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A COMPUTER PROGRAM TO CALCULATE THE LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF WING-FLAP CONFIGURATIONS WITH EXTERNALLY BLOWN FLAPS

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16. Abstract This document is a user's manual for the computer program developed to calculate the longitudinal aerodynamic characteristics of wing-flap combinations with externally blown flaps. A vortex-lattice lifting-surface method is used to model the wing and multiple flaps. Each lifting surface may be of arbitrary planform having camber and twist, and the multiple-slotted trailing-edge flap system may consist of up to ten flaps with different spans and deflection angles. The engine wake model consists of a series of closely spaced vortex rings with circular or elliptic cross sections. The rings are normal to a wake centerline which is free to move vertically and laterally to accommodate the local flow field beneath the wing and flaps. The two potential flow models are used in an iterative fashion to calculate the wing-flap loading distribution including the influence of the wakes from up to two turbofan engines on the semispan. The method is limited to the condition where the flow and geometry of the configurations are symmetric about the vertical plane containing the wing root chord.

The calculation procedure starts with arbitrarily positioned wake centerlines and the iterative calculation continues until the total configuration loading converges within a prescribed tolerance. The results available from the program include total configuration forces and moments, individual lifting-surface load distributions, including pressure distributions, individual flap hinge moments, and flow field calculation at arbitrary field points.

This program manual contains a description of the use of the program, instructions for preparation of input, a description of the output, program listings, and sample cases.

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SUMMARY

This document is a user's manual for the computer program developed to calculate the longitudinal aerodynamic characteristics of wing-flap combinations with externally blown flaps. A vortex-lattice lifting-surface method is used to model the wing and multiple flaps. Each lifting surface may be of arbitrary planform having camber and twist, and the multiple-slotted trailing-edge flap system may consist of up to ten flaps with different spans and deflection angles. The engine wake model consists of a series of closely spaced vortex rings with circular or elliptic cross sections. The rings are normal to a wake centerline which is free to move vertically and laterally to accommodate the local flow field beneath the wing and flaps. The two potential flow models are used in an iterative fashion to calculate the wing-flap loading distribution including the influence of the wakes from up to two turbofan engines on the semispan. The method is limited to the condition where the flow and geometry of the configurations are symmetric about the vertical plane containing the wing root chord.

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INTRODUCTION

An engineering prediction method for calculating the static longitudinal aerodynamic characteristics of wing-flap combinations with externally blown flaps (EBF) is presented in reference 1. An externally blown flap is a STOL high lift device in which the jet efflux from turbofan engines mounted beneath the wing is allowed to impinge directly on the trailing-edge slotted flap system. A large amount of additional lift is produced through engine wake deflection and mutual interference effects. The purpose of the analysis in reference 1 is to provide a potential flow method, requiring little use of empirically determined information, to predict the detailed loading distribution on EBF configurations. The method involves the combination of two potential flow models, a vortex-lattice lifting-surface model of the wing and flaps and a vortex ring model of the jet wakes. The two flow models are combined by direct superposition such that a tangency boundary condition is satisfied on the wing and flap surfaces. An iteration between the jet wake position and the wing loading is carried out until the solution converges.

The computer program described in this report is an improved and extended version of the program of reference 2. Modifications include the following. An improved vortex-lattice lifting-surface method is used in which the trailing legs of the horseshoe vortices are allowed to bend around the flap surfaces so that all the trailing vorticity leaves the configuration tangent to the last flap. The geometry specification has been changed so that each flap surface can be modeled as a separate lifting surface with a maximum of ten flaps permitted. The iteration procedure has been automated so that the jet centerlines are positioned according to the local flow field direction beneath the wing and flaps, and the iteration procedure can be carried out a specified number of times or until convergence to a specified tolerance is achieved. The jet centerline calculation has been automated so that, after starting with an arbitrary jet location, the centerline is allowed to move so that it lies along local flow angles. The jet model of reference 2 was defined by a series of circular vortex rings. The improved jet model will now handle elliptic rings; therefore, the jet may start at the engine exit with an axisymmetric cross section and change to an elliptic cross section as it moves downstream and interacts with the lifting surface. The jet cross-sectional area and shape must be specified by the user.

This document is a user's manual for the computer program developed to carry out the calculations in the EBF aerodynamic prediction method. Principal reliance is made herein to reference 1 for a description of the details of the method and the calculation procedure. Reference 1 also contains calculated results and comparisons with data for a variety of configurations. The following sections of this report will provide a description of the program, a description of the input, a description of the output, a program listing, and sample cases. The notation used is the same as that of reference 1.

DESCRIPTION OF PROGRAM

The purpose of this section is to describe the EBF aerodynamic prediction program in sufficient detail to permit a general understanding of the flow of the program and to make the user aware of the analytical models used to represent the jets and the lifting surfaces. Basically, the program models the lifting surfaces with horseshoe vortices whose circulation strengths are determined from a set of simultaneous equations provided by the flow tangency boundary condition applied at a finite set of control points distributed over the wing and flaps. The boundary conditions include interference velocities induced by some external source of disturbance such as the wake of a turbofan engine. The jet wake is modeled by a series of closely spaced ring vortices, circular or elliptical in shape, arranged on the boundary of the jet. The strength of the vortices is specified by the initial velocity in the wake which is determined from the momentum in the jet. The jet is allowed to interact with the wing and flaps through the jet induced velocity field on the lifting-surface control points. The wing and flaps are then allowed to interact with the jet by forcing the jet centerline to be aligned with the flow direction beneath the lifting surfaces. This process is repeated iteratively until convergence of both the lifting-surface loading and jet centerline position are attained.

Calculation Procedure

The general flow of the program, shown in the flow chart in figure 1, proceeds as follows. After run identification information and certain reference quantities are read in, the wing geometry is input and the wing lattice layout is set up and output. This is followed by similar calculations for the flap surfaces. This concludes the lifting-surface geometry specification; therefore, the influence coefficient matrix, which is the left-hand side of the equation set and a function of geometry only, can be calculated. The matrix is triangularized for use in the solution of the simultaneous equations. This concludes the first section of the program which need be considered only once in each calculation.

The next section of the main program is that part in which the solution is carried out and any iterations are performed. The first step is the input of the initial jet parameters and the set up of the jet centerlines in preparation for induced velocity calculations. The jet induced velocity field at each lifting-surface control point is computed at this time. The right-hand side of the equation set is now computed. Solution of the equation set produces the values for the circulation strengths of each horseshoe vortex describing the lifting surfaces. Given the circulation strengths and the induced velocity field, the load distributions on the lifting surfaces are calculated and resolved into total forces and moments. At this point in the solution, the total forces and moments correspond to those on a lifting surface in the presence of a jet or jets in some specified position relative to the wing and flaps. This may or may not be a converged solution. Using the just-computed circulation strengths on the wing and flaps, the induced velocity field at specified points on the jet centerlines is computed. The jet induced velocity field at these same points is also computed assuming each jet to be in its initially prescribed position. The total velocity field, including the free stream, is formed at the specified points on the centerline. The centerline at each of these points is assumed to have the computed flow direction, and its position is adjusted accordingly.

At this point in the solution, the first iteration is complete and the solution may or may not be converged. The jet centerlines have been moved; therefore, their new position does not correspond to the previously calculated induced velocity field on the wing and flaps; thus, the interference loading on these lifting surfaces does not correspond to the current jet positions unless the jets were moved only a small amount. The option is available in the program to stop here or to continue on for additional iterations.

If further iteration is indicated, the program returns to the beginning of the iteration section and starts a second iteration by computing the jet induced velocity field at the lifting-surface control points. The solution continues as before. At the end of the current iteration, two checks are made. The first test is on the local jet centerline slopes. If these slopes have not changed an amount greater than a prescribed convergence tolerance, convergence is assumed to be attained, an appropriate message is printed, and the solution is complete. If the centerline convergence test fails, the same tolerance is applied to the current and previous values of total normal-force coefficient. If this test indicates convergence, the program skips to the final portion of the calculation procedure. If the convergence test fails after the prescribed maximum number of iterations has been completed, an appropriate message is printed and the program skips to the final section.

In the final section of the program, the jet centerlines corresponding to the last iteration are output. This jet configuration does not correspond to the last set of loadings on the wing and flaps unless convergence has been achieved, but it corresponds to the jet which should be used for the next iteration. The purpose of printing these centerline parameters is two-fold. First, it allows the user to compare the last used centerlines with the new versions; and second, it provides a centerline configuration with which to continue the iterations by restarting the program.

The final calculation to be carried out, if requested, is the computation of the induced velocity field at specified field points. This option is provided so that the user may investigate the induced flow field in the vicinity of a horizional tail position or other points of interest in the flow field.

Program Operation

The EBF prediction program is written in Fortran IV and has been run on CDC 6600 and 7600 computers. The version described in this document was designed to be used under the FTN compiler with a level 2 optimization. Other compilers can be used with only minor modifications and lower optimization levels can be used with the only penalty being an increase in run time. No tapes other than standard input and output units are required for a typical run, although one option allows an externally induced velocity field to be brought in via tape unit 4.

The main program, WNGFLP, contains one item which is not a standard feature of all FTN compilers. Between cards WNG162 and WNG174 there are two calls to subroutine REQFL. This is a request for an adjustment in the core memory to make room for the influence coefficient matrix, FVN, which is stored in a one-dimensional array. The purpose of this adjustment is to minimize the core storage used until the large array is required. FVN is dimensioned for unit length on card WNG043. If subroutine REQFL or its equivalent is not available, the following changes are required. First, remove cards WNG162 through 174. Second, change the dimension of the FVN array on card WNG043 to a value which will cover the maximum number of elements in an influence coefficient matrix; that is, the square of the total number of vortex-lattice panels on the configuration of interest. Thus, the dimension of FVN can be made large enough to cover the largest array anticipated, or the minimum size array needed can be defined and the dimension changed as the number of vortex panels is increased.

There is an alternative solution which minimizes storage requirements for the FVN array when subroutine REQFL is not available. Program WNGFLP can be turned into a subroutine with cards WNG162-174 removed and the FVN dimension set at unity. A short main program can be written which consists of a blank common which sets the dimension of FVN to the required size and a call to subroutine WNGFLP. In this way, a short five-card main program is all that need be recompiled to change the size of the FVN array. This alternate set up for a main program is illustrated in figure 2 to accommodate a maximum vortex lattice of 165 elements. The changes to the current main program, WNGFLP, to make it a subroutine are also shown in this figure.

The following is a list of the components of the EBF program and a brief description of the function of each.

Main Program:

WNGFLP - controls the flow of the calculation and handles some input and output duties

Subroutines:

WNGLAT - reads in wing input data, lays out the vortex lattice on the wing, and outputs wing geometric information

FLPLAT - reads in flap input data, lays out vortex lattice on the flaps including wing trailing legs which lie on the flaps, and outputs flap geometric information

INFMAT - calculates influence coefficient matrix

FLVF - calculates influence function for a finite length vortex filament

SIVF - calculates influence function for a semi-infinite length vortex filament

RHSCLC - calculates the right-hand side of the simultaneous equations for the vortex strengths

LINEQS - triangularizes the square influence coefficient matrix

SOLVE - solves for the circulation strengths

LOAD - calculates the forces on the bound and trailing vorticity associated with each area element

FORCES - calculates and outputs the spanwise loading distributions and total forces and moments and pressure distribution on the complete configuration

VELSUM - computes wing-flap induced velocity field at a specified point

JET - reads in initial jet parameters, outputs total jet configurations, and calculates jet wake induced velocities at specified points

JETCL - calculates the modified centerline position due to total velocity field induced on the centerline

CORECT - corrects field point locations relative to vortex rings to avoid singularities

VRING - computes velocity components induced by a single, circular vortex ring at an arbitrary field point relative to the ring

ERING - computes velocity components induced by a single, elliptic vortex ring at an arbitrary field point relative to the ring

JINTEG - solves for the J-integrals required in elliptic vortex ring equations

ELI1 - computes the generalized elliptic integral of the first kind

Subroutines (Cont'd):

ELI2 - computes the generalized elliptic integral of the second kind

ELLIPS - obtains complete elliptic integrals of the first and second kinds from tables

QUART - solves a quartic equation

CUBIC - solves a cubic equation

QUAD - solves a quadratic equation

SIMSON - does a Simpson's Rule integration

Program Usage

Limitations.- It should be remembered that the prediction method is made up of potential flow models which presume the flow to be attached to the lifting surfaces at all times. When applying the program to configurations at very high angles of attack or to configurations with very large flap deflections, the results will generally be too high as separation may exist on portions of the real model.

The program is a model for the wing and flaps only; therefore, when comparing predicted results with measured characteristics on a complete configuration, the force and moment contributions due to such items as the fuselage, nacelles, and leading-edge slat must be included as additional items. This is illustrated in the data comparisons in reference 1.

There are certain limitations and requirements in laying out the vortex-lattice arrangement on the lifting surfaces. These are discussed in detail in the input section of this manual, but several of the more important items are noted as follows. Since the current version of the vortex-lattice method bends the trailing legs of the wing horseshoe vortices around the flaps, in laying out the geometry care must be taken that a flap surface not lie above the wing surface. For the same reason, flap surfaces may not overlap.

The program has the capability of computing the induced velocity field at any specified field point, but the modeling of the wing and flaps with horseshoe vortex singularities can cause numerical problems and unrealistic answers if a field point lies too near a singularity. A general rule to follow when computing induced velocities is that the field point should not be closer to a lifting surface than one half the width of the nearest horseshoe vortex. This also has an effect on the layout of the points defining the jet centerlines since wing and flap induced velocities are important in the centerline iterations. This detail is described when the preparation of jet input is discussed.

Run time.- Both the vortex-lattice lifting-surface and the vortex ring jet models can be time consuming in a typical calculation; consequently, their combination into the EBF program creates a calculation procedure which can be very costly in terms of computer time. When the program is used in the iterative mode, the required calculation time increases nearly linearly with the number of iterations. Estimating the computation time required for a calculation is difficult because of the variables involved. Size of the vortex lattice, number of flaps, number of jets, length of the jets, shape of the jets, spacing of the vortex rings, and iterations all help determine the total run time for a calculation. A list of typical execution times for different combinations of the above parameters is presented in Table I.

The long execution times for the elliptic jet cases are due entirely to the additional complexity involved in computing the induced velocities from elliptic vortex rings. The elliptic jet cases require so much execution time that multiple iterations have been avoided in the use of the program to date. There are some approximations to trim the run time for elliptic jets which have been used by the authors. An equivalent circular jet which has the same area distribution as the desired elliptic jet can be run through several iterations to get the approximate positions of the centerline. The elliptic jets can then be put along these centerlines, and the calculation continued for one or two additional iterations. In this way, the elliptic jet effect on the lifting surfaces can be obtained at some savings in total execution time.

Another method used to minimize execution time is to run the first several iterations with a minimum size lattice to determine the approximate position of the jet centerlines. Then, the full lattice can be input with the jets in their approximate positions and the solution carried out several more iterations to convergence.

DESCRIPTION OF INPUT

This section describes the preparation of input for the EBF computer program. In the following sections, some detailed information regarding the layout of the vortex lattice and the specification of the jet wake are presented. This is followed by a listing of all input variables and their format and positions in the input deck. The last topic in this section is a sample input deck illustrating a typical EBF calculation.

Vortex-Lattice Arrangement

The vortex-lattice method used in the EBF program is an extended and modified version of the wing-flap program presented in reference 2. For that reason, the wing-flap configuration considered herein is much more general than that previously handled, and the specification of the geometry for the input deck requires more detail than the input of reference 2. The characteristics of the configuration parameters are listed below.

<u>Wing</u>

- Mean camber surface may have camber and twist.
- Leading-edge sweep angle need not be constant across semispan.
- Trailing-edge sweep angle need not be constant across semispan.
- Taper need not be linear and there may be discontinuities in the local wing chords.
- Any dihedral angle is allowed but it must be constant over the semispan.
- Thickness effects are neglected.
- Tip chord must be parallel to root chord.

<u>Flaps</u>

- A maximum of ten flaps may be considered, but no more than three flaps may be behind any one wing chordwise row of panels.
- Each flap may have camber and twist.
- Leading and trailing edges must be straight and unbroken on each flap surface.

Flaps (cont'd)

- Flap chord must have linear taper.
- Thickness effects are neglected.
- There may be slots between the flaps, but the leading edge of each flap lies in the plane of the adjacent upstream lifting surface.

The vortex-lattice arrangement describing the wing and flaps is general enough to provide good flexibility in describing the lifting surfaces. A maximum of thirty (30) spanwise rows of vortices may be used, and each lifting-surface component can have a maximum of ten (10) chordwise vortices. The area elements on each lifting surface have a uniform chordwise length at each spanwise station. In the spanwise direction, the widths of the area elements may be varied to fit the loading situations; that is, in regions of large spanwise loading gradients, the element widths may be reduced to allow closer spacing and more detailed load predictions. The convergence of the predicted results as a function of lattice arrangement is described in Appendix A of reference 2. These results apply to the current program with the following exception. In reference 2, the spanwise distribution of the lattice elements on the flaps was chosen independent of the lattice on the wing. In the current program, the deflection of the wing trailing vortex legs requires that the spanwise lattice elements on the flaps be directly aligned with the lattice elements on the wing.

The maximum lattice size on the complete configuration is fixed at 250 in the program. The elements may be distributed in any proportion over the wing and flaps, and for the sake of economy, considerably less than this total number should be used for most calculations as illustrated by the run times in the table in the previous section of this document. The following comments, based on the recommendations of Appendix A of reference 2 and the authors' experience, are offered as an aid to selecting the proper vortex-lattice arrangement for a wing-flap configuration.

Spanwise distribution.- Convergence of gross aerodynamic forces and moments to within 1 percent is obtained by using not less than fourteen equally spaced spanwise rows of vortices. If an unequal spanwise spacing is required to create a locally dense region of vorticity, the initial spacing should be laid out approximately equal, with additional rows added in the regions of interest. The spanwise spacing can be adjusted small amounts to meet some additional requirements without changing the gross loading properties. For example, it is desirable that engine wake centerlines be positioned directly beneath a row of lattice element control points; therefore, small adjustments in the lattice can be made to meet this requirement. It is also desirable that there be some symmetry in the widths of the vortex elements about the engine centerline station. This can cause some unusual distributions of lattice widths as illustrated in figure 3 where a typical lattice arrangement on the four-engine EBF model of references 3 and 4 is illustrated. In this case the number of spanwise vortices was limited to fifteen to minimize the total number of elements in the lattice. In this particular case, the only suggested modification in the spanwise layout would be to add two additional narrow rows of vortices, one inboard of the inboard jet and one outboard of the outboard jet and redistribute the outboard vortices near the tip into slightly more narrow rows.

Chordwise distribution.- Results in Appendix A of reference 2 indicate that four is the minimum number of chordwise vortices on the wing for best results and more than six vortices do not change the predicted loads appreciably. A larger number of chordwise vortices on the wing can be used if a chordwise pressure distribution is the goal of the predictions.

The number of chordwise vortices on the flaps is somewhat arbitrary. A rule of thumb is that the chord of the vortex element on the flap should not be greater than the chord of the wing elements. Generally, the chord of the flap elements will be much smaller than the wing elements. If gross forces are the objective of the prediction, one or two chordwise vortices per flap are all that are needed. If pressure distributions are desired, there should be three to four chordwise vortices per flap. The gross force will change very little with additional flap vortices.

A comment that was made in reference 2 is also pertinent here. Care should be taken in laying out vortices in regions of wake impingement. Since interference of the jet on the lifting surfaces is "felt" only at the control points of the area elements, small vertical and/or lateral changes in the wake centerline can cause unrealistic changes in the wake induced loading if the area elements on the flap are too large. This is caused by the covering and uncovering of area elements whose control points fall near the boundary of the jet. Results indicate that if a sufficient number of elements are used in the wake region of the wing and flap, the element sizes will be sufficiently small so that results will not be unduly influenced by changes in wake location.

The chordwise distribution of lattice elements on the EBF model in figure 1 should be considered a minimum lattice. Flap 1 has but one row of vortices, and flaps 2 and 3 have only two rows of vortices. This is adequate for force and moment calculations, but the pressure distribution results are not detailed enough for comparisons with data.

Jet Wake Specification

The vortex ring model used in the EBF program is an extended version of the jet wake program presented in reference 2. Whereas the original program considered only axisymmetric jets with the centerlines positioned a priori, the present program will handle elliptic cross-section jets and the centerlines are positioned by an iterative solution. This new method removes some of the tedious input preparation required by the previous program; however, the new method requires careful layout of the points describing the centerline and of the rings defining the jet boundary. The best way to illustrate the description of a jet model is to go through a sample case for a typical jet. A vortex ring model of the inboard jet in references 3 and 4 is developed as follows.

The first step is to locate the geometric position of the actual engine. From figure 2 of reference 4, the inlet of the inboard engine on the left wing panel is at $X = 1.43$ m(4.68 ft), $Y = -1.48$ m(-4.85 ft), and $Z = 0.42$ m(1.38 ft) in the wing coordinate system with origin at the wing leading edge at the airplane centerline. The engine exit is at $X = -0.40$ m (-1.30 ft), $Y = -1.48$ m(-4.85 ft), and $Z = 0.42$ m(1.38 ft). As noted in reference 2, the jet model should be extended upstream of the actual engine exit a distance of a minimum of two initial radii to give the model a chance to develop the exit velocity profile. Thus, the jet model could start at $X = 1.43$ m(4.68 ft) and go to $X = -0.40$ m(-1.30 ft) with a constant radius. This initial portion of the jet is longer than necessary; therefore, in the interest of conserving computation time, the jet is assumed to start at $X = 0.14$ m(0.45 ft), $Y = -1.48$ m(-4.85 ft), $Z = 0.42$ m(1.38 ft) and have an initial, constant radius section with length of 0.91 m(3.0 ft).

The initial cross-sectional area of the jet is assumed to equal the sum of the fan exit area and the core engine exit area. From figure 4 of reference 4, the fan and core engine exit areas are 0.159 and 0.050 sq m (1.71 and 0.54 sq ft), respectively. Thus, the initial jet area is 0.209 sq m (2.25 sq ft) which is assumed to be modeled by an equivalent circular cross section with radius of 0.258 meters (0.845 ft).

The next step is to determine the initial exit velocity in the jet model so that we may specify the vortex cylinder strength. If the average velocity in the exit is known from measurement, the vortex strength can be determined directly from equation (28) of reference 1; that is,

$$\frac{\gamma}{V} = \frac{V_j}{V} - 1 \tag{1}$$

where V_j/V i the ratio of the jet exit velocity to the free-stream velocity and γ/V is the strength of a constant radius, semi-infinite length vortex cylinder which represents a jet with the correct initial momentum and velocity. Since the necessary velocity is not usually available, an approximate value is calculated using equation (29) from the same reference.

$$\frac{V_j}{V} = \frac{1}{2}\left[1 + \sqrt{1 + 2C_T \frac{S}{A_j}\frac{\rho}{\rho_j}}\right] \tag{2}$$

To get V_j from this equation, the engine thrust coefficient, C_T, and the density ratio, ρ/ρ_j, in the jet are required. The density ratio, defined as the ratio of the ambient air density to the jet exhaust density, can be estimated from the exhaust temperature. In equation (2), S is the reference area used in defining C_T, and A_j is the initial jet area which is calculated as the sum of the fan exit area and the core engine exit area. Assuming a density ratio of 2.6, which is reasonable for a tailpipe temperature of 538°C(1000°F), and choosing an engine thrust coefficient of 1.0, equation (2) produces $V_j/V \cong 11.1$. From equation(1), the vortex cylinder strength defining the jet model vorticity to be input into the program is $\gamma/V \approx 10.1$.

At this point the expansion rate and the shape of the jet must be chosen. If some empirical knowledge of the jet to be modeled or of a typical jet is available, it should be included in the specifications in order to get the best physical model possible. Before a jet is chosen, a decision must be made as to the cross-sectional shape of the selected. Based on figure 10 of reference 1, which was obtained from flow field measurements, it is assumed that the jet cross section is a 2:1 ellipse at a point just aft of the last flap. These same measurements are not used to determine the expansion rate because the measured jet velocity ratio is much lower than we are considering. If we assume that an elliptic jet expands at about the same rate as an axisymmetric jet, the rate of expansion can be obtained from figure 8 of reference 1. At approximately 12 radii downstream of the jet exit, the local radius is approximately 2.2 times the initial radius; therefore, the jet cross-sectional area has increased to approximately 4.8 times its initial area. Using this value and the assumed 2:1 axis ratio, the jet is completely described at this one point aft of the flaps.

Assuming an axisymmetric jet with linear expansion between the engine exit and this point aft of the flap provides an area distribution for the jet. If we further assume that the jet remains axisymmetric until it reaches the flap surfaces and then, through linear variation of the length of the vortex ring axes, approaches the 2:1 ellipse, we obtain the solid curve for $x_j \leq 12$ ft. shown in figure 4. The circular jet with the same area distribution is shown dashed in this figure. Both the circular and elliptic jets in figure 4 have nearly the same mass and momentum distributions along the jets. Beyond $x_j = 12$ ft, the jet is downstream of the flaps, and its shape has less effect on the induced velocity field. Two options are open for this region of the jet. The elliptic shape can be maintained and simply extrapolated to the end of the jet, or the shape can be changed back to circular and extraplated to the end. In the interest of saving computer time, the latter choice was made and the elliptic jet was returned to a circular shape in a short distance. This last region of the jet is assumed to have a lower rate of expansion as shown in figure 4. The following table illustrates the parameters of the jet in the jet coordinate system.

x_j m (ft)	Equivalent Radius, R m (ft)	Area Ratio A/A_o	Elliptic Axes a m (ft)	b m (ft)	a/b
0 (0)	0.258(0.845)	1.00	0.258(0.845)	0.258(0.845)	1.0
0.91 (3.0)	0.258(0.845)	1.00	0.258(0.845)	0.258(0.845)	1.0
1.98 (6.5)	0.375(1.23)	2.12	0.375(1.23)	0.375(1.23)	1.0
2.29 (7.5)	0.415(1.36)	2.55	0.451(1.48)	0.375(1.23)	1.20
2.59 (8.5)	0.448(1.47)	3.00	0.531(1.74)	0.375(1.23)	1.41
2.74 (9.0)	0.463(1.52)	3.25	0.570(1.87)	0.378(1.24)	1.51
2.90 (9.5)	0.482(1.58)	3.48	0.607(1.99)	0.381(1.25)	1.59
3.05(10.0)	0.500(1.64)	3.77	0.646(2.12)	0.387(1.27)	1.67
3.35(11.0)	0.533(1.75)	4.30	0.725(2.38)	0.393(1.29)	1.84
3.66(12.0)	0.567(1.86)	4.83	0.802(2.63)	0.399(1.31)	2.0
3.96(13.0)	0.576(1.89)	5.13	0.735(2.41)	0.463(1.52)	1.59
4.57(15.0)	0.597(1.96)	5.38	0.597(1.96)	0.597(1.96)	1.0
6.10(20.0)	0.634(2.08)	6.06	0.634(2.08)	0.634(2.08)	1.0

The above discussion includes the development of both an axisymmetric and an elliptic jet model. Either of the jets in figure 4 or the above table could be used to represent the momentum in the wake, and the only differences in the predicted interference effects would be caused by the different portions of the wing influenced by two jets. The elliptic jet would tend to spread the load out in a spanwise direction while the circular jet would concentrate the interference loading into narrow regions on the lifting surfaces.

A new rule of thumb has been developed to determine the total length of the jet. In reference 2, the length was specified on the basis of comparison with semi-infinite length vortex cylinder results. This method produced jets with lengths the order of 150 R_o. The computer time required to calculate the induced velocity field from a jet of this length is excessive and not warranted on the basis of the small increase in accuracy achieved over shorter jets. In using the current program, it is suggested that the jet extend downstream a distance behind the last flap equal to the total chord of the wing and flaps combined. The user should investigate the effect of jet length on a particular configuration by running one case with an extended jet and comparing predicted results. Generally, jets longer than suggested above are not required unless velocity fields a long distance aft of the wing and flaps are required. If this is the case, the jet should be lengthened so that it extends approximately one wing chord beyond the axial station at which field points are desired.

The next item to be considered once the jet length and shape are determined is the points on the centerline used to define the jet. Linear interpolation between specified points in the table of jet parameters is used for intermediate points along the jet. Thus, tabular points on the centerline are needed at the beginning, the end, and at any point at which there is a change in the expansion rate of the boundary. For example, in figure 4, the minimum required points in the jet table would be at $x_j = 0, 3, 6.5, 12, 15,$ and 20. This small number of points is adequate for a description of the jet if it did not move during the calculation; but since the program iterates on the centerline shape, additional points should be added to the table. The procedure for laying out the appropriate number and location of points on the centerline should be carried out in the following manner.

A sketch of the wing and flap surfaces at the spanwise station corresponding to an engine location is shown in figure 5. The jet centerline, assumed straight, is also shown in its correct position relative to the wing and flaps. Keeping in mind that more points on the centerline are required in the region of greatest movement, the points chosen to describe the centerline are shown as circles in the figure. The points should be dense along the portion of the centerline near the flaps except in the area immediately adjacent to the flap ($x_j \simeq 10.7$). Points are omitted from this area to avoid the numerical problems associated with being too near a horseshoe vortex. Points can be spread farther apart aft of the flaps since the induced velocities are reduced and the relative motion of these centerline points is less than other points upstream. In general, too many points are better than too few except in troublesome regions near the lifting surfaces.

The last critical parameter to be specified is the spacing between the vortex rings. Ideally, the closer the rings, the more accurate the results; but the closer the spacing, the more rings required to make up the jet model and the longer the computer time needed to compute an induced velocity field. A compromise number for the ring spacing is a distance equal to approximately 0.1 R_o. This is not a firm number, but it is generally a good estimate. The program has an option built into it that allows the spacing to vary along the jet through use of the variable DSFACT. This is simply a multiplying factor used to scale up the ring spacing to two or three times the initial value. This option should never be used in the vicinity of the wing and flaps as the accuracy of the induced velocity field at the control points will be reduced. It is permissible to increase the spacing downstream of the last flap. The use of this scaling factor is illustrated in the sample input decks.

Input Variables

The purpose of this section is to describe the variables required for input to the EBF program. An input form is presented in figure 6; and for each item of input data shown in the figure, the following information is given. The format for each card and the program variable names are shown first. The card column fields into which the data are to be punched are also shown. Within each block representing the card columns is the FORTRAN format type. Data punched in I format are right justified in the fields, and data punched in F format can be punched anywhere in the field and must contain a decimal point.

Note that all length parameters in the input list have dimensions; therefore, special care must be taken that all lengths and areas are input in a consistent set of units.

Item number 1 is an index NHEAD which indicates how many cards of information are to follow in item number 2. The value of NHEAD must be one or greater.

Item number 2 is a set of NHEAD cards containing hollerith information identifying the run and may start and end anywhere on the card. The cards are reproduced in the output just as they are read in.

Item number 3 consists of one card and contains the following information:

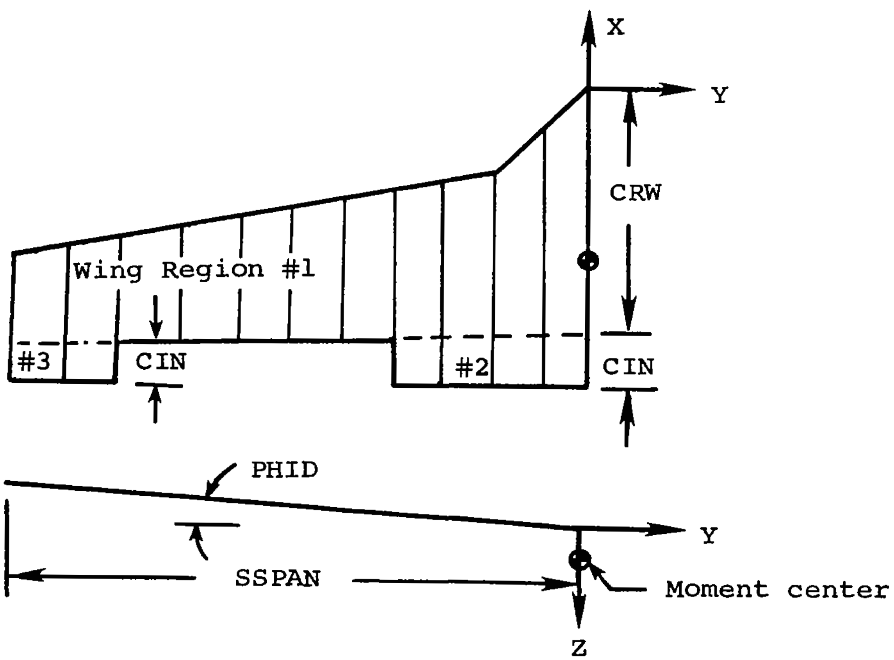
SREF	reference area used in forming aerodynamic coefficients
REFL	reference length used in forming aerodynamic moment coefficients
XM,ZM	X and Z coordinates of point about which pitching moment is calculated; wing coordinate system and positive directions are shown in figure 3 and the following sketch
TOL	tolerance on C_N used for convergence criterion; a typical value is 0.05

DTH   limit, in degrees, on the maximum deflection angle of the jet centerline; this value is generally 70-85 percent of the maximum flap deflection angle and is always input as a negative number

The variable DTH in Item 3 is used to model the turning effectiveness of the jet and flap system. Static jet turning efficiency results indicate that the efficiency decreases as the flap deflection angle increases. For example, in figure 3 of reference 3, the 40° flap deflection configuration has an efficiency of approximately 0.75, and the 55° deflection configuration has a turning efficiency of 0.70. Thus, appropriate values of DTH for these two cases are -30.0° and -38.5°, respectively. If this limit is not used, the jet turning angle approaches the maximum flap angle and inaccurate results are predicted. The use of the limit can be bypassed by defining DTH to be -90.0 in Item 3.

The next eight items of input data describe the wing.

Item number 4 specifies the value of NWREG, the number of wing regions. The value of NWREG must be one or greater. The purpose of dividing the wing into regions is to handle discontinuities in local chord length. Region 1 must always extend from Y = 0 to the tip. The sequence and position of other regions is arbitrary. A wing with three regions is shown in the following sketch.



Item number 5 contains three quantities which are also shown in the previous sketch. They are:

CRW — root chord of region 1, positive quantity

SSPAN — wing semispan, positive quantity

PHID — wing dihedral angle, degrees; positive dihedral is shown in the sketch

Items 6, 7, and 8 are data describing wing region number 1. Data input for this region determine the spanwise distribution of vortices for all wing regions and all flaps. The present program requires that the same spanwise distribution exist on all surfaces.

Item number 6 contains five indices. They are:

NCW — number of chordwise vortices on wing region 1, $1 \leq NCW \leq 10$

MSW — number of spanwise vortices on left wing panel, $1 \leq MSW \leq 30$

NTCW — twist and/or camber? NTCW = 0, no
NTCW = 1, yes

NUNI — if wing has no twist and the camber distribution is similar at all spanwise stations, NUNI = 1; for all other cases NUNI = 0 (omit if NTCW = 0)

NPRESW — is the wing pressure distribution to be calculated and printed? NPRESW = 0, no
NPRESW = 1, yes

The minimum number of spanwise horseshoe vortices is determined by the wing-flap combination geometry. The program requires that vortex trailing legs lie at the following locations:

(a) the root chord and tip chord
(b) the side edges of all wing regions
(c) the side edges of all flaps
(d) points where there are breaks in leading-edge or trailing-edge sweep

Item number 7 is a set of MSW+1 cards which specify the following:

Y(I) — Y coordinate of the I^{th} trailing leg on the left wing panel; Y is a negative number on the left wing panel, but positive values may be input and program will correct the sign [Y(1) = 0.0, Y(MSW + 1) = -SSPAN]

PSIWLE(I) — leading-edge sweep of wing section to the right of the I^{th} trailing leg, degrees; positive swept back (measured in wing planform plane)

PSIWTE(I) trailing-edge sweep of wing section to the right of the I^{th} trailing leg, degrees; positive swept back (measured in wing planform plane)

NFSEG(I) number of flaps behind wing section to the right of the I^{th} trailing leg

When I = 1, Y(I) = 0 and the other three quantities are omitted.

If NTCW = 1 in item number 6, <u>item number 8</u> is included in the input data deck. These data specify the twist and/or camber distribution of wing region number 1 in terms of the tangent of the local angle of attack of the camberline for a root chord angle of attack of zero degrees. The input data are:

ALPHAL(J) tan α_ℓ of the region 1 camberline at the vortex-lattice control points. If NUNI = 1, only data for the chordwise row adjacent to the root chord are input. The first value is for the control point nearest the leading edge. If NUNI = 0, data for all chordwise rows must be input starting nearest the root chord and working outboard. Data for each row start on a new card (omit if NTCW = 0).

The vortex-lattice control points are at the midspan of the three-quarter chordline of each elemental panel laid out by NCW, MSW, and the Y(I)'s of items 6 and 7.

<u>Item numbers 9, 10, and 11</u> are input data for the other wing regions. If NWREG, item number 4, is one, items 9, 10, and 11 are omitted. If NWREG > 1, these items are repeated in sequence for regions 2 through NWREG.

<u>Item number 9</u> contains two indices which locate this wing region spanwise relative to region 1. They specify the subscripts of the elements in the Y(I) array, input in item 7, associated with inboard and outboard side edges of this region.

IIN inboard side edge is at Y(IIN)

IOUT outboard side edge is at Y(IOUT)

<u>Item number 10</u> contains five quantities. They are:

NCW number of chordwise vortices in this region, $1 \leq NCW \leq 10$

NTCW twist and/or camber for this wing region?
NTCW = 0, no
NTCW = 1, yes

NUNI	if this wing region has no twist and the camber distribution is similar at all spanwise stations, NUNI = 1; for all other cases NUNI = 0 (omit if NTCW = 0 for this region)
CIN	inboard side-edge chord (see sketch), positive quantity
TESWP	sweep angle of the trailing edge of this region, degrees

The vortices are laid out using the value of NCW for this region and the portion of the Y(I) array beginning with Y(IIN) and ending with Y(IOUT).

Item number 11 is included in the input data deck if NTCW = 1 in item 10. These data specify the twist and/or camber distribution for this wing region. These data are prepared in the same manner as described under item number 8, the similar information for wing region 1.

Item number 12 specifies the number of flap regions, NFREG. For a wing alone, NFREG = 0 and items 13 through 16 are not included in the input data deck. A flap region is a particular flap arrangement behind some spanwise region of the wing. The program will handle a total of ten flaps.

Item number 13 contains four items of input which are repeated in sequence NFREG times.

NINREG	number of flaps in this region, $1 \leq \text{NINREG} \leq 3$
IIN	inboard side edge lies at Y(IIN) of item 7
IOUT	outboard side edge lies at Y(IOUT) of item 7

The next three items of input data are repeated in sequence NINREG times beginning with the flap nearest the wing trailing edge and moving rearward.

Item number 14 contains four indices. They are:

NCF	number of chordwise vortices on this flap, $1 \leq \text{NCF} \leq 10$
NTCF	twist and/or camber for this flap? NTCF = 0, no NTCF = 1, yes
NUNI	if this flap has no twist and the camber distribution is similar at all spanwise stations, NUNI = 1; for all other cases NUNI = 0 (omit if NTCF = 0 for this flap)

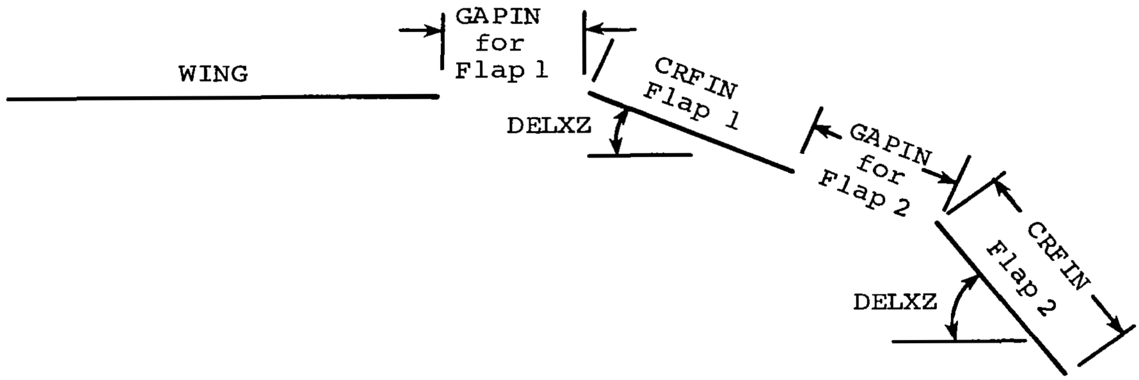
NPRESF is a pressure distribution to be calculated and printed for this flap?
NPRESF = 0, no
NPRESF = 1, yes

The vortices are laid out using the value of NCF for this flap and the portion of the Y(I) array input as item 7 beginning with Y(IIN) and ending with Y(IOUT). IIN and IOUT were input in item 13.

Item number 15 contains data which locate this flap with respect to the surface ahead of it, specify the inboard and outboard edge chords, and give the streamwise deflection angle.

GAPIN	the distance between the leading edge of this flap and the trailing edge of the preceding surface, measured in the plane of the preceding surface at the inboard side of the flap
CRFIN	inboard side-edge chord of this flap
GAPOUT	the gap distance at the outboard edge of the flap
CRFOUT	outboard side edge of this flap
DELXZ	the streamwise deflection angle measured relative to the wing root chord direction, degrees

A streamwise plane containing the inboard edge of a double-slotted flap configuration is shown in the following sketch. The leading edge of each flap lies in the plane of the preceding surface. All quantities in item 15 are input as positive values.



Item number 16 is included in the input data deck if NTCF = 1 in item 14. These data specify the twist and/or camber distribution of this flap. They are prepared in the same manner as described under item number 8 for the wing except that the twist and/or camber angles are measured relative to the angle of the flap inboard side-edge chord. These angles are all measured in a streamwise plane.

Item number 17 contains one index.

NRHS — the number of successive cases to be treated for this wing-flap combination, NRHS $\geq$ 1

The successive cases permitted by NRHS are those which affect only the right-hand side of the equation set for the circulation strengths (eqs. (14) and (15) in ref. 1). Thus, the wing-flap geometry must remain unchanged in successive cases. Changes are permitted in items 18 through 23; therefore, the successive cases may involve different angles of attack and/or different jet wakes.

The last six items of input data are repeated in sequence NRHS times.

Item number 18 contains seven quantities which are:

ALFA — wing root chord angle of attack relative to the free stream, degrees

KEI — index indicating whether or not an externally induced velocity data set is to be input via tape 4
KEI = 0, no
KEI = 1, yes; data set is read from TAPE4 in a 3E13.6 format

NFPTS — number of points in vicinity of wing-flap combination at which wing-flap induced velocities are to be calculated, NFPTS $\geq$ 0

KJET — index indicating type of interference calculation
KJET = 0, no jet calculation, externally induced velocities may be read in if KEI = 1
KJET = 1, jet interference calculation made one time, no iteration
KJET $\geq$ 2, iteration on jet centerline KJET times or until convergence is attained, which ever occurs first

MJETCL — index used to restrict vertical motion of jet centerline during iteration
MJETCL = 0, no restriction of centerline motion
MJETCL = 1, centerline restrained from moving vertically upwards toward wing or flaps

NJETV — index indicating whether or not jet induced velocities are to be included in external flow field calculation when NFPTS > 0
NJETV = 0, jet induced velocities not included
NJETV = 1, jet induced velocities included in flow field calculation

NJETCL index used to restrict horizontal motion of jet centerlines during iteration
- NJETCL = 0, jet centerline is restricted from moving laterally out of original X-Z plane
- NJETCL = 1, jet free to move laterally under influence of wing-flap induced velocity field

The indices KEI and MJETCL are included for diagnostic purposes; and for typical usage of the program, both indices should be zero. KEI is used to input an interference velocity field induced by some source of disturbance other than a jet wake. It cannot be used along with a jet wake; thus, if KEI = 1, KJET = 0. The index MJETCL = 1 is available to restrict the vertical motion of the jet centerlines in certain special cases. On occasion, large induced upwash velocities beneath the wing have forced the jets upward and caused unusually large jet interference effects on the wing. The index MJETCL is provided so that the effect of this upward jet motion can be investigated by the user.

The last index, NJETCL, is provided to restrict the lateral motion of the jet centerlines. Under a swept wing-flap configuration, large induced spanwise velocities can move the jet centerlines out of their original planes. This can cause difficulties in the interference calculation if the spanwise distribution of vortices is specified in a symmetric pattern about the initial centerline positions. Typical EBF measured span-load distributions (ref. 4) indicate very little lateral motion of the wake centerlines; therefore, the option to restrict this movement is provided. It is suggested that NJETCL = 0 be used for best results.

Items 19 through 22 identify the initial jet wakes, and they are omitted if KJET = 0.

Item number 19 is a single card containing six indices pertaining to the jet calculation. They are:

NHEAD number of heading cards to identify the jet model, NHEAD $\geq$ 1

NJET number of jet wakes ; NJET = 1 for one jet wake, etc.

NCYL number of entries in table defining jet parameters, $2 \leq$ NCYL ≤ 25

NNUM index controlling calculation of J-integrals required by elliptic vortex rings
- NNUM = 0, integrals calculated analytically
- NNUM = 1, integrals calculated numerically

NPRINT — index indicating whether or not optional output from the jet program is required
NPRINT = -1, minimum output
NPRINT = 0, induced velocities at wing control points output from subroutine JET
NPRINT = 1, individual jet velocities at each control point output from subroutine JET

NCRCT — index indicating whether or not field point locations are corrected with respect to vortex ring locations
NCRCT = 0, corrections made
NCRCT = 1, corrections not made (to be used for diagnostic purposes only)

The last three indices in item 19 are provided for diagnostic purposes only. For general program usage, these indices should be NNUM = 0, NPRINT = -1, and NCRCT = 0. NNUM should be nonzero only if difficulties arise in the calculation of elliptic jets. This is discussed in a later section describing error messages. When the index NPRINT is equal to zero, jet induced velocities at the control points are output as they are computed. This is a duplication of output. If the user requires information regarding the contribution of each individual jet to the total induced velocity at a control point, NPRINT = 1 will cause this output to be printed. NCRCT is an index used during program development to investigate a situation in which a control point was located very near the edge of a vortex ring. Unrealistically large velocities were induced until the relative positions between the control point and the vortex rings were corrected. This correction places the vortex rings on either side of the control point equidistant from the point.

Item number 20 is a set of NHEAD cards (from item 19) containing hollerith information identifying the jet. The information may start and end anywhere on the card and the information is reproduced in the output just as it is read in.

The following two items are repeated in sequence NJET times.

Item number 21 consists of one card which contains the following jet specifications:

GAMVJ(J) — the strength of the vortex cylinder representing the exit velocity of the J'th jet under the left wing panel

DS(J) — the ring spacing of the vortex rings in the J'th jet; a typical value is 0.1 R_o where R_o is the initial radius of a circular jet; if an elliptic jet is to be used, the appropriate spacing is 0.1 b_o

XQ,YQ,ZQ	the coordinates, in the wing system, of the origin of the jet model (YQ < 0)

Item number 22 consists of NCYL cards containing the following information.

XCLR(J,N) YCLR(J,N) ZCLR(J,N)	the N'th set of coordinates specifying the centerline of the J'th jet in the jet coordinate system (fig.8(b))
AJET(J,N)	the semi-major axis of the vortex ring at the N'th point on the centerline of the J'th jet
BJET(J,N)	the semi-minor axis at the same point
THETA(J,N)	the slope of the centerline in degrees at the point being considered; THETA is negative when the centerline is bent down to pass beneath the flap
DSFACT(J,N)	scale factor for the spacing between the vortex rings downstream of the N'th point; in region of wing and flaps, the values should be 1.0; aft of the last flap, the values can be greater than 1.0

When a circular jet cross section is being described, AJET = BJET; and when elliptic cross sections are being described, AJET > BJET.

Item number 23 is a set of NFPTS cards containing the X,Y,Z coordinates in the wing system, at which the wing-flap induced velocities are to be calculated. This term is omitted if NFPTS = 0.

Upon completion of the calculations specified by the above input deck, the program returns to the beginning. Additional input decks, starting with item 1, may be stacked one after another.

Sample Cases

In this section, two sample cases are described to illustrate the input preparation and the use of the program. The first sample case is a complete calculative example involving a four-engine EBF configuration with elliptic cross-section jets. The second sample case is an illustrative example of a wing with multiple regions and multiple flaps and a single engine. Its purpose is to provide a check run for the program.

The EBF configuration chosen for the first sample case is the four-engine model from references 3 and 4. The vortex-lattice layout on the wing and flaps is discussed in the Vortex Lattice Arrangement section and the actual lattice arrangement is shown in figure 3. The flap deflections chosen for this case correspond to the landing configuration, $\delta_{f_1}/\delta_{f_2}/\delta_{f_3} = 15^\circ/35^\circ/55^\circ$. This particular configuration and lattice arrangement are used extensively for the comparisons with data in reference 1

The jet wake model chosen for this sample case is the elliptic cross-section example discussed in the Jet Wake Specification section and shown in figure 4. The initial jet centerline is one which resulted from three iterations using the circular cross-section jet also shown in figure 4. The calculation is set up to run two iterations (KJET = 2) because of the large execution time required by elliptic jets. The total time required for two iterations, with the input deck set up as shown in figure 7(a), is approximately 600 seconds on the CDC 6600. If the circular jet radius distribution shown in figure 4 is substituted for the elliptic jet axes, the same run requires approximately 200 seconds.

A second sample input deck is illustrated in figure 7(b). This input deck, to be used as a check run for the program, describes the hypothetical EBF configuration shown in figure 8. The wing shown in figure 8(a), is modeled as two regions for illustrative purposes, but wing region 2 could just as easily be modeled as a flap surface with zero gap and zero deflection. Double-slotted flaps deflected 20° and 40° and a single, unslotted flap deflected 10° make up the two regions of the trailing-edge flap system. A minimum lattice is specified on the lifting surfaces to keep the calculation short. Wing region 1 is modeled by a 7×2 lattice and region 2 is modeled by a 2×1 lattice. Flaps 1 and 2 have three spanwise rows of vortices due to their position behind the wing. One chordwise row of vortices is placed on flap 1 and two chordwise rows on flap 2. Flap 3 is represented by a single vortex-lattice element.

A single circular jet wake with initial jet velocity five times free stream ($C_\mu \approx 0.5$) is placed at $Y = -11$. Since this case is only a check run for the program, the jet is not extended downstream of the last flap as far as is normally recommended. The expansion rate is linear as the radius increases to two and one-half times its initial value between $x_j = 3$ and 18. A sketch of the jet and its position relative to the wing and flap is presented in figure 8(b). The ring spacing is set at 0.1 and it is constant until $x_j = 15$ where it is doubled for the remainder of the jet length. Assuming a turning efficiency of 75 percent, the limit on the turning angle of the jet centerline is set at -30°.

Some incidental features of this sample calculation are the following. Two iterations are specified (KJET = 2), and after the last iteration, the induced velocity field, including the jet induced velocities (NJETV = 1), is calculated at four field points (NFPTS = 4). The jet is free to move vertically (MJETCL = 0) and laterally (NJETCL = 1) under the influence of the velocity field beneath the wing and flaps. Pressure distributions are computed on the left wing panel, flap 2 in region 1, and flap 1 in region 2. The output corresponding to this input deck is presented in the next section.

DESCRIPTION OF OUTPUT

This section describes the output from the EBF program. The contents of a typical set of output from one of the previously described sample cases is discussed. This is followed by a description of some of the error messages which may be output during execution of the program.

Sample Case

The output generated during the execution of the sample case shown in figure 8(b) is presented in figure 9. Each page of output is described as follows.

The first page of output, shown as figure 9(a), is headed by the program title "EBF AERODYNAMIC PREDICTION PROGRAM," followed by the identification information on the several cards at the front of the input deck. This is followed by the reference quantities consisting of the reference area and length and the center of moment location. Next on the first page is the wing input data. All of the input describing the wing geometry and lattice arrangement is included in this section.

Output page 2 in figure 9(b) contains all the input data describing the flaps including the geometry and the lattice arrangement. Also printed on this page are the coordinates of the four corners of each flap in a coordinate system fixed in the flap with the origin at the leading edge of the inboard chord of the flap. The purpose of these coordinates is two-fold. First, they illustrate the slightly distorted shape of the flaps that occurs because the flaps are attached to swept trailing edges of the upstream surface. The flaps are required to span a certain length which is defined in planform; therefore, the actual surface must be longer when it is deflected around a swept hinge line. Second, the coordinates are useful in locating the flap loading center of pressure defined in the flap coordinate system and printed on a later page.

Output page 3 in figure 9(c) is headed with the title "HORSESHOE VORTEX PROPERTIES." This table lists all the properties of the lattice elements on each lifting surface. The quantities in the last column on this page labeled "ALPHAL(J)" are the input values of combined twist and camber. This table completes the configuration dependent information. The first item following the table is a list of the variables pertaining to the run to follow. The angle of attack, ALPHA, in degrees, the indices from item 18 of the input deck, and the convergence tolerance (5 percent) are printed here. The last line of output on this page is a statement regarding the limit applied to the jet centerline deflection. If a limit is not specified, no statement is printed.

The fourth page of output is a listing of the jet input as shown in figure 9(d). The variables printed are the same values input via the card deck with the addition of two columns of numbers. The variable SCL is the curvilinear distance measured along the centerline in the same units as the other centerline distance variables. For a straight jet centerline with no inclination (THETA = 0), SCL is the same as XCL. The last column, identified as P, is the perimeter of the jet at the particular station.

The next page of output shown in figure 9(e) is the first output from the program after the circulation strengths are computed. This page, labeled "HORSESHOE VORTEX STRENGTHS FOR ALPHA = xx.x DEGREES," contains the computed circulation strength on each lattice element. The circulation strengths (GAMMA/V) are printed in the last column on the page. Also shown on this page are the externally induced jet velocities at each control point. These velocities, UEI, VEI, and WEI are made dimensionless by the free-stream velocity and their positive directions are defined according to the wing coordinate system; that is, UEI is positive forward and WEI is positive downward. If externally induced velocities are read in via tape 4 (KEI $\neq$ 0), these velocities are printed on this page. Also noted at the top of the page, directly beneath the angle of attack, is the iteration number "NTIME" that corresponds to the printed results.

The output shown in figure 9(f) is headed at the top "AERODYNAMIC LOADING RESULTS FOR ALPHA = xx.xx DEG." This is followed by a reiteration of the reference quantities which are followed by the spanwise load distributions. On each lifting surface at each spanwise lattice station the span-load coefficient, the section normal-force coefficient, and the section axial-force coefficient are presented. These results are normal and axial to the plane of the particular lifting surface. Following the section coefficients are the wing-alone force and moment coefficients. These results are for both right and left wing panels. The axial force, CAW, and the drag force, CDW, are both defined as positive aft. The pitching moment is positive in the direction that tends to increase the angle of attack of the wing.

The next section of output on this page is the individual flap force and moment coefficients. These coefficients are for the flaps on the left side of the configuration only. CNF is normal to the individual flap surface and the center of pressure of the normal force on this flap is at XF(CNF) and YF(CNF) where these coordinates are in the flap coordinate system defined in figure 9(b). The axial-force coefficient, CAF, and its spanwise center of pressure, YF(CAF), follow. The spanwise force, CYF, and its center of pressure, XF(CYF), are the next items; and finally, the hinge-moment coefficient, CHF, is the last item. The sign convention of the flap hinge moments is such that a positive hinge moment would tend to increase the flap deflection angle. The hinge moments are taken about the flap leading edge. The last items on this page are the complete configuration force and moment coefficients. These are resolved into the wing coordinate system and the sign convention is consistent with that described for the wing alone.

If pressure distributions are requested, they are output on the next page shown in figure 9(g). The chordwise location, X/C, at which the pressure coefficients are calculated corresponds to the location of the bound leg in each lattice element. It should be remembered that the pressure is constant over the entire lattice element. The last line on the page is the number of the iteration just completed.

The velocity field induced by the wing-flap loading and the jet models at specific points on the jet centerlines is printed at the top of figure 9(h). The coordinates, in the wing system, correspond to the points defining each jet centerline with the exception of the first two points on each centerline. These points represent the physical engine location and are assumed stationary and not allowed to move with the remainder of the wake; therefore, induced velocities are not needed. The perturbed jet position is shown on the lower portion of this page of output. Notice that the jet deflection angle, THETA, is set equal to the prescribed limit of -30° at two points on the centerline. Thus, the new centerline has not been allowed to move as far as the induced velocity field wanted to move it.

If a second iteration were not prescribed, the last page of output containing the induced velocity field at specified field points would be printed if requested (NFPTS $>$ 0). If not requested, this would complete the output.

However, additional iterations are requested; therefore, the jet defined in figure 9(h) is allowed to interfere on the wing and flaps. The results of the second iteration are shown in figures 9(i), (j), (k), and (ℓ) and these results are analogous to those just described in figures 9(e), (f), (g), and (h), respectively. If convergence has not been achieved or the maximum number of iterations completed, similar groups of four pages will be printed until convergence or maximum number of iteration is reached. At this point, a statement regarding the convergence situation, number of iterations, and current level of convergence (DEL) is printed as illustrated at the bottom of figure 9(ℓ). If convergence within the specified tolerance (TOL) is achieved, the message "**** CONVERGENCE ATTAINED IN x ITERATIONS, DEL = x.xx****" is printed.

The last page of output containing the induced velocity field at specified field points is shown in figure 9(m). Note that both wing-flap perturbation velocities and total velocities are printed on this page. This concludes the discussion of the output from the EBF prediction program.

Error Messages

The following error messages may be printed during program execution.

"ERROR IN JET, B.GT.A"

is printed when an elliptic jet is input with the semi-minor axis longer than the semi-major axis. This is a fatal error.

"EXECUTION TERMINATED, ERROR IN DS"

is printed when the vortex spacing is input as zero or less than zero. This is a fatal error.

"ANALYTICAL J(N) ERROR, XX POINTS"

is a warning message printed to alert the user that the analytical calculation of the J-integrals had numerical difficulties at the noted number of points. The program automatically switches to a numerical calculation technique for these points; therefore, the answers are correct. If the number of points is a large fraction of the total number of control points, there may be some error in the specifications of the jets or in the location of the jets with respect to the lifting surfaces. For example, this error message would be printed if one of the jets was located outboard of the wing tip by mistake or if the jet centerline was located in the plane of the wing. If the error message persists, consider switching to the numerical technique via the index NNUM in the input data. The penalty for using the numerical procedure is increased computer time and a slight decrease in the accuracy of the jet induced velocity calculations.

If the jet centerline deflection angle becomes -90° or less during iteration, the following message is printed.

"ERROR IN JETCL j k -90.00"

where j is the number of the jet and k is the number of the point on the centerline causing difficulty. This is a fatal error. The error is caused by this particular point being too near one of the vortices on the wing or flap. To correct the situation, adjust the position of the point in question upstream or downstream a small amount and rerun or restart the calculation with the previous iteration.

PROGRAM LISTING

The EBF aerodynamic prediction program consists of a main program, WNGFLP, and twenty-four subroutines. Each deck is identified by a three-letter code in columns 74-76 and each deck is sequenced with a three-digit number in columns 78-80. The table below will act as a table of contents for the program listing on the following pages.

PROGRAM	IDENTIFICATION	PAGE NO.
WNGFLP	WNG	35
WNGLAT	WLT	37
FLPLAT	FLT	39
INFMAT	INF	41
FLVF	FLV	43
SIVF	SIV	43
RHSCLC	RHS	44
LINEQS	LIN	44
SOLVE	SOL	45
LOAD	LOD	45
FORCES	FOR	46
VELSUM	VEL	49
JET	JET	51
JETCL	JCL	53
CORECT	CRT	53
VRING	VRG	54
ERING	ERG	54
JINTEG	JIN	55
ELI1	EL1	56
ELI2	EL2	56
ELLIPS	ELL	57
QUART	QRT	58
CUBIC	CBC	58
QUAD	QAD	58
SIMSON	SIM	58

```
      PROGRAM WNGFLP(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE4)
C*********************************************************************
C
C     TAPE4 IS THE INPUT UNIT FOR THE EXTERNALLY INDUCED VELOCITIES
C
C*********************************************************************
C
C     WING AND MULTIPLE FLAP VORTEX LATTICE PROGRAM WITH DEFLECTED WAKE
C
C      MODIFIED TO INCLUDE JET INDUCED VELOCITY FIELD CALCULATION
C      AND ITERATION ON JET CENTERLINE
C
C     DIMENSION STATEMENT
C
      DIMENSION HEAD(20)
      DIMENSION XCLR(2,25),YCLR(2,25),ZCLR(2,25),THETA(2,25),AJET(2,25),
     1          BJET(2,25),XO(2),YO(2),ZO(2),GAMVJ(2)
C
C     TYPE STATEMENT
C
      LOGICAL EXVEL
C
C     COMMON STATEMENTS
C
      COMMON /REFQUA/ SSPAN,SREF,REFL,XM,ZM
      COMMON /INDEX/ MSW,MW,MTOT,NCWI(30),IMAX,NFSEG(30),LASTF(30)
      COMMON /CPDAT/ ALPHAL(250),XCP(250),YCP(250),ZCP(250),
     1 CALPHL(250),SALPHL(250)
      COMMON / INDEXF/ NFREG,NFLAPS,IDFLAP(10,2),NCF(10),MSF(10),MF(10),
     1MSTART(10),MEND(10),NFSEGF(10)
      COMMON /BLDAT/ XBL(250),YBL(250),ZBL(250),TPSI(250),SW(250)
      COMMON /RSIDE/ CIR(250),UEI(250),VEI(250),WEI(250)
      COMMON /ATAK/ SINALF,COSALF
      COMMON /RVELS/ UP,VP,WP
      COMMON /NORM/ CNT
      COMMON /XYZCL/ NJET,NCYL,XCLR,YCLR,ZCLR,THETA,AJET,BJET,
     1               XO,YO,ZO,GAMVJ
      COMMON /UVWCL/ U(2,25),V(2,25),W(2,25)
      COMMON /CLCALC/ MJETCL,NJETCL,THMAX
C
C     BLANK COMMON -- INCREASE LENGTH FOR NON-SCS USE OF PROGRAM
C
      COMMON FVN(1)
C
C     FORMAT STATEMENTS
C
  701 FORMAT(10I5)
  702 FORMAT(1H1,28X,34HEBF AERODYNAMIC PREDICTION PROGRAM //)
  703 FORMAT(20A4)
  704 FORMAT(1X,20A4)
  705 FORMAT(8F10.0)
  706 FORMAT(//5X,57HREFERENCE QUANTITIES USED IN FORCE AND MOMENT CALCU
     1LATION/10X,4HAREA,10X,1H=,F11.5/10X,6HLENGTH,8X,1H=,F11.5/10X,
     213HMOMENT CENTER/15X,2HXM,7X,1H=,F11.5/15X,2HZM,7X,1H=,F11.5)
  722 FORMAT(1H1,48X,27HHORSESHOE VORTEX PROPERTIES//12X,10(1H*),11H WIN
     1G DATA ,10(1H*))
  723 FORMAT(/1X,6HVORTEX,2X,34H-COORDINATES OF BOUND LEG MIDPOINT,2X,
     1 34H---COORDINATES OF CONTROL POINT---,2X,10HB.L. SWEEP,2X,
     2  10HHALF-WIDTH,5X,7HSURFACE/1X,6HNUMBER,102X,5HSLOPE/6X,1HJ,6X,
     3 6HXBL(J),6X,6HYBL(J),6X,6HZBL(J),6X,6HXCP(J),6X,6HYCP(J),6X,
     4  6HZCP(J),6X,6HPSI(J),7X,5HSW(J),3X,9HALPHAL(J)/)
  724 FORMAT(4X,I3,9(2X,F10.5))
  725 FORMAT(/12X,10(1H*),6HREGION,I2,5H FLAP,I2,6H DATA ,10(1H*))
  726 FORMAT(1H1,20X,39HHORSESHOE VORTEX STRENGTHS FOR ALPHA = ,
     1  F5.1,8H DEGREES//12X,10(1H*),11H WING DATA ,10(1H*)
     2     15X,7HNTIME = ,I3)
  727 FORMAT(/1X,6HVORTEX,2X,38H-----CONTROL POINT COORDINATES-----,2X,
     1  34H---EXTERNALLY INDUCED VELOCITIES---,3X,9HGAMMA / V/1X,6HNUMBER
     2 /6X,1HJ,6X,6HXCP(J),6X,6HYCP(J),6X,6HZCP(J),6X,6HUEI(J),6X,
     3 6HVEI(J),6X,6HWEI(J)/)
  728 FORMAT(8X,I3,7(2X,F10.5))
  729 FORMAT(6F10.0)
  756 FORMAT (//10X,39HJET CENTERLINE DEFLECTION ANGLE LIMIT = ,F7.1)
  732 FORMAT(F10.0,9I5)
  733 FORMAT(3E13.6)
  734 FORMAT(1H1,20X,41HWING/FLAP INDUCED PERTURBATION VELOCITIES/28X,
     1 25HAT SPECIFIED FIELD POINTS//15X,1HX,9X,1HY,9X,1HZ,8X,6HU/VINF,
     2 4X,6HV/VINF,4X,6HW/VINF)
  735 FORMAT(10X,9F10.5)
  736 FORMAT (1H1,20X71HWING/FLAP AND JET INDUCED PERTURBATION VELOCITIE
     1S ON THE JET CENTERLINE  //   40X,
     261HI-------- WING/FLAP -----------I-------------- JET -----------I /
     3  15X,1HX,9X,1HY,9X1HZ,4X,2(4X,6HU/VINF,4X6HV/VINF,4X6HW/VINF ))
  750 FORMAT (// 5H ****,2X20HNO CONVERGENCE AFTER,I3,2X,10HITERATIONS,
     1               5X5HTOL =,F7.4,5X5HDEL =,F8.4,2X4H**** )
  751 FORMAT (//5H ****,2X23HCONVERGENCE ATTAINED IN,I3,2X10HITERATIONS,
     1             5X5HDEL =,F8.4,2X4H**** )
  752 FORMAT (////10X5HALPHA,5X3HKEI,7X5HNFPTS,5X4HNJET,6X3HTOL,4X6HNJET
     1CL,5X5HNJETV,5X6HNJETCL/5XF10.3,4XI3,8XI4,7XI2,F12.5,I6,2(7XI3))
  753 FORMAT (// 5H ****2X,38HCENTERLINE SLOPES INDICATE CONVERGENCE
     1             2X4H****)
  754 FORMAT (// 5X9HITERATION ,I3)
  755 FORMAT (1H1,28X,44HINDUCED VELOCITIES AT SPECIFIED FIELD POINTS //
     1          40X,61HI-------- WING/FLAP -----------I--- WING/FLAP+JET+VI
     2NF ------I/43X,23HPERTURBATION VELOCITIES  /
     3  15X,1HX,9X,1HY,9X1HZ,4X,2(4X,6HU/VINF,4X6HV/VINF,4X6HW/VINF ))
C
C     CONSTANTS
C
      DATA DTOR/.01745329/,FOURPI/12.56637062/,ZERO/0./
C
C     INPUT AND OUTPUT CASE IDENTIFYING INFORMATION
C
 1000 READ (5,701) NHEAD
      IF(EOF(5)) 1,2
    1 STOP
    2 CONTINUE
      WRITE(6,702)
      DO 3 I=1,NHEAD
      READ(5,703) HEAD
    3 WRITE(6,704) HEAD
C
C     INPUT AND OUTPUT REFERENCE QUANTITIES AND MOMENT CENTER LOCATION
C
      READ(5,729) SREF,REFL,XM,ZM,TOL,DTH
      IF (DTH.GE.0.0 .OR. DTH.LT.-90.0) DTH=-90.0
      WRITE(6,706) SREF,REFL,XM,ZM
C
C     INPUT AND OUTPUT WING DATA AND LAYOUT WING VORTEX LATTICE
C
      CALL WNGLAT
C
C     INPUT NUMBER OF FLAP REGIONS
C
      READ (5,701) NFREG
C
C     INPUT DATA FOR ALL FLAPS AND LAY OUT VORTICES
C
      NFLAPS =0
      IF (NFREG.GT.0) CALL FLPLAT
C
C     COMPUTE SINE AND COSINE OF LOCAL ANGLE OF ATTACK DUE TO TWIST AND
C     CAMBER
C
      DO 41 J=1,MTOT
      ALF=ATAN(ALPHAL(J))
      CALPHL(J)=COS(ALF)
   41 SALPHL(J)=SIN(ALF)
C
C     WRITE WING VORTEX DATA
C
      WRITE(6,722)
      WRITE(6,723)
      DO 50 K=1,MW
      PSIGH=ATAN(TPSI(K))/DTOR
   50 WRITE(6,724) K,XBL(K),YBL(K),ZBL(K),XCP(K),YCP(K),ZCP(K),PSIGH,
     1  SW(K),ALPHAL(K)
      IF(NFLAPS.EQ.0) GO TO 65
C
C     WRITE FLAP VORTEX DATA
C
      DO 60 NF=1,NFLAPS
      WRITE (6,725) IDFLAP(NF,1),IDFLAP(NF,2)
      WRITE(6,723)
      KL=MSTART(NF)
      KU=MEND(NF)
```

```
      DO 55 K=KL,KU
      PSIGH=ATAN(TPSI(K))/DTOR
   55 WRITE(6,724) K,XBL(K),YBL(K),ZBL(K),XCP(K),YCP(K),ZCP(K),PSIGH,
     1  SW(K),ALPHAL(K)
   60 CONTINUE
   65 CONTINUE
C
C************************************************************************
C
C      ADD CORE AREA FOR INFLUENCE COEFFICIENT MATRIX
C     IF REQFL IS NOT AVAILABLE , REMOVE THIS SECTION AND INCREASE
C     THE DIMENSIONS OF FVN IN BLANK COMMON, ABOVE, TO MTOT*MTOT
C        WHERE MTOT = TOTAL NUMBER OF VORTEX PANELS ON WING AND FLAP
C
      IFLB=0
      CALL REQFL(IFLB)
      LFL=IFLB+MTOT*MTOT-1
      CALL REQFL(LFL)
C
C************************************************************************
C
C     CALCULATE INFLUENCE COEFFICIENT LEFT HAND SIDE, FVN
C
      CALL INFMAT
C
C     TRIANGULARIZE LEFT HAND SIDE
C
      CALL LINEQS(MTOT,FVN)
C
C     READ NUMBER OF RIGHT SIDES, AND FOR EACH FIND VORTEX
C     STRENGTHS AND LOAD DISTRIBUTION
C
      READ(5,701) NRHS
      DO 75 KR=1,NRHS
      READ(5,732) ALFA,KEI,NFPTS,KJET,MJETCL,NJETV,NJETCL
      IF (KJET.LE.0) NJETV=0
C
C       IF  KJET=0  NO JET CALCULATION, INDUCED VELOCITIES MAY BE INPUT
C               =1  JET CALCULATION = NO ITERATION ON CENTERLINE
C               =2  JET CALCULATION = ITERATION ON CENTERLINE UNTIL
C                                     CONVERGENCE, OR KJET TIMES
C
C         MJETCL=0  ORIGINAL JET CL CALCULATION METHOD
C               =1  JET RESTRAINED FROM VERTICAL MOTION TOWARD WING
C
C          NFPTS=NUMBER OF FIELD POINTS AT WHICH WING-FLAP INDUCED
C                VELOCITIES ARE TO BE COMPUTED
C
C          NJETV=0  OMIT JET INDUCED VELOCITY FIELD
C               =1  INCLUDE JET INDUCED AND FREE STREAM VELOCITIES
C
C                NJETCL = 0  NO LATERAL MOTION OF JET CL ALLOWED
C                NJETCL = 1  JET CL FREE TO MOVE IN Y-DIRECTION
C
      NTIME=0
      IF (TOL.LE.0.0) TOL=0.05
C
      WRITE (6,752) ALFA,KEI,NFPTS,KJET,TOL,MJETCL,NJETV,NJETCL
      IF (DTH.NE.-90.0) WRITE (6,756) DTH
      THMAX=DTH*DTOR
      ALF=ALFA
      ALFA=ALFA*DTOR
      SINALF=SIN(ALFA)
      COSALF=COS(ALFA)
      IF (KJET.LE.0) GO TO 74
C
C      INPUT INITIAL JET PARAMETERS AND CALCULATE JET INDUCED VELOCITIES
C
      EXVEL=KJET.NE.0
   73 CALL JET (MTOT,XCP,YCP,ZCP,UEI,VEI,WEI,NTIME)
      NTIME=NTIME+1
      GO TO 77
C
C     READ EXTERNALLY INDUCED VELOCITIES FROM UNIT 4 IF KEI=4 AND KJET=0
C
   74 EXVEL=KEI.NE.0
      IF (KEI.EQ.0) GO TO 77
      DO 76 J=1,MTOT
   76 READ (4,733) UEI(J),VEI(J),WEI(J)
   77 CONTINUE
      WRITE(6,726) ALF ,NTIME
      WRITE(6,727)
C
C     CALCULATE RIGHT HAND SIDE OF EQUATIONS
C
      CALL RHSCLC(EXVEL)
C
C     SOLVE FOR VORTICITY DISTRIBUTION FOR THIS RIGHT HAND SIDE
C
      CALL SOLVE(CIR,FVN,MTOT)
C
C
C     PRINT VORTEX STRENGTHS
C
      IF(.NOT.EXVEL) GO TO 85
      DO 80 NP=1,MW
      GAMMA=CIR(NP)*FOURPI
   80 WRITE(6,728) NP,XCP(NP),YCP(NP),ZCP(NP),UEI(NP),VEI(NP),WEI(NP),
     1  GAMMA
      GO TO 89
   85 CONTINUE
      DO 88 NP=1,MW
      GAMMA=CIR(NP)*FOURPI
   88 WRITE(6,728) NP,XCP(NP),YCP(NP),ZCP(NP),ZERO,ZERO,ZERO,GAMMA
   89 IF(NFLAPS.EQ.0) GO TO 96
      DO 95 NF=1,NFLAPS
      WRITE (6,785) IDFLAP(NF,1),IDFLAP(NF,2)
      WRITE(6,727)
      MS=MSTART(NF)
      ME=MEND(NF)
      IF(.NOT.EXVEL) GO TO 92
      DO 91 NP=MS,ME
      GAMMA=CIR(NP)*FOURPI
   91 WRITE(6,728) NP,XCP(NP),YCP(NP),ZCP(NP),UEI(NP),VEI(NP),WEI(NP),
     1  GAMMA
      GO TO 95
   92 CONTINUE
      DO 93 NP=MS,ME
      GAMMA=CIR(NP)*FOURPI
   93 WRITE(6,728) NP,XCP(NP),YCP(NP),ZCP(NP),ZERO,ZERO,ZERO,GAMMA
   95 CONTINUE
   96 CONTINUE
C
C     CALCULATE LOADS, FORCES AND MOMENTS
C
      CALL LOAD(EXVEL)
      CALL FORCES
C
      IF (KJET.LE.0) GO TO 78
      WRITE (6,754) NTIME
      ITER=NTIME
C
C       JET CENTERLINE ITERATION
C
      IF (NTIME.GT.1) GO TO 79
      CNI=CNT
      DEL=1.0
      GO TO 173
   79 DEL=(CNI-CNT)/CNT
      CNI=CNT
C
C      CALCULATE WING-FLAP-JET INDUCED VELOCITY FIELD ON JET CENTERLINE
C
  173 CONTINUE
      WRITE (6,736)
      NTIME=-NTIME
      JA=1
      DO 176 J=1,NJET
      U(J,1)=0.0
      U(J,2)=0.0
      V(J,1)=0.0
      V(J,2)=0.0
      W(J,1)=0.0
      W(J,2)=0.0
      DO 176 K=3,NCYL
      XFP=XQ(J)-XCLR(J,K)
```

```
      YFP=YO(J)+YCLR(J,K)
      ZFP=ZO(J)-ZCLR(J,K)
      CALL VELSUM (XFP,YFP,ZFP)
      CALL JET (JA,XFP,YFP,ZFP,UEI,VEI,WEI,NTIME)
      U(J,K)=UP + UEI(1)
      V(J,K)=VP + VEI(1)
      W(J,K)=WP + WEI(1)
      WRITE (6,735) XFP,YFP,ZFP,UP,VP,WP,UEI(1),VEI(1),WEI(1)
  176 CONTINUE
      NTIME=-NTIME
      CALL JETCL (NTIME,TOL)
      IF (ABS(DEL).LE.TOL) GO TO 178
      IF (NTIME.GE.KJET) GO TO 178
      IF (NTIME.GE.99) GO TO 178
      GO TO 73
  178 NTIME=999
C
C       COMPUTE FINAL POSITION OF JET CENTERLINE
C
      CALL JET (MTOT,XCP,YCP,ZCP,UEI,VEI,WEI,NTIME)
C
      IF (ABS(DEL).LE.TOL) GO TO 170
      IF (NTIME.GE.KJET) GO TO 175
      IF (NTIME.GE.99) WRITE (6,753)
      GO TO 78
  175 WRITE (6,750) KJET,TOL,DEL
      GO TO 78
  170 WRITE (6,751)  ITER,DEL
C
C     CALCULATE VELOCITIES AT SPECIFIED FIELD POINTS
C
   78 IF (NFPTS.EQ.0) GO TO 110
      IF (NJETV.LE.0) GO TO 103
      WRITE (6,755)
      GO TO 102
  103 WRITE (6,734)
  102 CONTINUE
      NTIME=-1
      JA=1
      DO 105 J=1,NFPTS
      READ (5,708) XFP,YFP,ZFP
      CALL VELSUM (XFP,YFP,ZFP)
      IF (NJETV.LE.0) GO TO 104
      CALL JET (JA,XFP,YFP,ZFP,UEI,VEI,WEI,NTIME)
      UEI(1)=UEI(1)+UP-COSALF
      VEI(1)=VEI(1)+VP
      WEI(1)=WEI(1)+WP-SINALF
      WRITE (6,735) XFP,YFP,ZFP,UP,VP,WP,UEI(1),VEI(1),WEI(1)
      GO TO 105
  104 WRITE (6,735) XFP,YFP,ZFP,UP,VP,WP
  105 CONTINUE
  110 CONTINUE
   75 CONTINUE
      GO TO 1000
      END
```

```
      SUBROUTINE WNGLAT
C
C     THIS SUBROUTINE READS IN THE WING INPUT DATA AND LAYS OUT THE
C          WING VORTEX LATTICE
C
C     COMMON STATEMENTS
C
      COMMON /TOLRNC/ TOL
      COMMON /REFQUA/ SSPAN,SREF,REFL,XM,ZM
      COMMON / WNGDAT/ Y(30),PSIWLE(30),PSIWTE(30),SPHIW,CPHIW,TPHIW
      COMMON /INDEX/ MSW,MW,MTOT,NCWI(30),IMAX,NFSEG(30),LASTF(30)
      COMMON /CPDAT/ ALPHAL(250),XCP(250),YCP(250),ZCP(250),
     1 CALPHL(250),SALPHL(250)
      COMMON /TLDAT/ XTER(30),XTEL(30),XTLR(250),YTLR(250),ZTLR(250),
     1 XTLL(250),YTLL(250),ZTLL(250)
      COMMON /BLDAT/ XBL(250),YBL(250),ZBL(250),TPSI(250),SW(250)
      COMMON /FTLDAT/ FTLXR(250),FTLXL(250),FTLZR(250),FTLZL(250)
      COMMON /LOCONS/ CONA(250),CONBR(250),CONBL(250),TEMP,TEMR
      COMMON /CHORDS/ CHRDLW(30),CROOTF(10),CTIPF(10)
      COMMON /PRSDAT/NPRESW,NPRESF(10),ELAREA(250),XLE(30)
C
C     DIMENSION STATEMENT
C
      DIMENSION XTE(30)
C
C     FORMAT STATEMENTS
C
  701 FORMAT(10I5)
  702 FORMAT(8F10.0)
  703 FORMAT(//5X,15HWING INPUT DATA)
  704 FORMAT(//10X,13HREGION NUMBER,I3)
  705 FORMAT(15X,20HINBOARD EDGE CHORD =,F10.5/15X,8HSEMISPAN,11X,1H=,
     1F10.5/15X,14HDIHEDRAL ANGLE,5X,1H=,F10.5)
  706 FORMAT(/15X,I3,43H VORTICES ARE TO BE LAID OUT IN THIS REGION/20X,
     1I2,12H SPANWISE BY,I3,10H CHORDWISE)
  707 FORMAT(/15X,59HSPANWISE LOCATIONS OF TRAILING VORTEX LEGS, SWEEP A
     1NGLES OF/20X,65HWING SECTION TO THE RIGHT AND NUMBER OF FLAPS BEHI
     2ND THIS SECTION//21X,8HSPANWISE,7X,8HLE SWEEP,7X,8HTE SWEEP,7X,
     36HNUMBER/21X,8HLOCATION,37X,8HOF FLAPS)
  708 FORMAT(3F10.0,I5)
  709 FORMAT(15X,3F15.5,9X,I2)
  710 FORMAT(/15X,28HTHIS REGION EXTENDS FROM Y =,F10.5,7H TO Y =,F10.5)
  711 FORMAT(3I5,2F10.0)
  712 FORMAT(/15X,25HINBOARD SIDE-EDGE CHORD =,F10.5/15X,19HTRAILING EDG
     1E SWEEP,5X,1H=,F10.5)
C
C     CONSTANTS
C
      DATA DTOR/0.01745329/,PI/3.14159265/
C
C     INPUT NUMBER OF WING REGIONS
C
      READ (5,701) NWREG
C
C     INPUT REGION 1 DATA AND LAY OUT VORTICES
C
      READ (5,702) CRW,SSPAN,PHID
      NREG=1
      WRITE (6,703)
      WRITE (6,704) NREG
      WRITE (6,705) CRW,SSPAN,PHID
      TOL   =(SSPAN*(5.0E-05))**2
      READ (5,701) NCW,MSW,NTCW,NUNI,NPRESW
      MW=NCW*MSW
      MTOT=MW
      WRITE (6,706) MW,MSW,NCW
      IMAX=MSW+1
      WRITE (6,707)
      DO 10 I=1,IMAX
      READ (5,708) Y(I),PSIWLE(I),PSIWTE(I),NFSEG(I)
      NCWI(I)=NCW
      IF (I.EQ.1) WRITE (6,709) Y(I)
      IF (I.NE.1)
     1WRITE (6,709) Y(I),PSIWLE(I),PSIWTE(I),NFSEG(I)
      IF (Y(I).GT.0.0) Y(I)=-Y(I)
   10 CONTINUE
      DO 11 I=1,MSW
   11 NFSEG(I)=NFSEG(I+1)
      IF (NTCW.NE.0) GO TO 21
      DO 20 J=1,MW
   20 ALPHAL(J)=0.0
      GO TO 25
   21 IF (NUNI.NE.0) GO TO 23
      MN=0
      DO 22 JNW=1,MW,NCW
      MN=MN+NCW
   22 READ (5,702) (ALPHAL(J),J=JNW,MN)
      GO TO 25
   23 READ (5,702) (ALPHAL(J),J=1,NCW)
      DO 24 J=2,MSW
      JJ=(J-1)*NCW
      DO 24 K=1,NCW
```

```
      KK=JJ+K
   24 ALPHAL(KK)=ALPHAL(K)
   25 CONTINUE
C
C     LAY OUT REGION 1 WING VORTICES
C
      TEMP=16.0*PI/SREF
      TEMR=0.5*TEMP
      PHI=DTOR*PHID
      SPHIW=SIN(PHI)
      CPHIW=COS(PHI)
      TPHIW=SPHIW/CPHIW
      FNCW=NCW
      XLE(1)=0.0
      XTE(1)=-CRW
      CTLL=CRW
      DUMA=TEMR/FNCW
C
C     LOOP OVER CHORDWISE ROWS
C
      DO 40 I=2,IMAX
      IM=I-1
      LASTF(IM)=0
      TLRY=Y(IM)
      TLLY=Y(I)
      TLRZ=TLRY*TPHIW
      TLLZ=TLLY*TPHIW
      TPSILE=TAN(PSIWLE(I)*DTOR)
      TPSITE=TAN(PSIWTE(I)*DTOR)
      DY=TLLY-TLRY
      XLE(I)=XLE(IM)+DY*TPSILE
      XTE(I)=XTE(IM)+DY*TPSITE
      BLX=(XLE(I)+XLE(IM))*0.5
      XTER(IM)=XTE(IM)
      XTEL(IM)=XTE(I)
      DPSI=TPSILE-TPSITE
      CTLR=CTLL
      CTLL=CTLR+DY*DPSI
      CBL=(CTLR+CTLL)*0.5
      DCRD=CBL/FNCW
      CHROLW(IM)=CBL
      TLRX=XLE(IM)
      TLLX=XLE(I)
      TCONBR=DUMA*CTLR
      TCONBL=DUMA*CTLL
C
C     LOOP OVER VORTICES IN THIS ROW
C
      JJ=(I-2)*NCW
      DO 41 J=1,NCW
      IV=JJ+J
      FJ=J
      FACB=(FJ-0.75)/FNCW
      FACC=(FJ-0.25)/FNCW
      XCP(IV)=BLX-FACC*CBL
      XTLR(IV)=TLRX-FACB*CTLR
      YTLR(IV)=TLRY
      ZTLR(IV)=TLRZ
      XTLL(IV)=TLLX-FACB*CTLL
      YTLL(IV)=TLLY
      ZTLL(IV)=TLLZ
      FTLXR(IV)=TLRX-FACC*CTLR
      FTLZR(IV)=TLRZ
      FTLXL(IV)=TLLX-FACC*CTLL
      FTLZL(IV)=TLLZ
      ELAREA(IV)=DCRD
      CONBR(IV)=TCONBR
      CONBL(IV)=TCONBL
   41 CONTINUE
   40 CONTINUE
C
C     LOOP OVER OTHER WING REGIONS IF PRESENT
C
      IF (NWREG.EQ.1) GO TO 100
      DO 50 N=2,NWREG
      WRITE (6,704) N
      READ (5,701) IIN,IOUT
      WRITE (6,710) Y(IIN),Y(IOUT)
      READ (5,711) NCW,NTCW,NUNI,CIN,TESWP
      NSW=IOUT-IIN
      NVOR=NSW*NCW
      WRITE (6,706) NVOR,NSW,NCW
      WRITE (6,712) CIN,TESWP
C
C     LAY OUT VORTICES FOR THIS REGION
C
      FNCW=NCW
      CTLL=CIN
      DUMA=TEMR/FNCW
C
C     LOOP OVER CHORDWISE ROWS
C
      IBEG=IIN+1
      DO 60 I=IBEG,IOUT
      IM=I-1
C
C     SHIFT VORTEX DATA SO NEW VORTICES CAN BE INSERTED
C
      NCWSUM=0
      DO 61 J=1,IM
   61 NCWSUM=NCWSUM+NCWI(J)
      MW=MW+NCW
      MTOT=MW
      NCWSUM=NCWSUM+1
      IF (I.EQ.IMAX) GO TO 63
      J=MW+1
      K=J-NCW
   62 J=J-1
      K=K-1
      XCP(J)=XCP(K)
      XTLR(J)=XTLR(K)
      YTLR(J)=YTLR(K)
      ZTLR(J)=ZTLR(K)
      XTLL(J)=XTLL(K)
      YTLL(J)=YTLL(K)
      ZTLL(J)=ZTLL(K)
      FTLXR(J)=FTLXR(K)
      FTLZR(J)=FTLZR(K)
      FTLXL(J)=FTLXL(K)
      FTLZL(J)=FTLZL(K)
      ELAREA(J)=ELAREA(K)
      CONBR(J)=CONBR(K)
      CONBL(J)=CONBL(K)
      ALPHAL(J)=ALPHAL(K)
      ALPHAL(K)=0.0
      IF (K.GT.NCWSUM) GO TO 62
   63 NCWI(IM)=NCWI(IM)+NCW
      TLRY=Y(IM)
      TLLY=Y(I)
      TLRZ=TLRY*TPHIW
      TLLZ=TLLY*TPHIW
      BLX=(XTE(I)+XTE(IM))*0.5
      TPSILE=TAN(PSIWTE(I)*DTOR)
      TPSITE=TAN(TESWP*DTOR)
      PSIWTE(I)=TESWP
      DPSI=TPSILE-TPSITE
      DY=TLLY-TLRY
      CTLR=CTLL
      CTLL=CTLR+DY*DPSI
      CBL=(CTLR+CTLL)*0.5
      DCRD=CBL/FNCW
      CHROLW(IM)=CHROLW(IM)+CBL
      TLRX=XTE(IM)
      TLLX=XTE(I)
      XTER(IM)=XTE(IM)-CTLR
      XTEL(IM)=XTE(I)-CTLL
      TCONBR=DUMA*CTLR
      TCONBL=DUMA*CTLL
      IF (NTCW.NE.0.AND.I.EQ.IBEG) READ (5,702) (XBL(M),M=1,NCW)
      IF (NTCW.NE.0.AND.I.GT.IBEG.AND.NUNI.EQ.0) READ (5,702) (XBL(M),
     1 M=1,NCW)
C
C     LOOP OVER VORTICES IN THIS ROW
C
```

```
      JJ=NCWSUM-1
      DO 70 J=1,NCW
      IV=JJ+J
      FJ=J
      FACB=(FJ-0.75)/FNCW
      FACC=(FJ-0.25)/FNCW
      XCP(IV)=BLX-FACC*CBL
      XTLR(IV)=TLRX-FACB*CTLR
      YTLR(IV)=TLRY
      ZTLR(IV)=TLRZ
      XTLL(IV)=TLLX-FACB*CTLL
      YTLL(IV)=TLLY
      ZTLL(IV)=TLLZ
      FTLXR(IV)=TLRX-FACC*CTLR
      FTLZR(IV)=TLRZ
      FTLXL(IV)=TLLX-FACC*CTLL
      FTLZL(IV)=TLLZ
      ELAREA(IV)=DCRD
      CONBR(IV)=TCONBR
      CONBL(IV)=TCONBL
      ALPHAL(IV)=0.0
      IF (NTCW.GT.0) ALPHAL(IV)=XBL(J)
   70 CONTINUE
   60 CONTINUE
   50 CONTINUE
C
C     CALCULATE OTHER WING VORTEX QUANTITIES
C
  100 DUM=0.5/CPHIW
      DO 101 J=1,MW
      XBL(J)=(XTLL(J)+XTLR(J))*0.5
      YBL(J)=(YTLL(J)+YTLR(J))*0.5
      ZBL(J)=(ZTLL(J)+ZTLR(J))*0.5
      YCP(J)=YBL(J)
      ZCP(J)=ZBL(J)
      TPSI(J)=(XTLR(J)-XTLL(J))/ (YTLR(J)-YTLL(J))*CPHIW
      BW(J)=DUM*(YTLR(J)-YTLL(J))
      ELAREA(J)=ELAREA(J)*BW(J)*2.0
      CONA(J)=TEMP*BW(J)
  101 CONTINUE
      RETURN
      END

      SUBROUTINE FLPLAT
C
C     THIS SUBROUTINE READS IN THE FLAP DATA AND LAYS OUT THE FLAP
C          VORTICES INCLUDING THE WING VORTEX SEGMENTS IN THE FLAPS
C
C     COMMON STATEMENTS
C
      COMMON /CPDAT/ ALPHAL(250),XCP(250),YCP(250),ZCP(250),
     1 CALPHL(250),SALPHL(250)
      COMMON /BLDAT/ XBL(250),YBL(250),ZBL(250),TPSI(250),BW(250)
      COMMON / WNGDAT/ Y(30),PSIWLE(30),PSIWTE(30),SPHIW,CPHIW,TPHIW
      COMMON /INDEX/ MSW,MW,MTOT,NCWI(30),IMAX,NFSEG(30),LASTF(30)
      COMMON /TLDAT/ XTER(30),XTEL(30),XTLR(250),YTLR(250),ZTLR(250),
     1 XTLL(250),YTLL(250),ZTLL(250)
      COMMON / INDEXF/ NFREG,NFLAPS,IDFLAP(10,2),NCF(10),MSF(10),MF(10),
     1MSTART(10),MEND(10),NFSEGF(10)
      COMMON /FLPDAT/ SDELXZ(10),CDELXZ(10),YF(30,10),SPHIF(10),
     1CPHIF(10)
      COMMON /WKDATW/ XWKRW(30,3),YWKRW(30,3),ZWKRW(30,3),XWKLW(30,3),
     1YWKLW(30,3),ZWKLW(30,3)
      COMMON /WKDATF/ XWKRF(30,2,10),YWKRF(30,2,10),ZWKRF(30,2,10),
     1XWKLF(30,2,10),YWKLF(30,2,10),ZWKLF(30,2,10)
      COMMON /FTLDAT/ FTLXR(250),FTLXL(250),FTLZR(250),FTLZL(250)
      COMMON /LDCONS/ CONA(250),CONBR(250),CONBL(250),TEMP,TEMR
      COMMON /CHORDS/ CHRDLW(30),CROOTF(10),CTIPF(10)
      COMMON /FLAPLE/XWILE(10),YWILE(10),ZWILE(10),SWPFLE(10)
      COMMON /PRSDAT/NPRESW,NPRESF(10),ELAREA(250),XLE(30)
C
C     FORMAT STATEMENTS
C
  701 FORMAT(1H1,4X,15HFLAP INPUT DATA)
  702 FORMAT(10I5)
  703 FORMAT(/10X,13HREGION NUMBER,I2/15X,9HTHERE ARE12,21H FLAPS IN THI
     1S REGION/15X,20HTHEY EXTEND FROM Y =,F10.5,7H TO Y =,F10.5)
  704 FORMAT(8F10.0)
  705 FORMAT(/15X,11HFLAP NUMBER,I3/20X,21HINBOARD EDGE GAP     =,F10.5/
     120X,21HOUTBOARD EDGE GAP    =,F10.5/20X,21HINBOARD EDGE CHORD  =,
     2F10.5/20X,21HOUTBOARD EDGE CHORD =,F10.5/20X,21HDEFLECTION ANGLE
     3  =,F10.5)
  706 FORMAT(/20XI3,41H VORTICES ARE TO BE LAID OUT ON THIS FLAP/25X,I2,
     112H SPANWISE BY,I3,10H CHORDWISE)
  707 FORMAT(/20X,21HSPANWISE LOCATIONS OF/21X,20HTRAILING VORTEX LEGS)
  708 FORMAT(25X,F11.5)
  709 FORMAT(/20X,41HXF,YF COORDINATES OF FOUR CORNERS OF FLAP/28X,
     1 25H(FLAP LIES IN ZF=0 PLANE)/33X,2HXF,11X,2HYF)
  710 FORMAT(25X,2F13.5)
C
C     CONSTANTS
C
      DATA DTOR/0.01745329/
C
      WRITE (6,701)
C
C     LOOP OVER REGIONS
C
      DO 100 NR=1,NFREG
      READ (5,702) NINREG,IIN,IOUT
      WRITE (6,703) NR,NINREG,Y(IIN),Y(IOUT)
      XTEDGI=XTER(IIN)
      YTEDGI=Y(IIN)
      ZTEDGI=YTEDGI*TPHIW
      XTEDGO=XTEL(IOUT-1)
      YTEDGO=Y(IOUT)
      ZTEDGO=YTEDGO*TPHIW
      ANG=0.0
C
C     LOOP OVER FLAPS IN THIS REGION
C
      DO 200 NF=1,NINREG
      NFLAPS=NFLAPS+1
      IDFLAP(NFLAPS,1)=NR
      IDFLAP(NFLAPS,2)=NF
      NFS=NFLAPS
      MSF(NFS)=IOUT-IIN
      NFSEGF(NFS)=NINREG-NF
      READ (5,702) NCF(NFS),          NTCF,NUNI,NPRESF(NFS)
      READ (5,704) GAPIN,CRFIN,GAPOUT,CRFOUT,DELXZ
      WRITE (6,705) NF,GAPIN,GAPOUT,CRFIN,CRFOUT,DELXZ
      CROOTF(NFS)=CRFIN
      CTIPF(NFS)=CRFOUT
      ANGR=ANG*DTOR
      SANG=SIN(ANGR)
      CANG=COS(ANGR)
      ANG=DELXZ
      XWIN=XTEDGI-GAPIN*CANG
      YWIN=YTEDGI
      ZWIN=ZTEDGI+GAPIN*SANG
      XWILE(NFS)=XWIN
      YWILE(NFS)=YWIN
      ZWILE(NFS)=ZWIN
      XWOUT=XTEDGO-GAPOUT*CANG
      YWOUT=YTEDGO
      ZWOUT=ZTEDGO+GAPOUT*SANG
      DELR=DELXZ*DTOR
      SDELR=SIN(DELR)
      CDELR=COS(DELR)
      SDELXZ(NFS)=SDELR
      CDELXZ(NFS)=CDELR
      XTEDGI=XWIN-CRFIN*CDELR
      ZTEDGI=ZWIN+CRFIN*SDELR
      XTEDGO=XWOUT-CRFOUT*CDELR
      ZTEDGO=ZWOUT+CRFOUT*SDELR
      NV=NCF(NFS)*MSF(NFS)
```

```
      MF(NFS)=NV
      MSTART(NFS)=MTOT+1
      MEND(NFS)=MTOT+NV
      MTOT=MEND(NFS)
      WRITE (6,706) NV,MSF(NFS),NCF(NFS)
      MSFP=MSF(NFS)+1
      WRITE (6,707)
      K=IIN-1
      DO 210 J=1,MSFP
      K=K+1
      YF(J,NFS)=Y(K)
  210 WRITE (6,708) YF(J,NFS)
      MS=MSTART(NFS)
      ME=MEND(NFS)
      NCFF=NCF(NFS)
      MSFF=MSF(NFS)
      IF (NTCF.NE.0) GO TO 212
      DO 211 K=MS,ME
  211 ALPHAL(K)=0.0
      GO TO 216
  212 IF (NUNI.NE.0) GO TO 214
      MN=MS-1
      DO 213 JNF=MS,ME,NCFF
      MN=MN+NCFF
  213 READ (5,704) (ALPHAL(K),K=JNF,MN)
      GO TO 216
  214 NCFL=MS+NCFF-1
      READ (5,704) (ALPHAL(K),K=MS,NCFL)
      MN=MS-1
      DO 215 K=2,MSFF
      KK=(K-1)*NCFF+MN
      DO 215 L=1,NCFF
      LL=KK+L
      LLL=L+MN
  215 ALPHAL(LL)=ALPHAL(LLL)
  216 CONTINUE
C
C     LAY OUT VORTICES
C
      DXW=XWOUT-XWIN
      DZW=ZWOUT-ZWIN
      XFO=DXW*CDELR-DZW*SDELR
      YFO=YWOUT-YWIN
      ZFO=DXW*SDELR+DZW*CDELR
      TPHIF=ZFO/YFO
      PHIF=ATAN(TPHIF)
      SPHIF(NFS)=SIN(PHIF)
      CPHIF(NFS)=COS(PHIF)
      TPSILE=XFO/YFO
      TPSITE=(XFO-CRFOUT+CRFIN)/YFO
      DPSI=TPSILE-TPSITE
      FNCFF=NCFF
      XLEI=0.0
      CTLL=CRFIN
      CPHI=CPHIF(NFS)
      SWPFLE(NFS)=ATAN(TPSILE *CPHI)
      WRITE (6,709)
      XFF=0.0
      YFF=0.0
      WRITE (6,710) XFF,YFF
      XFF=-CRFIN
      WRITE (6,710) XFF,YFF
      XFF=XFO
      YFF=YFO/CPHI
      WRITE (6,710) XFF,YFF
      XFF=XFO-CRFOUT
      WRITE (6,710) XFF,YFF
      KK=MS-1
C
C     LOOP OVER CHORDWISE ROWS
C
      DO 220 I=2,MSFP
      IM=I-1
      TLRY=YF(IM,NFS)
      TLLY=YF(I,NFS)
      TLRZ=(TLRY-YWIN)*TPHIF
      TLLZ=(TLLY-YWIN)*TPHIF
      DY=TLLY-TLRY
      XLEIM=XLEI
      XLEI=XLEIM+DY*TPSILE
      BLX=(XLEI+XLEIM)*0.5
      CTLR=CTLL
      CTLL=CTLR+DY*DPSI
      CBL=(CTLL+CTLR)*0.5
      DCHD=CBL/FNCFF
      BLZ=(TLRZ+TLLZ)*0.5
      BLY=(TLRY+TLLY)*0.5
      S=-0.5*DY/CPHI
      ELARE=DCHD*S*2.0
      TCONA=TEMP*S
      TCONBL=TEMR*CTLL/FNCFF
      TCONBR=TEMR*CTLR/FNCFF
C
C     LOOP OVER VORTICES IN THIS ROW
C
      DUMA=BLZ *SDELR+XWIN
      DUMB=TLRZ*SDELR+XWIN
      DUMC=TLLZ*SDELR+XWIN
      DUMD=BLZ *CDELR+ZWIN
      DUME=TLRZ*CDELR+ZWIN
      DUMF=TLLZ*CDELR+ZWIN
      DO 230 K=1,NCFF
      KK=KK+1
      FK=K
      FACB=(FK-0.75)/FNCFF
      FACC=(FK-0.25)/FNCFF
      XCPF=BLX-FACC*CBL
      XTLRF=XLEIM-CTLR*FACB
      XTLLF=XLEI-CTLL*FACB
      FXTLR=XLEIM-CTLR*FACC
      FXTLL=XLEI-CTLL*FACC
      XCP(KK)=XCPF*CDELR+DUMA
      XTLR(KK)=XTLRF*CDELR+DUMB
      XTLL(KK)=XTLLF*CDELR+DUMC
      FTLXR(KK)=FXTLR*CDELR+DUMB
      FTLXL(KK)=FXTLL*CDELR+DUMC
      XBL(KK)=(XTLR(KK)+XTLL(KK))*0.5
      YCP(KK)=BLY
      YTLR(KK)=TLRY
      YTLL(KK)=TLLY
      YBL(KK)=BLY
      ZCP(KK)=-XCPF*SDELR+DUMD
      ZTLR(KK)=-XTLRF*SDELR+DUME
      ZTLL(KK)=-XTLLF*SDELR+DUMF
      FTLZR(KK)=-FXTLR*SDELR+DUME
      FTLZL(KK)=-FXTLL*SDELR+DUMF
      ZBL(KK)=(ZTLR(KK)+ZTLL(KK))*0.5
      SW(KK)=S
      ELAREA(KK)=ELARE
      TPSI(KK)=(TPSILE-FACB*DPSI)*CPHI
      CONA(KK)=TCONA
      CONBR(KK)=TCONBR
      CONBL(KK)=TCONBL
  230 CONTINUE
  220 CONTINUE
C
C     LOCATE INTERSECTION OF WING TRAILING LEGS WITH THIS FLAP
C
      DXW=XWOUT-XWIN
      DYW=YWOUT-YWIN
      DZW=ZWOUT-ZWIN
      IOUTM=IOUT-1
      DO 240 J=IIN,IOUTM
      JP=J+1
      IF (NF.EQ.NINREG) LASTF(J)=NFS
      YY=Y(J)
      FAC=(YY-YWIN)/DYW
      XWKRW(J,NF)=XWIN+FAC*DXW
      YWKRW(J,NF)=YY
      ZWKRW(J,NF)=ZWIN+FAC*DZW
      YY=Y(JP)
      FAC=(YY-YWIN)/DYW
      XWKLW(J,NF)=XWIN+FAC*DXW
      YWKLW(J,NF)=YY
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      ZWKLW(J,NF)=ZWIN+FAC*DZW
  240 CONTINUE
C
C     LOCATE INTERSECTION OF UPSTREAM FLAPS TRAILING LEGS WITH THIS FLAP
C
      IF (NF.EQ.1) GO TO 270
      NFF=NF
      JF=NFS-NFF+1
      JFF=NFS-1
C
C     LOOP OVER UPSTREAM FLAPS
C
      DO 250 K=JF,JFF
      MSFU=MSF(K)
      NS=JFF-K+1
C
C     LOOP OVER Y LOCATIONS OF TRAILING LEGS ON THIS UPSTREAM FLAP
C
      DO 260 J=1,MSFU
      JP=J+1
      YY=YF(J,JF)
      FAC=(YY-YWIN)/DYW
      XWKRF(J,NS,K)=XWIN+FAC*DXW
      YWKRF(J,NS,K)=YY
      ZWKRF(J,NS,K)=ZWIN+FAC*DZW
      YY=YF(JP,JF)
      FAC=(YY-YWIN)/DYW
      XWKLF(J,NS,K)=XWIN+FAC*DXW
      YWKLF(J,NS,K)=YY
      ZWKLF(J,NS,K)=ZWIN+FAC*DZW
  260 CONTINUE
  250 CONTINUE
  270 CONTINUE
  200 CONTINUE
  100 CONTINUE
      RETURN
      END




      SUBROUTINE INFMAT
C
C     CALCULATES INFLUENCE COEFFICIENT MATRIX
C
C     COMMON STATEMENTS
C
      COMMON FVN(1)
      COMMON /FLPDAT/ SDELXZ(10),CDELXZ(10),YF(30,10),SPHIF(10),
     1CPHIF(10)
      COMMON /WKDATW/ XWKRW(30,3),YWKRW(30,3),ZWKRW(30,3),XWKLW(30,3),
     1YWKLW(30,3),ZWKLW(30,3)
      COMMON /WKDATF/ XWKRF(30,2,10),YWKRF(30,2,10),ZWKRF(30,2,10),
     1XWKLF(30,2,10),YWKLF(30,2,10),ZWKLF(30,2,10)
      COMMON / WNGDAT/ Y(30),PSIWLE(30),PSINTE(30),SPHIW,CPHIW,TPHIW
      COMMON /INDEX/ MSW,MW,MTOT,NCWI(30),IMAX,NFSEG(30),LASTF(30)
      COMMON /CPDAT/ ALPHAL(250),XCP(250),YCP(250),ZCP(250),
     1 CALPHL(250),SALPHL(250)
      COMMON /TLDAT/ XTER(30),XTEL(30),XTLR(250),YTLR(250),ZTLR(250),
     1 XTLL(250),YTLL(250),ZTLL(250)
      COMMON /FLVFRG/X1,Y1,Z1,X2,Y2,Z2,XP,YP,ZP,FU,FV,FW,AX,AZ
      COMMON / INDEXF/ NFREG,NFLAPS,IDFLAP(10,2),NCF(10),MSF(10),MF(10),
     1MSTART(10),MEND(10),NFSEGF(10)
C
C     LOOP OVER ALL CONTROL POINTS
C
      JFLAP=1
      CPHF=CPHIF(1)
      SPHF=SPHIF(1)
      CDXZB=CDELXZ(1)
      SDXZB=SDELXZ(1)
      DO 200 J=1,MTOT
      XP=XCP(J)
      YP=YCP(J)
      ZP=ZCP(J)
      IBASE=0
      CALF=CALPHL(J)
      SALF=SALPHL(J)
      IF (J.LE.MW) GO TO 40
      IF (J.LE.MEND(JFLAP)) GO TO 30
      JFLAP=JFLAP+1
      CPHF=CPHIF(JFLAP)
      SPHF=SPHIF(JFLAP)
      CDXZB=CDELXZ(JFLAP)
      SDXZB=SDELXZ(JFLAP)
C
C     FLAP BOUNDARY CONDITION FACTORS
C
   30 RW=CPHF*CALF*CDXZB-SALF*SDXZB
      RV=-SPHF*CALF
      RU=SALF*CDXZB+CPHF*CALF*SDXZB
      GO TO 50
C
C     WING BOUNDARY CONDITION FACTORS
C
   40 RV=-SPHIW*CALF
      RW=CPHIW*CALF
      RU=SALF
   50 CONTINUE
C
C     LOOP OVER CHORDWISE ROWS OF WING VORTICES
C
      DO 150 ISW=1,MSW
      AFTU=0.
      AFTV=0.
      AFTW=0.
      LF=LASTF(ISW)
      NAFT=NFSEG(ISW)
      IF(NAFT.EQ.0) GO TO 125
      IF(NAFT.EQ.1) GO TO 122
C
C     CONTRIBUTION OF FINITE TRAILING LEGS IN FLAPS AFT OF THIS ROW.
C
      NAFTM=NAFT-1
      DO 120 IAS=1,NAFTM
      IASP=IAS+1
      X1=XWKRW(ISW,IAS)
      Y1=YWKRW(ISW,IAS)
      Z1=ZWKRW(ISW,IAS)
      X2=XWKRW(ISW,IASP)
      Y2=YWKRW(ISW,IASP)
      Z2=ZWKRW(ISW,IASP)
      CALL FLVF
      AFTU=AFTU+FU
      AFTV=AFTV+FV
      AFTW=AFTW+FW
      X1=XWKLW(ISW,IAS)
      Y1=YWKLW(ISW,IAS)
      Z1=ZWKLW(ISW,IAS)
      X2=XWKLW(ISW,IASP)
      Y2=YWKLW(ISW,IASP)
      Z2=ZWKLW(ISW,IASP)
      CALL FLVF
      AFTU=AFTU-FU
      AFTV=AFTV-FV
      AFTW=AFTW-FW
  120 CONTINUE
C
C     CONTRIBUTION OF SEMI-INFINITE TRAILING LEGS IN LAST AFT FLAP
C
  122 AX=-CDELXZ(LF)
      AZ=SDELXZ(LF)
      X1=XWKRW(ISW,NAFT)
      Y1=YWKRW(ISW,NAFT)
      Z1=ZWKRW(ISW,NAFT)
      CALL SIVF
      AFTU=AFTU-FU
      AFTV=AFTV-FV
      AFTW=AFTW-FW
```

```
      X1=XWKLW(ISW,NAFT)
      Y1=YWKLW(ISW,NAFT)
      Z1=ZWKLW(ISW,NAFT)
      CALL SIVF
      AFTU=AFTU+FU
      AFTV=AFTV+FV
      AFTW=AFTW+FW
  125 CONTINUE
C
C     LOOP OVER VORTICES IN THIS ROW
C
      NCWC=NCWI(ISW)
      DO 140 ICW=1,NCWC
      I=IBASE+ICW
C
C     CONTRIBUTION OF BOUND LEG
C
      X1=XTLL(I)
      X2=XTLR(I)
      Y1=YTLL(I)
      Y2=YTLR(I)
      Z1=ZTLL(I)
      Z2=ZTLR(I)
      CALL FLVF
      UTOT=FU
      VTOT=FV
      WTOT=FW
      IF(NAFT.NE.0) GO TO 135
C
C     NO SURFACES BEHIND THIS WING ROW - TRAILING LEGS IN WING PLANE
C
      AX=-1.0
      AZ=0.
      CALL SIVF
      UTOT=UTOT+FU
      VTOT=VTOT+FV
      WTOT=WTOT+FW
      X1=X2
      Y1=Y2
      Z1=Z2
      CALL SIVF
      UTOT=UTOT-FU
      VTOT=VTOT-FV
      WTOT=WTOT-FW
      GO TO 136
C
C     THERE ARE FLAPS BEHIND THIS ROW,  COMPUTE INFLUENCE OF
C     FINITE TRAILING LEGS IN THE WING PLANE
C
  135 X1=XTLR(I)
      Y1=YTLR(I)
      Z1=ZTLR(I)
      X2=XWKRW(ISW,1)
      Y2=YWKRW(ISW,1)
      Z2=ZWKRW(ISW,1)
      CALL FLVF
      UTOT=UTOT+FU
      VTOT=VTOT+FV
      WTOT=WTOT+FW
      X1=XTLL(I)
      Y1=YTLL(I)
      Z1=ZTLL(I)
      X2=XWKLW(ISW,1)
      Y2=YWKLW(ISW,1)
      Z2=ZWKLW(ISW,1)
      CALL FLVF
      UTOT=UTOT-FU
      VTOT=VTOT-FV
      WTOT=WTOT-FW
C
C     ADD CONTRIBUTIONS FROM PANELS AFT OF WING
C
      UTOT=UTOT+AFTU
      VTOT=VTOT+AFTV
      WTOT=WTOT+AFTW
  136 JJ=(I-1)*MTOT+J
      FVN(JJ)=UTOT*RU+VTOT*RV+WTOT*RW
  140 CONTINUE
      IBASE=IBASE+NCWC
  150 CONTINUE
      IF(NFLAPS.EQ.0) GO TO 200
C
C     INFLUENCE OF FLAP VORTICES -- LOOP OVER FLAPS
C
      DO 190 IFL=1,NFLAPS
      NAFT=NFBEGF(IFL)
      LFLP=IFL+NAFT
C
C     LOOP OVER CHORDWISE ROWS ON THIS FLAP
C
      MSFF=MSF(IFL)
      CDX=CDELXZ(IFL)
      SDX=SDELXZ(IFL)
      NCFF=NCF(IFL)
      MST=MSTART(IFL)
      DO 175 ISW=1,MSFF
      AFTU=0.
      AFTV=0.
      AFTW=0.
      IBASS=MST+(ISW-1)*NCFF-1
      IF(NAFT.EQ.0) GO TO 163
      IF(NAFT.EQ.1) GO TO 161
C
C     TWO FLAPS BEHIND THIS ONE -- COMPUTE INFLUENCE OF FINITE
C     TRAILING LEGS ON THE FIRST ONE.
C
      X1=XWKRF(ISW,1,IFL)
      Y1=YWKRF(ISW,1,IFL)
      Z1=ZWKRF(ISW,1,IFL)
      X2=XWKRF(ISW,2,IFL)
      Y2=YWKRF(ISW,2,IFL)
      Z2=ZWKRF(ISW,2,IFL)
      CALL FLVF
      AFTU=AFTU+FU
      AFTV=AFTV+FV
      AFTW=AFTW+FW
      X1=XWKLF(ISW,1,IFL)
      Y1=YWKLF(ISW,1,IFL)
      Z1=ZWKLF(ISW,1,IFL)
      X2=XWKLF(ISW,2,IFL)
      Y2=YWKLF(ISW,2,IFL)
      Z2=ZWKLF(ISW,2,IFL)
      CALL FLVF
      AFTU=AFTU-FU
      AFTV=AFTV-FV
      AFTW=AFTW-FW
C
C     CONTRIBUTION OF SEMI-INFINITE TRAILING LEGS IN LAST FLAP AFT OF
C     THIS ONE
C
  161 X1=XWKRF(ISW,NAFT,IFL)
      Y1=YWKRF(ISW,NAFT,IFL)
      Z1=ZWKRF(ISW,NAFT,IFL)
      AX=-CDELXZ(LFLP)
      AZ=SDELXZ(LFLP)
      CALL SIVF
      AFTU=AFTU-FU
      AFTV=AFTV-FV
      AFTW=AFTW-FW
      X1=XWKLF(ISW,NAFT,IFL)
      Y1=YWKLF(ISW,NAFT,IFL)
      Z1=ZWKLF(ISW,NAFT,IFL)
      CALL SIVF
      AFTU=AFTU+FU
      AFTV=AFTV+FV
      AFTW=AFTW+FW
C
C     LOOP OVER VORTICES IN THIS ROW
C
  163 CONTINUE
      DO 170 ICW=1,NCFF
C
C     INFLUENCE OF BOUND LEG
C
```

```
      I=IBASS+ICW
      X1=XTLL(I)
      Y1=YTLL(I)
      Z1=ZTLL(I)
      X2=XTLR(I)
      Y2=YTLR(I)
      Z2=ZTLR(I)
      CALL FLVF
      UTOT=FU
      VTOT=FV
      WTOT=FW
      IF(NAFT.NE.0) GO TO 165
C
C     NO FLAPS BEHIND THIS ONE.  COMPUTE INFLUENCE OF SEMI-INFINITE
C     TRAILING LEGS IN THE PLANE OF THIS FLAP.
C
      AX=-CDX
      AZ=SDX
      CALL SIVF
      UTOT=UTOT+FU
      VTOT=VTOT+FV
      WTOT=WTOT+FW
      X1=X2
      Y1=Y2
      Z1=Z2
      CALL SIVF
      UTOT=UTOT-FU
      VTOT=VTOT-FV
      WTOT=WTOT-FW
      GO TO 167
C
C     THERE ARE FLAPS BEHIND THIS ONE.  COMPUTE THE INFLUENCE OF
C     FINITE TRAILING LEGS INT THIS FLAP
C
  165 X1=XTLR(I)
      Y1=YTLR(I)
      Z1=ZTLR(I)
      X2=XWKRF(ISW,1,IFL)
      Y2=YWKRF(ISW,1,IFL)
      Z2=ZWKRF(ISW,1,IFL)
      CALL FLVF
      UTOT=UTOT+FU
      VTOT=VTOT+FV
      WTOT=WTOT+FW
      X1=XTLL(I)
      Y1=YTLL(I)
      Z1=ZTLL(I)
      X2=XWKLF(ISW,1,IFL)
      Y2=YWKLF(ISW,1,IFL)
      Z2=ZWKLF(ISW,1,IFL)
      CALL FLVF
      UTOT=UTOT-FU
      VTOT=VTOT-FV
      WTOT=WTOT-FW
      UTOT=UTOT+AFTU
      VTOT=VTOT+AFTV
      WTOT=WTOT+AFTW
  167 JJ=(I-1)*MTOT+J
      FVN(JJ)=UTOT*RU+VTOT*RV+WTOT*RW
  170 CONTINUE
  175 CONTINUE
  190 CONTINUE
  200 CONTINUE
C
C     LOOP OVER FLAP CONTROL POINTS
C
      RETURN
      END
```

```
      SUBROUTINE FLVF
C
C     APPLIES EQUATIONS FOR FINITE LENGTH VORTEX FILAMENT
C     INFLUENCE FUNCTIONS.  TAKE FROM BOEING REPORT D6-9244
C     BY RUBBERT PP. 88-89
C
C
C     COMMON STATEMENTS
C
      COMMON /TOLRNC/ TOL
      COMMON /FLVFRG/X1,Y1,Z1,X2,Y2,Z2,XP,YP,ZP,FU,FV,FW,AX,AZ
C
      XPO=XP-X1
      XTO=X2-X1
      XPT=XP-X2
      ZPO=ZP-Z1
      ZTO=Z2-Z1
      ZPT=ZP-Z2
      SPT=XPT*XPT+ZPT*ZPT
      SPO=XPO*XPO+ZPO*ZPO
      B=ZTO*XPO-XTO*ZPO
      BSQ=B*B
      FU=0.0
      FV=0.0
      FW=0.0
      SIGN=1.0
      YPO=YP-Y1
      YTO=Y2-Y1
      YPT=YP-Y2
      ELSQ=XTO*XTO+YTO*YTO+ZTO*ZTO
      EL=SQRT(ELSQ)
      DO 100 K=1,2
      A=YTO*ZPO-ZTO*YPO
      C=XTO*YPO-YTO*XPO
      RADCL=SQRT(A*A+BSQ+C*C)
      IF (RADCL.LE.TOL) GO TO 90
      R1SQ=SPO+YPO*YPO
      R2SQ=SPT+YPT*YPT
      R1=SQRT(R1SQ)
      R2=SQRT(R2SQ)
      RSD=R1SQ-R2SQ
      CSTH1=(RSD+ELSQ)/(2.0*EL*R1)
      CSTH2=(RSD-ELSQ)/(2.0*EL*R2)
      RR=R2*SQRT(1.0-CSTH2*CSTH2)
      FAC=SIGN*(CSTH1-CSTH2)/(RR*RADCL)
      FU=FU+A*FAC
      FV=FV+B*FAC
      FW=FW+C*FAC
   90 YTO=-YTO
      YPO=YP+Y1
      YPT=YP+Y2
  100 SIGN=-1.0
      RETURN
      END
```

```
      SUBROUTINE SIVF
C
C     INFLUENCE FUNCTIONS ,  REFERENCE -- RUBBERT PP. 88-89
C     APPLIES EQUATIONS FOR SEMI-INFINITE VORTEX FILAMENT
C
C     COMMON STATEMENTS
      COMMON /TOLRNC/ TOL
      COMMON /FLVFRG/X1,Y1,Z1,X2,Y2,Z2,XP,YP,ZP,FU,FV,FW,AX,AZ
C
      XX=XP-X1
      ZZ=ZP-Z1
      E=AZ*XX-AX*ZZ
      CUP=-(AX*XX+AZ*ZZ)
      XSPZS=XX*XX+ZZ*ZZ
```

```
      YY=YP-Y1
      FU=0.0
      FV=0.0
      FW=0.0
      SIGN=1.0
      DO 100 K=1,2
      D=-AZ*YY
      F=AX*YY
      RADCL=SQRT(D*D+E*E+F*F)
      IF (RADCL.LE.TOL) GO TO 90
      BIGR=SQRT(YY*YY+XSPZS)
      CSTHT=CUP/BIGR
      SHLR=BIGR*SQRT(1.0-CSTHT*CSTHT)
      FACT=(CSTHT-1.0)/(SHLR*RADCL)*SIGN
      FU=FU+D*FACT
      FV=FV+E*FACT
      FW=FW+F*FACT
   90 YY=YP+Y1
  100 SIGN=-1.0
      RETURN
      END
```

```
      SUBROUTINE RHSCLC(EXVEL)
C
C     THIS SUBROUTINE CALCULATES THE RIGHT HAND SIDE OF
C     THE EQUATIONS FOR HORSESHOE VORTEX STRENGTHS.
C     THE ARGUMENT EXVEL IS TRUE IF EXTERNALLY INDUCED
C     VELOCITIES ARE TO BE INCLUDED IN THE CALCULATION.
C
      LOGICAL EXVEL
C
C     COMMON STATEMENTS
C
      COMMON / INDEXF/ NFREG,NFLAPS,IDFLAP(10,2),NCF(10),MSF(10),MF(10),
     1MSTART(10),MEND(10),NFSEGF(10)
      COMMON /FLPDAT/ SDELXZ(10),CDELXZ(10),YF(30,10),SPHIF(10),
     1CPHIF(10)
      COMMON / WNGDAT/ Y(30),PSIWLE(30),PSIWTE(30),SPHIW,CPHIW,TPHIW
      COMMON /INDEX/ MSW,MW,MTOT,NCWI(30),IMAX,NFSEG(30),LASTF(30)
      COMMON /CPDAT/ ALPHAL(250),XCP(250),YCP(250),ZCP(250),
     1 CALPHL(250),SALPHL(250)
      COMMON /RSIDE/ CIR(250),UEI(250),VEI(250),WEI(250)
      COMMON /ATAK/SINALF,COSALF
C
C     RIGHT HAND SIDE FOR WING CONTROL POINTS
      IF(EXVEL) GO TO 45
C
C     LOOP OVER WING CONTROL POINTS FOR CASE WITH NO EXTERNALLY
C     INDUCED VELOCITIES
C
      SACP=SINALF*CPHIW
      DO 40 J=1,MW
   40 CIR(J)=   SACP     *CALPHL(J) + COSALF*SALPHL(J)
      GO TO 55
C
C     LOOP OVER WING CONTROL POINTS FOR CASE WITH EXTERNALLY INDUCED
C     VELOCITIES INCLUDED
C
   45 CONTINUE
      DO 50 J=1,MW
   50 CIR(J)=((SINALF-WEI(J))*CPHIW + VEI(J)*SPHIW)*CALPHL(J)
     1 +(COSALF-UEI(J))*SALPHL(J)
   55 IF(NFLAPS.EQ.0) RETURN
C
C     RIGHT HAND SIDE FOR FLAP CONTROL POINTS (IF PRESENT)
C
C     LOOP OVER FLAPS
C
      DO 90 JF=1,NFLAPS
      CPH=CPHIF(JF)
      SPH=SPHIF(JF)
      CDXZ=CDELXZ(JF)
      SDXZ=SDELXZ(JF)
      CADX=CDXZ*COSALF-SDXZ*SINALF
      SADX=CDXZ*SINALF+SDXZ*COSALF
      DA=SADX*CPH
      DC=CPH*CDXZ
      DD=CPH*SDXZ
      MS=MSTART(JF)
      ME=MEND(JF)
      IF(EXVEL) GO TO 75
C
C     LOOP OVER CONTROL POINTS ON FLAP WITHOUT EXTERNALLY INDUCED
C     VELOCITIES
C
      DO 70 J=MS,ME
   70 CIR(J)=DA*CALPHL(J)+CADX*SALPHL(J)
      GO TO 90
C
C     LOOP OVER CONTROL POINTS ON THIS FLAP FOR CASE WITH EXTERNALLY
C     INDUCED VELOCITIES INCLUDED
C
   75 CONTINUE
      DO 80 J=MS,ME
      CAL=CALPHL(J)
      SAL=SALPHL(J)
   80 CIR(J)=DA*CAL+CADX*SAL-WEI(J)*(DC*CAL-SDXZ*SAL)
     1  + VEI(J)*SPH*CAL - UEI(J)*(SAL*CDXZ+DD*CAL)
   90 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE LINEQS(N,A)
      DIMENSION A(N,N),IP(300)
      COMMON /LINSOL/IP
      IP(N)=1
      DO 6 K=1,N
      IF(K.EQ.N)GO TO 5
      KP1=K+1
      M=K
      DO 1 I=KP1,N
    1 CONTINUE
      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 SOLVE (B,A,N)
      DIMENSION B(1)
      DIMENSION A(N,N)
      COMMON /LINSOL/IP(300)
      IF(N.EQ.1)GO TO 9
      NM1=N-1
      DO 7 K=1,NM1
      KP1=K+1
      M=IP(K)
      T=B(M)
      B(M)=B(K)
      B(K)=T
      DO 7 I=KP1,N
    7 B(I)=B(I)+A(I,K)*T
      DO 8 KB=1,NM1
      KM1=N-KB
      K=KM1+1
      B(K)=B(K)/A(K,K)
      T=-B(K)
      DO 8 I=1,KM1
    8 B(I)=B(I)+A(I,K)*T
    9 B(1)=B(1)/A(1,1)
      RETURN
      END
```

```
      SUBROUTINE LOAD(EXVEL)
C
C     COMMON STATEMENTS
      COMMON /VORFOR/CXBL(250),CYBL(250),CZBL(250),CYTLL(250),CYTLR(250)
     1  ,  CZTLL(250),CZTLR(250)
      COMMON /RVELS/UP,VP,WP
      COMMON /RSIDE/ CIR(250),UEI(250),VEI(250),WEI(250)
      COMMON /BLDAT/ XBL(250),YBL(250),ZBL(250),TPSI(250),SW(250)
      COMMON / WNGDAT/ Y(30),PSIWLE(30),PSIWTE(30),SPHIW,CPHIW,TPHIW
      COMMON /INDEX/ MSW,MW,MTOT,NCWI(30),IMAX,NFSEG(30),LASTF(30)
      COMMON /TLDAT/ XTER(30),XTEL(30),XTLR(250),YTLR(250),ZTLR(250),
     1 XTLL(250),YTLL(250),ZTLL(250)
      COMMON /ATAK/ SINALF,COSALF
      COMMON / INDEXF/ NFREG,NFLAPS,IDFLAP(10,2),NCF(10),MSF(10),MF(10),
     1MSTART(10),MEND(10),NFSEGF(10)
      COMMON /FLPDAT/ SDELXZ(10),CDELXZ(10),YF(30,10),SPHIF(10),
     1CPHIF(10)
      COMMON /FTLDAT/ FTLXR(250),FTLXL(250),FTLZR(250),FTLZL(250)
      COMMON /LDCONS/ CONA(250),CONBR(250),CONBL(250),TEMP,TEMR
C
      LOGICAL EXVEL
      DIMENSION VL(10),VR(10),WR(10),WL(10),            GAMFWR(30),
     1              GAMFAR(30),GAMSUM(30)
C
C     CALCULATE FORCE COMPONENTS IN -X, Y, AND -Z DIRECTIONS AT
C     BOUND LEG MIDPOINTS ON WING
C
C
      CPSA=CPHIW*SINALF
      SPCA=SPHIW*COSALF
      CPCA=COSALF*CPHIW
      DO 100 JW=1,MW
      TPSJ=TPSI(JW)
      CALL VELSUM(XBL(JW),YBL(JW),ZBL(JW))
      IF(.NOT.EXVEL) GO TO 10
      UP=UP+UEI(JW)
      VP=VP+VEI(JW)
      WP=WP+WEI(JW)
   10 FACT=CONA(JW)*CIR(JW)
      CXBL(JW)=-FACT*(CPSA-WP*CPHIW+VP*SPHIW)
      CYBL(JW)=FACT*(SPCA-UP*SPHIW+(WP-SINALF)*TPSJ)
      CZBL(JW)=FACT*(VP*TPSJ+CPCA-UP*CPHIW)
  100 CONTINUE
      IF(NFLAPS.EQ.0) GO TO 201
C
C     BOUND LEG MIDPOINTS ON FLAPS
C
C     LOOP OVER FLAPS
C
      DO 200 JF=1,NFLAPS
      CDXZ=CDELXZ(JF)
      SDXZ=SDELXZ(JF)
      CSUM=CDXZ*COSALF-SDXZ*SINALF
      SSUM=CDXZ*SINALF+SDXZ*COSALF
      CPH=CPHIF(JF)
      SPH=SPHIF(JF)
      CPSAF=CPH*SSUM
      SPCAF=SPH*CSUM
      CPCAF=CSUM*CPH
      MS=MSTART(JF)
      ME=MEND(JF)
C
C     LOOP OVER BOUND LEG MIDPOINTS ON THIS FLAP
C
      DO 190 JC=MS,ME
      TPSJ=TPSI(JC)
      CALL VELSUM(XBL(JC),YBL(JC),ZBL(JC))
      IF(.NOT.EXVEL) GO TO 110
      UP=UP+UEI(JC)
      VP=VP+VEI(JC)
      WP=WP+WEI(JC)
C
C     ROTATE U AND W TO LIE IN THIS FLAP COORDINATE SYSTEM
C
  110 WU=UP
      WW=WP
      UP=WU*CDXZ-WW*SDXZ
      WP=WW*CDXZ+WU*SDXZ
      FACT=CIR(JC)*CONA(JC)
      CXBL(JC)=FACT*(WP*CPH-CPSAF-VP*SPH)
      CYBL(JC)=FACT*(SPCAF-UP*SPH+(WP-SSUM)*TPSJ)
      CZBL(JC)=FACT*(VP*TPSJ+CPCAF-UP*CPH)
  190 CONTINUE
  200 CONTINUE
  201 CONTINUE
C
C     LOADS ON WING TRAILING LEG POINTS
C
      NCWC=NCWI(1)
      DO 50 ICW=1,NCWC
      CALL VELSUM(FTLXR(ICW),YTLR(ICW),FTLZR(ICW))
      IF(.NOT.EXVEL) GO TO 20
      VP=VP+VEI(ICW)
      WP=WP+WEI(ICW)
   20 VR(ICW)=VP
      WR(ICW)=WP
      CALL VELSUM(FTLXL(ICW),YTLL(ICW),FTLZL(ICW))
      IF(.NOT.EXVEL) GO TO 30
      VP=VP+VEI(ICW)
      WP=WP+WEI(ICW)
   30 VL(ICW)=VP
   50 WL(ICW)=WP
C
C     LOOP OVER WING CHORDWISE ROWS
C
      IBASE=0
      DO 1200 ISW=1,MSW
      NCWC=NCWI(ISW)
      IF(ISW.EQ.1) GO TO 95
      NCWM=NCWI(ISW-1)
      JU=MINO(NCWC,NCWM)
      DO 60 J=1,JU
      VR(J)=VL(J)
   60 WR(J)=WL(J)
      IF(NCWC.LE.NCWM) GO TO 66
      JL=NCWM+1
      DO 65 J=JL,NCWC
      I=IBASE+J
      CALL VELSUM(FTLXR(I),YTLR(I),FTLZR(I))
      IF(.NOT.EXVEL) GO TO 62
      VP=VP+VEI(I)
      WP=WP+WEI(I)
   62 VR(J)=VP
```

```
   65 WR(J)=WP
   66 CONTINUE
      DO 70 J=1,NCWC
      I=IBASE+J
      CALL VELSUM(FTLXL(I),YTLL(I),FTLZL(I))
      IF(.NOT.EXVEL) GO TO 68
      VP=VP+VEI(I)
      WP=WP+WEI(I)
   68 VL(J)=VP
   70 WL(J)=WP
C
   95 DELGAM=0.0
      DO 1100 ICW=1,NCWC
      I=IBASE+ICW
      CIRR=CIR(I)
      DUMA=DELGAM+0.75*CIRR
      FACL=DUMA*CONBL(I)
      FACR=-DUMA*CONBR(I)
      CYTLL(I)=FACL*(WL(ICW)-SINALF)
      CYTLR(I)=FACR*(WR(ICW)-SINALF)
      IF (ISW.EQ.1) CYTLR(I)=-CYTLL(I)
      CZTLL(I)=FACL*VL(ICW)
      CZTLR(I)=FACR*VR(ICW)
      DELGAM=DELGAM+CIRR
 1100 CONTINUE
      GAMSUM(ISW)=DELGAM
 1200 IBASE=IBASE+NCWC
C
C     TRAILING LEG LOADS ON FLAPS -- LOOP OVER FLAPS
C
      IF(NFLAPS.EQ.0) RETURN
      DO 800 IFL=1,NFLAPS
      IF(ISFLAP(IFL,2).GT.1) GO TO 312
C
C     THIS IS THE FIRST FLAP AFT OF THE WING.  COMPUTE GAMMA
C     CONTRIBUTIONS FROM WING VORTICES AHEAD
C
      MS=MSTART(IFL)
      MSFF=MSF(IFL)
      NCFF=NCF(IFL)
      YSTRTF=YF(1,IFL)
      DO 305 ISWW=1,MSW
      JSW=ISWW
      IF (Y(ISWW).LE.YSTRTF) GO TO 306
  305 CONTINUE
  306 GAMFWR(1)=GAMSUM(JSW)
      DO 307 ISWF=2,MSFF
      JSW=JSW-1
      GAMFWR(ISWF)=GAMSUM(JSW)
  307 CONTINUE
      GO TO 390
C
C     THERE IS A FLAP AHEAD OF THIS ONE.  COMPUTE GAMMA CONTRIBUTIONS
C     FROM THE FLAP AHEAD
C
C     LOOP OVER CHORDWISE ROWS ON THIS FLAP
C
  312 IFLM=IFL-1
      NCFF=NCF(IFL)
      MSFF=MSF(IFL)
      MS=MSTART(IFL)
      DO 335 ISWF=1,MSFF
      GAMFWR(ISWF)=GAMFAR(ISWF)
  335 CONTINUE
  390 CONTINUE
C
C     COMPUTE THE TRAILING LEG LOADS ON THIS FLAP
C
      CDXZ=CDELXZ(IFL)
      SDXZ=SDELXZ(IFL)
      SALFP=SINALF*CDXZ+COSALF*SDXZ
C
C     RIGHT AND LEFT VELOCITIES ON FIRST ROW OF THIS FLAP
C
      II=MS-1
      DO 398 ICW=1,NCFF
      I=II+ICW
      CALL VELSUM(FTLXR(I),YTLR(I),FTLZR(I))
      IF(.NOT.EXVEL) GO TO 395
      UP=UP+UEI(I)
      VP=VP+VEI(I)
      WP=WP+WEI(I)
  395 WR(ICW)=WP*CDXZ+UP*SDXZ
      VR(ICW)=VP
      CALL VELSUM(FTLXL(I),YTLL(I),FTLZL(I))
      IF(.NOT.EXVEL) GO TO 396
      UP=UP+UEI(I)
      VP=VP+VEI(I)
      WP=WP+WEI(I)
  396 WL(ICW)=WP*CDXZ+UP*SDXZ
  398 VL(ICW)=VP
C
C     LOOP OVER CHORDWISE ROWS ON THIS FLAP -- LOAD CALCULATION
C
      DO 500 ISW=1,MSFF
      IY=0
      IF (ISW.EQ.1.AND.YTLR(MS).GE.0.0) IY=1
      IF(ISW.EQ.1) GO TO 401
C
C     UPDATE RIGHT AND LEFT VELOCITIES
C
      II=MS+(ISW-1)*NCFF-1
      DO 400 ICW=1,NCFF
      VR(ICW)=VL(ICW)
      WR(ICW)=WL(ICW)
      I=II+ICW
      CALL VELSUM(FTLXL(I),YTLL(I),FTLZL(I))
      IF(.NOT.EXVEL) GO TO 399
      UP=UP+UEI(I)
      VP=VP+VEI(I)
      WP=WP+WEI(I)
  399 WL(ICW)=WP*CDXZ+UP*SDXZ
  400 VL(ICW)=VP
  401 CONTINUE
C
C     LOOP OVER TRAILING LEG POINTS IN THIS ROW
C
      DELGMR=GAMFWR(ISW)
      II=(ISW-1)*NCFF+MS-1
      DO 450 ICW=1,NCFF
      I=II+ICW
      CIRR=CIR(I)
      DUMA=0.75*CIRR
      FACR=-(DELGMR+DUMA)*CONBR(I)
      FACL= (DELGMR+DUMA)*CONBL(I)
      CYTLL(I)=FACL*(WL(ICW)-SALFP)
      CYTLR(I)=FACR*(WR(ICW)-SALFP)
      IF (IY.EQ.1) CYTLR(I)=-CYTLL(I)
      CZTLL(I)=FACL*VL(ICW)
      CZTLR(I)=FACR*VR(ICW)
      DELGMR=DELGMR+CIRR
  450 CONTINUE
      GAMFAR(ISW)=DELGMR
  500 CONTINUE
  800 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE FORCES
C
C     THIS SUBROUTINE CALCULATES THE SPANWISE LOAD DISTRIBUTIONS AND
C          THE FORCES AND MOMENTS FROM THE FORCES ACTING ON THE VORTEX
C          FILAMENTS
C
C     COMMON STATEMENTS
C
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```
      COMMON /ATAK/SINALF,COSALF
      COMMON /BLDAT/ XBL(250),YBL(250),ZBL(250),TPSI(250),SW(250)
      COMMON / WNGDAT/ Y(30),PSIWLE(30),PSIWTE(30),SPHIW,CPHIW,TPHIW
      COMMON /INDEX/ MSW,MW,MTOT,NCWI(30),IMAX,NFSEG(30),LASTF(30)
      COMMON / INDEXF/ NFREG,NFLAPS,IDFLAP(10,2),NCF(10),MSF(10),MF(10),
     1MSTART(10),MEND(10),NFSEGF(10)
      COMMON /FLPDAT/ SDELXZ(10),CDELXZ(10),YF(30,10),SPHIF(10),
     1CPHIF(10)
      COMMON /FTLDAT/ FTLXR(250),FTLXL(250),FTLZR(250),FTLZL(250)
      COMMON /REFQUA/ SSPAN,SREF,REFL,XM,ZM
      COMMON /CHORDS/ CHRDLW(30),CROOTF(10),CTIPF(10)
      COMMON /VORFOR/CXBL(250),CYBL(250),CZBL(250),CYTLL(250),CYTLR(250)
     1  ,  CZTLL(250),CZTLR(250)
      COMMON /TLDAT/ XTER(30),XTEL(30),XTLR(250),YTLR(250),ZTLR(250),
     1 XTLL(250),YTLL(250),ZTLL(250)
      COMMON /FLAPLE/XWILE(10),YWILE(10),ZWILE(10),SWPFLE(10)
      COMMON /PRSDAT/NPRESW,NPRESF(10),ELAREA(250),XLE(30)
      COMMON /NORM/ CNT
C
C     DIMENSION STATEMENT
C
      DIMENSION XC(20),PRES(20)
C
C     FORMAT STATEMENTS
C
  701 FORMAT(1H1,15X,39HAERODYNAMIC LOADING RESULTS FOR ALPHA =,F6.2,
     1  5H DEG.)
  702 FORMAT(//30X,20HREFERENCE QUANTITIES/23X,12HWING SPAN, B,3X,4HAREA
     1  ,6X,6HLENGTH/23X,3F11.5)
  703 FORMAT(//27X,27HSPANWISE LOAD DISTRIBUTIONS/22X37H********** LEFT
     1WING PANEL **********)
  704 FORMAT(40X,5HLOCAL/19X7HSTATION,3X,7HY/(B/2),3X,8HCHORD, C,2X,
     115HCNORM*C/(2*B),4X,5HCNORM,8X2HCA)
  705 FORMAT(19XI5,F12.5,F11.4,F12.5,2F12.4)
  706 FORMAT(/22X10(1H*),1X,6HREGION,I2,5H FLAP,I2,1X,10(1H*))
  707 FORMAT(///21X,40HWING ALONE FORCE AND MOMENT COEFFICIENTS)
  708 FORMAT(29X,24H(WING COORDINATE SYSTEM))
  709 FORMAT(15X,3HCNW,9X,3HCAW,9X,3HCLW,9X,3HCDW,9X,3HCMW)
  710 FORMAT(9X,5F12.5)
  711 FORMAT(///13X,79HINDIVIDUAL FLAP FORCE AND MOMENT COEFFICIENTS AND
     1 LOCATIONS AT WHICH FORCES ACT/26X,52H(FLAP COORDINATE SYSTEMS - F
     2LAP LIES IN XF,YF PLANE)/1X,11HREGION FLAP,5X,3HCNF,7X,7HXF(CNF),
     35X,7HYF(CNF),7X,3HCAF,7X,7HYF(CAF),7X,3HCYF,7X,7HXF(CYF),7X,3HCMF)
  712 FORMAT(1X,I4,I5,8F12.5)
  713 FORMAT(///14X,52HCOMPLETE CONFIGURATION FORCE AND MOMENT COEFFICIE
     1NTS)
  714 FORMAT(11X,2HCN,10X,2HCA,10X,2HCL,10X,2HCD,10X,2HCM,6X,10HCD/(CL*C
     1L))
  715 FORMAT(4X,6F12.5)
  716 FORMAT(1H1,54X,22HPRESSURE DISTRIBUTIONS/61X,9HDELTA P/Q)
  717 FORMAT(/5X,10(1H*),1X,15HLEFT WING PANEL,1X,10(1H*))
  718 FORMAT(/3X,7HY/(B/2),2X,8HCHORD, C)
  719 FORMAT(2F10.5,7X,4HX/C=,F9.5,9F10.5/30X,10F10.5)
  720 FORMAT(21X,10HDELTA P/Q=,F9.5,9F10.5/30X,10F10.5)
  721 FORMAT(1H )
  722 FORMAT(/5X,10(1H*),1X,6HREGION,I2,5H FLAP,I2,1X,10(1H*))
C
C     CONSTANTS
C
      DATA RTOD/57.2957795/
C
      SPAN=2.0*SSPAN
      SREFTB=SREF/(2.*SPAN)
      ALF=ASIN(SINALF)*RTOD
      WRITE (6,701) ALF
      WRITE(6,702) SPAN,SREF,REFL
C
C     CALCULATE WING LOADS
C
      WRITE (6,703)
      WRITE(6,704)
      CON=SREFTB/(2.*CPHIW)
C
C     LOOP OVER CHORDWISE ROWS
C
      IBASE=0
      DO 1 I=2,IMAX
      CYS=0.
      CNS=0.
       CAS=0.0
      YBOT=(Y(I)+Y(I-1))/(2.*SSPAN)
      NSTAT=I-1
      CHLOC=CHRDLW(NSTAT)
C
C     LOOP OVER AREA ELEMENTS IN ROW
C
      NCWW=NCWI(NSTAT)
      DO 2 K=1,NCWW
      JJ=IBASE+K
      CYS=CYS+CYBL(JJ)+0.5*(CYTLL(JJ)+CYTLR(JJ))
      CNS=CNS+CZBL(JJ)+0.5*(CZTLL(JJ)+CZTLR(JJ))
       CAS=CAS+CXBL(JJ)
    2 CONTINUE
      TA=CON/SW(JJ)
      CYS=TA*CYS
      CNS=CNS*TA
      CNORM=CNS*CPHIW+CYS*SPHIW
      IBASE=IBASE+NCWW
      CN=CNORM*2.0*SPAN/CHLOC
       CAS=CAS*TA*2.0*SPAN/CHLOC
    1 WRITE(6,705) NSTAT,YBOT,CHLOC,CNORM,CN ,CAS
C
C     CALCULATE FLAP LOADS
C
C     LOOP OVER FLAPS
C
      IF(NFLAPS.EQ.0) GO TO 50
      DO 20 N=1,NFLAPS
      WRITE(6,706) IDFLAP(N,1),IDFLAP(N,2)
      WRITE (6,704)
      NCFF=NCF(N)
      CPHIFF=CPHIF(N)
      SPHIFF=SPHIF(N)
      CON=SREFTB/2.0
      IFM=MSF(N)+1
      CROOT=CROOTF(N)
      DCHORD=CROOT-CTIPF(N)
      YINBRD=YF(1,N)/(2.0*SSPAN)
      JBL=MSTART(N)-1
C
C     LOOP OVER CHORDWISE ROWS ON THIS FLAP
C
      DO 30 I=2,IFM
      NSTAT=I-1
      YBOT=(YF(I,N)+YF(NSTAT,N))/(2.*SSPAN)
      CHLOC=CROOT+(YBOT-YINBRD )*DCHORD
      CYS=0.0
      CNS=0.0
       CAS=0.0
C
C     LOOP OVER AREA ELEMENTS IN THIS ROW
C
      DO 40 J=1,NCFF
      JBL=JBL+1
      CYS=CYS+CYBL(JBL)+0.5*(CYTLL(JBL)+CYTLR(JBL))
      CNS=CNS+CZBL(JBL)+0.5*(CZTLL(JBL)+CZTLR(JBL))
       CAS=CXBL(JBL)
   40 CONTINUE
      TA=CON/SW(JBL)
      CYS=TA*CYS
      CNS=TA*CNS
      CNORM=CNS*CPHIFF+CYS*SPHIFF
      CN=CNORM*2.0*SPAN/CHLOC
       CAS=CAS*TA*2.0*SPAN/CHLOC
   30 WRITE(6,705) NSTAT,YBOT,CHLOC,CNORM,CN ,CAS
   20 CONTINUE
C
C     CALCULATE WING FORCES AND MOMENTS
C
   50 CNW=0.0
      CAW=0.0
      CMW=0.0
      DO 60 J=1,MW
      CXBLW=CXBL(J)
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      CZBLW=CZBL(J)
      CZTLRW=CZTLR(J)
      CZTLLW=CZTLL(J)
      IF (J.LE.NCWI(1)) CZTLRW=0.0
      CAW=CAW+CXBLW
      CNW=CNW+CZBLW+CZTLRW+CZTLLW
      CMW=CMW+(XBL(J)-XM)*CZBLW-(ZBL(J)-ZM)*CXBLW+(FTLXR(J)-XM)*CZTLRW
     1 +(FTLXL(J)-XM)*CZTLLW
   60 CONTINUE
      CNW=2.*CNW
      CAW=2.*CAW
      CMW=2.*CMW/REFL
      CLW=CNW*COSALF-CAW*SINALF
      CDW=CNW*SINALF+CAW*COSALF
      WRITE (6,707)
      WRITE (6,708)
      WRITE (6,709)
      WRITE(6,710) CNW,CAW,CLW,CDW,CMW
      CLT=CLW
      CDT=CDW
      CMT=CMW
C
C.    CALCULATE FLAP FORCE AND MOMENTS
      IF(NFLAPS.EQ.0) GO TO 100
C
C     LOOP OVER FLAPS
C
      WRITE (6,711)
      DO 70 N=1,NFLAPS
      CNF=0.0
      CAF=0.0
      CYF=0.0
      CMF=0.0
      CMXNF=0.0
      CMYNF=0.0
      CMZAF=0.0
      CMZYF=0.0
      NCFF=NCF(N)
      MS  =MSTART(N)
      ME  =MEND(N)
      CDXZ=CDELXZ(N)
      SDXZ=SDELXZ(N)
      XWL=XWILE(N)
      YWL=YWILE(N)
      ZWL=ZWILE(N)
      CPHIFF=CPHIF(N)
      SPHIFF=SPHIF(N)
      SPSD=SPHIFF*SDXZ
      SPCD=SPHIFF*CDXZ
      TPSILE=TAN(SWPFLE(N))
      CPSILE=COS(SWPFLE(N))
      CAPD=COSALF*CDXZ-SINALF*SDXZ
      SAPD=SINALF*CDXZ+COSALF*SDXZ
C
C     LOOP OVER VORTICES ON THIS FLAP
C
      DO 80 J=MS,ME
      CXBLF=CXBL(J)
      CYBLF=CYBL(J)
      CZBLF=CZBL(J)
      CZTLRF=CZTLR(J)
      CZTLLF=CZTLL(J)
      CYTLRF=CYTLR(J)
      CYTLLF=CYTLL(J)
      K=J-MS+1
      IF (K.GT.NCFF.OR.YF(1,N).NE.0.0) GO TO 81
      CZTLRF=0.0
      CYTLRF=0.0
   81 CONTINUE
      DXWBL=XBL(J)-XWL
      DYWBL=YBL(J)-YWL
      DZWBL=ZBL(J)-ZWL
      DXWTLR=FTLXR(J)-XWL
      DYWTLR=YTLR(J)-YWL
      DZWTLR=FTLZR(J)-ZWL
      DXWTLL=FTLXL(J)-XWL
      DYWTLL=YTLL(J)-YWL
      DZWTLL=FTLZL(J)-ZWL
      DXFBL=DXWBL*CDXZ-DZWBL*SDXZ
      DYFBL=DYWBL*CPHIFF+DXWBL*SPSD+DZWBL*SPCD
      DXFTLR=DXWTLR*CDXZ-DZWTLR*SDXZ
      DYFTLR=DYWTLR*CPHIFF+DXWTLR*SPSD+DZWTLR*SPCD
      DXFTLL=DXWTLL*CDXZ-DZWTLL*SDXZ
      DYFTLL=DYWTLL*CPHIFF+DXWTLL*SPSD+DZWTLL*SPCD
      CNFBL=CZBLF*CPHIFF+CYBLF*SPHIFF
      CYFBL=CYBLF*CPHIFF-CZBLF*SPHIFF
      CNFTLR=CZTLRF*CPHIFF+CYTLRF*SPHIFF
      CYFTLR=CYTLRF*CPHIFF-CZTLRF*SPHIFF
      CNFTLL=CZTLLF*CPHIFF+CYTLLF*SPHIFF
      CYFTLL=CYTLLF*CPHIFF-CZTLLF*SPHIFF
      CAF=CAF+CXBLF
      CNF=CNF+CNFBL+CNFTLR+CNFTLL
      CYF=CYF+CYFBL+CYFTLR+CYFTLL
      CMXNF=CMXNF+DYFBL*CNFBL+DYFTLR*CNFTLR+DYFTLL*CNFTLL
      CMYNF=CMYNF+DXFBL*CNFBL+DXFTLR*CNFTLR+DXFTLL*CNFTLL
      CMZAF=CMZAF+DYFBL*CXBLF
      CMZYF=CMZYF+DXFBL*CYFBL+DXFTLR*CYFTLR+DXFTLL*CYFTLL
      CMF=CMF+(XBL(J)-XM)*(CZBLF*CDXZ-CXBLF*SDXZ)-(ZBL(J)-ZM)
     1 *(CZBLF*SDXZ+CXBLF*CDXZ)
      CMF=CMF+(FTLXR(J)-XM)*CZTLRF*CDXZ-(FTLZR(J)-ZM)*CZTLRF*SDXZ
      CMF=CMF+(FTLXL(J)-XM)*CZTLLF*CDXZ-(FTLZL(J)-ZM)*CZTLLF*SDXZ
   80 CONTINUE
      CNFF=CNF*CPHIFF-CYF*SPHIFF
      CLF=CNFF*CAPD-CAF*SAPD
      CDF=CNFF*SAPD+CAF*CAPD
      XFCNF=999.999
      YFCNF=999.999
      YFCAF=999.999
      XFCYF=999.999
      IF (CNF.NE.0.0) XFCNF=CMYNF/CNF
      IF (CNF.NE.0.0) YFCNF=CMXNF/CNF
      IF (CAF.NE.0.0) YFCAF=CMZAF/CAF
      IF (CYF.NE.0.0) XFCYF=CMZYF/CYF
      CMF=CNF*(XFCNF-YFCNF*TPSILE)*CPSILE/REFL
      CMF=CMF/REFL
      WRITE (6,712) IDFLAP(N,1),IDFLAP(N,2),CNF,XFCNF,YFCNF,CAF,YFCAF,
     1CYF,XFCYF,CMF
      CLT=CLT+2.*CLF
      CDT=CDT+2.*CDF
      CMT=CMT+2.*CMF
   70 CONTINUE
C
C     CALCULATE COMPLETE CONFIGURATION FORCES AND MOMENTS
C
  100 WRITE(6,713)
      WRITE (6,708)
      WRITE (6,714)
      CNT=CLT*COSALF+CDT*SINALF
      CAT=CDT*COSALF-CLT*SINALF
      CDCLS=CDT/(CLT*CLT)
      WRITE(6,715) CNT,CAT,CLT,CDT,CMT,CDCLS
C
C     CALCULATE PRESSURE DISTRIBUTIONS
C
      IHEAD=0
C
C     WING PRESSURE DISTRIBUTION
C
      IF (NPRESW.EQ.0) GO TO 300
      WRITE (6,716)
      IHEAD=1
      WRITE (6,717)
      WRITE (6,718)
C
C     LOOP OVER CHORDWISE ROWS
C
      IBASE=0
      DO 200 I=2,IMAX
      IM=I-1
      YBOT=(Y(I)+Y(IM))/(2.0*SSPAN)
      CHLOC=CHRDLW(IM)
      XLEE=(XLE(I)+XLE(IM))/2.0
      NCWW=NCWI(IM)
      DO 210 K=1,NCWW
```

```
      JJ=IBASE+K
      XC(K)=(XLEE-XBL(JJ))/CHLOC
      CNS=CZBL(JJ)+CZTLR(JJ)+CZTLL(JJ)
      CYS=CYBL(JJ)+CYTLR(JJ)+CYTLL(JJ)
      CNORM=CNS*CPHIW+CYS*SPHIW
      PRES(K)=CNORM*SREF/ELAREA(JJ)
  210 CONTINUE
      WRITE (6,719) YBOT,CHLOC,(XC(J),J=1,NCWW)
      WRITE (6,720) (PRES(J),J=1,NCWW)
      WRITE (6,721)
      IBASE=IBASE+NCWW
  200 CONTINUE
C
C     FLAP PRESSURE DISTRIBUTIONS
C
  300 IF (NFLAPS.EQ.0) RETURN
C
C     LOOP OVER FLAPS
C
      DO 310 N=1,NFLAPS
      IF (NPRESF(N).EQ.0) GO TO 310
      IF (IHEAD.EQ.1) GO TO 320
      WRITE (6,716)
      IHEAD=1
  320 WRITE (6,722) IDFLAP(N,1),IDFLAP(N,2)
      WRITE (6,718)
      NCFF=NCF(N)
      FNCFF=NCFF
      DO 321 J=1,NCFF
      FJ=J
  321 XC(J)=(FJ-0.75)/FNCFF
      IFM=MSF(N)+1
      FSPAN=YF(1,N)-YF(IFM,N)
      YINBRD=YF(1,N)/FSPAN
      CROOT=CROOTF(N)
      DCHORD=CROOT-CTIPF(N)
      JBL=MSTART(N)-1
      CPF=CPHIF(N)
      SPF=SPHIF(N)
C
C     LOOP OVER CHORDWISE ROWS
C
      DO 330 I=2,IFM
      IM=I-1
      YROT=((YF(1,N)+YF(IM,N))/2.0)/SSPAN
      YFS=YROT-YINBRD
      CHLOC=CROOT+YFS *DCHORD
      DO 340 K=1,NCFF
      JBL=JBL+1
      CNS=CZBL(JBL)+CZTLL(JBL)+CZTLR(JBL)
      CYS=CYBL(JBL)+CYTLL(JBL)+CYTLR(JBL)
      CNORM=CNS*CPF+CYS*SPF
      PRES(K)=CNORM*SREF/ELAREA(JBL)
      WRITE (6,719) YBOT,CHLOC,(XC(J),J=1,NCFF)
      WRITE (6,720) (PRES(J),J=1,NCFF)
      WRITE (6,721)
  330 CONTINUE
  310 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE VELSUM(XX,YY,ZZ)
C
C     CALCULATES VELOCITIES DUE TO VORTICES AND THEIR WAKES AT
C     A FIELDPOINT (XX,YY,ZZ)
C
C     COMMON STATEMENTS
C
      COMMON / ANGDAT/ Y(30),PSIWLE(30),PSIWTE(30),SPHIW,CPHIW,IPHIW
      COMMON /INDEX/ MSW,NW,NTOT,NCW(30),IMAX,NFSEG(30),LASTF(30)
      COMMON /TLDAT/ XTER(30),XTEL(30),XTLR(250),YTLR(250),ZTLR(250),
     1 XTLL(250),YTLL(250),ZTLL(250)
      COMMON / INDEXF/ NFREG,NFLAPS,IDFLAP(10,2),NCF(10),MSF(10),MF(10),
     1MSTART(10),MEND(10),NFSEGF(10)
      COMMON /FLPDAT/ SDELXZ(10),CDELXZ(10),YF(30,10),SPHIF(10),
     1CPHIF(10)
      COMMON /WKDATW/ XWKRW(30,3),YWKRW(30,3),ZWKRW(30,3),XWKLW(30,3),
     1YWKLW(30,3),ZWKLW(30,3)
      COMMON /WKDATF/ XWKRF(30,2,10),YWKRF(30,2,10),ZWKRF(30,2,10),
     1XWKLF(30,2,10),YWKLF(30,2,10),ZWKLF(30,2,10)
      COMMON /RVELS/UP,VP,WP
      COMMON /FLVFRG/X1,Y1,Z1,X2,Y2,Z2,XP,YP,ZP,FU,FV,FW,AX,AZ
      COMMON /RSIDE/ CIR(250),UEI(250),VEI(250),WEI(250)
C
      XP=XX
      YP=YY
      ZP=ZZ
      UP=0.0
      VP=0.0
      WP=0.0
      IBASE=0
C
C     INFLUENCE OF WING VORTICES -- LOOP OVER CHORDWISE ROWS
C
      DO 200 ISW=1,MSW
      NAFT=NFSEG(ISW)
      AFTU=0.
      AFTV=0.
      AFTW=0.
      IF(NAFT.EQ.0) GO TO 133
      IF(NAFT.EQ.1) GO TO 131
C
C     INFLUENCE OF FINITE LENGTH WAKE PIECES BEHIND THIS ROW
C
      NAFTM=NAFT-1
      DO 130 IAS=1,NAFTM
      X1=XWKRW(ISW,IAS)
      Y1=YWKRW(ISW,IAS)
      Z1=ZWKRW(ISW,IAS)
      IASP=IAS+1
      X2=XWKRW(ISW,IASP)
      Y2=YWKRW(ISW,IASP)
      Z2=ZWKRW(ISW,IASP)
      CALL FLVF
      AFTU=AFTU+FU
      AFTV=AFTV+FV
      AFTW=AFTW+FW
      X1=XWKLW(ISW,IAS)
      Y1=YWKLW(ISW,IAS)
      Z1=ZWKLW(ISW,IAS)
      X2=XWKLW(ISW,IASP)
      Y2=YWKLW(ISW,IASP)
      Z2=ZWKLW(ISW,IASP)
      CALL FLVF
      AFTU=AFTU-FU
      AFTV=AFTV-FV
      AFTW=AFTW-FW
  130 CONTINUE
C
C     INFLUENCE OF SEMI-INFINITE TRAILING LEGS IN LAST AFT FLAP
C
  131 CONTINUE
      LF=LASTF(ISW)
      AX=-CDELXZ(LF)
      AZ=SDELXZ(LF)
      X1=XWKRW(ISW,NAFT)
      Y1=YWKRW(ISW,NAFT)
      Z1=ZWKRW(ISW,NAFT)
      CALL SIVF
      AFTU=AFTU-FU
      AFTV=AFTV-FV
      AFTW=AFTW-FW
      X1=XWKLW(ISW,NAFT)
      Y1=YWKLW(ISW,NAFT)
      Z1=ZWKLW(ISW,NAFT)
```

```
      CALL SIVF
      AFTU=AFTU+FU
      AFTV=AFTV+FV
      AFTW=AFTW+FW
  135 CONTINUE
C
C     LOOP OVER VORTICES IN THIS WING CHORDWISE ROW
C
      NCWC=NCWI(ISW)
      DO 150 ICW=1,NCWC
C
C     INFLUENCE OF BOUND LEG
C
      I=IBASE+ICW
      X1=XTLL(I)
      Y1=YTLL(I)
      Z1=ZTLL(I)
      X2=XTLR(I)
      Y2=YTLR(I)
      Z2=ZTLR(I)
      CALL FLVF
      CU=FU
      CV=FV
      CW=FW
      IF(NAFT.NE.0) GO TO 145
C
C     NO FLAPS BEHIND THIS ROW.  COMPUTE THE INFLUENCE OF INFINITE
C     TRAILING LEGS IN WING PLANE
C
      AX=-1.0
      AZ=0.0
      CALL SIVF
      CU=CU+FU
      CV=CV+FV
      CW=CW+FW
      X1=X2
      Y1=Y2
      Z1=Z2
      CALL SIVF
      CU=CU-FU
      CV=CV-FV
      CW=CW-FW
      GO TO 147
C
C     THERE ARE FLAPS BEHIND THIS ROW.  COMPUTE INFLUENCE OF
C     FINITE TRAILING LEGS IN WING PLANE
C
  145 X1=XTLR(I)
      Y1=YTLR(I)
      Z1=ZTLR(I)
      X2=XWKRW(ISW,1)
      Y2=YWKRW(ISW,1)
      Z2=ZWKRW(ISW,1)
      CALL FLVF
      CU=CU+FU
      CV=CV+FV
      CW=CW+FW
      X1=XTLL(I)
      Y1=YTLL(I)
      Z1=ZTLL(I)
      X2=XWKLW(ISW,1)
      Y2=YWKLW(ISW,1)
      Z2=ZWKLW(ISW,1)
      CALL FLVF
      CU=CU-FU
      CV=CV-FV
      CW=CW-FW
      CU=CU+AFTU
      CV=CV+AFTV
      CW=CW+AFTW
  147 VS=CIR(I)
      UP=UP+CU*VS
      VP=VP+CV*VS
      WP=WP+CW*VS
  150 CONTINUE
  200 IBASE=IBASE+NCWC
C
C     INFLUENCE OF FLAP VORTICES -- LOOP OVER FLAPS
C
      IF(NFLAPS.EQ.0) RETURN
      DO 300 IFL=1,NFLAPS
      NCFF=NCF(IFL)
      MSFF=MSF(IFL)
      CDXZ=CDELXZ(IFL)
      SDXZ=SDELXZ(IFL)
      NAFT=NFSEGF(IFL)
      IBASE=MSTART(IFL)
C
C     LOOP OVER CHORDWISE ROWS OF VORTICES ON THIS FLAP
C
      DO 250 ISW=1,MSFF
      AFTU=0.0
      AFTV=0.0
      AFTW=0.0
      IF(NAFT.EQ.0) GO TO 212
      IF(NAFT.EQ.1) GO TO 210
C
C     INFLUENCE OF FINITE TRAILING LEGS IN FIRST FLAP AFT OF THIS ONE
C
      X1=XWKRF(ISW,1,IFL)
      Y1=YWKRF(ISW,1,IFL)
      Z1=ZWKRF(ISW,1,IFL)
      X2=XWKRF(ISW,2,IFL)
      Y2=YWKRF(ISW,2,IFL)
      Z2=ZWKRF(ISW,2,IFL)
      CALL FLVF
      AFTU=AFTU+FU
      AFTV=AFTV+FV
      AFTW=AFTW+FW
      X1=XWKLF(ISW,1,IFL)
      Y1=YWKLF(ISW,1,IFL)
      Z1=ZWKLF(ISW,1,IFL)
      X2=XWKLF(ISW,2,IFL)
      Y2=YWKLF(ISW,2,IFL)
      Z2=ZWKLF(ISW,2,IFL)
      CALL FLVF
      AFTU=AFTU-FU
      AFTV=AFTV-FV
      AFTW=AFTW-FW
C
C     CONTRIBUTION OF SEMI-INFINITE TRAILING LEGS IN SECOND FLAP
C
  210 X1=XWKRF(ISW,NAFT,IFL)
      Y1=YWKRF(ISW,NAFT,IFL)
      Z1=ZWKRF(ISW,NAFT,IFL)
      NF=IFL+NAFT
      AX=-CDELXZ(NF)
      AZ=SDELXZ(NF)
      CALL SIVF
      AFTU=AFTU-FU
      AFTV=AFTV-FV
      AFTW=AFTW-FW
      X1=XWKLF(ISW,NAFT,IFL)
      Y1=YWKLF(ISW,NAFT,IFL)
      Z1=ZWKLF(ISW,NAFT,IFL)
      CALL SIVF
      AFTU=AFTU+FU
      AFTV=AFTV+FV
      AFTW=AFTW+FW
C
C     LOOP OVER VORTICES IN THIS CHORDWISE ROW
C
  212 CONTINUE
      II=IBASE+(ISW-1)*NCFF-1
      DO 220 ICW=1,NCFF
C
C     INFLUENCE OF BOUND LEG
C
      I=II+ICW
      X1=XTLL(I)
      Y1=YTLL(I)
      Z1=ZTLL(I)
      X2=XTLR(I)
      Y2=YTLR(I)
```

```
      Z2=ZTLR(I)
      CALL FLVF
      CU=FU
      CV=FV
      CW=FW
      IF(NAFT.NE.0) GO TO 214
C
C     NO FLAPS BEHIND THIS ONE,  COMPUTE INFLUENCE OF SEMI-INFINITE
C     TRAILING LEGS IN THE PLANE OF THIS FLAP
C
      AX=-CDXZ
      AZ=SDXZ
      CALL SIVF
      CU=CU+FU
      CV=CV+FV
      CW=CW+FW
      X1=X2
      Y1=Y2
      Z1=Z2
      CALL SIVF
      CU=CU-FU
      CV=CV-FV
      CW=CW-FW
      GO TO 216
C
C     THERE ARE FLAPS BEHIND THIS ONE,  COMPUTE INFLUENCE OF
C     FINITE TRAILING LEGS IN THIS FLAP
C
  214 X1=XTLR(I)
      Y1=YTLR(I)
      Z1=ZTLR(I)
      X2=XWKRF(ISW,1,IFL)
      Y2=YWKRF(ISW,1,IFL)
      Z2=ZWKRF(ISW,1,IFL)
      CALL FLVF
      CU=CU+FU
      CV=CV+FV
      CW=CW+FW
      X1=XTLL(I)
      Y1=YTLL(I)
      Z1=ZTLL(I)
      X2=XWKLF(ISW,1,IFL)
      Y2=YWKLF(ISW,1,IFL)
      Z2=ZWKLF(ISW,1,IFL)
      CALL FLVF
      CU=CU-FU
      CV=CV-FV
      CW=CW-FW
      CU=CU+AFTU
      CV=CV+AFTV
      CW=CW+AFTW
  216 VS=CIR(I)
      UP=UP+CU*VS
      VP=VP+CV*VS
  220 WP=WP+CW*VS
  250 CONTINUE
  300 CONTINUE
      RETURN
      END


      SUBROUTINE JET (NP,XP,YP,ZP,UP,VP,WP,NTIME)
C      COMPUTE VELOCITY INDUCED BY A SERIES OF ELLIPTIC VORTEX RINGS
C        WITH VARIABLE LENGTH AXES LYING ALONG A PRESCRIBED PATH
C
C       ALL FIELD POINT COORDINATES ARE INPUT IN THE WING SYSTEM AND
C         TRANSFORMED TO THE ENGINE SYSTEM FOR CALCULATIONS
C      JET CENTERLINE COORDINATES ARE INPUT IN ENGINE SYSTEM
C      ALL OUTPUT IS IN THE WING SYSTEM,OPTIONAL OUTPUT IN ENGINE SYSTEM
C
C               NNUM = 0  J(N) CALCULATED ANALYTICALLY
C               NNUM = 1  J(N) CALCULATED NUMERICALLY
C
C               NCRCT = 0  CORRECT FIELD POINT POSITIONS
C                          WITH RESPECT TO VORTEX RINGS
C               NCRCT = 1  DO NOT CORRECT FIELD POINT POSITIONS
C
C               NTIME = 0      INPUT AND PRINT JET PARAMETERS AND
C                                CALCULATE INDUCED VELOCITIES
C               NTIME .GT. 0   PRINT JET PARAMETERS AND CALCULATE
C                                INDUCED VELOCITIES
C               NTIME = 999    PRINT JET PARAMETERS ONLY
C               NTIME .LT. 0   CALCULATE INDUCED VELOCITIES FROM
C                                PREVIOUSLY DESCRIBED JETS - NO OUTPUT
C
C         OPTIONAL OUTPUT ...
C               NPRINT = -1      MINIMUM OUTPUT
C               NPRINT = 0       NONE
C               NPRINT = 1       JET VELOCITIES
C
C
      DIMENSION TITLE(8),XCLR(2, 25),YCLR(2, 25),ZCLR(2, 25),SCLR(2, 25)
      DIMENSION THETA(2, 25),AJET(2, 25),BJET(2, 25),GAMVJ(2),XO(2),
     1          YO(2),ZO(2),DS(2),PJET(2),XP(250),YP(250),ZP(250),
     2          XPR(250),YPR(250),ZPR(250),U(250),V(250),W(250),
     3          UP(250),VP(250),WP(250) ,DSFACT(2,25)
      COMMON /ERR/ JERR
      COMMON /JN/ AJNUM
      COMMON /XYZCL/ NJET,NCYL,XCLR,YCLR,ZCLR,THETA,AJET,BJET,
     1               XO,YO,ZO,GAMVJ
C
  700 FORMAT (8F10.5)
  701 FORMAT (15I5)
  702 FORMAT (8A10)
  703 FORMAT (10X,8A10)
  704 FORMAT (1H1)
  711 FORMAT (/2H (I1,16H) JET PARAMETERS,7X7HGAMMA/V,6X2HXO,8X2HYO,
     1        8X2HZO,7X4HD(S) / 23X,5F10.4 /
     2        10X3HXCL,7X3HYCL,7X3HZCL,7X3HSCL,5X5HTHETA,7X1HA,9X1HB
     3        6X6HDSFACT,7X1HP )
  712 FORMAT (3X,10F10.3)
  713 FORMAT (/3X4HNJET,2X4HNCYL,3X2HNP,3X4HNNUM,2X5HNCRCT,2X6HNPRINT)
  714 FORMAT (15I6)
  715 FORMAT ( 4X1HN,7X2HXW,8X2HYW,8X2HZW5X3HU/V,9X3HV/V,9X3HW/V)
  716 FORMAT (I5,3F10.3,3(1PE12.4))
  717 FORMAT (/2X,22HWING COORDINATE SYSTEM)
  718 FORMAT (/2X,25HVELOCITIES INDUCED BY JET,I2,24H - JET COORDINATE S
     1YSTEM/4X1HN,7X4HXP  ,6X4HYP  ,6X4HZP  ,3X3HU/V9X3HV/V9X3HW/V)
  720 FORMAT(/6X6H** JET,I2,5X22HANALYTICAL J(N) ERROR,I8,10H POINTS **)
  721 FORMAT (///10X, 34HEXECUTION TERMINATED,  ERROR IN DS  )
  991 FORMAT (////10X30H**** ERROR IN JET, B.GT.A **** )
C
      PI=3.1415926
      RAD=180./PI
C
      IF (NTIME) 193,10,997
C
   10 READ(5,701) NHEAD,NJET,NCYL,NNUM,NPRINT,NCRCT
      IF (EOF(5)) 999,998
  999 STOP
  998 CONTINUE
      IF (NPRINT.GT.1) NPRINT=1
      NA=NPRINT
      NERR=0
      WRITE (6,704)
      DO 9 J=1,NHEAD
      READ(5,702) TITLE
    9 WRITE (6,703) TITLE
      AJNUM=NNUM
C
C         INPUT INDIVIDUAL JET PARAMETERS
C
      DO 16 J=1,NJET
      READ (5,700) GAMVJ(J),  DS(J),XO(J),YO(J),ZO(J)
      DO 11 N=1,NCYL
      READ (5,700) XCLR(J,N),YCLR(J,N),ZCLR(J,N),AJET(J,N),BJET(J,N),
```

```
     1                 THETA(J,N),DSFACT(J,N)
      IF (DSFACT(J,N).LE.0.0) DSFACT(J,N)=1.0
   11 CONTINUE
   16 CONTINUE
C
  997 CONTINUE
      NPRINT=NA
C
C         SET UP TABLE OF JET CENTERLINE PARAMETERS
C
      DO 14 J=1,NJET
      SCLR(J,1)=0.0
      DO 13 N=2,NCYL
      SR = (XCLR(J,N)-XCLR(J,N-1))**2 + (YCLR(J,N)-YCLR(J,N-1))**2 +
     1     (ZCLR(J,N)-ZCLR(J,N-1))**2
   13 SCLR(J,N)=SQRT(SR) + SCLR(J,N-1)
   14 CONTINUE
C
C          PRELIMINARY OUTPUT
C
      WRITE (6,713)
      WRITE (6,714)   NJET,NCYL,NP,NNUM,NCRCT,NPRINT
      DO 15 N=1,NJET
      PJET(N)=2.0*PI*SQRT((AJET(N,1)**2 + BJET(N,1)**2)/2.0)
      WRITE (6,711) N,GAMVJ(N),XQ(N),YQ(N),ZQ(N),DS(N)
      DO 15 J=1,NCYL
      IF (AJET(N,J).LT.BJET(N,J)) NERR=NERR+1
      P=2.0*PI*SQRT((AJET(N,J)**2 + BJET(N,J)**2)/2.0)
   15 WRITE (6,712) XCLR(N,J),YCLR(N,J),ZCLR(N,J),SCLR(N,J),THETA(N,J),
     1                AJET(N,J),BJET(N,J),DSFACT(N,J),P
      IF (NERR.GT.0) GO TO 990
      IF (NTIME.GE.999) RETURN
      GO TO 194
  193 NPRINT=-1
  194 CONTINUE
C
      DO 192 J=1,NP
      UP(J)=0.0
      VP(J)=0.0
  192 WP(J)=0.0
      DO 40 M=1,NJET
      IF (DS(M).LE.0.0) GO TO 90
      DO 19 J=1,NP
      U(J)=0.0
      V(J)=0.0
   19 W(J)=0.0
      SREND=SCLR(M,NCYL)
C
C         TRANSFORM FIELD POINT COORDINATES TO ENGINE SYSTEM
C
  190 DO 191 J=1,NP
      XPR(J)= -XP(J)+XQ(M)
      YPR(J)= YP(J)-YQ(M)
  191 ZPR(J)= -ZP(J)+ZQ(M)
C
C          CORRECT FIELD POINT LOCATIONS IF DESIRED
C
      IF (NCRCT.LE.0) CALL CORECT (NP,XPR,YPR,ZPR,DS(M),M,NCYL,
     1                            XCLR,YCLR,ZCLR,SCLR,AJET,BJET,THETA)
      SR=DS(M)/2.0
      FACTOR=DSFACT(M,1)
      JSR=1
   20 CONTINUE
      DSR=DS(M)*FACTOR
      GAMI=GAMVJ(M)*PJET(M)*DSR
      SR=SR+DSR
C
C         LOCATE INDIVIDUAL VORTEX RINGS
C
   21 IF (SR-SCLR(M,JSR)) 23,25,22
   22 JSR=JSR+1
      IF(JSR.GT.NCYL) GO TO 51
      GO TO 21
   25 XG=XCLR(M,JSR)
      YG=YCLR(M,JSR)
      ZG=ZCLR(M,JSR)
      AG=AJET(M,JSR)
      BG=BJET(M,JSR)
      THG=THETA(M,JSR)/RAD
      FACTOR=DSFACT(M,JSR)
      GO TO 30
   23 DELTA=(SR-SCLR(M,JSR-1))/(SCLR(M,JSR)-SCLR(M,JSR-1))
      XG=XCLR(M,JSR-1)+(XCLR(M,JSR)-XCLR(M,JSR-1))*DELTA
      YG=YCLR(M,JSR-1)+(YCLR(M,JSR)-YCLR(M,JSR-1))*DELTA
      ZG=ZCLR(M,JSR-1)+(ZCLR(M,JSR)-ZCLR(M,JSR-1))*DELTA
      AG=AJET(M,JSR-1)+(AJET(M,JSR)-AJET(M,JSR-1))*DELTA
      BG=BJET(M,JSR-1)+(BJET(M,JSR)-BJET(M,JSR-1))*DELTA
      THG=THETA(M,JSR-1)+(THETA(M,JSR)-THETA(M,JSR-1))*DELTA
      THG=THG/RAD
      FACTOR=DSFACT(M,JSR-1)
   30 CONTINUE
      SNTH=SIN(THG)
      CSTH=COS(THG)
      PGAM=2.0*PI*SQRT((AG**2 + BG**2)/2.0)
   31 GAMMA=GAMI/PGAM
      DO 38 N=1,NP
      XIPR=(XPR(N)-XG)*CSTH + (ZPR(N)-ZG)*SNTH
      ETAR= (YPR(N)-YG)
      ZETAR=-(XPR(N)-XG)*SNTH + (ZPR(N)-ZG)*CSTH
      RP=SQRT(ETAR**2 + ZETAR**2)
   34 IF ((AG-BG)/AG .GT. 1.0E-02)  GO TO 35
      WG=0.0
C
C          COMPUTE VELOCITY INDUCED BY A CIRCULAR RING
C
      CALL VRING (AG,XIPR,RP,UG,VG)
      UG=UG*GAMMA
      IF (RP.LE.1.0E-05) GO TO 36
      WG= VG*ZETAR/RP*GAMMA
      VG= VG*ETAR/RP*GAMMA
      GO TO 36
C
C          COMPUTE VELOCITY INDUCED BY AN ELLIPTICAL RING
C
   35 CALL ERING (GAMMA,AG,BG,ETAR,ZETAR,XIPR,VG,WG,UG)
      IF (JERR.GT.0) NERR=NERR+1
   36 UGAM=UG*CSTH -WG*SNTH
      VGAM=VG
      WGAM=UG*SNTH + WG*CSTH
C
      U(N)=U(N)+UGAM
      W(N)=W(N)+WGAM
   38 V(N)=V(N)+VGAM
C
C         NOTE.. U(N),V(N),W(N) ARE VELOCITIES INDUCED IN ENGINE SYSTEM
C
      IF (SR.LT.SREND) GO TO 20
   51 CONTINUE
      IF (NERR.GT.0) WRITE (6,720) M,NERR
      NERR=0
      DO 52 N=1,NP
      UP(N)=UP(N)+U(N)
      VP(N)=VP(N)+V(N)
   52 WP(N)=WP(N)+W(N)
      IF (NPRINT) 40,40,92
C
C          OPTIONAL OUTPUT
C
   92 WRITE (6,718) M
      DO 50 N=1,NP
   50 WRITE (6,716) N,XPR(N),YPR(N),ZPR(N),U(N),V(N),W(N)
   40 CONTINUE
   91 DO 41 N=1,NP
      UP(N)=-UP(N)
      WP(N)=-WP(N)
   41 CONTINUE
      IF (NPRINT.LT.0) RETURN
C
C         OUTPUT INDUCED VELOCITIES IN WING SYSTEM
C
      WRITE (6,717)
      WRITE (6,715)
      DO 42 N=1,NP
   42 WRITE (6,716)N,XP(N),YP(N),ZP(N),UP(N),VP(N),WP(N)
```

```fortran
      RETURN
   90 WRITE (6,721)
      STOP
  990 WRITE (6,991)
      STOP
      END
```

```fortran
      SUBROUTINE JETCL (NTIME,TOL)
C
C      CALCULATE THE CHANGE IN JET CENTERLINE POSITION DUE TO THE
C        INDUCED VELOCITY FIELD OF THE WING/FLAP AND JET
C
      DIMENSION XCLR(2,25),YCLR(2,25),ZCLR(2,25),THETA(2,25),
     1          AJET(2,25),BJET(2,25),XQ(2),YQ(2),ZQ(2),GAMVJ(2),
     2          EPSZ(25),EPSY(25)
C
      COMMON /XYZCL/ NJET,NCYL,XCLR,YCLR,ZCLR,THETA,AJET,BJET,
     1               XQ,YQ,ZQ,GAMVJ
      COMMON /UVWCL/ U(2,25),V(2,25),W(2,25)
      COMMON /ATAK/ SINALF,COSALF
      COMMON /CLCALC/ MJETCL,NJETCL,THMAX
C
      NTH = 0
      RAD=57.29578
      DO 20 J=1,NJET
      DO 30 K=1,NCYL
      IF (K.GT.2) GO TO 35
      EPSZ(K)=THETA(J,K)/RAD
      EPSY(K)=0.0
      GO TO 30
   35 CONTINUE
      SAVE = THETA(J,K)
      M=K-1
      UT=COSALF - U(J,K)
      WT=SINALF - W(J,K)
   34 VT=V(J,K)
      DX=XCLR(J,K)-XCLR(J,K-1)
      EPSZ(K)=ATAN2(WT,UT)
      IF (MJETCL.GT.0 .AND. EPSZ(K).GT.0.0) EPSZ(K)=0.0
      EPSY(K)=0.0
      IF (K.LT.NCYL .AND. NJETCL.GT.0) EPSY(K)=ATAN2(VT,UT)
      IF (EPSZ(K).LT.THMAX) EPSZ(K)=THMAX
      THETA(J,K)=EPSZ(K)*RAD
      IF (ABS(THETA(J,K)) .LT. 90.0)  GO TO 51
      JJ=J
      KK=K
      GO TO 50
   51 CONTINUE
      ZCLR(J,K)=ZCLR(J,K-1)+DX*TAN((EPSZ(K)+EPSZ(K-1))/2.0)
      YCLR(J,K)=YCLR(J,K-1)+DX*TAN((EPSY(K)+EPSY(K-1))/2.0)
      DELTA=1.0
      IF (ABS(THETA(J,K)).GT.1.0E-05) DELTA=(THETA(J,K)-SAVE)/THETA(J,K)
      IF (ABS(DELTA) .GT.TOL) NTH = NTH + 1
   30 CONTINUE
   20 CONTINUE
      IF (NTH.EQ.0) NTIME = 100
      RETURN
   50 WRITE (6,700) JJ,KK,THETA(JJ,KK)
  700 FORMAT (////// 25X, 14HERROR IN JETCL ,2I5,F10.3)
       STOP
      END
```

```fortran
      SUBROUTINE CORECT (NP,XPR,YPR,ZPR,DSR,M,NCYL,XCLR,YCLR,ZCLR,SCLR,
     1                   AJET,BJET,THETA)
C
C       CORRECT FIELD POINT LOCATIONS TO AVOID VORTEX RING SINGULARITIES
C
      DIMENSION XPR(250),YPR(250),ZPR(250),XCLR(2, 25),YCLR(2, 25),
     1 ZCLR(2,25),AJET(2,25),BJET(2,25),SCLR(2,25),THETA(2,25),NFP(250)
C
      JSR=1
      SR=-DSR/2.0
      DO 11 J=1,NP
   11 NFP(J)=1
      NCT=0
      RAD=57.2957795
   20 SR=SR+DSR
   21 IF (SR-SCLR(M,JSR)) 23,25,22
   22 JSR=JSR+1
      IF (JSR .GT. NCYL) RETURN
      GO TO 21
   25 XG=XCLR(M,JSR)
      YG=YCLR(M,JSR)
      ZG=ZCLR(M,JSR)
C     AG=AJET(M,JSR)
      BG=BJET(M,JSR)
      THG=THETA(M,JSR)/RAD
      GO TO 30
   23 DELTA=(SR-SCLR(M,JSR-1))/(SCLR(M,JSR)-SCLR(M,JSR-1))
      XG=XCLR(M,JSR-1)+(XCLR(M,JSR)-XCLR(M,JSR-1))*DELTA
      YG=YCLR(M,JSR-1)+(YCLR(M,JSR)-YCLR(M,JSR-1))*DELTA
      ZG=ZCLR(M,JSR-1)+(ZCLR(M,JSR)-ZCLR(M,JSR-1))*DELTA
      BG=BJET(M,JSR-1)+(BJET(M,JSR)-BJET(M,JSR-1))*DELTA
C     AG=AJET(M,JSR-1)+(AJET(M,JSR)-AJET(M,JSR-1))*DELTA
      THG=THETA(M,JSR-1)+(THETA(M,JSR)-THETA(M,JSR-1))*DELTA
      THG=THG/RAD
   30 RG=BG*1.10
      SNTH=SIN(THG)
      CSTH=COS(THG)
      DO 38 N=1,NP
      IF (NFP(N) .EQ. 0) GO TO 38
      XIPR=(XPR(N)-XG)*CSTH + (ZPR(N)-ZG)*SNTH
      ETAR=-(YPR(N)-YG )
      ZETAR= (XPR(N)-XG)*SNTH - (ZPR(N)-ZG)*CSTH
      RPR=SQRT(ETAR**2 + ZETAR**2)
      IF (XIPR+DSR) 35,35,36
   35 NFP(N)=0
      NCT=NCT+1
      GO TO 38
   36 CONTINUE
      RTEST=RPR-RG
      XTEST=ABS(XIPR)
      IF (XTEST .GT. DSR/2.0) GO TO 38
      NFP(N)=0
      NCT=NCT+1
      IF (RTEST .GT. DSR) GO TO 38
      FSIGN=1.0
      IF (XIPR .LT. 0.0) FSIGN=-1.0
      XIPRP=FSIGN*(DSR/2.0-XTEST)
      XPR(N)=XPR(N)+XIPRP*CSTH
      ZPR(N)=ZPR(N)+XIPRP*SNTH
   38 CONTINUE
      IF (NCT .LT. NP) GO TO 20
      RETURN
      END
```

```
      SUBROUTINE VRING (RGAMR,XIPR,RPR,UGAM,VGAM)
C
C     SUBROUTINE TO COMPUTE VELOCITY INDUCED BY A SINGLE VORTEX RING
C
C          RGAMR = RING RADIUS/REFERENCE RADIUS
C          XIPR  = AXIAL DISTANCE TO FIELD POINT/REFERENCE RADIUS
C          RPR   = RADIAL DISTANCE TO FIELD POINT/REFERENCE RADIUS
C          UGAM  = AXIAL VELOCITY/GAMMA
C          VGAM  = RADIAL VELOCITY/GAMMA
C
      PI=3.1415926
      DENM=XIPR**2 + (RPR-RGAMR)**2
      DENP=XIPR**2 + (RPR+RGAMR)**2
      AK2=4.0*RPR*RGAMR/DENP
      CALL ELLIPS (AK2,ZK,ZE)
      UGAM=(ZK-(1.0+2.0*RGAMR*(RPR-RGAMR)/DENM)*ZE) /SQRT(DENP)/(2.0*PI)
      VGAM=0.0
      IF (RPR .LE. 1.0E-05) RETURN
      VGAM=-XIPR/RPR/(2.0*PI*SQRT(DENP))*(ZK-(1.+2.*RPR*RGAMR/DENM)*ZE)
      RETURN
      END
```

```
      SUBROUTINE ERING (GAMMA,SA,SB,XZ,YZ,ZZ,VPX,VPY,VPZ)
C
C      COMPUTE THE INDUCED VELOCITY COMPONENTS DUE TO AN ELLIPTICAL
C          VORTEX RING
C
      DIMENSION A(5),AS(5),RTR(4),RTI(4),ZJ(5)
       DIMENSION F(41),T(41)
C
      COMMON /ERR/ JERR
      COMMON /JN/ AJNUM
C
C
      PI=3.1415926
      JNUM=AJNUM
      FZ=1.0
      JERR=0
      SB2=SB*SB
      ZZ2=ZZ*ZZ
      SC2=SA*SA-SB*SB
      SC=SQRT(SC2)
      DUM=XZ*XZ+YZ*YZ-SC2
      BZ2=0.5*(DUM+SQRT(DUM*DUM+4.0*SC2*YZ*YZ))
      IF (BZ2.LT.0.0) BZ2=0.0
      AZ2=BZ2+SC2
      AZ=SQRT(AZ2)
      BZ=SQRT(BZ2)
      VPX=0.0
      VPY=0.0
      VPZ=0.0
C
C       BEGIN LOOP TO CALCULATE CONTRIBUTION OF FOUR QUADRANTS OF RING
C
      DO 30 J=1,4
      GO TO (11,12,13,14) ,J
   11 FX=1.0
      FY=1.0
      GO TO 15
   12 FX=-1.0
      FY= 1.0
      GO TO 15
   13 FX=-1.0
      FY=-1.0
      GO TO 15
   14 FX= 1.0
      FY=-1.0
   15 CONTINUE
      IF (ABS(XZ).GT.SC .AND. ABS(YZ).LT.1.0E-05) GO TO 180
      IF (BZ.GT.0.0) GO TO 16
      IF (ABS(XZ).LT.SC .AND. XZ.NE.0.0) GO TO 18
      CSETAZ=0.0
      SNETAZ=1.0
      IF (J.GT.1) GO TO 17
      FX=0.0
      FY=0.0
      FZ=4.0
      GO TO 17
   18 CSETAZ=XZ/AZ*FX
      SNETAZ=SIN(ACOS(CSETAZ))
      GO TO 17
  180 CSETAZ=FX*XZ/ABS(XZ)
      SNETAZ=0.0
      GO TO 17
   16 CSETAZ=XZ/AZ*FX
      SNETAZ=YZ/BZ*FY
   17 CONTINUE
C
C       SET UP COEFFICIENT ARRAY FOR QUARTIC EQUATION
C        A(5)*(T**4)+A(4)*(T**3)+A(3)*(T**2)+A(2)*T+A(1)=0.0
C
      A(5)=1.0
      Q=SC2*CSETAZ*CSETAZ + SB2 + BZ2 +ZZ2 + 2.0*AZ*SA*CSETAZ + SC2
      A(4)=-4.0*SB*BZ*SNETAZ/Q
      A(3)=2.0*(SC2*CSETAZ*CSETAZ + SB2 + BZ2 + ZZ2-SC2)/Q
      A(2)=A(4)
      A(1)=(SC2*CSETAZ*CSETAZ + SB2+BZ2+ZZ2+SC2-2.0*SA*AZ*CSETAZ)/Q
      DO 19 M=1,5
      MM=6-M
   19 AS(MM)=A(M)
      IF ( JNUM.GT.0  ) GO TO 28
      MP=4
      CALL QUART(AS,RTR,RTI)
      B1=RTR(1)
      B2=RTR(3)
      IF (ABS(B1) .LT. 1.0E-07) B1=0.0
      IF (ABS(B2) .LT. 1.0E-07) B2=0.0
      A1=ABS(RTI(1))
      A2=ABS(RTI(3))
      IF (B2 .GT.0.0 ) GO TO 54
      IF (B2 .LT.0.0 .AND. B1 .GT. 0.0) GO TO 56
      IF (B2 .EQ.0.0 .AND. B1 .LT. 0.0) GO TO 54
   56 CONTINUE
      DUM=B2
      B2=B1
      B1=DUM
      DUM=A2
      A2=A1
      A1=DUM
   54 CONTINUE
C
C      CALCULATE J-INTEGRALS
C
      CALL JINTEG (A1,B1,A2,B2,ZJ)
      IF (JERR.EQ.0) GO TO 29
      JNUM=13
   28 CONTINUE
C
C      CALCULATE J-INTEGRALS USING NUMERICAL INTEGRATION
C
       T(1)=0.
       NP=41
      DX=NP-1
      DX=1.0/DX
       DO 50 M=2,NP
   50  T(M)=T(M-1)+DX
      DO 51 M=1,NP
      F(M)=A(1)+A(2)*T(M)+A(3)*T(M)*T(M)+A(4)*(T(M)**3)+A(5)*(T(M)**4)
   51  F(M)=1.0/(F(M)**1.5)
       CALL SIMSON (NP,F,DX,ZJ(1))
       DO 53 MM=2,5
       DO  55 M=1,NP
   55 F(M)=F(M)*T(M)
   53 CALL SIMSON (NP,F,DX,ZJ(MM))
   29 CONTINUE
C
```

```
C       CALCULATE VELOCITY COMPONENTS
C
      DUM=PI*(W**1.5)
      VX=GAMMA*SB*ZZ/DUM*0.5*(ZJ(1)-ZJ(5))*FX
      VY=GAMMA*SA*ZZ/DUM*(ZJ(2)+ZJ(4))*FY
      VZ=GAMMA*0.5/DUM*((SA*SB+AZ*SB*CSETAZ)*ZJ(5)
     1     - (2.0*SA*BZ*SNETAZ)*ZJ(4) + 2.0*SA*SB*ZJ(3)
     2     - 2.0*SA*BZ*SNETAZ*ZJ(2) + (SA*SB-AZ*SB*CSETAZ)*ZJ(1))
      VZ=VZ*FZ
      VPX=VPX+VX
      VPY=VPY+VY
      VPZ=VPZ+VZ
   31 IF (FZ.GT.3.0) RETURN
   30 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE JINTEG(A1,B1,A2,B2,ZJ)
C
C        SOLUTION OF J-INTEGRALS
C
      DIMENSION ZJ(5)
      COMMON /ERR/ JERR
C
C
      JERR=0
      DO 1 N=1,5
    1 ZJ(N)=0.0
      IF (ABS(B1-B2).LT.1.0E-07)  GO TO 60
      PI=3.1415926
      PI2=PI/2.0
      RAD=180./PI
      TL=0.0
      TU=1.0
      TZP=0.0
      TZN=0.0
      F=0.0
      E=0.0
      CA2=(B1-B2)**2 + (A1+A2)**2
      CB2=(B1-B2)**2 + (A1-A2)**2
      CA=SQRT(CA2)
      CB=SQRT(CB2)
      AK2=4.0*CA*CB/((CA+CB)**2)
      CK2=1.0-AK2
      CK=SQRT(CK2)
      G=2.0/(CA+CB)
      G12=(4.0*A1*A1-(CA-CB)**2)/((CA+CB)**2 - 4.0*A1*A1)
      G1=SQRT(G12)
      NM=0
      TZP=B1-A1*G1
      GO TO 11
   10 G1=-G1
      NM=1
      TZN=B1-A1*G1
      TU=TZN
       IF (TU.GT.TZP) TU=TZP
   11 CONTINUE
      IF (TU.GT.1.0) TU=1.0
      TPHILN=TL+A1*G1-B1
      TPHILD=A1+G1*B1-G1*TL
      TPHIUN= TU+A1*G1-B1
      TPHIUD=A1+G1*B1-G1*TU
      PHIL=ATAN2(TPHILN,TPHILD)
      PHIU=ATAN2(TPHIUN,TPHIUD)
      DL=PHIL*RAD
      DU=PHIU*RAD
       IF (DL.LT.0.0 .AND. G1.GT.0.0 .AND. NM.EQ.0) GO TO 10
      IF (NM.EQ.0) NM=3
      EM=0.0
      PL=PHIL
      IF (PHIL.GT.PI2) EM=EM+1.0
      IF (PHIL.LT.PI) GO TO 22
      PL=PL-PI
      EM=2.0
   22 CONTINUE
      IF (PL.LE.PI2) GO TO 23
      DUM=TAN(PI2)
      CALL ELI1  (F,DUM,CK)
      CALL ELI2 (E,DUM,CK,1.0,CK2)
      DUM=TAN(PI-PL)
      CALL ELI1 (FPL,DUM,CK)
      CALL ELI2 (EPL,DUM,CK,1.0,CK2)
      FL=2.0*EM*F - FPL
      EL=2.0*EM*E - EPL
      GO TO 24
   23 DUM=TAN(PL)
      CALL ELI1(FL,DUM,CK)
      CALL ELI2(EL,DUM,CK,1.0,CK2)
   24 EM=0.0
      PU=PHIU
      IF (PHIU.GT.PI2) EM=EM+1.0
      IF (PHIU.LT.PI) GO TO 26
      PU=PU-PI
      EM=2.0
   26 CONTINUE
      IF (PU.LE.PI2) GO TO 27
      DUM=TAN(PI2)
      CALL ELI1(F,DUM,CK)
      CALL ELI2(E,DUM,CK,1.0,CK2)
      DUM=TAN(PI-PU)
      CALL ELI1(FPU,DUM,CK)
      CALL ELI2(EPU,DUM,CK,1.0,CK2)
      FU=2.0*EM*F - FPU
      EU=2.0*EM*E - EPU
      GO TO 28
   27 DUM=TAN(PU)
      CALL ELI1(FU,DUM,CK)
      CALL ELI2(EU,DUM,CK,1.0,CK2)
   28 CONTINUE
      SNUL=SIN(PHIL)
      SNUU=SIN(PHIU)
      CNUL=COS(PHIL)
      CNUU=COS(PHIU)
      DNUL=SQRT(1.0-AK2*SNUL*SNUL)
      DNUU=SQRT(1.0-AK2*SNUU*SNUU)
C
C        COMPUTE LAMBDA(0) THRU LAMBDA(4)
C
   50 DUM=SNUU*CNUU/DNUU - SNUL*CNUL/DNUL
      AK4=AK2*AK2
      ZLAM0=((1.0+CK2)*(EU-EL)-2.0*CK2*(FU-FL)-AK2*DUM)/(AK4*CK2)
      ZLAM1=(DNUU*1.0/DNUU -DNUL*1.0/DNUL)/AK4
      ZLAM2=(-2.0*(EU-EL)+(1.0+CK2)*(FU-FL)+AK2*DUM)/AK4
      ZLAM3=-(DNUU*CK2/DNUU -DNUL*CK2/DNUL)/AK4
      ZLAM4=((1.0+CK2)*(EU-EL)-2.0*CK2*(FU-FL)-AK2*CK2*DUM)/AK4
C
C       COMPUTE J(0) THRU J(4)
C
   51 TAU=(A1+B1*G1)/(B1-A1*G1)
      DUM=(G**3)/(A1*(1.0+G12))**2
      G13=G12*G1
      TAU2=TAU*TAU
      TAU3=TAU2*TAU
   52 ZJ0=DUM*(ZLAM4 + 4.0*G1*ZLAM3 + 6.0*G12*ZLAM2 + 4.0*G13*ZLAM1
     1          + G13*G1*ZLAM0)
      DUM=DUM*(B1-A1*G1)
   53 ZJ1=DUM*(ZLAM4 + (3.0*G1+TAU)*ZLAM3 + 3.0*G1*(G1+TAU)*ZLAM2
     1          + G12*(G1+3.0*TAU)*ZLAM1 + TAU*G13*ZLAM0)
      DUM=DUM*(B1-A1*G1)
      ZJ2=DUM*(ZLAM4 + 2.0*(G1+TAU)*ZLAM3 + (TAU2+4.0*G1*TAU+G12)*ZLAM2
     1          + 2.0*G1*TAU*(G1+TAU)*ZLAM1 + G12*TAU2*ZLAM0)
      DUM=DUM*(B1-A1*G1)
      ZJ3=DUM*(ZLAM4 + (3.0*TAU+G1)*ZLAM3 + 3.0*TAU*(TAU+G1)*ZLAM2
     1          + TAU2*(3.0*G1+TAU)*ZLAM1 + G1*TAU3*ZLAM0)
      DUM=DUM*(B1-A1*G1)
      ZJ4=DUM*(ZLAM4 + 4.0*TAU*ZLAM3 + 6.0*TAU2*ZLAM2 + 4.0*TAU3*ZLAM1
```

```
 1             + TAU*TAU3*ZLAM0)
C
 54 TNUL=SNUL/CNUL
    TNUU=SNUU/CNUU
    SUB2LL=1.0/((TL-B2)**2 + A2*A2)
    SUB2LU=1.0/((TU-B2)**2 + A2*A2)
    SUB2RL=((G*(1.0+G1*TNUL))**2)/((1.0+G12)*(1.0+CK2*TNUL*TNUL))
    SUB2RU=((G*(1.0+G1*TNUU))**2)/((1.0+G12)*(1.0+CK2*TNUU*TNUU))
    ZJ(1)=ZJ0 + ZJ(1)
    ZJ(2)=ZJ1 + ZJ(2)
    ZJ(3)=ZJ2 + ZJ(3)
    ZJ(4)=ZJ3 + ZJ(4)
    ZJ(5)=ZJ4 + ZJ(5)
    TEST1=ABS(SUB2LL-SUB2RL)
    TEST2=ABS(SUB2LU-SUB2RU)
    IF (TEST1.GT.1.0E-05.OR.TEST2.GT.1.0E-05) GO TO 60
    IF (NM.GT.2) RETURN
    IF ((1.0-TU) .LT. 1.0E-06) RETURN
    G1=-G1
    TL=TU
    TU=1.0
    NM=3
    GO TO 11
 60 JERR=99
    RETURN
    END
```

```
      SUBROUTINE ELI1(RES,X,CK)
C
C        PURPOSE
C           COMPUTES THE ELLIPTIC INTEGRAL OF FIRST KIND
C
C        USAGE
C           CALL ELI1(RES,X,CK)
C
C        DESCRIPTION OF PARAMETERS
C           RES  -  RESULT VALUE
C           X    -UPPER INTEGRATION BOUND(ARGUMENT OF ELLIPTIC
C                 INTEGRAL OF FIRST KIND
C           CK   -COMPLEMENTARY MODULUS
C
C        REMARKS
C           MODULUS K = SQRT(1.-CK*CK).
C
C        METHOD
C           DEFINITION
C           RES=INTEGRAL(1/SQRT((1+T*T)*(1+(CK*T)**2)), SUMMED
C           OVER T FROM 0 TO X).
C           EQUIVALENT ARE THE DEFINITIONS
C           RES=INTEGRAL(1/(COS(T)*SQRT(1+(CK*TAN(T))**2)), SUMMED
C           OVER T FROM 0 TO ATAN(X)),
C           RES=INTEGRAL(1/SQRT(1-(K*SIN(T))**2), SUMMED OVER
C           T FROM 0 TO ATAN(X)).
C           EVALUATION
C           LANDENS TRANSFORMATION IS USED FOR CALCULATION.
C           REFERENCE
C           R. BULIRSCH, NUMERICAL CALCULATION OF ELLIPTIC INTEGRALS AND
C                ELLIPTIC FUNCTIONS.
C                HANDBOOK SERIES OF SPECIAL FUNCTIONS
C                NUMERISCHE MATHEMATIK VOL. 7, 1965, PP. 78-90.
C
C        ..................................................................
C
      IF(X)2,1,2
    1 RES=0.
      RETURN
    2 IF(CK)4,3,4
    3 RES=ALOG(ABS(X)+SQRT(1.+X*X))
      GO TO 13
    4 ANGLE=ABS(1./X)
      GEO=ABS(CK)
      ARI=1.
      PIM=0.
    5 SQGEO=ARI*GEO
      AARI=ARI
      ARI=GEO+ARI
      ANGLE= -SQGEO/ANGLE+ANGLE
      SQGEO=SQRT(SQGEO)
      IF(ANGLE)7,6,7
C     REPLACE 0 BY SMALL VALUE
    6 ANGLE=SQGEO*1.E-8
    7 TEST=AARI*1.E-4
      IF(ABS(AARI-GEO)-TEST)10,10,8
    8 GEO=SQGEO+SQGEO
      PIM=PIM+PIM
      IF(ANGLE)9,5,5
    9 PIM=PIM+3.1415927
      GO TO 5
   10 IF(ANGLE)11,12,12
   11 PIM=PIM+3.1415927
   12 RES=(ATAN(ARI/ANGLE)+PIM)/ARI
   13 IF(X)14,15,15
   14 RES=-RES
   15 RETURN
      END
```

```
      SUBROUTINE ELI2(R,X,CK,A,B)
C
C        PURPOSE
C           COMPUTES THE GENERALIZED ELLIPTIC INTEGRAL OF SECOND KIND
C
C        USAGE
C           CALL ELI2(R,X,CK,A,B)
C
C        DESCRIPTION OF PARAMETERS
C           R   - RESULT VALUE
C           X    -UPPER INTEGRATION BOUND(ARGUMENT OF ELLIPTIC
C                 INTEGRAL OF SECOND KIND)
C           CK   -COMPLEMENTARY MODULUS
C           A    -CONSTANT TERM IN NUMERATOR
C           B    -QUADRATIC TERM IN NUMERATOR
C
C        REMARKS
C           MODULUS K = SQRT(1.-CK*CK).
C           SPECIAL CASES OF THE GENERALIZED ELLIPTIC INTEGRAL OF
C           SECOND KIND ARE
C           F(ATAN(X*,K) OBTAINED WITH A=1., B=1.
C           E(ATAN(X),K) OBTAINED WITH A=1.,B=CK*CK.
C           B(ATAN(X*,K) OBTAINED WITH A=1., B=0.
C           D(ATAN(X*,K) OBTAINED WITH A=0., B=1.
C
C        METHOD
C           DEFINITION
C           R=INTEGRAL((A+B*T*T)/(SQRT((1+T*T)*(1+(CK*T)**2))*(1+T*T)),
C                SUMMED OVER T FROM 0 TO X).
C           EQUIVALENT IS THE DEFINITION
C           R=INTEGRAL((A+(B-A)*(SIN(T))**2)/SQRT(1-(K*SIN(T))**2),
C                SUMMED OVER T FROM 0 TO ATAN(X)).
C           EVALUATION
C           LANDENS TRANSFORMATION IS USED FOR CALCULATION.
C           REFERENCE
C           R. BULIRSCH, NUMERICAL CALCULATION OF ELLIPTIC INTEGRALS AND
C                ELLIPTIC FUNCTIONS
C                HANDBOOK SERIES OF SPECIAL FUNCTIONS
C                NUMERISCHE MATHEMATIK VOL. 7, 1965, PP. 78-90
C
C     .................................................
C           TEST ARGUMENT
```

```
      IF(X)2,1,2
    1 R=0,
      RETURN
C             TEST MODULUS
    2 C=0,
      D=0,5
      IF(CK)7,3,7
    3 R=SQRT(1,+X*X)
      R=(A-B)*ABS(X)/R+B*ALOG(ABS(X)+R)
C             TEST SIGN OF ARGUMENT
    4 R=R+C*(A-B)
      IF(X)5,6,6
    5 R=-R
    6 RETURN
C             INITIALIZATION
    7 AN=(B+A)*0,5
      AA=A
      R=B
      ANG=ABS(1,/X)
      PIM=0,
      ISI=0
      ARI=1,
      GEO=ABS(CK)
C             LANDEN TRANSFORMATION
    8 R=AA*GEO+R
      SGEO=ARI*GEO
      AA=AN
      AARI=ARI
C             ARITHMETIC MEAN
      ARI=GEO+ARI
C             SUM OF SINE VALUES
      AN=(R/ARI+AA)*0,5
      AANG=ABS(ANG)
      ANG=-SGEO/ANG+ANG
      PIMA=PIM
      IF(ANG)10,9,11
    9 ANG=-1,E-8*AANG
   10 PIM=PIM+3,1415927
      ISI=ISI+1
   11 AANG=ARI*ARI+ANG*ANG
      P=D/SQRT(AANG)
      IF(ISI-4)13,12,12
   12 ISI=ISI-4
   13 IF(ISI-2)15,14,14
   14 P=-P
   15 C=C+P
      D=D*(AARI-GEO)*0,5/ARI
      IF (ABS(AARI-GEO)-1,E-4*AARI)17,17,16
   16 SGEO=SQRT(SGEO)
C             GEOMETRIC MEAN
      GEO=SGEO*SGEO
      PIM=PIM+PIMA
      ISI=ISI+ISI
      GOTO 8
C             ACCURACY WAS SUFFICIENT
   17 R=(ATAN(ARI/ANG)+PIM)*AN/ARI
      C=C+D*ANG/AANG
      GOTO 4
      END
```

```
      SUBROUTINE ELLIPS (AKSQ,TK,TE)
C
C                 -- TABLE LOOK-UP OF ELLIPTIC INTEGRALS --
C
      DIMENSION CKK(100),CK(100),CE(100)
C
C
C        CKK = ARGUMENT OF ELLIPTIC INTEGRALS
C
      DATA CKK/0,00,,01,,02,,03,,04,,05,,06,,07,,08,,09,,10,,11,,12,,13,
     1         ,14,,15,,16,,17,,18,,19,,20,,21,,22,,23,,24,,25,,26,,27,
     2         ,28,,29,,30,,31,,32,,33,,34,,35,,36,,37,,38,,39,,40,,41,
     3         ,42,,43,,44,,45,,46,,47,,48,,49,,50,,51,,52,,53,,54,,55,
     4         ,56,,57,,58,,59,,60,,61,,62,,63,,64,,65,,66,,67,,68,,69,
     5         ,70,,71,,72,,73,,74,,75,,76,,77,,78,,79,,80,,81,,82,,83,
     6         ,84,,85,,86,,87,,88,,89,,90,,91,,92,,93,,94,,95,,96,,97,
     7         ,98,,99/
C
C        CK = COMPLETE ELLIPTIC INTEGRALS OF FIRST KIND
C
      DATA CK/1,570796,1,574746,1,578740,1,582780,1,586868,1,591003,
     1         1,595188,1,599423,1,603710,1,608049,1,612441,1,616889,
     2         1,621393,1,625955,1,630576,1,635257,1,640000,1,644806,
     3         1,649678,1,654617,1,659624,1,664701,1,669850,1,675073,
     4         1,680373,1,685750,1,691208,1,696749,1,702374,1,708087,
     5         1,713889,1,719785,1,725776,1,731865,1,738055,1,744351,
     6         1,750754,1,757269,1,763898,1,770647,1,777519,1,784519,
     7         1,791650,1,798918,1,806328,1,813884,1,821593,1,829460,
     8         1,837491,1,845694,1,854075,1,862641,1,871400,1,880361,
     9         1,889533,1,898925,1,908547,1,918410,1,928526,1,938908,
     A         1,949568,1,960521,1,971783,1,983371,1,995303,2,007598,
     B         2,020279,2,033369,2,046894,2,060882,2,075363,2,090373,
     C         2,105948,2,122132,2,138970,2,156516,2,174827,2,193971,
     D         2,214022,2,235068,2,257205,2,280549,2,305232,2,331409,
     E         2,359264,2,389016,2,420933,2,455338,2,492635,2,533335,
     F         2,578092,2,627773,2,683551,2,747073,2,820752,2,908337,
     G         3,016112,3,155875,3,354141,3,695637/
C
C        CE = COMPLETE ELLIPTIC INTEGRALS OF SECOND KIND
C
      DATA CE/1,570796,1,566862,1,562913,1,558948,1,554969,1,550973,
     1         1,546963,1,542936,1,538893,1,534833,1,530758,1,526665,
     2         1,522555,1,518428,1,514284,1,510122,1,505942,1,501743,
     3         1,497526,1,493290,1,489035,1,484761,1,480466,1,476152,
     4         1,471818,1,467462,1,463086,1,458688,1,454269,1,449827,
     5         1,445363,1,440876,1,436366,1,431832,1,427274,1,422691,
     6         1,418083,1,413450,1,408791,1,404105,1,399392,1,394652,
     7         1,389883,1,385086,1,380259,1,375402,1,370515,1,365596,
     8         1,360645,1,355661,1,350644,1,345592,1,340505,1,335382,
     9         1,330223,1,325024,1,319788,1,314511,1,309192,1,303832,
     A         1,298428,1,292979,1,287484,1,281942,1,276350,1,270707,
     B         1,265013,1,259263,1,253458,1,247595,1,241671,1,235684,
     C         1,229632,1,223512,1,217321,1,211056,1,204714,1,198290,
     D         1,191781,1,185183,1,178490,1,171697,1,164798,1,157787,
     E         1,150656,1,143396,1,135998,1,128451,1,120742,1,112856,
     F         1,104775,1,096478,1,087938,1,079121,1,069986,1,060474,
     G         1,050502,1,039947,1,028595,1,015994/
C
      IF (AKSQ,LE,0,99) GO TO 20
   21 PARA=0,25*(1,0-AKSQ)
  700 TEST = 1,00E-07
      IF(PARA-TEST)701,702,702
  701 PARA=TEST
  702 ZLP=ALOG(4,/PARA)
      TK=ZLP*0,5*(1,+PARA)-PARA
      TE=1,0+(ZLP*PARA)-PARA
      GO TO 30
   20 JA=100,0*AKSQ
      JA=1+JA
      IF(CKK(JA)-AKSQ)22,23,22
   23 TK=CK(JA)
      TE=CE(JA)
      GO TO 30
   22 CON=(AKSQ-CKK(JA))/(CKK(JA+1)-CKK(JA))
      TK=CK(JA)+CON*(CK(JA+1)-CK(JA))
      TE=CE(JA)+CON*(CE(JA+1)-CE(JA))
   30 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE QUART(C,XR,XI)
C       SOLUTION OF THE QUARTIC EQUATION
C        A(1)*(X**4)+A(2)*(X**3)+A(3)*(X**2)+A(4)*X+A(5)=0.0
C
      DIMENSION C(5),XR(4),XI(4),AC(4),AQ(3),BQ(3),RT(3)
      EQUIVALENCE (AQ,BQ)
      A3=C(2)/C(1)
      A2=C(3)/C(1)
      A1=C(4)/C(1)
      A0=C(5)/C(1)
      A=A3/2.
      AC(1)=1.
      AC(2)=-A2
      AC(3)=A1*A3-4.*A0
      AC(4)=A0*(4.*A2-A3*A3)-A1*A1
      CALL CUBIC(AC,RT,RT1)
      IF(RT1) 20,10,20
   10 IF(RT(1)-RT(2)) 11,12,12
   11 RT(1)=RT(2)
   12 IF(RT(1)-RT(3)) 13,20,20
   13 RT(1)=RT(3)
   20 B=RT(1)/2.
      DUM=B*B-A0
      IF (DUM.GT.1.0E-05) GO TO 24
   22 D=0.
      CA=SQRT(A*A+2.*B-A2)
      GO TO 25
   24 D=SQRT(B*B-A0)
      CA=-(A1/2.-A*B)/D
   25 AQ(1)=1.
      AQ(2)=A-CA
      AQ(3)=B-D
      CALL QUAD(AQ,XR(1),XR(2),XI(1))
      BQ(2)=A+CA
      BQ(3)=B+D
      CALL QUAD(BQ,XR(3),XR(4),XI(3))
      XI(2)=-XI(1)
      XI(4)=-XI(3)
      RETURN
      END
```

```
      SUBROUTINE CUBIC (A,XR,XI)
C     SOLUTION OF CUBIC EQUATION
C     A(1)*X**3+A(2)*X**2+A(3)*X+A(4)=0.
C
      DIMENSION A(4),XR(3),AQ(3)
      IPATH=2
      EX=1./3.
      IF(A(4)) 1006,1004,1006
 1004 XR(1)=0.
      GO TO 1034
 1006 A2=A(1)*A(1)
      Q=(27.*A2*A(4)-9.*A(1)*A(2)*A(3)+2.*A(2)**3)/(54.*A2*A(1))
      IF(Q)1010,1008,1014
 1008 Z=0.
      GO TO 1032
 1010 Q=-Q
      IPATH=1
 1014 P=(3.*A(1)*A(3)-A(2)*A(2))/(9.*A2)
      ARG=P*P*P+Q*Q
      IF(ARG)1016,1018,1020
 1016 Z=-2.*SQRT (-P)*COS (ATAN (SQRT (-ARG)/Q)/3.)
      GO TO 1028
 1018 Z=-2.*Q**EX
      GO TO 1028
 1020 SARG=SQRT (ARG)
      IF (P)1022,1024,1026
 1022 Z=-(Q+SARG)**EX-(Q-SARG)**EX
      GO TO 1028
 1024 Z=-(2.*Q)**EX
      GO TO 1028
 1026 Z=(SARG-Q)**EX-(SARG+Q)**EX
 1028 GO TO (1030,1032),IPATH
 1030 Z=-Z
 1032 XR(1)=(3.*A(1)*Z-A(2))/(3.*A(1))
 1034 AQ(1)=A(1)
      AQ(2)=A(2)+XR(1)*A(1)
      AQ(3)=A(3)+XR(1)*AQ(2)
      CALL QUAD (AQ,XR(2),XR(3),XI)
      RETURN
      END
```

```
      SUBROUTINE QUAD (A,XR1,XR2,XI)
C     SOLUTION OF THE QUADRATIC EQUATION
C     A(1)*X*X+A(2)*X+A(3)=0.
C
      DIMENSION A(3)
      X1=-A(2)/(2.*A(1))
      DISC=X1*X1-A(3)/A(1)
      IF(DISC)10,20,20
   10 X2=SQRT (-DISC)
      XR1=X1
      XR2=X1
      XI=X2
      GO TO 30
   20 X2=SQRT (DISC)
      XR1=X1+X2
      XR2=X1-X2
      XI=0.
   30 RETURN
      END
```

```
      SUBROUTINE SIMSON (N,F,DX,SUM)
C
      DIMENSION F( 1 )
C
      SUM=F(1)+F(N)
      DO 1 I=2,N,2
    1 SUM=SUM+4.0*F(I)
      M=N-2
      DO 2 I=3,M,2
    2 SUM=SUM+2.0*F(I)
      SUM=DX*SUM/3.0
      RETURN
      END
```

REFERENCES

1. Mendenhall, M. R., Spangler, S. B., Nielsen, J. N., and Goodwin, F. K.: Calculation of the Longitudinal Aerodynamic Characteristics of Wing-Flap Configurations with Externally Blown Flaps. NASA CR-2705, 1976.

2. Dillenius, M. F. E., Mendenhall, M. R., and Spangler, S. B.: Calculation of the Longitudinal Aerodynamic Characteristics of STOL Aircraft with Externally-Blown Jet-Augmented Flaps. NASA CR-2358, Feb. 1974.

3. Aoyagi, K., Falarski, M. D., and Koenig, D. G.: Wind-Tunnel Investigation of a Large-Scale 25^{o} Swept-Wing Jet Transport Model with an External Blowing Triple-Slotted Flap. NASA TM X-62,197, Nov. 1973.

4. Perry, B., III and Greene, G. C.: Wind-Tunnel Investigation of Aerodynamic Loads on a Large-Scale Externally Blown Flap Model and Comparison with Theory. NASA TN D-7863, Mar. 1975.

NIELSEN ENGINEERING & RESEARCH, INC.
Mountain View, California
November 1975

Wing-Flaps	Jets				Iterations	Angles of Attack	Execution Time (sec.)	
Vortex Lattice Elements	No.	Shape	Length	Δs			CDC-6600 FTN,OPT=2	CDC-7600 FTN,OPT=2
26	1	Circular	18	0.1	2	1	8	
104	Off	--------	--	---	1	2	40	
120	Off	--------	--	---	1	1	48	
135	Off	--------	--	---	1	2	90	
156	Off	--------	--	---	1	2	120	
126	2	Circular	20	0.1	3	1	170	35
126	2	Circular	20	0.1	4	1	215	45
126	2	Circular	20	0.1	5	1	270	
135	2	Circular	20	0.1	1	1	85	
135	2	Circular	20	0.1	2	1	140	
135	2	Circular	20	0.1	3	1	200	
135	2	Circular	20	0.1	4	1	260	
135	2	Elliptical	20	0.1	1	1	330	
135	2	Elliptical	20	0.1	2	1	590	
149	2	Circular	20	0.1	1	1	100	

Table I.- Typical execution times for EBF prediction program.

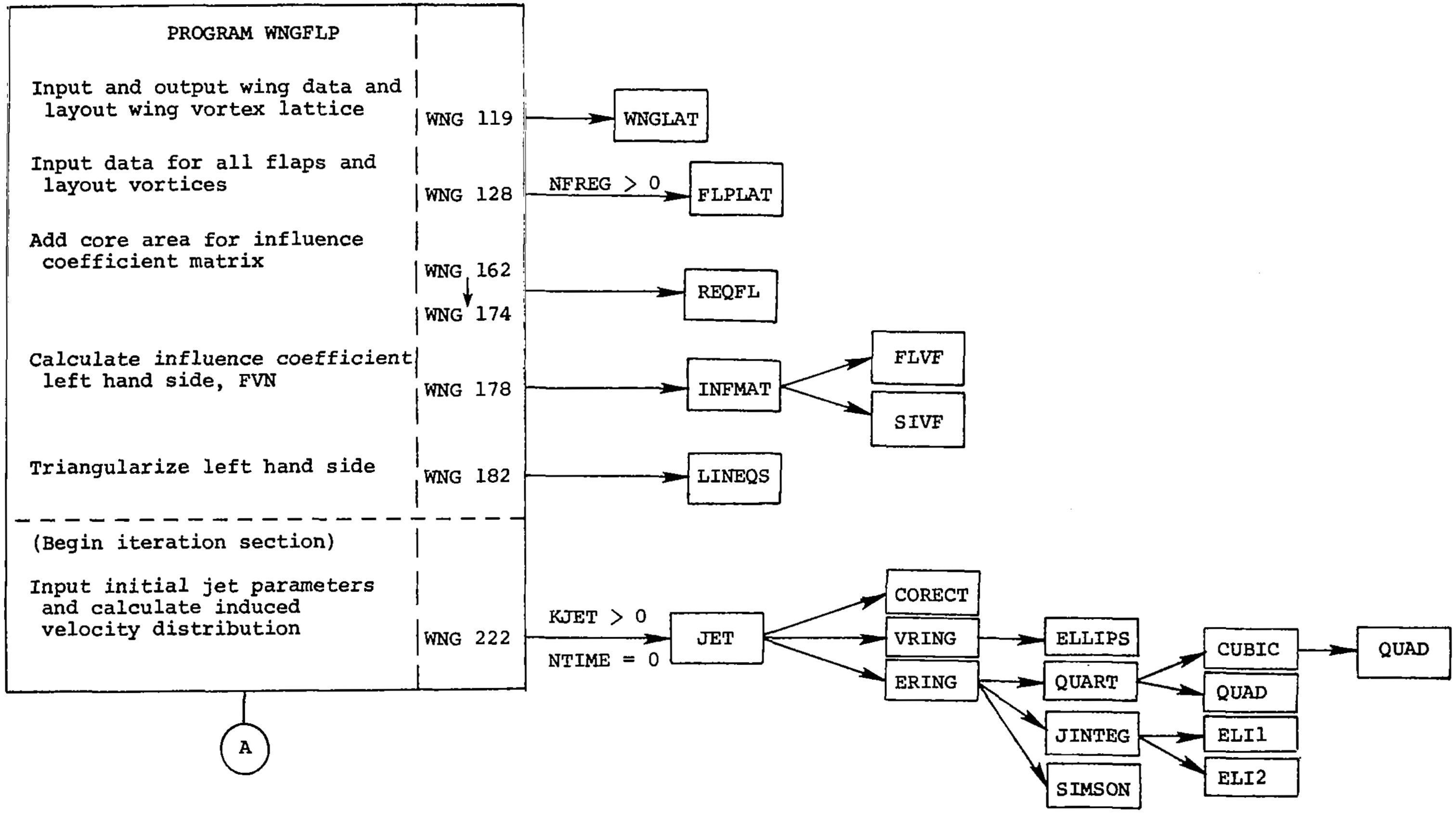


Figure 1.- General flow chart of program WNGFLP.

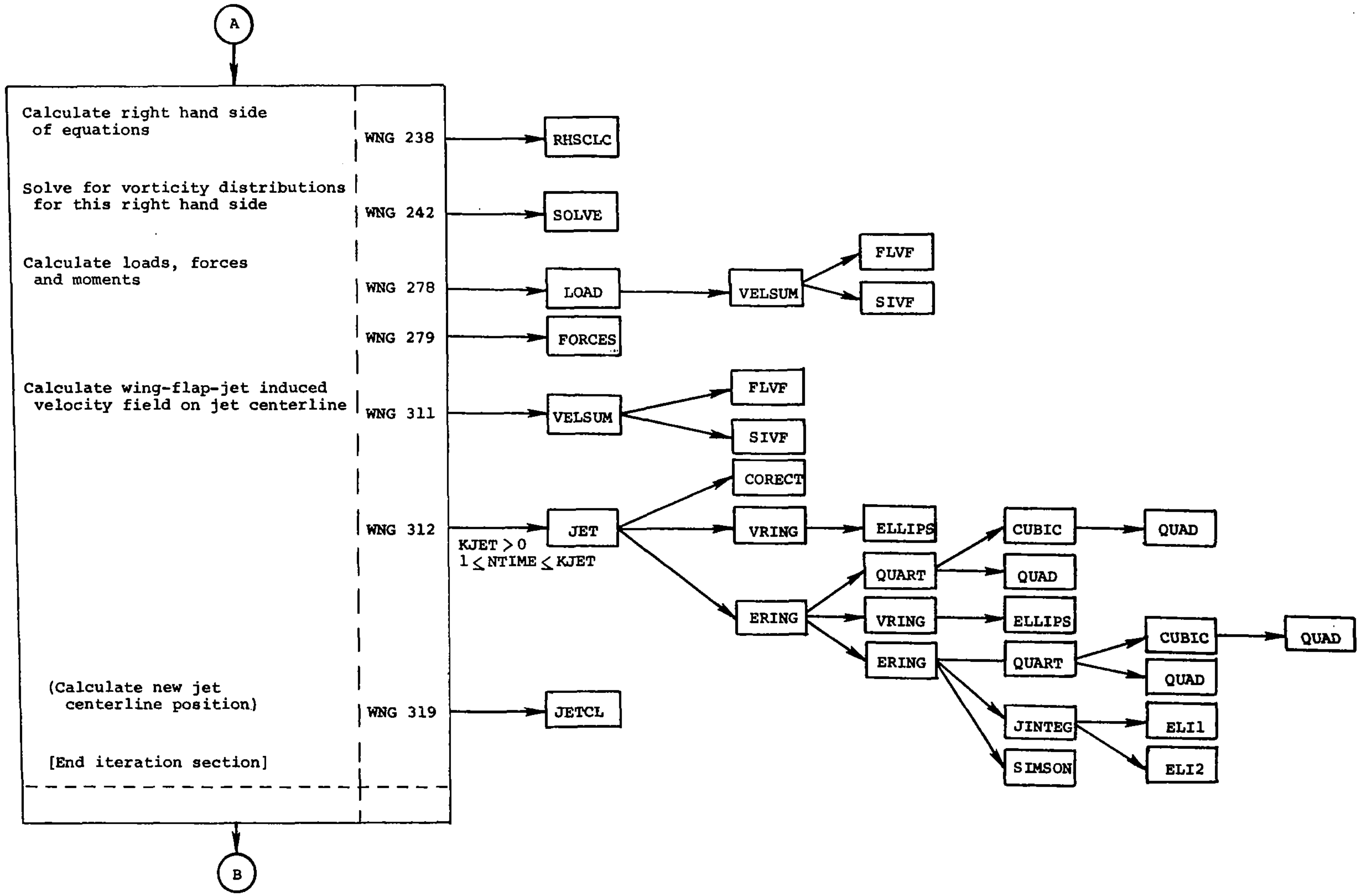


Figure 1.- Continued.

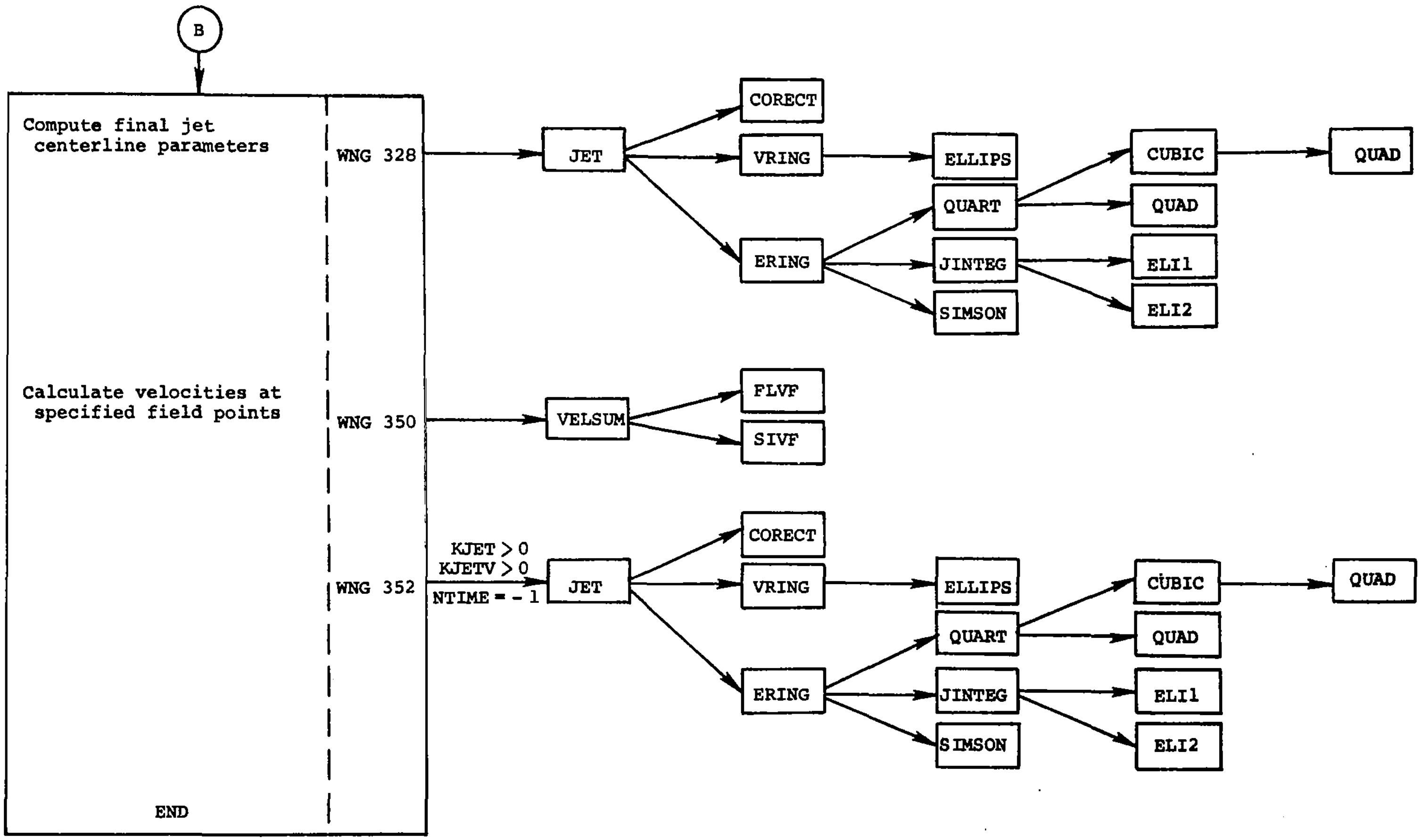


Figure 1.- Concluded.

```
      PROGRAM MAIN (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE4)
      COMMON FVN(27225)
      CALL WNGFLP
      STOP
      END
```

```
      SUBROUTINE WNGFLP                                                 WNG 001

       - - -

      COMMON FVN(1)                                                     WNG 043

       - - -

   65 CONTINUE                                                          WNG 160
C                                                                       WNG 161
C                                                                       WNG 175

       - - -

      GO TO 1000                                                        WNG 362
      RETURN                                                            WNGA362
      END                                                               WNG 363
```

Figure 2.- Alternate card decks defining program MAIN and Subroutine WNGFLP.

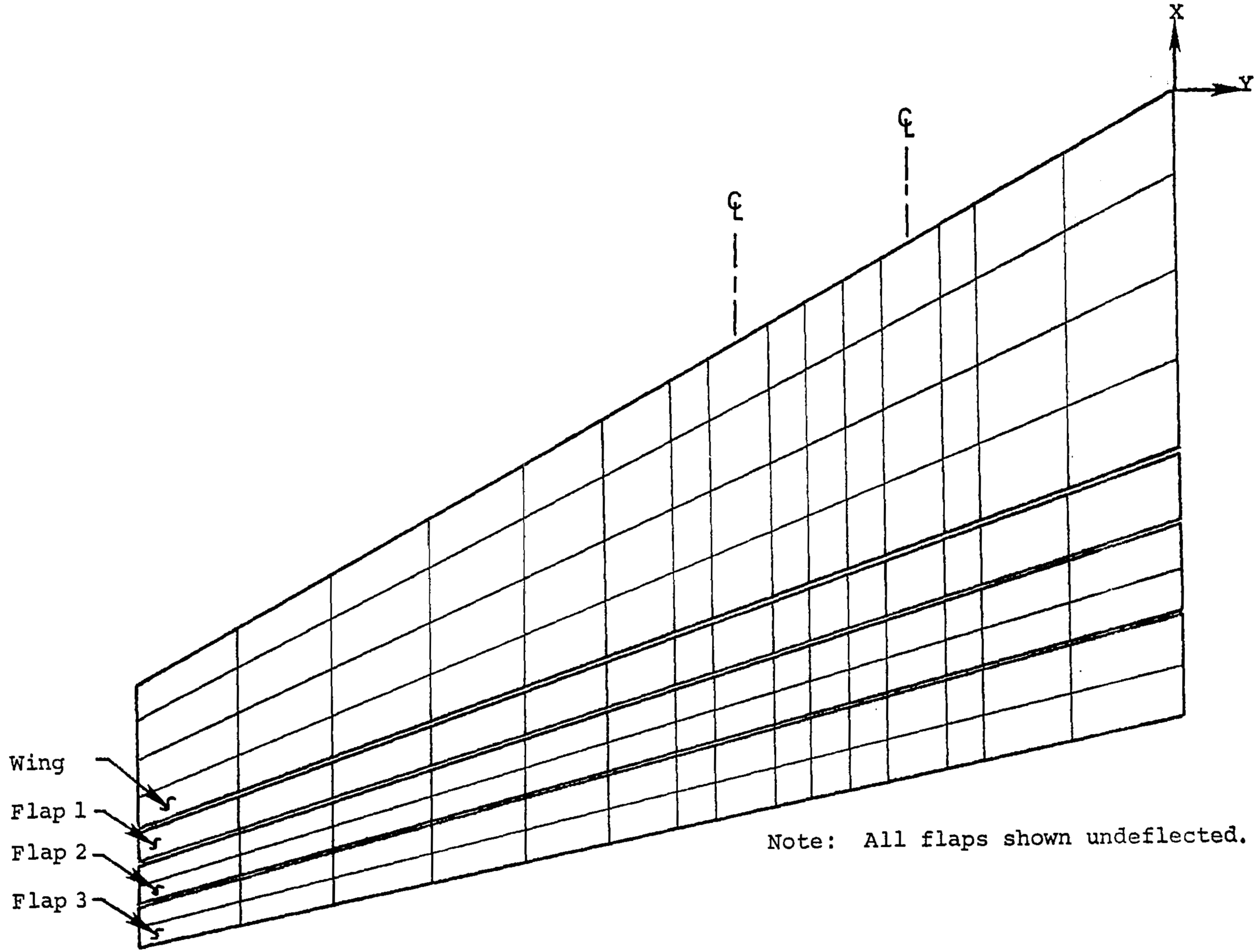


Figure 3.- Vortex-lattice arrangement for EBF configuration of references 3 and 4.

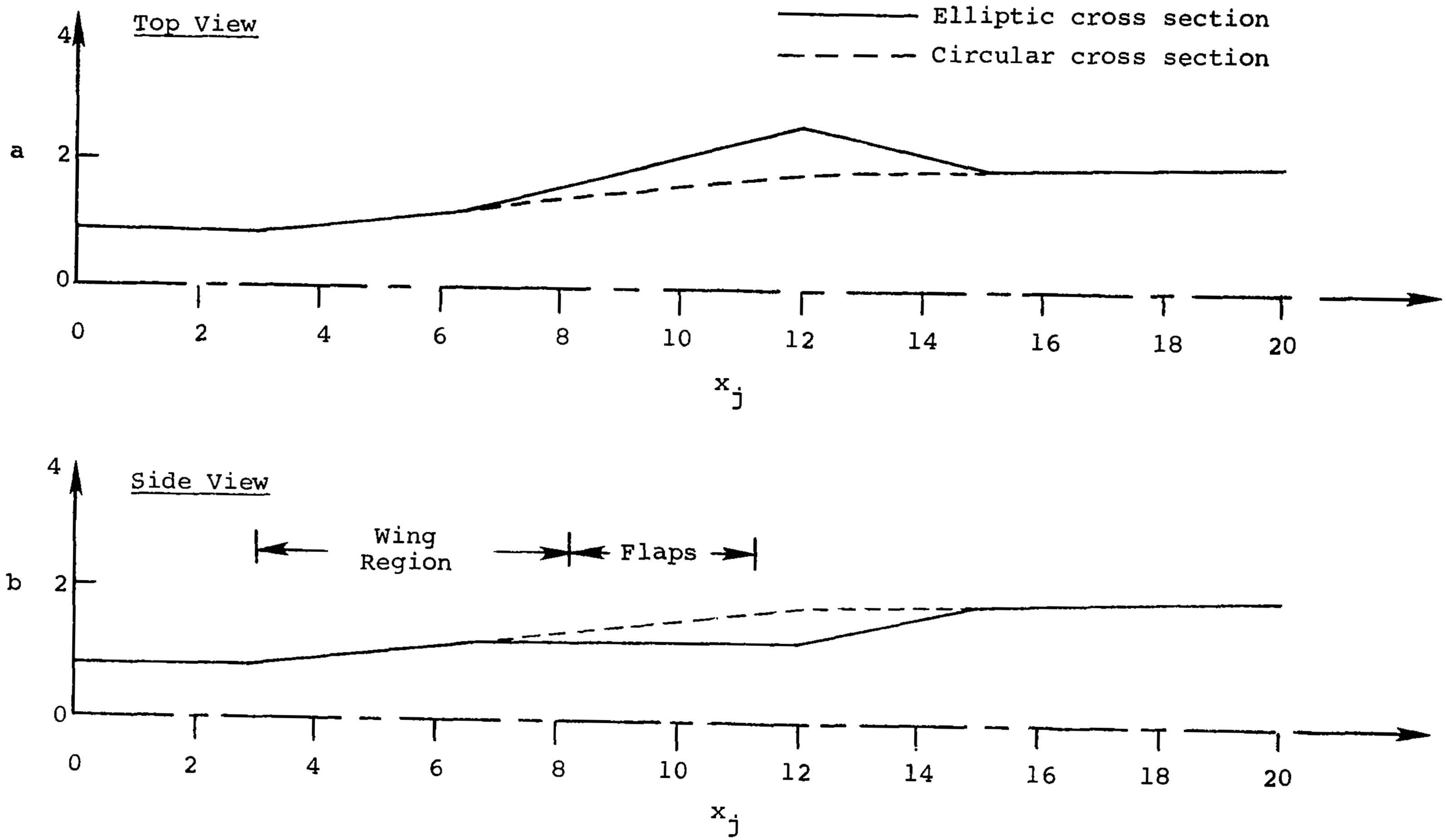


Figure 4.- Jet wake model boundary specification.

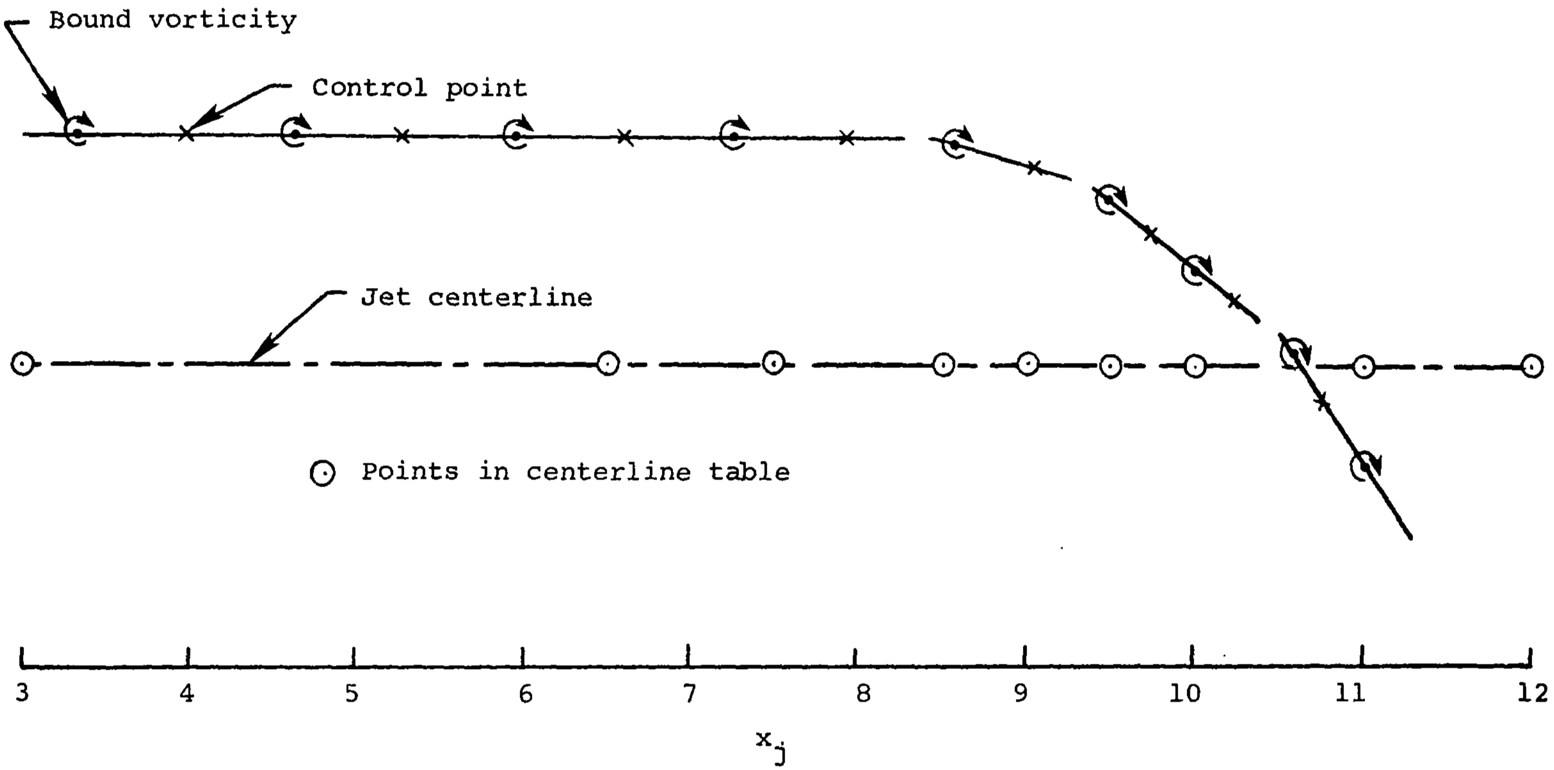


Figure 5.- Jet centerline specification in region near lifting surfaces.

ITEM 1 FORMAT (I5), 1 card

1 NHEAD 6
I

ITEM 2 FORMAT (20A4), NHEAD cards

1 TITLE
A

ITEM 3 FORMAT (6F10.0), 1 card

1 SREF	11 REFL	21 XM	31 ZM	41 TOL	51 DTH
F	F	F	F	F	F

ITEM 4 FORMAT (I5), 1 card

1 NWREG 6
I

ITEM 5 FORMAT (3F10.0), 1 card

1 CRW	11 SSPAN	21 PHID 31
F	F	F

ITEM 6 FORMAT (5I5), 1 card

1 NCW	6 MSW	11 NTCW	16 NUNI	21 NPRESW 26
I	I	I	I	I

(a) Page 1.

Figure 6.- Input forms for EBF prediction program.

ITEM 7 FORMAT (3F10.0,I5), MSW + 1 cards

1 Y(I)	11 PSIWLE(I)	21 PSIWTE(I)	31 NFSEG(I) 36
F	F	F	I

Omit item 8 if NTCW = 0

ITEM 8 FORMAT (8F10.0), NCW values, eight per card.

MSW sets of cards if NTCW = 1 and NUNI = 1
One set of cards if NTCW = 1 and NUNI = 1

1 ALPHAL(1)	11 ALPHAL(2)	21 . . .	31 ALPHAL(NCW)	41	51	61	71
F							

Omit items 9,10, and 11 if NWREG = 1. If NWREG > 1, repeat items 9,10, and 11 in sequence. NWREG - 1 times

ITEM 9 FORMAT (2I5)

1 IIN	6 IOUT 11
I	I

ITEM 10 FORMAT (3I5, 2F10.0)

1 NCW	6 NTCW	11 NUNI	16 CIN	26 TESWP 36
I	I	I	F	F

Omit item 11 if NTCW = 0

ITEM 11 FORMAT (8F10.0), NCW values, eight per card.

IOUT - IIN sets of cards if NTCW = 1 and NUNI = 0
One set of cards if NTCW = 1 and NUNI = 1.

1 ALPHAL(1)	11 ALPHAL(2)	21 ...	31 ALPHAL(NWC)	41	51	61	71
F							

(b) Page 2.

Figure 6.- Continued.

ITEM 12 FORMAT (I5), 1 card

1	6
NFREG	
I	

Omit items 13,14,15, and 16 if NFREG = 0.
If NFREG > 0, item 13,14,15, and 16 are repeated in sequence NFREG times.

ITEM 13 FORMAT (3I5), 1 card

1	6	11	16
NINREG	IIN	IOUT	
I	I	I	

ITEM 14 FORMAT (4I5), 1 card

1	6	11	16	21
NCF	NTCF	NUNI	NPRESF	
I	I	I	I	

NOTE: More than one set of items 14,15, and 16 may be required by NINREG on item 13.

ITEM 15 FORMAT (5F10.0), 1 card

1	11	21	31	41	51
GAPIN	CRFIN	GAPOUT	CRFOUT	DELXZ	
F	F	F	F	F	

Omit item 16 if NTCF = 0

ITEM 16 FORMAT (8F10.0), NCF values, eight to a card.

IOUT - IIN sets of cards if NTCF $\neq$ 1 and NUNI = 0
One set of cards if NTCF = 1 and NUNI = 1

1	11	21	31	41	51	61	71
ALPHAL(1)	ALPHAL(2)	. . .	ALPHAL(NCF)				
F							

ITEM 17 FORMAT (I5), 1 card

1	6
NRHS	
I	

Items 18,19,20,21,22 and 23 are repeated in sequence NRHS time.

ITEM 18 FORMAT (F10.0,6I5), 1 card

1	11	16	21	26	31	36	41
ALFA	KEI	NFPTS	KJET	MJETCL	MJETV	NJETCL	
F	I	I	I	I	I	I	

(c) Page 3.

Figure 6.- Continued.

Omit items 19,20,21 and 22 if KJET = 0

ITEM 19 FORMAT (6I5), 1 card

1	6	11	16	21	26
NHEAD	NJET	NCYL	NNUM	NPRINT	NCRCT
I	I	I	I	I	I

ITEM 20 FORMAT (8A10), NHEAD cards

TITLE
A

Items 21 and 22 are repeated in sequence NJET times.

ITEM 21 FORMAT (5F10.5), 1 card

1	11	21	31	41
GAMVJ(J)	DS(J)	XO(J)	YO(J)	ZO(J)
F	F	F	F	F

ITEM 22 FORMAT (7F10.5), NCYL cards

1	11	21	31	41	51	61
XCLR(J,N)	YCLR(J,N)	ZCLR(J,N)	AJET(J,N)	BJET(J,N)	THETA(J,N)	DSFACT(J,N)
F	F	F	F	F	F	F

Omit item 23 if NFPTS = 0

ITEM 23 FORMAT (3F10.0), NFPTS cards

1	11	21
XFP	YFP	ZFP
F	F	F

(d) Page 4.

Figure 6.- Concluded.

```
    5
 4-ENGINE EBF MODEL     FLAP ANGLES = 15/35/55  GAP=.015C       C(J)=4.0
     REF.       PERRY AND GREENE    NASA TN D-7863
                AOYAGI, FALARSKI, AND KOENIG    NASA TM X-62197     FIG. 9
SAMPLE CASE 1     ALPHA = 18.5          ELLIPTIC JET , 2 ITERATIONS SPECIFIED
                  JET CENTERLINE THETA LIMITED TO -38.5 DEGREES
 200.34     5.56     -6.52       1.38        0.05       -38.5
   1
 6.19      19.08       0.
   4    15     0      0     1
 0.        27.71       18.29         3
 2.        27.71       18.29         3
 3.62      27.71       18.29         3
 4.3       27.71       18.29         3
 5.4       27.71       18.29         3
 6.08      27.71       18.29         3
 6.77      27.71       18.29         3
 7.45      27.71       18.29         3
 8.55      27.71       18.29         3
 9.23      27.71       18.29         3
 10.5      27.71       18.29         3
 12.       27.71       18.29         3
 13.7      27.71       18.29         3
 15.5      27.71       18.29         3
 17.3      27.71       18.29         3
 19.08     27.71       18.29         3
   1
   3     1    16
   1     0     0     1
 0.11      1.125      0.045       0.45        15.0
   2     0     0     1
 0.11      1.5        0.045       0.6         35.0
   2     0     0     1
 0.11      1.688      0.045       .675        55.0
   1
 18.5          0    12     2     0     0     0
   1     2    13     0    -1     0
JET MODEL   JT15D-1    C(J)=4.0   C(T)=1.0   ELLIPTIC CROSS SECTION NEAR FLAPS
 10.10      .18        .45        -4.85       1.38
 0.         0.        -0.000      .845        .845       0.0         1.
 3.         0.        -0.000      .845        .845       0.0         1.
 6.50        0.        0.10       1.23        1.23       3.28        1.
 7.50        0.        0.133      1.48        1.23       0.41        1.
 8.50        0.        0.08       1.74        1.23       -6.61       1.
 9.0        0.        -.01        1.87        1.24       -12.9       1.
 9.50        0.       -.16        1.99        1.25       -21.1       1.
10.0        0.        -.40        2.12        1.27       -30.0       1.
11.0        0.        -1.08       2.38        1.29       -38.5       1.
12.0        0.        -1.88       2.63        1.31       -38.5       2.
13.0        0.        -2.4        2.41        1.52       -32.0       2.
15.         0.        -3.52       1.96        1.96       -18.8       3.
20.         0.        -4.83       2.08        2.08       -10.8       1.
 10.10      .1        -1.2        -8.         1.38
 0.         0.         0.0        .845        .845       0.0         1.
 3.         0.         0.0        .845        .845       0.0         1.
 6.50        0.        0.11       1.24        1.24       2.2         1.
 7.50        0.        0.10       1.48        1.24       -3.0        1.
 8.50        0.       -0.01       1.74        1.24       -13.7       1.
 9.0        0.        -0.17       1.87        1.25       -22.8       1.
 9.5        0.        -0.45       1.99        1.26       -35.5       1.
10.0        0.        -0.8        2.12        1.27       -36.0       1.
11.25       0.        -1.8        2.44        1.29       -38.5       1.
12.0        0.        -2.4        2.63        1.31       -36.3       2.
13.         0.        -2.8        2.41        1.52       -29.0       2.
15.         0.        -3.76       1.96        1.96       -13.4       3.
20.         0.        -4.5        2.08        2.08       -3.6        1.
  -12.        -4.85      0.
  -12.        -4.85      1.
  -12.        -4.85      2.
  -12.        -4.85      3.
  -12.        -4.85      3.5
  -12.        -4.85      4.
  -12.        -4.85      5.
  -12.        -4.85      6.
  -9.5        -4.85      0.
  -9.5        -4.85      0.5
  -9.5        -4.85      1.
  -9.5        -4.85      1.5
```

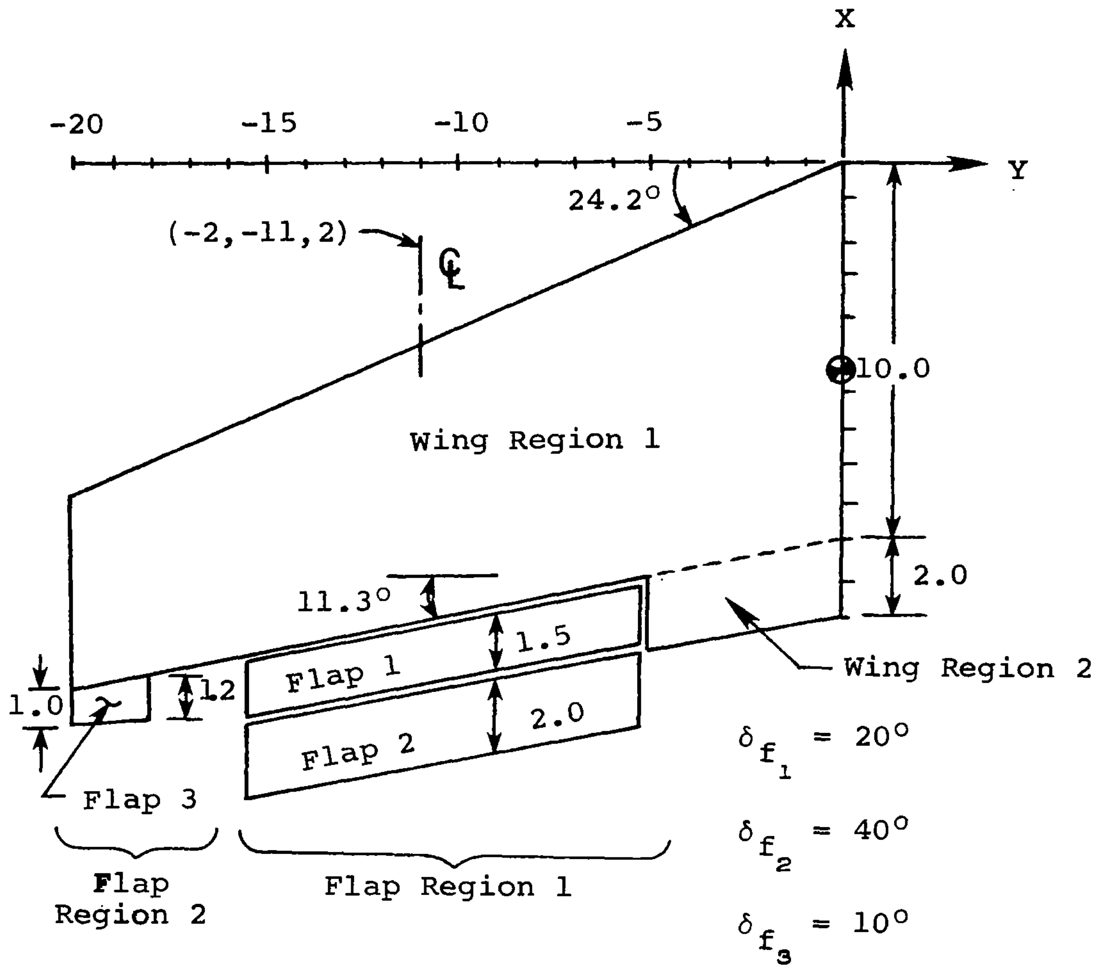
(a) Sample case 1.

Figure 7.- Sample input decks for EBF prediction program.

```
   3
SAMPLE EBF CONFIGURATION WITH 1 CIRCULAR JET WAKE, 2 WING REGIONS,
                               2 SLOTTED FLAPS, AND 1 AILERON TYPE FLAP
   ENGINE CENTERLINE FREE TO MOVE IN Y AND Z DIRECTIONS, 2 ITERATIONS SPECIFIED
  300.0     10.0      -5.0      0.0       0.05     -30.
   2
  10.0      20.0      0.0
   2    7    0    0    1
   0.0      24.2      11.3      0
   2.5      24.2      11.3      0
   5.0      24.2      11.3      0
   9.0      24.2      11.3      2
  13.0      24.2      11.3      2
  15.5      24.2      11.3      2
  18.0      24.2      11.3      0
  20.0      24.2      11.3      1
   1    3
   1    0    0    2.0       11.3
   2
   2    3    6
   1    0    0    0
   0.1      1.5       0.1       1.5       20.0
   2    0    0    1
   0.1      2.0       0.1       2.0       40.0
   1    7    8
   1    0    0    1
   0.0      1.2       0.0       1.0       10.0
   1
  10.0      0    4    2    0    1    1
   1    1    15   0   -1
  CIRCULAR JET WAKE MODEL FOR SAMPLE EBF CONFIGURATION ,    VJ/V=5
   4.0      0.1      -2.0      -11.0      2.0
   0.0      0.0       0.0       1.0       1.0       0.0       1.0
   3.0      0.0       0.0       1.0       1.0       0.0       1.0
   5.0      0.0       0.0       1.2       1.2       0.0       1.0
   7.0      0.0       0.0       1.4       1.4       0.0       1.0
   9.0      0.0       0.0       1.6       1.6       0.0       1.0
  10.0      0.0       0.0       1.7       1.7       0.0       1.0
  11.0      0.0       0.0       1.8       1.8       0.0       1.0
  11.5      0.0       0.0       1.85      1.85      0.0       1.0
  12.0      0.0       0.0       1.9       1.9       0.0       1.0
  12.5      0.0       0.0       1.95      1.95      0.0       1.0
  13.0      0.0       0.0       2.0       2.0       0.0       1.0
  14.5      0.0       0.0       2.15      2.15      0.0       1.0
  15.0      0.0       0.0       2.2       2.2       0.0       2.0
  16.0      0.0       0.0       2.3       2.3       0.0       2.0
  18.0      0.0       0.0       2.5       2.5       0.0       2.0
 -16.0     -11.0      0.0
 -16.0     -11.0      2.0
 -16.0     -11.0      4.0
 -16.0     -11.0      6.0
```

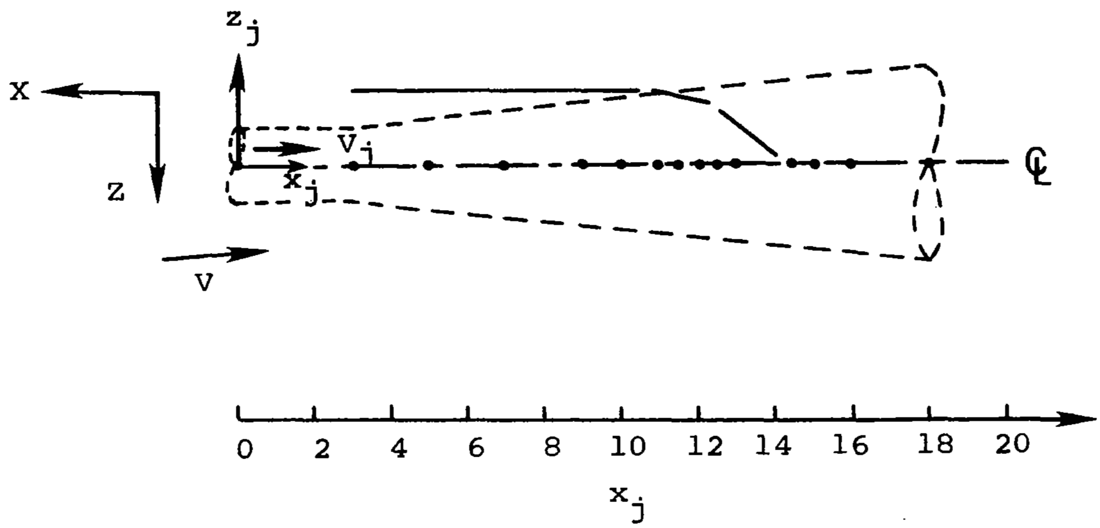
(b) Sample case 2.

Figure 7.- Concluded.



(a) Planform view.

Figure 8.- EBF configuration for Sample Case 2.



(b) Jet centerline detail.

Figure 8.- Concluded.

```
                    EBF AERODYNAMIC PREDICTION PROGRAM

SAMPLE EBF CONFIGURATION WITH 1 CIRCULAR JET WAKE, 2 WING REGIONS,
                           2 SLOTTED FLAPS, AND 1 AILERON TYPE FLAP
   ENGINE CENTERLINE FREE TO MOVE IN Y AND Z DIRECTIONS, 2 ITERATIONS SPECIFIED


   REFERENCE QUANTITIES USED IN FORCE AND MOMENT CALCULATION
        AREA            =  300.00000
        LENGTH          =   10.00000
        MOMENT CENTER
             XM         =   -5.00000
             ZM         =    0.00000


   WING INPUT DATA


        REGION NUMBER  1
             INBOARD EDGE CHORD =  10.00000
             SEMISPAN           =  20.00000
             DIHEDRAL ANGLE     =   0.00000

              14 VORTICES ARE TO BE LAID OUT IN THIS REGION
                  7 SPANWISE BY  2 CHORDWISE

             SPANWISE LOCATIONS OF TRAILING VORTEX LEGS, SWEEP ANGLES OF
                  WING SECTION TO THE RIGHT AND NUMBER OF FLAPS BEHIND THIS SECTION

                  SPANWISE       LE SWEEP        TE SWEEP         NUMBER
                  LOCATION                                        OF FLAPS
                    0.00000
                    2.50000      24.20000        11.30000            0
                    5.00000      24.20000        11.30000            0
                    9.00000      24.20000        11.30000            2
                   13.00000      24.20000        11.30000            2
                   15.50000      24.20000        11.30000            2
                   18.00000      24.20000        11.30000            0
                   20.00000      24.20000        11.30000            1

        REGION NUMBER  2

             THIS REGION EXTENDS FROM Y =   0.00000 TO Y =  -5.00000

               2 VORTICES ARE TO BE LAID OUT IN THIS REGION
                  2 SPANWISE BY  1 CHORDWISE

             INBOARD SIDE-EDGE CHORD =   2.00000
             TRAILING EDGE SWEEP     =  11.30000
```

(a) Page 1.

Figure 9.- Sample output from EBF prediction program.

```
FLAP INPUT DATA

     REGION NUMBER 1
          THERE ARE 2 FLAPS IN THIS REGION
          THEY EXTEND FROM Y =  -5.00000 TO Y = -15.50000

          FLAP NUMBER  1
               INBOARD EDGE GAP     =      .10000
               OUTBOARD EDGE GAP    =      .10000
               INBOARD EDGE CHORD   =     1.50000
               OUTBOARD EDGE CHORD  =     1.50000
               DEFLECTION ANGLE     =    20.00000

                 3 VORTICES ARE TO BE LAID OUT ON THIS FLAP
                     3 SPANWISE BY  1 CHORDWISE

               SPANWISE LOCATIONS OF
                TRAILING VORTEX LEGS
                        -5.00000
                        -9.00000
                       -13.00000
                       -15.50000

               XF,YF COORDINATES OF FOUR CORNERS OF FLAP
                        (FLAP LIES IN ZF=0 PLANE)
                              XF             YF
                            0.00000        0.00000
                           -1.50000        0.00000
                           -1.97158      -10.52449
                           -3.47158      -10.52449

          FLAP NUMBER  2
               INBOARD EDGE GAP     =      .10000
               OUTBOARD EDGE GAP    =      .10000
               INBOARD EDGE CHORD   =     2.00000
               OUTBOARD EDGE CHORD  =     2.00000
               DEFLECTION ANGLE     =    40.00000

                 6 VORTICES ARE TO BE LAID OUT ON THIS FLAP
                     3 SPANWISE BY  2 CHORDWISE

               SPANWISE LOCATIONS OF
                TRAILING VORTEX LEGS
                        -5.00000
                        -9.00000
                       -13.00000
                       -15.50000

               XF,YF COORDINATES OF FOUR CORNERS OF FLAP
                        (FLAP LIES IN ZF=0 PLANE)
                              XF             YF
                            0.00000        0.00000
                           -2.00000        0.00000
                           -1.60724      -10.58626
                           -3.60724      -10.58626

     REGION NUMBER 2
          THERE ARE 1 FLAPS IN THIS REGION

          THEY EXTEND FROM Y = -18.00000 TO Y = -20.00000

          FLAP NUMBER  1
               INBOARD EDGE GAP     =     0.00000
               OUTBOARD EDGE GAP    =     0.00000
               INBOARD EDGE CHORD   =     1.20000
               OUTBOARD EDGE CHORD  =     1.00000
               DEFLECTION ANGLE     =    10.00000

                 1 VORTICES ARE TO BE LAID OUT ON THIS FLAP
                     1 SPANWISE BY  1 CHORDWISE

               SPANWISE LOCATIONS OF
                TRAILING VORTEX LEGS
                       -18.00000
                       -20.00000

               XF,YF COORDINATES OF FOUR CORNERS OF FLAP
                        (FLAP LIES IN ZF=0 PLANE)
                              XF             YF
                            0.00000        0.00000
                           -1.20000        0.00000
                            -.39357       -2.00120
                           -1.39357       -2.00120
```

(b) Page 2.

Figure 9.- Continued.

HORSESHOE VORTEX PROPERTIES

********** WING DATA **********

VORTEX NUMBER J	-COORDINATES OF BOUND LEG MIDPOINT XBL(J)	YBL(J)	ZBL(J)	---COORDINATES OF CONTROL POINT--- XCP(J)	YCP(J)	ZCP(J)	B.L. SWEEP PSI(J)	HALF-WIDTH SW(J)	SURFACE SLOPE ALPHAL(J)
1	-1.77277	-1.25000	0.00000	-4.19477	-1.25000	0.00000	22.69556	1.25000	0.00000
2	-6.61677	-1.25000	0.00000	-9.03877	-1.25000	0.00000	16.35269	1.25000	0.00000
3	-10.74977	-1.25000	0.00000	-11.74977	-1.25000	0.00000	11.30000	1.25000	0.00000
4	-2.81832	-3.75000	0.00000	-5.08432	-3.75000	0.00000	22.69556	1.25000	0.00000
5	-7.35032	-3.75000	0.00000	-9.61632	-3.75000	0.00000	16.35269	1.25000	0.00000
6	-11.24932	-3.75000	0.00000	-12.24932	-3.75000	0.00000	11.30000	1.25000	0.00000
7	-4.17753	-7.00000	0.00000	-6.24073	-7.00000	0.00000	22.69556	2.00000	0.00000
8	-8.30393	-7.00000	0.00000	-10.36714	-7.00000	0.00000	16.35269	2.00000	0.00000
9	-5.85040	-11.00000	0.00000	-7.66400	-11.00000	0.00000	22.69556	2.00000	0.00000
10	-9.47761	-11.00000	0.00000	-11.29121	-11.00000	0.00000	16.35269	2.00000	0.00000
11	-7.20961	-14.25000	0.00000	-8.82041	-14.25000	0.00000	22.69556	1.25000	0.00000
12	-10.43122	-14.25000	0.00000	-12.04203	-14.25000	0.00000	16.35269	1.25000	0.00000
13	-8.25515	-16.75000	0.00000	-9.70996	-16.75000	0.00000	22.69556	1.25000	0.00000
14	-11.16477	-16.75000	0.00000	-12.61958	-16.75000	0.00000	16.35269	1.25000	0.00000
15	-9.19614	-19.00000	0.00000	-10.51055	-19.00000	0.00000	22.69556	1.00000	0.00000
16	-11.82496	-19.00000	0.00000	-13.13937	-19.00000	0.00000	16.35269	1.00000	0.00000

**********REGION 1 FLAP 1 DATA **********

VORTEX NUMBER J	-COORDINATES OF BOUND LEG MIDPOINT XBL(J)	YBL(J)	ZBL(J)	---COORDINATES OF CONTROL POINT--- XCP(J)	YCP(J)	ZCP(J)	B.L. SWEEP PSI(J)	HALF-WIDTH SW(J)	SURFACE SLOPE ALPHAL(J)
17	-11.85112	-7.00000	.12826	-12.55589	-7.00000	.38477	10.61036	2.00467	0.00000
18	-12.65040	-11.00000	.12826	-13.35517	-11.00000	.38477	10.61036	2.00467	0.00000
19	-13.29982	-14.25000	.12826	-14.00458	-14.25000	.38477	10.61036	1.25292	0.00000

**********REGION 1 FLAP 2 DATA **********

VORTEX NUMBER J	-COORDINATES OF BOUND LEG MIDPOINT XBL(J)	YBL(J)	ZBL(J)	---COORDINATES OF CONTROL POINT--- XCP(J)	YCP(J)	ZCP(J)	B.L. SWEEP PSI(J)	HALF-WIDTH SW(J)	SURFACE SLOPE ALPHAL(J)
20	-13.19376	-7.00000	.70793	-13.57678	-7.00000	1.02932	8.63292	2.01643	0.00000
21	-13.95980	-7.00000	1.35072	-14.34282	-7.00000	1.67211	8.63292	2.01643	0.00000
22	-13.99304	-11.00000	.70793	-14.37606	-11.00000	1.02932	8.63292	2.01643	0.00000
23	-14.75908	-11.00000	1.35072	-15.14210	-11.00000	1.67211	8.63292	2.01643	0.00000
24	-14.64245	-14.25000	.70793	-15.02547	-14.25000	1.02932	8.63292	1.26027	0.00000
25	-15.40849	-14.25000	1.35072	-15.79152	-14.25000	1.67211	8.63292	1.26027	0.00000

**********REGION 2 FLAP 1 DATA **********

VORTEX NUMBER J	-COORDINATES OF BOUND LEG MIDPOINT XBL(J)	YBL(J)	ZBL(J)	---COORDINATES OF CONTROL POINT--- XCP(J)	YCP(J)	ZCP(J)	B.L. SWEEP PSI(J)	HALF-WIDTH SW(J)	SURFACE SLOPE ALPHAL(J)
26	-14.86748	-19.00000	.04775	-14.60904	-19.00000	.14326	9.74161	1.00060	0.00000

ALPHA	KEI	NFPTS	KJET	TOL	MJETCL	NJETV	NJETCL
10.000	0	4	2	.05000	0	1	1

JET CENTERLINE DEFLECTION ANGLE LIMIT = -30.0

(c) Page 3.

Figure 9.- Continued.

CIRCULAR JET WAKE MODEL FOR SAMPLE EBF CONFIGURATION ,   VJ/V=5

NJET	NCYL	NP	NNUM	NCRCT	NPRINT
1	15	26	0	-0	-1

(1) JET PARAMETERS

GAMMA/V	XQ	YQ	ZQ	D(S)
4.0000	-2.0000	-11.0000	2.0000	.1000

XCL	YCL	ZCL	SCL	THETA	A	B	DSFACT	P
0.000	0.000	0.000	0.000	0.000	1.000	1.000	1.000	6.283
3.000	0.000	0.000	3.000	0.000	1.000	1.000	1.000	6.283
5.000	0.000	0.000	5.000	0.000	1.200	1.200	1.000	7.540
7.000	0.000	0.000	7.000	0.000	1.400	1.400	1.000	8.796
9.000	0.000	0.000	9.000	0.000	1.600	1.600	1.000	10.053
10.000	0.000	0.000	10.000	0.000	1.700	1.700	1.000	10.681
11.000	0.000	0.000	11.000	0.000	1.800	1.800	1.000	11.310
11.500	0.000	0.000	11.500	0.000	1.850	1.850	1.000	11.624
12.000	0.000	0.000	12.000	0.000	1.900	1.900	1.000	11.938
12.500	0.000	0.000	12.500	0.000	1.950	1.950	1.000	12.252
13.000	0.000	0.000	13.000	0.000	2.000	2.000	1.000	12.566
14.500	0.000	0.000	14.500	0.000	2.150	2.150	1.000	13.509
15.000	0.000	0.000	15.000	0.000	2.200	2.200	2.000	13.823
16.000	0.000	0.000	16.000	0.000	2.300	2.300	2.000	14.451
18.000	0.000	0.000	18.000	0.000	2.500	2.500	2.000	15.708

(d) Page 4.

Figure 9.- Continued.

HORSESHOE VORTEX STRENGTHS FOR ALPHA = 10.0 DEGREES

********** WING DATA **********   NTIME = 1

VORTEX NUMBER J	XCP(J)	YCP(J)	ZCP(J)	UEI(J)	VEI(J)	WEI(J)	GAMMA / V
	-----CONTROL POINT COORDINATES-----			---EXTERNALLY INDUCED VELOCITIES---			
1	-4.19477	-1.25000	0.00000	.00343	-.01297	.00266	3.48552
2	-9.03877	-1.25000	0.00000	.00970	-.00891	.00183	1.78442
3	-11.74977	-1.25000	0.00000	.01256	-.00424	.00087	.31417
4	-5.08432	-3.75000	0.00000	.00635	-.02111	.00582	3.63964
5	-9.61632	-3.75000	0.00000	.01481	-.01451	.00400	1.89226
6	-12.24932	-3.75000	0.00000	.01996	-.00756	.00209	.11296
7	-6.24073	-7.00000	0.00000	.01441	-.03782	.01891	3.75950
8	-10.36714	-7.00000	0.00000	.02443	-.03002	.01501	2.45213
9	-7.66400	-11.00000	0.00000	.01937	0.00000	.09614	3.58566
10	-11.29121	-11.00000	0.00000	.03409	0.00000	.09149	3.18416
11	-8.82041	-14.25000	0.00000	.02065	.03878	.02386	3.51225
12	-12.04203	-14.25000	0.00000	.03485	.03105	.01910	2.28995
13	-9.70996	-16.75000	0.00000	.01824	.02063	.00718	2.97452
14	-12.61958	-16.75000	0.00000	.02677	.01138	.00396	1.25389
15	-10.51055	-19.00000	0.00000	.01480	.01031	.00258	2.08460
16	-13.13937	-19.00000	0.00000	.01880	.00288	.00072	.63825

**********REGION 1 FLAP 1 DATA **********

VORTEX NUMBER J	XCP(J)	YCP(J)	ZCP(J)	UEI(J)	VEI(J)	WEI(J)	GAMMA / V
	-----CONTROL POINT COORDINATES-----			---EXTERNALLY INDUCED VELOCITIES---			
17	-12.55589	-7.00000	.38477	.03556	-.02501	.01010	1.84475
18	-13.35517	-11.00000	.38477	-2.09582	0.00000	-.10771	5.01915
19	-14.00458	-14.25000	.38477	.05181	.02375	.01180	1.78761

**********REGION 1 FLAP 2 DATA **********

VORTEX NUMBER J	XCP(J)	YCP(J)	ZCP(J)	UEI(J)	VEI(J)	WEI(J)	GAMMA / V
	-----CONTROL POINT COORDINATES-----			---EXTERNALLY INDUCED VELOCITIES---			
20	-13.57678	-7.00000	1.02932	.04382	-.02219	.00538	.88186
21	-14.34282	-7.00000	1.67211	.05121	-.01711	.00140	.28264
22	-14.37606	-11.00000	1.02932	-1.96547	0.00000	-.06417	2.72557
23	-15.14210	-11.00000	1.67211	-1.87086	0.00000	-.02239	.83326
24	-15.02547	-14.25000	1.02932	.06677	.01761	.00526	.79789
25	-15.79152	-14.25000	1.67211	.08054	.00642	.00065	.22293

**********REGION 2 FLAP 1 DATA **********

VORTEX NUMBER J	XCP(J)	YCP(J)	ZCP(J)	UEI(J)	VEI(J)	WEI(J)	GAMMA / V
	-----CONTROL POINT COORDINATES-----			---EXTERNALLY INDUCED VELOCITIES---			
26	-14.60904	-19.00000	.14326	.02041	-.00291	-.00068	.35480

(e) Page 5.

Figure 9.- Continued.

AERODYNAMIC LOADING RESULTS FOR ALPHA = 10.00 DEG.

REFERENCE QUANTITIES

WING SPAN, B	AREA	LENGTH
40.00000	500.00000	10.00000

SPANWISE LOAD DISTRIBUTIONS

********** LEFT WING PANEL **********

STATION	Y/(B/2)	LOCAL CHORD, C	CNORM*C/(2*B)	CNORM	CA
1	-.06250	11.6880	.14232	.9741	-.0968
2	-.18750	11.0640	.01709	.1236	-.1396
3	-.35000	8.2528	.13704	1.3285	-.1879
4	-.55000	7.2544	.14325	1.5797	-.1224
5	-.71250	6.4432	.13033	1.6181	-.2780
6	-.83750	5.8192	.10819	1.4874	-.3107
7	-.95000	5.2576	.06531	.9937	-.2366

********** REGION 1 FLAP 1 **********

STATION	Y/(B/2)	LOCAL CHORD, C	CNORM*C/(2*B)	CNORM	CA
1	-.35000	1.5000	.10908	5.8178	-.6584
2	-.55000	1.5000	.32688	17.4337	-5.2994
3	-.71250	1.5000	.12405	6.6160	-.6557

********** REGION 1 FLAP 2 **********

STATION	Y/(B/2)	LOCAL CHORD, C	CNORM*C/(2*B)	CNORM	CA
1	-.35000	2.0000	.04614	1.8455	-.0140
2	-.55000	2.0000	.18897	7.5588	-.0918
3	-.71250	2.0000	.06005	2.4021	-.0088

********** REGION 2 FLAP 1 **********

STATION	Y/(B/2)	LOCAL CHORD, C	CNORM*C/(2*B)	CNORM	CA
1	-.95000	1.1000	.10306	7.4956	-.0801

WING ALONE FORCE AND MOMENT COEFFICIENTS
(WING COORDINATE SYSTEM)

CNW	CAW	CLW	CDW	CMW
1.00834	-.18620	1.02535	-.00828	.05197

INDIVIDUAL FLAP FORCE AND MOMENT COEFFICIENTS AND LOCATIONS AT WHICH FORCES ACT
(FLAP COORDINATE SYSTEMS - FLAP LIES IN XF,YF PLANE)

REGION	FLAP	CNF	XF(CNF)	YF(CNF)	CAF	YF(CAF)	CYF	XF(CYF)	CHF
1	1	.67191	-1.61933	-5.17774	-.12765	-5.80908	-.07992	-2.35652	-.04289
1	2	.34008	-1.38234	-4.78196	-.06049	-5.84013	-.13597	-2.80870	-.02207
2	1	.10545	-.87911	-.02352	-.00059	-1.00060	-.00813	-1.14263	-.00905

COMPLETE CONFIGURATION FORCE AND MOMENT COEFFICIENTS

(WING COORDINATE SYSTEM)

CN	CA	CL	CD	CM	CD/(CL*CL)
3.19514	.43493	3.07108	.98315	-1.80744	.10424

(f) Page 6.

Figure 9.- Continued.

```
*********** LEFT WING PANEL ***********

Y/(B/2)   CHORD, C
-.06250   11.68800           X/C=    .10361     .51805     .87166
                       DELTA P/Q=   1.42433     .89042     .25868

-.18750   11.06401           X/C=    .10240     .51202     .86443
                       DELTA P/Q=   1.56002    1.15175  -10.31161

-.35000    8.25281           X/C=    .12500     .62500
                       DELTA P/Q=   1.68456     .81426

-.55000    7.25442           X/C=    .12500     .62500
                       DELTA P/Q=   1.82440    1.15559

-.71250    6.44323           X/C=    .12500     .62500
                       DELTA P/Q=   2.06625    1.11764

-.83750    5.81923           X/C=    .12500     .62500
                       DELTA P/Q=   1.91215    1.27870

-.95000    5.25764           X/C=    .12500     .62500
                       DELTA P/Q=   1.54649     .41007

*********** REGION 1 FLAP 2 ***********

Y/(B/2)   CHORD, C
-.35000    2.00000           X/C=    .12500     .62500
                       DELTA P/Q=   4.01272    2.06894

-.55000    2.00000           X/C=    .12500     .62500
                       DELTA P/Q=  11.18092    2.84862

-.71250    2.00000           X/C=    .12500     .62500
                       DELTA P/Q=   5.29840    3.00024

*********** REGION 2 FLAP 1 ***********

Y/(B/2)   CHORD, C
-.95000    2.81000           X/C=    .25000
                       DELTA P/Q=  14.37054


ITERATION  1
```

(g) Page 7.

Figure 9.- Continued.

WING/FLAP AND JET INDUCED PERTURBATION VELOCITIES ON THE JET CENTERLINE

			I------- WING/FLAP	----------	----------I	------------ JET	----------	----------I
X	Y	Z	U/VINF	V/VINF	W/VINF	U/VINF	V/VINF	W/VINF
-7.00000	-11.00000	2.00000	.36794	-.12766	.03353	-3.29939	0.00000	-0.00000
-9.00000	-11.00000	2.00000	.45060	-.12636	.10005	-2.81803	0.00000	-0.00000
-11.00000	-11.00000	2.00000	.57451	-.12909	.23553	-2.45125	0.00000	-0.00000
-12.00000	-11.00000	2.00000	.75987	-.15227	.32291	-2.29603	0.00000	-0.00000
-13.00000	-11.00000	2.00000	.99421	-.19291	.55893	-2.15335	0.00000	-0.00000
-13.50000	-11.00000	2.00000	1.10759	-.21920	.71718	-2.08521	0.00000	-0.00000
-14.00000	-11.00000	2.00000	1.20740	-.24829	.90245	-2.01827	0.00000	-0.00000
-14.50000	-11.00000	2.00000	1.27937	-.27459	1.10481	-1.95165	0.00000	-0.00000
-15.00000	-11.00000	2.00000	1.23345	-.27332	1.32083	-1.88428	0.00000	-0.00000
-16.50000	-11.00000	2.00000	.92065	-.15655	1.20205	-1.66494	0.00000	-0.00000
-17.00000	-11.00000	2.00000	.83926	-.10701	1.08941	-1.58221	0.00000	-0.00000
-18.00000	-11.00000	2.00000	.67901	-.02482	.86044	-1.38837	0.00000	-0.00000
-20.00000	-11.00000	2.00000	.43772	.04937	.51506	-.77902	0.00000	-0.00000

NJET	NCYL	NP	NNUM	NCRCT	NPRINT
1	15	26	0	-0	-1

(1) JET PARAMETERS

GAMMA/V	XO	YO	ZO	D(8)
4.0000	-2.0000	-11.0000	2.0000	.1000

XCL	YCL	ZCL	SCL	THETA	A	B	DSFACT	P
0.000	0.000	0.000	0.000	0.000	1.000	1.000	1.000	6.283
3.000	0.000	0.000	3.000	0.000	1.000	1.000	1.000	6.283
5.000	-.033	.036	5.001	2.049	1.200	1.200	1.000	7.540
7.000	-.103	.093	7.003	1.258	1.400	1.400	1.000	8.796
9.000	-.186	.094	9.004	-1.239	1.600	1.600	1.000	10.053
10.000	-.238	.053	10.007	-3.388	1.700	1.700	1.000	10.681
11.000	-.314	-.066	11.016	-10.188	1.800	1.800	1.000	11.310
11.500	-.364	-.180	11.532	-15.481	1.850	1.850	1.000	11.624
12.000	-.427	-.350	12.064	-22.091	1.900	1.900	1.000	11.938
12.500	-.502	-.590	12.624	-29.333	1.950	1.950	1.000	12.252
13.000	-.586	-.875	13.205	-30.000	2.000	2.000	1.000	12.566
14.500	-.779	-1.741	14.948	-30.000	2.150	2.150	1.000	13.509
15.000	-.817	-2.018	15.521	-27.925	2.200	2.200	2.000	13.823
16.000	-.855	-2.484	16.625	-22.067	2.300	2.300	2.000	14.451
18.000	-.870	-3.144	18.731	-14.437	2.500	2.500	2.000	15.708

(h) Page 8.

Figure 9.- Continued.

HORSESHOE VORTEX STRENGTHS FOR ALPHA = 10.0 DEGREES

*********** WING DATA ***********   NTIME = 2

VORTEX NUMBER J	XCP(J)	YCP(J)	ZCP(J)	UEI(J)	VEI(J)	WEI(J)	GAMMA / V
	-----CONTROL POINT COORDINATES----			---EXTERNALLY INDUCED VELOCITIES--			
1	-4.19477	-1.25000	0.00000	.00362	-.01267	.00168	3.19879
2	-9.03877	-1.25000	0.00000	.00922	-.00811	-.00005	1.58019
3	-11.74977	-1.25000	0.00000	.01094	-.00374	-.00163	.27465
4	-5.08432	-3.75000	0.00000	.00696	-.02054	.00433	3.31917
5	-9.61632	-3.75000	0.00000	.01439	-.01247	.00080	1.65892
6	-12.24932	-3.75000	0.00000	.01689	-.00558	-.00246	.09604
7	-6.24073	-7.00000	0.00000	.01691	-.03650	.01529	3.38045
8	-10.36714	-7.00000	0.00000	.02599	-.02327	.00577	2.10361
9	-7.66400	-11.00000	0.00000	.01765	-.02423	.09187	3.09228
10	-11.29121	-11.00000	0.00000	.05834	-.04670	.06127	2.52351
11	-8.82041	-14.25000	0.00000	.01305	.04265	.03140	2.99067
12	-12.04203	-14.25000	0.00000	.02414	.03591	.03565	1.78692
13	-9.70996	-16.75000	0.00000	.01318	.02598	.00858	2.57104
14	-12.61958	-16.75000	0.00000	.02088	.02171	.00636	1.02795
15	-10.51055	-19.00000	0.00000	.01211	.01487	.00193	1.83309
16	-13.13937	-19.00000	0.00000	.01655	.00999	-.00064	.54608

***********REGION 1 FLAP 1 DATA ***********

VORTEX NUMBER J	XCP(J)	YCP(J)	ZCP(J)	UEI(J)	VEI(J)	WEI(J)	GAMMA / V
	-----CONTROL POINT COORDINATES----			---EXTERNALLY INDUCED VELOCITIES--			
17	-12.55589	-7.00000	.38477	.03172	-.01254	-.00390	1.65711
18	-13.35517	-11.00000	.38477	-1.59857	-.03262	.13272	3.30812
19	-14.00458	-14.25000	.38477	.03590	.03972	.03742	1.47535

***********REGION 1 FLAP 2 DATA ***********

VORTEX NUMBER J	XCP(J)	YCP(J)	ZCP(J)	UEI(J)	VEI(J)	WEI(J)	GAMMA / V
	-----CONTROL POINT COORDINATES----			---EXTERNALLY INDUCED VELOCITIES--			
20	-13.57678	-7.00000	1.02932	.03494	-.00522	-.01054	.79245
21	-14.34282	-7.00000	1.67211	.03734	.00270	-.01545	.23489
22	-14.37606	-11.00000	1.02932	-1.57472	-.06910	.52610	1.63875
23	-15.14210	-11.00000	1.67211	-1.60531	-.08602	.78207	.33187
24	-15.02547	-14.25000	1.02932	.05439	.05843	.03535	.66700
25	-15.79152	-14.25000	1.67211	.08059	.06977	.01951	.15669

***********REGION 2 FLAP 1 DATA ***********

VORTEX NUMBER J	XCP(J)	YCP(J)	ZCP(J)	UEI(J)	VEI(J)	WEI(J)	GAMMA / V
	-----CONTROL POINT COORDINATES----			---EXTERNALLY INDUCED VELOCITIES--			
26	-14.60904	-19.00000	.14326	.01896	.00570	-.00322	.34483

(i) Page 9.

Figure 9.- Continued.

AERODYNAMIC LOADING RESULTS FOR ALPHA = 10,00 DEG,

REFERENCE QUANTITIES

WING SPAN, B	AREA	LENGTH
40,00000	300,00000	10,00000

SPANWISE LOAD DISTRIBUTIONS

********** LEFT WING PANEL **********

STATION	Y/(B/2)	LOCAL CHORD, C	CNORM*C/(2*B)	CNORM	CA
1	-,06250	11,6880	,12773	,8742	-,0843
2	-,18750	11,0640	,02710	,1960	-,1202
3	-,35000	8,2528	,12099	1,1728	-,1626
4	-,55000	7,2544	,11770	1,2979	-,1310
5	-,71250	6,4432	,11573	1,4370	-,2113
6	-,83750	5,8192	,09185	1,2627	-,2375
7	-,95000	5,2576	,05699	,8672	-,1860

********** REGION 1 FLAP 1 **********

STATION	Y/(B/2)	LOCAL CHORD, C	CNORM*C/(2*B)	CNORM	CA
1	-,35000	1,5000	,08871	4,7312	-,5618
2	-,55000	1,5000	,18789	10,0206	-2,3514
3	-,71250	1,5000	,09265	4,9415	-,4871

********** REGION 1 FLAP 2 **********

STATION	Y/(B/2)	LOCAL CHORD, C	CNORM*C/(2*B)	CNORM	CA
1	-,35000	2,0000	,03752	1,5008	-,0108
2	-,55000	2,0000	,10717	4,2869	-,0021
3	-,71250	2,0000	,04831	1,9325	-,0051

********** REGION 2 FLAP 1 **********

STATION	Y/(B/2)	LOCAL CHORD, C	CNORM*C/(2*B)	CNORM	CA
1	-,95000	1,1000	,07920	5,7600	-,0755

WING ALONE FORCE AND MOMENT COEFFICIENTS
(WING COORDINATE SYSTEM)

CNW	CAW	CLW	CDW	CMW
,90399	-,15849	,91778	,00090	,03476

INDIVIDUAL FLAP FORCE AND MOMENT COEFFICIENTS AND LOCATIONS AT WHICH FORCES ACT
(FLAP COORDINATE SYSTEMS - FLAP LIES IN XF,YF PLANE)

REGION	FLAP	CNF	XF(CNF)	YF(CNF)	CAF	YF(CAF)	CYF	XF(CYF)	CHF
1	1	,45338	-1,61431	-4,92468	-,06450	-5,62217	-,03880	-2,59432	-,03083
1	2	,22762	-1,38178	-4,62052	-,02583	-5,59633	-,04006	-3,97295	-,01531
2	1	,08015	-,87449	-,03763	-,00055	-1,00060	-,00622	-1,15852	-,00682

COMPLETE CONFIGURATION FORCE AND MOMENT COEFFICIENTS
(WING COORDINATE SYSTEM)

CN	CA	CL	CD	CM	CD/(CL*CL)
2,34847	,31553	2,25800	,71854	-1,19459	,14093

(j) Page 10.

Figure 9.- Continued.

PRESSURE DISTRIBUTIONS
DELTA P/Q

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********** LEFT WING PANEL **********

Y/(B/2)   CHORD, C
-.06250   11.68800        X/C=   .10361     .51805     .87166
                  DELTA P/Q=  1.30315     .76669     .22471

-.18750   11.06401        X/C=   .10240     .51202     .86443
                  DELTA P/Q=  1.41801     .97267   -8.20738

-.35000    8.25281        X/C=   .12500     .62500
                  DELTA P/Q=  1.51512     .68972

-.55000    7.25442        X/C=   .12500     .62500
                  DELTA P/Q=  1.55759     .88508

-.71250    6.44583        X/C=   .12500     .62500
                  DELTA P/Q=  1.85947    1.10729

-.83750    5.81923        X/C=   .12500     .62500
                  DELTA P/Q=  1.67560     .99657

-.95000    5.25764        X/C=   .12500     .62500
                  DELTA P/Q=  1.36037     .33801


********** REGION 1 FLAP 2 **********

Y/(B/2)   CHORD, C
-.35000    2.00000        X/C=   .12500     .62500
                  DELTA P/Q=  3.20992    1.63147

-.55000    2.00000        X/C=   .12500     .62500
                  DELTA P/Q=  6.80563    1.13462

-.71250    2.00000        X/C=   .12500     .62500
                  DELTA P/Q=  4.11576    2.52517


********** REGION 2 FLAP 1 **********

Y/(B/2)   CHORD, C
-.95000    2.81000        X/C=   .25000
                  DELTA P/Q= 10.92236


ITERATION  2
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(k) Page 11.

Figure 9.- Continued.

WING/FLAP AND JET INDUCED PERTURBATION VELOCITIES ON THE JET CENTERLINE

			WING/FLAP			JET		
X	Y	Z	U/VINF	V/VINF	W/VINF	U/VINF	V/VINF	W/VINF
-7,00000	-11,03259	1,96423	,30644	-,11816	,03673	-3,30012	-,04212	-,08834
-9,00000	-11,10288	1,90650	,35954	-,12186	,08829	-2,82186	-,05501	-,04081
-11,00000	-11,18568	1,90617	,42034	-,13648	,19782	-2,45782	-,06563	,09741
-12,00000	-11,23844	1,94657	,52592	-,16539	,24705	-2,29195	-,07663	,23619
-13,00000	-11,31361	2,06561	,63756	-,20906	,38987	-2,10836	-,08882	,45177
-13,50000	-11,36403	2,17952	,66847	-,23157	,47512	-2,00768	-,09401	,57545
-14,00000	-11,42651	2,34959	,67510	-,25191	,55711	-1,88930	-,09748	,71489
-14,50000	-11,50249	2,59035	,65601	-,26892	,61846	-1,80118	-,09850	,80475
-15,00000	-11,58569	2,87516	,62893	-,28485	,65309	-1,70644	-,09457	,86285
-16,50000	-11,77864	3,74118	,61558	-,32539	,70968	-1,49520	-,06434	,79425
-17,00000	-11,81675	4,01791	,62981	-,33061	,73359	-1,42921	-,05106	,72288
-18,00000	-11,85503	4,48413	,68289	-,30358	,80466	-1,28627	-,03018	,56496
-20,00000	-11,86968	5,14371	,73537	,00829	,87324	-,73017	-,00986	,25037

NJET	NCYL	NP	NNUM	NCRCT	NPRINT
1	15	26	0	-0	-1

(1) JET PARAMETERS	GAMMA/V	XQ	YQ	ZQ	D(S)
	4,0000	-2,0000	-11,0000	2,0000	,1000

XCL	YCL	ZCL	SCL	THETA	A	B	DSFACT	P
0,000	0,000	0,000	0,000	0,000	1,000	1,000	1,000	6,283
3,000	0,000	0,000	3,000	0,000	1,000	1,000	1,000	6,283
5,000	-,040	,057	5,001	3,241	1,200	1,200	1,000	7,540
7,000	-,132	,150	7,005	2,083	1,400	1,400	1,000	8,796
9,000	-,250	,146	9,009	-2,304	1,600	1,600	1,000	10,053
10,000	-,327	,069	10,015	-6,421	1,700	1,700	1,000	10,681
11,000	-,432	-,122	11,038	-15,218	1,800	1,800	1,000	11,310
11,500	-,497	-,284	11,568	-20,673	1,850	1,850	1,000	11,624
12,000	-,572	-,502	12,119	-26,541	1,900	1,900	1,000	11,938
12,500	-,655	-,771	12,692	-30,000	1,950	1,950	1,000	12,252
13,000	-,744	-1,060	13,277	-30,000	2,000	2,000	1,000	12,566
14,500	-1,039	-1,926	15,034	-30,000	2,150	2,150	1,000	13,509
15,000	-1,145	-2,214	15,620	-30,000	2,200	2,200	2,000	13,823
16,000	-1,357	-2,792	16,794	-30,000	2,300	2,300	2,000	14,451
18,000	-1,564	-3,946	19,113	-30,000	2,500	2,500	2,000	15,708

**** NO CONVERGENCE AFTER 2 ITERATIONS TOL = ,0500 DEL = ,3605 ****

(ℓ) Page 12.

Figure 10.- Continued.

INDUCED VELOCITIES AT SPECIFIED FIELD POINTS

			I======== WING/FLAP	==========	==I===	WING/FLAP+JET+VINF	======	=I
			PERTURBATION VELOCITIES					
X	Y	Z	U/VINF	V/VINF	W/VINF	U/VINF	V/VINF	W/VINF
=16,00000	=11,00000	0,00000	,24117	,02802	,58519	=,68550	=,01413	,41176
=16,00000	=11,00000	2,00000	,62041	=,12418	,79560	=2,00821	=,22307	1,48965
=16,00000	=11,00000	4,00000	,54993	=,16183	,61534	=1,98081	=,23167	1,34650
=16,00000	=11,00000	6,00000	,37314	=,12649	,40693	=,47428	=,15076	,32457

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Figure 11.- Concluded.