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A THEORETICAL INVESTIGATION OF GROUND EFFECTS ON USB CONFIGURATIONS

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A THEORETICAL INVESTIGATION OF GROUND EFFECTS ON USB CONFIGURATIONS

by

C. Edward Lan

Technical Report CRINC-FRL-281-3

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SUMMARY

A theoretical wing-jet interaction theory is presented for predicting the ground effects for upper-surface-blowing configurations. The formulation predicts the variation of circulation forces and jet reaction forces in ground proximity as a function of ground height. The predicted results agree well with available experimental data. It is shown that the wing-alone theory is not capable of predicting the ground effect for USB configurations.

1. List of Symbols

A	aspect ratio
b	span
c	chord length
$\bar{c}$	mean aerodynamic chord
C_D	drag coefficient
c_ℓ	sectional lift coefficient
C_L	lift coefficient
ΔC_p	lifting pressure coefficient
C_T	propulsive thrust coefficient
C_μ	jet momentum coefficient
D_e	equivalent jet diameter
h	ground height of wing aerodynamic center
h_1	ground height of mean surface on which the vortex is distributed.
h'	ground height of USB flap hinge
$\hat{i},\hat{j},\hat{k}$	unit vector in the x, y, and z directions
ℓ_c	characteristic jet length which is assumed to rotate rigidly in ground proximity
M	Mach number
n,s	coordinates normal and along the jet surface, respectively
$\hat{n}$	unit normal vector
s_c	length of the approximately straight portion of the jet
T	$= \rho_\infty / \rho_j$
u,v,w	induced velocity components in the x,y, and z directions, respectively.
V	velocity
x,y,z	rectangular coordinate system with positive x-axis pointing downstream, positive y-axis pointing to the right and positive z-axis point upward.
z_c	camber ordinate

α	angle of attack
δ_f	flap angle
δ_j	jet deflection angle out of ground effect
δ_j'	jet deflected angle in ground effect
γ	vortex density or flight path angle
λ	taper ratio
Λ	sweep angle
μ	$= V_\infty/V_j$
μ'	$= \mu \cos \alpha$
$\bar{\phi}$	nondimensional velocity potential
ψ	nondimensional additional velocity potential due to jet interaction
ρ	density
θ	pitch attitude angle

Subscripts

G	ground effect
i	image
j	jet flow
o	external flow
w	wing
wj	wing flow with jet Mach number
wo	wing flow with freestream Mach number
Γ	circulation
∞	freestream or free air

2. Introduction

Recent investigations of ground effect on aerodynamic characteristics have been stimulated by the interest in powered-lift STOL airplanes. Gratzer and Mahal (Ref. 1) have concluded from analyzing experimental data and theoretical study that the powered-lift ground effects will generally be adverse, i.e. with substantial lift loss. Early wind-tunnel data on augmentor wing and externally-blown-flap (EBF) configurations have also indicated adverse ground effect. However, the opposite has been found from flight tests of Augmentor Wing Aircraft C-8A and EBF aircraft YC-15. This disagreement of wind-tunnel and flight data has prompted Campbell, Hassell and Thomas (Ref. 2) to examine carefully the wind-tunnel data. They found that most of the disagreement could be traced to the wind-tunnel models which were not representative of the aircraft in wing sweep, taper ratio, flap angle, etc. and to the different operating lift coefficients. When a correct YC-14 model with upper-surface blowing (USB) was tested, generally favorable ground effect has been obtained, except at high angles of attack (Ref. 3).

In an effort to study theoretically the ground effect of the jet flap and EBF configurations, Gratzer and Mahal (Ref. 1) employed the conventional vortex-lattice method with flat wake to simulate the wing circulation lift. They indicated that if the jet reaction lift is less than 30% of the total lift, the wing-alone method of ground effect analysis without directly representing the jet is valid. Stevens and Wingrove (Ref. 4) used a simple horseshoe vortex to predict the ground effects of augmentor wing C-8A and EBF aircraft YC-15 and found that the predicted increase in lift in ground proximity is generally less than that obtained from flight tests. An accurate 3-D thin jet flap theory was presented in Ref. 5. Some ground-effect calculations using that theory was given in Ref. 6. The predicted list is in general higher than the experimental values. No theoretical methods for USB configurations in ground effect are available, however.

The main purpose of the present investigation is to extend the USB jet-wing interaction theory reported in Ref. 7 to treat the ground effect problem and to present some calculated results.

3. Theoretical Formulation

For the present analysis, the basis assumptions made in Ref. 7 are still valid. That is, 1) the unperturbed jet flow and freestream are uniform, and the perturbed flow field in each region is governed by the Prandtl-Glauert equation with Mach number M_o or M_j, for the freestream and the jet flow, respectively; 2) the jet is of constant shape and at a small deflection angle; and 3) the effects of fuselage, nacelle, and wing thickness are not included. The boundary conditions require that the jet surface be a stream surface and the static pressure be continuous across it, in addition to the usual wing surface tangency condition. To account for the difference in M_o and M_j, the linearized problem is regarded as the sum of the wing-alone flow field and the additional flow field due to jet interaction. The aforementioned boundary conditions —— jet stream surface condition, jet surface static pressure continuity and the wing tangency condition, in the linearized form in free air, are given by, respectively (see Ref. 7),

$$\frac{\partial \psi_o}{\partial n} - \frac{\partial \psi_j}{\partial n} = -\frac{\vec{V}\cdot\hat{n}(1-\mu')}{\vec{V}_o\cdot\hat{e}} + \frac{\partial \bar{\phi}_{wj}}{\partial n} - \frac{\partial \bar{\phi}_{wo}}{\partial n} \qquad (1)$$

$$\frac{\partial \psi_j}{\partial s} - T(\mu')^2\frac{\partial \psi_o}{\partial s} = -\frac{\partial \bar{\phi}_{wj}}{\partial s} + T(\mu')^2\frac{\partial \bar{\phi}_{wo}}{\partial s} \qquad (2)$$

$$\frac{\partial \psi_o}{\partial z} = 0 \qquad (3)$$

where the subscripts (o,j) denote the outer flow and the jet flow, respectively, ψ is the additional nondimensional velocity potential due to jet interaction and ϕ the wing-alone velocity potential. $\vec{V}_o$ is the freestream velocity vector and $(\hat{n}, \hat{e})$ the unit vectors normal and along the jet surface, respectively. With shallow jet approximation, $\hat{n} = \hat{k}$ and $\hat{e} = \hat{i}$.

In addition,

$$\mu' = \mu \cos\alpha \tag{4}$$

$$\mu = V_\infty / V_j \tag{5}$$

In Eqs. (1) and (2), $\bar{\phi}_{wo}$ and $\bar{\phi}_{wj}$ are the wing-alone velocity potentials satisfying the wing surface tangency conditions:

$$\frac{\partial \bar{\phi}_{wo}(M_o)}{\partial z} = \frac{\partial z_c}{\partial x} - \tan\alpha \tag{6}$$

$$\frac{\partial \bar{\phi}_{wj}(M_j)}{\partial z} = \frac{\partial z_c}{\partial x} - \tan\alpha \tag{7}$$

The above problem has been solved with the vortex distribution on wing and jet surfaces through the quasi-vortex-lattice method (QVLM) (Ref. 8). The jet flap effect within the present thick-jet formulation and the Coanda jet reaction forces have also been included (Ref. 7). The total aerodynamic characteristics are obtained through integrating the calculated pressure distribution.

In ground proximity, the additional boundary condition of no flow-through at the ground plane can be satisfied by using image vortex distribution with opposite circulation as illustrated in Fig. 1. In Fig. (1a), the

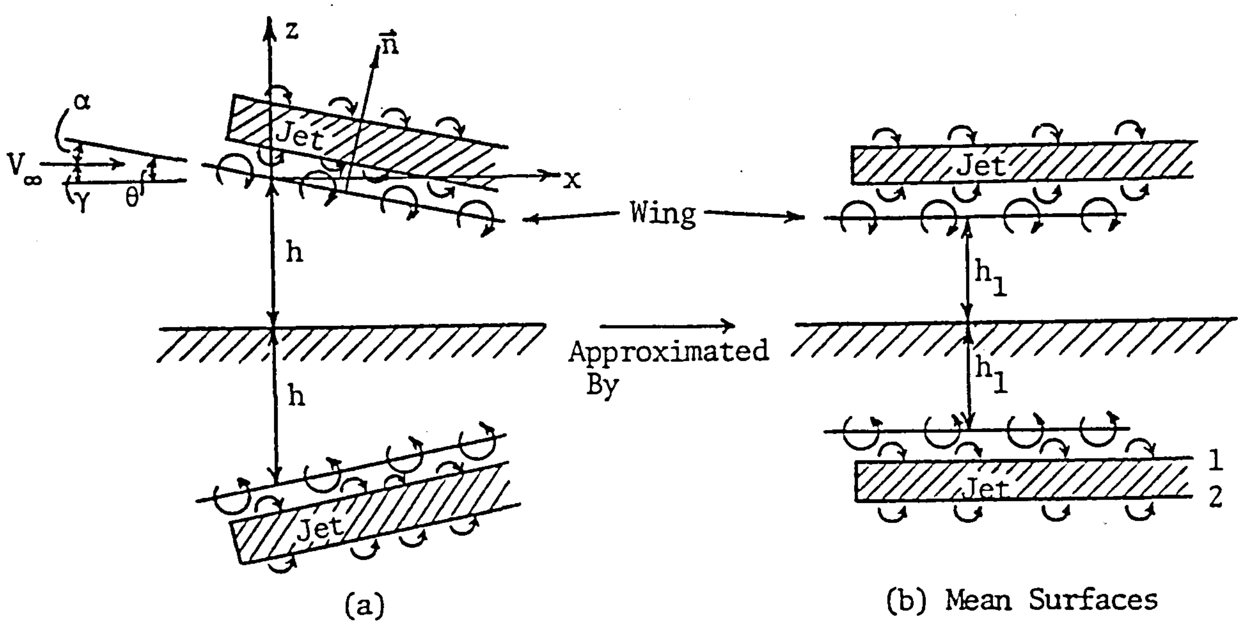

Figure 1. Geometry and Vortex Distribution in Ground Proximity

ground height h is assumed to be measured from the wing aerodynamic center or some reference point. Fig. (1b) shows that in the present linearized theory, the location of the wing mean surface is taken to be at h_1, where h_1 is the ground height of 3/4 chord point of the mean aerodynamic chord for clean configuration as indicated in Ref. 9, and is taken to be the ground height of the trailing edge of the mean aerodynamic chord for configurations with flap deflection. latter choice is to account approximately for the larger wake deflection associated with flap deflection. The induced velocities on the wing and jet surfaces due to the physical wing and jet vortices are calculated in the usual manner as shown in Ref. (7). The effects of the image vortices are twofold. Firstly, they will induce upwash on the physical wing and jet surfaces. Let $\vec{v}_t$ be the velocity vector induced by image horseshoe vortices at a given point on the wing:

$$\vec{v}_t = \hat{i} u_i + \hat{j} v_i + \hat{k} w_i \tag{8}$$

As shown in Fig.(1a), the unit normal vector on the wing surface is given by

$$\hat{n} = \hat{i} \sin\theta + \hat{k} \cos\theta \tag{9}$$

It follows that the upwash induced by the image vortex is

$$\vec{v}_t \cdot \hat{n} = w_i \cos\theta + u_i \sin\theta \approx w_i + u_i \theta \tag{10}$$

Although $u_i\theta$ is a second-order term, its retention improves the accuracy (Ref. 9). As can be seen from Fig. 1, this backwash term $u_i\theta$ is to produce downwash on the wing if θ is positive, thus reducing the loading. This is consistent with the 2-D solution given by Woods (Ref. 10):

$$c_\ell = 2\pi \sin\alpha \left[1 - \left(\frac{c}{2h}\right) \sin\alpha + \cdots \right] \tag{11}$$

where the second-order term in α is to reduce the lift coefficient. In Eq. (11), α inside the brackets is the same as θ in the present formulation. Flight test results also indicate the same trend (Ref. 4). Eq. (10) is to be incorporated into the left-hand side of Eqs. (1) and (3) and also the wing-alone problem Eqs. (6) and (7). Similarly, the image-induced x-perturbation velocity will be included in Eq. (2). Note that only $\frac{\partial \psi_0}{\partial \eta}$, $\frac{\partial \psi_0}{\partial s}$ and $\frac{\partial \psi_0}{\partial z}$ are affected by the image vortices. Secondly, the image wing and jet vortices will induce backwash on the wing to reduce the freestream velocity. Thus, once the vortex strengths have been calculated by satisfying the boundary conditions with ground effect, the lifting pressure will be given by

$$\Delta C_p = 2\gamma_w \cos\alpha \,(1 + u_i) \qquad (12)$$

where u_i is the backwash induced by the image vortices and is usually negative. The wing vortex density γ_w is the sum of wing-alone vortex density and the additional vortex density due to jet interaction. The term involving u_i in Eq. (12) is again a second-order term.

The special features described above for the ground effect are concerned only with wing circulation loading. Examination of some available USB force data (Ref. 11) indicates that the lift component of the jet reaction will be decreased as the aircraft approaches the ground. This implies that the USB jet deflection angle will be reduced if the ground height is small. This possibility has also been suggested by May and Bean (Ref. 3). The fundamental idea behind this concept is that as the nearly rectangular jet impinges on the ground, the increase in the upstream static pressure would force the jet to deform further in the downstream direction. Since the jet deflection angle is not constrained in the USB case, it would be decreased to accommmodate the stronger jet-cross flow interaction in ground proximity. Since the exact theory for this phenomenon is certainly complicated and is not available at the present time, the following empirical theory will be used for the present purpose.

Because of the similarity between the present case and a round jet in the cross flow, Margason's formula for the round jet trajectory (Ref. 12) will be used as a first step:

$$\frac{x}{D} = -\frac{\mu^2 T}{4\sin^2\delta_j}\left(\frac{z}{D}\right)^3 - \left(\frac{z}{D}\right)\cot\delta_j \qquad (13)$$

Differentiating Eq. (13) with respect to z gives

$$\frac{d(x/D)}{d(z/D)} = -\frac{3\mu^2 T}{4\sin^2\delta_j}\left(\frac{z}{D}\right)^2 - \cot\delta_j \tag{14}$$

where T = ρ_∞ / ρ_j . At this point, it is assumed that the jet possesses a characteristic length. When it touches the ground, the reduction of the jet deflection angle becomes possible. This characteristic length will be calculated as follows. First, the two terms on the right hand side of Eq. (14) are equated and solved for z which will be denoted by z'_c. Note that the first term represents the effect of cross flow interaction. Thus,

$$\left|\frac{z'_c}{D}\right| = \sqrt{\frac{2}{3}}\sqrt{\frac{\sin 2\delta_j}{\mu^2 T}} \tag{15}$$

When this expression is used to check against the experimental data on a round jet, see for example, Fig. 12 of Ref. 13, it indicates approximately the straight portion of a deformed jet. However, Eq. (15) shows that at $\delta_j = 90°$, the straight portion of the jet will vanish. This is not so according to the experimental data. Therefore, Eq. (15) is to be adjusted for correct representation at $\delta_j = 90°$. In addition, two more assumptions are made. First, the characteristics of the USB jet for the present purpose, i.e., μ and T, will be evaluated at the USB flap hinge, and will be denoted by $\bar{\mu}$ and $\bar{T}$. They will be obtained by the method shown in Ref. 14 for a turbulent round jet. The diameter D in Eq. (15) is taken to be the equivalent round jet diameter D_e at the USB flap hinge. Second, Unlike a round jet in a uniform cross flow, the USB jet is subject to the interference of wing flow field and the uniform freestream. It is assumed that the jet angle to be used in Eq. (15) is the average of δ_j and $\delta_j + \alpha$, to be denoted by $\bar{\delta}_j$:

$$\bar{\delta}_j = \delta_j + \alpha/2 \tag{16}$$

Accounting for the above assumptions, Eq. (15) becomes

$$\left|\frac{z'_c}{D}\right| = \sqrt{\frac{2}{3}}\sqrt{\frac{0.135 + \sin 2\bar{\delta}_j}{\bar{\mu}^2 \bar{T}}} \tag{17}$$

where the constant 0.135 is obtained by correlating with the experimental data shown on Fig. 12 of Ref. 13 with $\bar{\delta}_j = 90°$. The length of the approximately straight portion of the jet is therefore given by

$$s_c = \frac{z_c'}{\sin \bar{\delta}_j} \qquad (18)$$

When a length of jet equal to s_c is assumed rigid and, if it touches the ground, would be forced to rotate in the downstream direction to reduce the jet angle, it is found that the results are quite reasonable except when $\bar{\mu}$ is small, i.e. when the freestream velocity is low compared with the jet velocity. This can be seen from Eqs. (17) and (18). For small $\bar{\mu}$, z'_c and s_c would be large. For a given ground height, the resulting jet angle would be small. Therefore, the characteristic length mentioned above will be defined as

$$\ell_c = s_c \, (C_1 \bar{\mu}^2) \quad , \quad C_1 \bar{\mu}^2 < 1 \qquad (19a)$$

$$= s_c \quad , \quad C_1 \bar{\mu}^2 \geqslant 1 \qquad (19b)$$

where C_1 is a constant to be determined after correlation with experiment. (C_1 is finally chosen to be 19.2). The jet deflection angle δ'_j in ground proximity is then given by

$$\delta_j' + \theta = \sin^{-1} \frac{h'}{\ell_c} \qquad (20)$$

where h' is the ground height of the USB flap hinge. Of course, if ℓ_c does not reach the ground, the jet angle is assumed to be unchanged. The corresponding geometry for Eq. (20) is illustrated in Fig. 2.

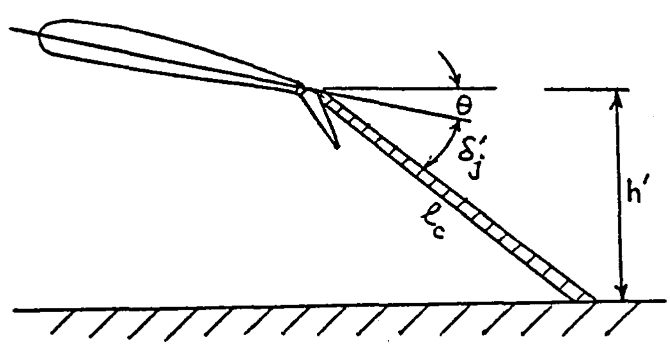

Figure 2. Geometry for Determining the Jet Deflection Angle in Ground Proximity

4. Numerical Results and Discussions

As indicated above, the present formulation is based on the quasi-vortex-lattice method. To check its accuracy, some predicted results for lift curve and moment curve slopes for rectangular wings are compared with Saunders' (Ref. 15) in Fig. 3. Saunders' method is based on the kernel function technique. It is seen that the agreement between the present method and Saunders' is quite good. The theoretical results also agree quite well with experimental data given in Ref. 16. Since the operation of aircraft in ground proximity usually involves the deflected flaps, their influence on the magnitude of the ground effect must be assessed. Gratzer and Mahal (Ref. 1) have presented some results showing the influence of various configuration parameters on the aerodynamic characteristics in ground effect. Fig. 4 shows the comparison of the present results with Gratzer and Mahal's for a tapered wing of aspect ratio 8.0 and sweep angle 30°. Note that the conventional vortex-lattice method was used in Ref. 1. It is seen that the agreement between the two methods is good.

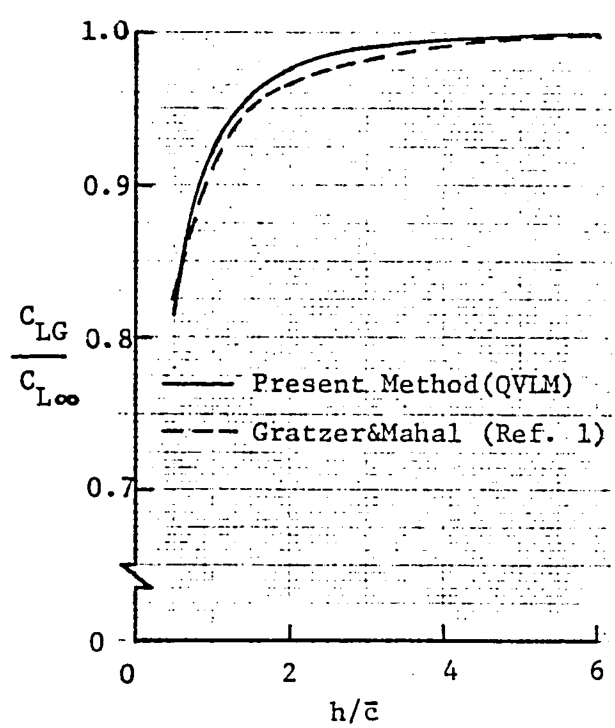

Figure 4. Comparison of Predicted Lift Coefficients in Ground Effect by Different Methods. $C_{L\infty}=3.0$, $\Lambda=30°$, $\lambda=0.4$, $A=8.0$, $\delta_f=50°$ (Full Span) and Flap-Chord Ratio of 0.35.

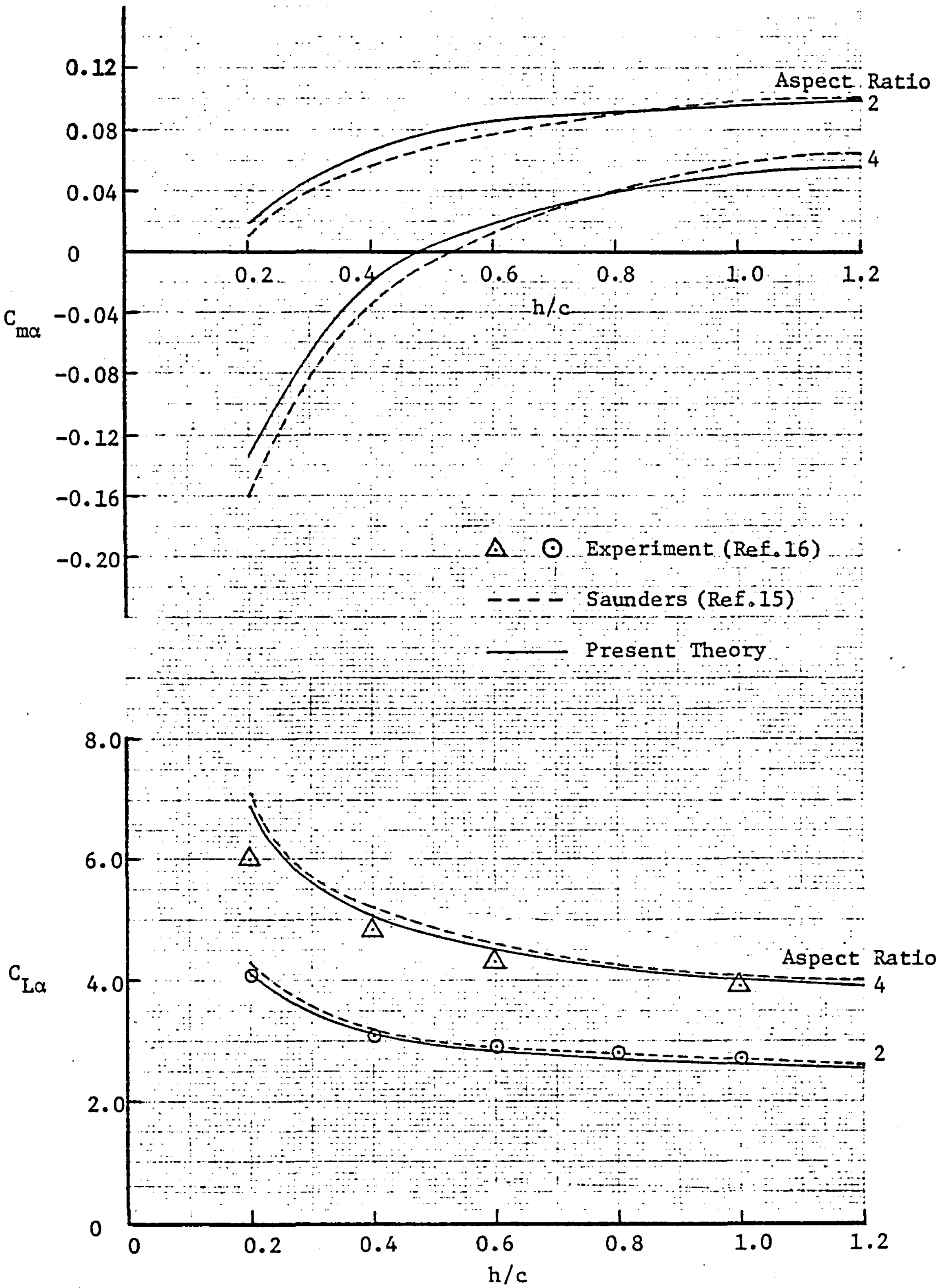

Figure 3. Comparison of Predicted Lift Curve Slope and Moment Curve Slope about Quarter Chord in Per Radian for Clean Rectangular Wings in Ground Effect.

The present thick-jet program is also applicable to the thin jet flap theory with appropriate changes as indicated in Ref. 7. Some predicted results for a full-span thin jet flap on a rectangular wing of aspect ratio 8.3 are compared with those given in Ref. 6 and experiment (Ref. 17) in Fig. 5. The agreement between theories is excellent. However, the experimental data show large adverse ground effect not predicted by the theory. Although some flow mechanisms responsible for the discrepancy have been discussed in Ref. 6, one important possible reason is that the experimental data are not reliable because a fixed ground plane was used in the test set-up. According to Turner's criterion discussed and applied in Ref. 2, a moving ground board would have to be used under the high lift conditions investigated.

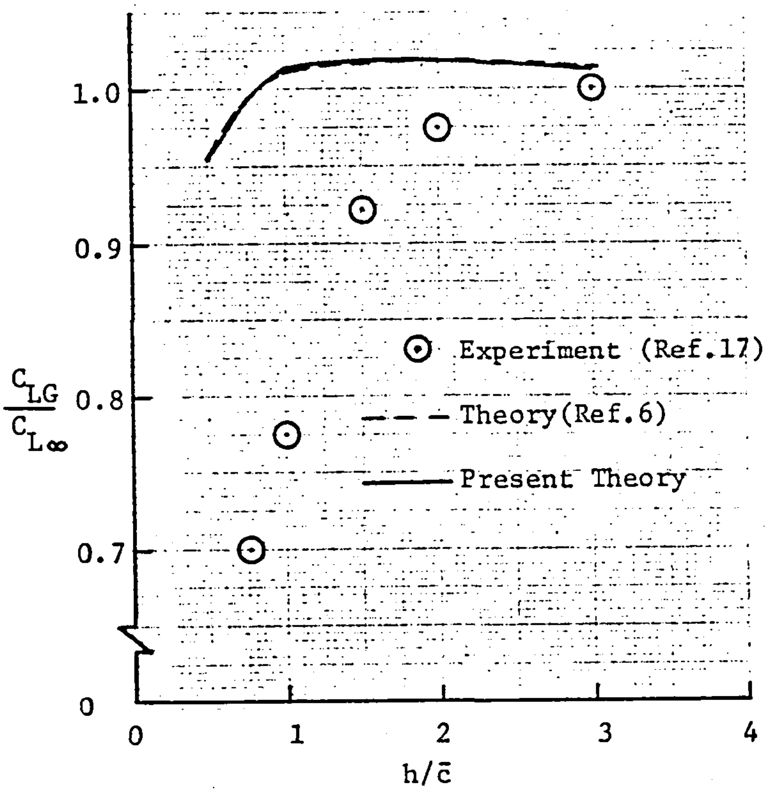

Figure 5. Comparison of Predicted Ground Effect for a Rectangular Wing of A = 8.3 with Full-Span Thin Jet Flap. C_μ = 3,0, α = 0°, δ_j = 55°.

Published data for USB configurations in ground effect are scarce. Some YC-14 data are given in Ref. 3. These data are for a complete configuration including the fuselage and horizontal tail which are not modelled in the present program. Since the actual jet deflection angle δ_j in free air is not available, and since the correct free-air C_L is important in predicting the ground effect, δ_j is taken to be a value so that at $\alpha=2°$, the lift coefficient in free air will match as closely as possible the experimental value. This is based on the assumption that at $\alpha = 2°$, the tail contribution to the total lift is small. Using the data at $\alpha = 2°$ with $C_T = 2.0$ in landing configuration for correlation to find the constant C_1 in Eq. (19.a), it is found that $C_1 = 19.2$ will provide the best over-all results. The predicted lift curves are compared with experimental data in Fig. 6 for the YC-14 landing configuration (thrust recovery efficient $\eta = 0.9$) and Fig. 7 for the takeoff configuration ($\eta = 1.0$). It should be noted that the theoretical C_L is obtained by adding the predicted incremental C_L due to ground effect to the experimental free-air values. It is seen from Fig. 6 that the predicted ground effect for the landing configuration agrees well with experiment. For the takeoff configuration in which the USB flaps are retracted, the ground effect at $C_T = 1.0$ is underpredicted by the theory.

Another set of available USB ground effect data is given in Ref.11. The predicted results are compared with the experimental data in landing configurations in Fig. 8. The free-air deflection angle is taken to be 42°. Also shown in Fig. 8 is the dashed curve predicted by the QVLM without the jet. In the latter case, the angle of attack is taken to be such that the free-air C_L can be correctly obtained and the jet reaction lift is assumed to be unchanged from the free-air value. It is seen that the present USB theory predicts the ground effect quite well. According to the theory, the jet deflection angle starts to be reduced at about $h/b = 0.3$ and the decrease in lift is mainly due to this reduction in jet deflection angle, which, of course will slightly affect the circulation lift also. The wing-alone method, which has been used in Refs. 1

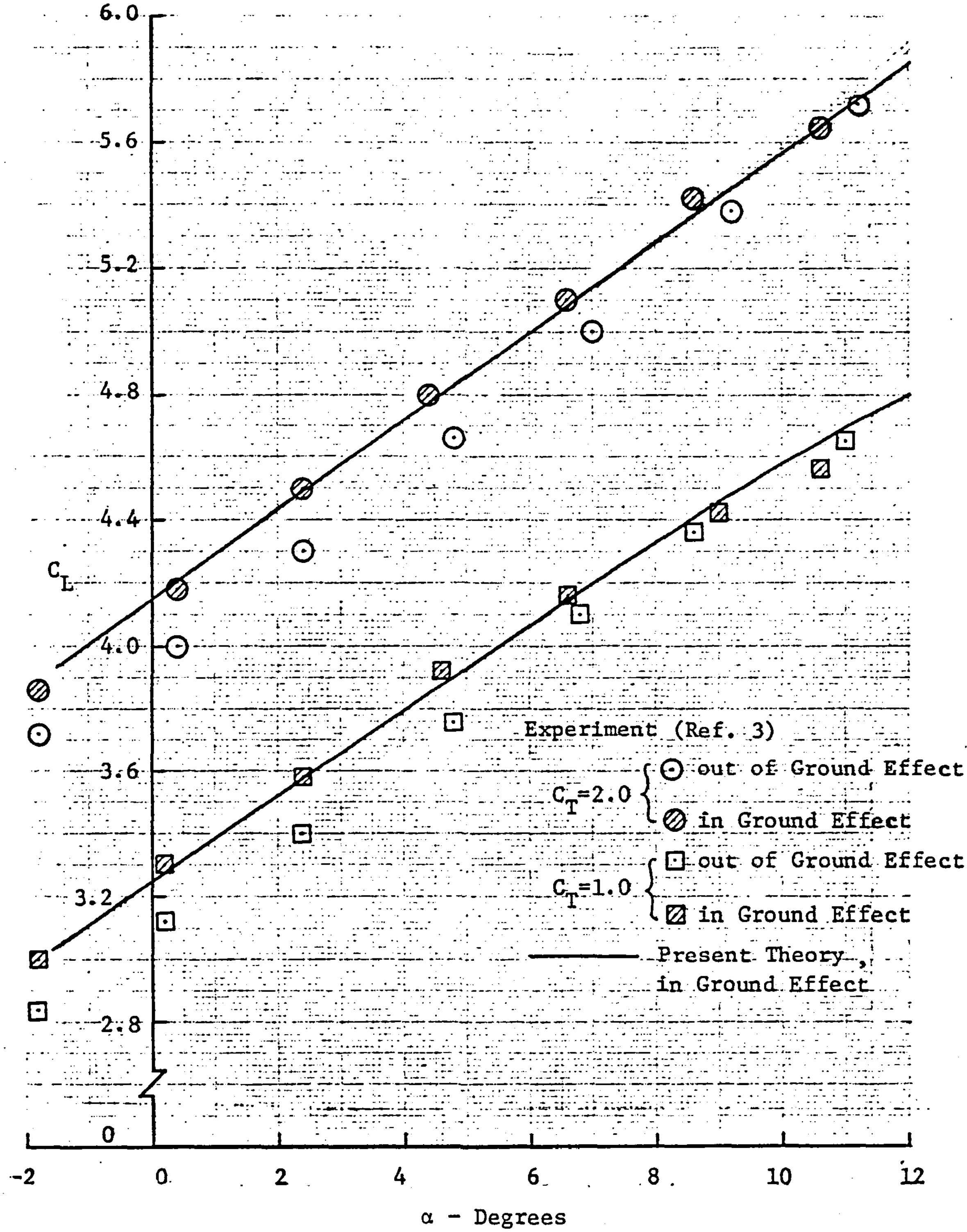

Figure 6. Comparison of Predicted Lift Curves with Experiment for YC-14 Landing Configuration in Ground Effect with h/b=0.187.

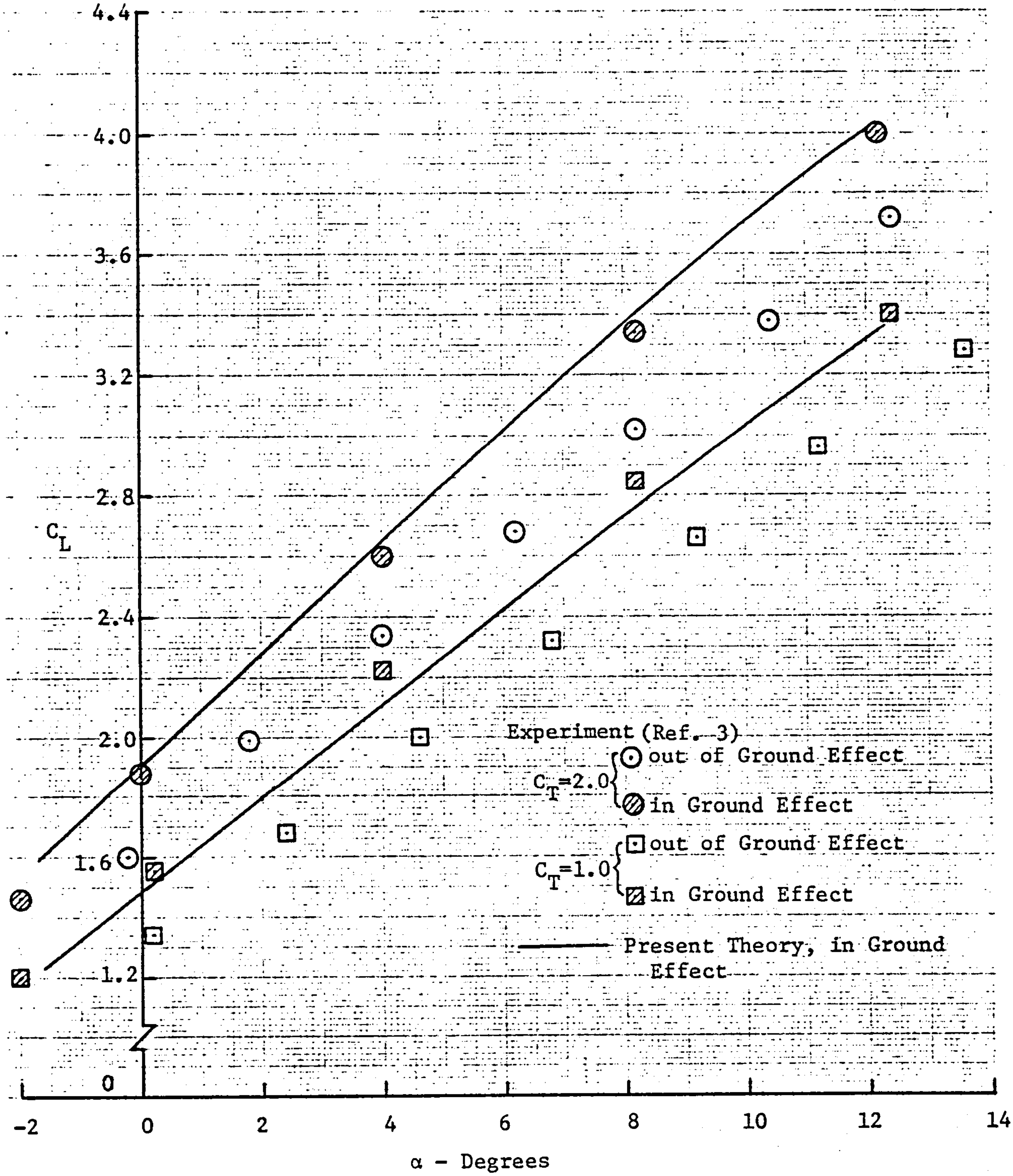

Figure 7. Comparison of Predicted Lift Curves with Experiment for YC-14 Takeoff Configuration in Ground Effect with h/b=0.187.

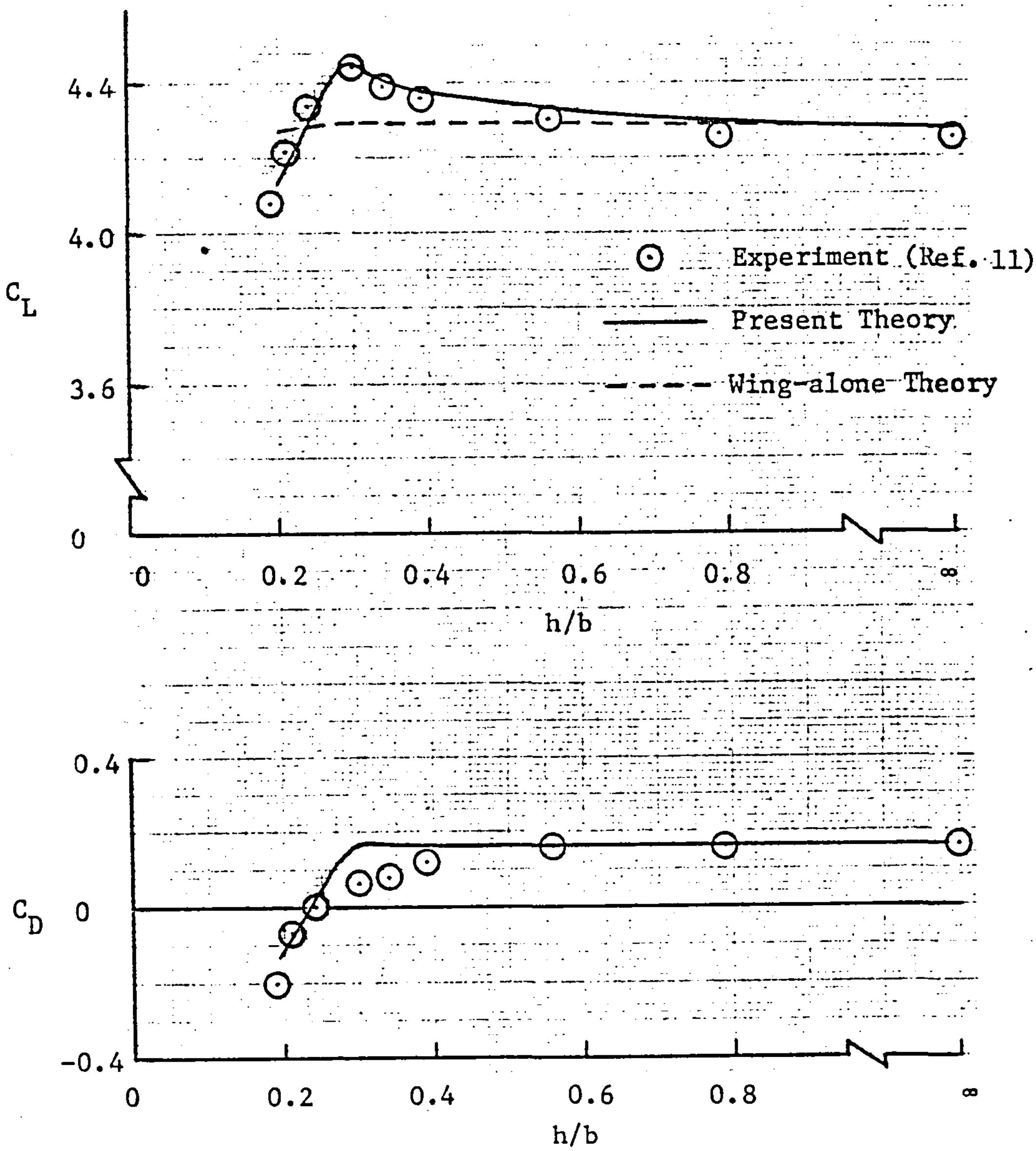

Figure 8. Comparison of Predicted Ground Effect on Longitudinal Aerodynamics of a USB Landing Configuration. $\alpha=5°$, $C_T=1.8$.

and 4 to predict the ground effect of the external-blown flap and augmentor-wing configurations, is seen to be incapable of predicting the ground effect of USB configurations. As shown in Fig. 9, the wing-alone theory does not predict the large increase in circulation lift predicted by the USB theory when the ground is approached. In addition to the difference in circulation distribution, one important mechanism is that the USB theory predicts less backwash on the wing due to the image vortex system. This is illustrated in Fig. 1b. As usual, the image wing vortices will induce backwash on the physical wing. However, the image jet vortices will either induce backwash (from surface 2) or increase the longitudinal velocity (from surface 1). In general, the effect of jet surface 1 is dominant because it is closer to the physical wing and the vortex strength is much larger. Therefore, the net backwash due to the image vortex system for the same free-air C_L is reduced.

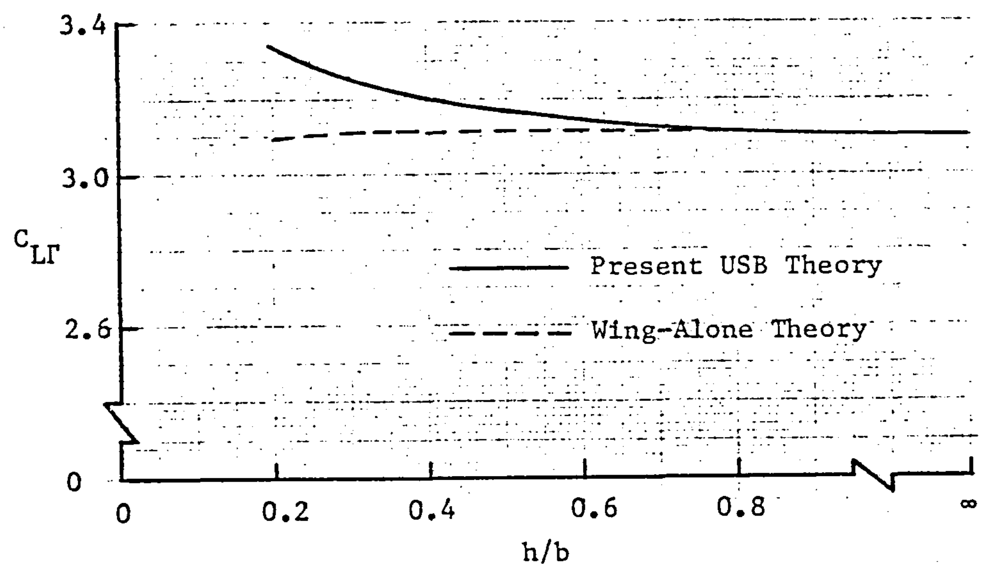

Figure 9. Comparison of Circulation Lift In Ground Effect Predicted by USB Jet Theory and Wing-Alone Theory for the Configuration of Figure 8.

The conclusion from the results presented above is that for a given USB configuration with a given thrust coefficient, the important parameters affecting the lift in ground effect are the pitch attitude angle and the jet deflection angle in free air. Large angles of both may decrease the lift in ground proximity. For given angles of both, there is a ground height at which the lift is maximum.

In Reference 4, typical results for the Augmentor Wing Research Aircraft C-8A exhibiting dynamic ground effect have been presented. It is shown that the ground effect is slightly more positive in descending flight than in ascending flight and there is an abrupt lift loss during the change of flight path. From the viewpoint of the present theoretical formulation, the phenomenon may be explained as follows. In descending flight, the pitch attitude angle for this aircraft is negative (Ref. 18) so that the backwash produced by the image vortices contributes to the upwash and hence, higher lift, as shown in Eq. (10). The opposite is true in ascending flight, in which the pitch attitude angle can be more than 20°. Of course, the flap angle is also changed in the transition. If the time history of the pitch attitude angle and the flap angle is known, it may be possible to predict this dynamic ground effect based on the quasi-steady approximation.

5. Conclusions

The ground effects on a USB configuration may involve changes in both the circulation forces and the jet reaction forces. In this report, a theoretical formulation to predict these effects has been presented. The predicted results agree well with available experimental data. The theory indicates that a positive pitch attitude angle will contribute to a reduction in lift. It is also shown that the wing-alone method is not capable of predicting the ground effect of a USB configuration.

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(19) Lan, C. E.; Fillman, G. L.; and Fox, C. H., Jr., "Computer Program for Calculating Aerodynamic Characteristics of Upper-Surface-Blowing and Over-Wing-Blowing Configurations," NASA TMX-73987, February 1977.

(20) Lan, C. E., "Theoretical Aerodynamics of Over-Wing-Blowing Configurations," NASA CR-144969, 1976.

Appendix Instructions on the Usage of the Computer Program and Program Listing.

The present computer program is a modified version of Ref. 19 by incorporating the ground effect calculation and the thin jet flap theory. Therefore, the program capabilities and limitations described in Ref. 19 are still applicable. The input instructions are described in the following.

The program is written in Fortran language and runs on CDC Cyber 175 computer. It is available from COSMIC of the University of Georgia, Athens, Georgia.

INPUT DATA FORMAT

Group 1. Format 13A6 1 card

Any title identifying the cases to be run.

Group 2. Format 4(6X,I4) 1 card

ICASE Numer of cases to be run.

NG = 0 if all cases have the same geometry other than the angle of attack.

= 1 if new configurations or different freestream-jet velocity ratios are to be treated.

ISYM = 0 for a centered jet

= 1, otherwise.

NGRD = 0 without ground effect.

= 1 in ground effect

Group 3. Format 8F10.5 1 card

AM1	Mach number of the freestream
AM2	Mach number of the jet flow
VMU	Freestream velocity divided by jet velocity.
TEMP	Jet static absolute temperature divided by freestream static absolute temperature. Assumed to be the same as ratio of freestream density and jet density.
ALP	Angle of attack in degrees.
XEL	X-coordinate of the wing L.E. at the jet centerline.
XET	X-coordinate of the wing T.E. at the jet centerline.

<u>Note</u>: If the thrust coefficient is given, VMU may be computed as

$$\frac{V_j}{V_\infty} = \frac{1}{2} \left\{ 1 + \left[1 + \frac{2C_T \; (S_w/2)}{A_j \; (\rho_j/\rho_\infty)} \right]^{1/2} \right\}$$

$VMU = V_\infty / V_j$

where C_T = thrust coefficient

S_W = wing area used to define C_T.

A_j = jet cross-sectional area

When the thrust coefficient is computed with the static thrust, the following formula for V_j/V_∞ is preferred:

$$\frac{V_j}{V_\infty} = \left[\frac{C_T \, (S_w/2)}{2A_j(\rho_j/\rho_\infty)} \right]^{1/2}$$

If the nozzle pressure ratio, $p_{t,j}/p_\infty$, is given, the following isentropic relations may be used.

$$M_j^2 = \frac{2}{\gamma-1} \left[\left(\frac{p_{t,j}}{p_\infty}\right)^{\frac{\gamma-1}{\gamma}} -1 \right]$$

$$\frac{T_j}{T_\infty} = \frac{1 + \frac{\gamma-1}{2} M_\infty^2}{1 + \frac{\gamma-1}{2} M_j^2}$$

$$\frac{V_\infty}{V_j} = VMU = \frac{M_\infty}{M_j} \frac{1}{\left(\frac{T_j}{T_\infty}\right)^{1/2}}$$

Group 4. Format 4F10.5 1 card

HEIGHT Ground height of wing aerodynamic center.

ATT Pitch attitude angle in degrees

XAC x-coordinate of wing aerodynamic center or the reference point about which the ground height is measured.

XHG x-coordinate of USB flap hinge. If the USB flap is not deflected, the trailing edge of the USB flap may be used.

Note: The above four variables may be set to 0. if NGRD = 0.

Group 5. Format 2(6X, I4) 5F10.5 1 card

NFP Number of flap sections, including the jet span. A maximum of five flap sections may be input.

NJP Numerical order of the jet span among the NFP sections.

DF(I) Flap deflection angles in degrees for the flap sections.

I=1, NFP

Group 6. Format 8F10.5 1 card

HALFSW One half of the reference wing area.

CREF Reference chord

TWIST Difference in angles of attack at the tip and the root in deg. Negative for washout.

TWISTR Incidence angle of the root chord in degrees.

XJ X, Y, and Z-coordinates of the midpoint of the jet cross-

YJ section at the exit.

ZJ

RJ Jet radius.

Note: The last four variables are needed only for over-wing-blowing applications. They may be any non-zero numbers for USB applications, unless the rectangular jet is not on the wing surface and the entrainment is to be accounted for, or the ground effect is to be calculated. For the latter cases, these variables are used to define the equivalent circular jet.

Group 7. Format 7F10.5 1 card

TEANGL Trailing-edge half angle of the airfoil at the jet centerline in deg. For USB applications, it may be arbitrary.

PTIAL = 0. for clean or full-span flap configuration

= 1. for partial-span flap deflection.

USB = 1. for USB applications.

= 2. for thin jet flap theory

= 0. for OWB applications

CAMLER L.E. camber slope at the root leading edge.

CAMLET L.E. camber slope at the tip leading edge.

CAMTER T.E. camber slope at the root trailing edge.

CAMTET T.E. camber slope at the tip trailing edge.

Note: For USB applications, TEANGL may be any value. If the camber ordinates are to be read in, the leading edge and trailing edge camber slopes may be arbitrary numbers.

Note: The following card must be omitted for OWB applications.

Group 8. Format 4F10.5 1 card

CMU Jet thrust coefficient

DFJ Jet deflection angle in degrees at the trailing edge relative to the chord line. At small flap angles, it may be taken as the sum of flap angle and the airfoil trailing edge half angle. At large flap angles, experimental values should be used.

TNJ = 0. if the entrainment is not to be accounted for. Usually this is the case if the jet is on the wing surface.

= 1. if the entrainment due to an equivalent round jet is to be accounted for when a rectangular jet is not on the wing surface.

DTEST = 1. if the USB jet deflection angle is to be modified by the program in ground effect.

= 0., otherwise.

Group 9. Format 8(6X, I4) 1 card

NC Number of spanwise sections. A natural way of dividing a planform into sections is to follow lines of discontinuity, such as edges of partial-span flap, jet boundaries, wing edge discontinuities, etc. NC is limited to 8.

M1(1) Number of vortex strips in each spanwise section, plus one.

.

. Minimum value for each is 3. Maximum for each M1(I) is 31.

.

I=1,NC The total number of spanwise strips is limited to 30.

Group 10. 5(6X, I4) 1 card

NJW(I) The numerical order of the flap and jet spans among

I=1,NFP the spanwise sections.

Group 11. 5(6X, I4) 1 card

NW(1) Number of chordwise vortex elements in each chordwise section.

NW(2) The planform is divided into chordwise sections according

NW(3) to such lines of discontinuity as jet exit, flap hinge, etc. If there is only one section, SET NW(2) = NW(3) = 0. For 2 sections, SET NW(3) = 0.

ICAM = 1 if the camber ordinates of the airfoils are to be read in.

= 0, otherwise. In this case, the camber functions $\left(\frac{dZ_c}{dx}\right)$ in close-form expressions are to be inserted manually into subprograms ZCR(x) and ZCT(X), the root chord and tip chord camber functions, respectively.

IM Number of camber ordinates to be read in. (Limited to eleven). Arbitrary if ICAM = 0.

Note: Group 12 must be deleted if ICAM = 0.

Group 12. Format 8F10.5 4 or 8 cards.

XT(1,J), J=1,IM Non-dimensional x-coordinates to define root camber.

ZC(1,J),J=1,IM Non-dimensional camber ordinates of the root chord.

XT(2,J),J=1,IM Non-dimensional x-coordinates to define tip camber.

ZC(2,J),J=1,IM Non-dimensional camber ordinates of the tip chord.

Group 13. Format 6F10.5 1 card for each wing section.

XXL(1) x-coordinate of the leading edge of the inboard boundary chord of a given spanwise section.

XXT(1) x-coordinate of the trailing edge of the inboard boundary chord of the same spanwise section.

YL(1) y-coordinate of the inboard boundary chord.

XXL(2) x-coordinate of the leading edge of the outboard boundary chord of the same spanwise section.

XXT(2) x-coordinate of the trailing edge of the outboard boundary chord.

YL(2) y-coordinate of the outboard boundary chord.

Group 14. Format 6(6X, I4), 1 card

NNJ Number of jet sections.

<u>Note</u>: The jet region above or on the wing must be divided into streamwise sections by following the divided planform pattern. It is important to start the jet sections always from the wing leading edge even if the jet exit is downstream of the leading edge. The only exception is when the jet exit is at the trailing edge. In this case, NNJ=1 and the jet section starts from the trailing edge. NNJ is limited to 4.

NSJ = Number of jet circumferential strips <u>minus</u> one for a non-centered jet (always use odd numbers).

= Number of jet circumferential strips on the half jet <u>plus</u> one for a centered jet (always use even numbers).

NCJ(I), I=1,NNJ Number of streamwise vortex elements in each section. There should be NNJ numbers. For those jet sections above the wing, these numbers should agree with the corresponding numbers of wing vortices. See NW(1). NW(2), NW(3) in Group 11.

<u>Note</u>: Group 15 must be deleted for USB applications

Group 15. Format 6F10.5 NNJ cards

XXL(1)

XXT(1)

YL(1)

XXL(2) Coordinates of bounding chords of the jet section

XXT(2) projected on the x-y plane. For definition, see Group 13.

YL(2)

Note: Group 16 is to be deleted for OWB applications.

Group 16. Format 4F10.5 (4xNNJ) cards.

XXL(I)	Coordinates of the bounding lines defining the
XXT(I)	rectangular jet sections in USB applications.
YL(I)	They are the x-coordinates of the leading and
ZL(I)	trailing edges, the y-coordinate and the z-
I=1,..,4	coordinate of the bounding line. The 4 stream-wise edges of each section are defined in the clockwise order (facing upstream), starting from the inboard lower bounding line. There are 4 cards for each jet section. The jet section behind the trailing edge, (trailing jet section), should be at least one local chord in length for thick jet applications and two local chord in length for thin jet flap theory.

Note: If ICASE > 1 and NG = 1, Groups 3-16 are to be repeated.

Group 17. Format F10.5 (ICASE-1) cards

ALP angles of attack in degrees. These cards are to be included only if additional angles of attack for the same configuration and VMU (NG=0 ,NGRD=0) are to be run.

Note: The read statements for the input data in group 3 thru group 16 can be found in subroutine "GEOMTY" of the program listing along with a short definition of the parameters to be read in. The read statements for groups 1, 2, and 17 along with the corresponding parameter definitions can be found near the beginning of the program listing in the main routine.

Pre-Run Check List

Before the program is run, the following checklist should be completed:

(1) The array, GAMMA, defined in the subroutine "SOLUTN", should be dimensioned to have at least $(N+1)^2/4$ elements, where N is the total number of unknowns (= LTOTAL).

(2) For N = 260, the minimum memory needed is 40K (decimal). For any other N, the required memory can be computed accordingly, based on the change in GAMMA array.

(3) The root and tip camber slope functions should be defined manually in the subprograms ZCR(X), ZCT(X) respectively; otherwise the root and tip camber ordinates should be read in. The camber slope function, dz_c/dx, is defined with respect to a unit chord length.

(4) Two temporary files or tapes must be provided, one being designated as (01) and the other (02).

(5) Check input data.

OUTPUT DATA FORMAT

First the title of the job and the input data will be printed in the same format as it was input. If the job is an over-wing blowing configuration, the computed jet entrainment will be printed after the fourth line of input data as follows:

XJET Downstream distance of a given cross-section from the jet exit divided by the jet radius at the exit (r_o).

R_{JET} the radius of the jet cross section divided by the original jet radius (r_o).

$\frac{DM}{DX}$ Values printed are actually the nondimensionalized entrainment function $E(\bar{x})$ (see equation 33 or reference 20).

If the job is with ground effect and the jet deflection angle is modified by the program, the equivalent velocity ratio, the equivalent jet radius and the estimated jet deflection angle will be printed at this point. The first two quantities are used to estimate the third one.

HALF SW the reference half-wing area

CREF the reference chord

LAST the number of wing vortices plus the number of outer jet vortices.

JPANEL the number of outer (or inner) jet vortices

LTOTAL LTOTAL is the total number of vortices used which is also the total number of unknowns to be solved.

LTOTAL = LAST + JPANEL

If the job is an OWB configuration a note will be printed at this time indicating the shape of the equivalent jet cross-section used for the interaction computations along with 3 parameters defined below.

1. x-coordinate where the equivalent jet properties are evaluated.

2. Equivalent Jet Radius: the radius of the jet at the x location listed above.

3. $\frac{Vo}{V_j}$ the velocity ratio of the equivalent jet.

Vortex Element Endpoint Coordinates

(X_1, Y_1, Z_1)	coordinates for the inboard enpoint of a bound vortex element
(X_2, Y_2, Z_2)	coordinates for the corresponding outboard endpoint. Wing elements are listed first and then jet elements. The number of elements listed should equal (LAST).

Control Point Coordinates

2 columns of control point coordinates, one point for each vortex element. Number of points listed should equal (LAST).

Sectional Pressure and Force Data

XV	Percent chord location
YV	Percent span location
CP	the total ΔC_p at the given (XV, YV) point due to both wing and jet induced circulation
CPW	The ΔC_p that would occur at that same point for the wing alone case
Y/SP	the y-coordinate of the chord in question divided by the half-span
CL	The sectional lift coefficient due to circulation (jet on), non-dimensionalized with $q_\infty c$.
CM	The sectional pitching moment coefficient about the Y-axis, nondimensionalized with $q_\infty c^2$.
CT	The sectional leading edge thrust coefficient, nondimensionalized with $q_\infty c$.
CDI	The sectional induced drag coefficient, nondimensionalized with $q_\infty c$.

CLW The sectional lift coefficient for the wing along case

CMW The sectional pitching moment about the Y-axis for the wing alone case

CDW The sectional induced drag coefficient for the wing alone case.

Total Force and Moment Data

The Lift Coefficient — The total circulation lift coefficient due to wing, wing-jet interaction and entrainment (if any).

Total Induced Drag Coefficient — Total induced drag coeff. for the jet on case

Induced drag parameter = $\frac{C_{D_I}}{C_L^2}$ or $\frac{1}{\pi e AR}$

Total Pitching Moment Coefficient = Pitching moment coefficient due to all circulation forces, about the Y-axis. Nondimensionalized with CREF.

Note: In the case of OWB jobs, these coefficients reflect the total jet-on forces and moments, but for USB jobs the coanda force and moment coefficients must be added to these; see below.

USB Jobs

Coanda Lift Coefficient - The lift coefficient due to the lift component of the jet reaction force

Coanda Drag Coefficient - Drag coefficient due to the drag component of the jet reaction.

The Coanda Moment Coeff. - Pitching moment coefficient due to the pitching moment caused by the jet reaction force (about Y-axis).

OWB Jobs

In the case of O.W.B. jobs the next three coefficients listed have the same definition as the first three except that the effects of wing-jet interaction have been ommitted from the computation.

The last four coefficients printed are due to aerodynamic forces and moments generated solely by the wing without any jet effects.

SAMPLE INPUT No. 1

```
 * YC-14 IN GROUND EFFFCT WITH LANDING FLAPS *
         1         1         1         1
0.        0.        0.18274   1.        12.       0.1849    1.933485
2.4123    12.       0.73861   1.35063
         2         1 56.      47.
8.8107    1.472     0.        0.        0.85328   1.35      0.32114   0.32114
0.        1.        1.
1.8       33.       0.        1.
         4         2         4         7         5
         2         3
         2         2         2
0.        0.8       0.        0.123285  0.853285  0.9
0.123285  0.853285  0.9       0.246569  0.853285  1.8
0.246569  0.853285  1.8       0.698613  1.058759  5.1
0.698613  1.058759  5.1       0.88354   1.14281   6.45
0.8       1.3493    0.        0.853285  1.3502    0.9
0.853285  1.3502    0.9       0.853285  1.351065  1.8
0.853285  1.351065  1.8       1.058759  1.354241  5.1
1.058759  1.354241  5.1       1.14281   1.35554   6.45
1.3493    2.024     0.        1.3502    1.963657  0.9
1.3502    1.963657  0.9       1.351065  1.903313  1.8
1.351065  1.903313  1.8       1.354241  1.682055  5.1
1.354241  1.682055  5.1       1.35554   1.59154   6.45
         4         7         2         2         2         4
0.123285  0.853285  0.9       0.
0.123285  0.853285  0.9       0.36
0.246569  0.853285  1.8       0.36
0.246569  0.853285  1.8       0.
0.853285  1.3502    0.9       0.
0.853285  1.3502    0.9       0.36
0.853285  1.351065  1.8       0.36
0.853285  1.351065  1.8       0.
1.3502    1.963657  0.9       0.
1.3502    1.963657  0.9       0.36
1.351065  1.903313  1.8       0.36
1.351065  1.903313  1.8       0.
1.96365   4.76135   0.9       0.
1.96365   4.76135   0.9       0.36
1.90331   4.70101   1.8       0.36
1.90331   4.70101   1.8       0.
```

SAMPLE OUTPUT No. 1

```
*****************************************
 * YC-14 IN GROUND EFFECT WITH LANDING FLAPS *
*****************************************
        1          1          1          1


                   XXXXXXXXXXXXXXXXXXXXXXXXX

                        CASE NUMBER = 1

                   XXXXXXXXXXXXXXXXXXXXXXXXX

INPUT DATA
  0.00000    0.00000     .18274    1.00000  12.00000     .18493    1.93349
  2.41230   12.00000     .73861    1.35063
        2          1   56.00000   47.00000
  8.81070    1.47200    0.00000    0.00000    .85328    1.35000     .32114     .32114
  0.00000    1.00000    1.00000    0.00000   0.00000    0.00000    0.00000
  1.80000   33.00000    0.00000    1.00000

 THE EQUIVALENT VELOCITY RATIO, VO/VJ, AT FLAP HINGE =     .19694

 THE EQUIVALENT JET RADIUS AT FLAP HINGE IN MULTIPLES OF EXIT RADIUS =   1.15813

 THE ACTUAL JET DEFLECTION ANGLE IS ESTIMATED TO BE = 24.407  DEGREES
        4          2          4          7          5
        2          3
        2          2          2          0          0
  0.00000     .80000    0.00000     .12329     .85329     .90000
   .12329     .85329     .90000     .24657     .85329    1.80000
   .24657     .85329    1.80000     .69861    1.05876    5.10000
   .69861    1.05876    5.10000     .88354    1.14281    6.45000
   .80000    1.34930    0.00000     .85329    1.35020     .90000
   .85329    1.35020     .90000     .85329    1.35107    1.80000
   .85329    1.35107    1.80000    1.05876    1.35424    5.10000
  1.05876    1.35424    5.10000    1.14281    1.35554    6.45000
  1.34930    2.02400    0.00000    1.35020    1.96366     .90000
  1.35020    1.96366     .90000    1.35107    1.90331    1.80000
  1.35107    1.90331    1.80000    1.35424    1.68206    5.10000
  1.35424    1.68206    5.10000    1.35554    1.59154    6.45000
```

4	7	2	2	2	4
.12329	.85329	.90000	0.00000		
.12329	.85329	.90000	.36000		
.24657	.85329	1.80000	.36000		
.24657	.85329	1.80000	0.00000		
.85329	1.35020	.90000	0.00000		
.85329	1.35020	.90000	.36000		
.85329	1.35107	1.80000	.36000		
.85329	1.35107	1.80000	0.00000		
1.35020	1.96366	.90000	0.00000		
1.35020	1.96366	.90000	.36000		
1.35107	1.90331	1.80000	.36000		
1.35107	1.90331	1.80000	0.00000		
1.96365	4.76135	.90000	0.00000		
1.96365	4.76135	.90000	.36000		
1.90331	4.70101	1.80000	.36000		
1.90331	4.70101	1.80000	0.00000		

HALF SW= .88107E+01 CREF= .14720E+01

LAST,JPANEL,LTOTAL=

164	80	244

VORTEX ELEMENT ENDPOINT COORDINATES=

X1	X2	Y1	Y2	Z1	Z2
.11716	.23019	0.00000	.90000	0.00000	0.00000
.68284	.74638	0.00000	.90000	0.00000	0.00000
.23019	.26267	.90000	1.17779	0.00000	0.00000
.74638	.75195	.90000	1.17779	0.00000	0.00000
.26267	.30294	1.17779	1.52221	0.00000	0.00000
.75195	.75886	1.17779	1.52221	0.00000	0.00000
.30294	.33542	1.52221	1.80000	0.00000	0.00000
.75886	.76443	1.52221	1.80000	0.00000	0.00000
.33542	.38079	1.80000	2.15998	0.00000	0.00000
.76443	.79079	1.80000	2.15998	0.00000	0.00000
.38079	.45315	2.15998	2.73409	0.00000	0.00000
.79079	.83282	2.15998	2.73409	0.00000	0.00000
.45315	.54339	2.73409	3.45000	0.00000	0.00000
.83282	.88523	2.73409	3.45000	0.00000	0.00000

.54339	.63362	3.45000	4.16591	0.00000	0.00000
.88523	.93763	3.45000	4.16591	0.00000	0.00000
.63362	.70598	4.16591	4.74002	0.00000	0.00000
.93763	.97966	4.16591	4.74002	0.00000	0.00000
.70598	.75136	4.74002	5.10000	0.00000	0.00000
.97966	1.00602	4.74002	5.10000	0.00000	0.00000
.75136	.78643	5.10000	5.37824	0.00000	0.00000
1.00602	1.02639	5.10000	5.37824	0.00000	0.00000
.78643	.83643	5.37824	5.77500	0.00000	0.00000
1.02639	1.05543	5.37824	5.77500	0.00000	0.00000
.83643	.88644	5.77500	6.17176	0.00000	0.00000
1.05543	1.08447	5.77500	6.17176	0.00000	0.00000
.88644	.91735	6.17176	6.41696	0.00000	0.00000
1.08447	1.10242	6.17176	6.41696	0.00000	0.00000
.88044	.92606	0.00000	.90000	0.00000	0.00000
1.26886	1.27743	0.00000	.90000	0.00000	0.00000
.92606	.92610	.90000	1.17779	0.00000	0.00000
1.27743	1.27766	.90000	1.17779	0.00000	0.00000
.92610	.92614	1.17779	1.52221	0.00000	0.00000
1.27766	1.27794	1.17779	1.52221	0.00000	0.00000
.92614	.92618	1.52221	1.80000	0.00000	0.00000
1.27794	1.27817	1.52221	1.80000	0.00000	0.00000
.92618	.94537	1.80000	2.15998	0.00000	0.00000
1.27817	1.28174	1.80000	2.15998	0.00000	0.00000
.94537	.97596	2.15998	2.73409	0.00000	0.00000
1.28174	1.28745	2.15998	2.73409	0.00000	0.00000
.97596	1.01411	2.73409	3.45000	0.00000	0.00000
1.28745	1.29457	2.73409	3.45000	0.00000	0.00000
1.01411	1.05226	3.45000	4.16591	0.00000	0.00000
1.29457	1.30168	3.45000	4.16591	0.00000	0.00000
1.05226	1.08285	4.16591	4.74002	0.00000	0.00000
1.30168	1.30739	4.16591	4.74002	0.00000	0.00000
1.08285	1.10203	4.74002	5.10000	0.00000	0.00000
1.30739	1.31097	4.74002	5.10000	0.00000	0.00000
1.10203	1.11686	5.10000	5.37824	0.00000	0.00000
1.31097	1.31373	5.10000	5.37824	0.00000	0.00000
1.11686	1.13800	5.37824	5.77500	0.00000	0.00000
1.31373	1.31768	5.37824	5.77500	0.00000	0.00000
1.13800	1.15914	5.77500	6.17176	0.00000	0.00000
1.31768	1.32162	5.77500	6.17176	0.00000	0.00000

1.15914	1.17220	6.17176	6.41696	0.00000	0.00000
1.32162	1.32406	6.17176	6.41696	0.00000	0.00000
1.44811	1.44004	0.00000	.90000	0.00000	0.00000
1.92519	1.87382	0.00000	.90000	0.00000	0.00000
1.44004	1.43754	.90000	1.17779	0.00000	0.00000
1.87382	1.85796	.90000	1.17779	0.00000	0.00000
1.43754	1.43444	1.17779	1.52221	0.00000	0.00000
1.85796	1.83830	1.17779	1.52221	0.00000	0.00000
1.43444	1.43194	1.52221	1.80000	0.00000	0.00000
1.83830	1.82244	1.52221	1.80000	0.00000	0.00000
1.43194	1.42870	1.80000	2.15998	0.00000	0.00000
1.82244	1.80189	1.80000	2.15998	0.00000	0.00000
1.42870	1.42354	2.15998	2.73409	0.00000	0.00000
1.80189	1.76911	2.15998	2.73409	0.00000	0.00000
1.42354	1.41709	2.73409	3.45000	0.00000	0.00000
1.76911	1.72824	2.73409	3.45000	0.00000	0.00000
1.41709	1.41065	3.45000	4.16591	0.00000	0.00000
1.72824	1.68737	3.45000	4.16591	0.00000	0.00000
1.41065	1.40549	4.16591	4.74002	0.00000	0.00000
1.68737	1.65460	4.16591	4.74002	0.00000	0.00000
1.40549	1.40225	4.74002	5.10000	0.00000	0.00000
1.65460	1.63405	4.74002	5.10000	0.00000	0.00000
1.40225	1.39974	5.10000	5.37824	0.00000	0.00000
1.63405	1.61816	5.10000	5.37824	0.00000	0.00000
1.39974	1.39617	5.37824	5.77500	0.00000	0.00000
1.61816	1.59551	5.37824	5.77500	0.00000	0.00000
1.39617	1.39260	5.77500	6.17176	0.00000	0.00000
1.59551	1.57286	5.77500	6.17176	0.00000	0.00000
1.39260	1.39040	6.17176	6.41696	0.00000	0.00000
1.57286	1.55886	6.17176	6.41696	0.00000	0.00000
.23019	.23019	.90000	.90000	0.00000	.36000
.74638	.74638	.90000	.90000	0.00000	.36000
.23019	.26267	.90000	1.17779	.36000	.36000
.74638	.75195	.90000	1.17779	.36000	.36000
.26267	.30294	1.17779	1.52221	.36000	.36000
.75195	.75886	1.17779	1.52221	.36000	.36000
.30294	.33542	1.52221	1.80000	.36000	.36000
.75886	.76443	1.52221	1.80000	.36000	.36000
.33542	.33542	1.80000	1.80000	.36000	0.00000
.76443	.76443	1.80000	1.80000	.36000	0.00000

.23019	.26267	.90000	1.17779	0.00000	0.00000
.74638	.75195	.90000	1.17779	0.00000	0.00000
.26267	.30294	1.17779	1.52221	0.00000	0.00000
.75195	.75886	1.17779	1.52221	0.00000	0.00000
.30294	.33542	1.52221	1.80000	0.00000	0.00000
.75886	.76443	1.52221	1.80000	0.00000	0.00000
.92606	.92606	.90000	.90000	0.00000	.36000
1.27743	1.27743	.90000	.90000	0.00000	.36000
.92606	.92610	.90000	1.17779	.36000	.36000
1.27743	1.27766	.90000	1.17779	.36000	.36000
.92610	.92614	1.17779	1.52221	.36000	.36000
1.27766	1.27794	1.17779	1.52221	.36000	.36000
.92614	.92618	1.52221	1.80000	.36000	.36000
1.27794	1.27817	1.52221	1.80000	.36000	.36000
.92618	.92618	1.80000	1.80000	.36000	0.00000
1.27817	1.27817	1.80000	1.80000	.36000	0.00000
.92606	.92610	.90000	1.17779	0.00000	0.00000
1.27743	1.27766	.90000	1.17779	0.00000	0.00000
.92610	.92614	1.17779	1.52221	0.00000	0.00000
1.27766	1.27794	1.17779	1.52221	0.00000	0.00000
.92614	.92618	1.52221	1.80000	0.00000	0.00000
1.27794	1.27817	1.52221	1.80000	0.00000	0.00000
1.44004	1.44004	.90000	.90000	0.00000	.36000
1.87382	1.87382	.90000	.90000	0.00000	.36000
1.44004	1.43754	.90000	1.17779	.36000	.36000
1.87382	1.85796	.90000	1.17779	.36000	.36000
1.43754	1.43444	1.17779	1.52221	.36000	.36000
1.85796	1.83830	1.17779	1.52221	.36000	.36000
1.43444	1.43194	1.52221	1.80000	.36000	.36000
1.83830	1.82244	1.52221	1.80000	.36000	.36000
1.43194	1.43194	1.80000	1.80000	.36000	0.00000
1.82244	1.82244	1.80000	1.80000	.36000	0.00000
1.44004	1.43754	.90000	1.17779	0.00000	0.00000
1.87382	1.85796	.90000	1.17779	0.00000	0.00000
1.43754	1.43444	1.17779	1.52221	0.00000	0.00000
1.85796	1.83830	1.17779	1.52221	0.00000	0.00000
1.43444	1.43194	1.52221	1.80000	0.00000	0.00000
1.83830	1.82244	1.52221	1.80000	0.00000	0.00000
2.07013	2.07013	.90000	.90000	0.00000	.36000
2.82718	2.82718	.90000	.90000	0.00000	.36000
3.89782	3.89782	.90000	.90000	0.00000	.36000
4.65487	4.65487	.90000	.90000	0.00000	.36000

2.07013	2.05151	.90000	1.17779	.36000	.36000
2.82718	2.80856	.90000	1.17779	.36000	.36000
3.89782	3.87919	.90000	1.17779	.36000	.36000
4.65487	4.63624	.90000	1.17779	.36000	.36000
2.05151	2.02842	1.17779	1.52221	.36000	.36000
2.80856	2.78547	1.17779	1.52221	.36000	.36000
3.87919	3.85610	1.17779	1.52221	.36000	.36000
4.63624	4.61315	1.17779	1.52221	.36000	.36000
2.02842	2.00979	1.52221	1.80000	.36000	.36000
2.78547	2.76684	1.52221	1.80000	.36000	.36000
3.85610	3.83748	1.52221	1.80000	.36000	.36000
4.61315	4.59453	1.52221	1.80000	.36000	.36000
2.00979	2.00979	1.80000	1.80000	.36000	0.00000
2.76684	2.76684	1.80000	1.80000	.36000	0.00000
3.83748	3.83748	1.80000	1.80000	.36000	0.00000
4.59453	4.59453	1.80000	1.80000	.36000	0.00000
2.07013	2.05151	.90000	1.17779	0.00000	0.00000
2.82718	2.80856	.90000	1.17779	0.00000	0.00000
3.89782	3.87919	.90000	1.17779	0.00000	0.00000
4.65487	4.63624	.90000	1.17779	0.00000	0.00000
2.05151	2.02842	1.17779	1.52221	0.00000	0.00000
2.80856	2.78547	1.17779	1.52221	0.00000	0.00000
3.87919	3.85610	1.17779	1.52221	0.00000	0.00000
4.63624	4.61315	1.17779	1.52221	0.00000	0.00000
2.02842	2.00979	1.52221	1.80000	0.00000	0.00000
2.78547	2.76684	1.52221	1.80000	0.00000	0.00000
3.85610	3.83748	1.52221	1.80000	0.00000	0.00000
4.61315	4.59453	1.52221	1.80000	0.00000	0.00000

CONTROL POINT COORDINATES=

XCP	YCP	ZCP	XCP	YCP	ZCP
.44414	.45000	0.00000	.82664	.45000	0.00000
.49731	1.03180	0.00000	.85329	1.03180	0.00000
.51911	1.35000	0.00000	.85329	1.35000	0.00000
.54090	1.66820	0.00000	.85329	1.66820	0.00000
.56621	1.96340	0.00000	.86346	1.96340	0.00000
.61182	2.42124	0.00000	.89197	2.42124	0.00000
.67773	3.08284	0.00000	.93316	3.08284	0.00000
.75088	3.81716	0.00000	.97888	3.81716	0.00000
.81680	4.47876	0.00000	1.02008	4.47876	0.00000
.86241	4.93660	0.00000	1.04858	4.93660	0.00000

.89153	5.22891	0.00000	1.06679	5.22891	0.00000
.92515	5.56641	0.00000	1.08780	5.56641	0.00000
.96671	5.98359	0.00000	1.11377	5.98359	0.00000
1.00033	6.32109	0.00000	1.13478	6.32109	0.00000
1.08820	.45000	0.00000	1.34975	.45000	0.00000
1.10181	1.03180	0.00000	1.35033	1.03180	0.00000
1.10196	1.35000	0.00000	1.35063	1.35000	0.00000
1.10211	1.66820	0.00000	1.35094	1.66820	0.00000
1.10734	1.96340	0.00000	1.35122	1.96340	0.00000
1.12181	2.42124	0.00000	1.35166	2.42124	0.00000
1.14273	3.08284	0.00000	1.35230	3.08284	0.00000
1.16594	3.81716	0.00000	1.35301	3.81716	0.00000
1.18686	4.47876	0.00000	1.35364	4.47876	0.00000
1.20133	4.93660	0.00000	1.35408	4.93660	0.00000
1.21058	5.22891	0.00000	1.35437	5.22891	0.00000
1.22124	5.56641	0.00000	1.35469	5.56641	0.00000
1.23443	5.98359	0.00000	1.35509	5.98359	0.00000
1.24510	6.32109	0.00000	1.35542	6.32109	0.00000
1.67179	.45000	0.00000	1.99383	.45000	0.00000
1.65257	1.03180	0.00000	1.95482	1.03180	0.00000
1.64206	1.35000	0.00000	1.93349	1.35000	0.00000
1.63154	1.66820	0.00000	1.91215	1.66820	0.00000
1.62179	1.96340	0.00000	1.89236	1.96340	0.00000
1.60666	2.42124	0.00000	1.86166	2.42124	0.00000
1.58480	3.08284	0.00000	1.81730	3.08284	0.00000
1.56054	3.81716	0.00000	1.76807	3.81716	0.00000
1.53868	4.47876	0.00000	1.72371	4.47876	0.00000
1.52355	4.93660	0.00000	1.69301	4.93660	0.00000
1.51389	5.22891	0.00000	1.67341	5.22891	0.00000
1.50274	5.56641	0.00000	1.65078	5.56641	0.00000
1.48895	5.98359	0.00000	1.62281	5.98359	0.00000
1.47780	6.32109	0.00000	1.60018	6.32109	0.00000
.48828	.90000	.18000	.85329	.90000	.18000
.49731	1.03180	.36000	.85328	1.03180	.36000
.51911	1.35000	.36000	.85328	1.35000	.36000
.54090	1.66820	.36000	.85329	1.66820	.36000
.54993	1.80000	.18000	.85329	1.80000	.18000
.49731	1.03180	0.00000	.85328	1.03180	0.00000
.51911	1.35000	0.00000	.85328	1.35000	0.00000
.54090	1.66820	0.00000	.85329	1.66820	0.00000
1.10174	.90000	.18000	1.35020	.90000	.18000

1.10181	1.03180	.36000	1.35033	1.03180	.36000
1.10196	1.35000	.36000	1.35063	1.35000	.36000
1.10211	1.66820	.36000	1.35094	1.66820	.36000
1.10217	1.80000	.18000	1.35107	1.80000	.18000
1.10181	1.03180	0.00000	1.35033	1.03180	0.00000
1.10196	1.35000	0.00000	1.35063	1.35000	0.00000
1.10211	1.66820	0.00000	1.35094	1.66820	0.00000
1.65693	.90000	.18000	1.96366	.90000	.18000
1.65257	1.03180	.36000	1.95482	1.03180	.36000
1.64206	1.35000	.36000	1.93349	1.35000	.36000
1.63154	1.66820	.36000	1.91215	1.66820	.36000
1.62719	1.80000	.18000	1.90331	1.80000	.18000
1.65257	1.03180	0.00000	1.95482	1.03180	0.00000
1.64206	1.35000	0.00000	1.93349	1.35000	0.00000
1.63154	1.66820	0.00000	1.91215	1.66820	0.00000
2.37336	.90000	.18000	3.36250	.90000	.18000
4.35164	.90000	.18000	4.76135	.90000	.18000
2.36453	1.03180	.36000	3.35366	1.03180	.36000
4.34280	1.03180	.36000	4.75251	1.03180	.36000
2.34319	1.35000	.36000	3.33233	1.35000	.36000
4.32147	1.35000	.36000	4.73118	1.35000	.36000
2.32186	1.66820	.36000	3.31100	1.66820	.36000
4.30013	1.66820	.36000	4.70985	1.66820	.36000
2.31302	1.80000	.18000	3.30216	1.80000	.18000
4.29130	1.80000	.18000	4.70101	1.80000	.18000
2.36453	1.03180	0.00000	3.35366	1.03180	0.00000
4.34280	1.03180	0.00000	4.75251	1.03180	0.00000
2.34319	1.35000	0.00000	3.33233	1.35000	0.00000
4.32147	1.35000	0.00000	4.73118	1.35000	0.00000
2.32186	1.66820	0.00000	3.31100	1.66820	0.00000
4.30013	1.66820	0.00000	4.70985	1.66820	0.00000

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

ALPHA = 12.000 DEGREES

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

VORTEX	XV	YV	CP	CPW
1	.05798	.06977	4.93840	4.49174
2	.33794	.06977	2.03630	1.80658
3	.43557	.06977	1.61966	1.41632

4	.62701	.06977	1.35171	1.14022
5	.71547	.06977	1.26255	1.04710
6	.95118	.06977	.55648	.43763
7	.05749	.15997	5.17628	4.91924
8	.33509	.15997	1.94055	2.13170
9	.43272	.15997	12.94878	1.83168
10	.62653	.15997	23.47637	2.76872
11	.71548	.15997	25.58114	2.64594
12	.95118	.15997	4.88929	.65845
13	.05598	.20930	5.49179	5.27058
14	.32626	.20930	2.03749	2.37103
15	.42389	.20930	12.61774	2.13158
16	.62501	.20930	30.66566	3.27826
17	.71548	.20930	29.91524	3.15942
18	.95118	.20930	5.66084	.80458
19	.05434	.25864	5.82602	5.61273
20	.31674	.25864	2.24051	2.52948
21	.41437	.25864	18.48643	2.31290
22	.62338	.25864	24.75371	3.43344
23	.71548	.25864	29.31779	3.28769
24	.95118	.25864	5.09970	.87123
25	.05363	.30440	6.27956	5.86603
26	.31258	.30440	2.82792	2.63523
27	.41021	.30440	2.66803	2.40955
28	.62267	.30440	3.83146	3.33918
29	.71548	.30440	3.65268	3.17765
30	.95118	.30440	1.12738	.89520
31	.05363	.37539	6.60530	6.14539
32	.31258	.37539	2.98516	2.75541
33	.41021	.37539	2.71678	2.50328
34	.62267	.37539	3.61212	3.39208
35	.71548	.37539	3.43112	3.21847
36	.95118	.37539	1.02036	.91740
37	.05363	.47796	6.83083	6.42785
38	.31258	.47796	3.03305	2.86224
39	.41021	.47796	2.73191	2.58819
40	.62267	.47796	3.57361	3.45521
41	.71548	.47796	3.37998	3.27261
42	.95118	.47796	.98585	.93773
43	.05363	.59181	6.85893	6.55062
44	.31258	.59181	3.01201	2.89290

45	.41021	.59181	2.70518	2.60905
46	.62267	.59181	3.54252	3.47165
47	.71548	.59181	3.34801	3.28590
48	.95118	.59181	.96614	.93903
49	.05363	.69438	6.61919	6.38674
50	.31258	.69438	2.86516	2.78002
51	.41021	.69438	2.57079	2.50375
52	.62267	.69438	3.42590	3.38113
53	.71548	.69438	3.24046	3.20224
54	.95118	.69438	.91511	.89795
55	.05363	.76536	6.18823	5.99843
56	.31258	.76536	2.56704	2.49930
57	.41021	.76536	2.26844	2.21579
58	.62267	.76536	3.08043	3.04784
59	.71548	.76536	2.90735	2.88006
60	.95118	.76536	.77877	.76599
61	.05363	.81068	5.75794	5.59202
62	.31258	.81068	2.20923	2.15046
63	.41021	.81068	1.82115	1.77537
64	.62267	.81068	1.47834	1.44702
65	.71548	.81068	1.32197	1.29526
66	.95118	.81068	.53080	.51966
67	.05363	.86301	5.09837	4.96020
68	.31258	.86301	1.79425	1.74582
69	.41021	.86301	1.40774	1.37001
70	.62267	.86301	.99004	.96398
71	.71548	.86301	.84997	.82771
72	.95118	.86301	.34788	.33869
73	.05363	.92769	4.14762	4.04358
74	.31258	.92769	1.33189	1.29704
75	.41021	.92769	1.01141	.98457
76	.62266	.92769	.67029	.65201
77	.71548	.92769	.56505	.54947
78	.95118	.92769	.22698	.22053
79	.05363	.98001	2.70343	2.64027
80	.31257	.98001	.68885	.67130
81	.41020	.98001	.50200	.48883
82	.62266	.98001	.32683	.31781
83	.71548	.98001	.27672	.26894
84	.95118	.98001	.11796	.11449

Y/SP	CL	CM	CT	CDI	CLW	CMW	CDW
.06977	2.39685	-1.01035	.62707	-.13161	2.11436	-.86374	-.11557
.15997	9.20284	-6.80517	.71562	6.00533	2.55332	-1.17296	.39475
.20930	10.87951	-8.29251	.77570	7.10137	2.84719	-1.39361	.49090
.25864	11.13111	-8.22672	.84321	6.90405	3.01614	-1.51926	.48851
.30440	3.51999	-1.88996	.92170	.46753	3.19384	-1.68191	.37693
.37539	3.57576	-1.93452	1.01240	.34117	3.31949	-1.79805	.33260
.47796	3.63258	-2.04619	1.08172	.27053	3.44493	-1.95117	.28729
.59181	3.62100	-2.15128	1.08835	.25414	3.48934	-2.08213	.26722
.69438	3.47233	-2.16881	1.01294	.27768	3.37889	-2.11685	.28321
.76536	3.15166	-2.02546	.89206	.26812	3.07813	-1.98265	.26936
.81068	2.62123	-1.67358	.78047	-.24075	2.55362	-1.63128	-.23805
.86301	2.10887	-1.34571	.62259	-.18825	2.05327	-1.30961	-.18840
.92769	1.59608	-1.04439	.42388	-.09410	1.55581	-1.01719	-.09636
.98001	.92471	-.61568	.20746	-.01555	.90252	-.60033	-.01795

THE LIFT COEFFICIENT = 4.09698

TOTAL INDUCED DRAG COEFFICIENT = 1.24738

THE INDUCED DRAG PARAMETER = .07431

TOTAL PITCHING MOMENT COEFFICIENT = -2.62551

THE COANDA LIFT COEFFICIENT, CLR = 1.06833

THE COANDA DRAG COEFFICIENT, CDR = -1.11975

THE COANDA MOMENT COEFFICIENT, CMR = -.30907

THE LIFT COEFFICIENT FOR THE WING ALONE= 2.66469

THE INDUCED DRAG COEFFICIENT FOR THE WING ALONE= .18863

THE PITCHING MOMENT COEFFICIENT FOR THE WING ALONE= -1.45559

THE INDUCED DRAG PARAMETER FOR THE WING ALONE= .02657

SAMPLE INPUT No. 2

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* OVER-WING-BLOWING CONFIGURATION OF TN D-7367 *
         1         1         1         1
0.4       1.003     0.43026   0.85914   5.        0.01386   3.08396
1.7664    10.       0.558617  3.08396
         1         1 0.
12.99971  3.22804   0.        0.        -1.299    2.032     0.508     0.254
1.5       0.        0.        0.        0.        0.        0.
         3         5         5         5
         2
         4         0         0         0         0
-2.40778  2.12077   0.        -0.28884  2.96356   1.778
-0.28884  2.96356   1.778     0.316567  3.20436   2.286
0.316567  3.20436   2.286     2.855     4.214     4.416
         3         9         3         4         2
-1.299    -0.28884  1.778     -1.299    0.316567  2.286
-0.28884  2.96356   1.778     0.316567  3.20436   2.286
2.96356   6.21596   1.778     3.20436   6.45676   2.286
```

SAMPLE OUTPUT No. 2

```
*****************************************
* OVER-WING-BLOWING CONFIGURATION OF TN D-7367 *
*****************************************
        1          1          1          1
```

XXXXXXXXXXXXXXXXXXXXXXXX

CASE NUMBER = 1

XXXXXXXXXXXXXXXXXXXXXXXX

INPUT DATA

.40000	1.00300	.43026	.85914	5.00000	.01386	3.08396	
1.76640	10.00000	.55862	3.08396				
1	1	0.00000					
12.99971	3.22804	0.00000	0.00000	-1.29900	2.03200	.50800	.25400
1.50000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	

THE COMPUTED JET ENTRAINMENT ARE AS FOLLOWS

XJET	RJET	DM/DX
10.76626	2.37532	.03114
12.01626	2.37532	.03114
14.51626	2.37905	.03104
17.01626	2.41896	.03000
19.51626	2.50324	.02793
22.01626	2.61298	.02547
24.51626	2.73386	.02302
27.01626	2.85818	.02077
29.51626	2.98203	.01876
32.01626	3.10350	.01700
34.51626	3.22167	.01545
37.01626	3.33617	.01410
39.51626	3.44692	.01292
42.01626	3.55396	.01188
44.51626	3.65744	.01096
47.01626	3.75751	.01015
49.51626	3.85436	.00943
52.01626	3.94818	.00878

```
54.51626    4.03915     .00820
57.01626    4.12742     .00767
59.51626    4.21317     .00720
62.01626    4.29654     .00677
64.51626    4.37767     .00638
67.01626    4.45669     .00603
69.51626    4.53372     .00570
72.01626    4.60886     .00541
74.51626    4.68222     .00513
77.01626    4.75355     .00488
79.51626    4.82394     .00465
82.01626    4.89216     .00443
84.51626    4.95926     .00423
       3          5          5          5
       2
       4          0          0          0          0
-2.40778    2.12077    0.00000    -.28884    2.96356    1.77800
 -.28884    2.96356    1.77800     .31657    3.20436    2.28600
  .31657    3.20436    2.28600    2.85500    4.21400    4.41600
       3          9          3          4          2
-1.29900    -.28884    1.77800   -1.29900     .31657    2.28600
 -.28884    2.96356    1.77800     .31657    3.20436    2.28600
 2.96356    6.21596    1.77800    3.20436    6.45676    2.28600
        HALF SW=  .13000E+02             CREF=  .32280E+01

LAST,JPANEL,LTOTAL=
     138         90         228

                   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

                   A RECTANGULAR JET WITH LATERAL EXTENT EQUAL
                   TO THE EQUIVALENT JET DIAMETER IS USED FOR
                   INTERACTION COMPUTATION

                   NOTE. CHECK WHETHER THE WING IS IMMERSED IN THE JET

                   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

THE EQUIVALENT JET PROPERTIES ARE EVALUATED AT   1.54891

THE EQUIVALENT JET RADIUS IS    .49329
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THE VELOCITY RATIO OF THE EQUIVALENT JET,VO/VJ,IS .66254

VORTEX ELEMENT ENDPOINT COORDINATES=

X1	X2	Y1	Y2	Z1	Z2
-2.23542	-1.86613	0.00000	.31714	0.00000	0.00000
-1.01001	-.70231	0.00000	.31714	0.00000	0.00000
.72300	.94358	0.00000	.31714	0.00000	0.00000
1.94841	2.10740	0.00000	.31714	0.00000	0.00000
-1.86613	-1.33956	.31714	.76935	0.00000	0.00000
-.70231	-.26357	.31714	.76935	0.00000	0.00000
.94358	1.25812	.31714	.76935	0.00000	0.00000
2.10740	2.33411	.31714	.76935	0.00000	0.00000
-1.33956	-.81298	.76935	1.22157	0.00000	0.00000
-.26357	.17518	.76935	1.22157	0.00000	0.00000
1.25812	1.57265	.76935	1.22157	0.00000	0.00000
2.33411	2.56082	.76935	1.22157	0.00000	0.00000
-.81298	-.44370	1.22157	1.53871	0.00000	0.00000
.17518	.48287	1.22157	1.53871	0.00000	0.00000
1.57265	1.79324	1.22157	1.53871	0.00000	0.00000
2.56082	2.71981	1.22157	1.53871	0.00000	0.00000
-.44370	-.20692	1.53871	1.74205	0.00000	0.00000
.48287	.68016	1.53871	1.74205	0.00000	0.00000
1.79324	1.93467	1.53871	1.74205	0.00000	0.00000
2.71981	2.82175	1.53871	1.74205	0.00000	0.00000
-.20692	.13071	1.74205	2.03200	0.00000	0.00000
.68016	.96147	1.74205	2.03200	0.00000	0.00000
1.93467	2.13635	1.74205	2.03200	0.00000	0.00000
2.82175	2.96711	1.74205	2.03200	0.00000	0.00000
.13071	.46834	2.03200	2.32195	0.00000	0.00000
.96147	1.24279	2.03200	2.32195	0.00000	0.00000
2.13635	2.33802	2.03200	2.32195	0.00000	0.00000
2.96711	3.11247	2.03200	2.32195	0.00000	0.00000
.46834	.70512	2.32195	2.52529	0.00000	0.00000
1.24279	1.44008	2.32195	2.52529	0.00000	0.00000
2.33802	2.47946	2.32195	2.52529	0.00000	0.00000
3.11247	3.21442	2.32195	2.52529	0.00000	0.00000
.70512	1.15889	2.52529	2.91498	0.00000	0.00000
1.44008	1.81816	2.52529	2.91498	0.00000	0.00000
2.47946	2.75051	2.52529	2.91498	0.00000	0.00000
3.21442	3.40978	2.52529	2.91498	0.00000	0.00000

1.15889	1.80592	2.91498	3.47065	0.00000	0.00000
1.81816	2.35727	2.91498	3.47065	0.00000	0.00000
2.75051	3.13700	2.91498	3.47065	0.00000	0.00000
3.40978	3.68835	2.91498	3.47065	0.00000	0.00000
1.80592	2.45296	3.47065	4.02631	0.00000	0.00000
2.35727	2.89638	3.47065	4.02631	0.00000	0.00000
3.13700	3.52349	3.47065	4.02631	0.00000	0.00000
3.68835	3.96692	3.47065	4.02631	0.00000	0.00000
2.45296	2.85285	4.02631	4.36973	0.00000	0.00000
2.89638	3.22958	4.02631	4.36973	0.00000	0.00000
3.52349	3.76235	4.02631	4.36973	0.00000	0.00000
3.96692	4.13908	4.02631	4.36973	0.00000	0.00000
-1.25044	-1.25044	1.53871	1.53871	0.00000	.77487
-.93651	-.93651	1.53871	1.53871	0.00000	.77487
-.62258	-.62258	1.53871	1.53871	0.00000	.77487
-1.25044	-1.23420	1.53871	1.74205	.77487	.77487
-.93651	-.81534	1.53871	1.74205	.77487	.77487
-.62258	-.39648	1.53871	1.74205	.77487	.77487
-1.23420	-1.21105	1.74205	2.03200	.77487	.77487
-.81534	-.64257	1.74205	2.03200	.77487	.77487
-.39648	-.07408	1.74205	2.03200	.77487	.77487
-1.21105	-1.18791	2.03200	2.32195	.77487	.77487
-.64257	-.46979	2.03200	2.32195	.77487	.77487
-.07408	.24832	2.03200	2.32195	.77487	.77487
-1.18791	-1.17167	2.32195	2.52529	.77487	.77487
-.46979	-.34863	2.32195	2.52529	.77487	.77487
.24832	.47442	2.32195	2.52529	.77487	.77487
-1.17167	-1.17167	2.52529	2.52529	.77487	0.00000
-.34863	-.34863	2.52529	2.52529	.77487	0.00000
.47442	.47442	2.52529	2.52529	.77487	0.00000
-1.25044	-1.23420	1.53871	1.74205	0.00000	0.00000
-.93651	-.81534	1.53871	1.74205	0.00000	0.00000
-.62258	-.39648	1.53871	1.74205	0.00000	0.00000
-1.23420	-1.21105	1.74205	2.03200	0.00000	0.00000
-.81534	-.64257	1.74205	2.03200	0.00000	0.00000
-.39648	-.07408	1.74205	2.03200	0.00000	0.00000
-1.21105	-1.18791	2.03200	2.32195	0.00000	0.00000
-.64257	-.46979	2.03200	2.32195	0.00000	0.00000
-.07408	.24832	2.03200	2.32195	0.00000	0.00000
-1.18791	-1.17167	2.32195	2.52529	0.00000	0.00000
-.46979	-.34863	2.32195	2.52529	0.00000	0.00000
.24832	.47442	2.32195	2.52529	0.00000	0.00000

-.44369	-.44369	1.53871	1.53871	0.00000	.77487
.48287	.48287	1.53871	1.53871	0.00000	.77487
1.79324	1.79324	1.53871	1.53871	0.00000	.77487
2.71981	2.71981	1.53871	1.53871	0.00000	.77487
-.44369	-.20692	1.53871	1.74205	.77487	.77487
.48287	.68016	1.53871	1.74205	.77487	.77487
1.79324	1.93467	1.53871	1.74205	.77487	.77487
2.71981	2.82175	1.53871	1.74205	.77487	.77487
-.20692	.13071	1.74205	2.03200	.77487	.77487
.68016	.96147	1.74205	2.03200	.77487	.77487
1.93467	2.13635	1.74205	2.03200	.77487	.77487
2.82175	2.96711	1.74205	2.03200	.77487	.77487
.13071	.46834	2.03200	2.32195	.77487	.77487
.96147	1.24279	2.03200	2.32195	.77487	.77487
2.13635	2.33802	2.03200	2.32195	.77487	.77487
2.96711	3.11247	2.03200	2.32195	.77487	.77487
.46834	.70512	2.32195	2.52529	.77487	.77487
1.24279	1.44008	2.32195	2.52529	.77487	.77487
2.33802	2.47946	2.32195	2.52529	.77487	.77487
3.11247	3.21442	2.32195	2.52529	.77487	.77487
.70512	.70512	2.52529	2.52529	.77487	0.00000
1.44008	1.44008	2.52529	2.52529	.77487	0.00000
2.47946	2.47946	2.52529	2.52529	.77487	0.00000
3.21442	3.21442	2.52529	2.52529	.77487	0.00000
-.44369	-.20692	1.53871	1.74205	0.00000	0.00000
.48287	.68016	1.53871	1.74205	0.00000	0.00000
1.79324	1.93467	1.53871	1.74205	0.00000	0.00000
2.71981	2.82175	1.53871	1.74205	0.00000	0.00000
-.20692	.13071	1.74205	2.03200	0.00000	0.00000
.68016	.96147	1.74205	2.03200	0.00000	0.00000
1.93467	2.13635	1.74205	2.03200	0.00000	0.00000
2.82175	2.96711	1.74205	2.03200	0.00000	0.00000
.13071	.46834	2.03200	2.32195	0.00000	0.00000
.96147	1.24279	2.03200	2.32195	0.00000	0.00000
2.13635	2.33802	2.03200	2.32195	0.00000	0.00000
2.96711	3.11247	2.03200	2.32195	0.00000	0.00000
.46834	.70512	2.32195	2.52529	0.00000	0.00000
1.24279	1.44008	2.32195	2.52529	0.00000	0.00000
2.33802	2.47946	2.32195	2.52529	0.00000	0.00000
3.11247	3.21442	2.32195	2.52529	0.00000	0.00000
3.32643	3.32643	1.53871	1.53871	0.00000	.77487
5.62623	5.62623	1.53871	1.53871	0.00000	.77487
3.32643	3.42282	1.53871	1.74205	.77487	.77487

5.62623	5.72262	1.53871	1.74205	.77487	.77487
3.42282	3.56026	1.74205	2.03200	.77487	.77487
5.72262	5.86006	1.74205	2.03200	.77487	.77487
3.56026	3.69770	2.03200	2.32195	.77487	.77487
5.86006	5.99750	2.03200	2.32195	.77487	.77487
3.69770	3.79409	2.32195	2.52529	.77487	.77487
5.99750	6.09389	2.32195	2.52529	.77487	.77487
3.79409	3.79409	2.52529	2.52529	.77487	0.00000
6.09389	6.09389	2.52529	2.52529	.77487	0.00000
3.32643	3.42282	1.53871	1.74205	0.00000	0.00000
5.62623	5.72262	1.53871	1.74205	0.00000	0.00000
3.42282	3.56026	1.74205	2.03200	0.00000	0.00000
5.72262	5.86006	1.74205	2.03200	0.00000	0.00000
3.56026	3.69770	2.03200	2.32195	0.00000	0.00000
5.86006	5.99750	2.03200	2.32195	0.00000	0.00000
3.69770	3.79409	2.32195	2.52529	0.00000	0.00000
5.99750	6.09389	2.32195	2.52529	0.00000	0.00000

CONTROL POINT COORDINATES=

XCP	YCP	ZCP	XCP	YCP	ZCP
-1.58493	.14693	0.00000	-.02113	.14693	0.00000
1.54267	.14693	0.00000	2.19042	.14693	0.00000
-1.16692	.53161	0.00000	.29926	.53161	0.00000
1.76545	.53161	0.00000	2.37276	.53161	0.00000
-.65024	1.00710	0.00000	.69529	1.00710	0.00000
2.04081	1.00710	0.00000	2.59814	1.00710	0.00000
-.23223	1.39177	0.00000	1.01568	1.39177	0.00000
2.26358	1.39177	0.00000	2.78048	1.39177	0.00000
.02981	1.63292	0.00000	1.21652	1.63292	0.00000
2.40324	1.63292	0.00000	2.89479	1.63292	0.00000
.29782	1.87956	0.00000	1.42195	1.87956	0.00000
2.54608	1.87956	0.00000	3.01170	1.87956	0.00000
.62911	2.18444	0.00000	1.67587	2.18444	0.00000
2.72263	2.18444	0.00000	3.15622	2.18444	0.00000
.89713	2.43108	0.00000	1.88130	2.43108	0.00000
2.86547	2.43108	0.00000	3.27313	2.43108	0.00000
1.19569	2.70584	0.00000	2.11014	2.70584	0.00000
3.02459	2.70584	0.00000	3.40337	2.70584	0.00000
1.70932	3.17852	0.00000	2.50382	3.17852	0.00000
3.29833	3.17852	0.00000	3.62742	3.17852	0.00000
2.34420	3.76278	0.00000	2.99044	3.76278	0.00000

3.63668	3.76278	0.00000	3.90437	3.76278	0.00000
2.85783	4.23545	0.00000	3.38413	4.23545	0.00000
3.91042	4.23545	0.00000	4.12842	4.23545	0.00000
-1.11775	1.53871	.38743	-.75526	1.53871	.38743
-.57402	1.53871	.38743	-1.08969	1.63292	.77487
-.67106	1.63292	.77487	-.46174	1.63292	.77487
-1.01620	1.87956	.77487	-.45060	1.87956	.77487
-.16780	1.87956	.77487	-.92537	2.18444	.77487
-.17810	2.18444	.77487	.19553	2.18444	.77487
-.85188	2.43108	.77487	.04235	2.43108	.77487
.48947	2.43108	.77487	-.82381	2.52529	.38743
.12656	2.52529	.38743	.60175	2.52529	.38743
-1.08969	1.63292	0.00000	-.67106	1.63292	0.00000
-.46174	1.63292	0.00000	-1.01620	1.87956	0.00000
-.45060	1.87956	0.00000	-.16780	1.87956	0.00000
-.92537	2.18444	0.00000	-.17810	2.18444	0.00000
.19553	2.18444	0.00000	-.85188	2.43108	0.00000
.04235	2.43108	0.00000	.48947	2.43108	0.00000
-.07256	1.53871	.38743	1.13806	1.53871	.38743
2.34868	1.53871	.38743	2.85013	1.53871	.38743
.02981	1.63292	.77487	1.21652	1.63292	.77487
2.40324	1.63292	.77487	2.89479	1.63292	.77487
.29783	1.87956	.77487	1.42195	1.87956	.77487
2.54608	1.87956	.77487	3.01170	1.87956	.77487
.62911	2.18444	.77487	1.67587	2.18444	.77487
2.72263	2.18444	.77487	3.15622	2.18444	.77487
.89713	2.43108	.77487	1.88130	2.43108	.77487
2.86547	2.43108	.77487	3.27313	2.43108	.77487
.99950	2.52529	.38743	1.95977	2.52529	.38743
2.92003	2.52529	.38743	3.31779	2.52529	.38743
.02981	1.63292	0.00000	1.21652	1.63292	0.00000
2.40324	1.63292	0.00000	2.89479	1.63292	0.00000
.29783	1.87956	0.00000	1.42195	1.87956	0.00000
2.54608	1.87956	0.00000	3.01170	1.87956	0.00000
.62911	2.18444	0.00000	1.67587	2.18444	0.00000
2.72263	2.18444	0.00000	3.15622	2.18444	0.00000
.89713	2.43108	0.00000	1.88130	2.43108	0.00000
2.86547	2.43108	0.00000	3.27313	2.43108	0.00000
4.47633	1.53871	.38743	6.10253	1.53871	.38743
4.52099	1.63292	.77487	6.14719	1.63292	.77487
4.63790	1.87956	.77487	6.26410	1.87956	.77487
4.78242	2.18444	.77487	6.40862	2.18444	.77487
4.89933	2.43108	.77487	6.52553	2.43108	.77487

4.94399	2.52529	.38743	6.57019	2.52529	.38743
4.52099	1.63292	0.00000	6.14719	1.63292	0.00000
4.63790	1.87956	0.00000	6.26410	1.87956	0.00000
4.78242	2.18444	0.00000	6.40862	2.18444	0.00000
4.89933	2.43108	0.00000	6.52553	2.43108	0.00000

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

ALPHA = 5.000 DEGREES

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

VORTEX	XV	YV	CP	CPW
1	.03806	.03327	.55466	.53297
2	.30866	.03327	.31487	.29304
3	.69134	.03327	.19362	.18808
4	.96194	.03327	.06992	.06924
5	.03806	.12038	.67586	.64303
6	.30866	.12038	.32142	.29846
7	.69134	.12038	.19132	.18791
8	.96194	.12038	.06478	.06467
9	.03806	.22806	.84434	.77634
10	.30866	.22806	.33053	.30929
11	.69134	.22806	.18079	.18348
12	.96194	.22806	.05858	.05967
13	.03806	.31517	1.01515	.86627
14	.30866	.31517	.32355	.32193
15	.69134	.31517	.17149	.18088
16	.96194	.31517	.05647	.05725
17	.03806	.36977	1.26691	.91789
18	.30866	.36977	.47674	.33014
19	.69134	.36977	.28746	.17957
20	.96194	.36977	.11785	.05610
21	.03806	.42563	1.30991	.96930
22	.30866	.42563	.45969	.33742
23	.69134	.42563	.27107	.17708
24	.96194	.42563	.12635	.05449
25	.03806	.49466	1.29880	1.02733
26	.30866	.49466	.46247	.34541
27	.69134	.49466	.26593	.17378
28	.96194	.49466	.12824	.05252
29	.03806	.55052	1.23668	1.06873
30	.30866	.55052	.50937	.35017

31	.69134	.55052	.26907	.16995
32	.96194	.55052	.11744	.05058
33	.03806	.61274	1.17011	1.11778
34	.30866	.61274	.37977	.35774
35	.69134	.61274	.18117	.16708
36	.96194	.61274	.05614	.04829
37	.03806	.71977	1.24057	1.18776
38	.30866	.71977	.38389	.36642
39	.69134	.71977	.16546	.15570
40	.96194	.71977	.04504	.04199
41	.03806	.85208	1.27622	1.23170
42	.30866	.85208	.35295	.33957
43	.69134	.85208	.11828	.11288
44	.96194	.85208	.02907	.02761
45	.03806	.95912	1.12402	1.09053
46	.30866	.95912	.16695	.16119
47	.69134	.95912	.04529	.04331
48	.96194	.95912	.01122	.01068

Y/SP	CL	CM	CT	CDI	CLW	CMW	CDW
.03327	.27768	.05924	.00447	.01981	.26442	.05562	.01888
.12038	.29704	.03839	.00970	.01626	.28252	.03509	.01567
.22806	.32132	.00735	.01538	.01267	.30444	.00337	.01304
.31517	.34142	-.02278	.02369	.00609	.32149	-.02884	.01066
.36977	.48434	-.08598	.00955	.03279	.33174	-.05158	.00943
.42563	.48014	-.11759	.01149	.03047	.34114	-.07619	.00782
.49466	.47798	-.16088	.01240	.02937	.35148	-.10863	.00582
.55052	.48486	-.20104	.00904	.03334	.35792	-.13575	.00405
.61274	.38917	-.17980	.03277	.00116	.36683	-.16828	.00244
.71977	.39414	-.23522	.03589	-.00155	.37572	-.22386	-.00063
.85208	.36908	-.28076	.03846	-.00632	.35521	-.27011	-.00531
.95912	.24950	-.21922	.03251	-.01081	.24147	-.21212	-.00991

THE LIFT COEFFICIENT = .35321

TOTAL INDUCED DRAG COEFFICIENT = .01248

THE INDUCED DRAG PARAMETER = .10004

TOTAL PITCHING MOMENT COEFFICIENT = -.08710

THE LIFT COEFFICIENT WITH JET ENTRAINMENT ALONE = .31601

THE INDUCED DRAG COEFFICIENT WITH JET ENTRAINMENT ALONE = .00741

THE PITCHING MOMENT COEFFICIENT WITH JET ENTRAINMENT ALONE = -.07680

THE LIFT COEFFICIENT FOR THE WING ALONE= .31057

THE INDUCED DRAG COEFFICIENT FOR THE WING ALONE= .00756

THE PITCHING MOMENT COEFFICIENT FOR THE WING ALONE= -.07524

THE INDUCED DRAG PARAMETER FOR THE WING ALONE= .07840

ERROR SUMMARY

ERROR	TIMES
0115	0328

```
      OVERLAY (USBIGE,0,0)
      PROGRAM USBIGE(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE1,TAPE2)
C           AERODYNAMICS OF WING-JET INTERACTION
C      BY C. EDWARD LAN OF THE UNIVERSITY OF KANSAS
C
C    THIS PROGRAM IS APPLICABLE TO BOTH UPPER-SURFACE-BLOWING AND OVER-
C      WING BLOWING  CONFIGURATIONS WITH AND WITHOUT GROUND EFFECT.
C
C    NOTE. ROOT AND TIP CAMBER FUNCTIONS MAY BE DEFINED AS FUNCTION
C    SUBPROGRAMS ZCR(X) AND ZCT(X), RESPECTIVELY.
C    THE ARRAY DIMENSIONS OF THIS PROGRAM RESTRICT THE NUMBER OF WING
C    VORTICES TO BE 100 MAXIMUM AND THE TOTAL WING AND JET VORTICES TO BE
C    200 MAXIMUM. ALSO, CHECK THE ARRAY SIZE OF GAMMA IN SUBROUTINE
C    "SOLUTN" BEFORE USING THE PROGRAM.
C
      DIMENSION TITLE(13)
      COMMON /CODE/ KCODE
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
     1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(95
     3,2),SC(160,5),ST(160,5),LC(3)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /CONST/ NCS,NCW,M1(9),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDE,SDE,TH,TDE,NGRD,HEIGHT,ATT
      COMMON /JET/ RK1,XC,YJT(31),A(31),B(31)
      COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
     1,TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
      COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFR
      COMMON /CAMB/ ICAM,IM,XT(2,11),ZC(2,11),AAM(2,10),BBM(2,10),CCM(2,
     110),DDM(2,10)
      DIMENSION ISPEC(6)
      DATA ISPEC/3*(-0),(0),2*(-0)/
C     SYSTEMC SUPPRESSES THE PRINTING OF NON-FATAL ERROR MESSAGES IN THE
C     EVALUATION OF EXP(A), WHEN (A) IS LESS THAN (-675.84) ON CYBER-175
C     . THIS CALL MAY NOT BE NEEDED FOR OTHER COMPUTER SYSTEMS.
      CALL SYSTEMC (115,ISPEC)
      PI=3.14159265
      READ (5,70) (TITLE(I),I=1,13)
      WRITE (6,80)
      WRITE (6,70) (TITLE(I),I=1,13)
      WRITE (6,80)
      NCON=1
C
C  ***NUMBER OF CASES TO BE RUN, GEOMETRY CODE (=1 IF GEOMETRY VARIES.
C     IN THIS CASE, ALPHA MAY ALSO BE DIFFERENT, =0 FOR THE SAME GEOME-
```

```
C     TRY OUT DIFFERENT ALPHAS) , AND SYMMETRY CODE (=0 FOR A CENTERED
C     JET, AND=1 OTHERWISE) ***
C     NGRD=1 IF THE WING IS IN GROUND EFFECT, =0 OTHERWISE
C
      READ (5,60) ICASE,NG,ISYM,NGRD
      WRITE (6,60) ICASE,NG,ISYM,NGRD
10    CONTINUE
      WRITE (6,90)
      WRITE (6,100) NCON
      WRITE (6,90)
      CALL OVERLAY (6HUSRIGE,1,0)
      CALL OVERLAY (6HUSRIGE,2,0)
      CALL OVERLAY (6HUSRIGE,3,0)
20    CONTINUE
      CALL OVERLAY (6HUSRIGE,4,0)
      CALL OVERLAY (6HUSRIGE,5,0)
      NCON=NCON+1
      IF (NCON.GT.ICASE) GO TO 40
      IF (NG.EQ.1) GO TO 10
C
C  ***ADDITIONAL ANGLES OF ATTACK IN DEGS. TO BE COMPUTED, TO BE READ IN
C     BEHIND THE GEOMETRY DATA DEFINED IN SUBROUTINE "GEOMTY" ***
C
      READ (5,50) ALP
      ALP=ALP*PI/180.
      ALPS=SIN(ALP)
      ALPC=COS(ALP)
      ALPT=ALPS/ALPC
      DO 30 I=1,NCS
      XLL(I)=ALP+(TWISTR+TWIST*YLE(I)/HALFB)*PI/180.
      T=XLL(I)
30    XTT(I)=SIN(T)/COS(T)
      WRITE (6,90)
      WRITE (6,100) NCON
      WRITE (6,90)
      GO TO 20
40    CONTINUE
      STOP
C
50    FORMAT (5F10.5)
60    FORMAT (7(6X,I4))
70    FORMAT (13A6)
80    FORMAT (40H****************************************)
90    FORMAT (1H0,20X,25HXXXXXXXXXXXXXXXXXXXXXXXXX)
100   FORMAT (1H0,25X,13HCASE NUMBER =,I2)
      END
      FUNCTION ZCP (X)
      COMMON /CAMB/ ICAM,IM,XT(2,11),ZC(2,11),AAM(2,10),BBM(2,10),CCM(2,
     110),DDM(2,10)
```

```
      IF (ICAM.EQ.1) GO TO 10
C
C   *** CAMBER FUNCTION FOR THE ROOT SECTION ***
C
      ZCR=0.
      GO TO 20
10    ZCR=ZCAM(1,X)
20    RETURN
      END
      FUNCTION ZCT (X)
      COMMON /CAMB/ ICAM,IM,XT(2,11),ZC(2,11),AAM(2,10),BBM(2,10),CCM(2,
     110),DDM(2,10)
      IF (ICAM.EQ.1) GO TO 10
C
C   *** CAMBER FUNCTION FOR THE TIP SECTION ***
C
      ZCT=ZCR(X)
      GO TO 20
10    ZCT=ZCAM(2,X)
20    RETURN
      END
      FUNCTION ZCAM (I,X)
      COMMON /CAMB/ ICAM,IM,XT(2,11),ZC(2,11),AAM(2,10),BBM(2,10),CCM(2,
     110),DDM(2,10)
      K=1
10    IF (X.GE.XT(I,K).AND.X.LT.XT(I,K+1)) GO TO 20
      K=K+1
      IF (K.GE.IM) GO TO 30
      GO TO 10
20    SM=X-XT(I,K)
      ZCAM=3.*AAM(I,K)*SM**2+2.*BBM(I,K)*SM+CCM(I,K)
      GO TO 50
30    IF (X.LT.XT(I,1)) GO TO 40
      K=IM-1
      GO TO 20
40    K=1
      GO TO 20
50    RETURN
      END
      SUBROUTINE VMSEQN (NC1,K,AA,A,CA)
C     TO SOLVE THE SIMULTANEOUS EQUATIONS BY PURCELL"S VECTOR METHOD
      DIMENSION AA(1), CA(1), A(1)
      NC=K*NC1
      SUM1=0.
      K1=K-1
      JJ=1
      DO 10 J=1,K1
      SUM1=SUM1+AA(J)*A(JJ)
10    JJ=JJ+NC1+1
```

```
      SUM1=SUM1+AA(K)
      DO 30 I=1,NC1
      SUM2=0.
      JJ=I+1
      DO 20 J=1,K1
      SUM2=SUM2+AA(J)*A(JJ)
   20 JJ=JJ+NC1+1
      KK=K+I
      SUM2=SUM2+AA(KK)
   30 CA(I)=-SUM2/SUM1
      M=1
      L=0
      KNC=(K-1)*NC1
      DO 60 I=1,NC
      IF (I.GT.KNC) GO TO 50
      MM=(M-1)*NC1+1
      IF (I.EQ.MM) GO TO 70
   40 KK=KK+1
      IL=I+L
      A(I)=CA(KK)*BASE+A(IL)
      GO TO 60
   50 II=I-KNC
      A(I)=CA(II)
   60 CONTINUE
      GO TO 80
   70 II=MM+M-1
      BASE=A(II)
      KK=0
      L=L+1
      M=M+1
      GO TO 40
   80 CONTINUE
      RETURN
      END
      SUBROUTINE INTEG (F,NN,LJ,IZ,IJ,R,IR)
C     TO MAKE REFINED INTEGRATION FOR INDUCED TANGENTIAL VELOCITIES
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
     1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),FX(95,2),TX(95
     3,2),SC(160,5),ST(160,5),LC(3)
      PI=3.14159265
      J=LJ+1
      JJ=NN*16
      IF (NN.GT.6) JJ=NN*8
      FJ=JJ
      C1=TX(IZ,1)-FX(IZ,1)
      C2=TX(IZ,2)-FX(IZ,2)
      SUM=0.
      DO 10 K=1,JJ
```

```
      XX1=EX(IZ,1)+C1*SC(K,IP)
      XX2=EX(IZ,2)+C2*SC(K,IP)
      X1=XX1-XCP(IJ)
      X2=XX2-XCP(IJ)
      Y1=YN(J,1)-YCP(IJ)
      Y2=YN(J,2)-YCP(IJ)
      Z1=ZN(J,1)-ZCP(IJ)
      Z2=ZN(J,2)-ZCP(IJ)
      X12=XX2-XX1
      Y12=YN(J,2)-YN(J,1)
      Z12=ZN(J,2)-ZN(J,1)
      YZI=Y1*Z12-Z1*Y12
      XYK=X1*Y12-Y1*X12
      XZJ=X1*Z12-Z1*X12
      ALP=XYK*XYK+XZJ*XZJ+B*YZI*YZI
      R1=SQRT(X1*X1+B*Y1*Y1+B*Z1*Z1)
      R2=SQRT(X2*X2+B*Y2*Y2+B*Z2*Z2)
      UU=(X2*X12+B*Y2*Y12+B*Z2*Z12)/R2-(X1*X12+B*Y1*Y12+B*Z1*Z12)/R1
   10 SUM=SUM+UU*YZI/ALP*SI(K,IP)
      F=SUM*CH(IZ)/(8.*FJ)
      RETURN
      END
      SUBROUTINE WING (AW,LPANEL,I,BB,LPAN1,LPAN2,NGRD,HEIGHT,ATT)
C     TO COMPUTE THE JET-OFF INFLUENCE COEFFICIENT MATRIX
      DIMENSION AW(1)
      DIMENSION W(4), W1(2)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
     1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(95
     3,2),SC(160,5),SI(160,5),IC(3)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      IP=1
      LG=1
      IF (NGRD.EQ.1) LG=2
      W1(1)=0.
      W1(2)=0.
      IZ=1
      IFF=1
      ISN=1
      NL=NW(1)
      NN=NW(1)
      DO 90 J=1,LPANEL
      MI=J-IFF+1
      EN=NL
      IF (J.GT.LPAN1.AND.J.LE.LPAN2) ISN=2
      IF (J.GT.LPAN2.AND.J.LE.LPANEL) ISN=3
      IF (J.GE.LPAN1.AND.J.LT.LPANEL) GO TO 10
```

```
      GO TO 20
10    NL=NW(2)
      IF (J.GE.LPAN2.AND.J.LT.LPANEL) NL=NW(3)
20    CONTINUE
      X1=XN(J,1)-XCP(I)
      X2=XN(J,2)-XCP(I)
      X12=XN(J,2)-XN(J,1)
      Y12=YN(J,2)-YN(J,1)
      Z12=ZN(J,2)-ZN(J,1)
      DO 80 II=1,2
      IF (II.EQ.1) GO TO 30
      N=1
      GO TO 40
30    N=2
40    CONTINUE
      YC=(-1.)**N*YCP(I)
      Y1=YN(J,1)-YC
      Y2=YN(J,2)-YC
      XYK=X1*Y12-Y1*X12
      DO 80 KK=1,LG
      IF (KK.EQ.1) GO TO 50
      GE=-1.
      ZC=-2.*(ZCP(I)+HEIGHT)+ZCP(I)
      ECON=1.
      GO TO 60
50    GE=1.
      ZC=ZCP(I)
      ECON=0.
60    Z1=ZN(J,1)-ZC
      Z2=ZN(J,2)-ZC
      XZJ=X1*Z12-Z1*X12
      UCOM=-Z1*Y12*ATT*ECON
      YZI=Y1*Z12-Z1*Y12
      ALF1=XYK*XYK+XZJ*XZJ+BB*YZI*YZI
      R1R1=SQRT(X1*X1+BB*Y1*Y1+BB*Z1*Z1)
      R2R1=SQRT(X2*X2+BB*Y2*Y2+BB*Z2*Z2)
      UUR1=(X2*X12+BB*Y2*Y12+BB*Z2*Z12)/R2R1-(X1*X12+BB*Y1*Y12+BB*Z1*Z12
     1)/R1R1
      G1R1=(1.-X1/R1R1)/(Y1*Y1+Z1*Z1)
      G2R1=(1.-X2/R2R1)/(Y2*Y2+Z2*Z2)
      F1=UUR1*(UCOM+XYK)*GE/ALF1
      F2=(-Y2*G2R1+Y1*G1R1)*GE
      IF (KK.EQ.2) GO TO 70
      W(II)=(F1+F2)*CH(IZ)*SN(MI,ISN)/(8.*FN)
      GO TO 80
70    W1(II)=(F1+F2)*CH(IZ)*SN(MI,ISN)/(8.*FN)
80    CONTINUE
      AW(J)=W(1)+W(2)+W1(1)+W1(2)
      IF (J.LT.NN.OR.J.EQ.LPANEL) GO TO 90
```

```
      IZ=IZ+1
      IFF=NN+1
      NN=NN+NL
90    CONTINUE
      RETURN
      END
      OVERLAY (USBIGE,1,0)
      PROGRAM GEOMTY
C     TO SET UP THE GEOMETRY OF THE VORTEX ELEMENTS AND CONTROL POINTS
      DIMENSION XXL(5), YL(5), XXT(5), ZL(5), CPCWL(31), CPSWL(31)
      COMMON /CODE/ KCODE
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
     1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFP,SJ(21,8),EX(95,2),TX(95
     3,2),SC(160,5),ST(160,5),LC(3)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CP(30),GAM(2,100)
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TCF,NGRD,HEIGHT,ATT
      COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
     1,TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
      COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFP
      COMMON /CAMB/ ICAM,IM,XT(2,11),ZC(2,11),AAM(2,10),BBM(2,10),CCM(2,
     110),DDM(2,10)
      WRITE (6,540)
      PI=3.14159265
      NCS=0
      KL=0
      IPANEL=1
      PT=0.
      DO 10 I=1,5
10    DF(I)=0.
C
C  ***MACH NUMBERS OF FREESTREAM AND JET FLOW, FREESTREAM/JET VELOCITY
C     RATIO,JET/FREESTREAM TEMPERATURE RATIO,ANGLE OF ATTACK IN DEGREE,
C     WING L.E. AND T.E. X-COORDINATES AT THE JET AXIS LOCATION***
C
      READ (5,490) AM1,AM2,VMU,TEMP,ALP,XEL,XET
      WRITE (6,490) AM1,AM2,VMU,TEMP,ALP,XEL,XET
C
C     HEIGHT= HEIGHT OF WING A. C. FROM GROUND IF NGRD=1,
C     =0. OTHERWISE
C     ATT=PITCH ATTITUDE OF WING IN DEGREES, =0. IF NGRD=0
C     XAC=X-COORDINATE OF WING A. C. OR THE REFERENCE POINT ABOUT WHICH
C     THE GROUND HEIGHT IS MEASURED.
C     XHG=X-COORDINATE OF USB FLAP HINGE.
```

```
C
      READ (5,490) HEIGHT,ATT,XAC,XHG
      WRITE (6,490) HEIGHT,ATT,XAC,XHG
      ATG=ATT*PI/180.
      ATT=SIN(ATG)
C  ***NUMBER OF FLAP SECTIONS (INCLUDING THE JET SPAN), THE NUMERICAL
C     ORDER OF JET SPAN AND THE CORRESPONDING FLAP DEFLECTION ANGLES IN
C     DEGREES ***
C
      READ (5,530) NFP,NJP,(DF(I),I=1,NFP)
      WRITE (6,530) NFP,NJP,(DF(I),I=1,NFP)
C
C  ***REFERENCE HALF WING AREA, REFERENCE CHORD, TWIST IN DEG.,
C     INCIDENCE OF ROOT CHORD IN DEG., X-, Y- AND Z-COORDINATES OF JET
C     CENTER AT EXIT, AND JET RADIUS. ZJ IS REFERRED TO THE WING PLANE.
C  * NOTE, FOR USB APPLICATIONS, YJ,ZJ AND RJ MAY BE ANY NON-ZERO VALUES
C     ,UNLESS THE RECTANGULAR JET IS NOT ON THE SURFACE AND THE ENTRAIN-
C     MENT EFFECT IS TO BE ACCOUNTED FOR.
C
      READ (5,490) HALFSW,CREF,TWIST,TWISTR,XJ,YJ,ZJ,RJ
      WRITE (6,490) HALFSW,CREF,TWIST,TWISTR,XJ,YJ,ZJ,RJ
C
C  ***TRAILING-EDGE ANGLE IN DEG., PARTIAL-SPAN FLAP INDICATOR (=0, FOR
C     NO OR FULL-SPAN FLAP, AND =1, OTHERWISE), CONFIGURATION INDICATOR
C     (=1, FOR USB, =2, FOR THIN JET FLAP, AND =0, FOR OWB), L.E. CAMBER
C     AT THE ROOT AND TIP, AND T.E. CAMBER AT THE ROOT AND TIP ***
C  * NOTE, FOR USB APPLICATIONS, TEANGL MAY BE ANY VALUE *
C
C  * IF CAMBER ORDINATES ARE TO BE READ IN, THE L.E. AND T.E. CAMBER
C     SLOPES TO BE READ IN BELOW MAY BE ARBITRARY NUMBERS *
C
      READ (5,490) TEANGL,PTIAL,USB,CAMLER,CAMLET,CAMTER,CAMTET
      WRITE (6,490) TEANGL,PTIAL,USB,CAMLER,CAMLET,CAMTER,CAMTET
      IUSB=USB
      DEJ=0.
      CMU=0.
      DTEST=0.
C
C  * THE FOLLOWING DATA ARE NOT NEEDED FOR OWB APPLICATIONS *
      IF (IUSB.EQ.0) GO TO 20
C
C  *** THRUST COEFFICIENT, JET DEFLECTION ANGLE IN DEG. AND ENTRAINMENT
C     CODE IF THE RECTANGULAR JET IS NOT ON THE WING SURFACE (=1, IF THE
C     ENTRAINMENT DUE TO AN EQUIVALENT ROUND JET IS TO BE INCLUDED, =0,
C     OTHERWISE)
C     DTEST=0, IF THE JET DEFLECTION ANGLE IS NOT TO BE CHANGED,
C     =1, OTHERWISE
C
      READ (5,490) CMU,DEJ,TNJ,DTEST
```

```
      WRITE (6,490) CMU,DEJ,TNJ,DTEST
20    CONTINUE
      DEJ=DEJ*PI/180.
      CDE=DEJ
      ITEST=DTEST
      DO 30 I=1,5
30    DE(I)=DE(I)*PI/180.
      TDE=DE(NJP)
      ALP=ALP*PI/180.
      ALPS=SIN(ALP)
      ALPC=COS(ALP)
      ALPT=ALPS/ALPC
      CMUT=CMU
      DE=TEANGL*PI/180.+TDE
      IF (IUSR.NE.0) CDE=DEJ
      EXIT=0.
      IF (XJ.GT.XEL) EXIT=1.
      HT=HEIGHT
      HEIGHT=HEIGHT-0.75*CEFF*ATT
      XTEJ=XET
      XEL=(XEL-XJ)/RJ
      XET=(XET-XJ)/RJ
      Z=ZJ/RJ
      TH=0.
      M1(4)=0
      ITN=TNJ
      XCON(23)=TNJ
      IF (NGRD.EQ.0.OR.DEJ.LT.0.01) GO TO 50
      IF (IUSR.EQ.0) GO TO 50
      IF (ITEST.EQ.0) GO TO 50
      XPP=(XHG-XJ)/RJ
      IUS=1
      KCP=1
      TEMT=TEMP
      CALL ENTRN (VMU,AM2,TEMT,XM,CV,RR,XEL,XPP,Z,KCP,XJC,IUS)
      RECU=RR*RJ
      DJT=DEJ+(ALP+TWISTR*PI/180.)*0.5
      ZCRIT=0.816497*SQRT((0.135+SIN(DJT*2.))/(CV*CV*TEMT))*RECU*2.
      H1=HT-(XHG-XJC)*ATT
      SCRIT=ZCRIT/SIN(DJT)
      CK=19.2*CV*CV
      IF (CK.GE.1.) GO TO 40
      SCRIT=SCRIT*CK
40    CONTINUE
      IF (SCRIT.LT.H1) GO TO 50
      XCRIT=SQRT(SCRIT*SCRIT-H1*H1)
      ANK=ATAN(H1/XCRIT)
      IF (ANK.GT.(DEJ+ATG)) GO TO 50
      DEJ=ANK-ATG
```

```
      IF (DEJ.LT.0.) DEJ=0.
      CDE=DEJ
      ANK=DEJ
      ANK=ANK*180./PI
      WRITE (6,720) CV
      WRITE (6,730) RE
      WRITE (6,740) ANK
   50 CONTINUE
      IF (IUSR.NE.0.AND.ITN.EQ.0) GO TO 60
      CALL ENTRN (VNU,AM2,TEMP,XM,CU,RT,XEL,XET,Z,KCODE,XJC,IUSR)
      XEOUT=XM*RJ+XJ
      REOUT=RT*RJ
      RT=REOUT
      IF (IUSR.NE.0) GO TO 60
      IF (XEL.LT.0..AND.ZJ.GE.(2.*RJ)) KCODE=0
      IF (ZJ.GE.(3.*RJ)) KCODE=0
      F1=-29.5428*CU*CU+33.7371*CU-8.9148
      IF (CU.GT.0.6339) F1=0.6+0.4*(CU-0.6339)/0.3661
      IF (F1.LT.0..AND.ZJ.GE.(1.9*RJ)) KCODE=0
      IF (KCODE.EQ.0) GO TO 60
      ZR=PI*RT/2.
      TH=ZR
   60 CONTINUE
      IF (IUSR.NE.0) KCODE=1
      IF (IUSR.EQ.0.AND.KCODE.EQ.1) GO TO 70
      GO TO 80
   70 AX=XEL*RJ
      DJX=2.*RJ
      IF (F1.LT.0.) F1=0.
      IF (ZJ.LT.(2.*RJ).AND.ZJ.GE.(1.5*RJ)) F1=F1+(1.-F1)*(2.*RJ-ZJ)/(0.
     15*RJ)
      IF (ZJ.LT.(1.5*RJ)) F1=1.
      IF (F1.GT.1.) F1=1.
      FACT=F1
      CDE=DE*FACT
   80 CONTINUE
      DO 90 I=1,8
   90 MI(I)=0
C
C *** TOTAL NUMBER OF SPANWISE SECTIONS, AND THE NUMBER OF VORTEX
C     STRIPS IN EACH SECTION PLUS 1 ***
C  *  THE NUMBER OF VORTEX STRIPS IN THE JET REGION SHOULD BE CONSISTENT
C     WITH THAT OF JET VORTEX STRIPS *
C
      READ (5,500) NC,(MI(I),I=1,NC)
      WRITE (6,500) NC,(MI(I),I=1,NC)
C
C ***THE NUMERICAL ORDER OF FLAP AND JET SPANS AMONG THE SPANWISE
C     SECTIONS ***
```

```
C
      READ (5,500) (NJW(I),I=1,NBP)
      WRITE (6,500) (NJW(I),I=1,NBP)
C
C  *** NUMBER OF CHORDWISE VORTEX ELEMENTS IN CHORDWISE SECTIONS, AND
C      CAMBER CODE (=1 IF CAMBER ORDINATES ARE TO BE READ IN, =0 IF
C      CAMBER FUNCTIONS ARE DEFINED BY CLOSED-FORM EXPRESSIONS MANUALLY
C      IN SUBPROGRAMS ZCR(X) AND ZCT(X)), AND THE NUMBER OF CAMBER ORDI-
C      NATES TO BE READ IN (ARBITRARY IF ICAM=0) ***
C  * NOTE, THE MAXIMUM NUMBER OF CAMBER ORDINATES ALLOWED IS 11 *
C
      READ (5,500) (NW(I),I=1,2),ICAM,IM
      WRITE (6,500) (NW(I),I=1,2),ICAM,IM
      NCW=NW(1)
      L=1
      IF (ICAM.NE.1) GO TO 110
C
C  *** IF ICAM=1, READ IN THE Y-COORDINATES AND THE CAMBER ORDINATES,
C      FIRST FOR THE ROOT SECTION AND THEN FOR THE TIP SECTION ***
C
      DO 100 I=1,2
      READ (5,490) (XT(I,J),J=1,IM)
100   READ (5,490) (ZC(I,J),J=1,IM)
      CALL SPLINE (IM,XT,ZC,AAM,BBM,CCM,DDM,1,2)
110   CONTINUE
120   CONTINUE
      LL=1
      FN=NCW
      DO 130 I=1,NCW
      FI=I
      CPCWL(I)=0.5*(1.-COS((2.*FI-1.)*PI/(2.*FN)))
      SN(I,L)=2.*SQRT(CPCWL(I)*(1.-CPCWL(I)))
130   CPCWL(I)=CPCWL(I)*100.
      DO 250 KK=1,NC
C
C   *** COORDINATES OF BREAK CHORDS BOUNDING SPANWISE SECTIONS ***
C
      READ (5,490) (XXL(I),XXT(I),YL(I),I=1,2)
      WRITE (6,490) (XXL(I),XXT(I),YL(I),I=1,2)
      IF (IUSE.NE.0) GO TO 210
      IF (ISYM.EQ.0.AND.KK.EQ.1) GO TO 140
      IF (KK.EQ.(NJW(NJP)+1)) GO TO 150
      IF (ISYM.NE.0.AND.KK.EQ.(NJW(NJP)-1)) GO TO 160
      IF (ISYM.NE.0.AND.KK.EQ.NJW(NJP)) GO TO 140
      GO TO 210
140   XXL(2)=XXL(1)+(XXL(2)-XXL(1))*(YL(2)-YL(1)+PT-FJ)/(YL(2)-YL(1))
      XXT(2)=XXT(1)+(XXT(2)-XXT(1))*(YL(2)-YL(1)+PT-FJ)/(YL(2)-YL(1))
      IF (ISYM.EQ.0) GO TO 170
150   XXL(1)=XL2
```

```
      XXT(1)=XT2
      GO TO 170
160   XXL(2)=XXL(1)+(XXL(2)-XXL(1))*(YL(2)-YL(1)-PT+PJ)/(YL(2)-YL(1))
      XXT(2)=XXT(1)+(XXT(2)-XXT(1))*(YL(2)-YL(1)-PT+PJ)/(YL(2)-YL(1))
170   XL2=XXL(2)
      XT2=XXT(2)
      IF (ISYM.EQ.0.AND.KK.EQ.1) GO TO 180
      IF (ISYM.NE.0.AND.KK.EQ.(NJW(NJP)-1)) GO TO 180
      YL(1)=YL2
180   IF (ISYM.EQ.0) GO TO 190
      IF (KK.EQ.(NJW(NJP)+1)) GO TO 210
      IF (KK.EQ.NJW(NJP)) YL(2)=YL(2)+PT-PJ
      IF (KK.EQ.(NJW(NJP)-1)) YL(2)=YL(2)-PT+PJ
      GO TO 200
190   IF (KK.EQ.1) YL(2)=YL(2)+PT-PJ
200   YL2=YL(2)
210   CONTINUE
      FM=M1(KK)
      NSW=M1(KK)
      DO 220 J=1,NSW
      FJ=J
      CPSWL(J)=0.5*(1.-COS((2.*FJ-1.)*PI/(2.*FM)))*100.
      YCON(J)=0.5*(1.-COS(FJ*PI/FM))
      SJ(J,KK)=SIN(FJ*PI/FM)
220   CONTINUE
      IF (KK.EQ.NC) GO TO 230
      CPSWL(1)=0.
      CPSWL(NSW)=100.
      GO TO 240
230   CPSWL(1)=0.
240   IF (KK.EQ.NJW(LL)) NJW1(L,LL)=IPANEL
      IF (KK.EQ.NJW(NJP)) LC(L)=KL+1
      LR=(L-1)*NC+KK
      CALL PANEL (XXL,YL,XXT,CPCWL,CPSWL,NSW,IPANEL,LPANEL,KL,LR,SWP)
      IPANEL=LPANEL+1
      NCS=NCS+NSW-1
      WIDTH(KK)=YL(2)-YL(1)
      BREAK(KK)=YL(1)
      IF (KK.EQ.NJW(LL)) NJW2(L,LL)=LPANEL
      IF (KK.NE.NC) GO TO 250
      HALFB=YL(2)
250   IF (KK.EQ.NJW(LL)) LL=LL+1
      IF (L.EQ.3) GO TO 300
      IF (L.EQ.1) LPAN1=LPANEL
      IF (L.EQ.2) LPAN2=LPANEL
      IF (NW(2).EQ.0) GO TO 260
      L=L+1
      NCW=NW(L)
      IF (L.EQ.3.AND.NW(3).EQ.0) GO TO 280
```

```
      GO TO 120
260   DO 270 I=2,3
      DO 270 J=1,NEP
      MJW1(I,J)=0
270   MJW2(I,J)=0
      LPAN2=LPANEL
      NCS=NCS*3
      GO TO 300
280   DO 290 I=1,NEP
      MJW1(3,I)=0
290   MJW2(3,I)=0
      L=L-1
      NCS=NCS+NCS/2
300   CONTINUE
      NCS=NCS/3
      NCW=NW(1)+NW(2)+NW(3)
      VU=VMU
      IF (IUSP.NE.0) CU=VMU
      VMU=CU
      RTJ=RJ
      ZJT=ZJ
      IF (RT.GT.ABS(ZJ).AND.KCODE.EQ.0) ZJT=RT*ZJ/ABS(ZJ)
      IF (IUSP.NE.0) GO TO 310
      AM2=AM1/(VMU*SQRT(TEMP))
      IF (AM2.GT.0.9) WRITE (6,880) AM2
      IF (AM2.GT.0.9) AM2=0.9
310   CONTINUE
      LAST=LPANEL
C
C  *** TOTAL NUMBER OF STREAMWISE JET SECTIONS, NUMBER OF JET CIRCUM-
C      FERENTIAL STRIPS MINUS ONE FOR A NON-CENTERED JET (USE ODD NUMBERS
C      ) AND PLUS ONE FOR A CENTERED JET (USE EVEN NUMBERS), AND NUMBERS
C      OF JET VORTEX ELEMENTS ON EACH JET SECTION ***
C
      READ (5,500) NNJ,NSJ,(NCJ(I),I=1,NNJ)
      WRITE (6,500) NNJ,NSJ,(NCJ(I),I=1,NNJ)
      IF (KCODE.EQ.0) CALL CIRCJ (ISYM,NSJ,Y)
      IF (ISYM.EQ.0) NSJJ=NSJ/2
      IF (ISYM.NE.0) NSJJ=(NSJ+1)/2
      NSYM=1-ISYM
      NSJ1=NSJJ-1
      FNJ=NSJJ
      CPSWL(1)=0.
      CPSWL(NSJJ)=1.
      YCON(1)=0.5*(1.-COS(PI/FNJ))
      DO 320 I=2,NSJ1
      FI=I
      CPSWL(I)=0.5*(1.-COS((2.*FI-1.)*PI/(2.*FNJ)))
320   YCON(I)=0.5*(1.-COS(FI*PI/FNJ))
```

```
      IENTN=NC
      JC=NCS*L
      NJ1=NNJ-1
      DO 420 JJ=1,NNJ
      IF (IUSR.NE.0) GO TO 370
C
C   *** COORDINATES OF BOUNDING LINES OF JET SECTIONS PROJECTED ON X-Y
C       PLANE ***
C
      READ (5,490) (XXL(I),XXT(I),YL(I),I=1,2)
      WRITE (6,490) (XXL(I),XXT(I),YL(I),I=1,2)
      IF (ISYM.EQ.0) GO TO 330
      XL1=XXL(1)-(XXL(2)-XXL(1))*(PT-PTJ)/(YL(2)-YL(1))
      XT1=XXT(1)-(XXT(2)-XXT(1))*(PT-PTJ)/(YL(2)-YL(1))
330   XL2=XXL(1)+(XXL(2)-XXL(1))*(PT+PTJ)/(YL(2)-YL(1))
      XT2=XXT(1)+(XXT(2)-XXT(1))*(PT+PTJ)/(YL(2)-YL(1))
      IF (ISYM.EQ.0) GO TO 340
      XXL(1)=XL1
      XXT(1)=XT1
340   XXL(2)=XL2
      XXT(2)=XT2
      IF (ISYM.EQ.0) GO TO 350
      YL(1)=YL(1)-PT+PTJ
350   YL(2)=YL(2)+PT-PTJ
      IF (KCODE.EQ.0) GO TO 360
      XXL(4)=XXL(2)
      XXT(4)=XXT(2)
      YL(4)=YL(2)
      XXL(2)=XXL(1)
      XXT(2)=XXT(1)
      YL(2)=YL(1)
      XXL(3)=XXL(4)
      XXT(3)=XXT(4)
      YL(3)=YL(4)
      ZL(1)=0.
      ZL(2)=ZR
      ZL(3)=ZR
      ZL(4)=0.
360   CONTINUE
      GO TO 390
C
C  ***COORDINATES OF BREAK POINTS DEFINING RECTANGULAR JET SECTIONS FOR
C      USR CONFIGURATIONS***
C
370   DO 380 I=1,4
      READ (5,490) XXL(I),XXT(I),YL(I),ZL(I)
380   WRITE (6,490) XXL(I),XXT(I),YL(I),ZL(I)
390   CONTINUE
      II=JJ
```

```
      JJ1=JJ+1
      FNCJ=NCJ(JJ)
      NJ=NCJ(JJ)
      NMJ=NJ*16
      IF (NJ.GT.6) NMJ=NJ*8
      FNJ=NMJ
      DO 400 J=1,NMJ
      FJ=J
      SC(J,JJ)=0.5*(1.-COS((2.*FJ-1.)*PI/(2.*FNJ)))
400   ST(J,JJ)=SIN((2.*FJ-1.)*PI/(2.*FNJ))
      DO 410 J=1,NJ
      FJ=J
      CPCWL(J)=0.5*(1.-COS((2.*FJ-1.)*PI/(2.*FNCJ)))
410   SN(J,JJ1)=2.*SQRT(CPCWL(J)*(1.-CPCWL(J)))
      IF (KCODE.EQ.0) CALL JSHAPE (XXL,XXT,YL,YJ,ZJT,FT,CPCWL,IPANEL,NJ,
     1JC,ISYM)
      IF (KCODE.EQ.1) CALL RESHAP (XXL,XXT,YL,ZL,CPCWL,CPSWL,IPANEL,NJ,J
     1C,IT,NSYM)
      MJJ(JJ)=LAST
420   IPANEL=LAST+1
      SDF=XXT(1)-XXL(1)
      IF (IUSR.NE.0) TH=ZL(3)-ZL(4)
      IF (KCODE.EQ.1) YCON(25)=ZL(4)
      YCON(24)=USR
      INTP=NJW(NJP)
      IF (IUSR.EQ.2) CMU=CMU*HALFSW/WIDTH(INTP)
      C(1)=CMU
      IF (KCODE.EQ.0) YCON(25)=1.
      IF (KCODE.EQ.1) CALL RECTJ (ISYM,NSJ,Y)
      WRITE (6,510) HALFSW,CREF
      JPANEL=LAST-LPANEL
      LTOTAL=LAST+JPANEL
      WRITE (6,550)
      WRITE (6,500) LAST,JPANEL,LTOTAL
      IF (IUSR.NE.0) GO TO 430
      WRITE (6,670)
      IF (KCODE.EQ.0) WRITE (6,690)
      IF (KCODE.EQ.1) WRITE (6,700)
      IF (KCODE.EQ.1) WRITE (6,710)
      WRITE (6,670)
      WRITE (6,650) XFCUT
      WRITE (6,660) RECUT
      WRITE (6,680) VMU
430   CONTINUE
      IF (ICAM.NE.1) GO TO 440
      WRITE (6,590)
      WRITE (6,610) (XT(1,I),I=1,IM)
      WRITE (6,620) (ZC(1,I),I=1,IM)
      WRITE (6,600)
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```
      WRITE (6,610) (XT(2,I),I=1,IM)                                    GE04360
      WRITE (6,620) (ZC(2,I),I=1,IM)                                    GE04370
      CAMLEP=ZCP(0.)                                                    GE04380
      CAMTEP=ZCP(1.)                                                    GE04390
      CAMLET=ZCT(0.)                                                    GE04400
      CAMTET=ZCT(1.)                                                    GE04410
  440 CONTINUE                                                          GE04420
      WRITE (6,560)                                                     GE04430
      WRITE (6,630)                                                     GE04440
      WRITE (6,520) (XN(I,1),XN(I,2),YN(I,1),YN(I,2),ZN(I,1),ZN(I,2),I=1GE04450
     1,LAST)                                                            GE04460
      WRITE (6,570)                                                     GE04470
      WRITE (6,640)                                                     GE04480
      WRITE (6,520) (XCP(I),YCP(I),ZCP(I),I=1,LAST)                     GE04490
      IF (KCODE.EQ.1) GO TO 460                                         GE04500
      IF (ISYM.EQ.0) GO TO 450                                          GE04510
      FN2=(NSJ-1)/2+1                                                   GE04520
      NJH=(NSJ-1)/2+2                                                   GE04530
      ANG=PI/(2.*FN2)                                                   GE04540
      FAC=(SIN(3.*ANG)-SIN(ANG)/COS(ANG))/(1.-COS(3.*ANG))              GE04550
      PHI=PI/2.-ATAN(FAC)                                               GE04560
      NJH1=NJH-1                                                        GE04570
      NJH2=NJH+1                                                        GE04580
      Y(3,2)=SIN(PHI)                                                   GE04590
      Y(4,2)=-COS(PHI)                                                  GE04600
      Y(3,NJH1)=Y(3,2)                                                  GE04610
      Y(4,NJH1)=-Y(4,2)                                                 GE04620
      Y(3,NJH2)=-Y(3,2)                                                 GE04630
      Y(4,NJH2)=Y(4,2)                                                  GE04640
      Y(3,NSJ1)=-Y(3,2)                                                 GE04650
      Y(4,NSJ1)=-Y(4,2)                                                 GE04660
      GO TO 460                                                         GE04670
  450 FN2=NSJ/2                                                         GE04680
      NJH=NSJ/2                                                         GE04690
      ANG1=1.-0.5*(1.-COS(PI/(2.*FN2)))                                 GE04700
      ANG3=1.-0.5*(1.-COS(3.*PI/(2.*FN2)))                              GE04710
      ANG1=ATAN(SQRT(1.-ANG1*ANG1)/ANG1)                                GE04720
      ANG3=ATAN(SQRT(1.-ANG3*ANG3)/ANG3)                                GE04730
      FAC=(SIN(ANG3)-SIN(ANG1)/COS(ANG1))/(1.-COS(ANG3))                GE04740
      PHI=PI/2.-ATAN(FAC)                                               GE04750
      NJH1=NJH-1                                                        GE04760
      NJH2=NSJ1                                                         GE04770
      Y(3,NJH1)=SIN(PHI)                                                GE04780
      Y(4,NJH1)=COS(PHI)                                                GE04790
      Y(3,NJH2)=-Y(3,NJH1)                                              GE04800
      Y(4,NJH2)=Y(4,NJH1)                                               GE04810
  460 CONTINUE                                                          GE04820
      FNJ=NCJ(NNJ)                                                      GE04830
      NPJ=NCJ(NNJ)                                                      GE04840
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      DO 470 J=1,NPJ                                                    GE04850
      FJ=J                                                              GE04860
470   PSI(J)=SIN(FJ*PI/FNJ)                                             GE04870
      BETA1=SQRT(1.-AM1*AM1)                                            GE04880
      BETA2=SQRT(1.-AM2*AM2)                                            GE04890
      B1=BETA1*BETA1                                                    GE04900
      B2=BETA2*BETA2                                                    GE04910
      DO 490 KK=1,NCS                                                   GE04920
      XLL(KK)=ALP+(TWISTR+TWISTS*YLE(KK)/HALFB)*PI/180.                 GE04930
      T=XLL(KK)                                                         GE04940
490   XTT(KK)=SIN(T)/COS(T)                                             GE04950
      XCON(22)=CMUT                                                     GE04960
      CL(20)=XAC                                                        GE04970
      RETURN                                                            GE04980
C                                                                       GE04990
495   FORMAT (8(F10.5))                                                 GE05000
500   FORMAT (8(6X,I4))                                                 GE05010
510   FORMAT (10X,9HHALF SW=,F12.5,10X,5HCREF=,F12.5)                   GE05020
520   FORMAT (6(F10.5))                                                 GE05030
530   FORMAT (2(6X,I4),7F10.5)                                          GE05040
540   FORMAT (1H0,10HINPUT DATA)                                        GE05050
550   FORMAT (1H0,19HLAST,JPANEL,LTOTAL=)                               GE05060
560   FORMAT (1H0,36HVORTEX ELEMENT ENDPOINT COORDINATES=)              GE05070
570   FORMAT (1H0,26HCONTROL POINT COORDINATES=)                        GE05080
580   FORMAT (1H0,42HWARNING, THE EQUIVALENT JET MACH NUMBER IS,F10.5,41GE05090
     1HIT HAS BEEN SET TO 0.9 IN THE COMPUTATION)                       GE05100
590   FORMAT (/45H*** CAMBER ORDINATES FOR THE ROOT SECTION ***)        GE05110
600   FORMAT (/44H*** CAMBER ORDINATES FOR THE TIP SECTION ***)         GE05120
610   FORMAT (/7X,3HX/C,11F10.5)                                        GE05130
620   FORMAT (/7X,3HZ/C,11F10.5)                                        GE05140
630   FORMAT (/4X,2HX1,8X,2HX2,8X,2HY1,8X,2HY2,8X,2HZ1,6X,2HZ2)         GE05150
640   FORMAT (/4X,3HXCP,7X,3HYCP,7X,3HZCP,7X,3HXCP,7X,3HYCP,7X,3HZCP)   GE05160
650   FORMAT (1H0,46HTHE EQUIVALENT JET PROPERTIES ARE EVALUATED AT,F10.GE05170
     15)                                                                GE05180
660   FORMAT (1H0,28HTHE EQUIVALENT JET RADIUS IS,F10.5)                GE05190
670   FORMAT (/20X,50HXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXGE05200
     1)                                                                 GE05210
680   FORMAT (1H0,49HTHE VELOCITY RATIO OF THE EQUIVALENT JET,VO/VJ,IS,FGE05220
     110.5)                                                             GE05230
690   FORMAT (/20X,39HAN EQUIVALENT CIRCULAR JET IS USED FOR/20X,23HINTEGE05240
     1RACTION COMPUTATION)                                              GE05250
700   FORMAT (/20X,43HA RECTANGULAR JET WITH LATERAL EXTENT EQUAL/20X,42GE05260
     1HTO THE EQUIVALENT JET DIAMETER IS USED FOR/20X,23HINTERACTION COMGE05270
     2PUTATION)                                                         GE05280
710   FORMAT (/20X,51HNOTE. CHECK WHETHER THE WING IS IMMERSED IN THE JEGE05290
     1T)                                                                GE05300
720   FORMAT (/2X,53HTHE EQUIVALENT VELOCITY RATIO, VC/VJ, AT FLAP HINGEGE05310
     1 =,F10.5)                                                         GE05320
730   FORMAT (/2X,69HTHE EQUIVALENT JET RADIUS AT FLAP HINGE IN MULTIPLEGE05330
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     1S OF EXIT RADIUS =,F10.5)
740   FORMAT (/2X,52HTHE ACTUAL JET DEFLECTION ANGLE IS ESTIMATED TO BE
     1=,F7.3,2X,7HDEGREES)
      END
      SUBROUTINE ENTRN (U,AMJ,T,XM,CMU,ET,XEL,XET,Z,KCODE,XJC,IUSR)
C     TO COMPUTE THE JET ENTRAINMENT FUNCTION
      DIMENSION CSJ(70), SSJ(70)
      DIMENSION PU1(31), PU2(31), FU1(31), FU2(31), FU3(31), RR2(31)
      COMMON /JET/ RK1,XC,X(31),A(31),B(31)
      IF (IUSR.EQ.0) WRITE (6,260)
      IF (IUSR.EQ.0) WRITE (6,270)
      PI=3.14159265
      IK=1
      REJ=T
      RK1=0.0125+0.011*U
      KCODE=0
      XMID=0.5*(XEL+XET)
      XM=XMID
      X0=0.
      R0=1.
      E=2.*RK1*SQRT((1.-U)*REJ)
      XC=0.35/E
      XJC=XC
      P1=1.-U
      UA=(1.+2.*U/(1.-U))/(1.+U/(1.-U))
      X(1)=XC
      DXX=(3.*XET-XEL)/30.
      IDX=DXX
      DXX=IDX
      IF (DXX.GT.3.) GO TO 10
      IF (DXX.GE.1..AND.DXX.LE.3.) DXX=2.5
      IF (DXX.LT.1.) DXX=1.5
10    CONTINUE
      X(2)=X(1)+DXX/2.
      DO 20 I=2,30
20    X(I+1)=X(I)+DXX
      DO 30 I=1,70
      FI=I
      CSJ(I)=COS((2.*FI-1.)*PI/140.)
30    SSJ(I)=SIN((2.*FI-1.)*PI/140.)
      DO 160 I=1,31
      IF (U.LE.0.01) GO TO 80
      IF (I.EQ.1.AND.ABS(T-1.).LE.0.01) GO TO 100
      IF (I.EQ.1) S=(2.*RK1*SQRT(REJ*(1.-U))*XC/0.72-0.35)*SQRT((1.-U)/U
     1*ALOG(UA))
      IF (I.EQ.2) S=DSX*(X(2)-XC)
      IF (I.GT.2) S=SH+DSX*DXX
      M=1
      IF (I.EQ.1) M=2
```

```
   40 CONTINUE
      SUM=0.
      DO 50 J=1,70
      SB=0.5*S*(1.-CSJ(J))
      AP1=(1.-U)*(1.-EXP(-1./(2.*SB)))
      AG=ALOG((1.+2.*U/AP1)/(1.+U/AP1))
   50 SUM=SUM+(1./SQRT(AP1*AG)-SQRT(2.*SB/((1.-U)*0.69314718)))*SSJ(J)
      RES=SUM*PI/70.*0.5*S*SQRT(U)+SQRT(2.*U/(1.-U))*S**1.5/1.0397208
      X1=RES+0.35
      IF (M.NE.1) GO TO 70
      XT=X1/(2.*PK1*SQRT((1.-U)*RFJ))
      P1=(1.-U)*(1.-EXP(-1./(2.*S)))
      G1=ALOG((1.+2.*U/P1)/(1.+U/P1))
      DSX=2.*PK1*SQRT(RFJ*(1.-U)*P1*G1/U)
      SH=S
      IF (ABS(X(I)-XT).LE.0.01) GO TO 60
      DX=X(I)-XT
      S=S+DX*DSX
      SH=S
      GO TO 40
   60 P1=(1.-U)*(1.-EXP(-1./(2.*SH)))
   70 IF (ABS(T-1.).LE.0.01) GO TO 100
      XH=X1*0.72/(2.*PK1*SQRT((1.-U)*RFJ))
      IF (ABS(X(I)-XH).LE.0.01) GO TO 90
      AK2=(1.-U)*(1.-EXP(-1./(2.*S)))
      AG2=ALOG((1.+2.*U/AK2)/(1.+U/AK2))
      DSX1=2.*PK1/0.72*SQRT(RFJ*(1.-U)*AK2*AG2/U)
      DX=X(I)-XH
      S=S+DX*DSX1
      M=M+1
      GO TO 40
   80 IF (I.NE.1) SH=2.*PK1*SQRT(RFJ)*X(I)-0.35
      IF (I.NE.1) P1=(1.-U)*(1.-EXP(-1./(2.*SH)))
      DSX=2.*PK1*SQRT(RFJ)
      IF (ABS(T-1.).LE.0.01) GO TO 100
      S=2.*PK1/0.72*SQRT(RFJ)*X(I)-0.35
   90 IF (I.EQ.1.AND.U.GT.0.01) DSX=2.*PK1*SQRT(RFJ*ALOG(UA)/U)*(1.-U)
      H0=1.-EXP(-1./(2.*S))
      H0P=-2.*H0**2/0.72
      P1P=-2.*P1*P1/(1.-U)
      P2=(T-1.+0.2*(1.-U*U)*AMJ*AMJ*T)*H0-0.2*P1*AMJ*AMJ*T*(P1+2.*U)
      P2P=(T-1.+0.2*(1.-U*U)*AMJ*AMJ*T)*H0P-0.2*P1P*AMJ*AMJ*T*(P1+2.*U)-
     10.2*P1*AMJ*AMJ*T*P1P
      F1P=-P2P*0.8907*(0.08901-0.04005*P2+0.01792*P2**2-0.00646*P2**3)/(
     11.+1.05001*P2)
      F2P=-P2P*0.79335*(0.0527-0.02886*P2+0.01479*P2**2-0.00589*P2**3)/(
     11.+1.08869*P2)
      F3P=-P2P*(0.12857-0.04653*P2+0.01820*P2**2-0.00599*P2**3)/(1.+1.02
     1272*P2)
```

```
      GO TO 110
100   P2=0.
      P2P=0.
      F1P=0.
      F2P=0.
      F3P=0.
      IF (I.EQ.1.AND.U.GT.0.01) CSX=2.*RK1*SQRT(REJ*ALOG(UA)/U)*(1.-U)
110   P1P=-2.*P1*P1/(1.-U)
      F1=0.9907*(0.12857+0.01617*P2-0.00607*P2**2+0.00192*P2**3)/(1.+0.8
     11817*P2)
      F2=0.79335*(0.06676+0.00453*P2-0.00204*P2**2+0.00075*P2**3)/(1.+0.
     185716*P2)
      F3=(0.21429+0.04061*P2-0.01249*P2**2+0.00351*P2**3)/(1.+0.78948*P2
     1)
      FU=U*P1*F1+P1*P1*F2
      DMC1=(P1P*F1+P1*F1P-U*P2P*F3-U*P2*F3P)/FU
      DMC2=(P1*F1-U*P2*F3)*(U*P1P*F1+U*P1*F1P+2.*P1*P1P*F2+P1*P1*F2P)/(F
     1U*FU)
      DMX=2.*(1.-U)*(DMC1-DMC2)*CSX/SQRT(REJ)
      RJ2=0.5*(1.-U)/FU
      RJ1=SQRT(RJ2)
      IF (IUSR.NE.1) WRITE (6,250) X(I),RJ1,DMX
      IF (Z.LT.0) GO TO 140
      IF (IK.GT.1) GO TO 140
      IF (X(I).GE.XEL) GO TO 120
      GO TO 140
120   IF (RJ1.LT.Z) GO TO 140
      XMJ=X0+(Z-R0)*(X(I)-X0)/(RJ1-R0)
      IF (XEL.LT.0) GO TO 130
      IF (XMJ.LT.XET) KCODE=1
      IK=IK+1
      GO TO 140
130   XM=0.5*XET
      IF (IUSR.NE.0) XM=XET
      IF (XMJ.LE.XM) KCODE=1
      IK=IK+1
140   CONTINUE
      R0=RJ1
      X0=X(I)
      PU1(I)=P1
      PU2(I)=P2
      FU1(I)=F1
      FU2(I)=F2
      FU3(I)=F3
      RR2(I)=RJ2
      IF (I.EQ.1) GO TO 150
      B(I)=(DMX-DMX0)/(X(I+1)-X(I))
      A(I)=DMX0-B(I)*X(I)
      GO TO 160
```

```
150   A(I)=0.145*DMX/0.32
      B(I)=(DMX-A(I))/XC
160   DMXO=DMX
      K=1
170   IF (K.GT.30) GO TO 240
      IF (XM.GE.0..AND.XM.LT.XC) GO TO 180
      IF (XM.GE.X(K).AND.XM.LT.X(K+1)) GO TO 180
      K=K+1
      GO TO 170
180   F11=PP2(K)*(PU1(K)*U*FU1(K)+PU1(K)**2*FU2(K))/(U*U)
      F12=PP2(K+1)*(PU1(K+1)*U*FU1(K+1)+PU1(K+1)**2*FU2(K+1))/(U*U)
      F21=PP2(K)*(PU1(K)*FU1(K)-U*PU2(K)*FU3(K))/U
      F22=PP2(K+1)*(PU1(K+1)*FU1(K+1)-U*PU2(K+1)*FU3(K+1))/U
      IF (ABS(T-1.).LE.0.001) GO TO 190
      F31=PP2(K)*(9.*PU1(K)/70.-PU1(K)*FU1(K)+U*PU2(K)*FU3(K))/U
      F32=PP2(K+1)*(9.*PU1(K+1)/70.-PU1(K+1)*FU1(K+1)+U*PU2(K+1)*FU3(K+
     1))/U
      X11=F11/(F21+F31)
      X12=F12/(F22+F32)
      GO TO 200
190   F31=0.
      F32=0.
200   CONTINUE
      X1=X(K)
      X2=X(K+1)
      X21=F11/(F21+F31)+F31*(F11/(F21+F31)-1.)/F21
      X22=F12/(F22+F32)+F32*(F12/(F22+F32)-1.)/F22
      X31=2.*F21*(F21+F31)/(F11-F21-F31)
      X31=SQRT(X31)
      X32=2.*F22*(F22+F32)/(F12-F22-F32)
      X32=SQRT(X32)
      IF (XM.GE.0..AND.XM.LT.XC) GO TO 210
      GO TO 220
210   X1=0.
      X2=XC
      X22=X21
      X32=X31
      X21=1./U
      X31=1.
      IF (ABS(T-1.).LE.0.001) GO TO 220
      X12=X11
      X11=1./(T*U)
220   CMU=X21+(XM-X1)*(X22-X21)/(X2-X1)
      PT=X31+(XM-X1)*(X32-X31)/(X2-X1)
      CMU=1./CMU
      IF (ABS(T-1.).LE.0.001) GO TO 230
      PU=X11+(XM-X1)*(X12-X11)/(X2-X1)
      T=1./(CMU*PU)
230   CONTINUE
```

```
240   CONTINUE
      RETURN
C
250   FORMAT (8F10.5)
260   FORMAT (/5X,42HTHE COMPUTED JET ENTRAINMENT ARE AS FOLLOWS)
270   FORMAT (/5X,4HYJET,5X,4HRJET,5X,5HDM/DX)
      END
      SUBROUTINE RECTJ (ISYM,NSJ,Y)
C     TO DEFINE THE UNIT NORMAL VECTORS TO THE SURFACE OF RECTANGULAR
C     JETS
      DIMENSION Y(10,41)
      IF (ISYM.EQ.0) GO TO 10
      NSJ1=NSJ+1
      NJH=(NSJ-1)/2+2
      GO TO 20
10    NSJ1=NSJ-1
      NJH=NSJ/2
20    DO 50 I=1,NSJ1
      IF (I.EQ.1.AND.ISYM.NE.0) GO TO 30
      IF (I.EQ.NJH) GO TO 40
      Y(3,I)=1.
      Y(4,I)=0.
      GO TO 50
30    Y(3,I)=0.
      Y(4,I)=-1.
      GO TO 50
40    Y(3,I)=0.
      Y(4,I)=1.
50    CONTINUE
      RETURN
      END
      SUBROUTINE CIRCJ (ISYM,NSJ,Y)
C     TO DEFINE THE UNIT NORMAL VECTORS TO THE SURFACE OF CIRCULAR JETS
      DIMENSION Y(10,41)
      PI=3.14159265
      IF (ISYM.EQ.0) GO TO 10
      NSJ1=NSJ+1
      NN=(NSJ-1)/2+1
      FN2=NN
      NJH=NN+1
      Y(1,1)=-SIN(PI/(2.*FN2))
       (2,1)=-COS(PI/(2.*FN2))
      GO TO 20
10    Y(1,1)=1.
      Y(2,1)=0.
      NSJ1=NSJ-1
      FN2=NSJ/2
      NJH=NSJ/2
20    CONTINUE
```

```
      DO 50 I=1,NSJ1
      K=I
      KI=I
      IF (I.GT.NJH.AND.ISYM.NE.0) K=I-NJH+1
      IF (I.GT.NJH.AND.ISYM.EQ.0) K=I-NJH
      FI=K
      IF (ISYM.NE.0) ANG2=(FI-1.)*PI/FN2
      IF (ISYM.EQ.0) ANG2=FI*PI/FN2
      YP=0.5*(1.-COS(ANG2))
      IF (ISYM.EQ.0) ANG2=PI-ATAN(SQRT(1.-YP*YP)/YP)
      II=I+1
      KK=I
      KII=II
      IF (I.GT.NJH) KK=II-NJH
      FII=KK
      IF (I.LE.NJH.AND.ISYM.EQ.0) FII=KK+1
      ANG1=(2.*FII-1.)*PI/(2.*FN2)
      YP=0.5*(1.-COS(ANG1))
      IF (ANG1.GT.PI) YP=-YP
      IF (ISYM.EQ.0) ANG1=PI-ATAN(SQRT(1.-YP*YP)/YP)
      IF (I.GT.NJH) GO TO 30
      GO TO 40
30    ANG1=-ANG1
      ANG2=-ANG2
40    CONTINUE
      Y(1,KII)=SIN(ANG1)
      Y(2,KII)=-COS(ANG1)
      Y(3,KI)=SIN(ANG2)
      Y(4,KI)=-COS(ANG2)
50    CONTINUE
      RETURN
      END
      SUBROUTINE SPLINE (N,X,Y,A,B,C,D,LM,NT)
      DIMENSION S(40), H(12), CA(11), X(2,11), Y(2,11)
      DIMENSION A(2,10), B(2,10), C(2,10), D(2,10)
      L=LM
      DO 90 MM=1,NT
      I=1
      NT=N+1
      N1=N-1
      H(NT)=0.
      H(1)=X(L,3)-X(L,2)
      H(2)=-X(L,3)+X(L,1)
      H(3)=X(L,2)-X(L,1)
      DO 10 K=4,N
10    H(K)=0.
      DO 20 K=1,N
20    S(K)=-H(K+1)/H(1)
      NJ=N-1
```

```
      DO 70 I=2,N
      IF (I.EQ.N) GO TO 30
      H(NI)=-6.*((Y(L,I+1)-Y(L,I))/(X(L,I+1)-X(L,I))-(Y(L,I)-Y(L,I-1))/(
     1X(L,I)-X(L,I-1)))
      GO TO 40
   30 H(NI)=0.
   40 DO 60 J=1,N
      H(J)=0.
      IF (I.EQ.N) GO TO 50
      IF (J.LT.(I-1).OR.J.GT.(I+1)) GO TO 60
      H(I-1)=X(L,I)-X(L,I-1)
      H(I)=2.*(X(L,I+1)-X(L,I-1))
      H(I+1)=X(L,I+1)-X(L,I)
      GO TO 60
   50 H(N-2)=X(L,N)-X(L,N-1)
      H(N-1)=-X(L,N)+X(L,N-2)
      H(N)=X(L,N-1)-X(L,N-2)
   60 CONTINUE
      II=I
      CALL VMSEQN (NJ,II,H,S,CA)
      NJ=NJ-1
   70 CONTINUE
      DO 80 I=1,N1
      A(L,I)=(S(I+1)-S(I))/(6.*(X(L,I+1)-X(L,I)))
      B(L,I)=S(I)/2.
      C(L,I)=(Y(L,I+1)-Y(L,I))/(X(L,I+1)-X(L,I))-(X(L,I+1)-X(L,I))*(2.*S
     1(I)+S(I+1))/6.
   80 D(L,I)=Y(L,I)
   90 L=L+1
      RETURN
      END
      SUBROUTINE RESHAP (XXL,XXT,YL,ZL,CPCWL,CPSWL,IPANEL,NJ,JC,JJ,NSYM)
C     TO DEFINE THE LOCATIONS OF VORTEX AND CONTROL POINTS ON RECT. JETS
      DIMENSION XXL(1), YL(1), XXT(1), ZL(1), CPCWL(1), CPSWL(1)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
     1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFP,SJ(21,8),FX(95,2),TX(95
     3,2),SC(160,5),ST(160,5),IC(3)
      COMMON /CONST/ NCS,NCW,N1(5),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      PI=3.14159265
      IF (NSYM.EQ.0) NSJJ=(NSJ+1)/2
      IF (NSYM.NE.0) NSJJ=NSJ/2
      NSJ1=NSJJ-1
      DO 10 J=1,NJ
      FJ=J
      FNJ=NJ
```

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10    PSI(J)=0.5*(1.-COS(FJ*PI/FNJ))
      DO 170 IS=1,4
      IF (NSYM.EQ.1.AND.IS.EQ.1) GO TO 170
      IF (IS.EQ.4) GO TO 20
      K1=IS
      K2=IS+1
      GO TO 30
20    K1=1
      K2=4
30    CONTINUE
      SPAN=YL(K2)-YL(K1)
      XDIF=XXL(K2)-XXL(K1)
      DO 40 I=1,2
      II=I+K1-1
      IF (IS.EQ.4.AND.I.EQ.2) II=4
      C(I)=XXT(II)-XXL(II)
      DO 40 J=1,NJ
40    XL(I,J)=XXL(II)+CPCWL(J)*C(I)
      IF (ABS(SPAN).LE.0.001) GO TO 70
      DO 50 J=1,NJ
50    SLOPE(J)=(XL(2,J)-XL(1,J))/SPAN
      DO 60 K=1,NSJ1
      YK=CPSWL(K)*SPAN
      DO 60 J=1,NJ
      Y(J,K)=YK+YL(K1)
      X(J,K)=XL(1,J)+SLOPE(J)*(Y(J,K)-YL(K1))
60    CONTINUE
      NS=NSJ1
70    IF (ABS(SPAN).LE.0.001) NS=1
      DO 160 K=1,NS
      YC=YCON(K)
      IF (ABS(SPAN).LE.0.001) YC=0.5
      KK=JC+K
      CH(KK)=C(1)-(C(1)-C(2))*YC
      IF (ABS(SPAN).LE.0.001) GO TO 80
      YC1=CPSWL(K)
      YC2=CPSWL(K+1)
      GO TO 90
80    YC1=0.
      YC2=1.
90    CONTINUE
      FX(KK,1)=XXL(K1)+XDIF*YC1
      FX(KK,2)=XXL(K1)+XDIF*YC2
      TX(KK,1)=XXT(K1)+(XXT(K2)-XXT(K1))*YC1
      TX(KK,2)=XXT(K1)+(XXT(K2)-XXT(K1))*YC2
      DO 160 J=1,NJ
      NPANEL=(K-1)*NJ+J-1+IPANEL
      NPAN1=NPANEL-1
      DO 130 I=1,2
```

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      KT1=K+I-1
      IF (ABS(SPAN).LE.0.001) GO TO 100
      X1=X(J,KT1)
      Y1=Y(J,KT1)
      IF (J.NE.1) GO TO 110
      ZZ=ZL(K1)+(ZL(K2)-ZL(K1))*(Y1-YL(K1))/SPAN
      XX=XDIF*(Y1-YL(K1))/SPAN+XXL(K1)
      GO TO 120
100   IZN=K1
      IF (I.EQ.2) IZN=K2
      X1=XL(I,J)
      Y1=YL(K1)
      IF (J.NE.1) GO TO 110
      ZZ=ZL(IZN)
      XX=XXL(IZN)
      GO TO 120
110   ZZ=ZN(NPAN1,I)
      XX=XN(NPAN1,I)
120   XN(NPANEL,I)=X1
      YN(NPANEL,I)=Y1
      ZN(NPANEL,I)=ZZ
130   CONTINUE
      XP=XDIF*YC+XXL(K1)
      XCP(NPANEL)=XP+CH(KK)*PSI(J)
      YCP(NPANEL)=YC*SPAN+YL(K1)
      IF (ABS(SPAN).LE.0.001) GO TO 140
      ZC=ZN(NPANEL,1)+(ZN(NPANEL,1)-ZN(NPANEL,2))*(YCP(NPANEL)-YN(NPANEL
     1,1))/(YN(NPANEL,1)-YN(NPANEL,2))
      XC=XN(NPANEL,1)+SLOPE(J)*(YCP(NPANEL)-YN(NPANEL,1))
      GO TO 150
140   ZC=0.5*(ZN(NPANEL,1)+ZN(NPANEL,2))
      XC=0.5*(XN(NPANEL,1)+XN(NPANEL,2))
150   ZCP(NPANEL)=ZC
      XV(NPANEL)=XC
160   CONTINUE
      IPANEL=NPANEL+1
      LAST=NPANEL
      JC=KK
170   CONTINUE
      RETURN
      END
      SUBROUTINE PANEL (XYL,YL,XXT,CPCWL,CPSWL,NSW,IPANEL,LPANEL,KK,LP,S
     1WP)
C     TO DEFINE THE LOCATIONS OF VORTEX AND CONTROL POINTS ON THE WING
      DIMENSION XYL(1), YL(1), XXT(1), CPCWL(1), CPSWL(1)
      DIMENSION SWP(8,15)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
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     1F(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(5),YCON(25),SWEEP(50),HALFR,SJ(21,8),FX(95,2),TX(95
     3,2),SC(160,5),ST(160,5),LC(3)
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      PI=3.1415926
      NSW1=NSW-1
      DO 10 I=1,2
      C(I)=XXT(I)-XXL(I)
      DO 10 J=1,NCW
   10 XL(I,J)=XXL(I)+CPCWL(J)*C(I)/100.
      SPAN=YL(2)-YL(1)
      DO 20 J=1,NCW
      PSI(J)=0.5*(1.-COS(FLOAT(J)*PI/FLOAT(NCW)))
      SLOPE(J)=(XL(2,J)-XL(1,J))/SPAN
   20 SWP(J,LP)=ATAN(SLOPE(J))
      DO 30 K=1,NSW
      YK=CPSWL(K)*SPAN/100.
      DO 30 J=1,NCW
      Y(J,K)=YK+YL(1)
      X(J,K)=XL(1,J)+SLOPE(J)*(Y(J,K)-YL(1))
   30 CONTINUE
      XLL(1)=XXL(1)
      XTT(1)=XXT(1)
      DO 40 I=2,NSW
      XLL(I)=XLL(I-1)+(XXL(2)-XXL(1))*(Y(1,I)-Y(1,I-1))/SPAN
   40 XTT(I)=XTT(I-1)+(XXT(2)-XXT(1))*(Y(1,I)-Y(1,I-1))/SPAN
      DO 60 K=1,NSW1
      KK=NCS+K
      YLE(KK)=YCON(K)*SPAN+YL(1)
      XLE(KK)=XLL(K)+(XLL(K+1)-XLL(K))*(YLE(KK)-Y(1,K))/(Y(1,K+1)-Y(1,K)
     1)
      XTE(KK)=XTT(K)+(XTT(K+1)-XTT(K))*(YLE(KK)-Y(1,K))/(Y(1,K+1)-Y(1,K)
     1)
      CH(KK)=XTE(KK)-XLE(KK)
      FX(KK,1)=XXL(1)+(XXL(2)-XXL(1))*CPSWL(K)/100.
      FX(KK,2)=XXL(1)+(XXL(2)-XXL(1))*CPSWL(K+1)/100.
      TX(KK,1)=XXT(1)+(XXT(2)-XXT(1))*CPSWL(K)/100.
      TX(KK,2)=XXT(1)+(XXT(2)-XXT(1))*CPSWL(K+1)/100.
      TANG=(XXL(2)-XXL(1))/SPAN
      SWEEP(KK)=ATAN(TANG)
      DO 60 J=1,NCW
      NPANEL=(K-1)*NCW+J-1+IPANEL
      DO 50 I=1,2
      KI1=K+I-1
      XN(NPANEL,I)=X(J,KI1)
      YN(NPANEL,I)=Y(J,KI1)
      ZN(NPANEL,I)=0.
   50 CONTINUE
```

```
      XCP(NPANEL)=XLE(KK)+PSI(J)*CH(KK)
      YCP(NPANEL)=YLE(KK)
      ZCP(NPANEL)=0.
      XV(NPANEL)=XLE(KK)+CPCWL(J)*CH(KK)/100.
      YV(NPANEL)=YLE(KK)
   60 CONTINUE
      LPANEL=NPANEL
      RETURN
      END
      SUBROUTINE JSHAPE (XXL,XXT,YL,YJ,ZJ,RJ,CPCWL,IPANEL,NJ,JC,ISYM)
C     TO DEFINE THE LOCATIONS OF VORTEX AND CONTROL POINTS ON CIRCULAR
C     JETS
      DIMENSION CPCWL(1), XXL(1), XXT(1), YL(1)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
     1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFR,SJ(21,8),FX(95,2),TX(95
     3,2),SC(160,5),SI(160,5),LC(3)
      COMMON /CONST/ NCS,NCW,NI(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      PI=3.14159265
      N1=NSJ+1
      IF (ISYM.EQ.0) N1=NSJ-1
      N2=N1+1
      IF (ISYM.EQ.0) N2=NSJ
      N12=N1/2+2
      IF (ISYM.EQ.0) N12=NSJ/2+1
      DO 10 I=1,2
      C(I)=XXT(I)-XXL(I)
      DO 10 J=1,NJ
   10 XL(I,J)=XXL(I)+CPCWL(J)*C(I)
      DO 20 J=1,NJ
      FJ=J
      FNCJ=NJ
      PSI(J)=0.5*(1.-COS(FJ*PI/FNCJ))
   20 SLOPE(J)=(XL(2,J)-XL(1,J))/(2.*RJ)
      DO 30 K=1,N2
      YY=Y(2,K)
      IF (ISYM.NE.0.AND.K.EQ.1) YY=-1.
      IF (ISYM.NE.0.AND.K.EQ.2) YY=-1.
      IF (K.EQ.(N12-1).OR.K.EQ.N12) YY=1.
      IF (K.EQ.N2) YY=1.
      XTT(K)=YJ+RJ*YY
      DO 30 J=1,NJ
   30 X(J,K)=XL(1,J)+SLOPE(J)*(XTT(K)-YL(1))
      DO 120 K=1,N1
      KK=JC+K
      L=K
```

```
      IF (K.EQ.N12) L=1
      FX(KK,1)=XXL(1)+(XXL(2)-XXL(1))*(XTT(L)-YL(1))/(2.*RJ)
      FX(KK,2)=XXL(1)+(XXL(2)-XXL(1))*(XTT(K+1)-YL(1))/(2.*RJ)
      TX(KK,1)=XXT(1)+(XXT(2)-XXT(1))*(XTT(L)-YL(1))/(2.*RJ)
      TX(KK,2)=XXT(1)+(XXT(2)-XXT(1))*(XTT(K+1)-YL(1))/(2.*RJ)
      CH(KK)=C(1)-(C(1)-C(2))*0.5*(1.+Y(4,K))
      DO 120 J=1,NJ
      NPANEL=(K-1)*NJ+J-1+IPANEL
      DO 90 I=1,2
      KI1=K+I-1
      SIGN=1.
      IF (K.EQ.N12.AND.I.EQ.1) KI1=1
      IF (ISYM.EQ.0) GO TO 40
      IF (KI1.EQ.1.OR.KI1.EQ.2) GO TO 60
      GO TO 50
40    IF (K.EQ.N12.AND.KI1.EQ.1) SIGN=-1.
50    CONTINUE
      IF (KI1.EQ.(N12-1).OR.KI1.EQ.N12) GO TO 70
      IF (KI1.EQ.N2) GO TO 70
      YY=Y(2,KI1)
      ZZ=Y(1,KI1)*SIGN
      GO TO 80
60    YY=-1.
      ZZ=-Y(1,KI1)/Y(2,KI1)
      GO TO 80
70    YY=1.
      ZZ=Y(1,KI1)/Y(2,KI1)
80    CONTINUE
      XN(NPANEL,I)=X(J,KI1)
      YN(NPANEL,I)=YJ+RJ*YY
90    ZN(NPANEL,I)=ZJ+RJ*ZZ
      YK=0.5*(1.+Y(4,K))
      IF (ISYM.EQ.0) YK=2.*YK-1.
      XCP(NPANEL)=XXL(1)+(XXL(2)-XXL(1))*YK+PSI(J)*CH(KK)
      IF (ABS(YN(NPANEL,2)-YN(NPANEL,1)).LE.0.0001) GO TO 100
      YCP(NPANEL)=YL(1)+YK*(YL(2)-YL(1))
      ZCP(NPANEL)=ZN(NPANEL,1)+(ZN(NPANEL,2)-ZN(NPANEL,1))*(YCP(NPANEL)-
     1YN(NPANEL,1))/(YN(NPANEL,2)-YN(NPANEL,1))
      GO TO 110
100   ZCP(NPANEL)=ZJ
      YCP(NPANEL)=YN(NPANEL,1)
110   CONTINUE
      XV(NPANEL)=XXL(1)+(XXL(2)-XXL(1))*YK+CPCWL(J)*CH(KK)
120   CONTINUE
      JC=JC+N1
      LAST=NPANEL
      RETURN
      END
      OVERLAY (USRIGE,2,0)
```

```
      PROGRAM JETOFF
C     TO SET UP THE JETOFF INFLUENCE COEFFICIENT MATRIX AND COMPUTE THE
C     CAMBER TERMS
      DIMENSION AW(101)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
     1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),FX(95,2),TX(95
     3,2),SC(160,5),ST(160,5),LC(3)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
     1,TEMP,FCP,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF,NGRD,HEIGHT,ATT
      COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFP
      REWIND 01
      J1=LPANEL+1
      ATH=-ATT
      B=B1
      IC=1
      MG=NW(1)
      NG=NW(1)
      NC=IENTN
      IG=1
10    CONTINUE
      LL=1
      IF (NW(2).EQ.0) GO TO 30
      II=1+NCS
      IF (NW(3).NE.0) GO TO 20
      CHORD=CH(1)+CH(II)
      GO TO 40
20    III=II+NCS
      CHORD=CH(1)+CH(II)+CH(III)
      GO TO 40
30    CHORD=CH(1)
40    CONTINUE
      CALL WING (AW,LPANEL,1,B,LPAN1,LPAN2,NGRD,HEIGHT,ATH)
      XC=(XCP(1)-XLE(IG))/CHORD
      CAM=ZCB(XC)-(ZCB(XC)-ZCT(XC))*YCP(1)/HALFB
      AW(J1)=-CAM
      WRITE (01) (AW(K),K=1,J1)
      IJ=2
      NJ=LPANEL-1
50    CONTINUE
      CALL WING (AW,LPANEL,IJ,B,LPAN1,LPAN2,NGRD,HEIGHT,ATH)
      IF (NW(2).EQ.0) GO TO 70
      II=IG+NCS
      IF (NW(3).NE.0) GO TO 60
```

```
      CHORD=CH(IG)+CH(II)
      CHEL=CH(IG)
      GO TO 80
60    III=II+NCS
      CHORD=CH(IG)+CH(II)+CH(III)
      CHEL=CH(IG)+CH(II)
      GO TO 80
70    CHORD=CH(IG)
      CHEL=CH(IG)
80    CONTINUE
      FCP=CHEL/CHORD
      XC=(XCP(IJ)-XLE(IG))/CHORD
      COM=ABS(XC-FCP)
      FCP1=FCP-0.01
      FCP2=FCP+0.01
      CZ=0.
      IF (ABS(1.-XC).LE.0.01) GO TO 90
      ZC1=ZCP(XC)
      ZC2=ZCT(XC)
      CZ=ZC1-(ZC1-ZC2)*YCP(IJ)/HALFP
90    CONTINUE
      IF (ABS(1.-XC).LE.0.01) CZ=CAMTEP-(CAMTEP-CAMTET)*YCP(IJ)/HALFP
      IF (XC.LT.FCP1) CAM=CZ
      IF (COM.LT.0.001) CAM=CZ-0.5*DF(LL)
      IF (XC.GT.FCP2.AND.ABS(1.-XC).GT.0.01) CAM=-DF(LL)+CZ
      IF (ABS(1.-XC).LE.0.01) CAM=-DF(LL)+CZ
      IF (PTIAL.LE.0.01.AND.XC.GT.FCP1) GO TO 140
      IF (PTIAL.GT.0.01) GO TO 110
100   IF (IJ.NE.MG) GO TO 140
      IF (ABS(XC-1.).LE.0.01) GO TO 120
      JK=1
      IF (NW(3).NE.0.AND.IJ.GT.LPAN1) JK=2
      NCM=IJ+(NCS-IG)*NW(JK)+(IG-1)*NW(JK+1)+1
      XC1=(XCP(NCM)-XLE(IG))/CHORD
      CAM1=ZCP(XC1)-(ZCP(XC1)-ZCT(XC1))*YCP(IJ)/HALFP
      CAM=(CAM+CAM1)/2.
      CZ=CAM
      GO TO 140
110   IF (IJ.GE.MJW1(1,LL).AND.IJ.LE.MJW2(1,LL)) GO TO 130
      IF (IJ.GE.MJW1(2,LL).AND.IJ.LE.MJW2(2,LL)) GO TO 140
      IF (IJ.GE.MJW1(3,LL).AND.IJ.LE.MJW2(3,LL)) GO TO 140
      CAM=CZ
      GO TO 100
120   CAM=CAMTEP-(CAMTEP-CAMTET)*YCP(IJ)/HALFP
      GO TO 140
130   IF (XC.GT.FCP1) GO TO 140
      GO TO 100
140   CONTINUE
      AW(J1)=-CAM
```

```
      WRITE (01) (AW(K),K=1,J1)
      IF (IJ.GE.LPAN1.AND.IJ.LT.LPAN2) NG=NW(2)
      IF (IJ.GE.LPAN2.AND.IJ.LT.LPANEL) NG=NW(3)
      IF (IJ.EQ.MJW2(1,LL).OR.IJ.EQ.MJW2(2,LL)) LL=LL+1
      IF (IJ.EQ.MJW2(3,LL)) LL=LL+1
      IF (LL.GT.NFP) LL=1
      IF (IJ.LT.MG) GO TO 150
      IG=IG+1
      MG=MG+NG
150   IF (IJ.EQ.LPAN1.OR.IJ.EQ.LPAN2) IG=1
      IF (IJ.EQ.LPAN1.OR.IJ.EQ.LPAN2) LL=1
      IJ=IJ+1
      NJ=NJ-1
      IF (IJ.LE.LPANEL) GO TO 50
      IC=IC+1
      B=B2
      IG=1
      NG=NW(1)
      MG=NW(1)
      IF (ABS(B1-B2).LE.0.001) GO TO 160
      IF (IC.LE.2) GO TO 10
160   CONTINUE
      RETURN
C
      END
      OVERLAY (USBIGE,3,0)
      PROGRAM JETON
C     TO SET UP THE JETON INFLUENCE COEFFICIENT MATRICES
      DIMENSION AW(300)
      COMMON /CODE/ KCODE
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
     1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(95
     3,2),SC(160,5),ST(160,5),LC(3)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF,NGRD,HEIGHT,ATT
      COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
     1,TEMP,FCP,CAMLEP,CAMLET,CAMTEP,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
      COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFP
      REWIND 02
      LP1=LTOTAL+1
      MJ=LPANEL+NCJ(1)
      MCON=LAST+NCJ(1)
      IPHI=1
      ATG=ATT
      ATT=-ATG
```

```
      JL=LAST+1
      INN=1
      LN=1
      LN1=1
      JNN=1
      VMUC=VMU*ALPC
      MK=1
      I=LAST+1
      I1=I-JPANEL
      CALL MATRIX (AW,LTOTAL,LPANEL,VMUC,I,MCON,MJ,IPHI,INN,LN,LN1,TEMP,
     1LPAN1,ISYM,KCODE,EXIT,LPAN2)
      WRITE (01) (AW(K),K=1,LTOTAL)
      KT=2
      NT=LTOTAL-1
      LT=LAST+2
      VMP=VMUC
10    KJ=LT
      IF (LT.GT.LAST) KJ=LT-JPANEL
      CALL MATRIX (AW,LTOTAL,LPANEL,VMP,LT,MCON,MJ,IPHI,INN,LN,LN1,TEMP,
     1LPAN1,ISYM,KCODE,EXIT,LPAN2)
      WRITE (01) (AW(K),K=1,LTOTAL)
      IF (KJ.LT.MJ.OR.KJ.EQ.LAST) GO TO 20
      IPHI=IPHI+1
      MJ=MJ+NCJ(INN)
20    CONTINUE
      MJT=MJJ(INN)-1
      IF (KJ.EQ.MJT) GO TO 30
      GO TO 40
30    JNN=INN
      INN=INN+1
40    IF (KJ.EQ.MJJ(JNN)) IPHI=1
      IF (LT.GT.LPANEL) GO TO 60
      IF (LT.EQ.MJW2(1,LL).OR.LT.EQ.MJW2(2,LL)) LL=LL+1
      IF (LT.EQ.MJW2(3,LL)) LL=LL+1
      IF (LL.GT.NFP) LL=1
      IF (LT.GE.LPAN1.AND.LT.LT.LPAN2) NG=NW(2)
      IF (LT.GE.LPAN2.AND.LT.LT.LPANEL) NG=NW(3)
      IF (LT.LT.MG) GO TO 50
      MG=MG+NG
50    IF (LT.EQ.LPAN1.OR.LT.EQ.LPAN2) LL=1
60    CONTINUE
      IF (LT.EQ.LTOTAL) GO TO 70
      GO TO 80
70    CONTINUE
      IPHI=1
      MJ=LPANEL+NCJ(1)
      JNN=1
      INN=1
80    CONTINUE
```

```
      KI=KI+1
      NI=NI-1
      IF (LI.EQ.LTOTAL) GO TO 90
      IF (LI.EQ.LAST) GO TO 100
      LI=LI+1
      GO TO 110
90    LI=LPANEL+1
      GO TO 110
100   LI=1
110   CONTINUE
      JP=LI-LAST+LPANEL
      JP1=JP-1
      IF (JP.EQ.MJJ(LN1)) LN1=LN1+1
      IF (JP1.EQ.MJJ(LN)) LN=LN+1
      IF (KI.LE.LTOTAL) GO TO 10
      ATT=ATG
      RETURN
      END
      SUBROUTINE MATRIX (AW,LTOTAL,LPANEL,VMU,I,MCON,MJ,IPHI,INN,LN,LN1,
     1TEMP,LPAN1,ISYM,KCODE,EXIT,LPAN2)
C     TO COMPUTE THE JETON INFLUENCE  COEFFICIENT MATRICES
      DIMENSION AW(1)
      DIMENSION W(4), W1(2)
      DIMENSION SV(300)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
     1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(95
     3,2),SC(160,5),SI(160,5),LC(3)
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1YLL(41)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF,NGRD,HEIGHT,ATT
      EQUIVALENCE (X(1,1),SV(1))
      PI=3.14159265
      ZJET=YCON(25)
      IUSP=YCON(24)
      IF (IUSP.EQ.2) VMU=0.2
      CMU=C(1)
      LG=1
      IF (NGRD.EQ.1) LG=2
      W1(1)=0.
      W1(2)=0.
      DEJ=CDF
      VUT=VMU
      TEM=TEMP
      NN2=NNJ-1
      N1=NNJ-1
```

```
      N2=NNJ-2
      N3=NNJ-3
      NJH=(NSJ+1)/2+1
      IF (ISYM.EQ.0) NJH=NSJ/2
      IF (ISYM.EQ.0) NP=NSJ-1
      IF (ISYM.NE.0) NP=NSJ+1
      NJT=NJH-1
      IZ=1
      IFF=1
      MM=NW(1)
      NN=NW(1)
      IND=1
      ISN=1
      L1=LPANEL+1
      LAST1=LAST-1
      IF (I.GT.LAST) GO TO 10
      IJ=I
      GO TO 20
   10 IJ=I-JPANEL
   20 CONTINUE
      DO 280 J=1,LAST
      MI=J-IFF+1
      FN=NN
      IF (J.GT.LPAN1.AND.J.LE.LPAN2) ISN=2
      IF (J.GT.LPAN2.AND.J.LE.LPANEL) ISN=3
      IF (J.GE.LPAN1.AND.J.LT.LPANEL) GC TO 30
      GO TO 40
   30 NN=NW(2)
      IF (J.GE.LPAN2.AND.J.LT.LPANEL) NN=NW(3)
   40 CONTINUE
      IF (J.GE.LPANEL.AND.J.LT.MJJ(IND)) NN=NCJ(IND)
      CHORD=CH(IZ)
      IF (J.EQ.L1) GO TO 50
      GO TO 60
   50 ISN=ISN+1
      L1=MJJ(IND)+1
   60 ML=MJJ(IND)-1
      IF (ML.EQ.LAST1) GO TO 70
      IF (J.EQ.ML) IND=IND+1
   70 CONTINUE
      X1=XN(J,1)-XCP(IJ)
      X2=XN(J,2)-XCP(IJ)
      X12=XN(J,2)-XN(J,1)
      Y12=YN(J,2)-YN(J,1)
      Z12=ZN(J,2)-ZN(J,1)
      DO 260 II=1,2
      IF (II.EQ.1) GO TO 80
      N=1
      GO TO 90
```

```
80    N=2
90    CONTINUE
      YC=(-1.)**N*YCP(IJ)
      Y1=YN(J,1)-YC
      Y2=YN(J,2)-YC
      XYK=X1*Y12-Y1*X12
      DO 250 KK=1,LG
      IF (KK.EQ.1) GO TO 100
      GE=-1.
      ZC=-2.*(ZCP(IJ)+HEIGHT)+ZCP(IJ)
      ECON=1.
      GO TO 110
100   GE=1.
      ZC=ZCP(IJ)
      ECON=0.
110   CONTINUE
      Z1=ZN(J,1)-ZC
      Z2=ZN(J,2)-ZC
      XZJ=X1*Z12-Z1*X12
      UCON=-Z1*Y12*ATT*ECON
      YZI=Y1*Z12-Z1*Y12
      ALP1=XYK*XYK+XZJ*XZJ+B1*YZI*YZI
      B1B1=SQRT(X1*X1+B1*Y1*Y1+B1*Z1*Z1)
      B2B1=SQRT(X2*X2+B1*Y2*Y2+B1*Z2*Z2)
      UUB1=(X2*X12+B1*Y2*Y12+B1*Z2*Z12)/B2B1-(X1*X12+B1*Y1*Y12+B1*Z1*Z12
     1)/B1B1
      G1B1=(1.-X1/B1B1)/(Y1*Y1+Z1*Z1)
      G2B1=(1.-X2/B2B1)/(Y2*Y2+Z2*Z2)
      IF (I.GT.LPANEL) GO TO 130
      F1=UUB1*(UCON+XYK)*GE/ALP1
      F2=(-Y2*G2B1+Y1*G1B1)*GE
      IF (J.GT.LPANEL) GO TO 120
      GO TO 220
120   F3=0.
      F4=0.
      F1=2.*F1
      F2=2.*F2
      GO TO 220
130   CONTINUE
      IF (J.LE.LPANEL) GO TO 150
      IF (ABS(B1-B2).LE.0.001) GO TO 140
      ALP2=XYK*XYK+XZJ*XZJ+B2*YZI*YZI
      B1B2=SQRT(X1*X1+B2*Y1*Y1+B2*Z1*Z1)
      B2B2=SQRT(X2*X2+B2*Y2*Y2+B2*Z2*Z2)
      UUB2=(X2*X12+B2*Y2*Y12+B2*Z2*Z12)/B2B2-(X1*X12+B2*Y1*Y12+B2*Z1*Z12
     1)/B1B2
      G1B2=(1.-X1/B1B2)/(Y1*Y1+Z1*Z1)
      G2B2=(1.-X2/B2B2)/(Y2*Y2+Z2*Z2)
      GO TO 150
```

```
140   ALB2=ALB1
      UUB2=UUB1
      G2B2=G2B1
      G1B2=G1B1
150   CONTINUE
      IF (I.GT.LAST) GO TO 180
      F13=UUB1*XZJ/ALB1
      F12=UUB1*(UCOM+XYK)/ALB1
      G13=Z2*G2B1-Z1*G1B1
      G12=-Y2*G2B1+Y1*G1B1
      IF (J.LE.LPANEL) GO TO 160
      F23=UUB2*XZJ/ALB2
      F22=UUB2*XYK/ALB2
      G23=Z2*G2B2-Z1*G1B2
      G22=-Y2*G2B2+Y1*G1B2
      GO TO 170
160   F22=0.
      G22=0.
      F23=0.
      G23=0.
170   F1=-F13*Y(4,IPHI)*(-1.)**N+F12*Y(3,IPHI)*GE
      F2=G13*Y(4,IPHI)*(-1.)**N+G12*Y(3,IPHI)*GE
      F3=-F23*Y(4,IPHI)*(-1.)**N+F22*Y(3,IPHI)
      F4=G23*Y(4,IPHI)*(-1.)**N+G22*Y(3,IPHI)
      IF (J.LE.LPANEL) GO TO 210
      F1=F1*2.
      F2=2.*F2
      F3=2.*F3
      F4=2.*F4
      GO TO 210
180   F1=UUB1*YZI/ALB1
      IF (EXIT.LE.0.001) GO TO 190
      IF (NNJ.EQ.1) GO TO 190
      IF (IJ.GT.LPANEL.AND.IJ.LE.MJJ(1)) VMU=1.
      IF (IJ.GT.LPANEL.AND.IJ.LE.MJJ(1)) TEMP=1.
190   CONTINUE
      F2=0.
      IF (J.LE.LPANEL) GO TO 200
      F3=UUB2*YZI/ALB2
      F4=0.
      F1=-F1*VMU*VMU*2.*TEMP
      F3=-F3*2.
      GO TO 210
200   F1=-F1*VMU*VMU*TEMP
210   CONTINUE
220   IF (KK.EQ.2) GO TO 230
      W(II)=(F1+F2)*CHORD*SN(MI,ISN)/(8.*FN)
      IF (J.LE.LPANEL) GO TO 240
      IF (II.EQ.2) GO TO 240
```

```
      K2=II+2
      W(K2)=(F3+F4)*CHORD*SN(MI,ISN)/(8.*FN)
      GO TO 240
230   W1(II)=(F1+F2)*CHORD*SN(MI,ISN)/(8.*FN)
240   CONTINUE
250   CONTINUE
260   CONTINUE
      IF (J.LT.MM) GO TO 270
      IZ=IZ+1
      IEE=MM+1
      MM=MM+NN
270   CONTINUE
      IF (J.LE.LPANEL) JA=J+2*JPANEL
      IF (J.GT.LPANEL) JA=J-LPANEL+JPANEL
      AW(JA)=W(1)+W(2)+W1(1)+W1(2)
      SV(JA)=W(1)
      IF (J.LE.LPANEL) GO TO 280
      J1=J-LPANEL
      AW(J1)=W(3)
      VMU=VUT
      TEMP=TEM
280   CONTINUE
      IF (IUSR.NE.2) GO TO 310
      IF (I.GT.LPANEL.AND.I.LE.LAST) GO TO 290
      GO TO 310
290   DO 300 K=1,JPANEL
300   AW(K)=0.
310   CONTINUE
      IF (KCODE.EQ.0) GO TO 430
      IF (IUSR.NE.0.AND.ZJET.GT.0.01) GO TO 410
      IF (DEJ.LE.0.0001) GO TO 410
      IF (NNJ.EQ.1.AND.I.LE.LPANEL) GO TO 410
      IF (NNJ.EQ.1.AND.I.GT.LPANEL) GO TO 320
      IF (I.LE.MJJ(NI).OR.I.GT.LAST) GO TO 410
320   CONTINUE
      IF (I.GT.LAST) GO TO 410
      IF (IPHI.EQ.NJH) GO TO 410
      IF (ISYM.NE.0.AND.IPHI.EQ.1) GO TO 410
      IF (IPHI.LT.NJH) IL=IPHI-ISYM
      IF (IPHI.GT.NJH) IL=IPHI-NJH
      REWIND 02
      IF (NNJ.EQ.1) MJN1=LPANEL
      IF (NNJ.NE.1) MJN1=MJJ(NI)
      ME=IJ-MJN1-(IPHI-1)*NCJ(NNJ)
      FNNJ=NCJ(NNJ)
      DISTJ=SDE
      DLX=DISTJ*0.5*PI/FNNJ
      SZX=-(1.-VMU)
      IF (IUSR.EQ.2) SZX=-1.
```

```
      IQ=(IL-1)*NCJ(NNJ)
      CALL SKIP (IQ,JPANEL)
      DO 360 JJ=1,MF
      READ (02) (SV(K),K=1,JPANEL)
      IF (JJ.EQ.MF) GO TO 330
      IF (IUSR.EQ.2) DXTH=DLX*PSI(JJ)*2./CMU
      IF (IUSR.NE.2) DXTH=DLX*PSI(JJ)/TH
      GO TO 340
330   IF (IUSR.EQ.2) DXTH=DLX*PSI(JJ)*2.*0.5/CMU
      IF (IUSR.NE.2) DXTH=DLX*PSI(JJ)*0.5/TH
340   CONTINUE
      PROD=SZX*DXTH
      DO 350 K1=1,JPANEL
      KK=K1+JPANEL
350   AW(KK)=AW(KK)+PROD*SV(K1)
360   CONTINUE
      IQ=NCJ(NNJ)-MF+((NP-1-ISYM)/2-1)*NCJ(NNJ)
      CALL SKIP (IQ,JPANEL)
      DO 400 JJ=1,MF
      READ (02) (SV(K),K=1,JPANEL)
      IF (JJ.EQ.MF) GO TO 370
      IF (IUSR.EQ.2) DXTH=DLX*PSI(JJ)*2./CMU
      IF (IUSR.NE.2) DXTH=DLX*PSI(JJ)/TH
      GO TO 380
370   IF (IUSR.EQ.2) DXTH=DLX*PSI(JJ)*2.*0.5/CMU
      IF (IUSR.NE.2) DXTH=DLX*PSI(JJ)*0.5/TH
380   PROD=SZX*DXTH
      DO 390 K1=1,JPANEL
      KK=K1+JPANEL
390   AW(KK)=AW(KK)-PROD*SV(K1)
400   CONTINUE
410   CONTINUE
      IF (EXIT.LE.0.001) GO TO 420
      IF (NNJ.EQ.1) GO TO 420
      IF (IJ.GT.LPANEL.AND.IJ.LE.MJJ(1)) VMU=1.
      IF (IJ.GT.LPANEL.AND.IJ.LE.MJJ(1)) TEMP=1.
420   CONTINUE
430   IF (I.LE.LAST) GO TO 790
      IF (IPHI.EQ.NJH) GO TO 640
      IF (ISYM.NE.0.AND.IPHI.EQ.1) GO TO 640
      IF (NNJ.EQ.1) GO TO 500
      IF (IJ.GT.MJJ(N1)) GO TO 500
      IF (IPHI.GT.NJH.AND.ZJET.LE.0.01) GO TO 500
      IF (IPHI.GT.NJH) L1=NJH
      IF (ISYM.EQ.0.AND.IPHI.GT.NJH) L1=NJH+1
      IF (IPHI.LE.NJH) L1=1
      NZ=1
      IF (NW(2).NE.0.AND.NW(3).EQ.0) NZ=2
      IF (NW(3).NE.0) NZ=3
```

```
      IF (NNJ.LE.3.AND.NW(2).NE.0) IP=N2
      IF (NNJ.LE.3.AND.NW(2).EQ.0) IP=N1
      IF (NNJ.GE.4.AND.NW(3).NE.0) IP=N3
      IF (NNJ.EQ.4.AND.NW(3).EQ.0) IP=N2
      DO 490 NP=1,N7
      K1=MJW1(NP,NJP)+(IPHI-L1-ISYM)*NW(NP)-1
      K2=LC(NP)+IPHI-L1-ISYM
      KNW=NW(NP)
      K1=K1-KNW
      K2=K2-1
      MP=3
      IF (K1.GE.0) GO TO 440
      K1=K1+KNW
      K2=K2+1
      MP=2
440   DO 480 NQ=1,MP
      SUM=0.
      DO 450 KK=1,KNW
      KL=K1+KK
      JA=KL+2*JPANEL
450   SUM=SUM+SV(JA)
      CALL INTEG (RES,KNW,K1,K2,IJ,R1,IP)
      DO 470 KK=1,KNW
      KL=K1+KK
      JA=KL+2*JPANEL
      AA=1.
      DO 460 L=1,KNW
      LL=K1+L
      IF (L.EQ.KK) GO TO 460
      AA=AA*(XCP(IJ)-XV(LL))/(XV(KL)-XV(LL))
460   CONTINUE
      AW(JA)=AW(JA)-SUM*AA-RES*AA*VMU*VMU*TEMP
470   CONTINUE
      K1=K1+KNW
      K2=K2+1
480   CONTINUE
      IP=IP+1
490   CONTINUE
500   CONTINUE
      IF (KCODE.EQ.0) GO TO 640
      IF (NW(2).EQ.0) NSTRIP=NCS
      IF (NW(2).NE.0.AND.NW(3).EQ.0) NSTRIP=NCS*2
      IF (NW(3).NE.0) NSTRIP=NCS*3
      IF (IPHI.LT.NJH) IP=NJH+1
      IF (IPHI.GT.NJH) IP=ISYM+1
      IF (NNJ.EQ.1) GO TO 550
      IF (IJ.GT.MJJ(N1)) GO TO 550
      IF (NNJ.EQ.2) GO TO 560
      IF (IJ.GT.MJJ(N2)) GO TO 560
```

```
      IF (NNJ.EQ.3) GO TO 540
      IF (IJ.GT.MJJ(N3)) GO TO 530
      IF (NNJ.EQ.4) GO TO 520
      IF (NNJ.EQ.5.AND.IJ.GT.MJJ(NNJ-4)) GO TO 510
      L1=NNJ-4
      I7=NSTRIP
      GO TO 570
510   L1=N3
      I7=NSTRIP+NP
      GO TO 570
520   L1=N3
      I7=NSTRIP
      GO TO 570
530   L1=N2
      I7=NSTRIP+(NNJ-3)*NP
      GO TO 570
540   CONTINUE
      L1=N2
      I7=NSTRIP
      GO TO 570
550   L1=NNJ
      I7=NSTRIP+(NNJ-1)*NP
      GO TO 570
560   L1=N1
      I7=NSTRIP+(NNJ-2)*NP
570   CONTINUE
      I7=I7+IP
      NT=NJT
      IF (ISYM.NE.0) NT=NJT-1
      KNW=NCJ(L1)
      DO 630 KP=1,NT
      SUM1=0.
      SUM2=0.
      K1=MJJ(L1)-NP*NCJ(L1)+(KP-1)*NCJ(L1)+(IP-1)*NCJ(L1)
      DO 580 KK=1,KNW
      KL=K1+KK
      KJ=KL+JPANEL
      IA=KL-LPANEL+JPANEL
      IB=KJ-LAST
      SUM1=SUM1+SV(IA)
580   SUM2=SUM2+AW(IB)
      CALL INTEG (RES,KNW,K1,I7,IJ,B1,L1)
      IF (ABS(B1-B2).LE.0.001) GO TO 590
      CALL INTEG (REF,KNW,K1,I7,IJ,B2,L1)
      GO TO 600
590   REF=RES
600   DO 620 KK=1,KNW
      KL=K1+KK
      KJ=KL+JPANEL
```

```
      IA=KL-LPANEL+JPANEL
      IB=KJ-LAST
      AA=1.
      DO 610 L=1,KNW
      LL=K1+L
      IF (L.EQ.KK) GO TO 610
      AA=AA*(XCP(IJ)-XV(LL))/(XV(KL)-XV(LL))
610   CONTINUE
      AW(IA)=AW(IA)-SUM1*AA-RES*AA*VMU*VMU*TEMP*2.
      AW(IB)=AW(IB)-SUM2*AA-REF*AA*2.
620   CONTINUE
      I7=I7+1
630   CONTINUE
640   CONTINUE
      SK=1.
      IF (IPHI.GT.NJH) SK=-1.
      JI=I-LAST+LPANEL
      K=MCON-LAST-NCJ(LN)+LPANEL
      JNJ=NCJ(LN)
      DO 660 KK=1,JNJ
      KL=K+KK
      KJ=KL+JPANEL
      IA=KL-LPANEL+JPANEL
      IB=KJ-LAST
      AA=1.
      DO 650 L=1,JNJ
      LL=K+L
      IF (L.EQ.KK) GO TO 650
      AA=AA*(XCP(JI)-XV(LL))/(XV(KL)-XV(LL))
650   CONTINUE
      AW(IB)=AW(IB)+AA*SK
660   AW(IA)=AW(IA)-AA*VMU*VMU*TEMP*SK
      IF (I.EQ.MCON.AND.I.LT.LTOTAL) MCON=MCON+NCJ(LN1)
      IF (KCODE.EQ.0) GO TO 750
      IF (IUSB.NE.0.AND.ZJET.GT.0.01) GO TO 750
      IF (NNJ.EQ.1) GO TO 750
      IF (IJ.GT.MJJ(N1)) GO TO 750
      IF (IPHI.LE.NJH) GO TO 750
      L1=NJH
      IF (ISYM.EQ.0) L1=NJH+1
      IF (NW(2).EQ.0) GO TO 680
      IF (NW(3).EQ.0) GO TO 670
      IF (IJ.GT.MJJ(N2)) GO TO 710
      IF (IJ.GT.MJJ(N3)) GO TO 700
      IF (NNJ.EQ.4) GO TO 690
      IF (NNJ.EQ.5.AND.IJ.GT.MJJ(NNJ-4)) GO TO 690
      GO TO 750
670   IF (IJ.GT.MJJ(N2)) GO TO 700
      IF (NNJ.EQ.3) GO TO 690
```

```
      IF (NNJ.EQ.4.AND.IJ.GT.MJJ(N3)) GO TO 690
      GO TO 750
680   IF (NNJ.EQ.2) GO TO 690
      IF (NNJ.EQ.3.AND.IJ.GT.MJJ(N2)) GO TO 690
      GO TO 750
690   K1=MJW1(1.NJP)+(IPHI-L1-ISYM)*NW(1)-1
      KNW=NW(1)
      GO TO 720
700   K1=MJW1(2.NJP)+(IPHI-L1-ISYM)*NW(2)-1
      KNW=NW(2)
      GO TO 720
710   K1=MJW1(3.NJP)+(IPHI-L1-ISYM)*NW(3)-1
      KNW=NW(3)
720   DO 740 KK=1.KNW
      KL=K1+KK
      JA=KL+2*JPANEL
      AA=1.
      DO 730 L=1.KNW
      LL=K1+L
      IF (L.EQ.KK) GO TO 730
      AA=AA*(XCP(IJ)-XV(LL))/(XV(KL)-XV(LL))
730   CONTINUE
740   AW(JA)=AW(JA)-AA*VMU*VMU*TEMP*0.5
750   CONTINUE
      IF (KCODE.EQ.0) GO TO 790
      IF (ZJET.GT.0.01) GO TO 790
      IF (DEJ.LE.0.0001) GO TO 790
      IF (NNJ.EQ.1) GO TO 760
      IF (IJ.LE.MJJ(N1)) GO TO 790
760   CONTINUE
      IF (IPHI.EQ.NJH) GO TO 790
      IF (ISYM.NE.0.AND.IPHI.EQ.1) GO TO 790
      DO 780 J=1.JPANEL
      JJ=J+JPANEL
      IF (IUSP.EQ.2) GO TO 770
      SV(J)=-AW(JJ)
      GO TO 780
770   SV(J)=-AW(JJ)/(TEMP*VMU*VMU)
      AW(JJ)=0.
780   CONTINUE
      WRITE (02) (SV(J).J=1.JPANEL)
790   CONTINUE
      VMU=VUT
      TEMP=TEM
      RETURN
C
      END
      SUBROUTINE SKIP (I.JPANEL)
      DIMENSION DUMMY(200)
```

```
      IF (I.EQ.0) GO TO 20
      DO 10 J=1,I
      READ (02) (DUMMY(K),K=1,JPANEL)
10    CONTINUE
20    RETURN
      END
      OVERLAY (USBIGE,4,0)
      PROGRAM SOLUTN
C     TO SOLVE THE JET ON AND JET OFF EQUATIONS
C
C  *** GAMMA MUST BE DIMENSIONED TO HAVE AT LEAST (N+1)**2/4 ELEMENTS,
C    WHERE N IS THE SIZE OF THE MATRIX ***
      DIMENSION GAMMA(15010)
C
      DIMENSION AW(301), CA(300)
      DIMENSION GAMVB(300), PHIN(250)
      COMMON /CODE/ KCODE
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
     1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(95
     3,2),SC(160,5),SI(160,5),LC(3)
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDE,SDE,TH,TDE,NGRD,HEIGHT,ATT
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
     1,TEMP,ECP,CAMLEP,CAMLET,CAMTEP,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTP
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DE(5),NEE
      EQUIVALENCE (X(1,1),PHIN(1))
      REWIND 01
      REWIND 02
      IUSB=YCON(24)
      NC=IENTN
      ZZ=YCON(25)
      ITN=YCON(23)
      IC=1
      J1=LPANEL+1
      LP1=LTOTAL+1
      BB=B1
      DEJ=CDE
      NA=3
      IF (NW(2).EQ.0) NA=1
      IF (NW(2).NE.0.AND.NW(3).EQ.0) NA=2
10    CONTINUE
      IG=1
      MG=NW(1)
```

```
      NG=NW(1)
      READ (01) (AW(I),I=1,J1)
      XR=XCP(1)
      YR=YCP(1)
      PHPV=0.
      IF (IUSR.NE.0.AND.ITN.EQ.0) GO TO 20
      CALL INDVEL (XR,YR,XJ,YJ,ZJ,RJ,RR,PHPV,PHX,TEMP,VU,PHY,ISYM,NGPD,H
     1EIGHT)
   20 CONTINUE
      AW(J1)=AW(J1)+XTT(IG)+PHPV/(ALPC*VU)
      DO 30 I=1,LPANEL
   30 GAMMA(I)=-AW(I+1)/AW(1)
      NJ=LPANEL-1
      DO 60 IJ=2,LPANEL
      READ (01) (AW(K),K=1,J1)
      XR=XCP(IJ)
      YR=YCP(IJ)
      IF (IUSR.NE.0.AND.ITN.EQ.0) GO TO 40
      CALL INDVEL (XR,YR,XJ,YJ,ZJ,RJ,RR,PHPV,PHX,TEMP,VU,PHY,ISYM,NGPD,H
     1EIGHT)
   40 CONTINUE
      AW(J1)=AW(J1)+XTT(IG)+PHPV/(ALPC*VU)
      IK=IJ
      CALL VMSEQN (NJ,IK,AW,GAMMA,CA)
      NJ=NJ-1
      IF (IJ.GE.LPAN1.AND.IJ.LT.LPAN2) NG=NW(2)
      IF (IJ.GE.LPAN2.AND.IJ.LT.LPANEL) NG=NW(3)
      IF (IJ.LT.MG) GO TO 50
      IG=IG+1
      MG=MG+NG
   50 IF (IJ.EQ.LPAN1.OR.IJ.EQ.LPAN2) IG=1
   60 CONTINUE
      DO 70 I=1,LPANEL
   70 GAM(IC,I)=GAMMA(I)
      IF (ABS(R1-R2).LE.0.001) GO TO 80
      IC=IC+1
      RR=R2
      IF (IC.GT.2) GO TO 80
      GO TO 10
   80 CONTINUE
      VMUC=VMU*ALPC
      IPHI=1
      MJ=LPANEL+NCJ(1)
      INN=1
      JNN=1
      I=LAST+1
      READ (01) (AW(K),K=1,LTOTAL)
      CALL STREAM (ALPHA,VMUC,I,IPHI,LPANEL,TEMP,LPAN1,LPAN2,ISYM,KCODE,
     1EXIT,MJ,PHIN)
```

```
      AW(LP1)=ALPHA
      DO 90 I=1,LTOTAL
90    GAMMA(I)=-AW(I+1)/AW(1)
      KI=2
      NI=LTOTAL-1
      LI=LAST+2
      IH=NW(NA)+MJW1(NA,NJP)-1
100   KJ=LI
      IF (LI.GT.LAST) KJ=LI-JPANEL
      READ (01) (AW(K),K=1,LTOTAL)
      CALL STREAM (ALPHA,VMUC,LI,IPHI,LPANEL,TEMP,LPAN1,LPAN2,ISYM,KCODE
     1,EXIT,MJ,PHIN)
      IF (KCODE.EQ.0) GO TO 120
      IF (ZZ.GE.0.01) GO TO 120
C  ADDITIONAL EXTERNAL FLOW DEFLECTION IS ALLOWED IF THE JET ANGLE IS
C     GREATER THAN THE FLAP ANGLE BECAUSE OF THE EFFECT OF FINITE TRAI-
C     LING-EDGE ANGLES. FOR THIN AIRFOILS, THIS CAN BE ELIMINATED BY
C     INSERTING THE STATEMENT, IF (KCODE.EQ.1) GO TO 63
      IF (LI.GE.MJW1(NA,NJP).AND.LI.LE.MJW2(NA,NJP)) GO TO 110
      GO TO 120
110   IF (LI.NE.IH) GO TO 120
      IF ((DEJ-TDE).LT.0.) GO TO 120
      CZT=CAMTER-(CAMTER-CAMTET)*YCP(LI)/HALFB
      APA=0.5*(DEJ-TDE+CZT)
      IF (VMU.GT.0.85) APA=APA*(1.-VMU)/0.15
      IF (APA.LT.0.) APA=0.
      ALPHA=ALPHA+APA
      IH=IH+NW(NA)
120   CONTINUE
      AW(LP1)=ALPHA
      CALL VMSEQN (NI,KI,AW,GAMMA,CA)
      IF (KJ.LT.MJ.OR.KJ.EQ.LAST) GO TO 130
      IPHI=IPHI+1
      MJ=MJ+NCJ(INN)
130   CONTINUE
      MJI=MJJ(INN)-1
      IF (KJ.EQ.MJI) GO TO 140
      GO TO 150
140   JNN=INN
      INN=INN+1
150   IF (KJ.EQ.MJJ(JNN)) IPHI=1
      IF (LI.EQ.LTOTAL) GO TO 160
      GO TO 170
160   CONTINUE
      IPHI=1
      MJ=LPANEL+NCJ(1)
      JNN=1
      INN=1
170   CONTINUE
```

```
      KI=KI+1
      NI=NI-1
      IF (LI.EQ.LTOTAL) GO TO 180
      IF (LI.EQ.LAST) GO TO 190
      LI=LI+1
      GO TO 200
180   LI=LPANEL+1
      GO TO 200
190   LI=1
200   CONTINUE
      IF (KI.LE.LTOTAL) GO TO 100
      IA=2*JPANEL
      JPAN1=JPANEL+1
      IA1=IA+1
      DO 210 I=1,LTOTAL
210   GAMVP(I)=GAMMA(I)
      DO 220 I=IA1,LTOTAL
      J=I-IA
220   GAMMA(I)=(GAMMA(I)+GAM(1,J))*ALPC
      WRITE (02) (GAMMA(I),I=1,LTOTAL)
      IF (IUSR.NE.0.AND.ITN.EQ.0) GO TO 270
      IG=1
      MG=NW(1)
      NG=NW(1)
      REWIND 01
      READ (01) (AW(I),I=1,J1)
      AW(J1)=AW(J1)+XTT(IG)
      DO 230 I=1,LPANEL
230   GAMMA(I)=-AW(I+1)/AW(1)
      NJ=LPANEL-1
      DO 250 IJ=2,LPANEL
      READ (01) (AW(K),K=1,J1)
      AW(J1)=AW(J1)+XTT(IG)
      IK=IJ
      CALL VMSEQN (NJ,IK,AW,GAMMA,CA)
      NJ=NJ-1
      IF (IJ.GE.LPAN1.AND.IJ.LT.LPAN2) NG=NW(2)
      IF (IJ.GE.LPAN2.AND.IJ.LT.LPANEL) NG=NW(3)
      IF (IJ.LT.MG) GO TO 240
      IG=IG+1
      MG=MG+NG
240   IF (IJ.EQ.LPAN1.OR.IJ.EQ.LPAN2) IG=1
250   CONTINUE
      DO 260 I=1,LPANEL
260   GAM(2,I)=GAMMA(I)
      GO TO 290
270   DO 280 I=1,LPANEL
280   GAM(2,I)=GAM(1,I)
290   CONTINUE
```

```
      CAM=CAMLEP
      CAMT=CAMLET
      CALL THRUST (LTOTAL,LPANEL,GAMVP,CAM,LPAN1,VU,XJ,YJ,ZJ,RJ,TEMP,GAL
     1,ISYM,LPAN2,CAMT)
      DO 300 I=1,LPANEL
      IP=I+IA
      IC=1
300   GAMVP(I)=GAMVP(IP)+GAM(IC,I)
      DO 310 I=1,LPANEL
310   CP(I)=GAMVP(I)*2.*ALPC
      C(1)=YCON(22)
      RETURN
C
      END
      SUBROUTINE STREAM (ALPHA,VMU,I,IPHI,LPANEL,TEMP,LPAN1,LPAN2,ISYM,K
     1CODE,EXIT,MJ,PHIN)
C     TO COMPUTE THE RIGHT HAND SIDE OF THE SIMULTANEOUS EQUATIONS
      DIMENSION PHIN(1)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
     1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(95
     3,2),SC(160,5),ST(160,5),LC(3)
      COMMON /AERO/ AM1,AM2,P1,P2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF,NGPD,HEIGHT,ATT
      PI=3.1415926
      IUSP=YCON(24)
      ZJET=YCON(25)
      CMU=C(1)
      IF (IUSP.EQ.2) VMU=0.
      N1=NNJ-1
      N2=NNJ-2
      N3=NNJ-3
      IF (NNJ.EQ.1) N1=1
      NJH=(NSJ+1)/2+1
      IF (ISYM.EQ.0) NJH=NSJ/2
      NP=NJH-1
      IF (ISYM.EQ.0) NP=NJH
      ALPHA=0.
      IF (I.GT.LPANEL) GO TO 10
      GO TO 230
10    IF (I.GT.LAST) GO TO 110
      IF (EXIT.LE.0.001) GO TO 20
      IF (NNJ.EQ.1) GO TO 20
      IF (I.LE.MJJ(1).AND.I.NE.MJ) GO TO 230
20    CONTINUE
```

```
      ALPHA=ALPT*Y(3,IPHI)*(1.-VMU)
      IF (KCODE.EQ.0) ALPHA=0.
      IF (TH.LE.0.001) GO TO 30
      IF (IPHI.EQ.NJH) GO TO 30
      IF (ISYM.NE.0.AND.IPHI.EQ.1) GO TO 30
      IF (NNJ.EQ.1.AND.I.GT.LPANEL) ALPHA=ALPHA+CDF*(1.-VMU)
      IF (NNJ.NE.1.AND.I.GT.MJJ(N1)) ALPHA=ALPHA+CDF*(1.-VMU)
30    CONTINUE
      IF (IUSP.EQ.2) GO TO 40
      IF (ABS(P1-P2).LE.0.001) GO TO 50
40    CONTINUE
      CALL NCPSPD (I,ALPH,LPANEL,IPHI,LPAN1,LPAN2,NGRD,HEIGHT,ATT)
      ALPHA=ALPHA+ALPH
50    IF (KCODE.EQ.0) GO TO 230
      IF (EXIT.LE.0.001) GO TO 60
      IF (NNJ.EQ.1) GO TO 60
      IF (I.LE.MJJ(1).AND.I.EQ.MJ) ALPHA=ALPHA/2.
60    IF (IPHI.EQ.NJH) GO TO 230
      IF (ISYM.NE.0.AND.IPHI.EQ.1) GO TO 230
      IF (IUSP.NE.0.AND.ZJET.GT.0.01) GO TO 230
      IF (CDF.LT.0.0001) GO TO 230
      IF (NNJ.EQ.1) GO TO 70
      IF (I.LE.MJJ(N1)) GO TO 230
70    IF (IPHI.LT.NJH) IL=IPHI+ISYM
      IF (IPHI.GT.NJH) IL=IPHI-NJH+ISYM
      IF (NNJ.EQ.1) MJN1=LPANEL
      IF (NNJ.NE.1) MJN1=MJJ(N1)
      ME=I-MJN1-(IPHI-1)*NCJ(NNJ)
      FNNJ=NCJ(NNJ)
      DISTJ=SDF
      DLX=DISTJ*0.5*PI/FNNJ
      SZX=-(1.-VMU)
      IQ=(IL-1)*NCJ(NNJ)
      IF (NNJ.EQ.1) IP=LPANEL+IQ+1
      IF (NNJ.NE.1) IP=MJJ(N1)+IQ+1
      DO 100 JJ=1,ME
      IF (JJ.EQ.ME) GO TO 80
      IF (IUSP.EQ.2) DXTH=DLX*PSI(JJ)*2./CMU
      IF (IUSP.NE.2) DXTH=DLX*PSI(JJ)*TEMP*VMU*VMU/TH
      GO TO 90
80    IF (IUSP.EQ.2) DXTH=DLX*PSI(JJ)*2.*0.5/CMU
      IF (IUSP.NE.2) DXTH=DLX*PSI(JJ)*TEMP*VMU*VMU*0.5/TH
90    JK1=IP+JJ
      JK2=JK1-1
      PROD=SZX*DXTH
      JK3=JK2+NP*NCJ(NNJ)
      ALPHA=ALPHA+PROD*(PHIN(JK2)-PHIN(JK3))
100   CONTINUE
      GO TO 230
```

```
110   CONTINUE
      IJ=I-JPANEL
      IF (KCODE.EQ.0) GO TO 210
      IF (EXIT.LE.0.01) GO TO 120
      IF (NNJ.EQ.1) GO TO 120
      IF (IJ.GT.LPANEL.AND.IJ.LE.MJJ(1)) GO TO 230
120   CONTINUE
      IF (IUSR.NE.0.AND.ZJET.GT.0.01) GO TO 210
      IF (NNJ.EQ.1) GO TO 210
      IF (IJ.GT.MJJ(N1)) GO TO 210
      IF (IPHI.LE.NJH) GO TO 210
      L1=NJH
      IF (ISYM.EQ.0) L1=NJH+1
      IF (NW(2).EQ.0) GO TO 140
      IF (NW(3).EQ.0) GO TO 130
      IF (IJ.GT.MJJ(N2)) GO TO 170
      IF (IJ.GT.MJJ(N3)) GO TO 160
      IF (NNJ.EQ.4) GO TO 150
      IF (NNJ.EQ.5.AND.IJ.GT.MJJ(NNJ-4)) GO TO 150
      GO TO 210
130   IF (IJ.GT.MJJ(N2)) GO TO 160
      IF (NNJ.EQ.3) GO TO 150
      IF (NNJ.EQ.4.AND.IJ.GT.MJJ(N3)) GO TO 150
      GO TO 210
140   IF (NNJ.EQ.2) GO TO 150
      IF (NNJ.EQ.3.AND.IJ.GT.MJJ(N2)) GO TO 150
      GO TO 210
150   K1=MJW1(1,NJP)+(IPHI-L1-ISYM)*NW(1)-1
      K2=LC(1)+IPHI-L1-ISYM
      KNW=NW(1)
      GO TO 180
160   K1=MJW1(2,NJP)+(IPHI-L1-ISYM)*NW(2)-1
      K2=LC(2)+IPHI-L1-ISYM
      KNW=NW(2)
      GO TO 180
170   K1=MJW1(3,NJP)+(IPHI-L1-ISYM)*NW(3)-1
      K2=LC(3)+IPHI-L1-ISYM
      KNW=NW(3)
180   CONTINUE
      ALPHA1=0.
      ALPHA2=0.
      DO 200 KK=1,KNW
      KL=K1+KK
      AA=1.
      DO 190 L=1,KNW
      LL=K1+L
      IF (L.EQ.KK) GO TO 190
      AA=AA*(XCP(IJ)-XV(LL))/(XV(KL)-XV(LL))
190   CONTINUE
```

```
      ALPHA1=ALPHA1+AA*GAM(1.KL)
      IF (ABS(B1-B2).LE.0.001) GO TO 200
      ALPHA2=ALPHA2+AA*GAM(2.KL)
200   CONTINUE
      IF (ABS(B1-B2).LE.0.001) ALPHA2=ALPHA1
      ALPHA=(ALPHA2-TEMP*VMU*VMU*ALPHA1)*0.5
      GO TO 230
210   CONTINUE
      CALL SPEED (VMU.I.ALPHA.LPANEL.TEMP.LPAN1.LPAN2.PHIS.IPHI.ISYM.NGR
     1D.HEIGHT)
      IF (IUSE.EQ.2) ALPHA=0.
      IF (KCODE.EQ.0) GO TO 230
      IF (CDF.LT.0.0001) GO TO 230
      IF (NNJ.EQ.1) GO TO 220
      IF (IJ.LE.MJJ(N1)) GO TO 230
220   PHIN(IJ)=PHIS
230   CONTINUE
      RETURN
C
      END
      SUBROUTINE THRUST (LTOTAL.LPANEL.GAMMA.CAM.LPAN1.VMU.XJ.YJ.ZJ.PJ.T
     1.GAL.ISYM.LPAN2.CAMLFT)
C     TO EVALUATE THE LEADING EDGE THRUST
      DIMENSION GAMMA(1). GAL(1)
      COMMON /SCHEME/ C(2).X(10.41).Y(10.41).SLOPE(15).XL(2.15).XTT(41).
     1XLL(41)
      COMMON /GEOM/ HALFSW.XCP(200).YCP(200).ZCP(200).XLE(50).YLE(50).XT
     1E(50).PSI(20).CH(95).XV(200).YV(100).SN(8.8).XN(200.2).YN(200.2).Z
     2N(200.2).WIDTH(8).YCON(25).SWEEP(50).HALFB.SJ(21.8).FX(95.2).TX(95
     3.2).SC(160.5).SI(160.5).LC(3)
      COMMON /AERO/ AM1.AM2.B1.B2.CL(30).CT(30).CD(30).GAM(2.100)
      COMMON /CONST/ NCS.NCW.N1(8).NSJ.NCJ(5).LAST.MJW1(3.5).MJW2(3.5).J
     1PANEL.MJJ(5).NW(3).NNJ.NJP
      COMMON /PARAM/ ALPT.ALPC.ALPS.CDF.SDF.TH.TDF.NGRD.HEIGHT.ATT
      PI=3.1415926E
      LG=1
      IF (NGRD.EQ.1) LG=2
      CAMLER=CAM
      CN=NW(1)
      IUSP=YCON(24)
      ITN=YCON(23)
      DO 240 I=1.NCS
      FCOS=COS(SWEEP(I))
      FTAN=TAN(SWEEP(I))
      NK=I*NW(1)
      IF (NW(2).EQ.0) GO TO 20
      II=I+NCS
      IF (NW(3).NE.0) GO TO 10
      CHL=CH(I)+CH(II)
```

```
      GO TO 30
10    III=II+NCS
      CHL=CH(I)+CH(II)+CH(III)
      GO TO 30
20    CHL=CH(I)
30    CONTINUE
      SRT=SQRT(CH(I)/CHL)
      BB=B1
      IC=1
      IZ=1
      MM=0
      ISN=1
      NM=NW(1)
      KP=1+(I-1)*NW(1)
      NL=NW(1)
      BC=0.
      A=0.
      DO 110 NN=1,LPANEL
      J=NN-MM
      FN=NL
      IF (NN.GE.LPAN1.AND.NN.LT.LPANEL) GO TO 40
      GO TO 50
40    NL=NW(2)
      IF (NN.GE.LPAN2.AND.NN.LT.LPANEL) NL=NW(3)
      IF (NN.GT.LPAN1.AND.NN.LE.LPAN2) ISN=2
      IF (NN.GT.LPAN2.AND.NN.LE.LPANEL) ISN=3
50    CONTINUE
      X1=XN(NN,1)-XLE(I)
      X2=XN(NN,2)-XLE(I)
      X12=XN(NN,2)-XN(NN,1)
      Y12=YN(NN,2)-YN(NN,1)
      Z12=0.
      DO 100 K=1,2
      IF (K.EQ.1) GO TO 60
      N1=1
      GO TO 70
60    N1=2
70    CONTINUE
      YC=YLE(I)*(-1.)**N1
      Y1=YN(NN,1)-YC
      Y2=YN(NN,2)-YC
      XYK=X1*Y12-Y1*X12
      DO 100 KK=1,LG
      IF (KK.EQ.1) GO TO 80
      GF=-1.
      ZC=-2.*(ZCP(KP)+HEIGHT)+ZCP(KP)
      FCON=1.
      GO TO 90
80    GF=1.
```

```
      ZC=ZCP(KP)
      ECON=0.
90    Z1=ZN(NN,1)-ZC
      Z2=ZN(NN,2)-ZC
      XZJ=X1*Z12-Z1*X12
      UCON=-Z1*Y12*(-ATT)*ECON
      YZI=Y1*Z12-Z1*Y12
      ALR1=XYK*XYK+XZJ*XZJ+BB*YZI*YZI
      R1=SQRT(X1*X1+BB*Y1*Y1+BB*Z1*Z1)
      R2=SQRT(X2*X2+BB*Y2*Y2+BB*Z2*Z2)
      UUR1=(X2*X12+BB*Y2*Y12+BB*Z2*Z12)/R2-(X1*X12+BB*Y1*Y12+BB*Z1*Z12)/
     1R1
      G1=(1.-X1/R1)/(Y1*Y1+Z1*Z1)
      G2=(1.-X2/R2)/(Y2*Y2+Z2*Z2)
      F1=UUR1*(UCON+XYK)*GE/ALR1
      F2=(-Y2*G2+Y1*G1)*GE
      BC=BC+(F1+F2)*SN(J,ISN)*GAM(2,NN)*CH(IZ)/EN
100   A=A+(F1+F2)*SN(J,ISN)*GAM(IC,NN)*CH(IZ)/EN
      IF (NN.LT.MM.OR.NN.EQ.LPANEL) GO TO 110
      IZ=IZ+1
      MM=NM
      NM=NM+NL
110   CONTINUE
      CAMLE=CAMLER-(CAMLER-CAMLET)*YLE(I)/HALFR
      A=A/8.+XTT(I)-CAMLE
      XB=XLE(I)
      YB=YLE(I)
      PHRV=0.
      IF (IUSR.NE.0.AND.ITN.EQ.0) GO TO 120
      CALL INDVEL (XB,YB,XJ,YJ,ZJ,RJ,R1,PHRV,PHX,T,VMU,PHY,ISYM,NGRD,HEI
     1GHT)
120   CONTINUE
      A=A+PHRV/(ALPC*VMU)
      A=A*SPT
      THRT1=A/(CN*SQRT(ETAN*ETAN+BB))
      XTE(I)=(PI/2.)*SQRT(1.-AM1*AM1*ECOS*ECOS)*THRT1*THRT1/ECOS
      BC=BC/8.+XTT(I)-CAMLE
      BC=BC*SPT
      THR=BC/(CN*SQRT(ETAN*ETAN+BB))
      X(5,I)=(PI/2.)*SQRT(1.-AM1*AM1*ECOS*ECOS)*THR*THR/ECOS
      NM=NW(1)
      IND=1
      ISN=1
      L1=LPANEL+1
      SK=1.
      IZ=1
      MM=0
      II=NW(1)
      A=0.
```

```
      FACTOR=1.
      AM=AM1
      BB=B1
      CONV=ALPC
      DO 230 NN=1,LAST
      IF (NN.GT.LPANEL) NA=NN-LPANEL+JPANEL
      IF (NN.LE.LPANEL) NA=NN+2*JPANEL
      FN=II
      IF (NN.GT.LPAN1.AND.NN.LE.LPAN2) ISN=2
      IF (NN.GT.LPAN2.AND.NN.LE.LPANEL) ISN=3
      IF (NN.GE.LPAN1.AND.NN.LT.LPANEL) GO TO 130
      GO TO 140
130   II=NW(2)
      IF (NN.GE.LPAN2.AND.NN.LT.LPANEL) II=NW(3)
140   CONTINUE
      IF (NN.GE.LPANEL.AND.NN.LT.MJJ(IND)) II=NCJ(IND)
      J=NN-MM
      CHORD=CH(IZ)
      IF (NN.EQ.L1) GO TO 150
      GO TO 160
150   ISN=ISN+1
      L1=MJJ(IND)+1
160   NL=MJJ(IND)-1
      IF (NN.EQ.NL) IND=IND+1
      IF (NN.GT.LPANEL) FACTOR=0.5
      X1=XN(NN,1)-XLE(I)
      X2=XN(NN,2)-XLE(I)
      X12=XN(NN,2)-XN(NN,1)
      Y12=YN(NN,2)-YN(NN,1)
      Z12=ZN(NN,2)-ZN(NN,1)
      DO 210 K=1,2
      IF (K.EQ.1) GO TO 170
      N1=1
      GO TO 180
170   N1=2
180   CONTINUE
      YC=YLE(I)*(-1.)**N1
      Y1=YN(NN,1)-YC
      Y2=YN(NN,2)-YC
      XYK=X1*Y12-Y1*X12
      DO 210 KK=1,LG
      IF (KK.EQ.1) GO TO 190
      GE=-1.
      ZC=-2.*(ZCP(KP)+HEIGHT)+ZCP(KP)
      FCON=1.
      GO TO 200
190   GE=1.
      ZC=ZCP(KP)
      FCON=0.
```

```
200   Z1=ZN(NN.1)-ZC
      Z2=ZN(NN.2)-ZC
      XZJ=X1*Z12-Z1*X12
      UCOM=-Z1*Y12*(-ATT)*ECON
      YZI=Y1*Z12-Z1*Y12
      ALPRIM=XYK*XYK+XZJ*XZJ+BB*YZI*YZI
      RXYZ1=SQRT(X1*X1+BB*Y1*Y1+BB*Z1*Z1)
      RXYZ2=SQRT(X2*X2+BB*Y2*Y2+BB*Z2*Z2)
      UU=(X2*X12+BB*Y2*Y12+BB*Z2*Z12)/RXYZ2-(X1*X12+BB*Y1*Y12+BB*Z1*Z12)
     1/RXYZ1
      GN1=(1.-X1/RXYZ1)/(Y1*Y1+Z1*Z1)
      GN2=(1.-X2/RXYZ2)/(Y2*Y2+Z2*Z2)
      F1=UU*(UCOM+XYK)*GF/ALPRIM
      F2=(GN1*Y1-GN2*Y2)*GF
210   A=A+(F1+F2)*SN(J.ISN)*CHORD*GAMMA(NA)/(8.*EN*FACTOR)
      IF (NN.LT.NM) GO TO 220
      I7=I7+1
      MM=NM
      NM=NM+II
220   CONTINUE
230   CONTINUE
      A=A*SRT
      THRT2=A/(CN*SQRT(ETAN*ETAN+BB))
      THRT=(THRT1+THRT2)*CONV
      GAL(I)=2.*THRT/(SRT*CONV)
      CT(I)=(PI/2.)*SQRT(1.-AM*AM*ECOS*ECOS)*THRT*THRT/ECOS
240   CONTINUE
      RETURN
      END
      SUBROUTINE NORSPD (I.ALPH.LPANEL.IPHI.LPAN1.LPAN2.NGRD.HEIGHT.ATT)
C     TO COMPUTE THE  INDUCED NORMAL VELOCITIES DUE TO WING ALONE
C     VORTICES
      COMMON /SCHEME/ C(2).X(10.41).Y(10.41).SLOPE(15).XL(2,15).XTT(41).
     1XLL(41)
      COMMON /GEOM/ HALFSW.XCP(200).YCP(200).ZCP(200).XLE(50).YLE(50).XT
     1E(50).PSI(20).CH(95).XV(200).YV(100).SN(8.8).XN(200,2).YN(200.2),Z
     2N(200.2).WIDTH(8).YCON(25).SWEEP(50).HALFB.SJ(21.8).EX(95.2).TX(95
     3,2).SC(160.5).ST(160.5).LC(3)
      COMMON /AERO/ AM1.AM2.B1.B2.CL(30).CT(30).CD(30).GAM(2.100)
      COMMON /CONST/ NCS.NCW.M1(8).NSJ,NCJ(5),LAST,MJW1(3.5).MJW2(3.5).J
     1PANEL.MJJ(5).NW(3).NNJ.NJP
      NJP=(NSJ-1)/2
      LG=1
      IUSR=YCON(24)
      IF (NGRD.EQ.1) LG=2
      I7=1
      MM=0
      NM=NW(1)
      ISN=1
```

```
      NL=NW(1)
      A1=0.
      A2=0.
      DO 80 J=1,LPANEL
      JJ=J-MM
      FN=NL
      IF (J.GT.LPAN1.AND.J.LE.LPAN2) ISN=2
      IF (J.GT.LPAN2.AND.J.LE.LPANEL) ISN=3
      IF (J.GE.LPAN1.AND.J.LT.LPANEL) GO TO 10
      GO TO 20
10    NL=NW(2)
      IF (J.GE.LPAN2.AND.J.LT.LPANEL) NL=NW(3)
20    CONTINUE
      X1=XN(J,1)-XCP(I)
      X2=XN(J,2)-XCP(I)
      X12=XN(J,2)-XN(J,1)
      Y12=YN(J,2)-YN(J,1)
      Z12=0.
      DO 70 K=1,2
      IF (K.EQ.1) GO TO 30
      N=1
      GO TO 40
30    N=2
40    CONTINUE
      YC=(-1.)**N*YCP(I)
      Y1=YN(J,1)-YC
      Y2=YN(J,2)-YC
      XYK=X1*Y12-Y1*X12
      DO 70 KK=1,LG
      IF (KK.EQ.1) GO TO 50
      GF=-1.
      ZC=-2.*(ZCP(I)+HEIGHT)+ZCP(I)
      FCON=1.
      GO TO 60
50    GF=1.
      ZC=ZCP(I)
      FCON=0.
60    Z1=ZN(J,1)-ZC
      Z2=ZN(J,2)-ZC
      XZJ=X1*Z12-Z1*X12
      UCOM=-Z1*Y12*(-ATT)*FCON
      YZI=Y1*Z12-Z1*Y12
      ALB1=XYK*XYK+XZJ*XZJ+B1*YZI*YZI
      R1B1=SQRT(X1*X1+B1*Y1*Y1+B1*Z1*Z1)
      R2B1=SQRT(X2*X2+B1*Y2*Y2+B1*Z2*Z2)
      UUB1=(X2*X12+B1*Y2*Y12+B1*Z2*Z12)/R2B1-(X1*X12+B1*Y1*Y12+B1*Z1*Z12
     1)/R1B1
      G1=(1.-X1/R1B1)/(Y1*Y1+Z1*Z1)
      G2=(1.-X2/R2B1)/(Y2*Y2+Z2*Z2)
```

```
      ALB2=XYK*XYK+XZJ*XZJ+B2*YZI*YZI
      R1B2=SQRT(X1*X1+B2*Y1*Y1+B2*Z1*Z1)
      R2B2=SQRT(X2*X2+B2*Y2*Y2+B2*Z2*Z2)
      UUB2=(X2*X12+B2*Y2*Y12+B2*Z2*Z12)/R2B2-(X1*X12+B2*Y1*Y12+B2*Z1*Z12
     1)/R1B2
      G3=(1.-X1/R1B2)/(Y1*Y1+Z1*Z1)
      G4=(1.-X2/R2B2)/(Y2*Y2+Z2*Z2)
      F13=UUB1*XZJ/ALB1
      F12=UUB1*XYK/ALB1
      G13=Z2*G2-Z1*G1
      G12=-Y2*G2+Y1*G1
      F23=UUB2*XZJ/ALB2
      F22=UUB2*XYK/ALB2
      G23=Z2*G4-Z1*G3
      G22=-Y2*G4+Y1*G3
      F1=-F13*Y(4,IPHI)*(-1.)**N+F12*Y(3,IPHI)*GE
      F2=G13*Y(4,IPHI)*(-1.)**N+G12*Y(3,IPHI)*GE
      F3=-F23*Y(4,IPHI)*(-1.)**N+F22*Y(3,IPHI)*GE
      F4=G23*Y(4,IPHI)*(-1.)**N+G22*Y(3,IPHI)*GE
      A1=A1+(F1+F2)*CH(IZ)*SN(JJ,ISN)*GAM(1,J)/FN
   70 A2=A2+(F3+F4)*CH(IZ)*SN(JJ,ISN)*GAM(2,J)/FN
      IF (J.LT.NM) GO TO 80
      IZ=IZ+1
      MM=NM
      NM=NM+NL
   80 CONTINUE
      IF (IUSR.EQ.2) ALPH=A1/8.
      IF (IUSR.NE.2) ALPH=(A1-A2)/8.
      RETURN
      END
      SUBROUTINE SPEED (VWU,I,ALPHA,LPANEL,TEMP,LPAN1,LPAN2,PHIS,IPHI,IS
     1YM,NGRD,HEIGHT)
C     TO COMPUTE THE INDUCED TANGENTIAL VELOCITIES DUE  TO WING ALONE
C     VORTICES
      DIMENSION SU(100)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1YLL(41)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
     1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(95
     3,2),SC(160,5),ST(160,5),IC(3)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      N1=NNJ-1
      N2=NNJ-2
      N3=NNJ-3
      ZJET=YCON(25)
      II=I-JPANEL
```

```
      PP=P1
      IC=1
      LG=1
      IF (NGRD.EQ.1) LG=2
10    CONTINUE
      IZ=1
      MM=0
      ISN=1
      NL=NW(1)
      NM=NW(1)
      P=0.
      DO 90 J=1,LPANEL
      JJ=J-MM
      FN=NL
      IF (J.GT.LPAN1.AND.J.LE.LPAN2) ISN=2
      IF (J.GT.LPAN2.AND.J.LE.LPANEL) ISN=3
      IF (J.GE.LPAN1.AND.J.LT.LPANEL) GO TO 20
      GO TO 30
20    NL=NW(2)
      IF (J.GE.LPAN2.AND.J.LT.LPANEL) NL=NW(3)
30    CONTINUE
      X1=XN(J,1)-XCP(II)
      X2=XN(J,2)-XCP(II)
      X12=XN(J,2)-XN(J,1)
      Y12=YN(J,2)-YN(J,1)
      Z12=0.
      DO 80 K=1,2
      IF (K.EQ.1) GO TO 40
      N=1
      GO TO 50
40    N=2
50    CONTINUE
      YC=(-1.)**N*YCP(II)
      Y1=YN(J,1)-YC
      Y2=YN(J,2)-YC
      XYK=X1*Y12-Y1*X12
      DO 80 KK=1,LG
      IF (KK.EQ.1) GO TO 60
      GF=-1.
      ZC=-2.*(ZCP(II)+HEIGHT)+ZCP(II)
      FCON=1.
      GO TO 70
60    GF=1.
      ZC=ZCP(II)
      FCON=0.
70    Z1=ZN(J,1)-ZC
      Z2=ZN(J,2)-ZC
      XZJ=-Z1*X12
      YZI=-Z1*Y12
```

```
      ALP1=XYK*XYK+XZJ*XZJ+BB*YZI*YZI
      R1P1=SQRT(X1*X1+BB*Y1*Y1+BB*Z1*Z1)
      R2P1=SQRT(X2*X2+BB*Y2*Y2+BB*Z2*Z2)
      UUP1=(X2*X12+BB*Y2*Y12+BB*Z2*Z12)/R2P1-(X1*X12+BB*Y1*Y12+BB*Z1*Z12
     1)/R1P1
      F1=UUP1*YZI/ALP1
      SUM=F1*CH(IZ)*SN(JJ,ISN)*GAM(IC,J)/FN
      IF (K.EQ.1.AND.KK.EQ.1) SU(J)=F1*CH(IZ)*SN(JJ,ISN)/FN
90    B=B+SUM
      IF (J.LT.NM) GO TO 50
      IZ=IZ+1
      MM=NM
      NM=NM+NL
50    CONTINUE
      NJH=(NSJ+1)/2+1
      IF (ISYM.EQ.0) NJH=NSJ/2
      IF (IPHI.EQ.NJH) GO TO 160
      IF (ISYM.NE.0.AND.IPHI.EQ.1) GO TO 160
      IF (NNJ.EQ.1) GO TO 160
      IF (II.GT.NJJ(N1)) GO TO 160
      IF (IPHI.GT.NJH.AND.ZJET.LE.0.01) GO TO 160
      IF (IPHI.GT.NJH) L1=NJH
      IF (ISYM.EQ.0.AND.IPHI.GT.NJH) L1=NJH+1
      IF (IPHI.LE.NJH) L1=1
      NZ=1
      IF (NW(2).NE.0.AND.NW(3).EQ.0) NZ=2
      IF (NW(3).NE.0) NZ=3
      IF (NNJ.LE.3.AND.NW(2).NE.0) IP=N2
      IF (NNJ.LE.3.AND.NW(2).EQ.0) IP=N1
      IF (NNJ.GE.4.AND.NW(3).NE.0) IP=N3
      IF (NNJ.EQ.4.AND.NW(3).EQ.0) IP=N2
      DO 150 MP=1,NZ
      K1=MJW1(MP,NJP)+(IPHI-L1-ISYM)*NW(MP)-1
      K2=LC(MP)+IPHI-L1-ISYM
      KNW=NW(MP)
      K1=K1-KNW
      K2=K2-1
      MR=3
      IF (K1.GE.0) GO TO 100
      K1=K1+KNW
      K2=K2+1
      MR=2
100   DO 140 NR=1,MR
      SUM=0.
      DO 110 KK=1,KNW
      KL=K1+KK
110   SUM=SUM+SU(KL)
      CALL INTEG (RES,KNW,K1,K2,II,BB,IP)
      CORN=0.
```

```
      DO 130 KK=1,KNW
      KL=K1+KK
      AA=1.
      DO 120 L=1,KNW
      LL=K1+L
      IF (L.EQ.KK) GO TO 120
      AA=AA*(XCP(II)-XV(LL))/(XV(KL)-XV(LL))
120   CONTINUE
130   CORN=CORN+AA*GAM(IC,KL)
      B=B-CORN*SUM+CORN*RES*8.
      K1=K1+KNW
      K2=K2+1
140   CONTINUE
      IP=IP+1
150   CONTINUE
160   CONTINUE
      IF (IC.EQ.2) GO TO 170
      ALPHA1=B/A.
      IC=IC+1
      B8=B2
      IF (ABS(B1-B2).LE.0.001) GO TO 180
      GO TO 10
170   ALPHA2=B/A.
      GO TO 190
180   ALPHA2=ALPHA1
190   ALPHA=ALPHA2-TEMP*VMU*VMU*ALPHA1
      PHIS=ALPHA2
      RETURN
C
      END
      SUBROUTINE INDVEL (XP,Y,XJ,YJ,ZJ,RJ,R2,PHPV,PHX,T,U,PHY,ISYM,NGRD,
     1HEIGHT)
C     TO COMPUTE THE INDUCED VELOCITIES DUE TO JET ENTRAINMENT
      DIMENSION VZ(2), VX(2), VY(2)
      COMMON /JET/ PK1,XC,X(31),A(31),B(31)
      REJ=T
      LG=1
      IF (NGRD.EQ.1) LG=2
      VZ(2)=0.
      VX(2)=0.
      VY(2)=0.
      SRJ=SQRT(REJ)
      XB=(XP-XJ)/RJ
      NCOT=ISYM+1
      DO 40 K=1,NCOT
      VX(K)=0.
      VY(K)=0.
      VZ(K)=0.
      IF (K.EQ.1) EC=1.
```

```
      IF (K.EQ.2) EC=-1.
      DO 40 KK=1,LG
      IF (KK.EQ.1) ZC=ZJ
      IF (KK.EQ.2) ZC=-(ZJ+2.*HEIGHT)
      RR=SQRT(ZC*ZC+(Y*EC-YJ)**2)/BJ
      F1=SQRT((XB-XC)**2+B2*RR*RR)
      F2=SQRT(XB**2+B2*RR*RR)
      G10=(XB-XC)/F1-XB/F2
      G20=1./F1-1./F2
      SUMR=-(A(1)+B(1)*XB)*G10/RR-B2*RR*B(1)*G20
      SUMX=(A(1)+B(1)*XB)*G20-B(1)*G10+B(1)*ALOG((XB-XC+F1)/(XB+F2))
      IF (U.LE.0.01) GO TO 20
      J=2
10    SUM1=SUMR
      SUM2=SUMX
      F1=SQRT((XB-X(J))**2+B2*RR*RR)
      F2=SQRT((XB-X(J-1))**2+B2*RR*RR)
      G1=(XB-X(J))/F1-(XB-X(J-1))/F2
      G2=1./F1-1./F2
      SUMR=SUMR-(A(J)+B(J)*XB)*G1/RR-B2*RR*B(J)*G2
      SUMX=SUMX+(A(J)+B(J)*XB)*G2-B(J)*G1+B(J)*ALOG((XB-X(J)+F1)/(XB-X(J
     1-1)+F2))
      IF (J.GE.31) GO TO 30
      J=J+1
      GO TO 10
20    SUMR=SUMR+0.32*(1.+(XB-XC)/F1)/RR
      SUMX=SUMX-0.32/F1
30    PHRV=SBJ*0.25*SUMR*ZC/(RR*BJ)
      PHY=-SBJ*0.25*SUMR*(Y-YJ*EC)/(RR*BJ)
      PHX=-SBJ*0.25*SUMX
      VX(K)=PHX/2.+VX(K)
      VY(K)=PHY/2.+VY(K)
40    VZ(K)=PHRV/2.+VZ(K)
      PHRV=VZ(1)+VZ(2)
      PHX=VX(1)+VX(2)
      PHY=VY(1)+VY(2)
      RETURN
C
      END
      OVERLAY (USBIGE,5,0)
      PROGRAM LOAD
C     TO EVALUATE THE AERODYNAMIC CHARACTERISTICS
      DIMENSION CA(30), CBSWL(30), AW(30), GAMJ(200), GAMW1(100), GAMW2(
     1100)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
     1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(95
     3,2),SC(160,5),SI(160,5),LC(3)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
```

```
      COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),JL
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF,NGRD,HEIGHT,ATT
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISYM,VMU,VU
     1,TEMP,FCP,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTP
      COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFP
      PI=3.14159265
      REWIND 02
      READ (02) (GAMJ(J),J=1,LTOTAL)
      DO 10 I=1,LPANEL
      GAMW1(I)=GAM(1,I)*ALPC
   10 GAMW2(I)=GAM(2,I)*ALPC
      ALPH=ALP*180./PI
      WRITE (6,360)
      WRITE (6,350) ALPH
      WRITE (6,360)
      ZJET=YCON(25)
      IUSR=YCON(24)
      ITN=YCON(23)
      XAC=CL(30)
      NC=IENTN
      DFJ=CDF
      CMU=C(1)
      CLT=0.
      CMT=0.
      CDT=0.
      CLW=0.
      CMWT=0.
      CDW=0.
      CLWW=0.
      CMWWT=0.
      CDWW=0.
      KC=1
      NCOL=M1(1)
      KLL=0
      MM=0
      IU=1
      IF (NW(2).NE.0) IU=2
      IF (NW(3).NE.0) IU=3
      NW2=NW(1)+NW(2)
      NW3=NW(2)+NW(3)
      NCW1=NCW+1
      NL=1
      DO 170 J=1,NCS
      IF (NW(2).EQ.0) GO TO 30
      II=I+NCS
```

```
      IF (NW(3).NE.0) GO TO 20
      CHORD=CH(I)+CH(II)
      GO TO 40
20    III=II+NCS
      CHORD=CH(I)+CH(II)+CH(III)
      GO TO 40
30    CHORD=CH(I)
40    CONTINUE
      CML=0.
      CL(I)=0.
      CD(I)=0.
      CA(I)=0.
      CMW=0.
      CPSWL(I)=0.
      CMWW=0.
      X(4,I)=0.
      X(6,I)=0.
      X(7,I)=0.
      DO 150 J=1,NCW
      NN=J+MM
      IF (NW(2).EQ.0) GO TO 60
      IF (J.LE.NW(1)) GO TO 60
      IF (J.GT.NW2) GO TO 50
      LL=LPAN1+NW(2)*(I-1)+J-NW(1)
      IL=II
      JLL=J-NW(1)
      L=2
      FN=NW(2)
      GO TO 70
50    LL=LPAN2+NW(3)*(I-1)+J-NW2
      IL=III
      JLL=J-NW2
      L=3
      FN=NW(3)
      GO TO 70
60    LL=NN
      IL=I
      JLL=J
      L=1
      FN=NW(1)
70    CONTINUE
      XC=(XV(LL)-XLE(I))/CHORD
      X(1,J)=ZCB(XC)
      X(2,J)=ZCT(XC)
      UJ=0.
      U1=0.
      U2=0.
      IF (NGRD.EQ.0) GO TO 90
      DZ=0.
```

```
      ZCW=-2.*(ZN(LL,1)+HEIGHT)+ZN(LL,1)-DZ
      CALL BACKWH (XV(LL),YV(LL),ZCW,LAST,LPANEL,P1,LPAN1,LPAN2,NW,GAMJ,
     1UJ,LAST,NCJ,MJJ)
      CALL BACKWH (XV(LL),YV(LL),ZCW,LAST,LPANEL,P1,LPAN1,LPAN2,NW,GAMW2
     1,U2,0,NCJ,MJJ)
      IF (IUSP.NE.0.AND.ITN.EQ.0) GO TO 80
      CALL BACKWH (XV(LL),YV(LL),ZCW,LAST,LPANEL,P1,LPAN1,LPAN2,NW,GAMW1
     1,U1,0,NCJ,MJJ)
      GO TO 90
80    U1=U2
90    CONTINUE
      GPS=CP(LL)*(1.+UJ)*SN(JLL,L)*CH(IL)/(2.*FN)
      WPS=GAM(1,LL)*SN(JLL,L)*CH(IL)*ALPC*(1.+U1)/FN
      WAS=GAM(2,LL)*SN(JLL,L)*CH(IL)*ALPC*(1.+U2)/FN
      CP(LL)=CP(LL)*(1.+UJ)
      GAM(2,LL)=GAM(2,LL)*(1.+U2)
      IF (DF(NL).LE.0.001) GO TO 100
      IF (PTIAL.LE.0.1) GO TO 110
      IF (NW(3).EQ.0) GO TO 130
      IF (LL.GE.MJW1(3,NL).AND.LL.LE.MJW2(3,NL)) GO TO 120
100   CAM=X(1,J)-(X(1,J)-X(2,J))*YV(LL)/HALFB
      EPHA=XLL(I)-ATAN(CAM)
      CS=COS(EPHA)
      SS=SIN(EPHA)
      GO TO 140
110   IF (NW(2).NE.0.AND.LL.LE.LPAN1) GO TO 100
      IF (NW(3).NE.0.AND.LL.LE.LPAN2) GO TO 100
120   FP=XLL(I)+DF(NL)
      CAM=X(1,J)-(X(1,J)-X(2,J))*YV(LL)/HALFB
      FP=FP-ATAN(CAM)
      CS=COS(FP)
      SS=SIN(FP)
      GO TO 140
130   IF (LL.GE.MJW1(2,NL).AND.LL.LE.MJW2(2,NL)) GO TO 120
      GO TO 100
140   CONTINUE
      CL(I)=CL(I)+GPS*CS
      CML=CML-GPS*XV(LL)*CS
      CD(I)=CD(I)+GPS*SS
      CA(I)=CA(I)+WPS*CS
      CMW=CMW-WPS*XV(LL)*CS
      CPSWL(I)=CPSWL(I)+WPS*SS
      X(4,I)=X(4,I)+WAS*CS
      CMWW=CMWW-WAS*XV(LL)*CS
      X(6,I)=X(6,I)+WAS*SS
150   CONTINUE
      CAMLE=CAMLER-(CAMLER-CAMLET)*YLE(I)/HALFB
      EPHA=YLL(I)-ATAN(CAMLE)
      X(1,NCW1)=COS(EPHA)
```

```
      X(2,NCW1)=SIN(EPHA)
      CL(I)=CL(I)*PI/CHORD+CT(I)*X(2,NCW1)
      CM(I)=CML*PI/(CREF*CHORD)
      CD(I)=CD(I)*PI/CHORD-CT(I)*X(1,NCW1)
      CA(I)=CA(I)*PI/CHORD+XTE(I)*X(2,NCW1)
      AW(I)=CMW*PI/(CREF*CHORD)
      CPSWL(I)=CPSWL(I)*PI/CHORD-XTE(I)*X(1,NCW1)
      X(4,I)=X(4,I)*PI/CHORD+X(5,I)*X(2,NCW1)
      X(7,I)=CMWW*PI/(CREF*CHORD)
      X(6,I)=X(6,I)*PI/CHORD-X(5,I)*X(1,NCW1)
      IF (I.LT.NCOL) GO TO 160
      KLL=NCOL-1
      KC=KC+1
      NCOL=NCOL+M1(KC)-1
160   KL=I-KLL
      FM=M1(KC)
      AA=CHORD*SJ(KL,KC)*WIDTH(KC)/FM
      CLT=CLT+CL(I)*AA
      CMT=CMT+CM(I)*AA
      CDT=CDT+CD(I)*AA
      CLW=CLW+CA(I)*AA
      CMWT=CMWT+AW(I)*AA
      CDW=CDW+CPSWL(I)*AA
      CLWW=CLWW+X(4,I)*AA
      CMWWT=CMWWT+X(7,I)*AA
      CDWW=CDWW+X(6,I)*AA
      MM=(NCW-NW3)*I
      IF (LL.EQ.MJW2(IU,ML)) ML=ML+1
170   CONTINUE
      CLT=CLT*PI/(2.*HALFSW)
      CMT=CMT*PI/(2.*HALFSW)
      CDT=CDT*PI/(2.*HALFSW)
      CDCL2=CDT/(CLT*CLT)
      CLW=CLW*PI/(2.*HALFSW)
      CMWT=CMWT*PI/(2.*HALFSW)
      CDW=CDW*PI/(2.*HALFSW)
      CLWW=CLWW*PI/(2.*HALFSW)
      CMWWT=CMWWT*PI/(2.*HALFSW)
      CDWW=CDWW*PI/(2.*HALFSW)
      IF (CLWW.LE.0.001) GO TO 180
      CDWL2=CDWW/(CLWW*CLWW)
      GO TO 190
180   CDWL2=0.
190   CONTINUE
      WRITE (6,370)
      K1=0
      JJ1=0
      DO 270 I=1,NCS
      IF (NW(2).EQ.0) GO TO 210
```

```
      II=I+NCS
      IF (NW(3).NE.0) GO TO 200
      CHORD=CH(I)+CH(II)
      GO TO 220
200   III=II+NCS
      CHORD=CH(I)+CH(II)+CH(III)
      GO TO 220
210   CHORD=CH(I)
220   CONTINUE
      DO 260 J=1,NCW
      JJ=JJ1+J
      KK=K1+J
      IF (NW(2).EQ.0) GO TO 240
      IF (J.LE.NW(1)) GO TO 240
      IF (J.GT.NW2) GO TO 230
      LL=LPAN1+NW(2)*(I-1)+J-NW(1)
      GO TO 250
230   LL=LPAN2+NW(3)*(I-1)+J-NW2
      GO TO 250
240   LL=JJ
250   CONTINUE
      XI=(XV(LL)-XLE(I))/CHORD
      ETA=YV(LL)/HALFB
      CPW=2.*GAM(2,LL)*ALPC
260   WRITE (6,380) KK,XI,ETA,CP(LL),CPW
      JJ1=(NCW-NW3)*I
      K1=K1+NCW
270   CONTINUE
      WRITE (6,390)
      DO 280 I=1,NCS
      YE=YLE(I)/HALFB
280   WRITE (6,400) YE,CL(I),CM(I),CT(I),CD(I),X(4,I),X(7,I),X(6,I)
      WRITE (6,410) CLT
      WRITE (6,420) CDT
      WRITE (6,430) CDCL2
      WRITE (6,440) CMT
      IF (IUSB.EQ.0) GO TO 330
      IF (ZJET.GT.0.01) GO TO 330
      SDEJ=SIN(DEJ)
      CDEJ=COS(DEJ)
      CLB=CMU*SIN(DEJ+ALP)
      CDB=CMU*(VMU-COS(DEJ+ALP))
      CF=COS(TDF)
      SF=SIN(TDF)
      IF (NNJ.EQ.1) CDB=-CMU*COS(DEJ+ALP)
      IJ=(NSJ+1)/2-1
      IF (ISYM.EQ.0) IJ=NSJ/2-1
      IF (NW(3).NE.0) GO TO 290
      IF (NW(2).EQ.0) GO TO 300
```

```
      I7=NCS+(MJW1(2,NJP)-LPAN1-1)/NW(2)+1
      KJ=MJW1(2,NJP)
      NN=NW(2)
      GO TO 310
290   I7=NCS*2+(MJW1(3,NJP)-LPAN2-1)/NW(3)+1
      KJ=MJW1(3,NJP)
      NN=NW(3)
      GO TO 310
300   I7=LC(1)
      KJ=MJW1(1,NJP)
      NN=NW(1)
310   CONTINUE
      CM1=0.
      DO 320 I=1,IJ
      YDIF=YN(KJ,2)-YN(KJ,1)
      CM1=CM1+YDIF/WIDTH(NJW(NJP))*((XLE(I7)+CH(I7)*CF)*SDFJ-CH(I7)*SF*C
     1DFJ)
      KJ=KJ+NN
320   I7=I7+1
      CMP=-CM1*CMU/CREF
      IF (NNJ.NE.1) WRITE (6,450) CLP
      IF (NNJ.EQ.1) WRITE (6,460) CLP
      IF (NNJ.NE.1) WRITE (6,470) CDP
      IF (NNJ.EQ.1) WRITE (6,480) CDP
      IF (DFJ.LE.0.001) GO TO 330
      IF (NNJ.NE.1) WRITE (6,490) CMP
      IF (NNJ.EQ.1) WRITE (6,500) CMP
330   CONTINUE
      IF (IUSR.NE.0) GO TO 340
      WRITE (6,510) CLW
      WRITE (6,520) CDW
      WRITE (6,530) CMWT
340   CONTINUE
      WRITE (6,540) CLWW
      WRITE (6,550) CDWW
      WRITE (6,560) CMWWT
      WRITE (6,570) CDWL2
      RETURN
C
350   FORMAT (1H0,26X,7HALPHA =,F10.3,3X,7HDEGREES)
360   FORMAT (1H0,20X,40HXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX)
370   FORMAT (1H0,3X,6HVORTEX,14X,2HXV,17X,2HYV,19X,2HCP,19X,3HCPW)
380   FORMAT (6X,I3,4(10X,F10.5))
390   FORMAT (1H0,9X,4HY/SP,11X,2HCL,13X,2HCM,12X,2HCT,13X,3HCDI,12X,3HC
     1LW,12X,3HCMW,12X,3HCDW)
400   FORMAT (8(5X,F10.5))
410   FORMAT (1H0,22HTHE LIFT COEFFICIENT =,F10.5)
420   FORMAT (1H0,32HTOTAL INDUCED DRAG COEFFICIENT =,F10.5)
430   FORMAT (1H0,28HTHE INDUCED DRAG PARAMETER =,F10.5)
```

```
440   FORMAT (1H0,25HTOTAL PITCHING MOMENT COEFFICIENT =,F10.5)
450   FORMAT (1H0,34HTHE COANDA LIFT COEFFICIENT, CLR =,F10.5)
460   FORMAT (1H0,47HTHE LIFT COEFFICIENT DUE TO JET REACTION, CLJ =,F10
     1.5)
470   FORMAT (1H0,34HTHE COANDA DRAG COEFFICIENT, CDR =,F10.5)
480   FORMAT (1H0,47HTHE DRAG COEFFICIENT DUE TO JET REACTION, CDJ =,F10
     1.5)
490   FORMAT (1H0,36HTHE COANDA MOMENT COEFFICIENT, CMR =,F10.5)
500   FORMAT (1H0,59HTHE PITCHING MOMENT COEFFICIENT DUE TO JET REACTION
     1, CMJ =,F10.5)
510   FORMAT (1H0,2X,45HTHE LIFT COEFFICIENT WITH JET ENTRAINMENT ALONE
     1=,F10.5)
520   FORMAT (1H0,2X,57HTHE INDUCED DRAG COEFFICIENT WITH JET ENTRAINMEN
     1T ALONE =,F10.5)
530   FORMAT (1H0,2X,60HTHE PITCHING MOMENT COEFFICIENT WITH JET ENTRAIN
     1MENT ALONE =,F10.5)
540   FORMAT (1H0,40HTHE LIFT COEFFICIENT FOR THE WING ALONE=,F10.5)
550   FORMAT (1H0,48HTHE INDUCED DRAG COEFFICIENT FOR THE WING ALONE=,F1
     10.5)
560   FORMAT (1H0,51HTHE PITCHING MOMENT COEFFICIENT FOR THE WING ALONE=
     1,F10.5)
570   FORMAT (1H0,46HTHE INDUCED DRAG PARAMETER FOR THE WING ALONE=,F10.
     15)
      END
      SUBROUTINE BACKWH (X,Y,Z,LAST,LPANEL,B1,LPAN1,LPAN2,NW,GAMMA,VX,JL
     1,NCJ,MJJ)
C
C     TO EVALUATE THE BACKWASH ON THE WING DUE TO IMAGE VORTEX SYSTEMS
      DIMENSION NW(1), GAMMA(1), U(2), NCJ(1), MJJ(1)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(50),YLE(50),XT
     1E(50),PSI(20),CH(95),XV(200),YV(100),SN(8,8),XN(200,2),YN(200,2),Z
     2N(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(95
     3,2),SC(160,5),ST(160,5),LC(3)
      PI=3.14159265
      ICON=LPANEL
      IF (JL.EQ.LAST) ICON=LAST
      IA=2*(LAST-LPANEL)
      IB=LAST-LPANEL
      IZ=1
      IFF=1
      ISN=1
      MM=NW(1)
      NN=NW(1)
      IND=1
      L1=LPANEL+1
      LAST1=LAST-1
      VX=0.
      DO 80 J=1,ICON
      MT=J-IFF+1
```

```
      FN=NN
      IF (J.GT.LPANEL) GO TO 20
      IF (J.GT.LPAN1.AND.J.LE.LPAN2) ISN=2
      IF (J.GT.LPAN2.AND.J.LE.LPANEL) ISN=3
      IF (J.GE.LPAN1.AND.J.LT.LPANEL) GO TO 10
      GO TO 20
10    NN=NW(2)
      IF (J.GE.LPAN2.AND.J.LT.LPANEL) NN=NW(3)
20    CONTINUE
      IF (J.GE.LPANEL.AND.J.LT.MJJ(IND)) NN=NCJ(IND)
      IF (JL.EQ.0) GO TO 50
      IF (J.EQ.L1) GO TO 30
      GO TO 40
30    ISN=ISN+1
      L1=MJJ(IND)+1
40    ML=MJJ(IND)-1
      IF (ML.EQ.LAST1) GO TO 50
      IF (J.EQ.ML) IND=IND+1
50    CONTINUE
      JJ=J
      IF (J.LE.LPANEL.AND.JL.EQ.LAST) JJ=J+IA
      IF (J.GT.LPANEL.AND.JL.EQ.LAST) JJ=J+IB-LPANEL
      CHORD=CH(IZ)
      X1=XN(J,1)-X
      X2=XN(J,2)-X
      X12=XN(J,2)-XN(J,1)
      Y12=YN(J,2)-YN(J,1)
      Z12=ZN(J,2)-ZN(J,1)
      Z1=ZN(J,1)-Z
      Z2=ZN(J,2)-Z
      XZJ=X1*Z12-Z1*X12
      DO 70 II=1,2
      FCP=1.
      IF (II.EQ.2) FCP=-1.
      YC=Y*FCP
      Y1=YN(J,1)-YC
      Y2=YN(J,2)-YC
      XYK=X1*Y12-Y1*X12
      YZI=Y1*Z12-Z1*Y12
      ALB1=XYK*XYK+XZJ*XZJ+B1*YZI*YZI
      R1B1=SQRT(X1*X1+B1*Y1*Y1+B1*Z1*Z1)
      R2B1=SQRT(X2*X2+B1*Y2*Y2+B1*Z2*Z2)
      UUB1=(X2*X12+B1*Y2*Y12+B1*Z2*Z12)/R2B1-(X1*X12+B1*Y1*Y12+B1*Z1*Z12
     1)/R1B1
      F3=UUB1*YZI/ALB1
      IF (J.LE.LPANEL) GO TO 60
      F3=2.*F3
60    CONTINUE
      U(II)=F3*CHORD*SN(MI,ISN)*GAMMA(JJ)/(8.*FN),
```

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70    CONTINUE                                                          BCH 750
      VX=U(1)+U(2)+VX                                                   BCH 760
      IF (J.LT.MM) GO TO 80                                             BCH 770
      I7=I7+1                                                           BCH 780
      IFF=MM+1                                                          BCH 790
      MM=MM+NN                                                          BCH 800
80    CONTINUE                                                          BCH 810
      RETURN                                                            BCH 820
      END                                                               BCH 830-
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15. Supplementary Notes

16. Abstract

A theoretical wing-jet interaction theory is presented for predicting the ground effects for upper-surface-blowing configurations. The formulation predicts the variation of circulation forces and jet reaction forces in ground proximity as a function of ground height. The predicted results agree well with available experimental data. It is shown that the wing-alone theory is not capable of predicting the ground effect for USB configurations.

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