NASA Contractor Report 145344

MINIMUM INDUCED DRAG CONFIGURATIONS WITH JET INTERACTION

Jenn Louh Pao and C. Edward Lan

THE UNIVERSITY OF KANSAS CENTER FOR RESEARCH, INC.
Lawrence, KA 66045

February 1978

MAY 1978
RECEIVED
NASA STI FACILITY

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23665

Minimum Induced Drag Configurations
with Jet Interaction

by

Jenn Louh Pao

and

C. Edward Lan

Technical Report CRINC-FRL-281-2

February 1978

The Flight Research Laboratory
The University of Kansas Center for Research, Inc.
Lawrence, Kansas 66045

Prepared under NASA Grant NSG 1139

for

Langley Research Center
National Aeronautics and Space Administration

Table of Contents

Summary

A theoretical method is presented here for determining the optimum camber shape and twist distribution for the minimum induced drag in the wing-alone case without prescribing the span loading shape. The same method was applied to find the corresponding minimum induced drag configuration with the upper-surface-blowing jet. Lan's Quasi-Vortex-Lattice Method and his wing-jet interaction theory has been used. Comparison of the predicted results with another theoretical method shows good agreement for configurations without the blowing jet. More applicable experimental data with blowing jets are needed to establish the accuracy of the theory.

1. LIST OF SYMBOLS

$[A]$	matrix $[N_{WW}]$ after transformation
a_j	Fourier series coefficient
a_{kj}	the element of the transformation matrix $[A]$
AR	aspect ratio
$[B]$	matrix $[N_{WJ}]$ after transformation
b	span
b_{kn}	the element of the transformation matrix $[B]$
c	chord length
$\bar{c}$	reference chord length
c_a	average chord length
$c_{d,i}$	sectional induced drag coefficient
c_ℓ	sectional lift coefficient
c_m	sectional pitching moment coefficient
C_L	total lift coefficient
$\bar{C}_L$	lift constraint
C_m	total pitching moment coefficient
$\bar{C}_m$	pitching moment constraint
ΔC_p	pressure coefficient
C_μ	jet-momentum coefficient
d_i	local induced drag
$\vec{e}$	unit vector tangent to jet path
E_k	step direction vector defined by Eq. (42)
f_1, f_2, f_3	the length of each section in the spanwise direction
g_n	a scalar defined by Eq. (26.a)
h_1, h_2	the length of each section in the chordwise direction
$[I]$	interpolation matrix

ℓ	local lift
M	Mach number
M_1,M_2,M_3	the numbers of spanwise strips plus one in each section
$\vec{n}$	unit vector normal to jet surface
n,s	jet axis system
$[N]$	normal velocity influence-coefficient matrix
N_1,N_2	numbers of vortices in each section along the chordwise direction
N_c	$= N_1 + N_2$
N_j	total number of jet vortices in the outer flow
N_t	total number of wing vortices over the semi-span
q	dynamic pressure
$[S]$	tangential velocity influence-coefficient matrix
S_w	wing area
T	$= \rho_o/\rho_j$
t_j	jet thickness
V	velocity
$\vec{V}$	unperturbed velocity vector
$\vec{v}$	perturbed velocity vector
$\vec{v}_{je}$	jet-entrained-flow velocity vector
x,y,z	wing-fixed rectangular coordinates with positive X-axis along axis of symmetry pointing downstream, positive Y-axis pointing to right, and positive Z-axis pointing upward
z_c	coordinate of camber surface
α	angle of attack
α_t	local angle of attack
γ	nondimensional vortex density
$\delta(x,y)$	$= \dfrac{\partial z_c}{\partial x}$ (see Fig.1)

δ_j	jet-deflection angle
$\Delta\sigma$	step length defined by Eq.(41)
θ	angular coordinate (see Eq.(22))
Λ	sweep angle
λ	taper ratio
λ_1,λ_2	Lagrange multipliers (see Eq.(31))
μ	$= V_o/V_j$
μ'	$= \vec{V}_o\cdot\vec{e}/\vec{V}_j\cdot\vec{e}$
ρ	density
ϕ	angular coordinate (see Eq.(29))
$\bar{\phi}$	nondimensional perturbation velocity potential

Subscripts

a	additional
c	control point (see Eq.(1))
j	jet flow
jj	jet flow perturbation due to jet vortices
JJ	jet control points being influenced by jet vortices
JW	jet control points being influenced by wing vortices
o	outer flow
oj	external flow perturbation due to jet vortices
w	wing
v	vortex point (see Eq.(3))
wa	additional wing vortices
wj	perturbation due to wing in jet flow
wo	perturbation due to wing in outer flow
w_o	wing alone vortices
∞	free stream

2. INTRODUCTION

It is well known that the induced drag of the conventional wing is minimized if the span loading is elliptical. In the early of this century, Munk (Ref. 1) developed a theory for minimizing the induced drag of arbitrary lifting configurations. According to the Munk theory, all loadings are assumed light so that the velocity perturbations are small and the wake in the Trefftz plane may be assumed undistorted. Later, Mangler (Ref. 2) studied the relationship of the circulation distribution over the wing and of the lift to the height of end plate. In his theory, an infinitely thin flat plate was assumed. The theoretical elliptical loading was obtained when the end plate has zero height. For the same problem, Cone (Ref. 3) experimentally determined the optimum spatial distribution of vorticity, corresponding to the minimum induced drag for a specified lift and a given configuration. He used the analogy of a velocity potential and an electrical potential in a medium of uniform conductivity. Lundry (Ref. 4) developed a procedure for accurate computation of the minimum induced drag of nonplanar wings with pylon-like panels. This method was restricted to a two-dimensional Trefftz plane so that the Schwartz-Christoffel transformation can be used. Stevens (Ref. 5) investigated the suitability of planar lifting surface theory to high lift wing design. In his theory the optimal camber surface of the wing is obtained by constraining the spanwise lift distribution to be elliptic. Loth (Ref. 6) determined the optimal span loading on bent lifting lines in the Trefftz plane. Lamar (Ref. 7) used the Vortex-Lattice Method to determine the optimal span loading for minimum drag for interacting surfaces, and to solve the mean camber surface of the wing which will provide the required loading.

In the above references, it was seen that different methods were used to find the minimum induced drag configuration for the conventional wings. They include the lifting line theory, the vortex lattice method, the Kernel function method (Ref. 8), etc. However, one common feature of these methods is that the span loading shape must be prescribed in advance. For the present investigation of configurations with jet interaction, this is not possible.

The main purposes of this investigation are therefore as follows: (1) to develop a new method to determine the optimum camber surface and twist distribution for the minimum induced drag in the wing-alone case without prescribing the span loading shape; (2) and to use the same method to find the corresponding minimum induced drag configuration with the upper-surface-blowing jet. In both cases, the optimum configurations are computed under constraints of specified lift and pitching moment. Lan's method (Ref. 9) and his formulation for the upper-surface-blowing problem will be used in the investigation.

3. THEORETICAL DEVELOPMENT

In the present analysis, the thin wing in the linear inviscid subsonic compressible flow will be assumed. Therefore, the assumption of small angle of attack, flap deflection, thickness ratio, and camber is applicable. The expressions of induced drag, lift and pitching moment coefficients can therefore be simplified. The near-field method is used here to predict the aerodynamic characteristics of wings under jet-off and jet-on conditions. In section 3.1 the boundary conditions in wing-alone and jet-on cases will be described. In section 3.2 the simplified formula of the sectional aerodynamic coefficients will be derived. In section 3.3 the overall aerodynamic characteristics are determined by spanwise integration of the sectional characteristics. In section 3.4 a method is presented to find the optimum wing-alone and jet-on vortex strengths. In section 3.5 the camber ordinates and local angle of attack are determined by integrating the camber slope in the chordwise direction. The detailed procedures of iteration are summarized in section 3.6.

3.1 Boundary Conditions and Interpolation Matrix

In the wing-jet interaction theory described in Refs. 10 and 11, the solution is obtained by solving the wing-alone case first and then the additional effect due to jet interaction. To set up all the influence coefficient matrices, the Quasi-Vortex-Lattice method (Ref. 9) is used in the computation. In the wing-alone case, there is only one boundary condition - wing flow tangency condition, to be satisfied. It can be written as :

$$\left[N_{WW}\right]\left\{\gamma_{w_0}\right\} = \left\{\frac{\partial z_c}{\partial x} - \alpha\right\}_c \qquad (1)$$

where $\left\{ \frac{\partial z_c}{\partial x} - \alpha \right\}_c$ are the camber slopes at the control points. Since the camber slopes at the vortex points are needed in the computation of the induced drag coefficient, it is necessary to interpolate the values at the control points. The trigonometric interpolation formula derived in Ref. 12 is suitable for this purpose.

$$\left(\frac{\partial z_c}{\partial x_i} - \alpha \right) = \sum_{k=1}^{N} \left(\frac{\partial z_c}{\partial x_k} - \alpha \right) \left(\frac{(-1)^{i+k} \sin\theta_k}{\cos\theta_k - \cos\theta_i} \right) \tag{2}$$

where the indices k and i represent the corresponding vortex and control points respectively. In matrix form, Eq. (2) becomes :

$$\left\{ \frac{\partial z_c}{\partial x} - \alpha \right\}_c = \left[I \right] \left\{ \frac{\partial z_c}{\partial x} - \alpha \right\}_v \tag{3}$$

where $\left[I \right]$ is the interpolation matrix. Thus,

$$\left\{ \frac{\partial z_c}{\partial x} - \alpha \right\}_v = \left[I \right]^{-1} \left\{ \frac{\partial z_c}{\partial x} - \alpha \right\}_c \tag{4}$$

or,

$$\begin{aligned} \left\{ \frac{\partial z_c}{\partial x} - \alpha \right\}_v &= \left[I \right]^{-1} \left[N_{WW} \right] \left\{ \gamma_{w_o} \right\} \\ &= \left[A \right] \left\{ \gamma_{w_o} \right\} \end{aligned} \tag{5}$$

In the jet-on case, there are three boundary conditions to be satisfied:

1) <u>Pressure continuity on the jet surface</u>

$$\left[S_{JJ} \right]_{(j)} \left\{ \gamma_{jj} \right\} - T(\mu')^2 \left[S_{JJ} \right]_{(o)} \left\{ \gamma_{oj} \right\} - T(\mu')^2 \left[S_{JW} \right]_{(o)} \left\{ \gamma_{wa} \right\}$$

$$= \left\{ - \frac{\partial \bar{\phi}_{wj}}{\partial s} + T(\mu')^2 \frac{\partial \bar{\phi}_{wo}}{\partial s} \right\} \tag{6}$$

2) <u>Flow tangency on the jet surface</u>

$$-\left[N_{JJ}\right]_{(j)} \left\{\gamma_{jj}\right\} + \left[N_{JJ}\right]_{(o)} \left\{\gamma_{oj}\right\} + \left[N_{JW}\right]_{(o)} \left\{\gamma_{wa}\right\}$$

$$= \left\{ - \frac{\vec{V}_o \cdot \vec{n}(1-\mu')}{\vec{V}_o \cdot \vec{e}} + \frac{\partial \bar{\phi}_{wj}}{\partial n} (M_j) - \frac{\partial \bar{\phi}_{wo}}{\partial n} (M_o) \right\} \tag{7}$$

3) <u>Flow tangency on the wing surface</u>

$$\left[N_{WJ}\right]_{(o)} \left\{\gamma_{oj}\right\} + \left[N_{WW}\right] \left\{\gamma_{wa}\right\} = \left\{ - \frac{\vec{v}_{je} \cdot \vec{k}}{V_\infty \cos\alpha} \right\} \tag{8}$$

Equations (6), (7) and (8) have been combined into an augmented matrix equation to determine γ_{jj} , γ_{oj} and γ_{wa} . Once γ_{wa} is obtained, the total wing vortex strength is then,

$$\gamma_w = \gamma_{w_o} + \gamma_{wa} \tag{9}$$

where γ_{w_o} is the wing-alone vortex strength and γ_{wa} is the additional wing vortex strength.

3.2 Sectional Aerodynamic Coefficients

From the geometry of the mean camber line (Fig. 1), the relation of the local camber slope, twist, lift and induced drag have the following relations with the wing vortex strength. Since,

$$\frac{\partial z_c}{\partial x} = \tan \delta(x,y) \simeq \delta(x,y) \tag{10}$$

the local lift and induced drag components due to the vortex strength are seen to be

$$\ell(x) = \gamma_w(x) \cos(\alpha - \delta(x,y)) \tag{11}$$

$$d_i(x) = \gamma_w(x) \sin(\alpha - \delta(x,y)) \tag{12}$$

where $\gamma_w(x)$ is the vortex strength and is proportional to the pressure loading acting normal to the camber surface.

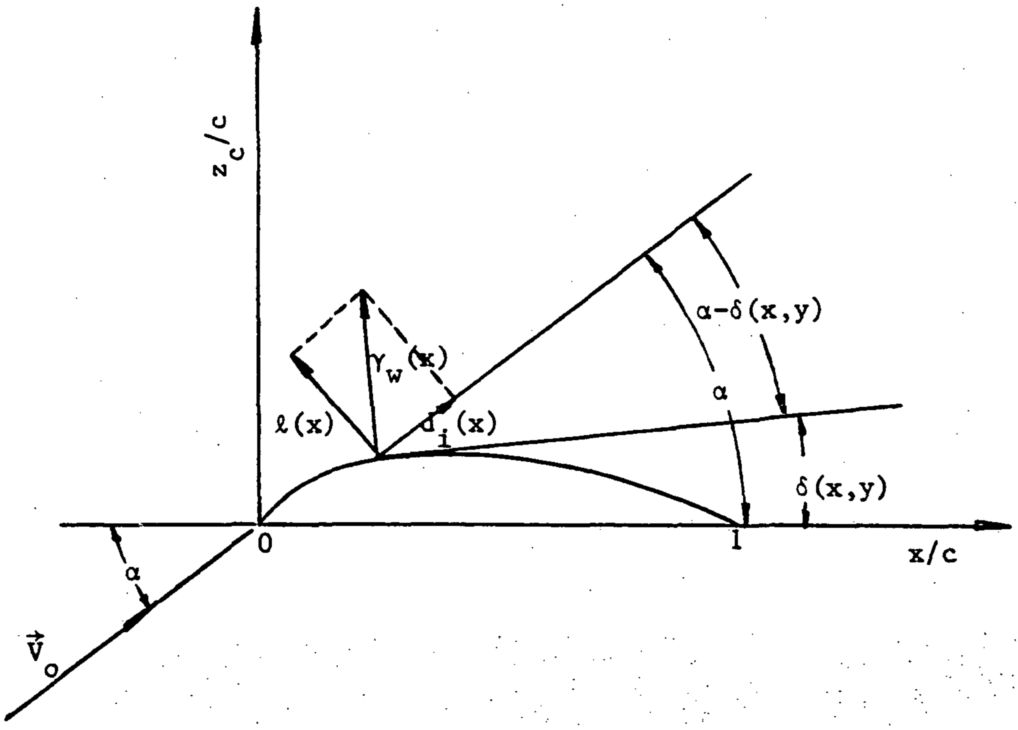


Figure 1. Decomposition of Pressure Loading on the Camber Surface

The effect of the leading-edge suction on the lift and pitching moment is assumed small enough to be ignored. It is assumed that the wing camber will be designed in such a way that the leading-edge suction is zero.

To find the sectional characteristics, it is assumed that the wing vortices are situated along the camber surface. Since the resulting pressure force is normal to the camber surface, the sectional characteristics can be determined by integrating Eqs. (11) and (12) across the local chord. Thus,

$$
\begin{aligned}
c_{d,i} &= \frac{1}{q_o c}\int_o^1 \rho_o V_o (\vec{V}_o \cdot \vec{e})\, d_i(x)\,dx \\
&= \frac{2\cos\alpha}{c}\int_o^1 \gamma_w(x)\sin(\alpha-\delta(x,y))\,dx \\
&\simeq \frac{2}{c}\left(\int_o^{x_1} + \int_{x_1}^1\right) \gamma_w(x)\sin(\alpha-\delta(x,y))\,dx \qquad (13)
\end{aligned}
$$

where $\cos\alpha \simeq 1$. The integration in Eq. (13) will first be transformed to an angular coordinate θ ($0 \leq \theta \leq \pi$) and then reduced to a finite sum by using the conventional trapezoidal rule. Then, Eq. (13) becomes

$$
\begin{aligned}
c_{d,i} \simeq \frac{2}{c}\Bigg(&\frac{x_1 \pi}{2N_1}\sum_{k=1}^{N_1} \gamma_{w_k}\sin(\alpha-\delta(x,y))\sin\theta_k \; + \\
&\frac{(1-x_1)\pi}{2N_2}\sum_{k=1}^{N_2} \gamma_{w_k}\sin(\alpha-\delta(x,y))\sin\theta_k \Bigg) \qquad (14)
\end{aligned}
$$

Similarly,

$$c_\ell = \frac{1}{q_o c}\int_o^1 \rho_o V_o(\vec{V}_o\cdot\vec{e})\ell(x)dx$$

$$= \frac{2}{c}\int_o^1 \gamma_w(x)\cos(\alpha-\delta(x,y))dx$$

$$= \frac{2}{c}\left(\int_o^{x_1} + \int_{x_1}^1\right)\gamma_w(x)\cos(\alpha-\delta(x,y))dx$$

$$\simeq \frac{2}{c}\left(\frac{x_1\pi}{2N_1}\sum_{k=1}^{N_1}\gamma_{w_k}\cos(\alpha-\delta(x,y))\sin\theta_k + \right.$$

$$\left.\frac{(1-x_1)\pi}{2N_2}\sum_{k=1}^{N_2}\gamma_{w_k}\cos(\alpha-\delta(x,y))\sin\theta_k\right) \qquad (15)$$

and,

$$c_m = \frac{1}{q_o c\bar{c}}\int_o^1 \rho_o V_o(\vec{V}_o\cdot\vec{e})\ell(x)x dx$$

$$= \frac{2}{c\bar{c}}\left(\int_o^{x_1} + \int_{x_1}^1\right)\gamma_w(x)\cos(\alpha-\delta(x,y))x dx$$

$$\simeq \frac{2}{c\bar{c}}\left(\frac{x_1\pi}{2N_1}\sum_{k=1}^{N_1}\gamma_{w_k}\cos(\alpha-\delta(x,y))\,x_k\,\sin\theta_k + \right.$$

$$\left.\frac{(1-x_1)\pi}{2N_2}\sum_{k=1}^{N_2}\gamma_{w_k}\cos(\alpha-\delta(x,y))\,x_k\,\sin\theta_k\right) \qquad (16)$$

From thin wing theory, $(\alpha - \delta(x,y))$ is assumed to be sufficiently small, so that,

$$\cos(\alpha-\delta(x,y)) \simeq 1 \tag{17}$$

$$\begin{aligned} \sin(\alpha-\delta(x,y)) &\simeq (\alpha - \delta(x,y)) \\ &\simeq \left(\alpha - \frac{\partial z_c}{\partial x}\right) \\ &= -\left(\frac{\partial z_c}{\partial x} - \alpha\right) \end{aligned} \tag{18}$$

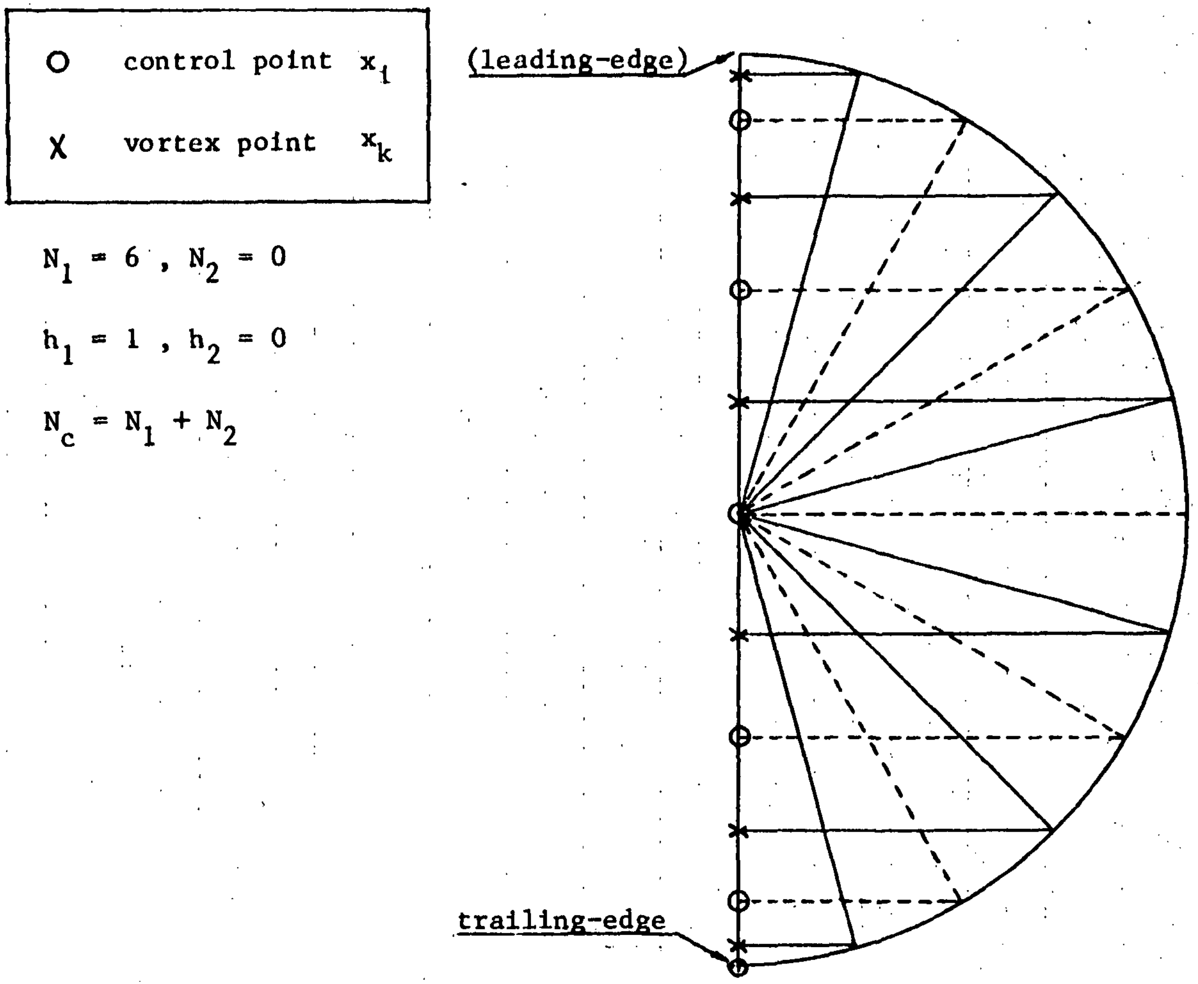
Therefore, from Eqs. (17) and (18), the Eqs. (14), (15), and (16) may be recast into the following simple expressions,

$$\begin{aligned} c_{d,i} = &-\frac{\pi}{c}\left(\frac{x_1}{N_1}\sum_{k=1}^{N_1}\gamma_{w_k}\left(\frac{\partial z_c}{\partial x}-\alpha\right)_k \sin\theta_k + \right. \\ &\left.\frac{(1-x_1)}{N_2}\sum_{k=1}^{N_2}\gamma_{w_k}\left(\frac{\partial z_c}{\partial x}-\alpha\right)_k \sin\theta_k\right) \\ = &-\frac{\pi}{c}\sum_{L=1}^{2}\frac{h_L}{N_L}\sum_{k=1}^{N_L}\gamma_{w_k}\left(\frac{\partial z_c}{\partial x}-\alpha\right)_k \sin\theta_k \end{aligned} \tag{19}$$

$$c_\ell = \frac{\pi}{c}\sum_{L=1}^{2}\frac{h_L}{N_L}\sum_{k=1}^{N_L}\gamma_{w_k}\sin\theta_k \tag{20}$$

$$c_m = \frac{\pi}{c\bar{c}}\sum_{L=1}^{2}\frac{h_L}{N_L}\sum_{k=1}^{N_L}\gamma_{w_k} x_k \sin\theta_k \tag{21}$$

where $h_1 = x_1$ and $h_2 = 1-x_1$, and N_1 and N_2 are the numbers of vortex points in each section along the chordwise direction. The control and vortex points are defined as follows, (see Fig. 2a)



$N_1 = 6$, $N_2 = 0$

$h_1 = 1$, $h_2 = 0$

$N_c = N_1 + N_2$

Figure 2a. Location of Control and Vortex Points in the chordwise direction.

$$x_k = x_{L-1} + \frac{h_L}{2}(1-\cos\theta_k) \quad , \quad L=1,2 \tag{22}$$

$$\theta_k = \frac{(2k-1)\pi}{2N_L} \quad , \quad k=1,2,\cdots,N_L \tag{23}$$

and,

$$x_i = x_{L-1} + \frac{h_L}{2}(1-\cos\theta_i) \quad , \quad L=1,2 \tag{24}$$

$$\theta_i = \frac{i\pi}{N_L} \quad , \quad i= 1,\cdots,N_L \tag{25}$$

Note that $x_o=0$ in Eqs. (22) and (24).

3.3 Overall Aerodynamic Characteristics

The total induced drag, lift and pitching moment coefficients of the wing are determined by spanwise integration of the sectional characteristics. Again, the integration is first transformed to an angular coordinate ϕ ($0 \le \phi \le \pi$) , and then reduced to finite sums by the conventional trapezoidal rule. Therefore, the total induced drag coefficient has the following expression,

$$\begin{aligned} C_{D,i} &= \frac{1}{S_w}\int_{-b/2}^{b/2} c_{d,i}\, c\, dy \\ &= \frac{2}{S_w}\int_{o}^{b/2} c_{d,i}\, c\, dy \\ &= \frac{-2\pi}{S_w}\int_{o}^{b/2} \left(\sum_{L=1}^{2} \frac{h_L}{N_L} \sum_{k=1}^{N_L} \gamma_{w_k} \left(\frac{\partial z_c}{\partial x} - \alpha\right)_k \sin\theta_k \right) dy \end{aligned}$$

$$C_{D,i} = \frac{-2\pi}{S_w}\left(\int_{o}^{y_1}+\int_{y_1}^{y_2}+\int_{y_2}^{1}\right)\left(\sum_{L=1}^{2}\frac{h_L}{N_L}\sum_{k=1}^{N_L}\gamma_{w_k}\left(\frac{\partial z_c}{\partial x}-\alpha\right)_k\sin\theta_k\right)dy$$

$$\simeq \frac{-2\pi}{S_w}\left\{\left[\frac{y_1\pi}{2M_1}\sum_{i=1}^{M_1-1}\left(\sum_{L=1}^{2}\frac{h_L}{N_L}\sum_{k=1}^{N_L}\gamma_{w_k}\left(\frac{\partial z_c}{\partial x}-\alpha\right)_k\sin\theta_k\right)\sin\phi_i\right] + \right.$$

$$\left[\frac{(y_2-y_1)\pi}{2M_2}\sum_{i=1}^{M_2-1}\left(\sum_{L=1}^{2}\frac{h_L}{N_L}\sum_{k=1}^{N_L}\gamma_{w_k}\left(\frac{\partial z_c}{\partial x}-\alpha\right)_k\sin\theta_k\right)\sin\phi_i\right] +$$

$$\left.\left[\frac{(b/2-y_2)\pi}{2M_3}\sum_{i=1}^{M_3-1}\left(\sum_{L=1}^{2}\frac{h_L}{N_L}\sum_{k=1}^{N_L}\gamma_{w_k}\left(\frac{\partial z_c}{\partial x}-\alpha\right)_k\sin\theta_k\right)\sin\phi_i\right]\right\}$$

$$= \frac{-\pi^2}{S_w}\left\{\sum_{p=1}^{3}\frac{f_p}{M_p}\sum_{i=1}^{M_p-1}\left(\sum_{L=1}^{2}\frac{h_L}{N_L}\sum_{k=1}^{N_L}\gamma_{w_k}\left(\frac{\partial z_c}{\partial x}-\alpha\right)_k\sin\theta_k\right)\sin\phi_i\right\}$$

$$= \frac{-\pi^2}{S_w}\left\{\sum_{p=1}^{3}\sum_{i=1}^{M_p-1}\sum_{L=1}^{2}\sum_{k=1}^{N_L}\left[\left(\frac{f_p h_L}{M_p N_L}\right)\sin\theta_k\sin\phi_i\right]\left(\frac{\partial z_c}{\partial x}-\alpha\right)_k\gamma_{w_k}\right\}$$

$$= -\frac{\pi^2}{S_w}\left(\sum_{n=1}^{N_t} g_n\left(\frac{\partial z_c}{\partial x}-\alpha\right)_n\gamma_{w_n}\right) \qquad (26)$$

where,

$$g_n = \frac{f_p h_L}{M_p N_L}\sin\theta_n\sin\phi_i \qquad (26.a)$$

and it is understood that the indices p, i and L will take proper values at the appropriate spanwise sections and chordwise locations, respectively.

In Eq. (26), N_t is total number of wing vortices over the semi-span, and the width of each spanwise section is :

$$f_1 = y_1 \tag{26.b}$$

$$f_2 = y_2 - y_1 \tag{26.c}$$

$$f_3 = b/2 - y_2 \tag{26.d}$$

Similarly, the lift and pitching moment coefficients have the following expressions,

$$C_L = \frac{\pi^2}{S_w} \left(\sum_{n=1}^{N_t} g_n \gamma_{w_n} \right) \tag{27}$$

$$C_m = \frac{\pi^2}{S_w} \left(\sum_{n=1}^{N_t} g_n x_n \gamma_{w_n} \right) \tag{28}$$

where the index n indicates the corresponding vortex point over the wing. Each spanwise section is divided into vortex strips by the semi-circle method. The vortex strips in each interval are obtained through the following relation:

$$y_j = y_{p-1} + \frac{f_p}{2} (1 - \cos \phi_j) \ , \ p = 1,2,3 \tag{29.a}$$

$$\phi_j = (2j - 1)\pi/(2M_p) \ , \ j = 1,\cdots,M_p \tag{29.b}$$

and y-control points are given by:

$$y_i = y_{p-1} + \frac{f_p}{2} (1 - \cos \phi_i) \ , \ p = 1,2,3 \tag{30.a}$$

$$\phi_i = i\pi/M_p \ , \ i = 1,\cdots,M_p - 1 \tag{30.b}$$

Note that $y_o = 0$ in Eqs. (29.a) and (30.a) . M_1, M_2, and M_3 are the numbers of spanwise strips plus one in each section. (see Fig. 2b)

3.4 Optimization Equations

From section 3.3, the expressions of induced drag, lift and pitching moment coefficients have been derived. Next, the method to find the opti-

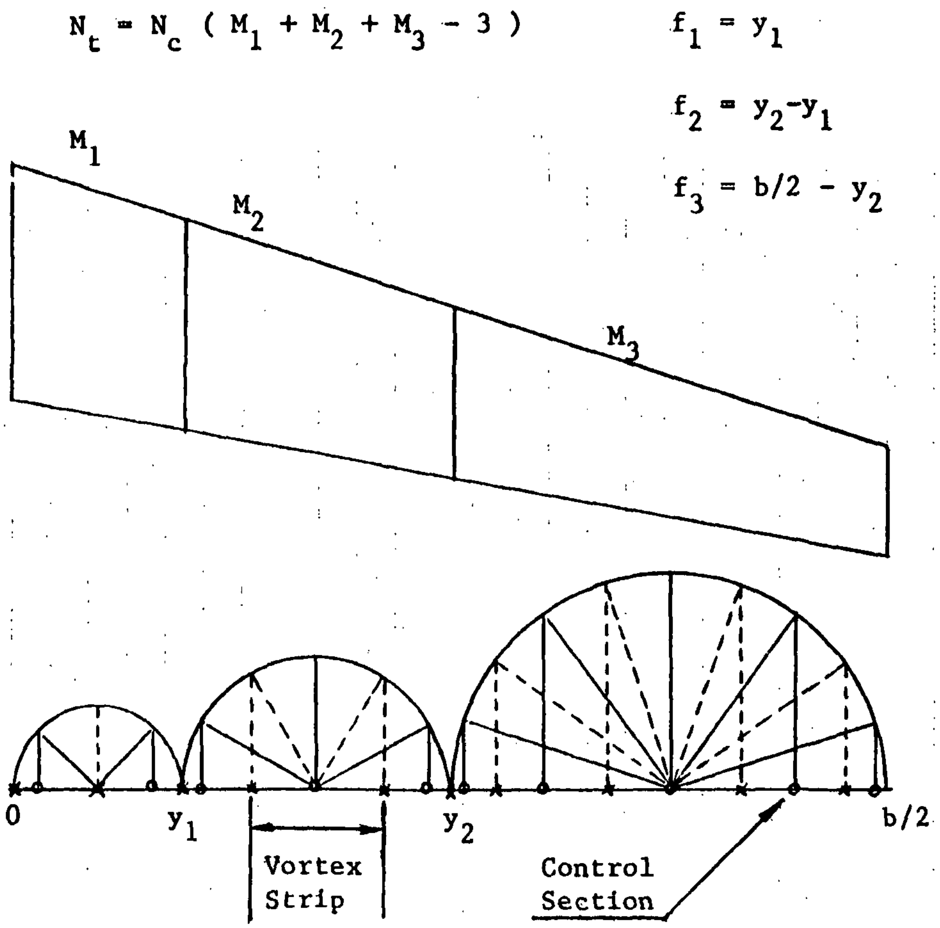


Figure 2b. Scheme of Spanwise Vortex Strip Distribution

mum solution of wing-alone loading such that the induced drag is minimized with the lift and pitching moment constraints will be described. To start the iteration, the wing vortex strengths are at first assumed zero. Then as shown in Appendix A, based on the Method of Gradients (ref. 13), the increment of the wing-alone vortex strength can be determined from the following equations,

$$\Delta\gamma_{w_k} + \lambda_1 \frac{\partial C_L}{\partial \gamma_{w_k}} \Delta\sigma + \lambda_2 \frac{\partial C_m}{\partial \gamma_{w_k}} \Delta\sigma = - \frac{\partial C_{D,i}}{\partial \gamma_{w_k}} \Delta\sigma \ , \qquad k=1,\cdots,N_t \tag{31}$$

$$\sum_{k=1}^{N_t} \frac{\partial C_L}{\partial \gamma_{w_k}} \Delta\gamma_{w_k} = \bar{C}_L - C_L^{(n)} \tag{32}$$

$$\sum_{k=1}^{N_t} \frac{\partial C_m}{\partial \gamma_{w_k}} \Delta\gamma_{w_k} = \bar{C}_m - C_m^{(n)} \tag{33}$$

where $\bar{C}_L$ and $\bar{C}_m$ are the specified constraints, $C_L^{(n)}$ and $C_m^{(n)}$ are the computed values in the n-th iteration. Therefore, the new vortex density will be given by:

$$\gamma_{w_k}^{(n)} = \gamma_{w_k}^{(n-1)} + \Delta\gamma_{w_k}^{(n)} \tag{34}$$

The optimum solution is obtained as $C_{D,i}$ becomes minimum, or the camber shapes do not change further by any significant amount.

In the wing-alone case, the step size $\Delta\sigma$ can be computed in each iteration by using one-dimensional optimization technique. Differentiating Eqs. (26), (27), and (28) with respect to γ_{w_k} gives the relations,

$$\frac{\partial C_L}{\partial \gamma_{w_k}} = \frac{\pi^2}{S_w} g_k \ , \quad k=1,\cdots,N_t \tag{35}$$

and,

$$\frac{\partial C_m}{\partial \gamma_{w_k}} = \frac{\pi^2}{S_w} g_k x_k \quad , \quad k=1,\cdots,N_t \tag{36}$$

From Eq. (5), the camber slope at vortex point k can be expressed as

$$\left(\frac{\partial z_c}{\partial x} - \alpha \right)_k = \sum_{n=1}^{N_t} a_{kn} \gamma_{w_n} \tag{37}$$

where a_{kn} is the element of matrix $[A]$. It follows that Eq. (26) becomes

$$C_{D,i} = - \frac{\pi^2}{S_w} \left(\sum_{k=1}^{N_t} g_k \gamma_{w_k} \left(\sum_{n=1}^{N_t} a_{kn} \gamma_{w_n} \right)\right) \tag{38}$$

Therefore,

$$\frac{\partial C_{D,i}}{\partial \gamma_{w_k}} = - \frac{\pi^2}{S_w} \left(g_k \sum_{n=1}^{N_t} a_{kn} \gamma_{w_n} + \sum_{i=1}^{N_t} g_i a_{ik} \gamma_{w_i} \right)$$

$$= - \frac{\pi^2}{S_w} \left(\sum_{n=1}^{N_t} (g_k a_{kn} + g_n a_{nk}) \gamma_{w_n} \right) \tag{39}$$

The objective is to find the best step size such that $C_{D,i}$ will decrease in the steepest descent direction. It can be shown by the chain rule that :

$$\frac{\partial C_{D,i}}{\partial (\Delta\sigma)} = \sum_{k=1}^{N_t} \left(\frac{\partial C_{D,i}}{\partial \gamma_{w_k}} \right) \left(\frac{d\gamma_{w_k}}{d(\Delta\sigma)} \right) \tag{40}$$

Since the new vortex strength and the old vortex strength may be assumed to be :

$$\gamma_{w_k}^{(n+1)} = \gamma_{w_k}^{(n)} + E_k^{(n)} \Delta\sigma \quad , \tag{41}$$

where the step direction vector E_k can be obtained from Eq. (31) to be :

$$E_k = -\left(\frac{\partial C_{D,i}}{\partial \gamma_{w_k}} + \lambda_1 \frac{\partial C_L}{\partial \gamma_{w_k}} + \lambda_2 \frac{\partial C_m}{\partial \gamma_{w_k}} \right) \quad , \tag{42}$$

$$k=1,\cdots,N_t$$

Substituting Eqs. (39), (41) and (42) into (40) gives :

$$\frac{\partial C_{D,i}}{\partial(\Delta\sigma)} = -\frac{\pi^2}{S_w} \sum_{k=1}^{N_t} \left(\sum_{n=1}^{N_t} (g_k a_{kn} + g_n a_{nk}) (\gamma_{w_n} + E_n \Delta\sigma) \right) E_k \tag{43}$$

The optimum step size $\Delta\sigma$ can be obtained by setting $\frac{\partial C_{D,i}}{\partial(\Delta\sigma)}$ to zero. It follows that

$$\Delta\sigma = -\frac{\sum_{k=1}^{N_t} \left(\sum_{n=1}^{N_t} (g_k a_{kn} + g_n a_{nk}) E_n \right) \gamma_{w_k}}{\sum_{k=1}^{N_t} \left(\sum_{n=1}^{N_t} (g_k a_{kn} + g_n a_{nk}) E_n \right) E_k} \tag{44}$$

In the jet-on case, the total wing vortex strength is equal to the sum of the wing-alone vortex strength γ_{w_o} and the additional wing vortex strength γ_{wa} . Therefore, from Eqs. (9), (26), (27) and (28),

$$C_{D,i} = -\frac{\pi^2}{S_w} \sum_{k=1}^{N_t} g_k \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k (\gamma_{w_o} + \gamma_{wa})_k \tag{45}$$

$$C_L = \frac{\pi^2}{S_w} \sum_{k=1}^{N_t} g_k \left(\gamma_{w_\circ} + \gamma_{wa} \right)_k \tag{46}$$

$$C_m = \frac{\pi^2}{S_w} \sum_{k=1}^{N_t} g_k \left(\gamma_{w_\circ} + \gamma_{wa} \right)_k x_k \tag{47}$$

In the optimization iteration, $\gamma_{w_\circ}$ is regarded as the independent variable. In the optimization Eqs. (31) - (33), the derivatives $\frac{\partial C_L}{\partial \gamma_{w_\circ}}$, $\frac{\partial C_m}{\partial \gamma_{w_\circ}}$ and $\frac{\partial C_{D,i}}{\partial \gamma_{w_\circ}}$ are needed. They can be obtained by differentiating Eqs. (45) - (47) with respect to $\gamma_{w_{\circ_k}}$. Hence,

$$\frac{\partial C_L}{\partial \gamma_{w_{\circ_k}}} = \frac{\pi^2}{S_w} \left(g_k + \sum_{i=1}^{N_t} g_i \left(\frac{\partial \gamma_{wa}}{\partial \gamma_{w_{\circ_k}}} \right)_i \right) \tag{48}$$

$$\frac{\partial C_m}{\partial \gamma_{w_{\circ_k}}} = \frac{\pi^2}{S_w} \left(g_k x_k + \sum_{i=1}^{N_t} g_i x_i \left(\frac{\partial \gamma_{wa}}{\partial \gamma_{w_{\circ_k}}} \right)_i \right) \tag{49}$$

From Eqs. (1) and (8), and the interpolation matrix $\left[I \right]$, the camber slope at the vortex point k is given by :

$$\left(\frac{\partial z_c}{\partial x} - \alpha \right)_k = \sum_{j=1}^{N_t} a_{kj} \left(\gamma_{w_\circ} + \gamma_{wa} \right)_j + \sum_{n=1}^{N_j} b_{kn} \gamma_{oj_n} \tag{50}$$

where N_j is the total number of jet vortices in the outer flow, and a_{kj} and b_{kn} are the elements of the transformation matrices $\left[A \right]$ and $\left[B \right]$ respectively. From Eqs. (4) and (8), $\left[A \right]$ and $\left[B \right]$ are defined as

$$\left[A \right] = \left[I \right]^{-1} \left[N_{WW} \right] \tag{50.a}$$

$$\left[B \right] = \left[I \right]^{-1} \left[N_{WJ} \right]_{(o)} \tag{50.b}$$

Differentiate Eq. (50) with respect to $\gamma_{w_{o_i}}$ gives:

$$\frac{\partial}{\partial \gamma_{w_{o_i}}} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k$$

$$= a_{ki} + \sum_{m=1}^{N_t} a_{km} \left(\frac{\partial \gamma_{wa}}{\partial \gamma_{w_{o_i}}} \right)_m + \sum_{n=1}^{N_j} b_{kn} \left(\frac{\partial \gamma_{oj}}{\partial \gamma_{w_{o_i}}} \right)_n \qquad (51)$$

With Eqs. (50) and (51), Eq. (45) gives:

$$\frac{\partial C_{D,i}}{\partial \gamma_{w_{o_i}}} = - \frac{\pi^2}{S_w} \left\{ g_i \left[\sum_{j=1}^{N_t} a_{ij} \left(\gamma_{w_o} + \gamma_{wa} \right)_j + \sum_{n=1}^{N_j} b_{in} \gamma_{oj_n} \right] + \right.$$

$$\sum_{k=1}^{N_t} g_k \left(\frac{\partial \gamma_{wa}}{\partial \gamma_{w_{o_i}}} \right)_k \left[\sum_{j=1}^{N_t} a_{kj} (\gamma_{w_o} + \gamma_{wa})_j + \sum_{n=1}^{N_j} b_{kn} \gamma_{oj_n} \right] +$$

$$\left. \sum_{n=1}^{N_t} g_n (\gamma_{w_o} + \gamma_{wa})_n \left[a_{ni} + \sum_{m=1}^{N_t} a_{nm} \left(\frac{\partial \gamma_{wa}}{\partial \gamma_{w_{o_i}}} \right)_m + \sum_{p=1}^{N_j} b_{np} \left(\frac{\partial \gamma_{oj}}{\partial \gamma_{w_{o_i}}} \right)_p \right] \right\}$$

$$(52)$$

Eqs. (48), (49), (51) and (52) will be evaluated in each iteration, because the needed derivatives depend on the values of γ_{w_o} , γ_{wa} and γ_{oj} in the preceeding step.

The derivatives $\frac{\partial \gamma_{wa}}{\partial \gamma_{w_o}}$, $\frac{\partial \gamma_{oj}}{\partial \gamma_{w_o}}$ can be obtained by differentiating Eqs. (6), (7) and (8) with respect to γ_{w_o} and solving the differentiated simultaneous equations.

From numerical experimentation, it was found that the one-dimensional optimization technique in finding the best step size used previously for the wing alone case did not produce consistently converging solutions in the jet-on case. In fact, the rate of convergence depends very much on the jet strength, or on μ . According to the author's experience, the following relation of step size and μ may be used:

$$\Delta\sigma = 3.0864\ \mu - 0.39506 \tag{53}$$

The above computed step size is assumed unchanged during iteration for the jet-on case.

3.5 The Determination of Camber Ordinates

Once the optimum solution of the wing vortices has been determined from section 3.4, the camber slope at vortex points over the wing may be found from Eq. (5). This section will describe the method used in finding the camber ordinates from the given camber slope. Let the wing camber slope be developed into Fourier cosine series. Then in each spanwise vortex strip over the wing, the camber slope functions have the following expression,

$$\left(\frac{\partial z_c}{\partial x} - \alpha \right)_k = \sum_{j=1}^{N_c} a_j \cos(j-1)\theta_k \tag{54}$$

and the Fourier coefficients are given by,

$$a_1 = \frac{1}{\pi} \int_0^{\pi} \left(\frac{\partial z_c}{\partial x} - \alpha \right) d\theta$$

$$\simeq \frac{1}{N_c} \sum_{k=1}^{N_c} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \tag{55}$$

and for $j>1$,

$$a_j = \frac{2}{\pi} \int_0^{\pi} \left(\frac{\partial z_c}{\partial x} - \alpha \right) \cos(j-1)\theta \; d\theta$$

$$= \frac{2}{N_c} \sum_{k=1}^{N_c} \left(\frac{\partial z_c}{\partial x} - \alpha \right)_k \cos(j-1)\theta_k \tag{56}$$

where $$\theta_k = \frac{(2k-1)\pi}{2N_c}, \quad k=1,\cdots,N_c \tag{57}$$

Once the Fourier coefficients are determined, the camber ordinates can be obtained by direct integration. For each vortex strip, Eq. (54) is :

$$\left(\frac{\partial z_c}{\partial x} - \alpha \right) = a_1 + a_2 \cos\theta + \cdots\cdots + a_{N_c} \cos(N_c-1)\,\theta \tag{58}$$

where N_c is the total number of chordwise vortex elements. By integrating Eq. (58) with respect to x, the camber ordinates along each spanwise vortex strip over the wing can be obtained. Thus,

$$z_c(x) = (\alpha + a_1)x + \int_o^x (a_2\cos\theta + \cdots\cdots + a_{N_c}\cos(N_c-1)\theta)\,dx \tag{59}$$

Since $x = (1 - \cos\theta) / 2$, Eq. (59) becomes

$$z_c(\theta) = (\alpha + a_1)(1-\cos\theta)/2 + \int_0^\theta (a_2\cos\theta + \cdots\cdots + a_{N_c}\cos(N_c-1)\theta)\sin\theta\,d\theta/2 \tag{60}$$

From the mathematics handbook (Ref. 15),

$$\int \sin x \cos Nx\,dx = -\frac{1}{2}\left(\frac{\cos(1-N)x}{1-N} + \frac{\cos(1+N)x}{1+N} \right), \tag{61}$$

$$N > 1$$

It follows that Eq. (60) becomes:

$$z_c(\theta) = (\alpha+a_1)\ (1-\cos\theta)/2 \quad - a_2\cos 2\theta/8 - \frac{1}{4}\sum_{n=2}^{N_c-1} \left(\frac{\cos(1+n)\theta}{1+n} + \frac{\cos(1-n)\theta}{1-n} \right) + C_1 \qquad (62)$$

where α and C_1 are the local angle of attack and integration constant respectively. They are determined by ends condition. Since $z_c(0) = z_c(\pi) = 0$, from the leading-edge end condition,

$$z_c(0) = -\frac{a_2}{8} - \frac{1}{4}\sum_{n=2}^{N_c-1} a_{n+1} \left(\frac{1}{1+n} + \frac{1}{1-n} \right) + C_1 = 0$$

Hence,

$$C_1 = \frac{a_2}{8} + \frac{1}{4}\sum_{n=2}^{N_c-1} a_{n+1} \left(\frac{1}{1+n} + \frac{1}{1-n} \right) \qquad (63)$$

From the trailing-edge end condition,

$$z_c(\pi) = (\alpha+a_1) - \frac{a_2}{8} - \frac{1}{4}\sum_{n=2}^{N_c-1} a_{n+1} \left(\frac{\cos(1-n)\pi}{1-n} + \frac{\cos(1+n)\pi}{1+n} \right) + C_1 = 0$$

Hence, the local angle of attack is given by:

$$\alpha = \frac{1}{4}\sum_{n=2}^{N_c-1} a_{n+1} \left(\frac{\cos(1-n)\pi-1}{1-n} + \frac{\cos(1+n)\pi-1}{1+n} \right) - a_1 \qquad (64)$$

Finally, the camber ordinates along each spanwise vortex strip are determined by,

$$z_c(\theta) = [\frac{1}{4} \sum_{n=2}^{N_c-1} a_{n+1} (\frac{\cos(1-n)\pi-1}{1-n} + \frac{\cos(1+n)\pi-1}{1+n})] (\frac{1-\cos\theta}{2}) -$$

$$\frac{a_2}{8} \cos 2\theta - \frac{1}{4} \sum_{n=2}^{N_c-1} (\frac{\cos(1-n)\theta}{1-n} + \frac{\cos(1+n)\theta}{1+n}) +$$

$$\frac{a_2}{8} + \frac{1}{4} \sum_{n=2}^{N_c-1} a_{n+1} (\frac{1}{1-n} + \frac{1}{1+n}) \qquad (65)$$

3.6 Summary of Solution Procedures

In the jet-off case, the basic unknowns to be determined are the wing-alone vortex strengths. The problem is solved by the iterative process described below :

1. Assume all the initial wing-alone vortex strengths are zero and the initial step size has some value, typically 50.
2. By solving the optimization equations, i.e., Eqs. (31) - (33), the new wing-alone vortex strengths are determined.
3. Calculate the camber slope at the vortex points from Eq. (5) and compute the aerodynamic characteristics.
4. Check the convergence of the induced drag coefficient and adjust the computed step size if necessary.
5. Compute the new step size by using one-dimensional optimization technique.
6. Repeat steps 2 through 5 until a converged solution is obtained.

7. Calculate the camber ordinates, local angles of attack and the optimum loading.

In the jet-on case, the value of additional wing vortex strengths depend on the value of wing-alone vortex strengths in each iteration. Therefore, the approach to find the optimum solution is described below;

1. Invert the augmented matrix of the boundary conditions, i.e., Eqs. (6) - (8).
2. Calculate the derivatives of the jet vortex strength in the outer flow and the additional wing vortex strength with respect to wing-alone vortex strength from the differentiated equations of Eq. (6), (7) and (8).
3. Set up the transformation matrices from Eqs. (50.a) and (50.b).
4. Compute the derivatives of the camber slopes at the vortex points with respect to the wing-alone vortex strength, i.e., Eq. (51).
5. Assume the initial wing-alone vortex strengths equal to the optimum loading which were found in the jet-off case.
6. By solving the optimization equations and varying the initial computed lift and pitching moment coefficients to the constrained values gradually, the new wing-alone vortex strengths can be obtained.
7. Calculate the camber slopes at vortex points from Eq. (50).
8. Use the new wing-alone vortex strengths to determine the right hand sides of Eqs. (6) - (8).
9. Calculate the jet vortex strengths in the outer flow and the additional wing vortex strengths by the results of steps 1 and 8.
10. Compute the total wing vortex strengths and the aerodynamic characteristics.

11. Once the computed lift and pitching moment coefficients achieve the constrained values, check the induced drag coefficient and adjust the assumed step size if necessary. Finally, calculate the camber ordinates, local angles of attack and the corresponding loading.
12. Check the changes in camber ordinates in consecutive iterations.
13. Assume a constant step size for each iteration, the step size being determined by the empirical formula of Eq.(53).
14. Repeat steps 6 through 13 until the desired solution is obtained.

It should be noted that in the first iteration, steps 6 and 7 are to be omitted. From the assumed wing-alone vortex strengths, the initial computed lift and pitching moment coefficients are determined.
To have a smooth transition in the entire iterative process, the initial computed lift and pitching moment coefficients will be varying through several intermediate cycles, and each cycle includes two or three iterations. Since the solution is very sensitive to the variation of the step size, the computed step size by one-dimensional optimization technique is not used. A reasonable step size in the entire iterative process should be such that the induced drag coefficient keeps decreasing as the specified constraints were reached.

4. NUMERICAL RESULTS AND DISCUSSIONS

A highly swept back tapered wing (NACA 64A010 uncambered) has been selected for analysis to check out the program and illustrate its application. The basic geometries of the planform are: (1) aspect ratio of 5.5; (2) taper ratio of 0.532; (3) sweep back angle at quarter chord of 45°. In the wing-alone case, all the results have been calculated by using six chordwise vortex elements and ten spanwise vortex strips over the semi-span of the wing. The geometry is shown in Fig. 3. In the jet-on case, the semi-span of the wing is divided into three sections, and there are three vortex strips inside the jet region. The length of trailing jet c_j used in the analysis was one local chord length and four trailing vortices in the computation. The jet exit is at the leading-edge.

The computed induced drag coefficient in the jet-off case approaches the theoretical minimum induced drag coefficient in about 10 iterations, as shown in Fig. 4. The speed of convergence depends on the absolute value of the computed step size. The solution is assumed to have converged if the difference between the computed induced drag coefficient and the theoretical minimum induced drag coefficient is less than five percent. With the wing design lift coefficient being 0.6 and the design pitching moment coefficient being -0.036, an iterative process is then used to derive the optimum camber and the local angle of attack distributions. Calculated mean camber ordinates and pressure distributions are compared with Stevens' (Ref. 5) theoretical results by the Kernel function method (Ref. 8) for three spanwise stations in Figs. 5 - 6. The agreement is seen to be reasonably good. It should be noted that to make the comparison at the same spanwise locations with Stevens' results, Lagrange interpolation technique is used here to find:

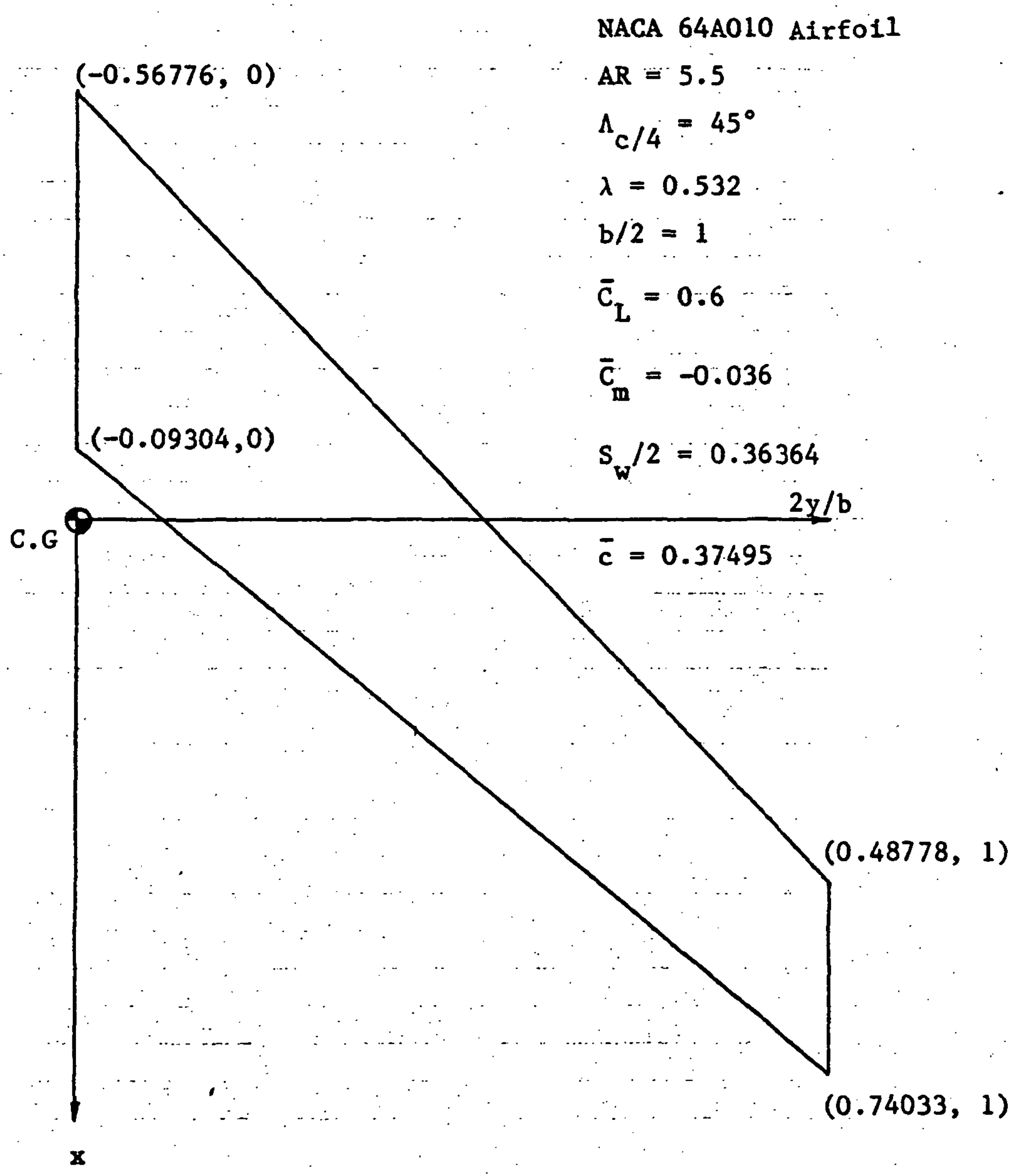


Figure 3. Geometry of Wing Planform in the jet-off case.

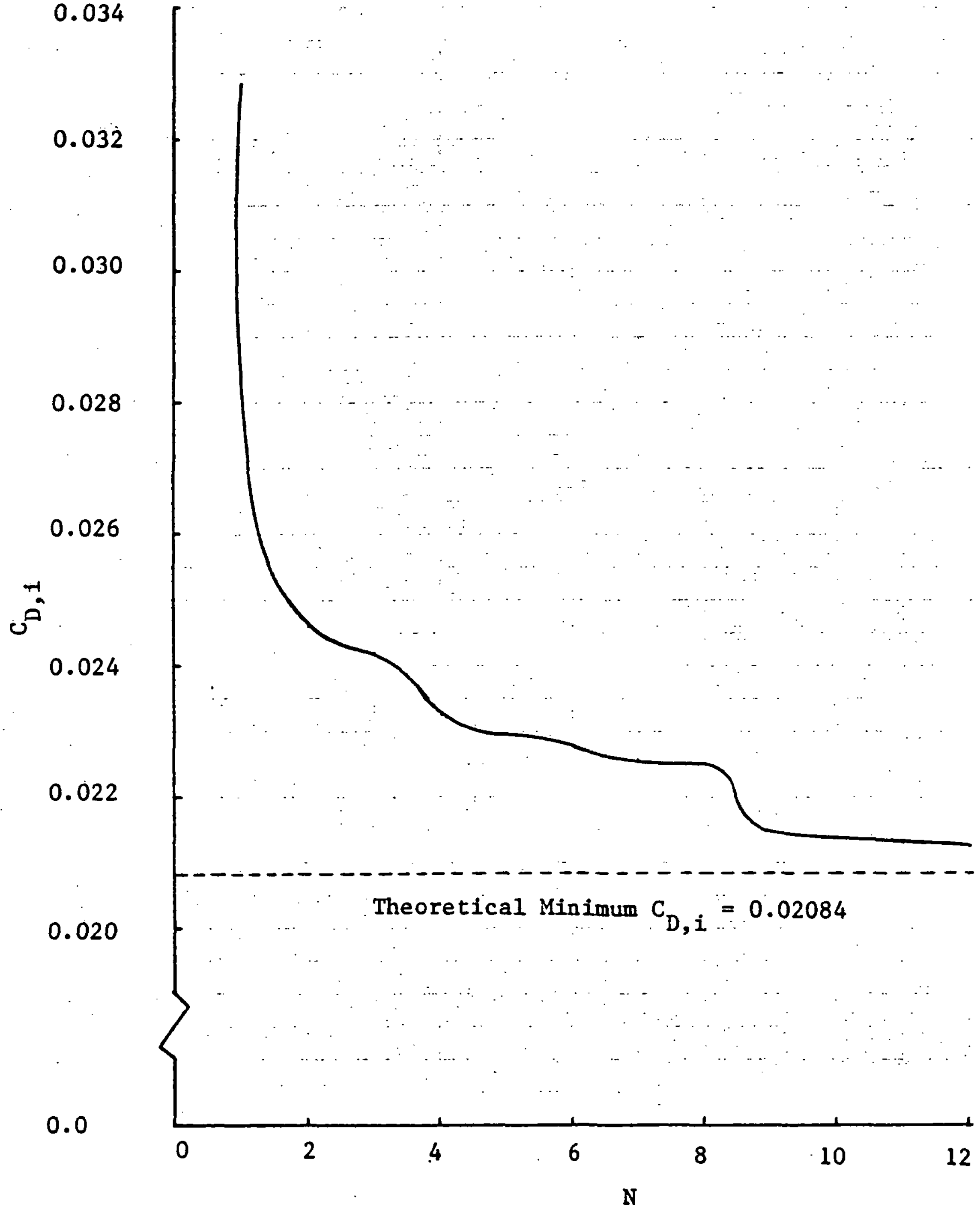


Figure 4. Convergence of Induced Drag Coefficient vs number of iterations in the jet-off case. AR= 5.5, $\bar{C}_L$= 0.6 , $\bar{C}_m$ = -0.036

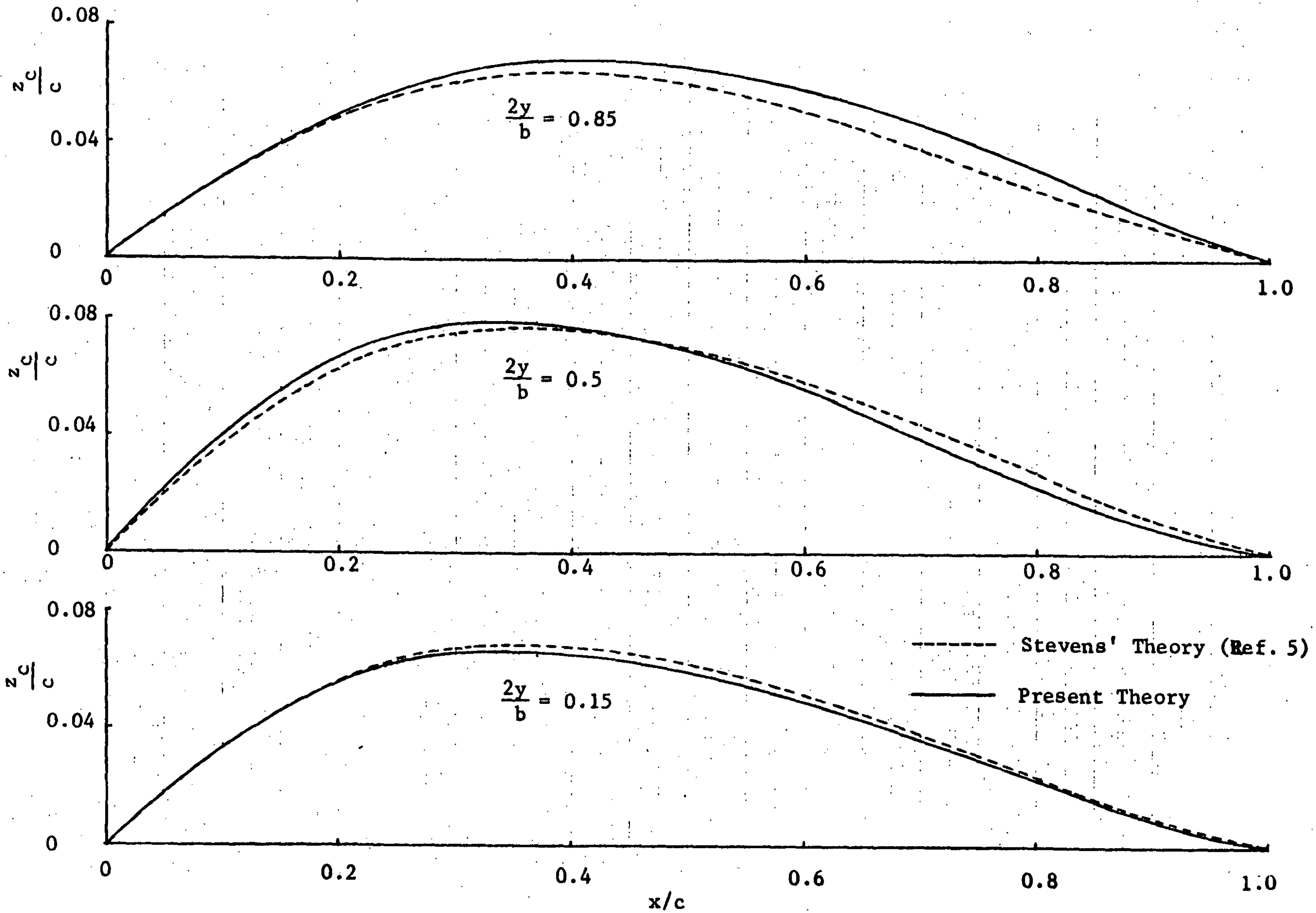


Figure 5. Mean Camber Shape in the jet-off case. ($\bar{C}_L = 0.6$, $\bar{C}_m = -0.036$, $\alpha = 0°$)

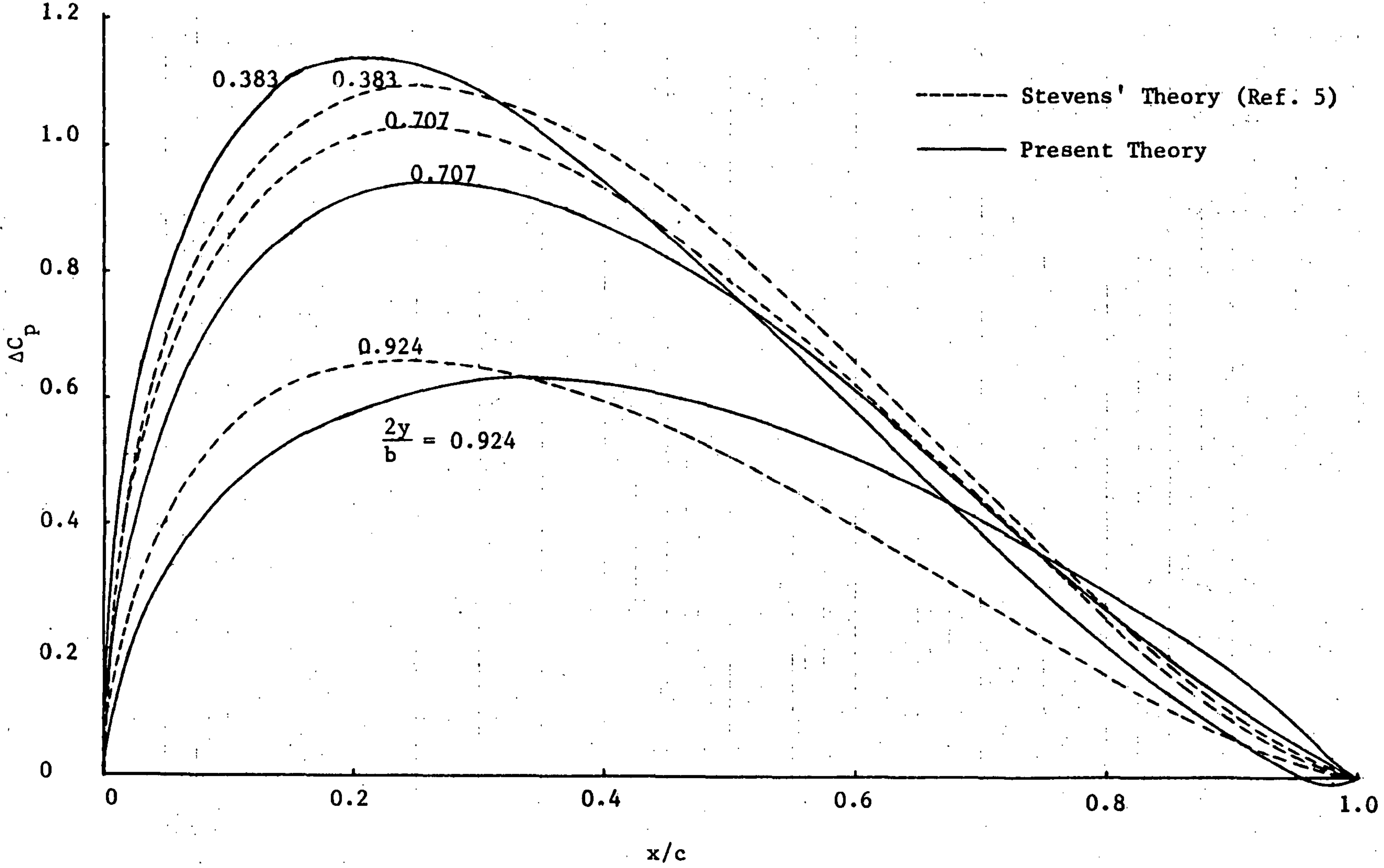


Figure 6. Pressure Distribution in the jet-off case. ($\bar{C}_L = 0.6$, $\bar{C}_m = -0.036$, $\alpha = 0°$)

(1) the calculated mean camber ordinates at spanwise stations of 0.15, 0.5 and 0.85 ; and (2) the computed pressure distribution at spanwise stations of 0.383, 0.707 and 0.924. The comparison of the local angles of attack (or twist) is shown in Fig.7. The agreement is again good. Near the root chord, the computed twist by the present method is seen to be quite nonlinear. This result is consistent with the swept wing design by Williams and Ross in Ref. 16. It is probably due to the planform kink effect . This kink effect seems to appear also in the calculated span loading by the present method, as shown in Fig. 8.

Having established the accuracy for the present method in the wing-alone case, it is of interest to see the minimum induced drag configuration with upper-surface-blowing jet. The geometry is shown in Fig. 9. To show the jet effects, two areas of interest will be investigated. First, how the wing-alone results will be modified by the blowing jet with given μ and δ_j. Second, what the effects of μ and δ_j would have on the camber ordinates, span loading, twist and pressure distribution. All the results are indicated in Figs.10-16. In the jet-on case, the design circulation lift coefficient is 1.2 and the design pitching moment coefficient is -0.075. The calculated camber ordinates at two spanwise stations outside the jet region are shown in Fig.10. It is seen that the mean camber lines are changed significantly in the jet-on case. How they are changed depends on whether they are inside or outside the jet region. The results in Fig. 10 are for $\mu = 0.1288$ and hence are for low speed and high thrust conditions. Also , as indicated in Fig. 10, the δ_j effect on the mean camber is very small. Inside the jet region the camber ordinates at two spanwise stations are shown in Fig. 11. It is seen that under high thrust conditions, the camber in the jet

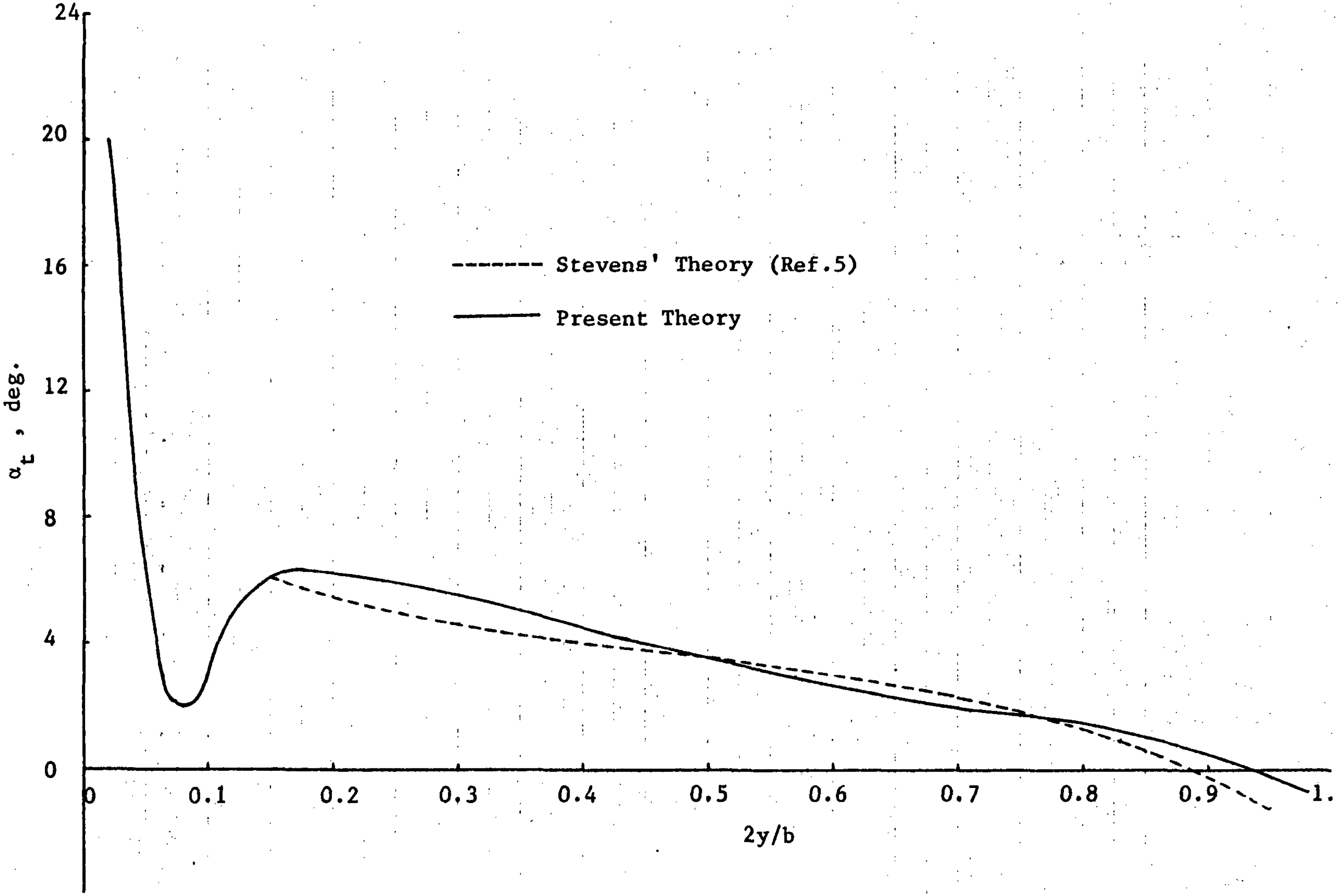


Figure 7. Twist Distribution in the jet-off case. (AR = 5.5 , $\bar{C}_L$ = 0.6, $\bar{C}_m$ = -0.036, α =0°)

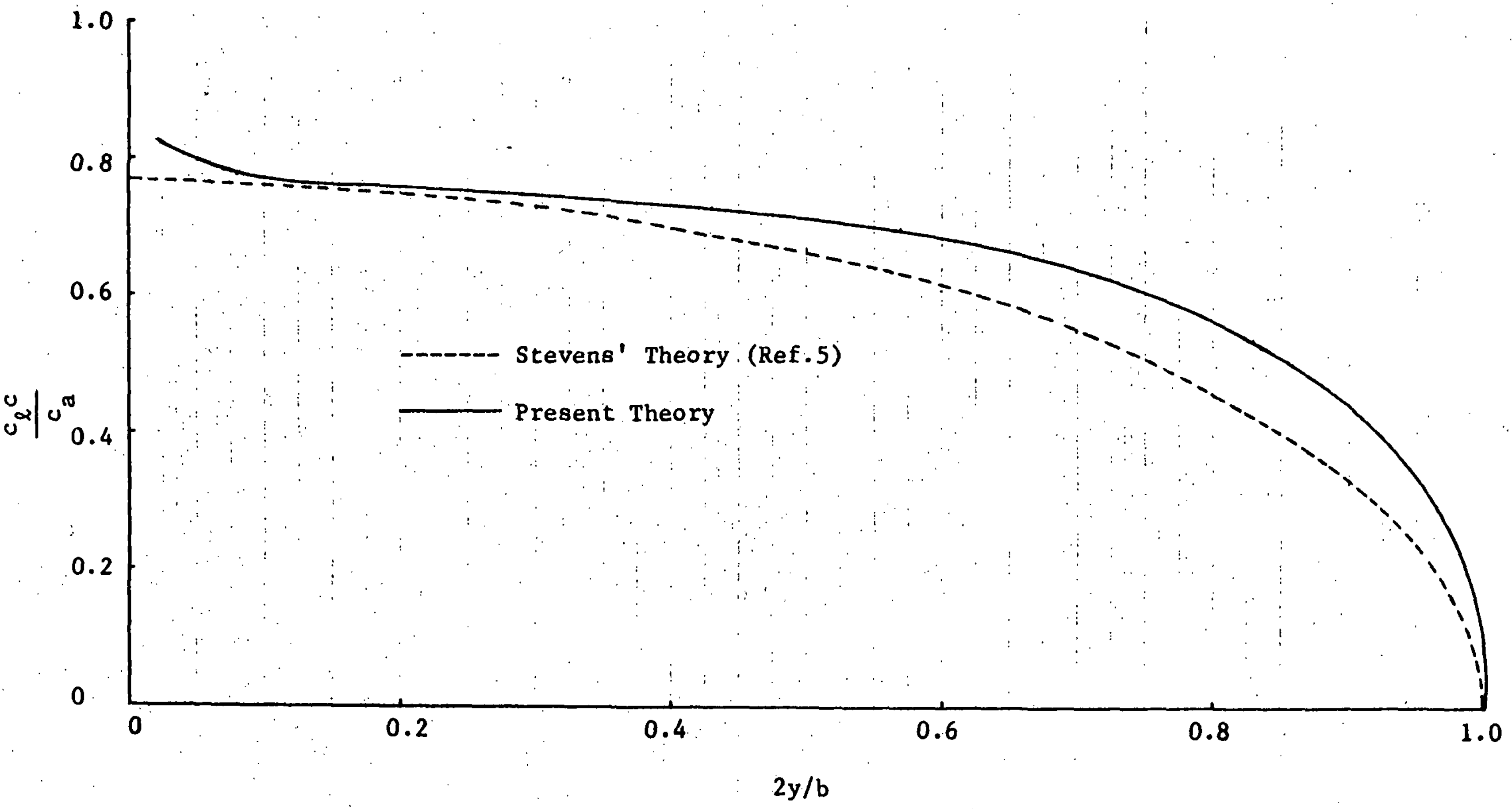


Figure 8. Span Loading in the jet-off case. (AR= 5.5, $\bar{C}_L = 0.6$, $\bar{C}_m = -0.036$, $\alpha = 0°$)

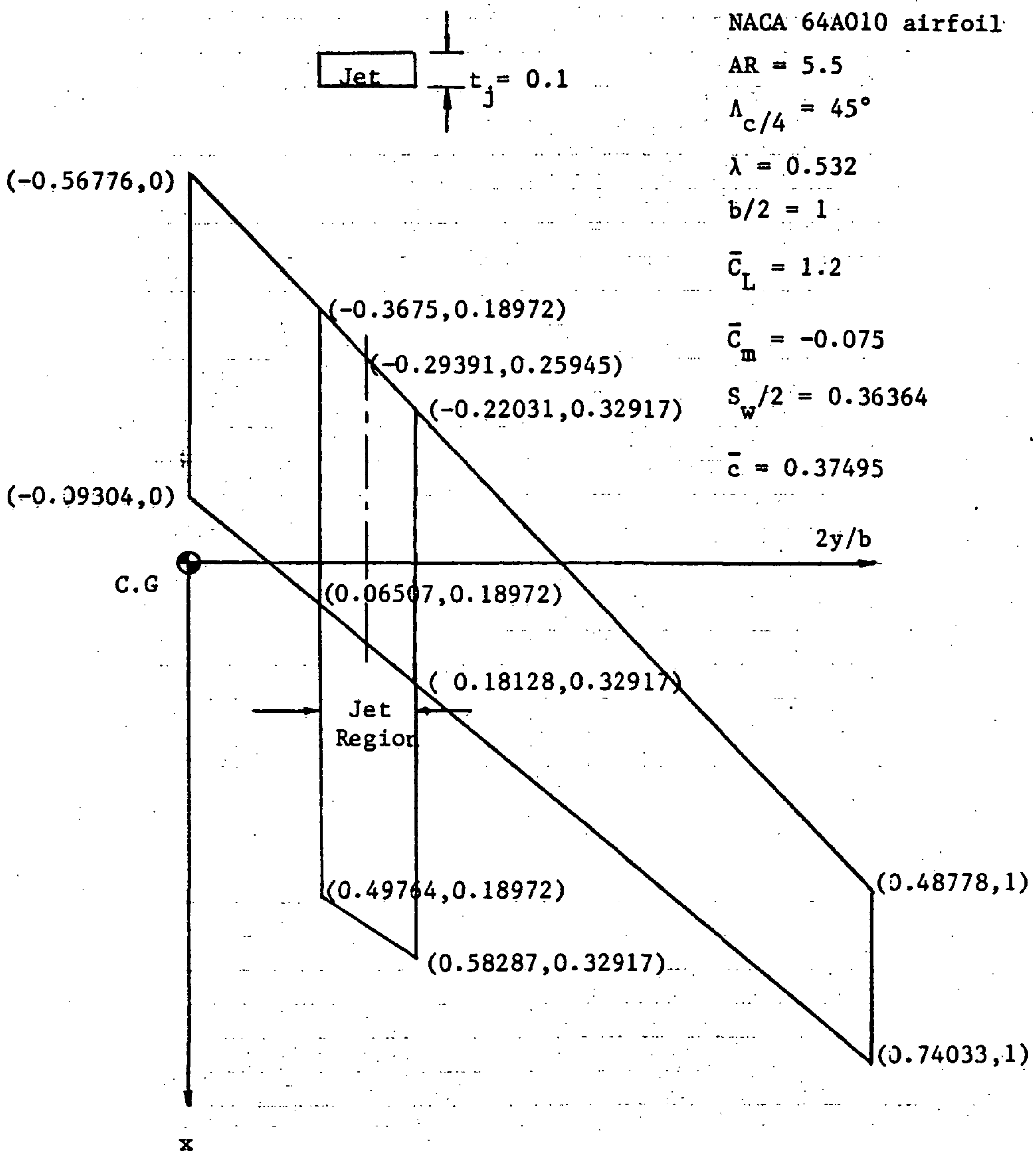


Figure 9. Geometry of Wing Planform and Jet location in the Jet-on case.

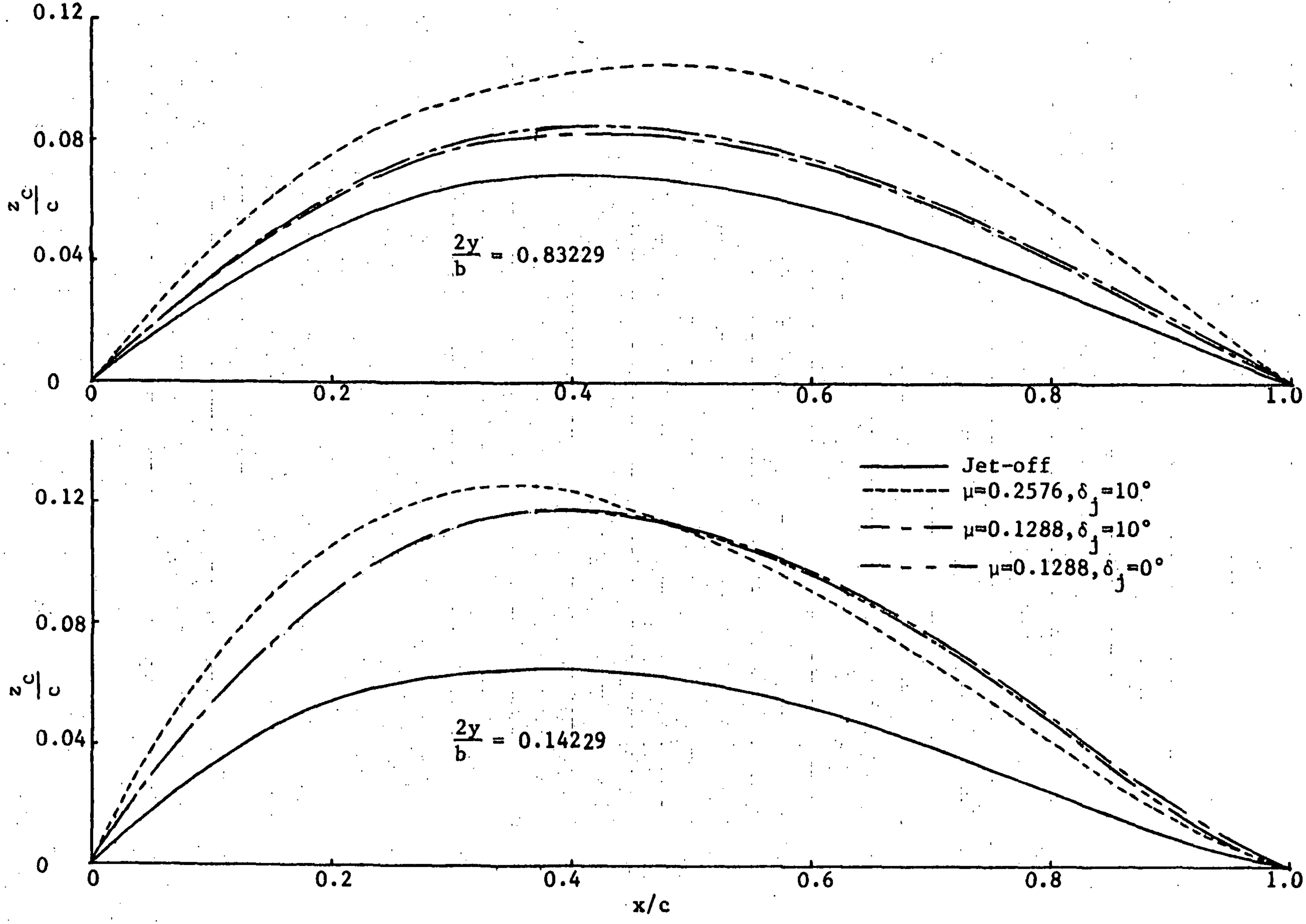


Figure 10. Mean Camber Shape (outside the jet region) in the jet-on case.
($\bar{C}_L=1.2, \bar{C}_m=-0.075, C_\mu=1.676, t_j=0.1, M_o=M_j=0, \alpha=0°$)

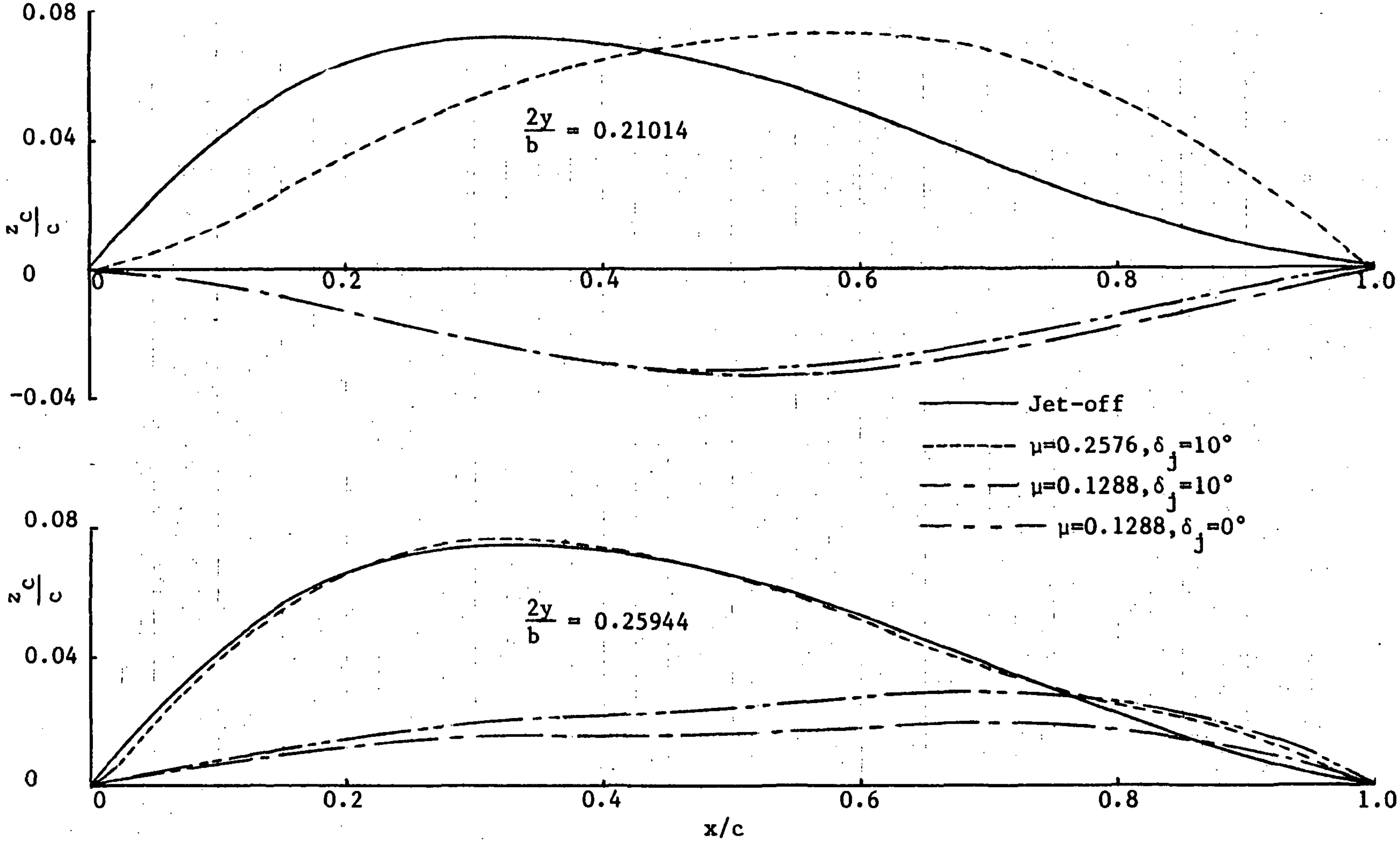


Figure 11. Mean Camber Shape (inside the jet region) in the jet-on case.

$(\bar{C}_L=1.2, \bar{C}_m=-0.075, C_\mu=1.676, t_j = 0.1, \alpha=0°, M_o=M_j=0)$

region must be largely reduced from the wing-alone configuration. In the example shown, the camber ordinates become negative in the inboard vortex strip and the flat smooth camber in the outboard vortex strip. When μ is increased to 0.2576 and δ_j is 10°, the aerodynamic jet interaction is either to shift the maximum camber ordinate backward (y = 0.21014) or to increase the camber ordinates near the trailing-edge (y = 0.25944). Also, in Fig. 11 when δ_j is increased from 0° to 10°, the mean camber is decreased positively, especially, near the trailing-edge. From the results of Figs. 10 - 11, the trend is seen to be that the distribution of the final mean camber shape after the optimization process should be such that the loading are decreased inside the jet region and increased outside the jet region. Figs. 12 - 14 illustrate the pressure distributions at four spanwise stations. In Fig. 12 the μ effect on the pressure distribution outside the jet region are as follows. In the figure, the so-called initial pressure distribution is obtained by applying the jet on the wing-alone optimized configuration. It is seen that at a given μ, the final pressure distributions are increased after the optimization process. Also, the final pressure distributions are increased as μ is increased from 0.1288 to 0.2576. The effect of δ_j is so small that its effect on the difference in pressure distribution is not shown in Fig. 12. Figs. 13 - 14 show the pressure distribution inside the jet region at two spanwise stations. It is seen that there is a high peak in the initial pressure distribution with strong jet strength. After the optimization process, the final pressure distributions become flat. As μ is increased from 0.1288 to 0.2576, it seems that the final pressure loading becomes smoother, and the difference between initial and final pressure distribution is small. At the same μ, when δ_j is increased from 0° to

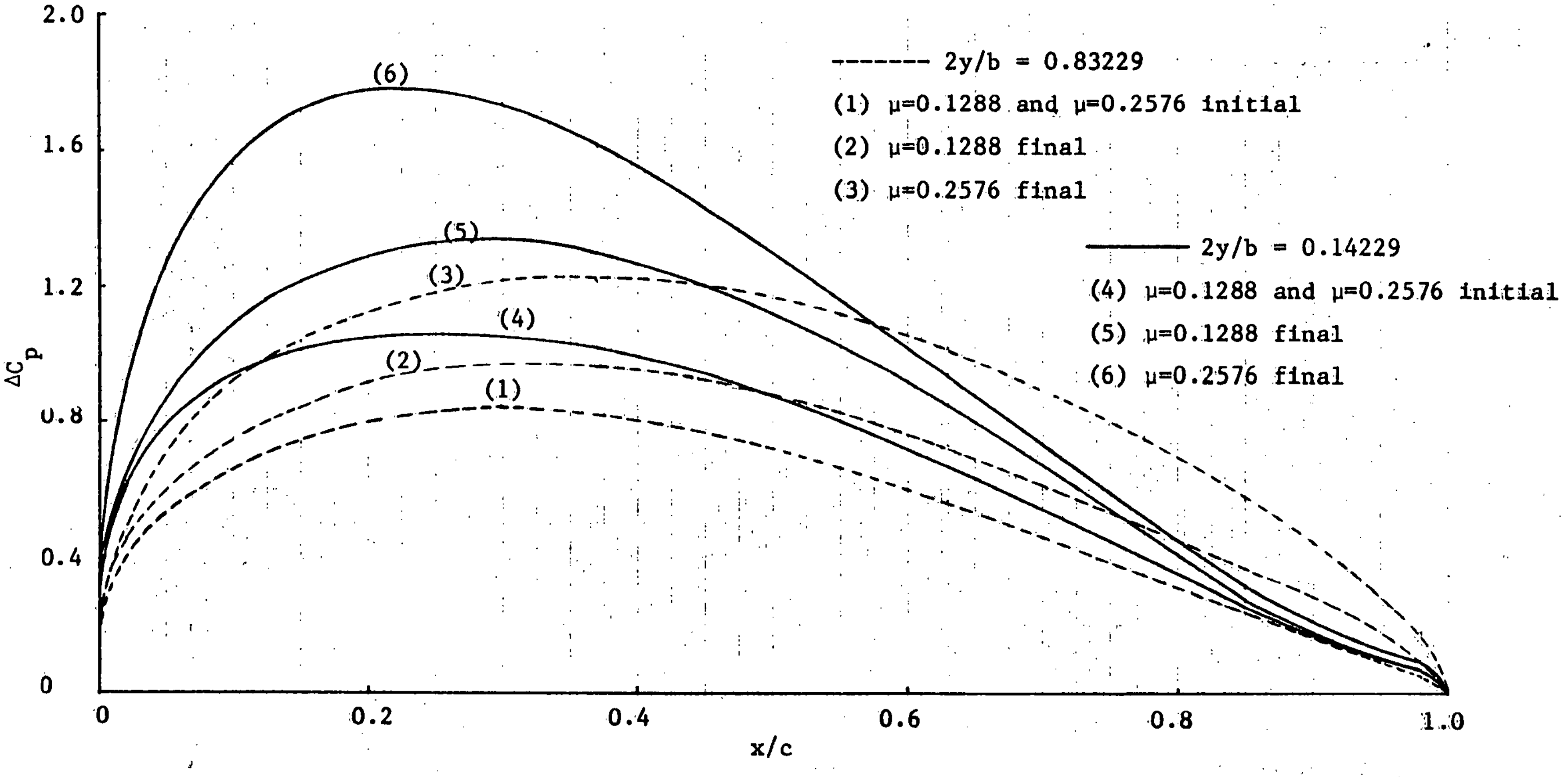


Figure 12. Pressure Distribution (outside the jet region) in the jet-on case.
($\bar{C}_L=1.2, \bar{C}_m=-0.075, C_\mu=1.676, t_j = 0.1, M_o=M_j=0, \alpha=0°$)

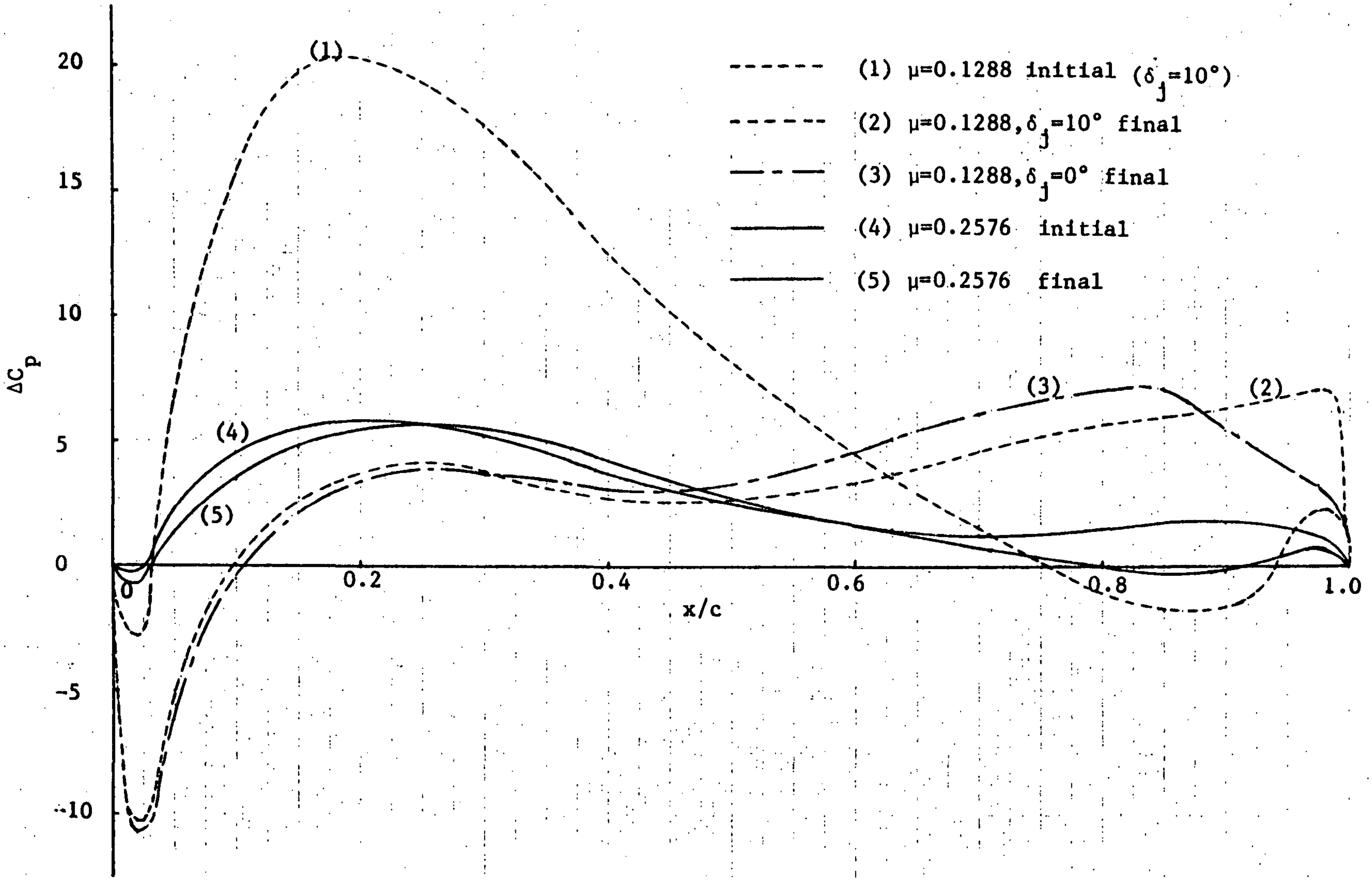


Figure 13. Pressure Distribution (inside the jet region 2y/b=0.25944) in the jet-on case. ($\bar{C}_L$=1.2, $\bar{C}_m$=-0.075, C_μ=1.676, t_j = 0.1, M_o=M_j=0, α=0°)

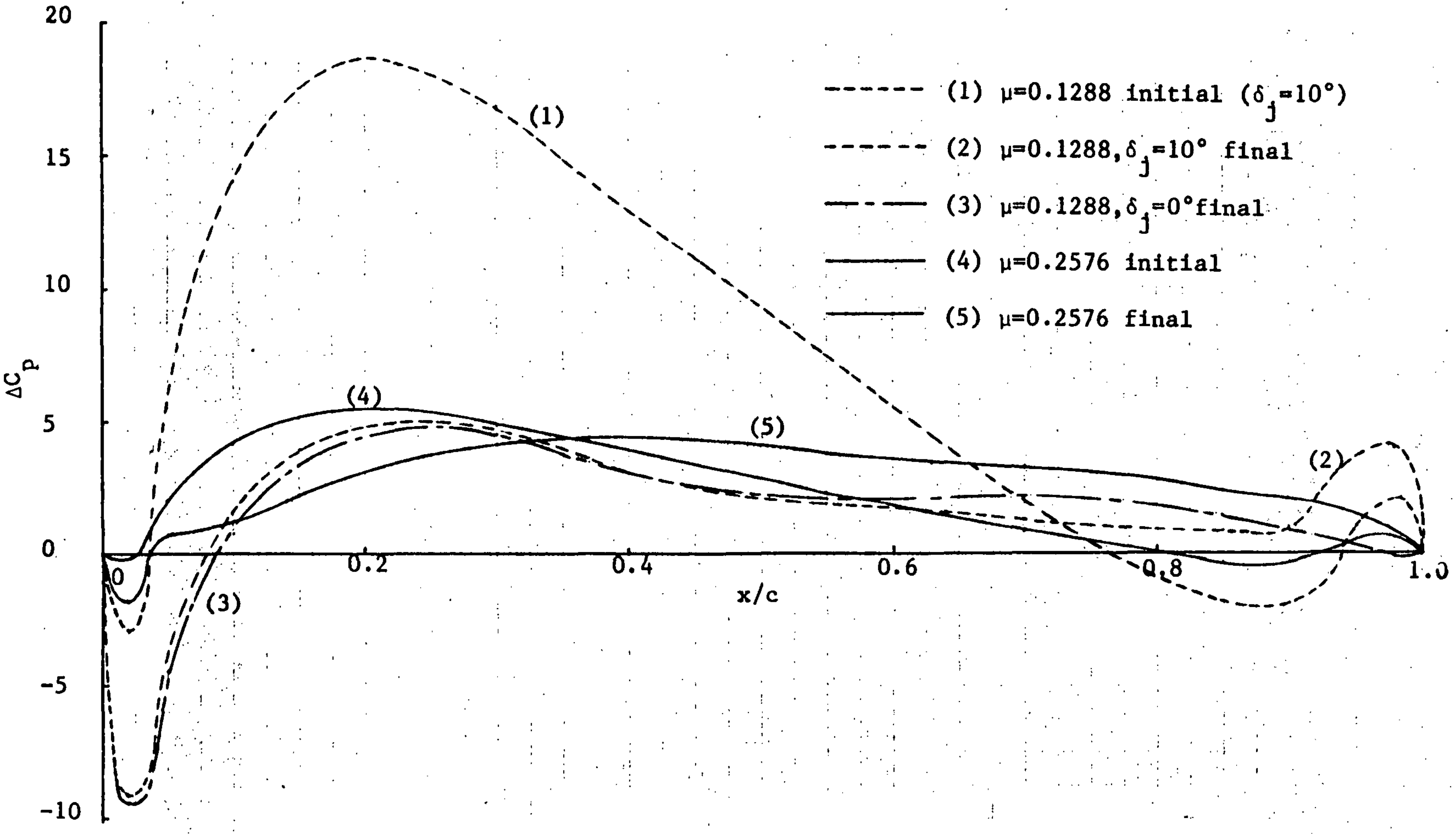


Figure 14. Pressure Distribution (inside the jet region 2y/b=0.21014) in the jet-on case.
($\bar{C}_L$=1.2,$\bar{C}_m$=-0.075,C_μ=1.676,t_j = 0.1, M_o=M_j=0,α=0°)

10°, the pressure distribution is again changed only slightly. Fig. 15 indicates that the final loading is seen to be still concentrated in the jet region. This is probably because of the jet spreading effect has not been accounted for. From the above results, it is seen that the smaller the μ is, the higher the span loading will be inside the jet region. The initial and final pressure distributions for $\mu = 0.1288$ and $\mu = 0.2576$ are also shown in Fig. 15. The distributions of local angle of attack in the spanwise direction over the semi-span are shown in Fig. 16. It is seen that to reduce the loading inside the jet region negative local angle of attack are needed. As μ is decreased, the local angle of attack is increased negatively inside the jet region. And the decrease of δ_j would increase the local angle of attack inside the jet region. The large variation in the local angle of attack inside and outside the jet region would be smoothed out if the jet spreading effect is accounted for.

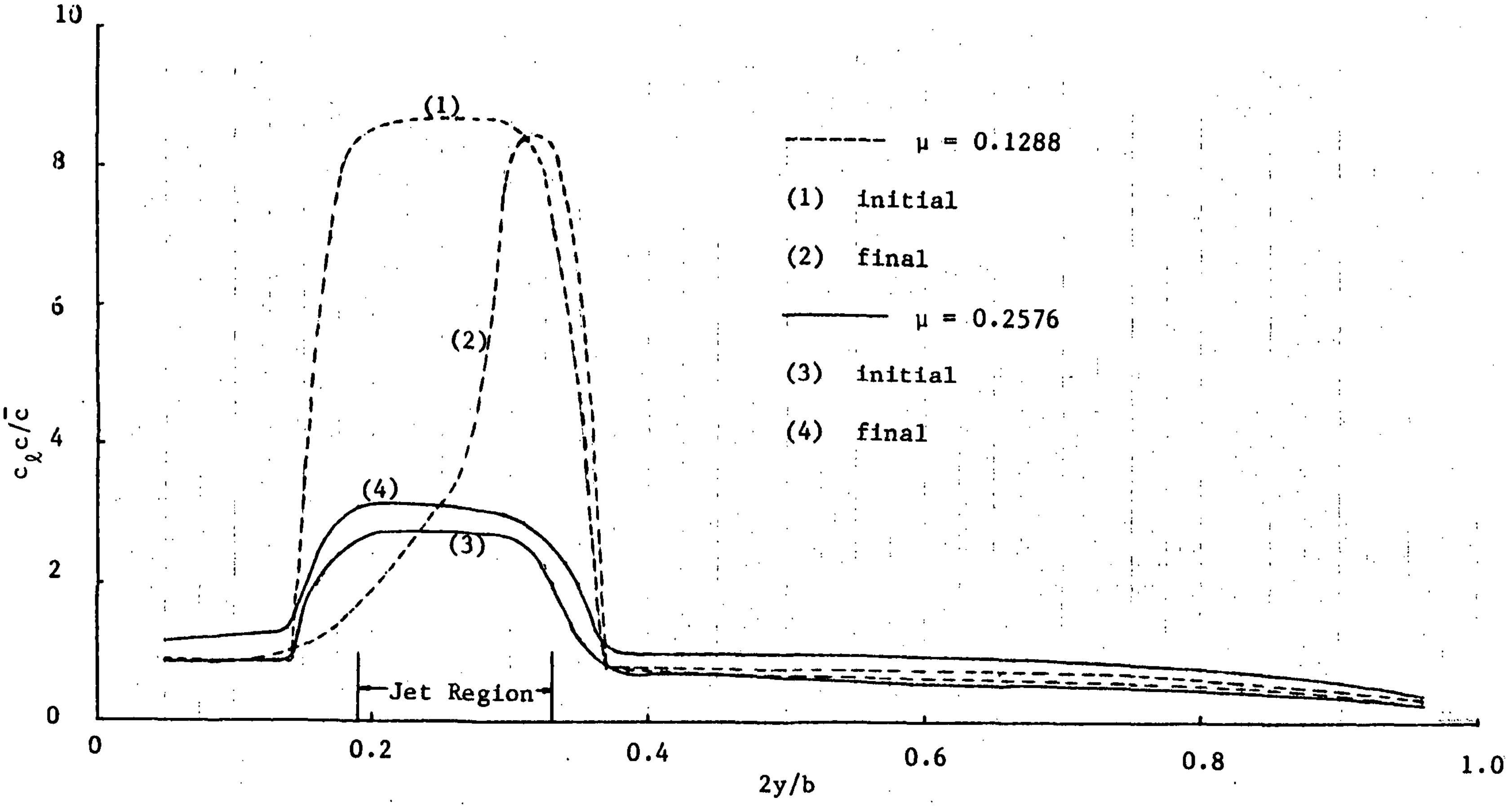


Figure 15. Span Loading in the jet-on case. ($\bar{C}_L$=1.2, $\bar{C}_m$=-0.075, C_μ=1.676, t_j =0.1 , M_o=M_j=0, α=0°)

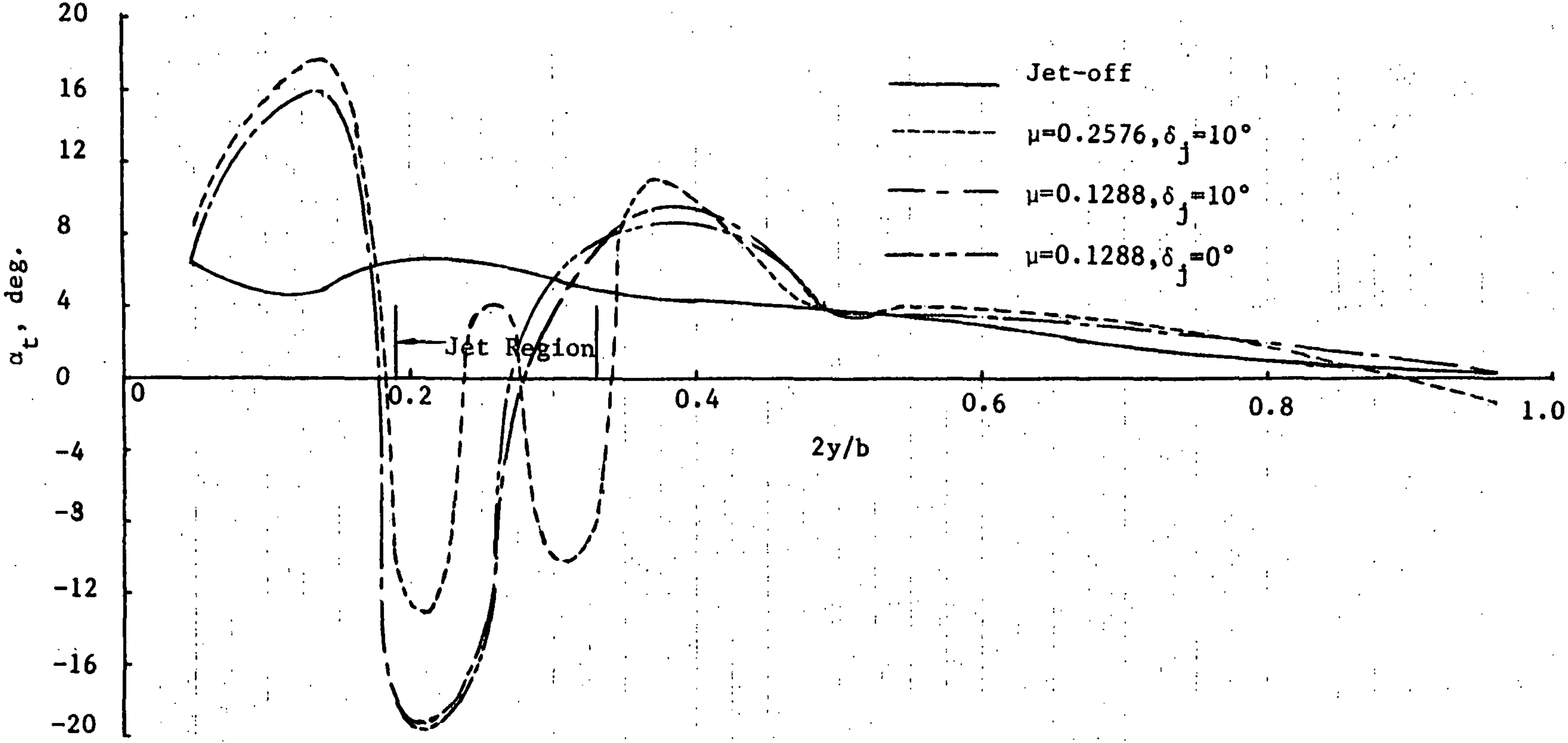


Figure 16. Twist Distribution in the jet-on case.
(C_L=1.2, C_m=-0.075, C_μ=1.676, t_j=0.1 M_o=M_j=0, α=0°)

5. CONCLUSIONS AND RECOMMENDATIONS

By using Lan's QVLM (Ref. 9) and his wing-jet interaction theory (Ref.10 and 11) , an optimization method for calculating the mean camber surface and twist distribution for the minimum induced drag configuration with the upper-surface-blowing jet has been developed. The predicted results show good agreement with Stevens' (Ref.5) theoretical method for configurations without the jet effect. Because of lack of data for comparison, the accuracy of the theory with the blowing jet effect cannot be established. However, the trend of jet effect on camber ordinates, span loading, twist and pressure distribution has been investigated.

The investigation made so far has been for a swept, tapered wing with zero leading-edge suction and the jet exit at the leading-edge in the incompressible flow only. The present method can be extended to handle jet exit away from the leading-edge. Further study for different planforms at some Mach numbers and higher free stream to jet velocity ratio is recommended.

6. REFERENCES

1. Munk,M.M., "The Minimum Induced Drag of Aerofoils", NACA TR 121, 1921.
2. Mangler,W., "The Lift Distribution of Wings with End Plates", NACA TM 856, 1938.
3. Cone,C.D.,Jr., "The Theory of Induced Lift and Minimum Induced Drag of Nonplanar Lifting System", NASA TR R-139, 1962.
4. Lundry,J.L. and Lissaman,P.B.S., "A Numerical Solution for the Minimum Induced Drag of Nonplanar Wings", Journal of Aircraft, Vol. 5, No. 1, Jan.-Feb. 1968, pp. 17-21.
5. Stevens,J.R. and McDonald,J.W., "Subsonic Lifting Surface Design and Analysis Procedure", NOR-64-195, 1965,Northrop Corp., Aircraft Div., Hawthorne, Calif.
6. Loth,J.L. and Boyle,R.E., "Optimum Loading on Nonplanar Wings at Minimum Induced Drag", Aerospace Eng. TR-19 (Contract N00014-68-A-1512), West Virginia Univ., Aug. 1969.
7. Lamar,J.E., "A Vortex-Lattice Method for The Mean Camber Shapes of Trimmed Noncoplanar Planforms with Minimum Vortex Drag", NASA TN D-8090, JUNE 1976.
8. Watkins,C.E., Woolston,D.S., and Cunningham,H.J., "A Systematic Kernel Function Procedure for Determining Aerodynamic Forces on Oscillating or Steady Finite Wings at Subsonic Speed", NASA TR R-48, 1958.
9. Lan,C.E., "A Quasi-Vortex-Lattice Method in Thin Wing Theory", Journal of Aircraft, Vol. 11, No. 9, Sept. 1974, pp. 518-527 .

10. Lan,C.E., and Campbell,J.F., "Theoretical Aerodynamics of Upper-Surface-Blowing Jet-Wing Interaction", NASA TN D-7936, Nov. 1975.

11. Lan,C.E., and Campbell,J.F., "A Wing-Jet Interaction Theory for USB Configurations", Journal of Aircraft, Vol. 13, No. 9, Sept. 1976, pp. 718-726.

12. Lan,C.E., "A Trigonometric Interpolation Formula", Appendix B of The Induced Drag of Oscillating Airfoils in Linear Subsonic Compressible Flow, KU-FRL-400, June 1975.

13. Kelly,H.J., "Method of Gradients", Ch.6 of Optimization Techniques with Applications to Aerospace Systems, ed. G.Leitmann, Academic Press, New York. 1962

14. Woodward,F.A.,Tinoco,E.N., and Larsen,J.W., "Analysis and Design of Supersonic Wing-Body Combinations, Including Flow Properties in the Near Field. Part I - Theory and Application", D6-15044-1, Aug. 1967, The Boeing Company, Commercial Airplane Division, Renton, Washington. pp. 81-86. (NASA CR-73106)

15. Selby,S.M., "Handbook of Tables for Mathematics", 3rd Edition,CRC, 1967.

16. Williams,J., and Ross,A.J., "Some Airframe Aerodynamic Problems at Low Speed", in "International Congress on Subsonic Aeronautics", Annals of the New York Academy of Science, Vol. 154, Art. 2, Nov. 1968.

17. Lan,C.E., Fillman,G.L. and Fox,C.H.Jr., "Computer Program for Calculating Aerodynamic Characteristics of Upper-Surface-Blowing and Over-Surface-Blowing Configurations", NASA TM X-73987, Feb. 1977.

Appendix A

Gradient Projection Method with Linear Constraints (Ref.13)

Consider the objective function $C_{D,i}$ of N variables $\gamma_{w1},\cdots,\gamma_{wn}$, which possesses continuous partial derivatives with respect to these variables. Starting at some point $\gamma_{wk} = \bar{\gamma}_{wk}$, $k=1,\cdots,n$, moving with a small distance ds defined in the Euclidean sense:

$$ds^2 = \sum_{k=1}^{N} (d\gamma_{wk})^2 \tag{A.1}$$

Then,

$$1 - \sum_{k=1}^{N} \left(\frac{d\gamma_{wk}}{ds} \right)^2 = 0 \tag{A.2}$$

Since the steepest descent direction of $C_{D,i}$ is the direction of the most negative $\frac{dC_{D,i}}{ds}$, thus,

$$\begin{aligned}\frac{dC_{D,i}}{ds} &= \sum_{k=1}^{N} \frac{\partial C_{D,i}}{\partial \gamma_{wk}} \frac{d\gamma_{wk}}{ds} \\ &= \nabla C_{D,i} \cdot \frac{d\gamma_w}{ds} < 0\end{aligned} \tag{A.3}$$

The method described below is to find the direction of steepest descent among the directions which make Eq.(A.3) stationary subject to Eq.(A.1). By using Lagrange multiplier λ_o , the following functional can be formed:

$$\sum_{k=1}^{N} \frac{\partial C_{D,i}}{\partial \gamma_{wk}} \frac{d\gamma_{wk}}{ds} + \lambda_o \left[1 - \sum_{m=1}^{N} \left(\frac{d\gamma_{wm}}{ds} \right)^2 \right] \tag{A.4}$$

Differentiating Eq.(A.4) with respect to $(\frac{d\gamma_{wk}}{ds})$ and setting the result to zero, it is found that :

$$\frac{\partial C_{D,i}}{\partial \gamma_{wk}} + \lambda_o \left(-2 \frac{d\gamma_{wk}}{ds}\right) = 0, \quad k = 1,\cdots,N \tag{A.5}$$

or,

$$\frac{d\gamma_{wk}}{ds} = \frac{1}{2\lambda_o} \frac{\partial C_{D,i}}{\partial \gamma_{wk}} \tag{A.6}$$

Substitution of Eq.(A.6) into Eq.(A.2) gives :

$$1 - \sum_{k=1}^{N} \left(\frac{1}{2\lambda_o} \frac{\partial C_{D,i}}{\partial \gamma_{wk}}\right)^2 = 0 \tag{A.7}$$

from which λ_o can be found :

$$\lambda_o = \pm \frac{1}{2} \left[\sum_{k=1}^{N} \left(\frac{\partial C_{D,i}}{\partial \gamma_{wk}} \right)^2 \right]^{1/2} \tag{A.8}$$

Provided the partial derivatives $\frac{\partial C_{D,i}}{\partial \gamma_{wk}}$ are not all zero, there are two distinct sets of directional numbers which make $\frac{dC_{D,i}}{ds}$ stationary. From Eqs.(A.5) and (A.8), it is easily seen that :

$$\frac{d\gamma_{wk}}{ds} = \pm \frac{\partial C_{D,i}}{\partial \gamma_{wk}} \left[\sum_{m=1}^{N} \left(\frac{\partial C_{D,i}}{\partial \gamma_{wm}}\right)^2 \right]^{-1/2} \tag{A.9}$$

$$k = 1,\cdots,N$$

From Eq.(A.3) the directional derivative can be shown to be :

$$\frac{dC_{D,i}}{ds} = \pm \left[\sum_{m=1}^{N} \left(\frac{\partial C_{D,i}}{\partial \gamma_{wm}} \right)^2 \right]^{1/2} \tag{A.10}$$

Let σ be a time parameter. Consider the motion along the negative gradient direction as a continuous process. Then Eq.(A.1) becomes :

$$\frac{ds}{d\sigma} = \left[\sum_{m=1}^{N} \left(\frac{d\gamma_{wm}}{d\sigma} \right)^2 \right]^{1/2} = V \tag{A.11}$$

From Eqs.(A.9) and (A.11), it can be seen that :

$$\frac{d\gamma_{wk}}{d\sigma} = - \left[\sum_{n=1}^{N} \left(\frac{d\gamma_{wn}}{d\sigma} \right)^2 \right]^{1/2} \left[\sum_{m=1}^{N} \left(\frac{\partial C_{D,i}}{\partial \gamma_{wm}} \right)^2 \right]^{-1/2} \frac{\partial C_{D,i}}{\partial \gamma_{wk}} ,$$

$$k = 1,\cdots,N \tag{A.12}$$

Let $$V = K \left[\sum_{m=1}^{N} \left(\frac{\partial C_{D,i}}{\partial \gamma_{wm}} \right)^2 \right]^{1/2} , \quad K > 0 \tag{A.13}$$

Then,

$$\frac{d\gamma_{wm}}{d\sigma} = - K \frac{\partial C_{D,i}}{\partial \gamma_{wm}} , \quad m=1,\cdots,N \tag{A.14}$$

Eq.(A.14) shows that the motion in the negative gradient direction is assured by setting the time derivatives of the coordinates γ_w proportional to the partial derivatives of $C_{D,i}$.

If the stepwise version is considered, then Eq.(A.14) becomes :

$$\gamma_{wm}^{(p+1)} = \gamma_{wm}^{(p)} - K \frac{\partial C_{D,i}}{\partial \gamma_{wm}} \Delta\sigma , \quad m=1,\cdots,N \tag{A.15}$$

where the constant K may be absorbed in the step size $\Delta\sigma$. Hence :

$$\gamma_{wm}^{(p+1)} = \gamma_{wm}^{(p)} - \frac{\partial C_{D,i}}{\partial \gamma_{wm}} \Delta\sigma , \quad m = 1,\cdots,N \tag{A.16}$$

If the objective function $C_{D,i}$ is subject to the two linear equality constraints,

$$C_L\ (\gamma_{w1},\cdots\cdots,\gamma_{wn}) = \bar{C}_L \tag{A.17}$$

$$C_m\ (\gamma_{w1},\cdots\cdots,\gamma_{wn}) = \bar{C}_m \tag{A.18}$$

the relation appropriate to a stepwise process analogous to that given by Eq.(A.16) are :

$$\gamma_{wk}^{(p+1)} = \gamma_{wk}^{(p)} - \left(\frac{\partial C_{D,i}}{\partial \gamma_{wk}} + \lambda_1 \frac{\partial C_L}{\partial \gamma_{wk}} + \lambda_2 \frac{\partial C_m}{\partial \gamma_{wk}} \right) \Delta\sigma$$

$$k = 1,\cdots, N \tag{A.19}$$

or,

$$\Delta\gamma_{wk} + \lambda_1 \frac{\partial C_L}{\partial \gamma_{wk}} \Delta\sigma + \lambda_2 \frac{\partial C_m}{\partial \gamma_{wk}} \Delta\sigma = - \frac{\partial C_{D,i}}{\partial \gamma_{wk}} \Delta\sigma \tag{A.20}$$

By Taylor's series expansion, Eqs.(A.17) and (A.18) become :

$$C_L\ (\gamma_{w1},\cdots\cdots,\gamma_{wn}) \simeq C_L\ (\bar{\gamma}_{w1},\cdots\cdots,\bar{\gamma}_{wn}) +$$

$$\sum_{k=1}^{N} \frac{\partial C_L}{\partial \gamma_{wk}} (\bar{\gamma}_{w1},\cdots\cdots,\bar{\gamma}_{wn})(\gamma_{wk} - \bar{\gamma}_{wk}) \tag{A.21}$$

$$C_m\ (\gamma_{w1},\cdots\cdots,\gamma_{wn}) \simeq C_m\ (\bar{\gamma}_{w1},\cdots\cdots,\bar{\gamma}_{wn}) +$$

$$\sum_{k=1}^{N} \frac{\partial C_m}{\partial \gamma_{wk}} (\bar{\gamma}_{w1},\cdots\cdots,\bar{\gamma}_{wn})(\gamma_{wk} - \bar{\gamma}_{wk}) \tag{A.22}$$

Assume that the constraints are satisfied at the point $\gamma_{wk} = \bar{\gamma}_{wk}$. Then Eqs.(A.21) and (A.22) become:

$$\sum_{i=1}^{N} \frac{\partial C_L}{\partial \gamma_{wi}} \Delta\gamma_{wi} = 0 \qquad (A.23)$$

$$\sum_{i=1}^{N} \frac{\partial C_m}{\partial \gamma_{wi}} \Delta\gamma_{wi} = 0 \qquad (A.24)$$

In the present method , since the initially computed C_L and C_m values approach the constrained values gradually, Eqs.(A.23) and (A.24) become the following modified form which are actually applied in the iterative process :

$$\sum_{i=1}^{N} \frac{\partial C_L}{\partial \gamma_{wi}} \Delta\gamma_{wi} = \bar{C}_L - C_L^{(p)} \qquad (A.25)$$

$$\sum_{i=1}^{N} \frac{\partial C_m}{\partial \gamma_{wi}} \Delta\gamma_{wi} = \bar{C}_m - C_m^{(p)} \qquad (A.26)$$

where $C_L^{(p)}$ and $C_m^{(p)}$ are the computed values at the p-th iteration. The optimization equations include Eqs.(A.20),(A.25) and (A.26). They are to restore the linear equality constraints and adjust the variables γ_{wk}. The optimal solution of γ_{wk} can be found as the objective function $C_{D,i}$ reaches the minimum.

Appendix B

Description of the Computer Program

This computer program provides a theoretical method for determining the minimum induced drag configurations in the wing-alone and jet-on (USB) cases. The first part of the program is used to set up the influence coefficient matrices of the boundary conditions (the detailed explanation is in Ref. 17). The calling routines of this part include " GEOMTY ", " JETOFF " and " JETON ". The optimum camber shape and twist distribution for the minimum induced drag can be determined by using the second part of the program. The calling routines of this part include " WALNOL "," INVMTX "," COMJET " and " JETNOL ". In the wing-alone case, the optimum solution can be found from the subroutine " WALNOL ". In the jet-on case, the subroutines " INVMTX ", " COMJET " and " JETNOL " should be used. The initial wing-alone vortex strengths used in the jet-on case are obtained by Lagrange interpolation from the optimum results in the wing-alone case.

Pre-Run Check List

Before running the computer program, the following checklist should be completed:

(1) To use the adjustable dimensions in the program, the three constants of IPANEL, ICW and JPANEE should be declared as input parameters in the following subroutines:

$$\text{IPANEL and JPANEE ------------ Subroutines}\left\{\begin{array}{l}\text{" WALNOL "}\\ \text{" INVMTX "}\end{array}\right.$$

$$\text{IPANEL, ICW and JPANEE ------- Subroutines}\left\{\begin{array}{l}\text{" COMJET "}\\ \text{" JETNOL "}\end{array}\right.$$

The constants IPANEL, ICW and JPANEE are defined as follows:

IPANEL	Total number of wing vortices (LPANEL).
ICW	Total number of chordwise vortices along each vortex strip.
JPANEE	Total number of jet vortices in the outer or inner flow (JPANEL).

(2) For IPANEL = 60, ICW = 6, JPANEE = 80, the minimum memory needed is 74K (decimal).

(3) If ITAPE = 0, the subroutines " INVMTX " and " COMJET " are executed and all the matrices are calculated and stored on tape. If ITAPE = 1, the subroutines " INVMTX " and " COMJET " are bypassed and the calculation proceeds using the matrices already computed (and available on tape).

(4) Nine temporary files and one tape must be provided. The detailed explanation of each file is given below:

File 01	The influence coefficient matrix $\left[N_{WW}\right]$ for the wing-alone case.
File 02	The tangential velocities on the trailing jet surface to be used to satisfy the jet flap effect.
File 03	All the influence coefficient matrices of the boundary conditions for the jet-on case.
File 04	The influence coefficient matrix after being interpolated for the wing-alone case ($\left[A\right]$).
File 08	The coefficient matrix of the optimization equations and the right hand side of those equations.
File 09	The inverted augmented matrix of the boundary conditions.
File 10	The derivatives of camber slope with respect to wing-alone vortex strength.
File 11	The influence coefficient matrices after being interpolated for the jet-on case ($\left[A\right]$, $\left[B\right]$).
File 12	The derivatives of the jet vortex strength in the outer flow and of the additional wing vortex strength —— both taken with respect to the wing-alone vortex strength.

(5) Check input data.

Input Data Format

Group 1.	Format	13A6	1 card
	Any title identifying the case to be run.		
Group 2.	Format	4(6X,I4)	1 card
	ICASE	Number 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.	
	ITAPE	= 0 if all matrices are to be calculated and stored on tape. = 1 if all matrices on tape are to be used.	
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 temperature divided by freestream static 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.	

Group 4.	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) I=1,NFP	Flap deflection angles in degrees for the flap sections.
Group 5.	Format	8F10.5 1 card
	HALFSW	One half of the reference wing area.
	TWIST	Difference in angle of attack at the tip and the root in degrees. Negative for washout.
	TWISTR	Incidence angle of the root chord in degrees.
	XJ YJ ZJ	X,Y, and Z-coordinates of the midpoint of the jet cross section at the exit.
	RJ	Jet radius.
	CREF	Reference chord length.
Group 6.	Format	3F10.5 1 card
	TEANGL	Trailing-edge half angle of the airfoil at the jet centerline in degrees. For USB applications, it may be arbitrary.
	PTIAL	= 0. for clean or full-span flap configuration. = 1. for partial-span flap deflection.
	USB	= 0. for OWB applications. = 1. for USB applications.

Group 7.	Format	3F10.5 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.
Group 8.	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 boundary, wing edge discontinuities,etc.
	M1(I) I=1,NC	Number of vortex strips in each spanwise section, plus one.

Group 9.	Format	5(6X,I4) 1 card
	NJW(I) I=1,NFP	The numerical order of the flap and jet spans among the spanwise sections.
Group 10.	Format	3(6X,I4) 1 card
	NW(I) I=1,2,3	Number of chordwise vortex elements in each chordwise section. The planform is divided into chordwise sections according to such lines of discontinuity as jet exit, flap hinge,etc.
Group 11.	Format	6F10.5 1 card
	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 12.	Format	6(6X,I4) 1 card
	NNJ	Number of jet sections.
	NSJ	= Number of jet circumferential strips minus one for a noncentered jet (always use odd numbers). = Number of jet circumferential strips on the half jet plus one for centered jet (always use even numbers).

	NCJ(I)	Number of streamwise vortex elements in each section. For those jet sections above the wing, these numbers should agree with the corresponding numbers of wing vortices.
Group 13.	Format	4F10.5 (4 x NNJ) cards
	XXL(I) XXT(I) YL(I) ZL(I) I=1,···,4	Coordinates of the bounding lines defining the rectangular jet sections in USB applications. They are the x-coordinates of the leading and trailing edges, the y-coordinate and the z-coordinate of the bounding line. There are 4 cards for each jet section. The jet section behind the trailing edge should be at least one local chord in length.
Group 14.	Format	(4F10.5,I10) 1 card
	CDBAR	Theoretical minimum induced drag coefficient in the wing alone case.
	CLBAR	Lift constraint in the wing alone case.
	CMBAR	Pitching moment constraint in the wing alone case.
	DELTA	Initial step size in the wing alone case.
	MAXP	Maximum number of iterations in the wing alone case.

Group 15.	Format	(3F10.5,I10) 1 card
	CLBAR	Lift constraint in the jet-on case.
	CMBAR	Pitching moment constraint in the jet-on case.
	DELTO	Initial step size in the jet-on case.
	MAXP	Maximum number of iterations in the jet-on case.
Group 16.	Format	(I10,F10.5) 1 card
	NUMB	Number of intermediate cycles for the initial computed lift and pitching moment coefficients to reach the constrained values. There are two or three iterations in each cycle.
	SIZE	The constant step size is to be used in the jet-on case.

Note: The read statements for the input data in groups 3-13 can be seen in subroutine " GEOMTY ", the input data of group 14 is in subroutine " WALNOL ", the input data in groups 15-16 are in subroutine " JETNOL ". The input data for groups 1 and 2 can be seen in the main program.

Sample Input Data for the Wing-alone and Jet-on cases

```
Card
   1    * * *  WING ALONE CASE   * * *
   2            1         1         1         1
   3  0.        0.        0.2576    1.        0.        -0.29391  0.12318
   4            1         1  0.
   5  0.36364   0.        0.        -0.29391  0.25945   0.05      1.        0.37495
   6  0.        1.        1.
   7  1.676     10.       0.
   8            1        11
   9            1
  10            6         0         0
  11  -0.56776  -0.09304  0.        0.48778   0.74033   1.
  12            1         7         6
  13  -0.56776  -0.09304  0.        0.
  14  -0.56776  -0.09304  0.        0.1
  15  0.48778   0.74033   1.        0.1
  16  0.48778   0.74033   1.        0.
  17  0.02084   0.6       -0.036    50.              15
  18    * * *  JET ON CASE WITH UPPER SURFACE BLOWING  * * *
  19  0.        0.        0.2576    1.        0.        -0.29391  0.12318
  20            1         1  0.
  21  0.36364   0.        0.        -0.29391  0.25945   0.05      1.        0.37495
  22  0.        1.        1.
  23  1.676     10.       0.
  24            3         3         4         6
  25            2
  26            6         0         0
  27  -0.56776  -0.09304  0.        -0.3675   0.06507   0.18972
  28  -0.3675   0.06507   0.18972   -0.22031  0.18128   0.32917
  29  -0.22031  0.18128   0.32917   0.48778   0.74033   1.
  30            2         7         6         4
  31  -0.3675   0.06507   0.18972   0.
  32  -0.3675   0.06507   0.18972   0.1
  33  0.22031   0.18128   0.32917   0.1
  34  0.22031   0.18128   0.32917   0.
  35  0.06507   0.49764   0.18972   0.
  36  0.06507   0.49764   0.18972   0.1
  37  0.18128   0.58287   0.32917   0.1
  38  0.18128   0.58287   0.32917   0.
  39  1.2       -0.075    0.1                 20
  40            5   0.4
```

Output Data Format

The title of the job and the input data will be printed in the same format as it was input. For the upper-surface-blowing configuration, the following output data will be printed :

HALFSW	The reference half-wing area.
CREF	The reference chord length.
LPANEL	Total number of wing vortices.
JPANEL	Total number of jet vortices in the outer or inner flow.
LAST	The number of wing vortices plus the number of outer jet vortices. LAST = LPANEL + JPANEL
LTOTAL	The total number of vortices which is the sum of wing vortices, outer jet vortices and inner jet vortices. LTOTAL = LAST + JPANEL = LPANEL + 2 (JPANEL)

Vortex Element Endpoint Coordinates

X_1,Y_1,Z_1	Coordinates for the inboard endpoint of a bound vortex element.
X_2,Y_2,Z_2	Coordinates for the outboard endpoint (corresponding to (X_1,Y_1,Z_1)) of a bound vortex element.

Note: Wing elements are listed first and then jet elements. The number of elements listed should equal (LAST).

Control Point Coordinates

XCP YCP ZCP	Two columns of control point coordinates, one point for each vortex element.

Note: Control points on the wing are listed first and then control points on the jet surface. The number of points listed should equal (LAST).

Overall Aerodynamic Coefficients

DELTA	The step size which is used in the N-th iteration.
CDII	The computed induced drag coefficient in the N-iteration.
CLII	The computed lift coefficient in the N-th iteration.
CMII	The computed pitching moment coefficient in the N-th iteration.

Camber Shape and Twist Distribution

ALPAO	Local angle of attack (twist) along each vortex strip.
CAMZC	Camber ordinates along each vortex strip.

Sectional Pressure and Force Data

XV	Fraction of local chord.
YV	Spanwise fraction of semispan.
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 divided by the half span.
CL	The sectional lift coefficient due to circulation (jet on), nondimensionalized 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 alone case.
CMW	The sectional pitching moment coefficient (about Y-axis) for the wing alone case.
CDW	The sectional induced drag coefficient for the wing alone case.

Span Loading Computation

Jet-Off Span Loading

$$= \frac{(\text{ CLW x CH })}{\text{CREF}}$$ (where CH is local chord length)

Jet-On Span Loading

$$= \frac{(\text{ CL x CH })}{\text{CREF}}$$ (where CH is local chord length)

Total Force and Moment Data

The Lift Coefficient

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

Total Induced Drag Coefficient

Total induced drag coefficient for the jet on case.

Induced Drag Parameter

$$= \frac{C_{D,i}}{{C_L}^2} \quad \text{or} \quad \frac{1}{\pi e \ AR}$$

Total Pitching Moment Coefficient

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

Coanda Effect

Coanda Lift Coefficient

The lift coefficient due to the lift component of the jet reaction force.

Coanda Drag Coefficient

The drag coefficient due to the drag component of the jet reaction force.

Coanda Moment Coefficient

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

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

Appendix C

Computer Program Listing

(This program is operational on Honeywell 66/60 computer)

```
Main Program                     I   Subroutine " WALNOL "
                                 I
Subroutine " STREAM "            I   Subroutine " WALNO2 "
                                 I
Subroutine " SPEED "             I   Subroutine " WALNO3 "
                                 I
Subroutine " NORSPD "            I   Subroutine " WALNO4 "
                                 I
Subroutine " VMSEQN "            I   Subroutine " WALNO5 "
                                 I
Subroutine " INTEG "             I   -----------------------
                                 I
Subroutine " INVRCX "            I   Subroutine " INVMTX "
                                 I
-----------------------          I   Subroutine " JETNO3 "
                                 I
Subroutine " GEOMTY "            I   -----------------------
                                 I
Subroutine " RESHAP "            I   Subroutine " COMJET "
                                 I
Subroutine " PANEL "             I   Subroutine " JETNO4 "
                                 I
Subroutine " ENTRN "             I   Subroutine " JETNO5 "
                                 I
Subroutine " RECTJ "             I   Subroutine " JETNO6 "
                                 I
Subroutine " CIRCJ "             I   -----------------------
                                 I
Subroutine " JSHAPE "            I   Subroutine " JETNOL "
                                 I
-----------------------          I   Subroutine " JETNO7 "
                                 I
                                 I   Subroutine " JETNO8 "
                                 I
Subroutine " JETOFF "            I   Subroutine " JETNO9 "
                                 I
Subroutine " JETON "             I   Subroutine " CAMBER "
                                 I
Subroutine " MATRIX "            I   Subroutine " LOAD "
                                 I
Subroutine " SKIP "              I
                                 I
Subroutine " WING "              I
                                 I
                                 I
```

```
        02-13-78   02.177

$      OPTION  FORTRAN
$      FORTY
$      INCODE  IBMF
C     MINIMUM INDUCED DRAG CONFIGURATION WITH JET INTERACTION
C     BY C. EDWARD LAN AND JENN-LOUH PAO OF THE UNIVERSITY OF KANSAS
C   THIS PROGRAM IS DESIGNED TO FIND THE OPTIMUM CAMBER SHAPE, TWIST
C   DISTRIBUTION, SPAN LOADING , AND CHORDWISE PRESSURE DISTRIBUTION
C   CORRESPONDING TO THE MINIMUM INDUCED DRAG CONFIGURATION IN THE
C   WING ALONE AND JET ON ( UPPER-SURFACE-BLOWING ) CASES.
C
      DIMENSION AW(300),TITLE(13)
      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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFP
      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,ALFC,ALPS,CDF,SDF,TH,TDF
      COMMON /JET/ PK1,XC,XJT(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 /CLOPE/ DZDXK(100),ALPAO(15),GCB(100),GCBX(100),THETAK(10)
     1,CCX(100),OZDXK(100),GAN(2,100)
      COMMON /LING/ GLBAR,GMBAR,FCLII,FCMII
      COMMON /WLONE/ DZDXKW(100),GAMW(100),CAMZCW(100),ALPAOW(20)
      COMMON /IDENT/ DZDXK1(100),GAM1(100),CAMZC1(100),ALPAO1(20),YLE1(2
     10)
    2 FORMAT (5F10.5)
    3 FORMAT (7(6X,I4))
   19 FORMAT (13A6)
  406 FORMAT (40H****************************************)
      PI=3.14159265
      READ (5,19) (TITLE(I),I=1,13)
      WRITE (6,406)
      WRITE (6,19) (TITLE(I),I=1,13)
      WRITE (6,406)
      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 BUT DIFFERENT ALPHA'S) , AND SYMMETRY CODE (=0 FOR A CENTERED
C     JET, AND=1 OTHERWISE), ITAPE=1 FOR MATRICES ON TAPE ARE TO BE USED
C     ITAPE=0 , THEN COMPUTE ALL MATRICES  ***
C
      READ (5,3) ICASE, NG,ISYM,ITAPE
      WRITE (6,3) ICASE,NG,ISYM,ITAPE
```

```
 20 CONTINUE
         CALL LLINK(6HLINK11)
    CALL GEOMTY(KCODE)
         CALL LLINK(6HLINK22)
    CALL JETOFF
         CALL LLINK(6HLINK33)
    CALL WALNOL
98  CONTINUE
    READ (5,19) (TITLE(I),I=1,13)
    WRITE (6,406)
    WRITE (6,19) (TITLE(I),I=1,13)
    WRITE (6,406)
         CALL LLINK(6HLINK11)
    CALL GEOMTY(KCODE)
    L1=LPANEL+1
    J7=LPANEL+JPANEL
    IF (ITAPE .EQ. 1) GO TO 40
         CALL LLINK(6HLINK22)
    CALL JETOFF
    CALL JETON(KCODE)
         CALL LLINK(6HLINK44)
    CALL INVMTX
         CALL LLINK(6HLINK55)
    CALL COMJET (KCODE)
10  CONTINUE
    REWIND 01
    REWIND 03
    REWIND 04
    REWIND 09
    REWIND 10
    REWIND 11
    REWIND 12
    REWIND 13
    DO 41 I=1,LPANEL
    READ (01) (AW(J),J=1,L1)
41  WRITE (13) (AW(J),J=1,L1)
    DO 42 I=1,LTOTAL
    READ (03) (AW(J),J=1,LTOTAL)
42  WRITE (13)(AW(J),J=1,LTOTAL)
    DO 44 I=1,LTOTAL
    READ (09) (AW(J),J=1,LTOTAL)
44  WRITE (13)(AW(J),J=1,LTOTAL)
    DO 45 I=1,LPANEL
    READ (10) (AW(J),J=1,LPANEL)
45  WRITE (13)(AW(J),J=1,LPANEL)
    DO 46 I=1,LPANEL
    READ (11) (AW(J),J=1,J7)
46  WRITE (13)(AW(J),J=1,J7)
    DO 47 I=1,LPANEL
    READ (12) (AW(J),J=1,J7)
47  WRITE (13)(AW(J),J=1,J7)
```

```
      GO TO 100
 40   REWIND (13)
      REWIND 01
      REWIND 03
      REWIND 04
      REWIND 09
      REWIND 10
      REWIND 11
      REWIND 12
      DO 51 I=1,LPANEL
      READ (13)  (AW(J),J=1,L1)
 51   WRITE (01)  (AW(J),J=1,L1)
      DO 52 I=1,LTOTAL
      READ (13)  (AW(J),J=1,LTOTAL)
 52   WRITE (03)(AW(J),J=1,LTOTAL)
      DO 54 I=1,LTOTAL
      READ (13)  (AW(J),J=1,LTOTAL)
 54   WRITE (09)(AW(J),J=1,LTOTAL)
      DO 55 I=1,LPANEL
      READ (13)  (AW(J),J=1,LPANEL)
 55   WRITE (10)(AW(J),J=1,LPANEL)
      DO 56 I=1,LPANEL
      READ (13)  (AW(J),J=1,J7)
 56   WRITE (11)(AW(J),J=1,J7)
      DO 57 I=1,LPANEL
      READ (13)  (AW(J),J=1,J7)
 57   WRITE (12)  (AW(J),J=1,J7)
 100  CONTINUE
      REWIND 04
      REWIND 11
      DO 25 I=1,LPANEL
      READ (11)  (AW(K),K=1,J7)
      WRITE (04)  (AW(K),K=JPANEL+1,J7)
 25   CONTINUE
            CALL LLINK(6HLINK66)
      CALL JETNOL(KCODE)
      NCON=NCON+1
      IF (NCON .LE. ICASE) GO TO 98
      IF (NCON .GT. ICASE) GO TO 5
      IF (NG .EQ. 1) GO TO 20
    5 CONTINUE
      STOP
      END
$      FORTY
$      LIMITS  ,27K
$      INCODE  IBMF
      SUBROUTINE STREAM(ALPHA,VMU,I,IPHI,LPANEL,TEMP,LPAN1,LPAN2,ISYM,
     1KCODE,EXIT,MJ,INDEX,BA)
C     TO COMPUTE THE RIGHT HAND SIDE OF THE SIMULTANEOUS EQUATIONS
      DIMENSION PHIN(300),BA(1)
      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
      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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      EQUIVALENCE (X(1,1),PHIN(1))
      PI=3.14159265
      IUSB=YCON(24)
      ZJET=YCON(25)
      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 1
      GO TO 5
    1 IF (I .GT. LAST) GO TO 10
      IF (EXIT .LE. 0.001) GO TO 2
      IF (NNJ .EQ. 1) GO TO 2
      IF (I .LE. MJJ(1) .AND. I .NE. MJ) GO TO 5
    2 CONTINUE
      ALPHA=ALPT*Y(3,IPHI)*(1.-VMU)
      IF (TH .LE. 0.001) GO TO 3
      IF (IPHI .EQ. NJH) GO TO 3
      IF (ISYM .NE. 0 .AND. IPHI .EQ. 1) GO TO 3
      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)
    3 CONTINUE
      IF (ABS(B1-B2) .LE. 0.001) GO TO 28
      CALL NORSPD (I,ALPH,LPANEL,IPHI,LPAN1,LPAN2,INDEX,BA)
      ALPHA=ALPHA+ALPH
   28 IF (KCODE .EQ. 0) GO TO 5
      IF (EXIT .LE. 0.001) GO TO 29
      IF (NNJ.EQ.1) GO TO 29
      IF (I .LE. MJJ(1) .AND. I .EQ. MJ) ALPHA=ALPHA/2.
   29 IF (IPHI .EQ. NJH) GO TO 5
      IF (ISYM .NE. 0 .AND. IPHI .EQ. 1) GO TO 5
      IF (IUSB .EQ. 1 .AND. ZJET .GT. 0.01) GO TO 5
      IF (CDF .LT. 0.0001) GO TO 5
      IF (NNJ .EQ. 1) GO TO 12
      IF (I .LE. MJJ(N1)) GO TO 5
   12 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)
      MF=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 6 JJ=1,MF
      IF (JJ .EQ. MF) GO TO 7
      DXTH=DLX*PSI(JJ)*TEMP*VMU*VMU/TH
      GO TO 8
    7 DXTH=DLX*PSI(JJ)*TEMP*0.5*VMU*VMU/TH
    8 JK1=IP+JJ
      JK2=JK1-1
      PROD=SZX*DXTH
      JK3=JK2+NP*NCJ(NNJ)
      ALPHA=ALPHA+PROD*(PHIN(JK2)-PHIN(JK3))
    6 CONTINUE
      GO TO 5
   10 CONTINUE
      IF (INDEX.EQ.1) GO TO 62
      GO TO 63
 62   DO 64 M=1,LPANEL
      BA(M)=0.0
 64   CONTINUE
 63   CONTINUE
      IJ=I-JPANEL
      IF (KCODE .EQ. 0) GO TO 30
      IF (EXIT .LE. 0.01) GO TO 4
      IF (NNJ .EQ. 1) GO TO 4
      IF (IJ .GT. LPANEL .AND. IJ .LE. MJJ(1)) GO TO 5
    4 CONTINUE
      IF (IUSB .EQ. 1 .AND. ZJET .GT. 0.01) GO TO 30
      IF (NNJ .EQ. 1) GO TO 30
      IF (IJ .GT. MJJ(N1)) GO TO 30
      IF (IPHI .LE. NJH) GO TO 30
      L1=NJH
      IF (ISYM .EQ. 0) L1=NJH+1
      IF (NW(2) .EQ. 0) GO TO 70
      IF (NW(3) .EQ. 0) GO TO 71
      IF (IJ .GT. MJJ(N2)) GO TO 32
      IF (IJ .GT. MJJ(N3)) GO TO 34
      IF (NNJ .EQ. 4) GO TO 33
      IF (NNJ . EQ. 5 .AND. IJ .GT. MJJ(NNJ-4)) GO TO 33
      GO TO 30
   71 IF (IJ .GT. MJJ(N2)) GO TO 34
      IF (NNJ .EQ. 3) GO TO 33
      IF (NNJ .EQ. 4 .AND. IJ .GT. MJJ(N3)) GO TO 33
```

```
      GO TO 30
   70 IF ( NNJ .EQ. 2) GO TO 33
      IF (NNJ .EQ. 3 .AND. IJ .GT. MJJ(N2)) GO TO 33
      GO TO 30
  33  K1=MJW1(1,NJP)+(IPHI-L1-ISYM)*NW(1)-1
      K2=LC(1)+IPHI-L1-ISYM
      KNW=NW(1)
      GO TO 35
  34  K1=MJW1(2,NJP)+(IPHI-L1-ISYM)*NW(2)-1
      K2=LC(2)+IPHI-L1-ISYM
      KNW=NW(2)
      GO TO 35
  32  K1=MJW1(3,NJP)+(IPHI-L1-ISYM)*NW(3)-1
      K2=LC(3)+IPHI-L1-ISYM
      KNW=NW(3)
   35 CONTINUE
      ALPHA1=0.
      ALPHA2=0.
      DO 40 KK=1,KNW
      KL=K1+KK
      AA=1.
      DO 42 L=1,KNW
      LL=K1+L
      IF (L .EQ. KK) GO TO 42
      AA=AA*(XCP(IJ)-XV(LL))/(XV(KL)-XV(LL))
   42 CONTINUE
      IF (INDEX.EQ.1) GO TO 65
      ALPHA1=ALPHA1+AA*GAM(1,KL)
      IF (ABS(B1-B2) .LE. 0.001) GO TO 40
      ALPHA2=ALPHA2+AA*GAM(2,KL)
      GO TO 40
  65  BA(KL)=AA*(1.-TEMP*VMU*VMU)*0.5
   40 CONTINUE
      IF (ABS(B1-B2) .LE. 0.001) ALPHA2=ALPHA1
      ALPHA=(ALPHA2-TEMP*VMU*VMU*ALPHA1)*0.5
      GO TO 5
   30 CONTINUE
      CALL SPEED (VMU,I,ALPHA,LPANEL,TEMP,LPAN1,LPAN2,PHIS,IPHI,ISYM,
     1INDEX,BA)
      IF (KCODE .EQ. 0) GO TC 5
      IF (CDF .LT. 0.0001) GC TO 5
      IF (NNJ .EQ. 1) GO TO 39
      IF (IJ .LE. MJJ(N1)) GC TO 5
   39 PHIN(IJ)=PHIS
    5 CONTINUE
   50 FORMAT (6(6X,I4))
      RETURN
      END
$       FORTY
$       LIMITS   ,27K
$       INCODE  IBMF
```

```
      SUBROUTINE SPEED(VMU,I,ALPHA,LPANEL,TEMP,LPAN1,LPAN2,PHIS,IPHI,
     1ISYM,INDEX,BA)
C     TO COMPUTE THE INDUCED TANGENTIAL VELOCITIES DUE TO WING ALONE
C     VORTICES
      DIMENSION SU(100),BA(1)
      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 /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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      N1=NNJ-1
      N2=NNJ-2
      N3=NNJ-3
      ZJET=YCON(25)
      II=I-JPANEL
      BE=B1
      IC=1
   10 CONTINUE
      IZ=1
      MM=0
      ISN=1
      NL=NW(1)
      NM=NW(1)
      B=0.
      DO 1 J=1,LPANEL
      IF (INDEX.EQ.1) BA(J)=0.0
      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 21
   20 NL=NW(2)
      IF (J .GE. LPAN2 .AND. J .LT. LPANEL) NL=NW(3)
   21 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)
      Z1=-ZCP(II)
      Z2=-ZCP(II)
      Z12=0.
      XZJ=-Z1*X12
      DO 2 K=1,2
      IF (K .EQ. 1) GO TO 3
      N=1
      GO TO 4
```

```
    3 N=2
    4 CONTINUE
      YC=(-1.)**N*YCP(II)
      Y1=YN(J,1)-YC
      Y2=YN(J,2)-YC
      XYK=X1*Y12-Y1*X12
      YZI=-Z1*Y12
      ALB1=XYK*XYK+XZJ*XZJ+BB*YZI*YZI
      R1B1=SQRT(X1*X1+BB*Y1*Y1+BB*Z1*Z1)
      R2B1=SQRT(X2*X2+BB*Y2*Y2+BB*Z2*Z2)
      UUB1=(X2*X12+BB*Y2*Y12+BB*Z2*Z12)/R2B1-(X1*X12+BB*Y1*Y12+BB*Z1*Z12
     1)/R1B1
      F1=UUB1*YZI/ALB1
      SUM=F1*CH(IZ)*SN(JJ,ISN)*GAM(IC,J)/FN
      IF (K .EQ. 1) SU(J)=F1*CH(IZ)*SN(JJ,ISN)/FN
      IF (INDEX.EQ.1) GO TO 54
      GO TO 56
 54   BA(J)=BA(J)+F1*CH(IZ)*SN(JJ,ISN)/FN
      GO TO 2
 56   B=B+SUM
 2    CONTINUE
      IF (J .LT. NM) GO TO 1
      IZ=IZ+1
      MM=NM
      NM=NM+NL
    1 CONTINUE
      NJH=(NSJ+1)/2+1
      IF (ISYM .EQ. 0) NJH=NSJ/2
      IF (IPHI .EQ. NJH) GO TO 30
      IF (ISYM .NE. 0 .AND. IPHI .EQ. 1) GO TO 30
      IF (NNJ .EQ. 1) GO TO 30
      IF (II .GT. MJJ(N1)) GO TO 30
      IF (IPHI .GT. NJH .AND. ZJET .LE. 0.01) GO TO 30
      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) IR=N2
      IF (NNJ .LE. 3 .AND. NW(2) .EQ. 0) IR=N1
      IF (NNJ .GE. 4 .AND. NW(3) .NE. 0) IR=N3
      IF (NNJ .EQ. 4 .AND. NW(3) .EQ. 0) IR=N2
      DO 41 MP=1,NZ
      K1=MJW1(MP,NJP)+(IPHI-L1-ISYM)*NW(MP)-1
      K2=LC(MP)+IPHI-L1-ISYM
      KNW=NW(MP)
   35 CONTINUE
      K1=K1-KNW
      K2=K2-1
      MR=3
```

```
      IF (K1 .GE. 0) GO TO 4C
      K1=K1+KNW
      K2=K2+1
      MR=2
   40 DO 42 NR=1,MR
      SUM=0.
      DO 36 KK=1,KNW
      KL=K1+KK
   36 SUM=SUM+SU(KL)
      CALL INTEG (RES,KNW,K1,K2,II,BB,IR)
      CORN=0.
      DO 37 KK=1,KNW
      KL=K1+KK
      AA=1.
      DO 38 L=1,KNW
      LL=K1+L
      IF (L .EQ. KK) GO TO 38
      AA=AA*(XCP(II)-XV(LL))/(XV(KL)-XV(LL))
   38 CONTINUE
      IF (INDEX.EQ.1) GO TO 58
      GO TO 59
  58  BA(KL)=BA(KL)-AA*SUM+AA*RES*8.
      GO TO 37
  59  CORN=CORN+AA*GAM(IC,KL)
  37  CONTINUE
      B=B-CORN*SUM+CORN*RES*8.
      K1=K1+KNW
      K2=K2+1
   42 CONTINUE
      IR=IR+1
   41 CONTINUE
   30 CONTINUE
      IF (INDEX .EQ. 1) GO TC 65
      GO TO 68
  65  CONTINUE
      DO 60 M=1,LPANEL
      BA(M)=BA(M)*(1.-TEMP*VMU*VMU)/8.
  60  CONTINUE
  68  CONTINUE
      IF (IC .EQ. 2) GO TO 8
      ALPHA1=B/8.
      IC=IC+1
      BB=B2
      IF (ABS(B1-B2) .LE. 0.C01) GO TO 7
      GO TO 10
    8 ALPHA2=B/8.
      GO TO 6
    7 ALPHA2=ALPHA1
    6 ALPHA=ALPHA2-TEMP*VMU*VMU*ALPHA1
      PHIS=ALPHA2
  100 FORMAT (6(F11.5))
```

```
  110 FORMAT (6(5X,I5))
      RETURN
      END
$       FORTY
$       INCODE  IBMF
      SUBROUTINE NORSPD (I,ALPH,LPANEL,IPHI,LPAN1,LPAN2,INDEX,BA)
C     TO COMPUTE THE INDUCED NORMAL VELOCITIES DUE TO WING ALONE
C     VORTICES
      DIMENSION BA(1)
      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 /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),
     2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      NJH=(NSJ-1)/2
      IZ=1
      MM=0
      NM=NW(1)
      ISN=1
      NL=NW(1)
      A1=0.
      A2=0.
      DO 1 J=1,LPANEL
      IF (INDEX.EQ.1) BA(J)=C.
      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 11
   10 NL=NW(2)
      IF (J .GE. LPAN2 .AND. J .LT. LPANEL) NL=NW(3)
   11 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.
      Z18-ZCP(I)
      Z2=-ZCP(I)
      XZJ=X1*Z12-Z1*X12
      DO 2 K=1,2
      IF (K .EQ. 1) GO TO 3
      N=1
      GO TO 4
    3 N=2
    4 CONTINUE
```

```
      YC=(-1.)**N*YCP(I)
      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
      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)
      F2=G13*Y(4,IPHI)*(-1.)**N+G12*Y(3,IPHI)
      F3=-F23*Y(4,IPHI)*(-1.)**N+F22*Y(3,IPHI)
      F4=G23*Y(4,IPHI)*(-1.)**N+G22*Y(3,IPHI)
    7 CONTINUE
      IF (INDEX.EQ.1) GO TO 8
      A1=A1+(F1+F2)*CH(IZ)*SN(JJ,ISN)*GAM(1,J)/FN
      A2=A2+(F3+F4)*CH(IZ)*SN(JJ,ISN)*GAM(2,J)/FN
      GO TO 2
  8   BA(J)=BA(J)+(F1+F2-F3-F4)*CH(IZ)*SN(JJ,ISN)/(FN*8.)
  2   CONTINUE
      IF (J .LT. NM) GO TO 1
      IZ=IZ+1
      MM=NM
      NM=NM+NL
    1 CONTINUE
      ALPH=(A1-A2)/8.
      RETURN
      END
$      FORTY
$      INCODE  IBMF
      SUBROUTINE VMSEQN (NC1,K,AA,A,CA)
      DIMENSION AA(1),CA(1),A(1)
      NC=K*NC1
```

```
      SUM1=0.
      K1=K-1
      JJ=1
      DO 3 J=1,K1
      SUM1=SUM1+AA(J)*A(JJ)
    3 JJ=JJ+NC1+1
      SUM1=SUM1+AA(K)
      DO 5 I=1,NC1
      SUM2=0.
      JJ=I+1
      DO 4 J=1,K1
      SUM2=SUM2+AA(J)*A(JJ)
    4 JJ=JJ+NC1+1
      KK=K+I
      SUM2=SUM2+AA(KK)
    5 CA(I)=-SUM2/SUM1
      M=1
      L=0
      KNC=(K-1)*NC1
      DO 8 I=1,NC
      IF (I.GT.KNC) GO TO 7
      MM=(M-1)*NC1+1
      IF (I.EQ.MM) GO TO 9
    6 KK=KK+1
      IL=I+L
      A(I)=CA(KK)*BASE+A(IL)
      GO TO 8
    7 II=I-KNC
      A(I)=CA(II)
    8 CONTINUE
      GO TO 10
    9 II=MM+M-1
      BASE=A(II)
      KK=0
      L=L+1
      M=M+1
      GO TO 6
   10 CONTINUE
      RETURN
      END
$       FORTY
$       INCODE  IBMF
      SUBROUTINE INTEG (F,NN,LJ,IZ,IJ,B,IR)
      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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(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)-EX(IZ,1)
      C2=TX(IZ,2)-EX(IZ,2)
      SUM=0.
      DO 1 K=1,JJ
      XX1=EX(IZ,1)+C1*SC(K,IR)
      XX2=EX(IZ,2)+C2*SC(K,IR)
      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
      ALB=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
    1 SUM=SUM+UU*YZI/ALB*SI(K,IR)
      F=SUM*CH(IZ)/(8.*FJ)
      RETURN
      END
$       FORTY
$       INCODE  IBMF
      SUBROUTINE INVRCX (THETAI,BONDN,AA,IPANEL,BIGCX,AK,ICW,CX)
C     FIND THE INVERSE TRANSFORMATION MATRIX
      DIMENSION THETAI(1),BONDN(1),AA(1),BIGCX(IPANEL,1)
      DIMENSION AK(1),CX(ICW,1)
      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 /CLOPE/ DZDXK(100),ALPAO(15),GCB(100),GCBX(100),THETAK(10)
     1,CCX(100),OZDXK(100),GAN(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 /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),
     2 ZN(200,2),WIDTH(3),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFP
      PI=3.14159265
      I=1
      ISM=1
      ISN=1
      IFF=1
      MJ=1
```

```
      NN=NW(ISN)
      MAX=(M1(ISM)-1)*NW(ISN)
      DO 15 J=1,LPANEL
      MI=J-IFF+1
      ML=M1(ISM)
      NL=NW(ISN)
      FML=ML
      FNL=NL
      GCBX(J)=-CH(I)*WIDTH(ISM)*XV(J)/(FNL*FML*CREF)*SN(MI,ISN)*SJ(MJ,IS
     1M)
      GCB(J)=CH(I)*WIDTH(ISM)/(FNL*FML)*SN(MI,ISN)*SJ(MJ,ISM)
      IF (J .LT. NN .OR. J .EQ. LPANEL) GO TO 15
      I=I+1
      IFF=NN+1
      IF (J .EQ. LPAN1 .OR. J .EQ. LPAN2) ISN=ISN+1
      NN=NN+NW(ISN)
      MJ=MJ+1
      IF (MJ .EQ. M1(ISM)) MJ=1
      IF (J.LT.MAX) GO TO 15
      ISM=ISM+1
      IF (J .EQ. LPAN1 .OR. J .EQ. LPAN2) ISM=1
      MAX=MAX+(M1(ISM)-1)*NW(ISN)
15    CONTINUE
      NW2=NW(1)+NW(2)
      IF (NW(2).EQ.0) GO TO 62
      II=1+NCS
      IF (NW(3).NE.0) GO TO 69
      CHORD=CH(1)+CH(II)
      XX1=CH(1)/CHORD
      THETA1=ARCOS(1.-2.*XX1)
      THETA2=PI
      GO TO 63
69    III=II+NCS
      CHORD=CH(1)+CH(II)+CH(III)
      XX1=CH(1)/CHORD
      THETA1=ARCOS(1.-2.*XX1)
      XX2=(CH(1)+CH(II))/CHORD
      THETA2=ARCOS(1.-2.*XX2)
      GO TO 63
62    CHORD=CH(1)
63    CONTINUE
      DO 61 J=1,NCW
      IF (NW(2).EQ.0) GO TO 64
      IF (J.LE.NW(1)) GO TO 64
      IF (J.GT.NW2) GO TO 59
      LL=LPAN1+J-NW(1)
      GO TO 65
59    LL=LPAN2+J-NW2
      GO TO 65
64    LL=J
65    CONTINUE
```

```
      XCK=(XV(LL)-XLE(1))/CHORD
      XCI=(XCP(LL)-XLE(1))/CHORD
      THETAI(J)=ARCOS(1.-2.*XCI)
      THETAK(J)=ARCOS(1.-2.*XCK)
 61   CONTINUE
      DO 13 K=1,NCW
      DO 13 J=1,NCW
      FM=NCW
      CX(K,J)=1./FM*(-1.)**(K+J)*SIN(THETAK(J))/(COS(THETAK(J))-COS(THET
     1AI(K)))
 13   CONTINUE
      ICA=ICW
      CALL SETDIM (CX,ICA,ICA)
      CALL HEMINV (CX,ICA,BONDN)
C     STORE THE INTERPOLATION MATRIX IN THE COMMON BLOCK CCX(I)
      DO 18 I=1,NCW
      DO 18 J=1,NCW
      IK=(I-1)*NCW+J
 18   CCX(IK)=CX(I,J)
      RETURN
      END
$      LINK    LINK11
$      FORTY
$      LIMITS  ,31K
$      INCODE  IBMF
      SUBROUTINE GEOMTY(KCODE)
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 /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,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
      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,DF(5),NFP
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
      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),
     2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
    1 FORMAT (3(I4,6X))
    2 FORMAT (8(F10.5))
    3 FORMAT (8(6X,I4))
    4 FORMAT (10X,8HHALF SW=,E12.5,10X,5HCREF=,E12.5)
    5 FORMAT (6(F10.5))
   6  FORMAT (2(6X,I4),7F10.5)
    8 FORMAT (13HCASE NUMBER =,I2)
  400 FORMAT(1H0,10HINPUT DATA)
  402 FORMAT(1H0,'LPANEL=',I3,3X,'JPANEL=',I3,3X,'LAST=',I3,3X,'LTOTAL='
```

```
     1,I3)
  403 FORMAT(1H0,36HVORTEX ELEMENT ENDPOINT COORDINATES=)
  610 FORMAT (1H0,'X1',8X,'X2',8X,'Y1',8X,'Y2',8X,'Z1',8X,'Z2',8X)
  404 FORMAT(1H0,26HCONTROL POINT COORDINATES=)
  620 FORMAT (1H0,'XCP',7X,'YCP',7X,'ZCP',7X,'XCP',7X,'YCP',7X,'ZCP')
  405 FORMAT(1H0,42HWARNING. THE EQUIVALENT JET MACH NUMBER IS,F10.5,41H
     1IT HAS BEEN SET TO 0.9 IN THE COMPUTATION)
   29 FORMAT (1H0,46HTHE EQUIVALENT JET PROPERTIES ARE EVALUATED AT,F10.
     *5)
   30 FORMAT (1H0,28HTHE EQUIVALENT JET RADIUS IS,F10.5)
   36 FORMAT(/20X,50HXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX)
   32 FORMAT (1H0,49HTHE VELCCITY RATIO OF THE EQUIVALENT JET,V0/VJ,IS,F
     *10.5)
   37 FORMAT(/20X,46HTHE JET HAS NOT WASHED THE WING. AN EQUIVALENT/20X,
     148HCIRCULAR JET IS USED FOR INTERACTION COMPUTATION)
   38 FORMAT(/20X,51HTHE JET HAS WASHED THE WING. A RECTANGULAR JET WITH
     1/20X,42HLATERAL EXTENT EQUAL TO THE EQUIVALENT JET/20X,44HDIAMETER
     2 IS USED FOR INTERACTION COMPUTATION)
   39 FORMAT(/20X,51HNOTE. CHECK WHETHER THE WING IS IMMERSED IN THE JET
     1)
      WRITE (6,400)
      PI=3.14159265
      NCS=0
      KL=0
      IPANEL=1
      RT=0.0
      DO 28 I=1,5
   28 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***
      READ (5,2) AM1,AM2,VMU,TEMP,ALP,XEL,XET
      WRITE (6,2) AM1,AM2,VMU,TEMP,ALP,XEL,XET
C
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 ***
      READ (5,6) NFP,NJP,(DF(I),I=1,NFP)
      WRITE (6,6) NFP,NJP,(DF(I),I=1,NFP)
C
C  ***REFERENCE HALF WING AREA, DISTANCE OF FLAP HINGE FROM LOCAL L.E.
C     REFERRED TO LOCAL CHORD, TWIST IN DEG., INCIDENCE OF ROOT CHORD IN
C     DEG., X-, Y- AND Z- COORDINATES OF JET CENTER AT EXIT, AND JET
C     RADIUS ***
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     CREF - MEAN  AERODYANMIC CHORD
      READ (5,2) HALFSW,TWIST,TWISTR,XJ,YJ,ZJ,RJ,CREF
      WRITE (6,2) HALFSW,TWIST,TWISTR,XJ,YJ,ZJ,RJ,CREF
```

```
C
C  ***TRAILINF-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, AND =0. FOR OWB)
C      NOTE FOR USB APPLICATICNS, TEANGL MAY BE ANY VALUE *
      READ (5,2) TEANGL,PTIAL,USB
      WRITE (6,2) TEANGL,PTIAL,USB
      CAMLER=0.
      CAMLET=0.
      CAMTER=0.
      CAMTET=0.
C
      IUSB=USB
      DFJ=0.
      CMU=0.
C  * THE FOLLOWING DATA ARE NOT NEEDED FOR OWB APPLICATIONS *
      IF (IUSB .NE. 1) GO TO 198
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)
      READ (5,2) CMU,DFJ,TNJ
      WRITE (6,2) CMU,DFJ,TNJ
C
  198 CONTINUE
      DFJ=DFJ*PI/180.
      DO 25 I=1,5
   25 DF(I)=DF(I)*PI/180.
      TDF=DF(NJP)
      ALP=ALP*PI/180.
      ALPS=SIN(ALP)
      ALPC=COS(ALP)
      ALPT=ALPS/ALPC
      DE=TEANGL*PI/180.+TDF
      IF (IUSB .EQ. 1) CDF=DFJ
      EXIT=0.
      IF (XJ .GT. XEL) EXIT=1.
      XEL=(XEL-XJ)/RJ
      XET=(XET-XJ)/RJ
      Z=ZJ/RJ
      TH=0.
      M1(4)=0
      ITN=TNJ
      YCON(23)=TNJ
      IF (IUSB .EQ. 1 .AND. ITN .EQ. 0) GO TO 199
      CALL ENTRN (VMU,AM2,TEMP,XM,CU,RT,XEL,XET,Z,KCODE,XJC)
      XEQUI=XM*RJ+XJ
      REQUI=RT*RJ
      RT=REQUI
      IF (IUSB .EQ. 1) GO TO 199
```

```
      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 TC 199
      ZR=PI*RT/2.
      TH=ZR
  199 CONTINUE
      IF (IUSB .EQ. 1) KCODE=1
      IF (IUSB .NE. 1 .AND. KCODE .EQ. 1) GO TO 197
      GO TO 196
  197 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-
     1ZJ)/(0.5*RJ)
      IF (ZJ .LT. (1.5*RJ)) F1=1.
      IF (F1 .GT. 1.) F1=1.
      FACT=F1
      CDF=DE*FACT
  196 CONTINUE
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 *
      READ (5,3) NC,(M1(I),I=1,NC)
      WRITE (6,3) NC,(M1(I),I=1,NC)
C
C  ***THE NUMERICAL ORDER OF FLAP AND JET SPANS AMONG THE SPANWISE
C      SECTIONS ***
      READ (5,3) (NJW(I),I=1,NFP)
      WRITE (6,3) (NJW(I),I=1,NFP)
C
C  *** NUMBER OF CHORDWISE VORTEX ELEMENTS IN CHORDWISE SECTIONS ***
      READ (5,3) (NW(I),I=1,3)
      WRITE (6,3) (NW(I),I=1,3)
C
      NCW=NW(1)
      L=1
  105 CONTINUE
      LL=1
      FN=NCW
      DO 100 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)))
 100  CPCWL(I)=CPCWL(I)*100.
      DO 10 KK=1,NC
C
```

```
C    *** COORDINATES OF BREAK CHORDS BOUNDING SPANWISE SECTIONS ***
      READ (5,2) (XXL(I),XXT(I),YL(I),I=1,2)
      WRITE (6,2) (XXL(I),XXT(I),YL(I),I=1,2)
C
      IF (IUSB .EQ. 1) GO TO 113
      IF (ISYM .EQ. 0 .AND. KK .EQ. 1) GO TO 99
      IF (KK .EQ. (NJW(NJP)+1)) GO TO 103
      IF (ISYM .NE. 0 .AND. KK .EQ. (NJW(NJP)-1)) GO TO 102
      IF (ISYM .NE. 0 .AND. KK .EQ. NJW(NJP)) GO TO 99
      GO TO 113
   99 XXL(2)=XXL(1)+(XXL(2)-XXL(1))*(YL(2)-YL(1)+RT-RJ)/(YL(2)-YL(1))
      XXT(2)=XXT(1)+(XXT(2)-XXT(1))*(YL(2)-YL(1)+RT-RJ)/(YL(2)-YL(1))
      IF (ISYM .EQ. 0) GO TO 104
  103 XXL(1)=XL2
      XXT(1)=XT2
      GO TO 104
  102 XXL(2)=XXL(1)+(XXL(2)-XXL(1))*(YL(2)-YL(1)-RT+RJ)/(YL(2)-YL(1))
      XXT(2)=XXT(1)+(XXT(2)-XXT(1))*(YL(2)-YL(1)-RT+RJ)/(YL(2)-YL(1))
  104 XL2=XXL(2)
      XT2=XXT(2)
      IF (ISYM .EQ. 0 .AND. KK .EQ. 1) GO TO 112
      IF (ISYM .NE. 0 .AND. KK .EQ. (NJW(NJP)-1)) GO TO 112
      YL(1)=YL2
  112 IF (ISYM .EQ. 0) GO TO 101
      IF (KK .EQ. (NJW(NJP)+1)) GO TO 113
      IF (KK .EQ. NJW(NJP)) YL(2)=YL(2)+RT-RJ
      IF (KK .EQ. (NJW(NJP)-1)) YL(2)=YL(2)-RT+RJ
      GO TO 111
  101 IF (KK .EQ. 1) YL(2)=YL(2)+RT-RJ
  111 YL2=YL(2)
  113 CONTINUE
      FM=M1(KK)
      NSW=M1(KK)
      DO 120 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)
  120 CONTINUE
      IF (KK .EQ. NC) GO TO 130
      CPSWL(1)=0.
      CPSWL(NSW)=100.
      GO TO 135
  130 CPSWL(1)=0.
  135 IF (KK .EQ. NJW(LL)) MJW1(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)) MJW2(L,LL)=LPANEL
      IF (KK .NE. NC) GO TO 10
      HALFB=YL(2)
   10 IF (KK .EQ. NJW(LL)) LL=LL+1
      IF (L .EQ. 3) GO TO 107
      IF (L .EQ. 1) LPAN1=LPANEL
      IF (L .EQ. 2) LPAN2=LPANEL
      IF (NW(2) .EQ. 0) GO TO 106
      L=L+1
      NCW=NW(L)
      IF (L .EQ. 3 .AND. NW(3) .EQ. 0) GO TO 108
      GO TO  105
  106 DO 23 I=2,3
      DO 23 J=1,NFP
      MJW1(I,J)=0
   23 MJW2(I,J)=0
      LPAN2=LPANEL
      NCS=NCS*3
      GO TO 107
  108 DO 24 I=1,NFP
      MJW1(3,I)=0
   24 MJW2(3,I)=0
      L=L-1
      NCS=NCS+NCS/2
  107 CONTINUE
      NCS=NCS/3
      NCW=NW(1)+NW(2)+NW(3)
      VU=VMU
      IF (IUSB .EQ. 1) CU=VMU
      VMU=CU
      RTJ=RJ
      ZJT=ZJ
      IF (RT .GT. ZJ .AND. KCODE .EQ. 0) ZJT=RT
      IF (IUSB .EQ. 1) GO TO 109
      AM2=AM1/(VMU*SQRT(TEMP))
      IF (AM2 .GT. 0.9) WRITE (6,405) AM2
      IF (AM2 .GT. 0.9) AM2=0.9
  109 CONTINUE
      LAST=LPANEL
C
C  *** TOTAL NUMEER OF STREAMWISE JET SECTIONS, NUMBER OF JET CIRCUM-
C     FERENTIAL STRIPS PLUS ONE( USE ODD NUMBERS FOR A NON-CENTERED JET
C     AND EVEN NUMBERS FOR A CENTERED JET), AND NUMBERS OF JET VORTEX
C     ELEMENTS ON EACH JET SECTION ***
      READ (5,3) NNJ,NSJ,(NCJ(I),I=1,NNJ)
      WRITE (6,3) NNJ,NSJ,(NCJ(I),I=1,NNJ)
C
      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 33 I=2,NSJ1
      FI=I
      CPSWL(I)=0.5*(1.-COS((2.*FI-1.)*PI/(2.*FNJ)))
   33 YCON(I)=0.5*(1.-COS(FI*PI/FNJ))
      IENTN=NC
      JC=NCS*L
      NJ1=NNJ-1
      DO 11 JJ=1,NNJ
      IF (IUSB .EQ. 1) GO TO 122
C
C    *** COORDINATES OF BOUNDING LINES OF JET SECTIONS PROJECTED ON X-Y
C        PLANE ***
      READ (5,2) (XXL(I),XXT(I),YL(I),I=1,2)
      WRITE (6,2) (XXL(I),XXT(I),YL(I),I=1,2)
C
      IF (ISYM .EQ. 0) GO TO 98
      XL1=XXL(1)-(XXL(2)-XXL(1))*(RT-RTJ)/(YL(2)-YL(1))
      XT1=XXT(1)-(XXT(2)-XXT(1))*(RT-RTJ)/(YL(2)-YL(1))
   98 XL2=XXL(1)+(XXL(2)-XXL(1))*(RT+RTJ)/(YL(2)-YL(1))
      XT2=XXT(1)+(XXT(2)-XXT(1))*(RT+RTJ)/(YL(2)-YL(1))
      IF (ISYM .EQ. 0) GO TO 97
      XXL(1)=XL1
      XXT(1)=XT1
   97 XXL(2)=XL2
      XXT(2)=XT2
      IF (ISYM .EQ. 0) GO TO 96
      YL(1)=YL(1)-RT+RTJ
   96 YL(2)=YL(2)+RT-RTJ
      IF (KCODE .EQ. 0) GO TO 13
      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.
   13 CONTINUE
      GO TO 121
C
```

```
C   ***COORDINATES OF BREAK POINTS DEFINING RECTANGULAR JET SECTIONS FOR
C      USB CONFIGURATIONS***
C
  122 DO 123 I=1,4
      READ (5,2) XXL(I),XXT(I),YL(I),ZL(I)
  123 WRITE (6,2) XXL(I),XXT(I),YL(I),ZL(I)
  121 CONTINUE
      II=JJ
      JJ1=JJ+L
      FNCJ=NCJ(JJ)
      NJ=NCJ(JJ)
      NMJ=NJ*16
      IF (NJ .GT. 6) NMJ=NJ*8
      FNJ=NMJ
      DO 1000 J=1,NMJ
      FJ=J
      SC(J,JJ)=0.5*(1.-COS((2.*FJ-1.)*PI/(2.*FNJ)))
 1000 SI(J,JJ)=SIN((2.*FJ-1.)*PI/(2.*FNJ))
      DO 12 J=1,NJ
      FJ=J
      CPCWL(J)=0.5*(1.-COS((2.*FJ-1.)*PI/(2.*FNCJ)))
   12 SN(J,JJ1)=2.*SQRT(CPCWL(J)*(1.-CPCWL(J)))
      IF (KCODE .EQ. 0) CALL JSHAPE(XXL,XXT,YL,YJ,ZJT,RT,CPCWL,IPANEL,NJ
     1,JC,ISYM)
      IF (KCODE .EQ. 1) CALL RESHAP(XXL,XXT,YL,ZL,CPCWL,CPSWL,IPANEL,NJ,
     1JC,II,NSYM)
      MJJ(JJ)=LAST
   11 IPANEL=LAST+1
   21 CONTINUE
      SDF=XXT(1)-XXL(1)
      IF (IUSB .EQ. 1) TH=ZL(3)-ZL(4)
      YCON(25)=ZL(4)
      YCON(24)=USB
      C(1)=CMU
      IF (KCODE .EQ. 0) YCON(25)=1.
      IF (KCODE .EQ. 1) CALL RECTJ(ISYM,NSJ,Y)
      WRITE (6,4) HALFSW,CREF
      JPANEL=LAST-LPANEL
      LTOTAL=LAST+JPANEL
      WRITE (6,402) LPANEL,JPANEL,LAST,LTOTAL
      IF (IUSB .EQ. 1) GO TO 124
      WRITE (6,36)
      IF (KCODE .EQ. 0) WRITE (6,37)
      IF (KCODE .EQ. 1) WRITE (6,38)
      IF (KCODE .EQ. 1) WRITE (6,39)
      WRITE (6,36)
      WRITE (6,29) XEQUI
      WRITE (6,30) REQUI
      WRITE (6,32) VMU
  124 CONTINUE
      WRITE (6,403)
```

```
      WRITE (6,610)
      WRITE (6,5) (XN(I,1),XN(I,2),YN(I,1),YN(I,2),ZN(I,1),ZN(I,2),I=1,L
     1AST)
      WRITE (6,404)
      WRITE (6,620)
      WRITE (6,5) (XCP(I),YCP(I),ZCP(I),I=1,LAST)
      IF (KCODE .EQ. 1) GO TC 2022
      IF (ISYM .EQ. 0) GO TO 2021
      FN2=(NSJ-1)/2+1
      NJH=(NSJ-1)/2+2
      ANG=PI/(2.*FN2)
      FAC=(SIN(3.*ANG)-SIN(ANG)/COS(ANG))/(1.-COS(3.*ANG))
      PHI=PI/2.-ATAN(FAC)
      NJH1=NJH-1
      NJH2=NJH+1
      Y(3,2)=SIN(PHI)
      Y(4,2)=-COS(PHI)
      Y(3,NJH1)=Y(3,2)
      Y(4,NJH1)=-Y(4,2)
      Y(3,NJH2)=-Y(3,2)
      Y(4,NJH2)=Y(4,2)
      Y(3,NSJ1)=-Y(3,2)
      Y(4,NSJ1)=-Y(4,2)
      GO TO 2022
 2021 FN2=NSJ/2
      NJH=NSJ/2
      ANG1=1.-0.5*(1.-COS(PI/(2.*FN2)))
      ANG3=1.-0.5*(1.-COS(3.*PI/(2.*FN2)))
      ANG1=ATAN(SQRT(1.-ANG1*ANG1)/ANG1)
      ANG3=ATAN(SQRT(1.-ANG3*ANG3)/ANG3)
      FAC=(SIN(ANG3)-SIN(ANG1)/COS(ANG1))/(1.-COS(ANG3))
      PHI=PI/2.-ATAN(FAC)
      NJH1=NJH-1
      NJH2=NSJ1
      Y(3,NJH1)=SIN(PHI)
      Y(4,NJH1)=COS(PHI)
      Y(3,NJH2)=-Y(3,NJH1)
      Y(4,NJH2)=Y(4,NJH1)
 2022 CONTINUE
      FNJ=NCJ(NNJ)
      NPJ=NCJ(NNJ)
      DO 777 J=1,NPJ
      FJ=J
  777 PSI(J)=SIN(FJ*PI/FNJ)
   22 CONTINUE
      BETA1=SQRT(1.-AM1*AM1)
      BETA2=SQRT(1.-AM2*AM2)
      B1=BETA1*BETA1
      B2=BETA2*BETA2
      DO 951 KK=1,NCS
      XLL(KK)=ALP+(TWISTR+TWIST*YLE(KK)/HALFB)*PI/180.
```

```
      T=XLL(KK)
  951 XTT(KK)=SIN(T)/COS(T)
      RETURN
      END
$       FORTY
$       INCODE  IBMF
      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 /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      PI=3.14159265
      IF (NSYM .EQ. 0) NSJJ=(NSJ+1)/2
      IF (NSYM .NE. 0) NSJJ=NSJ/2
      NSJ1=NSJJ-1
      DO 1 J=1,NJ
      FJ=J
      FNJ=NJ
    1 PSI(J)=0.5*(1.-COS(FJ*PI/FNJ))
      DO 2 IS=1,4
      IF (NSYM .EQ. 1 .AND. IS .EQ. 1) GO TO 2
      IF (IS .EQ. 4) GO TO 60
      K1=IS
      K2=IS+1
      GO TO 61
   60 K1=1
      K2=4
   61 CONTINUE
      SPAN=YL(K2)-YL(K1)
      XDIF=XXL(K2)-XXL(K1)
      DO 3 I=1,2
      II=I+K1-1
      IF (IS .EQ. 4 .AND. I .EQ. 2) II=4
      C(I)=XXT(II)-XXL(II)
      DO 3 J=1,NJ
    3 XL(I,J)=XXL(II)+CPCWL(J)*C(I)
      IF (ABS(SPAN) .LE. 0.001) GO TO 10
      DO 25 J=1,NJ
   25 SLOPE(J)=(XL(2,J)-XL(1,J))/SPAN
      DO 30 K=1,NSJJ
      YK=CPSWL(K)*SPAN
      DO 30 J=1,NJ
      Y(J,K)=YK+YL(K1)
      X(J,K)=XL(1,J)+SLOPE(J)*(Y(J,K)-YL(K1))
   30 CONTINUE
```

```
      NS=NSJ1
   10 IF (ABS(SPAN) .LE. 0.001) NS=1
      DO 35 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 70
      YC1=CPSWL(K)
      YC2=CPSWL(K+1)
      GO TO 71
   70 YC1=0.
      YC2=1.
   71 CONTINUE
      EX(KK,1)=XXL(K1)+XDIF*YC1
      EX(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 35 J=1,NJ
      NPANEL=(K-1)*NJ+J-1+IPANEL
      NPAN1=NPANEL-1
      DO 40 I=1,2
      KI1=K+I-1
      IF (ABS(SPAN) .LE. 0.001) GO TO 42
      X1=X(J,KI1)
      Y1=Y(J,KI1)
      IF (J .NE. 1) GO TO 44
      ZZ=ZL(K1)+(ZL(K2)-ZL(K1))*(Y1-YL(K1))/SPAN
      XX=XDIF*(Y1-YL(K1))/SPAN+XXL(K1)
      GO TO 46
   42 IZN=K1
      IF (I .EQ.  2) IZN=K2
      X1=XL(I,J)
      Y1=YL(K1)
      IF (J .NE. 1) GO TO 44
      ZZ=ZL(IZN)
      XX=XXL(IZN)
      GO TO 46
   44 ZZ=ZN(NPAN1,I)
      XX=XN(NPAN1,I)
   46 XN(NPANEL,I)=X1
      YN(NPANEL,I)=Y1
      ZN(NPANEL,I)=ZZ
   40 CONTINUE
      XD=XDIF*YC+XXL(K1)
      XCP(NPANEL)=XD+CH(KK)*FSI(J)
      YCP(NPANEL)=YC*SPAN+YL(K1)
      IF (ABS(SPAN) .LE. 0.001) GO TO 50
      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 55
   50 ZC=0.5*(ZN(NPANEL,1)+ZN(NPANEL,2))
      XC=0.5*(XN(NPANEL,1)+XN(NPANEL,2))
   55 ZCP(NPANEL)=ZC
      XV(NPANEL)=XC
   35 CONTINUE
      IPANEL=NPANEL+1
      LAST=NPANEL
      JC=KK
    2 CONTINUE
      RETURN
      END
$      FORTY
$      INCODE  IBMF
      SUBROUTINE PANEL(XXL,YL,XXT,CPCWL,CPSWL,NSW,IPANEL,LPANEL,KK,LR,
     1SWP)
C     TO DEFINE THE LOCATIONS OF VORTEX AND CONTROL POINTS ON THE WING
      DIMENSION XXL(1),YL(1),XXT(1),CPCWL(1),CPSWL(1)
      DIMENSION SWP(8,15)
      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 /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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      PI=3.14159265
      NSW1=NSW-1
      DO 1 I=1,2
      C(I)=XXT(I)-XXL(I)
      DO 1 J=1,NCW
    1 XL(I,J)=XXL(I)+CPCWL(J)*C(I)/100.
      SPAN=YL(2)-YL(1)
      DO 2 J=1,NCW
      PSI(J)=0.5*(1.-COS(FLOAT(J)*PI/FLOAT(NCW)))
      SLOPE(J)=(XL(2,J)-XL(1,J))/SPAN
    2 SWP(J,LR)=ATAN(SLOPE(J))
      DO 3 K=1,NSW
      YK=CPSWL(K)*SPAN/100.
      DO 3 J=1,NCW
      Y(J,K)=YK+YL(1)
      X(J,K)=XL(1,J)+SLOPE(J)*(Y(J,K)-YL(1))
    3 CONTINUE
      XLL(1)=XXL(1)
      XTT(1)=XXT(1)
      DO 15 I=2,NSW
      XLL(I)=XLL(I-1)+(XXL(2)-XXL(1))*(Y(1,I)-Y(1,I-1))/SPAN
   15 XTT(I)=XTT(I-1)+(XXT(2)-XXT(1))*(Y(1,I)-Y(1,I-1))/SPAN
      DO 6 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)
      EX(KK,1)=XXL(1)+(XXL(2)-XXL(1))*CPSWL(K)/100.
      EX(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 6 J=1,NCW
      NPANEL=(K-1)*NCW +J-1+IPANEL
      DO 5 I=1,2
      KI1=K+I-1
    4 XN(NPANEL,I)=X(J,KI1)
      YN(NPANEL,I)=Y(J,KI1)
      ZN(NPANEL,I)=0.
    5 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)
    6 CONTINUE
      LPANEL=NPANEL
      RETURN
      END
$       FORTY
$       LIMITS  ,28K
$       INCODE  IBMF
      SUBROUTINE ENTRN (U,AMJ,T,XM,CMU,RT,XEL,XET,Z,KCODE,XJC)
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/ PK1,XC,X(31),A(31),B(31)
C
   55 FORMAT(8F10.5)
      PI=3.14159265
      IK=1
      REJ=T
      PK1=0.0185+0.011*U
      KCODE=0
      XMID=0.5*(XEL+XET)
      XM=XMID
      X0=0.
      R0=1.
      F=2.*PK1*SQRT((1.-U)*REJ)
      XC=0.35/F
      XJC=XC
```

```
   AG2=ALOG((1.+2.*U/AK2)/(1.+U/AK2))
   DSX1=2.*PK1/0.72*SQRT(REJ*(1.-U)*AK2*AG2/U)
   DX=X(I)-XH
   S=S+DX*DSX1
   M=M+1
   GO TO 10
 5 IF (I .NE. 1) SH=2.*PK1*SQRT(REJ)*X(I)-0.35
   IF (I .NE. 1) P1=(1.-U)*(1.-EXP(-1./(2.*SH)))
   DSX=2.*PK1*SQRT(REJ)
   IF (ABS(T-1.) .LE. 0.01) GO TO 20
   S=2.*PK1/0.72*SQRT(REJ)*X(I)-0.35
15 IF (I .EQ. 1 .AND. U .GT. 0.01) DSX=2.*PK1*SQRT(REJ*ALOG(UA)/U)*
  1(1.-U)
   HO=1.-EXP(-1./(2.*S))
   HOP=-2.*HO**2/0.72
   P2=(T-1.+0.2*(1.-U*U)*AMJ*AMJ*T)*HO-0.2*P1*AMJ*AMJ*T*(P1+2.*U)
   P2P=(T-1.+0.2*(1.-U*U)*AMJ*AMJ*T)*HOP-0.2*P1P*AMJ*AMJ*T*(P1+2.*U)
  1-0.2*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+0.01478*P2**2-0.00589*P2**3)/
  1(1.+1.08869*P2)
   F3P=-P2P*(0.12857-0.04653*P2+0.01820*P2**2-0.00599*P2**3)/(1.
  1+1.02272*P2)
   GO TO 25
20 P2=0.
   P2P=0.
   F1P=0.
   F2P=0.
   F3P=0.
   IF (I .EQ. 1 .AND. U .GT. 0.01) DSX=2.*PK1*SQRT(REJ*ALOG(UA)/U)*
  1(1.-U)
25 P1P=-2.*P1*P1/(1.-U)
   F1=0.8907*(0.12857+0.01617*P2-0.00607*P2**2+0.00192*P2**3)/(1.
  1+0.81817*P2)
   F2=0.79335*(0.06676+0.00453*P2-0.00204*P2**2+0.00075*P2**3)/(1.
  1+0.85716*P2)
   F3=(0.21429+0.04061*P2-0.01249*P2**2+0.00351*P2**3)/(1.+0.78948*
  1P2)
   FU=U*P1*F1+P1*P1*F2
   DMC1=(P1P*F1+P1*F1P-U*F2P*F3-U*P2*F3P)/FU
   DMC2=(P1*F1-U*P2*F3)*(U*P1P*F1+U*P1*F1P+2.*P1*P1P*F2+P1*P1*F2P)
  1/(FU*FU)
   DMX=2.*(1.-U)*(DMC1-DMC2)*DSX/SQRT(REJ)
   RJ2=0.5*(1.-U)/FU
   RJ1=SQRT(RJ2)
   WRITE (6,55) X(I),RJ1,DMX
   IF (IK .GT. 1) GO TO 28
   IF (X(I) .GE. XEL) GO TO 26
   GO TO 28
26 IF (RJ1 .LT. Z) GO TO 28
```

"Page missing from available version"

page 99

```
      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 11
         IF (DXX .GE. 1. .AND. DXX .LE. 3.) DXX=2.5
      IF (DXX .LT. 1.) DXX=1.5
   11 CONTINUE
      X(2)=X(1)+DXX/2.
      DO 1 I=2,30
    1 X(I+1)=X(I)+DXX
      DO 2 I=1,70
      FI=I
      CSJ(I)=COS((2.*FI-1.)*PI/140.)
    2 SSJ(I)=SIN((2.*FI-1.)*PI/140.)
      DO 3 I=1,31
      IF (U .LE. 0.01) GO TO 5
      IF (I .EQ. 1 .AND. ABS(T-1.) .LE. 0.01) GO TO 20
      IF (I .EQ. 1) S=(2.*PK1*SQRT(REJ*(1.-U))*XC/0.72-0.35)*SQRT((1.-U)
     1/U*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
   10 CONTINUE
      SUM=0.
      DO 4 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))
    4 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 30
      XT=X1/(2.*PK1*SQRT((1.-U)*REJ))
      P1=(1.-U)*(1.-EXP(-1./(2.*S)))
      G1=ALOG((1.+2.*U/P1)/(1.+U/P1))
      DSX=2.*PK1*SQRT(REJ*(1.-U)*P1*G1/U)
      SH=S
      IF (ABS(X(I)-XT) .LE. 0.01) GO TO 35
      DX=X(I)-XT
      S=S+DX*DSX
      SH=S
      GO TO 10
   35 P1=(1.-U)*(1.-EXP(-1./(2.*SH)))
   30 IF (ABS(T-1.) .LE. 0.01) GO TO 20
      XH=X1*0.72/(2.*PK1*SQRT((1.-U)*REJ))
      IF (ABS(X(I)-XH) .LE. 0.01) GO TO 15
      AK2=(1.-U)*(1.-EXP(-1./(2.*S)))
```

```
      XMJ=X0+(Z-R0)*(X(I)-X0)/(RJ1-R0)
      IF (XEL .LT. 0) GO TO 29
      IF (XMJ .LT. XET) KCODE=1
      IK=IK+1
      GO TO 28
   29 XM=0.5*XET
      IF (XMJ .LE. XM) KCODE=1
      IK=IK+1
   28 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 40
      B(I)=(DMX-DMX0)/(X(I+1)-X(I))
      A(I)=DMX0-B(I)*X(I)
      GO TO 3
   40 A(I)=0.145*DMX/0.32
      B(I)=(DMX-A(I))/XC
    3 DMX0=DMX
      K=1
   50 IF (K .GT. 30) GO TO 65
      IF (XM .GE. 0. .AND. XM .LT. XC) GO TO 60
      IF (XM .GE. X(K) .AND. XM .LT. X(K+1)) GO TO 60
      K=K+1
      GO TO 50
   60 F11=RR2(K)*(PU1(K)*U*FU1(K)+PU1(K)**2*FU2(K))/(U*U)
      F12=RR2(K+1)*(PU1(K+1)*U*FU1(K+1)+PU1(K+1)**2*FU2(K+1))/(U*U)
      F21=RR2(K)*(PU1(K)*FU1(K)-U*PU2(K)*FU3(K))/U
      F22=RR2(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 61
      F31=RR2(K)*(9.*PU1(K)/70.-PU1(K)*FU1(K)+U*PU2(K)*FU3(K))/U
      F32=RR2(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 62
   61 F31=0.
      F32=0.
   62 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 70
      GO TO 75
   70 X1=0.
      X2=XC
      X22=X21
      X32=X31
      X21=1./U
      X12=X11
      X31=1.
      IF (ABS(T-1.) .LE. 0.001) GO TO 75
      X11=1./(T*U)
   75 CMU=X21+(XM-X1)*(X22-X21)/(X2-X1)
      RT=X31+(XM-X1)*(X32-X31)/(X2-X1)
      CMU=1./CMU
      IF (ABS(T-1.) .LE. 0.001) GO TO 63
      RU=X11+(XM-X1)*(X12-X11)/(X2-X1)
      T=1./(CMU*RU)
      WRITE (6,55) T,CMU,RU,XM
   63 CONTINUE
   65 CONTINUE
      RETURN
      END
$       FORTY
$       INCODE  IBMF
      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 1
      NSJ1=NSJ+1
      NJH=(NSJ-1)/2+2
      GO TO 5
    1 NSJ1=NSJ-1
      NJH=NSJ/2
    5 DO 10 I=1,NSJ1
      IF (I .EQ. 1 .AND. ISYM .NE. 0) GO TO 15
      IF (I .EQ. NJH) GO TO 20
      Y(3,I)=1.
      Y(4,I)=0.
      GO TO 10
   15 Y(3,I)=0.
      Y(4,I)=-1.
      GO TO 10
   20 Y(3,I)=0.
      Y(4,I)=1.
   10 CONTINUE
      RETURN
      END
$       FORTY
$       INCODE  IBMF
```

```
          02-18-78   02.177

      SUBROUTINE CIRCJ(ISYM,NSJ,Y)
C     TC DEFINE THE UNIT NORMAL VECTOR TO THE SURFACE OF CIRCULAR JETS
      DIMENSION Y(10,41)
      PI=3.14159265
      IF (ISYM .EQ. 0) GO TO 2014
      NSJ1=NSJ+1
      NN=(NSJ-1)/2+1
      FN2=NN
      NJH=NN+1
      Y(1,1)=-SIN(PI/(2.*FN2))
      Y(2,1)=-COS(PI/(2.*FN2))
      GO TO 2013
 2014 Y(1,1)=1.
      Y(2,1)=0.
      NSJ1=NSJ-1
      FN2=NSJ/2
      NJH=NSJ/2
 2013 CONTINUE
      DO 13 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 2015
      GO TO 2016
 2015 ANG1=-ANG1
      ANG2=-ANG2
 2016 CONTINUE
      Y(1,KII)=SIN(ANG1)
      Y(2,KII)=-COS(ANG1)
      Y(3,KI)=SIN(ANG2)
      Y(4,KI)=-COS(ANG2)
   13 CONTINUE
      RETURN
      END
$      FORTY
```

```
$       INCODE  IBMF
       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 /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
      1PANEL,MJJ(5),NW(3),NNJ,NJP
       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),
      2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
      395,2),SC(160,5),SI(160,5),LC(3)
       COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
      1XLL(41)
       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 1 I=1,2
       C(I)=XXT(I)-XXL(I)
       DO 1 J=1,NJ
     1 XL(I,J)=XXL(I)+CPCWL(J)*C(I)
       DO 2 J=1,NJ
       FJ=J
       FNCJ=NJ
       PSI(J)=0.5*(1.-COS(FJ*PI/FNCJ))
     2 SLOPE(J)=(XL(2,J)-XL(1,J))/(2.*RJ)
       DO 3 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 3 J=1,NJ
     3 X(J,K)=XL(1,J)+SLOPE(J)*(XTT(K)-YL(1))
       DO 6 K=1,N1
       KK=JC+K
       L=K
       IF (K .EQ. N12) L=1
       EX(KK,1)=XXL(1)+(XXL(2)-XXL(1))*(XTT(L)-YL(1))/(2.*RJ)
       EX(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 6 J=1,NJ
       NPANEL=(K-1)*NJ+J-1+IPANEL
       DO 5 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 21
      IF (KI1 .EQ. 1 .OR. KI1 .EQ. 2) GO TO 20
      GO TO 22
   21 IF (K .EQ. N12 .AND. KI1 .EQ. 1) SIGN=-1.
   22 CONTINUE
      IF (KI1 .EQ. (N12-1) .OR. KI1 .EQ. N12) GO TO 25
      IF (KI1 .EQ. N2) GO TO 25
      YY=Y(2,KI1)
      ZZ=Y(1,KI1)*SIGN
      GO TO 30
   20 YY=-1.
      ZZ=-Y(1,KI1)/Y(2,KI1)
      GO TO 30
   25 YY=1.
      ZZ=Y(1,KI1)/Y(2,KI1)
   30 CONTINUE
      XN(NPANEL,I)=X(J,KI1)
      YN(NPANEL,I)=YJ+RJ*YY
    5 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 10
      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 15
   10 ZCP(NPANEL)=ZJ
      YCP(NPANEL)=YN(NPANEL,1)
   15 CONTINUE
      XV(NPANEL)=XXL(1)+(XXL(2)-XXL(1))*YK+CPCWL(J)*CH(KK)
    6 CONTINUE
      JC=JC+N1
      LAST=NPANEL
      RETURN
      END
$       LINK     LINK22,LINK11
$       FORTY
$       LIMITS   ,27K
$       INCODE   IBMF
      SUBROUTINE JETOFF
C     TO SET UP THE JET OFF INFLUENCE COEFFICIENT MATRIX AND COMPUTE THE
C     CAMBER TERMS
      DIMENSION AW(101)
      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,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
      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),
```

"Page missing from available version"

105 – 106

```
      MG=NW(1)
      IF (ABS(B1-B2) .LE. 0.001) GO TO 208
      IF (IC .LE. 2) GO TO 209
  208 CONTINUE
      RETURN
      END
$       FORTY
$       INCODE  IBMF
      SUBROUTINE JETON(KCODE)
C     TO SET UP THE JET ON INFLUENCE COEFFICIENT MATRIX
      DIMENSION AW(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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),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),J
     1PANEL,MJJ(5),NW(3),NNJ,NJP
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
      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
      REWIND 03
      LP1=LTOTAL+1
      MJ=LPANEL+NCJ(1)
      MCON=LAST+NCJ(1)
      IPHI=1
      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 (03) (AW(K),K=1,LTOTAL)
      KI=2
      NI=LTOTAL-1
      LI=LAST+2
      VMP=VMUC
  310 KJ=LI
      ~~IF (LI .GT. LAST) KJ=LI-JPANEL~~
  301 CONTINUE
      CALL MATRIX(AW,LTOTAL,LPANEL,VMP ,LI,MCON,MJ,IPHI,INN,LN,LN1,TEMP,
     1LPAN1,ISYM,KCODE,EXIT,LPAN2)
      WRITE (03) (AW(K),K=1,LTOTAL)
  350 IF (KJ .LT. MJ .OR. KJ .EQ. LAST) GO TO 351
```

```
      IPHI=IPHI+1
      MJ=MJ+NCJ(INN)
  351 CONTINUE
      MJI=MJJ(INN)-1
      IF (KJ .EQ. MJI) GO TO 312
      GO TO 313
  312 JNN=INN
      INN=INN+1
  313 IF (KJ .EQ. MJJ(JNN)) IPHI=1
      IF (LI .EQ. LTOTAL) GO TO 355
      GO TO 356
  355 CONTINUE
      IPHI=1
      MJ=LPANEL+NCJ(1)
      JNN=1
      INN=1
  356 CONTINUE
      KI=KI+1
      NI=NI-1
      IF (LI .EQ. LTOTAL) GO TO 361
      IF (LI .EQ. LAST) GO TO 364
      LI=LI+1
      GO TO 362
  361 LI=LPANEL+1
      GO TO 362
  364 LI=1
  362 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 310
      RETURN
      END
$       FORTY
$       LIMITS   ,31K
$       INCODE   IBMF
      SUBROUTINE MATRIX(AW,LTOTAL,LPANEL,VMU,I,MCON,MJ,IPHI,INN,LN,LN1,T
     1EMP,LPAN1,ISYM,KCODE,EXIT,LPAN2)
C     TO COMPUTE THE JET ON INFLUENCE COEFFICIENT MATRIX
      DIMENSION SV(300),W(4),AW(1)
      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 /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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
```

```
      EQUIVALENCE (X(1,1),SV(1))
      PI=3.14159265
      ZJET=YCON(25)
      IUSB=YCON(24)
      DFJ=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 26
      IJ=I
      GO TO 27
   26 IJ=I-JPANEL
   27 CONTINUE
      DO 16 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) GO TO 24
      GO TO 25
   24 NN=NW(2)
      IF (J .GE. LPAN2 .AND. J .LT. LPANEL) NN=NW(3)
   25 CONTINUE
      IF (J .GE. LPANEL .AND. J .LT. MJJ(IND)) NN=NCJ(IND)
      CHORD=CH(IZ)
      IF (J .EQ. L1) GO TO 33
      GO TO 34
   33 ISN=ISN+1
      L1=MJJ(IND)+1
   34 NL=MJJ(IND)-1
      IF (NL .EQ. LAST1) GO TO 90
      IF (J .EQ. NL) IND=IND+1
   90 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)
      Z1=ZN(J,1)-ZCP(IJ)
      Z2=ZN(J,2)-ZCP(IJ)
      XZJ=X1*Z12-Z1*X12
      DO 201 II=1,2
      IF (II .EQ. 1) GO TO 2
      N=1
      GO TO 3
    2 N=2
    3 CONTINUE
      YC=(-1.)**N*YCP(IJ)
      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
      G1B1=(1.-X1/R1B1)/(Y1*Y1+Z1*Z1)
      G2B1=(1.-X2/R2B1)/(Y2*Y2+Z2*Z2)
      IF (I .GT. LPANEL) GO TO 20
      F1=UUB1*XYK/ALB1
      F2=-Y2*G2B1+Y1*G1B1
      IF (J .GT. LPANEL) GO TO 110
      GO TO 15
  110 F3=0.
      F4=0.
      F1=2.*F1
      F2=2.*F2
      GO TO 15
   20 CONTINUE
      IF (J .LE. LPANEL) GO TO 117
      IF (ABS(B1-B2) .LE. 0.001) GO TO 116
      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
      G1B2=(1.-X1/R1B2)/(Y1*Y1+Z1*Z1)
      G2B2=(1.-X2/R2B2)/(Y2*Y2+Z2*Z2)
      GO TO 117
  116 ALB2=ALB1
      UUB2=UUB1
      G2B2=G2B1
      G1B2=G1B1
  117 CONTINUE
      IF (I .GT. LAST) GO TO 40
```

```
      F13=UUB1*XZJ/ALB1
      F12=UUB1*XYK/ALB1
      G13=Z2*G2B1-Z1*G1B1
      G12=-Y2*G2B1+Y1*G1B1
      IF (J .LE. LPANEL) GO TO 122
      F23=UUB2*XZJ/ALB2
      F22=UUB2*XYK/ALB2
      G23=Z2*G2B2-Z1*G1B2
      G22=-Y2*G2B2+Y1*G1B2
      GO TO 125
  122 F22=0.
      G22=0.
      F23=0.
      G23=0.
  125 F1=-F13*Y(4,IPHI)*(-1.)**N+F12*Y(3,IPHI)
      F2=G13*Y(4,IPHI)*(-1.)**N+G12* Y(3,IPHI)
      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 17
      F1=F1*2.
      F2=2.*F2
      F4=2.*F4
      F3=2.*F3
      GO TO 17
   40 F1=UUB1*YZI/ALB1
      IF (EXIT .LE. 0.001) GO TO 41
      IF (NNJ .EQ. 1) GO TO 41
      IF (IJ .GT. LPANEL .AND. IJ .LE. MJJ(1)) VMU=1.
      IF (IJ .GT. LPANEL .AND. IJ .LE. MJJ(1)) TEMP=1.
   41 CONTINUE
      F2=0.
      IF (J .LE. LPANEL) GO TO 22
      F3=UUB2*YZI/ALB2
      F4=0.
      F3=-F3*2.
      F1=-F1*VMU*VMU*2.*TEMP
      GO TO 17
   22 F1=-F1*VMU*VMU*TEMP
   17 CONTINUE
   15 W(II)=(F1+F2)*CHORD*SN(MI,ISN)/(8.*FN)
      IF (J .LE. LPANEL) GO TO 200
      IF (II .EQ. 2) GO TO 200
      K2=II+2
      W(K2)=(F3+F4)*CHORD*SN(MI,ISN)/(8.*FN)
  200 CONTINUE
  201 CONTINUE
      IF (J .LT. MM) GO TO 32
      IZ=IZ+1
      IFF=MM+1
      MM=MM+NN
   32 CONTINUE
```

```
      IF (J .LE. LPANEL) JA=J+2*JPANEL
      IF (J .GT. LPANEL) JA=J-LPANEL+JPANEL
      AW(JA)=W(1)+W(2)
      SV(JA)=W(1)
      IF (J .LE. LPANEL) GO TO 16
      J1=J-LPANEL
      AW(J1)=W(3)
      VMU=VUT
      TEMP=TEM
   16 CONTINUE
      IF (KCODE .EQ. 0) GO TO 28
      IF (IUSB .EQ. 1 .AND. ZJET .GT. 0.01) GO TO 60
      IF (DFJ .LE. 0.0001) GO TO 60
      IF (NNJ.EQ. 1 .AND. I .LE. LPANEL) GO TO 60
      IF (NNJ.EQ. 1 .AND. I .GT. LPANEL) GO TO 66
      IF (I .LE. MJJ(N1) .OR. I .GT. LAST) GO TO 60
   66 CONTINUE
      IF (I .GT. LAST) GO TO 60
      IF (IPHI .EQ. NJH) GO TO 60
      IF (ISYM .NE. 0 .AND. IPHI .EQ. 1) GO TO 60
      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(N1)
      MF=IJ-MJN1-(IPHI-1)*NCJ(NNJ)
      FNNJ=NCJ(NNJ)
      DISTJ=SDF
      DLX=DISTJ*0.5*PI/FNNJ
      SZX=-(1.-VMU)
      IQ=(IL-1)*NCJ(NNJ)
      CALL SKIP(IQ,JPANEL)
      DO 61 JJ=1,MF
      READ (02) (SV(K),K=1,JPANEL)
      IF (JJ .EQ. MF) GO TO 65
      DXTH=DLX*PSI(JJ)/TH
      GO TO 67
   65 DXTH=DLX*PSI(JJ)*0.5/TH
   67 CONTINUE
      PROD=SZX*DXTH
      DO 62 K1=1,JPANEL
      KK=K1+JPANEL
   62 AW(KK)=AW(KK)+PROD*SV(K1)
   61 CONTINUE
      IQ=NCJ(NNJ)-MF+((NP-1-ISYM)/2-1)*NCJ(NNJ)
      CALL SKIP(IQ,JPANEL)
      DO 63 JJ=1,MF
      READ (02) (SV(K),K=1,JPANEL)
      IF (JJ .EQ. MF) GO TO 68
      DXTH=DLX*PSI(JJ)/TH
      GO TO 69
```

```
   68 DXTH=DLX*PSI(JJ)*0.5/TH
   69 PROD=SZX*DXTH
      DO 64 K1=1,JPANEL
      KK=K1+JPANEL
   64 AW(KK)=AW(KK)-PROD*SV(K1)
   63 CONTINUE
   60 CONTINUE
      IF (EXIT .LE. 0.001) GO TO 29
      IF (NNJ .EQ. 1) GO TO 29
      IF (IJ .GT. LPANEL .AND. IJ .LE. MJJ(1)) VMU=1.
      IF (IJ .GT. LPANEL .AND. IJ .LE. MJJ(1)) TEMP=1.
   29 CONTINUE
   28 IF (I  .LE. LAST) GO TO 70
      IF (IPHI .EQ. NJH) GO TO 300
      IF (ISYM .NE. 0 .AND. IPHI .EQ. 1) GO TO 300
      IF (NNJ .EQ. 1) GO TO 302
      IF (IJ .GT. MJJ(N1)) GO TO 302
      IF (IPHI .GT. NJH .AND. ZJET .LE. 0.01) GO TO 302
      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) IR=N2
      IF (NNJ .LE. 3 .AND. NW(2) .EQ. 0) IR=N1
      IF (NNJ .GE. 4 .AND. NW(3) .NE. 0) IR=N3
      IF (NNJ .EQ. 4 .AND. NW(3) .EQ. 0) IR=N2
      DO 311 NR=1,NZ
      K1=MJW1(NR,NJP)+(IPHI-L1-ISYM)*NW(NR)-1
      K2=LC(NR)+IPHI-L1-ISYM
      KNW=NW(NR)
      K1=K1-KNW
      K2=K2-1
      MR=3
      IF (K1 .GE. 0) GO TO 400
      K1=K1+KNW
      K2=K2+1
      MR=2
  400 DO 420 NQ=1,MR
      SUM=0.
      DO 310 KK=1,KNW
      KL=K1+KK
      JA=KL+2*JPANEL
  310 SUM=SUM+SV(JA)
      CALL INTEG(RES,KNW,K1,K2,IJ,B1,IR)
      DO 315 KK=1,KNW
      KL=K1+KK
      JA=KL+2*JPANEL
      AA=1.
      DO 320 L=1,KNW
```

```
      LL=K1+L
      IF (L .EQ. KK) GO TO 320
      AA=AA*(XCP(IJ)-XV(LL))/(XV(KL)-XV(LL))
 320  CONTINUE
      AW(JA)=AW(JA)-SUM*AA-RES*AA*VMU*VMU*TEMP
315   CONTINUE
      K1=K1+KNW
      K2=K2+1
420   CONTINUE
      IR=IR+1
311   CONTINUE
302   CONTINUE
      IF (KCODE .EQ. 0) GO TO 300
      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 325
      IF (IJ .GT. MJJ(N1)) GO TO 325
      IF (NNJ .EQ. 2) GO TO 330
      IF (IJ .GT. MJJ(N2)) GO TO 330
      IF (NNJ .EQ. 3) GO TO 381
      IF (IJ .GT. MJJ(N3)) GO TO 383
      IF (NNJ .EQ. 4) GO TO 385
      IF (NNJ .EQ. 5 .AND. IJ .GT. MJJ(NNJ-4)) GO TO 386
      L1=NNJ-4
      IZ=NSTRIP
      GO TO 335
 386  L1=N3
      IZ=NSTRIP+NP
      GO TO 335
 385  L1=N3
      IZ=NSTRIP
      GO TO 335
 383  L1=N2
      IZ=NSTRIP+(NNJ-3)*NP
      GO TO 335
 381  CONTINUE
      L1=N2
      IZ=NSTRIP
      GO TO 335
 325  L1=NNJ
      IZ=NSTRIP+(NNJ-1)*NP
      GO TO 335
 330  L1=N1
      IZ=NSTRIP+(NNJ-2)*NP
 335  CONTINUE
      IZ=IZ+IP
      NT=NJT
      IF (ISYM .NE. 0) NT=NJT-1
```

```
      KNW=NCJ(L1)
      DO 341 KP=1,NT
      SUM1=0.
      SUM2=0.
      K1=MJJ(L1)-NP*NCJ(L1)+(KP-1)*NCJ(L1)+(IP-1)*NCJ(L1)
      DO 340 KK=1,KNW
      KL=K1+KK
      KJ=KL+JPANEL
      IA=KL-LPANEL+JPANEL
      IB=KJ-LAST
      SUM1=SUM1+SV(IA)
  340 SUM2=SUM2+AW(IB)
      CALL INTEG(RES,KNW,K1,IZ,IJ,B1,L1)
      IF (ABS(B1-B2) .LE. 0.C01) GO TO 350
      CALL INTEG (REF,KNW,K1,IZ,IJ,B2,L1)
      GO TO 355
  350 REF=RES
  355 DO 360 KK=1,KNW
      KL=K1+KK
      KJ=KL+JPANEL
      IA=KL-LPANEL+JPANEL
      IB=KJ-LAST
      AA=1.
      DO 365 L=1,KNW
      LL=K1+L
      IF (L .EQ. KK) GO TO 365
      AA=AA*(XCP(IJ)-XV(LL))/(XV(KL)-XV(LL))
  365 CONTINUE
      AW(IA)=AW(IA)-SUM1*AA-RES*AA*VMU*VMU*TEMP*2.
      AW(IB)=AW(IB)-SUM2*AA-REF*AA*2.
  360 CONTINUE
  342 IZ=IZ+1
  341 CONTINUE
  300 CONTINUE
      SK=1.
      IF (IPHI .GT. NJH) SK=-1.
      JI=I-LAST+LPANEL
      K=MCON-LAST-NCJ(LN)+LPANEL
      JNJ=NCJ(LN)
      DO 52 KK=1,JNJ
      KL=K+KK
      KJ=KL+JPANEL
      IA=KL-LPANEL+JPANEL
      IB=KJ-LAST
      AA=1.
      DO 53 L=1,JNJ
      LL=K+L
      IF (L .EQ. KK) GO TO 53
      AA=AA*(XCP(JI)-XV(LL))/(XV(KL)-XV(LL))
   53 CONTINUE
      AW(IB)=AW(IB)+AA*SK
```

```
 52 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 71
    IF (IUSB .EQ. 1  .AND. ZJET .GT. 0.01) GO TO 71
    IF (NNJ .EQ. 1) GO TO 71
    IF (IJ .GT. MJJ(N1)) GO TO 71
    IF (IPHI .LE. NJH) GO TO 71
    L1=NJH
    IF (ISYM .EQ. 0) L1=NJH+1
    IF (NW(2) .EQ. 0) GO TO 170
    IF (NW(3) .EQ. 0) GO TO 171
    IF (IJ .GT. MJJ(N2)) GO TO 82
    IF (IJ .GT. MJJ(N3)) GO TO 72
    IF (NNJ .EQ. 4) GO TO 77
    IF (NNJ .EQ. 5 .AND. IJ .GT. MJJ(NNJ-4)) GO TO 77
    GO TO 71
171 IF (IJ .GT. MJJ(N2)) GO TO 72
    IF (NNJ .EQ. 3) GO TO 77
    IF (NNJ .EQ. 4 .AND. IJ .GT. MJJ(N3)) GO TO 77
    GO TO 71
170 IF (NNJ .EQ. 2) GO TO 77
    IF (NNJ .EQ. 3 .AND. IJ .GT. MJJ(N2)) GO TO 77
    GO TO 71
77  K1=MJW1(1,NJP)+(IPHI-L1-ISYM)*NW(1)-1
    KNW=NW(1)
    GO TO 73
72  K1=MJW1(2,NJP)+(IPHI-L1-ISYM)*NW(2)-1
    KNW=NW(2)
    GO TO 73
82  K1=MJW1(3,NJP)+(IPHI-L1-ISYM)*NW(3)-1
    KNW=NW(3)
 73 DO 74 KK=1,KNW
    KL=K1+KK
    JA=KL+2*JPANEL
    AA=1.
    DO 75 L=1,KNW
    LL=K1+L
    IF (L .EQ. KK) GO TO 75
    AA=AA*(XCP(IJ)-XV(LL))/(XV(KL)-XV(LL))
 75 CONTINUE
 74 AW(JA)=AW(JA)-AA*VMU*VMU*TEMP*0.5
71  CONTINUE
    IF (KCODE .EQ. 0) GO TO 70
     IF (ZJET .GT. 0.01) GO TO 70
    IF (DFJ .LE. 0.0001) GO TO 70
    IF (NNJ .EQ. 1) GO TO 76
    IF (IJ .LE. MJJ(N1)) GO TO 70
76  CONTINUE
    IF (IPHI .EQ. NJH) GO TO 70
    IF (ISYM .NE. 0 .AND. IPHI .EQ. 1) GO TO 70
    DO 79 J=1,JPANEL
```

```
      JJ=J+JPANEL
   79 SV(J)=-AW(JJ)
      WRITE (02) (SV(J),J=1,JPANEL)
   70 CONTINUE
      VMU=VUT
      TEMP=TEM
  101 FORMAT (10(F11.5))
  100 FORMAT (6(5X,I3))
      RETURN
      END
$       FORTY
$       INCODE  IBMF
      SUBROUTINE SKIP (I,JPANEL)
      DIMENSION DUMMY(200)
      IF (I .EQ. 0) GO TO 1
      DO 2 J=1,I
      READ (02) (DUMMY(K),K=1,JPANEL)
    2 CONTINUE
    1 RETURN
      END
$       FORTY
$       INCODE  IBMF
      SUBROUTINE WING (AW,LPANEL,I,BB,LPAN1,LPAN2)
C     TO COMPUTE THE JET OFF INFLUENCE COEFFICIENT MATRIX
      DIMENSION AW(1),W(2)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),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
      IZ=1
      IFF=1
      ISN=1
      NL=NW(1)
      NN=NW(1)
      DO 16 J=1,LPANEL
      MI=J-IFF+1
      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 21
   20 NL=NW(2)
      IF (J .GE. LPAN2 .AND. J .LT. LPANEL) NL=NW(3)
   21 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)
```

```
      DO 15 II=1,2
      IF (II.EQ.1) GO TO 2
      N=1
      GO TO 3
    2 N=2
    3 CONTINUE
      YC=(-1.)**N*YCP(I)
      Y1=YN(J,1)-YC
      Y2=YN(J,2)-YC
      XYK=X1*Y12-Y1*X12
      R1=SQRT(X1*X1+BB*Y1*Y1)
      R2=SQRT(X2*X2+BB*Y2*Y2)
      U1=(X12*X2+BB*Y12*Y2)/R2-(X12*X1+BB*Y12*Y1)/R1
      U1=U1/XYK
      U2=(1.-X1/R1)/Y1
      U3=(1.-X2/R2)/Y2
   15 W(II)=(U1+U2-U3)*CH(IZ)*SN(MI,ISN)/(8.*FN)
      AW(J)=W(1)+W(2)
      IF (J .LT. NN .OR. J .EQ. LPANEL)  GO TO 16
      IZ=IZ+1
      IFF=NN+1
      NN=NN+NL
   16 CONTINUE
      RETURN
      END
$      LINK    LINK33,LINK22
$      FORTY
$      INCODE  IBMF
      SUBROUTINE WALNOL
C     THIS PROGRAM DETERMINE THE OPTIMUM CAMBER SHAPE AND TWIST
C     DISTRIBUTION WITH SPECIFIED LIFT AND PITCHING MOMENT CONSTRAINTS
C     IN THE WING-ALONE CASE WITH ZERO LEADING EDGE SUCTION.
      PARAMETER IPANEL=60,ICW=6
      PARAMETER LL0=IPANEL**2,LL1=(IPANEL+3)**2/4+1
      EQUIVALENCE (BIGCX(1,1),AIJ(1,1),FNWW(1,1))
      DIMENSION CDGW(IPANEL),CLGW(IPANEL),CMGW(IPANEL)
      DIMENSION AW(200),CA(200),CDII(20),PAMBDA(2),BA(200)
      DIMENSION GAMMA(LL1),BCNDN(ICW),VKSTD(IPANEL),THETAI(ICW)
      DIMENSION AA(10), FNWW(IPANEL,IPANEL),BIGCX(IPANEL,IPANEL)
      DIMENSION AK(IPANEL),CONST(IPANEL),CAMZC(IPANEL)
      DIMENSION DNWW(ICW,IPANEL),CX(ICW,ICW),AIJ(IPANEL,IPANEL)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /PARAM/ ALPT,ALFC,ALPS,CDF,SDF,TH,TDF
      COMMON /CLOPE/ DZDXK(100),ALPAO(15),GCB(100),GCBX(100),THETAK(10)
     1,CCX(100),OZDXK(100),GAN(2,100)
      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 /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,DF(5),NFP
```

```
      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),
     2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /IDENT/ DZDXK1(100),GAM1(100),CAMZC1(100),ALPA01(20),YLE1(2
     10)
   13 FORMAT (4F10.5,I10)
   14 FORMAT (1H ,'CDBAR,CLBAR,CMBAR,DELTA,MAXP')
      CALL INVRCX (THETAI,BONDN,AA,IPANEL,BIGCX,AK,ICW,CX)
      CALL WALNO2 (AIJ,AW,FNWW,IPANEL,BA,DNWW,ICW,CX)
C
C  ***THEORETICAL MINIMUM INDUCED DRAG COEFFICIENT,LIFT CONSTRAINT,
C     PITCHING MOMENT CONSTRAINT,INITIAL STEP SIZE,MAXIMUM NUMBER OF
C     ITERATIONS   ***
      WRITE (6,14)
      READ (5,13) CDBAR,CLBAR,CMBAR,DELTA ,MAXP
      WRITE (6,13) CDBAR,CLBAR,CMBAR,DELTA,MAXP
C
      DO 91 J=1,LPANEL
      GAMMA(J)=0.0
   91 CONTINUE
      N=0
C
   38 N=N+1
      WRITE (6,200) DELTA,N
  200 FORMAT (1H ,'THE COMPUTED STEP SIZE,  DELTA=',F10.3,5X,'AT',I3,'TH
     1 ITERATION')
      DO 31 I=1,LPANEL
      GAM(1,I)=GAMMA(I)
      GAM(2,I)=GAMMA(I)
   31 CONTINUE
      CALL WALNO3 (GAMMA,DELTA,AW,CA,CDII,CLBAR,CMBAR,PAMBDA,N,IPANEL,
     1AIJ)
      IF (N.EQ.1) GO TO 79
      IF (CDII(N).LT.CDBAR) GO TO 29
      IF (ABS((CDII(N)-CDBAR)/CDBAR) .LT. 0.05) GO TO 60
      IF (CDII(N) .GT. CDII(N-1)) GO TO 39
      GO TO 79
   29 CDII(N)=CDII(N-1)
   39 CONTINUE
      DELTA=0.5*DELTA
      DO 49 I=1,LPANEL
      GAMMA(I)=GAM(1,I)
      GAMMA(I)=GAM(2,I)
   49 CONTINUE
      GO TO 68
   79 CONTINUE
      CALL WALNO4 (GAMMA,DELTA ,PAMBDA,CA,VKSTD,CDGW,CLGW,CMGW,IPANEL
     1,AIJ)
   68 CONTINUE
      IF (N.LT.MAXP) GO TO 38
```

```
C
   60 CONTINUE
      DO 81 I=1,LPANEL
      GAM(1,I)=GAMMA(I)
      GAM(2,I)=GAMMA(I)
   81 CONTINUE
      CALL WALNO5 (AK,CAMZC,CONST,GAMMA,BA)
      DO 71 I=1,LPANEL
      CP(I)=2.*GAMMA(I)*ALPC
   71 CONTINUE
      WRITE (6,9)
    9 FORMAT (1H ,'OPTIMUM PRESSURE LOADING IN THE WING ALONE CASE')
      WRITE (6,8) (CP(I),I=1,LPANEL)
    8 FORMAT (1H ,6F10.5)
      RETURN
      END
$      FORTY
$      INCODE  IBMF
      SUBROUTINE WALNO2 (AIJ,AW,FNWW,IPANEL,BA,DNWW,ICW,CX)
C     SET UP THE TRANSFORMATION MATRIX 'A(I,J)'
      DIMENSION AIJ(IPANEL,1),AW(1),FNWW(IPANEL,1),BA(1),DNWW(ICW,1)
      DIMENSION CX(ICW,1)
      COMMON /CLOPE/ DZDXK(100),ALPAO(15),GCB(100),GCBX(100),THETAK(10)
     1,CCX(100),OZDXK(100),GAN(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 /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFP
      L1=LPANEL+1
      IF (NW(2).EQ.0) GO TO 5
      REWIND 01
      DO 1 I=1,LPANEL
      READ (01) (AW(K),K=1,L1)
      DO 1 J=1,LPANEL
      FNWW(I,J)=AW(J)
    1 CONTINUE
      REWIND 08
      DO 2 I=1,LPANEL
      WRITE (03) (FNWW(J,I),J=1,LPANEL)
    2 CONTINUE
      REWIND 04
      DO 3 I=1,LPANEL
      REWIND 08
      READ (04) (AW(L),L=1,LPANEL)
      DO 4 J=1,LPANEL
      AIJ(I,J)=0.0
      READ (08) (BA(L),L=1,LPANEL)
      DO 4 K=1,LPANEL
    4 AIJ(I,J)=AIJ(I,J)+AW(K)*BA(K)
    3 CONTINUE
      GO TO 10
```

```
    5 CONTINUE
      REWIND 01
      DO 16 I=1,NCS
      DO 17 M=1,NCW
      READ (01) (AW(K),K=1,L1)
      DO 18 N=1,LPANEL
   18 DNWW(M,N)=AW(N)
   17 CONTINUE
      DO 6 IK=1,NCW
      DO 6 JJ=1,LPANEL
      II=(I-1)*NCW+IK
      AIJ(II,JJ)=0.0
      DO 7 L=1,NCW
    7 AIJ(II,JJ)=AIJ(II,JJ)+CX(IK,L)*DNWW(L,JJ)
    6 CONTINUE
   16 CONTINUE
   10 CONTINUE
      RETURN
      END
$      FORTY
$      INCODE  IBMF
      SUBROUTINE WALNO3 (GAMMA,DELTA,AW,CA,CDII,CLBAR,CMBAR,PAMBDA,N,
     1IPANEL,AIJ)
C     FIND THE WING ALONE VORTEX STRENGTH AT THE N-TH ITERATION
      DIMENSION AW(1),CA(1),GAMMA(1),CDII(1),PAMBDA(1),AIJ(IPANEL,1)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /CLOPE/ DZDXK(100),ALPAO(15),GCB(100),GCBX(100),THETAK(10)
     1,CCX(100),OZDXK(100),GAN(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 /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),
     2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFP
      PI=3.14159265
      L1=LPANEL+1
      L2=LPANEL+2
      L3=LPANEL+3
      REWIND 08
      DO 71 I=1,LPANEL
      DO 72 J=1,LPANEL
      IF (J .EQ. I) GO TO 73
      CA(J)=0.0
      GO TO 72
   73 CA(J)=1.0
   72 CONTINUE
      CA(L1)=PI**2*GCB(I)/(HALFSW*2.)*DELTA
      CA(L2)=PI**2*GCBX(I)/(HALFSW*2.)*DELTA
      ADGW=0.
```

```
      DO 74 K=1,LPANEL
      ADGW   =ADGW   -(GCB(I)*AIJ(I,K)+GCB(K)*AIJ(K,I))*GAM(1,K)
   74 CONTINUE
      CA(L3)=ADGW   *PI**2*DELTA/(HALFSW*2.)
      WRITE (08) (CA(KK),KK=1,L3)
   71 CONTINUE
      DO 75 K=1,LPANEL
      CA(K)=GCB(K)*PI*PI/(HALFSW*2.)
   75 CONTINUE
      CA(L1)=0.0
      CA(L2)=0.0
      CA(L3)=CLII-CLBAR
      WRITE (08) (CA(J),J=1,L3)
      DO 76 L=1,LPANEL
      CA(L)=GCBX(L)*PI*PI/(HALFSW*2.)
   76 CONTINUE
      CA(L1)=0.0
      CA(L2)=0.0
      CA(L3)=CMII-CMBAR
      WRITE (08) (CA(J),J=1,L3)
C
      REWIND 08
      READ (08) (AW(I),I=1,L3)
      DO 77 I=1,L2
      GAMMA(I)=-AW(I+1)/AW(1)
   77 CONTINUE
      NJ=L2-1
      DO 78 IJ=2,L2
      READ (08) (AW(I),I=1,L3)
      IK=IJ
      CALL VMSEQN (NJ,IK,AW,GAMMA,CA)
      NJ=NJ-1
   78 CONTINUE
      PAMBDA(1)=GAMMA(L1)
      PAMBDA(2)=GAMMA(L2)
      DO 36 I=1,LPANEL
      GAMMA(I)=GAM(1,I)+GAMMA(I)
   36 CONTINUE
      DO 21 I=1,LPANEL
      DZDXK(I)=0.0
      DO 22 J=1,LPANEL
      DZDXK(I)=DZDXK(I)+AIJ(I,J)*GAMMA(J)
   22 CONTINUE
   21 CONTINUE
      CLII=0.0
      CMII=0.0
      CDII(N)=0.0
      DO 50 I=1,LPANEL
      CDII(N)=CDII(N)+GCB(I)*DZDXK(I)*GAMMA(I)
      CLII=CLII+GCB(I)*GAMMA(I)
      CMII=CMII+GCBX(I)*GAMMA(I)
```

```
   50  CONTINUE
       CDII(N)=-PI**2*CDII(N)/(HALFSW*2.)
       CLII=PI*PI*CLII/(HALFSW*2.)
       CMII=PI*PI*CMII/(HALFSW*2.)
       WRITE (6,134) CDII(N)
  134  FORMAT (1H ,'INDUCED DRAG COEFFICIENT,   CDII=',F15.5)
       WRITE (6,135) CLII
  135  FORMAT (1H ,'LIFT  COEFFICIENT,         CLII=',F15.5)
       WRITE (6,136) CMII
  136  FORMAT (1H ,'PITCHING MOMENT COEFFICIENT,CMII=',F15.5)
       RETURN
       END
$       FORTY
$       INCODE  IBMF
       SUBROUTINE WALNO4 (GAMMA,DELTA ,PAMBDA,CA,VKSTD,CDGW,CLGW,CMGW,
      1IPANEL,AIJ)
C      CALCULATE THE STEP SIZE BY ONE DIMENSIONAL OPTIMIZATION
C      TECHNIQUE
       DIMENSION CA(1),VKSTD(1),CDGW(1),CLGW(1),CMGW(1),GAMMA(1)
       DIMENSION PAMBDA(1),AIJ(IPANEL,1)
       COMMON /CLOPE/ DZDXK(100),ALPAO(15),GCB(100),GCBX(100),THETAK(10)
      1,CCX(100),OZDXK(100),GAN(2,100)
       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),
      2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
      395,2),SC(160,5),SI(160,5),LC(3)
       COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
      1IST,DF(5),NFP
       PI=3.14159265
       DO 12 I=1,LPANEL
       CA(I)=0.0
       DO 13 J=1,LPANEL
       CA(I)=CA(I)+(GCB(I)*AIJ(I,J)+GCB(J)*AIJ(J,I))*GAMMA(J)
   13  CONTINUE
       CDGW(I)=-PI*PI*CA(I)/(HALFSW*2.)
   12  CONTINUE
       DO 15 I=1,LPANEL
       CLGW(I)=PI*PI*GCB(I)/(HALFSW*2.)
   15  CONTINUE
       DO 16 I=1,LPANEL
       CMGW(I)=PI*PI*GCBX(I)/(HALFSW*2.)
   16  CONTINUE
       DO 90 I=1,LPANEL
       VKSTD(I)=0.0
       VKSTD(I)=VKSTD(I)-(CDGW(I)+PAMBDA(1)*CLGW(I)+PAMBDA(2)*CMGW(I))
   90  CONTINUE
       CDGW1=0.0
       CDGW2=0.0
       DO 92 J=1,LPANEL
       DDGW=0.0
       DO 93 I=1,LPANEL
```

```
      DDGW=DDGW+(GCB(I)*AIJ(I,J)+GCB(J)*AIJ(J,I))*VKSTD(I)
   93 CONTINUE
      CDGW1=CDGW1+DDGW*GAMMA(J)
      CDGW2=CDGW2+DDGW*VKSTD(J)
   92 CONTINUE
      BOR=CDGW1
      DOR=CDGW2
      DELTA=ABS(BOR/DOR)
      RETURN
      END
$      FORTY
$      INCODE  IBMF
      SUBROUTINE WALNOS (AK,CAMZC,CONST,GAMMA,BA)
C     FIND THE CAMBER ORDINATES AND LOCAL ANGLE OF ATTACK
      DIMENSION ALPA(15)
      DIMENSION AK(1),CAMZC(1),CONST(1),GAMMA(1),BA(1)
       COMMON /CLOPE/ DZDXK(100),ALPAO(15),GCB(100),GCBX(100),THETAK(10)
     1,CCX(100),OZDXK(100),GAN(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 /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFP
       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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
       COMMON /IDENT/ DZDXK1(100),GAM1(100),CAMZC1(100),ALPAO1(20),YLE1(2
     10)
       PI=3.14159265
      NW2=NW(1)+NW(2)
      IF (NW(2) .EQ. 0) GO TO 48
      II=NCS+1
      IF (NW(3) .NE. 0) GO TC 50
      CHORD=CH(1)+CH(II)
      XX1=CH(1)/CHORD
      THETA1=ARCOS(1.-2.*XX1)
      THETA2=PI
      GO TO 51
   50 III=II+NCS
      CHORD=CH(1)+CH(II)+CH(III)
      XX1=CH(1)/CHORD
      THETA1=ARCOS(1.-2.*XX1)
      XX2=(CH(1)+CH(II))/CHORD
      THETA2=ARCOS(1.-2.*XX2)
   51 CONTINUE
      GO TO 49
   48 THETA1=PI
   49 CONTINUE
      WRITE (6,102)
  102 FORMAT (1H ,'THE TWIST DISTRIBUTION IN THE SPANWISE DIRECTION')
      K1=1
```

```
      K2=2
      DO 23 KI=1,NCS
      DO 25 N=1,NCW
      NA=(KI-1)*NCW+N
      AK(NA)=0.0
      FN=N-1
      DO 27 L=1,NCW
      IF (L.LE.NW(1))KB=(KI-1)*NW(1)+L
      IF (L.GT.NW(1) .AND. L.LE.NW2)KB=LPAN1+(KI-1)*NW(2)+L-NW(1)
      IF (L.GT.NW2) KB=LPAN2+(KI-1)*NW(3)+L-NW2
      IF (L .LE. NW(1)) GO TO 100
      IF (L .GT. NW(1) .AND. L .LE. NW2) GO TO 200
      IF (L .GT. NW2) GO TO 300
  100 FNW=NW(1)
      THETA=THETA1
      GO TO 400
  200 FNW=NW(2)
      THETA=THETA2-THETA1
      GO TO 400
  300 FNW=NW(3)
      THETA=PI-THETA2
  400 CONTINUE
      AK(NA)=AK(NA)+THETA*DZDXK(KB)*COS(FN*THETAK(L))/(FNW*PI)
   27 CONTINUE
      IF (N.GT.1) AK(NA)=2.*AK(NA)
   25 CONTINUE
      CONST1=0.0
      CONST2=0.0
      DO 88 J=3,NCW
      GK=J-1
      KG=(KI-1)*NCW+J
      CONST1=CONST1+0.25*AK(KG)*(1./(1.-GK)+1./(1.+GK))
      CONST2=CONST2+0.25*AK(KG)*(1./(1.-GK)*COS((1.-GK)*PI)+1./(1.+GK)*C
     1OS((1.+GK)*PI))
   88 CONTINUE
      CONST3=0.125*AK(K2)
      CONST(KI)=CONST1+CONST3
      ALPAO(KI)=CONST2-CONST1-AK(K1)
      ALPA(KI)=ALPAO(KI)*180./PI
      DO 29 M=1,NCW
      MM=(KI-1)*NCW+M
      CAMZC(MM)=0.0
      DO 30 K=3,NCW
      FK=K-1
      KD=(KI-1)*NCW+K
      CAMZC(MM)=CAMZC(MM)-0.25*AK(KD)*(1./(1.-FK)*COS((1.-FK)*THETAK(M))
     1+1./(1.+FK)*COS((1.+FK)*THETAK(M)))
   30 CONTINUE
      CONST4=-CONST3*COS(2.*THETAK(M))
      CAMZC(MM)=CAMZC(MM)+(ALPAO(KI)+AK(K1))*0.5*(1.-COS(THETAK(M)))+CON
     1ST4+CONST(KI)
```

```
  29   CONTINUE
       K1=K1+NCW
       K2=K2+NCW
       WRITE (6,126) KI,YLE(KI),KI,ALPA(KI)
  126 FORMAT (1H ,'YLE(',I2,')=',F15.5,5X,'ALPAO(',I2,')=',F15.5)
  23   CONTINUE
       WRITE (6,129)
  129 FORMAT (1H ,'THE CAMBER ORDINATES IN THE WING ALONE CASE')
       WRITE (6,127) (CAMZC(JJ),JJ=1,LPANEL)
  127 FORMAT (1H ,6F10.5)
       DO 60 I=1,NCS
       YLE1(I)=YLE(I)
       ALPA01(I)=ALPAO(I)
  60   CONTINUE
       DO 65 J=1,LPANEL
       CAMZC1(J)=CAMZC(J)
       DZDXK1(J)=DZDXK(J)
       GAM1(J)=GAMMA(J)
  65   CONTINUE
       RETURN
       END
$       LINK     LINK44,LINK33
$       FORTY
$       INCODE   IBMF
       SUBROUTINE INVMTX
C      INVERT THE AUGMENTED MATRIX OF THE BOUNDARY CONDITIONS
       PARAMETER JPANEE=80,IPANEL=60
       PARAMETER ITOTAL=2*JPANEE+IPANEL
       DIMENSION BIGTRX(ITOTAL,ITOTAL),CONDN(ITOTAL),AW(300)
       COMMON /COST/ LTOTAL,LFAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
      1IST,DF(5),NFP
       COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
      1PANEL,MJJ(5),NW(3),NNJ,NJP
       CALL JETNO3 (ITOTAL,AW,CONDN,BIGTRX)
       RETURN
       END
$       FCRTY
$       INCODE   IBMF
       SUBROUTINE JETNO3 (ITOTAL,AW,CONDN,BIGTRX)
C      INVERT THE AUGMENTED MATRIX BY H.E.M.P. SUBROUTINE
       DIMENSION AW(1),CONDN(1),BIGTRX(ITOTAL,1)
       COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
      1IST,DF(5),NFP
       COMMON /CONST/ NCS,NCW,M1(8),NSJ,NCJ(5),LAST,MJW1(3,5),MJW2(3,5),J
      1PANEL,MJJ(5),NW(3),NNJ,NJP
       REWIND 03
       DO 5 I=1,LTOTAL
       READ (03) (AW(K),K=1,LTOTAL)
       DO 6 J=1,LTOTAL
       BIGTRX(I,J)=AW(J)
  6    CONTINUE
```

```
    5  CONTINUE
       LTO=LTOTAL
       CALL SETDIM (BIGTRX,LTO,LTO)
       CALL HEMINV (BIGTRX,LTO,CONDN)
       REWIND 09
       DO 9 I=1,LTOTAL
       WRITE (09) (BIGTRX(I,J),J=1,LTOTAL)
    9  CONTINUE
       RETURN
       END
$       LINK    LINK55,LINK44
$       FORTY
$       INCODE  IBMF
       SUBROUTINE COMJET (KCODE)
C      FIND ALL MATRICES ARE NEEDED AND STORE THOSE MATRICES ON FILES
       PARAMETER IPANEL=60,ICW=6,JPANEE=80
       PARAMETER J1=2*JPANEE,J7=JPANEE+IPANEL
       EQUIVALENCE (BIGCX(1,1),AIJ(1,1))
       EQUIVALENCE (RHSIDE(1,1),BIJ(1,1))
       DIMENSION AIJ(IPANEL,IPANEL),BIJ(IPANEL,JPANEE)
       DIMENSION FNWW(IPANEL,IPANEL),FNWJ(IPANEL,JPANEE)
       DIMENSION AW(300),BA(300),CA(300),THETAI(10),DA(300),AK(IPANEL)
       DIMENSION BIGCX(IPANEL,IPANEL),BONDN(ICW),AA(10),CX(ICW,ICW)
       DIMENSION RHSIDE(JPANEE,IPANEL)
       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,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
       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 /CLOPE/ DZDXK(100),ALPAO(15),GCB(100),GCBX(100),THETAK(10)
      1,CCX(100),OZDXK(100),GAN(2,100)
       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),
      2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
      395,2),SC(160,5),SI(160,5),LC(3)
       COMMON /PARAM/ ALPT,ALFC,ALPS,CDF,SDF,TH,TDF
       COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
      1IST,DF(5),NFP
       CALL JETNO4 (BA,RHSIDE,JPANEE,KCODE)
       CALL JETNO5 (J7,AW,CA,RHSIDE,JPANEE)
       CALL JETNO6 (AW,BA,CA,AIJ,BIJ,FNWW,FNWJ,IPANEL,J1,J7,CX,ICW)
       RETURN
       END
$       FORTY
$       INCODE  IBMF
       SUBROUTINE JETNO4 (BA,RHSIDE,JPANEE,KCODE)
C      SET UP THE RIGHT HAND SIDE MATRIX  OF THE BOUNDARY CONDITIONS FOR
C      INDEX=1
       DIMENSION BA(1),RHSIDE(JPANEE,1)
       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,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
      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,DF(5),NFP
      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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      VMUC=VMU*ALPC
      IPHI=1
      MJ=LPANEL+NCJ(1)
      INN=1
      JNN=1
      DO 1 KI=1,JPANEL
      LI=LAST+KI
      KJ=LI
      IF (LI .GT. LAST) KJ=LI-JPANEL
      CALL STREAM (ALPHA,VMUC,LI,IPHI,LPANEL,TEMP,LPAN1,LPAN2,ISYM,
     1KCODE,EXIT,MJ,1,BA)
      IF (KJ .LT. MJ .OR. KJ .EQ. LAST) GO TO 50
      IPHI=IPHI+1
      MJ=MJ+NCJ(INN)
   50 CONTINUE
      MJI=MJJ(INN)-1
      IF (KJ .EQ. MJI) GO TO 55
      GO TO 60
   55 JNN=INN
      INN=INN+1
   60 IF (KJ .EQ. MJJ(JNN)) IPHI=1
      DO 2 I=1,LPANEL
  2   RHSIDE(KI,I)=-BA(I)
  1   CONTINUE
      RETURN
      END
$       FORTY
$       INCODE  IBMF
      SUBROUTINE JETNO5 (J7,AW,CA,RHSIDE,JPANEE)
C     FIND THE DERIVATIVES OF (DGOJ/DGWO) AND (DGWA/DGWO) AND STORE
C     THOSE DERIVATIVES ON FILE (12)
      DIMENSION AW(1),RHSIDE(JPANEE,1),CA(1)
      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,DF(5),NFP
      REWIND 12
      DO 1 I=1,LPANEL
      REWIND 09
```

```
      DO 3 L=1,JPANEL
      READ (09) (AW(M),M=1,LTOTAL)
    3 CONTINUE
      DO 2 J=1,J7
      READ (09) (AW(M),M=1,LTOTAL)
      CA(J)=0.0
      DO 2 K=1,JPANEL
    2 CA(J)=CA(J)+AW(K)*RHSIDE(K,I)
    1 WRITE (12) (CA(M),M=1,J7)
      RETURN
      END
$      FORTY
$      INCODE  IBMF
      SUBROUTINE JETN06(AW,BA,CA,AIJ,BIJ,FNWW,FNWJ,IPANEL,J1,J7,CX,ICW)
C     FIND THE MATRICES  (A)  AND  (B)  AND STORE THOSE MATRICES
C     ON FILE (11) , ALSO COMPUTE THE DERIVATIVES OF CAMBER SLOPES AND
C     STORE IT ON FILE (10)
      DIMENSION AW(1),BA(1),CA(1),AIJ(IPANEL,1),BIJ(IPANEL,1)
      DIMENSION FNWW(IPANEL,1),FNWJ(IPANEL,1),CX(ICW,1)
      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 /CLOPE/ DZDXK(1C0),ALPAO(15),GCB(100),GCBX(100),THETAK(10)
     1,CCX(100),OZDXK(100),GAN(2,100)
      COMMON /COST/ LTOTAL,LFAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFP
      DO 19 I=1,NCW
      DO 19 J=1,NCW
      IK=(I-1)*NCW+J
   19 CX(I,J)=CCX(IK)
      REWIND 03
      DO 20 J=1,J1
      READ (03) (AW(K),K=1,LTOTAL)
   20 CONTINUE
      DO 2 I=1,LPANEL
      READ (03) (AW(K),K=1,LTOTAL)
      DO 3 J=1,JPANEL
      JJ=JPANEL+J
    3 FNWJ(I,J)=AW(JJ)
      DO 4 K=1,LPANEL
      KK=J1+K
    4 FNWW(I,K)=AW(KK)
    2 CONTINUE
      REWIND 11
      DO 13 I=1,NCS
      DO 13 IK=1,NCW
      II=(I-1)*NCW+IK
      DO 14 J=1,LPANEL
      AIJ(II,J)=0.
      DO 14 L=1,NCW
      LL=(I-1)*NCW+L
   14 AIJ(II,J)=AIJ(II,J)+CX(IK,L)*FNWW(LL,J)
```

```
      DO 15 JK=1,JPANEL
      BIJ(II,JK)=0.
      DO 15 LK=1,NCW
      LN=(I-1)*NCW+LK
 15   BIJ(II,JK)=BIJ(II,JK)+CX(IK,LK)*FNWJ(LN,JK)
 13   CONTINUE
 29   CONTINUE
      DO 16 I=1,LPANEL
      DO 11 IK=1,JPANEL
 11   CA(IK)=BIJ(I,IK)
      DO 12 JK=1,LPANEL
      MK=JPANEL+JK
 12   CA(MK)=AIJ(I,JK)
      WRITE (11) (CA(LK),LK=1,J7)
 16   CONTINUE
      REWIND 12
      REWIND 10
      DO 8 I=1,LPANEL
      REWIND 11
      READ (12) (AW(L),L=1,J7)
      DO 10 J=1,LPANEL
      READ (11) (CA(L),L=1,J7)
      BA(J)=0.0
      DO 9 K=1,J7
 9    BA(J)=BA(J)+CA(K)*AW(K)
 10   BA(J)=AIJ(J,I)+BA(J)
      WRITE (10) (BA(M),M=1,LPANEL)
 8    CONTINUE
      RETURN
      END
$      LINK    LINK66,LINK55
$      FORTY
$      INCODE  IBMF
      SUBROUTINE JETNOL(KCODE)
C     THIS SUBROUTINE DETERMINE THE OPTIMUM CAMBER SHAPE AND TWIST
C     DISTRIBUTION WITH SPECIFIED LIFT AND PITCHING MOMENT CONSTRAINTS
C     IN THE JET ON CASE WITH UPPER-SURFACE-BLOWING AND ZERO LEADING
C     EDGE SUCTION
      PARAMETER IPANEL=60,ICW=6,JPANEE=80
      PARAMETER J7=JPANEE+IPANEL,J1=2*JPANEE,LL1=(IPANEL+3)**2/4+1
      DIMENSION GAMMA(LL1),CDII(20),OAMZC(IPANEL)
      DIMENSION AW(300),BA(300),CA(300),DA(300),THETAI(10),PAMBDA(2)
      DIMENSION GAMMT(IPANEL),GAMAA(IPANEL),GAMOJ(JPANEE),GAT(IPANEL)
      DIMENSION CAMZC(IPANEL),CONST(IPANEL),AK(IPANEL),RHS(300)
      DIMENSION BONDN(ICW),WA(10),BIGCX(IPANEL,IPANEL),CX(ICW,ICW)
      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 /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /CLOPE/ DZDXK(100),ALPAO(15),GCB(100),GCBX(100),THETAK(10)
     1,CCX(100),OZDXK(100),GAN(2,100)
      COMMON /LING/ GLBAR,GMBAR,FCLII,FCMII
```

```
      COMMON /WLONE/ DZDXKW(100),GAMW(100),CAMZCW(100),ALPAOW(20)
      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,DF(5),NFP
      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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
      COMMON /IDENT/ DZDXK1(100),GAM1(100),CAMZC1(100),ALPA01(20),YLE1(2
     10)
      CALL INVRCX (THETAI,BONDN,WA,IPANEL,BIGCX,AK,ICW,CX)
 13   FORMAT (3F10.5,I10)
 14   FORMAT (1H ,'CLII,CMII,DELTA,MAXP')
 15   FORMAT (1H ,'NUMB,SIZE')
 33   FORMAT (I10,F10.5)
      DO 44 I=1,NCS
      ALPAOW(I)=0.
      DO 46 J=1,NCS
      AA=1.
      DO 47 L=1,NCS
      IF (L.EQ.J) GO TO 47
      AA=AA*(YLE(I)-YLE1(L))/(YLE1(J)-YLE1(L))
 47   CONTINUE
      ALPAOW(I)=ALPAOW(I)+AA*ALPA01(J)
 46   CONTINUE
 44   CONTINUE
      DO 4 I=1,NCS
      DO 5 K=1,NCW
      JJ=(I-1)*NCW+K
      GAMW(JJ)=0.
      CAMZCW(JJ)=0.
      DZDXKW(JJ)=0.
      DO 6 J=1,NCS
      II=(J-1)*NCW+K
      AA=1.
      DO 7 L=1,NCS
      IF (L.EQ.J) GO TO 7
      AA=AA*(YLE(I)-YLE1(L))/(YLE1(J)-YLE1(L))
 7    CONTINUE
      GAMW(JJ)=GAMW(JJ)+AA*GAM1(II)
      DZDXKW(JJ)=DZDXKW(JJ)+AA*DZDXK1(II)
      CAMZCW(JJ)=CAMZCW(JJ)+AA*CAMZC1(II)
 6    CONTINUE
 5    CONTINUE
 4    CONTINUE
      DO 20 I=1,LPANEL
      DZDXK(I)=DZDXKW(I)
      GAM(1,I)=GAMW(I)
 20   GAM(2,I)=GAM(1,I)
```

```
C
C *** LIFT CONSTRAINT, PITCHING MOMENT CONSTRAINT, INITIAL STEP SIZE
C     AND MAXIMUM NUMBER OF ITERATIONS  ***
      WRITE (6,14)
      READ (5,13) CLBAR,CMBAR,DELTO,MAXP
      WRITE (6,13)CLBAR,CMBAR,DELTO,MAXP
C
C *** NUMBER OF INTERMEDIATE CYCLES WHICH ARE NEEDED TO REDUCE THE
C     INITIAL COMPUTED LIFT AND PITCHING MOMENT COEFFICIENTS TO THE
C     CONSTRAINTS, THE ASSUMED STEP SIZE IN THE JET ON CASE  ***
      WRITE (6,15)
      READ (5,33) NUMB,SIZE
      WRITE (6,33) NUMB,SIZE
C
      N=0
      ITN=0
      NCOUNT=0
  38  CONTINUE
      IF (ABS(CLII-CLBAR).LT.0.00001) GO TO 508
      IF (ITN.GT.2) GO TO 502
      GO TO 590
 508  CONTINUE
      NCOUNT=NCOUNT+1
      DO 560 I=1,LPANEL
      OAMZC(I)=CAMZC(I)
  560 CONTINUE
      WRITE (6,565) NCOUNT,DELTA
  565 FORMAT (1H0,'THE',I3,'TH   ITERATION IN THE FINAL CYCLE, DELTA=',
     1F10.3)
 590  CONTINUE
      N=N+1
  502 CONTINUE
      DO 31 I=1,LPANEL
      OCLII=CLII
      OCMII=CMII
      GAN(1,I)=GAM(1,I)
      GAN(2,I)=GAM(2,I)
      GAT(I)=GAMMT(I)
      OZDXK(I)=DZDXK(I)
  31  CONTINUE
      IF (ABS(CLII-CLBAR).LT.0.00001) GO TO 505
      IF (ITN.GT.2) GO TO 19
      IF (N.EQ.1) GO TO 32
 505  CONTINUE
      IF (ABS(CLII-CLBAR).GT.0.00001) WRITE (6,200) DELTA,ITN,NUMB1
  200 FORMAT (1H0,'DELTA=',F10.3,5X,I2,'TH  ITERATION  OF',I2,'TH  INTER
     1MEDIATE CYCLES')
      CALL JETNO7 (GAMMA,BA,DELTA,AW,CA,CLII,CMII,PAMBDA,GAT,J7)
  32  CONTINUE
      CALL JETNO8 (RHS,KCODE)
      CALL JETNO9 (GAMMT,GAMOJ,GAMAA,RHS,AW,BA,CA,J7,N,CDII,CLII,CMII,
```

```
     1CLBAR,CMBAR,NUMB,ITN)
      IF (N.EQ.1) CALL CAMBER (AK,CAMZC,CONST,GAMMA,BA,N,MAXP)
      IF (N.EQ.1) CALL LOAD
      IF (ABS(CLII-CLBAR).LT.0.00001) GO TO 555
      IF (N.EQ.1) GO TO 80
      IF (ITN.EQ.1) GO TO 89
 555  CONTINUE
      IF (CDII(ITN).GT.CDII(ITN-1)) GO TO 29
  89  ITN=ITN+1
      GO TO 79
  19  CONTINUE
      FCLII=FCLII-GLBAR
      FCMII=FCMII-GMBAR
      NUMB1=NUMB1+1
      DELTA=DELTO
      ITN=1
      GO TO 68
  29  CONTINUE
      DELTA=0.5*DELTA
      ITN=ITN+1
      DO 49 I=1,LPANEL
      GAM(1,I)=GAN(1,I)
      GAM(2,I)=GAN(2,I)
      GAMMT(I)=GAT(I)
      DZDXK(I)=OZDXK(I)
      CLII=OCLII
      CMII=OCMII
  49  CONTINUE
      GO TO 68
  80  ITN=1
      DELTA=DELTO
      NUMB1=1
      GO TO 68
  79  CONTINUE
      IF (ABS(CLII-CLBAR).LT.0.00001) GO TO 540
      IF (ITN.GT.2) GO TO 68
 540  DELTA=SIZE
  68  CONTINUE
      IF (ABS(CLII-CLBAR).LT.0.00001) CALL CAMBER (AK,CAMZC,CONST,GAMMA,
     1BA,N,MAXP)
      IF (NCOUNT.EQ.0) GO TO 561
      SUM=0.
      DO 562 I=1,LPANEL
      SUM=SUM+(CAMZC(I)-OAMZC(I))**2
 562  CONTINUE
      RMS=SQRT(SUM)/(FLOAT(LPANEL)*CREF)
      WRITE (6,563) RMS
 563  FORMAT (1H ,'THE ROOT MEAN SQUARE OF CAMBER ORDINATES=',F15.5)
 561  CONTINUE
      IF (N.LT.MAXP) GO TO 38
      CALL LOAD
```

```
      RETURN
      END
$       FORTY
$       INCODE   IBMF
      SUBROUTINE JETNO7 (GAMMA,BA,DELTA,AW,CA,CLII,CMII,PAMBDA,GAT,J7)
C     CALCULATE THE NEW WING-ALONE VORTEX STRENGTH AND THE CAMBER SLOPE
      DIMENSION AW(1),BA(1),CA(1),GAMMA(1),PAMBDA(1),GAT(1)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /CLOPE/ DZDXK(100),ALPAO(15),GCB(100),GCBX(100),THETAK(10)
     1,CCX(100),OZDXK(100),GAN(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 /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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /LING/ GLBAR,GMBAR,FCLII,FCMII
      COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFP
      PI=3.14159265
      L1=LPANEL+1
      L2=LPANEL+2
      L3=LPANEL+3
      REWIND 12
      REWIND 10
      REWIND 08
      DO 71 I=1,LPANEL
      DO 72 J=1,LPANEL
      IF (J .EQ. I) GO TO 73
      CA(J)=0.0
      GO TO 72
   73 CA(J)=1.0
   72 CONTINUE
      READ (12) (AW(L),L=1,J7)
      CA(L1)=0.0
      CA(L2)=0.0
      DO 60 L=1,LPANEL
      LL=JPANEL+L
      CA(L1)=CA(L1)+GCB(L)*AW(LL)
   60 CA(L2)=CA(L2)+GCBX(L)*AW(LL)
      CA(L1)=CA(L1)+GCB(I)
      CA(L2)=CA(L2)+GCBX(I)
      CA(L1)=PI**2*CA(L1)*DELTA/(HALFSW*2.)
      CA(L2)=PI**2*CA(L2)*DELTA/(HALFSW*2.)
      BDGW=0.0
      DO 14 M=1,LPANEL
      MM=JPANEL+M
      BDGW=BDGW+(GCB(M)*OZDXK(M)*AW(MM))
   14 CONTINUE
      ADGW=0.0
      READ (10) (BA(L),L=1,LPANEL)
```

```
      DO 74 K=1,LPANEL
      ADGW=ADGW+(GCB(K)*BA(K)*GAT(K))
   74 CONTINUE
      ADGW=-(ADGW+BDGW+GCB(I)*OZDXK(I))
      CA(L3)=ADGW*PI**2*DELTA/(HALFSW*2.)
      WRITE (08) (CA(KK),KK=1,L3)
   71 CONTINUE
      REWIND 12
      DO 75 K=1,LPANEL
      READ (12) (AW(J),J=1,J7)
      CA(K)=0.0
      DO 16 I=1,LPANEL
      II=JPANEL+I
      CA(K)=CA(K)+GCB(I)*AW(II)
   16 CONTINUE
      CA(K)=GCB(K)+CA(K)
      CA(K)=CA(K)*PI*PI/(HALFSW*2.)
   75 CONTINUE
      CA(L1)=0.0
      CA(L2)=0.0
      CA(L3)=CLII-FCLII
      WRITE (08) (CA(J),J=1,L3)
      REWIND 12
      DO 76 L=1,LPANEL
      READ (12) (AW(I),I=1,J7)
      CA(L)=0.0
      DO 18 J=1,LPANEL
      JJ=JPANEL+J
      CA(L)=CA(L)+GCBX(J)*AW(JJ)
   18 CONTINUE
      CA(L)=GCBX(L)+CA(L)
      CA(L)=CA(L)*PI*PI/(HALFSW*2.)
   76 CONTINUE
      CA(L1)=0.0
      CA(L2)=0.0
      CA(L3)=CMII-FCMII
      WRITE (08) (CA(J),J=1,L3)
C
      REWIND 08
      READ (08) (AW(I),I=1,L3)
      DO 77 I=1,L2
      GAMMA(I)=-AW(I+1)/AW(1)
   77 CONTINUE
      NJ=L2-1
      DO 78 IJ=2,L2
      READ (08) (AW(I),I=1,L3)
      IK=IJ
      CALL VMSEQN (NJ,IK,AW,GAMMA,CA)
      NJ=NJ-1
   78 CONTINUE
      PAMBDA(1)=GAMMA(L1)
```

```
      PAMBDA(2)=GAMMA(L2)
      DO 36 I=1,LPANEL
      GAM(1,I)=GAN(1,I)+GAMMA(I)
      GAM(2,I)=GAN(2,I)+GAMMA(I)
   36 CONTINUE
      REWIND 04
      DO 21 I=1,LPANEL
      READ (04) (AW(K),K=1,LPANEL)
      DZDXK(I)=0.
      DO 22 J=1,LPANEL
      DZDXK(I)=DZDXK(I)+AW(J)*GAM(1,J)
   22 CONTINUE
   21 CONTINUE
      RETURN
      END
$      FORTY
$      INCODE  IBMF
      SUBROUTINE JETN08 (RHS,KCODE)
C     SET UP THE RIGHT HAND SIDE VECTORS OF THE BOUNDARY CONDITIONS
C     FOR INDEX=2
      DIMENSION RHS(1)
      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,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
      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,DF(5),NFP
      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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      NA=3
      IF (NW(2) .EQ. 0) NA=1
      IF (NW(2).NE. 0 .AND. NW(3) .EQ. 0) NA=2
      ZZ=YCON(25)
      DFJ=CDF
      VMUC=VMU*ALPC
      IPHI=1
      MJ=LPANEL+NCJ(1)
      INN=1
      JNN=1
      KI=1
      LI=LAST+1
      IH=NW(NA)+MJW1(NA,NJP)-1
   40 KJ=LI
      IF (LI .GT. LAST) KJ=LI-JPANEL
      CALL STREAM (ALPHA,VMUC,LI,IPHI,LPANEL,TEMP,LPAN1,LPAN2,ISYM,
```

```
     1KCODE,EXIT,MJ,2,BA)
      IF (KCODE .EQ. 0) GO TO 63
      IF (ZZ .GE. 0.01) GO TO 63
C
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
C
      IF (LI .GE. MJW1(NA,NJP) .AND. LI .LE. MJW2(NA,NJP)) GO TO 62
      GO TO 63
   62 IF (LI .NE. IH) GO TO 63
      IF((DFJ-TDF) .LT. 0.) GO TO 63
      CZT=CAMTER-(CAMTER-CAMTET) *YCP(LI)/HALFB
      APA=0.5*(DFJ-TDF+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)
   63 CONTINUE
      RHS(KI)=-ALPHA
   45 IF (KJ .LT. MJ .OR. KJ .EQ. LAST) GO TO 50
      IPHI=IPHI+1
      MJ=MJ+NCJ(INN)
   50 CONTINUE
      MJI=MJJ(INN)-1
      IF (KJ .EQ. MJI) GO TO 55
      GO TO 60
   55 JNN=INN
      INN=INN+1
   60 IF (KJ .EQ. MJJ(JNN)) IPHI=1
      IF (LI .EQ. LTOTAL) GO TO 65
      GO TO 70
   65 CONTINUE
      IPHI=1
      MJ=LPANEL+NCJ(1)
      JNN=1
      INN=1
   70 CONTINUE
      KI=KI+1
      IF (LI .EQ. LTOTAL) GO TO 75
      IF (LI .EQ. LAST) GO TO 80
      LI=LI+1
      GO TO 85
   75 LI=LPANEL+1
      GO TO 85
   80 LI=1
   85 CONTINUE
      IF (KI .LE. LTOTAL) GO TO 40
      RETURN
      END
```

```
$       FORTY
$       INCODE  IBMF
      SUBROUTINE JETNO9 (GAMMT,GAMOJ,GAMAA,RHS,AW,BA,CA,J7,N,CDII,CLII,
     1CMII,CLBAR,CMBAR,NUMB,ITN)
C     FIND THE JET VORTICES IN THE OUTER FLOW AND THE WING ADDITIONAL
C     VORTICES
      DIMENSION AW(1),BA(1),RHS(1),GAMMT(1),GAMOJ(1),GAMAA(1)
      DIMENSION CDII(1),CA(1)
      COMMON /AERO/ AM1,AM2,B1,B2,CL(30),CT(30),CD(30),GAM(2,100)
      COMMON /CLOPE/ DZDXK(100),ALPAO(15),GCB(100),GCBX(100),THETAK(10)
     1,CCX(100),OZDXK(100),GAN(2,100)
      COMMON /LING/ GLBAR,GMBAR,FCLII,FCMII
      COMMON /ADD/ CP(100),CM(30),BREAK(8),SWP(8,15),GAL(30),ISOM,VMU,VU
     1,TEMP,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
      COMMON /PARAM/ ALPT,ALFC,ALPS,CDF,SDF,TH,TDF
      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),
     2 ZN(200,2),WIDTH(8),YCON(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),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 /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFP
      PI=3.14159265
      REWIND 09
      DO 9 I=1,JPANEL
      READ (09) (AW(K),K=1,LTOTAL)
  9   CONTINUE
      DO 1 I=1,J7
      READ (09) (AW(K),K=1,LTOTAL)
      BA(I)=0.0
      DO 2 J=1,LTOTAL
  2   BA(I)=BA(I)+AW(J)*RHS(J)
  1   CONTINUE
      DO 3 I=1,JPANEL
      GAMOJ(I)=BA(I)
  3   CONTINUE
      DO 4 I=1,LPANEL
      II=JPANEL+I
      GAMAA(I)=BA(II)
  4   CONTINUE
      DO 5 I=1,LPANEL
      GAMMT(I)=GAM(1,I)+GAMAA(I)
  5   CONTINUE
      DO 21 I=1,LPANEL
      CP(I)=GAMMT(I)*2.*ALPC
 21   CONTINUE
      CLII=0.0
      CMII=0.0
      CDII(ITN)=0.0
      DO 50 I=1,LPANEL
```

```
      CDII(ITN)=CDII(ITN)+GCB(I)*DZDXK(I)*GAMMT(I)
      CLII=CLII+GCB(I)*GAMMT(I)
      CMII=CMII+GCBX(I)*GAMMT(I)
   50 CONTINUE
      CDII(ITN)=-PI**2*CDII(ITN)/(HALFSW*2.)
      CLII=PI*PI*CLII/(HALFSW*2.)
      CMII=PI*PI*CMII/(HALFSW*2.)
      WRITE (6,134) CDII(ITN)
  134 FORMAT (1H ,'INDUCED DRAG COEFFICIENT,    CDII=',F15.5)
      WRITE (6,135) CLII
  135 FORMAT (1H ,'LIFT  COEFFICIENT,           CLII=',F15.5)
      WRITE (6,136) CMII
  136 FORMAT (1H ,'PITCHING MOMENT COEFFICIENT,CMII=',F15.5)
      IF (N.GT.1) GO TO 30
      DLBAR=CLII-CLBAR
      DMBAR=CMII-CMBAR
      GLBAR=DLBAR/NUMB
      GMBAR=DMBAR/NUMB
      FCLII=CLII-GLBAR
      FCMII=CMII-GMBAR
   30 CONTINUE
      RETURN
      END
$       FORTY
$       INCODE  IBMF
      SUBROUTINE CAMBER (AK,CAMZC,CONST,GAMMA,BA,NBC,MAXP)
C     COMPUTE THE CAMBER ORDINATES AND THE TWIST DISTRIBUTION
      DIMENSION ALPA(15)
      DIMENSION AK(1),CAMZC(1),CONST(1),GAMMA(1),BA(1)
      COMMON /CLOPE/ DZDXK(100),ALPAO(15),GCB(100),GCBX(100),THETAK(10)
     1,CCX(100),OZDXK(100),GAN(2,100)
      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),
     2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),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 /WLONE/ DZDXKW(100),GAMW(100),CAMZCW(100),ALPAOW(20)
      COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFP
  102 FORMAT (1H ,'THE TWIST DISTRIBUTION IN THE SPANWISE  DIRECTION')
      PI=3.14159265
      NW2=NW(1)+NW(2)
      IF (NW(2).EQ.0) GO TO 48
      II=NCS+1
      IF (NW(3) .NE. 0) GO TO 50
      CHORD=CH(1)+CH(II)
      XX1=CH(1)/CHORD
      THETA1=ARCOS(1.-2.*XX1)
      THETA2=PI
      GO TO 51
```

```
 50   III=II+NCS
      CHORD=CH(1)+CH(II)+CH(III)
      XX1=CH(1)/CHORD
      THETA1=ARCOS(1.-2.*XX1)
      XX2=(CH(1)+CH(II))/CHORD
      THETA2=ARCOS(1.-2.*XX2)
 51   CONTINUE
      GO TO 49
 48   THETA1=PI
 49   CONTINUE
      K1=1
      K2=2
      IF (NBC.EQ.1 .OR. NBC.EQ.MAXP) WRITE (6,102)
      DO 23 KI=1,NCS
      DO 25 N=1,NCW
      NA=(KI-1)*NCW+N
      AK(NA)=0.0
      FN=N-1
      DO 27 L=1,NCW
      IF (L.LE.NW(1))KB=(KI-1)*NW(1)+L
      IF (L.GT.NW(1)  .AND. L.LE.NW2)KB=LPAN1+(KI-1)*NW(2)+L-NW(1)
      IF (L.GT.NW2) KB=LPAN2+(KI-1)*NW(3)+L-NW2
      IF (L .LE. NW(1)) GO TO 100
      IF (L .GT. NW(1) .AND. L .LE. NW2) GO TO 200
      IF (L .GT. NW2) GO TO 300
100   FNW=NW(1)
      THETA=THETA1
      GO TO 400
200   FNW=NW(2)
      THETA=THETA2-THETA1
      GO TO 400
300   FNW=NW(3)
      THETA=PI-THETA2
400   CONTINUE
      AK(NA)=AK(NA)+THETA*DZDXK(KB)*COS(FN*THETAK(L))/(FNW*PI)
 27   CONTINUE
      IF (N .GT. 1) AK(NA)=2.*AK(NA)
 25   CONTINUE
      CONST1=0.0
      CONST2=0.0
      DO 88 J=3,NCW
      GK=J-1
      KG=(KI-1)*NCW+J
      CONST1=CONST1+0.25*AK(KG)*(1./(1.-GK)+1./(1.+GK))
      CONST2=CONST2+0.25*AK(KG)*(1./(1.-GK)*COS((1.-GK)*PI)+1./(1.+GK)*C
     1OS((1.+GK)*PI))
 88   CONTINUE
      CONST3=0.125*AK(K2)
      CONST(KI)=CONST1+CONST3
      ALPAO(KI)=CONST2-CONST1-AK(K1)
      ALPA(KI)=ALPAO(KI)*180./PI
```

```
      DO 29 M=1,NCW
      MM=(KI-1)*NCW+M
      CAMZC(MM)=0.0
      DO 30 K=3,NCW
      FK=K-1
      KD=(KI-1)*NCW+K
      CAMZC(MM)=CAMZC(MM)-0.25*AK(KD)*(1./(1.-FK)*COS((1.-FK)*THETAK(M))
     1+1./(1.+FK)*COS((1.+FK)*THETAK(M)))
   30 CONTINUE
      CONST4=-CONST3*COS(2.*THETAK(M))
      CAMZC(MM)=CAMZC(MM)+(ALPAO(KI)+AK(K1))*0.5*(1.-COS(THETAK(M)))+CON
     1ST4+CONST(KI)
   29 CONTINUE
      K1=K1+NCW
      K2=K2+NCW
      IF (NBC.EQ.1 .OR. NBC.EQ.MAXP) WRITE (6,126)KI,YLE(KI),KI,ALPA(KI)
  126 FORMAT (1H ,'YLE(',I2,')=',F15.5,5X,'ALPAO(',I2,')=',F15.5)
   23 CONTINUE
      IF (NBC.EQ.1 .OR. NBC.EQ.MAXP) WRITE (6,129)
  129 FORMAT (1H ,'CAMBER ORDINATES IN THE JET ON CASE')
      IF (NBC.EQ.1 .OR. NBC.EQ.MAXP)WRITE(6,127)(CAMZC(JJ),JJ=1,LPANEL)
  127 FORMAT (1H ,6F10.5)
      RETURN
      END
$      FORTY
$      LIMITS  ,30K
$      INCODE  IBMF
      SUBROUTINE LOAD
C     TO EVALUATE THE AERODYNAMIC CHARACTERISTICS
      DIMENSION CA(30),CPSWL(30),AW(30)
      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,FCR,CAMLER,CAMLET,CAMTER,CAMTET,XJ,YJ,ZJ,RJ,ALP,CREF,TWISTR
      COMMON /CLOPE/ DZDXK(100),ALPAO(15),GCB(100),GCBX(100),THETAK(10)
     1,CCX(100),OZDXK(100),GAN(2,100)
      COMMON /LING/ GLBAR,GMBAR,FCLII,FCMII
      COMMON /WLONE/ DZDXKW(100),GAMW(100),CAMZCW(100),ALPAOW(20)
      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 /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),
     2 ZN(200,2),WIDTH(8),YCCN(25),SWEEP(50),HALFB,SJ(21,8),EX(95,2),TX(
     395,2),SC(160,5),SI(160,5),LC(3)
      COMMON /PARAM/ ALPT,ALPC,ALPS,CDF,SDF,TH,TDF
      COMMON /COST/ LTOTAL,LPAN1,NJW(5),LPANEL,IENTN,LPAN2,EXIT,PTIAL,TW
     1IST,DF(5),NFP
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
    1 FORMAT (1H0,26X,7HALPHA =,F10.3,3X,7HDEGREES)
    2 FORMAT (1H0,20X,40HXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX)
  101 FORMAT (1H1)
```

```
      PI=3.14159265
      DO 18 I=1,NCS
      CT(I)=0.
      XTE(I)=0.
      X(5,I)=0.
 18   CONTINUE
      ALPH=ALP*180./PI
      WRITE (6,101)
      WRITE (6,2)
      WRITE (6,1) ALPH
      WRITE (6,2)
      ZJET=YCON(25)
      IUSB=YCON(24)
      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 150 I=1,NCS
      IF (NW(2) .EQ. 0) GO TO 160
      II=I+NCS
      IF (NW(3) .NE. 0) GO TO 144
      CHORD=CH(I)+CH(II)
      GO TO 161
 144  III=II+NCS
      CHORD=CH(I)+CH(II)+CH(III)
      GO TO 161
 160  CHORD=CH(I)
 161  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 155 J=1,NCW
      NN=J+MM
      IF (NW(2) .EQ. 0) GO TO 151
      IF (J .LE. NW(1)) GO TO 151
      IF (J .GT. NW2) GO TO 153
      LL=LPAN1+NW(2)*(I-1)+J-NW(1)
      IL=II
      JLL=J-NW(1)
      L=2
      FN=NW(2)
      GO TO 152
  153 LL=LPAN2+NW(3)*(I-1)+J-NW2
      IL=III
      JLL=J-NW2
      L=3
      FN=NW(3)
      GO TO 152
  151 LL=NN
      IL=I
      JLL=J
      L=1
      FN=NW(1)
  152 CONTINUE
      XC=(XV(LL)-XLE(I))/CHORD
      X(1,J)=0.
      X(2,J)=0.
  510 GBS=CP(LL)*SN(JLL,L)*CH(IL)/(2.*FN)
      WBS=GAMW( LL)*SN(JLL,L)*CH(IL)*ALPC/FN
      WAS=GAMW( LL)*SN(JLL,L)*CH(IL)*ALPC/FN
      IF (DF(NL) .LE. 0.001) GO TO 521
      IF (PTIAL .LE. 0.1) GO TO 520
      IF (NW(3) .EQ. 0) GO TO 524
      IF (LL .GE. MJW1(3,NL) .AND. LL .LE. MJW2(3,NL)) GO TO 523
  521 CS=1.
      SS=-DZDXK(LL)
      SW=-DZDXKW(LL)
      GO TO 522
  520 IF (NW(2) .NE. 0 .AND. LL .LE. LPAN1) GO TO 521
      IF (NW(3) .NE. 0 .AND. LL .LE. LPAN2) GO TO 521
  523 CS=1.
      SS=-DZDXK(LL)
      SW=-DZDXKW(LL)
      GO TO 522
  524 IF (LL .GE. MJW1(2,NL) .AND. LL .LE. MJW2(2,NL)) GO TO 523
       GO TO 521
```

```
 522 CONTINUE
     CL(I)=CL(I)+GBS*CS
     CML=CML-GBS*XV(LL)*CS
     CD(I)=CD(I)+GBS*SS
     CA(I)=CA(I)+WBS*CS
     CMW=CMW-WBS*XV(LL)*CS
     CPSWL(I)=CPSWL(I)+WBS*SS
     X(4,I)=X(4,I)+WAS*CS
     CMWW=CMWW-WAS*XV(LL)*CS
     X(6,I)=X(6,I)+WAS*SW
 155 CONTINUE
     CAMLE=CAMLER-(CAMLER-CAMLET)*YLE(I)/HALFB
     EPHA=XLL(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 210
     KLL=NCOL-1
     KC=KC+1
     NCOL=NCOL+M1(KC)-1
 210 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,NL)) NL=NL+1
 150 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 67
      CDWL2=CDWW/(CLWW*CLWW)
      GO TO 68
   67 CDWL2=0.
   68 CONTINUE
      WRITE (6,53)
 53   FORMAT (1H ,5X,'VORTEX',3X,'XV',8X,'YV',8X,'CP',8X,'CPW')
      K1=0
      JJ1=0
      DO 60 I=1,NCS
      IF (NW(2) .EQ. 0) GO TO 62
      II=I+NCS
      IF (NW(3) .NE. 0) GO TO 69
      CHORD=CH(I)+CH(II)
      GO TO 63
   69 III=II+NCS
      CHORD=CH(I)+CH(II)+CH(III)
      GO TO 63
   62 CHORD=CH(I)
   63 CONTINUE
      DO 61 J=1,NCW
      JJ=JJ1+J
      KK=K1+J
      IF (NW(2) .EQ. 0) GO TO 64
      IF (J .LE. NW(1)) GO TC 64
      IF (J .GT. NW2) GO TO 59
      LL=LPAN1+NW(2)*(I-1)+J-NW(1)
      GO TO 65
   59 LL=LPAN2+NW(3)*(I-1)+J-NW2
      GO TO 65
   64 LL=JJ
   65 CONTINUE
      XI=(XV(LL)-XLE(I))/CHORD
      ETA=YV(LL)/HALFB
      CPW=2.*GAMW( LL)*ALPC
   61 WRITE (6,54) KK,XI,ETA,CP(LL),CPW
      JJ1=(NCW-NW3)*I
      K1=K1+NCW
   60 CONTINUE
 54   FORMAT (7X,I3,3X,4F10.5)
      WRITE (6,30)
   30 FORMAT(1H0,5X,4HY/SP, 7X,2HCL, 7X,2HCM, 7X,2HCT, 7X,3HCDI, 6X,
     *3HCLW, 6X,3HCMW, 6X,3HCDW)
      DO 31 I=1,NCS
      YE=YLE(I)/HALFB
   31 WRITE(6,32) YE,CL(I),CM(I),CT(I),CD(I),X(4,I),X(7,I),X(6,I)
   32 FORMAT (3X,8F9.5)
      DO 80 I=1,NCS
      AW(I)=X(4,I)*CH(I)/CREF
```

```
      CA(I)=CL(I)*CH(I)/CREF
80    CONTINUE
      WRITE (6,81)
81    FORMAT (1H ,5X,'JET - OFF  SPAN LOADING',7X,'JET - ON SPAN LOADING
     1')
      WRITE (6,82) (AW(I),CA(I),I=1,NCS)
82    FORMAT (1H ,2X,F10.5,10X,F20.5)
      WRITE (6,33) CLT
33    FORMAT (1H ,    'THE LIFT COEFFICIENT =',F10.5)
      WRITE (6,24) CDT
24    FORMAT (1H ,    'TOTAL INDUCED DRAG COEFFICIENT =',F10.5)
      WRITE (6,35) CDCL2
 35   FORMAT(1H ,     'THE INDUCED DRAG PARAMETER =',F10.5)
      WRITE (6,42) CMT
 42   FORMAT(1H ,    'TOTAL PITCHING MOMENT COEFFICIENT =',F10.5)
      IF (IUSB .NE. 1) GO TO 157
      IF (DFJ .LE. 0.001) GO TO 157
      IF (ZJET .GT. 0.01) GO TO 157
      SDFJ=SIN(DFJ)
      CDFJ=COS(DFJ)
      CLR=CMU*SIN(DFJ+ALP)
      CDR=CMU*(VMU-COS(DFJ+ALP))
      CF=COS(TDF)
      SF=SIN(TDF)
      IF (NNJ .EQ. 1) CDR=-CMU*COS(DFJ+ALP)
      IJ=(NSJ+1)/2-1
      IF (ISYM .EQ. 0) IJ=NSJ/2-1
      IF (NW(3) .NE. 0) GO TC 156
      IF (NW(2) .EQ. 0) GO TC 154
      IZ=NCS+(MJW1(2,NJP)-LPAN1-1)/NW(2)+1
      KJ=MJW1(2,NJP)
      NN=NW(2)
      GO TO 159
156   IZ=NCS*2+(MJW1(3,NJP)-LPAN2-1)/NW(3)+1
      KJ=MJW1(3,NJP)
      NN=NW(3)
      GO TO 159
154   IZ=LC(1)
      KJ=MJW1(1,NJP)
      NN=NW(1)
159   CONTINUE
      CM1=0.
      DO 158 I=1,IJ
      YDIF=YN(KJ,2)-YN(KJ,1)
      CM1=CM1+YDIF/WIDTH(NJW(NJP))*((XLE(IZ)+CH(IZ)*CF)*SDFJ-CH(IZ)*SF*C
     1DFJ)
      KJ=KJ+NN
158   IZ=IZ+1
      CMR=-CM1*CMU/CREF
      IF (NNJ .NE. 1) WRITE (6,43) CLR
 43   FORMAT (1H ,    'THE COANDA LIFT COEFFICIENT, CLR=',F10.5)
```

```
      IF (NNJ .EQ. 1) WRITE (6,47) CLR
   47 FORMAT (1H0,47HTHE LIFT COEFFICIENT DUE TO JET REACTION, CLJ =,F10
     1.5)
      IF (NNJ .NE. 1) WRITE (6,44) CDR
 44   FORMAT (1H ,    'THE COANDA DRAG COEFFICIENT, CDR=',F10.5)
      IF (NNJ .EQ. 1) WRITE (6,48) CDR
   48 FORMAT (1H0,47HTHE DRAG COEFFICIENT DUE TO JET REACTION, CDJ =,F10
     1.5)
      IF (NNJ .NE. 1) WRITE (6,45) CMR
 45   FORMAT (1H ,    'THE COANDA MOMENT COEFFICIENT, CMR = ',F10.5)
      IF (NNJ .EQ. 1) WRITE (6,49) CMR
   49 FORMAT (1H0,58HTHE PITCHING MOMENT COEFFICIENT DUE TO JET REACTION
     1, CMJ =,F10.5)
  157 CONTINUE
      IF (IUS3 .EQ. 1) GO TO 171
      WRITE (6,5) CLW
      WRITE (6,6) CDW
      WRITE (6,7) CMWT
  171 CONTINUE
    5 FORMAT(1H0,2X,49HTHE LIFT COEFFICIENT WITH JET ENTRAINMENT ALONE =
     1,F10.5)
    6 FORMAT(1H0,2X,57HTHE INDUCED DRAG COEFFICIENT WITH JET ENTRAINMENT
     1 ALONE =,F10.5)
    7 FORMAT(1H0,2X,60HTHE PITCHING MOMENT COEFFICIENT WITH JET ENTRAINM
     1ENT ALONE =,F10.5)
      WRITE (6,70) CLWW
   70 FORMAT(1H ,    'THE LIFT COEFFICIENT FOR THE WING ALONE =',F10.5)
      WRITE (6,71) CDWW
   71 FORMAT(1H ,    'THE INDUCED DRAG COEFFICIENT FOR THE WING ALONE =',
     1F10.5)
      WRITE (6,72) CMWWT
 72   FORMAT (1H ,'THE PITCHING MOMENT COEFFICIENT FOR THE WING ALONE =
     1',F10.5)
      WRITE (6,73) CDWL2
   73 FORMAT(1H ,    'THE INDUCED DRAG PARAMETER FOR THE WING ALONE =',
     1F10.5)
      RETURN
      END
```

Sample Output

```
**************************************
     WING ALONE CASE
**************************************
         1         1         1         1

INPUT DATA
  0.        0.        0.25760   1.00000   0.        -0.29391  0.12318
         1         1  0.
  0.36364   0.        0.        -0.29391  0.25945   0.05000   1.00000   0.37495
  0.        1.00000   1.00000
  1.67600  10.00000   0.
         1        11
         1
         6         0         0
 -0.56776  -0.09304   0.        0.48778   0.74033   1.00000
         1         7         6
 -0.56776  -0.09304   0.        0.
 -0.56776  -0.09304   0.        0.10000
  0.48778   0.74033   1.00000   0.10000
  0.48778   0.74033   1.00000   0.
          HALF SW= 0.36364E 00          CREF= 0.37495E 00

LPANEL= 60   JPANEL= 48   LAST=108   LTOTAL=156

VORTEX ELEMENT ENDPOINT COORDINATES=

X1         X2         Y1         Y2         Z1         Z2
 -0.55967  -0.51215   0.         0.04518   0.         0.
 -0.49824  -0.45202   0.         0.04518   0.         0.
 -0.39183  -0.34786   0.         0.04518   0.         0.
 -0.26897  -0.22759   0.         0.04518   0.         0.
 -0.16256  -0.12344   0.         0.04518   0.         0.
 -0.10113  -0.06330   0.         0.04518   0.         0.
 -0.51215  -0.43123   0.04518    0.12213   0.         0.
 -0.45202  -0.37330   0.04518    0.12213   0.         0.
 -0.34786  -0.27298   0.04518    0.12213   0.         0.
 -0.22759  -0.15714   0.04518    0.12213   0.         0.
 -0.12344  -0.05681   0.04518    0.12213   0.         0.
 -0.06330   0.00111   0.04518    0.12213   0.         0.
 -0.43123  -0.31811   0.12213    0.22968   0.         0.
 -0.37330  -0.26328   0.12213    0.22968   0.         0.
 -0.27298  -0.16831   0.12213    0.22968   0.         0.
 -0.15714  -0.05865   0.12213    0.22968   0.         0.
 -0.05681   0.03632   0.12213    0.22968   0.         0.
  0.00111   0.09115   0.12213    0.22968   0.         0.
 -0.31811  -0.18195   0.22968    0.35913   0.         0.
 -0.26328  -0.13084   0.22968    0.35913   0.         0.
 -0.16831  -0.04232   0.22968    0.35913   0.         0.
 -0.05865   0.05989   0.22968    0.35913   0.         0.
  0.03632   0.14841   0.22968    0.35913   0.         0.
  0.09115   0.19952   0.22968    0.35913   0.         0.
 -0.18195  -0.03379   0.35913    0.50000   0.         0.
 -0.13084   0.01326   0.35913    0.50000   0.         0.
 -0.04232   0.09477   0.35913    0.50000   0.         0.
  0.05989   0.18889   0.35913    0.50000   0.         0.
  0.14841   0.27039   0.35913    0.50000   0.         0.
  0.19952   0.31745   0.35913    0.50000   0.         0.
 -0.03379   0.11436   0.50000    0.64087   0.         0.
```

0.01326	0.15737	0.50000	0.64087	0.	0.
0.09477	0.23186	0.50000	0.64087	0.	0.
0.18889	0.31788	0.50000	0.64087	0.	0.
0.27039	0.39237	0.50000	0.64087	0.	0.
0.31745	0.43538	0.50000	0.64087	0.	0.
0.11436	0.25052	0.64087	0.77032	0.	0.
0.15737	0.28980	0.64087	0.77032	0.	0.
0.23186	0.35785	0.64087	0.77032	0.	0.
0.31788	0.43642	0.64087	0.77032	0.	0.
0.39237	0.50446	0.64087	0.77032	0.	0.
0.43538	0.54375	0.64087	0.77032	0.	0.
0.25052	0.36364	0.77032	0.87787	0.	0.
0.28980	0.39983	0.77032	0.87787	0.	0.
0.35785	0.46252	0.77032	0.87787	0.	0.
0.43642	0.53491	0.77032	0.87787	0.	0.
0.50446	0.59760	0.77032	0.87787	0.	0.
0.54375	0.63379	0.77032	0.87787	0.	0.
0.36364	0.44456	0.87787	0.95482	0.	0.
0.39983	0.47854	0.87787	0.95482	0.	0.
0.46252	0.53740	0.87787	0.95482	0.	0.
0.53491	0.60536	0.87787	0.95482	0.	0.
0.59760	0.66422	0.87787	0.95482	0.	0.
0.63379	0.69820	0.87787	0.95482	0.	0.
0.44456	0.48673	0.95482	0.99491	0.	0.
0.47854	0.51956	0.95482	0.99491	0.	0.
0.53740	0.57642	0.95482	0.99491	0.	0.
0.60536	0.64208	0.95482	0.99491	0.	0.
0.66422	0.69894	0.95482	0.99491	0.	0.
0.69820	0.73177	0.95482	0.99491	0.	0.
-0.55967	-0.55967	0.	0.	0.	0.10000
-0.49824	-0.49824	0.	0.	0.	0.10000
-0.39183	-0.39183	0.	0.	0.	0.10000
-0.26897	-0.26897	0.	0.	0.	0.10000
-0.16256	-0.16256	0.	0.	0.	0.10000
-0.10113	-0.10113	0.	0.	0.	0.10000
-0.55967	-0.23504	0.	0.30866	0.10000	0.10000
-0.49824	-0.18248	0.	0.30866	0.10000	0.10000
-0.39183	-0.09145	0.	0.30866	0.10000	0.10000
-0.26897	0.01367	0.	0.30866	0.10000	0.10000
-0.16256	0.10471	0.	0.30866	0.10000	0.10000
-0.10113	0.15727	0.	0.30866	0.10000	0.10000
-0.23504	0.16745	0.30866	0.69134	0.10000	0.10000
-0.18248	0.20901	0.30866	0.69134	0.10000	0.10000
-0.09145	0.28098	0.30866	0.69134	0.10000	0.10000
0.01367	0.36410	0.30866	0.69134	0.10000	0.10000
0.10471	0.43608	0.30866	0.69134	0.10000	0.10000
0.15727	0.47763	0.30866	0.69134	0.10000	0.10000
0.16745	0.49208	0.69134	1.00000	0.10000	0.10000
0.20901	0.52477	0.69134	1.00000	0.10000	0.10000
0.28098	0.58137	0.69134	1.00000	0.10000	0.10000
0.36410	0.64674	0.69134	1.00000	0.10000	0.10000
0.43608	0.70334	0.69134	1.00000	0.10000	0.10000
0.47763	0.73603	0.69134	1.00000	0.10000	0.10000
0.49208	0.49208	1.00000	1.00000	0.10000	0.
0.52477	0.52477	1.00000	1.00000	0.10000	0.
0.58137	0.58137	1.00000	1.00000	0.10000	0.
0.64674	0.64674	1.00000	1.00000	0.10000	0.
0.70334	0.70334	1.00000	1.00000	0.10000	0.
0.73603	0.73603	1.00000	1.00000	0.10000	0.
-0.55967	-0.23504	0.	0.30866	0.	0.

```
 -0.49824   -0.18248    0.          0.30866    0.          0.
 -0.39183   -0.09145    0.          0.30866    0.          0.
 -0.26897    0.01367    0.          0.30866    0.          0.
 -0.16256    0.10471    0.          0.30866    0.          0.
 -0.10113    0.15727    0.          0.30866    0.          0.
 -0.23504    0.16745    0.30866     0.69134    0.          0.
 -0.18248    0.20901    0.30866     0.69134    0.          0.
 -0.09145    0.28098    0.30866     0.69134    0.          0.
  0.01367    0.36410    0.30866     0.69134    0.          0.
  0.10471    0.43608    0.30866     0.69134    0.          0.
  0.15727    0.47763    0.30866     0.69134    0.          0.
  0.16745    0.49208    0.69134     1.00000    0.          0.
  0.20901    0.52477    0.69134     1.00000    0.          0.
  0.28098    0.58137    0.69134     1.00000    0.          0.
  0.36410    0.64674    0.69134     1.00000    0.          0.
  0.43608    0.70334    0.69134     1.00000    0.          0.
  0.47763    0.73603    0.69134     1.00000    0.          0.

CONTROL POINT  COORDINATES=

XCP          YCP         ZCP          XCP         YCP         ZCP
 -0.51488    0.02025    0.         -0.42883     0.02025     0.
 -0.31127    0.02025    0.         -0.19372     0.02025     0.
 -0.10766    0.02025    0.         -0.07616     0.02025     0.
 -0.45336    0.07937    0.         -0.36971     0.07937     0.
 -0.25544    0.07937    0.         -0.14116     0.07937     0.
 -0.05751    0.07937    0.         -0.02689     0.07937     0.
 -0.35637    0.17257    0.         -0.27651     0.17257     0.
 -0.16742    0.17257    0.         -0.05832     0.17257     0.
  0.02154    0.17257    0.          0.05077     0.17257     0.
 -0.23178    0.29229    0.         -0.15679     0.29229     0.
 -0.05434    0.29229    0.          0.04810     0.29229     0.
  0.12310    0.29229    0.          0.15055     0.29229     0.
 -0.08968    0.42884    0.         -0.02024     0.42884     0.
  0.07462    0.42884    0.          0.16948     0.42884     0.
  0.23893    0.42884    0.          0.26434     0.42884     0.
  0.05842    0.57116    0.          0.12208     0.57116     0.
  0.20903    0.57116    0.          0.29599     0.57116     0.
  0.35965    0.57116    0.          0.38295     0.57116     0.
  0.20052    0.70771    0.          0.25863     0.70771     0.
  0.33800    0.70771    0.          0.41737     0.70771     0.
  0.47547    0.70771    0.          0.49674     0.70771     0.
  0.32511    0.82743    0.          0.37835     0.82743     0.
  0.45107    0.82743    0.          0.52379     0.82743     0.
  0.57703    0.82743    0.          0.59652     0.82743     0.
  0.42210    0.92063    0.          0.47154     0.92063     0.
  0.53909    0.92063    0.          0.60664     0.92063     0.
  0.65608    0.92063    0.          0.67418     0.92063     0.
  0.48362    0.97975    0.          0.53066     0.97975     0.
  0.59493    0.97975    0.          0.65919     0.97975     0.
  0.70623    0.97975    0.          0.72345     0.97975     0.
 -0.53596    0.          0.05000    -0.44908     0.          0.05000
 -0.33040    0.          0.05000    -0.21172     0.          0.05000
 -0.12484    0.          0.05000    -0.09304     0.          0.05000
 -0.38356    0.14645    0.10000    -0.30263     0.14645     0.10000
 -0.19209    0.14645    0.10000    -0.08154     0.14645     0.10000
 -0.00062    0.14645    0.10000     0.02900     0.14645     0.10000
 -0.01563    0.50000    0.10000     0.05092     0.50000     0.10000
  0.14183    0.50000    0.10000     0.23274     0.50000     0.10000
  0.29929    0.50000    0.10000     0.32364     0.50000     0.10000
```

```
  0.35230    0.85355    0.10000    0.40447    0.85355    0.10000
  0.47574    0.85355    0.10000    0.54701    0.85355    0.10000
  0.59919    0.85355    0.10000    0.61829    0.85355    0.10000
  0.50470    1.00000    0.05000    0.55092    1.00000    0.05000
  0.61406    1.00000    0.05000    0.67719    1.00000    0.05000
  0.72341    1.00000    0.05000    0.74033    1.00000    0.05000
 -0.38356    0.14645    0.        -0.30263    0.14645    0.
 -0.19209    0.14645    0.        -0.08154    0.14645    0.
 -0.00062    0.14645    0.         0.02900    0.14645    0.
 -0.01563    0.50000    0.         0.05092    0.50000    0.
  0.14183    0.50000    0.         0.23274    0.50000    0.
  0.29929    0.50000    0.         0.32364    0.50000    0.
  0.35230    0.85355    0.         0.40447    0.85355    0.
  0.47574    0.85355    0.         0.54701    0.85355    0.
  0.59919    0.85355    0.         0.61829    0.85355    0.
CDBAR,CLBAR,CMBAR,DELTA,MAXP
  0.02084    0.60000   -0.03600   50.00000        15
THE COMPUTED STEP SIZE,  DELTA=     50.000       AT   1TH ITERATION
INDUCED DRAG COEFFICIENT,    CDII=         0.03282
LIFT  COEFFICIENT,           CLII=         0.60000
PITCHING MOMENT COEFFICIENT,CMII=         -0.03600
THE COMPUTED STEP SIZE,  DELTA=      9.174       AT   2TH ITERATION
INDUCED DRAG COEFFICIENT,    CDII=         0.02461
LIFT  COEFFICIENT,           CLII=         0.60000
PITCHING MOMENT COEFFICIENT,CMII=         -0.03600
THE COMPUTED STEP SIZE,  DELTA=      1.670       AT   3TH ITERATION
INDUCED DRAG COEFFICIENT,    CDII=         0.02420
LIFT  COEFFICIENT,           CLII=         0.60000
PITCHING MOMENT COEFFICIENT,CMII=         -0.03600
THE COMPUTED STEP SIZE,  DELTA=     10.489       AT   4TH ITERATION
INDUCED DRAG COEFFICIENT,    CDII=         0.02326
LIFT  COEFFICIENT,           CLII=         0.60000
PITCHING MOMENT COEFFICIENT,CMII=         -0.03600
THE COMPUTED STEP SIZE,  DELTA=      5.512       AT   5TH ITERATION
INDUCED DRAG COEFFICIENT,    CDII=         0.02296
LIFT  COEFFICIENT,           CLII=         0.60000
PITCHING MOMENT COEFFICIENT,CMII=         -0.03600
THE COMPUTED STEP SIZE,  DELTA=      9.641       AT   6TH ITERATION
INDUCED DRAG COEFFICIENT,    CDII=         0.02277
LIFT  COEFFICIENT,           CLII=         0.60000
PITCHING MOMENT COEFFICIENT,CMII=         -0.03600
THE COMPUTED STEP SIZE,  DELTA=     15.344       AT   7TH ITERATION
INDUCED DRAG COEFFICIENT,    CDII=         0.02258
LIFT  COEFFICIENT,           CLII=         0.60000
PITCHING MOMENT COEFFICIENT,CMII=         -0.03600
THE COMPUTED STEP SIZE,  DELTA=      4.746       AT   8TH ITERATION
INDUCED DRAG COEFFICIENT,    CDII=         0.02252
LIFT  COEFFICIENT,           CLII=         0.60000
PITCHING MOMENT COEFFICIENT,CMII=         -0.03600
THE COMPUTED STEP SIZE,  DELTA=    215.245       AT   9TH ITERATION
INDUCED DRAG COEFFICIENT,    CDII=         0.02148
LIFT  COEFFICIENT,           CLII=         0.60000
PITCHING MOMENT COEFFICIENT,CMII=         -0.03600
THE TWIST DISTRIBUTION IN THE SPANWISE DIRECTION
YLE( 1)=           0.02025      ALPAO( 1)=        19.93581
YLE( 2)=           0.07937      ALPAO( 2)=         2.04388
YLE( 3)=           0.17257      ALPAO( 3)=         6.30106
YLE( 4)=           0.29229      ALPAO( 4)=         5.59977
YLE( 5)=           0.42884      ALPAO( 5)=         4.20544
YLE( 6)=           0.57116      ALPAO( 6)=         3.00911
```

```
YLE( 7)=          0.70771      ALPAO( 7)=        1.90836
YLE( 8)=          0.82743      ALPAO( 8)=        0.94083
YLE( 9)=          0.92063      ALPAO( 9)=        0.24668
YLE(10)=          0.97975      ALPAO(10)=       -0.78169
THE CAMBER ORDINATES IN THE WING ALONE CASE
    0.0C887    0.C6269    0.09079    0.05172    0.00993    0.00003
    0.00516    0.C3465    0.06392    0.06067    0.02714    0.00328
    0.00824    C.04995    0.06767    0.04448    0.01431    0.00140
    0.00921    0.05673    0.07562    0.04872    0.01569    0.00139
    0.00895    0.05666    0.07750    0.05047    0.01616    0.00137
    0.0C817    0.C5342    0.07682    0.05268    0.01785    0.00162
    0.00713    0.04825    0.07367    0.05439    0.02019    0.00202
    0.00597    0.04197    0.06835    0.05490    0.02258    0.00248
    0.00478    0.03515    0.06156    0.05456    0.02507    0.00296
    0.00337    0.02655    0.05C37    0.04884    0.02478    0.00313
OPTIMUM PRESSURE LOADING IN THE WING ALONE CASE
    0.33925    0.95849    1.10169    0.64982    0.13565   -0.03151
    0.30567    0.68236    0.90372    0.75224    0.33858    0.10925
    0.49081    1.C1350    0.95480    0.56554    0.17322    0.03985
    0.52897    1.12571    0.98873    0.52540    0.13808    0.00525
    0.49336    1.09702    0.99172    0.52162    0.12412   -0.00885
    0.42952    0.99758    0.96347    0.54116    0.14645    0.00098
    0.35511    C.86232    0.90144    0.56180    0.19145    0.02388
    0.27805    C.70889    0.80C97    0.55686    0.23455    0.04755
    0.19747    C.53467    0.63793    0.48581    0.24292    0.05915
    0.11020    0.30103    0.34792    0.28153    0.17088    0.04799
***************************************
       JET ON CASE WITH UPPER SURFACE BLOWING
***************************************

INPUT DATA
   0.          0.          0.25760    1.0C000    0.          -0.29391    0.12318
         1           1    0.
   0.36364    0.          0.         -0.29391    0.25945    0.05000    1.0C000    0.37495
   0.          1.0C000    1.000C0
   1.67600   10.0C000    0.
         3           3          4          6
         2
         6           0          0
  -0.56776   -0.09304    0.         -0.36750    0.06507    0.18972
  -0.36750    0.06507    0.18972   -0.22031    0.18128    0.32917
  -0.22031    0.18128    0.32917    C.48778    0.74033    1.00000
         2           7          6          4
  -0.36750    0.06507    0.18972    0.
  -0.36750    0.06507    0.18972    0.10000
  -0.22031    0.18128    0.32917    0.10000
  -0.22031    0.18128    0.32917    0.
   0.06507    0.49764    0.18972    0.
   0.06507    0.49764    0.18972    0.10000
   0.18128    0.58287    0.32917    0.10000
   0.18128    0.58287    0.32917    0.
          HALF SW= 0.36364E C0            CREF= 0.37495E 00

LPANEL= 60    JPANEL= 80    LAST=140    LTOTAL=220

VORTEX ELEMENT ENDPCINT COORDINATES=

X1            X2            Y1           Y2           Z1           Z2
  -0.55967   -0.45990    0.           0.09486    0.           0.
  -0.49824   -0.40120    0.           0.09486    0.           0.
```

-0.39183	-0.29951	0.	0.09486	0.	0.
-0.26897	-0.18210	0.	0.09486	0.	0.
-0.16256	-0.08042	0.	0.09486	0.	0.
-0.10113	-0.02171	0.	0.09486	0.	0.
-0.45990	-0.36013	0.09486	0.18972	0.	0.
-0.40120	-0.30415	0.09486	0.18972	0.	0.
-0.29951	-0.20719	0.09486	0.18972	0.	0.
-0.18210	-0.09524	0.09486	0.18972	0.	0.
-0.08042	0.00172	0.09486	0.18972	0.	0.
-0.02171	0.05770	0.09486	0.18972	0.	0.
-0.36013	-0.31486	0.18972	0.23276	0.	0.
-0.30415	-0.26012	0.18972	0.23276	0.	0.
-0.20719	-0.16531	0.18972	0.23276	0.	0.
-0.09524	-0.05582	0.18972	0.23276	0.	0.
0.00172	0.03899	0.18972	0.23276	0.	0.
0.05770	0.09373	0.18972	0.23276	0.	0.
-0.31486	-0.25874	0.23276	0.28613	0.	0.
-0.26012	-0.20553	0.23276	0.28613	0.	0.
-0.16531	-0.11337	0.23276	0.28613	0.	0.
-0.05582	-0.00696	0.23276	0.28613	0.	0.
0.03899	0.08520	0.23276	0.28613	0.	0.
0.09373	0.13841	0.23276	0.28613	0.	0.
-0.25874	-0.21347	0.28613	0.32917	0.	0.
-0.20553	-0.16150	0.28613	0.32917	0.	0.
-0.11337	-0.07148	0.28613	0.32917	0.	0.
-0.00696	0.03245	0.28613	0.32917	0.	0.
0.08520	0.12247	0.28613	0.32917	0.	0.
0.13841	0.17444	0.28613	0.32917	0.	0.
-0.21347	-0.11014	0.32917	0.42741	0.	0.
-0.16150	-0.06100	0.32917	0.42741	0.	0.
-0.07148	0.02412	0.32917	0.42741	0.	0.
0.03245	0.12241	0.32917	0.42741	0.	0.
0.12247	0.20754	0.32917	0.42741	0.	0.
0.17444	0.25668	0.32917	0.42741	0.	0.
-0.11014	0.04800	0.42741	0.57777	0.	0.
-0.06100	0.09282	0.42741	0.57777	0.	0.
0.02412	0.17046	0.42741	0.57777	0.	0.
0.12241	0.26010	0.42741	0.57777	0.	0.
0.20754	0.33774	0.42741	0.57777	0.	0.
0.25668	0.38256	0.42741	0.57777	0.	0.
0.04800	0.23061	0.57777	0.75140	0.	0.
0.09282	0.27044	0.57777	0.75140	0.	0.
0.17046	0.33943	0.57777	0.75140	0.	0.
0.26010	0.41909	0.57777	0.75140	0.	0.
0.33774	0.48808	0.57777	0.75140	0.	0.
0.38256	0.52791	0.57777	0.75140	0.	0.
0.23061	0.38876	0.75140	0.90176	0.	0.
0.27044	0.42426	0.75140	0.90176	0.	0.
0.33943	0.48576	0.75140	0.90176	0.	0.
0.41909	0.55678	0.75140	0.90176	0.	0.
0.48808	0.61828	0.75140	0.90176	0.	0.
0.52791	0.65378	0.75140	0.90176	0.	0.
0.38876	0.48006	0.90176	0.98857	0.	0.
0.42426	0.51307	0.90176	0.98857	0.	0.
0.48576	0.57025	0.90176	0.98857	0.	0.
0.55678	0.63627	0.90176	0.98857	0.	0.
0.61828	0.69345	0.90176	0.98857	0.	0.
0.65378	0.72646	0.90176	0.98857	0.	0.
-0.36013	-0.36013	0.18972	0.18972	0.	0.10000
-0.30415	-0.30415	0.18972	0.18972	0.	0.10000

-0.20719	-0.20719	0.18972	0.18972	0.	0.10000
-0.09524	-0.09524	0.18972	0.18972	0.	0.10000
0.00172	0.00172	0.18972	0.18972	0.	0.10000
0.05770	0.05770	0.18972	0.18972	0.	0.10000
-0.36013	-0.31486	0.18972	0.23276	0.10000	0.10000
-0.30415	-0.26012	0.18972	0.23276	0.10000	0.10000
-0.20719	-0.16531	0.18972	0.23276	0.10000	0.10000
-0.09524	-0.05582	0.18972	0.23276	0.10000	0.10000
0.00172	0.03899	0.18972	0.23276	0.10000	0.10000
0.05770	0.09373	0.18972	0.23276	0.10000	0.10000
-0.31486	-0.25874	0.23276	0.28613	0.10000	0.10000
-0.26012	-0.20553	0.23276	0.28613	0.10000	0.10000
-0.16531	-0.11337	0.23276	0.28613	0.10000	0.10000
-0.05582	-0.00696	0.23276	0.28613	0.10000	0.10000
0.03899	0.08520	0.23276	0.28613	0.10000	0.10000
0.09373	0.13841	0.23276	0.28613	0.10000	0.10000
-0.25874	-0.21347	0.28613	0.32917	0.10000	0.10000
-0.20553	-0.16150	0.28613	0.32917	0.10000	0.10000
-0.11337	-0.07148	0.28613	0.32917	0.10000	0.10000
-0.00696	0.03245	0.28613	0.32917	0.10000	0.10000
0.08520	0.12247	0.28613	0.32917	0.10000	0.10000
0.13841	0.17444	0.28613	0.32917	0.10000	0.10000
-0.21347	-0.21347	0.32917	0.32917	0.10000	0.
-0.16150	-0.16150	0.32917	0.32917	0.10000	0.
-0.07148	-0.07148	0.32917	0.32917	0.10000	0.
0.03245	0.03245	0.32917	0.32917	0.10000	0.
0.12247	0.12247	0.32917	0.32917	0.10000	0.
0.17444	0.17444	0.32917	0.32917	0.10000	0.
-0.36013	-0.31486	0.18972	0.23276	0.	0.
-0.30415	-0.26012	0.18972	0.23276	0.	0.
-0.20719	-0.16531	0.18972	0.23276	0.	0.
-0.09524	-0.05582	0.18972	0.23276	0.	0.
0.00172	0.03899	0.18972	0.23276	0.	0.
0.05770	0.09373	0.18972	0.23276	0.	0.
-0.31486	-0.25874	0.23276	0.28613	0.	0.
-0.26012	-0.20553	0.23276	0.28613	0.	0.
-0.16531	-0.11337	0.23276	0.28613	0.	0.
-0.05582	-0.00696	0.23276	0.28613	0.	0.
0.03899	0.08520	0.23276	0.28613	0.	0.
0.09373	0.13841	0.23276	0.28613	0.	0.
-0.25874	-0.21347	0.28613	0.32917	0.	0.
-0.20553	-0.16150	0.28613	0.32917	0.	0.
-0.11337	-0.07148	0.28613	0.32917	0.	0.
-0.00696	0.03245	0.28613	0.32917	0.	0.
0.08520	0.12247	0.28613	0.32917	0.	0.
0.13841	0.17444	0.28613	0.32917	0.	0.
0.08153	0.08153	0.18972	0.18972	0.	0.10000
0.19859	0.19859	0.18972	0.18972	0.	0.10000
0.36412	0.36412	0.18972	0.18972	0.	0.10000
0.48118	0.48118	0.18972	0.18972	0.	0.10000
0.08153	0.11704	0.18972	0.23276	0.10000	0.10000
0.19859	0.23150	0.18972	0.23276	0.10000	0.10000
0.36412	0.39338	0.18972	0.23276	0.10000	0.10000
0.48118	0.50785	0.18972	0.23276	0.10000	0.10000
0.11704	0.16106	0.23276	0.28613	0.10000	0.10000
0.23150	0.27232	0.23276	0.28613	0.10000	0.10000
0.39338	0.42966	0.23276	0.28613	0.10000	0.10000
0.50785	0.54091	0.23276	0.28613	0.10000	0.10000
0.16106	0.19656	0.28613	0.32917	0.10000	0.10000
0.27232	0.30523	0.28613	0.32917	0.10000	0.10000

```
  0.42966    0.45892    0.28613    0.32917    0.10000    0.10000
  0.54091    0.56759    0.28613    0.32917    0.10000    0.10000
  0.19656    0.19656    0.32917    0.32917    0.10000    0.
  0.30523    0.30523    0.32917    0.32917    0.10000    0.
  0.45892    0.45892    0.32917    0.32917    0.10000    0.
  0.56759    0.56759    0.32917    0.32917    0.10000    0.
  0.08153    0.11704    0.18972    0.23276    0.         0.
  0.19859    0.23150    0.18972    0.23276    0.         0.
  0.36412    0.39338    0.18972    0.23276    0.         0.
  0.48118    0.50785    0.18972    0.23276    0.         0.
  0.11704    0.16106    0.23276    0.28613    0.         0.
  0.23150    0.27232    0.23276    0.28613    0.         0.
  0.39338    0.42966    0.23276    0.28613    0.         0.
  0.50785    0.54091    0.23276    0.28613    0.         0.
  0.16106    0.19656    0.28613    0.32917    0.         0.
  0.27232    0.30523    0.28613    0.32917    0.         0.
  0.42966    0.45892    0.28613    0.32917    0.         0.
  0.54091    0.56759    0.28613    0.32917    0.         0.

CONTROL POINT COORDINATES=

XCP         YCP         ZCP         XCP         YCP         ZCP
 -0.48660    0.04743    0.          -0.40165    0.04743    0.
 -0.28560    0.04743    0.          -0.16956    0.04743    0.
 -0.08461    0.04743    0.          -0.05351    0.04743    0.
 -0.38788    0.14229    0.          -0.30679    0.14229    0.
 -0.19601    0.14229    0.          -0.08523    0.14229    0.
 -0.00414    0.14229    0.           0.02554    0.14229    0.
 -0.31727    0.21014    0.          -0.23894    0.21014    0.
 -0.13193    0.21014    0.          -0.02492    0.21014    0.
  0.05342    0.21014    0.           0.08209    0.21014    0.
 -0.26597    0.25944    0.          -0.18964    0.25944    0.
 -0.08537    0.25944    0.           0.01890    0.25944    0.
  0.09524    0.25944    0.           0.12317    0.25944    0.
 -0.21466    0.30875    0.          -0.14033    0.30875    0.
 -0.03880    0.30875    0.           0.06273    0.30875    0.
  0.13706    0.30875    0.           0.16426    0.30875    0.
 -0.14664    0.37411    0.          -0.07498    0.37411    0.
  0.02293    0.37411    0.           0.12083    0.37411    0.
  0.19250    0.37411    0.           0.21873    0.37411    0.
 -0.01888    0.49688    0.           0.04779    0.49688    0.
  0.13888    0.49688    0.           0.22996    0.49688    0.
  0.29664    0.49688    0.           0.32104    0.49688    0.
  0.15564    0.66458    0.           0.21550    0.66458    0.
  0.29727    0.66458    0.           0.37904    0.66458    0.
  0.43890    0.66458    0.           0.46080    0.66458    0.
  0.33017    0.83229    0.           0.38321    0.83229    0.
  0.45566    0.83229    0.           0.52811    0.83229    0.
  0.58115    0.83229    0.           0.60057    0.83229    0.
  0.45793    0.95506    0.           0.50598    0.95506    0.
  0.57161    0.95506    0.           0.63725    0.95506    0.
  0.68529    0.95506    0.           0.70288    0.95506    0.
 -0.33852    0.18972    0.05000     -0.25936    0.18972    0.05000
 -0.15122    0.18972    0.05000     -0.04307    0.18972    0.05000
  0.03609    0.18972    0.05000      0.06507    0.18972    0.05000
 -0.31727    0.21014    0.10000     -0.23894    0.21014    0.10000
 -0.13193    0.21014    0.10000     -0.02492    0.21014    0.10000
  0.05342    0.21014    0.10000      0.08209    0.21014    0.10000
 -0.26597    0.25944    0.10000     -0.18964    0.25944    0.10000
 -0.08537    0.25944    0.10000      0.01890    0.25944    0.10000
```

```
   0.09524    0.25944    0.10000    0.12317    0.25944    0.10000
  -0.21466    0.30875    0.10000   -0.14033    0.30875    0.10000
  -0.03880    0.30875    0.10000    0.06273    0.30875    0.10000
   0.13706    0.30875    0.10000    0.16426    0.30875    0.10000
  -0.19341    0.32917    0.05000   -0.11991    0.32917    0.05000
  -0.01952    0.32917    0.05000    0.08088    0.32917    0.05000
   0.15438    0.32917    0.05000    0.18128    0.32917    0.05000
  -0.31727    0.21014    0.        -0.23894    0.21014    0.
  -0.13193    0.21014    0.        -0.02492    0.21014    0.
   0.05342    0.21014    0.         0.08209    0.21014    0.
  -0.26597    0.25944    0.        -0.18964    0.25944    0.
  -0.08537    0.25944    0.         0.01890    0.25944    0.
   0.09524    0.25944    0.         0.12317    0.25944    0.
  -0.21466    0.30875    0.        -0.14033    0.30875    0.
  -0.03880    0.30875    0.         0.06273    0.30875    0.
   0.13706    0.30875    0.         0.16426    0.30875    0.
   0.12842    0.18972    0.05000    0.28135    0.18972    0.05000
   0.43429    0.18972    0.05000    0.49764    0.18972    0.05000
   0.14477    0.21014    0.10000    0.29611    0.21014    0.10000
   0.44744    0.21014    0.10000    0.51012    0.21014    0.10000
   0.18425    0.25944    0.10000    0.33171    0.25944    0.10000
   0.47918    0.25944    0.10000    0.54026    0.25944    0.10000
   0.22374    0.30875    0.10000    0.36732    0.30875    0.10000
   0.51091    0.30875    0.10000    0.57039    0.30875    0.10000
   0.24009    0.32917    0.05000    0.38207    0.32917    0.05000
   0.52406    0.32917    0.05000    0.58287    0.32917    0.05000
   0.14477    0.21014    0.         0.29611    0.21014    0.
   0.44744    0.21014    0.         0.51012    0.21014    0.
   0.18425    0.25944    0.         0.33171    0.25944    0.
   0.47918    0.25944    0.         0.54026    0.25944    0.
   0.22374    0.30875    0.         0.36732    0.30875    0.
   0.51091    0.30875    0.         0.57039    0.30875    0.
CLII,CMII,DELTA,MAXP
   1.20000   -0.07500    0.10000         20
NUMB,SIZE
         5    0.40000
INDUCED DRAG COEFFICIENT,    CDII=         0.02932
LIFT  COEFFICIENT,           CLII=         0.88280
PITCHING MOMENT COEFFICIENT,CMII=          0.06624
THE TWIST DISTRIBUTION IN THE SPANWISE  DIRECTION
YLE( 1)=          0.04743      ALPAO( 1)=         6.37815
YLE( 2)=          0.14229      ALPAO( 2)=         4.85762
YLE( 3)=          0.21014      ALPAO( 3)=         6.91677
YLE( 4)=          0.25944      ALPAO( 4)=         6.30695
YLE( 5)=          0.30875      ALPAO( 5)=         5.26961
YLE( 6)=          0.37411      ALPAO( 6)=         4.44399
YLE( 7)=          0.49688      ALPAO( 7)=         3.82860
YLE( 8)=          0.66458      ALPAO( 8)=         2.11882
YLE( 9)=          0.83229      ALPAO( 9)=         0.88134
YLE(10)=          0.95506      ALPAO(10)=         0.05737
CAMBER ORDINATES IN THE JET ON CASE
     0.00564    0.04024    0.07250    0.06315    0.02568    0.00281
     0.00730    0.04475    0.06478    0.04747    0.01730    0.00190
     0.00892    0.05413    0.07107    0.04421    0.01331    0.00118
     0.00921    0.05636    0.07428    0.04682    0.01456    0.00127
     0.00918    0.05677    0.07610    0.04947    0.01612    0.00143
     0.00906    0.05678    0.07718    0.05068    0.01660    0.00145
     0.00868    0.05571    0.07745    0.05083    0.01629    0.00138
     0.00745    0.04990    0.07499    0.05441    0.01977    0.00194
     0.00591    0.04164    0.06808    0.05499    0.02276    0.00251
     0.00416    0.03136    0.05646    0.05174    0.02481    0.00302
```

```
                    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

                         ALPHA =      0.       DEGREES

                    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
    VORTEX    XV         YV         CP         CPW
       1     0.01704    0.04743    0.36369    0.27324
       2     0.14645    0.04743    0.74771    0.69602
       3     0.37059    0.04743    1.01748    0.95547
       4     0.62941    0.04743    0.82461    0.76591
       5     0.85355    0.04743    0.35414    0.31755
       6     0.98296    0.04743    0.09244    0.08041
       7     0.01704    0.14229    0.60472    0.44343
       8     0.14645    0.14229    1.02375    0.91657
       9     0.37059    0.14229    1.04341    0.93288
      10     0.62941    0.14229    0.67637    0.61393
      11     0.85355    0.14229    0.24634    0.21871
      12     0.98296    0.14229    0.07384    0.06350
      13     0.01704    0.21014   -0.07581    0.52313
      14     0.14645    0.21014    5.09808    1.08728
      15     0.37059    0.21014    4.10085    0.97367
      16     0.62941    0.21014    1.51720    0.53386
      17     0.85355    0.21014   -0.29706    0.14443
      18     0.98296    0.21014    0.65598    0.02075
      19     0.01704    0.25944   -0.20226    0.53314
      20     0.14645    0.25944    5.58176    1.12298
      21     0.37059    0.25944    4.15151    0.98545
      22     0.62941    0.25944    1.33517    0.52403
      23     0.85355    0.25944   -0.22270    0.13686
      24     0.98296    0.25944    0.75326    0.00914
      25     0.01704    0.30875   -0.54272    0.52548
      26     0.14645    0.30875    5.29067    1.12427
      27     0.37059    0.30875    4.12287    0.98979
      28     0.62941    0.30875    1.62636    0.52630
      29     0.85355    0.30875   -0.14901    0.13835
      30     0.98296    0.30875    0.69648    0.00357
      31     0.01704    0.37411    0.55533    0.50901
      32     0.14645    0.37411    1.17755    1.11257
      33     0.37059    0.37411    1.08933    0.99236
      34     0.62941    0.37411    0.63420    0.52534
      35     0.85355    0.37411    0.22314    0.13237
      36     0.98296    0.37411    0.02890   -0.00368
      37     0.01704    0.49688    0.63958    0.46737
      38     0.14645    0.49688    1.13313    1.06074
      39     0.37059    0.49688    1.04020    0.98344
      40     0.62941    0.49688    0.56771    0.52471
      41     0.85355    0.49688    0.15053    0.12542
      42     0.98296    0.49688   -0.00061   -0.00870
      43     0.01704    0.66458    0.54141    0.37828
      44     0.14645    0.66458    0.96227    0.90573
      45     0.37059    0.66458    0.95878    0.92505
      46     0.62941    0.66458    0.58067    0.55977
      47     0.85355    0.66458    0.19068    0.17927
      48     0.98296    0.66458    0.02079    0.01716
      49     0.01704    0.83229    0.40050    0.27428
      50     0.14645    0.83229    0.74232    0.70117
      51     0.37059    0.83229    0.81743    0.79535
      52     0.62941    0.83229    0.56839    0.55616
```

```
        53        0.85355    0.83229    0.24280    0.23663
        54        0.98296    0.83229    0.05058    0.04868
        55        0.01704    0.95506    0.24694    0.15589
        56        0.14645    0.95506    0.45343    0.42816
        57        0.37059    0.95506    0.51478    0.50533
        58        0.62941    0.95506    0.39531    0.39131
        59        0.85355    0.95506    0.21155    0.20976
        60        0.98296    0.95506    0.05405    0.05351

     Y/SP       CL        CM         CT          CDI       CLW       CMW       CDW
    0.04743  0.70071  0.58443  0.           0.06288  0.64689  0.53890  0.05870
    0.14229  0.71599  0.46915  0.           0.03353  0.63567  0.41331  0.03247
    0.21014  2.34876  1.29871  0.           0.16684  0.64609  0.33297  0.04727
    0.25944  2.41687  1.04057  0.           0.12010  0.65168  0.25603  0.03664
    0.30875  2.41610  0.68023  0.           0.10127  0.65297  0.17240  0.02297
    0.37411  0.73473  0.05386  0.           0.02235  0.64850  0.06084  0.01286
    0.49688  0.68753 -0.15679  0.           0.00496  0.63204 -0.14489  0.00759
    0.66458  0.64082 -0.43835  0.          -0.00905  0.60313 -0.41597 -0.00433
    0.83229  0.56337 -0.64422  0.          -0.01178  0.53726 -0.61765 -0.00805
    0.95506  0.37364 -0.55137  0.          -0.01011  0.35902 -0.53237 -0.00783
     JET - OFF  SPAN LOADING             JET - ON SPAN LOADING
     0.80084                             0.86746
     0.75122                             0.84614
     0.73756                             2.68128
     0.72490                             2.68843
     0.70726                             2.61700
     0.67731                             0.76737
     0.61414                             0.66806
     0.52611                             0.55899
     0.41526                             0.43545
     0.25138                             0.26162
 THE LIFT COEFFICIENT =    0.88280
 TOTAL INDUCED DRAG COEFFICIENT =    0.02932
 THE INDUCED DRAG PARAMETER =    0.03762
 TOTAL PITCHING MOMENT COEFFICIENT =    0.06624
 THE COANDA LIFT COEFFICIENT, CLR=    0.29103
 THE COANDA DRAG COEFFICIENT, CDR=   -1.21880
 THE COANDA MOMENT COEFFICIENT, CMR =   -0.09561
 THE LIFT COEFFICIENT FOR THE WING ALONE =    0.57709
 THE INDUCED DRAG COEFFICIENT FOR THE WING ALONE =    0.01552
 THE PITCHING MOMENT COEFFICIENT FOR THE WING ALONE =   -0.04943
 THE INDUCED DRAG PARAMETER FOR THE WING ALONE =    0.04659

 DELTA=      0.100       1TH  ITERATION  OF 1TH  INTERMEDIATE CYCLES
 INDUCED DRAG COEFFICIENT,    CDII=         0.04594
 LIFT  COEFFICIENT,           CLII=         0.94622
 PITCHING MOMENT COEFFICIENT,CMII=          0.03800

 DELTA=      0.400       2TH  ITERATION  OF 1TH  INTERMEDIATE CYCLES
 INDUCED DRAG COEFFICIENT,    CDII=         0.04055
 LIFT  COEFFICIENT,           CLII=         0.94624
 PITCHING MOMENT COEFFICIENT,CMII=          0.03800

 DELTA=      0.100       1TH  ITERATION  OF 2TH  INTERMEDIATE CYCLES
 INDUCED DRAG COEFFICIENT,    CDII=         0.05243
 LIFT  COEFFICIENT,           CLII=         1.00966
 PITCHING MOMENT COEFFICIENT,CMII=          0.00975

 DELTA=      0.400       2TH  ITERATION  OF 2TH  INTERMEDIATE CYCLES
 INDUCED DRAG COEFFICIENT,    CDII=         0.04604
```

```
LIFT   COEFFICIENT,                CLII=          1.00968
PITCHING MOMENT COEFFICIENT,CMII=                 0.00975

DELTA=       0.100        1TH   ITERATION   OF 3TH   INTERMEDIATE CYCLES
INDUCED DRAG COEFFICIENT,    CDII=                0.05924
LIFT   COEFFICIENT,                CLII=          1.07310
PITCHING MOMENT COEFFICIENT,CMII=                -0.01850

DELTA=       0.400        2TH   ITERATION   OF 3TH   INTERMEDIATE CYCLES
INDUCED DRAG COEFFICIENT,    CDII=                0.05167
LIFT   COEFFICIENT,                CLII=          1.07311
PITCHING MOMENT COEFFICIENT,CMII=                -0.01850

DELTA=       0.100        1TH   ITERATION   OF 4TH   INTERMEDIATE CYCLES
INDUCED DRAG COEFFICIENT,    CDII=                0.06599
LIFT   COEFFICIENT,                CLII=          1.13654
PITCHING MOMENT COEFFICIENT,CMII=                -0.04675

DELTA=       0.400        2TH   ITERATION   OF 4TH   INTERMEDIATE CYCLES
INDUCED DRAG COEFFICIENT,    CDII=                0.05725
LIFT   COEFFICIENT,                CLII=          1.13655
PITCHING MOMENT COEFFICIENT,CMII=                -0.04675

DELTA=       0.100        1TH   ITERATION   OF 5TH   INTERMEDIATE CYCLES
INDUCED DRAG COEFFICIENT,    CDII=                0.07251
LIFT   COEFFICIENT,                CLII=          1.19998
PITCHING MOMENT COEFFICIENT,CMII=                -0.07500

DELTA=       0.400        2TH   ITERATION   OF 5TH   INTERMEDIATE CYCLES
INDUCED DRAG COEFFICIENT,    CDII=                0.06263
LIFT   COEFFICIENT,                CLII=          1.19999
PITCHING MOMENT COEFFICIENT,CMII=                -0.07500

THE   1TH    ITERATION IN THE FINAL CYCLE, DELTA=          0.400
INDUCED DRAG COEFFICIENT,    CDII=                0.05417
LIFT   COEFFICIENT,                CLII=          1.19999
PITCHING MOMENT COEFFICIENT,CMII=                -0.07500
THE ROOT MEAN SQUARE OF CAMBER ORDINATES=                0.00075

THE   2TH    ITERATION IN THE FINAL CYCLE, DELTA=          0.400
INDUCED DRAG COEFFICIENT,    CDII=                0.04681
LIFT   COEFFICIENT,                CLII=          1.20000
PITCHING MOMENT COEFFICIENT,CMII=                -0.07500
THE ROOT MEAN SQUARE OF CAMBER ORDINATES=                0.00068

THE   3TH    ITERATION IN THE FINAL CYCLE, DELTA=          0.400
INDUCED DRAG COEFFICIENT,    CDII=                0.04030
LIFT   COEFFICIENT,                CLII=          1.20000
PITCHING MOMENT COEFFICIENT,CMII=                -0.07500
THE ROOT MEAN SQUARE OF CAMBER ORDINATES=                0.00062

THE   4TH    ITERATION IN THE FINAL CYCLE, DELTA=          0.400
INDUCED DRAG COEFFICIENT,    CDII=                0.03450
LIFT   COEFFICIENT,                CLII=          1.20000
PITCHING MOMENT COEFFICIENT,CMII=                -0.07500
THE ROOT MEAN SQUARE OF CAMBER ORDINATES=                0.00057

THE   5TH    ITERATION IN THE FINAL CYCLE, DELTA=          0.400
INDUCED DRAG COEFFICIENT,    CDII=                0.02928
LIFT   COEFFICIENT,                CLII=          1.20000
```

```
PITCHING MOMENT COEFFICIENT,CMII=          -0.07500
THE ROOT MEAN SQUARE OF CAMBER ORDINATES=              0.00053

THE  6TH   ITERATION IN THE FINAL CYCLE, DELTA=       0.400
INDUCED DRAG COEFFICIENT,   CDII=          0.02454
LIFT  COEFFICIENT,          CLII=          1.20000
PITCHING MOMENT COEFFICIENT,CMII=          -0.07500
THE ROOT MEAN SQUARE OF CAMBER ORDINATES=              0.00050

THE  7TH   ITERATION IN THE FINAL CYCLE, DELTA=       0.400
INDUCED DRAG COEFFICIENT,   CDII=          0.02018
LIFT  COEFFICIENT,          CLII=          1.20000
PITCHING MOMENT COEFFICIENT,CMII=          -0.07500
THE ROOT MEAN SQUARE OF CAMBER ORDINATES=              0.00046

THE  8TH   ITERATION IN THE FINAL CYCLE, DELTA=       0.400
INDUCED DRAG COEFFICIENT,   CDII=          0.01615
LIFT  COEFFICIENT,          CLII=          1.20000
PITCHING MOMENT COEFFICIENT,CMII=          -0.07500
THE ROOT MEAN SQUARE OF CAMBER ORDINATES=              0.00044

THE  9TH   ITERATION IN THE FINAL CYCLE, DELTA=       0.400
INDUCED DRAG COEFFICIENT,   CDII=          0.01237
LIFT  COEFFICIENT,          CLII=          1.20000
PITCHING MOMENT COEFFICIENT,CMII=          -0.07500
THE TWIST DISTRIBUTION IN THE SPANWISE  DIRECTION
YLE( 1)=           0.04743      ALPAO( 1)=         8.58050
YLE( 2)=           0.14229      ALPAO( 2)=        18.26916
YLE( 3)=           0.21014      ALPAO( 3)=       -13.35170
YLE( 4)=           0.25944      ALPAO( 4)=         4.09779
YLE( 5)=           0.30875      ALPAO( 5)=       -10.28359
YLE( 6)=           0.37411      ALPAO( 6)=        11.19529
YLE( 7)=           0.49688      ALPAO( 7)=         3.86014
YLE( 8)=           0.66458      ALPAO( 8)=         3.46656
YLE( 9)=           0.83229      ALPAO( 9)=         1.20347
YLE(10)=           0.95506      ALPAO(10)=        -1.35737
CAMBER ORDINATES IN THE JET ON CASE
   0.00770   0.05095   0.08393   0.06981   0.02866   0.00332
   0.01452   0.09007   0.12577   0.08447   0.02843   0.00302
   0.00134   0.02399   0.06068   0.07131   0.04191   0.00505
   0.00597   0.05382   0.07719   0.04690   0.02129   0.00218
   0.00105   0.02396   0.04997   0.05066   0.03258   0.00401
   0.01422   0.08461   0.11489   0.08181   0.03076   0.00337
   0.01141   0.07264   0.10950   0.08672   0.03636   0.00423
   0.01090   0.07187   0.11509   0.09656   0.04255   0.00513
   0.00882   0.06103   0.10401   0.09259   0.04315   0.00534
   0.00572   0.04239   0.07835   0.07599   0.03840   0.00489
THE ROOT MEAN SQUARE OF CAMBER ORDINATES=              0.00041
```

```
                    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

                          ALPHA =      0.        DEGREES

                    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  VORTEX    XV          YV         CP          CPW
     1     0.01704    0.04743    0.47346    0.27324
     2     0.14645    0.04743    1.00333    0.69602
     3     0.37059    0.04743    1.31955    0.95547
     4     0.62941    0.04743    1.10117    0.76591
     5     0.85355    0.04743    0.53810    0.31755
     6     0.98296    0.04743    0.16716    0.08041
     7     0.01704    0.14229    0.95024    0.44343
     8     0.14645    0.14229    1.72062    0.91657
     9     0.37059    0.14229    1.60856    0.93288
    10     0.62941    0.14229    0.93595    0.61393
    11     0.85355    0.14229    0.31193    0.21871
    12     0.98296    0.14229    0.10460    0.06350
    13     0.01704    0.21014   -1.85986    0.52313
    14     0.14645    0.21014    2.19873    1.08728
    15     0.37059    0.21014    4.36602    0.97367
    16     0.62941    0.21014    3.36949    0.53386
    17     0.85355    0.21014    2.39451    0.14443
    18     0.98296    0.21014    1.00400    0.02075
    19     0.01704    0.25944   -0.75528    0.53314
    20     0.14645    0.25944    4.74276    1.12298
    21     0.37059    0.25944    4.65973    0.98545
    22     0.62941    0.25944    1.41030    0.52403
    23     0.85355    0.25944    1.73256    0.13686
    24     0.98296    0.25944    0.95776    0.00914
    25     0.01704    0.30875   -1.59881    0.52548
    26     0.14645    0.30875    2.74823    1.12427
    27     0.37059    0.30875    3.97128    0.98979
    28     0.62941    0.30875    2.64443    0.52630
    29     0.85355    0.30875    2.67985    0.13835
    30     0.98296    0.30875    1.15858    0.00357
    31     0.01704    0.37411    0.70660    0.50901
    32     0.14645    0.37411    1.61202    1.11257
    33     0.37059    0.37411    1.47902    0.99236
    34     0.62941    0.37411    1.02955    0.52534
    35     0.85355    0.37411    0.48928    0.13237
    36     0.98296    0.37411    0.14618   -0.00368
    37     0.01704    0.49688    0.74190    0.46737
    38     0.14645    0.49688    1.40284    1.06074
    39     0.37059    0.49688    1.41070    0.98344
    40     0.62941    0.49688    1.02394    0.52471
    41     0.85355    0.49688    0.50286    0.12542
    42     0.98296    0.49688    0.15149   -0.00870
    43     0.01704    0.66458    0.67556    0.37828
    44     0.14645    0.66458    1.29936    0.90573
    45     0.37059    0.66458    1.40971    0.92505
    46     0.62941    0.66458    1.09592    0.55977
    47     0.85355    0.66458    0.57263    0.17927
    48     0.98296    0.66458    0.18311    0.01716
    49     0.01704    0.83229    0.52237    0.27428
    50     0.14645    0.83229    1.04290    0.70117
    51     0.37059    0.83229    1.22420    0.79535
    52     0.62941    0.83229    1.01504    0.55616
```

```
        53       0.85355    0.83229    0.57032    0.23663
        54       0.98296    0.83229    0.18453    0.04868
        55       0.01704    0.95506    0.32196    0.15589
        56       0.14645    0.95506    0.62419    0.42816
        57       0.37059    0.95506    0.74849    0.50533
        58       C.62941    0.95506    0.64621    0.39131
        59       0.85355    0.95506    0.39385    0.20976
        60       0.98296    0.95506    0.12604    0.05351

     Y/SP        CL         CM         CT          CDI       CLW       CMW       CDW
   0.04743   0.94091   0.77565   0.          0.12627   0.64689   0.53890   0.05870
   0.14229   1.C9119   0.73811   0.          0.25540   0.63567   0.41331   0.03247
   0.21014   2.74845   0.88267   0.         -0.67459   0.64609   0.33297   0.04727
   0.25944   2.74741   0.90059   0.          0.11828   0.65168   0.25603   0.03664
   0.30875   2.64799   0.22817   0.         -0.48506   0.65297   0.17240   0.02297
   0.37411   1.08114   0.04516   0.          0.15507   0.64850   0.06084   0.01286
   0.49688   1.02899  -0.29282   0.          0.01429   0.63204  -0.14489   0.00759
   0.66458   1.03835  -0.75872   0.          0.01472   0.60313  -0.41597  -0.00433
   0.83229   0.91279  -1.07154   0.         -0.01101   0.53726  -0.61765  -0.00805
   0.95506   0.57151  -0.85388   0.         -0.02845   0.35902  -0.53237  -0.00783
    JET - OFF  SPAN LOADING           JET - ON SPAN LOADING
    0.80084                           1.16483
    0.75122                           1.28954
    0.73756                           3.13756
    0.72490                           3.05612
    0.70726                           2.86817
    0.67731                           1.12917
    0.61414                           0.99984
    0.52611                           0.90575
    0.41526                           0.70553
    0.25138                           C.40016
THE LIFT COEFFICIENT =    1.20000
TOTAL INDUCED DRAG COEFFICIENT =    0.01237
THE INDUCED DRAG PARAMETER =    0.00859
TOTAL PITCHING MOMENT COEFFICIENT =  -0.07500
THE COANDA LIFT COEFFICIENT, CLR=   0.29103
THE COANDA DRAG COEFFICIENT, CDR=  -1.21880
THE COANDA MOMENT COEFFICIENT, CMR =   -0.09561
THE LIFT COEFFICIENT FOR THE WING ALONE =    0.57709
THE INDUCED DRAG COEFFICIENT FOR THE WING ALONE =    0.01552
THE PITCHING MOMENT COEFFICIENT FOR THE WING ALONE =    -0.04943
THE INDUCED DRAG PARAMETER FOR THE WING ALONE =    0.04659
```