additional vortices are to be accounted for, the starting coordinates and strengths are read in at this time also. This information must be supplied for increasing axial location in synchronization with the number of vortices of item 7 and the axial station of item 9. Note that coordinates VX($=y_B$) and VY($=z_B$) are dimensional.

Item 9

These cards contain the axial stations at which the program will print vortex coordinates. Also, these stations are chosen such that they coincide with the introduction of additional vortices, if applicable, see items 7 and 8.

Item 10

This and the next three items read in specifications describing leading- and side-edge vorticity characteristics. They are obtained from the results calculated by program DEMON2 described in Appendix J of this report. This card contains the number of stations in the spanwise direction at which leading-edge vorticity locations and strengths are to be specified. This information must be supplied for all 4 fins of a cruciform configuration.

Item 11

If the information of item 10 is read in as nonzero, the locations along the leading edge and the strength of the leading-edge vorticity are read in. Note that the dimensional quantity XLE is measured in the wing coordinate system, as calculated by program DEMON2, not the body coordinate system. This information must be supplied for all fins.

Item 14

This optional input is specified when NCPIN of item 2 is read in as zero. The number NCP is the number of field points at which vortex induced velocity components are to be computed on the basis of the vortices being in the presence of the body only.

Item 15

If the information of item 14 is nonzero, these cards contain the coordinates, in the body coordinate system, if the fieldpoints at which vortex induced effects are to be computed. Note: in connection with the use of programs VPATH2 and VPATHL together with program DEMON2, index NCPIN is set equal to 1 and the information of items 14 and 15 is read in by means of a data set stored on TAPE4.

## INPUT VARIABLES FOR PROGRAM VPATH2
## (Circular Cross Section Bodies With Cruciform Fins)

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS | |
|---|---|---|---|
| Item 1 | (20A4) | Any alphanumeric information to identify the run. | |
| Item 2 | (8I10) | | |
| NS | | Number of body sections for which coefficients C(I,J) are required, 1 ≤ NS ≤ 7. | |
| NF | | Number of corner points used to define fin geometry, 1 ≤ NF ≤ 7. | |
| NIP | | Number of axial stations to be printed in output, 1 ≤ NIP ≤ 50. | |
| NCPIN | | NCPIN = 1 | Read in control point and body pressure points from data set (TAPE4). |
| | | NCPIN = 0 | No input. |
| NVLOUT | | NVLOUT = 1 | Write velocities induced by moving vortices (and calculated in this program) on data set (TAPE7). |
| | | NVLOUT = 0 | No input. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| NOUT | | NOUT = 1 Print additional output.<br>NOUT = 0 Minimum output. |
| IPLT | | IPLT = 0 No plots showing vortex positions in the output.<br>IPLT = 1 Vortex positions shown in crossflow planes. |
| Item 3 | (7F10.5) | |
| XE(I) | $x_{B,i}$ | Axial coordinate of the end of each body section, $1 \leq I \leq NS$. |
| Item 4 | (7F10.5) | |
| C(I,J) | $C_{ij}$ | Coefficients in the body meridian equation, $1 \leq I \leq NS$, $1 \leq J \leq 7$. |
| Item 5 | (8F10.5) | Optional input concerning fin planform geometry when $NF \neq 0$. |
| XF(I) | $x_{B,i}$ | Axial coordinate of fin corner point, $1 \leq I \leq NF$. |
| YF(I) | $y_{B,i}$ | Lateral coordinate of fin corner point, $1 \leq I \leq NF$. |
| Item 6 | (8F10.5) | |
| ALFAC | $\alpha_c$ | Included angle of attack, measured between free-stream velocity vector and body centerline. |
| PHI | $\phi$ | Angle of roll, positive right fin down. |
| D1 | $\delta_1$ | Deflection angle of upper vertical fin, positive: trailing edges to right, degrees. |
| D2 | $\delta_2$ | Deflection angle of right horizontal fin, positive: trailing edge down, degrees. |
| D3 | $\delta_3$ | Deflection angle of lower vertical fin, positive: trailing edge to right, degrees. |
| D4 | $\delta_4$ | Deflection angle of left horizontal fin, positive: trailing edge down, degrees. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| E5 | | Error allowed in integration subroutine DASCRU. Use the value 0.0001 or less. |
| VRTMAX | | Maximum magnitude of vortex induced velocities, use the value 0.35. |
| Item 7 | (16I5) | |
| NVV(I) | | Total number of vortices at each axial station, $1 \le I \le NIP$, NVMAX = NVV(NIP). |
| Item 8 | (6F10.5) | Starting coordinates of the vortices. |
| VX(I) | $y_B$ | $y_B$-coordinate of vortex I. |
| VY(I) | $z_B$ | $z_B$-coordinate of vortex I. |
| G(I) | $\frac{\Gamma_V}{V_\infty}$ | Vortex strength, counterclockwise positive (when viewing forward), $1 \le I \le NVMAX$, NVMAX = NVV(NIP). |
| Item 9 | (8F10.5) | |
| XIP(I) | $x_{B,i}$ | Axial station at which output is required, $1 \le I \le NIP$. |
| Item 10 | (8I10) | |
| MSWR | | Number of leading-edge vortex information stations for right horizontal fin. |
| MSWL | | Number of leading-edge vortex information stations for the left horizontal fin. |
| MSWU | | Number of leading-edge vortex information stations for the upper vertical fin. |
| MSWD | | Number of leading-edge vortex information stations for the lower vertical fin. |
| | | NEDGV = MSWR + MSWL + MSWU + MSWD. |
| Item 11 | (6F10.5) | Optional input when NEDGV $\neq$ 0. |
| XLE(JLE) | $x_{W,LE}$ | Wing x-coordinate of station on fin leading edge. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| CGLOC(JLE) | $\bar{y}_{LE}$, $\bar{z}_{LE}$ | Center of gravity of the leading-edge vorticity distribution at $x_{w,LE}$. |
| GAMLE(JLE) | $\frac{\Gamma_{LE}}{V_\infty}$ | Strength of the vorticity distribution at XLE(JLE).<br>$1 \le JLE \le NEDGV$. |
| **Item 12** | (I10) | |
| NCW | | Number of side-edge vortex information stations. Same for all fins. NSIDGE = 4 (NCW). |
| **Item 13** | (6F10.5) | Optional input when NSIDGE $\neq$ 0. |
| XSE(JSE) | $x_{w,SE}$ | Wing x-coordinate of station on fin side edge |
| CGSELC(JSE) | $\bar{y}_{SE}$, $\bar{z}_{SE}$ | Center of gravity of side-sdge vorticity distribution at $x_{w,SE}$. |
| GAMSE(JSE) | $\frac{\Gamma_{SE}}{V_\infty}$ | Strength of vorticity distribution at XSE(JSE).<br>$1 \le JSE \le NSIDGE$. |
| **Item 14** | (I10) | Next two items are optional input for NCPIN = 0, only. |
| NCP | | Number of control points and body pressure points or field points at which vortex induced velocities are to be calculated. |
| **Item 15** | (3F10.5 | Optional input when NCP $\neq$ 0 specifying field point coordinates. |
| CPX | $x_B$ | Body x-coordinate of field point. |
| CPY | $y_B$ | Body y-coordinate of field point. |
| CPZ | $z_B$ | Body z-coordinate of field point. |

## APPENDIX L

### Input for program VPATHL

Item 1

Refer to input item 1 under program VPATH2.

Item 2

Refer to input item 2 under program VPATH2. Only difference is option to set optional output plot size. The bounds read in as item 4 below.

Item 3

This card specifies the inverse of the ellipticity ratio of the elliptical cross section under consideration. This ratio is a constant for all axial locations.

Item 4

Refer to input item 3 under program VPATH2.

Item 5

Refer to input item 4 under program VPATH2. The polynomial is used to describe the meridian associated with the horizontal semiaxis of an elliptical cross section.

Item 6

Refer to input item 5 under program VPATHL.

Item 7

If IPLT equals 1 in item 2, the maximum and minimum values of the lateral coordinates are read in by this card. Now, XMAX and XMIN pertain to $y_B$ coordinate and YMAX and YMIN pertain to $z_B$ coordinate of the body coordinate system, see figure 1.

Item 8

Refer to input item 6 under program VPATH2. Omit deflection angles.

Item 9

Refer to item 7 under program VPATH2.

Item 10

Refer to item 8 under program VPATH2.

Item 11

Refer to item 9 under program VPATH2.

Item 12

Refer to item 10 under program VPATH2. Only MSWR and MSWL need be specified since the lifting surface is a monoplane wing designated as right and left "fins".

Item 13

Refer to item 11 under program VPATH2. Here, leading-edge vorticity characteristics need only be specified for the right and left "fins".

Item 14

Refer to item 12 under program VPATH2. Here NSIDGE = 2 NCW.

Item 15

Refer to item 13 under program VPATH2. In this instance, this information is only specified for the side edges of the right and left "fins".

Item 16

Refer to item 14 under program VPATH2.

Item 17

Refer to item 15 under program VPATH2.

## INPUT VARIABLES FOR PROGRAM VPATHL
(Elliptical Cross Section Bodies With Monoplane Wing)

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| Item 1 | (20A4) | Any alphanumeric information to identify the run. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| Item 2 | (8I10) | |
| NS | | Number of body sections for which coefficients C(I,J) are required, $1 \le NS \le 7$. |
| NF | | Number of corner points used to define fin geometry, $1 \le NF \le 7$. |
| NIP | | Number of axial stations to be printed in output, $1 \le NIP \le 50$. |
| NCPIN | | NCPIN = 1 Read in control point and body pressure points from data set (TAPE4). |
| | | NCPIN = 0 No input. |
| NVLOUT | | NVLOUT = 1 Write velocities induced by moving vortices (and calculated in this program) on data set (TAPE7). |
| | | NVLOUT = 0 No output on data set. |
| NOUT | | NOUT = 0 Minimum output. |
| | | NOUT = 1 Some additional debug output. |
| | | NOUT = 2,3 Large amount of debug output containing information about intermediate complex variables. (use only when NIP = 2) |
| IPLT | | IPLT = 0 No plots showing vortex positions in the output. |
| | | IPLT = 1 Specify maximum and minimum x and y to be used in the plots, also see Item 4. |
| | | IPLT = 3 Program determines plot size. |
| Item 3 | (F10.5) | |
| BFACT | $1/\varepsilon$ | Ratio of vertical semiaxis over horizontal semiaxis. |
| Item 4 | (7F10.5) | |
| XE(I) | $x_{B,i}$ | Axial coordinate of the end of each body section, $1 \le I \le NS$. |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| Item 5 | (7F10.5) | |
| C(I,J) | $C_{ij}$ | Coefficients in the body meridian equation, $1 \leq I \leq NS$, $1 \leq J \leq 7$. |
| Item 6 | (8F10.5) | Optional input concerning fin planform geometry when NF $\neq$ 0. |
| XF(I) | $x_{B,i}$ | Axial coordinate of fin corner point, $1 \leq I \leq NF$. |
| YF(I) | $y_{B,i}$ | Lateral coordinate of fin corner point, $1 \leq I \leq NF$. |
| Item 7 | (8F10.5) | Optional input required when IPLT = 1 in Item 2. |
| XMAX | | Maximum x-value used in program generated plots in output. |
| XMIN | | Minimum x-value used in program generated plots in output. |
| YMAX | | Maximum y-value used in program generated plots in output. |
| YMIN | | Minimum y-value used in program generated plots in output. |
| Item 8 | (8F10.5) | |
| ALFAC | $\alpha_C$ | Included angle of attack, measured between free-stream velocity vector and body centerline. |
| PHI | $\phi$ | Angle of roll, positive right fin down. |
| E5 | | Error allowed in integration subroutine DASCRU. Use the value 0.0001 or less. |
| VRTMAX | | Maximum magnitude of vortex induced velocities, if VRTMAX = 0, the value 0.35 is used. |
| Item 9 | (16I5) | |
| NVV(I) | | Total number of vortices at each axial station, $1 \leq I \leq NIP$, NVMAX = NVV(NIP). |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| Item 10 | (6F10.5) | Initial vortex positions in crossflow plane. |
| VX(I) | $y_{B,i}$ | $y_B$-coordinate of vortex I. |
| VY(I) | $z_{B,i}$ | $z_B$-coordinate of vortex I. |
| G(I) | $\frac{\Gamma_{V,i}}{V_\infty}$ | Vortex strength, counterclockwise positive (when viewing forward), $1 \leq I \leq$ NVMAX, NVMAX = NVV(NIP). |
| Item 11 | (8F10.5) | |
| XIP(I) | $x_{B,i}$ | Axial station at which output is required, $1 \leq I \leq$ NIP. |
| Item 12 | (8I10) | |
| MSWR | | Number of leading-edge vortex information stations for right horizontal fin. |
| MSWL | | Number of leading-edge vortex information stations for the left horizontal fin. |
| | | NEDGV = MSWR + MSWL |
| Item 13 | (6F10.5) | Optional input when NEDGV $\neq$ 0. |
| XLE(JLE) | $x_{w,LE}$ | Wing x-coordinate of station on fin leading edge. |
| CGLOC(JLE) | $\bar{y}_{LE}, \bar{z}_{LE}$ | Center of gravity of the leading-edge vorticity distribution at $x_{w,LE}$. |
| GAMLE(JLE) | $\frac{\Gamma_{LE}}{V_\infty}$ | Strength of the vorticity distribution at XLE(JLE). |
| | | $1 \leq$ JLE $\leq$ NEDGV |
| Item 14 | (I10) | |
| NCW | | Number of side-edge vortex information stations. Same for all fins. NSIDGE = 2 (NCW). |

| PROGRAM VARIABLE | ALGEBRAIC SYMBOL (IF APPLICABLE) | COMMENTS |
|---|---|---|
| Item 15 | (6F10.5) | Optional input when NSIDGE $\neq$ 0. |
| XSE(JSE) | $x_{w,SE}$ | Wing x-coordinate of station on fin side edge. |
| CGSELC(JSE) | $\bar{y}_{SE}, \bar{z}_{SE}$ | Center of gravity of side-edge vorticity distribution at $x_{w,SE}$. |
| GAMSE(JSE) | $\frac{\Gamma_{SE}}{V_\infty}$ | Strength of vorticity distribution at XSE(JSE).<br>1 $\leq$ JSE $\leq$ NSIDGE |
| Item 16 | (I10) | Next two items are optional input for NCPIN = 0, only. |
| NCP | | Number of control points and body pressure points or field points at which vortex induced velocities are to be calculated. |
| Item 17 | (3F10.5) | Optional input when NCP $\neq$ 0 specifying field point coordinates. |
| CPX | $x_B$ | Body x-coordinate of field point. |
| CPY | $y_B$ | Body y-coordinate of field point. |
| CPZ | $z_B$ | Body z-coordinate of field point. |

## Description of Output

This section describes the output generated by programs VPATH2 and VPATHL. Only a few items in the output of these programs are different as pointed out below. The output to be described is generated when print control index NOUT is set equal to zero. For nonzero values, large amounts of additional output results. Thus, other than for debugging purposes, index NOUT must be set equal to zero in item 2 of the input for both programs. The results of the output plot options are self evident and will not be discussed here.

The first page of output contains the run identification and the geometry of the fin or wing planform. Included angle of attack and roll are printed. Program VPATH2 also gives the deflection angles of the fins, if applicable. The permissible error in the integration scheme is specified. This output is followed by a list of vortex coordinates in the crossflow plane as a function of increasing axial location. Quantity Y,VRTX is $y_B$ and Z,VRTX is $z_B$, both in the body coordinate system, refer to figure 1. The vortex strengths divided by the free-stream velocity, GAMMA/VINF, are also indicated. This information is given for each of the output stations, XIP, specified in the input and printed as X. At each station, the local body geometry and semispan (distance from body centerline to edge of fin or wing as seen in the crossflow plane) are written. Program VPATH2 gives the local body radius for the axisymmetric body. Program VPATHL specifies the local horizontal semiaxis and the vertical semiaxis.

The final item in the output of both programs are the coordinates of field points (or control points), read in by means of input or data set, and the velocity components induced by the vortices at the points. The coordinates and the velocity components are given in the body coordinate system, refer to figure 1. The vortex effects are calculated on the basis of the vortices in the presence of the body only.

## Program Listings

Programs VPATH2 and VPATHL are written in FORTRAN IV (029 punch) computer language for the CDC 6600 computer. Program VPATH2 consists of a main routine, VPATH, and 12 subroutines. Program VPATHL consists of a main routine, VPATHL, and 13 subroutines. The listings are shown on the indicated pages with the main program first and the subroutines following in alphabetical order.

# APPENDIX L

## PROGRAM VPATH2

| | ROUTINE | IDENTIFICATION Cols. 73-77 | PAGE NO. |
|---|---|---|---|
| 1. | VPATH | VPC01 | 413 |
| 2. | CRUCI | 02 | 419 |
| 3. | DASCRU | 03 | 420 |
| 4. | F | 04 | 423 |
| 5. | FCT | 05 | 426 |
| 6. | PITROL | 06 | 427 |
| 7. | PLOTVB | 07 | 427 |
| 8. | SHAPE | 08 | 430 |
| 9. | SIMP | 09 | 431 |
| 10. | SYMFIN | 10 | 431 |
| 11. | VOTEX | 11 | 432 |
| 12. | VVELS | 12 | 433 |
| 13. | Z | 13 | 434 |

# PROGRAM VPATH2

```
      PROGRAM VPATH(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE4,TAPE7)
C
C     VERSION: VPATH2
C
C         THIS PROGRAM COMPUTES THE PATHS AND VORTEX INDUCED CROSSFLOW
C    VELOCITIES AT SPECIFIED FIELD POINTS FOR A SET OF VORTICES IN THE
C    PRESENCE OF A WING-BODY COMBINATION AT ANGLE OF ATTACK AND ROLL. ANY
C    OR ALL OF THE FINS MAY BE DEFLECTED.  SLENDER BODY THEORY IS USED
C    IN THE COMPUTATION OF THE CROSSFLOW VELOCITIES.
C
C
C   THE COORDINATE SYSTEM USED HERE IS THE BODY COORDINATE SYSTEM
C   WITH THE X-AXIS ALONG THE BODY CENTER-LINE STARTING AT THE NOSE TIP,
C      Y-AXIS TO THE RIGHT WHEN LOOKING FORWARD,Z-AXIS UP.
C
C         WHEN FINS ARE PRESENT,THE Y-AXIS FALLS ALONG RIGHT FIN,
C      THE Z-AXIS ALONG THE UPPER FIN.  THUS,THIS PROGRAM PERFORMS ALL
C      VORTEX PATH CALCULATIONS IN A ROLLED COORDINATE SYSTEM.
C
C   *********NOTE: CRUCIFORM FINS ONLY*****************
C
C
      DIMENSION TITLE(20),XO(60),XIP(50),WK(120)
      DIMENSION VXP(30,30,2),NVV(30)
C
      COMMON/VFL/AL,BE,D1,D2,D3,D4,VX(30),VY(30),G(30),NV,NDEL,MS,MF,
     1XE(7),XF(7),YF(7),C(7,7),IFIN
      COMMON/BLK2/AC,PHI
      COMMON/FINLE/XLE(80),CGLOC(80),GAMLE(80),MSWR,MSWL,MSWU,MSWD,
     1 NEDGV,XTIPLE
      COMMON/SIDEDG/XSE(80),CGSELC(80),GAMSE(80),NCW,NSIDGE,XTIPTE
      COMMON XPLT(30,52),YPLT(30,52),ZPLT(30,52),NPLT(52),ROT(3)
     *     ,XP2(17,18),YP2(17,18)
C
      NAMELIST/DEBUG/MS,MF,NIP,NFRIN,NVLOUT,NOUT,VRTMAX,XE,C,XF,YF,NVV
C
    1 FORMAT(20A4)
    4 FORMAT(8I10)
    5 FORMAT(7F10.5)
    6 FORMAT(8F10.5)
    7 FORMAT(6F10.5)
    9 FORMAT (/5X,20HLOCAL BODY RADIUS = ,F10.5,5X,
     1 20HLOCAL SEMI SPAN S = ,F10.5/)
   11 FORMAT (//5X,33H INCLUDED ANGLE OF ATTACK(DEG) = ,F10.5,
     1 24H       ROLL ANGLE(DEG)  = ,F10.5/)
   12 FORMAT (2X,24H          PANEL DEFL.(DEG) :,//9X,9H DELTA1= ,F6.3,
     1 11H   DELTA2= ,F6.3,11H   DELTA3= ,F6.3,11H   DELTA4= ,F6.3//)
   21 FORMAT(//19H        X-STATION NO.,I3,9H        X=,F6.3,6X,
     1 25H INTEGRATION STEP SIZE = ,F10.5//)
   22 FORMAT(I15,4X,2E17.5,E15.5)
   25 FORMAT (////10X,38HVORTEX COORDINATES IN CROSS-FLOW PLANE.//)
   26 FORMAT (//43H            INITIAL VORTEX POSITIONS AT   X = ,F6.3/)
   27 FORMAT (10X,7H VORTEX,10X,7H Y,VRTX,10X,7H Z,VRTX,6X,
     1   10HGAMMA/VINF/)
   30 FORMAT(16I5)
   31 FORMAT(/// 6X,76HCROSSFLOW VELOCITIES AT CONTROL POINTS INDUCED BY
     1 VORTICES AND THEIR IMAGES ,//
     1 6X,2HIC,10X,6HX,BODY,10X,6HY,BODY,10X,6HZ,BODY,10X,1HV,15X,1HW)
   32 FORMAT(5X,I5,6X,5E15.5)
   60 FORMAT(3F10.5)
  700 FORMAT (//5(1H*), 59HPERMISSIBLE RELATIVE ERROR,ES,USED IN INTEGRA
     1TION SCHEME = ,E12.5/)
  701 FORMAT (////5(1H*),61HSUBROUTINE DASCRU CAN NOT OBTAIN VALUE FOR I
```

```
     1NTEGRATION STEP H,5(1H*)/////)
  702 FORMAT (85X,I3,2F10.5)
  703 FORMAT (//85X,31HINTERPOLATED VORTEX COORDINATES/87X,1HI,5X,
     1  2HYV,10X,2HZV/)
  704 FORMAT (////17X,12HFIN GEOMETRY/10X,12HFIN SEMISPAN,11X,1H=,1X,
     A F10.5/
     1          10X,25HFIN ROOTCHORD             = ,F10.5/
     B          10X,25HFIN ROOT L.E. X-STATION= ,F10.5/
     2          10X,25H            L.E. Y-STATION= ,F10.5/
     3          10X,25HFIN TIP L.E. X-STATION = ,F10.5/
     4          10X,25H            L.E. Y-STATION = ,F10.5/
     5          10X,25HFIN TIP T.E. X-STATION = ,F10.5/
     6          10X,25H            T.E. Y-STATION = ,F10.9/
     8          10X,25HFIN ROOT T.E. X-STATION= ,F10.5/
     9          10X,25H            T.E. Y-STATION= ,F10.5,////)
  705 FORMAT (6X,I2,2X,F10.5,1X,F10.5,1X,F10.5)
  706 FORMAT (////10X,26HFIN LEADING EDGE VORTICITY/
     1 5X,3HJLE,6X,1HX,7X,10HY OR Z BAR,2X,11HGAMMA/VINF,/)
  707 FORMAT (////10X,23HFIN SIDE EDGE VORTICITY/5X,3HJSE,6X,1HX,7X,
     1    10HY OR Z BAR,2X,11HGAMMA/VINF,/)
  745 FORMAT (I5,3E12.5)
  746 FORMAT (I5,5E12.5)
C
C
C
      RAD=3.1415926/180.
C
C
C          ..........  INPUT  ...........
C
   99 READ(5,1)TITLE
      IF(EOF(5))2,3
    3 CONTINUE
C
C  .. GEOMETRY ..
C
C
C          NS== OF BODY SECTIONS WITH DIFFERENT GEOMETRY
C          NF= = OF CORNER POINTS OF CRUCIFORM WING SECTIONS
C          NIP= = OF X- STATIONS PRINTED IN OUTPUT
C          XE= X VALUES AT THE END OF EACH BODY SECTION
C          C= COEFFICIENTS IN THE BODY GEOMETRY EQUATION
C          XF,YF= X AND Y COODS OF THE FIN BREAK IN SWEEP POINTS.
C  NOTE: HERE FINS ARE NUMBERED 1=TOP, 2=RIGHT, 3=BOTTOM, 4=LEFT.
C
      READ(5,4)NS,NF,NIP,NCPIN,NVLOUT,NOUT,IPLT
      READ(5,5)(XE(I),I=1,NS)
      READ(5,5)((C(I,J),J=1,7),I=1,NS)
      IF(NF.NE.0) READ(5,6)(XF(I),YF(I),I=1,NF)
C
C
C     DETERMINE DISTANCE FROM BODY CENERLINE TO FIN TIP(=SEMISPAN)
C     AND X-LOCATIONS OF FIN TIP LEADING EDGE AND TRAILING EDGE.
C
      IF (NF.EQ.0) GO TO 84
      YMAX=0
       CRP=SQRT((XF(NF)-XF(1))*(XF(NF)-XF(1))+(YF(NF)-YF(1))*(YF(NF)-
     1 YF(1)))
      DO 80 I=1,NF
      IF (YF(I).GT.YMAX) YMAX=YF(I)
   80 CONTINUE
      NFM1=NF-1
      DO 81 I=1,NFM1
```

```
      IP1=I+1
      IF (YF(I).EQ.YMAX.AND.YF(IP1).EQ.YMAX) GO TO 82
      IF (YF(I).EQ.YMAX) GO TO 83
   81 CONTINUE
      GO TO 84
   82 IMAX=I
      IMAXP1=I+1
      XTIPLE=XF(IMAX)
      YTIPLE=YF(IMAX)
      XTIPTE=XF(IMAXP1)
      YTIPTE=YF(IMAXP1)
      GO TO 84
   83 XTIPLE=XF(IMAX)
      XTIPTE=XTIPLE
   84 CONTINUE
C
C
C
C        ALFAC =INCLUDED ANGLE OF ATTACK,  PHI=ROLL ANGLE BOTH IN DEGREE
C        D1,D2,D3,D4 ARE FIN DEFLECTIONS IN DEGREES, POSITIVE TRAILING
C        EDGE DOWN FOR HOR. FINS,TRAILING EDGE TO THE RIGHT FOR VERT.
C        FINS
C        E5 = PERMISSIBLE RELATIVE ERROR IN THE PATH INTEGRATION SCHEME
C
      READ(5,6)ALFAC,PHI,D1,D2,D3,D4,E5,VRTMAX
      IF (VRTMAX.EQ.0.0) VRTMAX=0.35
      HI=ABS(D1)+ABS(D2)+ABS(D3)+ABS(D4)
      NDEL=0
      IF (HI.NE.0.0) NDEL=1
C
C   .. X-STATIONS,INTEGRATION INFO, + INITIAL VORTEX POSITIONS AND STRENG
C
C
C        NVV = TOTAL NUMBER OF VORTICES AT EACH X-STATION
C
C
      READ(5,30)(NVV(I),I=1,NIP)
      NV=NVV(1)
      NVMAX=NVV(NIP)
C
C        READ IN CROSSFLOW STARTING COORDINATES AND STRENGTHS FOR ALL
C        VORTICES REGARDLESS OF THE X-STATION AT WHICH THEY START.
C        THIS INFO MUST BE INPUT FOR INCREASING X-STATION.
C
C     HERE....VX(I)..Y-COORDINATE
C             VY(I)..Z-COORDINATE
C             G(I)...GAMMA/VINF,COUNTERCLOCKWISE POSITIVE,
C                    WHEN VIEWING FORWARD.
C
      READ(5,7)(VX(I),VY(I),G(I),I=1,NVMAX)
      DO 8 I=1,NV
      J=2*I-1
      K=J+1
      VXP(1,I,1)=VX(I)
      VXP(1,I,2)=VY(I)
      XO(J)=VX(I)
    8 XO(K)=VY(I)
C
C        XIP= X- VALUES AT THE NIP X-STATIONS AT WHICH OUTPUT READ.
C        FIRST VALUE FOR XIP CAN BE ANY NUMBER LARGER THAN ZERO
C        INTEGRATION STARTS AT XIP(1)
C        INTEGRATION STEP SIZE DETERMINED BY DASCRU...H
C
```

```
      READ(5,6)(XIP(I),I=1,NIP)
C
C
      WRITE(6,1)TITLE
      IF (NF.NE.0)
     1WRITE (6,704) YMAX,CRP,XF(1),YF(1),XTIPLE,YTIPLE,XTIPTE,YTIPTE,
     1 XF(NF),YF(NF)
      WRITE(6,11)ALFAC,PHI
      WRITE(6,12)D1,D2,D3,D4
      IF (NOUT.NE.0) WRITE (6,DEBUG)
C
C
C     READ NUMBERS OF FIN LEADING EDGE VORTEX INFO STATIONS XLE FOR
C     EACH FIN.
C     FOR EACH XLE STATION,READ IN YBAR OR ZBAR(=CGLOC) AND STRENGTH
C     OF THE VORTICITY DISTRIBUTION.
C   NOTE: THIS VORTICITY IS FIXED IN POSITION,IT AFFECTS THE FLOWFIELD
C
C   NOTE: XLE AND XSE ARE READ IN IN THE FIN COORDINATE SYSTEM AND
C     MUST BE TRANSFORMED TO BODY COORDINATE SYSTEM.
C
      READ (5,4) NSWR,NSWL,NSWU,NSWD
      NEDGV=NSWR+NSWL+NSWU+NSWD
      IF (NEDGV.EQ.0) GO TO 19
                          READ (5,7) (XLE(IFV),CGLOC(IFV),GAMLE(IFV),
     1  IFV=1,NEDGV)
      WRITE (6,706)
      DO 15 JLE=1,NEDGV
      XLE(JLE)=XLE(JLE)+XF(1)
   15 WRITE (6,705) JLE,XLE(JLE),CGLOC(JLE),GAMLE(JLE)
   19 CONTINUE
C
C     READ NUMBER OF FIN SIDE EDGE VORTEX INFO STATIONS XSE FOR EACH
C     FIN.
C   NOTE: THIS VORTICITY IS FIXED IN POSITION,IT AFFECTS THE FLOWFIELD
C     FOR EACH XSE STATION,READ IN YBAR OR ZBAR(=CGSELC) AND THE
C     STRENGTH OF THE VORTICITY DISTRIBUTION
C
      READ (5,4) NCW
      NSIDGE=4*NCW
      IF (NSIDGE.EQ.0) GO TO 18
                          READ (5,7) (XSE(JSE),CGSELC(JSE),GAMSE(JSE),
     1 JSE=1,NSIDGE)
      WRITE (6,707)
      DO 16 JSE=1,NSIDGE
      XSE(JSE)=XSE(JSE)+XF(1)
   16 WRITE (6,705) JSE,XSE(JSE),CGSELC(JSE),GAMSE(JSE)
   18 CONTINUE
C
C
      WRITE (6,700) ES
      WRITE (6,25)
      WRITE(6,26)XIP(1)
      CALL SHAPE (XIP(1),RLOC,SLOC)
      WRITE (6,9) RLOC,SLOC
      WRITE(6,27)
      WRITE(6,22)(L,VX(L),VY(L),G(L),L=1,NV)
C
C         CONVERT ANGLES TO RADIANS
C
      AC=ALFAC*RAD
      BE=PHI*RAD
      PHI=BE
```

```
      D1=D1*RAD
      D2=D2*RAD
      D3=D3*RAD
      D4=D4*RAD
      AL=ASIN(SIN(AC)*COS(BE))
      BE=ASIN(SIN(AC)*SIN(BE))
C
C  ......COMPUTE VORTEX PATHS USING DASCRU INTEGRATION SUBROUTINE......
C
      NIP1=NIP-1
      H=XIP(2)-XIP(1)
      DO 20 I=1,NIP1
      I1=I+1
      NV=NVV(I)
      NVN=NVV(I1)
      NV1=NV+1
      N=2*NV
      A1=XIP(I)
      B1=XIP(I+1)
C
      CALL DASCRU(A1,B1,H,N,X0,WK,IER,ES,VRTMAX)
C
C         IF IER GREATER THAN 32,DASCRU HAD TROUBLE GETTING STEP SIZE.
C         THEN,RATHER THAN CONTINUING WITH THE INTEGRATION, STOP 40
C         REDUCE XIP(2)-XIP(1)AND RERUN
C
      IF (IER.GE.32) GO TO 28
      GO TO 29
   28 WRITE (6,701)
      STOP 40
   29 CONTINUE
C
C
C  .. ADD THE NEW VORTICES AND THEIR POSITIONS FOR THE NEXT X-INTERVAL
C
      IF(NVN.EQ.NV)GO TO 39
      DO 35 K1=NV1,NVN
      JL=2*K1-1
      KK=JL+1
      X0(JL)=VX(K1)
   35 X0(KK)=VY(K1)
   39 CONTINUE
C
C  .. OUTPUT VORTEX POSITIONS AND CONFIGURATION CHARACTERISTICS AT THIS
C     STATION.
C
      WRITE(6,21)I1,B1,H
      CALL SHAPE (B1,PLOC,SLOC)
      WRITE (6,9) PLOC,SLOC
      WRITE(6,27)
      DO 23 L=1,NVN
      J=2*L-1
      K=J+1
      VXP(I1,L,1)=X0(J)
      VXP(I1,L,2)=X0(K)
      WRITE(6,22)L,X0(J),X0(K),G(L)
C
C  SAVE VORTEX LOCATION FOR PLOT
C
      JCV=NIP1+L+1
      XPLT(I,JCV)=B1
      YPLT(I,JCV)=X0(J)
      ZPLT(I,JCV)=X0(K)
```

```
   23 CONTINUE                                                          VPC01316
C                                                                       VPC01317
C  SAVE BODY POINTS FOR PLOT                                            VPC01318
C                                                                       VPC01319
      XPLT(1,I1)=B1                                                     VPC01320
      YPLT(1,I1)=RLOC                                                   VPC01321
      ZPLT(1,I1)=RLOC                                                   VPC01322
      YPLT(2,I1)=SLOC                                                   VPC01323
   20 CONTINUE                                                          VPC01324
C                                                                       VPC01325
C  PLOT VORTEX LOCATIONS                                                VPC01326
C                                                                       VPC01327
      XPLT(1,1)=XIP(1)                                                  VPC01328
      IF (IPLT.GT.0)                                                    VPC01329
     * CALL PLOTVR(XPLT,YPLT,ZPLT,WPLT,NIP1,NVN,30,ROT,XF,YF,NF,XP2,YP2)VPC01330
C                                                                       VPC01331
C..COMPUTE VELOCITIES AT THE SPECIFIED CONTROL POINTS INDUCED BY NV     VPC01332
C    EXTERNAL VORTICES AND THEIR IMAGES.                                VPC01333
C                                                                       VPC01334
C                                                                       VPC01335
C  NOTE: IF CONTROL POINTS ARE PASSED THROUGH BY MEANS OF A DATA SET    VPC01336
C      I.E. WHEN NCPIN IS NOT EQUAL TO 0,    INDEX NCP IS READ IN FROM  VPC01337
C      THE DATA SET ALSO.                                               VPC01338
C  NOTE:X-COORDINATE OF CONTROL POINT MUST THEN BE TRANSFORMED TO BODY  VPC01339
C      COORDINATE SYSTEM.                                               VPC01340
C      THIS IS DONE BELOW.                                              VPC01341
C                                                                       VPC01342
C                                                                       VPC01343
      NCP=0                                                             VPC01344
      IF (NCPIN.NE.0) REWIND 4                                          VPC01345
      IF (NVLOUT.NE.0) REWIND 7                                         VPC01346
      IF (NCPIN.EQ.0) GO TO 72                                          VPC01347
      IF (NCPIN.NE.0) READ (4,745) NCP                                  VPC01348
      IF (EOF(4).NE.0) GO TO 99                                         VPC01349
      GO TO 73                                                          VPC01350
   72 READ (5,4) NCP                                                    VPC01351
   73 CONTINUE                                                          VPC01352
      IF(NCP.EQ.0)GO TO 99                                              VPC01353
      WRITE(6,31)                                                       VPC01354
      DO 69 J11=1,NCP                                                   VPC01355
      IF (NCPIN.EQ.0) GO TO 70                                          VPC01356
      READ (4,745) IC,CPX,CPY,CPZ                                       VPC01357
      CPX=CPX+XF(1)                                                     VPC01358
      GO TO 71                                                          VPC01359
   70 READ(5,60)CPX,CPY,CPZ                                             VPC01360
   71 CONTINUE                                                          VPC01361
C                                                                       VPC01362
C.. DETERMINE THE X-STATIONS ADJACENT TO THE CONTROL POINT              VPC01363
C                                                                       VPC01364
      DO 61 I=1,NIP                                                     VPC01365
      IF (CPX.LT.XIP(1)) GO TO 69                                       VPC01366
      J=I-1                                                             VPC01367
      IF (I.EQ.1) J=1                                                   VPC01368
      IF(CPX.LE.XIP(I))GO TO 62                                         VPC01369
   61 CONTINUE                                                          VPC01370
C                                                                       VPC01371
C  DETERMINE BY INTERPOLATION THE POSITION IN THE CROSSFLOW PLANE OF ALLVPC01372
C      VORTICES AT EACH STATION CPX.                                    VPC01373
C                                                                       VPC01374
   62 K=J+1                                                             VPC01375
      X1=XIP(J)                                                         VPC01376
      X2=XIP(K)                                                         VPC01377
      WT1=(X2-CPX)/(X2-X1)                                              VPC01378
```

```
      WT2=(CPX-X1)/(X2-X1)
      NV=NVV(J)
      CALL SHAPE (CPX,RB,SL)
      IF (JOUT.NE.0) WRITE (6,703)
      DO 63 I=1,NV
      VX(I)=WT1*VXP(J,I,1)+WT2*VXP(K,I,1)
      VY(I)=WT1*VXP(J,I,2)+WT2*VXP(K,I,2)
      IF (NOUT.EQ.0) GO TO 63
      WRITE (6,702) I,VX(I),VY(I)
   63 CONTINUE
C
C     SUBROUTINE VVELS CALCULATES VORTEX VELOCITIES INCLUDING EFFECTS
C     FROM IMAGE VORTICES. CENTER VORTEX EFFECTS ARE OMITTED.
C
      CALL VVELS(NV,CPY,CPZ,VX,VY,G,RB,V,W,VRTMAX)
      WRITE(6,32) J11,CPX,CPY,CPZ,V,W
      IF (NVLOUT.EQ.0) GO TO 69
      IC=J11
      WRITE (7,746) IC,CPX,CPY,CPZ,V,W
   69 CONTINUE
      GO TO 99
    2 STOP
      END
```

```
      SUBROUTINE CRUCI(NC,D,X,Y,VS,WS)
C
C     VERSION: VPATH2
C
C
C    USING (X,Y) AS COORDINATES IN THE CROSS FLOW PLANE.
C    THIS SUBROUTINE COMPUTES THE CROSSFLOW VELOCITY COMPONENTS AT A POIN
C    (X,Y) DUE TO THE DEFLECTION OF A SINGLE FIN IN A WING - BODY COMBINA
C    THE ANGLE OF DEFLECTION IS D RADIANS AND THE FIN THAT IS DEFLECTED I
C    IDENTIFIED BY THE CODE NC.  IF NC=1 THE RIGHT HORIZONTAL FIN IS DEFL
C    IF NC=2 ETC. WE COUNT COUNTERCLOCKWISE. . NUMERICAL INTEGRATION IS U
C    DETERMINE THE VELOCITIES . THE ACCURACY OF INTEGRATION IS DETERMINED
C    THE TOLERANCE TOL - IN THE DATA STATEMENT.  A POINT NEAR THE BODY RE
C    MANY INTEGRATION POINTS. THE SCHEME IS SINGULAR ON THE BODY.
C
      COMMON/BLK1/A,R,S,PI,CI
      COMMON AA,SIG,SS,GAM
      EXTERNAL FCT
      COMPLEX CI,TAU,TT,TPA,SIG,SS,EGP,EGM,T1,VEL,T2,DSDT,TP2,TM2,TP4,
     1FCT,   T21,T22,SIMP,T20
      DATA TOL/.02/
      SCA=R
      X=X/SCA
      Y=Y/SCA
      A=A/SCA
      AA=A*A
      GAM=.5*ACOS(AA)
      GAM1=.9*GAM
C
C    TRANSFORM X,Y TO PROPER QUADRANT
C
      TH=FLOAT(NC-1)*PI/2.
      XS=X*COS(TH)+Y*SIN(TH)
      YS=Y*COS(TH)-X*SIN(TH)
      TAU=CMPLX(XS,ABS(YS))
      TT=TAU*TAU
```

```
      TPA=TT+AA*AA/TT
      TM2=TPA-2.
      TP2=TPA+2.
      IF(AIMAG(TM2).GE.0.)TM2= CSQRT(TM2)
      IF(AIMAG(TM2).LT.0.)TM2=-CSQRT(TM2)
      IF(AIMAG(TP2).GE.0.)TP2= CSQRT(TP2)
      IF(AIMAG(TP2).LT.0.)TP2=-CSQRT(TP2)
      TP4=TP2*TM2
      SIG=.5*(TM2+TP2)
      SS=SIG*SIG
      EGP=CEXP(CI*GAM)
      EGM=1./EGP
      T1=A*(1./(SIG-EGP)-1./(SIG-EGM))
      NG=10
      T20=CMPLX(0.,0.)
   22 T21=SIMP(0.,GAM1,NG,FCT)
      IF(CABS(T21-T20)/CABS(T21).LT.TOL)GO TO 21
      IF(NG.GT.3000)WRITE(6,5)
      IF(NG.GT.3000)GO TO 21
    5 FORMAT(//* SORRY DOES NOT CONVERGE IN CRUCT *//)
      NG=NG*2
      T20=T21
      GO TO 22
   21 T20=CMPLX(0.,0.)
      NG=20
   33 T22=SIMP(GAM1,GAM,NG,FCT)
      IF(CABS(T22-T20)/CABS(T22).LT.TOL)GO TO 31
      IF(NG.GT.3000)WRITE(6,5)
      IF(NG.GT.3000)GO TO 31
      NG=NG*2
      T20=T22
      GO TO 33
   31 CONTINUE
      T2=T21+T22
      DSDT=.5*(TAU-AA*AA/(TT*TAU)) *(TP2+TM2)/TP4
      VEL=Q*DSDT*(T1-CI*T2/SQRT(2.))/PI
      V=REAL(VEL)
      W=-AIMAG(VEL)
      IF(YS.LT.0.)V=-V
C
C  ROTATE VELOCITIES BACK
C
      VS=V*COS(TH)-W*SIN(TH)
      WS=V*SIN(TH)+W*COS(TH)
      A=A*SCA
      X=X*SCA
      Y=Y*SCA
      RETURN
      END
```

```
      SUBROUTINE DASCRU (A,B,H,N,X0,WK,IER,ES,VRTMAX)
C
C     VERSION: VPATH2
C
C     THIS SUBROUTINE PERFORMS INTEGRATION
C
C                                      ES SHOULD BE SET TO .5 TIMES THE
C                                      DESIRED RELATIVE PRECISION OF
```

```
C                                   THE SOLUTION
C
      DIMENSION           WK(1),X0(1)
C
      INTEGER             SW
C
      LOGICAL             BE,BH,BR,BX
C
      DATA                ZERO,P5,OP5,THREE,FOUR/0.,.5,1.5,3.,4./
C
      IER = 0
      IF(A - B) 4,100,4
    4 IB1=N+N
      IB2=IB1+N
      HMIN=0.01*ABS(H)
      BH=.TRUE.
      BR=.TRUE.
      BX=.TRUE.
C
C                                   CHECK FOR THE PROPER SIGN OF H
C
      H=SIGN(ABS(H),B-A)
      X=A
    5 XS=X
      DO 10  J=1,N
         IJK0=N+J
         WK(IJK0)=X0(J)
   10 CONTINUE
   15 HS=H
      Q=X+H-B
      BE=.TRUE.
      IF(.NOT.((H.GT.ZERO.AND.Q.GE.ZERO).OR.(H.LT.ZERO.AND.Q.LE.ZERO)))
     1    GO TO 20
      H=B-X
      BR=.FALSE.
   20 H3=H/THREE
C
C                                   CALCULATE SOLN. AT X+H
C   NOTE: ARRAY WK CONTAINS V FOR ODD INDEX,W FOR EVEN INDEX.
C
C
      DO 90  SW=1,5
         CALL F(X0,X,N,WK,VRTMAX)
         DO 70  I=1,N
            Q=H3*WK(I)
            IJK0=N+I
            IJK1=IB1+I
            IJK2=IB2+I
            GO TO (25,30,35,40,45),SW
   25       R=Q
            WK(IJK1)=Q
            GO TO 50
   30       R=P5*(Q+WK(IJK1))
            GO TO 50
   35       R=THREE*Q
            WK(IJK2)=R
            R=.375*(R+WK(IJK1))
            GO TO 50
   40       R=WK(IJK1)+FOUR*Q
            WK(IJK1)=R
            R=OP5*(R-WK(IJK2))
            GO TO 50
   45       R=P5*(Q+WK(IJK1))
```

```
             Q= ABS(H*R - OP5*(Q+HK(IJK2)))
   50        X0(I)=HK(IJK3)+Q
             IF(SW.NE.5) GO TO 70
C
C                                          AUTOMATIC STEP CHANGE
C
             E=ABS(X0(I))
             R=ES
             IF(E.GE.1.E-3) R=E*ES
C
C                                          TEST ADJUSTMENT OF THE STEP
C
             IF(Q.LT.R .OR.(.NOT. BX)) GO TO 65
             BR=.TRUE.
             BH=.FALSE.
             H=P5*H
             IF(ABS(H).GE.HMIN) GO TO 55
C
C                                          THE STEP IS HALVED RESTORE X AND X0,
C                                          AND GO BACK FOR REPEATED INTEGRATION
C                                          WITH THIS NEW STEP
C
             H=SIGN(1.,H)*HMIN
             BX=.FALSE.
   55        DO 60  J=1,N
                IJK0=N+J
                X0(J)=HK(IJK0)
   60        CONTINUE
             X=XS
             GO TO 15
   65        IF(Q.GE.0.03125*R) BE=.FALSE.
   70     CONTINUE
          GO TO (75,90,80,85,90),SW
   75     X=X+H3
          GO TO 90
   80     X=X+P5*H3
          GO TO 90
   85     X=X+P5*H
   90 CONTINUE
C
C                                          TEST A POSSIBLE DOUBLING OF THE STEP
C
      IF(.NOT.(BE.AND.BH.AND.BR)) GO TO 95
      H=H+H
      BX=.TRUE.
   95 BH=.TRUE.
      IF(BR) GO TO 5
      H=H9
      IF(BX .OR. BE) GO TO 9005
      IER = 33
      GO TO 9005
  100 DO 105 I=1,N
         X0(I)=ZERO
  105 CONTINUE
 9005 RETURN
      END
```

```
      SUBROUTINE F(XO,PX,N,WK,VRTMAX)
C
C     VERSION: VPATH2
C
C     THIS SUBROUTINE IS CALLED BY NASCRU TO CALCULATE CROSS FLOW
C     PLANE VELOCITIES
C
      COMPLEX CI,Z,FCT,SIMP
      COMMON/VEL/AL,BE,D1,D2,D3,D4,VX(30),VY(30),G(30),NV,NDEL,NS,NF,
     1XE(7),XF(7),YF(7),C(7,7),IFIN
      COMMON/BLK1/A,R,S,PI,CI
      COMMON/BLK2/AC,PHI
      COMMON/FINLE/XLE(80),CGLOC(80),GAMLE(80),MSWR,MSWL,MSWU,MSWD,
     1 NEDGV,XTIPLE
      COMMON/SIDEDG/XSE(80),CGSELC(80),GAMSE(80),NCW,NSIDGE,XTIPTE
C
      DIMENSION XO(1),WK(1),V(30),W(30),VV(30),WW(30),NCC(4)
C
      EXTERNAL Z,FCT,SIMP
      CI=CMPLX(0.,1.)
      PI=3.14159265
      DO 888 I=1,NV
      J=2*I-1
      K=J+1
      VX(I)=XO(J)
  888 VY(I)=XO(K)
      CALL SHAPE(PX,A,S)
C
C  NOTE: COORDINATE VX(I) IS THE Y-COORDINATE IN THE CROSS FLOW PLANE.
C        COORDINATE VY(I) IS THE Z-COORDINATE IN THE CROSS FLOW PLANE.
C
C  .. COMPUTE VELOCITIES IN THE CROSSFLOW PLANE ...
C     V(I) IS IN THE Y-DIRECTION.
C     W(I) IS IN THE Z-DIRECTION.
C
C
      R=SQRT(.5*(S*S+A**4/(S*S)))
      DO 31 J=1,4
   31 NCC(J)=0
      IF(D1.NE.0.)NCC(1)=1
      IF(D2.NE.0.)NCC(2)=1
      IF(D3.NE.0.)NCC(3)=1
      IF(D4.NE.0.)NCC(4)=1
      MH=NCC(2)+NCC(4)
      MV=NCC(1)+NCC(3)
      DO 100 I=1,NV
      X=VX(I)
      Y=VY(I)
      VS=0.
      WS=0.
      IF(AL.NE.0.)CALL PITROL(AL,X,Y,VS,WS)
      V(I)=VS
      W(I)=WS
      IF(BE.EQ.0.)GO TO 17
      CALL PITROL(BE,Y,-X,VS,WS)
      V(I)=V(I)-WS
      W(I)=W(I)+VS
   17 CONTINUE
      IF(NDEL.EQ.0.OR.IFIN.EQ.0)GO TO 66
      IF(MH.EQ.0)GO TO 6
      IF(MH.EQ.1)GO TO 5
      CALL SYMFIN(1,D4,X,Y,VS,WS)
      V(I)=V(I)+VS
```

```
      W(I)=W(I)+WS
    5 CONTINUE
      IF(MH.EQ.2)GO TO 8
      IF(NCC(2).EQ.1)NC=1
      IF(NCC(4).EQ.1)NC=3
      IF(NCC(2).EQ.1)DD=D2
      IF(NCC(4).EQ.1)DD=-D4
      CALL CRUCI(NC,DD,X,Y,VS,WS)
      V(I)=V(I)+VS
      W(I)=W(I)+WS
      GO TO 6
    8 DD=D2-D4
      CALL CRUCI(1,DD,X,Y,VS,WS)
      V(I)=V(I)+VS
      W(I)=W(I)+WS
    6 CONTINUE
      IF(MV.EQ.0)GO TO 66
      IF(MV.EQ.1)GO TO 55
      CALL SYMFIN(2,D3,X,Y,VS,WS)
      V(I)=V(I)+VS
      W(I)=W(I)+WS
   55 CONTINUE
      IF(MV.EQ.2)GO TO 88
      IF(NCC(1).EQ.1)NC=2
      IF(NCC(3).EQ.1)NC=4
      IF(NCC(1).EQ.1)DD=D1
      IF(NCC(3).EQ.1)DD=-D3
      CALL CRUCI(NC,DD,X,Y,VS,WS)
      V(I)=V(I)+VS
      W(I)=W(I)+WS
      GO TO 66
   88 DD=D1-D3
      CALL CRUCI(2,DD,X,Y,VS,WS)
      V(I)=V(I)+VS
      W(I)=W(I)+WS
   66 CONTINUE
C
C     IF FIN LE   VORTICITY IS INCLUDED,DETERMINE BY INTERPOLATION THE
C     EFFECTS OF THE SPECIFIED VORTICITY.
C
C NOTE: HERE IFIN=1....RIGHT FIN
C                 2....LEFT FIN
C                 3....UPPER FIN
C                 4....LOWER FIN.
C
      IF (NEDGV.EQ.0) GO TO 20
      IFIN=1
      KSTART=1
      KUL=MSWR
   23 CONTINUE
      IF (IFIN.EQ.5) GO TO 20
      IF (IFIN.EQ.2) KSTART=MSWR+1
      IF (IFIN.EQ.3) KSTART=MSWR+MSWL+1
      IF (IFIN.EQ.4) KSTART=MSWR+MSWL+MSWU+1
      DO 21 IFV=KSTART,KUL
      IF (PX.LT.XLE(KSTART)) GO TO 20
      JV=IFV-1
      IF (IFV.EQ.1) JV=1
      IF (PX.LE.XLE(IFV)) GO TO 22
   21 CONTINUE
      IF (PX.LE.XTIPLE) GO TO 38
      GO TO 20
   22 KV=JV+1
```

```
      X1=XLE(JV)                                                        VPC04127
      X2=XLE(KV)                                                        VPC04128
      WT1=(X2-PX)/(X2-X1)                                               VPC04129
      WT2=(PX-X1)/(X2-X1)                                               VPC04130
      IF (IFIN.EQ.3.OR.IFIN.EQ.4) GO TO 24                              VPC04131
      YVINT=WT1*CGLOC(JV)+WT2*CGLOC(KV)                                 VPC04132
      ZVBAR=(PX-XF(1))*TAN(AL/2.0)                                      VPC04133
      GAMINT=WT1*GAMLE (JV)+WT2*GAMLE (KV)                              VPC04134
      GO TO 39                                                          VPC04135
   38 GAMINT=GAMLE(KUL)                                                 VPC04136
      IF (IFIN.EQ.3.OR.IFIN.EQ.4) GO TO 40                              VPC04137
      YVINT=CGLOC(KUL)                                                  VPC04138
      ZVBAR=(PX-XF(1))*TAN(AL/2.0)                                      VPC04139
      GO TO 39                                                          VPC04140
   40 ZVINT=CGLOC(KUL)                                                  VPC04141
      YVBAR=-(PX-XF(1))*TAN(BE/2.0)                                     VPC04142
      GO TO 41                                                          VPC04143
   39 CALL VVELS(1,X,Y,YVINT,ZVBAR,GAMINT,A,VS,WS,VRTMAX)               VPC04144
      GO TO 25                                                          VPC04145
   24 ZVINT=WT1*CGLOC(JV)+WT2*CGLOC(KV)                                 VPC04146
      YVBAR=-(PX-XF(1))*TAN(BE/2.0)                                     VPC04147
      GAMINT=WT1*GAMLE (JV)+WT2*GAMLE (KV)                              VPC04148
   41 CALL VVELS (1,X,Y,YVBAR,ZVINT,GAMINT,A,V,W,VRTMAX)                VPC04149
   25 V(I)=V(I)+VS                                                      VPC04150
      W(I)=W(I)+WS                                                      VPC04151
      IFIN=IFIN+1                                                       VPC04152
      IF (IFIN.EQ.2) KUL=MSWR+MSWL                                      VPC04153
      IF (IFIN.EQ.3) KUL=MSWR+MSWL+MSWU                                 VPC04154
      IF (IFIN.EQ.4) KUL=MSWR+MSWL+MSWU+MSWD                            VPC04155
      GO TO 23                                                          VPC04156
   20 CONTINUE                                                          VPC04157
C                                                                       VPC04158
C                                                                       VPC04159
C     IF FIN SE VORTICITY IS INCLUDED,DETERMINE BY INTERPOLATION THE    VPC04160
C     EFFECTS OF THE SPECIFIED VORTICITY.                               VPC04161
C                                                                       VPC04162
      IF (NSIDGE.EQ.0) GO TO 28                                         VPC04163
      IFIN=1                                                            VPC04164
      KSTART=1                                                          VPC04165
      KUL=NCW                                                           VPC04166
   27 CONTINUE                                                          VPC04167
      IF (IFIN.EQ.5) GO TO 28                                           VPC04168
      IF (IFIN.EQ.2) KSTART=NCW+1                                       VPC04169
      IF (IFIN.EQ.3) KSTART=2*NCW+1                                     VPC04170
      IF (IFIN.EQ.4) KSTART=3*NCW+1                                     VPC04171
      DO 29 JSE=KSTART,KUL                                              VPC04172
      IF (PX.LT.XSE(KSTART)) GO TO 28                                   VPC04173
      JVSE=JSE-1                                                        VPC04174
      IF (JSE.EQ.1) JVSE=1                                              VPC04175
      IF (PX.LE.XSE(JSE)) GO TO 30                                      VPC04176
   29 CONTINUE                                                          VPC04177
      IF (PX.LE.XTIPTE) GO TO 51                                        VPC04178
      GO TO 28                                                          VPC04179
   30 KVSE=JVSE+1                                                       VPC04180
      X1=XSE(JVSE)                                                      VPC04181
      X2=XSE(KVSE)                                                      VPC04182
      WT1=(X2-PX)/(X2-X1)                                               VPC04183
      WT2=(PX-X1)/(X2-X1)                                               VPC04184
      IF (IFIN.EQ.3.OR.IFIN.EQ.4) GO TO 32                              VPC04185
      YVINT=WT1*CGSELC(JVSE)+WT2*CGSELC(KVSE)                           VPC04186
      ZVBAR=(PX-XF(1))*TAN(AL/2.0)                                      VPC04187
      GAMINT=WT1*GAMSE(JVSE)+WT2*GAMSE(KVSE)                            VPC04188
      GO TO 59                                                          VPC04189
```

```
   51 GAMINT=GAMSE(KUL)                                                    VPC04190
      IF (IFIN.EQ.3.OR.IFIN.EQ.4) GO TO 52                                 VPC04191
      YVINT=CGSELC(KUL)                                                    VPC04192
      ZVBAR=(PX-XF(1))*TAN(AL/2.0)                                         VPC04193
      GO TO 59                                                             VPC04194
   52 ZVINT=CGSELC(KUL)                                                    VPC04195
      YVBAR=-(PX-XF(1))*TAN(BE/2.0)                                        VPC04196
      GO TO 53                                                             VPC04197
   59 CALL VVELS (1,X,Y,YVINT,ZVBAR,GAMINT,A,VS,WS,VRTMAX)                 VPC04198
      GO TO 35                                                             VPC04199
   32 ZVINT=WT1*CGSELC(JVSE)+WT2*CGSELC(KVSE)                              VPC04200
      YVBAR=-(PX-XF(1))*TAN(BE/2.0)                                        VPC04201
      GAMINT=WT1*GAMSE(JVSE)+WT2*GAMSE(KVSE)                               VPC04202
   53 CALL VVELS(1,X,Y,YVBAR,ZVINT,GAMINT,A,VS,WS,VRTMAX)                  VPC04203
   35 V(I)=V(I)+VS                                                         VPC04204
      W(I)=W(I)+WS                                                         VPC04205
      IFIN=IFIN+1                                                          VPC04206
      IF (IFIN.EQ.2) KUL=2*NCW                                             VPC04207
      IF (IFIN.EQ.3) KUL=3*NCW                                             VPC04208
      IF (IFIN.EQ.4) KUL=4*NCW                                             VPC04209
      GO TO 27                                                             VPC04210
   28 CONTINUE                                                             VPC04211
  100 CONTINUE                                                             VPC04212
      CALL VOTEX(NV,VX,VY,G,VV,WW)                                         VPC04213
      CAL=COS(AC)                                                          VPC04214
      DO 101 I=1,NV                                                        VPC04215
      V(I)=V(I)+VV(I)                                                      VPC04216
      W(I)=W(I)+WW(I)                                                      VPC04217
      J=2*I-1                                                              VPC04218
      K=J+1                                                                VPC04219
      WK(J)=V(I)/CAL                                                       VPC04220
      WK(K)=W(I)/CAL                                                       VPC04221
  101 CONTINUE                                                             VPC04222
      RETURN                                                               VPC04223
      END                                                                  VPC04224
```

```
      COMPLEX FUNCTION FCT(T)                                              VPC05   1
C                                                                          VPC05   2
C     VERSION: VPATH2                                                      VPC05   3
C                                                                          VPC05   4
C     FCT IS THE INTEGRAND OF THE INTEGRAL ASOCIATED WITH VELOCITY         VPC05   5
C     COMPONENTS FOR THE SINGLY DEFLECTED FIN CASE                         VPC05   6
C                                                                          VPC05   7
      COMPLEX SIG,SS                                                       VPC05   8
      COMMON AA,SIG,SS,GAM                                                 VPC05   9
      TE=COS(2.*T)-AA                                                      VPC05  10
      IF(T.GE.GAM)TE=0.                                                    VPC05  11
      FCT=2.*(SQRT(TE   )+SQRT(COS(2.*T)+AA  ))*((SS+1.)*COS(T)            VPC05  12
     1-2.*SIG)/((SS-2.*SIG*COS(T)+1.)*(SS-2.*SIG*COS(T)+1.))               VPC05  13
       RETURN                                                              VPC05  14
      END                                                                  VPC05  15
```

```
      SUBROUTINE PITROL(AL,X,Y,VS,WS)
C
C       VERSION: VPATH2
C
C    THIS SUBROUTINE COMPUTES THE CROSSFLOW VELOCITY COMPONENTS FOR A CRU
C    WING BODY COMBINATION AT ANGLE OF ATTACK AL, AND SIDESLIP ANGLE BE
C
      COMMON/BLK1/A,R,S,PI,CI
      COMPLEX Z,CI,ZA,SQ,SQS,VELAL
      AA=A*A
      Z=CMPLX(X,Y)
      ZA=Z+AA/Z
      SA=S+AA/S
      SQ=ZA*ZA-SA*SA
      AY=1.0
      IF(AIMAG(ZA).LT.0.0) AY=-1.0
      AYZ=1.0
      IF(AIMAG(SQ).LT.0.0) AYZ=-1.0
      SQS=CSQRT(SQ)*AY*AYZ
      IF((ABS(AIMAG(ZA)).LE.0.0).AND.(REAL(ZA).LT.0.0))SQS=CMPLX(-REAL(S
     1QS),AIMAG(SQS))
      VELAL=-CI*SIN(AL)*(1.-AA/Z**2)*ZA/SQS
C
C       VS....SIDEWASH INCLUDING FREE STREAM COMPONENT
C       WS....UPWASH INCLUDING FREE STREAM COMPONENT
C
      VS=REAL(VELAL)
      WS=-AIMAG(VELAL)
      RETURN
      END
```

```
      SUBROUTINE PLOTVB(X,Y,Z,NP,NIP1,NVN,NDP,ROT,XF,YF,NF,X2,Y2)
C
C       VERSION: VPATH2
C
C    ROUTINE TO GENERATE A PLOT VORTEX LOCATION RELATIVE TO
C    THE WING-BODY CONFIGURATION
C    DEFINITIONS:
C       NC    = INDEX OF CURVE
C       NIP1  = NO. OF BODY STATIONS
C       NVN   = NO. OF VORTICES
C       NF    = NO. OF WING DEFINITON CARDS
C
      DIMENSION X(NDP,52),Y(NDP,52),Z(NDP,52)
      DIMENSION NP(52),ROT(3),XCG(3),XF(7),YF(7)
      DIMENSION X2(17,18),Y2(17,18),NP2(18),SYMBOL(40)
C
      DATA LWID,LENG,XCG/ 100,50, 0.,0.,0./
      DATA SYMBOL / 1H*,1H+,1H-,1H.,1H0,1H1,1H2,1H3,1H4,1H5,1H6,
     *  1H7,1H8,1H9,1HA,1HB,1HC,1HD,1HE,1HF,1HG,1HH,1HI,1HJ,1HK,1HL,
     *   1HM,1HN,1HO,1HP,1HQ,1HR,1HS,1HT,1HU,1HV,1HW,1HX,1HY,1HZ/
      WRITE(6,10)
      WRITE(6,11)
10    FORMAT(1H1)
11    FORMAT(1H0)
C
C    FIND MAXIMUM DIAMETER
C
```

```
      BMAX=0.
      DO 100 I=1,NIP1
  100 BMAX=AMAX1(BMAX,Y(1,I+1),Z(1,I+1))
C
C  CURVE 1:  DRAW AXES
C
      NC=1
      DO 120 I=1,6
      X(I,1)=X(1,1)
      Y(I,1)=0.
  120 Z(I,1)=0.
      X(2,1)=X(1,NIP1+1)
      Y(4,1)=1.5*BMAX
      Z(6,1)=1.5*BMAX
      NP(1)=6
C
C  CURVES:  2 TO NIP1+1
C  GENERATE CROSS SECTIONS
C
      NGV=NIP1+NVN+3
      MERID=17
      DO 160 J=1,NIP1
      NC=NC+1
      B1  =X(1,NC)
      RLOC=Y(1,NC)
      BLOC=Z(1,NC)
      SLOC=Y(2,NC)
C         SAVE RLOC AND BLOC
      Y(J,NGV)=RLOC
      Z(J,NGV+1)=BLOC
      Y(J,NGV+2)=SLOC
C
C  GENERATE BODY CROSS SECTION
C
      DTH=2.*3.1415926/(MERID-1)
      DO 140 I=1,MERID
      PHI=(I-1)*DTH
      RAD=(COS(PHI)/BLOC)**2+(SIN(PHI)/RLOC)**2
      RAD=SQRT(1./RAD)
      Y(I,NC)=RAD*SIN(PHI)
      Z(I,NC)=RAD*COS(PHI)
      X(I,NC)=B1
  140 CONTINUE
  160 NP(NC)=MERID
C
C  PLOT VORTEX LOCATION (ALREADY DEFINED)
C
      DO 170 I=1,NVN
      NC=NC+1
  170 NP(NC)=NIP1
C
C  WING OUTLINE
C
      IF (NF.LE.0) GO TO 200
      DO 190 J=1,2
      NC=NC+1
      SGN=(-1)**(J+1)
      DO 180 I=1,NF
      X(I,NC)=XF(I)
      Y(I,NC)=YF(I)*SGN
      Z(I,NC)=0.0
  180 CONTINUE
      NF1=NF+1
```

```
      X(NF1,NC)=XF(1)                                                   VPC07 91
      Y(NF1,NC)=YF(1)*SGN                                               VPC07 92
      Z(NF1,NC)=0.0                                                     VPC07 93
      NP(NC)=NF1                                                        VPC07 94
190   CONTINUE                                                          VPC07 95
200   CONTINUE                                                          VPC07 96
C                                                                       VPC07 97
C  PLOT CROSS SECTIONS WITH VORTEX LOCATIONS  -------------------------VPC07 98
C                                                                       VPC07 99
      DO 240 ISECTN=1,3                                                 VPC07100
      IF (ISECTN.EQ.1) JSECTN=1                                         VPC07101
      IF (ISECTN.EQ.2) JSECTN=NIP1/2                                    VPC07102
      IF (ISECTN.EQ.3) JSECTN=NIP1                                      VPC07103
C                                                                       VPC07104
C  COPY BODY                                                            VPC07105
C                                                                       VPC07106
      DO 220 I=1,MERID                                                  VPC07107
      X2(I,1)=Y(I,JSECTN+1)                                             VPC07108
      Y2(I,1)=Z(I,JSECTN+1)                                             VPC07109
220   CONTINUE                                                          VPC07110
      NP2(1)=MERID                                                      VPC07111
      NC2=1                                                             VPC07112
C                                                                       VPC07113
C  WING OUTER BOUNDARIES                                                VPC07114
C                                                                       VPC07115
      SLOC=Y(JSECTN,NGV+2)                                              VPC07116
      X2(1,2)=SLOC                                                      VPC07117
      Y2(1,2)=0.                                                        VPC07118
      X2(2,2)=-SLOC                                                     VPC07119
      Y2(2,2)=0.                                                        VPC07120
      NP2(2)=2                                                          VPC07121
      NC2=NC2+1                                                         VPC07122
C                                                                       VPC07123
C  COPY VORTICES AT JSECTN                                              VPC07124
C                                                                       VPC07125
      DO 230 J=1,NVN                                                    VPC07126
      NC2=NC2+1                                                         VPC07127
      JCV=NIP1+1+J                                                      VPC07128
      X2(1,NC2)=Y(JSECTN,JCV)                                           VPC07129
      Y2(1,NC2)=Z(JSECTN,JCV)                                           VPC07130
      NP2(NC2)=1                                                        VPC07131
230   CONTINUE                                                          VPC07132
C                                                                       VPC07133
C  PLOT CROSS SECTIONS                                                  VPC07134
C                                                                       VPC07135
      CALL PLOTA2(X2,Y2,3,NP2,17,NC2,LWID,LENG)                         VPC07136
      WRITE(6,25) JSECTN,X(1,JSECTN+1)                                  VPC07137
      WRITE(6,24) (I,SYMBOL(I+2),I=1,NVN)                               VPC07138
240   CONTINUE                                                          VPC07139
C                                                                       VPC07140
C  PLOT PERSPECTIVE VIEWS  --------------------------------------------VPC07141
C                                                                       VPC07142
C  TOP VIEW                                                             VPC07143
      CALL PLOTA2(X,Y,3,NP,NDP,NC,LWID,LENG)                            VPC07144
C     CALL PLOTV2(X,Y,3,NP,NDP,NC,LWID,LENG,LINE,NLIM)                  VPC07145
      WRITE(6,20)                                                       VPC07146
      NSYM=NVN                                                          VPC07147
      JSYM=1+NIP1                                                       VPC07148
      JN = JSYM+NVN                                                     VPC07149
      IF (JN.GT.40) NSYM=JN-40                                          VPC07150
      WRITE(6,24) (I,SYMBOL(I+JSYM),I=1,NSYM)                           VPC07151
      IF (JN.LE.40) GO TO 210                                           VPC07152
                                                                        VPC07153
```

```
      JSYM=NSYM+1
      ISYM = NSYM                                                       VPC07154
      WRITE(6,24) (I,SYMBOL(I+ISYM),I=JSYM,NVM)                         VPC07155
210   CONTINUE                                                          VPC07156
C                                                                       VPC07157
C  SIDE VIEW                                                            VPC07158
      CALL PLOTA2(X,Z,3,NP,NDP,NC,LAID,LENG)                            VPC07159
C     CALL PLOTV2(X,Z,3,NP,NDP,NC,LAID,LENG,LINE,NLIN)                  VPC07160
      WRITE(6,21)                                                       VPC07161
C                                                                       VPC07162
C  PERSPECTIVE VIEW                                                     VPC07163
      ROT(1) = 0.                                                       VPC07164
      ROT(2)=30.                                                        VPC07165
      ROT(3)=20.                                                        VPC07166
      CALL PLOTA3(X,Y,Z,NP,NDP,NC,ROT,XCG,X,Y,3)                        VPC07167
      CALL PLOTA2(X,Y,3,NP,NDP,NC,LAID,LENG)                            VPC07168
C     CALL PLOTV2(X,Y,3,NP,NDP,NC,LAID,LENG,LINE,NLIN)                  VPC07169
      WRITE(6,22) ROT                                                   VPC07170
C                                                                       VPC07171
C                                                                       VPC07172
20    FORMAT(/20X,22HTOP VIEW  - Y VERSUS X)                            VPC07173
21    FORMAT(/20X,22HSIDE VIEW - Z VERSUS X)                            VPC07174
22    FORMAT(/20X,15HPERSPECTIVE - ROT=,3F10.2)                         VPC07175
23    FORMAT(/20X,29HBODY CROSS SECTION  - JSECTN=,I3,                  VPC07176
     *   5X,4HXIP=,F10.3)                                               VPC07177
24    FORMAT(20X,14HVORTEX SYMBOLS,10(1X,I2,1H=,A1,1H,))                VPC07178
C                                                                       VPC07179
C                                                                       VPC07180
      RETURN                                                            VPC07181
      END                                                               VPC07182


      SUBROUTINE SHAPE(X,R,S)                                           VPC08   1
C                                                                       VPC08   2
C     VERSION: VPATH2                                                   VPC08   3
C                                                                       VPC08   4
C   SUBROUTINE TO COMPUTE LOCAL BODY RADIUS AND FIN SPAN MEASURED FROM  VPC08   5
C     THE BODY CENTERLINE                                               VPC08   6
C                                                                       VPC08   7
      COMMON/VEL/AL,BE,D1,D2,D3,D4,VX(30),VY(30),G(30),NV,NDEL,NS,NF,   VPC08   8
     1XE(7),XF(7),YF(7),C(7,7),IFIN                                     VPC08   9
      IFIN=0                                                            VPC08  10
      DO 1 K=1,NS                                                       VPC08  11
      XL=XE(K)                                                          VPC08  12
      J=K                                                               VPC08  13
      IF(X.LE.XL)GO TO 2                                                VPC08  14
    1 CONTINUE                                                          VPC08  15
    2 R=C(J,1)+X*C(J,5)+X*X*C(J,6)                                      VPC08  16
      ARG=X*X*C(J,2)+X*C(J,3)+C(J,4)                                    VPC08  17
      R=R+SQRT(ARG)*C(J,7)                                              VPC08  18
      S=R                                                               VPC08  19
      IF(NF.EQ.0)RETURN                                                 VPC08  20
      IF(X.LE.XF(1).OR.X.GT.XF(NF))RETURN                               VPC08  21
      IFIN=1                                                            VPC08  22
      DO 3 K=2,NF                                                       VPC08  23
      J=K                                                               VPC08  24
      XL=XF(K)                                                          VPC08  25
      IF(X.LE.XL)GO TO 4                                                VPC08  26
    3 CONTINUE                                                          VPC08  27
    4 J1=J-1                                                            VPC08  28
      S=(X-XF(J1))*(YF(J)-YF(J1))/(XF(J)-XF(J1))+YF(J1)                 VPC08  29
      RETURN                                                            VPC08  30
      END                                                               VPC08  31
```

```
      COMPLEX FUNCTION SIMP(A,B,N,F)                                    VPC09   1
C                                                                       VPC09   2
C     VERSION: VPATH2                                                   VPC09   3
C                                                                       VPC09   4
C     SIMP INTEGRATES THE INTEGRAL INVOLVING FCT AS SET UP IN CRUCI     VPC09   5
C                                                                       VPC09   6
      EXTERNAL F                                                        VPC09   7
      COMPLEX F,SUMEND,SUMID                                            VPC09   8
      TWOH=(B-A)/N                                                      VPC09   9
      H=TWOH/2.                                                         VPC09  10
      SUMEND=CMPLX(0.,0.)                                               VPC09  11
      SUMID=CMPLX(0.,0.)                                                VPC09  12
      DO 1 K=1,N                                                        VPC09  13
      X=A+FLOAT(K-1)*TWOH                                               VPC09  14
      SUMEND=SUMEND+F(X)                                                VPC09  15
    1 SUMID=SUMID+F(X+H)                                                VPC09  16
      SIMP=(2.*SUMEND+4.*SUMID-F(A)+F(B))*H/3.                          VPC09  17
      RETURN                                                            VPC09  18
      END                                                               VPC09  19
```

```
      SUBROUTINE SYMFIN(NC,D,X,Y,VS,WS)                                 VPC10   1
C                                                                       VPC10   2
C     VERSION: VPATH2                                                   VPC10   3
C                                                                       VPC10   4
C  THIS SUBROUTINE COMPUTES THE CROSSFLOW VELOCITY COMPONENTS VS,WS     VPC10   5
C  AT THE POINT X,Y, INDUCED BY  A SYMMETRIC DEFLECTION OF A PAIR OF FIVPC10   6
C  BY AN ANGLE D RADIANS IN A CRUCIFORM WING BODY COMBINATION .  THE COVPC10   7
C  NC DETERMINES WHICH PAIR OF FINS ARE DEFLECTED. IF NC=1, HORIZONTAL VPC10   8
C  IF NC=2 IT IS THE VERTICAL PAIR  .                                   VPC10   9
C                                                                       VPC10  10
      COMMON/BLK1/A,R ,S,PI,CI                                          VPC10  11
      COMPLEX CI,T,TT,TPA,SQ,CC,   T2,T3,T4,VEL,TMA,TI,CLI,ARG,TINV,CCS VPC10  12
      R0=.5*(S+A*A/S)                                                   VPC10  13
      XS=X                                                              VPC10  14
      YS=Y                                                              VPC10  15
C                                                                       VPC10  16
C  IF THE VERTICAL FINS ARE DEFLECTED ROTATE (X,Y) BY PI/2              VPC10  17
C                                                                       VPC10  18
      IF(NC.NE.2)GO TO 1                                                VPC10  19
      XS=Y                                                              VPC10  20
      YS=-X                                                             VPC10  21
    1 T=CMPLX(ABS(XS),ABS(YS))                                          VPC10  22
      TT=T*T                                                            VPC10  23
      AA=A*A                                                            VPC10  24
      TPA=TT+AA                                                         VPC10  25
      R00=R0*R0                                                         VPC10  26
      SQ=TPA*TPA                                                        VPC10  27
      TMA=TT-AA                                                         VPC10  28
      CCS=SQ-4.*R00*TT                                                  VPC10  29
      SRT=SQRT(1.-AA/R00)                                               VPC10  30
      IF(AIMAG(CCS).GE.0.)CC= CSQRT(CCS)                                VPC10  31
      IF(AIMAG(CCS).LT.0.)CC=-CSQRT(CCS)                                VPC10  32
C                                                                       VPC10  33
C.... SECOND TERM                                                       VPC10  34
      TI=TPA*SRT/(A*CC/R0)                                              VPC10  35
      ARG=(CI+TI)/(CI-TI)                                               VPC10  36
      CLI=CLOG(ARG)                                                     VPC10  37
      TINV=CI*.5*CLI                                                    VPC10  38
      T2= (TMA/TT)*.5*CLI                                               VPC10  39
```

```
C... THIRD TERM
      T3=-CI*PI*.5*TPA/TT
C .... FOURTH TERM
      T4=CI*TMA*TPA*(PI*.5+ACOS(A/R0))/(CC*TT)
C.... VELOCITY
      VEL=-D*( T2+T3+T4)/PI
      V=REAL(VEL)
      W=-AIMAG(VEL)
      IF(XS*YS.LT.0.)V=-V
      VS=V
      WS=W
      IF(MC.NE.2)RETURN
      VS=-W
      WS=V
      RETURN
      END
```

```
      SUBROUTINE VOTEX(NV,XV,YV,GV,VV,WW)
C
C     VERSION: VPATH2
C
C   THIS SUBROUTINE COMPUTES THE PERTURBATION VELOCITY COMPONENTS AT THE
C     VORTEX LOCATIONS ACCOUNTING FOR MUTUAL EFFECTS AND THE PRESENCE
C     OF A CRUCIFORM WING  BODY COMBINATION
C
      DIMENSION XV(30),YV(30),GV(30),VV(30),WW(30)
      DIMENSION VX(30),VY(30),G(30)
      COMMON/V/A4,R4
      COMMON/BLK1/A,R,S,PI,CI
      EXTERNAL Z
      COMPLEX CI,T0,Z,S0,T2,S2,T3,S3,T4,S4,TMA4,SMR4,DSDT,DTDS,D2SDT
     1,V1,V2,V3,VEL,TAU,S1,S0B,S1B
      NN=NV-1
      AA=A*A
      A4=AA*AA
      RR=R*R
      R4=RR*RR
      DO 100 I=1,NV
      X0=XV(I)
      Y0=YV(I)
      G0=GV(I)
      K1=0
      DO 99 J=1,NV
      IF(J.EQ.I)GO TO 99
      K1=K1+1
      VX(K1)=XV(J)
      VY(K1)=YV(J)
      G(K1)=GV(J)
   99 CONTINUE
      T0=CMPLX(X0,Y0)
      S0=Z(T0)
      S0B=CONJG(S0)
      T2=T0*T0
      T3=T0*T2
      T4=T2*T2
      S2=S0*S0
      S3=S2*S0
      S4=S2*S2
      TMA4=T4-A4
      SMR4=S4-R4
```

```
      DSDT=TMA4*S3/(T3*SMR4)
      DTDS=SMR4*T3/(S3*TMA4)
      D2SDT=S3*(T3+3.*A4)/(SMR4*T4)-S2*DSDT*TMA4*(S4+3.*R4)/
     1(T3*SMR4*SMR4)
      V1=-G0*DTDS*D2SDT/2.
      V2=G0*DSDT*S0B/(S0B*S0-RR)
      V3=CMPLX(0.,0.)
      DO 3 K=1,NN
      TAU=CMPLX(VX(K),VY(K))
      SI=Z(TAU)
      SIB=CONJG(SI)
    3 V3=V3-G(K)*(1./(S0-SI)-SIB/(S0*SIB-RR))*DSDT
      VEL=CI*(V1+V2+V3)/(PI+PI)
      VV(I)=REAL(VEL)
      WW(I)=-AIMAG(VEL)
  100 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE VVELS(NV,YY,ZZ,VX,VY,G,RB,V,W,VRTMAX)
C
C     VERSION: VPATH2
C
C     THIS SUBROUTINE COMPUTES PERTURBATION VELOCITY COMPONENTS DUE TO
C     NV EXTERNAL VORTICES AND THEIR IMAGES INSIDE A BODY WITH CIRCULAR
C     CROSS SECTION.
C     CENTER VORTEX EFFECTS ARE NOT ACCOUNTED FOR.
C
      DIMENSION VX(1),VY(1),G(1)
C
      TLC=0.000001
      PI=3.1415926
      V=0.
      W=0.
      Y=YY/RB
      Z=ZZ/RB
      DO 1 I=1,NV
      GG=G(I)/(2.*PI*RB)
      XV=VX(I)/RB
      YV=VY(I)/RB
      ZVS=XV*XV+YV*YV
      DY=Y-XV
      DZ=Z-YV
      DYS=DY*DY
      DZS=DZ*DZ
      DEN1=DYS+DZS
      IF(DEN1.LE.TLC)GO TO 2
      V=V-GG*DZ/DEN1
      W=W+GG*DY/DEN1
    2 DEN2=(Y-XV/ZVS)**2+(Z-YV/ZVS)**2
      IF(ABS(DEN2).LE.TLC) GO TO 3
      V=V+GG*(Z-YV/ZVS)/DEN2
      W=W-GG*(Y-XV/ZVS)/DEN2
    3 CONTINUE
C
C     LIMIT MAGNITUDE OF PERTURBATION VELOCITIES TO VRTMAX.
C
    1 CONTINUE
      IF (V.GT.0.0.AND.ABS(V).GE.VRTMAX) V=VRTMAX
```

```
      IF (V.LT.0.0.AND.ABS(V).GE.VRTMAX) V=-VRTMAX
      IF (W.GT.0.0.AND.ABS(W).GE.VRTMAX) W=VRTMAX
      IF (W.LT.0.0.AND.ABS(W).GE.VRTMAX) W=-VRTMAX
      RETURN
      END
```

```
      COMPLEX FUNCTION Z(CT)
C
C     VERSION: VPATH2
C
C     THIS FUNCTION ROUTINE CALCULATES THE SIGMA VALUE IN THE
C     TRANSFORMED (CIRCLE) PLANE FOR GIVEN TAU IN THE PHYSICAL PLANE
C     TAU=X+IY
C
      COMMON/V/A4,R4
      COMPLEX T,TT,TPA,STP,SI,TPA2,SSI,SSTP,CT
      RT=ABS(REAL(CT))
      RI=ABS(AIMAG(CT))
      IR=0
      II=0
      IF(RT.NE.0.)IR=REAL(CT)/RT
      IF(RI.NE.0.)II=AIMAG(CT)/RI
      T=CMPLX(RT,RI)
      TT=T*T
      TPA=TT+A4/TT
      TPA2=TPA*TPA
      STP=TPA2-4.*R4
      AY=1.0
      IF(AIMAG(TPA).LT.0.0) AY=-1.0
      AYZ=1.0
      IF(AIMAG(STP).LT.0.0) AYZ=-1.0
      SSTP=CSQRT(STP)*AY*AYZ
      IF((ABS(AIMAG(TPA)).LE.0.0).AND.(REAL(TPA).LT.0.0))
     1      SSTP=CMPLX(-REAL(SSTP),AIMAG(SSTP))
      SSI=.5*(TPA+SSTP)
      SI=CSQRT(SSI)
      Z=CMPLX(IR*ABS(REAL(SI)),II*ABS(AIMAG(SI)))
      RETURN
      END
```

# PROGRAM VPATHL

# PROGRAM VPATHL

```
      PROGRAM VPATHL(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE4,TAPE7)
C
C          THIS PROGRAM COMPUTES THE PATHS AND VORTEX INDUCED CROSSFLOW
C    VELOCITIES AT SPECIFIED FIELD POINTS FOR A SET OF VORTICES IN THE
C    PRESENCE OF A WING=BODY COMBINATION AT ANGLE OF ATTACK AND ROLL.
C       SLENDER BODY THEORY IS USED IN THE COMPUTATION OF THE CROSSFLOW
C       VELOCITIES.  THE BODY IS ASSUMED TO HAVE ELLIPTICAL CROSS SECTION.
C
C
C   THE COORDINATE SYSTEM USED HERE IS THE BODY COORDINATE SYSTEM
C   WITH THE X=AXIS ALONG THE BODY CENTER=LINE STARTING AT THE NOSE TIP,
C      Y=AXIS TO THE RIGHT WHEN LOOKING FORWARD,Z=AXIS UP.
C
C
C   **********NOTE: WINGS ONLY - NO VERTICAL SURFACES*********************
C
C
      DIMENSION TITLE(20),X0(60),XIP(50),NK(120)
      DIMENSION VXP(30,30,2),NVV(30)
C
      COMMON/VEL/AL,BE,              VX(30).VY(30),G(30),NV.      NS,NF,
     1XE(7),XF(7),YF(7),C(7,7),IFIN
      COMMON/BLK2/AC,PHI
      COMMON/FINLE/XLE(80),CGLOC(80),GAMLE(80),MSWR,MSWL,MSWU,MSWD,
     1 NEDGV,XTIPLE
      COMMON/STGEDG/XSE(80),CGSELC(80),GAMSE(80),NCW,NSIDGE,XTIPTE
      COMMON/COMB/BFACT
      COMMON XPLT(30,52),YPLT(30,52),ZPLT(30,52),NPLT(52),ROT(5)
     *   ,XP2(17,16),YP2(17,18)
      COMMON /BSCALE/ XMAX,XMIN,YMAX,YMIN
      COMMON/PARAM/NOUT
C
      NAMELIST/DEBUG/NS,NF,NIP,NCPIN,NVLOUT,NOUT,VRTMAX,XE,C,XF,YF,NVV
C
    1 FORMAT(20A4)
    4 FORMAT(8I10)
    5 FORMAT(7F10.5)
    6 FORMAT(8F10.5)
    7 FORMAT(6F10.5)
    9 FORMAT(/5X,34HLOCAL BODY HORIZONTAL SEMI=AXIS = ,F10.5/5X,
     1              34HLOCAL BODY VERTICAL SEMI=AXIS   = ,F10.5/5X,
     2              34HLOCAL SEMI SPAN S               = ,F10.5/)
   11 FORMAT (//5X,35H INCLUDED ANGLE OF ATTACK(DEG) = ,F10.5,
     1 24H      ROLL ANGLE(DEG)   = ,F10.5/)
   21 FORMAT(//19H        X=STATION NO.,I3,9H        X=,F6.3,6X,
     1 25H INTEGRATION STEP SIZE = ,F10.5//)
   22 FORMAT(I15,4X,2E17.5,E15.5)
   25 FORMAT (////10X,36HVORTEX COORDINATES IN CROSS=FLOW PLANE,//)
   26 FORMAT (//43H             INITIAL VORTEX POSITIONS AT   X = ,F6.3/)
   27 FORMAT (10X,7H VORTEX,10X,7H Y,VRTX,10X,7H Z,VRTX,6X,
     1   10HGAMMA/VINF/)
   30 FORMAT(16I5)
   31 FORMAT(/// 6X,76HCROSSFLOW VELOCITIES AT CONTROL POINTS INDUCED BY
     1 VORTICES AND THEIR IMAGES.,//
     1 6X,2HIC,10X,6HX,BODY,10X,6HY,BODY,10X,6HZ,BODY,10X,1HV,15X,1HW)
   32 FORMAT(5X,I3,6X,5E15.5)
   40 FORMAT(3F10.5)
  700 FORMAT (//5(1H*), 59HPERMISSIBLE RELATIVE ERROR,E5,USED IN INTEGRA
     1TION SCHEME = ,F12.5/)
  701 FORMAT (////5(1H*),61HSUBROUTINE DASCRU CAN NOT OBTAIN VALUE FOR I
     1NTEGRATION STEP H,5(1H*)////)
  702 FORMAT (85X,I3,2F10.5)
  703 FORMAT (//85X,31HINTERPOLATED VORTEX COORDINATES/87X,1HI,5X,
```

```
     1   2HYV,10X,2HZV/)                                                  VPL01 64
 704 FORMAT (////17X,12HFIN GEOMETRY/10X,12HFIN SEMISPAN,11X,1H=,1X,      VPL01 65
     A F10.5/                                                             VPL01 66
     1        10X,25HFIN ROOTCHORD             = ,F10.5/                  VPL01 67
     8        10X,25HFIN ROOT L.E. X-STATION= ,F10.5/                     VPL01 68
     2        10X,25H          L.E. Y-STATION= ,F10.5/                    VPL01 69
     3        10X,25HFIN TIP L.E. X-STATION = ,F10.5/                     VPL01 70
     4        10X,25H          L.E. Y-STATION = ,F10.5/                   VPL01 71
     5        10X,25HFIN TIP T.E. X-STATION = ,F10.5/                     VPL01 72
     6        10X,25H          T.E. Y-STATION = ,F10.5/                   VPL01 73
     8        10X,25HFIN ROOT T.E. X-STATION= ,F10.5/                     VPL01 74
     9        10X,25H          T.E. Y-STATION= ,F10.5,////)               VPL01 75
 705 FORMAT (6X,I2,2X,F10.5,1X,F10.5,1X,F10.5)                            VPL01 76
 706 FORMAT (////10X,26HFIN LEADING EDGE VORTICITY/                       VPL01 77
     1 5X,3HJLE,6X,1HX,7X,10HY OR Z BAR,2X,11HGAMMA/VINF,/)               VPL01 78
 707 FORMAT (////10X,25HFIN SIDE EDGE VORTICITY/5X,3HJSE,6X,1HX,7X,       VPL01 79
     1    10HY OR Z BAR,2X,11HGAMMA/VINF,/)                               VPL01 80
 745 FORMAT (I5,3E12.5)                                                   VPL01 81
 746 FORMAT (I5,5E12.5)                                                   VPL01 82
C                                                                         VPL01 83
C                                                                         VPL01 84
C                                                                         VPL01 85
      RAD=3.1415926/180.                                                  VPL01 86
C                                                                         VPL01 87
C                                                                         VPL01 88
C       .........  INPUT  ...........                                     VPL01 89
C                                                                         VPL01 90
  99 READ(5,1)TITLE                                                       VPL01 91
     IF(EOF(5))2,3                                                        VPL01 92
   3 CONTINUE                                                             VPL01 93
C                                                                         VPL01 94
C   .. GEOMETRY ..                                                        VPL01 95
C                                                                         VPL01 96
C                                                                         VPL01 97
C         NS=NO. OF BODY SECTIONS WITH DIFFERENT GEOMETRY                 VPL01 98
C         NF= NO. OF CORNER POINTS USED TO DESCRIBE RIGHT WING PANEL.     VPL01 99
C         NTP= NO. OF X= STATIONS PRINTED IN OUTPUT                       VPL01100
C      NCPIN,NVLOUT GOVERN READING FROM AND WRITING ON DATA SETS.         VPL01101
C      NOUT=1 GIVES ADDITIONAL OUTPUT                                     VPL01102
C      IPLT =0 ....NO PLOTS IN PRINTED OUTPUT                             VPL01103
C            1 ....READ IN MAX. AND MIN.X*S AND Y*S                       VPL01104
C            5 ....PLOTS WILL BE SIZED AUTOMATICALLY                      VPL01105
C                                                                         VPL01106
C         XE= X VALUES AT THE END OF EACH BODY SECTION                    VPL01107
C         C= COEFFICIENTS IN THE BODY GEOMETRY EQUATION                   VPL01108
C                                                                         VPL01109
C         XF,YF= X AND Y COODS OF THE WING BREAK IN SWEEP POINTS.         VPL01110
C                                                                         VPL01111
C         RFACT=VERTICAL AXIS/HORIZONTAL AXIS                             VPL01112
C                                                                         VPL01113
      READ(5,4)NS,NF,NIP,NCPIN,NVLOUT,NOUT,IPLT                           VPL01114
      READ(5,5) RFACT                                                     VPL01115
      READ(5,5)(XE(I),I=1,NS)                                             VPL01116
      READ(5,5)((C(I,J),J=1,7),I=1,NS)                                    VPL01117
      IF(NF.NE.0) READ(5,6)(XF(I),YF(I),I=1,NF)                           VPL01118
      IF (IPLT.EQ.1) READ (5,6) XMAX,XMIN,YMAX,YMIN                       VPL01119
C                                                                         VPL01120
C                                                                         VPL01121
C      DETERMINE DISTANCE FROM BODY CENTERLINE TO WING TIP(=SEMISPAN)     VPL01122
C      AND X-LOCATIONS OF WING TIP LEADING EDGE AND TRAILING EDGE.        VPL01123
C                                                                         VPL01124
      IF (NF.EQ.0) GO TO 84                                               VPL01125
      YMAX=0                                                              VPL01126
```

```
      CRP=SQRT((XF(NF)-XF(1))*(XF(NF)-XF(1))+(YF(NF)-YF(1))*(YF(NF)-    VPL01127
     1 YF(1)))                                                          VPL01128
      DO 80 I=1,NF                                                      VPL01129
      IF (YF(I).GT.YMAX) YMAX=YF(I)                                     VPL01130
   80 CONTINUE                                                          VPL01131
      NFM1=NF-1                                                         VPL01132
      DO 81 I=1,NFM1                                                    VPL01133
      IP1=I+1                                                           VPL01134
      IF (YF(I).EQ.YMAX.AND.YF(IP1).EQ.YMAX) GO TO 82                   VPL01135
      IF (YF(I).EQ.YMAX) GO TO 83                                       VPL01136
   81 CONTINUE                                                          VPL01137
      GO TO 84                                                          VPL01138
   82 IMAX=I                                                            VPL01139
      IMAXP1=I+1                                                        VPL01140
      XTIPLE=XF(IMAX)                                                   VPL01141
      YTIPLE= YF(IMAX)                                                  VPL01142
      XTIPTE=XF(IMAXP1)                                                 VPL01143
      YTIPTE= YF(IMAXP1)                                                VPL01144
      GO TO 84                                                          VPL01145
   83 XTIPLE=XF(IMAX)                                                   VPL01146
      XTIPTE=XTIPLE                                                     VPL01147
   84 CONTINUE                                                          VPL01148
C                                                                       VPL01149
C                                                                       VPL01150
C                                                                       VPL01151
C         ALFAC =INCLUDED ANGLE OF ATTACK,  PHI=ROLL ANGLE BOTH IN DEGREEVPL01152
C         ES = PERMISSIBLE RELATIVE ERROR IN THE PATH INTEGRATION SCHEME VPL01153
C                                                                       VPL01154
      READ(5,6)ALFAC,PHI,ES,VRTMAX                                      VPL01155
      IF (VRTMAX.EQ.0.0) VRTMAX=0.35                                    VPL01156
C                                                                       VPL01157
C   .. X-STATIONS,INTEGRATION INFO, + INITIAL VORTEX POSITIONS AND STRENGVPL01158
C                                                                       VPL01159
C                                                                       VPL01160
C         NVV = TOTAL NUMBER OF VORTICES AT EACH X-STATION              VPL01161
C                                                                       VPL01162
C                                                                       VPL01163
C                                                                       VPL01164
      READ(5,30)(NVV(I),I=1,NIP)                                        VPL01165
      NV=NVV(1)                                                         VPL01166
      NVMAX=NVV(NIP)                                                    VPL01167
C                                                                       VPL01168
C         READ IN CROSSFLOW STARTING COORDINATES AND STRENGTHS FOR ALL  VPL01169
C         VORTICES REGARDLESS OF THE X-STATION AT WHICH THEY START.     VPL01170
C     THIS INFO MUST BE INPUT FOR INCREASING X-STATION.                 VPL01171
C     HERE....VX(I)..Y-COORDINATE                                       VPL01172
C             VY(I)..Z-COORDINATE                                       VPL01173
C             G(I)...GAMMA/VINF,COUNTERCLOCKWISE POSITIVE,              VPL01174
C                    WHEN VIEWING FORWARD.                              VPL01175
C                                                                       VPL01176
      READ(5,7)(VX(I),VY(I),G(I),I=1,NVMAX)                             VPL01177
      DO 8 I=1,NV                                                       VPL01178
      J=2*I-1                                                           VPL01179
      K=J+1                                                             VPL01180
      VXP(1,I,1)=VX(I)                                                  VPL01181
      VXP(1,I,2)=VY(I)                                                  VPL01182
      XO(J)=VX(I)                                                       VPL01183
    8 XO(K)=VY(I)                                                       VPL01184
C                                                                       VPL01185
C         XIP= X- VALUES AT THE NIP X-STATIONS AT WHICH OUTPUT REQD.    VPL01186
C         FIRST VALUE FOR XIP CAN BE ANY NUMBER LARGER THAN ZERO        VPL01187
C         INTEGRATION STARTS AT XIP(1)                                  VPL01188
C         INTEGRATION STEP SIZE DETERMINED BY DASCRU...H                VPL01189
```

```
C
      READ(5,6)(XIP(I),I=1,NIP)
C
C
      WRITE(6,1)TITLE
      IF (NF.NE.0)
     1WRITE (6,704) YMAX,CRP,XF(1),YF(1),XTIPLE,YTIPLE,XTIPTE,YTIPTE,
     1 XF(NF),YF(NF)
      WRITE(6,11)ALFAC,PHI
      IF (NOUT.NE.0) WRITE (6,DEBUG)
C
C
C     READ NUMBERS OF WING LEADING EDGE VORTEX INFO STATIONS XLE FOR
C     EACH WING.
C     FOR EACH XLE STATION,READ IN YBAR AND STRENGTH OF THE VORTICITY
C     DISTRIBUTION.
C
C  NOTE: XLE AND XSE ARE READ IN IN THE WING COORDINATE SYSTEM AND
C     MUST BE TRANSFORMED TO BODY COORDINATE SYSTEM.
C
      READ (5,4) MSWR,MSWL
      NEDGV=MSWR+MSWL
      IF (NEDGV.EQ.0) GO TO 19
                          READ (5,7) (XLE(IFV),CGLOC(IFV),GAMLE(IFV),
     1  IFV=1,NEDGV)
      WRITE (6,706)
      DO 15 JLE=1,NEDGV
      XLE(JLE)=XLE(JLE)+XF(1)
   15 WRITE (6,705) JLE,XLE(JLE),CGLOC(JLE),GAMLE(JLE)
   19 CONTINUE
C
C     READ NUMBER OF WING SIDE EDGE VORTEX INFO STATIONS XSE FOR EACH
C     WING.
C     FOR EACH XSE STATION,READ IN YBAR AND STRENGTH OF THE VORTICITY
C     DISTRIBUTION.
C
      READ (5,4) NCW
      NSIDGE=2*NCW
      IF (NSIDGE.EQ.0) GO TO 18
                          READ (5,7) (XSE(JSE),CGSELC(JSE),GAMSE(JSE),
     1 JSE=1,NSIDGE)
      WRITE (6,707)
      DO 16 JSE=1,NSIDGE
      XSE(JSE)=XSE(JSE)+XF(1)
   16 WRITE (6,705) JSE,XSE(JSE),CGSELC(JSE),GAMSE(JSE)
   18 CONTINUE
C
C
C  NOTE: HERE  RLOC.....HORIZONTAL SEMI-AXIS.
C              BLOC.....VERTICAL SEMI-AXIS.
C
C
      WRITE (6,700) ES
      WRITE (6,25)
      WRITE(6,26)XIP(1)
      CALL SHAPE (XIP(1),RLOC,BLOC,SLOC,RPLOC)
      WRITE (6,9) RLOC,BLOC,SLOC
      WRITE(6,27)
      WRITE(6,22)(L,VX(L),VY(L),G(L),L=1,NV)
C
C         CONVERT ANGLES TO RADIANS
C
      AC=ALFAC*RAD
```

```
      BE=PHI*RAD
      PHI=BE
      AL=ASIN(SIN(AC)*COS(BE))
      BE=ASIN(SIN(AC)*SIN(BE))
C
C   ......COMPUTE VORTEX PATHS USING DASCRU INTEGRATION SUBROUTINE......
C
      NIP1=NIP-1
      H=XIP(2)-XIP(1)
      DO 20 I=1,NIP1
      I1=I+1
      NV=NVV(I)
      NVN=NVV(I1)
      NV1=NV+1
      N=2*NV
      A1=XIP(I)
      B1=XIP(I+1)
C
      CALL DASCRU(A1,B1,H,N,XO,WK,IER,ES,VRTMAX)
C
C        IF IER GREATER THAN 32.DASCRU HAD TROUBLE GETTING STEP SIZE,
C        THEN,RATHER THAN CONTINUING WITH THE INTEGRATION, STOP 40
C        REDUCE XIP(2)-XIP(1)AND RERUN
C
      IF (IER.GE.32) GO TO 28
      GO TO 29
   28 WRITE (6,701)
      STOP 40
   29 CONTINUE
C
C
C   .. ADD THE NEW VORTICES AND THEIR POSITIONS FOR THE NEXT X-INTERVAL
C
      IF(NVN.EQ.NV)GO TO 39
      DO 35 K1=NV1,NVN
      JL=2*K1-1
      KK=JL+1
      XO(JL)=VX(K1)
   35 XO(KK)=VY(K1)
   39 CONTINUE
C
C   .. OUTPUT VORTEX POSITIONS AND CONFIGURATION CHARACTERISTICS AT THIS
C      STATION.
C
      WRITE(6,21)I1,B1,H
      CALL SHAPE (B1,RLOC,BLOC,SLOC,HPLOC)
      WRITE (6,9) HLOC,BLOC,SLOC
C
C   SAVE BODY POINTS FOR PLOT
C
      XPLT(1,I1)=B1
      YPLT(1,I1)=RLOC
      ZPLT(1,I1)=HLOC
      YPLT(2,I1)=SLOC
      WRITE(6,27)
      DO 23 L=1,NVN
      J=2*L-1
      K=J+1
      VXP(I1,L,1)=XO(J)
      VXP(I1,L,2)=XO(K)
      WRITE(6,22)L,XO(J),XO(K),G(L)
C
C   SAVE VORTEX LOCATION FOR PLOT
```

```
C
      JCV=NIP1+L+1
      XPLT(I,JCV)=B1
      YPLT(I,JCV)=XO(J)
      ZPLT(I,JCV)=XO(K)
   23 CONTINUE
   20 CONTINUE
C
C   PLOT VORTEX LOCATIONS
C
      XPLT(1,1)=XIP(1)
      IF (IPLT.GT.0)
     * CALL PLOTVB(XPLT,YPLT,ZPLT,NPLT,NIP1,NVN,30,ROT,XF,YF,NF,XP2,YP2,
     *             IPLT)
C
C..COMPUTE VELOCITIES AT THE SPECIFIED CONTROL POINTS INDUCED BY NV
C    EXTERNAL VORTICES AND THEIR IMAGES.
C
C
C   NOTE: IF CONTROL POINTS ARE PASSED THROUGH BY MEANS OF A DATA SET
C      I.E. WHEN NCPIN IS NOT EQUAL TO 0,     INDEX NCP IS READ IN FROM
C      THE DATA SET ALSO.
C   NOTE:X-COORDINATE OF CONTROL POINT MUST THEN BE TRANSFORMED TO BODY
C      COORDINATE SYSTEM.
C      THIS IS DONE BELOW.
C
C
      NCP=0
      IF (NCPIN.NE.0) REWIND 4
      IF (NVLOUT.NE.0) REWIND 7
      IF (NCPIN.EQ.0) GO TO 72
      IF (NCPIN.NE.0) READ (4,745) NCP
      IF (EOF(4).NE.0) GO TO 99
      GO TO 73
   72 READ (5,4) NCP
   73 CONTINUE
      IF(NCP.EQ.0)GO TO 99
      WRITE(6,31)
      DO 69 J11=1,NCP
      IF (NCPIN.EQ.0) GO TO 70
      READ (4,745) IC,CPX,CPY,CPZ
      CPX=CPX+XF(1)
      GO TO 71
   70 READ(5,60)CPX,CPY,CPZ
   71 CONTINUE
C
C.. DETERMINE THE X-STATIONS ADJACENT TO THE CONTROL POINT
C
      DO 61 I=1,NIP
      IF (CPX.LT.XIP(1)) GO TO 69
      J=I-1
      IF (I.EQ.1) J=1
      IF(CPX.LE.XIP(I))GO TO 62
   61 CONTINUE
C
C   DETERMINE BY INTERPOLATION THE POSITION IN THE CROSSFLOW PLANE OF ALL
C      VORTICES AT EACH STATION CPX.
C
   62 K=J+1
      X1=XIP(J)
      X2=XIP(K)
      WT1=(X2-CPX)/(X2-X1)
      WT2=(CPX-X1)/(X2-X1)
```

```
      NV=NVV(J)
      CALL SHAPE (CPX,RB,BL,SL,RPL)
      IF (NOUT.NE.0) WRITE (6,703)
      DO 63 I=1,NV
      VX(I)=WT1*VXP(J,I,1)+WT2*VXP(K,I,1)
      VY(I)=WT1*VXP(J,I,2)+WT2*VXP(K,I,2)
      IF (NOUT.EQ.0) GO TO 63
      WRITE (6,702) I,VX(I),VY(I)
   63 CONTINUE
C
      THETP=ATAN2(CPZ,CPY)
      SINTH=SIN(THETP)
      COSTH=COS(THETP)
      RCPT=SQRT(CPY*CPY+CPZ*CPZ)
      RBODY=SQRT(1.0/((SINTH/BL)**2+(COSTH/RB)**2))
      IF (RCPT.LE.RBODY) GO TO 64
      GO TO 65
   64 RBODYP=1.01*RBODY
      CPY=RBODYP*COSTH
      CPZ=RBODYP*SINTH
   65 CONTINUE
C
C     SUBROUTINE VVELS CALCULATES VELOCITIES INDUCED BY EXTERNAL
C     VORTICES AROUND ELLIPTICAL CROSS SECTION BODY BY SETTING S=RB IN
C     THE ARGUMENT LIST.
C
      CALL VVELS(NV,CPY,CPZ,VX,VY,G,RB,BL,RB,V,W,VRTMAX)
      WRITE(6,32) J11,CPX,CPY,CPZ,V,W
      IF (NVLOUT.EQ.0) GO TO 69
      IC=J11
      WRITE (7,746) IC,CPX,CPY,CPZ,V,W
   69 CONTINUE
      GO TO 99
    2 STOP
      END
```

```
      SUBROUTINE DASCRU (A,B,H,N,X0,WK,IER,ES,VRTMAX)
C
C     THIS SUBROUTINE PERFORMS INTEGRATION
C
C                                       ES SHOULD BE SET TO .5 TIMES THE
C                                       DESIRED RELATIVE PRECISION OF
C                                       THE SOLUTION
C
      DIMENSION             WK(1),X0(1)
C
      INTEGER               SW
C
      LOGICAL               BE,BH,BR,BX
C
      DATA                  ZERO,PS,OPS,THREE,FOUR/0.,.5,1.5,3.,4./
C
      IER = 0
      IF(A - B) 4,100,4
    4 IB1=N+N
      IB2=IB1+N
      HMIN=0.01*ABS(H)
```

```
      BH=.TRUE.
      BR=.TRUE.
      BX=.TRUE.
C
C                                        CHECK FOR THE PROPER SIGN OF H
C
      H=SIGN(ABS(H),B-A)
      X=A
    5 XS=X
      DO 10  J=1,N
         IJK0=N+J
         WK(IJK0)=X0(J)
   10 CONTINUE
   15 HS=H
      Q=X+H-B
      BE=.TRUE.
      IF(.NOT.((H.GT.ZERO.AND.Q.GE.ZERO).OR.(H.LT.ZERO.AND.Q.LE.ZERO)))
     1      GO TO 20
      H=B-X
      BR=.FALSE.
   20 HS=H/THREE
C
C                                        CALCULATE SOLN. AT X+H
C    NOTE: ARRAY WK CONTAINS V FOR ODD INDEX,W FOR EVEN INDEX.
C
C
      DO 90  SW=1,5
         CALL F(X0,X,N,WK,VDTMAX)
         DO 70  I=1,N
            Q=HS*WK(I)
            IJK0=N+I
            IJK1=IM1+I
            IJK2=IM2+I
            GO TO (25,30,35,40,45),SW
   25       R=Q
            WK(IJK1)=Q
            GO TO 50
   30       R=P5*(Q+WK(IJK1))
            GO TO 50
   35       R=THREE*Q
            WK(IJK2)=R
            R=.375*(R+WK(IJK1))
            GO TO 50
   40       R=WK(IJK1)+FOUR*Q
            WK(IJK1)=R
            R=OP5*(R-WK(IJK2))
            GO TO 50
   45       R=P5*(Q+WK(IJK1))
            G= ABS(R+R - OP5*(Q+WK(IJK2)))
   50       X0(I)=WK(IJK0)+R
            IF(SW.NE.5) GO TO 70
C
C                                        AUTOMATIC STEP CHANGE
C
            E=ABS(X0(I))
            R=ES
            IF(E.GE.1.E-3) R=E*ES
C
C                                        TEST ADJUSTMENT OF THE STEP
C
            IF(G.LT.R.OR.(.NOT.BX)) GO TO 65
            BR=.TRUE.
            BH=.FALSE.
```

```
            H=P5*H
            IF(ABS(H).GE.HMIN) GO TO 55
C
C                                  THE STEP IS HALVED RESTORE X AND X0,
C                                  AND GO BACK FOR REPEATED INTEGRATION
C                                  WITH THIS NEW STEP
C
            H=SIGN(1.,H)*HMIN
            BX=.FALSE.
   55       DO 60  J=1,N
             IJK0=N+J
              X0(J)=WK(IJK0)
   60       CONTINUE
            X=XS
            GO TO 15
   65       IF(Q.GE.0.03125*R) BE=.FALSE.
   70    CONTINUE
         GO TO (75,90,80,85,90),SW
   75    X=X+H3
         GO TO 90
   80    X=X+P5*H3
         GO TO 90
   85    X=X+P5*H
   90 CONTINUE
C
C                                  TEST A POSSIBLE DOUBLING OF THE STEP
C
      IF(.NOT.(BE.AND.BH.AND.BR)) GO TO 95
      H=H+H
      BX=.TRUE.
   95 BH=.TRUE.
      IF(BR) GO TO 5
      H=HS
      IF(BX .OR. BE) GO TO 9005
      IER = 33
      GO TO 9005
  100 DO 105 I=1,N
         X0(I)=ZERO
  105 CONTINUE
 9005 RETURN
      END
```

```
      COMPLEX FUNCTION OBLU(Z)
C
C     THIS FUNCTION SUBROUTINE CALCULATES THE INTERMEDIATE TRANSFORM
C     VARIABLE W FOR THE CONFORMAL TRANSFORMATION OF AN ELLIPTICAL
C     BODY WITH WINGS TO A CIRCLE.
C
      COMMON/COM1/A2,B2,R2
      COMMON/COM3/ZR,ZI
      COMMON/COM5/DWDZ
      COMMON/COM6/W2,W
      COMMON/PARAM/NOUT
C
      COMPLEX Z,Z2,DWDZ,W,W2,WW
C
  700 FORMAT (//19X,2HZ2,22X,4HDWDZ/14X,2HRE,9X,2HIM,11X,2HRE,9X,2HIM)
  701 FORMAT (10X,F10.5,1X,F10.5,2X,F10.5,1X,F10.5)
C
```

```
C
      IF (NOUT.EQ.2) WRITE (6,700)
      Z2=Z*Z
      ZR=REAL(Z)
      ZI=AIMAG(Z)
      IF(ZR.NE.0.0) ZR=ZR/ABS(ZR)
      IF(ZI.NE.0.0) ZI=ZI/ABS(ZI)
      Z2=Z2-A2+B2
      IF (NOUT.EQ.2) WRITE (6,701) Z2
      Y=AIMAG(Z2)
      AY=1.0
      IF(Y.LT.0.0) AY=-1.0
      AYZ=1.0
      IF(ZI.LT.0.0) AYZ=-1.0
      Z2=CSQRT(Z2)*AY*AYZ
      IF (NOUT.EQ.2) WRITE (6,701) Z2
      IF((ABS(ZI).LE.0.0).AND.(REAL(Z).LT.0.0)) Z2=CMPLX(-REAL(Z2),
     1       AIMAG(Z2))
      DWDZ=0.5*(1.0+Z/Z2)
      IF (NOUT.EQ.2) WRITE (6,701) Z2,DWDZ
      WW=0.5*(Z+Z2)
      W2=1.0/(WW*WW)
      DBLU=WW
      RETURN
      END
```

```
      COMPLEX FUNCTION DSDZ(S)
C
C     CALCULATE DZETA/DTAU
C
      COMMON/COM2/SIG2,H2
      COMMON/COM5/DWDZ
      COMMON/COM4/G2,G1
      COMMON/COM6/W2,W
      COMPLEX W,W2,DWDZ,G1,G2
      DSDZ=0.5*(1.0-SIG2*W2)*(1.0+G1/G2)*DWDZ
      RETURN
      END
```

```
      COMPLEX FUNCTION DZDS(S)
C
C     CALCULATE DZ/DZETA
C
      COMMON/COM1/A2,B2,R2
      COMMON/COM2/SIG2,H2
      COMMON/COM6/W2,W
      COMPLEX W,S,W2,G1,S2,Z,Z2
      S2=S*S
      G1=0.5*(1.0-0.25*(A2-B2)**2)*(1.0-R2/S2)
      Z=S+R2/S
      Z2=Z*Z-4.0*SIG2
      Y=AIMAG(Z)
      YZ=AIMAG(Z2)
      AY=1.0
      AYZ=1.0
```

```
      IF(Y.LT.0.0) AY=-1.0
      IF(YZ.LT.0.0) AYZ=-1.0
      Z2=CSQRT(Z2)*AY*AYZ
      IF((ABS(Y).LE.0.0).AND.(REAL(Z).LT.0.0)) Z2=CMPLX(-REAL(Z2),
     1      AIMAG(Z2))
      DZDS=G1*(1.0+Z/Z2)
      RETURN
      END
```

```
      COMPLEX FUNCTION D2SDZ2(S)
C
C     CALCULATE DZETA2/DZ2
C
      COMMON/COM2/SIG2,H2
      COMMON/COM4/G2,G1
      COMMON/COM6/W2,W
      COMMON/COM5/DWDZ
      COMPLEX W,W2,DWDZ,G2,G1
      D2SDZ2=(1.0+G1/G2)*SIG2**2/W
      D2SDZ2=D2SDZ2-0.5*(1.0-SIG2**2)*(1.0-SIG2*W2)*H2/(G2*(G1*G1-H2))
      D2SDZ2=D2SDZ2*DWDZ*DWDZ
      RETURN
      END
```

```
      SUBROUTINE EXPAND(RP,X,Y,VS,WS)
C
C     THIS SUBROUTINE CALCULATES VELOCITIES INDUCED BY EXPANDING OR
C     CONTRACTING ELLIPTICAL CROSS SECTION.
C
      COMMON/COM1/A2,B2,R2
      COMMON/BLK1/A,R,S,PI,CI
      COMMON/COM8/RFACT
      COMPLEX VE,Z,ZI,CI
      SP=RFACT*A*RP
      Z=CMPLX(X,Y)
      ZI=Z*Z
      AY=1.0
      IF(AIMAG(Z).LT.0.0) AY=-1.0
      AYZ=1.0
      IF(AIMAG(ZI).LT.0.0) AYZ=-1.0
      Z=CSQRT(ZI-A2+B2)*AY*AYZ
      IF((ABS(AIMAG(Z)).LE.0.0).AND.(REAL(Z).LT.0.0))
     1      Z=CMPLX(-REAL(Z),AIMAG(Z))
      VE=SP/Z
      VS=REAL(VE)
      WS=-AIMAG(VE)
      RETURN
      END
```

```
      SUBROUTINE F(XO,PX,N,WK,VRTMAX)                                   VPL08   1
C                                                                       VPL08   2
C     THIS SUBROUTINE IS CALLED BY DASCRU TO CALCULATE CROSS FLOW       VPL08   3
C     PLANE VELOCITIES                                                  VPL08   4
C                                                                       VPL08   5
      COMPLEX CI,Z,FCT,SIMP                                             VPL08   6
      COMMON/VEL/AL,BE,          VX(30),VY(30),G(30),NV,      NS,NF,    VPL08   7
     1XE(7),XF(7),YF(7),C(7,7),IFIN                                     VPL08   8
      COMMON/BLK1/A,B,S,PI,CI                                           VPL08   9
      COMMON/BLK2/AC,PHI                                                VPL08  10
      COMMON/FINLE/YLE(80),CGLUC(80),GAMLE(80),MSWR,MSWL,MSWU,MSWD,     VPL08  11
     1 NEDGV,XTIPLE                                                     VPL08  12
      COMMON/SIDEDG/YSE(80),CGSELC(80),GAMSE(80),NCW,NSIDGE,XTIPTE      VPL08  13
      COMMON/COM1/A2,B2,R2                                              VPL08  14
      COMMON/COM2/SIG2,H2                                               VPL08  15
      COMMON/COM7/B [illegible] VF                                      VPL08  16
      COMMON/COM9/IGROW                                                 VPL08  17
      COMMON/PARAM/NOUT                                                 VPL08  18
C                                                                       VPL08  19
      DIMENSION XO(1),WK(1),V(30),W(30),VV(30),WW(30)                   VPL08  20
C                                                                       VPL08  21
C                                                                       VPL08  22
      EXTERNAL Z,FCT,SIMP                                               VPL08  23
C                                                                       VPL08  24
      NAMELIST/DEBUG/X,Y,YVINT,ZVBAR,GAMINT,A,B,VRTMAX,VS,WS            VPL08  25
C                                                                       VPL08  26
      CI=CMPLX(0.,1.)                                                   VPL08  27
      PI=3.14159265                                                     VPL08  28
      DO 888 I=1,NV                                                     VPL08  29
      J=2*I-1                                                           VPL08  30
      K=J+1                                                             VPL08  31
      VX(I)=XO(J)                                                       VPL08  32
  888 VY(I)=XO(K)                                                       VPL08  33
      CALL SHAPE(PX,A,B,S,RP)                                           VPL08  34
C                                                                       VPL08  35
C NOTE: COORDINATE VX(I) IS THE Y-COORDINATE IN THE CROSS FLOW PLANE.   VPL08  36
C       COORDINATE VY(I) IS THE Z-COORDINATE IN THE CROSS FLOW PLANE.   VPL08  37
C                                                                       VPL08  38
C     COMPUTE VELOCITIES IN THE CROSSFLOW PLANE ...                     VPL08  39
C     V(I) IS IN THE Y-DIRECTION.                                       VPL08  40
C     W(I) IS IN THE Z-DIRECTION.                                       VPL08  41
C                                                                       VPL08  42
C                                                                       VPL08  43
      A2=A*A                                                            VPL08  44
      B2=B*B                                                            VPL08  45
      APB=A+B                                                           VPL08  46
      APB2=APB*APB                                                      VPL08  47
      R1=S+SQRT(S*S-A2+B2)                                              VPL08  48
      R=0.25*(R1+APB2/R1)                                               VPL08  49
      H=R+R                                                             VPL08  50
      H2=H*H                                                            VPL08  51
      SIG=0.5*APB                                                       VPL08  52
      SIG2=SIG*SIG                                                      VPL08  53
      R2=R*R                                                            VPL08  54
      DO 100 I=1,NV                                                     VPL08  55
      X=VX(I)                                                           VPL08  56
      Y=VY(I)                                                           VPL08  57
      VS=0.                                                             VPL08  58
      WS=0.                                                             VPL08  59
C                                                                       VPL08  60
C     COMPUTE VELOCITIES IN CROSS FLOW PLANE DUE TO ANGLE OF PITCH AND  VPL08  61
C     ANGLE OF SIDESLIP.                                                VPL08  62
C                                                                       VPL08  63
```

```
      IF (NOUT.EQ.3) WRITE (6,DEBUG)
      IF((AL.NE.0.0).OR.(BE.NE.0.0)) CALL PITROL(AL,BE,X,Y,VS,WS)
      IF (NOUT.EQ.3) WRITE (6,DEBUG)
      V(I)=VS
      W(I)=WS
C
C     COMPUTE VELOCITIES IN CROSSFLOW PLANE DUE TO EXPANDING BODY
C
      VS=0.0
      WS=0.0
      IF(IGROW.GT.0) CALL EXPAND(RP,X,Y,VS,WS)
      IF (NOUT.EQ.3) WRITE (6,DEBUG)
      V(I)=V(I)+VS
      W(I)=W(I)+WS
C
C     IF WING LE  VORTICITY IS INCLUDED,DETERMINE BY INTERPOLATION THE
C     EFFECTS OF THE SPECIFIED VORTICITY.
C
C NOTE: HERE IFIN=1,...RIGHT WING
C                 2,...LEFT WING
C
      IF (NEDGV.EQ.0) GO TO 20
      IFIN=1
      KSTART=1
      KUL=MSWR
   23 CONTINUE
      IF (IFIN.EQ.2) KSTART=MSWR+1
      DO 21 IFV=KSTART,KUL
      IF (PX.LT.XLE(KSTART)) GO TO 20
      JV=IFV-1
      IF (IFV.EQ.1) JV=1
      IF (PX.LE.XLE(IFV)) GO TO 22
   21 CONTINUE
      IF (PX.LE.XTIPLE) GO TO 38
      GO TO 20
   22 KV=JV+1
      X1=XLE(JV)
      X2=XLE(KV)
      WT1=(X2-PX)/(X2-X1)
      WT2=(PX-X1)/(X2-X1)
      YVINT=WT1*CGLOC(JV)+WT2*CGLOC(KV)
      ZVBAR=(PX-XF(1))*TAN(AL/2.0)
      GAMINT=WT1*GAMLE (JV)+WT2*GAMLE (KV)
      IF (NOUT.EQ.3) WRITE (6,DEBUG)
      GO TO 39
   38 GAMINT=GAMLE(KUL)
      YVINT=CGLOC(KUL)
      ZVBAR=(PX-XF(1))*TAN(AL/2.0)
      IF (NOUT.EQ.3) WRITE (6,DEBUG)
   39 CALL VVELS(1,X,Y,YVINT,ZVBAR,GAMINT,A,B,S,VS,WS,VRTMAX)
      IF (NOUT.EQ.3) WRITE (6,DEBUG)
      V(I)=V(I)+VS
      W(I)=W(I)+WS
      IFIN=IFIN+1
      IF(IFIN.GT.2) GO TO 20
      KUL=MSWR+MSWL
      GO TO 23
   20 CONTINUE
C
C
C     IF WING SE VORTICITY IS INCLUDED,DETERMINE BY INTERPOLATION THE
C     EFFECTS OF THE SPECIFIED VORTICITY.
C
```

```
      IF (NSIDGE.EQ.0) GO TO 28                                         VPL08127
      IFIN=1                                                            VPL08128
      KSTART=1                                                          VPL08129
      KUL=NCW                                                           VPL08130
   27 CONTINUE                                                          VPL08131
      IF (IFIN.EQ.2) KSTART=NCW+1                                       VPL08132
      DO 29 JSE=KSTART,KUL                                              VPL08133
      IF (PX.LT.XSE(KSTART)) GO TO 28                                   VPL08134
      JVSE=JSE-1                                                        VPL08135
      IF (JSE.EQ.1) JVSE=1                                              VPL08136
      IF (PX.LE.XSE(JSE)) GO TO 30                                      VPL08137
   29 CONTINUE                                                          VPL08138
      IF (PX.LE.XTIPTE) GO TO 51                                        VPL08139
      GO TO 28                                                          VPL08140
   30 KVSE=JVSE+1                                                       VPL08141
      X1=XSE(JVSE)                                                      VPL08142
      X2=XSE(KVSE)                                                      VPL08143
      WT1=(X2-PX)/(X2-X1)                                               VPL08144
      WT2=(PX-X1)/(X2-X1)                                               VPL08145
      YVINT=WT1*CGSELC(JVSE)+WT2*CGSELC(KVSE)                           VPL08146
      ZVBAR=(PX-XF(1))*TAN(AL/2.0)                                      VPL08147
      GAMINT=WT1*GAMSE(JVSE)+WT2*GAMSE(KVSE)                            VPL08148
      IF (NOUT.EQ.3) WRITE (6,DEBUG)                                    VPL08149
      GO TO 59                                                          VPL08150
   51 GAMINT=GAMSE(KUL)                                                 VPL08151
      YVINT=CGSELC(KUL)                                                 VPL08152
      ZVBAR=(PX-XF(1))*TAN(AL/2.0)                                      VPL08153
      IF (NOUT.EQ.3) WRITE (6,DEBUG)                                    VPL08154
   59 CALL VVELS(I,X,Y,YVINT,ZVBAR,GAMINT,A,B,S,VS,WS,VRTMAX)           VPL08155
      IF (NOUT.EQ.3) WRITE (6,DEBUG)                                    VPL08156
      V(I)=V(I)+VS                                                      VPL08157
      W(I)=W(I)+WS                                                      VPL08158
      IFIN=IFIN+1                                                       VPL08159
      IF(IFIN.GT.2) GO TO 28                                            VPL08160
      KUL=2*NCW                                                         VPL08161
      GO TO 27                                                          VPL08162
   28 CONTINUE                                                          VPL08163
  100 CONTINUE                                                          VPL08164
C                                                                       VPL08165
C     CALCULATE VELOCITIES INDUCED BY ALL VORTICES ON ONE VORTEX IN THE VPL08166
C     PRESENCE OF AN ELLIPTICAL BODY-MONOPLANE WING.                    VPL08167
C                                                                       VPL08168
      CALL VOTEX(NV,VX,VY,G,VV,WW)                                      VPL08169
      CAL=COS(AC)                                                       VPL08170
      DO 101 I=1,NV                                                     VPL08171
      V(I)=V(I)+VV(I)                                                   VPL08172
      W(I)=W(I)+WW(I)                                                   VPL08173
      J=2*I-1                                                           VPL08174
      K=J+1                                                             VPL08175
      WK(J)=V(I)/CAL                                                    VPL08176
      WK(K)=W(I)/CAL                                                    VPL08177
  101 CONTINUE                                                          VPL08178
      RETURN                                                            VPL08179
      END                                                               VPL08180


      SUBROUTINE PITROL(AL,BE,X,Y,VS,WS)                                VPL09   1
C                                                                       VPL09   2
C     THIS SUBROUTINE COMPUTES THE CROSSFLOW COMPONENTS FOR A WINGED    VPL09   3
C     ELLIPTICAL BODY AT ANGLE OF ATTACK,AL, AND SIDESLIP ANGLE, BE.    VPL09   4
C                                                                       VPL09   5
      COMMON/BLK1/A,B,S,PI,CI                                           VPL09   6
```

```
      COMPLEX SZ,CI,ZA,SQ,SQS,VELAL,Z,DSDZ
      EXTERNAL Z,DSDZ
      RR=R*R
      ZA=CMPLX(X,Y)
      SZ=Z(ZA)
      SQ=SZ*SZ
      SQS=DSDZ(ZA)
      VELAL=CMPLX(0.0,0.0)
      IF(AL.NE.0.0) VELAL=-CI*SIN(AL)*(1.0+RR/SQ)*SQS+VELAL
      IF(BE.NE.0.0) VELAL=VELAL-SIN(BE)*(1.0-RR/SQ)*SQS
      VS=REAL(VELAL)
      WS=-AIMAG(VELAL)
      RETURN
      END


      SUBROUTINE PLOTVB(X,Y,Z,NP,NIP1,NVN,NDP,ROT,XF,YF,NF,X2,Y2,IOPT)
C
C  ROUTINE TO GENERATE A PLOT VORTEX LOCATION RELATIVE TO
C  THE WING-BODY CONFIGURATION
C  DEFINITIONS:
C    NC    = INDEX OF CURVE
C    NIP1 = NO. OF BODY STATIONS
C    NVN  = NO. OF VORTICES
C    NF   = NO. OF WING DEFINITON CARDS
C
      DIMENSION X(NDP,52),Y(NDP,52),Z(NDP,52)
      DIMENSION NP(52),ROT(3),XCG(3),XF(7),YF(7)
      DIMENSION X2(17,18),Y2(17,18),NP2(18),SYMBOL(40)
C
      DATA SYMBOL / 1H*,1H+,1H-,1H.,1H0,1H1,1H2,1H3,1H4,1H5,1H6,
     *  1H7,1H8,1H9,1HA,1HB,1HC,1HD,1HE,1HF,1HG,1HH,1HI,1HJ,1HK,1HL,
     *  1HM,1HN,1HO,1HP,1HQ,1HR,1HS,1HT,1HU,1HV,1HW,1HX,1HY,1HZ/
C       LENG AND LWID GIVE A PLOT THAT IS 9"X10"
      DATA LWID,LENG,XCG/ 100,54, 0.,0.,0./
      IF (IOPT.LE.0) IOPT=5
C       1H0 WRITTEN HERE IS TO SUPPRESS THE AUTOMATIC PAGE EJECT
      WRITE(6,10)
      WRITE(6,11)
10    FORMAT(1H1)
11    FORMAT(1H0)
C
C  FIND MAXIMUM DIAMETER
C
      BMAX=0.
      DO 100 I=1,NIP1
100   BMAX=AMAX1(BMAX,Y(1,I+1),Z(1,I+1))
C
C  CURVE 1:  DRAW AXES
C
      NC=1
      DO 120 I=1,6
      X(I,1)=X(1,1)
      Y(I,1)=0.
120   Z(I,1)=0.
      X(2,1)=X(1,NIP1+1)
      Y(4,1)=1.5*BMAX
      Z(6,1)=1.5*BMAX
      NP(1)=6
C
C  CURVES:  2 TO NIP1+1
C  GENERATE CROSS SECTIONS
```

```
C                                                                       VPL10 47
      NGV=NIP1+NVN+5                                                    VPL10 48
      MERID=17                                                          VPL10 49
      DO 160 J=1,NIP1                                                   VPL10 50
      NC=NC+1                                                           VPL10 51
      R1  =X(1,NC)                                                      VPL10 52
      RLOC=Y(1,NC)                                                      VPL10 53
      BLOC=Z(1,NC)                                                      VPL10 54
      SLOC=Y(2,NC)                                                      VPL10 55
C         SAVE RLOC AND BLOC                                            VPL10 56
      Y(J,NGV)=RLOC                                                     VPL10 57
      Z(J,NGV+1)=BLOC                                                   VPL10 58
      Y(J,NGV+2)=SLOC                                                   VPL10 59
C                                                                       VPL10 60
C  GENERATE ELLIPTIC BODY CROSS SECTION                                 VPL10 61
C                                                                       VPL10 62
      DTH=2.*3.1415926/(MERID-1)                                        VPL10 63
      DO 140 I=1,MERID                                                  VPL10 64
      PHI=(I-1)*DTH                                                     VPL10 65
      RAD=(COS(PHI)/BLOC)**2+(SIN(PHI)/RLOC)**2                         VPL10 66
      RAD=SQRT(1./RAD)                                                  VPL10 67
      Y(I,NC)=RAD*SIN(PHI)                                              VPL10 68
      Z(I,NC)=RAD*COS(PHI)                                              VPL10 69
      X(I,NC)=R1                                                        VPL10 70
140   CONTINUE                                                          VPL10 71
160   NP(NC)=MERID                                                      VPL10 72
C                                                                       VPL10 73
C  PLOT VORTEX LOCATION (ALREADY DEFINED)                               VPL10 74
C                                                                       VPL10 75
      DO 170 I=1,NVN                                                    VPL10 76
      NC=NC+1                                                           VPL10 77
170   NP(NC)=NIP1                                                       VPL10 78
C                                                                       VPL10 79
C  WING OUTLINE                                                         VPL10 80
C                                                                       VPL10 81
      IF (NF.LE.0) GO TO 200                                            VPL10 82
      DO 190 J=1,2                                                      VPL10 83
      NC=NC+1                                                           VPL10 84
      SGN=(-1)**(J+1)                                                   VPL10 85
      DO 180 I=1,NF                                                     VPL10 86
      X(I,NC)=XF(I)                                                     VPL10 87
      Y(I,NC)=YF(I)*SGN                                                 VPL10 88
      Z(I,NC)=0.0                                                       VPL10 89
180   CONTINUE                                                          VPL10 90
      NF1=NF+1                                                          VPL10 91
      X(NF1,NC)=XF(1)                                                   VPL10 92
      Y(NF1,NC)=YF(1)*SGN                                               VPL10 93
      Z(NF1,NC)=0.0                                                     VPL10 94
      NP(NC)=NF1                                                        VPL10 95
190   CONTINUE                                                          VPL10 96
200   CONTINUE                                                          VPL10 97
C                                                                       VPL10 98
C  PLOT CROSS SECTIONS WITH VORTEX LOCATIONS  --------------------------VPL10 99
C                                                                       VPL10100
      DO 240 ISECTN=1,3                                                 VPL10101
      IF (ISECTN.EQ.1) JSECTN=1                                         VPL10102
      IF (ISECTN.EQ.2) JSECTN=NIP1/2                                    VPL10103
      IF (ISECTN.EQ.3) JSECTN=NIP1                                      VPL10104
C                                                                       VPL10105
C  COPY BODY                                                            VPL10106
C                                                                       VPL10107
      DO 220 I=1,MERID                                                  VPL10108
      X2(I,1)=Y(I,JSECTN+1)                                             VPL10109
```

```
      Y2(I,1)=Z(I,JSECTN+1)
220   CONTINUE
      NP2(1)=MERID
      NC2=1
C
C  WING OUTER BOUNDARIES
C
      SLOC=Y(JSECTN,NGV+2)
      X2(1,2)=SLOC
      Y2(1,2)=0.
      X2(2,2)=-SLOC
      Y2(2,2)=0.
      NP2(2)=2
      NC2=NC2+1
C
C  COPY VORTICES AT JSECTN
C
      DO 230 J=1,NVN
      NC2=NC2+1
      JCV=NIP1+1+J
      X2(1,NC2)=Y(JSECTN,JCV)
      Y2(1,NC2)=Z(JSECTN,JCV)
      NP2(NC2)=1
230   CONTINUE
C
C  PLOT CROSS SECTIONS
C
      CALL PLOTA2(X2,Y2,3,NP2,17,NC2,LWID,LENG)
      WRITE(6,23) JSECTN,Y(1,JSECTN+1)
      WRITE(6,24) (I,SYMBOL(I+2),I=1,NVN)
240   CONTINUE
C
C  PLOT PERSPECTIVE VIEWS  ----------------------------------------------
      LENG = 50
      IOPT = 3
C
C  SIDE VIEW
      CALL PLOTA2(X,Z,3,NP,NOP,NC,LWID,LENG)
C     CALL PLOTV2(X,Z,3,NP,NOP,NC,LWID,LENG,LINE,NLTN)
      WRITE(6,21)
      NSYM=NVN
      JSYM=1+NIP1
      JN = JSYM+NVN
      IF (JN.GT.40) NSYM=JN-40
      WRITE(6,24) (I,SYMBOL(I+JSYM),I=1,NSYM)
      IF (JN.LE.40) GO TO 210
      JSYM=NSYM+1
      ISYM = NSYM
      WRITE(6,24) (I,SYMBOL(I+ISYM),I=JSYM,NVN)
210   CONTINUE
      IOPT = 1
C
C  TOP VIEW
      CALL PLOTA2(X,Y,3,NP,NOP,NC,LWID,LENG)
C     CALL PLOTV2(X,Y,3,NP,NOP,NC,LWID,LENG,LINE,NLTN)
      WRITE(6,20)
C
C  PERSPECTIVE VIEW
      IOPT = 3
      ROT(1)=0.
      ROT(2)=30.
      ROT(3)=20.
```

```
      CALL PLOTA3(X,Y,Z,NP,NOP,NC,ROT,XCG,X,Y,3)
      CALL PLOTA2(X,Y,3,NP,NOP,NC,LWID,LENG)
C     CALL PLOTV2(X,Y,3,NP,NOP,NC,LWID,LENG,LINE,NLIN)
      WRITE(6,22) ROT
C
C
20    FORMAT(/20X,22HTOP VIEW  - Y VERSUS X)
21    FORMAT(/20X,22HSIDE VIEW - Z VERSUS X)
22    FORMAT(/20X,18HPERSPECTIVE - ROT=,3F10.2)
23    FORMAT(/20X,29HBODY CROSS SECTION  - JSECTN=,I3,
     *   5X,4HXIP=,F10.5)
24    FORMAT(20X,14HVERTEX SYMBOLS,10(1X,I2,1H=,A1,1H,))
C
C
      RETURN
      END
```

```
      SUBROUTINE SHAPE(X,H,R,S,RP)
C
C  THIS SUBROUTINE COMPUTES HORIZONTAL SEMI-MAJOR AXIS AND VERTICAL
C  SEMI-MAJOR AXIS AND WING SPAN MEASURED FROM THE BODY CENTERLINE.
C
C
C     IF ELLIPTICAL CROSS SECTION,H IS VERTICAL SEMI-AXIS
C                                 R IS HORIZONTAL SEMI-AXIS.
C
      COMMON/VEL/AL,BE,            VX(30),VY(30),G(30),NV,       NS,NF,
     1XF(7),XF(7),YF(7),C(7,7),IFIN
      COMMON/CON8/HFACT
      COMMON/CON9/IGROW
      IGROW=0
      IFIN=0
      DO 1 K=1,NS
      XL=XF(K)
      J=K
      IF(X.LE.XL)GO TO 2
    1 CONTINUE
    2 R=C(J,1)+X*C(J,5)+X*X*C(J,6)
      ARG=X*X*C(J,2)+X*C(J,3)+C(J,4)
      R=R+SQRT(ARG)*C(J,7)
      IF((C(J,5).GT.0.0).OR.(C(J,6).GT.0.0)) IGROW=1
      RP=C(J,5)+2.0*C(J,6)*X
      IF(ARG.LE.0.0) GO TO 5
      RP=RP+0.5*C(J,7)*(2.0*C(J,2)*X+C(J,3))/SQRT(ARG)
      IGROW=1
    5 CONTINUE
      S=R
      H=R*HFACT
      IF(NF.EQ.0)RETURN
      IF(X.LE.XF(1).OR.X.GT.XF(NF))RETURN
      IFIN=1
      DO 3 K=2,NF
      J=K
      XL=XF(K)
      IF(X.LE.XL)GO TO 4
    3 CONTINUE
    4 J1=J-1
      S=(X-XF(J1))*(YF(J)-YF(J1))/(XF(J)-XF(J1))+YF(J1)
      RETURN
      END
```

```
      SUBROUTINE VOTEX(NV,XV,YV,GV,VV,WW)
C
C   THIS SUBROUTINE COMPUTES THE PERTURBATION VELOCITY COMPONENTS AT THE
C     VORTEX LOCATIONS ACCOUNTING FOR MUTUAL EFFECTS AND THE PRESENCE
C     OF A WINGED ELLIPTICAL CROSS SECTION
C
      DIMENSION XV(30),YV(30),GV(30),VV(30),WW(30)
      DIMENSION VX(30),VY(30),G(30)
      COMMON/V/A4,B4
      COMMON/BLK1/A,R,S,PI,CI
      COMMON/COM7/B
      COMMON/COM1/AA,BB,RR
      COMMON/COM2/SIG2,H2
      COMPLEX CI,T0,Z,S0,DSDT,DTDS,D2SDT,V1,V2,V3,VEL,TAU,SI,S0B,SIB
     2,DSDZ,DZDS,D2SDZ2
      EXTERNAL Z,DSDZ,DZDS,D2SDZ2
      NN=NV-1
      AA=A*A
      BB=B*B
      APB=A+B
      APB2=APB*APB
      R1=S+SQRT(S*S-AA+BB)
      R=0.25*(R1+APB2/R1)
      H=R+R
      H2=H*H
      SIG=0.5*APB
      SIG2=SIG*SIG
      RR=R*R
      DO 100 I=1,NV
      X0=XV(I)
      Y0=YV(I)
      G0=GV(I)
      K1=0
      DO 99 J=1,NV
      IF(J.EQ.I)GO TO 99
      K1=K1+1
      VX(K1)=XV(J)
      VY(K1)=YV(J)
      G(K1)=GV(J)
   99 CONTINUE
      T0=CMPLX(X0,Y0)
      S0=Z(T0)
      S0B=CONJG(S0)
      DSDT=DSDZ(S0)
      DTDS=DZDS(S0)
      D2SDT=D2SDZ2(S0)
      V1=-G0*DTDS*D2SDT/2.
      V2=G0*DSDT*S0B/(S0B*S0-RR)
      V3=CMPLX(0.,0.)
      DO 3 K=1,NN
      TAU=CMPLX(VX(K),VY(K))
      SI=Z(TAU)
      SIB=CONJG(SI)
    3 V3=V3-G(K)*(1./(S0-SI)-SIB/(S0*SIB-RR))*DSDT
      VEL=CI*(V1+V2+V3)/(PI+PI)
      VV(I)=REAL(VEL)
      WW(I)=-AIMAG(VEL)
  100 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE VVELS(NV,YY,ZZ,VX,VY,G,AH,BH,S,V,W,VRTMAX)
C
C     THIS SUBROUTINE COMPUTES PERTURBATION VELOCITY COMPONENTS DUE TO
C     NV EXTERNAL VORTICES AND THEIR IMAGES INSIDE A BODY WITH
C     ELLIPTICAL CROSS SECTION WITH OR WITHOUT MONO-PLANE WING.
C
C
      DIMENSION VX(1),VY(1),G(1)
C
      COMMON/COM1/A2,B2,R2
      COMMON/COM2/SIG2,H2
      COMMON/PARAM/NOUT
C
      COMPLEX T0,V1,DSDT,Z,DSDZ,SI,SIB,S0,TAU,CI,VEL
C
      EXTERNAL Z,DSDZ
C
  700 FORMAT (5X,I5,5X,F10.5,1X,F10.5, 4(2X,F10.5,1X,F10.5))
  701 FORMAT (//6X,4HIVRT,15X,2HSI,21X,3HSIB,21X,2HV1,21X,4HDSDT,21X,
     1 2HS0/
     1 19X,2HRE,9X,2HIM,10X,2HRE,9X,2HIM,11X,2HRE,9X,2HIM,11X,2HRE,
     1  9X,2HIM,11X,2HRE,9X,2HIM)
C
      PI=3.14159265
      TLC=0.001
      CI=CMPLX(0.0,1.0)
      A2=AH*AH
      B2=BH*BH
      APB=AH+BH
      APB2=APB*APB
      R1=S+SQRT(S*S-A2+B2)
      R=0.25*(R1+APB2/R1)
      R2=R*R
      H=R+R
      H2=H*H
      SIG=0.5*APB
      SIG2=SIG*SIG
      T0=CMPLX(YY,ZZ)
      S0=Z(T0)
      V1=CMPLX(0.0,0.0)
      DSDT=DSDZ(S0)
C
C   LOOP OVER THE NUMBER OF VORTICES,NV
C
      IF (NOUT.GE.2) WRITE (6,701)
      DO 1 I=1,NV
      TAU=CMPLX(VX(I),VY(I))
      SI=Z(TAU)
      SIB=CONJG(SI)
      D=CABS(SI-S0)
      IF(D.LE.TLC) GO TO 2
      V1=V1-G(I)/(S0-SI)
    2 CONTINUE
      D=CABS(S0-R2/SIB)
      IF(D.LE.TLC) GO TO 1
      V1=V1+G(I)/(S0-R2/SIB)
      IF (NOUT.GE.2) WRITE (6,700) I,SI,SIB,V1,DSDT,S0
    1 CONTINUE
C
      VEL=0.5*CI*V1*DSDT/PI
      V=REAL(VEL)
      W=-AIMAG(VEL)
      AV=ABS(V)
```

```
      AW=ABS(W)
      IF(V.GT.0.0.AND.AV.GE.VRTMAX) V=VRTMAX
      IF(V.LT.0.0.AND.AV.GE.VRTMAX)V=-VRTMAX
      IF(W.GT.0.0.AND.AW.GE.VRTMAX) W=VRTMAX
      IF(W.LT.0.0.AND.AW.GE.VRTMAX)W=-VRTMAX
      RETURN
      END
```

```
      COMPLEX FUNCTION Z(CT)
C
C     THIS FUNCTION SUBROUTINE CALCULATES THE ZETA  VALUE IN THE
C     TRANSFORMED (CIRCLE) PLANE FOR GIVEN TAU IN THE PHYSICAL PLANE
C     FOR AN ELLIPTICAL BODY WITH WINGS
C
      COMMON/COM2/SIG2,H2
      COMMON/COM3/ZR,ZI
      COMMON/COM4/G2,G1
      COMMON/COM6/W2,W
      COMMON/PARAM/NOUT
C
      COMPLEX W,G1,G2,CT,W2,DBLU
C
  700 FORMAT (//19X,2HG1,22X,2HG2/14X,2HRE,9X,2HIM,11X,2HRE,9X,2HIM)
  701 FORMAT (10X,F10.5,1X,F10.5,2X,F10.5,1X,F10.5)
C
      EXTERNAL DBLU
C
      W=DBLU(CT)
      G1=W+SIG2/W
      G2=G1*G1-H2
      IF (NOUT.EQ.2) WRITE (6,700)
      IF (NOUT.EQ.2) WRITE (6,701) G1,G2
      Y=AIMAG(G2)
      AY=1.0
      IF(Y.LT.0.0) AY=-1.0
      YZ=AIMAG(G1)
      AYZ=1.0
      IF(YZ.LT.0.0)AYZ=-1.0
      G2=CSQRT(G2)*AY*AYZ
      IF (NOUT.EQ.2) WRITE (6,701) G1,G2
      IF((ABS(YZ).LE.0.0).AND.(REAL(G1).LT.0.0)) G2=CMPLX(-REAL(G2),
     1      AIMAG(G2))
      IF (NOUT.EQ.2) WRITE (6,701) G1,G2
      Z=0.5*(G1+G2)
      IF((ABS(ZI).NE.0.0).AND.(ABS(ZR).NE.0.0)) Z=CMPLX(ZR*ABS(REAL(Z)),
     1ZI*ABS(AIMAG(Z)))
      RETURN
      END
```

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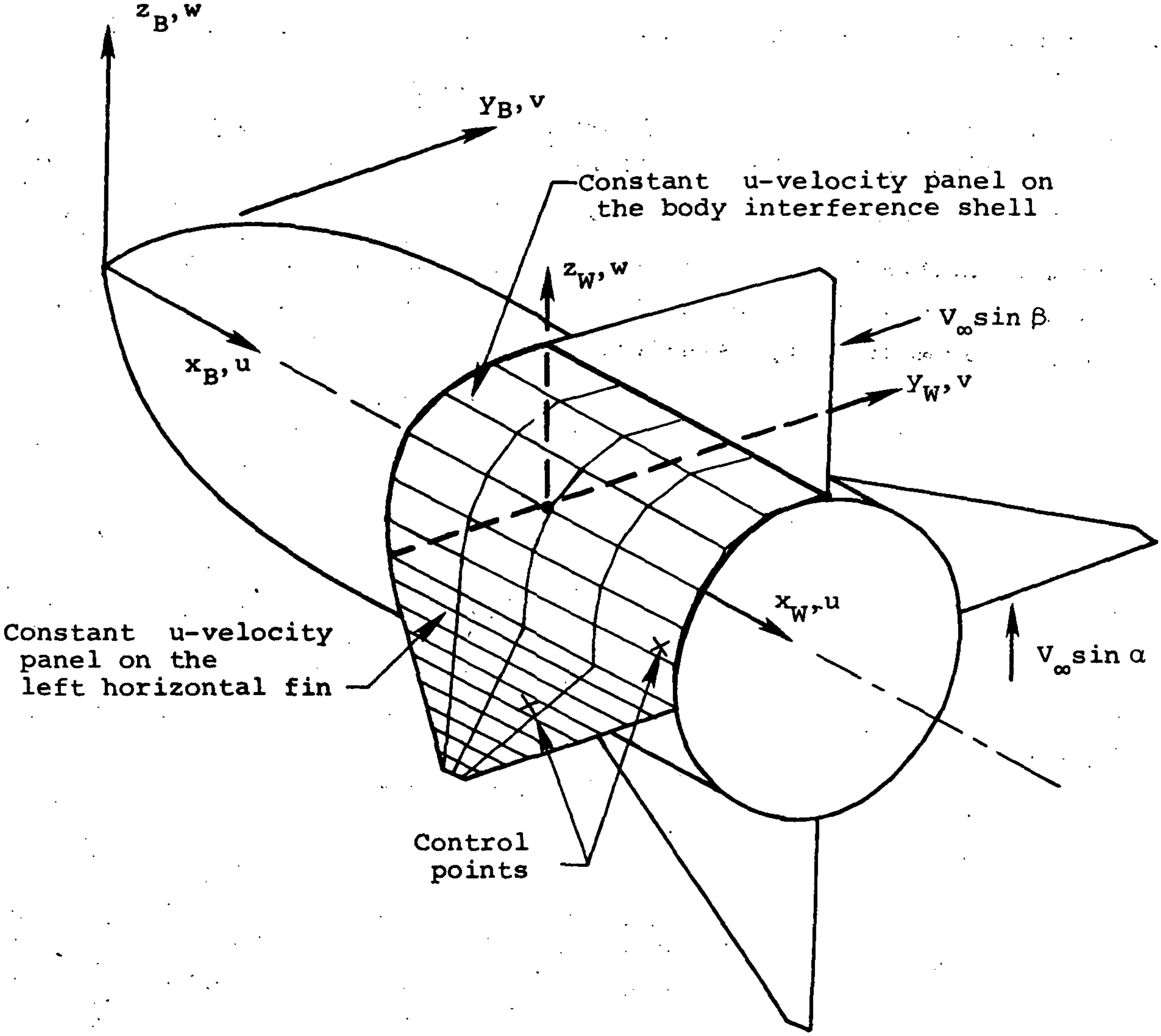


Figure 1.- Coordinate systems and typical panel layout shown for one fin and quarter of the interference shell.

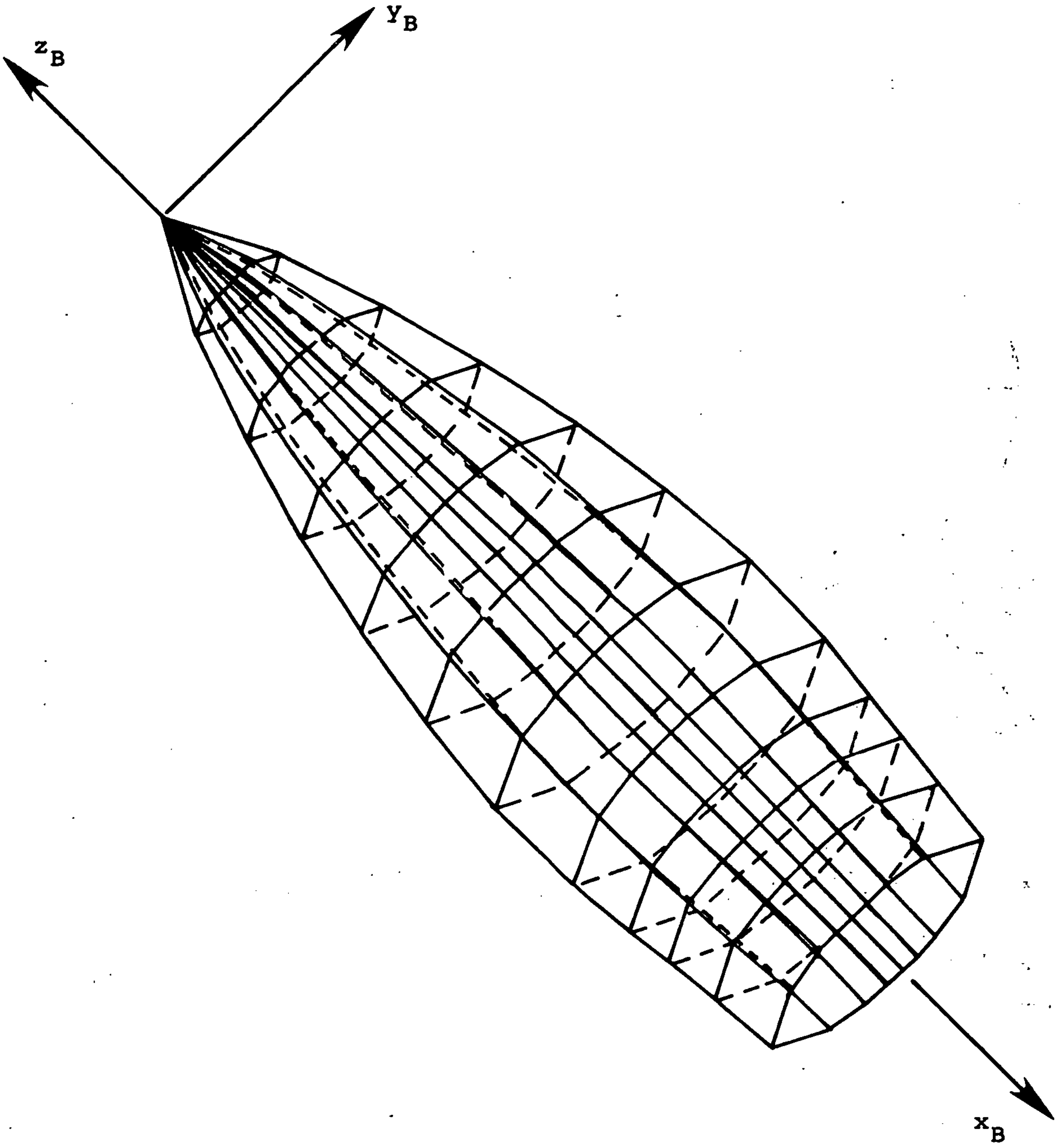
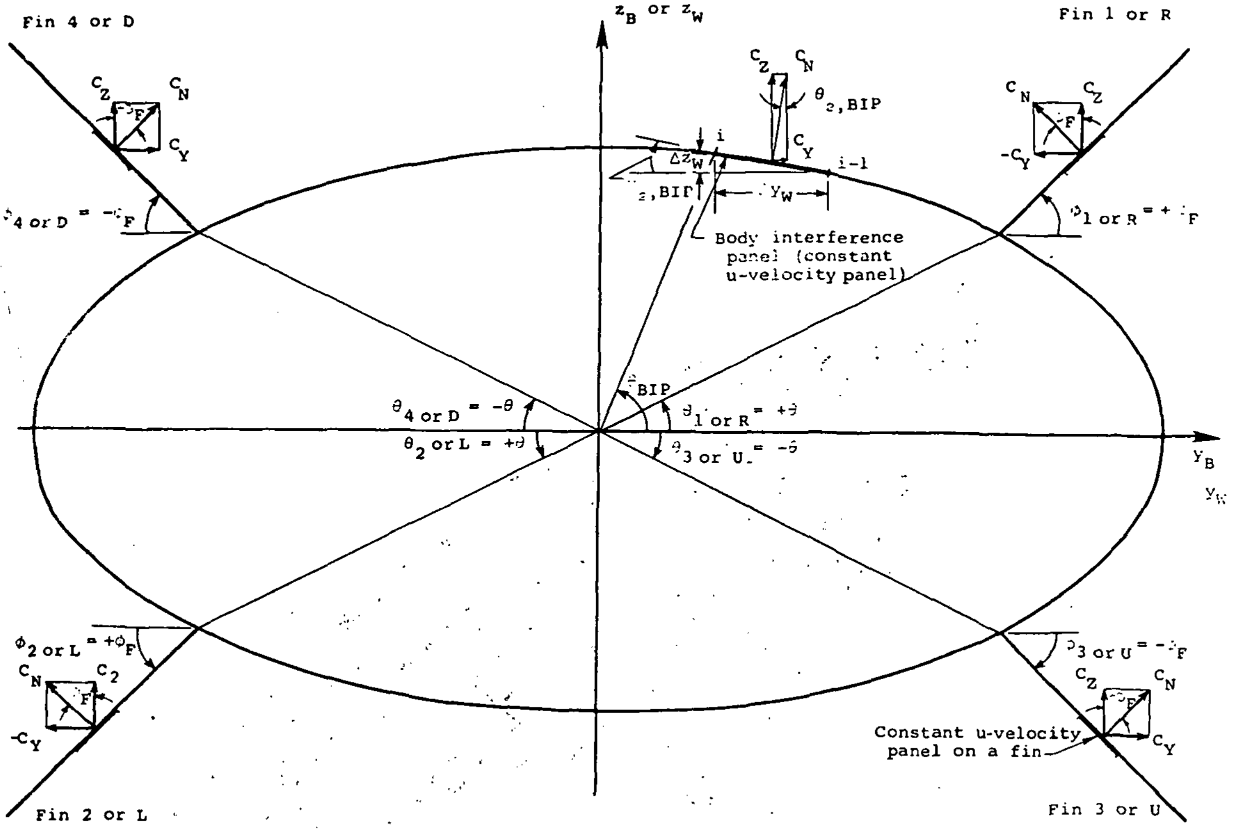


Figure 2.- Isometric view of typical layout of body source panels on the surface of a body with elliptical cross section, 11 rings with 16 panels each.



$\phi_F$ = fin dihedral angle, PHIDIH

$\phi_{1\ or\ R}$ = dihedral angle of right upper fin, PHIFR=PHIDIH

$\phi_{2\ or\ L}$ = dihedral angle of left lower fin, PHIFL=PHIDIH

$\phi_{3\ or\ U}$ = dihedral angle of right lower fin, PHIFU= -PHIDIH

$\phi_{4\ or\ D}$ = dihedral angle of left upper fin, PHIFD= -PHIDIH

$\theta$ = fin location polar angle, THETIT

$\theta_{1\ or\ R}$ = polar angle of right upper fin, THETR=THETIT

$\theta_{2\ or\ L}$ = polar angle of left lower fin, THETL=THETIT

$\theta_{3\ or\ U}$ = polar angle of right lower fin, THETI= -THETIT

$\theta_{4\ or\ D}$ = polar angle of left upper fin, THETD= -THETIT

Body interference panels:

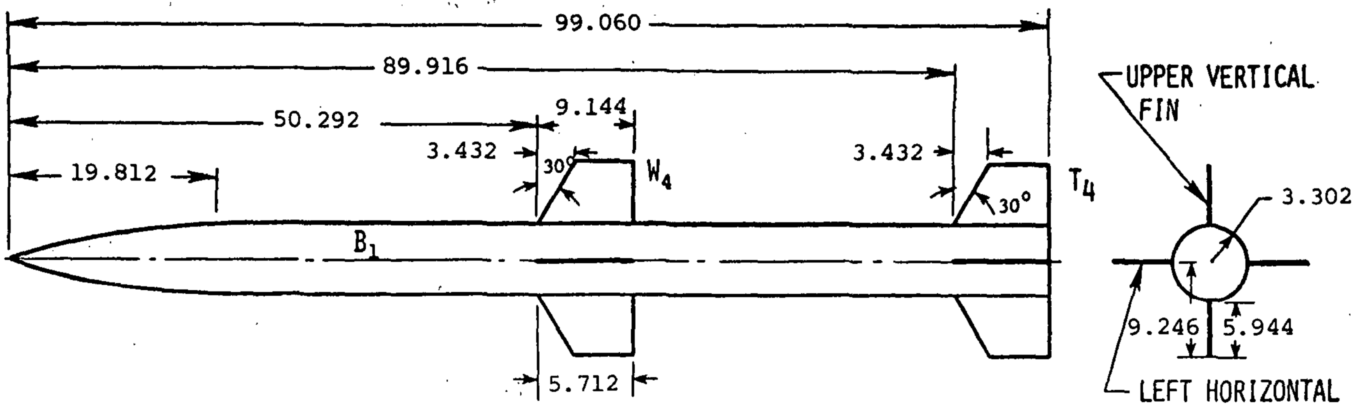
$$\theta_{BIP,j} = \text{THTI(J)}, \qquad \Delta z_W = z_{W,i} - z_{W,i-1}$$

$$\Delta y_W = y_{W,i} - y_{W,i-1}$$

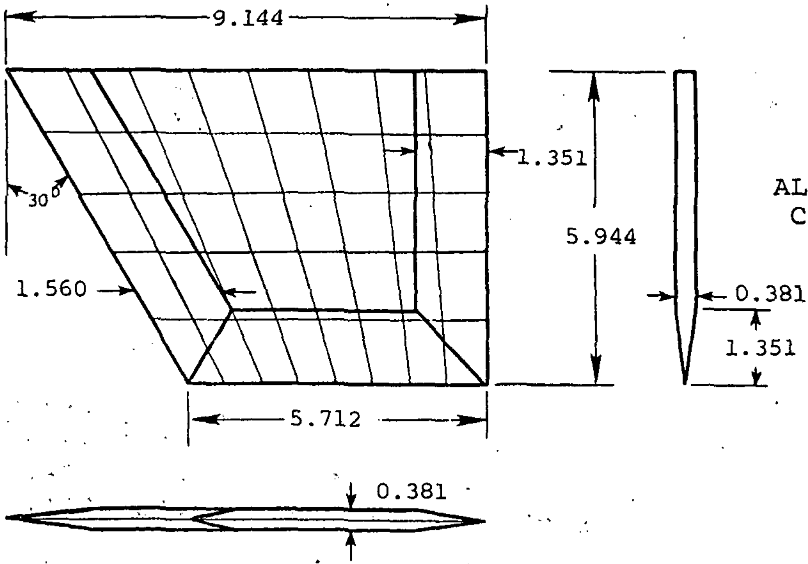
$$\left.\begin{aligned} \sin\theta_{2,BIP} &= \frac{\Delta z_W}{\sqrt{\Delta z_W^2 + \Delta y_W^2}} \\ \cos\theta_{2,BIP} &= \frac{-\Delta y_W}{\sqrt{\Delta z_W^2 + \Delta y_W^2}} \end{aligned}\right\}$$

these functions are used in the transformation (rotation) of the body interference panel to the reference $(x_B, y_B, z_B)$ or $(x_W, y_W, z_W)$ system

Figure 3.- Geometrical angles associated with case involving interdigitated tails on body with elliptical cross section as required by program DEMON2. Force coefficients associated with fins and body interference panel.



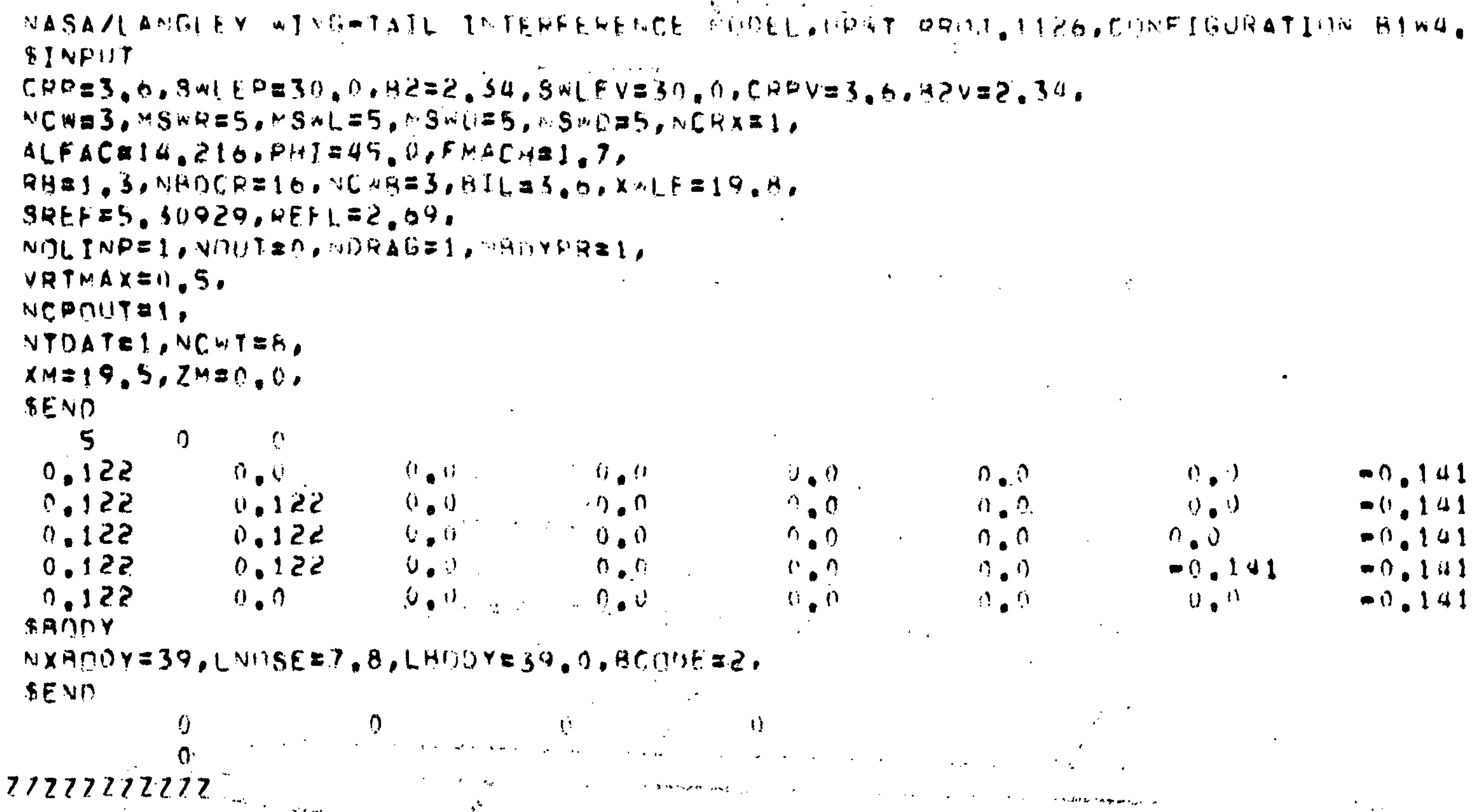
NASA/LANGLEY WING-TAIL-INTERFERENCE MODEL, UPWT PROJECT 1126



$W_4$, $T_4$ DETAIL

ALL DIMENSIONS IN CENTIMETERS

Figure 4.- Configuration used for first calculation example.



```
NASA/LANGLEY WING-TAIL INTERFERENCE MODEL,UPWT RUN,1126,CONFIGURATION B1W4,
$INPUT
CRP=3.6,SWLEP=30.0,B2=2.34,SWLEV=30.0,CRPV=3.6,B2V=2.34,
NCW=3,NSWR=5,NSWL=5,NSWU=5,NSWD=5,NCRX=1,
ALFAC=14.216,PHI=45.0,FMACH=1.7,
RB=1.3,NBDCR=16,NCWB=3,BIL=3.6,XWLE=19.8,
SREF=5.30929,REFL=2.69,
NOLINP=1,NOUT=0,NDRAG=1,NBDYPR=1,
VRTMAX=0.5,
NCPOUT=1,
NTDAT=1,NCWT=8,
XM=19.5,ZM=0.0,
$END
   5     0     0
 0.122      0.0        0.0        0.0        0.0        0.0        0.0       -0.141
 0.122      0.122      0.0        0.0        0.0        0.0        0.0       -0.141
 0.122      0.122      0.0        0.0        0.0        0.0        0.0       -0.141
 0.122      0.122      0.0        0.0        0.0        0.0       -0.141     -0.141
 0.122      0.0        0.0        0.0        0.0        0.0        0.0       -0.141
$BODY
NXBODY=39,LNOSE=7.8,LBODY=39.0,BCODE=2,
$END
         0          0          0          0
         0
ZZZZZZZZZZ
```

Figure 5.- Input for program DEMON2, first sample case, step 16.

```
NASA/LANGLEY WING-TAIL INTERFERENCE MODEL,UPWT PROJ.1126,CONFIGURATION B1W4.
$INPUT                                                            SREF     = .530929E+01,
CRP      = .36E+01,                                               REFL     = .269E+01,
SWLEP    = .3E+02,                                                PHIDIH   = 0.0,
SWTEP    = 0.0,                                                   THETIT   = 0.0,
NCW      = 3,                                                     XWLE     = .198E+02,
MSWR     = 5,                                                     NOLINP   = 1,
MSWL     = 5,                                                     NOUT     = 0,
ALFAC    = .14216E+02,                                            NPR      = 0,
PHI      = .45E+02,                                               NDRAG    = 1,
B2       = .234E+01,                                              NVRTX    = 0,
FMACH    = .17E+01,                                               NPRESS   = 0,
LVSWP    = 0,                                                     VRTMAX   = .5E+00,
FAC      = .95E+00,                                               NCWR     = 3,
NFVNPR   = 0,                                                     NAGAIN   = 0,
TOLFAC   = .1E+01,                                                BIL      = .36E+01,
MSWU     = 5,                                                     ITATL    = 0,
MSWD     = 5,                                                     NVRTPL   = 0,
SWLEV    = .3E+02,                                                NBDYPR   = 1,
SWTEV    = 0.0,                                                   NTPR     = 0,
CRPV     = .36E+01,                                               NTDAT    = 1,
B2V      = .234E+01,                                              NCWT     = 8,
NCRX     = 1,                                                     NCPOUT   = 1,
RB       = .13E+01,                                               NVLTU    = 0,
RA       = .13E+01,                                               XSTART   = 0.0,
ZRATIO   = .1E+01,                                                JCPT     = 0,
NBDCR    = 16,                                                    FKLE     = .5E+00,
DELR     = 0.0,                                                   FKSE     = .5E+00,
DELL     = 0.0,                                                   XM       = .195E+02,
DELU     = 0.0,                                                   ZM       = 0.0,
DELD     = 0.0,                                                   $END
```

Figure 6.- Output of program DEMON2, first sample case, step 1b.

```
                    WING GEOMETRY

                TIP CHORD =    2.24900

               ROOT CHORD =    3.60000

            WING SEMISPAN =    2.34000

      LEADING EDGE SWEEP =   30.00000  DEGREES

     TRAILING EDGE SWEEP =    0.00000  DEGREES


                    FLOW CONDITIONS

MACH =    1.70000    ALPHAC=   14.21600    PHI  =   45.00000    ALFA =   10.00000    BETA =   10.00010


      CRPT =    3.60000
     CRPTV =    3.60000
WING THICKNESS INPUT DATA

               SPANWISE LOCATIONS OF PANEL SIDE EDGES AND SWEEP ANGLES
                  OF WING SECTION TO THE LEFT

                           SPANWISE   LE SWEEP   TE SWEEP
                     I     LOCATION
                             FEET     DEGREES    DEGREES


     RIGHT WING SURFACE

                     1      1.30000   0.00000    0.00000
                     2      1.76800  30.00000    0.00000
                     3      2.23600  30.00000    0.00000
                     4      2.70400  30.00000    0.00000
                     5      3.17200  30.00000    0.00000
                     6      3.64000  30.00000    0.00000

                 40 THICKNESS PANELS ARE TO BE LAID OUT
                  5 CHORDWISE ROWS WITH  8 IN EACH ROW


     UPPER WING SURFACE

                     1      1.30000   0.00000    0.00000
                     2      1.76800  30.00000    0.00000
                     3      2.23600  30.00000    0.00000
                     4      2.70400  30.00000    0.00000
                     5      3.17200  30.00000    0.00000
                     6      3.64000  30.00000    0.00000

                 40 THICKNESS PANELS ARE TO BE LAID OUT
                  5 CHORDWISE ROWS WITH  8 IN EACH ROW
```

Figure 6.- Continued.

```
                    INPUT VALUES OF THE LOCAL SURFACE SLOPE OF THE THICKNESS
                     DISTRIBUTION, FOR EACH CHORDWISE ROW THE FIRST VALUE
                          IS FOR THE PANEL NEAREST THE LEADING EDGE

RIGHT WING SURFACE

      ROW                        SLOPES
       1               .12200   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       2               .12200    .12200   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       3               .12200    .12200   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       4               .12200    .12200   0.00000   0.00000   0.00000   0.00000   -.14100   -.14100
       5               .12200   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100

UPPER WING SURFACE

      ROW                        SLOPES
       1               .12200   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       2               .12200    .12200   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       3               .12200    .12200   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       4               .12200    .12200   0.00000   0.00000   0.00000   0.00000   -.14100   -.14100
       5               .12200   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100

   CONTROL POINTS WRITTEN ON TAPE4

 I     XCPT        YCPT       ZCPT
 1   1.2311      1.5310      0.
 2   2.3867      1.5310      0.
 3   3.5422      1.5310      0.
 4   1.4157      1.9987      0.
 5   2.4912      1.9987      0.
 6   3.5467      1.9987      0.
 7   1.6002      2.4664      0.
 8   2.5757      2.4664      0.
 9   3.5512      2.4664      0.
10   1.7847      2.9340      0.
11   2.6702      2.9340      0.
12   3.5557      2.9340      0.
13   1.9691      3.4016      0.
14   2.7647      3.4016      0.
15   3.5602      3.4016      0.
16   1.2311     -1.5310      0.
17   2.3867     -1.5310      0.
18   3.5422     -1.5310      0.
19   1.4157     -1.9987      0.
20   2.4912     -1.9987      0.
21   3.5467     -1.9987      0.
22   1.6002     -2.4664      0.
23   2.5757     -2.4664      0.
24   3.5512     -2.4664      0.
25   1.7847     -2.9340      0.
26   2.6702     -2.9340      0.
27   3.5557     -2.9340      0.
28   1.9691     -3.4016      0.
29   2.7647     -3.4016      0.
30   3.5602     -3.4016      0.
31   1.2311      0.          1.5310
32   2.3867      0.          1.5310
```

Figure 6.- Continued.

```
 33  3.5422     0.         1.5310
 34  1.4157     0.         1.9987
 35  2.4812     0.         1.9987
 36  3.5467     0.         1.9987
 37  1.6002     0.         2.4664
 38  2.5757     0.         2.4664
 39  3.5512     0.         2.4664
 40  1.7847     0.         2.9340
 41  2.6702     0.         2.9340
 42  3.5557     0.         2.9340
 43  1.9691     0.         3.4016
 44  2.7647     0.         3.4016
 45  3.5602     0.         3.4016
 46  1.2311     0.        -1.5310
 47  2.3967     0.        -1.5310
 48  3.5422     0.        -1.5310
 49  1.4157     0.        -1.9987
 50  2.4812     0.        -1.9987
 51  3.5467     0.        -1.9987
 52  1.6002     0.        -2.4664
 53  2.5757     0.        -2.4664
 54  3.5512     0.        -2.4664
 55  1.7847     0.        -2.9340
 56  2.6702     0.        -2.9340
 57  3.5557     0.        -2.9340
 58  1.9691     0.        -3.4016
 59  2.7647     0.        -3.4016
 60  3.5602     0.        -3.4016
 61  1.1400     1.2505     .24874
 62  1.1400     1.0601     .70836
 63  1.1400     .70836    1.0601
 64  1.1400     .24874    1.2505
 65  1.1400    -.24874    1.2505
 66  1.1400    -.70836    1.0601
 67  1.1400    -1.0601     .70836
 68  1.1400    -1.2505     .24874
 69  1.1400    -1.2505    -.24874
 70  1.1400    -1.0601    -.70836
 71  1.1400    -.70836   -1.0601
 72  1.1400    -.24874   -1.2505
 73  1.1400     .24874   -1.2505
 74  1.1400     .70836   -1.0601
 75  1.1400     1.0601    -.70836
 76  1.1400     1.2505    -.24874
 77  2.3400     1.2505     .24874
 78  2.3400     1.0601     .70836
 79  2.3400     .70836    1.0601
 80  2.3400     .24874    1.2505
 81  2.3400    -.24874    1.2505
 82  2.3400    -.70836    1.0601
 83  2.3400    -1.0601     .70836
 84  2.3400    -1.2505     .24874
 85  2.3400    -1.2505    -.24874
 86  2.3400    -1.0601    -.70836
 87  2.3400    -.70836   -1.0601
 88  2.3400    -.24874   -1.2505
 89  2.3400     .24874   -1.2505
 90  2.3400     .70836   -1.0601
```

```
  91  2.3400     1.0601    -.70836
  92  2.3400     1.2505    -.24874
  93  3.5400     1.2505     .24874
  94  3.5400     1.0601     .70836
  95  3.5400     .70836    1.0601
  96  3.5400     .24874    1.2505
  97  3.5400    -.24874    1.2505
  98  3.5400    -.70836    1.0601
  99  3.5400    -1.0601     .70836
 100  3.5400    -1.2505     .24874
 101  3.5400    -1.2505    -.24874
 102  3.5400    -1.0601    -.70836
 103  3.5400    -.70836   -1.0601
 104  3.5400    -.24874   -1.2505
 105  3.5400     .24874   -1.2505
 106  3.5400     .70836   -1.0601
 107  3.5400     1.0601    -.70836
 108  3.5400     1.2505    -.24874


$BODY

NXBODY  = 39,

LNOSE   = .78E+01,

LBODY   = .39E+02,

BCODE   = 2,

$END
```

Figure 6.- Continued.

```
PHYSICAL DIMENSIONS OF BODY AND LINE SINGULARITY STRENGTHS REPRESENTING THE BODY AT MACH= 1.7000      ALFAC= 14.2160
          X           R            DR/DX            TX           T(I)           TC(I)
  1    0.0000    -.42633E-13    .34286         .58610E-13     .10092         .39463E-01
  2    1.0263     .32639        .29353         .57761        -.44121E-01    -.10955E-01
  3    2.0526     .60316        .24611        1.2234         -.25012E-01    -.62846E-02
  4    3.0789     .85207        .20020        1.9350         -.23274E-01    -.81341E-02
  5    4.1053    1.0145         .15547        2.7106         -.18881E-01    -.74517E-02
  6    5.1316    1.1515         .11164        3.5485         -.15477E-01    -.75496E-02
  7    6.1579    1.2439         .68439E-01    4.4479         -.11952E-01    -.73645E-02
  8    7.1842    1.2921         .25613E-01    5.4078         -.83169E-02    -.70718E-02
  9    8.2105    1.3000        0.             6.4233          .31078E-01    -.28112E-02
 10    9.2368    1.3000        0.             7.4496          .35293E-02     .47755E-02
 11   10.2632    1.3000        0.             8.4760          .34046E-02     .39930E-02
 12   11.2895    1.3000        0.             9.5023          .14132E-02     .36673E-02
 13   12.3158    1.3000        0.            10.529           .93969E-03     .26432E-02
 14   13.3421    1.3000        0.            11.555           .55466E-03     .17866E-02
 15   14.3684    1.3000        0.            12.581           .36257E-03     .10708E-02
 16   15.3947    1.3000        0.            13.608           .23850E-03     .56355E-03
 17   16.4211    1.3000        0.            14.634           .16227E-03     .22980E-03
 18   17.4474    1.3000        0.            15.660           .11249E-03     .33410E-04
 19   18.4737    1.3000        0.            16.686           .79559E-04    -.67235E-04
 20   19.5000    1.3000        0.            17.713           .57218E-04    -.10629E-03
 21   20.5263    1.3000        0.            18.739           .41794E-04    -.10983E-03
 22   21.5526    1.3000        0.            19.765           .30961E-04    -.95708E-04
 23   22.5789    1.3000        0.            20.792           .23236E-04    -.75192E-04
 24   23.6053    1.3000        0.            21.818           .17650E-04    -.54633E-04
 25   24.6316    1.3000        0.            22.844           .13558E-04    -.37078E-04
 26   25.6579    1.3000        0.            23.871           .10525E-04    -.23532E-04
 27   26.6842    1.3000        0.            24.897           .82509E-05    -.13875E-04
 28   27.7105    1.3000        0.            25.923           .65280E-05    -.74713E-05
 29   28.7368    1.3000        0.            26.950           .52100E-05    -.35327E-05
 30   29.7632    1.3000        0.            27.976           .41922E-05    -.13202E-05
 31   30.7895    1.3000        0.            29.002           .33993E-05    -.22844E-06
 32   31.8159    1.3000        0.            30.029           .27766E-05     .19378E-06
 33   32.8421    1.3000        0.            31.055           .22835E-05     .25675E-06
 34   33.8684    1.3000        0.            32.081           .18903E-05     .15784E-06
 35   34.8947    1.3000        0.            33.108           .15745E-05     .11691E-07
 36   35.9211    1.3000        0.            34.134           .13191E-05    -.12295E-06
 37   36.9474    1.3000        0.            35.160           .11112E-05    -.22221E-06
 38   37.9737    1.3000        0.            36.186           .94102E-06    -.28188E-06
 39   39.0000    1.3000        0.            37.213          0.             0.


                          PRESSURE COEFFICIENTS AT POINTS ON BODY MERIDIANS


 J    THETA,      XB        YB        ZB       UTOT      VTOT      WTOT     CP,LIN.   CP,BERN.   DR/DX     P/PINF,    P/PINF,
      DEG.                                                                                                 BERN.      LIN.


            TOTAL NUMBER OF PRESSURE POINTS,JCPT=  320


                                        BODY RING=  1

 1  11.25000    .51316    .16626    .03307   -.20308    .36619    .16431    .40615    .31470    .31793    1.63664    1.82164
 2  22.50000    .51316    .15662    .06487   -.18464    .28906    .22763    .36935    .24360    .31793    1.49299    1.74720
```

Figure 6.- Continued.

```
 3  33.75000     .51316    .14095    .09418   -.16471    .20227    .26242    .32942    .18128    .31793   1.36673   1.66602
 4  45.00000     .51316    .11987    .11987   -.14395    .11616    .26874    .28789    .13035    .31793   1.26371   1.58241
 5  56.25000     .51316    .09418    .14095   -.12318    .04000    .25033    .24637    .09186    .31793   1.18583   1.49840
 6  67.50000     .51316    .06487    .15662   -.10322   -.01932    .21384    .20644    .06525    .31793   1.13200   1.41762
 7  78.75000     .51316    .03307    .16626   -.08482   -.05811    .16768    .16964    .04898    .31793   1.09908   1.34318
 8  90.00000     .51316   -.00000    .16952   -.06869   -.07629    .12065    .13738    .04083    .31793   1.08261   1.27792
 9 101.25000     .51316   -.03307    .16626   -.05545   -.07713    .08050    .11091    .03828    .31793   1.07744   1.22437
10 112.50000     .51316   -.06487    .15662   -.04562   -.06654    .05275    .09124    .03876    .31793   1.07842   1.18458
11 123.75000     .51316   -.09418    .14095   -.03956   -.05195    .03986    .07913    .04007    .31793   1.08107   1.16007
12 135.00000     .51316   -.11987    .11987   -.03752   -.04093    .04093    .07504    .04069    .31793   1.08232   1.15180
13 146.25000     .51316   -.14095    .09418   -.03956   -.03986    .05195    .07913    .04007    .31793   1.08107   1.16007
14 157.50000     .51316   -.15662    .06487   -.04562   -.05275    .06654    .09124    .03876    .31793   1.07842   1.18458
15 168.75000     .51316   -.16626    .03307   -.05545   -.08050    .07713    .11091    .03828    .31793   1.07744   1.22437
16 180.00000     .51316   -.16952   -.00000   -.06869   -.12065    .07629    .13738    .04083    .31793   1.08261   1.27792
17 191.25000     .51316   -.16626   -.03307   -.08482   -.16768    .05811    .16964    .04898    .31793   1.09908   1.34318
18 202.50000     .51316   -.15662   -.06487   -.10322   -.21384    .01932    .20644    .06525    .31793   1.13200   1.41762
19 213.75000     .51316   -.14095   -.09418   -.12318   -.25033   -.04000    .24637    .09186    .31793   1.18583   1.49840
20 225.00000     .51316   -.11987   -.11987   -.14395   -.26874   -.11616    .28789    .13035    .31793   1.26371   1.58241
21 236.25000     .51316   -.09418   -.14095   -.16471   -.26242   -.20227    .32942    .18128    .31793   1.36673   1.66642
22 247.50000     .51316   -.06487   -.15662   -.18468   -.22763   -.28906    .36935    .24369    .31793   1.49299   1.74720
23 258.75000     .51316   -.03307   -.16626   -.20308   -.16431   -.36619    .40615    .31470    .31793   1.63664   1.82164
24 270.00000     .51316    .00000   -.16952   -.21920   -.07629   -.42368    .43841    .38919    .31793   1.78734   1.88690
25 281.25000     .51316    .03307   -.16626   -.23244    .02907   -.45337    .46488    .46006    .31793   1.93070   1.94045
26 292.50000     .51316    .06487   -.15662   -.24227    .14177   -.45015    .48455    .51904    .31793   2.05002   1.98024
27 303.75000     .51316    .09418   -.14095   -.24833    .25047   -.41274    .49666    .55827    .31793   2.12939   2.00475
28 315.00000     .51316    .11987   -.11987   -.25038    .34397   -.34397    .50075    .57205    .31793   2.15725   2.01302
29 326.25000     .51316    .14095   -.09418   -.24833    .41274   -.25047    .49666    .55827    .31793   2.12939   2.00475
30 337.50000     .51316    .15662   -.06487   -.24227    .45015   -.14177    .48455    .51904    .31793   2.05002   1.98024
31 348.75000     .51316    .16626   -.03307   -.23244    .45337   -.02907    .46488    .46006    .31793   1.93070   1.94045
32 360.00000     .51316    .16952    .00000   -.21920    .42368    .07629    .43841    .38919    .31793   1.78734   1.88690


                                                 BODY RING#   2

 1  11.25000   2.56579    .70961    .14115   -.14124    .29958    .18203    .28247    .19422    .22298   1.39291   1.57144
 2  22.50000   2.56579    .66843    .27687   -.12479    .21696    .23429    .24959    .12886    .22298   1.26069   1.50491
 3  33.75000   2.56579    .60157    .40196   -.10695    .12713    .25530    .21390    .07368    .22298   1.14905   1.43273
 4  45.00000   2.56579    .51160    .51160   -.08840    .04161    .24586    .17679    .03113    .22298   1.06297   1.35766
 5  56.25000   2.56579    .40196    .60157   -.06984   -.02944    .21090    .13969    .00171    .22298   1.00347   1.28258
 6  67.50000   2.56579    .27687    .66843   -.05200   -.07871    .15864    .10400   -.01550    .22298    .96864   1.21040
 7  78.75000   2.56579    .14115    .70961   -.03556   -.10271    .09915    .07112   -.02244    .22298    .95460   1.14387
 8  90.00000   2.56579   -.00000    .72351   -.02115   -.10212    .04282    .04229   -.02170    .22298    .95609   1.08556
 9 101.25000   2.56579   -.14115    .70961   -.00932   -.08155   -.00133    .01864   -.01635    .22298    .96695   1.03770
10 112.50000   2.56579   -.27687    .66843   -.00053   -.04863   -.02703    .00106   -.00950    .22298    .98077   1.00214
11 123.75000   2.56579   -.40196    .60157    .00486   -.01272   -.03168   -.00977   -.00406    .22298    .99179    .98024
12 135.00000   2.56579   -.51160    .51160    .00671    .01671   -.01671   -.01342   -.00200    .22298    .99595    .97285
13 146.25000   2.56579   -.60157    .40196    .00488    .03168    .01272   -.00977   -.00406    .22298    .99179    .98024
14 157.50000   2.56579   -.66843    .27687   -.00053    .02703    .04863    .00196   -.00950    .22298    .98077   1.00214
15 168.75000   2.56579   -.70961    .14115   -.00932    .00133    .08155    .01864   -.01635    .22298    .96695   1.03770
16 180.00000   2.56579   -.72351   -.00000   -.02115   -.04282    .10212    .04229   -.02170    .22298    .95609   1.08556
17 191.25000   2.56579   -.70961   -.14115   -.03556   -.09915    .10271    .07112   -.02244    .22298    .95460   1.14387
18 202.50000   2.56579   -.66843   -.27687   -.05200   -.15864    .07871    .10400   -.01550    .22298    .96864   1.21040
19 213.75000   2.56579   -.60157   -.40196   -.06984   -.21090    .02944    .13969    .00171    .22298   1.00347   1.28258
20 225.00000   2.56579   -.51160   -.51160   -.08840   -.24586   -.04161    .17679    .03113    .22298   1.06297   1.35766
21 236.25000   2.56579   -.40196   -.60157   -.10695   -.25530   -.12713    .21390    .07368    .22298   1.14905   1.43273
22 247.50000   2.56579   -.27687   -.66843   -.12479   -.23429   -.21696    .24959    .12886    .22298   1.26069   1.50491
23 258.75000   2.56579   -.14115   -.70961   -.14124   -.18203   -.29958    .28247    .19422    .22298   1.39291   1.57144
```

Figure 6.- Continued.

```
24 270.00000   2.56579    .00000   -.72351   -.15565   -.10212   -.36372    .31130    .26490    .22298   1.53589   1.62975
25 281.25000   2.56579    .14115   -.70961   -.16748   -.00223   -.40006    .33495    .33372    .22298   1.67511   1.67761
26 292.50000   2.56579    .27687   -.66843   -.17627    .10695   -.40263    .35253    .39199    .22298   1.79299   1.71317
27 303.75000   2.56579    .40196   -.60157   -.18168    .21315   -.36971    .36335    .43119    .22298   1.87230   1.73507
28 315.00000   2.56579    .51160   -.51160   -.18350    .30418   -.30418    .36701    .44503    .22298   1.90030   1.74246
29 326.25000   2.56579    .60157   -.40196   -.18168    .36971   -.21315    .36335    .43119    .22298   1.87230   1.73507
30 337.50000   2.56579    .66843   -.27687   -.17627    .40263   -.10695    .35253    .39199    .22298   1.79299   1.71317
31 348.75000   2.56579    .70961   -.14115   -.16748    .40006    .00223    .33495    .33372    .22298   1.67511   1.67761
32 360.00000   2.56579    .72351    .00000   -.15565    .36372    .10212    .31130    .26490    .22298   1.53589   1.62975

                                              BODY RING   3

 1  11.25000   4.61842   1.06771    .21238   -.08033    .22574    .20086    .16066    .06989    .13346   1.14139   1.32501
 2  22.50000   4.61842   1.00576    .41660   -.06680    .13775    .24102    .13359    .01221    .13346   1.02471   1.27026
 3  33.75000   4.61842    .90516    .60481   -.05211    .04519    .24720    .10423   -.03411    .13346    .93100   1.21085
 4  45.00000   4.61842    .76977    .76977   -.03684   -.03919    .22098    .07369   -.06712    .13346    .86423   1.14907
 5  56.25000   4.61842    .60481    .90516   -.02157   -.10436    .16857    .04315   -.08669    .13346    .82463   1.08729
 6  67.50000   4.61842    .41660   1.00576   -.00689   -.14264    .09977    .01378   -.09400    .13346    .80985   1.02788
 7  78.75000   4.61842    .21238   1.06771    .00664   -.15070    .02641   -.01328   -.09112    .13346    .81567    .97313
 8  90.00000   4.61842   -.00000   1.08863    .01850   -.13008   -.03951   -.03701   -.08092    .13346    .83630    .92514
 9 101.25000   4.61842   -.21238   1.06771    .02824   -.08677   -.08768   -.05647   -.06693    .13346    .86461    .88575
10 112.50000   4.61842   -.41660   1.00576    .03547   -.03020   -.11104   -.07094   -.05303    .13346    .89273    .85649
11 123.75000   4.61842   -.60481    .90516    .03992    .02825   -.10687   -.07985   -.04289    .13346    .91324    .83847
12 135.00000   4.61842   -.76977    .76977    .04143    .07716   -.07716   -.08286   -.03916    .13346    .92075    .83238
13 146.25000   4.61842   -.90516    .60481    .03992    .10687   -.02825   -.07985   -.04289    .13346    .91324    .83847
14 157.50000   4.61842  -1.00576    .41660    .03547    .11104    .03020   -.07094   -.05303    .13346    .89273    .85649
15 168.75000   4.61842  -1.06771    .21238    .02824    .08768    .08677   -.05647   -.06693    .13346    .86461    .88575
16 180.00000   4.61842  -1.08863   -.00000    .01850    .03951    .13008   -.03701   -.08092    .13346    .83630    .92514
17 191.25000   4.61842  -1.06771   -.21238    .00664   -.02641    .15070   -.01328   -.09112    .13346    .81567    .97313
18 202.50000   4.61842  -1.00576   -.41660   -.00689   -.09977    .14264    .01378   -.09400    .13346    .80985   1.02788
19 213.75000   4.61842   -.90516   -.60481   -.02157   -.16857    .10436    .04315   -.08669    .13346    .82463   1.08729
20 225.00000   4.61842   -.76977   -.76977   -.03684   -.22098    .03919    .07369   -.06712    .13346    .86423   1.14907
21 236.25000   4.61842   -.60481   -.90516   -.05211   -.24720   -.04519    .10423   -.03411    .13346    .93100   1.21085
22 247.50000   4.61842   -.41660  -1.00576   -.06680   -.24102   -.13775    .13359    .01221    .13346   1.02471   1.27026
23 258.75000   4.61842   -.21238  -1.06771   -.08033   -.20086   -.22574    .16066    .06989    .13346   1.14139   1.32501
24 270.00000   4.61842    .00000  -1.08863   -.09219   -.13008   -.29660    .18438    .13453    .13346   1.27215   1.37300
25 281.25000   4.61842    .21238  -1.06771   -.10192   -.03661   -.33983    .20385    .19915    .13346   1.40288   1.41238
26 292.50000   4.61842    .41660  -1.00576   -.10916    .06818   -.34857    .21831    .25494    .13346   1.51574   1.44164
27 303.75000   4.61842    .60481   -.90516   -.11361    .17108   -.32064    .22722    .29296    .13346   1.59265   1.45967
28 315.00000   4.61842    .76977   -.76977   -.11511    .25895   -.25895    .23023    .30647    .13346   1.61998   1.46575
29 326.25000   4.61842    .90516   -.60481   -.11361    .32064   -.17108    .22722    .29296    .13346   1.59265   1.45967
30 337.50000   4.61842   1.00576   -.41660   -.10916    .34857   -.06818    .21831    .25494    .13346   1.51574   1.44164
31 348.75000   4.61842   1.06771   -.21238   -.10192    .33983    .03661    .20385    .19915    .13346   1.40288   1.41238
32 360.00000   4.61842   1.08863    .00000   -.09219    .29660    .13008    .18438    .13453    .13346   1.27215   1.37300

                                              BODY RING   4

 1  11.25000   6.67105   1.24902    .24845   -.01697    .14328    .22303    .03394   -.06233    .04699    .87392   1.06867
 2  22.50000   6.67105   1.17655    .48734   -.00804    .04966    .25004    .01608   -.10916    .04699    .77918   1.03254
 3  33.75000   6.67105   1.05887    .70751    .00165   -.04565    .24017   -.00329   -.14409    .04699    .70850    .99334
 4  45.00000   6.67105    .90049    .90049    .01172   -.12864    .19587   -.02345   -.16569    .04699    .66481    .95257
 5  56.25000   6.67105    .70751   1.05887    .02180   -.18734    .12471   -.04360   -.17404    .04699    .64791    .91180
 6  67.50000   6.67105    .48734   1.17655    .03149   -.21365    .03819   -.06298   -.17024    .04699    .65560    .87260
 7  78.75000   6.67105    .24845   1.24902    .04042   -.20449   -.05002   -.08084   -.15623    .04699    .68394    .83647
 8  90.00000   6.67105   -.00000   1.27349    .04825   -.16226   -.12618   -.09649   -.13495    .04699    .72699    .80480
```

Figure 6.- Continued.

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 9 101.25000    6.67105   -.24845   1.24902    .05467   -.09446   -.17860   -.10934   -.11043    .04699    .77659    .77881
10 112.50000    6.67105   -.48734   1.17655    .05944   -.01246   -.19939   -.11888   -.08758    .04699    .82282    .75950
11 123.75000    6.67105   -.70751   1.05887    .06238    .07024   -.18570   -.12476   -.07135    .04699    .85566    .74761
12 135.00000    6.67105   -.90049    .90049    .06337    .14011   -.14011   -.12675   -.06547    .04699    .86756    .74359
13 146.25000    6.67105  -1.05887    .70751    .06238    .18570   -.07024   -.12476   -.07135    .04699    .85566    .74761
14 157.50000    6.67105  -1.17655    .48734    .05944    .19939    .01246   -.11888   -.08758    .04699    .82282    .75950
15 168.75000    6.67105  -1.24902    .24845    .05467    .17860    .09446   -.10934   -.11003    .04699    .77659    .77881
16 180.00000    6.67105  -1.27349   -.00000    .04825    .12618    .16226   -.09649   -.13495    .04699    .72699    .80480
17 191.25000    6.67105  -1.24902   -.24845    .04042    .05002    .20448   -.08084   -.15623    .04699    .68394    .83607
18 202.50000    6.67105  -1.17655   -.48734    .03149   -.03819    .21365   -.06298   -.17024    .04699    .65560    .87260
19 213.75000    6.67105  -1.05887   -.70751    .02180   -.12471    .18734   -.04360   -.17404    .04699    .64791    .91180
20 225.00000    6.67105   -.90049   -.90049    .01172   -.19527    .12864   -.02345   -.15569    .04699    .66481    .95257
21 236.25000    6.67105   -.70751  -1.05887    .00165   -.24017    .04565   -.00329   -.14409    .04699    .70850    .99334
22 247.50000    6.67105   -.48734  -1.17655   -.00804   -.25004   -.04966    .01608   -.10916    .04699    .77918   1.03254
23 258.75000    6.67105   -.24845  -1.24902   -.01697   -.22303   -.14328    .03394   -.06233    .04699    .87392   1.06867
24 270.00000    6.67105    .00000  -1.27349   -.02480   -.16226   -.22127    .04960   -.00729    .04699    .98525   1.10034
25 281.25000    6.67105    .24845  -1.24902   -.03122   -.07591   -.27186    .06244    .04963    .04699   1.10040   1.12632
26 292.50000    6.67105    .48734  -1.17655   -.03600    .02393   -.28724    .07199    .09997    .04699   1.20223   1.14564
27 303.75000    6.67105    .70751  -1.05887   -.03893    .12307   -.26476    .07787    .13482    .04699   1.27274   1.15753
28 315.00000    6.67105    .90049   -.90049   -.03993    .20735   -.20735    .07985    .14730    .04699   1.29799   1.16154
29 326.25000    6.67105   1.05887   -.70751   -.03893    .26476   -.12307    .07787    .13482    .04699   1.27274   1.15753
30 337.50000    6.67105   1.17655   -.48734   -.03600    .28724   -.02393    .07199    .09997    .04699   1.20223   1.14564
31 348.75000    6.67105   1.24902   -.24845   -.03122    .27186    .07591    .06244    .04963    .04699   1.10040   1.12632
32 360.00000    6.67105   1.27349    .00000   -.02480    .22127    .16226    .04960   -.00729    .04699    .98525   1.10034


                         BODY RING=   5

                      BODY NOSE SEPARATION AT XB/RB                  =     5.52485
                      VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =        .07510
                      VORTEX Y/RLOC (UNROLLED COORDS)                =      .63291
                      VORTEX Z/RLOC (UNROLLED COORDS)                =     1.17494


                      RIGHT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)=        .07510
                      RIGHT VORTEX Y(ROLLED COORDS.)/RLOC           =      -.38327
                      RIGHT VORTEX Z(ROLLED COORDS.)/RLOC           =      1.27835
                      LEFT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =        -.07510
                      LEFT VORTEX Y(ROLLED COORDS.)/RLOC            =     -1.27835
                      LEFT VORTEX Z(ROLLED COORDS.)/RLOC            =       .38327

 1  11.25000    8.72368   1.27502    .25362    .01846    .09244    .24186   -.03692   -.13846   0.00000    .71989    .92531
 2  22.50000    8.72368   1.20104    .49749    .02098   -.00453    .25906   -.04195   -.17259   0.00000    .65086    .91513
 3  33.75000    8.72368   1.08091    .72224    .02371   -.09954    .23610   -.04742   -.19340   0.00000    .60875    .90407
 4  45.00000    8.72368    .91924    .91924    .02655   -.17601    .17601   -.05310   -.19873   0.00000    .59797    .89257
 5  56.25000    8.72368    .72224   1.08091    .02939   -.21820    .08758   -.05879   -.18674   0.00000    .62225    .88108
 6  67.50000    8.72368    .49749   1.20104    .03213   -.21115   -.01551   -.06425   -.15486   0.00000    .68673    .87002
 7  78.75000    8.72368    .25362   1.27502    .03464   -.13659   -.11342   -.06929   -.09967   0.00000    .79837    .85983
 8  90.00000    8.72368   -.00000   1.30000    .03685    .03919   -.17544   -.07370   -.02991   0.00000    .93950    .85090
 9 101.25000    8.72368   -.25362   1.27502    .03866    .31798   -.14709   -.07733   -.03667   0.00000    .92583    .84357
10 112.50000    8.72368   -.49749   1.20104    .04001    .37297   -.09365   -.08002   -.06200   0.00000    .87458    .83812
11 123.75000    8.72368   -.72224   1.08091    .04084    .23609   -.13492   -.08168   -.02545   0.00000    .94852    .83477
12 135.00000    8.72368   -.91924    .91924    .04112    .17544   -.17544   -.08224   -.02079   0.00000    .95795    .83364
13 146.25000    8.72368  -1.08091    .72224    .04084    .13492   -.23609   -.08168   -.02545   0.00000    .94852    .83477
14 157.50000    8.72368  -1.20104    .49749    .04001    .09365   -.37297   -.08002   -.06200   0.00000    .87458    .83812
15 168.75000    8.72368  -1.27502    .25362    .03866    .14709   -.31798   -.07733   -.03667   0.00000    .92583    .84357
16 180.00000    8.72368  -1.30000   -.00000    .03685    .17544   -.03919   -.07370   -.02991   0.00000    .93950    .85090
17 191.25000    8.72368  -1.27502   -.25362    .03464    .11342    .13639   -.06929   -.09967   0.00000    .79837    .85983
```

Figure 6.- Continued.

```
18 202.50000   8.72368  -1.20104   -.49749    .03213    .01531    .21115   -.06425   -.15486   0.00000    .68675    .87002
19 213.75000   8.72368  -1.08091   -.72224    .02939   -.06758    .21820   -.05679   -.18674   0.00000    .62223    .88108
20 225.00000   8.72368   -.91924   -.91924    .02655   -.17601    .17601   -.05310   -.19873   0.00000    .59797    .89257
21 236.25000   8.72368   -.72224  -1.08091    .02371   -.23610    .09954   -.04742   -.19540   0.00000    .60875    .90407
22 247.50000   8.72368   -.49749  -1.20104    .02098   -.25906    .00453   -.04195   -.17259   0.00000    .65086    .91513
23 258.75000   8.72368   -.25362  -1.27502    .01846   -.24186   -.09244   -.03692   -.13846   0.00000    .71969    .92531
24 270.00000   8.72368    .00000  -1.30000    .01625   -.18759   -.17544   -.03250   -.09467   0.00000    .80849    .93425
25 281.25000   8.72368    .25362  -1.27502    .01444   -.10489   -.23121   -.02888   -.04710   0.00000    .90472    .94157
26 292.50000   8.72368    .49749  -1.20104    .01309   -.00668   -.25088   -.02619   -.00372   0.00000    .99247    .94702
27 303.75000   8.72368    .72224  -1.08091    .01227    .09183   -.23132   -.02453    .02686   0.00000   1.05435    .95037
28 315.00000   8.72368    .91924   -.91924    .01199    .17544   -.17544   -.02397    .03792   0.00000   1.07671    .95151
29 326.25000   8.72368   1.08091   -.72224    .01227    .23132   -.09183   -.02453    .02686   0.00000   1.05435    .95037
30 337.50000   8.72368   1.20104   -.49749    .01309    .25088    .00668   -.02619   -.00372   0.00000    .99247    .94702
31 348.75000   8.72368   1.27502   -.25362    .01444    .23121    .10489   -.02888   -.04710   0.00000    .90472    .94157
32 360.00000   8.72368   1.30000   -.00000    .01625    .17544    .18759   -.03250   -.09467   0.00000    .80849    .93425

                                              BODY RING=    6

                                           BODY NOSE SEPARATION AT XB/RB              =    5.52485
                                           VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =         .07701
                                           VORTEX Y/RLOC (UNROLLED COORDS)           =       .63679
                                           VORTEX Z/RLOC (UNROLLED COORDS)           =      1.22147


                                           RIGHT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)=        .07701
                                           RIGHT VORTEX Y(ROLLED COORDS.)/RLOC          =     -.41343
                                           RIGHT VORTEX Z(ROLLED COORDS.)/RLOC          =     1.31399
                                           LEFT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =      -.07701
                                           LEFT VORTEX Y(ROLLED COORDS.)/RLOC           =    -1.31399
                                           LEFT VORTEX Z(ROLLED COORDS.)/RLOC           =      .41343

 1  11.25000  10.77632   1.27502    .25362    .01723    .09167    .24573   -.03446   -.13919   0.00000    .71841    .93030
 2  22.50000  10.77632   1.20104    .49749    .01669   -.00614    .26294   -.03338   -.16925   0.00000    .65760    .93247
 3  33.75000  10.77632   1.08091    .72224    .01611   -.10186    .23957   -.03222   -.18568   0.00000    .62437    .93482
 4  45.00000  10.77632    .91924    .91924    .01550   -.17871    .17871   -.03101   -.18601   0.00000    .62371    .93727
 5  56.25000  10.77632    .72224   1.08091    .01490   -.22080    .08932   -.02980   -.16797   0.00000    .66019    .93972
 6  67.50000  10.77632    .49749   1.20104    .01432   -.21334   -.01441   -.02863   -.12865   0.00000    .73975    .94207
 7  78.75000  10.77632    .25362   1.27502    .01378   -.13943   -.11281   -.02756   -.06501   0.00000    .86848    .94424
 8  90.00000  10.77632   -.00000   1.30000    .01331    .02598   -.17544   -.02662    .01263   0.00000   1.02555    .94615
 9 101.25000  10.77632   -.25362   1.27502    .01292    .27244   -.15615   -.02585    .02547   0.00000   1.05153    .94771
10 112.50000  10.77632   -.49749   1.20104    .01264    .34955   -.10333   -.02528   -.00024   0.00000    .99952    .94887
11 123.75000  10.77632   -.72224   1.08091    .01246    .24047   -.13199   -.02492    .03044   0.00000   1.06158    .94958
12 135.00000  10.77632   -.91924    .91924    .01240    .17544   -.17544   -.02480    .03706   0.00000   1.07497    .94982
13 146.25000  10.77632  -1.08091    .72224    .01246    .13199   -.24047   -.02492    .03044   0.00000   1.06158    .94958
14 157.50000  10.77632  -1.20104    .49749    .01264    .10333   -.34955   -.02528   -.00024   0.00000    .99952    .94887
15 168.75000  10.77632  -1.27502    .25362    .01292    .15615   -.27244   -.02585    .02547   0.00000   1.05153    .94771
16 180.00000  10.77632  -1.30000   -.00000    .01331    .17544   -.02598   -.02662    .01263   0.00000   1.02555    .94615
17 191.25000  10.77632  -1.27502   -.25362    .01378    .11281    .13943   -.02756   -.06501   0.00000    .86848    .94424
18 202.50000  10.77632  -1.20104   -.49749    .01432    .01441    .21334   -.02863   -.12865   0.00000    .73975    .94207
19 213.75000  10.77632  -1.08091   -.72224    .01490   -.08932    .22080   -.02980   -.16797   0.00000    .66019    .93972
20 225.00000  10.77632   -.91924   -.91924    .01550   -.17871    .17871   -.03101   -.18601   0.00000    .62371    .93727
21 236.25000  10.77632   -.72224  -1.08091    .01611   -.23957    .10186   -.03222   -.18568   0.00000    .62437    .93482
22 247.50000  10.77632   -.49749  -1.20104    .01669   -.26294    .00614   -.03338   -.16925   0.00000    .65760    .93247
23 258.75000  10.77632   -.25362  -1.27502    .01723   -.24573   -.09167   -.03446   -.13919   0.00000    .71841    .93030
24 270.00000  10.77632    .00000  -1.30000    .01770   -.19104   -.17544   -.03540   -.09925   0.00000    .79922    .92839
25 281.25000  10.77632    .25362  -1.27502    .01808   -.10759   -.23174   -.03617   -.05520   0.00000    .88853    .92683
26 292.50000  10.77632    .49749  -1.20104    .01837   -.00846   -.25162   -.03674   -.01473   0.00000    .97021    .92567
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Figure 6.- Continued.

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27 303.75000  10.77632    .72224  -1.08091    .01855    .09101   -.23186   -.03709    .01392   0.00000   1.02817    .92496
28 315.00000  10.77632    .91924   -.91924    .01861    .17544   -.17544   -.03721    .02430   0.00000   1.04915    .92472
29 326.25000  10.77632   1.08091   -.72224    .01855    .23186   -.09101   -.03709    .01392   0.00000   1.02817    .92496
30 337.50000  10.77632   1.20104   -.49749    .01837    .25162    .00846   -.03674   -.01473   0.00000    .97021    .92567
31 348.75000  10.77632   1.27502   -.25362    .01808    .23174    .10759   -.03617   -.05520   0.00000    .88833    .92683
32 360.00000  10.77632   1.30000    .00000    .01770    .17544    .19104   -.03540   -.09925   0.00000    .79922    .92839

                                   BODY RING=   7

                                 BODY NOSE SEPARATION AT XB/RB                 =    5.52485
                                 VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)        =     .07891
                                 VORTEX Y/RLOC (UNROLLED COORDS)               =     .64087
                                 VORTEX Z/RLOC (UNROLLED COORDS)               =    1.26800

                                 RIGHT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)=     .07891
                                 RIGHT VORTEX Y(ROLLED COORDS.)/RLOC         =    -.44345
                                 RIGHT VORTEX Z(ROLLED COORDS.)/RLOC         =    1.34977
                                 LEFT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =    -.07891
                                 LEFT VORTEX Y(ROLLED COORDS.)/RLOC          =   -1.34977
                                 LEFT VORTEX Z(ROLLED COORDS.)/RLOC          =     .44345

 1  11.25000  12.82895   1.27502    .25362    .01336    .09328    .23765   -.02672   -.12754   0.00000    .74199    .94594
 2  22.50000  12.82895   1.20104    .49749    .01226   -.00257    .25433   -.02452   -.15614   0.00000    .68412    .95039
 3  33.75000  12.82895   1.08091    .72224    .01107   -.09622    .23113   -.02214   -.17124   0.00000    .65359    .95522
 4  45.00000  12.82895    .91924    .91924    .00983   -.17112    .17112   -.01965   -.17022   0.00000    .65564    .96024
 5  56.25000  12.82895    .72224   1.08091    .00858   -.21166    .08321   -.01717   -.15079   0.00000    .69495    .96527
 6  67.50000  12.82895    .49749   1.20104    .00739   -.20346   -.01850   -.01478   -.11026   0.00000    .77695    .97010
 7  78.75000  12.82895    .25362   1.27502    .00629   -.13127   -.11444   -.01258   -.04674   0.00000    .90544    .97455
 8  90.00000  12.82895   -.00000   1.30000    .00533    .02363   -.17544   -.01065    .02799   0.00000   1.05663    .97845
 9 101.25000  12.82895   -.25362   1.27502    .00454    .24321   -.16196   -.00907    .04810   0.00000   1.09731    .98165
10 112.50000  12.82895   -.49749   1.20104    .00395    .32994   -.11145   -.00790    .02477   0.00000   1.05012    .98403
11 123.75000  12.82895   -.72224   1.08091    .00359    .24358   -.12992   -.00717    .04813   0.00000   1.09736    .98549
12 135.00000  12.82895   -.91924    .91924    .00346    .17544   -.17544   -.00693    .05568   0.00000   1.11264    .98599
13 146.25000  12.82895  -1.08091    .72224    .00359    .12992   -.24358   -.00717    .04813   0.00000   1.09736    .98549
14 157.50000  12.82895  -1.20104    .49749    .00395    .11145   -.32994   -.00790    .02477   0.00000   1.05012    .98403
15 168.75000  12.82895  -1.27502    .25362    .00454    .16196   -.24321   -.00907    .04810   0.00000   1.09731    .98165
16 180.00000  12.82895  -1.30000   -.00000    .00533    .17544   -.02363   -.01065    .02799   0.00000   1.05663    .97845
17 191.25000  12.82895  -1.27502   -.25362    .00629    .11444    .13127   -.01258   -.04674   0.00000    .90544    .97455
18 202.50000  12.82895  -1.20104   -.49749    .00739    .01850    .20346   -.01478   -.11026   0.00000    .77695    .97010
19 213.75000  12.82895  -1.08091   -.72224    .00858   -.08321    .21166   -.01717   -.15079   0.00000    .69495    .96527
20 225.00000  12.82895   -.91924   -.91924    .00983   -.17112    .17112   -.01965   -.17022   0.00000    .65564    .96024
21 236.25000  12.82895   -.72224  -1.08091    .01107   -.23113    .09622   -.02214   -.17124   0.00000    .65359    .95522
22 247.50000  12.82895   -.49749  -1.20104    .01226   -.25433    .00257   -.02452   -.15614   0.00000    .68412    .95039
23 258.75000  12.82895   -.25362  -1.27502    .01336   -.23765   -.09328   -.02672   -.12754   0.00000    .74199    .94594
24 270.00000  12.82895    .00000  -1.30000    .01433   -.18411   -.17544   -.02865   -.08923   0.00000    .81948    .94204
25 281.25000  12.82895    .25362  -1.27502    .01512   -.10230   -.23069   -.03023   -.04694   0.00000    .90503    .93884
26 292.50000  12.82895    .49749  -1.20104    .01570   -.00504   -.25020   -.03141   -.00813   0.00000    .98356    .93646
27 303.75000  12.82895    .72224  -1.08091    .01607    .09257   -.23082   -.03213    .01932   0.00000   1.03909    .93499
28 315.00000  12.82895    .91924   -.91924    .01619    .17544   -.17544   -.03238    .02925   0.00000   1.05918    .93450
29 326.25000  12.82895   1.08091   -.72224    .01607    .23082   -.09257   -.03213    .01932   0.00000   1.03909    .93499
30 337.50000  12.82895   1.20104   -.49749    .01570    .25020    .00504   -.03141   -.00813   0.00000    .98356    .93646
31 348.75000  12.82895   1.27502   -.25362    .01512    .23069    .10230   -.03023   -.04694   0.00000    .90503    .93884
32 360.00000  12.82895   1.30000    .00000    .01433    .17544    .18411   -.02865   -.08923   0.00000    .81948    .94204
```

Figure 6.- Continued.

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                                  BODY RING=   8

                                  BODY NOSE SEPARATION AT XB/RB                  =     5.52485
                                  VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =         .08082
                                  VORTEX Y/RLOC (UNROLLED COORDS)                =      .64591
                                  VORTEX Z/RLOC (UNROLLED COORDS)                =     1.31453

                                  RIGHT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)=      .08082
                                  RIGHT VORTEX Y(ROLLED COORDS.)/RLOC             =     -.47279
                                  RIGHT VORTEX Z(ROLLED COORDS.)/RLOC             =     1.38624
                                  LEFT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =     -.08082
                                  LEFT VORTEX Y(ROLLED COORDS.)/RLOC              =    -1.38624
                                  LEFT VORTEX Z(ROLLED COORDS.)/RLOC              =      .47279

  1  11.25000  14.88158   1.27502    .25362    .00928    .09490    .22946   -.01855   -.11532   0.00000    .76670    .96247
  2  22.50000  14.88158   1.20104    .49749    .00846    .00103    .24562   -.01691   -.14371   0.00000    .70927    .96579
  3  33.75000  14.88158   1.08091    .72224    .00757   -.09054    .22262   -.01513   -.15873   0.00000    .67888    .96939
  4  45.00000  14.88158    .91924    .91924    .00664   -.16351    .16351   -.01328   -.15776   0.00000    .68084    .97314
  5  56.25000  14.88158    .72224   1.08091    .00571   -.20255    .07712   -.01143   -.13858   0.00000    .71965    .97689
  6  67.50000  14.88158    .49749   1.20104    .00482   -.19377   -.02251   -.00964   -.09890   0.00000    .79993    .98049
  7  78.75000  14.88158    .25362   1.27502    .00400   -.12339   -.11600   -.00800   -.03793   0.00000    .92326    .98381
  8  90.00000  14.88158   -.00000   1.30000    .00328    .02217   -.17544   -.00656    .03169   0.00000   1.06410    .98672
  9 101.25000  14.88158   -.25362   1.27502    .00269    .22012   -.16656   -.00538    .05492   0.00000   1.11111    .98911
 10 112.50000  14.88158   -.49749   1.20104    .00225    .31040   -.11955   -.00451    .03517   0.00000   1.07114    .99089
 11 123.75000  14.88158   -.72224   1.08091    .00198    .24356   -.12993   -.00397    .05147   0.00000   1.10412    .99198
 12 135.00000  14.88158   -.91924    .91924    .00180    .17544   -.17544   -.00378    .05899   0.00000   1.11933    .99235
 13 146.25000  14.88158  -1.08091    .72224    .00198    .12993   -.24356   -.00397    .05147   0.00000   1.10412    .99196
 14 157.50000  14.88158  -1.20104    .49749    .00225    .11955   -.31040   -.00451    .03517   0.00000   1.07114    .99089
 15 168.75000  14.88158  -1.27502    .25362    .00269    .16656   -.22012   -.00538    .05492   0.00000   1.11111    .98911
 16 180.00000  14.88158  -1.30000   -.00000    .00328    .17544   -.02217   -.00656    .03169   0.00000   1.06410    .98672
 17 191.25000  14.88158  -1.27502   -.25362    .00400    .11600    .12339   -.00800   -.03793   0.00000    .92326    .98381
 18 202.50000  14.88158  -1.20104   -.49749    .00482    .02251    .19377   -.00964   -.09890   0.00000    .79993    .98049
 19 213.75000  14.88158  -1.08091   -.72224    .00571   -.07712    .20255   -.01143   -.13858   0.00000    .71965    .97689
 20 225.00000  14.88158   -.91924   -.91924    .00664   -.16351    .16351   -.01328   -.15776   0.00000    .68084    .97314
 21 236.25000  14.88158   -.72224  -1.08091    .00757   -.22262    .09054   -.01513   -.15873   0.00000    .67888    .96939
 22 247.50000  14.88158   -.49749  -1.20104    .00846   -.24562   -.00103   -.01691   -.14371   0.00000    .70927    .96579
 23 258.75000  14.88158   -.25362  -1.27502    .00928   -.22946   -.09490   -.01855   -.11532   0.00000    .76670    .96247
 24 270.00000  14.88158    .00000  -1.30000    .01000   -.17709   -.17544   -.01999   -.07743   0.00000    .84337    .95956
 25 281.25000  14.88158    .25362  -1.27502    .01099   -.09693   -.22962   -.02117   -.03571   0.00000    .92775    .95717
 26 292.50000  14.88158    .49749  -1.20104    .01102   -.00157   -.24877   -.02205    .00247   0.00000   1.00500    .95539
 27 303.75000  14.88158    .72224  -1.08091    .01130    .09416   -.22976   -.02259    .02942   0.00000   1.05952    .95430
 28 315.00000  14.88158    .91924   -.91924    .01139    .17544   -.17544   -.02277    .03916   0.00000   1.07922    .95393
 29 326.25000  14.88158   1.08091   -.72224    .01130    .22976   -.09416   -.02259    .02942   0.00000   1.05952    .95430
 30 337.50000  14.88158   1.20104   -.49749    .01102    .24877    .00157   -.02205    .00247   0.00000   1.00500    .95539
 31 348.75000  14.88158   1.27502   -.25362    .01059    .22962    .09693   -.02117   -.03571   0.00000    .92775    .95717
 32 360.00000  14.88158   1.30000    .00000    .01000    .17544    .17709   -.01999   -.07743   0.00000    .84337    .95956

                                  BODY RING=   9

                                  BODY NOSE SEPARATION AT XB/RB                  =     5.52485
                                  VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =         .08272
                                  VORTEX Y/RLOC (UNROLLED COORDS)                =      .65095
                                  VORTEX Z/RLOC (UNROLLED COORDS)                =     1.36106
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Figure 6.- Continued.

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                                        RIGHT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)=       .08272
                                        RIGHT VORTEX Y(ROLLED COORDS.)/RLOC         =     -.50213
                                        RIGHT VORTEX Z(ROLLED COORDS.)/RLOC         =     1.42271
                                        LEFT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =     -.08272
                                        LEFT VORTEX Y(ROLLED COORDS.)/RLOC          =    -1.42271
                                        LEFT VORTEX Z(ROLLED COORDS.)/RLOC          =       .50213

 1  11.25000  16.93421   1.27502    .25362    .00617    .09596    .22413   -.01234   -.10656   0.00000    .78443    .97504
 2  22.50000  16.93421   1.20104    .49749    .00572    .00339    .23992   -.01144   -.13511   0.00000    .72668    .97687
 3  33.75000  16.93421   1.08091    .72224    .00523   -.08678    .21701   -.01046   -.15036   0.00000    .69542    .97884
 4  45.00000  16.93421    .91924    .91924    .00472   -.15845    .15845   -.00944   -.14971   0.00000    .69714    .98090
 5  56.25000  16.93421    .72224   1.08091    .00421   -.19647    .07306   -.00842   -.13103   0.00000    .73493    .98296
 6  67.50000  16.93421    .49749   1.20104    .00372   -.18740   -.02515   -.00745   -.09241   0.00000    .81306    .98493
 7  78.75000  16.93421    .25362   1.27502    .00327   -.11886   -.11690   -.00655   -.03396   0.00000    .93130    .98676
 8  90.00000  16.93421   -.00000   1.30000    .00288    .01863   -.17544   -.00576    .03137   0.00000   1.06546    .98835
 9 101.25000  16.93421   -.25362   1.27502    .00255    .19951   -.17066   -.00511    .05687   0.00000   1.11504    .98966
10 112.50000  16.93421   -.49749   1.20104    .00231    .29103   -.12757   -.00463    .04108   0.00000   1.08311    .99064
11 123.75000  16.93421   -.72224   1.08091    .00217    .24097   -.13166   -.00433    .05163   0.00000   1.10445    .99124
12 135.00000  16.93421   -.91924    .91924    .00212    .17544   -.17544   -.00423    .05852   0.00000   1.11838    .99144
13 146.25000  16.93421  -1.08091    .72224    .00217    .13166   -.24097   -.00433    .05163   0.00000   1.10445    .99124
14 157.50000  16.93421  -1.20104    .49749    .00231    .12757   -.29103   -.00463    .04108   0.00000   1.08311    .99064
15 168.75000  16.93421  -1.27502    .25362    .00255    .17066   -.19951   -.00511    .05687   0.00000   1.11504    .98966
16 180.00000  16.93421  -1.30000   -.00000    .00288    .17544   -.01863   -.00576    .03137   0.00000   1.06546    .98835
17 191.25000  16.93421  -1.27502   -.25362    .00327    .11690    .11886   -.00655   -.03396   0.00000    .93130    .98676
18 202.50000  16.93421  -1.20104   -.49749    .00372    .02515    .18740   -.00745   -.09241   0.00000    .81306    .98493
19 213.75000  16.93421  -1.08091   -.72224    .00421   -.07306    .19647   -.00842   -.13103   0.00000    .73493    .98296
20 225.00000  16.93421   -.91924   -.91924    .00472   -.15845    .15845   -.00944   -.14971   0.00000    .69714    .98090
21 236.25000  16.93421   -.72224  -1.08091    .00523   -.21701    .08678   -.01046   -.15036   0.00000    .69582    .97884
22 247.50000  16.93421   -.49749  -1.20104    .00572   -.23992   -.00339   -.01144   -.13511   0.00000    .72668    .97687
23 258.75000  16.93421   -.25362  -1.27502    .00617   -.22413   -.09596   -.01234   -.10656   0.00000    .78443    .97504
24 270.00000  16.93421    .00000  -1.30000    .00656   -.17254   -.17544   -.01313   -.06861   0.00000    .86120    .97345
25 281.25000  16.93421    .25362  -1.27502    .00689   -.09346   -.22893   -.01377   -.02695   0.00000    .94547    .97214
26 292.50000  16.93421    .49749  -1.20104    .00713    .00066   -.24784   -.01426    .01110   0.00000   1.02245    .97116
27 303.75000  16.93421    .72224  -1.08091    .00728    .09518   -.22908   -.01455    .03792   0.00000   1.07670    .97056
28 315.00000  16.93421    .91924   -.91924    .00733    .17544   -.17544   -.01465    .04760   0.00000   1.09629    .97036
29 326.25000  16.93421   1.08091   -.72224    .00728    .22908   -.09518   -.01455    .03792   0.00000   1.07670    .97056
30 337.50000  16.93421   1.20104   -.49749    .00713    .24784   -.00066   -.01426    .01110   0.00000   1.02245    .97116
31 348.75000  16.93421   1.27502   -.25362    .00689    .22893    .09346   -.01377   -.02695   0.00000    .94547    .97214
32 360.00000  16.93421   1.30000    .00000    .00656    .17544    .17254   -.01313   -.06861   0.00000    .86120    .97345


                                        BODY RING=  10

                                        BODY NOSE SEPARATION AT XB/RB             =     5.52485
                                        VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)    =      .08688
                                        VORTEX Y/RLOC (UNROLLED COORDS)           =      .65576
                                        VORTEX Z/RLOC (UNROLLED COORDS)           =     1.40759


                                        RIGHT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)=       .08688
                                        RIGHT VORTEX Y(ROLLED COORDS.)/RLOC         =     -.53163
                                        RIGHT VORTEX Z(ROLLED COORDS.)/RLOC         =     1.45901
                                        LEFT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =     -.08688
                                        LEFT VORTEX Y(ROLLED COORDS.)/RLOC          =    -1.45901
                                        LEFT VORTEX Z(ROLLED COORDS.)/RLOC          =       .53163

 1  11.25000  18.98684   1.27502    .25362    .00416    .09660    .22095   -.00832   -.10104   0.00000    .79560    .98318
 2  22.50000  18.98684   1.20104    .49749    .00395    .00485    .23640   -.00791   -.12964   0.00000    .73774    .98401
 3  33.75000  18.98684   1.08091    .72224    .00373   -.08436    .21339   -.00746   -.14494   0.00000    .70679    .98491
 4  45.00000  18.98684    .91924    .91924    .00350   -.15498    .15498   -.00700   -.14430   0.00000    .70809    .98584
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Figure 6.- Continued.

```
 5  56.25000  18.98684    .72224   1.08091    .00327  -.19196   .07004  -.00653  -.12567  0.00000    .74577   .98678
 6  67.50000  18.98684    .49749   1.20104    .00304  -.18211  -.02734  -.00609  -.08742  0.00000    .82315   .98768
 7  78.75000  18.98684    .25362   1.27502    .00284  -.11411  -.11785  -.00568  -.03043  0.00000    .93844   .98851
 8  90.00000  18.98684   -.00000   1.30000    .00266   .01843  -.17544  -.00532   .03175  0.00000   1.06423   .98924
 9 101.25000  18.98684   -.25362   1.27502    .00251   .18801  -.17295  -.00503   .05746  0.00000   1.11625   .98983
10 112.50000  18.98684   -.49749   1.20104    .00240   .27961  -.13230  -.00481   .04404  0.00000   1.08910   .99028
11 123.75000  18.98684   -.72224   1.08091    .00234   .24039  -.13205  -.00467   .05139  0.00000   1.10397   .99055
12 135.00000  18.98684   -.91924    .91924    .00231   .17544  -.17544  -.00463   .05810  0.00000   1.11754   .99064
13 146.25000  18.98684  -1.08091    .72224    .00234   .13205  -.24039  -.00467   .05139  0.00000   1.10397   .99055
14 157.50000  18.98684  -1.20104    .49749    .00240   .13230  -.27961  -.00481   .04404  0.00000   1.08910   .99028
15 168.75000  18.98684  -1.27502    .25362    .00251   .17295  -.18801  -.00503   .05746  0.00000   1.11625   .98983
16 180.00000  18.98684  -1.30000   -.00000    .00266   .17544  -.01843  -.00532   .03175  0.00000   1.06423   .98924
17 191.25000  18.98684  -1.27502   -.25362    .00284   .11785   .11411  -.00568  -.03043  0.00000    .93844   .98851
18 202.50000  18.98684  -1.20104   -.49749    .00304   .02734   .18211  -.00609  -.08742  0.00000    .82315   .98768
19 213.75000  18.98684  -1.08091   -.72224    .00327  -.07004   .19196  -.00653  -.12567  0.00000    .74577   .98678
20 225.00000  18.98684   -.91924   -.91924    .00350  -.15498   .15498  -.00700  -.14430  0.00000    .70809   .98584
21 236.25000  18.98684   -.72224  -1.08091    .00373  -.21339   .08436  -.00746  -.14494  0.00000    .70679   .98491
22 247.50000  18.98684   -.49749  -1.20104    .00395  -.23640  -.00485  -.00791  -.12464  0.00000    .73774   .98401
23 258.75000  18.98684   -.25362  -1.27502    .00416  -.22095  -.09660  -.00832  -.10104  0.00000    .79560   .98318
24 270.00000  18.98684    .00000  -1.30000    .00434  -.16989  -.17544  -.00867  -.06304  0.00000    .87247   .98245
25 281.25000  18.98684    .25362  -1.27502    .00448  -.09147  -.22854  -.00897  -.02137  0.00000    .95677   .98185
26 292.50000  18.98684    .49749  -1.20104    .00459   .00193  -.24732  -.00919   .01666  0.00000   1.03371   .98141
27 303.75000  18.98684    .72224  -1.08091    .00466   .09575  -.22869  -.00932   .04345  0.00000   1.08790   .98114
28 315.00000  18.98684    .91924   -.91924    .00468   .17544  -.17544  -.00937   .05312  0.00000   1.10746   .98105
29 326.25000  18.98684   1.08091   -.72224    .00466   .22869  -.09575  -.00932   .04345  0.00000   1.08790   .98114
30 337.50000  18.98684   1.20104   -.49749    .00459   .24732  -.00193  -.00919   .01666  0.00000   1.03371   .98141
31 348.75000  18.98684   1.27502   -.25362    .00448   .22854   .09147  -.00897  -.02137  0.00000    .95677   .98185
32 360.00000  18.98684   1.30000    .00000    .00434   .17544   .16989  -.00867  -.06304  0.00000    .87247   .98245


         TOTAL NUMBER OF PRESSURE POINTS,JCPT=  428


         CONTROL POINT COORDINATES FOR  3 CHORDWISE BY  5 SPANWISE PANELS ON WING 1 OR R,   5     SPANWISE ON WING 2 OR L
                                                     AND 5 SPANWISE PANELS ONWING 3 OR U,  5     SPANWISE ON WING 4 OR D

 J       X(J)        Y(J)        Z(J)         BU(J)          BV(J)          BW(J)         VVRTX          WVRTX

 1     1.23112     1.53096     0.00000     .30415E-02     .12608E+00     .12789E+00    0.             0.
 2     2.38667     1.53096     0.00000     .25619E-02     .12617E+00     .12768E+00    0.             0.
 3     3.54222     1.53096     0.00000     .22035E-02     .12622E+00     .12755E+00    0.             0.
 4     1.41565     1.99870     0.00000     .30173E-02     .73266E-01     .75357E-01    0.             0.
 5     2.48119     1.99870     0.00000     .25678E-02     .73453E-01     .75200E-01    0.             0.
 6     3.54672     1.99870     0.00000     .22281E-02     .73581E-01     .75098E-01    0.             0.
 7     1.60017     2.46640     0.00000     .30518E-02     .47405E-01     .49768E-01    0.             0.
 8     2.57570     2.46640     0.00000     .26235E-02     .47650E-01     .49633E-01    0.             0.
 9     3.55122     2.46640     0.00000     .22924E-02     .47827E-01     .49541E-01    0.             0.
10     1.78466     2.93403     0.00000     .31062E-02     .32808E-01     .35417E-01    0.             0.
11     2.67019     2.93403     0.00000     .26948E-02     .33091E-01     .35293E-01    0.             0.
12     3.55572     2.93403     0.00000     .23729E-02     .33299E-01     .35206E-01    0.             0.
13     1.96912     3.40158     0.00000     .32017E-02     .23701E-01     .26577E-01    0.             0.
14     2.76467     3.40158     0.00000     .28029E-02     .24011E-01     .26461E-01    0.             0.
15     3.56022     3.40158     0.00000     .24715E-02     .24266E-01     .26377E-01    0.             0.
16     1.23112    -1.53096     0.00000     .23353E-02     .12635E+00     .12789E+00    0.             0.
17     2.38667    -1.53096     0.00000     .21254E-02     .12638E+00     .12768E+00    0.             0.
18     3.54222    -1.53096     0.00000     .19174E-02     .12640E+00     .12755E+00    0.             0.
19     1.41565    -1.99870     0.00000     .22883E-02     .73972E-01     .75357E-01    0.             0.
20     2.48119    -1.99870     0.00000     .21091E-02     .74042E-01     .75200E-01    0.             0.
```

Figure 6.- Continued.

```
 21    3.54672   -1.99870    0.00000   .19229E-02   .74077E-01   .75098E-01   0.          0.
 22    1.60017   -2.46640    0.00000   .21980E-02   .48455E-01   .49768E-01   0.          0.
 23    2.57570   -2.46640    0.00000   .20524E-02   .48538E-01   .49633E-01   0.          0.
 24    3.55122   -2.46640    0.00000   .18969E-02   .48586E-01   .49541E-01   0.          0.
 25    1.78466   -2.93403    0.00000   .21408E-02   .34196E-01   .35417E-01   0.          0.
 26    2.67019   -2.93403    0.00000   .20174E-02   .34274E-01   .35293E-01   0.          0.
 27    3.55572   -2.93403    0.00000   .18823E-02   .34317E-01   .35206E-01   0.          0.
 28    1.96912   -3.40158    0.00000   .20349E-02   .25363E-01   .26577E-01   0.          0.
 29    2.76467   -3.40158    0.00000   .19547E-02   .25454E-01   .26461E-01   0.          0.
 30    3.56022   -3.40158    0.00000   .18804E-02   .25558E-01   .26377E-01   0.          0.
 31    1.23112    0.00000    1.53096   .23353E-02  -.12789E+00  -.12635E+00   0.          0.
 32    2.38667    0.00000    1.53096   .21254E-02  -.12768E+00  -.12638E+00   0.          0.
 33    3.54222    0.00000    1.53096   .19174E-02  -.12755E+00  -.12640E+00   0.          0.
 34    1.41565    0.00000    1.99870   .22883E-02  -.75357E-01  -.73972E-01   0.          0.
 35    2.48119    0.00000    1.99870   .21091E-02  -.75200E-01  -.74042E-01   0.          0.
 36    3.54672    0.00000    1.99870   .19229E-02  -.75098E-01  -.74077E-01   0.          0.
 37    1.60017    0.00000    2.46640   .21980E-02  -.49768E-01  -.48455E-01   0.          0.
 38    2.57570    0.00000    2.46640   .20524E-02  -.49633E-01  -.48538E-01   0.          0.
 39    3.55122    0.00000    2.46640   .18969E-02  -.49541E-01  -.48586E-01   0.          0.
 40    1.78466    0.00000    2.93403   .21408E-02  -.35417E-01  -.34196E-01   0.          0.
 41    2.67019    0.00000    2.93403   .20174E-02  -.35293E-01  -.34274E-01   0.          0.
 42    3.55572    0.00000    2.93403   .18823E-02  -.35206E-01  -.34317E-01   0.          0.
 43    1.96912    0.00000    3.40158   .20349E-02  -.26577E-01  -.25363E-01   0.          0.
 44    2.76467    0.00000    3.40158   .19547E-02  -.26461E-01  -.25454E-01   0.          0.
 45    3.56022    0.00000    3.40158   .18804E-02  -.26377E-01  -.25558E-01   0.          0.
 46    1.23112    0.00000   -1.53096   .30415E-02  -.12789E+00  -.12608E+00   0.          0.
 47    2.38667    0.00000   -1.53096   .25619E-02  -.12768E+00  -.12617E+00   0.          0.
 48    3.54222    0.00000   -1.53096   .22035E-02  -.12755E+00  -.12622E+00   0.          0.
 49    1.41565    0.00000   -1.99870   .30173E-02  -.75357E-01  -.73266E-01   0.          0.
 50    2.48119    0.00000   -1.99870   .25678E-02  -.75200E-01  -.73453E-01   0.          0.
 51    3.54672    0.00000   -1.99870   .22281E-02  -.75098E-01  -.73581E-01   0.          0.
 52    1.60017    0.00000   -2.46640   .30518E-02  -.49768E-01  -.47405E-01   0.          0.
 53    2.57570    0.00000   -2.46640   .26235E-02  -.49633E-01  -.47650E-01   0.          0.
 54    3.55122    0.00000   -2.46640   .22924E-02  -.49541E-01  -.47827E-01   0.          0.
 55    1.78466    0.00000   -2.93403   .31062E-02  -.35417E-01  -.32808E-01   0.          0.
 56    2.67019    0.00000   -2.93403   .26945E-02  -.35293E-01  -.33091E-01   0.          0.
 57    3.55572    0.00000   -2.93403   .23729E-02  -.35206E-01  -.33299E-01   0.          0.
 58    1.96912    0.00000   -3.40158   .32017E-02  -.26577E-01  -.23701E-01   0.          0.
 59    2.76467    0.00000   -3.40158   .28029E-02  -.26461E-01  -.24011E-01   0.          0.
 60    3.56022    0.00000   -3.40158   .24715E-02  -.26377E-01  -.24266E-01   0.          0.


                         CONTROL POINT COORDINATES FOR HIP*9 (WING FRAME)

  J       X(J)        Y(J)        Z(J)       THU(J)        THV(J)        THW(J)


 61    1.14000     1.25052      .24874   -.13891E-02   -.18221E-01    .34655E-02
 62    1.14000     1.06014      .70836   -.15717E-01   -.88792E-02    .20553E-01
 63    1.14000      .70836     1.06014   -.15717E-01    .20553E-01   -.88792E-02
 64    1.14000      .24874     1.25052   -.13891E-02    .34655E-02   -.18221E-01
 65    1.14000     -.24874     1.25052   -.13891E-02   -.34655E-02   -.18221E-01
 66    1.14000     -.70836     1.06014   -.15717E-01   -.20553E-01   -.88792E-02
 67    1.14000    -1.06014      .70836   -.15717E-01    .88792E-02    .20553E-01
 68    1.14000    -1.25052      .24874   -.13891E-02    .18221E-01    .34655E-02
 69    1.14000    -1.25052     -.24874   -.13891E-02    .18221E-01   -.34655E-02
 70    1.14000    -1.06014     -.70836   -.15717E-01    .88792E-02   -.20553E-01
```

Figure 6.- Continued.

```
 71     1.14000     -.70836    -1.06014    -.15717E-01    -.20553E-01     .88792E-02
 72     1.14000     -.24874    -1.25052    -.13891E-02    -.34655E-02     .18221E-01
 73     1.14000      .24874    -1.25052    -.13891E-02     .34655E-02     .18221E-01
 74     1.14000      .70836    -1.06014    -.15717E-01     .20553E-01     .88792E-02
 75     1.14000     1.06014     -.70836    -.15717E-01    -.88792E-02    -.20553E-01
 76     1.14000     1.25052     -.24874    -.13891E-02    -.18221E-01    -.34655E-02
 77     2.34000     1.25052      .24874    -.10617E-01    -.85805E-02    -.48355E-02
 78     2.34000     1.06014      .70836    -.22211E-01    -.16042E-01     .68216E-02
 79     2.34000      .70836     1.06014    -.22211E-01     .68216E-02    -.16042E-01
 80     2.34000      .24874     1.25052    -.10617E-01    -.48355E-02    -.85805E-02
 81     2.34000     -.24874     1.25052    -.10617E-01     .48355E-02    -.85805E-02
 82     2.34000     -.70836     1.06014    -.22211E-01    -.68216E-02    -.16042E-01
 83     2.34000    -1.06014      .70836    -.22211E-01     .16042E-01     .68216E-02
 84     2.34000    -1.25052      .24874    -.10617E-01     .85805E-02    -.48355E-02
 85     2.34000    -1.25052     -.24874    -.10617E-01     .85805E-02     .48355E-02
 86     2.34000    -1.06014     -.70836    -.22211E-01     .16042E-01    -.68216E-02
 87     2.34000     -.70836    -1.06014    -.22211E-01    -.68216E-02     .16042E-01
 88     2.34000     -.24874    -1.25052    -.10617E-01     .48355E-02     .85805E-02
 89     2.34000      .24874    -1.25052    -.10617E-01    -.48355E-02     .85805E-02
 90     2.34000      .70836    -1.06014    -.22211E-01     .68216E-02     .16042E-01
 91     2.34000     1.06014     -.70836    -.22211E-01    -.16042E-01    -.68216E-02
 92     2.34000     1.25052     -.24874    -.10617E-01    -.85805E-02     .48355E-02
 93     3.54000     1.25052      .24874     .20323E-01     .26782E-01    -.54507E-01
 94     3.54000     1.06014      .70836    -.22241E-01     .11295E-01     .68311E-02
 95     3.54000      .70836     1.06014    -.22241E-01     .68311E-02     .11295E-01
 96     3.54000      .24874     1.25052     .20323E-01    -.54507E-01     .26782E-01
 97     3.54000     -.24874     1.25052     .20323E-01     .54507E-01     .26782E-01
 98     3.54000     -.70836     1.06014    -.22241E-01    -.68311E-02     .11295E-01
 99     3.54000    -1.06014      .70836    -.22241E-01    -.11295E-01     .68311E-02
100     3.54000    -1.25052      .24874     .20323E-01    -.26782E-01    -.54507E-01
101     3.54000    -1.25052     -.24874     .20323E-01    -.26782E-01     .54507E-01
102     3.54000    -1.06014     -.70836    -.22241E-01    -.11295E-01    -.68311E-02
103     3.54000     -.70836    -1.06014    -.22241E-01    -.68311E-02    -.11295E-01
104     3.54000     -.24874    -1.25052     .20323E-01     .54507E-01    -.26782E-01
105     3.54000      .24874    -1.25052     .20323E-01    -.54507E-01    -.26782E-01
106     3.54000      .70836    -1.06010    -.22241E-01     .68311E-02    -.11295E-01
107     3.54000     1.06014     -.70836    -.22241E-01     .11295E-01    -.68311E-02
108     3.54000     1.25052     -.24874     .20323E-01     .26782E-01     .54507E-01


                                                        LOADING INFORMATION

                MACH NUMBER =    .17000E+01
            ANGLE OF ATTACK =    10.000 DEGREES
            SIDE SLIP ANGLE =    10.000 DEGREES
                  WING AREA =    13.66666
             REFERENCE AREA =     5.30929
           REFERENCE LENGTH =     2.69000
      EXPOSED WING SPAN H =     3.48000
     MOMENT CENTERS      XM =    12.50000
                         ZM =     0.00000



U/VINF TYPE LOADING PRESSURE
```

Figure 6.- Continued.

```
                           TOTAL            FIN 1 OR R        FIN 2 OR L        FIN 3 OR U        FIN 4 OR D       INTERF, SHELL
DEFL, ANGLE DEG. =                           0.00000           0.00000           0.00000           0.00000
          CTHR =   .63832E-01            .15958E-01        .15958E-01        .15958E-01        .15958E-01
            CZ =   .15789E+01            .66031E+00        .66031E+00       0.                0.                  .25832E+00
            CY =  -.15789E+01           0.                0.                -.66031E+00       -.66031E+00        -.25832E+00
            CM =  -.15783E+01           -.64660E+00       -.64660E+00       0.                0.                 -.28514E+00
           CLN =   .15783E+01           0.                0.                  .64660E+00        .64660E+00        .28514E+00
           CRL =   .57937E-14           -.57494E+00        .57494E+00       -.57494E+00        .57494E+00        .24098E-15

        FOLLOWING ARE IN WIND-AXIS SYSTEM

            CL =   .21803E+01            .45653E+00        .45653E+00        .45653E+00        .45653E+00        .35414E+00
        CY-IND =   .76117E-12            .46691E+00        .46691E+00       -.46691E+00       -.46691E+00        .72387E-12
           CDI =   .48649E+00            .99193E-01        .99193E-01        .99193E-01        .99193E-01        .89715E-01
     CDI/CL**2 =   .10234E+00
        CM-IND =  -.22321E+01           -.45721E+00       -.45721E+00       -.45721E+00       -.45721E+00       -.40328E+00
       CLN-IND =  -.67146E-12           -.30202E+00       -.58440E+00        .58440E+00        .30202E+00       -.61640E-12



     NOTE: L.E. OF LEAD PANEL IN FIRST CHORDWISE ROW IS SUPERSONIC



----------------------RIGHT WING-----------------------



                          SPANWISE DISTRIBUTIONS


   I     Y/(B/2)  CN*C/(2*B)  CT*C/(2*B) CY1*C/(2*B) CYINT*C/(2*B) CS*C/(2*B)     CSINT     YBAR      GAMNET(I)  GAMMA,LE/VINF   XLE

   1      .65426     .18936    0.00000     0.00000       .00040     0.00000     0.00000   0.00000    -.88666    0.00000     .13330
   2      .85415     .18692    0.00000     0.00000       .00266     0.00000     0.00000   0.00000     .01136    0.00000     .40340
   3     1.05402     .17369    0.00000     0.00000       .00215     0.00000     0.00000   0.00000     .06021    0.00000     .67342
   4     1.25386     .14776    0.00000     0.00000       .00205     0.00000     0.00000   0.00000     .12554    0.00000     .94341
   5     1.45367     .10536    0.00000     0.00000      0.00000     0.00000     0.00000   0.00000     .20592    0.00000    1.21335
   6     1.55556    0.00000                                                                          .48293



        SUMFX  =  0.
        SUMFY1 =  0.
        SUMFY2 =   .59839E-02
        SUMFZ2 =   .27045E-01
```

Figure 6.- Continued.

```
            SIDE EDGE DISTRIBUTION

 JTIP  JSE  DISTANCE            SUCTION FORCE         GAMMA,SE         YBAR         XSE
            FROM LE             PER UNIT LENGTH       /VINF
            /TIPCHORD           /(Q*TIPCHORD)

   1     1      .33333              .00307              .00054         3.64000      1.35100
   2     2      .66667              .03561              .00686         3.64000      2.10067
   3     3     1.00000              .04649              .01511         3.64000      2.85033


****T.F. FIN VORTEX INFO*****

IVRT GAMMA/VINF   Y.C.G.

  1     .88621    3.27795
------------------- LEFT WING--------------------


                                  SPANWISE DISTRIBUTIONS

  I      Y/(B/2)  CN*C/(2*B)  CT*C/(2*B) CY1*C/(2*B) CYTOT*C/(2*B) CS*C/(2*B)     CSINT      YBAR        GAMNET(I)  GAMMA,LE/VINF  XLE

  7     -.65426      .18936     0.00000     0.00000     -.00040     0.00000     0.00000     0.00000      .88656     0.00000      .13334
  8     -.85415      .18692     0.00000     0.00000     -.00266     0.00000     0.00000     0.00000     -.01136     0.00000      .40340
  9    -1.05402      .17389     0.00000     0.00000     -.00215     0.00000     0.00000     0.00000     -.06091     0.00000      .67342
 10    -1.25386      .14706     0.00000     0.00000     -.00205     0.00000     0.00000     0.00000     -.12554     0.00000      .94341
 11    -1.45367      .10308     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     -.20592     0.00000     1.21335
 12    -1.55554     0.00000                                                                           -.48295


            SUMFX  =  0.
            SUMFY1 =  0.
            SUMFY2 =  -.59839E-02
            SUMFZ2 =  -.27045E-01


            SIDE EDGE DISTRIBUTION

 JTIP  JSE  DISTANCE            SUCTION FORCE         GAMMA,SE         YBAR         XSE
            FROM LE             PER UNIT LENGTH       /VINF
            /TIPCHORD           /(Q*TIPCHORD)

   1     1      .33333             -.00307             -.00054        -3.64000      1.35100
   2     2      .66667             -.03561             -.00686        -3.64000      2.10067
   3     3     1.00000             -.04649             -.01511        -3.64000      2.85033
```

Figure 6.- Continued.

```
*****T.E. FIN VORTEX INFO*****

IVRT GAMMA/VINF    Y.C.G.

  2    -.88621   -3.27795


---------------------UPPER WING---------------------


                               SPANWISE DISTRIBUTIONS

 I      Z/(B/2)   CN*C/(2*B)  CT*C/(2*B) CZ1*C/(2*B) CZTOT*C/(2*B) CS*C/(2*B)      CSINT      ZBAR        GAMNET(I)  GAMMA.LE/VINF  XLF

13      .65426      .18936     0.00000     0.00000       .00040     0.00000     0.00000    0.00000      -.88666     0.00000      .13334
14      .85415      .18692     0.00000     0.00000       .00266     0.00000     0.00000    0.00000       .01136     0.00000      .40340
15     1.05402      .17389     0.00000     0.00000       .00215     0.00000     0.00000    0.00000       .06091     0.00000      .67347
16     1.25386      .14706     0.00000     0.00000       .00205     0.00000     0.00000    0.00000       .12554     0.00000      .94341
17     1.45367      .10308     0.00000     0.00000      0.00000     0.00000     0.00000    0.00000       .20592     0.00000     1.21335
18     1.55556     0.00000                                                                             .48293


         SUMFX  =  0.
         SUMFZ1 =  0.
         SUMFZ2 =   .59839E-02
         SUMFT2 =   .27045E-01


         SIDE EDGE DISTRIBUTION

 JTIP  JSE  DISTANCE         SUCTION FORCE       GAMMA.SE      ZBAR        XSE
            FROM LE          PER UNIT LENGTH     /VINF
            /TIPCHORD        /(Q*TIPCHORD)

   1    4     .33333           .00307            .00054      3.64000    1.35100
   2    5     .66667           .03561            .00686      3.64000    2.10067
   3    6    1.00000           .04649            .01511      3.64000    2.95033


*****T.E. FIN VORTEX INFO*****

IVRT GAMMA/VINF    Z.C.G.

  3     .88621     3.27795
```

Figure 6.- Continued.

```
--------------------LOWER WING----------------------

                     SPANWISE DISTRIBUTIONS

  I     Z/(B/2)  CN*C/(2*B)  CT*C/(2*B) CZ1*C/(2*B) CZTOT*C/(2*B) CS*C/(2*B)    CSINT      ZBAR       GAMNET(I)  GAMMA,LE/VINF  XLE

 19     -.65426     .18936     0.00000     0.00000     -.00040     0.00000     0.00000    0.00000      .88666    0.00000     .13354
 20     -.85415     .18692     0.00000     0.00000     -.00266     0.00000     0.00000    0.00000     -.01136    0.00000     .40340
 21    -1.05402     .17389     0.00000     0.00000     -.00215     0.00000     0.00000    0.00000     -.06091    0.00000     .67342
 22    -1.25386     .14706     0.00000     0.00000     -.00205     0.00000     0.00000    0.00000     -.12554    0.00000     .94341
 23    -1.45367     .10598     0.00000     0.00000     0.00000     0.00000     0.00000    0.00000     -.20592    0.00000    1.21335
 24    -1.55556    0.00000                                                                             -.48293


          SUMFX  =  0.
          SUMFZ1 =  0.
          SUMFZ2 =  -.59839E-02
          SUMFT2 =  -.27045E-01



          SIDE EDGE DISTRIBUTION

JTIP  JSE  DISTANCE        SUCTION FORCE       GAMMA,SE       ZBAR        XSE
           FROM LE         PER UNIT LENGTH     /VINF
           /TIPCHORD       /(Q*TIPCHORD)

  1    7     .33333          -.00397           -.00054      -3.64000    1.35100
  2    8     .66667          -.03561           -.00686      -3.64000    2.10067
  3    9    1.00000          -.04619           -.01511      -3.64000    2.85033



*****T.E. FIN VORTEX INFO******

IVRT GAMMA/VINF    Z.C.G.

  4    -.88621   -3.27795



          VELOCITIES AND BERNOULLI PRESSURES AT CONTROL POINTS IMMEDIATELY ABOVE AND BELOW HORIZONTAL WING SURFACE

J       X(J)         Y(J)        Z(J)        UTOTA       VTOTA       WTOTA       PRESSA      UTOTB       VTOTB       WTOTB       PRESSB

1   1.231118    1.530959    0.000000     .150107    -.009157    -.173650    -.232106    -.186636     .185261    -.173650     .507944
2   2.386670    1.530959    0.000000     .129322     .070070    -.173650    -.185694    -.119079     .165680    -.173650     .336862
3   3.542222    1.530959    0.000000     .113465     .168769    -.314650    -.167160    -.068697     .203827    -.032650     .189374
4   1.415654    1.998701    0.000000     .251532    -.137014    -.173650    -.378470    -.111513     .072591    -.173650     .303894
5   2.481188    1.998701    0.000000     .130365     .023599    -.173650    -.195638    -.130793     .124119    -.173650     .362347
```

Figure 6.- Continued.

```
  6   3.546723   1.998701   0.000000   .145735    .120139   -.314650   -.218875   -.051527    .158102   -.032650    .151621
  7   1.600170   2.466397   0.000000   .176868   -.039452   -.173650   -.275450   -.179328    .166197   -.173650    .489158
  8   2.575697   2.466397   0.000000   .167531   -.001452   -.173650   -.254622   -.118118    .108495   -.173650    .328461
  9   3.551224   2.466397   0.000000   .237271    .088465   -.314650   -.337191    .044297    .125603   -.032650   -.047964
 10   1.784662   2.934030   0.000000   .180450   -.031710   -.173650   -.278223   -.158842    .164180   -.173650    .436543
 11   2.670193   2.934030   0.000000   .198586   -.055542   -.173650   -.305871   -.086151    .054054   -.173650    .237995
 12   3.555723   2.934030   0.000000   .117778    .029484   -.314650   -.189044   -.036092    .059096   -.032650    .102817
 13   1.969121   3.401580   0.000000   .126247    .042307   -.173650   -.185537   -.173276    .215237   -.173650    .470855
 14   2.760672   3.401580   0.000000   .091750    .018390   -.173650   -.134517   -.099502    .092063   -.173650    .279928
 15   3.560222   3.401580   0.000000   .212912   -.063327   -.314650   -.353055    .096642    .040951   -.032650   -.174457
 16   1.231118  -1.530959   0.000000   .152073    .265202   -.173650   -.218753   -.184670    .070784   -.173650    .485707
 17   2.386670  -1.530959   0.000000   .122868    .176860   -.173650   -.167575   -.125533    .081251   -.173650    .340432
 18   3.542222  -1.530959   0.000000   .228762    .162463   -.314650   -.324682    .046600    .127406   -.032650   -.052137
 19   1.415654  -1.998701   0.000000   .254058    .288904   -.173650   -.348754   -.108987    .079299   -.173650    .299637
 20   2.481188  -1.998701   0.000000   .146320    .146063   -.173650   -.205016   -.114838    .045543   -.173650    .303185
 21   3.546723  -1.998701   0.000000   .238483    .125737   -.314650   -.336291    .041221    .087774   -.032650   -.046884
 22   1.600170  -2.466397   0.000000   .176014    .135310   -.173650   -.248710   -.180182   -.070339   -.173650    .397380
 23   2.575697  -2.466397   0.000000   .170160    .102179   -.173650   -.242750   -.115489   -.007767   -.173650    .281738
 24   3.551224  -2.466397   0.000000   .242287    .015453   -.314650   -.349987    .049313   -.021685   -.032650   -.089321
 25   1.784662  -2.934030   0.000000   .179484    .098715   -.173650   -.255977   -.159807   -.097175   -.173650    .328657
 26   2.670193  -2.934030   0.000000   .201080    .127345   -.173650   -.282531   -.083658    .017789   -.173650    .219104
 27   3.555723  -2.934030   0.000000   .132135    .058671   -.314650   -.205623   -.021734    .029059   -.032650    .063939
 28   1.969121  -3.401580   0.000000   .125080    .006756   -.173650   -.191249   -.174403   -.166173   -.173650    .302127
 29   2.760672  -3.401580   0.000000   .090902    .031085   -.173650   -.130050   -.100350   -.042528   -.173650    .228046
 30   3.560222  -3.401580   0.000000   .215752    .118024   -.314650   -.311258    .099483    .095648   -.032650   -.148916


          VELOCITIES AND BERNOULLI PRESSURES AT CONTROL POINTS IMMEDIATELY TO RIGHT AND LEFT OF VERTICAL WING SURFACE

  J     X(J)       Y(J)       Z(J)      UTOTR      VTOTR      WTOTR      PRESSR     UTOTL      VTOTL      WTOTL      PRESSL

 31   1.231118   0.000000   1.530959  -.184670    .173650   -.070784    .485707    .152073    .173650   -.265202   -.218753
 32   2.386670   0.000000   1.530959  -.125533    .173650   -.081251    .340432    .122868    .173650   -.176860   -.167575
 33   3.542222   0.000000   1.530959   .046600    .314650   -.127406   -.052137    .228762    .032650   -.162463   -.324682
 34   1.415654   0.000000   1.998701  -.108987    .173650   -.079299    .299637    .254058    .173650   -.288904   -.348754
 35   2.481188   0.000000   1.998701  -.114834    .173650   -.045543    .303185    .146320    .173650   -.146063   -.205016
 36   3.546723   0.000000   1.998701   .041221    .314650   -.087774   -.046884    .238483    .032650   -.125737   -.336291
 37   1.600170   0.000000   2.466397  -.180182    .173650    .070339    .397380    .176014    .173650   -.135310   -.248710
 38   2.575697   0.000000   2.466397  -.115489    .173650    .007767    .281738    .170160    .173650   -.102179   -.242750
 39   3.551224   0.000000   2.466397   .049313    .314650    .021685   -.089321    .242287    .032650   -.015453   -.349987
 40   1.784662   0.000000   2.934030  -.159807    .173650    .097175    .328657    .179484    .173650   -.098715   -.255977
 41   2.670193   0.000000   2.934030  -.083658    .173650   -.017789    .219104    .201080    .173650   -.127345   -.282531
 42   3.555723   0.000000   2.934030  -.021734    .314650   -.029059    .063939    .132135    .032650   -.058671   -.205623
 43   1.969121   0.000000   3.401580  -.174403    .173650    .166173    .302127    .125080    .173650   -.006756   -.191249
 44   2.760672   0.000000   3.401580  -.100350    .173650    .042528    .228046    .090902    .173650   -.031085   -.130050
 45   3.560222   0.000000   3.401580   .099483    .314650   -.095648   -.148916    .215752    .032650   -.118024   -.311258
 46   1.231118   0.000000  -1.530959  -.186636    .173650   -.185261    .507944    .150107    .173650    .009157   -.232106
 47   2.386670   0.000000  -1.530959  -.119079    .173650   -.165680    .336862    .129322    .173650   -.070070   -.185698
 48   3.542222   0.000000  -1.530959  -.068697    .314650   -.203827    .189374    .113465    .032650   -.168769   -.167160
 49   1.415654   0.000000  -1.998701  -.111513    .173650   -.072591    .303894    .251532    .173650    .137014   -.376070
 50   2.481188   0.000000  -1.998701  -.130793    .173650   -.124119    .362347    .130365    .173650   -.023599   -.195638
 51   3.546723   0.000000  -1.998701  -.051527    .314650   -.158102    .151621    .145735    .032650   -.120139   -.218875
 52   1.600170   0.000000  -2.466397  -.179328    .173650   -.166197    .489158    .176868    .173650    .039452   -.275450
 53   2.575697   0.000000  -2.466397  -.118118    .173650   -.108495    .328461    .167531    .173650    .001452   -.254622
 54   3.551224   0.000000  -2.466397   .044297    .314650   -.125603   -.047964    .237271    .032650   -.088465   -.337191
 55   1.784662   0.000000  -2.934030  -.158842    .173650   -.164180    .436543    .180450    .173650    .031710   -.278223
 56   2.670193   0.000000  -2.934030  -.086151    .173650   -.054054    .237995    .198586    .173650    .055542   -.305871
 57   3.555723   0.000000  -2.934030  -.036092    .314650   -.059096    .102817    .117778    .032650   -.029484   -.189044
```

Figure 6.- Continued.

```
58   1.969121   0.000000  -3.401580   -.173276    .173650  -.215237    .470855    .126247    .173650   -.042307   -.185537
59   2.764672   0.000000  -3.401580   -.099502    .173650  -.092003    .279928    .091750    .173650   -.018390   -.134517
60   3.560222   0.000000  -3.401580    .096642    .314650   .040951   -.174457    .212912    .032650    .063327   -.333055


 PRESSURE LOADINGS AT CONTROL POINTS

 J        X(J)        Y(J)        Z(J)     DELTP.LIN. DELTP.HERN.

  1   1.231118    1.530959    0.000000    .673486    .740049
  2   2.386670    1.530959    0.000000    .496803    .522560
  3   3.542222    1.530959    0.000000    .364325    .356534
  4   1.415654    1.998701    0.000000    .726090    .682364
  5   2.481188    1.998701    0.000000    .522316    .557985
  6   3.546723    1.998701    0.000000    .394522    .370496
  7   1.600170    2.466397    0.000000    .712392    .764608
  8   2.575697    2.466397    0.000000    .571298    .583083
  9   3.551224    2.466397    0.000000    .385949    .289228
 10   1.784662    2.934030    0.000000    .678583    .714766
 11   2.670193    2.934030    0.000000    .569475    .543564
 12   3.555723    2.934030    0.000000    .307739    .291860
 13   1.969121    3.401580    0.000000    .599046    .656392
 14   2.764672    3.401580    0.000000    .382503    .414445
 15   3.560222    3.401580    0.000000    .232539    .158598
 16   1.231118   -1.530959    0.000000    .673486    .704460
 17   2.386670   -1.530959    0.000000    .496803    .508007
 18   3.542222   -1.530959    0.000000    .364325    .272545
 19   1.415654   -1.998701    0.000000    .726090    .648391
 20   2.481188   -1.998701    0.000000    .522316    .508200
 21   3.546723   -1.998701    0.000000    .394522    .289407
 22   1.600170   -2.466397    0.000000    .712392    .646089
 23   2.575697   -2.466397    0.000000    .571298    .524487
 24   3.551224   -2.466397    0.000000    .385949    .260665
 25   1.784662   -2.934030    0.000000    .678583    .584635
 26   2.670193   -2.934030    0.000000    .569475    .501635
 27   3.555723   -2.934030    0.000000    .307739    .269561
 28   1.969121   -3.401580    0.000000    .599046    .493376
 29   2.764672   -3.401580    0.000000    .382503    .358096
 30   3.560222   -3.401580    0.000000    .232539    .162342
 31   1.231118    0.000000    1.530959    .673486    .704460
 32   2.386670    0.000000    1.530959    .496803    .508007
 33   3.542222    0.000000    1.530959    .364325    .272545
 34   1.415654    0.000000    1.998701    .726090    .648391
 35   2.481188    0.000000    1.998701    .522316    .508200
 36   3.546723    0.000000    1.998701    .394522    .289407
 37   1.600170    0.000000    2.466397    .712392    .646089
 38   2.575697    0.000000    2.466397    .571298    .524487
 39   3.551224    0.000000    2.466397    .385949    .260669
 40   1.784662    0.000000    2.934030    .678583    .584635
 41   2.670193    0.000000    2.934030    .569475    .501635
 42   3.555723    0.000000    2.934030    .307739    .269561
 43   1.969121    0.000000    3.401580    .599046    .493376
 44   2.764672    0.000000    3.401580    .382503    .358096
 45   3.560222    0.000000    3.401580    .232539    .162342
 46   1.231118    0.000000   -1.530959    .673486    .740049
 47   2.386670    0.000000   -1.530959    .496803    .522560
 48   3.542222    0.000000   -1.530959    .364325    .356534
 49   1.415654    0.000000   -1.998701    .726090    .682364
```

Figure 6.- Continued.

```
 50    2.481188    0.000000   -1.998701      .522316     .557985
 51    3.546725    0.000000   -1.998701      .394522     .370496
 52    1.690174    0.000000   -2.466397      .712392     .764608
 53    2.575693    0.000000   -2.466397      .571298     .583083
 54    3.551224    0.000000   -2.466397      .385909     .289228
 55    1.784662    0.000000   -2.934030      .678583     .714766
 56    2.670193    0.000000   -2.934030      .569475     .543966
 57    3.555723    0.000000   -2.934030      .307739     .291860
 58    1.969121    0.000000   -3.401580      .599046     .656392
 59    2.764672    0.000000   -3.401580      .382503     .414485
 60    3.560222    0.000000   -3.401580      .232539     .158598

                                          LOADING INFORMATION

          MACH NUMBER =    .17000E+01
      ANGLE OF ATTACK =   10.000 DEGREES
      SIDE SLIP ANGLE =   10.000 DEGREES
            WING AREA =   13.58666
       REFERENCE AREA =    5.30929
     REFERENCE LENGTH =    2.69000
  EXPOSED WING SPAN B =    4.68000
  MOMENT CENTER:   XM =   10.50000
                   ZM =    0.00000




BERNOULLI TYPE LOADING PRESSURE


                         TOTAL             FIN 1 OR R          FIN 2 OR L          FIN 3 OR U          FIN 4 OR D        INTERF. SHELL
   DEFL. ANGLE DEG. =                       0.00000             0.00000             0.00000             0.00000
               CTHR =   .61347E-01        .16075E-01          .14598E-01          .14598E-01          .16075E-01
                 CZ =   .15087E+01        .66375E+00          .58666E+00         0.                  0.                   .25832E+00
                 CY =  -.15087E+01       0.                  0.                  -.58666E+00         -.66375E+00          -.25832E+00
                 CM =  -.14851E+01       -.63862E+00         -.56128E+00         0.                  0.                   -.28518E+00
                CLN =   .14851E+01       0.                  0.                   .56128E+00          .63862E+00           .28518E+00
                CLL =   .64190E-13       -.57593E+00          .50480E+00         -.50480E+00          .57593E+00           .24098E-15

          FOLLOWING ARE IN WIND-AXIS SYSTEM

                 CL =   .20834E+01        .45892E+00          .40571E+00          .40571E+00          .45892E+00           .35414E+00
             CY-IND =   .72249E-12        .46934E+00          .41483E+00         -.41483E+00         -.46934E+00           .72387E-12
                CDT =   .46452E+00        .99677E-01          .87723E-01          .87723E-01          .99677E-01           .89715E-01
         CDT/CL**2 =    .10702E+00
             CM-IND =  -.21002E+01       -.45157E+00         -.39688E+00         -.39688E+00         -.45157E+00          -.40328E+00
            CLN-IND =  -.65725E-12       -.29631E+00         -.50870E+00          .50870E+00          .29631E+00          -.61640E-12




       NOTE: L.E. OF LEAD PANEL IN FIRST CHORDWISE ROW IS SUPERSONIC
```

Figure 6.- Continued.

```
********************RIGHT WING********************


                         SPANWISE DISTRIBUTIONS

I     Y/(B/2)  CN*C/(2*B)  CT*C/(2*B) CY1*C/(2*B) CYTOT*C/(2*B) CS*C/(2*B)     CSINT      YBAR      GAMNET(I)  GAMMA,LE/VINF  XLE

1      .65426     .19979     0.00000    0.00000      .00325     0.00000    0.00000    0.00000     -.93550    0.00000     .13334
2      .85415     .18427     0.00000    0.00000      .00106     0.00000    0.00000    0.00000      .07730    0.00000     .40349
3     1.05402     .17048     0.00000    0.00000      .00208     0.00000    0.00000    0.00000      .05978    0.00000     .67342
4     1.25386     .14656     0.00000    0.00000      .00203     0.00000    0.00000    0.00000      .11192    0.00000     .94341
5     1.45367     .10438     0.00000    0.00000     0.00000     0.00000    0.00000    0.00000      .19747    0.00000    1.21335
6     1.55556    0.00000                                                                          .48904


      SUMFX  =  0.
      SUMFY1 =  0.
      SUMFY2 =   .69542E-02
      SUMFT2 =   .28355E-01


      SIDE EDGE DISTRIBUTION

JTIP  JSF  DISTANCE        SUCTION FORCE       GAMMA,SE      YBAR      XSE
           FROM LE         PER UNIT LENGTH     /VINF
           /TIPCHORD       /(Q*TIPCHORD)

 1     1      .33333          .00337            .00060      3.64000   1.35100
 2     2      .66667          .03885            .00749      3.64000   2.10067
 3     3     1.00000          .04707            .01984      3.64000   2.85033


****T.E. FIN VORTEX INFO*****

IVRT GAMMA/VINF   Y.C.G.

  1     .93503    3.18446
```

Figure 6.- Continued.

```
******************* LEFT WING*********************


                        SPANWISE DISTRIBUTIONS

  I     Y/(B/2)   CN*C/(2*B)  CT*C/(2*B) CY1*C/(2*B) CYTOT*C/(2*B) CS*C/(2*B)     CSINT      YBAR        GAMNET(I)  GAMMA,LE/VINF   YLE

  7    -.65426      .18324    0.00000     0.00000     -.00362     0.00000     0.00000    0.00000      .85800    0.00000     .13334
  8    -.85415      .16451    0.00000     0.00000     -.00281     0.00000     0.00000    0.00000     -.08762    0.00000     .40340
  9   -1.05402      .14906    0.00000     0.00000     -.00182     0.00000     0.00000    0.00000     -.07227    0.00000     .67342
 10   -1.25386      .12816    0.00000     0.00000     -.00197     0.00000     0.00000    0.00000     -.09779    0.00000     .94341
 11   -1.45367      .08638    0.00000     0.00000     0.00000     0.00000     0.00000    0.00000     -.19704    0.00000    1.21335
 12   -1.55556     0.00000                                                                         -.40327


          SUMFX  =  0.
          SUMFY1 =  0.
          SUMFY2 =  -.84305E-02
          SUMFT2 =  -.22939E-01


          SIDE EDGE DISTRIBUTIONS

 JTIP   JSE  DISTANCE         SUCTION FORCE         GAMMA,SE       YBAR       XSE
             FROM LE          PER UNIT LENGTH       /VINF
             /TIPCHORD        /(Q*TIPCHORD)

   1     1     .33333           -.00253             -.00045      -3.64000    1.35100
   2     2     .66667           -.03089             -.00593      -3.64000    2.10067
   3     3    1.00000           -.03882             -.01281      -3.64000    2.85033


****T.E. FIN VORTEX INFO*****

IVRT GAMMA/VINF   Y.C.G.

  2    -.85757   -3.11604
```

Figure 6.- Continued.

```
*******************UPPER WING*********************


                                SPANWISE DISTRIBUTIONS


  I       Z/(B/2)  CN*C/(2*B)  CT*C/(2*B) CZ1*C/(2*B) CZTOT*C/(2*B) CS*C/(2*B)      CSINT       ZBAR          GAMNET(I)  GAMMA,LE/VINF   XLE

 13       .65426      .18324    0.00000     0.00000      .00362     0.00000      0.00000     0.00000       -.85800     0.00000     .13334
 14       .85415      .16451    0.00000     0.00000      .00281     0.00000      0.00000     0.00000        .08762     0.00000     .40340
 15      1.05402      .14966    0.00000     0.00000      .00182     0.00000      0.00000     0.00000        .07227     0.00000     .67342
 16      1.25386      .12816    0.00000     0.00000      .00197     0.00000      0.00000     0.00000        .09779     0.00000     .94341
 17      1.45367      .08638    0.00000     0.00000     0.00000     0.00000      0.00000     0.00000        .19704     0.00000    1.21335
 18      1.55556     0.00000                                                                               .40327


          SUMFX  =  0.
          SUMFZ1 =  0.
          SUMFZ2 =   .84305E-02
          SUMFT2 =   .22939E-01


          SIDE EDGE DISTRIBUTION

 JTIP   JSE  DISTANCE         SUCTION FORCE          GAMMA,SE       ZBAR          XSE
             FROM LE          PER UNIT LENGTH        /VINF
             /TIPCHORD        /(Q*TIPCHORD)

   1     4     .33333             .00253              .00045        3.64000      1.35100
   2     5     .66667             .03089              .00593        3.64000      2.10067
   3     6    1.00000             .03882              .01281        3.64000      2.85033


****T.E. FIN VORTEX INFO******

IVRT GAMMA/VINF    Z.C.G.

  3      .85757     3.11604
```

Figure 6.- Continued.

```
*********************LOWER WING**********************

                     SPANWISE DISTRIBUTIONS

  I      Z/(B/2)   CN*C/(2*B)   CT*C/(2*B)  CZ1*C/(2*B)  CZTOT*C/(2*B)  CS*C/(2*B)     CSINT      ZBAR       GAMNET(I)   GAMMA,LE/VINF   XLE

 19     -.65426      .19979      0.00000      0.00000      -.00325      0.00000      0.00000    0.00000       .93556     0.00000      .13554
 20     -.85415      .18327      0.00000      0.00000      -.00106      0.00000      0.00000    0.00000      -.07730     0.00000      .40340
 21    -1.05402      .17048      0.00000      0.00000      -.00208      0.00000      0.00000    0.00000      -.05978     0.00000      .67342
 22    -1.25386      .14656      0.00000      0.00000      -.00203      0.00000      0.00000    0.00000      -.11192     0.00000      .94341
 23    -1.45367      .10438      0.00000      0.00000      0.00000      0.00000      0.00000    0.00000      -.19747     0.00000     1.21335
 24    -1.55556     0.00000                                                                                -.48904


         SUMFX  =  0.
         SUMFZ1 =  0.
         SUMFZ2 =  -.69542E-02
         SUMT2  =  -.28355E-01



         SIDE EDGE DISTRIBUTION

 JTIP   JSF   DISTANCE          SUCTION FORCE         GAMMA,SP        ZBAR        XSE
              FROM LE           PER UNIT LENGTH       /VINF
              /TIPCHORD         /(Q*TIPCHORD)

   1     7      .33333            -.00337             -.00060       -3.64000     1.35100
   2     8      .66667            -.03885             -.00749       -3.64000     2.10067
   3     9     1.00000            -.04707             -.01584       -3.64000     2.85033


****T.E. FIN VORTEX INFO*****

IVRT GAMMA/VINF    Z.C.G.

  4    -.93505   -5.18446



*********************************************************************************************************************
AFT OF LEADING EDGE OF FIN ROOTCHORDS
```

Figure 6.- Continued.

```
                         PRESSURE COEFFICIENTS AT POINTS ON BODY MERIDIANS

 J   THETA,      XB        YB        ZB        UTOT      VTOT      WTOT    CP,LIN.   CP,BERN.   DR/DX     P/PINF.   P/PINF.
      DEG.                                                                                                  BERN.     LIN.


                                              BODY RING=   1

 1  11.25000  20.94000   1.25052    .24874    .11130    .12273    .11776   -.22260   -.21167   0.00000    .57179    .54968
 2  33.75000  20.94000   1.06014    .70836    .02622   -.09448    .23203   -.05244   -.19266   0.00000    .61026    .89390
 3  56.25000  20.94000    .70836   1.06014   -.05100   -.19760    .07152    .10199   -.04014   0.00000    .91880   1.20633
 4  78.75000  20.94000    .24874   1.25052   -.12330   -.10673   -.12489    .24661    .23477   0.00000   1.47494   1.49888
 5 101.25000  20.94000   -.24874   1.25052    .11085    .02473   -.21377   -.22171   -.16584   0.00000    .66451    .55149
 6 123.75000  20.94000   -.70836   1.06014    .02416    .11698   -.22613   -.04832    .00696   0.00000   1.01407    .90226
 7 146.25000  20.94000  -1.06014    .70836    .02416    .22613   -.11698   -.04832    .00696   0.00000   1.01407    .90226
 8 168.75000  20.94000  -1.25052    .24874    .11085    .21377   -.02473   -.22171   -.16584   0.00000    .66451    .55149
 9 191.25000  20.94000  -1.25052   -.24874   -.12330    .12489    .10673    .24661    .23477   0.00000   1.47494   1.49888
10 213.75000  20.94000  -1.06014   -.70836   -.05100   -.07152    .19760    .10199   -.04014   0.00000    .91880   1.20633
11 236.25000  20.94000   -.70836  -1.06014    .02622   -.23203    .09448   -.05244   -.19266   0.00000    .61026    .89390
12 258.75000  20.94000   -.24874  -1.25052    .11130   -.11776   -.12273   -.22260   -.21167   0.00000    .57179    .54968
13 281.25000  20.94000    .24874  -1.25052   -.12286    .03577   -.21161    .24571    .31677   0.00000   1.64083   1.49707
14 303.75000  20.94000    .70836  -1.06014   -.04893    .15140   -.20317    .09787    .16871   0.00000   1.34131   1.19798
15 326.25000  20.94000   1.06014   -.70836   -.04893    .20317   -.15140    .09787    .16871   0.00000   1.34131   1.19798
16 348.75000  20.94000   1.25052   -.24874   -.12286    .21161   -.03577    .24571    .31677   0.00000   1.64083   1.49707

                                              BODY RING=   2

 1  11.25000  22.14000   1.25052    .24874    .10021    .12916    .08542   -.20841   -.18841   0.00000    .61884    .57838
 2  33.75000  22.14000   1.06014    .70836    .01537   -.02324    .12539   -.03074   -.09119   0.00000    .81552    .93781
 3  56.25000  22.14000    .70836   1.06014   -.07275   -.09832    .00518    .14551    .09614   0.00000   1.19449   1.29436
 4  78.75000  22.14000    .24874   1.25052   -.11800   -.08813   -.12859    .23600    .23666   0.00000   1.47876   1.47742
 5 101.25000  22.14000   -.24874   1.25052    .11874    .02657   -.21341   -.23748   -.17802   0.00000    .63987    .51958
 6 123.75000  22.14000   -.70836   1.06014    .10747    .12241   -.22251   -.21494   -.14596   0.00000    .70473    .56517
 7 146.25000  22.14000  -1.06014    .70836    .10747    .22251   -.12241   -.21494   -.14596   0.00000    .70473    .56517
 8 168.75000  22.14000  -1.25052    .24874    .11874    .21341   -.02657   -.23748   -.17802   0.00000    .63987    .51958
 9 191.25000  22.14000  -1.25052   -.24874   -.11800    .12859    .08813    .23600    .23666   0.00000   1.47876   1.47742
10 213.75000  22.14000  -1.06014   -.70836   -.07275   -.00518    .09832    .14551    .09614   0.00000   1.19449   1.29436
11 236.25000  22.14000   -.70836  -1.06014    .01537   -.12539    .02324   -.03074   -.09119   0.00000    .81552    .93781
12 258.75000  22.14000   -.24874  -1.25052    .10021   -.08542   -.12916   -.20841   -.18841   0.00000    .61884    .57838
13 281.25000  22.14000    .24874  -1.25052   -.13253    .02387   -.21397    .26506    .33497   0.00000   1.67765   1.53622
14 303.75000  22.14000    .70836  -1.06014   -.16485    .14948   -.20445    .32971    .44960   0.00000   1.90954   1.66699
15 326.25000  22.14000   1.06014   -.70836   -.16485    .20449   -.14948    .32971    .44960   0.00000   1.90954   1.66699
16 348.75000  22.14000   1.25052   -.24874   -.13253    .21397   -.02387    .26506    .33497   0.00000   1.67765   1.53622

                                              BODY RING=   3

 1  11.25000  23.34000   1.25052    .24874    .07229    .14316    .01498   -.14459   -.11128   0.00000    .77488    .70750
 2  33.75000  23.34000   1.06014    .70836    .00171    .00802    .07860   -.00342   -.03324   0.00000    .93275    .99307
 3  56.25000  23.34000    .70836   1.06014   -.01831   -.08238   -.00548    .03662    .00163   0.00000   1.00331   1.07408
 4  78.75000  23.34000    .24874   1.25052   -.00643   -.13339   -.11960    .01285   -.02404   0.00000    .95137   1.02601
 5 101.25000  23.34000   -.24874   1.25052    .17952    .06566   -.20564   -.35904   -.26020   0.00000    .47362    .27367
 6 123.75000  23.34000   -.70836   1.06014    .15449    .12491   -.22084   -.30897   -.21983   0.00000    .55528    .37495
 7 146.25000  23.34000  -1.06014    .70836    .15449    .22084   -.12491   -.30897   -.21983   0.00000    .55528    .37495
 8 168.75000  23.34000  -1.25052    .24874    .17952    .20564   -.06566   -.35904   -.26020   0.00000    .47362    .27367
 9 191.25000  23.34000  -1.25052   -.24874   -.00643    .11960    .13339    .01285   -.02404   0.00000    .95137   1.02601
10 213.75000  23.34000  -1.06014   -.70836   -.01831    .00548    .08238    .03662    .00163   0.00000   1.00331   1.07408
```

Figure 6.- Continued.

```
11 236,25000  23,34000   -,70836  -1,06014    ,00171   -,07860   -,00802   -,00342   -,03324   0,00000    ,93275    ,99307
12 258,75000  23,34000   -,24874  -1,25052    ,07229   -,01498   -,14316   -,10459   -,11128   0,00000    ,77488    ,70750
13 281,25000  23,34000    ,24874  -1,25052   -,11345   -,05276   -,22921    ,22730    ,24834   0,00000   1,50240   1,45983
14 303,75000  23,34000    ,70836  -1,06014   -,17108    ,12113   -,22339    ,34217    ,45961   0,00000   1,92980   1,69220
15 326,25000  23,34000   1,06014   -,70836   -,17108    ,22339   -,12113    ,34217    ,45961   0,00000   1,92980   1,69220
16 348,75000  23,34000   1,25052   -,24874   -,11345    ,22921    ,05276    ,22730    ,24834   0,00000   1,50240   1,45983
```

Figure 6.- Concluded.

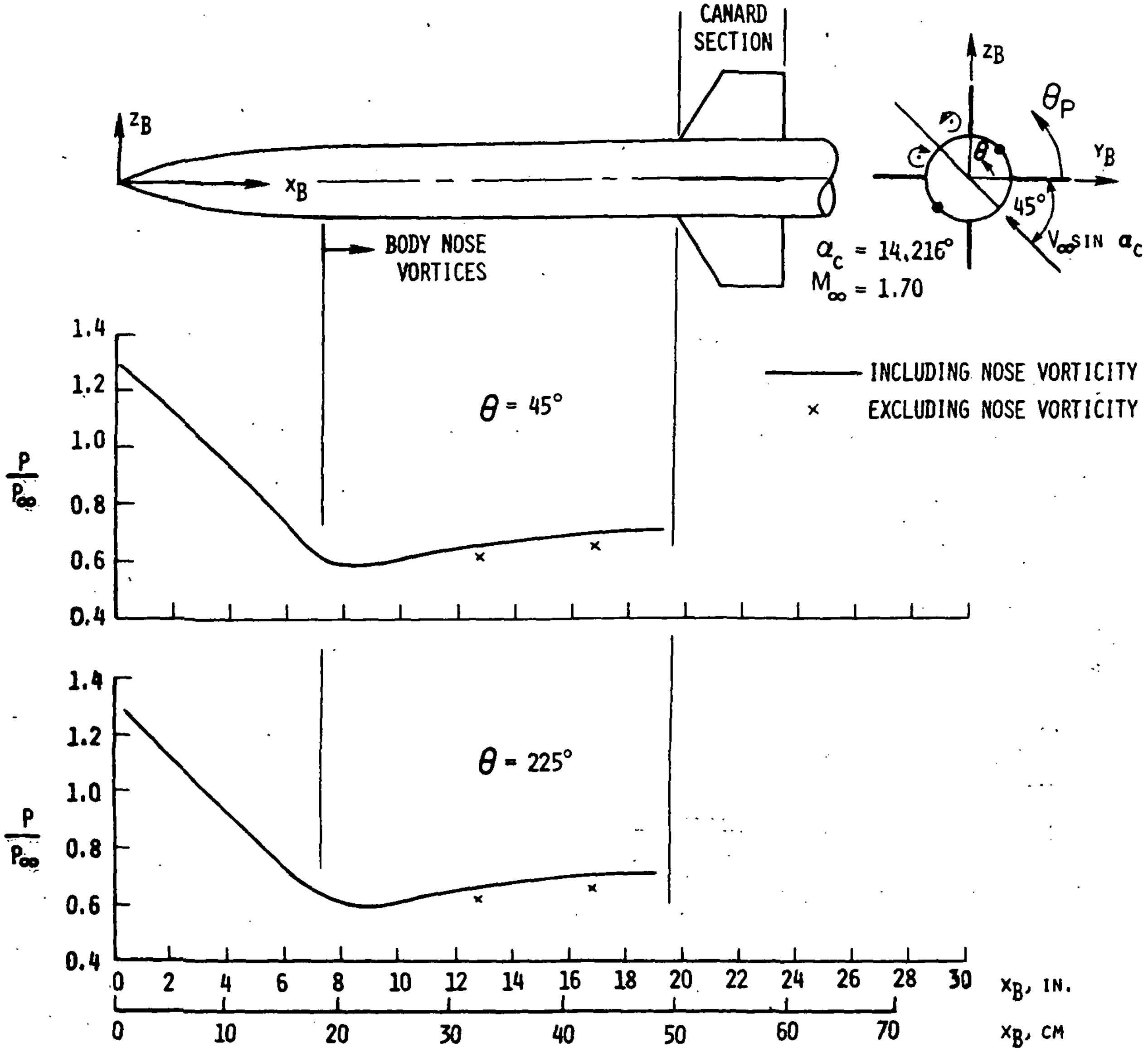

Figure 7(a).- Calculated pressure distributions along body meridians up to canard section; first sample case.

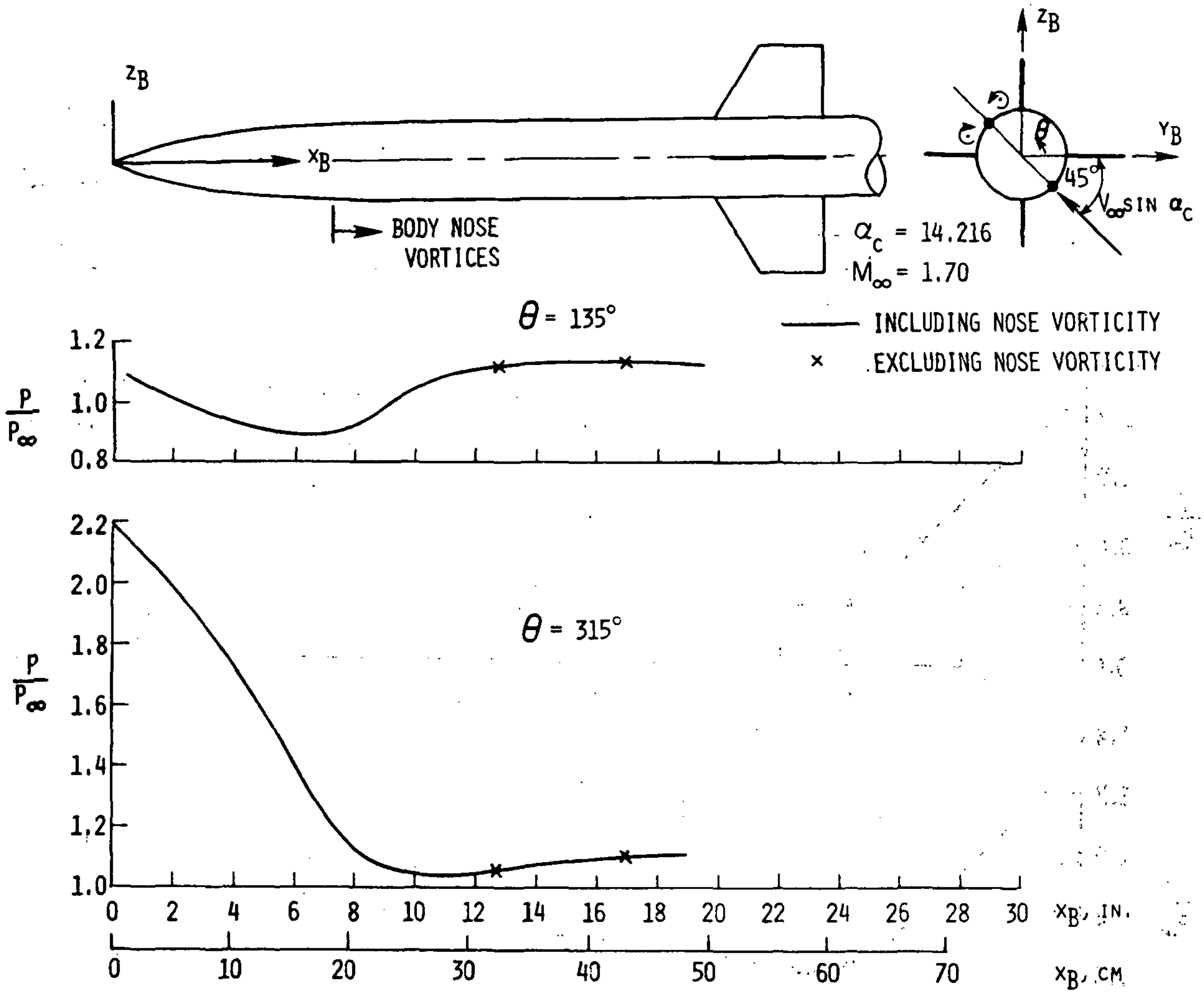

Figure 7(b).- Concluded.

```
NASA/LRC PROJECT 1126,CONFIGURATION B1W4,CHASE NOSE VORTICES PAST CANARD SECTION
         1         4        11         1         1         0         1
   23.4
  1.3
  19.8     1.3       21.151     3.64     23.4      3.64     23.400001   1.3
 14.216    45.0                                             0.0001    0.35
    2    2    2    2    2    2    2    2    2    2    2
 -0.64337   1.8382   0.8024   -1.8382   0.64337   -0.8024
 19.8     20.163     20.514   20.878    21.242    21.606   21.957     22.321
  22.685   23.036    23.4
         0         0         0         0
         0
```

Figure 8.- Input for program VPATH2, first sample case, step 2.

```
NASA/LRC PROJECT 1126,CONFIGURATION 81-4,CHASE NOSE VORTICES PAST CANARD SECTION


                    FIN GEOMETRY
          FIN SEMISPAN              =     3.64000
          FIN ROOTCHORD             =     3.60000
          FIN ROOT L.E. X-STATION=   19.80000
                   L.E. Y-STATION=    1.30000
          FIN TIP L.E. X-STATION =   21.15100
                  L.E. Y-STATION =    3.64000
          FIN TIP T.E. X-STATION =   23.40000
                  T.E. Y-STATION =    3.64000
          FIN ROOT T.E. X-STATION=   23.40000
                   T.E. Y-STATION=    1.30000



      INCLUDED ANGLE OF ATTACK(DEG) =   14.21600      ROLL ANGLE(DEG)   =    45.00000

        PANEL DEFL.(DEG) :

          DELTA1=  0.000   DELTA2=  0.000   DELTA3=  0.000   DELTA4=  0.000


  ****PERMISSIBLE RELATIVE ERROR,ES,USED IN INTEGRATION SCHEME =    .10000E-03



          VORTEX COORDINATES IN CROSS-FLOW PLANE


          INITIAL VORTEX POSITIONS AT    X = 19.800

      LOCAL BODY RADIUS =     1.30000     LOCAL SEMI SPAN S =     1.30000

            VORTEX              Y,VRTX              Z,VRTX       GAMMA/VINF

              1            -.64337E+00         .18382E+01      .80240E+00
              2            -.18382E+01         .64337E+00     -.80240E+00

       X-STATION NO.  2        X=20.163        INTEGRATION STEP SIZE =       .18150

      LOCAL BODY RADIUS =     1.30000     LOCAL SEMI SPAN S =     1.92873

            VORTEX              Y,VRTX              Z,VRTX       GAMMA/VINF
```

Figure 9.- Output of program VPATH2, first sample case, step 2.

```
       1          -.68037E+00        .18568E+01     .80240E+00
       2          -.18568E+01        .68037E+00    -.80240E+00

 X-STATION NO.  3      X=20.514       INTEGRATION STEP SIZE =       .18150

LOCAL BODY RADIUS =     1.30000     LOCAL SEMI SPAN S =    2.53668

      VORTEX              Y,VRTX           Z,VRTX       GAMMA/VINF

       1          -.70316E+00        .18633E+01     .80240E+00
       2          -.18633E+01        .70316E+00    -.80240E+00

 X-STATION NO.  4      X=20.878       INTEGRATION STEP SIZE =       .18150

LOCAL BODY RADIUS =     1.30000     LOCAL SEMI SPAN S =    3.16715

      VORTEX              Y,VRTX           Z,VRTX       GAMMA/VINF

       1          -.70923E+00        .18674E+01     .80240E+00
       2          -.18674E+01        .70923E+00    -.80240E+00

 X-STATION NO.  5      X=21.242       INTEGRATION STEP SIZE =       .18150

LOCAL BODY RADIUS =     1.30000     LOCAL SEMI SPAN S =    3.64000

      VORTEX              Y,VRTX           Z,VRTX       GAMMA/VINF

       1          -.70610E+00        .18736E+01     .80240E+00
       2          -.18736E+01        .70610E+00    -.80240E+00

 X-STATION NO.  6      X=21.606       INTEGRATION STEP SIZE =       .36300

LOCAL BODY RADIUS =     1.30000     LOCAL SEMI SPAN S =    3.64000

      VORTEX              Y,VRTX           Z,VRTX       GAMMA/VINF

       1          -.70153E+00        .18806E+01     .80240E+00
       2          -.18806E+01        .70153E+00    -.80240E+00

 X-STATION NO.  7      X=21.957       INTEGRATION STEP SIZE =       .36300

LOCAL BODY RADIUS =     1.30000     LOCAL SEMI SPAN S =    3.64000

      VORTEX              Y,VRTX           Z,VRTX       GAMMA/VINF
```

Figure 9.- Continued.

```
         1            -.69747E+00         .18877E+01       .80240E+00
         2            -.18877E+01         .69747E+00      -.80240E+00


  X=STATION NO.  8        X=22.321        INTEGRATION STEP SIZE =        .72600


LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =     3.64000

      VORTEX              Y,VRTX             Z,VRTX        GAMMA/VINF

         1            -.69365E+00         .18953E+01       .80240E+00
         2            -.18953E+01         .69363E+00      -.80240E+00

  X=STATION NO.  9        X=22.685        INTEGRATION STEP SIZE =        .72600


LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =     3.64000

      VORTEX              Y,VRTX             Z,VRTX        GAMMA/VINF

         1            -.69017E+00         .19031E+01       .80240E+00
         2            -.19031E+01         .69017E+00      -.80240E+00

  X=STATION NO. 10        X=23.036        INTEGRATION STEP SIZE =        .72600


LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =     3.64000

      VORTEX              Y,VRTX             Z,VRTX        GAMMA/VINF

         1            -.68720E+00         .19109E+01       .80240E+00
         2            -.19109E+01         .68720E+00      -.80240E+00

  X=STATION NO. 11        X=23.400        INTEGRATION STEP SIZE =        .72600


LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =     3.64000

      VORTEX              Y,VRTX             Z,VRTX        GAMMA/VINF

         1            -.68451E+00         .19192E+01       .80240E+00
         2            -.19192E+01         .68451E+00      -.80240E+00


CROSSFLOW VELOCITIES AT CONTROL POINTS INDUCED BY VORTICES AND THEIR IMAGES

IC              X,BODY          Y,BODY          Z,BODY                V             W
 1            .21031E+02      .15310E+01      0.                 .21494E-02    -.70848E-02
 2            .22187E+02      .15310E+01      0.                 .22417E-02    -.73904E-02
 3            .23342E+02      .15310E+01      0.                 .23375E-02    -.77102E-02
 4            .21216E+02      .19987E+01      0.                 .40063E-02    -.44570E-02
 5            .22281E+02      .19987E+01      0.                 .41696E-02    -.46394E-02
 6            .23347E+02      .19987E+01      0.                 .43342E-02    -.48258E-02
 7            .21400E+02      .24604E+01      0.                 .43372E-02    -.26581E-02
```

Figure 9.- Continued.

```
  8      .22376E+02     .24664E+01     0.              .44995E-02     -.27581E-02
  9      .23351E+02     .24664E+01     0.              .46627E-02     -.28607E-02
 10      .21585E+02     .29340E+01     0.              .41198E-02     -.14995E-02
 11      .22470E+02     .29340E+01     0.              .42595E-02     -.15510E-02
 12      .23356E+02     .29340E+01     0.              .44001E-02     -.16042E-02
 13      .21769E+02     .34016E+01     0.              .37321E-02     -.76368E-03
 14      .22565E+02     .34016E+01     0.              .38456E-02     -.78743E-03
 15      .23360E+02     .34016E+01     0.              .39599E-02     -.81237E-03
 16      .21031E+02    -.15310E+01     0.             -.76760E-01     -.17026E+00
 17      .22187E+02    -.15310E+01     0.             -.76729E-01     -.17591E+00
 18      .23342E+02    -.15310E+01     0.             -.75708E-01     -.18067E+00
 19      .21216E+02    -.19987E+01     0.             -.13321E+00     -.38546E-01
 20      .22281E+02    -.19987E+01     0.             -.13885E+00     -.42546E-01
 21      .23347E+02    -.19987E+01     0.             -.14371E+00     -.47503E-01
 22      .21400E+02    -.24664E+01     0.             -.76287E-01      .33442E-01
 23      .22376E+02    -.24664E+01     0.             -.80075E-01      .34808E-01
 24      .23351E+02    -.24664E+01     0.             -.84175E-01      .35781E-01
 25      .21585E+02    -.29340E+01     0.             -.32972E-01      .36466E-01
 26      .22470E+02    -.29340E+01     0.             -.34252E-01      .37988E-01
 27      .23356E+02    -.29340E+01     0.             -.35706E-01      .39482E-01
 28      .21769E+02    -.34016E+01     0.             -.14196E-01      .27926E-01
 29      .22565E+02    -.34016E+01     0.             -.14621E-01      .28902E-01
 30      .23360E+02    -.34016E+01     0.             -.15116E-01      .29897E-01
 31      .21031E+02     .73521E-13     .15310E+01     .17026E+00      .76760E-01
 32      .22187E+02     .73521E-13     .15310E+01     .17591E+00      .76729E-01
 33      .23342E+02     .73521E-13     .15310E+01     .18067E+00      .75708E-01
 34      .21216E+02     .95983E-13     .19987E+01     .38546E-01      .13321E+00
 35      .22281E+02     .95983E-13     .19987E+01     .42546E-01      .13885E+00
 36      .23347E+02     .95983E-13     .19987E+01     .47503E-01      .14371E+00
 37      .21400E+02     .11844E-12     .24664E+01    -.33442E-01      .76287E-01
 38      .22376E+02     .11844E-12     .24664E+01    -.34808E-01      .80075E-01
 39      .23351E+02     .11844E-12     .24664E+01    -.35781E-01      .84175E-01
 40      .21585E+02     .14090E-12     .29340E+01    -.36466E-01      .32972E-01
 41      .22470E+02     .14090E-12     .29340E+01    -.37988E-01      .34252E-01
 42      .23356E+02     .14090E-12     .29340E+01    -.39482E-01      .35706E-01
 43      .21769E+02     .16335E-12     .34016E+01    -.27926E-01      .14196E-01
 44      .22565E+02     .16335E-12     .34016E+01    -.28902E-01      .14621E-01
 45      .23360E+02     .16335E-12     .34016E+01    -.29897E-01      .15118E-01
 46      .21031E+02    -.73521E-13    -.15310E+01     .70848E-02     -.21494E-02
 47      .22187E+02    -.73521E-13    -.15310E+01     .73904E-02     -.22417E-02
 48      .23342E+02    -.73521E-13    -.15310E+01     .77102E-02     -.23375E-02
 49      .21216E+02    -.95983E-13    -.19987E+01     .44570E-02     -.40063E-02
 50      .22281E+02    -.95983E-13    -.19987E+01     .46394E-02     -.41696E-02
 51      .23347E+02    -.95983E-13    -.19987E+01     .48258E-02     -.43342E-02
 52      .21400E+02    -.11844E-12    -.24664E+01     .26581E-02     -.43372E-02
 53      .22376E+02    -.11844E-12    -.24664E+01     .27581E-02     -.44995E-02
 54      .23351E+02    -.11844E-12    -.24664E+01     .28607E-02     -.46627E-02
 55      .21585E+02    -.14090E-12    -.29340E+01     .14995E-02     -.41198E-02
 56      .22470E+02    -.14090E-12    -.29340E+01     .15510E-02     -.42595E-02
 57      .23356E+02    -.14090E-12    -.29340E+01     .16042E-02     -.44001E-02
 58      .21769E+02    -.16335E-12    -.34016E+01     .76368E-03     -.37321E-02
 59      .22565E+02    -.16335E-12    -.34016E+01     .78743E-03     -.38456E-02
 60      .23360E+02    -.16335E-12    -.34016E+01     .81237E-03     -.39599E-02
 61      .20940E+02     .12505E+01     .24874E+00     .20095E-02     -.12229E-01
 62      .20940E+02     .10601E+01     .70836E+00     .12919E-01     -.20885E-01
 63      .20940E+02     .70836E+00     .10601E+01     .42643E-01     -.31116E-01
 64      .20940E+02     .24874E+00     .12505E+01     .12866E+00     -.32286E-01
 65      .20940E+02    -.24874E+00     .12505E+01     .32968E+00      .55337E-01
 66      .20940E+02    -.70836E+00     .10601E+01     .16618E+00      .13512E+00
 67      .20940E+02    -.10601E+01     .70836E+00    -.13512E+00     -.16618E+00
 68      .20940E+02    -.12505E+01     .24874E+00    -.55337E-01     -.32968E+00
 69      .20940E+02    -.12505E+01    -.24874E+00     .32286E-01     -.12866E+00
 70      .20940E+02    -.10601E+01    -.70836E+00     .31116E-01     -.42643E-01
 71      .20940E+02    -.70836E+00    -.10601E+01     .20885E-01     -.12919E-01
 72      .20940E+02    -.24874E+00    -.12505E+01     .12229E-01     -.20095E-02
```

Figure 9.- Continued.

```
 73     .20940E+02    .24874E+00   -.12505E+01    .58282E-02    .14082E-02
 74     .20940E+02    .70836E+00   -.10601E+01    .13956E-02    .11524E-02
 75     .20940E+02    .10601E+01   -.70836E+00   -.11524E-02   -.13956E-02
 76     .20940E+02    .12505E+01   -.24874E+00   -.14082E-02   -.58282E-02
 77     .22140E+02    .12505E+01    .24874E+00    .20985E-02   -.12770E-01
 78     .22140E+02    .10601E+01    .70836E+00    .13486E-01   -.21799E-01
 79     .22140E+02    .70836E+00    .10601E+01    .44448E-01   -.32424E-01
 80     .22140E+02    .24874E+00    .12505E+01    .13321E+00   -.33330E-01
 81     .22140E+02   -.24874E+00    .12505E+01    .32996E+00    .56340E-01
 82     .22140E+02   -.70836E+00    .10601E+01    .15939E+00    .12975E+00
 83     .22140E+02   -.10601E+01    .70836E+00   -.12975E+00   -.15939E+00
 84     .22140E+02   -.12505E+01    .24874E+00   -.56340E-01   -.32996E+00
 85     .22140E+02   -.12505E+01   -.24874E+00    .33330E-01   -.13321E+00
 86     .22140E+02   -.10601E+01   -.70836E+00    .32424E-01   -.44448E-01
 87     .22140E+02   -.70836E+00   -.10601E+01    .21799E-01   -.13486E-01
 88     .22140E+02   -.24874E+00   -.12505E+01    .12770E-01   -.20985E-02
 89     .22140E+02    .24874E+00   -.12505E+01    .60864E-02    .14706E-02
 90     .22140E+02    .70836E+00   -.10601E+01    .14575E-02    .12035E-02
 91     .22140E+02    .10601E+01   -.70836E+00   -.12035E-02   -.14575E-02
 92     .22140E+02    .12505E+01   -.24874E+00   -.14706E-02   -.60864E-02
 93     .23340E+02    .12505E+01    .24874E+00    .21926E-02   -.13340E-01
 94     .23340E+02    .10601E+01    .70836E+00    .14077E-01   -.22751E-01
 95     .23340E+02    .70836E+00    .10601E+01    .46275E-01   -.33741E-01
 96     .23340E+02    .24874E+00    .12505E+01    .13737E+00   -.34239E-01
 97     .23340E+02   -.24874E+00    .12505E+01    .32742E+00    .56877E-01
 98     .23340E+02   -.70836E+00    .10601E+01    .15241E+00    .12413E+00
 99     .23340E+02   -.10601E+01    .70836E+00   -.12413E+00   -.15241E+00
100     .23340E+02   -.12505E+01    .24874E+00   -.56877E-01   -.32742E+00
101     .23340E+02   -.12505E+01   -.24874E+00    .34239E-01   -.13737E+00
102     .23340E+02   -.10601E+01   -.70836E+00    .33741E-01   -.46275E-01
103     .23340E+02   -.70836E+00   -.10601E+01    .22751E-01   -.14077E-01
104     .23340E+02   -.24874E+00   -.12505E+01    .13340E-01   -.21926E-02
105     .23340E+02    .24874E+00   -.12505E+01    .63609E-02    .15369E-02
106     .23340E+02    .70836E+00   -.10601E+01    .15235E-02    .12579E-02
107     .23340E+02    .10601E+01   -.70836E+00   -.12579E-02   -.15235E-02
108     .23340E+02    .12505E+01   -.24874E+00   -.15369E-02   -.63609E-02
```

Figure 9.- Concluded.

```
NASA/LANGLEY WING-TAIL INTERFERENCE MODEL,UPWT PROJ.1124,CONFIGURATION B1W0,
$INPUT                                                 SREF     = .550029E+01,
CRP      = .36E+01,                                    REFL     = .269E+01,
SWLEP    = .3E+02,                                     PHIDTH   = 0.0,
SWTEP    = 0.0,                                        THETIT   = 0.0,
NCW      = 3,                                          XWLE     = .198E+02,
MSWR     = 5,                                          NOLINP   = 1,
MSWL     = 5,                                          NOUT     = 0,
ALFAC    = .14216E+02,                                 NPR      = 0,
PHI      = .45E+02,                                    NDRAG    = 1,
B2       = .234E+01,                                   NVRTX    = 0,
FMACH    = .17E+01,                                    NPRESS   = 0,
LVSWP    = 0,                                          VRTMAX   = .5E+00,
FAC      = .95E+00,                                    NCWB     = 3,
NEVNPR   = 0,                                          NAGAIN   = 0,
TOLFAC   = .1E+01,                                     BIL      = .36E+01,
MSWU     = 5,                                          ITAIL    = 0,
MSWD     = 5,                                          NVRTPL   = 0,
SWLEV    = .3E+02,                                     NBDYPR   = 1,
SWTEV    = 0.0,                                        NTPR     = 0,
CRPV     = .36E+01,                                    NTDAT    = 1,
B2V      = .234E+01,                                   NCWT     = 8,
NCRX     = 1,                                          NCPOUT   = 0,
RB       = .13E+01,                                    NVLIN    = 1,
RA       = .13E+01,                                    XSTART   = 0.0,
ERATIO   = .1E+01,                                     JCPT     = 0,
NBDCR    = 16,                                         FKLE     = .5E+00,
DELR     = 0.0,                                        FKSE     = .5E+00,
DELL     = 0.0,                                        XM       = .195E+02,
DELU     = 0.0,                                        ZM       = 0.0,
DELD     = 0.0,                                        $END
```

Figure 10.- Output of program DEMON2, first sample case, step 3.

```
                WING GEOMETRY

             TIP CHORD =     2.24900

            ROOT CHORD =     3.60000

         WING SEMISPAN =     2.34000

     LEADING EDGE SWEEP =   30.00000  DEGREES

    TRAILING EDGE SWEEP =    0.00000  DEGREES


                FLOW CONDITIONS

MACH =     1.70000    ALPHAC=  14.21600    PHI   =   45.00000    ALFA =   10.00010    BETA =   10.00010


     CRPT =     3.60000
    CRPTV =     3.60000

WING THICKNESS INPUT DATA

              SPANWISE LOCATIONS OF PANEL SIDE EDGES AND SWEEP ANGLES
                  OF WING SECTION TO THE LEFT

                         SPANWISE   LE SWEEP  TF SWEEP
                   I     LOCATION
                           FEET      DEGREES   DEGREES


    RIGHT WING SURFACE

                   1       1.30000   0.00000   0.00000
                   2       1.76800  30.00000   0.00000
                   3       2.23600  30.00000   0.00000
                   4       2.70400  30.00000   0.00000
                   5       3.17200  30.00000   0.00000
                   6       3.64000  30.00000   0.00000

                40 THICKNESS PANELS ARE TO BE LAID OUT
                 5 CHORDWISE ROWS WITH  8 IN EACH ROW


    UPPER WING SURFACE

                   1       1.30000   0.00000   0.00000
                   2       1.76800  30.00000   0.00000
                   3       2.23600  30.00000   0.00000
                   4       2.70400  30.00000   0.00000
                   5       3.17200  30.00000   0.00000
                   6       3.64000  30.00000   0.00000

                40 THICKNESS PANELS ARE TO BE LAID OUT
                 5 CHORDWISE ROWS WITH  8 IN EACH ROW
```

Figure 10.- Continued.

```
                    INPUT VALUES OF THE LOCAL SURFACE SLOPE OF THE THICKNESS
                     DISTRIBUTION,, FOR EACH CHORD-WISE ROW THE FIRST VALUE
                          IS FOR THE PANEL NEAREST THE LEADING EDGE

RIGHT WING SURFACE

      ROW                          SLOPES
       1                  .12200   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       2                  .12200    .12200   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       3                  .12200    .12200   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       4                  .12200    .12200   0.00000   0.00000   0.00000   0.00000   -.14100   -.14100
       5                  .12200   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100

UPPER WING SURFACE

      ROW                          SLOPES
       1                  .12200   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       2                  .12200    .12200   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       3                  .12200    .12200   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       4                  .12200    .12200   0.00000   0.00000   0.00000   0.00000   -.14100   -.14100
       5                  .12200   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100

$BODY

NXBODY  = 39,

LNOSE   = .78E+01,

LBODY   = .39E+02,

BCODE   = 2,

$END


PHYSICAL DIMENSIONS OF BODY AND LINE SINGULARITY STRENGTHS REPRESENTING THE BODY AT MACH= 1.7000      ALFAC= 14.2160
            X             R               DR/DX              TX              T(I)             TC(I)
  1      0.0000     -.42633E-13        .34286           .58610E-13      .10092           .39465E-01
  2      1.0263      .32639            .29353           .57761         -.40121E-01      -.10955E-01
  3      2.0526      .60316            .24611          1.2234          -.25012E-01      -.62846E-02
  4      3.0789      .63207            .20020          1.9350          -.23274E-01      -.81381E-02
  5      4.1053     1.0145             .15547          2.7106          -.18881E-01      -.74517E-02
  6      5.1316     1.1515             .11164          3.5485          -.15477E-01      -.75496E-02
  7      6.1579     1.2439             .68439E-01      4.4479          -.11952E-01      -.73645E-02
  8      7.1842     1.2921             .25613E-01      5.4078          -.83169E-02      -.70718E-02
  9      8.2105     1.3000            0.               6.4233           .31078E-01      -.28112E-02
 10      9.2368     1.3000            0.               7.4496           .35293E-02       .47755E-02
 11     10.2632     1.3000            0.               8.4760           .34046E-02       .39930E-02
 12     11.2895     1.3000            0.               9.5023           .14132E-02       .36673E-02
 13     12.3158     1.3000            0.              10.529            .93969E-03       .26432E-02
 14     13.3421     1.3000            0.              11.555            .55466E-03       .17866E-02
 15     14.3684     1.3000            0.              12.581            .36257E-03       .10708E-02
 16     15.3947     1.3000            0.              13.608            .23850E-03       .54355E-03
 17     16.4211     1.3000            0.              14.634            .16227E-03       .22980E-03
 18     17.4474     1.3000            0.              15.660            .11249E-03       .33410E-04
```

Figure 10.- Continued.

```
19  18.4737      1.3000         0.             16.686        .79559E-04     -.67255E-04
20  19.5000      1.3000         0.             17.713        .57218E-04     -.11629E-03
21  20.5263      1.3000         0.             18.739        .41794E-04     -.11983E-03
22  21.5526      1.3000         0.             19.765        .30961E-04     -.95708E-04
23  22.5789      1.3000         0.             20.792        .23236E-04     -.75192E-04
24  23.6053      1.3000         0.             21.818        .17650E-04     -.54633E-04
25  24.6316      1.3000         0.             22.844        .13558E-04     -.37078E-04
26  25.6579      1.3000         0.             23.871        .10525E-04     -.23532E-04
27  26.6842      1.3000         0.             24.897        .82509E-05     -.13475E-04
28  27.7105      1.3000         0.             25.923        .65280E-05     -.74713E-05
29  28.7368      1.3000         0.             26.950        .52100E-05     -.35327E-05
30  29.7632      1.3000         0.             27.976        .41922E-05     -.13202E-05
31  30.7895      1.3000         0.             29.002        .33993E-05     -.22844E-06
32  31.8158      1.3000         0.             30.029        .27766E-05      .19378E-06
33  32.8421      1.3000         0.             31.055        .22835E-05      .25675E-06
34  33.8684      1.3000         0.             32.081        .18903E-05      .15784E-06
35  34.8947      1.3000         0.             33.108        .15745E-05      .11691E-07
36  35.9211      1.3000         0.             34.134        .13191E-05     -.12295E-06
37  36.9474      1.3000         0.             35.160        .11112E-05     -.22221E-06
38  37.9737      1.3000         0.             36.186        .94102E-06     -.28188E-06
39  39.0000      1.3000         0.             37.213       0.              0.


                          PRESSURE COEFFICIENTS AT POINTS ON BODY MERIDIANS


 J     THETA,        XB         YB          ZB         UTOT       VTOT       WTOT     CP,LIN.    CP,BERN.    DR/DX      P/PINF,    P/PINF,
        DEG.                                                                                                           BERN.      LIN.


                                                    BODY RING=   1

 1   11.25000     .51316     .16626     .03307    -.20308     .36619     .16431     .40615     .31470     .31793    1.63664    1.82164
 2   22.50000     .51316     .15662     .06487    -.18468     .28906     .22763     .36935     .24369     .31793    1.49299    1.74720
 3   33.75000     .51316     .14095     .09418    -.16471     .20227     .26242     .32942     .18128     .31793    1.36673    1.66642
 4   45.00000     .51316     .11987     .11987    -.14395     .11616     .26874     .28789     .13035     .31793    1.26371    1.58241
 5   56.25000     .51316     .09418     .14095    -.12318     .04000     .25033     .24637     .09186     .31793    1.18583    1.49840
 6   67.50000     .51316     .06487     .15662    -.10322    -.01932     .21384     .20644     .06525     .31793    1.13200    1.41762
 7   78.75000     .51316     .03307     .16626    -.08482    -.05811     .16768     .16964     .04898     .31793    1.09908    1.34318
 8   90.00000     .51316    -.00000     .16952    -.06869    -.07629     .12065     .13738     .04083     .31793    1.08261    1.27792
 9  101.25000     .51316    -.03307     .16626    -.05545    -.07713     .08050     .11091     .03828     .31793    1.07744    1.22437
10  112.50000     .51316    -.06487     .15662    -.04562    -.06654     .05275     .09124     .03876     .31793    1.07842    1.18458
11  123.75000     .51316    -.09418     .14095    -.03956    -.05195     .03986     .07913     .04007     .31793    1.08107    1.16007
12  135.00000     .51316    -.11987     .11987    -.03752    -.04093     .04093     .07504     .04069     .31793    1.08232    1.15180
13  146.25000     .51316    -.14095     .09418    -.03956    -.03986     .05195     .07913     .04007     .31793    1.08107    1.16007
14  157.50000     .51316    -.15662     .06487    -.04562    -.05275     .06654     .09124     .03876     .31793    1.07842    1.18458
15  168.75000     .51316    -.16626     .03307    -.05545    -.08050     .07713     .11091     .03828     .31793    1.07744    1.22437
16  180.00000     .51316    -.16952    -.00000    -.06869    -.12065     .07629     .13738     .04083     .31793    1.08261    1.27792
17  191.25000     .51316    -.16626    -.03307    -.08482    -.16768     .05811     .16964     .04898     .31793    1.09908    1.34318
18  202.50000     .51316    -.15662    -.06487    -.10322    -.21384     .01932     .20644     .06525     .31793    1.13200    1.41762
19  213.75000     .51316    -.14095    -.09418    -.12318    -.25033    -.04000     .24637     .09186     .31793    1.18583    1.49840
20  225.00000     .51316    -.11987    -.11987    -.14395    -.26874    -.11616     .28789     .13035     .31793    1.26371    1.58241
21  236.25000     .51316    -.09418    -.14095    -.16471    -.26242    -.20227     .32942     .18128     .31793    1.36673    1.66642
22  247.50000     .51316    -.06487    -.15662    -.18468    -.22763    -.28906     .36935     .24369     .31793    1.49299    1.74720
23  258.75000     .51316    -.03307    -.16626    -.20308    -.16431    -.36619     .40615     .31470     .31793    1.63664    1.82164
24  270.00000     .51316     .00000    -.16952    -.21920    -.07629    -.42368     .43841     .38919     .31793    1.78734    1.88690
```

Figure 10.- Continued.

```
25 281.25000    .51316    .03307   -.16626   -.23244    .02907   -.45337    .46488    .46006    .31793   1.93070   1.94045
26 292.50000    .51316    .06487   -.15662   -.24227    .14177   -.45015    .48455    .51904    .31793   2.05002   1.98024
27 303.75000    .51316    .09418   -.14095   -.24833    .25047   -.41274    .49666    .55827    .31793   2.12939   2.00475
28 315.00000    .51316    .11987   -.11987   -.25038    .34397   -.34397    .50075    .57205    .31793   2.15725   2.01302
29 326.25000    .51316    .14095   -.09418   -.24833    .41274   -.25047    .49666    .55827    .31793   2.12939   2.00475
30 337.50000    .51316    .15662   -.06487   -.24227    .45015   -.14177    .48455    .51904    .31793   2.05002   1.98024
31 348.75000    .51316    .16626   -.03307   -.23244    .45337   -.02907    .46488    .46006    .31793   1.93070   1.94045
32 360.00000    .51316    .16952    .00000   -.21920    .42368    .07629    .43841    .38919    .31793   1.78734   1.88690

                                          BODY RING=   2

 1  11.25000   2.56579    .70961    .14115   -.14124    .29958    .18203    .28247    .19422    .22298   1.39291   1.57144
 2  22.50000   2.56579    .66843    .27687   -.12479    .21696    .23429    .24959    .12886    .22298   1.26069   1.50491
 3  33.75000   2.56579    .60157    .40196   -.10695    .12713    .25530    .21390    .07368    .22298   1.14905   1.43273
 4  45.00000   2.56579    .51160    .51160   -.08840    .04161    .24586    .17679    .03113    .22298   1.06297   1.35766
 5  56.25000   2.56579    .40196    .60157   -.06984   -.02944    .21090    .13969    .00171    .22298   1.00347   1.28258
 6  67.50000   2.56579    .27687    .66843   -.05200   -.07871    .15864    .10400   -.01550    .22298    .96864   1.21040
 7  78.75000   2.56579    .14115    .70961   -.03556   -.10271    .09915    .07112   -.02244    .22298    .95460   1.14387
 8  90.00000   2.56579   -.00000    .72351   -.02115   -.10212    .04282    .04229   -.02170    .22298    .95609   1.08556
 9 101.25000   2.56579   -.14115    .70961   -.00932   -.08155   -.00133    .01864   -.01633    .22298    .96695   1.03770
10 112.50000   2.56579   -.27687    .66843   -.00053   -.04863   -.02703    .00106   -.00950    .22298    .98077   1.00214
11 123.75000   2.56579   -.40196    .60157    .00488   -.01272   -.03168   -.00977   -.00406    .22298    .99179    .98024
12 135.00000   2.56579   -.51160    .51160    .00671    .01671   -.01671   -.01342   -.00200    .22298    .99595    .97285
13 146.25000   2.56579   -.60157    .40196    .00488    .03168    .01272   -.00977   -.00406    .22298    .99179    .98024
14 157.50000   2.56579   -.66843    .27687   -.00053    .02703    .04863    .00106   -.00950    .22298    .98077   1.00214
15 168.75000   2.56579   -.70961    .14115   -.00932    .00133    .08155    .01864   -.01633    .22298    .96695   1.03770
16 180.00000   2.56579   -.72351   -.00000   -.02115   -.04282    .10212    .04229   -.02170    .22298    .95609   1.08556
17 191.25000   2.56579   -.70961   -.14115   -.03556   -.09915    .10271    .07112   -.02244    .22298    .95460   1.14387
18 202.50000   2.56579   -.66843   -.27687   -.05200   -.15864    .07871    .10400   -.01550    .22298    .96864   1.21040
19 213.75000   2.56579   -.60157   -.40196   -.06984   -.21090    .02944    .13969    .00171    .22298   1.00347   1.28258
20 225.00000   2.56579   -.51160   -.51160   -.08840   -.24586   -.04161    .17679    .03113    .22298   1.06297   1.35766
21 236.25000   2.56579   -.40196   -.60157   -.10695   -.25530   -.12713    .21390    .07368    .22298   1.14905   1.43273
22 247.50000   2.56579   -.27687   -.66843   -.12479   -.23429   -.21696    .24959    .12886    .22298   1.26069   1.50491
23 258.75000   2.56579   -.14115   -.70961   -.14124   -.18203   -.29958    .28247    .19422    .22298   1.39291   1.57144
24 270.00000   2.56579    .00000   -.72351   -.15565   -.10212   -.36372    .31130    .26490    .22298   1.53589   1.62975
25 281.25000   2.56579    .14115   -.70961   -.16748   -.00223   -.40006    .33495    .33372    .22298   1.67511   1.67761
26 292.50000   2.56579    .27687   -.66843   -.17627    .10695   -.40263    .35253    .39199    .22298   1.79299   1.71317
27 303.75000   2.56579    .40196   -.60157   -.18168    .21315   -.36971    .36335    .43119    .22298   1.87230   1.73507
28 315.00000   2.56579    .51160   -.51160   -.18350    .30418   -.30418    .36701    .44503    .22298   1.90030   1.74246
29 326.25000   2.56579    .60157   -.40196   -.18168    .36971   -.21315    .36335    .43119    .22298   1.87230   1.73507
30 337.50000   2.56579    .66843   -.27687   -.17627    .40263   -.10695    .35253    .39199    .22298   1.79299   1.71317
31 348.75000   2.56579    .70961   -.14115   -.16748    .40006    .00223    .33495    .33372    .22298   1.67511   1.67761
32 360.00000   2.56579    .72351    .00000   -.15565    .36372    .10212    .31130    .26490    .22298   1.53589   1.62975

                                          BODY RING=   3

 1  11.25000   4.61842   1.06771    .21238   -.08033    .22574    .20086    .16066    .06989    .13346   1.14139   1.32501
 2  22.50000   4.61842   1.00576    .41660   -.06680    .13775    .24102    .13359    .01221    .13346   1.02471   1.27026
 3  33.75000   4.61842    .90516    .60481   -.05211    .04519    .24720    .10423   -.03411    .13346    .93100   1.21085
 4  45.00000   4.61842    .76977    .76977   -.03684   -.03919    .22098    .07369   -.06712    .13346    .86423   1.14907
 5  56.25000   4.61842    .60481    .90516   -.02157   -.10436    .16857    .04315   -.08669    .13346    .82463   1.08729
 6  67.50000   4.61842    .41660   1.00576   -.00689   -.14264    .09977    .01378   -.09400    .13346    .80985   1.02788
 7  78.75000   4.61842    .21238   1.06771    .00664   -.15070    .02641   -.01328   -.09112    .13346    .81567    .97313
 8  90.00000   4.61842   -.00000   1.08863    .01850   -.13008   -.03951   -.03701   -.08092    .13346    .83630    .92514
 9 101.25000   4.61842   -.21238   1.06771    .02824   -.08677   -.08768   -.05647   -.06693    .13346    .86461    .88575
10 112.50000   4.61842   -.41660   1.00576    .03547   -.03020   -.11104   -.07094   -.05303    .13346    .89273    .85649
```

Figure 10.- Continued.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 123.75000 | 4.61842 | -.60481 | .90516 | .03992 | .02825 | -.10687 | -.07985 | -.04289 | .13346 | .91324 | .83847 |
| 12 | 135.00000 | 4.61842 | -.76977 | .76977 | .04143 | .07716 | -.07716 | -.08286 | -.03918 | .13346 | .92075 | .83238 |
| 13 | 146.25000 | 4.61842 | -.90516 | .60481 | .03992 | .10687 | -.02825 | -.07985 | -.04289 | .13346 | .91324 | .83847 |
| 14 | 157.50000 | 4.61842 | -1.00576 | .41660 | .03547 | .11104 | .03020 | -.07094 | -.05303 | .13346 | .89273 | .85649 |
| 15 | 168.75000 | 4.61842 | -1.06771 | .21238 | .02824 | .08768 | .08677 | -.05647 | -.06693 | .13346 | .86461 | .88575 |
| 16 | 180.00000 | 4.61842 | -1.08863 | -.00000 | .01850 | .03951 | .13008 | -.03701 | -.08092 | .13346 | .83650 | .92514 |
| 17 | 191.25000 | 4.61842 | -1.06771 | -.21238 | .00664 | -.02641 | .15070 | -.01328 | -.09112 | .13346 | .81567 | .97313 |
| 18 | 202.50000 | 4.61842 | -1.00576 | -.41660 | -.00689 | -.09977 | .14264 | .01378 | -.09400 | .13346 | .80985 | 1.02788 |
| 19 | 213.75000 | 4.61842 | -.90516 | -.60481 | -.02157 | -.16857 | .10436 | .04315 | -.08669 | .13346 | .82463 | 1.08729 |
| 20 | 225.00000 | 4.61842 | -.76977 | -.76977 | -.03684 | -.22098 | .03919 | .07369 | -.06712 | .13346 | .86423 | 1.14907 |
| 21 | 236.25000 | 4.61842 | -.60481 | -.90516 | -.05211 | -.24720 | -.04519 | .10423 | -.03411 | .13346 | .93100 | 1.21085 |
| 22 | 247.50000 | 4.61842 | -.41660 | -1.00576 | -.06680 | -.24102 | -.13775 | .13359 | .01221 | .13346 | 1.02471 | 1.27026 |
| 23 | 258.75000 | 4.61842 | -.21238 | -1.06771 | -.08033 | -.20086 | -.22574 | .16066 | .06989 | .13346 | 1.14139 | 1.32501 |
| 24 | 270.00000 | 4.61842 | .00000 | -1.08863 | -.09219 | -.13008 | -.29660 | .18438 | .13453 | .13346 | 1.27215 | 1.37300 |
| 25 | 281.25000 | 4.61842 | .21238 | -1.06771 | -.10192 | -.03661 | -.33983 | .20385 | .19915 | .13346 | 1.40288 | 1.41238 |
| 26 | 292.50000 | 4.61842 | .41660 | -1.00576 | -.10916 | .06818 | -.34857 | .21831 | .25494 | .13346 | 1.51574 | 1.44164 |
| 27 | 303.75000 | 4.61842 | .60481 | -.90516 | -.11361 | .17108 | -.32064 | .22722 | .29296 | .13346 | 1.59265 | 1.45967 |
| 28 | 315.00000 | 4.61842 | .76977 | -.76977 | -.11511 | .25895 | -.25895 | .23023 | .30647 | .13346 | 1.61998 | 1.46575 |
| 29 | 326.25000 | 4.61842 | .90516 | -.60481 | -.11361 | .32064 | -.17108 | .22722 | .29296 | .13346 | 1.59265 | 1.45967 |
| 30 | 337.50000 | 4.61842 | 1.00576 | -.41660 | -.10916 | .34857 | -.06818 | .21831 | .25494 | .13346 | 1.51574 | 1.44164 |
| 31 | 348.75000 | 4.61842 | 1.06771 | -.21238 | -.10192 | .33983 | .03661 | .20385 | .19915 | .13346 | 1.40288 | 1.41238 |
| 32 | 360.00000 | 4.61842 | 1.08863 | .00000 | -.09219 | .29660 | .13008 | .18438 | .13453 | .13346 | 1.27215 | 1.37300 |

BODY RING= 4

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11.25000 | 6.67105 | 1.24902 | .24845 | -.01697 | .14328 | .22303 | .03394 | -.06233 | .04699 | .87392 | 1.06867 |
| 2 | 22.50000 | 6.67105 | 1.17655 | .48734 | -.00804 | .04966 | .25004 | .01608 | -.10916 | .04699 | .77918 | 1.03254 |
| 3 | 33.75000 | 6.67105 | 1.05887 | .70751 | .00165 | -.04565 | .24017 | -.00329 | -.14409 | .04699 | .70850 | .99334 |
| 4 | 45.00000 | 6.67105 | .90049 | .90049 | .01172 | -.12864 | .19587 | -.02345 | -.16569 | .04699 | .66481 | .95257 |
| 5 | 56.25000 | 6.67105 | .70751 | 1.05887 | .02180 | -.18734 | .12471 | -.04360 | -.17404 | .04699 | .64791 | .91180 |
| 6 | 67.50000 | 6.67105 | .48734 | 1.17655 | .03149 | -.21365 | .03819 | -.06298 | -.17024 | .04699 | .65560 | .87260 |
| 7 | 78.75000 | 6.67105 | .24845 | 1.24902 | .04042 | -.20448 | -.05002 | -.08084 | -.15623 | .04699 | .68394 | .83647 |
| 8 | 90.00000 | 6.67105 | -.00000 | 1.27349 | .04825 | -.16226 | -.12618 | -.09649 | -.13495 | .04699 | .72699 | .80480 |
| 9 | 101.25000 | 6.67105 | -.24845 | 1.24902 | .05467 | -.09446 | -.17860 | -.10934 | -.11043 | .04699 | .77659 | .77881 |
| 10 | 112.50000 | 6.67105 | -.48734 | 1.17655 | .05944 | -.01246 | -.19939 | -.11888 | -.06758 | .04699 | .82282 | .75950 |
| 11 | 123.75000 | 6.67105 | -.70751 | 1.05887 | .06238 | .07024 | -.18570 | -.12476 | -.07135 | .04699 | .85566 | .74761 |
| 12 | 135.00000 | 6.67105 | -.90049 | .90049 | .06337 | .14011 | -.14011 | -.12675 | -.06547 | .04699 | .86756 | .74359 |
| 13 | 146.25000 | 6.67105 | -1.05887 | .70751 | .06238 | .18570 | -.07024 | -.12476 | -.07135 | .04699 | .85566 | .74761 |
| 14 | 157.50000 | 6.67105 | -1.17655 | .48734 | .05944 | .19939 | .01246 | -.11888 | -.08758 | .04699 | .82282 | .75950 |
| 15 | 168.75000 | 6.67105 | -1.24902 | .24845 | .05467 | .17860 | .09446 | -.10934 | -.11043 | .04699 | .77659 | .77881 |
| 16 | 180.00000 | 6.67105 | -1.27349 | -.00000 | .04825 | .12618 | .16226 | -.09649 | -.13495 | .04699 | .72699 | .80480 |
| 17 | 191.25000 | 6.67105 | -1.24902 | -.24845 | .04042 | .05002 | .20448 | -.08084 | -.15623 | .04699 | .68394 | .83647 |
| 18 | 202.50000 | 6.67105 | -1.17655 | -.48734 | .03149 | -.03819 | .21365 | -.06298 | -.17024 | .04699 | .65560 | .87260 |
| 19 | 213.75000 | 6.67105 | -1.05887 | -.70751 | .02180 | -.12471 | .18734 | -.04360 | -.17404 | .04699 | .64791 | .91180 |
| 20 | 225.00000 | 6.67105 | -.90049 | -.90049 | .01172 | -.19587 | .12864 | -.02345 | -.16569 | .04699 | .66481 | .95257 |
| 21 | 236.25000 | 6.67105 | -.70751 | -1.05887 | .00165 | -.24017 | .04565 | -.00329 | -.14409 | .04699 | .70850 | .99334 |
| 22 | 247.50000 | 6.67105 | -.48734 | -1.17655 | -.00804 | -.25004 | -.04966 | .01608 | -.10916 | .04699 | .77918 | 1.03254 |
| 23 | 258.75000 | 6.67105 | -.24845 | -1.24902 | -.01697 | -.22303 | -.14328 | .03394 | -.06233 | .04699 | .87392 | 1.06867 |
| 24 | 270.00000 | 6.67105 | .00000 | -1.27349 | -.02480 | -.16226 | -.22127 | .04960 | -.00729 | .04699 | .98525 | 1.10034 |
| 25 | 281.25000 | 6.67105 | .24845 | -1.24902 | -.03122 | -.07591 | -.27186 | .06244 | .04963 | .04699 | 1.10040 | 1.12632 |
| 26 | 292.50000 | 6.67105 | .48734 | -1.17655 | -.03600 | .02393 | -.28724 | .07199 | .09997 | .04699 | 1.20223 | 1.14564 |
| 27 | 303.75000 | 6.67105 | .70751 | -1.05887 | -.03893 | .12307 | -.26476 | .07787 | .13482 | .04699 | 1.27274 | 1.15753 |
| 28 | 315.00000 | 6.67105 | .90049 | -.90049 | -.03993 | .20735 | -.20735 | .07985 | .14730 | .04699 | 1.29799 | 1.16154 |
| 29 | 326.25000 | 6.67105 | 1.05887 | -.70751 | -.03893 | .26476 | -.12307 | .07787 | .13482 | .04699 | 1.27274 | 1.15753 |
| 30 | 337.50000 | 6.67105 | 1.17655 | -.48734 | -.03600 | .28724 | -.02393 | .07199 | .09997 | .04699 | 1.20223 | 1.14564 |
| 31 | 348.75000 | 6.67105 | 1.24902 | -.24845 | -.03122 | .27186 | .07591 | .06244 | .04963 | .04699 | 1.10040 | 1.12632 |
| 32 | 360.00000 | 6.67105 | 1.27349 | .00000 | -.02480 | .22127 | .16226 | .04960 | -.00729 | .04699 | .98525 | 1.10034 |

Figure 10.- Continued.

```
                          BODY RING=    5

                        BODY NOSE SEPARATION AT XB/RB                 =     5.52485
                        VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =      .07510
                        VORTEX Y/RLOC (UNROLLED COORDS)               =      .63291
                        VORTEX Z/RLOC (UNROLLED COORDS)               =     1.17494


                        RIGHT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)=       .07510
                        RIGHT VORTEX Y(ROLLED COORDS.)/RLOC         =      -.38327
                        RIGHT VORTEX Z(ROLLED COORDS.)/RLOC         =      1.27835
                        LEFT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =      -.07510
                        LEFT VORTEX Y(ROLLED COORDS.)/RLOC          =     -1.27835
                        LEFT VORTEX Z(ROLLED COORDS.)/RLOC          =       .38327

  1  11.25000   8.72368   1.27502    .25362    .01846    .09244    .24186   -.03692   -.13846   0.00000    .71989    .92531
  2  22.50000   8.72368   1.20104    .49749    .02098   -.00455    .25906   -.04195   -.17259   0.00000    .65086    .91513
  3  33.75000   8.72368   1.08091    .72224    .02371   -.09954    .23610   -.04742   -.19340   0.00000    .60875    .90407
  4  45.00000   8.72368    .91924    .91924    .02655   -.17601    .17601   -.05310   -.19873   0.00000    .59797    .89257
  5  56.25000   8.72368    .72224   1.08091    .02939   -.21820    .08758   -.05879   -.18674   0.00000    .62223    .88108
  6  67.50000   8.72368    .49749   1.20104    .03213   -.21115   -.01531   -.06425   -.15486   0.00000    .68673    .87002
  7  78.75000   8.72368    .25362   1.27502    .03464   -.13639   -.11342   -.06929   -.09967   0.00000    .79837    .85983
  8  90.00000   8.72368   -.00000   1.30000    .03685    .03919   -.17544   -.07370   -.02991   0.00000    .93950    .85090
  9 101.25000   8.72368   -.25362   1.27502    .03866    .31798   -.14709   -.07733   -.03667   0.00000    .92583    .84357
 10 112.50000   8.72368   -.49749   1.20104    .04001    .37297   -.09363   -.08002   -.06200   0.00000    .87458    .83812
 11 123.75000   8.72368   -.72224   1.08091    .04084    .23609   -.13492   -.08168   -.02545   0.00000    .94852    .83477
 12 135.00000   8.72368   -.91924    .91924    .04112    .17544   -.17544   -.08224   -.02079   0.00000    .95795    .83364
 13 146.25000   8.72368  -1.08091    .72224    .04084    .13492   -.23609   -.08168   -.02545   0.00000    .94852    .83477
 14 157.50000   8.72368  -1.20104    .49749    .04001    .09363   -.37297   -.08002   -.06200   0.00000    .87458    .83812
 15 168.75000   8.72368  -1.27502    .25362    .03866    .14709   -.31798   -.07733   -.03667   0.00000    .92583    .84357
 16 180.00000   8.72368  -1.30000   -.00000    .03685    .17544   -.03919   -.07370   -.02991   0.00000    .93950    .85090
 17 191.25000   8.72368  -1.27502   -.25362    .03464    .11342    .13639   -.06929   -.09967   0.00000    .79837    .85983
 18 202.50000   8.72368  -1.20104   -.49749    .03213    .01531    .21115   -.06425   -.15486   0.00000    .68673    .87002
 19 213.75000   8.72368  -1.08091   -.72224    .02939   -.08758    .21820   -.05879   -.18674   0.00000    .62223    .88108
 20 225.00000   8.72368   -.91924   -.91924    .02655   -.17601    .17601   -.05310   -.19873   0.00000    .59797    .89257
 21 236.25000   8.72368   -.72224  -1.08091    .02371   -.23610    .09954   -.04742   -.19340   0.00000    .60875    .90407
 22 247.50000   8.72368   -.49749  -1.20104    .02098   -.25906    .00453   -.04195   -.17259   0.00000    .65086    .91513
 23 258.75000   8.72368   -.25362  -1.27502    .01846   -.24186   -.09244   -.03692   -.13846   0.00000    .71989    .92531
 24 270.00000   8.72368    .00000  -1.30000    .01625   -.18759   -.17544   -.03250   -.09467   0.00000    .80849    .93425
 25 281.25000   8.72368    .25362  -1.27502    .01444   -.10489   -.23121   -.02888   -.04710   0.00000    .90472    .94157
 26 292.50000   8.72368    .49749  -1.20104    .01309   -.00668   -.25088   -.02619   -.00372   0.00000    .99247    .94702
 27 303.75000   8.72368    .72224  -1.08091    .01227    .09183   -.23132   -.02453    .02686   0.00000   1.05435    .95037
 28 315.00000   8.72368    .91924   -.91924    .01199    .17544   -.17544   -.02397    .03792   0.00000   1.07671    .95151
 29 326.25000   8.72368   1.08091   -.72224    .01227    .23132   -.09183   -.02453    .02686   0.00000   1.05435    .95037
 30 337.50000   8.72368   1.20104   -.49749    .01309    .25088    .00668   -.02619   -.00372   0.00000    .99247    .94702
 31 348.75000   8.72368  -1.27502   -.25362    .01444    .23121    .10489   -.02888   -.04710   0.00000    .90472    .94157
 32 360.00000   8.72368   1.30000    .00000    .01625    .17544    .18759   -.03250   -.09467   0.00000    .80849    .93425

                          BODY RING=    6

                        BODY NOSE SEPARATION AT XB/RB                 =     5.52485
                        VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =      .07701
                        VORTEX Y/RLOC (UNROLLED COORDS)               =      .63679
                        VORTEX Z/RLOC (UNROLLED COORDS)               =     1.22147
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Figure 10.- Continued.

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                              RIGHT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)=      .07701
                              RIGHT VORTEX Y(ROLLED COORDS.)/RLOC          =    -.41343
                              RIGHT VORTEX Z(ROLLED COORDS.)/RLOC          =    1.31399
                              LEFT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =    -.07701
                              LEFT VORTEX Y(ROLLED COORDS.)/RLOC          =   -1.31399
                              LEFT VORTEX Z(ROLLED COORDS.)/RLOC          =      .41343

 1  11.25000  10.77632   1.27502    .25362    .01723    .09167    .24573   -.03446   -.13919   0.00000    .71841    .93030
 2  22.50000  10.77632   1.20104    .49749    .01669   -.00614    .26294   -.03338   -.16925   0.00000    .65760    .93247
 3  33.75000  10.77632   1.08091    .72224    .01611   -.10186    .23957   -.03222   -.18568   0.00000    .62437    .93482
 4  45.00000  10.77632    .91924    .91924    .01550   -.17871    .17871   -.03101   -.18601   0.00000    .62371    .93727
 5  56.25000  10.77632    .72224   1.08091    .01490   -.22080    .08932   -.02980   -.16797   0.00000    .66019    .93972
 6  67.50000  10.77632    .49749   1.20104    .01432   -.21334   -.01441   -.02863   -.12865   0.00000    .73975    .94207
 7  78.75000  10.77632    .25362   1.27502    .01378   -.13943   -.11281   -.02756   -.06501   0.00000    .86848    .94424
 8  90.00000  10.77632   -.00000   1.30000    .01331    .02598   -.17544   -.02662    .01263   0.00000   1.02555    .94615
 9 101.25000  10.77632   -.25362   1.27502    .01292    .27244   -.15615   -.02585    .02547   0.00000   1.05153    .94771
10 112.50000  10.77632   -.49749   1.20104    .01264    .34955   -.10333   -.02528   -.00024   0.00000    .99952    .94887
11 123.75000  10.77632   -.72224   1.08091    .01246    .24047   -.13199   -.02492    .03044   0.00000   1.06158    .94958
12 135.00000  10.77632   -.91924    .91924    .01240    .17544   -.17544   -.02480    .03706   0.00000   1.07497    .94982
13 146.25000  10.77632  -1.08091    .72224    .01246    .13199   -.24047   -.02492    .03044   0.00000   1.06158    .94958
14 157.50000  10.77632  -1.20104    .49749    .01264    .10333   -.34955   -.02528   -.00024   0.00000    .99952    .94887
15 168.75000  10.77632  -1.27502    .25362    .01292    .15615   -.27244   -.02585    .02547   0.00000   1.05153    .94771
16 180.00000  10.77632  -1.30000   -.00000    .01331    .17544   -.02598   -.02662    .01263   0.00000   1.02555    .94615
17 191.25000  10.77632  -1.27502   -.25362    .01378    .11281    .13943   -.02756   -.06501   0.00000    .86848    .94424
18 202.50000  10.77632  -1.20104   -.49749    .01432    .01441    .21334   -.02863   -.12865   0.00000    .73975    .94207
19 213.75000  10.77632  -1.08091   -.72224    .01490   -.08932    .22080   -.02980   -.16797   0.00000    .66019    .93972
20 225.00000  10.77632   -.91924   -.91924    .01550   -.17871    .17871   -.03101   -.18601   0.00000    .62371    .93727
21 236.25000  10.77632   -.72224  -1.08091    .01611   -.23957    .10186   -.03222   -.18568   0.00000    .62437    .93482
22 247.50000  10.77632   -.49749  -1.20104    .01669   -.26294    .00614   -.03338   -.16925   0.00000    .65760    .93247
23 258.75000  10.77632   -.25362  -1.27502    .01723   -.24573   -.09167   -.03446   -.13919   0.00000    .71841    .93030
24 270.00000  10.77632    .00000  -1.30000    .01770   -.19104   -.17544   -.03540   -.09925   0.00000    .79922    .92839
25 281.25000  10.77632    .25362  -1.27502    .01808   -.10759   -.23174   -.03617   -.05520   0.00000    .88833    .92683
26 292.50000  10.77632    .49749  -1.20104    .01837   -.00846   -.25162   -.03674   -.01473   0.00000    .97021    .92567
27 303.75000  10.77632    .72224  -1.08091    .01855    .09101   -.23186   -.03709    .01392   0.00000   1.02817    .92496
28 315.00000  10.77632    .91924   -.91924    .01861    .17544   -.17544   -.03721    .02430   0.00000   1.04915    .92472
29 326.25000  10.77632   1.08091   -.72224    .01855    .23186   -.09101   -.03709    .01392   0.00000   1.02817    .92496
30 337.50000  10.77632   1.20104   -.49749    .01837    .25162    .00846   -.03674   -.01473   0.00000    .97021    .92567
31 348.75000  10.77632   1.27502   -.25362    .01808    .23174    .10759   -.03617   -.05520   0.00000    .88833    .92683
32 360.00000  10.77632   1.30000    .00000    .01770    .17544    .19104   -.03540   -.09925   0.00000    .79922    .92839

                               BODY RING=    7

                              BODY NOSE SEPARATION AT XB/RB.              =    5.52485
                              VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =      .07891
                              VORTEX Y/RLOC (UNROLLED COORDS)        =      .64087
                              VORTEX Z/RLOC (UNROLLED COORDS)        =     1.24800

                              RIGHT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)=      .07891
                              RIGHT VORTEX Y(ROLLED COORDS.)/RLOC          =    -.44345
                              RIGHT VORTEX Z(ROLLED COORDS.)/RLOC          =    1.34977
                              LEFT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =    -.07891
                              LEFT VORTEX Y(ROLLED COORDS.)/RLOC          =   -1.34977
                              LEFT VORTEX Z(ROLLED COORDS.)/RLOC          =      .44345

 1  11.25000  12.82895   1.27502    .25362    .01336    .09328    .23765   -.02672   -.12754   0.00000    .74199    .94594
 2  22.50000  12.82895   1.20104    .49749    .01226   -.00257    .25433   -.02452   -.15614   0.00000    .68412    .95039
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Figure 10.- Continued.

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 3  33.75000  12.82895   1.08091    .72224    .01107   -.09622    .23113   -.02214   -.17124   0.00000    .65359    .95522
 4  45.00000  12.82895    .91924    .91924    .00983   -.17112    .17112   -.01965   -.17022   0.00000    .65564    .96024
 5  56.25000  12.82895    .72224   1.08091    .00858   -.21166    .08321   -.01717   -.15079   0.00000    .69495    .96527
 6  67.50000  12.82895    .49749   1.20104    .00739   -.20346   -.01850   -.01478   -.11026   0.00000    .77695    .97010
 7  78.75000  12.82895    .25362   1.27502    .00629   -.13127   -.11444   -.01258   -.04674   0.00000    .90544    .97455
 8  90.00000  12.82895   -.00000   1.30000    .00533    .02363   -.17544   -.01065    .02799   0.00000   1.05663    .97845
 9 101.25000  12.82895   -.25362   1.27502    .00454    .24321   -.16196   -.00907    .04810   0.00000   1.09731    .98165
10 112.50000  12.82895   -.49749   1.20104    .00395    .32994   -.11145   -.00790    .02477   0.00000   1.05012    .98403
11 123.75000  12.82895   -.72224   1.08091    .00359    .24358   -.12992   -.00717    .04813   0.00000   1.09736    .98549
12 135.00000  12.82895   -.91924    .91924    .00346    .17544   -.17544   -.00693    .05568   0.00000   1.11264    .98599
13 146.25000  12.82895  -1.08091    .72224    .00359    .12992   -.24358   -.00717    .04813   0.00000   1.09736    .98549
14 157.50000  12.82895  -1.20104    .49749    .00395    .11145   -.32994   -.00790    .02477   0.00000   1.05012    .98403
15 168.75000  12.82895  -1.27502    .25362    .00454    .16196   -.24321   -.00907    .04810   0.00000   1.09731    .98165
16 180.00000  12.82895  -1.30000   -.00000    .00533    .17544   -.02363   -.01065    .02799   0.00000   1.05663    .97845
17 191.25000  12.82895  -1.27502   -.25362    .00629    .11444    .13127   -.01258   -.04674   0.00000    .90544    .97455
18 202.50000  12.82895  -1.20104   -.49749    .00739    .01850    .20346   -.01478   -.11026   0.00000    .77695    .97010
19 213.75000  12.82895  -1.08091   -.72224    .00858   -.08321    .21166   -.01717   -.15079   0.00000    .69495    .96527
20 225.00000  12.82895   -.91924   -.91924    .00983   -.17112    .17112   -.01965   -.17022   0.00000    .65564    .96024
21 236.25000  12.82895   -.72224  -1.08091    .01107   -.23113    .09622   -.02214   -.17124   0.00000    .65359    .95522
22 247.50000  12.82895   -.49749  -1.20104    .01226   -.25433    .00257   -.02452   -.15614   0.00000    .68412    .95039
23 258.75000  12.82895   -.25362  -1.27502    .01336   -.23765   -.09328   -.02672   -.12754   0.00000    .74199    .94594
24 270.00000  12.82895    .00000  -1.30000    .01433   -.18411   -.17544   -.02865   -.08923   0.00000    .81948    .94204
25 281.25000  12.82895    .25362  -1.27502    .01512   -.10230   -.23069   -.03023   -.04694   0.00000    .90503    .93884
26 292.50000  12.82895    .49749  -1.20104    .01570   -.00504   -.25020   -.03141   -.00813   0.00000    .98356    .93646
27 303.75000  12.82895    .72224  -1.08091    .01607    .09257   -.23082   -.03213    .01932   0.00000   1.03909    .93499
28 315.00000  12.82895    .91924   -.91924    .01619    .17544   -.17544   -.03238    .02925   0.00000   1.05918    .93450
29 326.25000  12.82895   1.08091   -.72224    .01607    .23082   -.09257   -.03213    .01932   0.00000   1.03909    .93499
30 337.50000  12.82895   1.20104   -.49749    .01570    .25020    .00504   -.03141   -.00813   0.00000    .98356    .93646
31 348.75000  12.82895   1.27502   -.25362    .01512    .23069    .10230   -.03023   -.04694   0.00000    .90503    .93884
32 360.00000  12.82895   1.30000    .00000    .01433    .17544    .18411   -.02865   -.08923   0.00000    .81948    .94204


                                        BODY RING=   8

                                 BODY NOSE SEPARATION AT XB/RB             =     5.52485
                                 VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)  =      .08082
                                 VORTEX Y/RLOC (UNROLLED COORDS)         =      .64591
                                 VORTEX Z/RLOC (UNROLLED COORDS)         =     1.31453


                                 RIGHT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)=       .08082
                                 RIGHT VORTEX Y(ROLLED COORDS.)/RLOC         =     -.47279
                                 RIGHT VORTEX Z(ROLLED COORDS.)/RLOC         =     1.38624
                                 LEFT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =     -.08082
                                 LEFT VORTEX Y(ROLLED COORDS.)/RLOC          =    -1.38624
                                 LEFT VORTEX Z(ROLLED COORDS.)/RLOC          =      .47279

 1  11.25000  14.88158   1.27502    .25362    .00928    .09490    .22946   -.01855   -.11532   0.00000    .76670    .96247
 2  22.50000  14.88158   1.20104    .49749    .00846    .00103    .24562   -.01691   -.14371   0.00000    .70927    .96579
 3  33.75000  14.88158   1.08091    .72224    .00757   -.09054    .22262   -.01513   -.15873   0.00000    .67848    .96939
 4  45.00000  14.88158    .91924    .91924    .00664   -.16351    .16351   -.01328   -.15776   0.00000    .68084    .97314
 5  56.25000  14.88158    .72224   1.08091    .00571   -.20255    .07712   -.01143   -.13858   0.00000    .71965    .97689
 6  67.50000  14.88158    .49749   1.20104    .00482   -.19377   -.02251   -.00964   -.09890   0.00000    .79993    .98049
 7  78.75000  14.88158    .25362   1.27502    .00400   -.12339   -.11600   -.00800   -.03793   0.00000    .92326    .98381
 8  90.00000  14.88158   -.00000   1.30000    .00328    .02217   -.17544   -.00656    .03169   0.00000   1.06410    .98672
 9 101.25000  14.88158   -.25362   1.27502    .00269    .22012   -.16656   -.00538    .05492   0.00000   1.11111    .98911
10 112.50000  14.88158   -.49749   1.20104    .00225    .31040   -.11955   -.00451    .03517   0.00000   1.07114    .99089
11 123.75000  14.88158   -.72224   1.08091    .00198    .24356   -.12993   -.00397    .05147   0.00000   1.10412    .99198
12 135.00000  14.88158   -.91924    .91924    .00189    .17544   -.17544   -.00378    .05899   0.00000   1.11933    .99235
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Figure 10.- Continued.

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13 146.25000  14.88158  -1.08091    .72224    .00198    .12993   -.24356   -.00397    .05147  0.00000   1.10412    .99198
14 157.50000  14.88158  -1.20104    .49749    .00225    .11955   -.31040   -.00451    .03517  0.00000   1.07114    .99089
15 168.75000  14.88158  -1.27502    .25362    .00269    .16656   -.22012   -.00538    .05492  0.00000   1.11111    .98911
16 180.00000  14.88158  -1.30000   -.00000    .00328    .17544   -.02217   -.00656    .03169  0.00000   1.06410    .98672
17 191.25000  14.88158  -1.27502   -.25362    .00400    .11600    .12339   -.00800   -.03793  0.00000    .92326    .98381
18 202.50000  14.88158  -1.20104   -.49749    .00482    .02251    .19377   -.00964   -.09890  0.00000    .79993    .98049
19 213.75000  14.88158  -1.08091   -.72224    .00571   -.07712    .20255   -.01143   -.13858  0.00000    .71965    .97689
20 225.00000  14.88158   -.91924   -.91924    .00664   -.16351    .16351   -.01328   -.15776  0.00000    .68084    .97314
21 236.25000  14.88158   -.72224  -1.08091    .00757   -.22262    .09054   -.01513   -.15873  0.00000    .67888    .96939
22 247.50000  14.88158   -.49749  -1.20104    .00846   -.24562   -.00103   -.01691   -.14371  0.00000    .70927    .96579
23 258.75000  14.88158   -.25362  -1.27502    .00928   -.22946   -.09490   -.01855   -.11532  0.00000    .76670    .96247
24 270.00000  14.88158    .00000  -1.30000    .01000   -.17709   -.17544   -.01999   -.07743  0.00000    .84337    .95956
25 281.25000  14.88158    .25362  -1.27502    .01059   -.09693   -.22962   -.02117   -.03571  0.00000    .92775    .95717
26 292.50000  14.88158    .49749  -1.20104    .01102   -.00157   -.24877   -.02205    .00247  0.00000   1.00500    .95539
27 303.75000  14.88158    .72224  -1.08091    .01130    .09416   -.22976   -.02259    .02942  0.00000   1.05952    .95430
28 315.00000  14.88158    .91924   -.91924    .01139    .17544   -.17544   -.02277    .03916  0.00000   1.07922    .95393
29 326.25000  14.88158   1.08091   -.72224    .01130    .22976   -.09416   -.02259    .02942  0.00000   1.05952    .95430
30 337.50000  14.88158   1.20104   -.49749    .01102    .24877    .00157   -.02205    .00247  0.00000   1.00500    .95539
31 348.75000  14.88158   1.27502   -.25362    .01059    .22962    .09693   -.02117   -.03571  0.00000    .92775    .95717
32 360.00000  14.88158   1.30000    .00000    .01000    .17544    .17709   -.01999   -.07743  0.00000    .84337    .95956


                                           BODY RING#   9

                                         BODY NOSE SEPARATION AT XN/RB           =     5.52485
                                         VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =      .08272
                                         VORTEX Y/RLOC (UNROLLED COORDS)         =      .65095
                                         VORTEX Z/RLOC (UNROLLED COORDS)         =     1.36106


                                         RIGHT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)=      .08272
                                         RIGHT VORTEX Y(ROLLED COORDS.)/RLOC          =    -.50213
                                         RIGHT VORTEX Z(ROLLED COORDS.)/RLOC          =    1.42271
                                         LEFT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =     -.08272
                                         LEFT VORTEX Y(ROLLED COORDS.)/RLOC           =   -1.42271
                                         LEFT VORTEX Z(ROLLED COORDS.)/RLOC           =      .50213

 1  11.25000  16.93421   1.27502    .25362    .00617    .09596    .22413   -.01234   -.10656  0.00000    .78403    .97504
 2  22.50000  16.93421   1.20104    .49749    .00572    .00339    .23992   -.01144   -.13511  0.00000    .72668    .97687
 3  33.75000  16.93421   1.08091    .72224    .00523   -.08678    .21701   -.01046   -.15036  0.00000    .69582    .97884
 4  45.00000  16.93421    .91924    .91924    .00472   -.15845    .15845   -.00944   -.14971  0.00000    .69714    .98090
 5  56.25000  16.93421    .72224   1.08091    .00421   -.19647    .07306   -.00842   -.13103  0.00000    .73493    .98296
 6  67.50000  16.93421    .49749   1.20104    .00372   -.18740   -.02515   -.00745   -.09241  0.00000    .81306    .98493
 7  78.75000  16.93421    .25362   1.27502    .00327   -.11886   -.11690   -.00655   -.03396  0.00000    .93130    .98676
 8  90.00000  16.93421   -.00000   1.30000    .00288    .01863   -.17544   -.00576    .03137  0.00000   1.06346    .98835
 9 101.25000  16.93421   -.25362   1.27502    .00255    .19951   -.17066   -.00511    .05697  0.00000   1.11504    .98966
10 112.50000  16.93421   -.49749   1.20104    .00231    .29103   -.12757   -.00463    .04108  0.00000   1.08311    .99064
11 123.75000  16.93421   -.72224   1.08091    .00217    .24097   -.13166   -.00433    .05163  0.00000   1.10445    .99124
12 135.00000  16.93421   -.91924    .91924    .00212    .17544   -.17544   -.00423    .05852  0.00000   1.11858    .99144
13 146.25000  16.93421  -1.08091    .72224    .00217    .13166   -.24097   -.00433    .05163  0.00000   1.10445    .99124
14 157.50000  16.93421  -1.20104    .49749    .00231    .12757   -.29103   -.00463    .04108  0.00000   1.08311    .99064
15 168.75000  16.93421  -1.27502    .25362    .00255    .17066   -.19951   -.00511    .05697  0.00000   1.11504    .98966
16 180.00000  16.93421  -1.30000   -.00000    .00288    .17544   -.01863   -.00576    .03137  0.00000   1.06346    .98835
17 191.25000  16.93421  -1.27502   -.25362    .00327    .11690    .11886   -.00655   -.03396  0.00000    .93130    .98676
18 202.50000  16.93421  -1.20104   -.49749    .00372    .02515    .18740   -.00745   -.09241  0.00000    .81306    .98493
19 213.75000  16.93421  -1.08091   -.72224    .00421   -.07306    .19647   -.00842   -.13103  0.00000    .73493    .98296
20 225.00000  16.93421   -.91924   -.91924    .00472   -.15845    .15845   -.00944   -.14971  0.00000    .69714    .98090
21 236.25000  16.93421   -.72224  -1.08091    .00523   -.21701    .08678   -.01046   -.15036  0.00000    .69582    .97884
22 247.50000  16.93421   -.49749  -1.20104    .00572   -.23992   -.00339   -.01144   -.13511  0.00000    .72668    .97687
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Figure 10.- Continued.

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23 258.75000  16.93421  -.25362 -1.27502   .00617  -.22413  -.09596  -.01234  -.10656  0.00000   .78443   .97504
24 270.00000  16.93421   .00000 -1.30000   .00656  -.17254  -.17544  -.01313  -.06861  0.00000   .86120   .97345
25 281.25000  16.93421   .25362 -1.27502   .00689  -.09346  -.22893  -.01377  -.02695  0.00000   .94547   .97210
26 292.50000  16.93421   .49749 -1.20104   .00713   .00066  -.24784  -.01426   .01110  0.00000  1.02245   .97116
27 303.75000  16.93421   .72224 -1.08091   .00728   .09518  -.22908  -.01455   .03792  0.00000  1.07670   .97056
28 315.00000  16.93421   .91924  -.91924   .00733   .17544  -.17544  -.01465   .04760  0.00000  1.09629   .97036
29 326.25000  16.93421  1.08091  -.72224   .00728   .22908  -.09518  -.01455   .03792  0.00000  1.07670   .97056
30 337.50000  16.93421  1.20104  -.49749   .00713   .24784  -.00066  -.01426   .01110  0.00000  1.02245   .97116
31 348.75000  16.93421  1.27502  -.25362   .00689   .22893   .09346  -.01377  -.02695  0.00000   .94547   .97210
32 360.00000  16.93421  1.30000   .00000   .00656   .17544   .17254  -.01313  -.06861  0.00000   .86120   .97345

                                   BODY RING=  10

                          BODY NOSE SEPARATION AT XB/RB                  =      5.52445
                          VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =       .08688
                          VORTEX Y/RLOC (UNROLLED COORDS)                =       .65576
                          VORTEX Z/RLOC (UNROLLED COORDS)                =      1.40759

                          RIGHT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF)=        .08688
                          RIGHT VORTEX Y(ROLLED COORDS.)/RLOC              =      -.53163
                          RIGHT VORTEX Z(ROLLED COORDS.)/RLOC              =      1.45901
                          LEFT VORTEX STRENGTH GAMMA/(2*PI*RLOC*VINF) =      -.08688
                          LEFT VORTEX Y(ROLLED COORDS.)/RLOC               =     -1.45901
                          LEFT VORTEX Z(ROLLED COORDS.)/RLOC               =       .53163

 1  11.25000  18.98684  1.27502   .25362   .00416   .09660   .22095  -.00832  -.10104  0.00000   .79560   .98318
 2  22.50000  18.98684  1.20104   .49749   .00395   .00485   .23640  -.00791  -.12964  0.00000   .73774   .98401
 3  33.75000  18.98684  1.08091   .72224   .00373  -.08436   .21339  -.00746  -.14494  0.00000   .70679   .98491
 4  45.00000  18.98684   .91924   .91924   .00350  -.15498   .15498  -.00700  -.14430  0.00000   .70809   .98584
 5  56.25000  18.98684   .72224  1.08091   .00327  -.19196   .07004  -.00653  -.12567  0.00000   .74577   .98678
 6  67.50000  18.98684   .49749  1.20104   .00304  -.18211  -.02734  -.00609  -.08742  0.00000   .82315   .98768
 7  78.75000  18.98684   .25362  1.27502   .00284  -.11411  -.11785  -.00568  -.03043  0.00000   .93844   .98851
 8  90.00000  18.98684  -.00000  1.30000   .00266   .01843  -.17544  -.00532   .03175  0.00000  1.06423   .98924
 9 101.25000  18.98684  -.25362  1.27502   .00251   .18801  -.17295  -.00503   .05746  0.00000  1.11625   .98983
10 112.50000  18.98684  -.49749  1.20104   .00240   .27961  -.13230  -.00481   .04404  0.00000  1.08910   .99028
11 123.75000  18.98684  -.72224  1.08091   .00234   .24039  -.13205  -.00467   .05139  0.00000  1.10397   .99055
12 135.00000  18.98684  -.91924   .91924   .00231   .17544  -.17544  -.00463   .05810  0.00000  1.11754   .99064
13 146.25000  18.98684 -1.08091   .72224   .00234   .13205  -.24039  -.00467   .05139  0.00000  1.10397   .99055
14 157.50000  18.98684 -1.20104   .49749   .00240   .13230  -.27961  -.00481   .04404  0.00000  1.08910   .99028
15 168.75000  18.98684 -1.27502   .25362   .00251   .17295  -.18801  -.00503   .05746  0.00000  1.11625   .98983
16 180.00000  18.98684 -1.30000  -.00000   .00266   .17544  -.01843  -.00532   .03175  0.00000  1.06423   .98924
17 191.25000  18.98684 -1.27502  -.25362   .00284   .11785   .11411  -.00568  -.03043  0.00000   .93844   .98851
18 202.50000  18.98684 -1.20104  -.49749   .00304   .02734   .18211  -.00609  -.08742  0.00000   .82315   .98768
19 213.75000  18.98684 -1.08091  -.72224   .00327  -.07004   .19196  -.00653  -.12567  0.00000   .74577   .98678
20 225.00000  18.98684  -.91924  -.91924   .00350  -.15498   .15498  -.00700  -.14430  0.00000   .70809   .98584
21 236.25000  18.98684  -.72224 -1.08091   .00373  -.21339   .08436  -.00746  -.14494  0.00000   .70679   .98491
22 247.50000  18.98684  -.49749 -1.20104   .00395  -.23640  -.00485  -.00791  -.12964  0.00000   .73774   .98401
23 258.75000  18.98684  -.25362 -1.27502   .00416  -.22095  -.09660  -.00832  -.10104  0.00000   .79560   .98318
24 270.00000  18.98684   .00000 -1.30000   .00434  -.16969  -.17544  -.00867  -.06504  0.00000   .87247   .98245
25 281.25000  18.98684   .25362 -1.27502   .00448  -.09147  -.22854  -.00897  -.02137  0.00000   .95677   .98185
26 292.50000  18.98684   .49749 -1.20104   .00459   .00193  -.24732  -.00919   .01666  0.00000  1.03371   .98141
27 303.75000  18.98684   .72224 -1.08091   .00466   .09575  -.22869  -.00932   .04345  0.00000  1.08790   .98114
28 315.00000  18.98684   .91924  -.91924   .00468   .17544  -.17544  -.00937   .05312  0.00000  1.10746   .98105
29 326.25000  18.98684  1.08091  -.72224   .00466   .22869  -.09575  -.00932   .04345  0.00000  1.08790   .98114
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Figure 10.- Continued.

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30 337.50000  18.98684   1.20194   -.49749    .00459   .24732  -.00193  -.00919   .01666  0.00000  1.03371   .98141
31 348.75000  18.98684   1.27502   -.25362    .00448   .22854   .09147  -.00897  -.02137  0.00000   .95677   .98185
32 360.00000  18.98684   1.30000    .00000    .00434   .17544   .16969  -.00867  -.06304  0.00000   .87247   .98245


      TOTAL NUMBER OF PRESSURE POINTS,JCPT=  320


    POINT COORDINATES AND PERTURBATION VELOCITIES CALCULATED BY PROGRAM VPATH2OR VPATHL

IC      XCP         YCP         ZCP       VVEL(IC)      WVEL(IC)

 1    21.03100    1.53100     0.00000    .21494E-02   -.70848E-02
 2    22.18700    1.53100     0.00000    .22417E-02   -.73904E-02
 3    23.34200    1.53100     0.00000    .23375E-02   -.77102E-02
 4    21.21600    1.99870     0.00000    .40063E-02   -.44570E-02
 5    22.28100    1.99870     0.00000    .41696E-02   -.46394E-02
 6    23.34700    1.99870     0.00000    .43342E-02   -.48259E-02
 7    21.40000    2.46640     0.00000    .43372E-02   -.26581E-02
 8    22.37600    2.46640     0.00000    .44995E-02   -.27581E-02
 9    23.35100    2.46640     0.00000    .46627E-02   -.28607E-02
10    21.58500    2.93400     0.00000    .41198E-02   -.14995E-02
11    22.47000    2.93400     0.00000    .42595E-02   -.15510E-02
12    23.35600    2.93400     0.00000    .44001E-02   -.16042E-02
13    21.76900    3.40160     0.00000    .47321E-02   -.76368E-03
14    22.56500    3.40160     0.00000    .38456E-02   -.78743E-03
15    23.36000    3.40160     0.00000    .39599E-02   -.81257E-03
16    21.03100   -1.53100     0.00000   -.76760E-01   -.17026E+00
17    22.18700   -1.53100     0.00000   -.76729E-01   -.17591E+00
18    23.34200   -1.53100     0.00000   -.75708E-01   -.18067E+00
19    21.21600   -1.99870     0.00000   -.13321E+00   -.38546E-01
20    22.28100   -1.99870     0.00000   -.13885E+00   -.42546E-01
21    23.34700   -1.99870     0.00000   -.14371E+00   -.47503E-01
22    21.40000   -2.46640     0.00000   -.76287E-01    .33442E-01
23    22.37600   -2.46640     0.00000   -.80075E-01    .34808E-01
24    23.35100   -2.46640     0.00000   -.84175E-01    .35781E-01
25    21.58500   -2.93400     0.00000   -.32972E-01    .36466E-01
26    22.47000   -2.93400     0.00000   -.34252E-01    .37988E-01
27    23.35600   -2.93400     0.00000   -.35706E-01    .39482E-01
28    21.76900   -3.40160     0.00000   -.14196E-01    .27926E-01
29    22.56500   -3.40160     0.00000   -.14621E-01    .28902E-01
30    23.36000   -3.40160     0.00000   -.15118E-01    .29897E-01
31    21.03100     .00000     1.53100    .17026E+00    .76760E-01
32    22.18700     .00000     1.53100    .17591E+00    .76729E-01
33    23.34200     .00000     1.53100    .18067E+00    .75708E-01
34    21.21600     .00000     1.99870    .38546E-01    .13321E+00
35    22.28100     .00000     1.99870    .42546E-01    .13885E+00
36    23.34700     .00000     1.99870    .47503E-01    .14371E+00
37    21.40000     .00000     2.46640   -.33442E-01    .76287E-01
38    22.37600     .00000     2.46640   -.34808E-01    .80075E-01
39    23.35100     .00000     2.46640   -.35781E-01    .84175E-01
40    21.58500     .00000     2.93400   -.36466E-01    .32972E-01
41    22.47000     .00000     2.93400   -.37988E-01    .34252E-01
42    23.35600     .00000     2.93400   -.39482E-01    .35706E-01
43    21.76900     .00000     3.40160   -.27926E-01    .14196E-01
44    22.56500     .00000     3.40160   -.28902E-01    .14621E-01
45    23.36000     .00000     3.40160   -.29897E-01    .15118E-01
46    21.03100    -.00000    -1.53100    .70848E-02   -.21494E-02
```

Figure 10.- Continued.

```
 47   22.19700   -.00000   -1.53100   .73904E-02   -.22417E-02
 48   23.34200   -.00000   -1.53100   .77102E-02   -.23375E-02
 49   21.21600   -.00000   -1.99870   .44570E-02   -.40063E-02
 50   22.28100   -.00000   -1.99870   .46594E-02   -.41696E-02
 51   23.34700   -.00000   -1.99870   .48258E-02   -.43342E-02
 52   21.40000   -.00000   -2.46640   .26581E-02   -.43372E-02
 53   22.37600   -.00000   -2.46640   .27581E-02   -.44495E-02
 54   23.35100   -.00000   -2.46640   .28607E-02   -.46627E-02
 55   21.58500   -.00000   -2.93400   .14995E-02   -.41198E-02
 56   22.47000   -.00000   -2.93400   .15510E-02   -.42595E-02
 57   23.35600   -.00000   -2.93400   .16042E-02   -.44001E-02
 58   21.76900   -.00000   -3.40160   .76368E-03   -.37321E-02
 59   22.56500   -.00000   -3.40160   .78743E-03   -.34456E-02
 60   23.36000   -.00000   -3.40160   .81237E-03   -.39599E-02
 61   20.94000   1.25050     .24874   .20095E-02   -.12229E-01
 62   20.94000   1.06010     .70836   .12919E-01   -.20885E-01
 63   20.94000    .70836    1.06010   .42643E-01   -.31116E-01
 64   20.94000    .24874    1.25050   .12866E+00   -.32286E-01
 65   20.94000   -.24874    1.25050   .32968E+00    .55337E-01
 66   20.94000   -.70836    1.06010   .16618E+00    .13512E+00
 67   20.94000  -1.06010     .70836  -.13512E+00   -.16618E+00
 68   20.94000  -1.25050     .24874  -.55337E-01   -.32968E+00
 69   20.94000  -1.25050    -.24874   .32286E-01   -.12866E+00
 70   20.94000  -1.06010    -.70836   .31116E-01   -.42643E-01
 71   20.94000   -.70836   -1.06010   .20885E-01   -.12919E-01
 72   20.94000   -.24874   -1.25050   .12229E-01   -.20095E-02
 73   20.94000    .24874   -1.25050   .58292E-02    .14082E-02
 74   20.94000    .70836   -1.06010   .13956E-02    .11524E-02
 75   20.94000   1.06010    -.70836  -.11524E-02   -.13956E-02
 76   20.94000   1.25050    -.24874  -.14082E-02   -.58282E-02
 77   22.14000   1.25050     .24874   .20985E-02   -.12770E-01
 78   22.14000   1.06010     .70836   .13486E-01   -.21799E-01
 79   22.14000    .70836    1.06010   .44448E-01   -.32424E-01
 80   22.14000    .24874    1.25050   .13321E+00   -.33330E-01
 81   22.14000   -.24874    1.25050   .32995E+00    .56340E-01
 82   22.14000   -.70836    1.06010   .15939E+00    .12975E+00
 83   22.14000  -1.06010     .70836  -.12975E+00   -.15939E+00
 84   22.14000  -1.25050     .24874  -.56340E-01   -.32995E+00
 85   22.14000  -1.25050    -.24874   .33330E-01   -.13321E+00
 86   22.14000  -1.06010    -.70836   .32424E-01   -.44448E-01
 87   22.14000   -.70836   -1.06010   .21799E-01   -.13486E-01
 88   22.14000   -.24874   -1.25050   .12770E-01   -.20985E-02
 89   22.14000    .24874   -1.25050   .60864E-02    .14706E-02
 90   22.14000    .70836   -1.06010   .14575E-02    .12035E-02
 91   22.14000   1.06010    -.70836  -.12035E-02   -.14575E-02
 92   22.14000   1.25050    -.24874  -.14706E-02   -.60864E-02
 93   23.34000   1.25050     .24874   .21926E-02   -.13340E-01
 94   23.34000   1.06010     .70836   .14077E-01   -.22751E-01
 95   23.34000    .70836    1.06010   .46275E-01   -.33741E-01
 96   23.34000    .24874    1.25050   .13737E+00   -.34239E-01
 97   23.34000   -.24874    1.25050   .32742E+00    .56877E-01
 98   23.34000   -.70836    1.06010   .15241E+00    .12413E+00
 99   23.34000  -1.06010     .70836  -.12413E+00   -.15241E+00
100   23.34000  -1.25050     .24874  -.56877E-01   -.32742E+00
101   23.34000  -1.25050    -.24874   .34239E-01   -.13737E+00
102   23.34000  -1.06010    -.70836   .33741E-01   -.46275E-01
103   23.34000   -.70836   -1.06010   .22751E-01   -.14077E-01
104   23.34000   -.24874   -1.25050   .13340E-01   -.21926E-02
105   23.34000    .24874   -1.25050   .63609E-02    .15369E-02
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Figure 10.- Continued.

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 106     23.34000       .70836    -1.06010     .15235E-02     .12579E-02
 107     23.34000      1.06010     -.70836    -.12579E-02    -.15235E-02
 108     23.34000      1.25050     -.24874    -.15349E-02    -.63609E-02

          CONTROL POINT COORDINATES FOR  3 CHORDWISE BY  5 SPANWISE PANELS ON WING 1 OR R,   5     SPANWISE ON WING 2 OR L
                                                  AND 5 SPANWISE PANELS ON WING 3 OR U,  5     SPANWISE ON WING 4 OR D

  J       X(J)         Y(J)         Z(J)        BU(J)          BV(J)          BW(J)         VVRTX          WVRTX

  1     1.23112      1.53096      0.00000     .30415E-02     .12608E+00     .12789E+00    0.             0.
  2     2.38667      1.53096      0.00000     .25619E-02     .12617E+00     .12768E+00    0.             0.
  3     3.54222      1.53096      0.00000     .22035E-02     .12622E+00     .12755E+00    0.             0.
  4     1.41565      1.99870      0.00000     .30173E-02     .73266E-01     .75357E-01    0.             0.
  5     2.48119      1.99870      0.00000     .25678E-02     .73453E-01     .75200E-01    0.             0.
  6     3.54672      1.99870      0.00000     .22281E-02     .73581E-01     .75098E-01    0.             0.
  7     1.60017      2.46640      0.00000     .30518E-02     .47405E-01     .49768E-01    0.             0.
  8     2.57570      2.46640      0.00000     .26235E-02     .47650E-01     .49633E-01    0.             0.
  9     3.55122      2.46640      0.00000     .22924E-02     .47827E-01     .49541E-01    0.             0.
 10     1.78466      2.93403      0.00000     .31062E-02     .32808E-01     .35417E-01    0.             0.
 11     2.67019      2.93403      0.00000     .26945E-02     .33091E-01     .35293E-01    0.             0.
 12     3.55572      2.93403      0.00000     .23729E-02     .33299E-01     .35206E-01    0.             0.
 13     1.96912      3.40158      0.00000     .32017E-02     .23701E-01     .26577E-01    0.             0.
 14     2.76467      3.40158      0.00000     .28029E-02     .24011E-01     .26461E-01    0.             0.
 15     3.56022      3.40158      0.00000     .24715E-02     .24266E-01     .26377E-01    0.             0.
 16     1.23112     -1.53096      0.00000     .23353E-02     .12635E+00     .12789E+00    0.             0.
 17     2.38667     -1.53096      0.00000     .21254E-02     .12638E+00     .12768E+00    0.             0.
 18     3.54222     -1.53096      0.00000     .19174E-02     .12640E+00     .12755E+00    0.             0.
 19     1.41565     -1.99870      0.00000     .22883E-02     .73972E-01     .75357E-01    0.             0.
 20     2.48119     -1.99870      0.00000     .21091E-02     .74042E-01     .75200E-01    0.             0.
 21     3.54672     -1.99870      0.00000     .19229E-02     .74077E-01     .75098E-01    0.             0.
 22     1.60017     -2.46640      0.00000     .21980E-02     .48453E-01     .49768E-01    0.             0.
 23     2.57570     -2.46640      0.00000     .20524E-02     .48538E-01     .49633E-01    0.             0.
 24     3.55122     -2.46640      0.00000     .18969E-02     .48586E-01     .49541E-01    0.             0.
 25     1.78466     -2.93403      0.00000     .21408E-02     .34196E-01     .35417E-01    0.             0.
 26     2.67019     -2.93403      0.00000     .20174E-02     .34274E-01     .35293E-01    0.             0.
 27     3.55572     -2.93403      0.00000     .18823E-02     .34317E-01     .35206E-01    0.             0.
 28     1.96912     -3.40158      0.00000     .20349E-02     .25363E-01     .26577E-01    0.             0.
 29     2.76467     -3.40158      0.00000     .19547E-02     .25464E-01     .26461E-01    0.             0.
 30     3.56022     -3.40158      0.00000     .18804E-02     .25558E-01     .26377E-01    0.             0.
 31     1.23112      0.00000      1.53096     .23353E-02    -.12789E+00    -.12635E+00    0.             0.
 32     2.38667      0.00000      1.53096     .21254E-02    -.12768E+00    -.12638E+00    0.             0.
 33     3.54222      0.00000      1.53096     .19174E-02    -.12755E+00    -.12640E+00    0.             0.
 34     1.41565      0.00000      1.99870     .22883E-02    -.75357E-01    -.73972E-01    0.             0.
 35     2.48119      0.00000      1.99870     .21091E-02    -.75200E-01    -.74042E-01    0.             0.
 36     3.54672      0.00000      1.99870     .19229E-02    -.75098E-01    -.74077E-01    0.             0.
 37     1.60017      0.00000      2.46640     .21980E-02    -.49768E-01    -.48453E-01    0.             0.
 38     2.57570      0.00000      2.46640     .20524E-02    -.49633E-01    -.48538E-01    0.             0.
 39     3.55122      0.00000      2.46640     .18969E-02    -.49541E-01    -.48586E-01    0.             0.
 40     1.78466      0.00000      2.93403     .21408E-02    -.35417E-01    -.34196E-01    0.             0.
 41     2.67019      0.00000      2.93403     .20174E-02    -.35293E-01    -.34274E-01    0.             0.
 42     3.55572      0.00000      2.93403     .18823E-02    -.35206E-01    -.34317E-01    0.             0.
 43     1.96912      0.00000      3.40158     .20349E-02    -.26577E-01    -.25363E-01    0.             0.
 44     2.76467      0.00000      3.40158     .19547E-02    -.26461E-01    -.25464E-01    0.             0.
 45     3.56022      0.00000      3.40158     .18804E-02    -.26377E-01    -.25558E-01    0.             0.
 46     1.23112      0.00000     -1.53096     .30415E-02    -.12789E+00    -.12608E+00    0.             0.
 47     2.38667      0.00000     -1.53096     .25619E-02    -.12768E+00    -.12617E+00    0.             0.
 48     3.54222      0.00000     -1.53096     .22035E-02    -.12755E+00    -.12622E+00    0.             0.
 49     1.41565      0.00000     -1.99870     .30173E-02    -.75357E-01    -.73266E-01    0.             0.
 50     2.48119      0.00000     -1.99870     .25678E-02    -.75200E-01    -.73453E-01    0.             0.
```

Figure 10.- Continued.

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  51    3,54672    0,00000   -1,99870   ,22281E-02   -,75098E-01   -,74581E-01   0,         0,
  52    1,60017    0,00000   -2,46640   ,30518E-02   -,49768E-01   -,47405E-01   0,         0,
  53    2,57570    0,00000   -2,46640   ,26235E-02   -,49633E-01   -,47650E-01   0,         0,
  54    3,55122    0,00000   -2,46640   ,22924E-02   -,49541E-01   -,47827E-01   0,         0,
  55    1,78466    0,00000   -2,93403   ,31062E-02   -,35417E-01   -,32808E-01   0,         0,
  56    2,67019    0,00000   -2,93403   ,26945E-02   -,35293E-01   -,33091E-01   0,         0,
  57    3,55572    0,00000   -2,93403   ,23729E-02   -,35206E-01   -,33299E-01   0,         0,
  58    1,96912    0,00000   -3,40158   ,32017E-02   -,26577E-01   -,25701E-01   0,         0,
  59    2,76467    0,00000   -3,40158   ,28029E-02   -,26461E-01   -,24011E-01   0,         0,
  60    3,56022    0,00000   -3,40158   ,24715E-02   -,26377E-01   -,24266E-01   0,         0,

                         CONTROL POINT COORDINATES FOR HIP*S (WING FRAME)
   J     X(J)       Y(J)       Z(J)      THU(J)        THV(J)        THW(J)


  61    1,14000    1,25052     ,24874   -,13891E-02   -,18221E-01    ,34655E-02
  62    1,14000    1,06014     ,70836   -,15717E-01   -,88792E-02    ,20553E-01
  63    1,14000     ,70836    1,06014   -,15717E-01    ,20553E-01   -,88792E-02
  64    1,14000     ,24874    1,25052   -,13891E-02    ,34655E-02   -,18221E-01
  65    1,14000    -,24874    1,25052   -,13891E-02   -,34655E-02   -,18221E-01
  66    1,14000    -,70836    1,06014   -,15717E-01   -,20553E-01   -,88792E-02
  67    1,14000   -1,06014     ,70836   -,15717E-01    ,88792E-02    ,20553E-01
  68    1,14000   -1,25052     ,24874   -,13891E-02    ,18221E-01    ,34655E-02
  69    1,14000   -1,25052    -,24874   -,13891E-02    ,18221E-01   -,34655E-02
  70    1,14000   -1,06014    -,70836   -,15717E-01    ,88792E-02   -,20553E-01
  71    1,14000    -,70836   -1,06014   -,15717E-01   -,20553E-01    ,88792E-02
  72    1,14000    -,24874   -1,25052   -,13891E-02   -,34655E-02    ,18221E-01
  73    1,14000     ,24874   -1,25052   -,13891E-02    ,34655E-02    ,18221E-01
  74    1,14000     ,70836   -1,06014   -,15717E-01    ,20553E-01    ,88792E-02
  75    1,14000    1,06014    -,70836   -,15717E-01   -,88792E-02   -,20553E-01
  76    1,14000    1,25052    -,24874   -,13891E-02   -,18221E-01   -,34655E-02
  77    2,34000    1,25052     ,24874   -,10617E-01   -,85805E-02   -,48355E-02
  78    2,34000    1,06014     ,70836   -,22211E-01   -,16042E-01    ,68216E-02
  79    2,34000     ,70836    1,06014   -,22211E-01    ,68216E-02   -,16042E-01
  80    2,34000     ,24874    1,25052   -,10617E-01   -,48355E-02   -,85805E-02
  81    2,34000    -,24874    1,25052   -,10617E-01    ,48355E-02   -,85805E-02
  82    2,34000    -,70836    1,06014   -,22211E-01   -,68216E-02   -,16042E-01
  83    2,34000   -1,06014     ,70836   -,22211E-01    ,16042E-01    ,68216E-02
  84    2,34000   -1,25052     ,24874   -,10617E-01    ,85805E-02   -,48355E-02
  85    2,34000   -1,25052    -,24874   -,10617E-01    ,85805E-02    ,48355E-02
  86    2,34000   -1,06014    -,70836   -,22211E-01    ,16042E-01   -,68216E-02
  87    2,34000    -,70836   -1,06014   -,22211E-01   -,68216E-02    ,16042E-01
  88    2,34000    -,24874   -1,25052   -,10617E-01    ,48355E-02    ,85805E-02
  89    2,34000     ,24874   -1,25052   -,10617E-01   -,48355E-02    ,85805E-02
  90    2,34000     ,70836   -1,06014   -,22211E-01    ,68216E-02    ,16042E-01
  91    2,34000    1,06014    -,70836   -,22211E-01   -,16042E-01   -,68216E-02
  92    2,34000    1,25052    -,24874   -,10617E-01   -,85805E-02    ,48355E-02
  93    3,54000    1,25052     ,24874    ,20323E-01    ,26782E-01   -,54507E-01
  94    3,54000    1,06014     ,70836   -,22241E-01    ,11295E-01    ,68311E-02
  95    3,54000     ,70836    1,06014   -,22241E-01    ,68311E-02    ,11295E-01
  96    3,54000     ,24874    1,25052    ,20323E-01   -,54507E-01    ,26782E-01
  97    3,54000    -,24874    1,25052    ,20323E-01    ,54507E-01    ,26782E-01
  98    3,54000    -,70836    1,06014   -,22241E-01   -,68311E-02    ,11295E-01
  99    3,54000   -1,06014     ,70836   -,22241E-01   -,11295E-01    ,68311E-02
 100    3,54000   -1,25052     ,24874    ,20323E-01   -,26782E-01   -,54507E-01
 101    3,54000   -1,25052    -,24874    ,20323E-01   -,26782E-01    ,54507E-01
 102    3,54000   -1,06014    -,70836   -,22241E-01   -,11295E-01   -,68311E-02
 103    3,54000    -,70836   -1,06014   -,22241E-01   -,68311E-02   -,11295E-01
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Figure 10.- Continued.

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 104     3.54000      -.24874     -1.25052     .20323E-01    .54507E-01   -.26782E-01
 105     3.54000       .24874     -1.25052     .20323E-01   -.54507E-01   -.26782E-01
 106     3.54000       .70836     -1.06014    -.22241E-01    .68311E-02   -.11295E-01
 107     3.54000      1.06014      -.70836    -.22241E-01    .11295E-01   -.68311E-02
 108     3.54000      1.25052      -.24874     .20323E-01    .26782E-01    .54507E-01


                                   LOADING INFORMATION

           MACH NUMBER =   .17000E+01
       ANGLE OF ATTACK =   10.000 DEGREES
       SIDE SLIP ANGLE =   10.000 DEGREES
             WING AREA =   13.68666
        REFERENCE AREA =    5.30929
      REFERENCE LENGTH =    2.69000
  EXPOSED WING SPAN B =    4.68000
  MOMENT CENTER:    XM =   19.50000
                    ZM =    0.00000



U/VINF TYPE LOADING PRESSURE


                            TOTAL            FIN 1 OR R        FIN 2 OR L        FIN 3 OR U        FIN 4 OR D       INTERF. SHELL
  DEFL. ANGLE DEG. =                          0.00000           0.00000           0.00000           0.00000
             CTHR =    .53916E-01          .14774E-01        .12184E-01        .12184E-01        .14774E-01
               CZ =    .14450E+01          .66234E+00        .55746E+00       0.                0.                  .22517E+00
               CY =   -.14450E+01         0.                0.                -.55746E+00       -.66234E+00         -.22517E+00
               CM =   -.14587E+01         -.65426E+00       -.54950E+00       0.                0.                  -.25492E+00
              CLN =    .14587E+01         0.                0.                 .54950E+00        .65426E+00          .25492E+00
              CLL =    .14346E-13         -.57478E+00        .50518E+00       -.50518E+00        .57478E+00          .13507E-15

                   FOLLOWING ARE IN WIND-AXIS SYSTEM

               CL =    .19942E+01          .45763E+00        .38511E+00        .38511E+00        .45763E+00          .30869E+00
           CY-IND =    .66169E-12          .46834E+00        .39419E+00       -.39419E+00       -.46834E+00          .63505E-12
              CDI =    .44957E+00          .10069E+00        .84992E-01        .84992E-01        .10069E+00          .78202E-01
        CDI/CL**2 =    .11305E+00
           CM-IND =   -.20629E+01         -.46263E+00       -.38855E+00       -.38855E+00       -.46263E+00          -.36052E+00
          CLN-IND =   -.62018E-12         -.30731E+00       -.50072E+00        .50072E+00        .30731E+00          -.56044E-12



          NOTE: L.E. OF LEAD PANEL IN FIRST CHORDWISE ROW IS SUPERSONIC
```

Figure 10.- Continued.

```
*******************RIGHT WING*********************


                         SPANWISE DISTRIBUTIONS

I       Y/(B/2)  CN*C/(2*B)  CT*C/(2*B) CY1*C/(2*B) CYTOT*C/(2*B) CS*C/(2*B)     CSINT     YBAR        GAMMET(I)  GAMMA,LE/VINF  XLE

1        .65426     .19397     0.00000     0.00000      .00070     0.00000     0.00000    0.00000      -.90825    0.00000      .13334
2        .85415     .16840     0.00000     0.00000      .00259     0.00000     0.00000    0.00000       .02601    0.00000      .40340
3       1.05402     .17267     0.00000     0.00000      .00225     0.00000     0.00000    0.00000       .07359    0.00000      .67342
4       1.25386     .14562     0.00000     0.00000      .00201     0.00000     0.00000    0.00000       .12655    0.00000      .94341
5       1.45367     .10212     0.00000     0.00000     0.00000     0.00000     0.00000    0.00000       .20368    0.00000     1.21335
6       1.55556    0.00000                                                                           .47841


       SUMFX  =  0.
       SUMFY1 =  0.
       SUMFY2 =   .62235E-02
       SUMFT2 =   .25696E-01


       SIDE EDGE DISTRIBUTION

JTIP  JSE  DISTANCE         SUCTION FORCE         GAMMA,SE       YBAR        XSE
           FROM LE          PER UNIT LENGTH       /VINF
           /TIPCHORD        /(Q*TIPCHORD)

  1     1      .33333           .00311            .00055       3.64000     1.35100
  2     2      .66667           .03528            .00681       3.64000     2.10067
  3     3     1.00000           .04568            .01491       3.64000     2.85033


*****T.E. FIN VORTEX INFO*******

IVRT GAMMA/VINF    Y,C.G.

  1      .90779    3.23687
```

Figure 10.- Continued.

```
------------------- LEFT WING----------------------


                          SPANWISE DISTRIBUTIONS

  I     Y/(B/2)  CN*C/(2*B)  CT*C/(2*B) CY1*C/(2*B) CYTOT*C/(2*B) CS*C/(2*B)     CSINT      YBAR        GAMNET(I)  GAMMA,LF/VINF  XLE

  7     -.65426     .12209    0.00000    0.00000      -.00401     0.00000     0.00000    0.00000      .57449     0.00000     .13334
  8     -.85415     .14651    0.00000    0.00000       .00178     0.00000     0.00000    0.00000      .11159     0.00000     .40340
  9    -1.05402     .15930    0.00000    0.00000      -.00165     0.00000     0.00000    0.00000      .05999     0.00000     .67342
 10    -1.25386     .14379    0.00000    0.00000      -.00351     0.00000     0.00000    0.00000     -.07257     0.00000     .94341
 11    -1.45367     .10337    0.00000    0.00000      0.00000     0.00000     0.00000    0.00000     -.18919     0.00000    1.21335
 12    -1.55556    0.00000                                                                         -.48431


       SUMFX  =  0.
       SUMFY1 =  0.
       SUMFY2 =  -.61037E-02
       SUMFT2 =  -.32174E-01


       SIDE EDGE DISTRIBUTION

JTIP  JSE  DISTANCE        SUCTION FORCE        GAMMA,SE      YBAR       XSE
           FROM LE         PER UNIT LENGTH      /VINF
           /TIPCHORD       /(Q*TIPCHORD)

  1    1     .33333          -.00495            -.00088     -3.64000    1.35100
  2    2     .66667          -.04691            -.00920     -3.64000    2.10067
  3    3    1.00000          -.04946            -.01797     -3.64000    2.85033


*****T.E. FIN VORTEX INFO******

IVRT GAMMA/VINF    Y,C.G.

  2      .17134   -1.93153
  3    -.74554    -3.43010
```

Figure 10.- Continued.

```
*******************UPPER WING*********************


                 SPANWISE DISTRIBUTIONS

   I    Z/(B/2)  CN*C/(2*B)  CT*C/(2*B)  CZ1*C/(2*B) CZTOT*C/(2*B) CS*C/(2*B)   CSINT     ZBAR      GAMNET(I)  GAMMA,LE/VINF  XLE

  13     .65426     .12269    0.00000     0.00000      .00401      0.00000     0.00000   0.00000    -.57449    0.00000     .13330
  14     .85415     .14651    0.00000     0.00000     -.00178      0.00000     0.00000   0.00000    -.11159    0.00000     .40340
  15    1.05402     .15930    0.00000     0.00000      .00365      0.00000     0.00000   0.00000    -.05999    0.00000     .67342
  16    1.25386     .14379    0.00000     0.00000      .00351      0.00000     0.00000   0.00000     .07257    0.00000     .94341
  17    1.45367     .10357    0.00000     0.00000     0.00000      0.00000     0.00000   0.00000     .18919    0.00000    1.21335
  18    1.55556    0.00000                                                                          .48431


        SUMFX  =  0.
        SUMFZ1 =  0.
        SUMFZ2 =   .61037E-02
        SUMFT2 =   .32174E-01


        SIDE EDGE DISTRIBUTION

 JTIP  JSE  DISTANCE        SUCTION FORCE       GAMMA,SE      ZBAR       XSE
            FROM LE         PER UNIT LENGTH     /VINF
            /TIPCHORD       /(Q*TIPCHORD)

   1    4     .33333           .00495           .00088       3.64000    1.35100
   2    5     .66667           .04691           .00920       3.64000    2.10067
   3    6    1.00000           .04986           .01797       3.64000    2.85033


*****T.E. FIN VORTEX INFO*******

IVRT GAMMA/VINF   Z.C.G.

  4    -.17134    1.93153
  5     .74554    3.43010
```

Figure 10.- Continued.

```
--------------------LOWER WING---------------------

                        SPANWISE DISTRIBUTIONS

  I     Z/(B/2)  CN*C/(2*B)  CT*C/(2*B) CZ1*C/(2*B) CZTOT*C/(2*B) CS*C/(2*B)      CSINT       ZBAR          GAMNET(I)  GAMMA,LE/VINF   XLE

 19     -.65426     .19397     0.00000     0.00000     -.00070     0.00000     0.00000     0.00000        .90825     0.00000      .13334
 20     -.85415     .18840     0.00000     0.00000     -.00259     0.00000     0.00000     0.00000       -.02601     0.00000      .40340
 21    -1.05402     .17267     0.00000     0.00000     -.00225     0.00000     0.00000     0.00000       -.07359     0.00000      .67342
 22    -1.25386     .14562     0.00000     0.00000     -.00201     0.00000     0.00000     0.00000       -.12655     0.00000      .94341
 23    -1.45367     .10212     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000       -.20368     0.00000     1.21335
 24    -1.55556    0.00000                                                                            -.47841


          SUMFX  =  0.
          SUMFZ1 =  0.
          SUMFZ2 =  -.62235E-02
          SUMFT2 =  -.26698E-01


          SIDE EDGE DISTRIBUTION

JTIP  JSE  DISTANCE         SUCTION FORCE         GAMMA,SE      ZBAR        XSE
           FROM LE          PER UNIT LENGTH       /VINF
           /TIPCHORD        /(Q*TIPCHORD)

  1     7     .33333           -.00311            -.00055    -3.64000     1.35100
  2     8     .66667           -.03528            -.00681    -3.64000     2.10067
  3     9    1.00000           -.04568            -.01491    -3.64000     2.85033


*****T.E. FIN VORTEX INFO*****

IVRT GAMMA/VINF    Z.C.G.

  6    -.90779    -3.23687


          VELOCITIES AND BERNOULLI PRESSURES AT CONTROL POINTS IMMEDIATELY ABOVE AND BELOW HORIZONTAL WING SURFACE

  J      X(J)        Y(J)        Z(J)       UTOTA       VTOTA       WTOTA      PRESSA      UTOTB       VTOTB       WTOTB       PRESSB

  1    1.251118    1.530959    0.000000    .146995    -.005464    -.173650    -.226794    -.182872    .190985    -.173650    .498202
  2    2.386670    1.530959    0.000000    .124987     .074735    -.173650    -.178168    -.116691    .167834    -.173650    .331516
  3    3.542222    1.530959    0.000000    .142488     .159554    -.314650    -.212304    -.071752    .200785    -.032650    .196546
  4    1.415650    1.998701    0.000000    .248685    -.131702    -.173650    -.374805    -.107871    .074156    -.173650    .295550
  5    2.481188    1.998701    0.000000    .129551     .026553    -.173650    -.193772    -.126751    .125204    -.173650    .352481
```

Figure 10.- Continued.

```
  6   3.546723   1.998701   0.000000     .164537    .112876   -.314650   -.246240   -.050582    .154275   -.032650    .149361
  7   1.600170   2.466397   0.000000     .174346   -.033659   -.173650   -.270827   -.176806    .169078   -.173650    .482705
  8   2.575697   2.466397   0.000000     .165859    .003287   -.173650   -.251365   -.115665    .111646   -.173650    .323032
  9   3.551224   2.466397   0.000000     .239154    .092494   -.314650   -.338894    .042893    .130264   -.032650   -.044916
 10   1.784662   2.934030   0.000000     .178746   -.026607   -.173650   -.274891   -.157138    .167316   -.173650    .432284
 11   2.670193   2.934030   0.000000     .197168   -.051134   -.173650   -.303190   -.083959    .057072   -.173650    .233814
 12   3.555723   2.934030   0.000000     .118982    .031854   -.314650   -.190418   -.034274    .061348   -.032650    .099520
 13   1.969121   3.401580   0.000000     .125277    .046599   -.173650   -.183220   -.172306    .218409   -.173650    .467925
 14   2.764672   3.401580   0.000000     .090547    .022698   -.173650   -.151423   -.096299    .095385   -.173650    .277790
 15   3.560222   3.401580   0.000000     .212661   -.059834   -.314650   -.332048    .097731   -.037715   -.032650   -.175148
 16   1.231118  -1.530959   0.000000     .070132    .140881   -.173650   -.076948   -.103380    .040703   -.173650    .274053
 17   2.386670  -1.530959   0.000000     .095711    .090433   -.173650   -.127488   -.096230    .016555   -.173650    .247741
 18   3.542222  -1.530959   0.000000     .190549    .073434   -.314650   -.284295    .058845    .048087   -.032650   -.086820
 19   1.415654  -1.998701   0.000000     .206874    .128113   -.173650   -.289825   -.062598   -.027466   -.173650    .151471
 20   2.481188  -1.998701   0.000000     .124540   -.002699   -.173650   -.192702   -.096286   -.087695   -.173650    .191176
 21   3.546723  -1.998701   0.000000     .206769   -.032055   -.314650   -.319963    .053188   -.061612   -.032650   -.110678
 22   1.600170  -2.466397   0.000000     .170030    .055568   -.173650   -.247981   -.174197   -.143171   -.173650    .323006
 23   2.575697  -2.466397   0.000000     .154059    .015503   -.173650   -.232395   -.100169   -.082349   -.173650    .203289
 24   3.551224  -2.466397   0.000000     .228727   -.071603   -.314650   -.351000    .062395   -.103614   -.032650   -.143375
 25   1.784662  -2.934030   0.000000     .192359    .073176   -.173650   -.275693   -.172682   -.137580   -.173650    .324580
 26   2.670193  -2.934030   0.000000     .190175    .088538   -.173650   -.271239   -.073527   -.012961   -.173650    .182647
 27   3.555723  -2.934030   0.000000     .119597    .018754   -.314650   -.194094   -.012219   -.006614   -.032650    .032195
 28   1.969121  -3.401580   0.000000     .141591    .002093   -.173650   -.217201   -.190954   -.189902   -.173650    .315261
 29   2.764672  -3.401580   0.000000     .086720    .014855   -.173650   -.126856   -.096168   -.055539   -.173650    .211039
 30   3.560222  -3.401580   0.000000     .203868    .100104   -.314650   -.298296    .110529    .082141   -.032650   -.168646


      VELOCITIES AND BERNOULLI PRESSURES AT CONTROL POINTS IMMEDIATELY TO RIGHT AND LEFT OF VERTICAL WING SURFACE

  J      X(J)       Y(J)       Z(J)      UTOTR      VTOTR      WTOTR      PRESSR     UTOTL      VTOTL      WTOTL      PRESSL

 31   1.231118   0.000000   1.530959   -.103380    .173650   -.040703    .274053    .070132    .173650   -.140881   -.076948
 32   2.386670   0.000000   1.530959   -.096230    .173650   -.016555    .247741    .095711    .173650   -.090433   -.127488
 33   3.542222   0.000000   1.530959    .058845    .314650   -.048087   -.086820    .190549    .032650   -.073434   -.284295
 34   1.415654   0.000000   1.998701   -.062598    .173650    .027466    .151471    .206874    .173650   -.128113   -.289825
 35   2.481188   0.000000   1.998701   -.096286    .173650    .087695    .191176    .124540    .173650    .002699   -.192702
 36   3.546723   0.000000   1.998701    .053188    .314650    .061612   -.110678    .206769    .032650    .032055   -.319963
 37   1.600170   0.000000   2.466397   -.174197    .173650    .143171    .323006    .170030    .173650   -.055568   -.247981
 38   2.575697   0.000000   2.466397   -.100169    .173650    .082349    .203289    .154059    .173650   -.015503   -.232395
 39   3.551224   0.000000   2.466397    .062395    .314650    .103614   -.143375    .228727    .032650    .071603   -.351000
 40   1.784662   0.000000   2.934030   -.172682    .173650    .137580    .324580    .192359    .173650   -.073176   -.275693
 41   2.670193   0.000000   2.934030   -.073527    .173650    .012961    .182647    .190175    .173650   -.088538   -.271239
 42   3.555723   0.000000   2.934030   -.012219    .314650    .006614    .032195    .119597    .032650   -.018754   -.194094
 43   1.969121   0.000000   3.401580   -.190954    .173650    .189902    .315261    .141591    .173650   -.002093   -.217201
 44   2.764672   0.000000   3.401580   -.096168    .173650    .055539    .211039    .086720    .173650   -.014855   -.126856
 45   3.560222   0.000000   3.401580    .110529    .314650   -.082141   -.168646    .203868    .032650   -.100104   -.298296
 46   1.231118   0.000000  -1.530959   -.182872    .173650   -.184985    .498202    .146995    .173650    .005464   -.226794
 47   2.386670   0.000000  -1.530959   -.116891    .173650   -.167834    .331516    .124947    .173650   -.074735   -.178168
 48   3.542222   0.000000  -1.530959   -.071752    .314650   -.200785    .196546    .142488    .032650   -.159554   -.212304
 49   1.415654   0.000000  -1.998701   -.107871    .173650   -.074156    .295550    .248685    .173650    .131702   -.374805
 50   2.481188   0.000000  -1.998701   -.126751    .173650   -.125204    .352481    .129551    .173650   -.026553   -.193772
 51   3.546723   0.000000  -1.998701   -.050582    .314650   -.154275    .149361    .164537    .032650   -.112876   -.246240
 52   1.600170   0.000000  -2.466397   -.176806    .173650   -.169078    .482705    .174346    .173650    .033659   -.270827
 53   2.575697   0.000000  -2.466397   -.115665    .173650   -.111646    .323032    .165859    .173650   -.003287   -.251365
 54   3.551224   0.000000  -2.466397    .042893    .314650   -.130264   -.044916    .239154    .032650   -.092494   -.338894
 55   1.784662   0.000000  -2.934030   -.157138    .173650   -.167316    .432284    .178746    .173650    .026607   -.274891
 56   2.670193   0.000000  -2.934030   -.083959    .173650   -.057072    .233814    .197168    .173650    .051134   -.303190
 57   3.555723   0.000000  -2.934030   -.034274    .314650   -.061348    .099520    .118982    .032650   -.031854   -.190418
```

Figure 10.- Continued.

```
58   1.969121   0.000000  -3.401580   -.172306    .173650   -.218409    .467925    .125277    .173650   -.046599   -.183220
59   2.764672   0.000000  -3.401580   -.098299    .173650   -.095385    .277790    .090547    .173650   -.022698   -.131423
60   3.560222   0.000000  -3.401580    .097731    .314650    .037715   -.175148    .212661    .032650    .059834   -.332048


PRESSURE LOADINGS AT CONTROL POINTS

J       X(J)        Y(J)        Z(J)     DELTP.LIN. DELTP.HERN.

 1   1.231118    1.530959    0.000000    .659734    .724996
 2   2.386670    1.530959    0.000000    .483756    .509684
 3   3.542222    1.530959    0.000000    .428480    .408850
 4   1.415654    1.998701    0.000000    .713112    .670355
 5   2.481188    1.998701    0.000000    .512603    .546253
 6   3.546723    1.998701    0.000000    .430237    .375601
 7   1.600170    2.466397    0.000000    .702303    .753532
 8   2.575697    2.466397    0.000000    .563049    .574397
 9   3.551224    2.466397    0.000000    .392520    .293978
10   1.784662    2.934030    0.000000    .671770    .707175
11   2.670193    2.934030    0.000000    .562255    .537004
12   3.555723    2.934030    0.000000    .306512    .289938
13   1.969121    3.401580    0.000000    .595167    .651145
14   2.764672    3.401580    0.000000    .377692    .409213
15   3.560222    3.401580    0.000000    .229861    .154900
16   1.231118   -1.530959    0.000000    .347024    .351000
17   2.386670   -1.530959    0.000000    .383882    .375229
18   3.542222   -1.530959    0.000000    .263406    .197475
19   1.415654   -1.998701    0.000000    .538940    .441296
20   2.481188   -1.998701    0.000000    .441654    .383878
21   3.546723   -1.998701    0.000000    .307162    .209285
22   1.600170   -2.466397    0.000000    .688454    .570987
23   2.575697   -2.466397    0.000000    .508455    .435683
24   3.551224   -2.466397    0.000000    .332665    .207625
25   1.784662   -2.934030    0.000000    .730082    .600274
26   2.670193   -2.934030    0.000000    .527405    .453886
27   3.555723   -2.934030    0.000000    .263632    .226288
28   1.969121   -3.401580    0.000000    .665088    .532461
29   2.764672   -3.401580    0.000000    .365775    .337895
30   3.560222   -3.401580    0.000000    .186679    .129650
31   1.231118    0.000000    1.530959    .347024    .351000
32   2.386670    0.000000    1.530959    .383882    .375229
33   3.542222    0.000000    1.530959    .263406    .197475
34   1.415654    0.000000    1.998701    .538940    .441296
35   2.481188    0.000000    1.998701    .441654    .383878
36   3.546723    0.000000    1.998701    .307162    .209285
37   1.600170    0.000000    2.466397    .688454    .570987
38   2.575697    0.000000    2.466397    .508455    .435683
39   3.551224    0.000000    2.466397    .332665    .207625
40   1.784662    0.000000    2.934030    .730082    .600274
41   2.670193    0.000000    2.934030    .527405    .453886
42   3.555723    0.000000    2.934030    .263632    .226288
43   1.969121    0.000000    3.401580    .665088    .532461
44   2.764672    0.000000    3.401580    .365775    .337895
45   3.560222    0.000000    3.401580    .186679    .129650
46   1.231118    0.000000   -1.530959    .659734    .724996
47   2.386670    0.000000   -1.530959    .483756    .509684
48   3.542272    0.000000   -1.530959    .428480    .408850
49   1.415654    0.000000   -1.998701    .713112    .670355
```

Figure 10.- Continued.

```
 50   2.481188   0.000000  -1.998701    .512603    .546253
 51   3.546723   0.000000  -1.998701    .430257    .595601
 52   1.603170   0.000000  -2.466397    .702503    .753532
 53   2.575697   0.000000  -2.466397    .563049    .570597
 54   3.551224   0.000000  -2.466397    .392520    .275978
 55   1.784662   0.000000  -2.934030    .671770    .707175
 56   2.670193   0.000000  -2.934030    .562255    .537008
 57   3.555723   0.000000  -2.934030    .306512    .289938
 58   1.969121   0.000000  -3.401580    .595167    .651145
 59   2.764672   0.000000  -3.401580    .377692    .409213
 60   3.560222   0.000000  -3.401580    .229861    .156900


                                             LOADING INFORMATION

                  MACH NUMBER =    .17000E+01
              ANGLE OF ATTACK =    10.000 DEGREES
              SIDE SLIP ANGLE =    10.000 DEGREES
                    WING AREA =    13.68666
               REFERENCE AREA =     5.30929
             REFERENCE LENGTH =     2.69000
          EXPOSED WING SPAN H =     4.66000
          MOMENT CENTER,   XM =    19.50000
                           ZM =     0.00000



 BERNOULLI TYPE LOADING PRESSURE


                          TOTAL             FIN 1 OR R        FIN 2 OR L        FIN 3 OR U        FIN 4 OR D        INTERF. SHELL
     DEFL. ANGLE DEG. =                       0.00000           0.00000           0.00000           0.00000
                 CTHR =   .49666E-01       .14912E-01        .99211E-02        .99211E-02        .14912E-01
                   CZ =   .13535E+01       .66294E+00        .46540E+00       0.                0.                 .22517E+00
                   CY =  -.13535E+01      0.                0.                -.46540E+00       -.66294E+00        -.22517E+00
                   CM =  -.13488E+01      -.64251E+00       -.45133E+00       0.                0.                 -.25492E+00
                  CLN =   .13488E+01      0.                0.                 .45133E+00        .64251E+00         .25492E+00
                  CLL =   .46320E-13      -.57378E+00        .41884E+00       -.41884E+00        .57378E+00         .13507E-15

                  FOLLOWING ARE IN WIND-AXIS SYSTEM

                   CL =   .18677E+01       .45808E+00        .32145E+00        .32145E+00        .45808E+00         .30869E+00
               CY-IND =   .62261E-12       .46877E+00        .32909E+00       -.32909E+00       -.46877E+00         .63505E-12
                  CDI =   .42193E+00       .10066E+00        .71199E-01        .71199E-01        .10066E+00         .78207E-01
            CDI/CL**2 =   .12095E+00
               CM-IND =  -.19074E+01      -.45432E+00       -.31914E+00       -.31914E+00       -.45432E+00        -.36052E+00
              CLN-IND =  -.56577E-12      -.29950E+00       -.41222E+00        .41222E+00        .29950E+00        -.56044E-12


       NOTE: L.E. OF LEAD PANEL IN FIRST CHORD-WISE ROW IS SUPERSONIC
```

Figure 10.- Continued.

```
********************RIGHT WING*********************


                       SPANWISE DISTRIBUTIONS

  I     Y/(B/2)  CN*C/(2*B)  CT*C/(2*B) CY1*C/(2*B) CYTOT*C/(2*B) CS*C/(2*B)     CSINT      YBAR      GAMNET(I)  GAMMA,LE/VINF  XLE

  1      .65426     .20280    0.00000    0.00000      .00352    0.00000     0.00000    0.00000    -.94959    0.00000     .13334
  2      .85415     .18342    0.00000    0.00000      .00198    0.00000     0.00000    0.00000     .09066    0.00000     .40340
  3     1.05402     .16892    0.00000    0.00000      .00223    0.00000     0.00000    0.00000     .06743    0.00000     .67342
  4     1.25385     .14501    0.00000    0.00000      .00198    0.00000     0.00000    0.00000     .11185    0.00000     .94341
  5     1.45367     .10335    0.00000    0.00000     0.00000    0.00000     0.00000    0.00000     .19506    0.00000    1.21335
  6     1.55556    0.00000                                                                         .48420


        SUMFX  =  0.
        SUMFY1 =  0.
        SUMFY2 =   .72775E-02
        SUMFT2 =   .27974E-01


        SIDE EDGE DISTRIBUTION

 JTIP  JSE  DISTANCE          SUCTION FORCE        GAMMA,SE       YBAR       XSE
            FROM LE           PER UNIT LENGTH      /VINF
            /TIPCHORD         /(Q*TIPCHORD)

   1    1     .33333             .00340            .00060       3.64000    1.35100
   2    2     .66667             .03845            .00742       3.64000    2.10067
   3    3    1.00000             .04624            .01563       3.64000    2.85033


****T.E. FIN VORTEX INFO*****

IVRT GAMMA/VINF   Y.C.G.

  1      .94911    3.15424
```

Figure 10.- Continued.

```
******************** LEFT WING ********************



                    SPANWISE DISTRIBUTIONS

 I     Y/(B/2)  CN*C/(2*B)  CT*C/(2*B) CY1*C/(2*B) CYTOT*C/(2*B) CS*C/(2*B)     CSINT      YBAR       GAMNET(I)  GAMMA,LE/VINF  XLE

 7    -.69426      .11396    0.00000    0.00000     -.00097     0.00000    0.00000    0.00000     .53369     0.00000     .13334
 8    -.85415      .11759    0.00000    0.00000      .00142     0.00000    0.00000    0.00000     .01743     0.00000     .40340
 9   -1.05402      .12647    0.00000    0.00000     -.00085     0.00000    0.00000    0.00000     .04116     0.00000     .67342
10   -1.25386      .12104    0.00000    0.00000     -.00310     0.00000    0.00000    0.00000    -.02535     0.00000     .94341
11   -1.45367      .08490    0.00000    0.00000     0.00000     0.00000    0.00000    0.00000    -.16916     0.00000    1.21335
12   -1.55556     0.00000                                                                     -.39778


        SUMFX  =  0.
        SUMFY1 =  0.
        SUMFY2 =  -.29015E-02
        SUMFT2 =  -.26735E-01


        SIDE EDGE DISTRIBUTION

JTIP  JSE  DISTANCE         SUCTION FORCE         GAMMA,SE      YBAR       XSE
           FROM LE          PER UNIT LENGTH       /VINF
           /TIPCHORD        /(Q*TIPCHORD)

  1     1     .33333          -.00396            -.00070     -3.64000    1.35100
  2     2     .66667          -.03961            -.00773     -3.64000    2.10067
  3     3    1.00000          -.04062            -.01493     -3.64000    2.85033


*****T.E. FIN VORTEX INFO******

IVRT GAMMA/VINF   Y.C.G.

  2     .05844    -2.09688
  3    -.59187    -3.46609
```

Figure 10.- Continued.

```
--------------------UPPER WING---------------------


                              SPANWISE DISTRIBUTIONS


  I      Z/(B/2)  CN*C/(2*B)  CT*C/(2*B) CZ1*C/(2*B) CZTOT*C/(2*B) CS*C/(2*B)     CSIN       ZBAR        GAMNET(I)  GAMMA,LE/VINF  XLE

 13       .65426     .11398    0.00000     0.00000      .00097     0.00000     0.00000     0.00000      -.53369     0.00000      .13334
 14       .85415     .11769    0.00000     0.00000     -.00142     0.00000     0.00000     0.00000      -.01743     0.00000      .40340
 15      1.05402     .12647    0.00000     0.00000      .00085     0.00000     0.00000     0.00000      -.04116     0.00000      .67342
 16      1.25386     .12104    0.00000     0.00000      .00310     0.00000     0.00000     0.00000       .02535     0.00000      .94341
 17      1.45367     .08490    0.00000     0.00000     0.00000     0.00000     0.00000     0.00000       .16916     0.00000     1.21335
 18      1.55556    0.00000                                                                           .39778


         SUMFX  =  0.
         SUMFZ1 =  0.
         SUMFZ2 =   .29015E-02
         SUMFT2 =   .26735E-01



         SIDE EDGE DISTRIBUTION

 JTIP  JSE  DISTANCE        SUCTION FORCE        GAMMA,SE       ZBAR        XSE
            FROM LE         PER UNIT LENGTH      /VINF
            /TIPCHORD       /(Q*TIPCHORD)

   1    4      .33333          .00396            .00070       3.64000    1.35100
   2    5      .66667          .03961            .00773       3.64000    2.10067
   3    6     1.00000          .04062            .01493       3.64000    2.85033


*****T.E. FIN VORTEX INFO******

IVRT GAMMA/VINF    Z.C.G.

  4    -.05844     2.09688
  5     .59187     3.46609
```

Figure 10.- Continued.

```
*******************LOWER WING*********************


                          SPANWISE DISTRIBUTIONS

  I     Z/(B/2)  CN*C/(2*B)  CT*C/(2*B) CZ1*C/(2*B) CZTOT*C/(2*B) CS*C/(2*B)     CSINT      ZBAR      GAMNET(I)  GAMMA,LE/VINF  XLE

 19    -.65425     .20280     0.00000     0.00000     -.00352     0.00000     0.00000    0.00000     .94959    0.00000     .13334
 20    -.85415     .18342     0.00000    -0.00000     -.00108     0.00000     0.00000    0.00000    -.09046    0.00000     .40340
 21   -1.05402     .16892     0.00000     0.00000     -.00223     0.00000     0.00000    0.00000    -.06783    0.00000     .67342
 22   -1.25386     .14501     0.00000     0.00000     -.00198     0.00000     0.00000    0.00000    -.11185    0.00000     .94341
 23   -1.45367     .10335     0.00000     0.00000     0.00000     0.00000     0.00000    0.00000    -.19506    0.00000    1.21335
 24   -1.55556    0.00000                                                                          -.48420


          SUMFX  =  0.
          SUMFZ1 =  0.
          SUMFZ2 =  -.72775E-02
          SUMFT2 =  -.27974E-01



          SIDE EDGE DISTRIBUTION

 JTIP  JSE  DISTANCE         SUCTION FORCE        GAMMA,SE      ZBAR       XSE
            FROM LE          PER UNIT LENGTH      /VINF
            /TIPCHORD        /(Q*TIPCHORD)

   1    7      .33333          -.00340            -.00060     -3.64000    1.35100
   2    8      .66667          -.03845            -.00742     -3.64000    2.10067
   3    9     1.00000          -.04624            -.01563     -3.64000    2.85033


****T.E. FIN VORTEX INFO*****

IVRT GAMMA/VINF   Z.C.G.

  6    -.94911   -3.15024
```

Figure 10.- Continued.

```
**********************************************************************************************************************
AFT OF LEADING EDGE OF FIN ROOTCHORDS


                       PRESSURE COEFFICIENTS AT POINTS ON BODY MERIDIANS

 J   THETA,      XB         YB         ZB        UTOT       VTOT       WTOT     CP,LIN,    CP,BERN,    DR/DX      P/PINF,    P/PINF,
     DEG,                                                                                                          BERN,      LIN,


                                              BODY RING=   1

 1  11,25000  20,94000   1,25052    ,24874     ,10899     ,12438     ,10735    -,21798    -,20414    0,00000     ,58702     ,55903
 2  33,75000  20,94000   1,06014    ,70836     ,02510    -,08031     ,20926    -,05019    -,17282    0,00000     ,65039     ,89846
 3  56,25000  20,94000    ,70836   1,06014    -,03284    -,16979     ,05031     ,06568    -,04375    0,00000     ,91148    1,13287
 4  78,75000  20,94000    ,24874   1,25052    -,06909    -,03950    -,14496     ,13818     ,15867    0,00000    1,32099    1,27954
 5 101,25000  20,94000   -,24874   1,25052     ,05658     ,29243    -,17076    -,11315    -,06355    0,00000     ,87145     ,77109
 6 123,75000  20,94000   -,70836   1,06014     ,00637     ,26577    -,10263    -,01273     ,03526    0,00000    1,07153     ,97424
 7 146,25000  20,94000  -1,06014    ,70836     ,00637     ,10263    -,26577    -,01273     ,03526    0,00000    1,07153     ,97424
 8 168,75000  20,94000  -1,25052    ,24874     ,05658     ,17076    -,29243    -,11315    -,06355    0,00000     ,87145     ,77109
 9 191,25000  20,94000  -1,25052   -,24874    -,06909     ,14496     ,03950     ,13818     ,15867    0,00000    1,32099    1,27954
10 213,75000  20,94000  -1,06014   -,70836    -,03284    -,05031     ,16979     ,06568    -,04375    0,00000     ,91148    1,13287
11 236,25000  20,94000   -,70836  -1,06014     ,02510    -,20926     ,08031    -,05019    -,17282    0,00000     ,65039     ,89846
12 258,75000  20,94000   -,24874  -1,25052     ,10899    -,10735    -,12438    -,21798    -,20414    0,00000     ,58702     ,55903
13 281,25000  20,94000    ,24874  -1,25052    -,12048     ,03923    -,21068     ,24096     ,31248    0,00000    1,63216    1,48746
14 303,75000  20,94000    ,70836  -1,06014    -,04817     ,15212    -,20247     ,09635     ,16708    0,00000    1,33800    1,19491
15 326,25000  20,94000   1,06014   -,70836    -,04817     ,20247    -,15212     ,09635     ,16708    0,00000    1,33800    1,19491
16 348,75000  20,94000   1,25052   -,24874    -,12048     ,21068    -,03923     ,24096     ,31248    0,00000    1,63216    1,48746

                                              BODY RING=   2

 1  11,25000  22,14000   1,25052    ,24874     ,10643     ,12970     ,08047    -,21286    -,18996    0,00000     ,61571     ,56939
 2  33,75000  22,14000   1,06014    ,70836     ,03484    -,02592     ,12779    -,06968    -,12572    0,00000     ,74567     ,85903
 3  56,25000  22,14000    ,70836   1,06014    -,04816    -,08119    -,00899     ,09632     ,06189    0,00000    1,12521    1,19486
 4  78,75000  22,14000    ,24874   1,25052    -,09199    -,01047    -,15087     ,18399     ,22506    0,00000    1,45530    1,37220
 5 101,25000  22,14000   -,24874   1,25052     ,08900     ,30860    -,16660    -,17800    -,12513    0,00000     ,74687     ,63991
 6 123,75000  22,14000   -,70836   1,06014     ,06068     ,27827    -,09511    -,12136    -,07382    0,00000     ,85066     ,75449
 7 146,25000  22,14000  -1,06014    ,70836     ,06068     ,09511    -,27827    -,12136    -,07382    0,00000     ,85066     ,75449
 8 168,75000  22,14000  -1,25052    ,24874     ,08900     ,16660    -,30860    -,17800    -,12513    0,00000     ,74687     ,63991
 9 191,25000  22,14000  -1,25052   -,24874    -,09199     ,15087     ,01047     ,18399     ,22506    0,00000    1,45530    1,37220
10 213,75000  22,14000  -1,06014   -,70836    -,04816     ,00899     ,08119     ,09632     ,06189    0,00000    1,12521    1,19486
11 236,25000  22,14000   -,70836  -1,06014     ,03484    -,12779     ,02592    -,06968    -,12572    0,00000     ,74567     ,85903
12 258,75000  22,14000   -,24874  -1,25052     ,10643    -,08047    -,12970    -,21286    -,18996    0,00000     ,61571     ,56939
13 281,25000  22,14000    ,24874  -1,25052    -,13102     ,02976    -,21254     ,26204     ,33398    0,00000    1,67563    1,53010
14 303,75000  22,14000    ,70836  -1,06014    -,16212     ,15054    -,20351     ,32425     ,44280    0,00000    1,89578    1,65595
15 326,25000  22,14000   1,06014   -,70836    -,16212     ,20351    -,15054     ,32425     ,44280    0,00000    1,89578    1,65595
16 348,75000  22,14000   1,25052   -,24874    -,13102     ,21254    -,02976     ,26204     ,33398    0,00000    1,67563    1,53010

                                              BODY RING=   3

 1  11,25000  23,34000   1,25052    ,24874     ,09347     ,14430     ,00695    -,18695    -,14480    0,00000     ,70707     ,62180
 2  33,75000  23,34000   1,06014    ,70836     ,01523     ,01571     ,06542    -,03046    -,04966    0,00000     ,89954     ,93838
 3  56,25000  23,34000    ,70836   1,06014    -,01296    -,06034    -,02303     ,02592     ,00788    0,00000    1,01593    1,05244
 4  78,75000  23,34000    ,24874   1,25052     ,00389    -,05293    -,14251    -,00778     ,00044    0,00000    1,00090     ,98426
```

Figure 10.- Continued.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 101.25000 | 23.34000 | -.24874 | 1.25052 | .14838 | .34261 | -.15880 | -.29676 | -.22665 | 0.00000 | .54148 | .39966 |
| 6 | 123.75000 | 23.34000 | -.70836 | 1.06014 | .13228 | .26647 | -.10396 | -.26457 | -.19226 | 0.00000 | .61106 | .46478 |
| 7 | 146.25000 | 23.34000 | -1.06014 | .70836 | .13228 | .10396 | -.26647 | -.26457 | -.19226 | 0.00000 | .61106 | .46478 |
| 8 | 168.75000 | 23.34000 | -1.25052 | .24874 | .14838 | .15880 | -.34261 | -.29676 | -.22665 | 0.00000 | .54148 | .39966 |
| 9 | 191.25000 | 23.34000 | -1.25052 | -.24874 | .00389 | .14251 | .05293 | -.00778 | .00044 | 0.00000 | 1.00090 | .98426 |
| 10 | 213.75000 | 23.34000 | -1.06014 | -.70836 | -.01296 | .02303 | .06034 | .02592 | .00788 | 0.00000 | 1.01593 | 1.05244 |
| 11 | 236.25000 | 23.34000 | -.70836 | -1.06014 | .01523 | -.06542 | -.01571 | -.03046 | -.04966 | 0.00000 | .69954 | .93838 |
| 12 | 258.75000 | 23.34000 | -.24874 | -1.25052 | .09347 | -.00695 | -.14430 | -.18695 | -.14480 | 0.00000 | .70707 | .62180 |
| 13 | 281.25000 | 23.34000 | .24874 | -1.25052 | -.11401 | -.04527 | -.22745 | .22802 | .25389 | 0.00000 | 1.51362 | 1.46128 |
| 14 | 303.75000 | 23.34000 | .70836 | -1.06014 | -.16774 | .12646 | -.21958 | .33549 | .45252 | 0.00000 | 1.91545 | 1.67870 |
| 15 | 326.25000 | 23.34000 | 1.06014 | -.70836 | -.16774 | .21958 | -.12646 | .33549 | .45252 | 0.00000 | 1.91545 | 1.67870 |
| 16 | 348.75000 | 23.34000 | 1.25052 | -.24874 | -.11401 | .22745 | .04527 | .22802 | .25389 | 0.00000 | 1.51362 | 1.46128 |

Figure 10.- Concluded.

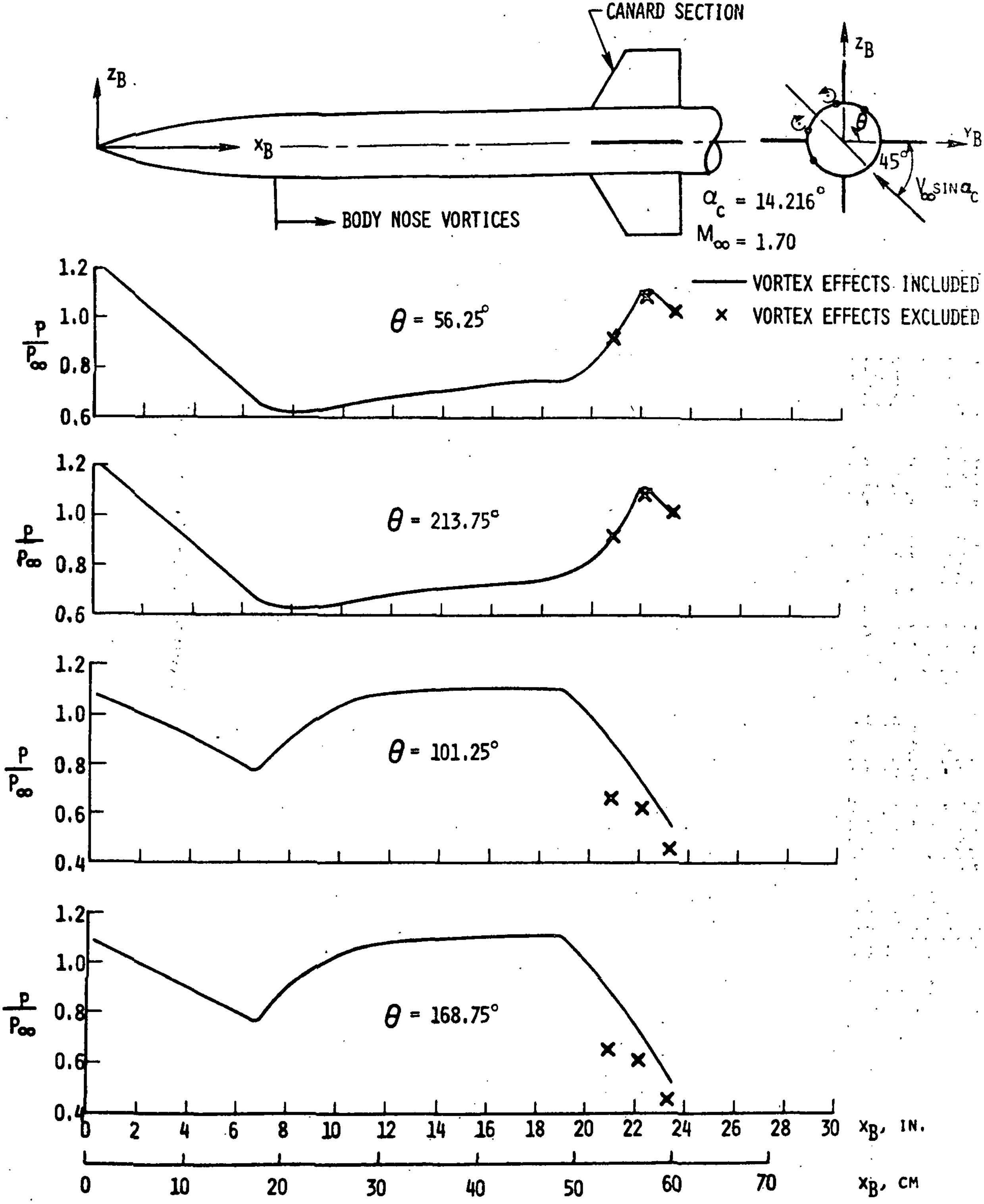

Figure 11(a).- Calculated pressure distributions along body meridians through canard section; first sample case.

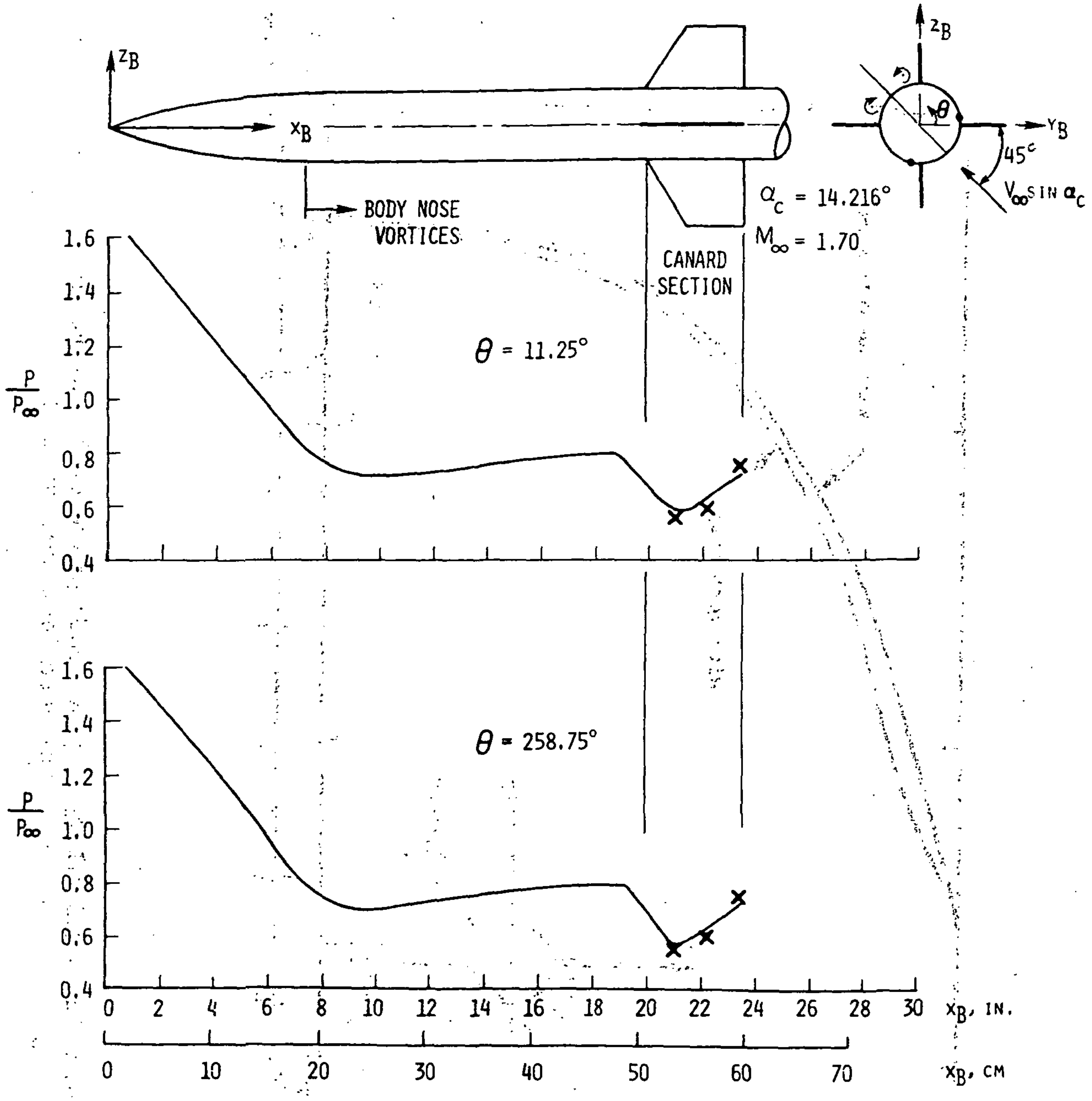

Figure 11(b).- Concluded.

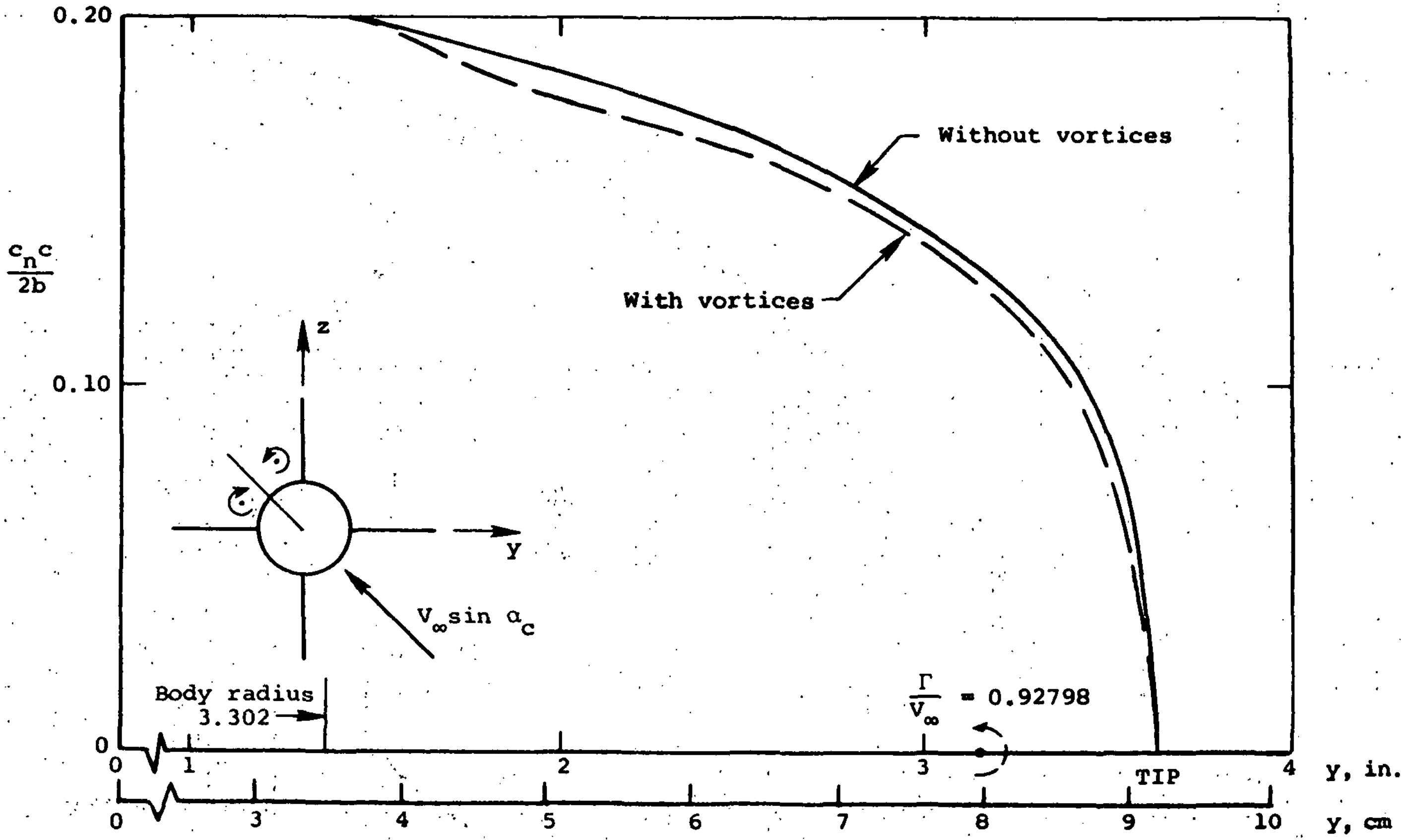

Figure 12.- Calculated span loading on right horizontal canard fin, first sample case, step 3.

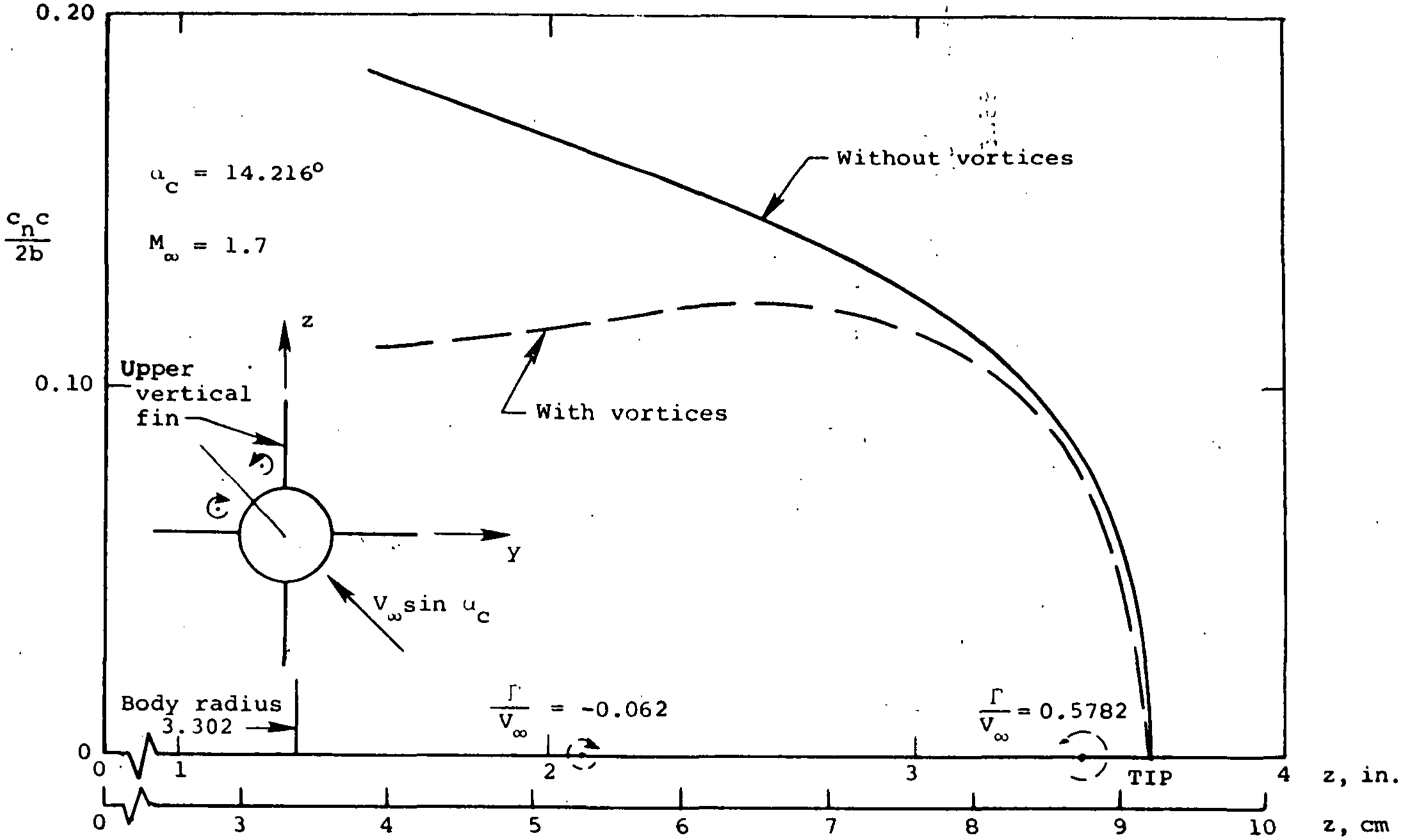

Figure 13.- Calculated span loading on the upper vertical fin, first sample case, step 3.

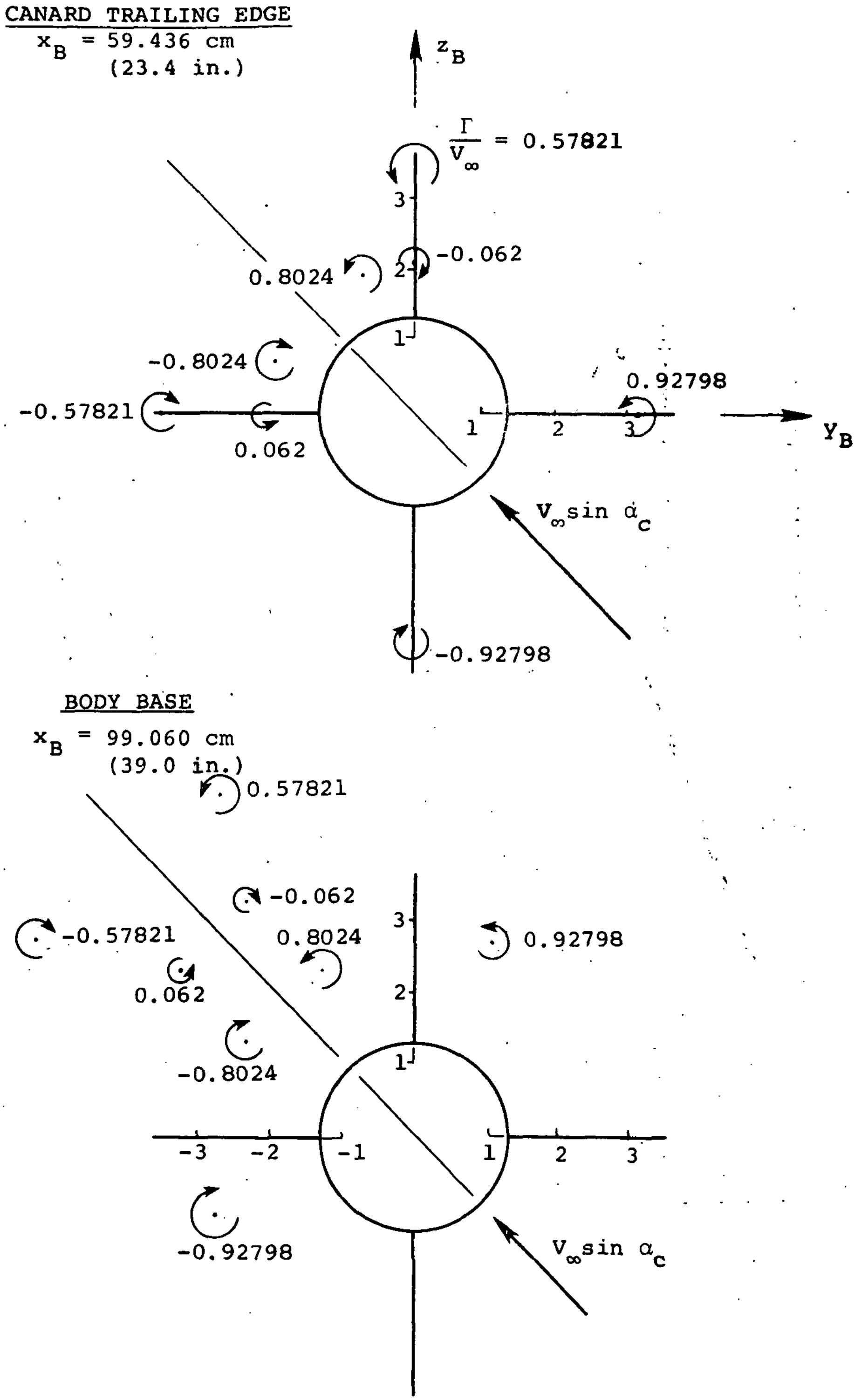

Figure 14.- Calculated vortex positions, first sample case, step 5.

```
NASA/LRC PROJECT 1126,CONFIGURATION B1T4,CHASE VORTICES AFT OF CANARD SECTION.
         1         4        26         1         1         0
  39.0
  1.3
  35.4      1.3      36.751    3.64      39.0     3.64      39.00001    1.3
 14.216      45.0     0.0      0.0       0.0       0.0       0.00001    0.35
   8    8    8    8    8    8    8    8    8    8    8    8    8    8    8    8
   8    8    8    8    8    8    8    8    8    8
-0.68451  1.9192    0.8024    -1.9192   0.68451   -0.8024
3.15424    0.0       0.94911   -2.09688  0.0       0.05844
-3.46609  0.0       -0.59187  0.0       2.09688   -0.05844
0.0       3.46609   0.59187   0.0       -3.15424  -0.94911
 23.4     24.024    24.648    25.272   25.896    26.52      27.144    27.768
 28.392    29.016   29.64     30.264    30.888    31.512    32.136    32.76
 33.384   34.008    34.632    35.256     35.88     36.504   37.128    37.752
 38.376    39.0
         0         0         0         0
         0
```

Figure 15.- Input for program VPATH2, first sample case, step 5.

```
NASA/LRC PROJECT 1126,CONFIGURATION B1T4,CHASE VORTICES AFT OF CANARD SECTION.


                FIN GEOMETRY
          FIN SEMISPAN                =    3.64000
          FIN ROOTCHORD               =    3.60001
          FIN ROOT L.E. X-STATION=    35.40000
                   L.E. Y-STATION=     1.30000
          FIN TIP L.E. X-STATION =    36.75100
                  L.E. Y-STATION =     3.64000
          FIN TIP T.E. X-STATION =    39.00000
                  T.E. Y-STATION =     3.64000
          FIN ROOT T.E. X-STATION=    39.00001
                   T.E. Y-STATION=     1.30000



      INCLUDED ANGLE OF ATTACK(DEG) =    14.21600    ROLL ANGLE(DEG)   =    45.00000

        PANEL DEFL.(DEG) :

          DELTA1=  0.000   DELTA2=  0.000   DELTA3=  0.000   DELTA4=  0.000


****PERMISSIBLE RELATIVE ERROR,E5,USED IN INTEGRATION SCHEME =    .10000E-04



          VORTEX COORDINATES IN CROSS-FLOW PLANE
          INITIAL VORTEX POSITIONS AT    X = 23.400

      LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =    1.30000

             VORTEX            Y,VRTX              Z,VRTX       GAMMA/VINF

               1             -.68451E+00         .19192E+01     .80240E+00
               2             -.19192E+01         .68451E+00    -.80240E+00
               3              .31542E+01        0.              .94911E+00
               4             -.20969E+01        0.              .58440E-01
               5             -.34661E+01        0.             -.59187E+00
               6             0.                  .20969E+01    -.58440E-01
               7             0.                  .34661E+01     .59187E+00
               8             0.                 -.31542E+01    -.94911E+00

      X-STATION NO.  2         X=24.024          INTEGRATION STEP SIZE =      .09984
```

Figure 16.- Output of program VPATH2, first sample case, step 5.

```
LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =     1.30000

      VORTEX            Y,VRTX             Z,VRTX         GAMMA/VINF

        1            -.70738E+00        .19461E+01       .80240E+00
        2            -.19461E+01        .70727E+00      -.80240E+00
        3             .30805E+01        .10549E+00       .94911E+00
        4            -.22397E+01        .90295E-01       .58440E-01
        5            -.35540E+01        .12835E+00      -.59187E+00
        6            -.60872E-01        .22397E+01      -.58440E-01
        7            -.12871E+00        .35539E+01       .59187E+00
        8            -.10505E+00       -.30805E+01      -.94911E+00

 X-STATION NO.  3        X=24.648        INTEGRATION STEP SIZE =      .19968


LOCAL BODY RADIUS =     1.30000      LOCAL SEMI-SPAN S =     1.30000

      VORTEX            Y,VRTX             Z,VRTX         GAMMA/VINF

        1            -.73263E+00        .19738E+01       .80240E+00
        2            -.19739E+01        .73252E+00      -.80240E+00
        3             .30063E+01        .21217E+00       .94911E+00
        4            -.23810E+01        .17808E+00       .58440E-01
        5            -.36395E+01        .25624E+00      -.59187E+00
        6            -.17871E+00        .23810E+01      -.58440E-01
        7            -.25660E+00        .36394E+01       .59187E+00
        8            -.21172E+00       -.30063E+01      -.94911E+00

 X-STATION NO.  4        X=25.272        INTEGRATION STEP SIZE =      .19968


LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =     1.30000

      VORTEX            Y,VRTX             Z,VRTX         GAMMA/VINF

        1            -.76032E+00        .20019E+01       .80240E+00
        2            -.20019E+01        .76021E+00      -.80240E+00
        3             .29315E+01        .32003E+00       .94911E+00
        4            -.25136E+01        .29043E+00       .58440E-01
        5            -.37227E+01        .38294E+00      -.59187E+00
        6            -.29112E+00        .25136E+01      -.58440E-01
        7            -.38330E+00        .37226E+01       .59187E+00
        8            -.31957E+00       -.29315E+01      -.94911E+00

 X-STATION NO.  5        X=25.896        INTEGRATION STEP SIZE =      .39936


LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =     1.30000

      VORTEX            Y,VRTX             Z,VRTX         GAMMA/VINF
        1            -.79013E+00        .20298E+01       .80240E+00
        2            -.20298E+01        .79003E+00      -.80240E+00
        3             .28560E+01        .42908E+00       .94911E+00
        4            -.26324E+01        .41257E+00       .58440E-01
        5            -.38038E+01        .50816E+00      -.59187E+00
        6            -.41532E+00        .26324E+01      -.58440E-01
        7            -.51852E+00        .38037E+01       .59187E+00
        8            -.42861E+00       -.28560E+01      -.94911E+00

 X-STATION NO.  6        X=26.520        INTEGRATION STEP SIZE =      .39936
```

Figure 16.- Continued.

```
LOCAL BODY RADIUS =    1.30000     LOCAL SEMI SPAN S =     1.30000

     VORTEX            Y,VRTX            Z,VRTX       GAMMA/VINF

        1           -.82163E+00       .20574E+01      .80240E+00
        2           -.20574E+01       .82154E+00     -.80240E+00
        3            .27796E+01       .53929E+00      .94911E+00
        4           -.27354E+01       .53923E+00      .58440E-01
        5           -.36629E+01       .63174E+00     -.59187E+00
        6           -.54005E+00       .27353E+01     -.58440E-01
        7           -.63209E+00       .38828E+01      .59187E+00
        8           -.53882E+00      -.27797E+01     -.94911E+00

 X-STATION NO.  7        X=27.144       INTEGRATION STEP SIZE =      .39936

LOCAL BODY RADIUS =    1.30000     LOCAL SEMI SPAN S =     1.30000

     VORTEX            Y,VRTX            Z,VRTX       GAMMA/VINF

        1           -.85443E+00       .20845E+01      .80240E+00
        2           -.20845E+01       .85435E+00     -.80240E+00
        3            .27022E+01       .65964E+00      .94911E+00
        4           -.28230E+01       .66517E+00      .58440E-01
        5           -.39604E+01       .75356E+00     -.59187E+00
        6           -.66704E+00       .28228E+01     -.58440E-01
        7           -.75391E+00       .39603E+01      .59187E+00
        8           -.65016E+00      -.27023E+01     -.94911E+00

 X-STATION NO.  8        X=27.768       INTEGRATION STEP SIZE =      .39936

LOCAL BODY RADIUS =    1.30000     LOCAL SEMI SPAN S =     1.30000

     VORTEX            Y,VRTX            Z,VRTX       GAMMA/VINF

        1           -.88821E+00       .21111E+01      .80240E+00
        2           -.21111E+01       .88813E+00     -.80240E+00
        3            .26237E+01       .76307E+00      .94911E+00
        4           -.28969E+01       .79060E+00      .58440E-01
        5           -.40363E+01       .87357E+00     -.59187E+00
        6           -.79151E+00       .28966E+01     -.58440E-01
        7           -.87392E+00       .40362E+01      .59187E+00
        8           -.76258E+00      -.26237E+01     -.94911E+00

 X-STATION NO.  9        X=28.392       INTEGRATION STEP SIZE =      .39936
```

Figure 16.- Continued.

```
LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =     1.30000

     VORTEX           Y,VRTX            Z,VRTX        GAMMA/VINF

        1          -.92271E+00        .21372E+01       .80240E+00
        2          -.21372E+01        .92263E+00      -.80240E+00
        3           .25437E+01        .87647E+00       .94911E+00
        4          -.29594E+01        .91105E+00       .58440E-01
        5          -.41110E+01        .99178E+00      -.59187E+00
        6          -.91200E+00        .29589E+01      -.58440E-01
        7          -.99212E+00        .41109E+01       .59187E+00
        8          -.87598E+00       -.25438E+01      -.94911E+00

  X-STATION NO. 10       X=29.016        INTEGRATION STEP SIZE =      .39936

LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =     1.30000

     VORTEX           Y,VRTX            Z,VRTX        GAMMA/VINF

        1          -.95776E+00        .21628E+01       .80240E+00
        2          -.21628E+01        .95769E+00      -.80240E+00
        3           .24623E+01        .99075E+00       .94911E+00
        4          -.30124E+01        .10269E+01       .58440E-01
        5          -.41847E+01        .11082E+01      -.59187E+00
        6          -.10279E+01        .30118E+01      -.58440E-01
        7          -.11085E+01        .41846E+01       .59187E+00
        8          -.99024E+00       -.24624E+01      -.94911E+00

  X-STATION NO. 11       X=29.640        INTEGRATION STEP SIZE =      .39936

LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =     1.30000

     VORTEX           Y,VRTX            Z,VRTX        GAMMA/VINF

        1          -.99319E+00        .21879E+01       .80240E+00
        2          -.21879E+01        .99312E+00      -.80240E+00
        3           .23791E+01        .11057E+01       .94911E+00
        4          -.30579E+01        .11379E+01       .58440E-01
        5          -.42575E+01        .12229E+01      -.59187E+00
        6          -.11389E+01        .30572E+01      -.58440E-01
        7          -.12232E+01        .42574E+01       .59187E+00
        8          -.11052E+01       -.23792E+01      -.94911E+00

  X-STATION NO. 12       X=30.264        INTEGRATION STEP SIZE =      .79872
```

Figure 16.- Continued.

```
LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =     1.30000

      VORTEX           Y,VRTX            Z,VRTX        GAMMA/VINF

         1         -.10289E+01       .22125E+01      .80240E+00
         2         -.22125E+01       .10288E+01     -.80240E+00
         3          .22942E+01       .12211E+01      .94911E+00
         4         -.30974E+01       .12443E+01      .58440E-01
         5         -.43297E+01       .13359E+01     -.59187E+00
         6         -.12454E+01       .30965E+01     -.58440E-01
         7         -.13363E+01       .43295E+01      .59187E+00
         8         -.12206E+01      -.22943E+01     -.94911E+00

  X-STATION NO. 13       X=30.885       INTEGRATION STEP SIZE =      .79872

LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =     1.30000

      VORTEX           Y,VRTX            Z,VRTX        GAMMA/VINF

         1         -.10646E+01       .22363E+01      .80240E+00
         2         -.22364E+01       .10646E+01     -.80240E+00
         3          .22073E+01       .13368E+01      .94911E+00
         4         -.31320E+01       .13463E+01      .58440E-01
         5         -.44013E+01       .14474E+01     -.59187E+00
         6         -.13473E+01       .31309E+01     -.58440E-01
         7         -.14477E+01       .44012E+01      .59187E+00
         8         -.13363E+01      -.22074E+01     -.94911E+00

  X-STATION NO. 14       X=31.512       INTEGRATION STEP SIZE =      .79872

LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =     1.30000

      VORTEX           Y,VRTX            Z,VRTX        GAMMA/VINF

         1         -.11004E+01       .22595E+01      .80240E+00
         2         -.22595E+01       .11003E+01     -.80240E+00
         3          .21165E+01       .14526E+01      .94911E+00
         4         -.31627E+01       .14440E+01      .58440E-01
         5         -.44726E+01       .15573E+01     -.59187E+00
         6         -.14451E+01       .31615E+01     -.58440E-01
         7         -.15576E+01       .44724E+01      .59187E+00
         8         -.14521E+01      -.21186E+01     -.94911E+00

  X-STATION NO. 15       X=32.136       INTEGRATION STEP SIZE =      .79872

LOCAL BODY RADIUS =     1.30000      LOCAL SEMI SPAN S =     1.30000

      VORTEX           Y,VRTX            Z,VRTX        GAMMA/VINF
```

Figure 16.- Continued.

```
       1           -.11559E+01        .22817E+01      .80240E+00
       2           -.22817E+01        .11559E+01     -.80240E+00
       3            .20278E+01        .15681E+01      .94911E+00
       4           -.31905E+01        .15379E+01      .58440E-01
       5           -.45435E+01        .16657E+01     -.59187E+00
       6           -.15389E+01        .31891E+01     -.58440E-01
       7           -.16661E+01        .45434E+01      .59187E+00
       8           -.15676E+01       -.20279E+01     -.94911E+00


 X-STATION NO. 16       X=32.760       INTEGRATION STEP SIZE =      .79872


LOCAL BODY RADIUS =     1.30000     LOCAL SEMI SPAN S =     1.30000

     VORTEX              Y,VRTX            Z,VRTX        GAMMA/VINF

       1           -.11712E+01        .23029E+01      .80240E+00
       2           -.23029E+01        .11712E+01     -.80240E+00
       3            .19352E+01        .16831E+01      .94911E+00
       4           -.32158E+01        .16280E+01      .58440E-01
       5           -.46143E+01        .17728E+01     -.59187E+00
       6           -.16290E+01        .32142E+01     -.58440E-01
       7           -.17732E+01        .46142E+01      .59187E+00
       8           -.16826E+01       -.19353E+01     -.94911E+00

 X-STATION NO. 17       X=33.384       INTEGRATION STEP SIZE =      .79872


LOCAL BODY RADIUS =     1.30000     LOCAL SEMI SPAN S =     1.30000

     VORTEX              Y,VRTX            Z,VRTX        GAMMA/VINF

       1           -.12060E+01        .23229E+01      .80240E+00
       2           -.23229E+01        .12060E+01     -.80240E+00
       3            .18409E+01        .17975E+01      .94911E+00
       4           -.32392E+01        .17147E+01      .58440E-01
       5           -.46850E+01        .18787E+01     -.59187E+00
       6           -.17157E+01        .32374E+01     -.58440E-01
       7           -.18790E+01        .46848E+01      .59187E+00
       8           -.17970E+01       -.18410E+01     -.94911E+00

 X-STATION NO. 18       X=34.008       INTEGRATION STEP SIZE =      .79872


LOCAL BODY RADIUS =     1.30000     LOCAL SEMI SPAN S =     1.30000

     VORTEX              Y,VRTX            Z,VRTX        GAMMA/VINF

       1           -.12401E+01        .23415E+01      .80240E+00
       2           -.23416E+01        .12401E+01     -.80240E+00
       3            .17450E+01        .19111E+01      .94911E+00
       4           -.32613E+01        .17982E+01      .58440E-01
       5           -.47555E+01        .19833E+01     -.59187E+00
       6           -.17992E+01        .32593E+01     -.58440E-01
       7           -.19836E+01        .47554E+01      .59187E+00
       8           -.19106E+01       -.17452E+01     -.94911E+00

 X-STATION NO. 19       X=34.632       INTEGRATION STEP SIZE =      .79872
```

Figure 16.- Continued.

```
LOCAL BODY RADIUS =     1.30000     LOCAL SEMI SPAN S =     1.30000

      VORTEX            Y,VRTX            Z,VRTX       GAMMA/VINF

         1           -.12735E+01       .23586E+01      .80240E+00
         2           -.23587E+01       .12735E+01     -.80240E+00
         3            .16478E+01       .20237E+01      .94911E+00
         4           -.32823E+01       .18786E+01      .58440E-01
         5           -.48261E+01       .20868E+01     -.59187E+00
         6           -.18796E+01       .32802E+01     -.58440E-01
         7           -.20871E+01       .48259E+01      .59187E+00
         8           -.20252E+01      -.16480E+01     -.94911E+00

  X-STATION NO. 20       X=35.256       INTEGRATION STEP SIZE =     .79872


LOCAL BODY RADIUS =     1.30000     LOCAL SEMI SPAN S =     1.30000

      VORTEX            Y,VRTX            Z,VRTX       GAMMA/VINF

         1           -.13058E+01       .23739E+01      .80240E+00
         2           -.23740E+01       .13058E+01     -.80240E+00
         3            .15495E+01       .21354E+01      .94911E+00
         4           -.33028E+01       .19563E+01      .58440E-01
         5           -.48966E+01       .21892E+01     -.59187E+00
         6           -.19572E+01       .33004E+01     -.58440E-01
         7           -.21895E+01       .48964E+01      .59187E+00
         8           -.21349E+01      -.15497E+01     -.94911E+00

  X-STATION NO. 21       X=35.880       INTEGRATION STEP SIZE =     .15600


LOCAL BODY RADIUS =     1.30000     LOCAL SEMI SPAN S =     2.13138

      VORTEX            Y,VRTX            Z,VRTX       GAMMA/VINF

         1           -.13363E+01       .23855E+01      .80240E+00
         2           -.23856E+01       .13363E+01     -.80240E+00
         3            .14500E+01       .22455E+01      .94911E+00
         4           -.33221E+01       .20309E+01      .58440E-01
         5           -.49667E+01       .22905E+01     -.59187E+00
         6           -.20318E+01       .33195E+01     -.58440E-01
         7           -.22908E+01       .49665E+01      .59187E+00
         8           -.22450E+01      -.14501E+01     -.94911E+00

  X-STATION NO. 22       X=36.504       INTEGRATION STEP SIZE =     .15600

LOCAL BODY RADIUS =     1.30000     LOCAL SEMI SPAN S =     3.21218

      VORTEX            Y,VRTX            Z,VRTX       GAMMA/VINF

         1           -.13557E+01       .23814E+01      .80240E+00
         2           -.23815E+01       .13558E+01     -.80240E+00
         3            .13547E+01       .23508E+01      .94911E+00
         4           -.33529E+01       .20992E+01      .58440E-01
         5           -.50321E+01       .23904E+01     -.59187E+00
         6           -.21000E+01       .33301E+01     -.58440E-01
         7           -.23907E+01       .50319E+01      .59187E+00
         8           -.23503E+01      -.13548E+01     -.94911E+00
```

Figure 16.- Continued.

```
X-STATION NO. 23        X=37.128        INTEGRATION STEP SIZE =      .31200

LOCAL BODY RADIUS =      1.30000     LOCAL SEMI SPAN S =     3.64000

       VORTEX              Y,VRTX              Z,VRTX      GAMMA/VINF

          1            -.13564E+01          .23648E+01     .80240E+00
          2            -.23649E+01          .13564E+01    -.80240E+00
          3             .12754E+01          .24485E+01     .94911E+00
          4            -.33298E+01          .21551E+01     .58440E-01
          5            -.50877E+01          .24880E+01    -.59187E+00
          6            -.21558E+01          .33269E+01    -.58440E-01
          7            -.24883E+01          .50875E+01     .59187E+00
          8            -.24880E+01         -.12756E+01    -.94911E+00

X-STATION NO. 24        X=37.752        INTEGRATION STEP SIZE =      .62400

LOCAL BODY RADIUS =      1.30000     LOCAL SEMI SPAN S =     3.64000

       VORTEX              Y,VRTX              Z,VRTX      GAMMA/VINF

          1            -.13546E+01          .23468E+01     .80240E+00
          2            -.23469E+01          .13546E+01    -.80240E+00
          3             .11981E+01          .25470E+01     .94911E+00
          4            -.33275E+01          .22076E+01     .58440E-01
          5            -.51432E+01          .25841E+01    -.59187E+00
          6            -.22082E+01          .33244E+01    -.58440E-01
          7            -.25844E+01          .51430E+01     .59187E+00
          8            -.25465E+01         -.11983E+01    -.94911E+00

X-STATION NO. 25        X=38.376        INTEGRATION STEP SIZE =      .62400

LOCAL BODY RADIUS =      1.30000     LOCAL SEMI SPAN S =     3.64000

       VORTEX              Y,VRTX              Z,VRTX      GAMMA/VINF
          1            -.13520E+01          .23281E+01     .80240E+00
          2            -.23282E+01          .13520E+01    -.80240E+00
          3             .11209E+01          .26476E+01     .94911E+00
          4            -.33261E+01          .22585E+01     .58440E-01
          5            -.51999E+01          .26790E+01    -.59187E+00
          6            -.22590E+01          .33246E+01    -.58440E-01
          7            -.26793E+01          .51997E+01     .59187E+00
          8            -.26471E+01         -.11209E+01    -.94911E+00

X-STATION NO. 26        X=39.000        INTEGRATION STEP SIZE =      .62400

LOCAL BODY RADIUS =      1.30000     LOCAL SEMI SPAN S =     3.64000

       VORTEX              Y,VRTX              Z,VRTX      GAMMA/VINF

          1            -.13485E+01          .23086E+01     .80240E+00
          2            -.23086E+01          .13486E+01    -.80240E+00
          3             .10430E+01          .27506E+01     .94911E+00
```

Figure 16.- Continued.

```
      4          -.33316E+01        .23082E+01       .58440E-01
      5          -.52578E+01        .27729E+01      -.59187E+00
      6          -.23086E+01        .33282E+01      -.58440E-01
      7          -.27732E+01        .52576E+01       .59187E+00
      8          -.27500E+01       -.10432E+01      -.94911E+00


CROSSFLOW VELOCITIES AT CONTROL POINTS INDUCED BY VORTICES AND THEIR IMAGES

IC          X,BODY          Y,BODY          Z,BODY            V              W
 1        .36631E+02      .15310E+01      0.              .22541E-01     -.74105E-01
 2        .37787E+02      .15310E+01      0.              .19927E-01     -.67006E-01
 3        .38942E+02      .15310E+01      0.              .17798E-01     -.61175E-01
 4        .36816E+02      .19987E+01      0.              .41619E-01     -.45614E-01
 5        .37881E+02      .19987E+01      0.              .37375E-01     -.42293E-01
 6        .38947E+02      .19987E+01      0.              .33859E-01     -.39479E-01
 7        .37000E+02      .24664E+01      0.              .44308E-01     -.26003E-01
 8        .37976E+02      .24664E+01      0.              .40555E-01     -.25016E-01
 9        .38951E+02      .24664E+01      0.              .37364E-01     -.24108E-01
10        .37185E+02      .29340E+01      0.              .40999E-01     -.13556E-01
11        .38070E+02      .29340E+01      0.              .38258E-01     -.13699E-01
12        .38956E+02      .29340E+01      0.              .35851E-01     -.13763E-01
13        .37369E+02      .34016E+01      0.              .36017E-01     -.60080E-02
14        .38165E+02      .34016E+01      0.              .34184E-01     -.65582E-02
15        .38960E+02      .34016E+01      0.              .32528E-01     -.70081E-02
16        .36631E+02     -.15310E+01      0.              .25922E-01     -.24335E+00
17        .37787E+02     -.15310E+01      0.              .24109E-01     -.25303E+00
18        .38942E+02     -.15310E+01      0.              .19507E-01     -.25801E+00
19        .36816E+02     -.19987E+01      0.              .51219E-01     -.17161E+00
20        .37881E+02     -.19987E+01      0.              .53408E-01     -.18545E+00
21        .38947E+02     -.19987E+01      0.              .48996E-01     -.19858E+00
22        .37000E+02     -.24664E+01      0.              .59843E-01     -.91572E-01
23        .37976E+02     -.24664E+01      0.              .74149E-01     -.10355E+00
24        .38951E+02     -.24664E+01      0.              .84330E-01     -.12168E+00
25        .37185E+02     -.29340E+01      0.              .56495E-01     -.21821E-01
26        .38070E+02     -.29340E+01      0.              .75910E-01     -.23056E-01
27        .38956E+02     -.29340E+01      0.              .98558E-01     -.29250E-01
28        .37369E+02     -.34016E+01      0.              .43993E-01      .14525E-01
29        .38165E+02     -.34016E+01      0.              .57886E-01      .19927E-01
30        .38960E+02     -.34016E+01      0.              .74961E-01      .25398E-01
31        .36631E+02      .73521E-13      .15310E+01      .24338E+00     -.25911E-01
32        .37787E+02      .73521E-13      .15310E+01      .25305E+00     -.24092E-01
33        .38942E+02      .73521E-13      .15310E+01      .25802E+00     -.19486E-01
34        .36816E+02      .95983E-13      .19987E+01      .17165E+00     -.51210E-01
35        .37881E+02      .95983E-13      .19987E+01      .18549E+00     -.53383E-01
36        .38947E+02      .95983E-13      .19987E+01      .19861E+00     -.48956E-01
37        .37000E+02      .11844E-12      .24664E+01      .91616E-01     -.59862E-01
38        .37976E+02      .11844E-12      .24664E+01      .10360E+00     -.74159E-01
39        .38951E+02      .11844E-12      .24664E+01      .12174E+00     -.84319E-01
40        .37185E+02      .14090E-12      .29340E+01      .21847E-01     -.56537E-01
41        .38070E+02      .14090E-12      .29340E+01      .23094E-01     -.75960E-01
42        .38956E+02      .14090E-12      .29340E+01      .29311E-01     -.98614E-01
43        .37369E+02      .16335E-12      .34016E+01     -.14321E-01     -.44031E-01
44        .38165E+02      .16335E-12      .34016E+01     -.19920E-01     -.57935E-01
45        .38960E+02      .16335E-12      .34016E+01     -.25385E-01     -.75025E-01
46        .36631E+02     -.73521E-13     -.15310E+01      .74107E-01     -.22546E-01
47        .37787E+02     -.73521E-13     -.15310E+01      .67006E-01     -.19931E-01
48        .38942E+02     -.73521E-13     -.15310E+01      .61173E-01     -.17801E-01
49        .36816E+02     -.95983E-13     -.19987E+01      .45611E-01     -.41626E-01
50        .37881E+02     -.95983E-13     -.19987E+01      .42289E-01     -.37381E-01
51        .38947E+02     -.95983E-13     -.19987E+01      .39475E-01     -.33864E-01
52        .37000E+02     -.11844E-12     -.24664E+01      .25997E-01     -.44314E-01
53        .37976E+02     -.11844E-12     -.24664E+01      .25009E-01     -.40561E-01
54        .38951E+02     -.11844E-12     -.24664E+01      .24101E-01     -.37368E-01
55        .37185E+02     -.14090E-12     -.29340E+01      .13548E-01     -.41002E-01
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Figure 16.- Continued.

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 56   .38070E+02   -.14090E-12   -.29340E+01    .13692E-01   -.36261E-01
 57   .36956E+02   -.14090E-12   -.29340E+01    .13756E-01   -.35854E-01
 58   .37369E+02   -.16335E-12   -.34016E+01    .60006E-02   -.36018E-01
 59   .38165E+02   -.16335E-12   -.34016E+01    .65510E-02   -.34185E-01
 60   .38960E+02   -.16335E-12   -.34016E+01    .70012E-02   -.32529E-01
 61   .36540E+02    .12505E+01    .24874E+00    .21274E-01   -.12873E+00
 62   .36540E+02    .10601E+01    .70836E+00    .12767E+00   -.20246E+00
 63   .36540E+02    .70836E+00    .10601E+01    .28783E+00   -.19570E+00
 64   .36540E+02    .24874E+00    .12505E+01    .32366E+00   -.60836E-01
 65   .36540E+02   -.24874E+00    .12505E+01    .24601E+00    .53505E-01
 66   .36540E+02   -.70836E+00    .10601E+01    .91774E-01    .73741E-01
 67   .36540E+02   -.10601E+01    .70836E+00   -.73710E-01   -.91728E-01
 68   .36540E+02   -.12505E+01    .24874E+00   -.53496E-01   -.24796E+00
 69   .36540E+02   -.12505E+01   -.24874E+00    .60831E-01   -.32364E+00
 70   .36540E+02   -.10601E+01   -.70836E+00    .19573E+00   -.26788E+00
 71   .36540E+02   -.70836E+00   -.10601E+01    .20250E+00   -.12770E+00
 72   .36540E+02   -.24874E+00   -.12505E+01    .12675E+00   -.21275E-01
 73   .36540E+02    .24874E+00   -.12505E+01    .61400E-01    .14560E-01
 74   .36540E+02    .70836E+00   -.10601E+01    .14602E-01    .12062E-01
 75   .36540E+02    .10601E+01   -.70836E+00   -.12966E-01   -.14607E-01
 76   .36540E+02    .12505E+01   -.24874E+00   -.14860E-01   -.61401E-01
 77   .37740E+02    .12505E+01    .24874E+00    .19040E-01   -.11463E+00
 78   .37740E+02    .10601E+01    .70836E+00    .11255E+00   -.17859E+00
 79   .37740E+02    .70836E+00    .10601E+01    .26421E+00   -.18128E+00
 80   .37740E+02    .24874E+00    .12505E+01    .32649E+00   -.62557E-01
 81   .37740E+02   -.24874E+00    .12505E+01    .25853E+00    .55706E-01
 82   .37740E+02   -.70836E+00    .10601E+01    .95893E-01    .77032E-01
 83   .37740E+02   -.10601E+01    .70836E+00   -.76997E-01   -.95841E-01
 84   .37740E+02   -.12505E+01    .24874E+00   -.55699E-01   -.25849E+00
 85   .37740E+02   -.12505E+01   -.24874E+00    .62555E-01   -.32650E+00
 86   .37740E+02   -.10601E+01   -.70836E+00    .18130E+00   -.26427E+00
 87   .37740E+02   -.70836E+00   -.10601E+01    .17862E+00   -.11257E+00

 88   .37740E+02   -.24874E+00   -.12505E+01    .11464E+00   -.19041E-01
 89   .37740E+02    .24874E+00   -.12505E+01    .55514E-01    .13401E-01
 90   .37740E+02    .70836E+00   -.10601E+01    .13307E-01    .10989E-01
 91   .37740E+02    .10601E+01   -.70836E+00   -.10993E-01   -.13314E-01
 92   .37740E+02    .12505E+01   -.24874E+00   -.13401E-01   -.55518E-01
 93   .38940E+02    .12505E+01    .24874E+00    .17227E-01   -.10318E+00
 94   .38940E+02    .10601E+01    .70836E+00    .99922E-01   -.15845E+00
 95   .38940E+02    .70836E+00    .10601E+01    .23901E+00   -.16495E+00
 96   .38940E+02    .24874E+00    .12505E+01    .31998E+00   -.62611E-01
 97   .38940E+02   -.24874E+00    .12505E+01    .26666E+00    .57132E-01
 98   .38940E+02   -.70836E+00    .10601E+01    .10026E+00    .80495E-01
 99   .38940E+02   -.10601E+01    .70836E+00   -.60458E-01   -.10022E+00
100   .38940E+02   -.12505E+01    .24874E+00   -.57127E-01   -.26062E+00
101   .38940E+02   -.12505E+01   -.24874E+00    .62613E-01   -.32000E+00
102   .38940E+02   -.10601E+01   -.70836E+00    .16499E+00   -.23906E+00
103   .38940E+02   -.70836E+00   -.10601E+01    .15848E+00   -.99937E-01
104   .38940E+02   -.24874E+00   -.12505E+01    .10318E+00   -.17227E-01
105   .38940E+02    .24874E+00   -.12505E+01    .50709E-01    .12211E-01
106   .38940E+02    .70836E+00   -.10601E+01    .12245E-01    .10108E-01
107   .38940E+02    .10601E+01   -.70836E+00   -.10113E-01   -.12252E-01
108   .38940E+02    .12505E+01   -.24874E+00   -.12212E-01   -.50714E-01
109   .25145E+02    .12750E+01    .25362E+00    .51694E-01   -.26088E+00
110   .25145E+02    .12010E+01    .49749E+00    .98361E-01   -.23745E+00
111   .25145E+02    .10809E+01    .72224E+00    .13105E+00   -.19612E+00
112   .25145E+02    .91924E+00    .91924E+00    .15447E+00   -.15447E+00
113   .25145E+02    .72224E+00    .10809E+01    .17758E+00   -.11866E+00
114   .25145E+02    .49749E+00    .12010E+01    .20820E+00   -.86245E-01
115   .25145E+02    .25362E+00    .12750E+01    .25233E+00   -.50196E-01
116   .25145E+02   -.46625E-09    .13000E+01    .31195E+00    .11168E-09
117   .25145E+02   -.25362E+00    .12750E+01    .35000E+00    .72225E-01
118   .25145E+02   -.49749E+00    .12010E+01    .32579E+00    .13497E+00
119   .25145E+02   -.72224E+00    .10809E+01    .17191E+00    .11488E+00
120   .25145E+02   -.91924E+00    .91924E+00    .21260E-04    .19278E-04
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Figure 16.- Continued.

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121        .25145E+02   -.10809E+01    .72224E+00   -.11485E+00   -.17187E+00
122        .25145E+02   -.12010E+01    .49749E+00   -.13496E+00   -.32577E+00
123        .25145E+02   -.12750E+01    .25362E+00   -.72226E-01   -.35000E+00
124        .25145E+02   -.13000E+01   -.93250E-09    .22377E-09   -.31196E+00
125        .25145E+02   -.12750E+01   -.25362E+00    .50195E-01   -.25232E+00
126        .25145E+02   -.12010E+01   -.49749E+00    .86201E-01   -.20819E+00
127        .25145E+02   -.10809E+01   -.72224E+00    .11865E+00   -.17757E+00
128        .25145E+02   -.91924E+00   -.91924E+00    .15445E+00   -.15445E+00
129        .25145E+02   -.72224E+00   -.10809E+01    .19610E+00   -.13103E+00
130        .25145E+02   -.49749E+00   -.12010E+01    .23743E+00   -.98352E-01
131        .25145E+02   -.25362E+00   -.12750E+01    .26088E+00   -.51893E-01
132        .25145E+02    .13988E-08   -.13000E+01    .24729E+00    .26608E-09
133        .25145E+02    .25362E+00   -.12750E+01    .19580E+00    .38953E-01
134        .25145E+02    .49749E+00   -.12010E+01    .12534E+00    .51932E-01
135        .25145E+02    .72224E+00   -.10809E+01    .56213E-01    .37564E-01
136        .25145E+02    .91924E+00   -.91924E+00    .18354E-04    .17729E-04
137        .25145E+02    .10809E+01   -.72224E+00   -.37535E-01   -.56170E-01
138        .25145E+02    .12010E+01   -.49749E+00   -.51913E-01   -.12530E+00
139        .25145E+02    .12750E+01   -.25362E+00   -.39944E-01   -.19576E+00
140        .25145E+02    .13000E+01    .18650E-08    .35473E-09   -.24726E+00
141        .27197E+02    .12750E+01    .25362E+00    .57843E-01   -.29080E+00
142        .27197E+02    .12010E+01    .49749E+00    .11538E+00   -.27853E+00
143        .27197E+02    .10809E+01    .72224E+00    .15419E+00   -.23075E+00
144        .27197E+02    .91924E+00    .91924E+00    .17505E+00   -.17505E+00
145        .27197E+02    .72224E+00    .10809E+01    .18984E+00   -.12685E+00
146        .27197E+02    .49749E+00    .12010E+01    .20942E+00   -.86749E-01
147        .27197E+02    .25362E+00    .12750E+01    .24021E+00   -.47784E-01
148        .27197E+02   -.46625E-09    .13000E+01    .28172E+00    .10104E-09
149        .27197E+02   -.25362E+00    .12750E+01    .31289E+00    .62238E-01
150        .27197E+02   -.49749E+00    .12010E+01    .27791E+00    .11513E+00
151        .27197E+02   -.72224E+00    .10809E+01    .15109E+00    .10096E+00
152        .27197E+02   -.91924E+00    .91924E+00    .15768E-04    .13993E-04
153        .27197E+02   -.10809E+01    .72224E+00   -.10095E+00   -.15106E+00
154        .27197E+02   -.12010E+01    .49749E+00   -.11512E+00   -.27789E+00
155        .27197E+02   -.12750E+01    .25362E+00   -.62237E-01   -.31289E+00
156        .27197E+02   -.13000E+01   -.93250E-09    .20208E-09   -.28172E+00
157        .27197E+02   -.12750E+01   -.25362E+00    .47781E-01   -.24019E+00
158        .27197E+02   -.12010E+01   -.49749E+00    .66740E-01   -.20940E+00
159        .27197E+02   -.10809E+01   -.72224E+00    .12583E+00   -.18982E+00
160        .27197E+02   -.91924E+00   -.91924E+00    .17503E+00   -.17503E+00
161        .27197E+02   -.72224E+00   -.10809E+01    .23072E+00   -.15416E+00
162        .27197E+02   -.49749E+00   -.12010E+01    .27852E+00   -.11537E+00
163        .27197E+02   -.25362E+00   -.12750E+01    .29082E+00   -.57847E-01
164        .27197E+02    .13988E-08   -.13000E+01    .25424E+00    .27356E-09
165        .27197E+02    .25362E+00   -.12750E+01    .18614E+00    .37032E-01
166        .27197E+02    .49749E+00   -.12010E+01    .11272E+00    .46701E-01
167        .27197E+02    .72224E+00   -.10809E+01    .49035E-01    .32767E-01
168        .27197E+02    .91924E+00   -.91924E+00    .16423E-04    .15883E-04
169        .27197E+02    .10809E+01   -.72224E+00   -.32741E-01   -.48996E-01
170        .27197E+02    .12010E+01   -.49749E+00   -.46681E-01   -.11267E+00
171        .27197E+02    .12750E+01   -.25362E+00   -.37021E-01   -.18608E+00
172        .27197E+02    .13000E+01    .18650E-08    .36467E-09   -.25419E+00
173        .29250E+02    .12750E+01    .25362E+00    .57819E-01   -.29069E+00
174        .29250E+02    .12010E+01    .49749E+00    .12823E+00   -.30958E+00
175        .29250E+02    .10809E+01    .72224E+00    .18263E+00   -.27333E+00
176        .29250E+02    .91924E+00    .91924E+00    .20763E+00   -.20763E+00
177        .29250E+02    .72224E+00    .10809E+01    .21495E+00   -.14362E+00
178        .29250E+02    .49749E+00    .12010E+01    .22129E+00   -.91664E-01
179        .29250E+02    .25362E+00    .12750E+01    .23612E+00   -.46969E-01
180        .29250E+02   -.46625E-09    .13000E+01    .25921E+00    .92966E-10
181        .29250E+02   -.25362E+00    .12750E+01    .27333E+00    .54369E-01
182        .29250E+02   -.49749E+00    .12010E+01    .23805E+00    .98619E-01
183        .29250E+02   -.72224E+00    .10809E+01    .13121E+00    .87680E-01
184        .29250E+02   -.91924E+00    .91924E+00    .12532E-04    .10972E-04
185        .29250E+02   -.10809E+01    .72224E+00   -.67664E-01   -.13119E+00
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Figure 16.- Continued.

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186     .29250E+02   -.12010E+01    .49749E+00   -.98611E-01   -.23804E+00
187     .29250E+02   -.12750E+01    .25362E+00   -.54366E-01   -.27331E+00
188     .29250E+02   -.13000E+01   -.93250E-09    .18592E-09   -.25919E+00
189     .29250E+02   -.12750E+01   -.25362E+00    .46963E-01   -.23609E+00
190     .29250E+02   -.12010E+01   -.49749E+00    .91548E-01   -.22125E+00
191     .29250E+02   -.10809E+01   -.72224E+00    .14360E+00   -.21491E+00
192     .29250E+02   -.91924E+00   -.91924E+00    .20759E+00   -.20759E+00
193     .29250E+02   -.72224E+00   -.10809E+01    .27551E+00   -.18262E+00
194     .29250E+02   -.49749E+00   -.12010E+01    .30960E+00   -.12824E+00
195     .29250E+02   -.25362E+00   -.12750E+01    .29075E+00   -.57251E-01
196     .29250E+02    .13986E-08   -.13000E+01    .22939E+00    .24683E-09
197     .29250E+02    .25362E+00   -.12750E+01    .15653E+00    .31141E-01
198     .29250E+02    .49749E+00   -.12010E+01    .91194E-01    .37785E-01
199     .29250E+02    .72224E+00   -.10809E+01    .58978E-01    .26047E-01
200     .29250E+02    .91924E+00   -.91924E+00    .11744E-04    .11517E-04
201     .29250E+02    .10809E+01   -.72224E+00   -.26027E-01   -.38949E-01
202     .29250E+02    .12010E+01   -.49749E+00   -.37768E-01   -.91154E-01
203     .29250E+02    .12750E+01   -.25362E+00   -.31130E-01   -.15647E+00
204     .29250E+02    .13000E+01    .18650E-08    .32900E-09   -.22933E+00
205     .31303E+02    .12750E+01    .25362E+00    .49546E-01   -.24911E+00
206     .31303E+02    .12010E+01    .49749E+00    .12370E+00   -.29865E+00
207     .31303E+02    .10809E+01    .72224E+00    .20006E+00   -.29940E+00
208     .31303E+02    .91924E+00    .91924E+00    .24551E+00   -.24551E+00
209     .31303E+02    .72224E+00    .10809E+01    .25475E+00   -.17021E+00
210     .31303E+02    .49749E+00    .12010E+01    .24885E+00   -.10308E+00
211     .31303E+02    .25362E+00    .12750E+01    .24583E+00   -.48900E-01
212     .31303E+02   -.46625E-09    .13000E+01    .24957E+00    .89510E-10
213     .31303E+02   -.25362E+00    .12750E+01    .24707E+00    .49147E-01
214     .31303E+02   -.49749E+00    .12010E+01    .20811E+00    .86214E-01
215     .31303E+02   -.72224E+00    .10809E+01    .11440E+00    .76448E-01
216     .31303E+02   -.91924E+00    .91924E+00    .12027E-04    .10661E-04
217     .31303E+02   -.10809E+01    .72224E+00   -.76431E-01   -.11438E+00
218     .31303E+02   -.12010E+01    .49749E+00   -.66203E-01   -.20809E+00
219     .31303E+02   -.12750E+01    .25362E+00   -.49141E-01   -.24704E+00
220     .31303E+02   -.13000E+01   -.93250E-09    .17899E-09   -.24954E+00
221     .31303E+02   -.12750E+01   -.25362E+00    .48891E-01   -.24579E+00
222     .31303E+02   -.12010E+01   -.49749E+00    .10306E+00   -.24880E+00
223     .31303E+02   -.10809E+01   -.72224E+00    .17019E+00   -.25470E+00
224     .31303E+02   -.91924E+00   -.91924E+00    .24549E+00   -.24549E+00
225     .31303E+02   -.72224E+00   -.10809E+01    .29943E+00   -.20007E+00
226     .31303E+02   -.49749E+00   -.12010E+01    .29872E+00   -.12373E+00
227     .31303E+02   -.25362E+00   -.12750E+01    .24918E+00   -.49560E-01
228     .31303E+02    .13986E-08   -.13000E+01    .18250E+00    .19637E-09
229     .31303E+02    .25362E+00   -.12750E+01    .12022E+00    .23918E-01
230     .31303E+02    .49749E+00   -.12010E+01    .69124E-01    .28640E-01
231     .31303E+02    .72224E+00   -.10809E+01    .29432E-01    .19668E-01
232     .31303E+02    .91924E+00   -.91924E+00    .62402E-05    .59178E-05
233     .31303E+02    .10809E+01   -.72224E+00   -.19657E-01   -.29416E-01
234     .31303E+02    .12010E+01   -.49749E+00   -.28631E-01   -.69101E-01
235     .31303E+02    .12750E+01   -.25362E+00   -.23911E-01   -.12018E+00
236     .31303E+02    .13000E+01    .18650E-08    .26173E-09   -.18244E+00
237     .33355E+02    .12750E+01    .25362E+00    .38101E-01   -.19157E+00
238     .33355E+02    .12010E+01    .49749E+00    .10173E+00   -.24562E+00
239     .33355E+02    .10809E+01    .72224E+00    .18542E+00   -.27750E+00
240     .33355E+02    .91924E+00    .91924E+00    .26061E+00   -.26061E+00
241     .33355E+02    .72224E+00    .10809E+01    .29458E+00   -.19683E+00
242     .33355E+02    .49749E+00    .12010E+01    .28977E+00   -.12003E+00
243     .33355E+02    .25362E+00    .12750E+01    .27176E+00   -.54056E-01
244     .33355E+02   -.46625E-09    .13000E+01    .25552E+00    .91645E-10
245     .33355E+02   -.25362E+00    .12750E+01    .23542E+00    .46831E-01
246     .33355E+02   -.49749E+00    .12010E+01    .18926E+00    .78408E-01
247     .33355E+02   -.72224E+00    .10809E+01    .12231E+00    .68364E-01
248     .33355E+02   -.91924E+00    .91924E+00    .14117E-04    .12898E-04
249     .33355E+02   -.10809E+01    .72224E+00   -.68343E-01   -.10227E+00
250     .33355E+02   -.12010E+01    .49749E+00   -.78393E-01   -.18923E+00
```

Figure 16.- Continued.

```
251          .33355E+02    -.12750E+01     .25362E+00    -.46822E-01    -.23538E+00
252          .33355E+02    -.13000E+01    -.93250E-09     .18325E-09    -.25548E+00
253          .33355E+02    -.12750E+01    -.25362E+00     .54046E-01    -.27171E+00
254          .33355E+02    -.12010E+01    -.49749E+00     .12001E+00    -.28973E+00
255          .33355E+02    -.10809E+01    -.72224E+00     .19682E+00    -.29457E+00
256          .33355E+02    -.91924E+00    -.91924E+00     .26064E+00    -.26064E+00
257          .33355E+02    -.72224E+00    -.10809E+01     .27756E+00    -.18546E+00
258          .33355E+02    -.49749E+00    -.12010E+01     .24568E+00    -.10176E+00
259          .33355E+02    -.25362E+00    -.12750E+01     .19162E+00    -.38111E-01
260          .33355E+02     .13446E-08    -.13000E+01     .13693E+00     .14734E-09
261          .33355E+02     .25362E+00    -.12750E+01     .89920E-01     .17890E-01
262          .33355E+02     .49749E+00    -.12010E+01     .51906E-01     .21507E-01
263          .33355E+02     .72224E+00    -.10809E+01     .22193E-01     .14830E-01
264          .33355E+02     .91924E+00    -.91924E+00     .16726E-05     .14291E-05
265          .33355E+02     .10809E+01    -.72224E+00    -.14827E-01    -.22188E-01
266          .33355E+02     .12010E+01    -.49749E+00    -.21503E-01    -.51898E-01
267          .33355E+02     .12750E+01    -.25362E+00    -.17887E-01    -.89904E-01

268          .33355E+02     .13000E+01     .18650E-08     .19641E-09    -.13690E+00
```

Figure 16.- Concluded.

```
NASA/LANGLEY UPWT PROJ.1126,CONFIGURATION B1T4,
$INPUT
CRP=3.6,SWLEP=30.0,B2=2.34,SWLEV=30.0,CRPV=3.6,B2V=2.34,
NCW=3,MSWR=5,MSWL=5,MSWU=5,MSWD=5,NCRX=1,
ALFAC=14.216,PHI=45.0,FMACH=1.70,
RB=1.3,NBDCR=16,NCWB=3,BIL=3.6,
XWLE=35.4,
XSTART=23.4,
SREF=5.30929,REFL=2.69,
NOLINP=1,NOUT=0,NDRAG=1,NBDYPR=1,NCPOUT=0,NVLIN=1,ITAIL=1,
JCPT=268,
VRTMAX=0.5,
XM=19.5,
NTDAT=1,NCWT=8,
$END
   5     0     0
 0.122    0.0      0.0      0.0      0.0      0.0      0.0      -0.141
 0.122    0.0      0.0      0.0      0.0      0.0      0.0      -0.141
 0.122    0.122    0.0      0.0      0.0      0.0      0.0      -0.141
 0.122    0.122    0.0      0.0      0.0      0.0      0.0      -0.141
 0.122    0.122    0.0      0.0      0.0      0.0     -0.141    -0.141
 0.122    0.0      0.0      0.0      0.0      0.0      0.0      -0.141
$BODY
NXBODY=39,LNOSE=7.8,LBODY=39.0,BCODE=2,
$END
         0         0         0         0
         0
ZZZZZZZZZZ
```

Figure 17.- Input for program DEMON2, first sample case, step 6.

```
NASA/LANGLEY UPWT PROJ.112A,CONFIGURATION B1T4,
$INPUT
CRP     = .36E+01,
SMLEP   = .5E+02,
SMTEP   = 0.0,
NCW     = 3,
MSWR    = 5,
MSWL    = 5,
ALFAC   = .14216E+02,
PHI     = .45E+02,
B2      = .234E+01,
FMACH   = .17E+01,
LVSWP   = 0,
FAC     = .95E+00,
NFVNPR  = 0,
TOLFAC  = .1E+01,
MSWU    = 5,
MSWD    = 5,
SMLEV   = .5E+02,
SMTEV   = 0.0,
CRPV    = .36E+01,
B2V     = .234E+01,
NCRX    = 1,
RH      = .13E+01,
RA      = .13E+01,
FRATIO  = .1E+01,
NHDCR   = 16,
DFLR    = 0.0,
DFLL    = 0.0,
DFLU    = 0.0,
DFLD    = 0.0,
```

```
SREF    = .530929E+01,
REFL    = .269E+01,
PHIDIH  = 0.0,
THETIT  = 0.0,
XMLE    = .354E+02,
NOLINP  = 1,
NOUT    = 0,
NPR     = 0,
NDRAG   = 1,
NVRTX   = 0,
NPRESS  = 0,
VRTMAX  = .5E+00,
NCWB    = 3,
NAGAIN  = 0,
HIL     = .36E+01,
ITAIL   = 1,
NVRTPL  = 0,
NHDYPR  = 1,
NTPR    = 0,
NTDAT   = 1,
NCWT    = 8,
NCPOUT  = 0,
NVLIN   = 1,
XSTART  = .234E+02,
JCPT    = 268,
FKLE    = .5E+00,
FKSE    = .5E+00,
XM      = .195E+02,
ZM      = 0.0,
$END
```

Figure 18.- Output of program DEMON2, first sample case, step 6.

```
                         WING GEOMETRY

                   TIP CHORD =     2.24900

                  ROOT CHORD =     3.60000

               WING SEMISPAN =     2.34000

          LEADING EDGE SWEEP =    30.00000  DEGREES

         TRAILING EDGE SWEEP =     0.00000  DEGREES


                        FLOW CONDITIONS

      MACH =    1.70000    ALPHAC=   14.21600    PHI  =   45.00000    ALFA =   10.00010    BETA =   10.00010


          CROT =    3.60000
         CROTV =    3.60000

      WING THICKNESS INPUT DATA

                  SPANWISE LOCATIONS OF PANEL SIDE EDGES AND SWEEP ANGLES
                      OF WING SECTION TO THE LEFT

                               SPANWISE   LE SWEEP  TE SWEEP
                         I     LOCATION
                                 FEET      DEGREES   DEGREES


       RIGHT WING SURFACE

                         1       1.30000   0.00000   0.00000
                         2       1.76800  30.00000   0.00000
                         3       2.23600  30.00000   0.00000
                         4       2.70400  30.00000   0.00000
                         5       3.17200  30.00000   0.00000
                         6       3.64000  30.00000   0.00000

                  40 THICKNESS PANELS ARE TO BE LAID OUT
                   5 CHORDWISE ROWS WITH  8 IN EACH ROW


       UPPER WING SURFACE

                         1       1.30000   0.00000   0.00000
                         2       1.76800  30.00000   0.00000
                         3       2.23600  30.00000   0.00000
                         4       2.70400  30.00000   0.00000
                         5       3.17200  30.00000   0.00000
                         6       3.64000  30.00000   0.00000

                  40 THICKNESS PANELS ARE TO BE LAID OUT
                   5 CHORDWISE ROWS WITH  8 IN EACH ROW
```

Figure 18.- Continued.

```
                    INPUT VALUES OF THE LOCAL SURFACE SLOPE OF THE THICKNESS
                     DISTRIBUTION, FOR EACH CHORDWISE ROW THE FIRST VALUE
                            IS FOR THE PANEL NEAREST THE LEADING EDGE

RIGHT WING SURFACE

      ROW                               SLOPES
       1                   .12200   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       2                   .12200   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       3                   .12200    .12200   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       4                   .12200    .12200   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       5                   .12200    .12200   0.00000   0.00000   0.00000   0.00000   -.14100   -.14100

UPPER WING SURFACE

      ROW                               SLOPES
       1                   .12200   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       2                   .12200   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       3                   .12200    .12200   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       4                   .12200    .12200   0.00000   0.00000   0.00000   0.00000   0.00000   -.14100
       5                   .12200    .12200   0.00000   0.00000   0.00000   0.00000   -.14100   -.14100

$BODY

NXBODY  = 39.,

LNOSE   = .78E+01,

LBODY   = .39E+02,

BCODE   = 2,

$END


PHYSICAL DIMENSIONS OF BODY AND LINE SINGULARITY STRENGTHS REPRESENTING THE BODY AT MACH= 1.7000     ALFAC= 14.2160
         X           R(X)          DR/DX              TX              T(I)             TC(I)
  1    0.0000    -.42633E-13      .34266         .58610E-13         .10092          .39463E-01
  2    1.0263     .32639          .29353         .57761           -.40121E-01      -.10955E-01
  3    2.0526     .60316          .24611         1.2234           -.25012E-01      -.62846E-02
  4    3.0789     .83207          .20020         1.9350           -.23274E-01      -.81381E-02
  5    4.1053    1.0145           .15547         2.7106           -.18881E-01      -.74517E-02
  6    5.1316    1.1515           .11164         3.5485           -.15477E-01      -.75496E-02
  7    6.1579    1.2439           .68039E-01     4.4479           -.11952E-01      -.73645E-02
  8    7.1842    1.2921           .25613E-01     5.4078           -.83169E-02      -.70718E-02
  9    8.2105    1.3000          0.              6.4233            .31078E-01      -.28112E-02
 10    9.2368    1.3000          0.              7.4496            .35293E-02       .47755E-02
 11   10.2632    1.3000          0.              8.4760            .34046E-02       .39930E-02
 12   11.2895    1.3000          0.              9.5023            .14132E-02       .36673E-02
 13   12.3158    1.3000          0.             10.529             .93969E-03       .26432E-02
 14   13.3421    1.3000          0.             11.555             .55466E-03       .17866E-02
 15   14.3684    1.3000          0.             12.581             .36257E-03       .10708E-02
 16   15.3947    1.3000          0.             13.608             .23850E-03       .56355E-03
 17   16.4211    1.3000          0.             14.634             .16227E-03       .22980E-03
 18   17.4474    1.3000          0.             15.660             .11249E-03       .33410E-04
```

Figure 18.- Continued.

```
19   18.4737      1.3000         0.            16.686          .79559E-04     -.67235E-04
20   19.5000      1.3000         0.            17.713          .57218E-04     -.10629E-03
21   20.5263      1.3000         0.            18.739          .41794E-04     -.10993E-03
22   21.5526      1.3000         0.            19.765          .30961E-04     -.95708E-04
23   22.5789      1.3000         0.            20.792          .23236E-04     -.75192E-04
24   23.6053      1.3000         0.            21.818          .17650E-04     -.54633E-04
25   24.6316      1.3000         0.            22.844          .13558E-04     -.37078E-04
26   25.6579      1.3000         0.            23.871          .10525E-04     -.23532E-04
27   26.6842      1.3000         0.            24.897          .82509E-05     -.13675E-04
28   27.7105      1.3000         0.            25.923          .65280E-05     -.74713E-05
29   28.7368      1.3000         0.            26.950          .52100E-05     -.35327E-05
30   29.7632      1.3000         0.            27.976          .41922E-05     -.13202E-05
31   30.7895      1.3000         0.            29.002          .33993E-05     -.22844E-06
32   31.8158      1.3000         0.            30.029          .27766E-05      .19378E-06
33   32.8421      1.3000         0.            31.055          .22835E-05      .25675E-06
34   33.8684      1.3000         0.            32.081          .16903E-05      .15784E-06
35   34.8947      1.3000         0.            33.108          .15745E-05      .11691E-07
36   35.9211      1.3000         0.            34.134          .13191E-05     -.12295E-06
37   36.9474      1.3000         0.            35.160          .11112E-05     -.22221E-06
38   37.9737      1.3000         0.            36.186          .94102E-06     -.28188E-06
39   39.0000      1.3000         0.            37.213          0.              0.

        POINT COORDINATES AND PERTURBATION VELOCITIES CALCULATED BY PROGRAM VPATH2

 IC       XCP           YCP          ZCP          VVEL(IC)        WVEL(IC)

  1    36.63100       1.53100      0.00000      .22541E-01     -.74105E-01
  2    37.78700       1.53100      0.00000      .19927E-01     -.67006E-01
  3    38.94200       1.53100      0.00000      .17798E-01     -.61175E-01
  4    36.81600       1.99870      0.00000      .41619E-01     -.45614E-01
  5    37.88100       1.99870      0.00000      .37375E-01     -.42293E-01
  6    38.94700       1.99870      0.00000      .33959E-01     -.39479E-01
  7    37.00000       2.46640      0.00000      .44308E-01     -.26003E-01
  8    37.97600       2.46640      0.00000      .40555E-01     -.25016E-01
  9    38.95100       2.46640      0.00000      .37344E-01     -.24108E-01
 10    37.18500       2.93400      0.00000      .40999E-01     -.13556E-01
 11    38.07000       2.93400      0.00000      .38258E-01     -.13699E-01
 12    38.95600       2.93400      0.00000      .35851E-01     -.13763E-01
 13    37.36900       3.40160      0.00000      .36017E-01     -.60080E-02
 14    38.16500       3.40160      0.00000      .34184E-01     -.65582E-02
 15    38.96000       3.40160      0.00000      .32528E-01     -.70081E-02
 16    36.63100      -1.53100      0.00000      .25922E-01     -.24335E+00
 17    37.78700      -1.53100      0.00000      .24109E-01     -.25303E+00
 18    38.94200      -1.53100      0.00000      .19507E-01     -.25801E+00
 19    36.81600      -1.99870      0.00000      .51219E-01     -.17161E+00
 20    37.88100      -1.99870      0.00000      .53408E-01     -.18545E+00
 21    38.94700      -1.99870      0.00000      .48996E-01     -.19858E+00
 22    37.00000      -2.46640      0.00000      .59843E-01     -.91572E-01
 23    37.97600      -2.46640      0.00000      .74149E-01     -.10355E+00
 24    38.95100      -2.46640      0.00000      .84330E-01     -.12168E+00
 25    37.18500      -2.93400      0.00000      .56495E-01     -.21821E-01
 26    38.07000      -2.93400      0.00000      .75910E-01     -.23056E-01
 27    38.95600      -2.93400      0.00000      .98558E-01     -.29250E-01
 28    37.36900      -3.40160      0.00000      .43943E-01      .14325E-01
 29    38.16500      -3.40160      0.00000      .57886E-01      .19927E-01
 30    38.96000      -3.40160      0.00000      .74961E-01      .25394E-01
 31    36.63100        .00000      1.53100      .24338E+00     -.25911E-01
 32    37.78700        .00000      1.53100      .25305E+00     -.24092E-01
```

Figure 18.- Continued.

```
33    38.94200     .00000     1.53100    .25802E+00   -.19486E-01
34    36.81600     .00000     1.99870    .17165E+00   -.51210E-01
35    37.88100     .00000     1.99870    .18549E+00   -.53383E-01
36    38.94700     .00000     1.99870    .19861E+00   -.48956E-01
37    37.00000     .00000     2.46640    .91616E-01   -.59462E-01
38    37.97600     .00000     2.46640    .10360E+00   -.74159E-01
39    38.95100     .00000     2.46640    .12174E+00   -.84319E-01
40    37.18500     .00000     2.93400    .21847E-01   -.56537E-01
41    38.07000     .00000     2.93400    .23094E-01   -.75960E-01
42    38.95600     .00000     2.93400    .29311E-01   -.98610E-01
43    37.36900     .00000     3.40160   -.14321E-01   -.44031E-01
44    38.16500     .00000     3.40160   -.19920E-01   -.57935E-01
45    38.96000     .00000     3.40160   -.25385E-01   -.75025E-01
46    36.63100    -.00000    -1.53100    .74107E-01   -.22546E-01
47    37.78700    -.00000    -1.53100    .67006E-01   -.19931E-01
48    38.94200    -.00000    -1.53100    .61173E-01   -.17801E-01
49    36.81600    -.00000    -1.99870    .45611E-01   -.41626E-01
50    37.88100    -.00000    -1.99870    .42289E-01   -.37381E-01
51    38.94700    -.00000    -1.99870    .39475E-01   -.33864E-01
52    37.00000    -.00000    -2.46640    .25997E-01   -.44314E-01
53    37.97600    -.00000    -2.46640    .25009E-01   -.40561E-01
54    38.95100    -.00000    -2.46640    .24101E-01   -.37368E-01
55    37.18500    -.00000    -2.93400    .13548E-01   -.41002E-01
56    38.07000    -.00000    -2.93400    .13692E-01   -.38261E-01
57    38.95600    -.00000    -2.93400    .13756E-01   -.35854E-01
58    37.36900    -.00000    -3.40160    .60006E-02   -.36018E-01
59    38.16500    -.00000    -3.40160    .65510E-02   -.34185E-01
60    38.96000    -.00000    -3.40160    .70012E-02   -.32529E-01
61    36.54000    1.25050      .24874    .21274E-01   -.12873E+00
62    36.54000    1.06010      .70836    .12767E+00   -.20246E+00
63    36.54000     .70836     1.06010    .28783E+00   -.19570E+00
64    36.54000     .24874     1.25050    .32366E+00   -.60836E-01
65    36.54000    -.24874     1.25050    .24801E+00    .53505E-01
66    36.54000    -.70836     1.06010    .91774E-01    .73741E-01
67    36.54000   -1.06010      .70836   -.73710E-01   -.91728E-01
68    36.54000   -1.25050      .24874   -.53496E-01   -.24796E+00
69    36.54000   -1.25050     -.24874    .60831E-01   -.32364E+00
70    36.54000   -1.06010     -.70836    .19573E+00   -.28788E+00
71    36.54000    -.70836    -1.06010    .20250E+00   -.12770E+00
72    36.54000    -.24874    -1.25050    .12975E+00   -.21275E-01
73    36.54000     .24874    -1.25050    .61400E-01    .14860E-01
74    36.54000     .70836    -1.06010    .14602E-01    .12062E-01
75    36.54000    1.06010     -.70836   -.12066E-01   -.14607E-01
76    36.54000    1.25050     -.24874   -.14860E-01   -.61401E-01
77    37.74000    1.25050      .24874    .19040E-01   -.11463E+00
78    37.74000    1.06010      .70836    .11255E+00   -.17859E+00
79    37.74000     .70836     1.06010    .26421E+00   -.18126E+00
80    37.74000     .24874     1.25050    .32649E+00   -.62557E-01
81    37.74000    -.24874     1.25050    .25853E+00    .55706E-01
82    37.74000    -.70836     1.06010    .95893E-01    .77032E-01
83    37.74000   -1.06010      .70836   -.76997E-01   -.95441E-01
84    37.74000   -1.25050      .24874   -.55699E-01   -.25849E+00
85    37.74000   -1.25050     -.24874    .62555E-01   -.32650E+00
86    37.74000   -1.06010     -.70836    .18130E+00   -.26427E+00
87    37.74000    -.70836    -1.06010    .17862E+00   -.11257E+00
88    37.74000    -.24874    -1.25050    .11464E+00   -.19041E-01
89    37.74000     .24874    -1.25050    .55514E-01    .13401E-01
90    37.74000     .70836    -1.06010    .13307E-01    .10989E-01
```

Figure 18.- Continued.

```
 91    37.74000     1.06010     -.70836    -.10093E-01   -.13314E-01
 92    37.74000     1.25050     -.24874    -.13401E-01   -.55518E-01
 93    38.94000     1.25050      .24874     .17227E-01   -.10318E+00
 94    38.94000     1.06010      .70836     .99922E-01   -.15845E+00
 95    38.94000      .70836     1.06010     .23901E+00   -.16495E+00
 96    38.94000      .24874     1.25050     .31998E+00   -.62611E-01
 97    38.94000     -.24874     1.25050     .26666E+00    .57132E-01
 98    38.94000     -.70836     1.06010     .10028E+00    .80495E-01
 99    38.94000    -1.06010      .70836    -.80458E-01   -.10022E+00
100    38.94000    -1.25050      .24874    -.57127E-01   -.26662E+00
101    38.94000    -1.25050     -.24874     .62613E-01   -.32000E+00
102    38.94000    -1.06010     -.70836     .16499E+00   -.23906E+00
103    38.94000     -.70836    -1.06010     .15848E+00   -.49937E-01
104    38.94000     -.24874    -1.25050     .10318E+00   -.17227E-01
105    38.94000      .24874    -1.25050     .50709E-01    .12211E-01
106    38.94000      .70836    -1.06010     .12245E-01    .10108E-01
107    38.94000     1.06010     -.70836    -.10113E-01   -.12252E-01
108    38.94000     1.25050     -.24874    -.12212E-01   -.50714E-01
109    25.14500     1.27500      .25362     .51894E-01   -.26088E+00
110    25.14500     1.20100      .49749     .98361E-01   -.23745E+00
111    25.14500     1.08090      .72224     .13105E+00   -.19612E+00
112    25.14500      .91924      .91924     .15447E+00   -.15447E+00
113    25.14500      .72224     1.08090     .17758E+00   -.11865E+00
114    25.14500      .49749     1.20100     .20820E+00   -.86245E-01
115    25.14500      .25362     1.27500     .25233E+00   -.50196E-01
116    25.14500     -.00000     1.30000     .31195E+00    .11188E-09
117    25.14500     -.25362     1.27500     .35000E+00    .72225E-01
118    25.14500     -.49749     1.20100     .32579E+00    .13497E+00
119    25.14500     -.72224     1.08090     .17191E+00    .11488E+00
120    25.14500     -.91924      .91924     .21260E-04    .19278E-04
121    25.14500    -1.08090      .72224    -.11485E+00   -.17187E+00
122    25.14500    -1.20100      .49749    -.13496E+00   -.32577E+00
123    25.14500    -1.27500      .25362    -.72226E-01   -.35000E+00
124    25.14500    -1.30000     -.00000     .22377E-09   -.31196E+00
125    25.14500    -1.27500     -.25362     .50195E-01   -.25232E+00
126    25.14500    -1.20100     -.49749     .86241E-01   -.20819E+00
127    25.14500    -1.08090     -.72224     .11865E+00   -.17757E+00
128    25.14500     -.91924     -.91924     .15445E+00   -.15445E+00
129    25.14500     -.72224    -1.08090     .19610E+00   -.13103E+00
130    25.14500     -.49749    -1.20100     .23743E+00   -.98352E-01
131    25.14500     -.25362    -1.27500     .26088E+00   -.51893E-01
132    25.14500      .00000    -1.30000     .24729E+00    .26608E-09
133    25.14500      .25362    -1.27500     .19580E+00    .38953E-01
134    25.14500      .49749    -1.20100     .12534E+00    .51932E-01
135    25.14500      .72224    -1.08090     .56213E-01    .37564E-01
136    25.14500      .91924     -.91924     .18554E-04    .17729E-04
137    25.14500     1.08090     -.72224    -.37535E-01   -.56170E-01
138    25.14500     1.20100     -.49749    -.51913E-01   -.12530E+00
139    25.14500     1.27500     -.25362    -.38944E-01   -.19576E+00
140    25.14500     1.30000      .00000     .35473E-09   -.24726E+00
141    27.19700     1.27500      .25362     .57843E-01   -.29080E+00
142    27.19700     1.20100      .49749     .11538E+00   -.27853E+00
143    27.19700     1.08090      .72224     .15419E+00   -.23075E+00
144    27.19700      .91924      .91924     .17505E+00   -.17505E+00
145    27.19700      .72224     1.08090     .18984E+00   -.12685E+00
146    27.19700      .49749     1.20100     .20942E+00   -.86749E-01
147    27.19700      .25362     1.27500     .24021E+00   -.47784E-01
148    27.19700     -.00000     1.30000     .28172E+00    .10104E-09
```

Figure 18.- Continued.

```
149    27.19700    -.25362    1.27500    .31289E+00    .62238E-01
150    27.19700    -.49749    1.20100    .27791E+00    .11513E+00
151    27.19700    -.72224    1.08090    .15109E+00    .10096E+00
152    27.19700    -.91924     .91924    .15788E-04    .13993E-04
153    27.19700   -1.08090     .72224   -.10095E+00   -.15106E+00
154    27.19700   -1.20100     .49749   -.11512E+00   -.27789E+00
155    27.19700   -1.27500     .25362   -.62237E-01   -.31289E+00
156    27.19700   -1.30000    -.00000    .20208E-09   -.28172E+00
157    27.19700   -1.27500    -.25362    .47781E-01   -.24019E+00
158    27.19700   -1.20100    -.49749    .86740E-01   -.20940E+00
159    27.19700   -1.08090    -.72224    .12683E+00   -.18982E+00
160    27.19700    -.91924    -.91924    .17503E+00   -.17503E+00
161    27.19700    -.72224   -1.08090    .23072E+00   -.15416E+00
162    27.19700    -.49749   -1.20100    .27852E+00   -.11537E+00
163    27.19700    -.25362   -1.27500    .29092E+00   -.57847E-01
164    27.19700     .00000   -1.30000    .25424E+00    .27356E-09
165    27.19700     .25362   -1.27500    .18610E+00    .37032E-01
166    27.19700     .49749   -1.20100    .11272E+00    .46701E-01
167    27.19700     .72224   -1.08090    .49035E-01    .32767E-01
168    27.19700     .91924    -.91924    .16423E-04    .15883E-04
169    27.19700    1.08090    -.72224   -.32741E-01   -.48996E-01
170    27.19700    1.20100    -.49749   -.46681E-01   -.11267E+00
171    27.19700    1.27500    -.25362   -.37021E-01   -.18608E+00
172    27.19700    1.30000     .00000    .36467E-09   -.25419E+00
173    29.25000    1.27500     .25362    .57819E-01   -.29069E+00
174    29.25000    1.20100     .49749    .12823E+00   -.30958E+00
175    29.25000    1.08090     .72224    .18263E+00   -.27333E+00
176    29.25000     .91924     .91924    .20763E+00   -.20763E+00
177    29.25000     .72224    1.08090    .21495E+00   -.14362E+00
178    29.25000     .49749    1.20100    .22124E+00   -.91664E-01
179    29.25000     .25362    1.27500    .23612E+00   -.46969E-01
180    29.25000    -.00000    1.30000    .25921E+00    .92466E-10
181    29.25000    -.25362    1.27500    .27333E+00    .54364E-01
182    29.25000    -.49749    1.20100    .23805E+00    .98619E-01
183    29.25000    -.72224    1.08090    .13121E+00    .87680E-01
184    29.25000    -.91924     .91924    .12532E-04    .10972E-04
185    29.25000   -1.08090     .72224   -.87644E-01   -.13119E+00
186    29.25000   -1.20100     .49749   -.98611E-01   -.23804E+00
187    29.25000   -1.27500     .25362   -.54366E-01   -.27331E+00
188    29.25000   -1.30000    -.00000    .18592E-09   -.25919E+00
189    29.25000   -1.27500    -.25362    .46963E-01   -.23609E+00
190    29.25000   -1.20100    -.49749    .91648E-01   -.22125E+00
191    29.25000   -1.08090    -.72224    .14360E+00   -.21491E+00
192    29.25000    -.91924    -.91924    .20759E+00   -.20759E+00
193    29.25000    -.72224   -1.08090    .27331E+00   -.18262E+00
194    29.25000    -.49749   -1.20100    .30950E+00   -.12824E+00
195    29.25000    -.25362   -1.27500    .29075E+00   -.57831E-01
196    29.25000     .00000   -1.30000    .22939E+00    .24683E-09
197    29.25000     .25362   -1.27500    .15455E+00    .31141E-01
198    29.25000     .49749   -1.20100    .91104E-01    .37785E-01
199    29.25000     .72224   -1.08090    .38978E-01    .26047E-01
200    29.25000     .91924    -.91924    .11744E-04    .11317E-04
201    29.25000    1.08090    -.72224   -.26027E-01   -.38949E-01
202    29.25000    1.20100    -.49749   -.37768E-01   -.91154E-01
203    29.25000    1.27500    -.25362   -.31130E-01   -.15647E+00
204    29.25000    1.30000     .00000    .32900E-09   -.22933E+00
205    31.30300    1.27500     .25362    .49546E-01   -.24911E+00
206    31.30300    1.20100     .49749    .12370E+00   -.29865E+00
207    31.30300    1.08090     .72224    .20006E+00   -.29940E+00
```

Figure 18.- Continued.

```
208    31.30300     .91924     .91924    .24551E+00   -.24551E+00
209    31.30300     .72224    1.08090    .25475E+00   -.17021E+00
210    31.30300     .49749    1.20100    .24885E+00   -.10308E+00
211    31.30300     .25362    1.27500    .24583E+00   -.48904E-01
212    31.30300    -.00000    1.30000    .24957E+00    .84510E-10
213    31.30300    -.25362    1.27500    .24707E+00    .49147E-01
214    31.30300    -.49749    1.20100    .20811E+00    .86214E-01
215    31.30300    -.72224    1.08090    .11440E+00    .76448E-01
216    31.30300    -.91924     .91924    .12027E-04    .10661E-04
217    31.30300   -1.08090     .72224   -.76431E-01   -.11438E+00
218    31.30300   -1.20100     .49749   -.66203E-01   -.20808E+00
219    31.30300   -1.27500     .25362   -.49141E-01   -.24704E+00
220    31.30300   -1.30000    -.00000    .17809E-09   -.24954E+00
221    31.30300   -1.27500    -.25362    .48891E-01   -.24579E+00
222    31.30300   -1.20100    -.49749    .10306E+00   -.24880E+00
223    31.30300   -1.08090    -.72224    .17019E+00   -.25470E+00
224    31.30300    -.91924    -.91924    .24549E+00   -.24549E+00
225    31.30300    -.72224   -1.08090    .29903E+00   -.20007E+00
226    31.30300    -.49749   -1.20100    .29872E+00   -.12373E+00
227    31.30300    -.25362   -1.27500    .24918E+00   -.49560E-01
228    31.30300     .00000   -1.30000    .18250E+00    .19637E-09
229    31.30300     .25362   -1.27500    .12022E+00    .23916E-01
230    31.30300     .49749   -1.20100    .69124E-01    .28640E-01
231    31.30300     .72224   -1.08090    .29432E-01    .19668E-01
232    31.30300     .91924    -.91924    .62402E-05    .59178E-05
233    31.30300    1.08090    -.72224   -.19657E-01   -.29416E-01
234    31.30300    1.20100    -.49749   -.28631E-01   -.69101E-01
235    31.30300    1.27500    -.25362   -.23911E-01   -.12018E+00
236    31.30300    1.30000     .00000    .26173E-09   -.18244E+00

237    33.35500    1.27500     .25362    .38101E-01   -.19157E+00
238    33.35500    1.20100     .49749    .10175E+00   -.24562E+00
239    33.35500    1.08090     .72224    .18542E+00   -.27750E+00
240    33.35500     .91924     .91924    .26061E+00   -.26061E+00
241    33.35500     .72224    1.08090    .29458E+00   -.19683E+00
242    33.35500     .49749    1.20100    .28977E+00   -.12003E+00
243    33.35500     .25362    1.27500    .27176E+00   -.54056E-01
244    33.35500    -.00000    1.30000    .25552E+00    .91645E-10
245    33.35500    -.25362    1.27500    .23542E+00    .46831E-01
246    33.35500    -.49749    1.20100    .18926E+00    .78408E-01
247    33.35500    -.72224    1.08090    .10231E+00    .58364E-01
248    33.35500    -.91924     .91924    .14117E-04    .12898E-04
249    33.35500   -1.08090     .72224   -.68343E-01   -.10227E+00
250    33.35500   -1.20100     .49749   -.78393E-01   -.18923E+00
251    33.35500   -1.27500     .25362   -.46922E-01   -.23538E+00
252    33.35500   -1.30000    -.00000    .18325E-09   -.25548E+00
253    33.35500   -1.27500    -.25362    .54046E-01   -.27171E+00
254    33.35500   -1.20100    -.49749    .12001E+00   -.28973E+00
255    33.35500   -1.08090    -.72224    .19682E+00   -.29457E+00
256    33.35500    -.91924    -.91924    .26064E+00   -.26064E+00
257    33.35500    -.72224   -1.08090    .27756E+00   -.18546E+00
258    33.35500    -.49749   -1.20100    .24568E+00   -.10176E+00
259    33.35500    -.25362   -1.27500    .19162E+00   -.38111E-01
260    33.35500     .00000   -1.30000    .13694E+00    .14734E-09
261    33.35500     .25362   -1.27500    .89920E-01    .17890E-01
262    33.35500     .49749   -1.20100    .51906E-01    .21507E-01
263    33.35500     .72224   -1.08090    .22193E-01    .14830E-01
264    33.35500     .91924    -.91924    .16726E-05    .14291E-05
265    33.35500    1.08090    -.72224   -.14827E-01   -.22188E-01
```

Figure 18.- Continued.

```
266     33.35500      1.20100      -.49749    -.21503E-01    -.51898E-01
267     33.35500      1.27500      -.25362    -.17887E-01    -.89904E-01
268     33.35500      1.30000       .00000     .19641E-09    -.13690E+00


                          PRESSURE COEFFICIENTS AT POINTS ON BODY MERIDIANS


 J     THETA,       XB          YB          ZB          UTOT        VTOT        WTOT      CP,LIN.     CP,BERN.     DR/DX       P/PINF,      P/PINF,
        DEG.                                                                                                                      BERN.        LIN.


            TOTAL NUMBER OF PRESSURE POINTS,JCPT=  268


                                               BODY RING=  13

 1  11.25000  25.14474   1.27502    .25362    .00178    .14660   -.03041   -.00356    .03653   0.00000   1.07390    .99279
 2  22.50000  25.14474   1.20104    .49749    .00176    .09783    .01196   -.00352    .01690   0.00000   1.03419    .99289
 3  33.75000  25.14474   1.08091    .72224    .00173    .03527    .03435   -.00347   -.00544   0.00000    .98899    .99299
 4  45.00000  25.14474    .91924    .91924    .00171   -.02205    .02205   -.00342   -.01932   0.00000    .96091    .99309
 5  56.25000  25.14474    .72224   1.08091    .00168   -.05289   -.02288   -.00337   -.01680   0.00000    .96602    .99319
 6  67.50000  25.14474    .49749   1.20104    .00166   -.04121   -.08571   -.00332    .00320   0.00000   1.00647    .99329
 7  78.75000  25.14474    .25362   1.27502    .00164    .02186   -.14490   -.00327    .03408   0.00000   1.06894    .99338
 8  90.00000  25.14474   -.00000   1.30000    .00162    .13545   -.17544   -.00323    .05799   0.00000   1.11731    .99346
 9 101.25000  25.14474   -.25362   1.27502    .00160    .25422   -.15717   -.00320    .05231   0.00000   1.10582    .99353
10 112.50000  25.14474   -.49749   1.20104    .00159    .32525   -.11337   -.00317    .03129   0.00000   1.06331    .99358
11 123.75000  25.14474   -.72224   1.08091    .00158    .26661   -.11451   -.00316    .04659   0.00000   1.09426    .99361
12 135.00000  25.14474   -.91924    .91924    .00158    .17547   -.17543   -.00315    .05965   0.00000   1.12067    .99362
13 146.25000  25.14474  -1.08091    .72224    .00158    .11454   -.26657   -.00316    .04660   0.00000   1.09428    .99361
14 157.50000  25.14474  -1.20104    .49749    .00159    .11339   -.32523   -.00317    .03130   0.00000   1.06332    .99358
15 168.75000  25.14474  -1.27502    .25362    .00160    .15717   -.25422   -.00320    .05231   0.00000   1.10582    .99353
16 180.00000  25.14474  -1.30000   -.00000    .00162    .17544   -.13544   -.00323    .05799   0.00000   1.11731    .99346
17 191.25000  25.14474  -1.27502   -.25362    .00164    .14490   -.02185   -.00327    .03407   0.00000   1.06893    .99338
18 202.50000  25.14474  -1.20104   -.49749    .00166    .08571    .04122   -.00332    .00320   0.00000   1.00646    .99329
19 213.75000  25.14474  -1.08091   -.72224    .00168    .02287    .05290   -.00337   -.01680   0.00000    .96600    .99319
20 225.00000  25.14474   -.91924   -.91924    .00171   -.02207    .02207   -.00342   -.01934   0.00000    .96088    .99309
21 236.25000  25.14474   -.72224  -1.08091    .00173   -.03437   -.03525   -.00347   -.00546   0.00000    .98896    .99299
22 247.50000  25.14474   -.49749  -1.20104    .00176   -.01198   -.09782   -.00352    .01689   0.00000   1.03417    .99289
23 258.75000  25.14474   -.25362  -1.27502    .00178    .03041   -.14660   -.00356    .03653   0.00000   1.07390    .99279
24 270.00000  25.14474    .00000  -1.30000    .00180    .07077   -.17544   -.00360    .04779   0.00000   1.09668    .99271
25 281.25000  25.14474    .25362  -1.27502    .00182    .10002   -.19044   -.00363    .05299   0.00000   1.10720    .99265
26 292.50000  25.14474    .49749  -1.20104    .00183    .12480   -.19641   -.00366    .05598   0.00000   1.11326    .99260
27 303.75000  25.14474    .72224  -1.08091    .00184    .15092   -.19183   -.00367    .05819   0.00000   1.11772    .99257
28 315.00000  25.14474    .91924   -.91924    .00184    .17546   -.17543   -.00368    .05910   0.00000   1.11955    .99256
29 326.25000  25.14474   1.08091   -.72224    .00184    .19186   -.15087   -.00367    .05819   0.00000   1.11771    .99257
30 337.50000  25.14474   1.20104   -.49749    .00183    .19643   -.12476   -.00366    .05598   0.00000   1.11324    .99260
31 348.75000  25.14474   1.27502   -.25362    .00182    .19045   -.09998   -.00363    .05299   0.00000   1.10719    .99265
32 360.00000  25.14474   1.30000    .00000    .00180    .17544   -.07074   -.00360    .04779   0.00000   1.09667    .99271

                                               BODY RING=  14

 1  11.25000  27.19737   1.27502    .25362    .00147    .15258   -.06048   -.00293    .04564   0.00000   1.09233    .99406
 2  22.50000  27.19737   1.20104    .49749    .00145    .11491   -.02928   -.00290    .03401   0.00000   1.06880    .99414
 3  33.75000  27.19737   1.08091    .72224    .00143    .05851   -.00043   -.00286    .01443   0.00000   1.02918    .99422
 4  45.00000  27.19737    .91924    .91924    .00141   -.00134    .00134   -.00281   -.00365   0.00000    .99261    .99431
```

Figure 18.- Continued.

```
 5  56.25000  27.19737    .72224   1.08091    .00138  -.00408  -.03117  -.00277  -.00848  0.00000   .98285   .99440
 6  67.50000  27.19737    .49749   1.20104    .00136  -.03983  -.08628  -.00273   .00447  0.00000  1.00904   .99448
 7  78.75000  27.19737    .25362   1.27502    .00135   .00989  -.14252  -.00269   .03057  0.00000  1.06183   .99456
 8  90.00000  27.19737   -.00000   1.30000    .00133   .10533  -.17544  -.00266   .05513  0.00000  1.11152   .99462
 9 101.25000  27.19737   -.25362   1.27502    .00132   .21721  -.16714  -.00263   .05810  0.00000  1.11755   .99468
10 112.50000  27.19737   -.49749   1.20104    .00130   .27744  -.13318  -.00261   .04687  0.00000  1.09483   .99472
11 123.75000  27.19737   -.72224   1.08091    .00130   .24582  -.12841  -.00260   .05241  0.00000  1.10602   .99475
12 135.00000  27.19737   -.91924    .91924    .00130   .17546  -.17543  -.00259   .06024  0.00000  1.12186   .99475
13 146.25000  27.19737  -1.08091    .72224    .00130   .12842  -.24579  -.00260   .05241  0.00000  1.10603   .99475
14 157.50000  27.19737  -1.20104    .49749    .00130   .13319  -.27742  -.00261   .04688  0.00000  1.09484   .99472
15 168.75000  27.19737  -1.27502    .25362    .00132   .16714  -.21721  -.00263   .05810  0.00000  1.11755   .99468
16 180.00000  27.19737  -1.30000   -.00000    .00133   .17544  -.10533  -.00266   .05513  0.00000  1.11152   .99462
17 191.25000  27.19737  -1.27502   -.25362    .00135   .14251  -.00987  -.00269   .03056  0.00000  1.06182   .99456
18 202.50000  27.19737  -1.20104   -.49749    .00136   .08627   .03985  -.00273   .00446  0.00000  1.00902   .99448
19 213.75000  27.19737  -1.08091   -.72224    .00138   .03115   .04050  -.00277  -.00849  0.00000   .98283   .99440
20 225.00000  27.19737   -.91924   -.91924    .00141  -.00136   .00136  -.00281  -.00367  0.00000   .99259   .99431
21 236.25000  27.19737   -.72224  -1.08091    .00143   .00040  -.05848  -.00286   .01441  0.00000  1.02915   .99422
22 247.50000  27.19737   -.49749  -1.20104    .00145   .02927  -.11490  -.00290   .03400  0.00000  1.06879   .99414
23 258.75000  27.19737   -.25362  -1.27502    .00147   .06050  -.15258  -.00293   .04565  0.00000  1.09234   .99406
24 270.00000  27.19737    .00000  -1.30000    .00148   .07785  -.17544  -.00297   .04995  0.00000  1.10106   .99400
25 281.25000  27.19737    .25362  -1.27502    .00150   .09046  -.19234  -.00300   .05198  0.00000  1.10515   .99394
26 292.50000  27.19737    .49749  -1.20104    .00151   .11225  -.20161  -.00302   .05488  0.00000  1.11102   .99390
27 303.75000  27.19737    .72224  -1.08091    .00151   .14377  -.19661  -.00303   .05825  0.00000  1.11784   .99387
28 315.00000  27.19737    .91924   -.91924    .00152   .17546  -.17543  -.00303   .05978  0.00000  1.12093   .99387
29 326.25000  27.19737   1.08091   -.72224    .00151   .19663  -.14373  -.00303   .05825  0.00000  1.11783   .99387
30 337.50000  27.19737   1.20104   -.49749    .00151   .20163  -.11220  -.00302   .05487  0.00000  1.11100   .99390
31 348.75000  27.19737   1.27502   -.25362    .00150   .19235  -.09040  -.00300   .05196  0.00000  1.10512   .99394
32 360.00000  27.19737   1.30000    .00000    .00148   .17544  -.07780  -.00297   .04994  0.00000  1.10104   .99400

                                             BODY RING=  15

 1  11.25000  29.25000   1.27502    .25362    .00123   .15258  -.06051  -.00247   .04613  0.00000  1.09332   .99501
 2  22.50000  29.25000   1.20104    .49749    .00122   .12782  -.06047  -.00243   .04439  0.00000  1.08981   .99508
 3  33.75000  29.25000   1.08091    .72224    .00120   .08704  -.04315  -.00239   .03427  0.00000  1.06933   .99516
 4  45.00000  29.25000    .91924    .91924    .00118   .03136  -.03136  -.00235   .01775  0.00000  1.03592   .99524
 5  56.25000  29.25000    .72224   1.08091    .00116  -.01523  -.04803  -.00232   .00664  0.00000  1.01343   .99532
 6  67.50000  29.25000    .49749   1.20104    .00114  -.02782  -.09125  -.00228   .01080  0.00000  1.02185   .99539
 7  78.75000  29.25000    .25362   1.27502    .00112   .00594  -.14173  -.00224   .02960  0.00000  1.05988   .99546
 8  90.00000  29.25000   -.00000   1.30000    .00111   .08294  -.17544  -.00221   .05176  0.00000  1.10471   .99552
 9 101.25000  29.25000   -.25362   1.27502    .00109   .17774  -.17499  -.00219   .06065  0.00000  1.12270   .99557
10 112.50000  29.25000   -.49749   1.20104    .00108   .23764  -.14967  -.00217   .05564  0.00000  1.11256   .99561
11 123.75000  29.25000   -.72224   1.08091    .00108   .22597  -.14168  -.00216   .05663  0.00000  1.11457   .99563
12 135.00000  29.25000   -.91924    .91924    .00108   .17546  -.17543  -.00215   .06070  0.00000  1.12280   .99564
13 146.25000  29.25000  -1.08091    .72224    .00108   .14169  -.22595  -.00216   .05664  0.00000  1.11457   .99563
14 157.50000  29.25000  -1.20104    .49749    .00108   .14968  -.23763  -.00217   .05564  0.00000  1.11256   .99561
15 168.75000  29.25000  -1.27502    .25362    .00109   .17499  -.17772  -.00219   .06065  0.00000  1.12270   .99557
16 180.00000  29.25000  -1.30000   -.00000    .00111   .17544  -.08292  -.00221   .05175  0.00000  1.10470   .99552
17 191.25000  29.25000  -1.27502   -.25362    .00112   .14172  -.00591  -.00224   .02959  0.00000  1.05986   .99546
18 202.50000  29.25000  -1.20104   -.49749    .00114   .09123   .02786  -.00228   .01078  0.00000  1.02181   .99539
19 213.75000  29.25000  -1.08091   -.72224    .00116   .04801   .01527  -.00232   .00662  0.00000  1.01339   .99532
20 225.00000  29.25000   -.91924   -.91924    .00118   .03132  -.03132  -.00235   .01773  0.00000  1.03587   .99524
21 236.25000  29.25000   -.72224  -1.08091    .00120   .04313  -.08703  -.00239   .03426  0.00000  1.06932   .99516
22 247.50000  29.25000   -.49749  -1.20104    .00122   .06049  -.12783  -.00243   .04440  0.00000  1.08982   .99508
23 258.75000  29.25000   -.25362  -1.27502    .00123   .06057  -.15259  -.00247   .04615  0.00000  1.09336   .99501
24 270.00000  29.25000    .00000  -1.30000    .00125   .05312  -.17544  -.00250   .04473  0.00000  1.09049   .99495
25 281.25000  29.25000    .25362  -1.27502    .00126   .06094  -.19821  -.00252   .04601  0.00000  1.09308   .99490
26 292.50000  29.25000    .49749  -1.20104    .00127   .09078  -.21050  -.00254   .05142  0.00000  1.10403   .99486
27 303.75000  29.25000    .72224  -1.08091    .00128   .13374  -.20331  -.00255   .05761  0.00000  1.11655   .99484
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Figure 18.- Continued.

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28 315.00000   29.25000     .91924    -.91924     .00128    .17546   -.17543   -.00256     .06028   0.00000   1.12195    .99483
29 326.25000   29.25000    1.08091    -.72224     .00128    .20333   -.13371   -.00255     .05761   0.00000   1.11654    .99484
30 337.50000   29.25000    1.20104    -.49749     .00127    .21052   -.09074   -.00254     .05142   0.00000   1.10401    .99486
31 348.75000   29.25000    1.27502    -.25362     .00126    .19823   -.06088   -.00252     .04599   0.00000   1.09305    .99490
32 360.00000   29.25000    1.30000     .00000     .00125    .17544   -.05306   -.00250     .04472   0.00000   1.09046    .99495

                                        BODY RING=  16

 1  11.25000   31.30263    1.27502     .25362     .00105    .14435   -.01905   -.00210     .03433   0.00000   1.06945    .99575
 2  22.50000   31.30263    1.20104     .49749     .00103    .12334   -.04966   -.00207     .04159   0.00000   1.08414    .99582
 3  33.75000   31.30263    1.08091     .72224     .00102    .10456   -.06934   -.00203     .04401   0.00000   1.08904    .99588
 4  45.00000   31.30263     .91924     .91924     .00100    .06935   -.06935   -.00200     .03759   0.00000   1.07604    .99596
 5  56.25000   31.30263     .72224    1.08091     .00098    .02469   -.07471   -.00196     .02693   0.00000   1.05448    .99603
 6  67.50000   31.30263     .49749    1.20104     .00097   -.00014   -.10272   -.00193     .02360   0.00000   1.04773    .99609
 7  78.75000   31.30263     .25362    1.27502     .00095    .01577   -.14568   -.00190     .03342   0.00000   1.06761    .99616
 8  90.00000   31.30263    -.00000    1.30000     .00094    .07341   -.17544   -.00187     .05016   0.00000   1.10147    .99621
 9 101.25000   31.30263    -.25362    1.27502     .00093    .15157   -.18019   -.00185     .06045   0.00000   1.12230    .99626
10 112.50000   31.30263    -.49749    1.20104     .00092    .20775   -.16205   -.00183     .05964   0.00000   1.12065    .99629
11 123.75000   31.30263    -.72224    1.08091     .00091    .20918   -.15289   -.00182     .05922   0.00000   1.11980    .99631
12 135.00000   31.30263    -.91924     .91924     .00091    .17546   -.17543   -.00182     .06105   0.00000   1.12351    .99632
13 146.25000   31.30263   -1.08091     .72224     .00091    .15291   -.20916   -.00182     .05922   0.00000   1.11980    .99631
14 157.50000   31.30263   -1.20104     .49749     .00092    .16206   -.20772   -.00183     .05964   0.00000   1.12065    .99629
15 168.75000   31.30263   -1.27502     .25362     .00093    .18020   -.15154   -.00185     .06045   0.00000   1.12229    .99626
16 180.00000   31.30263   -1.30000    -.00000     .00094    .17544   -.07338   -.00187     .05015   0.00000   1.10146    .99621
17 191.25000   31.30263   -1.27502    -.25362     .00095    .14568   -.01573   -.00190     .03341   0.00000   1.06758    .99616
18 202.50000   31.30263   -1.20104    -.49749     .00097    .10270    .00019   -.00193     .02357   0.00000   1.04769    .99609
19 213.75000   31.30263   -1.08091    -.72224     .00098    .07469   -.02464   -.00196     .02691   0.00000   1.05444    .99603
20 225.00000   31.30263    -.91924    -.91924     .00100    .06933   -.06933   -.00200     .03758   0.00000   1.07603    .99596
21 236.25000   31.30263    -.72224   -1.08091     .00102    .06937   -.10457   -.00203     .04402   0.00000   1.08906    .99588
22 247.50000   31.30263    -.49749   -1.20104     .00103    .04973   -.12337   -.00207     .04161   0.00000   1.08419    .99582
23 258.75000   31.30263    -.25362   -1.27502     .00105    .01912   -.14434   -.00210     .03436   0.00000   1.06950    .99575
24 270.00000   31.30263     .00000   -1.30000     .00106    .00634   -.17544   -.00213     .03092   0.00000   1.06254    .99570
25 281.25000   31.30263     .25362   -1.27502     .00107    .02472   -.20542   -.00215     .03593   0.00000   1.07269    .99566
26 292.50000   31.30263     .49749   -1.20104     .00108    .06876   -.21963   -.00216     .04658   0.00000   1.09424    .99562
27 303.75000   31.30263     .72224   -1.08091     .00109    .12422   -.20967   -.00217     .05663   0.00000   1.11457    .99560
28 315.00000   31.30263     .91924    -.91924     .00109    .17545   -.17544   -.00218     .06068   0.00000   1.12275    .99559
29 326.25000   31.30263    1.08091    -.72224     .00109    .20968   -.12420   -.00217     .05663   0.00000   1.11457    .99560
30 337.50000   31.30263    1.20104    -.49749     .00108    .21963   -.06874   -.00216     .04658   0.00000   1.09423    .99562
31 348.75000   31.30263    1.27502    -.25362     .00107    .20543   -.02468   -.00215     .03592   0.00000   1.07266    .99566
32 360.00000   31.30263    1.30000     .00000     .00106    .17544   -.00628   -.00213     .03090   0.00000   1.06250    .99570

                                        BODY RING=  17

 1  11.25000   33.35526    1.27502     .25362     .00090    .13291    .03838   -.00180     .01205   0.00000   1.02437    .99635
 2  22.50000   33.35526    1.20104     .49749     .00089    .10142    .00325   -.00178     .02243   0.00000   1.04537    .99641
 3  33.75000   33.35526    1.08091     .72224     .00087    .08999   -.04755   -.00175     .03664   0.00000   1.07413    .99646
 4  45.00000   33.35526     .91924     .91924     .00086    .08454   -.08454   -.00172     .04410   0.00000   1.08921    .99652
 5  56.25000   33.35526     .72224    1.08091     .00084    .06463   -.10140   -.00169     .04283   0.00000   1.08664    .99658
 6  67.50000   33.35526     .49749    1.20104     .00083    .04090   -.11972   -.00166     .03923   0.00000   1.07936    .99664
 7  78.75000   33.35526     .25362    1.27502     .00082    .04181   -.14886   -.00163     .04194   0.00000   1.08484    .99670
 8  90.00000   33.35526    -.00000    1.30000     .00081    .07945   -.17544   -.00161     .05169   0.00000   1.10457    .99674
 9 101.25000   33.35526    -.25362    1.27502     .00080    .13999   -.18249   -.00159     .05999   0.00000   1.12135    .99678
10 112.50000   33.35526    -.49749    1.20104     .00079    .18895   -.16984   -.00158     .06105   0.00000   1.12350    .99681
11 123.75000   33.35526    -.72224    1.08091     .00078    .19712   -.16096   -.00157     .06055   0.00000   1.12250    .99683
12 135.00000   33.35526    -.91924     .91924     .00078    .17546   -.17543   -.00157     .06132   0.00000   1.12406    .99683
13 146.25000   33.35526   -1.08091     .72224     .00078    .16098   -.19708   -.00157     .06056   0.00000   1.12251    .99683
14 157.50000   33.35526   -1.20104     .49749     .00079    .16985   -.18892   -.00158     .06105   0.00000   1.12350    .99681
```

Figure 18.- Continued.

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15 168.75000  33.35526  -1.27502    .25362     .00080     .18250   -.13995   -.00159     .05998  0.00000  1.12135    .99678
16 180.00000  33.35526  -1.30000   -.00000     .00081     .17544   -.07941   -.00161     .05168  0.00000  1.10456    .99674
17 191.25000  33.35526  -1.27502   -.25362     .00082     .14885   -.04176   -.00163     .04193  0.00000  1.08481    .99670
18 202.50000  33.35526  -1.20104   -.49749     .00083     .11970   -.00086   -.00166     .03922  0.00000  1.07934    .99664
19 213.75000  33.35526  -1.08091   -.72224     .00084     .10139   -.06462   -.00169     .04282  0.00000  1.08663    .99658
20 225.00000  33.35526   -.91924   -.91924     .00086     .08457   -.08457   -.00172     .04411  0.00000  1.08923    .99652
21 236.25000  33.35526   -.72224  -1.08091     .00087     .04761   -.09003   -.00175     .03667  0.00000  1.07417    .99646
22 247.50000  33.35526   -.49749  -1.20104     .00089    -.00319   -.10145   -.00178     .02245  0.00000  1.04542    .99641
23 258.75000  33.35526   -.25362  -1.27502     .00090    -.03833   -.15292   -.00180     .01207  0.00000  1.02441    .99635
24 270.00000  33.35526    .00000  -1.30000     .00091    -.03914   -.17544   -.00183     .01338  0.00000  1.02707    .99631
25 281.25000  33.35526    .25362  -1.27502     .00092    -.00551   -.21144   -.00185     .02545  0.00000  1.05148    .99627
26 292.50000  33.35526    .49749  -1.20104     .00093     .05159   -.22674   -.00186     .04200  0.00000  1.08498    .99624
27 303.75000  33.35526    .72224  -1.08091     .00093     .11700   -.21450   -.00187     .05573  0.00000  1.11274    .99622
28 315.00000  33.35526    .91924   -.91924     .00094     .17545   -.17544   -.00187     .06100  0.00000  1.12340    .99621
29 326.25000  33.35526   1.08091   -.72224     .00093     .21450   -.11699   -.00187     .05573  0.00000  1.11274    .99622
30 337.50000  33.35526   1.20104   -.49749     .00093     .22674   -.05158   -.00186     .04200  0.00000  1.08497    .99624
31 348.75000  33.35526   1.27502   -.25362     .00092     .21144    .00553   -.00185     .02544  0.00000  1.05146    .99627
32 360.00000  33.35526   1.30000    .00000     .00091     .17544    .03917   -.00183     .01337  0.00000  1.02704    .99631


        TOTAL NUMBER OF PRESSURE POINTS,JCPT=  268


        CONTROL POINT COORDINATES FOR  3 CHORDWISE BY  5 SPANWISE PANELS ON WING 1 OR R,   5     SPANWISE ON WING 2 OR L
                                             AND 5 SPANWISE PANELS ON WING 3 OR U,  5     SPANWISE ON WING 4 OR D

 J        X(J)        Y(J)        Z(J)        BU(J)          BV(J)          BW(J)        VVRTX          WVRTX

 1      1.23112     1.53096     0.00000     .73049E-03     .12641E+00     .12694E+00    0.             0.
 2      2.38667     1.53096     0.00000     .67838E-03     .12642E+00     .12691E+00    0.             0.
 3      3.54222     1.53096     0.00000     .63160E-03     .12643E+00     .12689E+00    0.             0.
 4      1.41565     1.99870     0.00000     .72683E-03     .74025E-01     .74581E-01    0.             0.
 5      2.48119     1.99870     0.00000     .67887E-03     .74039E-01     .74559E-01    0.             0.
 6      3.54672     1.99870     0.00000     .63539E-03     .74051E-01     .74538E-01    0.             0.
 7      1.60017     2.46640     0.00000     .72543E-03     .48483E-01     .49061E-01    0.             0.
 8      2.57570     2.46640     0.00000     .68143E-03     .48500E-01     .49043E-01    0.             0.
 9      3.55122     2.46640     0.00000     .64127E-03     .48516E-01     .49027E-01    0.             0.
10      1.78466     2.93403     0.00000     .72621E-03     .34141E-01     .34740E-01    0.             0.
11      2.67019     2.93403     0.00000     .68608E-03     .34160E-01     .34725E-01    0.             0.
12      3.55572     2.93403     0.00000     .64898E-03     .34177E-01     .34711E-01    0.             0.
13      1.96912     3.40158     0.00000     .72815E-03     .25290E-01     .25908E-01    0.             0.
14      2.76467     3.40158     0.00000     .69164E-03     .25309E-01     .25895E-01    0.             0.
15      3.56022     3.40158     0.00000     .65783E-03     .25326E-01     .25883E-01    0.             0.
16      1.23112    -1.53096     0.00000     .64864E-03     .12645E+00     .12694E+00    0.             0.
17      2.38667    -1.53096     0.00000     .60465E-03     .12645E+00     .12691E+00    0.             0.
18      3.54222    -1.53096     0.00000     .56508E-03     .12645E+00     .12689E+00    0.             0.
19      1.41565    -1.99870     0.00000     .63974E-03     .74120E-01     .74581E-01    0.             0.
20      2.48119    -1.99870     0.00000     .59980E-03     .74125E-01     .74559E-01    0.             0.
21      3.54672    -1.99870     0.00000     .56342E-03     .74129E-01     .74538E-01    0.             0.
22      1.60017    -2.46640     0.00000     .63001E-03     .48627E-01     .49061E-01    0.             0.
23      2.57570    -2.46640     0.00000     .59399E-03     .48631E-01     .49043E-01    0.             0.
24      3.55122    -2.46640     0.00000     .56103E-03     .48636E-01     .49027E-01    0.             0.
25      1.78466    -2.93403     0.00000     .62103E-03     .34329E-01     .34740E-01    0.             0.
26      2.67019    -2.93403     0.00000     .58890E-03     .34333E-01     .34725E-01    0.             0.
27      3.55572    -2.93403     0.00000     .55908E-03     .34336E-01     .34711E-01    0.             0.
28      1.96912    -3.40158     0.00000     .61243E-03     .25519E-01     .25908E-01    0.             0.
29      2.76467    -3.40158     0.00000     .58375E-03     .25521E-01     .25895E-01    0.             0.
30      3.56022    -3.40158     0.00000     .55720E-03     .25523E-01     .25883E-01    0.             0.
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Figure 18.- Continued.

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  31     1.23112     0.00000     1.53096    .64864E-03   -.12694E+00   -.12645E+00   0.          0.
  32     2.38667     0.00000     1.53096    .60465E-03   -.12691E+00   -.12645E+00   0.          0.
  33     3.54222     0.00000     1.53096    .56568E-03   -.12689E+00   -.12645E+00   0.          0.
  34     1.41565     0.00000     1.99870    .65974E-03   -.74581E-01   -.74120E-01   0.          0.
  35     2.48119     0.00000     1.99870    .59960E-03   -.74559E-01   -.74125E-01   0.          0.
  36     3.54672     0.00000     1.99870    .56302E-03   -.74538E-01   -.74129E-01   0.          0.
  37     1.60017     0.00000     2.46640    .65001E-03   -.49061E-01   -.48627E-01   0.          0.
  38     2.57570     0.00000     2.46640    .59309E-03   -.49043E-01   -.48631E-01   0.          0.
  39     3.55122     0.00000     2.46640    .56103E-03   -.49027E-01   -.48636E-01   0.          0.
  40     1.78466     0.00000     2.93403    .62103E-03   -.34740E-01   -.34329E-01   0.          0.
  41     2.67019     0.00000     2.93403    .58890E-03   -.34725E-01   -.34333E-01   0.          0.
  42     3.55572     0.00000     2.93403    .55908E-03   -.34711E-01   -.34336E-01   0.          0.
  43     1.96912     0.00000     3.40158    .61235E-03   -.25908E-01   -.25519E-01   0.          0.
  44     2.76467     0.00000     3.40158    .58375E-03   -.25895E-01   -.25521E-01   0.          0.
  45     3.56022     0.00000     3.40158    .55720E-03   -.25883E-01   -.25523E-01   0.          0.
  46     1.23112     0.00000    -1.53096    .73009E-03   -.12694E+00   -.12641E+00   0.          0.
  47     2.38667     0.00000    -1.53096    .67838E-03   -.12691E+00   -.12642E+00   0.          0.
  48     3.54222     0.00000    -1.53096    .65160E-03   -.12689E+00   -.12643E+00   0.          0.
  49     1.41565     0.00000    -1.99870    .72684E-03   -.74581E-01   -.74025E-01   0.          0.
  50     2.48119     0.00000    -1.99870    .67887E-03   -.74559E-01   -.74039E-01   0.          0.
  51     3.54672     0.00000    -1.99870    .63539E-03   -.74538E-01   -.74051E-01   0.          0.
  52     1.60017     0.00000    -2.46640    .72543E-03   -.49061E-01   -.48483E-01   0.          0.
  53     2.57570     0.00000    -2.46640    .68143E-03   -.49043E-01   -.48506E-01   0.          0.
  54     3.55122     0.00000    -2.46640    .64127E-03   -.49027E-01   -.48516E-01   0.          0.
  55     1.78466     0.00000    -2.93403    .72621E-03   -.34740E-01   -.34141E-01   0.          0.

  56     2.67019     0.00000    -2.93403    .68608E-03   -.34725E-01   -.34160E-01   0.          0.
  57     3.55572     0.00000    -2.93403    .64892E-03   -.34711E-01   -.34177E-01   0.          0.
  58     1.96912     0.00000    -3.40158    .72815E-03   -.25908E-01   -.25290E-01   0.          0.
  59     2.76467     0.00000    -3.40158    .69164E-03   -.25895E-01   -.25309E-01   0.          0.
  60     3.56022     0.00000    -3.40158    .65783E-03   -.25883E-01   -.25326E-01   0.          0.


                             CONTROL POINT COORDINATES FOR HIR*9 (WING FRAME)

   J       X(J)        Y(J)        Z(J)        THU(J)        THV(J)        THW(J)


  61     1.14000     1.25052      .24874    -.13891E-02   -.18221E-01    .34655E-02
  62     1.14000     1.06014      .70836    -.15717E-01   -.88792E-02    .20553E-01
  63     1.14000      .70836     1.06014    -.15717E-01    .20553E-01   -.88792E-02
  64     1.14000      .24874     1.25052    -.13891E-02    .34655E-02   -.18221E-01
  65     1.14000     -.24874     1.25052    -.13891E-02   -.34655E-02   -.18221E-01
  66     1.14000     -.70836     1.06014    -.15717E-01   -.20553E-01   -.88792E-02
  67     1.14000    -1.06014      .70836    -.15717E-01    .88792E-02    .20553E-01
  68     1.14000    -1.25052      .24874    -.13891E-02    .18221E-01    .34655E-02
  69     1.14000    -1.25052     -.24874    -.13891E-02    .18221E-01   -.34655E-02
  70     1.14000    -1.06014     -.70836    -.15717E-01    .88792E-02   -.20553E-01
  71     1.14000     -.70836    -1.06014    -.15717E-01   -.20553E-01    .88792E-02
  72     1.14000     -.24874    -1.25052    -.13891E-02   -.34655E-02    .18221E-01
  73     1.14000      .24874    -1.25052    -.13891E-02    .34655E-02    .18221E-01
  74     1.14000      .70836    -1.06014    -.15717E-01    .20553E-01    .88792E-02
  75     1.14000     1.06014     -.70836    -.15717E-01   -.88792E-02   -.20553E-01
  76     1.14000     1.25052     -.24874    -.13891E-02   -.18221E-01   -.34655E-02
  77     2.34000     1.25052      .24874    -.10403E-01   -.31303E-02   -.54293E-02
  78     2.34000     1.06014      .70836    -.71993E-02    .60701E-03   -.75132E-02
  79     2.34000      .70836     1.06014    -.71993E-02   -.75132E-02    .60701E-03
  80     2.34000      .24874     1.25052    -.10403E-01   -.54293E-02   -.31303E-02
  81     2.34000     -.24874     1.25052    -.10403E-01    .54293E-02   -.31303E-02
  82     2.34000     -.70836     1.06014    -.71993E-02    .75132E-02    .60701E-03
```

Figure 18.- Continued.

```
 83     2.34000    -1.06014      .70836    -.71993E-02   -.60701E-03   -.75132E-02
 84     2.34000    -1.25052      .24874    -.10403E-01    .31303E-02   -.54293E-02
 85     2.34000    -1.25052     -.24874    -.10403E-01    .31303E-02    .54293E-02
 86     2.34000    -1.06014     -.70836    -.71993E-02   -.60701E-03    .75132E-02
 87     2.34000     -.70836    -1.06014    -.71993E-02    .75132E-02   -.60701E-03
 88     2.34000     -.24874    -1.25052    -.10403E-01    .54293E-02    .31303E-02
 89     2.34000      .24874    -1.25052    -.10403E-01   -.54293E-02    .31303E-02
 90     2.34000      .70836    -1.06014    -.71993E-02   -.75132E-02   -.60701E-03
 91     2.34000     1.06014     -.70836    -.71993E-02    .60701E-03    .75132E-02
 92     2.34000     1.25052     -.24874    -.10403E-01   -.31303E-02    .54293E-02
 93     3.54000     1.25052      .24874     .26703E-01    .18903E-01   -.45436E-01
 94     3.54000     1.06014      .70836    -.26070E-01    .94557E-02    .92392E-02
 95     3.54000      .70836     1.06014    -.26070E-01    .92392E-02    .94557E-02
 96     3.54000      .24874     1.25052     .26703E-01   -.45436E-01    .18903E-01
 97     3.54000     -.24874     1.25052     .26703E-01    .45436E-01    .18903E-01
 98     3.54000     -.70836     1.06014    -.26070E-01   -.92392E-02    .94557E-02
 99     3.54000    -1.06014      .70836    -.26070E-01   -.94557E-02    .92392E-02
100     3.54000    -1.25052      .24874     .26703E-01   -.18903E-01   -.45436E-01
101     3.54000    -1.25052     -.24874     .26703E-01   -.18903E-01    .45436E-01
102     3.54000    -1.06014     -.70836    -.26070E-01   -.94557E-02   -.92392E-02
103     3.54000     -.70836    -1.06014    -.26070E-01   -.92392E-02   -.94557E-02
104     3.54000     -.24874    -1.25052     .26703E-01    .45436E-01   -.18903E-01
105     3.54000      .24874    -1.25052     .26703E-01   -.45436E-01   -.18903E-01
106     3.54000      .70836    -1.06014    -.26070E-01    .92392E-02   -.94557E-02
107     3.54000     1.06014     -.70836    -.26070E-01    .94557E-02   -.92392E-02
108     3.54000     1.25052     -.24874     .26703E-01    .18903E-01    .45436E-01


                                      LOADING INFORMATION

         MACH NUMBER =    .17000E+01
      ANGLE OF ATTACK =   10.000 DEGREES
      SIDE SLIP ANGLE =   10.000 DEGREES
            WING AREA =   13.48666
       REFERENCE AREA =    5.30929
     REFERENCE LENGTH =    2.69000
  EXPOSED WING SPAN B =    4.68000
  MOMENT CENTER:   XM =   19.50000
                   ZM =    0.00000


U/VINF TYPE LOADING PRESSURE


                           TOTAL              FIN 1 OR R        FIN 2 OR L        FIN 3 OR U        FIN 4 OR D        INTERF. SHELL
  DEFL. ANGLE DEG. =                          0.00000           0.00000           0.00000           0.00000
              CTHR =    .30615E-01         .10495E-01        .48137E-02        .48118E-02        .10495E-01
                CZ =    .10224E+01         .58122E+00        .28949E+00       0.                0.                .15172E+00
                CY =   -.10223E+01        0.                0.                -.28940E+00       -.58123E+00       -.15171E+00
                CM =   -.69633E+01        -.39520E+01       -.19585E+01       0.                0.                -.10528E+01
               CLN =    .69626E+01        0.                0.                 .19578E+01        .39521E+01        .10527E+01
               CLL =    .91616E-04        -.50670E+00        .27706E+00       -.27698E+00        .50671E+00        .87696E-16
```

Figure 18.- Continued.

```
            FOLLOWING ARE IN WIND-AXIS SYSTEM

             CL =    .14091E+01        .40098E+00        .19962E+00        .19956E+00        .40099E+00        .20799E+00
         CY*IND =    .66084E-04        .41099E+00        .20470E+00       -.20464E+00       -.41099E+00        .99703E-05
            CDT =    .32540E+00        .90756E-01        .45604E-01        .45591E-01        .90758E-01        .52691E-01
      CDI/CL**2 =    .16308E+00
         CM*IND =   -.98471E+01       -.27945E+01       -.13848E+01       -.13844E+01       -.27945E+01       -.14888E+01
        CLM*IND =   -.45862E-03       -.25845E+01       -.14105E+01        .14100E+01        .25845E+01       -.66543E-04



    NOTE: L.E. OF LEAD PANEL IN FIRST CHORDWISE ROW IS SUPERSONIC


-------------------RIGHT WING--------------------


                   SPANWISE DISTRIBUTIONS

 I     Y/(B/2)  CN*C/(2*B)  CT*C/(2*B) CY1*C/(2*B) CYTOT*C/(2*B) CS*C/(2*B)     CSINT      YBAR       GAMNET(I)  GAMMA,LE/VINF  XLE

 1     .65426     .16708     0.00000     0.00000       .00025     0.00000     0.00000    0.00000     -.78235    0.00000     .13334
 2     .85415     .16341     0.00000     0.00000       .00112     0.00000     0.00000    0.00000      .01711    0.00000     .40340
 3    1.05402     .15153     0.00000     0.00000       .00153     0.00000     0.00000    0.00000      .05558    0.00000     .67342
 4    1.25386     .12992     0.00000     0.00000       .00167     0.00000     0.00000    0.00000      .10112    0.00000     .94341
 5    1.45367     .09252     0.00000     0.00000      0.00000     0.00000     0.00000    0.00000      .17509    0.00000    1.21335
 6    1.55556    0.00000                                                                             .43345


        SUMFX  =  0.
        SUMFY1 =  0.
        SUMFY2 =   .37762E-02
        SUMFT2 =   .23655E-01


        SIDE EDGE DISTRIBUTION

 JTIP  JSE  DISTANCE        SUCTION FORCE        GAMMA,SE      YBAR       XSE
            FROM LE         PER UNIT LENGTH      /VINF
            /TIPCHORD       /(Q*TIPCHORD)

   1    1     .33333          .00354              .00063      3.64000    1.35100
   2    2     .66667          .03255              .00640      3.64000    2.10067
   3    3    1.00000          .03840              .01321      3.64000    2.85033
```

Figure 18.- Continued.

```
*****T.E. FIN VORTEX INFO******

IVRT GAMMA/VINF    Y.C.G.

  1      .78196    3.27310



******************** LEFT WING**********************



                          SPANWISE DISTRIBUTIONS


  I     Y/(B/2)  CN*C/(2*B)  CT*C/(2*B) CY1*C/(2*B) CYTOT*C/(2*B) CS*C/(2*B)     CSINT      YBAR        GAMNET(I)  GAMMA,LE/VINF  XLE

  7     -.65426      .04806    0.00000     0.00000     -.00151      0.00000    0.00000    0.00000        .27503    0.00000     .13334
  8     -.85415      .06115    0.00000     0.00000     -.00066      0.00000    0.00000    0.00000        .06143    0.00000     .40340
  9    -1.05402      .07844    0.00000     0.00000     -.00010      0.00000    0.00000    0.00000        .08102    0.00000     .67342
 10    -1.25386      .08807    0.00000     0.00000     -.00038      0.00000    0.00000    0.00000        .04513    0.00000     .94341
 11    -1.45367      .07516    0.00000     0.00000     0.00000      0.00000    0.00000    0.00000       -.06041    0.00000    1.21335
 12    -1.55556     0.00000                                                                          -.35211


          SUMFX  =   0.
          SUMFY1 =   0.
          SUMFY2 =   -.21914E-02
          SUMFT2 =   -.23666E-01



          SIDE EDGE DISTRIBUTION

JTIP  JSE  DISTANCE         SUCTION FORCE        GAMMA,SE      YBAR        XSE
           FROM LE          PER UNIT LENGTH      /VINF
           /TIPCHORD        /(Q*TIPCHORD)

  1    1      .33333          -.00686            -.00122     -3.64000    1.35100
  2    2      .66667          -.03686            -.00776     -3.64000    2.10067
  3    3     1.00000          -.03080            -.01322     -3.64000    2.85033



*****T.F. FIN VORTEX INFO******

IVRT GAMMA/VINF    Y.C.G.

  2      .18725   -2.19543
  3     -.41216   -3.57139
```

Figure 18.- Continued.

```
--------------------UPPER WING--------------------



                              SPANWISE DISTRIBUTIONS


 I      Z/(B/2)  CN*C/(2*B)  CT*C/(2*B) CZ1*C/(2*B) CZTOT*C/(2*B) CS*C/(2*B)     CSINT      ZBAR        GAMMET(I)  GAMMA,LE/VINF   XLE

13      .65026      .04804     0.00000     0.00000       .00151     0.00000    0.00000    0.00000      -.22494    0.00000      .13334
14      .85415      .06113     0.00010     0.00000       .00066     0.00000    0.00000    0.00000      -.06131    0.00000      .40340
15     1.05402      .07842     0.00000     0.00000       .00010     0.00000    0.00000    0.00000      -.08190    0.00000      .67342
16     1.25386      .08404     0.00000     0.00000       .00038     0.00000    0.00000    0.00000      -.04515    0.00000      .94341
17     1.45367      .07514     0.00000     0.00000      0.00000     0.00000    0.00000    0.00000       .06035    0.00000     1.21335
18     1.55556     0.00000                                                                            .35205


        SUMFX  =  0.
        SUMFZ1 =  0.
        SUMFZ2 =   .21909E-02
        SUMFT2 =   .23662E-01



        SIDE EDGE DISTRIBUTION

JTIP  JSE  DISTANCE         SUCTION FORCE        GAMMA,SE      ZBAR        XSE
           FROM LE          PER UNIT LENGTH      /VINF
           /TIPCHORD        /(Q*TIPCHORD)

  1     4     .33333           .00687            .00122       3.64000     1.35100
  2     5     .66667           .03686            .00776       3.64000     2.10067
  3     6    1.00000           .03079            .01322       3.64000     2.85033


****T.F. FIN VORTEX INFO******

IVRT GAMMA/VINF    Z.C.G.

  4     -.18721    2.19551
  5      .41204    3.57143
```

Figure 18.- Continued.

```
*******************LOWER WING*******************

                          SPANWISE DISTRIBUTIONS

 I     Z/(B/2)  CN*C/(2*B)  CT*C/(2*B) CZ1*C/(2*B) CZTOT*C/(2*B) CS*C/(2*B)    CSINT     ZBAR       GAMNET(I)  GAMMA,LE/VINF

19    -.65426     .16709     0.00000    0.00000     -.00025     0.00000    0.00000   0.00000      .78236    0.00000     .
20    -.85415     .16342     0.00000    0.00000     -.00112     0.00000    0.00000   0.00000     -.01711    0.00000     .
21   -1.05402     .15153     0.00000    0.00000     -.00153     0.00000    0.00000   0.00000     -.05557    0.00000     .
22   -1.25586     .12992     0.00000    0.00000     -.00167     0.00000    0.00000   0.00000     -.10112    0.00000     .
23   -1.45367     .09252     0.00000    0.00000     0.00000     0.00000    0.00000   0.00000     -.17509    0.00000    1.
24   -1.55556    0.00000                                                                        -.43346


          SUMFX  =  0.
          SUMFZ1 =  0.
          SUMFZ2 =  -.37762E-02
          SUMFT2 =  -.23655E-01


          SIDE EDGE DISTRIBUTION

JTIP  JSE  DISTANCE      SUCTION FORCE       GAMMA,SE     ZBAR       XSE
           FROM LE       PER UNIT LENGTH     /VINF
           /TIPCHORD     /(Q*TIPCHORD)

  1    7    .33333         -.00354           -.00063    -3.64000   1.35100
  2    8    .66667         -.03255           -.00640    -3.64000   2.10067
  3    9   1.00000         -.03840           -.01321    -3.64000   2.85033


*****T.E. FIN VORTEX INFO******

IVRT GAMMA/VINF   Z,C.G.

  6    -.78196   -3.27321


          VELOCITIES AND BERNOULLI PRESSURES AT CONTROL POINTS IMMEDIATELY ABOVE AND BELOW HORIZONTAL WING SURFACE

 J      X(J)       Y(J)       Z(J)       UTOTA      VTOTA      WTOTA      PRESSA     UTOTB      VTOTB      WTOTB      PRESSB

 1   1.231118   1.530959   0.000000    .129145    .068203   -.173650   -.185699   -.129028    .217259   -.173650    .358780
 2   2.386670   1.530959   0.000000    .101384    .088861   -.173650   -.137395   -.107142    .169123   -.173650    .307666
 3   3.542222   1.530959   0.000000    .150268    .168505   -.314650   -.223650   -.060070    .208985   -.032650    .169474
 4   1.415654   1.998701   0.000000    .152781   -.031297   -.173650   -.241259   -.138562    .136910   -.173650    .383371
 5   2.481188   1.998701   0.000000    .113561    .058478   -.173650   -.162344   -.109953    .144508   -.173650    .313347
```

Figure 18.- Continued.

```
  6   3.546723   1.998701   0.000000    .161209    .126025   -.314650   -.240721   -.042107    .165153   -.032650    .131624
  7   1.600170   2.466397   0.000000    .191832   -.054983   -.173650   -.297720   -.110893    .119796   -.173650    .312729
  8   2.575697   2.466397   0.000000    .129801    .030109   -.173650   -.193454   -.116276    .124824   -.173650    .326621
  9   3.551224   2.466397   0.000000    .206539    .076211   -.314650   -.303594    .027879    .110594   -.032650   -.018133
 10   1.784662   2.934030   0.000000    .148754    .003172   -.173650   -.227381   -.155865    .179044   -.173650    .429061
 11   2.670193   2.934030   0.000000    .167200    .012209   -.173650   -.251417   -.080142    .107411   -.173650    .237021
 12   3.555723   2.934030   0.000000    .209438    .100777   -.314650   -.304929    .074199    .126803   -.032650   -.102489
 13   1.969121   3.401580   0.000000    .157981    .032492   -.173650   -.234765   -.122717    .194553   -.173650    .345299
 14   2.764672   3.401580   0.000000    .104232    .026653   -.173650   -.153399   -.061653    .090537   -.173650    .190837
 15   3.560222   3.401580   0.000000    .101604    .046797   -.314650   -.160045    .003357    .065704   -.032650    .022616
 16   1.231118  -1.530959   0.000000    .037972    .181557   -.173650   -.014657   -.035365    .139216   -.173650    .138411
 17   2.386670  -1.530959   0.000000    .034291    .181043   -.173650   -.007363   -.045334    .150396   -.173650    .161572
 18   3.542222  -1.530959   0.000000    .124857    .146280   -.314650   -.185776    .083083    .138240   -.032650   -.117261
 19   1.415654  -1.998701   0.000000    .063527    .222175   -.173650   -.065850   -.046209    .156796   -.173650    .164037
 20   2.481188  -1.998701   0.000000    .060120    .168307   -.173650   -.057546   -.039398    .130002   -.173650    .146557
 21   3.546723  -1.998701   0.000000    .137855    .143383   -.314650   -.205846    .078405    .131942   -.032650   -.109508
 22   1.600170  -2.466397   0.000000    .127203    .218985   -.173650   -.176074   -.046454    .118724   -.173650    .161075
 23   2.575697  -2.466397   0.000000    .075503    .162503   -.173650   -.085958   -.058974    .110743   -.173650    .188398
 24   3.551224  -2.466397   0.000000    .154574    .136506   -.314650   -.230745    .086113    .123330   -.032650   -.123540
 25   1.784662  -2.934030   0.000000    .119560    .145998   -.173650   -.162743   -.126882    .003715   -.173650    .314459
 26   2.670193  -2.934030   0.000000    .126540    .156456   -.173650   -.173723   -.036527    .093692   -.173650    .134796
 27   3.555723  -2.934030   0.000000    .177642    .105272   -.314650   -.264600    .121313    .094432   -.032650   -.184191
 28   1.969121  -3.401580   0.000000    .155547    .096988   -.173650   -.222228   -.120515   -.062396   -.173650    .262251
 29   2.764672  -3.401580   0.000000    .079984    .106955   -.173650   -.097793   -.037631    .061685   -.173650    .129956
 30   3.560222  -3.401580   0.000000    .078544    .109215   -.314650   -.111764    .029624    .099801   -.032650   -.022946


      VELOCITIES AND BERNOULLI PRESSURES AT CONTROL POINTS IMMEDIATELY TO RIGHT AND LEFT OF VERTICAL WING SURFACE

  J     X(J)       Y(J)       Z(J)      UTOTR      VTOTR      WTOTR     PRESSR      UTOTL      VTOTL      WTOTL     PRESSL

 31   1.231118   0.000000   1.530959   -.035346    .173650   -.139216    .138369    .037954    .173650   -.181535   -.014620
 32   2.386670   0.000000   1.530959   -.045320    .173650   -.150384    .161541    .034277    .173650   -.181021   -.007336
 33   3.542222   0.000000   1.530959    .083091    .314650   -.158222   -.117276    .124856    .032650   -.146260   -.185776
 34   1.415654   0.000000   1.998701   -.046223    .173650   -.158802    .163978    .063501    .173650   -.222151   -.065799
 35   2.481188   0.000000   1.998701   -.039379    .173650   -.129985    .146515    .060103    .173650   -.168275   -.057314
 36   3.546723   0.000000   1.998701    .179414    .314650   -.131906   -.109527    .137850    .032650   -.143344   -.205841
 37   1.600170   0.000000   2.466397   -.046425    .173650   -.118760    .161013    .127173    .173650   -.218987   -.176027
 38   2.575697   0.000000   2.466397   -.058953    .173650   -.110761    .188352    .075492    .173650   -.162505   -.085919
 39   3.551224   0.000000   2.466397    .086130    .314650   -.123523   -.123571    .154557    .032650   -.134492   -.230721
 40   1.784662   0.000000   2.934030   -.126859    .173650   -.003770    .314432    .119538    .173650   -.146027   -.162704
 41   2.670193   0.000000   2.934030   -.036504    .173650   -.093750    .134756    .126517    .173650   -.156494   -.173685
 42   3.555723   0.000000   2.934030    .121337    .314650   -.098493   -.184220    .177617    .032650   -.105325   -.264566
 43   1.969121   0.000000   3.401580   -.126505    .173650    .062352    .262256    .155537    .173650   -.097021   -.222210
 44   2.764672   0.000000   3.401580   -.037616    .173650   -.061740    .129938    .079969    .173650   -.104998   -.097761
 45   3.560222   0.000000   3.401580    .029638    .314650   -.099867   -.022964    .078530    .032650   -.109277   -.111733
 46   1.231118   0.000000  -1.530959   -.129027    .173650   -.217264    .358778    .129144    .173650   -.068208   -.185697
 47   2.386670   0.000000  -1.530959   -.107144    .173650   -.169127    .307672    .101386    .173650   -.068864   -.137399
 48   3.542222   0.000000  -1.530959   -.060975    .314650   -.208990    .169483    .150266    .032650   -.168510   -.223645
 49   1.415654   0.000000  -1.998701   -.138563    .173650   -.136918    .383375    .152782    .173650    .031290   -.241259
 50   2.481188   0.000000  -1.998701   -.109956    .173650   -.144516    .313356    .115563    .173650   -.058483   -.162346
 51   3.546723   0.000000  -1.998701   -.042110    .314650   -.165161    .131032    .161207    .032650   -.126033   -.240718
 52   1.600170   0.000000  -2.466397   -.110897    .173650   -.119804    .312738    .191836    .173650    .054979   -.297723
 53   2.575697   0.000000  -2.466397   -.116279    .173650   -.124831    .326630    .129804    .173650   -.030114   -.193437
 54   3.551224   0.000000  -2.466397    .027877    .314650   -.110599   -.018130    .206540    .032650   -.076215   -.303595
 55   1.784662   0.000000  -2.934030   -.155870    .173650   -.179950    .429074    .148759    .173650   -.003172   -.227388
 56   2.670193   0.000000  -2.934030   -.080145    .173650   -.107415    .237028    .167202    .173650   -.012211   -.251420
 57   3.555723   0.000000  -2.934030    .074198    .314650   -.126807   -.102485    .209439    .032650   -.100780   -.304930
```

Figure 18.- Continued.

```
58   1.969121   0.000000  -3.401580   -.122722    .173650   -.194557    .345311    .157986    .173650   -.032490   -.234773
59   2.764672   0.000000  -3.401580   -.061665    .173650   -.090509    .190841    .104234    .173650   -.026654   -.153402
60   3.560222   0.000000  -3.401580    .003356    .314650   -.065706    .022617    .101604    .032650   -.046798   -.160046


PRESSURE LOADINGS AT CONTROL POINTS

J        X(J)        Y(J)        Z(J)     DELTP,LIN. DELTP,BERN.

 1   1.231118    1.530959    0.000000    .516345    .544479
 2   2.386670    1.530959    0.000000    .417051    .445061
 3   3.542222    1.530959    0.000000    .420677    .393123
 4   1.415654    1.998701    0.000000    .582686    .624629
 5   2.481188    1.998701    0.000000    .447027    .475691
 6   3.546723    1.998701    0.000000    .406632    .371745
 7   1.600170    2.466397    0.000000    .605451    .610449
 8   2.575697    2.466397    0.000000    .492153    .520055
 9   3.551224    2.466397    0.000000    .357319    .285461
10   1.784662    2.934030    0.000000    .609237    .656443
11   2.670193    2.934030    0.000000    .494683    .488438
12   3.555723    2.934030    0.000000    .270477    .202441
13   1.969121    3.401580    0.000000    .561396    .580064
14   2.764672    3.401580    0.000000    .331792    .344236
15   3.560222    3.401580    0.000000    .196493    .182661
16   1.231118   -1.530959    0.000000    .146674    .153068
17   2.386670   -1.530959    0.000000    .159248    .168935
18   3.542222   -1.530959    0.000000    .083548    .068515
19   1.415654   -1.998701    0.000000    .219553    .229887
20   2.481188   -1.998701    0.000000    .199036    .203993
21   3.546723   -1.998701    0.000000    .118900    .096358
22   1.600170   -2.466397    0.000000    .347314    .337149
23   2.575697   -2.466397    0.000000    .268955    .274356
24   3.551224   -2.466397    0.000000    .136922    .107204
25   1.784662   -2.934030    0.000000    .492684    .477202
26   2.670193   -2.934030    0.000000    .326135    .308519
27   3.555723   -2.934030    0.000000    .112657    .080410
28   1.969121   -3.401580    0.000000    .552124    .484479
29   2.764672   -3.401580    0.000000    .235230    .227749
30   3.560222   -3.401580    0.000000    .097841    .088818
31   1.231118    0.000000    1.530959    .146599    .152989
32   2.386670    0.000000    1.530959    .159195    .168877
33   3.542222    0.000000    1.530959    .083531    .068500
34   1.415654    0.000000    1.998701    .219449    .229778
35   2.481188    0.000000    1.998701    .198965    .203828
36   3.546723    0.000000    1.998701    .118871    .096314
37   1.600170    0.000000    2.466397    .347196    .337040
38   2.575697    0.000000    2.466397    .268869    .274270
39   3.551224    0.000000    2.466397    .136853    .107149
40   1.784662    0.000000    2.934030    .492793    .477136
41   2.670193    0.000000    2.934030    .326044    .308442
42   3.555723    0.000000    2.934030    .112565    .080346
43   1.969121    0.000000    3.401580    .552084    .484466
44   2.764672    0.000000    3.401580    .235170    .227699
45   3.560222    0.000000    3.401580    .097783    .088768
46   1.231118    0.000000   -1.530959    .516343    .544475
47   2.386670    0.000000   -1.530959    .417060    .445070
48   3.542222    0.000000   -1.530959    .420680    .393128
49   1.415654    0.000000   -1.998701    .582691    .624634
```

Figure 18.- Continued.

```
50   2.481188   0.000000  -1.998701    .447038    .475702
51   3.546725   0.000000  -1.998701    .406635    .371749
52   1.600170   0.000000  -2.466397    .605465    .610461
53   2.575697   0.000000  -2.466397    .492166    .520067
54   3.551224   0.000000  -2.466397    .357326    .285466
55   1.784662   0.000000  -2.934030    .609257    .656462
56   2.670193   0.000000  -2.934030    .494694    .488448
57   3.555725   0.000000  -2.934030    .270462    .202445
58   1.969121   0.000000  -3.401580    .561416    .580084
59   2.764672   0.000000  -3.401580    .331799    .344244
60   3.560222   0.000000  -3.401580    .196496    .182664

                                  LOADING INFORMATION

          MACH NUMBER =    .17000E+01
      ANGLE OF ATTACK =   10.000 DEGREES
      SIDE SLIP ANGLE =   10.000 DEGREES
            WING AREA =   13.66666
       REFERENCE AREA =    5.30929
     REFERENCE LENGTH =    2.69000
  EXPOSED WING SPAN B =    4.68000
  MOMENT CENTER:   XM =   19.50000
                   ZM =    0.00000


BERNOULLI TYPE LOADING PRESSURE

                         TOTAL           FIN 1 OR R        FIN 2 OR L        FIN 3 OR U        FIN 4 OR D        INTERF. SHELL
    DEFL. ANGLE DEG. =                     0.00000           0.00000           0.00000           0.00000
               CTHP =   .29847E-01       .10546E-01        .43780E-02        .43764E-02        .10546E-01
                 CZ =   .10099E+01       .58324E+00        .27494E+00       0.                0.                 .15172E+00
                 CY =  -.10098E+01      0.                0.                -.27486E+00       -.58325E+00        -.15171E+00
                 CM =  -.68630E+01      -.39542E+01       -.18559E+01       0.                0.                 -.10528E+01
                CLN =   .68624E+01      0.                0.                 .18554E+01        .39543E+01         .10527E+01
                CLL =   .80597E-04      -.50701E+00        .26086E+00       -.26079E+00        .50702E+00         .87696E-16

               FOLLOWING ARE IN WIND-AXIS SYSTEM

                 CL =   .13918E+01       .40237E+00        .18953E+00        .18948E+00        .40238E+00         .20799E+00
             CYWIND =   .59651E-04       .41241E+00        .19441E+00       -.19436E+00       -.41242E+00         .99703E-05
                CDI =   .32179E+00       .91056E-01        .43500E-01        .43487E-01        .91058E-01         .52691E-01
          CDI/CL**2 =   .16613E+00
             CMWIND =  -.97053E+01      -.27960E+01       -.13123E+01       -.13120E+01       -.27961E+01        -.14888E+01
            CLNWIND =  -.91251E-03      -.25859E+01       -.13362E+01        .13358E+01        .25860E+01        -.66543E-04


        NOTE: L.E. OF LEAD PANEL IN FIRST CHORDWISE ROW IS SUPERSONIC
```

Figure 18.- Continued.

```
--------------------RIGHT WING--------------------

                        SPANWISE DISTRIBUTIONS

 I     Y/(B/2)  CN*C/(2*H)  CT*C/(2*H) CY1*C/(2*H) CYTOT*C/(2*H) CS*C/(2*H)     CSINT      YBAR       GAMNET(I)  GAMMA,LE/VINF   XLE

 1      .65426     .17051    0.00000    0.00000      .00017     0.00000    0.00000    0.00000     -.79887    0.00000     .13334
 2      .85415     .16738    0.00000    0.00000      .00207     0.00000    0.00000    0.00000      .01460    0.00000     .40340
 3     1.05402     .14747    0.00000    0.00000      .00146     0.00000    0.00000    0.00000      .09361    0.00000     .67342
 4     1.25386     .12736    0.00000    0.00000      .00146     0.00000    0.00000    0.00000      .09411    0.00000     .94341
 5     1.45367     .09399    0.00000    0.00000     0.00000     0.00000    0.00000    0.00000      .15623    0.00000    1.21335
 6     1.55556    0.00000                                                                        .44032


        SUMFX  =  0.
        SUMFY1 =  0.
        SUMFY2 =   .42571E-02
        SUMFT2 =   .24246E-01



        SIDE EDGE DISTRIBUTION

JTIP  JSE  DISTANCE          SUCTION FORCE       GAMMA,SE       YBAR        XSE
           FROM LE           PER UNIT LENGTH     /VINF
           /TIPCHORD         /(Q*TIPCHORD)

  1    1     .33333             .00366           .00065       3.64000     1.35100
  2    2     .66667             .03368           .00662       3.64000     2.10067
  3    3    1.00000             .03901           .01354       3.64000     2.85033


****T.E. FIN VORTEX INFO******

IVRT GAMMA/VINF   Y.C.G.

  1      .79846    3.23908
```

Figure 18.- Continued.

```
******************** LEFT WING*********************



                          SPANWISE DISTRIBUTIONS


   I      Y/(B/2)   CN*C/(2*B)  CT*C/(2*B) CY1*C/(2*B) CYTOT*C/(2*B) CS*C/(2*B)       CSINT       YBAR          GAMNET(I)  GAMMA,LE/VINF   XLE

   7      -.65426      .04819      0.00000     0.00000      -.00150     0.00000     0.00000     0.00000          .22563     0.00000     .13334
   8      -.85415      .06031      0.00000     0.00000      -.00056     0.00000     0.00000     0.00000          .05690     0.00000     .40340
   9     -1.05402      .07485      0.00000     0.00000      -.00007     0.00000     0.00000     0.00000          .06813     0.00000     .67342
  10     -1.25386      .08147      0.00000     0.00000      -.00066     0.00000    -0.00000     0.00000          .03293     0.00000     .94341
  11     -1.45367      .06801      0.00000     0.00000      0.00000     0.00000     0.00000     0.00000         -.06486     0.00000    1.21335
  12     -1.55556     0.00000                                                                                  -.31864


          SUMFX  =  0.
          SUMFY1 =  0.
          SUMFY2 =  -.22984E-02
          SUMFT2 =  -.21352E-01



          SIDE EDGE DISTRIBUTION

  JTIP   JSE  DISTANCE          SUCTION FORCE        GAMMA,SE        YBAR        XSE
              FROM LE.          PER UNIT LENGTH      /VINF
              /TIPCHORD         /(Q*TIPCHORD)

   1      1     .33333             -.00602           -.00107       -3.64000     1.35100
   2      2     .66667             -.03334           -.00698       -3.64000     2.10067
   3      3    1.00000             -.02787           -.01193       -3.64000     2.85033



*****T.E. FIN VORTEX INFL******

IVRT GAMMA/VINF    Y.C.G.

  2      .15764    -2.16505
  3    -.38316     -3.56077
```

Figure 18.- Continued.

```
-------------------------UPPER WING-------------------------


                         SPANWISE DISTRIBUTIONS--

 I     Z/(B/2)  CN*C/(2*B)  CT*C/(2*B) CZ1*C/(2*B) CZTOT*C/(2*B) CS*C/(2*B)     CSINT      ZBAR     [illegible]FT(I)  GAMMA,LE/VINF  XLE
13      .65426     .04817     0.00000     0.00000      .00150     0.00000     0.00000    0.00000     -.22554    0.00000     .13334
14      .85415     .06029     0.00000     0.00000      .00056     0.00000     0.00000    0.00000     -.05678    0.00000     .40340
15     1.05402     .07483     0.00000     0.00000      .00007     0.00000     0.00000    0.00000     -.06811    0.00000     .67342
16     1.25386     .08185     0.00000     0.00000      .00066     0.00000     0.00000    0.00000     -.03296    0.00000     .94341
17     1.45367     .06800     0.00000     0.00000     0.00000     0.00000     0.00000    0.00000      .06481    0.00000    1.21335
18     1.55556    0.00000                                                                           .31859


          SUMFX  =  0.
          SUMFZ1 =  0.
          SUMFZ2 =   .22978E-02
          SUMFT2 =   .21549E-01


          SIDE EDGE DISTRIBUTION

JTIP  JSE  DISTANCE        SUCTION FORCE        GAMMA,SE      ZBAR       XSE
           FROM LE         PER UNIT LENGTH      /VINF
           /TIPCHORD       /(Q*TIPCHORD)

  1    4     .33333          .00602             .00107       3.64000    1.35100
  2    5     .66667          .03334             .00698       3.64000    2.10067
  3    6    1.00000          .02787             .01193       3.64000    2.85033


*****T.E. FIN VORTEX INFO******

IVRT GAMMA/VINF   Z.C.G.

  4    -.19764    2.16521
  5     .38307    3.56081
```

Figure 18.- Continued.

```
-------------------LOWER WING--------------------

                    SPANWISE DISTRIBUTIONS

  I     Z/(B/2)  CN*C/(2*B)  CT*C/(2*B) CZ1*C/(2*B) CZTOT*C/(2*B) CS*C/(2*B)     CSINT       ZBAR        GAMNET(I)  GAMMA,LE/VINF  XLF

 19    -.65426      .17051     0.00000     0.00000      -.00017     0.00000     0.00000     0.00000       .79888    0.00000      .13334
 20    -.85015      .16738     0.00000     0.00000      -.00207     0.00000     0.00000     0.00000     -.01460    0.00000      .40340
 21   -1.05402      .14747     0.00000     0.00000      -.00146     0.00000     0.00000     0.00000     -.09361    0.00000      .67342
 22   -1.25386      .12736     0.00000     0.00000      -.00146     0.00000     0.00000     0.00000     -.09411    0.00000      .94341
 23   -1.45367      .09399     0.00000     0.00000      0.00000     0.00000     0.00000     0.00000     -.15623    0.00000     1.21335
 24   -1.55556    0.00000                                                                            -.44033


        SUMFX  =  0.
        SUMFZ1 =  0.
        SUMFZ2 =  -.425716E-02
        SUMFT2 =  -.24247E-01



        SIDE EDGE DISTRIBUTION

JTIP  JSE  DISTANCE        SUCTION FORCE        GAMMA,SF     ZBAR        XSE
           FROM LE         PER UNIT LENGTH      /VINF
           /TIPCHORD       /(Q*TIPCHORD)

  1    7      .33333          -.00366          -.00065    -3.64000    1.35100
  2    8      .66667          -.03368          -.00642    -3.64000    2.10067
  3    9     1.00000          -.03901          -.01354    -3.64000    2.85033


****T.E. FIN VORTEX INFO******

IVRT GAMMA/VINF   Z.C.G.

  6     -.79847   -3.23910


 *****************************************************************************************************************
 AFT OF LEADING EDGE OF FIN ROOTCHORDS
```

Figure 18.- Continued.

```
                              PRESSURE COEFFICIENTS AT POINTS ON BODY MERIDIANS

 J    THETA,       XB         YB         ZB         UTOT       VTOT       WTOT     CP.LIN.   CP.BERN.     DR/DX      P/PINF.    P/PINF.
       DEG.                                                                                                          BERN.      LIN.

                                                  BODY RING#    1

 1  11.25000   36.54000    1.25052     .24874     .08219     .13852     .01640    -.16438    -.12894    0.00000      .73915     .66747
 2  33.75000   36.54000    1.06014     .70836     .01475     .03202     .03127    -.02949    -.02988    0.00000      .93955     .94034
 3  56.25000   36.54000     .70836    1.06014    -.02327     .06871    -.10981     .04655     .09578    0.00000     1.19375    1.09416
 4  78.75000   36.54000     .24874    1.25052    -.03442     .11770    -.16598     .06884     .13393    0.00000     1.27093    1.13926
 5 101.25000   36.54000    -.24874    1.25052     .01842     .17193    -.18030    -.03685     .02463    0.00000     1.04982     .92546
 6 123.75000   36.54000    -.70836    1.06014    -.00634     .18091    -.17097     .01267     .07637    0.00000     1.15449    1.02564
 7 146.25000   36.54000   -1.06014     .70836    -.00633     .17099    -.18087     .01266     .07636    0.00000     1.15448    1.02562
 8 168.75000   36.54000   -1.25052     .24874     .01844     .18031    -.17190    -.03688     .02460    0.00000     1.04977     .92540
 9 191.25000   36.54000   -1.25052    -.24874    -.03443     .16598    -.11769     .06887     .13396    0.00000     1.27099    1.13932
10 213.75000   36.54000   -1.06014    -.70836    -.02328     .10984    -.06876     .04655     .09580    0.00000     1.19381    1.09418
11 236.25000   36.54000    -.70836   -1.06014     .01475    -.03123    -.03205    -.02949    -.02986    0.00000      .93959     .94034
12 258.75000   36.54000    -.24874   -1.25052     .08219    -.01638    -.13852    -.16437    -.12894    0.00000      .73916     .66747
13 281.25000   36.54000     .24874   -1.25052    -.09828     .06821    -.20246     .19656     .26977    0.00000     1.54575    1.39765
14 303.75000   36.54000     .70836   -1.06014    -.04277     .15795    -.19643     .08555     .15552    0.00000     1.31462    1.17307
15 326.25000   36.54000    1.06014    -.70836    -.04277     .19642    -.15796     .08555     .15552    0.00000     1.31462    1.17307
16 348.75000   36.54000    1.25052    -.24874    -.09828     .20246    -.06821     .19656     .26977    0.00000     1.54575    1.39765

                                                  BODY RING#    2

 1  11.25000   37.74000    1.25052     .24874     .09340     .14188     .00241    -.18680    -.14353    0.00000      .70965     .62210
 2  33.75000   37.74000    1.06014     .70836     .05033     .06741    -.02045    -.10067    -.07064    0.00000      .85710     .79635
 3  56.25000   37.74000     .70836    1.06014    -.00353     .07850    -.11769     .00705     .05716    0.00000     1.11564    1.01427
 4  78.75000   37.74000     .24874    1.25052    -.03836     .12796    -.16918     .07671     .14399    0.00000     1.29128    1.15519
 5 101.25000   37.74000    -.24874    1.25052     .03431     .19227    -.17615    -.06861    -.00769    0.00000      .98444     .86120
 6 123.75000   37.74000    -.70836    1.06014     .02468     .21202    -.14964    -.04935     .00988    0.00000     1.01998     .90016
 7 146.25000   37.74000   -1.06014     .70836     .02468     .14967    -.21198    -.04937     .00987    0.00000     1.01997     .90013
 8 168.75000   37.74000   -1.25052     .24874     .03432     .17615    -.19224    -.06864    -.00771    0.00000      .98439     .86114
 9 191.25000   37.74000   -1.25052    -.24874    -.03837     .16918    -.12799     .07674     .14402    0.00000     1.29135    1.15525
10 213.75000   37.74000   -1.06014    -.70836    -.00354     .11774    -.07857     .00708     .05721    0.00000     1.11573    1.01431
11 236.25000   37.74000    -.70836   -1.06014     .05033     .02048    -.06743    -.10066    -.07062    0.00000      .85714     .79636
12 258.75000   37.74000    -.24874   -1.25052     .09340    -.00239    -.14188    -.18680    -.14352    0.00000      .70965     .62210
13 281.25000   37.74000     .24874   -1.25052    -.11208     .05872    -.20464     .22416     .29970    0.00000     1.60630    1.45348
14 303.75000   37.74000     .70836   -1.06014    -.12123     .14059    -.20823     .24245     .33892    0.00000     1.68564    1.49048
15 326.25000   37.74000    1.06014    -.70836    -.12122     .20823    -.14060     .24245     .33892    0.00000     1.68564    1.49048
16 348.75000   37.74000    1.25052    -.24874    -.11208     .20464    -.05872     .22416     .29970    0.00000     1.60630    1.45348

                                                  BODY RING#    3

 1  11.25000   38.94000    1.25052     .24874     .10902     .15137    -.04299    -.21804    -.15818    0.00000      .68000     .55890
 2  33.75000   38.94000    1.06014     .70836     .03374     .07278    -.02726    -.06749    -.03683    0.00000      .92549     .86347
 3  56.25000   38.94000     .70836    1.06014     .00734     .08662    -.12365    -.01469     .03689    0.00000     1.07462     .97029
 4  78.75000   38.94000     .24874    1.25052     .03709     .08564    -.16211    -.07418    -.02054    0.00000      .95845     .84994
 5 101.25000   38.94000    -.24874    1.25052     .08829     .23668    -.16751    -.17657    -.11217    0.00000      .77308     .64280
 6 123.75000   38.94000    -.70836    1.06014     .05319     .20442    -.15419    -.10638    -.04540    0.00000      .90816     .78479
 7 146.25000   38.94000   -1.06014     .70836     .05319     .15421    -.20438    -.10638    -.04539    0.00000      .90817     .78479
 8 168.75000   38.94000   -1.25052     .24874     .08829     .16751    -.23665    -.17657    -.11217    0.00000      .77309     .64279
 9 191.25000   38.94000   -1.25052    -.24874     .03708     .16211    -.08567    -.07416    -.02052    0.00000      .95848     .84997
10 213.75000   38.94000   -1.06014    -.70836     .00734     .12369    -.08668    -.01467     .03692    0.00000     1.07469     .97032
```

Figure 18.- Continued.

```
11 236.25000  38.94000  -.70836  -1.06014   .03373   .02729  -.07281  -.06747  -.03680  0.00000   .92555   .86351
12 258.75000  38.94000  -.24874  -1.25052   .10902   .04299  -.15137  -.21803  -.15817  0.00000   .68002   .55892
13 281.25000  38.94000   .24874  -1.25052  -.09663  -.00224  -.21700   .19326   .23784  0.00000  1.48116  1.39096
14 303.75000  38.94000   .70836  -1.06014  -.15488   .13903  -.20945   .30977   .42275  0.00000  1.85523  1.62666
15 326.25000  38.94000  1.06014   -.70836  -.15488   .20944  -.13904   .30977   .42275  0.00000  1.85523  1.62666
16 348.75000  38.94000  1.25052   -.24874  -.09663   .21700   .00223   .19325   .23784  0.00000  1.48115  1.39095
```

Figure 18.- Concluded.

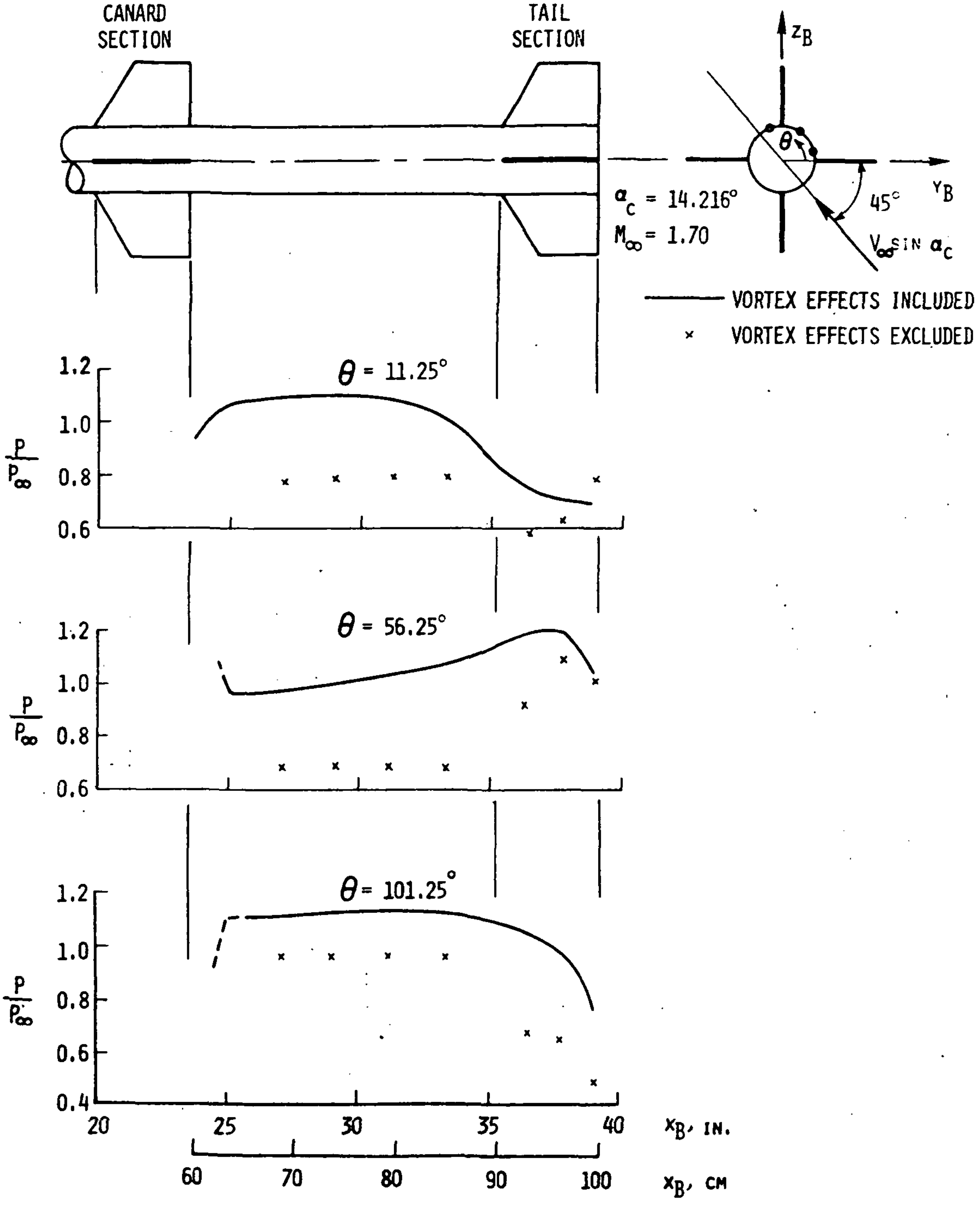


Figure 19.- Calculated pressure distributions along body meridians from canard section to body base, first sample case, step 6.

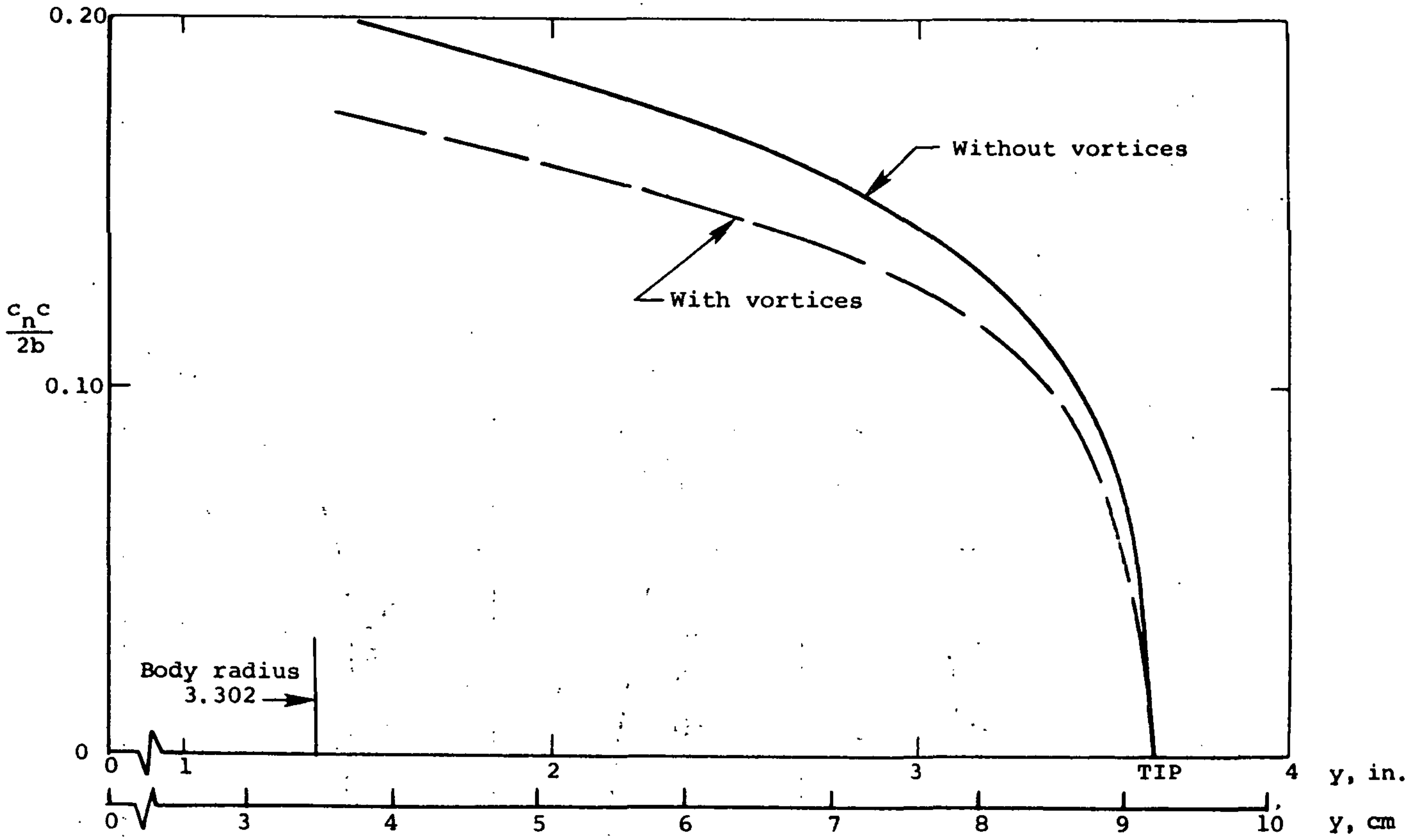


Figure 20.- Calculated span load distribution on right horizontal tail fin, first sample case, step 6.

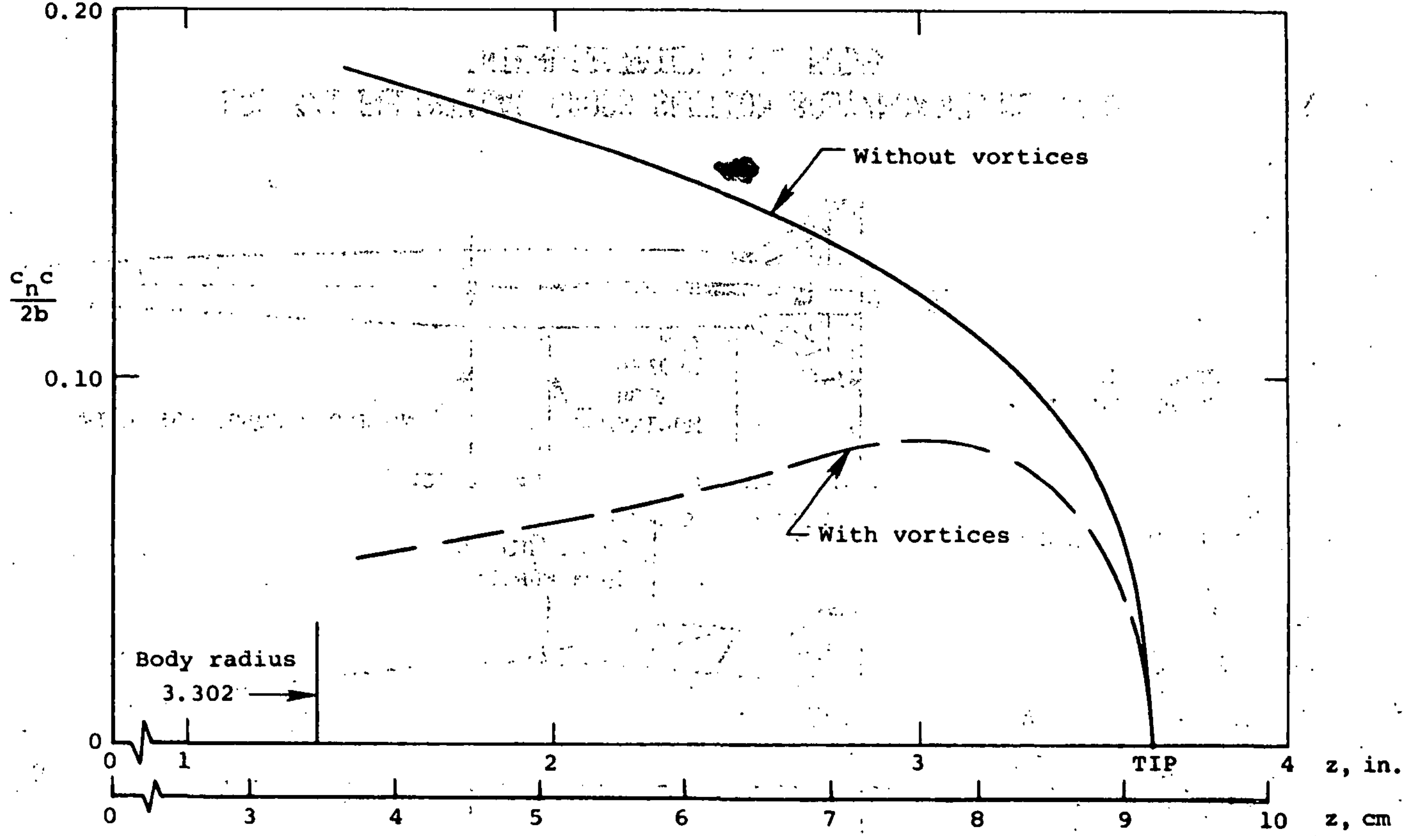
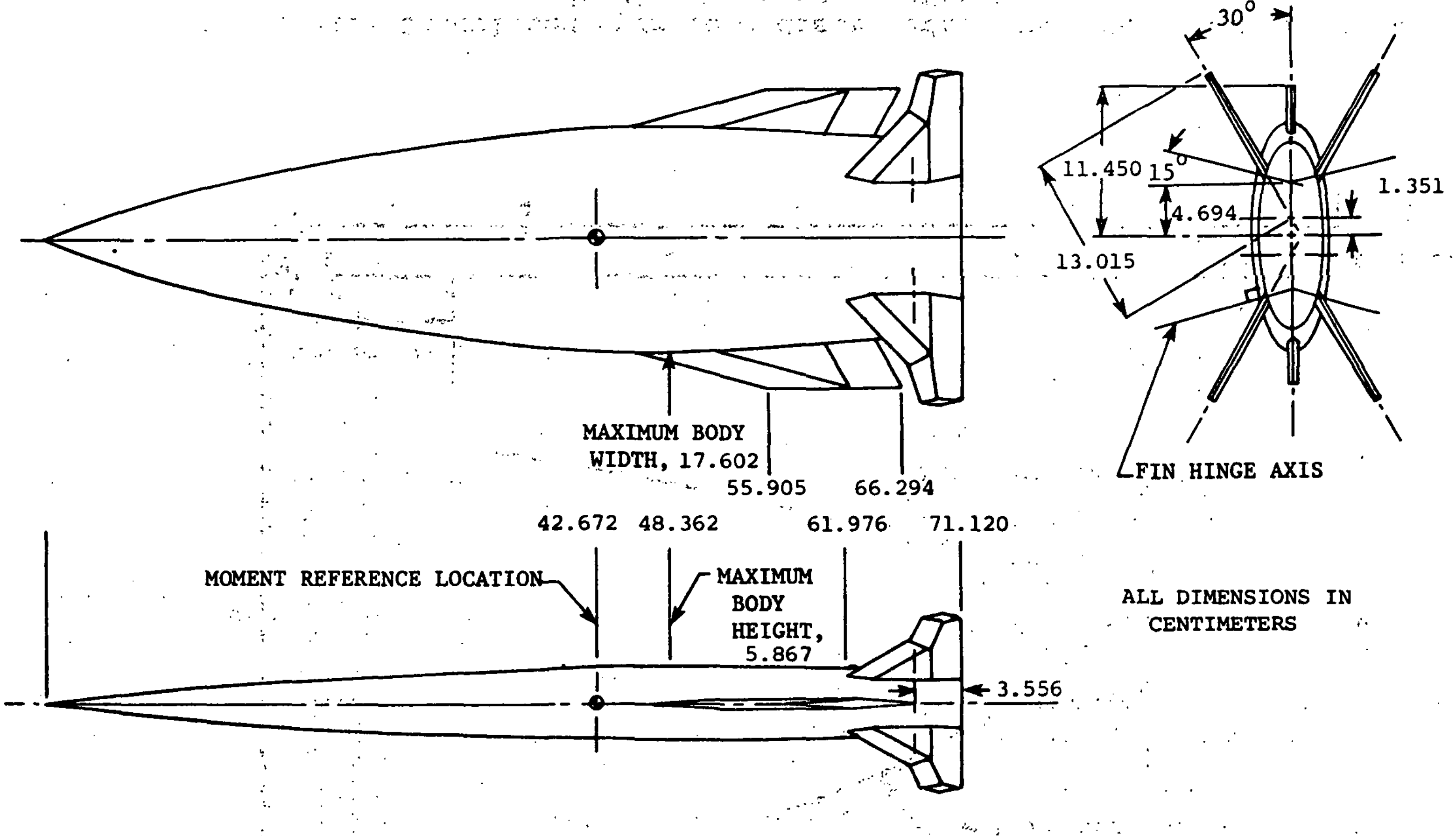


Figure 21.- Calculated span-load distribution on upper vertical fin, first sample case, step 6.



LRC 3/1 ELLIPTICAL CROSS SECTION BODY/MONOPLANE WING/
INTERDIGITATED TAIL MODEL

Figure 22.- Configuration used for second sample case.

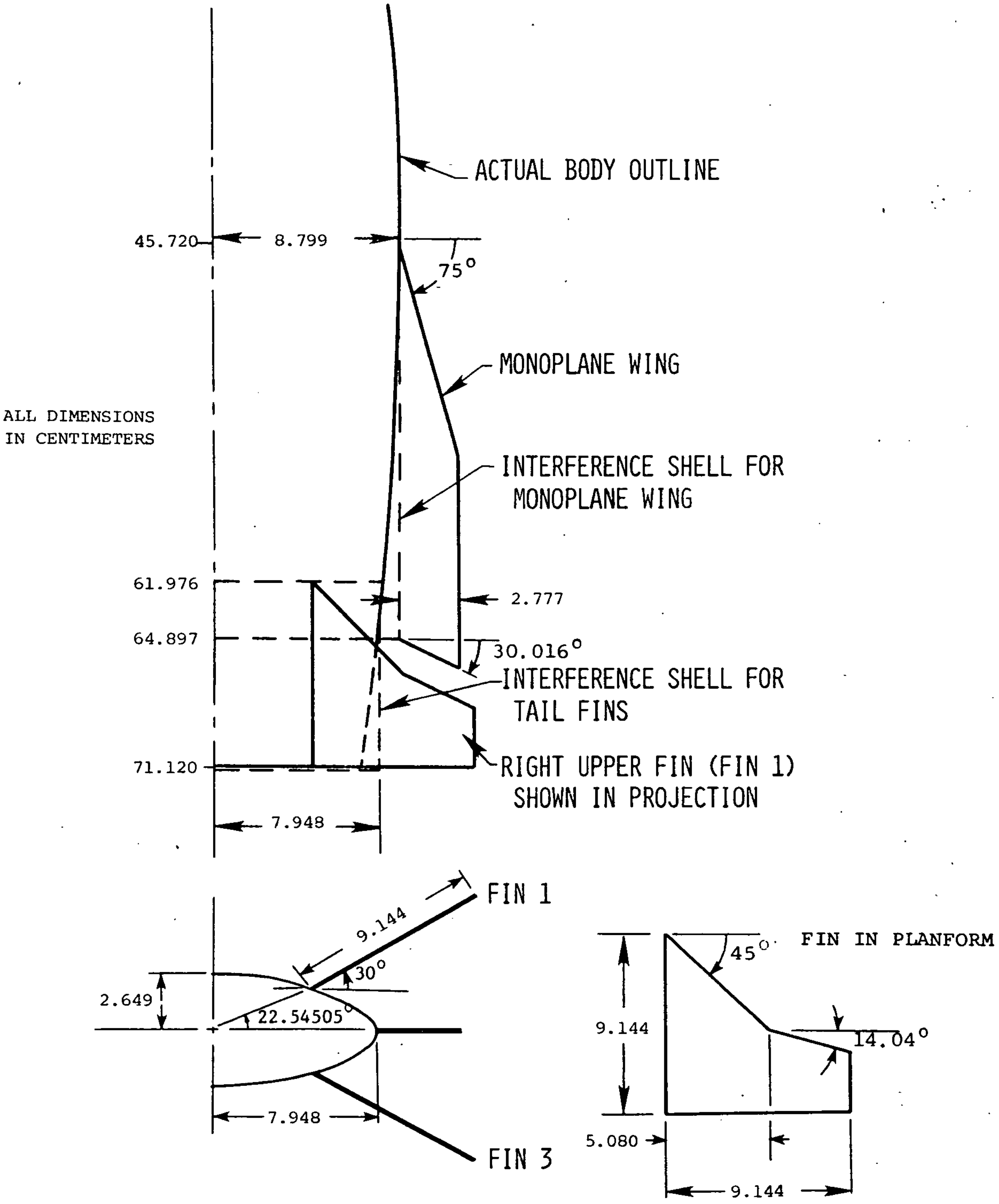
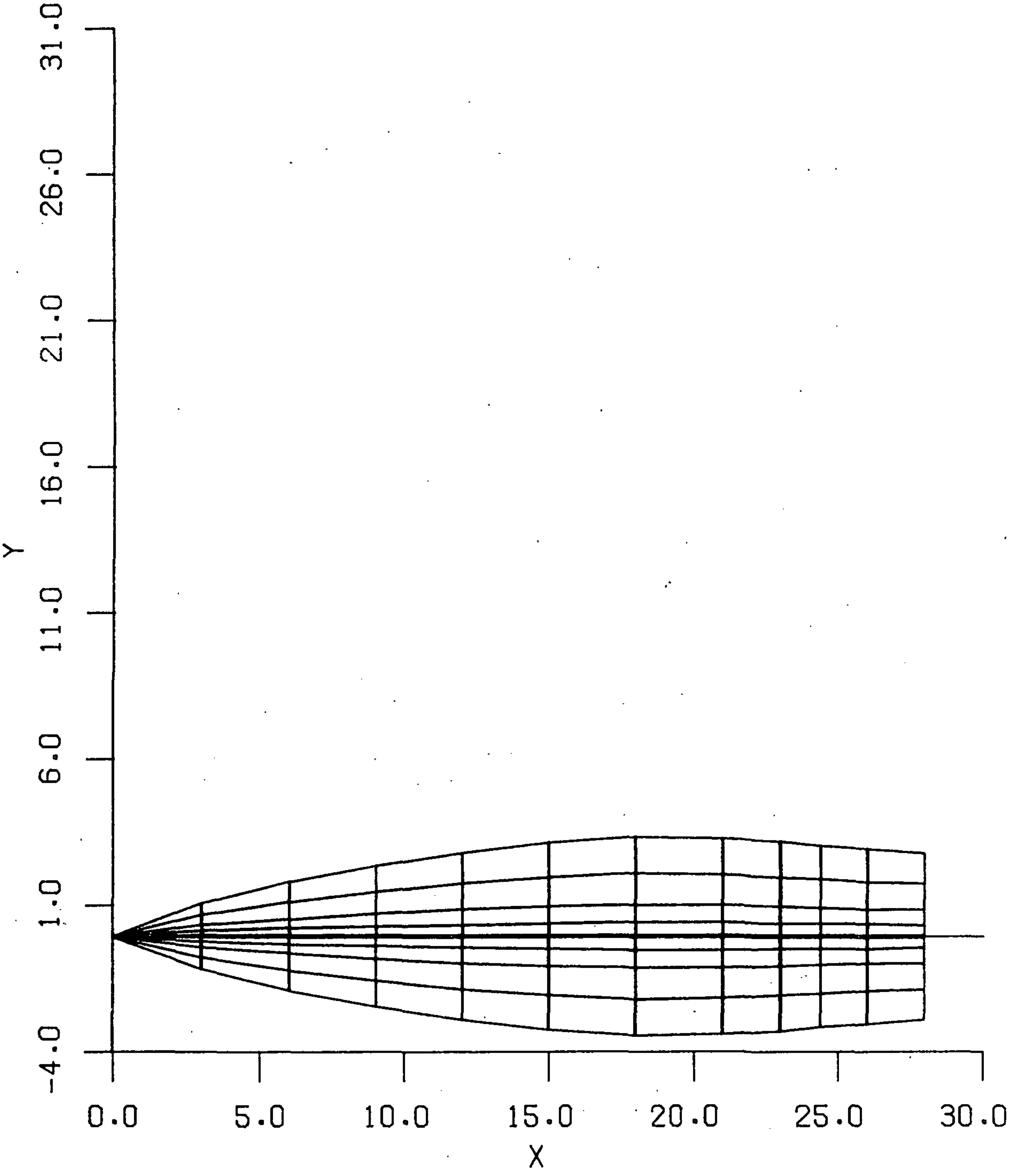
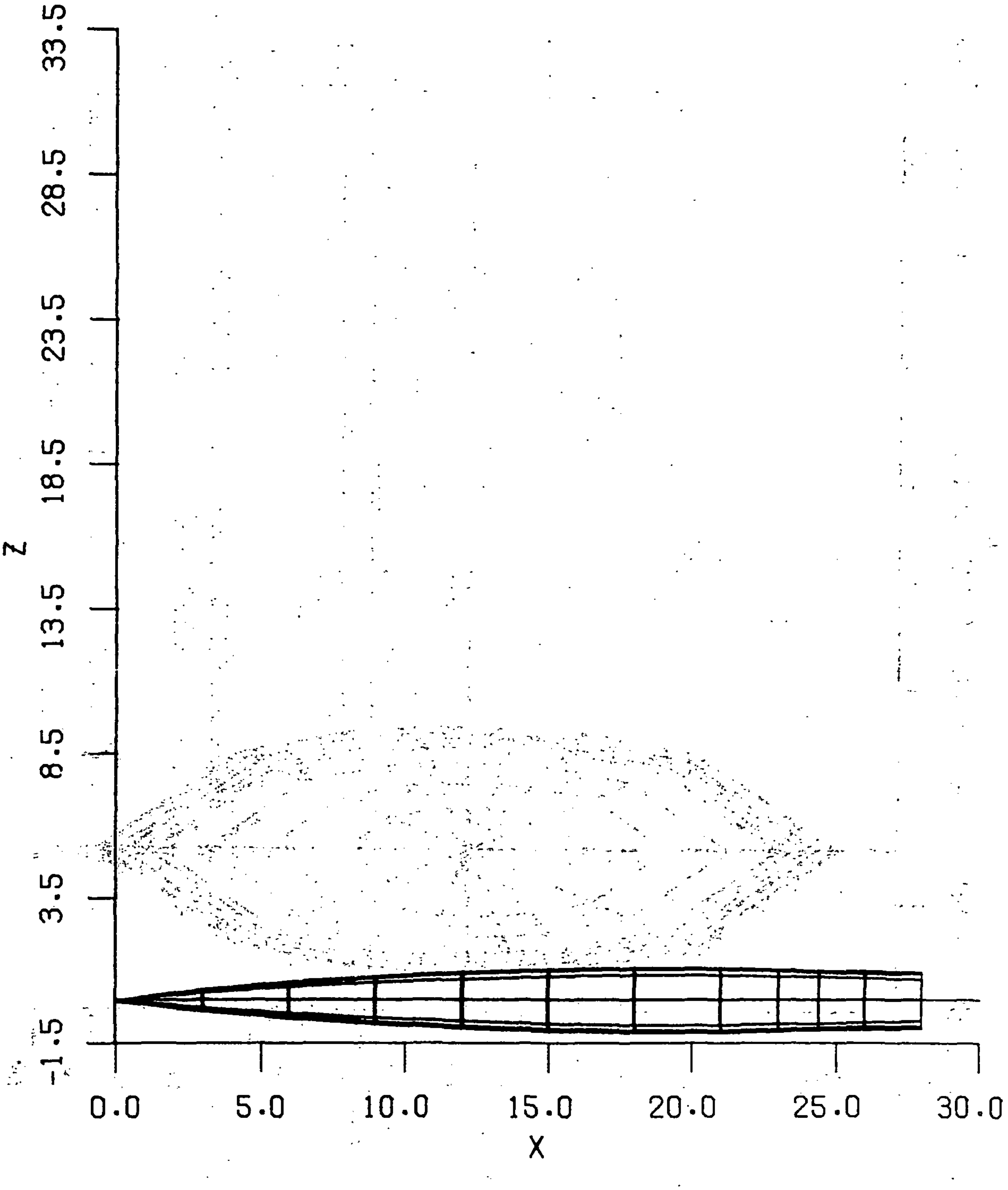


Figure 23.- Geometrical details, idealizations of configuration used for second sample case.



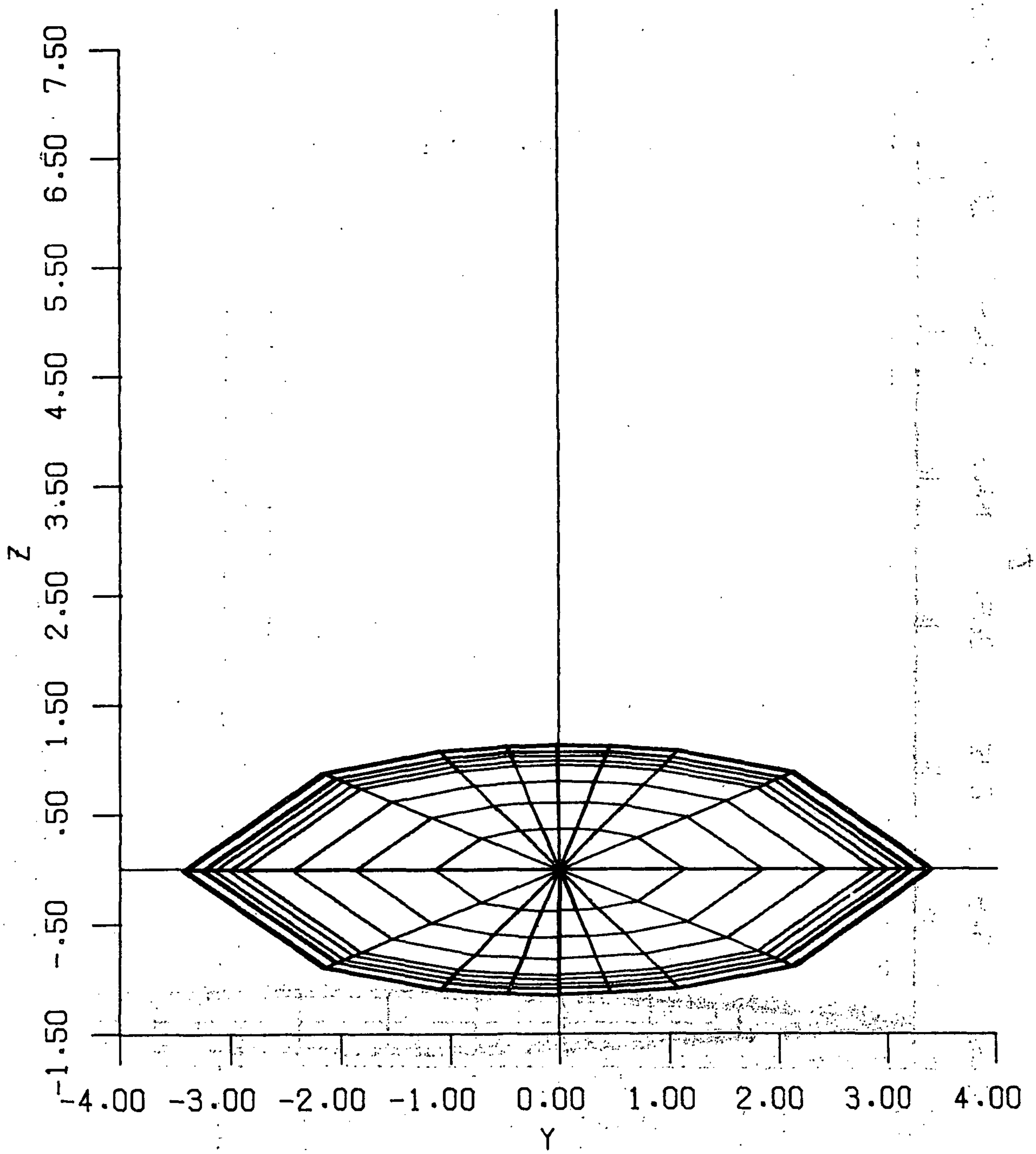
(a) Plan View

Figure 24.- Body source paneling layout, second sample case.



(b) Elevation

Figure 24.- Continued.



(c) End View

Figure 24.- Concluded.

```
 LRC 3/1 ELLIPTIC WING/BODY MISSILE CONFIGURATION - NOSE VORTICITY
  1  0  0  0  0  0  0  0  0  0 22  2 10  0                                  IPRT
18.0  0.0                                                                    XWLE
  0  0 -3  0  0  0 -1  0  0  1 13 30  0  0  0  0  0  0  0  0  0  0  0      0JCARD
  0.000   .420   .700  2.100  3.500  4.900  5.600  6.300  7.700  8.400      XFUS
  9.100 10.500 11.900 12.600 13.300 14.700 15.400 16.800 17.500 18.200      XFUS
 19.040 19.600 20.300 21.000 22.400 23.100 24.500 25.900 26.600 28.000      XFUS
 0.0000  .2675  .3914  .8808 1.2745 1.6168 1.7736 1.9222 2.1978 2.3256      FUSBY
 2.4471 2.6721 2.8735 2.9653 3.0510 3.2033 3.2692 3.3777 3.4184 3.4481      FUSBY
 3.4641 3.4563 3.4322 3.3970 3.3029 3.2476 3.1283 3.0090 2.9552 2.8846      FUSBY
 0.0000  .0892  .1305  .2936  .4248  .5389  .5912  .6407  .7326  .7752      FUSAZ
  .8157  .8907  .9578  .9884 1.0170 1.0678 1.0897 1.1259 1.1395 1.1494      FUSAZ
 1.1547 1.1521 1.1441 1.1323 1.1010 1.0825 1.0428 1.0030  .9851  .9615      FUSAZ
ELLIPTIC BODY PANELING -    KRAD=9, KFORX=11
  0  0 -2                                                                   BC/PRINT
  1  0  1  0  0  0 -1  0  0  1  9 11  0  0  0  0  0  0                     KCARD
12.567                3.4641            16.8                                REF
0.0     2.0    4.0    6.0    8.0    10.    12.    14.    16.    18.       XV
0.000  3.000  6.000  9.000  12.00  15.00  18.00  21.00  23.00  24.40       XFUS10
25.6                                                                        XFUS11
1.70    10.                                                                 MALPHA
0.0     .653   .990   1.281  1.528  1.7465 1.932  2.1    2.24   2.35       YVRTX1
 0.0    .299   .531   .739   .929   1.1028 1.272  1.423  1.551  1.673      ZVRTX1
 0.0     .191   .4725  .675   .851   1.008  1.151  1.283   1.406  1.52     GAM1
0.0     -.653  -.990  -1.281 -1.528 -1.7465-1.932 -2.1   -2.24  -2.35      YVRTX2
 0.0    .299   .531   .739   .929   1.1028 1.272  1.423  1.551  1.673      ZVRTX2
 0.0    -.191  -.4725 -.675  -.851  -1.008 -1.151 -1.283 -1.406 -1.52      GAM2
-1.0
```

Figure 25.- Input of program WDYBDY, second sample case, step 2.

```
WOODWARD*S SOURCE PANEL BODY MODELING PROGRAM          DATED JUNE, 1977

                 LIST OF INPUT CARDS


 LRC 3/1 ELLIPTIC WING/BODY MISSILE CONFIGURATION - NOSE VORTICITY
  1  0  0  0  0  0  0  0  0  0 22  2 10  0                                 IPRT
18.0   0.0                                                                XWLE
  0  0 -3  0  0  0 -1  0  0  1 13 30  0  0  0  0  0  0  0  0  0  0  0JCARD
  0.000   .420    .700   2.100   3.500   4.900   5.600   6.300   7.700   8.400  XFUS
  9.100  10.500  11.900  12.600  13.300  14.700  15.400  16.800  17.500  18.200  XFUS
 19.040  19.600  20.300  21.000  22.400  23.100  24.500  25.900  26.600  28.000  XFUS
 0.0000   .2675   .3914   .8808  1.2745  1.6168  1.7736  1.9222  2.1978  2.3256  FUSBY
 2.4471  2.6721  2.8735  2.9653  3.0510  3.2033  3.2692  3.3777  3.4184  3.4481  FUSBY
 3.4641  3.4563  3.4322  3.3970  3.3029  3.2476  3.1283  3.0090  2.9552  2.8846  FUSBY
 0.0000   .0892   .1305   .2936   .4248   .5389   .5912   .6407   .7326   .7752  FUSAZ
  .8157   .8907   .9578   .9884  1.0170  1.0678  1.0897  1.1259  1.1395  1.1494  FUSAZ
 1.1547  1.1521  1.1441  1.1323  1.1010  1.0825  1.0428  1.0030   .9851   .9615  FUSAZ
ELLIPTIC BODY PANELING -     KRAD=9, KFORX=11
  0  0 -2                                                                 BC/PRINT
  1  0  1  0  0  0 -1  0  0  1  9 11  0  0  0  0  0  0                     KCARD
12.567               3.4641              16.8                             REF
0.0      2.0      4.0      6.0      8.0      10.      12.      14.      16.      18.      XV
0.000    3.000    6.000    9.000    12.00    15.00    18.00    21.00    23.00    24.40    XFUS10
25.6                                                                      XFUS11
1.70     10.                                                              MALPHA
0.0      .653     .990     1.281    1.528    1.7465 1.932  2.1      2.24     2.35     YVRTX1
 0.0     .299     .531     .739     .929     1.1028 1.272  1.423    1.551    1.673    ZVRTX1
 0.0      .191     .4725    .675     .851     1.008   1.151   1.283    1.406   1.52   GAM1
0.0      -.653    -.990    -1.281   -1.528   -1.7465-1.932  -2.1     -2.24    -2.35    YVRTX2
 0.0     .299     .531     .739     .929     1.1028 1.272  1.423    1.551    1.673    ZVRTX2
 0.0     -.191    -.4725   -.675    -.851    -1.008  -1.151 -1.283   -1.406   -1.52    GAM2
-1.0


                 BEGIN A NEW CONFIGURATION                                                      ** WDYBDY **


   LRC 3/1 ELLIPTIC WING/BODY MISSILE CONFIGURATION - NOSE VORTICITY                            ** GEOM   **


   ADDITIONAL PRINT OPTIONS (IPRT) + XZ-PANEL SYMMETRY
   TN    GEOM VORTEX     VEL.   SOLN   IXZSYM
    1      0      0        0      0      0

   PLOT OPTIONS (IPLOT)
 GEOM     CP   U/V/W
   0       0      0      0
```

Figure 26.- Output of program WDYBDY, second sample case, step 2.

```
       VORTEX CALCULATION CONTROL
    N-CPT   NVTX  NXVTX NCPOUT  NVLIN
     22       2     10      0       0

      X-LE     YSTART
    18.000      0.000

            J-DATA CARDS REQUIRED (NO=0,YES.NE.0)

     REFA     WING    BODY      POD   V.FIN H.TAIL YY-SYM
      J0       J1      J2        J3     J4     J5     J6
      0        0       -3        0      0      0      -1

    WING GEOM:    NWAF=     0   NWAFOR=     0
    BODY GEOM:    NFUS=     1    NRADX=    13     0     0     0
                                 NFORX=    30     0     0     0
     POD GEOM:      NP=     0   NPODOR=     0
   V.FIN GEOM:      NF=     0   NFINOR=     0
  H.TAIL GEOM:    NCAN=     0   NCANOR=     0


            VEHICLE GEOMETRY DEFINITION                                                                              ** CONFIG **
       REFERENCE AREA (J0.GT.0)     REFA=  1.00000


   NFU      XFUS - FUSELAGE X-STATIONS
    1     0.0000     .4200     .7000    2.1000    3.5000    4.9000    5.6000    6.3000    7.7000    8.4000
    1     9.1000   10.5000   11.9000   12.6000   13.3000   14.7000   15.4000   16.8000   17.5000   18.2000
    1    19.0400   19.6000   20.3000   21.0000   22.4000   23.1000   24.5000   25.9000   26.6000   28.0000

   NFU      FUSRY - ELLIPTIC FUSELAGE SEMI-MAJOR AXES
    1     0.0000     .2675     .5914     .8808    1.2745    1.6168    1.7736    1.9222    2.1978    2.3256
    1     2.4071    2.6721    2.8735    2.9653    3.0510    3.2033    3.2692    3.3777    3.4184    3.4481
    1     3.4641    3.4563    3.4322    3.3970    3.3029    3.2476    3.1283    3.0090    2.9552    2.8846

   NFU      FUSRZ - ELLIPTIC FUSELAGE SEMI-MINOR AXES
    1     0.0000     .0892     .1305     .2936     .4248     .5389     .5912     .6407     .7326     .7752
    1      .8157     .8907     .9578     .9884    1.0170    1.0678    1.0897    1.1259    1.1395    1.1494
    1     1.1547    1.1521    1.1441    1.1323    1.1010    1.0825    1.0428    1.0030     .9851     .9615


       ELLIPTIC BODY PANELING -    NRAD=9, NFORX=11                                                                  ** GEOM   **

   LINBC  THICK IPRINT  LCPA   LCPB   LCPC  ITMAX CCTEST
     0      0     -2      0      0      0      0   0.00000
```

Figure 26.- Continued.

```
        K-DATA CARDS,  ADDITIONAL CARDS FOR PANELING

   REF     WING    BODY     N/A   V.FIN H.TAIL    N/A
   K0       K1      K2      K3      K4     K5      K6
    1        0       1       0       0      0      -1

WING PANEL:    K-AF=     0   KWAFOR=    0
BODY PANEL:    KFUS=     1    KRADX=    9     0     0     0
                              KFORX=   11     0     0     0


        PANEL REFERENCE LENGTHS
  REFAR       REFH        REFC        REFD        REFL        REFX        REFZ
 12.567       0.000       0.000       3.464       0.000      16.800       0.000


        VORTEX LOCATIONS AND BODY AXES                                                                               ** READVX **

XV=     0.0000     2.0000     4.0000     6.0000     8.0000    10.0000    12.0000    14.0000    16.0000    18.0000

BY=     0.0000      .8458     1.3968     1.8585     2.2526     2.5917     2.8866     3.1272     3.3157     3.4396

AZ=     0.0000      .2820      .4656      .6195      .7509      .8639      .9622     1.0424     1.1052     1.1466

      BODY PANEL CORNER POINT COORDINATES                                                                          ** BODPAN **

      1 AND 3 INDICATE BODY PANEL LEADING-EDGE POINTS, 2 AND 4 INDICATE TRAILING-EDGE POINTS
PANEL        X          Y          Z          X          Y          Z          X          Y          Z          X          Y          Z
             1          1          1          2          2          2          3          3          3          4          4          4

  1      0.00000    0.00000    0.00000    3.00000     .00000    -.37794    0.00000    0.00000    0.00000    3.00000     .15508    -.37439
  2      0.00000    0.00000    0.00000    3.00000     .15508    -.37439    0.00000    0.00000    0.00000    3.00000     .35855    -.35855
  3      0.00000    0.00000    0.00000    3.00000     .35855    -.35855    0.00000    0.00000    0.00000    3.00000     .71086    -.29445
  4      0.00000    0.00000    0.00000    3.00000     .71086    -.29445    0.00000    0.00000    0.00000    3.00000     .13389     .00000
  5      0.00000    0.00000    0.00000    3.00000    1.13389     .00000    0.00000    0.00000    0.00000    3.00000     .71086     .29445
  6      0.00000    0.00000    0.00000    3.00000     .71086     .29445    0.00000    0.00000    0.00000    3.00000     .35855     .35855
  7      0.00000    0.00000    0.00000    3.00000     .35855     .35855    0.00000    0.00000    0.00000    3.00000     .15508     .37439
  8      0.00000    0.00000    0.00000    3.00000     .15508     .37439    0.00000    0.00000    0.00000    3.00000    -.00000     .37794
  9      3.00000     .00000    -.37794    6.00000     .00000    -.61949    3.00000     .15508    -.37439    6.00000     .25419    -.61366
 10      3.00000     .15508    -.37439    6.00000     .25419    -.61366    3.00000     .35855    -.35855    6.00000     .58770    -.58770
 11      3.00000     .35855    -.35855    6.00000     .58770    -.58770    3.00000     .71086    -.29445    6.00000    1.16516    -.48263
 12      3.00000     .71086    -.29445    6.00000    1.16516    -.48263    3.00000    1.13389     .00000    6.00000    1.85851     .00000
 13      3.00000    1.13389     .00000    6.00000    1.85851     .00000    3.00000     .71086     .29445    6.00000    1.16516     .48263
 14      3.00000     .71086     .29445    6.00000    1.16516     .48263    3.00000     .35855     .35855    6.00000     .58770     .58770
 15      3.00000     .35855     .35855    6.00000     .58770     .58770    3.00000     .15508     .37439    6.00000     .25419     .61366
 16      3.00000     .15508     .37439    6.00000     .25419     .61366    3.00000    -.00000     .37794    6.00000    -.00000     .61949
 17      6.00000     .00000    -.61949    9.00000     .00000    -.80991    6.00000     .25419    -.61366    9.00000     .33232    -.80230
 18      6.00000     .25419    -.61366    9.00000     .33232    -.80230    6.00000     .58770    -.58770    9.00000     .76835    -.76835
 19      6.00000     .58770    -.58770    9.00000     .76835    -.76835    6.00000    1.16516    -.48263    9.00000    1.52331    -.63098
 20      6.00000    1.16516    -.48263    9.00000    1.52331    -.63098    6.00000    1.85851     .00000    9.00000    2.42974     .00000
```

Figure 26.- Continued.

```
21     6.00000  1.85951   .00000  9.00000  2.42974   .00000  6.00000  1.16516   .48263  9.00000  1.52331   .63098
22     6.00000  1.16516   .48263  9.00000  1.52331   .63098  6.00000   .58770   .58770  9.00000   .76835   .76835
23     6.00000   .58770   .58770  9.00000   .76835   .76835  6.00000   .25419   .61366  9.00000   .33232   .80230
24     6.00000   .25419   .61366  9.00000   .33232   .80230  6.00000  -.00000   .61949  9.00000  -.00000   .80991
25     9.00000   .00000  -.80991 12.00000   .00000  -.96217  9.00000   .33232  -.80230 12.00000   .39480  -.95313
26     9.00000   .33232  -.80230 12.00000   .39480  -.95313  9.00000   .76835  -.76835 12.00000   .91280  -.91280
27     9.00000   .76835  -.76835 12.00000   .91280  -.91280  9.00000  1.52331  -.63098 12.00000  1.80970  -.74960
28     9.00000  1.52331  -.63098 12.00000  1.80970  -.74960  9.00000  2.42974   .00000 12.00000  2.88661   .00000
29     9.00000  2.42974   .00000 12.00000  2.88661   .00000  9.00000  1.52331   .63098 12.00000  1.80970   .74960
30     9.00000  1.52331   .63098 12.00000  1.80970   .74960  9.00000   .76835   .76835 12.00000   .91280   .91280
31     9.00000   .76835   .76835 12.00000   .91280   .91280  9.00000   .33232   .80230 12.00000   .39480   .95313
32     9.00000   .33232   .80230 12.00000   .39480   .95313  9.00000  -.00000   .80991 12.00000  -.00000   .96217
33    12.00000   .00000  -.96217 15.00000   .00000 -1.07719 12.00000   .39480  -.95313 15.00000   .44199 -1.06706
34    12.00000   .39480  -.95313 15.00000   .44199 -1.06706 12.00000   .91280  -.91280 15.00000  1.02191 -1.02191
35    12.00000   .91280  -.91260 15.00000  1.02191 -1.02191 12.00000  1.80970  -.74960 15.00000  2.02600  -.83920
36    12.00000  1.80970  -.74960 15.00000  2.02600  -.83920 12.00000  2.88661   .00000 15.00000  3.23154   .00000
37    12.00000  2.88661   .00000 15.00000  3.23154   .00000 12.00000  1.80970   .74960 15.00000  2.02600   .83920
38    12.00000  1.80970   .74960 15.00000  2.02400   .83920 12.00000   .91280   .91280 15.00000  1.02191  1.02191
39    12.00000   .91280   .91280 15.00000  1.02191  1.02191 12.00000   .39480   .95313 15.00000   .44199  1.06706
40    12.00000   .39480   .95313 15.00000   .44199  1.06706 12.00000  -.00000   .96217 15.00000  -.00000  1.07719
41    15.00000   .00000 -1.07719 18.00000   .00000 -1.14657 15.00000   .44199 -1.06706 18.00000   .47046 -1.13580
42    15.00000   .44199 -1.06706 18.00000   .47046 -1.13580 15.00000  1.02191 -1.02191 18.00000  1.08773 -1.08773
43    15.00000  1.02191 -1.02191 18.00000  1.08773 -1.08773 15.00000  2.02600  -.83920 18.00000  2.15648  -.89324
44    15.00000  2.02600  -.83920 18.00000  2.15648  -.89324 15.00000  3.23154   .00000 18.00000  3.43961   .00000
45    15.00000  3.23154   .00000 18.00000  3.43961   .00000 15.00000  2.02600   .83920 18.00000  2.15648   .89324
46    15.00000  2.02600   .83920 18.00000  2.15648   .89324 15.00000  1.02191  1.02191 18.00000  1.08773  1.08773
47    15.00000  1.02191  1.02191 18.00000  1.08773  1.08773 15.00000   .44199  1.06706 18.00000   .47046  1.13580
48    15.00000   .44199  1.06706 18.00000   .47046  1.13580 15.00000  -.00000  1.07719 18.00000  -.00000  1.14657
49    18.00000   .00000 -1.14657 21.00000   .00000 -1.13230 18.00000   .47046 -1.13580 21.00000   .46461 -1.12166
50    18.00000   .47046 -1.13560 21.00000   .46461 -1.12166 18.00000  1.08773 -1.08773 21.00000  1.07420 -1.07420
51    18.00000  1.08773 -1.08773 21.00000  1.07420 -1.07420 18.00000  2.15648  -.89324 21.00000  2.12969  -.68215
52    18.00000  2.15648  -.89324 21.00000  2.12969  -.88215 18.00000  3.43961   .00000 21.00000  3.39700   .00000
53    18.00000  3.43961   .00000 21.00000  3.39700   .00000 18.00000  2.15648   .89324 21.00000  2.12969   .88215
54    18.00000  2.15648   .89324 21.00000  2.12969   .88215 18.00000  1.08773  1.08773 21.00000  1.07420  1.07420
55    18.00000  1.08773  1.08773 21.00000  1.07420  1.07420 18.00000   .47046  1.13580 21.00000   .46461  1.12166
56    18.00000   .47046  1.13580 21.00000   .46461  1.12166 18.00000  -.00000  1.14657 21.00000  -.00000  1.13230
57    21.00000   .00000 -1.13230 23.00000   .00000 -1.08514 21.00000   .46461 -1.12166 23.00000   .44526 -1.07495
58    21.00000   .46461 -1.12166 23.00000   .44526 -1.07495 21.00000  1.07420 -1.07420 23.00000  1.02946 -1.02946
59    21.00000  1.07420 -1.07420 23.00000  1.02946 -1.02946 21.00000  2.12969  -.88215 23.00000  2.04099  -.84540
60    21.00000  2.12969  -.68215 23.00000  2.04099  -.84540 21.00000  3.39700   .00000 23.00000  3.25550   .00000
61    21.00000  3.39700   .00000 23.00000  3.25550   .00000 21.00000  2.12969   .88215 23.00000  2.04099   .84540
62    21.00000  2.12969   .88215 23.00000  2.04099   .84540 21.00000  1.07420  1.07420 23.00000  1.02946  1.02946
63    21.00000  1.07420  1.07420 23.00000  1.02946  1.02946 21.00000   .46461  1.12166 23.00000   .44526  1.07495
64    21.00000   .46461  1.12166 23.00000   .44526  1.07495 21.00000  -.00000  1.13230 23.00000  -.00000  1.08514
65    23.00000   .00000 -1.08514 24.40000   .00000 -1.04564 23.00000   .44526 -1.07495 24.40000   .42905 -1.03581
66    23.00000   .44526 -1.07495 24.40000   .42905 -1.03581 23.00000  1.02946 -1.02946 24.40000   .99197  -.99197
67    23.00000  1.02946 -1.02946 24.40000   .99197  -.99197 23.00000  2.04099  -.84540 24.40000  1.96664  -.81461
68    23.00000  2.04099  -.84540 24.40000  1.96664  -.81461 23.00000  3.25550   .00000 24.40000  3.13682   .00000
69    23.00000  3.25550   .00000 24.40000  3.13682   .00000 23.00000  2.04099   .84540 24.40000  1.96664   .81461
70    23.00000  2.04099   .84540 24.40000  1.96664   .81461 23.00000  1.02946  1.02946 24.40000   .99197   .99197
71    23.00000  1.02946  1.02946 24.40000   .99197   .99197 23.00000   .44526  1.07495 24.40000   .42905  1.03581
72    23.00000   .44526  1.07495 24.40000   .42905  1.03581 23.00000  -.00000  1.08514 24.40000  -.00000  1.04564
```

Figure 26.- Continued.

```
73      24.40000    .00000 -1.04564 25.60000    .00000 -1.01153 24.40000    .42905 -1.03581 25.60000    .41505 -1.00202
74      24.40000    .42905 -1.03581 25.60000    .41505 -1.00202 24.40000    .99197  -.99197 25.60000    .95962  -.95962
75      24.40000    .99197  -.99197 25.60000    .95962  -.95962 24.40000   1.96664  -.81461 25.60000   1.90251  -.78804
76      24.40000   1.96664  -.81461 25.60000   1.90251  -.78804 24.40000   3.13682   .00000 25.60000   3.03456   .00000
77      24.40000   3.13682   .00000 25.60000   3.03456   .00000 24.40000   1.96664   .81461 25.60000   1.90251   .78804
78      24.40000   1.96644   .81461 25.60000   1.90251   .78804 24.40000    .99197   .99197 25.60000    .95962   .95962
79      24.40000    .99197   .99197 25.60000    .95962   .95962 24.40000    .42905  1.03581 25.60000    .41505  1.00202
80      24.40000    .42905  1.03581 25.60000    .41505  1.00202 24.40000   -.00000  1.04564 25.60000   -.00000  1.01153

BODY PANEL CENTROID POINT COORDINATES

  POINT     X            Y            Z
             CP           CP           CP

     1    2.00000      .05169     -.25078
     2    2.00000      .17121     -.24431
     3    2.00000      .35447     -.21767
     4    2.00000      .61492     -.09815
     5    2.00000      .61492      .09815
     6    2.00000      .35447      .21767
     7    2.00000      .17121      .24431
     8    2.00000      .05169      .25076
     9    4.62108      .10432     -.50607
    10    4.62108      .34550     -.49303
    11    4.62108      .71936     -.43925
    12    4.62107     1.24090     -.19807
    13    4.62107     1.24090      .19807
    14    4.62108      .71936      .43925
    15    4.62108      .34550      .49303
    16    4.62108      .10432      .50607
    17    7.56661      .14750     -.71555
    18    7.56661      .48851     -.69710
    19    7.56661     1.01711     -.62107
    20    7.56660     1.75450     -.28005
    21    7.56660     1.75450      .28005
    22    7.56661     1.01711      .62107
    23    7.56661      .48851      .69710
    24    7.56661      .14750      .71555
    25   10.54296      .18223     -.88405
    26   10.54296      .60355     -.86126
    27   10.54297     1.25463     -.76732
    28   10.54297     2.16767     -.34599
    29   10.54297     2.16767      .34599
    30   10.54297     1.25463      .76732
    31   10.54296      .60355      .86126
    32   10.54296      .18223      .88405
    33   13.52820      .20942    -1.01596
    34   13.52820      .69361     -.98977
    35   13.52819     1.44413     -.88181
    36   13.52818     2.49110     -.39762
    37   13.52818     2.49110      .39762
    38   13.52819     1.44413      .88181
    39   13.52820      .69361      .98977
    40   13.52820      .20942     1.01596
```

Figure 26.- Continued.

```
 41     16.51560     .22819   -1.10701
 42     16.51560     .75577   -1.07847
 43     16.51560    1.57354    -.96083
 44     16.51559    2.71429    -.43325
 45     16.51559    2.71429     .43325
 46     16.51560    1.57354     .96083
 47     16.51560     .75577    1.07847
 48     16.51560     .22819    1.10701
 49     19.49687     .23377   -1.13410
 50     19.49687     .77426   -1.10486
 51     19.49688    1.61204    -.98434
 52     19.49689    2.78073    -.44385
 53     19.49689    2.78073     .44385
 54     19.49688    1.61204     .98434
 55     19.49687     .77426    1.10486
 56     19.49687     .23377    1.13410
 57     21.99291     .22750   -1.10368
 58     21.99291     .75349   -1.07523
 59     21.99291    1.56882    -.95795
 60     21.99291    2.70620    -.43195
 61     21.99291    2.70620     .43195
 62     21.99291    1.56882     .95795
 63     21.99291     .75349    1.07523
 64     21.99291     .22750    1.10368
 65     23.69567     .21860   -1.06050
 66     23.69567     .72402   -1.03317
 67     23.69567    1.50744    -.92047
 68     23.69567    2.60029    -.41505
 69     23.69567    2.60029     .41505
 70     23.69567    1.50744     .92047
 71     23.69567     .72402    1.03317
 72     23.69567     .21860    1.06050
 73     24.99668     .21104   -1.02384
 74     24.99668     .69899    -.99745
 75     24.99669    1.45532    -.88864
 76     24.99669    2.51036    -.40070
 77     24.99669    2.51036     .40070
 78     24.99669    1.45532     .88864
 79     24.99668     .69899     .99745
 80     24.99668     .21104    1.02384

 BODY PANEL AREAS AND INCLINATION ANGLES

PANEL  AREA          DELTA      THETA        DELTA       THETA
                      RAD        RAD          DEG         DEG

  1       .23452     .12529   -3.11870     7.17849   -178.688
  2       .30865     .12773   -3.06389     7.31861   -175.548
  3       .54231     .13810   -2.96162     7.91231   -169.688
  4       .79094     .21266   -2.53353    12.18448   -145.160
  5       .79094     .21266    -.60807    12.18448    -34.840
  6       .54231     .13810    -.17998     7.91231    -10.312
```

Figure 26.- Continued.

```
  7      .30865     .12773    -.07770    7.31861    -4.452
  8      .23452     .12529    -.02290    7.17849    -1.312
  9      .61605     .08032   -3.11870    4.60200  -178.688
 10      .81063     .08190   -3.06389    4.69239  -175.548
 11     1.42314     .08859   -2.96161    5.07577  -169.688
 12     2.05964     .13713   -2.53351    7.85675  -145.160
 13     2.05964     .13713    -.60808    7.85675   -34.840
 14     1.42314     .08859    -.17998    5.07577   -10.312
 15      .81063     .08190    -.07770    4.69239    -4.452
 16      .61605     .08032    -.02290    4.60200    -1.312
 17      .88177     .06337   -3.11869    3.63109  -178.688
 18     1.16022     .06462   -3.06389    3.70252  -175.548
 19     2.03642     .06991   -2.96160    4.00557  -169.687
 20     2.94107     .10836   -2.53349    6.20859  -145.158
 21     2.94107     .10836    -.60810    6.20859   -34.842
 22     2.03642     .06991    -.17999    4.00557   -10.313
 23     1.16022     .06462    -.07771    3.70252    -4.452
 24      .88177     .06337    -.02290    3.63109    -1.312
 25     1.09238     .05070   -3.11869    2.90465  -178.688
 26     1.43729     .05169   -3.06389    2.96189  -175.548
 27     2.52243     .05593   -2.96160    3.20478  -169.687
 28     3.63850     .08678   -2.53350    4.97216  -145.159
 29     3.63850     .08678    -.60810    4.97216   -34.841
 30     2.52243     .05593    -.17999    3.20478   -10.313
 31     1.43729     .05169    -.07770    2.96189    -4.452
 32     1.09238     .05070    -.02290    2.90465    -1.312
 33     1.25644     .03831   -3.11869    2.19495  -178.688
 34     1.65312     .03906   -3.06389    2.23818  -175.548
 35     2.90091     .04227   -2.96160    2.42164  -169.687
 36     4.18047     .06560   -2.53349    3.75857  -145.158
 37     4.18047     .06560    -.60810    3.75857   -34.842
 38     2.90091     .04227    -.17999    2.42164   -10.313
 39     1.65312     .03906    -.07771    2.23818    -4.452
 40     1.25644     .03831    -.02290    2.19495    -1.312
 41     1.36941     .02312   -3.11869    1.32458  -178.688
 42     1.80171     .02357   -3.06386    1.35068  -175.548
 43     3.16135     .02551   -2.96159    1.46147  -169.687
 44     4.55203     .03961   -2.53347    2.26947  -145.157
 45     4.55203     .03961    -.60812    2.26947   -34.843
 46     3.16135     .02551    -.18000    1.46146   -10.313
 47     1.80171     .02357    -.07771    1.35068    -4.452
 48     1.36941     .02312    -.02290    1.32458    -1.312
 49     1.40299    -.00476   -3.11869    -.27248  -178.688
 50     1.84588    -.00485   -3.06389    -.27779  -175.548
 51     3.23873    -.00524   -2.96160    -.30034  -169.687
 52     4.66146    -.00813   -2.53348    -.46563  -145.158
 53     4.66146    -.00813    -.60811    -.46563   -34.842
 54     3.23873    -.00524    -.18000    -.30034   -10.313
 55     1.84588    -.00485    -.07771    -.27779    -4.452
 56     1.40299    -.00476    -.02290    -.27248    -1.312
 57      .91036    -.02357   -3.11869   -1.35035  -178.688
 58     1.19775    -.02403   -3.06389   -1.37700  -175.548
```

Figure 26.- Continued.

```
59     2.10167    -.02601    -2.96161    -1.49009    -169.687
60     3.02636    -.04040    -2.53350    -2.31449    -145.159
61     3.02636    -.04040     -.60809    -2.31449     -34.841
62     2.10167    -.02601     -.17999    -1.49009     -10.313
63     1.19775    -.02403     -.07770    -1.37700      -4.452
64      .91036    -.02357     -.02290    -1.35035      -1.312
65      .61242    -.02820    -3.11869    -1.61602    -178.688
66      .80576    -.02876    -3.06389    -1.64800    -175.548
67     1.41385    -.03113    -2.96160    -1.78371    -169.687
68     2.03629    -.04837    -2.53348    -2.77161    -145.158
69     2.03629    -.04837     -.60811    -2.77161     -34.842
70     1.41385    -.03113     -.18000    -1.78371     -10.313
71      .80576    -.02876     -.07771    -1.64800      -4.452
72      .61242    -.02820     -.02290    -1.61602      -1.312
73      .50680    -.02841    -3.11869    -1.62762    -178.688
74      .66679    -.02897    -3.06388    -1.65967    -175.548
75     1.17000    -.03134    -2.96159    -1.79569    -169.687
76     1.68508    -.04866    -2.53347    -2.78778    -145.157
77     1.68508    -.04866     -.60812    -2.78778     -34.843
78     1.17000    -.03134     -.18000    -1.79569     -10.313
79      .66679    -.02897     -.07771    -1.65967      -4.452
80      .50680    -.02841     -.02290    -1.62762      -1.312


     END GEOM  ,  TIME=      .228     DT=      .228


          AERODYNAMIC VELCITY MATRIX COMPUTATION                                          ** VELCMP **


PARTITION = 1
NWINGS=     0  NBODYS=    80  NCPTS=     0  NSEGS=    0
INFLUENCE OF BODY ON BODY

          END BODVEL,  TIME=    5.3050     DT=    5.0770     NPART=  1
          NBBLOK=    10  NWBLOK=     1

          END VELCMP,  TIME=    5.3630     DT=    5.1350

                   BEGIN A NEW CASE                                                       ** NDYBDY **

          END DIAGIN,  TIME=    5.4350     DT=      .0650

THE ITERATION CONVERGED AFTER  11  ITERATIONS WITH A TEST CRITERION OF  .0010000

THE SOLUTION AT THE PREVIOUS ITERATION IS
 GR(N),N=1, 80
    .60815    .60675    .60245    .62066   -.24230   -.35677   -.37133   -.37538    .77418    .72887
    .70514    .73049   -.46254   -.54706   -.56437   -.59123    .67301    .67160    .74809    .77486
   -.55746   -.61343   -.56460   -.57469    .69438    .69136    .69179    .79600   -.61080   -.59570
```

Figure 26.- Continued.

```
    -.60161    -.60523     .69517     .69731     .69166     .78268    -.64319    -.62537    -.63162    -.63179
     .70879     .70667     .69999     .79237    -.70788    -.66863    -.67059    -.66967     .72405     .70972
     .70103     .80192    -.83150    -.75263    -.75308    -.75563     .80566     .79111     .76535     .76222
    -.89037    -.81893    -.81511    -.81820     .73959     .74769     .85206     .80431    -.90644    -.85580
    -.79820    -.79912     .82312     .80987     .78823     .81892    -.94559    -.84463    -.85797    -.86823

THE SOLUTION AT THE PRESENT ITERATION IS
 GR(N),N=1, 80
     .60815     .60675     .60245     .62066    -.24230    -.35677    -.37133    -.37538     .77418     .72887
     .70514     .73044    -.46254    -.54706    -.56437    -.59123     .67301     .67160     .74809     .77486
    -.55746    -.61343    -.56960    -.57469     .69438     .69136     .69179     .79600    -.61060    -.59570
    -.60161    -.60523     .69517     .69731     .69166     .78268    -.64319    -.62537    -.63162    -.63179
     .70879     .70667     .69999     .79237    -.70788    -.66863    -.67059    -.66967     .72405     .70972
     .70103     .80192    -.83150    -.75263    -.75308    -.75563     .80566     .79111     .76535     .76222
    -.89037    -.81893    -.81511    -.81820     .73959     .74769     .85206     .80431    -.90644    -.85580
    -.79820    -.79912     .82312     .80987     .78823     .81892    -.94559    -.84463    -.85797    -.86823


           VORTEX LOCATION AND STRENGTH                                                                          ** ELHOVT **


  I=  1 YVRTX=    0.0000     .6530      .9900     1.2810     1.5280     1.7465     1.9320     2.1000     2.2400     2.3500

  I=  1 ZVRTX=    0.0000     .2990      .5310      .7390      .9290     1.1028     1.2720     1.4230     1.5510     1.6730

  I=  1     GX=   0.0000     .1910      .4725      .6750      .8510     1.0080     1.1510     1.2830     1.4060     1.5200


  I=  2 YVRTX=    0.0000    -.6530     -.9900    -1.2810    -1.5280    -1.7469    -1.9320    -2.1000    -2.2400    -2.3500

  I=  2 ZVRTX=    0.0000     .2990      .5310      .7390      .9290     1.1028     1.2720     1.4230     1.5510     1.6730

  I=  2     GX=   0.0000    -.1910     -.4725     -.6750     -.8510    -1.0080    -1.1510    -1.2830    -1.4060    -1.5200


           VORTEX INTERPOLATION TABLE

       VORTEX     1

 STAT        XV      YVRTX      ZVRTX       AY        AZ       GAM/V

   1       0.000    0.0000     0.0000    0.0000    0.0000    0.0000
   2       2.000     .6530      .2990     .8458     .2820     .1910
   3       4.000     .9900      .5310    1.3969     .4456     .4725
   4       6.000    1.2810      .7390    1.8585     .6195     .6750
   5       8.000    1.5280      .9290    2.2526     .7509     .8510
   6      10.000    1.7465     1.1028    2.5917     .8639    1.0080
   7      12.000    1.9320     1.2720    2.8866     .9622    1.1510
   8      14.000    2.1000     1.4230    3.1272    1.0424    1.2830
   9      16.000    2.2400     1.5510    3.3157    1.1052    1.4060
  10      18.000    2.3500     1.6730    3.4396    1.1466    1.5200
```

Figure 26.- Continued.

```
         VORTEX    2

       STAT       XV       YVRTX      ZVRTX        AY         AZ       GAM/V

          1      0.000    0.0000     0.0000     0.0000     0.0000     0.0000
          2      2.000    -.6530      .2990      .8458      .2820     -.1910
          3      4.000    -.9900      .5310     1.3968      .4656     -.4725
          4      6.000   -1.2810      .7390     1.8585      .6195     -.6750
          5      8.000   -1.5260      .9290     2.2526      .7509     -.8510
          6     10.000   -1.7465     1.1028     2.5917      .8639    -1.0080
          7     12.000   -1.9320     1.2720     2.8866      .9622    -1.1510
          8     14.000   -2.1000     1.4230     3.1272     1.0424    -1.2830
          9     16.000   -2.2400     1.5510     3.3157     1.1052    -1.4060
         10     18.000   -2.3500     1.6730     3.4396     1.1466    -1.5200


              VELOCITY ON BODY                                                                                      ** SOLVE  **

         MACH= 1.700   ALPHA= 10.000   PHIR=  0.000

            PANEL    SOURCE        AXIAL            LATERAL          VERTICAL          NORMAL          LAT.VORTEX        VER.VORTEX
             NO.     STRENGTH      VELOCITY.        VELOCITY         VELOCITY          VELOCITY         VELOCITY          VELOCITY
              1       .60815     -.11784          .16037E-01       -.28250           .29530         -.21087E-03       -.15168E-04
              2       .60675     -.11969          .53979E-01       -.28089           .29717         -.73365E-03       -.69852E-04
              3       .60245     -.12713          .12055           -.27287           .30478         -.18811E-02       -.36981E-03
              4       .62066     -.17190          .34530           -.14717           .34717         -.94219E-02       -.73666E-02
              5      -.24230     -.26758E-02     -.78232E-01        .13918           .68542E-01       .13435          -.87685E-01
              6      -.35677      .11105E-01     -.64029E-01       -.21314E-01      -.33651E-01       .10521          -.22110E-01
              7      -.37133      .94787E-02     -.29829E-01       -.43240E-01      -.46262E-01       .23587E-01      -.23402E-02
              8      -.37538      .90032E-02     -.89827E-02       -.48241E-01      -.49180E-01       .60384E-02      -.44081E-03
              9       .77418     -.49925E-01      .27541E-01       -.24829           .25206         -.27652E-03       -.19886E-04
             10       .72687     -.72574E-01      .82788E-01       -.24231           .25311         -.96108E-03       -.91463E-04
             11       .70514     -.84087E-01      .14475           -.22863           .25730         -.24535E-02       -.48204E-03
             12       .73049     -.11663          .36678           -.64315E-01       .27580         -.11940E-01       -.93151E-02
             13      -.46254      .28511E-01     -.18601            .12620          -.65632E-02       .13497          -.89632E-01
             14      -.54706      .23679E-01     -.99542E-01       -.64490E-01      -.83044E-01       .27169          -.57753E-01
             15      -.56437      .22294E-01     -.56889E-01       -.86305E-01      -.91981E-01       .53079E-01      -.53230E-02
             16      -.59123      .11527E-01     -.18945E-01       -.92995E-01      -.94028E-01       .13175E-01      -.96549E-03
             17       .67301     -.70611E-01      .87470E-02       -.23148           .23562         -.30468E-03       -.21911E-04
             18       .67160     -.68445E-01      .24471E-01       -.23122           .23636         -.10586E-02       -.10074E-03
             19       .74809     -.41681E-01      .11979           -.21898           .23922         -.26983E-02       -.53007E-03
             20       .77486     -.89709E-01      .37089           -.34114E-01       .24819         -.12995E-01       -.10132E-01
             21      -.55746      .31494E-01     -.22567            .11815          -.35178E-01       .13454          -.90011E-01
             22      -.61343      .11864E-01     -.90787E-01       -.86191E-01      -.10163           .35000          -.74316E-01
             23      -.56960      .30961E-01     -.20133E-01       -.10615          -.10917           .69585E-01      -.69921E-02
             24      -.57469      .31223E-01     -.65845E-02       -.10900          -.11088           .17166E-01      -.12591E-02
             25       .69438     -.46635E-01      .19372E-01       -.22082           .22328         -.33639E-03       -.24191E-04
             26       .69136     -.53028E-01      .55563E-01       -.21768           .22378         -.11685E-02       -.11119E-03
             27       .69179     -.54942E-01      .10612           -.20726           .22563         -.29757E-02       -.58452E-03
             28       .79600     -.59261E-01      .35246           -.26411E-01       .22734         -.14244E-01       -.11100E-01
             29      -.61080      .26301E-01     -.24216            .10210          -.56628E-01       .13957          -.93826E-01
             30      -.59570      .30622E-01     -.91269E-01       -.99251E-01      -.11552           .35000          -.81963E-01
             31      -.60161      .26979E-01     -.46534E-01       -.11752          -.12201           .82236E-01      -.82528E-02
             32      -.60523      .21438E-01     -.16269E-01       -.12221          -.12348           .20340E-01      -.14915E-02
```

Figure 26.- Continued.

```
33   .69517   -.39175E-01    .14733E-01   -.20956        .21119       -.37751E-03    -.27147E-04
34   .69731   -.37754E-01    .47779E-01   -.20705        .21145       -.13111E-02    -.12475E-03
35   .69166   -.43159E-01    .11499       -.19321        .21230       -.33363E-02    -.65531E-03
36   .78268   -.44979E-01    .34976       -.54079E-02    .20677       -.15889E-01    -.12378E-01
37  -.64319    .30170E-01   -.26128        .89072E-01   -.77656E-01    .14840        -.10019
38  -.62337    .32803E-01   -.10279       -.11120       -.12908        .35000        -.84902E-01
39  -.63162    .27081E-01   -.45964E-01   -.13040       -.13453        .93842E-01    -.93865E-02
40  -.63179    .26872E-01   -.13736E-01   -.13455       -.13576        .23403E-01    -.17147E-02
41   .70879   -.20666E-01    .12106E-01   -.19567        .19632       -.43398E-03    -.31208E-04
42   .70667   -.23565E-01    .50166E-01   -.19247        .19629       -.15071E-02    -.14339E-03
43   .69999   -.28498E-01    .10973       -.17848        .19590       -.39331E-02    -.75282E-03
44   .79237   -.19270E-01    .34912        .22758E-01    .18140       -.18192E-01    -.14168E-01
45  -.70788    .29386E-01   -.29248        .78930E-01   -.10341        .16369        -.11091
46  -.66863    .34123E-01   -.99607E-01   -.12910       -.14567        .35000        -.84639E-01
47  -.67059    .30967E-01   -.47305E-01   -.14594       -.14986        .10323        -.10276E-01
48  -.65967    .31067E-01   -.14531E-01   -.14982       -.15079        .26073E-01    -.19075E-02
49   .72405    .10358E-01    .17563E-01   -.16851        .16892       0.             0.
50   .70972    .18017E-03    .58609E-01   -.16429        .16835       0.             0.
51   .70103   -.27017E-02    .10653       -.14903        .16568       0.             0.
52   .80192    .36156E-01    .35251        .81845E-01    .13451       0.             0.
53  -.63150    .24808E-01   -.34667        .57674E-01   -.15052       0.             0.
54  -.75263    .44304E-01   -.10389       -.16023       -.17600       0.             0.
55  -.75308    .40954E-01   -.54426E-01   -.17440       -.17790       0.             0.
56  -.75563    .39542E-01   -.15980E-01   -.17815       -.17828       0.             0.
57   .80566    .32240E-01    .35015E-01   -.14887        .15035       0.             0.
58   .79111    .34623E-01    .80856E-01   -.14277        .14941       0.             0.
59   .76535    .28214E-01    .12924       -.12335        .14518       0.             0.
60   .76222    .54103E-01    .31738        .98433E-01    .10263       0.             0.
61  -.89037    .23917E-01   -.37223        .35782E-01   -.18217       0.             0.
62  -.81693    .34415E-01   -.12483       -.17788       -.19659       0.             0.
63  -.81511    .37500E-01   -.54330E-01   -.19407       -.19674       0.             0.
64  -.81820    .42046E-01   -.21014E-01   -.19738       -.19676       0.             0.
65   .73959    .43137E-01    .13606E-01   -.14433        .14576       0.             0.
66   .74769    .38085E-01    .31969E-01   -.14164        .14473       0.             0.
67   .85206    .56250E-01    .17220       -.10936        .14011       0.             0.
68   .80431    .42808E-01    .33927        .12314        .94731E-01   0.             0.
69  -.90644    .27204E-02   -.39092        .40723E-01   -.18997       0.             0.
70  -.85580    .21288E-01   -.13728       -.18051       -.20141       0.             0.
71  -.79820    .32517E-01   -.51720E-01   -.19898       -.20137       0.             0.
72  -.79912    .24432E-01   -.17669E-01   -.20172       -.20131       0.             0.
73   .82312    .37525E-01    .20165E-01   -.14413        .14556       0.             0.
74   .80987    .52087E-01    .57851E-01   -.13901        .14453       0.             0.
75   .78823    .74790E-01    .11422       -.11910        .13990       0.             0.
76   .81892    .41996E-01    .35553        .13477        .94450E-01   0.             0.
77  -.94559   -.57681E-02   -.41097        .54350E-01   -.19025       0.             0.
78  -.84463   -.41409E-02   -.12342       -.18244       -.20162       0.             0.
79  -.85797    .15042E-01   -.45874E-01   -.19913       -.20157       0.             0.
80  -.86823    .22590E-01   -.80174E-02   -.20210       -.20150       0.             0.
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Figure 26.- Continued.

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 LRC 3/1 ELLIPTIC WING/BODY MISSILE CONFIGURATION - NOSE VORTICITY
ELLIPTIC BODY PANELING -    KRAD=9, KFORX=11


INTEGRATION OF THE PRESSURE DISTRIBUTION                                                                      ** FORMOM **

ON THE BODY


MACH =  1.7000    ALPHAC= 10.0000    PHIR=  0.0000

POINT       X          Y          Z        THETP       CP         CX         CY         CZ         CM         CLN        CLL

   1     2.00000     .05169    -.25078  281.64720     .27940     .00819    -.00149     .06499     .95986    -.02161    -.00299
   2     2.00000     .17121    -.24431  305.02186     .28070     .01104    -.00667     .08567    1.26526    -.09683    -.01504
   3     2.00000     .35647    -.21767  328.59115     .28509     .02128    -.02741     .15066    2.22517    -.39812    -.04774
   4     2.00000     .61492    -.09815  350.93129     .26536     .04430    -.11720     .16838    2.48774   -1.70736    -.09204
   5     2.00000     .61492     .09815    9.06871    -.01818    -.00303     .00803     .01154     .17044     .11697    -.00631
   6     2.00000     .35647     .21767   31.40886    -.01042    -.00078     .00100     .00551     .08131     .01455    -.00174
   7     2.00000     .17121     .24431   54.97814    -.00503    -.00020     .00012     .00153     .02266     .00173    -.00023
   8     2.00000     .05169     .25078   78.35280    -.00328    -.00010     .00002     .00076     .01126     .00025    -.00004
   9     4.62106     .10432    -.50607  281.64720     .13039     .00644    -.00183     .08004     .97159    -.02165    -.00742
  10     4.62108     .34550    -.49303  305.02186     .17489     .01160    -.01097     .14087    1.70900    -.12457    -.04326
  11     4.62108     .71936    -.43925  328.59112     .18609     .02343    -.04722     .25954    3.15059    -.55827    -.16596
  12     4.62107    1.24090    -.19807  350.93123     .11943     .03362    -.13921     .19999    2.42901   -1.65365    -.22060
  13     4.62107    1.24090     .19807    9.06877    -.06978    -.01965     .08133     .11685    1.41917     .96617    -.12889
  14     4.62108     .71936     .43925   31.40888    -.04759    -.00599     .01208     .06637     .80571     .14277    -.04204
  15     4.62108     .34550     .49303   54.97815    -.02068    -.00137     .00130     .01666     .29218     .01532    -.00512
  16     4.62198     .10432     .50607   78.35281     .00093     .00005    -.00001    -.00057    -.00697    -.00016     .00005
  17     7.56661     .14750    -.71555  281.64719     .18039     .01007    -.00363     .15870    1.45815    -.03207    -.02081
  18     7.56661     .48851    -.69710  305.02184     .17489     .01310    -.01572     .20187    1.85485    -.13873    -.08766
  19     7.56661    1.01711    -.62107  328.59108     .10136     .01442    -.03686     .20257    1.86148    -.32568    -.18315
  20     7.56660    1.75450    -.28005  350.93114     .05610     .01784    -.09371     .13462    1.23799    -.83393    -.20995
  21     7.56660    1.75450     .28005    9.06886    -.07716    -.02454     .12889     .18516    1.70274    1.14700    -.28876
  22     7.56661    1.01711     .62107   31.40893    -.05810    -.00826     .02113     .11612    1.06707     .18669    -.10499
  23     7.56661     .48851     .69710   54.97816    -.03687    -.00276     .00331     .04256     .39101     .02925    -.01848
  24     7.56661     .14750     .71555   78.35281    -.03550    -.00198     .00072     .03123     .28695     .00631    -.00409
  25    10.54296     .18223    -.88405  281.64719     .12751     .00706    -.00319     .13908     .86397    -.01864    -.02253
  26    10.54296     .60355    -.86126  305.02185     .13894     .01032    -.01548     .19883    1.23519    -.09064    -.10667
  27    10.54297    1.25663    -.76732  328.59109     .13496     .01903    -.06085     .33441    2.07784    -.35682    -.37354
  28    10.54297    2.16767    -.34599  350.93117     .01052     .00332    -.02178     .03128     .19459    -.12906    -.06028
  29    10.54297    2.16767     .34599    9.06883    -.06288    -.01983     .13021     .18706    1.16358     .77175    -.36043
  30    10.54297    1.25663     .76732   31.40892    -.09134    -.01288     .04118     .22632    1.40621     .24148    -.25280
  31    10.54296     .60355     .86126   54.97816    -.02675    -.00199     .00298     .03827     .23777     .01745    -.02053
  32    10.54296     .18223     .88405   78.35281    -.01488    -.00082     .00037     .01623     .10081     .00218    -.00263
  33    13.52820     .20942   -1.01596  281.64719     .11238     .00541    -.00323     .14105     .45601    -.00944    -.02626
  34    13.52820     .69361    -.98977  305.02184     .10721     .00692    -.01375     .17656     .57083    -.04018    -.10886
  35    13.52819    1.44413    -.88181  328.59108     .10771     .01320    -.05588     .30712     .99320    -.16378    -.39424
  36    13.52818    2.49110    -.39762  350.93115    -.01878    -.00515     .04476    -.06430    -.20834     .13363     .14239
  37    13.52818    2.49110     .39762    9.06886    -.06605    -.01810     .15741     .22614     .73269     .46994    -.50075
  38    13.52819    1.44413     .88181   31.40893    -.09052    -.01110     .04697     .25812     .83473     .13765    -.33134
  39    13.52820     .69361     .98977   54.97816    -.02682    -.00173     .00344     .04417     .14281     .01005    -.02723
  40    13.52820     .20942    1.01596   78.35281    -.02454    -.00118     .00071     .03080     .09957     .00206    -.00573
  41    16.51560     .22819   -1.10701  281.64719     .07340     .00232    -.00230     .10046     .02600    -.00012    -.02038
  42    16.51560     .75577   -1.07847  305.02183     .07725     .00328    -.01080     .13872     .03591    -.00059    -.09319
```

Figure 26.- Continued.

```
43   16.51560   1.57354   -.96083  328.59103    .07829    .00631   -.04430    .24343    .06317   -.00267   -.34049
44   16.51559   2.71429   -.43325  350.93104   -.07101   -.01280    .18453   -.26508   -.06985    .01774    .63956
45   16.51559   2.71429    .43325    9.06896   -.06223   -.01122    .16171    .23230    .06121    .01554   -.56046
46   16.51560   1.57354    .96083   31.40897   -.09515   -.00767    .05384    .29586    .07677    .00324   -.41381
47   16.51560    .75577   1.07847   54.97617   -.03434   -.00146    .00480    .06167    .01597    .00026   -.04143
48   16.51560    .22819   1.10701   78.35281   -.03185   -.00101    .00100    .04360    .01128    .00005   -.00684
49   19.49687    .23377  -1.13410  281.64719    .00937   -.00006   -.00030    .01315   -.03538    .00080   -.00273
50   19.49687    .77426  -1.10486  305.02184    .02678   -.00024   -.00384    .04928   -.13264    .01016   -.03392
51   19.49688   1.61204   -.98434  328.59106    .02392   -.00041   -.01387    .07621   -.20512    .03674   -.10920
52   19.49689   2.78073   -.44385  350.93110   -.19561    .00741    .52092   -.74834   2.01489  -1.38027   1.84971
53   19.49689   2.78073    .44385    9.06890   -.16758    .00635    .44627    .64110  -1.72615  -1.18589  -1.58463
54   19.49686   1.61204    .98434   31.40895   -.06657    .00113    .03860    .21212   -.57094   -.10227   -.30395
55   19.49687    .77426   1.10486   54.97816   -.05299    .00047    .00759    .09751   -.26246   -.02011   -.06711
56   19.49687    .23377   1.13410   78.35281   -.00782    .00032    .00154    .06707   -.18052   -.00407   -.01394
57   21.99291    .22750  -1.10368  281.64720   -.03529    .00076    .00074   -.03211    .16539   -.00365    .00649
58   21.99291    .75349  -1.07523  305.02185   -.04517    .00130    .00420   -.05393    .27864   -.02082    .03612
59   21.99291   1.56882   -.95795  328.59110   -.04397    .00240    .01654   -.09089    .46969   -.08211    .12675
60   21.99291   2.70620   -.43195  350.93110   -.21081    .02576    .36418   -.52319   2.70573  -1.82143   1.25854
61   21.99291   2.70620    .43195    9.06881   -.17270    .02111    .29836    .42862  -2.21668  -1.49222  -1.03107
62   21.99291   1.56882    .95795   31.40891   -.05231    .00286    .01967    .10813   -.55875   -.09768   -.15078
63   21.99291    .75349   1.07523   54.97815   -.04681    .00135    .00435    .05588   -.28872   -.02158   -.03743
64   21.99291    .22750   1.10368   78.35281   -.05325    .00114    .00111    .04845   -.25033   -.00550   -.00980
65   23.69567    .21860  -1.06050  281.64719   -.05535    .00096    .00078   -.03387    .23257   -.00514    .00658
66   23.69567    .72402  -1.03317  305.02184   -.04669    .00108    .00292   -.03749    .25741   -.01935    .02413
67   23.69567   1.50744   -.92047  328.59105   -.10794    .00475    .02731   -.15007   1.03043   -.18114    .20108
68   23.69567   2.60029   -.41505  350.93110   -.21421    .02109    .24892   -.35758   2.45702  -1.66161    .82651
69   23.69567   2.60029    .41505    9.06890   -.15303    .01507    .17783    .25546  -1.75529  -1.18705   -.59045
70   23.69567   1.50744    .92047   31.40895   -.03043    .00134    .00770    .04231   -.29049   -.05107   -.05669
71   23.69567    .72402   1.03317   54.97817   -.03722    .00086    .00233    .02989   -.20520   -.01542   -.01923
72   23.69567    .21860   1.06050   78.35281   -.01939    .00033    .00027    .01187   -.08147   -.00180   -.00231
73   24.99668    .21104  -1.02384  281.64719   -.04490    .00065    .00052   -.02274    .18575   -.00413    .00427
74   24.99668    .69899   -.99745  305.02183   -.07521    .00145    .00389   -.04998    .40821   -.03088    .03105
75   24.99669   1.45532   -.88864  328.59103   -.12541    .00460    .02626   -.14428   1.17857   -.20852    .18665
76   24.99669   2.51036   -.40070  350.93104   -.22516    .01845    .21651   -.31103   2.54199  -1.72838    .69403
77   24.99669   2.51036    .40070    9.06896   -.15733    .01289    .15129    .21733  -1.77623  -1.20771   -.48496
78   24.99669   1.45532    .88864   31.40897    .02337   -.00086   -.00489   -.02688    .21959    .03885    .03478
79   24.99668    .69899    .99745   54.97817   -.00245    .00005    .00013    .00163   -.01329   -.00101   -.00101
80   24.99668    .21104   1.02384   78.35281   -.01555    .00022    .00018    .00787   -.06431   -.00143   -.00148

      TOTAL COEFFICIENTS
      ------------------
      ON THE BODY

      REFA=        12.5670   REFD=        3.4641   REFL=        1.0000

      XM  =        16.8000   ZM  =        0.0000

    MACH=         1.70000
  ALPHAC=        10.00000        ALPHA=       10.00000
    PHIR=         0.00000         BETA=        0.00000
      CX=          .04322
```

Figure 26.- Continued.

```
       CY=         0.00000
       CZ=          .85386
       CM=         1.94833
      CLN=         0.00000
      CLL=         0.00000
      XCP=         8.89360

       FOLLOWING ARE IN WIND AXIS SYSTEM
       CL=          .83338
       CY=         0.00000
       CD=          .19083
      CMW=         1.94883
   CNYAWW=         0.00000


        LRC 3/1 ELLIPTIC WING/BODY MISSILE CONFIGURATION - NOSE VORTICITY
       ELLIPTIC BODY PANELING -     KRAD=9, KBODY=11


       INTEGRATION OF THE PRESSURE DISTRIBUTION                                                              ** FORMOM **

       ON THE BODY FROM XSTART=     0.0000 TO XWLE=   18.0000


       MACH =  1.7000     ALPHAC= 10.0000     PHIR=  0.0000

POINT        X           Y           Z         THETP        CP          CX          CY          CZ          CM         CLN         CLL

    1    2.00000      .05169     -.25078   281.64720     .27940      .00819     -.00149      .06499      .95986     -.02161     -.00299
    2    2.00000      .17121     -.24431   305.02186     .28070      .01104     -.00667      .08567     1.26526     -.29683     -.01304
    3    2.00000      .35647     -.21767   328.59115     .28509      .02128     -.02741      .15066     2.22517     -.34812     -.04774
    4    2.00000      .61492     -.09815   350.93129     .26536      .04430     -.11720      .16838     2.48774    -1.70736     -.09204
    5    2.00000      .61492      .09815     9.06871    -.01818     -.00303      .00803      .01154      .17044      .11697     -.00631
    6    2.00000      .35647      .21767    31.40886    -.01042     -.00078      .00100      .00551      .08131      .01455     -.00174
    7    2.00000      .17121      .24431    54.97814    -.00503     -.00020      .00012      .00153      .02266      .00173     -.00023
    8    2.00000      .05169      .25078    78.35280    -.00328     -.00010      .00002      .00076      .01126      .00025     -.00004
    9    4.62108      .10432     -.50607   281.64720     .13039      .00644     -.00183      .08004      .97159     -.02165     -.00742
   10    4.62108      .34550     -.49303   305.02186     .17489      .01160     -.01097      .14087     1.70990     -.12957     -.04326
   11    4.62108      .71936     -.43925   328.59112     .18609      .02343     -.04722      .25954     3.15059     -.55827     -.16596
   12    4.62107     1.24090     -.19807   350.93123     .11943      .03362     -.13921      .19990     2.42901    -1.65365     -.22060
   13    4.62107     1.24090      .19807     9.06877    -.06978     -.01965      .08133      .11685     1.41917      .96617     -.12689
   14    4.62108      .71936      .43925    31.40888    -.04759     -.00599      .01208      .06637      .80571      .14277     -.04244
   15    4.62108      .34550      .49303    54.97815    -.02068     -.00137      .00130      .01666      .20218      .01532     -.00512
   16    4.62108      .10432      .50607    78.35281     .00093      .00005     -.00001     -.00057     -.00697     -.00016      .00005
   17    7.56661      .14750     -.71555   281.64719     .18039      .01007     -.00363      .15870     1.45815     -.03207     -.02081
   18    7.56661      .48851     -.69710   305.02184     .17489      .01310     -.01572      .20187     1.65485     -.13873     -.08766
   19    7.56661     1.01711     -.62107   328.59108     .10136      .01442     -.03686      .20257     1.86148     -.32568     -.18315
   20    7.56660     1.75450     -.28005   350.93119     .05610      .01784     -.09371      .13462     1.23799     -.83393     -.20995
   21    7.56660     1.75450      .28005     9.06886    -.07716     -.02454      .12889      .18516     1.70274     1.14700     -.28876
   22    7.56661     1.01711      .62107    31.40893    -.05810     -.00826      .02113      .11612     1.06707      .18669     -.10499
   23    7.56661      .48851      .69710    54.97816    -.03687     -.00276      .00331      .04256      .39101      .02925     -.01848
   24    7.56661      .14750      .71555    78.35281    -.03550     -.00198      .00072      .03123      .28695      .00631     -.00409
   25   10.54296      .18223     -.88405   281.64719     .12751      .00706     -.00319      .13908      .86397     -.01864     -.02253
```

Figure 26.- Continued.

```
26   10.54296     .60355    -.86126  305.02185     .13894     .01032    -.01548     .19883    1.23519    -.09964    -.10667
27   10.54297    1.25663    -.76732  328.59109     .13496     .01903    -.06085     .33441    2.07784    -.35682    -.37354
28   10.54297    2.16767    -.34599  350.93117     .01052     .00332    -.02178     .03128     .19459    -.12906    -.06028
29   10.54297    2.16767     .34599    9.06883    -.06288    -.01983     .13021     .18706    1.16358     .77175    -.36043
30   10.54297    1.25663     .76732   31.40892    -.09134    -.01288     .04118     .22632    1.40621     .24148    -.25280
31   10.54296     .60355     .86126   54.97816    -.02675    -.00199     .00298     .03827     .23777     .01745    -.07053
32   10.54296     .18223     .88405   78.35281    -.01488    -.00082     .00037     .01623     .10081     .00218    -.00263
33   13.52820     .20942   -1.01596  281.64719     .11238     .00541    -.00323     .14105     .45601    -.00944    -.02626
34   13.52820     .69361    -.98977  305.02184     .10721     .00692    -.01375     .17656     .57083    -.04018    -.10886
35   13.52819    1.44413    -.88181  328.59108     .10771     .01320    -.05588     .30712     .99320    -.16578    -.39424
36   13.52818    2.49110    -.39762  350.93115    -.01878    -.00515     .04476    -.06430    -.20834     .13363     .14239
37   13.52818    2.49110     .39762    9.06886    -.06605    -.01810     .15741     .22614     .73269     .46994    -.50075
38   13.52819    1.44413     .88181   31.40893    -.09052    -.01110     .04697     .25812     .83473     .13765    -.33134
39   13.52820     .69361     .98977   54.97816    -.02682    -.00173     .00344     .04417     .14281     .01005    -.02723
40   13.52820     .20942    1.01596   78.35281    -.02454    -.00118     .00071     .03080     .09957     .00206    -.00573
41   16.51560     .22819   -1.10701  281.64719     .07340     .00232    -.00230     .10046     .02600    -.00012    -.02038
42   16.51560     .75577   -1.07847  305.02183     .07725     .00328    -.01080     .13872     .03591    -.00059    -.09319
43   16.51560    1.57354    -.96083  328.59103     .07829     .00631    -.04430     .24343     .06317    -.00267    -.34049
44   16.51559    2.71429    -.43325  350.93104    -.07101    -.01280     .19453    -.26508    -.06985     .01774     .63956
45   16.51559    2.71429     .43325    9.06896    -.06223    -.01122     .16171     .23230     .06121     .01554    -.56046
46   16.51560    1.57354     .96083   31.40897    -.09515    -.00767     .05384     .29586     .07677     .00324    -.41381
47   16.51560     .75577    1.07847   54.97817    -.03434    -.00146     .00480     .06167     .01597     .00026    -.04143
48   16.51560     .22819    1.10701   78.35281    -.03185    -.00101     .00100     .04360     .01128     .00005    -.00884

           TOTAL COEFFICIENTS
           ------------------
           ON THE BODY FROM XSTART=    0.0000 TO XWLE=   18.0000


           REFA=        12.5670   REFD=         3.4641   REFL=        1.0000

           XM  =        16.8000   ZM  =         0.0000

          MACH=        1.70000
        ALPHAC=       10.00000         ALPHA=        10.00000
          PHIR=        0.00000          BETA=         0.00000
            CX=         .01861
            CY=        0.00000
            CZ=         .88865
            CM=        1.78654
           CLN=        0.00000
           CLL=        0.00000
           XCP=        9.83566

           FOLLOWING ARE IN WIND AXIS SYSTEM
            CL=         .87190
            CY=        0.00000
            CD=         .17264
           CMW=        1.78654
        CNYAWW=        0.00000

CPSTAG =   1.94562   CPCRIT =    .79466   CPVAC =   -.49431

    END SOLVE,   TIME=    6.4530     DT=    1.0900
```

Figure 26.- Continued.

```
         PERTURBATION VELOCITIES AT SPECIFIED CONTROL POINTS BY SOURCE PANELS                                ** BOYVEL **

         CONTROL POINT                              PANEL ANGLES          VELOCITIES

 JCPT     X           Y           Z          THET       DELTA        U          V          W         NORMAL

   1   21.98180    3.64130    0.00000    0.00000     .12529     .03077    -.03893     .27791     .27188
   2   25.47690    3.64130    0.00000    0.00000     .12773     .01671    -.03515     .20167     .19790
   3   22.79380    4.00490    0.00000    0.00000     .13810     .02826    -.03358     .17286     .16732
   4   25.71560    4.00490    0.00000    0.00000     .21266     .01619    -.02840     .14465     .13797
   5   23.60470    4.36790    0.00000    0.00000     .21266     .02664    -.03169     .12540     .11695
   6   25.95390    4.36790    0.00000    0.00000     .13810     .01549    -.02418     .11243     .10923
   7   21.58590    2.81800     .44979    0.00000     .12773     .02376    -.35273     .05990     .05639
   8   21.58590    1.63360     .99752    0.00000     .12529     .03627    -.12796    -.17431    -.17747
   9   21.58590     .78462    1.11960    0.00000     .08032     .03568    -.05563    -.18569    -.18796
  10   21.58590     .23690    1.14930    0.00000     .08190     .04522    -.01440    -.19518    -.19823
  11   21.58590     .23690   -1.14930    0.00000     .08859     .01995     .02000    -.15368    -.15484
  12   21.58590     .78462   -1.11960    0.00000     .13713     .04230     .08505    -.12776    -.13234
  13   21.58590    1.63360    -.99752    0.00000     .13713     .02622     .11854    -.12042    -.12288
  14   21.58590    2.81800    -.44979    0.00000     .08859     .05307     .30334     .12184     .11666
  15   25.36050    2.81800     .44979    0.00000     .08190    -.00575    -.33634     .14262     .14262
  16   25.36050    1.63360     .99752    0.00000     .08032     .00208    -.13981    -.18074    -.18033
  17   25.36050     .78462    1.11960    0.00000     .06337     .00767    -.06356    -.19388    -.19397
  18   25.36050     .23690    1.14930    0.00000     .06462     .02787    -.01179    -.20495    -.20632
  19   25.36050     .23690   -1.14930    0.00000     .06991     .03946     .01976    -.13909    -.14150
  20   25.36050     .78462   -1.11960    0.00000     .10836     .05313     .06791    -.13473    -.13968
  21   25.36050    1.63360    -.99752    0.00000     .10836     .05702     .12708    -.11184    -.11735
  22   25.36050    2.81800    -.44979    0.00000     .06991     .04292     .27085     .21186     .20835
```

Figure 26.- Concluded.

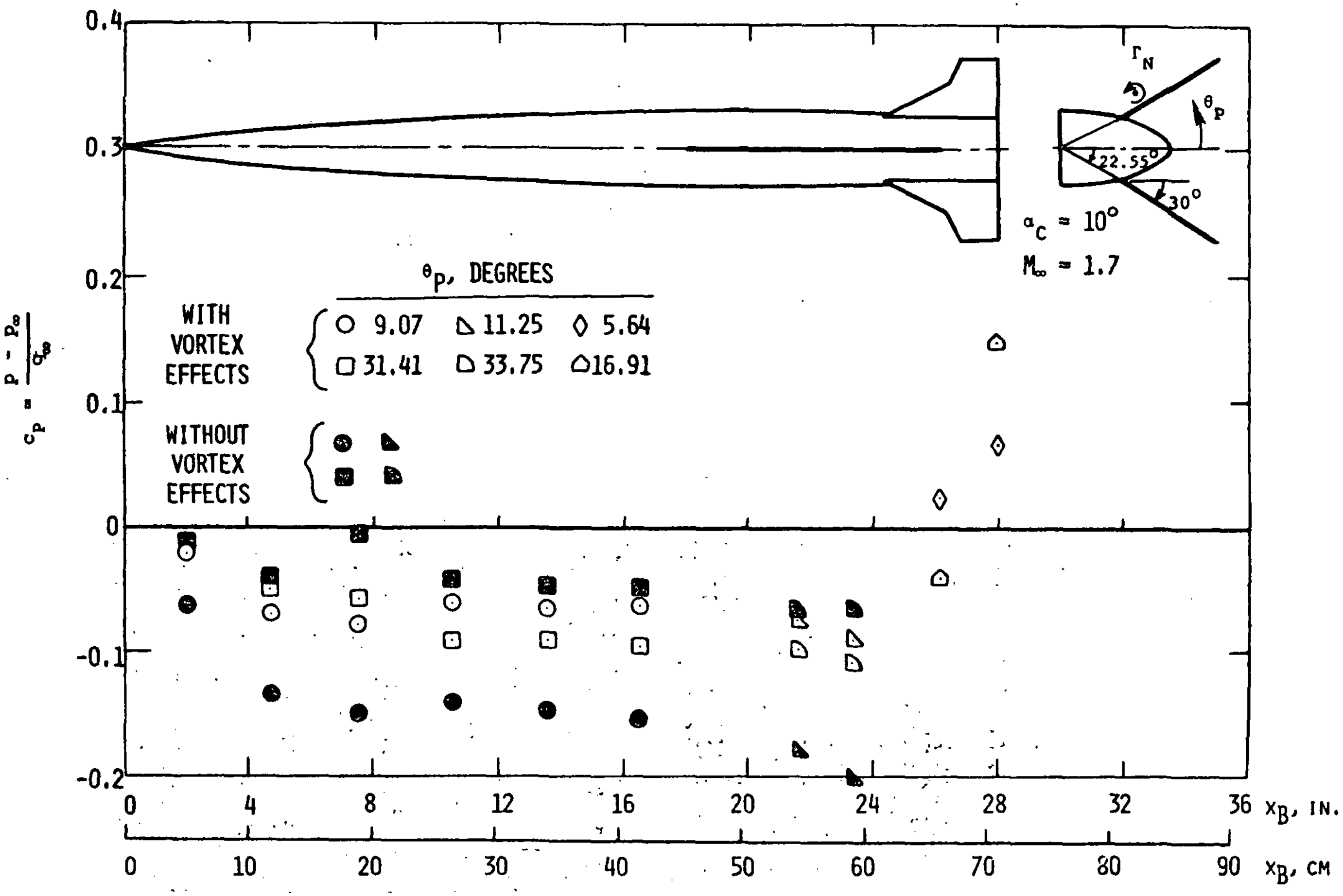

Figure 27(a).- Calculated pressure distributions, second sample case.

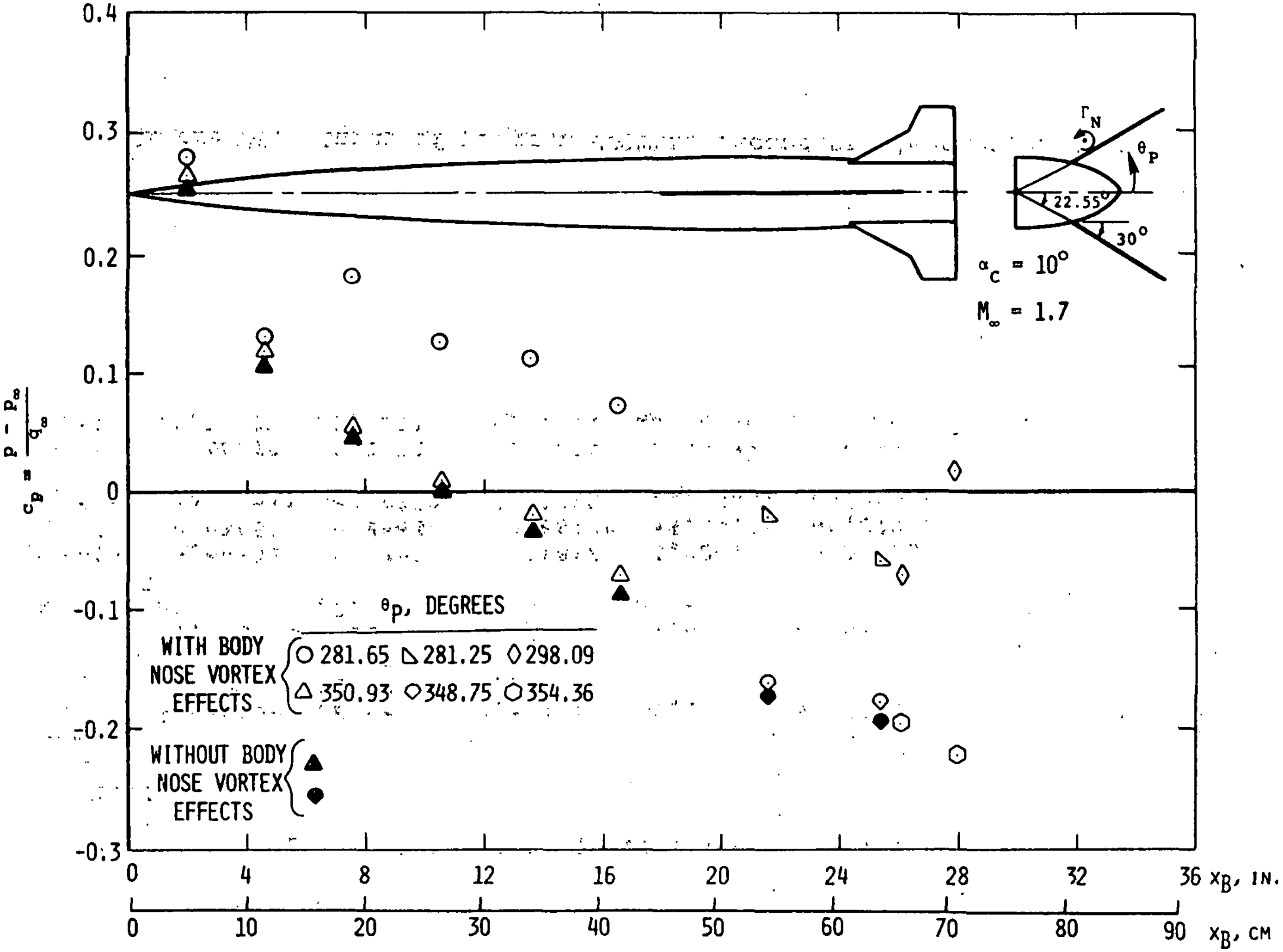

Figure 27(b).- Concluded.

```
LRC 3/1 ELLIPTICAL BODY/MONOPLANE WING,TRACK BODY NOSE VORTICES.
         1         4         5         1         1         0         0
0.3333333
25.55
3.464106
 18.0    3.464106  22.081    4.55761   25.55     4.55761   25.56     3.464106
  10.0     0.0     0.0001    0.50
   2    2    2    2    2
 2.35     1.673     1.52     -2.35       1.673     -1.52
 18.0    20.0      22.0      24.0      25.55
        3         3
 0.66148  3.64135   0.27984   2.01812   3.82511   0.27786
 3.37295  4.03457   0.28634    0.66148  -3.64135  -0.27984
2.01812   -3.82511  -0.27786  3.37295   -4.03457  -0.28634
        2
 4.081    4.34073   0.44937   6.13099   4.40075   0.58150
 4.081   -4.34073  -0.44937   6.13099  -4.40075  -0.58150
```

Figure 28.- Input of program VPATHL, second sample case, step 4.

```
LRC 3/1 ELLIPTICAL BODY/MONOPLANE WING,TRACK BODY NOSE VORTICES.


                FIN GEOMETRY
           FIN SEMISPAN               =     4,55761
           FIN ROOTCHORD              =     7,56000
           FIN ROOT L.E. X-STATION=    18,00000
                    L.E. Y-STATION=     3,46411
           FIN TIP L.E. X-STATION =    22,08100
                   L.E. Y-STATION =     4,55761
           FIN TIP T.E. X-STATION =    25,55000
                   T.E. Y-STATION =     4,55761
           FIN ROOT T.E. X-STATION=    25,56000
                    T.E. Y-STATION=     3,46411



        INCLUDED ANGLE OF ATTACK(DEG) =    10,00000      ROLL ANGLE(DEG)  =    0,00000



           FIN LEADING EDGE VORTICITY
        JLE       X         Y OR Z BAR  GAMMA/VINF.

          1     18,66148     3,64135      ,27984
          2     20,01812     3,82511      ,27786
          3     21,37295     4,03457      ,28634
          4     18,66148    -3,64135     -,27984
          5     20,01812    -3,82511     -,27786
          6     21,37295    -4,03457     -,28634



           FIN SIDE EDGE VORTICITY
        JSE       X         Y OR Z BAR  GAMMA/VINF.

          1     22,08100     4,34073      ,44937
          2     24,13099     4,40075      ,58150
          3     22,08100    -4,34073     -,44937
          4     24,13099    -4,40075     -,58150

****PERMISSIBLE RELATIVE ERROR,ES,USED IN INTEGRATION SCHEME =   ,10000E-03



           VORTEX COORDINATES IN CROSS-FLOW PLANE
```

Figure 29.- Output of program VPATHL, second sample case, step 4.

```
   INITIAL VORTEX POSITIONS AT    X = 18.000

LOCAL BODY HORIZONTAL SEMI-AXIS =     3.46411
LOCAL BODY VERTICAL SEMI-AXIS   =     1.15470
LOCAL SEMI SPAN S               =     3.46411

      VORTEX            Y,VRTX          Z,VRTX      GAMMA/VINF

        1             .23500E+01      .16730E+01    .15200E+01
        2            -.23500E+01      .16730E+01   -.15200E+01


 X-STATION NO.  2      X=20.000       INTEGRATION STEP SIZE =    1.00000


LOCAL BODY HORIZONTAL SEMI-AXIS =     3.46411
LOCAL BODY VERTICAL SEMI-AXIS   =     1.15470
LOCAL SEMI SPAN S               =     4.00001

      VORTEX            Y,VRTX          Z,VRTX      GAMMA/VINF

        1             .23864E+01      .17470E+01    .15200E+01
        2            -.23864E+01      .17470E+01   -.15200E+01


 X-STATION NO.  3      X=22.000       INTEGRATION STEP SIZE =    1.00000


LOCAL BODY HORIZONTAL SEMI-AXIS =     3.46411
LOCAL BODY VERTICAL SEMI-AXIS   =     1.15470
LOCAL SEMI SPAN S               =     4.53591

      VORTEX            Y,VRTX          Z,VRTX      GAMMA/VINF

        1             .24152E+01      .18080E+01    .15200E+01
        2            -.24152E+01      .18080E+01   -.15200E+01


 X-STATION NO.  4      X=24.000       INTEGRATION STEP SIZE =    1.00000


LOCAL BODY HORIZONTAL SEMI-AXIS =     3.46411
LOCAL BODY VERTICAL SEMI-AXIS   =     1.15470
LOCAL SEMI SPAN S               =     4.55761

      VORTEX            Y,VRTX          Z,VRTX      GAMMA/VINF

        1             .24432E+01      .18508E+01    .15200E+01
        2            -.24432E+01      .18508E+01   -.15200E+01


 X-STATION NO.  5      X=25.550       INTEGRATION STEP SIZE =    1.00000
```

Figure 29.- Continued.

```
LOCAL BODY HORIZONTAL SEMI-AXIS =     3.46411
LOCAL BODY VERTICAL SEMI-AXIS   =     1.15470
LOCAL SEMI SPAN S               =     4.55761

     VORTEX          Y,VRTX           Z,VRTY       GAMMA/VINF

        1          .24609E+01       .18792E+01     .15200E+01
        2         -.24609E+01       .18792E+01    -.15200E+01


CROSSFLOW VELOCITIES AT CONTROL POINTS INDUCED BY VORTICES AND THEIR IMAGES

IC          X,BODY          Y,BODY          Z,BODY            V             W
 1        .21982E+02      .36413E+01     0.                .22027E-01    -.73043E-01
 2        .25477E+02      .36413E+01     0.                .23261E-01    -.78140E-01
 3        .22794E+02      .40049E+01     0.                .32848E-01    -.38784E-01
 4        .25716E+02      .40049E+01     0.                .34452E-01    -.41193E-01
 5        .23605E+02      .43679E+01     0.                .32109E-01    -.21043E-01
 6        .25954E+02      .43679E+01     0.                .33399E-01    -.22172E-01
 7        .21586E+02      .31556E+01      .50368E+00       .18131E+00    -.12379E+00
 8        .21586E+02      .16764E+01      .10237E+01       .38057E+00    -.75801E-01
 9        .21586E+02      .79588E+00      .11357E+01       .11080E+00    -.10914E-01
10        .21586E+02      .23983E+00      .11635E+01       .28788E-01    -.20990E-02
11        .21586E+02      .23983E+00     -.11635E+01      -.52670E-03    -.37374E-04
12        .21586E+02      .79588E+00     -.11357E+01      -.18287E-02    -.17398E-03
13        .21586E+02      .16764E+01     -.10237E+01      -.46457E-02    -.91229E-03
14        .21586E+02      .31556E+01     -.50368E+00      -.21879E-01    -.17031E-01
15        .25361E+02      .31556E+01      .50368E+00       .18892E+00    -.12949E+00
16        .25361E+02      .16764E+01      .10237E+01       .35303E+00    -.69873E-01
17        .25361E+02      .79588E+00      .11357E+01       .11003E+00    -.10781E-01
18        .25361E+02      .23983E+00      .11635E+01       .29018E-01    -.21119E-02
19        .25361E+02      .23983E+00     -.11635E+01      -.57450E-03    -.41311E-04
20        .25361E+02      .79588E+00     -.11357E+01      -.19944E-02    -.18974E-03
21        .25361E+02      .16764E+01     -.10237E+01      -.50641E-02    -.99439E-03
22        .25361E+02      .31556E+01     -.50368E+00      -.23762E-01    -.18491E-01
```

Figure 29.- Concluded.

```
IDEALIZED LRC ELLIPTICAL BODY MONOPLANE WING
$INPUT
CRP=7.54926,  SWLEP=75.0,  SWTEP=30.01564, B2=1.0935, BIL=7.54926,
XWLE=18.0,
RB=3.464106,  RA=1.1547005,  ERATIO=3.0,
NCW=2,  MSWR=3,  MSWL=0,  NBDCR=8,  NCWB=2,
NBDCR=16,
ALFAC=10.0,  PHI=0.0,  FMACH=1.7,
SREF=12.567,  REFL=3.464106,
NOLINP=1,  NDRAG=1, NBDYPR=1,
NOUT=0,
NCPOUT=0,
NVLIN=1,
NTDAT=1,NCWT=4,
XM=16.8,ZM=0.0,
$END
   3     0     0
0.049692      0.0      0.0      -0.07889
0.049692  0.049692    0.0      -0.07889
0.049692  0.049692    0.0      -0.07889
        0          0          0          0
        0
ZZZZZZZZZZZZ
```

Figure 30.- Input of program DEMON2, second sample case, step 5.

```
IDEALIZED LRC ELLIPTICAL BODY MONOPLANE WING
 $INPUT                                                                    SREF     = .12567E+02,
 CRP      = .754926E+01,                                                   REFL     = .3464106E+01,
 SWLEP    = .75E+02,                                                       PHIDIH   = 0.0,
 SWTEP    = .3001564E+02,                                                  THETIT   = 0.0,
 NCW      = 2,                                                             XWLE     = .18E+02,
 MSWR     = 3,                                                             NOLINP   = 1,
 MSWL     = 0,                                                             NOUT     = 0,
 ALFAC    = .1E+02,                                                        NPR      = 0,
 PHI      = 0.0,                                                           NDRAG    = 1,
 B2       = .10935E+01,                                                    NVRTX    = 0,
 FMACH    = .17E+01,                                                       NPRESS   = 0,
 LVSWP    = 0,                                                             VRTMAX   = .35E+00,
 FAC      = .95E+00,                                                       NCWB     = 2,
 NEVNPR   = 0,                                                             NAGAIN   = 0,
 TOLFAC   = .1E+01,                                                        BIL      = .754926E+01,
 MSWU     = 0,                                                             ITAIL    = 0,
 MSWD     = 0,                                                             NVRTPL   = 0,
 SWLEV    = 0.0,                                                           NBDYPR   = 1,
 SWTEV    = 0.0,                                                           NTPR     = 0,
 CRPV     = 0.0,                                                           NTDAT    = 1,
 B2V      = 0.0,                                                           NCWT     = 4,
 NCRX     = 0,                                                             NCPOUT   = 0,
 RR       = .3464106E+01,                                                  NVLIN    = 1,
 RA       = .11547005E+01,                                                 XSTART   = 0.0,
 ERATIO   = .30000038971145E+01,                                           JCPT     = 0,
 NBDCR    = 16,                                                            FKLE     = .5E+00,
 DELR     = 0.0,                                                           FKSE     = .5E+00,
 DELL     = 0.0,                                                           XM       = .168E+02,
 DELU     = 0.0,                                                           ZM       = 0.0,
 DELD     = 0.0,                                                           $END
```

Figure 31.- Output of program DEMON2, second sampel case, step 5.

```
WING GEOMETRY

          TIP CHORD =     4.09999

         ROOT CHORD =     7.54926

      WING SEMISPAN =     1.09350

  LEADING EDGE SWEEP =   75.00000  DEGREES

 TRAILING EDGE SWEEP =   30.01564  DEGREES

          FLOW CONDITIONS

MACH =     1.70000    ALPHAC=   10.00000    PHI  =     0.00000    ALFA =   10.00000    BETA =    0.00000

     CRPT =     7.54926

WING THICKNESS INPUT DATA

          SPANWISE LOCATIONS OF PANEL SIDE EDGES AND SWEEP ANGLES
              OF WING SECTION TO THE LEFT

                        SPANWISE   LE SWEEP  TE SWEEP
               I        LOCATION
                          FEET      DEGREES   DEGREES

   RIGHT WING SURFACE

               1        3.46411    0.00000   0.00000
               2        3.82861   75.00000  30.01564
               3        4.19311   75.00000  30.01564
               4        4.55761   75.00000  30.01564

            12 THICKNESS PANELS ARE TO BE LAID OUT
             3 CHORDWISE ROWS WITH  4 IN EACH ROW

                        INPUT VALUES OF THE LOCAL SURFACE SLOPE OF THE THICKNESS
                         DISTRIBUTION, FOR EACH CHORDWISE ROW THE FIRST VALUE
                              IS FOR THE PANEL NEAREST THE LEADING EDGE

RIGHT WING SURFACE

    ROW                            SLOPES
     1                  .04969   0.00000   0.00000   -.07889
     2                  .04969    .04969   0.00000   -.07889
     3                  .04969    .04969   0.00000   -.07889
```

Figure 31.- Continued.

```
BODY UNDER CONSIDERATION HAS ELLIPTICAL CROSS SECTION.
INTERFERENCE SHELL HAS FOLLOWING PROPERTIES:
HORIZONTAL SEMI-AXIS =     1.40411
VERTICAL SEMI-AXIS   =     1.15470


       POINT COORDINATES AND PERTURBATION VELOCITIES CALCULATED BY PROGRAM VPATH OR VPATHL

IC        XCP          YCP           ZCP          VVEL(IC)        WVEL(IC)

 1     21.98200      3.64130       0.00000      .22027E-01     -.73045E-01
 2     25.47700      3.64130       0.00000      .23261E-01     -.78140E-01
 3     22.79400      4.00490       0.00000      .32848E-01     -.38780E-01
 4     25.71600      4.00490       0.00000      .34452E-01     -.41193E-01
 5     23.60500      4.36790       0.00000      .32109E-01     -.21043E-01
 6     25.95400      4.36790       0.00000      .33399E-01     -.22172E-01
 7     21.58600      3.15560        .50368      .18131E+00     -.12379E+00
 8     21.58600      1.67640       1.02370      .38057E+00     -.75801E-01
 9     21.58600       .79588       1.13570      .11080E+00     -.10914E-01
10     21.58600       .23983       1.16350      .28788E-01     -.20990E-02
11     21.58600       .23983      -1.16350     -.52670E-03     -.37874E-04
12     21.58600       .79588      -1.13570     -.18287E-02     -.17398E-03
13     21.58600      1.67640      -1.02370     -.46457E-02     -.91229E-03
14     21.58600      3.15560       -.50368     -.21879E-01     -.17031E-01
15     25.36100      3.15560        .50368      .18992E+00     -.12949E+00
16     25.36100      1.67640       1.02370      .35303E+00     -.69873E-01
17     25.36100       .79588       1.13570      .11003E+00     -.10781E-01
18     25.36100       .23983       1.16350      .29018E-01     -.21119E-02
19     25.36100       .23983      -1.16350     -.57450E-03     -.41311E-04
20     25.36100       .79588      -1.13570     -.19444E-02     -.18974E-03
21     25.36100      1.67640      -1.02370     -.50641E-02     -.99439E-03
22     25.36100      3.15560       -.50368     -.23762E-01     -.18491E-01

       CONTROL POINT COORDINATES FOR  2 CHORDWISE BY  3 SPANWISE PANELS ON WING 1 OR R,   0     SPANWISE ON WING 2 OR L
                                                   AND 0 SPANWISE PANELS ONWING 3 OR U,  0     SPANWISE ON WING 4 OR D

J        X(J)         Y(J)          Z(J)         BU(J)          BV(J)           BW(J)          VVRTX           WVRTX

 1     3.98181      3.64135       0.00000      .30766E-01    -.38935E-01     .27791E+00    0.              0.
 2     7.47690      3.64135       0.00000      .16709E-01    -.35151E-01     .20167E+00    0.              0.
 3     4.79380      4.00486       0.00000      .28259E-01    -.33580E-01     .17286E+00    0.              0.
 4     7.71557      4.00486       0.00000      .16194E-01    -.28395E-01     .14465E+00    0.              0.
 5     5.60471      4.36789       0.00000      .26643E-01    -.31692E-01     .12540E+00    0.              0.
 6     7.95393      4.36789       0.00000      .15490E-01    -.24185E-01     .11243E+00    0.              0.

                                   CONTROL POINT COORDINATES FOR BIP*S (WING FRAME)

 J        X(J)          Y(J)          Z(J)        THU(J)          THV(J)          THW(J)


 7      3.58590       2.81795        .44979    -.14293E-02     -.50900E-02      .19263E-02
 8      3.58590       1.63362        .99752    -.21755E-02     -.28706E-02      .14883E-02
 9      3.58590        .78462       1.11965    0.              0.               0.
10      3.58590        .23690       1.14927    0.              0.               0.
11      3.58590        .23690      -1.14927    0.              0.               0.
12      3.58590        .78462      -1.11965    0.              0.               0.
13      3.58590       1.63362       -.99752    -.21755E-02     -.28706E-02     -.14883E-02
14      3.58590       2.81795       -.44979    -.14293E-02     -.50900E-02     -.19263E-02
```

Figure 31.- Continued.

```
 15      7.36053      2.81795       .44979    .11729E-01    .12612E-01   -.75118E-02
 16      7.36053      1.63362       .99752   -.37810E-02   -.42403E-02    .22634E-02
 17      7.36053       .78442      1.11965   -.25780E-02    .13263E-02    .11738E-02
 18      7.36053       .23690      1.14927   -.26999E-02    .79477E-03    .13010E-02
 19      7.36053       .23690     -1.14927   -.26999E-02    .79477E-03   -.13010E-02
 20      7.36053       .78442     -1.11965   -.25780E-02    .13263E-02   -.11738E-02
 21      7.36053      1.63362      -.99752   -.37810E-02   -.42403E-02   -.22634E-02
 22      7.36053      2.81795      -.44979    .11729E-01    .12612E-01    .75118E-02

                                     LOADING INFORMATION

            MACH NUMBER =   .17000E+01
        ANGLE OF ATTACK =  10.000 DEGREES
        SIDE SLIP ANGLE =   0.000 DEGREES
              WING AREA =  12.73846
         REFERENCE AREA =  12.56700
       REFERENCE LENGTH =   3.46411
    EXPOSED WING SPAN B =   2.18700
    MOMENT CENTER:   XM =  16.80000
                     ZM =   0.00000


U/VINE TYPE LOADING PRESSURE


                         TOTAL             FIN 1 OR R        FIN 2 OR L        FIN 3 OR U        FIN 4 OR D      INTERF. SHELL
    DEFL. ANGLE DEG. =                       0.00000           0.00000           0.00000           0.00000
                CTHR =   .29818E-01       .10409E-01        .10409E-01       0.                0.
                  CZ =   .47064E+00       .95932E-01        .95932E-01       0.                0.                .27878E+00
                  CY =  0.               0.                0.                0.                0.               0.
                  CM =  -.10223E+01      -.18717E+00       -.18717E+00       0.                0.               -.64798E+00
                 CLN =  0.               0.                0.                0.                0.               0.
                 CLL =  0.              -.10990E+00        .10990E+00       0.                0.               0.

                 FOLLOWING ARE IN WIND-AXIS SYSTEM

                  CL =   .46711E+00       .96282E-01        .96282E-01       0.                0.                .27454E+00
              CYWIND =  0.               0.                0.                0.                0.               0.
                 CDI =   .61224E-01       .64074E-02        .64074E-02       0.                0.                .48410E-01
           CDI/CL**2 =   .28060E+00
              CMWIND =  -.10223E+01      -.18717E+00       -.18717E+00       0.                0.               -.64798E+00
             CLNWIND =  0.                .19084E-01       -.19084E-01       0.                0.               0.
```

Figure 31.- Continued.

```
--------------------RIGHT WING----------------------


                                   SPANWISE DISTRIBUTIONS

  I      Y/(B/2)  CN*C/(2*B)  CT*C/(2*B) CY1*C/(2*B) CYTOT*C/(2*B) CS*C/(2*B)     CSINT      YBAR        GAMNET(I)  GAMMA,LE/VINF  XLE

  1      3.32999     .27982      .02268      .06378      .02942       .08743      .03194    3.64135     -.61334      .19406     .66148
  2      3.66242     .27199      .02547      .07117      .09879       .09843      .06782    3.83365      .01657      .19763    2.01812
  3      3.99441     .20436      .03423      .10075      .10075       .13225      .11602    4.05562      .14759      .21123    3.37295
  4      4.16791    0.00000                                                                             .44919


        SUMFX  =   .10452E-01
        SUMFY1 =   .29902E-01
        SUMFY2 =  -.85395E-03
        SUMFZ2 =   .10511E+00


        SIDE EDGE DISTRIBUTION

 JTIP   JSE  DISTANCE         SUCTION FORCE        GAMMA,SE      YBAR       XSE
             FROM LE          PER UNIT LENGTH      /VINF
             /TIPCHORD        /(B*TIPCHORD)

   1     1     .50000             .09399            .35606     4.36126    4.08100
   2     2    1.00000             .06318            .47179     4.41928    6.13099


*****T.E. FIN VORTEX INFO******

IVRT GAMMA/VINF   Y.C.G.

  1      .61196    4.44912


          VELOCITIES AND BERNOULLI PRESSURES AT CONTROL POINTS IMMEDIATELY ABOVE AND BELOW HORIZONTAL WING SURFACE

 J      X(J)       Y(J)       Z(J)       UTOTA      VTOTA      WTOTA      PRESSA     UTOTB      VTOTB      WTOTB      PRESSB

 1   3.981812   3.641349   0.000000    .079046   -.240461   -.173648   -.165036   -.028511    .160947   -.173648    .062203
 2   7.476901   3.641349   0.000000    .067994   -.025306   -.252538   -.105974    .000063    .121077   -.094758    .009207
 3   4.793803   4.004860   0.000000    .078117   -.278806   -.123956   -.180050   -.072305    .282578   -.223340    .090370
 4   7.715573   4.004860   0.000000    .062914   -.027248   -.252538   -.097007    .009085    .088748   -.094758   -.001919
 5   5.604708   4.367885   0.000000    .115213   -.318855   -.123956   -.249191   -.055308    .317540   -.223340    .033511
 6   7.953725   4.367885   0.000000    .037632   -.036340   -.252538   -.050934    .016947    .008231   -.094758   -.009734
```

Figure 31.- Continued.

```
PRESSURE LOADINGS AT CONTROL POINTS

I        X(J)        Y(J)        Z(J)      DELTP.LIN. DELTP.BERN.

1     3.981812    3.641349    0.000000     .215114     .227239
2     7.476901    3.641349    0.000000     .135861     .115181
3     4.793803    4.004860    0.000000     .300845     .270421
4     7.715573    4.004860    0.000000     .107659     .095088
5     5.604708    4.367885    0.000000     .341043     .282701
6     7.953925    4.367885    0.000000     .041370     .041200


                                     LOADING INFORMATION

         MACH NUMBER =    .17000E+01
     ANGLE OF ATTACK =    10.000 DEGREES
     SIDE SLIP ANGLE =     0.000 DEGREES
           WING AREA =    12.75846
      REFERENCE AREA =    12.56700
    REFERENCE LENGTH =     3.46411
 EXPOSED WING SPAN B =     2.18700
 MOMENT CENTER:   XM =    16.80000
                  ZM =     0.00000



BERNOULLI TYPE LOADING PRESSURE


                          TOTAL              FIN 1 OR R         FIN 2 OR L         FIN 3 OR U         FIN 4 OR D       INTERF. SHELL
   DEFL. ANGLE DEG. =                         0.00000            0.00000            0.00000            0.00000
               CTHR =    .18894E-01         .94469E-02         .94469E-02        0.                 0.
                 CZ =    .45372E+00         .87468E-01         .87468E-01        0.                 0.                  .27878E+00
                 CY =   0.                 0.                 0.                 0.                 0.                 0.
                 CM =   -.98555E+00        -.16879E+00        -.16879E+00        0.                 0.                 -.64798E+00
                CLN =   0.                 0.                 0.                 0.                 0.                 0.
                CLL =   0.                 -.99789E-01         .99789E-01        0.                 0.                 0.

                FOLLOWING ARE IN WIND-AXIS SYSTEM

                 CL =    .45910E+00         .87779E-01         .87779E-01        0.                 0.                  .27454E+00
             CY-IND =   0.                 0.                 0.                 0.                 0.                 0.
                CDT =    .60180E-01         .58852E-02         .58852E-02        0.                 0.                  .48410E-01
          CDT/CL**2 =    .29705E+00
             CM-IND =   -.98555E+00        -.16879E+00        -.16879E+00        0.                 0.                 -.64798E+00
            CLN-IND =   0.                  .17328E-01        -.17328E-01        0.                 0.                 0.
```

Figure 31.- Continued.

```
********************RIGHT WING*********************



                         SPANWISE DISTRIBUTIONS


 I      Y/(B/2)  CN*C/(2*H)  CT*C/(2*H) CY1*C/(2*B) CYTOT*C/(2*B) CS*C/(2*H)    CSINT      YBAR       GAMNET(I)  GAMMA,LE/VINF  XLE

 1      3.32999      .27300      .02356      .06693      .07818      .09105      .03319    3.64135    -.59839      .20163     .66148
 2      3.66242      .24336      .02266      .06392      .10176      .08833      .06538    3.82035     .06403      .19760    2.01812
 3      3.99441      .17309      .02837      .08352      .08352      .10963      .10534    4.02805     .15351      .20115    3.37295
 4      4.16791     0.00000                                                                            .38046


         SUMFY  =   .94890E-02
         SUMFY1 =   .27183E-01
         SUMFY2 =   .62412E-02
         SUMFT2 =   .87896E-01



         SIDE EDGE DISTRIBUTION

 JTIP  JSE  DISTANCE          SUCTION FORCE         GAMMA,SE       YBAR        XSE
            FROM LE           PER UNIT LENGTH       /VINF
            /TIPCHORD         /(Q*TIPCHORD)

   1     1      .50000            .07791             .31498       4.33889     4.08100
   2     2     1.00000            .05351             .41103       4.40173     6.13099



****T.E. FIN VORTEX INFO*****

I/RT GAMMA/VINF    Y.C.G.

  1      .59700    4.38465



**************************************************************************************************************************
AFT OF LEADING EDGE OF FIN ROOTCHORDS


                    PRESSURE COEFFICIENTS AT POINTS ON BODY MERIDIANS

 J     THETA,      XB         YB         ZB         UTOT       VTOT       WTOT     CP,LIN.   CP,BERN.   DR/DX      P/PINF,    P/PINF,
        DEG.                                                                                                      BERN.      LIN.
```

Figure 31.- Continued.

```
                                    BODY RING=   1

1  11.25000  21.58590  2.81795   .44979   .03566  -.15872  -.07273  -.07133  -.07258  0.00000   .85317   .85570
2  33.75000  21.58590  1.63362   .99752   .04018   .25728  -.25096  -.08036  -.11227  0.00000   .77289   .83743
3  56.25000  21.58590   .78462  1.11965   .04365   .06333  -.19724  -.08730  -.05954  0.00000   .87956   .82340
4  78.75000  21.58590   .23690  1.14927   .04888   .01555  -.19731  -.09777  -.06592  0.00000   .86665   .80222
5 281.25000  21.58590   .23690 -1.14927   .02338   .02071  -.15369  -.04675  -.01705  0.00000   .96551   .90542
6 303.75000  21.58590   .78462 -1.11965   .04490   .08727  -.12762  -.08980  -.06656  0.00000   .86534   .81833
7 326.25000  21.58590  1.63362  -.99752   .02139   .11089  -.12188  -.04278  -.02688  0.00000   .94563   .91345
8 348.75000  21.58590  2.81795  -.44979   .03800   .26433   .09288  -.07599  -.16311  0.00000   .67003   .84627

                                    BODY RING=   2

1  11.25000  25.36053  2.81795   .44979   .04331  -.11684  -.00815  -.08663  -.09132  0.00000   .81526   .82475
2  33.75000  25.36053  1.63362   .99752   .04251   .24035  -.25555  -.08502  -.10983  0.00000   .77751   .82801
3  56.25000  25.36053   .78462  1.11965   .07093   .10105  -.20891  -.14186  -.11497  0.00000   .76741   .71302
4  78.75000  25.36053   .23690  1.14927   .06584   .03170  -.20739  -.13169  -.09814  0.00000   .80146   .73360
5 281.25000  25.36053   .23690 -1.14927   .04433   .02233  -.13906  -.08866  -.05820  0.00000   .88227   .82064
6 303.75000  25.36053   .78462 -1.11965   .06190   .08776  -.13315  -.12380  -.09722  0.00000   .80332   .74955
7 326.25000  25.36053  1.63362  -.99752   .03616   .11786  -.11359  -.07232  -.05733  0.00000   .88402   .85369
8 348.75000  25.36053  2.81795  -.44979   .02213   .24577   .19245  -.04425  -.17885  0.00000   .63819   .91047
```

Figure 31.- Concluded.

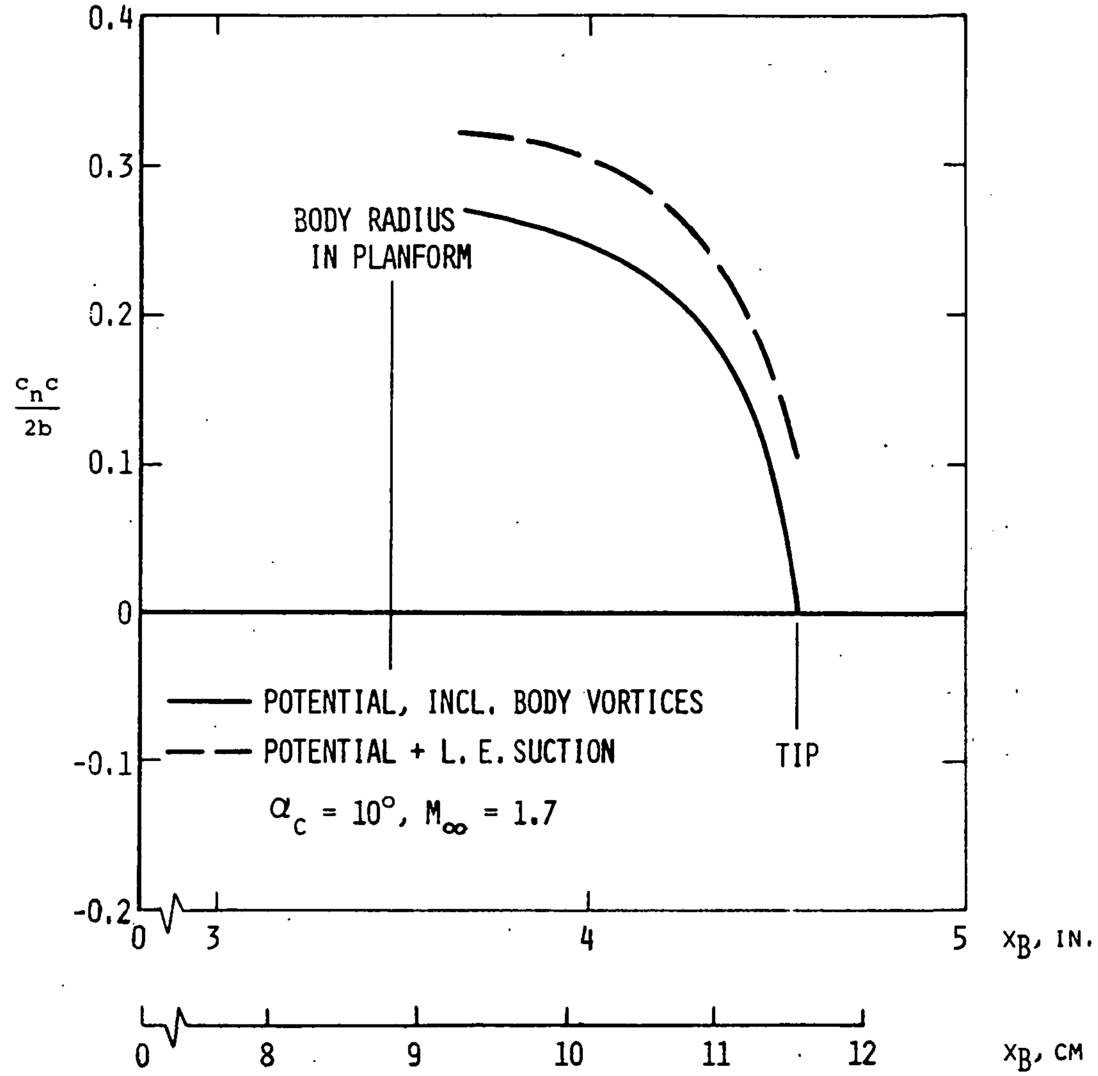

Figure 32.- Calculated span-load distribution on monoplane wing, second sample case.

```
 IDEALIIZED LRC ELLIPTICAL BODY-INTERDIGITATED FINS.
 $INPUT
 CRP=3.6, B2=3.6,CRPV=3.6, B2V=3.6, NCRX=1,
 BIL=3.6, RB=3.129, RA=1.043,
 PHIDIH=30.,  THETIT=22.545,
 XWLE=24.4,
 NCW=2,  MSWR=4,  MSWU=4,  NBDCR=8,  NCWB=2,
 NBDCR=16,
 ALFAC=10.0,  FMACH=1.7,  PHI=0.,
 SREF=12.567,  REFL=3.464106,
 NVRTX=6,
 LVSWP=1,  NOLINP=1,
 NOUT=0,
 NBDYPR=1,
 NDRAG=0,
 XM=16.8,ZM=0.0,
 $END
 0.0        45.0       0.0
 1.0        45.0       0.0
 2.0        45.0       0.0
 3.0        14.03624   0.0
 3.6        14.03624   0.0
 0.0        45.0       0.0
 1.0        45.0       0.0
 2.0        45.0       0.0
 3.0        14.03624   0.0
 3.6        14.03624   0.0
 1.52       2.4609     1.8809
-1.52      -2.4609     1.8809
 0.47179    4.41828    0.661
-0.47179   -4.41828    0.661
  0.59704   4.38465     0.0
 -0.59704  -4.38465     0.0
         0         0
         0
ZZZZZZZZZZ
```

Figure 33.- Input of program DEMON2, second case, step 10.

```
IDEALIZED LRC ELLIPTICAL BODY-INTERDIGITATED FINS.
$INPUT                                                                         SREF     = .12567E+02,
CRP      = .36E+01,                                                            REFL     = .3464106E+01,
SWLEP    = 0.0,                                                                PHIDIH   = .3E+02,
SWTEP    = 0.0,                                                                THETTT   = .22545E+02,
NCW      = 2,                                                                  X-LE     = .244E+02,
MSWR     = 4,                                                                  NOLINR   = 1,
MSWL     = 0,                                                                  NOUT     = 0,
ALFAC    = .1E+02,                                                             NPR      = 0,
PHI      = 0.0,                                                                NDRAG    = 0,
B2       = .36E+01,                                                            NVRTX    = 6,
FMACH    = .17E+01,                                                            NPRESS   = 0,
LVSWP    = 1,                                                                  VRTMAX   = .35E+00,
FAC      = .95E+00,                                                            NCWB     = 2,
NFVNPR   = 0,                                                                  NAGAIN   = 0,
TOLFAC   = .1E+01,                                                             BIL      = .36E+01,
MSWU     = 4,                                                                  ITAIL    = 0,
MSWD     = 0,                                                                  NVRTPL   = 0,
SWLEV    = 0.0,                                                                NBDYPR   = 1,
SWTEV    = 0.0,                                                                NTPR     = 0,
CRPV     = .36E+01,                                                            NTDAT    = 0,
B2V      = .36E+01,                                                            NCWT     = 0,
NCRX     = 1,                                                                  NCPOUT   = 0,
RB       = .3129E+01,                                                          NVLIN    = 0,
RA       = .1043E+01,                                                          XSTART   = 0.0,
ERATIO   = .3E+01,                                                             JCPT     = 0,
NBDCR    = 16,                                                                 FKLE     = .5E+00,
DELR     = 0.0,                                                                FKSF     = .5E+00,
DELL     = 0.0,                                                                XM       = .168E+02,
DELU     = 0.0,                                                                ZM       = 0.0,
DELD     = 0.0,                                                                $END
```

Figure 34.- Output of program DEMON2, second sample case, step 10.

```
     WING 1 SURFACE


   SPECIFIED SPANWISE LOCATIONS OF OUTBOARD PANEL EDGES AND SWEEP ANGLES.

   K    Y OR Z        L.E. SWEEP      T.E. SWEEP
                        ANGLE           ANGLE


   1    0.00000       45.00000        0.00000
   2    1.00000       45.00000        0.00000
   3    2.00000       45.00000        0.00000
   4    3.00000       14.03624        0.00000
   5    3.60000       14.03624        0.00000


     WING 3 SURFACE

   1    0.00000       45.00000        0.00000
   2    1.00000       45.00000        0.00000
   3    2.00000       45.00000        0.00000
   4    3.00000       14.03624        0.00000
   5    3.60000       14.03624        0.00000


                  WING GEOMETRY

               TIP CHORD =     1.20000

              ROOT CHORD =     3.60000

           WING SEMISPAN =     3.60000


                 FLOW CONDITIONS
  MACH =    1.70000    ALPHAC=   10.00000    PHI  =   0.00000    ALFA =   10.00000    BETA =    0.00000


       CRPT =     3.60000
      CRPTV =     3.60000



  BODY UNDER CONSIDERATION HAS ELLIPTICAL CROSS SECTION.
  INTERFERENCE SHELL HAS FOLLOWING PROPERTIES:
  HORIZONTAL SEMI-AXIS =     3.12900
  VERTICAL SEMI-AXIS   =     1.04300
```

Figure 34.- Continued.

```
TWO DIMENSIONAL VORTEX STRENGTHS AND FIXED COORDINATES IN CROSS FLOW PLANE

    IVRTX       GAMMA/VINF                       YVRTX               ZVRTX


      1          1.52000                        2.46090             1.88090
      2         -1.52000                       -2.46090             1.88090
      3           .47179                        4.41828              .66100
      4          -.47179                       -4.41828              .66100
      5           .59704                        4.38465             0.00000
      6          -.59704                       -4.38465             0.00000


          CONTROL POINT COORDINATES FOR  2 CHORDWISE BY  4 SPANWISE PANELS ON WING 1 OR R,    0      SPANWISE ON WING 2 OR L
                                                     AND 4 SPANWISE PANELS ONWING 3 OR U,  0     SPANWISE ON WING 4 OR D

 J        X(J)          Y(J)          Z(J)          BU(J)            BV(J)            BW(J)            VVRTX            WVRTX

 1      1.95839       2.36879       1.04983     -.22304E-01      -.22928E+00      -.24470E-01       .35000E+00      -.16737E+00
 2      3.52183       2.36879       1.04983     -.99857E-02      -.21752E+00      -.13710E-01       .35000E+00      -.16737E+00
 3      2.47667       3.22373       1.54343     -.35266E-02      -.12948E+00       .35743E-01       .16981E+00       .90173E-01
 4      3.54651       3.22373       1.54343     -.37760E-01      -.92972E-01       .72383E-01       .16981E+00       .90173E-01
 5      2.82377       4.11189       2.05621      .89070E-02      -.83780E-01       .30039E-01      -.44104E-01       .38832E-01
 6      3.56304       4.11189       2.05621      .49493E-02      -.77348E-01       .30450E-01      -.44104E-01       .38832E-01
 7      2.92985       4.81185       2.46033      .11607E-01      -.62414E-01       .21053E-01      -.52146E-01       .36886E-01
 8      3.56809       4.81185       2.46033      .10375E-01      -.61533E-01       .22700E-01      -.52146E-01       .36886E-01
 9      1.95839       2.36879      -1.04983      .66523E-01       .18515E+00       .39039E-01      -.56348E-01      -.49656E-01
10      3.52183       2.36879      -1.04983      .16705E-01       .18064E+00       .86807E-02      -.56348E-01      -.49656E-01
11      2.47667       3.22373      -1.54343      .46956E-01       .76537E-01       .78011E-01       .57644E-02      -.82758E-01
12      3.54651       3.22373      -1.54343      .45032E-01       .65613E-01       .78516E-01       .57644E-02      -.82758E-01
13      2.82377       4.11189      -2.05621      .18352E-01       .54070E-01       .53548E-01       .43949E-01      -.47547E-01
14      3.56304       4.11189      -2.05621      .33221E-01       .32119E-01       .60967E-01       .43949E-01      -.47547E-01
15      2.92985       4.81185      -2.46033      .19116E-01       .32005E-01       .44612E-01       .43341E-01      -.22704E-01
16      3.56809       4.81185      -2.46033      .17010E-01       .32962E-01       .43647E-01       .43341E-01      -.22704E-01


                                     CONTROL POINT COORDINATES FOR BIP*B (WING FRAME)

 J        X(J)          Y(J)          Z(J)       THU(J)           THV(J)           THW(J)


17      1.71000       2.90725        .26764    0.               0.               0.
18      1.71000       2.32228        .67428    0.               0.               0.
19      1.71000       1.31938        .91568    0.               0.               0.
20      1.71000        .33985       1.03055    0.               0.               0.
21      1.71000        .33985      -1.03055    0.               0.               0.
22      1.71000       1.31938       -.91568    0.               0.               0.
23      1.71000       2.32228       -.67428    0.               0.               0.
24      1.71000       2.90725       -.26764    0.               0.               0.
25      3.51000       2.90725        .26764    0.               0.               0.
26      3.51000       2.32228        .67428    0.               0.               0.
27      3.51000       1.31938        .91568    0.               0.               0.
28      3.51000        .33985       1.03055    0.               0.               0.
29      3.51000        .33985      -1.03055    0.               0.               0.
30      3.51000       1.31938       -.91568    0.               0.               0.
31      3.51000       2.32228       -.67428    0.               0.               0.
32      3.51000       2.90725       -.26764    0.               0.               0.
```

Figure 34.- Continued.

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                                        LOADING INFORMATION
        MACH NUMBER =    .17000E+01
    ANGLE OF ATTACK =    10.000 DEGREES
    SIDE SLIP ANGLE =     0.000 DEGREES
          WING AREA =    14.88000
     REFERENCE AREA =    12.56700
   REFERENCE LENGTH =     3.46411
EXPOSED WING SPAN B =     7.20000
MOMENT CENTER    XM =    16.80000
                 ZM =     0.00000


U/VINF TYPE LOADING PRESSURE


                         TOTAL           FIN 1 OR R       FIN 2 OR L       FIN 3 OR U       FIN 4 OR D     INTERF. SHELL
    DEFL. ANGLE DEG. =                    0.00000          0.00000          0.00000          0.00000
               CTHR =  0.             0.               0.               0.               0.
                 CZ =    .79276E+00    .15868E+00       .28077E+00       .28077E+00       .15868E+00      -.86142E-01
                 CY =    .44409E-15   -.91614E-01      -.16210E+00       .16210E+00       .91614E-01      0.
                 CM =   -.24358E+01   -.49867E+00      -.84948E+00      -.84948E+00      -.49867E+00       .26055E+00
                CLN =    .17764E-14    .28791E+00       .49044E+00      -.49044E+00      -.28791E+00      0.
                CLL =  0.             -.23775E+00       .33936E+00      -.33936E+00       .23775E+00      0.

              FOLLOWING ARE IN WIND-AXIS SYSTEM

                 CL =    .78071E+00    .15627E+00       .27650E+00       .27650E+00       .15627E+00      -.84834E-01
             CYWIND =    .44409E-15   -.91614E-01      -.16210E+00       .16210E+00       .91614E-01      0.
                CDI =    .13766E+00    .27554E-01       .48755E-01       .48755E-01       .27554E-01      -.14958E-01
          CDI/CL**2 =    .22585E+00
             CMWIND =   -.24358E+01   -.49867E+00      -.84948E+00      -.84948E+00      -.49867E+00       .26055E+00
            CLNWIND =   -.17764E-14    .32482E+00       .42406E+00      -.42406E+00      -.32482E+00      0.



      NOTE: L.E. OF LEAD PANEL IN FIRST CHORDWISE ROW IS SUPERSONIC
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Figure 34.- Continued.

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PRESSURE LOADINGS EXCLUDE VORTEX INDUCED COMPONENTS PARALLEL TO WING SURFACES



          VELOCITIES AND BERNOULLI PRESSURES AT CONTROL POINTS IMMEDIATELY ABOVE AND BELOW HORIZONTAL WING SURFACE

 J      X(J)        Y(J)        Z(J)       UTOTA       VTOTA       WTOTA       PRESSA      UTOTB       VTOTB       WTOTB       PRESSB

 1    1.958387    2.368794    1.049832    -.060417    -.244603    -.114140     .095448     .039836    -.222632    -.114140    -.095567
 2    3.521828    2.368794    1.049832     .029305    -.206153    -.126838    -.069335    -.039318    -.249348    -.126838     .042954
 3    2.476667    3.223734    1.543432     .121688    -.143424    -.148312    -.205019    -.103367    -.143647    -.148312     .232944
 4    3.546508    3.223734    1.543432     .003099    -.029810    -.089819     .016312    -.159358    -.094485    -.089819     .374784
 5    2.823771    4.111893    2.056211     .213850     .015533    -.194012    -.316096    -.196036    -.183093    -.194012     .438050
 6    3.563037    4.111893    2.056211     .189148     .009019    -.198712    -.286204    -.153581    -.192393    -.198712     .328900
 7    2.929853    4.811851    2.460332     .199154     .047522    -.188801    -.299565    -.175940    -.172390    -.188801     .394577
 8    3.568088    4.811851    2.460332     .142559     .029981    -.184547    -.222648    -.121809    -.153047    -.184547     .273116


          VELOCITIES AND BERNOULLI PRESSURES AT CONTROL POINTS IMMEDIATELY TO RIGHT AND LEFT OF VERTICAL WING SURFACE

 J      X(J)        Y(J)        Z(J)       UTOTR       VTOTR       WTOTR       PRESSR      UTOTL       VTOTL       WTOTL       PRESSL

 9    1.958387    2.368794   -1.049832    -.048981    -.168237     .373959    -.175641     .249192    -.168237    -.034052    -.372582
10    3.521828    2.368794   -1.049832    -.044396    -.140092     .362762    -.166626     .138586    -.140092     .071778    -.265562
11    2.476667    3.223734   -1.543432    -.101947    -.198473     .293438    -.027210     .243875    -.198473    -.062978    -.369046
12    3.546508    3.223734   -1.543432    -.056798    -.131307     .209349    -.024677     .168714    -.131307    -.058905    -.276415
13    2.823771    4.111893   -2.056211    -.136484     .003334     .191478     .163305     .173188     .003334    -.145856    -.265484
14    3.563037    4.111893   -2.056211    -.129189    -.048806     .262599     .079400     .239683    -.048806    -.158975    -.345343
15    2.929853    4.811851   -2.460332    -.125169    -.018274     .196437     .135183     .163401    -.018274    -.168686    -.251941
16    3.568088    4.811851   -2.460332    -.088420    -.012932     .152513     .095937     .122440    -.012932    -.126693    -.193134


  PRESSURE LOADINGS AT CONTROL POINTS

 J      X(J)        Y(J)        Z(J)     DELTP.LIN. DELTP.BERN.

 1    1.958387    2.368794    1.049832    -.208505    -.191010
 2    3.521828    2.368794    1.049832     .137247     .112289
 3    2.476667    3.223734    1.543432     .450110     .437964
 4    3.546508    3.223734    1.543432     .324916     .358472
 5    2.823771    4.111893    2.056211     .819773     .754146
 6    3.563037    4.111893    2.056211     .685458     .615104
 7    2.929853    4.811851    2.460332     .750189     .694140
 8    3.568088    4.811851    2.460332     .528737     .495764
 9    1.958387    2.368794   -1.049832     .596345     .196941
10    3.521828    2.368794   -1.049832     .365964     .098936
11    2.476667    3.223734   -1.543432     .691645     .341835
12    3.546508    3.223734   -1.543432     .451023     .251738
13    2.823771    4.111893   -2.056211     .619343     .428789
14    3.563037    4.111893   -2.056211     .737743     .424743
15    2.929853    4.811851   -2.460332     .577138     .387123
16    3.568088    4.811851   -2.460332     .421718     .289071
```

Figure 34.- Continued.

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                                        LOADING INFORMATION

          MACH NUMBER =   .17000E+01
      ANGLE OF ATTACK =   10.000 DEGREES
      SIDE SLIP ANGLE =    0.000 DEGREES
            WING AREA =   14.86000
       REFERENCE AREA =   12.56700
     REFERENCE LENGTH =    3.46411
  EXPOSED WING SPAN B =    7.20000
  MOMENT CENTER:   XM =   16.80000
                   ZM =    0.00000



BERNOULLI TYPE LOADING PRESSURE



                            TOTAL            FIN 1 OR R        FIN 2 OR L       FIN 3 OR U        FIN 4 OR D     INTERF. SHELL
     DEFL. ANGLE DEG. =                        0.00000           0.00000          0.00000           0.00000
                 CTHR =  0.                0.                0.                0.                0.
                   CZ =   .48572E+00        .15017E+00        .13576E+00        .13576E+00        .15017E+00       -.86142E-01
                   CY =  0.                -.86703E-01       -.78379E-01        .78379E-01        .86703E-01       0.
                   CM =  -.15093E+01       -.47168E+00       -.41326E+00       -.41326E+00       -.47168E+00        .26055E+00
                  CLN =  0.                 .27232E+00        .23859E+00       -.23859E+00       -.27232E+00       0.
                  CLL =  0.                -.22411E+00        .17658E+00       -.17658E+00        .22411E+00       0.

                   FOLLOWING ARE IN WIND-AXIS SYSTEM

                   CL =   .47834E+00        .14789E+00        .13369E+00        .13369E+00        .14789E+00       -.84834E-01
               CY-IND =  0.                -.86703E-01       -.78379E-01        .78379E-01        .86703E-01       0.
                  CDI =   .84344E-01        .26078E-01        .23574E-01        .23574E-01        .26078E-01       -.14958E-01
            CDI/CL**2 =   .36862E+00
               CM-IND =  -.15093E+01       -.47168E+00       -.41326E+00       -.41326E+00       -.47168E+00        .26055E+00
              CLN-IND =  0.                 .30710E+00        .20431E+00       -.20431E+00       -.30710E+00       0.



          NOTE: L.E. OF LEAD PANEL IN FIRST CHORDWISE ROW IS SUPERSONIC



**********************************************************************************************************
AFT OF LEADING EDGE OF FIN ROOTCHORDS
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Figure 34.- Continued.

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                              PRESSURE COEFFICIENTS AT POINTS ON BODY MERIDIANS

 J    THETA,      XB         YB          ZB        UTOT       VTOT       WTOT     CP,LIN.    CP,BERN.    DR/DX      P/PINF,    P/PINF,
      DEG.                                                                                                          BERN.      LIN.


                                                       BODY RING#   1

 1    5.63625  26.11000   2.90725     .26764     .00124    -.00456    -.06231    -.00247     .01547    0.00000    1.03129     .99500
 2   16.90875  26.11000   2.32228     .67428     .02845    -.06340    -.18355    -.05691    -.03014    0.00000     .93903     .88487
 3   50.63625  26.11000   1.31938     .91568    -.03987     .14166    -.18536     .07973     .09247    0.00000    1.18708    1.16130
 4   84.36375  26.11000    .33985    1.03055     .01492     .00238    -.21697    -.02983    -.00133    0.00000     .99732     .93965
 5  298.09125  26.11000    .33985   -1.03055     .05091     .03787    -.14973    -.10182    -.07077    0.00000     .85684     .79402
 6  331.81875  26.11000   1.31938    -.91568     .01217     .05166    -.15975    -.02435     .00221    0.00000    1.00448     .95075
 7  343.09125  26.11000   2.32228    -.67428     .23305     .00596    -.04719    -.46610    -.34416    0.00000     .30376     .05708
 8  354.36375  26.11000   2.90725    -.26764     .11716    -.04363    -.05913    -.23432    -.19382    0.00000     .60789     .52597

                                                       BODY RING#   2

 1    5.63625  27.91000   2.90725     .26764    -.04536     .21072    -.21777     .09073     .07482    0.00000    1.15136    1.18354
 2   16.90875  27.91000   2.32228     .67428    -.05182    -.01007    -.16570     .10365     .14193    0.00000    1.28712    1.20968
 3   50.63625  27.91000   1.31938     .91568    -.02660     .13444    -.17723     .05321     .06675    0.00000    1.13504    1.10764
 4   84.36375  27.91000    .33985    1.03055    -.04515    -.00781    -.19347     .09031     .12675    0.00000    1.25642    1.18269
 5  298.09125  27.91000    .33985   -1.03055     .00594    -.00849    -.14352    -.01189     .01765    0.00000    1.03571     .97595
 6  331.81875  27.91000   1.31938    -.91568     .00849     .02511    -.13126    -.01698     .01101    0.00000    1.02228     .96564
 7  343.09125  27.91000   2.32228    -.67428     .16337     .06735    -.04384    -.32673    -.26430    0.00000     .46532     .33902
 8  354.36375  27.91000   2.90725    -.26764     .14197    -.06378    -.07977    -.28393    -.22945    0.00000     .53582     .42560
```

Figure 34.- Concluded.

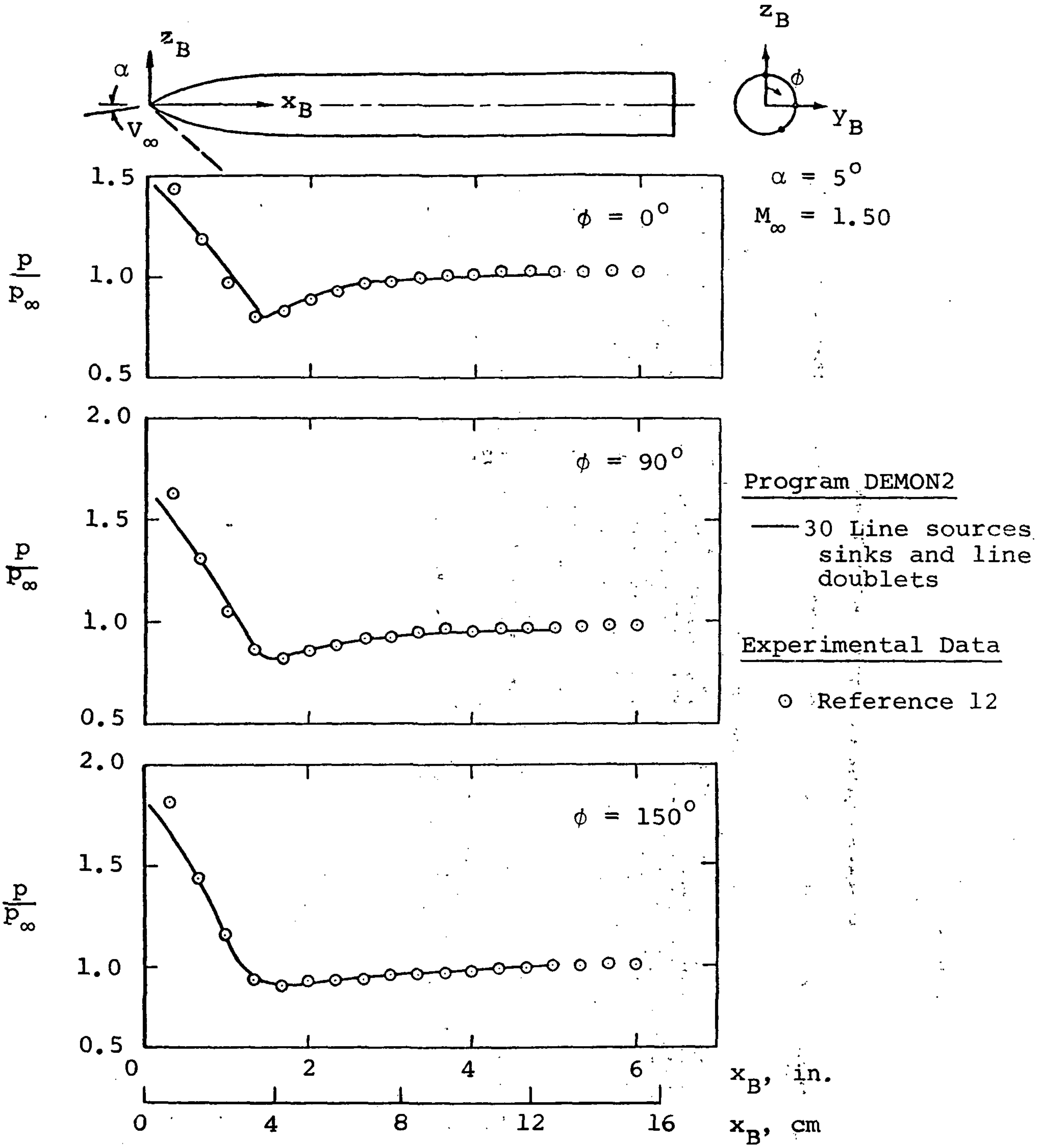

Figure 35.- Pressure distribution on ogive cylindrical body in uniform flow; $M_\infty = 1.50$.

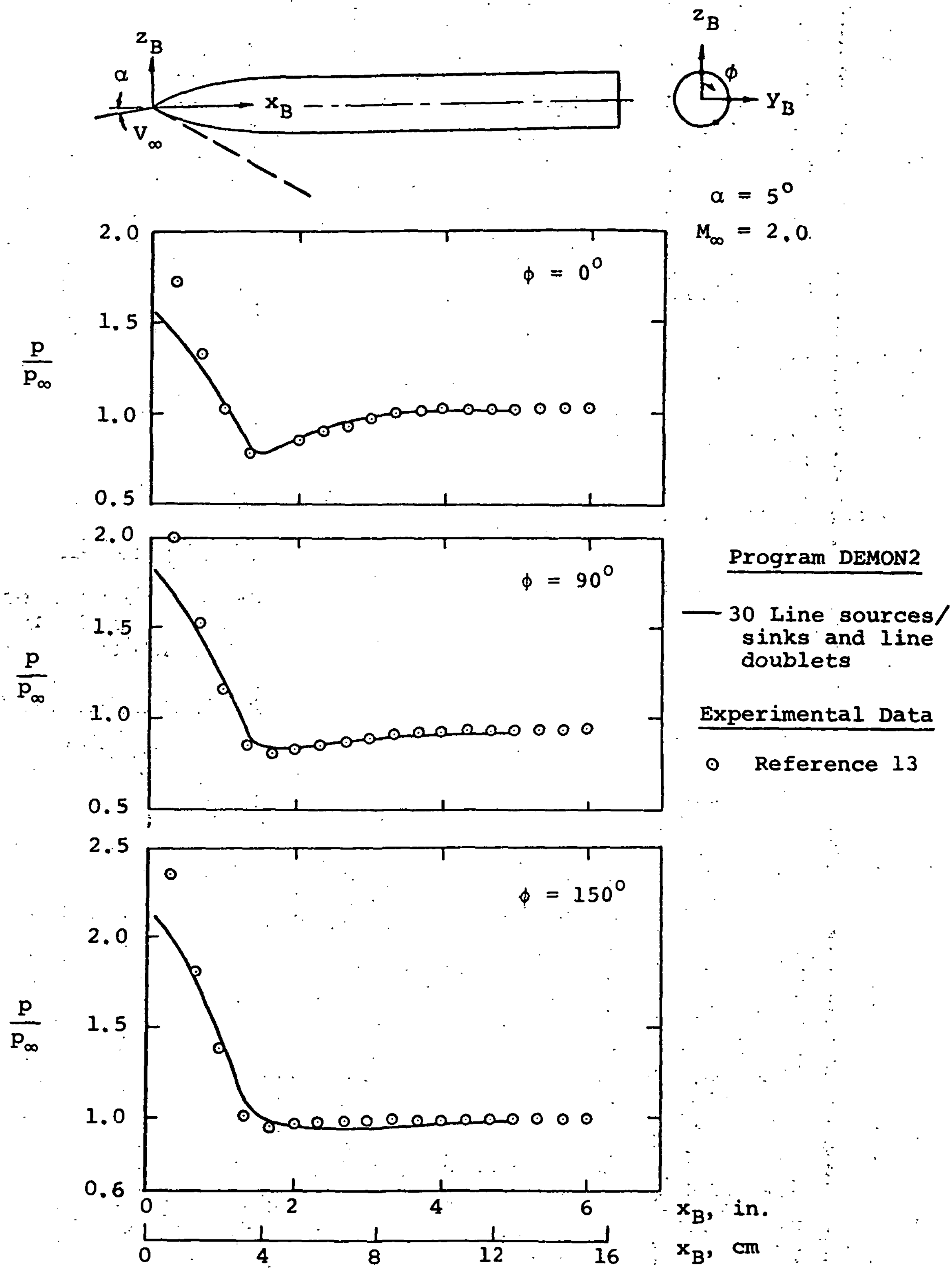

Figure 36.- Pressure distribution on ogive cylindrical body in uniform flow; $M_\infty = 2.0$.

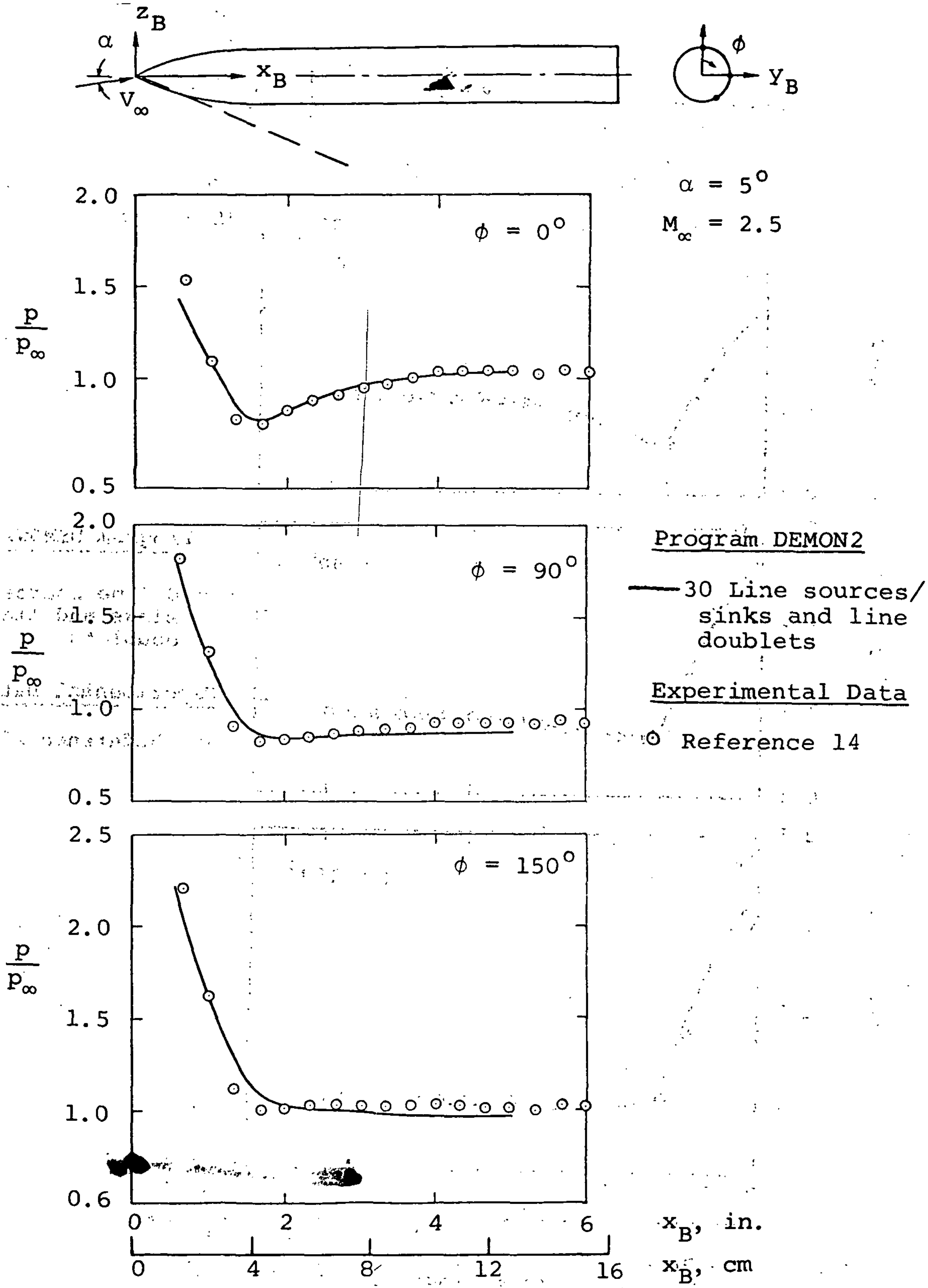

Figure 37.- Pressure distribution on ogive cylindrical body in uniform flow; $M_\infty = 2.5$.

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15. Supplementary Notes

Langley Technical Monitor: Wallace C. Sawyer
Final Report

16. Abstract

Computer programs are presented capable of calculating detailed aerodynamic loadings and pressure distributions acting on pitched and rolled supersonic missile configurations which utilize bodies of circular or elliptical cross sections. The applicable range of angle of attack is up to 20°, and the Mach number range is 1.3 to about 2.5. Effects of body and fin vortices are included in the methods, as well as arbitrary deflections of canard or fin panels.

| | |
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